ENGINEERING CHANGE NOTICE

Page 1 of 2

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16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
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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	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

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Tank Characterization Report for Single-Shell Tank 241-C-110

Cheryl J. Benar
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U.S. Department of Energy Contract DE-AC06-87RL10930

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Abstract: This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-C-110. This report supports the requirements of the Tri-Party Agreement Milestone M-44-05.

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Tank Characterization Report for Single-Shell Tank 241-C-110

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LIST OF TERMS

1C	first-cycle $BiPO_4$ waste
AA	atomic absorption
ANOVA	analysis of variance
APC	alpha proportional counting
BPC	beta proportional counting
Btu/hr	British thermal units per hour
c/s	counts per second
Ci	curies
Ci/L	curies per liter
cm	centimeters
CSR	secondary cesium recovery waste from tanks 241-BY-104 and 241-BX-104
CVAA	cold vapor atomic absorption
df	degrees of freedom
DL	drainable liquid
DOE	U.S. Department of Energy
DQO	data quality objectives
DSC	differential scanning calorimetry
ETOX	extractable organic halides
ft	feet
g/L	grams per liter
g	gram
g/mL	grams per milliliter
g/cm^3	grams per cubic centimeter
GEA	gamma energy analysis
GFAA	graphite furnace atomic absorption
HDW	Hanford defined waste
HTCE	historical tank content estimate
IC	ion chromatography
ICP	inductively coupled plasma spectroscopy
in.	inch
J/g	joules per gram
kg	kilogram
kg/MTU	kilograms per metric ton uranium
kg/L	kilograms per liter
kgal	kilogallon
kL	kiloliter
kW	kilowatt
LEL	lower explosive limit
LF	laser fluorimetry
LFL	lower flammability limit
LL	lower limit
LSC	liquid scintillation counting

LIST OF TERMS (Continued)

m	meter
M	molar
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mm	millimeter
mrad/hr	millirads per hour
MTU	metric tons uranium
n/a	not applicable
N/R	not reviewed
NA	not analyzed
NR	not reported
OWW	PUREX organic wash waste (general)
OWW1	PUREX organic wash waste, 1960-1961
OWW3	secondary PUREX organic wash waste
PHMC	Project Hanford Management Contractor
PNL	Pacific Northwest Laboratory
ppmv	parts per million volume
PUREX	plutonium/uranium extraction plant
QC	quality control
RPD	relative percent difference
SACS	Surveillance Analysis Computer System
SMM	supernatant mixing model
SVOA	semivolatile organic analysis
TCLP	toxic characteristic leach procedure
TCR	tank characterization report
TGA	thermogravimetric analysis
TIC	total inorganic carbon
TLM	tank layer model
TOC	total organic carbon
TWRS	Tank Waste Remediation System
UL	upper limit
UR	uranium recovery
VOA	volatile organic analysis
W	watts
WHC	Westinghouse Hanford Company
WSTRS	waste status and transaction record summary
wt%	weight percent

LIST OF TERMS (Continued)

μCi/gal	microcuries per gallon
μCi/L	microcuries per liter
μCi/g	microcuries per gram
μCi/mL	microcuries per milliliter
μg/g	micrograms per gram
μg/mL	micrograms per milliliter
μmol/g	micromoles per gram
°C	degrees Celsius
°F	degrees Fahrenheit

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1.0 INTRODUCTION

One of the major functions of the Tank Waste Remediation System (TWRS) is to characterize wastes in support of waste management and disposal activities at the Hanford Site. Analytical data from sampling and analysis, along with 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-C-110.

The objectives of this report are: 1) to use characterization data in response to technical issues associated with 241-C-110 waste; and 2) to provide a standard characterization of this waste in terms of a best-basis inventory estimate. The response to technical issues is summarized in Section 2.0, and the best-basis inventory estimate is presented in Section 3.0. Recommendations regarding safety status and additional sampling needs are provided in Section 4.0. Supporting data and information are contained in the appendixes. This report also supports the requirements of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996) milestone M-44-05.

1.1 SCOPE

Characterization information presented in this report originated from sample analyses and known historical sources. While only the results from recent sample events will be used to fulfill the requirements of the data quality objectives (DQOs), other information can be used to support (or question) conclusions derived from these results. Historical information for tank 241-C-110, provided in Appendix A, included surveillance information, records pertaining to waste transfers and tank operations, and expected tank contents derived from a process knowledge model.

The sampling events listed in Table 1-1, as well as sample data obtained before 1989, are summarized in Appendix B along with the sampling results. The results of the 1992 sampling events are also reported in the data package (Kocher 1993), and satisfy the data requirements specified in Hill et al. (1991). The statistical analysis and numerical manipulation of data used in issue resolution are reported in Appendix C. Appendix D contains the evaluation to establish the best basis for the inventory estimate and the statistical analysis performed for this evaluation. A bibliography that resulted from an in-depth literature search of all known information sources applicable to tank 241-C-110 and its respective waste types is contained in Appendix E. The reports listed in Appendix E may be found in the Lockheed Martin Hanford Corporation Tank Characterization and Safety Resource Center.

Table 1-1. Summary of Recent Sampling.

Sample/Date	Phase	Location	Number of Segments Recovered	Percent Recovery
Vapor sample (August 1994)	Gas	Tank headspace, riser 1, 7.3 m (23.9 ft) below top of riser	n/a	n/a
Push mode core samples (April 14-23, 1992)	Solid & liquid	Riser 5 Core 37	3	Segment 1 0 Segment 2 100 Segment 3 100 Segment 4 100
		Riser 7 Core 38	2	Segment 1 35 Segment 2 0 Segment 3 0 Segment 4 100
		Riser 2 Core 39	3	Segment 1 0 Segment 2 80 Segment 3 25 Segment 4 100

Note:
n/a = not applicable

1.2 TANK BACKGROUND

Tank 241-C-110 is located in the 200 East Area C Tank Farm on the Hanford Site. It was constructed in 1944 and 1945 and went into service in 1946, when it received first-cycle decontamination waste from B Plant. Later sources of waste included U Plant, Plutonium-Uranium Extraction (PUREX) Plant, and tanks 241-BY-104, 241-BX-104, and 241-BX-103. Tank 241-C-110 is the first tank in a cascade with tanks 241-C-111 and 241-C-112.

The tank has an operational capacity of 2,010 kL (530 kgal), and currently contains 674 kL (178 kgal) of dilute complexed waste, existing primarily as sludge. Approximately 106 kL (28 kgal) of drainable interstitial liquid remains (Hanlon 1997). The tank is not classified as a Watch List tank (Public Law 101-510); however, it is an assumed leaker, with a leakage volume estimated at 7.5 kL (2 kgal) of waste. The tank was primary stabilized in 1979 and underwent partial interim isolation in 1982. Interim stabilization was completed May 1995 and intrusion prevention was completed November 1995. Unreviewed safety questions associated with tank 241-C-110 at this time include the organic complexant and the flammable gas unreviewed safety questions. A description of tank 241-C-110 is summarized in Table 1-2.

Table 1-2. Description of Tank 241-C-110.

TANK DESCRIPTION	
Type	Single-shell
Constructed	1944-1945
In-service	1946
Diameter	22.9 m (75.0 ft)
Operating depth	5.2 m (17 ft)
Capacity	2,010 kL (530 kgal)
Bottom shape	Dish
Ventilation	Passive
TANK STATUS	
Waste classification	Dilute complexed
Total waste volume[1,2]	674 kL (178 kgal)
Supernatant volume[2]	4 kL (1 kgal)
Saltcake volume[2]	0 kL (0 kgal)
Sludge volume[2]	670 kL (177 kgal)
Drainable interstitial liquid volume[2]	106 kL (28 kgal)
Waste surface level (January 1997)	157.5 cm (62 in.)
Temperature (November 1975 to January 1997)	8.8 °C (47.8 °F) to 47.8 °C (118 °F)
Integrity	Assumed leaker
Watch List	None
SAMPLING DATE	
Headspace gas and vapor samples	August 1994
Core samples	April 1992
SERVICE STATUS	
Declared inactive	1977
Interim stabilized	1995
Intrusion prevention	1995

Notes:

[1]Waste volume is estimated from surface-level measurements.

[2]Hanlon (1997)

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2.0 RESPONSE TO TECHNICAL ISSUES

The following technical issues have been identified for tank 241-C-110:

- **Safety Screening:** Does the waste pose or contribute to any recognized potential safety problems?
- **Hazardous Vapor Safety Screening:** Does a potential exist for worker hazards associated with the toxicity of constituents in tank fugitive vapor emissions?
- **Organic Solvents:** Does an organic solvent pool exist that may cause an organic solvent pool fire or ignition of organic solvents entrained in the waste solids?

The 1992 sampling and analysis of cores 37, 38, and 39 predates current DQOs. However, the analytical results from this sampling event and the tank headspace flammability measurements obtained in 1994 provide useful information to respond to the technical issues. This response is detailed in the following sections. See Appendix B for sample and analysis data for tank 241-C-110.

2.1 SAFETY SCREENING

The data needed to screen the waste in tank 241-C-110 is documented in the safety screening DQO (Dukelow et al. 1995). Potential safety problems include exothermic conditions in the waste, flammable gases in the waste and/or tank headspace, and criticality conditions in the waste. Each condition is addressed separately below. Because the core sampling and analysis predate the DQO, this evaluation is provided for information only.

2.1.1 Exothermic Conditions (Energetics)

The first requirement in the safety screening DQO (Dukelow et al. 1995) is to ensure that exothermic constituents (organic) in tank 241-C-110 do not cause a safety hazard. The safety screening DQO requires that waste sample profiles be tested for energetics every 24 cm (half segment) to determine whether the energetics exceed 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 no exotherms were observed in any segment.

2.1.2 Flammable Gas

The tank headspace was sampled and analyzed for the presence of flammable gases in August 1994. Results showed that flammable gas was detected in the tank headspace at less than

one percent of the lower flammability limit (LFL). This is well below the safety screening limit of 25 percent of the LFL. Appendix B provides data from these measurements.

2.1.3 Criticality

The safety threshold limit is 1 g ^{239}Pu per liter of waste. Assuming that all total alpha activity is from ^{239}Pu, and using the highest measured density of 1.48 g/mL, 1 g/L of ^{239}Pu is equivalent to 41.6 μCi/g of alpha activity. Using the highest density result provides the lowest threshold limit.

The highest concentration of total alpha activity in any of the samples was 0.140 μCi/g, well below the limit. Additionally, as required by the DQO, the upper limits (ULs) of the one-sided 95 percent confidence interval for these results were all less than 0.2 μCi/g; therefore criticality is not an issue for this tank. Appendix C contains the method used to calculate the confidence limits and values.

2.2 HAZARDOUS VAPOR SAFETY SCREENING

The data required to support vapor screening are documented in *Data Quality Objective for Tank Hazardous Vapor Safety Screening* (Buckley and Osborne 1995). The vapor screening DQO addresses the following two technical issues: 1) are potential flammable levels of gases and vapors generated or released in waste storage tank headspaces above the 25 percent of the lower flammability limit; and 2) is there potential for worker hazards associated with the toxicity of constituents in any fugitive vapor emissions from these tanks? This section addresses these problems for tank 241-C-110.

2.2.1 Flammable Gas

This is the same requirement as the safety screening flammability requirement. Flammable gases are not an issue associated with this tank. See Section 2.1.2 for treatment of the flammability issue.

2.2.2 Toxicity

The vapor screening DQO requires the analysis of ammonia, carbon dioxide, carbon monoxide, nitric oxide, nitrous oxide, and nitrogen dioxide from a sample. The vapor screening DQO (Buckley and Osborne 1995) specifies a threshold limit for each of the above listed compounds. Results indicate that aside from water vapor, the most abundant constituents in the tank 241-C-110 headspace are ammonia, hydrogen, and nitrous oxide (Bratzel and Huckaby 1995). Ammonia and hydrogen were detected at levels less than

1 percent of the LFL and nitrous oxide had an average result of 21 ppmv, which is below the threshold value of 25 ppmv (Bratzel and Huckaby 1995). The toxicity issue has been closed for all tanks (Hewitt 1996).

2.3 ORGANIC SOLVENTS

The data required to support the organic solvent screening issue are documented in the 93-5 implementation plan (DOE-RL 1996). A new DQO is currently being developed to address the organic solvent issue. In the interim, tanks are to be sampled for total non-methane hydrocarbon to determine if an organic extractant pool greater than 1 m^2 (10.8 ft^2) exists (Cash 1996).

The purpose of this assessment is to ensure that the organic solvent pool is sufficiently small to ensure that an organic solvent pool fire or ignition of organic solvents cannot occur. Vapor sample results showed that the concentration of total non-methane organic hydrocarbon was 22.3 mg/m^3. At a later date, the size of the organic extractant pool will be estimated and reported by the Organics Program. The size of the organic extractant pool is based on the vapor data, tank headspace temperature, and the tank ventilation rate.

2.4 OTHER TECHNICAL ISSUES

Heat generation and waste temperature are factors in assessing tank safety. Because the waste in tank 241-C-110 is radioactive, it generates heat through radioactive decay. Based on results from the 1992 sampling event, the most significant radioactive contributors in the waste are ^{137}Cs and ^{90}Sr, contributing 20,000 and 5,140 curies, respectively.

Table 2-1 summarizes the heat produced by the radionuclides in the waste. The heat load calculations indicate that 127 W (433 Btu/hr) of heat are produced in the tank. The heat load estimate based on tank process history was 64.5 W (221 Btu/hr) (Agnew et al. 1997), and the estimate based on the tank headspace temperature was 934 W (3,188 Btu/hr) (Kummerer 1995). All three estimates are below the limit of 11,700 W (40,000 Btu/hr) that separates high- and low-heat-load tanks (Smith 1986).

2.5 SUMMARY

This section summarizes the results of sampling and analysis for the issues that apply to tank 241-C-110. The sampling performed on the tank to date has met the needs of the data quality objectives that apply to the tank. Table 2-2 summarizes the characterization results for the safety screening, hazardous vapor safety screening, and organic solvents issues.

The results from all analyses performed to address potential safety issues showed that no primary analytes exceeded safety decision threshold limits. Although DQOs were not

applicable to this sampling event, this report evaluates analytical results against the current safety screening DQO (Dukelow et al. 1995). Two vertical waste profiles were required. Although the riser locations, from which the core samples were taken, met the safety screening requirement of being separated radially to the maximum extent possible, the sample recovery did not fully meet the requirement of two complete vertical profiles. The safety screening DQO requirement that analyses be performed at the half segment level was also not met. The safety screening DQO also requires the determination of the flammability of tank headspace gases. This determination was completed in August 1994.

Table 2-1. Radionuclide Inventory and Projected Heat Load.

Analyte	Total Ci	Watts/Ci[1]	Watts
^{137}Cs	19,300	0.0047	91
$^{239/240}Pu$	82.4	0.0306	2.52
^{90}Sr	4,880	0.00669	32.7
	Total watts		127

Note:
[1]Kirkpatrick and Brown (1984)

Table 2-2. Summary of Safety Screening, Vapor Screening, and Organic Solvents Evaluation Results.

Issue	Sub-issue	Result
Safety screening	Energetics	No exotherms observed in any sample.
	Flammable gas	Vapor measurement reported less than 1% of lower flammability limit.
	Criticality	All analyses well below 41 μCi/g total alpha (within 95% confidence limit on each sample).
Hazardous vapor safety screening	Flammability	See safety screening - flammable gas
	Toxicity	All analytes were within the toxicity threshold limits.
Organic solvents	Solvent pool size	Total non-methane hydrocarbon concentration is 22.3 mg/m^3. The size of the organic solvent pool will be estimated from these results later.

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 assessments associated with waste management activities, as well as to address regulatory issues. Waste management 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 suitable for long-term storage.

Chemical and radiological inventory information is generally derived using three approaches: 1) component inventories are estimated using results of sample analyses; 2) component inventories are estimated 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. The information derived from these different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as the standard characterization for various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of chemical information for tank 241-C-110 was performed that used:

1. Data from three full-depth core samples obtained in 1992 (Kocher 1993).

2. An inventory estimate generated by the HDW model (Agnew et al. 1997).

3. An evaluation of 1C waste based on the $BiPO_4$ flowsheet, fuel records for B-Plant, and tank waste transactions for tank 241-C-110.

4. An analysis of uranium recovery (UR) sludge based on common sludge layers in tank 241-TY-105 and the waste transaction records for tanks 241-C-110 and 241-TY-105.

5. An analysis of the PUREX flowsheet and the composition of PUREX organic wash waste, 1960-1961 (OWW1), together with the waste transaction records for tank 241-C-110.

6. An evaluation of the estimated thermal loads provided by the sample-based inventories of ^{90}Sr and ^{137}Cs based on thermal modeling results for this tank.

Based on this analysis, a best-basis inventory was developed. The 1992 core sample results were used to generate estimates for the chemical and radionuclide components in this waste. The waste in tank 241-C-110 primarily consists of $BiPO_4$ 1C waste, with small amounts of

UR and OWW1 waste from the uranium recovery process and PUREX, respectively. The best-basis inventory for tank 241-C-110 is presented in Tables 3-1 and 3-2.

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-110.

Analyte	Total Inventory (kg)	Basis (S, M, E, or C)[1]	Comment
Al	14,322	S	
Bi	16,600	S	
Ca	1,136	S	
Cl	1,116	S	
CO_3	6,915	S	
Cr	469	S	
F	7,650	S	
Fe	10,871	S	
Hg	0.4	S	
K	662	S	
La	2	S	
Mn	56	S	
Na	82,790	S	
Ni	24	S	
NO_2	7,378	S	
NO_3	111,080	S	
OH	13,060	C	
Pb	255	S	
P as PO_4	61,630	S	
Si	7,073	S	
S as SO_4	15,310	S	
Sr	129	S	
TOC	7,480	S	
U_{TOTAL}	1,470	S	
Zr	170	S	

Note:
[1]S = Sample-based (see Appendix B), M = HDW model-based (Agnew et al. 1997), E = Engineering assessment-based, C = Based on charge balance

Table 3-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-C-110 (Decayed to January 1, 1994).

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	1.09	S	
^{14}C	4.75E-01	S	
^{60}Co	<34.4	S	
^{79}Se	1.34	S	
^{90}Sr	4.88E+03	S	
^{90}Y	4.88E+03	E	Based on ^{90}Sr
^{99}Tc	3.41E+01	S	
^{129}I	<2.6E+01	S	
^{137}Cs	1.93E+04	S	
^{137m}Ba	1.73E+04	E	Based on ^{137}Cs
^{154}Eu	<1E+02	S	
^{155}Eu	<9.4E+01	S	
^{238}Pu	<5.1E+01	S	
^{238}U	5.1E-01	S	
^{239}Pu	8.24E+01	S	
^{241}Am	<2.9E+02	S	

Note:

[1]S = Sample-based (see Appendix B), M = HDW model-based (Agnew et al. 1997), E = Engineering assessment-based

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4.0 RECOMMENDATIONS

The sampling and analysis of cores 37, 38, and 39 predated current DQOs. However, these results were evaluated against the requirements of the safety screening DQO (Dukelow et al. 1995), the hazardous vapor DQO (Buckley and Osborne 1995), and organic solvents requirements (Cash 1996). All analytical results were well within the safety notification limits. The tank has not been classified as "safe" because the results are still under review. Vapor samples showed that the LFL for gases in the tank headspace is below the threshold limit of 25 percent and that vapor toxicity is not a concern for this tank. The size of the organic solvents pool will be estimated and results reported at a later date.

Table 4-1 summarizes the status of Project Hanford Management Contract (PHMC) TWRS Program Office review and acceptance of the sampling and analysis results reported in this TCR. Table 4-1 lists the DQO issues addressed by the sampling and analysis. Column 2 indicates with "Yes" or "No" whether the requirements of the DQO were met by the sampling and analysis activities performed. The third column indicates the concurrence and acceptance by the program in TWRS responsible for the DQO that the sampling and analysis activities performed adequately meet the needs of the DQO. A "Yes" or "No" in column 3 indicates acceptance or disapproval of the sampling and analysis information presented in the TCR. If the results and information have not yet been reviewed, "N/R" is shown; if the results and information have been reviewed, but acceptance or disapproval have not been decided, "N/D" is shown.

Table 4-1. Acceptance of Tank 241-C-110 Sampling and Analysis.

Issue	Sampling and Analyses Performed	TWRS PHMC Program Acceptance
Safety screening DQO	Yes	Yes
Hazardous vapor DQO	Yes	Yes
Organic solvents requirement	Yes	Yes

Table 4-2 summarizes the status of TWRS Program review and acceptance of the evaluations and other characterization information contained in this report. The evaluations in this report include the best-basis inventory evaluation and the evaluation to determine whether the tank is safe, conditionally safe, or unsafe. Column 1 lists the evaluations performed in this report. Columns 2 and 3 are in the same format as Table 4-1. The manner in which concurrence and acceptance are summarized is also the same as that in Table 4-1.

Table 4-2. Acceptance of Evaluation of Characterization Data and Information for Tank 241-C-110.

Issue	Evaluation Performed	TWRS PHMC Program Acceptance[1]
Safety categorization (tank is safe)	Yes	N/R
Hazardous vapor DQO	Yes	Yes
Organic solvent pool size	No	N/R

Note:
[1]PHMC Program Office

5.0 REFERENCES

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APPENDIX A

HISTORICAL TANK INFORMATION

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APPENDIX A

HISTORICAL TANK INFORMATION

Appendix A describes tank 241-C-110 based on historical information. For this report, historical information includes any information about the fill history, waste types, surveillance, or modeling data about the tank. This information is necessary for providing a balanced assessment of the sampling and analytical results.

This appendix contains the following information:

- **Section A1:** Current status of the tank, including current waste levels and the stabilization and isolation status.
- **Section A2:** Information about the tank's design.
- **Section A3:** Process knowledge of the tank; i.e., the waste transfer history and the estimated contents of the tank based on modeling data.
- **Section A4:** Surveillance data for tank 241-C-110, including surface-level readings, temperatures, and a description of the waste surface based on photographs.
- **Section A5:** References for Appendix A.

Historical sampling results (results from samples obtained before 1989) are included in Appendix B.

A1.0 CURRENT TANK STATUS

As of February 28, 1997, tank 241-C-110 contained an estimated 674 kL (178 kgal) of waste classified as dilute complexed waste (Hanlon 1997). Liquid waste volumes were measured using a manual tape. The solid waste volumes were estimated using a sludge level measurement device. The solid waste volume was last updated on June 14, 1995. The amounts of various waste phases in the tank are presented in Table A1-1.

Tank 241-C-110 was removed from service in 1976. In 1984 it was categorized as an assumed leaker. The tank is not on any Watch List (Public Law 101-510) and is passively ventilated. The tank was interim stabilized in May 1995 and intrusion prevention was completed in November 1995 (Hanlon 1997). All monitoring systems were in compliance with documented standards as of February 28, 1997 (Hanlon 1997).

Table A1-1. Tank Contents Status Summary (Hanlon 1997).

Waste Type	kL (kgal)
Total waste	674 (178)
Supernatant	4 (1)
Sludge	670 (177)
Saltcake	0 (0)
Drainable interstitial liquid	106 (28)
Drainable liquid remaining	110 (29)
Pumpable liquid remaining	57 (15)

A2.0 TANK DESIGN AND BACKGROUND

The 241-C Tank Farm was constructed during 1943 and 1944 in the 200 East Area. Tank 241-C-110 is one of twelve 100-series tanks in C Farm with a capacity of 2,006 kL (530 kgal), a diameter of 23 m (75 ft), and an operating depth of 4.9 m (16 ft) (Leach and Stahl 1997). The C-farm was designed for nonboiling waste with a maximum temperature of 104 °C (Brevick et al. 1997). A cascade overflow line 75 mm (3 in.) in diameter connects tank 241-C-110 as first in a cascade series of three tanks continuing through tanks 241-C-111 and 241-C-112. Each tank in the cascade series is set one foot lower in elevation from the preceding tank. The cascade outlet was blocked in 1952 (Agnew et al. 1997b).

The tank has a dished bottom with a 1.2-m (4-ft) radius knuckle. Tank 241-C-110 was designed with a primary mild steel liner (ASTM[1] A283 Grade C) 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 a welded-wire-reinforced cement-like mixture. Two coats of primer were sprayed on all exposed interior tank surfaces. 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 (Rogers and Daniels 1944).

Tank 241-C-110 has 9 risers according to the drawings and engineering change notices. The risers range in diameter from 100 mm (4 in.) to 30 cm (12 in.). Table A2-1 shows numbers, diameters, and descriptions of the risers and the inlet, overflow, and spare nozzles. A plan view that depicts the riser and nozzle configuration is shown as Figure A2-1. Risers 1, 2, 3,

[1]American Society for Testing and Materials

5, 6, and 7 are tentatively available for sampling (Lipnicki 1997). A tank cross-section showing the approximate waste level, along with a schematic of the tank equipment, is shown in Figure A2-2.

