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Richland, Washington 99352

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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-101

Reference: ORP letter from K.W. Smith 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-101," 14-TF-0113, dated September 24, 2014.

1227039

The U.S. Department of Energy, Office of River Protection (ORP) is transmitting RPP-RPT-58386, *Retrieval Data Report for Single-Shell Tank 241-C-101,* Rev. 2, 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-58386, Rev. 2, documents completion of waste retrieval and post-retrieval sampling at Tank 241-C- 101 using modified sluicing as a first retrieval technology and high pressure water deployed with enhanced reach sluicer system as a second retrieval technology.

ORP provided a retrieval completion certification on Tank 241-C-101 on September 24, 2014 (Reference).

If you have any questions, please contact Thomas Fletcher, Assistant Manager for Tank Farm Project, at (509) 376-3434.

Kevin W. Smith
Manager

TF:CJK

Attachment

Distribution: Page 2

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cc w/attach:
TPA Administrative Record
Environmental Portal, LMSI
WRPS Correspondence

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RPP-RPT-58386, Retrieval Data Report for Single-Shell Tank 241-C-101, Rev. 2

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Prepared For the U.S. Department of Energy,
Assistant Secretary for Environmental Management
By Washington River Protection Solutions, LLC., PO Box 850, Richland, WA 99352
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RPP-RPT-58386, Rev. 2

Retrieval Data Report for Single-Shell Tank 241-C-101

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Abstract: This report describes the retrieval of waste from single-shell tank 241-C-101, a 100-series single-shell tank, constructed to store waste in Waste Management Area C. The U.S. Department of Energy began removing the waste stored in tank 241-C-101 on December 10, 2012, and completed waste removal operations using the modified sluicing and high-pressure water technologies (with a subsequent heel water wash) to the limits of technology on September 12, 2013, resulting in an estimated tank 241-C-101 waste volume remaining of ~5,620 gallons or 752 cubic feet. A practicability evaluation determined that further waste retrieval action was impractical.

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RPP-RPT-58386
Revision 2

Retrieval Data Report for Single-Shell Tank 241-C-101

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EXECUTIVE SUMMARY

This Retrieval Data Report presents information showing that waste stored in single-shell tank 241-C-101 (C-101) was retrieved by two waste retrieval technologies, each to its respective limits of technology. Tank C-101 was retrieved using modified sluicing with double-shell tank supernate and high-pressure water technologies deployed by two Extended Reach Sluicing System platforms as described in the Tank Waste Retrieval Work Plan (RPP-22520, "241-C-101 and 241-C-105 Tanks Waste Retrieval Work Plan," Revision 7) approved by the State of Washington Department of Ecology on February 23, 2012. The residual volume in tank C-101 according to RPP-CALC-56434, "Post-Retrieval Camera/CAD Modeling System Waste Volume Estimate for Tank 241-C-101" was 767 ft^3, ~5,740 gal. Since this volume of waste exceeded the Consent Decree (in Washington v. DOE, Case No. CV-08-5085-RMP [E.D. Wa. October 25, 2010]) goal of 360 ft^3, the U.S. Department of Energy, Office of River Protection submitted RPP-55849, "Practicability Evaluation Request to Forego a Third Retrieval Technology for Tank 241-C-101" on February 18, 2013, in accordance with Appendix C, Part 1, of the Decree. The State of Washington Department of Ecology approved this request on August 20, 2014 (Letter 14-NWP-164, "Re: Response to U.S. Department of Energy's Letter 14-TF-0012, dated February 18, 2014, "Request for Washington State Department of Ecology Agreement that the U.S. Department of Energy, Office of River Protection may Forego Implementing a Third Retrieval Technology in Tank 241-C-101"").

This Retrieval Data Report also presents an updated post-retrieval risk assessment, provides details on the technologies deployed and their respective performance during the waste removal campaign, and describes measures taken to prevent and detect leaks during waste retrieval operations.

The tank C-101 modified sluicing waste retrieval campaign began December 10, 2012 and suspended on September 12, 2013, after reaching the respective limits of technology for modified sluicing and high-pressure water waste retrieval technologies. The tank C-101 waste that was retrieved was transferred to double-shell tank 241-AN-101.

RPP-55849 was then developed to assess whether a third waste retrieval technology should be implemented at tank C-101. RPP-55849 was issued in January 2014 and concluded that the two waste retrieval technologies deployed at tank C-101 had each been deployed to their respective limits of technology, and that a further waste retrieval technology was not practicable as that term is used in Appendix C, Part 1, of the Consent Decree.

The tank C-101 leak detection, monitoring, and mitigation program during retrieval operations used high-resolution resistivity techniques along with readings from a combination of drywell moisture measurements, waste volume assessments (mass balances), and visual inspection to detect, prevent, and control potential leaks. No leaks were detected during tank C-101 retrieval operations.

Subsequent measurement of the residual waste in tank C-101 using topographical mapping survey techniques in accordance with RPP-23403, "Single-Shell Tank Component Closure Data Quality Objectives" estimated that the volume of waste remaining in tank C-101 was 752 ft^3

(95% upper confidence level of waste volume, RPP-CALC-56434, RPP-RPT-58803, "Tank 241-C-101 Residual Waste Inventory Estimates for Component Closure Risk Assessment").

The inventory of constituents in the residual waste remaining in tank C-101 was determined by laboratory analysis of waste samples taken after the implementation of the second retrieval technology to the limits of technology as described in Appendix C, Part 1 of the Consent Decree and an assessment was conducted that determined that the implementation of a third technology was not practicable. The risk assessment for the residual waste in tank C-101 based on sampling analysis shows that for the groundwater pathway, the estimated dose impacts (representing risk) for tank C-101 were well below current performance objectives. For all inadvertent intruder scenarios other than the suburban garden scenario (a sensitivity case) at 100 years after closure, the estimated dose impacts for tank C-101 were well below current performance measures (i.e., 500 mrem for acute exposure and 100 mrem/yr for chronic exposure). Dose impacts from the suburban garden scenario were the highest for all the chronic exposure scenarios and exceeded this performance measure at 100 years. However, the estimated doses were below the performance measure of 100 mrem/yr for chronic exposure by 200 years post-closure.

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LIST OF TERMS

Abbreviations and Acronyms

3D	three-dimensional
AES	atomic emission spectrometry
BBI	Best-Basis Inventory
BBIM	Best-Basis Inventory Maintenance
CAD	computer-aided design
CAS	Chemical Abstract Services
CCMS	Camera/CAD Modeling System
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
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
ERSS	Extended Reach Sluicing System
HFFACO	Hanford Federal Facility Agreement and Consent Order
HRR	high-resolution resistivity
HTWOS	Hanford Tank Waste Operations Simulator
ICP	inductively coupled plasma
ILCR	incremental lifetime cancer risk
LDM	leak detection and monitoring
LDMM	leak detection, monitoring, and mitigation
MS	mass spectrometry

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
QA	quality assurance
RCW	Revised Code of Washington
RDR	Retrieval Data Report
RSD	relative standard deviation
SST	single-shell tank
TIC	tentatively identified compound
TSAP	tank sampling and analysis plan
TSR	Technical Safety Requirement
TWINS	Tank Waste Information Network System
UCL	upper confidence level
WAC	Washington Administrative Code
WMA	waste management area
WRPS	Washington River Protection Solutions, LLC
WRS	waste retrieval system
WTT	drywell to tank
WTW	drywell to drywell

Units

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

1.0 INTRODUCTION AND BACKGROUND

Retrieval of single-shell tank (SST) 241-C-101 (C-101) waste was performed by implementing two waste retrieval technologies. Tank C-101 was retrieved using modified sluicing with double-shell tank (DST) supernate and high-pressure water technologies deployed by two Extended Reach Sluicing System (ERSS) platforms as described in the Tank Waste Retrieval Work Plan (RPP-22520, "241-C-101 and 241-C-105 Tanks Waste Retrieval Work Plan," Revision 7). The waste retrieval campaign began on December 10, 2012 and was suspended on September 12, 2013, deploying both technologies followed by a water rinse. After concluding the waste retrieval campaign, the quantity of waste remaining in tank C-101 was estimated to be ~5,620 gal or 752 ft^3 (RPP-CALC-56434, "Post-Retrieval Camera/CAD Modeling System Waste Volume Estimate for Tank 241-C-101"; RPP-RPT-58803, "Tank 241-C-101 Residual Waste Inventory Estimates for Component Closure Risk Assessment").

In accordance with Appendix C, Part 1, of the Consent Decree in Washington v. DOE, Case No. CV-08-5085-RMP (E.D. Wa. October 25, 2010) (hereinafter "Consent Decree"), RPP-55849, "Practicability Evaluation Request to Forego a Third Retrieval Technology for Tank 241-C-101" was developed to assess whether a third waste retrieval technology should be implemented at tank C-101. The Practicability Evaluation Request RPP-55849, issued in January 2014, determined that implementing a third technology was impractical under the terms of the Consent Decree, Appendix C, Part 1. The U.S. Department of Energy (DOE) Office of River Protection (ORP) formally requested the State of Washington Department of Ecology (Ecology) to agree with DOE's request to forego implementation of a third technology by way of a February 18, 2014 letter from T. W. Fletcher to J. A. Hedges (Letter 14-TF-0012), "Request for Washington State Department of Ecology Agreement that the U. S. Department of Energy, Office of River Protection May Forego Implementing a Third Retrieval Technology in Tank 241-C-101"). Ecology agreed with this request on August 20, 2014 via a letter from J. A. Hedges to T. W. Fletcher (Letter 14-NWP-164, "Re: Response to U.S. Department of Energy's Letter 14-TF-0012, dated February 18, 2014, "Request for Washington State Department of Ecology Agreement that the U.S. Department of Energy, Office of River Protection may Forego Implementing a Third Retrieval Technology in Tank 241-C-101"").

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 Revised Code of Washington (RCW) 70.105, "Hazardous Waste Management" 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-101 retrieval:

- Residual tank waste volume measurement, including associated calculations
- The results of residual tank waste characterization
- Retrieval technology performance documentation
- 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.

This report also references a discussion on the Practicability Evaluation Request to Forego a Third Retrieval Technology (RPP-55849).

1.2 REGULATORY REQUIREMENTS

Retrieval of waste from tank C-101 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 Consent Decree in Washington v. DOE, Case No. CV-08-5085-RMP (formerly CV-08-5085-FVS), Appendix C states that "If the waste residual goal of 360 cubic feet is not achieved using the established two technologies, an additional retrieval technology established in a revised TWRWP *[Tank Waste Retrieval Work Plan]* shall be deployed to the

"limits of technology;" provided that DOE may request that the State agree that DOE may forego implementing a third retrieval technology if DOE believes implementing such technology is not practicable under the criteria set forth above *[in Appendix C, Part 1]*." A Practicability Evaluation was prepared (RPP-55849) that addressed the limits of technology and concluded that a further waste retrieval action for tank C-101 was not practicable. As noted above, the DOE submitted the Practicability Evaluation to the State of Washington with a request to forego implementing third retrieval technology, and the State of Washington (Ecology) concurred with that request.

1.3 DOCUMENT STRUCTURE

This tank C-101 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-101 waste retrieval, presents requirements applicable to this report, and outlines the report structure.

- **Section 2**, *Single-Shell Tank 241-C-101 Residual Waste Volume Measurement* describes the method for determining the volume of residual waste in tank C-101 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-101 Risk Assessment* describes the potential risk to human health from tank C-101 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-101 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-101 and opportunities to refine future waste retrieval operations at other tanks 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-101 waste retrieval, and summarizes LDMM results.

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

2.0 SINGLE-SHELL TANK 241-C-101 RESIDUAL WASTE VOLUME MEASUREMENT

The waste in tank C-101 was retrieved using modified sluicing and high-pressure water technologies deployed by two ERSS platforms, as described by (RPP-22520, Revision 7). A description of the retrieval systems and chronology of the retrieval processes may be found in RPP-55849. Following retrieval, the residual waste volume was determined. This section presents the residual waste volume measurement process and the results for tank C-101. The post-retrieval residual waste volume estimate was performed using a method described in RPP-CALC-56434. The total measured volume of residual waste in tank C-101 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. Since RPP-CALC-56434 was completed, the equations for actual and upper bound inventories based on Camera/CAD [computer-aided design] Modeling System (CCMS) estimates were revised to reflect actual and 95% upper confidence level (UCL) equations.

2.1 RESIDUAL WASTE VOLUME MEASUREMENT PROCESS

The waste volume measurement approach is summarized in Sections 2.1.1 through 2.1.3 and is described in RPP-CALC-56434. The Camera/CAD (computer-aided design) Modeling System (CCMS) method was used to calculate the volume remaining in the tank dish. The waste volumes remaining on the tank wall, stiffener rings, and in void spaces were estimated using observation, records, and equipment drawings.

Tank C-101 post-retrieval volumes were previously estimated using Enraf[1] displacement and engineering judgment based on video observations (see RPP-CALC-55964, "Estimate of Residual Waste Volume for Single-Shell Tank 241-C-101"). However, the Enraf displacement provided only a preliminary estimate of waste in the tank bottom. As a result, a post-retrieval CCMS volume estimate was required per RPP-23403, "Single-Shell Tank Component Closure Data Quality Objectives."

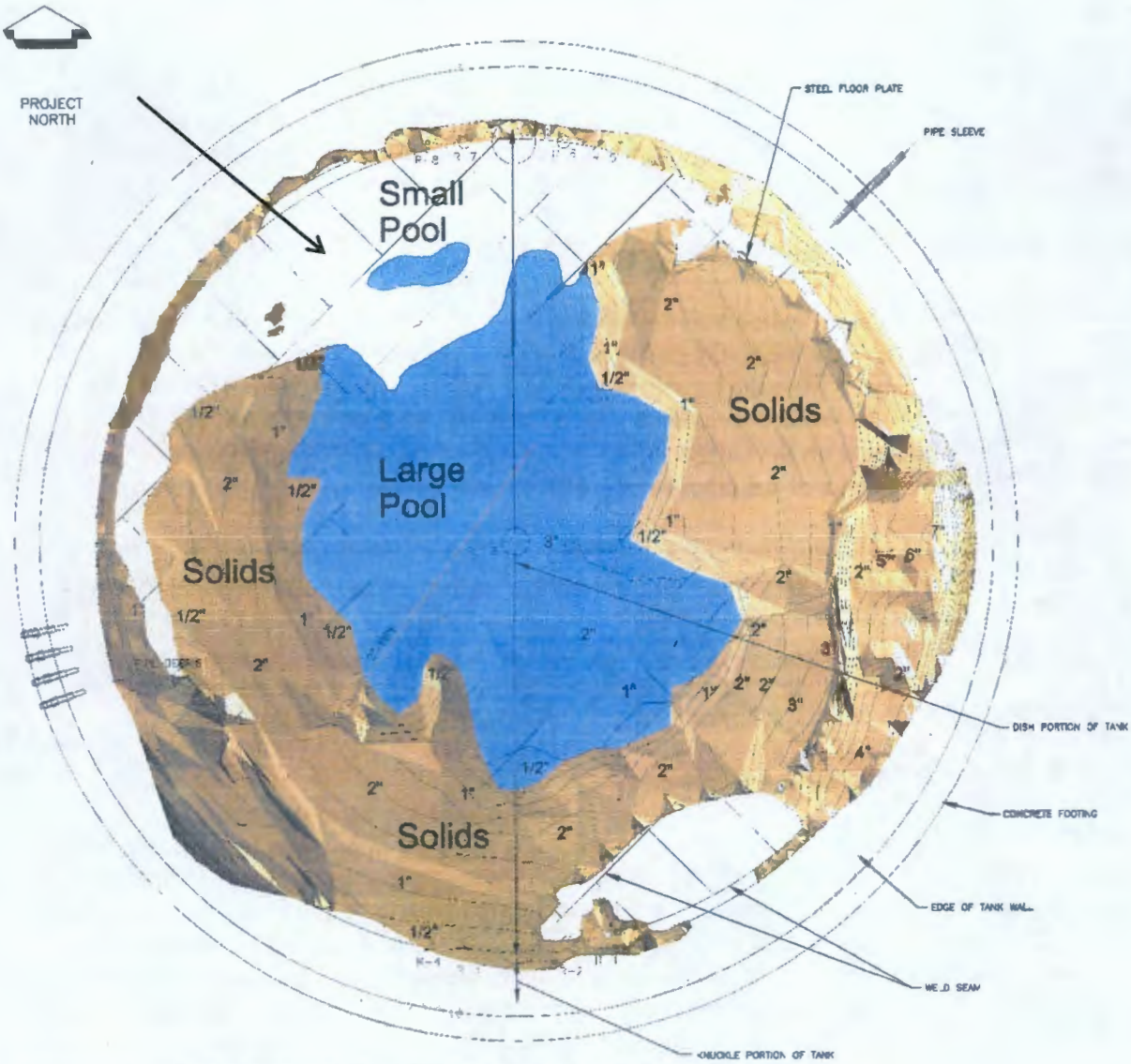
Retrieval of the tank C-101 hard heel was completed on September 12, 2013. The tank retrieval was declared complete at the limit of technology on September 11, 2013 with a preliminary volume estimate of 920 ft^3 (6,900 gal) of waste remaining based on Enraf displacement and tank video estimates.

2.1.1 Video Camera/Computer-aided Design Modeling System

The post-retrieval waste volume in the bottom of tank C-101 (see Figure 2-1) was estimated using the CCMS method per TFC-ENG-FACSUP-CD-22, "Post-Retrieval Tank Waste Volume Determination." The CCMS videos of tank C-101 were recorded on October 3, 2013 from cameras located in riser 3 and riser 8 and video was recorded at heights of ~9 ft, 14 ft, and 19 ft above the bottom of the tank.

[1] Honeywell Enraf is a product of Honeywell Process Solutions, Strahlenbergerstr. 110-112, 63067 Offenbach, Germany.

Figure 2-1. Tank 241-C-101, AutoCAD® Civil 3D® 2011, Revision 2, Post-Retrieval Tank Waste Volume Map.



Reference: H-14-109856, "CCMS Residual Waste Surface Volume Tank 241-C-101."

After the CCMS video was completed, the video was reviewed to develop an AutoCAD® Civil 3D®[2] drawing of tank C-101 and the tank waste residuals and to complete tank bottom volume estimates.

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

[2] AutoCAD® and Civil 3D® are trademarks of Autodesk, Inc., 111 McInnis Parkway San Rafael, California.

equipment and debris observed in the CCMS video. The waste contour information was then added to the template drawing to show waste remaining in the tank bottom. After completing the drawings, the Civil 3D® software calculated a waste volume by integrating between the waste contour lines and the tank bottom profile.

The estimated volume of waste on the tank bottom, calculated using AutoCAD® Civil 3D®, was 511.4 ft^3. The waste volume consists of an estimated 411.4 ft^3 (11.65 m^3) of solids piles and 100.0 ft^3 (2.83 m^3) in two pools of liquids and submerged solids. The main pool is near the center of the tank while a second, much smaller pool lies to its north.

2.1.2 Estimation of Waste Remaining on Tank Surfaces

After bulk retrieval, the estimated volume of waste on the stiffener rings was 49.3 ft^3 (367 gal) (RPP-CALC-55964). 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. The surface area of each set of stiffener rings was 97.6 ft^2. The average estimated depth of waste on the stiffener rings was estimated to be 1/16 in. on the top ring (ring #1) and 2 in. on each of the other rings (rings #2, #3 and #4).

After bulk retrieval, the estimated volume of waste on the tank walls was 106.8 ft^3 (799 gal) (RPP-CALC-55964). This was based on multiplying the surface area of the walls between each of the stiffener rings by the average depth of waste on the walls. Waste was observed from 1 ft below the bottom stiffener ring (ring #4) to the top stiffener ring (ring #1). The average depth of waste on the walls was estimated to be 3/8 inch. Except for bottom waste piles, no waste was observed on the walls from 1 ft below stiffener ring #4 and the tank bottom.

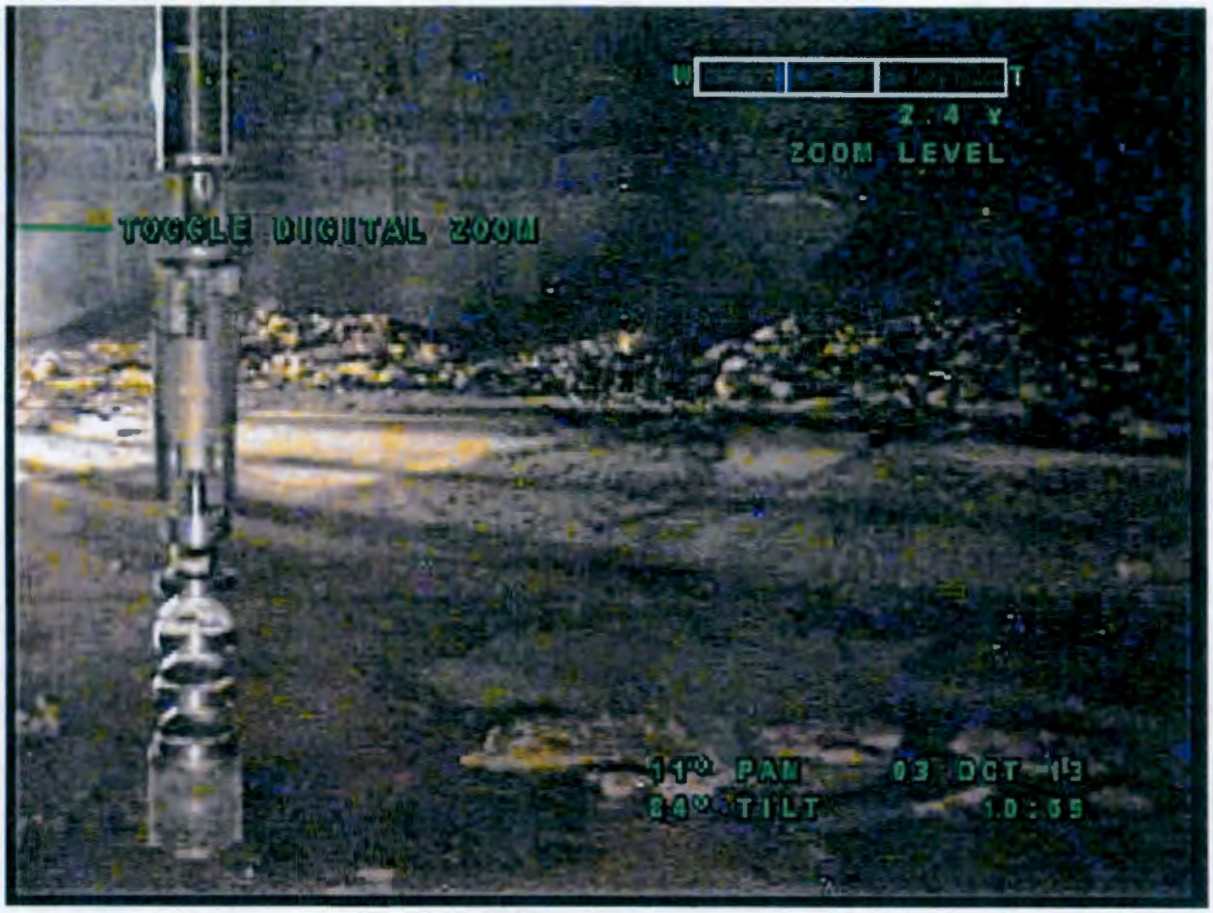
2.1.3 Estimation of Waste in Equipment

Per RPP-23403, tank waste remaining in equipment is included in the total waste volume; but the tank equipment is not included. A few small pipes are observed in the tank video. Although the pipes may be full of waste, the volume of waste potentially remaining in residual equipment in tank C-101 is negligible compared to the volume of waste in the tank bottom, on the stiffener rings and on the tank walls. Therefore, no waste volume is assigned to the tank equipment. A video still of the tank features and the dimensions of equipment and debris observed in the CCMS video next to a pile of waste is shown in Figure 2-2.

2.2 RESIDUAL WASTE VOLUME RESULTS

The total CCMS volume of post-retrieval residual waste in tank C-101 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-101 is 752 ft^3, the volume reported as the 95% UCL in Table 2-1.

Figure 2-2. Tank 241-C-101 Video Still, Recorded October 3, 2013, Camera Elevation Approximately 9 feet from Tank Bottom.



View of solids along tank knuckle near riser 8.

Table 2-1. Tank 241-C-101 Total Waste Volume and Component Waste Volumes.

Waste Component	CCMS Waste Volume			Actual[a] Volume (ft^3)	95% UCL[b] Volume (ft^3)
	m^3	gal	ft^3		
On the bottom of the tank (solids)	11.7	3,078	411	575	595.5
On the bottom of the tank (liquid pool)	2.8	749	100		
On the tank wall and stiffener rings[c]	4.4	1,168	156	156	156
Waste in tank equipment[d]	0	0	0	0	0
Total	18.9	4,995	667	731	751.5

Notes: 1 ft^3 = 7.481 gal, 1 m^3 = 264.2 gal, CCMS = Camera/Computer-aided design Modeling System, UCL = upper confidence level

[a] The actual residual waste volume of waste on the tank bottom is calculated by the formula = 1.125 * CCMS + 0.53 ft^3.

[b] The 95% UCL volume of waste on the tank bottom is calculated by the formula = 1.132 * CCMS + 17.09 ft^3.

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

[d] Negligible compared to other waste components.

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3.0 RESIDUAL TANK WASTE CHARACTERIZATION

This section describes the results of residual tank waste characterization for tank C-101. Presented are the average and upper bounding estimates of residual waste inventory based on laboratory analysis of waste samples taken after waste retrieval 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

The following documents provide requirements for sampling and analysis of the residual waste:

- RPP-23403, "Single-Shell Tank Component Closure Data Quality Objectives" – This document describes the sampling and analysis strategy developed by implementing the data quality objective (DQO) process to ensure appropriate data are collected to support SST component closure activities.

- RPP-PLAN-23827, "Sampling and Analysis Plan for Single-Shell Tanks Component Closure" – This document identifies regulatory requirements for field sampling, laboratory analysis, and data reporting for residual waste samples to ensure appropriate data are collected to support SST closure activities.

- RPP-PLAN-59975, "Sampling and Analysis Plan for Post-Retrieval Waste Solids in Tank 241-C-101" – This tank sampling and analysis plan (TSAP) summarizes the sampling and analysis requirements in the residual solids DQO. The TSAP provides additional guidance and clarification for satisfying the requirements. The guidance and clarification are necessary to address conditions that are specific to tank C-101.

The residual solids appeared to be primarily located in an ~2-in. high band, several feet wide, located about halfway between the wall and the center of the tank, and circling the center of the tank in three quadrants (RPP-PLAN-59975). Additionally, an ~3-in. deep pool of standing liquid was observed at the center of the tank, and much of the northern-most quadrant was devoid of waste residue. A tank-specific sampling design for the tank C-101 post-retrieval sample event divided the portion of the tank floor with solid waste into three regions for sampling purposes. From each of these sampling regions, three samples were planned, for a total of nine grab samples. The three samples from each region were initially planned to be composited into one sample of ~450 g.

Representatives from Ecology and DOE-ORP concurred with the sampling design as documented by approval signatures in RPP-PLAN-59975.

The Off-Riser Sampling System (ORSS) was used to collect waste samples from the desired locations and to deposit sample material into sample jars in the sample carrier located beneath the riser. A photograph of an ORSS is given in Figure 3-1.

Figure 3-1. Photograph of an Off-Riser Sampling System.

3.2 SAMPLING AT SINGLE-SHELL TANK 241-C-101

Sampling of the residual waste solids in tank C-101 was conducted on April 23, 2015. The resulting tank C-101 solid samples were shipped to the 222-S Laboratory for analysis. The approximate sample locations are shown in Appendix B of RPP-RPT-58803. The locations sampled are approximate, given the limitations of remote video viewing. Five (5) grab samples were taken from tank C-101 on April 23, 2015. The sample results are reported in RPP-RPT-58805, "Final Report for Tank 241-C-101 Post Retrieval Waste Solid Samples in Support of Tank Closure."

It was noted during sampling that, due to the physical nature of the waste and the resulting limited traction, areas not accessible by driving over bare tank floor (i.e., sampling Region 2) likely could not be sampled. Consequently, Regions 1 and 3 were attempted before attempting sampling in Region 2 (RPP-RPT-58803, Appendix D, "C-101 Post-Retrieval/Closure Sampling Meeting Notes"). The sampler operator was careful to avoid debris and encumbrances while driving the ORSS. However, while being pulled free during a loss of traction, the sampler was pulled through a partially buried manual tape, in which the sampler became entangled. At that point, the Sampling Operations group determined that due to the entanglement, the sampler was no longer operational and sampling operations were discontinued. At the time of the discontinuance of sampling operations, sampling of Region 3 was complete, sampling of Region 1 was nearly complete, and sampling of Region 2 had not begun. Because some of the

planned samples were not collected, the collected samples were analyzed individually, rather than as composites.

Representatives from Ecology and ORP agreed that further sampling was not necessary and that analysis results of the collected samples may be used to calculate the mean concentrations and inventories for constituents of interest, as documented by approval signatures on "C-101 Post-Retrieval/Closure Sampling Meeting Notes" (RPP-RPT-58803, Appendix D).

Descriptions of the solids samples are provided in Table 3-1 as reported in RPP-RPT-58805.

Table 3-1. Description of the Tank 241-C-101 Post-Retrieval Samples.

Sample Identification Number	Date Sampled	Date Received	Solid Weight (g)	Liquid Volume (mL)	Sample Description
01C-14-01	4/23/2015 09:25	4/23/2015 15:50	156.4	None	Partially full 240-mL bottle with yellow solids and brown chunks. No organic layer visible.
01C-14-02	4/23/2015 09:52	4/23/2015 15:50	152.1	None	Partially full 240-mL bottle with yellow solids and light gray chunks. No organic layer visible.
01C-14-07	4/23/2015 13:56	4/23/2015 15:50	224	None	Partially full 240-mL bottle with tan solids and white brown fragments. No organic layer visible.
01C-14-08	4/23/2015 13:08	4/23/2015 15:50	175.6	None	Partially full 240-mL bottle with yellow solids and light gray chunks. No organic layer visible.
01C-14-09	4/23/2015 10:14	4/23/2015 15:50	143.3	None	Partially full 240-mL bottle with tank solids and yellow and dark brown fragments. No organic layer visible.

3.3 SAMPLE ANALYSES

Analytical methods performed on the post-retrieval 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-58805. Electronic data were loaded into the Tank Waste Information Network System (TWINS).

3.4 CALCULATION OF RESIDUAL INVENTORY

The residual waste inventories were calculated in accordance with the best-basis inventory (BBI) process as described in RPP-7625, "Guidelines for Updating Best-Basis Inventory."
Two inventories were calculated: 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.

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

Analysis	SW-846 Reference Method
Inorganic Analyses	
Bulk Density – Gravimetric	Not applicable
pH	9045
Weight percent water – Thermogravimetric analysis	Not applicable
Cyanide – Spectrophotometric	9014
Mercury – Cold Vapor Atomic Absorption	7471B
Anions & Organic Acids – Ion chromatography	9056A
Metals – Inductively coupled plasma/Atomic emission spectrometry	6010C
^{99}Tc – Inductively coupled plasma/Mass spectrometry	3050B
^{126}Sn, Antimony – Inductively coupled plasma/Mass spectrometry	3050B
Actinides – Inductively coupled plasma/Mass spectrometry	3050B
Radiochemical Analyses	
Gamma energy analysis	Not applicable
$^{89/90}$Sr – Separation/Beta counting	Not applicable
^{14}C – Liquid scintillation counting	Not applicable
^{79}Se – Separation/Liquid scintillation counting	Not applicable
^{3}H – Liquid scintillation counting	Not applicable
^{63}Ni – Separation/Liquid scintillation counting	Not applicable
^{99}Tc – Separation/Liquid scintillation counting	Not applicable
^{129}I – Separation/Gamma energy analysis	Not applicable
^{241}Am – Separation/Alpha energy analysis	Not applicable
$^{239/240}$Pu – Separation/Alpha energy analysis	Not applicable
^{241}Pu – Separation/Liquid scintillation counting	Not applicable
^{228}Th – Separation/Alpha energy analysis	Not applicable
Organic Analyses	
Semivolatile organic compound – Gas chromatography-Mass spectrometry	8270D
Polychlorinated biphenyl – Gas chromatography-Electron capture detection	8082A

Reference: SW-846, 1986, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods"Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition as amended, U.S. Environmental Protection Agency, Washington, D.C.

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.

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 are used to compute means by weighting results based on the variance components. Some concentration results 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 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 retrieval when available. The concentration means used by the BBIM tool to calculate the average inventories are provided in Table 3-3. The BBIM also used the Searle et al. (1992) equations to calculate the mean density and standard deviation for each set of samples. The density for the samples taken after retrieval was used for the inventory calculations.

