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7. Abstract

This document provides the characterization information and interprets the data for single-shell tank 241-C-109.

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Tank Characterization Report for Single-Shell Tank 241-C-109

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EXECUTIVE SUMMARY

Single-Shell Tank 241-C-109 is an underground storage tank containing high-level radioactive waste. It is located in the C Tank Farm in the Hanford Site's 200 East Area. The tank was sampled in September of 1992 to address the Ferrocyanide Unreviewed Safety Question. Analyses of tank waste were also performed to support *Hanford Federal Facility Agreement and Consent Order* Milestone M-44-08 (Ecology et al. 1994).

Tank 241-C-109 went into service in 1946 and received first-cycle decontamination waste from bismuth phosphate process operations at B Plant in 1948. Other waste types added that are expected to contribute to the current contents include ferrocyanide scavenging waste and Strontium Semiworks waste. It is the last tank in a cascade with Tanks 241-C-107 and 241-C-108. The tank has a capacity of 2,010 kL (530 kgal) and currently contains 250 kL (66 kgal) of waste, existing primarily of sludge. Approximately 9.15 kL (4 kgal) of supernate remain. The sludge is heterogeneous, with significantly different chemical compositions depending on waste depth.

The major waste constituents in Tank 241-C-109 waste include aluminum, calcium, iron, nickel, nitrate, nitrite, phosphate, sodium, sulfate, and uranium. The major radionuclides present in the waste are ^{137}Cs and ^{90}Sr. Total alpha activity was extremely low and did not exceed the 1 g/L threshold. Comparisons to established limits of concern for selected analytes can be made by referring to the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

From 1955 to 1958, Tank 241-C-109 was used as a settling tank for scavenged ferrocyanide waste. As a result, solids high in ferrocyanide, nickel and nitrates were deposited. In 1990, the presence of ferrocyanide in the tanks was declared an unreviewed safety question and the Ferrocyanide Watch List was created. Twenty-four tanks, including Tank 241-C-109, were identified as potentially containing 1,000 g-moles or more of ferrocyanide and were placed on the watch list (Meacham et al. 1994). Due to the amount of iron present in Tank 241-C-109, the tank could theoretically contain more than 1000 g-moles of ferrocyanide. However, the thermodynamic data indicates that a propagating exothermic reaction is unlikely.

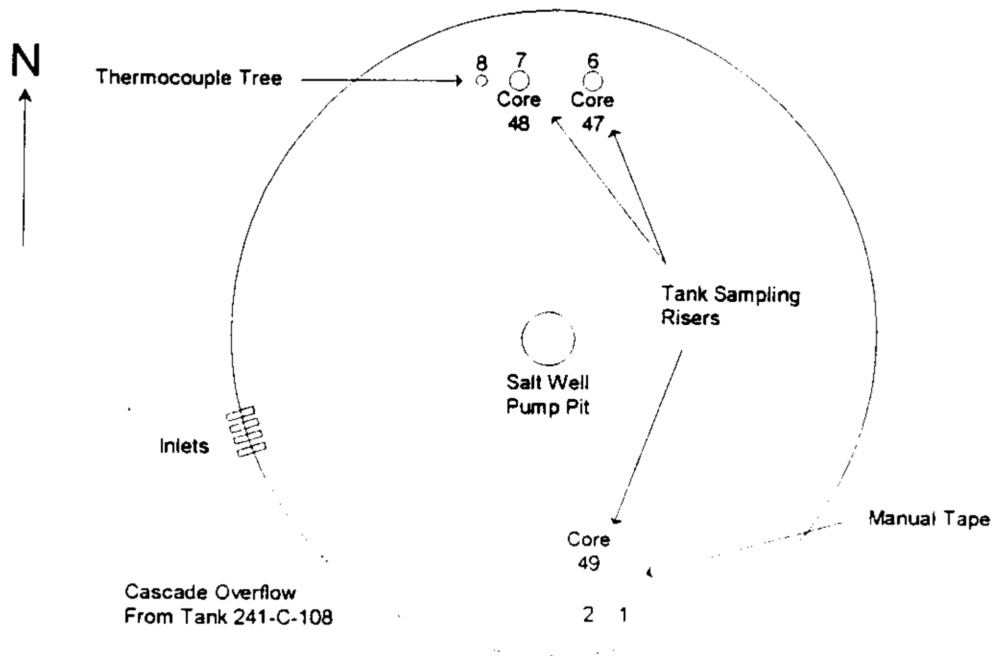
The results of the analyses have been compared to the dangerous waste codes in the *Washington Dangerous Waste Regulations* (Ecology 1991). This assessment was conducted by comparing tank contents against dangerous waste characteristics ("D" waste codes) and against state waste codes. It did not include checking tank contents against "U", "P", "F", or "K" waste codes since application of these codes is dependent on the source of the waste and not on particular constituent concentrations. The results indicate that the waste in this tank is adequately described in the Dangerous Waste Permit Application for the Single-Shell Tank System; this permit is discussed in the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

Tank 241-C-109	
TANK DESCRIPTION	
Type:	Single-Shell
Constructed:	1944
In-Service:	1946
Diameter:	23 m (75 ft)
Usable Depth:	4.9 m (16 ft)
Capacity:	2,010 kL (530 kgal)
Bottom Shape:	Dish
Ventilation:	Passive
TANK STATUS (as of December 1994)	
Watch List:	Ferrocyanide
Contents:	Non-Complexed waste
Total Waste Volume:	250 kL (66 kgal)
Sludge Volume:	235 kL (62 kgal)
Supernatant Volume:	15 kL (4 kgal)
Interstitial Liquid Volume:	-0- kL
Manual Tape Level:	47.0 cm (18.5 in)
Temperature:	30°C (86°F) (10/20/94)
Integrity Category:	Sound
ISOLATION STATUS	
Interim Isolated:	1982
Interim Stabilized:	1983
Intrusion Prevention:	1993

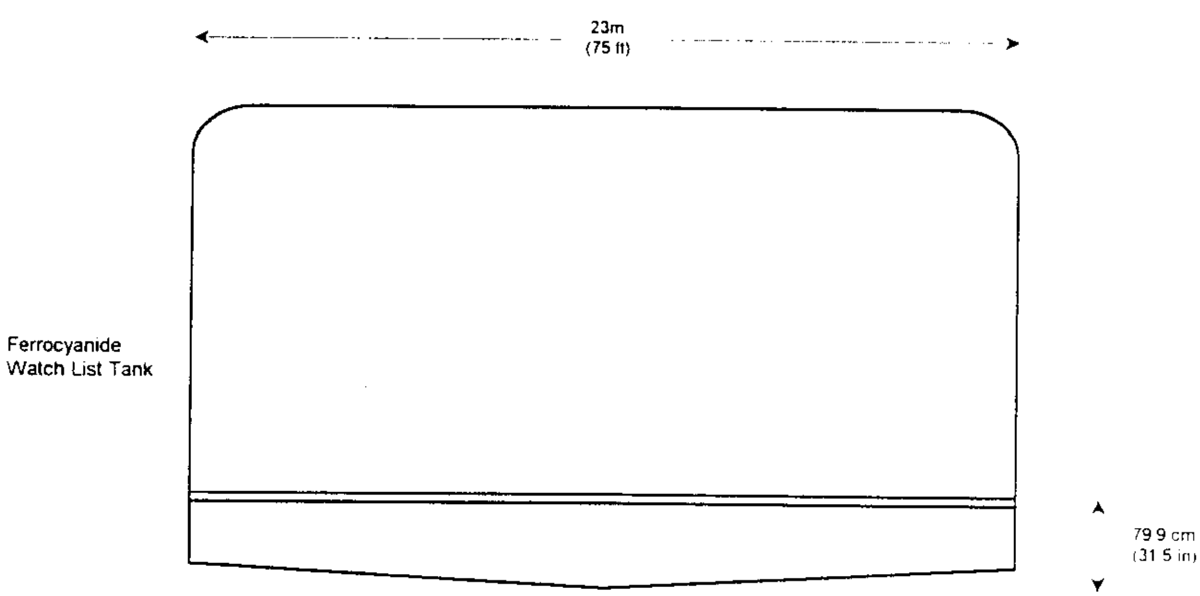
Single-Shell Tank 241-C-109 Concentrations and Inventories for Major Analytes and Analytes of Concern		
Physical Properties	**Result**	
Density	solid: 1.23 g/mL liquid: 1.15 g/mL	
pH	10.1	
Percent Water	35.7 %	
Heat Load	2,610 W	
Chemical Constituents	**Concentration (μg/g)**	**Solid Bulk Inventory (kg)**
Metals		
Al (Aluminum)	67,400	19,500
Ca (Calcium)	18,800	5,430
Fe (Iron)	18,700	5,410
Pb (Lead)	3,890	1,120
Ni (Nickel)	14,100	4,080
Si (Silicon)	6,760	1,950
Na (Sodium)	87,900	25,400
U (Uranium)	15,700	4,540
Total Inorganic Carbon	5,450	1,580
Ions		
CN^- (Cyanide)	882	255
NO_3^- (Nitrate)	40,300	11,600
NO_2^- (Nitrite)	40,700	11,800
*PO_4^{3-} (Phosphate)	56,100	16,200
SO_4^{2-} (Sulfate)	7,700	2,230
Organics		
Tributyl phosphate	205	31.5
Total Organic Carbon	2,850	824
Radionuclides	**μCi/g**	**Ci**
^{137}Cs	820	2.37E+05
^{90}Sr	767	2.22E+05
Total Alpha Pu	0.341	98.6

* Conversion from ICP phosphorus data

Tank 241-C-109



Waste Profile of Tank 241-C-109



Total Tank Volume: 2,010 kL (530 kgal)
Current Waste Volume: 250 kL (66 kgal)
Sludge Volume: 235 kL (62 kgal)
Supernate Volume: 15 kL (4 kgal)

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LIST OF TERMS

ANOVA	analysis of variance
CC	core composite
DL	detection limit
DLC	drainable liquid composite
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DQO	data quality objectives
DSC	differential scanning calorimetry
EPA	U.S. Environmental Protection Agency
HEDTA	N-(hydroxyethyl)-ethylenediaminetriacetic acid
HSP	honestly significant difference
HS/SSW	Hot Semiworks/Strontium Semiworks
IC	ion chromatography
ICP	inductively coupled plasma
IX	ion exchange
OWW	organic wash waste
PNL	Pacific Northwest Laboratory
PUREX	Plutonium-Uranium Extraction
QC	quality control
RSD	relative standard deviation
SACS	Surveillance Analysis Computer System
TGA	thermogravimetric analysis
TWRS	Tank Waste Remediation System
UR	uranium recovery
USQ	unreviewed safety question
WHC	Westinghouse Hanford Company
1C	first-cycle decontamination

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1.0 INTRODUCTION

In September of 1992, Single-Shell Tank 241-C-109 (hereafter, Tank 241-C-109) was sampled to address the Ferrocyanide Unresolved Safety Question (Deaton 1990). The results of the 1992 sampling event were further utilized to complete this Tank Characterization Report in order to comply with requirements stated in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1994). Additionally, the data were compared to the dangerous waste specifications in the *Washington Administrative Code* (Ecology 1991). The analyses also provided information to the Tank Waste Remediation System in terms of tank safety, waste retrieval, and waste disposal.

Obtaining measurements that determine overall waste energetics was a key step in closing the Ferrocyanide Unreviewed Safety Question. Although the Ferrocyanide Unreviewed Safety Question has been closed, characterization of the Ferrocyanide Watch List tanks is needed to resolve the ferrocyanide safety issue (Sheridan 1994). In addition, several of the analytes contributing to the energetic properties of the waste need to be measured as a function of position (e.g., total cyanide and nitrate/nitrite present, water content, and the distribution and inventory of ^{137}Cs and ^{90}Sr in the tank).

This Tank Characterization Report presents an overview of that tank sampling and analysis effort, and contains observations regarding waste characteristics. It also presents expected concentration and bulk inventory data for the waste contents based on this last sampling data and background tank information.

1.1 PURPOSE

The purpose of this report is to describe and characterize the waste in Tank 241-C-109 based on information gathered from various sources. This report summarizes the available information and arranges it in a useful format for making management and technical decisions concerning this particular waste tank.

Specific objectives reached by the sampling and characterization of the waste in Tank 241-C-109 are:

- Support the closure of the Ferrocyanide Unreviewed Safety Question involving this tank.
- Complete the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) Milestone M-10-00 concerning the characterization of Hanford Site high-level radioactive waste tanks (Ecology et al. 1994).
- Complete safety screening of the contents of Tank 241-C-109 to meet the characterization requirements of the *Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 93-5* (Conway 1993).
- Provide tank waste characterization to the Tank Waste Remediation System (TWRS) Program Elements in accordance with the *TWRS Tank Waste Analysis Plan* (Bell 1994).

1.2 SCOPE

This report presents a broad background of preliminary information available prior to the most recent sampling event, which initially guided the development of the sampling and analysis program. The results of Tank 241-C-109 core sample analyses are summarized and presented, along with a statistical interpretation of the data. The information obtained from historical sources are compared with the actual waste measurements in this report.

1.3 ASSUMPTIONS

The concentration and inventory estimates derived for this report are considered by the authors and by the Westinghouse Hanford Company Characterization Program to be the most accurate, defensible, technically valid, and contemporary data concerning Tank 241-C-109. This tank characterization report incorporates all available previous sampling, characterization, and transfer data concerning Tank 241-C-109. In addition, estimates of the current tank contents based on process knowledge and waste transaction records provide important cross-checks and corroboration to the inventory estimates derived from recent analytical data.

The term "analytical results" is used in this report to denote sample results from the most recent sampling event. Characterization data from these samples are used as the basis for the analytical section of this report, Section 5.0. The historical assessment of tank contents, Section 2.3, is based on the process history of the tank.

Tank 241-C-109, a ferrocyanide watch list tank, was removed from service in 1976. The tank has been interim stabilized and has undergone intrusion prevention. Tank data presented in this report is considered accurate and representative of the tank contents as of January 1995. Although Data Quality Objectives (DQOs) were not in place at the time of the most recent sampling of Tank 241-C-109, the following DQOs are appropriate to apply to the data assessment:

- Ferrocyanide Safety Issue (Meacham et al. 1994).
- Tank Safety Screening (Babad and Redus 1994).

2.0 HISTORICAL TANK INFORMATION

This section describes Tank 241-C-109 based on historical information. The first part of the section details the current status of the tank. This is followed by discussions of the tank's background, its transfer history, and the process sources that contributed to the tank waste, including an estimate of the current contents based on the process history. The final part details the surveillance data taken on the tank.

2.1 TANK STATUS

The most recent waste inventory report for Tank 241-C-109 shows 235,000 L (62,000 gal) of solid waste with an estimated 15,000 L (4,000 gal) of drainable liquids (Hanlon 1994). The current waste temperature in Tank 241-C-109 is about 27°C (80°F). Liquid levels and tank temperatures are further discussed in Section 2.4. The estimated heat load in Tank 241-C-109 is less than 2.93 kW (10,000 Btu/hr). Ventilation for Tank 241-C-109 is passive and all monitoring systems are currently in compliance with established standards (Hanlon 1994).

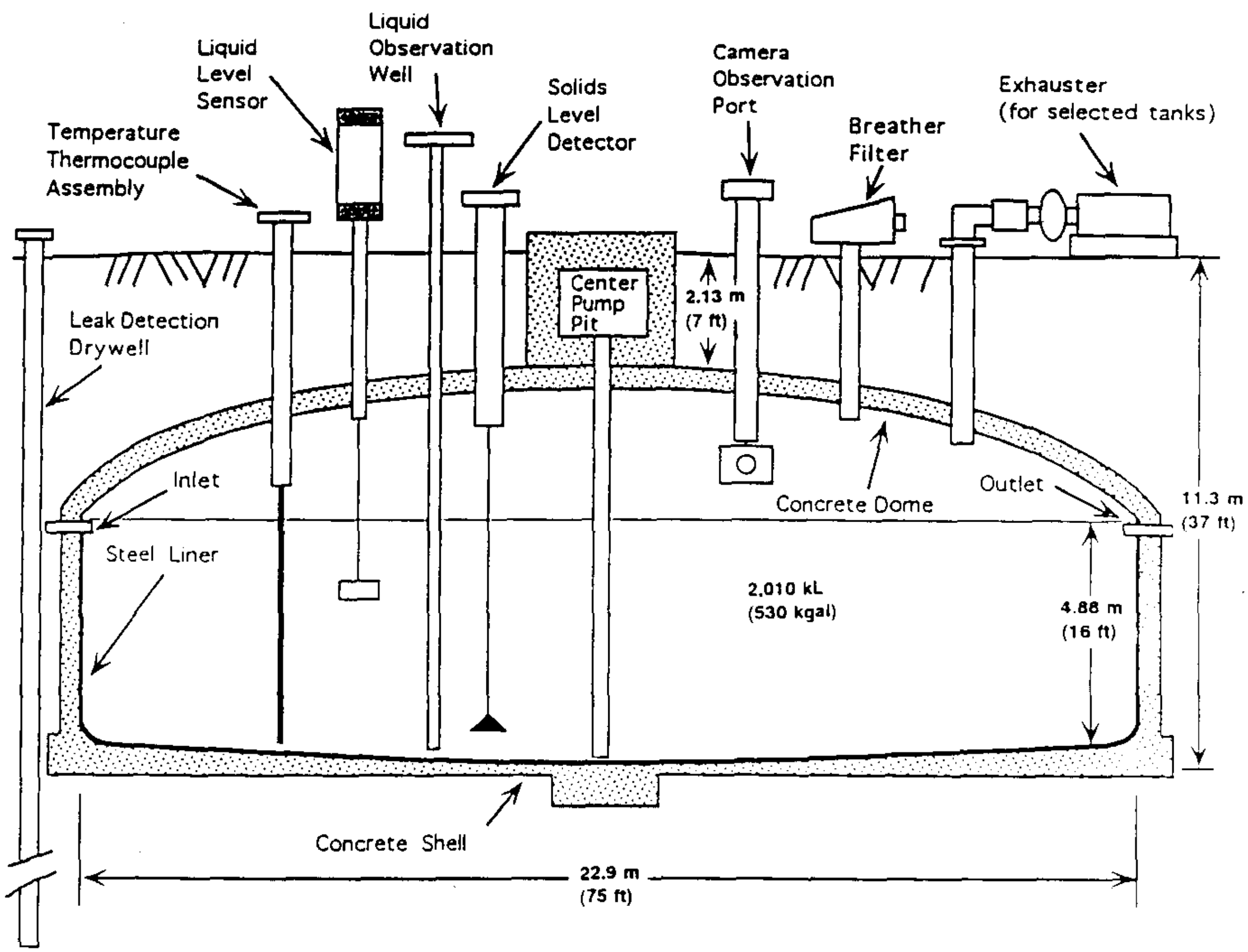
The current designation of the tank's contents is non-complexed waste. Tank 241-C-109 is on the Ferrocyanide Watch List and is considered to have one of the highest ferrocyanide concentrations of all the single-shell tanks (Borsheim and Simpson 1991). The tank is considered sound, has been interim stabilized, and has undergone intrusion prevention. A tank is considered interim stabilized if it contains less than 189,000 L (50,000 gal) of drainable interstitial liquid and less than 18,900 L (5,000 gal) of supernatant liquid. Removing liquids minimizes the risk of waste leaking out of the tank. Intrusion prevention is the administrative designation reflecting the completion of the physical effort required to minimize inadvertent addition of liquids into the tank (Hanlon 1994).

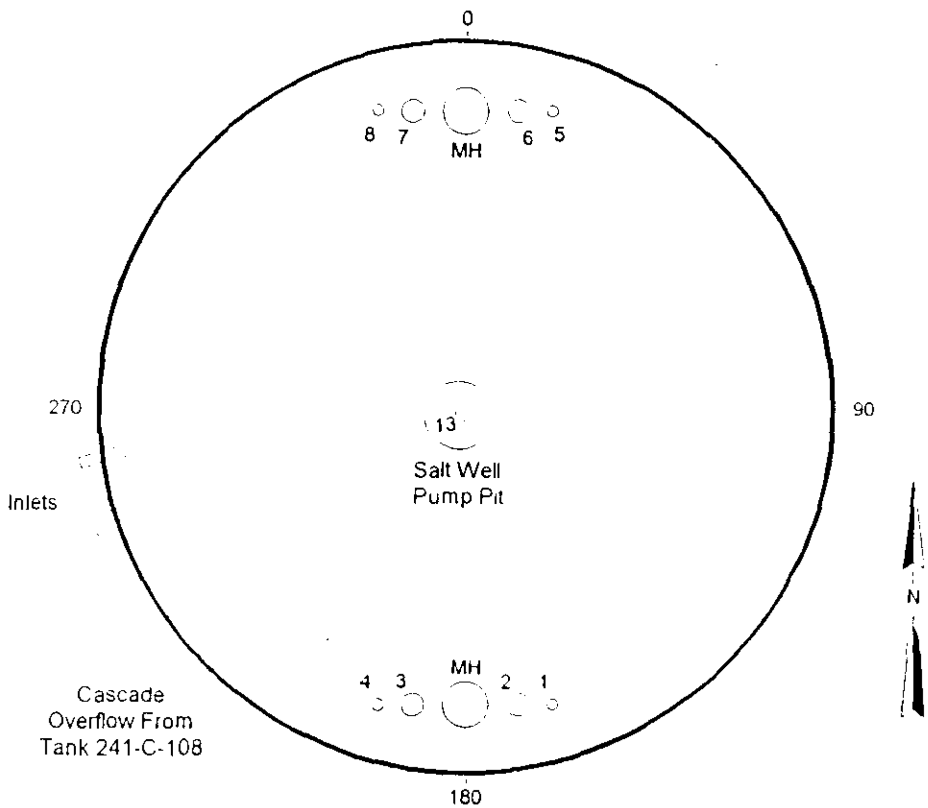
2.2 TANK BACKGROUND

Tank 241-C-109 is constructed of reinforced concrete with a mild steel liner covering its bottom and sides. The top of the tank is a concrete dome. The tank has a diameter of 23 m (75 ft), a usable depth of 4.9 m (16 ft), and a capacity of 2,010,000 L (530,000 gallons) (Husa et al. 1993). The bottom of the tank is dished. The basic design of Tank 241-C-109 is shown in Figure 2-1. Instruments access Tank 241-C-109 through risers and monitor the temperature, sludge level, and other bulk tank characteristics (Alstad 1991). The position of these risers is found in Figure 2-2.

The 241-C Tank Farm, built in 1943 and 1944, is one of the initial four tank farms to be used at the Hanford Site. It is on the eastern side of the 200 East Area. Figure 2-3 details the Hanford Site's 200 East Area and the location of the 241-C Tank Farm. Figure 2-2 shows the position of Tank 241-C-109 within the 241-C Tank Farm.

Figure 2-1. Basic Design of Tank 241-C-109.

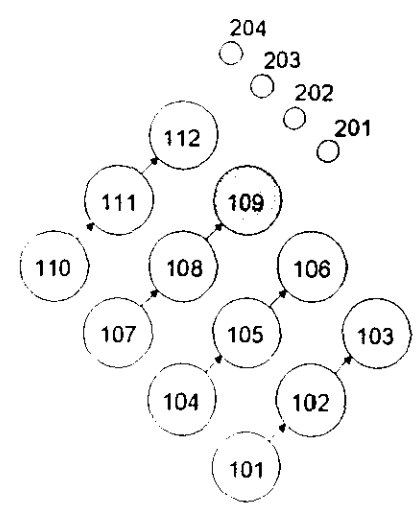




MH 42" Manhole in dome- no riser to the surface

No.	Dia.	Description and Comments
1	4"	Liquid Level Reel
2	12"	Blank
3	12"	Blank
4	4"	Breather Filter
5	4"	Drywell
6	12"	Spare
7	12"	Observation Port
8	4"	Thermocouple Tree
13	12"	Saltwell Screen

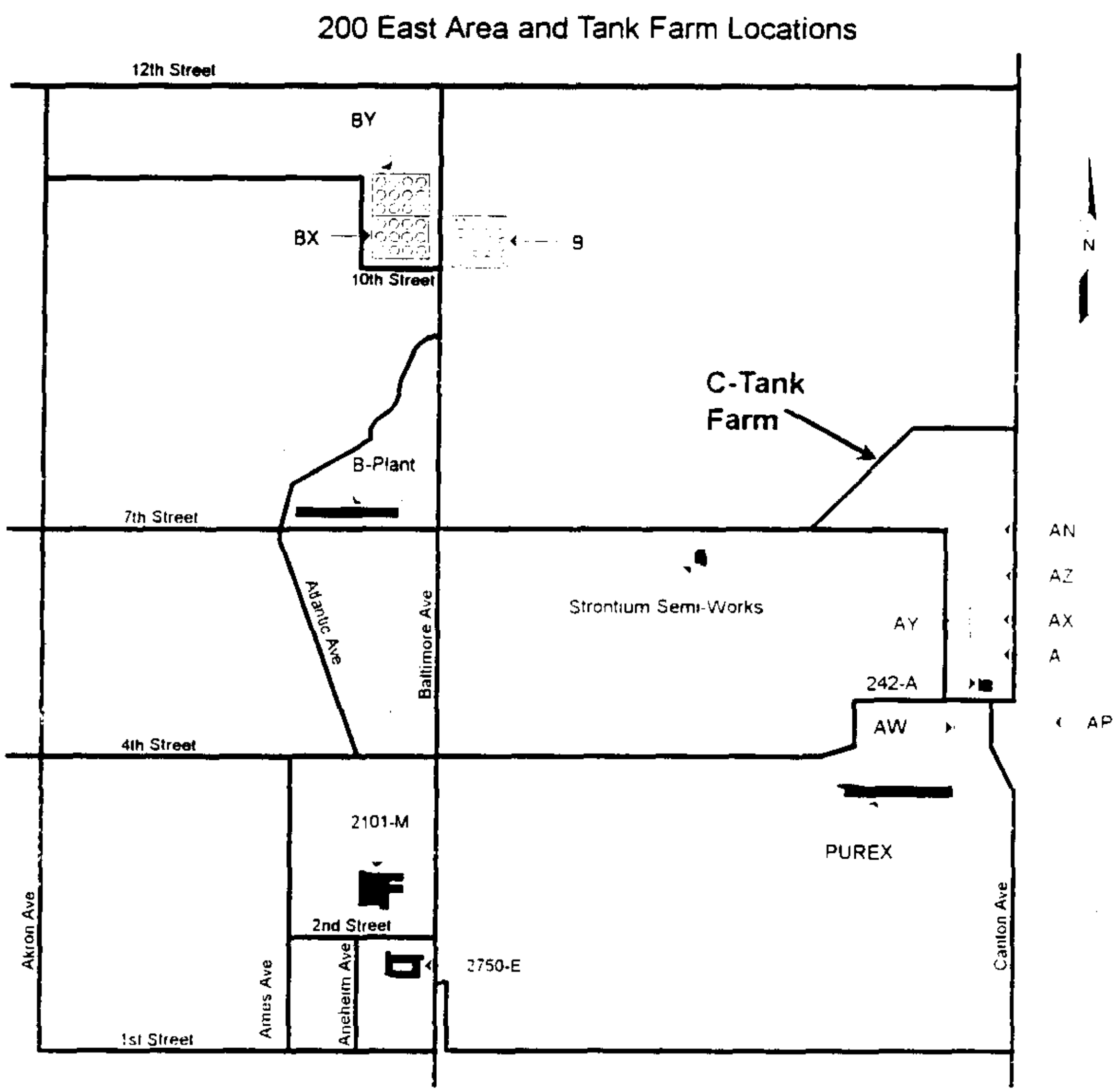
241-C Tank Farm
(Showing Cascade Connections)



Sources Alstad, 1991
Vitro Eng. Corp., 1986
Hanford Eng. Works, 1944

Figure 2-2. Riser Configuration for Tank 241-C-109.

Figure 2-3. Location of the 241-C Tank Farm.



Tank 241-C-109 is the last tank in a "cascade" connecting it to Tanks 241-C-107 and 241-C-108. A cascade was a system where a number of tanks were connected in series by pipes. These pipes were located near the top of the tanks' working depths. Waste added to the first, or primary tank in a cascade would flow to the following tanks when the waste reached the level of the previous tank's cascade piping. By using a cascade, fewer connections needed to be made during waste handling operations. This method reduced waste handling requirements, personnel exposure, and the chance of a loss of tank integrity from waste overflow. Another advantage of using the cascade system was waste volume reduction from the disposal of clarified liquid waste. Much of the entrained and precipitated solids would settle in the primary tank (in this case Tank 241-C-107), and the clarified liquids would flow through the cascade to the secondary tanks (241-C-108 and 241-C-109). This practice led to rapid accumulation of solids in the primary tank and disposal of clarified liquids from secondary tanks into cribs.

Tank 241-C-109 went into service in 1946 when it was connected as the last tank in the 241-C-107 -108 -109 cascade. The tank received its first waste in April of 1948. In the mid-1950's, Tank 241-C-109 was used as a settling tank for ferrocyanide scavenging. A comprehensive transfer history of the tank is found in the next section.