Table A2-1. Tank 241-C-110 Risers.[1, 2, 3,]

Number	Diameter (inches)	Description and Comments
R1*	4	Flange, spare
R2*	12	Flange, blank (benchmark)
R3*	12	Breather filter
R4	4	Liquid level reel
R5*	4	Flange (benchmark)
R6*	12	Flange with bale (blank)
R7*	12	B-222 observation port
R8	4	Thermocouple tree
R13	12	Salt well pump pit
A	6	Overflow outlet
C1	4	Fill line nozzle, sealed in diversion box 241-C-153
C2	4	Fill line nozzle, sealed in diversion box 241-C-153
C3	12	Fill line nozzle, sealed in diversion box 241-C-153
C4	3	Fill line nozzle, sealed in diversion box 241-C-153

Notes:

[1]Alstad (1993)
[2]Tran (1993)
[3]Vitro (1986)

*Indicates risers tentatively available for sampling (Lipnicki 1997).

Figure A2-1. Riser Configuration for Tank 241-C-110.

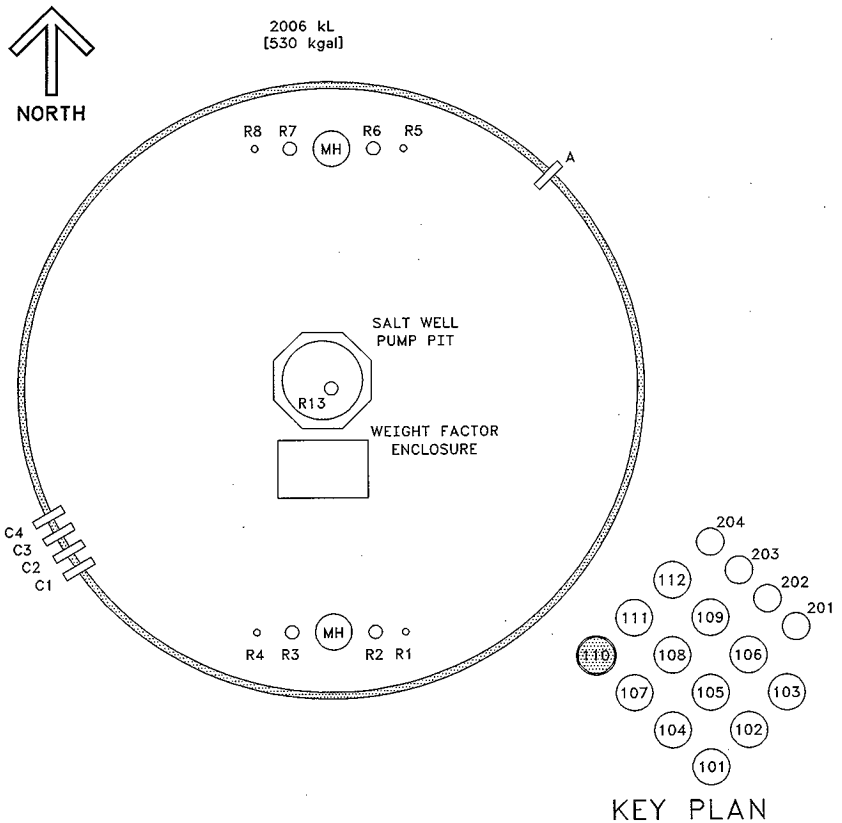
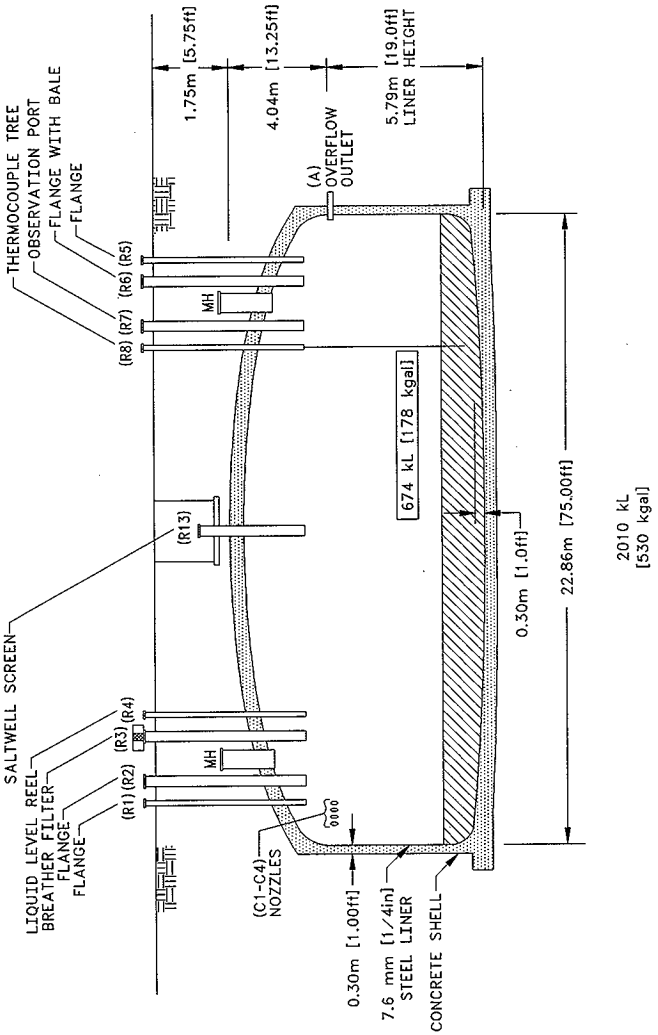


Figure A2-2. Tank 241-C-110 Cross Section and Schematic.



A3.0 PROCESS KNOWLEDGE

The sections below: 1) provide information about the transfer history of tank 241-C-110; 2) describe the process wastes that made up the transfers; and 3) give an estimate of the current tank contents based on transfer history.

A3.1 WASTE TRANSFER HISTORY

Table A3-1 summarizes the waste transfer history of tank 241-C-110 (Agnew et al. 1997b). Tank 241-C-110 began receiving waste in May 1946, and by April 1947 was filled with first-cycle waste (1C). During that time, waste was transferred to tank 241-C-111 through the cascade line. Supernatant waste was transferred to tank 241-B-106 in the third quarter of 1952.

In the fourth quarter of 1952 and first quarter of 1953, the tank received UR waste. In the first quarter of 1956, UR waste was transferred from tank 241-C-110 to the CR process vault through tank 241-C-109.

The tank received organic wash waste from PUREX in the second and third quarters of 1956. Waste was sent to tank 241-BY-112 in the fourth quarter of 1967 and to tank 241-C-102 in the second quarter of 1969.

From the first quarter of 1970 until the first quarter of 1972, evaporator bottoms waste and ion exchange waste were sent to the tank from tanks 241-BY-104, 241-BX-104 and 241-BX-103. During this time, supernatant waste was sent to tanks 241-C-108, 241-C-109, 241-C-112, and 241-C-104. Waste was sent to tank 241-C-112 in the third quarter of 1975 and to tank 241-C-103 in the first and second quarters of 1976.

The tank was removed from service in 1976 when salt well pumping began. Salt well pumping continued through the third quarter of 1977. The tank was primary stabilized in September 1979, and interim stabilized in May 1995.

Table A3-1. Tank 241-C-110 Major Transfers.[1,2] (2 sheets)

Transfer Source	Transfer Destination	Waste Type	Time Period	Estimated Waste Volume	
				kL	kgal
$BiPO_4$ process		1C	1946-1947	6,006	1,587
	241-C-111	1C	1946-1947	-4,000	-1,057
	241-B-106	Supernatant	1952	-1,132	-299
222-U		UR/TBP	1952-1953	1,162	307

Table A3-1. Tank 241-C-110 Major Transfers.[1,2] (2 sheets)

Transfer Source	Transfer Destination	Waste Type	Time Period	Estimated Waste Volume	
				kL	kgal
	CR Vault-001	UR/TBP	1956	-1,030	-272
PUREX		OWW	1956	1,007	266
	241-BY-112	Supernatant	1967	-276	-73
	241-C-102	Supernatant	1969	-814	-215
241-BY-104		Supernatant	1970	572	151
241-BX-104		Supernatant	1970	4,758	1,257
	241-C-108 241-C-109 241-C-112	Supernatant	1970	-4,153	-1,097
	241-C-104		1971	-1,234	-326
241-BX-103		Supernatant	1972	606	160
	241-C-103 241-C-112	Supernatant	1975, 1976	-647	-171

Notes:

1C = first-cycle $BiPO_4$ waste
UR/TBP = tri-butyl phosphate (TBP) waste from 222-U uranium recovery, 1952 to 1957
OWW = PUREX organic wash waste

[1]Agnew et al. (1997b)

[2]Because only major transfers are listed, the sum of these transfers will not equal the current tank waste volume.

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. A*, (Agnew et al. 1997b), 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), which 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, comprised of approximately 50 waste types defined by concentration for major analyses/compounds for sludge and supernatant layers.

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

- The SMM, which 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 supernatants 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-C-110 contains 708 kL (187 kgal) of first-cycle decontamination waste from the $BiPO_4$ process (1C) (Figure A3-1). Hanlon (1997) reports 4 kL (1 kgal) of supernatant and 670 kL (177 kgal) of 1C waste. Hanlon is based on more current measurements, and accounts for tank losses from the recent salt well pumping activity.

The 1C waste should contain sodium, aluminum, nitrate, iron, hydroxide, uranium, and phosphate at concentrations greater than one weight percent, and bismuth, nitrite, calcium, sulfate, carbonate, silicate, and fluoride between one and 0.1 weight percent. Radioactivity should be comparatively low for the 1C waste type, with very little strontium or cesium present. Table A3-2 shows the tank layer model estimate for waste types and concentrations in tank 241-C-110.

Figure A3-1. Tank Layer Model.

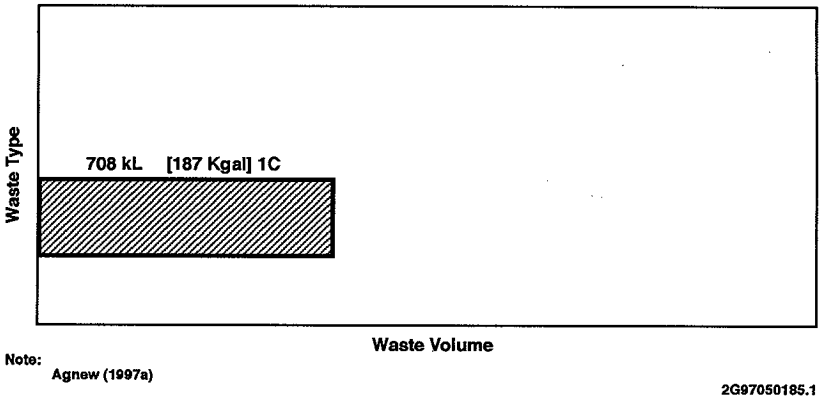


Table A3-2. Historical Tank Inventory Estimate.[1,2] (2 sheets)

Total Inventory Estimate			
Physical Properties			
Total solid waste	9.77E+05 kg (187 kgal)		
Heat load	6.47E-02 kW (221 Btu/hr)		
Bulk density	1.38 (g/cm^3)		
Water wt%	64.0		
Total organic carbon wt% carbon (wet)	0		
Chemical Constituents	***M***	***μg/g***	**kg**[3]
Na^+	5.23	8.70E+04	8.50E+04
Al^{3+}	0.599	1.17E+04	1.14E+04
Fe^{3+} (total Fe)	0.352	1.43E+04	1.39E+04
Cr^{3+}	4.86E-03	183	179
Bi^{3+}	6.24E-02	9.44E+03	9.23E+03
La^{3+}	0	0	0
Hg^{2+}	1.06E-04	15.4	15.0
Zr (as $ZrO(OH)_2$)	2.39E-04	15.8	15.4
Pb^{2+}	0	0	0

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

Total Inventory Estimate			
Chemical Constituents (Cont'd)	***M***	**μg/g**	**kg[3]**
Ni^{2+}	1.20E-03	50.8	49.7
Sr^{2+}	0	0	0
Mn^{4+}	0	0	0
Ca^{2+}	7.62E-02	2.21E+03	2.16E+03
K^{1+}	6.72E-03	190	186
OH^-	4.06	5.00E+04	4.89E+04
NO_3^-	1.04	4.65E+04	4.54E+04
NO_2^-	0.236	7.86E+03	7.68E+03
CO_3^{2-}	7.62E-02	3.31E+03	3.24E+03
PO_4^{3-}	1.15	7.92E+04	7.74E+04
SO_4^{2-}	5.20E-02	3.62E+03	3.54E+03
Si (as SiO_3^{2-})	0.224	1.91E+03	4.45E+03
F^-	0.139	1.91E+03	1.87E+03
Cl^-	3.09E-02	794	776
$C_6H_5O_7^{3-}$	0	0	0
$EDTA^{4-}$	0	0	0
$HEDTA^{3-}$	0	0	0
$Glycolate^-$	0	0	0
$Acetate^-$	0	0	0
$Oxalate^{2-}$	0	0	0
DBP	0	0	0
Butanol	0	0	0
NH_3	7.94E-02	978	955
$Fe(CN)_6^{4-}$	0.0000	0.0000	0.0000
Radiological Constituents			
Pu	2.74E-04 (g/L)		0.194 (kg)
U	0.213 (M)	3.50E+04 (μg/g)	3.43E+04 (kg)
Cs-137	8.11E-03 (Ci/L)	6.21 (μCi/g)	6.07E+03 (Ci)
Sr-90	7.61E-03 (Ci/L)	5.51 (μCi/g)	5.39E+03 (Ci)

Notes:

[1]Agnew et al. (1997a), current inventory is 674 kL (178 kgal) (Hanlon 1997).

[2]These predictions have not been validated and should be used with caution.

[3]Differences exist among the inventories in this column and the inventories calculated from the two sets of concentrations.

A4.0 SURVEILLANCE DATA

Tank 241-C-110 surveillance includes surface-level measurements (liquid and solid) and temperature monitoring inside the tank (waste and headspace). The data provide the basis for determining tank integrity.

Liquid-level measurements may indicate if there is a major leak from a tank. Solid surface-level measurements provide an indication of physical changes and consistency of the solid layers.

A4.1 SURFACE-LEVEL READINGS

The tank 241-C-110 surface level is monitored daily using a manual tape. The tank surface level on January 13, 1997 was 157.5 cm (62 in.) as measured using a manual tape. A graphical representation of the volume measurements is presented as a level history graph in Figure A4-1.

A4.2 DRY WELL READINGS

Tank 241-C-110 has four dry wells. Dry wells 30-10-02 and 30-10-09 (active before 1990, current readings are less than 200 c/s) had readings greater than the 50 c/s background radiation. Radioactivity in the dry wells was attributed to an assumed leak volume of 2,000 gal (Brevick et al. 1997).

A4.3 INTERNAL TANK TEMPERATURES

Tank 241-C-110 contains a single thermocouple tree located in riser 8, with 11 thermocouple probes. Thermocouples 5, 6, 8 and 9 are out of service. Temperature records obtained from the Surveillance Analysis Computer System (SACS) showed that between November 1975 and the present, temperatures readings ranged from a low of 8.8 °C (47.8 °F) to a high of 47.8 °C (118 °F).

The average temperature of the SACS data from January 1996 through January 1997 was 19.6 °C (67.3 °F), the minimum was 17.5 °C (63.5 °F), and the maximum was 22.4 °C (72.3 °F). The high temperature on January 13, 1997 was 19.6 °C (67.3 °F) on thermocouple 1 (located in the waste) and the minimum was 18.0 °C (64.4 °F) on thermocouple 10 (located in the headspace). A graph of the weekly high temperatures can be found in Figure A4-2. Plots of the individual thermocouple readings can be found in the C Tank Farm supporting document for the HTCE (Brevick et al. 1997).

Figure A4-1. Tank 241-C-110 Level History.

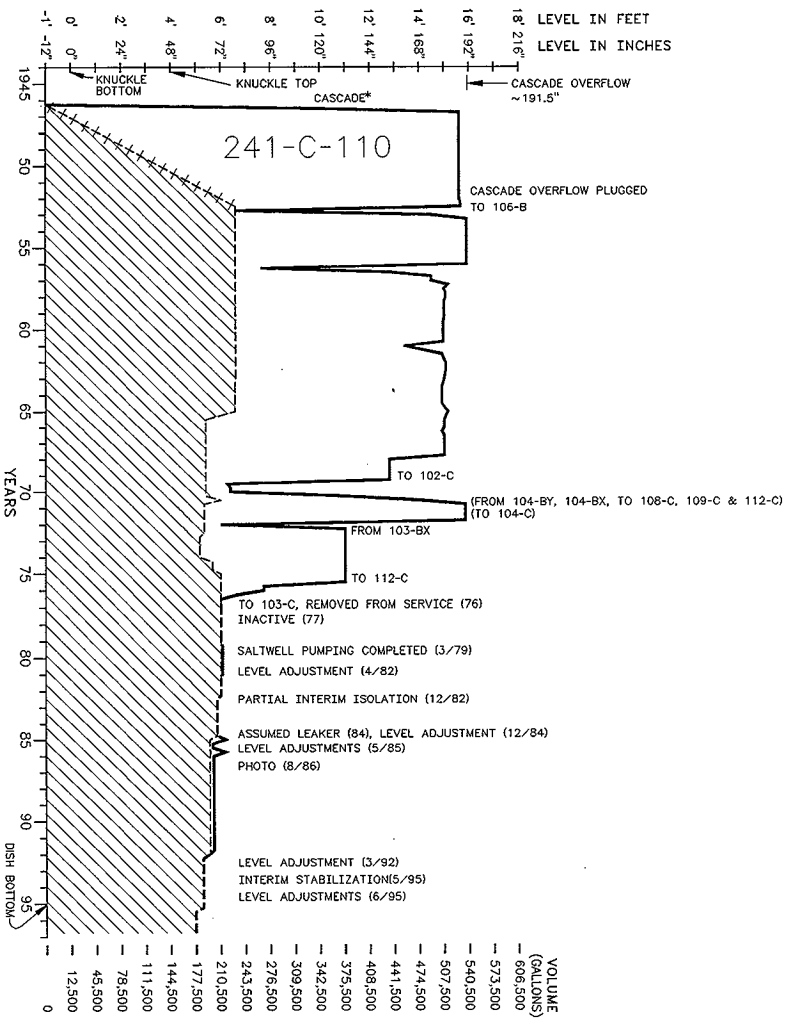
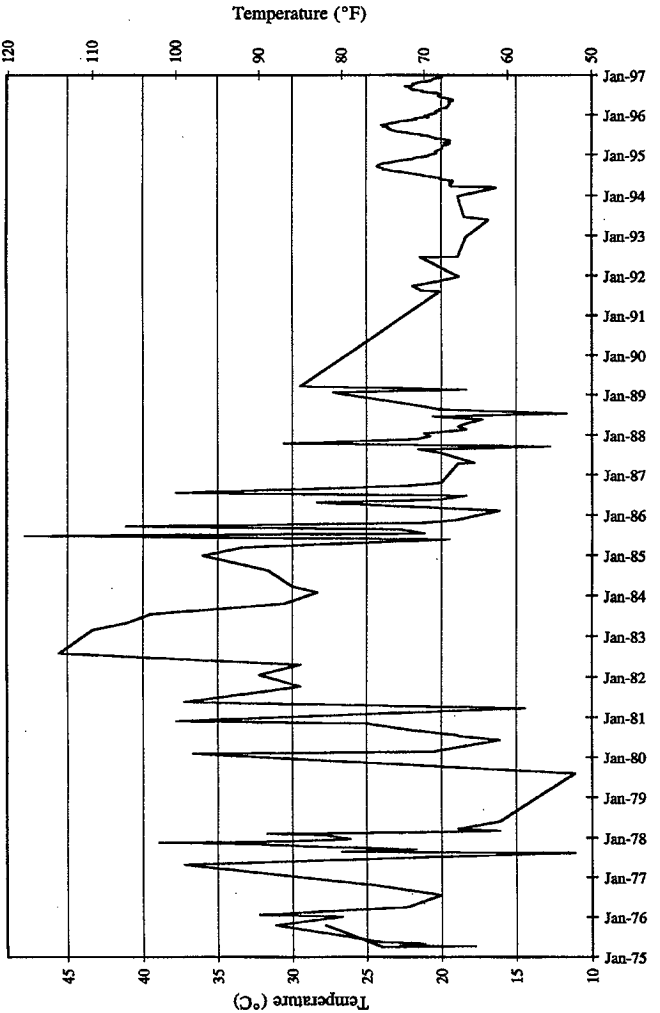


Figure A4-2. Tank 241-C-110 High Temperature Plot.



A4.4 TANK 241-C-110 PHOTOGRAPHS

The August 1986 photographic montage (Brevick et al. 1996) of tank 241-C-110's interior shows a rust-red sludge surface with pools of supernatant. Debris in the photo includes black tubing and old level measurement tapes. The tank was salt well pumped after these photos were taken; however, the photographic montage should represent the current appearance of the tank's waste.

A5.0 APPENDIX A REFERENCES

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APPENDIX B

SAMPLING OF TANK 241-C-110

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APPENDIX B

SAMPLING OF TANK 241-C-110

Appendix B provides sampling and analysis information for each known sampling event for tank 241-C-110 and assesses the core sampling results. It includes the following:

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

Future sampling results for tank 241-C-110 will be appended to the above list.

B1.0 TANK SAMPLING OVERVIEW

This section describes the sampling and analysis events for tank 241-C-110. The characterization information supported the design of pretreatment and final waste disposal systems and was used to make risk assessment-based decisions. Sampling and analytical requirements are summarized in Table B1-1.

Push core samples were taken in April, 1992. Push core sampling and analysis were performed as directed by the sampling and analysis plan (Hill et al. 1991). Although the sampling event predated current DQOs, sample results were evaluated against the safety screening DQO (Dukelow et al. 1995). For further discussion of the sampling and analysis procedures, refer to the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

Headspace gas sniff tests were conducted and vapor samples were collected from tank 241-C-110 on August 18, 1994. Westinghouse Hanford Company (WHC) Sampling and Mobile Laboratories collected the vapor samples using the vapor sampling system (Bratzel and Huckaby 1995). Vapor samples were taken to satisfy the tank hazardous vapor screening data quality objective (Osborne and Buckley 1995) and the organic solvents issue (DOE-RL 1996 and Cash 1996).

Supernatant and sludge historical samples were taken from this tank in 1975 and 1977 respectively; the sample results are presented in Section B1.5.

Table B1-1. Integrated Requirements for Tank 241-C-110.

Sampling Event	Applicable DQOs	Sampling Requirements	Applicable References
Push Mode Core Sampling	SAFETY SCREENING - Energetics - Moisture Content - Total Alpha - Flammable Gas	Core samples from a minimum of two risers separated radially to the maximum extent possible Combustible gas measurement	Dukelow et al. (1995)
Vapor Sampling	Hazardous vapor Organic solvents	Steel canisters, Triple Sorbent Traps, Sorbent Trap Systems	Osborne and Buckley (1995) DOE-RL (1996) and Cash (1996)

B1.1 DESCRIPTION OF THE PUSH CORE SAMPLING EVENT

Three core samples were taken from tank 241-C-110. All three cores consisted of four segments and were collected April 14 through April 23, 1992. Core 37 was taken through riser 5, core 38 through riser 7, and core 39 through riser 2. The samples were received by the WHC 222-S Process and Analytical Laboratory on May 9, 1992. Normal paraffin hydrocarbons were used as a hydrostatic head fluid during core sampling.

As described in Table B1-1, 5 of the 12 segments were recovered with 100 percent recovery, 4 segments were empty, 1 segment had an 80 percent recovery, and 2 segments contained less than 50 percent recovery. Only 1 segment from each core contained drainable liquids exceeding 15 percent.

Two vertical waste profiles are required to meet the safety screening DQO. Although the riser locations, from which the core samples were taken, met the safety screening requirement of being separated radially to the maximum extent possible, the sample did not fully meet the requirement of two complete vertical profiles. The safety screening DQO requirement that analyses be performed at the half segment level was also not met. The safety screening DQO also requires the determination of the flammability of tank headspace gases. This determination was completed in August 1994.