As shown in Table 2-1, ~575 ft^3 of waste were left on the bottom of the tank floor which included a pool of liquid and submerged sludge and solids on the tank floor (RPP-CALC-56434). The estimated volume of solids on the rings and side walls was ~156 ft^3. The total residual volume used for inventory estimates is 731 ft^3 (575 + 156 = 731 ft^3). There are 7.481 gallons per cubic foot and 3.785 liters per gallon, therefore the solid volume is 20.7 kL used for inventory ([731 ft^3 × 7.481 gal/ft^3 × 3.785 L/gal] × 1 kL/1,000 L = 20.7 kL).

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 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 Table 3-6) and density were calculated using the BBIM tool. The standard deviation for waste volume was estimated as described below.

RPP-CALC-56434 provides estimates of post-retrieval residual waste volumes on the tank bottom, on the tank wall, and on tank stiffener rings (see Table 2-1). The total waste volume was

estimated at 731 ft^3. The upper bounding estimates for the waste volume components added up to 751.5 ft^3. The estimated error for the total volume may be represented as ± 0.028 ([751.5-731]/731). 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 0.014 (0.028/2). This RSD was used to approximate the RSD associated with the solids volume.

The BBIM tool calculated the inventory RSD using the equation:

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

where $RSD^2(\hat{I})$ is the squared inventory RSD, $RSD^2(\bar{C})$ is the squared average concentration RSD, $RSD^2(D)$ 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 inventory estimate and $RSD(\hat{I})$ is the RSD of the 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

Tank C-101 residual waste solids were sampled using the ORSS, an accepted sampling method in the DQO (RPP-23403). A sampling design specific to the residual waste in tank C-101 was developed and documented in the sampling and analysis plan (RPP-PLAN-59975). Sample data collected by implementing this design can be used to estimate the mean concentration and data uncertainty for constituents of interest. The solids RSDs in 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 (QA) program to ensure data quality. The waste samples were analyzed according to QA 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 report (RPP-RPT-58805).

Based on this assessment, 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. For the inventories of the BBI analytes, see RPP-RPT-54440, "Derivation of Best-Basis Inventory for Tank 241-C-101 as of April 23, 2015," Revision 4.

- The inventories for ^{231}Pa are not reported, though it is a constituent specified in the DQO document (RPP-23403). It was omitted because it was not measured above the analytical method detection limit and the detection limit was very high, which would have resulted in inventory values much greater than the expected total tank farms inventory for ^{231}Pa.

- Only data from the post-retrieval 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 113 ft^3 pool of mostly liquids (RPP-CALC-56434). The volume of the submerged solids in the liquids is not estimated; therefore, the volume of the pool is included in the total residual solids volume in the tank.

- Thorium concentration was measured by inductively coupled plasma (ICP)/atomic emission spectrometry (AES) and ^{232}Th was measured by ICP/mass spectrometry (MS). Analyses by ICP/MS are generally more reliable at low concentration; therefore, the thorium inventory was calculated based on the ICP/MS results.

- Uranium concentration was based on concentrations of uranium isotopes detected by ICP/MS (^{235}U and ^{238}U).

- Uranium isotopes (^{232}U, ^{233}U, ^{234}U and ^{236}U) were calculated from total uranium using isotopic distribution ratios.

- Plutonium isotopes (^{239}Pu, ^{240}Pu and ^{242}Pu) were calculated from the $^{239/240}$Pu analytical results, using the isotopic distribution ratios (RPP-8847, "Best-Basis Inventory Template Compositions of Common Tank Waste Layers").

- Curium isotopes (^{243}Cm and ^{244}Cm) were calculated from the ^{241}Am analytical results, using the americium/curium isotopic distribution ratios (RPP-8847).

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

- The laboratory was not able to measure xylene (m) and xylene (p) separately; therefore, these compounds were reported as xylene (m&p).

- As the name implies, 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-58805 are in Appendix C, Table C-1. The samples contained numerous alkanes and their alterations to ketones and acids.

- Bulk density sample results had a range from 1.14 g/mL to 1.65 g/mL (RPP-RPT-58805) and a sample mean density of 1.38 g/mL.

3.5 INVENTORY ESTIMATES

The average and upper-bounding inventories for the residual solids are shown in Table 3-3. 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 are decay-corrected to July 1, 2015.

Table 3-3. Inventory Estimates for Selected Constituents in Tank 241-C-101 Residual Solids. (4 sheets)

Constituent	Chemical Abstract Services Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units*
1,4-Dichlorobenzene	106-46-7	<	5.46E-03	1.64E-02	kg
^{125}Sb	14234-35-6	<	2.33E+01	6.99E+01	Ci
^{126}Sn	15832-50-5	—	7.78E-02	9.74E-02	Ci
^{129}I	15046-84-1	—	2.72E-03	3.41E-03	Ci
^{137}Cs	10045-97-3	—	2.19E+03	2.71E+03	Ci
^{137m}Ba	N/A	—	2.06E+03	2.55E+03	Ci
^{14}C	14762-75-5	<	4.52E-03	1.36E-02	Ci
^{152}Eu	14683-23-9	<	2.03E+01	6.09E+01	Ci
^{154}Eu	15585-10-1	<	1.14E+01	3.42E+01	Ci
^{155}Eu	14391-16-3	<	1.83E+01	5.49E+01	Ci
^{228}Th	14274-82-9	<	1.61E-02	4.83E-02	Ci
^{230}Th	14269-63-7	<	3.71E+01	1.11E+02	Ci
^{232}Th	N/A	<	1.98E-04	5.94E-04	Ci
^{233}U	13968-55-3	—	1.73E-06	2.02E-06	Ci
^{234}U	13966-29-5	—	1.70E+00	1.99E+00	Ci
^{235}U	15117-96-1	—	7.78E-02	9.46E-02	Ci
^{236}U	13982-70-2	—	1.95E-02	2.28E-02	Ci
^{237}Np	13994-20-2	—	2.48E-02	3.72E-02	Ci
^{238}Pu	13981-16-3	—	3.14E-01	4.01E-01	Ci
^{238}U	N/A	—	1.73E+00	2.11E+00	Ci
^{239}Pu	15117-48-3	—	1.92E+01	2.52E+01	Ci
^{240}Pu	14119-33-6	—	2.06E+00	2.70E+00	Ci
^{241}Am	14596-10-2	—	5.71E+00	7.66E+00	Ci
^{241}Pu	14119-32-5	—	1.06E+01	1.48E+01	Ci
^{242}Cm	15510-73-3	—	1.19E-02	1.85E-02	Ci
^{242}Pu	13982-10-0	—	2.83E-05	3.71E-05	Ci
^{243}Cm	15757-87-6	—	8.60E-06	1.15E-05	Ci
^{244}Cm	13981-15-2	—	1.64E-04	2.20E-04	Ci
2-Butanone	78-93-3	<	6.61E-04	1.98E-03	kg
^{3}H	15086-10-9	<	8.10E-02	2.43E-01	Ci
4-Methyl-2-Pentanone	108-10-1	<	5.74E-04	1.72E-03	kg

Table 3-3. Inventory Estimates for Selected Constituents in Tank 241-C-101 Residual Solids. (4 sheets)

Constituent	Chemical Abstract Services Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units*
^{60}Co	10198-40-0	<	4.20E+00	0.00E+00	Ci
^{63}Ni	13981-37-8	—	5.70E+01	7.17E+01	Ci
^{79}Se	15758-45-9	—	4.51E-03	7.70E-03	Ci
^{90}Sr	10098-97-2	—	1.02E+04	1.43E+04	Ci
^{90}Y	10098-91-6	—	1.02E+04	1.43E+04	Ci
^{99}Tc	14133-76-7	—	7.88E-01	1.03E+00	Ci
Acetate	71-50-1	—	9.29E+00	1.20E+01	kg
Acetone	67-64-1	<	7.40E-04	2.22E-03	kg
Ag	7440-22-4	—	3.43E+00	4.07E+00	kg
Al	7429-90-5	—	5.11E+03	6.28E+03	kg
Aroclors (Total PCB)	1336-36-3	—	1.28E-03	2.37E-03	kg
As	7440-38-2	<	1.87E-01	5.61E-01	kg
B	7440-42-8	—	3.57E-02	5.18E-02	kg
Ba	7440-39-3	—	7.57E-01	1.50E+00	kg
Be	7440-41-7	<	2.80E-02	8.40E-02	kg
Benzo(a)pyrene	50-32-8	<	7.18E-03	2.15E-02	kg
Bi	7440-69-9	<	1.68E-01	0.00E+00	kg
Bis(2-ethylhexyl)phthalate	117-81-7	—	5.89E-02	7.99E-02	kg
Br	24959-67-9	<	8.44E-01	0.00E+00	kg
Butylbenzylphthalate	85-68-7	—	3.20E-02	4.45E-02	kg
Ca	7440-70-2	—	1.86E+01	2.47E+01	kg
Cd	7440-43-9	—	6.93E-02	8.48E-02	kg
Ce	7440-45-1	—	3.54E+00	4.50E+00	kg
Cl	16887-00-6	—	1.31E+01	1.72E+01	kg
CN	57-12-5	—	1.24E+01	1.61E+01	kg
Co	7440-48-4	—	7.96E-02	1.21E-01	kg
Cr	7440-47-3	—	4.96E+00	5.88E+00	kg
Cu	7440-50-8	—	7.61E+00	9.04E+00	kg
Dibenz[a,h]anthracene	N/A	<	3.12E-03	9.36E-03	kg
Diethylphthalate	84-66-2	<	1.50E-02	0.00E+00	kg
Diphenyl amine	122-39-4	<	2.98E-03	0.00E+00	kg

Table 3-3. Inventory Estimates for Selected Constituents in Tank 241-C-101 Residual Solids. (4 sheets)

Constituent	Chemical Abstract Services Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units*
Eu	7440-53-1	<	2.80E-02	0.00E+00	kg
F	16984-48-8	—	8.29E+00	1.47E+01	kg
Fe	7439-89-6	—	2.23E+02	2.86E+02	kg
Formate	12311-97-6	—	1.08E+01	1.36E+01	kg
Free OH	N/A	—	1.66E-02	2.98E-02	kg
Glycolate	666-14-8	<	9.00E-01	2.70E+00	kg
Hexachlorobenzene	118-74-1	<	6.50E-03	1.95E-02	kg
Hg	7439-97-6	—	5.12E-02	0.00E+00	kg
K	7440-09-7	—	1.99E+01	2.75E+01	kg
La	7439-91-0	—	6.48E-01	8.90E-01	kg
Li	7439-93-2	—	3.81E-01	4.61E-01	kg
Mg	7439-95-4	—	3.00E+00	4.17E+00	kg
Mn	7439-96-5	—	4.41E+01	6.79E+01	kg
Mo	7439-98-7	—	3.68E-01	4.95E-01	kg
Na	7440-23-5	—	2.52E+03	3.06E+03	kg
Nb	7440-03-1	<	1.68E-01	5.04E-01	kg
Nd	7440-00-8	—	1.63E+00	2.40E+00	Kg
NH_3	7664-41-7	—	1.81E-01	2.91E-01	kg
Ni	7440-02-0	—	2.11E+01	2.62E+01	kg
N-Nitrosodimethylamine	62-75-9	<	5.21E-03	1.56E-02	kg
NO_2	14797-65-0	—	5.11E+02	0.00E+00	kg
NO_3	14797-55-8	—	7.23E+02	9.15E+02	kg
Oxalate	338-70-5	—	1.70E+01	2.23E+01	kg
Pb	7439-92-1	—	8.10E+00	1.03E+01	kg
Pd	7440-05-3	—	4.14E+00	5.13E+00	kg
Pentachlorophenol	87-86-5	<	2.84E-03	8.52E-03	kg
Phenol	108-95-2	<	5.05E-03	1.52E-02	Kg
PO_4	14265-44-2	—	3.76E+02	5.52E+02	kg
Pr	7440-10-0	<	7.28E-01	2.18E+00	kg
Rb	7440-17-7	<	1.60E+00	4.80E+00	kg
Rh	7440-16-6	—	1.71E+00	2.08E+00	kg

Table 3-3. Inventory Estimates for Selected Constituents in Tank 241-C-101 Residual Solids. (4 sheets)

Constituent	Chemical Abstract Services Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units*
Ru	7440-18-8	<	1.12E-01	3.36E-01	kg
Sb	7440-36-0	—	7.63E-03	9.48E-03	kg
Se	7782-49-2	—	9.20E+00	1.16E+01	kg
Si	7440-21-3	—	5.44E+01	7.41E+01	kg
Sm	7440-19-9	—	2.20E+01	2.68E+01	kg
Sn	7440-31-5	<	2.28E-01	6.84E-01	Kg
SO_4	14808-79-8	—	1.26E+02	1.83E+02	kg
Sr	7440-24-6	—	6.71E+00	8.56E+00	kg
Ta	7440-25-7	<	2.36E-01	7.08E-01	kg
Te	13494-80-9	—	3.90E-01	4.77E-01	kg
Th	7440-29-1	<	1.80E+00	5.40E+00	kg
Ti	7440-32-6	<	8.21E-02	2.46E-01	kg
Tl	7440-28-0	<	1.12E-01	3.36E-01	kg
Tributyl phosphate	126-73-8	—	2.84E-02	3.39E-02	kg
Trichloroethene	79-01-6	<	4.07E-05	1.22E-04	kg
U	7440-61-1	—	5.20E+03	6.09E+03	kg
V	7440-62-2	<	6.42E-02	1.93E-01	kg
W	7440-33-7	—	2.41E+00	2.97E+00	kg
Xylene (m & p)	108-28-3M	<	5.63E-05	1.69E-04	kg
Xylene (o)	95-47-6	<	3.09E-05	9.27E-05	kg
Xylenes (total)	1330-20-7	<	1.37E-05	4.11E-05	kg
Y	7440-65-5	<	6.67E-02	2.00E-01	kg
Zn	7440-66-6	—	1.38E+00	1.83E+00	kg
Zr	7440-67-7	—	1.17E+00	2.08E+00	kg

* Radionuclide concentrations are decay corrected to July 1, 2015.

Ci = curie, kg = kilogram, N/A = not applicable, PCB = polychlorinated biphenyl

4.0 RETRIEVAL SYSTEM PERFORMANCE

This section discusses the performance of the tank C-101 waste retrieval system in terms of residual waste, retrieval duration, and water use. In addition, this section compares the achieved waste retrieval results against predicted performance. The residual tank volume at the end of retrieval was described in Section 2.0.

The tank C-101 waste retrieval system operation comprised 71 operating days (130 shifts) starting on December 10, 2012 and ending on September 11, 2013 which recovered ~67,400 gal of waste (RPP-CALC-55964). The BBI estimate of the initial waste volume in tank C-101 was 88,000 gal, based on a volume assessment following interim stabilization of the tank in 1983 (RPP-RPT-43028, "2009 Auto-TCR for Tank 241-C-101"). The initial waste volume estimate was later revised to 77,500 gal based on observations at the start of waste retrieval and an estimate of the volume of waste on the tank walls and stiffener rings (RPP-CALC-55964).

During the addition of ~40,000 gal of supernate into tank C-101 on September 11, 2013 a liquid displacement measurement was performed to determine the amount of solids that were left in the tank. Tank 241-AN-101 (AN-101) and tank C-101 waste level measurements taken before and after the transfer of the supernate from tank AN-101 to tank C-101 and then back to tank AN-101 along with video recordings were used to estimate the volume of waste remaining in tank C-101.

Previous tank waste volume estimates were performed for the waste remaining in the tank on February 20, 2013 (RPP-CALC-54614, "Estimate of Residual Waste Volume for Single-Shell Tank 241-C-101"). No apparent change was observed in the estimated amount of waste on the walls and stiffener rings previously reported.

4.1 WASTE RETRIEVAL PROCESS DESCRIPTION

Tank C-101 is the second tank to use the ERSS for retrieval of tank waste and the first to have two ERSSs. The ERSS is different from a standard sluicer in that it has a boom, as well as a mast, which can be used to place the sluicer nozzle closer to the waste and increase the effectiveness of sluicing in breaking up solid waste in the tank.

The ERSS boom is designed to extend and retract with a range of 15 to 28 ft and elevate approximately 90° along the vertical. The mast rotates ±180°, providing a side-to-side motion to the boom. These operations can be manipulated to bring the nozzle much closer to the waste in the tank than is possible with the fixed-elevation standard sluicer. The nozzle on the ERSS is capable of continuous rotation 360° in both the elevation and transverse functions.

Each ERSS in tank C-101 is also equipped with two high-pressure water nozzles that deliver water at ~4,800 psi to further break up hard waste material. Tank C-101 is the first tank to use these water nozzles with the ERSS.

The standard sluicer would have had little or no effect on the hard waste surface in tank C-101. The consistency of the waste surface appeared to be similar to the waste surface in tanks 241-C-111 and 241-C-112. Without the ERSSs, it is unlikely that much of the hard waste would have been broken up and the volume of waste retrieved from the tank would have been very low. Even with the ERSSs, the waste was slow to break up, but the ERSSs were able to break up the waste.

Leaks in the hydraulic fluid supply lines for the nozzle transverse and elevation operations in both sluicers occurred during the course of retrieval operations. To minimize leakage, the hydraulic line connections for the nozzles were disconnected and the ERSS was operated using the other remaining ERSS positioning functions. The ERSS wrist functions were connected several times during the remaining operations and reoriented to allow for more efficient retrieval activities, the hydraulic lines were subsequently disconnected.

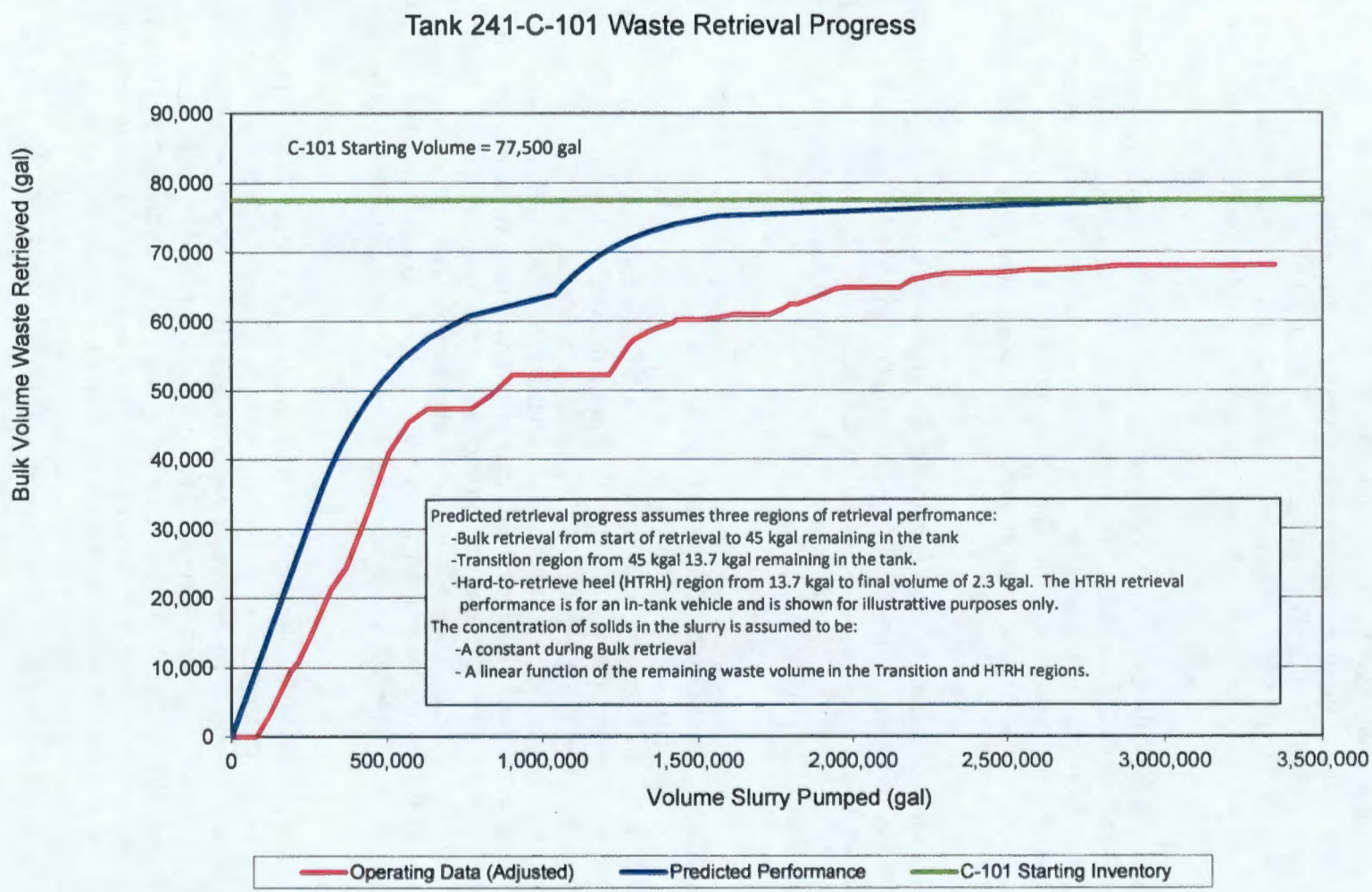
A supernatant soak of the hard solids in tank C-101 was also performed in an attempt to soften the hard waste surface. On January 22, 2013, ~42,000 gal of tank AN-101 supernate were transferred to tank C-101 and the solids were allowed to soak in the supernate. The supernate was pumped out on February 20, 2013. However, the supernatant soak appeared to have little effect on the ability to retrieve the waste.

4.2 RETRIEVAL SYSTEMS PERFORMANCE

Before modified sluicing began, most of the waste in tank C-101 consisted of a dark-colored hard crust waste that appeared to be several inches thick. Sluicing had to penetrate the hard waste to access the softer waste below. Once the softer waste was accessed, the retrieval progressed at a steady rate for the first part of the retrieval period. Retrieval efficiency then began to drop off as the more easily retrieved material was retrieved. Waste piles remained on the east and west sides of the tank, the areas furthest from the two sluicers. Large chunks of waste were scattered around the tank bottom and smaller particles and fine solids were easily pushed across the tank by the sluicers, but not easily suspended and pumped out. The high-pressure water was able to break up some solids, but did not significantly improve waste retrieval.

Figure 4-1 shows retrieval system performance (bulk volume of waste retrieved as a function of the volume of slurry, i.e., solids plus recycled tank AN-101 supernate, transferred from tank C-101 to tank AN-101). The volume of waste retrieved is estimated from the increase in the waste volume in tank AN-101 after accounting for water additions and adjusting for void space in the bulk tank C-101 waste. This method does not account for solids dissolution or liquid evaporation. Using this method, the volume of waste remaining was estimated to be 9,400 gal (1,260 ft^3). This differs slightly from the liquid displacement method which estimated 6,900 gal (920 ft^3). In part because the volume balance does not adjust for evaporation during retrieval operations, the liquid displacement method is considered to be a better estimate of the final waste volume.

Figure 4-1. Tank 241-C-101 Modified Sluicing Waste Retrieval System Performance.



As in most tanks that have been retrieved by modified sluicing, the rate of waste retrieval was initially high and began to fall off as the easily retrieved sludge was removed and heavier and larger waste remained. As shown by the slope of the line in Figure 4-1, the retrieval rate for tank C-101 was high and relatively constant through about the first 47,000 gal of waste retrieved (~61%). Retrieval rates then slowly began to drop off and approach the limit of technology.

Modified sluicing using the ERSS was performed from December 10, 2012 to September 11, 2013 in tank C-101. When modified sluicing alone did not appear effective in retrieving more material, high-pressure water was introduced to facilitate breakup of larger waste chunks. High-pressure water was alternated with additional modified sluicing to mobilize and retrieve any waste pieces and fines.

The waste remaining in the tank includes a pool of liquid in the center of the tank. A thin layer of fine solids covers almost all of the tank bottom. Piles of solids, a mix of dark- and light-colored "cobble," are located along the knuckle of the tank. The largest piles are in the southwest and southeast quadrants of the tank. Smaller piles are located on the north and northwest areas of the knuckle. Larger, light-colored chunks of waste are scattered about the tank floor.

Table 4-1 displays the volume percent of solids in the retrieved bulk waste for the amount of slurry transferred for the last three months of the tank C-101 retrieval operation. Table 4-1 shows that, starting in mid-August 2013, the volume percent of solids in the slurry had decreased to ~0.02%; therefore, the concentration of SST waste in the retrieval slurry sent to the DST is within or bracketing a 0 to 0.6 volume percent range for three operating periods, effective September 11, 2013.

All reasonable efforts to enhance the effectiveness of the waste retrieval system have been attempted. An attempt to soften solids by soaking the solids with tank AN-101 supernate, performed between January 22 and February 20, 2012, did not improve waste retrieval rates.

At the end of modified sluicing in tank C-101, waste had been mobilized and retrieved from the areas under the sluicers and the center of the tank. In these areas, the tank bottom was either exposed or covered by loose solids. Most of the solids that still remained were in the areas near the tank wall. Attempts were made to spray the tank wall and stiffener rings, and the liquid was able to reach these areas; also, the same operation was performed using high-pressure water. However, little to no reduction in the waste on the wall and stiffener rings was observed, even in the areas closest to the sluicer.

As a result, DOE-ORP concluded that modified sluicing/high-pressure water retrieval had been deployed to the limit of technology (RPP-57570, "Retrieval Completion Certification Report for Tank 241-C-101").

Table 4-1. Waste Retrieval Efficiency (June 19 to September 11, 2013).

Operating Period	Bulk Volume Solids Retrieved, gal*	Slurry Pumped, gal	Solids in Slurry, vol%
6/7/13	741	26,153	2.83%
6/10/13	0	24,946	1.44%
6/11/13, 09:33 to 9/12/13 08:45	2,171	125,511	
6/12/13, 08:45 to 13:36	161	22,351	0.72%
6/13/13	0	67,591	0.49%
6/14/13	0	71,302	
6/17/13	0	43,369	
6/19/13	1,078	39,335	
7/9/13	651	65,956	0.99%
7/10/13	322	49,388	0.65%
7/11/13	0	65,205	0.08%
7/22/13	80	41,886	
7/23/13	0	54,876	0.20%
7/24/13	241	65,298	
7/25/13	201	37,991	0.53%
7/26/13	0	0	0.04%
8/8/13	0	14,458	
8/9/13	0	57,972	
8/12/13	46	57,236	
8/13/13	201	77,577	0.26%
8/14/13	362	72,429	0.50%
8/15/13	0	9,532	0.02%
8/19/13, 10:25 to 23:00	0	69,024	
8/19/13, 23:00 to 8/20/13 17:09	0	33,608	
8/20/13, 17:09 to 8/21/13 21:18	0	132,171	
9/6/2013	0	0	
9/9/13, 16:58 to 22:50	0	30,224	
9/9/13, 22:50 to 9/10/13, 21:45	0	114,660	
9/10/13, 21:45 to 9/11/13 11:36	76	70,504	

*0 gal retrieved includes periods with net volume increase in tank 241-C-101 due to the addition of liquid (water or supernate) and periods with net volume decrease in tank 241-C-101 due only to the reduction of liquid volume in the tank.

Source: RPP-RPT-55573, "Retrieval Completion Report for Modified Sluicing of Tank 241-C-101 Using Extended Reach Sluicing and High-Pressure Water."

4.2.1 Waste Retrieval Efficiency

The preliminary estimate for the tank C-101 modified sluicing technology indicated that the rate of waste retrieval would require 3,300,000 gal of slurry to transfer the estimated 67,300 gal of tank C-101 waste to tank AN-101. In the first 500,000 gal of the slurry pumped from tank C-101, over half of the waste stored in tank C-101 was transferred to tank AN-101, at the expected rate. However, when about one third of the forecasted slurry volume had been transferred (1,000,000 gal) to tank AN-101, the tank C-101 waste retrieval rate become insignificant.

The high-pressure water was able to break up some of the large pieces of solids in the tank. However, it was only effective at close range. Large pieces of solids were not easily moved with the sluicers and a relatively small volume of waste was broken up by the high-pressure water. As a result, only ~800 gal of additional waste retrieval was achieved using over 6,000 gal of high-pressure water and 500,000 gal of supernate for sluicing.

All reasonable efforts to enhance the effectiveness of the waste retrieval system have been attempted. An attempt to soften solids by soaking the solids with tank AN-101 supernate, performed between January 22 and February 20, 2012, did not improve waste retrieval rates. Toward the end of retrieval operations, hydraulic lines to the ERSS nozzles were briefly reconnected and the nozzle angles were optimized to help move solids from the waste pile toward the opposite sluicers where high-pressure water could be used on the waste solids. Sluicing and high-pressure water washing of the tank walls and stiffener rings was attempted to remove adhered waste. Visual observations of this attempt showed no significant removal of the adhered waste.

4.3 CONCLUSION

Based on the information contained in Section 4.2 above, it was concluded that waste retrieval operations were performed to the limits of the modified sluicing technology. At that time the residual waste volume in tank C-101 was estimated (RPP-CALC-55964) to be 920 ft^3 (6,900 gal) RPP-RPT-55573, "Retrieval Completion Report for Modified Sluicing of Tank 241-C-101 Using Extended Reach Slicing and High Pressure Water," concluded that retrieval operations were completed to the limits of sluicing and high pressure water retrieval technologies.

A final tank C-101 waste volume evaluation, based largely on the tank video CCMS estimate for the waste volume in SST C-101 as of October 3, 2013, estimated a 95% UCL for the residual waste volume in tank C-101 of ~6,900 gal (~920 ft^3) (see RPP-CALC-56434). A Practicability Evaluation Request to Forego a Third Retrieval Technology (RPP-55849) determined that the two retrieval systems implemented in tank C-101 were completed to the limits of their respective technologies, and that implementation of a third technology was not practicable.

5.0 POST-RETRIEVAL SINGLE-SHELL TANK 241-C-101 RISK ASSESSMENT

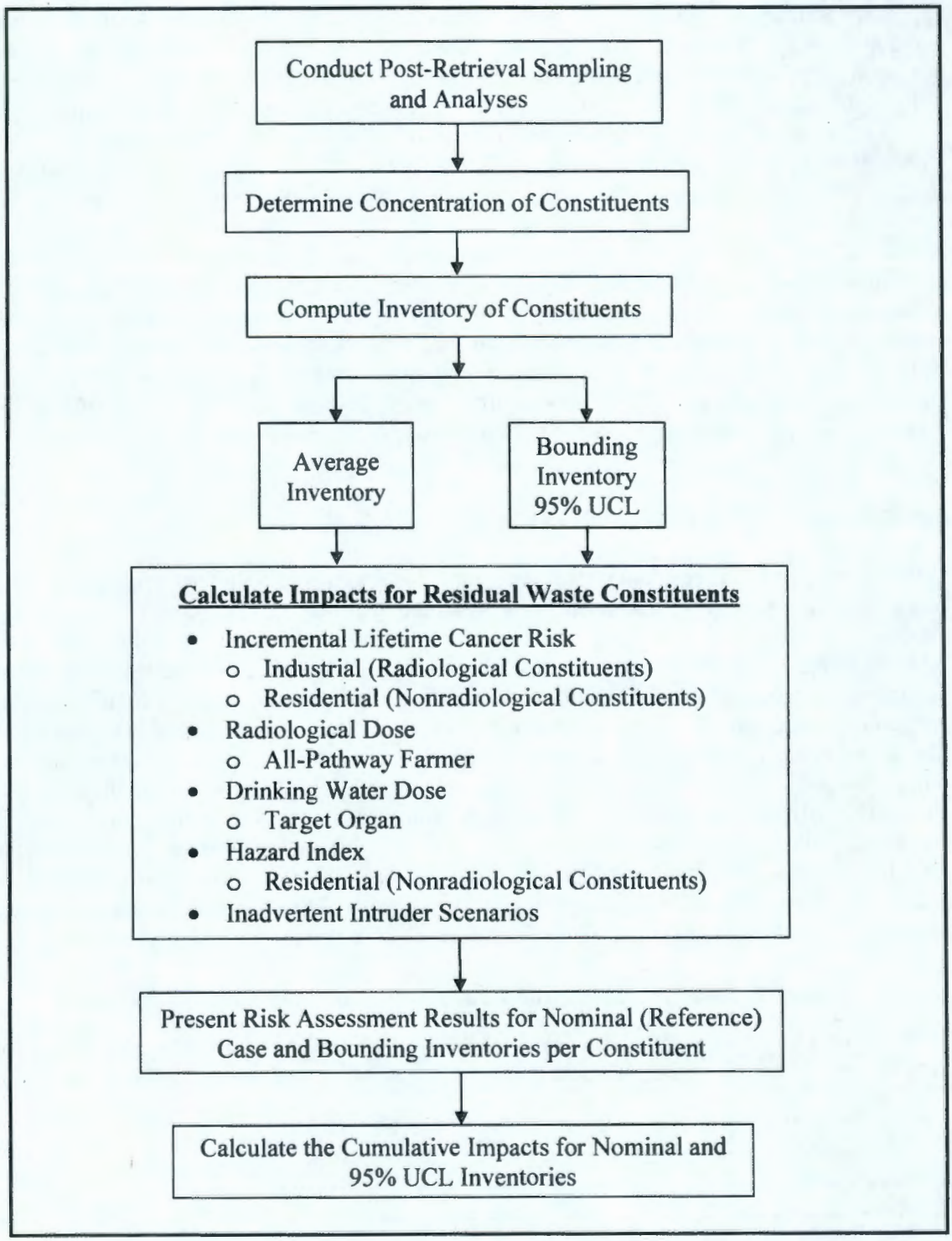
The potential impacts to human health posed by the residual waste in SST C-101 were evaluated using the methodology documented in DOE/ORP-2005-01, Initial Single-Shell Tank System Performance Assessment for the Hanford Site. Figure 5-1 provides a schematic of the process used for the tank C-101 risk 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-101, 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 the 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-101 risk assessment was derived from post-retrieval residual inventory samples (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 RPP-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 RPP-RPT-58803 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-101 are in the same order of magnitude to four orders of magnitude below current incremental lifetime cancer risk (ILCR) performance objectives (1.0E-06 to 1.0E-4) for radioactive analytes and one to nine orders of magnitude below the ILCR performance objectives (1.0E-05) for non-radioactive analytes. The hazard indices for the tank C-101 groundwater pathway are three to five orders of magnitude below the performance objective (1.0).

