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14-TF-0013

FEB 18 2014

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Ms. Hedges:

THE U.S. DEPARTMENT OF ENERGY, OFFICE OF RIVER PROTECTION SUBMITS THE RETRIEVAL DATA REPORT FOR TANK 241-C-104

Reference: ORP letter from T.W. Fletcher to J.A. Hedges, Ecology, "The U.S. Department of Energy, Office of River Protection Submits the Retrieval Completion Certification and Report for Tank 241-C-104," 13-TF-0018, dated March 21, 2013.

The U.S. Department of Energy, Office of River Protection (ORP) is transmitting RPP-RPT-54072, Rev. 0, *Retrieval Data Report for Single-Shell Tank 241-C-104*, completed in accordance with the requirements of the Hanford Federal Facility Agreement and Consent Order Milestone M-045-86, "Submit a retrieval data report to Ecology for the 19 tanks retrieved under the Consent Decree in *Washington v. DOE*, Case No. 08-5085-FVS…" RPP-RPT-54072, Rev. 0 documents completion of waste retrieval and post-retrieval sampling at Tank 241-C-104 using modified sluicing as a first retrieval technology and chemical dissolution as a second retrieval technology.

ORP provided a retrieval completion certification on Tank 241-C-104 on March 21, 2013 (Reference).

If you have any questions, please contact Joanne F. Grindstaff, Federal Project Director, Retrieval and Closure, at (509) 376-6202.

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Attachment

Distribution see page 2

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RPP-4072, REV. 0

RETRIEVAL DATA REPORT FOR SINGLE-SHELL TANK 241-C-104

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Retrieval Data Report for Single-Shell Tank 241-C-104

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Abstract: This report describes the retrieval of waste from single-shell tank 241-C-104, a 100-series single-shell tank, constructed to store waste in Waste Management Area C. The Department of Energy began removing the waste stored in tank 241-C-104 on January 8, 2010, and completed waste removal operations using the modified sluicing and chemical dissolution (caustic cleaning) technologies (with a subsequent heel water wash) to the limits of technology on August 17, 2012, resulting in an estimated tank 241-C-104 waste volume remaining of 217 cubic feet with a 95% upper confidence level of 255 cubic feet.

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EXECUTIVE SUMMARY

This Retrieval Data Report presents information in accordance with the requirements of *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) Milestone M-045-86, due 12 months after the U.S. Department of Energy (DOE) certifies to the Washington State Department of Ecology that DOE has completed retrieval of a single-shell tank covered by the Consent Decree in *Washington v. DOE*, Case No. CV-08-5085-FVS. The DOE submitted Revision 2A of its certification of retrieval, RPP-53823, *Retrieval Completion Certification Report for Tank 241-C-104*, on March 19, 2013.

This Retrieval Data Report presents information showing that single-shell tank 241-C-104 (C-104) has undergone two waste retrieval campaigns, each to its limits of technology. The first waste retrieval technology deployed was modified sluicing, which removed ~98% of the initial waste inventory; a second waste removal technology comprised of chemical dissolution (caustic cleaning) with a subsequent heel water wash removed more of the waste. The residual waste volume contained within tank C-104 is estimated to be 217 ft^3 with a 95% upper confidence level of 255 ft^3 (RPP-CALC-54284, *Post-Hard Heel Retrieval Camera/CAD Modeling System Waste Volume Estimate for Tank 241-C-104*). This Retrieval Data Report also summarizes the potential risk to human health from waste remaining in the tank, provides details on the technologies deployed and their respective performances during the waste removal campaigns, and describes measures taken to prevent and detect leaks during waste retrieval operations.

RPP-53823 documents that the two retrieval technologies deployed in tank C-104 retrieved the waste in tank C-104 to the limits of the technologies, resulting in a residual waste volume less than the Consent Decree waste residue goal of 360 ft^3. The tank C-104 modified sluicing waste retrieval campaign began January 8, 2010 and was completed on May 9, 2011. The caustic cleaning retrieval operations began on June 14, 2012 and reached the limits of technology on August 17, 2012. The tank C-104 waste which was removed was transferred to double-shell tank 241-AN-101.

The tank C-104 leak detection, monitoring, and mitigation program used during retrieval operations consisted of high-resolution resistivity techniques along with readings from a combination of drywell moisture measurements, waste volume assessments (mass balances), and visual inspection to detect and control potential leaks. No leaks were detected during tank C-104 retrieval operations.

Prior to retrieval, the best estimate of waste volume was ~259,000 gal (34,600 ft^3). After modified sluicing, the estimated volume of waste remaining in the tank was ~4,700 gal (~630 ft^3). After caustic cleaning the estimate volume of waste remaining in the tank was ~1,600 gal (~220 ft^3).

The inventory of constituents in the residual waste remaining in tank C-104 was determined by laboratory analysis of waste samples taken once it was determined that the Consent Decree waste residue goal had been met and that deployment of a third retrieval technology would not be necessary. The risk assessment for the residual waste in tank C-104 based on sampling analysis shows that for the groundwater pathway, the estimated risk impacts for tank C-104 are well

below performance objectives. For all inadvertent intruder scenarios other than the suburban garden scenario (a sensitivity case) at 100 years after closure, the estimated risk impacts for tank C-104 were well below performance objectives. For the suburban garden scenario at 500 years after closure, the effects are below performance objectives.

TABLE OF CONTENTS

1.0 INTRODUCTION AND BACKGROUND 1-1

1.1 PURPOSE 1-1
1.2 REGULATORY REQUIREMENTS 1-2
1.3 DOCUMENT STRUCTURE 1-2

2.0 SINGLE-SHELL TANK 241-C-104 RESIDUAL WASTE VOLUME MEASUREMENT 2-1

2.1 RESIDUAL WASTE VOLUME MEASUREMENT PROCESS 2-1
2.1.1 Video Camera/Computer-aided Design Modeling System 2-3
2.1.2 Estimation of Waste Remaining on Tank Surfaces 2-3
2.1.3 Estimation of Waste in Equipment 2-4
2.2 RESIDUAL WASTE VOLUME RESULTS 2-4

3.0 RESIDUAL TANK WASTE CHARACTERIZATION 3-1

3.1 SAMPLING AND ANALYSIS OF RESIDUAL WASTE 3-1
3.2 SAMPLING AT SINGLE-SHELL TANK 241-C-104 3-1
3.3 SAMPLE ANALYSES 3-3
3.4 CALCULATION OF RESIDUAL INVENTORY 3-4
3.4.1 Average Inventories 3-4
3.4.2 Bounding Inventories 3-6
3.4.3 Evaluation of Sample Data Usability 3-7
3.4.4 Inventory Calculation Assumptions and Clarifications 3-8
3.5 INVENTORY ESTIMATES 3-13

4.0 RETRIEVAL SYSTEM PERFORMANCE 4-1

4.1 WASTE RETRIEVAL PROCESS DESCRIPTION 4-1
4.2 RETRIEVAL SYSTEM PERFORMANCE 4-1
4.3 WASTE RETRIEVAL EFFICIENCY 4-6
4.4 RETRIEVAL DURATION 4-6
4.5 CONCLUSION 4-6

5.0 POST-RETRIEVAL SINGLE-SHELL TANK 241-C-104 RISK ASSESSMENT 5-1

5.1 CONSTITUENTS EVALUATED 5-3
5.2 RESULTS FOR INDIVIDUAL CONTAMINANTS FOR POST-RETRIEVAL SINGLE-SHELL TANK 241-C-104 5-7
5.3 CUMULATIVE ANALYSIS RESULTS FOR SINGLE-SHELL TANK 241-C-104 AND WASTE MANAGEMENT AREA C 5-8
5.4 INADVERTENT INTRUDER 5-13

5.5 COMPARISON OF TANK RESIDUALS WITH MODEL TOXICS CONTROL ACT SOIL CLEANUP LEVELS 5-16
5.5.1 WAC 173-340 Direct Contact and Soil Concentrations Protective of Groundwater 5-17
5.5.2 WAC 173-340 Ecological Risk 5-25
5.6 RISK ASSESSMENT SUMMARY 5-26

6.0 OPPORTUNITIES AND ACTIONS BEING TAKEN TO REFINE OR DEVELOP TANK WASTE RETRIEVAL TECHNOLOGIES, BASED ON LESSONS LEARNED 6-1

6.1 PREDICTED WASTE VOLUME 6-1
6.2 SAMPLING ASPECTS 6-1
6.3 SLUICING OPERATION 6-2
6.4 SLUICER EQUIPMENT 6-3
6.5 WASTE CIRCULATION 6-3
6.6 CAUSTIC CLEANING OPERATION 6-4

7.0 LEAK DETECTION, MONITORING, AND MITIGATION 7-1

7.1 REQUIREMENTS 7-1
7.2 LEAK DETECTION AND TANK MONITORING 7-2
7.2.1 Drywell Logging and High Resolution Resistivity 7-4
7.2.2 Single-Shell Tank 241-C-104 7-5
7.2.3 Double-Shell Tank 241-AN-101 7-6
7.2.4 Ancillary Equipment 7-7
7.3 MITIGATION 7-7
7.3.1 Single-Shell Tank 241-C-104 7-8
7.3.2 Double-Shell Tank 241-AN-101 7-8
7.4 CONCLUSION 7-9

8.0 REFERENCES 8-1

APPENDICES

A – SINGLE-SHELL TANK 241-C-104 INVENTORY PRE- AND POST-SLUICING TECHNOLOGY RETRIEVAL ..... A-i
B – MEAN CONCENTRATIONS AND RELATIVE STANDARD DEVIATIONS FOR TANK 241-C-104 RESIDUAL SOLIDS ..... B-i
C – COMPARISON OF SINGLE-SHELL TANK 241-C-104 FINAL INVENTORY TO SINGLE-SHELL TANK 241-C-104 INVENTORY USED IN DOE/ORP-2005-01, *INITIAL SINGLE-SHELL TANK SYSTEM PERFORMANCE ASSESSMENT FOR THE HANFORD SITE* ..... C-i
D – RISK ASSESSMENT INFORMATION FOR RESIDUAL WASTES REMAINING IN SINGLE-SHELL TANK 241-C-104 ..... D-i

LIST OF FIGURES

Figure 2-1. Tank 241-C-104 Video Still, Recorded September 25, 2012, Camera Elevation Approximately 18 feet from Tank Bottom. 2-2

Figure 3-1. Approximate Locations of Post-Heel Removal Samples (not to scale). 3-2

Figure 3-2. Photograph of an Off-Riser Sampling System. 3-3

Figure 4-1. Tank 241-C-104 Modified Sluicing System Performance. 4-3

Figure 4-2. Comparison of Caustic Concentration Levels and Sodium Hydroxide Extent of Reaction with Caustic Recirculation Time. 4-5

Figure 5-1. Single-Shell Tank 241-C-104 Residual Waste Inventory and Risk Assessment Process. 5-2

Figure 7-1. Tank 241-C-104 Leak Detection Monitoring Timeline. 7-3

LIST OF TABLES

Table 2-1. Tank 241-C-104 Total Waste Volume and Component Waste Volumes. 2-3

Table 3-1. Description of Tank 241-C-104 Post-Heel Retrieval Samples. 3-4

Table 3-2. Analytical Methods Used in Analysis of Post-Heel Removal Samples. 3-5

Table 3-3. Tentatively Identified Compounds in Tank 241-C-104 Residual Solids Samples. 3-10

Table 3-4. Inventory Estimates for Selected Constituents in Tank 241-C-104 Residual Solids. 3-13

Table 5-1. List of Analytes and Available Toxicity Information. 5-4

Table 5-2. Estimated Maximum Incremental Lifetime Cancer Risk/Radiological Dose During the Modeling Period for Primary Radionuclides Related to Average Residual Waste Inventory in Single-Shell Tank 241-C-104. 5-9

Table 5-3. Estimated Maximum Value for Incremental Lifetime Cancer Risk and Hazard Quotient for Selected Non-Radiological Analytes Related to Average Residual Waste Inventory in Single-Shell Tank 241-C-104. 5-10

Table 5-4. Comparison of Cumulative Incremental Lifetime Cancer Risk, Hazard Index, and Groundwater Concentration at Peak Waste Management Area C Fenceline for Average and 95% Upper Confidence Level Residual Waste Inventories in Single-Shell Tank 241-C-104. 5-11

Table 5-5. Comparison of Intruder Doses at 100 and 500 years After Closure from Residual Waste for Single-Shell Tank 241-C-104. 5-14

Table 5-6. Potential Future Impact from Inadvertent Intrusion into Residual Waste for Average and 95% Upper Confidence Level Inventories. 5-15

Table 5-7. Average and 95% Upper Limit Concentrations of Selected Constituents Estimated for Waste Residuals within Tank 241-C-104, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater. 5-18

Table 5-8. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Constituents above Detection in 241-C-104 Tank Residual Wastes. 5-21

Table 5-9. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Constituents above Detection in 241-C-104 Tank Residual Wastes. 5-23

Table 5-10. Comparison of Hanford Tank Waste Operations Simulator Predicted Inventory Used in DOE/ORP-2005-01 with the Average and 95% Upper Confidence Level Post-Retrieval Inventories. 5-30

Table 7-1. Tank 241-C-104 Leak Detection and Monitoring Functions and Requirements. 7-2

Table 7-2. Leak Detection and Monitoring Methods for Each Waste Retrieval System Component. 7-4

Table 7-3. High-Resolution Resistivity Anomaly Evaluation During and After Sluicing. 7-5

LIST OF TERMS

Abbreviations and Acronyms

3D	three-dimensional
AMS	Articulating Mast System
BBI	Best-Basis Inventory
BBIM	Best-Basis Inventory Maintenance
CAD	computer-aided design
CAS	Chemical Abstracts Service
CCMS	Camera/CAD Modeling System
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CPF	cancer potency factor
DFR	dose factor
DOE	U.S. Department of Energy
DQO	Data Quality Objectives
DST	double-shell tank
Ecology	State of Washington Department of Ecology
EPA	U.S. Environmental Protection Agency
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
HRR	high-resolution resistivity
HTWOS	Hanford Tank Waste Operations Simulator
HWMA	Hazardous Waste Management Act
ILCR	incremental lifetime cancer risk
LDM	leak detection and monitoring
LDMM	leak detection, monitoring, and mitigation
MTCA	Model Toxics Control Act
ORP	U.S. Department of Energy Office of River Protection

ORSS	Off-Riser Sampling System
PA	performance assessment
PCB	polychlorinated biphenyl
RCRA	*Resource Conservation and Recovery Act of 1976*
RCW	*Revised Code of Washington*
RDR	Retrieval Data Report
Rfd	reference dose
RSD	relative standard deviation
SST	single-shell tank
SVOA	semivolatile organics analysis
TGA	thermogravimetric analysis
TIC	tentatively identified compound
TSAP	tank sampling and analysis plan
TSR	Technical Safety Requirement
UCL	upper confidence level
VOA	volatile organic analysis
WAC	*Washington Administrative Code*
WMA	waste management area
WRPS	Washington River Protection Solutions, LLC
WRS	waste retrieval system

Units

ft^3	cubic feet
gal	gallon
in.	inch
kgal	thousand gallons

RPP-RPT-54072
Revision 0

Retrieval Data Report for Single-Shell Tank 241-C-104

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Prepared for the U.S. Department of Energy
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1.0 INTRODUCTION AND BACKGROUND

Retrieval of single-shell tank (SST) 241-C-104 (C-104) waste occurred in two campaigns. The first campaign on April 27, 2006 consisted of used modified sluicing technology to remove the bulk of the waste. The campaign began on January 8, 2010 and was suspended on May 9, 2011. This first campaign of retrieval reached the limit of its technology with an estimated 4,700 gal (~630 ft^3) of waste remaining in tank C-104 (RPP-CALC-49703, *Estimate of Waste Volume and Percent Retrieved for Single-Shell Tank 241-C-104*). The second campaign on September 25, 2009, was a caustic cleaning retrieval operation, which was comprised of a chemical dissolution step followed by a water rinse. This campaign began on June 14, 2012 and reached its limit of technology on August 17, 2012. After concluding the second waste retrieval campaign, the quantity of waste remaining in tank C-104 was estimated to be 1,624 gal or 217 ft^3 (RPP-CALC-53365, *Waste Volume of Single-Shell Tank 241-C-104 Remaining After Hard Heel Retrieval*). The modified sluicing campaign is described (and approved by the State of Washington Department of Ecology [Ecology]) in Revision 3A of RPP-22393, *C-102, C-104, C-107, C-108, and C-112 Tanks Waste Retrieval Work Plan.* A chemical retrieval process (caustic cleaning) was identified as the second technology as described (and approved by Ecology) in Revision 6 of RPP-22393, *241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan.*

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*, as amended) has been incorporated into this document, it is not incorporated for the purpose of regulating the radiation hazards of such components under the authority of Chapter 70.105, "Hazardous Waste Management," *Revised Code of Washington* (RCW) (known as the *Hazardous Waste Management Act* [HWMA]) and its implementing regulations, but is provided for information purposes only.

1.1 PURPOSE

This Retrieval Data Report (RDR) provides information required by *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) (HFFACO) Milestone M-045-86. The report documents the following aspects of tank C-104 retrieval:

- Residual tank waste volume measurement, including associated calculations
- The results of residual tank waste characterization
- Retrieval technology performance documentation
- The U.S. Department of Energy (DOE)'s updated post-retrieval risk assessment
- Opportunities and actions being taken to refine or develop tank waste retrieval technologies based on lessons learned
- Leak detection monitoring and performance results.

1.2 REGULATORY REQUIREMENTS

Retrieval of waste from tank C-104 and submittal of this RDR are necessary requirements for closing the Hanford SST system. The HFFACO Milestone M-045-86 provides in part:

> *Submit a retrieval data report to Ecology for the 19 tanks retrieved under the Consent Decree in Washington v. DOE, Case No. 08-5085-FVS, which report shall include the following elements only of Section 2.1.7 of Appendix I to the HFFACO:*
>
> 1) *Residual tank waste volume measurement, including associated calculations;*
> 2) *The results of residual tank waste characterization;*
> 3) *Retrieval technology performance documentation;*
> 4) *DOE's updated post-retrieval risk assessment;*
> 5) *Opportunities and actions being taken to refine or develop tank waste retrieval technologies, based on lessons learned and,*
> 6) *LDMM monitoring and performance results.*

The Tank Waste Retrieval Work Plan (RPP-22393) establishes the two retrieval technologies that are to be deployed to their respective "limits of technology" in an effort to obtain the Consent Decree waste residue volume of 360 ft^3 or less. The two technologies established by the Tank Waste Retrieval Work Plan for tank C-104 were deployed to their limits of technology resulting in a waste residual volume of ~220 ft^3, achieving less than the Consent Decree goal.

1.3 DOCUMENT STRUCTURE

This tank C-104 RDR is organized to present information required by Milestone M-045-86 of the HFFACO Action Plan.

- **Section 1**, *Introduction and Background* discusses the purpose and scope of tank C-104 waste retrieval, presents requirements applicable to this report, and outlines the report structure.

- **Section 2**, *Single-Shell Tank 241-C-104 Residual Waste Volume Measurement* describes the method for determining the volume of residual waste in tank C-104 and presents results of the volume measurement process.

- **Section 3**, *Residual Tank Waste Characterization* lists requirements for characterization of tank waste, describes methods and procedures used to sample and analyze the waste, and describes the results of laboratory analysis.

- **Section 4**, *Retrieval System Performance* provides an evaluation of how well the waste retrieval system (WRS) performed and provides a comparison of actual performance against predicted performance.

- **Section 5,** *Post-Retrieval Single-Shell Tank 241-C-104 Risk Assessment* describes the potential risk to human health from tank C-104 residual waste. This section identifies and discusses contaminants of potential concern in the waste, describes the effects of waste retrieval and closure on long-term human health risk, presents expected cumulative health effects of source terms, relates calculated risk to residual waste volume, and summarizes overall conclusions of the risk assessment. To satisfy recent requests by Ecology, this section also provides additional risk management information related to how concentrations of constituents remaining in waste residuals within tank C-104 compare against the *Washington Administrative Code* (WAC) 173-340, "Model Toxics Control Act – Cleanup" cleanup standards. These soil cleanup standards are developed to be protective of direct contact exposures and groundwater use.

- **Section 6,** *Opportunities* discusses recommendations for future actions associated with tank C-104 and actions being taken based on lessons learned.

- **Section 7,** *Leak Detection, Monitoring, and Mitigation* describes leak detection, monitoring, and mitigation (LDMM) methods and procedures, presents an LDMM chronology for tank C-104 waste retrieval, and summarizes LDMM results.

- **Section 8,** *References* contains references for material cited in the report.

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2.0 SINGLE-SHELL TANK 241-C-104 RESIDUAL WASTE VOLUME MEASUREMENT

This section presents the residual waste volume measurement process and the results for tank C-104. The post-retrieval residual waste volume estimate was performed using a method described in RPP-CALC-54284, *Post-Hard Heel Retrieval Camera/CAD Modeling System Waste Volume Estimate for Tank 241-C-104*. The total measured volume of residual waste in tank C-104 was the sum of volumes remaining in the tank dish, on the tank walls, on the stiffener rings, and in the void spaces in equipment left in the tank.

2.1 RESIDUAL WASTE VOLUME MEASUREMENT PROCESS

RPP-CALC-54284 documents the video camera/computer-aided design (CAD) computer modeling system (CCMS) estimate for the post-hard heel retrieval waste volume in tank C-104. All solids were covered for Enraf[1] volume displacement estimates, and the Enraf displacement values were reasonably consistent with video estimates (RPP-CALC-53365).

After the CCMS video was completed, the video was reviewed to develop an AutoCAD® Civil 3D®[2] drawing of tank C-104 and the tank waste residuals and to complete tank bottom volume estimates per TFC-ENG-FACSUP-CD-22, "Post-Retrieval Tank Waste Volume Determination." The AutoCAD® Civil 3D® software was tested and verified per RPP-52784, *Video Camera/CAD Modeling System for Retrieval: HISI #3254 Software Management Plan.*

A template of the 100-series 241-C Farm tanks was developed from tank construction drawings (BPF-73550, *Specifications For Construction of Composite Storage Tanks Bldg. No. 241 Hanford Engineer Works Project 9536*, Drawing D-3). The area and depth of waste and equipment in the tank bottom was estimated based on tank features and the dimensions of equipment and debris observed in the CCMS video (Figure 2-1 shows selected still photographs taken from the CCMS videos). The waste contour information was then added to the template drawing to show waste remaining in the tank bottom. After completing the drawings, the AutoCAD® Civil 3D® software calculated a waste volume by integrating between the waste contour lines and the tank bottom profile. These processes are described in more detail below.

[1] Honeywell Enraf is a product of Honeywell Process Solutions, Strahlenbergerstr. 110-112, 63067 Offenbach, Germany.
[2] AutoCAD® and Civil 3D® are trademarks of Autodesk, Inc., 111 McInnis Parkway, San Rafael, California.

Figure 2-1. Tank 241-C-104 Video Still, Recorded September 25, 2012, Camera Elevation Approximately 18 feet from Tank Bottom.

2.1.1 Video Camera/Computer-aided Design Modeling System

The post-hard heel retrieval waste volume in the bottom of tank C-104 was estimated using the CCMS method per TFC-ENG-FACSUP-CD-22. The estimated volume of waste on the tank bottom, calculated using AutoCAD® Civil 3D®, was 190.4 ft^3.

The waste volume consists of an estimated 48.4 ft^3 (1.370 m^3 × 35.31 ft^3/m^3) of solids piles and a 142.0-ft^3 (4.022-m^3 × 35.31-ft^3/m^3) pool of liquids and submerged solids near the center of the tank (Table 2-1). The shape of the pool, not round and off-centered (see Section 3.2), indicates that the shape of the tank dish is not the same as in the tank template drawing. This was considered in estimating the depth of waste at different locations in the tank. It was conservatively assumed that the waste in the pool and on the tank bottom remains saturated, and the tank bottom waste volume was not adjusted for porosity.

Table 2-1. Tank 241-C-104 Total Waste Volume and Component Waste Volumes.

Component	Waste volume			95% UCL[a] (ft^3)
	m^3	gal	ft^3	
In the bottom (dish) of the tank (solids and liquids)	5.392	1,425	190.4	228
Waste in tank equipment[b]	0	0	0	0
On the stiffener ring and tank walls[c]	0.753	199	26.6	26.6
Total[d]	6.145	1,624	217	255

1 ft^3 = 7.481 gal, 1 m^3 = 264.2 gal, UCL = upper confidence level, CCMS = camera/computer-aided design computer modeling system

Notes:

[a] Per RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, the estimated CCMS error is calculated using: Volume at 95% UCL = 1.195 × CCMS reading + 0.27 ft^3.

[b] Negligible compared to other waste components.

[c] The estimated volume for waste on the stiffener ring and on the tank wall is the upper bounding estimate.

[d] Total may not equal sum of individual volumes because of rounding.

2.1.2 Estimation of Waste Remaining on Tank Surfaces

The estimated volume of waste on the stiffener rings and tank walls after hard heel retrieval was 32.1 ft^3 (240 gal) (RPP-CALC-53365). This was estimated based on the surface area of four sets of stiffener rings located at 4.5-ft intervals from the top of the tank dish and the average depth of waste on the rings at each level (Figure 2-1). RPP-CALC-53365 provides a detailed analysis of the estimated waste thickness on the tank walls and each of the stiffener rings.

The waste volume estimate of 32.1 ft^3 is high because it includes not only the solid waste volume, but also the volume of voids in the waste. Assuming a drainable porosity value of 0.17 (HNF-2978, *Updated Pumpable Liquid Volume Estimates and Jet Pump Durations for Interim*

Stabilization of Remaining Single-Shell Tanks), the estimated volume of waste on the stiffener rings = 32.1 ft^3 × (1 – 0.17) = 26.6 ft^3 (199 gal).

2.1.3 Estimation of Waste in Equipment

Waste remaining in equipment was negligible compared to other volumes.

2.2 RESIDUAL WASTE VOLUME RESULTS

The total CCMS volume of post-retrieval residual waste in tank C-104 and the waste volumes associated with the various waste components are given in Table 2-1. The best estimate for the total post-retrieval waste volume in tank C-104 is 217 ft^3 with a 95% upper confidence level (UCL) of 255 ft^3.

3.0 RESIDUAL TANK WASTE CHARACTERIZATION

This section describes the results of residual tank waste characterization for tank C-104. Presented are the average and upper bounding estimates of residual waste inventory based on laboratory analysis of waste samples taken after waste removal actions were completed. The calculated inventories are used as input to estimate the potential risk to human health that arises from the residual waste. This risk assessment is discussed in Section 5.0.

3.1 SAMPLING AND ANALYSIS OF RESIDUAL WASTE

A tank sampling and analysis plan (TSAP) (RPP-PLAN-44844, *Sampling and Analysis Plan for Waste Solids in Tank 241-C-104 to Support Tank Closure*) identified sample collection, laboratory analysis, quality assurance/quality control, and reporting requirements for the characterization of waste solids remaining in tank C-104 after completion of retrieval to support tank closure. The samples were analyzed according to the requirements 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*.

Because much of the tank floor was essentially clear and most of the residual solids were located in two large masses, the general sampling design described in the Data Quality Objectives (DQO) document (RPP-23403) was not ideal for this tank. A sampling design that focused on these solids masses was needed. A tank-specific sampling design was agreed upon by the DOE Office of River Protection (ORP) and Ecology for the residual waste in this tank (*Tri-Party Agreement Project Manager (PM) Agreement for Single-Shell Tank (SST) Retrievals Completion Final Sampling* [Ecology and DOE-ORP 2013]). The sampling design consisted of:

- Average inventory – Estimate of the mean waste inventory calculated based on the mean sample concentration, mean sample density, and an estimate of the waste volume

- Upper-bounding inventory – Estimate of the 95% UCL inventory calculated based on the mean and standard deviation for sample concentration, sample density, and waste volume.

3.2 SAMPLING AT SINGLE-SHELL TANK 241-C-104

A tank-specific sampling design for the tank C-104 post-heel retrieval sample event focused on the two masses of residual solids (see Figure 3-1) using an Off-Riser Sampling System (ORSS) to retrieve solid samples from the approximate locations:

- Two samples from each solids mass for a total of four samples;

- Duplicate analyses performed on one sample and single analysis on the remaining three samples for a total of five analyses for each waste constituent.

Figure 3-1. Approximate Locations of Post-Heel Removal Samples (not to scale).

The ORSS was used to collect the solids samples. The ORSS consisted of a remotely-operated mobile sampler and a sample jar carrier. This tool was designed to collect residual waste samples from any location on a tank floor. The ORSS was lowered through a 12-in. diameter riser to the tank bottom. The sampler was then maneuvered remotely to collect a waste sample. The sampler deposited the waste material into a sample jar located in the sample carrier, which was then raised into the glove bag at the top of the riser. The sample jar with the waste material was replaced with an empty jar and the carrier was lowered back into the tank to collect the next sample. This process was repeated until all samples required by this TSAP were collected.

A photograph of an ORSS is shown in Figure 3-2. The ORSS was lowered through Riser 7.

Figure 3-2. Photograph of an Off-Riser Sampling System.

As shown in Figure 3-1, the residual solids remaining after heel removal were located in two large masses of the tank (RPP-CALC-53365); therefore, samples were taken at the four approximate locations as shown in the figure. All four samples were used for waste constituent analysis as described in Section 3.4.1.

The volume of waste solids collected in the first four samples was sufficient to characterize the bulk of the residual solids in the tank. Therefore, the sampling objectives were judged to have been achieved with the collected samples. The tank C-104 solid samples, retrieved February 6 and 7, 2013, in accordance with RPP-PLAN-44844 were shipped to the 222-S Laboratory for analysis.

The locations sampled are approximate given the sampling method limitations of remote video viewing and sampling. Descriptions of the solids samples 4C-13-1, 4C-13-2, 4C-13-3, and 4C-13-4 are provided in Table 3-1 as reported in RPP-RPT-55185, *Final Report for Tank 241-C-104 Waste Solid Samples in Support of Tank Closure*.

3.3 SAMPLE ANALYSES

The samples listed in Table 3-1 were analyzed for the constituents identified in RPP-23403 and RPP-PLAN-23827 as defined by RPP-PLAN-44844. Analytical methods performed on the samples are identified in Table 3-2. The table also shows the corresponding analysis methods

found in SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, where applicable. Sample analysis results are reported in RPP-RPT-55185. Electronic data were also loaded into the Tank Waste Information Network System.

Table 3-1. Description of Tank 241-C-104 Post-Heel Retrieval Samples.

Sample Identification Number*	Date Sampled	Date Received	Solid Weight (g)	Liquid Volume (mL)	Sample Description
4C-13-1	2/7/2013 14:30	2/8/2013 13:30	125	None	Partially full 240-mL bottle with tan and white dry solids; no organic layer visible
4C-13-2	2/7/2013 14:46	2/8/2013 13:30	219	None	Partially full 240-mL bottle with moist brown and white solids; no organic layer visible
4C-13-3	2/7/2013 12:35	2/7/2013 13:45	158	None	Partially full 240-mL bottle with tan and white dry solids; no organic layer visible
4C-13-4	2/6/2013 13:45	2/7/2013 13:45	152	None	Partially full 240-mL bottle with brown and white wet solids; no organic layer visible

* Last number in sample identification number references one of the sample locations shown in Figure 3-1.

3.4 CALCULATION OF RESIDUAL INVENTORY

The residual waste inventories were computed by following the Best-Basis Inventory (BBI) process as described in RPP-7625, *Guidelines for Updating Best-Basis Inventory*. Two inventories were computed: an average inventory based on mean concentrations, density, and volume and an upper bounding inventory that is an estimate of an inventory at the 95% UCL. The inventories are discussed in the following sections.

3.4.1 Average Inventories

The average inventory for each waste constituent was calculated using the automated Best-Basis Inventory Maintenance (BBIM) tool [RPP-5945, *Best-Basis Inventory Maintenance Tool (BBIM): Database Description and User Guide*]. This tool calculates the average inventory by finding the product of the mean concentration, the mean density, and the waste volume (i.e., inventory = concentration × density × volume). The calculations by the BBIM tool are summarized below.

As described earlier, tank C-104 solids were sampled in tank C-104 after the heel retrieval which removed more than half of the amount of waste after bulk retrieval. The mean concentrations were estimated as follows.

Table 3-2. Analytical Methods Used in Analysis of Post-Heel Removal Samples.

Analysis Technique	SW-846 Reference Method
Inorganic Analyses	
Bulk Density – Gravimetric	Not applicable
pH	9045D
Weight percent water – Thermogravimetric Analysis	Not applicable
Cyanide – Spectrophotometric	9010C4
Mercury – Cold Vapor Atomic Absorption	7471B
Ammonium – Ion Chromatography	EPA 300.7*
Anions & Organic Acids – Ion Chromatography	9056A
Metals – Inductively Coupled Plasma/Atomic Emission Spectrometry	6010C
^{99}Tc – Inductively Coupled Plasma/Mass Spectrometry	6020
Actinides – Inductively Coupled Plasma/Mass Spectrometry	3050B
Radiochemical Analyses	
Gamma Energy Analysis	Not applicable
^{90}Sr – Separation/Beta counting	Not applicable
^{14}C – Liquid Scintillation	Not applicable
^{129}I – Separation/Gamma Energy Analysis	Not applicable
^{79}Se – Liquid Scintillation	Not applicable
^{3}H – Liquid Scintillation	Not applicable
^{63}Ni – Liquid Scintillation	Not applicable
^{99}Tc – Liquid Scintillation	Not applicable
^{241}Am – Separation/Alpha Energy Analysis	Not applicable
$^{239/240}$Pu, ^{238}Pu – Separation/Alpha Energy Analysis	Not applicable
^{241}Pu – Separation/Liquid Scintillation	Not applicable
^{228}Th – Separation/Alpha Energy Analysis	Not applicable
Organic Analyses	
Volatile Organic Compound – Gas Chromatography-Mass Spectrometry	8260C
Semivolatile Organic Compound – Gas Chromatography-Mass Spectrometry	8270D
Polychlorinated Biphenyls – Gas Chromatography-Electron Capture Detection	8082A

EPA = U.S. Environmental Protection Agency

* EPA Method 300.7, *Dissolved Sodium, Ammonium, Potassium, Magnesium, and Calcium in Wet Deposition by Chemically Suppressed Ion Chromatography.*

Reference: SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, Third Edition as amended.

The BBIM used equations from *Variance Components* (Searle et al. 1992) to estimate the mean concentration and density and the associated standard deviation for all constituents that had 50% or more of their reported values greater than the detection limit. These equations compute means by weighting results based on the variance components. Some constituents had concentrations that were below the detection limits. In these cases, the analytical method detection limits were used for calculating the mean concentrations. For a constituent with a majority of the analytical results below the analytical method detection limit, a simple average of the detection limits was calculated as if they were the analytical results for the constituent. Note that in accordance with BBI protocol, the relative standard deviations for non-detected constituents were assumed to be "1" (RPP-6924, *Statistical Methods for Estimating the Uncertainty in the Best Basis Inventories*).

To calculate the average analyte inventories, the BBIM tool automatically used the mean concentrations from the samples taken after heel retrieval. The concentration means used by the BBIM tool to calculate the average inventories are provided in Appendix B.

As shown in Table 2-1, ~190.4 ft^3 of waste was left on the tank floor including a 142.0-ft^3 (1,062-gal) pool of liquid and submerged sludge (RPP-CALC-54284). The volume of the submerged sludge was assumed to be half the volume of the pool of liquid in the tank (RPP-CALC-53365). The volume of solids on the tank bottom is estimated to be 146.0 ft^3 (119.4 ft^3 + 26.6 ft^3 = 146.0 ft^3) which is the volume of the solids on the bottom of the tank plus the solids on the tank wall. There are 7.481 gal per cubic foot and 3.785 L per gallon; therefore, the solid volume is 4.1 kL [(146.0 × 7.481 × 3.785) × 1/1,000 = 4.1 kL] used for inventory.

3.4.2 Bounding Inventories

The 95% UCL inventory of each constituent was estimated based on a statistical method described in RPP-6924. This method is based on calculation of the average inventory (see Section 3.4.1) and a statistical uncertainty (quantified using a standard deviation) for the inventory. The standard deviation of the average inventory was calculated based on statistical uncertainties associated with the concentration, volume, and density measurements.

Standard deviations for the mean concentrations (provided in Appendix B) and density were calculated using the BBIM tool. The standard deviation for waste volume was estimated as described below.

RPP-CALC-54284 provides estimates of post-retrieval residual waste volumes on the tank bottom, on the tank wall, in discarded equipment in the tank, and on the tank stiffener rings (see Table 2-1). The total waste volume was estimated at 217 ft^3. The upper bounding estimates for the waste volume components added up to 255 ft^3. The estimated error for the total volume may be represented as ± 0.175 [(255 - 217)/217]. The upper bounding estimate for the volume component that makes up the bulk of the waste (waste on the tank bottom) is at the 95% UCL. Therefore, it was assumed that the error associated with the total volume is also at the 95% UCL. Using a factor of 2 for a two-sided 95% confidence level based on a normal distribution with a known variance, the relative standard deviation (RSD) for the total waste volume was estimated to be 0.088 (0.175/2). This RSD was used to approximate the RSD associated with the solids volume.

The BBIM tool calculated the inventory RSD using the equation:

$$RSD^2(\hat{I}) \cong RSD^2(\overline{C}) + RSD^2(\overline{D}) + RSD^2(\hat{V})$$

where $RSD^2(\hat{I})$ is the squared inventory RSD, $RSD^2(\overline{C})$ is the squared average concentration RSD, $RSD^2(\overline{D})$ is the squared average density RSD, and $RSD^2(\hat{V})$ is the squared total volume RSD.

According to RPP-6924, the Student's t distribution (or any other probability distribution) is not applicable for determining a confidence interval for the mean inventory because there are no degrees of freedom associated with the volume measurement. The 95% UCL inventory was approximated by the equation:

$$UCL = \hat{I} + 2 \times \hat{I} \times RSD(\hat{I})$$

where $\hat{I}$ is the average inventory estimate and $RSD(\hat{I})$ is the RSD of the average inventory estimate. The factor "2 times the standard deviation of the estimate" in this equation is analogous to the factor "1.96 times the standard deviation of the mean" for a two-sided 95% confidence interval on the mean based on a normal distribution with a known variance (in accordance with the BBI process which uses a two-sided 95% confidence interval for inventory). The 95% UCL inventories were calculated using the above equation and the average inventory estimates and associated RSDs that were calculated by the BBIM tool.

3.4.3 Evaluation of Sample Data Usability

Residual waste solids were sampled with the ORSS after heel removal using an accepted sampling method described in the DQO (RPP-23403). The solids RSDs in Appendix B, Table B-1 represent the uncertainty in the estimates due to sampling and analysis errors and to the waste variability in the tank.

The 222-S Laboratory maintains a quality assurance program to ensure data quality. The waste samples were analyzed according to quality assurance plans established by the program. In addition, the DQOs specify quality control criteria (e.g., standard recovery, matrix spike recovery, relative difference between duplicate analyses) that are specific to the closure project. The DQOs also provide direction for addressing data that do not meet the criteria. Results for most constituents satisfied the DQO criteria; those that did not meet the criteria were addressed according to the direction provided in the DQOs. Communications that were used to address data issues are included in the laboratory data reports (RPP-RPT-55185).

Based on this evaluation, it was concluded that the sampling and analysis met the DQO objectives and, therefore, the sample results are acceptable for uses discussed in the DQO, including risk assessment calculations.

3.4.4 Inventory Calculation Assumptions and Clarifications

The inventories were calculated in accordance with the BBI creation rules documented in RPP-7625. The calculation includes the following assumptions and clarifications.

- Inventories were generated only for constituents specified in the DQO document (RPP-23403). Inventories for BBI analytes that are not included in RPP-23403 were not calculated.

- Only data from post-heel removal samples were used to calculate the inventories. Inventories of constituents not detected in the samples were calculated using the analytical method detection limits. Therefore, these specific inventories are considered conservative estimates.

