ENGINEERING CHANGE NOTICE

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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	[ ]
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Procurement Spec.	[ ]	Operating Instruction	[ ]	Computer Software	[ ]
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Tank Characterization Report for Single-Shell Tank 241-U-110

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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-U-110. This report supports the requirements of the Tri-Party Agreement Milestone M-44-05.

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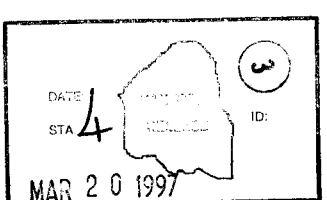

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Tank Characterization Report for Single-Shell Tank 241-U-110

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LIST OF TERMS

1C1	first-cycle decontamination waste (1944-1949)
AAS	atomic absorption spectroscopy
ANOVA	analysis of variance
Btu/hr	British thermal units per hour
cal/g	calories per gram
Ci	curies
Ci/L	curies per liter
CL	confidence limit
cm	centimeter
CW	aluminum cladding waste
CWR1	cladding waste from REDOX plant
DL	drainable liquid
DOE	U.S. Department of Energy
DQO	data quality objectives
DSC	differential scanning calorimetry
EPA	Washington State Department of Ecology
ft	feet
g	gram
GEA	gamma energy analysis
g/L	grams per liter
g/mL	grams per milliliter
g/mole	gram-mole
HDW	Hanford defined waste
HHF	hydrostatic head fluid
HTCE	historical tank content estimate
IC	ion chromatography
ICP	inductively coupled plasma spectroscopy
in.	inch
ISE	ion-specific electrode analysis
J/g	joules per gram
kg	kilogram
kgal	kilogallon
kL	kiloliter
LANL	Los Alamos National Laboratory
lbs/in.^{2}	pounds per square inch
LFL	lower flammability limit
LSC	liquid scintillation counting
LW	laboratory waste

LIST OF TERMS (Continued)

m	meter
M	moles per liter
MD	microdistillation
meq	milliequivalent
mL	milliliter
mm	millimeter
mcal/sec/g	millicalories per second per gram
mR/hr	millirem per hour
MT	metric ton
MW	metal waste
n/a	not applicable
NA	not available
NPH	normal paraffin hydrocarbons
NR	not reported
PHMC	Project Hanford Management Contractor
ppmv	parts per million volume
PNNL	Pacific Northwest National Laboratory
PUREX	plutonium-uranium extraction
QC	quality control
RA	radiological analysis
R1	REDOX concentrated waste (1952-1957)
RCOND	REDOX condensate from self-evaporation
RCRA	*Resource Conservation and Recovery Act of 1976*
RCW	REDOX process aluminum cladding waste
REDOX	reduction-oxidation
RIDS	records inventory and disposition schedule
RPD	relative percent difference
RSD	relative standard deviation
SACS	surveillance analysis computer systems
SMM	supernatant mixing model
SU	supernatant
TC	total carbon
TCD	tank characterization database
TCR	tank characterization report
TGA	thermogravimetric analysis
TIC	total inorganic carbon
TLM	tank layer model
TMACS	Tank Monitoring and Control System
TOC	total organic carbon
TWRS	Tank Waste Remediation System

LIST OF TERMS (Continued)

UA	untreated analysis
UL	upper limit
W	watts
WSTRS	waste status and transaction record summary
wt%	weight percent
°C	degrees Celsius
°F	degrees Fahrenheit
μCi/g	microcuries per gram
μCi/L	microcuries per liter
μg Bi/g	micrograms bismuth per gram
μg Bi/mL	micrograms bismuth per milliliter
μg/g	micrograms per gram
μg C/g	micrograms of carbon per gram
μm	micrometers
μg/mL	micrograms per milliliter
μg Si/g	micrograms silicon per gram
μg Si/mL	micrograms silicon per milliliter

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 appendices serve as the TCR for single-shell tank 241-U-110. The objectives of this report are: 1) to use characterization data in response to technical issues associated with 241-U-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 appendices. This report also supports the requirements of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996) milestone M-44-03.

1.1 SCOPE

Characterization information presented in this report originated from sample analyses and known historical sources. While only the results of recent sample events will be compared to the requirements of the safety screening data quality objective (DQO), other information can be used to support (or question) conclusions derived from these results. Historical information for tank 241-U-110, provided in Appendix A, includes 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 prior to 1989, are summarized in Appendix B along with the sampling results. The results of the 1989 core sampling events, also reported in the laboratory data packages (Winters 1993), satisfied the data requirements specified in the waste characterization plan for this tank (Winters et al. 1989). 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. A bibliography that resulted from an in-depth literature search of all known information sources applicable to tank 241-U-110 and its respective waste types is contained in Appendix E.

Table 1-1. Summary of Recent Sampling[1].

Sample/Date[2]	Phase	Location	Segment Recovery (range)
Vapor sample (3/19/96)	Gas	Tank headspace	n/a
Core 5 (9/19/89-11/7/89)	Solid	Riser 19	0-85 percent
Core 6 (11/13/89-11/14/89)	Solid	Riser 17	0-70 percent
Core 7 (11/15/89-11/16/89)	Solid	Riser 7	30-80 percent
Core 8 (11/17/89)	Solid	Riser 7	0-100 percent
Core 12 (11/29/89)	Solid	Riser 2	0-65 percent
Core 13 (11/30/89)	Solid	Riser 2	15-80 percent
Core 14 (12/3/89)	Solid	Riser 9	80-100 percent
Core 15 (12/4/89-12/6/89)	Solid	Riser 8	15-85 percent

Notes:

n/a = Not applicable

[1]Winters (1993)

[2]Dates in mm/dd/yy format

1.2 TANK BACKGROUND

Tank 241-U-110 is located in the 200 West Area U Tank Farm on the Hanford Site. It is the first tank in a three-tank cascade series. The tank went into service in 1946 when it received first-cycle decontamination waste (1C1). The tank began receiving metal waste (MW) in 1948. Throughout 1954, reduction-oxidation (REDOX) concentrated waste (R1) was sent to the tank, and from 1955-1957, it received cladding waste (CWR1) from the REDOX plant. In 1956, supernatant was transferred to a number of other tanks. Tank 241-U-110 was idle until 1969, when additional supernatant was transferred out. From 1972 until mid-1975, the tank received small amounts of laboratory waste from the 222-S Laboratory and the Pacific Northwest National Laboratory (PNNL), and supernatant was transferred out to various tanks (Agnew et al. 1996a).

A description of tank 241-U-110 is summarized in Table 1-2. The tank has an operating capacity of 2,010 kL (530 kgal), and presently contains an estimated 704 kL (186 kgal) of non-complexed waste (Hanlon 1996). The tank is not on any Watch Lists (Public Law 101-510). It is an assumed leaker and interium stabilization was completed in 1984.

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

TANK DESCRIPTION	
Type	Single-shell
Constructed	1943-1944
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	Non-complexed
Total waste volume[1]	704 kL (186 kgal)
Supernatant volume	0 kL (0 kgal)
Saltcake volume	0 kL (0 kgal)
Sludge volume	704 kL (186 kgal)
Drainable interstitial liquid volume	57 kL (15 kgal)
Waste surface level (October 7, 1996)	192 cm (75.5 in.)
Temperature (July 1987 to October 1996)	17.8 °C (64.0 °F) to 32.2 °C (90.0 °F)
Integrity	Assumed leaker
Watch List	None
SAMPLING DATES	
Vapor sample	March 1996
Core samples	September-December 1989
Historical sampling	August 1974 and October 1975
SERVICE STATUS	
Declared inactive	1975
Primary stabilization	1978
Partially isolated	1982
Interim stabilization	1984

Note:

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

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2.0 RESPONSE TO TECHNICAL ISSUES

The following technical issues have been identified for tank 241-U-110. They are:

- **Safety screening**: Does the waste pose or contribute to any recognized potential safety problems?

- **Vapor screening**: 1) Does the tank headspace exceed 25 percent of the lower flammability limit (LFL), and if so, what are the principal fuel components? 2) Is there an organic solvent pool in excess of 1 m^2 (10.8 ft^2) in area that may cause an organic solvent pool fire or ignition of organic solvents entrained in the waste?

The 1989 sampling event predates the safety screening DQO. However, the analytical results from this sampling event, the tank headspace flammability measurements obtained in 1996, and the results of the historical sludge sampling event in 1974 can provide useful information in response to the safety issue. This response is detailed in the following sections. The tank has not been sampled to address the organic solvent pool issue. See Appendix B for sample and analysis data for tank 241-U-110.

2.1 SAFETY AND ORGANIC SOLVENT SCREENING

The data needed to screen the waste in tank 241-U-110 for potential safety problems are documented in *Tank Safety Screening Data Quality Objective*, Rev. 2 (Dukelow et al. 1995) and in *Scope Increase of Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue* (Cash 1996). These potential safety problems are: exothermic conditions in the waste; flammable gases in the waste and/or tank headspace; and criticality conditions in the waste. Each of these conditions is addressed separately below. In addition, organic solvent screening requirements as required in DOE (1996) have been added to all passively ventilated tanks per Cash (1996). Cash (1996) requires that tank 241-U-110 be vapor sampled for total non-methane hydrocarbons as part of the organic DQO (Turner et al. 1995). The safety screening DQO was the only DQO applied to the available data.

In addition to the analytical requirements, the safety screening DQO also specifies sampling conditions that must be met for a proper safety assessment. Two full vertical profiles of the waste from at least two widely spaced risers are required. The 1989 core samples were removed from four widely spaced locations within tank 241-U-110. In general, the sample recovery from the first two of the four segments in a given core was poor. A full vertical profile of the waste was obtained from core 14, and a second vertical profile may be obtained by choosing segments from the remaining seven core samples.

2.1.1 Exothermic Conditions (Energetics)

The first requirement outlined in the safety screening DQO is to ensure that not enough exothermic constituents (organic or ferrocyanide) are present in tank 241-U-110 to pose a safety hazard. Because of this requirement, energetics in the tank waste were evaluated. The safety screening DQO required that the waste sample profile be tested for energetics every 24 cm (9.5 in.) to determine if the energetics exceed the safety threshold limit of 480 J/g on a dry weight basis. Results obtained using differential scanning calorimetry (DSC) indicated that no exotherms were apparent for any of the 1989 core samples (Winters 1993) or from the historical supernatant results (see Appendix B).

Note that the core samples were not subdivided into subsegments. Thus, the requirement of testing energetics for every 24 cm (9.5 in.) of the sample profile was not met for a given core sample. However, each of the four segments are represented in at least three of the core samples obtained.

Historically, there is no evidence that any exothermic agent should exist in this waste. Waste transfer records indicate that the major waste type expected to be in the tank is first-cycle decontamination waste (1C1), along with a small amount of metal waste, both from the bismuth phosphate process (Agnew et al. 1996a). Neither of these waste types is expected to have organic or ferrocyanide constituents.

2.1.2 Flammable Gas

Vapor phase measurements were taken in the tank headspace on March 19, 1996. The results indicated that the flammable gas was 2 percent of the LFL, well below the safety screening DQO threshold of 25 percent of the LFL. Data from these vapor phase measurements are presented in Appendix B.

2.1.3 Criticality

The safety threshold limit is 1 g ^{239}Pu per liter of waste. Assuming that all alpha is from ^{239}Pu and assuming a density of 1.46 g/mL (from Section D2.0), 1 g/L of ^{239}Pu is equivalent to 42.1 μCi/g of alpha activity. Waste samples were tested for total alpha activity at the segment level and composite level. Concentrations in all samples were well below this limit, with the highest sample mean being 2.84 μCi/g, from segment 3 of core 7. Also, the highest upper limit of the one-sided 95 percent confidence interval on the mean for the segment sample data set was 4.99 μCi/g (Table C1-1).

As with the DSC analyses, the requirement of analyzing for total alpha activity every 24 cm (9.5 in.) of the sample profile was not met for a given core sample. However, each of the four segments is represented in at least three of the core samples obtained.

2.2 OTHER TECHNICAL ISSUES

2.2.1 Analytical Data Quality

Upon completion of the analytical work, the data packages were validated against the *Resource Conservation and Recovery Act of 1976* (RCRA) criteria per *Sample Management and Administration* (WHC 1991). Much of the data was rejected or considered as approximate because of quality control (QC) issues such as violation of holding time requirements or QC data not being reported. The results of data validation are available in each segment data package (Winters 1993) and are briefly summarized in Section B. The data validation section in the respective data package should be consulted before the data reported in this document are used.

2.2.2 Heat Generation

Other factors in assessing tank safety are waste heat generation and waste temperature. Heat is generated in the tanks from radioactive decay. Using the four major radionuclides from Table 3-2, the estimated tank heat load based on the 1989 sampling event was 2,700 W (9,220 Btu/hr), as shown in Table 2-1. The heat load estimate based on the tank process history was 40.3 W (138 Btu/hr) (Agnew et al. 1996a), whereas the heat load estimate based on the tank headspace temperature was 1,310 W (4,485 Btu/hr) (Kummerer 1995). All of these estimates are well below the limit of 11,700 W (40,000 Btu/hr) that separates high- and low-heat-load tanks (Smith 1986).

Table 2-1. Tank 241-U-110 Projected Heat Load.

Radionuclide	Curies (Ci)	Watts
^{241}Am	90	2.95
^{137}Cs	29,000	137
$^{239/240}Pu$	260	7.93
^{90}Sr	380,000	2,550
Total		2,700

2.3 SUMMARY

Not all of the 1989 core sampling results were performed to the specific requirements of the safety screening DQO, because they predate the document. Nevertheless, the results from all analyses performed to address potential safety issues showed that no primary analyte exceeded safety decision threshold limits. Although the sample recovery was less than satisfactory for most cores, none of the waste types expected to be present in the tank have exothermic constituents, and thus do not represent a safety hazard. The analyses results are summarized in Table 2-2.

Table 2-2. Summary of Safety Screening and Historical Evaluation Results.

Issue	Sub-issue	Result
Safety screening	Energetics	No exotherms observed in any sample.
	Flammable gas	Vapor measurement reported 2 percent of lower flammability limit. (Combustible gas meter).
	Criticality	All analyses well below the 42.1 μCi/g total alpha activity threshold.

3.0 BEST-BASIS INVENTORY ESTIMATE

Information about the chemical and/or physical properties of tank wastes 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 the wastes into a form that is suitable for long-term storage. Chemical inventory information generally is derived using two approaches: 1) component inventories are estimated using the results of sample analyses; and 2) component inventories are predicted using a model based on process knowledge and historical information. The model was developed by Los Alamos National Laboratory (LANL) (Agnew et al. 1996b). Information derived from these two different approaches is often inconsistent.

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

- Data from the analyses of seven core samples collected in late 1989
- The solids composite inventory estimate for this tank generated from the Hanford defined waste (HDW) model (Agnew et al. 1996b).

Results from this evaluation, detailed in Appendix D, support using the sampling data as the basis for the best estimate inventory for tank 241-U-110 for the following reasons:

1. Data from seven core composite samples were used to estimate the component inventories. The core sample recovery was incomplete; however, assuming the core and segment samples that were recovered represent a random sample from tank 241-U-110, the concentration estimates are unbiased estimates of true unknown mean concentrations.

2. Results from this evaluation indicate that some of the assumptions governing the HDW model inventory are questionable. These assumptions include the following:

   - Only 1C1 contributed to the waste composition
   - Corrosion source terms for Fe and Cr that are based on PUREX-related data are applicable to 1C1 waste
   - The starting nitrate concentration in the 1C1 waste stream was 0.5M.

The best-basis inventory estimates are provided in Tables 3-1 and 3-2. Note that Bi and Si inventories are flagged as being potentially too large; however, no adjustments to these inventories are being made at this time.

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

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]	Comment
Bi	21,000	S	Potentially too large.
Cl	1,000	S	Based on analysis of water leach only.
TIC as CO_3^{2-}	4,500		Based on analysis of water leach only.
F	7,200	S	Based on analysis of water leach only.
Hg	3	S	Method/sample prep: AAS/Acid (Brown and Jensen 1993).
K	78	M	No sample basis available
La	0	M	No sample basis available
NO_2^-	9,400	S	Based on analysis of water leach only.
NO_3^-	46,000	S	Based on analysis of water leach only.
OH^-	46,000	M	No sample basis available
Si	23,000	S	Potentially too large.
TOC	980	S	Based on analysis of water leach only.

Notes:

AAS = Atomic absorption spectroscopy
TIC = Total inorganic carbon
TOC = Total organic carbon

[1]S = Sample-based. See Appendix B
M = HDW model-based
E = Engineering assessment-based

Table 3-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-U-110[1].

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[2]	Comment
^{14}C	0.35	S	Based on analysis of water leach only.
^{90}Sr	350,000	S	
^{90}Y	350,000	S	Referenced to ^{90}Sr
^{99}Tc	7.3	S	Based on analysis of water leach only.
^{137}Cs	26,000	S	
^{137m}Ba	25,000	S	Referenced to ^{137}Cs
$^{239/240}Pu$	260	S	
^{241}Am	89	S	

Notes:

[1]Curie values decayed to January 1, 1994.

[2]S = Sample-based. See Appendix B
M = HDW model-based
E = Engineering assessment-based
NR = Not reported

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4.0 RECOMMENDATIONS

As discussed in Section 2, the sampling and analysis of the 1989 core samples predated the application of the DQO process to tank waste characterization. Nevertheless, the data were evaluated against the decision criteria thresholds specified in the safety screening DQO and Cash (1996) for informational purposes. There was no evidence of an exothermic reaction in any of the DSC runs performed on each recovered segment, and all total alpha activity results were well below the criticality notification limit at the one-sided 95 percent upper confidence limit on the mean. Screening of the tank headspace revealed that its flammability was far below the safety screening threshold of 25 percent of the LFL. Therefore, the tank is classified as "safe" despite the fact that the DSC and total alpha analyses were not performed at the half-segment level, and that only one complete vertical profile was obtained from one core. Vapor sampling for organic solvent screening or for industrial hygiene purposes has not been performed. In addition to the safety evaluation, a characterization best-basis inventory was developed for the tank contents.

Table 4-1 summarizes the status of Project Hanford Management Contractor (PHMC) Program review and acceptance of the sampling and analysis results reported in this TCR. All DQO issues required to be addressed by sampling and analysis are listed in column one of Table 4-1. The second column indicates whether the requirements of the DQO were met by the sampling and analysis activities performed and is answered with a "yes" or a "no." The third column indicates concurrence and acceptance by the program in PHMC that is responsible for the DQO that the sampling and analysis activities performed adequately meet the needs of the DQO. A "Yes" or "No" in column three indicates acceptance or disapproval of the sampling and analysis information presented in the TCR. If the results/information have not yet been reviewed, that is stated in the column. If the results/information have been reviewed, but acceptance or disapproval has not been decided, "N/D" is shown in the column.

Table 4-1. Tank 241-U-110 Sampling and Analysis Performed.

Issue	Sampling and Analysis Performed	PHMC TWRS Program Acceptance
Safety screening DQO	Yes	Yes
Organic solvent screening	No	No

Table 4-2 summarizes the status of PHMC Program review and acceptance of the evaluations and other characterization information contained in this report. The evaluation specifically outlined in this report is to determine whether the tank is safe, conditionally safe, or unsafe. The format and manner in which concurrence and acceptance are summarized is the same as that in Table 4-1. The safety categorization of the tank is listed as safe in Table 4-2 due to the lack of observable energetics and the low amount of alpha activity found in eight core samples, and the low level of combustible gas found in the tank headspace.

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

Issue	Evaluation Performed	PHMC TWRS Program Acceptance
Safety categorization (tank is safe)	Yes	Yes

Additional vapor sampling of tank 241-U-108 is recommended in order to perform the organic solvent screening evaluation.

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APPENDIX A

HISTORICAL TANK INFORMATION

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APPENDIX A

HISTORICAL TANK INFORMATION

Appendix A describes tank 241-U-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 often useful for supporting or challenging conclusions based on sampling and analysis.

This appendix contains the following information:

- **Section A1**: Current status of the tank, including the current waste levels as well as the stabilization and isolation status of the tank.
- **Section A2**: Information about the design of the tank.
- **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-U-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 prior to 1989) are included in Appendix B, Section B2-9.

A1.0 CURRENT TANK STATUS

As of September 30, 1996, tank 241-U-110 contained 704 kL (186 kgal) of non-complexed waste (Hanlon 1996). The total tank volume was determined using an ENRAF[1] surface-level gauge. Table A1-1 shows the volumes of the various waste phases in the tank.

Tank 241-U-110 is passively ventilated, and all monitoring systems were in compliance with documented standards as of September 30, 1996 (Hanlon 1996). Tank 241-U-110 is not on a Watch List (Public Law 101-510). However, it was designated an assumed leaker and removed from service in 1975 (Brevick et al. 1994). It was partially isolated in December 1982 and administratively interim stabilized in December 1984.

[1]Trademark of ENRAF Corporation, Houston, Texas.

Table A1-1. Estimated Tank Contents.[1]

Waste Form	Estimated Volume	
	kL	kgal
Total waste	704	186
Supernatant liquid	0	0
Sludge	704	186
Saltcake	0	0
Drainable interstitial liquid	57	15
Drainable liquid remaining	57	15
Pumpable liquid remaining	34	9

Note:

[1]For definitions and calculation methods, refer to Appendix C of Hanlon (1996).

A2.0 TANK DESIGN AND BACKGROUND

The 241-U Tank Farm was constructed during 1943 and 1944 in the 200 West Area. The farm contains twelve 100 series tanks, including tank 241-U-110, and four 200 series tanks. The 100 series tanks have a capacity of 2,010 kL (530 kgal), a diameter of 22.9 m (75.0 ft), and an operating depth of 5.2 m (17 ft) (Leach and Stahl 1996). The 241-U Tank Farm was designed for nonboiling waste with a maximum fluid temperature of 104 °C (220 °F). A cascade overflow line 75 mm (3 in.) in diameter connects tank 241-U-110 as first in a cascade series of three tanks ending with tanks 241-U-111 and 241-U-112. Each tank in the cascade series is set one foot lower in elevation from the preceding tank. The cascade overflow height is approximately 4.9 m (16 ft) from the tank bottom and 600 mm (2 ft) below the top of the steel liner.

Tank 241-U-110 has a dished bottom with a 1.2-m (4-ft) radius knuckle. It was designed with a primary mild steel liner and a concrete dome with various risers. The tank is set on a reinforced concrete foundation. The tank and foundation were waterproofed by a coating of tar covered by a three-ply, asphalt impregnated, waterproofing fabric. The waterproofing was protected by welded-wire-reinforced gunite. Two coats of primer were sprayed on all exposed interior tank surfaces (Rogers and Daniels 1944). The tank ceiling dome was covered with three applications of magnesium zinc fluorosilicate wash. Lead flashing was

used to protect the joint where the steel liner meets the concrete dome. Asbestos gaskets were used to seal the risers in the tank dome. This tank was covered with approximately 2.1 m (7 ft) of overburden.

Tank 241-U-110 has 12 risers according to the drawings and engineering change notices. The risers are either 100 mm (4 in.) or 300 mm (12 in.) in diameter. Table A2-1 shows numbers, diameters, and descriptions of the risers and the nozzles. A plan view that depicts the riser configuration is shown as Figure A2-1. A tank cross-section showing the approximate waste level along with a schematic of the tank equipment is in Figure A2-2.

Instrument access to tank 241-U-110 is through risers fitted into the tank dome. The surface level is measured with an ENRAF™ gauge in riser 8. The waste inlet to the tank consisted of horizontal pipes intruding through the tank wall. The outlet of waste from tank 241-U-110 occurred through three distinct mechanisms. The first was the cascade overflow nozzle connecting it with tank 241-U-111. This was the primary mechanism of waste outlet until 1956 when cascading was stopped in the 241-U-110 to 241-U-112 series of tanks. The second outlet mechanism was via pumps inserted through risers. Because of the size of the pumps used, only the 30.1-cm (12-in.)-diameter risers (risers 2, 3, 6, and 7) could be used for this method. This process continued throughout the history of tank 241-U-110. The final method of removing waste, made possible in the mid-1970's, was the use of a salt well pump. This pump was located at riser 13.

In July 1975, a leak in tank 241-U-110 was determined to be the cause of slow liquid-level drops in the tank accompanied by a slow increase in radioactivity levels in one of the monitoring dry wells. The leak was confirmed in September 1975 and a salt well pump was installed in the tank (Hanlon 1996). Based on the monitoring performed since the leak occurred, an estimated 18.9 to 22.7 kL (5.0 to 6.0 kgal) of liquid waste leaked into the ground. The leakage contained an estimated 42 to 50 Ci of ^{137}Cs and 15 to 18 Ci of ^{90}Sr (Burton 1975). A leak estimate updated in 1986 indicated that up to 30.7 kL (8.1 kgal) may have leaked (Hanlon 1996).

Table A2-1. Tank 241-U-110 Risers and Lines.[1,2,3,4,5]

Number	Diameter (in.)	Description and Comments
1	4"	Thermocouple tree
2	12"	B-222 Observation port
3	12"	WC
4	4"	WC
5[6]	4"	Recirculation line dip tube, WC
6	12"	Pump, WC
7	12"	Blind flange
8	4"	ENRAF® 854 ECN-626467 11/17/95[7] [BM CEO-37532 12/11/86]
9	4"	Breather filter [BM CEO-37532 12/11/86]
13	12"	Salt well pump
17	4"	Blind flange
19	4"	Blank
N1	3"	Inlet line blanked in diversion box 241-U-153
N2	3"	Inlet line blanked in diversion box 241-U-153
N3	3"	Inlet line blanked in diversion box 241-U-153
N4	3"	Spare, capped
N5	3"	Overflow

Notes:

BM = benchmark
CEO = change engineering order
ECN = engineering change notice
WC = weather covered

[1]Alstad (1993)

[2]Lipnicki (1996)

[3]Tran (1993)

[4]Vitro Engineering Corporation (1988)

[5]Atlantic Richfield Hanford Company (1976)

[6]The Vitro Engineering Corporation drawing refers to this riser as 3" diameter; however, the Atlantic Richfield Hanford Company drawing refers to this riser as 4" diameter.

[7]Dates in mm/dd/yy format

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

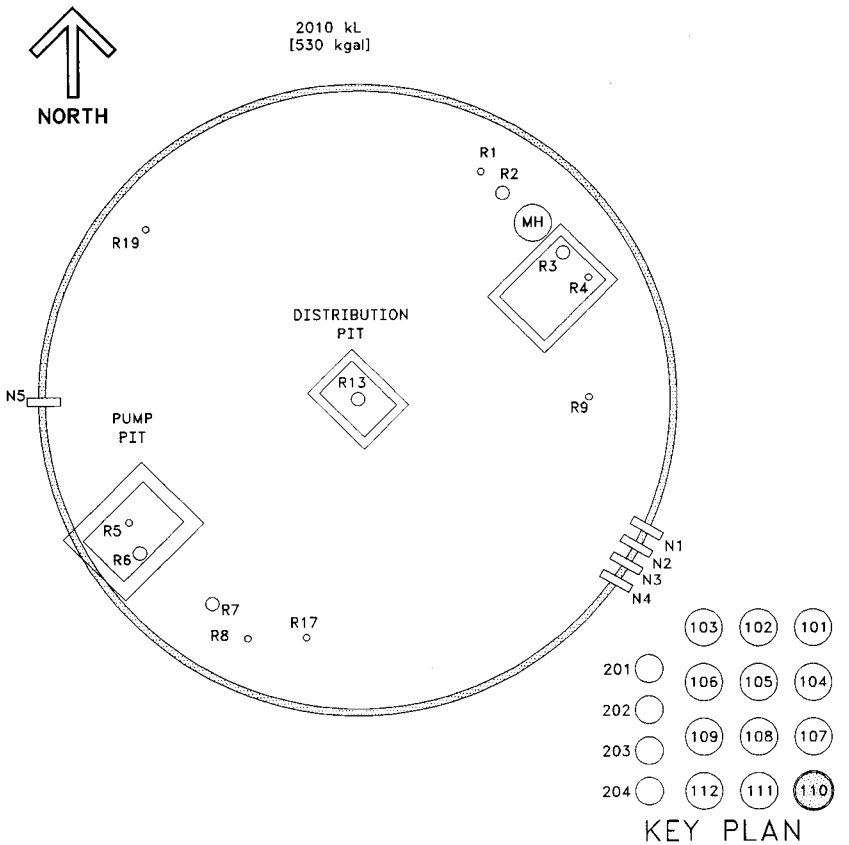
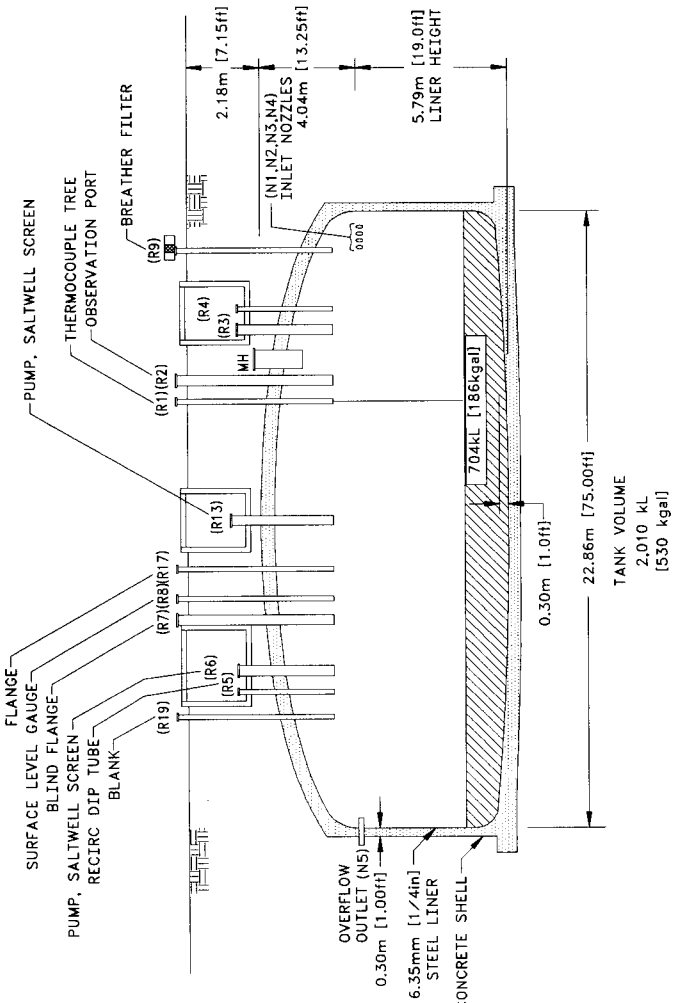


Figure A2-2. Tank 241-U-110 Cross-Section.



A3.0 PROCESS KNOWLEDGE

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

A3.1 WASTE TRANSFER HISTORY

The transfer history of tank 241-U-110 is summarized in Table A3-1. Tank 241-U-110 entered service in 1946 when it received first-cycle decontamination waste (1C1) (Agnew et al. 1996b). The 1C1 waste was produced in the bismuth phosphate process and consisted of fission products and aluminum coating waste. Tank 241-U-110 was filled by 1947; the entire cascade was filled by 1948. The tank also received metal waste (MW) during 1948. Tank 241-U-110 was idle from 1948 until 1952 when waste was transferred to tank 241-TX-118. In 1954, the cascade began to receive REDOX concentrated waste (R1). During this idle time it is very likely that the solids from the 1C1 waste began to settle and the first of the solid sludge began to form.

The tank was refilled with R1 waste in 1954, and the waste was allowed to cascade to tank 241-U-111. During this time, tank storage space was gained through self-evaporation of the waste. From 1955 to 1957, tank 241-U-110 received cladding waste (CWR1) from the REDOX Plant. In 1956, the supernatant was transferred to a number of tanks, including 241-T-106, 241-U-109, 241-U-112, and 241-U-204.

In 1958, tank 241-U-110 received flush water. The tank was idle until 1969 when supernatant from the tank was sent to tank 241-TX-118. It was again idle three more years until 1972. From 1972 until mid-1975, tank 241-U-110 received laboratory waste (LW) in small quantities from the 222-S Laboratory and from the PNNL. During this same time period, supernatant waste was transferred to tanks 241-U-107, 241-U-111, and a crib.

Liquid levels in the tank have not been constant since 1975. Although the reasons for the changes in liquid levels are not known, further leaking is still considered a possibility. The tank was interim stabilized in 1984 (Welty 1988). Tank 241-U-110 was one of the first tanks to have been interim stabilized because of its history as a leaker. By 1989 the leak was estimated to have released between 19 and 31 kL (5 and 8.1 kgal) of liquid (Hanlon 1996).

Table A3-1. Tank 241-U-110 Major Transfers.[1,2]

Transfer Source	Transfer Destination	Waste Type	Time Period	Estimated Waste Volume	
				kL	kgal
T Plant	U-110	1C1	1946-1948	4,879	1,289
T Plant	U-110	MW	1948	742	196
U-110	U-111	SU	1947-1948	-4,012	-1,060
U-110	TX-118	SU	1952	-734	-194
REDOX	U-110	R1	1954	4,512	1,192
U-110	U-111	SU	1954	-3,590	-949
U-110	U-003	RCOND	1954-1955	-1,150	-305
REDOX	U-110	CWR1	1955-1957	3,050	806
U-110	U-201, U-202, U-203, U-204, U-109, U-112, T-106	SU	1956	-2,480	-655
Unknown	U-110	Water	1958, 1973	148	39
U-110	TX-118, U-107, U-111	SU	1958-1975	-2,710	-715
222-S Laboratory	U-110	LW	1972-1975	1,380	364
Battelle Northwest	U-110	Battelle Northwest waste	1975	79	21

Notes:

1C1 First-cycle decontamination waste from the bismuth phosphate process
MW Metal waste from the $BiPO_4$
SU Supernatant (liquid considered free of contamination to the extent it could be pumped to a crib)
R1 REDOX concentrated waste generated between 1952 and 1957
RCOND REDOX condensate from self-evaporation
CWR1 REDOX cladding waste generated between 1952 and 1960
LW Waste from the 222-S laboratory

[1]Agnew et al. 1996a

[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:

- *Waste Status and Transaction Record Summary for the Southwest Quadrant of the Hanford 200 East Area* (WSTRS) (Agnew et al. 1996a). WSTRS is a tank-by-tank quarterly summary spreadsheet of waste transactions.

- *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 3* (Agnew et al. 1996b). This document contains the Hanford defined waste (HDW) list, the supernatant mixing model (SMM), and the tank layer model (TLM).