For the well driller (acute exposure), rural pasture (chronic exposure), and commercial farm (chronic exposure) inadvertent intruder scenarios, the radiological doses at 100 years after closure were below the 100 mrem/yr and 500 mrem/yr performance objectives, respectively. For the suburban garden (a sensitivity case) inadvertent intruder scenario, at 100 years after closure, the effects associated with tank C-101 exceeded the 100 mrem/yr performance objective for chronic exposure. Details of these results are provided in Sections 5.2 through 5.4.

Figure 5-1. Single-Shell Tank 241-C-101 Residual Waste Inventory and Risk Assessment Process.



UCL = upper confidence level

This section also provides additional risk management information related to concentrations of constituents remaining in waste residuals within tank C-101 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-101 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-101 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-101 were collected and analyzed as defined by the closure DQOs. The post-retrieval samples were analyzed for 119 constituents (i.e., radionuclides, volatile organic compounds, semi-volatile organic compounds, polychlorinated biphenyls, 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 cancer potency factor (also called a cancer slope factor), dose factor, or reference dose is published for that analyte.

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

Isotope/CAS	Analyte	Detect	Available Toxicity Information
106-46-7	1, 4-Dichlorobenzene	U	Reference dose/Cancer potency factor
^{125}Sb	Antimony-125	U	Dose factor/Cancer potency factor
^{126}Sn	Tin-126	—	Dose factor/Cancer potency factor
^{129}I	Iodine-129	—	Dose factor/Cancer potency factor
^{137}Cs	Cesium-137 + Daughters	—	Dose factor/Cancer potency factor
^{137m}Ba	Barium-137m	—	--
^{14}C	Carbon-14	U	Dose factor/Cancer potency factor

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

Isotope/CAS	Analyte	Detect	Available Toxicity Information
^{152}Eu	Europium-152	U	Dose factor/Cancer potency factor
^{154}Eu	Europium-154	U	Dose factor/Cancer potency factor
^{155}Eu	Europium-155	U	Dose factor/Cancer potency factor
^{228}Th	Thorium-228 + D	U	Dose factor/Cancer potency factor
^{230}Th	Thorium-230	U	Dose factor/Cancer potency factor
^{232}Th	Thorium-232	U	Dose factor/Cancer potency factor
^{233}U	Uranium-233	—	Dose factor/Cancer potency factor
^{234}U	Uranium-234	—	Dose factor/Cancer potency factor
^{235}U	Uranium-235 + D	—	Dose factor/Cancer potency factor
^{236}U	Uranium-236	—	Dose factor/Cancer potency factor
^{237}Np	Neptunium-237 + D	—	Dose factor/Cancer potency factor
^{238}Pu	Plutonium-238	—	Dose factor/Cancer potency factor
^{238}U	Uranium-238 + D	—	Dose factor/Cancer potency factor
^{239}Pu	Plutonium-239	—	Dose factor/Cancer potency factor
^{240}Pu	Plutonium-240	—	Dose factor/Cancer potency factor
^{241}Am	Americium-241	—	Dose factor/Cancer potency factor
^{241}Pu	Plutonium-241 + D	—	Dose factor/Cancer potency factor
^{242}Cm	Curium-242	—	Dose factor/Cancer potency factor
^{242}Pu	Plutonium-242	—	Dose factor/Cancer potency factor
^{243}Cm	Curium-243	—	Dose factor/Cancer potency factor
^{244}Cm	Curium-244	—	Dose factor/Cancer potency factor
78-93-3	2-Butanone(MEK)	U	Reference dose
^{3}H	Tritium	U	Dose factor/Cancer potency factor
108-10-1	4-Methyl-2-pentanone (MIBK)	U	Reference dose
^{60}Co	Cobalt-60	U	Dose factor/Cancer potency factor
^{63}Ni	Nickel-63	—	Dose factor/Cancer potency factor
^{79}Se	Selenium-79	—	Dose factor/Cancer potency factor
^{90}Sr	Strontium-90 + D	—	Dose factor/Cancer potency factor
^{90}Y	Yttrium-90	—	--
^{99}Tc	Technetium-99	—	Dose factor/Cancer potency factor
71-50-1	Acetate $C_2H_3O_2^-$	—	--
67-64-1	2-Propanone (Acetone)	U	Reference dose
7440-22-4	Silver	—	Reference dose
7429-90-5	Aluminum	—	Reference dose
1336-36-3	Polychlorinated Biphenyls (high risk)	—	Cancer potency factor
7440-38-2	Arsenic	U	Reference dose/Cancer potency factor
7440-42-8	Boron	—	Reference dose
7440-39-3	Barium	—	Reference dose
7440-41-7	Beryllium	U	Reference dose/Cancer potency factor
50-32-8	Benzo[a]pyrene	U	Cancer potency factor

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

Isotope/CAS	Analyte	Detect	Available Toxicity Information
7440-69-9	Bismuth	U	--
117-81-7	Di (2-ethylhexyl) phthalate (DEHP)	—	Reference dose/Cancer potency factor
24959-67-9	Bromide	U	--
85-68-7	Butylbenzylphthalate	—	Reference dose
7440-70-2	Calcium	—	--
7440-43-9	Cadmium	—	Reference dose/Cancer potency factor
7440-45-1	Cerium	—	Reference dose
16887-00-6	Chloride	—	--
57-12-5	Cyanide	—	Reference dose
7440-48-4	Cobalt	—	Reference dose/Cancer potency factor
7440-47-3	Chromium, Total	—	--
7440-50-8	Copper	—	Reference dose
53-70-3	Dibenz[a, h]anthracene	U	Cancer potency factor
84-66-2	Diethyl phthalate	U	Reference dose
122-39-4	N, N-Diphenylamine	U	Reference dose
7440-53-1	Europium	U	--
16984-48-8	Fluoride	—	Reference dose
7439-89-6	Iron	—	Reference dose
12311-97-6	Formate+A_2	—	--
OHDEMAND	Hydroxide OH	—	--
glycolate	Glycolate $C_2H_3O_3$	U	--
118-74-1	Hexachlorobenzene	U	Reference dose/Cancer potency factor
7439-97-6	Mercury	—	Reference dose
7440-09-7	Potassium	—	--
7439-91-0	Lanthanum	—	--
7439-93-2	Lithium	—	Reference dose
7439-95-4	Magnesium	—	--
7439-96-5	Manganese	—	Reference dose
7439-98-7	Molybdenum	—	Reference dose
7440-23-5	Sodium	—	--
7440-03-1	Niobium	U	--
7440-00-8	Neodymium	—	--
7664-41-7	Ammonia	—	Reference dose
7440-02-0	Nickel	—	Reference dose
62-75-9	N-Nitroso-N, N-dimethylamine	U	Reference dose/Cancer potency factor
14797-65-0	Nitrite	—	Reference dose
14797-55-8	Nitrate	—	Reference dose
338-70-5	Oxalate	—	--
7439-92-1	Lead	—	--
7440-05-3	Palladium	—	--

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

Isotope/CAS	Analyte	Detect	Available Toxicity Information
87-86-5	Pentachlorophenol	U	Reference dose/Cancer potency factor
108-95-2	Phenol	U	Reference dose
14265-44-2	Phosphate	—	--
7440-10-0	Praseodymium	U	--
7440-17-7	Rubidium	U	--
7440-16-6	Rhodium	—	--
7440-18-8	Ruthenium	U	--
7440-36-0	Antimony	—	Reference dose
7782-49-2	Selenium	—	Reference dose
7440-21-3	Silicon	—	--
7440-19-9	Samarium	—	--
7440-31-5	Tin	U	Reference dose
14808-79-8	Sulfate	—	--
7440-24-6	Strontium	—	Reference dose
7440-25-7	Tantalum	U	--
13494-80-9	Tellurium	—	--
7440-29-1	Thorium	U	--
7440-32-6	Titanium	U	--
7440-28-0	Thallium	U	Reference dose
126-73-8	Tributyl phosphate	—	Reference dose/Cancer potency factor
79-01-6	1, 1, 2-Trichloroethylene	U	Reference dose/Cancer potency factor
7440-61-1	Uranium	—	--
7440-62-2	Vanadium	U	Reference dose
7440-33-7	Tungsten	—	--
108-38-3	m-Xylene	U	Reference dose
95-47-6	o-Xylene	U	Reference dose
1330-20-7	Xylenes	U	Reference dose
7440-65-5	Yttrium	U	--
7440-66-6	Zinc	—	Reference dose
7440-67-7	Zirconium	—	--

CAS = Chemical Abstracts Service U = Analyte not detected in residual wastes -- = No available toxicity value

5.2 RESULTS FOR INDIVIDUAL CONTAMINANTS FOR POST-RETRIEVAL SINGLE-SHELL TANK 241-C-101

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-101. 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 SST C-101. 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.

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-101.

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	No	2.26E-03	3.48E-03	9,781	0.00E+00	5.73E+03	2.70E-11	1.95E-10	1.69E-05	6.96E-06
^{99}Tc	Yes	7.88E-01	3.15E+00	10,461	0.00E+00	2.11E+05	4.34E-08	1.06E-06	5.51E-03	1.40E-02
^{129}I	Yes	2.72E-03	<1.00E-03	12,032	2.00E-01	1.57E+07	NE	NE	NE	NE
^{234}U	Yes	1.70E+00	0.00E+00	DNA	6.00E-01	2.46E+05	NE	NE	NE	N/A
^{235}U	Yes	7.78E-02	0.00E+00	DNA	6.00E-01	7.04E+08	NE	NE	NE	N/A
^{236}U	Yes	1.95E-02	0.00E+00	DNA	6.00E-01	2.34E+07	NE	NE	NE	N/A
^{238}U	Yes	1.73E+00	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

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-101.

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]
						Washington Administrative Code 173-340 Method B	
Chromium, Total	Yes	4.96E+00	2.04E-02	10,481	0.00E+00	No CPF	No Rfd
Fluoride	Yes	8.29E+00	3.40E-02	10,481	0.00E+00	No CPF	3.55E-05
Nitrate	Yes	7.23E+02	2.97E+00	10,481	0.00E+00	No CPF	1.16E-04
Nitrite	Yes	5.11E+02	2.10E+00	10,481	0.00E+00	No CPF	1.31E-03
Uranium	Yes	5.20E+03	0.00E+00	DNA	6.00E-01	NE	NE
Performance Objective[d]						**1.0E-06[e]**	**1.0[f]**

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

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

[e] Washington Administrative Code 173-340-705, "Use of Method B" subsection (2)(c)(ii).

[f] Washington Administrative Code 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
No CPF = no cancer potency factor available
No RfD = no reference dose available

5.3 CUMULATIVE ANALYSIS RESULTS FOR SINGLE-SHELL TANK 241-C-101 AND WASTE MANAGEMENT AREA C

The cumulative analysis (i.e., sum of the risk metrics) for tank C-101 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.

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 DOE/ORP-2005-01 and 2) a rural pasture scenario that was used as a reference case for chronic exposure in DOE/ORP-2005-01. This assessment of doses from inadvertent intrusions also evaluated chronic exposure scenarios that included: 1) a suburban garden scenario and 2) a commercial farm scenario that were used as sensitivity cases for chronic exposure in DOE/ORP-2005-01.

A summary of doses calculated for each of the intruder scenarios for the average and 95% UCL inventories remaining at SST C-101 at 100 years and 500 years after closure for tank C-101 are provided in Table 5-6. 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-101 are provided in Table 5-7. 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 5-4. 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-101.

Metric[a]	Industrial Receptor		Residential Receptor		Performance Objective[b]
ILCR from Radioactive Analytes (unitless)	**Average Inventory**	**95% UCL Inventory**	**Average Inventory**	**95% UCL Inventory**	
Total without non-detects[c]	4.34E-08	5.69E-08	1.06E-06	1.39E-06	1.0E-06 to 1.0E-4[e]
Total with non-detects[d]	4.34E-08	5.70E-08	1.06E-06	1.39E-06	
ILCR from Non-Radioactive Analytes (unitless)	**Average Inventory**	**95% UCL Inventory**	**Average Inventory**	**95% UCL Inventory**	**Performance Objective[b]**
Total without non-detects[c]	2.21E-14	3.37E-14	7.11E-14	1.08E-13	1.0E-5[f]
Total with non-detects[d]	2.68E-09	8.03E-09	3.71E-07	1.11E-06	
Hazard Index (unitless)	**Average Inventory**	**95% UCL Inventory**	**Average Inventory**	**95% UCL Inventory**	**Performance Objective[b]**
Total without non-detects[c]	2.92E-04	1.30E-04	1.56E-03	3.16E-04	1.0[f]
Total with non-detects[d]	3.05E-04	1.65E-04	3.71E-03	6.78E-03	
Radiological Dose (mrem/yr)	**All Pathways**		**Drinking Water**		**Performance Objective[b]**
	Average Inventory	**95% UCL Inventory**	**Average Inventory**	**95% UCL Inventory**	
Total without non-detects[c]	5.51E-03	7.23E-03	1.40E-02	1.83E-02	25 and 4 mrem
Total with non-detects[d]	5.53E-03	7.28E-03	1.40E-02	1.84E-02	

Waste Management Area C Fenceline Concentration[c, d]				
Analyte	**Detected In Residual Wastes**	**Average Inventory**	**95% UCL Inventory**	**Maximum Concentration Limit**
Technetium-99	Yes	3.15E+00	4.13E+00	900 pCi/L
Iodine-129	Yes	<1.00E-03	<1.00E-03	1 pCi/L
Carbon-14	No	3.48E-03	1.04E-02	2,000 pCi/L
Chromium, Total	Yes	2.04E-02	2.41E-02	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 (WMA), not just a single component of the WMA.

[c] If detected, fenceline concentrations are 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 µg/L.

[d] If not detected, fenceline concentrations are 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 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).

UCL = upper confidence level

Results of a comparison done on Table 5-4 are summarized in Table 5-5.

Table 5-5. Comparison Summary of Cumulative Incremental Lifetime Cancer Risk, Hazard Index, Radiological Dose, 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-101.

Performance Metric	Comparison(s) with Performance Objective
Incremental Lifetime Cancer Risk (ILCR) for Radioactive Analytes (1.0E-06 to 1.0E-04 ILCR)	• Estimated ILCRs for all radionuclides are between two to four 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 six to nine 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 two to three 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 orders of magnitude below the performance objective for the all-pathways dose of 25 mrem/yr o Three 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 ^{99}Tc are three orders of magnitude below 900 pCi/L maximum contaminant level. • Predicted concentration levels of other constituents of potential concern (e.g., ^{129}I, ^{14}C, and Cr) are significantly lower than their respective maximum contaminant levels.

Table 5-6. Comparison of Intruder Doses at 100 and 500 Years after Closure from Residual Waste for Single-Shell Tank 241-C-101.

Years after Closure[1]	Inventory	SST PA Reference Cases		SST PA Sensitivity Cases	
		Well Driller[2] (mrem)	Rural Pasture[3] (mrem/yr)	Suburban Garden[3] (mrem/yr)	Commerical Farmer[3] (mrem/yr)
100	Average	1.97E+01	6.68E+01	9.32E+02	9.34E-02
	95% UCL	2.63E+01	9.34E+01	1.31E+03	1.28E-01
500	Average	3.63E+00	9.02E-01	1.94E+01	2.34E-02
	95% UCL	8.46E+00	2.02E+00	4.26E+01	5.11E-02

[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.

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

Table 5-7. 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	1.97E+01	4.48E+00	3.24E+00	3.37E+00	3.63E+00	3.89E+00	4.15E+00	4.40E+00	4.63E+00	4.86E+00
95% Upper Confidence Level Inventory	2.63E+01	7.84E+00	6.88E+00	7.60E+00	8.46E+00	9.30E+00	1.01E+01	1.09E+01	1.16E+01	1.23E+01
Inadvertent Intrusion Chronic Dose[3] (mrem/yr) – Rural Pasture Scenario										
Average Inventory	6.68E+01	6.42E+00	1.28E+00	8.84E-01	9.02E-01	9.53E-01	1.01E+00	1.06E+00	1.11E+00	1.15E+00
95% Upper Confidence Level Inventory	9.34E+01	9.37E+00	2.32E+00	1.89E+00	2.02E+00	2.19E+00	2.36E+00	2.52E+00	2.68E+00	2.83E+00
Inadvertent Intrusion Chronic Dose[3] (mrem/yr) – Suburban Gardener Scenario										
Average Inventory	9.32E+02	9.41E+01	2.34E+01	1.86E+01	1.94E+01	2.06E+01	2.19E+01	2.31E+01	2.42E+01	2.53E+01
95% Upper Confidence Level Inventory	1.31E+03	1.39E+02	4.32E+01	3.90E+01	4.26E+01	4.66E+01	5.06E+01	5.44E+01	5.81E+01	6.16E+01
Inadvertent Intrusion Chronic Dose[3] (mrem/yr) – Commercial Farm Scenario										
Average Inventory	9.34E-02	2.72E-02	2.18E-02	2.23E-02	2.34E-02	2.45E-02	2.56E-02	2.67E-02	2.77E-02	2.87E-02
95% Upper Confidence Level Inventory	1.28E-01	4.82E-02	4.41E-02	4.73E-02	5.11E-02	5.49E-02	5.85E-02	6.20E-02	6.53E-02	6.85E-02

[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 observations about key analytes for inadvertent intruder impacts as given in Table 5-8.

Table 5-8. Impact Results of Key Analytes for an Inadvertent Intruder.

Inadvertent Intrusion Scenario	Key Radionuclides				
	^{137}Cs	^{90}Sr	^{239}Pu	^{241}Am	^{230}Th
Well Driller	Primary contributor to dose up to ~200 yrs after closure	Secondary contributor to dose up to ~100 yrs after closure	Secondary contributor to dose up to ~200 yrs after closure; primary contributor to dose after ~200 yrs post-closure	Primary contributor to dose ~180 yrs after closure	Secondary contributor to dose up to ~200 yrs post-closure; primary contributor to dose after ~200 yrs after closure
Rural Pasture	Secondary contributor to dose up to ~100 yrs after closure	Primary contributor to dose up to ~200 yrs after closure	Primary contributor to dose ~500 yrs after closure	Secondary contributor to dose after ~500 yrs after closure	Secondary contributor to dose up to ~500 years after closure; primary contributer to dose ~500 yrs after closure
Suburban Gardener	Secondary contributor to dose up to ~200 yrs after closure	Primary contributor to dose up to ~200 yrs after closure	Secondary contributor to dose	Secondary contributor to dose	Secondary contribute to dose up to ~200 years after closure; primary contributer to dose after ~200 yrs after closure
Commercial Farm	Primary contribute to dose up to ~200 years after closure	Secondary contributor to dose up to ~100 yrs after closure	Secondary contributor to dose	Tertiary contributor to dose	Secondary contributor to dose up to ~100 years post-closure; primary contributor to dose after ~200 years after closure

At 100 years after closure (see Table 5-6 and 5-7), doses for the well driller scenario were estimated to be ~4% and 5% 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 ~67% and 93% 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 ~930% and 1,300% of the 100 mrem/yr chronic exposure performance objective for the average and 95% UCL inventories, respectively (see Table 5-6). Doses resulting from the commercial farm scenario were well below (e.g., 0.1%) the 100 mrem/yr chronic exposure performance objective for the average and 95% UCL inventories, respectively (see Table 5-6).

By 500 years after closure (see Tables 5-6 and 5-7), the estimated doses for the well driller scenario for the average and 95% UCL inventories was ~1% and 2% 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 garden scenario using the 95% UCL inventory, which yielded a dose that was estimated to be ~43% of the 100 mrem/yr performance objective (see Table 5-6).

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-101 compared against the Model Toxics Control Act (MTCA) (RCW 70.105D, "Hazardous Waste Cleanup — Model Toxics Control Act") WAC 173-340 cleanup standards. In this section, specific comparisons are made between the concentrations of constituents remaining in tank C-101 against the MTCA 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-101 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 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-101 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 5-9 contains the average and 95% UCL concentrations of detected constituents estimated in residual waste for tank C-101 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. Table 5-9 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-11 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 5-10 and 5-11, 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-101 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 5-10 and 5-11 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 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, cyanide, and uranium are above the cleanup levels. Cyanide is listed as a dangerous constituent per WAC 173-303-9905.

- For direct contact under an industrial land use scenario, only uranium exceeded their respective cleanup levels. Uranium had a concentration 17 times greater than the cleanup level.

- For soil concentrations protective of groundwater, aluminum, cadmium, cyanide, iron, manganese, nitrate, nitrite, sulfate, tributyl phosphate, and uranium are all above the concentrations predicted by the MTCA fixed parameter three-phase model. Arsenic had a concentration two orders of magnitude greater than the concentration protective of groundwater. Cadmium and cyanide are listed as dangerous constituents per 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, cyanide, and uranium are above the cleanup levels. Cyanide is listed as a dangerous constituent per WAC 173-303-9905.

- For direct contact under an industrial land use scenario, only uranium exceeded the cleanup levels. Uranium had a concentration 1.9 times greater than the cleanup level.

- For soil concentrations protective of groundwater, cadmium, copper, cyanide, iron, manganese, mercury, nitrate, nitrite, silver, sulfate, tributyl phosphate, and uranium are all above the concentrations predicted by the MTCA fixed parameter three-phase model. Cadmium, cyanide, mercury, and silver are listed as dangerous constituents per WAC 173-303-9905.

Table 5-9. Average and 95% Upper Limit Concentrations of Selected Constituents Estimated for Waste Residuals within Tank 241-C-101, 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)[d,e,f]	Above Detection Limits
Acetate	3.25E+02	4.07E+02	--	--	--	--	Yes
Silver*	1.20E+02	1.33E+02	4.00E+02	1.75E+04	1.36E+01	1.67E-01	Yes
Aluminum	1.79E+05	2.10E+05	8.00E+04	3.50E+06	4.80E+05	1.18E+04	Yes
Polychlorinated Biphenyls*	4.48E-02	8.23E-02	5.00E-01	6.56E+01	--	--	Yes
Boron	1.25E+00	1.78E+00	1.60E+04	7.00E+05	2.05E+02	3.89E+00	Yes
Barium*	7.22E+01	8.55E+01	--	--	--	--	Yes
Di (2-ethylhexyl) phthalate (DEHP)	2.06E+00	2.73E+00	7.14E+01	9.38E+03	1.34E+01	--	Yes
Butylbenzylphthalate*	1.12E+00	1.53E+00	5.26E+02	6.91E+04	1.29E+01	--	Yes
Calcium	6.50E+02	8.39E+02	--	--	--	1.72E+04	Yes
Cadmium*	2.43E+00	2.84E+00	8.00E+01	3.50E+03	6.90E-01	5.63E-01	Yes
Cerium	1.24E+02	1.52E+02	--	--	--	--	Yes
Chloride	4.60E+02	5.88E+02	--	--	1.00E+03	1.00E+02	Yes
Cyanide*	4.34E+02	5.45E+02	4.80E+01	2.10E+03	9.70E-01	--	Yes
Cobalt	2.79E+00	4.19E+00	2.40E+01	1.05E+03	4.34E+00	1.57E+01	Yes
Chromium, Total*	1.74E+02	1.93E+02	1.20E+05	5.25E+06	2.00E+03	--	Yes
Copper	2.66E+02	2.97E+02	3.20E+03	1.40E+05	2.84E+02	2.20E+01	Yes
Fluoride	2.90E+02	5.12E+02	4.80E+03	2.10E+05	2.88E+03	2.81E+00	Yes
Iron	7.80E+03	9.69E+03	5.60E+04	2.45E+06	5.64E+03	3.26E+04	Yes
Formate+A_2	3.80E+02	4.61E+02	--	--	--	--	Yes
Hydroxide OH	5.80E-01	1.03E+00	--	--	--	--	Yes

Table 5-9. Average and 95% Upper Limit Concentrations of Selected Constituents Estimated for Waste Residuals within Tank 241-C-101, 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)[d,e,f]	Above Detection Limits
Mercury*	1.79E+00	3.08E+00	2.40E+01	1.05E+03	2.09E+00	1.30E-02	Yes
Potassium	6.97E+02	9.42E+02	--	--	--	2.15E+03	Yes
Lanthanum	2.27E+01	3.05E+01	--	--	--	--	Yes
Lithium	1.33E+01	1.53E+01	1.60E+02	7.00E+03	1.92E+02	1.33E+01	Yes
Magnesium	1.05E+02	1.43E+02	--	--	--	7.06E+03	Yes
Manganese	1.54E+03	2.34E+03	1.12E+04	4.90E+05	5.01E+02	5.12E+02	Yes
Molybdenum	1.29E+01	1.69E+01	4.00E+02	1.75E+04	3.23E+01	4.70E-01	Yes
Sodium	8.84E+04	1.02E+05	--	--	--	6.90E+02	Yes
Neodymium	5.71E+01	8.28E+01	--	--	--	--	Yes
Ammonia	6.33E+00	1.01E+01	--	--	--	9.23E+00	Yes
Nickel*	1.99E+00	2.41E+00	--	--	--	--	Yes
Nitrite	1.79E+04	2.26E+04	2.40E+04	1.05E+06	1.32E+01	--	Yes
Nitrate[c]	2.53E+04	3.09E+04	5.68E+05	2.49E+07	1.80E+02	5.20E+01	Yes
Oxalate	5.95E+02	7.57E+02	--	--	--	--	Yes
Lead*	2.84E+02	3.48E+02	--	1.00E+03	3.00E+03	1.02E+01	Yes
Palladium	1.45E+02	1.72E+02	--	--	--	--	Yes
Phosphate	2.35E+02	1.89E+04	--	--	--	7.85E-01	Yes
Rhodium	5.98E+01	6.90E+01	--	--	--	--	Yes
Ruthenium	3.92E+00	1.18E+01	--	--	--	--	Yes
Selenium*	1.58E-04	2.67E-04	--	--	--	--	Yes
Silicon	1.90E+03	2.53E+03	--	--	--	--	Yes

Table 5-9. Average and 95% Upper Limit Concentrations of Selected Constituents Estimated for Waste Residuals within Tank 241-C-101, 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)[d,e,f]	Above Detection Limits
Samarium	7.69E+02	8.89E+02	--	--	--	--	Yes
Sulfate	4.43E+03	6.32E+03	--	--	1.00E+03	2.37E+02	Yes
Strontium	2.35E+02	2.90E+02	4.80E+04	2.10E+06	6.76E+03	--	Yes
Tellurium	1.37E+01	1.60E+01	--	--	--	--	Yes
Tributyl phosphate	9.93E-01	1.12E+00	1.11E+02	1.46E+04	4.96E-01	--	Yes
Uranium	1.82E+05	1.97E+05	2.40E+02	1.05E+04	2.70E+02	3.21E+00	Yes
Tungsten	8.45E+01	9.95E+01	--	--	--	--	Yes
Zinc	4.83E+01	6.23E+01	2.40E+04	1.05E+06	5.97E+03	6.78E+01	Yes
Zirconium	4.10E+01	7.22E+01	--	--	--	--	Yes

[a] Mean Concentrations taken from Table A-1, Appendix A of RPP-RPT-58803, "Tank 241-C-101 Residual Waste Inventory Estimates for Component Closure Risk Assessment."

[b] 95% Upper Confidence Level Concentration = Mean Concentration + (1.96 × Mean Concentration × Relative Standard Deviation). Mean Concentrations and Relative Standard Deviation provided in Table A-1 in Appendix A of RPP-RPT-58803.

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

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

[e] DOE/RL-96-12, Hanford Site Background: Part 2, Soil Background for Radionuclides.

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

* 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 5-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Constituents above Detection in 241-C-101 Tank Residual Wastes. (3 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Average Concentrations in Tank 241-C-101 Residual Wastes to Soil Cleanup Standards				
		Soil Direct Contact (Method B)	Soil Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Acetate	3.25E+02	--	--	--	Yes	--
Silver*	1.20E+02	3.00E-01	6.86E-03	8.82E+00	Yes	Yes
Aluminum	1.79E+05	2.24E+00	5.11E-02	3.73E-01	Yes	Yes
Polychlorinated Biphenyls*	4.48E-02	8.96E-02	6.83E-04	--	Yes	--
Boron	1.25E+00	7.81E-05	1.79E-06	6.10E-03	Yes	No
Barium*	7.22E+01	--	--	--	Yes	--
Di (2-ethylhexyl) phthalate (DEHP)	2.06E+00	2.88E-02	2.20E-04	1.54E-01	Yes	--
Butylbenzylphthalate*	1.12E+00	2.13E-03	1.62E-05	8.69E-02	Yes	--
Calcium	6.50E+02	--	--	--	Yes	No
Cadmium*	2.43E+00	3.04E-02	6.94E-04	3.52E+00	Yes	Yes
Cerium	1.24E+02	--	--	--	Yes	--
Chloride	4.60E+02	--	--	4.60E-01	Yes	Yes
Cyanide*	4.34E+02	9.04E+00	2.07E-01	4.48E+02	Yes	--
Cobalt	2.79E+00	1.16E-01	2.66E-03	6.43E-01	Yes	No
Chromium, Total*	1.74E+02	1.45E-03	3.31E-05	8.70E-02	Yes	--
Copper	2.66E+02	8.31E-02	1.90E-03	9.36E-01	Yes	Yes
Fluoride	2.90E+02	6.04E-02	1.38E-03	1.01E-01	Yes	Yes
Iron	7.80E+03	1.39E-01	3.18E-03	1.38E+00	Yes	No

Table 5-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Constituents above Detection in 241-C-101 Tank Residual Wastes. (3 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Average Concentrations in Tank 241-C-101 Residual Wastes to Soil Cleanup Standards				
		Soil Direct Contact (Method B)	Soil Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Formate+A_2	3.80E+02	--	--	--	Yes	--
Hydroxide OH	5.80E-01	--	--	--	Yes	--
Mercury*	1.79E+00	7.46E-02	1.70E-03	8.57E-01	Yes	Yes
Potassium	6.97E+02	--	--	--	Yes	No
Lanthanum	2.27E+01	--	--	--	Yes	--
Lithium	1.33E+01	8.31E-02	1.90E-03	6.92E-02	Yes	Yes
Magnesium	1.05E+02	--	--	--	Yes	No
Manganese	1.54E+03	1.38E-01	3.14E-03	3.08E+00	Yes	Yes
Molybdenum	1.29E+01	3.23E-02	7.37E-04	3.99E-01	Yes	Yes
Sodium	8.84E+04	--	--	--	Yes	Yes
Neodymium	5.71E+01	--	--	--	Yes	--
Ammonia	6.33E+00	--	--	--	Yes	Yes
Nickel*	1.99E+00	--	--	--	Yes	--
Nitrite	1.79E+04	7.46E-01	1.70E-02	1.36E+03	Yes	--
Nitrate[b]	2.53E+04	4.45E-02	1.02E-03	1.41E+02	Yes	Yes
Oxalate	5.95E+02	--	--	--	Yes	--
Lead*	2.84E+02	--	2.84E-01	9.47E-02	Yes	Yes
Palladium	1.45E+02	--	--	--	Yes	--

Table 5-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Constituents above Detection in 241-C-101 Tank Residual Wastes. (3 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Average Concentrations in Tank 241-C-101 Residual Wastes to Soil Cleanup Standards				
		Soil Direct Contact (Method B)	Soil Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Phosphate	2.35E+02	--	--	--	Yes	Yes
Rhodium	5.98E+01	--	--	--	Yes	--
Ruthenium	3.92E+00	--	--	--	Yes	--
Selenium*	1.58E-04	--	--	--	Yes	--
Silicon	1.90E+03	--	--	--	Yes	--
Samarium	7.69E+02	--	--	--	Yes	--
Sulfate	4.43E+03	--	--	4.43E+00	Yes	Yes
Strontium	2.35E+02	4.90E-03	1.12E-04	3.48E-02	Yes	--
Tellurium	1.37E+01	--	--	--	Yes	--
Tributyl phosphate	9.93E-01	8.94E-03	6.81E-05	2.00E+00	Yes	--
Uranium	1.82E+05	7.58E+02	1.73E+01	6.74E+02	Yes	Yes
Tungsten	8.45E+01	--	--	--	Yes	--
Zinc	4.83E+01	2.01E-03	4.60E-05	8.09E-03	Yes	No
Zirconium	4.10E+01	--	--	--	Yes	--

[a] Mean Concentrations taken from Table A-1, Appendix A of RPP-RPT-58803, "Tank 241-C-101 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.