- Concentration data are available only for solids on the bottom of the tank. Solids on the tank stiffener ring and the tank wall were not sampled and were assumed to have the same composition as the solids on the tank bottom.

- The volume estimate for the residual waste on the tank bottom includes a 142.0-ft^3 (1,062-gal) pool of liquid and submerged solids (RPP-CALC-54284). The volume of the submerged solids was assumed in RPP-CALC-53365 to be half of the volume of the pool of liquids and submerged solids. Using 142.0 ft^3, the submerged solids equal 71.0 ft^3 (142.0 ft^3/2). The waste was sluiced and rinsed with water at the end of retrieval; therefore, the liquid in the tank was assumed to be water (RPP-CALC-53365).

- The initial sample physical appearances were noted as heterogeneous and proved difficult to homogenize. For As Low as Reasonably Achievable reasons, to prevent possible contamination spread while homogenizing and subsampling, 4 wt% to 10 wt% water was added to dry appearing samples before analyses (Table 2, RPP-RPT-55185). The thermogravimetric analysis (TGA) results for subsamples of 4C-13-1 of 37 wt% to 40 wt% water were much higher than expected. For these subsamples, the TGA analyses were rerun and still had consistent high wt% water results. A subsample was submitted for limited analyses that included x-ray diffraction, scanning electron microscopy, and polarized light microscopy in order to determine if bound water or waters of hydration was causing the unexpected results. The subsample consisted mostly of two major constituents: gibbsite [$Al(OH)_3$] and thermonatrite [$Na_2CO_3 \cdot H_2O$]. Natrophosphate [$Na_7F(PO_4)2 \cdot 19H_2O$] and cancrinite [$Na_6Ca_2Al_6Si_6O_{24}(CO_3) \cdot 2.2H_2O$] were identified as minor phases (LAB-RPT-13-00005, *C-104 Solid Phase Characterization of Sample 4C-13-1 From Tank 241-C-104 Closure Sampling Event*). Sample results from microscopy were inconclusive to determine the cause of high TGA results. The correction for water of 4% to 10% would be less than the variability introduced by sample heterogeneity and homogenization issues; therefore, no correction for the added water is attempted for inventory. The sample mean from all reported results for wt% water by TGA is 26.6 wt%, with a range of 44 wt% to 15 wt% water.

- Bulk density results were also affected by heterogeneity of tank C-104 residual waste with wide range of sample results from 1.13 g/mL to 2.28 g/mL. A mean of 1.58 g/mL with high variance describes the extreme heterogeneity of the residual solids remaining in tank C-104 after caustic dissolution and water sluicing, i.e., flighty dry, porous particles to dense rocklike particles. Three of the four samples were not homogenized well and contained large particles after using both a tissue homogenizer and mortar and pestle (RPP-RPT-55185).

- Thorium concentration was calculated based on the inductively coupled plasma/mass spectrometry results using ^{232}Th measured by inductively coupled plasma/mass spectrometry.

- Uranium concentration was estimated from concentrations of uranium isotopes detected by inductively coupled plasma/mass spectrometry (^{234}U, ^{235}U, ^{236}U, and ^{238}U).

- Plutonium and curium (except for ^{242}Cm) isotopes were calculated from the $^{239/240}$Pu and $^{243/244}$Cm analytical results, using process knowledge of the isotopic distributions ratios of tank C-104.

- In accordance with RPP-7625, the ^{137m}Ba inventory was equal to 0.944 times the ^{137}Cs inventory and the ^{90}Y inventory was equal to the ^{90}Sr inventory.

- For inductively coupled plasma/atomic emission spectrometry metals, acid digest was the preferred analysis method for calculating inventory, excluding aluminum, silicon, cerium and manganese of which the preferred analysis method is fusion digest. For aluminum inventory, the acid digest method was preferred because the sample mean had a higher concentration with a lower RSD.

- The laboratory was not able to distinguish xylene (m) and xylene (p). Inventories of these xylene isomers were calculated by assuming the xylene (m&p) detection limit was the upper bound for the individual isomers.

The samples were analyzed for the 61 compounds that the laboratory currently reports. In addition to the primary analytes listed in the TSAP, the following secondary analytes, which had results above the minimum detection limit, have been reported: 2-butanone, 2 hexanone, 2-pentanone, cyclohexane, hexane, methylcyclohexane, and tetrahydrofuran in Attachment 1 of RPP-RPT-55185. N-butanol, benzene, ethylbenzene, methylene chloride, and toluene are non-requested analytes with results above the minimum detection limit and have been reported in Attachment 2 of RPP-RPT-55185.

Tentatively identified compounds (TICs) from organic analyses were not identified with certainty. In addition, measured concentrations for these compounds are only semi-quantitative. Therefore, inventories were not computed for TICs. Only TICs that met the TIC evaluation criteria in RPP-23403 and were reported as a TIC in RPP-RPT-55185 are in Table 3-3. The samples contained numerous alkanes and their alterations to ketones.

Table 3-3. Tentatively Identified Compounds in Tank 241-C-104 Residual Solids Samples. (3 sheets)

Laboratory Sample Number	Result Type	Tentatively Identified Compound	Result (µg/kg)	Retention Time (minutes)	CAS Number	Organic: SVOA or VOA
S13T001056	Primary	5-Tridecanone	2.90E+03	11.91	30692-16-1	SVOA
S13T001056	Duplicate	5-Tridecanone	2.60E+03	11.91	30692-16-1	SVOA
S13T001056	Primary	Dodecane	3.10E+03	9.31	112-40-3	SVOA
S13T001056	Duplicate	Dodecane	2.70E+03	9.31	112-40-3	SVOA
S13T001056	Primary	Tetradecane	3.10E+03	11.23	629-59-4	SVOA
S13T001056	Duplicate	Tetradecane	2.40E+03	11.23	629-59-4	SVOA
S13T001056	Primary	Tridecane	7.00E+03	10.3	629-50-5	SVOA
S13T001056	Duplicate	Tridecane	5.90E+03	10.3	629-50-5	SVOA
S13T001077	Primary	4-Dodecanone	2.00E+03	11.01	6137-26-4	SVOA
S13T001077	Primary	5-Tridecanone	3.00E+03	11.91	30692-16-1	SVOA
S13T001077	Primary	Decane	1.60E+03	7.12	124-18-5	SVOA
S13T001077	Primary	Dodecane	1.40E+04	9.32	112-40-3	SVOA
S13T001077	Primary	Tetradecane	5.70E+03	11.23	629-59-4	SVOA
S13T001077	Primary	Tridecane	1.70E+04	10.3	629-50-5	SVOA
S13T001098	Primary	2-Propanol, 1-chloro-,	2.00E+04	14.48	13674-84-5	SVOA
S13T001098	Primary	2-Tetradecanone	3.00E+03	12.93	2345-27-9	SVOA
S13T001098	Primary	4-Dodecanone	3.30E+03	11.01	6137-26-4	SVOA
S13T001098	Primary	5-Tridecanone	1.00E+04	11.91	30692-16-1	SVOA
S13T001098	Primary	Cyclotrisiloxane, hexa	4.20E+03	4.84	541-05-9	SVOA
S13T001098	Primary	Dodecane	9.60E+03	9.31	112-40-3	SVOA
S13T001098	Primary	Dodecanoic acid	3.60E+03	12.57	143-07-7	SVOA
S13T001098	Primary	Eicosane	2.10E+03	16.59	112-95-8	SVOA
S13T001098	Primary	n-Decanoic acid	9.00E+03	10.85	334-48-5	SVOA
S13T001098	Primary	Nonanoic acid	5.90E+03	9.9	112-05-0	SVOA
S13T001098	Primary	Octanoic Acid	2.40E+03	8.88	124-07-2	SVOA
S13T001098	Primary	Oxirane, trimethyl-	2.20E+03	3.18	5076-19-7	SVOA
S13T001098	Primary	Pentadecane	2.70E+03	12.11	629-62-9	SVOA
S13T001098	Primary	Tetradecane	1.20E+04	11.23	629-59-4	SVOA
S13T001098	Primary	Tridecane	2.30E+04	10.3	629-50-5	SVOA
S13T001098	Primary	Undecanoic acid	9.00E+03	11.74	112-37-8	SVOA
S13T001119	Primary	2-Dodecanone	3.90E+03	11.19	6175-49-1	SVOA

Table 3-3. Tentatively Identified Compounds in Tank 241-C-104 Residual Solids Samples. (3 sheets)

Laboratory Sample Number	Result Type	Tentatively Identified Compound	Result (µg/kg)	Retention Time (minutes)	CAS Number	Organic: SVOA or VOA
S13T001119	Primary	2-Dodecene, (Z)-	6.30E+03	9.23	7206-26-0	SVOA
S13T001119	Primary	2-Tridecanone	6.00E+03	12.09	593-08-8	SVOA
S13T001119	Primary	4-Undecene, (E)-	3.80E+03	8.17	693-62-9	SVOA
S13T001119	Primary	5-Undecanone	1.20E+04	10.04	33083-83-9	SVOA
S13T001119	Primary	Decane	8.50E+03	7.13	124-18-5	SVOA
S13T001119	Primary	Docosane	2.20E+03	16.59	629-97-0	SVOA
S13T001119	Primary	Dodecane	5.70E+04	9.33	112-40-3	SVOA
S13T001119	Primary	Heneicosane	1.80E+03	16.5	629-94-7	SVOA
S13T001119	Primary	Heptadecane	1.70E+03	13.73	629-78-7	SVOA
S13T001119	Primary	Hexadecane-	3.40E+03	12.94	544-76-3	SVOA
S13T001119	Primary	Octadecane	1.70E+03	14.47	593-45-3	SVOA
S13T001119	Primary	Pentadecane	7.60E+03	12.11	629-62-9	SVOA
S13T001119	Primary	Tetradecane	2.90E+04	11.24	629-59-4	SVOA
S13T001119	Primary	Tridecane	7.20E+04	10.33	629-50-5	SVOA
S13T001047	Duplicate	4-Dodecanone	1.50E+01	20.55	6137-26-4	VOA
S13T001047	Primary	5-Dodecanone	4.00E+01	20.55	19780-10-0	VOA
S13T001047	Primary	Decane	5.70E+01	15.19	124-18-5	VOA
S13T001047	Duplicate	Decane	5.70E+01	15.19	124-18-5	VOA
S13T001047	Primary	Dodecane	1.90E+02	17.23	112-40-3	VOA
S13T001047	Duplicate	Dodecane	2.20E+02	17.23	112-40-3	VOA
S13T001047	Primary	Tridecane	1.60E+02	18.24	629-50-5	VOA
S13T001047	Duplicate	Tridecane	2.00E+02	18.24	629-50-5	VOA
S13T001047	Primary	Undecane	1.80E+02	16.25	1120-21-4	VOA
S13T001047	Duplicate	Undecane	2.00E+02	16.24	1120-21-4	VOA
S13T001068	Primary	1-Propene, 2-methyl-	2.50E+01	4.92	115-11-7	VOA
S13T001068	Primary	2-Decanone	4.90E+01	18.38	693-54-9	VOA
S13T001068	Primary	2-Heptanone	5.00E+01	15.14	109-66-2	VOA
S13T001068	Primary	5-Dodecanone	4.20E+01	20.55	19780-10-0	VOA
S13T001068	Primary	6-Dodecene, (E)-	6.30E+01	17.17	7206-17-9	VOA
S13T001068	Primary	6-Tridecene, (Z)-	5.10E+01	18.17	6508-77-6	VOA
S13T001068	Primary	Decane	5.80E+02	15.19	124-18-5	VOA

Table 3-3. Tentatively Identified Compounds in Tank 241-C-104 Residual Solids Samples. (3 sheets)

Laboratory Sample Number	Result Type	Tentatively Identified Compound	Result (µg/kg)	Retention Time (minutes)	CAS Number	Organic: SVOA or VOA
S13T001068	Primary	Dodecane, 3-methyl-	2.00E+03	18.24	17312-57-1	VOA
S13T001068	Primary	Heptane	9.40E+01	10.46	142-82-5	VOA
S13T001068	Primary	Nonane	6.90E+01	13.98	111-84-2	VOA
S13T001068	Primary	n-Pentane	3.00E+01	6.2	109-66-0	VOA
S13T001068	Primary	Octanenitrile	3.20E+01	17.78	124-12-9	VOA
S13T001068	Primary	Tetradecane	3.60E+01	19.38	629-59-4	VOA
S13T001068	Primary	Undecane	1.60E+03	16.25	1120-21-4	VOA
S13T001089	Primary	5-Dodecanone	5.80E+01	20.55	19780-10-0	VOA
S13T001089	Primary	6-Tridecene, (Z)-	2.80E+01	18.17	6508-77-6	VOA
S13T001089	Primary	Decane	9.90E+01	15.19	124-18-5	VOA
S13T001089	Primary	Dodecane	8.40E+02	17.23	112-40-3	VOA
S13T001089	Primary	Nonanal	2.70E+01	17.37	124-19-6	VOA
S13T001089	Primary	Tetradecane	4.20E+01	19.38	629-59-4	VOA
S13T001089	Primary	Tridecane	1.30E+03	18.24	629-50-5	VOA
S13T001089	Primary	Undecane	4.60E+02	16.24	1120-21-4	VOA
S13T001110	Primary	1-Propene, 2-methyl-	1.00E+02	4.92	115-11-7	VOA
S13T001110	Primary	2-Decanone	1.20E+02	18.38	693-54-9	VOA
S13T001110	Primary	2-Heptanone	1.10E+02	15.14	110-43-0	VOA
S13T001110	Primary	5-Tridecene, (E)-	5.30E+01	18.17	23051-84-5	VOA
S13T001110	Primary	5-Undecanone	1.10E+02	19.19	33083-83-9	VOA
S13T001110	Primary	6-Dodecene, (E)-	2.00E+02	17.18	7206-17-9	VOA
S13T001110	Primary	Decane	1.50E+03	15.19	124-18-5	VOA
S13T001110	Primary	Heptane	3.00E+02	10.46	142-82-5	VOA
S13T001110	Primary	Nonane	1.80E+02	13.98	111-84-2	VOA
S13T001110	Primary	Nonanenitrile	6.00E+01	18.96	2243-27-8	VOA
S13T001110	Primary	Octanenitrile	1.10E+02	17.78	124-12-9	VOA
S13T001110	Primary	Pentadecane	1.60E+03	18.24	629-62-9	VOA
S13T001110	Primary	Pentane	2.00E+02	6.2	109-66-1	VOA
S13T001110	Primary	Tetradecane	4.90E+01	19.38	629-59-4	VOA

µg/kg = microgram per kilogram
CAS = Chemical Abstracts Service
SVOA = semivolatile organics analysis
VOA = volatile organic analysis

3.5 INVENTORY ESTIMATES

The average and upper-bounding inventories for the residual solids are shown in Table 3-4. Note that the symbol "<" indicates the inventory was calculated based on the analytical method detection limit because the analyte was not detected in the samples. Radionuclide inventories were decay-corrected to January 1, 2008.

Table 3-4. Inventory Estimates for Selected Constituents in Tank 241-C-104 Residual Solids. (4 Sheets)

Constituent	CAS No.	< Detection Limit	Average Inventory	Upper Bounding Inventory	Inventory Unit
^{125}Sb	14234-35-6	<	1.12E+01	3.40E+01	Ci
^{126}Sn	15832-50-5		5.01E-03	9.57E-03	Ci
^{129}I	15046-84-1	<	2.76E-04	8.39E-04	Ci
^{137}Cs	10045-97-3		4.67E+02	8.58E+02	Ci
^{137m}Ba	N/A		4.41E+02	7.90E+02	Ci
^{14}C	14762-75-5		1.76E-03	2.65E-03	Ci
^{152}Eu	14683-23-9	<	3.28E+00	9.97E+00	Ci
^{154}Eu	15585-10-1	<	2.35E+00	7.14E+00	Ci
^{155}Eu	14391-16-3	<	4.71E+00	1.43E+01	Ci
^{228}Th	14274-82-9		1.48E-02	3.12E-02	Ci
^{230}Th	14269-63-7	<	4.84E-04	1.47E-03	Ci
^{231}Pa	14331-85-2	<	2.13E-01	6.48E-01	Ci
^{232}Th	N/A		2.11E-03	4.11E-03	Ci
^{233}U	13968-55-3	<	1.24E+00	3.77E+00	Ci
^{234}U	13966-29-5		2.37E-01	3.46E-01	Ci
^{235}U	15117-96-1		1.13E-02	1.70E-02	Ci
^{236}U	13982-70-2		2.76E-03	4.16E-03	Ci
^{237}Np	13994-20-2	<	4.54E-02	1.38E-01	Ci
^{238}Pu	13981-16-3		3.69E-01	6.65E-01	Ci
^{238}U	N/A		2.50E-01	3.77E-01	Ci
^{239}Pu	15117-48-3		2.93E+00	5.14E+00	Ci
^{240}Pu	14119-33-6		8.82E-01	1.55E+00	Ci
^{241}Am	14596-10-2		4.91E+00	9.71E+00	Ci
^{241}Pu	14119-32-5		1.16E+01	1.93E+01	Ci

Table 3-4. Inventory Estimates for Selected Constituents in Tank 241-C-104 Residual Solids. (4 Sheets)

Constituent	CAS No.	< Detection Limit	Average Inventory	Upper Bounding Inventory	Inventory Unit
^{242}Cm	15510-73-3		1.89E-02	3.55E-02	Ci
^{242}Pu	NA		1.12E-02	1.99E-02	Ci
^{243}Cm	15757-87-6		2.76E-03	6.14E-03	Ci
^{244}Cm	13981-15-2		6.01E-02	1.34E-01	Ci
1-Butanol	71-36-3		2.93E-03	5.77E-03	kg
2-Butanone	78-93-3	<	1.84E-04	5.59E-04	kg
^{3}H	15086-10-9	<	1.04E-02	3.16E-02	Ci
^{60}Co	10198-40-0	<	1.29E+00	3.92E+00	Ci
^{63}Ni	13981-37-8		6.15E+01	1.61E+02	Ci
^{79}Se	15758-45-9	<	4.88E-03	1.48E-02	Ci
^{90}Sr	10098-97-2		3.72E+03	7.40E+03	Ci
^{90}Y	500784-58-7		3.72E+03	7.40E+03	Ci
^{99}Tc	14133-76-7		1.73E-01	2.65E-01	Ci
Acetate	71-50-1		4.15E-01	5.81E-01	kg
Acetone	67-64-1	<	2.53E-04	7.69E-04	kg
Ag	7440-22-4		9.35E+00	1.36E+01	kg
Al	7429-90-5		6.48E+02	1.03E+03	kg
Aroclors (Total PCB dry weight basis)	1336-36-3		2.44E-03	4.74E-03	kg
As	7440-38-2	<	6.44E-02	1.96E-01	kg
Ba	7440-39-3		3.75E-01	6.02E-01	kg
Be	7440-41-7		2.10E-02	2.98E-02	kg
Benzene	71-43-2		2.21E-05	6.72E-05	kg
Bi	7440-69-9		1.66E+00	2.48E+00	kg
Br	24959-67-9	<	3.33E-01	1.01E+00	kg
Ca	7440-70-2		7.71E+00	1.36E+01	kg
Cd	7440-43-9		1.12E+00	2.03E+00	kg
Ce	7440-45-1		3.95E+00	5.85E+00	kg
Cl	16887-00-6		3.39E-01	5.17E-01	kg
CN	57-12-5	<	1.05E-02	3.19E-02	kg

Table 3-4. Inventory Estimates for Selected Constituents in Tank 241-C-104 Residual Solids. (4 Sheets)

Constituent	CAS No.	< Detection Limit	Average Inventory	Upper Bounding Inventory	Inventory Unit
Co	7440-48-4		2.05E-02	3.12E-02	kg
Cr	7440-47-3		1.74E+00	2.53E+00	kg
Cu	7440-50-8		1.05E+00	1.58E+00	kg
Ethylbenzene	100-41-4		1.37E-05	4.16E-05	kg
Eu	7440-53-1	<	1.29E-02	3.92E-02	kg
F	16984-48-8		8.74E+00	1.71E+01	kg
Fe	7439-89-6		1.84E+02	2.75E+02	kg
Formate	12311-97-6		7.70E-01	1.08E+00	kg
Glycolate	666-14-8	<	1.22E-01	3.71E-01	kg
Hexone	108-10-1	<	9.94E-05	3.02E-04	kg
Hg	7439-97-6		7.66E-01	1.11E+00	kg
K	7440-09-7		7.48E-01	1.04E+00	kg
La	7439-91-0	<	1.33E-02	4.04E-02	kg
Li	7439-93-2		9.15E-02	1.41E-01	kg
Methylenechloride	75-09-2		2.39E-05	4.39E-05	kg
Mg	7439-95-4		1.60E+00	2.99E+00	kg
Mn	7439-96-5		2.44E+01	5.06E+01	kg
Mo	7439-98-7		4.56E-02	7.75E-02	kg
Na	7440-23-5		6.55E+02	9.13E+02	kg
Nb	7440-03-1		2.91E-01	5.05E-01	kg
Nd	7440-00-8		4.86E-01	7.76E-01	kg
NH_3	7664-41-7		4.53E-02	7.97E-02	kg
Ni	7440-02-0		3.42E+00	6.29E+00	kg
NO_2	14797-65-0		2.88E+00	4.44E+00	kg
NO_3	14797-55-8		5.34E+00	7.38E+00	kg
Oxalate	338-70-5		1.35E+02	2.30E+02	kg
Pb	7439-92-1		3.69E+00	5.65E+00	kg
Pd	7440-05-3		2.09E+00	3.16E+00	kg
PO_4	14265-44-2		2.44E+01	4.29E+01	kg
Pr	7440-10-0		2.48E+00	3.74E+00	kg

Table 3-4. Inventory Estimates for Selected Constituents in Tank 241-C-104 Residual Solids. (4 Sheets)

Constituent	CAS No.	< Detection Limit	Average Inventory	Upper Bounding Inventory	Inventory Unit
Rb	7440-17-7	<	3.86E-01	1.17E+00	kg
Rh	7440-16-6	<	1.03E-01	3.13E-01	kg
Ru	7440-18-8	<	5.15E-02	1.57E-01	kg
Sb	7440-36-0	<	7.73E-02	2.35E-01	kg
Se	7782-49-2	<	7.73E-02	2.35E-01	kg
Si	7440-21-3		7.47E+01	1.04E+02	kg
Sn	7440-31-5		2.13E-01	4.45E-01	kg
SO_4	14808-79-8		6.57E-01	9.13E-01	kg
Sr	7440-24-6		5.32E-01	8.28E-01	kg
Ta	7440-25-7		1.96E+00	2.97E+00	kg
Te	13494-80-9		1.13E-01	1.72E-01	kg
Th	7440-29-1		1.91E+01	3.72E+01	kg
Ti	7440-32-6		2.50E-01	3.63E-01	kg
Tl	7440-28-0	<	7.73E-02	2.35E-01	kg
Toluene	108-88-3		2.10E-05	4.77E-05	kg
Tributyl phosphate	126-73-8	<	1.06E-02	3.22E-02	kg
Trichloroethene	79-01-6	<	7.04E-06	2.14E-05	kg
U	7440-61-1		7.50E+02	1.13E+03	kg
V	7440-62-2		2.30E-01	3.42E-01	kg
W	7440-33-7		9.38E-02	1.34E-01	kg
Xylene (m & p)	108-38-3M	<	1.11E-05	3.37E-05	kg
Xylene (o)	95-47-6	<	5.45E-06	1.66E-05	kg
Xylenes (total)	1330-20-7	<	1.41E-05	4.29E-05	kg
Y	7440-65-5		3.08E-01	4.82E-01	kg
Zn	7440-66-6		8.14E-01	1.20E+00	kg
Zr	7440-67-7		1.42E+01	3.16E+01	kg

CAS = Chemical Abstracts Service N/A = not available PCB = polychlorinated biphenyl

Note: Radionuclide concentrations are decay corrected to January 1, 2008.

4.0 RETRIEVAL SYSTEM PERFORMANCE

This section discusses the tank C-104 WRS performance in terms of residual waste, retrieval duration, and water use. In addition, this section compares the achieved waste retrieval results against predicted performance.

The DOE-ORP has deployed two technologies at tank C-104: modified sluicing and caustic cleaning. Modified sluicing operations started on January 8, 2010 with an initial waste volume of ~259,000 gal (~34,600 ft^3), and reached the limits of technology on May 9, 2011. A total of ~254,300 gal (~34,000 ft^3) of waste were removed by the first retrieval technology, leaving ~4,700 gal (~630 ft^3). The second retrieval technology using caustic dissolution started on June 14, 2012 and reached the limits of technology on August 17, 2012. The residual waste solids volume remaining in the tank was estimated at 1,624 gal (217 ft^3) (RPP-CALC-53365), which is less than the Consent Decree retrieval goal of 360 ft^3.

4.1 WASTE RETRIEVAL PROCESS DESCRIPTION

The WRSs deployed at tank C-104 were designed to mobilize and dissolve the sludge waste so it could be transferred to a double-shell tank (DST), tank 241-AN-101 (AN-101). Descriptions of WRSs may be found in RPP-22393. The bulk WRS used supernate from the DST to break up and fluidize the waste, and transfer it to tank AN-101. Supernate from tank AN-101 was recycled continuously. The volume of supernate transferred to tank C-104 was monitored and balanced by the volume pumped out of tank C-104. The flow rate of the recycled supernate was roughly the same as the flow rate of the slurry pumped to the DST. The bulk sluicing operation directed the supernate toward the tank C-104 waste using sluicers, eroding and moving the waste toward the center transfer pump so as much pumpable material was transferred to the DST as was possible.

The second waste retrieval technology deployed at tank C-104 was a combination of water dissolution of sodium fluoride phosphate and caustic cleaning to remove the gibbsite waste portion. The sodium fluoride phosphate was removed first by dissolving it in water and pumping the liquid out of tank C-104. The gibbsite was then removed by adding concentrated sodium hydroxide solution to metathesize the gibbsite to sodium aluminate, then adding water to dissolve the sodium aluminate, and finally pumping the liquid out of tank C-104.

4.2 RETRIEVAL SYSTEM PERFORMANCE

The retrieval system effectively removed most of the sludge from tank C-104. Most of the waste consisted of moist, soft, brown sludge that was easily retrieved. As retrieval proceeded, gray- and brown-colored coarse solids were revealed on the bottom of the tank. The solids were generally difficult to mobilize with the sluicers, and most were too large to be entrained and pumped to tank AN-101. Near the end of retrieval, some water additions were performed to attempt to dissolve or soften the waste material in order to increase sluicing effectiveness. The water additions were unsuccessful at increasing the effectiveness enough to meet the retrieval objective of less than 360 ft^3.

Figure 4-1 shows retrieval system performance as a function of the volume of slurry (solids plus recycled tank AN-101 supernate) transferred from tank C-104 to tank AN-101. The occasional decreases in the volume retrieved in Figure 4-1 reflected fluctuations in the tank C-104 liquid pool volume near the end of the retrieval process. It was not always possible to pump the tank C-104 liquid pool to the same minimum heel at the end of each operating period. Figure 4-1 is annotated to highlight key events during the retrieval process.

Retrieval system performance was tracked by trending the net waste volume increase in the receiver tank AN-101 after accounting for water additions. This running volume balance did not distinguish between liquids and solids and did not account for solids dissolution or liquid evaporation. As the volume retrieved approached the starting waste volume, the estimate of the volume remaining in tank C-104 by difference became increasingly sensitive to uncertainties in the starting waste volume estimate because of pore space in the waste and cumulative measurement uncertainties. Near the end of retrieval, the operating data was adjusted to account for evaporation and pore space, as shown in the "Adjusted Operating Data" line in Figure 4-1.

Both the sluicing Operating Data and Adjusted waste retrieval volumes show the limit of technology being reached at ~4,000,000 gal of slurry pumped.

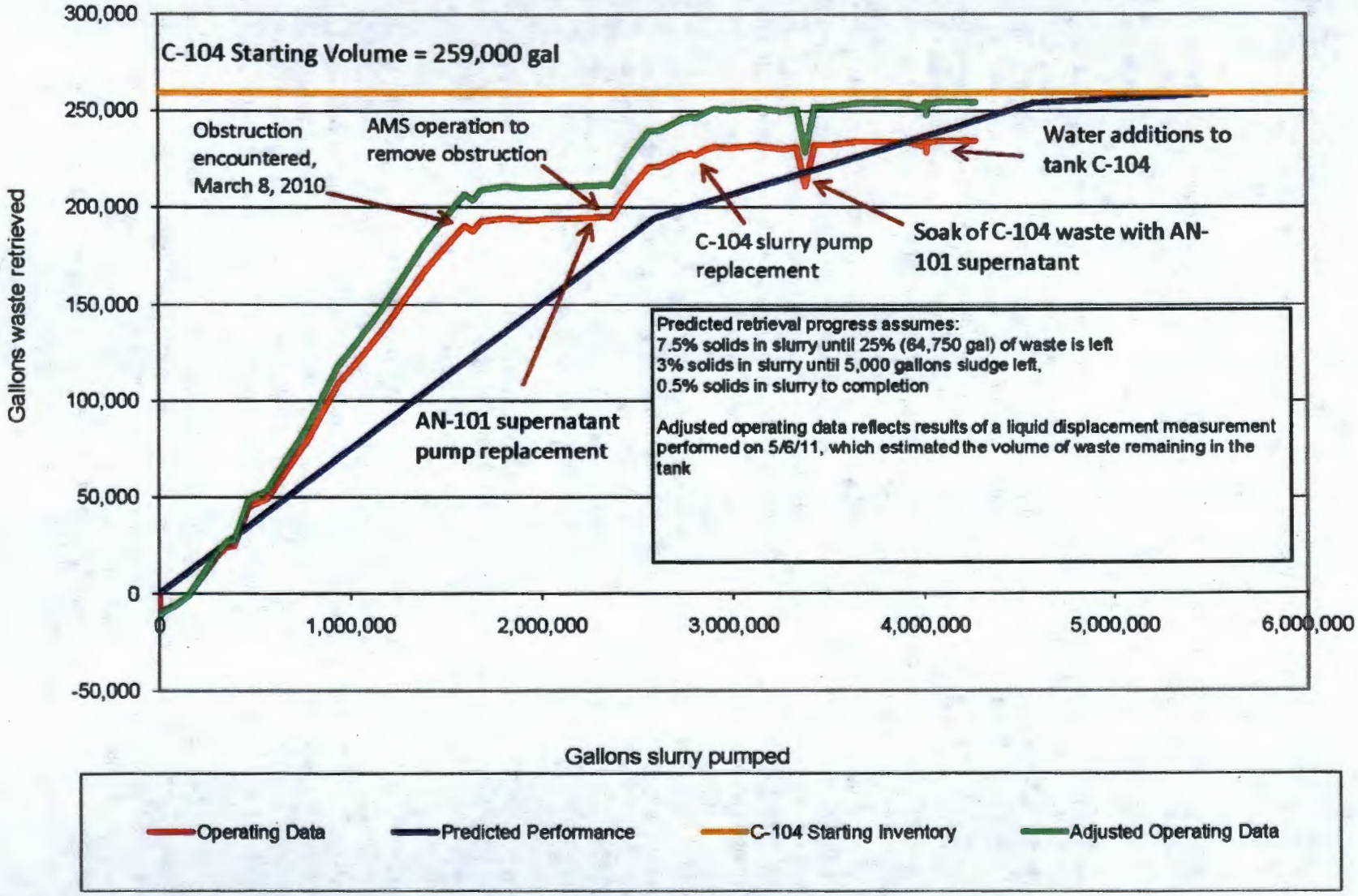
The volume of the waste remaining in tank C-104 at the end of modified sluicing was initially estimated using volume displacement measurements (RPP-CALC-49703). Approximately 25,000 gal of supernate was added to tank C-104 from tank AN-101, and subsequently pumped out.

Video recordings were also made before, during, and after the supernate addition. At the end of the sluicing, this information was used to estimate the volume of waste remaining in tank C-104, below the surface level of the supernatant liquid. Evaluation of the videos was used to estimate the volume of waste piles protruding above the liquid surface, and waste remaining on tank walls and stiffener rings. Details of that evaluation are provided in RPP-CALC-49703.

Based on the performance metrics evaluated with the implementation of this technology and consideration of these other factors, DOE-ORP concluded that the modified sluicing retrieval technology was deployed to the limit of technology in its use at tank C-104 (RPP-53823, *Retrieval Completion Certification Report for Tank 241-C-104*).

As no sampling of the residual waste was conducted after modified sluicing, RPP-RPT-46616, *Derivation of Best-Basis Inventory for Tank 241-C-104 as of October 1, 2012* prepared BBI estimates by scaling the tank waste materials by volume (see Appendix A). That is, pre-sluicing chemical and radiological compositions were retained but simply reduced in magnitude as a ratio of starting and ending waste volume. Resulting inventory estimates for major BBI analytes, in order of chemical and radiological prevalence, are detailed in RPP-RPT-46616 totaling 10,561 kg, excluding water. Supplemental BBI analytes total only 0.44% of the major chemical analytes. The BBI estimated that waste density was 1.68 g/mL and water represents 47.9 wt% of the waste.

Figure 4-1. Tank 241-C-104 Modified Sluicing System Performance.



The following is a discussion of the performance of the caustic cleaning process steps as specified in the tank C-104 process control plan (RPP-PLAN-51575, *Process Control Plan for Tank 241-C-104 Hard Heel Retrieval*) that demonstrates that the limit of technology was met in tank C-104.

The caustic cleaning process was divided into two parts. Each part addressed a different chemical species; sodium fluoride phosphate and gibbsite. The first process was water dissolution of sodium fluoride phosphate.

The second part of the caustic dissolution process was designed to retrieve aluminum compounds with specific emphasis on gibbsite. The process converted the aluminum compounds from a largely insoluble form to a much more soluble form by soaking in very high concentration caustic solution. This is a slow reaction and requires a long contact time to go to completion. Once the reaction went to completion, water was added to dilute the hydroxide and allow the soluble form, sodium aluminate, to dissolve. The sodium aluminate dissolution is rapid. After the dissolution was complete, the contents were pumped from tank C-104. The process of converting gibbsite to the sodium aluminate form was tracked by sampling and analyzing the caustic concentration. Because much of the waste heel was above the liquid level in tank C-104, the liquid was circulated and the waste solids were sprayed with the caustic solution. The video showed that the large piles of waste were broken down and were washed below the liquid pool surface during the process. Figure 4-2 shows the results from sampling the caustic during the conversion reaction.

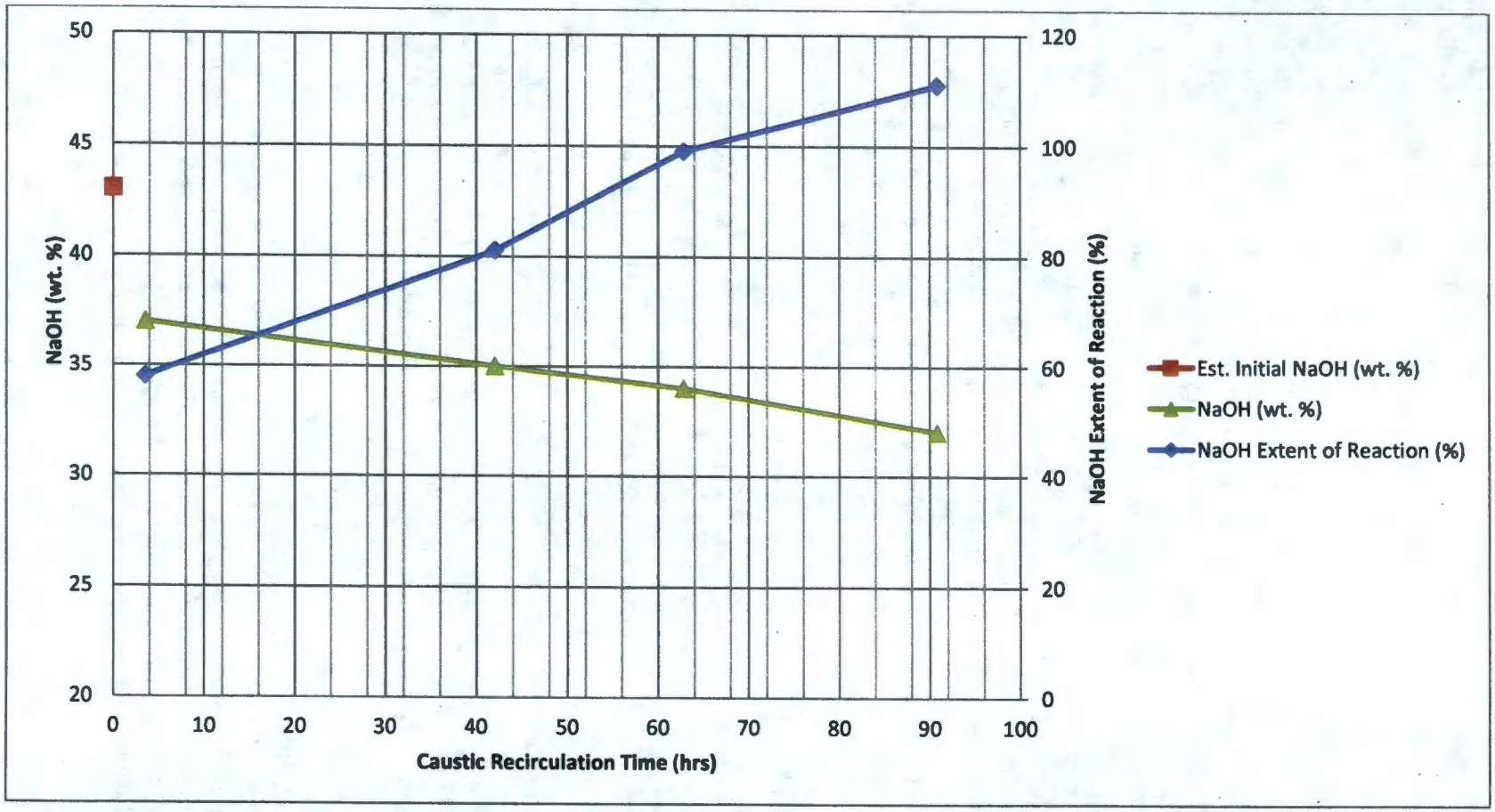
An additional process step of final water sluicing was deemed necessary to remove solid materials which were deposited upon the tank bottom during the volumetric displacement transfer following this dissolution step. From lessons learned in the caustic cleaning step used at tank 241-C-108 (C-108), this sluicing step was defined as a part of the caustic cleaning process that was within the limits defined by the process control plan (see RPP-PLAN-51575).

Following the transfer of the dissolution liquors to tank AN-101, 29,455 gal of water were used to sluice additional solids from tank C-104. At the completion of the water sluicing, the water and suspended waste slurry was transferred to tank AN-101.

On August 17, 2012, final sluicing and hard heel removal operations were shut down on tank C-104. RPP-CALC-53365 detailed a net reduction of ~236 ft^3 (1,768 gal) of tank waste residuals with water sluicing. At the conclusion of final sluicing retrieval operations, tank C-104 was estimated to contain about 217 ft^3 (1,624 gal) of remaining waste (see RPP-RPT-53367, *Single-Shell Tank 241-C-104 Hard Heel Retrieval Completion Report*), meeting the volume requirement provided in the Consent Decree (*Washington v. DOE* [E.D.Wa. October 25, 2010]).

Water sluicing effectively removed additional solids and allowed for some additional dissolution of remaining solids. Video evidence showed that sluicing operations continued to break up remaining waste solids, further diminished the size of waste piles, and moved fine waste materials toward the slurry pump. Additionally, as noted above, chemical analysis of samples of the dissolution liquor suggested that nearly half of the sodium aluminate generated during the metathesis was dissolved and removed during this sluicing operation.

Figure 4-2. Comparison of Caustic Concentration Levels and Sodium Hydroxide Extent of Reaction with Caustic Recirculation Time.



