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ENGINEERING CHANGE NOTICE

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1. ECN 635600

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental [] Direct Revision [X] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	Jim G. Field, Data Assessment and Interpretation, R2-12, 376-3753	[] Yes [X] No	03/23/98
	6. Project Title/No./Work Order No.	7. Bldg./Sys./Fac. No.	8. Approval Designator
	Tank 241-U-112	241-U-112	N/A
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.)	10. Related ECN No(s).	11. Related PO No.
	HNF-SD-WM-ER-720, Rev. 0	N/A	N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change — 13b. Design Baseline Document? [] Yes [X] No

The document has been totally revised to include the results of recent sampling to address technical issues associated with the waste, and to update the best basis standard inventory.

14a. Justification (mark one)

Criteria Change	[X]	Design Improvement	[]	Environmental	[]	Facility Deactivation	[]
As-Found	[]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

14b. Justification Details

Changes required to incorporate new sampling data.

15. Distribution (include name, MSIN, and no. of copies)

See attached distribution.

RELEASE STAMP

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ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1) ECN-635600

16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[] $	Additional	[] $	Improvement	[]
[X] No	Savings	[] $	Savings.	[] $	Delay	[]

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
N/A		

21. Approvals

	Signature	Date		Signature	Date
Design Authority			Design Agent		
Cog. Eng. J.G. Field	J G Field	5/28/98	PE		
Cog. Mgr. K.M. Hall	Kathleen M. Hall	5/28/98	QA		
QA			Safety		
Safety			Design		
Environ.			Environ.		
Other J.W. Cammann	J.W. Cammann	5/28/98	Other		
R.J. Cash	[signature] for RJC	5/28/98	DEPARTMENT OF ENERGY		
			Signature or a Control Number that tracks the Approval Signature		
J.G. Kristofzski	[signature]	5/28/98	ADDITIONAL		

S

Tank Characterization Report for Single-Shell Tank 241-U-112

Jim G. Field
Lockheed Martin Hanford Corp., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-87RL10930

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Key Words: Waste Characterization, Single-Shell Tank, SST, Tank 241-U-112, Tank U-112, U-112, U Farm, Tank Characterization Report, TCR, Waste Inventory, TPA Milestone M-44

Abstract: This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-U-112. This report supports the requirements of the Tri-Party Agreement Milestone M-44-15B.

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Revision 1

Tank Characterization Report for Single-Shell Tank 241-U-112

J. G. Field
S. R. Wilmarth
Lockheed Martin Hanford Corp.

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Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Fluor Daniel Hanford, Inc.
P.O. Box 1000
Richland, Washington

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LIST OF TERMS

1C	first cycle decontamination waste
AES	atomic emission spectroscopy
ANOVA	analysis of variance
Btu/hr	British thermal units per hour
Ci	curie
Ci/L	curies per liter
cm	centimeter
CEO	Change Engineering Order
CWR	REDOX cladding waste
CWR1	REDOX cladding waste from 1952 to 1960
CW	Cladding waste
DQO	data quality objective
DSC	differential scanning calorimetry
ft	feet
g	gram
g/cc	grams per cubic centimeter
g/L	grams per liter
g/mL	grams per milliliter
HDW	Hanford defined waste
HHF	hydrostatic head fluid
HTCE	historical tank content estimate
IC	ion chromatography
ICP	inductively coupled plasma spectroscopy
in.	inch
J/g	joules per gram
kg	kilogram
kg/L	kilograms per liter
kgal	kilogallon
kL	kiloliter
kW	kilowatt
LFL	lower flammability limit
L	liter
LL	lower limit
m	meter
m^2	square meters
M	moles per liter
mg/g	milligrams per gram
mg/L	milligrams per liter
mm	millimeter
MOU	memorandum of understanding

LIST OF TERMS (Continued)

n/a	not applicable
n/r	not reported
PHMC	Project Hanford Management Contractor
ppm	parts per million
QC	quality control
R1	REDOX high-level waste from 1952 to 1957
REML	restricted maximum likelihood estimation
REDOX	reduction-oxidation
R/CWR	REDOX high-level waste/REDOX cladding waste
RPD	relative percent difference
SAP	sampling and analysis plan
SMM	supernatant mixing model
TCD	Tank Characterization Database
TGA	thermogravimetric analysis
TLM	tank layer model
TOC	total organic carbon
TSAP	Tank Safety Analysis Plan
TWRS	Tank Waste Remediation System
UL	upper limit
W	watt
WSTRS	Waste Status and Transaction Record Summary
WTR	flushwater from miscellaneous sources
wt%	weight percent
%	percent
°C	degrees Celsius
°F	degrees Fahrenheit
µCi/g	microcuries per gram
µCi/mL	microcuries per milliliter
µeg/g	microequivalents per gram
µg/g	micrograms per gram

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1.0 INTRODUCTION

A major function of the Tank Waste Remediation System (TWRS) is to characterize waste in support of waste management and disposal activities at the Hanford Site. Analytical data from sampling and analysis and other available information about a tank are compiled and maintained in a tank characterization report (TCR). This report and its appendixes serve as the TCR for single-shell tank 241-U-112. The objectives of this report are 1) to use characterization data in response to technical issues associated with tank 241-U-112 waste, and 2) to provide a standard characterization of this waste in terms of a best-basis inventory estimate. Section 2.0 summarizes the response to technical issues, Section 3.0 shows the best-basis inventory estimate, Section 4.0 makes recommendations about the safety status of the tank and additional sampling needs. The appendixes contain supporting data and information. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1997), Milestone M-44-15b, change request M-44-97-03 to "issue characterization deliverables consistent with the Waste Information Requirements Document developed for 1998."

1.1 SCOPE

The characterization information in this report originated from sample analyses and known historical sources. The results of recent sample events will be used to fulfill the requirements of the data quality objectives (DQOs) and memorandums of understanding (MOUs) specified in Brown et al. (1997) for this tank. Other information can be used to support conclusions derived from these results. Appendix A contains historical information for tank 241-U-112 including surveillance information, records pertaining to waste transfers and tank operations, and expected tank contents derived from a process knowledge model. Appendix B summarizes recent sampling events (see Table 1-1), sample data obtained before 1989, and sampling results. Appendix C reports the statistical analysis and numerical manipulation of data used in issue resolution. Appendix D contains the evaluation to establish the best basis for the inventory estimate and the statistical analysis performed for this evaluation. Appendix E is a bibliography that resulted from an in-depth literature search of all known information sources applicable to tank 241-U-112 and its respective waste types. The reports listed in Appendix E are available in the Tank Characterization and Safety Resource Center.

Table 1-1. Summary of Recent Sampling.

Sample/Date[1]	Phase	Location	Segmentation	% Recovery
Vapor samples[2] and Combustible Gas Test (7/09/96)	Gas	Tank headspace, Riser 11, 6 m (20 ft) below top of riser	n/a	n/a
Push core[3] (9/12/97)	Solid	Riser 3	One segment (upper and lower half)	65 percent, 28 cm (11 in.) solids
Push core[3] (9/19/97)	Solid	Riser 6	One segment (upper and lower half)	69 percent, 20 cm (7.9 in.) solids

Note:

n/a = not applicable

[1]Dates are in the mm/dd/yy format.
[2]Evans et al. (1997)
[3]Steen (1997)

1.2 TANK BACKGROUND

Tank 241-U-112 was filled with first-cycle decontamination waste from the bismuth phosphate processes from the fourth quarter of 1947 until the second quarter of 1948. In 1952 waste was transferred to tank 241-TX-118. Tank 241-T-105 received REDOX high-level waste in 1954 and water in 1956. Waste was again transferred in 1970. The tank was removed from service in 1975 and labeled an assumed leaker 32,200 L (8,500 gal) in 1980. The tank was administratively interim stabilized in September 1979 and intrusion prevention was completed in December 1982. A salt well pump was installed in 1974 and pumping was completed in 1978. The tank level was adjusted in June 1976, April 1982, and February 1984 (Agnew 1997b).

Table 1-2 summarizes the description of tank 241-U-112. The tank has an operating capacity of 2,010 kL (530 kgal), and presently contains an estimated 170 kL (45 kgal) of noncomplexed waste, based on tank surface level measurements. The tank is not on the Watch List (Public Law 101-510).

Table 1-2. Description of Tank 241-U-112.

TANK DESCRIPTION	
Type	Single-Shell
Constructed	1943-1944
In service	1947
Diameter	22.9 m (75 ft)
Operating depth	5.2 m (17 ft)
Capacity	2,010 kL (530 kgal)
Bottom shape	Dish
Ventilation	Passive
TANK STATUS	
Waste classification	Non-complexed
Total waste volume[1]	170 kL (45 kgal)
Supernatant volume[1]	0 kL (0 kgal)
Saltcake volume	0 kL (0 kgal)
Sludge volume	170 kL (45 kgal)
Drainable interstitial liquid volume	0 kL (0 kgal)
Waste surface level (October 16, 1997)[2]	31.1 cm (12.25) in
Temperature (Nov. 30, 1996 to Nov. 30, 1997)	14.6 °C (58.3 °F) to 20.8 °C (69.4 °F)
Integrity	Assumed leaker
Watch List	None
Flammable Gas Facility Group	3
SAMPLING DATE	
Push Core Samples	September, 1997
Vapor Samples	July, 1996
SERVICE STATUS	
Declared inactive	1976
Interim stabilization	1979
Intrusion prevention	1982

Notes:

[1]Based on sample observations and tank surface level measurements, differs from Hanlon (1998)

[2]Last measured date before November 30, 1997

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2.0 RESPONSE TO TECHNICAL ISSUES

The following technical issues have been identified for tank 241-U-112 (Brown et al. 1997).

- **Safety screening**: Does the waste pose or contribute to any recognized potential safety problems?
- **Organic complexants**: Does the possibility exist for a point source ignition in the waste followed by a propagation of the reaction in the solid/liquid phase of the waste?
- **Hazardous vapor screening**: Do hazardous storage conditions exist associated with gases and vapors in the tank?
- **Organic solvents**: Does an organic solvent pool exist that may cause a fire or ignition of organic solvents in entrained waste solids?

The sampling and analysis plan (SAP) (Field 1997) provides the types of sampling and analysis used to address the above issues. Data from the analysis of push core samples and tank vapor space measurements, along with available historical information, provided the means to respond to the technical issues. Sections 2.1 and 2.2 present the response. Data from the July 1996 vapor sample provided the means to address the vapor screening issue. See Appendix B for sample and analysis data for tank 241-U-112.

2.1 SAFETY SCREENING

The data needed to screen the waste in tank 241-U-112 for potential safety problems are documented in *Tank Safety Screening Data Quality Objective*, (Dukelow et al. 1995). These potential safety problems in the waste are exothermic conditions, flammable gases and/or tank headspace, and criticality conditions. Each condition is addressed separately below.

2.1.1 Exothermic Conditions (Energetics)

The first requirement outlined in the safety screening DQO (Dukelow et al. 1995) is to ensure that there are not sufficient exothermic constituents (organic or ferrocyanide) in tank 241-U-112 to pose a safety hazard. Because of this requirement, energetics in tank 241-U-112 waste were evaluated. The safety screening DQO required that the waste sample profile be tested for energetics every 24 cm (9.5 in.) to determine whether the energetics exceeded the safety threshold limit. The threshold limit for energetics is 480 J/g on a dry weight basis. Results obtained using differential scanning calorimetry (DSC) indicated that no exotherms were found in any of the samples obtained from tank 241-U-112.

2.1.2 Flammable Gas

Combustible gas tests (sniff tests) were conducted before the September 1997 push core sample event and before the July 1996 vapor samples were obtained. The flammable gas measurements in the tank headspace in 1996 and 1997 were respectively 2 percent and 0 percent of the lower flammability limit [LFL]). This is below the safety screening limit of 25 percent of the LFL. Combustible gas test results and vapor sample data are presented in Appendix B.

2.1.3 Criticality

The safety screening DQO threshold for criticality, based on the total alpha activity, is 1 g/L. Because total alpha activity is measured in μCi/mL instead of g/L, the 1 g/L limit is converted into units of μCi/mL by assuming that all alpha decay originates from ^{239}Pu. The safety threshold limit is 1 g ^{239}Pu per liter of waste. Assuming that all alpha is from ^{239}Pu for a measured density of 1.86 g/mL, 1 g/L of ^{239}Pu is 33.1 μCi/g of alpha activity. The maximum total alpha activity result was $<$0.00395 μCi/g (core 220, segment 1), well below the limit. Therefore, criticality is not a concern for this tank.

2.2 ORGANIC COMPLEXANTS

The data required to support the issue of organic complexants are documented in *Memorandum of Understanding for the Organic Complexant Safety Issue Data Requirements* (Schreiber 1997). Energetics by DSC, and sample moisture analyses were conducted to address the organic complexants issue. This issue is expected to be closed in fiscal year 1998.

The tank is classified as safe for the organic complexants issue, because no exotherms were observed in the samples. Because no exotherms were observed, total organic carbon (TOC) analyses were not conducted.

2.3 HAZARDOUS VAPOR SAFETY SCREENING

The data required to support vapor screening are documented in *Data Quality Objective for Tank Hazardous Vapor Safety Screening* (Osborne and Buckley 1995). The vapor screening DQO addresses two issues: 1) does the vapor headspace exceed 25 percent of the LFL, if so, what are the principal fuel components; and 2) does the potential exist for worker hazards associated with the toxicity of constituents in any fugitive vapor emissions from these tanks?

2.3.1 Flammable Gas

This is the same requirement as the safety screening flammability requirement. As noted previously, flammable gas measurements in the tank headspace showed 2 percent of the LFL in 1996 and 0 percent in 1997. This is below the limit of 25 percent of the LFL.

2.3.2 Toxicity

The vapor screening DQO requires the analysis of ammonia, carbon dioxide (CO_2), carbon monoxide (CO), nitric oxide (NO), nitrous oxide (N_2O), and nitrogen dioxide (NO_2) from a sample. The vapor screening DQO specifies a threshold limit for each of these compounds. Data from the July, 1996 vapor sampling event (Evans et al. 1997) were used to address the issue of toxicity. All of the analytes were within the threshold limits, except ammonia (see Appendix B). The toxicity issue has been closed for all tanks (Hewitt 1996).

2.4 ORGANIC SOLVENTS SAFETY SCREENING

The data required to support the organic solvent screening issue are documented in the *Data Quality Objective to Support Resolution of the Organic Solvent Safety Issue* (Meacham et al. 1997). The DQO requires tank headspace samples be analyzed for total nonmethane organic compounds to determine whether the organic extractant pool in the tank is a hazard. The purpose of this assessment is to ensure that an organic solvent pool fire or ignition of organic solvents cannot occur. This issue is expected to be closed in fiscal year 1998.

Analytical results showed that the concentration of total nonmethane organic compounds was 2.03 mg/m^3. (Evans et al. 1997). This equates to a 0.10 m^2 organic solvent surface area, below the 1 m^2 limit

2.5 OTHER TECHNICAL ISSUES

A factor in assessing tank safety is the heat generation and temperature of the waste. Heat is generated in the tanks from radioactive decay. An estimate of the tank heat load based on the best-basis inventory results (Appendix D) was 545 W (1,860 Btu/hr). The heat load estimate based on the tank process history was 184 W (629 Btu/hr) (Agnew et al. 1997a) and the heat load based on tank temperature measurements was 507 W (1,730 Btu/hr) (Kummerer 1995). All of these estimates are well below the limit of 11,700 W (40,000 Btu/hr) that separates high- and low-heat-load tanks (Smith 1986).

2.6 SUMMARY

The results of all analyses performed to address potential safety issues showed that primary analytes did not exceed safety screening threshold limits and sampling and analytical requirements for all applicable DQO's and tank issues were met. The results are summarized in Table 2-1.

Table 2-1. Summary of Tank 241-U-112 Issues.

Issue	Sub-issue	Results
Safety screening	Energetics	No exotherms detected
	Flammable gas	Combustible gas tests showed a flammable gas reading of 2 percent of the lower flammability limit - below the threshold of 25 percent of the lower flammability limit.
	Criticality	All samples were < 0.00395 μCi/g, well below the limited 33.1 μCi/g total alpha.
Organic complexants[1]	Total organic carbon	No exotherms observed.
	Moisture	Average 26 percent.
Hazardous vapor	Flammability	2 percent of the LFL
	Toxicity	Ammonia 308 ppmv, exceeded 150 ppmv threshold.
Organic solvent[1]	Estimated solvent pool size	Total non-methane organic compounds 2.03 mg/m^3, equates to 0.10 m^2 organic solvent surface area - below the 1 m^2 limit

Note:

[1]The organic complexants and organic solvent safety issues are expected to be closed in fiscal year 1998.

3.0 BEST-BASIS STANDARD INVENTORY ESTIMATE

Information about chemical, radiological, and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessment associated with waste management activities, as well as regulatory issues. These activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes, and facilities for retrieving wastes and processing them into a form that is suitable for long-term storage/disposal.

Chemical and radiological inventory information are generally derived using three approaches: (1) component inventories are estimated using the results of sample analyses, (2) component inventories are predicted using the Hanford defined waste (HDW) model based on process knowledge and historical information, or (3) a tank-specific process estimate is made based on process flowsheets, reactor fuel data, essential material usage, and other operating data.

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of chemical information for tank 241-U-112 was performed. The evaluation included the following information:

- Two core samples obtained in September 1997.
- The inventory estimate generated by the HDW model (Agnew et al. 1997a)
- An engineering evaluation to estimate the sludge inventory based on evaluation of process knowledge previously gathered about the R/CWR and 1C waste types.