* 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 5-11. 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-101 Tank Residual Wastes. (3 sheets)

Analyte	95 % Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-101 Residual Wastes to Soil Cleanup Standards				
		Soil Direct Contact (Method B)	Soil Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Acetate	4.07E+02	--	--	--	Yes	--
Silver*	1.33E+02	3.33E-01	7.62E-03	9.81E+00	Yes	Yes
Aluminum	2.10E+05	2.62E+00	5.99E-02	4.37E-01	Yes	Yes
Polychlorinated Biphenyls*	8.23E-02	1.65E-01	1.25E-03	--	Yes	--
Boron	1.78E+00	1.11E-04	2.54E-06	8.69E-03	Yes	No
Barium*	8.55E+01	--	--	--	Yes	--
Di (2-ethylhexyl) phthalate (DEHP)	2.73E+00	3.82E-02	2.91E-04	2.04E-01	Yes	--
Butylbenzylphthalate*	1.53E+00	2.90E-03	2.21E-05	1.18E-01	Yes	--
Calcium	8.39E+02	--	--	--	Yes	No
Cadmium*	2.84E+00	3.55E-02	8.11E-04	4.11E+00	Yes	Yes
Cerium	1.52E+02	--	--	--	Yes	--
Chloride	5.88E+02	--	--	5.88E-01	Yes	Yes
Cyanide*	5.45E+02	1.14E+01	2.60E-01	5.62E+02	Yes	--
Cobalt	4.19E+00	1.74E-01	3.99E-03	9.64E-01	Yes	No
Chromium, Total*	1.93E+02	1.61E-03	3.68E-05	9.65E-02	Yes	--
Copper	2.97E+02	9.28E-02	2.12E-03	1.04E+00	Yes	Yes
Fluoride	5.12E+02	1.07E-01	2.44E-03	1.77E-01	Yes	Yes
Iron	9.69E+03	1.73E-01	3.95E-03	1.72E+00	Yes	No
Formate+A_2	4.61E+02	--	--	--	Yes	--
Hydroxide OH	1.03E+00	--	--	--	Yes	--

Table 5-11. 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-101 Tank Residual Wastes. (3 sheets)

Analyte	95 % Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-101 Residual Wastes to Soil Cleanup Standards				
		Soil Direct Contact (Method B)	Soil Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Mercury*	3.08E+00	1.28E-01	2.93E-03	1.47E+00	Yes	Yes
Potassium	9.42E+02	--	--	--	Yes	No
Lanthanum	3.05E+01	--	--	--	Yes	--
Lithium	1.53E+01	9.55E-02	2.18E-03	7.95E-02	Yes	Yes
Magnesium	1.43E+02	--	--	--	Yes	No
Manganese	2.34E+03	2.09E-01	4.78E-03	4.67E+00	Yes	Yes
Molybdenum	1.69E+01	4.23E-02	9.67E-04	5.24E-01	Yes	Yes
Sodium	1.02E+05	--	--	--	Yes	Yes
Neodymium	8.28E+01	--	--	--	Yes	--
Ammonia	1.01E+01	--	--	--	Yes	Yes
Nickel*	2.41E+00	--	--	--	Yes	--
Nitrite	2.26E+04	9.43E-01	2.15E-02	1.71E+03	Yes	--
Nitrate[b]	3.09E+04	5.43E-02	1.24E-03	1.71E+02	Yes	Yes
Oxalate	7.57E+02	--	--	--	Yes	--
Lead*	3.48E+02	--	3.48E-01	1.16E-01	Yes	Yes
Palladium	1.72E+02	--	--	--	Yes	--
Phosphate	1.89E+04	--	--	--	Yes	Yes
Rhodium	6.90E+01	--	--	--	Yes	--
Ruthenium	1.18E+01	--	--	--	Yes	--

Table 5-11. 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-101 Tank Residual Wastes. (3 sheets)

Analyte	95 % Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-101 Residual Wastes to Soil Cleanup Standards				
		Soil Direct Contact (Method B)	Soil Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Selenium*	2.67E-04	--	--	--	Yes	--
Silicon	2.53E+03	--	--	--	Yes	--
Samarium	8.89E+02	--	--	--	Yes	--
Sulfate	6.32E+03	--	--	6.32E+00	Yes	Yes
Strontium	2.90E+02	6.04E-03	1.38E-04	4.29E-02	Yes	--
Tellurium	1.60E+01	--	--	--	Yes	--
Tributyl phosphate	1.12E+00	1.01E-02	7.66E-05	2.25E+00	Yes	--
Uranium	1.97E+05	8.21E+02	1.88E+01	7.30E+02	Yes	Yes
Tungsten	9.95E+01	--	--	--	Yes	--
Zinc	6.23E+01	2.60E-03	5.93E-05	1.04E-02	Yes	No
Zirconium	7.22E+01	--	--	--	Yes	--

[a] 95% Upper Confidence Level Concentration = Mean Concentration + (1.96 × Mean Concentration × Relative Standard Deviation). Mean Concentrations and Relative Standard Deviation provided in Table A-1, Appendix A of RPP-RPT-58803, "Tank 241-C-101 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.

* 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

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-101 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 SST C-101 are summarized as follows.

- The impacts estimated for residual waste left in SST C-101, 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 four orders of magnitude below the performance objective range of 1.0E-06 to 1.0E-04 ILCR.

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

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

- Estimated doses for all detectable radionuclides are between:

    - Three to five orders of magnitude below the performance objective for the all-pathways dose of 25 mrem/yr

    - Two to 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 SST C-101 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 μg/L, did not arrive at the WMA C fenceline within the 10,000-year period of interest, or did not have available toxicological information.

- **Hazard Indices:** For both the average and 95% UCL inventory, fluoride, nitrate, and nitrite are the primary contributors to the hazard indices. The contribution from other 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, did not arrive at the WMA C fenceline within the 10,000-year period of interest, or did not have available toxicological information.

- **All-Pathways Dose:** ^{99}Tc, with a maximum dose rate of 5.5E-03 mrem/yr, and ^{14}C with a maximum dose of 1.7E-05 mrem/yr contributed the majority of the radiological dose for the all-pathways farmer scenario (25 mrem/yr). 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 1.4E-02 mrem/yr, and ^{14}C with a maximum dose of 7.0E-05 mrem/yr contributed the majority of the radiological dose for beta/photon emitters (4 mrem/yr target organ dose). 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 100 to 450 years. Doses from ^{239}Pu and ^{241}Am contribute the majority of the dose realized after 200 to 450 years. For both average and 95% UCL inventories estimated for SST C-101, none of the inadvertent intruder evaluations produce results that exceed the performance objectives for either acute exposure or chronic exposure after ~300 years following closure.

As additional risk management information, concentrations of constituents remaining in waste residuals within tank C-101 are compared against the MTCA 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-101 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-101 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-101 water residual concentrations against MTCA cleanup levels.

- **MTCA Method B Unrestricted Land Use:** For both the average and 95% UCL inventory, aluminum, arsenic, benzo[a]pyrene, cyanide, N-Nitroso-N, N-dimethylamine, and uranium are above the cleanup levels. Arsenic, benzo[a]pyrene, cyanide, and N-Nitroso-N, N-dimethylamine are listed as dangerous constituents per WAC 173-303-9905.

- **MTCA Method C Industrial Land Use:** For both the average and 95% UCL inventory, only uranium is above the cleanup levels. Uranium is not listed as a dangerous constituent per WAC 173-303-9905.

- **MTCA Soil Concentrations Protective of Groundwater:** For both the average and 95% UCL inventory, 1,4-dichlorobenzene, arsenic, benzo[a]pyrene, cadmium, cyanide, iron, hexachlorobenzene, manganese, nitrate, nitrite, pentachlorophenol, silver, sulfate, thallium, tributyl phosphate, and uranium are greater than the soil cleanup level. Arsenic, benzo[a]pyrene, cadmium, cyanide, hexachlorobenzene, pentachlorophenol, silver, and thallium are listed as dangerous constituents per WAC 173-303-9905.

Table 5-12 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 5-12 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:
    - Post-retrieval inventories for ^{99}Tc are ~1 to 1.3 times greater than the HTWOS estimate for ^{99}Tc
    - Post-retrieval inventories for chromium are ~40 to 45 times greater than the HTWOS estimate for chromium
    - Post-retrieval inventories for nitrate are ~56 to 68 times greater than the HTWOS estimates for nitrate
    - Post-retrieval inventories for nitrite are ~299 to 378 times greater than the HTWOS estimates for nitrite
    - Post-retrieval inventories for fluoride are ~59 to 104 times greater than the HTWOS estimate for fluoride.

- 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 ~1.1 to 1.6 times greater than HTWOS estimates for ^{90}Sr
  - Post-retrieval inventories for ^{137}Cs are 1.6 to 1.9 times less than the HTWOS inventory estimates for ^{137}Cs
  - Post-retrieval inventories for ^{232}Th are ~8.3 to 25 times greater than the HTWOS estimates for ^{232}Th
  - Post-retrieval inventories for the plutonium isotopes are 2.3 to 19.9 times less than those in the HTWOS estimate
  - Post-retrieval inventories for ^{241}Am are ~5.8 to 7.5 times less than those in the HTWOS estimate
  - Post-retrieval inventories for the uranium isotopes range from approximately 4,800 times less than (^{233}U) to approximately equal to (^{234}U, ^{235}U, ^{236}U, ^{238}U) the HTWOS inventory.

Table 5-12. 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% UCL Inventory[b]	Detected in Residual Wastes	Ratio Average/ HTWOS	Ratio Bounding/ HTWOS
Analytes Important for Groundwater Impacts	^{14}C	Ci	5.42E-03	1.58E-04	4.74E-04	No	0.03	0.09
	^{99}Tc	Ci	2.76E-02	2.76E-02	3.52E-02	Yes	1.00	1.27
	Chromium, Total	Kg	4.30E+00	1.74E+02	1.93E+02	Yes	40.45	44.87
	Fluoride	Kg	4.91E+00	2.90E+02	5.12E+02	Yes	59.02	104.10
	Nitrate	Kg	4.51E+02	2.53E+04	3.09E+04	Yes	56.10	68.44
	Nitrite	Kg	5.98E+01	1.79E+04	2.26E+04	Yes	299.13	378.10
Analytes Important for Inadvertent Intruder	^{90}Sr	Ci	3.14E+02	3.56E+02	4.91E+02	Yes	1.13	1.56
	^{137}Cs	Ci	1.47E+02	7.65E+01	9.06E+01	Yes	0.52	0.62
	^{232}Th	Ci	8.32E-07	6.93E-06	2.08E-05	No	8.33	24.99
	^{233}U	Ci	2.88E-04	6.05E-08	6.55E-08	Yes	0.00	0.00
	^{234}U	Ci	6.35E-02	5.96E-02	6.46E-02	Yes	0.94	1.02
	^{235}U	Ci	2.76E-03	2.72E-03	3.15E-03	Yes	0.99	1.14
	^{236}U	Ci	1.19E-03	6.81E-04	7.38E-04	Yes	0.57	0.62
	^{238}U	Ci	6.50E-02	6.07E-02	7.05E-02	Yes	0.93	1.08
	^{237}Np	Ci	1.33E-04	8.69E-04	1.28E-03	Yes	6.54	9.66
	^{238}Pu	Ci	9.03E-02	1.10E-02	1.36E-02	Yes	0.12	0.15
	^{239}Pu	Ci	8.12E+00	6.73E-01	8.56E-01	Yes	0.08	0.11
	^{240}Pu	Ci	1.43E+00	7.21E-02	9.17E-02	Yes	0.05	0.06
	^{241}Pu	Ci	1.14E+00	3.70E-01	5.05E-01	Yes	0.32	0.44
	^{241}Am	Ci	1.50E+00	2.00E-01	2.62E-01	Yes	0.13	0.17
	^{242}Cm	Ci	3.00E-04	4.16E-04	6.36E-04	Yes	1.39	2.13
	^{243}Cm	Ci	2.17E-06	3.01E-07	3.94E-07	Yes	0.14	0.18
	^{244}Cm	Ci	3.18E-05	5.75E-06	7.52E-06	Yes	0.18	0.24

[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.

HTWOS = Hanford Tank Waste Operations Simulator

UCL = upper confidence level

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

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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-101 waste retrieval operations, provides recommendations for further actions, and addresses opportunities to refine waste retrieval technologies based on lessons learned from the tank C-101 retrieval operation. The format of this section is to provide brief discussions of the major Lessons-Learned topic areas; some of those areas are taken from other tank waste retrieval activities.

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-101 retrieval operation.

6.1 POTENTIAL ENHANCEMENTS

Improvements implemented during the retrieval of tank C-101 are as follows.

- Tank C-101 used the ERSS for retrieving tank waste and was the first tank retrieval to use two ERSSs. The ERSS is different from a standard sluicer in that it has a boom, as well as a mast, which can be used to place the sluicer nozzle closer to the waste and increase the effectiveness in breaking up solid waste in the tank.

- Leaks in the hydraulic fluid supply lines for the nozzle transverse and elevation operations in both sluicers occurred during the course of retrieval operations. To minimize leakage, the hydraulic line connections for the nozzles were disconnected and the ERSS was operated using the other remaining ERSS positioning functions. The ERSS wrist functions were connected several times during the remaining operations and reoriented to allow for more efficient retrieval activities; the hydraulic lines were subsequently disconnected.

- A supernatant soak of hard solids in tank C-101 was also performed in an attempt to soften the hard waste surface, and was found to have no effect on the waste surface. On January 22, 2013, ~42,000 gal of tank AN-101 supernate were transferred to tank C-101 and the solids were allowed to soak in the supernate. The supernate was pumped out on February 20, 2013. However, the supernatant soak appeared to have little effect on the ability to retrieve the waste.

- Hot water additions were made for better chemical dissolution, such as phosphate dissolution.

6.2 PRACTICABILITY EVALUATION REQUEST

The Practicability Evaluation Request (RPP-57570) was done to assess whether a third waste retrieval operation should be implemented at tank C-101. The Practicability Evaluation Request concluded that the two waste retrieval technologies deployed at tank C-101 were operated to the limits of the technology, and that a further waste removal operation was not practicable as that term is used in Appendix C, Part 1, of the Consent Decree. The Practicability Evaluation Request concluded that the incremental reduction in inventory and risk would have been relatively small, even if the retrieval operation had been successful. The incremental increase in worker exposure, duration of field activities, potential delay in subsequent retrieval activities, and cost, are similar to those expected from other hard heel removal operations and outweigh whatever level of success may have resulted from installation and operation of a third retrieval technology.

Therefore, the practicability evaluation determined that deployment of a third technology into tank C-101 was not practicable (identified as caustic dissolution). To further support this prognosis, the resulting waste residual sample showed that the waste was comprised mostly of calcium, iron, and heavy metals that would not be as susceptible to caustic dissolution as aluminum compounds.

6.3 OTHER POTENTIAL ENHANCEMENTS

Use of the same riser for the camera and light resulted in wrapping the camera around the light and limiting or impacting camera mobility. Use of separate risers for each camera should be considered for future retrievals.

Volume balance results need to be more consistent and complete. The volume balance estimates had to be revised and reset several times. The key reasons identified were inaccurate low flow meter measurements and neglecting evaporation.

a. Before retrieval starts, need to ensure meters are capable of providing, and calibrated for, accurate low flow meter measurements.

b. Although the original plan was to use little or no water during mechanical removal (<2 gpm, just enough to prevent plugging of the nozzles), the Mobile Retrieval Tool flow rate had to be increased to >5 gpm for the flow meter provided to work correctly.

c. When using hot water, evaporation during retrieval is high and must be considered in volume balance estimates.

The hot water skid was designed for high flow. A better low flow design (e.g., flow meters) should be considered for future retrievals.

6.4 PREDICTED WASTE VOLUME

A shortcoming of the deployed technologies was that the amount of waste dissolved salts and transferred from tank C-101, and thus the volume of waste retrieved from the tank, was again less than predicted. The initial waste volume was adjusted from the initial BBI volume of 88,000 gal reduced to 77,500 gal. Furthermore, the waste was found to be mobile and potentially susceptible to sluicing operations. Future deployments of the waste retrieval technologies should include the option of addressing dissolution of waste compounds (especially when high-pressure water is used) in material and volume balances.

6.5 SAMPLING ASPECTS

The waste residual sampling event was conducted using an ORSS in accordance with the approved tank waste sampling and analysis plan (RPP-PLAN-59975), intending to pull samples for compositing from three designated regions on the floor of the tank. Based on in-tank videos, field observations, and sample photographs, the waste in all three regions appeared to have visually comparable consistency. The samples collected from identified sampling regions 2 and 3 included all the observable waste forms (i.e., sandy, powdery, and chunky materials) and so represented all the waste in the tank.

Insufficient sample material was collected to prepare all the required composite samples. Because sufficient sample material was obtained to allow complete analysis of each sample individually, it was determined and agreed to analyze each sample individually. This change was documented in RPP-RPT-58803, and did not adversely impact the laboratory nor alter the intent of the sampling plan.

6.6 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 allow 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 more engineering time needed to evaluate the process.

6.7 SLUICING EQUIPMENT AND OPERATION

As in most tanks that have been retrieved by modified sluicing, the rate of waste retrieved is initially high and begins to fall off as the easier-retrieved waste is removed and heavier and larger waste remains. The retrieval of tank C-101 remained relatively constant throughout the sluicing operations, being slightly higher during the initial sluicing operations.

Furthermore, the ERSSs were more effective in moving waste to the pump.

6.8 FINES SLUICING/RINSING WITH WATER

The final step was to rinse the remaining waste to remove the remaining supernate and soluble constituents, and satisfy triple rinse requirements of RPP-22520. With the second technology being high-pressure water, the residual waste rinse could be modified to follow the wash-down concept that was used during the tank 241-C-107 water rise. After supernate was pumped down to the pump heel in tank C-101, it showed that the actual residual waste volume was significantly greater than predicted in the flowsheet. In order to assess the volume of residual waste, a waste volume displacement measurement was made. Tank C-101 then underwent three water rinses to remove soluble residual waste. All liquid was pumped to a minimum heel between each rinse.

Furthermore, based on the starting inventory of 77,500 gal and the preliminary residual volume estimate, ~90% of the initial waste in tank C-101 was retrieved to tank AN-101 over the course of the bulk and heel retrieval campaign.

All reasonable efforts to enhance the effectiveness of the waste retrieval system have been attempted. Sluicing and washing of the tank walls and stiffener rings was attempted to remove adhered waste. Visual observations of this attempt showed some removal of waste from the stiffener rings. The walls of the tank have little waste remaining on them as documented in RPP-CALC-56434.

Post-retrieval analysis of the data resulted in the conclusion that the water addition flowmeter was reading ~20% high. When this correction was introduced to the data, the material balance results became qualitatively consistent with other indications of performance of waste retrieval in the tank, i.e., the video and material balance agreed as to when positive retrieval was experienced. This adjustment also showed that there may have been some waste dissolved during the final rinsing of the tank with hot water.

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 may have quantified liquid waste release volumes.

The operational history and decades of waste and liquid level monitoring indicate that tank C-101 had not leaked and was sound before starting retrieval (HNF-EP-0182, "Waste Tank Summary Report for Month Ending June 30, 2015," Rev. 330). Additionally, there was no evidence of a leak during retrieval of waste from tank C-101.

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-101 waste retrieval were as follows.

a. Drywell moisture and gamma logging showed no evidence of leaks during the tank C-101 waste retrieval.

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

c. Material balance calculations showed no evidence of leaks during the tank C-101 waste retrieval.

Retrieval of tank C-101 was begun and the majority of the waste in the tank was removed under Revision 7 of RPP-22520. Revision 8 of RPP-22520 was applicable to requirement aspects of tank C-101 waste retrieval operations (as are any additional revisions to this work plan).

7.1 REQUIREMENTS

Details of the LDMM program are presented in RPP-22520. 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-101 LDM functions and requirements.

Table 7-1. Tank 241-C-101 Leak Detection and Monitoring Functions and Requirements.

Function	Requirement	Basis	Key Elements
Detect leaks during waste retrieval from SST	The leak detection and monitoring (LDM) system shall be capable of detecting liquid waste releases during all waste retrieval 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 retrieval	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	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

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities."
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-101, LDM was accomplished by the use of high-resolution resistivity (HRR), drywell monitoring, visual inspection, leak detectors, Enraf gauges in DST AN-101, radiological monitoring, and material balances as shown in Table 7-2 and discussed in Sections 7.2.1 through 7.2.4. This is in accordance with RPP-32477, "High Resolution Resistivity Leak Detection Data Processing and Evaluation Methods and Requirements," which describes how the data generated by HRR leak detection system deployed during SST waste retrieval operations are process and evaluated. Document RPP-32478, "High Resolution Resistivity Leak Detection Equipment Description" provides a description of the HRR equipment and installation that is deployed for leak detection used during SST waste retrieval operations.

7.2.1 Drywell Logging and High Resolution Resistivity

During the sluicing retrieval of tank C-101 (December 10, 2012 to September 12, 2013), moisture logging with gamma scans was the primary leak detection method. High resolution resistivity leak detection and monitoring was a demonstration leak detection method, but anomalous result tracking and reporting was required. The tank operations contractor monitored and evaluated the HRR LDM data. Figure 7-1 is a timeline of the leak detection monitoring used for tank C-101 retrieval.

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-101	Drywells, liquid level indicators, visual inspection, material balance and high-resolution resistivity
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

The HRR LDM system monitors the soil resistance between each measurement electrode pair. These measurements are repeated up to four times per hour and the subsequent time-series data are analyzed for changes with time. Drywell-to-tank and drywell-to-drywell resistivity measurements are available to review.

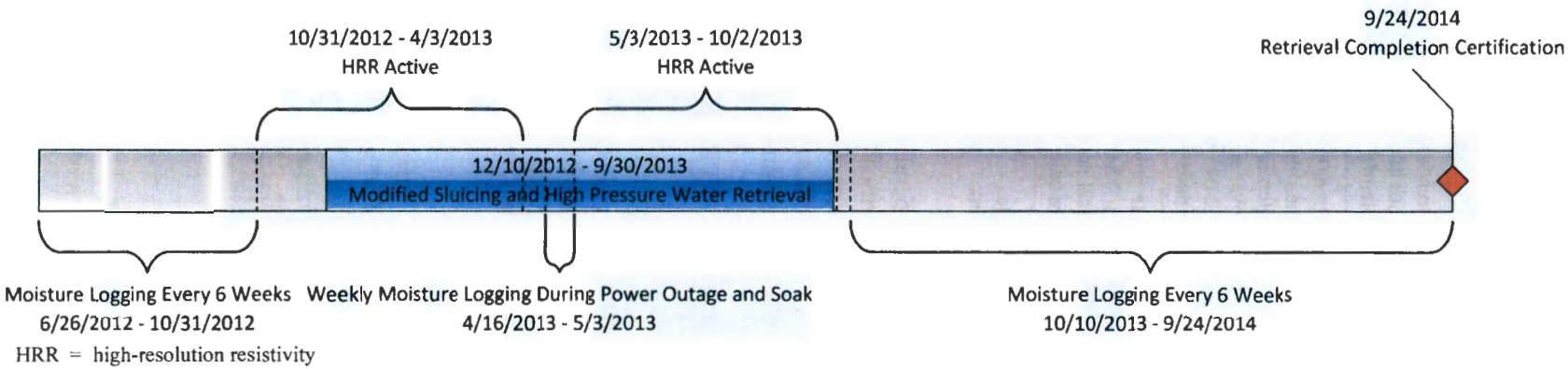
Table 7-3 identifies the anomalies and provides a description of each anomaly and its resolution. During sluicing, a leak determination was made for each day of operation by the HRR LDM; no leaks were indicated by the data.

Subsequent to tank C-101 retrieval, additional drywell logging was performed by a subcontractor [RPP-RPT-58828, "241-C-101 Tank Waste Retrieval Project Final Report of Drywell Monitoring Data (HGLP-MBL-017, Rev. 0)"]. None of the drywells around tank C-101 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.

7.2.2 Single-Shell Tank 241-C-101

7.2.2.1 Liquid Level Monitoring. The overall waste retrieval operating strategy for tank C-101 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.

Figure 7-1. Leak Detection Monitoring Timeline.



HRR = high-resolution resistivity

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

Number	Date	Anomaly Description	Resolution/Comments
2012-04	12/17/12	Resistance noise has increased on all tanks being monitored.	Plots were made and trends reviewed. There was no overall change in the trend lines but an obvious increase in the noise that can cause leak potentials to be high.
2013-01	3/17/13	Leak potentials for WTT pairs 30-01-01 and 30-01-12	Plots were made and trends reviewed. There was no overall change in the trend lines but an obvious increase in the noise that can cause leak potentials to be high. High leak potentials have been registered ever since the changes in the power grid noted in anomaly 2012-04. A leak should have been indicated on all WTT pairs and it was not.
2013-03	3/27/13	None. This was a followup evaluation for historical purposes.	Attached plots evaluate previous anomalous data with new process data constants. New constants were calculated to account for the electrical noise that started 12/16/12 after the original constants were calculated.

HRR = high-resolution resistivity
LDM = leak detection and monitoring
N/A = not applicable
WTT = drywell to tank
WTW = drywell to drywell

7.2.2.2 Visual Inspection. Before initiating waste retrieval operations, a visual assessment and documentation of in-tank conditions in tank C-101 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-101 indicated that the surface level decrease corresponded with waste retrieval activities.

7.2.2.3 Material Balance. Process control measurements were used periodically to perform a material balance and determine the change in tank C-101 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 DST AN-101 based on results of liquid level monitoring. The DST AN-101 liquid level increase corresponded with the material balance results for tank C-101.

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-101 waste retrieval campaign, no leaks were detected by any of the leak detectors in DST 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 DST 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 DST 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. Retrieval from the center out

c. Liquid removed between implementation of the waste retrieval technologies

d. Leak assessment protocols were in accordance with procedures

e. Drywell surveys were conducted.

Conditions to control leak minimization included the following:

a. Liquid addition minimized and liquid pools removed as practical

b. Retrieval from the center out

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

d. Maintaining a benchmark waste level.

7.3.1 Single-Shell Tank 241-C-101

A summary of the tank C-101 mitigation actions to minimize or prevent a leak were as follows.

a. Minimizing the addition of water to the retrieval tank 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-101 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-22520), Sections 4.6.2 and 4.6.3.

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-101 waste retrieval operations. The tank C-101 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-101 as set forth in RPP-22520 was achieved.

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APPENDIX A

SINGLE-SHELL TANK 241-C-101 INVENTORY PRE- AND POST-SLUICING TECHNOLOGY RETRIEVAL

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APPENDIX A

SINGLE-SHELL TANK 241-C-101 INVENTORY PRE- AND POST-SLUICING RETRIEVAL

Table A-1. Single-Shell Tank 241-C-101 Best-Basis Inventory Pre-Retrieval Inventory and Post-Retrieval Operations. (2 sheets)

	BBI April 2004[a]	BBI July 2015[b]				BBI April 2004	BBI July 2015	
Volume (Kgal)	88	5.6						
Analyte	Inventory	Inventory	Unit		Analyte	Inventory	Inventory	Unit
Al	7.94E+04	7.93E+01	Kg		^{99}Tc	4.54E-01	4.34E-02	Ci
Bi	1.74E+02	2.23E+01	Kg		^{106}Ru	1.34E-11	3.17E-16	Ci
Ca	2.06E+03	1.15E+02	Kg		^{113m}Cd	6.21E-01	2.65E-03	Ci
Cl	5.93E+02	6.17E+01	Kg		^{125}Sb	4.68E-04	1.91E-05	Ci
CN	7.34E+02	1.61E+01	Kg		^{126}Sn	5.19E-03	5.13E-04	Ci
Cr	2.49E+02	7.23E+00	Kg		^{129}I	1.39E-01	5.55E-05	Ci
F	6.88E+02	3.46E+01	Kg		^{134}Cs	5.64E-06	1.13E-07	Ci
Fe	9.92E+03	8.77E+02	Kg		^{137}Cs	2.74E+04	4.76E+02	Ci
Hg	2.32E+01	2.98E+00	Kg		^{137m}Ba	2.69E+04	4.50E+02	Ci
K	9.18E+01	8.68E+00	Kg		^{151}Sm	4.48E+01	4.39E+00	Ci
La	1.22E+01	1.56E+00	Kg		^{152}Eu	1.99E-03	1.18E-04	Ci
Mn	1.85E+02	7.14E+00	Kg		^{154}Eu	1.20E-01	7.29E-03	Ci
Na	5.50E+04	4.80E+03	Kg		^{155}Eu	3.84E-02	2.70E-03	Ci
Ni	2.55E+01	3.27E+00	Kg		^{226}Ra	4.98E-06	5.93E-07	Ci
NO_2	7.55E+03	5.64E+02	Kg		^{227}Ac	2.01E-05	2.31E-06	Ci
NO_3	6.63E+04	8.20E+03	Kg		^{228}Ra	1.34E-11	1.12E-12	Ci
Oxalate	5.05E+02	8.45E+00	Kg		^{229}Th	1.62E-09	1.33E-10	Ci
Pb	1.78E+03	2.07E+01	Kg		^{231}Pa	3.91E-06	2.48E-08	Ci
PO_4	3.07E+04	3.79E+03	Kg		^{232}Th	1.34E-11	1.12E-12	Ci
Si	3.75E+03	2.40E+01	Kg		^{232}U	1.19E-04	1.97E-06	Ci
SO_4	6.89E+03	7.71E+02	Kg		^{233}U	6.58E-06	1.71E-07	Ci
Sr	2.70E+02	2.34E+01	Kg		^{234}U	3.67E+00	1.69E-01	Ci
TIC as CO_3	7.62E+03	6.57E+01	Kg		^{235}U	1.59E-01	7.54E-03	Ci
TOC	1.66E+03	3.00E+01	Kg		^{236}U	6.87E-02	1.93E-03	Ci

Table A-1. Single-Shell Tank 241-C-101 Best-Basis Inventory Pre-Retrieval Inventory and Post-Retrieval Operations. (2 sheets)

	BBI April 2004[a]	BBI July 2015[b]				BBI April 2004	BBI July 2015	
Volume (Kgal)	88	5.6						
Analyte	Inventory	Inventory	Unit		Analyte	Inventory	Inventory	Unit
U_{TOTAL}	1.13E+04	5.16E+02	Kg		^{237}Np	7.71E-03	3.45E-04	Ci
Zr	2.07E+02	3.79E-01	Kg		^{238}Pu	6.37E+00	1.24E-01	Ci
^{3}H	4.60E+01	4.82E-02	Ci		^{238}U	3.79E+00	1.72E-01	Ci
^{14}C	6.60E-01	2.76E-03	Ci		^{239}Pu	4.67E+02	1.83E+01	Ci
^{59}Ni	2.51E+00	7.23E-04	Ci		^{240}Pu	8.26E+01	1.96E+00	Ci
^{60}Co	1.99E+00	8.55E-04	Ci		^{241}Am	8.61E+01	1.01E+01	Ci
^{63}Ni	2.24E+02	6.00E-02	Ci		^{241}Pu	2.29E+02	2.75E+00	Ci
^{79}Se	2.78E-03	2.80E-04	Ci		^{242}Cm	1.86E-02	2.37E-03	Ci
^{90}Sr	3.45E+04	4.39E+03	Ci		^{242}Pu	2.31E-03	2.70E-05	Ci
^{90}Y	3.45E+04	4.39E+03	Ci		^{243}Am	1.12E-02	1.43E-03	Ci
^{93m}Nb	1.41E-02	3.06E-05	Ci		^{243}Cm	1.94E-04	2.47E-05	Ci
^{93}Zr	1.60E-02	3.35E-05	Ci		^{244}Cm	4.10E-03	5.25E-04	Ci