Table B1-2. Tank 241-C-110 Push Core Sample Description.[1] (2 sheets)

Riser	Segment	Sample Number	Sample recovery (%)	Sample characteristics
37	1	92-007	0	No sample
	2	92-008	100	All solids, material was reddish brown and wet
	3	92-009	100	All liquid, reddish-brown and opaque
	4	92-010	100	85% solids, reddish-brown slurry 15% liquids
38	1	92-011	35	25% solids, brownish-red, slurry 10% liquids, brownish-red 65% air
	2	92-012	0	No sample
	3	92-013	0	No sample
	4	92-014	100	50% solids, reddish-brown slurry 50% liquids, reddish brown
39	1	92-015	0	No sample
	2	92-016	80	65% solids, reddish-brown, slurry 15% liquid, reddish brown 20% air
39	3	92-017	25	25% solids, reddish-brown slurry no liquids 75% air
	4	92-018	100	All solids, reddish-brown, thicker than segment 3 samples, but moist

Note:
[1]Shaver (1993)

B1.2 PUSH CORE SAMPLE HANDLING

The solids in the waste collected from tank 241-C-110 were reddish brown and homogenous. The consistency of the solids was like soft sludge; however, some of the solids were significantly softer and more fluid. The hot cell chemist hypothesized that the softer solids were caused by normal paraffin hydrocarbon saturation. The liquids in the samples were also reddish brown and opaque (Simpson et al. 1994).

B1.3 PUSH CORE SAMPLE ANALYSIS

The analyses performed on the core samples were to evaluate the waste in meeting requirements of the 1993 version of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996). Analytical requirements for this sampling event are described in the *Waste Characterization Plan for the Hanford Site Single-Shell Tanks* (Hill et al. 1991). Information on holding times can be found in *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

Water, acid, and KOH fusion digestions were used to extract metals and several radioisotopes from solid samples. Table B1-3 shows a list of sample numbers and applicable analyses. In order to verify analyte recoveries resulting from separation techniques, laboratory control samples, carriers, tracers, and surrogates are routinely analyzed concurrently with the samples. For further discussion of sample preparation procedures, refer to the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994). The analyses were split between the Westinghouse Hanford Company 222-S Laboratory and Battelle's Pacific Northwest Laboratory (PNL) (renamed Pacific Northwest National Laboratory [PNNL] in 1995).

Table B1-3. Tank 241-C-110 Sample and Analysis Summary. (2 sheets)

Core	Segment	Sample Portion	Analyses
37	2	Solid	Physical tests, TGA/DSC
	3	Liquid	ICP, IC, TIC/TOC, GEA, APC, BPC
	4	Solid	Physical tests, TGA/DSC
	Core composite	Solid	AA, CVAA, ICP, LF(f), IC(w), Ammonia(w), ETOX, SVOA, TIC/TOC(w), GEA(f), APC(f), alpha spectroscopy(f), BPC(f), LSC(f), physical tests, TGA/DSC
38	1	Solid	VOA, physical tests, TGA/DSC
	4	Solid	ICP(a), IC, GEA(a), APC(a), physical tests, TGA/DSC
		Liquid	ICP, TIC/TOC, GEA, APC, BPC
	Core composite	Solid	AA, CVAA, ICP, LF(f), IC(w), Ammonia(w), ETOX, SVOA, TIC/TOC(w), GEA(f), APC(f), alpha spectroscopy(f), BPC(f), LSC(f), physical tests, TGA/DSC

Table B1-3. Tank 241-C-110 Sample and Analysis Summary. (2 sheets)

39	2	Solid	VOA, physical tests, TGA/DSC
	3	Solid	ICP(a), VOA, GEA(a), APC(a), physical tests, TGA/DSC
		Liquid	ICP, IC, TIC/TOC, GEA, APC, BPC
	4	Solid	VOA, physical tests, TGA/DSC
	Core composite	Solid	AA, CVAA, ICP, LF(f), IC(w), Ammonia(w), ETOX, SVOA, TIC/TOC(w), GEA(f), APC(f), alpha spectroscopy(f), BPC(f), LSC(f), physical tests, TGA/DSC

Notes:

(a)	=	acid digest
AA	=	atomic absorption
APC	=	alpha proportional counting
CVAA	=	cold vapor atomic absorption
BPC	=	beta proportional counting
ETOX	=	extractable organic halides
(f)	=	fusion
GEA	=	gamma energy analysis
IC	=	ion chromatography
ICP	=	inductively coupled plasma spectroscopy
LF	=	laser fluorimetry
LSC	=	liquid scintillation counting
SVOA	=	semivolatile organic analysis
TIC	=	total inorganic carbon
TGA	=	thermogravimetric analysis
TOC	=	total organic carbon
VOA	=	volatile organic analysis
(w)	=	water digest

B1.4 DESCRIPTION OF VAPOR SAMPLING EVENT

Tank 241-C-110 headspace gas and vapor samples were collected on August 18, 1994, to help determine the potential risks to tank farm workers caused by fugitive emissions from the tank. The objectives of the waste tank headspace sampling and analysis are discussed in *Program Plan for the Resolution of Tank Vapor Issues* (Osborne and Huckaby 1994). Data are presented in Section B2.8 and in *Tank 241-C-110 Headspace Gas and Vapor Characterization Results for Samples Collected in August 1994* (Bratzel and Huckaby 1995).

B1.5 DESCRIPTION OF HISTORICAL SAMPLING EVENT

Sampling data for tank 241-C-110 have been obtained for samples obtained in 1975 (Wheeler 1975) and in 1977 (Starr 1977). The data are presented in Section B2.6. Pre-1989 analytical data have not been validated and should be used with caution.

B2.0 ANALYTICAL RESULTS

B2.1 OVERVIEW

This section summarizes the sampling and analytical results associated with the April 1992 sampling and analysis of tank 241-C-110. The chemical, physical, and thermodynamic tests associated with this tank are presented in Table B2-1.

Table B2-1. Analytical Presentation Tables. (2 sheets)

Analysis	Table Number
Metals by graphite furnace atomic absorption	B2-2 through B2-3
Mercury by CVAA	B2-4
TCLP metals by GFAA	B2-5
TCLP metals by ICP	B2-6
Metals by ICP	B2-7 through B2-36
Uranium by LF	B2-37
Anions by IC	B2-38 through B2-43
Ammonium distillation	B2-44
ETOX	B2-45
SVOA	B2-46 through B2-57
VOA	B2-58 through B2-65
TIC/TOC	B2-66 and B2-67
Radionuclides by GEA	B2-68
Radionuclides by APC and AEA	B2-69 and B2-71

Table B2-1. Analytical Presentation Tables. (2 sheets)

Analysis	Table Number
Radionuclides by BPC	B2-72 and B2-73
Radionuclides by liquid scintillation	B2-74 through B2-77
Analyses for physical properties	B2-78 through B2-81
Analyses for percent water	B2-82
Analyses for headspace flammability	B2-83

Notes:

GFAA = graphite furnace atomic absorption
TCLP = toxic characteristic leach procedure

Quality control (QC) and quality assurance parameters included standard recoveries, spike recoveries, duplicate analyses, and blanks. The original QC criteria are in Table D-6 of Hill et al. (1991). The current QC criteria are 80 to 120 percent recovery for standards, 75 to 125 percent recovery for spikes and $\leq$20 percent for relative percent differences (RPDs). These criteria applied to all of the analytes. The limits for blanks are set forth in guidelines followed by the laboratory, and all data results presented in this report have met those guidelines. Sample and duplicate pairs in which any of the QC parameters were outside of these limits are footnoted in the sample mean column of the following data summary tables with an a, b, c, d, or e as follows:

- "a" indicates that the standard recovery was below the QC limit.
- "b" indicates that the standard recovery was above the QC limit.
- "c" indicates that the spike recovery was below the QC limit.
- "d" indicates that the spike recovery was above the QC limit.
- "e" indicates that the RPD was above the QC limit.
- "f" indicates field blank contamination.

B2.2 INORGANIC ANALYSES

B2.2.1 Graphite Furnace Atomic Absorption

Analyses by GFAA for arsenic, selenium, and antimony were performed on segment and composite samples. Results ranged from less than detection limit to 1.6 μg/g.

Table B2-2. Tank 241-C-110 Analytical Results: Arsenic (AA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 37	Core composite (1)	0.26	0.42	0.34[QC:e]
	Core composite (2)	<0.25	<0.25	<0.25
Core 38	Core composite	0.712	0.642	0.677
Core 39	Core composite (1)	0.397	0.494	0.4455[QC:e]
	Core composite (2)	0.555	0.535	0.545
Liquid		µg/g	µg/g	µg/g
Tank composite		0.0062	0.0072	0.0067

Table B2-3. Tank 241-C-110 Analytical Results: Selenium (AA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 37	Core composite (1)	0.744	0.562	0.653[QC:b,e]
	Core composite (2)	0.735	0.776	0.7555[QC:b]
Core 38	Core composite	0.56	0.658	0.609
Core 39	Core composite (1)	1.28	1.16	1.22
	Core composite (2)	1.46	1.71	1.585
Liquid		µg/g	µg/g	µg/g
Tank composite		0.0651	0.0615	0.0633

B2.2.2 Cold Vapor Atomic Absorption

A mercury analysis was performed by CVAA on core composite samples and a tank composite liquid sample. Results are shown in Table B2-4.

Table B2-4. Tank 241-C-110 Analytical Results: Mercury (CVAA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 37	Core composite (1)	0.516	0.382	0.449[QC:e]
	Core composite (2)	0.853	0.385	0.619[QC:e]
Core 38	Core composite	0.457	0.506	0.4815
Core 39	Core composite (1)	0.343	0.31	0.3265
	Core composite (2)	0.338	0.338	0.338
Liquid		µg/g	µg/g	µg/g
Tank composite		0.0936	0.1009	0.0972

B2.2.3 Toxicity Characteristics Leaching Procedure

TCLP analyses were performed on the core 39 composite sample. Tables B2-5a through B2-5c present TCLP analytical results performed by GFAA.

Table B2-5a. Tank 241-C-110 Analytical Results: Arsenic (AA).

Sample Location	Sample Portion	Result	Duplicate	Mean
TCLP and acid digest		µg/mL	µg/mL	µg/mL
Core 39	Core composite	0.0442	0.0464	0.045

Table B2-5b. Tank 241-C-110 Analytical Results: Selenium (AA).

Sample Portion	Sample Location	Result	Duplicate	Mean
TCLP		µg/mL	µg/mL	µg/mL
Core composite	Core 39	<0.0125	<0.0125	<0.0125[QC1]

Table B2-5c. Tank 241-C-110 Analytical Results: Mercury (AA).

Sample Portion		Result	Duplicate	Mean
TCLP		µg/mL	µg/mL	µg/mL
Core 39	Core composite	0.0115	0.0107	0.0111

Tables B2-6a through B2-6g present TCLP analytical results performed by ICP.

Table B2-6a. Tank 241-C-110 Analytical Results: Arsenic (ICP).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: TCLP and acid digest		µg/mL	µg/mL	µg/mL
Core 39	Core composite	0.151	0.151	0.151

Table B2-6b. Tank 241-C-110 Analytical Results: Barium (ICP).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: TCLP and acid digest		µg/mL	µg/mL	µg/mL
Core 39	Core composite	0.1	0.0932	0.0966

Table B2-6c. Tank 241-C-110 Analytical Results: Cadmium (ICP).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: TCLP and acid digest		µg/mL	µg/mL	µg/mL
Core 39	Core composite	0.0353	0.0353	0.0353

Table B2-6d. Tank 241-C-110 Analytical Results: Chromium (ICP).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: TCLP and acid digest		µg/mL	µg/mL	µg/mL
Core 39	Core composite	13.2	13.3	13.25

Table B2-6e. Tank 241-C-110 Analytical Results: Lead (ICP).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: TCLP and acid digest		µg/mL	µg/mL	µg/mL
Core 39	Core composite	1.25	1.21	1.23[QC:b]

Table B2-6f. Tank 241-C-110 Analytical Results: Selenium (ICP).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: TCLP and acid digest		µg/mL	µg/mL	µg/mL
Core 39	Core composite	5.46	5.25	5.355[QC:b]

Table B2-6g. Tank 241-C-110 Analytical Results: Silver (ICP).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: TCLP and acid digest		µg/mL	µg/mL	µg/mL
Core 39	Core composite	0.0504	0.0504	0.0504

B2.2.4 Inductively Coupled Plasma

Analyses for the waste's metallic constituents were performed by ICP. The ICP analyses were run after fusion, acid, and water digestions on solid samples and on drainable liquid samples. The major constituents identified by ICP analysis in the solid phase of the waste were aluminum, bismuth, calcium, iron, phosphorus, silicon, sodium, sulfur, and uranium; all were present in concentrations exceeding 100 μg/g. Phosphorus, sodium, and sulfur were present in the drainable liquid samples at concentrations above 1,000 μg/g; sodium exhibited a value of 44,700 μg/g. Results are in Tables B2-7 through B2-36.

Table B2-7. Tank 241-C-110 Analytical Results: Aluminum (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		μg/g	μg/g	μg/g
Core 38	Segment 4a	15,400	16,100	15,750[QC:b,c]
	Segment 4b	15,200	15,300	15,250[QC:b,c]
Core 39	Segment 3a	13,100	11,200	12,150[QC:b,c]
	Segment 3b	12,600	12,300	12,450[QC:b,c]
Core 37	Core composite (1)	14,000	14,200	14,100[QC:b,c]
	Core composite (2)	14,600	13,500	14,050[QC:b,c]
Core 38	Core composite	13,900	14,300	14,100[QC:b,c]
Core 39	Core composite (1)	15,500	15,300	15,400[QC:b,c]
	Core composite (2)	15,100	15,300	15,200[QC:b,c]
Solids: fusion		μg/g	μg/g	μg/g
Core 37	Core composite (1)	13,600	13,800	13,700
	Core composite (2)	14,000	14,700	14,350
Core 38	Core composite	14,300	13,800	14,050
Core 39	Core composite (1)	14,900	15,206.2	15,053.1
Core 39	Core composite (2)	14,600	14,500	14,550
Drainable liquid		μg/g	μg/g	μg/g
Core 37	Segment 3	46.8807	47.7982	47.3394
Core 38	Segment 4	77.156	64.8624	71.0092
Core 39	Segment 3	12.2936	14.2202	13.2569
Tank composite		188.991	193.578	191.284

Table B2-7. Tank 241-C-110 Analytical Results: Aluminum (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	2,770	2,650	2,710
	Core composite (2)	<94.9	94.7	<94.8
Core 38	Core composite	968	680	824[QC:e]
Core 39	Core composite (1)	1,060	1,150	1,105
	Core composite (2)	1,390	1,260	1,325

Table B2-8. Tank 241-C-110 Analytical Results: Antimony (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	<36	22.1	<29.05[QC:b,e]
	Segment 4b	<45.1	19.5	<32.3[QC:b,e]
Core 39	Segment 3a	<34.9	37.2	<36.05[QC:c]
	Segment 3b	<34.9	34.7	<34.8[QC:c]
Core 37	Core composite (1)	<17.7	17.9	<17.8[QC:c]
	Core composite (2)	<17.4	17.5	<17.45[QC:c]
Core 38	Core composite	<36.5	40.6	<38.55[QC:a]
Core 39	Core composite (1)	<17.6	33.8	<25.7[QC:e,c]
	Core composite (2)	<26.6	31.8	<29.2[QC:e,c]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	185	252	218.5[QC:e,c]
	Core composite (2)	409	357	383[QC:c]
Core 38	Core composite	<183	182	<182.5
Core 39	Core composite (1)	<182	181	<181.5
	Core composite (2)	<183	182	<182.5
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<16.789	16.789	<16.789
Core 38	Segment 4	<17.156	17.156	<17.156
Core 39	Segment 3	<17.156	17.156	<17.156
Tank composite		<33.945	33.945	<33.945

Table B2-8. Tank 241-C-110 Analytical Results: Antimony (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<37.2	37.3	<37.25
	Core composite (2)	<71.5	71.8	<71.65
Core 38	Core composite	<18	18	<18
Core 39	Core composite (1)	<37	37.3	<37.15[QC:c]
	Core composite (2)	<37.3	37.1	<37.2[QC:c]

Table B2-9. Tank 241-C-110 Analytical Results: Arsenic (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	<2.98	3.17	<3.075
	Segment 4b	<2.86	2.85	<2.855
Core 39	Segment 3a	<2.86	3.05	<2.955
	Segment 3b	<2.86	3.41	<3.135[QC:c]
Core 37	Core composite (1)	4.02	4.99	4.505[QC:c]
	Core composite (2)	<2.95	2.96	<2.955
Core 38	Core composite	<5.13	2.77	<3.95[QC:c]
Core 39	Core composite (1)	2.99	4.96	3.975[QC:c,c]
	Core composite (2)	<3.95	2.99	<3.47[QC:c,c]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<15	15	<15
	Core composite (2)	<14.8	14.9	<14.85
Core 38	Core composite	<15	14.9	<14.95
Core 39	Core composite (1)	<1 4.9	14.8	<14.85
	Core composite (2)	<15	14.9	<14.95
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	1.68807	1.37615	1.53211[QC:c]
Core 38	Segment 4	<1.40367	1.40367	<1.40367
Core 39	Segment 3	<1.40367	1.40367	<1.40367
Tank composite		<2.77982	2.77982	<2.77982[QC:c]

Table B2-9. Tank 241-C-110 Analytical Results: Arsenic (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<3.05	3.06	<3.055
	Core composite (2)	<6.23	7.24	<6.735
Core 38	Core composite	<3.06	3.05	<3.055
Core 39	Core composite (1)	<3.04	3.06	<3.05
	Core composite (2)	<3.06	3.04	<3.05

Table B2-10. Tank 241-C-110 Analytical Results: Barium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	8.87	8.91	8.89
	Segment 4b	8.98	8.92	8.95
Core 39	Segment 3a	4.66	4.04	4.35
	Segment 3b	4.86	4.7	4.78
Core 37	Core composite (1)	8.97	8.85	8.91
	Core composite (2)	9.34	8.67	9.005
Core 38	Core composite	8.18	8.6	8.39
Core 39	Core composite (1)	5.51	5.62	5.565
	Core composite (2)	<5.87	5.77	<5.82
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	7.76	8.46	8.11
	Core composite (2)	8.68	9.1	8.89
Core 38	Core composite	9.04	9.89	9.465
Core 39	Core composite (1)	6.27	6.71	6.49
	Core composite (2)	8.43	8.39	8.41

Table B2-10. Tank 241-C-110 Analytical Results: Barium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<0.137615	0.137615	<0.137615
Core 38	Segment 4	<0.140367	0.140367	<0.140367
Core 39	Segment 3	<0.140367	0.140367	<0.140367
Tank composite		<0.277982	0.277982	<0.277982
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	2.65	2.72	2.685
	Core composite (2)	<0.603	0.605	<0.604
Core 38	Core composite	0.609	0.402	0.5055[QC:c]
Core 39	Core composite (1)	<0.304	0.306	<0.305
	Core composite (2)	<0.306	0.304	<0.305

Table B2-11. Tank 241-C-110 Analytical Results: Bismuth (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	17,200	16,500	16,850[QC:a,c]
	Segment 4b	16,900	16,800	16,850[QC:a,c]
Core 39	Segment 3a	12,700	11,200	11,950[QC:a,c]
	Segment 3b	12,800	12,700	12,750[QC:a,c]
Core 37	Core composite (1)	17,700	17,800	17,750[QC:a,c]
	Core composite (2)	18,200	17,600	17,900[QC:a,c]
Core 38	Core composite	17,900	18,200	18,050[QC:a,c]
Core 39	Core composite (1)	14,600	14,200	14,400[QC:a,c]
	Core composite (2)	14,200	14,700	14,450[QC:a,c]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	12,400	13,000	12,700
	Core composite (2)	13,300	12,800	13,050
Core 38	Core composite	15,100	15,700	15,400[QC:c]
Core 39	Core composite (1)	13,800	14,200	14,000[QC:c]
	Core composite (2)	13,500	10,200	11,850[QC:c,e]

Table B2-11. Tank 241-C-110 Analytical Results: Bismuth (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	4.41284	2.66055	3.5367[QC:e,c]
Core 38	Segment 4	33.6697	36.9725	35.3211[QC:c]
Core 39	Segment 3	16.6055	19.633	18.1193[QC:e,c]
Tank composite		170.642	180.734	175.688
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	100	104	102[QC:c]
	Core composite (2)	21.5	56.7	39.1[QC:e,c]
Core 38	Core composite	41.3	71.9	56.6[QC:e,c]
Core 39	Core composite (1)	66.5	99.1	82.8[QC:e,c]
	Core composite (2)	70.9	74.9	72.9

Table B2-12. Tank 241-C-110 Analytical Results: Boron (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	<27.4	29.1	<28.25[QC:c]
	Segment 4b	<28.4	31.1	<29.75[QC:c]
Core 39	Segment 3a	<24.6	31.9	<28.25[QC:b,e,c]
	Segment 3b	<24.2	32.8	<28.5[QC:b,e,c]
Core 37	Core composite (1)	<23.2	24.6	<23.9[QC:b,c]
	Core composite (2)	<25.3	25	<25.15[QC:b,c]
Core 38	Core composite	<16.1	18.4	<17.25[QC:b,c]
Core 39	Core composite (1)	<18.6	23	<20.8[QC:b,e,c]
	Core composite (2)	<19.4	26.1	<22.75[QC:b,e,c]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	9.52	5.46	7.49[QC:c]
	Core composite (2)	6.14	8.47	7.305[QC:c]
Core 38	Core composite	16	16.8	16.4
Core 39	Core composite (1)	<15.3	18.4	<16.85[QC:c]
	Core composite (2)	<23	21.6	<22.3

Table B2-12. Tank 241-C-110 Analytical Results: Boron (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	5.20183	5.16514	5.18349
Core 38	Segment 4	20.8257	22.5688	21.6972
Core 39	Segment 3	21.0092	20.8257	20.9174
Tank composite		10.0917	9.81651	9.95413
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<27.7	28.7	<28.2
	Core composite (2)	<14.9	13.9	<14.4
Core 38	Core composite	25.3	25.9	25.6
Core 39	Core composite (1)	<28	29.2	<28.6
	Core composite (2)	<27.3	27.7	<27.5

Table B2-13. Tank 241-C-110 Analytical Results: Cadmium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	3.48	3.71	3.595
	Segment 4b	3.78	3.59	3.685
Core 39	Segment 3a	1.52	1.6	1.56
	Segment 3b	1.72	2.03	1.875[QC:e]
Core 37	Core composite (1)	2.55	2.77	2.66
	Core composite (2)	2.96	2.59	2.775
Core 38	Core composite	4.46	5.07	4.765
Core 39	Core composite (1)	1.94	2.02	1.98
	Core composite (2)	<2.42	2.5	<2.46
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	5.06	4.33	4.695[QC:e]
	Core composite (2)	5.93	4.51	5.22[QC:e]
Core 38	Core composite	7.32	5	6.16[QC:e]
Core 39	Core composite (1)	4.13	3.45	3.79[QC:e]
	Core composite (2)	3.49	8.77	6.13[QC:e]

Table B2-13. Tank 241-C-110 Analytical Results: Cadmium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<0.321101	0.321101	<0.321101
Core 38	Segment 4	<0.327523	0.327523	<0.327523
Core 39	Segment 3	<0.327523	0.327523	<0.327523
Tank composite		<0.648624	0.648624	<0.648624
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<0.712	0.787	<0.7495
	Core composite (2)	<1.41	1.41	<1.41
Core 38	Core composite	0.548	0.407	0.4775[QC:e]
Core 39	Core composite (1)	<0.709	0.714	<0.7115
	Core composite (2)	<0.714	0.709	<0.7115

Table B2-14. Tank 241-C-110 Analytical Results: Calcium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	<272	587	<429.5[QC:b,e]
	Segment 4b	<1,320	1,060	<1,190[QC:b,e]
Core 39	Segment 3a	<319	168	<243.5[QC:b,e]
	Segment 3b	<2,230	1,600	<1,915[QC:b,e]
Core 37	Core composite (1)	<1,040	628	<834[QC:b,c,e]
	Core composite (2)	<487	708	<597.5[QC:b,c,e]
Core 38	Core composite	<257	229	<243[QC:b]
Core 39	Core composite (1)	<184	188	<186[QC:b]
	Core composite (2)	<177	189	<183[QC:b]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<1,640	862	<1,251[QC:e]
	Core composite (2)	<636	535	<585.5[QC:e]
Core 38	Core composite	<1,220	813	<1,016.5[QC:e]
Core 39	Core composite (1)	<414	393	<403.5
	Core composite (2)	<475	4,720	<2,597.5[QC:e]

Table B2-14. Tank 241-C-110 Analytical Results: Calcium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<12.4771	12.4771	<12.4771
Core 38	Segment 4	<12.7523	12.7523	<12.7523
Core 39	Segment 3	<12.7523	12.7523	<12.7523
Tank composite		<25.2294	25.2294	<25.2294
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<127	111	<119
	Core composite (2)	<312	285	<298.5
Core 38	Core composite	414	8.21	211.105[QC:e]