Based on this evaluation, a best-basis inventory was developed for tank 241-U-112 (Tables 3-1 and 3-2). Samples taken from above the dish portion of tank 241-U-112 were entirely R/CWR waste. An engineering assessment based on sample results for other tanks was used to calculate the inventory for the 1C waste layer assumed to be in the bottom of the tank. The total inventory is a combination of these two assessments. A combination of sample data and the engineering assessment determination was chosen as the best basis for analytes for which sample data was available. Hanford defined waste model inventory values were used for those analytes for which sample values and engineering assessment tests were not available. Engineering assessment values were selected for trace analytes with little supporting sample data. The inventory values reported in Tables 3-1 and 3-2 are subject to change. Refer to the Tank Characterization Database (TCD) for the most current inventory values (LMHC 1998).

Best-basis tank inventory values are derived for 46 key radionuclides (as defined in Section 3.1 of Kupfer et al. 1997), all decayed to a common report date of January 1, 1994. Often, waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, and total uranium (or total beta and total alpha), while other key radionuclides such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, have been infrequently reported. For this reason it has been necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various plant waste streams, and track their movement with tank waste transactions. These computer models are described in Kupfer et al. (1997), Section 6.1 and in Watrous and Wootan (1997). Model generated values for radionuclides in any of 177 tanks are reported in the HDW Rev. 4 model results (Agnew et al. 1997a). The best-basis value for any one analyte may be either a model result or a sample or engineering assessment-based result, if available.

Uranium isotope inventories were based on total uranium inductively coupled plasma spectroscopy (ICP) values ratioed to HDW model values. Alpha isotope inventories were based on average total alpha analytical results (0.00329 μCi/g) and engineering estimates of the alpha content of the K waste, ratioed to HDW model values.

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-U-112 (Effective January 31, 1998). (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, C, or E)[1]	Comment
Al	40,600	S/E	
Bi	1,110	S/E	1C waste only, none expected in CWR waste
Ca	524	S/E	
Cl	172	S/E	
TIC as CO_3	1,510	E	
Cr	123	S/E	
F	2,340	S/E	
Fe	1,390	S/E	Upper-bound. Sample value was "less than detect."
Hg	14.6	E	Change package #7 (Simpson 1998)
K	117	E	
La	0	E	None expected in CWR and 1C wastes
Mn	53.4	E	
Na	22,100	S/E	
Ni	31.5	E	
NO_2	1,170	S/E	
NO_3	16,300	S/E	
OH_{total}	76,700	C	Calculated from charge balance.

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-U-112 (Effective January 31, 1998). (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, C, or E)[1]	Comment
Pb	462	S/E	Upper-bound. Sample value was "less than detect."
PO_4	20,500	S/E	Sample results based on IC analysis.
Si	721	S/E	Upper-bound. Sample value was "less than detect."
SO_4	836	S/E	Sample results based on IC analysis.
Sr	461	S/E	1C waste only. Sr unexpected in CWR waste.
TOC	458	E	
U_{TOTAL}	2,620	E	
Zr	51.6	S/E	Upper-bound. Sample value was "less than detect."

Note:

[1]S = sample-based (see Appendix B), E = engineering assessment-based, M = Hanford defined waste model-based (Agnew et al. 1997a), and C = calculated by charge balance; includes oxides as hydroxides, not including CO_3, NO_2, NO_3, PO_4, SO_4, and SiO_3.

Table 3-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-U-112. Decayed to January 1, 1994 (Effective January 31, 1998). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	0.839	M	
^{14}C	0.0729	M	
^{59}Ni	0.397	M	
^{60}Co	0.0262	M	
^{63}Ni	37.1	M	
^{79}Se	0.0155	M	
^{90}Sr	67,600	E	
^{90}Y	67,600	E	Based on ^{90}Sr activity.
^{93}Zr	0.0732	M	
^{93m}Nb	0.0603	M	
^{99}Tc	0.51	M	
^{106}Ru	7.24E-08	M	
^{113m}Cd	0.215	M	
^{125}Sb	0.0373	M	
^{126}Sn	0.0237	M	
^{129}I	9.76E-04	M	
^{134}Cs	7.7E-04	M	
^{137}Cs	19,100	E	
^{137m}Ba	18,100	E	Based on 0.946 of ^{137}Cs activity.
^{151}Sm	55.7	M	
^{152}Eu	0.19	M	
^{154}Eu	0.618	M	
^{155}Eu	9.1	M	
^{226}Ra	2.96E-05	M	
^{227}Ac	1.31E-04	M	
^{228}Ra	2.66E-10	M	
^{229}Th	5.05E-08	M	
^{231}Pa	2.97E-05	M	
^{232}Th	1.86-11	M	
^{232}U	1.44E-05	S/M	Based on ICP U Sample result ratioed to HDW estimates for U isotopes
^{233}U	7.35E-07	S/M	Based on ICP U Sample result ratioed to HDW estimates for U isotopes

Table 3-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-U-112. Decayed to January 1, 1994 (Effective January 31, 1998). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{234}U	0.869	S/M	Based on ICP U Sample result ratioed to HDW estimates for U isotopes
^{235}U	0.0388	S/M	Based on ICP U Sample result ratioed to HDW estimates for U isotopes
^{236}U	7.57E-05	S/M	Based on ICP U Sample result ratioed to HDW estimates for U isotopes
^{237}Np	3.28E-03	M	
^{238}Pu	0.140	S/M	Based on total alpha sample result ratioed to HDW estimates for alpha isotopes
^{238}U	0.875	S/M	Based on ICP U Sample result ratioed to HDW estimates for U isotopes
^{239}Pu	9.54	S/M	Based on total alpha sample result ratioed to HDW estimates for alpha isotopes
^{240}Pu	1.32	S/M	Based on total alpha sample result ratioed to HDW estimates for alpha isotopes
^{241}Am	0.0424	S/M	Based on total alpha sample result ratioed to HDW estimates for alpha isotopes
^{241}Pu	7.86	S/M	Based on total alpha sample result ratioed to HDW estimates for alpha isotopes
^{242}Cm	8.13E-04	S/M	Based on total alpha sample result ratioed to HDW estimates for alpha isotopes
^{242}Pu	3.40E-05	S/M	Based on total alpha sample result ratioed to HDW estimates for alpha isotopes
^{243}Am	3.92E-07	S/M	Based on total alpha sample result ratioed to HDW estimates for alpha isotopes
^{243}Cm	1.86E-05	S/M	Based on total alpha sample result ratioed to HDW estimates for alpha isotopes
^{244}Cm	1.40E-05	S/M	Based on total alpha sample result ratioed to HDW estimates for alpha isotopes

Note:
[1]S = sample-based, M = Hanford defined waste model-based (Agnew et al. (1997a) and E = engineering assessment-based.

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4.0 RECOMMENDATIONS

September, 1997 push core sampling and analyses were conducted to satisfy the safety screening DQO and Organic Complexants MOU. One segment was obtained for each of two cores. Results showed that all safety screening requirements were met and analytical results were well below threshold levels. No exotherms were observed in the samples, consequently the tank was classified as safe for the organic complexants issue.

Vapor samples obtained in July 1996 satisfied the requirements for the Hazardous Vapor Safety Screening DQO and Organic Solvents issue.

Table 4-1 summarizes the Project Hanford Management Contractor (PHMC) TWRS Program review status and acceptance of the sampling and analysis results reported in this TCR. All issues required to be addressed by sampling and analysis are listed in column 1 of Table 4-1. Column 2 indicates by "yes" or "no" whether issue requirements were met by the sampling and analyses performed. Column 3 indicates concurrence and acceptance by the program in PHMC/TWRS that is responsible for the applicable issue. A "yes" in column 3 indicates that no additional sampling or analyses are needed. Conversely, "no" indicates additional sampling or analyses may be needed to satisfy issue requirements.

Table 4-2 summarizes the status of PHMC TWRS Program review and acceptance of the evaluations for characterization information contained in this report. Column 1 lists the different evaluations performed in this report. Column 2 shows whether evaluations have been completed or are or in progress. Column 3 indicates concurrence and acceptance with the evaluation by the program in PHMC/TWRS that is responsible for the applicable issue. A "yes" indicates that the evaluation is completed and meets all issue requirements. A "no" indicates that evaluations are incomplete.

Table 4-1. Acceptance of Tank 241-U-112 Sampling and Analysis.

Issue	Sampling and Analysis Performed	Program[1] Acceptance
Safety screening DQO	Yes	Yes
Organic complexant MOU	Yes	Yes
Hazardous vapor screening DQO	Yes	Yes
Organic solvents DQO	Yes	Yes

Note:

[1]PHMC TWRS Program Office

Table 4-2. Acceptance of Evaluation of Characterization Data and Information for Tank 241-U-112.

Issue	Evaluation Performed	TWRS[1] Program Acceptance
Safety screening DQO	Yes	Yes
Organic complexant MOU[2] (SAFE)	Yes	Yes
Hazardous Vapor Screening DQO	Yes	Yes
Organic solvents DQO[2]	Yes	Yes

Note:

[1]PHMC TWRS Program Office

[2]This issue is expected to be closed in fiscal year 1998.

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APPENDIX A

HISTORICAL TANK INFORMATION

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APPENDIX A

HISTORICAL TANK INFORMATION

Appendix A describes tank 241-U-112 based on historical information. For this report, historical information includes information about the fill history, waste types, surveillance, or modeling data about the tank. This information is necessary for providing a balanced assessment of sampling and analytical results.

This appendix contains the following information:

- **Section A1.0**: Current tank status, including the current waste levels and the tank stabilization and isolation status
- Section A2.0: Information about the tank design
- Section A3.0: Process knowledge about the tank, the waste transfer history and the estimated contents of the tank based on modeling data
- Section A4.0: Surveillance data for tank 241-U-112 including surface-level readings, temperatures, and a description of the waste surface based on photographs
- Section A5.0: References for Appendix A.

A1.0 CURRENT TANK STATUS

As of November 30, 1997, tank 241-U-112 contained an estimated 170 kL (45 kgal) of noncomplexed waste. The waste volumes were estimated using a manual tape surface-level gauge and photographic evaluation. Although Hanlon (1998) includes a 15 kL (4 kgal) supernatant layer, no supernatant was observed in tank samples or in tank zip cord measurements. Table A1-1 shows the volumes of the waste phases found in the tank.

In 1975, tank 241-U-112 was removed from service. It was declared an assumed leaker in 1980, interim stabilized in 1979 and intrusion prevention (interim isolation) was completed in December 1982. The tank is passively ventilated and is not on the Watch List (Public Law 101-510).

Table A1-1. Tank Contents Status Summary.

Waste Type	kL (kgal)
Total waste[1]	170 (45)
Supernatant[1]	0 (0)
Sludge[2]	170 (45)
Saltcake	0 (0)
Drainable interstitial liquid	0 (0)
Drainable liquid remaining	0 (0)
Pumpable liquid remaining	0 (0)

Notes:

[1]Based on surface level measurements, sample based observations (Appendix B), and zip cord readings (work package WS-96-00274 and WS-96-00050).

[2]Hanlon (1998) and Agnew et al. (1997a)

A2.0 TANK DESIGN AND BACKGROUND

The 241-U Tank Farm was constructed during 1943 and 1944 in the 200 West Area. The farm contains twelve 100 series tanks, including tank 241-U-112, and four 200 series tanks. The 100 series tanks have a capacity of 2,010 kL (530 kgal), a diameter of 22.9 m (75.0 ft), and an operating depth of 5.2 m (17 ft) (Hanlon 1998). The 241-U Tank Farm was designed for nonboiling waste with a maximum fluid temperature of 104 °C (220 °F). A cascade overflow line 76 mm (3 in.) in diameter connects tank 241-U-112 as third in a cascade series of three tanks starting with tank 241-U-110. Each tank in the cascade series is set one foot lower in elevation from the preceding tank. The cascade overflow height is approximately 4.9 m (16 ft) from the tank bottom and 610 mm (2 ft) below the top of the steel liner.

Tank 241-U-112 has a dished bottom with a 1.2-m- (4-ft) radius knuckle. It was designed with a primary mild steel liner and a concrete dome with various risers. The tank is set on a reinforced concrete foundation. The tank and foundation were waterproofed by a coating of tar covered by a three-ply, asphalt impregnated, waterproofing fabric. The waterproofing was protected by welded-wire-reinforced gunite. Two coats of primer were sprayed on all exposed interior tank surfaces (Rogers and Daniels 1944). The tank ceiling dome was covered with three applications of magnesium zinc fluorosilicate wash. Lead flashing was used to protect the joint where the steel liner meets the concrete dome. Asbestos gaskets were used to seal the risers in the tank dome. This tank was covered with approximately 2.1 m (7 ft) of overburden.

Tank 241-U-112 has 12 risers according to the drawings and engineering change notices. The risers are either 100 mm (4 in.) or 305 mm (12 in.) in diameter. Table A2-1 shows numbers, diameters, and descriptions of the risers and the nozzles. A plan view that depicts the riser configuration is shown as Figure A2-1. A tank cross-section showing the approximate waste level along with a schematic of the tank equipment is in Figure A2-2.

Instrument access to tank 241-U-112 is through risers fitted into the tank dome. The surface level is measured with a manual tape in riser 8. The waste inlet to the tank consists of horizontal pipes intruding through the tank wall. Waste was transferred from the tank by way of pumps inserted through risers. Because of the size of the pumps used, only the 30.5-cm- (12- in.) diameter risers (risers 2, 3, 6, and 7) could be used for this method. Another method of removing waste, made possible in the mid-1970's, was the use of a salt well pump. This pump was located at riser 13.

A salt well pump was installed in the tank in 1974 and the tank was interim stabilized in 1979 (Hanlon 1998). Tank 241-U-112 was labeled an assumed leaker in 1980. An estimated 32.2 kL (8.5 kgal) of liquid waste leaked from the tank.

Table A2-1. Tank 241-U-112 Risers and Lines.[1]

Number	Diameter (in.)	Description and Comments
1[2]	4	Breather filter [Bench Mark CEO-37534 12/8/86]
2[2]	12	Blind flange
3[2]	12	Blind flange
4	4	Cut and capped, below grade
5	4	Thermocouple tree
6[2]	12	Blind flange
7[2]	12	241-B-222 observation port
8	4	Liquid level reel
13	12	Salt well pump, weather covered
N1	3	Spare, capped
N2	3	Spare, capped
N3	3	Spare, capped
N4	3	Spare, capped
N5	3	Fill line, capped in 20 cm (8 in.) caisson

Notes:

CEO = Change Engineering Order

[1]Alstad (1993), Lipnicki (1997), Tran (1993), and Vitro Engineering Corporation (1986)
[2]Denotes risers tentatively available for sampling

Figure A2-1. Riser Configuration for Tank 241-U-112.

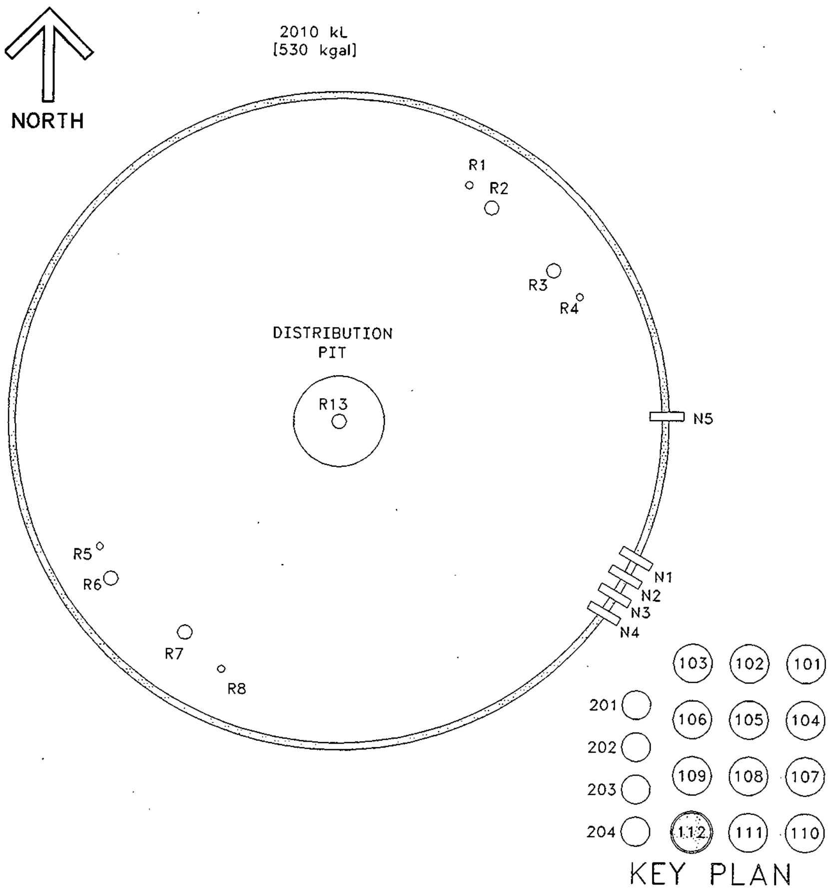
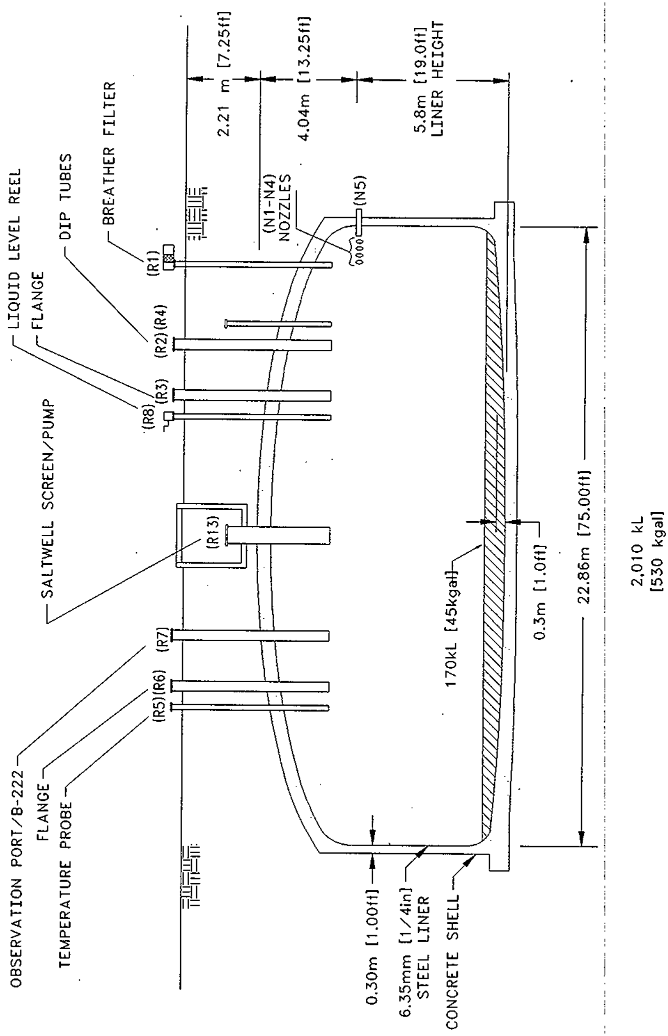


Figure A2-2. Tank 241-U-112 Cross Section and Schematic.



