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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)

1. Document Title and Number: RPP-22520, Rev. 6, 241-C-101 and 241-C-105 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: 4/1/09 **4.** Document Modification Notice Date: 12/1/11	**5.** Notice Number: 2011-9 RECEIVED FEB 23 2012 EDMC
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 update the retrieval technology selection for both C-101 and C-105. Changes are also 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 This opportunity is being taken to clean up a number of out-of-date or inaccurate words in the TWRWP.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. x, xi, 1-1 to 1-2, 2-1, 2-9 to 2-15, 2-18, 2-19, 3-1 to 3-43, 4-1, 4-3, 4-4, 4-6, 4-9, 4-10, 4-12, 4-13, 4-21 to 4-26, 5-1, 5-2, 5-8, 5-11, 6-1, 6-2, 7-1, 7-9, 9-1 to 9-11, A-2-A-6, A-9, B-2-B-6, B-9.

Justifications:

- pg x, added high pressure water definition and bgs acronym
- pg xi, added TOC as acronym
- pgs 1-1 to 1-2, changed tank status and retrieval technologies, changed to update for Consent Decree wording, deleted unnecessary old wording
- pg 2-1, revised date wording for consistency with Consent Decree wording
- pgs 2-9 to 2-15, provided discussion supporting change to C-101 leak status and document updates
- pg 2-18 removed statement on leaks
- pg 2-19 updated dates
- pgs 3-1 to 3-43, changed to comply with Consent Decree wording on second technologies, new technology descriptions and operations, informed instead of notify, and reference updates (see Modification notices approved by Ecology 2011-02 and 2011-05 for similar changes)
- pg 4-1, added words referencing Consent Decree for TWRWP requirements

WMA-C

- pg 4-3, clarified responsibility of ground water report
- pgs 4-4 and 4-12 added in words approved by Ecology in Modification Notice 2011-1 for annulus leak detection
- pg 4-6 corrected reference
- pg 4-9 clarified moisture logging range
- pg 4-10, updated date
- pg 4-12, updated leak detection description for selected technology
- pg 4-13, softened time restriction for obtaining post retrieval gamma scan and changed annulus leak detection
- pgs 4-21 to 4-26, changed language to match other TWRWP and retrieval technology.
- pgs 5-1 to 5-2, clarified Consent Decree applicability and updated TOC and contract number, added words consistent with Ecology approved C-111 TWRWP
- pg 5-8, corrected typo
- pg 5-11 updated reference
- pgs 6-1 to 6-2, added language consistent with C-111 TWRWP
- pg 7-1, added reference to Consent Decree
- pg 7-9 explained bounding concentration values
- pgs 9-1 to 9-11, updated references
- pgs A-2 to A-6, updated risk plots and contaminant concentrations to reflect select retrieval technology
- pg A-9 updated reference
- pgs B-2 to B-6, updated risk plots and contaminant concentrations to reflect select retrieval technology
- pg B-9 updated reference

10. Impact of Change:

Allows the use of modified sluicing in C-101 and MARS-V in C-105 and the 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]: It is noted that there are increases in hazard quotients, cancer risk values, concentrations and inventories associated with the risk assessment due to the change in retrieval methodology. We are aware that the indicator contaminant concentrations are high estimates that are intended to be bounding. Ecology requests these calculations be refined as retrieval activities are conducted including known volume of water added, DST decants performed, and other waste transfers to the DSTs.

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 2/23/12	☒ Final Approval Date 2/23/12	☒ Final Approval Date 2/23/12

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.

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.~~None required; terms are defined within the document text.~~

Abbreviations and Acronyms

~~**Abbreviations, Acronyms, and Initialisms**~~

1C	bismuth phosphate first-cycle decontamination
AC	Administrative Control
ALARA	as low as reasonably achievable
AMS	articulated mast system
BBI	best-basis inventory
BGS	below ground surface
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
EDE	effective dose equivalent
EPA	U.S. Environmental Protection Agency
HDW	Hanford Defined Waste
HEPA	high-efficiency particulate air
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
HI	hazard index
HQ	hazard quotient
HIHTL	hose-in-hose transfer line
HPGe	high purity germanium
IH	Industrial Hygiene
~~ITV~~	~~in-tank vehicle~~
ILCR	incremental lifetime cancer risk
LDM	leak detection and monitoring
LDMM	leak detection, mitigation, and monitoring
LETF	Liquid Effluent Treatment Facility
MRS	mobile retrieval system
ORP	Office of River Protection
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyls
PNNL	Pacific Northwest National Laboratory
PUREX	plutonium-uranium extraction
RCRA	*Resource Conservation and Recovery Act of 1976*

RMS	retrieval monitoring system
SGLS	spectral gamma logging system
SST	single-shell tank
TOC	tank operations contractor
UPR	unplanned release
WMA	waste management area
WRS	waste retrieval system

Units

%	percent
Ci/kg	curie per kilogram
Ci	curie
°F	degrees Fahrenheit
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
mL/g	milliliters per gram
mm/yr	millimeters per year
mrem	millirem
pCi/g	picocurie per gram
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~~ Tank 241-C-101 (C-101) will be retrieved with modified sluicing (MS) and tank 241-C-105 (C-105) ~~single-shell tanks (SSTs), located in the 200 East Area (Figure 1-1), are scheduled for waste retrieval~~will be retrieved using the mobile arm retrieval system vacuum (MARS-V) waste retrieval technology. The ~~se tanks were identified for waste retrieval with the~~ basis for the retrieval technology selected ~~MRS based on the~~is as ~~-follow~~ings:

Tank C-101 is classified as an 'assumed leaker' in HNF-EP-0182, *Waste Tank Summary Report for Month Ending ~~March 31~~September 30, ~~2005~~2011*. The tank history was reevaluated as described in RPP-ENV-33418, *Hanford C-Farm Leak Assessments Report; Tanks 241-C-101, 241-C-110, 241-C-111, 241-C-105 and Unplanned Waste Releases*, Rev. 1. No conclusion was reached during the reevaluation, but subsequent analysis and new data allowed for qualifying the "assumed leaker" tank status. There is sufficient evidence to conclude that there were and are no tank leaks below 54". Soil contamination in the drywells was likely from near surface events such as small leaks from spare inlet nozzles. ~~The MRS provides for waste retrieval in a batch mode where limited volumes of water are introduced into the tank. This technology represents the best available waste retrieval technology for tanks with suspect integrity.~~

- Tank C-105 is classified as a sound tank; however, vadose zone characterization data collected around tank C-105 indicates that an unplanned release occurred near tank C-105. Because the cause or source of this unplanned release cannot be confirmed, the MARS-V was selected for retrieving the waste from tank C-105 to minimize the potential for leakage to occur.

This ~~is a primary~~ document was originally developed to meet the requirements identified in ~~Change Request M-45-04-01 of Ecology et al. (1989),~~ *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) become the regulating direction for TWRWPs for tanks retrieved as Project B-1 and Project B-4 of the Decree. ~~The relationship of the tank waste retrieval work plans to the overall SST waste retrieval and closure process is described in Appendix I of the HFFACO under Change Request M-45-04-01.~~ 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-101 and C-105 to allow Ecology to approve the waste retrieval ~~action~~activity in Project B-1.

~~Tank waste retrieval work plans have been developed for the other 100-series tanks in the C-farm including RPP-21895, *241-C-103 and 241-C-109 Tanks Waste Retrieval Work Plan*; RPP-22393, *241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan*, and RPP-33116, *241-C-110 Tank Waste Retrieval Work Plan*. A similar document was also prepared for the C-200-series tanks, RPP-16525, *C-200-Series Tanks Retrieval Functions and Requirements*. Neither a functions and requirements document nor a work plan was~~

~~developed for tank C-106. Regulatory approval to retrieve waste from tank C-106 was established through the HFFACO.~~

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."

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

2.1 RETRIEVAL START DATES

The current baseline includes initiating waste retrieval from tank C-101 in ~~October 2010~~ November 2012 and tank C-105 in ~~September~~ August 2013. ~~In accordance with the HFFACO, Appendix I, Section 2.1.5, it is understood waste retrieval is to be completed within 12 months of these retrieval start dates. The tank retrieval process will be completed within this time frame, or the TWRWP will be revised to provide an estimated completion date for the retrieval process.~~ Completion dates are specified in the Decree. 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 work plan addresses waste retrieval from two 100-series tanks, C-101 and C-105, located in the C tank farm in the 200 East Area (Figure 2-1). Summary-level historical data related to the configuration and operating history for these tanks are provided in Table 2-1.

Table 2-1. Summary-Level Tank Data.*

Tank	C-101	C-105
Constructed	1943-44	1943-44
In service	1946	1947
Diameter (ft)	75	75
Operating depth (in.)	185	185
Design capacity (gal.)	530,000	530,000
Bottom shape	Dish	Dish
Ventilation	Passive	Passive
Nominal burial depth (ft)	6	6
Declared inactive	1977	1980
Interim stabilized	11/83	10/95

* Best-basis inventory AutoTCR documents (6-10-2005) from TWINS, Web Site - http://twinsweb.pnl.gov/twins.htm.
TWINS = Tank Waste Information Network System.

data appears to be inconsistent and a high uncertainty exists whether evaporation or a tank leak occurred. The document further states that until better supporting evidence is obtained that the 20,000 gal leak estimate in HNF-EP-0182 should be maintained.

In 2011 direct push slant holes under the tank (C8101/2 at site A and C8103/4 at site B) were logged and sampled in accordance with the WMA C work plan (RPP-PLAN-39114). The field activities report is RPP-RPT-50581, *Completion Report for the 241-C Tank Farm, C-101 Angle Direct Push Characterization*. Electrode strings were placed in the holes to enable collection of resistivity data in support of Surface Geophysics Exploration (SGE) and or leak detection monitoring during retrieval. Site A was selected to run under the tank near the spare inlets. Site B was selected to investigate the East side of the tank where no dry wells were installed. Low gamma activity was observed throughout the logged profile in both holes. Sample results show low nitrate and ^{99}Tc was not detected except at low concentrations deep in slant hole C8104.

In summary, tank C-101 experienced a level decrease of approximately 36,000 gal. between 1965 and 1969. Evaporation due to the high temperature of the waste may explain much of the liquid level decrease, and the fact that the liquid submerged the spare inlet lines (which were not designed to be leak tight) could also explain some of the liquid decrease and the elevated radiation detected in two of the drywells near the spare lines. A 20,000 gal. leak estimate has been published for years for this tank based apparently upon conclusions in RHO-CD-896, but no details are provided for this number. Subsequent evaluations indicated there is little evidence for a 20,000 gal. leak so no leakage from this tank was assumed in RPP-15317 or RPP-14430, and none was assumed in the risk assessment in RPP-13774. Subsequent to RPP-13774 being issued, a nominal 1,000 gal. leak volume was assigned to tank C-101 in RPP-23405, Rev 0, for risk assessment purposes. The drywell and direct push logging results indicate that if a large volume of waste was released, mobile contaminants may have been flushed below the depth of the direct push hole (~180 ft below ground surface) to the ground water. RPP-ENV-33418 Rev. 1 evaluated the existing data and concluded the 20,000 gal leak estimate in HNF-EP-0182 should be maintained until supporting data is available to change this estimate. ~~RPP-23405 was revised in Rev 3 to reflect this same 20,000 gal value.~~Supporting data was obtained in 2011 (RPP-ENV-33418, Rev. 2) and given that no high gamma activity and little or no nitrate or ^{99}Tc were detected (depending on the segment) in the direct push slant hole logs and soil samples, the slant hole data appears to support the conclusion that the tank liner did not leak, but that the liquid level decrease and activity observed in drywells may be attributed to releases from the spare inlets, cascade line releases and leaks from the condenser.

2.4.1.1. Proposed Revision or Qualification to Assumed Leaker Status

On October 7, 2010 representatives of the Washington State Department of Ecology (Ecology), the U.S. Department of Energy, Office of River Protection (ORP), and Washington River Protection Solutions, LLC (WRPS), met to discuss results of an informal evaluation and the current understanding of the factors associated with the leak status of tank 241-C-101 (C-101) to determine whether the existing data provides any indication tank C-101 might be a candidate for retrieval using Modified Sluicing rather than the designated Mobile Arm Retrieval System (RPP-ENV-33418, Rev. 2A Appendix A).

Discussed during the presentation were the tank C-101 historic liquid level data and dry well monitoring data. Participants concluded that current data indicate the tank liner probably did not leak, but that liquid level decreases between 1965 and 1969 were likely a result of the tank being over filled and that supernate was likely released through the spare inlets and potentially cascade line and condenser leaks. If the tank did leak it was probably on the tank wall because a stable liquid level was observed at about 54 inches above the base of the tank. It was also concluded that, in light of the data presented, regardless of its future leak status, the tank can probably be retrieved using sluicing technology with low risk by keeping the working volume below the 54-inch level during retrieval operations. (The current waste level is ~40 inches.)

It was agreed during this meeting that a revision to RPP-22520, "*241-C-101 and 241-C105 Tanks Waste Retrieval Work Plan*", will be made to accommodate modified sluicing of tank C-101 contingent upon the following:

a. "Two direct push hole pairs will be installed near tank C-101. These holes will be logged and sampled as specified in the WMA-C work plan (RPP-PLAN-39114). One of the direct push holes will be installed near the spare inlets.

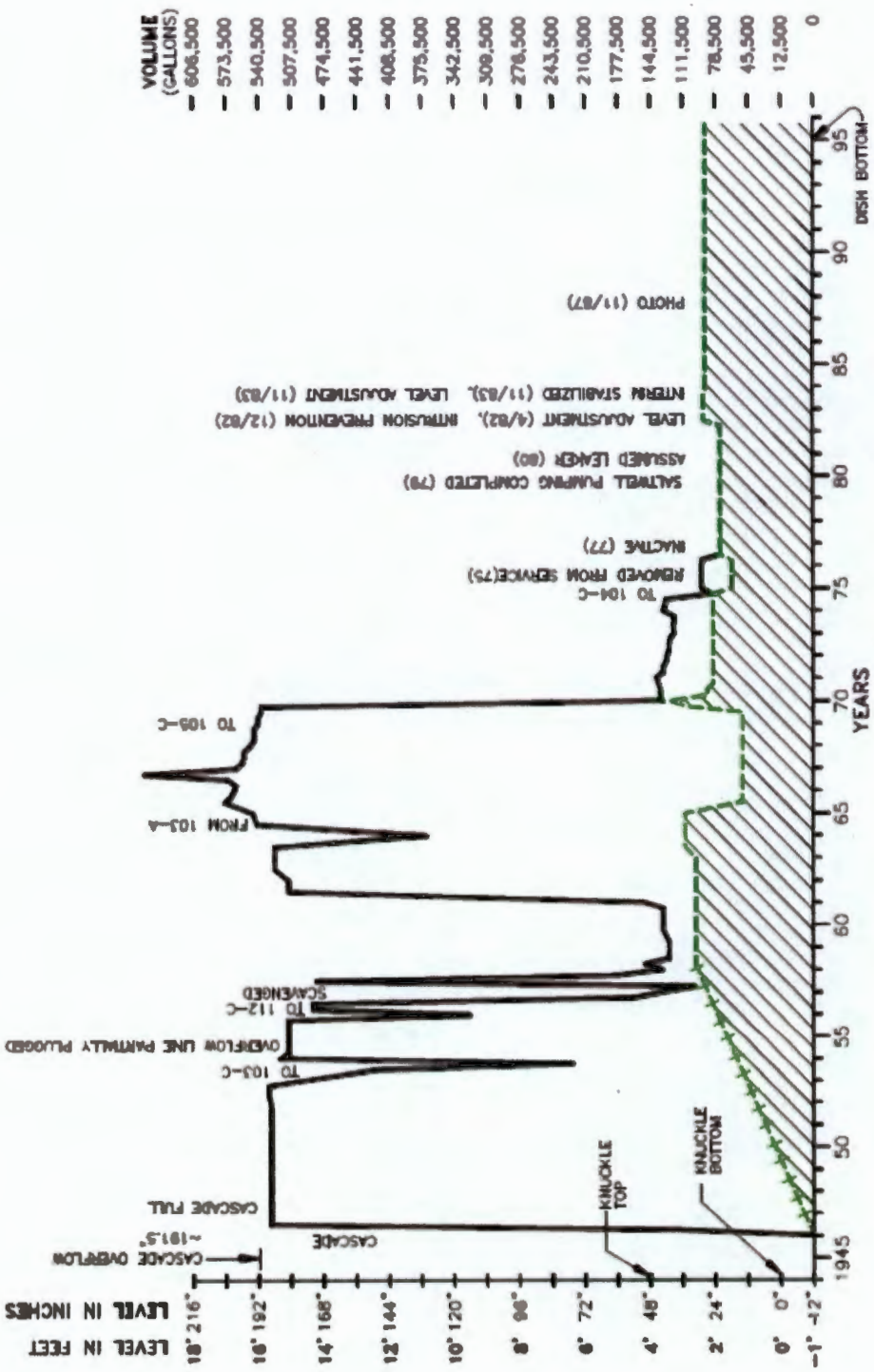
   Additional direct push holes will be drilled as needed for complete HRR coverage during retrieval. Gamma and neutron logging will be performed and an electrode string will be placed in these holes. The electrodes will be placed to an approximate depth of 80 ft, near the high moisture zone in this area.

b. Additional pushes for sampling near the HRR system holes will be contingent on logging results and determined jointly by ORP and Ecology."

"The liquid level in tank C-101 will be limited to below ~54 inches in total waste depth during all retrieval activities."

The required work has been completed providing supporting evidence that the tank liner did not leak, but no change to the tank status in HNF-0182 is proposed until the formal process in procedure TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process* is followed.

Figure 2-4. *Tank C-101 Surface Level History from 1946 to 1995.



2.4.2 Tank C-105

Tank status is officially declared in HNF-EP-0182. The report HNF-EP-0182 is a summary report that includes tank status and tank leak volume estimates. Reports, records, data, and a probabilistic assessment process are used to determine the status of the tank and subsequently a leak volume.