- Historical Tank Content Estimate for the (Northeast, Northwest, Southeast, Southwest) Quadrant of the Hanford 200 (East or West) Area (HTCE). This set of four documents compiles and summarizes much of the process history, design, and technical information regarding the underground waste storage tanks in the 200 Areas.

- Tank Layer Model (TLM). The TLM defines the sludge and saltcake layers in each tank using waste composition and waste transfer information.

- Supernatant Mixing Model (SMM). This 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 both the WSTRS and the TLM to describe the supernates and concentrates in each tank. Together the WSTRS, TLM, and SMM determine each tank's inventory estimate. These model predictions are considered estimates that require further evaluation using analytical data.

Based on the HDW, tank 241-U-110 contains two layers of waste listed from the first deposit into the tank to the last deposit: 91 kL (24 kgal) of MW, and 613 kL (162 kgal) of 1C1. The tank may also contain R1 and CWR1 sludge remnants (Agnew et al. 1996a). Figure A3-1 shows a graph representing the estimated waste types and volumes for the two tank layers. The MW (bottom) layer should contain large quantities of sodium, total inorganic carbon (TIC), and hydroxide. The 1C1 (upper) layer should contain large quantities of sodium, iron, bismuth, hydroxide, nitrate, phosphate, and water. Neither waste type contains large amounts of any radionuclides, accounting for the low activity of the tank contents.

Figure A3-1. Tank Layer Model for Tank 241-U-110.

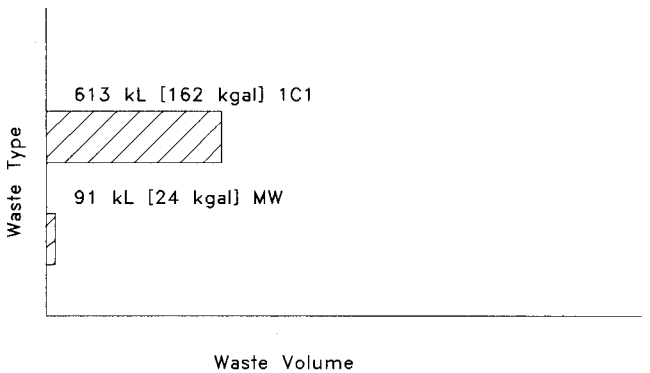


Table A3-2. Historical Tank Inventory Estimate.[1,2,3] (2 sheets)

Total Inventory Estimate			
Physical Properties			
Total waste	950,000 kg (186 kgal)		
Heat load	40.3 W (138 Btu/hr)		
Bulk density[4]	1.35 g/mL		
Water wt%[4]	66.4		
Total organic carbon wt% carbon (wet)[4]	0		
Chemical Constituents	**M**	**μg/g**	**kg[5]**
Na^+	4.90	83,400	79,300
Al^{3+}	0.414	8,280	7,860
Fe^{3+} (total Fe)	0.297	12,300	11,700
Cr^{3+}	0.00344	133	126
Bi^{3+}	0.0671	10,400	9,870
La^{3+}	0	0	0
Hg^{2+}	9.20E-05	13.7	13.0
Zr (as $ZrO(OH)^2$)	0.00897	606	576
Pb^{2+}	0	0	0
Ni^{2+}	0.00109	47.4	45.1
Sr^{2+}	0	0	0
Mn^{4+}	0	0	0
Ca^{2+}	0.0766	2,270	2,160
K^+	0.00285	82.4	78.3
OH^-	3.87	48,700	46,300
NO_3^-	0.334	15,300	14,600
NO_2^-	0.157	5,350	5,090
CO_3^{2-}	0.309	13,700	13,100
PO_4^{3-}	1.21	85,300	81,000
SO_4^{2-}	0.0495	3,520	3,350
Si (as SiO_3^{2-})	0.0552	1,150	1,090

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

Total Inventory Estimate			
Chemical Constituents	**M**	**μg/g**	**kg[4]**
F^-	0.144	2,030	1,930
Cl^-	0.0131	344	326
Citrate	0	0	0
$EDTA^{4-}$	0	0	0
$HEDTA^{3-}$	0	0	0
glycolate	0	0	0
acetate	0	0	0
oxalate	0	0	0
DBP	0	0	0
butanol	0	0	0
NH_3	1.57E-04	1.97	1.87
$Fe(CN)_6^{4-}$	0	0	0
Radiological Constituents	**Ci/L**	**μCi/g**	**Ci[5]**
Pu	---	0.00556	0.0880 (kg)
U	0.257 (M)	45,300 (μg/g)	43,100 (kg)
Cs	0.0107	7.95	7,550
Sr	0.00104	0.772	733

Notes:

[1]Agnew et al. (1996a)

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

[3]Unknowns in tank solids inventory are assigned by the TLM.

[4]Volume average for density, mass average for wt% water and total organic carbon (TOC) wt% carbon.

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

A4.0 SURVEILLANCE DATA

Tank 241-U-110 surveillance consists of surface-level measurements (liquid and solid), temperature monitoring inside the tank (waste and headspace), and leak detection drywell monitoring for radioactivity outside the tank. The data are significant because they provide the basis for determining tank integrity.

Liquid-level measurement provides an indication of a leak from a tank, or an intrusion of rain or snowmelt. Solid surface-level measurements provide an indication of physical changes and consistency of the solid layers of a tank. Drywells located around the tank perimeter may show increased radioactivity caused by leaks.

A4.1 SURFACE-LEVEL READINGS

Tank 241-U-110 is categorized as an assumed leaker. The surface level in tank 241-U-110 is monitored with an ENRAF™ gauge. Because of the gauge setting, a limited number of surface-level measurements are available (the available data are plotted in Figure A4-1). The most recent surface-level measurement available from the Computer Automated Surveillance System is 192 cm (75.5 in.) measured October 7, 1996. An occurrence report was issued in February 1979 because of a liquid-level intrusion into tank 241-U-110. The cause of the intrusion was attributed to rapid snowmelt entering the tank via the pump pit (Brevick 1994). A graphical representation of the volume measurements is presented as a level history graph in Figure A4-1.

A4.2 INTERNAL TANK TEMPERATURES

Tank 241-U-110 contains a single thermocouple tree (which enters the tank through riser 1) that is equipped with 11 thermocouples arranged at different heights in the tank (Brevick et al. 1994). Temperatures are currently recorded semiannually. The thermocouples have similar readings from January 1987 to the present. The Surveillance Analysis Computer System mean temperature reading from July 1987 to October 1996 was 24.7 °C (76.5 °F), with a minimum of 17.8 °C (64.0 °F) and a maximum of 32.2 °C (90.0 °F). Temperature readings over the previous year (October 1995 to October 1996) yielded a mean of 24.6 °C (76.3 °F), with a minimum of 21.6 °C (70.9 °F) and a maximum of 27.6 °C (81.7 °F). The most recent data available, for October 7, 1996, gave a minimum temperature reading of 25.0 °C (77.0 °F) and a maximum of 25.9 °C (78.6 °F). Available readings over the history of the tank show a maximum temperature decrease of 2.8 °C from the bottom-most thermocouple to the highest. This temperature gradient can likely be attributed to the position of each thermocouple: available waste surface-level readings indicate the two bottom-most thermocouples (no. 1 and no. 2) are in or near the solids level, while the rest are in the headspace. A graph of the weekly high temperatures can be found in Figure A4-2.

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

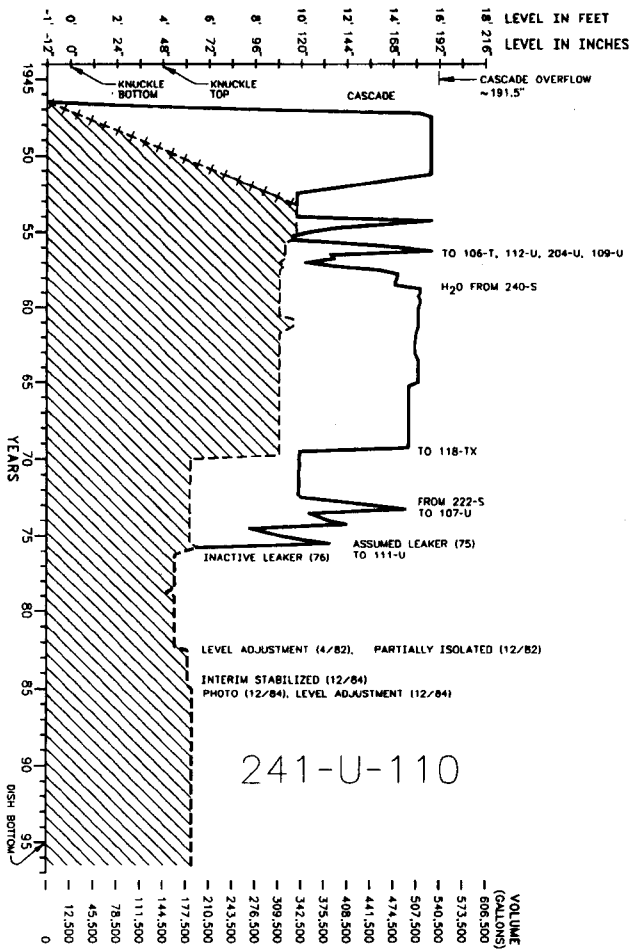
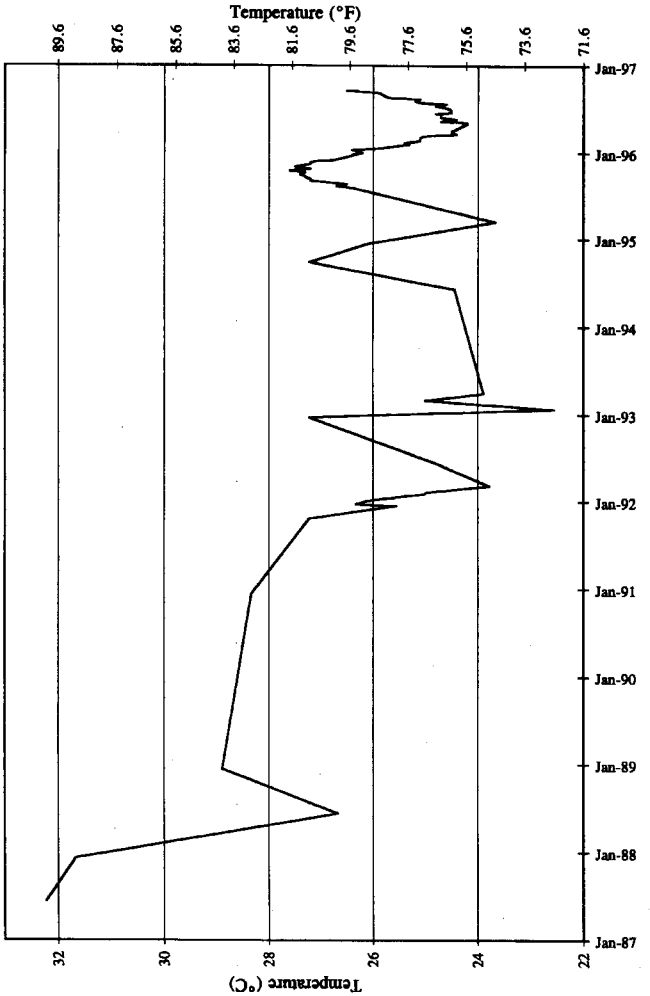


Figure A4-2. Tank 241-U-110 Weekly High Temperature Plot.

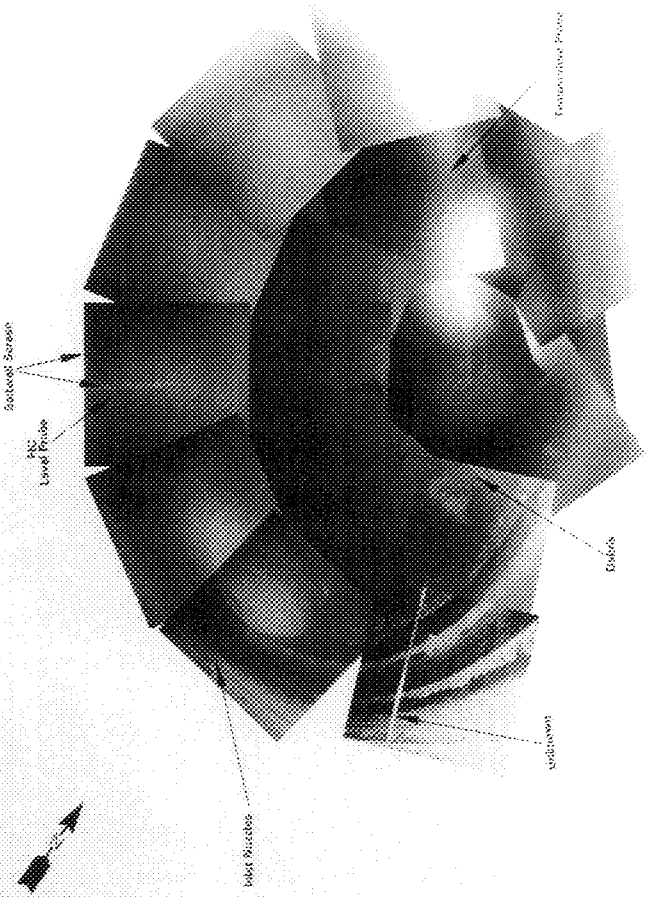


A4.3 TANK 241-U-110 PHOTOGRAPHS

Figure A4-3 presents a montage of photographs taken inside tank 241-U-110 in December 1984, the most recent photographs available (Hanlon 1996). The tank waste in the photographs appears to be dry material (Brevick et al. 1994). The quality of the pictures makes it impossible to see the waste surface in some locations. Debris visible on the surface between the thermocouple tree and an unknown device is probably a pipe. A mound is apparent at the upper left of the photographs below the inlet nozzles, and probably below a riser, used as a waste inlet. A surface-level probe and two salt well screens with debris scattered about are in the background. Some sludge has collected on the ribs of the side of the tank at various levels.

241-U-110

Figure A4-3. Photographic Montage of Tank 241-U-110.



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APPENDIX B

SAMPLING OF TANK 241-U-110

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APPENDIX B

SAMPLING OF TANK 241-U-110

Appendix B provides sampling and analysis information for each known sampling event for tank 241-U-110 and provides an assessment of the core sample results.

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

Future sampling of tank 241-U-110 will be appended to the above list.

B1.0 TANK SAMPLING OVERVIEW

This section describes the 1989 sampling and analysis events for tank 241-U-110. The sampling and analyses were performed in accordance with the *Waste Characterization Plan for the Hanford Single-Shell Tanks* (Winters et al. 1989), which was a plan to identify sampling and analysis requirements for regulatory, performance assessment, and technology and process development purposes. The 1989 sampling and analysis events predated all DQO documents. Nevertheless, the analytical results were compared to the most recent revision of the safety screening DQO, *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995), for informational purposes. Further discussions of the sampling and analysis procedures can be found in the *Tank Characterization Reference Guide* (DeLorenzo et al. 1994). A solid and supernatant sample were also taken from this tank in 1974 and 1975, respectively; these sampling events are discussed in Section B1.4.

Regarding the 1989 core samples, a separate report was issued for each of the individual segments that were recovered, and a separate report was issued for each of the eight core composites that were created from the segments. Because this totaled 22 individual reports, for the sake of convenience they will hereafter be referred to collectively as Winters (1993). The analytical results from these data packages were summarized in Appendixes A and B of Brown and Jensen (1993).

B1.1 DESCRIPTION OF SAMPLING EVENT

During the last four months of 1989, eight core samples of four segments each were collected from tank 241-U-110. Because the sampling in September 1989 consisted entirely of segments 1 and 2 of core 5 (taken from riser 19), neither of which contained any waste material, the actual recovery of tank waste samples did not begin until November. Thus, for practical purposes, the sampling took place from November 7 to December 6, 1989. All cores and segments were received at the Westinghouse Hanford Company 222-S Laboratory within four days after removal from the tank (Winters 1993). Table B1-1 gives the location of the eight core samples by riser, the tank farm sample numbers for each segment, the date each segment was removed from the tank, and the date each segment was received by the 222-S Laboratory. A visual representation of the sample locations within the waste is given in Figure B1-1.

Table B1-1. Segment Location and Numbering for Tank 241-U-110.[1] (2 sheets)

Sequential Core Numbering	Riser	Segment Number	Sample Number	Date Sampled[2]	Date Received by 222-S Laboratory
5	19	1	89-038	9/19/89 - 11/7/89	11/7/89
		2	89-039		
		3	89-040		
		4	89-041		
6	17	1	89-042	11/13/89 - 11/14/89	11/15/89
		2	89-043		
		3	89-044		
		4	89-045		
7	7	1	89-046	11/15/89 - 11/16/89	11/17/89
		2	89-047		
		3	89-048		
		4	89-049		
8	7	1	89-050	11/17/89	11/20/89
		2	89-051		
		3	89-052		
		4	89-053		

Table B1-1. Segment Location and Numbering for Tank 241-U-110.[1] (2 sheets)

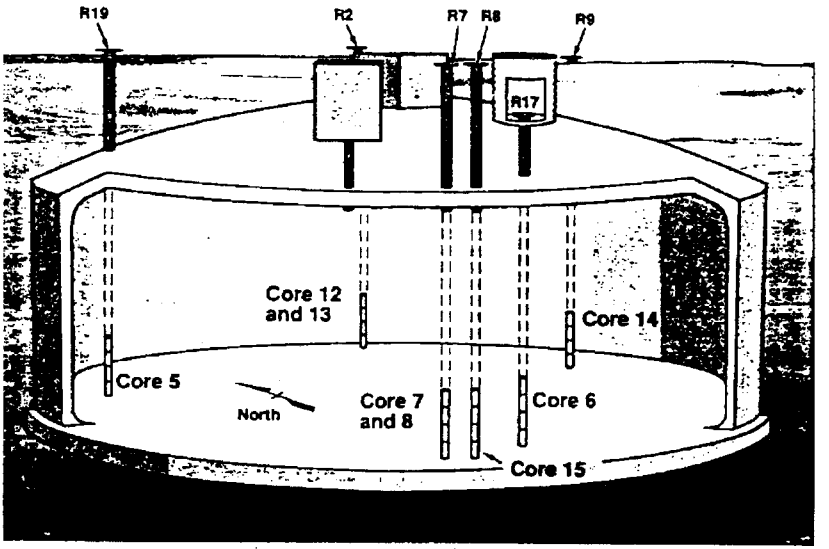
Sequential Core Numbering	Riser	Segment Number	Sample Number	Date Sampled[2]	Date Received by 222-S Laboratory
12	2	1	89-069	11/29/89	11/29/89
		2	89-070		
		3	89-071		
		4	89-072		
13	2	1	89-073	11/30/89	12/1/89
		2	89-074		
		3	89-075		
		4	89-076		
14	9	1	89-077	12/3/89	12/4/89
		2	89-078		
		3	89-079		
		4	89-080		
15	8	1	89-081	12/4/89 - 12/6/89	12/8/89
		2	89-082		
		3	89-083		
		4	89-084		

Notes:

[1]Winters (1993)

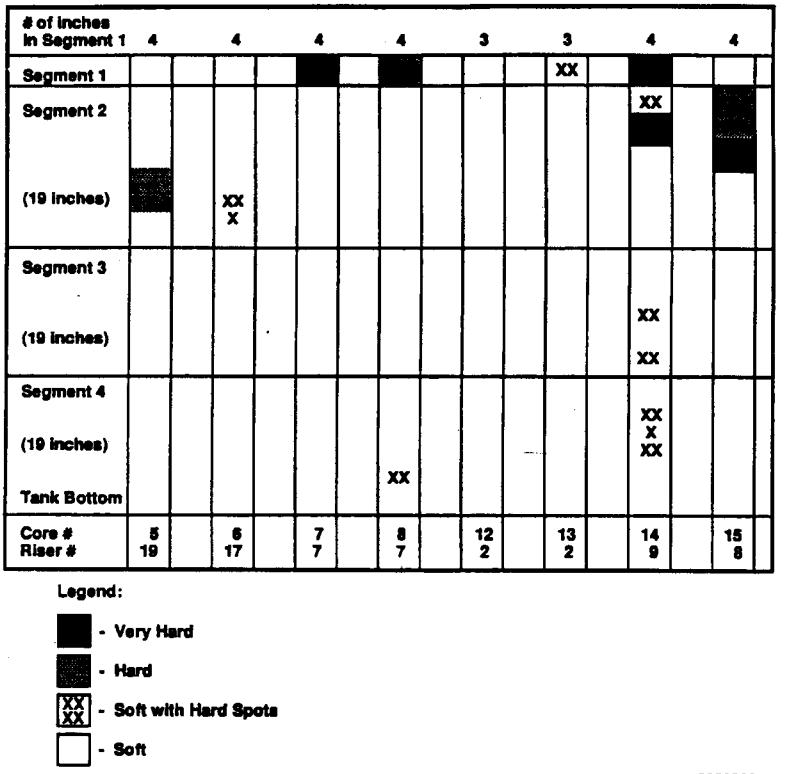
[2]Dates in mm/dd/yy format

Figure B1-1. Core Sample Locations.



Normal paraffin hydrocarbons (NPH) were used as a hydrostatic head fluid (HHF) during sampling. The core sampling equipment worked effectively when recovering liquids or soft sludge, but was not as effective when sampling some of the harder material found in the tank. Harder wastes were sampled in rotary mode, which allowed the sampler to penetrate the waste more easily. The rotary mode was especially needed for the first two segments of the tank waste, which indicated that a harder layer of waste was at the top of the tank. This observation was confirmed from the pressure transducer readings. As the sampler was passing through the waste, a pressure transducer was used to record the resistance of the waste to the sampler, which identified where the hard layers of waste were located. The readings do not quantify the hardness of the waste, but do indicate the relative hardness of the waste in a given segment. The information gained from these pressure readings is summarized in Figure B1-2. From this figure, it can be seen that many of the core samples appear to have a hard layer in segment 1 and/or segment 2. The only exceptions to this observation are cores 12 and 13 from riser 2 where both of the cores, from top to bottom, are composed of soft waste.

Figure B1-2. Hardness of Cores Taken From Tank 241-U-110.



In two separate instances, two core samples were taken from the same riser location in the tank. The hardness profile of the waste under these risers should be the same for both samples, which allows a check of the agreement of the pressure data between duplicate samples. These duplicate samples are cores 7 and 8 from riser 7 and cores 12 and 13 from riser 2. From Figure B1-2, cores 7 and 8 are similar. When drilling core 7 (the first core from riser 7), a very hard layer was encountered in the first segment. Core 8 also had a hard layer in the first segment but did not meet the resistance that core 7 did. Core 8 met a little resistance in segment 4. Overall, the two cores were very similar in their hardness profiles. Cores 12 and 13 were also very similar in their hardness profile in that both were very soft from the top to the bottom of the core. The similarity of these duplicate cores indicates that the pressure transducer readings were an accurate way of establishing where the harder layers of material are in the core.

From the above discussion, it can be seen that a hard layer of material constitutes the upper portion of the waste with the exception of the northeast portion of the tank (riser 2). The poor waste recoveries and the problems encountered while sampling the tank verify that the waste in this tank, particularly at the top, is hard and noncohesive. The lack of liquid in the tank correlates with the process history that the tank has undergone salt well pumping and interim stabilization. This lack of liquid may also explain the hardness of the waste material in the tank.

Some operational difficulties were experienced regarding the recoveries of some of the waste segments, and were recorded in the chain-of-custody records. Chain-of-custody forms can be found in the data packages (Winters 1993). Chain-of-custody records were not included in the data packages for segment 1 of core 6, segment 1 of core 12, and segments 1 and 2 of core 13. All of these segments had either very little recovery or no recovery.

B1.2 SAMPLE HANDLING AND DESCRIPTION

B1.2.1 Sample Handling

The tank 241-U-110 samples were received at the 222-S Laboratory. Because of uncertainty regarding the effects of the HHF on the samples, and regulatory concerns about potential sample degradation, it was desirable to minimize the time the samples were stored before extrusion. The actual sample holding times ranged from extrusion on the same day as core sampling to two months after core sampling. Six of the eight cores were extruded within ten days of sampling, and the fourth segment of core 15 was extruded one month after sampling. The other two cores (12 and 13) were extruded two months after sampling. In some instances, holding times for some of the core 14 samples were prolonged to perform a statistical study of the effect of holding time on sample analysis. Statistical holding time

results for this tank will be presented later in this report to determine if prolonged holding times affected the quality of the data or altered the nature of the waste to any degree (Section B3.4.7).

After a segment was extruded onto a metal tray, it was sampled for any analyses required on unhomogenized material. These pre-homogenization analyses were particle size analysis and volatile organic analysis. The particle size analysis was performed and will be discussed in Section B2.6.3. However, the volatile organic analysis was never performed.

The next step in the sample preparation process was homogenization of the segments. This was performed in an apparatus called a stomacher, a bag with paddles on the inside that mixes the segment in a motion similar to kneading bread. The consistency of the samples ranged from soft to clay-like to hard and crusty. The stomacher is only mildly effective at mixing hard waste if the waste is noncohesive (or brittle). The stomacher is ineffective with cohesive material, whether it is hard or claylike, and is most effective with soft, wet, sludge-like waste. Most of the laboratory analyses were performed on these homogenized samples, the results of which are presented in Section B2.0.

Some of the analyses that were performed on tank 241-U-110 samples were performed on core composites. A core composite is a single representation of the entire core, created by mixing portions of each segment of a core together. These portions were proportional by weight to the recovery for each segment of that core. The analyses of these core composites will also be considered in Sections B2.0. When all of the homogenizing and compositing activities were completed, the aliquots for analysis were taken. Remaining samples were archived and are now stored at the 222-S Laboratory.

B1.2.2 Sample Description

In general, the waste recovery for tank 241-U-110 was poor. The only core sample to receive 80 percent or better recovery on all segments was core 14 from riser 9. Seven of the 32 segments were not recovered at all, and three others were not analyzed because of poor recovery. Because of the poor waste recoveries, for both the cores as a whole and within the individual segments, the analytical results given later in this report may be biased. The magnitude of this bias cannot be determined. Table B1-2 gives the percent core recoveries as well as a summary of general waste attributes by segment.

Table B1-2. Subsampling Scheme for Tank 241-U-110.[1] (2 sheets)

Core Number	Segment Number	Core Recovery %	Mass g	Length cm	Drainable Liquid mL	Drill String Dose Rate mR/hr
5	1	0	0	No sample recovery.		
	2	0	0	No sample recovery.		
	3	75	187	35.6	< 10	200
	4	85	n/a	40.6	< 10	100
6	1	0	0	No sample recovery.		
	2	27	102	12.7	None	70
	3	70	203	33.0	10	120
	4	35	139	15.2	25	70
7	1	50	183	20.3	None	7
	2	80	282	38.1	38.3	120
	3	30	118	15.2	< 10	110
	4	40	149	15.2	< 10	80
8	1	100	n/a	No information available.		0.5
	2	0	0	No sample recovery.		
	3	0	0	No sample recovery.		
	4	0	0	No sample recovery.		
12	1	0	0	No sample recovery.		
	2	21	91	10.2	20	120
	3	65	155	30.5	< 10	130
	4	60	192	25.7	< 10	380
13	1	15	---	Sample not analyzed.		
	2	37	---	Sample not analyzed.		
	3	80	221	38.1	< 10	200
	4	40	151	20.3	< 10	150

Table B1-2. Subsampling Scheme for Tank 241-U-110.[1] (2 sheets)

Core Number	Segment Number	Core Recovery %	Mass g	Length cm	Drainable Liquid mL	Drill String Dose Rate mR/hr
14	1	83	192	25.4	None	1.5
	2	80	269	38.1	< 10	200
	3	100	341	48.3	25	200
	4	85	314	38.1	Not available	220
15	1	25	---	Sample not analyzed.		
	2	85	262	40.6	< 10	140
	3	70	219	33.0	None	160
	4	15	51	7.6	None	80

Note:
[1]Winters (1993)

There were very few liquid recoveries from any of the samples. Only five segments had 10 mL or more of fluid in them, and the most fluid recorded for a given segment was 38.3 mL from core 7 segment 2 (Table B1-2). All of the observed liquids were clear, indicating that they were probably HHF from the sampling operations. The true nature of the liquids is not known, because liquid analyses were not performed.

Photographs of each segment were taken after extrusion and show the segments on the metal tray in the hot cell. The segments range in color from white to light or dark brown to black, and were generally crumbly but sometimes still held the cylindrical shape of the sampler. Sample photographs of segments 1 through 4 of core 14 were provided in Appendix E of DiCenso et al. (1995) to show the appearance of the waste. Brief descriptions of each segment are provided in Table B1-3. Some segments were extruded that had no recovery or such a small recovery that they were not analyzed. Descriptions of these segments were not recorded in the data packages, and are labeled "samples not analyzed" in Table B1-3. The material from these segments was still used in the core composites.

The first and most distinctive layer is at the top of the waste in the tank. The predominant feature of this layer is its bright white color. This layer is approximately 10 to 40 cm (5 to 14 in.) thick and was observed in segment 1 and the top of segment 2 of some of the samples. Because segment 1 was not retrieved in every sample, it is uncertain if this layer exists throughout the whole tank. Photographs of this white layer can be seen in core 7

segment 1, core 7 segment 2, core 8 segment 1, core 14 segment 1, and in core 14 segment 2 (only core 14 photos were shown in Appendix E of DiCenso et al. (1995). The penetrometer data given in Table B2-69 indicate that these segments were very hard. This white layer was described generally as being noncohesive to semicohesive, granular, and chalk-like. The only exception to this description is for core 14 segment 2, where the white layer was described as being runny.

The second layer comprises most of the waste in the tank, and encompasses the second and third segments of the core samples plus part of the top of the fourth segment in many instances. This layer is dark brown to black in color and varies in consistency. It is more moist and cohesive than the first layer, and many of the segments retrieved in this layer held the cylindrical shape of the sampler upon extrusion. Many of the segments in this layer, particularly the ones that held their shape, were described by the technician as having the consistency of clay. This layer ranges from being smooth to granular and also ranges from being cohesive to noncohesive.

The last layer is made up of the last segment of the core (or the bottom portion of the last segment in some instances) and represents the waste closest to the bottom of the tank. The fourth segment extruded from every core was always crumbly and in some instances also contained runny or sludge-like material. This layer was also a lighter brown than the second layer. In many of the fourth segments, small solid chunks of material were observed, which is expected because any solid waste would have settled to the bottom of the tank. It is possible that the chemical makeup of this bottom layer and the middle layer are similar and that the major difference between the two is the settling of the larger solids that has occurred in the bottom layer.

Table B1-3. Sample Descriptions.[1] (3 sheets)

Core	Segment 1	Segment 2	Segment 3	Segment 4
5	No sample recovered	No sample recovered	Sample was dark brown. Slightly moist on the lower surface drying towards top. The last 2.5 cm (1 in.) of the top was dry and crumbly with no cohesion.	Bottom 10 cm (4 in.) very soft, runny, light to medium brown. Middle firmer, medium brown. Top 13 cm (5 in.) rubbery, firm (very cohesive), black in color. Small hard chunks (possibly crystals) of approximately 0.32 cm (1/8 in.) in diameter.
6	No sample recovered	Sample was semi-cohesive at bottom, grading to crumbly at top. Sample was uniform brown color.	Sample graded upward from medium brown to dark brown. Sample was firm and cohesive throughout, and there was a 5.1-cm (2-in.) segment at bottom which was separated from the rest of the segment by a small void.	Sample was dark brown grading to medium brown. Granular looking throughout. Moist and sticky appearance at bottom grading toward crumbly and noncohesive at top.
7	20 cm (8 in.) of white semi- to noncohesive material. Color changed from bright white at bottom to brownish white at top. Bottom 8 to 10 cm (3 to 4 in.) semi-cohesive. Broke into chunks.	Bottom 31 cm (12 in.) of sample dark gray to black in color, cohesive and firm. Top 8 cm (3 in.) white, granular, crumbly, noncohesive with a slippery/slimy texture.	Sample dark brown except for bottom chunk (which is medium brown) of about 2 cm (3/4 in.). Granular texture throughout the sample with some hard bits. Semi-cohesive consistency with bottom portion much less cohesive than rest of sample, almost runny.	Bottom 5.1 cm (2 in.) dark brown; rest of sample is medium brown. Surface of bottom 5.1 cm (2 in.) appeared moist; the rest was dry and very crumbly. Sample broke into 6 segments, 2.5 cm (1 in.) or more in length. Middle section had a complete lack of cohesiveness. Hard chunks found in crumbly part.

Table B1-3. Sample Descriptions.[1] (3 sheets)

Core	Segment 1	Segment 2	Segment 3	Segment 4
8	Hard, white crumbly solids. Material is more sticky than previous cores.	No sample recovered	No sample recovered	No sample recovered
12	No sample recovered	Very dark brown in color with firm crumbles of solids. At least one 0.6-cm (1/4-in.) chunk of solid found in the sample. There was insufficient material to perform a penetrometer test.	Very dark brown color with firm solids.	Light brown solids. Upper 3.8 cm (1.5 in.) medium brown, and very smooth in appearance.
13	Sample not analyzed	Sample not analyzed	Sample was dark brown with firm solids. During the early stage of extrusion, no sample but air noted leaking from the sample valve.	The solid sample was slightly soft. Most of the solids were dark brown. The top 2.5 cm (1 in.) was chocolate brown. Some hard "chunks" noted in the solids.
14	Extrusion completed only after hammering free. White, chalk-like sample of approximately 25 cm (10 in.), only 10 cm (4 in.) expected.	Top 10 cm (4 in.) granular and white in color. Remainder of segment firm and dark brown to black at the bottom 7.6 cm (3 in.). White portion of segment runny but semi-cohesive.	Very dark brown solids. Darker towards top segment. Firm, broke into 2.5-cm (1-in.) sections on extrusion. Surface "greases" with some clear liquid in tray around the valve assembly. Somewhat crumbly when taking volatile organic analysis.	Top 5 cm (2 in.) brown, the rest dark brown. Somewhat crumbly, but moist texture throughout. Clear liquid, some lost through valve. Small hard solids found in the sample.

Table B1-3. Sample Descriptions.[1] (3 sheets)

Core	Segment 1	Segment 2	Segment 3	Segment 4
15	No sample recovered	Fibrous strands at very bottom segment. Bottom 36 cm (14 in.) dark brown, cohesive but crumbly looking. Evidence of twisting the sample. Upper 5 cm (2 in.) very crumbly, lighter brown material. Many small "rocks" in the sample.	The bottom 7.6 cm (3 in.) is light brown cohesive. The next 25 to 28 cm (10 to 11 in.) is very dark brown/black cohesive. Material is very dry and crumbly at the top.	Sample was chocolate brown solids. Cohesive. Sample was extruded into jar.