A3.0 PROCESS KNOWLEDGE

The sections below 1) provide information about the transfer history of tank 241-U-112, 2) describe the process wastes that made up the transfers, and 3) estimate the current tank contents based on transfer history.

A3.1 WASTE TRANSFER HISTORY

Table A3-1 summarizes the waste transfer history of tank 241-U-112. Tank 241-U-112 entered service in the fourth quarter of 1947 when it received first-cycle decontamination waste (1C1) by way of the tank cascade (Agnew et al. 1997b). The 1C waste was produced in the bismuth phosphate process and consisted of fission products and aluminum coating waste. Tank 241-U-112 was filled by the second quarter of 1948. No transfers to or from the tank occurred until the second quarter of 1952 when supernatant waste was transferred to tank 241-TX-118. In the first and second quarters of 1954, tank 241-U-112 received REDOX high level waste (R1) from the cascade. The tank received flush water and supernatant wash from tank 241-U-110 in the second quarter of 1956. In the first quarter of 1970 waste was transferred to tank 241-TY-103. Waste was transferred to tank 241-U-109 in the fourth quarter of 1974 and first and third quarters of 1975 after installing a salt well pump. Finally, supernatant was transferred to tank 241-U-111 in the third quarter of 1979.

Table A3-1. Tank 241-U-112 Major Transfers.[1]

Transfer Source	Transfer Destination	Waste Type	Time Period	Estimated Waste Volume	
				kL	kgal
241-U-111		1C	1947 to 1948	2,006	530
	241-TX-118	supernatant	1952	-1,885	-498
241-U-111		1C	1954	1,643	434
		WTR	1956	30.3	8
241-U-110		supernatant	1956	121	32
	241-TY-103	supernatant	1970	-1,582	-418
	241-U-109	supernatant	1974 to 1975	-106	-28
	241-U-111	supernatant	1979	-4	-1

Note:

1C = First Cycle decontamination waste from the Bismuth Phosphate process
WTR = Flush waster from miscellaneous sources

[1]Agnew et al. (1997b)

A3.2 HISTORICAL ESTIMATION OF TANK CONTENTS

The historical transfer data used for this estimate are from the following sources:

- The *Waste Status and Transaction Record Summary: WSTRS, Rev. 4*, (Agnew et al. 1997b) is a tank-by-tank quarterly summary spreadsheet of waste transactions.

- The *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 4* (Agnew et al. 1997a) contains the Hanford defined waste (HDW) list, the supernatant mixing model (SMM), the tank layer model (TLM), and the historical tank content estimate (HTCE).

- The HDW list is comprised of approximately 50 waste types defined by concentration for major analytes/compounds for sludge and supernatant layers.

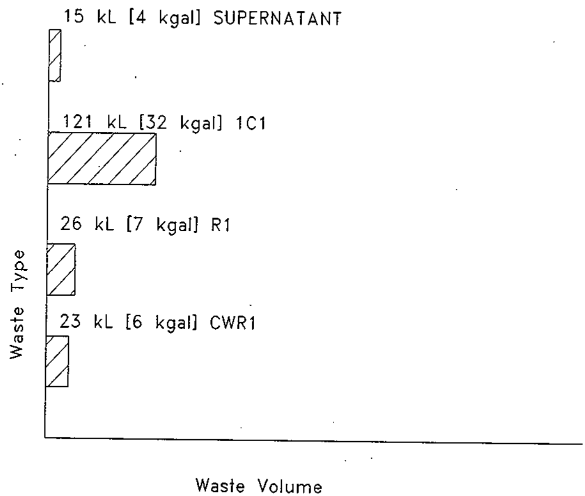
- The TLM defines the sludge and saltcake layers in each tank using waste composition and waste transfer information.

- The SMM is a subroutine within the HDW model that calculates the volume and composition of certain supernatant blends and concentrates.

Using these records, the TLM defines the sludge and saltcake layers in each tank. The SMM uses information from the WSTRS, the TLM, and the HDW list to describe the supernatant and concentrates in each tank. Together the WSTRS, TLM, SMM, and HDW list determine the inventory estimate for each tank. These model predictions are considered estimates that require further evaluation using analytical data.

Based on Agnew et al. (1997a), tank 241-U-112 contains 15 kL (4 kgal) of supernatant and 170 kL (45 kgal) of unknown waste type, assigned as follows: 121 kL (32 kgal) of 1C1, 26 kL (7 kgal) of R1 and 23 kL (6 kgal) of CWR1. Figure A3-1 is a graphical representation of the estimated waste type and volume for the tank layer. The historical tank content estimate model predicts that tank 241-U-112 contains greater than 1 weight percent of sodium, aluminum, iron, hydroxide, nitrate, nitrite, uranium, and phosphate; and between one and 0.1 weight percent of bismuth, lead, calcium, carbonate, sulfate, silicate, ammonia, and fluoride. Tank radioactivity is assumed to be primarily from strontium-90. Table A3-2 shows the historical estimate of the expected waste constituents and their concentrations.

Figure A3-1. Tank Layer Model Volume Estimates.[1]



[1]Although included by Hanlon (1998), no supernatant was observed in tank samples or zip cord measurements. Also, tank samples indicate substantially less 1C waste than predicted by Agnew et al. (1997b)

A4.0 SURVEILLANCE DATA

Tank 241-U-112 surveillance consists of surface-level measurements (liquid and solid) and temperature monitoring inside the tank (waste and headspace) and leak detection well (drywell) monitoring for radioactivity outside the tank. Surveillance data provide the basis for determining tank integrity.

Liquid-level measurements can indicate whether the tank has a major leak. Solid surface-level measurements indicate physical changes in and consistencies of the solid layers of a tank. Drywells located around the tank perimeter may show increased radioactivity because of leaks.

Table A3-2. Historical Tank Inventory Estimate.[1] (3 sheets)

Total Inventory Estimate					
Physical Properties-95 CI+95 CI					
Total Waste	2.69E+05 (kg)	(49.0 kgal)	----	----	----
Heat Load	0.184 (kW)	(629 Btu/hr)	----	0.137	0.203
Bulk Density[2]	1.45 (g/cc)	----	----	1.39	1.52
Water wt%[2]	53.7	----	----	47.4	58.4
TOC wt% C (wet)[2]	0	----	----	0	0
Chemical Constituents	mole/L	ppm	kg	-95 CI (mole/L)	+95 CI (mole/L)
Na+	5.54	8.77E+04	2.36E+04	4.28	6.97
Al3+	2.76	5.13E+04	1.38E+04	2.10	3.35
Fe3+	0.395	1.52E+04	4.09E+03	0.391	0.399
Cr3+	1.23E-02	439	118	4.43E-03	0.155
Bi3+	4.07E-02	5.87E+03	1.58E+03	3.24E-02	4.52E-02
La3+	0	0	0	0	0
Hg2+	5.69E-04	78.6	21.2	5.48E-04	5.80E-04
Zr (as ZrO(OH)2)	1.56E-04	9.81	2.64	1.24E-04	1.89E-04
Pb2+	1.44E-02	2.06E+03	554	1.32E-02	1.54E-02
Ni2+	8.15E-03	330	88.7	6.13E-03	9.59E-03
Sr2+	0	0	0	0	0
Mn4+	0	0	0	0	0
Ca2+	9.60E-02	2.65E+03	713	7.71E-02	0.110
K+	6.18E-03	167	44.8	4.76E-03	7.11E-03
OH-	11.4	1.34E+05	3.60E+04	8.77	13.8
NO3-	1.50	6.41E+04	1.73E+04	0.755	3.30
NO2-	0.480	1.52E+04	4.09E+03	0.290	0.578
CO32-	9.60E-02	3.97E+03	1.07E+03	7.71E-02	0.110
PO43-	0.752	4.92E+04	1.32E+04	0.439	0.919
SO42-	3.65E-02	2.41E+03	650	2.95E-02	4.37E-02
Si (as SiO32-)	0.150	2.90E+03	779	7.84E-02	0.219
F-	9.07E-02	1.19E+03	320	7.21E-02	0.211
Cl-	2.84E-02	694	187	2.19E-02	4.35E-02
C6H5O73-	0	0	0	0	0
EDTA4-	0	0	0	0	0

Table A3-2. Historical Tank Inventory Estimate.[1] (3 sheets)

Total Inventory Estimate					
Chemical Constituents	**mole/L**	**ppm**	**kg**	**-95 CI (mole/L)**	**+95 CI (mole/L)**
HEDTA3-	0	0	0	0	0
glycolate-	0	0	0	0	0
acetate-	0	0	0	0	0
oxalate2-	0	0	0	0	0
DBP	0	0	0	0	0
butanol	0	0	0	0	0
NH3	8.84E-02	1.04E+03	279	6.12E-02	9.79E-02
Fe(CN)64-	0	0	0	0	0
Radiological Constituents	**Ci/L**	**μCi/g**	**Ci**	**-95 CI (Ci/L)**	**+95 CI (Ci/L)**
H-3	4.52E-06	3.12E-03	0.839	7.81E-07	6.21E-06
C-14	3.93E-07	2.71E-04	7.29E-02	1.07E-07	5.08E-07
Ni-59	2.14E-06	1.48E-03	0.397	1.55E-06	2.30E-06
Ni-63	2.00E-04	0.138	37.1	1.45E-04	2.15E-04
Co-60	1.41E-07	9.74E-05	2.62E-02	2.83E-08	1.87E-07
Se-79	8.34E-08	5.75E-05	1.55E-02	2.27E-08	1.04E-06
Sr-90	0.138	95.0	2.56E+04	9.98E-02	0.153
Y-90	0.138	95.0	2.56E+04	9.98E-02	0.153
Zr-93	3.95E-07	2.72E-04	7.32E-02	1.08E-07	4.40E-06
Nb-93m	3.25E-07	2.24E-04	6.03E-02	9.04E-08	4.64E-06
Tc-99	2.75E-06	1.90E-03	0.510	7.46E-07	3.56E-06
Ru-106	3.90E-13	2.69E-10	7.24E-08	7.47E-14	5.17E-13
Cd-113m	1.16E-06	7.97E-04	0.215	2.73E-07	1.51E-06
Sb-125	2.01E-07	1.39E-04	3.73E-02	3.54E-08	2.68E-07
Sn-126	1.28E-07	8.79E-05	2.37E-02	3.42E-08	1.66E-06
I-129	5.26E-09	3.62E-06	9.76E-04	1.41E-09	6.81E-09
Cs-134	4.15E-09	2.86E-06	7.70E-04	1.30E-09	5.30E-09
Cs-137	1.39E-02	9.57	2.58E+03	8.00E-03	1.63E-02
Ba-137m	1.31E-02	9.06	2.44E+03	7.57E-03	1.54E-02
Sm-151	3.00E-04	0.207	55.7	8.34E-05	3.82E-03
Eu-152	1.03E-06	7.07E-04	0.190	1.01E-06	1.04E-06
Eu-154	3.33E-06	2.29E-03	0.618	5.99E-07	4.43E-06
Eu-155	4.90E-05	3.38E-02	9.10	4.80E-05	4.94E-05

Table A3-2. Historical Tank Inventory Estimate.[1] (3 sheets)

Total Inventory Estimate					
Radiological Constituents	Ci/L	μCi/g	Ci	-95 CI (Ci/L)	+95 CI (Ci/L)
Ra-226	1.60E-10	1.10E-07	2.96E-05	2.65E-11	2.93E-10
Ra-228	1.43E-15	9.88E-13	2.66E-10	1.41E-15	1.45E-15
Ac-227	7.07E-10	4.87E-07	1.31E-04	7.10E-11	1.48E-09
Pa-231	1.60E-10	1.10E-07	2.97E-05	6.92E-11	2.45E-09
Th-229	2.72E-13	1.87E-10	5.05E-08	2.67E-13	2.74E-13
Th-232	1.07E-16	7.37E-14	1.98E-11	3.22E-17	1.37E-16
U-232	2.03E-10	1.40E-07	3.77E-05	1.93E-10	2.09E-10
U-233	1.04E-11	7.13E-09	1.92E-06	9.88E-12	1.06E-11
U-234	1.22E-05	8.44E-03	2.27	1.16E-05	1.26E-05
U-235	5.46E-07	3.76E-04	0.101	5.17E-07	5.62E-07
U-236	1.07E-07	7.35E-05	1.98E-02	1.01E-07	1.09E-07
U-238	1.23E-05	8.50E-03	2.29	1.17E-05	1.27E-05
Np-237	1.77E-08	1.22E-05	3.28E-03	4.70E-09	2.29E-08
Pu-238	4.05E-06	2.79E-03	0.752	3.79E-06	4.32E-06
Pu-239	2.75E-04	0.190	51.1	2.56E-04	3.02E-04
Pu-240	3.81E-05	2.62E-02	7.06	3.54E-05	4.08E-05
Pu-241	2.27E-04	0.156	42.1	2.11E-04	2.43E-04
Pu-242	9.81E-10	6.76E-07	1.82E-04	9.08E-10	1.05E-09
Am-241	1.23E-06	8.45E-04	0.227	2.02E-07	2.05E-05
Am-243	1.13E-11	7.80E-09	2.10E-06	1.75E-12	1.92E-10
Cm-242	2.35E-08	1.62E-05	4.35E-03	2.30E-08	2.37E-08
Cm-243	5.38E-10	3.70E-07	9.97E-05	5.26E-10	5.42E-10
Cm-244	4.03E-10	2.78E-07	7.47E-05	6.09E-11	5.40E-10
Totals	M	μg/g	kg	-95 CI (M or g/L)	+95 CI (M or g/L)
Pu	4.60E-03 (g/L)	----	0.853	4.28E-03	5.03E-03
U	0.155	2.55E+04	6.85E+03	0.147	0.160

Notes:

[1]Historical tank inventory estimate predictions have not been validated and should be used with caution.

[2]Volume average for density, mass average water wt% and TOC wt% C.

A4.1 SURFACE-LEVEL READINGS

Tank 241-U-112 is categorized as an assumed leaker. A manual tape is used to monitor the surface level through riser 8. Manual readings are taken quarterly. The surface-level plot indicates a near steady waste level from February 1984 to the present of 30.5 cm (12 in.). On October 16, 1997 the waste surface level was 31.1 cm (12.25 in.). Figure A4-1 is a level history graph of the volume measurements.

Tank 241-U-112 has only one of the drywells, 60-R-01 has current readings above 200 counts/sec drywells.

A4.2 INTERNAL TANK TEMPERATURES

Tank 241-U-112 has a single thermocouple tree with 11 thermocouples to monitor the waste temperature through riser 5.

Temperature data for all 11 thermocouples were available from the surveillance analysis computer system from July 1, 1976 to August 15, 1995. After August 15, 1995, readings are reported only for thermocouples 1, 2 and 10.

The average temperature of the SACS data over the last year (December 1, 1996 to November 30, 1997) was 17.7 °C (63.9 °F), the minimum was 14.0 °C (58.3 °F), and the maximum was 20.8 °C (64.4 °F). The maximum temperature on November 29, 1997 was 19.2 °C (66.6 °F) on thermocouple #1. For plots of the thermocouple readings, refer to the U Tank Farm supporting document for the HTCE (Brevick et al. 1997). Figure A4-2 is a graph of the weekly high temperature.

A4.3 TANK 241-U-112 PHOTOGRAPHS

The photographic montage of the inside of tank 241-U-112 shows a dark yellow material covering a large area of the surface (Brevick et al. 1997). A white sludge spotted with dark material forms a perimeter around the yellow surface which slopes up to the sidewall.
A yellow residue is on the tank wall. Debris, including old level measurement tapes, can be seen discarded on the sludge surface. An active temperature probe and a manual measurement tape can be seen. A salt well screen penetrates the surface. Various risers and a manhole are visible in the ceiling. The photographs were taken in 1989, but they should be representative of the current contents of the tank because no transfers have occurred since the photographs were taken.

Figure A4-1. Tank 241-U-112 Level History.