Five dry wells were drilled around Tank 241-C-109 in 1974 (Anderson 1990). Another dry well (30-09-07) was drilled in 1982 to help determine the source of activity in one of the original dry wells, dry well 30-09-06. The increasing activity in dry well 30-09-06 was attributed to the migration of existing radionuclides in the soil from the vicinity of Tank 241-C-108 (Welty 1988). Tank 241-C-109 was officially removed from service in 1976. A new salt well was installed in 1976 and pumping of the salt well was completed in 1979. The tank was interim isolated in 1982 and interim stabilized in 1983 (Welty 1988). The administrative designation *intrusion prevention* replaced *interim isolation* in June 1993 and carries similar requirements (Hanlon 1994).

In October 1990, the presence of ferrocyanide in waste tanks was declared an unreviewed safety question (USQ). This was because research had shown that the existing safety analysis report no longer bounded the issue (Meacham et al. 1994). As a result, the Ferrocyanide Watch List was created. Tank 241-C-109 was added to this list in 1991. The Ferrocyanide USQ was closed on March 1, 1994. Tank 241-C-109 continues to be on the Ferrocyanide Watch List (Meacham et al. 1994).

2.3 PROCESS HISTORY

This section presents the transfer history of Tank 241-C-109 and describes the process wastes that made up these transfers. The majority of the transfer history information for this section is found in the *Waste Status Transaction Record Summary* (Agnew 1994a). Table 2-1 presents the transfer history of Tank 241-C-109. The following discussion accompanies the table. The text describes the characteristics of waste types that entered the tank and the conditions of their entry. Information about waste type characteristics is taken from *Hanford Defined Wastes: Chemical and Radionuclide Compositions* (Agnew 1994b).

Table 2-1. Waste Transfer History for Tank 241-C-109 (Agnew 1994a). (2 sheets)

Year: Qtr	Transaction Source	Waste Type	Transaction Amount kL (kgal)	Destination	Comment
1948: 1 - 1948: 3	241-C-108	1C	2,606 (545)	**241-C-109**	Third tank in the 241-C-107, -108, -109 cascade.
1952: 2-3	**241-C-109**	Supernate	-1,950 (-515)	241-B-106	Finished pumping 7-25-52.
1952: 4	241-C Tank Farm	Supernate	1,840 (486)	**241-C-109**	Temporary supernate tank for 241-C farm removal operations.
1953: 1	**241-C-109**	unknown	unknown	unknown	Tank was emptied 1/9/53.
1953: 1-2	241-C-108	UR	1,830 (483)	**241-C-109**	Received UR through the cascade beginning in March, ending in April.
1955: 4	**241-C-109**	TFeCN	-1,750 (-463)	241-C-112	
1956: 1 - 1957: 4	241-C-101, -102, -106, -108, -110, -111, 241-B-101, -103, -107, 241-BX-111, 241-BY-101, -102	TFeCN	11,300 (2,978)	**241-C-109**	Used as a decant tank for ferrocyanide scavenging. Scavenged waste was transferred into Tank 241-C-109 and allowed to settle. The supernate was then pumped to cribs.
1956: 1 - 1958: 1	**241-C-109**	TFeCN	-12,300 (-3,225)	Cribs	The net negative waste volume is due to inaccuracies in the transfer records.
1959: 2-3	241-C-105	CW	1,570 (415)	**241-C-109**	Supernate. Unlikely to contain high concentrations of solids.
1962: 1	**241-C-109**	Supernate	-519 (-137)	241-BY-109	
1962: 2 - 1965: 2	Hot Semiworks	HS/SSW	503 (133)	**241-C-109**	Three relatively small transfers.
1966: 2	241-C-108	HS/SSW Supernate	49.2 (13)	**241-C-109**	Tank 241-C-108 held HS/SSW.
1970: 1	241-C-203	HS/SSW Supernate	71.9 (19)	**241-C-109**	Tank 241-C-203 held HS/SSW.
1970: 1	**241-C-109**	Supernate	-1,500 (-397)	241-C-104	
1970:2	241-C-110	OWW & IX Supernate	1,420 (375)	**241-C-109**	Tank 241-C-110 held OWW and had recently received some IX.

Table 2-1. Waste Transfer History for Tank 241-C-109 (Agnew 1994a). (2 sheets)

Year: Qtr	Transaction Source	Waste Type	Transaction Amount kL (kgal)	Destination	Comment
1975: 3 - 1976: 1	241-C-109	Supernate	-1,730 (-458)	241-C-103	Last recorded set of transfers out of Tank 241-C-109.

1C	First-cycle decontamination waste from B-Plant.
CW	Aluminum cladding dissolution waste from PUREX.
HS/SSW Semiworks	Strontium Semi Works waste from strontium extraction at the Hot Semiworks.
IX	Ion exchange waste from the recovery of cesium from tank supernates at B-Plant.
TFeCN	Waste from ferrocyanide scavenging.
UR	Waste from uranium recovery operations.
OWW	Organic solvent wash waste from PUREX.

First-cycle decontamination (1C) waste entered Tank 241-C-109 through cascade lines in 1948. This waste was produced by the bismuth phosphate process at B-Plant. Characteristics of 1C waste were high concentrations of uranium, phosphate, sodium, and aluminum, and a modest concentration of bismuth. The concentration of aluminum was high because aluminum decladding waste was combined with 1C waste at that time. First cycle waste was comparatively high in solids, but since this waste previously cascaded through two tanks, the solids content entering Tank 241-C-109 would be low.

A very large unknown transfer in late 1952 is accompanied by the comment that Tank 241-C-109 was a temporary supernate tank for 241-C Tank Farm removal operations. This is the extent of the transfer information volunteered by the historical transfer record. Since sluicing of the first six tanks in the 241-C Tank Farm for uranium recovery was started at this time (Rodenhizer 1987), it is reasonable to assume that the removal operations were in preparation for sluicing these tanks.

There is no record indicating that Tank 241-C-109 was sluiced when it was declared "empty" in January 1953. It is likely that the 38,000 L (10,000 gal) heel of 1C that was left over from a previous pumping remained in the tank. In March 1953, Tank 241-C-109 began receiving unscavenged uranium recovery (UR) waste through the cascade lines. Solids from UR waste were comparatively high in uranium, sodium, sulfate, and phosphate, and low in nitrates. The UR waste stream tended to be about 5% solids, but since it was received through the cascade, the UR waste entering Tank 241-C-109 would have a much lower solids content.

Beginning in May 1955, unscavenged UR waste already stored in 200 East Area underground tanks at the Hanford Site was routed to the 244-CR vault for scavenging ^{137}Cs and ^{90}Sr with ferrocyanide. From late 1955 until early 1958, Tank 241-C-109 was used for settling scavenged ferrocyanide waste. During this "in farm" ferrocyanide scavenging, waste was not cascaded through the Tank 241-C-107, -108, -109 series. Instead, Tank 241-C-109 received the waste slurry in direct transfers from the process vessel (General Electric 1958).

The scavenged waste was settled and the supernate was sampled and then decanted to a crib. Repeated settling and decanting resulted in the accumulation of solids in Tank 241-C-109. These solids were very high in nitrates and ferrocyanide; they were also high in ^{137}Cs, ^{90}Sr, sodium, and nickel. A further discussion of ferrocyanide scavenging is included in the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

The cladding waste supernate transferred to Tank 241-C-109 from Tank 241-C-105 in 1959 likely contained very little solids content. Although cladding waste tends to be relatively high in solids, these solids likely had already settled in Tank 241-C-105 and were not included in the supernate transferred to Tank 241-C-109. Produced during the dissolution of aluminum fuel cladding at PUREX, cladding waste was comparatively high in aluminum, sodium, and hydroxide, and low in bismuth.

Tank 241-C-109 received hot semiworks/strontium semiworks (HS/SSW) waste directly in a series of transfers between 1962 and 1965. Transfers of supernate from tanks containing HS/SSW waste followed in 1966 and in 1970. This waste was produced at the Hot Semiworks (C-Plant) when it was configured as the pilot plant for strontium recovery. HS/SSW waste contained a high concentration of lead and ^{90}Sr, a somewhat lower concentration of acetate, hydroxide, nitrate, and iron, and lacked bismuth and aluminum.

Organic solvent wash waste (OWW) and ion exchange (IX) waste were added to Tank 241-C-109 in a supernate transfer from Tank 241-C-110 in 1970. These waste types had only slight solids content so it is unlikely that any OWW or IX solids are currently found in the tank. Organic solvent wash waste was produced at PUREX, was high in nitrate, and contained significant concentrations of sodium and carbonate. Ion exchange waste was produced at B-Plant from the recovery of cesium from tank supernates. It held significant concentrations of cesium and uranium and small amounts of citrate and HEDTA. The supernate transfer from Tank 241-C-110 in 1970 was the last time waste was added to Tank 241-C-109.

The liquid in Tank 241-C-109 was removed through a series of three supernate transfers in late 1975 and early 1976 followed by salt well pumping, which was completed in 1977. There have been no changes in the tank's level measurements since 1977. The process history of Tank 241-C-109 is presented graphically in Figure 2-4. Table 2-2 presents an estimate of the total volumes of the specific waste types that were added to the tank and an estimate of the volume of specific waste types that remain in the tank.

Figure 2-4. Waste Volume History of Tank 241-C-109.

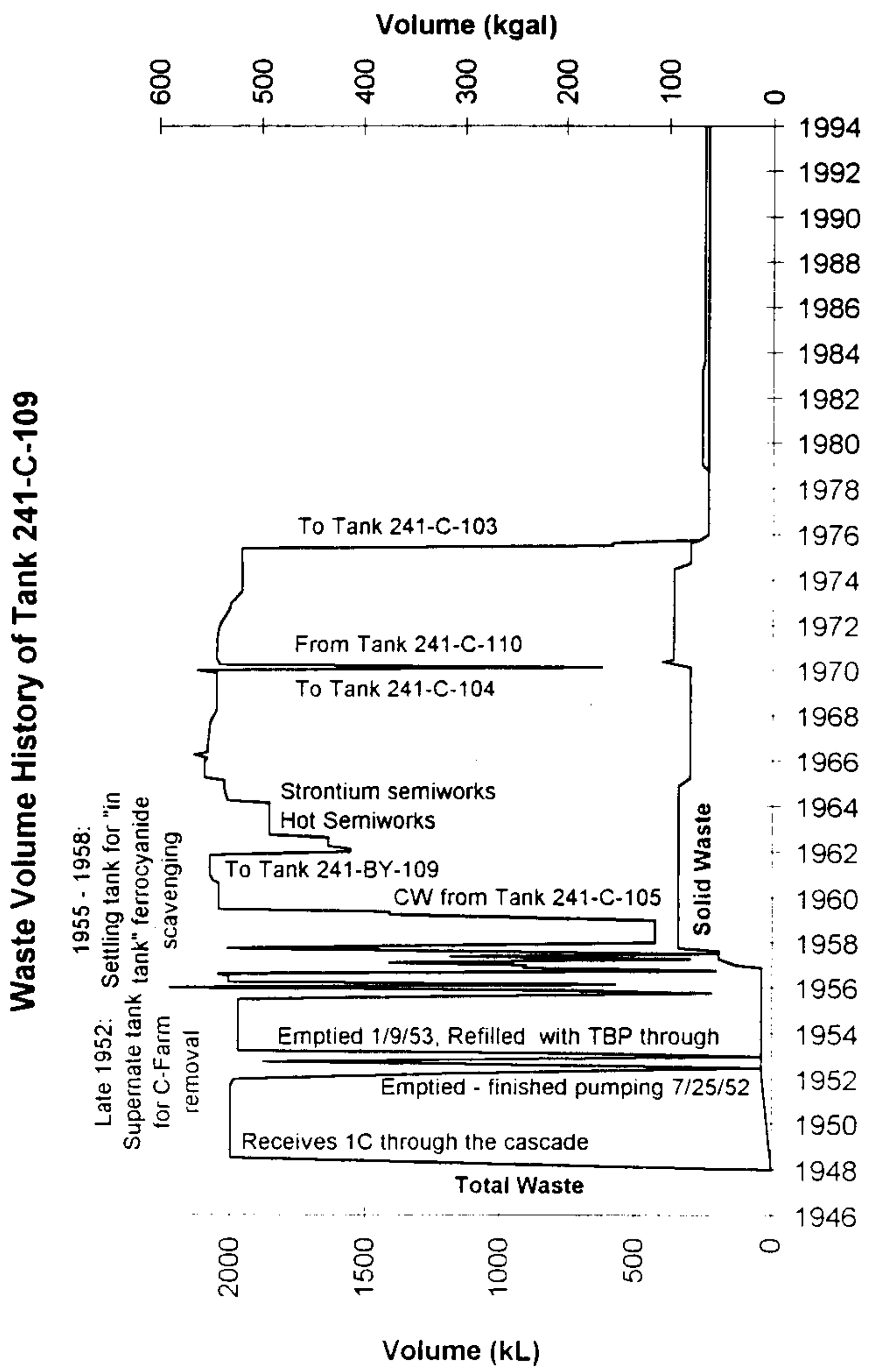


Table 2-2. Estimated Total and Current Volumes of Waste Types Received By Tank 241-C-109 (Agnew 1994a, 1994b; Brevick et al. 1994).

Waste Type	Estimated Volume* L (gal)	Years Received	Estimated Current Volume** L (gal)
1C***	2.06E+06 (5.45E+05)	1948	37,900 (10,000)
UR***	1.83E+06 (4.83E+05)	1952 - 1953	---
TFeCN	11.3E+06 (2.98E+06)	1955 - 1957	1.59E+05 (42,000)
CW	1.62E+06 (4.28E+05)	1959	---
HS/SSW	6.24E+05 (1.65E+05)	1962-1965, 1970	26,500 (7,000)
OWW & IX	1.42E+06 (3.75E+05)	1970	---

* Total volume is greater than 2,010,000 L (530,000 gallons) because waste was routinely pumped from Tank 241-C-109.

** From Tank Layer Model estimates. Included in the Tank Layer Model but not shown on the table is 15,100 L (4,000 gal) of supernate in the tank.

*** These wastes were received through the cascade, and thus would have a lower solids content than waste received directly.

1C First-cycle decontamination waste from the $BiPO_4$ Process at B-Plant.

CW Waste from the dissolution of aluminum fruel cladding at PUREX.

HS/SSW Waste from Hot Semi Works (C-Plant), which was configured as the pilot plant for strontium recovery from 1960 to 1967.

IX Dilute ion exchange waste returned from cesium recovery. Tank 241-C-109 received IX with OWW as supernate from Tank 241-C-110.

OWW Organic solvent wash waste from PUREX. Tank 241-C-109 received OWW with IX as supernate from Tank 241-C-110.

TFeCN Ferrocyanide sludge produced by in-tank or in-farm scavenging.

UR Waste from the uranium recovery campaign at U-Plant.

2.3.1 Expected Contents of Tank 241-C-109 Based on Process History

The *Tank Layer Model* has been developed at Los Alamos National Laboratory (Brevick et al. 1994). This model combines waste type inventories and historical waste stream data to arrive at an estimate of the current chemical contents of Tank 241-C-109. The estimated current waste volumes shown in Table 2-2 were derived for this model. The Tank Layer Model uses these current volumes for calculations. This estimate is included as Table 2-3.

Table 2-3. Tank Layer Model Estimate of Tank 241-C-109 (Brevick et al. 1994).

Physical Properties		
Total Waste	2.35E+06 L (3.11E+05 kg)	
Heat Load	6.79 kW	
Bulk Density	1.32 g/mL	
wt % Water	80.44	
wt % C (wet)	1.66	
Chemical Constituents		
Analyte	**μg/g**	**kg**
Na	68,500	21,300
Al	985	306
Fe	19,600	6,080
Bi	2,600	808
Pb	30,000	9,330
Ni	23,000	7,140
U	0	0
OH^-	21,600	6,720
NO_3^-	88,500	27,500
NO_2^-	4,850	1,510
PO_4^{3-}	27,200	8,450
SO_4^{2-}	1,640	510
SiO_3^{2-}	949	295
acetate	6,000	1,860
$Fe(CN)_6^{4-}$		60,800 g-mol
Radiological Constituents		
Pu	0.0072 μCi/g	0.0375 kg
Cs	979 μCi/g	3.04E+05 Ci
Sr	2,560 μCi/g	7.95E+05 Ci

2.4 SURVEILLANCE DATA

2.4.1 Surface Level Readings

To determine the surface level of the waste, Tank 241-C-109 is equipped with a manual tape. The manual tape uses a conductivity probe which is lowered by a hand crank until an electric circuit is completed as the probe contacts the waste surface. The measurement is later manually recorded on the Computer Automated Surveillance System and the Surveillance Analysis Computer System (SACS).

Surface level readings for this tank are currently being taken quarterly. The most recent manual tape reading as recorded on SACS was 47.0 cm (18.5 in.) measured October 5, 1994. This reading is a recheck of a reading taken a few days earlier that registered 23.5 cm (9.25 in.). The earlier reading was much lower than expected, prompting both the recheck and a request for a photo package to determine why the manual tape registered the lower reading. The waste level in Tank 241-C-109 has remained very consistent for several years, as is to be expected from a stabilized out-of-service tank.

2.4.2 Internal Tank Temperatures

To measure local tank temperatures, two thermocouple trees (probes with 11 thermocouples assembled in a pipe), are inserted into Tank 241-C-109. The thermocouple trees monitor the waste temperatures at various levels in the tank. The thermocouple trees in Tank 241-C-109 are inserted through risers three and eight (see Figure 2-2 for riser locations). Six of the thermocouples on the tree in riser three, and four of the thermocouples on the tree in riser eight are currently in service. The tank is connected to the Tank Monitoring and Acquisition Control System, which continuously monitors the tank's thermocouples and downloads readings once a day to SACS.

Temperature readings for Tank 241-C-109 since 1975 are plotted as Figure 2-5. Each plotted temperature point is the highest of the readings recorded for that week by the thermocouples on the thermocouple trees. The temperature record is fairly complete except for an absence of temperature readings from August 1983 to October 1989. As of October 20, 1994, the temperature reading for Tank 241-C-109 was 30°C (86°F). Figure 2-5 illustrates that since 1989 temperatures have mostly remained between 20 and 30°C.

2.4.3 Tank 241-C-109 Photographs

Figure 2-6 presents a montage of photographs taken inside Tank 241-C-109 in 1974. The photographs are hazy and incomplete; no equipment is visible. It appears that the waste surface is brown and some darker objects can be seen. The photos were taken when the tank held over 1.89E+06 L of waste; thus it does not accurately represent the tank's current contents (Brevick et al. 1994).

Figure 2-5. Tank 241-C-109 Historical Temperature Data.

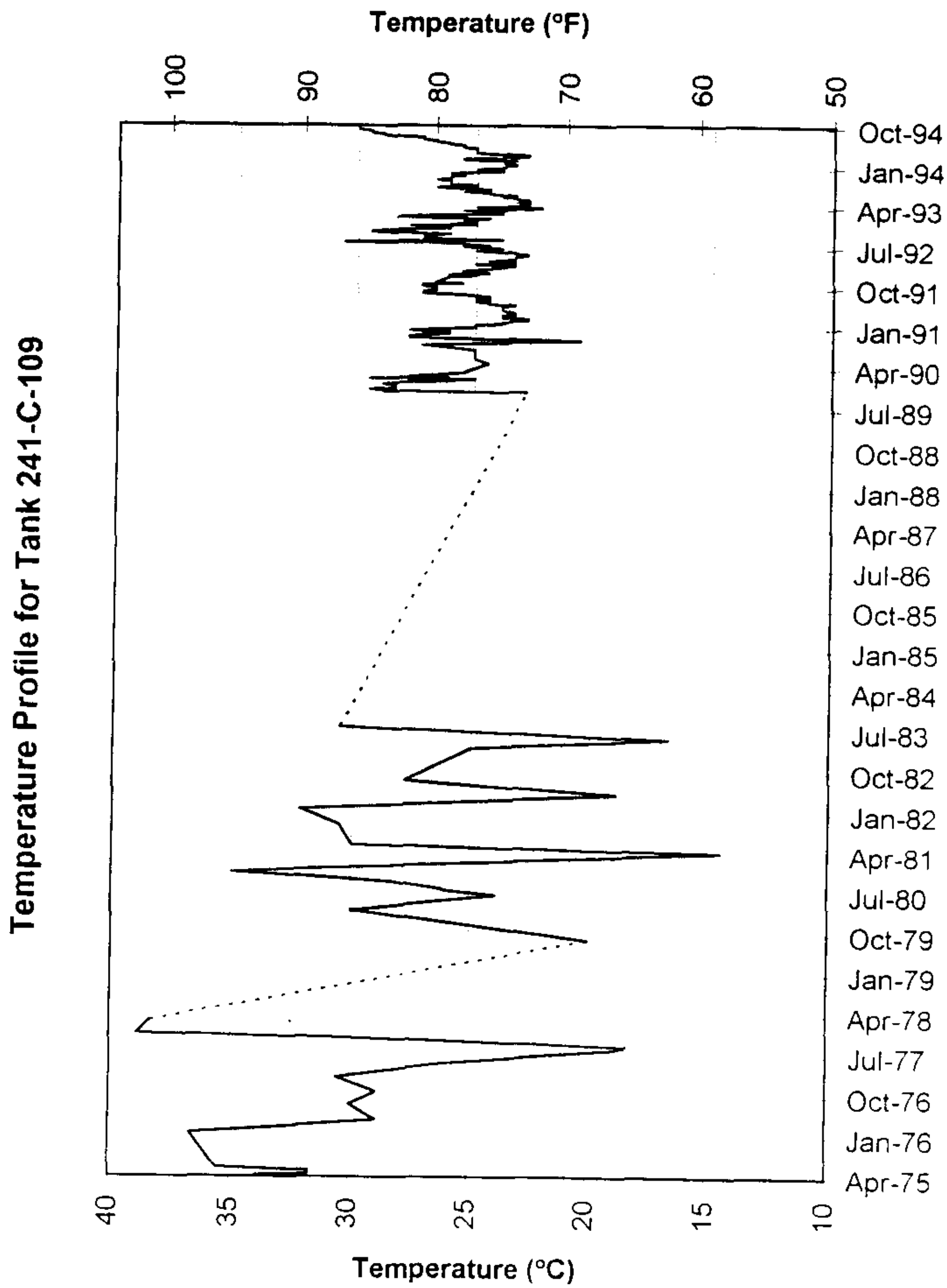
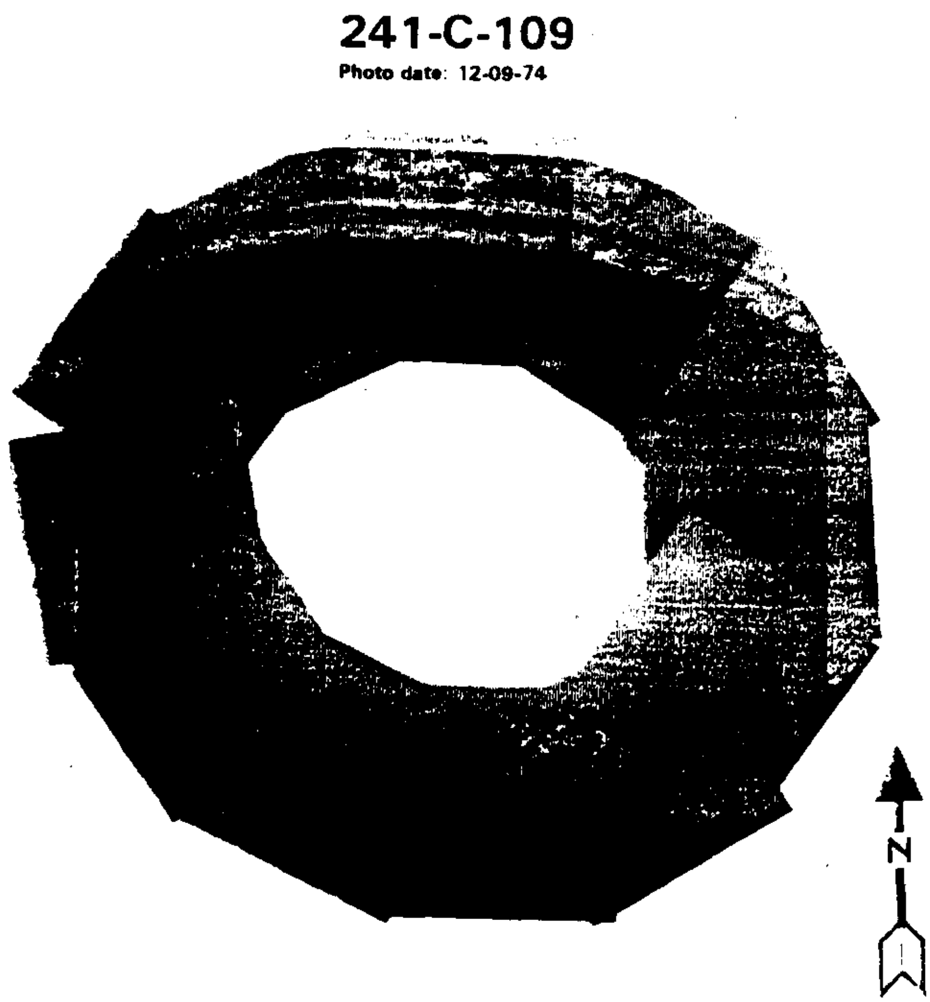


Figure 2-6. In-Tank Photo Montage of Tank 241-C-109.



3.0 TANK SAMPLING OVERVIEW

3.1 DESCRIPTION OF SAMPLING EVENT

Tank 241-C-109 was push-mode core sampled through three risers on September 2, 1992. One segment was expected from each of the three cores. Since Tank Farm Operations has determined that sampling events of one or two segments do not require hydrostatic head fluid, potential contamination originating from head fluid was eliminated. For a description of routine core sampling procedures, see the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994). Chain-of-custody forms were completed for each segment. Table 3-1 defines drill string dose rates (taken from the chain-of-custody forms) for the three cores from Tank-241-C-109.

Table 3-1. Drill String Dose Rates.

Sample	Core 47	Core 48	Core 49
Place Taken	Riser 6	Riser 7	Riser 2
Smearable Contamination	< DL alpha < DL beta-gamma	<DL alpha <DL beta-gamma	<DL alpha <DL beta-gamma
Dose rate through the drill string	1.0 R/hr	2.5 R/hr	1.5 R/hr

3.2 SAMPLE LOCATIONS

Core 47, core 48 and core 49 were taken from risers 6, 7 and 2 respectively. Sample locations for Tank-C-109 are displayed in Figure 3-1. Table 3-2 shows a list of sample numbers with the date of sampling and location.

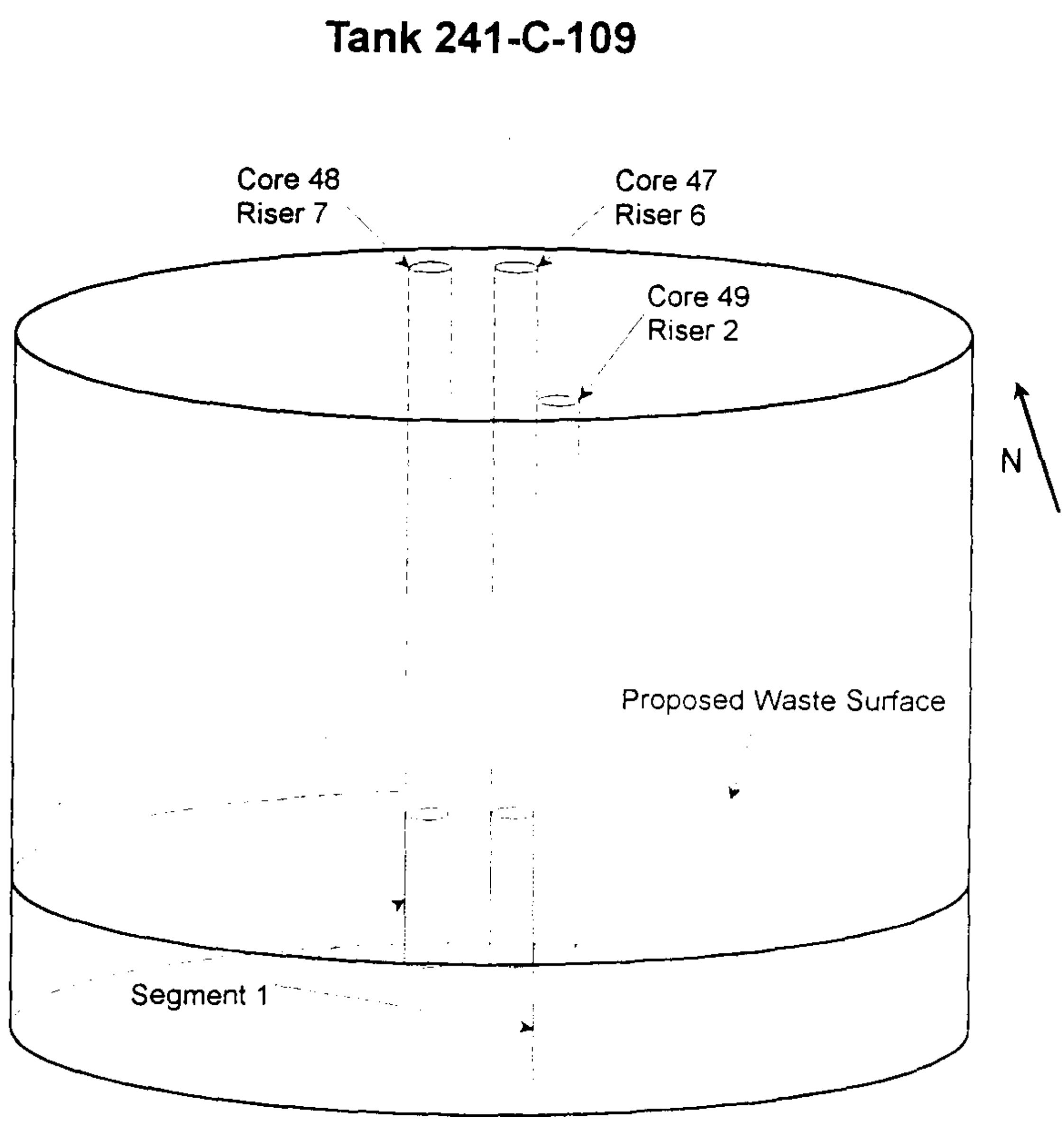
3.3 SAMPLE PROBLEMS

Core 48 contained only 73 grams of solid and was only 14.0 cm (5.5 inches) in length. No liquid was obtained from the liner of core 48.