Based on the performance metrics examined with the implementation of this technology and consideration of the factors specified in the Consent Decree, DOE-ORP has concluded that the caustic cleaning retrieval technology has been deployed to the limit of technology at tank C-104.

4.3 WASTE RETRIEVAL EFFICIENCY

The preliminary estimate for the tank C-104 modified sluicing rate campaign indicated that it would require 10,270,000 gal of slurry to transfer the estimated 259,000 gal of tank C-104 waste to tank AN-101. In the first 1,600,000 gal of the slurry pumped from tank C-104, over 200,000 gal of waste was transferred from tank C-104 to tank AN-101, at almost twice the expected rate. However, when the campaign had transferred ~82% (operating day 22) of the forecasted waste volume (~210,000 gal) to tank AN-101, the tank C-104 waste retrieval rate dropped off because an obstruction in the tank prevented the slurry pump from being lowered further. An articulating mast system (AMS) was installed in tank C-104 to move the obstruction out from underneath the slurry pump. Retrieval activities restarted and 252,000 gal of waste was transferred by operating day 50 (see Figure 4-2 for retrieval efficiency rates).

As can be seen from Figure 4-2, the rate of waste retrieval by caustic cleaning progressed linearly as anticipated.

4.4 RETRIEVAL DURATION

The pre-retrieval modified sluicing duration estimate was ~87 days as indicated in Figure 4-1 based on a progression of waste per gallon of slurry and the expected slurry per shift. Early in the modified sluicing retrieval operation, progress was better than expected. After 20 days of sluicing, sluicing efficiency began to fall off (see Figure 4-2). The limit of technology for modified sluicing was reached at day 66.

Caustic cleaning was completed to the limit of technology in 107 hours of recirculation.

The tank C-104 WRS campaigns consisted of a sluicing operation over a 486-calendar-day period starting on January 8, 2010 and ending on May 9, 2011. The caustic cleaning waste retrieval campaign extended over a 65-calendar-day period from June 14, 2012 to August 17, 2012.

4.5 CONCLUSION

Based on the information contained in Section 4.2 above, DOE-ORP concluded that waste retrieval operations were performed to the limits of the modified sluicing technology and of the caustic cleaning technology (RPP-53823). The waste residual volume estimate of 255 ft^3 at the 95% upper confidence level reached the goal of 360 ft^3 using the two technologies.

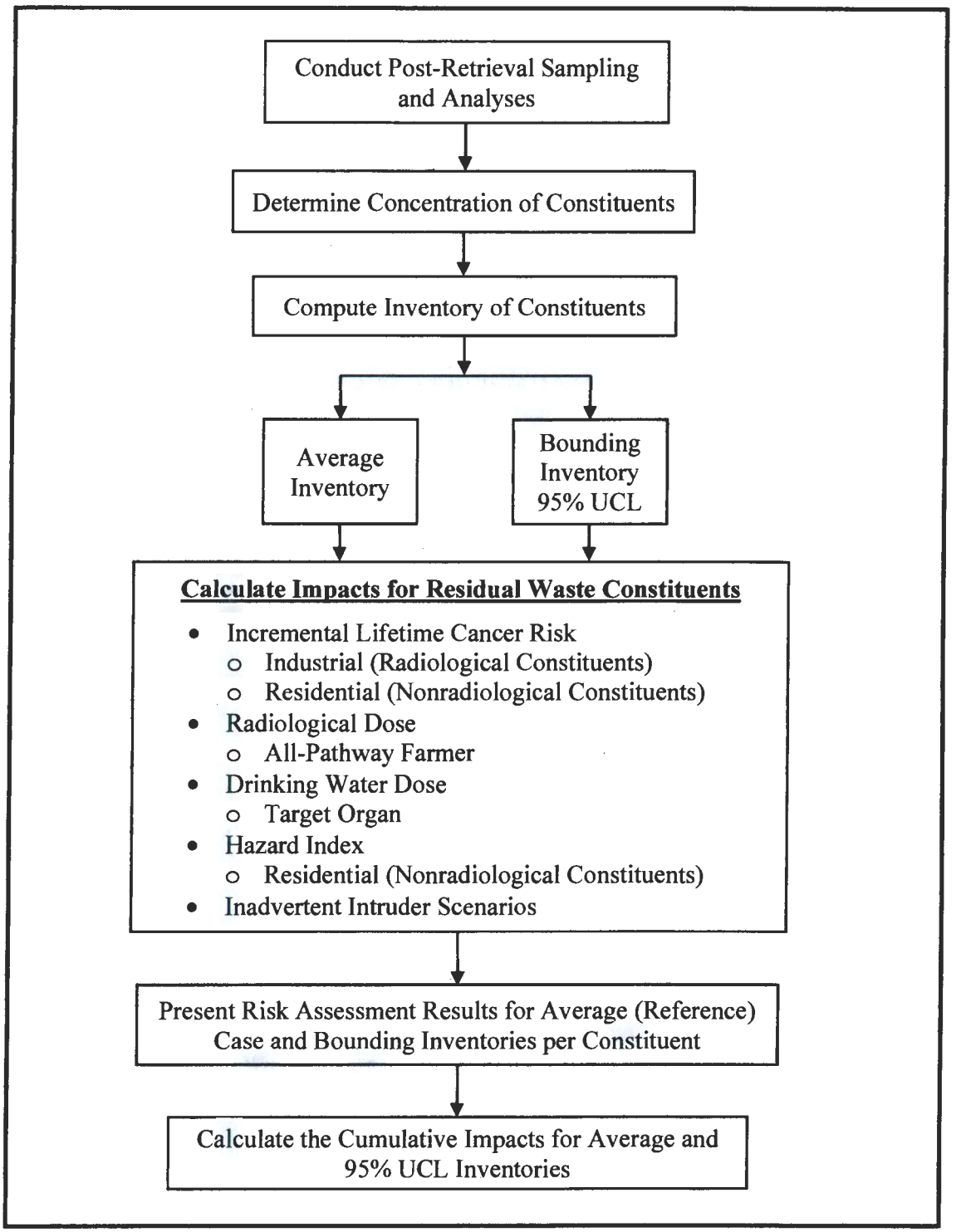
5.0 POST-RETRIEVAL SINGLE-SHELL TANK 241-C-104 RISK ASSESSMENT

The potential impacts to human health posed by the residual waste in tank C-104 were evaluated using the methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*. Figure 5-1 provides a schematic of the process used for the tank C-104 risk assessment, and this methodology is described in detail in Chapter 3 of DOE/ORP-2005-01. The SST performance assessment (PA) methodology represents the current approach being used to support the assessment of long-term impacts to human health from tank residuals left in individual SSTs in RDRs. Decisions on final closure of tank C-104, all other SSTs, and ancillary facilities and equipment within Waste Management Area (WMA) C will be supported by a site-specific PA as outlined in Appendix I of the HFFACO. That single PA will evaluate whether closure conditions at WMA C will be protective of human health and the environment for all contaminants of concern, both radiological and non-radiological. The DOE intends that PA will document by reference relevant performance requirements defined by *Resource Conservation and Recovery Act of 1976* (RCRA), RCW 70.105, *Federal Water Pollution Control Act* (Clean Water Act), *Safe Drinking Water Act of 1974*, and the *Atomic Energy Act of 1954*, as well as any other performance requirements that might be Applicable or Relevant and Appropriate Requirements under *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA).

The inventory used in this tank C-104 risk assessment was derived from post-retrieval residual inventory results (see Section 3.0). A comparison of post-retrieval inventory to the inventory used in DOE/ORP-2005-01 is provided in Appendix C for information purposes. The inventory used in DOE/ORP-2005-01 is based on RRP-RPT-23412, *Hanford Tank Waste Operations Simulator Model Data Package for the Development Run for the Refined Target Case*. The post-retrieval inventory used in this RDR provides a more accurate representation of tank residuals than RRP-RPT-23412, and will be incorporated in the WMA C PA.

Results of the potential impacts to human health were calculated using the average and 95% UCL inventories. Results show that for the groundwater pathway, the effects associated with tank C-104 are one to two orders of magnitude below current incremental lifetime cancer risk (ILCR) performance objectives (1.0E-06 to 1.0E-4) for radioactive analytes and seven to eight orders of magnitude below the ILCR performance objectives (1.0E-05) for non-radioactive analytes. The hazard indices for the tank C-104 groundwater pathway are four to five orders of magnitude below the performance objective (1.0). For all inadvertent intruder scenarios other than the suburban garden scenario (a sensitivity case) at 100 years after closure, the effects associated with tank C-104 were well below both the 100 mrem/yr performance objective for chronic exposure and the 500 mrem performance objective for acute exposure. For comparison, at 500 years after closure, the effects estimated for the suburban garden scenario are two orders of magnitude below the 100 mrem/yr performance objectives for chronic exposure. Details of these results are provided in Sections 5.2 through 5.4.

Figure 5-1. Single-Shell Tank 241-C-104 Residual Waste Inventory and Risk Assessment Process.



UCL = upper confidence level

Also provided is additional risk management information related to concentrations of constituents remaining in waste residuals within tank C-104 compared against the WAC 173-340 cleanup standards. The soil cleanup standards evaluated are developed for direct contact exposures and for groundwater protection. Selected constituent concentrations estimated for the average and 95% UCL inventories of tank residuals are specifically compared against soil direct contact cleanup levels for unrestricted land use (Method B), soil direct contact cleanup levels for industrial land use (Method C), and soil cleanup levels protective of groundwater using the fixed parameter three-phase partitioning model given in WAC 173-340-747, "Deriving Soil Concentrations for Groundwater Protection," subsection (4), "Fixed parameter three-phase partitioning model." Results of these comparisons are found in Section 5.5.1.

Section 5.5 also includes a discussion of the appropriateness of comparisons for constituent concentrations remaining in waste residuals within tank C-104 against cleanup standards protective of ecological risk found in WAC 173-340. Because footnotes in tables containing the cleanup standards protective of ecological concerns indicate these standards are not intended to be used for evaluation of sludges or wastes, specific comparisons of concentrations of constituents remaining in waste residuals within tank C-104 against the WAC 173-340 cleanup standards related to ecosystem risk are not provided.

5.1 CONSTITUENTS EVALUATED

Following retrieval, the residual waste was sampled and analyzed. This risk assessment is based on the analytical results from the post-retrieval sample (Section 3.0).

Analytical data for tank C-104 were collected and analyzed as defined by the closure DQOs. The post-retrieval samples were analyzed for 109 constituents (i.e., radionuclides, volatile organic compounds, semi-volatile organic compounds, polychlorinated biphenyls [PCBs], and inorganics [including metals and conventional parameters]) in accordance with approved 222-S Laboratory procedures based on U.S. Environmental Protection Agency (EPA) approved methods. However, analytes flagged as a non-detect were evaluated at one-half the detection limit in accordance with EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.* Table 5-1 presents a complete listing of the analytes evaluated, whether the analyte was detected, and whether a dose factor (DFR) reference dose (Rfd), or cancer potency factor (CPF), also a Cancer Slope Factor, is published for that analyte.

Table 5-1. List of Analytes and Available Toxicity Information. (3 sheets)

Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]	Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]
^{241}Am	Americium-241		DFR/CPF	7440-50-8	Copper		Rfd
^{125}Sb	Antimony-125*	U	DFR/CPF	57-12-5	Cyanide*	U	Rfd
^{137m}Ba	Barium-137m*		--	75-09-2	Dichloromethane (methylene chloride)*		Rfd/CPF
^{14}C	Carbon-14		DFR/CPF	100-41-4	Ethylbenzene		Rfd/CPF
^{137}Cs	Cesium-137 + Daughters		DFR/CPF	7440-53-1	Europium	U	--
^{60}Co	Cobalt-60	U	DFR/CPF	16984-48-8	Fluoride		Rfd
^{242}Cm	Curium-242		DFR/CPF	12311-97-6	Formate+A2		--
^{243}Cm	Curium-243		DFR/CPF	Glycolate	Glycolate	U	--
^{244}Cm	Curium-244		DFR/CPF	7439-89-6	Iron		Rfd
^{152}Eu	Europium-152	U	DFR/CPF	7439-91-0	Lanthanum	U	--
^{154}Eu	Europium-154	U	DFR/CPF	7439-92-1	Lead*		--
^{155}Eu	Europium-155	U	DFR/CPF	7439-93-2	Lithium		Rfd
^{129}I	Iodine-129	U	DFR/CPF	7439-95-4	Magnesium		--
^{237}Np	Neptunium-237 + D	U	DFR/CPF	7439-96-5	Manganese		Rfd
^{63}Ni	Nickel-63*		DFR/CPF	7439-97-6	Mercury*		Rfd
^{238}Pu	Plutonium-238		DFR/CPF	7439-98-7	Molybdenum		Rfd
^{239}Pu	Plutonium-239		DFR/CPF	108-38-3	m-Xylene	U	Rfd
^{240}Pu	Plutonium-240		DFR/CPF	71-36-3	n-Butyl alcohol (1-butanol)		Rfd
^{241}Pu	Plutonium-241 + D		DFR/CPF	7440-00-8	Neodymium		--
^{242}Pu	Plutonium-242		DFR/CPF	7440-02-0	Nickel*		Rfd
^{231}Pa	Protactinium-231	U	DFR/CPF	7440-03-1	Niobium		--
^{79}Se	Selenium-79*	U	DFR/CPF	14797-55-8	Nitrate		Rfd

Table 5-1. List of Analytes and Available Toxicity Information. (3 sheets)

Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]	Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]
^{90}Sr	Strontium-90 + D		DFR/CPF	14797-65-0	Nitrite		Rfd
^{99}Tc	Technetium-99		DFR/CPF	338-70-5	Oxalate		--
^{228}Th	Thorium-228 + D		DFR/CPF	95-47-6	o-Xylene	U	Rfd
^{230}Th	Thorium-230	U	DFR/CPF	7440-05-3	Palladium		--
^{232}Th	Thorium-232		DFR/CPF	14265-44-2	Phosphate		--
^{126}Sn	Tin-126		DFR/CPF	1336-36-3	Polychlorinated biphenyls*		CPF
^{3}H	Tritium	U	DFR/CPF	7440-09-7	Potassium		--
^{233}U	Uranium-233	U	DFR/CPF	7440-10-0	Praseodymium		--
^{234}U	Uranium-234		DFR/CPF	7440-16-6	Rhodium	U	--
^{235}U	Uranium-235 + D		DFR/CPF	7440-17-7	Rubidium	U	--
^{236}U	Uranium-236		DFR/CPF	7440-18-8	Ruthenium	U	--
^{238}U	Uranium-238 + D		DFR/CPF	7782-49-2	Selenium*	U	Rfd
^{90}Y	Yttrium-90		CPF	7440-21-3	Silicon		--
79-01-6	1, 1, 2-Trichloroethylene	U	Rfd/CPF	7440-22-4	Silver*		Rfd
78-93-3	2-Butanone (MEK)*	U	Rfd	7440-23-5	Sodium		--
67-64-1	2-Propanone (Acetone)*	U	Rfd	7440-24-6	Strontium		Rfd
108-10-1	4-Methyl-2-pentanone (MIBK)	U	Rfd	14808-79-8	Sulfate		--
71-50-1	Acetate		--	7440-25-7	Tantalum		--
7429-90-5	Aluminum		Rfd	13494-80-9	Tellurium		--
7664-41-7	Ammonia		Rfd	7440-28-0	Thallium*	U	Rfd
7440-36-0	Antimony*	U	Rfd	7440-29-1	Thorium		--
7440-38-2	Arsenic*	U	Rfd/CPF	7440-31-5	Tin		Rfd

Table 5-1. List of Analytes and Available Toxicity Information. (3 sheets)

Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]	Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]
7440-39-3	Barium*		Rfd	7440-32-6	Titanium		--
71-43-2	Benzene*		Rfd/CPF	108-88-3	Toluene*		Rfd
7440-41-7	Beryllium*		Rfd/CPF	126-73-8	Tributyl phosphate	U	Rfd/CPF
7440-69-9	Bismuth		--	7440-33-7	Tungsten		--
24959-67-9	Bromide	U	--	7440-61-1	Uranium		Rfd
7440-43-9	Cadmium*		Rfd/CPF	7440-62-2	Vanadium		Rfd
7440-70-2	Calcium		--	1330-20-7	Xylenes	U	Rfd
7440-45-1	Cerium		Rfd	7440-65-5	Yttrium		--
16887-00-6	Chloride		--	7440-66-6	Zinc		Rfd
7440-47-3	Chromium, Total*		--	7440-67-7	Zirconium		Rfd
7440-48-4	Cobalt		Rfd/CPF				

* Dangerous waste constituent per *Washington Administrative Code* 173-303-9905, "Dangerous Waste Constituents List."

[a] RPP-RPT-55307, *Tank 241-C-104 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

[b] HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments.*

CAS = Chemical Abstracts Service
CPF = Cancer Potency factor (also known as Cancer Slope factor)
DFR = Dose factor
Rfd = Reference dose
U = Analyte not detected in residual wastes
-- = No available toxicity value (dose factor, slope factor, and reference dose)

Gray shaded area indicates non-detect for this analyte.

5.2 RESULTS FOR INDIVIDUAL CONTAMINANTS FOR POST-RETRIEVAL SINGLE-SHELL TANK 241-C-104

Table 5-2 identifies the main contributors to the ILCR (industrial and residential scenarios), groundwater dose (all-pathways farmer scenario), and drinking water dose for radiological components of the residual waste remaining in tank C-104. Table 5-3 identifies the primary hazardous chemicals that contribute to ILCR and the Hazard Quotient. These results are provided for the average residual waste inventory for tank C-104. A more complete listing of all analytes for the same average inventory is provided in Tables D-1 and D-2 of Appendix D. A similar set of tables based on the 95% UCL inventory is provided in Tables D-3 and D-4 of Appendix D. In each of these tables, the following columns are provided.

a. **Analyte Name**.

b. **Detected in Residual Wastes** is an indicator as to whether an analyte was detected in the laboratory.

c. **Inventory** as shown here for non-detects is calculated at one-half the detection limit.

d. **WMA C Fenceline Concentration** is the maximum modeled concentration for a constituent at the WMA C fenceline over the modeling period. In the methodology used in DOE/ORP-2005-01, this concentration was estimated using cross-sectional modeling of vadose zone and groundwater flow and transport. In some cases, individual analytes may not have a corresponding concentration at the fenceline because short-lived radionuclides will decay away before the contaminant can arrive at the WMA C fenceline. Relatively immobile contaminants (i.e., K_d greater than 0.6 mg/L) will also result in a zero concentration at the fenceline as they will not reach the fenceline within 10,000 years (based on assumptions and transport modeling approach used).

e. **Peak Year** is the year in which the simulation estimates that peak concentration for a given analyte arrives at the fenceline.

f. **K_d** is the mobility factor used in the groundwater modeling for the analyte. The smaller the K_d, the more mobile the contaminant; if the K_d is zero, the contaminant moves with the groundwater.

g. **Half-life** is the duration in years for a radionuclide to decay to half its activity. Organic compounds were assumed not to decay (radionuclides only).

h. **Incremental Lifetime Cancer Risk** (groundwater) is described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments* for the industrial and residential exposure scenarios [including WAC 173-340, Method B (residential)].

i. **Radiological Dose** is the estimated drinking water dose for the all-pathways farmer exposure scenario (radionuclides only).

j. **Radiological Dose – Beta/Photon** is the drinking water dose from beta/photon emitting radionuclides using equivalent dose (radionuclides only).

k. **Hazard Quotient** (groundwater) – Hazard quotients calculated for residential and industrial scenarios described in HNF-SD-WM-TI-707.

5.3 CUMULATIVE ANALYSIS RESULTS FOR SINGLE-SHELL TANK 241-C-104 AND WASTE MANAGEMENT AREA C

The cumulative analysis (i.e., sum of the risk metrics) for tank C-104 residual average and 95% UCL risk levels were calculated and are provided in this section.

- **Average Inventory**—best estimate of the residual waste inventory computed using mean sample concentrations, mean sample density, and best estimate of the residual volume.

- **95% UCL Inventory**—considered the bounding inventory. The 95% UCL of the average inventory was calculated based on uncertainties associated with the concentration, volume, and density (for solids) measurements (see Section 3.0).

The impacts for the groundwater pathway associated with each residual waste inventory are evaluated with a variety of performance metrics. The ILCRs are evaluated for radiological analytes using the average and 95% UCL inventories and industrial and residential exposure scenarios. The ILCR and hazard indices are examined for the same inventories using a residential exposure scenario.

Radiological doses using the same two inventories are also evaluated for an all-pathways farmer and a drinking water only exposure scenario. Estimated concentration levels of some selected analytes are also provided and compared against current maximum concentration levels.

A comparison of impacts from the average and the 95% UCL inventories and current performance metrics for ILCR, hazard indices, and maximum concentration limits are summarized in Table 5-4.

Table 5-2. Estimated Maximum Incremental Lifetime Cancer Risk/Radiological Dose During the Modeling Period for Primary Radionuclides Related to Average Residual Waste Inventory in Single-Shell Tank 241-C-104.

Analyte	Above Detection Limits in Residual Waste	Inventory (Ci)	Waste Management Area C Fenceline Concentration (pCi/L)	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Lifetime Cancer Risk		Radiological Dose (mrem/yr) All Pathways Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
^{14}C	Yes	1.76E-03	2.71E-03	9.78E+03	0.00E+00	5.73E+03	2.11E-11	1.52E-10	1.31E-05	5.42E-06
^{99}Tc	Yes	1.73E-01	6.91E-01	1.05E+04	0.00E+00	2.11E+05	9.52E-09	2.32E-07	1.21E-03	3.07E-03
^{129}I	No	1.38E-04	<1.00E-03[c]	1.20E+04	2.00E-01	1.57E+07	NE	NE	NE	NE
^{234}U	Yes	2.37E-01	0.00E+00	DNA	6.00E-01	2.46E+05	NE	NE	NE	N/A
^{235}U	Yes	1.13E-02	0.00E+00	DNA	6.00E-01	7.04E+08	NE	NE	NE	N/A
^{236}U	Yes	2.76E-03	0.00E+00	DNA	6.00E-01	2.34E+07	NE	NE	NE	N/A
^{238}U	Yes	2.50E-01	0.00E+00	DNA	6.00E-01	4.47E+09	NE	NE	NE	N/A
Performance Objective[d]							1-0E-6 to 1.0E-4[e]	1-0E-6 to 1.0E-4[e]	25[f]	4[g]

[a] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, for the basis for the K_d values listed for the radionuclides.

[b] All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*.

[c] Simulation predicted contaminant arrives at the fenceline, but at a concentration (<0.001 pCi/L) that is much below the minimum detection limit for standard analytical methods.

[d] Performance objectives apply to the cumulative (i.e., all contaminants) for the entire waste management area.

[e] EPA/540/R-99/006, *Radiation Risk Assessment at CERCLA Sites: Q & A*, Directive 9200.4-31P.

[f] DOE O 435.1, *Radioactive Waste Management*.

[g] 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule."

DNA = Did not arrive at fenceline within the modeling period.
N/A = Radionuclide is not a beta/photon emitter.
NE = Constituent analyzed, but this risk metric was not calculated because the analyte was predicted to have a concentration less than 0.001 pCi/L, which is well below the ability of standard laboratory methods to detect it or did not arrive at fenceline within the modeling period.

Shaded cells indicate nondetects in sludge or supernate, and the inventory used in the risk assessment is calculated at one-half the minimum detection limit.

Table 5-3. Estimated Maximum Value for Incremental Lifetime Cancer Risk and Hazard Quotient for Selected Non-Radiological Analytes Related to Average Residual Waste Inventory in Single-Shell Tank 241-C-104.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[a]	Incremental Lifetime Cancer Risk Scenarios (Groundwater)[b]	Hazard Quotient (Groundwater)[b]
						WAC 173-340 Method B	
Chromium, Total*	Yes	1.74E+00	7.14E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Fluoride	Yes	8.74E+00	3.59E-02	1.05E+04	0.00E+00	No CPF	3.74E-05
Nitrate	Yes	5.34E+00	2.19E-02	1.05E+04	0.00E+00	No CPF	8.56E-07
Nitrite	Yes	2.88E+00	1.18E-02	1.05E+04	0.00E+00	No CPF	7.39E-06
Uranium	Yes	7.50E+02	0.00E+00	DNA	6.00E-01	No CPF	NE
Performance Objective[c]						1.0E-06[d]	1.0[e]

Reference: *Washington Administrative Code* (WAC) 173-340, "Model Toxics Control Act – Cleanup."

[a] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, for the basis for the K_d values listed for chromium and nitrate. The K_d values listed for the organic chemical compounds are determined from the chemicals' organic carbon/water partitioning coefficient and an estimate of 0.03% for the Hanford Site sediments fraction of organic content (PNNL-13895, Rev. 1, page 11, paragraph 3).

[b] All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*.

[c] Single Analyte Performance objectives apply to entire waste management area, not just a single component of the waste management area.

[d] WAC 173-340-705, "Use of Method B" subsection (2)(c)(ii).

[e] WAC 173-340-705 (2)(c)(i).

DNA = Did not arrive at fenceline within the modeling period.
NE = Constituent analyzed, but this risk metric was not calculated because the analyte was predicted to have a concentration less than 0.001 µg/L, which is well below the ability of standard laboratory methods to detect it or did not arrive at fenceline within the modeling period.
No CPF = No cancer potency factor available.

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III) insoluble salts.

Table 5-4. Comparison of Cumulative Incremental Lifetime Cancer Risk, Hazard Index, and Groundwater Concentration at Peak Waste Management Area C Fenceline for Average and 95% Upper Confidence Level Residual Waste Inventories in Single-Shell Tank 241-C-104. (2 sheets)

Metric[a]	Industrial Receptor		Residential Receptor		Performance Objective[b]
	Average Inventory	95% Upper Confidence Level Inventory	Average Inventory	95% Upper Confidence Level Inventory	
Incremental Lifetime Cancer Risk from Radioactive Analytes (unitless)					
Total without non-detects[c]	9.54E-09	1.46E-08	2.32E-07	3.55E-07	1.0E-06 to 1.0E-4[e]
Total with non-detects[d]	9.54E-09	1.46E-08	2.32E-07	3.55E-07	
Incremental Lifetime Cancer Risk from Non-Radioactive Analytes (unitless)					
Total without non-detects[c]	9.56E-14	2.82E-13	2.25E-13	6.55E-13	1.0E-5[f]
Total with non-detects[d]	2.40E-13	7.12E-13	5.12E-13	1.51E-12	
Hazard Index (unitless)					
Total without non-detects[c]	8.56E-06	1.57E-05	5.15E-05	9.66E-05	1.0[f]
Total with non-detects[d]	8.56E-06	1.57E-05	5.15E-05	9.66E-05	
	All Pathways Farmer		**Drinking Water Only**		
Radiological Dose (mrem/yr)	**Average Inventory**	**95% Upper Confidence Level Inventory**	**Average Inventory**	**95% Upper Confidence Level Inventory**	**Performance Objective[b]**
Total without non-detects[c]	1.22E-03	1.87E-03	3.08E-03	4.71E-03	25[g] and 4[h] mrem/yr
Total with non-detects[d]	1.22E-03	1.87E-03	3.08E-03	4.71E-03	

Table 5-4. Comparison of Cumulative Incremental Lifetime Cancer Risk, Hazard Index, and Groundwater Concentration at Peak Waste Management Area C Fenceline for Average and 95% Upper Confidence Level Residual Waste Inventories in Single-Shell Tank 241-C-104. (2 sheets)

		Waste Management Area C Fenceline Concentration[c, d]		
Analyte	**Detected In Residual Wastes**	**Average Inventory**	**95% Upper Confidence Level Inventory**	**Maximum Concentration Limit**
Technetium-99	Yes	6.91E-01 pCi/L	1.06E+00 pCi/L	900 pCi/L
Iodine-129	No	<1.00E-03 pCi/L	<1.00E-03 pCi/L	1 pCi/L
Carbon-14	Yes	2.71E-03 pCi/L	4.08E-03 pCi/L	2,000 pCi/L
Chromium*	Yes	7.14E-03 µg/L	1.04E-02 µg/L	100 µg/L

[a] Incremental lifetime cancer risks (ILCRs) of radioactive analytes were evaluated using industrial and residential land use scenarios described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments.* ILCRs and hazard indices for non-radiological analytes were evaluated using *Washington Administrative Code* (WAC) 173-340-705, "Use of Method B," subsection (4) "Multiple hazardous substances or pathways" (residential).

[b] Performance objectives apply to entire waste management area, not just a single component of the waste management area.

[c] If detected, fenceline concentration is based on an inventory that is calculated from actual laboratory results. Analytes with a fenceline concentration of less than either 0.001 pCi/L (radioactive) or 0.001 µg/L (nonradioactive), which is a value that is well below the minimum detection limit for standard analytical methods, are reported as less than 1.00E-03 pCi/L or 0.001 µg/L.

[d] If not detected, fenceline concentration is based on an inventory that is calculated at half the detection limits of analytical results. Concentrations that are less than either 0.001 pCi/L (radioactive) or 0.001 µg/L (nonradioactive), which is a value that is well below the minimum detection limit for standard analytical methods, are reported as less than 1.00E-03 pCi/L or 0.001 µg/L.

[e] EPA/540/R-99/006, *Radiation Risk Assessment at CERCLA Sites: Q & A*, Directive 9200.4-31P.

[f] WAC 173-340-705 (4).

[g] DOE O 435.1, *Radioactive Waste Management.*

[h] 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule."

Gray shaded cells are nondetects and the inventory used in the risk assessment is calculated at one-half the minimum detection limit.

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III) insoluble salts.

Results of the Table 5-4 comparison can be summarized as follows:

Performance Metric	Comparison(s) with Performance Objective
ILCR for Radioactive Analytes (1.0E-06 to 1.0E-04 ILCR)	• Estimated ILCRs for all radionuclides are between one to two orders of magnitude below performance objective range of 1.0E-06 to 1.0E-04 ILCR.
ILCR for Non-Radiological Analytes (1.0E-05 ILCR)	• Estimated ILCRs for all non-radionuclides are seven to eight orders of magnitude lower than the upper end of the performance objective of 1.0E-05 ILCR.
Hazard Indices (1.0)	• Estimated hazard indices for all analytes are four to five orders of magnitude below performance objective of 1.0.
Radiological Dose • 25 mrem/yr All-Pathways • 4 mrem/yr Drinking Water Only	• Estimated doses for all radionuclides are between o Four and six orders of magnitude below the performance objective for the all-pathways dose of 25 mrem/yr o Three and six orders of magnitude below the performance objective for drinking water dose of 4 mrem/yr.
Maximum Concentration Limits of Key Analytes: • ^{99}Tc – 900 pCi/L • ^{129}I – 1 pCi/L • ^{14}C – 2,000 pCi/L • Cr – 100 µg/L	• Estimated concentrations for Cr are five orders of magnitude less than 100 µg/L maximum concentration level. • Estimated concentrations for ^{99}Tc are four orders of magnitude below 900 pCi/L maximum contaminant level. • Predicted concentration levels of other constituents of potential concern (e.g., ^{129}I and ^{14}C) are significantly lower than their respective maximum contaminant levels.

5.4 INADVERTENT INTRUDER

The DOE recognizes that an inadvertent intruder may be onsite and not be discovered until after exposure has occurred. The radiological dose to an inadvertent intruder is therefore estimated as a part of this risk assessment.

The scenarios considered in this assessment for radiological doses from inadvertent intrusions included: 1) a well driller scenario that was used as a reference case for acute exposure in the SST PA and 2) a rural pasture scenario that was used as a reference case for chronic exposure in the SST PA. This assessment of doses from inadvertent intrusions also evaluated chronic exposure scenarios that included: 1) a suburban gardener scenario and 2) a commercial farmer scenario that were used as sensitivity cases for chronic exposure in the SST PA.

A summary of doses calculated for each of the intruder scenarios for the average and 95% UCL inventories remaining at tank C-104 at 100 years and 500 years after closure for tank C-104 are provided in Table 5-5. A summary of doses calculated for each of the intruder scenarios for the average and 95% UCL inventories at 100-year intervals between 100 and 1,000 years after closure for tank C-104 are provided in Table 5-6. Tables and plots of doses related to individual radioactive analytes are provided in Tables D-5 through D-8 and Figures D-1 through D-4 in Appendix D.

Table 5-5. Comparison of Intruder Doses at 100 and 500 years After Closure from Residual Waste for Single-Shell Tank 241-C-104.

Years after Closure[1]	Inventory	SST PA Reference Case		SST PA Sensitivity Cases	
		Well Driller[2] (mrem)	Rural Pasture[3] (mrem/yr)	Suburban Garden[3] (mrem/yr)	Commercial Farm[3] (mrem/yr)
100	Average	4.4	24	332	2.1E-02
	95% UCL	8.2	47	659	4.0E-02
500	Average	0.43	0.12	2.7	3.4E-03
	95% UCL	0.87	0.24	5.5	6.7E-03

PA = performance assessment SST = single-shell tank UCL = upper confidence level

Notes:
[1] Site closure is assumed to occur on January 1, 2032.
[2] Performance Objective (Acute Exposure) – 500 mrem.
[3] Performance Objective (Chronic Exposure) – 100 mrem/yr.

A review of detailed results and plots in Appendix D (Tables D-5 through D-8 and Figures D-1 through D-4) resulted in the following observations about key analytes for inadvertent intruder impacts:

Inadvertent Intrusion Scenario	Key Radionuclides			
	^{137}Cs	^{90}Sr	^{239}Pu	^{241}Am
Well Driller	Primary contributor to dose up to ~220 yrs after closure	Secondary contributor to dose up to ~120 yrs after closure	Secondary contributors to dose between ~120 and ~220 yrs after closure; primary contributors to dose after ~220 yrs post-closure	
Rural Pasture	Secondary contributor to dose up to ~220 yrs after closure	Primary contributor to dose up to ~350 yrs after closure	Secondary contributors to dose between ~220 and ~340 yrs after closure; primary contributor to dose after ~340 yrs post-closure	
Suburban Gardener	Secondary contributor to dose up to ~180 yrs after closure	Primary contributor to dose up to ~340 yrs after closure	Secondary contributors to dose between ~180 and ~340 yrs after closure; primary contributor to dose after ~340 yrs post-closure	
Commercial Farm	Primary contributor to dose up to ~180 yrs after closure	Is not a primary or secondary contributor after ~100 yrs	Secondary contributor to dose between ~100 and ~180 yrs after closure; primary contributor to dose after ~180 yrs post-closure	

Table 5-6. Potential Future Impact from Inadvertent Intrusion into Residual Waste for Average and 95% Upper Confidence Level Inventories.

Years After Closure[1]	100	200	300	400	500	600	700	800	900	1,000
Inadvertent Intrusion Acute Dose[2] (mrem) – Well Driller Scenario										
Average Inventory	4.4	0.90	0.52	0.46	0.43	0.41	0.39	0.38	0.36	0.35
95% Upper Confidence Level Inventory	8.2	1.7	1.04	0.93	0.87	0.83	0.80	0.77	0.74	0.72
Inadvertent Intrusion Acute Dose[3] (mrem/yr) – Rural Pasture Scenario										
Average Inventory	24	2.2	0.31	0.14	0.12	0.11	0.11	0.10	0.10	0.10
95% Upper Confidence Level Inventory	47	4.3	0.61	0.28	0.24	0.23	0.22	0.21	0.20	0.20
Inadvertent Intrusion Chronic Dose[3] (mrem/yr) – Suburban Gardener Scenario										
Average Inventory	332	31	5.5	3.1	2.7	2.6	2.5	2.4	2.3	2.2
95% Upper Confidence Level Inventory	659	62	10.9	6.2	5.5	5.2	5.0	4.8	4.6	4.5
Inadvertent Intrusion Chronic Dose[3] (mrem/yr) – Commercial Farm Scenario										
Average Inventory	2.1E-02	5.7E-03	4.0E-03	3.6E-03	3.4E-03	3.2E-03	3.1E-03	2.9E-03	2.8E-03	2.7E-03
95% Upper Confidence Level Inventory	4.0E-02	1.1E-02	7.8E-03	7.1E-03	6.7E-03	6.4E-03	6.1E-03	5.9E-03	5.7E-03	5.6E-03

[1] Site closure is assumed to occur on January 1, 2032.
[2] Performance Objective (Acute Exposure) – 500 mrem.
[3] Performance Objective (Chronic Exposure) – 100 mrem/yr.

At 100 years after closure (see Table 5-5 and 5-6), doses for the well driller scenario were estimated to be ~0.88% and 1.6% of the 500 mrem acute exposure performance objective for the average and the 95% UCL inventories, respectively. At 100 years after closure, doses with the rural pasture scenario were estimated to be ~24% and 47% of the 100 mrem/yr chronic exposure performance objective for the average and 95% UCL inventories, respectively. However, doses resulting from chronic exposure in the suburban garden scenario were ~330% and 660% higher than the 100 mrem/yr chronic exposure performance objective for the average and 95% UCL inventories, respectively (see Table 5-5). Doses resulting from the commercial farmer were well below (e.g., 0.02% and 0.04%) the 100 mrem/yr chronic exposure performance objective for the average and 95% UCL inventories, respectively (see Table 5-5).

By 500 years after closure (see Tables 5-5 and 5-6), the estimated doses for the well driller scenario for the average and 95% UCL inventories were ~0.09% and 0.17% of the acute exposure performance objective of 500 mrem, respectively. At 500 years after closure, doses for all inadvertent intruder scenarios used to evaluate the doses from chronic exposure were well below the chronic exposure performance objective of 100 mrem/yr. The highest estimated dose at 500 yrs after closure was for the suburban gardener scenario using the 95% UCL inventory, which yielded a dose that was estimated to be ~5.5% of the 100 mrem/yr performance objective (see Table 5-5).

5.5 COMPARISON OF TANK RESIDUALS WITH MODEL TOXICS CONTROL ACT SOIL CLEANUP LEVELS

This section provides additional risk management information related to concentrations of constituents remaining in waste residuals within tank C-104 compared against the WAC 173-340 cleanup standards. In this section, specific comparisons are made between the concentrations of constituents remaining in tank C-104 against the Model Toxics Control Act (MTCA) (RCW 70.105D, "Hazardous Waste Cleanup — Model Toxics Control Act") WAC 173-340 cleanup standards for soil direct contact unrestricted land use (Method B), industrial land use (Method C), and soil concentrations protective of groundwater using the fixed parameter three-phase partitioning model given in WAC 173-340-747(4).

Per WAC 173-340-740, "Unrestricted Land Use Soil Cleanup Standards," for soil cleanup levels based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to 15 ft below the ground surface. Under a closure configuration, waste residuals left in tank C-104 and other SSTs in WMA C would be expected to be below 15 ft below ground surface.

Implicit in the use of the fixed parameter three-phase partitioning model given in WAC 173-340-747 deriving soil cleanup levels for groundwater protection is the assumption that constituents of interest are found in soils and are immediately available to be leached by infiltrating precipitation. Under a closure configuration, constituents associated with waste residuals left in tank C-104 and other SSTs in WMA C would be contained within a grout-filled

tank, a steel tank liner, and an underlying concrete pad below the liner and would not be immediately available for leaching by infiltrating water.

5.5.1 WAC 173-340 Direct Contact and Soil Concentrations Protective of Groundwater

Table 5-7 contains the average and 95% UCL concentrations of detected constituents estimated in residual waste for tank C-104 on a mass basis for comparison against WAC 173-340 cleanup levels for soil direct contact unrestricted land use (Method B), industrial land use (Method C), and soil concentration protective of groundwater. An expanded list of WAC 173-340 Method B and Method C soil cleanup levels and soil concentrations protective of groundwater is provided in Table D-9. Table 5-7 also provides Hanford Site-specific 90th percentile background concentrations, and identifies analytes that are dangerous waste constituents per WAC 173-303-9905, "Dangerous Waste Constituents List." A more detailed list of background concentrations and references is provided in Table D-12 of Appendix D.