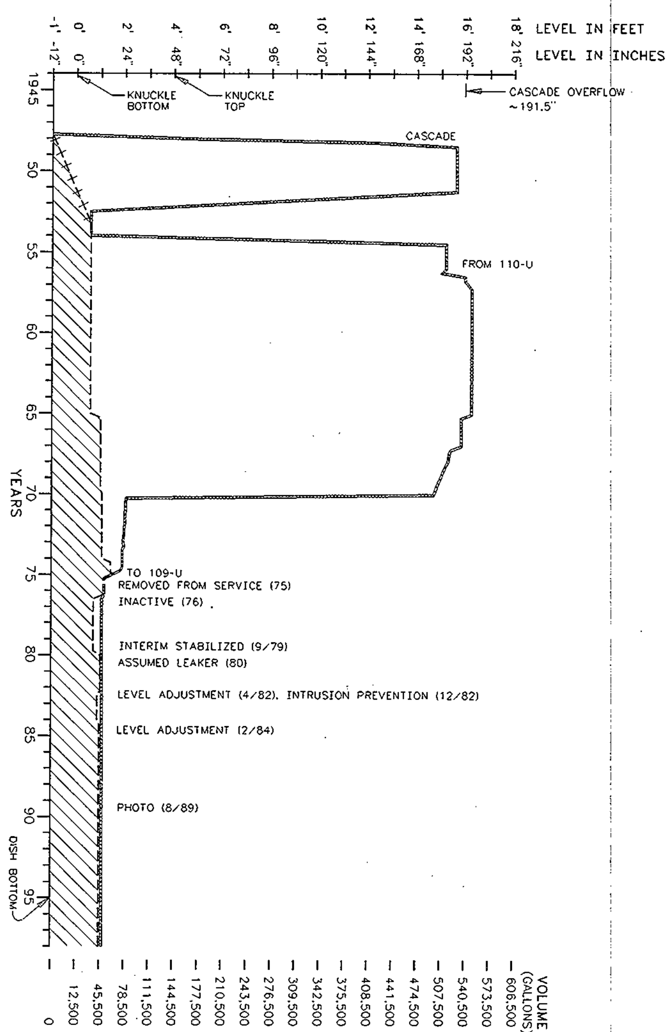
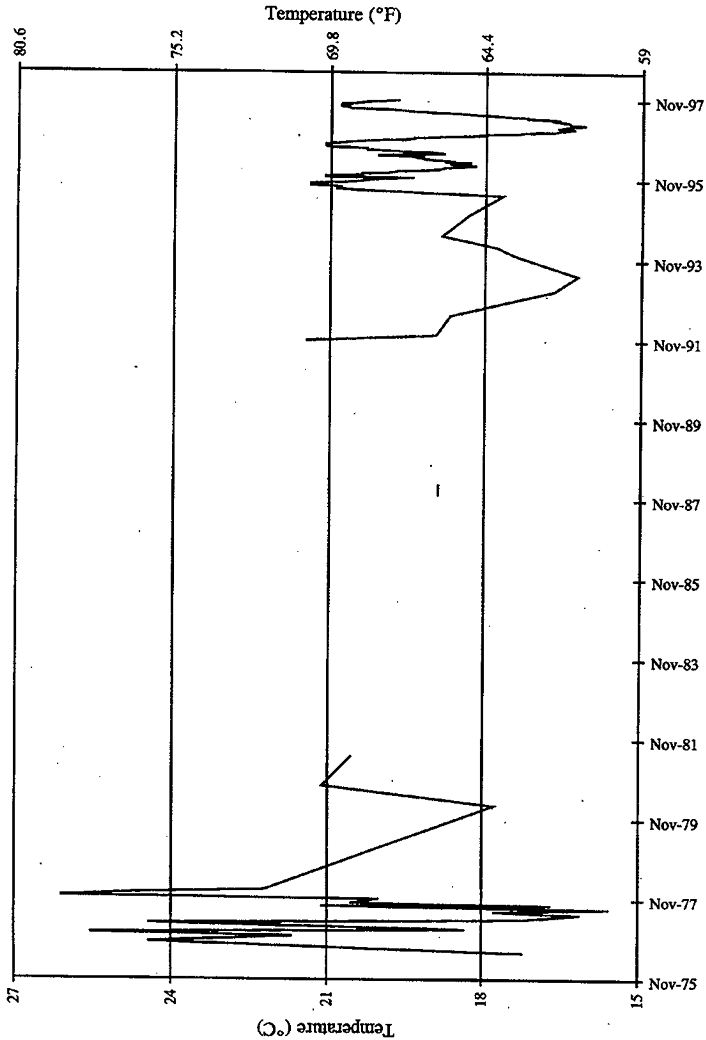


Figure A4-2. Tank 241-U-112 High Temperature Plot.



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APPENDIX B

SAMPLING OF TANK 241-U-112

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APPENDIX B

SAMPLING OF TANK 241-U-112

Appendix B provides sampling and analysis information for each known sampling event for tank 241-U-112 and assesses the push core sample results. It includes the following.

- **Section B1.0**: Tank Sampling Overview
- **Section B2.0**: Sampling Events
- **Section B3.0**: Assessment of Characterization Results
- **Section B4.0**: References for Appendix B

Future sampling information for tank 241-U-112 will be appended to the above list.

B1.0 TANK SAMPLING OVERVIEW

This section identifies applicable requirements for the September, 1997 push core sampling and analysis event and the July, 1996 Vapor sampling event for tank 241-U-112.

Push core samples were taken to satisfy the requirements of the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995) and the Organic Complexant Safety Issue (Schreiber 1997). Sampling and analyses were performed in accordance with the Tank 241-U-112 Sampling and Analysis Plan (Field 1997). Further discussions of the sampling and analysis procedures can be found in the *Tank Characterization Reference Guide* (DeLorenzo et al. 1994).

Vapor samples were taken to satisfy the requirements of the Organic Solvents DQO (Meacham et al. 1997) and the Hazardous Vapor Safety Screening DQO (Osborne and Buckley 1995). Vapor samples were taken in accordance with Buckley (1996).

B2.0 SAMPLING EVENTS

This section describes the 1997 push core and 1996 vapor sampling events. Tables B2-8 through B2-53 show analytical results. No historical sample data were avilable for this tank. Table B2-1 summarizes the sampling and analytical requirements from the applicable DQOs and issues.

B2.1 1997 PUSH CORE SAMPLING EVENT

Two samples were collected from tank 241-U-112. Core 219 was obtained on September 12, 1997 from riser 3, and core 220 was obtained from riser 6 on September 18 and 19, 1997. Only one segment was retrieved for each core. High down forces were encountered for both cores resulting in termination with 65 percent recovery for core 219 and 69 percent for core 220.

Sampling satisfied the safety screening DQO. Analyses included: total alpha to determine criticality, DSC to ascertain the fuel energy value, thermogravimetric analysis (TGA) to obtain the total moisture content, and bulk density. In addition, combustible gas meter readings in the tank headspace were performed to measure flammability. Inductively coupled plasma spectroscopy (ICP) and ion chromatography (IC) analyses were conducted to assess potential contamination by hydrostatic head fluid, used during sampling. Opportunistic ICP and IC analytes were also reported.

Table B2-1. Integrated Data Quality Objective Requirements for Tank 241-U-112.

Sampling Event	Applicable DQOs	Sampling Requirements	Analytical Requirements
Push mode core sampling	Safety screening - Energetics - Moisture content - Total alpha - Flammable gas Dukelow et al. (1995) Organic complexants Schreiber (1997)	Core samples from a minimum of two risers separated radially to the maximum extent possible. Combustible gas measurement	Flammability, energetics, moisture, total alpha activity, density, anions, cations, radionuclides, separable organics, physical properties
Vapor sampling	Hazardous vapor Osborne and Buckley (1995) Organic solvents Meacham et al. (1997)	Steel canisters, triple sorbent traps, sorbent trap systems	Flammable gas, organic vapors, permanent gases

Note:
[1]Field (1997)

B2.1.1 Sample Handling

Core 219 and 220 samples were received by the 222-S laboratory on September 15 and September 23, 1997, respectively.

The SAP (Field 1997) states that the core samples should be transported to the laboratory within three calendar days from the time each segment is removed from the tank. This requirement was not met for the segment from core 220.

A description and characteristics of the two, one-segment core samples at the time of extrusion is shown in Table B2-2.

Table B2-2. Tank 241-U-112 Subsampling Scheme and Sample Description.[1]

Core/Riser	Sample ID	Weight (g)	Sample Portion	Sample Characteristics
219/3	219-01	149.6	Upper half	The solids were white-yellow to light brown and resembled a moist salt, no drainable liquids, 29.9 g of liner liquid.
		179.4	Lower half	
220/6	220-01	94.7	Upper half	The solids were white-yellow to light brown and resembled a moist salt, no drainable liquids, no liner liquid.
		126.0	Lower half	

Note:
[1]Steen (1997)

B2.1.2 Sample Analysis

The analyses performed on the push core samples were limited to those required by the safety screening DQO. The analyses required by the safety screening DQO included analyses for thermal properties by DSC, moisture content by TGA, content of fissile material by total alpha activity analysis, and bulk density. The safety screening DQO also required ICP and IC analyses for lithium and bromide, to assess the potential for hydrostatic head fluid contamination. Other ICP and IC analytes were also reported as "opportunistic" analytes (Field 1997).

All reported analyses were performed according to approved laboratory procedures (Table B2-3). Table B2-4 is a summary of the sample portions, sample numbers, and analyses performed on each sample.

Table B2-3. Analytical Procedures.[1]

Analysis	Method	Procedure Number
Energetics	Differential scanning calorimetry	LA-514-114
Percent water	Thermogravimetric analysis	LA-505-151 LA-514-114
Total alpha activity	Alpha proportional counter	LA-508-101
Flammable gas	Combustible gas analyzer	WHC-IP-0030[2] IH 1.4 and IH-2.1[2]
Metals by ICP/AES	Inductively coupled plasma spectrometer	LA-505-161
Anions by IC	Ion chromatograph	LA-533-105
Bulk density	Gravimetry	LO-160-103
Specific gravity	Gravimetry	LA-510-112

Notes:

AES = atomic emission spectroscopy

[1]Steen (1997)

[2]Safety Department Administrative Manuals, Westinghouse Hanford Company, Richland, Washington (WHC 1992):

IH 1.4, Industrial Hygiene Direct Reading Instrument Survey

IH 2.1, Standard Operating Procedure, MSA Model 260 Combustible Gas and Oxygen Analyzer.

Table B2-4. Sample Analyses Summary[1]

Segment	Segment Portion	Sample Number	Analyses
Core 219, riser 3			
1	Upper half	S97T002053	DSC, TGA
		S97T002055	ICP (fusion)
		S97T002056	IC (water digest)
	Lower half	S97T002057	DSC, TGA
		S97T002059	ICP (fusion), total alpha
		S97T002060	IC (water digest)
		S97T002052	Bulk density
Core 220, riser 6			
1	Upper half	S97T002132	DSC, TGA
		S97T002138	ICP (fusion)
		S97T002139	IC (water digest)
	Lower half	S97T002133	DSC, TGA
		S97T002131	Bulk density
		S97T002136	ICP (fusion)
		S97T002137	IC (water digest)

Note:

[1]Steen (1997)

B2.1.3 Analytical Results

This section summarizes the sampling and analytical results associated with the September 1997 sampling and analysis of tank 241-U-112. Table B2-5 shows the location of analytical results included in this report. These results are documented in Steen (1997).

Table B2-5. Analytical Tables.

Analysis	Table Number
Summary data for metals by ICP	B2-8 to B2-42
Anions by IC	B2-43 to B2-50
Bulk density	B2-51
Percent water	B2-52
Total alpha activity	B2-53

The quality control (QC) parameters assessed in conjunction with tank 241-U-112 samples were standard recoveries, spike recoveries, duplicate analyses (RPDs), and blanks. The QC criteria are specified in the SAP. The limits for blanks are set forth in guidelines followed by the laboratory, and all data results in this report have met those guidelines. Sample and duplicate pairs, in which any QC parameter was outside these limits, are footnoted in the sample mean column of the following data summary tables with an a, b, c, d, or e.

- "a" indicates the standard recovery was below the QC limit
- "b" indicates the standard recovery was above the QC limit
- "c" indicates the spike recovery was below the QC limit
- "d" indicates the spike recovery was above the QC limit
- "e" indicates the RPD was above the QC limit.

In the analytical tables in this section, the "mean" is the average of the result and duplicate value. All values, including those below the detection level (denoted by "<") were averaged. If both sample and duplicate values were non-detected or if one value was detected while the other was not, the mean is expressed as a non-detected value. If both values were detected, the mean is expressed as a detected value.

B2.1.3.1 Total Alpha Activity. Analyses for total alpha activity were performed on the samples recovered from tank 241-U-112. The samples were prepared by fusion digestion. Each fused dilution was analyzed twice, and the results were averaged and reported as one value. All results were below detection limits. The highest result returned was <0.00395 μCi/g.

B2.1.3.2 Thermogravimetric Analysis. Thermogravimetric analysis measures the mass of a sample as its temperature is increased at a constant rate. Nitrogen is passed over the sample during heating to remove any released gases. A decrease in the weight of a sample during TGA represents a loss of gaseous matter from the sample, through evaporation or through a reaction that forms gas phase products. The moisture content is estimated by assuming that all TGA sample weight loss up to a certain temperature (typically 150 to 200 °C [300 to 390 °F]) is caused by water evaporation. The temperature limit for moisture loss is chosen by the operator at an inflection point on the TGA plot. Other volatile matter fractions can often be differentiated by inflection points as well.

The percent water for tank 241-U-112 samples ranged from 19.8 to 35.8 percent by weight.

B2.1.3.3 Differential Scanning Calorimetry. In a DSC analysis, heat absorbed or emitted by a substance is measured while the sample is heated at a constant rate. Nitrogen is passed over the sample material to remove any gases being released. The onset temperature for an endothermic or exothermic event is determined graphically.

No exothermic reactions were observed; therefore, an upper limit of a 95 percent confidence interval on the mean for each sample was not calculated.

B2.1.3.4 Inductively Coupled Plasma. Samples were prepared by fusion or acid digest. Although a full suite of analytes were reported, only lithium was specifically requested for the safety screening DQO. The primary ICP analytes detected were aluminum and sodium, other analytes observed at concentrations above detection limits were chromium, iron, phosphorous and silicon.

Lithium values were below detection levels (208 milligrams per meters cubed). This suggests that hydrostatic head fluid (HHF) contamination was not a problem.

B2.1.3.5 Ion Chromatography (Ions). Samples were prepared by water digest. Although a full suite of analytes were reported, only bromide was requested for the safety screening DQO. The primary ICP analytes were nitrate and phosphate. Also detected were chloride, nitrite, fluoride, and sulfate. The maximum bromide concentration was 607 μg/g, indicating that hydrostatic head fluid intrusion was not a problem.

B2.1.3.6 Specific Gravity and Bulk Density. Bulk density was performed on core 219 segment 1 as required by the SAP (Field 1997). The results of the bulk density test was 1.86 g/mL. This value was used to calculate the solid total alpha activity action limit and analyte inventories for the tank.

B2.2 VAPOR PHASE MEASUREMENT

Combustible gas vapor tests (sniff tests) were conducted on July 3, 1996 and on September 18, 1997. In addition, vapor samples were obtained from riser 11 on July 9, 1996. These measurements supported the hazardous vapor safety screening DQO (Osborne and Buckley 1995) and the organic solvents DQO (Meacham et al. 1997). . All vapor phase measurements were taken 610 cm (20 ft) below the riser in the dome space of the tank. The results of the vapor phase measurements are provided in Tables B2-6 and B2-7. Detailed results for the vapor samples are presented in Evans et al. (1997).

Table B2-6. Results of Combustible Gas Tests for Tank 241-U-112.

Measurement	Result July, 1996	Result September, 1997
Total organic carbon (TOC)	17 ppm	0
Lower flammability limit (LFL)	2% of LFL	0%
Oxygen	not measured	20.8
Ammonia	200 ppm	300 ppm

Table B2-7. Results of July 9, 1996, Headspace Vapor Sample Measurements.[1] (2 sheets)

Category	Sample Medium	Analyte	Concentration	Units
Inorganic analytes	Sorbent Traps	NH_3	308±15	ppmv
		NO_2	<0.16	ppmv
		NO	<0.16	ppmv
		H_2O	13.6±0.6	mg/L
Permanent gases	SUMMA™ Cannister	H_2	232	ppmv
		CH_4	<25	ppmv
		CO_2	<17	ppmv
		CO	<17	ppmv
		N_2O	398	ppmv
TNMOC	SUMMA™ Cannister	TNMOC	2.03	mg/m^3
Organics	SUMMA™ Cannister	Methanol	1.418	ppmv
		Ethanol	0.494	ppmv
		Propane	0.095[2]	ppmv
Organics	Sorbent Traps	Methanol	0.757	ppmv
		Toluene	0.240[2]	ppmv
		2-4 dimethylheptane	0.234	ppmv

Notes:

[1]Evans et al (1997)

[2]Tentatively identified compounds.