Table B2-15. Tank 241-C-110 Analytical Results: Cerium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	214	216	215
	Segment 4b	214	212	213
Core 39	Segment 3a	153	130	141.5[QC:e]
	Segment 3b	161	151	156[QC:b]
Core 37	Core composite (1)	220	219	219.5
	Core composite (2)	223	217	220
Core 38	Core composite	222	231	226.5[QC:b]
Core 39	Core composite (1)	175	182	178.5[QC:b]
	Core composite (2)	197	179	188[QC:b]
Solid: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	119	181	150[QC:e]
	Core composite (2)	186	155	170.5[QC:e]
Core 38	Core composite	195	234	214.5[QC:e]
Core 39	Core composite (1)	157	167	162
	Core composite (2)	193	174	183.5

Table B2-15. Tank 241-C-110 Analytical Results: Cerium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	4.49541	4.49541	4.49541
Core 38	Segment 4	4.58716	4.58716	4.58716
Core 39	Segment 3	4.58716	4.58716	4.58716
Tank composite		9.08257	9.08257	9.08257
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	34.6	48.3	41.45[QC:e]
	Core composite (2)	17.3	17.4	17.35
Core 38	Core composite	10.3	10.3	10.3
Core 39	Core composite (1)	9.92	9.99	9.955
	Core composite (2)	9.99	9.93	9.96

Table B2-16. Tank 241-C-110 Analytical Results: Chromium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	567	542	554.5[QC:e]
	Segment 4b	561	558	559.5[QC:e]
Core 39	Segment 3a	334	290	312[QC:e]
	Segment 3b	321	320	320.5[QC:e]
Core 37	Core composite (1)	496	488	492[QC:e]
	Core composite (2)	503	483	493[QC:e]
Core 38	Core composite	484	492	488[QC:e]
Core 39	Core composite (1)	437	426	431.5
	Core composite (2)	413	446	429.5
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	475	481	478
	Core composite (2)	474	464	469
Core 38	Core composite	486	505	495.5
Core 39	Core composite (1)	427	435	431
	Core composite (2)	422	413	417.5

Table B2-16. Tank 241-C-110 Analytical Results: Chromium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	28.6239	28.8991	28.7615
Core 38	Segment 4	134.862	140.367	137.615[QC:c]
Core 39	Segment 3	361.468	358.716	360.092[QC:c]
Tank composite		110.092	108.257	109.174
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	302	287	294.5
	Core composite (2)	26.3	28.6	27.45
Core 38	Core composite	188	182	185
Core 39	Core composite (1)	273	277	275
	Core composite (2)	259	279	269

Table B2-17. Tank 241-C-110 Analytical Results: Cobalt (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	1.82	1.91	1.865
	Segment 4b	1.92	1.25	1.585[QC:c]
Core 39	Segment 3a	1.03	1.02	1.025
	Segment 3b	1.96	1.88	1.92
Core 37	Core composite (1)	2.28	2.74	2.51[QC:c]
	Core composite (2)	2.23	3.36	2.795[QC:c]
Core 38	Core composite	<2.97	2.97	<2.97
Core 39	Core composite (1)	<2.3	2.21	<2.255
	Core composite (2)	<3.19	2.1	<2.645[QC:c]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<4.99	5.17	<5.08
	Core composite (2)	<4.94	5.21	<5.075
Core 38	Core composite	12.9	4.97	8.935[QC:c]
Core 39	Core composite (1)	<4.98	4.93	<4.955
	Core composite (2)	<4.99	8.05	<6.52[QC:c]

Table B2-17. Tank 241-C-110 Analytical Results: Cobalt (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<0.458716	0.458716	<0.458716
Core 38	Segment 4	<0.46789	0.46789	<0.46789
Core 39	Segment 3	0.537615	0.519266	0.52844
Tank composite		<0.926606	0.926606	<0.926606
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<1.02	1.02	<1.02
	Core composite (2)	<2.41	2.42	<2.415
Core 38	Core composite	<0.815	0.814	<0.8145
Core 39	Core composite (1)	<1.01	1.02	<1.015
	Core composite (2)	<1.02	1.01	<1.015

Table B2-18. Tank 241-C-110 Analytical Results: Copper (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	25.3	29.4	27.35
	Segment 4b	24.8	24.6	24.7
Core 39	Segment 3a	22	19.2	20.6
	Segment 3b	21.4	21.3	21.35
Core 37	Core composite (1)	43.1	43.6	43.35
	Core composite (2)	43.8	42.2	43
Core 38	Core composite	25.5	27	26.25
Core 39	Core composite (1)	19.3	19.1	19.2
	Core composite (2)	20.6	22.8	21.7
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<56.1	54.4	<55.25
	Core composite (2)	<70.8	77	<73.9
Core 38	Core composite	<96.4	268	<182.2[QC:e]
Core 39	Core composite (1)	<35.2	70.2	<52.7[QC:e]
	Core composite (2)	<50.1	44	<47.05

Table B2-18. Tank 241-C-110 Analytical Results: Copper (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	0.304587	0.183486	0.244037[QC:e]
Core 38	Segment 4	3.77064	3.88991	3.83028
Core 39	Segment 3	1.23853	1.3578	1.29817
Tank composite		1.04587	0.972477	1.00917
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	8.19	8.51	8.35
	Core composite (2)	<1.21	1.21	<1.21
Core 38	Core composite	0.996	0.913	0.9545
Core 39	Core composite (1)	0.569	0.683	0.626[QC:e]
	Core composite (2)	0.549	0.546	0.5475

Table B2-19. Tank 241-C-110 Analytical Results: Iron (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	10,400	9,900	10,150[QC:b,c]
	Segment 4b	10,100	10,100	10,100[QC:b,c]
Core 39	Segment 3a	9,620	8,360	8,990[QC:b,c]
	Segment 3b	9,090	9,230	9,160[QC:b,c]
Core 37	Core composite (1)	12,000	12,100	12,050[QC:b,c]
	Core composite (2)	12,600	11,900	12,250[QC:b,c]
Core 38	Core composite	11,300	11,600	11,450[QC:b,c]
Core 39	Core composite (1)	9,580	9,220	9,400[QC:c]
	Core composite (2)	9,300	10,000	9,650[QC:c]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	11,600	11,500	11,550
	Core composite (2)	11,400	11,700	11,550
Core 38	Core composite	11,500	11,100	11,300
Core 39	Core composite (1)	9,350	9,720	9,535
	Core composite (2)	9,210	8,990	9,100

Table B2-19. Tank 241-C-110 Analytical Results: Iron (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<0.688073	0.688073	<0.688073
Core 38	Segment 4	29.9083	27.7064	28.8073
Core 39	Segment 3	15.8716	15.5046	15.6881
Tank composite		125.688	131.193	128.44
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	2,160	2,040	2,100
	Core composite (2)	31.6	47.5	39.55[QC:e]
Core 38	Core composite	513	327	420[QC:e]
Core 39	Core composite (1)	298	204	251[QC:e]
	Core composite (2)	248	301	274.5[QC:e]

Table B2-20. Tank 241-C-110 Analytical Results: Lanthanum (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	1.39	1.31	1.35[QC:e]
	Segment 4b	1.34	1.33	1.335[QC:e]
Core 39	Segment 3a	1.53	1.63	1.58[QC:e]
	Segment 3b	1.53	1.52	1.525[QC:e]
Core 37	Core composite (1)	1.4	1.42	1.41[QC:e]
	Core composite (2)	1.38	1.38	1.38[QC:e]
Core 38	Core composite	1.6	1.48	1.54
Core 39	Core composite (1)	1.39	1.39	1.39[QC:e]
	Core composite (2)	<1.39	1.39	<1.39[QC:e]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	7.98	7.98	7.98
	Core composite (2)	7.91	7.95	7.93
Core 38	Core composite	8	7.95	7.975
Core 39	Core composite (1)	7.96	7.89	7.925
	Core composite (2)	7.98	7.95	7.965

Table B2-20. Tank 241-C-110 Analytical Results: Lanthanum (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	0.733945	0.733945	0.733945
Core 38	Segment 4	0.748624	0.748624	0.748624
Core 39	Segment 3	0.748624	0.748624	0.748624
Tank composite		1.48624	1.48624	1.48624
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	1.63	1.63	1.63
	Core composite (2)	4.22	4.24	4.23
Core 38	Core composite	1.43	1.42	1.425
Core 39	Core composite (1)	1.62	1.63	1.625
	Core composite (2)	1.63	1.62	1.625

Table B2-21. Tank 241-C-110 Analytical Results: Lead (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	137	132	134.5[QC:e]
	Segment 4b	137	126	131.5[QC:e]
Core 39	Segment 3a	73.8	62.3	68.05[QC:e]
	Segment 3b	76.2	78.1	77.15
Core 37	Core composite (1)	419	429	424[QC:e]
	Core composite (2)	441	411	426[QC:e]
Core 38	Core composite	158	176	167[QC:e]
Core 39	Core composite (1)	104	103	103.5
	Core composite (2)	96.5	118	107.25[QC:e]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	436	461	448.5
	Core composite (2)	443	424	433.5
Core 38	Core composite	209	215	212
Core 39	Core composite (1)	111	118	114.5
	Core composite (2)	128	126	127

Table B2-21. Tank 241-C-110 Analytical Results: Lead (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<3.25688	3.25688	<3.25688
Core 38	Segment 4	9.81651	3.3211	6.56881[QC:e]
Core 39	Segment 3	<3.3211	3.3211	<3.3211
Tank composite		<6.57798	6.57798	<6.57798
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	58	64.5	61.25
	Core composite (2)	<17.1	17.2	<17.15
Core 38	Core composite	<6.31	6.31	<6.31
Core 39	Core composite (1)	<7.19	7.24	<7.215
	Core composite (2)	<7.24	7.19	<7.215

Table B2-22. Tank 241-C-110 Analytical Results: Magnesium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	<146	154	<150[QC:b]
	Segment 4b	<241	245	<243[QC:b]
Core 39	Segment 3a	118	123	120.5
	Segment 3b	<175	336	<255.5[QC:b,e]
Core 37	Core composite (1)	229	166	197.5[QC:e,e]
	Core composite (2)	176	164	170[QC:e]
Core 38	Core composite	146	149	147.5
Core 39	Core composite (1)	114	113	113.5
	Core composite (2)	112	119	115.5
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	182	150	166[QC:e]
	Core composite (2)	144	145	144.5
Core 38	Core composite	172	150	161
Core 39	Core composite (1)	113	121	117
	Core composite (2)	108	227	167.5[QC:e]

Table B2-22. Tank 241-C-110 Analytical Results: Magnesium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	0.43211	0.350459	0.391284[QC:e]
Core 38	Segment 4	1.30275	0.944954	1.12385[QC:e]
Core 39	Segment 3	0.80367	0.853211	0.82844
Tank composite		2.77982	2.76147	2.77064
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	20	18.9	19.45
	Core composite (2)	<12.3	11.8	<12.05
Core 38	Core composite	49.9	6.51	28.205[QC:e]
Core 39	Core composite (1)	<4.55	6.94	<5.745[QC:e]
	Core composite (2)	<5.18	5.81	<5.495

Table B2-23. Tank 241-C-110 Analytical Results: Manganese (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	33.3	32.1	32.7
	Segment 4b	34.2	33.7	33.95
Core 39	Segment 3a	31.6	27.4	29.5
	Segment 3b	<32.6	33.1	<32.85
Core 37	Core composite (1)	41.5	40.8	41.15
	Core composite (2)	42.7	40.5	41.6
Core 38	Core composite	36.5	37.5	37
Core 39	Core composite (1)	28.9	27.7	28.3
	Core composite (2)	28.3	31	29.65
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<56	48.2	<52.1
	Core composite (2)	<50.2	46.4	<48.3
Core 38	Core composite	93.4	52.1	72.75[QC:e]
Core 39	Core composite (1)	31	32.8	31.9
	Core composite (2)	35.1	84.5	59.8[QC:e]

Table B2-23. Tank 241-C-110 Analytical Results: Manganese (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<0.137615	0.137615	<0.137615
Core 38	Segment 4	0.244037	0.174312	0.209174[QC:e]
Core 39	Segment 3	0.224771	0.211927	0.218349
Tank composite		0.47156	0.505505	0.488532
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	7.17	6.69	6.93
	Core composite (2)	<0.603	0.605	<0.604
Core 38	Core composite	2.09	0.957	1.5235[QC:e]
Core 39	Core composite (1)	0.762	0.588	0.675[QC:e]
	Core composite (2)	0.658	0.664	0.661

Table B2-24. Tank 241-C-110 Analytical Results: Nickel (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	18.8	24.8	21.8[QC:e]
	Segment 4b	19.2	18.5	18.85
Core 39	Segment 3a	16.8	15.4	16.1
	Segment 3b	<15.3	16.8	<16.05
Core 37	Core composite (1)	27.2	24.6	25.9
	Core composite (2)	25.7	24.8	25.25
Core 38	Core composite	22.2	23.4	22.8
Core 39	Core composite (1)	<10.7	9.72	<10.21
	Core composite (2)	<11.7	61.9	<36.8[QC:e]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	5,590	4,010	4,800[QC:e]
	Core composite (2)	<4,080	3,460	<3,770[QC:e]
Core 38	Core composite	19,900	5,030	12,465[QC:e]
Core 39	Core composite (1)	<877	1,050	<963.5[QC:e]
	Core composite (2)	1,050	19,000	10,025[QC:e]

Table B2-24. Tank 241-C-110 Analytical Results: Nickel (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<0.642202	0.642202	<0.642202
Core 38	Segment 4	2.01835	1.27523	1.64679[QC:e]
Core 39	Segment 3	<0.655046	0.655046	<0.655046
Tank composite		<1.29358	1.29358	<1.29358
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	6.38	6.04	6.21
	Core composite (2)	<3.62	3.63	<3.625
Core 38	Core composite	2.18	1.73	1.955[QC:e]
Core 39	Core composite (1)	<1.42	1.43	<1.425
	Core composite (2)	<1.43	1.42	<1.425

Table B2-25. Tank 241-C-110 Analytical Results: Phosphorus (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	18,200	17,800	18,000[QC:e]
	Segment 4b	17,900	18,900	18,400[QC:e]
Core 39	Segment 3a	32,400	39,600	36,000[QC:d,e,c]
	Segment 3b	32,400	30,500	31,450[QC:d,c]
Core 37	Core composite (1)	20,000	22,800	21,400[QC:d,c]
	Core composite (2)	21,300	21,400	21,350[QC:d,c]
Core 38	Core composite	17,100	15,100	16,100[QC:e,c]
Core 39	Core composite (1)	18,200	18,900	18,550[QC:e]
	Core composite (2)	18,400	16,900	17,650[QC:e]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	21,100	21,000	21,050
	Core composite (2)	23,500	23,800	23,650
Core 38	Core composite	20,100	17,100	18,600[QC:e]
Core 39	Core composite (1)	20,200	20,400	20,300
	Core composite (2)	19,100	19,900	19,500

Table B2-25. Tank 241-C-110 Analytical Results: Phosphorus (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	606.422	607.339	606.881
Core 38	Segment 4	2,366.97	2,678.9	2,522.94
Core 39	Segment 3	2,798.17	2,917.43	2,857.8
Tank composite		1,440.37	1,614.68	1,527.52[QC:c]
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	18,000	17,600	17,800[QC:c]
	Core composite (2)	540	558	549[QC:c]
Core 38	Core composite	6,810	5,580	6,195[QC:e]
Core 39	Core composite (1)	5,270	6,160	5,715[QC:e]
	Core composite (2)	12,200	6,800	9,500[QC:e]

Table B2-26. Tank 241-C-110 Analytical Results: Potassium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	406	417	411.5[QC:b]
	Segment 4b	422	409	415.5[QC:b]
Core 39	Segment 3a	656	588	622[QC:c]
	Segment 3b	614	597	605.5[QC:b,c]
Core 37	Core composite (1)	570	562	566[QC:c]
	Core composite (2)	565	561	563[QC:c]
Core 38	Core composite	492	514	503[QC:b,c]
Core 39	Core composite (1)	584	579	581.5[QC:b]
	Core composite (2)	630	619	624.5[QC:b]
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	71.4679	69.8165	70.6422
Core 38	Segment 4	340.367	376.147	358.257[QC:c]
Core 39	Segment 3	903.67	905.505	904.587[QC:c]
Tank composite		265.138	266.972	266.055

Table B2-26. Tank 241-C-110 Analytical Results: Potassium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	549	565	557
	Core composite (2)	115	106	110.5
Core 38	Core composite	382	367	374.5
Core 39	Core composite (1)	492	527	509.5
	Core composite (2)	542	533	537.5

Table B2-27. Tank 241-C-110 Analytical Results: Selenium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	<7.56	7.09	<7.325
	Segment 4b	<7.25	7.21	<7.23
Core 39	Segment 3a	<7.91	8.44	<8.175[QC:c]
	Segment 3b	80.4	72.4	76.4[QC:b,c]
Core 37	Core composite (1)	<25	32.1	<28.55[QC:b,c]
	Core composite (2)	<21.4	31.3	<26.35[QC:b,c]
Core 38	Core composite	115	110	112.5[QC:b]
Core 39	Core composite (1)	<7.56	7.54	<7.55
	Core composite (2)	<7.56	7.56	<7.56
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	166	196	181[QC:e,c]
	Core composite (2)	177	117	147[QC:e,c]
Core 38	Core composite	58.2	43.5	50.85[QC:e]
Core 39	Core composite (1)	<41.3	40.9	<41.1
	Core composite (2)	<41.4	41.2	<41.3
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<3.80734	4.66972	<4.23853[QC:e,c]
Core 38	Segment 4	23.6697	27.4312	25.5505
Core 39	Segment 3	75.5963	70.6422	73.1193
Tank composite		15.7798	15.8716	15.8257

Table B2-27. Tank 241-C-110 Analytical Results: Selenium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<114	114	<114[QC:c]
	Core composite (2)	<26.3	26.4	<26.35[QC:c]
Core 38	Core composite	<16.3	20.4	<18.35[QC:c]
Core 39	Core composite (1)	61.7	62.7	62.2[QC:c]
	Core composite (2)	52.8	58.9	55.85[QC:c]

Table B2-28. Tank 241-C-110 Analytical Results: Silicon (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	347	368	357.5[QC:b,d,c]
	Segment 4b	384	377	380.5[QC:b,d,c]
Core 39	Segment 3a	686	937	811.5[QC:b,d,e,c]
	Segment 3b	654	625	639.5[QC:b,d,c]
Core 37	Core composite (1)	841	973	907[QC:b,d,c]
	Core composite (2)	766	696	731[QC:b,d,c]
Core 38	Core composite	917	1,060	988.5[QC:b,d,c]
Core 39	Core composite (1)	<452	343	<397.5[QC:b,e,c]
	Core composite (2)	<287	393	<340[QC:b,e,c]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	7,530	7,480	7,505
	Core composite (2)	7,540	7,220	7,380
Core 38	Core composite	7,860	7,580	7,720
Core 39	Core composite (1)	6,430	6,370	6,400
	Core composite (2)	6,280	6,260	6,270
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	10.9174	8.47706	9.69725[QC:e,c]
Core 38	Segment 4	66.422	70.2752	68.3486[QC:c]
Core 39	Segment 3	29.2661	30.7339	30[QC:c]
Tank composite		144.954	120.183	132.569[QC:e,c]

Table B2-28. Tank 241-C-110 Analytical Results: Silicon (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	519	464	491.5
	Core composite (2)	<19.4	31.4	<25.4[QC:e]
Core 38	Core composite	226	208	217
Core 39	Core composite (1)	371	193	282[QC:e]
	Core composite (2)	215	157	186[QC:e]

Table B2-29. Tank 241-C-110 Analytical Results: Sodium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	79,000	78,900	78,950[QC:b,e]
	Segment 4b	79,100	79,900	79,500[QC:b,e]
Core 39	Segment 3a	1.130E+05	1.290E+05	1.210E+05[QC:b,d,e]
	Segment 3b	77,000	77,600	77,300[QC:b,d,e]
Core 37	Core composite (1)	82,800	86,800	84,800[QC:b,d,e]
	Core composite (2)	84,600	83,000	83,800[QC:b,d,e]
Core 38	Core composite	80,000	79,900	79,950[QC:b,e]
Core 39	Core composite (1)	88,600	59,400	74,000[QC:b,c,e]
	Core composite (2)	59,600	59,800	59,700[QC:b,e]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	81,000	80,100	80,550
	Core composite (2)	85,800	84,800	85,300
Core 38	Core composite	80,600	73,900	77,250[QC:e]
Core 39	Core composite (1)	89,200	87,700	88,450
	Core composite (2)	86,800	86,700	86,750
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	8,155.96	8,302.75	8,229.36[QC:e]
Core 38	Segment 4	41,284.4	44,770.6	43,027.5[QC:e]
Core 39	Segment 3	82,935.8	86,880.7	84,908.3[QC:e]
Tank composite		27,706.4	28,073.4	27,889.9

Table B2-29. Tank 241-C-110 Analytical Results: Sodium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	96,000	93,800	94,900[QC:e]
	Core composite (2)	9,870	9,620	9,745[QC:e]
Core 38	Core composite	68,700	64,800	66,750[QC:e]
Core 39	Core composite (1)	75,200	78,700	76,950
	Core composite (2)	87,400	77,700	82,550

Table B2-30. Tank 241-C-110 Analytical Results: Strontium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	178	171	174.5
	Segment 4b	172	172	172
Core 39	Segment 3a	90.1	56.5	73.3[QC:e]
	Segment 3b	104	101	102.5
Core 37	Core composite (1)	151	150	150.5
	Core composite (2)	155	149	152
Core 38	Core composite	143	154	148.5
Core 39	Core composite (1)	83	78	80.5
	Core composite (2)	86.8	93.3	90.05
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	140	140	140
	Core composite (2)	146	178	162[QC:e]
Core 38	Core composite	157	154	155.5
Core 39	Core composite (1)	96.4	77.3	86.85[QC:e]
	Core composite (2)	83.8	84.7	84.25
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	0.183486	0.183486	0.183486
Core 38	Segment 4	1.01835	1.07339	1.04587
Core 39	Segment 3	0.257798	0.288073	0.272936
Tank composite		1.6789	1.22936	1.45413[QC:e]

Table B2-30. Tank 241-C-110 Analytical Results: Strontium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	18.6	19.4	19
	Core composite (2)	1.7	1.71	1.705
Core 38	Core composite	4.95	2.66	3.805[QC:e]

Table B2-31. Tank 241-C-110 Analytical Results: Sulfur (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	4,270	4,270	4,270[QC:b,e]
	Segment 4b	4,320	4,290	4,305[QC:b,e]
Core 39	Segment 3a	3,770	3,310	3,540[QC:b,e]
	Segment 3b	3,670	3,490	3,580[QC:b,e]
Core 37	Core composite (1)	3,600	3,620	3,610[QC:b,e]
	Core composite (2)	3,540	3,610	3,575[QC:b,e]
Core 38	Core composite	3,970	3,820	3,895[QC:b,e]
Core 39	Core composite (1)	4,830	4,760	4,795[QC:b,e]
	Core composite (2)	4,740	4,650	4,695[QC:b,e]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	3,410	3,370	3,390
	Core composite (2)	3,390	3,230	3,310
Core 38	Core composite	3,780	3,750	3,765
Core 39	Core composite (1)	4,790	4,850	4,820
	Core composite (2)	4,710	4,700	4,705
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	488.073	490.826	489.45
Core 38	Segment 4	2,724.77	2,981.65	2,853.21[QC:e]
Core 39	Segment 3	5,660.55	5,724.77	5,692.66[QC:e]
Tank composite		1,752.29	1,816.51	1,784.4[QC:e]

Table B2-31. Tank 241-C-110 Analytical Results: Sulfur (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	4,330	4,350	4,340
	Core composite (2)	406	439	422.5
Core 38	Core composite	3,920	3,840	3,880
Core 39	Core composite (1)	4,850	4,670	4,760
	Core composite (2)	4,450	4,770	4,610

Table B2-32. Tank 241-C-110 Analytical Results: Tin (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	7.63	8.18	7.905
	Segment 4b	9.4	8.83	9.115
Core 39	Segment 3a	9.28	9.23	9.255
	Segment 3b	10.2	12.4	11.3[QC:e]
Core 37	Core composite (1)	8.71	6.75	7.73[QC:e]
	Core composite (2)	6.83	6.61	6.72
Core 38	Core composite	10.2	8.58	9.39[QC:e]
Core 39	Core composite (1)	6.39	7.49	6.94[QC:e]
	Core composite (2)	8.31	7.69	8
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	11.5	11.5	11.5
	Core composite (2)	11.4	11.4	11.4
Core 38	Core composite	11.5	11.4	11.45
Core 39	Core composite (1)	13.3	11.3	12.3[QC:e]
	Core composite (2)	18.1	18.3	18.2
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	1.05505	1.05505	1.05505
Core 38	Segment 4	1.07339	1.07339	1.07339
Core 39	Segment 3	1.07339	1.07339	1.07339
Tank composite		2.12844	2.12844	2.12844