3.4 PREVIOUS SAMPLING EFFORTS

There were no previous sampling efforts recorded.

Figure 3-1. Sample Locations for Tank 241-C-109.



NOTE: Sample recoveries and divisions of segments into subsegments are not illustrated in this figure.

Table 3-2. Tank 241-C-109 Sample Numbers and Locations.

Core	Riser	Segment	Laboratory Sample number	Date Sampled
47	6	1B	93-01355	9-92
47	6	1C	93-01356	9-92
47	6	1D	93-01357	9-92
47	6	Composite	93-01358	9-92
48	7	1C	93-01360	9-92
48	7	1D	93-01361	9-92
48	7	Composite	93-01363	9-92
49	2	1B	93-01365	9-92
49	2	1C	93-01366	9-92
49	2	1D	93-01367	9-92
49	2	Composite	93-01371	9-92
Liquid	2	Composite	93-01354	9-92

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4.0 SAMPLE HANDLING AND ANALYTICAL SCHEME

This chapter focuses on the handling of the samples after the sampling event and the analytical procedures performed on the samples. In addition, the characterization program analyses specific to Tank 241-C-109 are discussed.

4.1 SAMPLE HANDLING

Three core samples of waste from Tank 241-C-109 were received and extruded at PNL's High Level Radiochemistry Facility (325-A Hot-Cell Facility) in September 1992. Sample receipt for Tank 241-C-109 consisted of 3 cores, identified as numbers 47, 48 and 49.

A chain of custody record was kept during the sampling event for each segment sampled. This document ensures safe transport and maintains a record of personnel involved in sampling and transport to the laboratory. For a further discussion of chain of custody functions see the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

4.2 WASTE DESCRIPTION

The samples obtained from core sampling activities in Tank 241-C-109 were a mixture of sludge, liquids and solids. The following is a description of the contents of each core after sampler extrusion. Table 4-1 contains a summary of core sample contents and physical descriptions.

Core 47 - Core 47 contained 134 grams of sample including the liquid in the liner. The solids were a dark brown sludge which held its shape upon extrusion from the sampler. A white stripe of solid material was observed approximately 12.7 cm (5 in.) from the bottom of the sample. A significant amount of moisture was observed in the sludge. The liquid in the liner of this sample had a brownish yellow tint and contained suspended solids. The extruded sample from core 47 was divided into three subsegments.

Core 48 - Core 48 contained 73 grams of solid and was 14.0 cm (5.5 in.) in length. No liquid was obtained from the liner of this sample. The moisture and appearance of the sample were similar to those observed for core 47. The extruded sample from core 48 was divided into two subsegments.

Core 49 - Core 49 contained 182 grams of sample including the liquid in the liner. The solids were a light brown sludge with white streaks apparent throughout the sample. The sample held its shape upon extrusion from the sampler. A hard white chunk of solid material was observed at the bottom of the sample. A significant amount of moisture was observed in the sludge. The liquid was similar to that observed in core 47. The extruded sample from core 49 was divided into three subsegments.

A hot cell blank was also taken for Tank 241-C-109.

Table 4-1. Sample Description Summary.

Core No.	Segment	Core recovery (volume basis)	Total mass (g)	Comments
47	1	64.5%	134	Liquid volume was 11 ml; it contained suspended solids. Solids portion was 26.7 cm (10.5 in.) long.
48	1	30.6%	73	No liquid captured. Solids portion was 14.0 cm (5.5 in.) long.
49	1	87.4%	182	Liquid volume was 22 ml. Solids were medium brown color; Solid segment was 41.9 cm (13.5 in.) long.

Note: Sampler linear volume is 3.88 mL/cm (9.85 mL/inch).

4.3 HOLD TIME CONSIDERATIONS

The highly radioactive nature of Hanford wastes makes the use of standard preservation techniques used in conventional environmental sampling difficult and in many cases inappropriate. In addition, the complexity of sampling, transporting, and storing of wastes makes some of the shorter holding times difficult to achieve. Results for samples analyzed outside of holding times must be considered to be minimum values only. Such data may be used to demonstrate that a waste is hazardous when it is above the regulatory threshold, but cannot be used to demonstrate that a waste is not hazardous. A further discussion of hold time considerations is given in the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

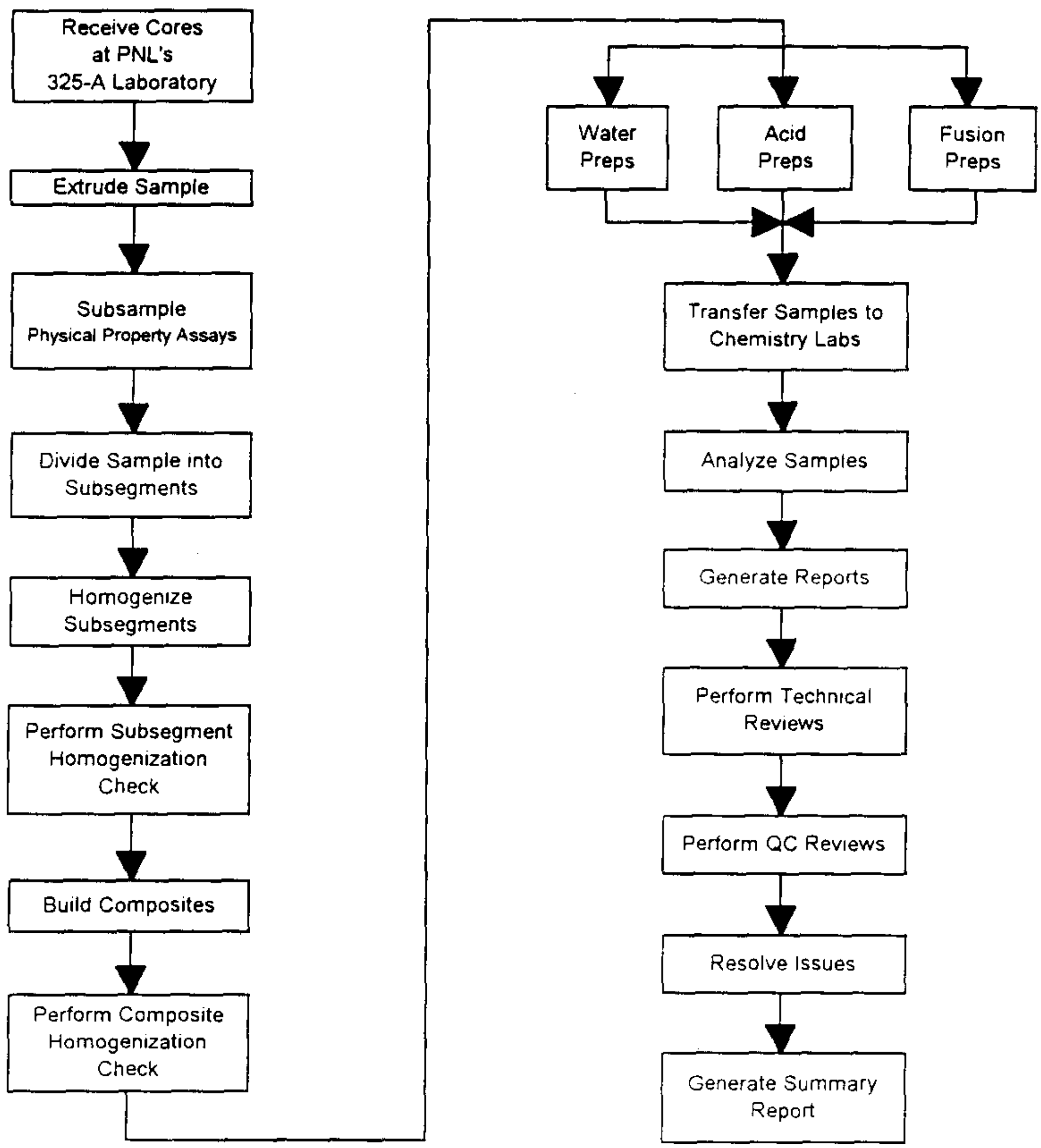
4.4 SAMPLE PREPARATION

Figure 4-1 is a flowchart of the typical steps taken to analyze the tank core samples. After sample extrusion, one 25-mL pre-homogenization aliquot from core 47 was taken for the full suite of rheological and physical measurements (some selected physical measurements were performed on all of the core samples).

Also prior to homogenization, the segment associated with each core was further divided into subsegments. Under ideal conditions, each segment would yield four quarter subsegments measuring 12 cm (4.75 in) in length. When recoveries were less than 100%, the segments were divided into 12 cm sections until the last subsegment was less than 12 cm long. Each subsegment is considered to be a quarter segment regardless of whether or not the material was divided into four parts (Bell 1993). Core 47 and core 49 were each separated into three subsegments, designated B, C, and D. Only two subsegments (C and D) were possible from core 48.

The subsegments were then homogenized to ensure that aliquots removed for analysis would be representative of the entire subsegment. A composite for each core was built by combining equal quantities of each homogenized subsegment. The core composites were then homogenized. Finally, the free liquids from cores 47 and 49 were combined to form a separate liquid core composite.

Figure 4-1. Flowchart for Data Collection and Preparation.



When all of the homogenizing and compositing activities were completed, the aliquots for analysis were taken. Analyses were done both on the subsegments and the core composites. Aliquots were either directly evaluated or analyzed after subjection to a digestion, extraction, or other preparation method as indicated in the Appendix A tables. Sample preparation procedures are discussed further in the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994). The remaining sample from each subsegment has been archived.

4.5 SAMPLE ANALYSES

All analyses were performed at PNL's 325 Laboratory. Analyses were performed on the core composites and the subsegments. The objectives of subsegment-level analyses are to provide the following: information pertaining to the overall waste energetics as a function of depth; the vertical distribution of ^{137}Cs and ^{90}Sr; the concentration and solubility of the CN^- present in the sample; and a higher resolution for determining bulk tank composition for certain analytes. To accomplish these goals, a limited suite of analyses, listed in Table B-1 in Appendix B, was performed on each homogenized subsegment.

The type and number of analytical tests performed on the core composites were similar to the suite done on the subsegments but were much more extensive. An organics speciation analysis was also performed on the core composites. A liquid core composite, assembled from the free liquids of cores 47 and 49, was analyzed separately.

Procedures (along with procedure number) used for chemical and radiochemical analyses on the core composites are listed in Table B-2 in Appendix B. Also in Appendix B are the procedures used for physical and rheological analyses (Table B-3), and the procedures utilized to analyze for organic compounds (Table B-4). Additional information on analytical methods can be obtained in the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

5.0 ANALYTICAL RESULTS AND WASTE INVENTORY

5.1 OVERVIEW

The chemical, radiochemical, physical, and organic results associated with Tank 241-C-109 are presented within this document as indicated in Table 5-1. The samples from which these results were derived were collected in September of 1992. This sampling event was the most recent regarding Tank 241-C-109 and reflected the most accurate characterization of the tank waste available at the present time. A detailed discussion of the sampling process was presented in Section 3.

Table 5-1. Analytical Data Presentation Tables.

Analysis	Tabulated Result Location
Single-Shell Tank 241-C-109 Chemical Composition Summary	Table 5-2
Tank Characterization Report Analytical Summary	Table A-1
Metals	Table A-2
Ions	Table A-3
Radionuclides	Table A-4
Physical Properties	Table A-5
Total Carbon	Table A-6
Extractable Organic Halides	Table A-7

The Appendix A tables present the data acquired from liquid composite, solid core composite, and segment analyses. Data from all digestion methods are listed. Only data from the preferred method of analysis for the core composites (no segment data) were used to calculate inventory estimates. A preferred method of analysis for a specific analyte is that method which yielded the highest concentration.

The sample data presented in the Appendix A tables were obtained by calculating an average concentration value from the initial and duplicate analyses associated with each sample. If an analyte was detected during the original analysis but not the duplicate, or vice-versa, the detected value and the detection limit were averaged. When both sample runs failed to detect an analyte, the result was stated to be less than the detection limit, (< DL).

The relative standard deviation values for most analytes were calculated from a statistical model by PNL personnel which is further discussed in the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994). The projected tank inventory value for Tank 241-C-109 constituents was calculated by multiplying the statistical or weighted mean by the volume of waste in the tank at the time of sampling: liquid = 9,150 L; sludge = 2.35E+05 L. The appropriate conversion factors were included in the calculations to obtain the reported units.

5.2 DATA PRESENTATION

A summary of the data obtained from the analyses of composite samples is presented in Table 5-2. No data from segment analyses were used to construct the table. The first column 'Analyte Preferred Method' is the method used to determine the analyte concentration, followed by the digestion method which yielded the highest result. The second column 'Number of Samples' is the total number of composite samples for each measured analyte, which, with the exception of the analyses of physical properties and extractable halides, includes a primary and duplicate sample for each of two samples taken from all three cores. The third column 'Percent Non-detect Samples' is the ratio of samples which yielded results below the detection limit, and the total number of samples for a particular analyte, times 100. The fourth and fifth columns 'Minimum Observed Value' and 'Maximum Observed Value' present the least and the highest values (above the detection limit) measured by the preferred method and digestion of all primary and duplicate composite samples.

Columns six, seven, and eight contain data which are taken from Appendix A of this report. The sixth column 'Mean' is the average of all primary and duplicate samples regarding the specified method of preparation. This value is a simple (non-weighted) mean of all sample results. Column seven 'RSD' lists the relative standard deviation (standard deviation divided by the mean) of the sample results. Column eight 'Projected Inventory' is the product of the Mean value and the sludge waste volume, along with the appropriate conversion factors to obtain the desired units. Specific segment or quarter segment analyte concentrations are presented in the Appendix A Tables.

Table 5-2. Single-Shell Tank 241-C-109 Chemical Composition Data Summary (3 sheets).

Analyte Preferred Method	Number of Samples	Percent Non-detect Samples	Minimum Observed Value	Maximum Observed Value	Mean	RSD (Mean)	Projected Inventory
Metals		%	µg/g	µg/g	µg/g	%	kg
ICP.f.Al	6	0	7,280	1.34E+05	67,400	47	19,500
ICP.f.Sb	6	100	---	---	< 141	---	< 40.8
ICP.f.As	6	100	---	---	< 300	---	< 86.7
ICP.f.Ba	6	0	41.0	90.0	68.2	20	19.7
ICP.f.Be	6	100	---	---	< 9.47	---	< 2.74
ICP.f.B	6	100	---	---	< 134	---	< 38.7
ICP.f.Cd	6	100	---	---	< 22.2	---	< 6.42
ICP.f.Ca	6	0	14,500	24,400	18,800	14	5,430
ICP.f.Ce	6	100	---	---	< 301	---	< 87.0
ICP.f.Cr	6	0	215	274	250	7	72.3
ICP.f.Co	6	100	---	---	< 551	---	< 159
ICP.f.Cu	6	0	50.0	90.0	62.8	18	18.2
ICP.f.Dy	6	100	---	---	< 15.7	---	< 4.54
ICP.a.Fe	6	0	5,900	35,200	18,700	34	5,410
ICP.a.La	6	0	6.00	81.0	44.0	49	12.7
ICP.a.Pb	6	0	586	10,500	3,890	81	1,120
ICP.f.Li	6	100	---	---	< 21.9	---	< 6.33
ICP.f.Mg	6	0	334	681	551	19	159

Table 5-2. Single-Shell Tank 241-C-109 Chemical Composition Data Summary (3 sheets).

Analyte Preferred Method	Number of Samples	Percent Non-detect Samples	Minimum Observed Value	Maximum Observed Value	Mean	RSD (Mean)	Projected Inventory
Metals (continued)		%	µg/g	µg/g	µg/g	%	kg
ICP.f.Mn	6	0	82.0	172	128	17	37.0
CVAA.Hg	6	0	6.50	9.20	7.35	10	2.12
ICP.f.Mo	6	66.7	35.0	37.0	40.0	17	11.6
ICP.f.Nd	6	100	---	---	< 147	---	< 42.5
ICP.a.Ni	6	0	10,600	16,300	14,100	8	4,080
ICP.a.P	6	0	11,700	27,100	18,300	8	5,290
ICP.a.K	6	0	354	665	544	13	157
ICP.f.Re	6	100	---	---	< 51.1	---	< 14.8
ICP.f.Rh	6	100	---	---	< 183	---	< 52.9
ICP.f.Ru	6	100	---	---	< 103	---	< 29.8
ICP.f.Se	6	100	---	---	< 448	---	< 129
ICP.f.Si	6	0	2,080	16,800	6,760	67	1,950
ICP.f.Ag	6	100	---	---	< 23.1	---	< 6.68
ICP.f.Na	6	0	71,300	1.07E+05	87,900	8	25,400
ICP.f.Sr	6	0	167	831	378	51	109
ICP.f.Te	6	100	---	---	< 281	---	< 81.2
ICP.f.Tl	6	100	---	---	< 1,620	---	< 468
ICP.f.Th	6	100	---	---	< 217	---	< 62.7
ICP.a.Ti	6	0	4.00	64.0	25.2	68	7.28
ICP.f.U	6	0	3,890	27,800	12,900	47	3,730
ICP.f.V	6	100	---	---	< 26.6	---	< 7.69
ICP.f.Zn	6	0	320	398	362	4	105
ICP.f.Zr	6	100	---	---	< 22.5	---	< 6.50
Ions		%	µg/g	µg/g	µg/g	%	kg
Titrat.NH_3	6	0	43.0	64.0	53.0	10	15.3
IC.Cl^-	6	0	700	800	733	8	212
Cr^{6+}	6	0	27.0	48.0	37.2	15	10.8
IC.CN^-	6	0	540	1,320	882	24	255
IC.F^-	6	0	400	2,200	700	43	202
IC.NO_3^-	6	0	35,000	51,000	40,300	10	11,600
IC.NO_2	6	0	38,000	48,000	40,700	5	11,800
IC.PO_4^{3-}	6	0	12,000	35,900	20,500	20	5,930
IC.SO_4^{2-}	6	0	6,200	9,600	7,700	10	2,230
Radionuclides		%	µCi/g	µCi/g	µCi/g	%	Ci
AEA.^{241}Am	6	0	0.00888	0.390	0.154	84	44.5
LSC.^{14}C	6	16.7	6.30E-06	3.70E-05	1.97E-05	44	0.00569
GEA.f.^{137}Cs	6	0	547	1,110	820	17	2.37E+05
GEA.f.^{60}Co	6	100	---	---	< 0.0213	---	< 6.16

Table 5-2. Single-Shell Tank 241-C-109 Chemical Composition Data Summary (3 sheets).

Analyte Preferred Method	Number of Samples	Percent Non-detect Samples	Minimum Observed Value	Maximum Observed Value	Mean	RSD (Mean)	Projected Inventory
Radionuclides (continued)		%	µCi/g	µCi/g	µCi/g	%	Ci
GEA.f.^{154}Eu	6	66.7	0.333	0.390	0.227	37	65.6
GEA.f.^{155}Eu	6	100	---	---	< 0.843	---	< 24.4
LSC.^{79}Se	6	66.7	5.00E-05	6.00E-05	6.17E-05	15	0.0178
BPC.^{90}Sr	6	0	190	1,050	767	39	2.22E+05
BPC.^{99}Tc	6	0	0.0936	0.117	0.106	6	30.6
LSC.^{3}H	6	0	0.00547	0.00989	0.00710	10	2.05
APC.f.Total α	6	100	---	---	< 0.395	---	< 114
Plutonium.f. Total α	6	0	0.0666	0.949	0.341	78	98.6
BPC.f.Total β	6	0	1,200	2,940	2,120	20	6.13E+05
LF.U	6	0	7,420 µg/g	30,000 µg/g	15,700 µg/g	39	4,540 kg
Physical Properties							
*H.pH	3	0	9.40	10.8	10.1		
Liq.Density	2	0	1.10	1.20	1.15		
Sol. Density	3	0	1.20	1.30	1.23		
TGA.Wt.%H_2O	2	0	14.8	26.6	20.7		
Percent Water	3	0	21.5	57.7	35.7	54	
Total Organic Carbon		%	µg/g	µg/g	µg/g		kg
TOC	6	0	2,100	3,300	2,850	7	824
TIC	6	0	5,000	5,800	5,450	3	1,580
TC	6	0	7,200	9,100	8,300	4	2,400
Extractable Halides		%	µg/g	µg/g	µg/g		kg
mCoul.Titrat.EOX	2	50	11.0	11.0	10.5		3.04

5.3 PHYSICAL MEASUREMENTS AND THERMODYNAMIC ANALYSES

5.3.1 Density, Percent Solids, and Settling Behavior

Denisty measurements were perfomred on solid composite samples from cores 47, 48, and 49 and on liquid composite samples from cores 47 and 49. The results from these analyses are reported in Appenix A.

Percent solids and settling behavior analyses were conducted on samples obtained from core 47; summary information pertaining to the as-received sample and the 1:1 and 3:1 water:sample dilutions are presented in Table 5-3.

Due to the absence of free liquid with the waste in the sampler, no settling was observed in the as-received segment samples over a period of three days, and there was no standing liquid in the samples. The 1:1 dilution reached a final volume percent settled solids of 88% (avg.). Settling continued throughout the 3-day period, but the majority of the settling was seen in the first 24 hours. The 3:1 dilution reached a final volume percent settled solids of 41% (avg.). The majority of the solids completely settled within 10 hours. The results of the settling behavior studies are graphed in Appendix C.

Table 5-3. Physical Measurements of Core 47.

Property	As-Received	Segment	
		1:1 Dilution	3:1 Dilution
Settled solids (vol%)	100%	88%	41%
Centrifuged solids			
Volume %	100%	NM	21.1%
Weight %	100%	NM	27.0%
Density (g/ml)			
solid	*	NM	1.11
liquid	*	----	----
Centrifuged supernate	NM	NM	1.01
Centrifuged solid	NM	NM	1.39

NM = No measurement.
* See Appendix Table A-5

5.3.2 Particle Size

Particle size analyses were performed on all three cores. Refer to the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994) for specifics regarding the method of analysis.

The mean particle size in the number distribution ranges from 0.80 to 1.38 μm in diameter for Tank 241-C-109 waste samples. Table 5-4 presents the summary results of the measurements. The most common occurrences (modes) for particle size range between 0.5 and 1.0 μm. The majority (over 88%) of the measured particles fit within the narrow band of 0.0 to 2.0 μm.

The particle size in the volume distribution ranges from 0.0 μm to 70 μm in diameter between the three cores with relatively wide variation between the means of these samples (5.73 to 37.56 μm). Table 5-4 shows the summary results of the measurements. The average particle size represented in the volume distribution is considerably larger than that in the number distribution. In Core 47 there are relatively few small particles; most of the particle volume is evenly dispersed within the 0.0 to 70 μm range. In Core 48 the majority of the particles are much smaller, with particle volumes concentrated in two narrow ranges, the 0.0 to 2.0 μm range and the 9.0 to 20.0 μm range. Core 49 is quite similar to Core 47 in that there are relatively few small particles. Most of the particles are evenly dispersed within the 10.0 to 60.0 μm range. The disparity between the core sample measurements possibly indicates a difference in waste type; however, these differences cannot be attributed to the proximity of sample locations to tank inlets as demonstrated in Figure 2-2.

Table 5-4. Particle Size Data.

	Distribution by number (μm)			**Distribution by Volume (μm)**		
Sample	**Mean**	**Median**	**Standard Deviation**	**Mean**	**Median**	**Standard Deviation**
Core 47	1.14	0.85	1.45	37.56	38.72	21.1
Core 48	0.80	0.77	0.28	5.73	2.97	5.76
Core 49	1.38	0.90	1.92	24.47	24.08	12.64

5.3.3 Rheology

The shear strength was measured on a combined, unhomogenized sample from core 47. The shear strength was measured to be 17,300 dynes/cm^2. Refer to the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994) for explanation of the analytical method.

Shear strength and viscosity measurements (as functions of shear rate) were also performed on the 1:1 (water:sample) dilution of the sample at ambient hot cell temperatures (29 to 32°C or 84 to 90°F) and at 95°C (203°F). Table 5-5 shows the power law model parameters for the 1:1 sample dilutions at 30°C (86°F). The power law model describes the change in shear stress as a function of shear rate and the flow behavior index, and yields the necessary parameters for the yield-pseudoplastic rheological model. The power law model and further discussion may be found in the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

Table 5-5. Power Law Model Parameters.

Sample	**Temp°C**	**Trial**	**Yield Stress, σ (Pa)**	**Consistency factor, ß (Pa•s)**	**flow behavior index, n**
1:1 dilution	30	Sample	50	0.017	1
1:1 dilution	30	Duplicate	40	0.019	1

A typical viscosity versus shear rate graph for a sludge type of material consists of two parts. The initial part of the graph demonstrates yield-pseudoplastic behavior; it consists of a curve with a negative slope and reflects decreasing viscosity as a function of increasing shear rate. Once the yield point is reached, the curve bends sharply and exhibits a slope which approaches zero. In the flat part of the curve, Newtonian behavior is observed, and viscosity no longer changes as a function of shear rate.

The viscosity of the 1:1 diluted sample at a low shear rate (i.e., near zero) ranged between 2,800 and 4,200 cP. The viscosity gradually declined with increasing shear rates to 100 cP at 468 s^{-1}. The 1:1 dilution of the composite sample, therefore, exhibited yield-pseudoplastic behavior. Viscosity of the 3:1 (water:sample) diluted sample at a low shear rate ranged between 12 and 42 cP; the viscosity rapidly declined with increasing shear rates to approximately 5 cP at 100 s^{-1} and 3 cP at 468 s^{-1}. Consequently, both the 1:1 and 3:1 diluted samples displayed near-Newtonian behavior when shear rates exceeded approximately 100 s^{-1}. Higher viscosities were observed at higher temperatures for these sample matrices, but this is not unusual since drying of the sample often has a significant impact on its flow behavior. Rheograms of all these measurements can be found in the complete data package (Shaver 1993).

Turbulent flow is often, but not always, necessary to keep particles in suspension. Furthermore, a fluid waste consisting of suspended particles is desired to prevent the accumulation of solids in retrieval and/or pretreatment process equipment. Characteristics regarding the transition from laminar to turbulent flow were calculated for the 1:1 dilution slurry using the parameters determined from measurement and a curve-fitted rheological model (Shaver 1993) (refer to Table 5-6).

Table 5-6. Turbulent Flow Model Calculations.

Sample	Temp. (° C)	Trial	Pipe Diameter (inch)	Velocity (m/s)	Critical Flow Rate (L/min)	Reynolds Number
1:1	30	S	2	3.26	424	12,800
1:1	30	D	2	3.14	405	16,900
1:1	30	S	3	2.90	833	16,900
1:1	30	D	3	2.77	799	14,400

S = Sample
D = Duplicate

5.3.4 Thermodynamic Analyses

Thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) were performed on both subsegment and core composite material. TGA and DSC determine the thermal stability or reactivity of a material. In DSC analysis, heat flow over and above the usual heat capacity of the substance is measured while the substance is exposed to a linear increase in temperature. While the substance is being heated, air is passed over the waste material to remove any gases being released. The onset temperature for an endothermic or exothermic event on a DSC is determined graphically.

TGA measures the mass of a sample while the temperature of the sample is increased at a constant rate. Air is passed over the sample during heating. Any decrease in the weight of a sample represents a loss of gaseous matter from the sample either through evaporation or through a reaction that forms gas phase products.

The results of the thermal analyses performed are summarized in Tables 5-7 and 5-8. The first transition in each sample is endothermic, beginning at the lower temperature limit of the analysis (30°C), and is complete between 140°C and 200°C. In this region, mainly the loss of bulk and interstitial water in the core sample is observed. The endotherms exhibited in this region are substantial (typically 350 to 1,030 J/g). The second transition between 260°C to 300°C in cores 47 and 49 shows no exothermic reactions. The phenomena occurring in this region could be attributedd to the loss of covalently bound water molecules or the dehydration of aluminum hydroxide to alumina and water vapor. The third transition is very small compared with the other two observed transitions (< 100 J/g). A minor weight loss was observed in the samples at temperatures above 300°C.

Table 5-7. Thermogravimetric Analysis Results.