Ratios of the average and 95% UCL concentrations to cleanup levels for soil direct contact (Method B and Method C) and soil concentrations protective of groundwater are provided in Tables 5-8 and 5-9, respectively. The ratios are obtained by dividing the analyte concentration by the soil direct contact cleanup level or the soil concentration protective of groundwater. The level of exceedance (ratio) corresponds to the level of residual waste concentration remaining in tank C-104 above or below the cleanup level. A level of exceedance greater than 1 corresponds to a residual waste concentration greater than the cleanup level. Tables 5-8 and 5-9 also identify analytes that are dangerous waste constituents per WAC 173-303-9905 and analytes with concentrations that exceed 90th percentile background concentrations. Expanded lists of non-radioactive analytes that were not detected are provided in Tables D-10 and D-11 in in Appendix D.

The results for waste residual concentrations estimated for the average residual waste inventory from detected analytes are briefly summarized below.

- For direct contact under an unrestricted land use scenario, only aluminum, cadmium, mercury, PCBs, silver, and uranium are above the cleanup levels, with only uranium having a concentration more than 100 times the soil cleanup level. Cadmium, mercury, PCBs, and silver are listed as dangerous constituents in WAC 173-303-9905.

- For direct contact under an industrial land use scenario, only uranium is above the cleanup level, and has a concentration more than 10 times the soil cleanup level.

- For soil concentrations protective of groundwater, cadmium, iron, manganese, mercury, nickel, nitrate, nitrite, silver, and uranium are all above the concentration predicted by the MTCA fixed parameter three-phase model, with silver and uranium being greater than 100 times above the concentration protective of groundwater. Cadmium, mercury, nickel, and silver are listed as dangerous constituents in WAC 173-303-9905.

Table 5-7. Average and 95% Upper Limit Concentrations of Selected Constituents Estimated for Waste Residuals within Tank 241-C-104, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater. (3 sheets)

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Lognormal 90 Percentile Background Value (mg/kg)	Above Detection Limits
Aluminum	1.00E+05	1.44E+05	8.00E+04	3.50E+06	4.80E+05	1.18E+07[e]	Yes
Barium*	5.78E+01	8.46E+01	1.60E+04	7.00E+05	1.65E+03	1.32E+05[e]	Yes
Benzene*	3.42E-03	1.01E-02	1.82E+01	2.39E+03	4.48E-03	--	Yes
Beryllium*	3.25E+00	3.86E+00	1.60E+02	7.00E+03	6.32E+01	1.51E+03[e]	Yes
Cadmium*	1.72E+02	2.94E+02	8.00E+01	3.50E+03	6.90E-01	5.63E+02[g]	Yes
Chloride	5.23E+01	7.11E+01	--	--	1.00E+03	1.00E+05[e]	Yes
Chromium, Total*	2.69E+02	3.37E+02	1.20E+05	5.25E+06	2.00E+03	--	Yes
Cobalt	3.17E+00	4.29E+00	2.40E+01	1.05E+03	4.34E+00	1.57E+04[e]	Yes
Copper	1.61E+02	2.14E+02	3.20E+03	1.40E+05	2.84E+02	2.20E+04[e]	Yes
Dichloromethane (methylene chloride)*	3.68E-03	6.38E-03	4.80E+02	2.10E+04	2.18E-02	--	Yes
Ethylbenzene	2.11E-03	6.25E-03	9.09E+01	1.19E+04	3.44E-02	--	Yes
Fluoride	1.35E+03	2.52E+03	4.80E+03	2.10E+05	2.88E+03	2.81E+03[e]	Yes
Iron	2.84E+04	3.75E+04	5.60E+04	2.45E+06	5.64E+03	3.26E+07[e]	Yes
Lead*	5.69E+02	7.80E+02	--	1.00E+03	3.00E+03	1.02E+04[e]	Yes
Lithium	1.41E+01	1.95E+01	1.60E+02	7.00E+03	1.92E+02	1.33E+04[g]	Yes
Manganese	3.77E+03	7.49E+03	1.12E+04	4.90E+05	5.01E+02	5.12E+05[e]	Yes

Table 5-7. Average and 95% Upper Limit Concentrations of Selected Constituents Estimated for Waste Residuals within Tank 241-C-104, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater. (3 sheets)

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Lognormal 90 Percentile Background Value (mg/kg)	Above Detection Limits
Mercury*	1.18E+02	1.47E+02	2.40E+01	1.05E+03	2.09E+00	1.30E+01[g]	Yes
Molybdenum	7.04E+00	1.11E+01	4.00E+02	1.75E+04	3.23E+01	4.70E+02[g]	Yes
n-Butyl alcohol (1-butanol)	4.53E-01	8.49E-01	8.00E+03	3.50E+05	--	--	Yes
Nickel*	5.28E+02	9.15E+02	1.60E+03	7.00E+04	1.30E+02	1.91E+04[g]	Yes
Nitrate[c]	8.25E+02	8.87E+02	5.68E+05	2.49E+07	1.80E+02	5.20E+04[e]	Yes
Nitrite[d]	4.45E+02	6.16E+02	2.40E+04	1.05E+06	1.32E+01	--	Yes
Polychlorinated Biphenyls*	5.13E-01	9.48E-01	5.00E-01	6.56E+01	--	--	Yes
Silver*	1.44E+03	1.82E+03	4.00E+02	1.75E+04	1.36E+01	1.67E+02[e]	Yes
Strontium	8.22E+01	1.15E+02	4.80E+04	2.10E+06	6.76E+03	--	Yes
Sulfate	1.01E+02	1.12E+02	--	--	1.00E+03	2.37E+05[e]	Yes
Tin	3.29E+01	6.59E+01	4.80E+04	2.10E+06	4.80E+04	--	Yes
Toluene*	3.24E-03	7.09E-03	6.40E+03	2.80E+05	4.65E+00	--	Yes
Uranium	1.16E+05	1.55E+05	2.40E+02	1.05E+04	2.70E+02	3.21E+03[e]	Yes
Vanadium	3.55E+01	4.64E+01	4.00E+02	1.75E+04	1.60E+03	8.51E+04[e]	Yes
Zinc	1.26E+02	1.62E+02	2.40E+04	1.05E+06	5.97E+03	6.78E+04[e]	Yes

Table 5-7. Average and 95% Upper Limit Concentrations of Selected Constituents Estimated for Waste Residuals within Tank 241-C-104, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater. (3 sheets)

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Lognormal 90 Percentile Background Value (mg/kg)	Above Detection Limits

-- = Value is not available

[a] Mean Concentrations taken from Table A-1, Appendix A of RPP-RPT-55307, *Tank 241-C-104 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

[b] 95% Upper Confidence Level Concentration = Mean Concentration + (1.96 × Mean Concentration × Relative Standard Deviation). Relative Standard Deviation provided in Table B-1 in Appendix B.

[c] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43 (DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, Rev. 4, Volume 1).

[d] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

[e] DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, Rev. 4, Volume 1.

[f] DOE/RL-96-12, Rev. 0, *Hanford Site Background: Part 2, Soil Background for Radionuclides.*

[g] ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site.*

[h] ECF-HANFORD-10-0442, *Calculation of Nonradiological Soil Concentrations Protective of Groundwater Using the Fixed Parameter 3-Phase Equilibrium Partitioning Equation for the 100 Areas and 300 Area.*

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

Table 5-8. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Constituents above Detection in 241-C-104 Tank Residual Wastes. (2 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-104 Nominal Inventory of Residual Wastes to Soil Cleanup Standards				
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Aluminum	1.00E+05	1.25E+00	2.86E-02	2.08E-01	Yes	No
Barium*	5.78E+01	3.61E-03	8.26E-05	3.51E-02	Yes	No
Benzene*	3.42E-03	1.88E-04	1.43E-06	7.63E-01	Yes	--
Beryllium*	3.25E+00	2.03E-02	4.64E-04	5.14E-02	Yes	No
Cadmium*	1.72E+02	2.15E+00	4.91E-02	2.49E+02	Yes	No
Chloride	5.23E+01	--	--	5.23E-02	Yes	No
Chromium, Total*	2.69E+02	2.24E-03	5.12E-05	1.34E-01	Yes	--
Cobalt	3.17E+00	1.32E-01	3.02E-03	7.31E-01	Yes	No
Copper	1.61E+02	5.03E-02	1.15E-03	5.67E-01	Yes	No
Dichloromethane (methylene chloride)*	3.68E-03	7.67E-06	1.75E-07	1.69E-01	Yes	--
Ethylbenzene	2.11E-03	2.32E-05	1.77E-07	6.14E-02	Yes	--
Fluoride	1.35E+03	2.81E-01	6.43E-03	4.68E-01	Yes	No
Iron	2.84E+04	5.07E-01	1.16E-02	5.03E+00	Yes	No
Lead*	5.69E+02	--	5.69E-01	1.90E-01	Yes	No
Lithium	1.41E+01	8.81E-02	2.01E-03	7.34E-02	Yes	No
Manganese	3.77E+03	3.37E-01	7.69E-03	7.53E+00	Yes	No
Mercury*	1.18E+02	4.92E+00	1.12E-01	5.65E+01	Yes	Yes
Molybdenum	7.04E+00	1.76E-02	4.02E-04	2.18E-01	Yes	No

Table 5-8. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Constituents above Detection in 241-C-104 Tank Residual Wastes. (2 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-104 Nominal Inventory of Residual Wastes to Soil Cleanup Standards				
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
n-Butyl alcohol (1-butanol)	4.53E-01	5.66E-05	1.29E-06	--	Yes	--
Nickel*	5.28E+02	3.30E-01	7.54E-03	4.05E+00	Yes	No
Nitrate[b]	8.25E+02	1.45E-03	3.32E-05	4.58E+00	Yes	No
Nitrite[c]	4.45E+02	1.85E-02	4.24E-04	3.37E+01	Yes	--
Polychlorinated Biphenyls*	5.13E-01	1.03E+00	7.82E-03	--	Yes	--
Silver*	1.44E+03	3.60E+00	8.23E-02	1.06E+02	Yes	Yes
Strontium	8.22E+01	1.71E-03	3.91E-05	1.22E-02	Yes	--
Sulfate	1.01E+02	--	--	1.01E-01	Yes	No
Tin	3.29E+01	6.85E-04	1.57E-05	6.85E-04	Yes	--
Toluene*	3.24E-03	5.06E-07	1.16E-08	6.96E-04	Yes	--
Uranium	1.16E+05	4.83E+02	1.10E+01	4.29E+02	Yes	Yes

-- = Value is not available

[a] Mean Concentrations taken from Table A-1, Appendix A of RPP-RPT-55307, *Tank 241-C-104 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

[b] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

[c] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

Table 5-9. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Constituents above Detection in 241-C-104 Tank Residual Wastes. (2 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-104 Nominal Inventory of Residual Wastes to Soil Cleanup Standards				
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Aluminum	1.44E+05	1.80E+00	4.12E-02	3.01E-01	Yes	No
Barium*	8.46E+01	5.29E-03	1.21E-04	5.14E-02	Yes	No
Benzene*	1.01E-02	5.57E-04	4.24E-06	2.26E+00	Yes	--
Beryllium*	3.86E+00	2.41E-02	5.52E-04	6.11E-02	Yes	No
Cadmium*	2.94E+02	3.67E+00	8.39E-02	4.26E+02	Yes	No
Chloride	7.11E+01	--	--	7.11E-02	Yes	No
Chromium, Total*	3.37E+02	2.81E-03	6.42E-05	1.68E-01	Yes	--
Cobalt	4.29E+00	1.79E-01	4.08E-03	9.88E-01	Yes	No
Copper	2.14E+02	6.70E-02	1.53E-03	7.54E-01	Yes	No
Dichloromethane (methylene chloride)*	6.38E-03	1.33E-05	3.04E-07	2.93E-01	Yes	--
Ethylbenzene	6.25E-03	6.87E-05	5.23E-07	1.82E-01	Yes	--
Fluoride	2.52E+03	5.25E-01	1.20E-02	8.75E-01	Yes	No
Iron	3.75E+04	6.69E-01	1.53E-02	6.64E+00	Yes	No
Lead*	7.80E+02	--	7.80E-01	2.60E-01	Yes	No
Lithium	1.95E+01	1.22E-01	2.78E-03	1.01E-01	Yes	No
Manganese	7.49E+03	6.69E-01	1.53E-02	1.50E+01	Yes	No
Mercury*	1.47E+02	6.12E+00	1.40E-01	7.04E+01	Yes	Yes
Molybdenum	1.11E+01	2.78E-02	6.35E-04	3.44E-01	Yes	No

Table 5-9. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Constituents above Detection in 241-C-104 Tank Residual Wastes. (2 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-104 Nominal Inventory of Residual Wastes to Soil Cleanup Standards				
		Direct Contact (Method B)	Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
n-Butyl alcohol (1-butanol)	8.49E-01	1.06E-04	2.43E-06	--	Yes	--
Nickel*	9.15E+02	5.72E-01	1.31E-02	7.02E+00	Yes	No
Nitrate[b]	8.87E+02	1.56E-03	3.57E-05	4.93E+00	Yes	No
Nitrite[c]	6.16E+02	2.57E-02	5.87E-04	4.67E+01	Yes	--
Polychlorinated Biphenyls*	9.48E-01	1.90E+00	1.45E-02	--	Yes	--
Silver*	1.82E+03	4.54E+00	1.04E-01	1.33E+02	Yes	Yes
Strontium	1.15E+02	2.40E-03	5.49E-05	1.71E-02	Yes	--
Sulfate	1.12E+02	--	--	1.12E-01	Yes	No
Tin	6.59E+01	1.37E-03	3.14E-05	1.37E-03	Yes	--
Toluene*	7.09E-03	1.11E-06	2.53E-08	1.52E-03	Yes	--
Uranium	1.55E+05	6.46E+02	1.48E+01	5.74E+02	Yes	Yes

-- = Value is not available

[a] 95% Upper Confidence Level Concentration = Average Concentration + (1.96 × Average Concentration × Relative Standard Deviation). Average Concentrations and Relative Standard Deviation taken from Table A-1, Appendix A of RPP-RPT-55307, *Tank 241-C-104 Residual Waste Inventory Estimates for Component Closure Risk Assessment*.

[b] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

[c] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

The results for waste residual concentrations estimated in the 95% UCL residual waste inventory are briefly summarized below.

- For direct contact under an unrestricted land use scenario, aluminum, cadmium, mercury, PCBs, silver, and uranium are above the cleanup levels with uranium having a concentration more than 100 times the cleanup level. Cadmium, mercury, PCBs, and silver are listed as dangerous constituents in WAC 173-303-9905.

- For direct contact under an industrial land use scenario, only uranium is above the cleanup level, and has a concentration more than 10 times the soil cleanup level.

For soil concentrations protective of groundwater, benzene, cadmium, iron, manganese, mercury, nickel, nitrate, nitrite, silver, and uranium are all above the concentration predicted by the MTCA fixed parameter three-phase model, with cadmium, silver, and uranium being greater than 100 times above the concentration protective of groundwater. Benzene, cadmium, mercury, nickel, and silver are listed as dangerous constituents in WAC 173-303-9905.

The results for waste residual concentrations estimated in the 95% UCL residual waste inventory are briefly summarized below.

- For direct contact under an unrestricted land use scenario, aluminum, cadmium, mercury, PCBs, silver, and uranium are above the cleanup levels with uranium having a concentration more than 100 times the cleanup level. Cadmium, mercury, PCBs, and silver are listed as dangerous constituents in WAC 173-303-9905.

- For direct contact under an industrial land use scenario, only uranium is above the cleanup level, and has a concentration more than 10 times the soil cleanup level.

- For soil concentrations protective of groundwater, benzene, cadmium, iron, manganese, mercury, nickel, nitrate, nitrite, silver, and uranium are all above the concentration predicted by the Model Toxics Control Act fixed parameter three-phase model, with cadmium, silver, and uranium being greater than 100 times above the concentration protective of groundwater. Benzene, cadmium, mercury, nickel, and silver are listed as dangerous constituents in WAC 173-303-9905.

5.5.2 WAC 173-340 Ecological Risk

WAC 173-340-900, "Tables" includes the following tables:

- Table 749-2, Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified Terrestrial Ecological Evaluation Procedure

- Table 749-3, Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals.

Each of these tables contains a footnote stating that it is not intended for the purpose of evaluating sludges or waste, as follows (key statement bolded for this report).

- Table 749-2, footnote a: "Caution on misusing these chemical concentration numbers. These values have been developed for use at sites where a site-specific terrestrial ecological evaluation is not required. They are not intended to be protective of terrestrial ecological receptors at every site. Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under this chapter. **The table is not intended for purposes such as evaluating sludges or wastes.**
  This list does not imply that sampling must be conducted for each of these chemicals at every site. Sampling should be conducted for those chemicals that might be present based on available information, such as current and past uses of chemicals at the site."

- Table 749-3, footnote a: "Caution on misusing ecological indicator concentrations. Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under this chapter. Natural background concentrations may be substituted for ecological indicator concentrations provided in this table. **The table is not intended for purposes such as evaluating sludges or wastes.**
  This list does not imply that sampling must be conducted for each of these chemicals at every site. Sampling should be conducted for those chemicals that might be present based on available information, such as current and past uses of chemicals at the site."

Because of the limitations stated above, comparisons between the concentrations of waste constituents remaining in tank C-104 have not been made against Table 749-2 [under WAC 173-340-7492, "Simplified Terrestrial Ecological Evaluation Procedures," subsection (1) "Purpose"] or Table 749-3 [under WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures," subsection (2) "Problem formulation step," (i) "The chemicals of ecological concern"].

5.6 RISK ASSESSMENT SUMMARY

Cumulative analysis results of the risk assessment performed to examine impacts from post-retrieval inventories for tank C-104 are summarized as follows.

- The impacts estimated for residual waste left in tank C-104, using either the average or the 95% UCL inventory, are orders of magnitude below the various performance objectives identified for the groundwater pathway.

- Total ILCRs estimated for all radionuclides are one to two orders of magnitude below the upper end of the performance objective range 1.0E-06 to 1.0E-04 ILCR.

- Total ILCRs estimated for all detectable non-radionuclides are seven to eight orders of magnitude below the performance objective of 1.0E-05 ILCR.

- Total hazard indices estimated for all detectable analytes are four to five orders of magnitude below the performance objective of 1.0.

- Estimated doses for all detectable radionuclides are between:

    - Four and six orders of magnitude below the performance objective for the all-pathways dose of 25 mrem/yr

    - Three and six orders of magnitude below the performance objective for drinking water dose of 4 mrem/yr.

Following are conclusions about the impacts from key analytes identified in the residual wastes within tank C-104 for each of the performance metrics evaluated.

- **Total ILCR for Radionuclides:** For both the average and 95% UCL inventory, ^{99}Tc and ^{14}C are the primary contributors to the total ILCR for all radionuclides with the industrial land use and residential land use scenarios. The contribution from all other detectable radionuclides, including ^{129}I and the uranium isotopes, was not detectable in residual waste samples, arrived at the WMA C fenceline within the 10,000-year period of interest below concentrations of 1.0E-03 pCi/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.

- **Total ILCR for Nonradionuclides:** For both the average and 95% UCL inventory, the contribution from non-radioactive analytes detectable in residual waste samples arrived at the WMA C fenceline within the 10,000-year period of interest below concentrations of 1.0E-03 mg/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.

- **Hazard Indices:** The contribution from non-radioactive analytes detectable in residual waste samples arrived at the WMA C fenceline within the 10,000-year period of interest below concentrations of 1.0E-03 mg/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.

- **All-Pathways Dose:** ^{99}Tc and ^{14}C are the primary contributors to the total all-pathways dose estimated for the all-pathways farmer scenario. The contribution from all other radionuclides, including ^{129}I and the uranium isotopes, was not detectable in residual waste samples, arrived at the WMA C fenceline below concentrations of 1.0E-03 pCi/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.

- **Drinking Water Dose (Target Organ):** ^{99}Tc, with a maximum dose rate of 4.7E-03 mrem/yr, contributed the majority of the EPA maximum contaminant level for beta/photon emitters (4 mrem/yr target organ dose). ^{14}C, with a maximum dose rate of 8.2E-6 mrem/yr, was a secondary contributor to the EPA maximum contaminant level for beta/photon emitters. The contribution to dose from all other radionuclides, including ^{129}I, and the uranium isotopes, was not detectable in residual waste samples, arrived at the

WMA C fenceline below concentrations of 1.0E-03 pCi/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.

- **Intruder Dose:** Doses calculated from inadvertent intrusion are primarily attributable to doses from ^{90}Sr, ^{137}Cs, ^{239}Pu, and ^{241}Am. The relative contribution and timing of doses from these radionuclides to the total doses estimated during the 1,000-year period of analysis depends on the scenario considered. In general, dose contributions from ^{90}Sr and ^{137}Cs typically account for the majority of the dose during the first 200 to 300 years. Doses from ^{239}Pu and ^{241}Am contribute the majority of the dose realized after 200 to 300 years, and in the cases of the commercial farm and well driller, are the primary and secondary contributors to the total dose estimated after 200 years. For both average and 95% UCL inventories estimated for tank C-104, none of the inadvertent intruder evaluations produce results that exceed the performance objectives for either acute exposure or chronic exposure after ~120 years following closure.

As additional risk management information, concentrations of constituents remaining in waste residuals within tank C-104 are compared against the WAC 173-340 cleanup standards. For MTCA Method B and Method C soil cleanup levels based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to 15 ft below the ground surface. Under a closure configuration, waste residuals left in tank C-104 and other SSTs in WMA C would be expected to be below 15 ft below ground surface.

For MTCA soil cleanup levels protective of groundwater, the assumption is that constituents of interest are found in soils and are immediately available to be leached by infiltrating precipitation. Under a closure configuration, constituents associated with waste residuals left in tank C-104 and other SSTs in WMA C would be contained within a grout-filled tank, a steel tank liner, and an underlying concrete pad below the liner and would not be immediately available for leaching by infiltrating water.

Following are conclusions about the comparison of tank C-104 waste residual concentrations against MTCA cleanup levels.

- **MTCA Method B Unrestricted Land Use:** For both the average and 95% UCL inventory, aluminum, cadmium, mercury, PCBs, silver, and uranium are above the soil cleanup levels. Cadmium, mercury, PCBs, and silver are dangerous constituents per WAC 173-303-9905.

- **MTCA Method C Industrial Land Use:** For both the average and 95% UCL inventory, only uranium concentrations are above the soil cleanup level.

- **MTCA Soil Concentrations Protective of Groundwater:** For both the average and 95% UCL inventory, benzene, cadmium, iron, manganese, mercury, nickel, nitrate, nitrite, silver, and uranium are greater than the soil cleanup levels. Benzene, cadmium, mercury, nickel, and silver are dangerous constituents per WAC 173-303-9905.

Table 5-10 provides a comparison of the inventory used in DOE/ORP-2005-01 against the inventory for detected analytes calculated using post-retrieval samples for the average inventory and the 95% UCL inventories. For the purpose of this comparison, Table 5-10 includes inventories calculated from the laboratory's minimum detection limit for an analyte. Inventories calculated from one half of the laboratory's minimum detection limit are included in the risk assessment analysis. The following observations are made from the comparison of the Hanford Tank Waste Operations Simulator (HTWOS) and post-retrieval inventories.

- Comparison of the HTWOS estimated inventories and post-retrieval inventories for analytes important for assessment of groundwater impacts are as follows:
    - A good agreement exists between the HTWOS predicted inventory and the inventory from the post-retrieval inventories for ^{99}Tc, the key analytes for assessing groundwater impacts
    - Post-retrieval inventories for ^{14}C are between ~3 and 4 times less than the HTWOS estimate for ^{14}C
    - Post-retrieval inventories for chromium are between ~4 and 6 times less than the HTWOS estimate for chromium
    - Post-retrieval inventories for fluoride, nitrate, and nitrite are approximately one to two orders of magnitude below those in the HTWOS estimates.
- Comparison of the HTWOS estimated inventories and post-retrieval inventories for analytes important to assessing inadvertent intruder impacts are as follows:
    - Post-retrieval inventories for ^{90}Sr are between ~1.2 and 2.4 times higher than HTWOS estimates for ^{90}Sr
    - Post-retrieval inventories for ^{137}Cs are slightly higher to ~2 times higher than the HTWOS inventory estimates for ^{137}Cs
    - Post-retrieval inventories for ^{232}Th are approximately one order of magnitude less than the HTWOS estimates for ^{232}Th
    - Post-retrieval inventories for the plutonium isotopes are approximately an order of magnitude less than those in the HTWOS estimate
    - Post-retrieval inventories for ^{241}Am are approximately one order of magnitude less than those in the HTWOS estimate
    - Post-retrieval inventories for the uranium isotopes are between ~2 times less than and ~5 times higher than estimated in the HTWOS inventory.

Table 5-10. Comparison of Hanford Tank Waste Operations Simulator Predicted Inventory Used in DOE/ORP-2005-01 with the Average and 95% Upper Confidence Level Post-Retrieval Inventories.

Analyte		Units	DOE/ORP-2005-01[a] (HTWOS Predicted)	Average Post-Retrieval Inventory[b]	95% Upper Confidence Level Inventory[b]	Detected in Residual Wastes	Ratio Average/ HTWOS	Ratio Bounding/ HTWOS
Analytes Important for Groundwater Impacts	^{14}C	Ci	7.22E-03	1.76E-03	2.65E-03	Yes	2.44E-01	3.67E-01
	^{99}Tc	Ci	2.35E-01	1.73E-01	2.65E-01	Yes	7.36E-01	1.13E+00
	Chromium	Kg	9.75E+00	1.74E+00	2.53E+00	Yes	1.78E-01	2.59E-01
	Fluoride	Kg	1.31E+02	8.74E+00	1.71E+01	Yes	6.67E-02	1.31E-01
	Nitrate	Kg	7.40E+01	5.34E+00	7.38E+00	Yes	7.22E-02	9.97E-02
	Nitrite	Kg	1.38E+02	2.88E+00	4.44E+00	Yes	2.09E-02	3.22E-02
Analytes Important for Inadvertent Intruder	^{90}Sr	Ci	3.12E+03	3.72E+03	7.40E+03	Yes	1.19E+00	2.37E+00
	^{137}Cs	Ci	4.62E+02	4.67E+02	8.58E+02	Yes	1.01E+00	1.86E+00
	^{232}Th	Ci	3.89E-02	2.11E-03	4.11E-03	Yes	5.43E-02	1.06E-01
	^{233}U	Ci	2.88E+00	1.24E+00	3.77E+00	No	N/A	N/A
	^{234}U	Ci	1.45E-01	2.37E-01	3.46E-01	Yes	1.64E+00	2.39E+00
	^{235}U	Ci	4.20E-03	1.13E-02	1.70E-02	Yes	2.69E+00	4.05E+00
	^{236}U	Ci	4.76E-03	2.76E-03	4.16E-03	Yes	5.80E-01	8.74E-01
	^{238}U	Ci	8.16E-02	2.50E-01	3.77E-01	Yes	3.06E+00	4.62E+00
	^{237}Np	Ci	3.06E-02	4.54E-02	1.38E-01	No	N/A	N/A
	^{238}Pu	Ci	1.61E+00	3.69E-01	6.65E-01	Yes	2.30E-01	4.14E-01
	^{239}Pu	Ci	3.63E+01	2.93E+00	5.14E+00	Yes	8.08E-02	1.42E-01
	^{240}Pu	Ci	9.33E+00	8.82E-01	1.55E+00	Yes	9.45E-02	1.66E-01
	^{241}Pu	Ci	8.79E+01	1.16E+01	1.93E+01	Yes	1.32E-01	2.20E-01
	^{241}Am	Ci	4.44E+01	4.91E+00	9.71E+00	Yes	1.11E-01	2.19E-01
	^{242}Cm	Ci	1.44E-02	1.89E-02	3.55E-02	Yes	1.31E+00	2.47E+00
	^{243}Cm	Ci	1.28E-03	2.76E-03	6.14E-03	Yes	2.16E+00	4.81E+00
	^{244}Cm	Ci	2.85E-02	6.01E-02	1.34E-01	Yes	2.11E+00	4.70E+00

HTWOS = Hanford Tank Waste Operations Simulator
N/A = Not applicable because the inventory in both supernate and sludge was calculated from one half of the laboratory's minimum detection limit for that analyte.

[a] Inventories for contaminants having the greatest impact for groundwater or inadvertent intruder pathway.
[b] Includes inventories in sludge calculated from one half of the laboratory's minimum detection limit for an analyte.

Reference: DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site.*

6.0 OPPORTUNITIES AND ACTIONS BEING TAKEN TO REFINE OR DEVELOP TANK WASTE RETRIEVAL TECHNOLOGIES, BASED ON LESSONS LEARNED

This section discusses aspects of the tank C-104 waste retrieval operations, provides recommendations for further actions, and addresses opportunities to refine waste retrieval technologies based on lessons learned from the tank C-104 retrieval operation. The format of this section is to provide brief discussions of the major Lessons-Learned topic areas.

There are opportunities to improve future waste retrieval operations by looking at the ways to modify equipment, make operational changes (e.g., operating sequencing and conditions), plan work, and enhance the design and fabrication of equipment. All RDRs have a Lessons Learned section and it must be recognized that several of the previously identified lessons learned have been incorporated in the formulation and operation of subsequent tank waste retrieval operations, and in the tank C-104 retrieval operation.

6.1 PREDICTED WASTE VOLUME

One aspect of the deployed second technology was derived from tank C-108 experience. For tank C-108, the amount of waste dissolved, and thus the volume of waste retrieved from the tank, was less than predicted by the laboratory work. Laboratory work predicted that all but 300 gal of solids should be removed by the second technology process. It was projected that the resulting residual material could then be easily suspended and removed by sluicing operations. In actuality, the tank C-108 residual waste was reduced to a large volume of mud-like consistency by the second technology. The waste was found to be mobile and potentially susceptible to a sluicing campaign. Future deployments of the caustic dissolution technology should include the option of a limited sluicing campaign to remove the undissolved solids.

6.2 SAMPLING ASPECTS

The second technology deployed in tank C-108 was a process never used before and the process control strategy included sample analysis which guided process decisions, such as to estimate amount of solids reacted, determine reaction progress, and verify the process works as intended. Because the analysis of sample results was performed during the retrieval operation, unanticipated additional time was spent during and after retrieval operations to evaluate the sample data. Due to the successes experienced in tank C-108, similar but improved sampling methods were used during tank C-104 retrieval.

The process sampling events were conducted by lowering a grab sample bottle into a sleeve with a slot cut out. The sleeve was installed into a riser in the tank prior to retrieval operations. The circulated sluicing stream was aimed into the slot until the bottle was filled. This method worked successfully to sample circulated liquid when the pool was not deep enough to sample by traditional methods.

The greatest difficulty from a retrieval operations standpoint during the sampling events was aiming the sluicing stream at the slot. Due to the poor visibility and camera angles, some sampling events took longer than expected. However, all sampling events were successful in that the required volume of liquid was collected in the bottle.

Analysis of the first natrophosphate dissolution batch sample set suggested a second natrophosphate dissolution batch would be necessary prior to using caustic for metathesis. However, analysis of the second natrophosphate dissolution batch sample set suggested that either the natrophosphate was dissolved or the second batch was relatively ineffective in a reasonable timeframe at dissolving any remaining natrophosphate.

For tank C-104, the overall trend of the reaction appeared to progress fairly well and linearly over the increasing amounts of caustic recirculation time. However, the results from the last two sampling events suggested that the extent of reaction was beyond expectations for hydroxide consumption for the initial estimated inventory of 199,735 moles of hydroxide in gibbsite within the remaining wastes.

Interpretation of these results, documented in RPP-RPT-53367, suggested that a number of factors could explain why the extent of reaction could go beyond 100% in the samples collected at the end of the caustic cleaning process. A primary factor is likely to be related to errors in initial inventories of gibbsite before the caustic cleaning campaign. An underestimate of this initial inventory would likely provide results that would be consistent with the calculated extent of excess reaction.

Other factors that could contribute to the observed extent of reactions but are postulated to have much less influence would include 1) potential errors in the waste volumes used to estimate the hydroxide inventories in the initial liquids, 2) potential errors related to influences of competing reactions in the consumption of hydroxide, and 3) potential errors associated with the precision and accuracy in analytical results. A more detailed discussion of these potential errors is provided in RPP-RPT-53367.

6.3 SLUICING OPERATION

The in-tank cameras, as installed, did provide the necessary visibility to operate the retrieval system safely; however, deterioration in the video quality limited further use of the stored media for follow-on activities such as final volume estimates or close-ups of tank waste. Improving the video equipment could avoid follow-on specific tasks to acquire high-resolution pictures.

During the sluicing operations, positioning the sluice stream across the tank resulted in buildup of solids on the light. Future considerations need to be made that address this operational aspect.

Addressing potential impacts is advisable when there are significant changes from the planned process (such as extended downtimes). Such changes may require additional process samples and/or even more time needed to evaluate the process.

During sluicing operations, the tank C-104 slurry pump encountered an obstruction in the waste and could not be lowered below 18 in. from the tank bottom. Retrieval efficiencies fell as the pump could not be lowered further into the waste. The obstruction was a piece of a pump left behind during removal of an old heel jet pump from the tank. Sluicing under the pump was not able to move the obstruction. An AMS fitted with two high-pressure water spray nozzles and a shovel assembly for moving waste and debris was installed in December 2010. The AMS was used to "sweep" the area underneath the pump and move the obstruction to the side. The pump was then lowered and retrieval resumed. During retrieval, the AMS was also used to help move solids or serve as a backstop to the pump during sluicing operations.

The tank AN-101 supernatant pump was replaced when the nitrogen seals on the existing pump failed. The replacement pump was a 100-horsepower hydraulically-driven pump of the same type that was installed in tank C-104. This design eliminated the need for water to prime the pump and nitrogen for the pump seals.

6.4 SLUICER EQUIPMENT

Modified sluicing performed well for bulk retrieval of sludge. By using two sluicers, sludge could be mobilized throughout most of the tank.

Opportunistic water sluicing was added following the sodium aluminate dissolution transfer. This added step resulted in hundreds more gallons of solids removed. The added water sluicing step allowed recovery of additional waste.

During sluicing operations in tank C-104, in-tank obstructions limited the ability to lower the slurry pump. The AMS was successfully used to move the obstruction and permit the slurry pump to be lowered.

Retrieval operations in tank C-104 on February 16, 2010 experienced problems with the Material Balance Discrepancy due to problems with the flow meters. The flow meters registered flows of greater than 0 gpm even when pumps were shut down. The Material Balance Discrepancy issues were resolved on February 17, 2010 when water was removed from the POR138 junction box.

6.5 WASTE CIRCULATION

Another lesson learned from retrieval of tank C-108 that was applicable to tank C-104 retrieval was that during circulation pre-start activities, low temperatures in the pump pit made it difficult to begin circulation. Due to the cold temperatures in January and the strict temperature limits of 50% sodium hydroxide solution, project delays were incurred while attempts were made to heat up the boxes to acceptable operating temperatures. Using caustic during the warm summer months for tank C-104 helped to mitigate such a delay.

During initial caustic circulation activities of tank C-108, the slurry pump had high amperage readings resulting from pumping heavier (higher specific gravity) solution. At first, the project

was not sure about operating the pump at the higher amp level. After discussions with the vendor and based on operating experience, the pump was operated safely at the higher amp levels. After the solution was circulated for some time, the pump amps would drop into normal operating ranges. Preparation for such incidents would enable continuity in the pump operation and startup.

A water flush at the slurry pump was done after high pump amp readings were experienced during initial caustic circulation startup on tank C-108. Adding the water diluted the liquid and/or heated the solution near the pump, allowing the pump to circulate the solution successfully. The recommendation is to pump the caustic solution before it cools and/or use small flush volumes prior to beginning circulating the solution.

6.6 CAUSTIC CLEANING OPERATION

Lesson Learned WRPS-IB-12-005, *Caustic Addition Process Improvements* on caustic addition to tank C-108 was determined to be applicable to tank C-104. Since the caustic addition process sometimes takes longer than planned, sufficient manpower and resources were allocated for caustic addition to tank C-104.

7.0 LEAK DETECTION, MONITORING, AND MITIGATION

The LDMM program was implemented to protect the workers, public, and environment from leaks of radioactive liquid waste. The LDMM program included technologies and methods used prior to, during, and after waste retrieval to detect leaks, reduce the potential for a leak to occur, or minimize leak volumes. In addition, if a leak had occurred, the LDMM program would have quantified liquid waste release volumes.

The operational history and decades of waste and liquid level monitoring indicate that tank C-104 had not leaked and was sound before starting retrieval (HNF-EP-0182, *Waste Tank Summary Report for Month Ending July 31, 2013*, Rev. 304). Additionally, there was no evidence of a leak during retrieval of waste from tank C-104.

The following sections describe the LDMM requirements, leak detection monitoring implementation, mitigative approach, chronology, and results. The major results for the LDMM program during tank C-104 waste retrieval were as follows.

a. Drywell moisture and gamma logging showed no evidence of leaks during the tank C-104 waste retrieval.

b. Modified static level monitoring demonstrated no evidence to support leakage during retrieval.

c. Material balance calculations showed no evidence of leaks during the tank C-104 waste retrieval.

Retrieval of tank C-104 was begun and the majority of the waste in the tank was removed under work plan RPP-22393 Revisions 3A through 3D. Work plan RPP-22393 Revision 6 (and any additional revisions to this work plan) was applicable to the remaining tank C-104 waste retrieval operations.

7.1 REQUIREMENTS

Details of the LDMM program are presented in RPP-22393. The leak detection and monitoring (LDM) system requirements are contained in the safety basis controls given in HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements*, specifically Technical Safety Requirement (TSR) Limiting Condition for Operation Section 3.1.1, "Transfer Leak Detection Systems." Material balances during transfers are required by the TSR Administrative Control Section 5.11, "Transfer Control," and RPP-12711, *Temporary Waste Transfer Line Management Program Plan*. The primary procedures governing notification and reporting of leaks are TFC-OPS-OPER-C-24, "Occurrence Reporting and Processing of Operations Information," and TFC-ESHQ-ENV_FS-C-01, "Environmental Notification." Table 7-1 presents the tank C-104 LDM functions and requirements.

Table 7-1. Tank 241-C-104 Leak Detection and Monitoring Functions and Requirements.

Function	Requirement	Basis	Key Elements
Detect leaks during waste removal from SST	The leak detection and monitoring (LDM) system shall be capable of detecting liquid waste releases during all waste removal operations.	*Washington Administrative Code* (WAC) 173-303	Utilize LDM technologies to detect loss of liquid from a tank; see Section 7.2.
Monitor leaks from SST during waste removal	The waste retrieval system (WRS) shall be capable of providing data to support quantifying leak volumes from the tanks in the event a release is detected during waste retrieval operations.	WAC 173-303	Utilize both ex-tank LDM technologies and process data that will allow estimate of leak volume and migration rate to be developed to the extent practical in the event of a leak.
Mitigate leaks during SST waste retrieval	The integrated retrieval and LDM system shall be designed and operated to mitigate leaks as the primary means of minimizing environmental impacts from leaks during waste retrieval if they occur.	WAC 173-303	Leak mitigation strategy described in Section 7.3.
WRS secondary containment and leak detection RP103DT.	For ex-tank equipment and piping, the WRS shall incorporate secondary containment and leak-detection design features in accordance with 40 CFR 265.193 and DOE O 435.1.	40 CFR 265 WAC 173-303 DOE O 435.1 RPP-13033 HNF-SD-WM-TSR-006	Provide for safe and compliant transfer of waste to the receiver double-shell tank.