Note:

[1]Winters (1993)

B1.3 SAMPLE ANALYSIS

All analyses were performed at the 222-S Laboratory, and were conducted in accordance with approved laboratory procedures. After sample extrusion, the pre-homogenization aliquots were taken from the segments for particle size analysis and volatile organic analysis. All other laboratory analyses were performed on the homogenized segment samples or core composites. No analyses were conducted on the liquids recovered from the tank. The remaining samples for tank 241-U-110 were archived and are now stored at the 222-S Laboratory.

Aliquots were either analyzed directly or after an appropriate sample preparation method such as water, acid, or fusion dissolution. These preparations were applicable only to the chemical and radiochemical analyses.

Water digestion involves dissolving as much of the sample as possible in water, allowing analysis of the soluble analytes to be performed. Water digestion was performed before the analysis of ions by ion selective electrode, ion chromatography (IC), atomic absorption spectroscopy (AAS), and inductively coupled plasma (ICP). Water digestion was also performed before analysis for total inorganic carbon (TIC), total organic carbon (TOC), and radionuclides. The ICP analysis on water-digested samples may be of particular interest when determination of the water-soluble species of the element is desired.

The second preparation method was acid digestion, in which the samples were dissolved in hydrochloric acid. This preparation brings most of the insoluble metals into solution and is best used for the detection of trace and some major metals during ICP analysis. The fundamental purpose in determining trace metals in the tank was to meet regulatory requirements. When tank 241-U-110 was initially sampled, the "leave (the waste in the tank)/retrieve" decision had not been made. The AAS analyses were also conducted on acid-digested samples. These elements were detectable in acid digestion but not in water digestion, indicating that they generally occur in the tank in insoluble forms.

The final preparation used was potassium hydroxide fusion. This preparation brought essentially everything into solution. One disadvantage of fusion preparation is that large amounts of potassium hydroxide are required to bring a sample into solution, which means that a large dilution is required before analysis of the sample by ICP. Thus, trace elements are less likely to be detected.

Because a nickel crucible was used in the fusion dissolution of the samples, nickel results in the ICP analysis should be disregarded. Also, because potassium hydroxide is the substance used to dissolve the sample, potassium readings on the ICP should also be disregarded. The two analyses that were performed on fusion-prepared samples were ICP and radiological analysis. Fusion dissolution is the preferred method of analyzing radionuclide content with the exception of carbon-14 and tritium, which should be performed on a water digestion.

All of the analyses discussed above were performed on the composite samples, but only some were performed on segment samples. The most noteworthy example was for the fusion ICP. Because fusion ICP analysis was not included for segment analysis, the major metals listed above are not well characterized for segment samples.

B1.4 DESCRIPTION OF HISTORICAL SAMPLING EVENT

Tank 241-U-110 had been sampled twice before the 1989 sampling event. A sludge sample was taken in 1974, followed by a supernatant sample in 1975. The sludge sample should be representative of the sludge currently in the tank, based on the tank waste history (Agnew et al. 1996). The sampling of the tank's supernatant was initiated in response to a suspected leak, to determine the composition of any leaked fluids. Because all supernatant was removed shortly after the sampling, the results are presented for informational purposes only. There were no details regarding either sampling event, such as the number of samples taken, or sample locations. The analytical results from these two samples are summarized in Table B2-74.

B2.0 ANALYTICAL RESULTS

B2.1 OVERVIEW

This section summarizes the sampling and analytical results associated with the 1989 core sampling and analysis of tank 241-U-110. The tabulated locations for the inorganic, carbon, radionuclide, physical properties, and thermodynamic analytical results associated with this tank are presented in Table B2-1. These results are documented in Winters (1993).

Data validation procedures for both chemical and radiological data were in place during the analysis of tank 241-U-110. The procedures for the validation of chemical data, also known as *Resource Conservation and Recovery Act of 1976* (RCRA) data, are described in detail in *Sample Management and Administration* (WHC 1991). The procedures for validation of radiological data are outlined in Section 2.4 of WHC (1991). Validation of the chemical data was performed; however, validation of the radiological data for tank 241-U-110 was not performed because of time constraints.

Many QC and quality assurance parameters were investigated during the validation, including standard recoveries, spike recoveries, duplicate analyses, and blanks. Winters (1993) provides the complete data validation information. Refer to Section B3.3 for more information about the QC investigation.

Table B2-1. Analytical Presentation Tables.

Analysis	Table Number
Differential scanning calorimetry (DSC)	B2-2 and B2-4
Thermogravimetric analysis (TGA)	B2-3 and B2-5
Summary data for metals by ICP	B2-7 through B2-45
Arsenic and mercury by AAS	B2-9, B2-23
Ammonia by ion selective electrode	B2-46
Cyanide by microdistillation and spectrophotometric determination	B2-47
Anions by IC	B2-48 through B2-54
^{237}Np by alpha energy analysis	B2-59
Total alpha activity by alpha proportional counting	B2-64
^{241}Am and $^{239/240}$Pu by alpha spectrometry	B2-55 and B2-60
^{90}Sr and total beta activity by beta proportional counting	B2-61 and B2-65
^{137}Cs, and ^{129}I by gamma energy analysis	B2-57 and B2-58
^{14}C, ^{99}Tc, and ^{3}H by liquid scintillation counting	B2-56, B2-62, and B2-63
Uranium by laser fluorimetry	B2-66
Bulk density	B2-67
Particle size analysis	B2-68
Penetrometry	B2-69
pH	B2-70
Weight percent water by gravimetric analysis	B2-71
TIC and TOC by persulfate coulometry	B2-72 and B2-73
Historical sampling results	B2-74

The following subsections of Section B2.0 discuss the methods used in analyzing the core samples. Because of the large size of the data set, the discussion of all analytical procedures is presented first, followed by the data tables.

The four QC parameters assessed in conjunction with the tank 241-U-110 samples were standard recoveries, spike recoveries, duplicate analyses (relative percent differences [RPDs]), and blanks. No QC criteria were specified in the sampling and analysis

documentation (Winters et al. 1989); therefore, the QC parameters were evaluated against the *Hanford Analytical Services Quality Requirements Document* (DOE 1996). The criteria were 90 to 110 percent recovery for standards, <25 percent recovery for spikes, and ≤20 percent for RPDs and blanks. Assessment of the QC criteria is provided in Section B3.2.

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

B2.2 INORGANIC ANALYSES

B2.2.1 Atomic Absorption Spectroscopy

Three analytes were analyzed using AAS. Mercury was analyzed by cold vapor atomic absorption using procedure LA-325-102, whereas arsenic and selenium were analyzed using hydride atomic absorption per procedures LA-355-131 and LA-365-131, respectively. All three analytes reported water and acid digested analytical results, and mercury was also analyzed directly. The results from the analyses for arsenic, mercury, and selenium are reported in Tables B2-9, B2-23, and B2-30, respectively.

B2.2.2 Inductively Coupled Plasma

Analyses for cations were performed by ICP per procedure LA-505-151, and a full suite of analytes were reported. Water, acid, and fusion digestion results were reported for the composite level data, whereas acid digestions only were conducted on the segment level results. As stated in section B1.3, the nickel results for the ICP fusion analyses should be disregarded because the samples were prepared in a nickel crucible. The concentrations of metals in the samples are shown in Tables B2-7 through B2-45. The results from the composite samples are listed first, followed by the segment level data.

B2.2.3 Ion Chromatography

The samples for IC were prepared by water digestion and performed per procedure LA-533-105. These analyses were conducted on both the composite and segment level samples. The concentrations of anions by IC are shown in Tables B2-48 through B2-56.

B2.2.4 Ion Selective Electrode

Ammonia was analyzed on the water-digested composite samples using an ion-selective electrode according to procedure LA-631-001. The results are given in Table B2-46.

B2.2.5 Laser Fluorimetry

Uranium was analyzed by laser fluorimetry using procedure LA-925-106. Both composite and segment level results are reported in Table B2-66.

B2.2.6 Microdistillation and Spectrophotometric Determination

Cyanide analyses were performed directly at the composite level using procedures LA-695-101 and LA-695-102. The results are reported in Table B2-47.

B2.3 CARBON ANALYSES

Results for TIC and TOC were both obtained during the same analysis using procedure LA-622-102 following a water digestion preparation. The TOC content was determined for both the composite and the segment level samples, while the TIC content was determined for the composite samples only. The data for TIC and TOC are given in Tables B2-72 and B2-73, respectively.

B2.4 RADIONUCLIDE ANALYSES

B2.4.1 Alpha Energy Analysis

Aliquots of the composite level waste material were extracted and analyzed for the presence of ^{237}Np following procedure LA-933-141 for both water- and fusion-digested samples. The results are presented in Table B2-59.

B2.4.2 Alpha Proportional Counting

Aliquots of the composite level waste material were analyzed for total alpha activity following procedure LA-508-101 for both water- and fusion-digested samples. Segment level analyses were also conducted for fusion-digested samples only. The results are presented in Table B2-64.

B2.4.3 Alpha Spectrometry

Aliquots of the composite level waste material were analyzed for the presence of ^{241}Am and $^{239/240}Pu$ following procedure LA-503-156 for both water- and fusion-digested samples. The results are presented in Table B2-55 and B2-60.

B2.4.4 Beta Proportional Counting

Aliquots of the composite level waste material were analyzed for the presence of ^{90}Sr (after extraction) and total beta activity for both water and fusion digested samples. Total beta was also analyzed on the segment level following a fusion digestion. The results for ^{90}Sr and total beta activity are presented in Tables B2-61 and B2-65.

B2.4.5 Gamma Energy Analysis

Aliquots of the composite level waste material were analyzed for the presence of ^{137}Cs and ^{129}I for both water- and fusion-digested samples. Segment level fusion-digested samples were also analyzed for ^{137}Cs. Procedure LA-548-121 was used for the ^{137}Cs analyses, and the results are presented in Table B2-57. Procedure LA-378-101 was used for the ^{129}I, and the results are presented in Table B2-58.

B2.4.6 Liquid Scintillation Counting

Aliquots of the composite level waste material were analyzed for the presence of ^{14}C, ^{3}H, and ^{99}Tc with water digested samples, and ^{99}Tc was also analyzed following preparation by a fusion digestion. Procedure LA-348-104 was used for the ^{14}C analyses, and the results are presented in Table B2-56. Procedure LA-438-101 was used for the ^{99}Tc analyses, and the results are presented in Table B2-62. Procedure LA-218-114 was used for the ^{3}H analyses, and the results are presented in Table B2-63.

B2.5 PHYSICAL ANALYSES

B2.5.1 Bulk Density

Densities were measured directly on the segment level samples following procedure LA-510-112, and the results are presented in Table B2-67. The wide ranging results were most likely due to the method of volume approximation which did not account for any porous spaces in the waste material. Depending on the porosity of the waste at any location, the

bulk density of a sample will vary. Another consideration that needs to be made with this type of volume measurement is the void space created when a sample crumbles upon extrusion. For these reasons, a wide range in sample densities was expected.

B2.5.2 Particle Size Analysis

Particle size analysis was performed on each segment prior to homogenization using the Brinkmann particle size analyzer and following procedure LT-519-101. The output for these analyses can be found in the segment data packages (Winters 1993).

To perform particle size analysis, a small amount of sample is placed in a dispersant, which is a liquid used to disperse and suspend the particles from the solid sample. Water was used as the dispersant for cores 5, 6, 7, and segments 2 through 4 of core 14. A mixture of 75 percent glycerine and 25 percent ethanol by volume was used as the dispersant for cores 8, 12, 13, 15 and the first segment of core 14. The diameter of a solid particle in the dispersant can be determined by the amount of light that it blocks as the particle passes through a laser beam. Particle sizes below 0.5 microns cannot be detected by the analyzer.

The data assembled from the Brinkmann Analyzer consists primarily of a statistical summary of the particle size as well as several particle size density and distribution graphs. An example of the particle size analysis was given in Appendix E of Brown and Jensen (1993) for core 6 segment 4. The required confidence for all samples is 95 percent. There are two distributions of importance for this analysis. The first (number, length) represents the distribution of the diameter of the particles based upon the particle diameter, commonly called the number distribution. The second (number, volume) represents the distribution of the diameter of the particles based upon the volume of the particles, commonly called the volume distribution.

The mean particle size in the number distribution ranged from 0.90 microns to 1.96 microns in diameter (Table B2-68). The probability number density graph indicated that the most common particle size was 0.7 microns. The probability number distribution (cumulative) graph indicated that the majority (90 percent) of the identifiable particles fit within the narrow band of 0.4 to 1.5 microns. More than 99 percent of the particles had a diameter of less than 5 microns, which was characteristic of most of the segment samples taken. Although the above description generally fit most of the samples analyzed, all segment particle size analyses were different and the particle size analysis for each segment should be consulted for the broadest overview of the true particle sizes within the tank.

The average particle size in the volume distribution ranged from 2 microns to 12 microns in diameter. Under the assumption that the density of the solid crystalline material within the tank is effectively constant, the volume distribution is also the best estimation of the mass particle size distribution of the tank. As with the number distribution, the volume distribution is represented by a probability volume density graph and a probability volume distribution (cumulative) graph. The mean particle size in the volume distribution was

5 microns, considerably larger than that of the number distribution. The majority of the identifiable particles were within the range of 0.5 to 20 microns. It is important to point out that even though more than 99 percent of the particles for this particular sample had a diameter of less than 5 microns, about 50 percent of the volume (and hence the mass) of this sample was represented by particles with a diameter greater than 5 microns. Again, for the broadest overview of the particle volume distribution within the tank, all of the particle size analyses (for each segment) should be consulted.

As mentioned before, the dispersant used for about one half of the samples was water. Because of the presence of some immiscible organics (mostly HHF from the drilling operations), the other half of the samples was analyzed using an ethanol-glycerine mixture to avoid agglomeration. The primary concern involved with using these dispersants was the dissolving of the particulates. Any water soluble (or ethanol/glycerine soluble) particles existing in the tank will dissolve or decrease in size during the analysis. This means that the particle size analysis presented in the tank 241-U-110 data packages may not represent the true particle size distribution in the tank.

There is no recognizable difference in the particle size distribution curves between the water dispersant and the ethylene-glycerine dispersant analyses. A statistical analysis of the particle size data would have to be performed to prove if there is a difference or not.

B2.5.3 Penetrometry

Penetrometry measurements were performed on various segments from cores 5, 6, 7, 12, 13, 14 and 15. Penetrometry is a measurement of the force required to overcome the resistance of the waste to the penetrometer. A high penetrometer reading indicates that the waste is either hard or very cohesive, whereas a low reading indicates that the waste is soft. There is no noticeable trend or pattern in the penetrometer readings from segment to segment or from core to core. Table B2-69 shows the penetrometer readings. The mean penetrometer reading was 10.0 lbs/in^2.

B2.5.4 pH

The pH of the waste material was analyzed directly on the composite samples, whereas the segment level samples were analyzed both directly and following a water digestion. The pH was determined using a 1:1 mixture of the untreated sample with water. Procedure LA-212-103 was used in all cases. The results are presented in Table B2-70.

B2.5.5 Weight Percent Water by Gravimetric Analysis

Gravimetric analysis for estimating the weight percent water was conducted directly on segment and composite samples following procedure LA-564-101. The weight percent water was determined by drying the samples overnight in an oven and measuring the gravimetric difference in the masses. This procedure is similar to that of the TGA analysis except that the drying is slower and the temperature of drying is constant. Because this method of estimating weight percent water is considered more accurate than TGA, the gravimetric results are used in the overall mean estimates and all other evaluations in this report, and the TGA data are reported in Section B2.6 for informational purposes only. The gravimetric results are presented in Table B2-71.

B2.6 THERMODYNAMIC ANALYSES

The thermal analyses for tank 241-U-110 consisted of differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). These analyses were performed on the core composite data only (Winters 1993). The primary purpose of these thermal analyses was to detect any exothermic reactions that may occur in the waste material. The presence of an uncontrollable exothermic reaction would be a safety concern, especially if for any reason the waste was exposed to elevated temperatures that could trigger such a reaction. No exothermic reactions were found during the thermal analysis of tank 241-U-110 samples, as is shown by the thermal analysis portion of the data for the core composite data packages.

The second reason for performing these analyses was for the detection of any other reactions or change of state that may aid in characterizing the sample. The DSC analysis is used to detect reactions or changes of state that involve the release or absorption of energy. The TGA analysis is used to detect the loss of gaseous matter (usually water) from reactions or changes of state at elevated temperatures. For an example of the DSC and TGA analysis plots on the tank 241-U-110 core composites, refer to Appendix D of Brown and Jensen (1993). The plots are useful in understanding the thermal analysis of the core samples.

B2.6.1 Differential Scanning Calorimetry

In DSC analysis, heat absorbed or released by a sample is measured while the sample is exposed to a linear increase in temperature. While the substance was being heated, air was passed over the sample to remove any released gases. The magnitude and onset temperature for any endothermic or exothermic events were determined graphically.

Although the DSC scans differed for each core composite, the number and onset temperature of the endothermic peaks were noticeably similar for each core. Most of the DSC plots have two endotherms, one at about 100 °C (212 °F)and the other at about 330 °C (626 °F). Two hypotheses will be made to account for these two peaks. The first of these peaks probably

represents the evaporation of the water in the sample. The second of these peaks is suspected to be the dehydration of aluminum hydroxide to alumina and gaseous water as per the following equation:

$$Al(OH)_{3(s)} \rightarrow \frac{1}{2}Al_2O_{3(s)} + \frac{3}{2}H_2O_{(g)}\uparrow \qquad (\sim 300\ ^\circ C).$$

The location (temperature) of the water peak and aluminum hydroxide peak are summarized in Tables B2-2 and B2-4, respectively. These tables show the core composite number and the bottle number. The bottle number is a unique identification for each core composite sample that underwent thermal analysis. The start temperature, end temperature, and the maximum temperature are recorded on the table and are given in degrees Celsius. The last row on this table is the computed value of the heat supplied to the sample in calorie/gram.

Table B2-2. Differential Scanning Calorimetry of Tank 241-U-110 Core Composites - Water Evaporation Occurrence.[1]

Core Composite Number	Water Evaporation Peak			
	From °C	To °C	Maximum at Temperature °C	Heat Supplied to Sample (mcal/sec/g)
5	55	142	104	91.6
6	55	155	107	92.8
7	55	102	78	24.5
8	No water peak recorded			
12	55	165	117	132
13	55	190	125	139
14	54	133	80	11.2
15	55	140	98	69.5

Note:
[1]Brown and Jensen (1993)

Pure (dry) aluminum hydroxide was analyzed by DSC under the same conditions as the tank waste samples and then compared to the second peak of the core composite from core 8. Core 8 was chosen for this comparison because it consists only of the white layer characteristic to segment 1. Because of an error in the compilation of the data packages, this

comparison is found in the thermal analysis of core 5. Note that for such a comparison to be made, this particular graph was normalized. A normalized analysis shows the heat on a per gram basis so that both the pure aluminum hydroxide sample and the core 8 sample can be compared graphically despite their sample weights. This comparison is shown in Appendix D of Brown and Jensen (1993). As can be seen in Appendix D of Brown and Jensen (1993), the two peaks are very similar, thus suggesting that the endotherm encountered in the tank 241-U-110 samples at about 330 °C (626 °F) was the dehydration of aluminum hydroxide. Note that core composite number 8 showed no water peak and cores 12 and 13 showed no aluminum hydroxide peak, which was expected because cores 12 and 13 had no recovery in segment 1.

B2.6.2 Thermogravimetric Analysis

Thermogravimetric analysis measures the mass of a sample while its temperature is increased at a constant rate. Air was passed over the sample during heating to remove any released gases. Any decrease in the mass of the sample represents a loss of gaseous matter from the sample either through evaporation or through a reaction with gas phase products.

As with the DSC results, there are two noticeable mass losses in the TGA printouts. The first was attributed to the evaporation of water and occurred at about 100 °C. The second was attributed to the dehydration of aluminum hydroxide and occurred at about 330 °C. All eight core composites showed a water loss on the TGA but cores 12 and 13 did not show an aluminum hydroxide loss.

The losses observed for water evaporation and aluminum hydroxide dehydration are summarized in Tables B2-3 and B2-5, respectively. In these tables, the percent loss (gaseous water in both instances) is the difference between a start value and an end value. The starting point is the temperature at which the event started to occur and as a percent of remaining sample weight at the same point. The end event is presented in the same manner. The overall mass loss of the water (in both tables) is calculated as the difference between the start and end points. This number represents the percentage of the mass of the water evaporated (or dehydrated in the case of aluminum hydroxide) from the bulk of the sample and released to the air.

Because aluminum hydroxide is a white crystalline solid, it is suspected that the top layer of the tank is primarily composed of aluminum hydroxide (see Section 4.2). Furthermore, this top white layer of the waste is very dry in comparison to the rest of the tank waste. These two hypotheses may be confirmed in the thermal analysis graphs. In core 8, only the top white layer of waste material was recovered. The DSC for core 8 has no water peak and a very large aluminum hydroxide peak. The TGA for core 8 strongly suggests that very little water exists in this top layer but a very large quantity of aluminum hydroxide exists in the top layer. Table B2-5 indicates that more than 75 percent of the mass of this core composite is aluminum, and is composed exclusively of brown waste material. The DSC for both of these cores indicates a very large water peak but no aluminum hydroxide dehydration peak.

The rest of the cores are in between these two extremes, depending on how much of the top layer was recovered. Generally, the whiter samples have a larger aluminum hydroxide peak and the browner samples have a higher water peak. The theory that this white layer is aluminum hydroxide is further confirmed in Section B3.3.2, where it is shown that aluminum is the major constituent of the top layer.

Table B2-3. Thermogravimetric Analysis of U-110 Core Composites - Water Evaporation Occurrence.[1]

Core Composite Number	Water Evaporation Peak		
	From °C	To °C	Percent Water
5	43	136	11.1
6	42	134	19
7	43	125	5.98
8	43	149	5.67
12	42	149	29.1
13	42	135	29.1
14	43	130	18.4
15	43	125	14.4

Note:

[1]Brown and Jensen (1993)

Table B2-4. Differential Scanning Calorimetry of Tank 241-U-110 Core Composites - Aluminum Hydroxide Dehydration Peak.[1]

Core Composite Number	$Al(OH)_3$ Dehydration Peak			
	From °C	To °C	Maximum Temperature °C	Heat of $Al(OH)_3$ Decomposition (cal/g)
5	250	350	299	13.3
6	270	370	326	50.7
7	238	357	313	170
8	280	360	320	245
12	No $Al(OH)_3$ peak recorded			
13	No $Al(OH)_3$ peak recorded			
14	267	361	313	102
15	230	340	299	19.2

Note:
[1]Brown and Jensen (1993)

Table B2-5. Thermogravimetric Analysis of Tank 241-U-110 Core Composites - Aluminum Hydroxide Dehydration Loss.[1]

Core Composite Number	$Al(OH)_3$ Dehydration Peak				
	From °C	From %	To °C	To %	Wt%
5	235	87.9	348	85.1	2.83
6	226	80.3	348	75.7	4.53
7	227	93.5	350	78.4	15.1
8	240	94.3	368	67.8	26.5
12	No $Al(OH)_3$ peak recorded				
13	No $Al(OH)_3$ peak recorded				
14	240	81.1	349	70.8	10.3
15	244	84.8	329	80.7	4.1

Note:
[1]Brown and Jensen (1993)

In Section B3-5, aluminum will be presented as a key identifier for tank 241-U-110 waste. The high quantities of aluminum hydroxide identified in the top layer of the waste confirm this hypothesis.

B2.7 ANALYTICAL DATA TABLES

This section presents the tabulated raw analytical data for the various metals, anions, carbon compounds, radionuclides, and physical properties that were measured for tank 241-U-110 based on the 1989 sampling event. The location of the tables containing this information were outlined in Table B2-1, and Table B2-6 lists the abbreviations used for the different analytical methods. Each of the following data tables contains four columns. Column one identifies the analytical method by which the analyte was measured, including the digestion method used, if applicable. Column two identifies the sample number. Column three identifies the location of either the particular core composite sample, or the particular core:segment from which a sample was taken. Column four gives the sample mean, which is the average of the primary and duplicate sample.

Table B2-6. Standard Abbreviations Used to Describe Analytical Methods.

Metals:	ICP - inductively coupled plasma (generic for all metals unless otherwise known)
Anions:	IC - ion chromatography
	MD - microdistillation (cyanide)
	ISE - ion-specific electrode analysis (ammonia)
Carbon:	PC - persulfate coulometry
Radionuclides:	GEA - gamma energy analysis
	APC - alpha proportional counting
	BPC - beta proportional counting
	LSC - liquid scintillation counting
Radionuclides:	MS - mass spectrometry
	LF - laser fluorimetry
Physical properties:	DM - direct measurement
	TGA - thermogravimetric analysis

Table B2-7. Tank 241-U-110 Analytical Data: Aluminum. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	1.06E+05
	006	6	1.01E+05
	007	7	1.41E+05
	008	8	1.04E+05
	012	12	56,600
	013	13	56,800
	014	14	98,700
	015	15	77,300
ICP: fusion	005	5	1.13E+05
	006	6	96,400
	007	7	1.69E+05
	008	8	3.10E+05
	012	12	1.43E+05
	013	13	1.50E+05
	014	14	1.68E+05
	015	15	2.15E+05
ICP: water	005	5	4,610
	006	6	3,260
	007	7	2,390
	012	12	3,400
	013	13	2,840
	014	14	2,940
	015	15	5,140

Table B2-7. Tank 241-U-110 Analytical Data: Aluminum. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	1.27E+05
	89-041	5:4	36,300
	89-043	6:2	91,700
	89-044	6:3	89,700
	89-045	6:4	49,100
	89-046	7:1	85,400
	89-047	7:2	1.30E+05
	89-048	7:3	84,000
	89-049	7:4	56,200
	89-050	8:1	1.04E+05
	89-070	12:2	1.37E+05
	89-071	12:3	45,600
	89-072	12:4	42,600
	89-075	13:3	1.11E+05
	89-076	13:4	47,300
	89-077	14:1	72,400
	89-078	14:2	1.01E+05
	89-079	14:3	20,000
	89-080	14:4	52,700
	89-082	15:2	84,800
	89-083	15:3	89,700
	89-084	15:4	60,700

Table B2-8. Tank 241-U-110 Analytical Data: Antimony. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	007	7	444
	008	8	387
	012	12	337
	013	13	435
	014	14	324
	015	15	468
ICP: fusion	005	5	1,240
	006	6	< 1,160
	007	7	< 913
	008	8	< 1,260
	012	12	2,030
	013	13	1,570
	014	14	< 1,000
	015	15	1,390
ICP: water	005	5	< 298
	006	6	< 298
	007	7	< 306
	012	12	< 297
	013	13	< 155
	015	15	< 282

Table B2-8. Tank 241-U-110 Analytical Data: Antimony. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-043	6:2	445
	89-044	6:3	387
	89-045	6:4	< 263
	89-046	7:1	520
	89-047	7:2	413
	89-048	7:3	388
	89-049	7:4	< 265
	89-050	8:1	387
	89-070	12:2	1,500
	89-071	12:3	< 278
	89-072	12:4	709
	89-075	13:3	< 1,410
	89-076	13:4	< 277
	89-077	14:1	< 316
	89-078	14:2	198
	89-079	14:3	< 150
	89-080	14:4	< 263
	89-082	15:2	< 303
	89-083	15:3	729
	89-084	15:4	849

Table B2-9. Tank 241-U-110 Analytical Data: Arsenic. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	005	5	171
	006	6	184
	007	7	157
ICP: fusion	007	7	274
ICP: water	012	12	73.0
	013	13	< 36.5
	014	14	< 70.0
	015	15	< 66.0
Segment		**Core:Seg**	**µg/g**
ICP: acid	89-043	6:2	93.0
	89-044	6:3	75.0
	89-045	6:4	< 61.5
	89-046	7:1	154
	89-047	7:2	87.5
	89-048	7:3	78.5
	89-049	7:4	< 62.5
	89-070	12:2	< 345
	89-071	12:3	< 65.5
	89-072	12:4	127
	89-075	13:3	< 330
	89-076	13:4	< 65.5
	89-077	14:1	< 74.0
	89-078	14:2	96.0
	89-079	14:3	< 35.0
	89-080	14:4	< 62.0
	89-082	15:2	75.5
	89-083	15:3	1685
	89-084	15:4	165

Table B2-9. Tank 241-U-110 Analytical Data: Arsenic. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
AAS: acid	005	5	0.425
	006	6	0.425
	007	7	0.375
	008	8	< 0.453
	012	12	< 0.976
	013	13	< 1.02
	014	14	< 0.886
	015	15	< 1.13
Solid Core Composite		**Core Composite**	**µg/g**
AAS: water	005	5	< 0.500
	006	6	< 0.712
	007	7	0.294
	008	8	< 0.501
	012	12	< 0.497
	013	13	< 0.495
	014	14	0.490
	015	15	0.241

Table B2-10. Tank 241-U-110 Analytical Data: Barium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	67.5
	006	6	166
	007	7	35.0
	008	8	< 7.50
	012	12	40.0
	013	13	28.5
	014	14	21.5
	015	15	35.5
ICP: fusion	005	5	< 33.0
	006	6	< 36.0
	007	7	73.5
	008	8	< 34.5
	012	12	89.0
	013	13	< 43.0
	014	14	< 30.5
	015	15	59.0
Solid Core Composite		Core Composite	µg/g
ICP: water	005	5	< 8.00
	006	6	< 8.00
	007	7	< 8.50
	012	12	32.0
	014	14	9.50
	015	15	12.0

Table B2-10. Tank 241-U-110 Analytical Data: Barium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	373
	89-041	5:4	20.5
	89-043	6:2	56.0
	89-044	6:3	30.5
	89-045	6:4	< 7.00
	89-046	7:1	39.5
	89-047	7:2	17.5
	89-048	7:3	31.0
	89-049	7:4	< 7.50
	89-050	8:1	< 7.50
	89-070	12:2	168
	89-071	12:3	< 7.50
	89-072	12:4	64.5
	89-075	13:3	152
	89-076	13:4	17.5
	89-077	14:1	< 9.00
	89-078	14:2	34.0
	89-079	14:3	11.0
	89-080	14:4	11.5
	89-082	15:2	36.0
	89-083	15:3	68.5
	89-084	15:4	37.0

Table B2-11. Tank 241-U-110 Analytical Data: Beryllium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	3.50
	006	6	4.50
	007	7	1.50
	008	8	< 1.00
	012	12	1.50
	013	13	2.00
	014	14	1.50
	015	15	2.50
ICP: fusion	005	5	< 5.00
	006	6	< 4.50
	007	7	< 4.00
	008	8	< 5.50
	012	12	10.5
	013	13	< 6.50
	014	14	< 4.00
	015	15	7.50
ICP: water	005	5	< 1.00
	006	6	< 1.00
	007	7	< 1.00
	012	12	2.00
	013	13	< 1.00
	015	15	< 1.00

Table B2-11. Tank 241-U-110 Analytical Data: Beryllium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-043	6:2	2.00
	89-044	6:3	1.00
	89-045	6:4	< 1.00
	89-046	7:1	4.00
	89-047	7:2	1.00
	89-048	7:3	1.50
	89-049	7:4	< 1.00
	89-050	8:1	< 1.00
	89-070	12:2	< 6.00
	89-071	12:3	< 1.00
	89-072	12:4	4.00
	89-075	13:3	< 6.00
	89-076	13:4	1.50
	89-077	14:1	< 1.00
	89-078	14:2	< 1.00
	89-079	14:3	< 1.00
	89-080	14:4	< 1.00
	89-082	15:2	< 1.00
	89-083	15:3	3.50
	89-084	15:4	4.50

Table B2-12. Tank 241-U-110 Analytical Data: Bismuth. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	005	5	45,400
	006	6	20,100
	007	7	10,500
	008	8	< 240
	013	13	15,000
	014	14	8,320
	015	15	13,300
ICP: fusion	005	5	39,800
	006	6	13,900
	007	7	19,000
	008	8	< 1,110
	012	12	31,100
	014	14	8,940
	015	15	11,300
Solid Core Composite		**Core Composite**	**µg/g**
ICP: water	013	13	< 137
	014	14	< 264
Segment		**Core:Seg**	**µg/g**
ICP: acid	89-040	5:3	4,250
	89-041	5:4	20,300
	89-043	6:2	5,050
	89-044	6:3	19,500
	89-045	6:4	24,100

Table B2-12. Tank 241-U-110 Analytical Data: Bismuth. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
ICP: acid	89-046	7:1	527
	89-047	7:2	2,630
	89-048	7:3	12,400
	89-049	7:4	32,700
	89-050	8:1	< 240
	89-070	12:2	7,470
	89-071	12:3	39,300
	89-072	12:4	5,870
	89-075	13:3	13,800
	89-076	13:4	17,000
	89-077	14:1	< 280
	89-078	14:2	2,440
	89-079	14:3	2,730
	89-080	14:4	24,800
	89-082	15:2	3,870
	89-083	15:3	22,100
	89-084	15:4	47,300

Table B2-13. Tank 241-U-110 Analytical Data: Boron. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	57.0
	006	6	83.0
	007	7	< 23.0
	008	8	< 24.0
	012	12	103
	013	13	57.5
	014	14	51.5
	015	15	46.5
ICP: fusion	005	5	107
	006	6	367
	007	7	115
	008	8	302
	012	12	8,280
	013	13	690
	014	14	350
	015	15	9,080
Solid Core Composite		Core Composite	µg/g
ICP: water	005	5	447
	006	6	339
	007	7	282
	012	12	482
	013	13	229
	014	14	290
	015	15	248

Table B2-13. Tank 241-U-110 Analytical Data: Boron. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	383
	89-041	5:4	< 24.0
	89-043	6:2	44.5
	89-044	6:3	< 27.5
	89-045	6:4	< 23.0
	89-046	7:1	106
Segment		Core:Seg	µg/g
ICP: acid	89-047	7:2	< 25.5
	89-048	7:3	< 29.0
	89-049	7:4	< 23.0
	89-050	8:1	< 24.0
	89-070	12:2	< 129
	89-071	12:3	414
	89-072	12:4	517
	89-075	13:3	< 123
	89-076	13:4	46.5
	89-077	14:1	< 28.0
	89-078	14:2	19.0
	89-079	14:3	13.5
	89-080	14:4	88.0
	89-082	15:2	58.0
	89-083	15:3	95.5
	89-084	15:4	76.5

