CH2M HILL ENGINEERING CHANGE NOTICE

Page 1 of 2 ☒ DM ☐ FM ☐ TM

1a. ECN 721402 R 1

1b. Proj. ECN - - R

2. Simple Modification	3. Design Inputs – For full ECNs, record information on the ECN-1 Form (not required for Simple Modifications)	4. Date
☒ Yes ☐ No		2/6/2004

5. Originator's Name, Organization, MSIN, & Phone No.	6. USQ Number	7. Related ECNs
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8. Title	9. Bldg. / Facility No.	10. Equipment / Component ID	11. Approval Designator
Tanks C-103 and C-105 Waste Retrieval Functions and Requirements	C-103, C-105/241-C	C-100 Series Tanks	EQ

12. Engineering Documents/Drawings to be Changed (Incl. Sheet & Rev. Nos.)	13. Safety Designation	14. Expedited/Off-Shift ECN?
RPP-18811, Rev. 1	☐ SC ☐ SS ☐ GS ☒ N/A	☐ Yes ☒ No

15a. Work Package Number	15b. Modification Work Completed	15c. Restored to Original Status (TM)	16. Fabrication Support ECN?
N/A	N/A Responsible Engineer / Date	N/A Responsible Engineer / Date	☐ Yes ☒ No

17. **Description of the Change** (Use ECN Continuation pages as needed)

Revision of RPP-18811, revision 1, to incorporate additional comments as directed by Office of River Protection (ORP).

The following statement is being added to section 1.0, Introduction:

"Please note that source, special nuclear and byproduct materials, as defined in the Atomic Energy Act of 1954 (AEA), as amended, are regulated at DOE facilities exclusively by DOE acting pursuant to its AEA authority. DOE asserts that, under AEA, it has sole and exclusive responsibility and authority to regulate source, special nuclear, and byproduct materials at DOE-owned nuclear facilities. To the extent that this Functions and Requirements document provides data or discussions about materials regulated by the AEA, that information is provided for informational purposes only."

18. **Justification of the Change** (Use ECN Continuation pages as needed)

This document is required to incorporate comments resulting from ORP review.

The USQ procedure/process is determined to be not applicable to the changes made by this ECN, as this ECN does not implement physical or procedural changes to the facility and is not associated with a test or experiment.

19. **ECN Category**

☒ Direct Revision
☐ Supplemental
☐ Void/Cancel

ECN Type

☐ Supercedure
☒ Revision

20. **Distribution**

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E.W. Girgis	S7-12	R.S. Robinson	S7-70
J.R. Bellomy	S7-24	C.J. Kemp	R1-51
W.T. Thompson	S-7-70	K.E. Carpenter	S-7-20
J.F. Bores	S7-07	D.B. Parkman	S7-12
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CH2M HILL ENGINEERING CHANGE NOTICE	1a. ECN 721402 R 1
Page 2 of 2 ☒ DM ☐ FM ☐ TM	1b. Proj. ECN - - R

21. Revisions Planned (Include a brief description of the contents of each revision)

Revisions based on comments received from the Office of River Protection (ORP) reviews and Ecology reviews.

Note: All revisions shall have the approvals of the affected organizations as identified in block 11 "Approval Designator," on page 1 of this ECN.

22. Design Basis Documents

☒ Yes ☐ No

23. Commercial Grade Item Dedication Numbers (associated with this design change)

N/A

24. Engineering Data Transmittal Numbers (associated with this design change, e.g., new drawings, new documents)

N/A

25. Other Non Engineering (not in HDCS)documents that need to be modified due to this change

Type of Document	Document Number	Type of Document	Document Number
N/A			

26. Field Change Notice(s) Used?

☐ Yes ☒ No

If Yes, Record Information on the ECN-2 Form, attach form(s), include a description of the interim resolution on ECN Page 1, block 17, and identify permanent changes.

NOTE: ECNs are required to record and approve all FCNs issued. If the FCNs have not changed the original design media then they are just incorporated into the design media via an ECN. If the FCN did change the original design media then the ECN will include the necessary engineering changes to the original design media.

27. Design Verification Required?

☐ Yes ☒ No

If Yes, as a minimum attach the one page checklist from TFC-ENG-DESIGN-P-17.

28. Approvals

	Facility/Project Signatures	Date		A/E Signatures	Date
Design Authority	E.W. Girgis	2/9/04	S7-12	Originator/Design Agent	
Resp. Engineer	J.R. Bellomy	2/9/04	S7-24	Professional Engineer	
Resp. Manager	W.T. Thompson	2/9/04	S7-70	Project Engineer	
Quality Assurance	J.F. Bores	02/09/04	S7-07	Quality Assurance	
IS&H Engineer	R.E. Butler	02/09/04	S7-83	Safety	
NS&L Engineer	R.D. Smith	2/4/04	S7-90	Designer	
Environ. Engineer	C.J. Kemp	2-9-04	R1-51	Environ. Engineer	
Engineering Checker	R.S. Robinson	2-6-04	S7-70	Other	
Other	K.E. Carpenter	2/6/04	S7-20	Other	
Other				DEPARTMENT OF ENERGY / OFFICE OF RIVER PROTECTION	
Other				Signature or a Control Number that tracks the Approval Signature	
Other					
Other				ADDITIONAL SIGNATURES	
Other					
Other					

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RPP-18811, Rev. 2

Tanks C-103 and C-105 Waste Retrieval Functions and Requirements

J.R. Bellomy
CH2M HILL Hanford Group, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-99RL14047

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Key Words: 241-C-103, C-103, 241-C-105, C-105, Functions and Requirements Waste Retrieval

Abstract: This document establishes the C-103 and C-105 Tank Waste Retrieval Functions and Requirements (including leak detection, monitoring and mitigation system specifications), required by milestone M-45-00 of the Hanford Federal Facility agreement and Consent Order.

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RECORD OF REVISION

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Page 1

(2) Title: Tanks C-103 and C-105 Waste Retrieval Functions and Requirements

Change Control Record

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		(5) Cog. Engr.	(6) Cog. Mgr. Date
0	(7) Initial Release RPP-18811 Rev. 0	JR Bellomy	WT Thompson
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A-7320-005 (10/97)

TANKS C-103 AND C-105 WASTE RETRIEVAL FUNCTIONS AND REQUIREMENTS

February 6, 2004

Prepared By
CH2M HILL Hanford Group, Inc.
Richland, Washington

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EXECUTIVE SUMMARY

This document establishes the functions and requirements for the retrieval of waste stored in tanks C-103 and C-105. Both of these tanks are designated as sound[1] and are located in the 200 East Area of the Hanford Site. The retrieval of waste from tanks C-103 and C-105 will integrate leak detection, monitoring, and mitigation strategies with retrieval technologies to minimize the potential for and volume of leaks to occur during retrieval.

The goals of this waste retrieval deployment are to remove as much waste as technically possible, with tank waste residues not to exceed 360 cubic feet, or to the limit of the waste retrieval technology, whichever is less. Waste retrieval from tanks C-103 and C-105 will utilize a modified sluicing system that introduces controlled volumes of liquid (DST supernate) to mobilize solids in the tanks for retrieval.

This document establishes the tanks C-103 and C-105 waste retrieval functions and requirements (including leak detection, monitoring, and mitigation system approaches). The functions and requirements are based on the use of best available technologies and consider human health risks associated with the tank waste and potential waste volumes that could leak during retrieval.

The waste retrieval system being deployed will be operated to reduce the potential for leakage to occur and to limit the resulting volumes if a leak were to occur. Therefore, the risk-based leak detection and monitoring strategy is based on preventing leakage and minimizing leak volumes if a leak should occur. Waste will be retrieved from tanks C-103 and C-105 using supernate from double-shell tank AN-106 as the primary retrieval liquid. Supernate from tank AN-106 will be supplemented with raw water if there is insufficient liquid volume and for transfer line and equipment flushes. Current plans also include a demonstration deployment of a high-resolution resistivity leak detection system.

[1] HNF-EP-0182, 2003, *Waste Tank Summary Report for Month Ending June 30, 2003*, Rev. 183, CH2M HILL Hanford Group, Inc., Richland, Washington.

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LIST OF TERMS

DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
F&R	functions and requirements
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
ILCR	incremental lifetime cancer risk
LDM	leak detection and monitoring
LDMM	leak detection, monitoring, and mitigation
ORP	Office of River Protection
SST	single-shell tank
WRS	waste retrieval system

1.0 INTRODUCTION

The River Protection Project mission includes storage, retrieval, immobilization, and disposal of high-level mixed radioactive waste presently stored in 177 underground tanks located in the 200 East and 200 West Areas of the U.S. Department of Energy (DOE) Hanford Site. The River Protection Project is in the process of accelerating single-shell tank (SST) waste retrievals. Tanks C-103 and C-105, located in the 200 East Area, are scheduled for accelerated waste retrieval (Figure 1). These tanks were chosen for early waste retrieval based on the following criteria:

- The existing waste transfer infrastructure from tank C-106 waste retrieval activities will be available to reduce overall retrieval costs.
- Waste retrieval will provide sludge waste for feed to the Waste Treatment Plant.
- Waste retrieval will contribute to closure of the C tank farm.
- Waste retrieval from tank C-103 will provide long-term mitigation of vapor issues associated with the tank.

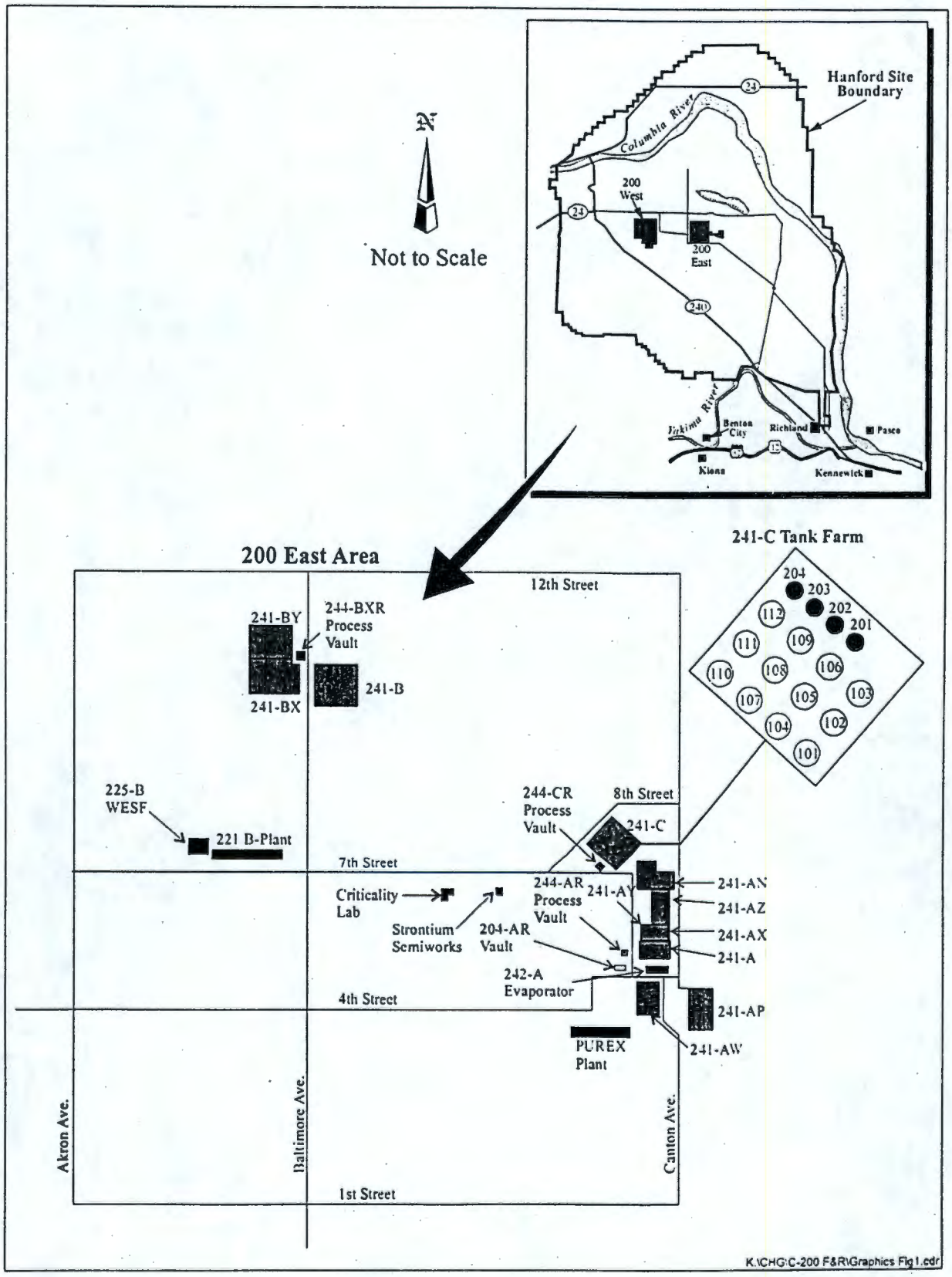
Because of the recent schedule acceleration, tank-specific waste retrieval milestones have not been established in the *Hanford Federal Facility Agreement and Consent Order* (HFFACO; Ecology et al. 1989) for tanks C-103 and C-105. However, this functions and requirements (F&R) document has been prepared to serve as a waste retrieval F&R document. This document follows a streamlined approach to developing waste retrieval F&R documents.

