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Tank Characterization Report for Single-Shell Tank 241-C-106

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

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Abstract: This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-C-106. This report supports the requirements of the Tri-Party Agreement Milestone M-44-09.

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Tank Characterization Report for Single-Shell Tank 241-C-106

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EXECUTIVE SUMMARY

This tank characterization report summarizes information on the historical uses, current status, and sampling and analysis results of waste stored in single-shell underground tank 241-C-106. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order*, Milestone M-44-09 (Ecology et al. 1996).

Tank 241-C-106 is the only tank on the High-Heat Load Watch List. As a result of the analyses addressed by this report, the supernate and upper 60 percent of the sludge in the tank do not pose any safety concerns in addition to the high-heat load issue based on the decision limits of the safety screening data quality objective (DQO) (Dukelow et al. 1995). The lower 40 percent of the sludge was not sampled; therefore, no statements regarding the safety of this waste can be made. A portion of the tank sludge is scheduled to be retrieved in fiscal year 1997 in order to mitigate the high-heat load in the tank.

Tank 241-C-106 is one of 12, 100-series, single-shell, underground waste storage tanks located in the 200 East Area C Tank Farm on the Hanford Site. It is the last tank in a three-tank cascade series beginning with tanks 241-C-104 and 241-C-105. Tank 241-C-106 was constructed between 1943 and 1944 and was put into service in September 1947.

Tank 241-C-106 received its first waste in June 1947 -- metal waste from the cascade overflow of tank 241-C-105. The metal waste was sluiced for uranium recovery in the first quarter of 1953, and the tank became the metal waste supernate blend tank. During the third quarter of 1954, tank 241-C-106 received uranium recovery waste. In the second quarter of 1957, waste from tank 241-C-106 was transferred to tanks 241-C-109 and 241-C-112 for ferrocyanide scavenging of radiocesium. From the second quarter of 1958 until the second quarter of 1960, tank 241-C-106 received cladding waste from the Plutonium Uranium Extraction (PUREX) facility. During the first quarter of 1965, the tank received decontamination waste. From the first quarter of 1969 until the second quarter of 1972, the tank received washed PUREX sludge; this sludge is thought to be the primary source of the heat-generating ^{90}Sr in the tank (Agnew et al. 1996). The tank received wastewater from the third quarter of 1971 until the second quarter of 1975. From the third quarter of 1974 until the second quarter of 1976, the tank received B-Plant low-level waste. From 1976 to 1978, the tank received B-Plant strontium recovery waste, supernate, and complexed and evaporator wastes from tank 241-A-102. Water is periodically added to the tank to cool the tank waste by evaporation. As of May 31, 1996, the tank waste was classified as non-complexed (Hanlon 1996). However, the 1996 grab analysis results exceeded the 100 nCi/g specification limit for classification as transuranic (TRU) waste (Fowler 1995).

A description and status of tank 241-C-106 are presented in Table ES-1 and Figure ES-1. The tank has an operating capacity of 2,006 kL (530 kgal) and as of May 31, 1996, contained approximately 867 kL (229 kgal) of waste. Of this volume, approximately 121 kL (32 kgal) was supernate and 746 kL (197 kgal) was sludge (Hanlon 1996). The sludge is estimated to contain approximately 182 kL (48 kgal) of drainable interstitial liquid. Waste surface levels have remained relatively constant over the past three years, although the supernate surface level fluctuates somewhat as cooling water is added and evaporates.

Table ES-1. Description and Status of Tank 241-C-106

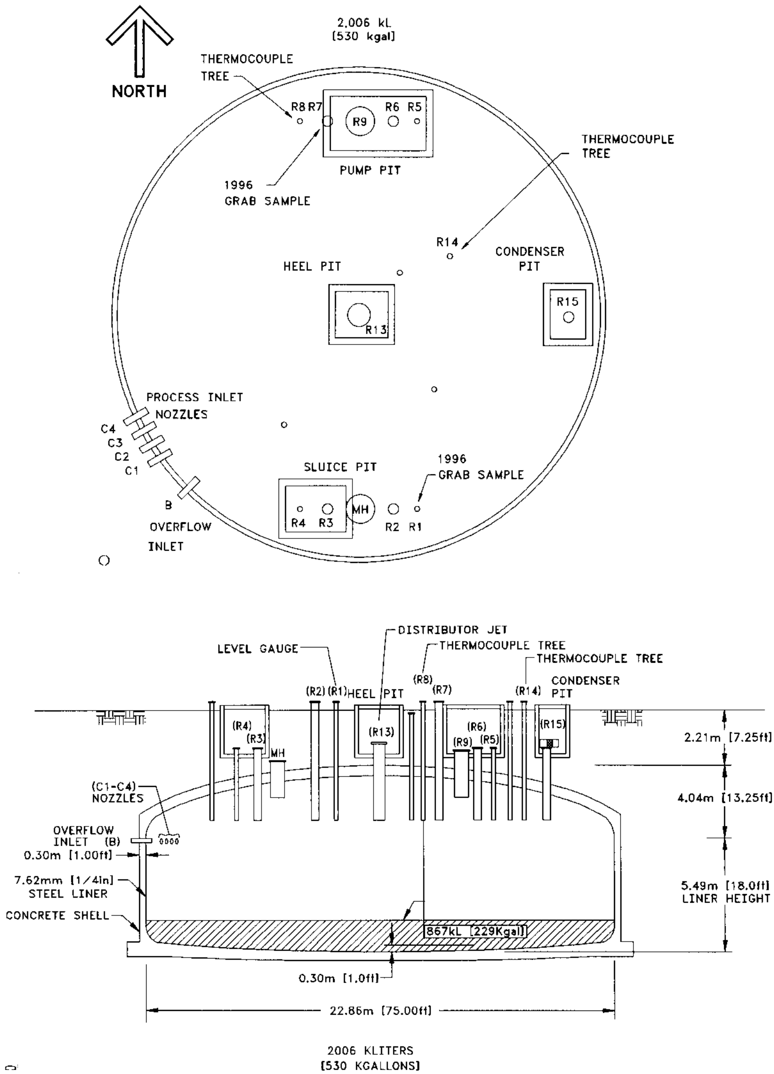
TANK DESCRIPTION	
Type	Single-shell
Constructed	1943 to 1944
In-service	1947
Diameter	23 m (75 ft)
Maximum operating depth	5.2 m (17 ft)
Capacity	2,006 kL (530 kgal)
Bottom shape	Dish
Ventilation	Active
TANK STATUS	
Waste classification	Non-complexed[1]
Total waste volume	867 kL (229 kgal)
Supernate volume	121 kL (32 kgal)
Sludge volume	746 kL (197 kgal)
Drainable interstitial liquid	182 kL (48 kgal)
Waste surface level (June 12, 1996)[2]	195 cm (76.6 in.)
Temperature (1982 to 1996)	7 °C (45 °F) to 98 °C (208 °F)
Integrity	Sound
Watch List	High-Heat Load
SAMPLING DATES	
Grab sample	February/March 1996
Tank headspace vapor samples	February 1994 and March 1996
SERVICE STATUS	
Interim stabilized	not completed
Partially isolated	August 1983
Declared Inactive	March 1979

Note:

[1]Hanlon (1996). However, the 1996 grab sampling results indicate that the transuranic content exceeds the 100 nCi/g limit in Fowler (1995).

[2]Referenced to an offset that is 30 cm (12 in.) above the centerline of the tank (i.e., add 30 cm to the above measurement to obtain the surface level referenced to the tank bottom centerline).

Figure ES-1. Profile of Tank 241-C-106.



The tank surface level on June 12, 1996, was approximately 195 cm (76.6 in) as measured from an offset 30 cm (12 in) above the tank bottom centerline.

The characterization of tank 241-C-106 was based on a grab sampling event that took place during February and March 1996 and vapor samples collected in February 1994 and March 1996. During the 1996 grab sampling event, samples of the supernate and the upper 60 percent of the sludge were taken at different depths from riser 1 and riser 7.

The samples were analyzed at the Westinghouse Hanford Company 222-S Laboratory and the Pacific Northwest National Laboratory in accordance with the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995), *Data Quality Objectives for Tank Farms Waste Compatibility Program* (Fowler 1995), and *Tank 241-C-106 Grab Sample - Technical Letter of Instruction* (Cash and Babad 1996). Sample analyses included determinations for energetics, moisture content, total alpha activity, density, metals, anions, total organic carbon (TOC), and radionuclides (Schreiber 1996a).

Table ES-2 shows concentration and inventory estimates for the most prevalent analytes, analytes of concern, and physical properties of the waste in tank 241-C-106 based on the 1996 grab sample analytical results. The Table ES-2 projected inventory estimates are biased because only the upper 60 percent of the sludge layer was grab sampled, but the entire sludge volume was used to calculate the projected inventory values. In addition, some of the grab samples appeared to be supernate samples where sludge samples were expected. Further, the inventory estimates were obtained by assuming that the grab samples were a random sampling of the waste. If this assumption is not valid, the results given in Table ES-2 are biased. The magnitude of these biases cannot be estimated.

The 1996 grab samples were analyzed in accordance with the safety screening DQO; a summary of the results supporting this DQO follows. Differential scanning calorimetry (DSC) was performed to determine the fuel content of the samples. Only two sample dry-weight DSC exotherm means exceeded the safety screening DQO decision threshold of -480 J/g (dry weight). The largest magnitude mean dry-weight exotherm observed was -681 J/g; the temperature range for the exotherm was 260 to 420 °C (500 to 790 °F). Six samples had exotherms, with a one-sided 95 percent upper confidence limit on the mean, which exceeded the DQO decision threshold; the largest one-sided 95 percent upper confidence limit on the mean value was -1,340 J/g. Although there were a few results that exceeded the safety screening DQO threshold, the sludge has high levels of inert compounds and the organics that are present are energy-poor (i.e., oxalates). Therefore, the likelihood of a propagating exothermic reaction is remote.

The sludge overall mean weight percent water as determined by thermogravimetric analysis (TGA) was 36.3, and the lower limit to a two-sided 95 percent confidence interval on the mean was 24.0. The supernate overall mean weight percent water by TGA was 80.1, and the corresponding lower limit to a two-sided 95 percent confidence interval on the mean was 75.3. These values are in excess of the 17 weight percent water required to prevent propagating exothermic reactions (Turner et al. 1995). Furthermore, the practice of adding cooling water to the waste prevents the waste from drying out.

Table ES-2. Major Analytes and Analytes of Concern. (2 sheets)

	Supernate Mean Value		Sludge Mean Value		Projected Inventory[1]
Metals	**μg/mL**	**RSD of Mean (%)[2]**	**μg/mL**	**RSD of Mean (%)[2]**	**kg**
Aluminum	<3.00E+01	n/a	4.82E+04	10.5	3.60E+04
Calcium	<6.01E+01	n/a	1.31E+03	17.3	9.81E+02
Chromium	<6.01E+00	n/a	6.36E+02	12.7	4.75E+02
Iron	<3.00E+01	n/a	6.28E+04	11.5	4.68E+04
Phosphorous	2.86E+02	6.5	2.37E+03	9.6	1.80E+03
Silicon	<3.00E+01	n/a	2.46E+04	9.0	1.84E+04
Silver	8.01E+00	25.2	1.87E+03	13.0	1.39E+03
Sodium	1.05E+05	1.8	1.77E+05	6.8	1.45E+05
Sulfur	2.58E+03	6.0	2.42E+03	6.1	2.12E+03
Uranium (total)	1.68E+03	7.0	1.61E+03	6.0	1.40E+03
Anions	**μg/mL**	**RSD of Mean (%)**	**μg/mL**	**RSD of Mean (%)**	**kg**
Nitrate	1.32E+03	18.5	2.36E+03	14.6	1.92E+03
Nitrite	2.78E+04	6.8	2.46E+04	4.5	2.17E+04
Oxalate	3.39E+03	6.2	8.02E+04	17.7	6.02E+04
Phosphate	8.62E+02	23.1	1.53E+03	22.4	1.25E+03
Sulfate	7.36E+03	5.7	6.96E+03	4.9	6.08E+03
Radionuclides	**μCi/mL**	**RSD of Mean (%)**	**μCi/mL**	**RSD of Mean (%)**	**Ci**
^{137}Cs	1.08E+02	0.7	6.54E+02	7.5	5.01E+05
$^{239/240}Pu$	7.45E–01	4.0	1.67E+00	8.0	1.33E+03
^{90}Sr	4.23E–01	13.6	5.46E+02	8.2	4.07E+05
Total alpha	1.03E+00	11.7	n/a	n/a	n/a
Carbon[3]	**μg C/mL**	**RSD of Mean (%)**	**μg C/mL**	**RSD of Mean (%)**	**kg C**
Total organic carbon	2.91E+03	13.5	2.00E+04	18.9	1.52E+04
Total inorganic carbon	2.23E+04	9.8	3.60E+04	7.0	2.95E+04

Table ES-2. Major Analytes and Analytes of Concern. (2 sheets)

	Supernate Mean Value		Sludge Mean Value		Projected Inventory[1]
Physical properties	g/mL	RSD of Mean (%)	g/mL	RSD of Mean (%)	kg
SpG/density	1.17	0.9	1.55	2.8	n/a
	Wt%		Wt%		kg
Percent water-gravimetry	80.2	0.4	47.2	4.5	5.33E+05
Percent water-TGA	80.1	0.5	36.3	12.2	6.51E+05

Notes:

n/a = not available

[1]Based on a supernate volume of 121 kL (32.0 kgal) and a sludge volume of 746 kL (197 kgal) (Hanlon 1996).

[2]Relative standard deviation of the mean expressed as 100 times the standard deviation of the mean divided by the mean concentration.

[3]Concentrations of all carbon species given as wet-weight values.

The heat load in the tank produced by radioactive decay was estimated to be between 5,100 W (17,400 Btu/hr) and 8,600 W (29,400 Btu/hr) from the 1996 radionuclide data, assuming uniform distribution of ^{90}Sr and ^{137}Cs. This estimate is lower than the heat-generating capacity criteria of 11,700 W (40,000 Btu/hr) for placing a tank on the High-Heat Load Watch List. However, the distribution of the radionuclides is considered non-uniform. The low 1996 heat load estimate may be indicative of samples that did not sufficiently capture the degree of radionuclide non-uniformity present in the waste. The bulk of the heat-generating radionuclides is thought to reside in the portion of the sludge that was not sampled. Surveillance data show that tank temperatures recorded from two thermocouple trees ranged from 7 °C (45 °F) to 98 °C (208 °F) from 1982 to 1996. On June 12, 1996, temperatures ranged from 26 °C (78.8 °F) to 66.4 °C (151 °F). In general, tank temperature appears to be decreasing with time.

As required by the safety screening DQO, the flammability of the tank headspace gases was measured. Vapor samples taken from the tank headspace were measured for flammability by means of a combustible gas meter prior to grab sampling. Results of zero percent of the lower flammability limit (LFL) were measured for flammable gases in the tank headspace; these results are expected because tank 241-C-106 is actively ventilated. This result is well below the safety screening DQO decision threshold of 25 percent of the LFL. Samples of the tank headspace gases were also taken from the tank exhauster port in February 1994 and March 1996 and analyzed for flammable gases. Both sets of gas analyses showed the concentration of flammable species in the headspace to be less than 10 parts per million by volume (ppmv). During the 1996 vapor sampling event, hydrogen and methane were both measured at less than 10 ppmv. These results are far below the safety screening notification limits of 10,000 ppmv for hydrogen and 12,500 ppmv for methane (Buckley 1996).

Total alpha activity in the samples was determined in order to gauge the potential for criticality in the tank waste. The total alpha activity results for the grab samples were well below the safety screening limits. The highest supernate sample total alpha activity result was 1.03 μCi/mL; the safety screening limit for the supernate was 61.5 μCi/mL. The highest sludge subsample total alpha activity result was 4.38 μCi/g, and the corresponding upper limit to a one-sided 95 percent confidence interval on the mean was 16.7 μCi/g; the safety screening limit for the sludge was 39.8 μCi/g. These results indicate that the potential for a criticality event is low. However, these results do exceed the 100 nCi/g specification limit for classification as TRU waste.

The TOC results were compared with the safety criteria limit of 3.0 weight percent (30,000 μg C/g) on a dry-weight basis (Turner et al. 1995). The overall mean dry-weight result for the supernate was 12,700 μg C/g, and for the sludge was 23,500 μg C/g. The upper limit to a one-sided, 95 percent confidence interval on the mean for the supernate was 29,200 μg C/g, and for the sludge was 29,300 μg C/g. The upper limit to the one-sided, 95 percent confidence interval on the mean dry-weight TOC values for the supernate and the sludge did not exceed the 30,000 μg C/g decision threshold.

During the preparation of the sludge samples for analysis, a second liquid phase was discovered and reported. This phase was designated a potential organic layer and constituted approximately 0.5 to 3 percent of the sludge volume. Babad et al. (1996) report that this layer consisted largely of bis(2-ethylhexyl)phosphate. When subjected to propagating reaction tests, bis(2-ethylhexyl)phosphate did not produce a propagating exothermic reaction.