Table B2-32. Tank 241-C-110 Analytical Results: Tin (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	2.34	2.34	2.34
	Core composite (2)	3.22	3.23	3.225
Core 38	Core composite	1.63	1.63	1.63
Core 39	Core composite (1)	2.33	2.34	2.335
	Core composite (2)	2.34	2.33	2.335

Table B2-33. Tank 241-C-110 Analytical Results: Titanium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	4.32	4.5	4.41
	Segment 4b	4.4	4.4	4.4
Core 39	Segment 3a	5.43	4.9	5.165
	Segment 3b	5.31	5.44	5.375
Core 37	Core composite (1)	5.94	4.99	5.465[QC:e]
	Core composite (2)	5.11	5.22	5.165
Core 38	Core composite	<5.32	5.69	<5.505
Core 39	Core composite (1)	3.89	4.17	4.03
	Core composite (2)	5.23	4.47	4.85[QC:e]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	6.58	6.31	6.445
	Core composite (2)	10.1	8.31	9.205[QC:e]
Core 38	Core composite	15.8	12.9	14.35[QC:e]
Core 39	Core composite (1)	7.28	6.62	6.95
	Core composite (2)	8.1	15.7	11.9[QC:e]
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<0.183486	0.183486	<0.183486
Core 38	Segment 4	<0.187156	0.187156	<0.187156
Core 39	Segment 3	<0.187156	0.187156	<0.187156
Tank composite		<0.370642	0.370642	<0.370642

Table B2-33. Tank 241-C-110 Analytical Results: Titanium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	0.965	1.34	1.1525[QC:e]
	Core composite (2)	<1	1.01	<1.005
Core 38	Core composite	<0.407	0.407	<0.407
Core 39	Core composite (1)	<0.405	0.408	<0.4065
	Core composite (2)	<0.408	0.405	<0.4065

Table B2-34. Tank 241-C-110 Analytical Results: Vanadium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	5.25	5.27	5.26
	Segment 4b	5.47	5.5	5.485
Core 39	Segment 3a	7.21	6.25	6.73
	Segment 3b	5.02	4.77	4.895
Core 37	Core composite (1)	8.05	8.25	8.15
	Core composite (2)	8.62	8.45	8.535
Core 38	Core composite	4.73	3.19	3.96[QC:e]
Core 39	Core composite (1)	6.12	5.81	5.965
	Core composite (2)	5.95	6.91	6.43
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<3.99	3.99	<3.99
	Core composite (2)	6.37	4.52	5.445[QC:e]
Core 38	Core composite	5.45	7.94	6.695[QC:e]
Core 39	Core composite (1)	<3.98	3.95	<3.965
	Core composite (2)	<3.99	3.97	<3.98
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<0.366972	0.366972	<0.366972
Core 38	Segment 4	0.781651	0.730275	0.755963
Core 39	Segment 3	3.66055	3.7156	3.68807
Tank composite		1.22936	0.954128	1.09174[QC:e]

Table B2-34. Tank 241-C-110 Analytical Results: Vanadium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	1.22	0.815	1.0175[QC:e]
	Core composite (2)	<2.21	2.22	<2.215
Core 38	Core composite	<0.509	0.509	<0.509
Core 39	Core composite (1)	<0.81	0.83	<0.82
	Core composite (2)	1.19	0.811	1.0005[QC:e]

Table B2-35. Tank 241-C-110 Analytical Results: Zinc (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	<102	108	<105[QC:b]
	Segment 4b	<150	139	<144.5[QC:b]
Core 39	Segment 3a	86.4	71.5	78.95[QC:e]
	Segment 3b	<161	150	<155.5[QC:b]
Core 37	Core composite (1)	241	212	226.5[QC:e]
	Core composite (2)	218	215	216.5[QC:e]
Core 38	Core composite	95.9	99.2	97.55
Core 39	Core composite (1)	107	96	101.5
	Core composite (2)	<91.6	102	<96.8
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<269	254	<261.5
	Core composite (2)	<241	245	<243
Core 38	Core composite	223	272	247.5[QC:e]
Core 39	Core composite (1)	125	139	132
	Core composite (2)	126	294	210[QC:e]
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	<1.14679	1.14679	<1.14679
Core 38	Segment 4	<1.17431	1.17431	<1.17431
Core 39	Segment 3	<1.17431	1.17431	<1.17431
Tank composite		<2.3211	2.3211	<2.3211

Table B2-35. Tank 241-C-110 Analytical Results: Zinc (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	32.9	30.1	31.5
	Core composite (2)	<5.02	5.05	<5.035
Core 38	Core composite	22.9	0.634	11.767[QC:e]
Core 39	Core composite (1)	4.25	4.38	4.315
	Core composite (2)	3.41	4.05	3.73[QC:e]

Table B2-36. Tank 241-C-110 Analytical Results: Zirconium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µg/g	µg/g	µg/g
Core 38	Segment 4a	34.1	30.4	32.25[QC:e]
	Segment 4b	34.2	33.1	33.65[QC:e]
Core 39	Segment 3a	26.7	32.6	29.65[QC:e,e]
	Segment 3b	31.2	28.7	29.95[QC:e]
Core 37	Core composite (1)	48.065	45.1	46.5825[QC:e]
	Core composite (2)	40.2	43.1	41.65[QC:e]
Core 38	Core composite	59.3	49.5	54.4[QC:e]
Core 39	Core composite (1)	27.3	25.3	26.3[QC:e]
	Core composite (2)	26.8	25.8	26.3[QC:e]
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	167	172	169.5
	Core composite (2)	180	176	178
Core 38	Core composite	197	201	199
Core 39	Core composite (1)	151	156	153.5
	Core composite (2)	136	133	134.5
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	0.412844	0.366972	0.389908
Core 38	Segment 4	0.66789	0.833028	0.750459[QC:e]
Core 39	Segment 3	0.746789	0.861468	0.804128
Tank composite		1.44037	1.90826	1.67431[QC:e]

Table B2-36. Tank 241-C-110 Analytical Results: Zirconium (ICP). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	40.3	40.5	40.4
	Core composite (2)	2.21	2.22	2.215
Core 38	Core composite	10.4	7.03	8.715[QC:e]
Core 39	Core composite (1)	5.66	4.62	5.14[QC:e]
	Core composite (2)	5.93	5.59	5.76

B2.2.5 Laser Fluorimetry

Total uranium concentrations were measured on the KOH fusion preparations of cores 37, 38, and 39 samples using laser fluorimetry. Results are shown in Table B2-37.

Table B2-37. Tank 241-C-110 Analytical Results: Total Uranium (LF).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion		µg/g	µg/g	µg/g
Core 37	Core composite (1)	1,980	2,050	2,015
	Core composite (2)	1,960	2,050	2,005
	Core composite (3)	2,090	14,400	8,245[QC:e]
	Core composite (4)	2,670	2,100	2,385[QC:e]
Core 38	Core composite (1)	1,510	1,270	1,390
	Core composite (2)	1,280	1,310	1,295
Core 39	Core composite (1)	943	1,080	1,011.5
	Core composite (2)	1,050	1,170	1,110
	Core composite (3)	1,170	1,400	1,285
	Core composite (4)	1,220	1,250	1,235
Drainable liquid		µg/g	µg/g	µg/g
Tank composite		306.422	283.486	294.954

B2.2.6 Ion Chromatography

Ion chromatography analyses were performed on water leachates prepared from core 37, 38, and 39 solid samples and drainable liquid samples. They were analyzed for fluoride, chloride, nitrite, nitrate, phosphate, and sulfate. The most abundant anion in both the liquid and solid phases of the waste was nitrate, which ranged from 21,000 to 182,000 μg/g. Fluoride and phosphate were detected in greater concentrations in the solid samples as opposed to the liquid samples. Levels of chloride, nitrate, nitrite, and sulfate in the solid and liquid samples agreed closely. Cyanide was not detected in the solid portion of the waste, and its reported concentration from liquid samples was 2.62 μg/g. Results are presented in Tables B2-38 through B2-43.

Table B2-38. Tank 241-C-110 Analytical Results: Chloride (IC).

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		μg/g	μg/g	μg/g
Core 37	Segment 3	306.422	363.303	334.862[QC:e]
Core 38	Segment 4	917.431	877.982	897.706
Core 39	Segment 3	1,752.29	1,752.29	1,752.29
Tank composite		626.606	711.009	668.807
Solids: water digest		μg/g	μg/g	μg/g
Core 37	Core composite (1)	788	806	797
	Core composite (2)	735	661	698
Core 38	Core composite	914	852	883
Core 39	Core composite (1)	2,020	2,020	2,020
	Core composite (2)	1,110	1,100	1,105

Table B2-39. Tank 241-C-110 Analytical Results: Fluoride (IC). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		μg/g	μg/g	μg/g
Core 37	Segment 3	200	191.743	195.872
Core 38	Segment 4	615.596	501.835	558.716[QC:e]
Core 39	Segment 3	402.752	388.073	395.413
Tank composite		706.422	777.064	741.743

Table B2-39. Tank 241-C-110 Analytical Results: Fluoride (IC). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	8,510	8,770	8,640
	Core composite (2)	9,140	9,370	9,255
Core 38	Core composite	7,810	8,590	8,200
Core 39	Core composite (1)	6,740	7,060	6,900
	Core composite (2)	4,860	4,330	4,595

Table B2-40. Tank 241-C-110 Analytical Results: Nitrate (IC).

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	17,522.9	21,009.2	19,266.1[QC:c]
Core 38	Segment 4	91,651.4	91,743.1	91,697.2
Core 39	Segment 3	1.633E+05	1.697E+05	1.665E+05
Tank composite		55,229.4	55,412.8	55,321.1
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	95,900	96,900	96,400
	Core composite (2)	96,500	91,400	93,950
Core 38	Core composite	1.220E+05	1.100E+05	1.160E+05
Core 39	Core composite (1)	1.190E+05	1.220E+05	1.205E+05
	Core composite (2)	1.180E+05	1.170E+05	1.175E+05

Table B2-41. Tank 241-C-110 Analytical Results: Nitrite (IC). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	1,577.98	1,495.41	1,536.7
Core 38	Segment 4	5,834.86	5,963.3	5,899.08
Core 39	Segment 3	17,247.7	17,064.2	17,156
Tank composite		4,174.31	4,256.88	4,215.6

Table B2-41. Tank 241-C-110 Analytical Results: Nitrite (IC). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	2,810	2,600	2,705
	Core composite (2)	2,840	2,790	2,815
Core 38	Core composite	5,420	4,760	5,090
Core 39	Core composite (1)	12,300	13,500	12,900
	Core composite (2)	12,400	13,100	12,750

Table B2-42. Tank 241-C-110 Analytical Results: Phosphate (IC).

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	1,862.39	1,862.39	1,862.39
Core 38	Segment 4	6,853.21	6,935.78	6,894.5
Core 39	Segment 3	7,394.5	7,220.18	7,307.34
Tank composite		4,247.71	4,201.83	4,224.77
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	37,100	38,100	37,600
	Core composite (2)	41,500	49,300	45,400[QC:e]
Core 38	Core composite	18,900	32,000	25,450[QC:e]
Core 39	Core composite (1)	14,700	16,800	15,750
	Core composite (2)	19,600	18,700	19,150

Table B2-43. Tank 241-C-110 Analytical Results: Sulfate (IC). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	5,321.1	3,504.59	4,412.84[QC:e]
Core 38	Segment 4	9,541.28	9,174.31	9,357.8
Core 39	Segment 3	20,275.2	20,183.5	20,229.4
Tank composite		6,733.94	6,706.42	6,720.18

Table B2-43. Tank 241-C-110 Analytical Results: Sulfate (IC). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	10,900	11,200	11,050
	Core composite (2)	11,100	10,600	10,850
Core 38	Core composite	13,400	12,400	12,900
Core 39	Core composite (1)	19,200	18,900	19,050
	Core composite (2)	24,400	20,100	22,250[QC:e]

B2.2.7 Distillation/Titration

Table B2-44. Tank 241-C-110 Analytical Results: Ammonium (Distillation).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<4,500	<4,500	<4,500
	Core composite (2)	<4,500	<4,500	<4,500
Core 38	Core composite	<4,500	<4,500	<4,500
Core 39	Core composite (1)	<4,500	<4,500	<4,500
	Core composite (2)	<4,500	<4,500	<4,500
Drainable liquid: water digest		µg/g	µg/g	µg/g
Tank composite		<80.2752	78.3486	<79.3119

B2.3 ORGANIC ANALYSES

B2.3.1 Extractable Organic Halides

Cores 37, 38, and 39 were analyzed for the presence of extractable organic halides (ETOX). Results are presented in Table B2-45.

Table B2-45. Tank 241-C-110 Analytical Results: ETOX (Extractable Organic Halides).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 37	Core composite (1)	23	4	13.5[QC:e]
	Core composite (2)	9	106	57.5[QC:e]
Core 38	Core composite	7	3	5[QC:e]
Core 39	Core composite		4	4
Drainable liquid		µg/g	µg/g	µg/g
Tank composite		0.92	0.86	0.89

B2.3.2 Semivolatiles and Volatiles

Semivolatile and volatile organic compounds were analyzed on the solid composite samples and the tank composite liquid samples. Most of the mean values for the analytes were less than the detection limits. Because of the volatile nature of these compounds and the small amount originally in the waste, these compounds were not expected to be detected. Tributylphosphate was detected in the waste; however, its presence is consistent with the fill history of this tank. Contamination during the sampling process may have resulted in the detection of certain compounds that were not indigenous to the waste and do not contribute substantially to the overall inventory of the tank. Results are presented in Tables B2-46 through B2-65.

Table B2-46. Tank 241-C-110 Analytical Results: 2-Chloronitrophenol-d3 (SVOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Tank composite		12	11	11.5

Table B2-47. Tank 241-C-110 Analytical Results: 2-Fluoro-4-nitrophenol (SVOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Tank composite		19	17	18

Table B2-48. Tank 241-C-110 Analytical Results: 2-Fluoronitrophenol (SVOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Tank composite		34	31	32.5

Table B2-49. Tank 241-C-110 Analytical Results: 2-Nitrophenol-d4 (SVOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Tank composite		45	43	44

Table B2-50. Tank 241-C-110 Analytical Results: 4-Nitrophenol-d4 (SVOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Tank composite		39	37	38

Table B2-51. Tank 241-C-110 Analytical Results: Decane (SVOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 39	Core composite (1)	8.7		8.7
	Core composite (2)	8.6		8.6

Table B2-52. Tank 241-C-110 Analytical Results: Dodecane (SVOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 38	Core composite	830	890	860
Core 39	Core composite (1)	820	460	640[QC:e]
	Core composite (2)	780	650	715

Table B2-53. Tank 241-C-110 Analytical Results: Pentadecane (SVOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 38	Core composite	58	67	62.5
Core 39	Core composite (1)	62	33	47.5[QC:e]
	Core composite (2)	61	50	55.5

Table B2-54. Tank 241-C-110 Analytical Results: TBP (SVOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 37	Core composite (1)		8.1	8.1
	Core composite (2)	34	45	39.5[QC:e]
Core 38	Core composite	9.6	7.1	8.35[QC:e]
Core 39	Core composite (1)	12		12
	Core composite (2)	10		10

Table B2-55. Tank 241-C-110 Analytical Results: Tetradecane (SVOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 37	Core composite		9	9
Core 38	Core composite	1,400	1,500	1,450
Core 39	Core composite (1)	1,300	770	1,035[QC:e]
	Core composite (2)	1,200	1,100	1,150
Drainable Liquid		µg/g	µg/g	µg/g
Tank composite			11	11

Table B2-56. Tank 241-C-110 Analytical Results: Tridecane (SVOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 37	Core composite (1)	8.7		8.7
	Core composite (2)	9.1	9.6	9.35
Core 38	Core composite	1,900	2,000	1,950
Core 39	Core composite (1)	1,700	1,100	1,400[QC:e]
	Core composite (2)	1,600	1,500	1,550
Drainable liquid		µg/g	µg/g	µg/g
Tank composite			9.5	9.5

Table B2-57. Tank 241-C-110 Analytical Results: Undecane (SVOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 38	Core composite	18	20	19
Core 39	Core composite (1)	20	10	15[QC:e]
	Core composite (2)	20	16	18[QC:e]

Table B2-58. Tank 241-C-110 Analytical Results: 1,1,1-Trichloroethane (VOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 38	Segment 1	0.8	0.57	0.685[QC:e]
Core 38	Segment 4	<3.2	<2.6	<2.9[QC:e]
Core 39	Segment 2	<3.1	<2.8	<2.95
Core 39	Segment 3	<2.9	<2.7	<2.8
Core 39	Segment 4	<3.3	<2.5	<2.9[QC:e]

Table B2-59. Tank 241-C-110 Analytical Results: 2-butanone (VOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 38	Segment 1	<6.8	<6.7	<6.75
Core 38	Segment 4	<6.4	<5.3	<5.85
Core 39	Segment 2	1.3	<5.7	<3.5[QC:e]
Core 39	Segment 3	<5.8	<5.4	<5.6
Core 39	Segment 4	1.6	1.3	1.45[QC:e]

Table B2-60. Tank 241-C-110 Analytical Results: Decane (VOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 38	Segment 1	5.7	4	4.85[QC:e]
Core 38	Segment 4	3.8	3.4	3.6
Core 39	Segment 2	2.2	2.5	2.35
Core 39	Segment 3	5.5	5.7	5.6
Core 39	Segment 4	2.4	1.7	2.05[QC:e]

Table B2-61. Tank 241-C-110 Analytical Results: Dodecane (VOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 38	Segment 1	45	44	44.5
Core 38	Segment 4	33	33	33
Core 39	Segment 2	25	28	26.5
Core 39	Segment 3	36	33	34.5
Core 39	Segment 4	43	32	37.5[QC:e]

Table B2-62. Tank 241-C-110 Analytical Results: Tetradecane (VOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 38	Segment 1	3.4	4.1	3.75
Core 38	Segment 4	2.5	2.5	2.5
Core 39	Segment 2	2.3	1.8	2.05[QC:e]
Core 39	Segment 3	4.3	5	4.65
Core 39	Segment 4	4.6	2.4	3.5[QC:e]

Table B2-63. Tank 241-C-110 Analytical Results: Tridecane (VOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 38	Segment 1	18	20	19
Core 38	Segment 4	15	16	15.5
Core 39	Segment 2	11	9.8	10.4
Core 39	Segment 3	15	20	17.5[QC:e]
Core 39	Segment 4	22	16	19[QC:e]

Table B2-64. Tank 241-C-110 Analytical Results: Undecane (VOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 38	Segment 1	5.4	4.4	4.9[QC:e]
Core 38	Segment 4	3.3	3	3.15
Core 39	Segment 2	2.4	2.9	2.65
Core 39	Segment 3	5.4	4.7	5.05
Core 39	Segment 4	3.3	2.4	2.85[QC:e]

Table B2-65. Tank 241-C-110 Analytical Results: Xylenes (total) (VOA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		µg/g	µg/g	µg/g
Core 38	Segment 1	<3.4	<3.3	<3.35
Core 38	Segment 4	<3.2	<2.6	<2.9[QC:e]
Core 39	Segment 2	3.1	2.8	2.95
Core 39	Segment 3	2.9	2.7	2.8
Core 39	Segment 4	3.3	2.5	2.9[QC:e]

B2.4 CARBON ANALYSES

Results for TOC and TIC were obtained during the same analysis; therefore, the discussion of the analytical method for these two analytes has been combined. The TIC/TOC analyses were performed direct and on water leachates prepared from cores 37, 38, and 39. Because the inorganic carbon was detected in the core composite samples but not the drainable liquid, the data indicate that the carbonate in tank 241-C-110 exists in the form of precipitated salt. The average amount of total inorganic carbon in the tank, 2,030 µg/g, translates into an average carbonate concentration of 10,200 µg/g. Results are presented in Tables B2-66a, B2-66b, and B2-67.

Table B2-66a. Tank 241-C-110 Analytical Results: Total Organic Carbon.

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µg/g	µg/g	µg/g
Core 37	Segment 3	373.394	377.982	375.688
Core 38	Segment 4	550.459	555.046	552.752
Core 39	Segment 3	716.514	706.422	711.468

Table B2-66b. Tank 241-C-110 Analytical Results: Total Organic Carbon.

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	<500	1,047	<773.5[QC:e]
	Core composite (2)	1,090	1,090	1,090
Core 38	Core composite	<500	<500	<500
Core 39	Core composite (1)	528	<500	<514
	Core composite (2)	<500	<500	<500
Drainable liquid: water digest		µg/g	µg/g	µg/g
Tank composite		474.312	589.908	532.11[QC:e]

Table B2-67. Tank 241-C-110 Analytical Results: Total Inorganic Carbon.

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest		µg/g	µg/g	µg/g
Core 37	Core composite (1)	4,380	1,595	2,987.5[QC:e]
	Core composite (2)	1,780	1,390	1,585[QC:e]
Core 38	Core composite	1,390	1,920	1,655[QC:e]
Core 39	Core composite (1)	1,630	1,795	1,712.5
	Core composite (2)	3,110	1,980	2,545[QC:e]
Drainable liquid		µg/g	µg/g	µg/g
Tank composite		<497.248	499.083	<498.165

B2.5 RADIONUCLIDE ANALYSES

A full suite of radiochemical analyses were performed on water and the KOH fusion preparations of cores 37, 38, and 39.

B2.5.1 Gamma Energy Analyses

A GEA was performed on segment and composite samples prepared by caustic fusion. Mean values from ^{241}Am, ^{60}Co, ^{154}Eu, ^{155}Eu, and ^{129}I analyses are less than the detection limits. Table B2-68 presents the ^{137}Cs results.

Table B2-68. Tank 241-C-110 Analytical Results: Cesium-137 (GEA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µCi/g	µCi/g	µCi/g
Core 38	Segment 4a	14.5	14.2	14.35
	Segment 4b	14	14.2	14.1
Core 39	Segment 3a	21.7	19.3	20.5
	Segment 3b	21.5	21.1	21.3
Solids: fusion		µCi/g	µCi/g	µCi/g
Core 37	Core composite (1)	15.4	15.3	15.35
	Core composite (2)	15.1	14.1	14.6
Core 38	Core composite	19.1	20.5	19.8
Core 39	Core composite (1)	23.9	22.9	23.4
	Core composite (2)	24.1	24	24.05
Drainable liquid		µCi/g	µCi/g	µCi/g
Core 39	Segment 3	20	20.5	20.25
Drainable liquid		µCi/mL	µCi/mL	µCi/mL
Core 37	Segment 3	0.851	0.831	0.841
Core 38	Segment 4	5.9	5.98	5.94
Tank composite		4.84	4.86	4.85

B2.5.2 Total Alpha Activity, Pu, Am/Cm, and Np Analysis

Total alpha activity, Pu, Am/Cm, and Np analyses were performed on acid digests and KOH fusions of the segment and composite samples from cores 37, 38, and 39. The mean values for Np are less than the detection limit. Results from the total alpha and Pu analyses are presented in Tables B2-69a through B2-71.

Table B2-69a. Tank 241-C-110 Analytical Results: Total Alpha (APC). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest		µCi/g	µCi/g	µCi/g
Core 38	Segment 4a	0.128	0.136	0.132
	Segment 4b	0.131	0.134	0.1325

Table B2-69a. Tank 241-C-110 Analytical Results: Total Alpha (APC). (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest (Cont'd)		µCi/g	µCi/g	µCi/g
Core 39	Segment 3a	0.118	0.104	0.111[QC:e]
	Segment 3b	0.124	0.116	0.12
Drainable liquid		µCi/g	µCi/g	µCi/g
Core 39	Segment 3	0.00447	0.00426	0.004365
Drainable liquid		µCi/mL	µCi/mL	µCi/mL
Core 37	Segment 3	<7.340E-04	<6.020E-04	<6.680E-04[QC:e]
Core 38	Segment 4	<6.020E-04	<6.020E-04	<6.020E-04
Tank composite		0.00207	0.00207	0.00207

Table B2-69b. Tank 241-C-110 Analytical Results: Total Alpha (APC).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion		µCi/g	µCi/g	µCi/g
Core 37	Core composite (1)	0.136	0.136	0.136
	Core composite (2)	0.145	0.136	0.1405
Core 38	Core composite	0.127	0.124	0.1255
Core 39	Core composite (1)	0.121	0.104	0.1125[QC:e]
	Core composite (2)	0.119	0.107	0.113[QC:e]

Table B2-70. Tank 241-C-110 Analytical Results: Plutonium-238 (GEA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion		µCi/g	µCi/g	µCi/g
Core 37	Solid composite (1)	<0.0045	<0.0045	<0.0045
	Solid composite (2)	<0.00445	<0.00448	<0.004465
Core 38	Solid composite	<0.00225	<0.00225	<0.00225
Core 39	Solid composite (1)	<0.00498	<0.00493	<0.004955
	Solid composite (2)	<0.0045	<0.00447	<0.004485
Drainable liquid		µCi/mL	µCi/mL	µCi/mL
Tank composite		<9.000E-06	<9.000E-06	<9.000E-06

Table B2-71. Tank 241-C-110 Analytical Results: Plutonium-239/40 (Alpha Spec).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion		µCi/g	µCi/g	µCi/g
Core 37	Core composite (1)	0.0558	0.0583	0.05705[QC:c]
	Core composite (2)	0.0617	0.0652	0.06345[QC:c]
Core 38	Core composite	0.0765	0.0885	0.0825[QC:c]
Core 39	Core composite (1)	0.135	0.153	0.144[QC:c]
	Core composite (2)	0.0518	0.0544	0.0531
Drainable liquid		µCi/mL	µCi/mL	µCi/mL
Tank composite		0.00177	0.00175	0.00176[QC:c]

B2.5.3 Total Beta, ^{90}Sr, and ^{99}Tc

Total beta, ^{90}Sr, and ^{99}Tc analyses were performed on the KOH fusions of the composites from both cores. Total beta values were determined by drying a small aliquot of each solution and counting in a beta proportional counter. Technetium-99 and ^{90}Sr were also measured by beta counting after separating each fraction by ion exchange and/or solvent extraction. The results are shown in Tables B2-72a, B2-72b, and B2-73.