Table B2-14. Tank 241-U-110 Analytical Data: Cadmium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	005	5	21.0
	006	6	22.5
	007	7	15.0
	008	8	< 11.0
	012	12	< 12.0
	013	13	< 12.5
	014	14	11.5
	015	15	< 13.5
Solid Core Composite		**Core Composite**	**µg/g**
ICP: fusion	005	5	< 49.5
	006	6	< 47.5
	007	7	< 37.5
	008	8	< 51.5
	012	12	< 50.0
	013	13	< 64.0
	014	14	< 41.0
	015	15	< 51.5
ICP: water	005	5	< 12.0
	006	6	< 12.0
	007	7	< 12.5
	012	12	13.0
	013	13	< 6.00
	014	14	< 12.0
	015	15	< 11.5

Table B2-14. Tank 241-U-110 Analytical Data: Cadmium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	429
	89-041	5:4	< 136
	89-043	6:2	< 12.5
	89-044	6:3	< 12.5
	89-045	6:4	< 10.5
	89-046	7:1	17.5
	89-047	7:2	< 12.0
	89-048	7:3	< 13.5
	89-049	7:4	< 11.0
	89-050	8:1	< 11.0
	89-070	12:2	< 60.5
	89-071	12:3	< 11.5
	89-072	12:4	22.0
	89-075	13:3	< 57.5
	89-076	13:4	< 11.5
	89-077	14:1	< 13.0
	89-078	14:2	8.50
	89-079	14:3	< 6.00
	89-080	14:4	< 11.0
	89-082	15:2	< 12.5
	89-083	15:3	18.0
	89-084	15:4	22.0

Table B2-15. Tank 241-U-110 Analytical Data: Calcium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	005	5	559
	006	6	584
	007	7	338
	008	8	116
	012	12	603
	013	13	535
	014	14	294
	015	15	551
ICP: fusion	005	5	3,520
	006	6	1,440
	007	7	3,580
	008	8	3,290
	012	12	6,170
	013	13	4,380
	014	14	2,120
	015	15	1,190
Solid Core Composite		**Core Composite**	**µg/g**
ICP: water	005	5	53.0
	006	6	193
	007	7	162
	012	12	241
	013	13	22.5
	014	14	55.5
	015	15	164

Table B2-15. Tank 241-U-110 Analytical Data: Calcium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	567
	89-041	5:4	154
	89-043	6:2	1,000
	89-044	6:3	507
	89-045	6:4	703
	89-046	7:1	156
	89-047	7:2	319
	89-048	7:3	665
	89-049	7:4	514
	89-050	8:1	116
	89-070	12:2	949
	89-071	12:3	465
	89-072	12:4	504
	89-075	13:3	1,490
	89-076	13:4	377
	89-077	14:1	109
	89-078	14:2	258
	89-079	14:3	122
	89-080	14:4	303
	89-082	15:2	500
	89-083	15:3	626
	89-084	15:4	483

Table B2-16. Tank 241-U-110 Analytical Data: Cerium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	939
	006	6	1,050
	007	7	699
	008	8	< 388
	012	12	613
	013	13	< 438
	014	14	536
	015	15	526
ICP: fusion	007	7	1,740
	008	8	< 1,800
	012	12	2,810
	014	14	< 1,440
	015	15	1,970
ICP: water	005	5	< 427
	006	6	< 427
	007	7	< 438
	012	12	915
	013	13	222
	014	14	< 427
	015	15	< 403

Table B2-16. Tank 241-U-110 Analytical Data: Cerium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	< 215
	89-041	5:4	< 340
	89-043	6:2	441
	89-044	6:3	< 444
	89-045	6:4	< 377
	89-046	7:1	1,440
	89-047	7:2	< 412
	89-048	7:3	< 472
	89-049	7:4	< 380
	89-050	8:1	< 388
	89-070	12:2	2,410
	89-071	12:3	< 398
	89-072	12:4	907
	89-075	13:3	2,710
	89-076	13:4	< 397
	89-077	14:1	< 453
	89-078	14:2	< 248
	89-079	14:3	< 215
	89-080	14:4	< 377
	89-082	15:2	< 434
	89-083	15:3	943
	89-084	15:4	1,280

Table B2-17. Tank 241-U-110 Analytical Data: Chromium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	1,290
	006	6	623
	007	7	394
	008	8	< 11.0
	012	12	610
	013	13	567
	014	14	389
	015	15	420
ICP: fusion	005	5	625
	007	7	384
	012	12	740
	013	13	816
	015	15	318
ICP: water	005	5	892
	006	6	339
	007	7	164
	012	12	762
	013	13	734
	014	14	302
	015	15	297

Table B2-17. Tank 241-U-110 Analytical Data: Chromium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	1,190
	89-041	5:4	525
	89-043	6:2	480
	89-044	6:3	530
	89-045	6:4	154
	89-046	7:1	18.5
	89-047	7:2	231
	89-048	7:3	471
	89-049	7:4	172
	89-050	8:1	< 11.0
	89-070	12:2	1,280
	89-071	12:3	921
	89-072	12:4	810
	89-075	13:3	1,520
	89-076	13:4	1,180
	89-077	14:1	< 13.0
	89-078	14:2	383
	89-079	14:3	193
	89-080	14:4	349
	89-082	15:2	382
	89-083	15:3	1,020
	89-084	15:4	537

Table B2-18. Tank 241-U-110 Analytical Data: Lanthanum. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	75.0
	006	6	92.5
	008	8	< 40.0
	012	12	62.5
	013	13	66.0
	014	14	< 39.0
	015	15	62.0
ICP: fusion	005	5	< 180
	006	6	< 171
	007	7	< 136
	008	8	< 187
	014	14	< 149
	015	15	< 187
ICP: water	005	5	< 44.5
	006	6	< 44.0
	007	7	< 45.5
	012	12	74.5
	013	13	< 23.0
	014	14	< 44.0
	015	15	< 42.0

Table B2-18. Tank 241-U-110 Analytical Data: Lanthanum. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	297
	89-041	5:4	< 27.5
	89-043	6:2	57.0
	89-044	6:3	48.5
	89-045	6:4	< 39.0
	89-046	7:1	96.0
	89-047	7:2	< 42.5
	89-048	7:3	< 49.0
	89-049	7:4	< 39.5
	89-050	8:1	< 40.0
	89-070	12:2	304
	89-071	12:3	< 41.0
	89-072	12:4	92.5
	89-075	13:3	291
	89-076	13:4	< 41.0
	89-077	14:1	< 47.0
	89-078	14:2	< 25.5
	89-079	14:3	< 22.5
	89-080	14:4	40.0
	89-082	15:2	< 45.0
	89-083	15:3	84.5
	89-084	15:4	231

Table B2-19. Tank 241-U-110 Analytical Data: Lead. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	005	5	1,830
	006	6	858
	007	7	479
	008	8	313
	013	13	820
	014	14	505
	015	15	702
ICP: fusion	005	5	1,140
	006	6	< 331
	007	7	600
Solid Core Composite		**Core Composite**	**µg/g**
ICP: fusion	008	8	< 361
	012	12	1,550
	014	14	< 269
	015	15	1,080
ICP: water	013	13	111
	014	14	100

Table B2-19. Tank 241-U-110 Analytical Data: Lead. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	991
	89-041	5:4	< 1,220
	89-043	6:2	2,200
	89-044	6:3	407
	89-045	6:4	334
	89-046	7:1	483
	89-047	7:2	399
	89-048	7:3	547
	89-049	7:4	292
	89-050	8:1	313
	89-070	12:2	2,720
	89-071	12:3	315
	89-072	12:4	425
	89-075	13:3	1,910
	89-076	13:4	429
	89-077	14:1	< 91.0
	89-078	14:2	290
	89-079	14:3	< 43.5
	89-080	14:4	193
	89-082	15:2	369
	89-083	15:3	657
	89-084	15:4	880

Table B2-20. Tank 241-U-110 Analytical Data: Lithium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	22.0
	006	6	30.0
	007	7	16.0
	008	8	< 9.00
	012	12	11.5
	013	13	11.5
	014	14	19.0
	015	15	13.5
ICP: fusion	005	5	< 41.0
	006	6	< 38.5
	007	7	< 30.5
	008	8	< 42.5
	012	12	112
	013	13	53.0
	014	14	< 33.5
	015	15	71.5
ICP: water	005	5	< 10.0
	006	6	< 10.0
	007	7	< 10.5
	012	12	44.0
	013	13	8.00
	014	14	13.5
	015	15	12.5

Table B2-20. Tank 241-U-110 Analytical Data: Lithium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	494
	89-041	5:4	< 165
	89-043	6:2	11.5
	89-044	6:3	< 10.5
	89-045	6:4	< 9.00
	89-046	7:1	213
	89-047	7:2	< 9.50
	89-048	7:3	< 11.0
	89-049	7:4	< 9.00
	89-050	8:1	< 9.00
	89-070	12:2	91.0
	89-071	12:3	< 9.50
	89-072	12:4	26.0
	89-075	13:3	103
	89-076	13:4	< 9.50
	89-077	14:1	< 11.0
	89-078	14:2	< 5.50
	89-079	14:3	< 5.00
	89-080	14:4	< 9.00
	89-082	15:2	< 10.0
	89-083	15:3	24.5
	89-084	15:4	29.5

Table B2-21. Tank 241-U-110 Analytical Data: Magnesium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	655
	006	6	1,680
	007	7	333
	008	8	24.5
	012	12	489
	013	13	224
	014	14	289
	015	15	855
ICP: fusion	005	5	7,490
	006	6	2,110
	007	7	1,640
	008	8	572
	012	12	2,500
	013	13	1,830
	014	14	1,110
	015	15	1,150
ICP: water	005	5	196
	006	6	1,370
	007	7	498
	012	12	256
	013	13	82.5
	014	14	136
	015	15	129

Table B2-21. Tank 241-U-110 Analytical Data: Magnesium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	952
	89-041	5:4	125
	89-043	6:2	4,890
	89-044	6:3	2,000
	89-045	6:4	464
	89-046	7:1	116
	89-047	7:2	2,200
	89-048	7:3	7,430
	89-049	7:4	346
	89-050	8:1	24.5
	89-070	12:2	3,170
	89-071	12:3	429
	89-072	12:4	667
	89-075	13:3	777
	89-076	13:4	138
	89-077	14:1	101
	89-078	14:2	629
	89-079	14:3	41.0
	89-080	14:4	213
	89-082	15:2	1,040
	89-083	15:3	237
	89-084	15:4	714

Table B2-22. Tank 241-U-110 Analytical Data: Manganese. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	5,350
	006	6	3,830
	007	7	2,270
	008	8	43.5
	012	12	3,920
	013	13	5,490
	014	14	2,450
	015	15	5,310
ICP: fusion	005	5	4,930
	006	6	3,430
	007	7	2,250
	008	8	60.0
	012	12	4,370
	013	13	4,610
	014	14	2,250
	015	15	2,420
ICP: water	005	5	< 3.50
	006	6	< 3.00
	007	7	< 3.50
	012	12	6.00
	013	13	< 2.00
	014	14	< 3.00
	015	15	< 3.00

Table B2-22. Tank 241-U-110 Analytical Data: Manganese. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	5,240
	89-041	5:4	2,010
	89-043	6:2	6,660
	89-044	6:3	5,630
	89-045	6:4	213
	89-046	7:1	253
	89-047	7:2	3,910
	89-048	7:3	5,840
	89-049	7:4	380
	89-050	8:1	43.5
	89-070	12:2	8,870
	89-071	12:3	950
	89-072	12:4	6,200
	89-075	13:3	9,930
	89-076	13:4	3,740
	89-077	14:1	< 4.00
	89-078	14:2	3,430
	89-079	14:3	1,370
	89-080	14:4	899
	89-082	15:2	5,150
	89-083	15:3	5,780
	89-084	15:4	534

Table B2-23. Tank 241-U-110 Analytical Data: Mercury. (3 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	459
	006	6	694
	007	7	839
	008	8	< 10.0
	012	12	474
	013	13	< 11.5
	014	14	119
	015	15	45.0
ICP: fusion	005	5	< 46.0
	006	6	< 44.0
	007	7	< 35.0
	008	8	< 47.5
	012	12	80.5
	013	13	< 59.5
	014	14	664
	015	15	1,030
ICP: water	005	5	60.0
	006	6	39.5
	007	7	35.0
	012	12	46.5
	013	13	13.0
	014	14	12.5
	015	15	30.5

Table B2-23. Tank 241-U-110 Analytical Data: Mercury. (3 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
AAS: acid	005	5	0.0435
	006	6	1.51
	007	7	1.29
	008	8	0.301
	012	12	0.563
	013	13	0.564
	014	14	0.590
	015	15	16.2
AAS: water	005	5	< 0.145
	006	6	0.116
	007	7	< 0.174
	008	8	0.101
	012	12	0.0380
	013	13	0.0175
	014	14	< 0.246
	015	15	0.0390
AAS: direct	005	5	0.110
	006	6	3.72
	007	7	2.85
	008	8	0.428
	012	12	0.935
	013	13	1.14
	014	14	1.00
	015	15	1.95

Table B2-23. Tank 241-U-110 Analytical Data: Mercury. (3 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-043	6:2	41.5
	89-044	6:3	41.0
	89-045	6:4	< 10.0
	89-046	7:1	22.0
	89-047	7:2	< 11.0
	89-048	7:3	< 12.5
	89-049	7:4	36.0
	89-050	8:1	< 10.0
	89-070	12:2	< 55.5
	89-071	12:3	743
	89-072	12:4	1,430
	89-075	13:3	< 53.5
	89-076	13:4	411
	89-077	14:1	< 12.0
	89-078	14:2	28.0
	89-079	14:3	6.50
	89-080	14:4	132
	89-082	15:2	360
	89-083	15:3	942
	89-084	15:4	845

Table B2-24. Tank 241-U-110 Analytical Data: Molybdenum. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	005	5	61.0
	006	6	65.5
	007	7	59.5
	008	8	26.0
	012	12	22.0
	013	13	25.0
	014	14	29.5
	015	15	30.0
Solid Core Composite		**Core Composite**	**µg/g**
ICP: fusion	005	5	< 63.0
	006	6	< 59.5
	007	7	92.0
	008	8	< 65.0
	012	12	109
	013	13	< 81.0
	014	14	< 51.5
	015	15	74.0
ICP: water	005	5	< 15.5
	006	6	< 15.0
	007	7	< 15.5
	012	12	30.0
	013	13	10.0
	014	14	< 15.0
	015	15	< 14.5

Table B2-24. Tank 241-U-110 Analytical Data: Molybdenum. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	446
	89-041	5:4	< 146
	89-043	6:2	28.0
	89-044	6:3	22.5
	89-045	6:4	< 13.5
	89-046	7:1	64.5
	89-047	7:2	24.5
	89-048	7:3	21.0
	89-049	7:4	< 13.5
	89-050	8:1	26.0
	89-070	12:2	101
	89-071	12:3	< 14.5
	89-072	12:4	40.0
	89-075	13:3	101
	89-076	13:4	< 14.5
	89-077	14:1	< 16.0
	89-078	14:2	38.0
	89-079	14:3	9.50
	89-080	14:4	14.0
	89-082	15:2	< 15.5
	89-083	15:3	54.0
	89-084	15:4	52.5

Table B2-25. Tank 241-U-110 Analytical Data: Neodymium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	005	5	< 601
	006	6	738
	007	7	< 600
	014	14	626
ICP: fusion	007	7	< 2,050
	013	13	< 3,510
ICP: water	005	5	< 669
	006	6	< 669
	007	7	< 686
	012	12	< 667
	013	13	< 348
	014	14	< 669
	015	15	< 632
Segment		**Core:Seg**	**µg/g**
ICP: acid	89-040	5:3	325
	89-041	5:4	< 146
	89-043	6:2	< 684
	89-044	6:3	< 696
	89-045	6:4	< 590
	89-046	7:1	1,020
	89-047	7:2	645
	89-048	7:3	< 740
	89-049	7:4	< 595
	89-070	12:2	< 3.300

Table B2-25. Tank 241-U-110 Analytical Data: Neodymium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-071	12:3	< 624
	89-072	12:4	822
	89-075	13:3	< 3,160
	89-076	13:4	< 622
	89-078	14:2	< 388
	89-079	14:3	< 338
	89-080	14:4	< 590
	89-082	15:2	< 679
	89-083	15:3	718
	89-084	15:4	807

Table B2-26. Tank 241-U-110 Analytical Data: Nickel. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	184
	006	6	159
	007	7	104
	008	8	< 42.0
	012	12	98.5
	013	13	104
	014	14	64.0
	015	15	119
ICP: fusion	005	5	7,260
	006	6	6,040
	007	7	6,830
	008	8	2,570
	012	12	7,810
	013	13	7,750
	014	14	4,840
	015	15	6,150
ICP: water	005	5	< 46.0
	006	6	< 46.0
	007	7	< 47.5
	012	12	49.0
	013	13	< 24.0
	014	14	< 46.0
	015	15	< 43.5

Table B2-26. Tank 241-U-110 Analytical Data: Nickel. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	519
	89-041	5:4	< 92.0
	89-043	6:2	162
	89-044	6:3	123
	89-045	6:4	< 41.0
	89-046	7:1	71.5
	89-047	7:2	75.0
	89-048	7:3	128
	89-049	7:4	< 41.0
	89-050	8:1	< 42.0
	89-070	12:2	348
	89-071	12:3	< 43.0
	89-072	12:4	200
	89-075	13:3	347
	89-076	13:4	90.5
	89-077	14:1	< 49.0
	89-078	14:2	102
	89-079	14:3	< 41.0
	89-080	14:4	44.5
	89-082	15:2	127
	89-083	15:3	206
	89-084	15:4	101

Table B2-27. Tank 241-U-110 Analytical Data: Phosphorus. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	005	5	20,800
	006	6	24,200
	007	7	13,300
	014	14	13,400
	015	15	4,750
ICP: fusion	007	7	25,400
	012	12	13,700
	013	13	3,480
ICP: water	013	13	2,840
	014	14	16,200
Segment		**Core:Seg**	**µg/g**
ICP: acid	89-040	5:3	2,040
	89-041	5:4	9,220
	89-043	6:2	3,160
	89-044	6:3	11,700
	89-045	6:4	50,500
	89-046	7:1	515
	89-047	7:2	1,550
	89-048	7:3	13,700
	89-049	7:4	50,300
	89-070	12:2	1,520
	89-071	12:3	19,400
	89-072	12:4	1,870
	89-075	13:3	3,200

Table B2-27. Tank 241-U-110 Analytical Data: Phosphorus. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-076	13:4	3,630
	89-077	14:1	< 103
	89-078	14:2	866
	89-079	14:3	905
	89-080	14:4	40,900
	89-083	15:3	6,180
	89-084	15:4	44,900

Table B2-28. Tank 241-U-110 Analytical Data: Potassium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	005	5	958
	006	6	1,250
	007	7	1,280
	008	8	< 606
	012	12	< 652
	013	13	< 683
	014	14	723
	015	15	< 753
ICP: water	005	5	< 667
	006	6	< 666
	007	7	< 683
	012	12	1,600
	013	13	< 347
	014	14	< 667
	015	15	669
Segment		**Core:Seg**	**µg/g**
ICP: acid	89-040	5:3	589
	89-041	5:4	< 680
	89-043	6:2	< 681
	89-044	6:3	< 694
	89-045	6:4	< 588
	89-046	7:1	2,390
	89-047	7:2	< 642
	89-048	7:3	< 737

Table B2-28. Tank 241-U-110 Analytical Data: Potassium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-049	7:4	< 593
	89-050	8:1	< 606
	89-070	12:2	< 3,280
	89-071	12:3	< 622
	89-072	12:4	1,200
	89-075	13:3	3,470
	89-076	13:4	< 620
	89-077	14:1	< 706
	89-078	14:2	< 387
	89-079	14:3	< 336
	89-080	14:4	< 588
	89-082	15:2	< 677
	89-083	15:3	1,110
	89-084	15:4	1,280

Table B2-29. Tank 241-U-110 Analytical Data: Samarium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	793
	006	6	997
	007	7	653
	008	8	< 436
	012	12	571
	013	13	< 491
	014	14	613
	015	15	557
ICP: fusion	005	5	< 1,950
	006	6	< 1,850
	007	7	1,900
	008	8	< 2,020
	012	12	3,110
	013	13	< 2,510
	014	14	< 1,610
	015	15	1,310
Solid Core Composite		Core Composite	µg/g
ICP: water	013	13	262
	014	14	< 479
	89-043	6:2	484
	89-044	6:3	< 498
	89-045	6:4	< 422
	89-046	7:1	1,650
	89-047	7:2	< 462

Table B2-29. Tank 241-U-110 Analytical Data: Samarium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	89-048	7:3	< 530
	89-049	7:4	< 426
	89-050	8:1	< 436
	89-070	12:2	3,050
	89-071	12:3	< 447
	89-072	12:4	925
	89-075	13:3	3,310
	89-076	13:4	< 446
	89-077	14:1	< 508
	89-078	14:2	< 278
	89-079	14:3	< 242
	89-080	14:4	< 423
	89-082	15:2	< 486
	89-083	15:3	889
	89-084	15:4	1,020

Table B2-30. Tank 241-U-110 Analytical Data: Selenium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	1,300
	006	6	1,050
	007	7	873
	008	8	346
	012	12	546
	013	13	461
	014	14	501
	015	15	462
ICP: fusion	005	5	865
	006	6	< 765
	007	7	1,090
	008	8	< 835
	012	12	1,560
	013	13	< 1,040
	014	14	< 664
	015	15	1,150
ICP: water	005	5	256
	006	6	198
	007	7	< 203
	012	12	475
	013	13	272
	015	15	< 187

Table B2-30. Tank 241-U-110 Analytical Data: Selenium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-043	6:2	539
	89-044	6:3	467
	89-045	6:4	< 175
	89-046	7:1	614
	89-047	7:2	393
	89-048	7:3	365
	89-049	7:4	< 176
	89-050	8:1	346
	89-070	12:2	1,610
	89-071	12:3	232
	89-072	12:4	947
	89-075	13:3	1,630
	89-076	13:4	405
	89-077	14:1	< 210
	89-078	14:2	572
	89-079	14:3	147
	89-080	14:4	285
	89-082	15:2	391
	89-083	15:3	1,020
	89-084	15:4	876

Table B2-31. Tank 241-U-110 Analytical Data: Silicon. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	013	13	3,990
	015	15	3,570
ICP: fusion	005	5	20,000
	007	7	10,900
	013	13	35,800
ICP: water	013	13	1,100
	014	14	1,650
Segment		**Core:Seg**	**µg/g**
ICP: acid	89-040	5:3	2,810
	89-041	5:4	834
	89-043	6:2	2,960
	89-044	6:3	4,320
	89-045	6:4	2,480
	89-046	7:1	625
	89-047	7:2	4,430
	89-048	7:3	4,300
	89-049	7:4	2,270
	89-070	12:2	3,900
	89-071	12:3	2,510
	89-072	12:4	2,940
	89-075	13:3	4,480
	89-076	13:4	386
	89-077	14:1	< 105
	89-078	14:2	2,200

Table B2-31. Tank 241-U-110 Analytical Data: Silicon. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-079	14:3	1,550
	89-080	14:4	2,900
	89-082	15:2	2,520
	89-083	15:3	3,660
	89-084	15:4	4,700

Table B2-32. Tank 241-U-110 Analytical Data: Silver. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	66.5
	006	6	88.0
	007	7	61.5
	008	8	< 52.0
	012	12	< 56.0
	013	13	< 58.5
	014	14	55.0
	015	15	< 65.0
ICP: fusion	005	5	< 234
	006	6	< 222
	007	7	< 176
	008	8	< 242
	012	12	271
	013	13	< 301
	014	14	< 193
	015	15	< 243
ICP: water	005	5	< 57.5
	006	6	< 57.5
	007	7	< 59.0
	012	12	70.5
	013	13	< 30.0
	014	14	< 57.0
	015	15	< 54.5

Table B2-32. Tank 241-U-110 Analytical Data: Silver. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	269
	89-041	5:4	< 14.5
	89-043	6:2	< 59.0
	89-044	6:3	< 59.5
	89-045	6:4	< 50.5
	89-046	7:1	105
	89-047	7:2	< 55.5
	89-048	7:3	< 63.5
	89-049	7:4	< 51.0
	89-050	8:1	< 52.0
	89-070	12:2	< 283
	89-071	12:3	< 53.5
	89-072	12:4	85.5
	89-075	13:3	< 271
	89-076	13:4	< 53.5
	89-077	14:1	< 61.0
	89-078	14:2	< 33.5
	89-079	14:3	< 29.0
	89-080	14:4	< 50.5
	89-082	15:2	< 58.5
	89-083	15:3	78.5
	89-084	15:4	90.5

Table B2-33. Tank 241-U-110 Analytical Data: Sodium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	1.53E+05
	006	6	1.08E+05
	007	7	72,500
	008	8	619
	012	12	81,100
	013	13	73,700
	014	14	82,500
	015	15	82,700
ICP: fusion	005	5	1.43E+05
	006	6	1.30E+05
	007	7	1.06E+05
	008	8	5,050
	012	12	1.14E+05
	013	13	79,400
	014	14	1.11E+05
	015	15	96,500
ICP: water	005	5	1.14E+05
	006	6	90,700
	007	7	53,000
	012	12	86,700
	013	13	62,800
	014	14	78,700
	015	15	78,900

Table B2-33. Tank 241-U-110 Analytical Data: Sodium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	78,200
	89-041	5:4	65,500
	89-043	6:2	77,700
	89-044	6:3	87,600
	89-045	6:4	1.79E+05
	89-046	7:1	2,900
	89-047	7:2	49,100
	89-048	7:3	85,800
	89-049	7:4	1.89E+05
	89-050	8:1	619
	89-070	12:2	80,300
	89-071	12:3	1.13E+05
	89-072	12:4	49,900
	89-075	13:3	78,400
	89-076	13:4	89,500
	89-077	14:1	< 161
	89-078	14:2	45,000
	89-079	14:3	20,700
	89-080	14:4	1.51E+05
	89-082	15:2	64,500
	89-083	15:3	81,700
	89-084	15:4	1.81E+05

Table B2-34. Tank 241-U-110 Analytical Data: Strontium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	717
	006	6	498
	007	7	344
	008	8	< 3.00
	012	12	475
	013	13	519
	014	14	251
	015	15	626
ICP: fusion	005	5	662
	006	6	405
	007	7	469
	008	8	22.0
	012	12	764
	013	13	573
	014	14	335
	015	15	326
ICP: water	005	5	< 3.00
	006	6	< 3.00
	007	7	< 3.00
	012	12	11.5
	013	13	11.5
	014	14	4.00
	015	15	3.50

Table B2-34. Tank 241-U-110 Analytical Data: Strontium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	709
	89-041	5:4	246
	89-043	6:2	767
	89-044	6:3	547
	89-045	6:4	113
	89-046	7:1	64.0
	89-047	7:2	478
	89-048	7:3	586
	89-049	7:4	218
	89-050	8:1	< 3.00
	89-070	12:2	1,240
	89-071	12:3	233
	89-072	12:4	591
	89-075	13:3	923
	89-076	13:4	339
	89-077	14:1	< 3.00
	89-078	14:2	405
	89-079	14:3	127
	89-080	14:4	152
	89-082	15:2	586
	89-083	15:3	727
	89-084	15:4	318

Table B2-35. Tank 241-U-110 Analytical Data: Sulfur. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	2,080
	006	6	465
	007	7	203
	008	8	61.0
	012	12	612
	013	13	795
	014	14	383
	015	15	439
ICP: fusion	005	5	1,590
	006	6	294
	007	7	453
	008	8	< 216
	012	12	1,250
	013	13	782
	014	14	407
	015	15	825
ICP: water	005	5	1,380
	006	6	416
	007	7	169
	012	12	877
	013	13	761
	014	14	640
	015	15	248

Table B2-35. Tank 241-U-110 Analytical Data: Sulfur. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-043	6:2	444
	89-044	6:3	435
	89-045	6:4	196
	89-046	7:1	179
	89-047	7:2	191
	89-048	7:3	1,180
	89-049	7:4	96.0
	89-050	8:1	61.0
	89-070	12:2	1,130
	89-071	12:3	684
	89-072	12:4	818
	89-075	13:3	1,330
	89-076	13:4	1,110
	89-077	14:1	< 54.0
	89-078	14:2	220
	89-079	14:3	168
	89-080	14:4	400
	89-082	15:2	165
	89-083	15:3	366
	89-084	15:4	318

Table B2-36. Tank 241-U-110 Analytical Data: Tantalum. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	199
	006	6	212
	007	7	151
	008	8	< 78.0
	012	12	93.5
	013	13	< 88.0
	014	14	93.5
	015	15	104
ICP: fusion	005	5	< 349
	006	6	< 331
	007	7	282
	008	8	< 361
	012	12	441
	013	13	< 449
	014	14	< 287
	015	15	< 362
ICP: water	005	5	< 86.0
	006	6	< 86.0
	007	7	< 87.5
	012	12	138
	013	13	< 44.5
	014	14	< 86.0
	015	15	< 80.5

Table B2-36. Tank 241-U-110 Analytical Data: Tantalum. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	484
	89-041	5:4	< 272
	89-043	6:2	92.5
	89-044	6:3	< 89.0
	89-045	6:4	< 75.5
	89-046	7:1	213
	89-047	7:2	< 82.5
	89-048	7:3	< 94.5
	89-049	7:4	< 76.0
	89-050	8:1	< 78.0
	89-070	12:2	< 423
	89-071	12:3	< 80.0
	89-072	12:4	183
	89-075	13:3	< 405
	89-076	13:4	< 79.5
	89-077	14:1	< 91.0
	89-078	14:2	< 49.5
	89-079	14:3	< 43.5
	89-080	14:4	< 75.5
	89-082	15:2	< 87.0
	89-083	15:3	196
	89-084	15:4	254

Table B2-37. Tank 241-U-110 Analytical Data: Thallium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	4,860
	006	6	4,550
	007	7	2,770
	008	8	< 125
	013	13	477
	014	14	576
	015	15	860
ICP: fusion	005	5	< 559
	006	6	< 530
	007	7	18,600
	008	8	< 578
	012	12	3,330
	013	13	< 720
	014	14	644
	015	15	1,930
ICP: water	005	5	< 138
	006	6	411
	007	7	593
	012	12	1,140
	013	13	358
	015	15	271

Table B2-37. Tank 241-U-110 Analytical Data: Thallium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-043	6:2	937
	89-044	6:3	200
	89-045	6:4	< 121
	89-046	7:1	10,000
	89-047	7:2	2,280
	89-048	7:3	466
	89-049	7:4	< 122
	89-050	8:1	< 125
	89-070	12:2	4,330
	89-071	12:3	< 128
	89-072	12:4	3,200
	89-075	13:3	3,770
	89-076	13:4	417
	89-077	14:1	< 146
	89-078	14:2	662
	89-079	14:3	158
	89-080	14:4	< 111
	89-082	15:2	859
	89-083	15:3	5,700
	89-084	15:4	4,270

Table B2-38. Tank 241-U-110 Analytical Data: Thorium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	005	5	2,510
	006	6	2,830
	007	7	719
	008	8	59.0
	013	13	1,070
	014	14	254
	015	15	254
ICP: fusion	005	5	< 156
	006	6	< 148
	007	7	7,210
	008	8	< 162
	012	12	1,620
	013	13	< 201
	014	14	< 129
	015	15	821
ICP: water	013	13	115
	014	14	188
Segment		**Core:Seg**	**µg/g**
ICP: acid	89-043	6:2	258
	89-044	6:3	< 40.0
	89-045	6:4	< 34.0
	89-046	7:1	4,830
	89-047	7:2	< 37.0

Table B2-38. Tank 241-U-110 Analytical Data: Thorium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-048	7:3	102
	89-049	7:4	< 34.0
	89-050	8:1	59.0
	89-070	12:2	1,880
	89-071	12:3	< 36.0
	89-072	12:4	1,510
	89-075	13:3	1,920
	89-076	13:4	< 35.5
	89-077	14:1	< 41.0
	89-078	14:2	136
	89-079	14:3	47.0
	89-080	14:4	124
	89-082	15:2	66.5
	89-083	15:3	2,790
	89-084	15:4	2,730

Table B2-39. Tank 241-U-110 Analytical Data: Tin. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	005	5	146
	006	6	153
	007	7	129
	008	8	57.0
	012	12	74.0
	013	13	56.0
	014	14	70.5
	015	15	73.5
ICP: fusion	005	5	< 184
	006	6	< 175
	007	7	154
	008	8	< 191
	012	12	252
	013	13	< 237
	014	14	< 152
	015	15	211
Solid Core Composite		**Core Composite**	**µg/g**
ICP: water	005	5	< 45.0
	006	6	< 45.0
	007	7	< 46.5
	012	12	52.5
	013	13	< 23.5
	015	15	< 42.5

Table B2-39. Tank 241-U-110 Analytical Data: Tin. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	460
	89-041	5:4	< 146
	89-043	6:2	82.5
	89-044	6:3	49.0
	89-045	6:4	< 39.5
	89-046	7:1	123
	89-047	7:2	59.5
	89-048	7:3	61.0
	89-049	7:4	< 40.5
	89-050	8:1	57.0
	89-070	12:2	< 223
	89-071	12:3	< 42.0
	89-072	12:4	105
	89-075	13:3	< 214
	89-076	13:4	< 42.0
	89-077	14:1	< 48.5
	89-078	14:2	92.5
	89-079	14:3	24.0
	89-080	14:4	57.5
	89-082	15:2	84.5
	89-083	15:3	138
	89-084	15:4	141

Table B2-40. Tank 241-U-110 Analytical Data: Titanium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	67.0
	006	6	91.0
	007	7	55.5
	008	8	10.5
	012	12	25.0
	013	13	19.5
	014	14	28.5
	015	15	53.5
ICP: fusion	005	5	< 44.5
	006	6	< 42.5
	007	7	78.5
	008	8	< 46.5
	012	12	106
	013	13	< 57.5
	014	14	< 36.5
	015	15	67.5
ICP: fusion	005	5	< 11.0
	006	6	< 11.0
	007	7	< 11.5
	012	12	41.5
	013	13	8.50
	014	14	< 11.0
	015	15	12.0