Because of concerns related to the liquid containment integrity of the older SSTs, current plans call for retrieving the SST waste and staging it in the more reliable double-shell tanks (DSTs) to serve as feed material for the waste immobilization process in the Waste Treatment Plant. Although waste retrieval is a significant closure action, it does not constitute final closure. The tank C-103 and C-105 waste retrieval activities will be conducted, to the extent practical, to meet requirements that allow ultimate closure of the tanks and the tank farm. Therefore, the steps taken to retrieve waste from tanks C-103 and C-105 will not preclude any future closure decisions.

The approach used to develop this document includes an integrated waste retrieval and leak detection, monitoring, and mitigation (LDMM) strategy that considers human health risk in the planning and development of waste retrieval system (WRS) requirements. The overall waste retrieval strategy includes deployment of a modified sluicing system utilizing DST supernate as the primary retrieval liquid. Recirculation of DST supernate to tanks C-103 and C-105 will minimize the volume of waste requiring storage in the DST system.

Please note that source, special nuclear and byproduct materials, as defined in the Atomic Energy Act of 1954 (AEA), as amended, are regulated at DOE facilities exclusively by DOE acting pursuant to its AEA authority. DOE asserts that, under AEA, it has sole and exclusive responsibility and authority to regulate source, special nuclear, and byproduct materials at DOE-owned nuclear facilities. To the extent that this Functions and Requirements document provides data or discussions about materials regulated by the AEA, that information is provided for informational purposes only.

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



1.1 PURPOSE

This document provides the F&R necessary to support the design of the WRS for SSTs C-103 and C-105. This document also provides a preliminary waste retrieval and LDMM strategy compatible with the F&R. The strategy combines the current baseline leak detection and monitoring (LDM) methods with an operational strategy designed to reduce the potential for leaks to occur, and to limit the resulting volume in the event a leak does occur. This document additionally provides risk information to establish a basis for making informed decisions in the event a leak is detected during waste retrieval.

1.2 SCOPE

This F&R document will establish the following:

- Waste retrieval F&R
- LDMM strategy
- Waste retrieval strategy for tanks C-103 and C-105.

The F&R identified in this document provide the foundation for the design criteria and design requirements documented in the *Level 2 Specification for the C-100 Series Tank Waste Retrieval System* (RPP-18633). Specifications are used to develop the project engineering concepts, scope, and boundaries. The content of the specification will include detailed requirements such as operating pressures, temperatures, materials of construction and control system requirements, confinement boundaries and controls, interface requirements, and similar detailed application requirements. The specification for tanks C-103 and C-105 will be consistent with this F&R document.

1.3 CURRENT TANK CONDITIONS

Figure 2 provides a plan view of the C tank farm and the surrounding *Resource Conservation and Recovery Act of 1976* groundwater monitoring wells. Groundwater monitoring activities will be consistent with the current *Resource Conservation and Recovery Act of 1976* monitoring plan (*RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site* [PNNL-13024]). There are a number of drywells surrounding the 100-series tanks within the C tank farm, with five of these drywells associated with tank C-103, and with nine of these drywells directly associated with tank C-105 (Figure 3).(WHC-SD-WM-ER-349). Additional discussion of tank-specific conditions is provided in Sections A1.0 and B1.0 for tanks C-103 and C-105, respectively.

Figure 2. Waste Management Area C and Regulated Structures

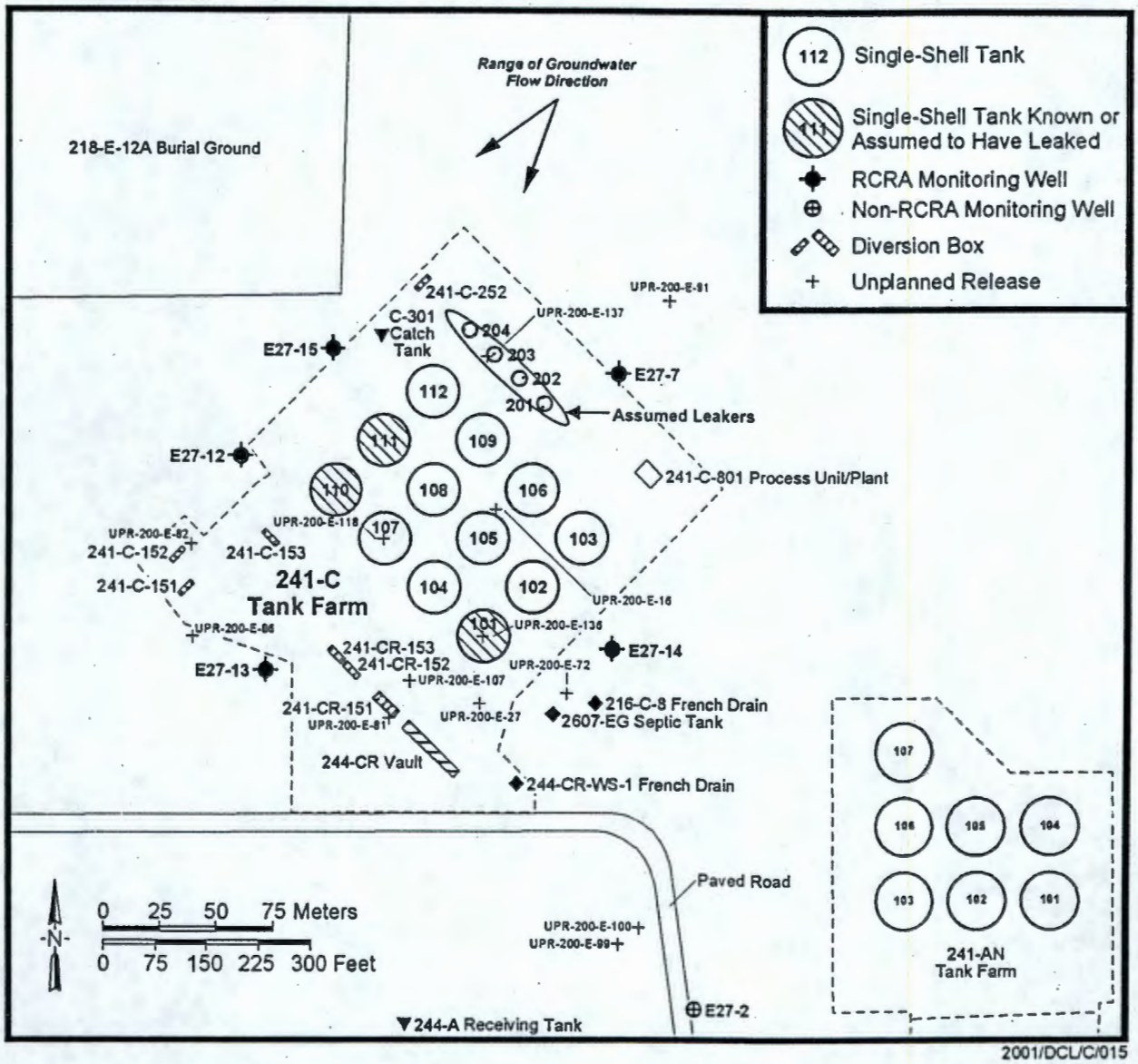


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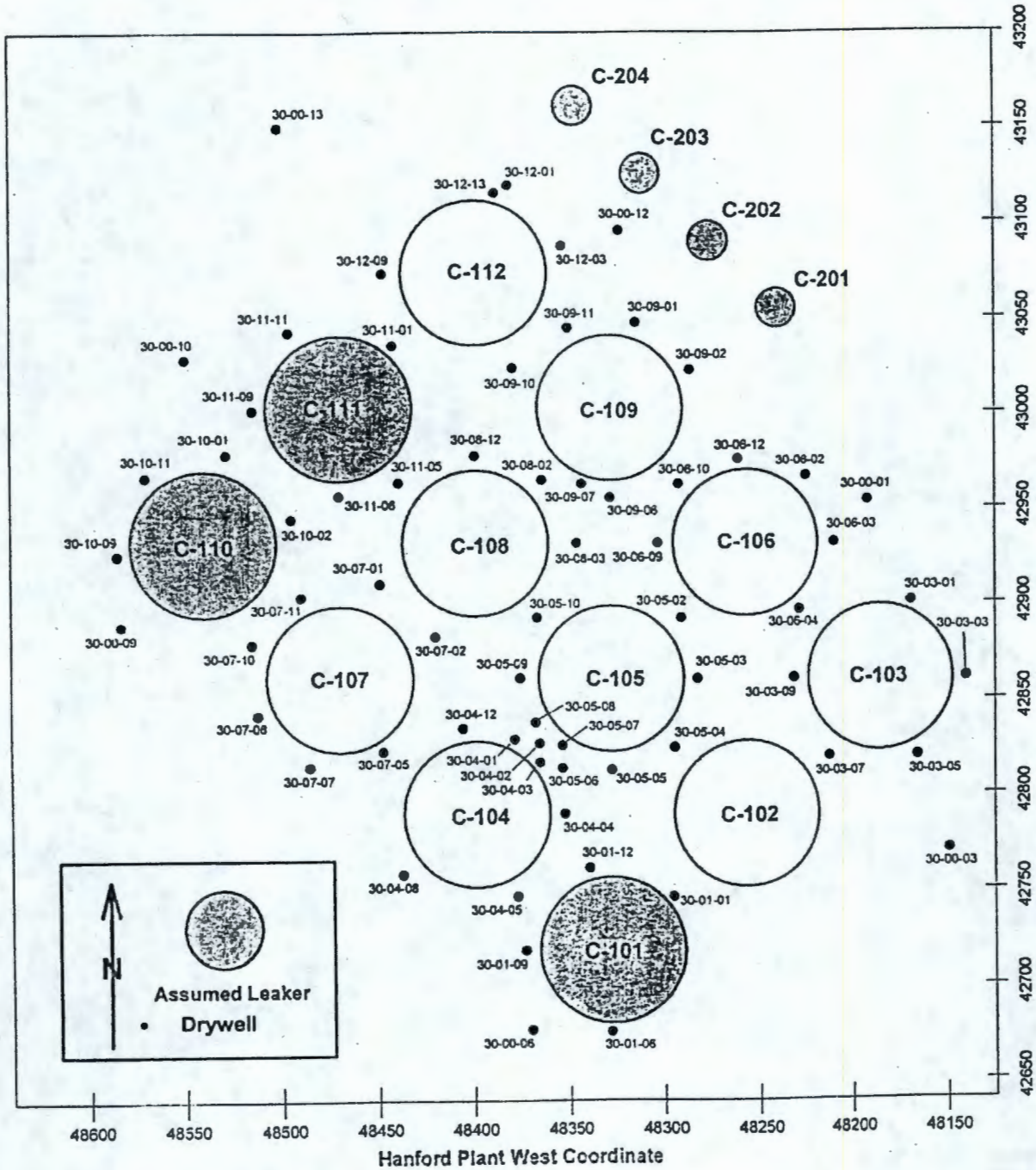
Figure 3. Plan View of the C Tank Farm Showing Drywells



2.0 RISK BASIS

This F&R document includes the results of a preliminary evaluation of the long-term human health risks associated with the waste in tanks C-103 and C-105 and potential leaks that could occur during waste retrieval operations. The need to consider long-term human health risks in developing waste retrieval F&R was established in the HFFACO M-45 milestone series through Change Package M-45-00-01A. Milestones established by this change package require a scoping-level risk assessment be prepared as part of the waste retrieval F&R documents. The Washington State Department of Ecology (Ecology) and the Office of River Protection (ORP) have agreed that a scoping level risk assessment is interpreted to be the same as a screening-level risk assessment that utilizes currently available data and information.