In summary, the requirements of the safety screening DQO were met for the supernate and upper 60 percent of the sludge in tank 241-C-106. Based on these results and the amount of TOC found, those portions of the tank waste that were sampled should be considered "safe" from an energetics perspective. However, the addition of water to tank 241-C-106 is still necessary to maintain evaporative cooling and prevent the waste from exceeding the tank temperature operating limit of 149 °C (300 °F) (WHC 1996f). Exceeding the operating temperature specification could compromise the tank's integrity.

The waste compatibility evaluation revealed several issues that may affect waste management decisions:

- Exotherm-to-endotherm ratios as determined by DSC were less than the decision threshold value of one for all samples portions (except one that failed the quality control requirements).
- Significant amounts of organic carbon, predominately in the form of oxalate, were found in the tank 241-C-106 waste -- 2,910 μg C/mL (wet-weight) in the supernate, and 20,000 μg C/mL (wet-weight) in the sludge. Therefore, the waste in the tank may need to be segregated from non-complexant waste types when transferred to the double-shell tank system.
- The waste compatibility criticality decision threshold value was 0.800 μCi/mL of $^{239/240}$Pu. The overall mean $^{239/240}$Pu value for the supernate was 0.745 μCi/mL, nearly equalling the threshold value. The overall mean $^{239/240}$Pu value for the sludge was 1.67 μCi/mL, which exceeded the threshold value. The overall mean TRU content of the waste was found to be 0.648 μCi/g for the supernate and 1.08 μCi/g for the sludge; both values exceed the 0.1 μCi/g TRU limit in the DQO.
- The overall supernate mean pH of 10.2 and the caustic demand results of Herting (1996) indicate that the waste is very caustic deficient.

- The heat-load estimates for the tank ranged from 32,200 to 38,700 W (110,000 to 132,000 Btu/hr) (Bander 1993a; Ogden et al. 1996). The decision threshold for the receiver tank, 241-AY-102, is 205,000 W (700,000 Btu/hr). These estimates are based on temperature profiles of the tank waste and assume non-uniform distribution of the heat-generating radionuclides in the waste. Therefore, these estimates differ from those provided earlier which are based on the ^{90}Sr and ^{137}Cs activities in the waste and assume uniform distribution of the radionuclides.
- Waste from tank 241-C-106 exceeds the 100 nCi/g segregation limit, and could be designated as TRU waste.

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LIST OF TERMS

AES	atomic emission spectrometry
ANOVA	analysis of variance
AR	washed PUREX sludge
BL	B-Plant low-level wase
Btu/hr	British thermal units per hour
c/s	counts per second
CEO	change engineering order
Ci	curies
Ci/g	curies per gram
Ci/L	curies per liter
cm	centimeters
CWP	PUREX cladding waste
DBP	dibutyl phosphate
DL	drainable liquid
DQO	data quality objective
DSC	differential scanning calorimetry
ECN	engineering change notice
EDTA	ethylenediaminetetraacetic acid
FCN	facility change notice
ft	feet
ft^3/min	cubic feet per minute
g	grams
g/cc	grams per cubic centimeter
g/L	grams per liter
g/mL	grams per milliliter
FIC	Food Instrument Corporation
GC	gas chromatography
GEA	gamma energy analysis
HDW	Hanford Defined Waste
HEDTA	N-(2-hydroxyethyl)-ethylenediaminetriacetic acid
HTCE	Historical Tank Content Estimate
IC	ion chromatography
ICP	inductively coupled plasma
ICP:A	inductively coupled plasma of acid-digested samples
in.	inches
J/g	joules per gram
kg	kilograms
kg C	kilograms of carbon
kgal	kilogallons
kL	kiloliters
kPa	kilopascals
kW	kilowatts

LIST OF TERMS (continued)

LFL	lower flammability limit
m	meters
mg	milligrams
mL	milliliters
mm	millimeters
m^3/min	cubic meters per minute
mR/hr	milliroentgen per hour
NPH	normal paraffin hydrocarbons
MS	mass spectroscopy
n/a	not available or not applicable
OGIST	Oregon Graduate Institute of Science and Technology
ORNL	Oak Ridge National Laboratory
PAS	PUREX acidified sludge
PFeCN2	ferrocyanide waste
PNNL	Pacific Northwest National Laboratory
ppm	parts per million
ppmv	parts per million by volume
PUREX	Plutonium Uranium Extraction (Facility)
QC	quality control
REML	restricted estimated maximum likelihood
Rev.	revision
RPD	relative percent difference
RSD	relative standard deviation
RSST	reactive systems screening tool
SACS	Surveillance Analysis Computer System
SAP	sampling and analysis plan
SRS	strontium recovery waste
TC	total carbon
TIC	total inorganic carbon
TGA	thermogravimetric analysis
TLM	tank layer model
TOC	total organic carbon
TBP	tributyl phosphate
TRU	transuranic
UR	uranium recovery waste
W	watts
WHC	Westinghouse Hanford Company
WSTRS	Waste Status and Transaction Record Summary
wt%	weight percent
°C	degrees Celsius
°C/minute	degrees Celsius per minute
°F	degrees Fahrenheit

LIST OF TERMS (continued)

μCi/g	microcuries per gram
μCi/L	microcuries per liter
μCi/mL	microcuries per milliliter
μeq/g	microequivalents per gram
μg C/g	micrograms carbon per gram
μg C/mL	micrograms carbon per milliliter
μg/g	micrograms per gram
μg/mL	micrograms per milliliter
μm	micrometers
ΔH	change in enthalpy

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1.0 INTRODUCTION

This tank characterization report summarizes the information on the historical uses, current status, and sampling and analysis results of waste stored in single-shell tank 241-C-106. The tank was grab sampled in 1996 to satisfy the requirements of the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995), the *Data Quality Objectives for Tank Farms Waste Compatibility Program* (Fowler 1995), and *Tank 241-C-106 Grab Sample — Technical Letter of Instruction* (Cash and Babad 1996). In addition, the tank was vapor sampled in 1996 and 1994 in support of Osborne et al. (1994). This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order*, Milestone M-44-09 (Ecology et al. 1996).

Tank 241-C-106 is on the High-Heat Load Watch List. It has been removed from service and is partially isolated. Water is periodically added to the tank for cooling purposes; however, waste removals or additions that substantially affect the tank inventory are unlikely until retrieval activities commence. The concentration estimates reported in this document reflect the composition of the waste based on the most current data.

1.1 PURPOSE

This report summarizes information about the use and contents of tank 241-C-106. When possible, this information will be used to assess issues associated with safety, operations, environmental, and process activities.

1.2 SCOPE

Fifteen grab samples, consisting of both supernate and sludge material, were obtained in February and March 1996. Of these fifteen samples, two supernate and five sludge samples were analyzed in accordance with the requirements of the safety screening and waste compatibility data quality objectives (DQOs) and the technical letter of instruction. The main objectives of the sampling event were four-fold (Schreiber 1996a):

- To verify the High-Heat Load Watch List tank status and identify any additional safety issues associated with tank 241-C-106;
- To ensure that no compatibility issues arise regarding the mixing of tank 241-C-106 waste with tank 241-AY-102 waste during retrieval;
- To spot check the ^{137}Cs content in solution to verify dose estimates during retrieval;

- To measure the ^{90}Sr and transuranic (TRU) content to determine whether these chemical constituents are present in significant quantities in the topmost sludge layer in the tank.

The primary grab sample analyses included the following: differential scanning calorimetry (DSC) to evaluate fuel content and energetics; thermogravimetric analysis (TGA) and gravimetry to determine moisture content; total alpha activity, $^{239/240}Pu$ analysis, and density measurements by centrifugation to evaluate criticality potential; ion chromatography (IC) to determine anion concentrations; inductively coupled plasma/atomic emission spectrometry (ICP/AES) to determine metal concentrations; gamma energy analysis to obtain radiochemical (^{137}Cs) activities; persulfate oxidation and furnace combustion to determine the total organic carbon (TOC) and total inorganic carbon (TIC) concentrations; a visual inspection to determine the presence of a separable organic layer; and separation and beta counting to determine ^{90}Sr content.

The remaining samples obtained from tank 241-C-106 were mainly used for non-routine analyses related to the retrieval of tank 241-C-106 sludge for transfer to tank 241-AY-102. The details and results of these analyses are discussed in *Chemical and Chemically Related Considerations Associated with Sluicing Tank C-106 to Tank AY-102* (Babad et al. 1996).

In addition to the February/March 1996 grab sampling event, vapor sampling events of the tank 241-C-106 headspace gases were performed in February 1994 and March 1996. The March 1996 event obtained one vapor sample from the tank exhaust to assess the flammability of the tank exhaust gases. In February 1994, a complete in-tank headspace gas and vapor characterization was performed in accordance with the *Data Quality Objectives for Generic In-Tank Health and Safety Vapor Issues Resolution* (Osborne et al. 1994). During this event, organic, flammable, and inorganic vapors were analyzed. The 1994 results are summarized in this tank characterization report, and the full details may be found in *Tank 241-C-106 Headspace Gas and Vapor Characterization Results for Samples Collected in February 1994* (Huckaby and Bratzel 1995).

2.0 HISTORICAL TANK INFORMATION

This section describes tank 241-C-106 based on historical information. Details on the current condition of the tank are discussed, followed by discussions of the tank's design, transfer history, and process sources that contributed to the tank waste, including an estimate of the current contents based on the process history. Events that may be related to tank safety issues, such as potentially hazardous tank contents or off-normal operating temperatures, are included. The available surveillance data for the tank are also summarized. Solid and liquid level data are used to determine tank integrity (leaks) and to provide clues on the internal activity in the solid layers of the tank. Temperature data are provided to evaluate the heat-generating characteristics of the waste.

2.1 TANK STATUS

As of May 31, 1996, tank 241-C-106 contained an estimated 867 kL (229 kgal) of waste classified as non-complexed (Hanlon 1996). Liquid waste volume is estimated using an ENRAF® surface level gauge. Solid waste volume is estimated using a combination of a photographic evaluation and a sludge level measurement device. The solid waste volume was last updated on April 28, 1982 and reconfirmed by in-tank video in 1994 (Bander 1995). Table 2-1 lists the amounts of various waste phases existing in the tank.

Table 2-1. Estimated Contents of Tank 241-C-106 as of May 31, 1996.[1]

Waste Form	Estimated Volume[2]	
	kL	kgal
Total waste	867	229
Supernatant liquid	121	32
Sludge	746	197
Saltcake	0	0
Drainable interstitial liquid	61	16
Drainable liquid remaining	182	48
Pumpable liquid remaining	159	42

Notes:

[1]Hanlon (1996)

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

ENRAF® is a registered trademark of ENRAF Corporation, Houston, Texas.

Tank 241-C-106 was removed from service in March 1979. The tank is categorized as sound and is partially isolated. The tank was placed on the High-Heat Load Watch List in January 1991. Active ventilation is used to cool the tank by evaporation. Periodic water additions are made to replace the evaporated moisture. All monitoring systems were in compliance with documented standards as of May 31, 1996 (Hanlon 1996).

2.2 TANK DESIGN AND BACKGROUND

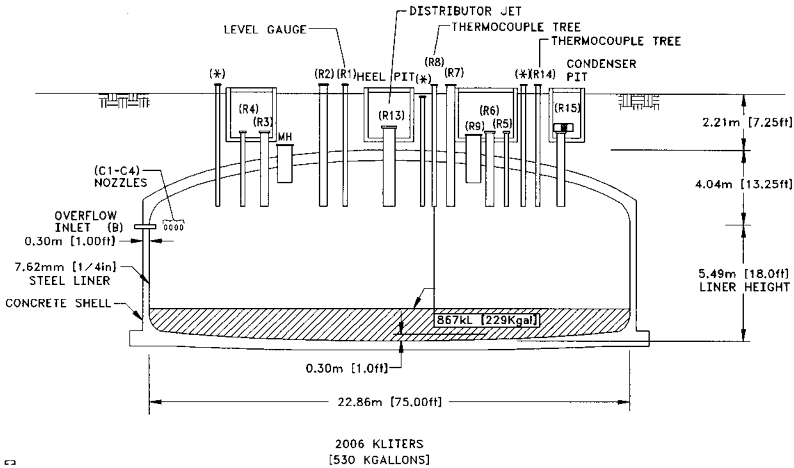
The 241-C Tank Farm was constructed during 1943 and 1944 in the 200 East Area. The farm contains twelve 100-series tanks and four 200-series tanks. The 100-series tanks have a capacity of 2,006 kL (530 kgal), a diameter of 22.9 m (75 ft), and an operating depth of 5.2 m (17 ft). A cascade overflow line 75 mm (3 in.) in diameter connects tank 241-C-106 as third in a cascade series of three tanks beginning with tanks 241-C-104 and 241-C-105. Each tank in the cascade series is set one foot lower in elevation from the preceding tank. The cascade overflow height is approximately 4.9 m (16 ft) from the tank bottom and 600 mm (2 ft) below the top of the steel liner.

The tank has a dished bottom with a 1.2-m (4-ft) radius knuckle. Tank 241-C-106 was designed with a primary mild steel liner (ASTM A283 Grade C) and a concrete dome with various risers. The tank is set on a reinforced concrete foundation. This tank was covered with approximately 2.1 m (7 ft) of overburden. Figure 2-1 depicts a tank cross-section showing the approximate waste level along with a schematic of the tank equipment.

Tank 241-C-106 has 15 risers, according to the drawings and change notices (Alstad 1993). The risers range in diameter from 100 mm (4 in.) to 1.1 m (42 in.). Table 2-2 identifies numbers, diameters, and descriptions of the risers and the nozzles. Figure 2-2 shows a plan view of the riser configuration. Riser 1 and riser 7 are listed as risers tentatively available for sampling (Lipnicki 1996).

ASTM is a registered trademark of the American Society for Testing and Materials.

Figure 2-1. Tank 241-C-106 Configuration.



*Risers installed from Facilities Change Notice (FCN) Nos. 50547 (10/11/79) and 54902 (3/11/81); no riser numbers were given in the FCNs.

Table 2-2. Tank 241-C-106 Risers.[1]

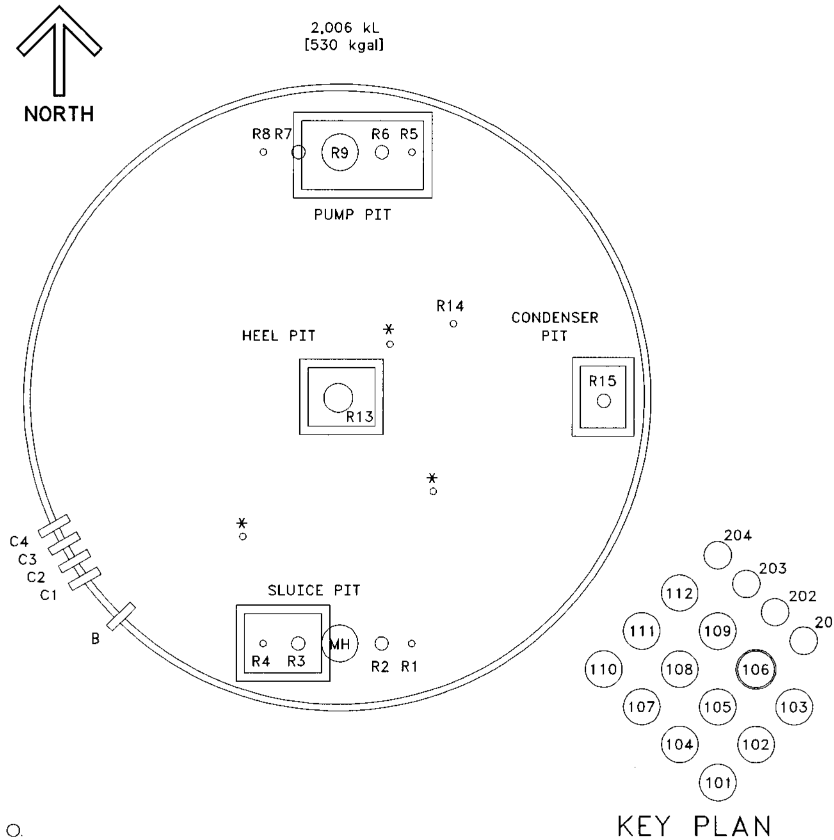
Riser Number	Diameter (inches)	Description and Comments
1	4	FIC level gauge [bench mark, CEO-36922, 12/11/86] [ENRAF® 854, ECN-629511, 01/25/96]
2	12	Exhauster port
3	12	Blank, weather covered
4	4	Recirculating dip leg, weather covered
5	4	Recirculating dip leg, weather covered
6	12	Sluicing access, water addition port
7	12	B-222 Observation Port [multi-port riser adapter, ECN-613184, 08/11/94] [temperature probe, ECN-613207L, 09/15/94] [ENRAF® and pressure gauge, ECN-629512L, 01/30/96]
8	4	Thermocouple tree
9	42	Sludge pump
13	26	Distributor jet, weather covered
14	4	Thermocouple tree
15	12	[Inlet filter, ECN-103653, 10/24/88]
See Note [2]	4	[Add new 10.16 cm (4-in.) riser, FCN-54902, 05/14/81] [Add two new 10.16 cm (4-in.) risers, FCN-50547, 10/16/79]
Nozzle Number	**Diameter (inches)**	**Description and Comments**
B	3	Overflow inlet
C1	3	Spare inlet, capped
C2	3	Spare inlet, capped
C3	3	Spare inlet, capped
C4	3	Spare inlet, capped

Notes:

[1]Alstad (1993), ARHCO (1978), Tran (1993), Vitro (1986)

[2]Created by Facilities Change Notice FCN-50547 and written against Drawing H-2-72352, Rev. 0, and FCN-54902.