Core Sample	Total Wt% Loss	Transition 1 Wt% Loss	Transition 2 Wt% Loss	Transition 3 Wt% Loss
47-1B	31.4	10.2	17.9	3.3
47-1C	39.3	18.0	17.6	3.7
47-1D	28.2	19.7	6.8	1.7
47-Comp	33.4	14.8	14.9	3.7
48-1C	NM	NM	NM	NM
48-1D	48.1	45.1	3.2	-0.2
48-Comp	NM	NM	NM	NM
49-1B	34.1	4.2	25.8	4.1
49-1C	46.6	29.6	14.2	2.8
49-1D	40.0	29.3	9.6	1.1
49-Comp	46.1	26.6	15.8	3.7

Transition 1: 31° - 150°C
Transition 2: 150° - 425°C
Transition 3: 330° - 500°C
- These ranges are approximate, and there is some overlap.
NM = No measurement
Comp = Core composite.

Table 5-8. Differential Scanning Calorimetry Energetic Results.

Core Sample	Transition 1			Transition 2			Transition 3		
	Range ° C	Avg. onset ° C	Avg. Δ H (J/g)	Range ° C	Avg. onset ° C	Avg. ΔH J/g	Range ° C	Avg. onset ° C	Avg. ΔH J/g
47-1B	33-150	70	350	190-338	259	1,560	(a)	N/A	---
47-1C	35-144	53	425	167-318	217	610	380-461	391	72
47-1D	34-154	59	767	190-369	225	508	369-441	375	21
47Comp	34-150	55	785	159-330	216	1,080	(a)	N/A	---
48-1D	34-196	104	1,030	249-338	272	-27	336-431	359	31
49-1B	33-115	40	368	193-373	270	2,199	(a)	N/A	---
49-1C	33-197	72	658	167-316	242	565	(a)	N/A	---
49-1D	34-166	71	712	152-324	225	305	379-483	394	48
49-Comp	34-192	99	964	190-329	243	922	(a)	N/A	---

(a) No quantifiable transition is observed.
Note: To convert from J to cal, divide by 4.18
Note: Negative Δ H indicates an exotherm.
N/A = not applicable.
Comp = core composite.

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6.0 ANALYTICAL RESULTS INTERPRETATION

6.1 TANK WASTE INVENTORY AND PROFILE

The waste in Tank 241-C-109 is approximately 94% sludge and 6% supernate by volume. The sludge is composed of approximately 64% solids and 36% water by weight. With respect to the sludge, water was the analyte present in the greatest concentration. The following analytes were also found in abundance (in descending concentration): Na, Al, PO_4^{3-}, NO_2^-, NO_3^-, Ca, Fe, U, Ni, and SO_4^{2-}. Through ion chromatography analysis, it was found that the tank contained 255 kg of soluble CN^-. The principle radioactive constituents were ^{137}Cs and ^{90}Sr. The tank was found to hold 824 kg of organic carbon, 31.5 kg of which were tributyl phosphate. One exotherm of 8.13 cal/g (dry weight), which corresponds to 27 J/g (6.5 cal/g) wet weight, was observed in subsegment 1D of core 48.

The waste in Tank 241-C-109 was determined to be heterogeneous, as there were statistical differences in analyte concentrations within individual cores. Although horizontal variability exists, no distinct trends in the data as a function of horizontal position were able to be discerned. Vertically, there were some pronounced trends in analyte concentrations within cores. Refer to Sections 6.2.6 and 6.2.7 for an in-depth discussion of tank homogeneity and spatial variability.

6.2 ASSESSMENT OF ANALYTICAL RESULTS

6.2.1 Process History Summary of Tank 241-C-109

Tank 241-C-109 began its service life in 1948, when it received first-cycle decontamination (1C) waste as the last tank in the 241-C-107 -108 -109 cascade. The tank was emptied, except for a 37,900 L (10,000 gal) heel and was then used as a temporary supernate tank for 241-C Tank Farm removal operations. Tank 241-C-109 was emptied again in early 1953 and was soon after filled through the cascade with unscavenged uranium recovery waste.

From 1955 to 1958, Tank 241-C-109 was used as a primary settling tank for "in tank" ferrocyanide scavenging. This involved the repeated transfer of scavenged waste into the tank to allow ^{137}Cs and ^{90}Sr bearing particulate material to settle; the resulting decontaminated supernate was then transferred out of the tank to cribs. This is, therefore, the period when Tank 241-C-109 accumulated most of its solids contents. After ferrocyanide scavenging was completed, Tank 241-C-109 received coating waste supernate, which was later pumped out of the tank.

From 1962 to 1965, the tank received a series of small transfers of strontium retrieval waste from the Hot Semiworks (C-Plant). Supernate from tanks holding this strontium retrieval waste was twice added to Tank 241-C-109 in the next few years. Supernate was transferred out of Tank 241-C-109 in early 1970, but this space was replaced with a transfer of organic wash waste and ion exchange waste supernate from Tank 241-C-110 in the next quarter. The last recorded transfers involved the removal of supernate from Tank 241-C-109 in 1975 and 1976 (Agnew 1994a). Section 2.3 provides a more detailed discussion of the tank's transfer history and waste contents.

6.2.2 Quality Control Assessment

An attempt is always made to quantify the different sources of error possible during the chemical analysis of a sample. When these errors are summarized, they give a strong indication of data reliability. If one or more of the error estimates are outside the acceptable limits, the accuracy of a particular concentration estimate is drawn into question. Possible sources of error are sample contamination, matrix interferences, analytical method error, and poor instrument calibration.

Matrix spikes are used to estimate the bias of the analytical method due to matrix interferences. 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 quality control criterion for spikes in this series of assays is 100 ± 25% recovery. If a spike is above or below the criterion, then the analytical result may be biased high or low, respectively. Table 6-1 indicates that matrix interference was present to some degree. Eighty-five of 274 total spike measurements (31%) were outside the acceptable quality control limits. With regard to Al, Pb, Ni, and Na, the added spike amounts were less than 25% of the corresponding analyte concentrations; as a consequence, the resulting spike failures did not yield meaningful information since the spike concentrations were insignificant compared to that of the analytes. Specifically, the matrix spike data associated with core composite samples which were acid digested and analyzed by ICP indicated that the reported concentrations of the following analytes exhibited a low bias: Mn, Pb, Si, Se, and Zr.

Table 6-1. Summary of Recoveries Calculated from Spike Measurements for Tank 241-C-109.

Analyte: Preparation Method	Within Range*	Outside* Range
Inductively Coupled Plasma, acid	107	45
Ion Chromatography, water	26	16
Graphite Furnace Atomic Absorption, acid: As, Sb	0	1
Hg CVAA	2	3
Extraction Organic (SVOA)	48	18
Persulfate Oxidation (TOC)	5	2
Extractible Organic Halides	1	0

* Range = 75% to 125%

Method blanks, summarized in Table 6-2, 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 1,006 blank measurements were made on Tank 241-C-109, with 16.5% above the detection limit, indicating some degree of contamination. However, the vast majority of blanks detected were two orders of magnitude or more below the analyte concentration. Only manganese and boron may have had analytical results biased inordinately high, and the boron values were near the detection limit. Therefore, contamination of the samples does not appear to be large source of error in the estimates of analyte concentration.

Table 6-2. Summary of Blank Measurements on Tank 241-C-109.

Assay: Sample Preparation	No. of Blanks <DL	No. of Blanks >DL
Inductively Coupled Plasma:		
ICP: acid	260	56
ICP: fusion	125	35
ICP: water	139	21
Ion Chromatography, water	32	3
Graphite Furnace Atomic Absorption, acid:		
As	1	1
Se	2	0
Sb	2	0
Hg CVAA	6	2
Extraction Organic (SVOA)	193	2
Persulfate Oxidation (TOC)	5	11
Extractible Organic Halides	1	0
Gamma Energy Analysis:		
GEA: acid	10	2
GEA: water	4	1
GEA: fusion	11	5
GEA: residual solids	12	3
Radiochemistry:		
Beta: acid	6	4
Beta: water	1	0
Beta: fusion	4	5
Beta: direct	0	3
Radiochemistry:		
Alpha: acid	2	2
Alpha: water	1	0
Alpha: fusion	3	2
Alpha: direct	0	3
Liquid Scintillation Counting:		
LSC: acid	2	0
LSC: water	2	1
LSC: fusion	2	0
Laser Fluorimetry:		
LF: acid	4	0
LF: fusion	1	1
Water Digestion:		
Calorimetric	1	0
SEI (NH_3)	1	0
TIC,TOC,TC	7	3
pH	0	0

Another quality control check is accomplished by conducting homogenization tests on several of the tank constituents. This procedure evaluates the ability of PNL's 325 Analytical Chemistry Laboratory to homogenize core subsegments. Subsegment D from cores 47, 48, and 49 was individually homogenized and arbitrarily divided into two parts, top and bottom. One subsample was obtained from each part and two aliquots were taken from each subsample and prepared for chemical analysis. ICP acid digestion and fusion dissolution analyses were conducted on the aliquots for the following analytes: aluminum, calcium, iron, lead, nickel, phosphorus, sodium, and uranium. The acid and fusion results for ^{137}Cs were also reported. The homogenization test data were all above the detection limit, and are tabulated in the Appendix A tables.

The structure of the data allows a hierarchical statistical model to be fit to the data that separates the different components of variability. The total variability in the data has three components: subsegment variability (differences between subsegments), homogenization variability (homogenization differences between subsamples within the same subsegment), and analytical error (differences between duplicate aliquots from the same subsample). To detect whether there was significant variation between the homogenized subsamples, a statistical method known as the Analysis of Variance (ANOVA) was calculated. The ANOVA output was used to test the homogenization variability.

The p-values of the homogenization test are given in Table 6-3. All p-values are compared with a standard significance level (α = 0.05). If a p-value is below 0.05, there is sufficient evidence to conclude that the sub-sample means are significantly different from each other. However, if a p-value is above 0.05, there is not sufficient evidence to conclude that the sub-samples are significantly different. For example, the aluminum/acid p-value in Table 6-3 is 0.890; therefore, sufficient evidence does not exist to indicate that the corresponding sub-samples are significantly different.

Examining Table 6-3, it is apparent that only the p-value for aluminum/fusion is less than 0.05. Therefore, of the 18 homogenization tests conducted (9 analytes times 2 digestion methods), only one showed a significant difference between the homogenized subsamples. This indicates that the 325 Laboratory can adequately homogenize core segments for waste materials of this type, leading to uniform samples and more reliable data results.

Table 6-3. Homogenization Test (p-values).

Analyte	Acid	Fusion
Aluminum	0.890	0.036
Calcium	0.649	0.389
Iron	0.922	0.072
Lead	0.572	0.606
Nickel	0.551	NA
Phosphorus	0.290	0.706
Sodium	0.229	0.216
Uranium	0.667	0.164
^{137}Cesium	0.214	0.092

6.2.3 Field Observations

The general characteristics of Tank 241-C-109 waste are summarized below. For specific core and segment observations, refer to Section 4.2.

The core samples ranged from dark brown to light brown in color, with white streaks running throughout. No sharp boundaries were apparent in the samples. The sludge had a thick consistency and held its shape upon extrusion from the sampler (high viscosity, non-Newtonian fluids). A significant amount of moisture was observed within the sludge. Liquid was recovered from the liner for two of the three cores (47 and 49). In both cases, the liquid had a brownish yellow tint and contained suspended solids.

6.2.4 Data Consistency Checks

6.2.4.1 Comparison of ICP and IC Results for Phosphate. All phosphorous in the tank is assumed to be present as phosphate since the primary source of phosphorous, according to the historical records, was bismuth phosphate. A theoretical value for phosphate was calculated from the Inductively Coupled Plasma (ICP) analyses data obtained from KOH samples prepared by fusion. The result was compared to the corresponding data obtained by ion chromatography (IC). The comparison is displayed in Table 6-4.

Table 6-4. Comparison of ICP and IC Results for Phosphate.

Analyte	Sludge Phase	
	IC Result (μg/g)	ICP derived Result (μg/g)
Phosphate	20,500	56,100

The ICP analyses revealed higher phosphate concentrations than the IC analyses. The difference between IC and ICP results are due to different sample preparation methods. IC is performed after water digestion and gives water soluble phosphorus; ICP, based on fusion digestion, gives total phosphorus. The results indicate that the ICP phosphate concentration is approximately three times higher than the IC phosphate concentration. Since IC measures soluble phosphate, it can be assumed that one third of the phosphate is soluble and two thirds is insoluble.

The phosphorus concentration derived from the analyses of water digested samples by ICP was 6,610 μg/g. This value calculates to 20,200 μg/g of soluble phosphate and differs by less than 2% with the IC phosphate result.

6.2.4.2 Comparison of Total Alpha and Beta Activities with Gross Alpha and Beta Activities. A comparison was made between the sums of the gross beta and gross alpha activities with the sum of the individual beta and alpha emitters. This was done as a check on the accuracy of the two analyses. A close agreement indicates that both analyses were probably representative of the tank contents. The activities of the individual beta emitters were summed according to the following equation:

$$\text{Total beta} = (2 * {}^{90}\text{Sr}) + ({}^{137}\text{Cs})$$

The activities of the individual alpha emitters were summed according to:

$$\text{Total alpha} = {}^{241}\text{Am} + \text{total Pu}$$

The comparisons are given in Tables 6-5 and 6-6.

Table 6-5. Tank 241-C-109 Comparison of Gross Beta Activities with the Total of the Individual Activities.

Analyte	Half-Life	Solid (μCi/g)
^{90}Sr	28.6y	1,530[2]
^{137}Cs	30.17y	820
Total Beta Sum (a)	-----	2,350
Gross Beta Result (b)	-----	2,120
Relative percent difference[1]	-----	10.0

[1] Relative Percent Difference = [(a-b)/(a+b/2)] * 100
[2] (2 * ^{90}Sr)

Table 6-6. Tank 241-C-109 Comparison of Gross Alpha Activities with the Total of the Individual Activities.

Analyte	Half-life	Solid(μCi/g)
^{241}Am	458y	0.154
Total Pu	-----	0.341
Total Alpha (a)	-----	0.495
Gross Alpha (b)	-----	<0.395
Relative Percent Difference[1]	------	22.5%

[1] Relative Percent Difference = [(a-b)/(a+b/2)] * 100

6.2.4.3 Comparison of Water Digestion Data with Fusion Data. A comparison is made between the water digestion data and the fusion data for analytes exceeding a concentration of 500 μg/g (fusion method). The water digestion measures the water soluble analyte whereas the fusion method measures the total analyte concentration. Table 6-7 presents the analytical results from both types of digestion methods, and analyte solubility is expressed as a percentage.

The table demonstrates that most of the sodium and potassium ions are water soluble. Approximately 20% of the sodium and 6% of potassium ions form insoluble salts. The phosphorus results indicate that one third of the phosphorus is water soluble and two thirds is insoluble. This is in agreement with the previously discussed phosphate comparison. All of the other analytes including ^{137}Cs appear to be present in the form of water insoluble compounds and demonstrate very limited solubility.

6.2.4.4 Mass and Charge Balance. The principle objective in performing a mass and charge balance is to determine if the measurements are self-consistent. In calculating the balances, only sludge phase analytes listed in detected at a concentration of 1000 μg/g or greater were considered.

Table 6-7. Comparison of Water Digestion Data with Fusion Data.

Analyte	Water digestion (μg/g)	Fusion (μg/g)	% soluble
Cations			
Al	209	67,400	0.31
Ca	107	18,800	0.57
Fe	978	18,700	5.23
Pb	38.7	3,890	0.99
Mg	7.00	551	1.27
Ni	69.7	14,100*	0.49
P	6,610	18,300	36.1
K	513	544	94.3
Si	128	6,760	1.89
Na	70,400	87,900	80.1
U	136	12,900	1.05
Radionuclides (μCi/g)			
^{137}Cs	7.95	820	0.97
Total alpha	<0.0019	<0.395	0.47
Total Beta	11.7	2,120	0.55

* Acid digestion result

With the exception of sodium, all cations listed in Table 6-8 were assumed to be present in their most common hydroxide or oxide forms, and the concentrations of the assumed species were calculated stoichiometrically. For example, aluminum hydroxide, $Al(OH)_3$, is taken as the assumed species for the aluminum analyte. Although smaller concentrations of other forms of aluminum such as aluminosilicate are probably also present in the waste, they are not included in order to keep the mass-charge balance calculations simple and consistent.

With regard to phosphorus, total phosphate was calculated from the ICP phosphorous result and yielded a value of 56,100 µg/g. The soluble phosphate value from the IC data, 20,500 µg/g, was then subtracted from the total phosphate concentration in order to derive an insoluble phosphate concentration of 35,600 µg/g. Insoluble phosphate was assumed to be present in the form of $BiPO_4$, and the concentration of this assumed species was calculated from the derived result corresponding to insoluble phosphate. Bismuth data is not available for Tank 241-C-109, but its presence is supported by the process history. Based on the assumptions used to derive the mass and charge balance, the Bi concentration has been calculated to be 78,320 µg/g; the historical estimate reported in Chapter 2 was only 2,600 µg/g.

Table 6-8. Cation Mass and Charge Data.

Analyte	**Concentration (µg/g)**	**Assumed Species**	**Concentration of Assumed Species (µg/g)**	**RSD (%)**	**Charge (µmol/g)**
Aluminum	67,400	$Al(OH)_3$	195,000	47	0
Calcium	18,800	CaO	26,300	14	0
Iron	18,700	Fe(O)(OH)	29,800	34	0
Lead	3,890	$Pb(OH)_2$	4,530	81	0
Nickel	14,100	NiO	17,900	8	0
Phosphorus	18,300	$BiPO_4$	114,000[a]	10	0
Silicon	6,760	SiO_2	14,500	67	0
Sodium	87,900	Na^+	87,900	8	3,820
Uranium	12,900	U_3O_8	15,200	47	0
Totals			506,000	6.5	3,820

[a] See the above text regarding the bismuth phosphate derivation.

Since precipitates are neutral species, all positive charge was attributed to the sodium cation. The anionic analytes listed in Table 6-9 were assumed to be present as sodium salts and were expected to balance the positive charge exhibited by sodium. The acetate and carbonate data were derived from the total organic carbon and total inorganic carbon analyses, respectively. Soluble phosphate from the IC data was included to account for the remaining phosphorous. The concentrations of the assumed species in Table 6-8, of the anionic species in Table 6-9, and the percent water were ultimately used to calculate the mass balance. The uncertainty estimates (RSDs) associated with each analyte, along with the uncertainty for the cation and anion totals, are also given in the tables.

Table 6-9. Anion Mass and Charge Data.

Analyte	Concentration (μg/g)	RSD (%)	Charge (μmol/g)
Acetate (TOC)[a]	7,010 (2,850)	7	119
Carbonate (TIC)[a]	27,300 (5,450)	3	908
Nitrate	40,300	10	650
Nitrite	40,700	5	885
Phosphate	20,500	20	647
Sulfate	7,700	10	160
Totals	123,000	3.7	3,370

[a] The values in parentheses are from the TOC and TIC analytical results, and were used to derive the acetate and carbonate values on the left.

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

Mass balance = % Water + 0.0001 x {Total Analyte Concentration}
= % Water + 0.0001 x {$Al(OH)_3$ + CaO + FeO(OH) + $Pb(OH)_2$ + NiO + $BiPO_4$ + SiO_2 + Na^+ + U_3O_8 + $C_2H_3O_2^-$ + CO_3^{-2} + NO_3^- + NO_2^- + PO_4^{-3} + SO_4^{-2}}

The total analyte concentrations calculated from the above equation was 629,000 μg/g. The mean weight % water obtained from gravimetric analysis reported in Table A-5 of Appendix A is 35.7. The mass balance resulting from adding the % water to the total concentration of chemical constituents is 98.6%, as demonstrated in Table 6-10.

Table 6-10. Mass Balance Totals.

Totals	RSD (%)	Concentrations (μg/g)
Total from Table 6-8	6.5	506,000
Total from Table 6-9	3.7	123,000
Water	54	357,000
Grand Total	19	986,000

The charge balance is the ratio of total cations (microequivalents) to total anions (microequivalents).

<u>Total cations</u> (microequivalents) = $Na^+/23.0$
The sodium concentration from Inductively Coupled Plasma (ICP.a.) represents the total cation charge, 3,820 microequivalents.

<u>Total anions</u> (microequivalents)

$$= \frac{C_2H_3O_2^-}{59} + \frac{CO_3^{-2}}{30} + \frac{NO_3^-}{62} + \frac{NO_2^-}{46} + \frac{PO_4^{-3}}{31.7} + \frac{SO_4^{-2}}{48}$$

The charge balance obtained from using the sodium concentration and dividing by the set of anion concentrations (+/-) was 1.13.

In summary, the above calculations yield acceptable (close to 1.00 for charge balance and 100% for mass balance) mass and charge balance values, giving a strong indication that the analytical results are reasonably self-consistent with the applied assumptions and therefore considered reliable. The mass balance value of 98.6% was well within the uncertainty estimate of 19%.

At this point, a brief discussion concerning the percent water data is warranted. The TGA analyses of core composite samples indicate that the weight percent of water regarding the sludge in Tank 241-C-109 is 20.7%. When the analyses were conducted by calculating the differences between the weights of composite samples before and after oven drying, the weight percent of water was determined to be 35.7%. This latter value was supported by the mass balance calculations. However, the decision criteria thresholds pertaining to percent moisture as specified by data quality objective (DQO) documents require that weight percent water be evalutated by TGA. Therefore, only TGA data is compared to relevant DQO specifications in the discussion presented in Section 6.3.

6.2.4.5 Projected Tank Heat Load. Temperature information for Tank 241-C-109 was given in section 2.4.2. The amount of heat resulting from radioactivity in the tank was calculated in Table 6-11. The estimated total curies for each analyte are listed in column 2 (from), the uncertainty expressed as a relative standard deviation (RSD) is listed in column 3, and the number of Watts is given in column 4. The total tank heat load is estimated to be 2,610 Watts, with an uncertainty of 21%. The temperature of the tank over the last five years has ranged between 20°C and 31°C. Since an upper temperature limit is exhibited, it may be concluded that any heat generated from radioactive sources throughout the year is dissipated.

Table 6-11. Tank 241-C-109 Projected Heat Load.

Radionuclide	Ci	RSD (mean)	Watts
^{241}Am	44.5	84	1.46
^{137}Cs	2.37E+05	17	1,120
^{154}Eu	65.6	37	0.592
^{90}Sr	2.22E+05	39	1,490
^{99}Tc	30.6	6	0.0153
^{235}U[a]	0.657	(39)[b]	0.0178
^{238}U[a]	1.42	(39)[b]	0.0354
Watts		**21**	**2,610**

[a] Uranium values were calculated from the laser fluorimetry data, and the isotopic percents of 93.3 for ^{238}U and 6.7 for ^{235}U were used.
[b] The RSD of 39 is for elemental uranium, and enters into the calculation of the overall RSD only once.

6.2.5 Comparison of Historical and Analytical Results

Historical estimates for Na, Al, Fe, Pb, Ni, NO_3^{2-}, NO_2^{-}, PO_4^{3-}, SO_4^{2-}, ^{137}Cs, ^{90}Sr and Pu were compared in Table 6-12 to the analytical results acquired from the sample analyses of Tank 241-C-109.

As can be seen from the table, the historical and analytical results agree moderately for sodium, iron, nickel, nitrate, phosphate, sulfate and cesium. There is poor agreement for aluminum, potassium, nitrite, plutonium and strontium.

6.2.6 Statistical Treatment of Tank Data

As mentioned in Chapter 3, three core samples were taken from Tank 241-C-109. Since the tank waste volume is only approximately 12% of tank capacity, only one core segment was recovered. That one segment was divided into 3 subsegments for chemical analysis. Samples were obtained for subsegments 1b, 1c and 1d. The subsegments were each homogenized, and the core composites formed by combining samples from the homogenized subsegments. The core composite samples were then also homogenized. Two measurements, the sample and the duplicate, were taken from each core composite and subsegment aliquot, and then prepared for chemical analysis. Drainable liquids were recovered from cores 47 and 49 and formed into one drainable liquid composite. However the statistics reported in this section are based on the "solid" tank material only. Due to the incomplete segment sample recovery, the estimates given in this report are somewhat biased. The magnitude of this bias is unknown.

Table 6-12. Comparison of Analytical and Historical Data for Elemental Constituents of Tank 241-C-109 (Brevick 1994).

Element	Lab result (μg/g) a	Historical estimate (μg/g) b	Relative percent difference[1] (%)
Na	87,900	68,500	24.8
Al	67,400	985	194
Fe	18,700	19,600	-4.70
Pb	3,890	30,000	-154
Ni	14,100	23,000	-48.0
NO_3^{2-}	40,300	88,500	-74.8
NO_2^-	40,700	4,850	157
PO_4^{3-}	20,500	27,200	-28.1
SO_4^{2-}	7,700	16,400	-72.2
Radionuclides (μCi/g)			
Total Pu	0.314	0.0072	191
^{137}Cs	820	979	-17.7
^{90}Sr	767	2,560	-108

1 RPD = [(a-b)/((a+b)/2)] * 100

The statistics in this section were calculated for all analytes that had at least 25% of the measurements above the detection limit. In cases where some of the analyte values were below the detection limit and some were above, all data was used equally. The reason for this approach to detection limits was to provide the most conservative estimate of tank analyte concentrations possible. Pacific Northwest Laboratories personnel, Richland, WA, computed all statistics in this and the following sections.

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

To test the significance of the variance components, an analysis of variance (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 estimates for each component of variability along with the p-values for the core term are given in Table 6-13. The digestion method used to prepare the analytes listed are the same as those in Table 5-2. A description and definition of p-values was given in Section 6.2.2. Those analytes with at least one significant difference between cores are designated by a * next to the p-value.

Columns 2 and 4 of Table 6-13 represent the relative standard deviation (RSD) variability estimates for the core and analytical terms, respectively. The RSD is a unitless measure of variability that allows comparisons of variation across constituents whose magnitudes may vary widely. It is calculated by dividing the standard deviation by the overall analyte mean. Columns 5 and 6 estimate the total amount of variability (in % terms) in the data due to core differences and laboratory analytical error, respectively. As expected, the variability in analytical error is much smaller in most cases than the variability due to differences among cores, with the core term being larger for 34 of 42 analytes. The much higher core term is simply reflecting the variation in analyte concentrations throughout the tank.

Table 6-13. Variance Component Estimates. (2 sheets)

Analyte	RSD (Core)	Core p-value	RSD (Analytical)	Core % of variance	Analytical % of variance
ICP.f.Al	65	0.21	69	47	53
ICP.f.Ba	34	0.009*	9	94	6
ICP.f.Ca	24	.004*	5	97	3
ICP.f.Cr	12	.008*	3	95	5
ICP.f.Cu	31	.016*	9	91	9
ICP.a.Fe	51	.13	40	63	37
CVAA.Hg	17	.009*	4	94	6
ICP.a.La	84	.002*	12	98	2
ICP.a.K	21	.037*	9	85	15
ICP.f.Mg	33	.001*	4	99	1
ICP.f.Mn	28	.027*	11	88	12
ICP.f.Mo	28	.087	17	72	28
ICP.f.Na	12	.097	8	70	30
ICP.a.Ni	12	.111	9	67	33
ICP.a.P	0	.90	20	0	100
ICP.a.Pb	141	.000*	6	100	0
ICP.f.Si	115	.001*	13	99	1
ICP.f.Sr	87	.003*	15	97	3
ICP.a.Ti	118	.002*	17	98	2
ICP.f.U	80	.009*	20	94	6
ICP.f.Zn	4	.366	8	18	82
Titrat.NH_3	16	.027*	6	88	12
DSC.$C_2H_3O_2^-$ (TOC-dir)	10	.218	11	45	55
DSC.CO_3^{-2} (TIC-dir)	5	.201	5	48	52
Cr^{+6}	26	.001*	3	98	2
IC.CN^-	42	.001*	4	99	1

Table 6-13. Variance Component Estimates. (2 sheets)

Analyte	RSD (Core)	Core p-value	RSD (Analytical)	Core % of variance	Analytical % of variance
IC.w.Cl^-	---	---	0	100	0
IC.w.F^-	0	.465	105	0	100
IC.w.NO_2^-	8	.149	6	59	41
IC.w.NO_3^-	16	.032*	6	86	14
IC.w.PO_4^{-3}	22	.321	38	26	74
IC.w.SO_4^{-2}	18	.015*	5	92	8
AEA.^{241}Am	143	.028*	37	94	6
LSC.^{14}C	76	.002*	11	98	2
GEA.f.^{137}Cs	29	.012*	8	93	7
GEA.f.^{154}Eu	64	.003*	10	97	3
LSC.^{79}Se	26	.01*	7	94	6
BPC.^{90}Sr	66	.006*	15	95	5
BPC.^{99}Tc	10	.002*	2	98	2
LSC.^{3}H	11	.331	19	24	76
BPC.f.Total β	34	.013*	10	92	8
LF.U	66	.004*	13	96	4

* significant at the α = 0.05 level

The p-values from the composite level core variability test (Table 6.13, column 3) were less than p = 0.05 for 28 of 41 analytes tested. This indicates that, relative to the analytical error, there was at least one significant difference between cores for 28 analytes, and that the tank contents are horizontally nonhomogeneous.

A second ANOVA was calculated on the segment level data, and the results it produced for core comparisons contradicted the composite results. Of the 29 analytes tested at the segment level, only 3 showed at least one significant difference between cores (data not shown). The reasons for this lack of agreement are not clear; however, core composite data is considered more reliable since more analyte measurements are included in the calculation than at the segment level.