Although tank C-105 is designated as a 'sound' tank in HNF-EP-0182, there is contamination reported in the vadose zone from routine geophysical monitoring between tanks C-105 and C-104. Contamination was noted in the soil around drywell 30-05-07 when it was drilled in 1974. Spectral gamma measurement shows a definite Cs^{137} peak between 34 to 44 ft below grade. Based upon this data the document states that if C-105 did leak it was prior to 1974 and that the leak appeared to seal afterwards since the tank was used repeatedly until 1978 as an active receipt and feed tank. A small Cs^{137} peak is seen in adjacent drywell 30-05-05 between 60 and 65 ft below grade and a very small Cs^{137} peak in adjacent drywell 30-05-08 at 47 ft below grade.~~This data indicates that an unplanned release occurred near tank C-105. The cause or source of this unplanned release cannot be confirmed. See Section 7.1.3.3 for UPR information and the leak volume size assumed in RPP-13774 for tank C-105.~~

~~Tank C-105 is classified as a sound tank in HNF-EP-0182. There have been no reported unexplained level drops for this tank. Since it is designated as a sound tank there is no estimated leak volume.~~

~~RPP-15317 discusses monitoring data associated with tank C-105. Contamination was noted in the soil around drywell 30-05-07 when it was drilled in 1974. Spectral gamma measurement shows a definite Cs^{137} peak between 34 to 44 ft below grade. Based upon this data the document states that if C-105 did leak it was prior to 1974 and that the leak appeared to seal afterwards since the tank was used repeatedly until 1978 as an active receipt and feed tank. Because there was no other explanation available for the Cs^{137} presence, a nominal 1,000 gal. leak volume was assigned to the tank.~~

~~RPP-14430 provides similar information, and expands upon it. In addition to the same wording about drywell 30-05-07, a small Cs^{137} peak is mentioned in adjacent drywell 30-05-05 between 60 and 65 ft below grade and a very small Cs^{137} peak in adjacent drywell 30-05-08 at 47 ft below grade. The document mentions there was a 36 in. level drop in the tank between 1963 and 1967 when it held PUREX HLW supernate, and that liquid losses due to evaporation are noted in historical records. The document discounts the likelihood of a leak from the cascade line between tanks C-104 and C-105, which has been theorized as a source of the leak. The document assigns a 1,000 gal. estimated leak volume to tank C-105 for risk evaluation purposes.~~

~~RPP-13774 assumed a 1,000 gal. leak from tank C-105 for the risk assessment based upon the contamination levels found in drywell 30-05-07.~~

~~RPP-20820 provided a thorough evaluation of the tank C-105 history. The tank was filled with thermally hot (94 – 105°C) high PUREX HLW supernate in May of 1963. The Cs^{137} concentration was high enough so that the tank heat generation rate was estimated to exceed 140,000 Btu/hr. From this time until December 1967 the tank liquid level decrease was about 36~~

~~in., or about 101,000 gal. Records state that the decrease was due to 'steaming', without further elaboration. (Note: WHC-MR-0132 probably is the source for this information as it lists three entries in the 1963 to 1967 time period stating the volume decrease is due to 'steaming' or evaporation.) Drywell 30-04-02 was drilled in 1972, and shortly following a transfer from tank AX-103 to tank C-105 in 1974 using line V-103, an increase in radioactivity at 40 ft below grade showed up. The contamination level rose slowly for a few months until June of 1974. Since then the radiation level has decreased consistent with the decay rate for Cs^{137}. Five other drywells were installed in 1974 to better define this contamination, and when the drywells were first monitored the high radiation levels were noted in drywell 30-05-07. RPP-20820 describes in detail the different occurrence reports and evaluation of the likelihood of the contamination coming from a cascade line or transfer line. The document also discusses the additional transfers (3.4 million gal. of waste in and out of the tank) in the years after the contamination was noted without any increase or movement of the contamination seen in the drywells. The document concludes that a cascade line leak and/or a V-103 transfer line leak were probable, but that there is insufficient data to say the tank is safe to sluice below a certain depth because there has not been a sufficient time period with a stable surface level over which to demonstrate there was no liquid level decrease.~~

~~RPP-23405, Rev 0, reiterated much of the information from the documents above, and stated that regardless of the source of the contamination, a contaminant plume clearly exists. Based upon the size of the plume and the expected composition, if it did come from tank C-105 the estimated leak volume was about 1,000 gal.~~

~~RPP-ENV-33418 documents the RPP-32681 re-assessment process for contamination found in the soil adjacent to C-105. This document concluded that the data indicate multiple sources near C-105 which could have been from line failures, overflow through a spare inlet nozzle, the C-104 condenser, or a tank leak. No statement is made concerning the tank integrity, but the document states that 40 to 2,000 gal should be assumed in the soil below the base of C-105.In summary, the only evidence of a leak from tank C-105 is the level of contamination found in drywell 30-05-07, and residual contamination in adjacent two drywells. There has been no increase in radiation level or change in depth of the indicated radiation since mid 1974. The rate of change in the drywell 30-05-07 radiation levels since then has approximated the decay rate for Cs^{137}. About 3.4 million gal. of waste was transferred in and out of the tank during this period. The 36 in. liquid level change in tank C-105 from 1963 to 1967 was likely due to evaporation from the high level waste in the tank. A leak volume of 1,000 gal. was assumed in RPP-15317, RPP-14430 and used in RPP-13774. RPP-23405, Rev 0 recommended a value of 1,000 gal. be assumed for a leak in the vicinity of tank C-105. RPP-20820 concludes that the contamination in the vicinity of tank C-105 probably did come from a cascade line or transfer line leak, but that level data are not available due to transfers in and out of the tank and periodic water additions to prove conclusively the tank is sound. RPP-ENV-33418 concludes the contamination around C-105 could have come from multiple sources, including a potential tank leak, and recommends a volume of 40-2,000 gal should be assumed in the soil next to the tank. RPP-23405 was revised in Rev 3 to reflect this same 40-2,000 gal range.~~

2.4.2.1. Proposed Revision or Qualification to Assumed Leaker Status

RPP-ASMT-46452, *Tank 241-C-105 Leak Assessment Completion Report,* concludes that a leak from the tank could not be ruled out. The tank status summary report HNF-EP-0182 Rev. 282 states in footnote 13 to Table 4-3 that the leak integrity status be revised to "Assumed Leaker" with an estimated leak volume < 2,000 gallons.

2.5 TANK WASTE VOLUME/CHARACTERISTICS

The waste volume and physical properties of the waste currently stored in tanks C-101 and C-105 and awaiting retrieval are summarized in Table 2-3.

The tank waste inventory data, including uncertainty, extracted from the best-basis inventory (BBI) (http://twinsweb.pnl.gov/twins.htm) is provided in Appendix C (Tables C-1 and C-2 for tanks C-101 and C-105 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 standard deviation is calculated from the variation in the sample analysis results. Details on 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 contaminants that drive long-term risk (e.g., technetium-99) can be used for tanks C-101 and C-105 to provide insight to the uncertainty in long-term human health risks presented in Section 7.0. Indicator contaminants identified in Section 7.1.1.1 are noted in Tables D-1 and D-2.

Table 2-3. Waste Volume and Physical Properties Summary.

Waste Property	Unit	Tank C-101	Tank C-105
Solids volume [a]	gal.	88,000	132,000
Supernate volume [a]	gal.	0	0
Interstitial liquid volume [a]	gal.	4,000	10,000
Sludge density [b]	kg/L	1.78	1.55
Sludge percent water [b]	%	23.4	28.3

[a] HNF-EP-0182, 2005, *Waste Tank Summary Report for Month Ending March 31, 2005*, Rev. 204.

[b] Source: Best-basis inventory download from http://twinsweb.pnl.gov/twins.htm dated June 10, 2005.

Although there are uncertainties associated with contaminant inventories in the tanks (Appendix C, Tables C-1 and C-2), 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. The information used for waste volumes and constituents is the

best available and is deemed sufficient based upon knowledge of those attributes necessary for planning and design purposes to proceed with the 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 requirements 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 tanks C-101 or C-105 to support waste retrieval and transfer. Sampling and analysis activities associated with component closure actions will be performed in accordance with RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, and RPP-PLAN-23827, *Sampling and Analysis Plan for Single-Shell Tanks Component Closure*." The information and risk and hazard values for future closure actions will be derived from post-retrieval samples.

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

~~1.~~ ~~HNF-SD-WM-EV-053~~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 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 (~~HNF-SD-WM-EV-053~~RPP-29002, ~~Appendix~~ 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).

- **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. Unplanned releases (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-101 Ancillary Equipment

Tank C-101 is connected to tank C-102 by a 3-in. diameter cascade line (WHC-SD-WM-ER-473). Tank C-101 has 10 risers of varying diameters and lengths of protrusion into the tank and 5 nozzles. The risers provide access to various in-tank equipment. Table 2-2 identifies the purpose of each riser and nozzle. A cross-section view of tank C-101 is shown in Figure 2-2. Figure 2-5 illustrates the line and riser locations into and around tank C-101 along with their current uses.

Twenty-four pathways enter tank C-101 or its associated pits. The pathways include lines, risers, pit drains, weep holes, and ventilation ducts. Twenty pathways into tank C-101 have already been isolated, as shown in Table 2-5. Current plans for isolation of all remaining pathways are shown in Table 2-6. This work will be accomplished in accordance with the tank closure plan.

2.6.2 Tank C-105 Ancillary Equipment

Tank C-105 is connected to tanks C-104 and C-106 by 3-in. diameter cascade lines (WHC-SD-WM-ER-489). Tank C-105 has 12 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-105 is shown in Figure 2-2. Figure 2-6 illustrates the line and riser locations into and around tank C-105 along with their current uses.

Twenty-eight pathways enter tank C-105 or its associated pits. The pathways include lines, risers, pit drains, weep holes, and ventilation ducts. Twenty-three pathways into tank C-105 have already been isolated, as shown in Table 2-7. Current plans for isolation of all remaining pathways are shown in Table 2-8. This work will be accomplished in accordance with the tank closure plan.

Table 2-4. C Tank Farm Components Associated with Tanks C-101 and C-105.* (2 Sheets)

Single-Shell Tanks			
Tank 241-	**Constructed**	**Declared Inactive**	**Constructed Operating Capacity (gal.)**
C-101	1943 – 1944	1977	530,000
C-105	1943 – 1944	1980	530,000
Diversion Boxes			
Unit 241-	**Constructed**	**Removed from Service**	**Description**
241-C-151	1946	1985	Interconnected 241-C-151 diversion box and C tank farm
241-CR-152	1946	1985	Interconnected 241-C-151 diversion box and C tank farm
241-CR-153	~~TBD~~1946	~~TBD~~1985	Interconnected 241-CR-152 diversion box and C tank farm
Valve Pits			
Facility Number		**Description**	
241-C		Valve pit	
Tank Pits			
Facility Number		**Description**	
241-C-01A		Pump pit	
241-C-01B		Heel pit	

3.0 PLANNED WASTE RETRIEVAL TECHNOLOGY

This section provides a description of the primary and secondary ~~planned~~ waste retrieval ~~technology~~ technologies for retrieving the waste from tanks C-101 and C-105. 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-101 will be modified sluicing. If required to meet the tank residual waste conditions in the Decree, the second technology for C-101 will be a chemical retrieval process.

The primary technology for C-105 will be venturi vacuum with supernate or water. The second technology will be high-pressure water spray. Both of these technologies will be deployed via MARS-V. The MARS-V 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 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."

3.1 SYSTEM DESCRIPTION

This section provides a description of the waste retrieval system (WRS) and each will be operated. ~~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. ~~While final equipment and operating descriptions may differ from that described in this section, the general process of waste retrieval using a vacuum system, with assistance if needed from an in-tank vehicle (ITV) is expected to remain.~~

3.1.1 Waste Retrieval System Physical System Description

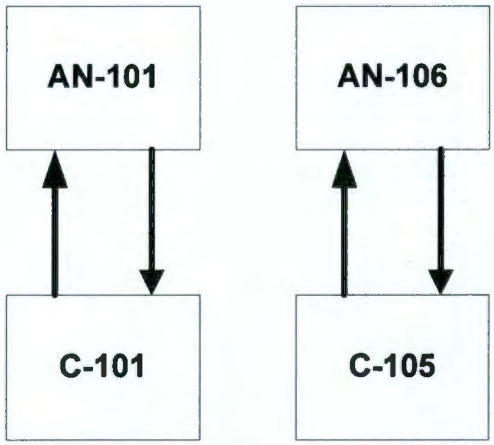
For tank C-101 the physical equipment will consist of a modified sludge sluicing system to mobilize and retrieve waste. The sluicing system will include two (or more) sluice nozzles and a slurry pump in the tank. The sluice nozzles will be controlled from a control trailer located outside the tank farm fence. The sluice nozzles can 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 tank. Double-shell tank supernate will be used as the primary sluicing liquid. The WRS will also have the capacity to use raw water for sluicing with minor modifications. 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-105 will be the MARS-V. The MARS-V mobilizing 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. For one technology, the end of the arm is equipped with nozzles that direct supernate and/or water onto the waste surface from a short distance away and vacuums the mobilized waste slurry backwards to a slurry pump. A second technology provided by the MARS arm 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-101 and C-105 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/mobilizing liquid (see Section 3.1.3 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 December 2011 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 Transfer Liquid Supply



Various monitoring instruments will be used to collect data to support operation of the WRS and perform environmental monitoring. Camera(s) will be installed in each SST 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. The DST ENRAFs will be used to monitor the waste levels.

During waste retrieval operations tanks C-101 and C-105 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. Any change to this drainage routing will be covered by a change to this TWRWP.

A new slurry pump will be installed in a riser located in the C-101 heel pit and Riser 13. The slurry pump design for C-101 will allow the pump installation height to be adjusted to facilitate maximum waste removal. The C-101 pump will be installed using a crane so that the inlet will be just under the waste surface to start, as determined by the in-tank camera. Little or no water should be required for this pump installation. This same installation method would be used for replacement pumps. The C-101 pump will be mounted on a system that will allow the pump to be lowered to the bottom of the tank as waste retrieval progresses. Other designs or arrangements may be used to optimize the pump installation or operation.

The sluice nozzles for tanks C-101 will be installed in risers 2 and 7. The WRS for tank C-101 may require design and construction of riser extensions to support the installation of the sluice nozzles and a slurry pump. Table 3-1 provides the planned riser use for tank C-101. This riser use may change.

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

Table 3-1. Planned Riser Use for Tank C-101 Waste Retrieval System.

Riser Number	Tank C-101
1	ENRAF* level gauge
2	Sluicer Box
3	Camera, Breather Filter, Vacuum Cntrl
7	Sluicer Box
8	Camera
13	Slurry Pump/Vacuum Relief
Hatch	Exhauster

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

A new central riser will need to be installed in C-105 to provide access for the MARS-V to the tank. The MARS-V design puts the weight of the MARS-V 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-105.

Once the new riser is in place and the MARS-V support pad is installed the rest of the equipment can be placed. The installation sequence described here may be altered as needed for safe and efficient installation and to accommodate field conditions. The platform is installed that supports the weight of the MARS-V and distributes the load to the support pad. The C-105 MARS-V abovegrade equipment sits on this support platform located around the new riser. The turntable is installed next. The MARS-V mast is installed onto the turntable and extends down into the tank. The mast supports the MARS-V 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, high pressure water nozzles, and vacuum eductor attached to the wrist. A strongback is deployed alongside the mast/arm within the riser. It supports the hose management system and includes 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.

The mast also supports the waste accumulator tank with hydraulically powered slurry pump and the waste accumulator tank eductor. The waste accumulator tank is open topped and has an inlet line for the motive fluid along with level sensors and a dump valve for cleanout.

When the in-tank equipment is in place, the abovegrade equipment, including rotary union and the transfer hoses for the MARS-V is installed. The last items installed are the shielding panels. Drawing H-14-109100 (draft) shows the MARS assembly installation and H-14-109101 (draft) shows the MARS-V general arrangement. The MARS-V is designed to meet the requirements in RPP-SPEC-47363, *Performance Specification for the Vacuum Mode Mobile Arm Retrieval System for C-Farm Tank 241-C-105.*

The MARS-V 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 mobilizing fluid) waste and vacuum it to the waste accumulator tank. 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 vacuumed up with the eductor to the waste accumulator tank and from there pumped to the DST with the slurry pump.

The MARS-V 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-V head will also minimize bumping of the MARS-V head into the tank wall or bottom. The sensor will be operable prior to insertion of the MARS-V into the tank, but it is not planned to remove the arm to repair the sensor should it fail after the MARS-V is installed.

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

Table 3-2 provides the projected riser usage for the tank C-105 WRS. The WRS design for tank C-105 has not been completed; therefore, the riser usage for this tank can only be projected at this time. Volumes associated with tanks C-105 retrieval have been evaluated and are provided in the flowsheet RPP-21753, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description.*

Table 3-2. Projected Riser Usage for Tank C-105.

Riser Number	Tank C-105
R1	Not used
R2	Camera and ventilation exhaust duct
R3	Not used
R4	Not used
R5	Not used
R6	Not used
R7	Camera and breather filter
R8	ENRAF* level gauge
R9	TBD
New 13	MARS
Condenser pit	TBD

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

Double-shell tank AN-101 and AN-106 are planned to be used for both waste receipt and as the source tank for supernate recycle. The DSTs were selected based on its location, available space, and existing equipment.

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 tank C-101 and C-105 and in their respective 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.

A valve/transfer line diversion box may be needed to permit routing of solutions to and from the SSTs and other tanks which may be undergoing retrieval concurrently. If a suitable pump cannot be obtained that will provide adequate capacity, a booster pump may also be required. Any booster pump will be located within a separate steel pit. Any new pits required will be inspected, will have a leak detector, and will either drain to a tank or have a sump pump. Leak detectors may be a conductivity probe, a thermal leak detector, or another type of leak detector as appropriate.

Should a transfer leak from the primary hose occur, the leak detection system is designed to shut the pump off when liquid covers the leak detection element contacts. Secondary containment structures will not overflow as a result of the transfer line leakage, including any transfer line drainback, because either the free volume of the structure exceeds the volume of leaked waste plus drainback, or there are openings in the structure which allow free-drain to the tank.

Transfer of waste from the SSTs to the DSTs and the transfer of supernate from DSTs back to tank SSTs will be performed using transfer lines that provide secondary containment. The waste retrieval project currently plans to use overground hose-in-hose transfer lines (HIHTL) and the *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant DST transfer system.

The receiver DSTs will have a supernate pumps that will be used to pump liquid back to tank SSTs. The receiver DST will also have a slurry distributor to distribute the sludge received from the SSTs.

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

The transfer lines and DSTs are RCRA compliant.

~~The MRS is a vacuum-based WRS~~

3.1.1.1 Installation of New Large Central Riser for MARS-V in C-105

Prior to installation of the MARS-V all or portions of the central pump pit will need be removed and a hole cut in the top of the tank. ~~that will consist of an articulated mast installed near the center of the tank along with an ITV designed to move waste toward the center of the tank where it can be removed with the mast. A conceptual diagram of the MRS in-tank components is~~

~~shown in Figure 3-1. The articulating~~ Following is a description of the planned method for installation of the new large central riser for C-105. The description 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. If there are to be major deviations from the method described and approved below, Ecology will be informed prior to the changes being implemented in the field. This method was previously approved by Ecology November 5, 2010 for the installation of MARS sluicing technology. Ecology approved this method for up to three C-Farm tanks; C-105 will be the second tank.

The new central riser for C-105 will require excavation of soil around the existing central pump pit down to the concrete dome. Excavation will be performed per the requirements developed to minimize tank structural issues while meeting personnel safety concerns. All or portions of the existing old heel pit on the tank will be removed and a new nominal 74 inch diameter temporary caisson to support cutting activities is installed. The area around the new caisson will be backfilled and a support pad 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. 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-14-109478, *Pit Removal Details* (this drawing is expected to be released in the spring of 2012). Related information is shown on drawing H-14-109471, *241-C-105 Large Riser Site Plan*, H-14-109472, *Large Riser Details*, H-14-109473, *Pad Structural Details,* and H-14-109476, *Large Riser Shield Plug*. 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-V equipment weight is not put on the large riser), the loads from the retrieval equipment and concrete pad are instead distributed to the soil.

Installation of the large riser will be evaluated for hazards following current tank operations contractor (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 will be performed evaluating the tank dome loading conditions resulting from cutting the hole into C-105 and adding the large riser for support of the MARS equipment, and monitoring/evaluation will be performed during the riser installation process. The pre-cut evaluations are RPP-CALC-49671 *Calculation Package for the Installation of a Large Riser on*

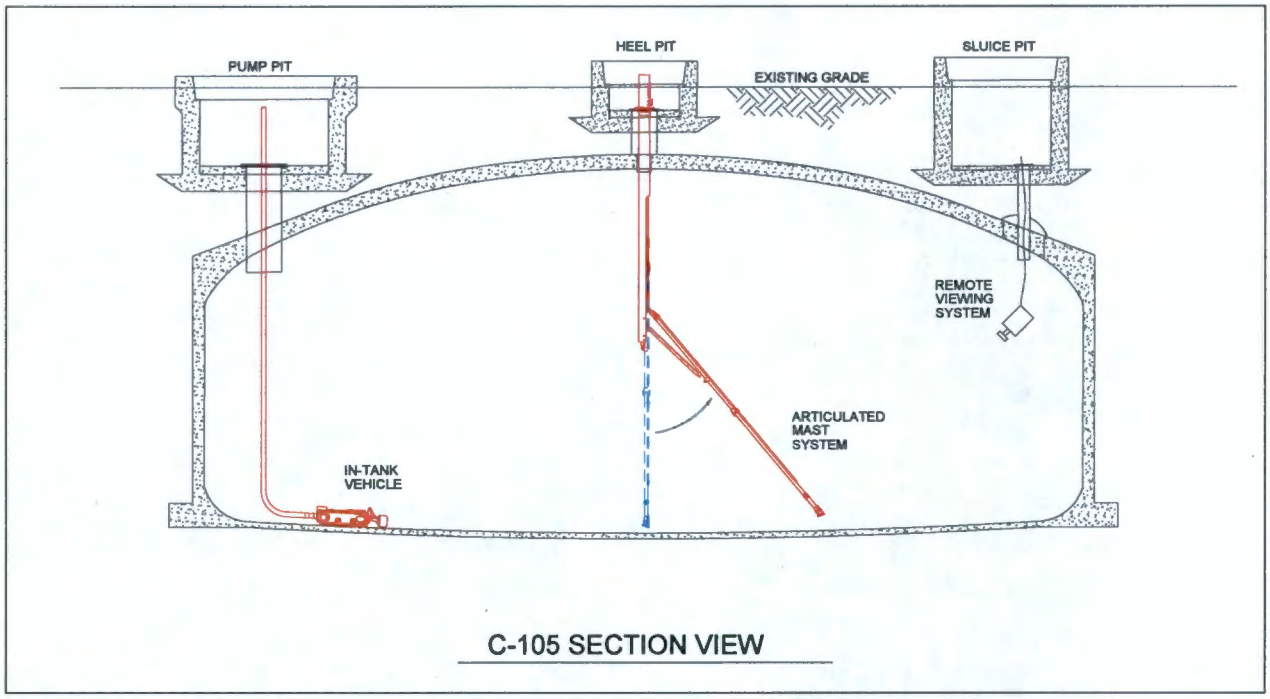
Tank 241-C-105 and RPP-CALC-51195, *An Evaluation of Single-Shell Tank 241-C-105 for the Addition of a Large Penetration in the Tank Dome.* These pre-cut evaluations show the structural integrity of the tank dome will be maintained following the installation of the large riser.