Figure 2-2. Riser Configuration for Tank 241-C-106.



*Risers installed from Facilities Change Notice (FCN) Nos. 50547 (10/16/79) and 54902 (5/14/81), no riser numbers were given in the FCNs.

2.3 PROCESS KNOWLEDGE

Section 2.3.1 and Table 2-3 present the history of the major transfers to and from tank 241-C-106, along with a narrative describing the transfers (Agnew et al. 1995; Anderson 1990). Evaporated water sent out of the tank through the condenser is not included in Section 2.3.1 or in Table 2-3. Section 2.3.2 presents an estimate of the tank's contents.

2.3.1 Waste Transfer History

Tank 241-C-106 first received waste via the cascade line from tank 241-C-105 in the second quarter of 1947. This cascade of metal waste from B-Plant continued until the fourth quarter of 1947 when the tank and cascade series were full. The tank remained full until the second quarter of 1953, when waste was transferred to U-Plant for uranium recovery. During the second quarter, the tank also received metal waste from tanks 241-BY-102, 241-C-104, 241-C-105, 241-C-202, 241-C-203, and 241-C-204. The tank received flush water during the third and fourth quarters of 1953. Metal waste slurry was sent to U-Plant for uranium recovery during the fourth quarter of 1953 and the first quarter of 1954. The tank received uranium recovery waste in the third quarter of 1954.

Liquid waste from tank 241-C-106 was sent to tanks 241-C-112 and 241-C-109 for ferrocyanide scavenging during the second quarter of 1957. During the second and third quarters of 1957, the tank received flush water, high-level PUREX waste from tanks 241-A-101 and 241-A-102, and organic wash water from tank 241-A-102. Waste was sent to tank 241-BY-103 during the fourth quarter of 1957.

The tank received cladding waste from PUREX during the second and third quarters of 1958. Supernate was sent to tank 241-BY-110 in the third quarter of 1958. The tank again received cladding waste during the second quarter of 1960. Supernate was sent to tanks 241-B-101 and 241-B-107 in the third quarter of 1963. During 1963 and 1964, waste was received from and sent to tank 241-A-102. The tank received some decontamination waste from the CR Vault during the first quarter of 1965.

In 1968, most of the waste in tank 241-C-106 was sent to tank 241-C-105. In 1969, tank 241-C-106 received washed PUREX waste from the 244-AR Vault. Waste was also sent to tank 241-C-105 during this time. During 1970, the tank received waste from the 244-AR Vault and tank 241-A-106, and waste was sent to tanks 241-C-103 and 241-A-102. In 1971, the tank received waste from the 244-AR Vault and tanks 241-A-104, 241-C-103, and 241-A-102, as well as flush water. During this time, waste was sent to tanks 241-C-103 and 241-C-105. In the second quarter of 1972, tank 241-C-106 received waste from tank 241-A-106.

Table 2-3. Summary of Tank 241-C-106 Waste Transfer History.[1] (2 sheets)

Transfer Location	Waste Type	Time	Estimated Waste Volume[2]	
			In	Out
241-C-105	Metal waste supernate	1947	2,006 kL (530 kgal)	n/a
241-BY-102, 241-C-104, 241-C-105, 241-C-202, 241-C-203, 241-C-204	Metal waste	1953	5,250 kL (1,387 kgal)	n/a
Miscellaneous	Flush water	1953	6,920 kL (1,828 kgal)	n/a
U-Plant	Sluicing metal waste for uranium recovery	1953 - 1954	2,036 kL (538 kgal)	13,930 kL (3,680 kgal)
Miscellaneous	Flush water	1957	621 kL (164 kgal)	n/a
241-C-109, 241-C-112	Uranium recovery waste for ferrocyanide scavenging	1957	n/a	2,082 kL (550 kgal)
241-A-101, 241-A-102	Organic wash waste and high-level PUREX waste	1957	1,821 kL (481 kgal)	n/a
241-BY-103, 241-BY-110	Supernatant	1957 - 1958	n/a	1,753 kL (463 kgal)
PUREX	Cladding waste	1958, 1960	1,589 kL (420 kgal)	n/a
241-B-101, 241-B-107	Supernatant	1963	n/a	1,336 kL (353 kgal)
241-A-102	PUREX waste	1963 - 1964	1,616 kL (427 kgal)	375 kL (99 kgal)
CR Vault	Decontamination waste	1965	136 kL (36 kgal)	n/a
241-C-105	Supernatant	1968 - 1969	n/a	2,411 kL (637 kgal)

Table 2-3. Summary of Tank 241-C-106 Waste Transfer History.[1] (2 sheets)

Transfer Location	Waste Type	Time	Estimated Waste Volume[2]	
			In	Out
244-AR Vault, 241-A-106	Washed PUREX waste	1969 - 1970	3,857 kL (1,019 kgal)	n/a
241-A-102, 241-C-103, 241-C-105	PUREX and low-level B-Plant supernate	1970 - 1971	2,415 kL (638 kgal)	5,474 kL (1,446 kgal)
Miscellaneous	Flush water	1971	102 kL (27 kgal)	n/a
244-AR Vault, 241-A-106	Washed PUREX waste	1971 - 1972	572 kL (151 kgal)	n/a
241-AX-103	Supernatant	1974	n/a	837 kL (221 kgal)
Miscellaneous	Flush water	1974 - 1975	98 kL (26 kgal)	n/a
241-C-103, 241-C-104	Supernatant	1974 - 1976	n/a	9,055 kL (2,392 kgal)
B-Plant	Low-level B-Plant waste	1974 - 1976	11,118 kL (2,937 kgal)	n/a
241-A-102	Strontium recovery waste from B-Plant	1976 - 1977	935 kL (247 kgal)	1,370 kL (362 kgal)
241-AZ-101	Supernatant	1978	n/a	322 kL (85 kgal)
241-A-102	Complexed and evaporator wastes	1978 - 1979	1,382 kL (365 kgal)	1,685 kL (445 kgal)

Note:

[1]Waste volumes and types are best estimates based on historical data. Information was obtained from Anderson (1990) and Agnew et al. (1995).

[2]Waste volumes in table do not include unknown transfers or transfers out to the condenser.

Low-level waste from B-Plant and flush water was sent to tank 241-C-106 from the third quarter of 1974 until the second quarter of 1976. During this time, waste was sent from tank 241-C-106 to tanks 241-AX-103, 241-C-103, and 241-C-104. Strontium recovery waste (SRS) from B-Plant and complexed and evaporator wastes were sent to and received from tank 241-A-102 from 1976 to the first quarter of 1978. During the first quarter of 1978, waste was sent to 241-AZ-101. Waste was again sent to and received from tank 241-A-102 from the second quarter of 1978 to the second quarter of 1979. Tank 241-C-106 was declared inactive in 1979. Agnew et al. (1995) classifies the waste in tank 241-C-106 as non-complexed.

2.3.2 Historical Estimation of Tank Contents

The following is an estimate of the contents for tank 241-C-106 based on historical transfer data. The historical data used for the estimate are taken from the *Waste Status and Transaction Record Summary for the Northeast Quadrant* (WSTRS) (Agnew et al. 1995), the *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 3* (Agnew et al. 1996) (this document contains the Hanford defined waste [HDW] list and the tank layer model [TLM]), and the *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 East Area* (HTCE) (Brevick et al. 1994a).

The WSTRS is a compilation of available waste transfer and volume status data. The HDW provides the assumed typical compositions for approximately 50 waste types. In most cases, the available data are incomplete, thus reducing the reliability of the transfer data and the model results derived from those data. The TLM, using the WSTRS and HDW data, models the waste deposition processes and generates an estimate of the tank contents. Both WSTRS and the HDW introduce errors into the estimated tank contents. Thus, these model predictions are presented for information only and are considered as estimates that require further evaluation using analytical data.

Based on the TLM, tank 241-C-106 contains a layer of supernate and six layers of sludge, which are listed from the last deposit into the tank (top) to the first deposit (bottom): 121 kL (32 kgal) of an unknown waste assumed to be washed PUREX sludge (AR), 121 kL (32 kgal) of an unknown waste assumed to be B-Plant low-level waste (BL), 76 kL (20 kgal) of BL, 242 kL (64 kgal) AR, 129 kL (34 kgal) PUREX cladding waste (CWP), and 57 kL (15 kgal) uranium recovery waste (UR).

Figure 2-3 is a representation of the estimated waste types and volumes for the tank layers (Agnew et al. 1996). In the figure, the unknown layers are assumed to be AR and BL waste types. The UR (bottom waste layer) should contain greater than one weight percent of sodium, iron, uranium, calcium, hydroxide, carbonate, nitrate, and nitrite; between 1 and 0.1 weight percent of phosphate, sulfate, and chloride; and other assorted trace analytes. This layer is expected to show a very small amount of activity from the low amounts of cesium and strontium.

The layer of CWP should contain greater than one weight percent of sodium, aluminum, lead, uranium, hydroxide, nitrate, and nitrite; between 1 and 0.1 weight percent of iron, calcium, and carbonate; and other assorted trace analytes. The amount of cesium and strontium is expected to be very low.

The AR layers should contain greater than one weight percent of sodium, iron, hydroxide, nitrite, carbonate, and silicate; between 1 and 0.1 weight percent of aluminum, nickel, calcium, phosphate, sulfate, and ammonia. These layers will show very high radioactivity, due primarily to the presence of strontium. Cesium is also expected to be present and will contribute to the activity, but the cesium radioactivity is about 1/50th that of strontium.

The BL layer is expected to contain greater than one weight percent of sodium, hydroxide, aluminum, iron, nitrite, carbonate, uranium, and silicate. This waste should contain between 1 and 0.1 weight percent of calcium, phosphate, and glycolate, with trace amounts of other analytes. The activity of this layer is expected to be high in strontium, with no cesium expected. Table 2-4 shows an estimate of the expected tank waste constituents and concentration inventory.

Figure 2-3. Tank Layer Model for Tank 241-C-106.

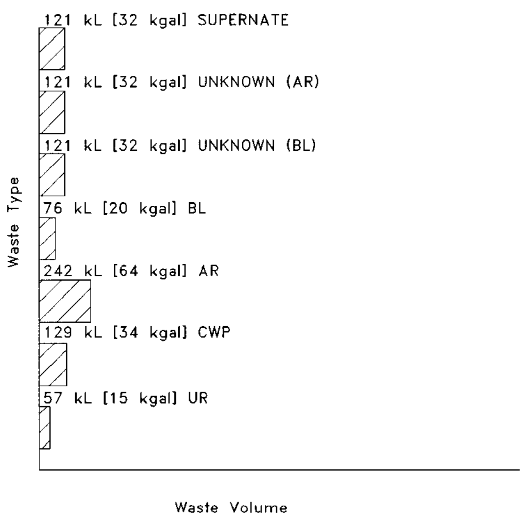


Table 2-4. Tank 241-C-106 Historical Inventory Estimate[1,2] (2 sheets).

Historical Total Inventory Estimate[3]			
Physical properties			
Total solid waste	1.24E+06 kg (229 kgal)		
Heat load	35.6 kW (1.22E+05 Btu/hr)		
Bulk density	1.44 (g/cc)		
Water wt%	58.5		
Total organic carbon wt% carbon (wet)	6.27E-02		
Chemical constituents	**mole/L**	**ppm**	**Total (kg)**
Na^+	4.47	7.16E+04	8.91E+04
Al^{3+}	2.18	4.10E+04	5.11E+04
Fe^{3+} (total iron)	1.17	4.57E+04	5.69E+04
Cr^{3+}	6.52E-03	236	294
Bi^{3+}	4.04E-06	0.588	0.732
La^{3+}	9.73E-19	9.41E-14	1.17E-13
Hg^{2+}	3.75E-04	52.4	65.2
Zr (as $ZrO(OH)_2$)	1.44E-07	9.15E-03	1.14E-02
Pb^{2+}	1.75E-02	2.52E+03	3.14E+03
Ni^{2+}	0.333	1.36E+04	1.69E+04
Sr^{2+}	3.24E-19	1.98E-14	2.46E-14
Mn^{4+}	9.28E-04	35.5	44.2
Ca^{2+}	0.133	3.71E+03	4.61E+03
K^+	5.85E-03	159	198
OH^-	11.9	1.41E+05	1.76E+05
NO_3^-	0.263	1.14E+04	1.41E+04
NO_2^-	0.620	1.99E+04	2.47E+04

Table 2-4. Tank 241-C-106 Historical Inventory Estimate[1,2] (2 sheets).

Chemical constituents	mole/L	ppm	Total (kg)
CO_3^{2-}	0.231	9.66E+03	1.20E+04
PO_4^{3-}	1.75E-02	1.16E+03	1.44E+03
SO_4^{2-}	4.53E-02	3.03E+03	3.77E+03
Si (as SiO_3^{2-})	1.50	2.93E+04	3.64E+04
F^-	1.37E-04	1.82	2.26
Cl^-	2.27E-02	559	696
$Citrate^{3-}$	2.29E-03	302	376
$EDTA^{4-}$	5.12E-13	1.03E-07	1.28E-07
$HEDTA^{3-}$	4.33E-13	8.27E-08	1.03E-07
$Glycolate^-$	3.06E-02	1.60E+03	1.99E+03
$Acetate^-$	1.90E-12	7.81E-08	9.71E-08
$Oxalate^{2-}$	8.32E-19	5.10E-14	6.35E-14
DBP	1.82E-06	0.338	0.420
Butanol	1.82E-06	9.41E-02	0.117
NH_3	0.101	1.20E+03	1.49E+03
$Fe(CN)_6^{4-}$	0.0000	0.0000	0.0000
Radiological constituents			
Plutonium		3.67 (μCi/g)	76.1 (kg)
Uranium	0.152 (M)	2.52E+04 (μg/g)	3.14E+04 (kg)
Cesium	9.66E-02 (Ci/L)	67.3 (μCi/g)	8.37E+04 (Ci)
Strontium	6.03 (Ci/L)	4.20E+03 (μCi/g)	5.23E+06 (Ci)

Notes:

[1]Agnew et al. (1996)

[2]These estimates have not been validated; no decisions affecting the waste in Tank 241-C-106 may be based on these data.

[3]Differences appear to exist among the total inventory and the inventories calculated from the two sets of concentrations. These differences are being evaluated.

2.4 SURVEILLANCE DATA

Tank 241-C-106 surveillance includes surface-level measurements (liquid and solid) and temperature monitoring inside the tank (waste and vapor space). The data provide the basis for determining tank integrity.

Liquid-level measurement may indicate if there is a major leak from a tank. Solid surface-level measurements provide an indication of physical changes and consistency of the solid layers. Tank 241-C-106 has no liquid observation well but has six drywells. None of these drywells have or had measurements greater than the 200 c/s background levels (Brevick et al. 1994b).

2.4.1 Surface Level

Before the February/March 1996 sampling event, an FIC gauge was used for surface level measurements. After the sampling event an ENRAF® gauge was installed in riser 1. The surface level measurements for both gauges were referenced to an offset 30 cm (12 in.) above the tank bottom centerline. The allowable deviations from the tank 241-C-106 baseline of 1.96 m (77 in.) are a 50 mm (2 in.) increase and a 50 mm (2 in.) decrease over two weeks. Although water evaporates from tank 241-C-106 at a rate of approximately 0.25 cm (0.1 in.) per day, the tank is kept within these parameters through periodic water additions. The surface-level reading, from the automatic ENRAF® surface-level gauge, on June 12, 1996, was 1.95 m (76.6 in.) (WHC 1996d). Figure 2-4 is a graphical representation of the tank volume history.

2.4.2 Internal Tank Temperatures

Tank 241-C-106 has two thermocouple trees to monitor the waste temperature: tree 1 in riser 8 has six thermocouples, and tree 2 in riser 14 has 12 thermocouples. Elevations of the thermocouples are available for both trees. Plots of the individual thermocouple readings can be found in *Supporting Document for the Historical Tank Content Estimate for C Tank Farm* (Brevick et al. 1996).