1997 PUSH MODE CORE SAMPLE DATA TABLES

Table B2-8. Tank 241-U-112 Analytical Results: Aluminum (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	2.03E+05	2.04E+05	2.04E+05
S97T002059		Lower half	1.88E+05	1.70E+05	1.79E+05
S97T002138	220:1	Upper half	1.39E+05	1.39E+05	1.39E+05
S97T002136		Lower half	1.73E+05	1.66E+05	1.70E+05

Table B2-9. Tank 241-U-112 Analytical Results: Antimony (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<1,080	<1,090	<1,090
S97T002059		Lower half	<1,130	<1,120	<1,130
S97T002138	220:1	Upper half	<1,220	<1,250	<1,240
S97T002136		Lower half	<1,170	<1,190	<1,180

Table B2-10. Tank 241-U-112 Analytical Results: Arsenic (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<1,810	<1,810	<1,810
S97T002059		Lower half	<1,880	<1,860	<1,870
S97T002138	220:1	Upper half	<2,030	<2,080	<2,060
S97T002136		Lower half	<1,950	<1,990	<1,970

Table B2-11. Tank 241-U-112 Analytical Results: Barium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<904	<906	<905
S97T002059		Lower half	<940	<930	<935
S97T002138	220:1	Upper half	<,1020	<1,040	<1,030
S97T002136		Lower half	<975	<995	<985

Table B2-12. Tank 241-U-112 Analytical Results: Beryllium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<90.4	<90.6	<90.5
S97T002059		Lower half	<94	<93	<93.5
S97T002138	220:1	Upper half	<102	<104	<103
S97T002136		Lower half	<97.5	<99.5	<98.5

Table B2-13. Tank 241-U-112 Analytical Results: Bismuth (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<1,810	<1,810	<1,810
S97T002059		Lower half	<1,880	<1,860	<1,870
S97T002138	220:1	Upper half	<2,030	<2,080	<2,060
S97T002136		Lower half	<1,950	<1,990	<1,970

Table B2-14. Tank 241-U-112 Analytical Results: Boron (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<904	<906	<905
S97T002059		Lower half	<940	<930	<935
S97T002138	220:1	Upper half	<1,020	<1,040	<1,030
S97T002136		Lower half	<975	<995	<985

Table B2-15. Tank 241-U-112 Analytical Results: Cadmium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<90.4	<90.6	<90.5
S97T002059		Lower half	<94	<93	<93.5
S97T002138	220:1	Upper half	<102	<104	<103
S97T002136		Lower half	<97.5	<99.5	<98.5

Table B2-16. Tank 241-U-112 Analytical Results: Calcium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<1,810	<1,810	<1,810
S97T002059		Lower half	<1,880	<1,860	<1,870
S97T002138	220:1	Upper half	<2,030	<2,080	<2,060
S97T002136		Lower half	<1,950	<1,990	<1,970

Table B2-17. Tank 241-U-112 Analytical Results: Cerium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			μg/g	μg/g	μg/g
S97T002055	219:1	Upper half	<1,810	<1,810	<1,810
S97T002059		Lower half	<1,880	<1,860	<1,870
S97T002138	220:1	Upper half	<2,030	<2,080	<2,060
S97T002136		Lower half	<1,950	<1,990	<1,970

Table B2-18. Tank 241-U-112 Analytical Results: Chromium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			μg/g	μg/g	μg/g
S97T002055	219:1	Upper half	350	349	350
S97T002059		Lower half	398	391	395
S97T002138	220:1	Upper half	<203	<208	<206
S97T002136		Lower half	290	285	288

Table B2-19. Tank 241-U-112 Analytical Results: Cobalt (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			μg/g	μg/g	μg/g
S97T002055	219:1	Upper half	<362	<362	<362
S97T002059		Lower half	<376	<372	<374
S97T002138	220:1	Upper half	<407	<415	<411
S97T002136		Lower half	<390	<398	<394

Table B2-20. Tank 241-U-112 Analytical Results: Copper (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<181	<181	<181
S97T002059		Lower half	<188	<186	<187
S97T002138	220:1	Upper half	<203	<208	<206
S97T002136		Lower half	<195	<199	<197

Table B2-21. Tank 241-U-112 Analytical Results: Iron (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<904	<906	<905
S97T002059		Lower half	<940	<930	<935
S97T002138	220:1	Upper half	5,560	26,200	15,900[QC:e]
S97T002136		Lower half	<975	<995	<985

Table B2-22. Tank 241-U-112 Analytical Results: Lanthanum (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<904	<906	<905
S97T002059		Lower half	<940	<930	<935
S97T002138	220:1	Upper half	<1,020	<1,040	<1,030
S97T002136		Lower half	<975	<995	<985

Table B2-23. Tank 241-U-112 Analytical Results: Lead (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<1,810	<1,810	<1,810
S97T002059		Lower half	<1,880	<1,860	<1,870
S97T002138	220:1	Upper half	<2,030	<2,080	<2,060
S97T002136		Lower half	<1,950	<1,990	<1,970

Table B2-24. Tank 241-U-112 Analytical Results: Lithium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<181	<181	<181
S97T002059		Lower half	<188	<186	<187
S97T002138	220:1	Upper half	<203	<208	<206
S97T002136		Lower half	<195	<199	<197

Table B2-25. Tank 241-U-112 Analytical Results: Magnesium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<1,810	<1,810	<1,810
S97T002059		Lower half	<1,880	<1,860	<1,870
S97T002138	220:1	Upper half	<2,030	<2,080	<2,060
S97T002136		Lower half	<1,950	<1,990	<1,970

Table B2-26. Tank 241-U-112 Analytical Results: Manganese (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<181	<181	<181
S97T002059		Lower half	<188	<186	<187
S97T002138	220:1	Upper half	<203	<208	<206
S97T002136		Lower half	<195	<199	<197

Table B2-27. Tank 241-U-112 Analytical Results: Molybdenum (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<904	<906	<905
S97T002059		Lower half	<940	<930	<935
S97T002138	220:1	Upper half	<1020	<1040	<1030
S97T002136		Lower half	<975	<995	<985

Table B2-28. Tank 241-U-112 Analytical Results: Neodymium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<1,810	<1,810	<1,810
S97T002059		Lower half	<1,880	<1,860	<1,870
S97T002138	220:1	Upper half	<2,030	<2,080	<2,060
S97T002136		Lower half	<1,950	<1,990	<1,970

Table B2-29. Tank 241-U-112 Analytical Results: Phosphorus (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	8,330	8,690	8,510
S97T002059		Lower half	9,020	17,000	13,000[QC:e]
S97T002138	220:1	Upper half	34,100	26,900	30,500[QC:e]
S97T002136		Lower half	20,800	21,800	21,300

Table B2-30. Tank 241-U-112 Analytical Results: Samarium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<1,810	<1,810	<1,810
S97T002059		Lower half	<1,880	<1,860	<1,870
S97T002138	220:1	Upper half	<2,030	<2,080	<2,060
S97T002136		Lower half	<1,950	<1,990	<1,970

Table B2-31. Tank 241-U-112 Analytical Results: Selenium (ICP)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<1,810	<1,810	<1,810
S97T002059		Lower half	<1,880	<1,860	<1,870
S97T002138	220:1	Upper half	<2,030	<2,080	<2,060
S97T002136		Lower half	<1,950	<1,990	<1,970

Table B2-32. Tank 241-U-112 Analytical Results: Silicon (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			μg/g	μg/g	μg/g
S97T002055	219:1	Upper half	<904	<906	<905
S97T002059		Lower half	<940	<930	<935
S97T002138	220:1	Upper half	1,730	1,670	1,700
S97T002136		Lower half	<975	<995	<985

Table B2-33. Tank 241-U-112 Analytical Results: Silver (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			μg/g	μg/g	μg/g
S97T002055	219:1	Upper half	<181	<181	<181
S97T002059		Lower half	<188	<186	<187
S97T002138	220:1	Upper half	<203	<208	<206
S97T002136		Lower half	<195	<199	<197[QC:c]

Table B2-34. Tank 241-U-112 Analytical Results: Sodium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			μg/g	μg/g	μg/g
S97T002055	219:1	Upper half	46,100	46,300	46,200
S97T002059		Lower half	51,100	69,200	60,200[QC:e]
S97T002138	220:1	Upper half	1.06E+05	85,400	95,700[QC:e]
S97T002136		Lower half	76,200	78,400	77,300

Table B2-35. Tank 241-U-112 Analytical Results: Strontium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<181	<181	<181
S97T002059		Lower half	<188	<186	<187
S97T002138	220:1	Upper half	<203	<208	<206
S97T002136		Lower half	<195	<199	<197

Table B2-36. Tank 241-U-112 Analytical Results: Sulfur (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<1,810	<1,810	<1,810
S97T002059		Lower half	<1,880	<1,860	<1,870
S97T002138	220:1	Upper half	<2,030	<2,080	<2,060
S97T002136		Lower half	<1,950	<1,990	<1,970

Table B2-37. Tank 241-U-112 Analytical Results: Thallium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<3,620	<3,620	<3,620
S97T002059		Lower half	<3,760	<3,720	<3,740
S97T002138	220:1	Upper half	<4,070	<4,150	<4,110
S97T002136		Lower half	<3,900	<3,980	<3,940

Table B2-38. Tank 241-U-112 Analytical Results: Titanium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<181	<181	<181
S97T002059		Lower half	<188	<186	<187
S97T002138	220:1	Upper half	<203	<208	<206
S97T002136		Lower half	<195	<199	<197

Table B2-39. Tank 241-U-112 Analytical Results: Total Uranium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<9,040	<9,060	<9,050
S97T002059		Lower half	<9,400	<9,300	<9,350
S97T002138	220:1	Upper half	<10,200	<10,400	<10,300
S97T002136		Lower half	<9,750	<9,950	<9,850

Table B2-40. Tank 241-U-112 Analytical Results: Vanadium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<904	<906	<905
S97T002059		Lower half	<940	<930	<935
S97T002138	220:1	Upper half	<1,020	<1,040	<1,030
S97T002136		Lower half	<975	<995	<985

Table B2-41. Tank 241-U-112 Analytical Results: Zinc (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	269	<181	<225[QC:e]
S97T002059		Lower half	<188	<186	<187
S97T002138	220:1	Upper half	<203	<208	<206
S97T002136		Lower half	<195	<199	<197

Table B2-42. Tank 241-U-112 Analytical Results: Zirconium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S97T002055	219:1	Upper half	<181	<181	<181
S97T002059		Lower half	<188	<186	<187
S97T002138	220:1	Upper half	<203	<208	<206
S97T002136		Lower half	<195	<199	<197

Table B2-43. Tank 241-U-112 Analytical Results: Bromide (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
S97T002056	219:1	Upper half	599	<247	<423[QC:e]
S97T002060		Lower half	<252	264	<258
S97T002139	220:1	Upper half	<507	<508	<507
S97T002137		Lower half	607	607	607

Table B2-44. Tank 241-U-112 Analytical Results: Chloride (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
S97T002056	219:1	Upper half	1,230	460	847[QC:e]
S97T002060		Lower half	410	511	460[QC:e]
S97T002139	220:1	Upper half	252	291	271
S97T002137		Lower half	383	407	395

Table B2-45. Tank 241-U-112 Analytical Results: Fluoride (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
S97T002056	219:1	Upper half	6,930	2,600	4,760[QC:e]
S97T002060		Lower half	7,290	5,210	6,250[QC:d,e]
S97T002139	220:1	Upper half	12,500	10,800	11,600
S97T002137		Lower half	6,640	7,870	7,250[QC:d]

Table B2-46. Tank 241-U-112 Analytical Results: Nitrate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
S97T002056	219:1	Upper half	1.16E+05	45,400	80,700[QC:e]
S97T002060		Lower half	38200	49,400	43,800[QC:e]
S97T002139	220:1	Upper half	19800	21,900	20,800
S97T002137		Lower half	34300	35,300	34,800

Table B2-47. Tank 241-U-112 Analytical Results: Nitrite (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			μg/g	μg/g	μg/g
S97T002056	219:1	Upper half	3,670	1,340	2,500[QC:e]
S97T002060		Lower half	1,270	1,490	1,380
S97T002139	220:1	Upper half	862	931	896
S97T002137		Lower half	1,050	1,080	1,060

Table B2-48. Tank 241-U-112 Analytical Results: Phosphate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			μg/g	μg/g	μg/g
S97T002056	219:1	Upper half	63,100	23,300	43,200[QC:e]
S97T002060		Lower half	69,200	47,300	58,200[QC:d,e]
S97T002139	220:1	Upper half	1.11E+05	95600	1.03E+05
S97T002137		Lower half	58,200	70,500	64,400[QC:d]

Table B2-49. Tank 241-U-112 Analytical Results: Sulfate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			μg/g	μg/g	μg/g
S97T002056	219:1	Upper half	2,390	1,000	1,690[QC:e]
S97T002060		Lower half	837	1,080	959[QC:e]
S97T002139	220:1	Upper half	<560	<561	<560
S97T002137		Lower half	623	698	660

Table B2-50. Tank 241-U-112 Analytical Results: Oxalate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			μg/g	μg/g	μg/g
S97T002056	219:1	Upper half	<462	<208	<335
S97T002060		Lower half	<212	<214	<213
S97T002139	220:1	Upper half	461	<427	<444
S97T002137		Lower half	<235	<230	<233

Table B2-51. Tank 241-U-112 Analytical Results: Bulk Density.

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids			g/mL	g/mL	g/mL
S97T002052	219: 1	Lower half	1.86	n/a	1.86

Table B2-52. Tank 241-U-112 Analytical Results: Percent Water (TGA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids			%	%	%
S97T002053	219:1	Upper half	20.7	32.2	26.4[QC:e]
S97T002057		Lower half	35.8	31.4	33.6
S97T002132	220:1	Upper half	20.8	19.8	20.3
S97T002133		Lower half	23.2	23.8	23.5

Table B2-53. Tank 241-U-112 Analytical Results: Total Alpha.

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			μCi/g	μCi/g	μCi/g
S97T002059	219:1	Lower half	<0.00372	<0.00339	<0.00356[QC:c]
S97T002136	220:1	Lower half	<0.00395	<0.00209	<0.00302[QC:c]

B3.0 ASSESSMENT OF CHARACTERIZATION RESULTS

This section discusses the overall quality and consistency of the current sampling results for tank 241-U-112 and provides the results of an analytical-based inventory calculation.

This section also evaluates sampling and analysis factors that may impact data interpretation. These factors are used to assess overall data quality and consistency and to identify limitations in data use.

B3.1 FIELD OBSERVATIONS

Only one segment was obtained for core 219 and one segment for core 220. Sample recovery for the two segments was 65 percent and 69 percent respectively. Lithium bromide hydrostatic head fluid was used because high down forces were reached for both cores. The high down forces were reached at 43 cm (17 in.) into the stroke for riser 3 (core 219) and 29 cm (11.5 in.) for riser 6 (core 220). Both cores were abandoned after the high down forces were reached.

B3.2 QUALITY CONTROL ASSESSMENT

The usual QC assessment includes an evaluation of the appropriate standard recoveries, spike recoveries, duplicate analyses, and blanks that are performed in conjunction with the chemical analyses. All pertinent QC tests were conducted on the samples, allowing a full assessment regarding the accuracy and precision of the data. The SAP (Field 1997) established specific criteria for all analytes. Sample and duplicate pairs with one or more QC results outside the specified criteria are identified by footnotes in the data summary tables.

As noted previously, the QC review for IC and ICP analyses was limited to only bromide and lithium. Other IC and ICP analytes are listed in the data tables, but are considered "opportunistic". Specific quality checks and review for these analytes were not conducted.

The standard and spike recovery results provide an estimate of analysis accuracy. If a standard or spike recovery is above or below the given criterion, the analytical results may be biased high or low, respectively. Spike recoveries outside of the required range (75 to 125 percent) were reported for two subsamples for total alpha analyses. The samples were reanalyzed several times with no improvement in spike recoveries. The chemist noted that the low spike recoveries were a result of matrix interferences and no further reruns were requested.

The precision is estimated by the RPD, which is defined as the absolute value of the difference between the primary and duplicate samples, divided by their mean, times 100. A high RPD was noted for one of the four thermogravimetric analyses. This was attributed to the nonhomogeneous material and small sample size.

No sample exceeded the criterion for preparation blanks; thus, contamination was not a problem.

In summary, the vast majority of QC results were within the boundaries specified in the SAPs. The discrepancies mentioned here and footnoted in the data summary tables should not impact data validity or use.

B3.3 DATA CONSISTENCY CHECKS

Comparing different analytical methods is helpful in assessing the consistency and quality of the data. With the data set provided by the two core samples, phosphorous and sulfur as analyzed by ICP were compared to phosphate and sulfate as analyzed by IC. In addition, mass and charge balances were calculated to help assess the overall data consistency.

B3.3.1 Comparison of Results from Different Analytical Methods

The following data consistency checks compare the results from two analytical methods. Agreement between the two methods strengthens the credibility of both results, but poor agreement brings the reliability of the data into question. All analytical mean results were taken from Table B3-4.

The analytical phosphorous mean result as determined by ICP was 18,300 μg/g which converts to 56,100 μg/g of phosphate. This was slightly lower than the IC phosphate mean result of 67,300 μg/g, indicating that the phosporous is nearly 100 percent soluble. The RPD between these two results was 16.6 percent.

The analytical sulfur mean result as determined by ICP was less than 1,930 μg/g which converts to 5,790 μg/g of phosphate. This was much higher than the IC sulfate mean result of 968 μg/g. No conclusion about data reliability or analyte solubility can be drawn from the data.

B3.3.2 Mass and Charge Balance

The principle objective in performing mass and charge balances is to determine whether the measurements are consistent. In calculating the balances, only the analytes listed in Section B2.0, which were detected at a concentration of 1,000 μg/g or greater, were considered.

Except sodium, all cations listed in Table B3-1 were assumed to be in their most common hydroxide or oxide form, and the concentrations of the assumed species were calculated stoichiometrically. Because precipitates are neutral species, all positive charge was attributed to the sodium cation. The anions listed in Table B3-2 were assumed to be present as sodium salts and were expected to balance the positive charge exhibited by the cations. The concentrations of cationic species in Table B3-1, the anionic species in Table B3-2, and the percent water were used to calculate the mass balance.

The mass balance was calculated from the formula below. The factor 0.0001 is the conversion factor from μg/g to weight percent.