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 retrieval equipment. See Section 3.8 for clarifying words on WAC compliance.~~arm on the mast has a vacuum head that can be moved around the central region of the tank with an effective reach of approximately 16 ft. Air or water can be injected at the vacuum head to assist in mobilizing the waste. If needed, a series of five scarifying, high-pressure, low-volume water jets located around the outside of the vacuum head can be used to dislodge waste. Both the central mast and the ITV have the capability to use low-pressure water (approximately 125 lb/in^2) and high-pressure water (approximately 1,500 lb/in^2) to mobilize waste. The waste is deposited in a batch vessel located above grade in the vessel/pump skid where load cells and a level gauge indicate the waste batch volume. The batch vessel has a working volume of approximately 400 gal.~~

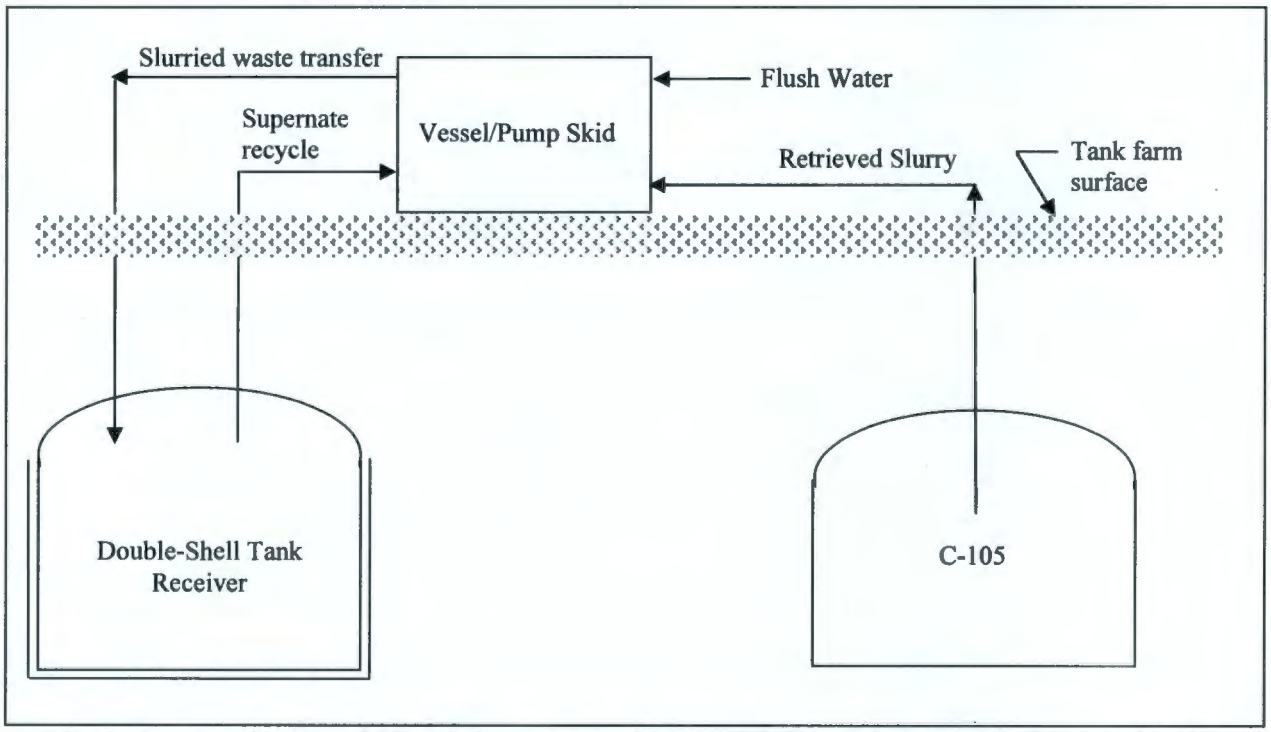
~~The ITV is an adaptation of a commercially available tracked vehicle. The ITV will have the ability to push waste, a low-pressure water cannon to wash down tank walls and equipment, and a three-nozzle scarifier system that can be used to dislodge and mobilize waste, if necessary. The ITV may be deployed at any time. The purpose of the ITV is to push or jet waste toward the center of the tank where it can be removed with the vacuum system.~~

~~Water and hydraulic lines are routed to the ITV through an umbilical line that is controlled using the umbilical management system. The umbilical management system consists of a hydraulically driven spool used to play out and reel in the umbilical line during ITV operation. The umbilical management system is located above grade over a riser large enough to permit ITV access to the tank and includes an enclosure that serves to minimize fugitive emissions by maintaining ventilation flow back into the tank. The umbilical management system may include a decontamination system to wash down the outside of equipment removed from the tank. Any decontamination liquid would drain back into the tank.~~

~~**Figure 3-1. Mobile Retrieval System In-Tank Components Conceptual Diagram.**~~



~~**To minimize waste volumes, the current waste retrieval plan includes the use of water, or DST supernate, to facilitate waste transfers from the batch vessel to the DST receiver tank. The MRS is capable of removing waste from the tanks at a solids loading that may be too high to be transferred to the DST receiver tank without dilution. If used, the recycled supernate would only be used for waste transfers and would not be introduced into the SST during waste retrieval other than for off-normal system draining. The current waste retrieval strategy for using DST supernate is shown in Figure 3-2. Additional detail on the planned use of supernate during waste retrieval is discussed in Section 3.2.Figure 3-2. Waste Transfer Liquid Supply.**~~



~~Both the vessel/pump skid and the vacuum skid provide secondary containment and leak detection. Both skids provide for leak collection and drainage back to the tank being retrieved.~~

~~The vacuum will be produced by tandem vacuum pumps installed upstream of the waste receiving vessel. The tandem vacuum pumps provide a level of redundancy in that normally only one pump would be operated. The system does have the capability to run both of the vacuum pumps simultaneously if needed for waste removal. Offgas from the vacuum system will be returned to the tank being retrieved. Active ventilation of the tank will be provided per the requirements of the NOC.The major components of the MRS include the following:~~

~~Articulated mast system (AMS)~~

~~ITV~~

~~Vessel/pump skid~~

~~Vacuum skid~~

~~Hydraulic power packs~~

~~Monitoring and control system~~

~~Ventilation system~~

~~Compressed air skid~~

~~Water supply skid~~

~~Closed-circuit television camera system~~

~~Control trailer.~~

~~The modular design of the system incorporates reliability and maintainability features that allow for continued operation, repair, and/or replacement of components in the event of a component failure. Redundant slurry pumps are contained in the vessel/pump skid and provide the capability to transfer waste out of the batch vessel in the event that one of the pumps fail. Spare parts required to support operations have been evaluated and are being procured to support system operations.~~

~~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 flowrates). Existing ENRAF[2] level gauges will be retracted during waste retrieval operations but may be used periodically to monitor waste levels. This information will be used to support material balance calculations.~~

~~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.~~

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

~~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 (HEPA) filtered portable exhausters. The ventilation system(s) 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 (WDOH) include a heater, prefilter, demister, two HEPA filters and test sections, exhaust fan, and stack. Project plans may include the design and installation of ventilation systems(s) to support waste retrieval operations for the C farm tanks as shown in Figure 3-3. Details of the ventilation systems are provided in AIR 07-305, *Categorical Tank Farm Facility Waste Retrieval and Closure: Phase II Waste Retrieval Operations* (including as amended in updates) and DE05NWP-002R1, *Approval of Criteria and Toxics Air Emissions Notice of Construction (NOC) Application for Hanford Single-Shell Tank Waste Retrieval,* (including as amended in updates). ORP and the tank farm contractor, 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 Industrial Hygiene (IH) department(s) per the tank farm contractor 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.~~

~~Condensate drainage from the exhauster(s) will be routed back to an SST undergoing waste retrieval. Any change to this drainage routing will covered by a Change Notice Form to this TWRWP. The rate of condensate coming from the exhausters and demisters which originated in a tank undergoing MRS retrieval is dependent upon a variety of items which include, but are not limited to, the ambient air temperature, the tank vapor space temperature, the air flow from the tank, the percent relative humidity in the tank exit air, whether retrieval conditions are being performed or not, the temperature of the air stream returned to the SST from the air separator blowers, the amount of insulation on the vent duct, and the operational status of the vent duct heat trace. It is roughly estimated that the condensate formation rate from one of these four tanks will be about 0 to 5 gal/day/tank when it is exhausted and not undergoing MRS retrieval, and about 0 to 25 gal/day/tank when it is undergoing MRS retrieval. The rates will likely be in the lower end of both of these ranges most of the time. These numbers are very rough estimates only.~~

~~See Section 4.1.3 on level monitoring for SST used as receiver tank for exhauster condensate drainage. If retrieval of this SST is completed prior to completion of retrieval of tanks C-101 or C-105, Ecology will be informed via a Change Notice of any subsequent routing change for disposition of the condensate.~~

~~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. It is currently planned that the articulated mast will be installed in the center riser located in the center pit; however, the AMS could be deployed in other risers if available.~~

~~All pits will be inspected and will drain to the SST or will have leak detection. Table 3-1 provides the planned riser usage for the tank C-101 WRS. The WRS designs for tank C-105 has not been completed; therefore, the riser usage for this tank has not been established at this time.~~

~~Riser usage for tank C-105 should be similar to that shown for tank C-101. Volumes associated with tanks C-105 retrieval have been evaluated and are provided in the flowsheet RPP-21753, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description*. A proposed equipment layout is provided in Figure 3-3. The final layout may be different than Figure 3-3, but should be functionally similar to that shown.~~

~~**3.1.2** Table 3-1. Planned Riser Usage for Tank C-101.~~

~~Riser Number~~	~~**3.1.3** Tank C-101~~
~~R1~~	~~Not used~~
~~R2~~	~~Camera and ventilation exhaust duct~~
~~R3~~	~~Not used~~
~~R4~~	~~Not used~~
~~R5~~	~~Not used~~
~~R6~~	~~Not used~~
~~R7~~	~~Camera and breather filter~~
~~R8~~	~~ENRAF* level gauge~~
~~R9~~	~~In-tank vehicle~~
~~R13~~	~~AMS~~
~~Condenser pit~~	~~MRS drain lines and vacuum return~~

~~AMS = articulated mast system.~~
~~MRS = mobile retrieval system.~~

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

~~**3.1.4**~~

~~3.1.5~~3.1.2 Double-Shell Receiver Tanks

The planning includes using tank AN-101 as the receiver tank for waste retrieved from tanks C-~~105 and~~ C-101. Waste retrieved from C-105 will be sent to AN-106. Ongoing evaluations may result in identifying alternate receiver tank(s).

A ~~new~~ slurry distributor ~~will be needed for AN-101. The~~was installed in AN-101 ~~slurry distributor is planned for installation by~~as part of the C-104 waste retrieval project. A new slurry distributor and pump was installed in AN-106 to support retrievals with AN-106 supernate.

Because the elevation of the AN tank farm is approximately 22 ft higher than the C tank 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 the WRS vessel/pump skid above the 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.

~~3.1.6~~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-101 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.

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 routine MARS-V operations the supernate or high pressure water nozzles spray the solidified waste- near the vacuum educator and then the waste and mobilizing solution is vacuumed up minimizing residence time. The MARS-V arm will be moved radially and axially to reach all areas of the tank. The slurried waste is directed back to the waste accumulator tank pump and then pumped to the receiver DST. An additional technology provided by the MARS-V 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.

The MARS-V is designed to remove by vacuum more liquid than is added to mobilize the solids. The high pressure water or supernate fan spray nozzles mobilize the solids around the eductor and solids and mobilizing liquid are vacuumed with minimal residence time in the tank. Cameras are used to ensure the operation is as planned.

If initial sluicing efforts show the tank C-101 sludge is not readily mobilized, it may be necessary to add sufficient liquid to the tank to cover the sludge and allow it to sit for a period of time to soften the solid waste before sluicing is resumed. Liquid can break down bonds in dried waste or dissolve salt crystals holding the waste together. The DST supernate used will not be saturated 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. The time needed to soften the waste is unknown but would likely not be more than a few days.

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.

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.

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

- RPP-29002, *Double-Shell Tank System Waste Analysis Plan.* Single-shell tank 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 EPA guidance document OSWER 9938.4-03, *Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Waste.*

- Waste Stream Profile Sheet (RPP-29002, Attachment A). The sheet addresses the applicable sections of WAC 173-303-300; Title 40, *Code of Federal Regulations*, Part 761, "Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions" (40 CFR 761); 40 CFR 268, "Land Disposal Restrictions"; and WAC 173-303-140, "Land Disposal Restrictions," 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).

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 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, costs, the potential for exacerbating leaks, worker safety and the overall impact on the tank waste retrieval and treatment missions."

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-V waste retrieval process. A limit of technology definition will not be developed until sufficient MARS-V retrieval operations have been performed to enable development of a justifiable definition. Until a MARS-V limit of technology definition is developed the same value used for modified sluicing in RPP-50910 is applied to MARS-V retrieval operations. Also for MARS-V, 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).

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.

Ecology is notified in the Tri-Party Agreement project manager's monthly meeting 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 retrie*val 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 heels 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 observations, 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 operation 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-101. 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.

~~The overall WRS operating strategy will consist of retrieving waste beginning from the center of the tank and working outward with the AMS while limiting the volume of water introduced to the tank for any batch to only that necessary for efficient waste removal. The ITV will be deployed when needed to move waste to the center of the tank for removal. The waste retrieval process will be monitored using closed-circuit television to facilitate waste retrieval operations. The retrieval system will introduce limited volumes of water into the SSTs to help mobilize waste and provide lubrication in the vacuum lines. Recycled DST supernate or water will be used for waste dilution and transfer from the batch vessel to the DST receiver tank.~~

~~During routine operations, waste retrieval will be initiated by energizing the vacuum pumps to begin the pneumatic-assisted vacuum conveyance system. A high-pressure water spray (200 to 1,200 lb/in^2) mounted to the vacuum head can be used as necessary to break up or dislodge the waste. The introduction of water into the tank through the vacuum system is controlled by the operator and can range from 0 to approximately 12 gal/min. The ITV has a low-pressure water cannon (approximately 125 lb/in^2) that can be controlled by the operator over a range of 0 to approximately 75 gal/min. and a high-pressure scarifier (up to 1,500 lb/in^2) that can be controlled by the operator over a range of 0 to approximately 15 gal/min. System operators remotely position and move the vacuum head within the tank to retrieve waste. The addition of water into the tank through the mast or the ITV can be controlled so that on average the rate of removal is greater than the rate of addition and there is not an accumulation of liquid in the tank.~~
~~All operations within the tank are monitored and controlled using cameras mounted in the tank dome space. From the tank, the waste is vacuumed up into the batch vessel located in the topside vessel/pump skid. Waste removal rates using the vacuum are expected to range from 5 to approximately 40 gal/min. When the batch vessel is full, as measured by the tank level switch or tank weight, the WRS is switched from retrieval mode to transfer mode. Water, or recycled supernate, is used to dilute or the transfer solution as needed for the transfer to the DST or to flush the line if needed following the transfer.~~

~~During the transfer mode water, or recycled supernate, may also be used to mobilize and fluidize heavier wastes inside of the batch vessel and dilute the waste to a consistency that can be pumped to the double-shell receipt tank.~~

~~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.~~

~~During waste retrieval operations, waste retrieval progress will be monitored by estimating the volume of residual waste remaining in the tank. Engineering estimates will be based on initial waste volume estimates and material balance calculations. Following completion of waste retrieval, the residual waste volume will be calculated in accordance with an approved data quality objective(s) and sampling and analysis plan.~~

~~Waste retrieval operations will continue until the criteria of Section 3.4 have been met.~~

~~The following information will be used to evaluate termination of retrieval and will be shared with Ecology before making 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 will be 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 notified 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, the residual waste volume will be determined using the methodology defined in RPP-23403 and RPP-PLAN-23827.~~

3.2 LIQUID ADDITIONS DURING WASTE RETRIEVAL

For tank C-101, the pump adjustment features described previously should allow the tank C-101 pump to be installed with little or no water addition However, if tank conditions require water additions to successfully install the pump (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 back flushing through the pump.

The MARS-V installation into tank C-105 is not anticipated to require any water addition beyond the riser cutting slurry. The waste accumulator tank will be above the waste level so it should not be necessary to move any material to install the MARS-V. However, if tank conditions require water additions to successfully install the MARS-V (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*,

Water could also be added to the tank as needed to flush equipment removed from the tank or for a number of operational reasons. The use of water is minimized to avoid taking up DST storage space. Experience to date with sludge retrieval in other C-Farm tanks has shown little water use during retrieval operations.

Utilizing recycled supernate to retrieve the waste minimizes the overall volume of waste stored in the DST system as a result of the waste retrieval process.

An estimate of the retrieval time is provided in Table 3-3. A nominal 105 kgal of raw water for tank and equipment flushing is assumed consistent with planning for past tank waste retrievals.

Table 3-3. Tank C-101 Waste Retrieval Summary Data.

Tank	Initial Tank Waste Volume prior to Retrieval (kgal)	Retrieval Flush Volume (kgal)	DST Supernate Recycle (kgal)	Estimated Operating Duration (days) [c]
C-101	88 [a]	105 [b]	2900	46
C-105	132 [a]	105 [b]	4400	70

DST = double-shell tank

[a] From Table 2-3.

[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.

~~a.~~

The use of supernatant will be limited by the following:

- The waste compatibility assessment for supernatant 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 tank C-101 and C-105 solids. Ecology will

be informed of the results of this assessment before initiation of retrieval operations. A copy of the assessment report shall be provided to Ecology.

- Ecology will be informed when the cumulative volume of supernatant liquid being recycled exceeds the estimated quantity of 1,000,000 gal, and for each incremental million gallon quantity recycled. Timely status by e-mail will be sufficient.
- Following the use of supernatant, 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.
- Should tank C-101 or C-105 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-101 or C-105 retrieval process for corrosion control or other reasons, a ^{99}Tc analysis will be requested on the sample.

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

- 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.
- The benchmark level described in Section 4.6.1 will not be exceeded during the liquid addition.
- Excess liquid will be removed from the tank as soon as practical once a usable waste level measurement is obtained.
- 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.

At the cessation of waste retrieval operations, the tank walls and heel will be flushed to the extent practical with water. Flush water will not be purposely sprayed on the walls above the maximum level stated in the process control plan. 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, 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 that can be used to support the final tank residual waste measurement.

The timing for transfers out of tank C-101 and C-105 is dependent on 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 tanks C-101 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 on experience with other modified sluicing and saltcake dissolution retrievals, it will likely last for an 8- to 16-hr period, then be followed by a one shift to several days wait, then continue. Work continuity will be dependent on resource availability. Ideally the retrieval will be completed within a few months, but delays with tank farm work and lack of available resources could increase retrieval duration.