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

[a] RPP-RPT-43028, 2009, "2009 Auto-TCR for Tank 241-C-101," Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

[b] RPP-RPT-58803, 2015, "Tank 241-C-101 Residual Waste Inventory Estimates for Component Risk Assessment," Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

APPENDIX B

MEAN CONCENTRATIONS AND RELATIVE STANDARD DEVIATIONS FOR TANK 241-C-101 RESIDUAL SOLIDS

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APPENDIX B

MEAN CONCENTRATIONS AND RELATIVE STANDARD DEVIATIONS FOR TANK 241-C-101 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-101 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-58803, "Tank 241-C-101 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-101. Tank 241-C-101 solids were sampled twice: first after completion of modified sluicing which removed the bulk of the solids, and again after heel retrieval which further removed a comparatively small amount of waste. 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 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 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[a] and Relative Standard Deviations[b] for Selected Constituents in Residual Waste Samples from Tank 241-C-101. (3 sheets)

Constituent Name	Chemical Abstract Services Number	< Detection Limit	Mean Concentration*	Units	RSD†
1,4-Dichlorobenzene	106-46-7	<	1.91E-01	µg/g	1.00E+00
^{125}Sb	14234-35-6	<	8.17E-01	µCi/g	1.00E+00
^{126}Sn	15832-50-5	—	2.72E-03	µCi/g	1.01E-01
^{129}I	15046-84-1	—	9.51E-05	µCi/g	1.01E-01
^{137}Cs	10045-97-3	—	7.65E+01	µCi/g	9.23E-02
^{137m}Ba	N/A	—	7.22E+01	µCi/g	9.23E-02
^{14}C	14762-75-5	<	1.58E-04	µCi/g	1.00E+00
^{152}Eu	14683-23-9	<	7.11E-01	µCi/g	1.00E+00
^{154}Eu	15585-10-1	<	4.00E-01	µCi/g	1.00E+00
^{155}Eu	14391-16-3	<	6.39E-01	µCi/g	1.00E+00
^{228}Th	14274-82-9	<	5.65E-04	µCi/g	1.00E+00
^{230}Th	14269-63-7	<	1.30E+00	µCi/g	1.00E+00
^{232}Th	N/A	<	6.93E-06	µCi/g	1.00E+00
^{233}U	13968-55-3	—	6.05E-08	µCi/g	4.16E-02
^{234}U	13966-29-5	—	5.96E-02	µCi/g	4.16E-02
^{235}U	15117-96-1	—	2.72E-03	µCi/g	7.83E-02
^{236}U	13982-70-2	—	6.81E-04	µCi/g	4.16E-02
^{237}Np	13994-20-2	—	8.69E-04	µCi/g	2.38E-01
^{238}Pu	13981-16-3	—	1.10E-02	µCi/g	1.17E-01
^{238}U	N/A	—	6.07E-02	µCi/g	8.04E-02
^{239}Pu	15117-48-3	—	6.73E-01	µCi/g	1.36E-01
^{240}Pu	14119-33-6	—	7.21E-02	µCi/g	1.36E-01
^{241}Am	14596-10-2	—	2.00E-01	µCi/g	1.54E-01
^{241}Pu	14119-32-5	—	3.70E-01	µCi/g	1.83E-01
^{242}Cm	15510-73-3	—	4.16E-04	µCi/g	2.65E-01
^{242}Pu	13982-10-0	—	9.92E-07	µCi/g	1.36E-01
^{243}Cm	15757-87-6	—	3.01E-07	µCi/g	1.54E-01
^{244}Cm	13981-15-2	—	5.75E-06	µCi/g	1.54E-01
2-Butanone	78-93-3	<	2.31E-02	µg/g	1.00E+00
^{3}H	15086-10-9	<	2.83E-03	µCi/g	1.00E+00
4-Methyl-2-Pentanone	108-10-1	<	2.01E-02	µg/g	1.00E+00
^{60}Co	10198-40-0	<	1.47E-01	µCi/g	1.00E+00
^{63}Ni	13981-37-8	—	1.99E+00	µCi/g	1.06E-01
^{79}Se	15758-45-9	—	1.58E-04	µCi/g	3.46E-01
^{90}Sr	10098-97-2	—	3.56E+02	µCi/g	1.89E-01
^{90}Y	10098-91-6	—	3.56E+02	µCi/g	1.89E-01
^{99}Tc	14133-76-7	—	2.76E-02	µCi/g	1.37E-01
Acetate	71-50-1	—	3.25E+02	µg/g	1.26E-01
Acetone	67-64-1	<	2.59E-02	µg/g	1.00E+00
Ag	7440-22-4	—	1.20E+02	µg/g	5.57E-02
Al	7429-90-5	—	1.79E+05	µg/g	8.61E-02
Aroclors (Total PCB)	1336-36-3	—	4.48E-02	µg/g	4.19E-01
As	7440-38-2	<	6.54E+00	µg/g	1.00E+00
B	7440-42-8	—	1.25E+00	µg/g	2.12E-01
Ba	7440-39-3	—	2.65E+01	µg/g	4.86E-01
Be	7440-41-7	<	9.81E-01	µg/g	1.00E+00
Benzo(a)pyrene	50-32-8	<	2.51E-01	µg/g	1.00E+00
Bi	7440-69-9	<	5.88E+00	µg/g	1.00E+00
Bis(2-ethylhexyl)phthalate	117-81-7	—	2.06E+00	µg/g	1.62E-01

Table B-1. Mean Concentrations[a] and Relative Standard Deviations[b] for Selected Constituents in Residual Waste Samples from Tank 241-C-101. (3 sheets)

Constituent Name	Chemical Abstract Services Number	< Detection Limit	Mean Concentration*	Units	RSD†
Br	24959-67-9	<	2.95E+01	µg/g	1.00E+00
Butylbenzylphthalate	85-68-7	—	1.12E+00	µg/g	1.81E-01
Ca	7440-70-2	—	6.50E+02	µg/g	1.45E-01
Cd	7440-43-9	—	2.43E+00	µg/g	8.41E-02
Ce	7440-45-1	—	1.24E+02	µg/g	1.14E-01
Cl	16887-00-6	—	4.60E+02	µg/g	1.39E-01
CN	57-12-5	—	4.34E+02	µg/g	1.28E-01
Co	7440-48-4	—	2.79E+00	µg/g	2.50E-01
Cr	7440-47-3	—	1.74E+02	µg/g	5.47E-02
Cu	7440-50-8	—	2.66E+02	µg/g	5.79E-02
Dibenz[a,h]anthracene	N/A	<	1.09E-01	µg/g	1.00E+00
Diethylphthalate	84-66-2	<	5.24E-01	µg/g	1.00E+00
Diphenyl amine	122-39-4	<	1.04E-01	µg/g	1.00E+00
Eu	7440-53-1	<	9.81E-01	µg/g	1.00E+00
F	16984-48-8	—	2.90E+02	µg/g	3.82E-01
Fe	7439-89-6	—	7.80E+03	µg/g	1.21E-01
Formate	12311-97-6	—	3.80E+02	µg/g	1.07E-01
Free OH	N/A	—	5.80E-01	µg/g	3.90E-01
Glycolate	666-14-8	<	3.15E+01	µg/g	1.00E+00
Hexachlorobenzene	118-74-1	<	2.27E-01	µg/g	1.00E+00
Hg	7439-97-6	—	1.79E+00	µg/g	3.59E-01
K	7440-09-7	—	6.97E+02	µg/g	1.76E-01
La	7439-91-0	—	2.27E+01	µg/g	1.72E-01
Li	7439-93-2	—	1.33E+01	µg/g	7.44E-02
Mg	7439-95-4	—	1.05E+02	µg/g	1.80E-01
Mn	7439-96-5	—	1.54E+03	µg/g	2.60E-01
Mo	7439-98-7	—	1.29E+01	µg/g	1.56E-01
Na	7440-23-5	—	8.84E+04	µg/g	7.71E-02
Nb	7440-03-1	<	5.88E+00	µg/g	1.00E+00
Nd	7440-00-8	—	5.71E+01	µg/g	2.25E-01
NH_3	7664-41-7	—	6.33E+00	µg/g	2.94E-01
Ni	7440-02-0	—	7.38E+02	µg/g	9.39E-02
N-Nitrosodimethylamine	62-75-9	<	1.82E-01	µg/g	1.00E+00
NO_2	14797-65-0	—	1.79E+04	µg/g	1.32E-01
NO_3	14797-55-8	—	2.53E+04	µg/g	1.10E-01
Oxalate	338-70-5	—	5.95E+02	µg/g	1.36E-01
Pb	7439-92-1	—	2.84E+02	µg/g	1.12E-01
Pd	7440-05-3	—	1.45E+02	µg/g	9.34E-02
Pentachlorophenol	87-86-5	<	9.95E-02	µg/g	1.00E+00
Phenol	108-95-2	<	1.77E-01	µg/g	1.00E+00
PO_4	14265-44-2	—	1.31E+04	µg/g	2.22E-01
Pr	7440-10-0	<	2.55E+01	µg/g	1.00E+00
Rb	7440-17-7	<	5.59E+01	µg/g	1.00E+00
Rh	7440-16-6	—	5.98E+01	µg/g	7.71E-02
Ru	7440-18-8	<	3.92E+00	µg/g	1.00E+00
Sb	7440-36-0	—	2.67E-01	µg/g	9.59E-02
Se	7782-49-2	—	3.22E+02	µg/g	1.08E-01
Si	7440-21-3	—	1.90E+03	µg/g	1.65E-01
Sm	7440-19-9	—	7.69E+02	µg/g	7.77E-02

Table B-1. Mean Concentrations[a] and Relative Standard Deviations[b] for Selected Constituents in Residual Waste Samples from Tank 241-C-101. (3 sheets)

Constituent Name	Chemical Abstract Services Number	< Detection Limit	Mean Concentration*	Units	RSD†
Sn	7440-31-5	<	7.98E+00	µg/g	1.00E+00
SO_4	14808-79-8	—	4.43E+03	µg/g	2.13E-01
Sr	7440-24-6	—	2.35E+02	µg/g	1.17E-01
Ta	7440-25-7	<	8.26E+00	µg/g	1.00E+00
Te	13494-80-9	—	1.37E+01	µg/g	8.30E-02
Th	7440-29-1	<	6.30E+01	µg/g	1.00E+00
Ti	7440-32-6	<	2.87E+00	µg/g	1.00E+00
Tl	7440-28-0	<	3.92E+00	µg/g	1.00E+00
Tributyl phosphate	126-73-8	—	9.93E-01	µg/g	6.27E-02
Trichloroethene	79-01-6	<	1.42E-03	µg/g	1.00E+00
U	7440-61-1	—	1.82E+05	µg/g	4.16E-02
V	7440-62-2	<	2.25E+00	µg/g	1.00E+00
W	7440-33-7	—	8.45E+01	µg/g	8.89E-02
Xylene (m & p)	108-28-3M	<	1.97E-03	µg/g	1.00E+00
Xylene (o)	95-47-6	<	1.08E-03	µg/g	1.00E+00
Xylenes (total)	1330-20-7	<	4.78E-04	µg/g	1.00E+00
Y	7440-65-5	<	2.34E+00	µg/g	1.00E+00
Zn	7440-66-6	—	4.83E+01	µg/g	1.45E-01
Zr	7440-67-7	—	4.10E+01	µg/g	3.80E-01

µg/g = micrograms per gram, µCi/g = microcurie per gram, PCB = polychlorinated biphenyl, RSD = Relative Standard Deviation

[a] Radionuclide concentrations are decay corrected to July 1, 2015.

[b] In accordance with Best-Basis Inventory protocol, the relative standard deviation is assumed to be 1.00 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-58803, 2015, "Tank 241-C-101 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-101 FINAL INVENTORY TO SINGLE-SHELL TANK 241-C-101 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-101 FINAL INVENTORY TO SINGLE-SHELL TANK 241-C-101 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-101 Final Inventory to Single-Shell Tank 241-C-101 Inventory Used in DOE/ORP-2005-01.

Analyte	Units	DOE/ORP-2005-01, Rev. 0	RPP-RPT-58803, Rev. 0 Average Inventory	RPP-RPT-58803, Rev. 0 Upper Bounding Inventory
Tritium	Ci	2.93E-01	<8.10E-02	<2.43E-01
C-14	Ci	3.65E-03	<4.52E-03	<1.36E-02
I-129	Ci	1.68E-03	2.72E-03	3.41E-03
Tc-99	Ci	2.79E-03	7.88E-01	1.03E+00
Cr	kg	4.18E+00	4.96E+00	5.88E+00
F	kg	3.50E+00	8.29E+00	1.47E+01
NO_2	kg	3.84E+01	5.11E+02	0.00E+00
NO_3	kg	3.37E+02	7.23E+02	9.15E+02
U	kg	1.93E+02	5.20E+03	6.09E+03

REFERENCE

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-58803, 2015, "Tank 241-C-101 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-101

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APPENDIX D

RISK ASSESSMENT INFORMATION FOR RESIDUAL WASTES REMAINING IN SINGLE-SHELL TANK 241-C-101

This appendix provides risk assessment information related to post-retrieval inventories estimated to remain in single-shell tank (SST) 241-C-101 (C-101) incorporating information from RPP-RPT-58803, "Tank 241-C-101 Residual Waste Inventory Estimates for Component Closure Risk Assessment." The potential risk impacts to human health posed by the residual waste in SST C-101 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-101 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-101, 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-101 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-101 (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-101 (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-101 (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-101 (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-101 (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-101 (see Table D-6 and Figure D-2)

- Tables and plots of doses from a suburban garden scenario for radioactive contaminants of concern found within the average and 95% UCL inventories estimated for SST C-101 (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-101 (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-101 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-101 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-101.

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-101. (2 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)	Radiological Dose - Beta/Photon (mrem/yr)
							Industrial	Residential	All-Pathway Farmer Scenario[b]	Drinking Water Only Scenario[b]
Americium-241	Yes	5.71E+00	0.00E+00	DNA	3.00E+00	4.33E+02	NE	NE	NE	NE
Antimony-125	No	1.17E+01	0.00E+00	DNA	1.00E+00	2.73E+00	NE	NE	NE	NE
Barium-137m	Yes	2.06E+03	0.00E+00	DNA	0.00E+00	4.86E-06	NE	NE	NE	NE
Carbon-14	No	2.26E-03	3.48E-03	9,781	0.00E+00	5.73E+03	2.70E-11	1.95E-10	1.69E-05	6.96E-06
Cesium-137 + Daughters	Yes	2.19E+03	0.00E+00	DNA	2.50E+01	3.00E+01	NE	NE	NE	NE
Cobalt-60	No	2.10E+00	0.00E+00	DNA	1.00E-01	5.27E+00	NE	NE	NE	NE
Curium-242	Yes	1.19E-02	0.00E+00	DNA	3.00E+00	4.46E-01	NE	NE	NE	NE
Curium-243	Yes	8.60E-06	0.00E+00	DNA	3.00E+00	2.85E+01	NE	NE	NE	NE
Curium-244	Yes	1.64E-04	0.00E+00	DNA	3.00E+00	1.81E+01	NE	NE	NE	NE
Europium-152	No	1.02E+01	0.00E+00	DNA	1.00E+00	1.33E+01	NE	NE	NE	NE
Europium-154	No	5.70E+00	0.00E+00	DNA	1.00E+00	8.59E+00	NE	NE	NE	NE
Europium-155	No	9.15E+00	0.00E+00	DNA	1.00E+00	4.68E+00	NE	NE	NE	NE
Iodine-129	Yes	2.72E-03	<1.00E-03	12,032	2.00E-01	1.57E+07	NE	NE	NE	NE
Neptunium-237 + D	Yes	2.48E-02	0.00E+00	DNA	2.00E+00	2.14E+06	NE	NE	NE	NE
Nickel-63	Yes	5.70E+01	0.00E+00	DNA	4.80E+01	1.00E+02	NE	NE	NE	NE
Plutonium-238	Yes	3.14E-01	0.00E+00	DNA	3.00E+00	8.77E+01	NE	NE	NE	NE
Plutonium-239	Yes	1.92E+01	0.00E+00	DNA	3.00E+00	2.41E+04	NE	NE	NE	NE
Plutonium-240	Yes	2.06E+00	0.00E+00	DNA	3.00E+00	6.56E+03	NE	NE	NE	NE
Plutonium-241 + D	Yes	1.06E+01	0.00E+00	DNA	3.00E+00	1.44E+01	NE	NE	NE	NE
Plutonium-242	Yes	2.83E-05	0.00E+00	DNA	3.00E+00	3.74E+05	NE	NE	NE	NE
Protactinium-231	Yes	0.00E+00	0.00E+00	DNA	5.50E+02	3.28E+04	NE	NE	NE	NE
Selenium-79	Yes	4.51E-03	0.00E+00	DNA	3.10E+00	8.05E+05	NE	NE	NE	NE
Strontium-90 + D	Yes	1.02E+04	0.00E+00	DNA	1.61E+01	2.81E+01	NE	NE	NE	NE
Technetium-99	Yes	7.88E-01	3.15E+00	10,461	0.00E+00	2.11E+05	4.34E-08	1.06E-06	5.51E-03	1.40E-02
Thorium-228 + D	No	8.05E-03	0.00E+00	DNA	3.00E+00	1.91E+00	NE	NE	NE	NE
Thorium-230	No	1.86E+01	0.00E+00	DNA	3.00E+00	7.54E+04	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-101. (2 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)	Radiological Dose - Beta/Photon (mrem/yr)
							Industrial	Residential	All-Pathway Farmer Scenario[b]	Drinking Water Only Scenario[b]
Thorium-232	No	9.90E-05	0.00E+00	DNA	3.00E+00	1.41E+10	NE	NE	NE	NE
Tin-126	Yes	7.78E-02	0.00E+00	DNA	1.00E+00	2.46E+05	NE	NE	NE	NE
Tritium	No	4.05E-02	0.00E+00	DNA	0.00E+00	1.23E+01	NE	NE	NE	NE
Uranium-233	Yes	1.73E-06	0.00E+00	DNA	6.00E-01	1.59E+05	NE	NE	NE	NE
Uranium-234	Yes	1.70E+00	0.00E+00	DNA	6.00E-01	2.46E+05	NE	NE	NE	NE
Uranium-235 + D	Yes	7.78E-02	0.00E+00	DNA	6.00E-01	7.04E+08	NE	NE	NE	NE
Uranium-236	Yes	1.95E-02	0.00E+00	DNA	6.00E-01	2.34E+07	NE	NE	NE	NE
Uranium-238 + D	Yes	1.73E+00	0.00E+00	DNA	6.00E-01	4.47E+09	NE	NE	NE	NE
Yttrium-90	Yes	1.02E+04	0.00E+00	DNA	0.00E+00	7.31E-03	NE	NE	NE	NE
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 WMA.

[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-101. (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	5.11E+03	0.00E+00	DNA	1.00E+00	NE	NE
Ammonia -- (a)	Yes	1.81E-01	<1.00E-03	10,481	9.30E-04	NE	NE
Antimony[a]	No	3.82E-03	0.00E+00	DNA	1.00E+00	NE	NE
Arsenic[a]	No	9.35E-02	0.00E+00	DNA	3.90E+01	NE	NE
Barium[a]	Yes	7.57E-01	0.00E+00	DNA	6.00E+01	NE	NE
Beryllium[a]	No	1.40E-02	0.00E+00	DNA	7.00E+01	NE	NE
Bismuth	No	8.40E-02	<1.00E-03	10,481	0.00E+00	NE	NE
Boron	Yes	3.57E-02	0.00E+00	DNA	3.00E+00	NE	NE
Bromide	No	4.22E-01	1.73E-03	10,481	0.00E+00	No CPF	No Rfd
Cadmium[a]	Yes	6.93E-02	0.00E+00	DNA	1.26E+00	NE	NE
Calcium	Yes	1.86E+01	0.00E+00	DNA	4.00E+00	NE	NE
Cerium	Yes	3.54E+00	1.45E-02	10,481	0.00E+00	No CPF	No Rfd
Chloride	Yes	1.31E+01	5.38E-02	10,481	0.00E+00	No CPF	No Rfd
Chromium, Total[a]	Yes	4.96E+00	2.04E-02	10,481	0.00E+00	No CPF	No Rfd
Cobalt	Yes	7.96E-02	<1.00E-03	12,032	1.00E-01	NE	NE
Copper	Yes	7.61E+00	0.00E+00	DNA	3.50E+01	NE	NE
Cyanide[a]	Yes	1.24E+01	0.00E+00	DNA	9.90E+00	NE	NE
Europium	No	1.40E-02	0.00E+00	DNA	5.00E+01	NE	NE
Fluoride	Yes	8.29E+00	3.40E-02	10,481	0.00E+00	No CPF	3.55E-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-101. (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+A_2	Yes	1.08E+01	4.43E-02	10,481	0.00E+00	No CPF	No Rfd
Iron	Yes	2.23E+02	0.00E+00	DNA	2.50E+01	NE	NE
Hydroxide OH	Yes	1.66E-02	<1.00E-03	10,481	0.00E+00	NE	NE
Lanthanum	Yes	6.48E-01	2.66E-03	10,481	0.00E+00	No CPF	No Rfd
Lead[a]	Yes	8.10E+00	0.00E+00	DNA	5.20E+00	NE	NE
Lithium	Yes	3.81E-01	0.00E+00	DNA	3.00E+02	NE	NE
Magnesium	Yes	3.00E+00	0.00E+00	DNA	4.50E+00	NE	NE
Manganese	Yes	4.41E+01	0.00E+00	DNA	1.00E+00	NE	NE
Mercury[a]	Yes	5.12E-02	0.00E+00	DNA	5.20E+00	NE	NE
Molybdenum	Yes	3.68E-01	0.00E+00	DNA	4.00E+00	NE	NE
Neodymium	Yes	1.63E+00	6.69E-03	10,481	0.00E+00	No CPF	No Rfd
Nickel[a]	Yes	2.11E+01	0.00E+00	DNA	4.80E+01	NE	NE
Niobium	No	8.40E-02	0.00E+00	DNA	1.00E+02	NE	NE
Nitrate	Yes	7.23E+02	2.97E+00	10,481	0.00E+00	No CPF	1.16E-04
Nitrite	Yes	5.11E+02	2.10E+00	10,481	0.00E+00	No CPF	1.31E-03
Oxalate	Yes	1.70E+01	6.98E-02	10,481	0.00E+00	No CPF	No Rfd
o-Xylene	Yes	0.00E+00	<1.00E-03	DNA	7.23E-02	NE	NE
Palladium	Yes	4.14E+00	0.00E+00	DNA	5.00E+01	NE	NE
Phosphate	Yes	3.76E+02	1.54E+00	10,481	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-101. (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	
Potassium	Yes	1.99E+01	8.17E-02	10,481	0.00E+00	No CPF	No Rfd
Praseodymium	No	3.64E-01	1.49E-03	10,481	0.00E+00	No CPF	No Rfd
Rhodium	Yes	1.71E+00	7.02E-03	10,481	0.00E+00	No CPF	No Rfd
Rubidium	No	8.00E-01	3.28E-03	10,481	0.00E+00	No CPF	No Rfd
Ruthenium	Yes	1.12E-01	0.00E+00	DNA	1.00E+00	NE	NE
Samarium	Yes	2.20E+01	0.00E+00	DNA	1.00E+00	NE	NE
Selenium[a]	Yes	9.20E+00	0.00E+00	DNA	5.00E+00	NE	NE
Silicon	Yes	5.44E+01	0.00E+00	DNA	3.00E+01	NE	NE
Silver[a]	Yes	3.43E+00	0.00E+00	DNA	2.70E+00	NE	NE
Sodium	Yes	2.52E+03	1.03E+01	10,481	0.00E+00	No CPF	No Rfd
Strontium	Yes	0.00E+00	<1.00E-03	DNA	1.61E+01	NE	NE
Sulfate	Yes	1.26E+02	5.17E-01	10,481	0.00E+00	No CPF	No Rfd
Tantalum	No	1.18E-01	<1.00E-03	10,481	0.00E+00	NE	NE
Tellurium	Yes	3.90E-01	1.60E-03	10,481	0.00E+00	No CPF	No Rfd
Thallium[a]	No	5.60E-02	0.00E+00	DNA	7.10E+01	NE	NE
Thorium	No	9.00E-01	0.00E+00	DNA	1.00E+00	NE	NE
Tin	No	1.14E-01	0.00E+00	DNA	2.50E+02	NE	NE
Titanium	No	4.11E-02	0.00E+00	DNA	1.00E+03	NE	NE
Tungsten	Yes	0.00E+00	<1.00E-03	DNA	0.00E+00	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-101. (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	
Uranium	Yes	5.20E+03	0.00E+00	DNA	6.00E-01	NE	NE
Vanadium	No	3.21E-02	0.00E+00	DNA	5.00E+01	NE	NE
Yttrium	Yes	0.00E+00	<1.00E-03	DNA	0.00E+00	NE	NE
Zinc	Yes	0.00E+00	<1.00E-03	DNA	6.20E+01	NE	NE
Zirconium	Yes	0.00E+00	<1.00E-03	DNA	5.00E+02	NE	NE
1, 1, 2-Trichloroethylene	No	2.04E-05	<1.00E-03	12,032	2.82E-02	NE	NE
1, 2, 4-Trichlorobenzene[a]	Yes	0.00E+00	<1.00E-03	DNA	4.98E-01	NE	NE
1, 4-Dichlorobenzene[a]	No	2.73E-03	<1.00E-03	12,032	1.85E-01	NE	NE
2-Butanone(MEK)[a]	No	3.31E-04	<1.00E-03	10,481	1.35E-03	NE	NE
2-Propanone (Acetone)[a]	No	3.70E-04	<1.00E-03	10,481	1.73E-04	NE	NE
Acetate $C_2H_3O_2^-$	Yes	9.29E+00	3.81E-02	10,481	3.00E-04	No CPF	No Rfd
Butylbenzylphthalate[a]	Yes	3.20E-02	0.00E+00	DNA	4.14E+00	NE	NE
Dichloromethane (methylene chloride)	Yes	0.00E+00	<1.00E-03	DNA	3.00E-03	NE	NE
Glycolate $C_2H_3O_3$	Yes	0.00E+00	<1.00E-03	DNA	0.00E+00	NE	NE
m-Xylene	Yes	6.71E+00	2.19E-02	12,032	5.88E-02	No CPF	1.37E-05
Pentachlorophenol	No	1.42E-03	<1.00E-03	12,032	1.77E-01	NE	NE
Phenol	No	2.53E-03	<1.00E-03	10,481	8.64E-03	NE	NE
Polychlorinated Biphenyls (high risk)[a] -- (di)	Yes	1.28E-03	0.00E+00	DNA	9.27E+01	NE	NE
Toluene	Yes	0.00E+00	<1.00E-03	DNA	4.20E-02	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-101. (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	
Tributyl phosphate	Yes	2.84E-02	<1.00E-03	12,032	5.67E-01	NE	NE
Xylenes	Yes	0.00E+00	<1.00E-03	DNA	5.88E-02	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 the 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.
No CPF = No cancer potency factor available.
No RfD = No reference dose available.
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.

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water for Single-Shell Tank 241-C-101 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 (pCi/L)	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr)	Radiological Dose - Beta/Photon (mrem/yr)
							Industrial	Residential	All-Pathway Farmer Scenario[b]	Drinking Water Only Scenario[b]
Americium-241	Yes	7.66E+00	0.00E+00	DNA	3.00E+00	4.33E+02	NE	NE	NE	NE
Antimony-125	No	3.50E+01	0.00E+00	DNA	1.00E+00	2.73E+00	NE	NE	NE	NE
Barium-137m	Yes	2.55E+03	0.00E+00	DNA	0.00E+00	4.86E-06	NE	NE	NE	NE
Carbon-14	No	6.78E-03	1.04E-02	9,781	0.00E+00	5.73E+03	8.11E-11	5.86E-10	5.06E-05	2.09E-05
Cesium-137 + D	Yes	2.71E+03	0.00E+00	DNA	2.50E+01	3.00E+01	NE	NE	NE	NE
Cobalt-60	No	0.00E+00	0.00E+00	DNA	1.00E-01	5.27E+00	NE	NE	NE	NE
Curium-242	Yes	1.85E-02	0.00E+00	DNA	3.00E+00	4.46E-01	NE	NE	NE	NE
Curium-243	Yes	1.15E-05	0.00E+00	DNA	3.00E+00	2.85E+01	NE	NE	NE	NE
Curium-244	Yes	2.20E-04	0.00E+00	DNA	3.00E+00	1.81E+01	NE	NE	NE	NE
Europium-152	No	3.05E+01	0.00E+00	DNA	1.00E+00	1.33E+01	NE	NE	NE	NE
Europium-154	No	1.71E+01	0.00E+00	DNA	1.00E+00	8.59E+00	NE	NE	NE	NE
Europium-155	No	2.75E+01	0.00E+00	DNA	1.00E+00	4.68E+00	NE	NE	NE	NE
Iodine-129	Yes	3.41E-03	<1.00E-03	12,032	2.00E-01	1.57E+07	NE	NE	NE	NE
Neptunium-237 + D	Yes	3.72E-02	0.00E+00	DNA	2.00E+00	2.14E+06	NE	NE	NE	NE
Nickel-63	Yes	7.17E+01	0.00E+00	DNA	4.80E+01	1.00E+02	NE	NE	NE	NE
Plutonium-238	Yes	4.01E-01	0.00E+00	DNA	3.00E+00	8.77E+01	NE	NE	NE	NE
Plutonium-239	Yes	2.52E+01	0.00E+00	DNA	3.00E+00	2.41E+04	NE	NE	NE	NE
Plutonium-240	Yes	2.70E+00	0.00E+00	DNA	3.00E+00	6.56E+03	NE	NE	NE	NE

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water for Single-Shell Tank 241-C-101 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 (pCi/L)	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr)	Radiological Dose - Beta/Photon (mrem/yr)
							Industrial	Residential	All-Pathway Farmer Scenario[b]	Drinking Water Only Scenario[b]
Plutonium-241 + D	Yes	1.48E+01	0.00E+00	DNA	3.00E+00	1.44E+01	NE	NE	NE	NE
Plutonium-242	Yes	3.71E-05	0.00E+00	DNA	3.00E+00	3.74E+05	NE	NE	NE	NE
Protactinium-231	Yes	0.00E+00	0.00E+00	DNA	5.50E+02	3.28E+04	NE	NE	NE	NE
Selenium-79	Yes	7.70E-03	0.00E+00	DNA	3.10E+00	8.05E+05	NE	NE	NE	NE
Strontium-90 + D	Yes	1.43E+04	0.00E+00	DNA	1.61E+01	2.81E+01	NE	NE	NE	NE
Technetium-99	Yes	1.03E+00	4.13E+00	10,461	0.00E+00	2.11E+05	5.69E-08	1.39E-06	7.23E-03	1.83E-02
Thorium-228 + D	No	2.42E-02	0.00E+00	DNA	3.00E+00	1.91E+00	NE	NE	NE	NE
Thorium-230	No	5.57E+01	0.00E+00	DNA	3.00E+00	7.54E+04	NE	NE	NE	NE
Thorium-232	No	2.97E-04	0.00E+00	DNA	3.00E+00	1.41E+10	NE	NE	NE	NE
Tin-126	Yes	9.74E-02	0.00E+00	DNA	1.00E+00	2.46E+05	NE	NE	NE	NE
Tritium	No	1.22E-01	0.00E+00	DNA	0.00E+00	1.23E+01	NE	NE	NE	NE
Uranium-233	Yes	2.02E-06	0.00E+00	DNA	6.00E-01	1.59E+05	NE	NE	NE	N/A
Uranium-234	Yes	1.99E+00	0.00E+00	DNA	6.00E-01	2.46E+05	NE	NE	NE	N/A
Uranium-235 + D	Yes	9.46E-02	0.00E+00	DNA	6.00E-01	7.04E+08	NE	NE	NE	N/A
Uranium-236	Yes	2.28E-02	0.00E+00	DNA	6.00E-01	2.34E+07	NE	NE	NE	N/A
Uranium-238 + D	Yes	2.11E+00	0.00E+00	DNA	6.00E-01	4.47E+09	NE	NE	NE	N/A
Yttrium-90	Yes	1.43E+04	0.00E+00	DNA	0.00E+00	7.31E-03	NE	NE	NE	NE

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water for Single-Shell Tank 241-C-101 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 (pCi/L)	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr)	Radiological Dose - Beta/Photon (mrem/yr)
							Industrial	Residential	All-Pathway Farmer Scenario[b]	Drinking Water Only Scenario[b]
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.