Table B2-40. Tank 241-U-110 Analytical Data: Titanium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	480
	89-041	5:4	< 19.5
	89-043	6:2	135
	89-044	6:3	16.5
	89-045	6:4	< 9.50
	89-046	7:1	71.0
	89-047	7:2	30.0
	89-048	7:3	19.5
	89-049	7:4	< 10.0
	89-050	8:1	10.5
	89-070	12:2	233
	89-071	12:3	< 10.0
	89-072	12:4	42.5
	89-075	13:3	130
	89-076	13:4	< 10.0
	89-077	14:1	< 12.0
	89-078	14:2	43.5
	89-079	14:3	6.50
	89-080	14:4	10.5
	89-082	15:2	76.5
	89-083	15:3	55.0
	89-084	15:4	62.0

Table B2-41. Tank 241-U-110 Analytical Data: Tungsten.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: fusion	007	7	410
Segment		Core:Seg	µg/g
ICP: acid	89-043	6:2	126
	89-044	6:3	103
	89-045	6:4	< 75.5
	89-046	7:1	245
	89-047	7:2	112
	89-048	7:3	150
	89-049	7:4	84.0
	89-070	12:2	< 423
	89-071	12:3	< 80.0
	89-072	12:4	181
	89-075	13:3	< 405
	89-076	13:4	< 79.5
	89-077	14:1	< 91.0
	89-078	14:2	199
	89-079	14:3	51.0
	89-080	14:4	< 75.5
	89-082	15:2	< 87.0
	89-083	15:3	238
	89-084	15:4	244

Table B2-42. Tank 241-U-110 Analytical Data: Uranium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
ICP: acid	005	5	11,400
	006	6	12,400
	008	8	< 3,260
	013	13	6,120
	014	14	5,970
	015	15	8,330
ICP: fusion	005	5	< 14,600
	006	6	< 13,900
	007	7	15,100
	008	8	< 15,100
	014	14	< 12,000
ICP: water	013	13	< 1,860
	014	14	< 3,580
Segment		**Core:Seg**	**µg/g**
ICP: acid	89-043	6:2	13,500
	89-044	6:3	4,650
	89-045	6:4	< 3,160
	89-046	7:1	9,350
	89-047	7:2	7,090
	89-048	7:3	4,980
	89-049	7:4	< 3,190
	89-050	8:1	< 3,260
	89-070	12:2	38,200
	89-071	12:3	< 3,340

Table B2-42. Tank 241-U-110 Analytical Data: Uranium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-072	12:4	11,900
	89-075	13:3	25,900
	89-076	13:4	3,680
	89-077	14:1	< 3,800
	89-078	14:2	8,860
	89-079	14:3	1,830
	89-080	14:4	< 3,160
	89-082	15:2	11,100
	89-083	15:3	12,600
	89-084	15:4	8,310

Table B2-43. Tank 241-U-110 Analytical Data: Vanadium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	80.0
	006	6	83.5
	007	7	47.5
	008	8	< 35.5
	012	12	50.0
	013	13	< 40.0
	014	14	44.0
	015	15	59.5
ICP: fusion	005	5	< 159
	006	6	< 151
	007	7	144
	008	8	< 164
	012	12	218
	013	13	< 204
	014	14	< 131
	015	15	< 165
Solid Core Composite		Core Composite	µg/g
ICP: water	005	5	< 39.0
	006	6	< 39.0
	007	7	< 40.0
	012	12	53.0
	013	13	20.5
	015	15	37.0

Table B2-43. Tank 241-U-110 Analytical Data: Vanadium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-043	6:2	66.0
	89-044	6:3	< 40.5
	89-045	6:4	< 34.5
	89-046	7:1	99.0
	89-047	7:2	39.5
	89-048	7:3	44.5
	89-049	7:4	< 34.5
	89-050	8:1	< 35.5
	89-070	12:2	237
	89-071	12:3	< 36.0
	89-072	12:4	76.0
	89-075	13:3	189
	89-076	13:4	< 36.0
	89-077	14:1	< 41.0
	89-078	14:2	38.0
	89-079	14:3	< 19.5
	89-080	14:4	< 34.5
	89-082	15:2	53.0
	89-083	15:3	89.0
	89-084	15:4	72.0

Table B2-44. Tank 241-U-110 Analytical Data: Zinc. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	195
	006	6	150
	007	7	76.0
	008	8	102
	012	12	156
	013	13	1,130
	014	14	202
	015	15	276
ICP: fusion	005	5	5,810
	006	6	112
	007	7	189
	008	8	104
	012	12	618
	013	13	426
	014	14	176
	015	15	223
ICP: water	005	5	19.5
	006	6	37.5
	007	7	17.0
	012	12	30.0
	013	13	6.50
	014	14	34.5
	015	15	16.0

Table B2-44. Tank 241-U-110 Analytical Data: Zinc. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	482
	89-041	5:4	53.5
	89-043	6:2	505
	89-044	6:3	238
	89-045	6:4	2,760
	89-046	7:1	41.5
	89-047	7:2	126
	89-048	7:3	435
	89-049	7:4	171
	89-050	8:1	102
	89-070	12:2	368
	89-071	12:3	208
	89-072	12:4	80.0
	89-075	13:3	254
	89-076	13:4	192
	89-077	14:1	9.00
	89-078	14:2	38.0
	89-079	14:3	11.5
	89-080	14:4	907
	89-082	15:2	147
	89-083	15:3	116
	89-084	15:4	98.0

Table B2-45. Tank 241-U-110 Analytical Data: Zirconium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ICP: acid	005	5	244
	006	6	171
	007	7	126
	008	8	< 40.0
	012	12	85.0
	013	13	89.0
	014	14	100
	015	15	125
ICP: fusion	005	5	< 180
	006	6	< 172
	007	7	289
	008	8	< 187
	012	12	481
	013	13	< 232
	014	14	< 149
	015	15	272
ICP: water	005	5	< 45.0
	006	6	< 44.0
	007	7	< 45.5
	012	12	114
	013	13	25.0
	014	14	< 44.0
	015	15	< 42.0

Table B2-45. Tank 241-U-110 Analytical Data: Zirconium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
ICP: acid	89-040	5:3	488
	89-041	5:4	< 141
	89-043	6:2	71.0
	89-044	6:3	64.0
	89-045	6:4	65.5
	89-046	7:1	174
	89-047	7:2	< 42.5
	89-048	7:3	49.0
	89-049	7:4	< 39.5
	89-050	8:1	< 40.0
	89-070	12:2	453
	89-071	12:3	< 41.0
	89-072	12:4	195
	89-075	13:3	292
	89-076	13:4	70.5
	89-077	14:1	< 47.0
	89-078	14:2	73.5
	89-079	14:3	31.5
	89-080	14:4	85.5
	89-082	15:2	72.0
	89-083	15:3	144
	89-084	15:4	269

Table B2-46. Tank 241-U-110 Analytical Data: Ammonia.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
ISE: water	005	5	< 11,900
	006	6	< 16,400
	007	7	< 1,690
	008	8	< 5,320
	012	12	< 5,250
	013	13	< 4,750
	014	14	< 5,350
	015	15	< 4,120

Table B2-47. Tank 241-U-110 Analytical Data: Cyanide.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
MD: direct	005	5	< 2.08
	006	6	< 0.125
	007	7	< 1.00
	008	8	< 1,150
	012	12	< 7,340
	013	13	< 9.50
	014	14	< 0.825
	015	15	< 5.50

Table B2-48. Tank 241-U-110 Analytical Data: Carbonate.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
IC: water	005	5	2,730
	007	7	5,190
	012	12	7,270
	013	13	8,320
	014	14	1,230

Table B2-49. Tank 241-U-110 Analytical Data: Chloride. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
IC: water	005	5	< 1,010
	006	6	< 1,440
	007	7	941
	008	8	31.0
	012	12	< 1,220
	013	13	< 512
	014	14	< 1,010
	015	15	1,100
Segment		**Core:Seg**	**µg/g**
IC: water	89-040	5:3	1,550
	89-041	5:4	< 1,090
	89-043	6:2	< 1,300
	89-044	6:3	< 1,130
	89-045	6:4	< 966
	89-046	7:1	56.5
	89-047	7:2	< 1,180
	89-048	7:3	< 1,190
	89-049	7:4	< 1,010
	89-050	8:1	31.4
	89-070	12:2	1,650
	89-071	12:3	1,970
	89-072	12:4	1,340
	89-075	13:3	1,690

Table B2-49. Tank 241-U-110 Analytical Data: Chloride. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
IC: water	89-076	13:4	2,390
	89-077	14:1	12.6
	89-078	14:2	744
	89-079	14:3	1,320
	89-080	14:4	< 563
	89-082	15:2	< 1,130
	89-083	15:3	1,240
	89-084	15:4	< 995

Table B2-50. Tank 241-U-110 Analytical Data: Fluoride. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
IC: water	005	5	9,290
	006	6	5,720
	007	7	5,900
	008	8	30.0
	012	12	9,040
	013	13	4,270
	014	14	8,960
	015	15	6,200
Segment		**Core:Seg**	**µg/g**
IC: water	89-040	5:3	1,420
	89-041	5:4	21,800
	89-043	6:2	< 986
	89-044	6:3	3,200
	89-045	6:4	17,900
	89-046	7:1	< 19.5
	89-047	7:2	< 1,180
	89-048	7:3	3,030
	89-049	7:4	15,600
	89-050	8:1	1,170
	89-070	12:2	1,570
	89-071	12:3	15,600
	89-072	12:4	1,670
	89-075	13:3	1,730

Table B2-50. Tank 241-U-110 Analytical Data: Fluoride. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
IC: water	89-076	13:4	2,970
	89-077	14:1	< 10.5
	89-078	14:2	524
	89-079	14:3	3,230
	89-080	14:4	19,600
	89-082	15:2	1,310
	89-083	15:3	3,550
	89-084	15:4	24,100

Table B2-51. Tank 241-U-110 Analytical Data: Nitrate. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
IC: water	005	5	48,300
	006	6	45,700
	007	7	28,200
	008	8	279
	012	12	50,100
	013	13	60,100
	014	14	35,300
Segment		Core:Seg	µg/g
IC: water	89-040	5:3	73,800
	015	15	48,300
	89-041	5:4	62,700
	89-043	6:2	49,800
	89-044	6:3	52,300
	89-045	6:4	26,100
	89-046	7:1	194
	89-047	7:2	27,900
	89-048	7:3	39,800
	89-049	7:4	27,700
	89-050	8:1	279
	89-070	12:2	31,200
	89-071	12:3	69,900
	89-072	12:4	54,000
	89-075	13:3	54,200

Table B2-51. Tank 241-U-110 Analytical Data: Nitrate. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
IC: water	89-076	13:4	83,500
	89-077	14:1	< 105
	89-078	14:2	36,500
	89-079	14:3	61,400
	89-080	14:4	30,400
	89-082	15:2	32,200
	89-083	15:3	45,800
	89-084	15:4	33,600

Table B2-52. Tank 241-U-110 Analytical Data: Nitrite.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
IC: water	005	5	10,400
	006	6	10,100
	007	7	4,850
	008	8	12,600
	012	12	< 43.5
	013	13	12,100
	014	14	8,390
	015	15	9,140

Table B2-53. Tank 241-U-110 Analytical Data: Phosphate. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
IC: water	005	5	19,700
	006	6	35,100
	007	7	36,200
	008	8	163
	012	12	43,500
	013	13	15,100
	014	14	51,700
	015	15	26,000
Segment		Core:Seg	µg/g
IC: water	89-040	5:3	10,500
	89-041	5:4	44,700
	89-043	6:2	< 9,860
	89-044	6:3	23,800
	89-045	6:4	1.53E+05
	89-046	7:1	216
	89-047	7:2	< 11,800
	89-048	7:3	18,500
	89-049	7:4	1.23E+05
	89-050	8:1	163
	89-070	12:2	< 9,630
	89-071	12:3	50,500
	89-072	12:4	< 10,200

Table B2-53. Tank 241-U-110 Analytical Data: Phosphate. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
IC: water	89-075	13:3	< 7,930
	89-076	13:4	< 10,500
	89-077	14:1	< 105
	89-078	14:2	1,880
	89-079	14:3	13,900
	89-080	14:4	1.38E+05
	89-082	15:2	< 11,300
	89-083	15:3	19,200
	89-084	15:4	99,700

Table B2-54. Tank 241-U-110 Analytical Data: Sulfate. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg/g**
IC: water	005	5	7,620
	006	6	< 14,400
	007	7	< 2,070
	008	8	< 201
	012	12	< 12,200
	013	13	< 10,600
	014	14	< 10,100
	015	15	< 5,050
Segment		**Core:Seg**	**µg/g**
IC: water	89-040	5:3	2,440
	89-041	5:4	5,360
	89-043	6:2	< 9,860
	89-044	6:3	< 11,300
	89-045	6:4	< 9,660
	89-046	7:1	< 196
	89-047	7:2	< 11,800
	89-048	7:3	< 11,900
	89-049	7:4	< 10,100
	89-050	8:1	< 201
	89-070	12:2	2,940
	89-071	12:3	4,930
	89-072	12:4	3,860
	89-075	13:3	3,790

Table B2-54. Tank 241-U-110 Analytical Data: Sulfate. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
IC: water	89-076	13:4	5,120
	89-077	14:1	< 105
	89-078	14:2	1,700
	89-079	14:3	2,930
	89-080	14:4	< 5,630
	89-082	15:2	< 11,300
	89-083	15:3	< 10,300
	89-084	15:4	< 9,950

Table B2-55. Tank 241-U-110 Analytical Data: Americium-241.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core	µCi/g
GEA: fusion	005	5	0.0700
	006	6	0.119
	007	7	0.0650
	008	8	0.0116
	013	13	0.132
	014	14	0.0631
	015	15	0.0736
GEA: water	005	5	< 0.00110
	006	6	< 0.00257
	007	7	< 0.00190
	008	8	< 0.00185
	012	12	< 0.00373
	013	13	< 0.00144
	014	14	< 0.00201
	015	15	< 9.88E-04

Table B2-56. Tank 241-U-110 Analytical Data: Carbon-14.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µCi/g
LSC: water	005	5	4.75E-04
	006	6	2.18E-04
	007	7	< 1.12E-04
	008	8	< 1.13E-04
	012	12	4.41E-04
	013	13	4.99E-04
	014	14	1.46E-04
	015	15	1.59E-04

Table B2-57. Tank 241-U-110 Analytical Data: Cesium-137. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core:Seg	μCi/g
GEA: fusion	005	5	38.3
	006	6	23.0
	007	7	17.8
	008	8	0.395
	012	12	53.6
	013	13	30.0
	014	14	17.7
	015	15	17.3
GEA: water	005	5	13.8
	006	6	5.74
	007	7	2.13
	008	8	0.258
	012	12	8.64
	013	13	9.25
	014	14	5.88
	015	15	5.28
Segment		Core:Seg	μCi/g
GEA: fusion	89-040	5:3	34.6
	89-041	5:4	45.7
	89-043	6:2	33.9
	89-044	6:3	23.2
	89-045	6:4	21.1

Table B2-57. Tank 241-U-110 Analytical Data: Cesium-137. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	μCi/g
GEA: fusion	89-046	7:1	7.52
	89-047	7:2	17.7
	89-048	7:3	22.9
	89-049	7:4	28.7
	89-050	8:1	0.395
	89-070	12:2	32.6
	89-071	12:3	59.0
	89-072	12:4	23.0
	89-075	13:3	54.3
	89-076	13:4	25.7
	89-077	14:1	< 0.198
	89-078	14:2	19.2
	89-079	14:3	23.4
	89-080	14:4	23.5
	89-082	15:2	24.4
	89-083	15:3	130
	89-084	15:4	43.3

Table B2-58. Tank 241-U-110 Analytical Data: Iodine-129.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µCi/g
GEA: fusion	005	5	< 0.155
	006	6	< 0.00730
	007	7	< 0.0101
	008	8	< 0.0452
	013	13	< 0.00897
	014	14	< 0.00366
	015	15	< 0.00736
GEA: water	005	5	< 0.00830
	006	6	< 0.0115
	007	7	< 0.00398
	008	8	< 0.0293
	012	12	< 0.00547
	013	13	< 0.00651
	014	14	< 0.00505
	015	15	< 0.00621

Table B2-59. Tank 241-U-110 Analytical Data: Neptunium-237.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µCi/g
GEA: fusion	005	5	< 0.435
	006	6	< 0.415
	007	7	< 0.331
	008	8	< 0.454
	012	12	< 0.443
	013	13	< 0.564
	014	14	< 0.361
	015	15	< 0.455
GEA: water	005	5	< 0.108
	006	6	< 0.154
	007	7	< 0.110
	008	8	< 0.109
	012	12	< 0.130
	014	14	< 0.106
	015	15	< 0.102

Table B2-60. Tank 241-U-110 Analytical Data: Plutonium-239/240.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µCi/g
GEA: fusion	005	5	0.345
	006	6	0.265
	007	7	0.195
	008	8	0.00449
	012	12	0.356
	013	13	0.268
	014	14	0.149
	015	15	0.177
GEA: water	005	5	0.00323
	006	6	< 0.00123
	007	7	0.00120
	008	8	< 9.30E-04
	012	12	< 0.00121
	013	13	< 6.72E-04
	014	14	< 7.38E-04
	015	15	< 5.99E-04

Table B2-61. Tank 241-U-110 Analytical Data: Strontium-90.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core:Seg	µCi/g
BPC: fusion	005	5	364
	006	6	321
	007	7	269
	008	8	0.851
	012	12	470
	013	13	524
	014	14	252
BPC: water	005	5	0.0665
	006	6	0.0636
	007	7	0.346
	008	8	0.0645
	012	12	0.128
	013	13	0.0463
	014	14	0.117
	015	15	0.0667

Table B2-62. Tank 241-U-110 Analytical Data: Technetium-99.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µCi/g
BPC: fusion	005	5	< 0.0215
	006	6	< 0.0190
	007	7	< 0.00573
	008	8	< 0.00915
	012	12	< 0.00813
	013	13	< 0.0107
	014	14	< 0.00825
	015	15	< 0.00905
BPC: water	005	5	0.00485
	006	6	0.0224
	007	7	0.00305
	008	8	< 0.00188
	012	12	0.00711
	013	13	0.00594
	014	14	0.00377
	015	15	0.00301

Table B2-63. Tank 241-U-110 Analytical Data: Tritium.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µCi/g
LSC: water	005	5	0.00245
	006	6	0.00254
	007	7	< 0.00113
	008	8	< 0.00113
	012	12	0.00232
	013	13	0.00203
	014	14	0.00225
	015	15	0.00260

Table B2-64. Tank 241-U-110 Analytical Data: Total Alpha. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**μCi/g**
APC: fusion	005	5	< 0.705
	006	6	< 0.460
	007	7	0.188
	008	8	0.00862
	012	12	< 0.767
	013	13	< 0.954
	014	14	0.160
	015	15	0.145
APC: water	005	5	< 0.00340
	006	6	< 0.00512
	007	7	0.00108
	008	8	< 0.00195
	012	12	0.00473
	013	13	< 0.00261
	014	14	< 0.00256
	015	15	< 0.00208
Segment		**Core:Seg**	**μCi/g**
APC: fusion	89-040	5:3	0.742
	89-041	5:4	0.401
	89-043	6:2	2.64
	89-044	6:3	0.268
	89-045	6:4	< 0.695

Table B2-64. Tank 241-U-110 Analytical Data: Total Alpha. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µCi/g
APC: fusion	89-046	7:1	0.0986
	89-047	7:2	1.70
	89-048	7:3	2.84
	89-049	7:4	0.131
	89-050	8:1	0.00860
	89-070	12:2	0.931
	89-071	12:3	0.437
	89-072	12:4	0.549
	89-075	13:3	< 0.744
	89-076	13:4	< 0.657
	89-077	14:1	0.00770
	89-078	14:2	0.156
	89-079	14:3	1.40
	89-080	14:4	0.296
	89-082	15:2	2.29
	89-083	15:3	2.16
	89-084	15:4	0.151

Table B2-65. Tank 241-U-110 Analytical Data: Total Beta. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**μCi/g**
BPC: fusion	005	5	1,350
	006	6	996
	007	7	626
	008	8	3.02
	012	12	1,330
	013	13	1,540
	014	14	607
	015	15	627
BPC: water	005	5	12.6
	006	6	9.89
	007	7	3.77
	008	8	0.269
	012	12	0.617
	013	13	16.5
Solid Core Composite		**Core Composite**	**μCi/g**
BPC: water	014	14	9.95
	015	15	7.33
Segment		**Core:Seg**	**μCi/g**
BPC: fusion	89-040	5:3	1,880
	89-041	5:4	1,110
	89-043	6:2	1,630
	89-044	6:3	1,590
	89-045	6:4	85.3

Table B2-65. Tank 241-U-110 Analytical Data: Total Beta. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µCi/g
BPC: fusion	89-046	7:1	20.3
	89-047	7:2	827
	89-048	7:3	1,580
	89-049	7:4	152
	89-050	8:1	3.02
	89-070	12:2	1,350
	89-071	12:3	910
	89-072	12:4	2,020
	89-075	13:3	1,840
	89-076	13:4	906
	89-077	14:1	1.74
	89-078	14:2	47.4
	89-079	14:3	1,280
	89-080	14:4	237
	89-082	15:2	1,470
	89-083	15:3	1,480
	89-084	15:4	204

Table B2-66. Tank 241-U-110 Analytical Data: Uranium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg/g
LF: fusion	005	5	5,300
	006	6	5,590
	007	7	4,090
	008	8	1,050
	012	12	6,870
	013	13	5,620
	014	14	3,430
	015	15	3,800
Segment		Core:Seg	µg/g
LF: fusion	89-040	5:3	12,800
	89-041	5:4	2,530
	89-043	6:2	14,100
	89-044	6:3	5,590
	89-045	6:4	1,350
	89-046	7:1	35.3
	89-047	7:2	13,000
	89-048	7:3	< 5,130
	89-049	7:4	1,680
	89-050	8:1	1,050
	89-070	12:2	12,600
	89-071	12:3	1,890
	89-072	12:4	6,980
	89-075	13:3	6,060

Table B2-66. Tank 241-U-110 Analytical Data: Uranium. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	µg/g
LF: fusion	89-076	13:4	3,740
	89-077	14:1	45.9
	89-078	14:2	8,980
	89-079	14:3	2,630
	89-080	14:4	1,440
	89-082	15:2	13,000
	89-083	15:3	5,590
	89-084	15:4	1,550

Table B2-67. Tank 241-U-110 Analytical Data: Bulk Density.

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core/Seg	g/mL
Direct	89-040	5:3	1.04
	89-043	6:2	1.59
	89-044	6:3	1.22
	89-045	6:4	1.80
	89-046	7:1	1.78
	89-047	7:2	1.46
	89-048	7:3	1.53
	89-049	7:4	1.93
	89-070	12:2	1.77
Segment		Core:Seg	g/mL
Direct	89-071	12:3	1.00
	89-072	12:4	1.48
	89-075	13:3	1.14
	89-076	13:4	1.46
	89-077	14:1	1.50
	89-078	14:2	1.39
	89-079	14:3	1.40
	89-080	14:4	1.62
	89-082	15:2	1.27
	89-083	15:3	1.30
	89-084	15:4	1.31

Table B2-68. Tank 241-U-110 Analytical Data: Particle Size Data Analysis.[1]

Sample		Distribution by Number		Standard Deviation (μm)
Core	Segment	Mean (μm)	Median (μm)	
5	3	1.67	0.99	1.69
6	2	1.12	0.88	0.9
	3	1.96	1.24	1.93
	4	1.17	0.9	0.89
7	1	1.15	0.82	1.01
	2	1.72	1.09	1.58
	3	1.49	0.93	1.64
	4	0.9	0.76	0.7
8	Composite	1.35	0.91	1.18
12	2	1.86	1.1	1.77
13	3	1.14	0.84	1.25
	4	1.25	0.85	1.73
14	--	--	--	--
15	--	--	--	--

Note:
[1]Winters (1993)

Table B2-69. Tank 241-U-110 Analytical Data: Penetrometer Results.

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	lbs/in^2
Direct	89-040	5:3	18.8
	89-041	5:4	3.8
	89-043	6:2	13.8
	89-044	6:3	6.3
	89-045	6:4	10.0
	89-046	7:1	10.0
	89-047	7:2	12.2
	89-048	7:3	9.4
Segment		Core:Seg	lbs/in^2
Direct	89-049	7:4	1.8
	89-070	12:2	n/a
	89-071	12:3	10.0
	89-072	12:4	11.3
	89-075	13:3	13.8
	89-076	13:4	n/a
	89-077	14:1	2.5
	89-078	14:2	25.0
	89-079	14:3	7.5
	89-080	14:4	3.1
	89-082	15:2	15.0
	89-083	15:3	6.3
	89-084	15:4	n/a

Table B2-70. Tank 241-U-110 Analytical Data: pH. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	
Direct	005	5	12.9
	006	6	13.0
	007	7	12.7
	008	8	10.6
	012	12	12.7
	013	13	12.7
	014	14	12.5
	015	15	12.6
	005	5	11.7
	006	6	10.7
	007	7	10.8
	008	8	7.85
Solid Core Composite		**Core Composite**	
Direct	012	12	11.7
	013	13	11.7
	014	14	11.8
	015	15	11.8
	89-040	5:3	12.6
	89-041	5:4	12.8
	89-043	6:2	11.7
	89-044	6:3	12.5
	89-045	6:4	12.1

Table B2-70. Tank 241-U-110 Analytical Data: pH. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	
Direct	89-046	7:1	9.69
	89-047	7:2	12.7
	89-048	7:3	12.7
	89-049	7:4	11.6
	89-050	8:1	10.6
	89-070	12:2	12.9
	89-071	12:3	12.8
	89-072	12:4	12.5
	89-075	13:3	12.3
	89-076	13:4	12.7
	89-077	14:1	7.87
	89-078	14:2	12.3
	89-079	14:3	12.2
	89-080	14:4	12.5
	89-082	15:2	12.0
	89-083	15:3	13.2
	89-084	15:4	12.2

Table B2-71. Tank 241-U-110 Analytical Data: Weight Percent Water. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**%**
Gravimetric	005	5	33.5
	006	6	37.0
	007	7	25.8
	008	8	8.39
	012	12	39.5
	013	13	39.8
	014	14	25.8
	015	15	42.1
Segment		**Core:Seg**	**%**
Gravimetric	89-040	5:3	39.2
	89-041	5:4	39.0
	89-043	6:2	38.6
	89-044	6:3	44.5
	89-045	6:4	37.9
	89-046	7:1	3.62
	89-047	7:2	35.9
	89-048	7:3	47.5
	89-049	7:4	37.4
	89-050	8:1	8.39
	89-070	12:2	40.9
	89-071	12:3	39.1
	89-072	12:4	44.3
	89-075	13:3	43.1

Table B2-71. Tank 241-U-110 Analytical Data: Weight Percent Water. (2 sheets)

Analytical Method	Sample Number	Sample Location	Sample Mean
Segment		Core:Seg	%
Gravimetric	89-076	13:4	45.8
	89-077	14:1	5.17
	89-078	14:2	28.0
	89-079	14:3	42.6
	89-080	14:4	37.3
	89-082	15:2	41.6
	89-083	15:3	43.0
	89-084	15:4	41.1

Table B2-72. Tank 241-U-110 Analytical Data: Total Inorganic Carbon.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		Core Composite	µg C/g
PC: Water	006	6	3,140
	008	8	327
	013	13	8,320
	014	14	1,230
	015	15	2,570

Table B2-73. Tank 241-U-110 Analytical Data: Total Organic Carbon.

Analytical Method	Sample Number	Sample Location	Sample Mean
Solid Core Composite		**Core Composite**	**µg C/g**
PC: Water	006	6	< 548
	007	7	983
	008	8	853
	012	12	1,040
	013	13	189
	014	14	1,730
	015	15	1,010
Segment		**Core:Seg**	**µg C/g**
PC: Water	89-040	5:3	542
	89-041	5:4	980
	89-045	6:4	710
	89-046	7:1	673
	89-047	7:2	1,510
	89-050	8:1	853
	89-070	12:2	787
	89-071	12:3	724
	89-072	12:4	807
	89-075	13:3	559
Segment		**Core:Seg**	**µg C/g**
PC: Water	89-076	13:4	841
	89-077	14:1	428
	89-078	14:2	626
	89-079	14:3	446
	89-080	14:4	1,110
	89-082	15:2	6,590

B2.8 VAPOR PHASE MEASUREMENTS

In support of the safety screening DQO (Dukelow et al. 1995), a vapor phase measurement in the headspace of tank 241-U-110 was taken on March 19, 1996 to estimate the potential flammability of the headspace gases. A combustible gas meter was used to obtain the readings, according to procedure WHC-IP-0030 (WHC 1996), IH 1.4 and IH 2.1. The results indicated that the tank headspace contained 26 ppmv of TOC, 450 ppmv of ammonia, and the flammability of the gases was 2 percent of the LFL. The latter result was far below the safety screening DQO decision threshold of 25 percent of the LFL.

B2.9 HISTORICAL SAMPLE RESULTS

The composition of the historical sludge and supernatant samples is summarized in Table B2-74. The sludge sample was described as having large grayish-brown chunks dispersed throughout the soft, runny, dark brown mud-like sludge. Analyses were performed following fusion dissolution.

The supernatant sample was described as a light yellow liquid. No further details regarding the appearance or analysis of these samples were available. Because the sludge sample represents both the soluble and the non-soluble portions of tank 241-U-110 waste, it will provide the more accurate estimate. All of the tank supernatant was removed in the third quarter of 1975, and the date given in Table B2-74 for the supernatant is October 21, 1975; this is assumed to be the date of the sample analysis. The supernatant sampling would have taken place some time earlier, prior to its removal in the third quarter of 1975.

Note that the solid sample analyses are given in micrograms per gram (μg/g) or microcuries per gram (μCi/g), whereas the supernatant analyses are represented on a per liter basis. As a note, these data have not been validated and should be used with caution.

Table B2-74. Historical Sampling Data for Tank 241-U-110.[1,2]

Sample #	Unknown	T-5956
Type of Sample	Solid-Sludge	Supernate
Date	August 27, 1974 (received July 3, 1974)	October 21, 1975
Chemical Analysis	(μg/g)	(μg/mL)
OH^-	---	1,730
Al	135,000	41.8
Fe	9,710	---
Na	---	5,660
NO_2^-	613	235
NO_3^-	221,000	11,800
CO_3^{-2}	55,600	1,640
SO_4^{-2}	8,320	---
PO_4^{-3}	41,200	391
Radionuclides	(μCi/g)	(μCi/L)
Pu	---	0 (g/mL)
$^{89,90}Sr$	620	0.208
^{134}Cs	38.1	0.0176
^{137}Cs	0.555	2.18
^{60}Co	0.367	---
^{125}Sb	3.75	---
^{154}Eu	0.559	0.00293
^{155}Eu	---	0.0121
Physical Properties		
Bulk density (g/mL)	1.5	1.01
Dry particle density (g/mL)	2.13	---
Percent water	44.3	97.6

Note:

[1]1975 sample data from Brevick et al. (1994)

[2]1974 sample data from Horton (1974)

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-U-110, and to present the results of the calculation of an analytical-based inventory.

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

Waste recovery from several of the tank 241-U-110 core samples was quite poor, as discussed in Section B1.2.2, especially for the segment 1 recovery. This situation raises questions about how representative the recovered waste is of the entire tank contents, and creates the possibility of bias in the analytical estimates of mean concentration and inventories. Because the tank contents appear to be quite heterogeneous, representative sampling was especially important. Operational difficulties were at least partially responsible for the poor recoveries (Section B1.1). The laboratory personnel speculated that the liquid recovered from several of the segments was probably HHF, indicating that the data from these segments may be biased as a result of this contamination.

B3.2 QUALITY CONTROL ASSESSMENT

The usual quality control (QC) assessment includes an evaluation of the appropriate reference standards, matrix spikes, blanks, and duplicate analyses that are performed in conjunction with the chemical analyses. All the pertinent quality control tests were conducted on the 1989 core samples, allowing a full assessment regarding the accuracy and precision of the data.

B3.2.1 Standards

Reference standards are samples used to estimate the accuracy of the analytical method, and are analyzed in conjunction with the duplicate samples. They are prepared by adding a known amount of a particular analyte at a concentration other than that used for equipment calibration. For the purposes of this TCR, the criterion for recovery was established at 100 ± 10 percent. If a standard is above or below the criterion, then the analytical result may be biased high or low, respectively. Table B3-1 indicates that standard recoveries were very good, with only 4.2 percent outside the quality control criterion. Gamma energy analysis was the only analytical method in which a notable number of the measurements

deviated from the QC range. These results were evenly distributed above and below 100 percent recovery, and thus there doesn't appear to be a high or low bias for the GEA results.

Table B3-1. Summary of Recoveries Calculated from Standard Measurements.

Analyte: Sample Preparation	Outside Range	Within Range	% in Range
Inductively coupled plasma:			
ICP: acid	0	524	100
ICP: fusion	7	597	98.8
ICP: water	0	500	100
Ion chromatography, water	0	124	100
Graphite furnace atomic absorption, As, Se, Hg			
acid:	9	39	81.3
water:	1	27	96.4
Persulfate oxidation, water: TIC, TOC	0	22	100
Untreated sample:			
pH	2	24	92.3
Percent water	0	14	100
Hg, CN^-	4	20	83.3
Gamma energy analysis:			
GEA: fusion	35	91	72.2
GEA: water	30	106	77.9
Beta: fusion	0	16	100
Beta: water	1	26	96.3
Alpha: fusion	5	11	68.8
Alpha: water	1	17	94.4
Liquid scintillation counting: water			
^{14}C, ^{3}H	1	11	91.7

B3.2.2 Spike Measurements

Matrix spikes are used to estimate the bias of the analytical method resulting from interferences caused by certain analytes. Spike samples are prepared by splitting a sample into two aliquots and adding a known amount of a particular analyte to one aliquot to calculate a percent recovery. The QC criterion for spikes is 100 $\pm$ 25 percent recovery. As with the standards, the analytical result may be biased high or low depending on whether the

spike result is above or below the criterion. Of the spikes analyzed, approximately 25 percent were outside the QC limits. Table B3-2 indicates there was some matrix interference, especially for the acid and fusion ICP methods, and to a lesser extent with the GEA results. Close examination of the data revealed that for many of the analytes, the spikes outside the limits were inconsistent, with some above and some below the limits. For others, there was a clear pattern. The ICP acid and fusion results showed a high bias for chromium and magnesium, and a low bias for cerium, potassium, silver, tantalum, zinc, and zirconium. For the GEA data, neptunium exhibited a low bias on almost all the spike measurements.