~~During waste retrieval, water will be used by the retrieval/transfer system to mobilize and remove waste from within the SST to the batch vessel contained in the vessel/pump skid. From the batch vessel water, or recycled DST supernate, will be used for dilution before transferring the waste to the designated receiver DST. Supernate input will be approximately 20 to 30 gal/min. and slurry flow rate outputs will be approximately 75 to 80 gal/min.~~

~~A process flowsheet, RPP-21753, has been prepared for the C farm 100-series tanks. The flowsheet document is based on simulations performed with the Hanford Tank Waste Operations Simulator model. The flowsheet uses the Hanford Tank Waste Operations Simulator to simulate the waste storage, retrieval, transfer, and treatment processes to provide an operating strategy for C farm waste retrieval. The flowsheet document shows the waste transfers needed to support C tank farm retrievals. Table 3-2 shows the estimated waste volumes to be retrieved from each of the tanks addressed by this document. It also shows the estimated water volumes for retrieving waste from each SST and the estimated number of batches required for waste retrieval. The values in Table 3-2 are based upon the referenced revision of the flowsheet and may change in subsequent revisions. The volume of DST supernate used is not shown; since this volume is not additive to the system, it is a transport fluid that is recycled, if utilized.~~

~~Table 3-2. Tanks C-101 and C-105 Waste Retrieval Summary Data.*~~

~~Tank~~	~~Initial Tank Waste Volume Prior to Retrieval (kgal)~~	~~Estimated Water Volume Used for Retrieval (kgal)~~	~~Estimated Number of Batches~~
~~C-101~~	~~88~~	~~161~~	~~620~~
~~C-105~~	~~132~~	~~189~~	~~800~~

~~Note: Water volumes and the batches shown are estimates only. Final values may be outside the ranges indicated. Recycled DST supernate volumes planned for use as a carrier fluid for waste transfers are not included in this table.~~

~~DST = double-shell tank.~~
~~SST = single-shell tank.~~

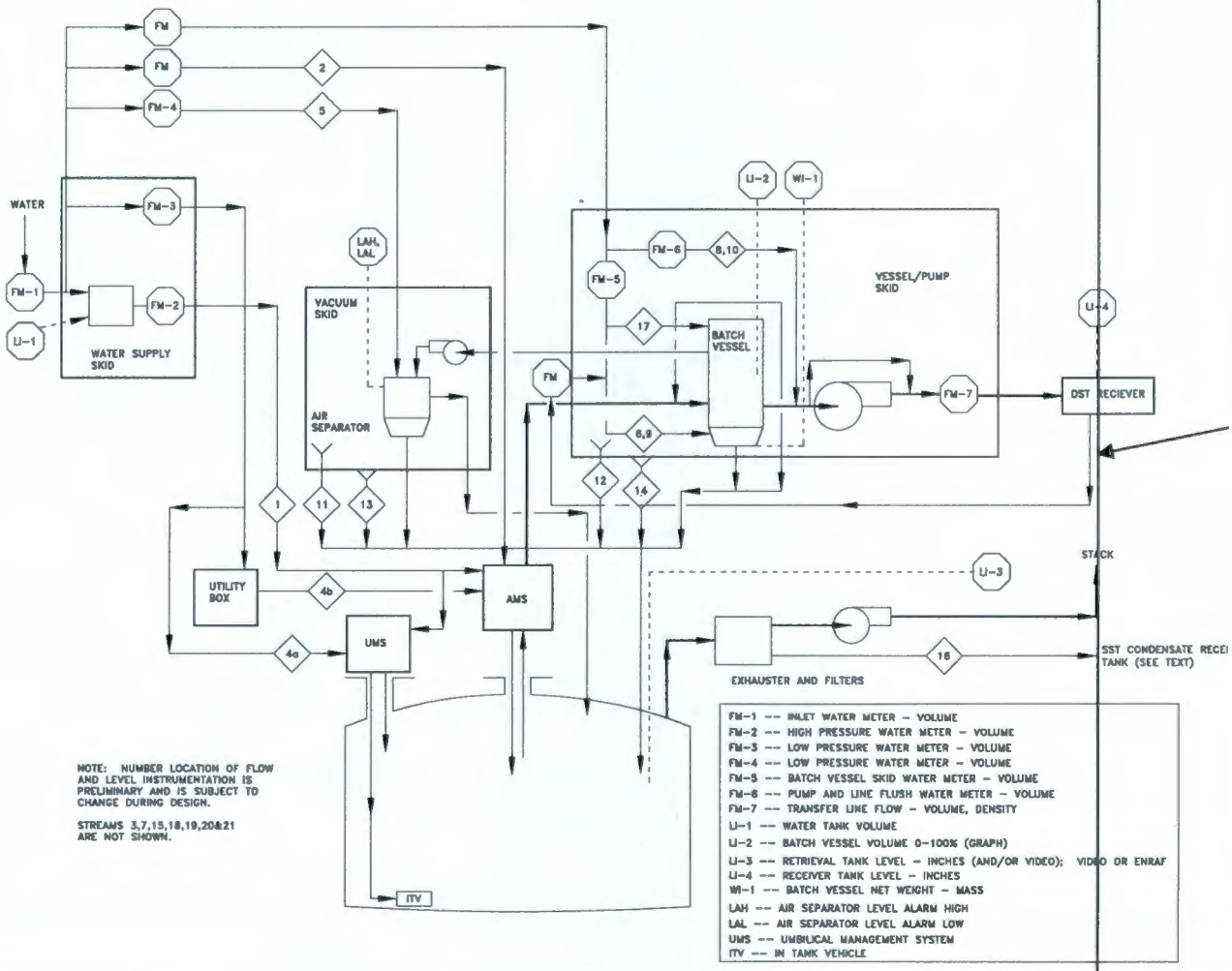
~~* Data source is RPP-21753. Water volume estimates are based on using 160 gal. of water for each 240-gal. batch of waste solids plus an allocation of 100,000 gal. of water per tank to account for additions that may occur over the course of waste retrieval. The number of batches is based upon a 400 gal. batch volume.~~

~~RPP-21753, 2005, *C Farm 100 Series Tanks Retrieval Process Flowsheet Description*, Rev. 1~~

~~The timing for waste transfers 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 those 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 addition of water during waste retrieval may be continuous or intermittent. Based upon experience with other waste retrievals, it will likely last 8 to 16 hours, then be followed by a day or more wait, then continue.~~

~~Table 3-3 provides an estimate of the distribution of water used in the MRS process. The values in Table 3-3 are based upon the referenced revision of the flowsheet and may change in subsequent revisions. A potential simplified flowsheet schematic is shown in Figure 3-4.~~

~~Figure 3-4. Tanks C-101 and C-105 Potential Simplified Flowsheet Schematic.~~



~~Low-pressure water or DST supernate to mobilize waste in batch vessel for transfer to DST.~~

~~Low-pressure water to backflush line between air separator and batch vessel.~~

~~Low-pressure water or DST supernate to prime and flush transfer pump.~~

~~Low-pressure dilution water or DST supernate for waste transfer to keep waste density in transfer line within limits.~~

~~Low-pressure water or DST supernate to flush transfer line to DST.~~

~~In addition, liquid may drain back to the retrieval tank from the following sources:~~

~~Condensate drain from vacuum skid air conditioner.~~

~~Condensate drain from vessel/pump skid air conditioner.~~

~~Floor drainage from leak in vacuum skid.~~

~~Floor drainage from leak in vessel/pump skid.~~

~~Water held up in batch vessel piping that may 'bounce' into vacuum relief line to tank when vacuum is released.~~

~~Seal pot drainage from exhauster seal pot (if exhauster drains to the tank).~~

~~Low-pressure water to flush batch vessel if needed to reduce dose rate for skid entry.~~

~~Low-pressure water to calibrate instrumentation.~~

~~One more stream may be added to the retrieval tank following completion of waste retrieval. This solution will be transferred to a DST:~~

~~Final tank wall and bottom flush.~~

~~Two streams may be added to the retrieval tank following completion of waste retrieval:~~

~~Drainback from last air separator tank drain, miscellaneous piping drainage, exhauster seal pot drainage, and final flush water from hose-in-hose transfer line to DST (if air blow of line is unsuccessful).~~

~~Equipment decontamination flush if needed to reduce dose rate so equipment can be handled for the next configuration. This will also include low-pressure water to decontaminate the ITV if it needs to be removed for repair or reuse elsewhere. (If decontamination is done for repair during waste retrieval the water used obviously would be added prior to completion of waste retrieval.) Up to an estimated 200 gal of water may be added during post retrieval grab sampling.~~

~~Of these, streams 1, 2, 3, and the ITV usage fraction of stream 4, are sent to the retrieval tank during waste retrieval. A small fraction of the AMS fraction of stream 4 also goes to the~~

~~retrieval tank, but the majority goes directly up the mast. Stream 1, the high-pressure water, is estimated to be greater than 90% of the sum of all four, the remaining three streams are either zero or small.~~

~~Streams 5, 11, 12, 13, 14, 15, 16, and a small fraction of stream 17 drain back to the retrieval tank. Stream 5, the air separator water, is estimated to be greater than 95% of the sum of all eight, the remaining seven streams are either zero or small.~~

~~Streams 6, 7, 8, 9, 10 and the large majority of streams 4 and 17 are sent from the batch vessel skid directly to the receiving DST; they do not enter the retrieval tank.~~

~~Stream 18 is a yearly generation of a nominal 2,000 gal. of drain water. This will normally be pumped to the receiving DST. Under certain conditions, a fraction of this could be drained to the retrieval tank depending upon conditions and calibration status of equipment at the time calibrations are performed.~~

~~The need for a final tank flush will be assessed prior to cessation of waste retrieval operations. These tanks are of questionable integrity and adding additional water to them may not be prudent. However, attempts to remove as much tank waste as technically practical will be undertaken and flushing tank walls may be part of this effort. If it is estimated there is more than 360 ft^3 of waste remaining in the tank, and it is determined that the remaining material could be readily removed by flushing, without engendering a tank leak, the material located on the tank walls or bottom may be flushed to help reduce the residual waste volume. Much of the walls will likely be flushed down as the waste level decreases during retrieval, so a final tank flush, if needed, is expected to be mostly of the tank bottom. This flush, if needed, may be done using water from the AMS head or the ITV. Final flush water will be removed after it is added to the tank.~~

~~The volume of waste adhering to the tank walls is estimated by visually comparing waste accumulations with known dimensions in the tank. The majority of residual waste will likely be on the stiffener rings. The dimensions of these stiffener rings are known from engineering drawings. The fraction of a stiffener ring which contains waste is used along with an estimate of the cross-sectional area of a waste accumulation to calculate how much waste is on the stiffener ring. The volume of any other waste adhering to the walls is calculated from the visually estimated dimensions of the waste~~

~~Stream 21 liquid is dependent upon dose rate conditions following waste retrieval. If personnel exposures can be kept low while handling the equipment, there may be no flush required. High dose rates may require flushing until personnel can effectively handle the equipment, or the equipment may be left in the tank for ALARA considerations. The volume of water necessary for such flushing cannot be known in advance, but 3 equipment volumes of water passed through both skids would be less than 1,500 gal. A flush of the ITV would likely require 300 to 1,000 gal. of water, but the volume could be greater if there was significant waste stuck to the unit.~~

~~Liquid added to the retrieval tank is minimized and removed as soon as practical. Regardless of the retrieval duration the liquid is removed to the extent practical by the vacuum system when it can drain to the AMS head location. Assuming a 16-ft radius for the AMS vacuum head, it~~

~~should be able to remove liquid from the central region of the tank. The AMS vacuum head cannot reach the remaining portion of the tank, which is an area approximately 21 ft wide between the central region of the tank and the tank wall. The riser where the air separator liquid, batch vessel drain, and other drains return is near the tank wall, so local pooling could occur in this location until liquid height is sufficient to run off to the center of the tank. A localized pool sized 200 to 2,000 gal. could form. Eventually, as retrieval progresses the edge of the central depression will move outward and once the ITV is deployed any liquid pooling at the outer wall is expected to drain to the central depression where it can be removed. Once the central depression gets deeper than the depth of any depression under the liquid return riser, the interstitial liquid should flow to the central depression and pooling should equalize.~~

~~Most of the liquid added to the tank with the ITV or AMS scarifier will be added where the liquid can be accessed with the AMS. Liquid that is not removed by the AMS should sink into the waste until the waste becomes saturated. Based upon experience in saltwell pumping, tank sludges have an average capillary retention height of about 24 in. and an average 17% porosity. The waste surfaces vary with location in the tank, but tank C-101 has about 39 to 40 in. of waste, and tank C-105 has about 52 to 53 in.. The estimated interstitial liquid volume in each tank is provided in Table 2-3.~~

During C-105 retreival with the MARS-V ~~L~~liquid will be removed as practical from the ~~central~~ local depression created by the end effector, and as the depression gets deeper the volume of interstitial liquid in the tank will decrease. Minimizing the interstitial liquid is achieved by minimizing free liquid in the ~~central~~ depressions to the extent practical during retrieval. The volume of free liquid present cannot be measured, but it can be effectively controlled by visually monitoring the waste surface during retrieval and vacuuming up the free liquid instead of waste solids when the free liquid appears to exceed a reasonable quantity.

Should the free liquid observed in the tank appear to cover more than one third of the waste surface, as estimated from observation with the video system, retrieval activities will be focused on surface liquid removal. The limiting condition for free liquid in the tank should be when a large volume of water is added to the tank and it pools up on the waste surface prior to a central depression being formed. A 100 Series SST with one third of the waste surface being free liquid will have about 900 gal. of free liquid per inch of depth. Assuming an average 2-in. depth of such a liquid pool, should there be a simultaneous failure of ~~both vacuum~~the slurry pumps or some other equipment failure that prevents retrieval of liquid added to a tank, the likely volume of pooled liquid present in the tank until the equipment is fixed would be a nominal 1,800 gal. Should the ~~batch vessel~~accumlator tank need to be drained during this time period, up to an additional ~~400~~ 300 gal. could be added, giving a potential "worst case" estimate of about 2,~~200~~ 100 gal of free liquid present in the tank. The assumption as to a 2-in. average liquid pool depth is subjective, but reasonable. These tanks primarily contain sludge, not saltcake, and sludge is more prone to seeking a reasonable level across the tank surface during settling than salt when crystallizing.

The one third value for the maximum free liquid accumulation on the waste surface is selected because it is a reasonable percentage that most personnel could subjectively determine. A value of less than one third could be chosen but the lower the value selected, the more difficult it becomes to judge effectively. It is not expected that the waste surface would routinely reach one

third free liquid. There should not be any significant liquid surface maintained in the tank during vacuum retrieval since the presence of a liquid pool over the sludge should not enhance retrieval of waste solids. The free liquid quantity in the tank being retrieved will normally be kept to a minimum. As retrieval proceeds a depression is expected to be formed as the waste is vacuumed up with the ~~AMS~~eductor. Once a depression is formed there should be negligible free liquid on the waste surface except for in the depression area. A free liquid pool in the depression with a diameter of 10 ft. would contain about 50 gal of liquid per in. of depth. Assuming this was no more than a 2-in. depth would mean that there would be no more than 100 gal of free liquid present at a given time, or ~~500~~ 400 gal i~~f both blowers failed~~, it became necessary to ~~simultaneously~~ dump the ~~batch vessel~~waste accumulator tank, and all the waste solids in the tank were saturated with interstitial liquid and couldn't absorb any of the batch vessel liquid.

The length of time this free liquid would remain in the tank would be dependent upon the time to repair the equipment (i.e., hours to months).

~~When vacuum operations are begun, water is added to the AMS as needed to enhance retrieval. At the same time, h~~High-pressure spray water is added to the waste around the suction nozzle to breakup and/or fluidize the waste near the nozzle as needed. ~~When the batch vessel has accumulated enough waste and water to make a transfer, vacuuming is halted along with any AMS or high-pressure water. Water or recycled supernate is then added to the batch vessel as needed to fluidize the waste for transfer, and the waste pumped to the receiver tank. During transfer, water or recycled supernate is added to the transfer line as necessary to maintain acceptable flow conditions. When the transfer is completed, the transfer line is flushed as required per procedure. The air separator for the vacuum blower discharge is also drained and water added for refill as needed during the process. This is done before or after a batch transfer when needed, or automatically when a high-level alarm is activated in the air separator. The ITV is not planned to be added to the tank until it is necessary to enhance waste retrieval with the mast. Once it is added, high-pressure water will be used as necessary to the ITV to break up hard waste in front of it. Low-pressure water is also added to the ITV to wash down tank walls and aid in pushing waste to the AMS head.~~

3.2.1 Basis for Using Supernate

~~Either water or recycled supernate will be used for diluting the C-101 and C-105 solids concentration if needed during waste transfer to the receiving DST, or for flushing the line after transfer.~~ By using DST supernatant as the waste retrieval liquid, the wastes from tanks C-101 and C-105 may be able to be retrieved without the need for a specific evaporator campaign or transfer of waste to other DST's.

If water were used the retrieved waste volume may require additional 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, at least two evaporator campaigns lasting for between 40 and 60 days would be required for every million gallons of water. Extra evaporator campaigns and associated transfers could cause delays to waste retrieval operations.

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

~~a.~~• 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.

~~b.~~• The dilute sluicing fluid would require two passes through the evaporator to achieve full concentration.

~~c.~~• The first pass through the evaporator would achieve a 50% waste volume reduction.

~~d.~~• An average of 1 week of transfers is required to fill the feed tank with 1 million gal. of feed.

~~e.~~• 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.

Using C-101 as an example, ~~T~~the number of campaigns is determined by starting with the initial volume of waste to be processed, ~~1.1 million~~981,000 gal. To this is added the volume of waste left after the first pass through the evaporator (i.e., 0.5 × ~~1.1 million~~981,000 gal. = ~~0.6 million~~490,500 gal.). Summing these volumes gives 1.~~7~~5 million gal. Dividing by the 1-million-gal. campaign volume gives about ~~2~~1.5 campaigns.

The duration of 1.5 consecutive campaigns is 31.5 days. Adjusting this value for operating efficiencies of between 70 and 90% gives a duration for 1.5 consecutive 1-million-gal campaigns of about 2 months. This is a theoretical time only. To this must be added downtime for maintenance and other issues, and the additional problems associated with transferring millions of gal of waste within tank farms. The 25 DSTs in the 200 East Area contain approximately 23.4 million gal as of October 2010. 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 and Immobilization Plant (WTP) startup. Therefore, evaporation time for water sluicing only will take much longer than 2 months.

~~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 2 consecutive campaigns is 42 days. Adjusting this value for the operating efficiencies of between 70 and 90%, gives a total duration for two consecutive 1-million-gal. campaigns of between 46 and 60 days. This is a theoretical time only. To this must be added downtime for maintenance and other issues, and the additional problems associated with transferring 1.1 million gal. of waste within tank farms.~~

This evaluation of the impact of water-only waste transfers 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.

~~This use of supernate recycle instead of water for waste transfer of the insoluble solids in the batch vessel removed from tanks C-101 and C-105 results in the following benefits:~~

- ~~Approximately 1 million gal. less liquid effluent discharged from the Liquid Effluent Treatment Facility (LETF) in the 200 East Area for every 1 million gal. of water saved.~~
- ~~An estimated 13 to 22 fewer drums of waste sent to disposal from LETF for every 1 million gal. of water not added.~~
- ~~An equivalent increase in DST room available for waste retrieved from SSTs. If this volume is not available, some SST waste retrievals besides those discussed in this document may be delayed, resulting in wastes remaining stored in noncompliant tanks for a longer period.~~
- ~~A nominal 2 to 3 fewer evaporator campaigns for each 1 million gal. of water saved.~~
- ~~Less fresh NaOH and $NaNO_2$ needed to bring the resulting DST solutions into the concentration limits specified for corrosion control in Administrative Control (AC) 5.16 (HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements*). Depending upon 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 upon other constituent concentrations in the DST solutions following mixing with the insoluble solids slurry and flush water.~~
- ~~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.~~

~~Although the benefits to using DST supernate far outweigh the disadvantages, there are several disadvantages. These include, but are not limited to:~~

- ~~The design and equipment costs to recycle supernate are more than the design and equipment costs associated with water addition.~~
- ~~The process is not as flexible due to the added difficulties of maintaining equipment which is contaminated vs. that which has only contacted water.~~
- ~~The process is more complex due to the need for encased lines and leak detection equipment which may not be needed with water.~~
- ~~A DST pump with an adjustable suction, or a suction fixed in the supernate well above the sludge level is required.~~

The advantages and disadvantages of using supernate recycle instead of water for retrieval of the waste in tank C-101 and C-105 are provided in Table 3-4:

Table 3-4. Advantages and Disadvantages of Using DST Supernate for Retrieval of Insoluble Waste Solids in Tank C-101. (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 Advantage	An estimated 13 to 22 fewer drums of waste sent to disposal from the 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

Candidate waste retrieval technologies currently available for deployment at tanks C-101 and C-105 as primary retrieval technologies are (1) modified sluicing ~~and~~ (2) the MARS-V, and mobile retrieval system (MRS). Modified sluicing and MARS-V uses water or DST supernate to mobilize waste to a pump where it can be removed from a tank. As discussed in section 3.2 there are many advantages of using supernate to mobilize waste. The MRS is not capable of using superanate and its use would greatly impact DST space, retrieval schedule, and cost. Also, when water is mixed with waste to be retrieved a dilute waste solution similar to DST supernate is produced, so the risk of having supernate in the SST remains if MRS is used.