[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.
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-101 of Potential Concern Using 95% Upper Confidence Level Post-Retrieval Inventory. (4 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	6.28E+03	0.00E+00	DNA	1.00E+00	NE	NE
Ammonia -- (a)	Yes	2.91E-01	1.19E-03	10,481	9.30E-04	No CPF	No Rfd
Antimony[a]	No	4.74E-03	0.00E+00	DNA	1.00E+00	NE	NE
Arsenic[a]	No	2.81E-01	0.00E+00	DNA	3.90E+01	NE	NE
Barium[a]	Yes	1.50E+00	0.00E+00	DNA	6.00E+01	NE	NE
Beryllium[a]	No	4.20E-02	0.00E+00	DNA	7.00E+01	NE	NE
Bismuth	No	0.00E+00	<1.00E-03	DNA	0.00E+00	NE	NE
Boron	Yes	5.18E-02	0.00E+00	DNA	3.00E+00	NE	NE
Bromide	No	0.00E+00	<1.00E-03	DNA	0.00E+00	NE	NE
Cadmium[a]	Yes	8.48E-02	0.00E+00	DNA	1.26E+00	NE	NE
Calcium	Yes	2.47E+01	0.00E+00	DNA	4.00E+00	NE	NE
Cerium	Yes	4.50E+00	1.85E-02	10,481	0.00E+00	No CPF	No Rfd
Chloride	Yes	1.72E+01	7.08E-02	10,481	0.00E+00	No CPF	No Rfd
Chromium, Total[a]	Yes	5.88E+00	2.41E-02	10,481	0.00E+00	No CPF	No Rfd
Cobalt	Yes	1.21E-01	<1.00E-03	12,032	1.00E-01	NE	NE
Copper	Yes	9.04E+00	0.00E+00	DNA	3.50E+01	NE	NE
Cyanide[a]	Yes	1.61E+01	0.00E+00	DNA	9.90E+00	NE	NE
Europium	No	0.00E+00	<1.00E-03	DNA	5.00E+01	NE	NE
Fluoride	Yes	1.47E+01	6.05E-02	10,481	0.00E+00	No CPF	6.30E-05
Formate+A_2	Yes	1.36E+01	5.59E-02	10,481	0.00E+00	No CPF	No Rfd
Iron	Yes	2.86E+02	0.00E+00	DNA	2.50E+01	NE	NE
Hydroxide OH	Yes	2.98E-02	<1.00E-03	10,481	0.00E+00	NE	NE
Lanthanum	Yes	8.90E-01	3.66E-03	10,481	0.00E+00	No CPF	No Rfd
Lead[a]	Yes	1.03E+01	0.00E+00	DNA	5.20E+00	NE	NE
Lithium	Yes	4.61E-01	0.00E+00	DNA	3.00E+02	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-101 of Potential Concern Using 95% Upper Confidence Level Post-Retrieval Inventory. (4 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	
Magnesium	Yes	4.17E+00	0.00E+00	DNA	4.50E+00	NE	NE
Manganese	Yes	6.79E+01	0.00E+00	DNA	1.00E+00	NE	NE
Mercury[a]	Yes	0.00E+00	<1.00E-03	DNA	5.20E+00	NE	NE
Molybdenum	Yes	4.95E-01	0.00E+00	DNA	4.00E+00	NE	NE
Neodymium	Yes	2.40E+00	9.86E-03	10,481	0.00E+00	No CPF	No Rfd
Nickel[a]	Yes	2.62E+01	0.00E+00	DNA	4.80E+01	NE	NE
Niobium	No	2.52E-01	0.00E+00	DNA	1.00E+02	NE	NE
Nitrate	Yes	9.15E+02	3.76E+00	10,481	0.00E+00	No CPF	1.47E-04
Nitrite	Yes	0.00E+00	<1.00E-03	DNA	0.00E+00	NE	NE
Oxalate	Yes	2.23E+01	9.14E-02	10,481	0.00E+00	No CPF	No Rfd
o-Xylene	No	4.64E-05	<1.00E-03	12,032	7.23E-02	NE	NE
Palladium	Yes	5.13E+00	0.00E+00	DNA	5.00E+01	NE	NE
Phosphate	Yes	5.52E+02	2.27E+00	10,481	0.00E+00	No CPF	No Rfd
Potassium	Yes	2.75E+01	1.13E-01	10,481	0.00E+00	No CPF	No Rfd
Praseodymium	No	1.09E+00	4.48E-03	10,481	0.00E+00	No CPF	No Rfd
Rhodium	Yes	2.08E+00	8.52E-03	10,481	0.00E+00	No CPF	No Rfd
Rubidium	No	2.40E+00	9.85E-03	10,481	0.00E+00	No CPF	No Rfd
Ruthenium	Yes	3.36E-01	0.00E+00	DNA	1.00E+00	NE	NE
Samarium	Yes	2.68E+01	0.00E+00	DNA	1.00E+00	NE	NE
Selenium[a]	Yes	1.16E+01	0.00E+00	DNA	5.00E+00	NE	NE
Silicon	Yes	7.41E+01	0.00E+00	DNA	3.00E+01	NE	NE
Silver[a]	Yes	4.07E+00	0.00E+00	DNA	2.70E+00	NE	NE
Sodium	Yes	3.06E+03	1.26E+01	10,481	0.00E+00	No CPF	No Rfd
Strontium	Yes	8.56E+00	0.00E+00	DNA	1.61E+01	NE	NE
Sulfate	Yes	1.83E+02	7.50E-01	10,481	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-101 of Potential Concern Using 95% Upper Confidence Level Post-Retrieval Inventory. (4 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	
Tantalum	No	3.54E-01	1.45E-03	10,481	0.00E+00	No CPF	No Rfd
Tellurium	Yes	4.77E-01	1.96E-03	10,481	0.00E+00	No CPF	No Rfd
Thallium[a]	No	1.68E-01	0.00E+00	DNA	7.10E+01	NE	NE
Thorium	No	2.70E+00	0.00E+00	DNA	1.00E+00	NE	NE
Tin	No	3.42E-01	0.00E+00	DNA	2.50E+02	NE	NE
Titanium	No	1.23E-01	0.00E+00	DNA	1.00E+03	NE	NE
Tungsten	Yes	2.97E+00	1.22E-02	10,481	0.00E+00	No CPF	No Rfd
Uranium	Yes	6.09E+03	0.00E+00	DNA	6.00E-01	NE	NE
Vanadium	No	9.63E-02	0.00E+00	DNA	5.00E+01	NE	NE
Yttrium	No	1.00E-01	<1.00E-03	10,481	0.00E+00	NE	NE
Zinc	Yes	1.83E+00	0.00E+00	DNA	6.20E+01	NE	NE
Zirconium	Yes	2.08E+00	0.00E+00	DNA	5.00E+02	NE	NE
1, 1, 2-Trichloroethylene	No	6.11E-05	<1.00E-03	12,032	2.82E-02	NE	NE
1, 2, 4-Trichlorobenzene[a]	Yes	0.00E+00	<1.00E-03	DNA	4.98E-01	NE	NE
1, 4-Dichlorobenzene[a]	No	8.19E-03	<1.00E-03	12,032	1.85E-01	NE	NE
2-Butanone(MEK)[a]	No	9.92E-04	<1.00E-03	10,481	1.35E-03	NE	NE
2-Propanone (Acetone)[a]	No	1.11E-03	<1.00E-03	10,481	1.73E-04	NE	NE
Acetate $C_2H_3O_2^-$	Yes	1.20E+01	4.94E-02	10,481	3.00E-04	No CPF	No Rfd
Butylbenzylphthalate[a]	Yes	4.45E-02	0.00E+00	DNA	4.14E+00	NE	NE
Dichloromethane (methylene chloride)[a]	Yes	0.00E+00	<1.00E-03	DNA	3.00E-03	NE	NE
Glycolate $C_2H_3O_3$	Yes	0.00E+00	<1.00E-03	DNA	0.00E+00	NE	NE
m-Xylene	No	8.45E-05	<1.00E-03	12,032	5.88E-02	NE	NE
Pentachlorophenol[a]	No	4.26E-03	<1.00E-03	12,032	1.77E-01	NE	NE
Phenol[a]	No	7.58E-03	<1.00E-03	10,481	8.64E-03	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant for Single-Shell Tank 241-C-101 of Potential Concern Using 95% Upper Confidence Level Post-Retrieval Inventory. (4 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	
Polychlorinated Biphenyls (high risk)[a] -- (di)	Yes	2.37E-03	0.00E+00	DNA	9.27E+01	NE	NE
Toluene[a]	Yes	0.00E+00	<1.00E-03	DNA	4.20E-02	NE	NE
Tributyl phosphate	Yes	3.39E-02	<1.00E-03	12,032	5.67E-01	NE	NE
Xylenes	No	2.06E-05	<1.00E-03	12,032	5.88E-02	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 the Hanford Tank Waste Performance Assessments."

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

[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.
No CPF = No cancer potency factor available.
No RfD = No reference dose available.
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.

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-101 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (3 sheets)

A – Average Inventory										
Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Antimony-125	1.89E-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
Tin-126	3.62E-02	3.62E-02	3.62E-02	3.62E-02	3.61E-02	3.61E-02	3.61E-02	3.61E-02	3.61E-02	3.61E-02
Iodine-129	8.11E-06	8.11E-06	8.11E-06	8.11E-06	8.11E-06	8.11E-06	8.11E-06	8.11E-06	8.11E-06	8.11E-06
Cesium-137 + Daughters	1.62E+01	1.61E+00	1.59E-01	1.58E-02	1.57E-03	1.55E-04	1.54E-05	1.53E-06	1.52E-07	1.51E-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
Carbon-14	3.73E-08	3.69E-08	3.64E-08	3.60E-08	3.56E-08	3.51E-08	3.47E-08	3.43E-08	3.39E-08	3.35E-08
Europium-152	3.98E-03	2.20E-05	1.21E-07	6.69E-10	3.70E-12	2.70E-14	6.74E-15	6.62E-15	6.62E-15	6.62E-15
Europium-154	6.76E-05	2.12E-08	6.65E-12	2.08E-15	6.53E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	8.52E-10	3.15E-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	8.78E-01	1.23E+00	1.56E+00	1.88E+00	2.19E+00	2.49E+00	2.77E+00	3.03E+00	3.29E+00	3.54E+00
Protactinium-231	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-232	7.10E-05	7.10E-05	7.10E-05	7.10E-05	7.10E-05	7.10E-05	7.10E-05	7.10E-05	7.10E-05	7.10E-05
Uranium-233	9.48E-09	1.31E-08	1.67E-08	2.03E-08	2.38E-08	2.73E-08	3.07E-08	3.41E-08	3.75E-08	4.09E-08
Uranium-234	4.71E-03	4.80E-03	4.91E-03	5.06E-03	5.23E-03	5.42E-03	5.64E-03	5.89E-03	6.15E-03	6.44E-03
Uranium-235 + D	3.09E-03	3.18E-03	3.26E-03	3.34E-03	3.43E-03	3.51E-03	3.59E-03	3.67E-03	3.76E-03	3.84E-03
Uranium-236	5.04E-05	5.04E-05	5.04E-05	5.04E-05	5.04E-05	5.04E-05	5.04E-05	5.04E-05	5.04E-05	5.04E-05
Neptunium-237 + D	3.03E-03	3.03E-03	3.03E-03	3.03E-03	3.03E-03	3.03E-03	3.03E-03	3.03E-03	3.03E-03	3.03E-03
Plutonium-238	6.16E-03	2.80E-03	1.27E-03	5.76E-04	2.61E-04	1.19E-04	5.41E-05	2.47E-05	1.14E-05	5.42E-06
Uranium-238 + D	1.38E-02	1.38E-02	1.38E-02	1.38E-02	1.38E-02	1.38E-02	1.38E-02	1.38E-02	1.38E-02	1.38E-02
Plutonium-239	1.11E+00	1.11E+00	1.10E+00	1.10E+00	1.10E+00	1.09E+00	1.09E+00	1.09E+00	1.08E+00	1.08E+00
Plutonium-240	1.18E-01	1.17E-01	1.15E-01	1.14E-01	1.13E-01	1.12E-01	1.11E-01	1.09E-01	1.08E-01	1.07E-01
Americium-241	2.93E-01	2.49E-01	2.12E-01	1.81E-01	1.54E-01	1.31E-01	1.12E-01	9.55E-02	8.14E-02	6.93E-02
Plutonium-241 + D	1.86E-02	1.59E-02	1.35E-02	1.15E-02	9.82E-03	8.37E-03	7.13E-03	6.08E-03	5.18E-03	4.41E-03
Curium-242	1.19E-06	5.42E-07	2.46E-07	1.12E-07	5.06E-08	2.30E-08	1.05E-08	4.78E-09	2.20E-09	1.03E-09

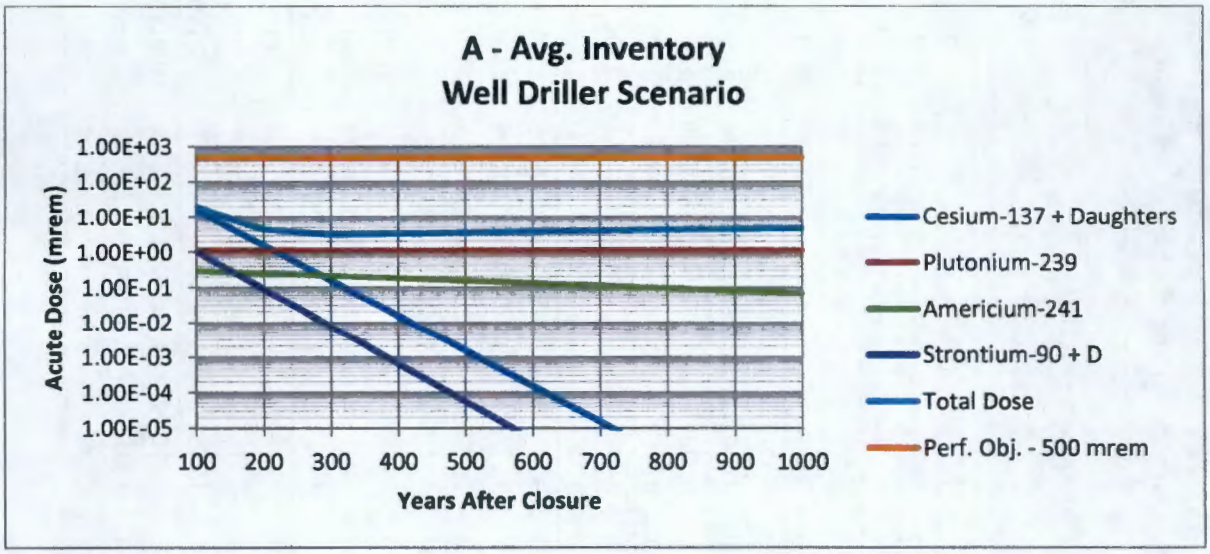
Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-101 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (3 sheets)

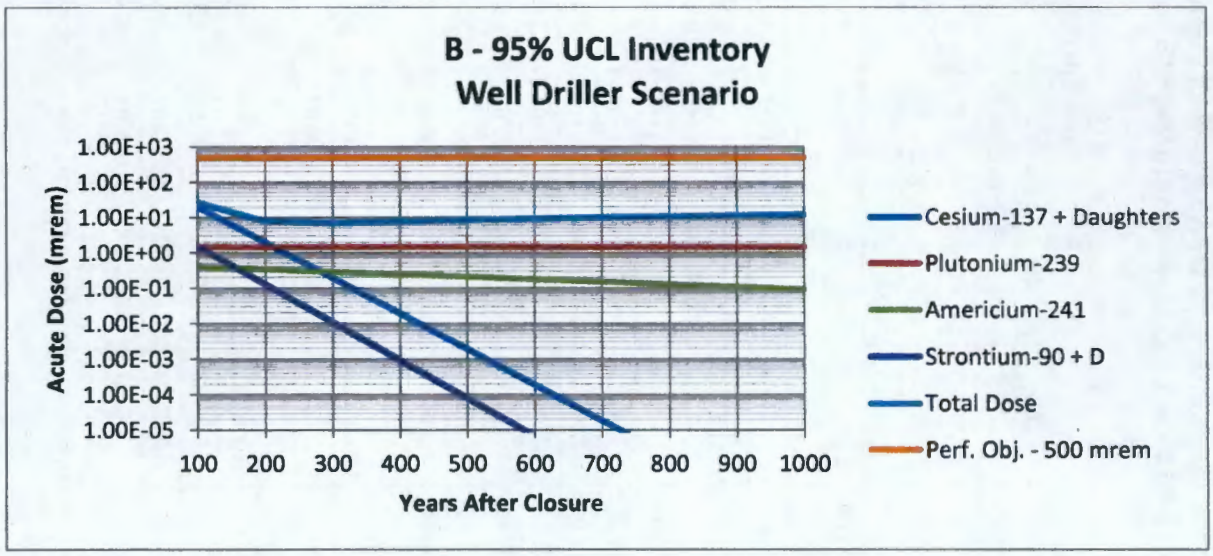
A – Average Inventory (continued)										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Plutonium-242	1.56E-06	1.56E-06	1.56E-06	1.56E-06	1.56E-06	1.56E-06	1.56E-06	1.56E-06	1.56E-06	1.56E-06
Curium-243	2.89E-08	3.08E-09	8.09E-10	6.09E-10	5.90E-10	5.86E-10	5.84E-10	5.83E-10	5.81E-10	5.79E-10
Curium-244	7.13E-08	2.67E-08	2.54E-08	2.51E-08	2.49E-08	2.46E-08	2.44E-08	2.41E-08	2.38E-08	2.36E-08
Tritium	1.76E-11	6.36E-14	2.30E-16	8.33E-19	3.02E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	8.74E-08	1.70E-13	3.31E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nickel-63	1.08E-04	5.42E-05	2.71E-05	1.36E-05	6.79E-06	3.40E-06	1.70E-06	8.50E-07	4.25E-07	2.13E-07
Selenium-79	3.03E-07	3.03E-07	3.03E-07	3.03E-07	3.03E-07	3.03E-07	3.03E-07	3.03E-07	3.03E-07	3.03E-07
Strontium-90 + D	1.07E+00	9.11E-02	7.77E-03	6.62E-04	5.64E-05	4.81E-06	4.10E-07	3.49E-08	2.98E-09	2.54E-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	1.50E-05	1.49E-05	1.49E-05	1.49E-05	1.49E-05	1.49E-05	1.49E-05	1.49E-05	1.49E-05	1.49E-05
Total Dose	**1.97E+01**	**4.48E+00**	**3.24E+00**	**3.37E+00**	**3.63E+00**	**3.89E+00**	**4.15E+00**	**4.40E+00**	**4.63E+00**	**4.86E+00**
B – 95% Upper Confidence Level Inventory										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Antimony-125	5.67E-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
Tin-126	4.53E-02	4.53E-02	4.53E-02	4.53E-02	4.53E-02	4.52E-02	4.52E-02	4.52E-02	4.52E-02	4.52E-02
Iodine-129	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05	1.02E-05
Cesium-137 + Daughters	2.00E+01	1.99E+00	1.97E-01	1.96E-02	1.94E-03	1.92E-04	1.91E-05	1.89E-06	1.88E-07	1.86E-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
Carbon-14	1.12E-07	1.11E-07	1.09E-07	1.08E-07	1.07E-07	1.05E-07	1.04E-07	1.03E-07	1.02E-07	1.00E-07
Europium-152	1.19E-02	6.59E-05	3.64E-07	2.01E-09	1.11E-11	8.09E-14	2.02E-14	1.99E-14	1.99E-14	1.99E-14
Europium-154	2.03E-04	6.36E-08	1.99E-11	6.25E-15	1.96E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	2.56E-09	9.45E-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	2.64E+00	3.69E+00	4.69E+00	5.65E+00	6.58E+00	7.46E+00	8.30E+00	9.10E+00	9.87E+00	1.06E+01

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-101 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (3 sheets)

B – 95% Upper Confidence Level Inventory (continued)										
Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Protactinium-231	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-232	2.13E-04	2.13E-04	2.13E-04	2.13E-04	2.13E-04	2.13E-04	2.13E-04	2.13E-04	2.13E-04	2.13E-04
Uranium-233	1.11E-08	1.53E-08	1.95E-08	2.37E-08	2.78E-08	3.19E-08	3.60E-08	4.00E-08	4.39E-08	4.78E-08
Uranium-234	5.51E-03	5.61E-03	5.75E-03	5.92E-03	6.12E-03	6.35E-03	6.60E-03	6.89E-03	7.20E-03	7.53E-03
Uranium-235 + D	3.76E-03	3.86E-03	3.97E-03	4.07E-03	4.17E-03	4.27E-03	4.37E-03	4.47E-03	4.57E-03	4.67E-03
Uranium-236	5.89E-05	5.89E-05	5.89E-05	5.89E-05	5.89E-05	5.89E-05	5.89E-05	5.89E-05	5.89E-05	5.89E-05
Neptunium-237 + D	4.54E-03	4.54E-03	4.54E-03	4.54E-03	4.54E-03	4.54E-03	4.54E-03	4.54E-03	4.54E-03	4.54E-03
Plutonium-238	7.88E-03	3.57E-03	1.62E-03	7.36E-04	3.34E-04	1.52E-04	6.91E-05	3.16E-05	1.46E-05	6.93E-06
Uranium-238 + D	1.68E-02	1.68E-02	1.68E-02	1.68E-02	1.68E-02	1.68E-02	1.68E-02	1.68E-02	1.68E-02	1.68E-02
Plutonium-239	1.45E+00	1.45E+00	1.44E+00	1.44E+00	1.44E+00	1.43E+00	1.43E+00	1.42E+00	1.42E+00	1.42E+00
Plutonium-240	1.54E-01	1.53E-01	1.51E-01	1.50E-01	1.48E-01	1.46E-01	1.45E-01	1.43E-01	1.42E-01	1.40E-01
Americium-241	3.93E-01	3.35E-01	2.85E-01	2.43E-01	2.07E-01	1.76E-01	1.50E-01	1.28E-01	1.09E-01	9.30E-02
Plutonium-241 + D	2.60E-02	2.22E-02	1.89E-02	1.61E-02	1.37E-02	1.17E-02	9.96E-03	8.49E-03	7.23E-03	6.16E-03
Curium-242	1.85E-06	8.41E-07	3.82E-07	1.73E-07	7.86E-08	3.57E-08	1.62E-08	7.42E-09	3.42E-09	1.60E-09
Plutonium-242	2.05E-06	2.05E-06	2.05E-06	2.05E-06	2.05E-06	2.05E-06	2.05E-06	2.05E-06	2.05E-06	2.05E-06
Curium-243	3.87E-08	4.13E-09	1.09E-09	8.17E-10	7.91E-10	7.87E-10	7.84E-10	7.82E-10	7.80E-10	7.77E-10
Curium-244	9.57E-08	3.58E-08	3.41E-08	3.37E-08	3.34E-08	3.30E-08	3.27E-08	3.23E-08	3.20E-08	3.17E-08
Tritium	5.28E-11	1.91E-13	6.91E-16	2.50E-18	9.05E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	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
Nickel-63	1.36E-04	6.82E-05	3.41E-05	1.71E-05	8.54E-06	4.27E-06	2.14E-06	1.07E-06	5.35E-07	2.68E-07
Selenium-79	5.18E-07	5.18E-07	5.18E-07	5.18E-07	5.18E-07	5.18E-07	5.18E-07	5.17E-07	5.17E-07	5.17E-07
Strontium-90 + D	1.50E+00	1.28E-01	1.09E-02	9.31E-04	7.93E-05	6.76E-06	5.76E-07	4.91E-08	4.19E-09	3.57E-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	1.96E-05	1.96E-05	1.96E-05	1.96E-05	1.96E-05	1.96E-05	1.96E-05	1.96E-05	1.96E-05	1.96E-05
Total Dose	**2.63E+01**	**7.84E+00**	**6.88E+00**	**7.60E+00**	**8.46E+00**	**9.30E+00**	**1.01E+01**	**1.09E+01**	**1.16E+01**	**1.23E+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-101.





UCL = upper confidence level

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank C-101 Showing Major Constituents for A) Average Inventory and B) 95% UCL Inventory (decayed as of January 2008) and Pathways. (2 sheets)

A – Average Inventory										
Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Antimony-125	1.98E-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
Tin-126	4.10E-03	4.10E-03	4.10E-03	4.10E-03	4.10E-03	4.10E-03	4.10E-03	4.10E-03	4.09E-03	4.09E-03
Iodine-129	8.25E-05	8.25E-05	8.25E-05	8.25E-05	8.24E-05	8.24E-05	8.24E-05	8.24E-05	8.24E-05	8.24E-05
Cesium-137 + Daughters	4.35E+00	4.32E-01	4.28E-02	4.25E-03	4.22E-04	4.18E-05	4.15E-06	4.12E-07	4.08E-08	4.05E-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
Carbon-14	4.12E-06	4.07E-06	4.02E-06	3.97E-06	3.92E-06	3.87E-06	3.83E-06	3.78E-06	3.74E-06	3.69E-06
Europium-152	4.51E-04	2.49E-06	1.37E-08	7.57E-11	4.19E-13	4.17E-15	1.88E-15	1.87E-15	1.87E-15	1.87E-15
Europium-154	7.64E-06	2.39E-09	7.51E-13	2.35E-16	7.38E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	7.31E-11	2.70E-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	2.13E-01	2.88E-01	3.60E-01	4.28E-01	4.94E-01	5.57E-01	6.17E-01	6.74E-01	7.29E-01	7.82E-01
Protactinium-231	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-232	1.29E-05	1.29E-05	1.29E-05	1.29E-05	1.29E-05	1.29E-05	1.29E-05	1.29E-05	1.29E-05	1.29E-05
Uranium-233	3.85E-09	4.68E-09	5.51E-09	6.32E-09	7.13E-09	7.92E-09	8.72E-09	9.50E-09	1.03E-08	1.10E-08
Uranium-234	2.71E-03	2.73E-03	2.75E-03	2.79E-03	2.82E-03	2.87E-03	2.92E-03	2.97E-03	3.03E-03	3.09E-03
Uranium-235 + D	4.19E-04	4.40E-04	4.62E-04	4.83E-04	5.04E-04	5.25E-04	5.46E-04	5.67E-04	5.88E-04	6.09E-04
Uranium-236	2.93E-05	2.93E-05	2.93E-05	2.93E-05	2.93E-05	2.93E-05	2.93E-05	2.93E-05	2.93E-05	2.93E-05
Neptunium-237 + D	6.44E-04	6.44E-04	6.44E-04	6.44E-04	6.44E-04	6.44E-04	6.44E-04	6.44E-04	6.44E-04	6.44E-04
Plutonium-238	1.75E-03	7.94E-04	3.60E-04	1.64E-04	7.43E-05	3.38E-05	1.54E-05	7.11E-06	3.33E-06	1.62E-06
Uranium-238 + D	3.56E-03	3.56E-03	3.56E-03	3.56E-03	3.56E-03	3.56E-03	3.56E-03	3.56E-03	3.56E-03	3.56E-03
Plutonium-239	3.16E-01	3.15E-01	3.14E-01	3.13E-01	3.12E-01	3.11E-01	3.10E-01	3.10E-01	3.09E-01	3.08E-01
Plutonium-240	3.36E-02	3.32E-02	3.29E-02	3.25E-02	3.22E-02	3.18E-02	3.15E-02	3.12E-02	3.08E-02	3.05E-02
Americium-241	8.06E-02	6.87E-02	5.85E-02	4.99E-02	4.25E-02	3.62E-02	3.08E-02	2.63E-02	2.24E-02	1.91E-02
Plutonium-241 + D	5.13E-03	4.37E-03	3.73E-03	3.18E-03	2.71E-03	2.31E-03	1.96E-03	1.67E-03	1.43E-03	1.22E-03
Curium-242	3.39E-07	1.54E-07	6.98E-08	3.17E-08	1.44E-08	6.55E-09	2.99E-09	1.37E-09	6.42E-10	3.10E-10

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank C-101 Showing Major Constituents for A) Average Inventory and B) 95% UCL Inventory (decayed as of January 2008) and Pathways. (2 sheets)

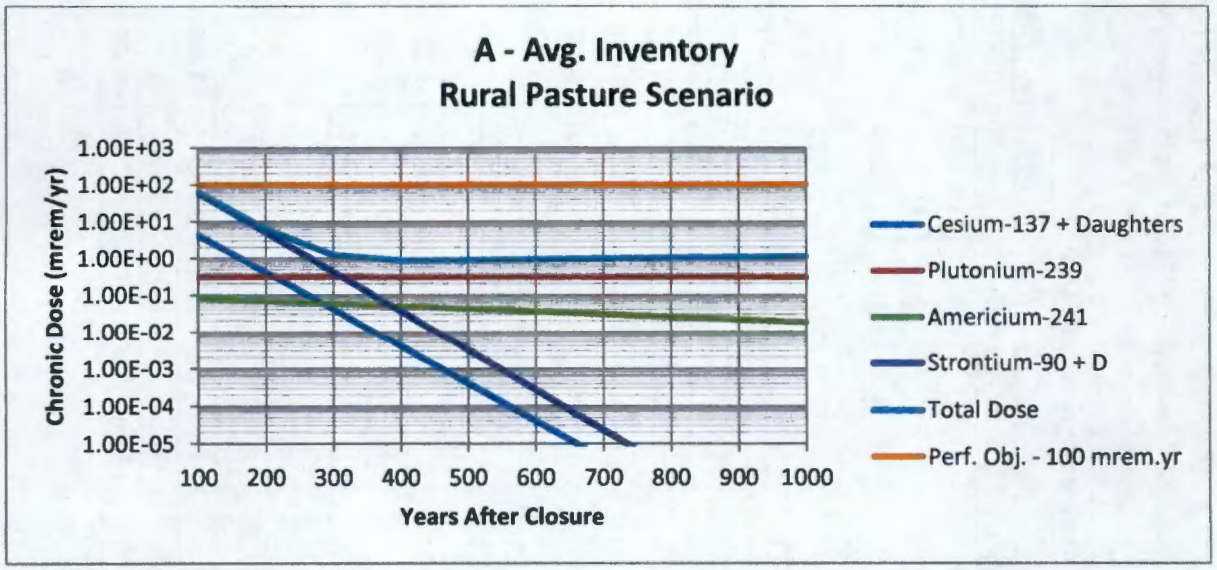
A – Average Inventory (continued)										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Plutonium-242	4.45E-07	4.45E-07	4.45E-07	4.45E-07	4.45E-07	4.45E-07	4.45E-07	4.45E-07	4.45E-07	4.45E-07
Curium-243	6.23E-09	7.00E-10	2.14E-10	1.71E-10	1.67E-10	1.66E-10	1.66E-10	1.65E-10	1.65E-10	1.64E-10
Curium-244	2.04E-08	7.59E-09	7.24E-09	7.16E-09	7.08E-09	7.01E-09	6.93E-09	6.86E-09	6.79E-09	6.72E-09
Tritium	6.53E-10	2.36E-12	8.55E-15	3.09E-17	1.12E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	9.97E-09	1.94E-14	3.78E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nickel-63	2.88E-03	1.44E-03	7.22E-04	3.61E-04	1.81E-04	9.04E-05	4.52E-05	2.26E-05	1.13E-05	5.67E-06
Selenium-79	1.45E-06	1.45E-06	1.45E-06	1.45E-06	1.45E-06	1.45E-06	1.45E-06	1.45E-06	1.45E-06	1.45E-06
Strontium-90 + D	6.17E+01	5.26E+00	4.49E-01	3.82E-02	3.26E-03	2.78E-04	2.37E-05	2.02E-06	1.72E-07	1.47E-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	2.73E-03	2.73E-03	2.73E-03	2.72E-03	2.72E-03	2.72E-03	2.72E-03	2.72E-03	2.72E-03	2.72E-03
Total Dose	**6.68E+01**	**6.42E+00**	**1.28E+00**	**8.84E-01**	**9.02E-01**	**9.53E-01**	**1.01E+00**	**1.06E+00**	**1.11E+00**	**1.15E+00**