6.2.7 Review of Analyte Profiles

As mentioned in Section 6.2.6, spatial variability in analyte concentrations was examined by the calculation of two separate analyses of variance (ANOVA): one at the core composite level and one at the segment level. The core composite ANOVA reveals information about analyte differences in the horizontal direction, while the segment level ANOVA reveals information about differences in both the horizontal and vertical directions.

Since two-thirds of the analytes tested at the composite level showed at least one 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 Tukey's HSD (Honest Significant Difference) was calculated on the composite and segment data.

The composite level Tukey HSD results showing differences between cores for 12 major analytes is given in Table 6-14. The concentration values given are for the preferred method used to summarize the tank concentration in (except for phosphorus, ICP.fusion). For a given row, analyte values that have the same letter are not significantly different from each other at the $p=0.05$ significance level, whereas those with different letters are significantly different. Only those analytes that showed a significant difference in Table 6-13 will show a difference in Table 6-14. For example, even though the Al values for cores 47 and 48 differ by a factor of approximatley 14, the analytical error was too large and/or the sample size too small to distinguish between the two. Of the 12 major analytes listed, five showed that the concentration in one core was significantly higher or lower than for the other two cores. Core 47 and 48 each had two analytes with concentrations significantly lower than at least one other core, while core 49 had four analytes significantly lower.

The composite level ANOVA results convincingly show that there are significant differences between cores for many of the analytes; however, Tukeys' test failed to reveal any clear pattern in how the waste was horizontally distributed in the tank.

Table 6-14. Tukey's Multiple Comparisons Between Core Composites.

Analyte	Concentration		
	Core 47	Core 48	Core 49
Aluminum	117000 a	8570 a	76600 a
Calcium*	23900 a	17700 b	14900 b
Iron	28800 a	20200 a	7150 a
Sodium	87200 a	100000 a	76600 a
Nickel	14800 a	15500 a	11900 a
Phosphorus	19900 a	20200 a	14600 a
Uranium*	9180 b	24800 a	4740 b
Nitrate*	37000 b	48000 a	36000 b
Nitrite	39000 a	45000 a	38500 a
Phosphate	22100 a	26700 a	12800 a
^{137}Cesium*	874 a	1030 a	557 b
^{90}Strontium*	1180 a	190 b	932 a

* Analytes with one core concentration significantly different from the other two.

At the segment level, only ICP fusion digestion was conducted on the metallic elements. The segment level ANOVA results found 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 6-15. For a given analyte, one row is assigned to each of the three sub-segments that were recovered, and the last three columns represent the three cores sampled. Moving down the columns represents increasing tank depth (segment 1b is highest in the tank, followed by segments 1c and 1d). 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. In studying the trends in Table 6-15, 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.. Although there are many differences between segments between the three cores, this does not necessarily translate into differences between cores as a whole (see discussion above). The only thing that can be inferred from this table is differences between individual segments.

Studying Table 6-15 reveals a general trend for two of the three cores. Relying only on the letters beside the analyte concentrations to determine differences, core 47 shows that for seven of the eleven major analytes tested (calcium, sodium, phosphorus, nitrate, nitrite, phosphate, and ^{137}Cs), concentration increases as a function of depth, whereas concentration decreases as a function of depth for the other four analytes. Only two quarter segments were recovered from core 48, greatly restricting the information available on it. Based on those two segments, only calcium showed a significant difference, decreasing in concentration as a function of depth. Core 49 showed the most pronounced trend, with only the aluminum concentration decreasing as a function of depth. Iron and phosphate showed no trend, and the other eight analytes increased as a function of depth.

Due to the limited number of core samples taken from Tank 241-C-109, all information observed from the statistical analysis must be qualified. However, based on the information made available, there does appear to be significant horizontal differences in the tank for many analytes, with no specific trends apparent. Vertically, the major analytes demonstrated a trend of increasing concentration as a function of depth. Thus, the tank cannot be considered homogeneous in either the horizontal or vertical directions.

Table 6-15. Tukey's Multiple Comparisons Between Segments.

Analyte	Segment	Concentration		
		Core 47	Core 48	Core 49
Aluminum	1b	132000 b	---	185000 a
	1c	120000 b	7,290 f	95800 c
	1d	32000 e	9,850 f	70900 d
Calcium	1b	10500 d	---	4310 e
	1c	18100 c	29300 a	18600 bc
	1d	28000 a	16800 c	22500 b
Iron	1b	63400 a	---	15600 b
	1c	21000 b	20000 b	4580 b
	1d	15300 b	21100 b	15400 b
Sodium	1b	51100 cd	---	43100 d
	1c	63100 bcd	116000 a	62900 bcd
	1d	103000 ab	102000 ab	91400 abc
Phosphorus	1b	7630 cd	---	4110 d
	1c	12500 c	23300 b	11500 c
	1d	30100 a	20900 b	20400 b
Uranium	1b	11800 b	---	7910 c
	1c	6150 c	16800 a	1300 d
	1d	5840 c	14400 ab	12400 b
Nitrate	1b	27600 d	---	25700 d
	1c	36000 c	56000 a	42000 bc
	1d	38500 bc	53500 a	43000 b
Nitrite	1b	27900 e	---	26500 e
	1c	37000 d	51000 a	43500 c
	1d	39500 cd	49500 ab	45000 bc
Phosphate	1b	7300 c	---	6100 c
	1c	9550 c	15800 bc	8800 c
	1d	44500 a	36000 ab	25200 abc
^{137}Cesium	1b	337 cd	---	118 d
	1c	772 abc	1160 a	349 cd
	1d	947 ab	1170 a	702 bc
^{90}Strontium	1b	4560 a	---	2400 b
	1c	469 c	152 c	196 c
	1d	---	121 c	193 c

6.3 COMPARISON OF RESULTS TO PROGRAM REQUIREMENTS

This section provides selected results obtained from core sampling for some of the most pertinent analytes for the various Tank Waste Remediation System program elements, enumerated in program specific data quality objectives (DQOs). The DQOs for waste safety screening and for ferrocyanide tanks can be compared to the results from Tank 241-C-109. The DQOs developed to address these issues were developed after the sampling and analysis of Tank 241-C-109 waste. Therefore, the samples and their subsequent analyses were not performed to satisfy these DQOs, and the decision criteria presented in this section are for discussion and comparison purposes only.

Further information regarding the DQOs discussed in this section can be found in the following two documents: *Data Requirements for the Ferrocyanide Safety Issue Developed through the Data Quality Objectives Process* (Meacham et al. 1994) which describes the sampling and analytical requirements for tanks on the Ferrocyanide Watch List; and *Safety Screening Data Quality Objective* (Babad and Redus 1994) which describes the sampling and analytical requirements for screening tanks for unidentified safety issues. The safety screening DQO also details the criteria that determine when a tank is placed on a particular Watch List.

Tables 6-16 and 6-17 tabulate the decision criteria required by each applicable DQO. The analytical results from Tank 241-C-109 are also tabulated for comparision. The decision criteria are used to determine if a tank is safe, or if further investigation into the tank's safety is warranted. If results from one of the primary analyses exceed any of the decision criteria, further secondary and tertiary analyses are performed to determine the tank's safety and/or Watch List classification. The individual DQO documents specify the sample intervals on which the liquid and solid analysis are to be performed (i.e., every half-segment, full-segment, liquid composite etc.). The analysis of samples from Tank 241-C-109 may not meet the specified sample interval requirements due to analysis prior to development of the DQOs. Thus analytical data from Tank 241-C-109 found to be in compliance with the decision criteria may not necessarily be used to demonstrate a tank's safety, however, results exceeding the decision criteria thresholds may be used to determine if a tank is not safe. As a note, the decision criteria thresholds pertaining to percent moisture as specified by the DQO documents require that weight percent water be evaluated by TGA. Therefore, only TGA data is compared to relevant DQO specifications involving weight percent water in this discussion.

As can be seen in Table 6-16, the percent moisture mean (evaluated by thermogravimetric analysis) was found to be 20.7%, above the decision criterion of 17 wt%. However, two of the quarter segments had a result below the 17 wt% threshold. Quarter segment 1B of core 47 had a value of 10.2%, while quarter segment 1B of core 49 had a value of 4.20%. Both of these quarter segments were located in the top layer of the waste, indicating that the surface of the waste may be a near-crust layer and may pose a safety concern due to insufficient moisture. However, the fuel content and reactvity observed for the sample materials do not suggest that an unsafe condition exists in the tank.

Table 6-16. Safety Screening DQO Decision Variables and Criteria.

Safety Issue	Primary Decision Variable	Decision Criteria Threshold	Analytical Value	% RSD
Ferrocyanide/Organic	Total Fuel Content	115 cal/g	8.13 cal/g[1]	---
Ferrocyanide	Moisture Content	[2]If fuel is above 8 wt%, then wt% H_2O < [(0.0932*DSC exotherm) - 10.7][3]	N/A (below 8wt% fuel)	---
Organic	Percent Moisture	17 wt%	20.7 wt%	---
Criticality	Total Alpha	50 μCi/g (1 g/L)[4]	0.341 μCi/g	78
Flammable Gas	Flammable Gas	N/A	---	---

[1]Any exotherm determined by differential scanning calorimetry (DSC) must be reported on a dry weight basis as shown in the following equation, using the weight percent water determined from the thermogravimetric analysis. The 6.45 cal/g wet weight exotherm converts to a dry weight exotherm of 8.13 cal/g.

$$Exotherm\ (dry\ wt) = \frac{[exotherm\ (wet\ wt)\ x\ 100]}{(100\ -\ \%\ water)}$$

[2]See Figure 4-1 in Meacham et al. (1994) for explanation of the moisture decision rule.

[3]Fuel content is weight percent disodium nickel ferrocyanide, $Na_2NiFe(CN)_6$. The fuel percentage was calculated according to the following equation. The differential scanning calorimetry value is divided by 1430, which is the experimentally-determined heat of reaction of $Na_2NiFe(CN)_6$ with nitrate in waste simulant (Postma et al. 1994).

$$wt\%\ Na_2NiFe(CN)_6 = \frac{[DSC\ exotherm\ (cal/g\ dry\ weight)]}{1430\ cal/g}\ x\ 100$$

Using this equation, the decision criterion of 4/3(wt% fuel - 8 wt%) listed in the DQO becomes: **wt% H_2O < [(0.0932 x DSC exotherm) - 10.7]**

[4]Although the actual decision criterion listed in the DQO is 1 g/L, total alpha is measured in μCi/g rather than g/L. To convert the notification limit for total alpha into a number more readily usable by the laboratory, it was assumed that all alpha decay originates from ^{239}Pu. Using the tank density of 1.23 and the specific activity of ^{239}Pu (0.0615 Ci/g), the decision criterion may be converted to 50 μCi/g as shown:

$$\left(\frac{1\ g}{L}\right)\left(\frac{1\ L}{10^3\ mL}\right)\left(\frac{1}{density}\frac{mL}{g}\right)\left(\frac{0.0615\ Ci}{1\ g}\right)\left(\frac{10^6\ \mu Ci}{1\ Ci}\right) = \frac{61.5}{density}\frac{\mu Ci}{g}$$

Table 6-17. Primary Decision Variables and Criteria Used for Ferrocyanide Classification.

Primary Decision Variable	Decision Criteria Threshold	Analytical Value	% RSD
Total Fuel Content	8 wt% $Na_2NiFe(CN)_6$ or 115 cal/g	8.13 cal/g	---
Moisture Content	N/A[1]	20.7 wt %	---

[1]The DQO specified threshold is 4/3(wt% fuel - 8 wt%). However, when the wt% fuel is less than 8%, a negaive wt% is calculated. For example, the wt% fuel in Tank 241-C-109 is 0.717, corresponding to a threshold of -9.71. Since a negaive value is impractical for comparison purposes, the moisture content decision variable is not applicable to Tank 241-C-109. In other words, any detetion of moisture, no matter how small, satisifes the limit.

The results of analyses have been compared to the dangerous waste codes in the *Washington Dangerous Waste Regulations* (Ecology 1991). This assessment was conducted by comparing tank contents against dangerous waste characteristics ("D" waste codes) and against state waste codes. It did not include checking tank contents against "U", "P", "F", or "K" waste codes since application of these codes is dependent on the source of the waste and not on particalur constituent concentrations. The results indicate that the waste in this tank is adequately described in the Dangerous Waste Permit Application for the Single-Shell Tank System; this permit is discussed in the the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

7.0 CONCLUSIONS

Tank 241-C-109 is within established operating safety requirements, as defined by applicable Data Quality Objectives (DQOs). Thermogravimetric analyses did reveal that the surface or top layer of the waste contained less moisture than the DQO required threshold of 17 wt%. Quarter segments B (top quarter segment) of cores 47 and 49 had 10.2 and 4.20 wt% H_2O respectively. However, the overall tank mean for water percent was 20.7%, within the DQO boundary. The gravimetric percent water analyses for the quarter segments exhibited no results below the 17% notification limit. These B quarter segments were also the quarter segments with the lowest concentrations of cyanide. One exotherm of 8.13 cal/g (dry weight) was observed in subsegment 1D of core 48. However, this result was below the Safety Screening and Ferrocyanide DQO limits of 115 cal/g. Temperatures in the tank have mainly remained between 20 and 30°C since 1989. The data from Tank 241-C-109 strongly indicate that the waste lacks the fuel concentration to sustain any propagating exothermic behavior, and a heat source intense enough to trigger a reaction is absent.

One notable observation are the differences between core 48 and the other two cores. Core 48 was the only core to show an exotherm, and the core composite from core 48 contained substantially more cyanide than the other core composites, 57% more than core 47 and 132% more than core 49 (these figures are higher if the quarter segment data are included). However, only eight feet separates the risers from which cores 47 and 48 were taken. Neither are located near the inlets or any outlets to the tank. It is difficult to explain these large differences in data when the two cores are located so closely together. Also, the 30.6% recovery of core 48 was poor, much less than the other two cores.

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APPENDIX A

ANALYTICAL RESULTS

SINGLE SHELL TANK 241-C-109

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A.1 INTRODUCTION

A.1.1 Appendix A presents the chemical and radiological characteristics of Tank 241-C-109 in a tabular form, in terms of the specific concentrations of metals, ions, radionuclides, physical properties, organic complexes and volatile and semivolatile compounds (Shaver 1993).

The data table for each analyte lists laboratory sample identification, a description of where the sample was obtained, an analytical data result for each sample, an evaluated data result, a relative standard deviation for each sample category, and a projected tank inventory for the particular analyte using the highest concentration as a base. The projected tank inventory column is not applicable for the specific gravity, pH, density, or percent water data. The data are listed in standard notation for values greater than .001 and less than 100,000. Values outside these limits are listed in scientific notation.

A.2 TABLE DESCRIPTION

A.2.1 The tables are divided into groups dependent on the characteristics of the analytes.

Analyte Characteristic	Table Number
Appendix Summary (preferred method and digestion).	Table A-1
Metals	Table A-2
Ions (anions & cations)	Table A-3
Radionuclides	Table A-4
Physical Properties	Table A-5
Total Organic Carbon	Table A-6
Extractable Organic Halide	Table A-7

A.2.2 Standard abbreviations are used to describe analytical methods.

Metals:	ICP - Inductively Coupled Plasma (generic for all metals unless otherwise known)
	GFAA - Graphite Furnace Atomic Absorption
	CVAA - Cold Vapor Atomic Absorption
Anions:	IC - Ion Chromatography
	ISE - Ion Specific Electrode analysis (Ammonia)
Radionuclides:	GEA - Gamma Energy Analysis
	AEA - Alpha Energy Analysis
	APC - Alpha Proportional Counting
	BPC - Beta Proportional Counting
	LSC - Liquid Scintillation Counting
	MS - Mass Spectrometry
Physical Properties	DM - Direct Measurement
	TGA - Thermogravimetric Analysis

A.3 COLUMN HEADINGS

A.3.1 The "Analyte" column contains, in addition to the name of the analyte or physical characteristic, information about the method of measurement, and where applicable, information about the method of digestion.

Digestion methods will be denoted for those analytes that were digested by more than one method. Digestion methods used are abbreviated: a - acid digestion; w - water leach; and f - potassium hydroxide fusion, followed by acid digestion. Analytes may also be measured directly on an undigested sample and these are abbreviated: d-direct.

The analyte and method are presented as follows: "method.analyte," or, (where applicable) "method.digestion.analyte." For example, the specific concentration of ^{90}Sr was measured with a beta proportional counter and is listed "BPC.^{90}Sr." A specific concentration of Pb was determined by the inductively coupled plasma method which was preceded by acid digestion, and is listed as "ICP.a.Pb."

A.3.2 The "Sample Number" column lists the laboratory sample from which the analyte was measured; this identification number is different from the number assigned to the samples at the tank farm. Sampling rationale, locations, and descriptions of sampling events are contained in Section 3.0.

A.3.3 Column three describes the core and segment from each each sample was derived. The first number listed is the core number. This number is followed by a colon and either letters or numbers. Letters that follow the colon indicate that this sample was a solid core composite (CC), or a drainable liquid composite (DLC). Numbers that follow the colon indicate the segment of the core from which the sample was derived.

In the case where a homogenization test was performed, the segment number will be followed by top or bottom, indicating that portion of the homogenized sample tested.

A.3.4 "Result" is the specific concentration of the analyte determined at different sampling points. No quality control data such as matrix spikes, serial dilutions, or duplicate analyses are listed. This information may be obtained from the Tank 241-C-109 data package (Shaver 1993).

The number listed is an average between of primary sample and its duplicate sample. Where more than one duplicate sample was performed the primary sample was averaged with all the duplicates.

Numbers that are preceded by a less than symbol (<) indicate the analyte was noted, but was below the analytical instrument's calibrated detection limit for the sample.

A.3.5 The "Mean" column is derived as discussed in Section 5.0.

A.3.6 Column 6 ,"Relative Standard Deviation" (RSD), is a measure of variability defined as the standard deviation divided by the mean. This number is expressed as a percentage and is statistically computed by Pacific Northwest Laboratory personnel.

A.3.7 Column 7, "Projected Inventory", is the product of the concentration of the analyte and the volume of the waste in the tank (4 kgal or 9.15 kL liquid/ 62 kgal. or 235 kL solid).

Formula:
(Waste Inventory)(Result)(Density)(Conversion Factors) = Projected Inventory

Liquid Composite (kg) = (9,150 L)(Result μg/g)(1.15 g/mL)(1000 mL/L)(kg/1.00E+09 μg)

Solid Core Composite (kg) = (235,000 L)(Result μg/g)(1.23 g/mL)(1000 mL/L)(kg/1.00E+09 μg)

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LIST OF TABLES FOR APPENDIX A

LIST OF TABLES FOR APPENDIX A (continued)

Table A-1. Tank Characterization Report Analytical Summary for Single-Shell Tank 241-C-109. (3 sheets)

Analyte	Analytical Method: Sample Preparation	Composite Mean	RSD (Mean)	Historical Estimate	Projected Inventory
METALS		µg/g	%	µg/g	kg
Aluminum (Al)	ICP.fusion	67,400	47	985	19,500
Antimony (Sb)	ICP.fusion	< 141	---	---	< 40.8
Arsenic (As)	ICP.fusion	< 300	---	---	< 86.7
Barium (Ba)	ICP.fusion	68.2	20	---	19.7
Beryllium (Be)	ICP.fusion	< 9.47	---	---	< 2.74
Bismuth (Bi)	---	---	---	2,600	---
Boron (B)	ICP.fusion	< 134	---	---	< 38.7
Cadmium (Cd)	ICP.fusion	< 22.2	---	---	< 6.42
Calcium (Ca)	ICP.fusion	18,800	14	---	5,430
Cerium (Ce)	ICP.fusion	< 301	---	---	< 87.0
Chromium (Cr)	ICP.fusion	250	7	---	72.3
Cobalt (Co)	ICP.fusion	< 551	---	---	< 159
Copper (Cu)	ICP.fusion	62.8	18	---	18.2
Dysprosium(Dy)	ICP.fusion	< 15.7	---	---	< 4.54
Iron (Fe)	ICP.acid	18,700	34	19,600	5,410
Lanthanum (La)	ICP.acid	44.0	49	---	12.7
Lead (Pb)	ICP.acid	3,890	81	30,000	1,120
Lithium (Li)	ICP.fusion	< 21.9	---	--	< 6.33
Magnesium (Mg)	ICP.fusion	551	19	---	159
Manganese (Mn)	ICP.fusion	128	17	---	37.0
Mercury (Hg)	CVAA	7.35	10	---	2.12
Molybdenum (Mo)	ICP.fusion	40.0	17	---	11.6
Neodymium (Nd)	ICP.fusion	< 147	---	---	< 42.5
Nickel (Ni)	ICP.fusion	14,100	8	23,000	4,080
Phosphorus (P)	ICP.acid	18,300	8	---	5,290
Potassium (K)	ICP.acid	544	13	---	157
Rhenium (Re)	ICP.fusion	< 51.1	---	---	< 14.8
Rhodium (Rh)	ICP.fusion	< 183	--	---	< 52.9
Ruthenium (Ru)	ICP.fusion	< 103	---	---	< 29.8
Selenium (Se)	ICP.fusion	< 448	---	---	< 129
Silicon (Si)	ICP.fusion	6,760	67	---	1,950
Silver (Ag)	ICP.fusion	< 23.1	--	---	< 6.68
Sodium (Na)	ICP.fusion	37,900	3	68,500	25,400
Strontium (Sr)	ICP.fusion	378	51	--	109
Tellurium (Te)	ICP.fusion	< 281	---	---	< 81.2
Thallium (Tl)	ICP.fusion	< 1,620	---	---	< 468
Thorium (Th)	ICP.fusion	< 217	---	---	< 62.7
Titanium (Ti)	ICP.acid	25.2	68	---	7.28
Uranium (U)	ICP.fusion	12,900	47	---	3,730

Table A-1. Tank Characterization Report Analytical Summary for Single-Shell Tank 241-C-109. (3 sheets)

Analyte	Analytical Method: Sample Preparation	Composite Mean	RSD (Mean)	Historical Estimate	Projected Inventory
METALS (continued)		**µg/g**	**%**	**µg/g**	**kg**
Vanadium (V)	ICP.fusion	< 26.6	---	---	< 7.69
Zinc (Zn)	ICP.fusion	362	4	---	105
Zirconium (Zr)	ICP.fusion	< 22.5	---	---	< 6.50
IONS		**µg/g**	**%**	**µg/g**	**kg**
Ammonia (NH_3)	Titration	53.0	10	---	15.3
Chloride (Cl^-)	IC	733		---	212
Chromium (VI) (Cr^{+6})		37.2	15	---	10.8
Cyanide (CN^-)	IC	882	24	---	255
Fluoride (F^-)	IC	700	43	---	202
Hydroxide (OH^-)	---	---	---	21,600	---
Nitrate (NO_3^-)	IC	40,300	10	88,500	11,600
Nitrite (NO_2^-)	IC	40,700	5	4,850	11,800
Phosphate (PO_4^{-3})	IC	20,500	20	27,200	5,930
Sulfate (SO_4^{-2})	IC	7,700	10	1,640	2,230
RADIONUCLIDE		**µCi/g**	**%**	**µCi/g**	**Ci**
Americium-241	AEA	0.154		---	44.5
Carbon-14	LSC	1.97E-05	44	---	0.00569
Cesium-137	GEA.fusion	820	17	979	2.37E+05
Cobalt-60	GEA.fusion	< 0.0213	---	---	< 6.16
Europium-154	GEA.fusion	0.227	37	---	65.6
Europium-155	GEA.fusion	< 0.843	---	---	< 24.4
Selenium-79	LSC	6.17E-05	15	---	0.0178
Strontium-90	BPC	767	39	2,560	2.22E+05
Technetium-99	BPC	0.106	6	---	30.6
Tritium	LSC	0.00710	10	---	2.05
Uranium	LF	15,700 µg/g	39	---	4,540 kg
Total Alpha	APC	< 0.395	---	---	< 114
Total Alpha Plutonium	APC	0.341	---	---	98.6
Total Beta	BPC	2,120	20	---	6.13E+05
Mass Percent Plutonium-238	Mass Spec	0.0100 %	---	---	
Mass Percent Plutonium-239	Mass Spec	95.3 %	---	---	
Mass Percent Plutonium-240	Mass Spec	4.60 %	---	---	
Mass Percent Plutonium-241	Mass Spec	0.0901 %	---	---	
Mass Percent Plutonium-242	Mass Spec	0.0249 %	---	---	
Mass Percent Uranium-234	Mass Spec	0.00371 %	---	---	
Mass Percent Uranium-235	Mass Spec	0.639 %	---	---	
Mass Percent Uranium-236	Mass Spec	0.00807 %	---	---	
Mass Percent Uranium-238	Mass Spec	93.3 %	---	---	

Table A-1. Tank Characterization Report Analytical Summary for Single-Shell Tank 241-C-109.
(3 sheets)

Analyte	Analytical Method: Sample Preparation	Composite Mean	RSD (Mean)	Historical Estimate	Projected Inventory
PHYSICAL PROPERTY					
pH		10.1	---	---	
Wt % Water		35.7 %	---	80.4	
TGA.Wt. % Water	TGA	20.7 %	---	---	
Liquid Density		1.15 g/mL	---	---	
Solid Density		1.23 g/mL	---	1.32 g/mL	
ORGANIC		**μg/g**	**%**	**μg/g**	**kg**
TOTAL ORGANIC CARBON		2,850	7	---	824
TOTAL INORGANIC CARBON		5,450	3	---	1,580
TOTAL CARBON		8,300	4	---	2,400
Extractable Halide		10.5	---	---	3.04

Table A-2. Tank 241-C-109 Analytical Data: ALUMINUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	µg/g	%	kg
ICP.a.Al	93-01354	47/49:DLC	157	157	N/A	1.65
Solid Core Composite			**µg/g**	**µg/g**	%	**kg**
ICP.f.Al	93-01358	47:CC	1.17E+05	67,400	47	19,500
	93-01363	48:CC	8,570			
	93-01371	49:CC	76,600			
ICP.a.Al	93-01358	47:CC	72,900	54,300		
	93-01363	48:CC	6,420			
	93-01371	49:CC	83,700			
ICP.w.Al	93-01358	47:CC	412	209		
	93-01363	48:CC	110			
	93-01371	49:CC	105			
Quarter Segment			**µg/g**			
ICP.f.Al	93-01355	47:1B	1.32E+05			
	93-01356	47:1C	1.20E+05			
	93-0.1357	47:1D	32,000			
	93-01360	48:1C	7,290			
	93-01361	48:1D	9,850			
	93-01365	49:1B	1.85E+05			
	93-01366	49:1C	95,800			
	93-01367	49:1D	70,900			
Homogenization Results			**µg/g**			
ICP.f.Al	93-01367	49:1D TOP	62,400			
	93-0.1367	49:1D BOTTOM	54,500			
ICP.a.Al	93-01361	48:1D TOP	8,310			
	93-01361	48:1D BOTTOM	9,150			
	93-01367	49:1D TOP	43,000			
	93-01367	49:1D BOTTOM	44,300			

Table A-2. Tank 241-C-109 Analytical Data: ANTIMONY

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		Core:Segment	μg/g	μg/g	%	kg
ICP.a.Sb	93-01354	47/49:DLC	< 8.32	< 8.32	N/A	< 0.0875
Solid Core Composite			μg/g	μg/g	%	kg
ICP.f.Sb	93-01358	47:CC	< 199	< 141	N/A	< 40.8
	93-01363	48:CC	< 113			
	93-01371	49:CC	< 110			
ICP.a.Sb	93-01358	47:CC	45.0	43.0		
	93-01363	48:CC	56.5			
	93-01371	49:CC	27.5			
ICP.w.Sb	93-01358	47:CC	< 12.0	< 11.7		
	93-01363	48:CC	< 11.5			
	93-01371	49:CC	< 11.5			
Quarter Segment			μg/g			
ICP.f.Sb	93-01355	47:1B	< 158			
	93-01356	47:1C	< 112			
	93-0.1357	47:1D	< 135			
	93-01360	48:1C	< 129			
	93-01361	48:1D	< 98.0			
	93-01365	49:1B	< 104			
	93-01366	49:1C	< 102			
	93-01367	49:1D	< 107			
Homogenization Results			μg/g			
ICP.f.Sb	93-01367	49:1D TOP	< 102			
	93-0.1367	49:1D BOTTOM	< 104			
ICP.a.Sb	93-01361	48:1D TOP	40.0			
	93-01361	48:1D BOTTOM	42.5			
	93-01367	49:1D TOP	33.5			
	93-01367	49:1D BOTTOM	39.5			
Solid Composite Core			μg/g	μg/g	%	kg
GFAA.Sb	93-01358	47:CC	< 3.15	< 2.22	N/A	< 0.642
	93-01363	48:CC	< 0.600			
	93-01371	49:CC	< 2.90			