Mass balance = Percent water + 0.0001 x {total analyte concentration}

= Percent water + 0.0001 x $\{Al(OH)_3 + Na^+ + F^- + NO_2^- + NO_3^- + PO_4^{-3}\}$

The total analyte concentration calculated from the above equation is 690,800 μg/g. The mean weight percent water reported in Table B3-4 is 26.0 percent or 260,000 μg/g. The mass balance resulting from adding the percent water to the total analyte concentration is 95.1 percent.

The following equations demonstrate the derivation of total cations and total anions; the charge balance is the ratio of these two values.

<u>Total cations</u> (μeq/g) = $[Na^+]/23.0 = 3{,}030$ μeq/g

<u>Total anions</u> (μeq/g) = $[F^-]/19.0 + [NO_2^-]/46.0 + [NO_3^-]/62.0 + [PO_4^{-3}]/31.7 = 3{,}272$ μeq/g

The charge balance obtained by dividing the sum of the positive charge by the sum of the negative charge was 0.926.

In summary, the above calculations yield reasonable mass and charge balance values (close to 1.00 for charge balance and 100 percent for mass balance), indicating that the analytical results are generally self-consistent.

Table B3-1. Cation Mass and Charge Data.

Analyte	Concentration ($\mu g/g$)	Assumed Species	Concentration of Assumed Species ($\mu g/g$)	Charge ($\mu eq/g$)
Aluminum	173,000	$Al(OH)_3$	500,000	0.00
Sodium	69,800	Na^+	69,800	3,030
Total			569,800	3,030

Table B3-2. Anion Mass and Charge Data.

Analyte	Concentration ($\mu g/g$)	Charge ($\mu eq/g$)
Nitrate	45,000	726
Nitrite	1,460	32
Fluoride	7,480	394
Phosphate	67,300	2,120
Total	121,000	3,272

Table B3-3. Mass and Charge Balance Totals.

Totals	Concentrations ($\mu g/g$)	Charge ($\mu eq/g$)
Total from Table B3-2 (cations)	569,800	3,030
Total from Table B3-3 (anions)	121,000	-3,272
Water Content	260,000	n/a
Total	951,000	-242

B3.4 MEAN CONCENTRATIONS AND CONFIDENCE INTERVALS

B3.4.1 Means and Confidence Intervals

A nested analysis of variance (ANOVA) model was fit to the core sample data. Mean values, and 95 percent confidence intervals on the mean, were determined from the ANOVA. Three variance components were used in the calculations. The variance components represent concentration differences between risers, laboratory samples, and analytical replicates. The model is:

$$Y_{ijk} = \mu + R_i + L_{ij} + A_{ijk},$$

$$I=1,2,\ldots,a;\ j=1,2,\ldots,b_i;\ k=1,2,\ldots,n_{ij};$$

where

Y_{ijk}	=	concentration from the k^{th} analytical result of the j^{th} sample of the i^{th} riser
μ	=	the mean
R_i	=	the effect of the i^{th} riser
L_{ij}	=	the effect of the j^{th} sample from the i^{th} riser
A_{ijk}	=	the analytical error
a	=	the number of risers
b_i	=	the number of samples from the i^{th} riser
n_{ij}	=	the number of analytical results from the ij^{th} sample

The variables R_i, and L_{ij} are random effects. These variables, as well as A_{ijk}, are assumed to be uncorrelated and normally distributed, with means of zero and variances $\sigma^2(R)$, $\sigma^2(L)$ and $\sigma^2(A)$, respectively.

The restricted maximum likelihood method (REML) was used to estimate the mean concentration and standard deviation of the mean for all analytes that had 50 percent or more of their reported values greater than the detection limit. The mean value and standard deviation of the mean were used to calculate the 95 percent confidence intervals. Table B3-4 gives the mean, degrees of freedom, and confidence interval for each constituent.

Some analytes had results that were below the detection limit. In these cases the value of the detection limit was used for non-detected results. For analytes with a majority of results below the detection limit, a simple average is all that is reported.

The lower limits (LL) (95 percent) and upper limits (UL) (95 percent), of a two-sided 95 percent confidence interval on the mean were calculated using the following equation:

$$LL(95\%) = \hat{\mu} - t_{(df, 0.025)} \times \hat{\sigma}(\hat{\mu}),$$
$$UL(95\%) = \hat{\mu} + t_{(df, 0.025)} \times \hat{\sigma}(\hat{\mu}).$$

In this equation, $\hat{\mu}$ is the REML estimate of the mean concentration, $\hat{\sigma}(\hat{\mu})$ is the REML estimate of the standard deviation of the mean, and $t_{(df, 0.025)}$ is the quantile from Student's t distribution with *df* degrees of freedom. The degrees of freedom equals the number of risers with data minus one. In cases where the LL of the confidence interval was negative, it is reported as zero (Stat Sci 1993).

Table B3-4. 95 Percent Two-Sided Confidence Intervals for Mean Concentrations. (2 sheets)

Analyte	Method	$\hat{\mu}$	df	LL	UL	Units
Aluminum	ICP:F	1.73E+05	1	0.00E+00	4.08E+05	µg/g
Antimony[1]	ICP:F	<1.16E+03	n/a	n/a	n/a	µg/g
Arsenic[1]	ICP:F	<1.93E+03	n/a	n/a	n/a	µg/g
Barium[1]	ICP:F	<9.64E+02	n/a	n/a	n/a	µg/g
Beryllium[1]	ICP:F	<9.64E+01	n/a	n/a	n/a	µg/g
Bismuth[1]	ICP:F	<1.93E+03	n/a	n/a	n/a	µg/g
Boron[1]	ICP:F	<9.64E+02	n/a	n/a	n/a	µg/g
Bromide[1,2]	IC:W	4.49E+02	1	0.00E+00	1.83E+03	µg/g
Cadmium[1]	ICP:F	<9.64E+01	n/a	n/a	n/a	µg/g
Calcium[1]	ICP:F	<1.93E+03	n/a	n/a	n/a	µg/g
Cerium[1]	ICP:F	<1.93E+03	n/a	n/a	n/a	µg/g
Chloride	IC:W	4.93E+02	1	0.00E+00	2.53E+03	µg/g
Chromium[1]	ICP:F	3.09E+02	1	0.00E+00	1.11E+03	µg/g
Cobalt[1]	ICP:F	<3.85E+02	n/a	n/a	n/a	µg/g
Copper[1]	ICP:F	<1.93E+02	n/a	n/a	n/a	µg/g
Fluoride	IC:W	7.48E+03	1	0.00E+00	3.25E+04	µg/g
Gross alpha[1]	Alpha:F	<3.29E-03	n/a	n/a	n/a	µCi/g
Iron[1]	ICP:F	<4.68E+03	n/a	n/a	n/a	µg/g
Lanthanum[1]	ICP:F	<9.64E+02	n/a	n/a	n/a	µg/g
Lead[1]	ICP:F	<1.93E+03	n/a	n/a	n/a	µg/g
Lithium[1,2]	ICP:F	<1.93E+02	n/a	n/a	n/a	µg/g
Magnesium[1]	ICP:F	<1.93E+03	n/a	n/a	n/a	µg/g
Manganese[1]	ICP:F	<1.93E+02	n/a	n/a	n/a	µg/g
Molybdenum[1]	ICP:F	<9.64E+02	n/a	n/a	n/a	µg/g
Neodymium[1]	ICP:F	<1.93E+03	n/a	n/a	n/a	µg/g
Nitrate	IC:W	4.50E+04	1	0.00E+00	2.64E+05	µg/g
Nitrite	IC:W	1.46E+03	1	0.00E+00	7.56E+03	µg/g
Oxalate[1]	IC:W	<3.06E+02	n/a	n/a	n/a	µg/g
Percent water	DSC/TGA	2.60E+01	1	0.00E+00	7.76E+01	%
Phosphate	IC:W	6.73E+04	1	0.00E+00	2.78E+05	µg/g
Phosphorus	ICP:F	1.83E+04	1	0.00E+00	1.15E+05	µg/g
Samarium[1]	ICP:F	<1.93E+03	n/a	n/a	n/a	µg/g

Table B3-4. 95 Percent Two-Sided Confidence Intervals for Mean Concentrations. (2 sheets)

Analyte	Method	$\hat{\mu}$	df	LL	UL	Units
Selenium[1]	ICP:F	<1.93E+03	n/a	n/a	n/a	µg/g
Silicon[1]	ICP:F	<1.13E+03	n/a	n/a	n/a	µg/g
Silver[1]	ICP:F	<1.93E+02	n/a	n/a	n/a	µg/g
Sodium	ICP:F	6.98E+04	1	0.00E+00	2.82E+05	µg/g
Strontium[1]	ICP:F	<1.93E+02	n/a	n/a	n/a	µg/g
Sulfate[1]	IC:W	9.68E+02	1	0.00E+00	5.51E+03	µg/g
Sulfur[1]	ICP:F	<1.93E+03	n/a	n/a	n/a	µg/g
Thallium[1]	ICP:F	<3.85E+03	n/a	n/a	n/a	µg/g
Titanium[1]	ICP:F	<1.93E+02	n/a	n/a	n/a	µg/g
Uranium[1]	ICP:F	<9.64E+03	n/a	n/a	n/a	µg/g
Vanadium[1]	ICP:F	<9.64E+02	n/a	n/a	n/a	µg/g
Zinc[1]	ICP:F	<2.04E+02	n/a	n/a	n/a	µg/g
Zirconium[1]	ICP:F	<1.93E+02	n/a	n/a	n/a	µg/g

Notes:

[1]a "less than value was used in the calculations

[2]Introduced as a tracer, not present in the waste.

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APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

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APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

Appendix C documents the results of the analyses and statistical and numerical manipulations required by the DQOs applicable for tank 241-U-112. The analyses required for tank 241-U-112 are reported as follows:

- **Section C1.0**: Statistical analysis and numerical manipulations supporting the safety screening DQO (Dukelow et al. 1995).
- **Section C2.0**: References for Appendix C.

C1.0 STATISTICS FOR THE SAFETY SCREENING DATA QUALITY OBJECTIVE

The safety screening DQO (Dukelow et al. 1995) defines decision limits in terms of one-sided 95 percent confidence intervals. Based on a measured density of 1.86 g/mL the safety screening DQO limits are 33 µCi/g for gross alpha and 480 Joules/g for DSC.

Every gross alpha result was below the detection limit. The largest value was 3.95E-03 µCi/g, for core 220, segment 1. This is well below the limit of 33 µCi/g. All eight DSC results had no exothermic reaction. Because all of the alpha results were below the detection limit, and no exotherms were observed in any sample, 95% confidence intervals were not calculated.

C2.0 APPENDIX C REFERENCES

Dukelow, G. T., J. W. Hunt, H. Babad, and J. E. Meacham, 1995, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS STANDARD INVENTORY FOR TANK 241-U-112

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS STANDARD INVENTORY FOR TANK 241-U-112

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available information for single-shell tank 241-U-112 was performed, and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

D1.0 CHEMICAL INFORMATION SOURCES

As part of this effort an evaluation was made of available chemical information for tank 241-U-112, including the following.

- Analytical data for two 1997 core samples from tank 241-U-112 (Appendix B).
- Analytical data from tanks containing bismuth phosphate process first decontamination cycle waste (1C1).
- Analytical data from tanks which contain reduction and oxidation (REDOX) high-level waste (R) and REDOX cladding waste (CWR).
- The HDW model document (Agnew et al. 1997a) that provides tank content estimates in terms of component concentrations and inventories.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

A sample based inventory was not calculated because the sample results do not include the waste in the dished portion of the tank. Hanford defined waste model inventories, and previous best-basis inventories (effective May 31, 1997) are shown in Tables D2-1 and D2-2. (The chemical species are reported without charge designation per the best-basis inventory convention.) Two core samples, each consisting of one segment, were taken from tank 241-U-112 in September 1997. Analytical results for these samples were not available at the time the previous best basis was prepared. The tank waste volume used to generate the HDW model inventories and previous best-basis inventories was 170 kL (45 kgal) (Agnew et al. 1997a). The HDW model estimates the density of the waste to be 1.45 g/mL (Agnew et al. 1997a), this value was also used for the previous best basis.

Table D2-1. Hanford Defined Waste Model and Previous Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-U-112. (2 sheets)

Analyte	HDW Inventory Estimate[1] (kg)	Previous Best-Basis Inventory[2] (kg)
Al	13,800	11,200
Bi	1,580	2,940
Ca	713	225
Cl	187	392
Cr	118	250
F	320	1,350
Fe	4,090	2,070
La	0	0.35
Mn	0	126
Na	23,600	23,300
Ni	88.7	14.5
NO_2	4,090	3,840
NO_3	17,300	30,200
Pb	554	48
PO_4	13,200	5,080
Si	779	1,370
SO_4	650	2,730
Sr	0.0	59.3
TIC as CO_3	1,070	1,070
TOC	0	292
U_{TOTAL}	6,850	930

Table D2-1. Hanford Defined Waste Model and Previous Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-U-112. (2 sheets)

Analyte	HDW Inventory Estimate[1] (kg)	Previous Best-Basis Inventory[2] (kg)
Zr	2.64	36
H_2O (wt%)	53.7	n/r
Density (kg/L)	1.45	1.45

Notes:
n/r = not reported

[1] Agnew et al. (1997a), decayed to January 1, 1994.
[2] LMHC (1998), effective May 31, 1997

Table D2-2. Hanford Defined Waste Model and Previous Best-Basis Inventory Estimates for Radioactive Components in Tank 241-U-112.

Analyte	HDW[1] Inventory Estimate (Ci)	Previous Best-Basis Inventory[2] (Ci)
^{90}Sr	25,600	17,100
^{137}Cs	2,580	15,900

Notes:
[1] Agnew et al. (1997a), decayed to January 1, 1994.
[2] LMHC (1998), effective May 31, 1997

D3.0 COMPONENT INVENTORY EVALUATION

D3.1 WASTE HISTORY TANK 241-U-112

Tank 241-U-112 was the third tank in the 241-U-110, 241-U-111, 241-U-112 cascade. The cascade first began receiving bismuth phosphate process first cycle decontamination (1C) waste in July 1946. Tank 241-U-112 was filled to 1,999 kL (528 kgal) in May 1948. The tank remained full until the supernatant was removed in 1951 through 1952. In the second quarter of 1952, Anderson (1990) reported that the tank contained only solids (121 kL [32 kgal]). In 1954, tank

241-U-110 and 241-U-111 were filled with R waste solids and supernatant. Tank 241-U-112 was filled to 1,946 kL (514 kgal) by the second quarter of 1954. An additional 132 to 151 kL (35 to 40 kgal) of CWR waste was added to the tank in 1956. The tank supernatant was pumped out between the first quarter of 1970 and the fourth quarter of 1974 (Agnew 1997b).

D3.2 CONTRIBUTING WASTE TYPES

The HDW model (Agnew et al. 1997a) predicts that the tank contains a total of 170 kL (45 kgal) of solids consisting of 121 kL (32 kgal) of 1C waste, 26 kL (7 kgal) of R1 waste, and 23 kL (6 kgal) of CWR1 waste.

The Sort on Radioactive Waste Type model (Hill et al. 1995) lists the tank as containing "unknown" waste types.

On October 16, 1997, the manual tape surface level reading for tank 241-U-112 was 31.1 cm (12.25 in) which corresponds to 175 kL (46.2 kgal) of total waste. This value is in good agreement with the 170 kL (45 kgal) total waste volume predicted in the HDW model (Agnew et al. 1997a). However, it is less than the total volume predicted by Hanlon (1998). This is attributed to the 15 kL (4 kgal) supernatant layer predicted by Hanlon (1998) which was not observed in sample extrusions.

Although Agnew et al. (1997a) predicts 121 kL (2 kgal) of 1C waste, bismuth, iron and uranium sample concentrations were significantly lower and aluminum significantly higher than expected for the 1C waste type. High phosphate results, indicate that some of the 1C anions cascaded to tank 241-U-112. However, many of the 1C metals apparently dropped out in tanks 241-U-110 and 241-U-111. Consequently, it appears that the portion of the waste represented by the samples was mostly R/CWR waste.

Because samples were recovered from risers located on opposite sides of the tank, the samples do not include the waste in the dished portion of the tank (47.3 kL [12.5 kgal]). Based on Agnew et al. (1997a), it is probable that the dished bottom of the tank contains 1C waste.

D3.3 ASSUMPTIONS USED

The sample based inventory combined with an engineering evaluation for 1C waste was used as the best-basis inventory for this tank. Engineering inventory values or HDW model inventory values are used where tank 241-U-112 sample data were not obtained for an analyte.

The following evaluation provides an engineering assessment of tank 241-U-112 contents. For this evaluation, the following assumptions and observations were made:

- The tank waste total volume is (170 kL [45 kgal]) based on surface level measurements the volume of solids predicted in Agnew et al. (1997a) and Hanlon (1998).
- Only R/CWR waste contributed to the top 123 kL (32.5 kgal) of waste in the tank.
- The dished bottom of the tank contains 47.3 kL (12.5 kgal) of 1C waste.
- There is no supernatant in tank 241-U-112, based on sample results and zip cord measurements.

D3.4 BASIS FOR THE ENGINEERING EVALUATION

D3.4.1 R/CWR Waste Assessment

Where available, sample results are used as the best basis for the R/CWR waste layer. Table D3-1 compares sample results for tank 241-U-112 with sample results from other tanks. Tank 241-S-101 (Kruger et al. 1996), 241-S-104 (DiCenso et al. 1994), and 241-S-107 (Simpson et al. 1996), were all direct receivers of R/CWR waste. The analytical data were reviewed and only the segments that were located within the predicted R/CWR sludge location were used for each tank. The average concentration from each tank, the segments used in the calculation, and the analyte R/CWR calculation is shown in Table D3-1. The average sludge layer compositions predicted by the HDW model for R1 and CWR1 waste in tank 241-U-112 are also shown.