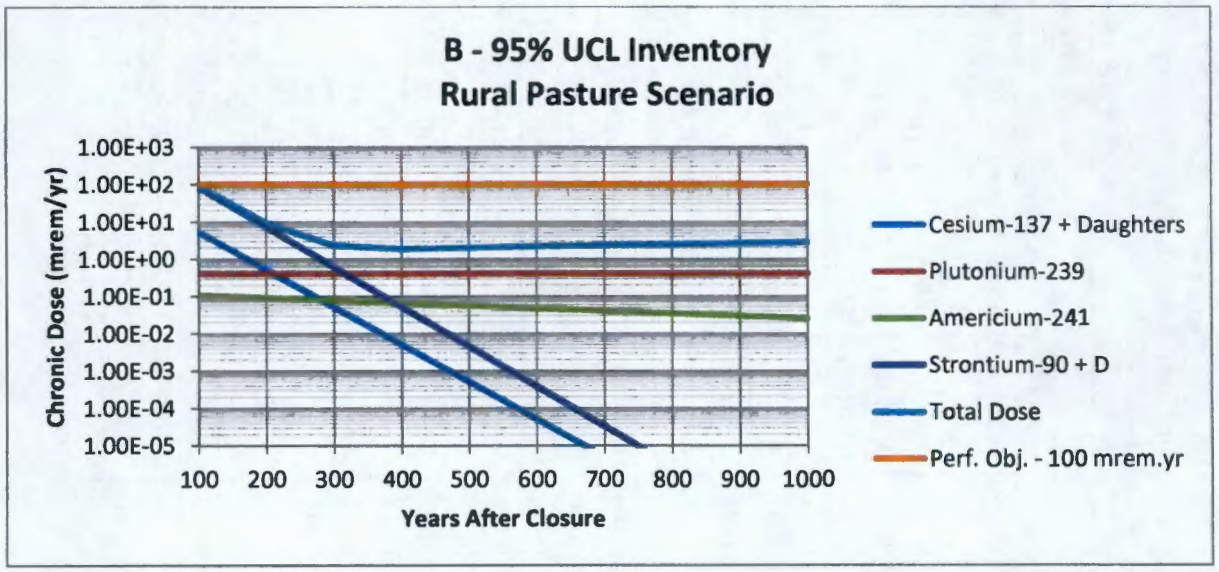
B – 95% Upper Confidence Level Inventory										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**
Antimony-125	5.94E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tin-126	5.14E-03	5.14E-03	5.14E-03	5.13E-03	5.13E-03	5.13E-03	5.13E-03	5.13E-03	5.13E-03	5.13E-03
Iodine-129	1.03E-04	1.03E-04	1.03E-04	1.03E-04	1.03E-04	1.03E-04	1.03E-04	1.03E-04	1.03E-04	1.03E-04
Cesium-137 + Daughters	5.39E+00	5.34E-01	5.30E-02	5.26E-03	5.22E-04	5.18E-05	5.14E-06	5.09E-07	5.05E-08	5.01E-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
Carbon-14	1.23E-05	1.22E-05	1.21E-05	1.19E-05	1.18E-05	1.16E-05	1.15E-05	1.13E-05	1.12E-05	1.11E-05
Europium-152	1.35E-03	7.46E-06	4.11E-08	2.27E-10	1.26E-12	1.25E-14	5.64E-15	5.61E-15	5.61E-15	5.61E-15
Europium-154	2.29E-05	7.18E-09	2.25E-12	7.06E-16	2.22E-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	6.39E-01	8.63E-01	1.08E+00	1.28E+00	1.48E+00	1.67E+00	1.85E+00	2.02E+00	2.19E+00	2.34E+00

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank C-101 Showing Major Constituents for A) Average Inventory and B) 95% UCL Inventory (decayed as of January 2008) and Pathways. (2 sheets)

B – 95% Upper Confidence Level Inventory (continued)										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**
Protactinium-231	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-232	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
Uranium-233	4.51E-09	5.48E-09	6.44E-09	7.40E-09	8.34E-09	9.27E-09	1.02E-08	1.11E-08	1.20E-08	1.29E-08
Uranium-234	3.17E-03	3.19E-03	3.22E-03	3.26E-03	3.30E-03	3.36E-03	3.41E-03	3.47E-03	3.54E-03	3.62E-03
Uranium-235 + D	5.10E-04	5.36E-04	5.61E-04	5.87E-04	6.13E-04	6.39E-04	6.64E-04	6.90E-04	7.15E-04	7.41E-04
Uranium-236	3.43E-05	3.43E-05	3.43E-05	3.43E-05	3.43E-05	3.43E-05	3.43E-05	3.43E-05	3.43E-05	3.43E-05
Neptunium-237 + D	9.65E-04	9.65E-04	9.65E-04	9.65E-04	9.65E-04	9.65E-04	9.65E-04	9.65E-04	9.65E-04	9.65E-04
Plutonium-238	2.24E-03	1.01E-03	4.60E-04	2.09E-04	9.49E-05	4.32E-05	1.97E-05	9.09E-06	4.26E-06	2.07E-06
Uranium-238 + D	4.33E-03	4.33E-03	4.33E-03	4.33E-03	4.33E-03	4.34E-03	4.34E-03	4.34E-03	4.34E-03	4.34E-03
Plutonium-239	4.14E-01	4.13E-01	4.11E-01	4.10E-01	4.09E-01	4.08E-01	4.07E-01	4.05E-01	4.04E-01	4.03E-01
Plutonium-240	4.40E-02	4.35E-02	4.30E-02	4.26E-02	4.21E-02	4.17E-02	4.13E-02	4.08E-02	4.04E-02	4.00E-02
Americium-241	1.08E-01	9.22E-02	7.85E-02	6.69E-02	5.70E-02	4.86E-02	4.14E-02	3.53E-02	3.01E-02	2.56E-02
Plutonium-241 + D	7.16E-03	6.11E-03	5.20E-03	4.43E-03	3.78E-03	3.22E-03	2.74E-03	2.34E-03	1.99E-03	1.70E-03
Curium-242	5.26E-07	2.39E-07	1.08E-07	4.92E-08	2.23E-08	1.02E-08	4.64E-09	2.13E-09	9.97E-10	4.81E-10
Plutonium-242	5.84E-07	5.83E-07	5.83E-07	5.83E-07	5.83E-07	5.83E-07	5.83E-07	5.83E-07	5.83E-07	5.83E-07
Curium-243	8.35E-09	9.40E-10	2.88E-10	2.30E-10	2.24E-10	2.23E-10	2.22E-10	2.22E-10	2.21E-10	2.21E-10
Curium-244	2.74E-08	1.02E-08	9.72E-09	9.61E-09	9.50E-09	9.40E-09	9.31E-09	9.21E-09	9.11E-09	9.02E-09
Tritium	1.96E-09	7.09E-12	2.57E-14	9.28E-17	3.36E-19	1.22E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	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
Nickel-63	3.63E-03	1.81E-03	9.08E-04	4.54E-04	2.27E-04	1.14E-04	5.69E-05	2.85E-05	1.42E-05	7.13E-06
Selenium-79	2.47E-06	2.47E-06	2.47E-06	2.47E-06	2.47E-06	2.47E-06	2.47E-06	2.47E-06	2.47E-06	2.47E-06
Strontium-90 + D	8.68E+01	7.40E+00	6.31E-01	5.37E-02	4.58E-03	3.90E-04	3.33E-05	2.84E-06	2.42E-07	2.06E-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	3.58E-03	3.58E-03	3.58E-03	3.57E-03	3.57E-03	3.57E-03	3.57E-03	3.57E-03	3.57E-03	3.57E-03
Total Dose	**9.34E+01**	**9.37E+00**	**2.32E+00**	**1.89E+00**	**2.02E+00**	**2.19E+00**	**2.36E+00**	**2.52E+00**	**2.68E+00**	**2.83E+00**

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-101.





UCL = upper confidence level

Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-101 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways. (3 sheets)

A – Average Inventory										
Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Antimony-125	1.92E-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
Tin-126	3.95E-02	3.95E-02	3.95E-02	3.95E-02	3.95E-02	3.95E-02	3.94E-02	3.94E-02	3.94E-02	3.94E-02
Iodine-129	4.09E-04	4.09E-04	4.09E-04	4.09E-04	4.09E-04	4.09E-04	4.09E-04	4.09E-04	4.09E-04	4.09E-04
Cesium-137 + Daughters	4.22E+01	4.18E+00	4.15E-01	4.12E-02	4.09E-03	4.05E-04	4.02E-05	3.99E-06	3.96E-07	3.93E-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
Carbon-14	7.22E-05	7.13E-05	7.05E-05	6.96E-05	6.88E-05	6.80E-05	6.71E-05	6.63E-05	6.55E-05	6.47E-05
Europium-152	4.33E-03	2.39E-05	1.32E-07	7.27E-10	4.04E-12	4.86E-14	2.66E-14	2.65E-14	2.65E-14	2.65E-14
Europium-154	7.35E-05	2.30E-08	7.22E-12	2.27E-15	7.10E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	7.18E-10	2.65E-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	3.64E+00	5.37E+00	7.03E+00	8.62E+00	1.01E+01	1.16E+01	1.30E+01	1.43E+01	1.56E+01	1.68E+01
Protactinium-231	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-232	1.49E-04	1.49E-04	1.49E-04	1.49E-04	1.49E-04	1.49E-04	1.49E-04	1.49E-04	1.49E-04	1.49E-04
Uranium-233	1.48E-07	1.60E-07	1.71E-07	1.83E-07	1.94E-07	2.05E-07	2.16E-07	2.27E-07	2.38E-07	2.49E-07
Uranium-234	1.28E-01	1.29E-01	1.29E-01	1.30E-01	1.31E-01	1.31E-01	1.32E-01	1.34E-01	1.35E-01	1.36E-01
Uranium-235 + D	8.70E-03	9.15E-03	9.60E-03	1.00E-02	1.05E-02	1.09E-02	1.14E-02	1.18E-02	1.23E-02	1.27E-02
Uranium-236	1.40E-03	1.40E-03	1.40E-03	1.40E-03	1.40E-03	1.40E-03	1.40E-03	1.40E-03	1.40E-03	1.40E-03
Neptunium-237 + D	4.45E-02	4.45E-02	4.45E-02	4.45E-02	4.45E-02	4.45E-02	4.45E-02	4.45E-02	4.45E-02	4.45E-02
Plutonium-238	3.87E-02	1.76E-02	7.97E-03	3.62E-03	1.65E-03	7.52E-04	3.46E-04	1.62E-04	7.82E-05	4.04E-05
Uranium-238 + D	1.33E-01	1.33E-01	1.33E-01	1.33E-01	1.33E-01	1.33E-01	1.33E-01	1.33E-01	1.33E-01	1.33E-01
Plutonium-239	7.01E+00	6.99E+00	6.97E+00	6.95E+00	6.93E+00	6.91E+00	6.89E+00	6.87E+00	6.85E+00	6.83E+00
Plutonium-240	7.44E-01	7.37E-01	7.29E-01	7.21E-01	7.14E-01	7.06E-01	6.99E-01	6.91E-01	6.84E-01	6.77E-01
Americium-241	1.77E+00	1.50E+00	1.28E+00	1.09E+00	9.31E-01	7.94E-01	6.76E-01	5.77E-01	4.92E-01	4.19E-01
Plutonium-241 + D	1.12E-01	9.58E-02	8.16E-02	6.96E-02	5.93E-02	5.05E-02	4.31E-02	3.67E-02	3.13E-02	2.67E-02
Curium-242	7.50E-06	3.40E-06	1.54E-06	7.02E-07	3.19E-07	1.46E-07	6.70E-08	3.13E-08	1.51E-08	7.73E-09

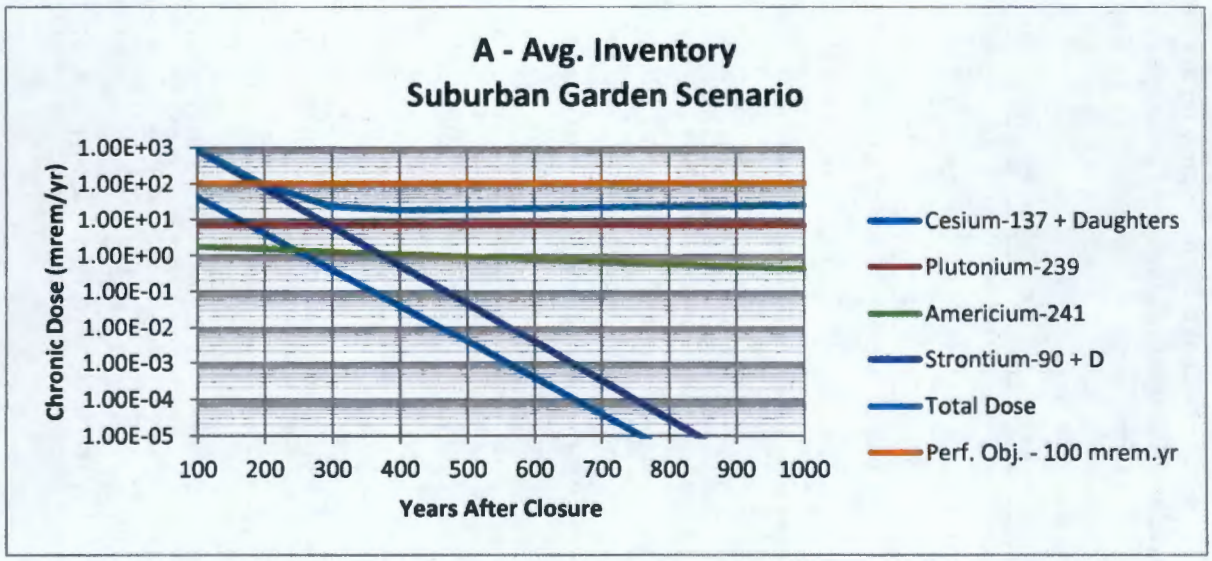
Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-101 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways. (3 sheets)

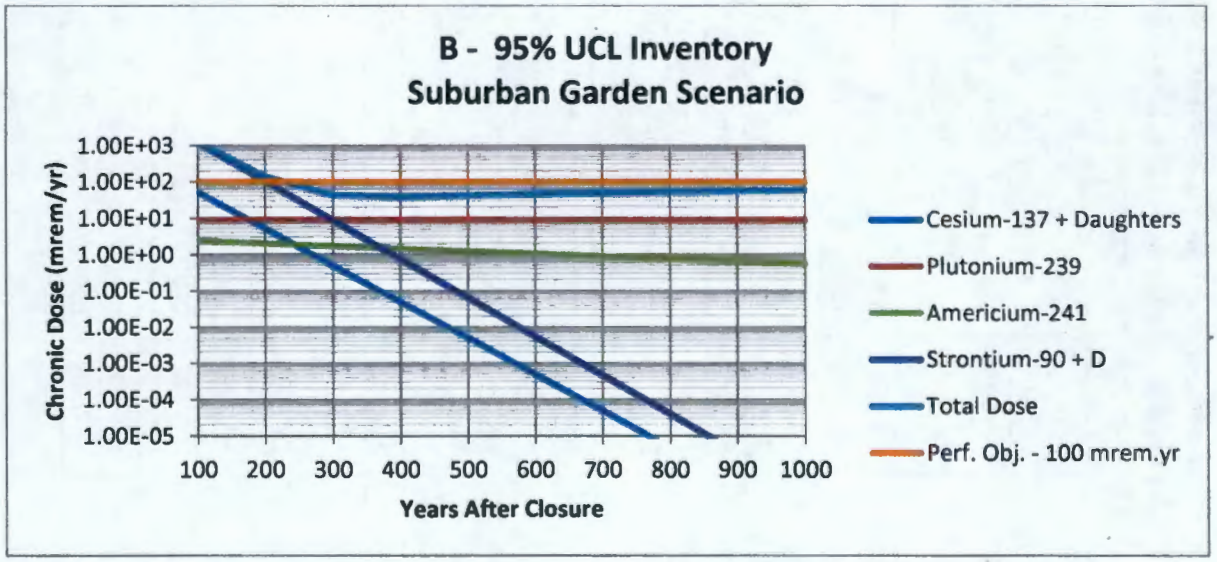
A – Average Inventory (continued)										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Plutonium-242	9.86E-06	9.85E-06	9.85E-06	9.85E-06	9.85E-06	9.85E-06	9.84E-06	9.84E-06	9.84E-06	9.84E-06
Curium-243	1.19E-07	1.39E-08	4.61E-09	3.78E-09	3.70E-09	3.68E-09	3.67E-09	3.66E-09	3.65E-09	3.64E-09
Curium-244	4.41E-07	1.68E-07	1.61E-07	1.59E-07	1.57E-07	1.55E-07	1.54E-07	1.52E-07	1.51E-07	1.49E-07
Tritium	5.70E-09	2.06E-11	7.47E-14	2.70E-16	9.78E-19	3.54E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	9.98E-08	1.94E-13	3.78E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nickel-63	1.96E-02	9.78E-03	4.90E-03	2.45E-03	1.23E-03	6.13E-04	3.07E-04	1.53E-04	7.68E-05	3.84E-05
Selenium-79	2.35E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05
Strontium-90 + D	8.76E+02	7.46E+01	6.36E+00	5.42E-01	4.62E-02	3.94E-03	3.36E-04	2.86E-05	2.44E-06	2.08E-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	2.08E-01	2.08E-01	2.08E-01	2.08E-01	2.08E-01	2.07E-01	2.07E-01	2.07E-01	2.07E-01	2.07E-01
Total Dose	**9.32E+02**	**9.41E+01**	**2.34E+01**	**1.86E+01**	**1.94E+01**	**2.06E+01**	**2.19E+01**	**2.31E+01**	**2.42E+01**	**2.53E+01**
B – 95% Upper Confidence Level Inventory										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Antimony-125	5.77E-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
Tin-126	4.95E-02	4.94E-02	4.94E-02	4.94E-02	4.94E-02	4.94E-02	4.94E-02	4.94E-02	4.94E-02	4.93E-02
Iodine-129	5.13E-04	5.13E-04	5.13E-04	5.13E-04	5.13E-04	5.13E-04	5.13E-04	5.13E-04	5.13E-04	5.13E-04
Cesium-137 + Daughters	5.22E+01	5.18E+00	5.14E-01	5.10E-02	5.06E-03	5.02E-04	4.98E-05	4.94E-06	4.90E-07	4.86E-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
Carbon-14	2.17E-04	2.14E-04	2.11E-04	2.09E-04	2.06E-04	2.04E-04	2.01E-04	1.99E-04	1.97E-04	1.94E-04
Europium-152	1.30E-02	7.17E-05	3.95E-07	2.18E-09	1.21E-11	1.46E-13	7.98E-14	7.95E-14	7.95E-14	7.95E-14
Europium-154	2.20E-04	6.91E-08	2.17E-11	6.80E-15	2.13E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	2.15E-09	7.96E-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	1.09E+01	1.61E+01	2.11E+01	2.59E+01	3.04E+01	3.48E+01	3.90E+01	4.30E+01	4.68E+01	5.05E+01

Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-101 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways. (3 sheets)

B – 95% Upper Confidence Level Inventory (continued)										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Protactinium-231	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-232	4.47E-04	4.47E-04	4.47E-04	4.47E-04	4.47E-04	4.47E-04	4.47E-04	4.47E-04	4.47E-04	4.47E-04
Uranium-233	1.73E-07	1.87E-07	2.00E-07	2.14E-07	2.27E-07	2.40E-07	2.53E-07	2.66E-07	2.78E-07	2.91E-07
Uranium-234	1.50E-01	1.51E-01	1.51E-01	1.52E-01	1.53E-01	1.54E-01	1.55E-01	1.56E-01	1.58E-01	1.59E-01
Uranium-235 + D	1.06E-02	1.11E-02	1.17E-02	1.22E-02	1.28E-02	1.33E-02	1.38E-02	1.44E-02	1.49E-02	1.55E-02
Uranium-236	1.63E-03	1.63E-03	1.63E-03	1.63E-03	1.63E-03	1.63E-03	1.63E-03	1.63E-03	1.63E-03	1.63E-03
Neptunium-237 + D	6.66E-02	6.66E-02	6.66E-02	6.66E-02	6.66E-02	6.66E-02	6.66E-02	6.66E-02	6.66E-02	6.66E-02
Plutonium-238	4.95E-02	2.24E-02	1.02E-02	4.63E-03	2.11E-03	9.61E-04	4.42E-04	2.07E-04	1.00E-04	5.16E-05
Uranium-238 + D	1.62E-01	1.62E-01	1.62E-01	1.62E-01	1.62E-01	1.62E-01	1.62E-01	1.62E-01	1.62E-01	1.62E-01
Plutonium-239	9.18E+00	9.15E+00	9.12E+00	9.10E+00	9.07E+00	9.05E+00	9.02E+00	8.99E+00	8.97E+00	8.94E+00
Plutonium-240	9.75E-01	9.65E-01	9.55E-01	9.45E-01	9.35E-01	9.25E-01	9.15E-01	9.06E-01	8.96E-01	8.87E-01
Americium-241	2.37E+00	2.02E+00	1.72E+00	1.47E+00	1.25E+00	1.07E+00	9.08E-01	7.74E-01	6.60E-01	5.63E-01
Plutonium-241 + D	1.57E-01	1.34E-01	1.14E-01	9.71E-02	8.28E-02	7.05E-02	6.01E-02	5.13E-02	4.37E-02	3.73E-02
Curium-242	1.16E-05	5.28E-06	2.40E-06	1.09E-06	4.95E-07	2.26E-07	1.04E-07	4.85E-08	2.34E-08	1.20E-08
Plutonium-242	1.29E-05	1.29E-05	1.29E-05	1.29E-05	1.29E-05	1.29E-05	1.29E-05	1.29E-05	1.29E-05	1.29E-05
Curium-243	1.60E-07	1.86E-08	6.18E-09	5.08E-09	4.97E-09	4.94E-09	4.93E-09	4.91E-09	4.90E-09	4.89E-09
Curium-244	5.92E-07	2.26E-07	2.16E-07	2.13E-07	2.11E-07	2.09E-07	2.06E-07	2.04E-07	2.02E-07	2.00E-07
Tritium	1.71E-08	6.19E-11	2.24E-13	8.11E-16	2.93E-18	1.06E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	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
Nickel-63	2.46E-02	1.23E-02	6.16E-03	3.08E-03	1.54E-03	7.71E-04	3.86E-04	1.93E-04	9.66E-05	4.83E-05
Selenium-79	4.02E-05	4.02E-05	4.02E-05	4.02E-05	4.02E-05	4.01E-05	4.01E-05	4.01E-05	4.01E-05	4.01E-05
Strontium-90 + D	1.23E+03	1.05E+02	8.95E+00	7.62E-01	6.50E-02	5.54E-03	4.72E-04	4.02E-05	3.43E-06	2.92E-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	2.73E-01	2.73E-01	2.72E-01	2.72E-01	2.72E-01	2.72E-01	2.72E-01	2.72E-01	2.72E-01	2.72E-01
Total Dose	**1.31E+03**	**1.39E+02**	**4.32E+01**	**3.90E+01**	**4.26E+01**	**4.66E+01**	**5.06E+01**	**5.44E+01**	**5.81E+01**	**6.16E+01**

Figure D-3. Comparison of Doses from Suburban Garden 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-101.





UCL = upper confidence level

Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-101 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (3 sheets)

A – Average Inventory										
Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Antimony-125	7.55E-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
Tin-126	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04
Iodine-129	3.80E-08	3.80E-08	3.80E-08	3.80E-08	3.80E-08	3.80E-08	3.80E-08	3.80E-08	3.80E-08	3.80E-08
Cesium-137 + Daughters	6.96E-02	6.91E-03	6.85E-04	6.80E-05	6.74E-06	6.69E-07	6.64E-08	6.58E-09	6.53E-10	6.48E-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
Carbon-14	1.99E-10	1.97E-10	1.95E-10	1.92E-10	1.90E-10	1.88E-10	1.85E-10	1.83E-10	1.81E-10	1.79E-10
Europium-152	1.72E-05	9.48E-08	5.23E-10	2.89E-12	1.60E-14	1.53E-16	6.58E-17	6.53E-17	6.53E-17	6.53E-17
Europium-154	2.91E-07	9.14E-11	2.86E-14	8.98E-18	2.82E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	2.78E-12	1.03E-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	6.07E-03	7.68E-03	9.23E-03	1.07E-02	1.21E-02	1.35E-02	1.48E-02	1.60E-02	1.72E-02	1.83E-02
Protactinium-231	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-232	3.83E-07	3.83E-07	3.83E-07	3.83E-07	3.83E-07	3.83E-07	3.83E-07	3.83E-07	3.83E-07	3.83E-07
Uranium-233	6.62E-11	9.41E-11	1.22E-10	1.49E-10	1.76E-10	2.03E-10	2.29E-10	2.56E-10	2.82E-10	3.07E-10
Uranium-234	3.00E-05	3.06E-05	3.13E-05	3.21E-05	3.31E-05	3.42E-05	3.53E-05	3.66E-05	3.80E-05	3.95E-05
Uranium-235 + D	1.26E-05	1.32E-05	1.38E-05	1.44E-05	1.50E-05	1.56E-05	1.62E-05	1.68E-05	1.74E-05	1.80E-05
Uranium-236	3.20E-07	3.20E-07	3.20E-07	3.20E-07	3.20E-07	3.20E-07	3.20E-07	3.20E-07	3.20E-07	3.20E-07
Neptunium-237 + D	1.93E-05	1.93E-05	1.93E-05	1.93E-05	1.93E-05	1.93E-05	1.93E-05	1.93E-05	1.93E-05	1.93E-05
Plutonium-238	4.94E-05	2.24E-05	1.02E-05	4.61E-06	2.09E-06	9.51E-07	4.32E-07	1.98E-07	9.09E-08	4.27E-08
Uranium-238 + D	6.52E-05	6.52E-05	6.52E-05	6.53E-05	6.53E-05	6.53E-05	6.53E-05	6.53E-05	6.53E-05	6.53E-05
Plutonium-239	8.90E-03	8.87E-03	8.85E-03	8.82E-03	8.80E-03	8.77E-03	8.75E-03	8.72E-03	8.70E-03	8.67E-03
Plutonium-240	9.45E-04	9.36E-04	9.26E-04	9.16E-04	9.06E-04	8.97E-04	8.87E-04	8.78E-04	8.69E-04	8.60E-04
Americium-241	2.28E-03	1.94E-03	1.66E-03	1.41E-03	1.20E-03	1.03E-03	8.73E-04	7.44E-04	6.34E-04	5.40E-04
Plutonium-241 + D	1.45E-04	1.24E-04	1.06E-04	8.99E-05	7.66E-05	6.53E-05	5.56E-05	4.74E-05	4.04E-05	3.44E-05
Curium-242	9.56E-09	4.34E-09	1.97E-09	8.93E-10	4.05E-10	1.84E-10	8.37E-11	3.82E-11	1.75E-11	8.16E-12

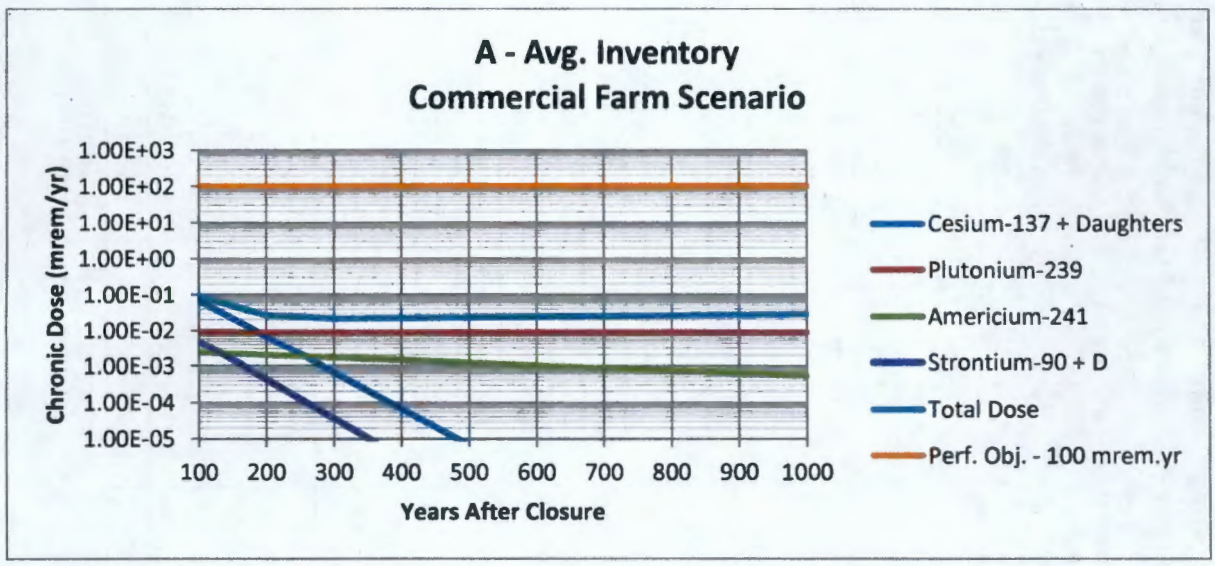
Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-101 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (3 sheets)

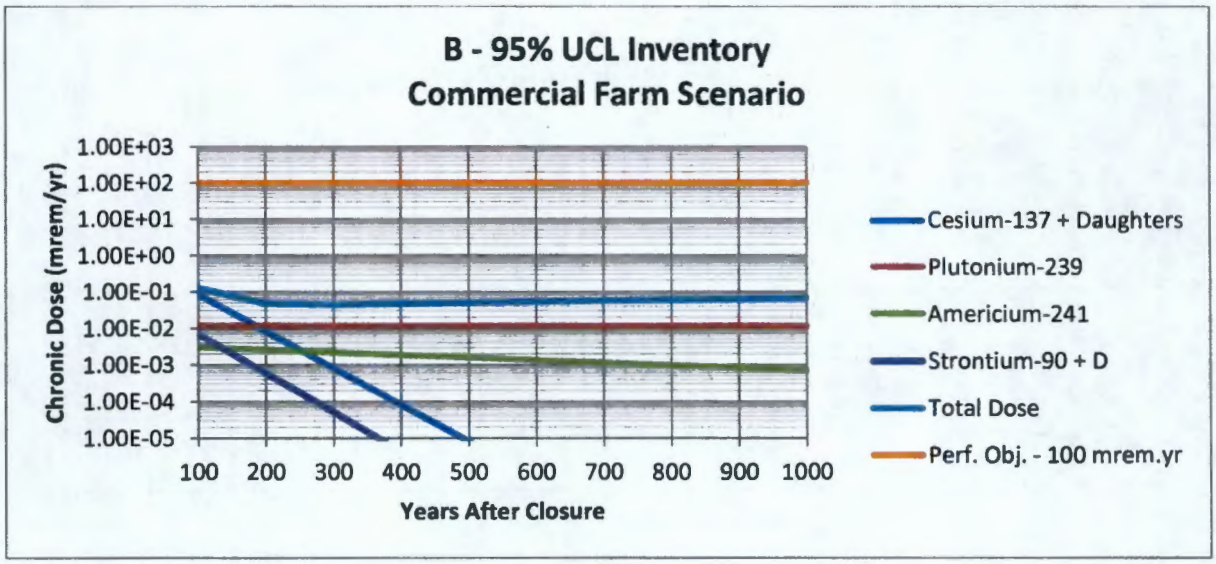
A – Average Inventory (continued)										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Plutonium-242	1.26E-08	1.26E-08	1.26E-08	1.26E-08	1.26E-08	1.26E-08	1.26E-08	1.26E-08	1.26E-08	1.25E-08
Curium-243	1.83E-10	2.04E-11	6.11E-12	4.84E-12	4.71E-12	4.69E-12	4.67E-12	4.66E-12	4.65E-12	4.63E-12
Curium-244	5.67E-10	2.14E-10	2.04E-10	2.02E-10	2.00E-10	1.97E-10	1.95E-10	1.93E-10	1.91E-10	1.89E-10
Tritium	2.29E-11	8.27E-14	2.99E-16	1.08E-18	3.92E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	3.79E-10	7.38E-16	1.44E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nickel-63	6.15E-07	3.08E-07	1.54E-07	7.70E-08	3.85E-08	1.93E-08	9.65E-09	4.83E-09	2.42E-09	1.21E-09
Selenium-79	1.58E-09	1.58E-09	1.58E-09	1.58E-09	1.58E-09	1.58E-09	1.58E-09	1.58E-09	1.58E-09	1.58E-09
Strontium-90 + D	5.09E-03	4.34E-04	3.70E-05	3.15E-06	2.69E-07	2.29E-08	1.95E-09	1.66E-10	1.42E-11	1.21E-12
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	6.77E-08	6.76E-08	6.76E-08	6.76E-08	6.76E-08	6.75E-08	6.75E-08	6.75E-08	6.75E-08	6.75E-08
Total Dose	**9.34E-02**	**2.72E-02**	**2.18E-02**	**2.23E-02**	**2.34E-02**	**2.45E-02**	**2.56E-02**	**2.67E-02**	**2.77E-02**	**2.87E-02**
B – 95% Upper Confidence Level Inventory										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Antimony-125	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	0.00E+00
Tin-126	1.95E-04	1.95E-04	1.95E-04	1.95E-04	1.95E-04	1.95E-04	1.95E-04	1.95E-04	1.95E-04	1.95E-04
Iodine-129	4.75E-08	4.75E-08	4.75E-08	4.75E-08	4.75E-08	4.75E-08	4.75E-08	4.75E-08	4.75E-08	4.75E-08
Cesium-137 + Daughters	8.62E-02	8.55E-03	8.48E-04	8.42E-05	8.35E-06	8.28E-07	8.22E-08	8.15E-09	8.09E-10	8.02E-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
Carbon-14	5.98E-10	5.91E-10	5.84E-10	5.77E-10	5.70E-10	5.63E-10	5.56E-10	5.49E-10	5.43E-10	5.36E-10
Europium-152	5.16E-05	2.85E-07	1.57E-09	8.66E-12	4.80E-14	4.60E-16	1.97E-16	1.96E-16	1.96E-16	1.96E-16
Europium-154	8.74E-07	2.74E-10	8.59E-14	2.69E-17	8.45E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	8.35E-12	3.09E-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	1.82E-02	2.30E-02	2.77E-02	3.21E-02	3.63E-02	4.04E-02	4.43E-02	4.80E-02	5.15E-02	5.49E-02

Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-101 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways. (3 sheets)

B – 95% Upper Confidence Level Inventory (continued)										
Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Protactinium-231	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-232	1.15E-06	1.15E-06	1.15E-06	1.15E-06	1.15E-06	1.15E-06	1.15E-06	1.15E-06	1.15E-06	1.15E-06
Uranium-233	7.75E-11	1.10E-10	1.42E-10	1.74E-10	2.06E-10	2.37E-10	2.68E-10	2.99E-10	3.29E-10	3.60E-10
Uranium-234	3.51E-05	3.58E-05	3.66E-05	3.76E-05	3.87E-05	4.00E-05	4.14E-05	4.29E-05	4.45E-05	4.62E-05
Uranium-235 + D	1.53E-05	1.61E-05	1.68E-05	1.75E-05	1.83E-05	1.90E-05	1.97E-05	2.05E-05	2.12E-05	2.19E-05
Uranium-236	3.75E-07	3.75E-07	3.75E-07	3.75E-07	3.75E-07	3.75E-07	3.75E-07	3.75E-07	3.75E-07	3.75E-07
Neptunium-237 + D	2.89E-05	2.89E-05	2.89E-05	2.89E-05	2.89E-05	2.89E-05	2.89E-05	2.89E-05	2.89E-05	2.89E-05
Plutonium-238	6.31E-05	2.86E-05	1.30E-05	5.89E-06	2.67E-06	1.21E-06	5.53E-07	2.52E-07	1.16E-07	5.45E-08
Uranium-238 + D	7.94E-05	7.95E-05	7.95E-05	7.95E-05	7.95E-05	7.95E-05	7.95E-05	7.95E-05	7.95E-05	7.95E-05
Plutonium-239	1.17E-02	1.16E-02	1.16E-02	1.16E-02	1.15E-02	1.15E-02	1.15E-02	1.14E-02	1.14E-02	1.14E-02
Plutonium-240	1.24E-03	1.23E-03	1.21E-03	1.20E-03	1.19E-03	1.17E-03	1.16E-03	1.15E-03	1.14E-03	1.13E-03
Americium-241	3.06E-03	2.61E-03	2.22E-03	1.89E-03	1.61E-03	1.38E-03	1.17E-03	9.99E-04	8.51E-04	7.25E-04
Plutonium-241 + D	2.03E-04	1.73E-04	1.47E-04	1.25E-04	1.07E-04	9.11E-05	7.76E-05	6.62E-05	5.64E-05	4.80E-05
Curium-242	1.48E-08	6.73E-09	3.06E-09	1.39E-09	6.29E-10	2.86E-10	1.30E-10	5.93E-11	2.72E-11	1.27E-11
Plutonium-242	1.65E-08	1.65E-08	1.65E-08	1.65E-08	1.65E-08	1.65E-08	1.64E-08	1.64E-08	1.64E-08	1.64E-08
Curium-243	2.46E-10	2.74E-11	8.20E-12	6.49E-12	6.32E-12	6.29E-12	6.27E-12	6.25E-12	6.24E-12	6.22E-12
Curium-244	7.61E-10	2.87E-10	2.74E-10	2.71E-10	2.68E-10	2.65E-10	2.62E-10	2.59E-10	2.57E-10	2.54E-10
Tritium	6.86E-11	2.48E-13	8.98E-16	3.25E-18	1.18E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	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
Nickel-63	7.74E-07	3.87E-07	1.94E-07	9.69E-08	4.85E-08	2.43E-08	1.21E-08	6.07E-09	3.04E-09	1.52E-09
Selenium-79	2.71E-09	2.70E-09	2.70E-09	2.70E-09	2.70E-09	2.70E-09	2.70E-09	2.70E-09	2.70E-09	2.70E-09
Strontium-90 + D	7.16E-03	6.10E-04	5.20E-05	4.43E-06	3.78E-07	3.22E-08	2.74E-09	2.34E-10	1.99E-11	1.70E-12
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	8.88E-08	8.87E-08	8.87E-08	8.87E-08	8.86E-08	8.86E-08	8.86E-08	8.86E-08	8.85E-08	8.85E-08
Total Dose	**1.28E-01**	**4.82E-02**	**4.41E-02**	**4.73E-02**	**5.11E-02**	**5.49E-02**	**5.85E-02**	**6.20E-02**	**6.53E-02**	**6.85E-02**

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-101.





UCL = upper confidence level

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-101, 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% UCL Concentration (mg/kg)[a]	Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
1, 1, 2-Trichloroethylene	1.42E-03	4.26E-03	2.17E+01	1.75E+03	6.29E-03	No
1, 4-Dichlorobenzene	1.91E-01	5.73E-01	1.85E+02	2.43E+04	1.34E-01	No
2-Butanone(MEK)	2.31E-02	6.93E-02	4.80E+04	2.10E+06	1.97E+01	No
2-Propanone (Acetone)	2.59E-02	7.77E-02	7.20E+04	3.15E+06	2.89E+01	No
4-Methyl-2-pentanone (MIBK)	2.01E-02	6.03E-02	6.40E+03	2.80E+05	2.73E+00	No
Acetate	3.25E+02	4.07E+02	--	--	--	Yes
Aluminum	1.79E+05	2.10E+05	8.00E+04	3.50E+06	4.80E+05	Yes
Ammonia	6.33E+00	1.01E+01	--	--	--	Yes
Antimony*	8.17E-01	2.45E+00	--	--	--	No
Arsenic*	6.54E+00	1.96E+01	6.67E-01	8.75E+01	3.41E-02	No
Barium*	7.22E+01	8.55E+01	--	--	--	Yes
Benzo[a]pyrene*	2.51E-01	7.53E-01	1.37E-01	1.80E+01	2.32E-01	No
Beryllium*	9.81E-01	2.94E+00	1.60E+02	7.00E+03	6.32E+01	No
Bismuth	5.88E+00	1.76E+01	--	--	--	No
Boron	1.25E+00	1.78E+00	1.60E+04	7.00E+05	2.05E+02	Yes
Bromide	2.95E+01	8.85E+01	--	--	--	No
Butylbenzylphthalate*	1.12E+00	1.53E+00	5.26E+02	6.91E+04	1.29E+01	Yes
Cadmium*	2.43E+00	2.84E+00	8.00E+01	3.50E+03	6.90E-01	Yes
Calcium	6.50E+02	8.39E+02	--	--	--	Yes
Cerium	1.24E+02	1.52E+02	--	--	--	Yes
Chloride	4.60E+02	5.88E+02	--	--	1.00E+03	Yes
Chromium, Total*	1.74E+02	1.93E+02	1.20E+05	5.25E+06	2.00E+03	Yes
Cobalt	2.79E+00	4.19E+00	2.40E+01	1.05E+03	4.34E+00	Yes

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-101, 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% UCL Concentration (mg/kg)[a]	Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Copper	2.66E+02	2.97E+02	3.20E+03	1.40E+05	2.84E+02	Yes
Cyanide*	4.34E+02	5.45E+02	4.80E+01	2.10E+03	9.70E-01	Yes
Di (2-ethylhexyl) phthalate (DEHP)	2.06E+00	2.73E+00	7.14E+01	9.38E+03	1.34E+01	Yes
Dibenz[a, h]anthracene*	1.09E-01	3.27E-01	1.37E+00	1.80E+02	4.29E+00	No
Diethyl phthalate *	4.10E+01	1.57E+00	6.40E+04	2.80E+06	7.22E+01	No
Europium	9.81E-01	2.94E+00	--	--	--	No
Fluoride	2.90E+02	5.12E+02	4.80E+03	2.10E+05	2.88E+03	Yes
Formate+A_2	3.80E+02	4.61E+02	--	--	--	Yes
Glycolate $C_2H_3O_3$	3.15E+01	9.45E+01	--	--	--	No
Hexachlorobenzene*	2.27E-01	6.81E-01	6.25E-01	8.20E+01	8.77E-02	No
Hydroxide OH	5.80E-01	1.03E+00	--	--	--	Yes
Iron	7.80E+03	9.69E+03	5.60E+04	2.45E+06	5.64E+03	Yes
Lanthanum	2.27E+01	3.05E+01	--	--	--	Yes
Lead*	2.84E+02	3.48E+02	--	1.00E+03	3.00E+03	Yes
Lithium	1.33E+01	1.53E+01	1.60E+02	7.00E+03	1.92E+02	Yes
Magnesium	1.05E+02	1.43E+02	--	--	--	Yes
Manganese	1.54E+03	2.34E+03	1.12E+04	4.90E+05	5.01E+02	Yes
Mercury*	1.79E+00	3.08E+00	2.40E+01	1.05E+03	2.09E+00	Yes
Molybdenum	1.29E+01	1.69E+01	4.00E+02	1.75E+04	3.23E+01	Yes
m-Xylene	1.97E-03	5.91E-03	1.60E+04	7.00E+05	1.35E+01	No
N, N-Diphenylamine*	1.04E-01	3.12E-01	--	--	--	No
Neodymium	5.71E+01	8.28E+01	--	--	--	Yes
Nickel*	1.99E+00	2.41E+00	--	--	--	Yes

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-101, 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% UCL Concentration (mg/kg)[a]	Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Niobium	5.88E+00	1.76E+01	--	--	--	No
Nitrate	2.53E+04	3.09E+04	5.68E+05	2.49E+07	1.80E+02	Yes
Nitrite	1.79E+04	2.26E+04	2.40E+04	1.05E+06	1.32E+01	Yes
N-Nitroso-N, N-dimethylamine*	1.82E-01	5.46E-01	1.96E-02	2.57E+00	--	No
Oxalate	5.95E+02	7.57E+02	--	--	--	Yes
o-Xylene	1.08E-03	3.24E-03	1.60E+04	7.00E+05	1.47E+01	No
Palladium	1.45E+02	1.72E+02	--	--	--	Yes
Pentachlorophenol*	9.95E-02	2.99E-01	2.50E+00	3.28E+02	3.47E-03	No
Phenol*	1.77E-01	5.31E-01	2.40E+04	1.05E+06	1.10E+01	No
Phosphate	2.35E+02	1.89E+04	--	--	--	Yes
Polychlorinated Biphenyls*	4.48E-02	8.23E-02	5.00E-01	6.56E+01	--	Yes
Potassium	6.97E+02	9.42E+02	--	--	--	Yes
Praseodymium	2.55E+01	7.65E+01	--	--	--	No
Rhodium	5.98E+01	6.90E+01	--	--	--	Yes
Rubidium	5.59E+01	1.68E+02	--	--	--	No
Ruthenium	3.92E+00	1.18E+01	--	--	--	Yes
Samarium	7.69E+02	8.89E+02	--	--	--	Yes
Selenium*	1.58E-04	2.67E-04	--	--	--	Yes
Silicon	1.90E+03	2.53E+03	--	--	--	Yes
Silver*	1.20E+02	1.33E+02	4.00E+02	1.75E+04	1.36E+01	Yes
Sodium	8.84E+04	1.02E+05	--	--	--	Yes
Strontium	2.35E+02	2.90E+02	4.80E+04	2.10E+06	6.76E+03	Yes
Sulfate	4.43E+03	6.32E+03	--	--	1.00E+03	Yes

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-101, 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% UCL Concentration (mg/kg)[a]	Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Tantalum	8.26E+00	2.48E+01	--	--	--	No
Tellurium	1.37E+01	1.60E+01	--	--	--	Yes
Thallium*	3.92E+00	1.18E+01	--	--	2.28E-01	No
Thorium	6.30E+01	1.89E+02	--	--	--	No
Tin	7.98E+00	2.39E+01	4.80E+04	2.10E+06	4.80E+04	No
Titanium	2.87E+00	8.61E+00	--	--	--	No
Tributyl phosphate	9.93E-01	1.12E+00	1.11E+02	1.46E+04	4.96E-01	Yes
Tritium	2.83E-03	8.49E-03	--	--	--	No
Tungsten	8.45E+01	9.95E+01	--	--	--	Yes
Uranium	1.82E+05	1.97E+05	2.40E+02	1.05E+04	2.70E+02	Yes
Vanadium	2.25E+00	6.75E+00	4.00E+02	1.75E+04	1.60E+03	No
Xylenes	4.78E-04	1.43E-03	1.60E+04	7.00E+05	1.46E+01	No
Yttrium	2.34E+00	7.02E+00	--	--	--	No
Zinc	4.83E+01	6.23E+01	2.40E+04	1.05E+06	5.97E+03	Yes
Zirconium	4.10E+01	7.22E+01	--	--	--	Yes

[a] 95% Upper Confidence Level Concentration = Mean Concentration + (1.96 × Mean Concentration × Relative Standard Deviation). Mean Concentrations and Relative Standard Deviation provided in Table A-1, Appendix A of RPP-RPT-58803, "Tank 241-C-101 Residual Waste Inventory Estimates for Component Closure Risk Assessment."

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

UCL = Upper Confidence Level

-- = 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-101 Tank Residual Wastes. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-101 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
1, 1, 2-Trichloroethylene	1.42E-03	6.53E-05	8.11E-07	2.26E-01	No
1, 4-Dichlorobenzene	1.91E-01	1.03E-03	7.86E-06	1.43E+00	No
2-Butanone(MEK)	2.31E-02	4.81E-07	1.10E-08	1.18E-03	No
2-Propanone (Acetone)	2.59E-02	3.60E-07	8.22E-09	8.96E-04	No
4-Methyl-2-pentanone (MIBK)	2.01E-02	3.14E-06	7.18E-08	7.37E-03	No
Acetate	3.25E+02	--	--	--	Yes
Aluminum	1.79E+05	2.24E+00	5.11E-02	3.73E-01	Yes
Ammonia	6.33E+00	--	--	--	Yes
Antimony*	8.17E-01	--	--	--	No
Arsenic*	6.54E+00	9.81E+00	7.47E-02	1.92E+02	No
Barium*	7.22E+01	--	--	--	Yes
Benzo[a]pyrene*	2.51E-01	1.83E+00	1.40E-02	1.08E+00	No
Beryllium*	9.81E-01	6.13E-03	1.40E-04	1.55E-02	No
Bismuth	5.88E+00	--	--	--	No
Boron	1.25E+00	7.81E-05	1.79E-06	6.10E-03	Yes
Bromide	2.95E+01	--	--	--	No
Butylbenzylphthalate*	1.12E+00	2.13E-03	1.62E-05	8.69E-02	Yes
Cadmium*	2.43E+00	3.04E-02	6.94E-04	3.52E+00	Yes
Calcium	6.50E+02	--	--	--	Yes
Cerium	1.24E+02	--	--	--	Yes
Chloride	4.60E+02	--	--	4.60E-01	Yes
Chromium, Total*	1.74E+02	1.45E-03	3.31E-05	8.70E-02	Yes
Cobalt	2.79E+00	1.16E-01	2.66E-03	6.43E-01	Yes
Copper	2.66E+02	8.31E-02	1.90E-03	9.36E-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-101 Tank Residual Wastes. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-101 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
Cyanide*	4.34E+02	9.04E+00	2.07E-01	4.48E+02	Yes
Di (2-ethylhexyl) phthalate (DEHP)	2.06E+00	2.88E-02	2.20E-04	1.54E-01	Yes
Dibenz[a, h]anthracene*	1.09E-01	7.96E-02	6.06E-04	2.54E-02	No
Diethyl phthalate *	4.10E+01	6.41E-04	1.46E-05	5.68E-01	No
Europium	9.81E-01	--	--	--	No
Fluoride	2.90E+02	6.04E-02	1.38E-03	1.01E-01	Yes
Formate+A_2	3.80E+02	--	--	--	Yes
Glycolate $C_2H_3O_3$	3.15E+01	--	--	--	No
Hexachlorobenzene*	2.27E-01	3.63E-01	2.77E-03	2.59E+00	No
Hydroxide OH	5.80E-01	--	--	--	Yes
Iron	7.80E+03	1.39E-01	3.18E-03	1.38E+00	Yes
Lanthanum	2.27E+01	--	--	--	Yes
Lead*	2.84E+02	--	2.84E-01	9.47E-02	Yes
Lithium	1.33E+01	8.31E-02	1.90E-03	6.92E-02	Yes
Magnesium	1.05E+02	--	--	--	Yes
Manganese	1.54E+03	1.38E-01	3.14E-03	3.08E+00	Yes
Mercury*	1.79E+00	7.46E-02	1.70E-03	8.57E-01	Yes
Molybdenum	1.29E+01	3.23E-02	7.37E-04	3.99E-01	Yes
m-Xylene	1.97E-03	1.23E-07	2.81E-09	1.46E-04	No
N, N-Diphenylamine*	1.04E-01	--	--	--	No
Neodymium	5.71E+01	--	--	--	Yes
Nickel*	1.99E+00	--	--	--	Yes
Niobium	5.88E+00	--	--	--	No
Nitrate	2.53E+04	4.45E-02	1.02E-03	1.41E+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-101 Tank Residual Wastes. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-101 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
Nitrite	1.79E+04	7.46E-01	1.70E-02	1.36E+03	Yes
N-Nitroso-N, N-dimethylamine*	1.82E-01	9.28E+00	7.07E-02	--	No
Oxalate	5.95E+02	--	--	--	Yes
o-Xylene	1.08E-03	6.75E-08	1.54E-09	7.35E-05	No
Palladium	1.45E+02	--	--	--	Yes
Pentachlorophenol*	9.95E-02	3.98E-02	3.03E-04	2.87E+01	No
Phenol*	1.77E-01	7.38E-06	1.69E-07	1.61E-02	No
Phosphate	2.35E+02	--	--	--	Yes
Polychlorinated Biphenyls*	4.48E-02	8.96E-02	6.83E-04	--	Yes
Potassium	6.97E+02	--	--	--	Yes
Praseodymium	2.55E+01	--	--	--	No
Rhodium	5.98E+01	--	--	--	Yes
Rubidium	5.59E+01	--	--	--	No
Ruthenium	3.92E+00	--	--	--	Yes
Samarium	7.69E+02	--	--	--	Yes
Selenium*	1.58E-04	--	--	--	Yes
Silicon	1.90E+03	--	--	--	Yes
Silver*	1.20E+02	3.00E-01	6.86E-03	8.82E+00	Yes
Sodium	8.84E+04	--	--	--	Yes
Strontium	2.35E+02	4.90E-03	1.12E-04	3.48E-02	Yes
Sulfate	4.43E+03	--	--	4.43E+00	Yes
Tantalum	8.26E+00	--	--	--	No
Tellurium	1.37E+01	--	--	--	Yes
Thallium*	3.92E+00	--	--	1.72E+01	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-101 Tank Residual Wastes. (4 sheets)

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-101 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
Thorium	6.30E+01	--	--	--	No
Tin	7.98E+00	1.66E-04	3.80E-06	1.66E-04	No
Titanium	2.87E+00	--	--	--	No
Tributyl phosphate	9.93E-01	8.94E-03	6.81E-05	2.00E+00	Yes
Tritium	2.83E-03	--	--	--	No
Tungsten	8.45E+01	--	--	--	Yes
Uranium	1.82E+05	7.58E+02	1.73E+01	6.74E+02	Yes
Vanadium	2.25E+00	5.63E-03	1.29E-04	1.41E-03	No
Xylenes	4.78E-04	2.99E-08	6.83E-10	3.27E-05	No
Yttrium	2.34E+00	--	--	--	No
Zinc	4.83E+01	2.01E-03	4.60E-05	8.09E-03	Yes
Zirconium	4.10E+01	--	--	--	Yes

[a] 95% Upper Confidence Level Concentration = Mean Concentration + (1.96 × Mean Concentration × Relative Standard Deviation). Mean Concentrations and Relative Standard Deviation provided in Table A-1, Appendix A of RPP-RPT-58803, "Tank 241-C-101 Residual Waste Inventory Estimates for Component Closure Risk Assessment."

* 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-101 Tank Residual Wastes. (3 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-101 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
1, 1, 2-Trichloroethylene	4.26E-03	1.96E-04	2.43E-06	6.77E-01	No
1, 4-Dichlorobenzene	5.73E-01	3.09E-03	2.36E-05	4.29E+00	No
2-Butanone(MEK)	6.93E-02	1.44E-06	3.30E-08	3.53E-03	No
2-Propanone (Acetone)	7.77E-02	1.08E-06	2.47E-08	2.69E-03	No
4-Methyl-2-pentanone (MIBK)	6.03E-02	9.42E-06	2.15E-07	2.21E-02	No
Acetate	4.07E+02	--	--	--	Yes
Aluminum	2.10E+05	2.62E+00	5.99E-02	4.37E-01	Yes
Ammonia	1.01E+01	--	--	--	Yes
Antimony*	2.45E+00	--	--	--	No
Arsenic*	1.96E+01	2.94E+01	2.24E-01	5.76E+02	No
Barium*	8.55E+01	--	--	--	Yes
Benzo[a]pyrene*	7.53E-01	5.50E+00	4.19E-02	3.24E+00	No
Beryllium*	2.94E+00	1.84E-02	4.20E-04	4.66E-02	No
Bismuth	1.76E+01	--	--	--	No
Boron	1.78E+00	1.11E-04	2.54E-06	8.69E-03	Yes
Bromide	8.85E+01	--	--	--	No
Butylbenzylphthalate*	1.53E+00	2.90E-03	2.21E-05	1.18E-01	Yes
Cadmium*	2.84E+00	3.55E-02	8.11E-04	4.11E+00	Yes
Calcium	8.39E+02	--	--	--	Yes
Cerium	1.52E+02	--	--	--	Yes
Chloride	5.88E+02	--	--	5.88E-01	Yes
Chromium, Total*	1.93E+02	1.61E-03	3.68E-05	9.65E-02	Yes
Cobalt	4.19E+00	1.74E-01	3.99E-03	9.64E-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-101 Tank Residual Wastes. (3 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-101 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
Copper	2.97E+02	9.28E-02	2.12E-03	1.04E+00	Yes
Cyanide*	5.45E+02	1.14E+01	2.60E-01	5.62E+02	Yes
Di (2-ethylhexyl) phthalate (DEHP)	2.73E+00	3.82E-02	2.91E-04	2.04E-01	Yes
Dibenz[a, h]anthracene*	3.27E-01	2.39E-01	1.82E-03	7.62E-02	No
Diethyl phthalate*	1.57E+00	2.46E-05	5.61E-07	2.18E-02	No
Europium	2.94E+00	--	--	--	No
Fluoride	5.12E+02	1.07E-01	2.44E-03	1.77E-01	Yes
Formate+A2	4.61E+02	--	--	--	Yes
Glycolate C2H3O3	9.45E+01	--	--	--	No
Hexachlorobenzene*	6.81E-01	1.09E+00	8.30E-03	7.76E+00	No
Hydroxide OH	1.03E+00	--	--	--	Yes
Iron	9.69E+03	1.73E-01	3.95E-03	1.72E+00	Yes
Lanthanum	3.05E+01	--	--	--	Yes
Lead*	3.48E+02	--	3.48E-01	1.16E-01	Yes
Lithium	1.53E+01	9.55E-02	2.18E-03	7.95E-02	Yes
Magnesium	1.43E+02	--	--	--	Yes
Manganese	2.34E+03	2.09E-01	4.78E-03	4.67E+00	Yes
Mercury*	3.08E+00	1.28E-01	2.93E-03	1.47E+00	Yes
Molybdenum	1.69E+01	4.23E-02	9.67E-04	5.24E-01	Yes
m-Xylene	5.91E-03	3.69E-07	8.44E-09	4.38E-04	No
N, N-Diphenylamine*	3.12E-01	--	--	--	No
Neodymium	8.28E+01	--	--	--	Yes
Nickel*	2.41E+00	--	--	--	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-101 Tank Residual Wastes. (3 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-101 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
Niobium	1.76E+01	--	--	--	No
Nitrate	3.09E+04	5.43E-02	1.24E-03	1.71E+02	Yes
Nitrite	2.26E+04	9.43E-01	2.15E-02	1.71E+03	Yes
N-Nitroso-N, N-dimethylamine*	5.46E-01	2.78E+01	2.12E-01	--	No
Oxalate	7.57E+02	--	--	--	Yes
o-Xylene	3.24E-03	2.03E-07	4.63E-09	2.20E-04	No
Palladium	1.72E+02	--	--	--	Yes
Pentachlorophenol*	2.99E-01	1.19E-01	9.10E-04	8.61E+01	No
Phenol*	5.31E-01	2.21E-05	5.06E-07	4.83E-02	No
Phosphate	1.89E+04	--	--	--	Yes
Polychlorinated Biphenyls*	8.23E-02	1.65E-01	1.25E-03	--	Yes
Potassium	9.42E+02	--	--	--	Yes
Praseodymium	7.65E+01	--	--	--	No
Rhodium	6.90E+01	--	--	--	Yes
Rubidium	1.68E+02	--	--	--	No
Ruthenium	1.18E+01	--	--	--	Yes
Samarium	8.89E+02	--	--	--	Yes
Selenium*	2.67E-04	--	--	--	Yes
Silicon	2.53E+03	--	--	--	Yes
Silver*	1.33E+02	3.33E-01	7.62E-03	9.81E+00	Yes
Sodium	1.02E+05	--	--	--	Yes
Strontium	2.90E+02	6.04E-03	1.38E-04	4.29E-02	Yes
Sulfate	6.32E+03	--	--	6.32E+00	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-101 Tank Residual Wastes. (3 sheets)

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-101 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	2.48E+01	--	--	--	No
Tellurium	1.60E+01	--	--	--	Yes
Thallium*	1.18E+01	--	--	5.16E+01	No
Thorium	1.89E+02	--	--	--	No
Tin	2.39E+01	4.99E-04	1.14E-05	4.98E-04	No
Titanium	8.61E+00	--	--	--	No
Tributyl phosphate	1.12E+00	1.01E-02	7.66E-05	2.25E+00	Yes
Tritium	8.49E-03	--	--	--	No
Tungsten	9.95E+01	--	--	--	Yes
Uranium	1.97E+05	8.21E+02	1.88E+01	7.30E+02	Yes
Vanadium	6.75E+00	1.69E-02	3.86E-04	4.22E-03	No
Xylenes	1.43E-03	8.96E-08	2.05E-09	9.80E-05	No
Yttrium	7.02E+00	--	--	--	No
Zinc	6.23E+01	2.60E-03	5.93E-05	1.04E-02	Yes
Zirconium	7.22E+01	--	--	--	Yes

[a] 95% Upper Confidence Level Concentration = Mean Concentration + (1.96 × Mean Concentration × Relative Standard Deviation). Mean Concentrations and Relative Standard Deviation provided in Table A-1, Appendix A of RPP-RPT-58803, "Tank 241-C-101 Residual Waste Inventory Estimates for Component Closure Risk Assessment."

* 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. (2 sheets)

Analyte Name	Analyte Symbol	Analyte Class	Units	Lognormal 90th Percentile Background Value	Maximum Background Value	Source of Background Value
Aluminum	Al	Metal	µg/kg	1.18E+07	28,800,000	DOE/RL-96-12, Rev. 0
Ammonia	NH3	Anion	µg/kg	9,230	26,400	DOE/RL-96-12, Rev. 0
Antimony*	An	Metal	µg/kg	130	385	DOE/RL-96-12, Rev. 0
Arsenic*	Ar	Metal	µg/kg	6,470	27,700	DOE/RL-96-12, Rev. 0
Barium*	Ba	Metal	µg/kg	132,000	480,000	DOE/RL-96-12, Rev. 0
Beryllium*	Be	Metal	µg/kg	1,510	10,000	DOE/RL-96-12, Rev. 0
Boron	Bo	Metal	µg/kg	3,890	5,860	DOE/RL-96-12, Rev. 0
Cadmium*	Cd	Metal	µg/kg	563	2,900	DOE/RL-96-12, Rev. 0
Calcium	Ca	Metal	µg/kg	1.72E+07	105,000,000	DOE/RL-96-12, Rev. 0
Cesium-137	Cs-137	RAD	pCi/g	1.1	1.6	DOE/RL-96-12, Rev. 0
Chloride	Cl	Anion	µg/kg	100,000	1,480,000	DOE/RL-96-12, Rev. 0
Chromium	Cr	Metal	µg/kg	18,500	320,000	DOE/RL-96-12, Rev. 0
Cobalt	Co	Metal	µg/kg	15,700	110,000	DOE/RL-96-12, Rev. 0
Cobalt-60	Co-60	RAD	pCi/g	0.0084	0.039	DOE/RL-96-12, Rev. 0
Copper	Cu	Metal	µg/kg	22,000	61,000	DOE/RL-96-12, Rev. 0
Europium-154	Eu-154	RAD	pCi/g	0.033	0.079	DOE/RL-92-24, Vol. 1, Rev. 4
Europium-155	Eu-155	RAD	pCi/g	0.054	0.1	ECF-HANFORD-11-0038
Fluoride	Fl	Anion	µg/kg	2,810	73,300	DOE/RL-92-24, Vol. 1, Rev. 4
Gross Beta	--	RAD	pCi/g	23	25	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	ECF-HANFORD-11-0038
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	DOE/RL-92-24, Vol. 1, Rev. 4
Molybdenum	Mo	Metal	µg/kg	470	3,170	DOE/RL-92-24, Vol. 1, Rev. 4
Nickel*	Ni	Metal	µg/kg	19,100	200,000	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

Table D-12. Background Data for Selected Constituents for the Hanford Site. (2 sheets)

Analyte Name	Analyte Symbol	Analyte Class	Units	Lognormal 90th Percentile Background Value	Maximum Background Value	Source of Background Value
Phosphate	PO_4	Anion	µg/kg	785	225,000	ECF-HANFORD-11-0038
Plutonium-238	Pu-238	RAD	pCi/g	0.0038	0.019	DOE/RL-92-24, Vol. 1, Rev. 4
Plutonium-239/240	Pu-239-240	RAD	pCi/g	0.025	0.033	DOE/RL-92-24, Vol. 1, Rev. 4
Potassium	K	Metal	µg/kg	2.15E+06	7,900,000	ECF-HANFORD-11-0038
Potassium-40	K-40	RAD	pCi/g	17	20	ECF-HANFORD-11-0038
Radium-226	Ra-226	RAD	pCi/g	0.82	1.2	ECF-HANFORD-11-0038
Selenium*	Se	Metal	µg/kg	780	840	ECF-HANFORD-11-0038
Silver*	Ag	Metal	µg/kg	167	273	Ecology Publication #94-115
Sodium	Na	Metal	µg/kg	690,000	6,060,000	ECF-HANFORD-11-0038
Strontium-90	Sr-90	RAD	pCi/g	0.18	0.37	DOE/RL-92-24, V.1, Rev.4
Sulfate	SO_4	Anion	µg/kg	237,000	12,600,000	ECF-HANFORD-11-0038
Thallium*	Th	Metal	µg/kg	185	523	Isotopic Activity Conversion based on DOE/RL-96-12 values
Thorium-232	Th-232	RAD	pCi/g	1.3	1.6	DOE/RL-92-24, Vol. 1, Rev. 4
Total beta radiostrontium	--	RAD	pCi/g	0.18	0.37	DOE/RL-92-24, Vol. 1, Rev. 4
Uranium	U	Metal	µg/kg	3,210	4,042	DOE/RL-92-24, Vol. 1, Rev. 4
Uranium-233/234	U-233/234	RAD	pCi/g	1.1	1.5	DOE/RL-92-24, Vol. 1, Rev. 4
Uranium-234	U-234	RAD	pCi/g	1.1	1.5	DOE/RL-92-24, Vol. 1, Rev. 4
Uranium-235	U-235	RAD	pCi/g	0.11	0.39	DOE/RL-92-24, Vol. 1, Rev. 4
Vanadium	V	Metal	µg/kg	85,100	140,000	DOE/RL-92-24, Vol. 1, Rev. 4
Zinc	Zn	Metal	µg/kg	67,800	366,000	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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