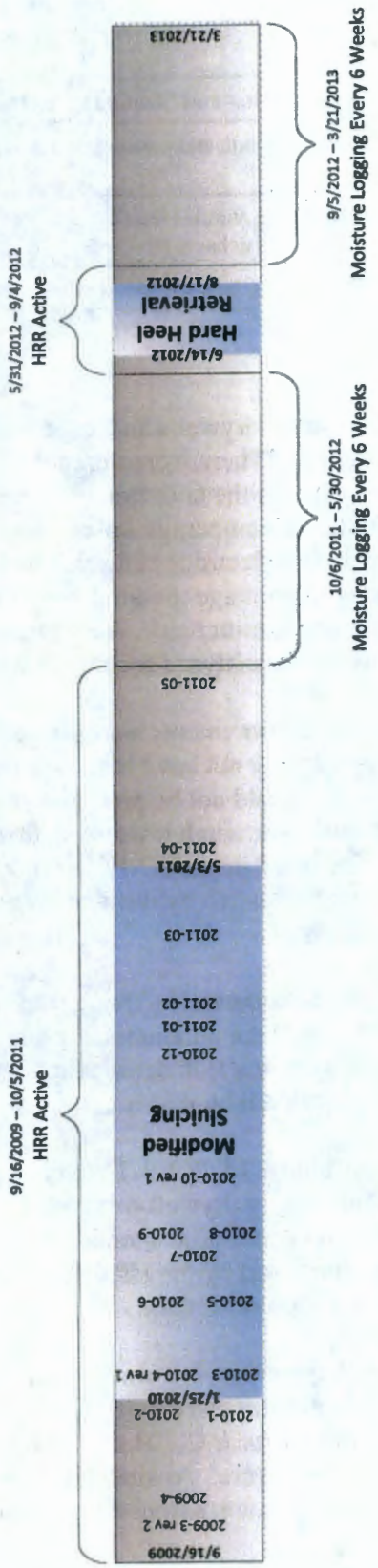
CFR = *Code of Federal Regulations* DOE = U.S. Department of Energy SST = single-shell tank

References:
40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart J—Tank Systems, §265.193 Containment and detection of releases.
DOE O 435.1, *Radioactive Waste Management.*
HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements.*
RPP-13033, *Tank Farms Documented Safety Analysis.*
WAC 173-303, "Dangerous Waste Regulations."

7.2 LEAK DETECTION AND TANK MONITORING

During retrieval of waste from tank C-104 (January 25, 2010 to October 5, 2011), high-resolution resistivity (HRR) was the primary leak detection method used. When the HRR was not in operation, moisture data logging and gamma scans were used for leak detection. Figure 7-1 is a timeline of the leak detection monitoring used for tank C-104 retrieval. Leak detection and monitoring was accomplished by the use of HRR, drywell monitoring, visual inspection, leak detectors, Enraf gauges in tank AN-101, radiological monitoring, and material balances as shown in Table 7-2 and discussed in Sections 7.2.1 through 7.2.3.

Figure 7-1. Tank 241-C-104 Leak Detection Monitoring Timeline.



HRR = high-resolution resistivity

Table 7-2. Leak Detection and Monitoring Methods for Each Waste Retrieval System Component.

Component	Leak Detection and Monitoring Method
Single-shell tank 241-C-104	Drywells, liquid level indicators, visual inspection, material balance
Double-shell tank 241-AN-101	Liquid level indicators, annulus leak detectors, radiation monitoring for annulus exhaust air
Ancillary equipment (hose-in-hose transfer line)	Secondary containment, leak detectors, radiation monitoring

7.2.1 Drywell Logging and High Resolution Resistivity

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

Ideally, drywell-to-tank and drywell-to-drywell resistivity measurements are available to review. When the waste level in the tank was low the thermocouple may not have been in contact with the waste so the drywell-to-tank data had less credibility. It could not be proven that an electrical pathway existed through the thermocouple and tank structure although it was likely that a pathway exists through structural rebar. When sluicing finished in tank C-104, the thermocouple tree was not in contact with the waste and drywell-to-drywell resistivity measurements were relied on more heavily for leak determinations.

During the first phase deployment of HRR on tank C-104, encompassing sluicing retrieval, several anomalous results were evaluated. Table 7-3 identifies the anomalies and provides a description of each anomaly and its resolution. During sluicing, a leak determination was made for each day of active retrieval operation; no leaks were indicated by the data.

The second phase of retrieval, hard heel dissolution, began June 14, 2012. Due to concurrent retrieval activities and HRR equipment capacity limitations, only drywell-to-drywell measurements were available to be monitored. There were no potential anomalies during hard heel dissolution retrieval operations. There was no leak indicated by the HRR data. Figure 7-1 is a timeline of the leak detection monitoring used for tank C-104 retrieval.

Subsequent to tank C-104 retrieval, additional drywell logging was performed by a subcontractor [RPP-RPT-56085, *241-C-104 Tank Waste Retrieval Project Final Report of Drywell Monitoring Data (HGLP-MBL-012, Rev. 0)*]. None of the drywells around tank C-104 show evidence of significant changes in either gamma activity or subsurface moisture. Available data from these drywells provide no evidence of any leak or contaminant movement associated with tank retrieval operations.

Table 7-3. High-Resolution Resistivity Anomaly Evaluation During and After Sluicing.

Number	Date	Anomaly Description	Resolution/Comments
2009-3 Rev. 2	11/5/09	Erratic data associated with drywell 30-04-04	No leak indicated. No active retrieval.
2009-4	12/21/09	Erratic data associated with drywells 30-04-04, 30-07-05, and 30-04-12	No leak indicated. No active retrieval.
2010-1	1/6/10	Erratic data associated with drywell 30-04-12	No leak indicated. No active retrieval.
2010-2	1/19/10	Erratic data associated with drywell 30-04-02	No leak indicated. No active retrieval.
2010-3	3/4/10	Erratic data associated with drywell 30-04-04	No leak indicated.
2010-4 Rev. 1	3/15/10	Erratic data associated with drywell 30-04-08	No leak indicated.
2010-5	4/9/10	Erratic data associated with drywell 30-04-04	No leak indicated.
2010-6	4/21/10	Erratic data	No leak indicated.
2010-7	5/6/10	Cathodic protection system turned on	No leak indicated.
2010-8	6/14/10	Erratic data	No leak indicated.
2010-9	6/21/10	Erratic data	No leak indicated.
2010-10 Rev. 1	8/26/10	High-resolution resistivity equipment problem	No leak indicated.
2010-12	12/30/10	Erratic data associated with drywell 30-04-12	No leak indicated.
2011-01	1/17/11	Possible weather effect	No leak indicated.
2011-02	2/17/11	Erratic data associated with drywell 30-04-12	No leak indicated.
2011-03	4/9/11	Step changes in trend line	No leak indicated.
2011-04	5/16/11	Data spikes due to lightning	No leak indicated.
2011-05	9/19/11	High-resolution resistivity system problem	No leak indicated.

7.2.2 Single-Shell Tank 241-C-104

7.2.2.1 Liquid Level Monitoring. The overall waste retrieval operating strategy for tank C-104 was to reduce the tank liquid inventory and minimize liquid additions during waste retrieval operations. Liquid levels were monitored to evaluate liquid inventories and indicate potential leaks in the system to implement this strategy.

No active retrieval occurred during the following stagnant periods:

a. 2011: May 10, 2011 through December 31, 2011
b. 2012: January 1, 2012 through June 13, 2012.

During these stagnant periods, liquid levels in tanks C-104 and AN-101 did not decrease, indicating that no leaks occurred.

7.2.2.2 Visual Inspection. Before initiating waste retrieval operations, a visual assessment and documentation of in-tank conditions in tank C-104 were performed using an in-tank video camera. Throughout waste retrieval, the closed-circuit television system was used to identify the waste surface condition, qualitatively assess the amount of liquid in the tank, observe any significant changes, and implement the mitigation strategy of minimizing liquid pools.

Observations of the waste surface in tank C-104 indicated that the surface level decrease corresponded with waste retrieval activities.

7.2.2.3 Groundwater Monitoring. The 241-C Tank Farm is in RCRA corrective action. Groundwater monitoring activities will continue consistent with the current RCRA groundwater monitoring plan (PNNL-13024, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*). Results of the groundwater monitoring will be made available in the Quarterly Groundwater Monitoring reports.

7.2.2.4 Material Balance. Process control measurements were used periodically to perform a material balance and determine the change in tank C-104 waste inventory. Once determined, the change in waste inventory was compared to the anticipated change (gallons of slurry produced and/or released per gallon of water added, adjusted for changes in the central pool and interstitial liquid volumes).

During retrieval operations, material balances were performed during transfers by Operations for tank leak detection and mitigation for the portion of the system between the portable valve pit and tank AN-101, inclusive. Radiation surveys were required for the portion of the transfer line where volume material balance could not be performed. The frequency of material balance measurements and radiation surveys met the requirements of HNF-IP-1266, *Tank Farms Operations Administrative Controls*.

7.2.3 Double-Shell Tank 241-AN-101

7.2.3.1 Liquid Level Monitoring. The waste level in the DST was monitored using an Enraf, and annulus leak detector probes were used to provide indication of leaks, as described in Section 4.0 of OSD-T-151-00031, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection*.

Daily liquid level measurements were recorded for the receiving DST. The Enraf gauge was capable of measuring liquid level changes to a precision of 0.1 inch.

During waste retrieval there was no evidence of a release from tank AN-101 based on results of liquid level monitoring. The tank AN-101 liquid level increase corresponded with the material balance results for tank C-104.

7.2.3.2 Leak Detection. Tank AN-101 was monitored for leaks in the inner shell by a conductivity probe leak detection system installed in the tank annulus during tank construction. Slots cut in the concrete that support the tank at the bottom were designed to drain any leakage to the annulus floor. Enraf assemblies in the annulus would have activated an audible alarm and an

annunciator panel light in the event of liquid leaking to the annulus so that mitigation could have begun. Throughout the tank C-104 waste retrieval campaign, no leaks were detected by any of the leak detectors in tank AN-101.

7.2.3.3 Radiation Monitoring. A continuous air monitor operated to detect airborne radionuclides entrained in the ventilation exhaust stream of the annulus of tank AN-101. Detection of radiation exceeding a set limit in the annulus of the DST would have activated an audible alarm and an annunciator panel light, initiating mitigative action.

The continuous air monitor for the tank AN-101 annulus detected no radiation levels above background during retrieval that could have been attributed to leak-induced airborne radionuclides.

7.2.4 Ancillary Equipment

Leak detectors were installed in the valve pits to detect the presence of liquid through conductivity, which would have activated alarms and shut down the WRS.

In accordance with RPP-12711, the hose-in-hose transfer line system underwent radiation monitoring and was equipped with leak detectors as part of the leak detection program.

7.3 MITIGATION

Leak mitigation was accomplished through design features and the operational strategy developed for the retrieval system. Mitigation included actions that reduced the chance of a leak and the environmental impact of a leak should one have occurred. Potential leaks were proactively prevented and minimized throughout the waste retrieval operations.

The leak mitigation strategy (i.e., reduction of leak loss potential) was to minimize the liquid volume within the tank during waste retrieval operations. Conditions to control leak potential involved the following:

a. In-tank liquid levels during retrieval were lower than liquid levels present before interim stabilization

b. Tank C-104 was retrieved from the center out

c. Liquid was removed between waste retrieval campaigns

d. Leak assessment protocols were in accordance with procedures

e. Drywell surveys were conducted.

Conditions to control leak minimization included the following.

a. Liquid additions were minimized and liquid pools were removed as practical.

b. Tank C-104 was retrieved from the center out.

c. Equipment handling controls were imposed to minimize the potential for dropping equipment that could have penetrated the tank bottom.

d. A benchmark waste level was maintained to ensure a low head of introduced liquid. The waste level did not exceed this benchmark.

7.3.1 Single-Shell Tank 241-C-104

A summary of the tank C-104 mitigation actions to minimize or prevent a leak were as follows.

a. The addition of water to the retrieval tank was minimized to the extent practical.

b. Waste was retrieved to the extent practical by working from the center of the tank outwards. In the center-out waste retrieval strategy, mobilized waste and interstitial liquids drain quickly into a central pool and could have been rapidly pumped from the tank had a leak been detected.

c. Waste sluicing activities were performed only while a video camera was in place to observe the sluicing operation and the waste surface.

d. Equipment handling controls were used to minimize the potential for dropping equipment into the tank, which could have penetrated the tank bottom during installation.

e. A benchmark level was maintained to ensure a low head of introduced liquid. The waste level did not exceed this benchmark.

The mitigative approach was implemented to ensure that potential leakage from tank C-104 was monitored at all times. Key mitigative actions which would have been taken in the event of a leak are described in the Tank Waste Retrieval Work Plan (RPP-22393), Sections 4.3.2 and 4.3.3.

7.3.2 Double-Shell Tank 241-AN-101

Mitigating actions for a leak from AN-101 primary tank piping into the secondary DST containment system during a waste transfer from tank C-104 would have included (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 was no longer increasing, and (3) removing the waste from the secondary containment system as soon as practicable. Leaks at or near the AN-101 tank bottom might have required saltwell jet pumping to remove

trapped liquids from between solid layers in the tank. Transfer line leakage would have drained to a common point for collection, detection, and removal.

7.4 CONCLUSION

Based on the available data (presented in Sections 7.2 and 7.3), no evidence of a tank leak occurred during tank C-104 waste retrieval operations. The tank C-104 LDMM program focused on a mitigation strategy to successfully control potential leaks. This strategy included the following.

a. Minimize residual tank waste.

b. Minimize in-tank water use.

c. Minimize standing liquid pools in the tank.

d. Control and monitor additions of water.

e. Visually monitor tank conditions and retrieval operations.

f. Retrieve from the center of the tank out to minimize water accumulation around the tank knuckle.

The goal of the LDMM program for tank C-104 as set forth in RPP-22393 was achieved.

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APPENDIX A

SINGLE-SHELL TANK 241-C-104 INVENTORY PRE- AND POST-SLUICING TECHNOLOGY RETRIEVAL

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APPENDIX A

SINGLE-SHELL TANK 241-C-104 INVENTORY PRE- AND POST-SLUICING TECHNOLOGY RETRIEVAL

Table A-1. Single-Shell Tank 241-C-104 Best-Basis Inventory Pre-Retrieval Inventory and Post-Sluicing Operations. (2 sheets)

Constituent Name	BBI February 2005[a]	BBI May 2011[b]			Constituent Name	BBI February 2005[a]	BBI May 2011[b]	
Volume (Kgal)	259	4.7						
Analyte	Inventory	Inventory	Unit		Analyte	Inventory	Inventory	Unit
Al	8.96E+04	1.63E+03	Kg		^{99}Tc	5.76E+01	1.05E+00	Ci
Bi	7.01E-01	8.21E-02	Kg		^{106}Ru	1.80E-04	1.39E-06	Ci
Ca	2.97E+03	5.39E+01	Kg		^{113m}Cd	3.10E+00	1.72E-01	Ci
Cl	7.95E+02	1.85E+01	Kg		^{125}Sb	8.27E+01	5.11E-01	Ci
CN	2.07E+01	3.46E-01	Kg		^{126}Sn	8.29E-02	8.92E-03	Ci
Cr	1.45E+03	2.64E+01	Kg		^{129}I	7.49E-01	1.21E-02	Ci
F	3.44E+04	6.25E+02	Kg		^{134}Cs	5.41E-02	7.52E-04	Ci
Fe	2.74E+04	4.98E+02	Kg		^{137}Cs	8.86E+04	1.47E+03	Ci
Hg	6.69E+01	1.00E+00	Kg		^{137m}Ba	8.36E+04	1.39E+03	Ci
K	1.32E+03	2.41E+01	Kg		^{151}Sm	5.73E+04	6.50E+03	Ci
La	4.84E+01	8.78E-01	Kg		^{152}Eu	1.53E+01	1.46E+00	Ci
Mn	6.97E+03	1.27E+02	Kg		^{154}Eu	8.54E+02	1.12E+01	Ci
Na	1.77E+05	3.21E+03	Kg		^{155}Eu	5.14E+02	4.44E+00	Ci
Ni	2.62E+03	4.75E+01	Kg		^{226}Ra	1.31E-04	6.09E-07	Ci
NO_2	3.63E+04	6.59E+02	Kg		^{227}Ac	2.02E+00	3.04E-05	Ci
NO_3	1.95E+04	3.53E+02	Kg		^{228}Ra	1.96E+00	7.20E-02	Ci
Oxalate	5.58E+03	1.01E+02	Kg		^{229}Th	5.53E-01	1.60E-07	Ci
Pb	8.32E+02	1.51E+01	Kg		^{231}Pa	1.70E-01	1.39E-04	Ci
PO_4	3.19E+03	5.79E+01	Kg		^{232}Th	5.55E+00	7.20E-02	Ci
Si	1.02E+04	1.85E+02	Kg		^{232}U	1.92E+00	7.43E-02	Ci
SO_4	3.40E+03	6.17E+01	Kg		^{233}U	4.11E+02	6.12E+00	Ci
Sr	8.69E+01	1.58E+00	Kg		^{234}U	2.07E+01	3.08E-01	Ci
Tic as CO_3	4.82E+04	8.76E+02	Kg		^{235}U	5.99E-01	7.96E-03	Ci
TOC	1.41E+04	2.56E+02	Kg		^{236}U	6.80E-01	1.01E-02	Ci

Table A-1. Single-Shell Tank 241-C-104 Best-Basis Inventory Pre-Retrieval Inventory and Post-Sluicing Operations. (2 sheets)

Constituent Name	BBI February 2005[a]	BBI May 2011[b]			Constituent Name	BBI February 2005[a]	BBI May 2011[b]	
Volume (Kgal)	259	4.7						
Analyte	Inventory	Inventory	Unit		Analyte	Inventory	Inventory	Unit
U_{TOTAL}	3.51E+04	5.20E+02	Kg		^{237}Np	4.36E+00	6.51E-02	Ci
Zr	6.45E+04	1.17E+03	Kg		^{238}Pu	2.29E+02	7.90E+00	Ci
^{3}H	4.71E+01	5.80E-01	Ci		^{238}U	1.17E+01	1.74E-01	Ci
^{14}C	1.84E+00	3.30E-02	Ci		^{239}Pu	5.18E+03	5.52E+01	Ci
^{59}Ni	5.68E+00	1.61E-01	Ci		^{240}Pu	1.33E+03	1.66E+01	Ci
^{60}Co	1.82E+02	1.95E+00	Ci		^{241}Am	6.34E+03	8.13E+01	Ci
^{63}Ni	5.28E+02	1.47E+01	Ci		^{241}Pu	1.25E+04	1.58E+02	Ci
^{79}Se	6.37E+00	9.52E-02	Ci		^{242}Cm	2.07E+00	6.41E-02	Ci
^{90}Sr	4.47E+05	7.38E+03	Ci		^{242}Pu	1.24E-01	2.28E-03	Ci
^{90}Y	4.47E+05	7.38E+03	Ci		^{243}Am	1.38E+00	4.78E-02	Ci
^{93m}Nb	1.45E+00	9.87E-02	Ci		^{243}Cm	1.84E-01	4.28E-03	Ci
^{93}Zr	1.79E+00	1.16E-01	Ci		^{244}Cm	4.11E+00	9.31E-02	Ci

BBI = Best-Basis Inventory TIC = total inorganic carbon TOC = total organic carbon

[a] RPP-22393, 2011, *241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan*, Rev. 6, Washington River Protection Solutions, LLC, Richland, Washington.

[b] RPP-RPT-46616, 2013, *Derivation of Best-Basis Inventory for Tank 241-C-104 as of October 1, 2012*, Rev. 4, Washington River Protection Solutions, LLC, Richland, Washington.

APPENDIX B

MEAN CONCENTRATIONS AND RELATIVE STANDARD DEVIATIONS FOR TANK 241-C-104 RESIDUAL SOLIDS

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APPENDIX B

MEAN CONCENTRATIONS AND RELATIVE STANDARD DEVIATIONS FOR TANK 241-C-104 RESIDUAL SOLIDS

A summary of concentrations estimated for selected radioactive and non-radioactive analytes in residual waste solids left in single-shell tank 241-C-104 following final retrieval is provided in this appendix.

Waste concentrations provided in this appendix in Table B-1 were taken from Table A.1 in RPP-RPT-55307, *Tank 241-C-104 Residual Waste Inventory Estimates for Component Closure Risk Assessment*. These calculated concentrations were developed from sampling of waste solids in single-shell tank 241-C-104. The mean concentrations for each sample set were estimated as follows.

Equations from *Variance Components* (Searle et al. 1992) were used in the automated Best-Basis Inventory Maintenance (BBIM) tool [RPP-5945, *Best-Basis Inventory Maintenance Tool (BBIM): Database Description and User Guide*] to estimate the mean concentration and density and the associated standard deviation for all constituents that had 50% or more of their reported values greater than the detection limit. These equations compute means by weighting results based on the variance components. Some constituents had concentrations that were below the detection limits. In these cases, the detection limits were used for calculating the mean concentrations. For a constituent with a majority of results below the detection limit, a simple average of the detection limits was calculated. Note that in accordance with Best-Basis Inventory protocol, the relative standard deviations for non-detected constituents were assumed to be "1" (RPP-6924, *Statistical Methods for Estimating the Uncertainty in the Best Basis Inventories*).

The mean concentrations for the samples taken after modified sluicing are not directly applicable to the post-retrieval residual solids because additional waste was removed by heel retrieval. Estimates of these means were calculated by adjusting for the volume change [Adjusted means = sample means × volume before heel removal (630 ft^3) / volume after heel removal (217 ft^3)]. This is equivalent to assuming that no mass of the constituents of interest was removed during the heel retrieval.

To calculate the average analyte inventories provided in Table B-1, the BBIM tool automatically used the mean concentrations from the samples taken after heel retrieval when available. Otherwise, the adjusted mean concentrations of analytes from the samples taken after modified sluicing were used.

Table B-1. Mean Concentrations[1] and Relative Standard Deviations for Selected Constituents in Tank 241-C-104 Residual Solids. (4 Sheets)

Constituent Name	Chemical Abstract Services Number	< Detection Limit	Mean Concentration	Units	Relative Standard Deviation[2]
^{125}Sb	14234-35-6	<	1.73E+00	µCi/g	1.00E+00
^{126}Sn	15832-50-5		7.74E-04	µCi/g	4.14E-01
^{129}I	15046-84-1	<	4.26E-05	µCi/g	1.00E+00
^{137}Cs	10045-97-3		7.21E+01	µCi/g	3.75E-01
^{137m}Ba	N/A		6.81E+01	µCi/g	3.54E-01
^{14}C	14762-75-5		2.71E-04	µCi/g	1.72E-01
^{152}Eu	14683-23-9	<	5.07E-01	µCi/g	1.00E+00
^{154}Eu	15585-10-1	<	3.64E-01	µCi/g	1.00E+00
^{155}Eu	14391-16-3	<	7.27E-01	µCi/g	1.00E+00
^{228}Th	14274-82-9		2.29E-03	µCi/g	5.23E-01
^{230}Th	14269-63-7	<	7.47E-05	µCi/g	1.00E+00
^{231}Pa	14331-85-2	<	3.28E-02	µCi/g	1.00E+00
^{232}Th	N/A		3.25E-04	µCi/g	4.37E-01
^{233}U	13968-55-3	<	1.92E-01	µCi/g	1.00E+00
^{234}U	13966-29-5		3.66E-02	µCi/g	1.34E-01
^{235}U	15117-96-1		1.74E-03	µCi/g	1.72E-01
^{236}U	13982-70-2		4.26E-04	µCi/g	1.71E-01
^{237}Np	13994-20-2	<	7.01E-03	µCi/g	1.00E+00
^{238}Pu	13981-16-3		5.70E-02	µCi/g	3.54E-01
^{238}U	N/A		3.86E-02	µCi/g	1.72E-01
$^{239/240}Pu$	N/A		5.88E-01	µCi/g	3.27E-01
^{239}Pu	15117-48-3		4.52E-01	µCi/g	3.27E-01
^{240}Pu	14119-33-6		1.36E-01	µCi/g	3.27E-01
^{241}Am	14596-10-2		7.58E-01	µCi/g	4.52E-01
^{241}Pu	14119-32-5		1.79E+00	µCi/g	2.75E-01
^{242}Cm	15510-73-3		2.91E-03	µCi/g	3.97E-01
^{242}Pu	N/A		1.73E-03	µCi/g	3.39E-01
$^{243/244}Cm$	N/A		7.97E-03	µCi/g	5.83E-01
^{243}Cm	15757-87-6		4.26E-04	µCi/g	5.83E-01

Table B-1. Mean Concentrations[1] and Relative Standard Deviations for Selected Constituents in Tank 241-C-104 Residual Solids. (4 Sheets)

Constituent Name	Chemical Abstract Services Number	< Detection Limit	Mean Concentration	Units	Relative Standard Deviation[2]
^{244}Cm	13981-15-2		9.28E-03	µCi/g	5.83E-01
1-Butanol	71-36-3		4.53E-01	µg/g	4.46E-01
2-Butanone	78-93-3	<	2.84E-02	µg/g	1.00E+00
^{3}H	15086-10-9	<	1.61E-03	µCi/g	1.00E+00
^{60}Co	10198-40-0	<	1.99E-01	µCi/g	1.00E+00
^{63}Ni	13981-37-8		9.49E+00	µCi/g	7.88E-01
^{79}Se	15758-45-9	<	7.53E-04	µCi/g	1.00E+00
^{90}Sr	10098-97-2		5.74E+02	µCi/g	4.59E-01
^{90}Y	500784-58-7		5.74E+02	µCi/g	4.59E-01
^{99}Tc	14133-76-7		2.67E-02	µCi/g	1.88E-01
Acetate	71-50-1		6.41E+01	µg/g	6.98E-02
Acetone	67-64-1	<	3.91E-02	µg/g	1.00E+00
Ag	7440-22-4		1.44E+03	µg/g	1.33E-01
Al	7429-90-5		1.00E+05	µg/g	2.26E-01
Aroclors (Total PCB)	1336-36-3		5.13E-01	µg/g	4.33E-01
As	7440-38-2	<	9.94E+00	µg/g	1.00E+00
Ba	7440-39-3		5.78E+01	µg/g	2.37E-01
Be	7440-41-7		3.25E+00	µg/g	9.61E-02
Benzene	71-43-2		3.42E-03	µg/g	1.00E+00
Bi	7440-69-9		2.56E+02	µg/g	1.61E-01
Br	24959-67-9	<	5.13E+01	µg/g	1.00E+00
Ca	7440-70-2		1.19E+03	µg/g	3.36E-01
Cd	7440-43-9		1.72E+02	µg/g	3.61E-01
Ce	7440-45-1		6.10E+02	µg/g	1.50E-01
Cl	16887-00-6		5.23E+01	µg/g	1.83E-01
CN	57-12-5	<	1.63E+00	µg/g	1.00E+00
Co	7440-48-4		3.17E+00	µg/g	1.80E-01
Cr	7440-47-3		2.69E+02	µg/g	1.29E-01
Cu	7440-50-8		1.61E+02	µg/g	1.69E-01

Table B-1. Mean Concentrations[1] and Relative Standard Deviations for Selected Constituents in Tank 241-C-104 Residual Solids. (4 Sheets)

Constituent Name	Chemical Abstract Services Number	< Detection Limit	Mean Concentration	Units	Relative Standard Deviation[2]
Ethylbenzene	100-41-4		2.11E-03	µg/g	1.00E+00
Eu	7440-53-1	<	1.99E+00	µg/g	1.00E+00
F	16984-48-8		1.35E+03	µg/g	4.43E-01
Fe	7439-89-6		2.84E+04	µg/g	1.63E-01
Formate	12311-97-6		1.19E+02	µg/g	8.18E-02
Glycolate	666-14-8	<	1.88E+01	µg/g	1.00E+00
Hexone	108-10-1	<	1.53E-02	µg/g	1.00E+00
Hg	7439-97-6		1.18E+02	µg/g	1.25E-01
K	7440-09-7		1.15E+02	µg/g	5.06E-02
La	7439-91-0	<	2.06E+00	µg/g	1.00E+00
Li	7439-93-2		1.41E+01	µg/g	1.95E-01
Methylene chloride	75-09-2		3.68E-03	µg/g	3.74E-01
Mg	7439-95-4		2.47E+02	µg/g	3.92E-01
Mn	7439-96-5		3.77E+03	µg/g	5.04E-01
Mo	7439-98-7		7.04E+00	µg/g	2.95E-01
Na	7440-23-5		1.01E+05	µg/g	6.11E-02
Nb	7440-03-1		4.50E+01	µg/g	3.17E-01
Nd	7440-00-8		7.50E+01	µg/g	2.32E-01
NH_3	7664-41-7		6.99E+00	µg/g	3.30E-01
Ni	7440-02-0		5.28E+02	µg/g	3.74E-01
NO_2	14797-65-0		4.45E+02	µg/g	1.96E-01
NO_3	14797-55-8		8.25E+02	µg/g	3.84E-02
Oxalate	338-70-5		2.08E+04	µg/g	2.98E-01
Pb	7439-92-1		5.69E+02	µg/g	1.89E-01
Pd	7440-05-3		3.23E+02	µg/g	1.73E-01
PO_4	14265-44-2		3.76E+03	µg/g	3.30E-01
Pr	7440-10-0		3.83E+02	µg/g	1.74E-01
Rb	7440-17-7	<	5.97E+01	µg/g	1.00E+00
Rh	7440-16-6	<	1.59E+01	µg/g	1.00E+00

Table B-1. Mean Concentrations[1] and Relative Standard Deviations for Selected Constituents in Tank 241-C-104 Residual Solids. (4 Sheets)

Constituent Name	Chemical Abstract Services Number	< Detection Limit	Mean Concentration	Units	Relative Standard Deviation[2]
Ru	7440-18-8	<	7.95E+00	µg/g	1.00E+00
Sb	7440-36-0	<	1.19E+01	µg/g	1.00E+00
Se	7782-49-2	<	1.19E+01	µg/g	1.00E+00
Si	7440-21-3		1.15E+04	µg/g	6.20E-02
Sn	7440-31-5		3.29E+01	µg/g	5.12E-01
SO_4	14808-79-8		1.01E+02	µg/g	5.55E-02
Sr	7440-24-6		8.22E+01	µg/g	2.06E-01
Ta	7440-25-7		3.03E+02	µg/g	1.76E-01
Te	13494-80-9		1.74E+01	µg/g	1.79E-01
Th	7440-29-1		2.95E+03	µg/g	4.37E-01
Ti	7440-32-6		3.86E+01	µg/g	1.26E-01
Tl	7440-28-0	<	1.19E+01	µg/g	1.00E+00
Toluene	108-88-3		3.24E-03	µg/g	6.07E-01
Tributyl phosphate	126-73-8	<	1.63E+00	µg/g	1.00E+00
Trichloroethene	79-01-6	<	1.09E-03	µg/g	1.00E+00
U	7440-61-1		1.16E+05	µg/g	1.72E-01
V	7440-62-2		3.55E+01	µg/g	1.57E-01
W	7440-33-7		1.45E+01	µg/g	1.01E-01
Xylene (m & p)	108-38-3M	<	1.72E-03	µg/g	1.00E+00
Xylene (o)	95-47-6	<	8.42E-04	µg/g	1.00E+00
Xylenes (total)	1330-20-7	<	2.17E-03	µg/g	1.00E+00
Y	7440-65-5		4.75E+01	µg/g	2.11E-01
Zn	7440-66-6		1.26E+02	µg/g	1.47E-01

µg/g = micrograms per gram µCi/g = microcurie per gram N/A = not available

[1] Radionuclide concentrations are decay corrected to January 1, 2008.

[2] In accordance with the Best-Basis Inventory protocol, the relative standard deviation is assumed to be 1 if the constituent was not detected.

REFERENCES

RPP-5945, 2000, *Best-Basis Inventory Maintenance Tool (BBIM): Database Description and User Guide*, Rev. 0, CH2M HILL Hanford Group Inc., Richland, Washington.

RPP-6924, 2010, *Statistical Methods for Estimating the Uncertainty in the Best Basis Inventories*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-55307, 2013, *Tank 241-C-104 Residual Waste Inventory Estimates for Component Closure Risk Assessment*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

Searle, S. R., Casella, G., and McCulloch, C. E., 1992, *Variance Components*, John Wiley and Sons, Inc., New York, New York.

APPENDIX C

COMPARISON OF SINGLE-SHELL TANK 241-C-104 FINAL INVENTORY TO SINGLE-SHELL TANK 241-C-104 INVENTORY USED IN DOE/ORP-2005-01, *INITIAL SINGLE-SHELL TANK SYSTEM PERFORMANCE ASSESSMENT FOR THE HANFORD SITE*

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APPENDIX C

COMPARISON OF SINGLE-SHELL TANK 241-C-104 FINAL INVENTORY TO SINGLE-SHELL TANK 241-C-104 INVENTORY USED IN DOE/ORP-2005-01, *INITIAL SINGLE-SHELL TANK SYSTEM PERFORMANCE ASSESSMENT FOR THE HANFORD SITE*

Table C-1. Comparison of Single-Shell Tank 241-C-104 Final Inventory to Single-Shell Tank 241-C-104 Inventory Used in DOE/ORP-2005-01.

Analyte	Units	DOE/ORP-2005-01, Rev. 0	RPP-RPT-55307, Rev. 0 Average Inventory	RPP-RPT-55307, Rev. 0 Upper Bounding Inventory
Tritium	Ci	1.79E-01	1.04E-02	3.16E-02
C-14	Ci	7.22E-03	1.73E-03	2.65E-03
I-129	Ci	4.23E-03	2.76E-04	8.39E-04
Tc-99	Ci	2.35E-01	1.73E-01	2.65E-01
Cr	kg	9.75E+00	1.74E+00	2.53E+00
F	kg	1.31E+02	8.74E+00	1.71E+01
NO2	kg	1.38E+02	2.88E+00	4.44E+00
NO3	kg	7.40E+01	5.34E+00	7.38E+00
U	kg	2.45E+02	7.05E+02	1.13E+03

REFERENCES

DOE/ORP-2005-01, 2006, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*, Rev. 0, U.S. Department of Energy Office of River Protection, Richland, Washington.

RPP-RPT-55307, 2013, *Tank 241-C-104 Residual Waste Inventory Estimates for Component Closure Risk Assessment*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

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APPENDIX D

RISK ASSESSMENT INFORMATION FOR RESIDUAL WASTES REMAINING IN SINGLE-SHELL TANK 241-C-104

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APPENDIX D

RISK ASSESSMENT INFORMATION FOR RESIDUAL WASTES REMAINING IN SINGLE-SHELL TANK 241-C-104

This appendix provides risk assessment information related to post-retrieval inventories estimated to remain in single-shell tank (SST) 241-C-104 (C-104). The potential risk impacts to human health posed by the residual waste in SST C-104 were evaluated using the methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*. The process used for the SST C-104 risk assessment, and this methodology, is described in detail in Chapter 3 of DOE/ORP-2005-01. The SST performance assessment methodology represents the current approach being used to support the assessment of long-term impacts to human health from tank residuals left in individual SSTs in retrieval data reports. Decisions on final closure of tank C-104, all other SSTs, and ancillary facilities and equipment within Waste Management Area C will be supported by a site-specific performance assessment as outlined in Appendix I of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989).

The risk assessment-related information for post-retrieval inventories estimated to remain in SST C-104 and contained in this appendix are as follows:

- Summary of incremental lifetime cancer risk, radiological dose, and drinking water dose for radionuclide contaminants of potential concern estimated in the average post-retrieval inventory for SST C-104 (see Table D-1)

- Summary of maximum value for incremental lifetime cancer risk and hazard index for non-radionuclide contaminants of potential concern estimated in the average post-retrieval inventory for SST C-104 (see Table D-2)

- Summary of incremental lifetime cancer risk, radiological dose, and drinking water dose for radionuclide contaminants of potential concern estimated in the 95% upper confidence level (UCL) post-retrieval inventory for SST C-104 (see Table D-3)

- Summary of maximum value for incremental lifetime cancer risk and hazard index for non-radionuclide contaminants of potential concern estimated in the 95% UCL post-retrieval inventory for SST C-104 (see Table D-4)

- Tables and plots of doses from a well driller scenario for radioactive contaminants of concern found within the average and 95% UCL inventory estimated for SST C-104 (see Table D-5 and Figure D-1)

- Tables and plots of doses from a rural pasture scenario for radioactive contaminants of concern found within the average and 95% UCL inventories estimated for SST C-104 (see Table D-6 and Figure D-2)

- Tables and plots of doses from a suburban gardener scenario for radioactive contaminants of concern found within the average and 95% UCL inventories estimated for SST C-104 (see Table D-7 and Figure D-3)

- Tables and plots of doses from a commercial farm scenario for radioactive contaminants of concern found within the average and 95% UCL inventories estimated for SST C-104 (see Table D-8 and Figure D-4).

Table D-9 provides a comparison of the average and 95% UCL concentrations for waste residuals within tank C-104 against *Washington Administrative Code* 173-340, "Model Toxics Control Act – Cleanup" cleanup levels for soil direct contact unrestricted land use (Method B), industrial land use (Method C), and soil concentrations protective of groundwater.

Tables D-10 and D-11 provide additional risk management information related to (average and 95% UCL) concentrations of constituents remaining in waste residuals within tank C-104 compared against the *Washington Administrative Code* 173-340 cleanup standards. See Section 5.5 for additional discussion.

Table D-12 provides information on background concentration levels at the Hanford Site that have been developed for selected constituents. This is provided to bring additional perspective in the concentration levels of constituents remaining in residual wastes within tank C-104.

Table D-1. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the Average Inventory for Single-Shell Tank 241-C-104. (3 sheets)

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Tritium	No	5.20E-03	0.00E+00	DNA	0.00E+00	1.23E+01	NE	NE	NE	NE
Carbon-14	Yes	1.76E-03	2.71E-03	9.78E+03	0.00E+00	5.73E+03	2.11E-11	1.52E-10	1.31E-05	5.42E-06
Nickel-63	Yes	6.15E+01	0.00E+00	DNA	4.80E+01	1.00E+02	NE	NE	NE	NE
Cobalt-60	No	6.45E-01	0.00E+00	DNA	1.00E-01	5.27E+00	NE	NE	NE	NE
Selenium-79	No	2.44E-03	0.00E+00	DNA	3.10E+00	8.05E+05	NE	NE	NE	NE
Strontium-90 + D	Yes	3.72E+03	0.00E+00	DNA	1.61E+01	2.81E+01	NE	NE	NE	NE
Yttrium-90	Yes	3.72E+03	0.00E+00	DNA	0.00E+00	7.31E-03	NE	NE	NE	NE
Technetium-99	Yes	1.73E-01	6.91E-01	1.05E+04	0.00E+00	2.11E+05	9.52E-09	2.32E-07	1.21E-03	3.07E-03
Tin-126	Yes	5.01E-03	0.00E+00	DNA	1.00E+00	2.46E+05	NE	NE	NE	NE
Antimony-125	No	5.60E+00	0.00E+00	DNA	1.00E+00	2.73E+00	NE	NE	NE	NE
Iodine-129	No	1.38E-04	<1.00E-03	1.20E+04	2.00E-01	1.57E+07	NE	NE	NE	NE
Cesium-137 + Daughters	Yes	4.67E+02	0.00E+00	DNA	2.50E+01	3.00E+01	NE	NE	NE	NE
Barium-137m	Yes	4.41E+02	0.00E+00	DNA	0.00E+00	4.86E-06	NE	NE	NE	NE
Europium-152	No	1.64E+00	0.00E+00	DNA	1.00E+00	1.33E+01	NE	NE	NE	NE
Europium-154	No	1.18E+00	0.00E+00	DNA	1.00E+00	8.59E+00	NE	NE	NE	NE
Europium-155	No	2.36E+00	0.00E+00	DNA	1.00E+00	4.68E+00	NE	NE	NE	NE
Thorium-228 + D	Yes	1.48E-02	0.00E+00	DNA	3.00E+00	1.91E+00	NE	NE	NE	NE

Table D-1. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the Average Inventory for Single-Shell Tank 241-C-104. (3 sheets)

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Thorium-230	No	2.42E-04	0.00E+00	DNA	3.00E+00	7.54E+04	NE	NE	NE	NE
Thorium-232	Yes	2.11E-03	0.00E+00	DNA	3.00E+00	1.41E+10	NE	NE	NE	NE
Protactinium-231	No	1.07E-01	0.00E+00	DNA	5.50E+02	3.28E+04	NE	NE	NE	NE
Uranium-233	No	6.20E-01	0.00E+00	DNA	6.00E-01	1.59E+05	NE	NE	NE	N/A
Uranium-234	Yes	2.37E-01	0.00E+00	DNA	6.00E-01	2.46E+05	NE	NE	NE	N/A
Uranium-235 + D	Yes	1.13E-02	0.00E+00	DNA	6.00E-01	7.04E+08	NE	NE	NE	N/A
Uranium-236	Yes	2.76E-03	0.00E+00	DNA	6.00E-01	2.34E+07	NE	NE	NE	N/A
Uranium-238 + D	Yes	2.50E-01	0.00E+00	DNA	6.00E-01	4.47E+09	NE	NE	NE	N/A
Neptunium-237 + D	No	2.27E-02	0.00E+00	DNA	2.00E+00	2.14E+06	NE	NE	NE	NE
Plutonium-238	Yes	3.69E-01	0.00E+00	DNA	3.00E+00	8.77E+01	NE	NE	NE	NE
Plutonium-239	Yes	2.93E+00	0.00E+00	DNA	3.00E+00	2.41E+04	NE	NE	NE	NE
Plutonium-240	Yes	8.82E-01	0.00E+00	DNA	3.00E+00	6.56E+03	NE	NE	NE	NE
Plutonium-241 + D	Yes	1.16E+01	0.00E+00	DNA	3.00E+00	1.44E+01	NE	NE	NE	NE
Plutonium-242	Yes	1.12E-02	0.00E+00	DNA	3.00E+00	3.74E+05	NE	NE	NE	NE
Americium-241	Yes	4.91E+00	0.00E+00	DNA	3.00E+00	4.33E+02	NE	NE	NE	NE
Curium-242	Yes	1.89E-02	0.00E+00	DNA	3.00E+00	4.46E-01	NE	NE	NE	NE
Curium-243	Yes	2.76E-03	0.00E+00	DNA	3.00E+00	2.85E+01	NE	NE	NE	NE
Curium-244	Yes	6.01E-02	0.00E+00	DNA	3.00E+00	1.81E+01	NE	NE	NE	NE

Table D-1. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the Average Inventory for Single-Shell Tank 241-C-104. (3 sheets)

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Performance Objectives[c]							1-0E-6 to 1.0E-4[d]	1-0E-6 to 1.0E-4[d]	25[e]	4[f]

[a] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, and Section 4.3 of PNNL-14702, *Vadose Zone Hydrogeology Data Package for Hanford Assessments* for the basis for the K_d values listed for the radionuclides.