The tanks C-103 and C-105 waste retrieval risk basis was developed using estimated groundwater pathway human health risk. For this screening-level assessment, contaminant transport calculations were not performed. Rather, the effects of contaminant release and transport were taken from previous studies that are the most relevant to the case being studied. For tanks C-103 and C-105, these are the waste retrieval performance evaluation work for tank C-106 (*Data to Support Tank C-106 Waste Retrieval Determination* [RPP-6596]) and the vadose zone field investigation work for waste management area B-BX-BY (*Field Investigation Report for Waste Management Area B-BX-BY* [RPP-10098]).

DOE and Ecology have recognized that there are risks associated with retrieving waste from aging SSTs, including the potential for leakage during waste retrieval. However, DOE and Ecology have also recognized that there are risks associated with continued storage of waste in the SSTs. Not retrieving the waste will result in its eventual and certain release, when the tanks ultimately fail. Tanks C-103 and C-105 are approximately 38 years beyond their design lives, and continued storage will increase the potential for leakage to occur during waste retrieval. Time will make the situation worse so there is a bias for moving forward with waste retrieval and transfer of waste from the aging SSTs to the safer, more reliable DSTs.

Retrieval of all the waste from tanks C-103 and C-105 with no leakage is the goal of the waste retrieval project. A risk evaluation was performed to provide a basis for making informed decisions during waste retrieval operations in the event a leak is detected or unexpected waste retrieval conditions arise. The evaluation methodology is discussed in this section. The evaluation results are provided in Sections A2.0 and B2.0 for tanks C-103 and C-105, respectively.

The evaluation methodology followed guidance provided in *Contents of Risk Assessments to Support the Retrieval and Closure of Tanks for the Washington State Department of Ecology* (RPP-14284). That document describes the technical basis for a streamlined risk assessment process that DOE and Ecology have agreed to use for purposes of preparing F&R documents. The main elements of the approach can be summarized as follows:

- Focuses on potential long-term groundwater pathway human healthrisk at the tank farm fenceline
- Uses incremental lifetime cancer risk (ILCR) as the risk metric

- Provides ILCR for one indicator contaminant
- Derives effects of contaminant release and transport from previous studies; involves no new contaminant transport analysis
- Uses the best available existing data and information to the maximum extent possible, with little new data generated for the creation of the document.

Risk was calculated for this evaluation using the following equation:

$$R_i = I_i \times T_i \times d_i.$$

Where:

i = indicator contaminant
R_i = risk (ILCR)
I_i = inventory (Ci)
T_i = transport transfer function (pCi/L per Ci)
d_i = health effects conversion factor (ILCR per pCi/L).

Technetium-99 was selected as the indicator contaminant for both tanks C-103 and C-105 based on tank-specific screening analyses. Results of the screening analyses are summarized in Sections A2.0 and B2.0. The screening criterion used in the analyses was the calculated product of the residual waste inventories from *Inventory and Source Term Data Package* (DOE/ORP-2003-02) and the ILCR conversion factors from *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment* (HNF-SD-WM-TI-707). Contaminants included in the screening analysis were the long-lived mobile radionuclides that previous tank farm studies (e.g., RPP-10098) have shown contribute to peak ILCR. These were carbon-14, selenium-79, technetium-99, and iodine-129. Chemical carcinogens were disregarded because previous studies (e.g., RPP-6696) have shown that cancer risk from radionuclides is usually more restrictive (e.g., lower residual waste volumes) than either the cancer risk from carcinogenic chemicals or the hazard index from noncarcinogenic chemicals. Cancer risks from radionuclides and chemicals typically are not summed because of differences in how risk is estimated for these two categories of substances.

Tanks C-103 and C-105 were both assumed to be retrieved using supernate recirculated from tank AN-106. It was assumed that the retrieval process would be initiated on tank C-103, followed by tank C-105. Residual waste and retrieval leak inventories for this waste retrieval scenario were not available in existing data sources and had to be generated for this evaluation. It was assumed that the recirculation waste retrieval process would produce a composite retrieval fluid with a composition unique to each retrieval. The tank-specific assumptions, methods, and results for the inventory development effort are discussed in Sections A2.0 and B2.0.

Transport transfer functions were calculated from the results of previous contaminant transport analyses by dividing the reported 10,000-year peak technetium-99 groundwater concentration at the tank farm fenceline by the technetium-99 inventory released at the source. Separate transport transfer functions were calculated for in-tank waste (residual waste) and ex-tank waste (past leaks, potential retrieval leaks). The in-tank transfer function was calculated using tank C-106 residual waste data from the RPP-6696 analysis as shown in Table 1. The ex-tank transfer

function was calculated using waste management area B-BX-BY past leak data from the RPP-10098 analysis as shown in Table 2.

Table 1. In-Tank Transport Transfer Function

Peak Technetium-99 Groundwater Concentration at C Tank Farm Fenceline from Residual Waste in Tank C-106 (pCi/L)[a]	Technetium-99 Inventory in Residual Waste in Tank C-106 (Ci)[b]	In-Tank Transport Transfer Function (pCi/L per Ci)
230	26.2	8.78

[a]Source = RPP-6696, Table 3.6.
[b]Source = RPP-6696, Table 3.1.

Table 2. Ex-Tank Transport Transfer Function

Peak Technetium-99 Groundwater Concentration at BX Tank Farm Fenceline from Past Leaks (pCi/L)[a]	Technetium-99 Inventory in BX Tank Farm Past Leaks (Ci)[b]	Ex-Tank Transport Transfer Function (pCi/L per Ci)
6,650	4.37	1,410

[a]Source = RPP-10098, Table E-14.
[b]Source = RPP-10098, Table 4-13.

Risks were calculated for two exposure scenarios, industrial and residential. Both scenarios are based on scenarios described in *Hanford Site Risk Assessment Methodology* (DOE/RL-91-45). The health effects conversion factors for both scenarios were taken from tables provided in HNF-SD-WM-TI-707. The conversion factors provide the lifetime cancer morbidity risk per unit concentration of technetium-99 in the groundwater. The conversion factor values used for the evaluation are shown in Table 3.

Table 3. Health Effects Conversion Factors for Industrial and Residential Exposure Scenarios

Scenario	Technetium-99 Groundwater Unit Risk Factor (ILCR per pCi/L)
Industrial[a]	1.38×10^{-8}
Residential[b]	3.36×10^{-7}

[a]Source = HNF-SD-WM-TI-707, Rev. 3, Table 22.
[b]Source = HNF-SD-WM-TI-707, Rev. 3, Table 26.
ILCR = incremental lifetime cancer risk

The industrial scenario represents 20 years of occupational exposure in an industrial setting. The receptor is an individual whose work activity is primarily indoors but also includes outdoor activities such as building and grounds maintenance. Contaminants enter the worker primarily through use of groundwater for drinking water and showering. External exposure to irrigated soil and soil inhalation are also included. The residential scenario represents 30 years of exposure in a residential setting. The receptor is an individual who resides on the land, grows fruits and vegetables, and raises livestock and poultry for personal consumption. Contaminants enter the receptor through use of groundwater for domestic needs (drinking, cooking, and showering), for irrigation (ingestion of produce, soil, and water; inhalation of soil and water; and external exposure), and watering livestock (ingestion of meat, poultry, and dairy products). Complete descriptions of the industrial and residential scenarios can be found in HNF-SD-WM-TI-707.

Evaluation results are presented in Sections A2.0 and B2.0 in the form of plots depicting the estimated peak groundwater pathway ILCR at the C tank farm fenceline for residual waste and retrieval leak volumes of interest. Tank-specific risks are provided for the estimated technetium-99 inventories associated with the current tank waste, 360 cubic feet of residual waste, and a hypothetical 8,000 gallon retrieval leak. A residual waste volume of 360 cubic feet was used because it corresponds to the HFFACO Milestone M-45 interim retrieval goal for 100-series SSTs. A hypothetical 8,000-gallon retrieval leak volume was assumed for informational purposes only. This volume is not intended to represent an anticipated retrieval leak volume or a leak detection limit for waste retrieval from tanks C-103 and C-105.

In accordance with RPP-14284, the methodology described above was also applied to all tanks in the C tank farm to provide a perspective on the risks from tanks C-103 and C-105 relative to the other C farm tanks. Results of the C tank farm analysis (RPP-19071) are presented in the form of summary tables depicting the risk associated with residual waste, retrieval leakage, and past leaks for all tanks in the C tank farm. Because the C tank farm analysis is not unique to either tank C-103 or C-105, the C tank farm analysis results are presented only once, in Section A2.0, Tables A.1 and A.2, and are not repeated in Section B2.0.

3.0 FUNCTIONS AND REQUIREMENTS

This section establishes the upper-level functions and corresponding requirements to which the tanks C-103 and C-105 WRS must be designed and operated. Other requirements not directly

applicable at the level of detail in this F&R are disseminated to CH2M HILL Hanford Group, Inc. via the DOE and CH2M HILL Hanford Group, Inc. Contract (Contract DE-AC-27-99RL14047). Specifically, the F&R included in this document are derived from the need to satisfy the HFFACO Milestone M-45-00 requirements to retrieve as much tank waste as technically possible, with tank waste residues in each tank not to exceed 360 cubic feet for tanks C-103 and C-105, or the limit of the waste retrieval technology, whichever is less. Additionally, the F&R ensure that waste retrieval actions do not result in adverse impacts to workers, the public, or the environment. Some of these requirements are derived from regulatory documents (e.g., *Code of Federal Regulations*, *Washington Administrative Code*) while others are based on the design constraints of tanks C-103 and C-105. The F&R are provided in Table 4 and are focused on driving the design of the tanks C-103 and C-105 WRSs.