Modified sluicing is a proven technology that has been 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.

Even though tank C-101 is classified as an "assumed leaker" there is sufficient evidence to conclude that there were and are no tank leaks below 54"; therefore, modified sluicing is a viable retrieval technology. When modified sluicing is performed using DST supernate, the overall volume of waste requiring management (storage and/or volume reduction) in the DST system is significantly reduced over that associated with the MRS. The retrieval duration is also significantly less with modified sluicing. Modified sluicing is the preferred primary technology for tank C-101.

Although modified sluicing is simpler and potentially costs less than the MARS-V for retrieving waste, it requires the use of greater volumes of liquid in the tank. The MARS-V consists of an articulating arm with an end effector and uses localized waste mobilization and subsequent vacuum removal. MARS-V is an eligible technology for use in tanks with questionable integrity. ~~AMS, 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.~~

The MARS-V sluicing system is expected to be an improvement over a MRS 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. Limited volumes of water are used with the vacuum-based retrieval system to mobilize and dilute the waste. The first deployment of the MARS-V system will demonstrate the system capabilities, as well as provide time for making improvements if necessary prior to further deployment.

~~The MRS uses vacuum to remove waste to a batch vessel at the tank farm surface where liquid is added to slurry the retrieved waste for transfer to a DST. Limited volumes of water are used with the vacuum-based retrieval system to mobilize and dilute the waste. Waste retrieval with the MRS is a batch process, so even if waste retrieval efficiencies are lower than expected and retrieval takes longer than planned, the amount of water in the tank at any time during retrieval is relatively small. Because of this, the MRS is currently considered to be the preferred waste retrieval technology for tanks that are classified as 'assumed leakers.'~~

~~Because tank C-101 is classified as an 'assumed leaker,' the MRS was selected as the waste retrieval technology.~~ Although tank C-105 is classified as 'sound,' the integrity of the tank is uncertain because of an unknown source of contamination in the soil near the tank. Ecology has reviewed the available historical information and determined that the modified sluicing is unacceptable for deployment at tank C-105 at this time (Lyon [2004], *Use of Double Shell Tank 241-AN-106 Supernate for Waste Retrieval from Single-Shell Tanks (SST) 241-C-103 and 241-C-105*). Based on the available information, Ecology will not approve the use of modified sluicing without additional data defining the source of the vadose zone contamination near tank C-105. Following ~~preliminary~~ discussions with Ecology, the MARS-V was selected to minimize the potential leakage volumes that might occur during waste retrieval.

The second technology alternatives should one be required for residual waste removal following modified sluicing, are an in-tank vehicle 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 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-101 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.

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-101 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 ~~WRS~~ retrieval technology equipment selected for tanks C-101 and C-105 will be designed deployed and operated to ~~retrieve as much waste from the tanks as technically possible with waste residues not to exceed 360 ft^3 or the limits of the technology, whichever is less in accordance with the requirements of HFFACO Milestone M-45-00~~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.

3.5 WASTE RETRIEVAL SYSTEM DIAGRAM

~~A d~~Diagrams of the C-101 and C-105 WRS in-tank components ~~is~~ are provided in Figures 3-~~1~~2 and. 3-3. A plan view showing the abovegrade skid locations ~~is~~ are provided in Figures 3-~~3~~4 and 3-5. As noted in Section 3.1.2, the elevation in the AN tank farm is approximately ~~32~~ 22 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-101 and C-105 WRS must be designed and operated. This work plan is not a system specification that defines design criteria for the WRS. However, the system specification for the tanks will be consistent with this work plan. The functions and requirements are provided in Table 3-~~4~~5 and are focused on defining the upper-level requirements for the tanks.

Figure 3-2. Tank C-101 Waste Retrieval System In-Tank Components

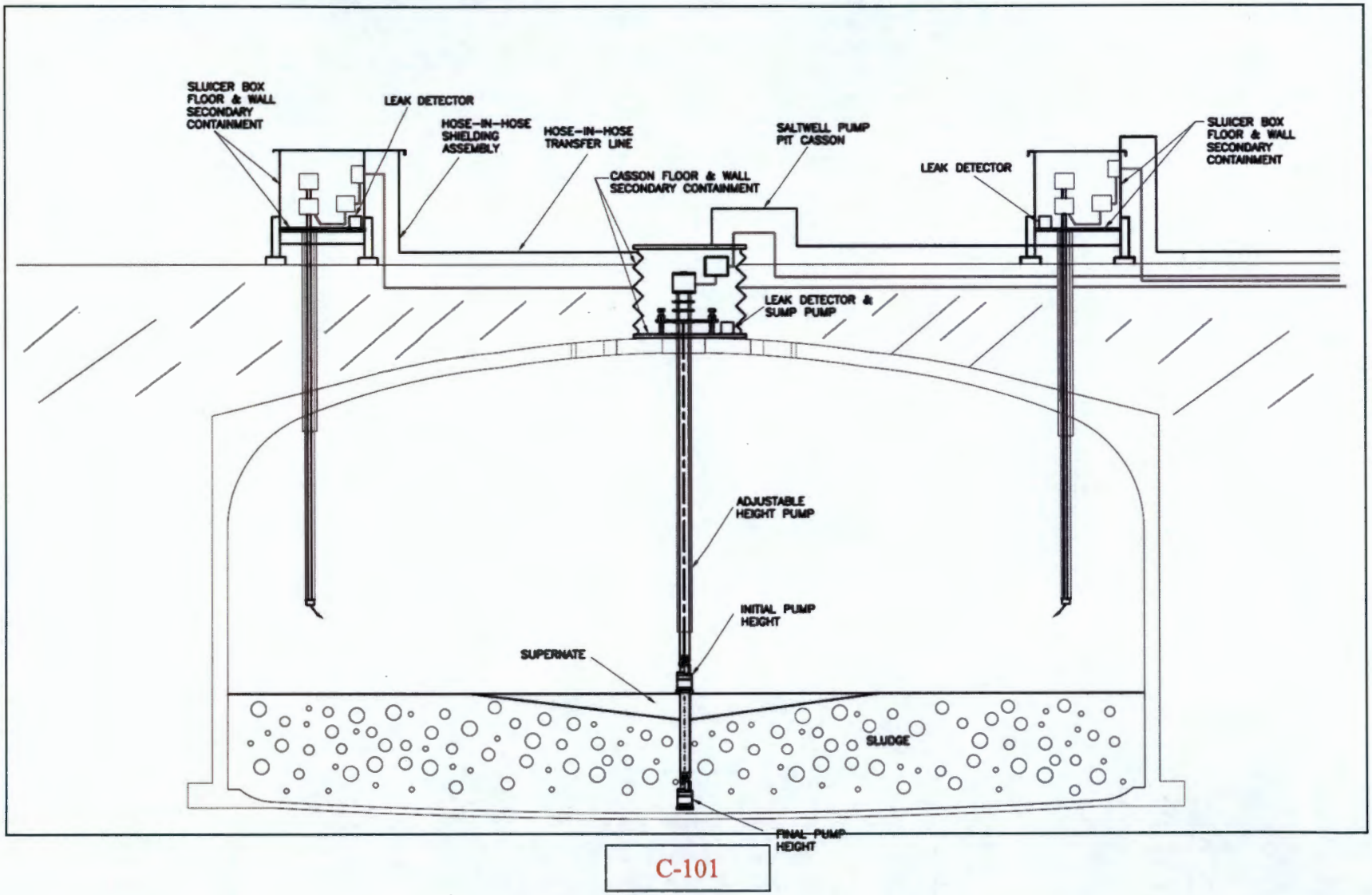


Figure 3-3: Tank C-105 Waste Retrieval System In-Tank Components

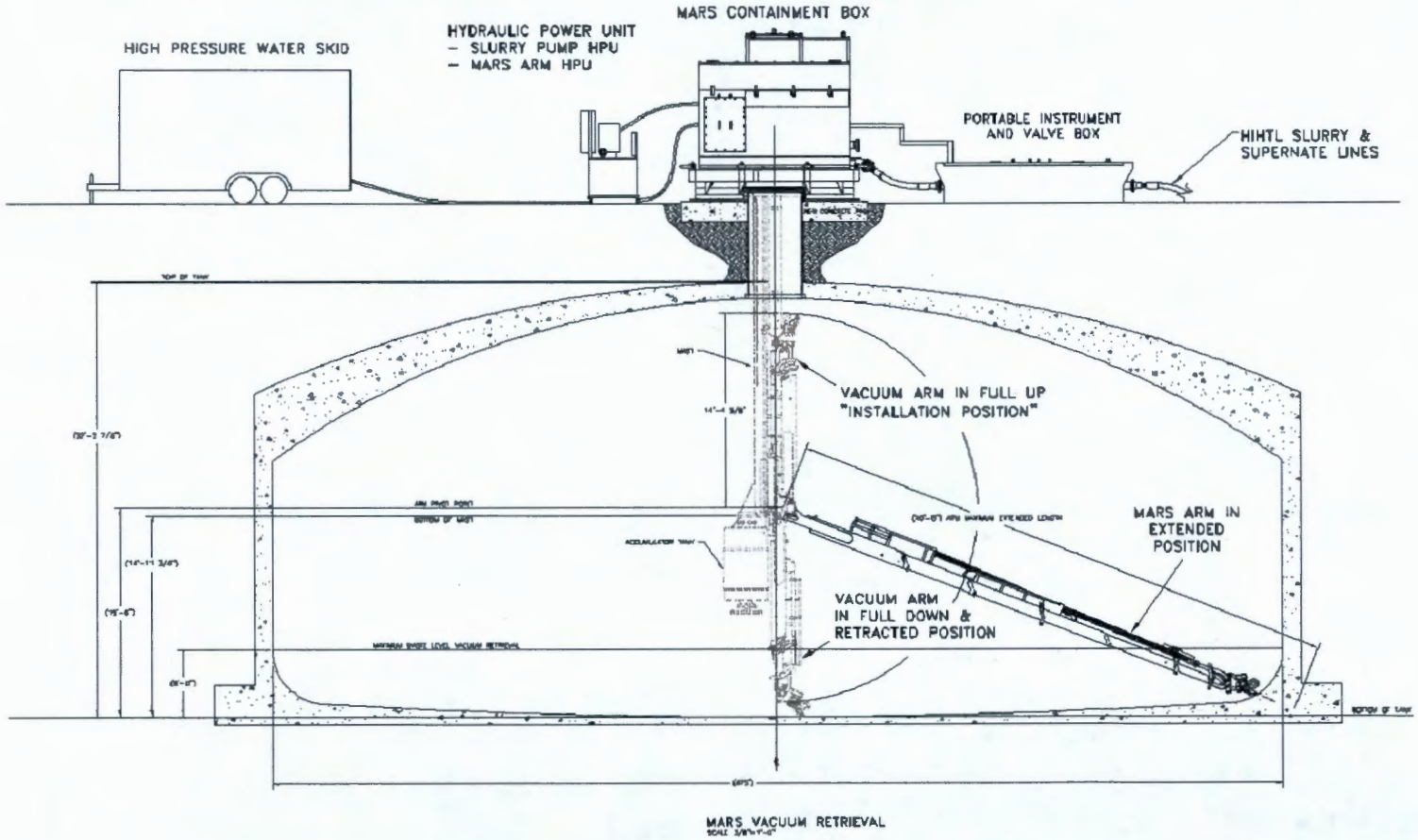


Figure 3-4. Potential New Equipment Layout for C-101.

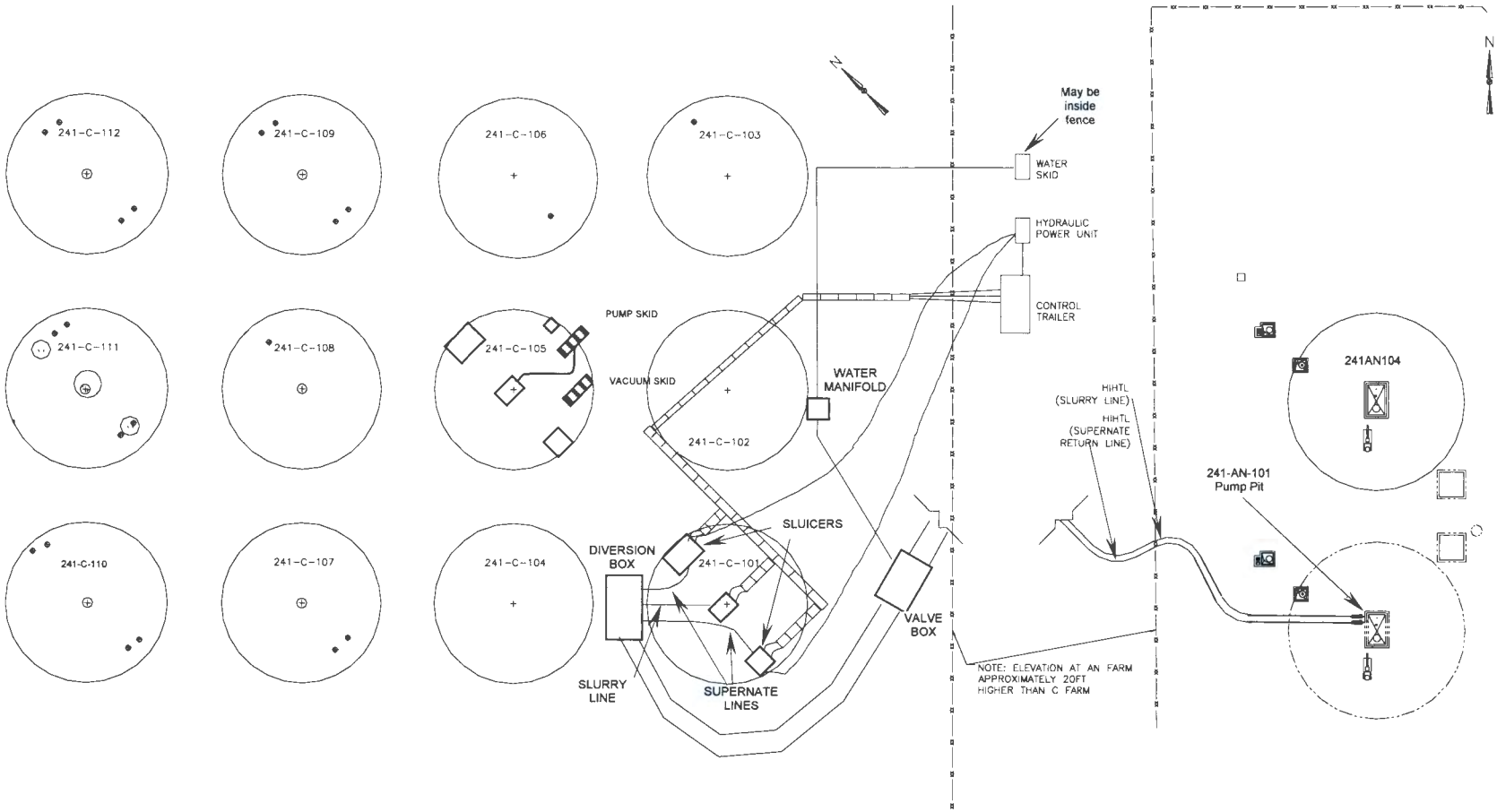


Figure 3-5. Potential New Equipment Layout for C-105.

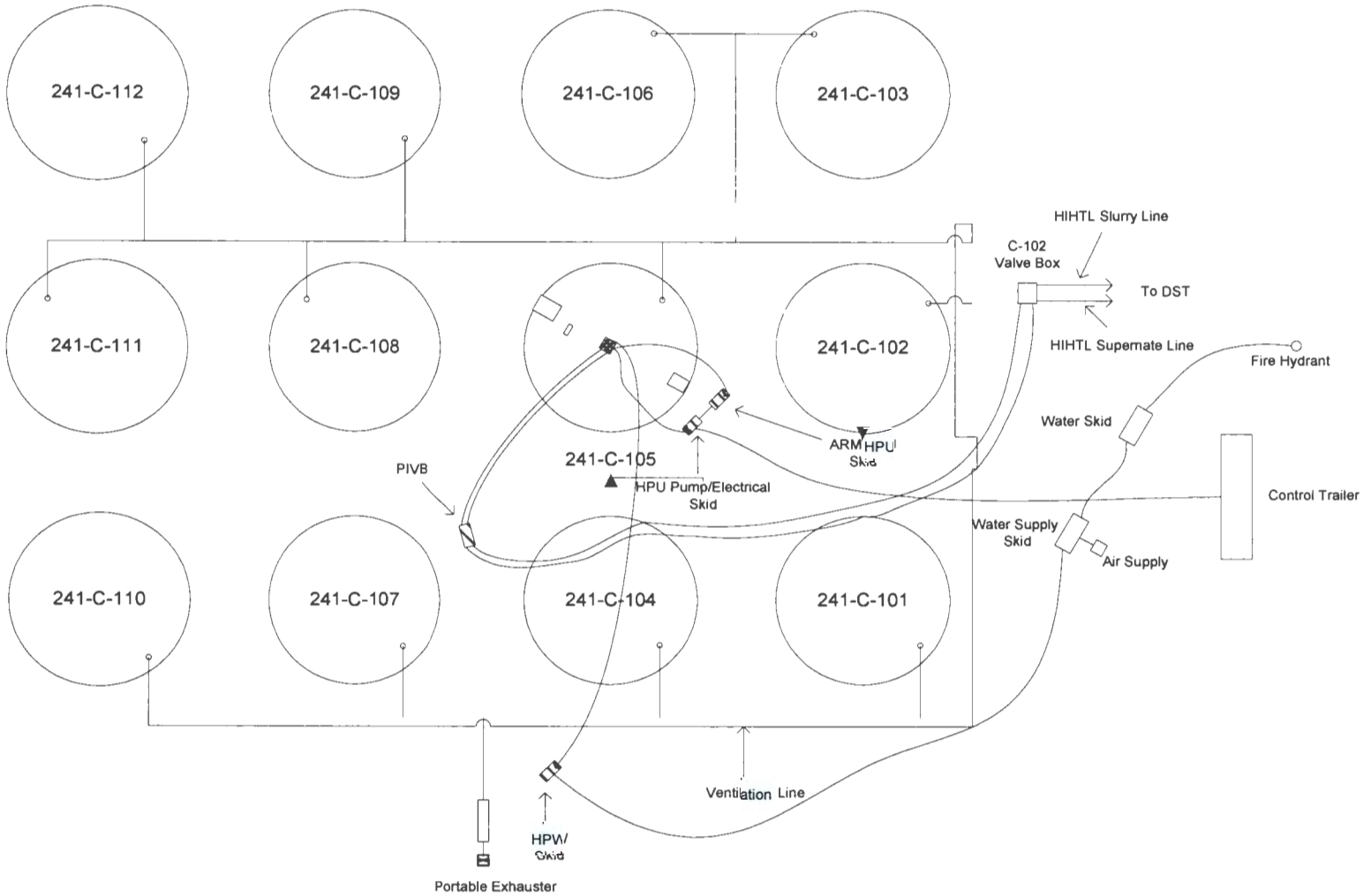


Table 3-4~~5~~. Tanks C-101 and C-105 Waste Retrieval System Functions and Requirements. (2 Sheets)

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-101or C-105 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-101 and C-105	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-151-0007	Provide for safe waste storage in DSTs.
Remove waste from tanks C-101 and C-105	The ~~WRS shall be capable of removing as much waste as technically possible, with tank waste residues not to exceed 360 ft^3, or the limit of the waste retrieval technology, whichever is less.~~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 ~~HFFACO Milestone M-45-00~~Decree	The ~~WRS~~ retrieval technologies shall ~~provide~~ have the ~~ability to retrieve as much waste as technically possible~~ potential to achieve a waste residue of 360 ft^3 or less.
Control and monitor the waste removal process in tanks C-101 and C-105	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.