[b] All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*.

[c] Performance objectives apply to the cumulative (i.e., all contaminants) for the entire waste management area.

[d] EPA/540/R-99/006, *Radiation Risk Assessment at CERCLA Sites: Q & A*, Directive 9200.4-31P.

[e] DOE O 435.1, *Radioactive Waste Management*.

[f] 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule."

DNA = Did not arrive at fenceline within the 10,000-year modeling period.
N/A = Radionuclide is not a beta/photon emitter.
NE = Incremental cancer risk for industrial and residential scenarios or radiological dose evaluated for the all-pathways farmer and drinking water only scenarios not evaluated because radiological constituent had no estimated initial inventory or did not arrive in concentrations greater than at the fenceline within the 10,000-year modeling period. In the Decision Management Tool (DMT) that is used to implement the calculational methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* for this Retrieval Data Report, calculated concentrations less than 1.00E-21 pCi/L are considered to be effectively zero. This risk metric may have also not been calculated because the radioactive analyte was predicted to have a concentration less than 0.001 pCi/L, which is well below the ability of standard laboratory analytical methods to detect it.

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern Using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-104. (5 sheets)

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Aluminum	Yes	6.48E+02	0.00E+00	DNA	1.00E+00	NE	NE
Ammonia	Yes	4.53E-02	<1.00E-03	1.05E+04	9.30E-04	NE	NE
Antimony[a]	No	3.87E-02	0.00E+00	DNA	1.00E+00	NE	NE
Arsenic[a]	No	3.22E-02	0.00E+00	DNA	3.90E+01	NE	NE
Barium[a]	Yes	3.75E-01	0.00E+00	DNA	6.00E+01	NE	NE
Beryllium[a]	Yes	2.10E-02	0.00E+00	DNA	7.00E+01	NE	NE
Bismuth	Yes	1.66E+00	6.82E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Bromide	No	1.67E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Cadmium[a]	Yes	1.12E+00	0.00E+00	DNA	1.26E+00	NE	NE
Calcium	Yes	7.71E+00	0.00E+00	DNA	4.00E+00	NE	NE
Cerium	Yes	3.95E+00	1.62E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Chloride	Yes	3.39E-01	1.39E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Chromium, Total	Yes	1.74E+00	7.14E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Cobalt	Yes	2.05E-02	<1.00E-03	1.20E+04	1.00E-01	No CPF	NE
Copper	Yes	1.05E+00	0.00E+00	DNA	3.50E+01	NE	NE
Cyanide[a]	No	5.25E-03	0.00E+00	DNA	9.90E+00	NE	NE
Europium	No	6.45E-03	0.00E+00	DNA	5.00E+01	NE	NE
Fluoride	Yes	8.74E+00	3.59E-02	1.05E+04	0.00E+00	No CPF	3.74E-05

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern Using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-104. (5 sheets)

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Formate+A2	Yes	7.70E-01	3.16E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Iron	Yes	1.84E+02	0.00E+00	DNA	2.50E+01	NE	NE
Lanthanum	No	6.65E-03	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Lead[a]	Yes	3.69E+00	0.00E+00	DNA	5.20E+00	NE	NE
Lithium	Yes	9.15E-02	0.00E+00	DNA	3.00E+02	NE	NE
Magnesium	Yes	1.60E+00	0.00E+00	DNA	4.50E+00	NE	NE
Manganese	Yes	2.44E+01	0.00E+00	DNA	1.00E+00	NE	NE
Mercury[a]	Yes	7.66E-01	0.00E+00	DNA	5.20E+00	NE	NE
Molybdenum	Yes	4.56E-02	0.00E+00	DNA	4.00E+00	NE	NE
Neodymium	Yes	4.86E-01	2.00E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Nickel[a]	Yes	3.42E+00	0.00E+00	DNA	4.80E+01	NE	NE
Niobium	Yes	2.91E-01	0.00E+00	DNA	1.00E+02	NE	NE
Nitrate	Yes	5.34E+00	2.19E-02	1.05E+04	0.00E+00	No CPF	8.56E-07
Nitrite	Yes	2.88E+00	1.18E-02	1.05E+04	0.00E+00	No CPF	7.39E-06
Oxalate	Yes	1.35E+02	5.54E-01	1.05E+04	0.00E+00	No CPF	No Rfd
Palladium	Yes	2.09E+00	0.00E+00	DNA	5.00E+01	NE	NE
Phosphate	Yes	2.44E+01	1.00E-01	1.05E+04	0.00E+00	No CPF	No Rfd
Potassium	Yes	7.48E-01	3.07E-03	1.05E+04	0.00E+00	No CPF	No Rfd

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern Using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-104. (5 sheets)

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Praseodymium	Yes	2.48E+00	1.02E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Rhodium	No	5.15E-02	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Rubidium	No	1.93E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Ruthenium	No	2.58E-02	0.00E+00	DNA	1.00E+00	NE	NE
Selenium[a]	No	3.87E-02	0.00E+00	DNA	5.00E+00	NE	NE
Silicon	Yes	7.47E+01	0.00E+00	DNA	3.00E+01	NE	NE
Silver[a]	Yes	9.35E+00	0.00E+00	DNA	2.70E+00	NE	NE
Sodium	Yes	6.55E+02	2.69E+00	1.05E+04	0.00E+00	No CPF	No Rfd
Strontium	Yes	5.32E-01	0.00E+00	DNA	1.61E+01	NE	NE
Sulfate	Yes	6.57E-01	2.70E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Tantalum	Yes	1.96E+00	8.05E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Tellurium	Yes	1.13E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Thallium[a]	No	3.87E-02	0.00E+00	DNA	7.10E+01	NE	NE
Thorium	Yes	1.91E+01	0.00E+00	DNA	1.00E+00	NE	NE
Tin	Yes	2.13E-01	0.00E+00	DNA	2.50E+02	NE	NE
Titanium	Yes	2.50E-01	0.00E+00	DNA	1.00E+03	NE	NE
Tungsten	Yes	9.38E-02	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Uranium	Yes	7.50E+02	0.00E+00	DNA	6.00E-01	NE	NE

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern Using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-104. (5 sheets)

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Vanadium	Yes	2.30E-01	0.00E+00	DNA	5.00E+01	NE	NE
Yttrium	Yes	3.08E-01	1.26E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Zinc	Yes	8.14E-01	0.00E+00	DNA	6.20E+01	NE	NE
Zirconium	Yes	1.42E+01	0.00E+00	DNA	5.00E+02	NE	NE
1, 1, 2-Trichloroethylene	No	3.52E-06	<1.00E-03	1.20E+04	2.82E-02	NE	NE
2-Butanone (MEK)[a]	No	9.20E-05	<1.00E-03	1.05E+04	1.35E-03	NE	NE
2-Propanone (Acetone)[a]	No	1.27E-04	<1.00E-03	1.05E+04	1.73E-04	NE	NE
4-Methyl-2-pentanone (MIBK)	No	4.97E-05	<1.00E-03	1.20E+04	4.02E-02	NE	NE
Acetate $C_2H_3O_2^-$	Yes	4.15E-01	1.70E-03	1.05E+04	3.00E-04	No CPF	No Rfd
Benzene[a]	Yes	2.21E-05	<1.00E-03	1.05E+04	1.86E-02	NE	NE
Dichloromethane (methylene chloride)[a]	Yes	2.39E-05	<1.00E-03	1.05E+04	3.00E-03	NE	NE
Ethylbenzene	Yes	1.37E-05	<1.00E-03	1.20E+04	6.00E-02	NE	NE
Glycolate $C_2H_3O_3$	No	6.10E-02	<1.00E-03	1.05E+04	0.00E+00	NE	NE
m-Xylene	No	5.55E-06	<1.00E-03	1.20E+04	5.88E-02	NE	NE
n-Butyl alcohol (1-butanol)	Yes	2.93E-03	<1.00E-03	1.05E+04	2.08E-03	NE	NE
o-Xylene	No	2.73E-06	<1.00E-03	1.20E+04	7.23E-02	NE	NE
Toluene[a]	Yes	2.10E-05	<1.00E-03	1.20E+04	4.20E-02	NE	NE
Tributyl phosphate	No	5.30E-03	<1.00E-03	1.20E+04	5.67E-01	NE	NE

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern Using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-104. (5 sheets)

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Xylenes	No	7.05E-06	<1.00E-03	1.20E+04	5.88E-02	NE	NE
Polychlorinated Biphenyls (high risk)[a]	Yes	2.44E-03	0.00E+00	DNA	9.27E+01	NE	NE
Performance Objective[d]						**1.0E-06[e]**	**1.0[f]**

[a] Dangerous waste constituent per *Washington Administrative Code* (WAC) 173-303-9905, "Dangerous Waste Constituents List."

[b] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, for the basis for the K_d values listed for chromium and nitrate. The K_d values listed for the organic chemical compounds are determined from the chemicals' organic carbon/water partitioning coefficient and an estimate of 0.03% for the Hanford Site sediments fraction of organic content (PNNL-13895, Rev. 1, page 11, paragraph 3).

[c] All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments.*

[d] Single Analyte Performance objectives apply to entire waste management area, not just a single component of the waste management area.

[e] WAC 173-340-705, "Use of Method B," subpart (2)(c)(ii).

[f] WAC 173-340-705 (2)(c)(i).

DNA = Did not arrive at fenceline within the 10,000-year modeling period.

NE = Incremental cancer risk or hazard quotient calculated under WAC 173-340, "Model Toxics Control Act – Cleanup," Method B not evaluated because hazardous chemical constituent had no estimated initial inventory or did not arrive in concentrations greater than zero at the fenceline within the 10,000-year modeling period. In the Decision Management Tool (DMT) that is used to implement the calculational methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* for this Retrieval Data Report, calculated concentrations less than 1.00E-21 µg/L are considered to be effectively zero. The risk metric may have also not been calculated because the chemical analyte was predicted to have a concentration less than 0.001 µg/L, which is well below the ability of standard laboratory analytical methods to detect it.

No CPF = No cancer slope factor available.

No Rfd = No reference dose available.

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water for Single-Shell Tank 241-C-104 Dose per Radionuclide Contaminant of Potential Concern for the 95% Upper Confidence Level Inventory. (3 sheets)

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Tritium	No	1.58E-02	0.00E+00	DNA	0.00E+00	1.23E+01	NE	NE	NE	NE
Carbon-14	Yes	2.65E-03	4.08E-03	9.78E+03	0.00E+00	5.73E+03	3.17E-11	2.29E-10	1.98E-05	8.17E-06
Nickel-63	Yes	1.61E+02	0.00E+00	DNA	4.80E+01	1.00E+02	NE	NE	NE	NE
Cobalt-60	No	1.96E+00	0.00E+00	DNA	1.00E-01	5.27E+00	NE	NE	NE	NE
Selenium-79	No	7.40E-03	0.00E+00	DNA	3.10E+00	8.05E+05	NE	NE	NE	NE
Strontium-90 + D	Yes	7.40E+03	0.00E+00	DNA	1.61E+01	2.81E+01	NE	NE	NE	NE
Yttrium-90	Yes	7.40E+03	0.00E+00	DNA	0.00E+00	7.31E-03	NE	NE	NE	NE
Technetium-99	Yes	2.65E-01	1.06E+00	1.05E+04	0.00E+00	2.11E+05	1.46E-08	3.55E-07	1.85E-03	4.70E-03
Tin-126	Yes	9.57E-03	0.00E+00	DNA	1.00E+00	2.46E+05	NE	NE	NE	NE
Antimony-125	No	1.70E+01	0.00E+00	DNA	1.00E+00	2.73E+00	NE	NE	NE	NE
Iodine-129	No	4.20E-04	<1.00E-03	1.20E+04	2.00E-01	1.57E+07	NE	NE	NE	NE
Cesium-137 + Daughters	Yes	8.58E+02	0.00E+00	DNA	2.50E+01	3.00E+01	NE	NE	NE	NE
Barium-137m	Yes	7.90E+02	0.00E+00	DNA	0.00E+00	4.86E-06	NE	NE	NE	NE
Europium-152	No	4.99E+00	0.00E+00	DNA	1.00E+00	1.33E+01	NE	NE	NE	NE
Europium-154	No	3.57E+00	0.00E+00	DNA	1.00E+00	8.59E+00	NE	NE	NE	NE
Europium-155	No	7.15E+00	0.00E+00	DNA	1.00E+00	4.68E+00	NE	NE	NE	NE
Thorium-228 + D	Yes	3.12E-02	0.00E+00	DNA	3.00E+00	1.91E+00	NE	NE	NE	NE

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water for Single-Shell Tank 241-C-104 Dose per Radionuclide Contaminant of Potential Concern for the 95% Upper Confidence Level Inventory. (3 sheets)

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Thorium-230	No	7.35E-04	0.00E+00	DNA	3.00E+00	7.54E+04	NE	NE	NE	NE
Thorium-232	Yes	4.11E-03	0.00E+00	DNA	3.00E+00	1.41E+10	NE	NE	NE	NE
Protactinium-231	No	3.24E-01	0.00E+00	DNA	5.50E+02	3.28E+04	NE	NE	NE	NE
Uranium-233	No	1.89E+00	0.00E+00	DNA	6.00E-01	1.59E+05	NE	NE	NE	N/A
Uranium-234	Yes	3.46E-01	0.00E+00	DNA	6.00E-01	2.46E+05	NE	NE	NE	N/A
Uranium-235 + D	Yes	1.70E-02	0.00E+00	DNA	6.00E-01	7.04E+08	NE	NE	NE	N/A
Uranium-236	Yes	4.16E-03	0.00E+00	DNA	6.00E-01	2.34E+07	NE	NE	NE	N/A
Uranium-238 + D	Yes	3.77E-01	0.00E+00	DNA	6.00E-01	4.47E+09	NE	NE	NE	N/A
Neptunium-237 + D	No	6.90E-02	0.00E+00	DNA	2.00E+00	2.14E+06	NE	NE	NE	NE
Plutonium-238	Yes	6.65E-01	0.00E+00	DNA	3.00E+00	8.77E+01	NE	NE	NE	NE
Plutonium-239	Yes	5.14E+00	0.00E+00	DNA	3.00E+00	2.41E+04	NE	NE	NE	NE
Plutonium-240	Yes	1.55E+00	0.00E+00	DNA	3.00E+00	6.56E+03	NE	NE	NE	NE
Plutonium-241 + D	Yes	1.93E+01	0.00E+00	DNA	3.00E+00	1.44E+01	NE	NE	NE	NE
Plutonium-242	Yes	1.99E-02	0.00E+00	DNA	3.00E+00	3.74E+05	NE	NE	NE	NE
Americium-241	Yes	9.71E+00	0.00E+00	DNA	3.00E+00	4.33E+02	NE	NE	NE	NE
Curium-242	Yes	3.55E-02	0.00E+00	DNA	3.00E+00	4.46E-01	NE	NE	NE	NE
Curium-243	Yes	6.14E-03	0.00E+00	DNA	3.00E+00	2.85E+01	NE	NE	NE	NE
Curium-244	Yes	1.34E-01	0.00E+00	DNA	3.00E+00	1.81E+01	NE	NE	NE	NE

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water for Single-Shell Tank 241-C-104 Dose per Radionuclide Contaminant of Potential Concern for the 95% Upper Confidence Level Inventory. (3 sheets)

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Performance Objectives[c]							**1-0E-6 to 1.0E-4[d]**	**1-0E-6 to 1.0E-4[d]**	**25[e]**	**4[f]**

[a] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, and Section 4.3 of PNNL-14702, *Vadose Zone Hydrogeology Data Package for Hanford Assessments* for the basis for the K_d values listed for the radionuclides.

[b] All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments.*

[c] Performance objectives apply to the cumulative (i.e., all contaminants) for the entire waste management area.

[d] EPA/540/R-99/006, *Radiation Risk Assessment at CERCLA Sites: Q & A*, Directive 9200.4-31P.

[e] DOE O 435.1, *Radioactive Waste Management.*

[f] 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule."

DNA = Did not arrive at fenceline within the 10,000-year modeling period.
N/A = Radionuclide is not a beta/photon emitter.
NE = Incremental cancer risk for industrial and residential scenarios or radiological dose evaluated for the all-pathways farmer and drinking water only scenarios not evaluated because radiological constituent had no estimated initial inventory or did not arrive in concentrations greater than at the fenceline within the 10,000-year modeling period. In the Decision Management Tool (DMT) that is used to implement the calculational methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* for this Retrieval Data Report, calculated concentrations less than 1.00E-21 pCi/L are considered to be effectively zero. This risk metric may have also not been calculated because the radioactive analyte was predicted to have a concentration less than 0.001 pCi/L, which is well below the ability of standard laboratory analytical methods to detect it.

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-104 of Potential Concern Using 95% Upper Confidence Level Post-Retrieval Inventory. (5 sheets)

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Aluminum	Yes	1.03E+03	0.00E+00	DNA	1.00E+00	NE	NE
Ammonia	Yes	7.97E-02	<1.00E-03	1.05E+04	9.30E-04	NE	NE
Antimony[a]	No	1.18E-01	0.00E+00	DNA	1.00E+00	NE	NE
Arsenic[a]	No	9.80E-02	0.00E+00	DNA	3.90E+01	NE	NE
Barium[a]	Yes	6.02E-01	0.00E+00	DNA	6.00E+01	NE	NE
Beryllium[a]	Yes	2.98E-02	0.00E+00	DNA	7.00E+01	NE	NE
Bismuth	Yes	2.48E+00	1.02E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Bromide	No	5.05E-01	2.07E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Cadmium[a]	Yes	2.03E+00	0.00E+00	DNA	1.26E+00	NE	NE
Calcium	Yes	1.36E+01	0.00E+00	DNA	4.00E+00	NE	NE
Cerium	Yes	5.85E+00	2.40E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Chloride	Yes	5.17E-01	2.12E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Chromium, Total[a]	Yes	2.53E+00	1.04E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Cobalt	Yes	3.12E-02	<1.00E-03	1.20E+04	1.00E-01	NE	NE
Copper	Yes	1.58E+00	0.00E+00	DNA	3.50E+01	NE	NE
Cyanide[a]	No	1.60E-02	0.00E+00	DNA	9.90E+00	NE	NE
Europium	No	1.96E-02	0.00E+00	DNA	5.00E+01	NE	NE
Fluoride	Yes	1.71E+01	7.02E-02	1.05E+04	0.00E+00	No CPF	7.31E-05

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-104 of Potential Concern Using 95% Upper Confidence Level Post-Retrieval Inventory. (5 sheets)

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Formate+A2	Yes	1.08E+00	4.43E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Iron	Yes	2.75E+02	0.00E+00	DNA	2.50E+01	NE	NE
Lanthanum	No	2.02E-02	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Lead[a]	Yes	5.65E+00	0.00E+00	DNA	5.20E+00	NE	NE
Lithium	Yes	1.41E-01	0.00E+00	DNA	3.00E+02	NE	NE
Magnesium	Yes	2.99E+00	0.00E+00	DNA	4.50E+00	NE	NE
Manganese	Yes	5.06E+01	0.00E+00	DNA	1.00E+00	NE	NE
Mercury[a]	Yes	1.11E+00	0.00E+00	DNA	5.20E+00	NE	NE
Molybdenum	Yes	7.75E-02	0.00E+00	DNA	4.00E+00	NE	NE
Neodymium	Yes	7.76E-01	3.19E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Nickel[a]	Yes	6.29E+00	0.00E+00	DNA	4.80E+01	NE	NE
Niobium	Yes	5.05E-01	0.00E+00	DNA	1.00E+02	NE	NE
Nitrate	Yes	7.38E+00	3.03E-02	1.05E+04	0.00E+00	No CPF	1.18E-06
Nitrite	Yes	4.44E+00	1.82E-02	1.05E+04	0.00E+00	No CPF	1.14E-05
Oxalate	Yes	2.30E+02	9.44E-01	1.05E+04	0.00E+00	No CPF	No Rfd
Palladium	Yes	3.16E+00	0.00E+00	DNA	5.00E+01	NE	NE
Phosphate	Yes	4.29E+01	1.76E-01	1.05E+04	0.00E+00	No CPF	No Rfd
Potassium	Yes	1.04E+00	4.27E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Praseodymium	Yes	3.74E+00	1.54E-02	1.05E+04	0.00E+00	No CPF	No Rfd

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-104 of Potential Concern Using 95% Upper Confidence Level Post-Retrieval Inventory. (5 sheets)

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Rhodium	No	1.57E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Rubidium	No	5.85E-01	2.40E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Ruthenium	No	7.85E-02	0.00E+00	DNA	1.00E+00	NE	NE
Selenium[a]	No	1.18E-01	0.00E+00	DNA	5.00E+00	NE	NE
Silicon	Yes	1.04E+02	0.00E+00	DNA	3.00E+01	NE	NE
Silver[a]	Yes	1.36E+01	0.00E+00	DNA	2.70E+00	NE	NE
Sodium	Yes	9.13E+02	3.75E+00	1.05E+04	0.00E+00	No CPF	No Rfd
Strontium	Yes	8.28E-01	0.00E+00	DNA	1.61E+01	NE	NE
Sulfate	Yes	9.13E-01	3.75E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Tantalum	Yes	2.97E+00	1.22E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Tellurium	Yes	1.72E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Thallium[a]	No	1.18E-01	0.00E+00	DNA	7.10E+01	NE	NE
Thorium	Yes	3.72E+01	0.00E+00	DNA	1.00E+00	NE	NE
Tin	Yes	4.45E-01	0.00E+00	DNA	2.50E+02	NE	NE
Titanium	Yes	3.63E-01	0.00E+00	DNA	1.00E+03	NE	NE
Tungsten	Yes	1.34E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Uranium	Yes	1.13E+03	0.00E+00	DNA	6.00E-01	NE	NE
Vanadium	Yes	3.42E-01	0.00E+00	DNA	5.00E+01	NE	NE
Yttrium	Yes	4.82E-01	1.98E-03	1.05E+04	0.00E+00	No CPF	No Rfd

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-104 of Potential Concern Using 95% Upper Confidence Level Post-Retrieval Inventory. (5 sheets)

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Zinc	Yes	1.20E+00	0.00E+00	DNA	6.20E+01	NE	NE
Zirconium	Yes	3.16E+01	0.00E+00	DNA	5.00E+02	NE	NE
1, 1, 2-Trichloroethylene	No	1.07E-05	<1.00E-03	1.20E+04	2.82E-02	NE	NE
2-Butanone (MEK)[a]	No	2.80E-04	<1.00E-03	1.05E+04	1.35E-03	NE	NE
2-Propanone (Acetone)[a]	No	3.85E-04	<1.00E-03	1.05E+04	1.73E-04	NE	NE
4-Methyl-2-pentanone (MIBK)	No	1.51E-04	<1.00E-03	1.20E+04	4.02E-02	NE	NE
Acetate $C_2H_3O_2^-$	Yes	5.81E-01	2.39E-03	1.05E+04	3.00E-04	No CPF	No Rfd
Benzene[a]	Yes	6.72E-05	<1.00E-03	1.05E+04	1.86E-02	NE	NE
Dichloromethane (methylene chloride)[a]	Yes	4.39E-05	<1.00E-03	1.05E+04	3.00E-03	NE	NE
Ethylbenzene	Yes	4.16E-05	<1.00E-03	1.20E+04	6.00E-02	NE	NE
Glycolate $C_2H_3O_3$	No	1.86E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
m-Xylene	No	1.69E-05	<1.00E-03	1.20E+04	5.88E-02	NE	NE
n-Butyl alcohol (1-butanol)	Yes	5.77E-03	<1.00E-03	1.05E+04	2.08E-03	NE	NE
o-Xylene	No	8.30E-06	<1.00E-03	1.20E+04	7.23E-02	NE	NE
Toluene[a]	Yes	4.77E-05	<1.00E-03	1.20E+04	4.20E-02	NE	NE
Tributyl phosphate	No	1.61E-02	<1.00E-03	1.20E+04	5.67E-01	NE	NE
Xylenes	No	2.15E-05	<1.00E-03	1.20E+04	5.88E-02	NE	NE
Polychlorinated Biphenyls (high risk)[a]	Yes	4.74E-03	0.00E+00	DNA	9.27E+01	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-104 of Potential Concern Using 95% Upper Confidence Level Post-Retrieval Inventory. (5 sheets)

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Performance Objective[d]						1.0E-06[e]	1.0[f]

[a] Dangerous waste constituent per *Washington Administrative Code* (WAC) 173-303-9905, "Dangerous Waste Constituents List."

[b] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, for the basis for the K_d values listed for chromium and nitrate. The K_d values listed for the organic chemical compounds are determined from the chemicals' organic carbon/water partitioning coefficient and an estimate of 0.03% for the Hanford Site sediments fraction of organic content (PNNL-13895, Rev. 1, page 11, paragraph 3).

[c] All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments.*

[d] Single Analyte Performance objectives apply to entire waste management area, not just a single component of the waste management area.

[e] WAC 173-340-705, "Use of Method B," subpart (2)(c)(ii).

[f] WAC 173-340-705 (2)(c)(i).

DNA = Did not arrive at fenceline within the 10,000-year modeling period.

NE = Incremental cancer risk or hazard quotient calculated under WAC-173-340, "Model Toxics Control Act – Cleanup," Method B not evaluated because hazardous chemical constituent had no estimated initial inventory or did not arrive in concentrations greater than zero at the fenceline within the 10,000-year modeling period. In the Decision Management Tool (DMT) that is used to implement the calculational methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* for this Retrieval Data Report, calculated concentrations less than 1.00E-21 µg/L are considered to be effectively zero. The risk metric may have also not been calculated because the chemical analyte was predicted to have a concentration less than 0.001 µg/L, which is well below the ability of standard laboratory analytical methods to detect it.

No CPF = No cancer slope factor available.

No Rfd = No reference dose available.

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (4 sheets)

A – Average Inventory										
	Years After Site Closure (January 1, 2032)									
Nuclide	100	200	300	400	500	600	700	800	900	1,000
Tritium	2.26E-12	8.17E-15	2.96E-17	1.07E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	2.91E-08	2.87E-08	2.84E-08	2.80E-08	2.77E-08	2.74E-08	2.70E-08	2.67E-08	2.64E-08	2.61E-08
Nickel-63	1.17E-04	5.85E-05	2.93E-05	1.46E-05	7.32E-06	3.66E-06	1.83E-06	9.17E-07	4.59E-07	2.30E-07
Cobalt-60	2.68E-08	5.22E-14	1.02E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	1.64E-07	1.64E-07	1.64E-07	1.64E-07	1.64E-07	1.64E-07	1.64E-07	1.64E-07	1.64E-07	1.64E-07
Strontium-90 + D	3.90E-01	3.32E-02	2.83E-03	2.41E-04	2.06E-05	1.75E-06	1.49E-07	1.27E-08	1.09E-09	9.25E-11
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	3.28E-06	3.28E-06	3.28E-06	3.28E-06	3.28E-06	3.28E-06	3.28E-06	3.28E-06	3.27E-06	3.27E-06
Tin-126	2.33E-03	2.33E-03	2.33E-03	2.33E-03	2.33E-03	2.33E-03	2.33E-03	2.33E-03	2.33E-03	2.32E-03
Antimony-125	9.09E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodine-129	4.11E-07	4.11E-07	4.11E-07	4.11E-07	4.11E-07	4.11E-07	4.11E-07	4.11E-07	4.11E-07	4.11E-07
Cesium-137 + Daughters	3.45E+00	3.42E-01	3.40E-02	3.37E-03	3.34E-04	3.32E-05	3.29E-06	3.26E-07	3.24E-08	3.21E-09
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-152	6.43E-04	3.55E-06	1.96E-08	1.08E-10	5.97E-13	4.36E-15	1.09E-15	1.07E-15	1.07E-15	1.07E-15
Europium-154	1.39E-05	4.37E-09	1.37E-12	4.30E-16	1.35E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	2.19E-10	8.11E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	1.15E-05	1.60E-05	2.04E-05	2.46E-05	2.86E-05	3.24E-05	3.61E-05	3.96E-05	4.29E-05	4.61E-05

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (4 sheets)

A – Average Inventory (continued)										
	Years After Site Closure (January 1, 2032)									
Nuclide	100	200	300	400	500	600	700	800	900	1,000
Thorium-232	1.51E-03	1.51E-03	1.51E-03	1.51E-03	1.51E-03	1.51E-03	1.51E-03	1.51E-03	1.51E-03	1.51E-03
Protactinium-231	5.34E-02	5.39E-02	5.38E-02	5.37E-02	5.36E-02	5.35E-02	5.34E-02	5.33E-02	5.31E-02	5.30E-02
Uranium-233	3.40E-03	4.70E-03	5.99E-03	7.26E-03	8.52E-03	9.77E-03	1.10E-02	1.22E-02	1.34E-02	1.46E-02
Uranium-234	6.57E-04	6.69E-04	6.85E-04	7.05E-04	7.29E-04	7.56E-04	7.87E-04	8.21E-04	8.58E-04	8.97E-04
Uranium-235 + D	4.49E-04	4.62E-04	4.74E-04	4.86E-04	4.98E-04	5.10E-04	5.22E-04	5.34E-04	5.46E-04	5.58E-04
Uranium-236	7.13E-06	7.13E-06	7.13E-06	7.13E-06	7.13E-06	7.13E-06	7.13E-06	7.13E-06	7.13E-06	7.13E-06
Uranium-238 + D	1.99E-03	1.99E-03	1.99E-03	1.99E-03	1.99E-03	1.99E-03	1.99E-03	1.99E-03	1.99E-03	1.99E-03
Neptunium-237 + D	2.77E-03	2.77E-03	2.77E-03	2.77E-03	2.77E-03	2.77E-03	2.77E-03	2.77E-03	2.77E-03	2.77E-03
Plutonium-238	7.24E-03	3.29E-03	1.49E-03	6.77E-04	3.07E-04	1.40E-04	6.36E-05	2.91E-05	1.34E-05	6.37E-06
Plutonium-239	1.69E-01	1.69E-01	1.68E-01	1.68E-01	1.67E-01	1.67E-01	1.66E-01	1.66E-01	1.65E-01	1.65E-01
Plutonium-240	5.05E-02	4.99E-02	4.94E-02	4.89E-02	4.84E-02	4.79E-02	4.74E-02	4.69E-02	4.64E-02	4.59E-02
Plutonium-241 + D	2.04E-02	1.74E-02	1.48E-02	1.26E-02	1.08E-02	9.16E-03	7.81E-03	6.65E-03	5.67E-03	4.83E-03
Plutonium-242	6.19E-04	6.19E-04	6.19E-04	6.19E-04	6.19E-04	6.19E-04	6.19E-04	6.18E-04	6.18E-04	6.18E-04
Americium-241	2.52E-01	2.14E-01	1.83E-01	1.56E-01	1.33E-01	1.13E-01	9.63E-02	8.21E-02	7.00E-02	5.96E-02
Curium-242	1.90E-06	8.61E-07	3.90E-07	1.77E-07	8.04E-08	3.65E-08	1.66E-08	7.60E-09	3.50E-09	1.64E-09
Curium-243	9.26E-06	9.87E-07	2.60E-07	1.95E-07	1.89E-07	1.88E-07	1.88E-07	1.87E-07	1.86E-07	1.86E-07
Curium-244	2.61E-05	9.77E-06	9.32E-06	9.21E-06	9.12E-06	9.02E-06	8.93E-06	8.83E-06	8.74E-06	8.65E-06
Total Dose	**4.41E+00**	**8.99E-01**	**5.24E-01**	**4.61E-01**	**4.33E-01**	**4.11E-01**	**3.93E-01**	**3.78E-01**	**3.65E-01**	**3.54E-01**

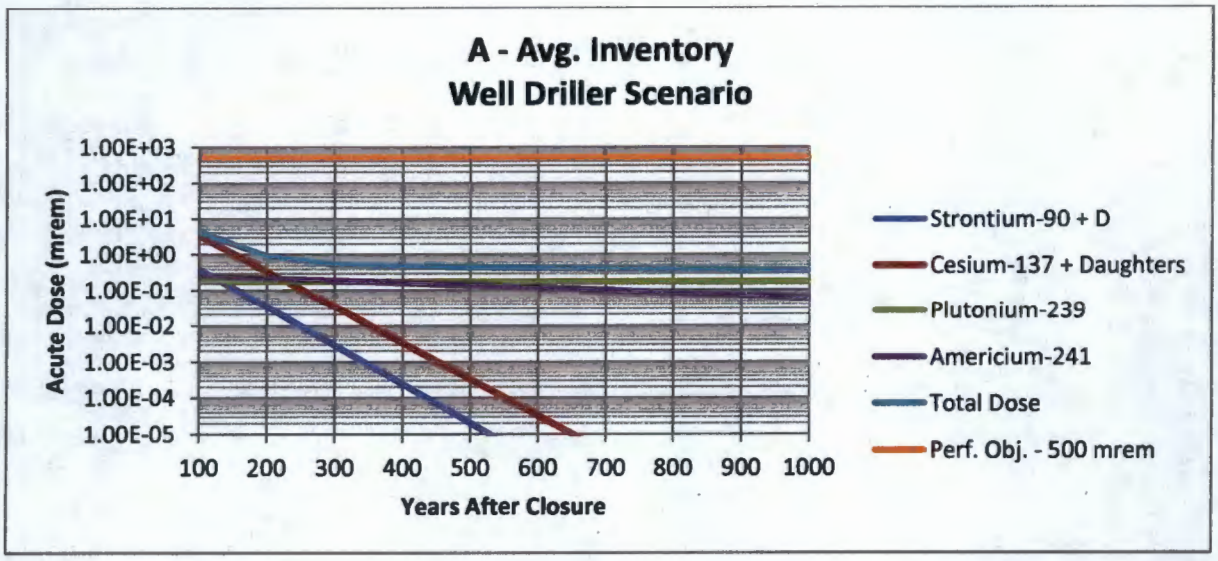
Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (4 sheets)

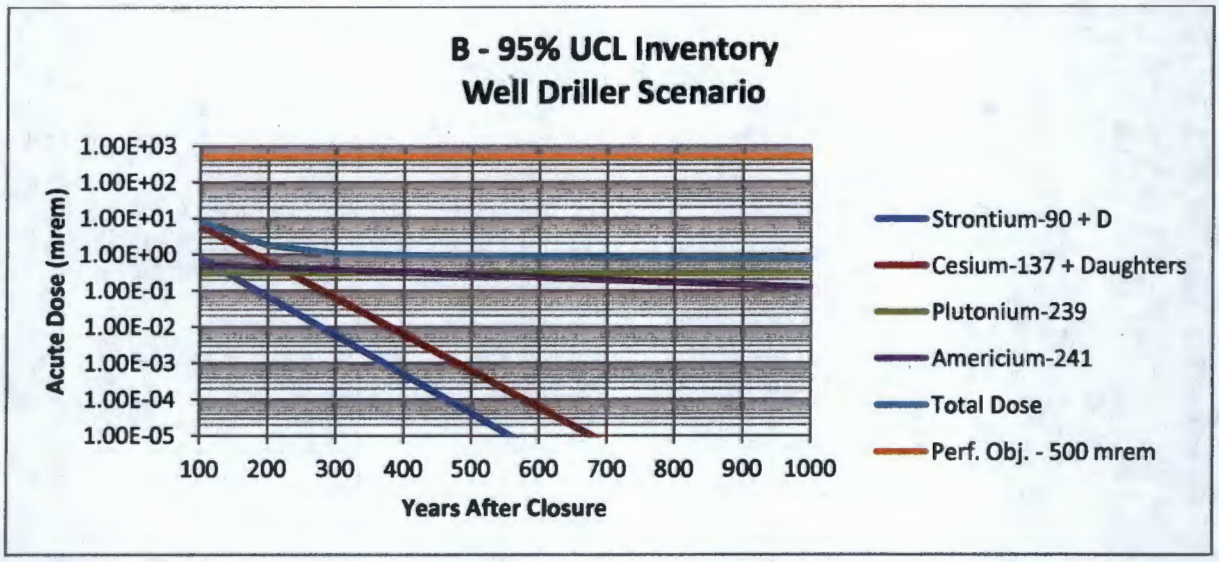
B – 95% Upper Confidence Level Inventory										
	Years After Site Closure (January 1, 2032)									
Nuclide	100	200	300	400	500	600	700	800	900	1,000
Tritium	6.86E-12	2.48E-14	8.98E-17	3.25E-19	1.18E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	4.38E-08	4.32E-08	4.27E-08	4.22E-08	4.17E-08	4.12E-08	4.07E-08	4.02E-08	3.97E-08	3.93E-08
Nickel-63	3.06E-04	1.53E-04	7.66E-05	3.83E-05	1.92E-05	9.59E-06	4.80E-06	2.40E-06	1.20E-06	6.01E-07
Cobalt-60	8.15E-08	1.59E-13	3.09E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	4.97E-07	4.97E-07	4.97E-07	4.97E-07	4.97E-07	4.97E-07	4.97E-07	4.97E-07	4.97E-07	4.97E-07
Strontium-90 + D	7.76E-01	6.61E-02	5.64E-03	4.80E-04	4.09E-05	3.49E-06	2.97E-07	2.53E-08	2.16E-09	1.84E-10
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	5.03E-06	5.03E-06	5.03E-06	5.02E-06	5.02E-06	5.02E-06	5.02E-06	5.02E-06	5.02E-06	5.01E-06
Tin-126	4.45E-03	4.45E-03	4.45E-03	4.45E-03	4.45E-03	4.45E-03	4.44E-03	4.44E-03	4.44E-03	4.44E-03
Antimony-125	2.76E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodine-129	1.25E-06	1.25E-06	1.25E-06	1.25E-06	1.25E-06	1.25E-06	1.25E-06	1.25E-06	1.25E-06	1.25E-06
Cesium-137 + Daughters	6.34E+00	6.29E-01	6.24E-02	6.19E-03	6.14E-04	6.09E-05	6.04E-06	5.99E-07	5.95E-08	5.90E-09
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-152	1.96E-03	1.08E-05	5.95E-08	3.28E-10	1.82E-12	1.33E-14	3.31E-15	3.25E-15	3.25E-15	3.25E-15
Europium-154	4.23E-05	1.33E-08	4.16E-12	1.31E-15	4.09E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	6.66E-10	2.46E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	3.48E-05	4.87E-05	6.20E-05	7.47E-05	8.68E-05	9.85E-05	1.10E-04	1.20E-04	1.30E-04	1.40E-04

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (4 sheets)

B – 95% Upper Confidence Level Inventory (continued)										
	Years After Site Closure (January 1, 2032)									
Nuclide	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Thorium-232	2.95E-03	2.95E-03	2.95E-03	2.95E-03	2.95E-03	2.95E-03	2.95E-03	2.95E-03	2.95E-03	2.95E-03
Protactinium-231	1.62E-01	1.64E-01	1.64E-01	1.63E-01	1.63E-01	1.63E-01	1.62E-01	1.62E-01	1.62E-01	1.61E-01
Uranium-233	1.03E-02	1.43E-02	1.82E-02	2.21E-02	2.59E-02	2.97E-02	3.35E-02	3.72E-02	4.09E-02	4.45E-02
Uranium-234	9.58E-04	9.76E-04	1.00E-03	1.03E-03	1.06E-03	1.10E-03	1.15E-03	1.20E-03	1.25E-03	1.31E-03
Uranium-235 + D	6.76E-04	6.94E-04	7.13E-04	7.31E-04	7.49E-04	7.67E-04	7.85E-04	8.03E-04	8.21E-04	8.39E-04
Uranium-236	1.07E-05	1.07E-05	1.07E-05	1.07E-05	1.07E-05	1.07E-05	1.07E-05	1.07E-05	1.07E-05	1.07E-05
Uranium-238 + D	3.00E-03	3.00E-03	3.00E-03	3.00E-03	3.00E-03	3.00E-03	3.00E-03	3.00E-03	3.00E-03	3.00E-03
Neptunium-237 + D	8.43E-03	8.43E-03	8.43E-03	8.43E-03	8.43E-03	8.43E-03	8.43E-03	8.43E-03	8.43E-03	8.43E-03
Plutonium-238	1.31E-02	5.92E-03	2.69E-03	1.22E-03	5.54E-04	2.52E-04	1.15E-04	5.24E-05	2.42E-05	1.15E-05
Plutonium-239	2.97E-01	2.96E-01	2.95E-01	2.94E-01	2.94E-01	2.93E-01	2.92E-01	2.91E-01	2.90E-01	2.89E-01
Plutonium-240	8.87E-02	8.78E-02	8.68E-02	8.59E-02	8.50E-02	8.41E-02	8.32E-02	8.24E-02	8.15E-02	8.06E-02
Plutonium-241 + D	3.39E-02	2.89E-02	2.46E-02	2.10E-02	1.79E-02	1.52E-02	1.30E-02	1.11E-02	9.43E-03	8.04E-03
Plutonium-242	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.10E-03
Americium-241	4.98E-01	4.24E-01	3.61E-01	3.08E-01	2.62E-01	2.24E-01	1.91E-01	1.62E-01	1.38E-01	1.18E-01
Curium-242	3.56E-06	1.62E-06	7.33E-07	3.33E-07	1.51E-07	6.86E-08	3.12E-08	1.43E-08	6.57E-09	3.08E-09
Curium-243	2.06E-05	2.20E-06	5.78E-07	4.35E-07	4.21E-07	4.19E-07	4.17E-07	4.16E-07	4.15E-07	4.14E-07
Curium-244	5.83E-05	2.18E-05	2.08E-05	2.05E-05	2.03E-05	2.01E-05	1.99E-05	1.97E-05	1.95E-05	1.93E-05
Total Dose	**8.24E+00**	**1.74E+00**	**1.04E+00**	**9.25E-01**	**8.71E-01**	**8.31E-01**	**7.97E-01**	**7.68E-01**	**7.44E-01**	**7.24E-01**

Figure D-1. Comparison of Well Driller Scenario Doses (mrem) with Performance Objective for Acute Exposure for Key Analytes – A) Average Inventory and B) 95% Upper Confidence Level Inventory in Residual Wastes within Single-Shell Tank 241-C-104.