Table B2-72a. Tank 241-C-110 Analytical Results: Total Beta (BPC).

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µCi/g	µCi/g	µCi/g
Core 39	Segment 3	27.3	27.9	27.6
Drainable liquid		µCi/mL	µCi/mL	µCi/mL
Core 37	Segment 3	1.19	1.21	1.2
Core 38	Segment 4	8.19	8.11	8.15
Tank composite		5.63	5.73	5.68

Table B2-72b. Tank 241-C-110 Analytical Results: Total Beta (BPC).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion		µCi/g	µCi/g	µCi/g
Core 37	Core composite (1)	41	42.3	41.65
	Core composite (2)	40.6	39.6	40.1
Core 38	Core composite	41.9	39.9	40.9
Core 39	Core composite (1)	48.1	43.3	45.7[QC:e]
	Core composite (2)	45.9	45.6	45.75

Table B2-73. Table 241-C-110 Analytical Results: Strontium-90 (BPC).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion		µCi/g	µCi/g	µCi/g
Core 37	Core composite (1)	7.13	7.21	7.17
	Core composite (2)	7.15	6.5	6.825
Core 38	Core composite	4.38	4.26	4.32
Core 39	Core composite (1)	3.72	2.59	3.155[QC:e]
	Core composite (2)	3.94	3.55	3.745
Drainable liquid		µCi/mL	µCi/mL	µCi/mL
Tank composite		0.0283	0.0272	0.02775

B2.5.4 Liquid Scintillation Counting

Carbon-14 and technetium-99 was determined by the hot persulfate oxidation/liquid scintillation counting method. These analyses were performed direct and on core composite samples. Results are presented in the Tables B2-74 through B2-77.

Table B2-74. Table 241-C-110 Analytical Results: Technetium-99 (LSC).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion		µCi/g	µCi/g	µCi/g
Core 37	Core composite (1)	0.046	0.0466	0.0463
	Core composite (2)	0.0381	0.0408	0.03945
Core 38	Core composite	0.0203	0.0192	0.01975
Core 39	Core composite (1)	0.0334	0.0371	0.03525
	Core composite (2)	0.0369	0.0354	0.03615
Drainable liquid		µCi/g	µCi/g	µCi/g
Tank composite		0.0162	0.0161	0.01615

Table B2-75. Tank 241-C-110 Analytical Results: Carbon-14 (LSC).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion		µCi/g	µCi/g	µCi/g
Core 37	Core composite (1)	2.520E-04	<2.250E-04	<2.385E-04
	Core composite (2)	<2.230E-04	3.500E-04	<2.865E-04[QC:e]
Core 38	Core composite	<6.100E-05	<6.200E-05	<6.150E-05
Core 39	Core composite (1)	5.590E-04	6.440E-04	6.015E-04
	Core composite (2)	7.070E-04	6.190E-04	6.630E-04
Drainable liquid		µCi/mL	µCi/mL	µCi/mL
Tank composite		1.990E-04	1.990E-04	1.990E-04

Table B2-76a. Tank 241-C-110 Analytical Results: Tritium (LSC).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion		µCi/g	µCi/g	µCi/g
Core 37	Core composite (1)	8.090E-04	8.300E-04	8.195E-04
	Core composite (2)	9.390E-04	8.750E-04	9.070E-04
Core 38	Core composite	0.00128	0.00102	0.00115[QC:e]
Core 39	Core composite (1)	0.0014	0.00149	0.001445
	Core composite (2)	0.00177	0.00151	0.00164

Table B2-76b. Tank 241-C-110 Analytical Results: Tritium (LSC).

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		µCi/mL	µCi/mL	µCi/mL
Tank composite		7.920E-04	6.450E-04	7.185E-04[QC:a,c]

Table B2-77. Tank 241-C-110 Analytical Results: Selenium-79 (LSC).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion		µCi/g	µCi/g	µCi/g
Core 37	Core composite (1)	<2.810E-04	2.630E-04	<2.720E-04
	Core composite (2)	<2.910E-04	<2.840E-04	<2.875E-04
Core 38	Core composite	<0.00351	0.00384	<0.003675
Core 39	Core composite (1)	<0.00259	<0.00245	<0.00252
	Core composite (2)	<0.00248	<0.00251	<0.002495
Drainable liquid		µCi/mL	µCi/mL	µCi/mL
Tank composite		6.190E-05	6.150E-05	6.170E-05

B2.6 PHYSICAL ANALYSES

Measurements of physical characteristics such as weight percent solids, pH measurements, and density were performed. The physical properties of segments 2 and 4 of core 37 were extensively analyzed by PNL. The results of physical tests performed at the 222-S Laboratory are presented in Tables B2-78 through B2-81.

Table B2-78. Tank 241-C-110 Analytical Results: Percent Water. (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		%	%	%
Core 37	Segment 2	61.1	59.6	60.35
	Segment 4	56.8	60.4	58.6
Core 38	Segment 1	59.8	62.5	61.15
	Segment 4	62.5	64.5	63.5

Table B2-78. Tank 241-C-110 Analytical Results: Percent Water. (2 sheets)

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids (Cont'd)		%	%	%
Core 39	Segment 2	61.9	56.6	59.25
	Segment 3	60.3	60.9	60.6
	Segment 4	60.4	60.4	60.4
Core 38	Core composite	65.24	50.51	57.875[QC:e]
Core 39	Core composite (1)	61.7		61.7
	Core composite (2)	62.7	60.8	61.75

Table B2-79. Tank 241-C-110 Analytical Results: Weight Percent Solids (Percent Solids).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solid		%	%	%
Core 37	Core composite (1)	45.77	45.33	45.55
	Core composite (2)	44.78	44.1	44.44
Core 38	Core composite	40.34	41.92	41.13
Core 39	Core composite (1)	40.21	42.5	41.355
	Core composite (2)	47.17	47.16	47.165

Table B2-80. Tank 241-C-110 Analytical Results: pH Measurement.

Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid		unitless	unitless	unitless
Tank composite		10.42	10.44	10.43
Solids: water digest		unitless	unitless	unitless
Core 37	Core composite (1)	11	11.07	11.035
	Core composite (2)	11.33	11.29	11.31
Core 38	Core composite	10.7	10.86	10.78
Core 39	Core composite (1)	10.86	10.9	10.88
	Core composite (2)	11.12	11.11	11.115

Table B2-81. Tank 241-C-110 Analytical Results: Density (Physical Properties).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids			g/mL	g/mL	g/mL
Core 37	Segment 2a	Whole	1.41		1.41
	Segment 2b	Whole	1.21		1.21
	Segment 4	Whole	1.48		1.48
Core 39	Segment 2	Whole	1.24		1.24
Drainable liquid			g/mL	g/mL	g/mL
Core 37	Segment 3	Drainable liquid	1		1
Core 38	Segment 4	Drainable liquid	1.1		1.1
Core 39	Segment 3	Drainable liquid	1.18		1.18

B2.7 THERMODYNAMIC ANALYSES

Thermogravimetric analysis (TGA) and DSC are techniques used to determine the thermal stability or reactivity of a material. Differential scanning calorimetry measures heat released or absorbed while the temperature of the sample is increased at a constant rate. It is often used to measure thermal decomposition temperatures, heats of reaction, reaction temperatures, melting points, and solid-solid transition temperatures. Thermogravimetric analysis measures the mass of a sample while the temperature is increased at a constant rate. It is used to measure thermal decomposition temperatures, water contents, and reaction temperatures. Both methods can be modified to measure isothermal change in the material and provide complimentary information.

B2.7.1 Thermogravimetric Analysis

Thermogravimetric analysis was performed on sample material from each segment of cores 37, 38, and 39. Results are presented in Table B2-82.

Table B2-82. Tank 241-C-110 Analytical Results: Percent Water (TGA).

Sample Location	Sample Portion	Result	Duplicate	Mean
Solids		%	%	%
Core 37	Segment 2	50.1		50.1
	Segment 4	50.6		50.6
Core 38	Segment 1	54.2		54.2
	Segment 4	53.8		53.8
Core 39	Segment 2	53.2		53.2
	Segment 3	52.6		52.6
	Segment 4	49.3		49.3
Core 37	Core composite (1)	57.6	59.8	58.7
	Core composite (2)	57.8	50.4	54.1[QC:e]
Core 38	Core composite	61.9	62	61.95
Core 39	Core composite (1)	57.2	55.3	56.25
	Core composite (2)	55.3	48.6	51.95[QC:e]

B2.7.2 Differential Scanning Calorimetry

Differential scanning calorimetry was performed on aliquots from each segment from cores 37, 38 and 39 (Simpson et al. 1994). An indium standard was run on the differential scanning calorimeter to check the temperature and enthalpy calibrations. In the DSC analysis, heat absorbed or emitted by a substance is measured while the temperature of 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.

Exotherms were not observed in any of the tank waste samples during the differential scanning calorimetry analyses.

B2.8 VAPOR PHASE MEASUREMENT

Headspace gas and vapor samples were collected from tank 241-C-110 using the vapor sampling system on August 18, 1994, by WHC Sampling and Mobile Laboratories (Caprio 1995). The tank was vapor sampled in accordance with *Data Quality Objectives for Generic In-Tank Health and Safety Issue Resolution* (Osborne et al. 1994). Results are presented in Table B2-83.

Table B2-83. Results of Vapor Phase Measurements of Tank 241-C-110.[1]

Measurement	Result August 1994
Total nonmethane organic carbon	22.3 mg/m^3
Lower explosive limit (LEL)	<1% of LEL
Water vapor	12.4 mg/L
Ammonia	124 ppmv
Carbon dioxide	94 ppmv
Carbon monoxide	<12 ppmv
Hydrogen	<94 ppmv
Nitric oxide	0.08 ppmv
Nitrogen dioxide	<= 0.06
Nitrous oxide	21 ppmv
Positively identified organic compounds	
Ethanenitrile (acetonitrile)	0.24 ppmv
Propanone (acetone)	0.22 ppmv
Trichlorofluoromethane	0.024 ppmv
Propanenitrile	0.030 ppmv
1-Propanol	0.020 ppmv
2-Butanone	0.047 ppmv
Tetrahydrofuran	0.013 ppmv
n-Butanenitrile	0.019 ppmv
Cyclohexane	0.011 ppmv
n-Decane	0.008 ppmv
Methane	1.9 ppmv

Note:
[1]Bratzel and Huckaby (1995)

B2.9 HISTORICAL SAMPLE RESULTS

The results of the June 19, 1975, supernatant sample (Wheeler 1975) are shown in Table B2-84. Because the sample was liquid and the tank has since been pumped of liquids, the sample probably does not represent present tank contents. These data have not been validated and should be used with caution.

Table B2-84. Supernatant Sample.[1]

Date Received: June 19, 1975		
T-5491		
Component	Lab Value	Lab Unit
Physical data		
Sample description	Light yellow, no solids. 300 mrad/hr at 4 inches.	
pH	11.8	
Specific gravity	1.134	
Water	83.36	%
Differential thermal analysis	No exotherm below 200 °C	
Chemical analysis		
OH	0.831	*M*
Al	3.83E-02	*M*
NO_2	0.807	*M*
NO_3	0.541	*M*
Radiological analysis		
^{134}Cs	215	μCi/L
^{137}Cs	1.21E+06	μCi/L
$^{89,90}Sr$	125	μCi/L

Note:
[1]Pre-1989 analytical data have not been validated and should be used with caution.

The results of the August 31, 1977, sludge samples (Starr 1977) are shown in Table B2-85. Two KOH fusions were performed on portions of this sample. Results from sample #9501, JS #17 are shown.

Table B2-85. Sludge Sample.[1].

Date received: August 31, 1977		
#9501, JS-17		
Component	Lab Value	Lab Unit
Physical data		
Sample description	sludge	
Chemical analysis		
Fe	0.68	*M*
Al	11.0	*M*
Ni	0.07	*M*
NO_2	<6.2	*M*
NO_3	<0.94	*M*
SO_4	<1.2	*M*
PO_4	<6.2	*M*
Mn	0.02	*M*
Mg	0.06	*M*
Cr	0.03	*M*
Hg	0.13	*M*
Ca	0.08	*M*
Cd	<4.2E-03	*M*
Si	0.98	*M*
Ba	0.01	*M*
Radiological analysis		
U	5.7E-04	g/L
Pu	5.1E-03	g/L
^{137}Cs	1.40E+05	μCi/L
$^{89,90}Sr$	4.9E+04	μCi/L

Note:
[1]Pre-1989 analytical data have not been validated and should be used with caution.

B3.0 ASSESSMENT OF CHARACTERIZATION RESULTS

The purpose of this chapter is to discuss the overall quality and consistency of the current sampling results for tank 241-C-110. This section also evaluates sampling and analysis factors that may impact interpretation of the data. These factors are used to assess the overall quality and consistency of the data and to identify any limitations in the use of the data.

B3.1 FIELD OBSERVATIONS

As described in Table B1-1, five of the 12 segments were recovered with 100 percent recovery, four segments were empty, one segment had an 80 percent recovery, and two segments contained less than 50 percent recovery. Each core had at least one empty segment, and core 38 contained only segments 1 and 4. There were very few liquid recoveries in any of the samples. Only one segment from each core contained drainable liquids exceeding 15 percent. Because of the poor recovery of the sampling effort and the poor mechanical performance of the sampling equipment for tank 241-C-110, the results given in Section B3.4 may be biased. The magnitude of this bias cannot be determined.

B3.2 QUALITY CONTROL ASSESSMENT

The usual quality control assessment included an evaluation of the appropriate standard recoveries, duplicate analyses, and blanks performed in conjunction with the chemical analyses. All the pertinent quality control tests were conducted on the 1992 core samples, allowing a full assessment regarding the accuracy and precision of the data. QC criteria are included in Hill et al. (1991). Samples with one or more QC results outside of the criteria are identified in Tables B2-1 and B2-2. Additional detail is provided in Shaver (1993).

The standard and spike recovery results provide an estimate of the accuracy of the analysis. If a standard or spike recovery is above or below the given criterion, the analytical results may be biased high or low, respectively. Low standard and spike recoveries consistently occurred for several elements in the ICP acid digest analysis. This may have been due to a high concentration of elements in the sample compared to the concentration of analytes in the spike. Although standard and spike recoveries for the ICP acids data were low, the analytical values appeared to be consistent with the ICP fusion analyses.

The precision is estimated by the relative percent difference [RPD], defined as the absolute value of the difference between the primary and duplicate samples, divided by their mean, times one hundred. Difficulties in producing a highly homogeneous subsample are probably responsible for most of the RPD values exceeding 20 percent. The analytes exhibited high RPDs most frequently at concentration levels less than 10,000 μg/g. Sample preparation also appears to influence this behavior.

Preparation blanks are used to identify any sample contamination that was introduced in the laboratory during the process of sample breakdown, digestion, and dilution. The blank results indicated that contamination was not a problem.

Although some samples did have quality control results outside the boundaries, the majority of the quality control results were within the boundaries specified (Hill et al. 1991).

B3.3 DATA CONSISTENCY CHECKS

Comparisons of different analytical methods for the same analyte can help to assess the consistency and quality of the data. A comparison was made of phosphorous and sulfur as analyzed by ICP with 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 different analytical methods. Close agreement between the two methods strengthens the credibility of both results, whereas a poor agreement brings the reliability of the data into question. This comparison also gives an indication of chemical speciation. For example, if the IC determination of phosphate from water digestion agrees with the phosphorus by ICP on the fusion digestion, it indicates that the phosphorus is present as soluble phosphate. If the ICP result is significantly higher, it may indicate the presence of insoluble phosphate.

After the phosphorous and sulfur values derived from the ICP analyses were converted into corresponding phosphate and sulfate data, the results were compared, as displayed in Table B3-1, to the phosphate and sulfate data obtained by IC. Inspection of the table reveals a large difference between the IC and ICP solid phase phosphate data; therefore, it is surmised that precipitated phosphate salts account for the majority (approximately 92 percent) of the phosphorus in tank 241-C-110. Furthermore, the concentration of phosphate contained within the solid phase of tank 241-C-110 appears to be most accurately represented by the value calculated from the ICP data, and the historical data supports this claim.

Table B3-1. Comparison of ICP and IC Phosphate and Sulfate Results..

Analyte	Liquid Phase		Solid Phase	
	IC Result (μg/g)	ICP Result (μg/g)	IC Result (μg/g)	ICP Result (μg/g)
Phosphate	5,070	5,760	28,100	62,200
Sulfate	11,100	8,120	14,800	12,200

B3.3.2 Mass and Charge Balance

The principle objective in performing a mass and charge balance is to determine if the measurements are consistent. The mass and charge balance calculations also provide a method for estimating the weight percent of water. In calculating the balances, only analytes detected at a concentration of 1 μg/g or greater were considered.

Mass and charge balance results are reported in Table B3-2. This represents data for the solid portion of the tank contents only (96 percent). The charge balance agrees, assuming that hydroxide ions account for part of the missing negative charge. The mass concentration, μg/g, resulting from the sum of the cations and anions, was subtracted from a million in order to obtain an estimated value for the weight percent of water. In other words, mass not accountable to the analyte concentrations is attributed to water. Inspection of the table indicates that the predicted weight percent of water is 62.7 percent. This agrees fairly closely with the evaluated data result of 59.8 percent.

Table B3-2. Tank 241-C-110 Mass and Charge Balance. (2 pages)

	Mass μg/g	Charge μmol/g
Cations		
[1]ICP.a.Al^{+3}	14,500	1,611
[1]ICP.f.Sb^{+5}	301	12.3
[2]ICP.a.As^{+5}	4.1	0.27
ICP.a.Ba^{+2}	7.68	0.11
ICP.a.Bi^{+3}	16,800	241
ICP.f.Cd^{+2}	5.36	0.10
ICP.f.Ca^{+2}	1,150	57.4
ICP.a.Ce^{+3}	210	4.50
ICP.f.Co^{+2}	6.59	0.22
ICP.a.Cr^{+6}	470	54.2
ICP.f.Cu^{+2}	98.9	3.11
ICP.a.Fe^{+3}	11,000	591
[3]ICP.w.La^{+3}	2.00	0.04
ICP.f.Pb^{+2}	258	2.49
ICP.f.Mg^{+2}	153	12.6
ICP.f.Mn^{+2}	56.3	2.05
ICP.a.Ni^{+2}	23.9	0.81
ICP.a.K^{+}	557	14.2
ICP.w.Ag^{+}	1.05	0.01

Table B3-2. Tank 241-C-110 Mass and Charge Balance. (2 pages)

	Mass μg/g	Charge μmol/g
Cations (Cont'd)		
ICP.f.Na^{+}	82,600	3,590
ICP.f.Sr^{+2}	131	3.00
ICP.f.Sn^{+2}	12.8	0.22
ICP.a.Ti^{+2}	5.09	0.21
[4]LF.U^{+6}	1,480	37.3
ICP.a.V^{+5}	6.17	0.60
ICP.f.Zn^{+2}	224	6.85
ICP.f.Zr^{+4}	172	7.56
Anions		
Metasilicate ICP.f.SiO_3^{-2}	19,400	510
Selenite ICP.a.SeO_3^{-2}	113	1.77
Tetraborate ICP.w.$B_4O_7^{-2}$	89.8	1.16
[5]IC.w.F^{-}	7,520	396
IC.w.Cl^{-}	1,100	31.0
IC.w.NO_3^{-}	110,000	1,770
IC.w.PO_4^{-3}	62,200	1,904
IC.w.SO_4^{-2}	15,200	317
Spec.w.NO_2^{-}	7,260	158
Totals		
Cations	131,000	6,226
Anions	223,000	5,150
Hydroxide	18,800	1,103
Water (est.)	627,000	
Tank characterization report results		
Water (TCR)	598,000	

Notes:

[1]ICP.a = inductively coupled plasma, acid digestion
[2]ICP.f = inductively coupled plasma, KOH/nickel fusion dissolution
[3]ICP.w = inductively coupled plasma, water digestion
[4]LF = laser fluorimetry
[5]IC = ion chromatography, water digestion

B3.4 MEAN CONCENTRATION AND CONFIDENCE INTERVALS

The following evaluation was performed on the analytical data from the samples from tank 241-C-110.

Because an inventory estimate is needed without comparing it to a threshold value, two-sided 95 percent confidence intervals on the mean inventory are computed using composite-level data.

The upper and lower limits (UL and LL) to a two-sided 95 percent confidence interval for the mean are

$$\hat{\mu} \pm t_{(df,0.025)} \times \hat{\sigma}_{\hat{\mu}}.$$

In this equation, $\hat{\mu}$ is the estimate of the mean concentration, $\hat{\sigma}_{\hat{\mu}}$ is the estimate of the standard deviation of the mean concentration, and $t_{(df,0.025)}$ is the quantile from Student's t distribution with df degrees of freedom for a two-sided 95 percent confidence interval.

The mean, $\hat{\mu}$, and the standard deviation, $\hat{\sigma}_{\hat{\mu}}$, were estimated using restricted maximum likelihood estimation methods. The degrees of freedom (df), for tank 241-C-110, is the number of cores sampled minus one.

B3.4.1 Composite Means

The statistics in this section were based on analytical data from the most recent sampling event of tank 241-C-110. Analysis of variance (ANOVA) techniques were used to estimate the mean, and to calculate confidence limits on the mean for all analytes that had at least 50 percent of reported values above the detection limit. If at least 50 percent of the reported values were above the detection limit, all of the data was used in the computations. The detection limit was used as the value for nondetected results. No ANOVA estimates were computed for analytes with less than 50 percent detected values. Only arithmetic means were computed for these analytes.

The results given below are ANOVA estimates based on the core composite data from core 37, core 38, and core 39 for tank 241-C-110. Estimates of the mean concentration and confidence interval on the mean concentration are given in Table B3-3. The lower limit, LL, to a 95 percent confidence interval can be negative. Because an actual concentration of less than zero is not possible, the lower limit is reported as zero, whenever this occurred.