Table 3-45. Tanks C-101 and C-105 Waste Retrieval System Functions and Requirements. (2 Sheets)

Function	Requirement	Basis*	Key Elements
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.
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.*~~
~~LDM = leak detection and monitoring.~~
OSHA = Occupational Safety and Health Administration.
SST = single-shell tank.
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-101 and C-105 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 back to the batch vessel skid and then to the tank just retrieved, unless a valve change could be made to direct the solution to another SST which had not yet completed retrieval that is covered by this tank waste retrieval work plan.~~
~~Flushing of any abovegrade skids should not be necessary following retrieval because 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. In the event the situation arises where a skid needs to be flushed following completion of 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 which had not yet completed retrieval that is covered by this tank waste retrieval work plan. If the solution went to the tank following completion of retrieval, the exhauster could be operated to evaporate the water as necessary.~~Most line flushes for new transfer lines will direct the flush solution to the receiver DST. However, because of the physical location of C tank farm at a lower elevation than the DST, there will be some line drain back unless the line is air blown after the transfer. The holdup for each transfer line is in the 150 to 200 gallon range. This solution would go to tank C-101 or C-105 or a valve change made to direct the drainage to another SST that had not yet completed retrieval.

Should the situation arise where a structure needs to be flushed following retrieval, it is estimated that the flush volume would be in the 100 to 200 gallon range. This solution would go to tanks C-101 or C-105 unless a valve change was made to direct the solution to another SST that had not yet completed retrieval.

When retrieval activities are completed, the exhauster(s) used ~~will~~ may 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 AMS)~~ in the tank following waste retrieval. However, in the 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 100 to 500 gallon~~.~~ range ~~for any equipment besides the MRS crawler. Decontamination of the MRS crawler could take in the 300 to 1,000 gal. range, or more depending upon contamination location~~.

Existing risers, pits, and/or caissons associated with the tanks will be isolated following the retrieval activities, when agreement has been reached with Ecology on tank C-101 and C-105

closure. These isolation methods are designed to minimize water intrusion to the tank; however, by the general design and nature of the equipment, intrusion of rainwater or snowmelt cannot be precluded.~~.~~

The old process line and pits used for previous waste transfers should have limited potential for containing residual liquid. The abandoned lines were constructed with positive slopes to facilitate drainage (a design requirement) and 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. 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 approved tank fill process of the closure plan. ~~See Section 7.1.3.2 for assumptions regarding characterization of residual waste in piping system components.~~

Following waste retrieval, it may be necessary to add small (0 to 50 gal.) volumes of water periodically to flush the ENRAF plummet before tank closure or to flush off heel sample containers. 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~~ notified per existing notification channels.

Post-retrieval intrusion monitoring of the tanks is addressed in Section 6.3.

3.8 INFORMATION FOR NEW ABOVE GROUND TANK SYSTEMS

~~The vessel/pump skid that will be located above ground includes a batch vessel. The batch vessel will have a working volume of approximately 400 gal. The batch vessel will be designed to meet the requirements of Section VIII, Division 1 of the ASME B&PVC (2001), *International Boiler and Pressure Vessel Code*. All process piping will meet the requirements of ASME B31.3, *Process Piping*, and will be verified through calculations and testing. The specific design requirements for the vessel are provided in RPP-8144, *Level 2 Specification for the Tank 241-C-101 Waste Retrieval System*.~~While there are no new aboveground waste tanks or waste treatment systems, the ancillary and containment equipment are considred 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 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 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 and leak detection equipment, used for C-101 and C-105 waste retrieval.

~~The requirements for an IQRPE assessment need 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*.~~ The requirements for an IQRPE assessment need 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 Assessment Process* (currently in draft) or successor document.

~~Before initiating waste retrieval operations, the vessel/pump skid will be visually inspected to assess the physical condition of the vessel/pump skid components. During waste retrieval operations, personnel will make regular rounds to physically observe and monitor equipment for evidence of equipment problems or signs of a waste release. Also during waste retrieval operations, the inside of the vessel/pump skid will be a primary radiation source and will not be physically inspected. Radiation monitors and video cameras are installed inside of the skid to provide dose rate and visual monitoring of the skid internals. The leak detection system installed at the vessel/pump skid will be monitored at all times during waste retrieval operations. The response to a leak from the vessel/pump skid would include an orderly shutdown of the retrieval system followed by an evaluation of the monitoring data and equipment. In the event that a leak did occur from within the vessel/pump skid, any waste remaining would drain back into the tank being retrieved, the skid would be decontaminated as required, and the equipment repaired or replaced, as necessary. Should a leak occur from the batch vessel into the vessel's secondary containment the released material will be removed within twenty-four hours or in as timely a manner as possible, in compliance with WAC 173-303-640(7)(b)(ii).~~

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.~~The transfer lines associated with transfers covered in this document and DSTs are RCRA compliant.~~

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 may be left in place for disposition during component closure actions. The abovegrade equipment (e.g., transfer lines, equipment skids) will be reused to the extent possible for future waste retrieval activities~~ in the C tank farm~~. Transfer lines and the equipment skids 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 as mixed waste onsite in accordance with the approved waste acceptance criteria for the Hanford Site burial grounds. If contaminated equipment is reused it will be controlled per TFC-OPS-WM-C-10, *Contaminated Equipment Management Practices*. Where or if required and needed to support the retrieval of SSTs, the HIHTLs will be managed to ensure the availability and functionality of each as needed for future retrievals. At the conclusion of their mission, or upon reaching the end of life for a HIHTL, the HIHTL 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-101 and C-105 is limited to waste transfer lines and equipment installed in pits and abovegrade risers. The current status of the existing ancillary equipment associated with tanks C-101 and C-105 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 or controlled per 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~~ Sitewide permit.

3.10 AIR MONITORING PLAN

ORP and the tank ~~farm~~ operations contractor, 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-101 and C-105. 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 tank farm contractor 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.

4.0 DESCRIPTION OF PLANNED LEAK DETECTION AND MONITORING TECHNOLOGIES

NOTE: Section 4 on leak detection was revised in RPP-22520 Rev 5 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 required subsection contents in RPP-33116; however, the Decree establishes the requirements for TWRWP content.

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.* When retrieval operations are ready to commence for C-101 or C-105 the tanks enter 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 six drywells spaced around tank C-101 that are between 2 and 20 ft from the edge of the tank (Figure 4-1). The six drywells include 30-01-01, 30-01-06, 30-00-06, 30-01-09, 30-04-05, and 30-01-12. Five of the drywells are 100 ft deep. One drywell (30-00-06) is drilled to 150 ft deep but can only be logged to 111 ft because of grouting (GJ-HAN-85, *Vadose Zone Characterization Project at the Hanford Site Tank Farms Tank Summary Data Report for Tank C-101*).

Ten drywells are spaced around tank C-105 that are between 2 and 12 ft from the edge of the tank (Figure 4-1). The ten drywells include 30-05-02, 30-05-03, 30-05-04, 30-05-05, 30-05-06, 30-05-07, 30-04-02, 30-05-08, 30-05-09 and 30-05-10. Three of the drywells are between 50 and 70 ft deep, 3 drywells are 100 ft deep, and 4 are between 120 and 135 ft deep (GJ-HAN-83, *Vadose Zone Characterization Project at the Hanford Tank Farms Tank Summary Data Report for Tank C-105*).

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

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 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. Quarterly samples are analyzed at a minimum for anions, cyanide, inductively coupled plasma metals, gross beta, technetium, and total uranium, and a low-level gamma scan is performed.

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~~ are ~~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.~~issued by the groundwater project.

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-5, requires quarterly groundwater sampling 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.

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-101 and C-105 currently have operable ENRAF level gauges installed. The receiver DSTs currently have the same type of level gauge installed. The receiver DSTs ~~also~~annulus have ~~three conductivity probe gauges~~leak detection devices installed~~ in the annulus~~ such as conductivity gauges, Enraf level gauges or similar instruments~~. These annulus level gauges are used~~ for detection of leaks from the tank primary tank liner.

The waste levels in tanks C-101 and C-105 while in storage mode are monitored for intrusion on a quarterly basis using an ENRAF level gauge (OSD-T-151-00031). 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~~, 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~~.

Level monitoring for the tank receiving the exhauster condensate, if not C-101 or C-105 during their retrieval, 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 tanks C-101 and C-105 during waste retrieval along with a description of how it 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 6.03.

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 tanks C-101 and C-105 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 will be used to survey the drywells surrounding C-101 and C-105 prior to the start of retrieval, and 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. 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 hr through the Change Notice form.

Should moisture logging be necessary after the start of 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 weekly drywell logging is performed as a backup leak detection method will be specified in the process control plan. The lower depth target is normally about 20' below the bottom of the tank.

Due to operational constraints, required drywell logging may be missed occasionally if it is used as a 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®)[3] 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 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 ~~during waste retrieval.~~.

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

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[3] 503DR HYDROPROBE® is a registered trademark of CPN International, Inc., Concord, California.

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 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 late ~~2007~~ 2011 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 Hydroprobe Neutron Moisture Detection.*

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.

The basic resistivity measurement concept utilizes the existing drywells and 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 not be able to be discerned from the data

~~**4.2.1.4 Leak Detection Monitoring for Abovegrade Equipment Skids**. There are two abovegrade skids that will contain waste or drainwater solutions: (1) the batch vessel skid, which contains the batch vessel and associated transfer pumps, and (2) the vacuum skid, which contains the vacuum blowers and air separator vessel. The planned LDM for these skids includes the following features:~~

- ~~Each skid will have a sealed containment floor with a drain. The drain will be routed back to the tank being retrieved. The drain lines will contain leak detectors that will activate in the event liquid is detected and shut down any waste transfers.~~
- ~~Each skid will have internal video capability. These can be used to help determine the source of a detected leak.~~

4.2.1.5 Leak Detection in Transfer Lines and Pits During Waste Retrieval. Supernate will be transferred from the receiver DST receiver tank~~(s)~~ ~~to the waste transfer system at the vessel/pump skid,~~ and liquid waste and slurries will be transferred ~~from the vessel/pump skid~~ back to their respective receiver tank using temporary hose-in-hose overground transfer lines and pits. Leak detectors located in pits will be monitored during waste transfers. Leaks are also 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 shut down the transfer pumps either automatically or manually.

4.2.1.6 Leak Detection in the Receiver Double-Shell Tanks. The existing leak detection systems in the receiver DSTs will be used 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.

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 waste retrieval operations 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.~~ The post retrieval gamma scans may be done by any of the gamma logging methods discussed in Section 4.2.1.1 within approximately 6 months following completion of active retrieval operations in 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 at tanks C-101 and C-105 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 is performed 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.

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

Leak mitigation strategy for an SST leak during waste retrieval refers to both reducing the potential for a leak to occur and to minimizing the volume of waste that could leak to the ground if there were a 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 will be removed between waste retrieval campaigns.
- Waste is retrieved to the extent practical by working from the center of the tank outwards.
- Retrieval activities are performed while a video camera is in place to observe ~~the AMS suction nozzle, ITV,~~in tank activities and the waste surface.
- 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 waste liquid level (the waste liquid level shall not exceed this benchmark)~~;~~. For C-101 the benchmark level of 54 inches shall not be exceeded and this level will be specified in the process control plan.~~the benchmark waste liquid level shall be~~

~~defined in the process control plan. The benchmark shall be based upon minimizing free liquid in the tank.~~

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 following will occur:

~~These leak assessment process steps are:~~

1. All liquid additions to the tank are stopped. 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.

~~1.~~2. Implement TFC-ENG-CHEM-D-42, the tank 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.

~~2.~~3. 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.

~~3.~~4. 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.)
- Specific actions to mitigate the impact of an SST leak, including spill response, interim measures, remedial actions, and closure activities, will require consultation with Ecology and DOE-ORP. Specific response(s) to a confirmed release are contingent on the specifics of the release, including time to closure of farm, size of release, relation of release to previous releases, retrieval processes and equipment in farm.

4.6.2 ~~Leak Mitigation for Aboveground Skid Leakage~~Receiving Tank Leak

4.6.2.1. Receiving Tank Leak Mitigation

The only receiver tank for the tank C-101 and C-105 wastes is a DST. There are no double-contained receiver tanks or catch tanks along the transfer route between the batch vessel/pump skid and the receiver DSTs. Transfer line leakage will drain back to the batch vessel/pump skid and from there to the SST being retrieved. 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.

~~**A leak within the skids will drain back to the SST being retrieved, not to the environment. Should a leak occur within the skid, the waste retrieval process would be halted automatically when the leak detectors activate and shut down the transfer pumps. The process could also be halted manually if the leak is spotted earlier by a video camera. The leak would then be fixed or the leak location bypassed before the process was restarted. The response to a leak is the same regardless of leak rate. An occurrence report may be issued depending upon whether the leak met the reporting requirements of TFC-OPS-OPER-C-24.**~~

~~**Any leakage within the skids is contained by the secondary containment. In the unlikely event that equipment failure causes leakage to the environment from the secondary containment, the steps in procedure TFC-ESHQ-ENV_FS-C-01 would be implemented for reporting requirements and in adherence with WAC 173-303.**~~

~~4.6.3~~4.6.2.2. ~~Leak Mitigation for~~ Receiving Tank Leak Response

~~The only receiver tank for the tank C-101 and C-105 wastes is a DST. There are no double-contained receiver tanks or catch tanks along the transfer route between the batch vessel/pump skid and the receiver DSTs. Transfer line leakage will drain back to the batch vessel/pump skid and from there to the SST being retrieved. 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~~generic leak response plan is provided in HNF-3484, *Double-Shell Tank Emergency Pumping Guide*, and RPP-5482, *Time Deployment Study for Annulus Pumping*. The following is a summary of leak mitigation actions for a DST.

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 saltwell jet pumping to remove trapped liquids from between solid layers in the tank.

Pumping out waste from the primary tank and from the annulus would require tank specific response plans in the form of procedures or work packages.

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.

~~4.6.4~~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 the containment structure on the transfer line. Leakage to the containment structure is transferred to the SST being retrieved.

4.6.3.1. Transfer Line Leak Mitigation

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.

4.6.3.2. Transfer Line Leak Response

Response to transfer leak detection alarms is performed per procedure (procedures for waste transfer will be developed before waste retrieval operations). Transfer line ~~L~~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 transfer line leak detection system logic when compared to existing tank farms transfer line leak detection. 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 pumps. 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 questionable integrity. The leaks would be repaired or the leak location bypassed before resuming waste retrieval operations. ~~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 an aboveground diversion box or pit, the waste transfer pumps would be shut down and the leakage would be transferred to the SST being retrieved after draining back to the batch vessel skid. 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 ~~HFFACO~~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 the Chapter 70.105 RCW pending closure in accordance with WAC 173-303-610, *Closure and Post Closure*, under the authority of HFFACO Milestone M-45-00, *Complete Closure of all Single-Shell Tank 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 status 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-AC27-0RV14800 for current TOC). These requirements are implemented through operating plans and procedures by the ~~Tank Farm Contractor~~TOC.

Interim status facility standards in WAC 173-303-400(3)(a) incorporate, by reference, the interim status standards set forth by the 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-101 and C-105 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*.

Those components of the aboveground system using DST supernate to transfer SST waste to the receiving DST will be handled consistently with the current method of addressing polychlorinated biphenyl (PCB) waste in the DST system.

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).*

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 leak 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 with 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
		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~~34.
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)	Applicable operating plans and procedures are referenced throughout the document; too numerous to appropriately reference herein.

* 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.
TSD = treatment, storage, and disposal.

6.0 PRELIMINARY ISOLATION EVALUATION

(preliminary evaluation to be finalized in follow-on closure plans)

This section provides a preliminary isolation evaluation for tanks C-101 and C-105. 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:

- *Piping Waste Tank Isolation C-Tank Farm Plot Plan* (H-2-73338, Sheet 1)
- *Piping Waste Tank Isolation 241-C-101* (H-2-73340, Sheet 1)
- *Piping Waste Tank Isolation 241-C-105* (H-2-73345, Sheet 1)

~~Installation of waste retrieval equipment in tanks C-101 and C-105 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.~~

6.1 PLANS FOR PIPELINE AND ANCILLARY EQUIPMENT ISOLATION FOLLOWING WASTE RETRIEVAL

1. Plans for pipelines and ancillary equipment isolation following waste retrieval

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. Isolation of pipelines and ancillary equipment will be performed in accordance with an Ecology-approved closure plan.

6.2 TIMING AND SEQUENCE FOR TANK OR ANCILLARY EQUIPMENT COMPONENT CLOSURE

2. General timing/sequence of planned tank and/or ancillary equipment component closure

Tank and/or ancillary equipment component closure will not begin until there is an approved component closure plan for WMA C.

6.3 Timing and Plans for Tank or Ancillary Equipment Intrusion Prevention Before Component Closure

3. General timing and plans for isolating the tank and/or ancillary equipment component from inadvertent intrusion pending component closure.

Isolation of intrusion routes into the tank will be done within the closest diversion box to the tank when C-101 and C-105 waste retrieval has been completed. Additional isolation of any other tank and/or ancillary equipment, excluding HIHTLs, once C-101 and C-105 waste retrievals have been completed will be performed as needed for operational purposes related to future tank waste retrievals. HIHITLs will be handled as described in 3.9.1. Once the final closure plan has been agreed to the intrusion prevention will proceed per the schedule for final tank closure at that time.

Post-retrieval intrusion monitoring will be conducted in accordance with OSD-T-151-00031 until specific post-retrieval monitoring requirements are defined.

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-101 and C-105. 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. ~~Minimally it will contain the following~~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 the 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 changes in assumptions, (e. g. concentration or K_d variation) will be

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. The WRS design and operational strategy for tanks C-101 and C-105 are designed to minimize the leak potential from the tank structure during waste retrieval. If a leak is detected, however, the risk graphs provided in Appendices A and B 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-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 supernate leak. The 8,000-gal. volume was used only for information purposes to provide a point of reference on the graphs.

The indicator contaminant concentrations in RPP-22521 are high estimates that are intended to be bounding. An explanation of the bounding assumptions follows. Prior to retrieval a decant of the DST is conducted reducing the volume of supernate. The estimated volume of water that will be used in the retrieval is not added to the supernate volume thereby minimizing the estimated supernate volume and increasing the estimated concentration. It was assumed that the DST will not be decanted prior to retrieving C-101 and C-105, so all of the mass from SSTs retrieved into the DST prior to C-101 and C-105 remains in the DST supernate. Further, it is assumed that the salt cake shown by the BBI in the DST dissolves increasing the concentration of contaminants.

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

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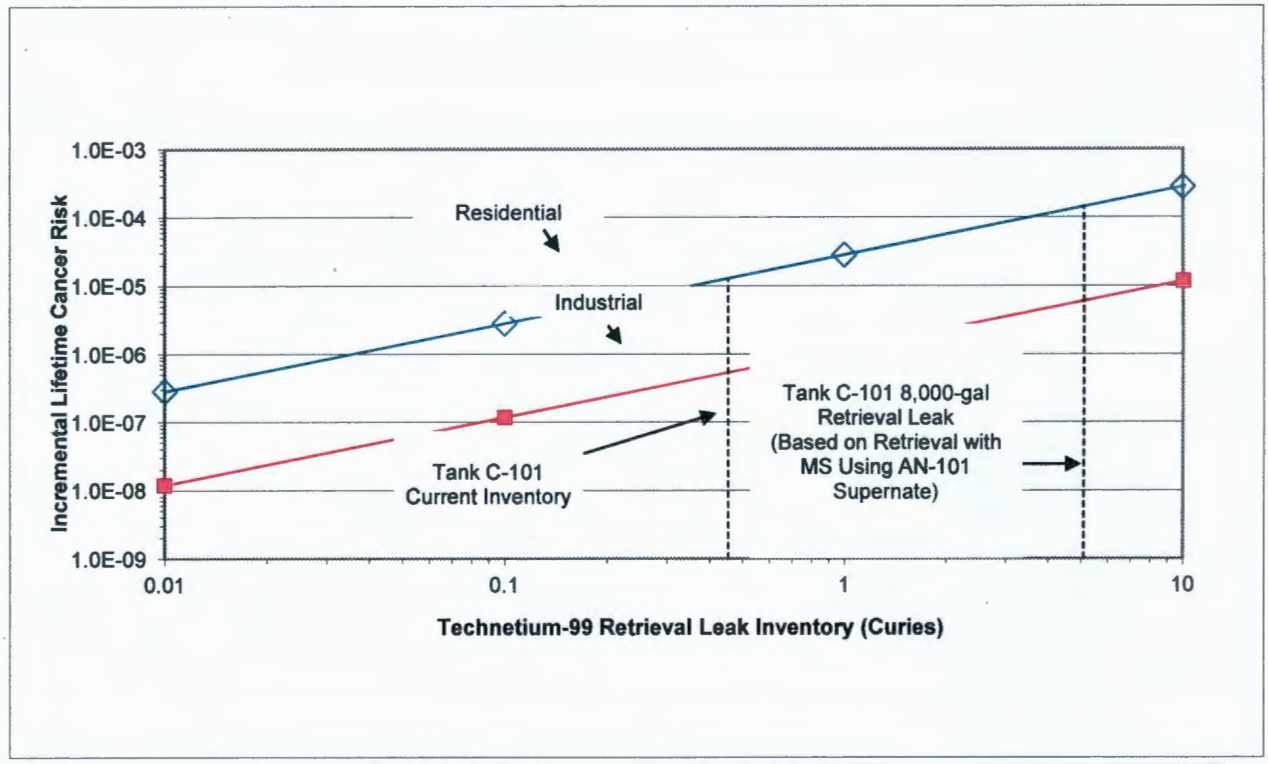
Figure A-1. Tank C-101 Technetium-99 Risk Plot.