UCL = upper confidence level

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (4 sheets)

A – Average Inventory										
	Years After Site Closure (January 1, 2032)									
Nuclide	100	200	300	400	500	600	700	800	900	1,000
Tritium	8.38E-11	3.03E-13	1.10E-15	3.97E-18	1.44E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	3.20E-06	3.17E-06	3.13E-06	3.09E-06	3.05E-06	3.02E-06	2.98E-06	2.94E-06	2.91E-06	2.87E-06
Nickel-63	3.11E-03	1.56E-03	7.79E-04	3.90E-04	1.95E-04	9.75E-05	4.88E-05	2.44E-05	1.22E-05	6.11E-06
Cobalt-60	3.06E-09	5.96E-15	1.16E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	7.83E-07	7.83E-07	7.83E-07	7.83E-07	7.83E-07	7.83E-07	7.82E-07	7.82E-07	7.82E-07	7.82E-07
Strontium-90 + D	2.25E+01	1.92E+00	1.64E-01	1.39E-02	1.19E-03	1.01E-04	8.63E-06	7.36E-07	6.27E-08	5.34E-09
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	5.99E-04	5.99E-04	5.98E-04	5.98E-04	5.98E-04	5.98E-04	5.98E-04	5.97E-04	5.97E-04	5.97E-04
Tin-126	2.64E-04	2.64E-04	2.64E-04	2.64E-04	2.64E-04	2.64E-04	2.64E-04	2.64E-04	2.64E-04	2.64E-04
Antimony-125	9.52E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodine-129	4.18E-06	4.18E-06	4.18E-06	4.18E-06	4.18E-06	4.18E-06	4.18E-06	4.18E-06	4.18E-06	4.18E-06
Cesium-137 + Daughters	9.28E-01	9.21E-02	9.13E-03	9.06E-04	8.99E-05	8.92E-06	8.85E-07	8.78E-08	8.71E-09	8.64E-10
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-152	7.28E-05	4.02E-07	2.22E-09	1.22E-11	6.77E-14	6.74E-16	3.04E-16	3.02E-16	3.02E-16	3.02E-16
Europium-154	1.57E-06	4.94E-10	1.55E-13	4.85E-17	1.52E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	1.88E-11	6.96E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	2.78E-06	3.75E-06	4.69E-06	5.59E-06	6.44E-06	7.26E-06	8.05E-06	8.79E-06	9.51E-06	1.02E-05
Thorium-232	2.74E-04	2.74E-04	2.74E-04	2.74E-04	2.74E-04	2.74E-04	2.74E-04	2.74E-04	2.74E-04	2.74E-04

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (4 sheets)

A – Average Inventory (continued)										
	Years After Site Closure (January 1, 2032)									
Nuclide	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Protactinium-231	1.36E-02	1.38E-02	1.37E-02	1.37E-02	1.37E-02	1.36E-02	1.36E-02	1.36E-02	1.36E-02	1.35E-02
Uranium-233	1.38E-03	1.68E-03	1.97E-03	2.27E-03	2.55E-03	2.84E-03	3.12E-03	3.40E-03	3.68E-03	3.96E-03
Uranium-234	3.77E-04	3.80E-04	3.84E-04	3.88E-04	3.94E-04	4.00E-04	4.06E-04	4.14E-04	4.22E-04	4.31E-04
Uranium-235 + D	6.09E-05	6.40E-05	6.71E-05	7.01E-05	7.32E-05	7.63E-05	7.93E-05	8.24E-05	8.54E-05	8.85E-05
Uranium-236	4.15E-06	4.15E-06	4.15E-06	4.15E-06	4.15E-06	4.15E-06	4.15E-06	4.15E-06	4.15E-06	4.15E-06
Uranium-238 + D	5.14E-04	5.14E-04	5.14E-04	5.14E-04	5.14E-04	5.14E-04	5.15E-04	5.15E-04	5.15E-04	5.15E-04
Neptunium-237 + D	5.90E-04	5.90E-04	5.90E-04	5.90E-04	5.90E-04	5.90E-04	5.90E-04	5.90E-04	5.90E-04	5.90E-04
Plutonium-238	2.06E-03	9.33E-04	4.23E-04	1.92E-04	8.73E-05	3.97E-05	1.81E-05	8.36E-06	3.92E-06	1.91E-06
Plutonium-239	4.82E-02	4.81E-02	4.79E-02	4.78E-02	4.76E-02	4.75E-02	4.74E-02	4.72E-02	4.71E-02	4.70E-02
Plutonium-240	1.44E-02	1.42E-02	1.41E-02	1.39E-02	1.38E-02	1.36E-02	1.35E-02	1.33E-02	1.32E-02	1.31E-02
Plutonium-241 + D	5.61E-03	4.79E-03	4.08E-03	3.47E-03	2.96E-03	2.52E-03	2.15E-03	1.83E-03	1.56E-03	1.33E-03
Plutonium-242	1.76E-04	1.76E-04	1.76E-04	1.76E-04	1.76E-04	1.76E-04	1.76E-04	1.76E-04	1.76E-04	1.76E-04
Americium-241	6.93E-02	5.91E-02	5.03E-02	4.29E-02	3.65E-02	3.11E-02	2.65E-02	2.26E-02	1.93E-02	1.64E-02
Curium-242	5.38E-07	2.44E-07	1.11E-07	5.03E-08	2.29E-08	1.04E-08	4.75E-09	2.18E-09	1.02E-09	4.92E-10
Curium-243	2.00E-06	2.25E-07	6.88E-08	5.50E-08	5.36E-08	5.34E-08	5.32E-08	5.30E-08	5.29E-08	5.27E-08
Curium-244	7.49E-06	2.78E-06	2.65E-06	2.62E-06	2.60E-06	2.57E-06	2.54E-06	2.51E-06	2.49E-06	2.46E-06
Total Dose	**2.36E+01**	**2.16E+00**	**3.09E-01**	**1.42E-01**	**1.22E-01**	**1.14E-01**	**1.09E-01**	**1.05E-01**	**1.01E-01**	**9.82E-02**

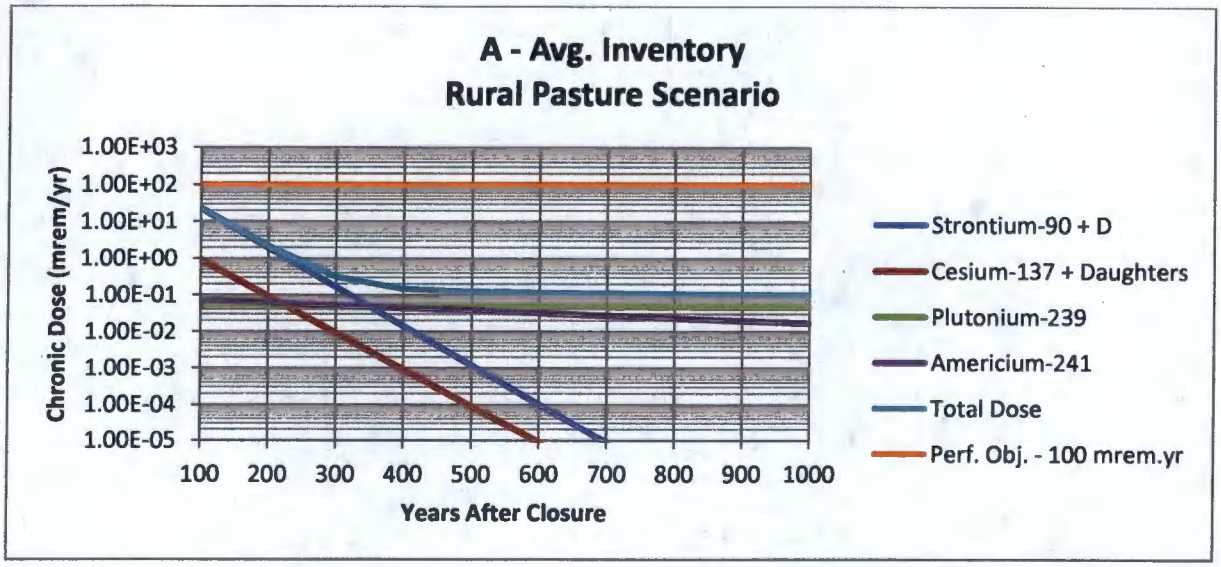
Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (4 sheets)

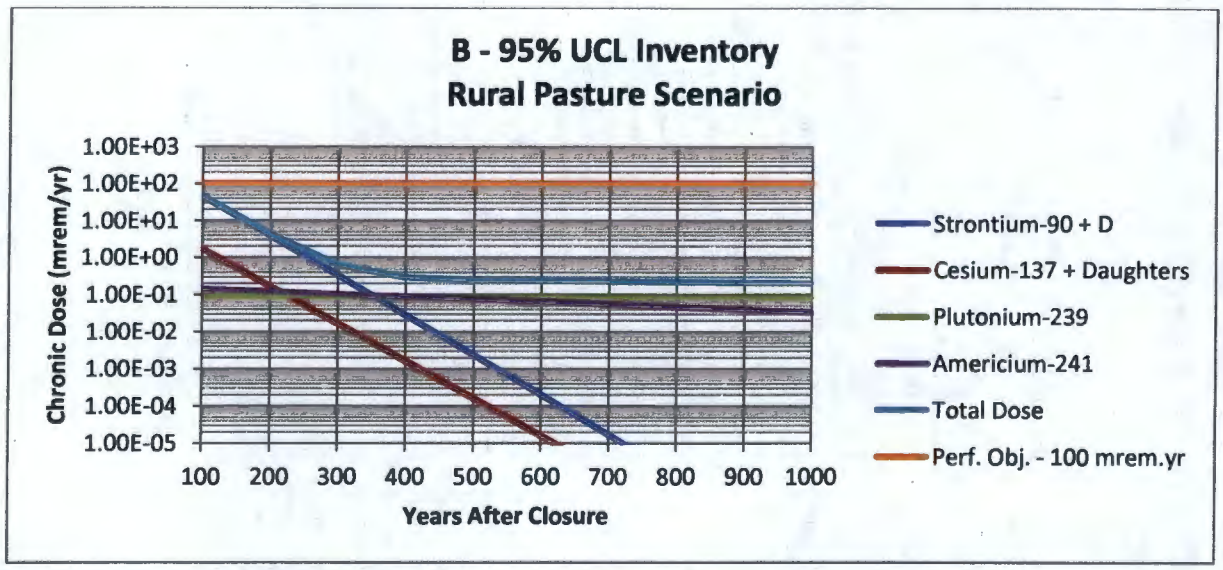
B – 95% Upper Confidence Level Inventory										
	Years After Site Closure (January 1, 2032)									
Nuclide	100	200	300	400	500	600	700	800	900	1,000
Tritium	2.55E-10	9.22E-13	3.34E-15	1.21E-17	4.37E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	4.83E-06	4.77E-06	4.71E-06	4.65E-06	4.60E-06	4.54E-06	4.49E-06	4.43E-06	4.38E-06	4.33E-06
Nickel-63	8.14E-03	4.07E-03	2.04E-03	1.02E-03	5.10E-04	2.55E-04	1.28E-04	6.39E-05	3.20E-05	1.60E-05
Cobalt-60	9.31E-09	1.81E-14	3.53E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	2.37E-06	2.37E-06	2.37E-06	2.37E-06	2.37E-06	2.37E-06	2.37E-06	2.37E-06	2.37E-06	2.37E-06
Strontium-90 + D	4.48E+01	3.82E+00	3.25E-01	2.77E-02	2.36E-03	2.01E-04	1.72E-05	1.46E-06	1.25E-07	1.06E-08
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	9.17E-04	9.17E-04	9.17E-04	9.16E-04	9.16E-04	9.16E-04	9.15E-04	9.15E-04	9.15E-04	9.15E-04
Tin-126	5.05E-04	5.05E-04	5.05E-04	5.04E-04	5.04E-04	5.04E-04	5.04E-04	5.04E-04	5.04E-04	5.04E-04
Antimony-125	2.89E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodine-129	1.27E-05	1.27E-05	1.27E-05	1.27E-05	1.27E-05	1.27E-05	1.27E-05	1.27E-05	1.27E-05	1.27E-05
Cesium-137 + Daughters	1.70E+00	1.69E-01	1.68E-02	1.66E-03	1.65E-04	1.64E-05	1.63E-06	1.61E-07	1.60E-08	1.59E-09
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-152	2.21E-04	1.22E-06	6.73E-09	3.72E-11	2.06E-13	2.05E-15	9.24E-16	9.18E-16	9.18E-16	9.18E-16
Europium-154	4.78E-06	1.50E-09	4.70E-13	1.47E-16	4.62E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	5.71E-11	2.11E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	8.43E-06	1.14E-05	1.42E-05	1.70E-05	1.96E-05	2.21E-05	2.44E-05	2.67E-05	2.89E-05	3.10E-05
Thorium-232	5.34E-04	5.34E-04	5.34E-04	5.34E-04	5.34E-04	5.34E-04	5.34E-04	5.34E-04	5.34E-04	5.34E-04

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (4 sheets)

B – 95% Upper Confidence Level Inventory (continued)										
	Years After Site Closure (January 1, 2032)									
Nuclide	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Protactinium-231	4.15E-02	4.18E-02	4.18E-02	4.17E-02	4.16E-02	4.15E-02	4.14E-02	4.13E-02	4.12E-02	4.12E-02
Uranium-233	4.20E-03	5.10E-03	6.00E-03	6.89E-03	7.77E-03	8.63E-03	9.50E-03	1.03E-02	1.12E-02	1.20E-02
Uranium-234	5.51E-04	5.55E-04	5.60E-04	5.67E-04	5.75E-04	5.84E-04	5.93E-04	6.04E-04	6.16E-04	6.29E-04
Uranium-235 + D	9.16E-05	9.62E-05	1.01E-04	1.06E-04	1.10E-04	1.15E-04	1.19E-04	1.24E-04	1.29E-04	1.33E-04
Uranium-236	6.25E-06	6.25E-06	6.25E-06	6.25E-06	6.25E-06	6.25E-06	6.25E-06	6.25E-06	6.25E-06	6.25E-06
Uranium-238 + D	7.75E-04	7.75E-04	7.75E-04	7.75E-04	7.76E-04	7.76E-04	7.76E-04	7.76E-04	7.76E-04	7.76E-04
Neptunium-237 + D	1.79E-03	1.79E-03	1.79E-03	1.79E-03	1.79E-03	1.79E-03	1.79E-03	1.79E-03	1.79E-03	1.79E-03
Plutonium-238	3.70E-03	1.68E-03	7.63E-04	3.46E-04	1.57E-04	7.16E-05	3.27E-05	1.51E-05	7.06E-06	3.44E-06
Plutonium-239	8.45E-02	8.43E-02	8.41E-02	8.38E-02	8.36E-02	8.33E-02	8.31E-02	8.29E-02	8.26E-02	8.24E-02
Plutonium-240	2.52E-02	2.50E-02	2.47E-02	2.45E-02	2.42E-02	2.40E-02	2.37E-02	2.34E-02	2.32E-02	2.30E-02
Plutonium-241 + D	9.33E-03	7.96E-03	6.79E-03	5.78E-03	4.93E-03	4.20E-03	3.58E-03	3.05E-03	2.60E-03	2.21E-03
Plutonium-242	3.13E-04	3.13E-04	3.13E-04	3.13E-04	3.13E-04	3.13E-04	3.13E-04	3.13E-04	3.13E-04	3.13E-04
Americium-241	1.37E-01	1.17E-01	9.95E-02	8.48E-02	7.23E-02	6.16E-02	5.25E-02	4.47E-02	3.81E-02	3.25E-02
Curium-242	1.01E-06	4.59E-07	2.08E-07	9.45E-08	4.29E-08	1.95E-08	8.92E-09	4.10E-09	1.92E-09	9.25E-10
Curium-243	4.44E-06	5.00E-07	1.53E-07	1.22E-07	1.19E-07	1.19E-07	1.18E-07	1.18E-07	1.18E-07	1.17E-07
Curium-244	1.67E-05	6.20E-06	5.92E-06	5.85E-06	5.79E-06	5.73E-06	5.67E-06	5.61E-06	5.55E-06	5.49E-06
Total Dose	**4.68E+01**	**4.28E+00**	**6.14E-01**	**2.84E-01**	**2.43E-01**	**2.29E-01**	**2.20E-01**	**2.11E-01**	**2.05E-01**	**1.99E-01**

Figure D-2. Comparison of Rural Pasture Scenario Doses with Performance Objective for Chronic Exposure for Key Analytes within A) Average Inventory and B) 95% Upper Confidence Level Inventory Estimated for Residual Wastes in Single-Shell Tank 241-C-104.





UCL = upper confidence level

Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways. (4 sheets)

A – Average Inventory										
	Years After Site Closure (January 1, 2032)									
Nuclide	100	200	300	400	500	600	700	800	900	1,000
Tritium	7.32E-10	2.65E-12	9.59E-15	3.47E-17	1.26E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	5.62E-05	5.55E-05	5.49E-05	5.42E-05	5.36E-05	5.29E-05	5.23E-05	5.17E-05	5.10E-05	5.04E-05
Nickel-63	2.11E-02	1.06E-02	5.28E-03	2.64E-03	1.32E-03	6.62E-04	3.31E-04	1.66E-04	8.29E-05	4.15E-05
Cobalt-60	3.07E-08	5.97E-14	1.16E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	1.27E-05	1.27E-05	1.27E-05	1.27E-05	1.27E-05	1.27E-05	1.27E-05	1.27E-05	1.27E-05	1.27E-05
Strontium-90 + D	3.19E+02	2.72E+01	2.32E+00	1.98E-01	1.69E-02	1.44E-03	1.22E-04	1.04E-05	8.89E-07	7.58E-08
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	4.56E-02	4.56E-02	4.56E-02	4.56E-02	4.56E-02	4.55E-02	4.55E-02	4.55E-02	4.55E-02	4.55E-02
Tin-126	2.54E-03	2.54E-03	2.54E-03	2.54E-03	2.54E-03	2.54E-03	2.54E-03	2.54E-03	2.54E-03	2.54E-03
Antimony-125	9.25E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodine-129	2.08E-05	2.08E-05	2.08E-05	2.08E-05	2.08E-05	2.08E-05	2.08E-05	2.08E-05	2.08E-05	2.08E-05
Cesium-137 + Daughters	8.99E+00	8.92E-01	8.85E-02	8.78E-03	8.71E-04	8.64E-05	8.57E-06	8.51E-07	8.44E-08	8.37E-09
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-152	7.00E-04	3.86E-06	2.13E-08	1.17E-10	6.52E-13	7.86E-15	4.30E-15	4.28E-15	4.28E-15	4.28E-15
Europium-154	1.51E-05	4.75E-09	1.49E-12	4.67E-16	1.46E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	1.85E-10	6.83E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	4.75E-05	7.00E-05	9.17E-05	1.13E-04	1.32E-04	1.51E-04	1.70E-04	1.87E-04	2.04E-04	2.19E-04

Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways. (4 sheets)

A – Average Inventory (continued)										
	Years After Site Closure (January 1, 2032)									
Nuclide	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Thorium-232	3.17E-03	3.17E-03	3.17E-03	3.17E-03	3.17E-03	3.17E-03	3.17E-03	3.17E-03	3.17E-03	3.17E-03
Protactinium-231	2.89E-01	2.91E-01	2.91E-01	2.90E-01	2.90E-01	2.89E-01	2.88E-01	2.88E-01	2.87E-01	2.87E-01
Uranium-233	5.30E-02	5.72E-02	6.13E-02	6.54E-02	6.95E-02	7.35E-02	7.74E-02	8.14E-02	8.53E-02	8.91E-02
Uranium-234	1.79E-02	1.79E-02	1.80E-02	1.81E-02	1.82E-02	1.83E-02	1.85E-02	1.86E-02	1.88E-02	1.90E-02
Uranium-235 + D	1.26E-03	1.33E-03	1.39E-03	1.46E-03	1.52E-03	1.59E-03	1.65E-03	1.72E-03	1.78E-03	1.85E-03
Uranium-236	1.98E-04	1.98E-04	1.98E-04	1.98E-04	1.98E-04	1.98E-04	1.98E-04	1.98E-04	1.98E-04	1.98E-04
Uranium-238 + D	1.92E-02	1.92E-02	1.92E-02	1.92E-02	1.92E-02	1.92E-02	1.92E-02	1.92E-02	1.92E-02	1.92E-02
Neptunium-237 + D	4.07E-02	4.07E-02	4.07E-02	4.07E-02	4.07E-02	4.07E-02	4.07E-02	4.07E-02	4.07E-02	4.07E-02
Plutonium-238	4.55E-02	2.06E-02	9.37E-03	4.26E-03	1.94E-03	8.84E-04	4.07E-04	1.90E-04	9.19E-05	4.74E-05
Plutonium-239	1.07E+00	1.07E+00	1.06E+00	1.06E+00	1.06E+00	1.05E+00	1.05E+00	1.05E+00	1.04E+00	1.04E+00
Plutonium-240	3.19E-01	3.15E-01	3.12E-01	3.09E-01	3.06E-01	3.02E-01	2.99E-01	2.96E-01	2.93E-01	2.90E-01
Plutonium-241 + D	1.23E-01	1.05E-01	8.93E-02	7.61E-02	6.49E-02	5.53E-02	4.71E-02	4.02E-02	3.43E-02	2.92E-02
Plutonium-242	3.90E-03	3.90E-03	3.90E-03	3.90E-03	3.90E-03	3.90E-03	3.90E-03	3.90E-03	3.89E-03	3.89E-03
Americium-241	1.52E+00	1.29E+00	1.10E+00	9.40E-01	8.01E-01	6.82E-01	5.82E-01	4.96E-01	4.23E-01	3.60E-01
Curium-242	1.19E-05	5.40E-06	2.45E-06	1.11E-06	5.07E-07	2.31E-07	1.06E-07	4.97E-08	2.39E-08	1.23E-08
Curium-243	3.82E-05	4.45E-06	1.48E-06	1.21E-06	1.19E-06	1.18E-06	1.18E-06	1.18E-06	1.17E-06	1.17E-06
Curium-244	1.62E-04	6.16E-05	5.89E-05	5.82E-05	5.76E-05	5.70E-05	5.64E-05	5.58E-05	5.52E-05	5.46E-05
Total Dose	**3.32E+02**	**3.14E+01**	**5.48E+00**	**3.09E+00**	**2.74E+00**	**2.60E+00**	**2.48E+00**	**2.39E+00**	**2.30E+00**	**2.23E+00**

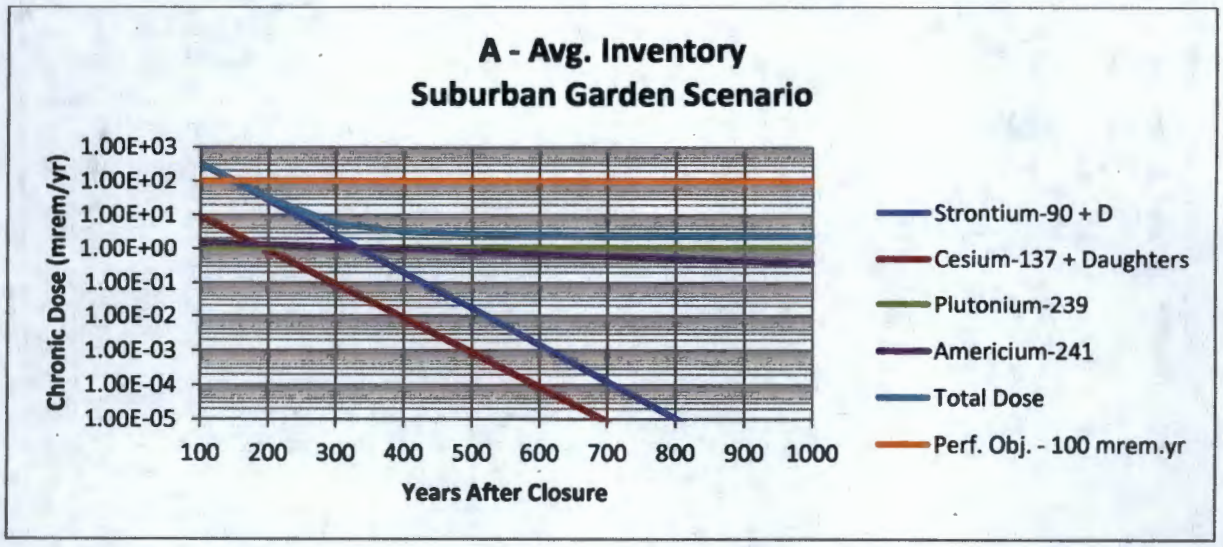
Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways. (4 sheets)

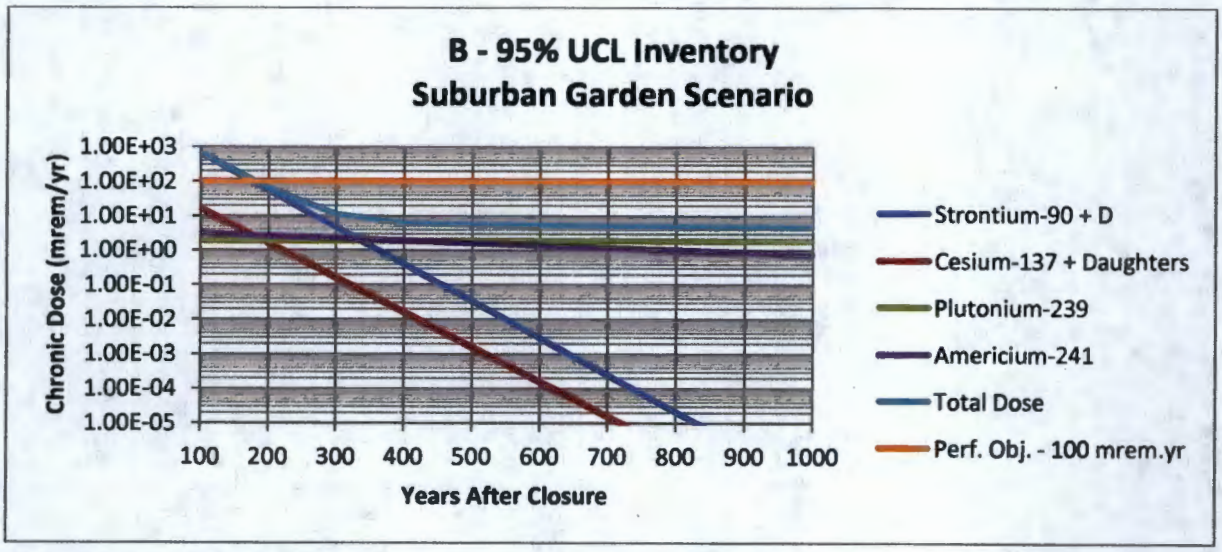
B - 95% Upper Confidence Level Inventory										
	Years After Site Closure (January 1, 2032)									
Nuclide	100	200	300	400	500	600	700	800	900	1,000
Tritium	2.23E-09	8.05E-12	2.91E-14	1.05E-16	3.82E-19	1.38E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	8.46E-05	8.36E-05	8.26E-05	8.16E-05	8.06E-05	7.97E-05	7.87E-05	7.78E-05	7.68E-05	7.59E-05
Nickel-63	5.52E-02	2.76E-02	1.38E-02	6.92E-03	3.46E-03	1.73E-03	8.67E-04	4.34E-04	2.17E-04	1.09E-04
Cobalt-60	9.32E-08	1.81E-13	3.53E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	3.86E-05	3.86E-05	3.86E-05	3.86E-05	3.86E-05	3.86E-05	3.86E-05	3.86E-05	3.86E-05	3.86E-05
Strontium-90 + D	6.35E+02	5.42E+01	4.62E+00	3.93E-01	3.35E-02	2.86E-03	2.44E-04	2.08E-05	1.77E-06	1.51E-07
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	6.99E-02	6.99E-02	6.98E-02	6.98E-02	6.98E-02	6.98E-02	6.97E-02	6.97E-02	6.97E-02	6.97E-02
Tin-126	4.86E-03	4.86E-03	4.86E-03	4.86E-03	4.85E-03	4.85E-03	4.85E-03	4.85E-03	4.85E-03	4.85E-03
Antimony-125	2.81E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodine-129	6.31E-05	6.31E-05	6.31E-05	6.31E-05	6.31E-05	6.31E-05	6.31E-05	6.31E-05	6.31E-05	6.31E-05
Cesium-137 + Daughters	1.65E+01	1.64E+00	1.63E-01	1.61E-02	1.60E-03	1.59E-04	1.58E-05	1.56E-06	1.55E-07	1.54E-08
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-152	2.13E-03	1.17E-05	6.47E-08	3.57E-10	1.98E-12	2.39E-14	1.31E-14	1.30E-14	1.30E-14	1.30E-14
Europium-154	4.60E-05	1.44E-08	4.53E-12	1.42E-15	4.45E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	5.61E-10	2.07E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	1.44E-04	2.13E-04	2.79E-04	3.42E-04	4.02E-04	4.60E-04	5.15E-04	5.68E-04	6.18E-04	6.66E-04

Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways. (4 sheets)

B - 95% Upper Confidence Level Inventory (continued)										
	Years After Site Closure (January 1, 2032)									
Nuclide	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Thorium-232	6.18E-03	6.18E-03	6.18E-03	6.18E-03	6.18E-03	6.18E-03	6.18E-03	6.18E-03	6.18E-03	6.18E-03
Protactinium-231	8.79E-01	8.86E-01	8.85E-01	8.83E-01	8.81E-01	8.79E-01	8.77E-01	8.76E-01	8.74E-01	8.72E-01
Uranium-233	1.61E-01	1.74E-01	1.86E-01	1.99E-01	2.11E-01	2.23E-01	2.35E-01	2.47E-01	2.59E-01	2.71E-01
Uranium-234	2.61E-02	2.62E-02	2.63E-02	2.64E-02	2.66E-02	2.67E-02	2.69E-02	2.72E-02	2.74E-02	2.77E-02
Uranium-235 + D	1.90E-03	2.00E-03	2.10E-03	2.20E-03	2.29E-03	2.39E-03	2.49E-03	2.59E-03	2.68E-03	2.78E-03
Uranium-236	2.98E-04	2.98E-04	2.98E-04	2.98E-04	2.98E-04	2.98E-04	2.98E-04	2.98E-04	2.98E-04	2.98E-04
Uranium-238 + D	2.89E-02	2.89E-02	2.89E-02	2.89E-02	2.90E-02	2.90E-02	2.90E-02	2.90E-02	2.90E-02	2.90E-02
Neptunium-237 + D	1.24E-01	1.24E-01	1.24E-01	1.24E-01	1.24E-01	1.24E-01	1.24E-01	1.24E-01	1.24E-01	1.24E-01
Plutonium-238	8.20E-02	3.72E-02	1.69E-02	7.67E-03	3.49E-03	1.59E-03	7.33E-04	3.43E-04	1.66E-04	8.55E-05
Plutonium-239	1.88E+00	1.87E+00	1.86E+00	1.86E+00	1.85E+00	1.85E+00	1.84E+00	1.84E+00	1.83E+00	1.83E+00
Plutonium-240	5.60E-01	5.54E-01	5.48E-01	5.43E-01	5.37E-01	5.31E-01	5.26E-01	5.20E-01	5.15E-01	5.09E-01
Plutonium-241 + D	2.04E-01	1.74E-01	1.49E-01	1.27E-01	1.08E-01	9.20E-02	7.84E-02	6.69E-02	5.70E-02	4.86E-02
Plutonium-242	6.93E-03	6.93E-03	6.93E-03	6.93E-03	6.92E-03	6.92E-03	6.92E-03	6.92E-03	6.92E-03	6.92E-03
Americium-241	3.00E+00	2.56E+00	2.18E+00	1.86E+00	1.58E+00	1.35E+00	1.15E+00	9.81E-01	8.36E-01	7.13E-01
Curium-242	2.24E-05	1.02E-05	4.61E-06	2.09E-06	9.52E-07	4.35E-07	2.00E-07	9.33E-08	4.50E-08	2.31E-08
Curium-243	8.50E-05	9.90E-06	3.29E-06	2.70E-06	2.64E-06	2.63E-06	2.62E-06	2.61E-06	2.61E-06	2.60E-06
Curium-244	3.61E-04	1.37E-04	1.31E-04	1.30E-04	1.28E-04	1.27E-04	1.26E-04	1.24E-04	1.23E-04	1.22E-04
Total Dose	**6.59E+02**	**6.24E+01**	**1.09E+01**	**6.17E+00**	**5.49E+00**	**5.20E+00**	**4.98E+00**	**4.80E+00**	**4.65E+00**	**4.51E+00**

Figure D-3. Comparison of Doses from Suburban Gardener Scenario with Performance Objective for Chronic Exposure for Key Analytes within A) Average Inventory and B) 95% Upper Confidence Level Inventory Estimated for Residual Wastes in Single-Shell Tank 241-C-104.