Table 4. Tanks C-103 and C-105 Waste Retrieval System Functions and Requirements (3 Sheets)

Function	Requirement	Basis	Key Elements
Control structure and waste temperature in tanks C-103 and C-105	The WRS shall control the structure and waste temperature in the tanks within established limits specified in the operating specification for single-shell waste storage tanks.	OSD-T-151-00013	Maximum 280 °F for bulk waste and 250 °F for dome.
Control tanks C-103 and C-105 waste level	The WRS shall prevent waste overflow into connected lines and limit hydrostatic head-induced stresses in the tank.	OSD-T-151-00013	Maintain waste level from exceeding 185 in. and minimize liquid level to the extent practical.
Control vapor space pressure in tanks C-103 and C-105	The WRS shall control the vapor space pressure in the tanks during retrieval within established limits specified in the operating specification for single-shell waste storage tanks.	OSD-T-151-00013	If active ventilation is required, the vacuum shall not exceed (0.8 in w.g. + [waste height (inches)] x [specific gravity of waste]); not to exceed 9 in. w.g.
Remove waste from tanks C-103 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. If DOE believes that waste retrieval to these levels is not possible for a tank, DOE will submit a detailed explanation to EPA and Ecology explaining why these levels cannot be achieved, and specifying the quantities of waste that DOE proposes to leave in the tank. The request will be approved or disapproved by EPA and Ecology on a case-by-case basis.	HFFACO Milestone M-45-00	The WRS shall provide the capability to retrieve as much waste as technically possible.

Table 4. Tanks C-103 and C-105 Waste Retrieval System Functions and Requirements (3 Sheets)

Function	Requirement	Basis	Key Elements
Control and monitor the waste removal process in tanks C-103 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 tank process parameters as necessary: • Pressures • Flow rates • Differential pressures across HEPA filters The WRS shall provide instrumentation to support performing material balance calculations.	HNF-SD-WM-TSR-006 WAC 173-303	Provide for safe and effective operation of the WRS.
Occupational safety and health	The WRS shall be designed for safe installation, operation, and maintenance.	29 CFR 1910 29 CFR 1926 10 CFR 835	OSHA standards Occupational Radiation Protection.
SST and DST dome loading	The WRS shall not impose loads on the tanks that exceed the dome loading limits.	HNF-SD-WM-TSR-006 TFC-ENG-FACSUP-C-10 RPP-11802	Mitigate possible structural failure of tank dome.
WRS secondary containment and leak detection	For ex-tank equipment and piping, the WRS shall incorporate secondary containment and leak detection design features.	WAC 173-303	Provide for safe and compliant transfer of waste to the receiving tank/facility.
Control gaseous discharges from tanks C-103 and C-105	The ventilation system exhaust, if required, shall be filtered to restrict radioactive and non-radioactive hazardous emissions to the environment. The ventilation system shall provide emissions control by filtering radioactive particulates in the gaseous effluent, and shall conduct volatile organic compounds and noxious vapors away from plant workers.	WAC 173-400 WAC 173-460 HNF-IP-0842, Volume 6 WAC 173-480 WAC 246-247	Mitigate potential release to the public and the environment.
Nuclear safety	The WRS shall be designed and operated to protect workers, public, and the environment from exposure to radioactive tank waste and emissions during the waste retrieval campaign.	10 CFR 830 HNF-SD-WM-TSR-006 RPP-13033	Ensure protection of workers, the public, and the environment from routine and potential accident conditions.

Table 4. Tanks C-103 and C-105 Waste Retrieval System Functions and Requirements (3 Sheets)

Function	Requirement	Basis	Key Elements
Detect leaks during waste removal from tanks C-103 and C-105	The WRS shall be capable of detecting liquid waste releases during all waste removal operations. The system shall be designed to detect leakage from the tank using technologies consistent with waste retrieval methods to detect tank leaks during retrieval.	WAC 173-303 HNF-SD-WM-TSR-006	Utilize best available LDM technologies coupled with mitigation strategies to minimize the potential for retrieval leakage.
Monitor leaks from tanks C-103 and C-105 during waste removal	The WRS shall quantify liquid release volumes from tanks C-103 and C-105 if a release is detected during waste retrieval operations.	WAC 173-303	Utilize best available LDM technologies coupled with mitigation strategies to minimize the potential for retrieval leakage.
Measure and estimate residual waste in tanks C-103 and C-105	The WRS design shall allow for estimating the residual waste in tanks C-103 and C-105 following waste retrieval operations.	HFFACO WAC 173-303	Provide data for determination of waste removal effectiveness.
Minimize waste generation	The WRS shall minimize waste generation to the greatest extent practical, including water introduced into the tank.	WAC 173-303	No numerical requirement.
Mitigate leaks during tanks C-103 and C-105 waste retrieval	The integrated retrieval and LDMM system shall be designed and operated to mitigate leaks as the primary means of minimizing environmental impacts from leaks.	HNF-SD-WM-AP-005	Leak mitigation strategy described in Section 4.0.
Maintain design and operating limits for DST used as a receiver tank	The WRS shall not adversely affect the function of the DST system or exceed the DST design and operational limits	HNF-SD-WM-TRD-007	Ensure safe and effective receipt and storage of the tank C-103 and C-105 waste in receiver DST.

ALARA = as low as reasonably achievable.
CFR = *Code of Federal Regulations*.
DOE = U.S. Department of Energy.
DST = double-shell tank.
Ecology = Washington State Department of Ecology.
EPA = U.S. Environmental Protection Agency.
HEPA = high-efficiency particulate air.
HFFACO = *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989).
LDM = leak detection and monitoring.
LDMM = leak detection, monitoring, and mitigation.
OSHA = Occupational Safety and Health Administration.
SST = single-shell tank.
WAC = *Washington Administrative Code*.
w.g. = water gauge.
WPS = waste packaging system.
WRS = waste retrieval system.

4.0 LEAK DETECTION, MONITORING, MITIGATION, AND WASTE RETRIEVAL STRATEGY

This section describes the LDMM and waste retrieval strategy for the tanks C-103 and C-105 WRSs, including definitions for LDMM, technical issues associated with detecting and monitoring leaks, LDMM and waste retrieval strategy, and preliminary system descriptions. LDMM activities are defined in *Annual Progress Report on the Development of Waste Tank Leak Monitoring/Detection And Mitigation Activities in Support of M-45-08 (TPA Milestone M-45-09E Fiscal Year 2000 Progress Report)* (RPP-7012). These definitions have been accepted by DOE ORP and Ecology and are presented here for reference:

- **Leak Detection**: Technologies, methods, or systems used to detect a leak.
- **Leak Monitoring**: Technologies, methods, or systems used to quantify liquid waste release volumes from an SST, if a release is detected during waste retrieval operations. Leak monitoring also includes assessment of leak monitoring data in an effort to estimate the rate and direction of movement through the soil.
- **Leak Mitigation**: Technologies, waste retrieval methods, or systems that can reduce the potential for a leak to occur, the volume of a leak if it were to occur, and action taken to minimize leak volumes in the event a leak is detected during waste retrieval.

4.1 LEAK DETECTION, MONITORING, AND MITIGATION STRATEGY

The integrated LDMM strategy for tanks C-103 and C-105 has been developed to meet the requirements specified in the HFFACO M-45-series of milestones and manage the risk posed by potential waste leakage during waste retrieval operations. The strategy for LDMM is summarized in the following sections and is based on retrieving as much waste as technically practicable while minimizing the potential for leaks. The purpose is to ensure that waste retrieval and LDMM strategy for tanks C-103 and C-105:

- Is technically practicable and defensible
- Considers applicable regulations and requirements
- Meets the programmatic needs of ORP to move forward with waste retrieval using available technologies
- Utilizes LDMM technologies and strategies that are consistent with the waste retrieval technology selected for deployment.
- Minimizes waste releases to the environment should a leak occur
- Reduces the risks to human health.

4.1.1 Leak Mitigation Strategy

The leak mitigation strategy (i.e., reduction of leak loss potential) has two aspects.
The operational strategy involves taking actions to minimize leakage potential from the onset of

waste retrieval and, if a leak is detected, involves responding to minimize the overall environmental impact. The operational strategy to minimize the leak potential (initiation of a leak and leak volume) during waste retrieval in the absence of any indication of a leak involves the following:

- Control in-tank liquid inventory during waste retrieval to levels less than previous non-leaking interstitial liquid levels.
- Retrieving waste from advantageous location; given the limited number of risers in tanks C-103 and C-105, the systems will be operated to focus on retrieving waste from the center region of the tank first. This center-out waste retrieval strategy allows mobilized waste and released interstitial liquids to drain quickly into a center pool that can be rapidly pumped from a tank if a leak is detected. This strategy will minimize the amount of liquid that comes in contact with the tank walls; and will assist in the liquid collecting near the pump so the pump can operate from the lowest reasonably achievable level in a tank if a leak should occur, reducing liquid inventory.
- Design the WRSs and operational strategy to minimize "time at risk." By minimizing the time at risk, potential leak volumes are limited in size. The relatively short retrieval duration (approximately 100 days) limits the overall leakage volume from a leak, should it go undetected.
- Use the waste retrieval pump to minimize tanks C-103 and C-105 liquid inventories between waste retrieval campaigns, in the event multiple waste retrieval campaigns are required, to further reduce any leak driving force and exposure of the tank walls.
- Minimize potential leak volume by providing a relatively high-capacity pump, located as close to tank bottoms as possible, to pump down liquids if a leak were to be detected.
- Improve leak response time by more frequent surveys of drywells to provide early recognition of a potential leak condition, allowing timely implementation of response actions.

Potential response actions to a leak are discussed in Section 4.3.2.

4.1.2 Leak Detection Strategy

The best practical and available leak detection methods will be used to monitor conditions in and around the tanks for evidence of a tank or transfer line leak. The overall strategy for detecting leaks from the SSTs is to monitor the existing drywells surrounding the tanks and performing mass balance calculations. Additional detail on the SST leak detection approach is provided in the following sections. Leak detection in the waste transfer system and in the receiver tank AN-106 will be performed using standard leak detection methods in the transfer pits and DST annulus.

4.1.2.1 Ex-Tank Leak Detection

Monitoring the existing drywells using both gamma and neutron moisture probes will constitute the primary leak detection system. The existing drywells will be monitored before and after waste retrieval using the truck-mounted logging system to establish a baseline. Additionally,

monthly scans will be performed depending on the waste retrieval duration. This will be supplemented by a manually deployed calibrated moisture gauge deployed more frequently during waste retrieval to shorten the detection interval. Neutron moisture probes will be used to look for changes in soil moisture content that could indicate a potential tank leak. In the event of an unexplained increase in soil moisture content, the truck-mounted logging systems using gamma logging tools will be deployed to monitor for changes in the concentration of isotopes in the soil around the tank at issue, and to verify the neutron moisture probe's response. Leak detection capabilities using drywell monitoring are described in RPP-10413.

4.1.2.2 Mass Balance

Conducting mass/volume balance calculations will be used to supplement the primary leak detection system. This will be accomplished by diligent observation and process control data for liquid volumes and waste volumes in tanks C-103, C-105, and AN-106.

4.2 SYSTEM DESCRIPTION

The waste retrieval and LDM systems described in this section represent a conceptual view of the systems currently planned for deployment in tanks C-103 and C-105. Detailed design will enhance the definition of the systems and may change the features described. However, the final design shall comply with the requirements established in this document.