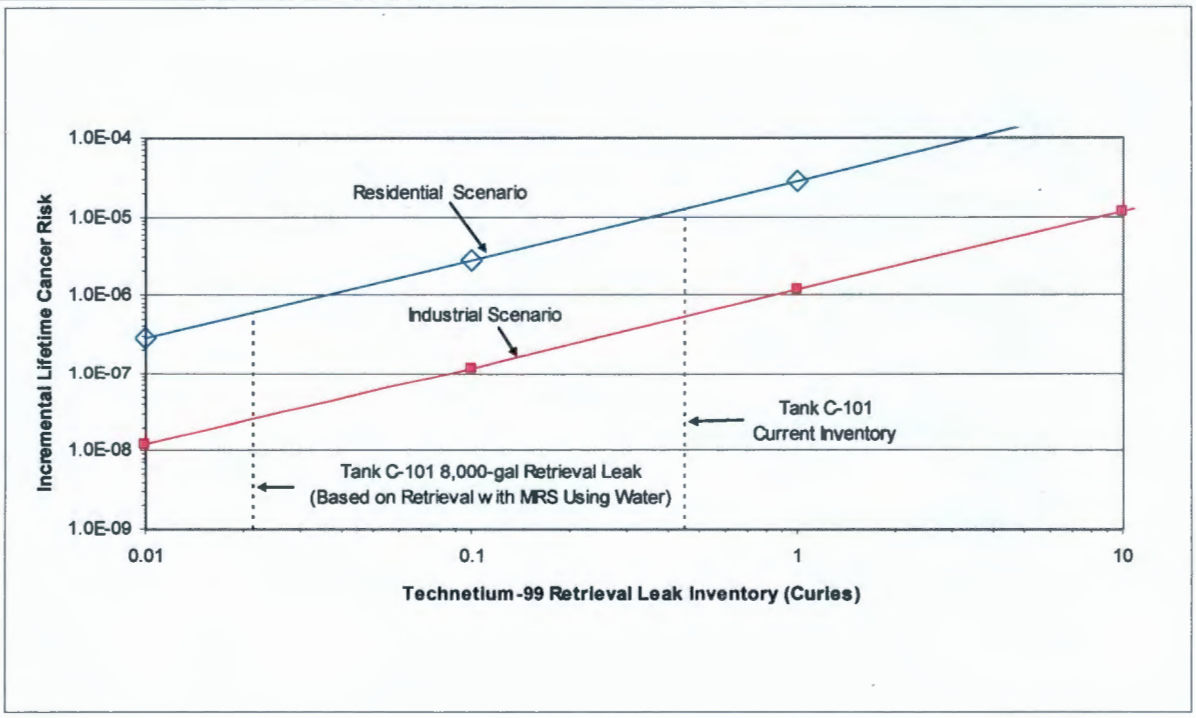
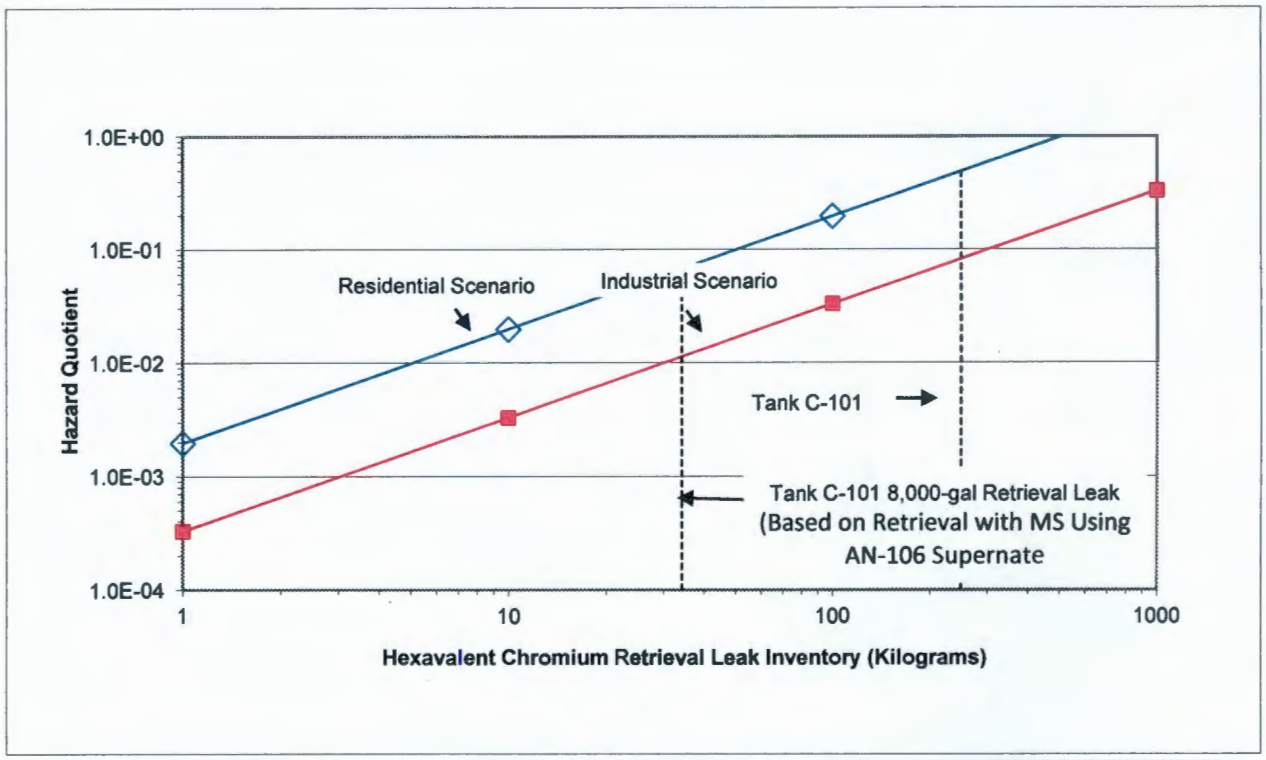


Figure A-2. Tank C-101 Hexavalent Chromium Hazard Quotient Plot.



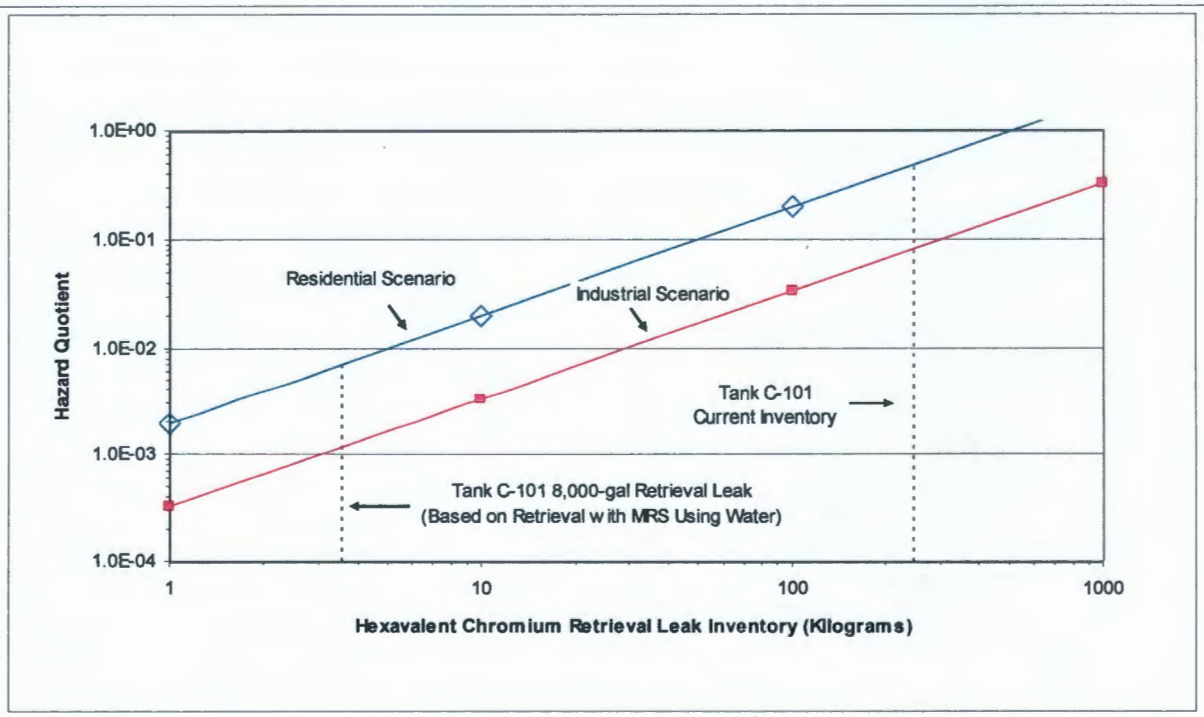
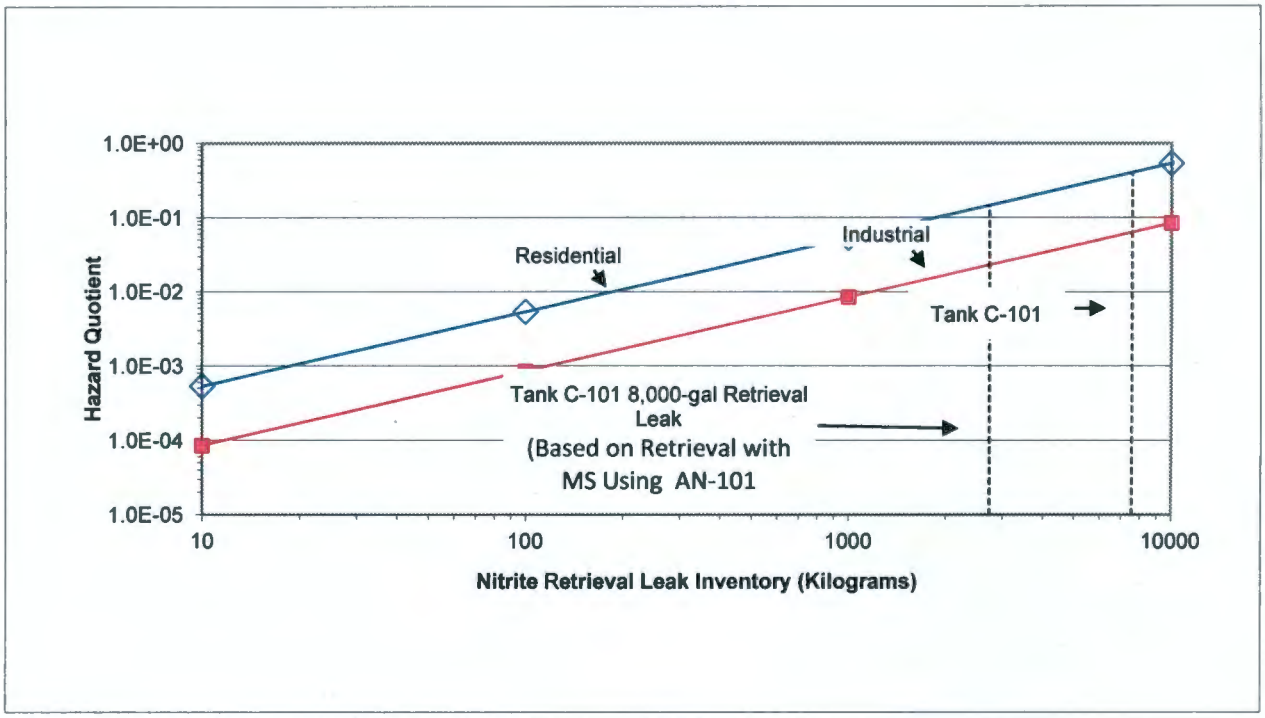


Figure A-3. Tank C-101 Nitrite Hazard Quotient Plot.



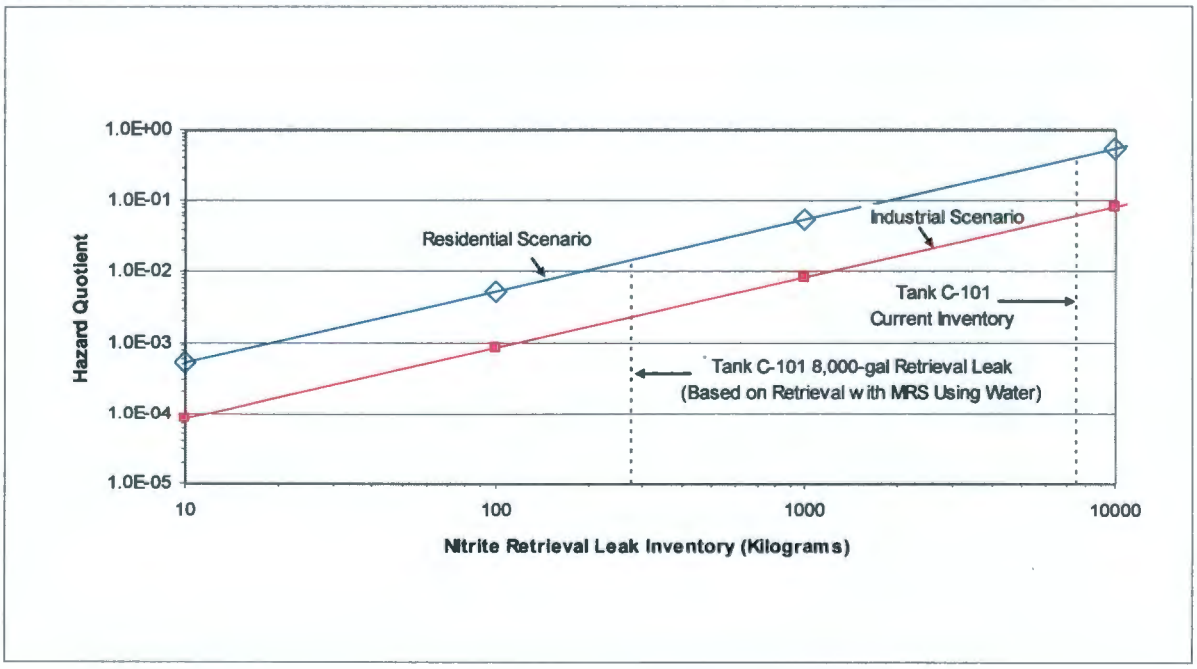


Figure A-1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-101 during waste retrieval. Figures A-2 and A-3 show the peak groundwater pathway hazard quotient (HQ) from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-101 during waste retrieval.

The ILCR and HQ 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-101 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 data points 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-101 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-101.

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 through 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 through 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 (BBI) 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-101 with the mobile retrieval system (MRS) using water. The retrieval leak fluid concentrations for this retrieval scenario were developed using data from RPP-21753, *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description*. The RPP-21753 flowsheet description provides representative contaminant concentrations for the fluids inside the SST, the MRS batch vessel, and the receiver double-shell tank (DST) during retrieval with the MRS. Retrieval leak inventories were developed from the representative SST fluid concentrations from RPP-21753 (Table A-1).

Table A-1. Tank C-101 Retrieval Leak Inventory Estimate.

Contaminant	Leak Fluid Concentration *	Inventory in 8,000-gal. Retrieval Leak
Technetium-99	~~7.07E-07~~1.68E-4 Ci/L	~~2.14E-02~~5.09E+00 Ci

Hexavalent Chromium	~~1.18E-04~~1.13E-3 kg/L	3.~~57E~~42E+~~00~~01 kg
Nitrite	9.~~08E~~03E-~~03~~02 kg/L	2.~~75E~~73E+~~02~~03 kg

* ~~Appendix D, Table D-3 from RPP-21753, 2005, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description.*~~Concentrations from Table C-27 of RPP-22521, *Tanks C-101, 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-101 was estimated to be approximately ~~0.0214~~5.09 curie (RPP-22521). As shown in Figure A-1, this corresponds to an ILCR of approximately ~~2.48~~5.90 × 10^{-8}~~-~~^{6} for the industrial scenario and ~~6.05~~1.44 × 10^{-7}~~-~~^{4} for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately ~~1.80~~427 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000 gal. retrieval leak from tank C-101 was estimated to be approximately ~~3.57~~34.2 kg (RPP-22521). As shown in Figure A-2, this corresponds to an HQ of approximately 1.~~16~~12 × 10^{-3}~~-~~^{2} for the industrial scenario and ~~7.02~~6.73 × 10^{-3}~~-~~^{2} for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately ~~3.00~~2.87 × 10^{-4}~~-~~^{3} mg/L.

The nitrite inventory associated with an 8,000 gal. retrieval leak from tank C-101 was estimated to be approximately ~~275~~2730 kg (RPP-22521). As shown in Figure A-3, this corresponds to an HQ of approximately 2.~~29~~27 × 10^{-3}~~-~~^{2} for the industrial scenario and 1.~~47~~46 × 10^{-2}~~-~~^{1} for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately 2.~~31~~30 × 10^{-2}~~-~~^{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 ~~2.48~~5.9 × 10^{-8}~~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:

$$\text{ILCR} = (\cancel{0.0214}5.09\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = \cancel{2.48}5.90 \times 10^{-\cancel{8}6}$$

Complete calculation details are provided in RPP-22521.

Table A-3. Tank C-101 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	0.007	0.001
Technetium-99	0.000	0.001	0.000
Tin-126	0.000	0.000	0.000
Cesium-137	0.002	0.002	0.000
Plutonium-239	0.105	0.592	0.027
Plutonium-240	0.017	0.095	0.004
Americium-241	0.001	0.005	0.000
Other Radionuclides	0.001	0.002	0.000
TOTAL	0.126	0.704	0.032

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.

A4.0 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.