UCL = upper confidence level

Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (4 sheets)

A – Average Inventory										
	Years After Site Closure (January 1, 2032)									
Nuclide	100	200	300	400	500	600	700	800	900	1,000
Tritium	2.93E-12	1.06E-14	3.84E-17	1.39E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	1.55E-10	1.53E-10	1.52E-10	1.50E-10	1.48E-10	1.46E-10	1.44E-10	1.43E-10	1.41E-10	1.39E-10
Nickel-63	6.63E-07	3.32E-07	1.66E-07	8.31E-08	4.16E-08	2.08E-08	1.04E-08	5.21E-09	2.61E-09	1.30E-09
Cobalt-60	1.16E-10	2.27E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	8.57E-10	8.57E-10	8.57E-10	8.57E-10	8.57E-10	8.57E-10	8.56E-10	8.56E-10	8.56E-10	8.56E-10
Strontium-90 + D	1.86E-03	1.58E-04	1.35E-05	1.15E-06	9.80E-08	8.35E-09	7.12E-10	6.07E-11	5.17E-12	4.41E-13
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	1.49E-08	1.48E-08	1.48E-08	1.48E-08	1.48E-08	1.48E-08	1.48E-08	1.48E-08	1.48E-08	1.48E-08
Tin-126	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05
Antimony-125	3.63E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodine-129	1.93E-09	1.93E-09	1.93E-09	1.93E-09	1.93E-09	1.93E-09	1.93E-09	1.93E-09	1.93E-09	1.93E-09
Cesium-137 + Daughters	1.48E-02	1.47E-03	1.46E-04	1.45E-05	1.44E-06	1.43E-07	1.42E-08	1.40E-09	1.39E-10	1.38E-11
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-152	2.78E-06	1.53E-08	8.45E-11	4.66E-13	2.58E-15	2.48E-17	1.06E-17	1.06E-17	1.06E-17	1.06E-17
Europium-154	6.01E-08	1.88E-11	5.91E-15	1.85E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	7.17E-13	2.65E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	7.92E-08	1.00E-07	1.20E-07	1.40E-07	1.58E-07	1.76E-07	1.92E-07	2.09E-07	2.24E-07	2.39E-07
Thorium-232	8.16E-06	8.16E-06	8.16E-06	8.16E-06	8.16E-06	8.16E-06	8.16E-06	8.16E-06	8.16E-06	8.16E-06

Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (4 sheets)

A – Average Inventory (continued)										
	Years After Site Closure (January 1, 2032)									
Nuclide	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Protactinium-231	3.87E-04	3.91E-04	3.90E-04	3.89E-04	3.88E-04	3.88E-04	3.87E-04	3.86E-04	3.85E-04	3.84E-04
Uranium-233	2.37E-05	3.37E-05	4.36E-05	5.34E-05	6.31E-05	7.27E-05	8.22E-05	9.16E-05	1.01E-04	1.10E-04
Uranium-234	4.19E-06	4.27E-06	4.36E-06	4.48E-06	4.61E-06	4.76E-06	4.93E-06	5.11E-06	5.30E-06	5.51E-06
Uranium-235 + D	1.83E-06	1.92E-06	2.01E-06	2.10E-06	2.18E-06	2.27E-06	2.36E-06	2.44E-06	2.53E-06	2.62E-06
Uranium-236	4.54E-08	4.54E-08	4.54E-08	4.54E-08	4.54E-08	4.54E-08	4.54E-08	4.54E-08	4.54E-08	4.54E-08
Uranium-238 + D	9.43E-06	9.43E-06	9.43E-06	9.43E-06	9.43E-06	9.43E-06	9.43E-06	9.43E-06	9.44E-06	9.44E-06
Neptunium-237 + D	1.77E-05	1.77E-05	1.77E-05	1.77E-05	1.77E-05	1.77E-05	1.77E-05	1.77E-05	1.77E-05	1.77E-05
Plutonium-238	5.80E-05	2.63E-05	1.19E-05	5.42E-06	2.46E-06	1.12E-06	5.08E-07	2.32E-07	1.07E-07	5.01E-08
Plutonium-239	1.36E-03	1.35E-03	1.35E-03	1.35E-03	1.34E-03	1.34E-03	1.33E-03	1.33E-03	1.33E-03	1.32E-03
Plutonium-240	4.05E-04	4.01E-04	3.96E-04	3.92E-04	3.88E-04	3.84E-04	3.80E-04	3.76E-04	3.72E-04	3.68E-04
Plutonium-241 + D	1.59E-04	1.36E-04	1.15E-04	9.84E-05	8.38E-05	7.14E-05	6.09E-05	5.19E-05	4.42E-05	3.77E-05
Plutonium-242	4.97E-06	4.97E-06	4.97E-06	4.97E-06	4.97E-06	4.97E-06	4.97E-06	4.97E-06	4.97E-06	4.97E-06
Americium-241	1.96E-03	1.67E-03	1.42E-03	1.21E-03	1.03E-03	8.81E-04	7.51E-04	6.40E-04	5.45E-04	4.65E-04
Curium-242	1.52E-08	6.89E-09	3.13E-09	1.42E-09	6.44E-10	2.92E-10	1.33E-10	6.07E-11	2.78E-11	1.30E-11
Curium-243	5.88E-08	6.56E-09	1.96E-09	1.55E-09	1.51E-09	1.50E-09	1.50E-09	1.50E-09	1.49E-09	1.49E-09
Curium-244	2.08E-07	7.83E-08	7.48E-08	7.39E-08	7.31E-08	7.24E-08	7.16E-08	7.08E-08	7.01E-08	6.94E-08
Total Dose	**2.11E-02**	**5.71E-03**	**3.95E-03**	**3.57E-03**	**3.36E-03**	**3.20E-03**	**3.05E-03**	**2.94E-03**	**2.83E-03**	**2.75E-03**

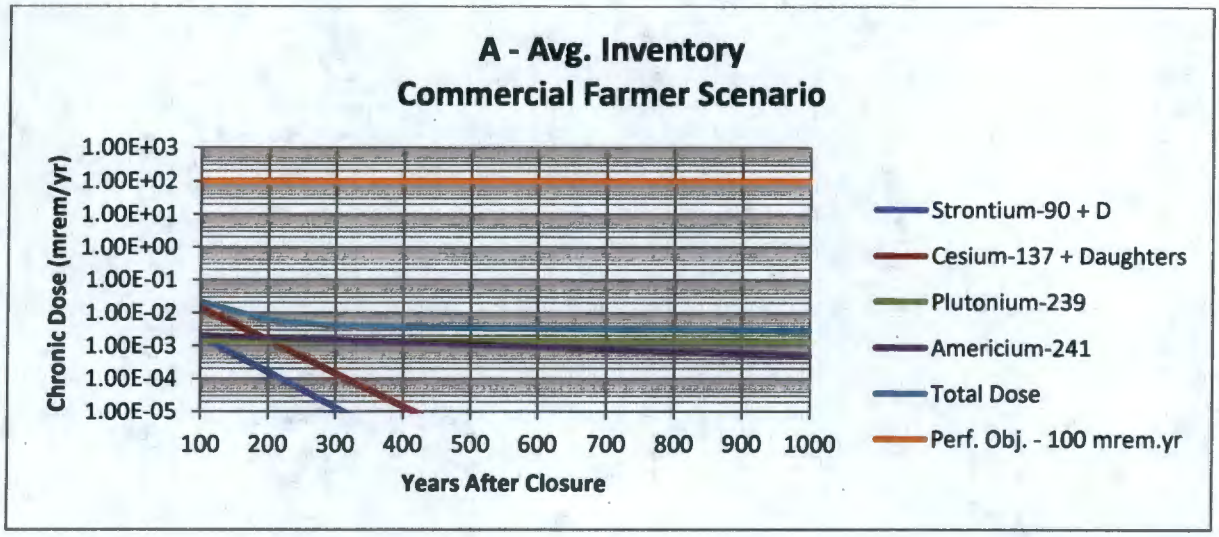
Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (4 sheets)

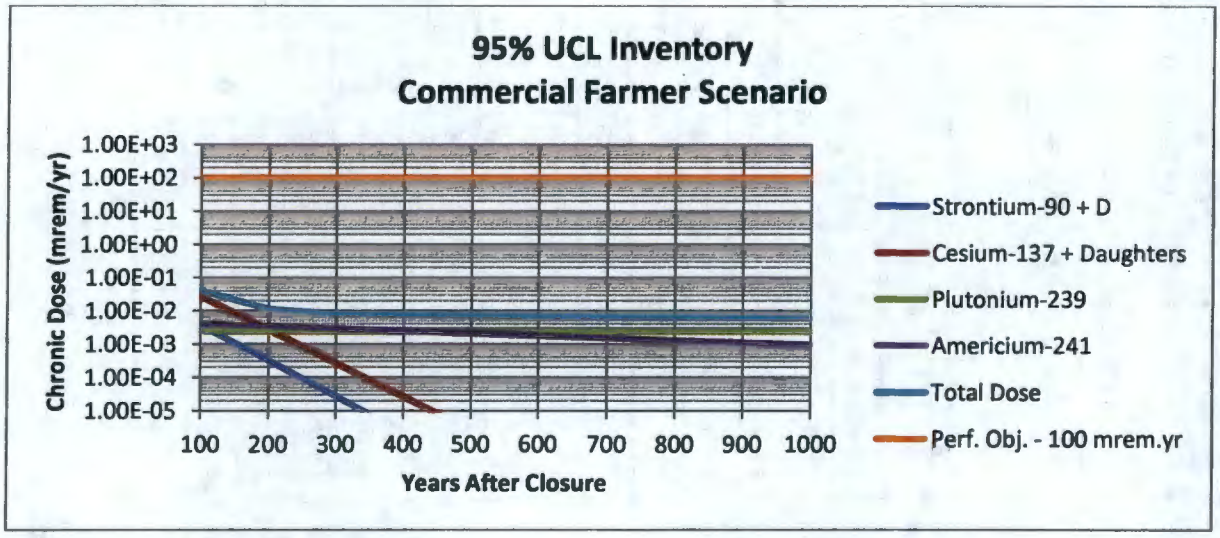
B – 95% Upper Confidence Level Inventory										
	Years After Site Closure (January 1, 2032)									
Nuclide	100	200	300	400	500	600	700	800	900	1,000
Tritium	8.92E-12	3.23E-14	1.17E-16	4.22E-19	1.53E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	2.34E-10	2.31E-10	2.28E-10	2.25E-10	2.23E-10	2.20E-10	2.17E-10	2.15E-10	2.12E-10	2.10E-10
Nickel-63	1.74E-06	8.69E-07	4.35E-07	2.18E-07	1.09E-07	5.45E-08	2.73E-08	1.36E-08	6.82E-09	3.41E-09
Cobalt-60	3.54E-10	6.89E-16	1.34E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Selenium-79	2.60E-09	2.60E-09	2.60E-09	2.60E-09	2.60E-09	2.60E-09	2.60E-09	2.60E-09	2.60E-09	2.60E-09
Strontium-90 + D	3.69E-03	3.15E-04	2.68E-05	2.29E-06	1.95E-07	1.66E-08	1.42E-09	1.21E-10	1.03E-11	8.77E-13
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	2.28E-08	2.27E-08	2.27E-08	2.27E-08	2.27E-08	2.27E-08	2.27E-08	2.27E-08	2.27E-08	2.27E-08
Tin-126	1.92E-05	1.92E-05	1.92E-05	1.92E-05	1.92E-05	1.92E-05	1.92E-05	1.91E-05	1.91E-05	1.91E-05
Antimony-125	1.10E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodine-129	5.85E-09	5.85E-09	5.85E-09	5.85E-09	5.85E-09	5.85E-09	5.85E-09	5.85E-09	5.85E-09	5.85E-09
Cesium-137 + Daughters	2.73E-02	2.71E-03	2.68E-04	2.66E-05	2.64E-06	2.62E-07	2.60E-08	2.58E-09	2.56E-10	2.54E-11
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-152	8.44E-06	4.66E-08	2.57E-10	1.42E-12	7.85E-15	7.52E-17	3.23E-17	3.21E-17	3.21E-17	3.21E-17
Europium-154	1.82E-07	5.72E-11	1.79E-14	5.63E-18	1.76E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	2.18E-12	8.04E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	2.41E-07	3.04E-07	3.66E-07	4.24E-07	4.80E-07	5.33E-07	5.85E-07	6.34E-07	6.80E-07	7.25E-07
Thorium-232	1.59E-05	1.59E-05	1.59E-05	1.59E-05	1.59E-05	1.59E-05	1.59E-05	1.59E-05	1.59E-05	1.59E-05

Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-104 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (4 sheets)

B – 95% Upper Confidence Level Inventory (continued)										
	Years After Site Closure (January 1, 2032)									
Nuclide	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Protactinium-231	1.18E-03	1.19E-03	1.19E-03	1.18E-03	1.18E-03	1.18E-03	1.18E-03	1.17E-03	1.17E-03	1.17E-03
Uranium-233	7.22E-05	1.03E-04	1.33E-04	1.62E-04	1.92E-04	2.21E-04	2.50E-04	2.78E-04	3.07E-04	3.35E-04
Uranium-234	6.11E-06	6.23E-06	6.37E-06	6.54E-06	6.74E-06	6.95E-06	7.19E-06	7.45E-06	7.74E-06	8.04E-06
Uranium-235 + D	2.76E-06	2.89E-06	3.02E-06	3.15E-06	3.28E-06	3.42E-06	3.55E-06	3.68E-06	3.81E-06	3.94E-06
Uranium-236	6.84E-08	6.84E-08	6.84E-08	6.84E-08	6.84E-08	6.84E-08	6.84E-08	6.84E-08	6.84E-08	6.84E-08
Uranium-238 + D	1.42E-05	1.42E-05	1.42E-05	1.42E-05	1.42E-05	1.42E-05	1.42E-05	1.42E-05	1.42E-05	1.42E-05
Neptunium-237 + D	5.37E-05	5.37E-05	5.37E-05	5.37E-05	5.37E-05	5.37E-05	5.37E-05	5.37E-05	5.37E-05	5.37E-05
Plutonium-238	1.05E-04	4.74E-05	2.15E-05	9.76E-06	4.43E-06	2.01E-06	9.16E-07	4.18E-07	1.93E-07	9.03E-08
Plutonium-239	2.38E-03	2.38E-03	2.37E-03	2.36E-03	2.35E-03	2.35E-03	2.34E-03	2.33E-03	2.33E-03	2.32E-03
Plutonium-240	7.11E-04	7.04E-04	6.97E-04	6.89E-04	6.82E-04	6.75E-04	6.68E-04	6.61E-04	6.54E-04	6.47E-04
Plutonium-241 + D	2.64E-04	2.25E-04	1.92E-04	1.64E-04	1.39E-04	1.19E-04	1.01E-04	8.63E-05	7.35E-05	6.27E-05
Plutonium-242	8.84E-06	8.84E-06	8.84E-06	8.83E-06	8.83E-06	8.83E-06	8.83E-06	8.83E-06	8.83E-06	8.82E-06
Americium-241	3.88E-03	3.31E-03	2.82E-03	2.40E-03	2.05E-03	1.74E-03	1.49E-03	1.27E-03	1.08E-03	9.19E-04
Curium-242	2.85E-08	1.29E-08	5.87E-09	2.66E-09	1.21E-09	5.49E-10	2.50E-10	1.14E-10	5.23E-11	2.43E-11
Curium-243	1.31E-07	1.46E-08	4.36E-09	3.45E-09	3.36E-09	3.35E-09	3.34E-09	3.33E-09	3.32E-09	3.31E-09
Curium-244	4.63E-07	1.75E-07	1.67E-07	1.65E-07	1.63E-07	1.61E-07	1.60E-07	1.58E-07	1.56E-07	1.55E-07
Total Dose	**3.97E-02**	**1.11E-02**	**7.84E-03**	**7.13E-03**	**6.73E-03**	**6.41E-03**	**6.15E-03**	**5.93E-03**	**5.74E-03**	**5.58E-03**

Figure D-4. Comparison of Doses from Commercial Farm Scenario with Performance Objective for Chronic Exposure for Key Analytes within A) Average Inventory and B) 95% Upper Confidence Level Inventory Estimated for Residual Wastes in Single-Shell Tank 241-C-104.





UCL = upper confidence level

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-109, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Above Detection Limits
Acetate $C_2H_3O_2^-$	6.41E+01	7.29E+01	--	--	--	Yes
Aluminum	1.00E+05	1.44E+05	8.00E+04	3.50E+06	4.80E+05	Yes
Ammonia -- (a)	6.99E+00	1.15E+01	--	--	--	Yes
Barium*	5.78E+01	8.46E+01	1.60E+04	7.00E+05	1.65E+03	Yes
Benzene*	3.42E-03	1.01E-02	1.82E+01	2.39E+03	4.48E-03	Yes
Beryllium*	3.25E+00	3.86E+00	1.60E+02	7.00E+03	6.32E+01	Yes
Bismuth	2.56E+02	3.37E+02	--	--	--	Yes
Cadmium*	1.72E+02	2.94E+02	8.00E+01	3.50E+03	6.90E-01	Yes
Calcium	1.19E+03	1.97E+03	--	--	--	Yes
Cerium	6.10E+02	7.89E+02	--	--	--	Yes
Chloride	5.23E+01	7.11E+01	--	--	1.00E+03	Yes
Chromium, Total*	2.69E+02	3.37E+02	1.20E+05	5.25E+06	2.00E+03	Yes
Cobalt	3.17E+00	4.29E+00	2.40E+01	1.05E+03	4.34E+00	Yes
Copper	1.61E+02	2.14E+02	3.20E+03	1.40E+05	2.84E+02	Yes
Dichloromethane (methylene chloride)*	3.68E-03	6.38E-03	4.80E+02	2.10E+04	2.18E-02	Yes
Ethylbenzene	2.11E-03	6.25E-03	9.09E+01	1.19E+04	3.44E-02	Yes
Fluoride	1.35E+03	2.52E+03	4.80E+03	2.10E+05	2.88E+03	Yes
Formate+A2	1.19E+02	1.38E+02	--	--	--	Yes
Iron	2.84E+04	3.75E+04	5.60E+04	2.45E+06	5.64E+03	Yes
Lead*	5.69E+02	7.80E+02	--	1.00E+03	3.00E+03	Yes

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-109, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Above Detection Limits
Lithium	1.41E+01	1.95E+01	1.60E+02	7.00E+03	1.92E+02	Yes
Magnesium	2.47E+02	4.37E+02	--	--	--	Yes
Manganese	3.77E+03	7.49E+03	1.12E+04	4.90E+05	5.01E+02	Yes
Mercury*	1.18E+02	1.47E+02	2.40E+01	1.05E+03	2.09E+00	Yes
Molybdenum	7.04E+00	1.11E+01	4.00E+02	1.75E+04	3.23E+01	Yes
n-Butyl alcohol (1-butanol)	4.53E-01	8.49E-01	8.00E+03	3.50E+05	--	Yes
Neodymium	7.50E+01	1.09E+02	--	--	--	Yes
Nickel*	5.28E+02	9.15E+02	1.60E+03	7.00E+04	1.30E+02	Yes
Niobium	4.50E+01	7.30E+01	--	--	--	Yes
Nitrate[c]	8.25E+02	8.87E+02	5.68E+05	2.49E+07	1.80E+02	Yes
Nitrite[d]	4.45E+02	6.16E+02	2.40E+04	1.05E+06	1.32E+01	Yes
Oxalate	2.08E+04	3.29E+04	--	--	--	Yes
Palladium	3.23E+02	4.33E+02	--	--	--	Yes
Phosphate	3.76E+03	6.19E+03	--	--	--	Yes
Polychlorinated Biphenyls*	5.13E-01	9.48E-01	5.00E-01	6.56E+01	--	Yes
Potassium	1.15E+02	1.26E+02	--	--	--	Yes
Praseodymium	3.83E+02	5.14E+02	--	--	--	Yes
Silicon	1.15E+04	1.29E+04	--	--	--	Yes
Silver*	1.44E+03	1.82E+03	4.00E+02	1.75E+04	1.36E+01	Yes
Sodium	1.01E+05	1.13E+05	--	--	--	Yes

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-109, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Above Detection Limits
Strontium	8.22E+01	1.15E+02	4.80E+04	2.10E+06	6.76E+03	Yes
Sulfate	1.01E+02	1.12E+02	--	--	1.00E+03	Yes
Tantalum	3.03E+02	4.08E+02	--	--	--	Yes
Tellurium	1.74E+01	2.35E+01	--	--	--	Yes
Thorium	2.95E+03	5.48E+03	--	--	--	Yes
Tin	3.29E+01	6.59E+01	4.80E+04	2.10E+06	4.80E+04	Yes
Titanium	3.86E+01	4.81E+01	--	--	--	Yes
Toluene*	3.24E-03	7.09E-03	6.40E+03	2.80E+05	4.65E+00	Yes
Tungsten	1.45E+01	1.74E+01	--	--	--	Yes
Uranium	1.16E+05	1.55E+05	2.40E+02	1.05E+04	2.70E+02	Yes
Vanadium	3.55E+01	4.64E+01	4.00E+02	1.75E+04	1.60E+03	Yes
Yttrium	4.75E+01	6.71E+01	--	--	--	Yes
Zinc	1.26E+02	1.62E+02	2.40E+04	1.05E+06	5.97E+03	Yes
Zirconium	2.19E+03	4.70E+03	--	--	--	Yes
1, 1, 2-Trichloroethylene	1.09E-03	3.23E-03	2.17E+01	1.75E+03	6.29E-03	No
2-Butanone (MEK)	2.84E-02	8.41E-02	4.80E+04	2.10E+06	1.97E+01	No
2-Propanone (Acetone)	3.91E-02	1.16E-01	7.20E+04	3.15E+06	2.89E+01	No
4-Methyl-2-pentanone (MIBK)	1.53E-02	4.53E-02	6.40E+03	2.80E+05	2.73E+00	No
Antimony*	1.19E+01	3.52E+01	3.20E+01	1.40E+03	5.42E+00	No
Arsenic*	9.94E+00	2.94E+01	6.67E-01	8.75E+01	3.41E-02	No

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-109, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Above Detection Limits
Bromide	5.13E+01	1.52E+02	--	--	--	No
Cyanide*	1.63E+00	4.82E+00	4.80E+01	2.10E+03	9.70E-01	No
Europium	1.99E+00	5.89E+00	--	--	--	No
Glycolate $C_2H_3O_3$	1.88E+01	5.56E+01	--	--	--	No
Lanthanum	2.06E+00	6.10E+00	--	--	--	No
m-Xylene	1.72E-03	5.09E-03	1.60E+04	7.00E+05	1.35E+01	No
o-Xylene	8.42E-04	2.49E-03	1.60E+04	7.00E+05	1.47E+01	No
Rhodium	1.59E+01	4.71E+01	--	--	--	No
Rubidium	5.97E+01	1.77E+02	--	--	--	No
Ruthenium	7.95E+00	2.35E+01	--	--	--	No
Selenium*	1.19E+01	3.52E+01	4.00E+02	1.75E+04	5.20E+00	No
Thallium*	1.19E+01	3.52E+01	--	--	2.28E-01	No
Tributyl phosphate	1.63E+00	4.82E+00	1.11E+02	1.46E+04	4.96E-01	No
Xylenes	2.17E-03	6.42E-03	1.60E+04	7.00E+05	1.46E+01	No

[a] Mean Concentrations taken from Table A-1, Appendix A of RPP-RPT-55307, *Tank 241-C-104 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

[b] 95% Upper Confidence Level Concentration = Average Concentration + (1.96 × Average Concentration × Relative Standard Deviation). Average Concentrations and Relative Standard Deviation taken from Table A-1, Appendix A of RPP-RPT-55307.

[c] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

[d] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

-- = Value is not available

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-104 Tank Residual Wastes. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-104 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Acetate $C_2H_3O_2^-$	6.41E+01	--	--	--	Yes
Aluminum	1.00E+05	1.25E+00	2.86E-02	2.08E-01	Yes
Ammonia	6.99E+00	--	--	--	Yes
Barium*	5.78E+01	3.61E-03	8.26E-05	3.51E-02	Yes
Benzene*	3.42E-03	1.88E-04	1.43E-06	7.63E-01	Yes
Beryllium*	3.25E+00	2.03E-02	4.64E-04	5.14E-02	Yes
Bismuth	2.56E+02	--	--	--	Yes
Cadmium*	1.72E+02	2.15E+00	4.91E-02	2.49E+02	Yes
Calcium	1.19E+03	--	--	--	Yes
Cerium	6.10E+02	--	--	--	Yes
Chloride	5.23E+01	--	--	5.23E-02	Yes
Chromium, Total*	2.69E+02	2.24E-03	5.12E-05	1.34E-01	Yes
Cobalt	3.17E+00	1.32E-01	3.02E-03	7.31E-01	Yes
Copper	1.61E+02	5.03E-02	1.15E-03	5.67E-01	Yes
Dichloromethane (methylene chloride)*	3.68E-03	7.67E-06	1.75E-07	1.69E-01	Yes
Ethylbenzene	2.11E-03	2.32E-05	1.77E-07	6.14E-02	Yes
Fluoride	1.35E+03	2.81E-01	6.43E-03	4.68E-01	Yes
Formate+A2	1.19E+02	--	--	--	Yes
Iron	2.84E+04	5.07E-01	1.16E-02	5.03E+00	Yes
Lead*	5.69E+02	--	5.69E-01	1.90E-01	Yes
Lithium	1.41E+01	8.81E-02	2.01E-03	7.34E-02	Yes

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-104 Tank Residual Wastes. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-104 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Magnesium	2.47E+02	--	--	--	Yes
Manganese	3.77E+03	3.37E-01	7.69E-03	7.53E+00	Yes
Mercury*	1.18E+02	4.92E+00	1.12E-01	5.65E+01	Yes
Molybdenum	7.04E+00	1.76E-02	4.02E-04	2.18E-01	Yes
n-Butyl alcohol (1-butanol)	4.53E-01	5.66E-05	1.29E-06	--	Yes
Neodymium	7.50E+01	--	--	--	Yes
Nickel*	5.28E+02	3.30E-01	7.54E-03	4.05E+00	Yes
Niobium	4.50E+01	--	--	--	Yes
Nitrate[b]	8.25E+02	1.45E-03	3.32E-05	4.58E+00	Yes
Nitrite[c]	4.45E+02	1.85E-02	4.24E-04	3.37E+01	Yes
Oxalate	2.08E+04	--	--	--	Yes
Palladium	3.23E+02	--	--	--	Yes
Phosphate	3.76E+03	--	--	--	Yes
Polychlorinated Biphenyls*	5.13E-01	1.03E+00	7.82E-03	--	Yes
Potassium	1.15E+02	--	--	--	Yes
Praseodymium	3.83E+02	--	--	--	Yes
Silicon	1.15E+04	--	--	--	Yes
Silver*	1.44E+03	3.60E+00	8.23E-02	1.06E+02	Yes
Sodium	1.01E+05	--	--	--	Yes
Strontium	8.22E+01	1.71E-03	3.91E-05	1.22E-02	Yes
Sulfate	1.01E+02	--	--	1.01E-01	Yes

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-104 Tank Residual Wastes. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-104 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Tantalum	3.03E+02	--	--	--	Yes
Tellurium	1.74E+01	--	--	--	Yes
Thorium	2.95E+03	--	--	--	Yes
Tin	3.29E+01	6.85E-04	1.57E-05	6.85E-04	Yes
Titanium	3.86E+01	--	--	--	Yes
Toluene*	3.24E-03	5.06E-07	1.16E-08	6.96E-04	Yes
Tungsten	1.45E+01	--	--	--	Yes
Uranium	1.16E+05	4.83E+02	1.10E+01	4.29E+02	Yes
Vanadium	3.55E+01	8.88E-02	2.03E-03	2.22E-02	Yes
Yttrium	4.75E+01	--	--	--	Yes
Zinc	1.26E+02	5.25E-03	1.20E-04	2.11E-02	Yes
Zirconium	2.19E+03	--	--	--	Yes
1, 1, 2-Trichloroethylene	1.09E-03	5.01E-05	6.23E-07	1.73E-01	No
2-Butanone (MEK)	2.84E-02	5.92E-07	1.35E-08	1.45E-03	No
2-Propanone (Acetone)	3.91E-02	5.43E-07	1.24E-08	1.35E-03	No
4-Methyl-2-pentanone (MIBK)	1.53E-02	2.39E-06	5.46E-08	5.61E-03	No
Antimony*	1.19E+01	3.72E-01	8.50E-03	2.19E+00	No
Arsenic*	9.94E+00	1.49E+01	1.14E-01	2.92E+02	No
Bromide	5.13E+01	--	--	--	No
Cyanide*	1.63E+00	3.40E-02	7.76E-04	1.68E+00	No
Europium	1.99E+00	--	--	--	No

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-104 Tank Residual Wastes. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-104 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Glycolate $C_2H_3O_3$	1.88E+01	--	--	--	No
Lanthanum	2.06E+00	--	--	--	No
m-Xylene	1.72E-03	1.08E-07	2.46E-09	1.27E-04	No
o-Xylene	8.42E-04	5.26E-08	1.20E-09	5.73E-05	No
Rhodium	1.59E+01	--	--	--	No
Rubidium	5.97E+01	--	--	--	No
Ruthenium	7.95E+00	--	--	--	No
Selenium*	1.19E+01	2.98E-02	6.80E-04	2.29E+00	No
Thallium*	1.19E+01	--	--	5.22E+01	No
Tributyl phosphate	1.63E+00	1.47E-02	1.12E-04	3.29E+00	No
Xylenes	2.17E-03	1.36E-07	3.10E-09	1.48E-04	No

[a] Mean Concentrations taken from Table A-1, Appendix A of RPP-RPT-55307, *Tank 241-C-104 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

[b] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

[c] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

-- = Value is not available

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-104 Tank Residual Wastes. (5 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-104 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Acetate $C_2H_3O_2^-$	7.29E+01	--	--	--	Yes
Aluminum	1.44E+05	1.80E+00	4.12E-02	3.01E-01	Yes
Ammonia	1.15E+01	--	--	--	Yes
Barium*	8.46E+01	5.29E-03	1.21E-04	5.14E-02	Yes
Benzene*	1.01E-02	5.57E-04	4.24E-06	2.26E+00	Yes
Beryllium*	3.86E+00	2.41E-02	5.52E-04	6.11E-02	Yes
Bismuth	3.37E+02	--	--	--	Yes
Cadmium*	2.94E+02	3.67E+00	8.39E-02	4.26E+02	Yes
Calcium	1.97E+03	--	--	--	Yes
Cerium	7.89E+02	--	--	--	Yes
Chloride	7.11E+01	--	--	7.11E-02	Yes
Chromium, Total*	3.37E+02	2.81E-03	6.42E-05	1.68E-01	Yes
Cobalt	4.29E+00	1.79E-01	4.08E-03	9.88E-01	Yes
Copper	2.14E+02	6.70E-02	1.53E-03	7.54E-01	Yes
Dichloromethane (methylene chloride)*	6.38E-03	1.33E-05	3.04E-07	2.93E-01	Yes
Ethylbenzene	6.25E-03	6.87E-05	5.23E-07	1.82E-01	Yes
Fluoride	2.52E+03	5.25E-01	1.20E-02	8.75E-01	Yes

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-104 Tank Residual Wastes. (5 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-104 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Formate+A2	1.38E+02	--	--	--	Yes
Iron	3.75E+04	6.69E-01	1.53E-02	6.64E+00	Yes
Lead*	7.80E+02	--	7.80E-01	2.60E-01	Yes
Lithium	1.95E+01	1.22E-01	2.78E-03	1.01E-01	Yes
Magnesium	4.37E+02	--	--	--	Yes
Manganese	7.49E+03	6.69E-01	1.53E-02	1.50E+01	Yes
Mercury*	1.47E+02	6.12E+00	1.40E-01	7.04E+01	Yes
Molybdenum	1.11E+01	2.78E-02	6.35E-04	3.44E-01	Yes
n-Butyl alcohol (1-butanol)	8.49E-01	1.06E-04	2.43E-06	--	Yes
Neodymium	1.09E+02	--	--	--	Yes
Nickel*	9.15E+02	5.72E-01	1.31E-02	7.02E+00	Yes
Niobium	7.30E+01	--	--	--	Yes
Nitrate[b]	8.87E+02	1.56E-03	3.57E-05	4.93E+00	Yes
Nitrite[c]	6.16E+02	2.57E-02	5.87E-04	4.67E+01	Yes
Oxalate	3.29E+04	--	--	--	Yes
Palladium	4.33E+02	--	--	--	Yes
Phosphate	6.19E+03	--	--	--	Yes

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-104 Tank Residual Wastes. (5 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-104 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Polychlorinated Biphenyls*	9.48E-01	1.90E+00	1.45E-02	--	Yes
Potassium	1.26E+02	--	--	--	Yes
Praseodymium	5.14E+02	--	--	--	Yes
Silicon	1.29E+04	--	--	--	Yes
Silver*	1.82E+03	4.54E+00	1.04E-01	1.33E+02	Yes
Sodium	1.13E+05	--	--	--	Yes
Strontium	1.15E+02	2.40E-03	5.49E-05	1.71E-02	Yes
Sulfate	1.12E+02	--	--	1.12E-01	Yes
Tantalum	4.08E+02	--	--	--	Yes
Tellurium	2.35E+01	--	--	--	Yes
Thorium	5.48E+03	--	--	--	Yes
Tin	6.59E+01	1.37E-03	3.14E-05	1.37E-03	Yes
Titanium	4.81E+01	--	--	--	Yes
Toluene*	7.09E-03	1.11E-06	2.53E-08	1.52E-03	Yes
Tungsten	1.74E+01	--	--	--	Yes
Uranium	1.55E+05	6.46E+02	1.48E+01	5.74E+02	Yes
Vanadium	4.64E+01	1.16E-01	2.65E-03	2.90E-02	Yes

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-104 Tank Residual Wastes. (5 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-104 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Yttrium	6.71E+01	--	--	--	Yes
Zinc	1.62E+02	6.76E-03	1.55E-04	2.72E-02	Yes
Zirconium	4.70E+03	--	--	--	Yes
1, 1, 2-Trichloroethylene	3.23E-03	1.48E-04	1.84E-06	5.13E-01	No
2-Butanone (MEK)	8.41E-02	1.75E-06	4.00E-08	4.28E-03	No
2-Propanone (Acetone)	1.16E-01	1.61E-06	3.67E-08	4.00E-03	No
4-Methyl-2-pentanone (MIBK)	4.53E-02	7.08E-06	1.62E-07	1.66E-02	No
Antimony*	3.52E+01	1.10E+00	2.52E-02	6.49E+00	No
Arsenic*	2.94E+01	4.41E+01	3.36E-01	8.64E+02	No
Bromide	1.52E+02	--	--	--	No
Cyanide*	4.82E+00	1.01E-01	2.30E-03	4.98E+00	No
Europium	5.89E+00	--	--	--	No
Glycolate $C_2H_3O_3$	5.56E+01	--	--	--	No
Lanthanum	6.10E+00	--	--	--	No
m-Xylene	5.09E-03	3.18E-07	7.27E-09	3.77E-04	No
o-Xylene	2.49E-03	1.56E-07	3.56E-09	1.70E-04	No
Rhodium	4.71E+01	--	--	--	No

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-104 Tank Residual Wastes. (5 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-104 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Rubidium	1.77E+02	--	--	--	No
Ruthenium	2.35E+01	--	--	--	No
Selenium*	3.52E+01	8.81E-02	2.01E-03	6.77E+00	No
Thallium*	3.52E+01	--	--	1.55E+02	No
Tributyl phosphate	4.82E+00	4.34E-02	3.31E-04	9.73E+00	No
Xylenes	6.42E-03	4.01E-07	9.18E-09	4.39E-04	No

[a] 95% Upper Confidence Level Concentration = Average Concentration + (1.96 × Average Concentration × Relative Standard Deviation). Average Concentrations and Relative Standard Deviation taken from Table A-1, Appendix A of RPP-RPT-55307, *Tank 241-C-104 Residual Waste Inventory Estimates for Component Closure Risk Assessment*.

[b] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

[c] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

-- = Value is not available

Table D-12. Background Data for Selected Constituents for the Hanford Site. (3 sheets)

Analyte Name	Analyte Symbol	Analyte Class	Units	Lognormal 90th Percentile Background Value	Maximum Background Value	Source of Background Value
Cesium-137	Cs-137	RAD	pCi/g	1.1	1.6	DOE/RL-96-12, Rev. 0
Cobalt-60	Co-60	RAD	pCi/g	0.0084	0.039	DOE/RL-96-12, Rev. 0
Europium-154	Eu-154	RAD	pCi/g	0.033	0.079	DOE/RL-96-12, Rev. 0
Europium-155	Eu-155	RAD	pCi/g	0.054	0.1	DOE/RL-96-12, Rev. 0
Gross Beta	--	RAD	pCi/g	23	25	DOE/RL-96-12, Rev. 0
Plutonium-238	Pu-238	RAD	pCi/g	0.0038	0.019	DOE/RL-96-12, Rev. 0
Plutonium-239/240	Pu-239/240	RAD	pCi/g	0.025	0.033	DOE/RL-96-12, Rev. 0
Potassium-40	K-40	RAD	pCi/g	17	20	DOE/RL-96-12, Rev. 0
Radium-226	Ra-226	RAD	pCi/g	0.82	1.2	DOE/RL-96-12, Rev. 0
Strontium-90	Sr-90	RAD	pCi/g	0.18	0.37	DOE/RL-96-12, Rev. 0
Thorium-232	Th-232	RAD	pCi/g	1.3	1.6	DOE/RL-96-12, Rev. 0
Total beta radiostrontium	--	RAD	pCi/g	0.18	0.37	DOE/RL-96-12, Rev. 0
Uranium-233/234	U-233/234	RAD	pCi/g	1.1	1.5	DOE/RL-96-12, Rev. 0
Uranium-234	U-234	RAD	pCi/g	1.1	1.5	DOE/RL-96-12, Rev. 0
Uranium-235	U-235	RAD	pCi/g	0.11	0.39	DOE/RL-96-12, Rev. 0
Aluminum	Al	Metal	µg/kg	1.18E+07	28,800,000	DOE/RL-92-24, Vol. 1, Rev. 4
Antimony*	An	Metal	µg/kg	130	385	ECF-HANFORD-11-0038
Arsenic*	Ar	Metal	µg/kg	6,470	27,700	DOE/RL-92-24, Vol. 1, Rev. 4
Barium*	Ba	Metal	µg/kg	132,000	480,000	DOE/RL-92-24, Vol. 1, Rev. 4
Beryllium*	Be	Metal	µg/kg	1,510	10,000	DOE/RL-92-24, Vol. 1, Rev. 4
Boron	Bo	Metal	µg/kg	3,890	5,860	ECF-HANFORD-11-0038

Table D-12. Background Data for Selected Constituents for the Hanford Site. (3 sheets)

Analyte Name	Analyte Symbol	Analyte Class	Units	Lognormal 90th Percentile Background Value	Maximum Background Value	Source of Background Value
Cadmium*	Cd	Metal	µg/kg	563	2,900	ECF-HANFORD-11-0038
Calcium	Ca	Metal	µg/kg	1.72E+07	105,000,000	DOE/RL-92-24, Vol. 1, Rev. 4
Chromium	Cr	Metal	µg/kg	18,500	320,000	DOE/RL-92-24, Vol. 1, Rev. 4
Cobalt	Co	Metal	µg/kg	15,700	110,000	DOE/RL-92-24, Vol. 1, Rev. 4
Copper	Cu	Metal	µg/kg	22,000	61,000	DOE/RL-92-24, Vol. 1, Rev. 4
Iron	Fe	Metal	µg/kg	3.26E+07	68,100,000	DOE/RL-92-24, Vol. 1, Rev. 4
Lead*	Pb	Metal	µg/kg	10,200	74,100	DOE/RL-92-24, Vol. 1, Rev. 4
Lithium	Li	Metal	µg/kg	13,300	19,200	ECF-HANFORD-11-0038
Magnesium	Mg	Metal	µg/kg	7.06E+06	32,300,000	DOE/RL-92-24, Vol. 1, Rev. 4
Manganese	Mn	Metal	µg/kg	512,000	1,110,000	DOE/RL-92-24, Vol. 1, Rev. 4
Mercury*	Hg	Metal	µg/kg	13	29	ECF-HANFORD-11-0038
Molybdenum	Mo	Metal	µg/kg	470	3,170	ECF-HANFORD-11-0038
Nickel*	Ni	Metal	µg/kg	19,100	200,000	ECF-HANFORD-11-0038
Potassium	K	Metal	µg/kg	2.15E+06	7,900,000	ECF-HANFORD-11-0038
Selenium*	Se	Metal	µg/kg	780	840	Ecology Publication #94-115
Silver*	Ag	Metal	µg/kg	167	273	ECF-HANFORD-11-0038
Sodium	Na	Metal	µg/kg	690,000	6,060,000	DOE/RL-92-24, V.1, Rev.4
Thallium*	Th	Metal	µg/kg	185	523	ECF-HANFORD-11-0038
Uranium	U	Metal	µg/kg	3,210	4,042	Isotopic Activity Conversion based on DOE/RL-96-12 values
Vanadium	V	Metal	µg/kg	85,100	140,000	DOE/RL-92-24, Vol. 1, Rev. 4

Table D-12. Background Data for Selected Constituents for the Hanford Site. (3 sheets)

Analyte Name	Analyte Symbol	Analyte Class	Units	Lognormal 90th Percentile Background Value	Maximum Background Value	Source of Background Value
Zinc	Zn	Metal	µg/kg	67,800	366,000	DOE/RL-92-24, Vol. 1, Rev. 4
Ammonia	NH_3	Anion	µg/kg	9,230	26,400	DOE/RL-92-24, Vol. 1, Rev. 4
Chloride	Cl	Anion	µg/kg	100,000	1,480,000	DOE/RL-92-24, Vol. 1, Rev. 4
Fluoride	Fl	Anion	µg/kg	2,810	73,300	DOE/RL-92-24, Vol. 1, Rev. 4
Nitrate	NO_3	Anion	µg/kg	52,000	906,000	DOE/RL-92-24, Vol. 1, Rev. 4
Phosphate	PO_4	Anion	µg/kg	785	225,000	DOE/RL-92-24, Vol. 1, Rev. 4
Sulfate	SO_4	Anion	µg/kg	237,000	12,600,000	DOE/RL-92-24, Vol. 1, Rev. 4

* Dangerous waste constituent per *Washington Administrative Code* 173-303-9905, "Dangerous Waste Constituents List."

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