Table B3-3. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (5 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_p$	df	LL	UL
%H_2O(TGA)	%	5.69E+01	2.03E+00	2	4.82E+01	6.57E+01
%H_2O(%solids)#	%	6.02E+01	2.53E+00	1	2.80E+01	9.24E+01
^{238}Pu/Ratio	%	2.51E-02	1.30E-02	2	0.00E+00	8.08E-02
^{239}Pu/Ratio	%	9.83E+01	5.89E-02	2	9.80E+01	9.85E+01
^{240}Pu/Ratio	%	1.65E+00	3.00E-02	2	1.52E+00	1.78E+00
^{241}Pu/Ratio	%	2.16E-02	9.52E-03	2	0.00E+00	6.25E-02
^{242}Pu/Ratio	%	1.25E-02	7.65E-03	2	0.00E+00	4.54E-02
^{234}U/Ratio	%	5.67E-03	1.23E-04	2	5.14E-03	6.20E-03
^{235}U/Ratio	%	6.81E-01	2.93E-03	2	6.69E-01	6.94E-01
^{236}U/Ratio	%	5.54E-03	2.91E-04	2	4.28E-03	6.79E-03
^{238}U/Ratio	%	9.93E+01	2.68E-03	2	9.93E+01	9.93E+01
Wt% solids	%	4.39E+01	1.18E+00	2	3.89E+01	4.90E+01
pH	pH	1.10E+01	1.01E-01	2	1.06E+01	1.14E+01
Alpha	μCi/g	1.26E-01	7.51E-03	2	9.32E-02	1.58E-01
Alpha from Pu	μCi/g	1.48E-01	1.40E-02	2	8.77E-02	2.08E-01
^{241}Am.Alpha[1]	μCi/g	<9.55E-03	n/a	n/a	n/a	n/a
^{241}Am.GEA[1]	μCi/g	<2.34E-01	n/a	n/a	n/a	n/a
Beta	μCi/g	4.25E+01	1.63E+00	2	3.55E+01	4.96E+01
^{14}C[2]	μCi/g	3.20E-04	1.67E-04	2	0.00E+00	1.04E-03
^{60}Co[1]	μCi/g	<3.61E-02	n/a	n/a	n/a	n/a
^{137}Cs	μCi/g	1.95E+01	2.54E+00	2	8.59E+00	3.04E+01
^{154}Eu[1]	μCi/g	<9.33E-02	n/a	n/a	n/a	n/a
^{155}Eu[1]	μCi/g	<1.12E-01	n/a	n/a	n/a	n/a
^{129}I[1]	μCi/g	<1.41E-02	n/a	n/a	n/a	n/a
^{237}Np[1]	μCi/g	<3.66E-02	n/a	n/a	n/a	n/a
^{238}Pu[1]	μCi/g	<4.13E-03	n/a	n/a	n/a	n/a
^{239}Pu/40	μCi/g	8.00E-02	1.68E-02	2	7.85E-03	1.52E-01
^{79}Se[1]	μCi/g	<1.85E-03	n/a	n/a	n/a	n/a
^{90}Sr	μCi/g	4.93E+00	1.07E+00	2	3.11E-01	9.54E+00
^{99}Tc	μCi/g	3.30E-02	6.75E-03	2	3.92E-03	6.20E-02
Tritium	μCi/g	1.19E-03	2.00E-04	2	3.26E-04	2.05E-03
As(AA)[2]	μg/g	4.85E-01	1.09E-01	2	1.50E-02	9.55E-01
Chloride	μg/g	1.09E+03	2.76E+02	2	0.00E+00	2.28E+03

Table B3-3. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (5 sheets)

Analyte	Units	$\bar{\mu}$	$\sigma_{\bar{\mu}}$	df	LL	UL
Cyanide[1]	μg/g	<3.19E+00	n/a	n/a	n/a	n/a
Fluoride	μg/g	7.59E+03	1.02E+03	2	3.20E+03	1.20E+04
Hg(CVAA)	μg/g	4.46E-01	6.67E-02	2	1.59E-01	7.32E-01
ICP.a.Ag[2]	μg/g	6.90E-01	1.20E-01	2	1.71E-01	1.21E+00
ICP.a.Al	μg/g	1.45E+04	4.08E+02	2	1.27E+04	1.63E+04
ICP.a.As[2]	μg/g	3.77E+00	3.05E-01	2	2.46E+00	5.09E+00
ICP.a.B[2]	μg/g	2.13E+01	2.06E+00	2	1.25E+01	3.02E+01
ICP.a.Ba[2]	μg/g	7.68E+00	1.01E+00	2	3.34E+00	1.20E+01
ICP.a.Be[2]	μg/g	1.62E-01	6.28E-02	2	0.00E+00	4.33E-01
ICP.a.Bi	μg/g	1.68E+04	1.17E+03	2	1.17E+04	2.18E+04
ICP.a.Ca[2]	μg/g	3.85E+02	1.71E+02	2	0.00E+00	1.12E+03
ICP.a.Cd[2]	μg/g	3.23E+00	7.75E-01	2	0.00E+00	6.56E+00
ICP.a.Ce	μg/g	2.10E+02	1.35E+01	2	1.52E+02	2.68E+02
ICP.a.Co[2]	μg/g	2.64E+00	1.47E-01	2	2.00E+00	3.27E+00
ICP.a.Cr	μg/g	4.70E+02	2.01E+01	2	3.84E+02	5.57E+02
ICP.a.Cu	μg/g	3.00E+01	6.83E+00	2	5.84E-01	5.93E+01
ICP.a.Fe	μg/g	1.10E+04	7.88E+02	2	7.65E+03	1.44E+04
ICP.a.K	μg/g	5.59E+02	2.84E+01	2	4.36E+02	6.81E+02
ICP.a.La[2]	μg/g	1.44E+00	4.85E-02	2	1.23E+00	1.65E+00
ICP.a.Mg	μg/g	1.49E+02	2.05E+01	2	6.03E+01	2.37E+02
ICP.a.Mn	μg/g	3.58E+01	3.64E+00	2	2.01E+01	5.14E+01
ICP.a.Na	μg/g	7.68E+04	5.60E+03	2	5.27E+04	1.01E+05
ICP.a.Ni[2]	μg/g	2.42E+01	4.70E+00	2	3.98E+00	4.44E+01
ICP.a.P	μg/g	1.86E+04	1.53E+03	2	1.20E+04	2.52E+04
ICP.a.Pb	μg/g	2.32E+02	9.79E+01	2	0.00E+00	6.54E+02
ICP.a.S	μg/g	4.08E+03	3.45E+02	2	2.59E+03	5.56E+03
ICP.a.Sb[2]	μg/g	2.77E+01	5.98E+00	2	1.94E+00	5.34E+01
ICP.a.Se[2]	μg/g	4.91E+01	3.22E+01	2	0.00E+00	1.88E+02
ICP.a.Si[2]	μg/g	7.22E+02	1.85E+02	2	0.00E+00	1.52E+03
ICP.a.Sn	μg/g	7.93E+00	6.28E-01	2	5.22E+00	1.06E+01
ICP.a.Sr	μg/g	1.28E+02	2.16E+01	2	3.54E+01	2.21E+02
ICP.a.Ti[2]	μg/g	5.05E+00	3.34E-01	2	3.62E+00	6.49E+00
ICP.a.V	μg/g	6.18E+00	1.26E+00	2	7.49E-01	1.16E+01

Table B3-3. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (5 sheets)

Analyte	Units	μ	$\hat{\sigma}_{\mu}$	df	LL	UL
ICP.a.Zn[2]	μg/g	1.39E+02	4.11E+01	2	0.00E+00	3.16E+02
ICP.a.Zr	μg/g	4.15E+01	8.20E+00	2	6.26E+00	7.68E+01
ICP.f.Ag[2]	μg/g	4.97E+00	7.52E-03	2	4.94E+00	5.01E+00
ICP.f.Al	μg/g	1.43E+04	2.71E+02	2	1.32E+04	1.55E+04
ICP.f.As[2]	μg/g	1.49E+01	3.00E-02	2	1.48E+01	1.50E+01
ICP.f.B[2]	μg/g	1.44E+01	3.74E+00	2	0.00E+00	3.05E+01
ICP.f.Ba	μg/g	8.30E+00	5.29E-01	2	6.02E+00	1.06E+01
ICP.f.Be[2]	μg/g	1.49E+00	3.00E-03	2	1.48E+00	1.50E+00
ICP.f.Bi	μg/g	1.35E+04	6.92E+02	2	1.05E+04	1.65E+04
ICP.f.Ca[2]	μg/g	1.17E+03	4.14E+02	2	0.00E+00	2.95E+03
ICP.f.Cd	μg/g	5.20E+00	5.40E-01	2	2.88E+00	7.52E+00
ICP.f.Ce	μg/g	1.80E+02	1.53E+01	2	1.15E+02	2.46E+02
ICP.f.Co[2]	μg/g	6.28E+00	1.01E+00	2	1.91E+00	1.06E+01
ICP.f.Cr	μg/g	4.64E+02	2.10E+01	2	3.74E+02	5.55E+02
ICP.f.Cu[2]	μg/g	9.58E+01	4.03E+01	2	0.00E+00	2.69E+02
ICP.f.Fe	μg/g	1.07E+04	7.09E+02	2	7.67E+03	1.38E+04
ICP.f.La	μg/g	7.96E+00	1.15E-02	2	7.91E+00	8.00E+00
ICP.f.Mg	μg/g	1.51E+02	1.13E+01	2	1.03E+02	2.00E+02
ICP.f.Mn[2]	μg/g	5.30E+01	6.72E+00	2	2.40E+01	8.19E+01
ICP.f.Na	μg/g	8.28E+04	2.92E+03	2	7.03E+04	9.54E+04
ICP.f.Ni[2]	μg/g	6.40E+03	2.24E+03	2	0.00E+00	1.60E+04
ICP.f.P	μg/g	2.04E+04	1.08E+03	2	1.58E+04	2.51E+04
ICP.f.Pb	μg/g	2.58E+02	9.53E+01	2	0.00E+00	6.68E+02
ICP.f.S	μg/g	3.96E+03	4.20E+02	2	2.15E+03	5.77E+03
ICP.f.Sb[2]	μg/g	2.28E+02	4.29E+01	2	4.28E+01	4.12E+02
ICP.f.Se[2]	μg/g	8.57E+01	3.97E+01	2	0.00E+00	2.56E+02
ICP.f.Si	μg/g	7.16E+03	4.23E+02	2	5.34E+03	8.99E+03
ICP.f.Sn	μg/g	1.29E+01	1.39E+00	2	6.93E+00	1.89E+01
ICP.f.Sr	μg/g	1.30E+02	2.27E+01	2	3.26E+01	2.28E+02
ICP.f.Ti	μg/g	9.87E+00	1.59E+00	2	3.05E+00	1.67E+01
ICP.f.V[2]	μg/g	5.05E+00	7.76E-01	2	1.71E+00	8.39E+00
ICP.f.Zn[2]	μg/g	2.21E+02	2.79E+01	2	1.01E+02	3.42E+02
ICP.f.Zr	μg/g	1.72E+02	1.57E+01	2	1.04E+02	2.39E+02

Table B3-3. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (5 sheets)

Analyte	Units	$\bar{\mu}$	$\sigma_{\bar{\mu}}$	df	LL	UL
ICP.w.Ag[2]	μg/g	1.14E+00	2.72E-01	2	0.00E+00	2.31E+00
ICP.w.Al[2]	μg/g	1.21E+03	4.28E+02	2	0.00E+00	3.05E+03
ICP.w.As[2]	μg/g	3.79E+00	7.37E-01	2	6.20E-01	6.96E+00
ICP.w.B[2]	μg/g	2.49E+01	2.67E+00	2	1.34E+01	3.63E+01
ICP.w.Ba[2]	μg/g	8.73E-01	4.77E-01	2	0.00E+00	2.93E+00
ICP.w.Be[2]	μg/g	3.12E-01	9.21E-02	2	0.00E+00	7.08E-01
ICP.w.Bi	μg/g	7.07E+01	1.08E+01	2	2.43E+01	1.17E+02
ICP.w.Ca[2]	μg/g	1.48E+02	5.89E+01	2	0.00E+00	4.02E+02
ICP.w.Cd[2]	μg/g	8.04E-01	1.67E-01	2	8.55E-02	1.52E+00
ICP.w.Ce	μg/g	1.74E+01	6.92E+00	2	0.00E+00	4.71E+01
ICP.w.Co[2]	μg/g	1.26E+00	2.92E-01	2	0.00E+00	2.51E+00
ICP.w.Cr	μg/g	2.10E+02	4.94E+01	2	0.00E+00	4.23E+02
ICP.w.Cu[2]	μg/g	2.33E+00	1.53E+00	2	0.00E+00	8.92E+00
ICP.w.Fe	μg/g	6.17E+02	3.76E+02	2	0.00E+00	2.23E+03
ICP.w.K	μg/g	4.18E+02	8.32E+01	2	5.98E+01	7.76E+02
ICP.w.La	μg/g	2.11E+00	5.32E-01	2	0.00E+00	4.40E+00
ICP.w.Mg[2]	μg/g	1.54E+01	6.11E+00	2	0.00E+00	4.17E+01
ICP.w.Mn[2]	μg/g	2.08E+00	1.22E+00	2	0.00E+00	7.35E+00
ICP.w.Na	μg/g	6.62E+04	1.48E+04	2	2.40E+03	1.30E+05
ICP.w.Ni[2]	μg/g	2.82E+00	1.14E+00	2	0.00E+00	7.72E+00
ICP.w.P	μg/g	7.95E+03	2.85E+03	2	0.00E+00	2.02E+04
ICP.w.Pb[2]	μg/g	1.92E+01	1.17E+01	2	0.00E+00	6.94E+01
ICP.w.S	μg/g	3.60E+03	8.16E+02	2	9.37E+01	7.11E+03
ICP.w.Sb[2]	μg/g	3.95E+01	9.46E+00	2	0.00E+00	8.02E+01
ICP.w.Se[2]	μg/g	5.54E+01	1.69E+01	2	0.00E+00	1.28E+02
ICP.w.Si[2]	μg/g	2.40E+02	7.57E+01	2	0.00E+00	5.66E+02
ICP.w.Sn	μg/g	2.32E+00	3.06E-01	2	1.00E+00	3.63E+00
ICP.w.Sr	μg/g	5.54E+00	3.39E+00	2	0.00E+00	2.01E+01
ICP.w.Ti[2]	μg/g	6.32E-01	2.25E-01	2	0.00E+00	1.60E+00
ICP.w.V[2]	μg/g	1.09E+00	3.12E-01	2	0.00E+00	2.44E+00
ICP.w.Zn[2]	μg/g	1.13E+01	5.26E+00	2	0.00E+00	3.39E+01
ICP.w.Zr	μg/g	1.24E+01	7.06E+00	2	0.00E+00	4.28E+01
Nitrate	μg/g	1.10E+05	7.53E+03	2	7.76E+04	1.42E+05

Table B3-3. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (5 sheets)

Analyte	Units	μ	$\sigma_{\hat{\mu}}$	df	LL	UL
Nitrite	μg/g	6.89E+03	3.04E+03	2	0.00E+00	2.00E+04
Nitrite.Spec	μg/g	9.29E+03	2.57E+03	2	0.00E+00	2.03E+04
Phosphate	μg/g	2.82E+04	7.20E+03	2	0.00E+00	5.91E+04
Se(AA)	μg/g	9.14E-01	2.52E-01	2	0.00E+00	2.00E+00
Sulfate	μg/g	1.49E+04	2.99E+03	2	1.98E+03	2.78E+04
TIC	μg/g	2.10E+03	2.97E+02	2	8.19E+02	3.38E+03
TOC[1]*	μg/g	<6.76E+02	n/a	n/a	n/a	n/a
Uranium(LF:F)	μg/g	2.14E+03	8.71E+02	2	0.00E+00	5.89E+03
Alpha - ratio to Pu+Am	----	1.74E+00	2.66E-01	2	5.98E-01	2.88E+00
Beta - ratio to Cs+Sr	----	9.81E-01	1.36E-02	2	9.22E-01	1.04E+00

Notes:

= Percent water (percent solids method) was measured in cores 38 and 39 only; therefore, there is only one degree of freedom for the confidence interval.

* = wet basis

[1]More than 50 percent of the analytical results were less than values; therefore, confidence intervals were not computed.

[2]Some "less-than" values are in the analytical results.

B3.4.2 Analysis of Variance Models

A statistical model is needed to account for the spatial and measurement variability in $\sigma^2_{\hat{\mu}}$. This cannot be done using an ordinary variance of the data (Snedecor and Cochran 1980).

The statistical model fit to the composite sample data is

$$Y_{ijk} = \mu + S_i + C_{ij} + A_{ijk},$$

$$i=1,\ldots,a,\ j=1,\ldots,b_i,\ k=1,\ldots,n_{ij}$$

where

Y_{ijk}	=	laboratory results from the kth duplicate from the jth composite in the ith core in the tank
μ	=	the grand mean
S_i	=	the effect of the ith core
n_{ij}	=	the effect of the jth composite in the ith core
A_{ijk}	=	the effect of the kth analytical result from the jth composite in the ith core
a	=	the number of cores
b_i	=	the number of composites in the ith core
c_{ij}	=	the number of analytical results from the jth composite in the ith core.

The variables S_i and C_{ij} are assumed to be random effects. These variables and A_{ijk} are assumed to be uncorrelated and normally distributed with means zero and variances $\sigma^2(S)$, $\sigma^2(C)$, and $\sigma^2(A)$, respectively. Estimates of $\sigma^2(S)$, $\sigma^2(C)$, and $\sigma^2(A)$ were obtained using restricted maximum likelihood estimation techniques. This method, applied to variance component estimation, is described in Harville (1977). The statistical results were obtained using the statistical analysis package S-PLUS[2] (StatSci 1993).

[2]Trademark of Statistical Sciences, Inc., Seattle, Washington.

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APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

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APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

C1.0 STATISTICS FOR SAFETY SCREENING DQO

The safety screening DQO (Dukelow et al. 1995) defines acceptable decision confidence limits in terms of one-sided 95 percent confidence intervals. In this appendix, the results of calculating one-sided confidence limits supporting the safety screening DQO are reported for tank 241-C-110. All data in this section are from the final laboratory data package for the 1992 core sampling event for tank 241-C-110 (WHC 1992).

Confidence intervals were computed for each sample number from tank 241-C-110 analytical data. The sample numbers and confidence intervals are provided in Table C1-1 for alpha. No exotherms were observed in any segments, therefore, DSC confidence intervals were not calculated.

The upper limit (UL) of a one-sided 95 percent confidence interval on the mean is

$$\hat{\mu} + t_{(df,0.05)} * \hat{\sigma}_{\hat{\mu}}.$$

In this equation, $\hat{\mu}$ is the arithmetic mean of the data, $\hat{\sigma}_{\hat{\mu}}$ is the estimate of the standard deviation of the mean, and $t_{(df,0.05)}$ is the quantile from Student's t distribution with df degrees of freedom for a one-sided 95 percent confidence interval.

For the tank 241-C-110 data (per sample number), df equals the number of observations minus one.

The upper limit of the 95 percent confidence interval for each core composite sample based on alpha data is listed in Table C1-1. The maximum upper limit to a 95 percent CI on the mean for alpha was 0.16 percent μCi/g (core 37, composite #2). This is well below the threshold limit of 41.6 μCi/g. Therefore, criticality is not of concern for this tank.

Table C1-1. 95 Percent Confidence Interval Upper Limits for Alpha for Tank 241-C-110 (Units are μCi/g).

Sample Number	Sample Description	$\hat{\mu}$	$\hat{\sigma}_g$	UL
B08VP0	Core 37, core composite 1	1.36E-01	0.00E+00	1.36E-01
B08VP5	Core 37, core composite 2	1.41E-01	4.50E-03	1.69E-01
B08VG7	Core 38, core composite 1	1.26E-01	1.50E-03	1.35E-01
B08VJ9	Core 39, core composite 1	1.13E-01	8.50E-03	1.66E-01
B08VK5	Core 39, core composite 2	1.13E-01	6.00E-03	1.51E-01

C2.0 APPENDIX C REFERENCES

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS STANDARD INVENTORY FOR TANK 241-C-110

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR TANK 241-C-110

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 tank 241-C-110 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

The data for tank 241-C-110 (Kocher 1993) provide characterization results from the most recent sampling event for this tank. Three full-depth core samples were obtained in April 1992 from risers 2, 5, and 7. The sample-based inventory presented in this report uses the core sample analytical results. The sludge and supernatant volumes used to calculate the sample-based inventory are 681 kL and 27 kL (180 and 7 kgal), respectively, based on sample recoveries. The average densities for the sludge and supernatant used in this report are 1.45 g/mL and 1.09 g/mL, based on analytical data from the cores. Because of recent salt well pumping activities, the waste volume has now been reduced to 673 kL (178 kgal), including 4 kL (1 kgal) of supernatant. This small change in the relative volumes of sludge and supernatant has only a very small effect on the current inventory projections based on the 1992 sampling data. The HDW model (Agnew et al. 1997a) provides tank content estimates in terms of component concentrations and inventories. A projected inventory of waste components in tank 241-C-110 has been prepared from the process flow sheet, production records and waste volume records.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

Sample-based inventories derived from the analytical concentration data and HDW model inventories (Agnew et al. 1997a) are compared in Tables D2-1 and D2-2. Significant differences exist between the sample- and HDW model-based estimates for Al, Bi, Ca, CO_3, F, K, NO_3, NO_2, Si, SO_4, U, and Zr. Among the radionuclides, appreciable differences are apparent for ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$. The total waste volume used by both inventories is

708 kL (187 kgal); however, the HDW model (Agnew et al. 1997a) assumes the total waste volume in the tank is sludge. Radionuclides reported in Table D2-2 are mean values and have been decayed to January 1, 1994.

Table D2-1. Comparison of Sample-Based and Hanford Defined Waste Model Inventory Estimates for Nonradioactive Components in Tank 241-C-110.

Analyte	Sample-Based Inventory[1] (kg)	HDW Model-Based Inventory[2] (kg)
Al	14,322	11,400
Bi	16,600	9,230
Ca	1,136	2,160
Cl	1,116	776
CO_3	6,915	3,240
Cr	469	179
F	7,650	1,870
Fe	10,871	13,900
Hg	0.4	15
K	662	186
La	NR	0
Mn	56	0
Ni	24	49.7
OH	NR	48,900
NO_3	111,080	45,400
NO_2	7,378	7,680
Pb	255	0
PO_4	61,630	77,400
Si	7,073	4,450
Na	82,790	85,000
Sr	129	0
SO_4	15,309	3,540
U	1,470	34,300
Zr	170	15.4

Notes:

NR = not reported

[1]Appendix B
[2]Agnew et al. (1997a)

Table D2-2. Comparison of Sample-Based and Hanford Defined Waste Model Estimates for Radioactive Components in Tank 241-C-110 (Decayed to January 1, 1994).

Radionuclide	Sample-Based Inventory[1], Ci	HDW Model-Based Inventory[2], Ci
^{90}Sr	4.88E+03	5.39E+03
^{137}Cs	1.93E+04	6.07E+03
$^{239/240}Pu$	8.24E+01	12.6E+0

Notes:
[1]Appendix B
[2]Agnew et al. (1997a)

D3.0 COMPONENT INVENTORY EVALUATION

The following evaluation of tank contents is performed to identify potential errors and/or missing information that would influence the sample-based and HDW model component inventories.

D3.1 CONTRIBUTING WASTE TYPES

Based on waste transaction records (Agnew et al. 1997b) tank 241-C-110 received the following wastes:

1C	=	first cycle $BiPO_4$ waste
UR	=	uranium recovery
OWW1	=	PUREX organic wash waste
CSR	=	secondary cesium recovery waste from 241-BY-104 and 241-BX-104
OWW3	=	secondary PUREX organic wash waste

Tank 241-C-110 is first in a cascade series of three tanks with tanks 241-C-111 and 241-C-112. Tank 241-C-110 received 6,006 kL (1,587 kgal) of 1C waste from 1946 to 1947. From 1952 to 1953, and in 1956, tank 241-C-110 received 1,162 kL (307 kgal) of UR waste, of which 1,029 kL (272 kgal) of supernatant was later cribbed from tank 241-C-109. In 1956, 1,007 kL (266 kgal) of OWW1 waste was sent to tank 241-C-110. In 1970, tank 241-C-110 received 5,329 kL (1,408 kgal) of CSR waste from 241-BY-104 and 241-BX-104. In 1972, 606 kL (160 kgal) of OWW3 waste was sent to tank 241-C-110. More detailed transfer information can be found in Table A3-1 of Appendix A of this report.

The major waste types in this tank are 1C, UR, and OWW1. These waste types are wastes that were initially added directly to tank 241-C-110 and are known as primary wastes.

Secondary wastes, such as CSR and OWW3, were added to a different tank initially before being transferred. These waste types can usually be ignored because 80 to 90 percent of the solids in these wastes are likely to have already precipitated in one of the primary receiver tanks. In the 241-TY-105 and 241-TY-106 UR tank waste cascade, for example, about 81 percent of the Al, 87 percent of the Fe, 94 percent of the Na, and 97 percent of the PO_4 precipitate in the first tank of the cascade (241-TY-105) (Colton 1995).

D3.2 EVALUATION OF PROCESS FLOWSHEET INFORMATION

Based on process flowsheets, fuel production, and waste transaction records, a projected inventory estimate can be made for tank 241-C-110. This inventory is presented in Table D3-1. The following section discusses the primary waste types in this tank.