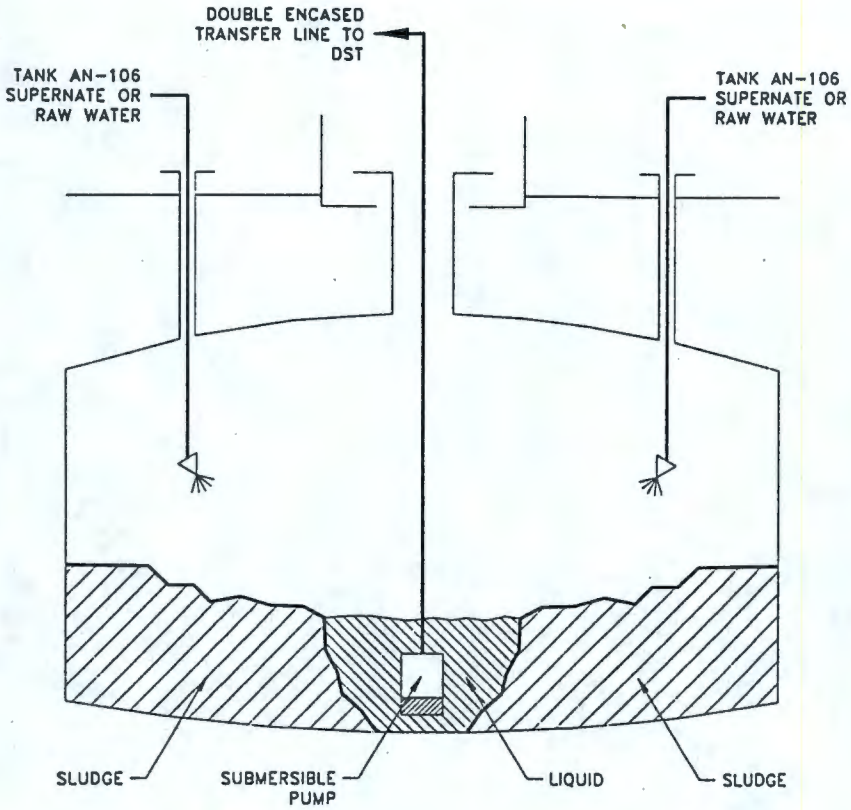
4.2.1 Waste Retrieval System Description

The WRSs will consist of a modified sludge sluicing system to mobilize and retrieve waste from tanks C-103 and C-105. The WRSs will include a pumping system, monitoring and control system, an operator control station, ventilation system, and liquid distribution system. The liquid distribution nozzles will be installed in existing tank risers located around the perimeter of the tank. The liquid distribution nozzles will have the capability to direct liquid at various locations in the tanks. The flow rate through the liquid distribution system will be adjusted based on the pump-out rate such that, once equilibrium is reached in a tank, the rate of liquid introduction will approximately equal the rate of solution removal. To minimize waste volume in DST systems, current plans are to use tank AN-106 supernate as the primary sluice liquid. The systems will also have the capability to use raw water.

New equipment will replace the existing saltwell pumping system and some of the associated existing components in the tanks. The new pump will be installed in the center riser with the pump suction as low as possible in the tanks to facilitate removal of sufficient waste to achieve a residual volume of 360 cubic feet or less.

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 and retrieving the tank waste from the center out. As the sluice liquid contacts the tank waste, the sludge will be mobilized and retrieved via the new pumps. Transfer line flushing will occur as needed. Tank C-103/C-105 WRS is depicted in Figure 4.

Figure 4. Tank C-103/C-105 Waste Retrieval System



Due to the elevation difference between tanks C-103 and C-105 and tank AN-106, some transfer line drainback into their tank of origin (C-103 or C-105) will occur. Miscellaneous equipment drains will also be routed back to either tank C-103 or tank C-105. These drains would include the ventilation system condensate drain and the portable valve box drain. These liquids are not retrieval liquids nor are they considered waste placed into tanks C-103 and C-105.

4.2.2 Leak Detection and Monitoring System Description

The primary method for leak detection and leak monitoring involves periodic gamma and neutron moisture surveys of the drywells surrounding the tank. In-tank process control parameters will be used to supplement the ex-tank methods and provide a defense-in-depth approach to leak detection. The following sections summarize these methods.

4.2.2.1 Ex-Tank Leak Detection

Leak detection is accomplished through periodic logging of the drywells using geophysical and neutron moisture logging methods. Existing truck-mounted logging systems will be used with gamma and neutron moisture probes to establish a baseline. The only constituent to be monitored with the neutron moisture probe is the moisture (e.g., water) content in the sediments around the drywells. Manually-deployed neutron moisture gauges are readily available and can be deployed by waste retrieval personnel on a more frequent basis than truck-mounted systems.

The primary leak detection methodology involves deployment of the existing truck-mounted geophysical logging systems using both gamma and moisture monitoring tools. This system will be deployed before waste retrieval operations begin and at the end of waste retrieval operations. Moisture monitoring will be done periodically during waste retrieval operations. An initial baseline will be established by deploying calibrated gamma and neutron moisture probes over the full depth of each drywell. During waste retrieval operations, the truck-mounted systems will be supplemented by the use of manually deployed moisture gauges on a frequency to be established in operating procedures. Specific depths of interest corresponding to the compacted layer beneath the base of the tank and layers with fine sediments that have higher moisture contents will be the focus of the manually deployed moisture gauges. Moist layers should be the first affected by a new leak plume and may decrease detection times. In the event of an unexplained increase in soil moisture content, additional monitoring with the truck-mounted system will be used to determine if there have been any changes in gamma-emitting radionuclide concentration surrounding the drywells.

- Tank C-103 drywells: Six drywells ranging in depth from 100 to 155 feet below ground surface are in relatively close proximity to tank C-103 (Figure 3). The drywells surrounding tank C-103 will be used in addition to other methods for LDM of possible leaks. Five of the drywells (30-03-01, 30-03-03, 30-03-05, 30-03-07, 30-03-09) are within 10 feet of tank C-103 and are spaced approximately equidistant from each other around the perimeter of the tank in a 240° arc from north to west. The remaining drywell is located adjacent to tank C-106 to the northwest (30-06-04).

- Tank C-105 drywells: Twelve drywells ranging in depth from 50 to 135 feet below ground surface are in relatively close proximity to tank C-105 (Figure 3). The drywells surrounding tank C-105 will be used in addition to other methods for LDM of possible leaks. Seven of the drywells (30-05-02, 30-05-03, 30-05-04, 30-05-05, 30-05-07, 30-05-08, 30-05-09) are situated within 10 feet of tank C-105. The remaining drywells are located adjacent to tank C-104 (30-04-01, 30-04-02, 30-04-03, 30-05-06) and between tank C-108 and C-105 (30-05-10).

The project recognizes that ex-tank monitoring has technical limitations. The project will attempt to improve confidence in data obtained by the primary leak detection equipment by routinely collecting corroborating data from in-tank measurements, video surveillance, and operating data as potential indicators of a leak. Details of the drywell monitoring plan will be defined in tank-specific operating plans.

4.2.2.2 In-Tank Static Liquid Level Monitoring

Accurate liquid level monitoring will not be available unless a stable liquid pool exists beneath the riser where the Enraf™ level gauge is mounted. For both tanks C-103 and C-105, the Enraf™ level gauge is installed near the perimeter of the tank. It is unlikely that there will be a liquid surface beneath the level gauge during waste retrieval operations because of the center-out retrieval strategy, the dished bottom of the tank, and the placement of the pump in the center of the tank. Because a gauge could be damaged during sluicing, the liquid level will be measured continuously only during periods when sluicing and pumping operations have stopped and there is liquid surface to measure.

As the mitigation strategy requires that the liquid levels be minimized between or at the end of waste retrieval operations, it is likely that there will be no liquid level under the existing Enraf™ level gauges, and it will not be possible to directly measure the liquid levels.

If waste retrieval operations were suspended and a free liquid surface were present below the Enraf™ gauge, level measurements would be collected for evaluation of potential leaks from the central portion of the tank floors.

4.2.2.3 In-Tank Volume Balance (During Operation)

The volumes of tank AN-106 supernate and water introduced to tanks C-103 and C-105, and the volumes of liquid transferred out of the tanks during waste retrieval will be recorded as an aspect of routine process control. This is accomplished by the use of flow meters, and tank level gauges. Because of the large uncertainty in initial waste conditions (inventory and volume), mass balance monitoring will not be used as a primary leak detection method. This technique will provide potential indication of a catastrophic leak and will be used to provide defense in depth to the primary leak detection equipment.

4.2.2.4 High-Resolution Resistivity

High-resolution resistivity (HRR) long electrode LDM is currently planned as a demonstration deployment at tanks C-103 and C-105. These demonstration deployments will serve to gather data and gain working knowledge and experience with the system. The HRR method uses geophysical resistivity measurement methods as a means to detect fluid leaks. The electrical resistivity of the sediments beneath a waste tank depends on a number of parameters, one of which is moisture content. The leakage of water or tank waste into these sediments lowers the sediment resistivity. The HRR method detects a leak by comparing a current resistivity measurement against a previously obtained base-line measurement, or a "pre-leak" measurement. This delta processing allows the HRR method to "ignore" existing resistivity differences in the soil due to conductive structures, prior leaks, etc.

The basic resistivity measurement concept is a four pole resistivity method. With the four pole resistivity, two poles or electrodes are connected to a power source that injects a current in the soil. The resulting voltage gradient from this current is then measured with the second pair of electrodes. This arrangement allows very small resistivity measurements to be made without impacting the measurement process (a high impedance measurement system is used with the system that has a minimum affect on the induced current field). By applying power to each electrode pair and while making resistivity measurements from all other electrode pairs, a "picture" of the sediment resistivity can be obtained that is an indicator of a leaked plume.

The planned use of HRR during this demonstration deployment is as a data collection tool. The viability of HRR as a process control leak detection method on SSTs is pending successful performance and evaluation of the planned demonstration and liquid injection leak testing (RPP-17191). Resistivity data from the HRR system will be collected and evaluated throughout the waste retrieval operations. Any changes in conditions identified by the HRR system as a potential leak would be further investigated using drywell monitoring and mass balance methods.

4.2.2.5 Leak Detection in Transfer Lines and Pits

Supernate will be transferred from tank AN-106 and liquid waste and slurries will be transferred from tanks C-103 and C-105 to tank AN-106 using temporary hose-in-hose overground transfer

lines and pits. Leak detectors located in pits and pump pits will be monitored, and will be interlocked to shut down transfer pumps if a leak is detected. 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 has been designed to drain any fluid released from the primary hose to a common point for collection, detection, and removal. Leak detection elements installed at the lower end of the secondary containment will actuate an alarm and, and if a leak is detected the transfer pumps will be interlocked to shutdown.

4.2.2.6 Leak Detection in the Receiver Double-Shell Tank

The existing DST leak detection system for tank AN-106 will be utilized. A leak from the primary vessel of tank AN-106 will be detected by either a conductivity probe installed in the annulus or leak detection pit or a continuous air monitor that detects airborne radionuclides entrained in the annulus ventilation exhaust stream.

4.3 OPERATING STRATEGY

The operating strategy for performing LDM and retrieval applies before, during, and after waste retrieval as described in the following sections.

4.3.1 Leak Detection and Monitoring Operations

Before initiating waste retrieval operations, a visual assessment of tanks C-103 and C-105 in-tank conditions will be performed using an in-tank camera. During waste retrieval operations, the leak monitoring as described in Section 4.2 will be implemented. Drywell monitoring will constitute the primary leak detection system. Additionally, process control data will be collected and volume balance performed as a defense-in-depth approach to leak detection. If a leak is detected during waste retrieval operations, data collection activities will be continued in an effort to monitor leak rates and total leak volumes to the extent possible.

4.3.2 Leak Mitigation Operations

If a leak is indicated during waste retrieval, operating procedures will be implemented. The first response to an indication of a potential leak will be to validate the instrumentation. If the validation process concludes that no leak is indicated, waste retrieval operations will start up and continue under normal operating procedures. However, if a leak is validated, the operating contractor will notify ORP, which will in turn notify Ecology. Pending formal direction from ORP, the operating procedures will be used to determine the appropriate response action. Any response will consider the potential risk associated with the leak as described in the Risk Basis Section (A2.0 for tank C-103 leaks, and Section B.2 for tank C-105 leaks), the estimated leak rate, and the estimated time required to complete waste retrieval. For example, the response action to a small volume slow leak discovered near the end of tank C-103 waste retrieval may be to continue retrieving waste and finish as soon as possible.