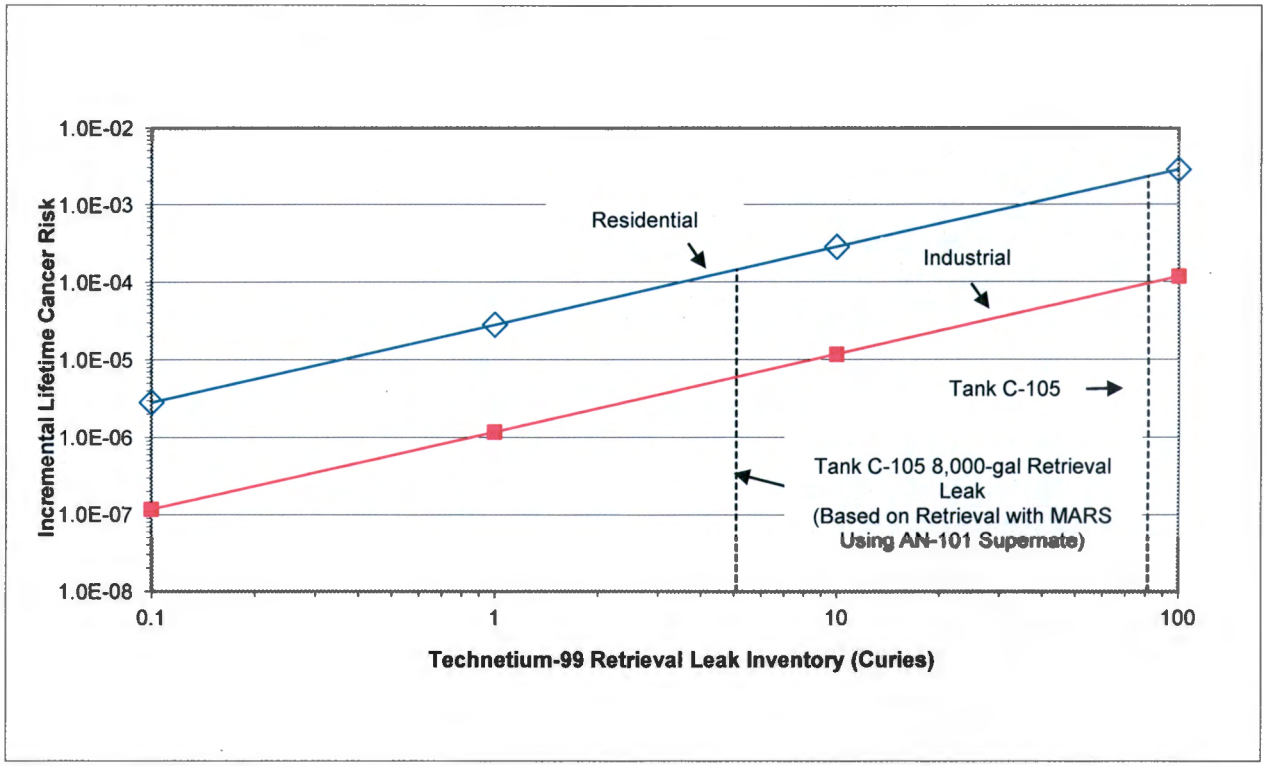
RPP-13774, 2004, *Single-Shell Tank System Closure Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

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-22521, ~~2008,~~ *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~~Latest Revision, ~~CH2M HILL Hanford Group~~Washington River Protection Solutions, ~~Inc~~LLC., Richland, Washington.

Figure B-1. Tank C-105 Technetium-99 Risk Plot.



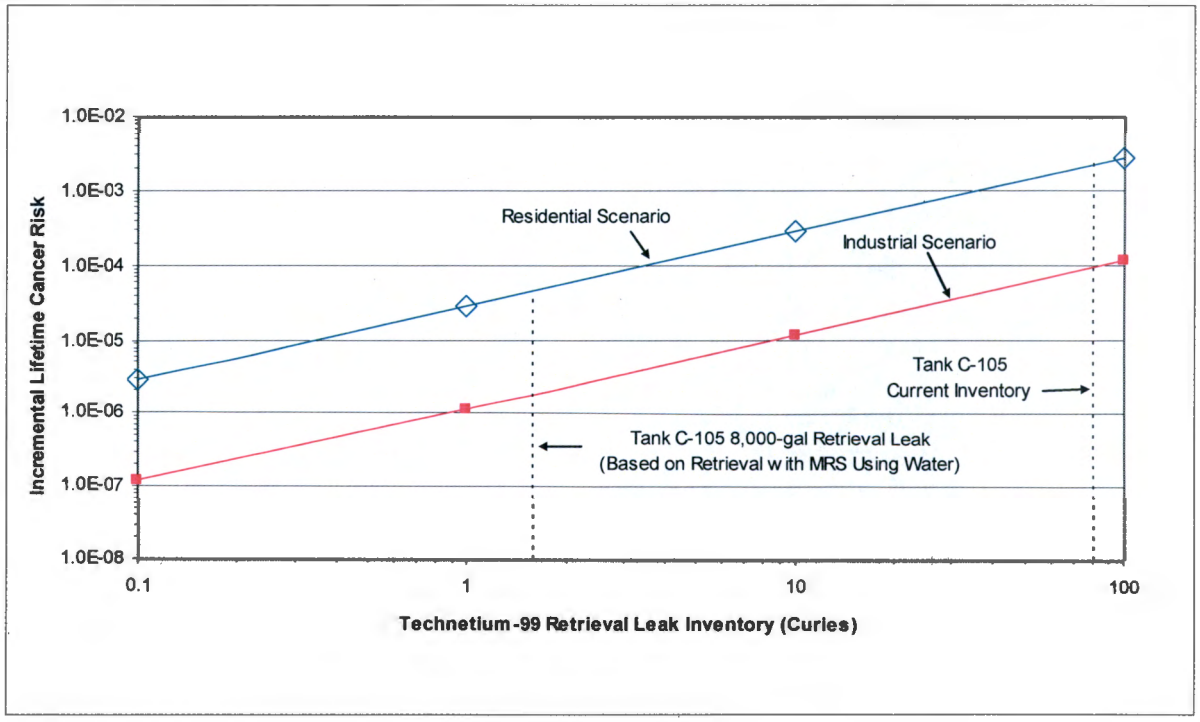
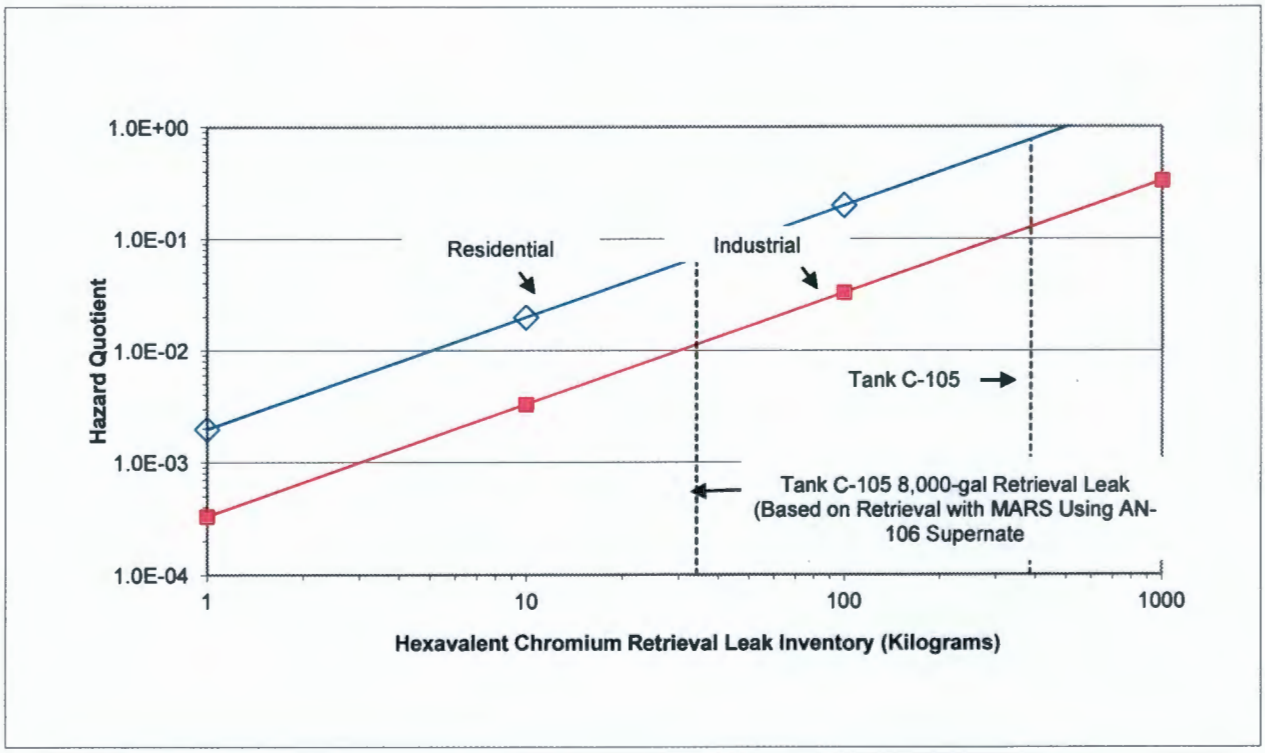


Figure B-2. Tank C-105 Hexavalent Chromium Hazard Quotient Plot.



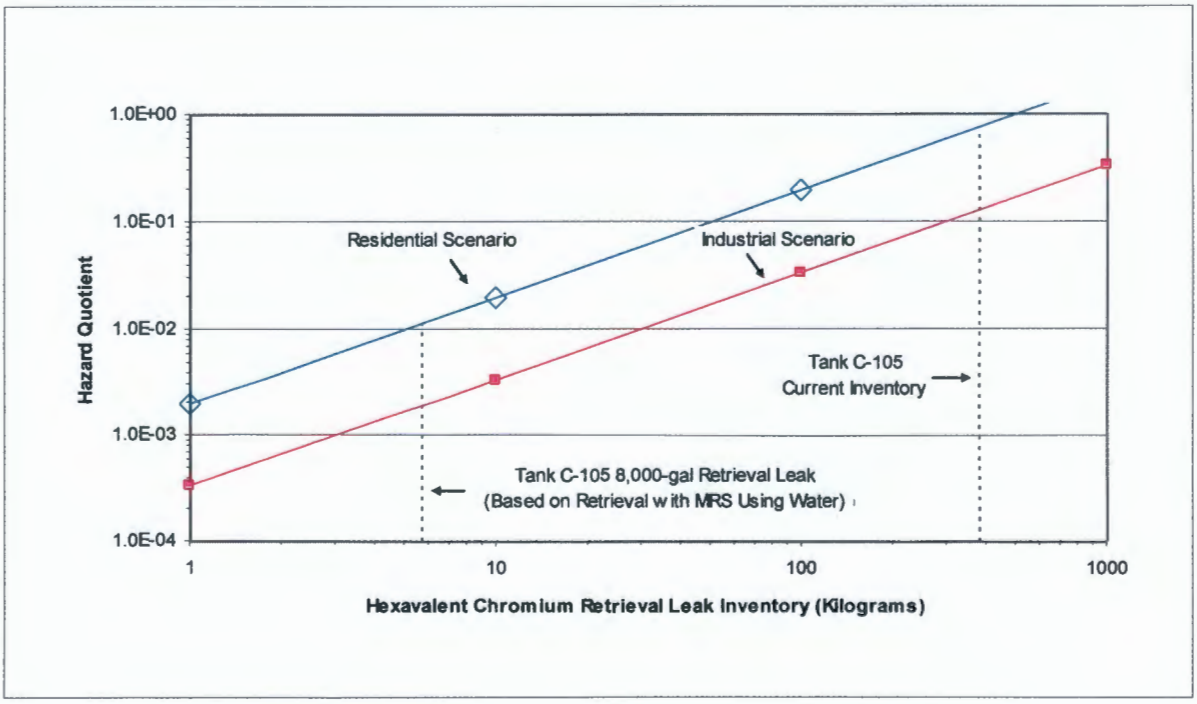
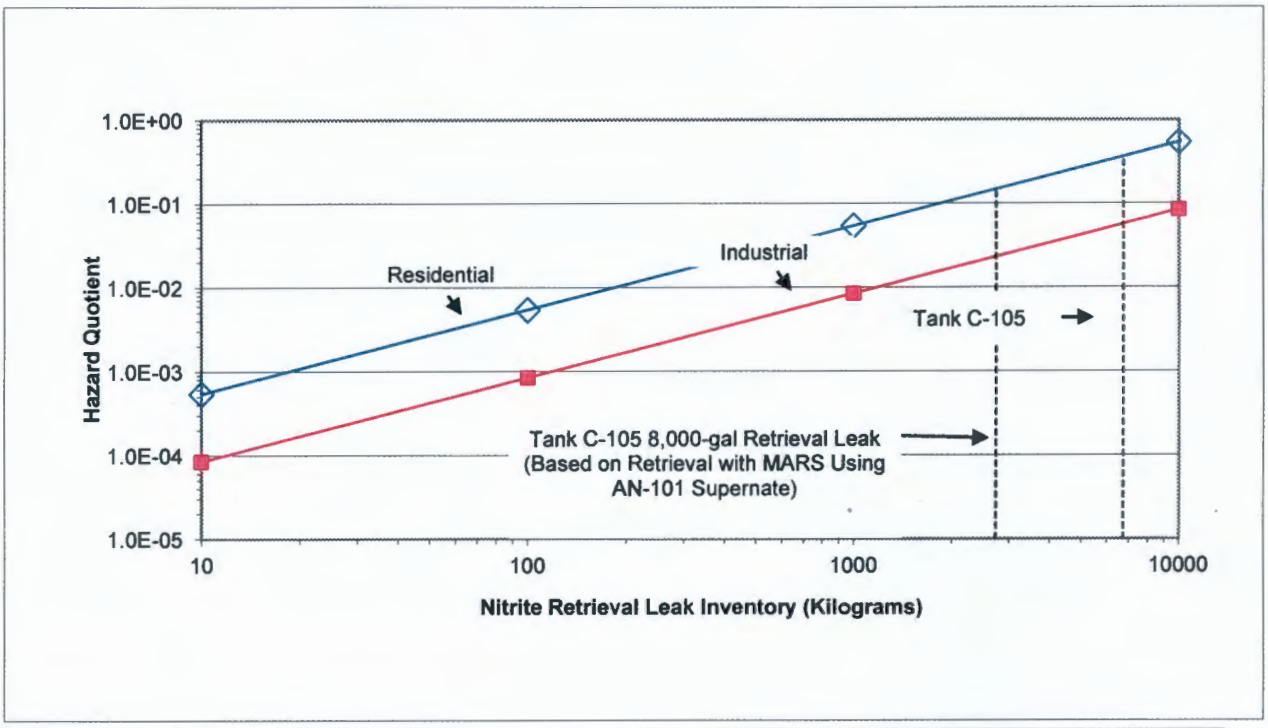


Figure B-3. Tank C-105 Nitrite Hazard Quotient Plot.



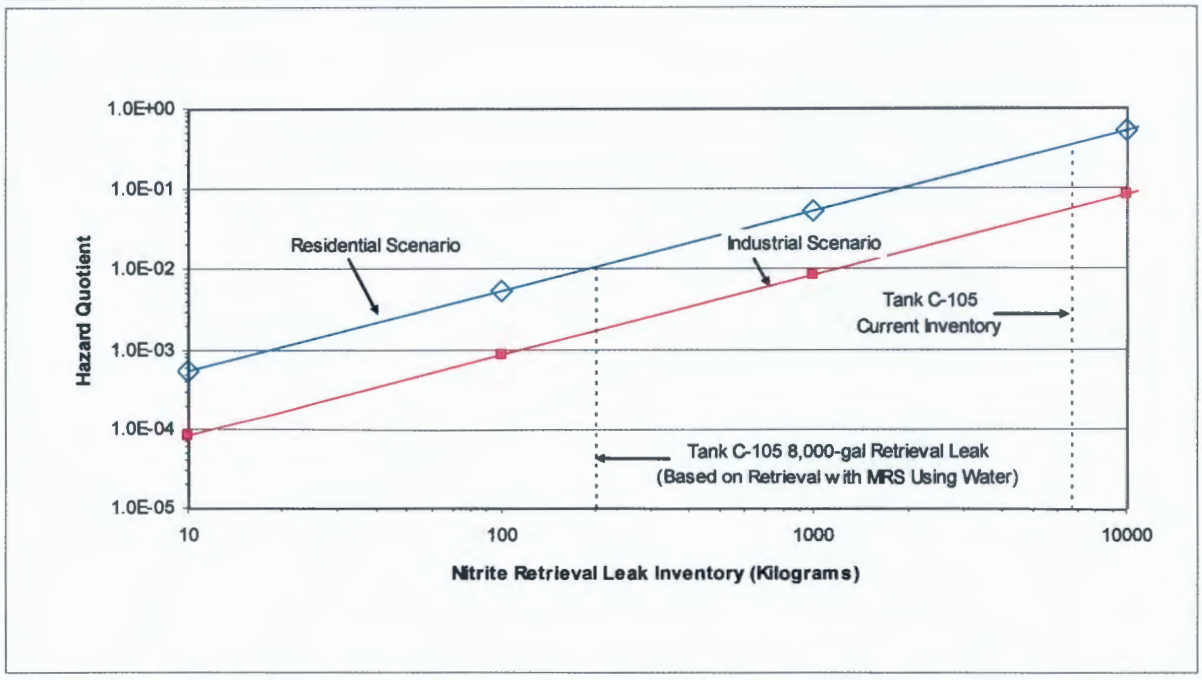


Figure B-1 shows the peak groundwater pathway incremental lifetime cancer risk (ILCR) from technetium-99 as a function of the amount of technetium-99 leaked from tank C-105 during waste retrieval. Figures B-2 and B-3 show the peak groundwater pathway hazard quotient (HQ) from hexavalent chromium and nitrite, respectively, as a function of the amount of hexavalent chromium and nitrite leaked from tank C-105 during waste retrieval.

The ILCR and HQ 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-105 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 data points 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-105 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-105.

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 through 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 through 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 (BBI) 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-105 with the mobile retrieval system (MRS) using water. The retrieval leak fluid concentrations for this retrieval scenario were developed using data from RPP-21753, *C-Farm 100 Series Tanks, Retrieval Process Flowsheet Description.* The RPP-21753 flowsheet description provides representative contaminant concentrations for the fluids inside the SST, the MRS batch vessel, and the double-shell tank (DST) receiver tank during retrieval with the MRS. Retrieval leak inventories were developed for the representative SST fluid concentrations for RPP 21753 (Table B-1).

Table B-1. Tank C-105 Retrieval Leak Inventory Estimate.

Contaminant	Leak Fluid Concentration *	Inventory in 8,000-gal. Retrieval Leak
Technetium-99	~~5.25~~1.68E-~~05~~-04 Ci/L	~~1.59~~5.09E+00 Ci

Hexavalent Chromium	~~1.90~~1.13E-~~04~~03 kg/L	~~5.76~~3.42E+~~00~~01 kg
Nitrite	~~6.71~~9.03E-~~03~~02 kg/L	~~2.03~~2.73E+~~02~~03 kg

* Appendix D, Table D-3 from RPP-21753, 2005, *C Farm 100-Series Tanks, Retrieval Process Flowsheet Description.*

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-105 was estimated to be approximately ~~1.59~~5.09 curies (RPP-22521). As shown in Figure B-1, this corresponds to an ILCR of approximately ~~1.84~~5.90 × 10^{-6} for the industrial scenario and ~~4.49~~1.44 × 10^{-5}~~-4~~ for the residential scenario. The peak technetium-99 groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately ~~134~~427 pCi/L.

The hexavalent chromium inventory associated with a hypothetical 8,000 gal. retrieval leak from tank C-105 was estimated to be approximately ~~5.76~~34.2 kg (RPP-22521). As shown in Figure B-2, this corresponds to an HQ of approximately ~~1.88~~1.12 × 10^{-3}~~-2~~ for the industrial scenario and ~~1.13~~6.73 × 10^{-2} for the residential scenario. The peak hexavalent chromium groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately ~~4.84~~2.87 × 10^{-4}~~-3~~ mg/L.

The nitrite inventory associated with an 8,000 gal. retrieval leak from tank C-105 was estimated to be approximately ~~203~~2730 kg (RPP-22521). As shown in Figure B-3, this corresponds to an HQ of approximately ~~1.69~~2.27 × 10^{-3}~~-2~~ for the industrial scenario and 1.~~09~~46 × 10^{-2}~~-1~~ for the residential scenario. The peak nitrite groundwater concentration at the WMA C fenceline from this retrieval leak would be approximately ~~1.71~~2.30 × 10^{-2}~~-1~~ 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 1.84 × 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:

$$\text{ILCR} = (\cancel{1.59}5.09\ \text{Ci}) \cdot (8.4 \times 10^{1}\ \text{pCi/L per Ci}) \cdot (1.38 \times 10^{-8}\ \text{ILCR per pCi/L}) = \cancel{1.84}5.90 \times 10^{-6}$$

Complete calculation details are provided in RPP-22521.

B3.0 INADVERTENT INTRUDER IMPACTS

The starting inventories for the tank C-105 intruder calculation were the estimated radionuclide inventories remaining in the tank following retrieval to the Ecology et al. (1989), *Hanford*

Table B-3. Tank C-105 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	0.008	0.001
Technetium-99	0.000	0.044	0.001
Tin-126	0.000	0.000	0.000
Cesium-137	0.002	0.003	0.000
Plutonium-239	0.268	1.513	0.068
Plutonium-240	0.039	0.223	0.010
Americium-241	0.107	0.431	0.021
Other Radionuclides	0.002	0.001	0.000
TOTAL	0.418	2.223	0.101

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.

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.

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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-22521, ~~2008,~~ *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~~Latest Revision, CH2M HILL Hanford Group, Inc., Richland, Washington.