Table D3-1. Projected Inventory of 1C, UR and OWW1 Wastes in Tank 241-C-110. (2 sheets)

Analyte	1C Waste (Based on $BiPO_4$ Flowsheet) (kg/MTU)	1C Inventory[1] (kg)	UR Inventory[2] (kg)	OWW1 Inventory[3] (kg)	Projected Tank Inventory[4] (kg)
Al			126		126
Bi	36	15,552	26		15,578
Ce	0.4	173			173
Cr	2.4	1,037	8.7		1,046
F	48	20,736			20,736
Fe	26	11,232	1,376		12,608
Pb			26		26
Mn			10.7	221	232
Ni			5.6		6
NO_3	1,268	547,800	11,720	2,497	562,017
PO_4	361	155,950	7,668		163,618
Si	12	5,184	24.2		5,208
Na	1,268	279,100	7,592	3,937	290,629
SO_4	89	38,450			38,450
U			355	71.9	427
Zr	0.4	173			173

Table D3-1. Projected Inventory of 1C, UR and OWW1 Wastes in Tank 241-C-110. (2 sheets)

Notes:

[1]Estimated inventory of 1C waste based on 432 MTU of fuel. Projected inventory includes all soluble and semi-soluble F, Na, NO_3, PO_4, and SO_4 added to the tank.

[2]Estimated inventory of UR waste based the relative volumes of such waste added to 241-C-110 and 241-TY-105 and the measured sludge composition in 241-TY-105. This estimate includes all of the Na, NO_3, and PO_4 that precipitated in the tank but not the fraction that remained in the supernatant.

[3]Estimated inventory of OWW1 waste includes both soluble and insoluble components added to 241-C-110.

[4]Tank inventory based on 681.3 kL (180 kgal) of sludge with an average density of 1.45 g/mL and 26.5 kL (7 kgal) of supernatant with a density of 1.09 kg/L.

D3.2.1 Basis for Assessing 1C Waste Inventory in 241-C-110

According to the tank transaction records (Agnew et al. 1997b), 6,006 kL (1,587 kgal) of 1C waste was transferred to tank 241-C-110 from the second quarter of 1946 to the second quarter of 1947. Based on the fuel records from B Plant, this volume is equivalent to 432 MTU of 1C waste. Table D3-1 provides the expected composition profile of 1C waste, in kg/MTU, based on the $BiPO_4$ flowsheet, together with the estimated inventory of these components in the 241-C-110 1C waste.

D3.2.2 Basis for Assessing UR Waste Inventory in 241-C-110

The waste transaction records indicate that 1,162 kL (307 kgal) of UR waste was added to tank 241-C-110. The composition of this waste can be estimated from the known composition of UR waste in tank 241-TY-105, which received 23,600 kL (6,237 kgal) of such waste. This estimate can be generated by multiplying the volume of UR waste added to tank 241-C-110 divided by the volume added to tank 241-TY-105 multiplied by the composition of UR waste in tank 241-TY-105. The results are summarized in Table D3-1.

D3.2.3 Basis for Assessing OWW1 Waste Inventory in 241-C-110

About 1,007 kL (266 kgal) of OWW1 waste was added to tank 241-C-110 as well. The solvent used in PUREX was treated before reuse by washing with potassium permanganate and sodium carbonate, followed by dilute nitric acid and then a sodium carbonate wash (Anderson 1990).

D3.3 COMPARISON OF INVENTORY ESTIMATES

The projected inventories of key components, presented in Table D3-1, are compared with the sample-based and HDW model-based estimates for this tank in Table D3-2. Estimated inventories for the 1C, UR, and OWW1 components were added together to provide the projected inventory. The HDW model-based inventory estimate assumes all the waste to be 1C, and does not include any UR or OWW wastes that might have accumulated as well in tank 241-C-110.

Table D3-2. Comparison of Projected Inventory to Sample-Based and HDW Model-Based Inventory Estimates for Tank 241-C-110.

Analyte	Projected Inventory[1] (kg)	Sample-Based Inventory[2] (kg)	HDW Model-Based Inventory[3] (kg)
Al	126	14,322	11,400
Bi	15,578	16,600	9,230
Ce	173	NR	NR
Cr	1,046	469	179
F	20,736	7,650	1,870
Fe	12,608	10,871	13,900
Pb	26	255	0
Mn	232	56	0
Ni	6	24	49.7
NO_3	547,800	111,080	45,400
PO_4	155,950	61,630	77,400
Si	5,184	7,073	4,450
Na	279,100	89,860	85,000
SO_4	38,450	15,309	3,540
U	427	1,470	34,300
Zr	173	170	15

Notes:
[1]From Table D3-1
[2]From Table D2-1

The flowsheet- and common sludge layer-derived estimates are consistent with the sample-based estimates for Bi, Fe, Si and Zr. Although projected estimates for Cr and Mn are high and estimates for Pb, Ni and U low, these estimates are generally consistent with sample-based values for these components. Most of these components (except for Pb, Cr, and possibly U) are ones that would be expected to concentrate in the 1C, UR, and OWW1 sludge layers in tank 241-C-110. Based on the indicated matches, it appears that the

flowsheet- and common sludge layer-derived estimates support the credibility of the sample-based estimates. The HDW model-based estimates are generally inferior to core sample-derived estimates for this tank.

High Al concentrations in the core samples were apparently caused by atmospheric absorption of CO_2 and precipitation of Al from the supernatants routed through tank 241-C-110 (with secondary CSR waste being the likely source, because primary wastes added to tank 241-C-110 contained little Al). Soluble and semi-soluble components such as F, Na, NO_3, PO_4, and SO_4 readily distribute to the supernatant and only rarely can be used to identify the source of waste in the tank. The flowsheet estimates, however, are at least consistent, because the projected inventories of F, Na, NO_3, PO_4, and SO_4 are higher than their measured values in the 241-C-110 sludge.

Tank 241-C-110 has an estimated heat load of 3,188 Btu/hr (934 W) (Kummerer 1995). This heat load corresponds to 197,500 Ci of ^{137}Cs or 139,000 Ci of ^{90}Sr, values that are considerably higher than the sample-based estimates for this tank (19,300 Ci of ^{137}Cs and 4,880 Ci of ^{90}Sr). Sample-based values are equivalent to a heat load of 423 Btu/hr (123.8 W), only 13 percent of the estimated heat load based on a headspace temperature of 18.3 °C (64.9 °F) and a waste temperature of 18.4 °C)65.2 °F). Because the reliability of the tank thermal model has not been independently verified for this tank, it will be assumed for purposes of the standard inventory estimate that the sample-based estimates for ^{137}Cs and ^{90}Sr are correct.

Sample-based estimates for Bi, Fe, Si and Zr are in good agreement with the $BiPO_4$ flowsheet, common sludge layer estimates for UR waste, and the waste transaction records for tank 241-C-110. While flowsheet- and common sludge layer-derived estimates for Cr, Pb, Mn, Ni, and U are less satisfactory, these values are also generally consistent (within a factor of 2 to 4) with the core sample-based estimates for these components. Sample-based estimates for ^{137}Cs and ^{90}Sr are generally consistent with the thermal modeling results for this tank, although the analytical values are well below the concentrations that might be expected from the thermal model. Based on this comparison, the 1992 core samples appear to offer the most reasonable and consistent set of estimates currently available for this tank. These samples will be used to develop the best basis inventory for tank 241-C-110 because these samples are based on multiple samples from different risers, and in some cases replicate analysis of analytes.

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 assessments associated with waste management activities, as well as to address 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 suitable for long-term storage.

Chemical and radiological inventory information is generally derived using three approaches: 1) component inventories are estimated using results of sample analyses; 2) component inventories are estimated 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. Not surprisingly, the information derived from these different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as the standard characterization for various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of chemical information for tank 241-C-110 was performed that used:

1. Data from three full-depth core samples obtained in 1992 (Kocher 1993).

2. An inventory estimate generated by the HDW model (Agnew et al. 1997a).

3. An evaluation of 1C waste based on the $BiPO_4$ flowsheet, fuel records for B Plant and tank waste transactions for tank 241-C-110.

4. An analysis of UR sludge based on common sludge layers in tank 241-TY-105 and the waste transaction records for tanks 241-C-110 and 241-TY-105.

5. An analysis of the PUREX flowsheet and the composition of OWW1 waste, together with the waste transaction records for tank 241-C-110.

6. An evaluation of the estimated thermal loads provided by the sample-based inventories of ^{90}Sr and ^{137}Cs relative thermal modelling results for this tank.

Based on this analysis, a best-basis inventory was developed. The 1992 core sample results were used to generate estimates for the chemical and radionuclide components in this waste. The waste in tank 241-C-110 primarily consists of 1C waste, with small amounts of UR and OWW1 waste. The best-basis inventory estimates for tank 241-C-110 are presented in Tables D4-1 and D4-2.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-110.

Analyte	Total Inventory (kg)	Basis (S, M, E, or C)[1]	Comment
Al	14,322	S	
Bi	16,600	S	
Ca	1,136	S	
Cl	1,116	S	
CO_3	6,915	S	
Cr	469	S	
F	7,650	S	
Fe	10,871	S	
Hg	0.4	S	
K	662	S	
La	2	S	
Mn	56	S	
Na	82,790	S	
Ni	24	S	
NO_2	7,378	S	
NO_3	111,080	S	
OH	13,060	C	
Pb	255	S	
P as PO_4	61,630	S	
Si	7,073	S	
S as SO_4	15,310	S	
Sr	129	S	
TOC	7,480	S	
U_{TOTAL}	1,470	S	
Zr	170	S	

Notes:
[1]S = Sample-based (see Appendix B), M = HDW model-based (Agnew et al. 1997a), E = Engineering assessment-based, C = Based on charge balance

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-C-110 (decayed to January 1, 1994). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	1.09	S	
^{14}C	4.75E-01	S	
^{59}Ni	NR		
^{60}Co	<34.4	S	
^{63}Ni	NR		
^{79}Se	1.34	S	
^{90}Sr	4.88E+03	S	
^{90}Y	4.88E+03	E	Based on ^{90}Sr
^{93}Zr	NR		
^{93m}Nb	NR		
^{99}Tc	3.41E+01	S	
^{106}Ru	NR		
^{113m}Cd	NR		
^{125}Sb	NR		
^{126}Sn	NR		
^{129}I	<2.6E+01	S	
^{134}Cs	NR		
^{137}Cs	1.93E+04	S	
^{137m}Ba	1.73E+04	E	Based on ^{137}Cs
^{151}Sm	NR		
^{152}Eu	NR		
^{154}Eu	<1E+02	S	
^{155}Eu	<9.4E+01	S	
^{226}Ra	NR		
^{227}Ac	NR		
^{228}Ra	NR		
^{229}Th	NR		
^{231}Pa	NR		
^{232}Th	NR		

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-C-110 (decayed to January 1, 1994). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{232}U	NR		
^{233}U	NR		
^{234}U	NR		
^{235}U	NR		
^{236}U	NR		
^{237}Np	NR		
^{238}Pu	<5.1E+01	S	
^{238}U	5.1E-01	S	
^{239}Pu	8.24E+01	S	
^{240}Pu	NR		
^{241}Am	<2.9E+02	S	
^{241}Pu	NR		
^{242}Cm	NR		
^{242}Pu	NR		
^{243}Am	NR		
^{243}Cm	NR		
^{244}Cm	NR		

Notes:

[1]S = Sample-based (Appendix B), M = HDW model-based (Agnew et al. 1997a), E = Engineering assessment-based

D5.0 APPENDIX D REFERENCES

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

Agnew, S. F., P. Baca, R. A. Corbin, T. B. Duran, and K. A. Jurgensen, 1997b, *Waste Status and Transaction Record Summary*, LA-UR-97-311, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

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

Colton, N. G., 1995, *Sludge Pretreatment Chemistry Evaluation: Enhanced Sludge Washing Separation Factors*, PNL-10512, Pacific Northwest National Laboratory, Richland, Washington.

Hodgson, K. M., and M. D. LeClair, 1996, *Work Plan for Defining a Standard Inventory Estimate for Wastes Stored in Hanford Site Underground Tanks*, WHC-SD-WM-WP-311, Rev. 1, Lockheed Martin Hanford Corporation, Richland, Washington.

Kocher, K. L., 1993, *222-S Single-Shell Tank Waste Characterization, Tank C-110 Cores 37, 38, and 39*, WHC-SD-WM-DP-027, Rev. 0D, Westinghouse Hanford Company, Richland, Washington.

Kummerer, M., 1995, *Topical Report on Heat Removal Characterization of Waste Storage Tanks*, WHC-SD-WM-SARR-010, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

APPENDIX E

BIBLIOGRAPHY FOR TANK 241-C-110

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-C-110

Appendix E provides a bibliography of information that supports the characterization of tank 241-C-110. This bibliography represents an in-depth literature search of all known information sources that provide sampling, analysis, surveillance, and modeling information, as well as processing occurrences associated with tank 241-C-110 and its respective waste types.

The references in this bibliography are separated into three broad 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-C-110 Waste
- IIb. Sampling of Tanks with Similar Waste Type (1C)

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

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

This bibliography is broken down into the appropriate sections of material to use, with an annotation at the end of each reference describing the information source. Where possible, a reference is provided for information sources. A majority of the information listed below may be found in the Lockheed Martin Hanford Corporation 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/waste type information up 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/constraints are also given.

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

- Contains compositions of process stream waste before transfer to 200 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, 1995, *Waste Status and Transaction Record Summary for the Northeast Quadrant*, WHC-SD-WM-TI-615, Rev. 1, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Contains spreadsheets depicting all available data on tank additions/ transfers for the northeast quadrant.

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

- Document contains single-shell tank fill history and primary campaign/ waste type information up to 1981.

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 tank aerial view as well as a description of riser and its contents.

Lipnicki, J., 1996, *Waste Tank Risers Available for Sampling*, WHC-SD-WM-TI-710, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

- Lists tank risers and identifies risers available for sampling.

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 operability information and location of thermocouple trees in Hanford Site 200 Area underground waste tanks.

Id. Sample Planning/Tank Prioritization

Brown, T. M., T. J. Kunthara, and J. W. Hunt, 1996, *Tank Waste Characterization Basis*, WHC-SD-WM-TA-164, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

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

Grimes, G. W., 1977, *Hanford Long-Term Defense High-Level Waste Management Program Waste Sampling and Characterization Plan*, RHO-CD-137, Rockwell Hanford Operations, Richland, Washington.

- Contains plan for characterizing waste, short and long term goals, tank priority, analysis needs, estimates of analyte concentrations per waste type, and a characterization flowsheet.

Hill, J. G., W. I. Winters, B. C. Simpson, J. W. Buck, P. J. Chamberlain, and V. L. Hunter, 1991, *Waste Characterization Plan for the Hanford Site Single-Shell Tanks*, WHC-EP-0210, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

- Analytical plan for the 1992 core sampling of tank 241-C-110.

Winkelman, W. D., J. W. Hunt, and L. J. Fergestrom, 1996, *Fiscal Year 1997 Tank Waste Analysis Plan*, WHC-SD-WM-PLN-120, Rev. 1, Lockheed Martin Hanford Corporation, Richland, Washington.

- Document contains TPA requirement-driven TWRS Characterization program information and a list of tanks addressed in fiscal year 1997.

Deaton, D. E., 1990, <no subject>, (DSI[3] to R. S. Edrington, August 6), Westinghouse Hanford Company, Richland, Washington.

- Contains a list of analyses requests be run on liquid samples from tank 241-C-110.

Ie. Data Quality Objectives/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.

- Contains objectives to sample all tanks for safety concerns (ferrocyanide, organic, flammable gas, and criticality) as well as decision thresholds for energetics, criticality and flammability.

Edrington, R. S., 1994, *Waste Compatibility Assessment of Tank 241-C-102, Tank 241-C-107, and Tank 241-C-110 Waste To Be Pumped to CR-003 Vault*, (internal memorandum #7CF10-032-094 to R. Ni, September 28), Westinghouse Hanford Company, Richland, Washington.

- Contains a compatibility study of the wastes in tanks 241-C-102, 241-C-107, and 241-C-110 using sampling data.

Dodd, R. A., 1994, *Waste Compatibility Assessment of Tank 241-C-102, Tank 241-C-107, and Tank 241-C-110 Waste To Be Pumped to Tank 241-AY-101 via DCRT CR-003 Vault*, (internal memorandum #7CF10-062-094 to R. E. Raymond, November 22), Westinghouse Hanford Company, Richland, Washington.

- Contains a compatibility study of the wastes in tanks 241-C-102, 241-C-107, and 241-C-110 with the waste in tank 241-AY-101 using sampling data.

[3]"Don't Say It - Write It" memorandum

Osborne, J. W., J. L. Huckaby, T. P. Rudolph, E. R. Hewitt, D. D. Mahlum, J. Y. Young, and C. M. Anderson 1994, *Data Quality Objectives for Generic In-Tank Health and Safety Issue Resolution*, WHC-SD-WM-DQO-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains requirements to vapor sample and analyze tanks.

Vail, T. S., 1992, *Criticality Safety Evaluation For 102-BY, 102-C, 107-C, and 110-C*, (internal memorandum #7C240-92-053 to P. C. Doto, June 19), Westinghouse Hanford Company, Richland, Washington.

- Contains criticality evaluation based on sample analysis results.

II. ANALYTICAL DATA

IIa. Sampling of Tank 241-C-110 Waste

Wheeler, R. E., 1975, *Analysis of Tank Farm Samples, Sample: T-5491, Tank: 110-C, Received: June 19, 1975*, (internal memorandum <number unknown> to R. L. Walser, September 19), Atlantic Richfield Hanford Company Operations, Richland, Washington.

- Contains historical sample analysis results.

Starr, J. L., 1977, *Analysis of Tank 110-C Sludge*, (internal memorandum <number unknown> to J. W. Bailey, November 10), Rockwell Hanford Operations, Richland, Washington.

- Contains historical sludge sample analysis results.

Edrington, R. S., 1991, *BY and C Tank Farm Supernate Sample Analyses (Revision of 16220-PCL90-117)*, (internal memorandum #28110-PCL91-048 to R. K. Tranbarger, June 3), Westinghouse Hanford Company, Richland, Washington.

- Contains supernatant sample analysis results.

Edrington, R. S., 1991, *Cooling Curves For BY and C Tank Farm Liquid Samples*, (internal memorandum #28110-PCL91-014 to R. K. Tranbarger, February 15), Westinghouse Hanford Company, Richland, Washington.

- Contains cooling curve analyses on supernatant samples.

Keele, B. D., 1992, *The Radiological Characterization of BX-107 and C-110 Core segments as Received by the Laboratories*, (internal memorandum #12240-SAS92-059 to B. C. Simpson, August 11), Westinghouse Hanford Company, Richland, Washington.

- Contains in cask core sample GEA scan analysis results.

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Huckaby, J. L., and D. R. Bratzel, 1995, *Tank 241-C-110 Headspace Gas and Vapor Characterization Results For Samples Collected in August 1994*, WHC-SD-WM-ER-464, Rev. 1A, Westinghouse Hanford Company, Richland, Washington.

- Contains vapor sampling analysis results from August 18, 1994 vapor sampling of tank 241-C-110.

Bechtold, D. B., 1991, *Total Cyanide Results For Tank Farm Supernates*, (DSI to R. J. Cash, March 13), Westinghouse Hanford Company, Richland, Washington.

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Jensen, L., and K. M. Remund, 1994, *Statistical Characterization Report for Single-Shell Tank 241-C-110*, WHC-SD-WM-TI-585, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains a statistical evaluation of the tank core sample laboratory analysis results.

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IIb. Sampling of Tanks with Similar Waste Type (1C)

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- Contains information on 1C waste type.

Raphael, G. F., 1996, *Tank Characterization Report For Single-Shell Tank 241-BX-107*, WHC-SD-WM-ER-539, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

IIIa. Inventories from Campaign and Analytical Information

Agnew, S. F., J. Boyer, R. Corbin, T. Duran, J. FitzPatrick, K. Jurgensen, T. Ortiz, and B. Young, 1996, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 3*, LA-UR-96-858, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Contains waste type summaries, primary chemical compound/analyte and radionuclide estimates for sludge, supernatant, and solids, as well as SMM, TLM, and individual tank inventory estimates.

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

- Contains major components for waste types, and some assumptions.

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

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Kupfer, M. J., 1996, *Interim Report: Best Basis Total Chemical and Radionuclide Inventories in Hanford Site Tank Waste*, WHC-SD-WM-TI-740, Rev. B-Draft, Westinghouse Hanford Company, Richland, Washington.

- Contains a global component inventory for 200 Area waste tanks; 14 chemical and 2 radionuclide components are currently inventoried.

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

- Contains a global inventory based on process knowledge and radioactive decay estimations using ORIGEN2. Pu and U waste contributions are taken at 1 percent of the amount used in processes. Also compares information on Tc-99 from both ORIGEN2 and analytical data.

IIIb. Compendium of Data from Other Sources Physical and Chemical

Agnew, S. F., John G. Watkin, 1994, *Estimation of Limiting Solubilities for Ionic Species in Hanford Waste Tank Supernates*, LA-UR-94-3590, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Gives solubility ranges used for key chemical and radionuclide components based on supernatant sample analyses.

Brevick, C. H., R. L. Newell, and J. W. Funk, 1996, *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 Areas*, WHC-SD-WM-ER-349, Rev. 1A, Westinghouse Hanford Company, Richland, Washington.

- Contains summary information from the supporting documents for Tank Farms A, AX, B, BX, BY, and C, as well as in-tank photo collages and the historical inventory estimates.

Brevick, C.H., J. L. Stroup, and J. W. Funk, 1996, *Supporting Document for the Historical Tank Content Estimate for C Tank Farm*, WHC-SD-WM-ER-320, Rev. 1B, Westinghouse Hanford Company, Richland, Washington.

- Contains summary tank farm and tank write-ups on historical data and solid inventory estimates as well as appendixes for the data. The appendixes contain the following information: App. C - Level History

AutoCAD sketch; App. D - Temperature Graphs; App. E - Surface Level Graph; App. F - Riser Configuration Drawing and Table; and App. 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.

- 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., 1997, *Waste Summary Report for Month Ending February 28, 1997*, HNF-EP-0182-107, Lockheed Martin Hanford Corporation, Richland, Washington.

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

Husa, E. I., R. E. Raymond, R. K. Welty, S. M. Griffith, B. M. Hanlon, R. R. Rios, and N. J. Vermeulen, 1993, *Hanford Site Waste Storage Tank Information Notebook*, WHC-EP-0625, Westinghouse Hanford Company, Richland, Washington.

- Contains in-tank photos as well as summaries of the tank description, tank leak detection system, and tank status.

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

- Gives assessment of relative dryness between tanks.

Hartley, S. A., G. Chen, C. A. LoPresti, T. M. Liebetrau, K. M. Remund, S. A. Allen, and B. C. Simpson, 1996, *A Comparison of Historical Tank Content Estimate (HTCE) Model, Rev. 3, and Sample-Based Estimates of Hanford Waste Contents*, PNNL-11429, Pacific Northwest National Laboratory, Richland, Washington.

- Contains a statistical evaluation of the HDW inventory estimate against analytical values from existing TCR reports using a select component data set.

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

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

Shelton, L. W., 1995, *Chemical and Radionuclide Inventory for Single and Double Shell tanks*, (internal memorandum #75520-95-007 to R. M. Orme, August 8), Westinghouse Hanford Company, Richland, Washington.

- Contains a tank inventory estimate based on analytical information.

Shelton, L. W., 1995, *Radionuclide Inventories for Single and Double Shell Tanks*, (internal memorandum #71320-95-002 to F. M. Cooney, February 14), Westinghouse Hanford Company, Richland, Washington.

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- Contains an tank inventory estimate based on analytical information.

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

- Contains selected sample analysis tables before 1993 for single-shell tanks.

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Project Title/Work Order		EDT No. N/A
Tank Characterization Report for Single-Shell Tank 241-C-110, HNF-SD-WM-ER-367, Rev. 1		ECN No. ECN-635468

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
ONSITE					
Department of Energy - Richland Operations					
J. F. Thompson	S7-54	X			
W. S. Liou	S7-54	X			
J. A. Poppiti	S7-54	X			
N. W. Willis	S7-54	X			
DE&S Hanford, Inc.					
R. J. Cash	S7-14	X			
W. L. Cowley	R2-54	X			
G. L. Dunford	A2-34	X			
G. D. Johnson	S7-14	X			
J. E. Meacham	S7-14	X			
Fluor Daniel Northwest					
J. L. Stroup	S3-09	X			
Lockheed Martin Hanford, Corp.					
C. J. Benar	R2-12	X			
K. M. Hodgson	H0-34	X			
T. J. Kelley	S7-21	X			
L. M. Sasaki	R2-12	X			
B. C. Simpson	R2-12	X			
L. R. Webb	R2-12	X			
ERC (Environmental Resource Center)	R1-51	X			
T.C.S.R.C.	R1-10	5			
Lockheed Martin Services, Inc.					
B. G. Lauzon	R1-08	X			
Central Files	A3-88	X			
EDMC	H6-08	X			
Numatec Hanford Corporation					
J. S. Garfield	H5-49	X			
J. S. Hertzel	H5-61	X			
D. L. Lamberd	H5-61	X			
Pacific Northwest National Laboratory					
A. F. Noonan	K9-91	X			
Rust Federal Services of Hanford, Inc.					
C. T. Narquis	T6-16	X			