Potential response actions include the following:

- Modifying leak monitoring (e.g., implementing more frequent in-tank and/or ex-tank measurements)
- Modifying operating conditions
- Discontinuing adding or recycling liquids
- Implementing emergency waste retrieval
- Stopping all tank C-103 or C-105 waste retrieval operations.

The response actions would then be implemented and, if appropriate, waste retrieval operations would continue under modified procedures through the completion of the waste retrieval activities.

4.3.3 Waste Retrieval Operations

The overall waste retrieval operating strategy will consist of reducing the tank waste inventories. The process will be monitored using closed-circuit television to facilitate waste retrieval and minimize any liquids in the tanks. Supernate from tank AN-106 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 normal operations, liquids will be removed from the tanks approximately at the same rate they are introduced to the tanks. The composite material removed will consist of both mobilized tank waste and supernate used to affect mobilization. Maintaining a balanced pumping rate out of the tanks is integral to minimizing the liquid volume in the tanks and reducing the potential for leakage.

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

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APPENDIX A
TANK C-103 WASTE RETRIEVAL FUNCTIONS AND REQUIREMENTS

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A1.0 INTRODUCTION

Tank C-103 was constructed between 1943 and 1944, and was put into service in August 1946. Tank C-103 is one of twelve 100-series single-shell tanks in the C farm. Tank C-103 is the third tank in a three-tank cascade that includes tanks C-101, C-102, and C-103. The tank was constructed with a dish-shaped bottom, a painted grout layer, an asphalt (waterproof) membrane, and an outer reinforced-concrete shell to maintain the structural integrity of the steel liner by protecting it from soil loads. The reinforced-concrete shell is cylindrical and supports the steel liner, which is constructed of carbon steel. Tank C-103 is 75 feet in diameter and has a capacity of 530,000 gallons (*Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 East Area* [WHC-SD-WM-ER-349]).

As of June 2003, tank C-103 contained approximately 88,000 gallons of waste consisting of sludge. Tank C-103 is presently passively ventilated. Tank C-103 is categorized as "sound" (*Waste Tank Summary Report for Month Ending June 30, 2003* [HNF-EP-0182]).

Tank C-103 received primarily metal waste. Tank C-103 also received PUREX Plant fission product waste from tank C-106 (WHC-MR-0132). Metal waste was accumulated and stored in tank C-103 until it was sluiced for uranium recovery between 1952 and 1955 (WHC-SD-WM-ER-349).

A2.0 RISK BASIS

This section presents the results of a preliminary evaluation of the long-term human health risks associated with waste in tank C-103 and potential leaks that could occur during waste retrieval operations. The purpose of the evaluation was to provide a basis for making informed decisions during waste retrieval in the event a leak is detected or unexpected waste retrieval conditions arise. The evaluation was performed using the methodology described in Section 2.0.

Technetium-99 was selected as the indicator contaminant based on the results of a screening analysis. The analysis indicated that technetium-99 would contribute approximately 74% (industrial scenario) to 92% (residential scenario) of the total long-term groundwater pathway incremental lifetime cancer risk (ILCR). The risk evaluation performed in support of the functions and requirements documents is based on a set of conservative assumptions (i.e., over-predicts the anticipated risks from a more detailed analysis). Follow-on risk analyses used to support tank closure will include a more detailed accounting of the contaminants remaining in the tank (both radiological and chemical).

Inventory calculations were performed using best-basis inventory data accessed on November 11, 2003 (RPP-19071). It was assumed that the recirculation retrieval process would produce a composite retrieval fluid containing inventory from both the tank AN-106 liquids and the tank C-103 solids. The tank C-103 technetium-99 residual waste and retrieval leak inventories were calculated as the product of the composite retrieval fluid concentration and the assumed residual waste and retrieval leak volumes. The composite retrieval fluid concentration was calculated as the sum of the current technetium-99 inventories in the tank AN-106 supernate

and the tank C-103 solids, divided by the current tank AN-106 supernate volume. This method conservatively assumed that 100% of the technetium-99 inventory in the tank C-103 solids is soluble and would go into solution in the composite retrieval fluid. It was assumed that the tank AN-106 solids would not be agitated and would not go into solution in the composite retrieval fluid. It was also assumed that no raw water additions would made during the tank C-103 retrieval operation.

Waste stored in the C-200-series tanks and tank C-106 is currently scheduled to be transferred to tank AN-106 before the start of waste retrieval operations for tank C-103. Because the technetium-99 inventory associated with tank C-106 and the C-200-series tanks combined is approximately 14% of the technetium-99 inventory in tank AN-106, the addition of waste from these tanks was assumed to have minimal impact on the residual waste and retrieval leak inventories for tank C-103 and were disregarded for this evaluation.

Evaluation results are provided in Figures A.1 and A.2. These two figures present a risk picture for tank C-103 but do not include contributions from other C tank farm sources. All sources in Waste Management Area C will be included in the risk assessment supporting final waste management area closure (RPP-14284). Four separate curves are shown in Figure A.1, two for in-tank waste (residuals) for the industrial and residential scenarios, and two for ex-tank waste (retrieval leakage) for the industrial and residential scenarios.

Figure A.1. Tank C-103 Risk Plot

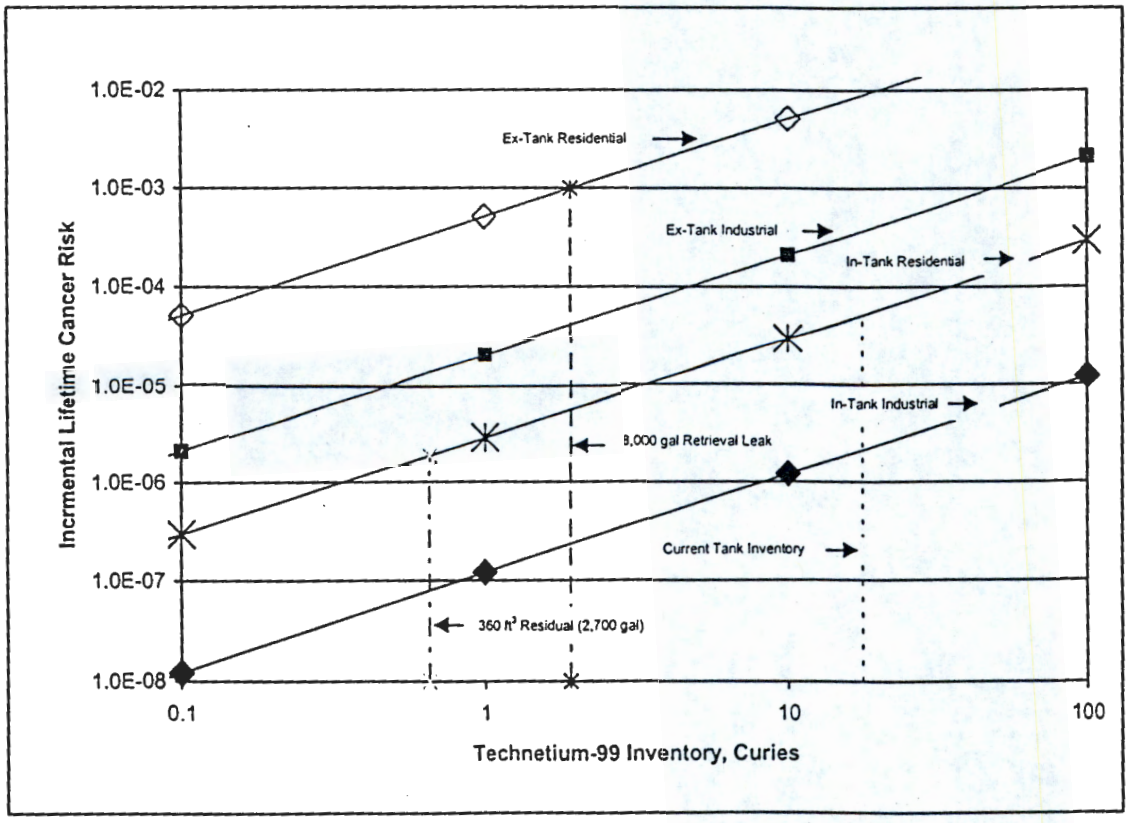
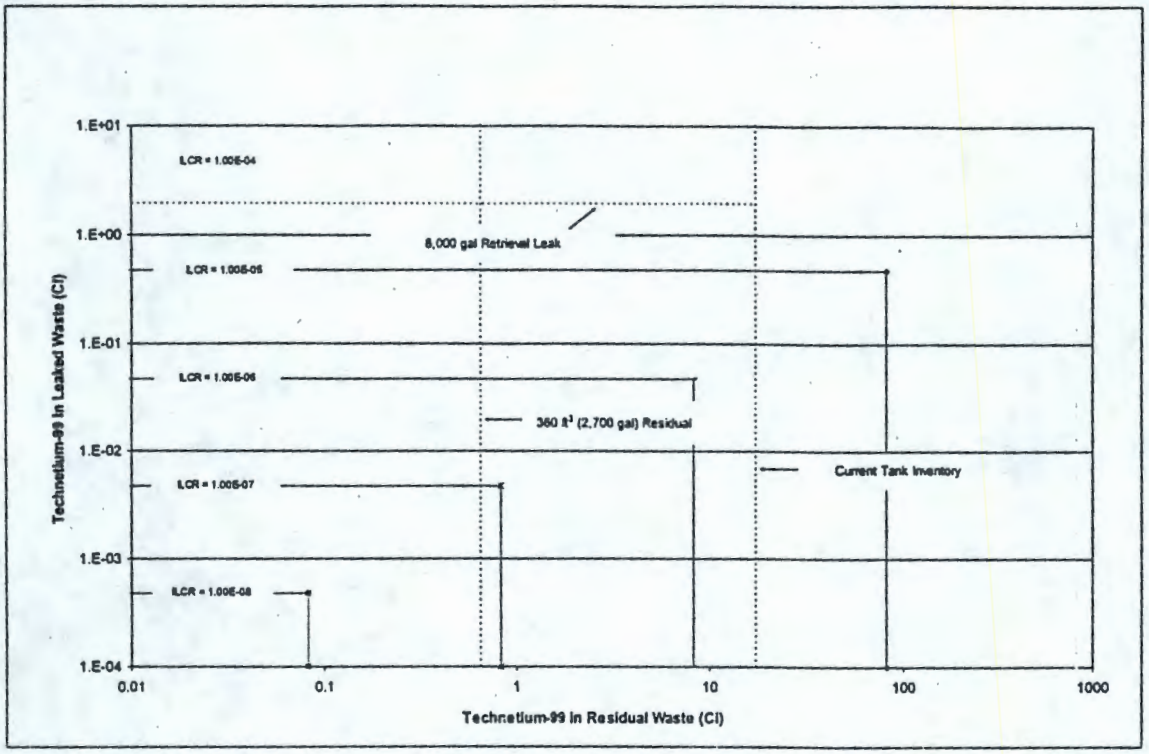


Figure A.2. Tank C-103 Residual Waste and Leaked Waste (Industrial Scenario)



As shown in Figure A.1, the ILCR posed by the current technetium-99 inventory in tank C-103 is approximately 2×10^{-6} for the industrial scenario and 5×10^{-5} for the residential scenario. Waste retrieval down to approximately 360 cubic feet reduces the ILCR by approximately one order of magnitude. The inventory of technetium-99 associated with a potential leak (ex-tank) of 8,000 gallons from tank C-103 is approximately 2 curies and corresponds to a risk of approximately 4×10^{-5} for the industrial scenario and 1×10^{-3} for the residential scenario.