Table D3-1 shows that tank 241-U-112 sample results for cations, such as aluminum, bismuth, iron, silicon, and uranium were in reasonably good agreement with sample results for other tanks containing R/CWR waste and predictions by Agnew et al. (1997a) for the R1 and CWR1 waste types. Tank 241-U-112 sample values for fluoride and phosphate ions were larger than expected for R/CWR waste and better resembled 1C waste values. Because tank 241-U-112 was the third tank in the cascade, it is plausible that most of the metals in the 1C waste settled out in tanks 241-U-110 and 241-U-111 and primarily anions such as fluoride and phosphate cascaded over to tank 241-U-112. This theory may explain why less 1C waste was observed in tank 241-U-112 samples than was predicted by Agnew et al (1997a).

Table D3-1. R1 Sludge Concentration Estimates. (2 sheets)

Analyte	241-S-101 Segments 7U-8L[1] (μg/g)	241-S-104 Total Sludge Concentration[2] (μg/g)	241-S-107 Segments[3] (μg/g)	Average Concentration[4] (μg/g)	HDW R1 Sludge Layer Concentration[5] (μg/g)	HDW CWR1 Sludge Layer Concentration[5] (μg/g)	241-U-112 Sample Results[6] (μg/g)
Al	127,000	117,000	56,400	100,000	107,000	171,000	173,000
Bi	<38.8	<45.7	n/r	<42.2	0	0	<1,930
Ca	322	247	234	268	5,020	2,730	<1,930
Cl	2,050	3,200	1,860	2,370	1,040	141	493
Cr	2,230	2,350	1,180	1,920	1,830	59.8	309
F	<65.7	145	150	<120	0	0	7,480
Fe	1,960	1,720	1,160	1,613	32,200	5,200	<1,930
Hg	n/r	<0.126	n/r	<0.126	0	462	n/r
K	539	300	457	432	250	33.9	n/r
La	<19.5	<2.07	n/r	<10.8	0	0	<964
Mn	2,750	1,150	83	1,330	0	0	<193
Na	112,000	121,000	60,400	97,800	106,000	102,000	69,800
Ni	90.7	56	206	118	1,690	33.7	n/r
NO_2	31,100	25,900	34,300	30,433	38,200	24,900	1,460
NO_3	119,000	191,000	57,600	122,500	187,000	20,000	45,000
Pb	37	29.6	33	33.2	0	13,800	<1,930
PO_4	1,360	<2,190	1,630	<1,730	0	0	67,300
Si	1,360	1,330	1,060	1,250	129	319	<1,130
SO_4	897	2,270	1,300	1,489	569	455	968

Table D3-1. R1 Sludge Concentration Estimates. (2 sheets)

Analyte	241-S-101 Segments 7U-8L[1] (μg/g)	241-S-104 Total Sludge Concentration[2] (μg/g)	241-S-107 Segments[3] (μg/g)	Average Concentration[4] (μg/g)	HDW R1 Sludge Layer Concentration[5] (μg/g)	HDW CWR1 Sludge Layer Concentration[5] (μg/g)	241-U-112 Sample Results[6] (μg/g)
Sr	456	424	378	420	0	0	<1,930
TIC as CO_3	n/r	4,140	n/r	4,140	7,510	4,090	n/r
TOC	n/r	1,730	n/r	1,730	0	0	n/r
U	7,684	6,690	8,685	7,690	207	24,400	<9,640
Zr	36	33.6	131	66.9	0	0	<193
Radionuclides (μCi/g)[6]							
^{90}Sr	n/r	301	276	288	528.6	1.16	n/r
^{137}Cs	98	60.5	74	77.6	31.9	1.33	n/r
density (g/mL)	1.77	1.64	1.90	1.77	1.76	1.77	1.86

Notes:

n/r = not reported

[1] Kruger et al. (1996)
[2] DiCenso et al. (1994)
[3] Statistically determined median R1 sludge concentrations for tank 241-S-107 contained in the attachment to Simpson et al. (1996)
[4] Average of analyte concentrations for tank 241-S-101, 241-S-104, and 241-S-107
[5] Agnew et al. (1997a)
[6] Radionuclides decayed to January 1, 1994.

D3.4.2 Assessment of 1C Sample Data

No 1C waste was recovered in tank 241-U-112 samples. No samples were obtained from the dished portion of the tank. Because tank 241-U-112 was at one time filled with 1C waste cascaded from tank 241-U-111 (Agnew et al. 1997b), it is assumed that the bottom 47.3 kL (12.5 kgal) is 1C waste.

An estimate of the 1C sludge layer composition was made based on sample results for other tanks containing 1C sludge. In the $BiPO_4$ process from 1944 through 1954, the 1C waste was combined with the cladding waste (CW) stream before discharge from the plant (Anderson 1990).

Several tanks received 1C/CW waste directly from T Plant, including tanks 241-T-104, 241-T-107, 241-TX-109, 241-TX-110, 241-U-110, 241-TY-101 and 241-TY-103. Sample data are not available for the solid layers of tanks 241-TX-109 and 241-TX-110. The 1C waste was mixed with substantial quantities of other wastes in tanks 241-U-110, 241-TY-101 and 241-TY-103 making it difficult to accurately determine the composition of the 1C/CW sludge. Tanks 241-T-104 and 241-T-107, however, provide some of the best examples of T Plant 1C/CW sludge composition.

Several tanks, received 1C/CW waste from the B Plant $BiPO_4$ process 1C operations. These included 241-C-110 (Benar et al. 1997), 241-BX-107 (Winkelman et al. 1997), 241-BX-110 (Schreiber and Tran 1996) and 241-BX-112 (Winkelman and Morris 1996). Tanks 241-C-110, 241-BX-107 and 241-BX-112 provide the best examples of B Plant 1C/CW waste because these tanks contain nearly exclusively 1C/CW waste and analyses of core samples are available for these tanks. Calculations show that the composition for both the B Plant 1C waste and the T Plant 1C waste are consistent with the flowsheet basis (Schneider 1951 and Kupfer and Boldt 1997) for the first cycle $BiPO_4$ process and no significant plant to plant differences exist. The relative concentrations of components expected to precipitate essentially 100 percent to the waste solids (for example, Bi, Fe, Si, Zr) are consistent (up to a factor of 3) between the samples, and are approximately proportionate to the relative 1C flowsheet concentrations for those components (see Appendix C of Kupfer and Boldt 1997). It can be concluded that the sample data for these tanks are consistent with the flowsheet basis. In addition, the concentrations of components that partition between solids and supernatants are comparable between the tanks and, in general, represent expected chemical behavior.

The composition of waste in tanks 241-T-104, 241-T-107, 241-C-110, 241-BX-107 and 241-BX-112, based on the respective TCRs (Sasaki et al. 1997a and b, Benar et al. 1997, Winkelman et al. 1997) is provided in Table D3-2. The averages of these compositions are used for estimating the composition of the 1C sludge layer in tank 241-U-112. Also shown for comparison is the 1C defined waste from Agnew et al. (1997a).

Table D3-2. Component Concentrations for Tanks 241-BX-107, 241-BX-112, 241-C-110, 241-T-104, and 241-T-107. (3 sheets)

Analyte	241-BX-107[1] µg/g	241-BX-112[2] µg/g	241-C-110[3] µg/g	241-T-104[4] µg/g	241-T-107[5] µg/g	Average concentration µg/g	HDW Model 1C1[6] µg/g
Ag	<0.942	<46.4	<0.690	<1.09	7.37	<11.3	n/r
Al	14,300	13,600	14,300	16,200	16,400	15,000	11,700
Bi	22,300	17,500	13,500	18,900	11,200	16,700	9,440
Ca	396	2,510	<386	1,450	1,500	1,250	2,210
Cd	2.27	<59.5	5.20	1.69	6.40	<15.8	n/r
Cl	1,140	1,050	1,090	670	547	900	794
CO_3	5,800	10,500	10,500	<500	14,800	8,430	3,310
Cr	968	1,290	464	901	354	795	183
F	9,190	10,700	7,590	8,570	11,500	9,510	1,912
Fe	11,100	9,460	10,700	9,020	31,500	14,300	14,250
Hg	0.565	n/r	0.446	<0.125	0.134	<0.318	15.4
K	263	406	559	89.0	32	270	190
La	<1.51	<156	7.69	<10.2	<2	<35	0
Mn	64.6	323.0	35.8	61.8	222	140	0

Table D3-2. Component Concentrations for Tanks 241-BX-107, 241-BX-112, 241-C-110, 241-T-104, and 241-T-107. (3 sheets)

Analyte	241-BX-107[1] µg/g	241-BX-112[2] µg/g	241-C-110[3] µg/g	241-T-104[4] µg/g	241-T-107[5] µg/g	Average concentration µg/g	HDW Model 1C1[6] µg/g
Na	102,000	81,800	82,800	64,500	130,200	92,300	87,000
Ni	12.2	<2.76	<24.2	11.3	292	68	51
NO_2	12,300	25,600	9,290	4,080	11,800	12,600	7,860
NO_3	137,000	75,100	110,000	58,000	75,400	91,100	46,500
Pb	62.8	<331.0	258	49.8	796	300	0
P as PO_4	71,700	59,200	62,600	75,700	114,000	76,600	79,200
Si	6,780	8,400	7,160	6,520	6,070	6,990	4,550
S as SO_4	13,700	6,480	11,900	3,840	10,600	9,290	3,620
Sr	168	132	130	99.1	962	298	0
TOC	798	959	<676	<570	1,700	940	0
U	4,838	1,040	2,140	897	22,600	6,300	35,100
Zr	136	<78.1	172	67.5	113.0	113	16
Density g/mL	1.44	1.31	1.45	1.29	1.51	1.40	1.38
% H_2O	59	64	60	70	46	60	64

Table D3-2. Component Concentrations for Tanks 241-BX-107, 241-BX-112, 241-C-110, 241-T-104, and 241-T-107. (3 sheets)

Analyte	241-BX-107[1] μg/g	241-BX-112[2] μg/g	241-C-110[3] μg/g	241-T-104[4] μg/g	241-T-107[5] μg/g	Average concentration μg/g	HDW Model 1C1[6] μg/g
Radionuclides[7] (μCi/g)							
^{241}Am	0.013	<0.167	<0.00953	<0.0173	<0.0722	<0.056	2.20 E-05
^{14}C	2.60 E-04	n/r	3.20 E-04	<4.5 E-05	<1.91 E-04	<2.0 E-04	6.3 E-05
^{60}Co	<0.0057	<0.0122	<0.0297	<2.18 E-04	<0.0132	<0.012	8.7 E-06
^{137}Cs	16.9	51.8	18.8	0.193	12.1	20.0	6.21
^{154}Eu	<0.015	<0.0336	<0.0827	0.00295	<0.0497	<0.037	1.2 E-04
^{155}Eu	<0.029	<0.168	<0.091	0.00288	<0.0586	<0.070	9.3 E-04
$^{239/240}$Pu	0.0572	n/r	0.0800	0.14	0.15	0.107	0.0129
^{90}Sr	9.58	6.05	4.76	2.55	106	25.8	5.51
^{99}Tc	0.0369	n/r	0.0330	<6.30 E-04	<0.0505	<0.030	4.3 E-04

Notes:

[1] Winkelman et al. (1997)
[2] Winkelman and Morris (1996)
[3] Benar et al. (1997)
[4] Sasaki et al. (1997a)
[5] Sasaki et al. (1997b)
[6] 1C1 Defined waste (Agnew et al. 1997a)
[7] Decayed to January 1, 1994.

D3.4.3 Tank Inventory Calculations

The sample based waste concentrations for tank 241-U-112 shown in Table D3-1 were multiplied by a sample density of 1.86 g/mL and a volume of 123 kL (32.5 kgal) to calculate the R/CWR waste inventory. Average sample based waste concentrations shown in Table D3-2 were multiplied by a density of 1.4 g/mL and a volume of 47.3 kL (12.5 kgal) to derive the 1C waste inventory for tank 241-U-112. The 1C, R/CWR and total waste inventories for tank 241-U-112 are shown in Table D3-3. Hanford defined waste model inventory estimates for the tank are included for comparison.

Table D3-3. Comparison of Selected Component Inventory Estimates for Tank 241-U-112. (2 sheets)

Component	This Evaluation 1C1 Waste (kg)	This Evaluation R/CWR Waste (kg)	This Evaluation Total (kg)	HDW Estimated (kg)
Al	993	39,600	40,600	13,800
Bi	1,110	<442	1,110	1,580
Ca	82.8	<442	524	713
TIC as CO_3	558	947	1,510	1,070
Cr	52.6	70.7	123	118
F	630	1,710	2,340	320
Fe	947	<442	1,390	4,090
Hg	0.03	0.03	0.05	2.12
K	17.9	98.8	117	44.8
La	0	0	0	0
Mn	9.27	<44.2	53.4	0
Na	6,110	16,000	22,100	23,600
Ni	4.50	27.0	31.5	88.7
NO_2	834	334	1,170	4,090
NO_3	6,030	10,300	16,300	17,300
PO_4	5,070	15,400	20,500	13,200
Si	463	258	721	779
SO_4	615	221	836	650

Table D3-3. Comparison of Selected Component Inventory Estimates for Tank 241-U-112. (2 sheets)

Component	This Evaluation 1C1 Waste (kg)	This Evaluation R/CWR Waste (kg)	This Evaluation Total (kg)	HDW Estimated (kg)
TOC	62.3	<396	458	0
Cl	59.6	113	172	187
Pb	19.9	<442	462	554
Sr	19.7	<442	462	0
Zr	7.48	44.2	51.6	2.64
^{90}Sr (Ci)	1,710	65,900	67,600	25,600
^{137}Cs (Ci)	1,320	17,800	19,100	2,580
U	417	2,210	2,620	6,850
H_2O (percent)	64.0	26.0	n/a	53.7

D3.5 ESTIMATED COMPONENT INVENTORIES

The best-basis inventory for tank 241-U-112 was determined based on the sample results from the September 1997 and engineering evaluations for the 1C sludge layer. Component inventories estimated by the HDW model were used to estimate radionuclide inventories when no other information was available and are included for comparison with the engineering based inventory. Some significant differences were noted between the HDW model and engineering based inventories. The primary reason for these differences was that the engineering assessment is based on a much smaller volume of 1C waste than predicted for the HDW model. Comments and observations regarding inventory comparisons for selected analytes follow:

Aluminum. The HDW model prediction of the aluminum content of tank 241-U-112 is about a factor of three lower than the engineering assessment (13,800 kg versus 40,600 kg). The difference is attributed to the HDW model assuming the tank contains a larger volume of 1C waste which has lower aluminum concentrations than R/CWR waste.

Manganese. Manganese was below sample detection limits in tank 241-U-112 samples. The HDW model predicts no manganese in tank 241-U-112.

Bismuth. The HDW model estimate (1,580 kg) for the bismuth inventory is about the same as the value (1,110 kg) calculated by the engineering assessment. Most of the bismuth is attributed to the 1C waste in the bottom of the tank.

Phosphate. The HDW model inventory for phosphate (13,200 kg) was slightly lower than the engineering assessment value of 20,500 kg. The HDW model assumes most of the phosphate inventory is from the 1C waste. Sample results showed much higher concentrations of phosphate than expected for R/CWR waste. This may be attributed to the R/CWR solids settling through a 1C supernatant, trapping phosphate in the interstitial liquid.

Fluoride. The fluoride inventory prediction for the HDW model (320 kg) was lower than the engineering based inventory (2,340 kg). The HDW model also underpredicts the fluoride concentration compared to concentrations seen in other tanks containing 1C waste. The HDW model assumes none of the fluoride precipitates with the solids while the samples show significant fluoride concentrations are associated with the solids.

Iron. The iron inventory for the HDW model estimate (4,090 kg) is almost four times higher than the engineering assessment value (1,390 kg). This attributed to the lower 1C waste concentrations used for the engineering assessment, and solubility assumptions for iron in the HDW model.

Sodium. The engineering based inventory and HDW model predicted inventory for sodium content were in excellent agreement. Such agreement is somewhat surprising because different bases for predicting the waste content of the tank were used for the HDW model and engineering assessment.

Total Hydroxide. Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valence of other analytes. This charge balance approach is consistent with that used by Agnew et al. (1997a).

Radionuclides. The ^{137}Cs and ^{90}Sr radionuclide estimates for the HDW model estimates are lower than engineering assessment value of 19,100 Ci and 67,600 Ci, respectively, this attributed to less 1C waste than predicted by Agnew et al. (1997a).

D4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

Information about chemical, radiological, and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessment associated with waste management activities, as well as regulatory issues. These activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes, and facilities for retrieving wastes and processing them into a form that is suitable for long-term storage/disposal.

Chemical and radiological inventory information are generally derived using three approaches: (1) component inventories are estimated using the results of sample analyses, (2) component inventories are predicted using the HDW model based on process knowledge and historical information, or (3) a tank-specific process estimate is made based on process flowsheets, reactor fuel data, essential material usage, and other operating data.

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of chemical information for tank 241-U-112 was performed.

The evaluation included the following information:

- Two core samples obtained in September 1997
- The inventory estimate generated by the HDW model (Agnew et al. 1997a)
- An engineering evaluation to estimate the R/CWR sludge inventory based on process knowledge previously gathered about the R/CWR and 1C waste types.