Table A-2. Tank 241-C-109 Analytical Data: ARSENIC

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	µg/g	µg/g	%	kg
ICP.a.As	93-01354	47/49:DLC	< 17.7	< 17.7	N/A	< 0.186
Solid Core Composite			µg/g	µg/g	%	kg
ICP.f.As	93-01358	47:CC	< 424	< 300	N/A	< 86.7
	93-01363	48:CC	< 241			
	93-01371	49:CC	< 235			
ICP.a.As	93-01358	47:CC	< 21.8	< 21.1		
	93-01363	48:CC	< 21.3			
	93-01371	49:CC	< 20.3			
ICP.w.As	93-01358	47:CC	< 25.6	< 24.9		
	93-01363	48:CC	< 24.6			
	93-01371	49:CC	< 24.5			
Quarter Segment			µg/g			
ICP.f.As	93-01355	47:1B	< 337			
	93-01356	47:1C	< 239			
	93-0.1357	47:1D	< 288			
	93-01360	48:1C	< 276			
	93-01361	48:1D	< 209			
	93-01365	49:1B	< 222			
	93-01366	49:1C	< 219			
	93-01367	49:1D	< 229			
Homogenization Results			µg/g			
ICP.f.As	93-01367	49:1D TOP	< 218			
	93-0.1367	49:1D BOTTOM	< 222			
ICP.a.As	93-01361	48:1D TOP	< 20.2			
	93-01361	48:1D BOTTOM	< 20.2			
	93-01367	49:1D TOP	< 19.8			
	93-01367	49:1D BOTTOM	< 20.0			
Solid Composite Core			µg/g	µg/g	%	kg
GFAA.As	93-01358	47:CC	81.0	65.6	51	19.0
	93-01363	48:CC	1.85			
	93-01371	49:CC	114			

Table A-2. Tank 241-C-109 Analytical Data: BARIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Ba	93-01354	47/49:DLC	3.50	3.50	N/A	0.0368
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Ba	93-01358	47:CC	80.5	68.2	20	19.7
	93-01363	48:CC	83.0			
	93-01371	49:CC	41.0			
ICP.a.Ba	93-01358	47:CC	57.0	45.3		
	93-01363	48:CC	51.0			
	93-01371	49:CC	28.0			
ICP.w.Ba	93-01358	47:CC	< 2.02	< 1.96		
	93-01363	48:CC	< 1.93			
	93-01371	49:CC	< 1.93			
Quarter Segment			**µg/g**			
ICP.f.Ba	93-01355	47:1B	92.0			
	93-01356	47:1C	45.0			
	93-0.1357	47:1D	78.0			
	93-01360	48:1C	79.5			
	93-01361	48:1D	68.5			
	93-01365	49:1B	53.5			
	93-01366	49:1C	40.5			
	93-01367	49:1D	60.0			
Homogenization Results			**µg/g**			
ICP.f.Ba	93-01367	49:1D TOP	52.5			
	93-0.1367	49:1D BOTTOM	48.5			
ICP.a.Ba	93-01361	48:1D TOP	44.0			
	93-01361	48:1D BOTTOM	49.5			
	93-01367	49:1D TOP	33.0			
	93-01367	49:1D BOTTOM	32.0			

Table A-2. Tank 241-C-109 Analytical Data: BERYLLIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Be	93-01354	47/49:DLC	< 0.554	< 0.554	N/A	< 0.00583
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Be	93-01358	47:CC	< 13.4	< 9.47	N/A	< 2.74
	93-01363	48:CC	< 7.59			
	93-01371	49:CC	< 7.42			
ICP.a.Be	93-01358	47:CC	< 0.688	< 0.667		
	93-01363	48:CC	< 0.672			
	93-01371	49:CC	< 0.640			
ICP.w.Be	93-01358	47:CC	< 0.801	< 0.779		
	93-01363	48:CC	< 0.768			
	93-01371	49:CC	< 0.767			
Quarter Segment			**µg/g**			
ICP.f.Be	93-01355	47:1B	< 10.6			
	93-01356	47:1C	< 7.55			
	93-0.1357	47:1D	< 9.09			
	93-01360	48:1C	< 8.71			
	93-01361	48:1D	< 6.60			
	93-01365	49:1B	< 7.00			
	93-01366	49:1C	< 6.90			
	93-01367	49:1D	< 7.22			
Homogenization Results			**µg/g**			
ICP.f.Be	93-01367	49:1D TOP	< 6.89			
	93-0.1367	49:1D BOTTOM	< 7.01			
ICP.a.Be	93-01361	48:1D TOP	< 0.639			
	93-01361	48:1D BOTTOM	< 0.639			
	93-01367	49:1D TOP	< 0.624			
	93-01367	49:1D BOTTOM	< 0.631			

Table A-2. Tank 241-C-109 Analytical Data: BORON

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.B	93-01354	47/49:DLC	66.5	66.5	N/A	0.700
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.B	93-01358	47:CC	< 249	< 134	N/A	< 38.7
	93-01363	48:CC	< 141			
	93-01371	49:CC	< 138			
ICP.a.B	93-01358	47:CC	154	115		
	93-01363	48:CC	135			
	93-01371	49:CC	55.5			
ICP.w.B	93-01358	47:CC	19.5	42.8		
	93-01363	48:CC	87.0			
	93-01371	49:CC	22.0			
Quarter Segment			**µg/g**			
ICP.f.B	93-01355	47:1B	< 198			
	93-01356	47:1C	< 141			
	93-0.1357	47:1D	< 169			
	93-01360	48:1C	< 162			
	93-01361	48:1D	< 123			
	93-01365	49:1B	< 130			
	93-01366	49:1C	< 129			
	93-01367	49:1D	< 134			
Homogenization Results			**µg/g**			
ICP.f.B	93-01367	49:1D TOP	< 128			
	93-0.1367	49:1D BOTTOM	< 130			
ICP.a.B	93-01361	48:1D TOP	96.0			
	93-01361	48:1D BOTTOM	74.5			
	93-01367	49:1D TOP	71.5			
	93-01367	49:1D BOTTOM	46.0			

Table A-2. Tank 241-C-109 Analytical Data: CADMIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Cd	93-01354	47/49:DLC	< 1.31	< 1.31	N/A	< 0.0138
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Cd	93-01358	47:CC	< 31.3	< 22.2	N/A	< 6.42
	93-01363	48:CC	< 17.8			
	93-01371	49:CC	< 17.4			
ICP.a.Cd	93-01358	47:CC	17.5	11.3		
	93-01363	48:CC	8.50			
	93-01371	49:CC	8.00			
ICP.w.Cd	93-01358	47:CC	< 1.89	< 1.84		
	93-01363	48:CC	< 1.82			
	93-01371	49:CC	< 1.81			
Quarter Segment			**µg/g**			
ICP.f.Cd	93-01355	47:1B	< 24.9			
	93-01356	47:1C	< 17.7			
	93-0.1357	47:1D	< 21.3			
	93-01360	48:1C	< 20.4			
	93-01361	48:1D	< 15.5			
	93-01365	49:1B	< 16.4			
	93-01366	49:1C	< 16.2			
	93-01367	49:1D	< 16.9			
Homogenization Results			**µg/g**			
ICP.f.Cd	93-01367	49:1D TOP	< 16.2			
	93-0.1367	49:1D BOTTOM	< 16.4			
ICP.a.Cd	93-01361	48:1D TOP	7.00			
	93-01361	48:1D BOTTOM	7.50			
	93-01367	49:1D TOP	6.00			
	93-01367	49:1D BOTTOM	6.50			

Table A-2. Tank 241-C-109 Analytical Data: CALCIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Ca	93-01354	47/49:DLC	209	209	N/A	2.20
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Ca	93-01358	47:CC	23,900	18,800	14	5,430
	93-01363	48:CC	17,700			
	93-01371	49:CC	14,900			
ICP.a.Ca	93-01358	47:CC	20,000	15,000		
	93-01363	48:CC	12,600			
	93-01371	49:CC	12,300			
ICP.w.Ca	93-01358	47:CC	184	107		
	93-01363	48:CC	59.5			
	93-01371	49:CC	77.5			
Quarter Segment			**µg/g**			
ICP.f.Ca	93-01355	47:1B	10,500			
	93-01356	47:1C	18,100			
	93-0.1357	47:1D	28,000			
	93-01360	48:1C	29,300			
	93-01361	48:1D	16,800			
	93-01365	49:1B	4,310			
	93-01366	49:1C	18,600			
	93-01367	49:1D	22,500			
Homogenization Results			**µg/g**			
ICP.f.Ca	93-01367	49:1D TOP	22,000			
	93-0.1367	49:1D BOTTOM	21,600			
ICP.a.Ca	93-01361	48:1D TOP	14,800			
	93-01361	48:1D BOTTOM	16,500			
	93-01367	49:1D TOP	17,000			
	93-01367	49:1D BOTTOM	17,300			

Table A-2. Tank 241-C-109 Analytical Data: CERIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Ce	93-01354	47/49:DLC	< 17.8	< 17.8	N/A	< 0.187
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Ce	93-01358	47:CC	< 426	< 301	N/A	< 87.0
	93-01363	48:CC	< 242			
	93-01371	49:CC	< 236			
ICP.a.Ce	93-01358	47:CC	174	79.1		
	93-01363	48:CC	27.3			
	93-01371	49:CC	36.0			
ICP.w.Ce	93-01358	47:CC	< 25.7	< 25.0		
	93-01363	48:CC	< 24.7			
	93-01371	49:CC	< 24.6			
Quarter Segment			**µg/g**			
ICP.f.Ce	93-01355	47:1B	< 339			
	93-01356	47:1C	< 240			
	93-0.1357	47:1D	< 290			
	93-01360	48:1C	< 277			
	93-01361	48:1D	< 210			
	93-01365	49:1B	< 223			
	93-01366	49:1C	< 220			
	93-01367	49:1D	< 230			
Homogenization Results			**µg/g**			
ICP.f.Ce	93-01367	49:1D TOP	< 219			
	93-0.1367	49:1D BOTTOM	< 223			
ICP.a.Ce	93-01361	48:1D TOP	< 20.3			
	93-01361	48:1D BOTTOM	< 20.3			
	93-01367	49:1D TOP	< 19.9			
	93-01367	49:1D BOTTOM	< 20.1			

Table A-2. Tank 241-C-109 Analytical Data: CHROMIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**μg/g**	**μg/g**	**%**	**kg**
ICP.a.Cr	93-01354	47/49:DLC	291	291	N/A	3.06
Solid Core Composite			**μg/g**	**μg/g**	**%**	**kg**
ICP.f.Cr	93-01358	47:CC	274	250	7	72.3
	93-01363	48:CC	260			
	93-01371	49:CC	217			
ICP.a.Cr	93-01358	47:CC	223	205		
	93-01363	48:CC	210			
	93-01371	49:CC	182			
ICP.w.Cr	93-01358	47:CC	175	192		
	93-01363	48:CC	226			
	93-01371	49:CC	176			
Quarter Segment			**μg/g**			
ICP.f.Cr	93-01355	47:1B	208			
	93-01356	47:1C	230			
	93-0.1357	47:1D	283			
	93-01360	48:1C	395			
	93-01361	48:1D	281			
	93-01365	49:1B	143			
	93-01366	49:1C	219			
	93-01367	49:1D	259			
Homogenization Results			**μg/g**			
ICP.f.Cr	93-01367	49:1D TOP	259			
	93-0.1367	49:1D BOTTOM	245			
ICP.a.Cr	93-01361	48:1D TOP	206			
	93-01361	48:1D BOTTOM	233			
	93-01367	49:1D TOP	194			
	93-01367	49:1D BOTTOM	199			

Table A-2. Tank 241-C-109 Analytical Data: COBALT

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	μg/g	μg/g	%	kg
ICP.a.Co	93-01354	47/49:DLC	< 32.6	< 32.6	N/A	< 0.343
Solid Core Composite			μg/g	μg/g	%	kg
ICP.f.Co	93-01358	47:CC	< 779	< 551	N/A	< 159
	93-01363	48:CC	< 442			
	93-01371	49:CC	< 432			
ICP.a.Co	93-01358	47:CC	54.5	49.2		
	93-01363	48:CC	< 39.2			
	93-01371	49:CC	54.0			
ICP.w.Co	93-01358	47:CC	< 47.1	< 45.8		
	93-01363	48:CC	< 45.2			
	93-01371	49:CC	< 45.1			
Quarter Segment			μg/g			
ICP.f.Co	93-01355	47:1B	< 620			
	93-01356	47:1C	< 440			
	93-0.1357	47:1D	< 530			
	93-01360	48:1C	< 508			
	93-01361	48:1D	< 385			
	93-01365	49:1B	< 408			
	93-01366	49:1C	< 402			
	93-01367	49:1D	< 421			
Homogenization Results			μg/g			
ICP.f.Co	93-01367	49:1D TOP	< 402			
	93-0.1367	49:1D BOTTOM	< 408			
ICP.a.Co	93-01361	48:1D TOP	< 37.2			
	93-01361	48:1D BOTTOM	< 37.2			
	93-01367	49:1D TOP	< 36.3			
	93-01367	49:1D BOTTOM	< 36.3			

Table A-2. Tank 241-C-109 Analytical Data: COPPER

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Cu	93-01354	47/49:DLC	< 1.55	< 1.55	N/A	< 0.0163
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Cu	93-01358	47:CC	85.0	62.8	18	18.2
	93-01363	48:CC	46.5			
	93-01371	49:CC	57.0			
ICP.a.Cu	93-01358	47:CC	59.5	35.0		
	93-01363	48:CC	21.0			
	93-01371	49:CC	24.5			
ICP.w.Cu	93-01358	47:CC	< 2.23	< 2.17		
	93-01363	48:CC	< 2.14			
	93-01371	49:CC	< 2.14			
Quarter Segment			**µg/g**			
ICP.f.Cu	93-01355	47:1B	202			
	93-01356	47:1C	1305			
	93-0.1357	47:1D	59.5			
	93-01360	48:1C	94.0			
	93-01361	48:1D	140			
	93-01365	49:1B	193			
	93-01366	49:1C	112			
	93-01367	49:1D	95.5			
Homogenization Results			**µg/g**			
ICP.f.Cu	93-01367	49:1D TOP	106			
	93-0.1367	49:1D BOTTOM	52.0			
ICP.a.Cu	93-01361	48:1D TOP	13.0			
	93-01361	48:1D BOTTOM	14.0			
	93-01367	49:1D TOP	14.5			
	93-01367	49:1D BOTTOM	15.0			

Table A-2. Tank 241-C-109 Analytical Data: DYSPROSIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Dy	93-01354	47/49:DLC	< 0.924	< 0.924	N/A	< 0.00972
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Dy	93-01358	47:CC	< 22.2	< 15.7	N/A	< 4.54
	93-01363	48:CC	< 12.6			
	93-01371	49:CC	< 12.3			
ICP.a.Dy	93-01358	47:CC	2.00	1.69		
	93-01363	48:CC	2.00			
	93-01371	49:CC	< 1.06			
ICP.w.Dy	93-01358	47:CC	< 1.34	< 1.30		
	93-01363	48:CC	< 1.28			
	93-01371	49:CC	< 1.28			
Quarter Segment			**µg/g**			
ICP.f.Dy	93-01355	47:1B	< 17.6			
	93-01356	47:1C	< 12.5			
	93-0.1357	47:1D	< 15.1			
	93-01360	48:1C	< 14.4			
	93-01361	48:1D	< 10.9			
	93-01365	49:1B	< 11.6			
	93-01366	49:1C	< 11.4			
	93-01367	49:1D	< 12.0			
Homogenization Results			**µg/g**			
ICP.f.Dy	93-01367	49:1D TOP	< 11.4			
	93-0.1367	49:1D BOTTOM	< 11.6			
ICP.a.Dy	93-01361	48:1D TOP	< 1.06			
	93-01361	48:1D BOTTOM	< 1.06			
	93-01367	49:1D TOP	< 1.03			
	93-01367	49:1D BOTTOM	< 1.05			

Table A-2. Tank 241-C-109 Analytical Data: IRON

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		Core:Segment	µg/g	µg/g	%	kg
ICP.a.Fe	93-01354	47/49:DLC	1,680	1,680	N/A	17.7
Solid Core Composite			µg/g	µg/g	%	kg
ICP.f.Fe	93-01358	47:CC	21,800	17,700		
	93-01363	48:CC	22,200			
	93-01371	49:CC	9,110			
ICP.a.Fe	93-01358	47:CC	28,800	18,700	34	5,410
	93-01363	48:CC	20,200			
	93-01371	49:CC	7,150			
ICP.w.Fe	93-01358	47:CC	879	978		
	93-01363	48:CC	1,140			
	93-01371	49:CC	916			
Quarter Segment			µg/g			
ICP.f.Fe	93-01355	47:1B	63,400			
	93-01356	47:1C	21,000			
	93-0.1357	47:1D	15,300			
	93-01360	48:1C	20,000			
	93-01361	48:1D	21,100			
	93-01365	49:1B	15,600			
	93-01366	49:1C	4,580			
	93-01367	49:1D	15,400			
Homogenization Results			µg/g			
ICP.f.Fe	93-01367	49:1D TOP	14,100			
	93-0.1367	49:1D BOTTOM	12,800			
ICP.a.Fe	93-01361	48:1D TOP	18,800			
	93-01361	48:1D BOTTOM	17,300			
	93-01367	49:1D TOP	10,200			
	93-01367	49:1D BOTTOM	10,100			

Table A-2. Tank 241-C-109 Analytical Data: LANTHANUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**μg/g**	**μg/g**	**%**	**kg**
ICP.a.La	93-01354	47/49:DLC	< 2.17	< 2.17	N/A	< 0.0228
Solid Core Composite			**μg/g**	**μg/g**	**%**	**kg**
ICP.f.La	93-01358	47:CC	< 51.8	< 36.6		
	93-01363	48:CC	< 29.4			
	93-01371	49:CC	< 28.7			
ICP.a.La	93-01358	47:CC	81.0	44.0	49	12.7
	93-01363	48:CC	6.50			
	93-01371	49:CC	44.5			
ICP.w.La	93-01358	47:CC	< 3.13	< 3.04		
	93-01363	48:CC	< 3.00			
	93-01371	49:CC	< 3.00			
Quarter Segment			**μg/g**			
ICP.f.La	93-01355	47:1B	1167			
	93-01356	47:1C	32.7			
	93-0.1357	47:1D	< 35.2			
	93-01360	48:1C	< 33.8			
	93-01361	48:1D	< 25.6			
	93-01365	49:1B	86.0			
	93-01366	49:1C	< 26.7			
	93-01367	49:1D	< 28.0			
Homogenization Results			**μg/g**			
ICP.f.La	93-01367	49:1D TOP	< 26.7			
	93-0.1367	49:1D BOTTOM	< 27.1			
ICP.a.La	93-01361	48:1D TOP	6.00			
	93-01361	48:1D BOTTOM	8.00			
	93-01367	49:1D TOP	9.50			
	93-01367	49:1D BOTTOM	8.00			

Table A-2. Tank 241-C-109 Analytical Data: LEAD

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Pb	93-01354	47/49:DLC	< 14.5	< 14.5	N/A	< 0.153
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Pb	93-01358	47:CC	7,280	2,940		
	93-01363	48:CC	702			
	93-01371	49:CC	824			
ICP.a.Pb	93-01358	47:CC	10,200	3,890	81	1,120
	93-01363	48:CC	606			
	93-01371	49:CC	864			
ICP.w.Pb	93-01358	47:CC	48.0	38.7		
	93-01363	48:CC	48.0			
	93-01371	49:CC	20.1			
Quarter Segment			**µg/g**			
ICP.f.Pb	93-01355	47:1B	5,050			
	93-01356	47:1C	2,890			
	93-0.1357	47:1D	14,300			
	93-01360	48:1C	554			
	93-01361	48:1D	693			
	93-01365	49:1B	1,090			
	93-01366	49:1C	371			
	93-01367	49:1D	729			
Homogenization Results			**µg/g**			
ICP.f.Pb	93-01367	49:1D TOP	685			
	93-0.1367	49:1D BOTTOM	648			
ICP.a.Pb	93-01361	48:1D TOP	593			
	93-01361	48:1D BOTTOM	684			
	93-01367	49:1D TOP	578			
	93-01367	49:1D BOTTOM	562			

Table A-2. Tank 241-C-109 Analytical Data: LITHIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**μg/g**	**μg/g**	**%**	**kg**
ICP.a.Li	93-01354	47/49:DLC	< 1.29	< 1.29	N/A	< 0.0136
Solid Core Composite			**μg/g**	**μg/g**	**%**	**kg**
ICP.f.Li	93-01358	47:CC	< 30.9	< 21.9	N/A	< 6.33
	93-01363	48:CC	< 17.6			
	93-01371	49:CC	< 17.2			
ICP.a.Li	93-01358	47:CC	4.00	5.17		
	93-01363	48:CC	9.00			
	93-01371	49:CC	2.50			
ICP.w.Li	93-01358	47:CC	< 1.87	< 1.82		
	93-01363	48:CC	< 1.79			
	93-01371	49:CC	< 1.79			
Quarter Segment			**μg/g**			
ICP.f.Li	93-01355	47:1B	< 24.6			
	93-01356	47:1C	< 17.5			
	93-0.1357	47:1D	< 21.0			
	93-01360	48:1C	< 20.1			
	93-01361	48:1D	< 15.3			
	93-01365	49:1B	< 16.2			
	93-01366	49:1C	< 16.0			
	93-01367	49:1D	< 16.7			
Homogenization Results			**μg/g**			
ICP.f.Li	93-01367	49:1D TOP	< 15.9			
	93-0.1367	49:1D BOTTOM	< 16.2			
ICP.a.Li	93-01361	48:1D TOP	5.00			
	93-01361	48:1D BOTTOM	6.50			
	93-01367	49:1D TOP	3.50			
	93-01367	49:1D BOTTOM	4.50			

Table A-2. Tank 241-C-109 Analytical Data: MAGNESIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	μg/g	μg/g	%	kg
ICP.a.Mg	93-01354	47/49:DLC	26.0	26.0	N/A	0.274
Solid Core Composite			μg/g	μg/g	%	kg
ICP.f.Mg	93-01358	47:CC	647	551	19	159
	93-01363	48:CC	665			
	93-01371	49:CC	341			
ICP.a.Mg	93-01358	47:CC	469	426		
	93-01363	48:CC	512			
	93-01371	49:CC	296			
ICP.w.Mg	93-01358	47:CC	8.00	7.00		
	93-01363	48:CC	7.00			
	93-01371	49:CC	6.00			
Quarter Segment			μg/g			
ICP.f.Mg	93-01355	47:1B	908			
	93-01356	47:1C	364			
	93-0.1357	47:1D	561			
	93-01360	48:1C	702			
	93-01361	48:1D	582			
	93-01365	49:1B	186			
	93-01366	49:1C	289			
	93-01367	49:1D	498			
Homogenization Results			μg/g			
ICP.f.Mg	93-01367	49:1D TOP	479			
	93-0.1367	49:1D BOTTOM	460			
ICP.a.Mg	93-01361	48:1D TOP	563			
	93-01361	48:1D BOTTOM	621			
	93-01367	49:1D TOP	442			
	93-01367	49:1D BOTTOM	442			

Table A-2. Tank 241-C-109 Analytical Data: MANGANESE

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		Core:Segment	µg/g	µg/g	%	kg
ICP.a.Mn	93-01354	47/49:DLC	< 0.185	< 0.185	N/A	< 0.00195
Solid Core Composite			µg/g	µg/g	%	kg
ICP.f.Mn	93-01358	47:CC	161	128	17	37.0
	93-01363	48:CC	135			
	93-01371	49:CC	87.5			
ICP.a.Mn	93-01358	47:CC	134	92.7		
	93-01363	48:CC	96.0			
	93-01371	49:CC	48.0			
ICP.w.Mn	93-01358	47:CC	< 0.267	< 0.260		
	93-01363	48:CC	< 0.256			
	93-01371	49:CC	< 0.256			
Quarter Segment			µg/g			
ICP.f.Mn	93-01355	47:1B	465			
	93-01356	47:1C	225			
	93-0.1357	47:1D	289			
	93-01360	48:1C	256			
	93-01361	48:1D	143			
	93-01365	49:1B	213			
	93-01366	49:1C	160			
	93-01367	49:1D	270			
Homogenization Results			µg/g			
ICP.f.Mn	93-01367	49:1D TOP	174			
	93-0.1367	49:1D BOTTOM	115			
ICP.a.Mn	93-01361	48:1D TOP	81.0			
	93-01361	48:1D BOTTOM	76.0			
	93-01367	49:1D TOP	54.0			
	93-01367	49:1D BOTTOM	52.5			

Table A-2. Tank 241-C-109 Analytical Data: MERCURY

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		Core:Segment	µg/g	µg/g	%	kg
CVAA.Hg	93-01354	47/49:DLC	0.0910	0.0910	N/A	3.58E-04
			µg/L	µg/L	%	
			111	111	N/A	
Solid Core Composite			µg/g	µg/g	%	kg
CVAA.Hg	93-01358	47:CC	8.85	7.35	10	2.12
	93-01363	48:CC	6.55			
	93-01371	49:CC	6.65			

Table A-2. Tank 241-C-109 Analytical Data: MOLYBDENUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	μg/g	μg/g	%	kg
ICP.a.Mo	93-01354	47/49:DLC	40.0	40.0	N/A	0.421
Solid Core Composite			μg/g	μg/g	%	kg
ICP.f.Mo	93-01358	47:CC	< 53.5	40.0	17	11.6
	93-01363	48:CC	< 30.4			
	93-01371	49:CC	36.0			
ICP.a.Mo	93-01358	47:CC	43.0	38.0		
	93-01363	48:CC	31.0			
	93-01371	49:CC	40.0			
ICP.w.Mo	93-01358	47:CC	24.5	26.0		
	93-01363	48:CC	30.0			
	93-01371	49:CC	23.5			
Quarter Segment			μg/g			
ICP.f.Mo	93-01355	47:1B	47.6			
	93-01356	47:1C	42.0			
	93-0.1357	47:1D	< 36.4			
	93-01360	48:1C	38.5			
	93-01361	48:1D	34.5			
	93-01365	49:1B	55.0			
	93-01366	49:1C	38.0			
	93-01367	49:1D	45.0			
Homogenization Results			μg/g			
ICP.f.Mo	93-01367	49:1D TOP	36.5			
	93-0.1367	49:1D BOTTOM	< 28.0			
ICP.a.Mo	93-01361	48:1D TOP	29.0			
	93-01361	48:1D BOTTOM	32.0			
	93-01367	49:1D TOP	34.0			
	93-01367	49:1D BOTTOM	34.0			

Table A-2. Tank 241-C-109 Analytical Data: NEODYMIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	μg/g	μg/g	%	kg
ICP.a.Nd	93-01354	47/49:DLC	< 8.67	< 8.67	N/A	< 0.0912
Solid Core Composite			μg/g	μg/g	%	kg
ICP.f.Nd	93-01358	47:CC	< 207	< 147	N/A	< 42.5
	93-01363	48:CC	< 118			
	93-01371	49:CC	< 115			
ICP.a.Nd	93-01358	47:CC	130	84.3		
	93-01363	48:CC	44.0			
	93-01371	49:CC	79.0			
ICP.w.Nd	93-01358	47:CC	< 12.5	< 12.2		
	93-01363	48:CC	< 12.0			
	93-01371	49:CC	< 12.0			
Quarter Segment			μg/g			
ICP.f.Nd	93-01355	47:1B	< 165			
	93-01356	47:1C	< 117			
	93-0.1357	47:1D	< 141			
	93-01360	48:1C	< 135			
	93-01361	48:1D	< 102			
	93-01365	49:1B	< 114			
	93-01366	49:1C	< 107			
	93-01367	49:1D	< 112			
Homogenization Results			μg/g			
ICP.f.Nd	93-01367	49:1D TOP	< 107			
	93-0.1367	49:1D BOTTOM	< 109			
ICP.a.Nd	93-01361	48:1D TOP	29.0			
	93-01361	48:1D BOTTOM	34.5			
	93-01367	49:1D TOP	32.5			
	93-01367	49:1D BOTTOM	38.5			

Table A-2. Tank 241-C-109 Analytical Data: NICKEL

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		Core:Segment	μg/g	μg/g	%	kg
ICP.a.Ni	93-01354	47/49:DLC	344	344	N/A	3.62
Solid Core Composite			μg/g	μg/g	%	kg
ICP.a.Ni	93-01358	47:CC	14,800	14,100	8	4,080
	93-01363	48:CC	15,500			
	93-01371	49:CC	11,900			
ICP.w.Ni	93-01358	47:CC	125	69.7		
	93-01363	48:CC	31.0			
	93-01371	49:CC	53.0			
Homogenization Results			μg/g			
ICP.a.Ni	93-01361	48:1D TOP	16,400			
	93-01361	48:1D BOTTOM	18,400			
	93-01367	49:1D TOP	13,800			
	93-01367	49:1D BOTTOM	13,900			

Table A-2. Tank 241-C-109 Analytical Data: PHOSPHORUS

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**μg/g**	**μg/g**	**%**	**kg**
ICP.a.P	93-01354	47/49:DLC	4,200	4,200	N/A	44.2
Solid Core Composite			**μg/g**	**μg/g**	**%**	**kg**
ICP.f.P	93-01358	47:CC	19,900	18,200		
	93-01363	48:CC	20,200			
	93-01371	49:CC	14,600			
ICP.a.P	93-01358	47:CC	18,400	18,300	8	5,290
	93-01363	48:CC	17,100			
	93-01371	49:CC	19,400			
ICP.w.P	93-01358	47:CC	6,990	6,610		
	93-01363	48:CC	8,680			
	93-01371	49:CC	4,160			
Quarter Segment			**μg/g**			
ICP.f.P	93-01355	47:1B	7,630			
	93-01356	47:1C	12,500			
	93-0.1357	47:1D	30,100			
	93-01360	48:1C	23,300			
	93-01361	48:1D	20,900			
	93-01365	49:1B	4,110			
	93-01366	49:1C	11,500			
	93-01367	49:1D	20,400			
Homogenization Results			**μg/g**			
ICP.f.P	93-01367	49:1D TOP	18,900			
	93-0.1367	49:1D BOTTOM	19,100			
ICP.a.P	93-01361	48:1D TOP	27,600			
	93-01361	48:1D BOTTOM	21,300			
	93-01367	49:1D TOP	25,500			
	93-01367	49:1D BOTTOM	19,200			