Figure A.2 uses the same data used in Figure A.1 for the industrial scenario but depicts the risk results from a slightly different perspective. Figure A.2 shows five curves, each depicting the relationship between residual waste and retrieval leakage technetium-99 inventory for a constant ILCR level. The ILCR levels shown are 1×10^{-4}, 1×10^{-5}, 1×10^{-6}, 1×10^{-7}, and 1×10^{-8}. Three dashed lines are added to depict the technetium-99 inventories associated with the current tank C-103 waste, 360 cubic feet of residual waste in tank C-103, and an 8,000-gallon retrieval leak from tank C-103.

Results of the C tank farm risk evaluation are presented in Tables A.1 and A.2 for the industrial and residential scenarios, respectively. The methodology for this evaluation does not lend itself to developing a total or composite tank farm risk number but does allow for risk comparisons to be made between tanks and tank rows. Note that a "row" as used here refers to the tank groupings used for hydrologic modeling, not to the tanks in a cascade series. Composite impacts at the C tank farm fenceline are presented for each of the four rows of tanks as the sum of the impacts from the tanks in that row. This approach is consistent with that used for field investigation reports (e.g., RPP-10098) and is based on an assumption that long-term groundwater flow beneath the C tank farm will return to its pre-Hanford operations flow

direction (i.e., to the southeast). Using this assumption, the plumes from the tanks within each row will overlap at the fence line but the plumes from each row will not have had time to overlap with adjacent rows by the time they reach the fence line.

The technetium-99 inventories presented in Tables A.1 and A.2 (for tanks other than tanks C-103 and C-105) are based on the data and recommendations in DOE/ORP-2003-02. The residual waste inventories are for volumes of 360 cubic feet and 30 cubic feet for the 100- and 200-series tanks, respectively. The waste retrieval leak inventories are for assumed leak volumes of 8,000 gallons and 100 gallons for the 100- and 200-series tanks, respectively. These leak volumes used are for comparison purposes only and are not intended to represent anticipated leak volumes or leak detection limits. Consistent with the information in DOE/ORP-2003-02 and *Hanford Tank Farms Vadose Zone and C Tank Farm Report* (GJO-HAN-18), the past leak source term shown in Tables A.1 and A.2 reflects the fact that the preponderance of data supports the existence of one source of pre-existing vadose zone contamination (past leaks) in the C tank farm in the vicinity of tank C-105.

As shown in Tables A.1 and A.2, the retrieval leak ILCR values exceed the residual waste ILCR values by several orders of magnitude for all tanks and drive the total (post-retrieval) ILCR values for all tanks. For the individual tanks, tank C-105 has the highest estimated residual waste ILCR, followed by tanks C-112, C-109, and C-103. These four tanks also rank in that same order based on estimated retrieval leak ILCR and estimated total (post-retrieval) ILCR. The tank C-103 row has the highest estimated total (post-retrieval) ILCR, followed by the tank C-102 row, the tank C-101 row, and the C-200-series row.

Table A.1. C Tank Farm Risk Evaluation Results for Industrial Scenario

Tank	Current Inventory	Residual Waste (360 ft³ [2,700 gal] C-100-Series Tanks, 30 ft³ [220 gal] C-200-Series Tanks		Assumed 8,000 gal (C-100-Series Tanks) or 100 gal (C-200-Series Tanks) Waste Retrieval Leak		Measured Contamination in C Tank Farm Vadose Zone		Total (Post Waste Retrieval)	
	Tc-99 (Ci)	Tc-99 (Ci)	ILCR	Tc-99 (Ci)	ILCR	Tc-99 (Ci)	ILCR	Tc-99 (Ci)	ILCR
241-C-101	6.97E-01	2.13E-02	2.59E-09	6.32E-02	1.33E-06	0.00E+00	0.00E+00	8.46E-02	1.33E-06
241-C-102	1.32E+00	1.13E-02	1.36E-09	3.34E-02	7.01E-07	0.00E+00	0.00E+00	4.46E-02	7.02E-07
241-C-103	1.74E+01	6.54E-01	7.92E-08	1.94E+00	4.07E-05	0.00E+00	0.00E+00	2.59E+00	4.08E-05
241-C-104	5.80E+01	6.02E-01	7.30E-08	1.78E+00	3.75E-05	0.00E+00	0.00E+00	2.39E+00	3.76E-05
241-C-105	8.14E+01	1.97E+00	2.38E-07	5.83E+00	1.22E-04	1.93E+00[e]	4.05E-05[e]	9.73E+00	1.63E-04
241-C-106	3.14E+00	4.57E-01	5.53E-08	1.35E+00	2.84E-05	0.00E+00	0.00E+00	1.81E+00	2.85E-05
241-C-107	3.79E+01	4.11E-01	4.98E-08	1.22E+00	2.56E-05	0.00E+00	0.00E+00	1.63E+00	2.56E-05
241-C-108	6.19E+00	2.52E-01	3.06E-08	7.48E-01	1.57E-05	0.00E+00	0.00E+00	1.00E+00	1.57E-05
241-C-109	3.23E+01	1.37E+00	1.66E-07	4.06E+00	8.53E-05	0.00E+00	0.00E+00	5.44E+00	8.55E-05
241-C-110	3.18E+01	4.84E-01	5.86E-08	1.43E+00	3.01E-05	0.00E+00	0.00E+00	1.92E+00	3.02E-05
241-C-111	2.70E+00	1.27E-01	1.54E-08	3.76E-01	7.89E-06	0.00E+00	0.00E+00	5.03E-01	7.91E-06
241-C-112	6.11E+01	1.59E+00	1.92E-07	4.70E+00	9.86E-05	0.00E+00	0.00E+00	6.28E+00	9.88E-05
241-C-201	1.41E-02	2.99E-03	3.63E-10	1.36E-03	2.86E-08	0.00E+00	0.00E+00	4.36E-03	2.89E-08
241-C-202	1.47E-02	3.12E-03	3.78E-10	1.42E-03	2.98E-08	0.00E+00	0.00E+00	4.54E-03	3.02E-08
241-C-203	2.82E-02	2.40E-03	2.90E-10	1.09E-03	2.29E-08	0.00E+00	0.00E+00	3.48E-03	2.32E-08
241-C-204	1.81E-02	1.54E-03	1.86E-10	6.99E-04	1.47E-08	0.00E+00	0.00E+00	2.24E-03	1.49E-08
C-101 row[a]	1.28E+02	1.52E+00	1.84E-07	4.50E+00	9.45E-05	0.00E+00	0.00E+00	6.02E+00	9.47E-05
C-102 row[b]	9.16E+01	2.36E+00	2.86E-07	6.99E+00	1.47E-04	1.93E+00	4.05E-05	1.13E+01	1.88E-04
C-103 row[c]	1.14E+02	4.07E+00	4.93E-07	1.21E+01	2.53E-04	0.00E+00	0.00E+00	1.61E+01	2.54E-04
C-200 row[d]	7.51E-02	1.01E-02	1.22E-09	4.57E-03	9.59E-08	0.00E+00	0.00E+00	1.46E-02	9.72E-08
Total	3.34E+02	7.95E+00	NA	2.35E+01	NA	1.93E+00	NA	3.34E+01	NA

[a] C-101 row includes tanks C-101, C-104, C-107, and C-110.
[b] C-102 row includes tanks C-102, C-105, C-108, and C-111.
[c] C-103 row includes tanks C-103, C-106, C-109, and C-112.
[d] C-200 row includes tanks C-201, C-202, C-203, and C-204.
[e] These values are based on measurements of contamination found near or under tank C-105.
ILCR = Incremental lifetime cancer risk.
NA = not applicable.

Table A.2. C Tank Farm Risk Evaluation Results for Residential Scenario

Tank	Current Inventory	Residual Waste (360 ft³ [2,700 gal] C-100-Series Tanks, 30 ft³ [220 gal] C-200-Series Tanks		Assumed 8,000 gal (C-100-Series Tanks) or 100 gal (C-200-Series Tanks) Waste Retrieval Leak		Measured Contamination in C Tank Farm Vadose Zone		Total (Post Waste Retrieval)	
	Tc-99 (Ci)	Tc-99 (Ci)	ILCR	Tc-99 (Ci)	ILCR	Tc-99 (Ci)	ILCR	Tc-99 (Ci)	ILCR
241-C-101	6.97E-01	2.13E-02	6.29E-08	6.32E-02	3.23E-05	0.00E+00	0.00E+00	8.46E-02	3.24E-05
241-C-102	1.32E+00	1.13E-02	3.32E-08	3.34E-02	1.71E-05	0.00E+00	0.00E+00	4.46E-02	1.71E-05
241-C-103	1.74E+01	6.54E-01	1.93E-06	1.94E+00	9.91E-04	0.00E+00	0.00E+00	2.59E+00	9.93E-04
241-C-104	5.80E+01	6.02E-01	1.78E-06	1.78E+00	9.13E-04	0.00E+00	0.00E+00	2.39E+00	9.14E-04
241-C-105	8.14E+01	1.97E+00	5.80E-06	5.83E+00	2.98E-03	1.93E+00[e]	9.87E-04[e]	9.73E+00	3.97E-03
241-C-106	3.14E+00	4.57E-01	1.35E-06	1.35E+00	6.92E-04	0.00E+00	0.00E+00	1.81E+00	6.93E-04
241-C-107	3.79E+01	4.11E-01	1.21E-06	1.22E+00	6.23E-04	0.00E+00	0.00E+00	1.63E+00	6.24E-04
241-C-108	6.19E+00	2.52E-01	7.44E-07	7.48E-01	3.82E-04	0.00E+00	0.00E+00	1.00E+00	3.83E-04
241-C-109	3.23E+01	1.37E+00	4.05E-06	4.06E+00	2.08E-03	0.00E+00	0.00E+00	5.44E+00	2.08E-03
241-C-110	3.18E+01	4.84E-01	1.43E-06	1.43E+00	7.33E-04	0.00E+00	0.00E+00	1.92E+00	7.35E-04
241-C-111	2.70E+00	1.27E-01	3.74E-07	3.76E-01	1.92E-04	0.00E+00	0.00E+00	5.03E-01	1.92E-04
241-C-112	6.11E+01	1.59E+00	4.68E-06	4.70E+00	2.40E-03	0.00E+00	0.00E+00	6.28E+00	2.41E-03
241-C-201	1.41E-02	2.99E-03	8.83E-09	1.36E-03	6.96E-07	0.00E+00	0.00E+00	4.36E-03	7.05E-07
241-C-202	1.47E-02	3.12E-03	9.21E-09	1.42E-03	7.26E-07	0.00E+00	0.00E+00	4.54E-03	7.35E-07
241-C-203	2.82E-02	2.40E-03	7.07E-09	1.09E-03	5.57E-07	0.00E+00	0.00E+00	3.48E-03	5.64E-07
241-C-204	1.81E-02	1.54E-03	4.54E-09	6.99E-04	3.57E-07	0.00E+00	0.00E+00	2.24E-03	3.62E-07
C-101 Row	1.28E+02	1.52E+00	4.48E-06	4.50E+00	2.30E-03	0.00E+00	0.00E+00	6.02E+00	2.31E-03
C-102 Row	9.16E+01	2.36E+00	6.96E-06	6.99E+00	3.57E-03	1.93E+00	9.87E-04	1.13E+01	4.57E-03
C-103 Row	1.14E+02	4.07E+00	1.20E-05	1.21E+01	6.16E-03	0.00E+00	0.00E+00	1.61E+01	6.17E-03
C-200 Row	7.51E-02	1.01E-02	2.96E-08	4.57E-03	2.34E-06	0.00E+00	0.00E+00	1.46E-02	2.37E-06
Total	3.34E+02	7.95E+00	NA	2.35E+01	NA	1.93E+00	N/A	3.34E+01	NA

[a] C-101 row includes tanks C-101, C-104, C-107, and C-110.
[b] C-102 row includes tanks C-102, C-105, C-108, and C-111.
[c] C-103 row includes tanks C-103, C-106, C-109, and C-112.
[d] C-200 row includes tanks C-201, C-202, C-203, and C-204.
[e] These values are based on measurements of contamination found near or under tank C-105.
ILCR = incremental lifetime cancer risk.
NA = not applicable.