Table B3-2. Summary of Recoveries Calculated from Spike Measurements.

Analyte: Sample Preparation	Outside Range	Within Range	% In Range
Inductively coupled plasma:			
ICP: acid	100	72	41.9
ICP: fusion	43	76	63.9
ICP: water	17	202	92.2
Ion chromatography, water	5	55	91.7
Graphite furnace atomic absorption, As, Se, Hg			
acid:	2	23	92.0
water:	0	14	100
Persulfate oxidation, water: TIC, TOC	0	11	100
Untreated sample:			
pH	---	---	---
Percent water	---	---	---
Hg, CN^-	3	12	80.0
Gamma energy analysis:			
GEA: fusion	10	44	81.5
GEA: water	11	51	82.3
Beta: fusion	3	1	25.0
Beta: water	3	6	66.7
Alpha: fusion	0	5	100
Alpha: water	1	9	90.0
Liquid scintillation counting: water			
^{14}C, ^{3}H	0	8	100

B3.2.3 Blank Measurements

Method blanks document the contamination resulting from the analytical process, and are prepared by filling sample containers with deionized, distilled water. They are carried through the complete sample preparation and analytical procedure, and all reagents used in the sample processing are added in the same volumes. A total of 1,166 blank measurements were conducted on the tank 241-U-110 samples, with 31 percent above the detection limit, implying some degree of contamination. Upon closer examination, however, it was found that for those above the detection limit, the contamination was generally less than 10 percent of the analyte concentration for the vast majority of analytes. No single analyte stood out as being subjected to notable contamination with those few blanks that were greater than 10 percent of the detection limit. Table B3-3 summarizes the blank measurements.

Table B3-3. Summary of Blank Measurements.

Analyte: Sample Preparation	# Blanks < DL	# Blanks > DL
Inductively coupled plasma:		
ICP: acid	193	110
ICP: fusion	200	100
ICP: water	183	67
Ion chromatography, water	49	14
Graphite furnace atomic absorption, As, Se, Hg		
acid:	18	6
water:	11	2
Persulfate oxidation, water: TIC, TOC	0	11
Untreated sample:		
pH	0	13
Percent water	0	5
Hg, CN^-	12	1
Gamma energy analysis:		
GEA: fusion	43	11
GEA: water	59	8
Beta: fusion	11	1
Beta: water	6	4
Alpha: fusion	11	1
Alpha: water	4	4
Liquid scintillation counting: water		
^{14}C, ^{3}H	8	0

Note:
DL = Drainable liquid

B3.2.4 Duplicate Analysis

The variation between duplicate samples provides an estimate of laboratory precision. Precision is measured by the relative percent difference (RPD) for each duplicate pair. The RPD is defined as the absolute value of one duplicate minus the other, divided by the mean, multiplied by one hundred. The relative standard deviation (RSD) is then calculated by taking the standard deviation of the two or more duplicate pairs, dividing by the overall analyte mean, and multiplying by one hundred. The RSD is a unitless measure of variability and allows the comparison of variation across constituents whose magnitudes may vary widely. The laboratory measurement control system set the quality control criterion of no RPD being larger than three times the RSD for a given analyte.

Forty-one analytes from Tables B3-1 to B3-3 were checked for violations of this criterion. Only detected values and analytes that had at least two pairs of duplicates were used. Twelve analytes (29 percent of those tested) had one or more duplicate pairs with an RPD over the criterion: aluminum, sodium, ^{137}Cs, and percent water with one of eight RPDs over the limit; iron, manganese, phosphate, and total beta with two of eight over the limit; ^{241}Am and total organic carbon with one of six over the limit; plutonium with one of seven over the limit; and ^{90}Sr with two of seven over the limit. Considering that these 17 violations of the quality control criterion represent only 6.8 percent of all the duplicate pairs tested, the results generally gave very good precision.

B3.2.5 Quality Control Assessment Summary

Validation of the tank 241-U-110 data packages was performed by Hanford Analytical Services to the requirements of RCRA through WHC (1991). The primary objective of the data validation efforts was to ensure the usability and defensibility of data produced for the single-shell tank characterization project as it related to the possibility of leaving the single-shell tank waste in place. However, at this time and for the purposes of this TCR, the data are being used to evaluate the safety of tank 241-U-110.

In summary, the data validation process indicated that there is uncertainty about the quality of some of the tank 241-U-110 data. While most of the spike and standard problems were with the ICP results, the duplication problems were found throughout all of the analyses, although some of the duplication problems may have resulted from poor homogenization of the samples. Despite the concerns with some of the data, the data are believed to be of sufficient quality for evaluation against the requirements of the safety screening DQO, and thus may be used to determine if tank 241-U-110 is safe, conditionally safe, or unsafe.

B3.3 DATA CONSISTENCY CHECKS

Comparisons of different analytical methods can help to assess the data's consistency and quality. Several comparisons were possible with the data set provided by the eight core samples, including a comparison of phosphorous as analyzed by ICP with phosphate as analyzed by IC, and a comparison of total alpha activity and total beta activity with the sum of the individual alpha and beta emitters, respectively. In addition, mass and charge balances were calculated to help assess the overall data consistency. All analytical mean results were taken from tables in Section B3.4.2, and used the preferred method discussed above.

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 performed on the same digestate strengthens the credibility of both results, whereas poor agreement brings the reliability of the data into question.

The analytical phosphorous mean result on the acid-digested segment samples as determined by ICP was 19,300 μg/g, which converts to 59,240 μg/g of phosphate. The IC phosphate mean result on the same water-digested samples was 53,610 μg/g, yielding a ratio between the two methods of 1.10. This comparison indicates most of the phosphate in the tank is water soluble.

Comparison of the total alpha activities of the fusion-digested core composite samples with the $^{239/240}$Pu and ^{241}Am activities did not yield good results. Total alpha activity was only detected in four of the eight fusion-digested samples analyzed. The four detected samples averaged 0.125 μCi/g. This value is low when compared to the average sum (0.185 μCi/g) of the plutonium and americium activities on the same four samples. The discrepancy is reasonable if one considers that the total alpha results are probably biased low because of self- (sample) absorption of the alpha particles.

The sum of the mean activities of the major beta emitters, $^{89/90}$Sr and ^{137}Cs, from seven of the fusion-digested core composite samples was 655 μCi/g. This sum was low compared to the mean total beta activity result of 922 μCi/g for the same fusion-digested samples. Note that the activity of $^{89/90}$Sr was multiplied by two to account for the activity of ^{90}Y, which exists in secular equilibrium with ^{90}Sr. The sum of the Sr and Cs activities probably did not equal the total beta result partly because there are additional beta emitters that were either not detected or not measured.

B3.3.2 Mass and Charge Balance

A material balance is a tool used for evaluating the overall quality of data. Material balances were not considered for segment data because of the lack of fusion ICP analysis for segment samples. A material balance involves summing the individual components of a sample to make sure that the whole mass of the sample was accounted for by the laboratory analysis. To produce a material balance of the sample results, assumptions about the nature of the waste are made and then a material balance model is produced based on those assumptions. A material balance that falls short of 100 weight percent indicates that one or more of the analyses produced a low result, that there are no results available for one or more waste components, or that an incorrect model was used to produce the material balance. A high material balance would indicate that one or more of the analyses produced a high result or that an incorrect model was used to produce the material balance.

In analytical chemistry, material balances are used to determine the quality of the data. However, in this report, this approach will be reversed. The data will be assumed to be accurate and the material balances will be used as a tool in characterizing the contents of the tank. To accomplish this, several assumptions will be made about the nature of the contents of the tank and material balance models will be used to verify the legitimacy of these assumptions. Five different models were applied to the composite data and are found in Table B3-4. The material balances in these tables are shown as a weight percent. A model that accurately describes the contents of the tank will have an average material balance composition close to 100 percent and a small standard deviation over the different samples taken. The statistics for the composite material balances are found in Table B3-5. Because trace elements will be neglected in these models, a model that falls just short of 100 percent (i.e., 96 to 100 percent) would also be considered to be a good model.

The assumptions of the material balance models are described below. The corresponding equations for these models are given in Appendix F of Brown and Jensen (1993).

Table B3-4. Mass and Charge Balance Summary for Core Composite Data. (3 sheets)

Analyte	Core 5 Composite	Core 6 Composite	Core 7 Composite	Core 8 Composite	Core 12 Composite	Core 13 Composite	Core 14 Composite	Core 15 Composite
Percent water	33.5	37.0	25.8	8.38	39.5	39.9	25.8	42.1
KOH fusion Radiological analysis (μg/g)								
Uranium	5,300	5,590	4,080	1,050	6,860	5,620	3,420	3,800
ICP analysis (μg/g)								
Aluminum	112,000	96,200	169,000	3.09 E+06	143,000	148,000	168,000	215,000
Calcium	3,520	1,440	3,570	3,280	6,170	4,380	2,120	1,190
Iron	17,300	12,700	12,300	493	15,300	16,600	7,880	4,640
Magnesium	7,490	2,110	1,610	572	2,490	1,820	1,110	1,150
Silicon	20,000	0	10,900	0	0	35,800	0	0
Sodium	143,000	130,000	106,000	5,050	114,000	79,400	111,000	96,500
Water digestion IC analysis (μg/g)								
Fluoride	9,290	5,720	5,900	30	9,030	4,270	8,950	6,190
Chloride	0 L	0 L	941	31	0 L	0 L	0 L	1,100
Nitrate	48,200	45,600	28,200	279	50,100	60,100	35,300	48,200
Phosphate	19,600	35,100	36,200	163	43,500	15,100	51,600	25,900
Sulphate	7,620	0 L	0 L	0 L	0 L	0 L	0 L	0 L
Carbonate	2,730	0	5,180	0	7,270	8,310	1,220	0
Nitrite	10,400	10,100	4,850	12,600	0 L	12,000	8,390	9,140

Table B3-4. Mass and Charge Balance Summary for Core Composite Data. (3 sheets)

Analyte	Core 5 Composite	Core 6 Composite	Core 7 Composite	Core 8 Composite	Core 12 Composite	Core 13 Composite	Core 14 Composite	Core 15 Composite
Carbon analysis (μg/g)								
TIC	0	3,130	0	327	0	8,310	1,220	2,560
TOC	0	0 L	983	853	1,040	189	1,720	1,010
Acid digestion ICP analysis (μg/g)								
Bismuth	45,400	20,100	10,500	0	0	14,900	8,320	13,200
Manganese	5,350	3,830	2,270	44	3,910	5,490	2,450	5,300
Thermogravimetric Analysis								
% Water	11.1	19.0	5.98	0	29.1	29.1	18.4	14.4
% Aluminum hydroxide	8.18	13.1	43.7	76.6	0	0	29.8	11.8
Al(OH)3 (μg/g)	81,800	131,000	437,000	766,000	0	0	298,000	118,000
Al from AL(OH)3 (μg/g)	28,300	45,300	151,000	265,000	0	0	103,000	41,000
Material balances								
Model 1:	93.5	85.1	82.9	69.8	93.2	103	83.4	106
Model 2: (except NaOH)	102	87.5	97.7	101	105	119	96.0	123
Model 2: (NaOH)	15.4	13.1	9.52	0.00	8.21	4.97	7.79	8.16
Model 2: Total	118	100	107	101	113	124	104	131
Model 3:	105	94.7	99.8	101	108	118	100	128
Model 4:	97.8	90.3	98.4	96.3	93.2	104	94.0	111
Model 5:	79.9	69.5	77.8	92.5	94.5	108	88.5	95.6

Table B3-4. Mass and Charge Balance Summary for Core Composite Data. (3 sheets)

Analyte	Core 5 Composite	Core 6 Composite	Core 7 Composite	Core 8 Composite	Core 12 Composite	Core 13 Composite	Core 14 Composite	Core 15 Composite
Model 5:	15.4	13.1	9.52	0	8.21	4.97	7.79	8.16
Model 5:	95.3	82.6	87.4	92.2	103	113	96.3	104
Charge balances								
Model 1: Cation (meq)	21.4	17.8	24.6	34.9	22.4	21.7	24.4	29.0
Model 1: Anion (meq)	16.3	13.1	21.8	34.7	18.8	21.2	21.6	26.1
Model 1: Cation/Anion	1.31	1.36	1.13	1.00	1.19	1.02	1.13	1.11

Table B3-5. Statistical Summary of Mass and Charge Balance Models for Composite Data.

	Mean	Relative Standard Deviation
Material balances		
Model 1:	89.7%	11.2%
Model 2:	112%	10.6%
Model 3:	107%	10.4%
Model 4:	98.1%	6.23%
Model 5:	96.7%	9.08%
Charge balances		
Model 1: Cation/anion	1.16	0.120

Model 1 assumes that all of the metals are present as oxides and that the anions are present in their standard forms. Also, in this model, the TIC is assumed to be carbonate and the TOC is assumed to be acetate. The average (as found in Table B3-5) for model 1 is shown to be 89.7 percent with a relative standard deviation of 11.2 percent.

Model 2 assumes that all of the anions are present as sodium salts and all the metals are hydroxides except bismuth, which is in the form of bismuth phosphate. The sodium that is not present as a salt with the anions is assumed to be sodium hydroxide. As shown on Table B3-4, the first line of this model represents all of the analytes except for sodium hydroxide and the second line represents the sodium hydroxide. The amount of sodium hydroxide present is estimated by subtracting the sodium associated with the anionic salts from the total sodium in the sample. The average for this model is 112.3 percent with a relative standard deviation of 10.6 percent.

Model 3 is the same as model 1 (oxide model) with the exception that instead of the aluminum being present as an oxide, it is present as aluminum hydroxide. From the thermal analysis in Section B2.6 , it is suspected that the upper layer and possibly even more of the aluminum in the tank is in the form of aluminum hydroxide. The average for this model is 106.8 percent, slightly closer than the previous two models. The relative standard deviation is 10.4 percent.

Model 4 is the same as model 1 (oxide model) with the exception that some percentage of the aluminum is present as a hydroxide and some percentage is present as an oxide. To make the distinction, the amount of aluminum existing as aluminum hydroxide is calculated from the aluminum hydroxide peak of the thermogravimetric analysis discussed in Section B2.6.

The remainder is assumed to be aluminum oxide and is calculated from the difference of the total aluminum and the aluminum from aluminum hydroxide. Another difference with this model is that bismuth is assumed to come in the form of bismuth phosphate instead of oxide. This assumption led to the closest model result of 98.1 percent with a relative standard deviation of 6.2 percent.

The final model, model 5, resembles model 2 (hydroxide model) except that the water is calculated from the thermogravimetric water loss taken from the thermogravimetric analysis in Section B2.6. The average for this model is 96.6 percent with a relative standard deviation of 9.1 percent.

The model that yields the best mass and charge balances is model 4. This model assumed that most of the metals occur in their oxide form except aluminum, which can occur as an oxide or a hydroxide, and bismuth, which is most likely a phosphate. Because of the high alkalinity of the tank, the chance that many of the metals are in a hydroxide form should not be discredited.

One reason the hydroxide model (model 2) gives a high material balance would be the possibility that the percent water analysis might be high. The water analysis is performed by drying the sample in an oven overnight at a temperature slightly over 100 °C (212 °F). This method is different than the thermogravimetric method of water detection where the sample is heated quickly with a constant rise in temperature. If the waste contained a high amount of metal hydroxides or hydrates, it is possible that many of these metal hydroxides and hydrates would dehydrate if left at high temperatures for a long period of time, thus causing the percent water reading to be high. For this reason, the thermogravimetric percent water reading was used in model 5. The thermogravimetric method dries the waste faster, thus allowing less of a chance for the metal hydroxides or hydrates to dehydrate. It is for the data user to choose which model, if any, should be used to characterize the contents of the tank.

Another possibility that was not considered in the mass balance is that the aluminum that does not occur in the form of aluminum hydroxide [$Al(OH)_3$] may occur in the tank in the form of aluminum hydroxide (AlOOH), also known as boehmite.

The second tool used in the interpretation of the composite data is the charge balance. The positive charge associated with the anions should equal the negative charge of the cations. As with the material balance, assumptions were made and a charge balance model was created. The results are shown in Table B3-4 with the material balance models. The statistical summary for the charge balance model is shown in Table B3-5.

B3.4 MEAN CONCENTRATIONS AND CONFIDENCE INTERVALS

The following evaluation was performed on the analytical data from the 1989 core samples for tank 241-U-110. These statistics are used to support the characterization best-basis inventory presented in Appendix D.

This section contains estimates of the mean concentration and confidence intervals on the mean concentration of various analytes in tank 241-U-110, and were taken directly from the report *Statistical Characterization Report for Single-Shell Tank 241-U-110* (Jensen and Remund 1993). The concentration estimates were based on observations from incomplete core samples; consequently, the results given may be biased, and the magnitude of that bias cannot be evaluated. However, if it is assumed that the core and segment samples that were recovered constitute a random sample, then the concentration estimates given are unbiased. The data in this report were evaluated as if the recovered segments were a random sample.

B3.4.1 Introduction

A task outlined in the waste characterization plan (Winters et al. 1989) for tank 241-U-110 was to estimate the inventory of various analytes found in the tank. The inventory was to be based upon the chemical analyses of the core composite sample formed from each core. This section reports the results of a statistical analysis of the core composite sample data.

Analytical concentration data from the seven tank 241-U-110 core samples were used to estimate the concentration of the various analytes found in the waste. Each core theoretically consisted of four segments. The recovered core segments were homogenized, and a composite sample, representing each core, was formed. The composite sample was formed by combining individual samples from each homogenized segment. The core composite samples were constructed from incomplete segments; therefore the composite samples may be a biased representation of the complete core.

The core composite sample was also homogenized. Two aliquots were drawn from each core composite sample and prepared for chemical analysis. For each analyte, the concentration estimates were computed based upon these pairs of data.

Two assumptions must be valid to estimate the mean composition of the waste in tank 241-U-110 based upon the chemical analysis of core composite samples.

- The 222-S Laboratory can homogenize and sample individual segments.
- The 222-S Laboratory can combine and rehomogenize samples from the segments to form the core composite sample.

If these two assumptions are valid, the composite sample will represent the entire core. The validity of both assumptions is addressed in Section B3.4.5. Based upon the results in this section, both assumptions are valid.

B3.4.2 Concentration Estimates

The concentration data from the seven core composite samples are shown in Appendix B. The "<" symbol in the data tables means that the chemical analysis result was less than the detection limit. The "NA" abbreviation means that the result was not available. Such observations were omitted from all computations.

Tables B3-6, B3-7, and B3-8 give the mean concentration and 95 percent confidence intervals on the mean concentration for the analytes in tank 241-U-110. The computational formulas for the confidence intervals are given in the theory section of Appendix G of Brown and Jensen (1993). These formulas are based upon the results from a one-way analysis of variance (ANOVA) associated with the hierarchical structure of the data.

Tables B3-6, B3-7, and B3-8 contain the following summary statistics:

- $\bar{y}$ = arithmetic mean of the concentration data
- $\hat{\sigma}^2(\bar{y})$ = estimated variance of $\bar{y}$
- df = degrees of freedom associated with between mean square
- Lower limit = lower limit to the 95 percent confidence interval on the mean
- Upper Limit = upper limit to the 95 percent confidence interval on the mean
- CL = confidence limit expressed as a percent of the mean concentration.

For some analytes, the lower limit of the confidence interval was negative. Because concentrations are strictly greater than or equal to zero, any negative value for the lower limit was set equal to zero. For the confidence interval expressed as a percent of the mean concentration, these tables give the confidence interval as $\pm$ CL, where the confidence limit (CL) is a percent of $\bar{y}$. The percent values range between 4 percent and 205 percent. The magnitude of these values give an indication of the heterogeneity of the waste.

Table B3-6. Acid Digestion Statistics.

Method and Analyte		$\bar{y}$	$s^2(\bar{y})$	df	Lower Limit	Upper Limit	CL (%)
AAS (μg/g)	As	0.408	2.83E-04	2	0.336	0.481	18.0
	Hg	2.96	4.9	6	0	8.38	183
	Se	1.77	0.57	4	0	3.87	119
ICP (μg/g)	Al	90,900	1.28 E+08	6	63,300	1.19E+05	30.0
	As	171	61	2	137	204	20.0
	Ba	64	380	6	16	112	74.0
	Be	3.2	0.14	6	2.2	4.1	29.0
	Bi	18,700	3.10 E+07	5	4,410	33,100	76.0
	B	69	71	5	48	91	31.0
	Ca	494	2,220	6	379	610	23.0
	Cr	612	14,000	6	323	902	47.0
	Cu	134	1,190	6	50	219	63.0
	Fe	12,600	2.28 E+06	6	8,860	16,200	29.0
	Pb	866	41,400	5	343	1,390	60.0
	Mg	647	36,800	6	177	1,120	73.0
	Mn	4,080	2.65E+05	6	2,830	5,340	31.0
	Hg	477	1.41E+05	5	172	782	64.0
	Mo	49	38	6	34	64	31.0
	Ni	124	182	6	91	157	27.0
	P	15,300	1.14E+07	4	5,900	24,700	61.0
	Se	779	15,100	6	479	1,080	39.0
	Si	3,770	45,700	1	1,060	6,490	72.0
	Na	93,300	1.17 E+08	6	66,800	1.2E+05	28.0
	Sr	490	3,570	6	344	636	30.0
	S	710	56,700	6	128	1,290	82.0
	Tl	3,080	5.E+05	5	1,260	4,900	59.0
	Th	1,790	1.66E+05	5	748	2,840	58.0
	Sn	114	184	6	81	147	29.0
	Ti	55	73	6	34	76	38.0
	U	11,000	6.09E+05	4	8,820	13,200	20.0
	V	67	43	5	50	84	25.0
	Zn	312	19,200	6	0	651	109
	Zr	169	314	6	126	213	26.0

Table B3-7. KOH Fusion Dissolution Statistics.

Method and Analyte		$\bar{y}$	$s^2(\bar{y})$	df	Lower Limit	Upper Limit	CL (%)
RA (μCi/g)	Total α	0.164	1.58E-04	2	0.11	0.218	33.0
	Total β	1,010	22,700	6	641	1,380	36.0
	Cs-137	28.2	26.5	6	15.6	40.8	45.0
	U (μg/g)	4,950	2.15E+05	6	3,820	6,090	23.0
	Pu-239/240	0.25	0.001	6	0.176	0.325	30.0
	Am-241	0.0871	1.52E-04	5	0.0554	0.119	36.0
	Sr-90	367	2,010	5	251	482	31.0
ICP (μg/g)	Al	1.50E+05	2.21 E+08	6	11,400	1.87E+05	24.0
	Bi	20,600	2.49 E+07	5	7,810	33,500	62.0
	B	3,430	2.64 E+06	6	0	7,400	116
	Ca	3,200	4.47E+05	6	1,560	4,830	51.0
	Cr	535	13,100	3	172	899	90.0
	Fe	12,400	3.12 E+06	6	8,070	16,700	35.0
	Pb	1,090	37,600	3	474	1,710	57.0
	Mg	2,540	7.0E-05	6	471	4,610	81.0
	Mn	3,460	1.98E+05	6	2,370	4,550	31.0
	Ni	6,660	1.65E+05	6	5,660	7,650	15.0
	Se	1,260	18,800	3	821	1,690	35.0
	Si	22,200	5.26 E+07	2	0	53,500	140
	Na	1.11E+05	6.25 E+07	6	92,000	1.31E+05	17.0
	Sr	505	4,010	6	350	659	31.0
	S	846	29,700	6	425	1,270	50.0
	Zn	1,080	6.26E+05	6	0	3,010	179
	Zr	372	4,000	2	100	644	73.0

Note:
RA = Radiological Analysis

Table B3-8. Water Digestion Statistics.

Method and Analyte		$\bar{y}$	$s^2(\bar{y})$	df	Lower Limit	Upper Limit	CL (%)
UA	pH	11.4	0.035	6	11	11.9	4.00
IC (μg/g)	F	7,050	5.75E+05	6	5,200	8,910	26.0
	Cl	1,020	6,240	1	16	2,020	98.0
	NO_3	45,100	1.55 E+07	6	35,500	54,800	21.0
	PO_4	32,500	1.00 E+06	6	20,400	44,500	37.0
	NO_2	9,150	9.99E+05	5	6,580	11,700	28.0
Carbon (μg/g)	TOC	955	2.42 E+07	5	436	1,470	54.0
	CO_3	4,350	40,600	6	1,900	6,790	56.0
RA (μCi/g)	Total β	8.66	4.05	6	3.73	13.6	57.0
	Cs-137	7.24	1.98	6	3.8	10.7	48.0
	C-14	0	4.16 E-09	5	2.0E-04	50,000	48.0
	Sr-90	0.119	0.0016	6	0.0225	0.215	81.0
	Tc-99	0.0072	6.75 E-06	6	8.0E-04	0.0135	89.0
	H-3	0.0024	7.37 E-09	5	0.00214	0.00258	9.00
AAS (μg/g)	Hg	0.00585	4.0E-04	3	0	0.126	115
ICP (μg/g)	Al	3,510	1.42E+05	6	2,590	4,430	26.0
	B	330	1,350	6	240	420	27.0
	Ca	127	983	6	50	204	60.0
	Cr	498	11,800	6	232	764	53.0
	Fe	43	84	5	20	67	54.0
	Li	21	76	3	0	49	133
	Mg	381	30,000	6	0	805	111
	Hg	36	38	6	20	51	43.0
	Na	80,600	5.53 E+07	6	62,400	98,800	23.0
	Sr	5.8	5	3	0	12.9	121
	S	641	24,700	6	256	1,020	60.0
	Tl	649	22,700	5	261	1,040	60.0
	Ti	23	118	2	0	69	205
	Zn	23	18	6	13	33	45.0

B3.4.3 Analytes

Each of the three sets of concentration estimates is based upon a different sample preparation method: acid digestion, KOH fusion dissolution, and water digestion. Table B3-9 lists the chemical analysis methods used with each preparation and the analytes in each category.

Table B3-9. Analytes Measured in Tank 241-U-110.

Sample Preparation	Method	Analytes
Acid digestion	AAS	As, Hg, Se
	ICP	Al, As, B, Ba, Be, Bi, Ca, Cr, Cu, Fe, Hg, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Si, Sn, Sr, Th, Ti, Tl, U, V, Zn, Zr
KOH fusion dissolution	RA	Am-241, Cs-137, Pu-239/240, Sr-90, U, Total α, Total β
	ICP	Al, B, Bi, Ca, Cr, Fe, Mg, Mn, Na, Ni, Pb, S, Se, Si, Sr, Zn, Zr
Water digestion	UA	pH
	IC	Cl, F, NO_2, NO_3, PO_4
	Carbon	TOC, CO_3
	AAS	Hg
	ICP	Al, B, Ca, Cr, Fe, Hg, Li, Mg, Na, S, Sr, Ti, Tl, Zn
	RA	TB, Cs-137, C-14, Sr-90, Tc-99, Tritium

Notes:

AAS = Atomic absorption spectroscopy
IC = Ion chromatography
ICP = Inductively coupled plasma
RA = Radiological analysis
UA = Untreated analysis

B3.4.4 Remaining Statistical Tests for Tank 241-U-110

Analytical concentration data from the seven core samples from tank 241-U-110 were used to estimate the concentration of the various analytes found in the waste. Each core sample consisted of four segments. The recovered core segments were homogenized and a composite sample, representing each core, was formed by combining individual samples from each homogenized segment.

The core composite sample was also homogenized. Two aliquots were drawn from each core composite sample and prepared for chemical analysis. For each analyte, the concentration estimates were computed based upon these pairs of data.

To estimate the mean composition of the tank based upon the chemical analysis of core composite samples two assumptions must be valid.

- The 222-S Laboratory can homogenize and sample individual segments.
- The 222-S Laboratory can combine and rehomogenize samples from the segments to form the core composite sample.

If these two assumptions are valid, the composite sample will represent the entire core. To check the validity of these assumptions, two statistically designed tests were performed in the 222-S Laboratory. Based upon the results from these two tests, both assumptions are valid (Jensen and Remund 1993).

The results of these two tests are summarized in the following paragraphs. In addition, the results of a third test performed in the 222-S Laboratory are also summarized. The third test, the holding time study, was designed to determine whether or not the core sample analytical concentrations changed as the sample aged.

B3.4.5 Summary of the Statistical Evaluation of Homogenization Test Data

A core sample of waste consists of disjoint segments which are 48 cm (19 in.) long and approximately 2.5 cm (1 in.) in diameter. In the laboratory, a segment is homogenized (mixed) so that it can be characterized by analyzing a minimum number of aliquots. The aliquots are formed from a sample drawn from the homogenized segment, and the aliquots are prepared for chemical analysis.

Because homogenization of samples is a critical step in preparing sample material for analysis, a homogenization test was performed on three different segments from tank 241-U-110 in order to evaluate the ability of the laboratory to homogenize samples. Data were available for seven analytes (aluminum, ^{137}Cs, iron, magnesium, silicon, sodium,

and strontium). The results of the statistical analysis indicated that for these seven analytes, the 222-S Laboratory can adequately homogenize sample material similar to that found in tank 241-U-110.

B3.4.6 Summary of the Comparison Between a Simulated Core Composite and the Core Composite Sample

A simulated core composite was formed by combining data obtained from the individual segments within a core. The results from this simulated core composite were statistically compared with the corresponding data from the core composite sample formed in the 222-S Laboratory.

The general conclusion from this study was that the core composite sample composition cannot be distinguished from the composition predicted by using the individual segments, indicating that the 222-S Laboratory can construct a core composite sample from individual segments. This also indicates that the tank concentration data obtained from a core composite sample agree with the corresponding values obtained from the individual segments.

There was a lack of agreement between certain pairs of segment data. The influence of this lack of agreement on the conclusions above was checked by deleting outlying pairs of data and reevaluating the statistical comparisons. The general conclusions did not change.

B3.4.7 Summary of the Statistical Evaluation of the Holding Time Test Data

The holding time is the length of time a sample is held in the 222-S Laboratory before the chemical analysis is initiated. The holding time study was designed to determine whether or not the concentration of an analyte changed with time as the samples aged in the 222-S Laboratory. This test was performed on samples obtained from homogenized material from segments 1, 2, 3, and 4 of core 14 from tank 241-U-110. Segment 1 was noticeably different than the other segments in the analyte concentrations. For this reason, statistical analyses were performed for segment 1 alone and segments 2, 3, and 4 were combined.

For segments 2, 3, and 4, there were significant differences between holding times for mercury, nitrite, TOC, and chloride. The differences for mercury and TOC depended on the segment (e.g., one segment may show a concentration increase over time while another segment may show a decrease). There were no significant differences for pH, hydrogen concentration, percent water, nitrate, and phosphate for these segments.

Regarding segment 1, there was a significant difference between holding times for percent water, and no significant differences for pH and mercury. There was insufficient data for a statistical analysis on nitrate, nitrite, TOC, phosphate, and sulfate. The segment 1 results should be viewed with caution because of the small number of observations.

B3.4.8 Summary of the Variance Components

The *Statistical Characterization Report for Single-Shell Tank 241-U-110* (Jensen and Remund 1993) also contains a section listing estimates of the spatial and analytical variance components for the analytes found in tank 241-U-110. These variance components are determined from the ANOVA model used to estimate the concentration of the analytes in the tank. In addition, for each of the variance components, confidence intervals, relative standard deviations, and relative percent variance values are also given. These statistics are used to judge the magnitude of the variance components and the degree of heterogeneity of the waste.

The general conclusion is that there is large variability in the data (in the waste). The analytical relative standard deviation varies between 6 and 150 percent. The spatial relative standard deviation varies between 0 and 89 percent. The analytical variance, as a percent of the total, varies between 1 and 100 percent. The spatial variance, as a percent of the total, varies between 0 and 99 percent. There is no apparent pattern in the magnitudes of the variances.

B3.5 INTERPRETATION OF SEGMENT DATA

B3.5.1 Data Trends

In this section, trend analysis of the segment data will be considered. One important use of segment data that cannot be performed with composite data is to observe the concentration of a particular analyte as a function of the waste depth. It is observed in tank 241-U-110 that many of the major analytes have a varying concentration over the depth of the tank and that many of these trends are similar throughout the cores of the tank. These concentration-depth profiles will be referred to in this section as trends.

The analytes that will be presented and discussed in these trending profiles are water, ^{137}Cs, uranium, fluoride, nitrate, phosphate, total carbon (TC), aluminum, bismuth, iron, and sodium. The trends for these analytes are given in Tables B3-10 through B3-20. These tables show the concentration of the particular analyte for each core containing three or more recovered segments taken from the tank. Finally, an average of the eight cores is shown at the end of the table. The first segment depicts the waste in only approximately the first 10 cm (4 in.) from the top of the waste surface, the white layer mentioned in Section B1.2.2. Each segment below segment 1 represents the next 48 cm (19 in.) of waste in the tank ending with segment 4, which consists of the bottom 48 cm (19 in.) of waste in the tank.

Table B3-10. Trending Table for Water (Weight Percent Water).

Segment	Core								
	5	6	7	8	12	13	14	15	Average
1			3.62	8.39			5.17		5.7
2		38.5	35.9		40.9		28.0	41.5	36.9
3	39.1	44.5	47.4		39.0	43.1	42.6	42.9	42.7
4	38.9	37.9	37.4		44.2	45.7	37.3	41.1	40.4

Table B3-11. Trending Table for Cesium-137 (μCi/g).

Segment	Core								
	5	6	7	8	12	13	14	15	Average
1			7.52	0.390					3.90
2		33.8	17.7		32.5		19.2	24.3	25.5
3	34.6	23.2	22.9		58.9	54.3	23.3	30.1	35.3
4	45.6	21.0	28.6		23.0	25.7	23.5	43.3	30.1

Table B3-12. Trending Table for Uranium (μg/g).

Segment	Core								
	5	6	7	8	12	13	14	15	Average
1			35	1,050			44		377
2		14,000	12,900		12,600		8,980	13,000	12,000
3	12,800	5,590			1,890	6,060	2,630	5,580	5,760
4	2,520	1,350	1,680		6,970	3,730	1,440	1,550	2,750

Table B3-13. Trending Table for Fluoride (IC - μg/g).