Temperature data, obtained from the Surveillance Analysis Computer System (SACS), were recorded beginning in April 1982. Data are available for all thermocouples on both trees. The mean temperature of the SACS data for thermocouple tree 1 is 41.6 °C (106.9 °F), with a minimum temperature of 10.3 °C (50.5 °F) and a maximum temperature of 98 °C (208 °F). The mean temperature of the SACS data for thermocouple tree 2 is 32 °C (89.5 °F), with a minimum temperature of 7 °C (45 °F) and a maximum temperature of 102.5 °C (216.5 °F). The mean temperature of the SACS data for thermocouple tree 1 for the last year is 40.3 °C (104.5 °F), with a minimum temperature of 10.3 °C (50.5 °F) and a maximum temperature of 70 °C (158 °F). The mean temperature of the SACS data for thermocouple tree 2 for the last year is 29.7 °C (85.4 °F), with a minimum temperature of

9.2 °C (48.6 °F) and a maximum temperature of 59 °C (138 °F). Tank 241-C-106 is on the High-Heat Watch List and has a weekly temperature monitoring requirement. On June 12, 1996, the low temperatures recorded were 26.5 °C (79.7 °F) from tree 1 on thermocouple 6 and 26 °C (78.8 °F) from tree 2 on thermocouple 6 and the high temperature recordings were 66.4 °C (151.52 °F) from tree 1 on thermocouple 1 and 52 °C (125.6 °F) from tree 2 on thermocouple 1. Figure 2-5 shows a graph of the weekly high temperature.

Like many other single-shell tanks, the lowest thermocouple in either of the trees tends to have the highest temperature reading. Thermocouples 2 and 3 on both trees are in layers with high predicted amounts of strontium; however, the temperatures of these thermocouples do not exceed those of thermocouple 1 on either tree.

From March through June 1994, a process test that stopped water additions to tank 241-C-106 was performed. After the water additions were resumed, temperature readings on tree 2 (riser 14) immediately began to rise, while temperature readings from tree 1 (riser 8) remained approximately the same. These temperature anomalies were investigated as an unusual occurrence. The conclusion was that before resuming the water additions, an annular air gap surrounded tree 2 in riser 14 and insulated the thermocouples from direct contact with the waste. After addition of the cooling water, the air gap filled with waste and the temperatures at the thermocouples increased as the waste came into direct contact with the tree. While there was a local temperature change around riser 14, it was believed that there was no change in the safety status of the tank or the bulk thermal conditions in the tank (Hanlon 1994).

Figure 2-4. Tank 241-C-106 Level History.

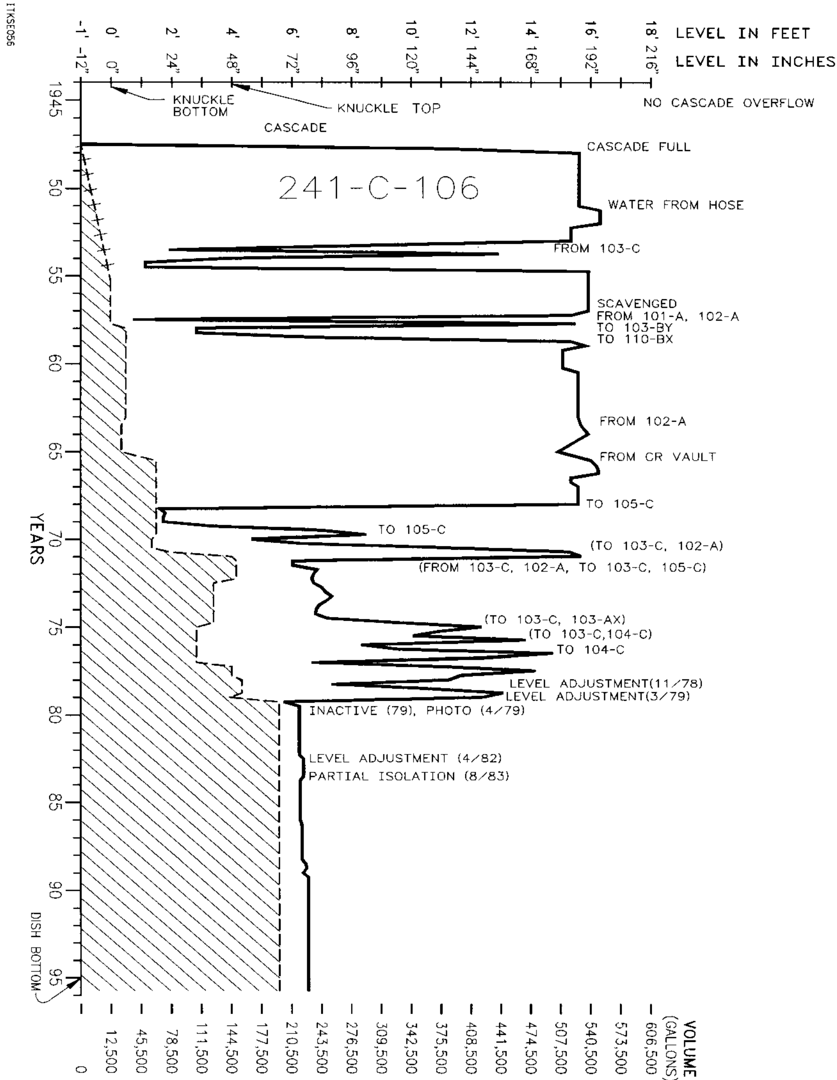
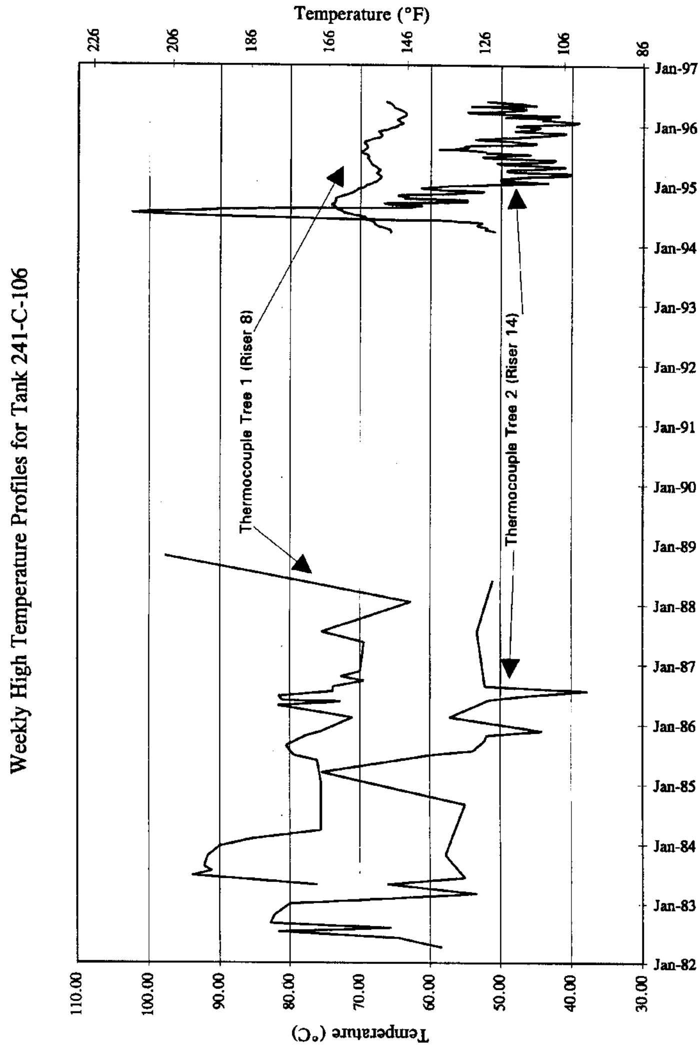


Figure 2-5. Tank 241-C-106 Weekly High Temperature Plot.



2.4.3 Tank 241-C-106 Photographs

Digitized images are electronically available from an in-tank video of tank 241-C-106 that was taken on June 15, 1994 (WHC 1996e). A 1979 photographic montage of the tank 241-C-106 interior is also available; however, it only shows part of the tank and is very difficult to interpret. No in-tank images or photographs are presented in this report because the digitized images have not been assembled to show a good representation of the tank interior, and the photographs from tank 241-C-106 are not very clear. Based on the 1979 photograph, tank 241-C-106 appears to have a rust brown supernate surface. Water has been added to this tank since the video and the photographs; therefore, these observations may not represent present tank conditions. The tank contained approximately 867 kL (229 kgal) of waste at the time the video was taken and 833 kL (220 kgal) of waste at the time the photographs were taken.

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3.0 TANK SAMPLING OVERVIEW

This section describes the February/March 1996 grab sampling event of tank 241-C-106 and March 1996 and February 1994 vapor sampling events for the tank. Seven historical sampling and analysis events of the tank waste from 1974 to 1986 are also summarized. Section 3.1 describes the grab sampling event of February/March 1996 and the subsequent analysis of those samples. The two headspace vapor sampling events from February 1994 and March 1996 are briefly discussed in Section 3.2. Section 3.3 presents the seven historical sampling events for tank 241-C-106 from 1974 to 1986, which are presented in reverse chronological order. The historical data from these events are tabulated in Appendix D. Because tank 241-C-106 was deactivated in 1979, the samples taken after the deactivation date should represent the present tank constituents.

3.1 DESCRIPTION OF FEBRUARY/MARCH 1996 SAMPLING EVENT

The February/March grab samples were taken to satisfy the requirements of the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995), *Data Quality Objectives for Tank Farms Waste Compatibility Program,* (Fowler 1995), and *Tank 241-C-106 Grab Sample — Technical Letter of Instruction* (Cash and Babad 1996). The sampling and analyses were performed according to the *Tank 241-C-106 Grab Sampling and Analysis Plan* (Schreiber 1996a) and the *Sample Preparation of Tank 241-C-106 Grab Samples and Testing for Compatibility with Tank 241-AY-102 Supernate* test plan (Crawford 1996a). Table 3-1 summarizes the DQO sampling and analysis requirements that governed the February/March 1996 sampling event. The test plan requirements are not included in this table. A generic discussion of the sampling and analysis procedures may be found in the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

Grab samples were taken from tank 241-C-106 during two separate sampling events -- one on February 8, 1996, the second on February 24 and March 1, 1996 (Esch 1996). No cooling water additions to the tank were made during or between the February and March 1996 sampling events. All samples were collected in glass bottles and were a nominal 125 mL in volume. The February 8, 1996, sampling event yielded four samples numbered 6C-96-1 through 6C-96-4. Duplicate samples were collected at two different depths through riser 1 to capture samples of supernate and sludge.

The four samples were shipped to and received at the Westinghouse Hanford Company (WHC) 222-S Laboratory for analysis on February 8, 1996. At the laboratory, the samples were to be maintained at a temperature of approximately 55 °C (130 °F) in a water bath to keep the samples in a state similar to that of the tank. Unfortunately, the water bath went dry and overheated the samples. Upon overheating, the containers for supernate samples 6C-96-1 and 6C-96-2 cracked and those samples evaporated to dryness. The container for sludge sample 6C-96-3 also cracked and the sludge dried out. The container for sample

6C-96-4 remained intact, and this sample was analyzed as planned. For a discussion of observations related to this incident, please refer to Section 5.5.1.

Table 3-1. Integrated Data Quality Objective Requirements for Tank 241-C-106 1996 Grab Samples.

Applicable DQO	Sampling Requirements	Analytical Requirements
Safety screening[1]	Vertical profile from two widely spaced risers and field blank	▸ Moisture content (TGA) ▸ Energetics (DSC) ▸ Density (for sludges and saltcakes) ▸ Total alpha activity ▸ Flammability of tank headspace gases/tank headspace flammable gas concentration
Waste compatibility[2]	not defined	▸ Moisture content (TGA) ▸ Energetics (DSC) ▸ Density, viscosity, vol% solids, pH, cooling curve[3] ▸ TRU ($^{239/240}$Pu, ^{241}Am) ▸ $^{233/235}$U[3] ▸ ^{90}Sr, ^{137}Cs ▸ TOC, separable organics ▸ IC anions ▸ Carbonate, hydroxide ▸ Aluminum, Sodium

Notes:

[1]Dukelow et al. (1995)

[2]Fowler (1995)

[3]The sampling and analysis plan (Schreiber 1996a) did not require the determinations of the cooling curve or of $^{233/235}$U.

The second sampling event occurred on February 24, 1996, (riser 1) and March 1, 1996 (riser 7). All samples were collected in glass bottles and had a nominal volume of 125 mL. The second set of samples were again collected at depths to provide supernate and sludge samples. Five grab samples (numbered 6C-96-5 through 6C-96-10) were acquired through riser 1. Grab sample 6C-96-9 was not recovered from the tank because the sample bottle broke during the sampling process. Six grab samples (numbered 6C-96-11 through 6C-96-16) were collected through riser 7. A field blank, 6C-96-17, was also acquired and sent to the laboratory. The blank was prepared by filling a sample bottle with deionized water. It was then lowered to a depth of 6.7 m (22 ft) below the top of riser 1 into the tank domespace. All samples were received at the 222-S Laboratory within 16 hours of sample collection. Table 3-2 provides additional information about the samples from both sampling events.

Prior to sampling each riser, the tank headspace was field screened to determine the flammability of the tank headspace gases as required by the safety screening DQO. Tank headspace gas samples were drawn from 6.1 m (20 ft) below the tops of risers 1 and 7. Tank headspace flammability was determined using a portable combustible gas meter. Section 4.4.1 and Table 4-7 report the results of the flammable gas screenings.

3.1.1 Sample Handling (February/March 1996 Grab Samples)

This section summarizes the sample handling and sample preparation for the February/March 1996 grab samples (Esch 1996). The February/March 1996 grab samples were received in the 222-S Laboratory on February 8 and 24, and March 1, 1996. The samples were loaded into a hot cell and visually examined; Table 3-3 describes each grab sample and Table 3-4 provides a synopsis of how each sample was prepared for analysis. Appendix B contains a flowchart of how each sample was prepared for analysis.

Table 3-2. Tank 241-C-106 February/March 1996 Sample Identification Numbers, Dates, Elevations, and Dose Rates.[1]

Sample Number	Laboratory Number	Date Sampled	Date Received	Sample Elevation[2,3] [m (in.)]	Contact Dose Rate (mR/hr)
Riser 1					
6C-96-1	S96T000529	2/8/96	2/8/96	1.68 (66)	700
6C-96-2	S96T000603	2/8/96	2/8/96	1.68 (66)	600
6C-96-3	S96T000530	2/8/96	2/8/96	0.97 (38)	2,500
6C-96-4	S96T000532	2/8/96	2/8/96	0.91 (36)	3,500
6C-96-5	S96T000836	2/23/96	2/24/96	1.88 (74)	1,000
6C-96-6	S96T000840	2/23/96	2/24/96	1.88 (74)	1,600
6C-96-7	S96T000537	2/23/96	2/24/96	1.52 (60)	3,000
6C-96-8	S96T000843	2/23/96	2/24/96	1.52 (60)	2,500
6C-96-10	S96T000531	2/23/96	2/24/96	1.35 (53)	2,100
6C-96-17[4]	S96T000855	2/23/96	2/24/96	5.49 (216)	< 0.5
Riser 7					
6C-96-11	S96T001021	3/1/96	3/1/96	1.88 (74)	1,000
6C-96-12	S96T001022	3/1/96	3/1/96	1.65 (65)	1,000
6C-96-13	S96T001026	3/1/96	3/1/96	1.23 (48)	2,500
6C-96-14	S96T001028	3/1/96	3/1/96	1.23 (48)	1,500
6C-96-15	S96T001027	3/1/96	3/1/96	1.23 (48)	800
6C-96-16	S96T001029	3/1/96	3/1/96	1.17 (46)	800

Notes:

[1]Esch (1996)

[2]Schofield (1996)

[3]Sample elevation is the vertical distance from the tank bottom centerline to the mouth of the sample bottle.

[4]Sample 6C-96-17 was the field blank.

Table 3-3. Tank 241-C-106 February/March 1996 Grab Sample Descriptions.[1] (2 sheets)

Sample Number	Sample Type	Percent Settled Solids	Sample Description
Riser 1			
6C-96-1	supernate	trace	Clear yellow liquid; no organic layer; trace of yellow/brown solids and rust colored pieces of material.
6C-96-2	supernate	trace	Clear yellow liquid; no organic layer; trace of rust colored flakes.
6C-96-3	sludge	100%	Brown/black solids with no apparent supernate or organic layer.
6C-96-4	sludge	100%	Brown/black solids with no apparent supernate or organic layer.
6C-96-5	supernate	20%	Slightly cloudy yellow liquid; no organic layer; red/brown solids.
6C-96-6	sludge	80%	Slightly cloudy yellow liquid; no organic layer; red/brown solids.
6C-96-7	sludge	100%	Brown solids with no apparent supernate or organic layer - sludge contained large pieces of very hard solid material.
6C-96-8	sludge	100%	Brown solids with no apparent supernate or organic layer - no chunks of harder material were noted.
6C-96-10	sludge	100%	Brown solids with no apparent supernate or organic layer.
6C-96-17	field blank	none	Clear colorless liquid; no organic layer; no solids.
Riser 7			
6C-96-11	sludge	82.3%	Cloudy yellow liquid; no organic layer; red/brown solids.
6C-96-12	supernate	1.2%	Clear yellow liquid; no organic layer; red/brown solids.