Table A-2. Tank 241-C-109 Analytical Data: POTASSIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	µg/g	µg/g	%	kg
ICP.a.K	93-01354	47/49:DLC	840	840	N/A	8.84
Solid Core Composite			µg/g	µg/g	%	kg
ICP.a.K	93-01358	47:CC	587	544	13	157
	93-01363	48:CC	637			
	93-01371	49:CC	407			
ICP.w.K	93-01358	47:CC	534	513		
	93-01363	48:CC	558			
	93-01371	49:CC	448			
Homogenization Results			µg/g			
ICP.a.K	93-01361	48:1D TOP	588			
	93-01361	48:1D BOTTOM	632			
	93-01367	49:1D TOP	446			
	93-01367	49:1D BOTTOM	484			

Table A-2. Tank 241-C-109 Analytical Data: RHENIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Re	93-01354	47/49:DLC	< 1.81	< 1.81	N/A	< 0.0190
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Re	93-01358	47:CC	< 72.3	< 51.1	N/A	< 14.8
	93-01363	48:CC	< 41.0			
	93-01371	49:CC	< 40.1			
ICP.a.Re	93-01358	47:CC	9.50	7.33		
	93-01363	48:CC	6.00			
	93-01371	49:CC	6.50			
ICP.w.Re	93-01358	47:CC	< 4.37	< 4.25		
	93-01363	48:CC	< 4.19			
	93-01371	49:CC	< 4.18			
Quarter Segment			**µg/g**			
ICP.f.Re	93-01355	47:1B	< 57.5			
	93-01356	47:1C	< 40.8			
	93-0.1357	47:1D	< 49.2			
	93-01360	48:1C	< 47.1			
	93-01361	48:1D	< 35.7			
	93-01365	49:1B	< 37.8			
	93-01366	49:1C	< 37.3			
	93-01367	49:1D	< 39.0			
Homogenization Results			**µg/g**			
ICP.f.Re	93-01367	49:1D TOP	< 37.3			
	93-0.1367	49:1D BOTTOM	< 37.9			
ICP.a.Re	93-01361	48:1D TOP	5.00			
	93-01361	48:1D BOTTOM	6.00			
	93-01367	49:1D TOP	7.00			
	93-01367	49:1D BOTTOM	8.00			

Table A-2. Tank 241-C-109 Analytical Data: RHODIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		Core:Segment	μg/g	μg/g	%	kg
ICP.a.Rh	93-01354	47/49:DLC	< 14.4	< 14.4	N/A	< 0.152
Solid Core Composite			μg/g	μg/g	%	kg
ICP.f.Rh	93-01358	47:CC	< 343	< 183	N/A	< 52.9
	93-01363	48:CC	< 195			
	93-01371	49:CC	< 190			
ICP.a.Rh	93-01358	47:CC	< 17.6	< 17.1		
	93-01363	48:CC	< 17.2			
	93-01371	49:CC	< 16.4			
ICP.w.Rh	93-01358	47:CC	< 20.8	< 20.2		
	93-01363	48:CC	< 19.9			
	93-01371	49:CC	< 19.9			
Quarter Segment			μg/g			
ICP.f.Rh	93-01355	47:1B	< 273			
	93-01356	47:1C	< 194			
	93-0.1357	47:1D	< 233			
	93-01360	48:1C	< 223			
	93-01361	48:1D	< 169			
	93-01365	49:1B	< 179			
	93-01366	49:1C	< 177			
	93-01367	49:1D	< 185			
Homogenization Results			μg/g			
ICP.f.Rh	93-01367	49:1D TOP	< 177			
	93-0.1367	49:1D BOTTOM	< 180			
ICP.a.Rh	93-01361	48:1D TOP	< 16.4			
	93-01361	48:1D BOTTOM	< 16.4			
	93-01367	49:1D TOP	< 16.0			
	93-01367	49:1D BOTTOM	< 16.2			

Table A-2. Tank 241-C-109 Analytical Data: RUTHENIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Ru	93-01354	47/49:DLC	< 6.12	< 6.12	N/A	< 0.0644
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Ru	93-01358	47:CC	< 146	< 103	N/A	< 29.8
	93-01363	48:CC	< 83.0			
	93-01371	49:CC	< 81.1			
ICP.a.Ru	93-01358	47:CC	< 7.52	< 7.29		
	93-01363	48:CC	< 7.35			
	93-01371	49:CC	< 7.00			
ICP.w.Ru	93-01358	47:CC	< 8.84	< 8.59		
	93-01363	48:CC	< 8.47			
	93-01371	49:CC	< 8.46			
Quarter Segment			**µg/g**			
ICP.f.Ru	93-01355	47:1B	< 116			
	93-01356	47:1C	< 82.6			
	93-0.1357	47:1D	< 99.5			
	93-01360	48:1C	< 95.3			
	93-01361	48:1D	< 72.2			
	93-01365	49:1B	< 76.5			
	93-01366	49:1C	< 75.5			
	93-01367	49:1D	< 78.9			
Homogenization Results			**µg/g**			
ICP.f.Ru	93-01367	49:1D TOP	< 75.4			
	93-0.1367	49:1D BOTTOM	< 76.6			
ICP.a.Ru	93-01361	48:1D TOP	< 6.99			
	93-01361	48:1D BOTTOM	< 6.99			
	93-01367	49:1D TOP	< 6.82			
	93-01367	49:1D BOTTOM	< 6.90			

Table A-2. Tank 241-C-109 Analytical Data: SELENIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	%	**kg**
ICP.a.Se	93-01354	47/49:DLC	< 26.5	< 26.5	N/A	< 0.279
Solid Core Composite			**µg/g**	**µg/g**	%	**kg**
ICP.f.Se	93-01358	47:CC	< 633	< 448	N/A	< 129
	93-01363	48:CC	< 359			
	93-01371	49:CC	< 351			
ICP.a.Se	93-01358	47:CC	< 32.6	< 31.6		
	93-01363	48:CC	< 31.8			
	93-01371	49:CC	< 30.3			
ICP.w.Se	93-01358	47:CC	< 38.3	< 37.2		
	93-01363	48:CC	< 36.7			
	93-01371	49:CC	< 36.6			
Quarter Segment			**µg/g**			
ICP.f.Se	93-01355	47:1B	< 503			
	93-01356	47:1C	< 357			
	93-0.1357	47:1D	< 430			
	93-01360	48:1C	< 412			
	93-01361	48:1D	< 313			
	93-01365	49:1B	< 331			
	93-01366	49:1C	< 327			
	93-01367	49:1D	< 342			
Homogenization Results			**µg/g**			
ICP.f.Se	93-01367	49:1D TOP	< 326			
	93-0.1367	49:1D BOTTOM	< 332			
Solid Composite Core			**µg/g**	**µg/g**	%	kg
GFAA.Se	93-01358	47:CC	< 2.40	< 2.38	N/A	< 0.688
	93-01363	48:CC	< 2.45			
	93-01371	49:CC	< 2.30			

Table A-2. Tank 241-C-109 Analytical Data: SILICON

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		Core:Segment	μg/g	μg/g	%	kg
ICP.a.Si	93-01354	47/49:DLC	68.5	68.5	N/A	0.721
Solid Core Composite			μg/g	μg/g	%	kg
ICP.f.Si	93-01358	47:CC	15,800	6,760	67	1,950
	93-01363	48:CC	2,170			
	93-01371	49:CC	2,310			
ICP.a.Si	93-01358	47:CC	1,910	1,540		
	93-01363	48:CC	1,310			
	93-01371	49:CC	1,400			
ICP.w.Si	93-01358	47:CC	117	128		
	93-01363	48:CC	197			
	93-01371	49:CC	70.0			
Quarter Segment			μg/g			
ICP.f.Si	93-01355	47:1B	18,800			
	93-01356	47:1C	6,110			
	93-0.1357	47:1D	22,300			
	93-01360	48:1C	2,890			
	93-01361	48:1D	2,220			
	93-01365	49:1B	2,900			
	93-01366	49:1C	884			
	93-01367	49:1D	1,690			
Homogenization Results			μg/g			
ICP.f.Si	93-01367	49:1D TOP	1,370			
	93-0.1367	49:1D BOTTOM	1,210			
ICP.a.Si	93-01361	48:1D TOP	948			
	93-01361	48:1D BOTTOM	1,130			
	93-01367	49:1D TOP	713			
	93-01367	49:1D BOTTOM	675			

Table A-2. Tank 241-C-109 Analytical Data: SILVER

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Ag	93-01354	47/49:DLC	< 1.36	< 0.136	N/A	< 0.0143
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Ag	93-01358	47:CC	< 32.6	< 23.1	N/A	< 6.68
	93-01363	48:CC	< 18.5			
	93-01371	49:CC	< 18.1			
ICP.a.Ag	93-01358	47:CC	< 1.68	< 1.63		
	93-01363	48:CC	< 1.64			
	93-01371	49:CC	< 1.56			
ICP.w.Ag	93-01358	47:CC	< 1.97	< 1.91		
	93-01363	48:CC	< 1.89			
	93-01371	49:CC	< 1.88			
Quarter Segment			**µg/g**			
ICP.f.Ag	93-01355	47:1B	< 25.9			
	93-01356	47:1C	< 18.4			
	93-0.1357	47:1D	< 22.2			
	93-01360	48:1C	< 21.2			
	93-01361	48:1D	< 16.1			
	93-01365	49:1B	< 17.1			
	93-01366	49:1C	< 16.8			
	93-01367	49:1D	< 17.6			
Homogenization Results			**µg/g**			
ICP.f.Ag	93-01367	49:1D TOP	< 16.8			
	93-0.1367	49:1D BOTTOM	< 17.1			
ICP.a.Ag	93-01361	48:1D TOP	< 1.56			
	93-01361	48:1D BOTTOM	< 1.56			
	93-01367	49:1D TOP	< 1.52			
	93-01367	49:1D BOTTOM	< 1.54			

Table A-2. Tank 241-C-109 Analytical Data: SODIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**μg/g**	**μg/g**	**%**	**kg**
ICP.a.Na	93-01354	47/49:DLC	96,900	96,900	N/A	1,020
Solid Core Composite			**μg/g**	**μg/g**	**%**	**kg**
ICP.f.Na	93-01358	47:CC	87,200	87,900	8	25,400
	93-01363	48:CC	1.00E+05			
	93-01371	49:CC	76,600			
ICP.a.Na	93-01358	47:CC	81,900	83,600		
	93-01363	48:CC	87,600			
	93-01371	49:CC	81,300			
ICP.w.Na	93-01358	47:CC	67,800	70,400		
	93-01363	48:CC	83,600			
	93-01371	49:CC	59,900			
Quarter Segment			**μg/g**			
ICP.f.Na	93-01355	47:1B	51,100			
	93-01356	47:1C	63,100			
	93-0.1357	47:1D	1.03E+05			
	93-01360	48:1C	1.16E+05			
	93-01361	48:1D	1.02E+05			
	93-01365	49:1B	43,100			
	93-01366	49:1C	62,900			
	93-01367	49:1D	91,400			
Homogenization Results			**μg/g**			
ICP.f.Na	93-01367	49:1D TOP	90,700			
	93-0.1367	49:1D BOTTOM	89,700			
ICP.a.Na	93-01361	48:1D TOP	1.19E+05			
	93-01361	48:1D BOTTOM	1.03E+05			
	93-01367	49:1D TOP	6.37E+05			
	93-01367	49:1D BOTTOM	84,100			

Table A-2. Tank 241-C-109 Analytical Data: STRONTIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Sr	93-01354	47/49:DLC	0.534	0.534	N/A	0.00562
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Sr	93-01358	47:CC	204	378	51	109
	93-01363	48:CC	760			
	93-01371	49:CC	169			
ICP.a.Sr	93-01358	47:CC	189	263		
	93-01363	48:CC	445			
	93-01371	49:CC	155			
ICP.w.Sr	93-01358	47:CC	1.00	0.849		
	93-01363	48:CC	1.00			
	93-01371	49:CC	0.546			
Quarter Segment			**µg/g**			
ICP.f.Sr	93-01355	47:1B	168			
	93-01356	47:1C	141			
	93-0.1357	47:1D	196			
	93-01360	48:1C	603			
	93-01361	48:1D	463			
	93-01365	49:1B	102			
	93-01366	49:1C	77.0			
	93-01367	49:1D	429			
Homogenization Results			**µg/g**			
ICP.f.Sr	93-01367	49:1D TOP	411			
	93-0.1367	49:1D BOTTOM	374			
ICP.a.Sr	93-01361	48:1D TOP	421			
	93-01361	48:1D BOTTOM	476			
	93-01367	49:1D TOP	352			
	93-01367	49:1D BOTTOM	341			

Table A-2. Tank 241-C-109 Analytical Data: TELLURIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		Core:Segment	µg/g	µg/g	%	kg
ICP.a.Te	93-01354	47/49:DLC	< 16.6	< 16.6	N/A	< 0.175
Solid Core Composite			µg/g	µg/g	%	kg
ICP.f.Te	93-01358	47:CC	< 397	< 281	N/A	< 81.2
	93-01363	48:CC	< 225			
	93-01371	49:CC	< 220			
ICP.a.Te	93-01358	47:CC	71.5	57.5		
	93-01363	48:CC	< 19.9			
	93-01371	49:CC	81.0			
ICP.w.Te	93-01358	47:CC	< 24.0	< 23.3		
	93-01363	48:CC	< 23.0			
	93-01371	49:CC	< 23.0			
Quarter Segment			µg/g			
ICP.f.Te	93-01355	47:1B	< 316			
	93-01356	47:1C	< 224			
	93-0.1357	47:1D	< 270			
	93-01360	48:1C	< 259			
	93-01361	48:1D	< 196			
	93-01365	49:1B	< 208			
	93-01366	49:1C	< 205			
	93-01367	49:1D	< 214			
Homogenization Results			µg/g			
ICP.f.Te	93-01367	49:1D TOP	< 205			
	93-0.1367	49:1D BOTTOM	< 208			
ICP.a.Te	93-01361	48:1D TOP	< 19.0			
	93-01361	48:1D BOTTOM	< 19.0			
	93-01367	49:1D TOP	39.5			
	93-01367	49:1D BOTTOM	42.5			

Table A-2. Tank 241-C-109 Analytical Data: THALLIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Tl	93-01354	47/49:DLC	< 96.1	< 96.1	N/A	< 1.01
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Tl	93-01358	47:CC	< 2,300	< 1,620	N/A	< 468
	93-01363	48:CC	< 1,300			
	93-01371	49:CC	< 1,270			
ICP.a.Tl	93-01358	47:CC	< 118	< 114		
	93-01363	48:CC	< 115			
	93-01371	49:CC	< 110			
ICP.w.Tl	93-01358	47:CC	< 139	< 135		
	93-01363	48:CC	< 133			
	93-01371	49:CC	< 133			
Quarter Segment			**µg/g**			
ICP.f.Tl	93-01355	47:1B	< 1,830			
	93-01356	47:1C	< 1,300			
	93-0.1357	47:1D	< 1,560			
	93-01360	48:1C	< 1,500			
	93-01361	48:1D	< 1,130			
	93-01365	49:1B	< 1,200			
	93-01366	49:1C	< 1,180			
	93-01367	49:1D	< 1,240			
Homogenization Results			**µg/g**			
ICP.f.Tl	93-01367	49:1D TOP	< 1,180			
	93-0.1367	49:1D BOTTOM	< 1,200			
ICP.a.Tl	93-01361	48:1D TOP	< 110			
	93-01361	48:1D BOTTOM	< 110			
	93-01367	49:1D TOP	< 107			
	93-01367	49:1D BOTTOM	< 108			

Table A-2. Tank 241-C-109 Analytical Data: THORIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Th	93-01354	47/49:DLC	< 12.8	< 12.8	N/A	< 0.135
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Th	93-01358	47:CC	< 307	< 217	N/A	< 62.7
	93-01363	48:CC	< 174			
	93-01371	49:CC	< 170			
ICP.a.Th	93-01358	47:CC	69.5	45.2		
	93-01363	48:CC	39.5			
	93-01371	49:CC	26.5			
ICP.w.Th	93-01358	47:CC	< 18.6	< 18.0		
	93-01363	48:CC	< 17.8			
	93-01371	49:CC	< 17.7			
Quarter Segment			**µg/g**			
ICP.f.Th	93-01355	47:1B	< 244			
	93-01356	47:1C	< 173			
	93-0.1357	47:1D	< 209			
	93-01360	48:1C	< 200			
	93-01361	48:1D	< 151			
	93-01365	49:1B	< 160			
	93-01366	49:1C	< 158			
	93-01367	49:1D	< 166			
Homogenization Results			**µg/g**			
ICP.f.Th	93-01367	49:1D TOP	< 158			
	93-0.1367	49:1D BOTTOM	< 161			
ICP.a.Th	93-01361	48:1D TOP	< 14.7			
	93-01361	48:1D BOTTOM	< 14.7			
	93-01367	49:1D TOP	< 14.3			
	93-01367	49:1D BOTTOM	< 14.5			

Table A-2. Tank 241-C-109 Analytical Data: TITANIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Ti	93-01354	47/49:DLC	< 0.941	< 0.941	N/A	< 0.00990
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Ti	93-01358	47:CC	< 22.6	16.3		
	93-01363	48:CC	13.2			
	93-01371	49:CC	13.1			
ICP.a.Ti	93-01358	47:CC	59.5	25.2	68	7.28
	93-01363	48:CC	10.5			
	93-01371	49:CC	5.50			
ICP.w.Ti	93-01358	47:CC	< 1.36	< 1.32		
	93-01363	48:CC	< 1.30			
	93-01371	49:CC	< 1.30			
Quarter Segment			µg/g			
ICP.f.Ti	93-01355	47:1B	408			
	93-01356	47:1C	109			
	93-0.1357	47:1D	195			
	93-01360	48:1C	40.7			
	93-01361	48:1D	27.5			
	93-01365	49:1B	65.0			
	93-01366	49:1C	< 11.6			
	93-01367	49:1D	14.5			
Homogenization Results			**µg/g**			
ICP.f.Ti	93-01367	49:1D TOP	< 11.6			
	93-0.1367	49:1D BOTTOM	< 11.8			
ICP.a.Ti	93-01361	48:1D TOP	6.50			
	93-01361	48:1D BOTTOM	7.00			
	93-01367	49:1D TOP	3.50			
	93-01367	49:1D BOTTOM	3.00			

Table A-2. Tank 241-C-109 Analytical Data: URANIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	µg/g	µg/g	%	kg
ICP.a.U	93-01354	47/49:DLC	< 94.0	< 94.0	N/A	< 0.989
Solid Core Composite			µg/g	µg/g	%	kg
ICP.f.U	93-01358	47:CC	9,180	12,900	47	3,730
	93-01363	48:CC	24,800			
	93-01371	49:CC	4,740			
ICP.a.U	93-01358	47:CC	10,800	10,700		
	93-01363	48:CC	15,100			
	93-01371	49:CC	6,270			
ICP.w.U	93-01358	47:CC	147	136		
	93-01363	48:CC	< 130			
	93-01371	49:CC	< 130			
Quarter Segment			µg/g			
ICP.f.U	93-01355	47:1B	11,300			
	93-01356	47:1C	6,150			
	93-0.1357	47:1D	5,840			
	93-01360	48:1C	16,800			
	93-01361	48:1D	14,400			
	93-01365	49:1B	7,910			
	93-01366	49:1C	1,300			
	93-01367	49:1D	12,400			
Homogenization Results			µg/g			
ICP.f.U	93-01367	49:1D TOP	12,700			
	93-0.1367	49:1D BOTTOM	11,300			
ICP.a.U	93-01361	48:1D TOP	15,000			
	93-01361	48:1D BOTTOM	16,500			
	93-01367	49:1D TOP	11,600			
	93-01367	49:1D BOTTOM	11,100			

Table A-2. Tank 241-C-109 Analytical Data: VANADIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.V	93-01354	47/49:DLC	< 1.58	< 1.56	N/A	< 0.0166
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.V	93-01358	47:CC	< 37.6	< 26.6	N/A	< 7.69
	93-01363	48:CC	< 21.3			
	93-01371	49:CC	< 20.9			
ICP.a.V	93-01358	47:CC	14.0	8.50		
	93-01363	48:CC	6.50			
	93-01371	49:CC	5.00			
ICP.w.V	93-01358	47:CC	2.16	2.18		
	93-01363	48:CC	< 2.19			
	93-01371	49:CC	< 2.18			
Quarter Segment			**µg/g**			
ICP.f.V	93-01355	47:1B	< 29.9			
	93-01356	47:1C	< 21.2			
	93-0.1357	47:1D	< 25.6			
	93-01360	48:1C	< 24.5			
	93-01361	48:1D	< 18.6			
	93-01365	49:1B	< 19.7			
	93-01366	49:1C	< 19.4			
	93-01367	49:1D	< 20.3			
Homogenization Results			**µg/g**			
ICP.f.V	93-01367	49:1D TOP	< 19.4			
	93-0.1367	49:1D BOTTOM	< 19.7			
ICP.a.V	93-01361	48:1D TOP	2.50			
	93-01361	48:1D BOTTOM	2.00			
	93-01367	49:1D TOP	4.00			
	93-01367	49:1D BOTTOM	3.50			

Table A-2. Tank 241-C-109 Analytical Data: ZINC

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Zn	93-01354	47/49:DLC	10.5	10.5	N/A	0.110
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Zn	93-01358	47:CC	351	362	4	105
	93-01363	48:CC	345			
	93-01371	49:CC	389			
ICP.a.Zn	93-01358	47:CC	257	244		
	93-01363	48:CC	196			
	93-01371	49:CC	278			
ICP.w.Zn	93-01358	47:CC	9.00	8.17		
	93-01363	48:CC	8.50			
	93-01371	49:CC	7.00			
Quarter Segment			**µg/g**			
ICP.f.Zn	93-01355	47:1B	343			
	93-01356	47:1C	263			
	93-0.1357	47:1D	239			
	93-01360	48:1C	373			
	93-01361	48:1D	308			
	93-01365	49:1B	642			
	93-01366	49:1C	311			
	93-01367	49:1D	352			
Homogenization Results			**µg/g**			
ICP.f.Zn	93-01367	49:1D TOP	345			
	93-0.1367	49:1D BOTTOM	276			
ICP.a.Zn	93-01361	48:1D TOP	198			
	93-01361	48:1D BOTTOM	224			
	93-01367	49:1D TOP	196			
	93-01367	49:1D BOTTOM	196			

Table A-2. Tank 241-C-109 Analytical Data: ZIRCONIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
METAL						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
ICP.a.Zr	93-01354	47/49:DLC	< 1.33	< 1.33	N/A	< 0.0140
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
ICP.f.Zr	93-01358	47:CC	< 31.8	< 22.5	N/A	< 6.50
	93-01363	48:CC	< 18.0			
	93-01371	49:CC	< 17.6			
ICP.a.Zr	93-01358	47:CC	3.50	4.75		
	93-01363	48:CC	7.50			
	93-01371	49:CC	3.26			
ICP.w.Zr	93-01358	47:CC	< 1.92	< 1.87		
	93-01363	48:CC	< 1.84			
	93-01371	49:CC	< 1.84			
Quarter Segment			**µg/g**			
ICP.f.Zr	93-01355	47:1B	< 25.3			
	93-01356	47:1C	< 17.9			
	93-0.1357	47:1D	< 21.6			
	93-01360	48:1C	< 20.7			
	93-01361	48:1D	< 15.7			
	93-01365	49:1B	< 16.6			
	93-01366	49:1C	< 16.4			
	93-01367	49:1D	< 17.1			
Homogenization Results			**µg/g**			
ICP.f.Zr	93-01367	49:1D TOP	< 16.4			
	93-0.1367	49:1D BOTTOM	< 16.6			
ICP.a.Zr	93-01361	48:1D TOP	15.0			
	93-01361	48:1D BOTTOM	8.50			
	93-01367	49:1D TOP	10.5			
	93-01367	49:1D BOTTOM	11.5			

Table A-3. Tank 241-C-109 Analytical Data: AMMONIA

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
ION						
Solid Core Composite		**Core:Segment**	**μg/g**	**μg/g**	**%**	**kg**
Titration.NH_3	93-01358	47:CC	43.5	53.0	10	15.3
	93-01363	48:CC	61.0			
	93-01371	49:CC	54.5			

Table A-3. Tank 241-C-109 Analytical Data: CHLORIDE

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
ANION						
Liquid Composite		**Core:Segment**	**μg/g**	**μg/g**	**%**	**kg**
IC.Cl	93-01354	47/49:DLC	1,300	1,300	N/A	13.7
Solid Core Composite			**μg/g**	**μg/g**	**%**	**kg**
IC.Cl	93-01358	47:CC	700	733	8	212
	93-01363	48:CC	800			
	93-01371	49:CC	700			
Quarter Segment			**μg/g**			
IC.Cl	93-01355	47:1B	500			
	93-01356	47:1C	700			
	93-0.1357	47:1D	750			
	93-01360	48:1C	5,000			
	93-01361	48:1D	1,000			
	93-01365	49:1B	500			
	93-01366	49:1C	800			
	93-01367	49:1D	800			

Table A-3. Tank 241-C-109 Analytical Data: CHROMIUM (VI)

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
CATION						
Solid Core Composite		**Core:Segment**	**μg/g**	**μg/g**	**%**	**kg**
Cr^{6+}	93-01358	47:CC	47.0	37.2	15	10.8
	93-01363	48:CC	36.5			
	93-01371	49:CC	28.0			

Table A-3. Tank 241-C-109 Analytical Data: CYANIDE

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
ANION						
Liquid Composite		**Core:Segment**	**μg/g**	**μg/g**	**%**	**kg**
IC.CN	93-01354	47/49:DLC	1,340	1,340	N/A	[illegible]
Solid Core Composite			**μg/g**	**μg/g**	**%**	**kg**
IC.CN	93-01358	47:CC	815	882	24	255
	93-01363	48:CC	1,280			
	93-01371	49:CC	550			
Quarter Segment			**μg/g**			
IC.CN	93-01355	47:1B	570			
	93-01356	47:1C	676			
	93-0.1357	47:1D	905			
	93-01360	48:1C	1,480			
	93-01361	48:1D	1,360			
	93-01365	49:1B	365			
	93-01366	49:1C	645			
	93-01367	49:1D	715			

Table A-3. Tank 241-C-109 Analytical Data: FLUORIDE

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
ANION						
Liquid Composite		**Core:Segment**	µg/g	µg/g	%	kg
IC.F	93-01354	47/49:DLC	< 200	< 200	N/A	< 2.10
Solid Core Composite			µg/g	µg/g	%	kg
IC.F	93-01358	47:CC	400	700	43	202
	93-01363	48:CC	1,300			
	93-01371	49:CC	400			
Quarter Segment			µg/g			
IC.F	93-01355	47:1B	300			
	93-01356	47:1C	300			
	93-0.1357	47:1D	300			
	93-01360	48:1C	500			
	93-01361	48:1D	750			
	93-01365	49:1B	< 300			
	93-01366	49:1C	300			
	93-01367	49:1D	950			

Table A-3. Tank 241-C-109 Analytical Data: NITRATE

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
ANION						
Liquid Composite		**Core:Segment**	µg/g	µg/g	%	kg
IC.NO_3	93-01354	47/49:DLC	72,000	72,000	N/A	758
Solid Core Composite			µg/g	µg/g	%	kg
IC.NO_3	93-01358	47:CC	37,000	40,300	10	11,600
	93-01363	48:CC	48,000			
	93-01371	49:CC	36,000			
Quarter Segment			µg/g			
IC.NO_3	93-01355	47:1B	27,600			
	93-01356	47:1C	36,000			
	93-0.1357	47:1D	38,500			
	93-01360	48:1C	56,000			
	93-01361	48:1D	53,500			
	93-01365	49:1B	25,700			
	93-01366	49:1C	42,000			
	93-01367	49:1D	43,000			

Table A-3. Tank 241-C-109 Analytical Data: NITRITE

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
ANION						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
IC.NO_2^-	93-01354	47/49:DLC	71,000	71,000	N/A	747
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
IC.NO_2^-	93-01358	47:CC	39,000	40,700	5	11,800
	93-01363	48:CC	45,000			
	93-01371	49:CC	38,500			
Quarter Segment			**µg/g**			
IC.NO_2	93-01355	47:1B	27,900			
	93-01356	47:1C	37,000			
	93-0.1357	47:1D	39,500			
	93-01360	48:1C	51,000			
	93-01361	48:1D	49,500			
	93-01365	49:1B	26,500			
	93-01366	49:1C	43,500			
	93-01367	49:1D	45,000			