Segment	Core								
	5	6	7	8	12	13	14	15	Average
1				30					30
2					1,560		524	1,460	1,180
3	1,420	3,190	3,020		15,600	1,720	3,230	3,540	4,530
4	21,700	17,900	15,600		1,660	2,960	19,500	24,100	14,790

Table B3-14. Trending Table for Nitrate (IC - μg/g).

Segment	Core								
	5	6	7	8	12	13	14	15	Average
1			194	279					236
2		49,700	27,900		31200		36,400	32,200	35,000
3	73,800	52,200	39,800		69,800	54,100	61,300	45,800	56,700
4	62,700	26,000	27,700		54,000	83,500	30,300	33,600	45,400

Table B3-15. Trending Table for Phosphate (IC - μg/g).

Segment	Core								
	5	6	7	8	12	13	14	15	Average
1			216	163					189
2							1,870		1,870
3	10,500	23,800	18,400		50,500		13,800	19,200	22,700
4	44,600	1.52E+05	1.23E+05				137,000	99,600	111,000

Table B3-16. Trending Table for Total Carbon (μg/g).

Segment	Core								
	5	6	7	8	12	13	14	15	Average
1				1,550			1,500		1,520
2		2,620					2,790		2,710
3	2,020	10,000	2,260				9,460	2,090	5,170
4	4,860		7,370				15,800	9,000	9,260

Table B3-17. Trending Table for Aluminum (μg/g).

Segment	Core								
	5	6	7	8	12	13	14	15	Average
1			85,400	104,000			72300		87,000
2		91,600	130,000		136,000		101,000	84,800	109,000
3	126,000	89,700	84,000		45,600	111,000	20,000	89,600	80,900
4	36,300	49,000	56,200		42,500	47,200	52,700	60,700	49,200

Table B3-18. Trending Table for Bismuth (μg/g).

Segment	Core								
	5	6	7	8	12	13	14	15	Average
1			527						527
2		5,040	2,630		7,470		2,440	3,860	4,290
3	4,250	19,500	12,400		39,200	13,800	2,730	22,100	16,300
4	20,300	24,100	32,600		5,870	17,000	24,800	47,300	24,600

Table B3-19. Trending Table for Iron (μg/g).

Segment	Core								
	5	6	7	8	12	13	14	15	Average
1			1,990	150			441		861
2		18,100	5,950		27,800		4,670	7,290	12,700
3	8,230	12,900	12,700		22,400	13,500	2,250	15,100	12,400
4	8,040	15,900	20,800		7,620	27,300	12,200	24,100	16,600

Table B3-20. Trending Table for Sodium (μg/g).

Segment	Core								
	5	6	7	8	12	13	14	15	Average
1			2,910	1,110					2,010
2		77,700	49,100		80,300		45,000	64,500	63,300
3	78,200	87,600	85,800		113,000	78,300	20,700	81,700	77,900
4	65,500	17,800	188,000		49,900	89,500	151,000	181,000	129,000

Table B3-10 shows the trending data for water expressed in weight percent water. As the table shows, the top (white) layer of the tank is very dry with an average of about 6 weight percent water. The moisture level rises in the second segment to about 40 percent water in the middle and bottom of the tank. This gradient in the concentration of water in the tank is best explained by considering that the tank has been drying since it was salt-well pumped in 1975. Diffusion of water to the surface of the tank (where evaporation occurs) would be greatest towards the top of the waste, which explains the dryness of the top segments as compared to those at the bottom.

Uranium also has an interesting trending plot. The first segment contains practically no uranium. Directly below the first segment, the concentration of the uranium rises to a peak of approximately 12,000 μg/g and then slowly decreases to about 2,000 μg/g at the bottom of the tank. This indicates that uranium has a tendency to accumulate towards the top of the waste. One reason for this may be that the later waste types, R1 and CWR1, had a higher uranium content than the earlier bismuth phosphate process 1C1 waste. Hence, the uranium constituents would have been deposited higher in the tank.

The three major anions in the tank, fluoride, nitrate, and phosphate, generally follow the same trend. This trend can be seen in Tables B3-13 through B3-15. The concentrations are negligible at the top segment but large at the bottom. Phosphate is of particular interest. The top segment has almost no phosphate, but the concentration from the top to the bottom of the tank rises almost by an order of magnitude for each segment. Hence, more than 80 percent of the phosphate lies in the bottom 48 cm (19 in.) of the tank. This occurrence is explained by the fact that the first waste type to enter tank 241-U-110 was 1C1 waste from the bismuth phosphate process that contained high concentrations of both bismuth and phosphate. Hence, waste from this process would have been the first to settle to the bottom of the tank. Bismuth phosphate is insoluble in alkaline conditions, which would also explain why its constituents have settled at the bottom of the tank. It should also be observed from Table B3-18 that bismuth has a similar trending curve. That is, its concentration is low at the top of the waste and rises dramatically towards the bottom of the waste.

Because of the solid aluminum hydroxide layer at the top of the waste, the aluminum concentration should be expected to be high in the first segment of the tank. It is seen from Table B3-17 that while the aluminum concentration is high in the first segment, it actually peaks in the second segment and is very high throughout the tank. This result indicates that aluminum occurs in a form other than aluminum hydroxide. It was shown in Section B3.3.2 that aluminum, as well as most of the other metals in the tank, probably occur in both an oxide and a hydroxide form.

Again, it should be noted that trending values are from acid digestion ICP analysis because fusion ICP was not performed on the segments, which means that the aluminum values given on this trending table are lower than they should be. This result can be seen in core 8 segment 1 because this sample is both a segment and a composite. Core 8 shows that the acid ICP value for aluminum is 104,000 μg/g (i.e., 10 percent aluminum or 30 percent aluminum hydroxide equivalent) and that the fusion ICP value is 309,000 μg/g (i.e., 31 percent aluminum or 92 percent aluminum hydroxide equivalent). It was stated earlier that the top segment was composed primarily of aluminum hydroxide. The acid ICP results from the segment analysis do not support this conclusion because they are low.

The reason that aluminum hydroxide has accumulated at the top of the tank waste in relatively high purity is unknown. Aluminum cladding waste from both the bismuth phosphate process and the REDOX process were added to the tank throughout its working lifetime, which suggests a dispersion of aluminum hydroxide throughout the tank. The specific gravity of aluminum hydroxide is 2.42, higher than that of sodium nitrate, sodium nitrite, and many other of the compounds that would be expected in the tank. This result would suggest that buoyancy is not the reason that aluminum hydroxide is at the top of the waste. One possibility has to do with the solubility of aluminum hydroxide. Aluminum hydroxide is amphoteric. That is, in normal conditions (pH = 7), aluminum hydroxide is insoluble but in more acidic or alkaline conditions the substance becomes soluble and even tends to supersaturate. The average pH in the tank is about 12.4, high enough to bring the aluminum hydroxide into solution. It is likely that when the tank started to dry out (at the air/liquid interface) that aluminum hydroxide was the last substance to precipitate out of

solution and settle with the rest of the solid wastes before the remaining liquids were pumped, thus causing it to form on the top of the waste. This result would also explain why the pH in this top layer of the tank is lower than the rest of the tank. When the aluminum hydroxide precipitated from solution, it bound up much of the hydroxide into a solid form, thus causing the pH of the liquid solution to decrease. Another possible explanation for the lower pH at the top of the waste may be due to CO_2 absorption at the surface.

Like most of the analytes mentioned above, sodium has a very low concentration in the first segment and a much larger concentration in the bottom three segments (or sludge section) of the tank. The sodium probably occurs in the form of sodium salts that are dispersed throughout the darker sludge section of the waste, especially at the bottom. Most of the anions detected in this tank, including fluoride, chloride, sulphate, carbonate, nitrate, and nitrite, very likely occur in the form of sodium salts because sodium is the most likely major metal in the tank to form ionic bonds. A more exhaustive study of the thermodynamic properties of the tank waste components would be necessary to further speciate the waste.

One of the analytes that was presented in the trending tables but not on the trend charts is total carbon (TC). TC is a combination of TOC and TIC. Because organic NPH was used in the drilling operations, the estimated TOC content of the tank may not be accurate.

B3.5.2 Statistical Analysis of Spatial Variability

The statistics in this section were calculated for all analytes that had at least 25 percent of the measurements above the detection limit, and had an adequate number of measurements to support a statistical analysis. In cases where some of the analyte values were below the detection limit and some were above, all data were used equally. The reason for this approach to detection limits was to obtain the most conservative estimate of tank analyte concentrations possible.

Both segment-level and composite-level sampling produce data that can best be described using a random effects nested, or hierarchical, statistical model. In these statistical models, each observation contains many different types of variability (measurement, mixing, sampling, spatial) that are to be estimated. The composite model is a simplified version of the core-segment-level model that eliminates the segment-level term. The variabilities associated with the core composite data include estimates of the core variability and analytical measurement variability. The variabilities associated with the segment-level data include the core and analytical measurement variability in addition to the segment variability. The core variance is a measure of tank horizontal variability, while the segment variance yields information on tank horizontal and vertical variability. The analytical measurement variability measures the difference between results from the sample and duplicate analyses.

To test the significance of the core level variance components, an ANOVA based on the hierarchical model was calculated for the core composite data. The ANOVA output was used to test the core and analytical variability. The digestion method used to prepare the analytes listed are from the "preferred" method discussed earlier. The estimates for each component of variability along with the p-values for the core term are given in Table B3-21. All p-values are compared with a standard significance level ($\alpha = 0.05$). If a p-value is below 0.05, there is sufficient evidence to conclude that the subsample means for core composite samples are significantly different from each other. However, if a p-value is above 0.05, there is not sufficient evidence to conclude that the core composite samples are significantly different.

The p-values from the composite level core variability test were less than $p = 0.05$ for 29 analytes and greater than $p = 0.05$ for 17 analytes of 46 analytes tested. This indicates that there was significant difference in concentration between cores for 63 percent of the analytes, and no differences between cores for 37 percent. Thus, the tank contents appear to be horizontally heterogeneous.

Columns 2 and 4 of Table B3-21 represent the RSD variability estimates for the core and analytical terms, respectively. Columns 5 and 6 estimate the total amount of variability (in percent terms) in the data due to core differences and laboratory analytical error, respectively. As expected, the variability in analytical error makes a smaller contribution to the total error than the core variance, with the core term being larger for 67 percent of the analytes tested. The higher core term is simply reflecting the variation in analyte concentrations throughout the tank.

Table B3-21. Variance Component Estimates. (3 sheets).

Analyte	RSD (Core)	Core p-value	RSD (Analytical)	Core % of Variance	Analytical % of Variance
ICP.f.Al	39	0.00*	6	97	3
ICP.a.Ba	16	0.48	138	1	99
ICP.f.Bi	73	0.00*	23	91	9
ICP.f.Ca	45	0.03*	34	63	37
ICP.f.Ce	9	0.44	35	6	94
ICP.f.Cr	35	0.03*	31	74	26
ICP.f.Cu	23	0.06	21	54	46
ICP.f.Eu	6	0.46	31	3	97
ICP.a.Fe	55	0.00*	11	96	4

Table B3-21. Variance Component Estimates. (3 sheets).

Analyte	RSD (Core)	Core p-value	RSD (Analytical)	Core % of Variance	Analytical % of Variance
ICP.a.Hg	90	0.01*	59	70	30
ICP.a.K	0	0.55	45	0	100
ICP.f.Mg	91	0.00*	40	84	16
ICP.a.Mn	52	0.00*	16	92	8
ICP.f.Mo	13	0.34	31	15	85
ICP.f.Na	42	0.00*	13	91	9
ICP.f.Ni	26	0.01*	17	69	31
ICP.a.P	33	0.27	53	28	72
ICP.a.Pb	17	0.46	87	4	96
ICP.f.Sb	24	0.17	33	35	65
ICP.f.Sm	0	0.53	39	0	100
ICP.f.Se	21	0.15	27	37	63
ICP.f.Si	48	0.16	42	57	43
ICP.f.Sr	47	0.01*	31	70	30
ICP.f.Tl	182	0.00*	47	94	6
ICP.f.Th	170	0.01*	111	70	30
ICP.f.Sn	13	0.17	19	34	66
ICP.f.Ti	14	0.43	52	7	93
ICP.f.Zn	200	0.00*	71	89	11
ICP.f.Zr	24	0.31	52	18	82
Coul.$C_2H_3O_2^-$ (TOC)	51	0.00*	16	92	8
IC.CO_3^{-2}	59	0.00*	19	90	10
IC.w.Cl^-	45	0.01*	26	75	25
IC.w.F^-	40	0.09	43	46	54
IC.w.NO_2^-	42	0.04*	35	59	41
IC.w.NO_3^-	45	0.00*	21	82	18

Table B3-21. Variance Component Estimates. (3 sheets).

Analyte	RSD (Core)	Core p-value	RSD (Analytical)	Core % of Variance	Analytical % of Variance
IC.w.PO_4^{-3}	56	0.00*	24	85	15
Wt.% H_2O	35	0.00*	4	99	1
$^{+}$H.d.pH	6	0.00*	2	90	10
APC.^{241}Am	40	0.14	47	42	58
APC.^{137}Cs	65	0.00*	6	99	1
GEA.f.Pu	51	0.00*	14	93	7
BPC.f.^{90}Sr	54	0.00*	10	97	3
LSC.^{3}H	28	0.00*	11	88	12
LF.f.U	39	0.00*	14	88	12
APC.Total α	81	0.00*	23	93	7
BPC.Total β	57	0.00*	12	96	4

Note:

* Significant at the $\alpha = 0.05$ level.

Because 63 percent of the analytes tested at the composite level showed significant difference between cores, a closer look at which cores showed differences was warranted. The ANOVA test is limited in that it only reveals whether or not there is at least one difference between cores, without indicating which cores are different or how many are different from each other. In order to make these determinations, and to see if any trends are discernible in the disposition of the tank waste, a multiple comparison test known as Tukeys' HSD was calculated on the composite and segment data.

The composite level Tukey's HSD results showing differences between cores for 9 major analytes are given in Table B3-22. The concentration values given are for the "preferred" method. For a given row, analyte values that have the same letter are not significantly different from each other at the 0.05 level, whereas those with different letters are significantly different. Only those analytes that showed a significant difference in Table B3-21 are shown in Table B3-22. In studying these trends, it may be helpful to note that for a given analyte, the letter "a" always represents a higher concentration than the letter "b", which is larger than "c", etc. Core 8 data were not used because only one segment was recovered. The seven cores listed are separated into four groups by double lines. This arrangement corresponds to their spatial separation in the tank and can help in determining

any patterns present in the waste (see Figure B1-1 for the proximity of the risers from which the cores were taken). Of the analytes listed, phosphorus and nitrate showed no differences between cores, and sodium showed just one difference. Examination of the core groupings shows that cores 6, 15, and 7 have only one of nine analytes with differences between cores (aluminum), and cores 12 and 13 show only two of nine analytes with differences (phosphate and ^{137}Cs). When comparing trends within groupings to trends between groupings, it appears that a given analyte concentration is more consistent within a group than between a group. Thus, patterns in the waste disposition may be present. However, no clear overall pattern is apparent in how the waste was horizontally distributed in the tank.

A separate ANOVA was conducted on the segment level data, and the results showed at least one significant difference in concentration between segments for all of the major analytes. The specific results for the Tukey's HSD test is given in Table B3-23. For a given analyte, one row is assigned to each of the four segments recovered, and the cores are grouped in the columns as in Table B3-22. Moving down the columns represents increasing tank depth (segment 1 is highest in the tank, and segment 4 the lowest). As with the core composite results, analyte concentrations that have the same letter are not significantly different from each other at the 0.05 level, whereas those with different letters are significantly different. Although there are many differences among the segments, there are not necessarily differences between the cores as a whole (see discussion above).

Table B3-22. Tukey's Multiple Comparisons Between Cores.

Analyte	Concentration (μg/g or μCi/g)						
	Core 5	Core 6	Core 15	Core 7	Core 12	Core 13	Core 14
ICP.f.Al	113,000 cd	96,400 d	215,000 a	169,000 b	143,000 bc	150,000 bc	168,000 b
ICP.f.Bi	39,800 a	13900 cd	11,300 cd	19,000 bc	31100 ab	---	8,940 cd
ICP.a.Fe	17,500 a	12900 abc	11,200 abc	8,820 bc	16000 ab	15,100 ab	6,460 cd
ICP.f.Na	143,000 a	130,000 ab	96,500 ab	106,000 ab	114000 ab	79,400 b	111,000 ab
ICP.a.P	20,800 a	24200 a	4,750 a	13,300 a	---	---	13,400 a
IC.w.NO_3^-	48,300 a	45700 a	48,300 a	28,200 ab	50100 a	60,100 a	35,300 a
IC.w.PO_4^{-3}	19,700 bcd	35100 abc	26,000 abcd	36,200 abc	43500 ab	15,100 cd	51,700 a
GEA.f.^{137}Cs	38.3 b	23.0 d	17.3 d	17.8 d	53.6 a	30.0 c	17.7 d
BPC.f.^{90}Sr	364 bc	321 c	---	269 c	470 ab	524 a	252 c

Table B3-23. Tukey's Multiple Comparisons Between Segments. (2 sheets)

Analyte	Segment	Concentration (µg/g or µCi/g)						
		Core 5	Core 6	Core 15	Core 7	Core 12	Core 13	Core 14
ICP.f.Al	1	---	---	---	85,400 cdefghi	---	---	72,400 defghij
	2	---	91,700 bcdefg	84,800 cdefghi	130,000 ab	137,000 a	---	101,000 abcdef
	3	127,000 abc	89,700 bcdefgh	89,700 bcdefgh	84,000 cdefghi	45,600 hijk	111,000 abcd	20,000 k
	4	36,300 jk	49,100 ghijk	60,800 efghijk	56,200 fghijk	42,600 ijk	47,300 ghijk	52,700 ghijk
ICP.f.Bi	1	---	---	---	527 i	---	---	< 280 i
	2	---	5,050 hi	3,870 hi	2,630 i	7,470 ghi	---	2,440 i
	3	4,250 hi	19,500 def	22,100 de	12,400 fgh	39,300 ab	13,800 efg	2,730 i
	4	20,300 def	24,100 cd	47,300 a	32,700 bc	5,870 ghi	17,000 def	24,800 cd
ICP.a.Fe	1	---	---	---	1,990 g	---	---	441 g
	2	---	18,100 bcd	7,290 efg	5,960 fg	27,800 a	---	4,680 fg
	3	8,230 efg	12,900 def	15,200 cde	12,700 def	22,400 abc	13,500 def	2,260 g
	4	8,040 efg	15,900 cde	24,100 ab	20,800 abcd	7,620 efg	27,300 a	12,200 def
ICP.f.Na	1	---	---	---	29,000 h	---	---	< 161 h
	2	---	77,700 de	64,500 def	49,100 efg	80,300 de	---	45,000 fg
	3	78,200 de	87,600 cd	81,700 de	85,800 cd	113,000 c	78,400 de	20,700 gh
	4	65,500 def	179,000 ab	181,000 ab	189,000 a	49,900 efg	89,500 cd	151,000 b

Table B3-23. Tukey's Multiple Comparisons Between Segments. (2 sheets)

Analyte	Segment	Concentration (μg/g or μCi/g)						
		Core 5	Core 6	Core 15	Core 7	Core 12	Core 13	Core 14
ICP.a.P	1	---	---	---	515 d	---	---	< 103 d
	2	---	3,160 cd	---	1,550 cd	1,520 cd	---	866 cd
	3	2,040 cd	11,700 bcd	6,180 cd	13,700 bc	19,400 b	3,200 cd	905 cd
	4	9,220 bcd	50,500 a	44,900 a	50,300 a	1,870 cd	3,630 cd	40,900 a
ICP.f.U	1	---	---	---	9,350 c	---	---	< 3,800 c
	2	---	13,500 c	11,100 c	7,090 c	38,200 a	---	8,860 c
	3	---	4,650 c	12,600 c	4,980 c	< 3,340 c	25,900 b	1,830 c
	4	---	< 3,160 c	8,310 c	< 3,190 c	11,900 c	3,680 c	< 3,160 c
IC.NO_3^-	1	---	---	---	194 i	---	---	< 105 i
	2	---	49,800 cdefg	32,200 fgh	27900 h	31,200 gh	---	36,500 efgh
	3	73,800 ab	52,300 cdef	45,800 defgh	39800 efgh	69,900 abc	54,200 bcde	61,400 bcd
	4	62,700 bcd	26,100 h	33,600 fgh	27,700 h	54,000 cde	83,500 a	30,400 gh
IC.PO_4^{-3}	1	---	---	---	216 e	---	---	< 105 e
	2	---	< 9,860 e	< 11,300 e	11,800 e	< 9,630 e	---	1,880 e
	3	10,500 e	23,800 cde	19,200 de	18,500 de	50,500 c	7,930 e	13,900 de
	4	44,700 cd	153,000 a	99,700 b	123,000 ab	< 10,200 e	10,500 e	138,000 a

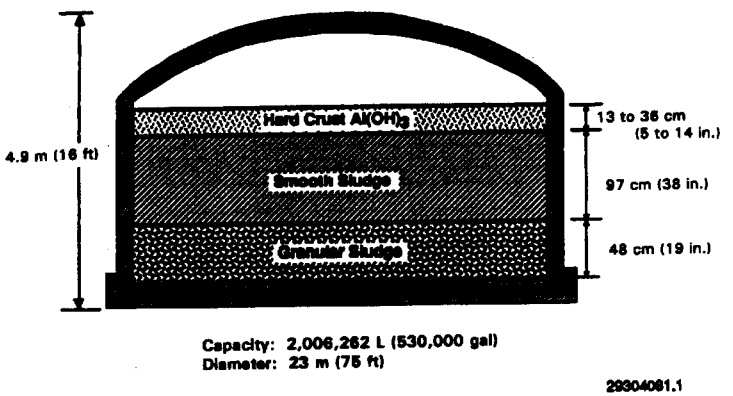
The data in Table B3-23 show trends in selected analyte concentrations as a function of depth. For example, aluminum shows a decreasing concentration as a function of depth for cores 5, 12, and 13. Bismuth shows an increasing concentration as a function of depth for five cores.

Due to the incomplete recovery of segments from the core samples taken from tank 241-U-110, all information gleaned from the statistical analysis must be qualified. However, based on the information made available, there do appear to be significant horizontal differences in the tank for many analytes. Vertically, all major analytes showed some differences, but a trend of increasing analyte concentration with depth was apparent. In summary, the tank cannot be considered homogeneous in either the horizontal or vertical directions.

B3.5.3 Summary of Tank Profile

Based on the information presented in Sections B1.1, B1.2.2, B2.6, B3.3.2, B3.5.1, and B3.5.2, it is apparent that the waste in tank 241-U-110 is a heterogeneous mixture of water, metal hydroxides and oxides, and inert salts. The top 10 to 38 cm of the waste consists of a layer of hard, white material. This white material consists primarily of aluminum hydroxide ($Al(OH)_3$) and contains very little water (approximately 5 percent). The next 96 cm consists of a layer of softer brown sludge. This sludge is more moist than the top layer, with a water content of approximately 40 to 45 percent. The major cations in this sludge are aluminum and sodium. The aluminum is primarily in an insoluble form. It is likely to be aluminum oxide or aluminum hydroxide in the form of boehmite (AlOOH). The sodium generally occurs in a soluble form and is likely ionically bonded to the anions in the form of sodium salts. The major anions that are believed to be bonded with sodium are nitrate, nitrite, and fluoride. The bottom 48 cm of the tank consists of a layer of sludge that is chemically similar to the middle sludge layer of the tank. The primary difference between the bottom and middle sludge layer is that the bottom layer is very grainy in appearance and consistency and also has high proportions of bismuth and phosphate in addition to the analytes common to the middle sludge layer. Both the bismuth and phosphate are in insoluble forms and are primarily found in the bottom of the tank, most likely in the form of bismuth phosphate. A summary diagram of these layers as they sit in the tank is given in Figure B3-1.

Figure B3-1. Summary of Layers in Tank 241-U-110.



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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, one-sided confidence limits for total alpha activity supporting the safety screening DQO are calculated for tank 241-U-110. All data in this section are from the final laboratory data packages for the 1989 core sampling event for tank 241-U-110 (Winters 1993). Statics were not calculated on the DSC data because no exotherms were observed.

Confidence intervals were computed for each sample number from tank 241-U-110 analytical data. The confidence intervals are provided in Table C1-1 for alpha.

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 the $t_{(df,\ 0.05)}$ 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-U-110 data (per sample), df equals the number of observations minus one.

The upper limit of the 95 percent confidence interval for each sample number based on alpha data is listed in Table C1-1. Each confidence interval can be used to make the following statement. If the upper limit is less then 41 μCi/g, then one would reject the null hypothesis that the alpha is greater than or equal to 41 μCi/g at the 0.05 level of significance.

Table C1-1. 95 Percent Confidence Interval Upper Limits for Alpha for Tank 241-U-104 (Units are μCi/g).

Sample Location	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	UL
Core 5, Segment 3	7.42E-01	4.85E-02	1.05E+00
Core 5, Segment 4	4.01E-01	3.75E-02	6.37E-01
Core 6, Segment 2	2.64E+00	1.75E-01	3.74E+00
Core 6, Segment 3	2.68E-01	8.25E-02	7.88E-01
Core 6, Segment 4	6.95E-01	1.78E-01	1.82E+00
Core 7, Segment 1	9.86E-02	8.95E-02	6.63E-01
Core 7, Segment 2	1.70E+00	2.45E-01	3.24E+00
Core 7, Segment 3	2.84E+00	3.40E-01	4.99E+00
Core 7, Segment 4	1.31E-01	2.50E-03	1.46E-01
Core 8, Segment 1	8.60E-03	1.50E-03	1.81E-02
Core 12, Segment 2	9.31E-01	9.90E-02	1.56E+00
Core 12, Segment 3	4.37E-01	7.50E-03	4.84E-01
Core 12, Segment 4	5.49E-01	4.85E-02	8.55E-01
Core 13, Segment 3	7.44E-01	1.25E-02	8.22E-01
Core 13, Segment 4	6.57E-01	2.85E-02	8.36E-01
Core 14, Segment 1	7.70E-03	1.40E-03	1.65E-02
Core 14, Segment 2	1.56E-01	1.75E-02	2.66E-01
Core 14, Segment 3	1.40E+00	3.50E-01	3.61E+00
Core 14, Segment 4	2.96E-01	2.50E-03	3.11E-01
Core 15, Segment 2	2.29E+00	1.85E-01	3.45E+00
Core 15, Segment 3	2.16E+00	1.45E-01	3.07E+00
Core 15, Segment 4	1.51E-01	3.20E-02	3.53E-01

C2.0 APPENDIX C REFERENCES

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-U-110

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-U-110

The following evaluation provided a best-basis inventory estimate of chemical and radionuclide components in tank 241-U-110.

D1.0 CHEMICAL INFORMATION SOURCES

Characterization results from the most recent sampling event for this tank are shown in Appendix B. Eight core samples were obtained and analyzed. Tables B3-6 to B3-8 summarize the results from the statistical analysis of data from seven core composites. These tables provide mean concentration values for analytes, along with confidence intervals around the mean values. Component inventories can be calculated by multiplying the concentration of an analyte by the current tank volume and by the density of the waste. The HDW model document (Agnew et al. 1996a) provides tank content estimates, in terms of component concentrations and inventories.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

Sample-based inventories, derived from analytical concentration data, and HDW model (Agnew et al. 1996a) inventories, are compared in Tables D2-1 and D2-2. The tank volume used to generate these inventories is 704 kL (186 kgal) (Hanlon 1996). The mean density used to calculate the sample-based component inventories is 1.46 g/mL, and the HDW model density is estimated to be 1.35 g/mL. Note the significant differences between the sample-based and HDW model inventories for several of the bulk components; e.g., Al, Bi, Na, NO_3, PO_4 and U, as well as for the weight percent water values.

Table D2-1. Sample- and Historical Tank Content-Based Inventory Estimates for Nonradioactive Components in Tank 241-U-110.

Analyte	Sampling Inventory Estimate (kg)	HDW model[1] Inventory Estimate (kg)	Analyte	Sampling Inventory Estimate (kg)	HDW model[1] Inventory Estimate (kg)
Al	150,000	79,000	NO_3	46,000[2]	15,000
As	0.42	NR	OH	NR	46,000 (total)
Ba	66	NR	Pb	1,100	0
Be	33	NR	P as PO_4	48,000	81,000
Bi	21,000	9,900	Se	1.8	NR
Ca	3,300	2,200	Si	23,000	11,000
Cl	1,000[2]	330	S as SO_4	2,600	3,400
Cr	630	130	Sr	520	0
F	7,200[2]	1,900	TIC as CO_3	4,500[2]	13,000
Fe	13,000	12,000	Th	1,800	NR
Hg	3.0	13	Tl	3,200	NR
K	NR	78	TOC	980[2]	0
La	NR	0	U_{TOTAL}	11,000	43,000
Mg	2,600	NR	V	69	NR
Mn	4,200	0	Zn	1,100	NR
Mo	50	NR	Zr	380	580
Na	110,000	78,000	H_2O (wt%)	40	66
Ni	130	45	density (kg/L)	1.46	1.35
NO_2	9,400[2]	5,100			

Notes:

HDW = Hanford defined waste
NR = Not reported

[1]Agnew et al. (1996a)
[2]Based on analysis of water leach only.

Table D2-2. Sample-Based and Historical Tank Content-Based Inventory Estimates for Radioactive Components in Tank 241-U-110.

Analyte	Sampling inventory estimate (Ci)	HDW model[1] inventory estimate (Ci)	Analyte	Sampling inventory estimate (Ci)	HDW model[1] inventory estimate (Ci)
^{14}C	0.35[2]	NR	$^{239/240}Pu$	260	53
^{90}Sr	380,000	730	^{241}Am	90	NR
^{99}Tc	7.3[2]	NR	Total α	170	NR
^{137}Cs	29,000	47,000	Total β	1,000,000	NR

Notes:

HDW = Hanford Defined Waste
NR = Not reported

[1]Agnew et al. (1996a)
[2]Based on analysis of water leach only.

D3.0 COMPONENT INVENTORY EVALUATION

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

D3.1 CONTRIBUTING WASTE TYPES

Expected waste types and volumes entering tank 241-U-110, based on waste transfer records, are as follows (Agnew et al. 1996a):

through 1951	1C1	5,277 kL	(1,394 kgal)
through 1955	R1	4,512 kL	(1,192 kgal)
through 1957	RCW	3,051 kL	(806 kgal)
		12,840 kL	3,392 kgal

1C1 = First-cycle decontamination waste
R1 = REDOX concentrated waste (1952-1957)
RCW = REDOX process aluminum cladding waste.

In the bismuth phosphate process, the 1C1 waste stream was neutralized with aluminum cladding waste (CW). This neutralized waste stream, that contains approximately 24 percent CW, is also referred to as 1C1. Cascade overflows from tanks 241-U-110 were to 241-U-111 and 241-U-112. Additional information on the waste transfer history of tank 241-U-110 is provided in Appendix A, Section A3.0.

D3.2 TECHNICAL FLOWSHEET INFORMATION

Technical flowsheet information for 1C1, R1, and RCW streams is provided in Table D3-1. The comparative HDW streams also are provided in this table; however, HDW used only the 1C1 waste stream to account for 614 kL (162 kgal) of tank 241-U-110 waste (the remaining 91 kL [24 kgal] is attributed to metal waste). Note the difference in the NO_3 concentration in the 1C1 flowsheet and defined waste streams. The 1C1 defined waste stream appears to be a "second generation" flowsheet waste stream, derived by Jungfleisch (1984) for an earlier modeling effort.

Expected Solids

SORWT (Hill et al. 1995):	1C1/R1/RCW
HDW (Agnew et al. 1996a):	MW/1C1

MW = Metal waste from the $BiPO_4$ process
SORWT = Sort on Radioactive Waste Type Model

The HDW model (Agnew et al. 1996a) assumes that because the "measured" solids volume defined in Agnew (1996b) did not appear to change with the addition of R1 and RCW streams to the tank, the R1 and RCW streams did not contribute to any of the solids in the waste. This assumption is questionable. Color photographs of the waste inside the tank and of the core composites show that the top layer of the waste is white. Analytical results (Segment 1, Core 8) indicate that these white solids are comprised almost entirely of Al with little or no Bi from a 1C1 waste type. High aluminum concentrations are characteristic of both R1 and RCW streams.

Table D3-1. Technical Flowsheet and Los Alamos National Laboratory Hanford Defined Waste Streams.

Analyte	Flowsheet 1C1[1] (M)	Def Waste 1C1[2] (M)	Flowsheet 4[4] REDOX[3] (M)	HDW R1[2] (M)	Flowsheet RCW[3] (M)	HDW RCW[2] (M)
NO_3	1.44	0.588	3.62	2.5	0.98	0.88
NO_2	0.058	0.174	0	0	1.27	1.4
SO_4	0.063	0.0616	0.029	0.019	0	0
Bi	0.012	0.014	0	0	0	0
Fe	0.032	0.046	0.014	0.0475	0	0.0152
Si	0.031	0.038	0	0.0147	0.020	0.03
U	0.00096	0.0008	0.0075	0.0048	0.001	0.019
Al	0.083	0.233	1.05	0.65	1.7	2
$Cr^{+3/+6}$	0.0033	0.0052	0.053	0.068	0	0.003
PO_4	0.258	0.314	0	0	0	0
F	0.170	0.23	0	0	0	0
Ce	0.0002	NR	0	0	0	0

Notes:

[1]Schneider (1951)
[2]Agnew et al. (1996a)
[3]GE (1951)
[4]REDOX Flowsheet #4 operated until August 1955.

D3.3 ESTIMATE OF WASTE INVENTORIES

The following assessment is performed to provide a basis for evaluating the HDW component inventories that are based on the assumption that R1 and RCW did not contribute to solids in tank 241-U-110. For this particular assessment, the following assumptions and observations are made:

- Tank waste mass is calculated using the measured density and the tank volume listed in Hanlon (1996). While this volume may not be correct, both the analytical-based and the model-based inventories are derived using this volume. As a result, inventory comparisons are made on the same volume basis.

- 1C1, R1, and RCW streams contributed to solids formation.

- Only bulk components listed in the technical flowsheets are being evaluated. Initial bulk component concentrations are obtained from technical flowsheets (see Table D3-1).

- No radiolysis of NO_3 to NO_2 and no additions of NO_2 to the waste for corrosion purposes are factored into this independent assessment.

- All Bi, Fe, Si, and U compounds precipitate.

- All NO_3, NO_2, and SO_4 compounds remain dissolved in the interstitial liquid.