Table 3-3. Tank 241-C-106 February/March 1996 Grab Sample Descriptions.[1] (2 sheets)

Sample Number	Sample Type	Percent Settled Solids	Sample Description
Riser 7 (continued)			
6C-96-13	sludge	approx. 100%	Red/brown solids with a trace of supernate on top - no apparent organic layer.
6C-96-14	sludge	approx. 100%	Red/brown solids with a trace of supernate on top - no apparent organic layer.
6C-96-15	supernate	14%	Clear yellow liquid; no organic layer; red/brown solids - solids appeared to have white crystalline material on the surface at the time the sample was loaded into the hotcell.
6C-96-16	supernate	9%	Slightly cloudy yellow liquid; no organic layer; red/brown solids - no visible crystalline material.

Note:

[1]Esch (1996)

Table 3-4. Tank 241-C-106 February/March 1996 Grab Sample Breakdown Information.[1] (2 sheets)

Sample Number	Laboratory Number	Sample Breakdown
Riser 1		
6C-96-1	S96T000529	Sample overheated and jar broke; no analysis performed.
6C-96-2	S96T000603	Sample overheated and jar broke; no analysis performed.
6C-96-3	S96T000530	Sample dried due to overheating, limited analysis performed.
6C-96-4	S96T000532	Sample overheated. Ultrafiltered to separate solids and liquids, then each phase was subsampled.
6C-96-5	S96T000836	Ultrafiltered supernate in centrifuge at tank temperature, then subsampled.
6C-96-6	S96T000840	Archived for possible future analysis.
6C-96-7	S96T000537	Ultrafiltered to separate solids and liquids, then subsampled each phase.
6C-96-8	S96T000843	Removed separable supernate and subsampled sludge for caustic demand, viscosity, particle size and compatibility mixing studies with tank 241-AY-102 waste.
6C-96-10	S96T000531	Ultrafiltered to separate solids and liquids, then subsampled each phase.
6C-96-17[2]	S96T000855	Subsampled for liquid analyses.
Riser 7		
6C-96-11	S96T001021	Ultrafiltered to separate solids and liquids, then subsampled each phase.
6C-96-12	S96T001022	Ultrafiltered supernate in centrifuge at tank temperature, then subsampled.
6C-96-13	S96T001026	Ultrafiltered to separate solids and liquids, then subsampled each phase.

Table 3-4. Tank 241-C-106 February/March 1996 Grab Sample Breakdown Information.[1] (2 sheets)

Sample Number	Laboratory Number	Sample Breakdown
Riser 7 (continued)		
6C-96-14	S96T001028	Removed separable supernate and subsample sludge for caustic demand, viscosity, particle size and compatibility mixing studies with tank 241-AY-102 waste.
6C-96-15	S96T001027	Subsampled supernate for metals (ICP) and anions (IC) analysis.
6C-96-16	S96T001029	Archived for possible future analysis.

Notes:
[1]Esch (1996)

[2]Field blank

As previously noted in Section 3.1, the first four grab samples from riser 1 (6C-96-1 through 6C-96-4) were to be maintained at approximately 55 °C (130 °F) in a water bath to keep the samples at tank temperature. When the water bath went dry, the samples overheated to about 200 °C (392 °F). The sample jars for supernate samples 6C-96-1 and 6C-96-2 broke, resulting in the loss of these samples. Sludge sample 6C-96-3 overheated and dried out; the dried sludge was homogenized by grinding with a mortar and pestle in the hot cell. The resulting solids, designated as *sludge*, were subdivided into two samples and were submitted for analysis by DSC, TGA, TOC, and ion chromatography. Sludge sample 6C-96-4 also overheated, but its sample container remained sealed and intact with no apparent drying of the sample. Because sample 6C-96-4 appeared to be unaffected by the overheating, the sample was analyzed as planned.

When samples 6C-96-15 and 6C-96-16 were loaded into the hotcell, both had approximately 10% settled solids. The laboratory was asked to attempt to collect the crystalline material from sample 6C-96-15 to determine if oxalate was present. However, after standing at ambient hotcell temperature for about a week, most of the solids had dissolved, leaving only a trace of solids on the bottom of the sample bottles. This redissolution of solids most likely occurred because the samples warmed from the colder field temperature to the warmer temperature of the hot cell. No crystalline material remained in sample 6C-96-15. Because there were insufficient solids to collect for analysis, a decision was made to perform a limited set of analyses on the supernate of sample 6C-96-15. Sample 6C-96-16 was archived for possible future analysis.

Aliquots of supernate samples 6C-96-5, 6C-96-12, and 6C-96-15 were ultrafiltered in a filter centrifuge cone prior to subsampling for analysis.

The tank sampling and analysis plan required that the sludge samples be ultrafiltered in filter centrifuge cones for maximum separation of solids and liquids (Schreiber 1996a). Initial attempts to ultrafilter a sludge sample revealed the existence of a two-phase liquid layer, where the top phase was thought to be a liquid organic phase. Notification was made to the East Tank Farms Shift Operations manager and to the program contact.

To prevent the potential organic phase from interfering with the ultrafiltration step, the sampling and analysis plan was changed to allow an initial centrifugation of the sludge prior to the ultrafiltration step (Crawford 1996a). The solid and liquid fractions from this initial centrifugation were then separated, and the solid fraction was subjected to ultrafiltration.

The sludge sample breakdown scheme is discussed as follows (see Appendix B for diagrams of the breakdown scheme):

Any standing supernate in the original sludge sample was decanted and archived; no analyses were performed on this standing supernate. The remaining sludge, still in the original sample bottle, was then subsampled into two 50-mL centrifuge cones and two 15-mL tapered centrifuge cones. (The exception to this scheme was sample 6C-96-7, for which the 15-mL tapered cones were loaded with portions of the centrifuged solids from 50-mL cones.) Both sets of cones were centrifuged in a heated centrifuge, typically at 35 to 50 °C (95 to 122 °F), to separate the liquid and solid phases.

The supernate from the 50-mL cones frequently exhibited two liquid phases. The top phase, identified as *potential organic layer*, typically formed about 0.5 to 3 percent by volume of the centrifuged sample. The supernate phases were decanted from the two 50-mL cones, combined, and either centrifuged again or ultrafiltered in filter centrifuge cones. The two liquid phases were then separated; the lower liquid (presumably aqueous) phase was designated as *decanted supernate*.

The potential organic layers that were separated after the centrifugation of samples 6C-96-7, 6C-96-10, 6C-96-11 and 6C-96-13 were analyzed for energetics by DSC and for percent moisture by TGA. The potential organic layers from samples 6C-96-7 and 6C-96-13 were then shipped to the Pacific Northwest National Laboratory (PNNL) for determination of TOC and for further analysis by gas chromatography/mass spectroscopy (GC/MS). The potential organic layers from samples 6C-96-10 and 6C-96-11 were analyzed for TOC, and $^{239/240}$Pu at the 222-S Laboratory.

The DSC and TGA analysis results from samples 6C-96-7, 6C-96-10, 6C-96-11, and 6C-96-13 exhibited poor precision. It was speculated that inclusions of supernate or sludge particulates in the potential organic layer may have been the source of this behavior. Therefore, in an attempt to improve the precision of the analyses for the potential organic layer from sample 6C-96-4, the sample was washed with aqueous sodium nitrate. It was believed that washing the layer could remove any potential inclusions and thus improve the precision of the DSC and TGA results.

The wash consisted of adding 0.024 mole/L aqueous sodium nitrate in a ratio of 17.26 g solution to 1 g of the potential organic layer. The concentration of the sodium nitrate solution was chosen to approximate the sodium nitrate concentration in the mother liquor originally in contact with the potential organic layer. The mixture foamed upon adding the sodium nitrate wash solution to the potential organic layer. The foam broke up after approximately 30 minutes and left a clear, red-brown root-beer-colored solution with a small amount of settled solids. The solution was centrifuged in an attempt to recover the washed potential organic layer, but only a very slight ring of material separated. A decision was made to analyze the washed potential organic layer sample only for $^{239/240}Pu$.

The centrifuged solid phase from the two 50-mL cones was not combined. Small portions (0.5 to 1 g) of solids were extracted from one or both cones and combined (if from both cones) into a sample identified as *control sample*. The remainder of the solids in the 50-mL cones were loaded into two to four filter centrifuge cones for the ultrafiltration step. After ultrafiltration in the centrifuge, the filtrate was collected, combined, and designated as *interstitial liquid*. The filtered solids were likewise collected, homogenized together, and designated as *filtered centrifuged solids*.

For the sludges, the majority of the analytical results were generated from the interstitial liquid and filtered centrifuged solids samples. However, because the initial centrifugation step separated most of the liquid from the sludge, there was occasionally insufficient interstitial liquid remaining to perform all of the requested analyses on this sample portion. For some of the sludges, there was enough decanted supernate from the initial centrifugation step to perform some of the liquid analyses. For sample 6C-96-10, all of the decanted supernate from the 50-mL cones was inadvertently spilled in the hot cell. In either case, analyses were assigned to the interstitial liquid and the decanted supernate, according to the priority given from the safety program and to the extent that sample was available.

Two 15-mL tapered centrifuge cones were loaded with settled sludge from the parent sample jar (except for sample 6C-96-7 for which the 15-mL tapered cones were loaded with portions of the centrifuged solids from 50-mL cones). After centrifugation of the two 15-mL cones, any supernate recovered from those cones was decanted, combined, and also designated as *decanted supernate*; no potential organic layers were recovered from the supernate decanted from the 15-mL cones. For a given sludge sample, the decanted supernate from the 15-mL cones was kept separate from that of the 50-mL centrifuge cones, and the two sets of decanted supernate were given their own laboratory identification numbers. After removal of any supernate, the 15-mL cones were returned to the heated centrifuge and centrifuged until dried to a constant weight. An aliquot of about 0.1 to 1 g of the dried solids was removed from the 15-mL cones and designated as *centrifuged solids*. The centrifuged solids were submitted for determination of particle density and for analysis by DSC and TGA.

3.1.2 Sample Analysis (February/March 1996 Grab Samples)

This section summarizes the analytical methods used to analyze the samples after the sample handling and preparation described in Section 3.1.1. The analyses were performed in support of the safety screening and waste compatibility DQOs and a letter of instruction from the Tank Waste Remediation Systems Safety Program Office, as described in Section 3.1 and Table 3-1.

Table 3-5 summarizes the analytical procedures performed and the procedure numbers used on the samples. Appendix B charts the breakdown of the grab samples and the analyses performed on the prepared samples. The weight percent of water was determined using TGA and gravimetry. The fuel content or energetics of the waste was determined by DSC. Metals were determined using ICP; the solid samples were prepared by acid digestion. Anions were determined using IC; solid samples were prepared using a water leach, and liquid samples were analyzed directly. The TOC was determined using either furnace oxidation or hot persulfate oxidation followed by coulometric titration. The TIC was determined by sulfamic acid/sulfuric acid evolution of carbon dioxide with coulometric titration detection. Sample pH was determined using a glass pH electrode. For solid samples, pH was determined in a water leach of the solid sample. Ammonium was determined with an ammonium-selective electrode and the method of standard additions.

Radiochemical determinations were performed on direct mounts or chemical separations of liquid samples. The sludge samples were dissolved by using an alkali metal fusion (potassium or sodium hydroxide) procedure followed by dissolution with dilute hydrochloric acid, and an aliquot of the dissolved sludge was then mounted or separated for counting. Total alpha activity was determined using an alpha proportional counter. ^{90}Sr was determined using a strontium carbonate carrier precipitation followed by beta counting. ^{99}Tc was determined by extracting the ^{99}Tc into an organic extractant followed by liquid scintillation counting. ^{137}Cs was determined by gamma energy analysis. $^{239/240}Pu$ and ^{241}Am were determined by ion-exchange separation followed by total alpha counting and alpha energy analysis.

In addition to the standard analytical determinations tabulated in Table 3-5, Schreiber (1996a) and Crawford (1996a) required several other analyses be performed on the tank 241-C-106 samples. The potential organic layers from samples 6C-96-7 and 6C-96-13 and methylene chloride extracts of the sludges from samples 6C-96-8 and 6C-96-14 were sent to PNNL for further analysis by GC/MS and TOC. The results are reported in Babad et al. (1996).

Viscosity measurements were performed on the supernate and sludge from samples 6C-96-8 and 6C-96-14. Particle size distributions were determined on only the sludge from samples 6C-96-8 and 6C-96-14 (O'Rourke 1996). The majority of the viscosity results are completed and presented in Esch (1996) and are not discussed in this tank characterization report. The remaining viscosity analyses are pending and the results will be reported at a later date.

Table 3-5. Tank 241-C-106 February/March 1996 Grab Sample Analytical Procedures.[1] (2 sheets)

Analysis	Matrix	Preparation Procedure/Revision	Analysis Procedure/Revision
Energetics by DSC	Liquid/solid	n/a	LA-514-113 / B-1, C-1 LA-514-114 / B-1
% water by TGA	Liquid/solid	n/a	LA-514-114 / C-1 LA-560-112 / B-1
Specific gravity	Liquid	n/a	LA-510-112 / C-3
% water by gravimetry	Liquid/solid	n/a	LA-564-101 / F-1
pH	Liquid solid	n/a	LA-212-106 / A-0 LA-212-105 / A-0
Particle size	Solid	n/a	LT-519-101 / A-1
Viscosity	Liquid/solid	n/a	LT-519-115 / A-0
Ammonium	Liquid	n/a	LA-631-001 / B-2
IC anions	Liquid solid	n/a LA-504-101 / E-0[2]	LA-533-105 / D-1
ICP metals	Liquid solid	n/a LA-505-159 / D-0[3]	LA-505-151 / D-3 LA-505-161 / B-0
Total organic carbon	Liquid (furnace) Liquid/solid (persulfate)	n/a	LA-344-105 / C-0 LA-342-100 / C-0, D-0
Total inorganic carbon	Liquid (acid) solid (acid persulfate)	n/a	LA-622-102 / C-0 LA-342-100 / C-0, D-0
Total alpha activity	Liquid solid	n/a LA-549-141 / F-0[4]	LA-508-101 / D-2
^{90}Sr	Liquid solid	n/a LA-549-141 / F-0[4]	LA-220-101 / D-1
^{99}Tc	Liquid solid	n/a LA-549-141 / F-0[4]	LA-438-101 / D-2
^{137}Cs	Liquid solid	n/a LA-549-141 / F-0[4]	LA-548-121 / D-1, E-0

Table 3-5. Tank 241-C-106 February/March 1996 Grab Sample Analytical Procedures.[1] (2 sheets)

Analysis	Matrix	Preparation Procedure/Revision	Analysis Procedure/Revision
^{241}Am	Liquid solid	n/a LA-549-141 / F-0[4]	LA-953-103 / A-5, B-0
$^{239/240}Pu$	Liquid solid	n/a LA-549-141 / F-0[4]	LA-943-128 / A-1
NPH/TBP	Liquid	methylene chloride extraction	LA-523-437 / B-0
Semivolatile organics	Liquid	methylene chloride extraction	LA-523-406 / A-0

Notes:
n/a = not applicable
NPH = normal paraffin hydrocarbon
TBP = tributyl phosphate

[1]Esch (1996)

[2]Water digest procedure.

[3]Acid digest procedure.

[4]Fusion digest procedure.

Caustic demand was measured for the sludge from samples 6C-96-8 and 6C-96-14 (Herting 1996). Caustic demand was determined by mixing sludge samples with known volumes of 2.78 mole/L sodium hydroxide for 24 hours, centrifuging the mixtures for two hours, and measuring the free hydroxide remaining in supernate using 222-S Laboratory procedure LA-211-102, Rev. C-0. The total inorganic carbon and ICP metals in the supernates were also measured.

Compatibility studies of tank 241-C-106 sludge with tank 241-AY-102 waste were performed and included several tests (Crawford 1996a, Crawford 1996b). Foaming-upon-agitation tests were performed on supernate from samples 6C-96-8 and 6C-96-14. The mixing and settling behavior of tank 241-C-106 sludge (samples 6C-96-8 and 6C-96-14) with tank 241-AY-102 supernate was investigated. The investigations included measuring the volume percent settled solids of the mixture, the pH and density of supernate before and after mixing, and the weight percent water (by TGA), energetics (by DSC), and the density of the sludge layer after mixing.

The compatibility studies were repeated with two mixtures of tank 241-C-106 and tank 241-AY-102 sludges. One mixture consisted of four parts of tank 241-C-106 sludge from sample 6C-96-8 mixed with one part tank 241-AY-102 sludge; the other mixture was four parts sludge from sample 6C-96-14 to one part tank 241-AY-102 sludge. Finally, the sedimentation characteristics of the waste mixtures in tanks 241-C-106 and 241-AY-102 were determined by centrifugation. Babad et al. (1996) reports the results of these studies.

3.2 DESCRIPTION OF VAPOR SAMPLING EVENTS

This section describes the vapor sampling events associated with tank 241-C-106. The sampling events (from March 1996 and February 1994) are discussed in reverse chronological order.