Table A-3. Tank 241-C-109 Analytical Data: PHOSPHATE

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
ANION						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	%	kg
IC.PO_4^{3-}	93-01354	47/49:DLC	13,500	13,500	N/A	142
Solid Core Composite			µg/g	µg/g	%	kg
IC.PO_4^{3-}	93-01358	47:CC	22,100	20,500	20	5,930
	93-01363	48:CC	26,700			
	93-01371	49:CC	12,800			
Quarter Segment			µg/g			
IC.PO_4^{3-}	93-01355	47:1B	7,300			
	93-01356	47:1C	9,550			
	93-0.1357	47:1D	44,500			
	93-01360	48:1C	15,800			
	93-01361	48:1D	36,000			
	93-01365	49:1B	6,100			
	93-01366	49:1C	8,300			
	93-01367	49:1D	25,200			

Table A-3. Tank 241-C-109 Analytical Data: SULFATE

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
ANION						
Liquid Composite		**Core:Segment**	**μg/g**	**μg/g**	**%**	**kg**
$IC.SO_4^{2-}$	93-01354	47/49:DLC	12,800	12,800	N/A	135
Solid Core Composite			**μg/g**	**μg/g**	**%**	**kg**
$IC.SO_4^{2-}$	93-01358	47:CC	7,300	7,700	10	2,230
	93-01363	48:CC	9,250			
	93-01371	49:CC	6,550			
Quarter Segment			**μg/g**			
$IC.SO_4^{2-}$	93-01355	47:1B	5,050			
	93-01356	47:1C	7,100			
	93-0.1357	47:1D	7,350			
	93-01360	48:1C	11,000			
	93-01361	48:1D	10,000			
	93-01365	49:1B	4,650			
	93-01366	49:1C	8,150			
	93-01367	49:1D	8,100			

Table A-4. Tank 241-C-109 Analytical Data: AMERICIUM-241

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Liquid Composite		**Core:Segment**	**μCi/mL**	**μCi/mL**	**%**	**Ci**
GEA.a.^{241}Am	93-01354	47/49:DLC	< 0.00140	< 0.00140	N/A	< 0.0128
Solid Core Composite			**μCi/g**	**μCi/g**	**%**	**Ci**
GEA.w.^{241}Am	93-01358	47:CC	< 0.00395	< 0.00348		
	93-01363	48:CC	< 0.00360			
	93-01371	49:CC	< 0.00290			
GEA.f.^{241}Am	93-01358	47:CC	< 0.575	< 0.545	N/A	< 158
	93-01363	48:CC	< 0.710			
	93-01371	49:CC	< 0.350			
Quarter Segment			**μCi/g**			
GEA.f.^{241}Am	93-01355	47:1B	< 0.751			
	93-01356	47:1C	< 0.480			
	93-0.1357	47:1D	< 0.555			
	93-01360	48:1C	< 0.590			
	93-01361	48:1D	< 0.630			
	93-01365	49:1B	0.520			
	93-01366	49:1C	< 0.136			
	93-01367	49:1D	< 0.265			
Solid Core Composite			**μCi/g**	**μCi/g**	%	Ci
AEA.f.^{241}Am	93-01358	47:CC	0.320	0.154	34	44.5
	93-01363	48:CC	0.0101			
	93-01371	49:CC	0.133			

Table A-4. Tank 241-C-109 Analytical Data: CARBON-14

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Liquid Composite		**Core:Segment**	**μCi/mL**	**μCi/mL**	%	Ci
LSC.a.^{14}C	93-01354	47/49:DLC	0.00245	0.00245	N/A	0.0224
Solid Core Composite			**μCi/g**	**μCi/g**	%	Ci
LSC.w.^{14}C	93-01358	47:CC	5.65E-06	1.97E-05	44	0.00569
	93-01363	48:CC	1.80E-05			
	93-01371	49:CC	3.55E-05			

Table A-4. Tank 241-C-109 Analytical Data: CESIUM-137

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Liquid Composite		Core:Segment	µCi/mL	µCi/mL	%	Ci
GEA.a.^{137}Cs	93-01354	47/49:DLC	5.61	5361	N/A	51.3
Solid Core Composite			µCi/g	µCi/g	%	Ci
GEA.w.^{137}Cs	93-01358	47:CC	9.24	7.95		
	93-01363	48:CC	9.33			
	93-01371	49:CC	5.28			
GEA.f.^{137}Cs	93-01358	47:CC	874	820	17	2.37E+05
	93-01363	48:CC	1,030			
	93-01371	49:CC	557			
Quarter Segment			µCi/g			
GEA.f.^{137}Cs	93-01355	47:1B	337			
	93-01356	47:1C	772			
	93-0.1357	47:1D	947			
	93-01360	48:1C	1,160			
	93-01361	48:1D	1,170			
	93-01365	49:1B	118			
	93-01366	49:1C	349			
	93-01367	49:1D	702			
Homogenization Test			µCi/g			
GEA.f.^{137}Cs	93-01367	49:1D TOP	732			
	93-01368	49:1D BOTTOM	698			
GEA.a.^{137}Cs	93-01361	48:1D TOP	12.6			
	93-01361	48:1D BOTTOM	11.6			
	93-01367	49:1D TOP	39.4			
	93-01367	49:1D BOTTOM	23.4			

Table A-4. Tank 241-C-109 Analytical Data: COBALT-60

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Liquid Composite		**Core:Segment**	**μCi/mL**	**μCi/mL**	%	Ci
GEA.a.^{60}Co	93-01354	47/49:DLC	0.00146	0.00146	N/A	0.0134
Solid Core Composite			**μCi/g**	**μCi/g**	%	Ci
GEA.w.^{60}Co	93-01358	47:CC	6.87E-04	7.83E-04		
	93-01363	48:CC	0.00103			
	93-01371	49:CC	6.31E-04			
GEA.f.^{60}Co	93-01358	47:CC	< 0.0240	< 0.0213	N/A	< 6.16
	93-01363	48:CC	< 0.0265			
	93-01371	49:CC	< 0.0135			
Quarter Segment			**μCi/g**			
GEA.f.^{60}Co	93-01355	47:1B	< 0.0275			
	93-01356	47:1C	< 0.0245			
	93-0.1357	47:1D	< 0.0195			
	93-01360	48:1C	< 0.0155			
	93-01361	48:1D	< 0.0155			
	93-01365	49:1B	< 0.0130			
	93-01366	49:1C	< 0.00630			
	93-01367	49:1D	< 0.0110			

Table A-4. Tank 241-C-109 Analytical Data: EUROPIUM-154

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Liquid Composite		**Core:Segment**	**µCi/mL**	**µCi/mL**	**%**	**Ci**
GEA.a.^{154}Eu	93-01354	47/49:DLC	< 3.00E-04	3.00E-04	N/A	< 0.00275
Solid Core Composite			**µCi/g**	**µCi/g**	**%**	**Ci**
GEA.w.^{154}Eu	93-01358	47:CC	< 0.00220	< 0.00144		
	93-01363	48:CC	< 6.55E-04			
	93-01371	49:CC	< 0.00145			
GEA.f.^{154}Eu	93-01358	47:CC	< 0.245	0.227	37	65.6
	93-01363	48:CC	< 0.0725			
	93-01371	49:CC	0.362			
Quarter Segment			**µCi/g**			
GEA.f.^{154}Eu	93-01355	47:1B	0.882			
	93-01356	47:1C	< 0.130			
	93-0.1357	47:1D	< 0.110			
	93-01360	48:1C	< 0.0755			
	93-01361	48:1D	< 0.0950			
	93-01365	49:1B	0.779			
	93-01366	49:1C	< 0.0385			
	93-01367	49:1D	< 0.0620			

Table A-4. Tank 241-C-109 Analytical Data: EUROPIUM-155

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Liquid Composite		**Core:Segment**	**µCi/mL**	**µCi/mL**	%	Ci
GEA.a.^{155}Eu	93-01354	47/49:DLC	< 0.00240	< 0.00240	N/A	< 0.0220
Solid Core Composite			**µCi/g**	**µCi/g**	%	Ci
GEA.w.^{155}Eu	93-01358	47:CC	< 0.00805	< 0.00717		
	93-01363	48:CC	< 0.00755			
	93-01371	49:CC	< 0.00590			
GEA.f.^{155}Eu	93-01358	47:CC	< 0.860	< 0.843	N/A	< 24.4
	93-01363	48:CC	< 1.15			
	93-01371	49:CC	< 0.520			
Quarter Segment			**µCi/g**			
GEA.f.^{155}Eu	93-01355	47:1B	1.16			
	93-01356	47:1C	< 0.860			
	93-0.1357	47:1D	< 1.02			
	93-01360	48:1C	< 1.10			
	93-01361	48:1D	< 1.20			
	93-01365	49:1B	0.929			
	93-01366	49:1C	< 0.252			
	93-01367	49:1D	< 0.490			

Table A-4. Tank 241-C-109 Analytical Data: SELENIUM-79

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Solid Core Composite		**Core:Segment**	**μCi/g**	**μCi/g**	**%**	**Ci**
LSC.f.^{79}Se	93-01358	47:CC	< 8.00E-05	6.17E-05	15	0.0178
	93-01363	48:CC	5.50E-05			
	93-01371	49:CC	5.00E-05			

Table A-4. Tank 241-C-109 Analytical Data: STRONTIUM-90

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Liquid Composite		**Core:Segment**	**μCi/mL**	**μCi/mL**	%	Ci
BPC.a.^{90}Sr	93-01354	47/49:DLC	0.0102	0.0102	N/A	[illegible]
Solid Core Composite			**μCi/g**	**μCi/g**	%	Ci
BPC.f.^{90}Sr	93-01358	47:CC	1,180	767	39	2.22E+05
	93-01363	48:CC	190			
	93-01371	49:CC	932			
Quarter Segment			**μCi/g**			
BPC.f.^{90}Sr	93-01355	47:1B	4,560			
	93-01356	47:1C	469			
	93-0.1357	47:1D	215			
	93-01360	48:1C	152			
	93-01361	48:1D	121			
	93-01365	49:1B	2,400			
	93-01366	49:1C	196			
	93-01367	49:1D	193			

Table A-4. Tank 241-C-109 Analytical Data: TECHNETIUM-99

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Liquid Composite		**Core:Segment**	**μCi/mL**	**μCi/mL**	%	Ci
LSC.a.^{99}Tc	93-01354	47/49:DLC	0.156	0.156	N/A	1.43
Solid Core Composite			**μCi/g**	**μCi/g**	%	Ci
LSC.w.^{99}Tc	93-01358	47:CC	0.108	0.106	6	30.6
	93-01363	48:CC	0.116			
	93-01371	49:CC	0.0944			

Table A-4. Tank 241-C-109 Analytical Data: TRITIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Liquid Composite		Core:Segment	μCi/mL	μCi/mL	%	Ci
LSC.a.^{3}H	93-01354	47/49:DLC	0.00329	0.00329	N/A	0.0301
Solid Core Composite			μCi/g	μCi/g	%	Ci
LSC.w.^{3}H	93-01358	47:CC	0.00852	0.00710	10	2.05
	93-01363	48:CC	0.00644			
	93-01371	49:CC	0.00635			

Table A-4. Tank 241-C-109 Analytical Data: URANIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Liquid Composite		Core:Segment	μg/g	μg/g	%	kg
LF.a.U	93-01354	47/49:DLC	3.75	3.75	N/A	0.0394
Solid Core Composite			μg/g	μg/g	%	kg
LF.f.U	93-01358	47:CC	12,000	15,700	39	1,540
	93-01363	48:CC	27,600			
	93-01371	49:CC	7,530			

Table A-4. Tank 241-C-109 Analytical Data: TOTAL ALPHA

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Liquid Composite		**Core:Segment**	**µCi/mL**	**µCi/mL**	%	Ci
APC.a.Total α	93-01354	47/49:DLC	< 5.00E-05	< 5.00E-05	N/A	< 4.58E-04
Solid Core Composite			**µCi/g**	**µCi/g**	%	Ci
APC.w.Total α	93-01358	47:CC	< 0.00484	< 0.00187		
	93-01363	48:CC	< 1.35E-04			
	93-01371	49:CC	< 6.25E-04			
APC.f.Total α	93-01358	47:CC	< 0.992	< 0.395	N/A	< 114
	93-01363	48:CC	< 0.0646			
	93-01371	49:CC	< 0.129			
Homogenization Test			**µCi/g**			
APC.a.Total α	93-01361	48:1D TOP	0.0559			
	93-01361	48:1D BOTTOM	0.0600			
	93-01367	49:1D TOP	0.0476			
	93-01367	49:1D BOTTOM	0.0449			

Table A-4. Tank 241-C-109 Analytical Data: TOTAL ALPHA PLUTONIUM

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Solid Core Composite		**Core:Segment**	µCi/g	µCi/g	%	Ci
AEA.f.Total αPu	93-01358	47:CC	0.877	0.341	78	98.6
	93-01363	48:CC	0.0681			
	93-01371	49:CC	0.0790			

Table A-4. Tank 241-C-109 Analytical Data: TOTAL BETA

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Liquid Composite		**Core:Segment**	**µCi/mL**	**µCi/mL**	%	Ci
BPC.a.Total β	93-01354	47/49:DLC	5.43	5.43	N/A	49.7
Solid Core Composite			**µCi/g**	**µCi/g**	%	Ci
BPC.w.Total β	93-01358	47:CC	17.9	11.7		
	93-01363	48:CC	8.60			
	93-01371	49:CC	8.74			
BPC.f.Total β	93-01358	47:CC	2,750	2,120	20	6.13E+05
	93-01363	48:CC	1,310			
	93-01371	49:CC	2,300			

Table A-4. Tank 241-C-109 Analytical Data: MASS ISOTOPIC PERCENT PLUTONIUM-238

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Solid Core Composite		Core:Segment	%	%	%	%
MS.f.^{238}Pu	93-01358	47:CC	0.00500	0.0100		
	93-01363	48:CC	0.0110			
	93-01371	49:CC	0.0140			

Table A-4. Tank 241-C-109 Analytical Data: MASS ISOTOPIC PERCENT PLUTONIUM-239

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Solid Core Composite		**Core:Segment**	%	%	%	%
MS.f.^{239}Pu	93-01358	47:CC	93.2	95.3		
	93-01363	48:CC	97.6			
	93-01371	49:CC	95.0			

Table A-4. Tank 241-C-109 Analytical Data: MASS ISOTOPIC PERCENT PLUTONIUM-240

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Solid Core Composite		Core:Segment	%	%	%	%
MS.f.^{240}Pu	93-01358	47:CC	6.63	4.60		
	93-01363	48:CC	2.30			
	93-01371	49:CC	4.88			

Table A-4. Tank 241-C-109 Analytical Data: MASS ISOTOPIC PERCENT PLUTONIUM-241

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Solid Core Composite		Core:Segment	%	%	%	%
MS.f.^{241}Pu	93-01358	47:CC	0.122	0.0901		
	93-01363	48:CC	0.0364			
	93-01371	49:CC	0.112			

Table A-4. Tank 241-C-109 Analytical Data: MASS ISOTOPIC PERCENT PLUTONIUM-242

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Solid Core Composite		Core:Segment	%	%	%	%
MS.f.^{242}Pu	93-01358	47:CC	0.0241	0.0249		
	93-01363	48:CC	0.0176			
	93-01371	49:CC	0.0329			

Table A-4. Tank 241-C-109 Analytical Data: MASS ISOTOPIC PERCENT URANIUM-234

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Solid Core Composite		Core:Segment	%	%	%	%
MS.f.^{234}U	93-01358	47:CC	0.00605	0.00371		
	93-01363	48:CC	0.00570			
	93-01371	49:CC	0.00535			

Table A-4. Tank 241-C-109 Analytical Data: MASS ISOTOPIC PERCENT URANIUM-235

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Solid Core Composite		Core:Segment	%	%	%	%
MS.f.^{235}U	93-01358	47:CC	0.658	0.673		
	93-01363	48:CC	0.685			
	93-01371	49:CC	0.675			

Table A-4. Tank 241-C-109 Analytical Data: MASS ISOTOPIC PERCENT URANIUM-236

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Solid Core Composite		Core:Segment	%	%	%	%
MS.f.^{236}U	93-01358	47:CC	0.0104	0.00807		
	93-01363	48:CC	0.00540			
	93-01371	49:CC	0.00840			

Table A-4. Tank 241-C-109 Analytical Data: MASS ISOTOPIC PERCENT URANIUM-238

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
RADIONUCLIDE						
Solid Core Composite		Core:Segment	%	%	%	%
MS.f.^{238}U	93-01358	47:CC	99.3	93.3		
	93-01363	48:CC	99.3			
	93-01371	49:CC	99.3			

Table A-5. Tank 241-C-109 Analytical Data: SOLID BULK DENSITY

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
PHYSICAL PROPERTY						
Solid Core Composite		Core/Seg.	μg/mL	μg/mL	%	kg
Solid Density	93-069	47:CC	1.20	1.23		
	93-070	48:CC	1.30			
	93-071	49:CC	1.20			

Table A-5. Tank 241-C-109 Analytical Data: LIQUID BULK DENSITY

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
PHYSICAL PROPERTY						
Solid Core Composite		Core/Seg.	μg/mL	μg/mL	%	kg
Liquid Density	93-069	47:CC	1.20	1.15		
	93-071	49:CC	1.10			

Table A-5. Tank 241-C-109 Analytical Data: pH

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
Physical Property						
Liquid Composite		Core:Segment				
pH	93-01354	47/49:DLC	12.1	12.1		
Solid Core Composite						
pH	93-01358	47:CC	10.8	10.1		
	93-01363	48:CC	10.1			
	93-01371	49:CC	9.40			

Table A-5. Tank 241-C-109 Analytical Data: THERMOGRAVIMETRIC PERCENT WATER

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
Physical Property						
Solid Core Composite		Core/Seg	%	%	%	%
TGA.%H_2O	93-01358	47:CC	14.8	20.7		
	93-01371	49:CC	26.6			
Quarter Segment			%			
TGA.%H_2O	93-01355	47:1B	10.2			
	93-01356	47:1C	18.0			
	93-01357	47:1D	19.7			
	93-01360	48:1D	45.1			
	93-01365	49:1B	4.20			
	93-01366	49:1C	29.6			
	93-01367	49:1D	29.3			

Table A-5. Tank 241-C-109 Analytical Data: PERCENT WATER

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
Physical Property						
Solid Core Composite		Core/Seg	%	%	%	%
%H_2O	93-01358	47:CC	21.5	35.7	54	
	93-01363	48:CC	57.7			
	93-01371	49:CC	27.8			
Quarter Segment			%			
%H_2O	93-01355	47:1B	19.3			
	93-01356	47:1C	28.4			
	93-01357	47:1D	39.4			
	93-01360	48:1C	52.8			
	93-01361	481D	51.6			
	93-01365	49:1B	19.6			
	93-01366	49:1C	38.3			
	93-01367	49:1D	39.6			

Table A-6. Tank 241-C-109 Analytical Data: TOTAL ORGANIC CARBON

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
ORGANIC						
Liquid Composite		**Core:Segment**	**μg/g**	**μg/g**	**%**	**kg**
COUL.TOC	93-01354	47/49:DLC	2,600	2,600	N/A	27.4
Solid Core Composite			**μg/g**	**μg/g**	**%**	**kg**
COUL.Dir.TOC	93-01358	47:CC	3,150	2,850	7	824
	93-01363	48:CC	2,950			
	93-01371	49:CC	2,450			
COUL.w.TOC	93-01358	47:CC	2,310	2,570		
	93-01363	48:CC	3,080			
	93-01371	49:CC	2,330			
Quarter Segment			**μg/g**			
COUL.TOC	93-01355	47:1B	2,150			
	93-01356	47:1C	2,000			
	93-0.1357	47:1D	2,200			
	93-01360	48:1C	3,650			
	93-01361	48:1D	3,280			
	93-01365	49:1B	1,800			
	93-01366	49:1C	2,200			
	93-01367	49:1D	2,550			

Table A-6. Tank 241-C-109 Analytical Data: TOTAL INORGANIC CARBON

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
ORGANIC						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	**%**	**kg**
COUL.TIC	93-01354	47/49:DLC	6,150	6,150	N/A	64.7
Solid Core Composite			**µg/g**	**µg/g**	**%**	**kg**
COUL.Dir.TIC	93-01358	47:CC	5,800	5,450	3	1,580
	93-01363	48:CC	5,150			
	93-01371	49:CC	5,400			
COUL.w.TIC	93-01358	47:CC	5,710	5,260		
	93-01363	48:CC	5,650			
	93-01371	49:CC	4,420			
Quarter Segment			**µg/g**			
TIC	93-01355	47:1B	5,400			
	93-01356	47:1C	5,200			
	93-0.1357	47:1D	5,350			
	93-01360	48:1C	8,650			
	93-01361	48:1D	6,930			
	93-01365	49:1B	3,900			
	93-01366	49:1C	6,600			
	93-01367	49:1D	6,800			

Table A-6. Tank 241-C-109 Analytical Data: TOTAL CARBON

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
ORGANIC						
Liquid Composite		**Core:Segment**	**µg/g**	**µg/g**	%	kg
COUL.TC	93-01354	47/49:DLC	8,750	8,750	N/A	92.1
Solid Core Composite			**µg/g**	**µg/g**	%	**kg**
COUL.Dir.TC	93-01358	47:CC	8,950	8,300	4	2,400
	93-01363	48:CC	8,100			
	93-01371	49:CC	7,850			
COUL.w.TC	93-01358	47:CC	8,010	7,830		
	93-01363	48:CC	8,730			
	93-01371	49:CC	6,740			
Quarter Segment			**µg/g**			
TC	93-01355	47:1B	7,600			
	93-01356	47:1C	7,200			
	93-0.1357	47:1D	7,600			
	93-01360	48:1C	12,500			
	93-01361	48:1D	10,200			
	93-01365	49:1B	5,700			
	93-01366	49:1C	3,800			
	93-01367	49:1D	9,400			

Table A-7. Tank 241-C-109 Analytical Data: EXTRACTABLE HALIDE

Analyte	Sample Number	Sample Identification	Result	Mean	RSD (Mean)	Projected Inventory
ORGANIC						
Solid Core Composite		Core/Seg.	µg/g	µg/g	%	kg
Coul/Titrate.Halide	93-01371	49:CC	10.5	10.5		[illegible]

APPENDIX B

PROCEDURE NUMBERS OF ANALYTICAL METHODS

SINGLE SHELL TANK 241-C-109

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Table B-1. Subsegment-Level Analysis.

Direct	Fusion Dissolution	Water Leach
TOC/TIC	ICP (Metals)	IC (Anions)
TGA	GEA (^{137}Cs)	CN^-
DSC	^{90}Sr	pH
Total CN^-		GEA
Wt% H_2O		

DSC = Differential scanning calorimetry
GEA = Gamma energy analysis
ICP = Inductively coupled plasma
TGA = Thermogravimetric analysis
TIC = Total inorganic carbon
TOC = Total organic carbon

Table B-2. Analytical Methods for Chemical and Radionuclide Analyses.

Analyte	Method	Procedure Number
Hg	Cold Vapor Atomic Absorption	PNL-ALO-213
F^-, Cl^-, NO_3^-, NO_2^-, PO_4^{3-}, SO_4^{2-}	Ion Chromatography	PNL-ALO-212
CN^-	Distillation/Spectrometric Analysis	PNL-ALO-285
U	Laser Fluorimetry	PNL-ALO-445
Total Alpha Total Beta	Proportional Counting	PNL-ALO-421 PNL-ALO-423 PNL-ALO-430 PNL-ALO-431
^{238}Pu, $^{239/240}Pu$, ^{241}Am, ^{237}Np	Alpha Spectrometry	PNL-ALO-423 PNL-ALO-417 PNL-ALO-425
Total Metals	Inductively Coupled Plasma	PNL-ALO-211
^{90}Sr	Beta Proportional Counting	PNL-ALO-433 PNL-ALO-431
^{99}Tc	Liquid Scintillation	PNL-ALO-432
^{129}I	Low Energy Gamma Analysis	PNL-ALO-454
^{14}C ^{3}H	Liquid Scintillation	PNL-ALO-442 PNL-SP-30
^{154}Eu, ^{155}Eu, ^{241}Am, ^{137}Cs, ^{60}Co	Gamma Energy Analysis	PNL-ALO-450
H^+	pH	PNL-ALO-225
As Se	Atomic Absorption	PNL-ALO-214 PNL-ALO-215
Pu Isotopic U Isotopic	Mass Spectrometry	PNL-ALO-455
TOC	Total Organic Carbon	PNL-ALO-381
TIC	Total Inorganic Carbon	PNL-ALO-381

Table B-3. Analytical Methods for Physical and Rheological Testing.

Analyte	Procedure
Particle Size	PNL-ALO-530
Thermogravimetric Analysis	PNL-ALO-508
Differential Scanning Calorimetry	PNL-ALO-508
Specific Gravity	PNL-ALO-501
% Water	PNL-ALO-508
Rheology	WHC-053-1
Visual Inspection	PNL-ALO-501

Table B-4. Analytical Methods For Organic Analyses.

Analysis	Method	Procedure Number
VOA	Gas Chromatography/Mass Spectrometry	PNL-ALO-335
SVOA	Gas Chromatography/Mass Spectrometry	PNL-ALO-345
EOX/TOX	Microcoulometric Titration	PNL-ALO-320

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APPENDIX C

SETTLING RATE BEHAVIOR

SINGLE SHELL TANK 241-C-109

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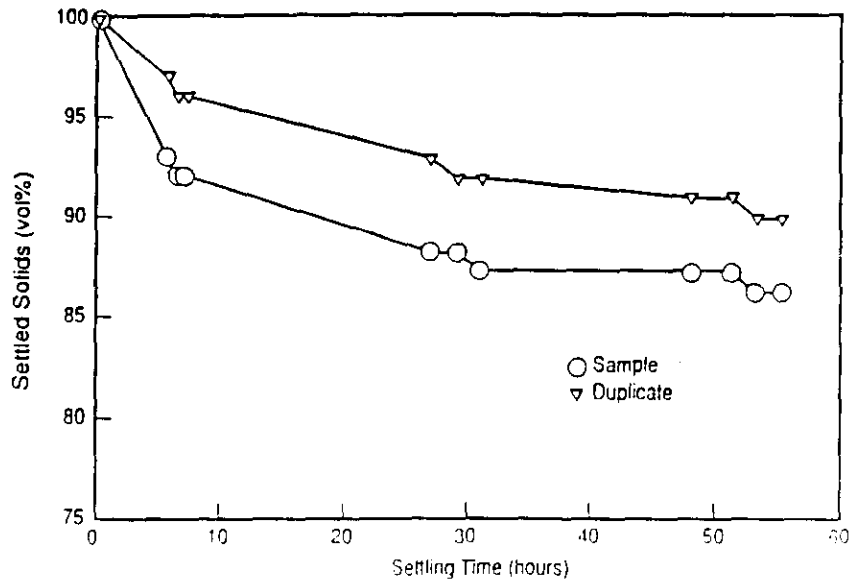
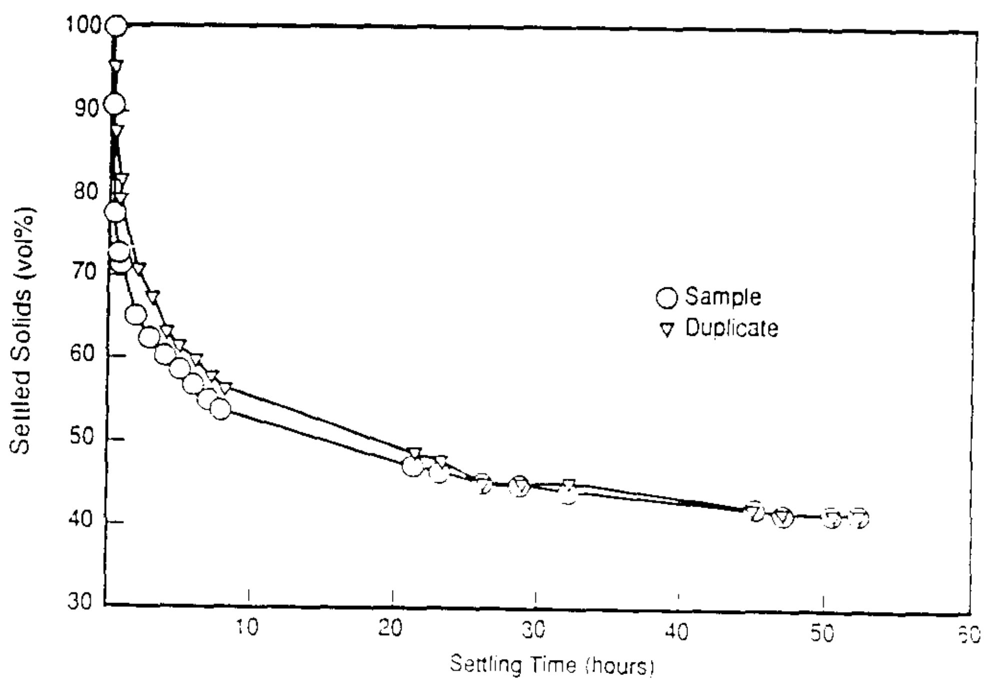
Settling Rate Data for Tank 241-C-109
Core 47, 1:1 Dilution



Settling Rate Data for Tank 241-C-109
Core 47, 3:1 Dilution



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