- Interstitial liquid is a composite of all wastes. Contributions of dissolved components are weighted by volume:

1C1	0.41
R1	0.35
CW	0.24

- Concentration of components in interstitial liquid is based on a void fraction of 0.7.

- Al, Cr, PO_4, and F compounds partition between the liquid and solid phases.

  - Cr remains in the +3 state in 1C1 and in the +6 state in REDOX wastes

  - Al partitioning is 0.6 aqueous, 0.4 solid (based on an evaluation of 1C1-type waste [single-shell tank 241-T-104] by Colton et al. [1995])

  - 0.18M PO_4 and 0.14M F remain in solution and the balance precipitates (based on an evaluation of 1C1-type waste [single-shell tank 241-T-104] by Colton et al. [1995] and in line with solubility information compiled by LANL [Agnew and Watkin 1994]).

- The Na inventory is calculated based on:

  - 1 mole Na for each mole of NO_3, NO_2, and F
  - 2 moles Na for each mole of Si, SO_4, and $Cr_{interstitial}$
  - 3 moles Na for each mole PO_4

- Water mass is the difference between the total waste mass and the dried solids mass. The following oxide factors are used to convert bulk chemical components; e.g., Fe, to chemical species; e.g., Fe_2O_3, for mass balance purposes:

-	Fe (Fe_2O_3)	1.43	U (UO_3)	1.20
-	Bi (Bi_2O_3)	1.12	Cr (Cr_2O_3)	1.46
-	Si (SiO_2)	2.14	Al (60% $Al(OH)_3$	(40% Al_2O_3) 2.49

Sample calculations used in this independent evaluation follow for:

Components assumed to precipitate (Fe, Bi, Si, and U).

(MT = metric tons)

Fe: $[0.032\ moles_{Fe}/L_{1C} \times 1{,}394\ kgal_{1C} + 0.014\ moles_{Fe}/L_R \times 1{,}192\ kgal_R + 0_{RCW}] \times 3{,}785\ L/kgal \times 55.8\ g/mole_{Fe} \times MT/1E6\ g = 13\ MT$

Similarly:

Bi: 13 MT

Si: 6.3 MT

U: 9.5 MT

Components assumed to remain dissolved in the interstitial liquid (NO_3, NO_2, and SO_4).

NO_3: $[0.41_{1C} \times 1.44\ moles_{NO3}/L_{1C} + 0.35_R \times 3.62\ moles_{NO3}/L_R + 0.24_{RCW} \times 0.98\ moles_{NO3}/L_{RCW}] \times 0.7_{porosity} \times 3{,}785\ L/kgal \times 186\ kgal_{241\text{-}U\text{-}110\ waste} \times 62\ g/mole_{NO3} \times MT/1E6\ g = 64\ MT$

NO_2: 7.4 MT

SO_4: 1.7 MT

Components assumed to partition between aqueous and solid phases (Al, Cr, PO_4, and F).

Total Al:	$[0.41_{1C}$ x 0.083 $moles_{Al}/L_{1C}$ + 0.35_R x 1.05 $moles_{Al}/L_R$ + $.24_{RCW}$ x 1.7 $moles_{Al}/L_{RCW}] = 0.809$ $moles_{Al}/L$
Al_{solids}:	0.4 x 0.809 $moles_{Al}/L$ x 3,785 L/kgal x 3,392 kgal x 27 $g/mole_{Al}$ x MT/1E6 g = 110 MT
$Al_{interstitial}$:	0.6 x 0.809 $moles_{Al}/L$ x $0.7_{porosity}$ x 3,785 L/kgal x 186 $kgal_{241\text{-}U\text{-}110\ waste}$ x 27 $g/mole_{Al}$ x MT/1E6 g = 6.4 MT
Total Al:	120 MT
$Cr_{(solids)}$:	0.0033 $moles_{Cr+3}/L_{1C}$ x 1,394 $kgal_{1C}$ x 3,785 L/kgal x 52 $g/mole_{Cr}$ x MT/1E6 g = 0.90 MT
$Cr_{(interstitial)}$:	$[0.41_{1C}$ x 0 + 0.35_R x 0.053 $moles_{Cr+6}/L_R$ + 0.24_{RCW} x 0] x $0.7_{porosity}$ x 3,785 L/kgal x 186 $kgal_{241\text{-}U\text{-}110\ waste}$ x 52 $g/mole_{Cr+6}$ x MT/1e6g = 0.47 MT
Total Cr:	1.4 MT
$PO_{4(solids)}$:	0.078 $moles_{PO4}/L_{1C}$ x 3,785 L/kgal x 1,394 $kgal_{1C}$ x 95 $g/mole_{PO4}$ x MT/1E6 g = 39 MT
$PO_{4(interstitial)}$:	$[0.41_{1C}$ x 0.18 $moles_{PO4}/L_{1C}$ + 0.35_R x 0 + 0.24_{RCW} x 0] x $0.7_{porosity}$ x 3,785 L/kgal x 186 $kgal_{241\text{-}U\text{-}110\ waste}$ x 95 $g/mole_{Al}$ x MT/1E6 g = 3.4 MT
Total PO_4:	43 MT
$F_{(solids)}$:	0.030 $moles_F/L_{1C}$ x 3,785 L/kgal x 1,394 $kgal_{1C}$ x 19 $g/mole_F$ x MT/1E6 g = 3.0 MT
$F_{(interstitial)}$:	$[0.41_{1C}$ x 0.14 $moles_F/L_{1C}$ + 0.35_R x 0 + 0.24_{RCW} x 0] x $0.7_{porosity}$ x 3,785 L/kgal x 186 $kgal_{241\text{-}U\text{-}110\ waste}$ x 19 $g/mole_F$ x MT/1E6 g = 0.54 MT
Total F:	3.5 MT
Water Mass	
Waste:	186 kgal x 3,785 L/kgal x 1.46 kg/L x 1MT/1E3 kg = 1,030 MT
Dried solids:	$(1.43$ x 13 $MT)_{Fe}$ + $(1.12$ x 13 $MT)_{Bi}$ + $(2.14$ x 6.3 $MT)_{Si}$ + $(1.20$ x 9.5 $MT)_U$ + 64 MT_{NO3} + 7.4 MT_{NO2} + 1.7 MT_{SO4} + $(2.49$ x 120 $MT)_{Al}$ + $(1.46$ x 1.4 $MT)_{Cr}$ + 43 MT_{PO4} + 3.5 MT_F + 74 MT_{Na} = 550 MT
Water:	1,030 MT - 610 MT = 480 MT (47 percent)

Estimated component inventories from this independent evaluation are compared with sample- and HDW model-based inventories for selected components in Table D3-2. Observations regarding these inventories are noted, by component, in the following text.

Table D3-2. Comparison of Selected Component Inventory Estimates for Tank 241-U-110 Waste.

Component	This Evaluation (kg)	Sample-Based (kg)	HDW Model (kg)
Fe	13,000	13,000	12,000
Bi	13,000	21,000	9,900
Si	6,300	23,000	11,000
U	9,500	11,000	43,000
NO_3	64,000	46,000	15,000
NO_2	7,400	9,400	5,100
SO_4	1,700	2,600	3,400
Al	120,000	150,000	79,000
Cr	1,400	630	130
PO_4	43,000	48,000	81,000
F	3,500	7,200	1,900
Na	74,000	110,000	79,000
H_2O (%)	47	40	66

Iron. The sample-based and HDW model inventories compare favorably with each other and with the inventory estimated in this evaluation. However, the fact that the sample-based and HDW model inventories compare fairly well may be coincidental. The HDW model inventory is based predominantly on the 1C1 waste stream with 0.03M Fe because of chemicals added in the process and 0.016M Fe assumed from corrosion; Fe in the R1 waste stream was not taken into account. The LANL corrosion source term is based on plutonium-uranium extraction (PUREX)-related data and may not be applicable to 1C1 waste streams.

Bismuth. The sample-based inventory is larger and the HDW model inventory is smaller than the inventory estimated in this evaluation. The statistical mean concentration (20,600 μg Bi/g waste), used to calculate the sample-based inventory, reflects the average concentration in the bottom portion (Segment 4 of a core) of the tank (24,600 μg Bi/g waste). If the average concentration of Bi from segments 1 - 4 or segments 2 - 4 in the trending table is used to calculate the sample-based inventory, the inventory is 12 MT or 15 MT, respectively. If the average concentration from Core 15 composite (90 percent recovery) is used, the inventory is 12 MT. The HDW model inventory reflects the LANL assumption that approximately 780 μg Bi/mL remains in solution (or that only 73 percent of the Bi precipitates).

Silicon. Both the sample-based inventory and the HDW model inventory are larger than the inventory estimated in this evaluation. This evaluation does not, however, account for any blowsand; i.e., dirt, that may have entered the tank. The lower HDW model inventory reflects the LANL assumptions (1) that approximately 900 μg Si/mL remains in solution and (2) that R1 waste (approximately 0.015M Si) did not contribute to the solids in this tank. Unfortunately, analytical data for Si from fused samples were reported for only 3 of the 8 core composites. The statistical mean for these data (22,000 μg Si/g waste) was used to calculate the sample-based inventory.

Uranium. The sample-based inventory compares favorably with the inventory estimated in this evaluation. The HDW model inventory is approximately four times higher than the sample-based and estimated inventories. The inventory derived in this evaluation is based on U contributions from 1C1, R1, and RCW waste streams; the HDW model inventory is based on U contributions from MW (0.16M U) and 1C1 waste streams. If MW comprises the bottom layer of the waste in the tank, the highest U concentrations should appear in Segment 4 from each core sample (unless the sampler failed to retrieve any of the MW heel assumed by LANL). The highest U concentration appears in Segment 2 (second segment from the top), and the lowest U concentration appears in Segment 1 (top segment). These trends are more consistent with a layering scheme based on 1C1, R1, and RCW streams than a layering scheme based on MW and 1C1 waste streams.

Nitrate. The HDW model inventory is smaller than the sample-based inventory, and both of these inventories are smaller than the inventory estimated in this evaluation. The inventory derived in this evaluation is based on a composite of 1C1, R1, and RCW streams and does not account for any dilution by process water or other dilute waste streams that may have entered the tank or for any radiolysis of NO_3 to NO_2. The HDW model inventory is derived from the LANL 1C1 defined waste stream and does not account for any contributions from R1 and RCW streams that passed through the tank. As noted earlier, the NO_3 concentration in this defined waste stream is approximately two and a half times lower than the NO_3 concentration in the technical flowsheet. The sample-based inventory could be larger than 46 MT if cancrinite [$Na_8(AlSiO_4)_6(NO_3)_2$] is present in the waste. Nitrate in cancrinite would not dissolve in a water leach; as a result, the concentration of NO_3 in the water leach, which is used to derive the sample-based inventory, would not reflect the total NO_3 concentration.

Nitrite. The inventory estimated in this evaluation is approximately 20 percent less than the sample-based inventory. The inventory derived in this evaluation does not account for any NO_2 from radiolysis of NO_3 or for any NO_2 additions for corrosion purposes. The HDW model inventory does not account for any contribution from the RCW (1.27M NO_2) and is smaller than the sample-based inventory.

Sulfate. The HDW model inventory is larger than the sample-based inventory, and both of these inventories are larger than the inventory estimated in this evaluation. As mentioned previously, the HDW model inventory does not account for any contributions from the R1 and RCW streams that passed through the tank. The SO_4 concentration in the R1 waste stream is more dilute than the SO_4 concentration in the 1C1 waste stream. A further dilution effect might be expected from the RCW because no SO_4 was intentionally added to this waste stream.

Aluminum. The inventory estimated in this evaluation is within 20 percent of the sample-based inventory. Both of these inventories are significantly larger than the HDW model inventory. The HDW model inventory reflects the LANL assumptions (1) that R1 and RCW streams did not contribute to any of the solids in this tank and (2) that 70 percent of the Al remains in solution (30 percent precipitates).

Chromium. The HDW model inventory is derived from 0.0052M Cr in the 1C1 defined waste stream. This concentration is approximately two times higher than the concentration derived from the technical flowsheet and may include a Cr corrosion source term. Even though the 1C1 defined waste stream has a potentially inflated Cr concentration, the HDW model inventory derived from this concentration is still smaller than the sample-based inventory by a factor of five. The HDW model inventory does not account for any Cr from the R1 waste that was added to the tank. Both the HDW model and sample-based inventories are smaller than the inventory estimated in this evaluation. As mentioned earlier, this evaluation does not account for any dilution of dissolved components by process water or other dilute waste streams.

Phosphate. Phosphate originated from the 1C1 waste stream (PO_4 was not added to R1 or RCW). As a result, the HDW model inventory, derived from the 1C1 waste stream, and the inventory estimated in this evaluation should be comparable. The HDW model inventory is larger than the inventory estimated in this evaluation, and the sample-based inventory. The HDW model inventory reflects the LANL assumptions (1) that the PO_4 concentration in the LANL 1C1 defined waste stream is 0.314M (in comparison to 0.258M derived from the technical flowsheet) and (2) that 0.15M remains in solution (in contrast to this evaluation that assumes 0.18M remains in solution). In addition, the HDW model assumes a larger contribution of 1C1 waste in the tank than assumed for this evaluation.

Fluoride. The inventory estimated in this evaluation is lower than the sample-based inventory. Both of these inventories are larger than the HDW model inventory. The HDW model inventory reflects the assumption that all of the 0.23M F in the defined waste stream remains in solution; this evaluation assumes 0.14M remains in solution (0.057M precipitates). Because the phosphate content is high in this tank, the high fluoride content in the sample may be attributed to formation of a sodium fluoride-diphosphate double salt ($Na_7F(PO_4)_2 \cdot 19H_2O$) (Herting 1996).

Sodium. The HDW model inventory reflects the 0.59M NO_3 concentration used to define the 1C1 waste stream (refer to discussion on nitrate). If the NO_3 concentration (as HNO_3) is >0.59M, then the Na concentration would be higher, and the resulting Na inventory larger, because of the additional NaOH required to neutralize the acid.

Water. The percent water estimated in this evaluation compares favorably with the percent water determined from the analysis of core samples. These values are considerably lower than the HDW model percent water value. Conversely, the solids mass calculated in this evaluation and reported in the TCR is higher than the solids mass predicted by the LANL model.

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

The sample-based data set provides the best basis for estimating the tank 241-U-110 waste inventory for the following reasons:

1. Data from seven core composite samples were used to estimate the component inventories. The core sample recovery was incomplete; however, assuming the core and segment samples that were recovered represent a random sample from tank 241-U-110, the concentration estimates are unbiased estimates of true unknown mean concentrations.

2. Results from this evaluation indicate that some of the assumptions governing the HDW model inventory are questionable. These assumptions include the following:

   - Only 1C1 contributed to the waste composition

   - Corrosion source terms for Fe and Cr that are based on PUREX-related data are applicable to 1C1 waste

   - The starting NO_3 concentration in the 1C1 waste stream was 0.5M.

The best-basis inventory estimates are provided in Tables D4-1 and D4-2. Note that Bi and Si inventories are flagged as being potentially too large; however, no adjustments to these inventories are being made at this time. These inventories will be revised, if necessary, during reconciliation of all tank-specific inventories with the global inventories.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-U-110 (July 2, 1996). (2 Sheets)

Analyte	Total Inventory (kg)	Basis (S, M, or E)	Comment
Al	150,000	S	
Bi	21,000	S	Potentially too large.
Ca	3,300	S	
Cl	1,000	S	Based on analysis of water leach only.
TIC as CO_3	4,500		Based on analysis of water leach only.
Cr	630	S	
F	7,200	S	Based on analysis of water leach only.
Fe	13,000	S	
Hg	3	S	Method/sample prep: AAS/Acid (Brown and Jensen 1993).
K	78	M	No sample basis
La	0	M	No sample basis
Mn	4,200	S	
Na	110,000	S	
Ni	130	S	
NO_2	9,400	S	Based on analysis of water leach only.
NO_3	46,000	S	Based on analysis of water leach only.
OH	46,000	M	No sample basis

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-U-110 (July 2, 1996). (2 Sheets)

Analyte	Total Inventory (kg)	Basis (S, M, or E)	Comment
Pb	1,100	S	
P as PO_4	48,000	S	
Si	23,000	S	Potentially too large.
S as SO_4	2,600	S	
Sr	520	S	
TOC	980	S	Based on analysis of water leach only.
U_{TOTAL}	11,000	S	
Zr	380	S	

Notes:

S = Sample-based
M = HDW model-based
E = Engineering assessment-based

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-U-110 (July 2, 1996)[1]. (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)	Comment
^{3}H	NR		
^{14}C	0.35	S	Based on analysis of water leach only.
^{59}Ni	NR		
^{60}Co	NR		
^{63}Ni	NR		
^{79}Se	NR		
^{90}Sr	350,000	S	
^{90}Y	350,000	S	Referenced to ^{90}Sr
^{93}Zr	NR		
^{93m}Nb	NR		
^{99}Tc	7.3	S	Based on analysis of water leach only.
^{106}Ru	NR		
^{113m}Cd	NR		
^{125}Sb	NR		
^{126}Sn	NR		
^{129}I	NR		
^{134}Cs	NR		
^{137}Cs	26,000	S	
^{137m}Ba	25,000	S	Referenced to ^{137}Cs
^{151}Sm	NR		
^{152}Eu	NR		
^{154}Eu	NR		
^{155}Eu	NR		
^{226}Ra	NR		
^{227}Ac	NR		
^{228}Ra	NR		
^{229}Th	NR		
^{231}Pa	NR		

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-U-110 (July 2, 1996)[1]. (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)	Comment
^{232}Th	NR		
^{232}U	NR		
^{233}U	NR		
^{234}U	NR		
^{235}U	NR		
^{236}U	NR		
^{237}Np	NR		
^{238}Pu	NR		
^{238}U	NR		
^{239}Pu	NR		
$^{239/240}$Pu	260	S	
^{240}Pu	NR		
^{241}Am	89	S	
^{241}Pu	NR		
^{242}Cm	NR		
^{242}Pu	NR		
^{243}Am	NR		
^{243}Cm	NR		
^{244}Cm	NR		

Notes:

S = Sample-based
M = Hanford Defined Waste model-based
E = Engineering assessment-based
NR = Not reported

[1]Curie values decayed to January 1, 1994.

D5.0 APPENDIX D REFERENCES

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Herting, D. L., 1996, *Clean Salt Process Final Report*, WHC-EP-0915, Westinghouse Hanford Company, Richland, Washington.

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Jungfleisch, F. M., 1984, *Preliminary Estimation of the Waste Inventories in Hanford Tanks Through 1980*, SD-WM-TI-057, Rev. 0, Rockwell Hanford Operations, Richland, Washington.

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-U-110

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-U-110

Appendix E provides a bibliography of information that supports the characterization of tank 241-U-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-U-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 and Customers of Characterization Data

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

- IIa Sampling of Tank 241-U-110
- IIb Other - Non-Documented or Electronic Sources

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

- IIIa. Inventories using both Campaign and Analytical Information
- IIIb. Compendium of Existing Physical and Chemical Documented Data Sources
- IIIc. Other - Non/Documented or Electronic Sources

IV. OTHER DOCUMENTED RESOURCES

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 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.

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

Boldt, A. L., 1966, *REDOX Chemical Flowsheet HW No. 9*, ISO-335, Isochem, Inc., Richland, Washington.

- Contains compositions of material balance for REDOX process as well as a separations plan denoting process stream waste before transfer to 200 Area waste tanks.

Crawley, D. T., 1960, *REDOX Chemical Flowsheet HW-No. 6*, HW-66203, Hanford Atomic Products Operation, General Electric Company, Richland, Washington.

- Contains compositions of material balance for REDOX process as well as a separations plan denoting process stream waste before transfer to 200 Area waste tanks.

GE, 1951, *REDOX Technical Manual*, HW-18700, General Electric Company, Richland, Washington.

- Specifies information on the REDOX process and the waste streams produced.

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.

Merrill, E. T., and R. L. Stevenson, 1955, *REDOX Chemical Flowsheet HW No. 5*, HW-38684, Hanford Atomic Products Operation, Richland, Washington.

- Contains compositions of material balance for REDOX process as well as a separations plan denoting process stream waste before transfer to 200 Area waste tanks.

Schneider, K. J., 1951, *Flow Sheet and Flow Diagrams of Precipitation Separations Process*, HW-23043, General Electric Company, Richland, Washington.

- Document contains compositions of first concentration cycle waste before transfer to 200 East Area waste tanks.

Ib. Fill History/Waste Transfer Records

Agnew, S. F., R. A. Corbin, T. B. Duran, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1996, *Waste Status and Transaction Record Summary for the Southwest Quadrant*, WHC-SD-WM-TI-614, Rev. 1, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Document contains spreadsheets depicting all available data on tank additions/transfers.

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

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Koreski, G. M., 1991, *Operational Waste Volume Projection*, WHC-SD-WM-ER-029, Rev. 15, Westinghouse Hanford Company, Richland, Washington.

- Contains spreadsheets depicting all available data on tank additions/transfers from 1981 up to 1991.

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.

- Document shows tank riser locations in relation to tank aerial view as well as a description of riser and its contents.

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Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1994, *Supporting Document for the Historical Tank Content Estimate for U Tank Farm*, WHC-SD-WM-ER-325, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains summary tank farm and tank write-ups on historical data and solid inventory estimates as well as appendices for the data. The appendices contain the following information: Appendix C - Level History AutoCAD sketch; Appendix D - Temperature Graphs; Appendix E - Surface-Level Graph; Appendix F, pg F-1 - Cascade/ Drywell Chart; Appendix G - Riser Configuration Drawing and Table; Appendix H - Historical Sampling Data; Appendix I - In-Tank Photos; and Appendix K - Tank Layer Model Bar Chart and Spreadsheet.

Burton, G. Jr., 1975, *Status of Tank 241-U-110*, (internal memorandum [number, addressee, and date not available]), U. S. Energy Research and Development Administration, Richland, Washington.

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- Discusses whether these previously declared interim stabilized tanks are currently meeting that criteria, and a proposed course of action if the criteria is not met.

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- Most recent release of a series of summaries including fill volumes, Watch List tanks, occurrences, integrity information, equipment readings, equipment status, tank location, and other miscellaneous tank information. The series includes monthly summaries from Dec. 1947 - present; however, Hanlon has only authored the monthly summaries from November 1989 to present.

Johnson, L. L., 1979, *Liquid Intrusion Into Tank 241-U-110*, (Occurrence report number OR-79-20 to C. R. Carter [date not available]), Rockwell Hanford Operations, Richland, Washington.

- An intrusion of liquid into the tank that was attributed to snowmelt. The baseline waste surface level increased from 154.7 cm (60.90 in.) to 155.4 cm (61.20 in.).

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

- Gives an assessment of riser locations for each tank; however, not all tanks are included/completed. Also includes an estimate of which risers are available for sampling.

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- Compilation information on thermocouple trees installed in the Hanford Site underground waste tanks.

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- Document gives an assessment of riser locations for each tank; however, not all tanks are included/completed. Also included is an estimate of the risers that are available for sampling.

Welty, R. K., 1988, *Waste Storage Tank Status and Leak Detection Criteria, Volumes I and II*, WHC-SD-WM-TI-553, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Describes the nature, scope, and frequency of surveillance employed for waste storage tanks, states action criteria for response to data deviation, and presents tank data reviews between June 15, 1973 and June 15, 1988.

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

IIa. Sampling of Tank Waste and Waste Types

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- Original TCR based on the 1989 core sampling event.

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- Contains data on the samples taken for privatization earlier this year to provide privatization vendors with washed C-106 sludge for high-level waste vitrification studies. A pretreatment screening study was performed on about 15 g of material. (Location note: A. E. Young, "Topical Reports" file, Tank Characterization Resource Center, 200 East Area, 2750E Building).

WHC, 1991, *Laboratory Report 222-S/RCRA Analytical Laboratories, Single Shell Tank Waste Characterization, Tank 241-U-110, Core Composite and Segment Level Data*, Westinghouse Hanford Company, Richland, Washington.

- This is actually a general reference for the eight individual reports on the core composite data, and the twenty-two individual reports on the segment level data for the 1989 core sampling and analyses event.

IIb. Other - Non/Documented or Electronic Sources

ICF Kaiser Hanford, 1996, Kaiser Electronic: Historical Sampling Data. In: Microsoft Excel 5.0. Available: Tank Waste Information Network System (TWINS), Pacific Northwest National Laboratory, Richland, Washington.

- Spreadsheets contain historical sampling data for dates prior to samples available in Tank Characterization Database.

Pacific Northwest National Laboratory, 1996, Tank Characterization Database. In: SYBASE 4.0. Available: Tank Waste Information Network System (TWINS), Pacific Northwest National Laboratory, Richland, Washington.

- Database contains qualified raw sampling data taken in the past few years from 222-S Laboratory. A small amount of information from the 325 laboratory data is included at this time.

WHC, 1996, Extrusion Video Tapes. In: VHS. Available: 222-S Hotcell, Westinghouse Hanford Company, Richland, Washington.

- Videos contain a visual presentation of the extrusion process of the samples, and the relative color of the extruded material.

WHC, 1996, Extrusion laboratory notebooks. In: Hardcopy. Available: 222-S Hotcell, Westinghouse Hanford Company, Richland, Washington.

- Lab notebooks contain a record of the events surrounding sample extrusion and analysis as well as some actual data.

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

IIIa. Inventories using both Campaign and Analytical Information

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

- Document contains waste type summaries as well as primary chemical compound/analyte and radionuclide estimates for sludge, supernatant, and solids.

Agnew, S. F., 1995, *Strategy for Analytical Data Comparisons to HDW Model*, (letter report CST-4:95-sfa272 to Susan Eberlein, Westinghouse Hanford Company, September 28), Los Alamos National Laboratory, Los Alamos, New Mexico.

- Contains proposed tank groups based on TLM, and statistical method for comparing analytical information to HDW predictions.

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

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

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

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

Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1994, *Supporting Document for the Historical Tank Content Estimate for U Tank Farm*, WHC-SD-WM-ER-325, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains summary tank farm and tank write-ups on historical data and solid inventory estimates as well as appendices for the data. The appendices contain the following information: Appendix C - Level History AutoCAD sketch; Appendix D - Temperature Graphs; Appendix E - Surface-Level Graph; Appendix F, pg F-1 - Cascade/ Drywell Chart; Appendix G - Riser Configuration Drawing and Table; Appendix H - Historical Sampling Data; Appendix I - In-Tank Photos; and Appendix K - Tank Layer Model Bar Chart and Spreadsheet.

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

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

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 Existing Physical and Chemical Documented Data Sources

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

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

Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1994, *Supporting Document for the Historical Tank Content Estimate for U Tank Farm*, WHC-SD-WM-ER-325, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains summary tank farm and tank write-ups on historical data and solid inventory estimates as well as appendices for the data. The appendices contain the following information: Appendix C - Level History AutoCAD sketch; Appendix D - Temperature Graphs; Appendix E - Surface-Level Graph; Appendix F, pg F-1 - Cascade/ Drywell Chart; Appendix G - Riser Configuration Drawing and Table; Appendix H - Historical Sampling Data; Appendix I - In-Tank Photos; and Appendix K - Tank Layer Model Bar Chart and Spreadsheet.

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

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

Hanlon, B. M., 1996, *Waste Tank Summary Report for Month Ending September 30, 1996*, WHC-EP-0182-102 Westinghouse Hanford Company, Richland, Washington.

- These documents contain a monthly summary of: fill volumes, Watch List tanks, occurrences, integrity information, equipment readings, equipment status, tank location, and other miscellaneous tank information. Grouped here are all the monthly summaries from Dec. 1947 - present, however Hanlon has only authored the monthly summaries from Nov. 1989 to present.

Husa, E. I., R. E. Raymond, R. K. Welty, S. M. Griffith, B. M. Hanlon, R. R. Rios, N. J. Vermeulen, 1993, *Hanford Site Waste Storage Tank Information Notebook*, WHC-EP-0625, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains in-tank photos as well as summaries on the tank description, 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.

- Document gives assessment of relative dryness between tanks.

Jungfleisch, F. M., 1980, *Hanford High-Level Defense Waste Characterization - A Status Report*, RHO-CD-1019, Rockwell Hanford Operations, Richland, Washington.

- Document provides status information to plan outlined by G. W. Grimes, October 1977, containing a summary of sampling, characterization, and analysis data for the tanks sampled.

Leach, C. E., and S. M. Stahl, 1996, *Hanford Site Tank Farm Facilities Interim Safety Basis*, WHC-SD-WM-ISB-001, Rev. 0L, Westinghouse Hanford Company, Richland, Washington.

- Provides a ready reference to the tank farms safety envelope.

Remund, K. M., G. Chen, S. A. Hartley, J. York, and B. C. Simpson, 1995, *Historical Tank Content Estimate (HTCE) and Sampling Estimate Comparisons*, PNL-10840, Pacific Northwest Laboratory, Richland, Washington.

- Document contains a statistical evaluation of the HDW inventory estimate against analytical values from 12 existing TCR reports using a select component data set.

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

- Memo contains a tank inventory estimate based on analytical information.

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

- Memo contains a tank inventory estimate based on analytical information.

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

- Memo 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.

- Document contains selected sample analysis tables prior to 1993 for single shell tanks.

IIIc. Other - Non/Documented or Electronic Sources

ICF Kaiser Hanford, 1996. Kaiser Electronic: Historical Sampling Data. In: Microsoft Excel 5.0. Available: Tank Waste Information Network System (TWINS), Pacific Northwest National Laboratory, Richland, Washington.

- Spreadsheets contain historical sampling data for dates prior to samples available in Tank Characterization Database.

Pacific Northwest National Laboratory, 1996, TWINS: Tank Waste Information Network System. In: SYBASE 4.0. Available: Hanford Local Area Network (HLAN), Westinghouse Hanford Company, Richland, Washington; or TCP/IP access, Pacific Northwest National Laboratory, Richland, Washington.

- Database provides access to Surveillance Analysis Computer System, Tank Monitoring and Control System, Tank Characterization Database, and Kaiser electronic data.

Pacific Northwest National Laboratory, 1996, TCD: Tank Characterization Database. In: SYBASE 4.0. Available: Tank Waste Information Network System (TWINS), Pacific Northwest National Laboratory, Richland, Washington

- Database contains qualified raw sampling data taken in the past few years from 222-S Laboratory. A small amount of information from the 325 Laboratory data is included at this time.

IV. OTHER DOCUMENTED RESOURCES

FDH, 1996a, RMIS: Record Management Information System, Records Database. In: Database. Available: Hanford Local Area Network (HLAN), Fluor Daniel Hanford, Inc., Richland, Washington.

- Records database that contains all released documents since November 1995; the database will be back loaded with previous years' data. It can be queried to find documents for any subject either in the keyword or description field.

FDH, 1996b, RMIS: Record Management Information System, Tank Farms Information Center Database. In: Database. Available: Hanford Local Area Network (HLAN), Fluor Daniel Hanford, Inc., Richland, Washington.

- Database of tank-related reports, memos, and letters that have been optically scanned. The database can be queried to find indexed information for a tank (in the tank or description field) or information referenced to any subject either in the keyword or description field.

FDH, 1997, LSIS: Large-Scale Information System, Engineering Release Station Database. In: Database. Available: Hanford Local Area Network (HLAN), Flour Daniel Hanford, Inc., Richland, Washington.

- The records database contains any released document information. Most expedient to search by title and keyword for tank in question.

FDNW, 1996, 209-E Waste Tanks Document Index. In: Hard copy. Available: Fluor Daniel Northwest, Inc., Richland, Washington.

- An index of general and tank specific information for the 200 Area tanks.

ICF Kaiser Hanford (ICF KH), 1996, ICF KH Tank Characterization Library. In: Hard copy. Available: 200 East Area, Trailer MO-971, Room 26, S. Consort (custodian), ICF Kaiser Hanford Company, Richland, Washington.

- A resource of 200 Area tank, process campaign, reactor, and other historical records, unclassified and declassified.

LMHC, 1996, TCRC: Tank Characterization Resource Center. In: Hard copy. Available: 200 East Area, 2750E Building, Room A-243, A. E. Young (custodian), Lockheed Martin Hanford Company, Richland, Washington.

- A resource of TWRS characterization data including: hard copy file folders of sampling data for each tank, an index of multiple tank documents folders, physical/chemical data compendiums, and studies or reports on 200 Area tanks or tank waste generated by various contractors.

LMHC, 1997a, Cog Engineer's Tank Sampling Field Data. In: Hardcopy. Available: 200 East Area, 2704HV Building, Suite A, Lockheed Martin Hanford Incorporated, Richland, Washington.

- Location has field sampling strip charts giving approximate downward force.

LMHC, 1997b, Surveillance Analysis Computer System. In: SYBASE/Visual Basic (Mainframe). Available: Hanford Local Area Network (HLAN), Lockheed Martin Hanford Company, Richland, Washington; or Tank Waste Information Network System, Pacific Northwest National Laboratory, Richland, Washington.

- Database contains 200 Area tank surveillance data from both Computer Automated Surveillance System and Tank Monitoring and Control System.

McCain, D. J., 1997, *Characterization Status Table (a.k.a. Characterization Progress Data Report),* In: Hypertext Mark-Up Language (HTML), Available: http://www.hanford.gov/TWRS/char.pub/progdata.htm

- Table reports Watch List, Characterization Basis, DQO applicability, and characterization status per tank; updated weekly.

Ogden Environmental Company, 1993, Track Radioactive Components (TRAC) Reference Documentation at Ogden. In: Hard copy. Available: ICF Kaiser Hanford Library, ICF Kaiser Hanford Company, Richland, Washington.

- An index of general information used in support of Track Radioactive Components.

WHC, 1995, 222-S Laboratory RIDS: Records Inventory and Disposition Schedule. In: Hardcopy. Available: In 222-S Laboratory RIDS index, Westinghouse Hanford Company, Richland, Washington.

- A RIDS report of the information archived for 1992-1993 from the 222-S Laboratory, last printed May 17, 1995. Lab notebooks may have been archived that contain pertinent information.

WHC, 1996, VIDON In-Tank Photo Library. In: Hard copy. Available: 200 East Area, 2750E Building, Room D-164, Westinghouse Hanford Company, Richland, Washington.

- Library consists of file cabinets containing folders of 8-in. x 10-in. in-tank photos.

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Tank Advisory Panel					
102 Windham Road					
Oak Ridge, TN 37830					
D. O. Campbell		X			
ONSITE					
Department of Energy - Richland Operations					
J. F. Thompson	S7-54	X			
W. S. Liou	S7-54	X			
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