3.2.1 Description of the March 1996 Vapor Sampling Event

Matheson (1996) reports the March 1996 vapor sampling event and the associated sample results, and Section 4.4.2 summarizes these results. Two sets of gas samples were collected for hydrogen analysis in March 1996 from Tank 241-C-106 to address continuing in-tank hydrogen generation issues related to potential flammability concerns and to compare these data with results from the 1994 headspace hydrogen generation data.

The samples were drawn from the tank exhauster port and collected using evacuated Whitey[1] stainless-steel sample bottles and SUMMA[2] gas collection canisters. The tank 241-C-106 exhauster flow rate the day before sampling was 68.64 m^3/min (2,424 ft^3/min). The dry-bulb temperature in the exhaust pipe was 16 °C (61 °F). At the time the samples were collected, the ambient air temperature was 14 °C (58 °F), the humidity was near 100%, and the ambient air pressure was 99.9 kPa (749 Torr).

3.2.2 Description of the February 1994 Vapor Sampling Event

Huckaby and Bratzel (1995) report the collection of vapor samples during February 1994 and report the results for this sampling event; Section 4.4.3 summarizes these results. Tank 241-C-106 headspace gas and vapor samples were collected and analyzed in accordance with *Data Quality Objectives for Generic In-Tank Health and Safety Vapor Issues Resolution* (Osborne et al. 1994). This DQO directed the collection and analysis of headspace vapor samples to help determine the potential risks of fugitive emissions to tank farm workers.

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[1]Whitey is a registered trademark of Whitey Company, Highland Heights, Ohio.

[2]SUMMA is a trademark of Molectrics, Inc., Cleveland, Ohio.

The headspace of tank 241-C-106 was sampled in February 1994 by WHC Sampling and Mobile Laboratories using SUMMA™ canisters and chemical sorbent traps. Sampling media were prepared and analyzed by WHC, Oak Ridge National Laboratory, and PNNL. The vapor samples were collected from a port on the exhaust header while the exhauster was operating. The flowrate and temperature of the exhaust on February 4, 1994, was 41.46 m^3/min (1,464 ft^3/min) and 13.9 °C (57.0 °F), and on March 2, 1994, was 46.38 m^3/min (1,638 ft^3/min) and 19.4 °C (66.9 °F).

3.3 DESCRIPTION OF HISTORICAL SAMPLING EVENTS

This section presents, in reverse chronological order, seven historical sampling events for tank 241-C-106 from 1974 to 1986. The historical data from these events are tabulated in Appendix D. Because data generated before 1989 may not be considered valid for some applications under the constraints of Ecology et al. (1994), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

3.3.1 Description of the 1986 Sampling Event

Pauly and Torgerson (1987) and Weiss (1986) describe the sampling and analysis of a full-depth, 2.00 m (79.3-in.), four segment, push-mode core sample taken from riser 1 of tank 241-C-106 on May 19, 1986. Strip charts were used to record the pressure required to insert the drill strings into the tank waste. The interpretation of the strip charts indicated two crusts located between approximately the 7.8 m (70 in.) and 1.9 m (76 in.) levels and between the 483 mm (19 in.) and 559 mm (22 in.) levels. The upper crust indicates the top of the sludge; the lower crust could indicate the top of a 257 to 273 kL (68 to 72 kgal) heel. The recorded heel in the first quarter of 1968 was 265 kL (70 kgal) with 257 kL (68 kgal) of sludge. Sampling methods and analytical results identified in Pauly and Torgerson (1987) are identical with Weiss (1988).

3.3.1.1 Sample Handling and Analysis. The four segments were combined into a composite sample that was centrifuged into solid and liquid portions. Direct analyses were performed on the liquid composite samples. Analyses of the solid composite sample were performed by first dissolving in water or acid and then analyzing the solute. Table D-3 tabulates the analytical results. Weiss (1988) reports additional sample handling and analysis information.

Weiss (1987a) also presents these analyses and describes additional analyses of the samples. Weiss (1987b) and Weiss (1987c) corrects some of the information first reported in Weiss (1987a). These additional analyses consist of projections of tank inventories and comparisons with earlier sampling events. The results from these analyses are not reported in this tank characterization report.

McCown (1988) and Thomas et al. (1991) describe the results of additional analyses performed on the archived core samples using established U. S. Environmental Protection Agency protocols and radiochemical procedures and document the sample preparation and instrument calibrations used to obtain the analytical results. Table D-2 lists the results from McCown (1988) and Table D-1 presents the analytical results from Thomas et al. (1991).

3.3.2 Description of the 1980 Sampling Event

Jungfleisch (1980) and Bratzel (1980) report the results of four sludge core segments received in January 1980. The samples were described as brown in color. No information concerning the sampled riser was available. No information was available as to how the samples were handled once received for analysis. Table D-4 reports the analytical results.

3.3.3 Description of the 1977 Sampling Event

Horton (1977) reports the results from a sludge sample received on January 24, 1977. The sample was described as reddish-brown in color and soft. A description of the technique or procedure used to obtain the sample was not available, and no information concerning the sampled riser or sample depth was available. The report for this event contains a correction page for the 1974 sampling event (Section 3.3.7).

3.3.3.1 Sample Handling and Analysis. The received sludge was analyzed by fusing a known volume of sludge with potassium hydroxide, dissolving the melt in concentrated hydrochloric acid and diluting with a known amount of water. Table D-5 reports the analytical results.

3.3.4 Description of the 1976 Sampling Event

ARHCO (1976) reports the results of a sample received on March 15, 1976. The sample was described as dark brown in color. A description of the technique or procedure used to obtain the sample was not available, and no information concerning the sampled riser or sample depth was available. No information was available as to how the sample was handled once received for analysis. Table D-6 reports the analytical results.

3.3.5 Description of the September 15, 1975, Sampling Event

Wheeler (1976a) reports the results of a sludge sample received on September 15, 1975. The sample was described as dark brown in color. A description of the technique or procedure used to obtain the sample was not available, and no information concerning the sampled riser or sample depth was available. No information was available as to how the sample was handled once received for analysis. Table D-7 reports the analytical results.

3.3.6 Description of the September 8, 1975, Sampling Event

Wheeler (1976b) describes the results of this 1975 sampling event. A sample was received on September 8, 1975, and reported on March 3, 1976. The sample was described as brown in color. A description of the technique or procedure used to obtain the sample was not available, and no information concerning the sampled riser or sample depth was available. No information was available as to how the sample was handled once received for analysis. Table D-8 reports the analytical results.

3.3.7 Description of the 1974 Sampling Event

Horton (1975) describes the results from the 1974 sampling event. A sludge sample was received on October 10, 1974, and reported on January 6, 1975. The sample was described as dark brown in color and very soft. A description of the technique or procedure used to obtain the sample was not available, and no information concerning the sampled riser or sample depth was available.

3.3.7.1 Sample Handling and Analysis. The sample was prepared by fusing a known volume of solids with potassium hydroxide, dissolving the melt in hydrochloric acid, and then diluting the sample with a known volume of water. The PUREX acidified sludge (PAS) was made by acidifying a slurry from tank 241-C-106 of 30% solids and 70% supernatant with nitric acid. No additional information was available as to how the sample was handled once received for analysis. Table D-9 reports the analytical results.

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4.0 ANALYTICAL RESULTS

4.1 OVERVIEW

This section summarizes the analytical results associated with the grab samples taken in February and March 1996 from tank 241-C-106. Babad et al. (1996) present much of the non-routine analytical data from the February/March samples in addition to brief summaries of the key analytical results. Pertinent findings from that report will be reproduced here. However, Babad et al. (1996) also present detailed discussions of the sample analysis for organic content and the compatibility and settling studies with tank 241-AY-102 supernate and sludge. Those results are not discussed in this tank characterization report.

This report does include the data that supported the applicable data quality objectives. The February/March 1996 grab samples were taken and analyzed to satisfy the requirements of the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995), *Data Quality Objectives for Tank Farms Waste Compatibility Program*, (Fowler 1995), and *Tank 241-C-106 Grab Sample — Technical Letter of Instruction* (Cash and Babad 1996). The sampling and analyses were performed according to the *Tank 241-C-106 Grab Sampling and Analysis Plan* (Schreiber 1996a) and the *Sample Preparation of Tank 241-C-106 Grab Samples and Testing for Compatibility with Tank 241-AY-102 Supernate* test plan (Crawford 1996a).

Table 4-1 summarizes the data covered in this report and shows the table locations for each set of analytical results. Data from the analysis of all 1996 grab samples were reported in Esch (1996) and can also be found in the Tank Characterization Database[1].

In addition to the results of the 1996 grab sampling event, this section summarizes the analyses and the results of the March 1996 and February 1994 vapor sampling events from tank 241-C-106. Data from the 1996 vapor sample analyses can be found in Matheson (1996). Results of the 1994 sampling event are discussed in Huckaby and Bratzel (1995). The 1996 vapor samples were taken from the tank 241-C-106 exhauster port to address continuing in-tank hydrogen generation issues related to potential fuel flammability concerns. The governing document for this event was *Tank C-106 Flammable Vapor Sampling and Analysis Plan* (Homi 1996). The February 1994 full-vapor characterization event was performed in accordance with *Data Quality Objectives for Generic In-Tank Health and Safety Vapor Issues Resolution* (Osborne et al. 1994).

[1]The Tank Characterization Database can be found on the Internet at website http://twins.pnl.gov:8001/refmain.htm.

Table 4-1. Analytical Data Tables.

Analysis	Table Location
1996 grab sample chemical data summary -- Supernate -- Sludge -- Total tank	 Table 4-2 Table 4-3 Table 4-4
1996 grab sample thermogravimetric analysis results	Table 4-5
1996 grab sample differential scanning calorimetry results	Table 4-6
1996 vapor sample data -- Flammability testing -- Exhaust gas hydrogen testing	 Table 4-7 Table 4-8
1994 vapor sample data -- Inorganic compounds -- Organic compounds	 Table 4-9 Table 4-10
1996 grab sample comprehensive analytical data	Appendix A
1996 grab sample breakdown flowcharts	Appendix B
Statistical analysis	Appendix C

4.2 1996 GRAB SAMPLE CHEMICAL DATA SUMMARY

Tables 4-2, 4-3, and 4-4 list the analytes that are found in the supernate, the sludge, and the total tank, respectively. Samples were identified as supernate or sludge using visual observations. For each analyte, the following information is provided: the restricted estimated maximum likelihood (REML) mean, the REML-derived relative standard deviation (RSD) of the mean, and the projected inventory in kilograms or curies.

The means and uncertainties reported are derived from statistical analysis of variance (ANOVA) methods (see Section 5.3 and Appendix C). When more than half of the subsamples had detected results, the mean was reported as a detected value. When more than half the subsamples had non-detected results, a less-than (<) sign was placed preceding the mean. In both situations, non-detected results were used in the mean calculation by using the detection limit for the assay as the mean concentration. Since the detection limit is the highest value possible for a non-detect result, these mean concentration results may be biased. The original subsample analytical data used to calculate those means are in Appendix A.

The RSD of the mean is expressed as a percentage and is defined as the standard deviation divided by the mean, multiplied by 100. Appendix C contains further information about the assumptions and methodology for calculating the means and the RSDs.

The projected inventories in Tables 4-2 through 4-4 were derived by multiplying the mean analyte concentration (μg/mL or μCi/mL) by the estimated waste phase volumes -- approximately 121 kL (32 kgal) for the supernate and approximately 746 kL (197 kgal) for the sludge (Hanlon 1996).

Table 4-2. Chemical Data Summary for Tank 241-C-106: Supernate. (3 sheets)

Analyte	REML Mean Concentration	RSD (mean)[1]	Projected Inventory[2]
Metals	**μg/mL**	**%**	**kg**
Aluminum	< 3.00E+01	n/a	< 3.63E+00
Barium	< 3.00E+01	n/a	< 3.63E+00
Boron	< 3.00E+01	n/a	< 3.63E+00
Cadmium	< 3.00E+00	n/a	< 3.63E-01
Calcium	< 6.01E+01	n/a	< 7.28E+00
Cerium	< 6.01E+01	n/a	< 7.28E+00
Chromium	< 6.01E+00	n/a	< 7.28E-01
Copper	< 6.01E+00	n/a	< 7.28E-01
Iron	< 3.00E+01	n/a	< 3.63E+00
Lanthanum	< 3.00E+01	n/a	< 3.63E+00
Lead	< 6.01E+01	n/a	< 7.28E+00
Magnesium	< 6.01E+01	n/a	< 7.28E+00
Manganese	< 6.01E+00	n/a	< 7.28E-01
Neodymium	< 6.01E+01	n/a	< 7.28E+00
Nickel	1.61E+01	5.3	1.94E+00
Phosphorus	2.86E+02	6.5	3.46E+01
Potassium	6.58E+02	11.8	7.96E+01
Silicon	< 3.00E+01	n/a	< 3.63E+00
Silver	8.01E+00	25.2	9.70E-01

Table 4-2. Chemical Data Summary for Tank 241-C-106: Supernate. (3 sheets)

Analyte	REML Mean Concentration	RSD (mean)[1]	Projected Inventory[2]
Metals (continued)	**µg/mL**	**%**	**kg**
Sodium	1.05E+05	1.8	1.28E+04
Strontium	< 6.01E+00	n/a	< 7.28E-01
Sulfur	2.58E+03	6.0	3.13E+02
Titanium	< 6.01E+00	n/a	< 7.28E-01
Uranium	1.68E+03	7.0	2.04E+02
Zinc	4.92E+00	11.4	5.95E-01
Zirconium	3.81E+02	6.5	4.61E+01
Anions	**µg/mL**	**%**	**kg**
Fluoride	2.44E+02	18.4	2.96E+01
Chloride	3.18E+02	7.7	3.85E+01
Nitrate	1.32E+03	18.5	1.60E+02
Nitrite	2.78E+04	6.8	3.36E+03
Oxalate	3.39E+03	6.2	4.11E+02
Phosphate	8.62E+02	23.1	1.04E+02
Sulfate	7.36E+03	5.7	8.92E+02
Radionuclides	**µCi/mL**	**%**	**Ci**
^{137}Cs	1.08E+02	0.7	1.31E+04
^{241}Am	1.25E-02	20.0	1.51E+00
$^{239/240}$Pu	7.45E-01	4.0	9.02E+01
^{99}Tc	2.05E-01	56.1	2.48E+01
^{90}Sr	4.23E-01	13.6	5.12E+01
Total alpha	1.03E+00	11.7	1.24E+02
Carbon	**µg C/mL**	**%**	**kg C**
Total organic carbon	2.91E+03	13.5	3.52E+02
Total inorganic carbon	2.23E+04	9.8	2.70E+03

Table 4-2. Chemical Data Summary for Tank 241-C-106: Supernate. (3 sheets)

Analyte	REML Mean Concentration	RSD (mean)[1]	Projected Inventory[2]
Physical properties	**wt%**	**%**	**kg**
Percent water - TGA	80.1	0.5	1.13E+05
Percent water - gravimetry	80.2	0.4	1.14E+05

Notes:

n/a = not applicable

[1]Relative standard deviations are not computed for components with values below the detection limit.
[2]Tank supernate volume = approx. 121 kL (32 kgal) (Hanlon 1996)

Table 4-3. Chemical Data Summary for Tank 241-C-106: Sludge. (3 sheets)

Analyte	REML Mean Concentration	RSD (mean)	Projected Inventory[1,2]
Metals	**µg/mL**	**%**	**kg**
Aluminum	4.82E+04	10.5	3.59E+04
Barium	2.92E+02	9.5	2.17E+02
Boron	6.63E+01	14.1	4.94E+01
Cadmium	3.24E+01	13.1	2.42E+01
Calcium	1.31E+03	17.3	9.74E+02
Cerium	2.02E+02	8.2	1.51E+02
Chromium	6.36E+02	12.7	4.74E+02
Copper	1.05E+02	3.7	7.81E+01
Iron	6.28E+04	11.5	4.68E+04
Lanthanum	7.12E+01	8.8	5.31E+01
Lead	2.33E+03	10.5	1.73E+03
Magnesium	2.54E+02	3.9	1.90E+02
Manganese	2.16E+03	6.9	1.61E+03
Neodymium	1.64E+02	6.9	1.22E+02
Nickel	6.07E+02	9.8	4.53E+02
Phosphorus	2.37E+03	9.6	1.77E+03
Potassium	9.32E+02	6.3	6.95E+02

Table 4-3. Chemical Data Summary for Tank 241-C-106: Sludge. (3 sheets)