Based on this evaluation, a best-basis inventory was developed for tank 241-U-112 (Tables D4-1 and D4-2). Samples taken from above the dish portion of tank 241-U-112 were entirely R/CWR waste. An engineering assessment based on sample results for other tanks was used to calculate the inventory for the 1C waste layer assumed to be in the bottom (dished portion) of the tank. The total inventory is a combination of these two assessments. The engineering assessment was chosen as the best basis for analytes for which sample data was available. Hanford defined waste model inventory values were used for those analytes for which sample values and engineering assessment estimates were not available. Engineering assessment values were selected for trace analytes with little supporting sample data. The inventory values reported in Tables D4-1 and D4-2 are subject to change. Refer to the Tank Characterization Database (TCD) for the most current inventory values (LMHC 1998).

Best-basis tank inventory values are derived for 46 key radionuclides (as defined in Section 3.1 of Kupfer et al. 1997), all decayed to a common report date of January 1, 1994. Often, waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}$Pu, and total uranium (or total beta and total alpha), while other key radionuclides such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, have been infrequently reported. For this reason it has been necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separate plant waste streams, and track their movement with tank waste transactions. These computer models are described in Kupfer et al. (1997), Section 6.1, and in Watrous and Wootan (1997). Model generated values for radionuclides in any of 177 tanks are reported in the HDW Rev. 4 model results (Agnew et al. 1997a). The best-basis value for any one analyte may be either a model result or a sample or engineering assessment-based result, if available.

Uranium isotope inventories were based on total uranium ICP values ratioed to HDW model values. Alpha isotope inventories were based on average total alpha analytical results (0.00329 μCi/g) and engineering estimates of the alpha content of the 1C waste ratioed to HDW model values.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-U-112 (Effective January 31, 1998). (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, C, or E)[1]	Comment
Al	40,600	S/E	
Bi	1,110	S/E	1C waste only, none expected in CWR waste
Ca	524	S/E	
Cl	172	S/E	
TIC as CO_3	1,510	E	
Cr	123	S/E	
F	2,340	S/E	
Fe	1,390	S/E	Upper-bound. Sample value was "less than detect."
Hg	14.6	E	#7 (Simpson change package)[2]
K	117	E	
La	0	E	None expected in CWR and 1C waste.
Mn	53.4	E	
Na	22,100	S/E	
Ni	31.5	E	

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-U-112 (Effective January 31, 1998). (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, C, or E)[1]	Comment
NO_2	1,170	S/E	
NO_3	16,300	S/E	
OH_{total}	76,700	C	Calculated from charge balance.
Pb	462	S/E	Upper-bound. Sample value was "less than detect."
PO_4	20,500	S/E	Sample results based on IC analysis.
Si	721	S/E	Upper-bound. Sample value was "less than detect." However, significant Si is 1C waste.
SO_4	836	S/E	Sample results based on IC analysis.
Sr	19.7	S/E	1C waste only. Sr not expected in CWR waste.
TOC	458	E	
U_{TOTAL}	2,620	E	
Zr	51.6	S/E	Upper-bound. Sample value was "less than detect."

Notes:

[1]S = sample-based (see Appendix B), E = engineering assessment-based, M = HDW model-based (Agnew et al. 1997a), and C = Calculated by charge balance; includes oxides as hydroxides, not including CO_3, O_2, NO_3, PO_4, SO_4, and SiO_3.

[2]Simpson 1998

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-U-112. Decayed to January 1, 1994 (Effective January 31, 1998). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	0.839	M	
^{14}C	0.0729	M	
^{59}Ni	0.397	M	
^{60}Co	0.0262	M	
^{63}Ni	37.1	M	
^{79}Se	0.0155	M	
^{90}Sr	67,600	E	
^{90}Y	67,600	E	Based on ^{90}Sr activity.
^{93}Zr	0.0732	M	
^{93m}Nb	0.0603	M	
^{99}Tc	0.51	M	
^{106}Ru	7.24E-08	M	
^{113m}Cd	0.215	M	
^{125}Sb	0.0373	M	
^{126}Sn	0.0237	M	
^{129}I	9.76E-04	M	
^{134}Cs	7.7E-04	M	
^{137}Cs	19,100	E	
^{137m}Ba	18,100	E	Based on 0.946 of ^{137}Cs activity.
^{151}Sm	55.7	M	
^{152}Eu	0.19	M	
^{154}Eu	0.618	M	
^{155}Eu	9.1	M	
^{226}Ra	2.96E-05	M	
^{227}Ac	1.31E-04	M	
^{228}Ra	2.66E-10	M	
^{229}Th	5.05E-08	M	
^{231}Pa	2.97E-05	M	
^{232}Th	1.98E-11	M	
^{232}U	1.44E-05	S/M	Based on ICP U sample result ratio'd to HDW estimates for U isotopes.

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-U-112. Decayed to January 1, 1994 (Effective January 31, 1998). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{233}U	7.35E-07	S/M	Based on ICP U sample result ratio'd to HDW estimates for U isotopes.
^{234}U	0.869	S/M	Based on ICP U sample result ratio'd to HDW estimates for U isotopes.
^{235}U	0.0388	S/M	Based on ICP U sample result ratio'd to HDW estimates for U isotopes.
^{236}U	7.57E-03	S/M	Based on ICP U sample result ratio'd to HDW estimates for U isotopes.
^{237}Np	3.28E-03	M	
^{238}Pu	0.140	S/M	Based on total alpha sample result ratio'd to HDW estimates for alpha isotopes.
^{238}U	0.875	S/M	Based on ICP U sample result ratio'd to HDW estimates for U isotopes.
^{239}Pu	9.54	S/M	Based on total alpha sample result ratio'd to HDW estimates for alpha isotopes.
^{240}Pu	1.32	S/M	Based on total alpha sample result ratio'd to HDW estimates for alpha isotopes.
^{241}Am	0.0424	S/M	Based on total alpha sample result ratio'd to HDW estimates for alpha isotopes.
^{241}Pu	7.86	S/M	Based on total alpha sample result ratio'd to HDW estimates for alpha isotopes.
^{242}Cm	8.13E-04	S/M	Based on total alpha sample result ratio'd to HDW estimates for alpha isotopes.
^{242}Pu	3.40E-05	S/M	Based on total alpha sample result ratio'd to HDW estimates for alpha isotopes.
^{243}Am	3.92E-07	S/M	Based on total alpha sample result ratio'd to HDW estimates for alpha isotopes.
^{243}Cm	1.86E-05	S/M	Based on total alpha sample result ratio'd to HDW estimates for alpha isotopes.
^{244}Cm	1.40E-05	S/M	Based on total alpha sample result ratio'd to HDW estimates for alpha isotopes.

Note:

[1]S = sample-based, M = HDW model-based (Agnew et al. (1997a), and E = engineering assessment-based.

D5.0 APPENDIX D REFERENCES

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-U-112

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-U-112

Appendix E is a bibliography that supports the characterization of tank 241-U-112. This bibliography represents an in-depth literature search of all known information sources that provide sampling, analysis, surveillance, modeling information, and processing occurrences associated with tank 241-U-112 and its respective waste types.

The references in this bibliography are separated into three categories containing references broken down into subgroups. These categories and their subgroups are listed below.

I. NON-ANALYTICAL DATA

- Ia. Models/Waste Type Inventories/Campaign Information
- Ib. Fill History/Waste Transfer Records
- Ic. Surveillance/Tank Configuration
- Id. Sample Planning/Tank Prioritization
- Ie. Data Quality Objectives/Customers of Characterization Data

II. ANALYTICAL DATA - SAMPLING OF TANK WASTE AND WASTE TYPES

- IIa. Sampling of tank 241-U-112
- IIb. Sampling of similar waste types

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

- IIIa. Inventories using both Campaign and Analytical Information
- IIIb. Compendium of Existing Physical and Chemical Documented Data Sources

The bibliography is broken down into the appropriate sections of material with an annotation at the end of each reference describing the information source. Most information listed below is available in the Lockheed Martin Hanford Corp. Tank Characterization and Safety Resource Center.

I. NON-ANALYTICAL DATA

Ia. Models/Waste Type Inventories/Campaign Information

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

- Contains single-shell tank fill history and primary campaign and waste information to 1981.

Jungfleisch, F. M., and B. C. Simpson, 1993, *Preliminary Estimation of the Waste Inventories in Hanford Tanks Through 1980*, WHC-SD-WM-TI-057, Rev. 0A, Westinghouse Hanford Company, Richland, Washington.

- A model based on process knowledge and radioactive decay estimations using ORIGEN for different compositions of process waste streams assembled for total, solution, and solids compositions per tank. Assumptions about waste/waste types and solubility parameters and constraints are also given.

Schneider, K. J., 1951, *Flow Sheets and Flow Diagrams of Precipitation Separations Process*, HW-23043, Hanford Atomic Products Operation, Richland, Washington

- Contains compositions of first cycle decontamination waste before transfer to Hanford 200 East Area waste tanks.

Ib. Fill History/Waste Transfer Records

Agnew, S. F., R. A. Corbin, T. B. Duran, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1997, *Waste Status and Transaction Record Summary (WSTRS) Rev. 4*, LA-UR-97-311, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Contains spreadsheets showing all available data on tank additions and transfers.

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

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Ic. Surveillance/Tank Configuration

Alstad, A. T., 1993, *Riser Configuration Document for Single-Shell Waste Tanks*, WHC-SD-RE-TI-053, Rev. 9, Westinghouse Hanford Company, Richland, Washington.

- Shows tank riser locations in relation to a tank aerial view and a description of risers and their contents.

Lipnicki, J., 1997, *Waste Tank Risers Available for Sampling*, HNF-SD-RE-TI-710, Rev. 4, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Assesses riser locations for each tank; however, not all tanks are included or completed. An estimate, of the risers available for sampling, is also included.

Tran, T. T., 1993, *Thermocouple Status Single-Shell & Double-Shell Waste Tanks*, WHC-SD-WM-TI-553, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains riser and thermocouple information for Hanford Site waste tanks.

Welty, R. K., 1988, *Waste Storage Tank Status and Leak Detection Criteria*, WHC-SD-WM-TI-356, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains surveillance information and leak detection status for tank 241-U-112.

Id. Sample Planning/Tank Prioritization

Brown, T. M., J. W. Hunt, and L. J. Fergestrom, 1997, *Tank Characterization Technical Sampling Basis*, HNF-SD-WM-TA-164, Rev. 3, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Summarizes the technical basis for characterizing tank waste and assigns a priority number to each tank.

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- Vapor sampling and analysis procedure for tank 241-U-112.

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- Document contains waste analysis requirements for single-shell tanks for acceptance of waste into double-shell tanks.

Stanton, G. A., 1998, *Baseline Sampling Schedule*, Change 98-01, (internal memorandum 79250-98-001 to Distribution, February 5), Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains schedule and completion dates for tank samples taken starting in 1944, and tentative schedules for future sampling events.

Winkelman, W. D., M. R. Adams, T. M. Brown, J. W. Hunt, D. J. McCain, L. S. Fergestrom, 1997, *Fiscal Year 1997-1998 Waste Information Requirements Document*, HNF-SD-WM-PLN-126, Rev. 0A, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains Tri-Party Agreement (Ecology et al. 1997) requirement-driven TWRS Characterization Program information.

Ie. Data Quality Objectives and Customers of Characterization Data

Dukelow, G. T., J. W. Hunt, H. Babad, and J. E. Meacham, 1995, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- Determines whether tanks are under safe operating conditions.

Meacham, J. E., D. L. Banning, M. R. Allen, and L. D. Muhlestein, 1997, *Data Quality Objective to Support Resolution of the Organic Solvent Safety Issue*, HNF-SD-WM-DQO-026, Rev. 0, Duke Engineering & Services, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains requirements for the organic solvents DQO.

Osborne, J. W., and L. L. Buckley, 1995, *Data Quality Objectives for Tank Hazardous Vapor Safety Screening*, WHC-SD-WM-DQO-002, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- Contains requirements for addressing hazardous vapor issues.

Schreiber, R. D., 1997, *Memorandum of Understanding for the Organic Complexant Safety Issue Data Requirements*, HNF-SD-WM-RD-060, Rev. 0, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains requirements, methodology, and logic for analyses to support organic complexant issue resolution.

Simpson, B. C., and D. J. McCain, 1997, *Historical Model Evaluation Data Requirements*, WHC-SD-WM-DQO-018, Rev. 2, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Provides data needs for evaluating the Los Alamos National Laboratory model for estimating tank waste compositions.

II. ANALYTICAL DATA - SAMPLING OF TANK WASTE AND WASTE TYPES

IIa. Sampling of Tank 241-U-112

Evans, J. C., K. H. Pool, B. L. Thomas, K. B. Olsen, J. S. Fruchter and K. L. Silvers, 1997, *Headspace Vapor Characterization of Hanford Waste Tank 241-U-112: Results from Samples Collected on 07/09/96*, PNNL-11265, Pacific Northwest National Laboratory, Richland, Washington.

- Contains headspace vapor results for tank 241-U-112 samples.

Steen, F. H., 1997, *Tank 241-U-112, Cores 219 and 220 Analytical Results for the Final Report*, WHC-SD-WM-DP-271, Rev. 0, Waste Management Federal Services of Hanford, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains laboratory results for 1997 push core sample analyses.

IIb. Sampling of Similar Waste Types

Bell, K. E., 1997, *Tank Characterization Report for Single-Shell Tank 241-U-110*, HNF-SD-WM-ER-551, Rev. 1A, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Richland, Washington.

- Tank contains 1C waste type.

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

IIIa. Inventories from Campaign and Analytical Information

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. Fitzpatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1997, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 4*, LA-UR-96-3860, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Contains waste type summaries and primary chemical compound/analyte and radionuclide estimates for sludge, supernatant, and solids.

Allen, G. K., 1976, *Estimated Inventory of Chemicals Added to Underground Waste Tanks, 1944 - 1975*, ARH-CD-601B, Atlantic Richfield Hanford Company, Richland, Washington.

- Document contains major components for waste types, and some assumptions. Purchase records are used to estimate chemical inventories.

Allen, G. K., 1975, *Hanford Liquid Waste Inventory As Of September 30, 1974*, ARH-CD-229, Atlantic Richfield Hanford Company, Richland, Washington.

- Document contains major components for waste types, and some assumptions.

Brevick, C. H., J. L. Stroup, and J. W. Funk, 1997, *Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 Area*, WHC-SD-WM-ER-352, Rev. 1, Fluor Daniel Northwest, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Document contains summary information from the supporting document as well as in-tank photo collages and the solid composite inventory estimates Rev. 0 and Rev. 0A.

Kupfer, J. J., A. L. Boldt, and M. D. LeClair, 1997, *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes*, HNF-SD-WM-TI-740, Rev. 0A, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains flowsheet estimates and strategy for establishing best-basis standard inventory estimates.

Schmittroth, F. A., 1995, *Inventories for Low-Level Tank Waste*, WHC-SD-WM-RPT-164, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains tank inventory information.

IIIb. Compendium of Data from Other Physical and Chemical Sources

Brevick, C. H., J. L. Stroup, and J. W. Funk, 1997, *Supporting Document for the Historical Tank Content Estimate for U Farm*, WHC-SD-WM-ER-325, Rev. 1, Fluor Daniel Northwest, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Document contains historical data and solid inventory estimates. The appendices contain the following information: Appendix C - Level History AutoCAD sketch; Appendix D - Temperature Graphs; Appendix E - Surface Level Graph; Appendix F- Tank Riser Location; Appendix G - In-Tank Photos.

Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1995, *Tank Waste Source Term Inventory Validation, Vol I & II.*, WHC-SD-WM-ER-400, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains a quick reference to sampling information in spreadsheet or graphical form for 23 chemicals and 11 radionuclides for all the tanks.

Hanlon, B. M., 1998, *Waste Tank Summary Report for Month Ending November 30, 1997*, WHC-EP-0182-116, Lockheed Martin Hanford Corp. for Fluor Daniel Hanford, Inc., Richland, Washington.

- Contains a monthly summary of the following: fill volumes, Watch List tanks, occurrences, integrity information, equipment readings, equipment status, tank location, and other miscellaneous tank information.

Hill, J. G., S. Anderson, and B. C. Simpson, 1995, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*, PNL-9814, Rev. 2, Pacific Northwest Laboratory, Richland, Washington.

- Contains statistical model results to sort tanks for similar waste types.

Hula, E. I., 1993, *Hanford Site Waste Storage Tank Information Notebook*, WHC-EP-0625, Westinghouse Hanford Company, Richland, Washington.

- Contains in-tank photographs and summaries on the tank description, leak detection system, and tank status.

Hula, E. I., 1995, *Hanford Waste Tank Preliminary Dryness Evaluation*, WHC-SD-WM-TI-703, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Assesses relative dryness between tanks.

Klem, M. J., 1990, *Inventory of Chemicals used at Hanford Production Plants and Support Operations—1944 to 1980,* WHC-EP-0172, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Contains information for chemicals in 1C and K/CWR waste.

Remund, K. M., and B. C. Simpson, 1996, *Hanford Waste Tank Grouping Study*, PNNL-11433, Pacific Northwest National Laboratory, Richland, Washington.

- Document contains a statistical evaluation to group tanks into classes with similar waste properties.

Shelton, L. W., 1996, *Chemical and Radionuclide Inventory for Single- and Double-Shell Tanks*, (internal memorandum 74A20-96-30 to D. J. Washenfelder, February 28), Westinghouse Hanford Company, Richland, Washington.

- Contains a tank inventory estimate based on analytical information.

Van Vleet, R. J., 1993, *Radionuclide and Chemical Inventories*, WHC-SD-WM-TI-565, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Contains tank inventory information.

LMHC, 1998, Tank Characterization Database, Internet at http://twins.pnl.gov:8001/TCD/main.html

- Contains analytical data for each of the 177 Hanford Site waste tanks.

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DISTRIBUTION SHEET

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