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APPENDIX B
TANK C-105 WASTE RETRIEVAL FUNCTIONS AND REQUIREMENTS

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B1.0 INTRODUCTION

Tank C-105 was constructed between 1943 and 1944, and was put into service in February 1946. Tank C-105 is one of twelve 100-series single-shell tanks in the C farm. Tank C-105 is the second tank in a three-tank cascade. The tank is a first-generation tank constructed with a dish-shaped bottom, a painted grout layer, an asphalt (waterproof) membrane, and an outer reinforced-concrete shell to maintain the structural integrity of the steel liner by protecting it from soil loads. The reinforced-concrete shell is cylindrical and supports the steel liner, which is constructed of carbon steel. Tank C-105 is 75 feet in diameter, and has a capacity of 530,000 gallons (*Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 East Area* [WHC-SD-WM-ER-349]).

As of June 2003, tank C-105 contained approximately 132,000 gallons of waste consisting of 132,000 gallons of sludge that contains 10,000 gallons of drainable interstitial liquid. Tank C-105 is presently passively ventilated. Tank C-105 is categorized as "sound" (*Waste Tank Summary Report for Month Ending June 30, 2003* [HNF-EP-0182]).

Tank C-105 received primarily metal waste from T Plant operations. It also received PUREX Plant fission product waste from tank C-106 (WHC-MR-0132). Metal waste was accumulated and stored in tank C-105 until it was sluiced for uranium recovery between 1952 and 1955 (WHC-SD-WM-ER-349).

B2.0 RISK BASIS

This section presents the results of a preliminary evaluation of the long-term human health risks associated with waste in tank C-105 and potential leaks that could occur during waste retrieval operations. The purpose of the evaluation was to provide a basis for making informed decisions during waste retrieval in the event a leak is detected or unexpected waste retrieval conditions arise. The evaluation was performed using the methodology described in Section 2.0.

Technetium-99 was selected as the indicator contaminant based on the results of a screening analysis. The analysis indicated that technetium-99 would contribute approximately 94% (industrial scenario) to 99% (residential scenario) of the total long-term groundwater pathway ILCR. The risk evaluation performed in support of the functions and requirements documents is based on a set of conservative assumptions (i.e., over-predicts the anticipated risks from a more detailed analysis). Follow-on risk analyses used to support tank closure will include a more detailed accounting of the contaminants remaining in the tank (both radiological and chemical).

Inventory calculations were performed using best-basis inventory data accessed on November 11, 2003 (RPP-19071). It was assumed that the supernate in tank AN-106 at the start of the tank C-105 waste retrieval would have the composition of the composite retrieval fluid calculated for the tank C-103 waste retrieval (see Section A2.0). The technetium-99 concentration in this starting retrieval fluid was assumed to increase during the tank C-105 retrieval as a result of inventory dissolved from the tank C-105 solids. The tank C-105 technetium-99 residual waste and retrieval leak inventories were calculated as the product of the

new composite retrieval fluid concentration and the assumed residual waste and retrieval leak volumes. The new composite retrieval fluid concentration was calculated at the sum of the technetium-99 inventories in the tank AN-106 supernate (post-tank C-103 retrieval) and the tank C-105 solids, divided by the current tank AN-106 supernate volume. This method conservatively assumed that 100% of the technetium-99 inventory in the tank C-105 solids is soluble and would go into solution in the composite retrieval fluid. It was assumed that the tank AN-106 solids would not be agitated and would not go into solution in the composite retrieval fluid. It was also assumed that no raw water additions would made during the tank C-105 retrieval operation.

Waste stored in the C-200-series tanks and tank C-106 is currently scheduled to be transferred to tank AN-106 before the start of waste retrieval operations for tank C-105. Because the technetium-99 inventory associated with tank C-106 and the C-200-series tanks combined is approximately 14% of the technetium-99 inventory in tank AN-106, the addition of waste from these tanks was assumed to have minimal impact on the residual waste and retrieval leak inventories for tank C-105 and were disregarded for this evaluation.

Evaluation results are provided in Figures B.1 and B.2. These two figures present a risk picture for tank C-105 but do not include contributions from other C tank farm sources. All sources in waste management area C will be included in the risk assessment supporting final waste management area closure (RPP-14284). Four separate curves are shown in Figure B.1, two for in-tank waste (residuals) for the industrial and residential scenarios, and two for ex-tank waste (retrieval leakage) for the industrial and residential scenarios.

Figure B.1. Tank C-105 Risk Plot

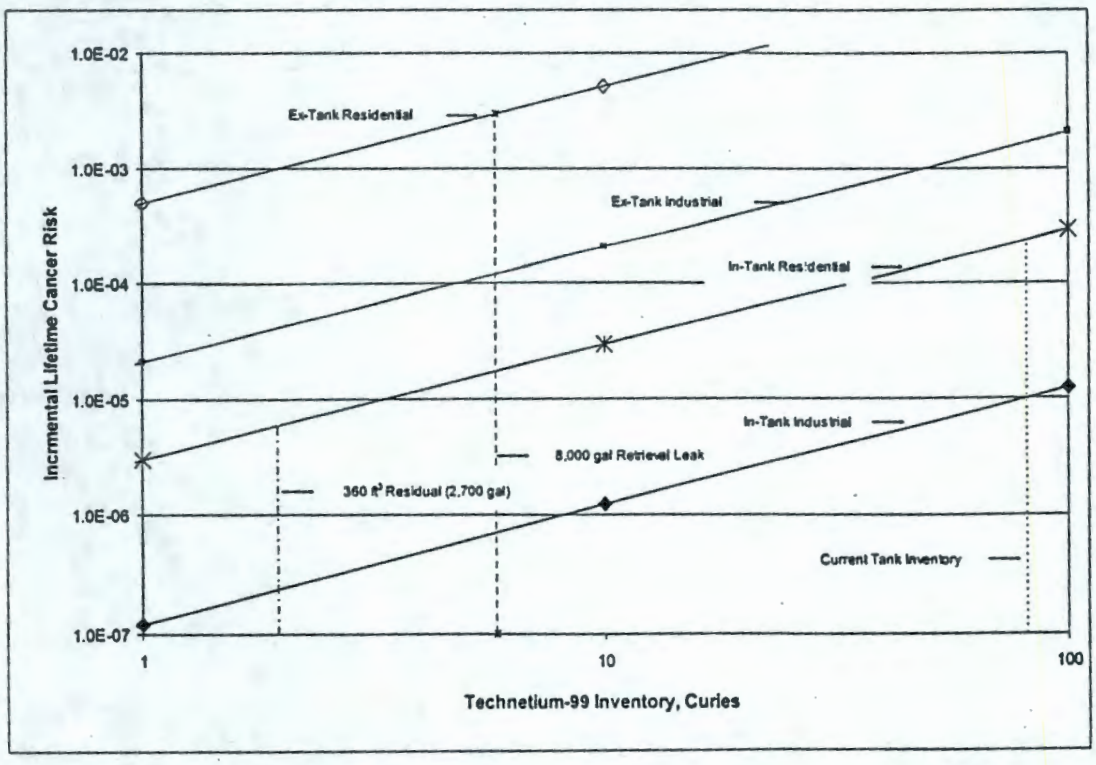
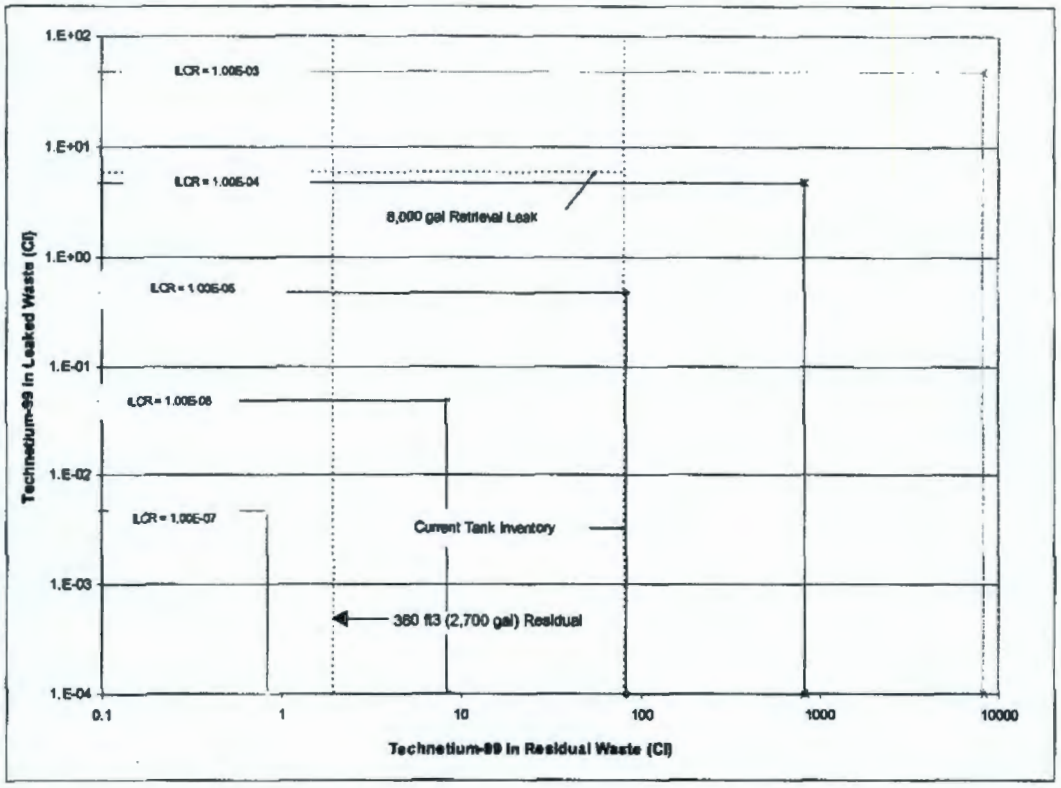


Figure B.2. Tank C-105 Residual Waste and Leaked Waste (Industrial Scenario)



As shown in Figure B.1, the ILCR posed by the current technetium-99 inventory in tank C-105 is approximately 1×10^{-5} for the industrial scenario and 2×10^{-4} for the residential scenario. Waste retrieval down to approximately 360 cubic feet reduces the ILCR by approximately one and one-half orders of magnitude. The inventory of technetium-99 associated with a potential leak (ex-tank) of 8,000 gallons from tank C-105 is approximately 6 curies and corresponds to a risk of approximately 1×10^{-4} for the industrial scenario and 3×10^{-3} for the residential scenario.

Figure B.2 uses the same data used in Figure B.1 for the industrial scenario but depicts the risk results from a slightly different perspective. Figure B.2 shows five curves, each depicting the relationship between residual waste and retrieval leakage technetium-99 inventory for a constant ILCR level. The ILCR levels shown are 1×10^{-3}, 1×10^{-4}, 1×10^{-5}, 1×10^{-6}, and 1×10^{-7}. Three dashed lines are added to depict the technetium-99 inventories associated with the current tank C-105 waste, 360 cubic feet of residual waste in tank C-105, and an 8,000-gallon retrieval leak from tank C-105.

A C tank farm risk evaluation was performed to provide a perspective of the tank C-105 risk relative to other C farm tanks. The results of this evaluation are presented in Section A2.0 and Tables A.1 and A.2.

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