Analyte	REML Mean Concentration	RSD (mean)	Projected Inventory[1,2]
Metals (continued)	**μg/mL**	**%**	**kg**
Silver	1.87E+03	13.0	1.39E+03
Sodium	1.77E+05	6.8	1.32E+05
Strontium	4.02E+01	2.7	3.00E+01
Sulfur	2.42E+03	6.1	1.80E+03
Titanium	1.29E+02	9.7	9.60E+01
Uranium	1.61E+03	6.0	1.20E+03
Zinc	6.34E+01	9.0	4.73E+01
Zirconium	7.25E+02	25.4	5.40E+02
Anions	**μg/mL**	**%**	**kg**
Fluoride	3.24E+02	9.6	2.42E+02
Chloride	3.84E+02	21.2	2.86E+02
Nitrate	2.36E+03	14.6	1.76E+03
Nitrite	2.46E+04	4.5	1.83E+04
Oxalate	8.02E+04	17.7	5.98E+04
Phosphate	1.53E+03	22.4	1.14E+03
Sulfate	6.96E+03	4.9	5.19E+03
Radionuclides	**μCi/mL**	**%**	**Ci**
^{137}Cs	6.54E+02	7.5	4.88E+05
^{241}Am	n/a	n/a	n/a
$^{239/240}Pu$	1.67E+00	8.0	1.24E+03
^{99}Tc	n/a	n/a	n/a
^{90}Sr	5.46E+02	8.2	4.07E+05
Total alpha	n/a	n/a	n/a
Carbon	**μg C/mL**	**%**	**kg C**
Total organic carbon	2.00E+04	18.9	1.49E+04
Total inorganic carbon	3.60E+04	7.0	2.68E+04
Physical properties	**wt%**	**%**	**kg**
Percent water - TGA	36.3	12.3	4.20E+05
Percent water - gravimetry	47.2	4.6	5.37E+05

Table 4-3. Chemical Data Summary for Tank 241-C-106: Sludge. (3 sheets)

Analyte	REML Mean Concentration	RSD (mean)	Projected Inventory[1,2]

Notes:

n/a = not available

[1]Tank sludge volume = approx. 746 kL (197 kgal) (Hanlon 1996)

[2]Sludge density of 1.55 g/mL was used to calculate the projected inventory

Table 4-4. Chemical Data Summary for Tank 241-C-106: Total Tank. (2 sheets)

Analyte	Projected Inventory[1,2]
Metals	**kg**
Aluminum	3.60E+04
Barium	2.21E+02
Boron	5.30E+01
Cadmium	2.45E+01
Calcium	9.81E+02
Cerium	1.58E+02
Chromium	4.75E+02
Copper	7.88E+01
Iron	4.68E+04
Lanthanum	5.67E+01
Lead	1.74E+03
Magnesium	1.97E+02
Manganese	1.61E+03
Neodymium	1.29E+02
Nickel	4.55E+02
Phosphorus	1.80E+03
Potassium	7.74E+02
Silicon	1.84E+04
Silver	1.39E+03
Sodium	1.45E+05

Table 4-4. Chemical Data Summary for Tank 241-C-106: Total Tank. (2 sheets)

Analyte	Projected Inventory[1,2]
Metals (continued)	**kg**
Strontium	3.07E+01
Sulfur	2.12E+03
Titanium	9.67E+01
Uranium	1.40E+03
Zinc	4.79E+01
Zirconium	5.87E+02
Anions	**kg**
Fluoride	2.71E+02
Chloride	3.25E+02
Nitrate	1.92E+03
Nitrite	2.17E+04
Oxalate	6.02E+04
Phosphate	1.25E+03
Sulfate	6.08E+03
Radionuclides	**Ci**
^{137}Cs	5.01E+05
^{241}Am	n/a
$^{239/240}Pu$	1.33E+03
^{99}Tc	n/a
^{90}Sr	4.07E+05
Total alpha	n/a
Carbon	**kg C**
Total organic carbon	1.52E+04
Total inorganic carbon	2.95E+04
Physical properties	**kg**
Water - TGA	5.33E+05
Water - gravimetry	6.51E+05

Table 4-4. Chemical Data Summary for Tank 241-C-106: Total Tank. (2 sheets)

Analyte	Projected Inventory[1,2]

Notes:
[1]Total tank volume = approx. 867 kL (229 kgal) (Hanlon 1996)

[2]Projected inventory is the sum of Tables 4-2 and 4-3. Less-than values were treated as estimates and were included in the total tank inventory calculation.

4.3 1996 GRAB SAMPLE PHYSICAL DATA SUMMARY

Thermal analyses were performed on the tank 241-C-106 grab samples to satisfy the requirements of the safety screening DQO (Dukelow et al. 1995), the compatibility DQO (Fowler 1995), and the technical letter of instruction (Cash and Babad 1996). Thermal analyses were performed on both the solid and liquid phases of the waste samples.

4.3.1 Thermogravimetric Analysis

In a TGA, the mass of a sample is measured while it is heated at a constant rate. A gas, such as nitrogen or air, is passed over the sample during the heating to remove any sample off-gases. Any decrease in the mass of a sample represents a loss of gases from the sample through evaporation or through a reaction that forms gas-phase products.

Mass loss from ambient temperature to approximately 150 °C (302 °F) is assumed to be water, unless the responsible chemist evaluates the data to be an exception to this rule. For instance, sample S96T001544 displayed two transitions: the first transition was from ambient to approximately 85 °C (185 °F) , and the second transition was from 85 °C (185 °F) to 125 °C (257 °F). Although both of these transitions lie below 150 °C (302 °F), the responsible chemist did not consider the second weight loss to be water because of the dramatic slope change at the step between the two transitions. The slope change in this region was very unique, and the chemist could not state with certainty that the second transition weight loss represented water. Therefore, the conservative approach was taken, and the second transition was not included in the percent water result.

The weight percent water by TGA was performed using procedures LA-560-112, Revision B-1 (Mettler™ equipment) and LA-514-114, Revision C-1 (Perkin-Elmer™ equipment). Most samples were run under a nitrogen purge, although a limited number of samples were run under air to compare the two purge methods (see footnotes in Table 4-5 for those samples run under air). An evaluation of the TGA results using the two purge methods is provided in Section 5.1.

Table 4-5 shows the TGA percent water data for tank 241-C-106. Included in the table are each subsample's laboratory number, original field sample number, sample portion, and TGA results. Section 3.1.1 and Appendix B contain information regarding the sample portions and breakdown treatment. For each transition, the table lists the temperature range of the weight loss and the percentage of weight loss. As expected, the solid subsamples that underwent centrifugation generally had TGA results lower than the uncentrifuged or liquid samples. An evaluation of these results is provided in Section 5.5.1.

Table 4-5. Thermogravimetric Analysis Results for Tank 241-C-106. (5 sheets)

Laboratory Sample Number[1]	Sample Portion	Run	Transition 1		Transition 2		Total[2]	Sample Mean
			Range (°C)	Weight Loss (%)	Range (°C)	Weight Loss (%)	Percent Water	Percent Water
Grab sample 6C-96-3								
1526	Raw sludge[4]	1	35-125	3.54	125-490	9.12	3.54	3.18
		2	35-105	2.82	105-490	9.33	2.82	
Grab sample 6C-96-4								
1527	Centrifuged solids	1	35-170	3.63	210-490	17.38	3.63	3.585
		2	35-160	3.54	210-490	17.56	3.54	
1530	Control sludge sample	1	35-135	32.71	135-500	9.19	32.71	33.515
		2	35-160	34.32	160-500	8.52	34.32	
1537	Filtered centrifuged solids	1	35-135	22.14	135-500	11.78	22.14	24.105
		2	35-135	26.07	135-500	11.58	26.07	
1544	Interstitial liquid	1	35-85	58.94	85-125	16.22	58.94	58.015
		2	35-85	57.09	85-125	17.9	57.09	
Grab sample 6C-96-5								
0538	Supernate	1	35-135	80.91			80.91	80.875
		2	35-140	80.84			80.84	
Grab sample 6C-96-7								
0542	Centrifuged solids	1	35-150	8.04	150-380	11.17	8.04	8.275
		2	35-155	8.51	155-395	10.83	8.51	

Table 4-5. Thermogravimetric Analysis Results for Tank 241-C-106. (5 sheets)

Laboratory Sample Number[1]	Sample Portion	Run	Transition 1		Transition 2		Total[2]	Sample Mean
			Range (°C)	Weight Loss (%)	Range (°C)	Weight Loss (%)	Percent Water	Percent Water
Grab sample 6C-96-7 (continued)								
0543	Control sludge sample	1	30-135	29.76	280-375	6.29	29.76	31.115
		2	30-160	32.47	280-380	6.5	32.47	
0563	Interstitial liquid	1	35-90	61.32	90-450	16.75	61.32	60.345
		2	35-95	59.37	95-430	18.89	59.37	
0567	Filtered centrifuged solids	1	35-115	26.22	115-495	13.07	26.22	25.745
		2	35-120	25.27	120-495	14.45	25.27	
1548	Potential organic layer	1	35-175	34.16	385-460	31.01	34.16	34.97
		2	35-190	35.78	380-455	34.93	35.78	
Grab sample 6C-96-8								
2021	Raw sludge	1	35-80	59.60	80-385	15.2	59.60	52.88
		2	35-75	46.16	75-425	22.58	46.16	
2042	Raw sludge[3]	1	35-145	60.45	150-440	5.27	60.45	60.50
		2	35-165	60.55	175-430	4.99	60.55	
		3	35-115	56.10	215-325	4.55	56.10	55.3
		4	35-120	54.50	230-350	4.84	54.50	
Grab sample 6C-96-10								
0545	Interstitial liquid	1	35-115	34.27	125-175	37.91	34.27	35.4
		2	35-115	36.53	125-160	35.4	36.53	

Table 4-5. Thermogravimetric Analysis Results for Tank 241-C-106. (5 sheets)

Laboratory Sample Number[1]	Sample Portion	Run	Transition 1		Transition 2		Total[2]	Sample Mean
			Range (°C)	Weight Loss (%)	Range (°C)	Weight Loss (%)	Percent Water	Percent Water
Grab sample 6C-96-10 (continued)								
0551	Filtered centrifuged solids	1	35-130	9.44	135-485	7.14	9.44	12.775
		2	35-125	16.11	135-485	13.2	16.11	
0558	Centrifuged solids	1	35-150	11.71	155-500	14.86	11.71	12.855
		2	35-160	14.0	165-500	13.23	14.0	
0560	Control sludge sample	1	35-95	13.39			13.39	13.49
		2	35-95	13.59			13.59	
1567	Potential organic layer	1	35-120	71.58	120-425	5.14	71.58	69.55
		2	35-115	67.52	115-405	8.7	67.52	
Grab sample 6C-96-11								
1674	Centrifuged solids	1	35-100	9.63	100-490	14.29	9.63	9.03
		2	35-95	8.43	95-490	15.45	8.43	
1676	Control sludge sample	1	35-130	40.05	130-475	7.64	40.05	39.76
		2	35-140	39.47	140-480	7.09	39.47	
1679	Potential organic layer	1	35-140	28.37	140-380	54.11	28.37	29.855
		2	35-125	31.34	125-380	49.75	31.34	
1681	Interstitial liquid	1	35-130	48.47	130-165	28.2	48.47	46.42
		2	35-125	44.37	130-170	32.47	44.37	

Table 4-5. Thermogravimetric Analysis Results for Tank 241-C-106. (5 sheets)

Laboratory Sample Number[1]	Sample Portion	Run	Transition 1		Transition 2		Total[2]	Sample Mean
			Range (°C)	Weight Loss (%)	Range (°C)	Weight Loss (%)	Percent Water	Percent Water
Grab sample 6C-96-11 (continued)								
1685	Filtered centrifuged solids	1	35-160	32.54	165-410	8.24	32.54	31.915
		2	35-155	31.29	155-410	8.07	31.29	
Grab sample 6C-96-12								
1023	Supernate	1	35-155	79.05			79.05	79.27
		2	35-190	79.49			79.49	
Grab sample 6C-96-13								
1030	Centrifuged solids	1	35-150	9.24	150-500	10.21	9.24	9.36
		2	35-150	9.48	155-500	9.90	9.48	
1034	Control sludge sample	1	35-95	31.29	95-460	11.16	31.29	31.1
		2	35-95	30.91	95-460	10.04	30.91	
1553	Potential organic layer	1	35-140	72.40	320-410	4.29	72.40	51.255
		2	35-150	30.11	150-490	53.78	30.11	
1559	Filtered centrifuged solids	1	35-140	21.28	145-395	9.52	21.28	23.7
		2	35-135	26.12	135-390	10.65	26.12	
1566	Interstitial liquid	1	35-130	74.92			74.92	75.76
		2	35-125	76.6			76.6	

Table 4-5. Thermogravimetric Analysis Results for Tank 241-C-106. (5 sheets)

Laboratory Sample Number[1]	Sample Portion	Run	Transition 1		Transition 2		Total[2]	Sample Mean
			Range (°C)	Weight Loss (%)	Range (°C)	Weight Loss (%)	Percent Water	Percent Water
Grab sample 6C-96-14								
2350	Raw sludge	1	35-110	65.05			65.05	64.155
		2	35-160	63.26			63.26	
2351	Raw sludge[3]	1	35-160	56.03	260-360	2.49	56.03	55.295
		2	35-175	54.56			54.56	
Summary								
Sludge mean weight percent water = 36.3%.								
Relative standard deviation of the mean = 12.2%.								
Supernate mean weight percent water = 80.1%.								
Relative standard deviation of the mean = 0.5%.								

Notes:

[1]All laboratory sample numbers begin with the prefix S96T00.

[2]Only the weight loss associated with Transition 1 was assumed to be water and used in the mean and inventory calculations for percent water.

[3]These samples were run under an air purge rather than a nitrogen purge.

[4]This sample was inadvertently overheated to dryness (see Section 3.1).

4.3.2 Differential Scanning Calorimetry

In a DSC analysis, heat absorbed or emitted by a substance is measured while the substance is heated at a constant rate. The onset temperature for an endothermic event (characterized by or causing the absorption of heat) or exothermic event (characterized by or causing the release of heat) is determined graphically.

The DSC analyses were performed using procedure LA-514-113, Rev. B-1 (Mettler™ Model 20 differential scanning calorimeter) and procedure LA-514-114, Rev. B-0 (Perkin-Elmer™ equipment). Most samples were run under a nitrogen purge, although a limited number of samples were run under air to compare the two purge methods (see footnotes in Table 4-6 for those samples run under air).

Table 4-6 shows the DSC results. Included in the table are each subsample's laboratory number, original field sample number, sample portion, and DSC wet weight basis results. For each transition, the table lists the sample weight, temperature at maximum enthalpy change, and the magnitude of the enthalpy change. Convention dictates that a negative enthalpy change indicates an energy release or an exotherm, and positive enthalpy change indicates energy absorbed or an endotherm.

For the majority of the samples, the first transition, which ranged from ambient to approximately 150 °C (302 °F), represented the endothermic reaction associated with the evaporation of free and interstitial water. Generally, these endotherms were quite large, usually greater than 400 J/g. One sample (the centrifuged solids from sample 6C-96-4) did not exhibit an endotherm in this temperature range for three of its five runs. However, this sample was one of the samples inadvertently overheated at the laboratory (see Sections 3.1), which may have affected its analysis results.

In the subsequent transitions, various behaviors occurred. Both exotherms and endotherms were observed in these transitions. The endotherms (most often between 50 and 150 J/g) were not as large as the majority of endotherms in the first transition and probably represented the energy (heat) required to remove bound water from hydrated compounds such as aluminum hydroxide or to melt salts such as sodium nitrate. The exotherms ranged from modest enthalpy changes of -5 to -75 J/g to substantial enthalpy changes of up to -1,000 J/g. However, in almost every case, the exotherm to endotherm ratio of the DSC runs (required by the compatibility DQO) was less than one. The one exception was for the centrifuged solids from sample 6C-96-4, which displayed an exotherm of -1,000 J/g in one of its five runs (see Section 5.5.2, Table 5-17). Again, these results may be biased due to the overheating of the sample in the laboratory.

Table 4-6. Differential Scanning Calorimetry Results for Tank 241-C-106. (6 sheets)

Lab Sample Number[1]	Sample Portion	Run	Sample Weight (mg)	Transition 1		Transition 2		Transition 3		Transition 4		Exo/ Endo Ratio[2]
				Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	
Grab sample 6C-96-3												
1526	Raw sludge	1	26.58	113.4	78.2	326.1	29.9					0
		2	18.04	103.7	40.89	316.4	20.6					0
Grab sample 6C-96-4												
1527	Centrifuged solids	1[3]	13.25	314.0	175.7[QC:e]							0
		2[3]	16.51	342.0	-1,000[QC:e]							2.92
		3[3]	19.51	321.3	215.0							0
		4	17.58	80.6	28.7	264.5	-13.5[QC:e]	315.6	131.8			0.08
		5	15.96	80.6	38.3	264.6	-25.5[QC:e]	315.7	128.0			0.15
1530	Control sludge sample	1	37.12	123.5	835.0	330.9	89.3					0
		2	59.3	122.1	853.2	338.9	95.9					0
1537	Filtered centrifuged solids	1	18.02	118.5	589.1	326.0	117.3					0
		2	26.28	126.4	605.1	328.3	101.3					0
1544	Interstitial liquid	1	13.12	117.2	1,814							0
		2	12.11	111.5	1,808							0

Table 4-6. Differential Scanning Calorimetry Results for Tank 241-C-106. (6 sheets)

Lab Sample Number[1]	Sample Portion	Run	Sample Weight (mg)	Transition 1		Transition 2		Transition 3		Transition 4		Exo/ Endo Ratio[2]
				Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	
Grab sample 6C-96-5												
0538	Supernate	1	12.20	105.3	1,586							0
		2	14.13	105.3	1,350							0
Grab sample 6C-96-7												
0542	Centrifuged solids	1	16.15	111.9	381.6	276.8	-70.4	320.2	39.3	364.7	-41.6	0.27
		2	4.98	96.5	344.6	266.8	-39.6	302.6	44.2	366.7	-49.5	0.23
0543	Control sludge sample	1	22.82	115.9	942.1	323.5	49.0					0
		2	32.13	127.3	1,016	335.1	60.7					0
0563	Interstitial liquid	1	12.11	116.4	1,801							0
		2	12.45	118.9	1,801							0
0567	Filtered centrifuged solids	1	11.60	117.4	939.7	266.7	-69.7[QC:e]	318.1	82.0			0.07
		2	8.07	95.9	871.7	270.8	-94.7[QC:e]	312.4	38.6			0.10
1548	Potential organic layer	1	18.01	105.3	1257							0
		2	16.40	118.0	1,009	414.7	39.7					0

Table 4-6. Differential Scanning Calorimetry Results for Tank 241-C-106. (6 sheets)

Lab Sample Number[1]	Sample Portion	Run	Sample Weight (mg)	Transition 1		Transition 2		Transition 3		Transition 4		Exo/ Endo Ratio[2]
				Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	
Grab sample 6C-96-8												
2021	Raw sludge	1	36.44	101.3	724.6	253.8	11.6	352.1	-33.5[QC:e]			0.05
		2	40.15	105.3	501.6	364.9	-100.6[QC:e]					0.20
2042	Raw sludge[4]	1	14.79	124.4	1,069							0
		2	12.34	123.7	1,089							0
Grab sample 6C-96-10												
0545	Interstitial liquid	1	12.05	121.1	1,716							0
		2	11.91	115.8	1,681							0
0551	Filtered centrifuged solids	1	4.42	66.5	429.3	276.9	-286.9					0.67
		2	6.24	72.4	384.1	276.9	-279.9					0.73
0558	Centrifuged solids	1	7.41	108.2	513.6							0
		2	14.91	132.3	529.0							0
0560	Control sludge sample	1	19.88	111.2	351.4							0
		2	7.55	99.2	338.4							0
1567	Potential organic layer	1	11.20	109.3	1,401	399.3	-215.1[QC:e]					0.15
		2	12.00	107.3	1,395	397.5	-142.4[QC:e]					0.10

Table 4-6. Differential Scanning Calorimetry Results for Tank 241-C-106. (6 sheets)

Lab Sample Number[1]	Sample Portion	Run	Sample Weight (mg)	Transition 1		Transition 2		Transition 3		Transition 4		Exo/ Endo Ratio[2]
				Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	
Grab sample 6C-96-11												
1674	Centrifuged solids	1	7.06	109.6	281.8	247.2	347.0	401.1	112.4	439.2	-19.7[QC:e]	0.03
		2	10.82	111.7	258.3	255.5	139.1	296.0	-109.6[QC:e]			0.28
		3	8.18	103.9	243.2	249.6	151.0	297.9	-101.7			0.26
1676	Control sludge sample	1	11.12	115.0	922.3	346.9	-146.0					0.16
		2	11.30	123.1	900.3	338.9	-137.2					0.15
1679	Potential organic layer	1	10.32	123.4	973.8	346.7	91.7	445.3	46.0			0
		2	17.83	133.3	1055	354.4	55.9	444.9	14.2			0
1681	Interstitial liquid	1	13.45	107.3	1452	373.0	-5.5					<0.01
		2	13.51	105.3	1506	366.9	-5.5					<0.01
1685	Filtered centrifuged solids	1	46.03	120.2	816.1	322.7	49.6					0
		2	15.05	98.32	641.2	317.7	39.3					0
Grab sample 6C-96-12												
1023	Supernate	1	17.17	105.3	1,228							0
		2	12.99	107.3	1,331							0

Table 4-6. Differential Scanning Calorimetry Results for Tank 241-C-106. (6 sheets)

Lab Sample Number[1]	Sample Portion	Run	Sample Weight (mg)	Transition 1		Transition 2		Transition 3		Transition 4		Exo/ Endo Ratio[2]
				Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	
Grab sample 6C-96-13												
1030	Centrifuged solids	1	21.91	110.9	550.4	339.1	-180.9[QC:e]					0.33
		2	11.60	102.0	578.2	333.2	-258.9[QC:e]					0.45
1034	Control sludge sample	1	10.59	113.4	941.0	273.1	-55.1	310.8	25.5	363.0	-32.3	0.09
		2	11.06	113.4	868.4	261.0	-54.2	310.8	34.6	365.0	-12.5	0.07
1553	Potential organic layer	1	24.36	103.3	970.5	393.8	-208.1[QC:e]					0.21
		2	8.54	90.4	665.4	347.1	52.0	429.7	-167.9[QC:e]			0.23
1559	Filtered centrifuged solids	1	8.55	107.0	525.5	312.5	72.6					0
		2	11.92	109.5	558.3	314.7	72.5					0
1566	Interstitial liquid	1	11.00	109.3	1575	371.2	-118.9[QC:e]					0.08
		2	12.03	105.3	1575	373.2	-96.8[QC:e]					0.06
Grab sample 6C-96-14												
2350	Raw sludge	1	6.04	102.7	1230	246.7	22.4	318.7	-29.8[QC:e]			0.02
		2	7.20	100.3	1281	248.7	18.9	312.9	-61.1[QC:e]			0.05
2351	Raw sludge[4]	1	22.67	105.3	626.6	212.6	-27.8	317.3	-152.8			0.29
		2	10.02	103.9	1093	206.8	-97.0	313.0	-121.1			0.20

Table 4-6. Differential Scanning Calorimetry Results for Tank 241-C-106. (6 sheets)

Lab Sample Number[1]	Sample Portion	Run	Sample Weight (mg)	Transition 1		Transition 2		Transition 3		Transition 4		Exo/ Endo Ratio[2]
				Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	Peak (°C)	ΔH (J/g)	

Notes:

[1]All laboratory sample numbers start with the prefix S96T00.

[2]Ratio of the total exothermic to total endothermic values for that sample.

[3]This sample did not exhibit an endothermic transition associated with the evaporation of free water for these three runs. For an evaluation of these DSC results, see Section 5.5.

[4]These samples were run under an air purge rather than a nitrogen purge.

The DSC results are reported on a wet-weight basis. The safety screening DQO, however, requires that the exothermic reactions be evaluated on a dry-weight basis in order to make a decision about tank safety. The dry-weight value is obtained from the wet-weight value by dividing the reported exothermic value for a subsample by the solid fraction of the subsample (that is, one minus the fractional percent water value for that subsample). The largest mean exotherm observed for the subsamples was -681.15 J/g (dry) for the potential organic layer from sample 6C-96-13. It is important to note, though, that the potential organic layer represents 0.5 to 3 percent of the total tank volume and was only discovered after vigorous centrifugation and sample treatment (i.e., it is not representative of the tank waste matrix).

4.3.3 Separable Organic Layer

Prior to breakdown, each grab sample was visually inspected for the presence of a separable organic layer. Separable organic layers were not observed in any of the raw samples taken from tank 241-C-106. However, upon centrifugation of the sludge material at tank temperature (approximately 55 °C [130 °F]), a separable phase was found (Schreiber 1996b through 1996e). The separable phase was identified as a potential organic layer. This layer was estimated to be approximately 0.5 to 3 percent of the total sample volume, and its color was described as very dark reddish-brown. Analysts at PNNL determined that the potential organic layer was composed primarily of sodium bis(2-ethylhexyl)phosphate, an extracting agent used in B-Plant as part of the ^{90}Sr separation process. Minor amounts of tributyl phosphate, normal paraffin hydrocarbons, and the trans-esterification products of tributyl phosphate were also found in the samples. Babad et al. (1996) present further information regarding these and other analyses performed on the potential organic layer samples.

4.4 TANK HEADSPACE VAPOR DATA SUMMARY

This section summarizes the data resulting from three different tank vapor sampling and analysis events. Section 4.4.1 describes the results from the tank headspace vapor field screening conducted in association with the February/March 1996 grab samples. Sections 4.4.2 and 4.4.3 outline the results from the March 1996 and February 1994 tank exhauster vapor samples.

4.4.1 February/March 1996 Tank Headspace Vapor Field Screening Data

The safety screening DQO threshold decision value for flammable gas screening in the tank headspace is 25 percent of the LFL (Dukelow et al. 1995). Prior to obtaining the grab samples, tank headspace vapors were field screened using a combustible gas meter and an organic vapor meter. Table 4-7 presents these results. The result of zero percent of the LFL in the tank headspace did not exceed the safety screening threshold value of 25 percent of the LFL. This result is expected because tank 241-C-106 is actively ventilated.

Table 4-7. Flammability Testing Vapor Survey Results for Tank 241-C-106.

Riser	Location	Measurement	Result
1	Tank headspace[1]	Flammable vapor concentration as percent of LFL	0%
		Volume percent oxygen	20.7-20.9%
		Total organic vapor	0 ppm
		Ammonia gas	0 ppm
1	Exhauster vent	Flammable vapor concentration as percent of LFL	0%
		Volume percent oxygen	20.8-20.9%
		Total organic vapor	0-1.1 ppm
		Ammonia gas	<5 ppm
1	Breathing zone	Flammable vapor concentration as percent of LFL	0%
		Volume percent oxygen	20.9%
		Total organic vapor	0 ppm
		Ammonia gas	0 ppm
7	Tank headspace[1]	Flammable vapor concentration as percent of LFL	0%
		Volume percent oxygen	20.9%
		Total organic vapor	0 ppm
		Ammonia gas	<5 ppm
7	Exhauster vent	Flammable vapor concentration as percent of LFL	0%
		Volume percent oxygen	21.0%
		Total organic vapor	0 ppm
		Ammonia gas	2 ppm
7	Breathing zone	Total organic vapor	0 ppm
		Ammonia gas	<5 ppm

Note:
[1]Samples were obtained 6.1 m (20 ft) below the top of the riser.

4.4.2 March 1996 Vapor Sample Data

Sampling and analysis of the exhaust gases from tank 241-C-106 were performed in March 1996 to ensure that the concentrations of the tank headspace flammable gases were within the acceptable limits. The vapor samples were analyzed for hydrogen, methane, carbon dioxide, carbon monoxide, and nitrous oxide. Table 4-8 summarizes these results and provides the safety screening threshold value (25 percent of the LFL) in terms of parts per million volume for each analyte. Matheson (1996) provides additional discussion of the vapor samples collected during this sampling event.

Table 4-8. March 1996 Exhaust Gas Analysis Results from Tank 241-C-106.

Constituent	Tank Sample Average Concentration		25% LFL (ppmv)[3]
	Whitey® Cylinder (ppmv)	SUMMA™ Canister (ppmv)	
Hydrogen, H_2	9	4[1]	10,000
Methane, CH_4	3	5[1]	12,500
Carbon dioxide, CO_2	393	379	n/a
Carbon monoxide, CO	see note 2	4[1]	31,250
Nitrous oxide, N_2O	5[1]	2[1]	n/a

Notes:

n/a = not applicable
ppmv = parts per million by volume

[1]Constituent not detected at instrument detection limit.
[2]Not available for this analysis because of nitrogen interference.
[3]Buckley (1996)

4.4.3 February 1994 Vapor Sample Data

A complete vapor characterization was performed on the tank 241-C-106 headspace gases in February 1994. The data from this sampling and analysis event are in *Tank 241-C-106 Headspace Gas and Vapor Characterization Results for Samples Collected in February 1994* (Huckaby and Bratzel 1995). Table 4-9 shows the inorganic gas results and Table 4-10 lists the organic gas results from this vapor sampling event. Analysts at the Oregon Graduate Institute of Science and Technology (OGIST) and PNNL generated the results in Table 4-9. The results obtained by OGIST should be considered secondary to those of PNNL because OGIST did not have an approved quality assurance program at the time of the analysis. The organic vapor results in Table 4-10 were generated at ORNL.

Table 4-9. February 1994 Tank 241-C-106 Inorganic Gas and Vapor Concentrations.

Compound	Sample Type	Average[1] (ppmv)	Standard Deviation (ppmv)	RSD[1] (%)
Ammonia, NH_3	Sorbent trap	≤ 9	n/a	n/a
Carbon monoxide, CO	SUMMA™	[0.25]	[0.05]	[20]
Hydrogen, H_2	SUMMA™	[9.7]	[1.9]	[20]
Nitric oxide, NO	Sorbent trap	≤ 0.1	n/a	n/a
Nitrogen dioxide, NO_2	Sorbent trap	≤ 0.1	n/a	n/a
Nitrous oxide, N_2O	SUMMA™	[3.7]	[0.49]	[13]
Water vapor, H_2O	Sorbent trap	24,300 (17.8 mg/L)	3,670 (2.7 mg/L)	15

Notes:
RSD = relative standard deviation

[1]Bracketed values are from OGIST and should be considered secondary results; non-bracketed values are from PNNL and should be considered primary results.

Table 4-10. Positively Identified Organic Compounds in Triple Sorbent Trap Samples from Tank 241-C-106.[1]

Compound	Average[2] (ppmv)	Average Difference[3] (ppmv)	RPD[4] (%)
Ethanenitrile (acetonitrile)	0.0023	0.0007	62
Dichloromethane (methylene chloride)	0.092	0.030	65
Benzene	0.00022	< 0.0001	59
n-butanenitrile	0.00033	0.00023	143
Toluene	0.00025	< 0.0001	22
n-dodecane	0.0036	0.0004	22
n-tridecane	0.0087	0.0003	7
Propanenitrile	< 0.0001	< 0.0001	200
2-hexanone	< 0.0001	< 0.0001	97
n-octane	< 0.0001	< 0.0001	200
n-hexanenitrile	< 0.0001	< 0.0001	63
2-heptanone	< 0.0001	< 0.0001	124
n-nonane	< 0.0001	< 0.0001	36
n-heptanenitrile	< 0.0001	< 0.0001	87
2-octanone	< 0.0001	< 0.0001	67
n-octanenitrile	< 0.0001	< 0.0001	73
n-nonanenitrile	< 0.0001	< 0.0001	16

Notes:

[1]Results in this table are not quantitative values because at least one result for the samples was outside instrument calibration limits.

[2]Average of two 10-L (2.6-gal) triple sorbent trap samples.

[3]Because only two triple sorbent trap samples were reported, the average difference (i.e., the difference divided by 2) is provided rather than the standard deviation.

[4]RPD = relative percent difference

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5.0 INTERPRETATION OF CHARACTERIZATION RESULTS

Section 5.0 discusses the overall quality and consistency of the current sampling results for tank 241-C-106 and assesses the results against historical information and program requirements.

5.1 ASSESSMENT OF SAMPLING AND ANALYTICAL RESULTS

Section 5.1 evaluates sampling and analysis factors that may impact data interpretation. These factors are used to assess the overall data quality and consistency and to identify any limitations in data use. Section 5.1.1 discusses any field observations regarding the collection and handling of the samples that may affect interpretation of the results. Section 5.1.2 summarizes any quality control factors that impact the data, and Section 5.1.3 presents several data consistency checks for the tank 241-C-106 sample data.

5.1.1 Field Observations

This section discusses field observations regarding the collecting and subsequent handling of the samples that may affect the data interpretation for those samples. Section 5.1.1.1 discusses the field observations for the February/March 1996 grab samples, Section 5.1.1.2 discusses observations for the March 1996 vapor sampling, and Section 5.1.1.3 presents observations for the February 1994 vapor sampling.

5.1.1.1 Field Observations for the February/March 1996 Grab Samples. The safety screening DQO required a vertical profile of the tank waste be obtained from two widely spaced risers (Dukelow et al. 1995). The February/March 1996 grab samples were obtained from tank 241-C-106 using risers 1 and 7. These risers are on opposite sides of the tank; thus, the requirement was met that samples be retrieved that represent the horizontal variability in the tank.

However, apparently only the supernate and top 60 percent of the sludge in the tank were sampled. Therefore, the chemical safety screening data, waste compatibility data, and spatial profiles of the waste will apply only to the supernate and top 60 percent of the sludge. The inventory estimates for the sludge and total tank waste presented in Tables 4-3 and 4-4 are biased because the samples did not accurately represent a full vertical profile of the tank waste. Furthermore, the depths at which some of the samples were taken and how well some of the samples represent the waste at the indicated sample depths may be questioned.

The three work packages that governed the collection of the grab samples from tank 241-C-106 contain the field observations from the sampling effort (WHC 1996a, WHC 1996b, WHC 1996c). The only sampling anomaly noted in the work packages was that sample 6C-96-9 was not retrieved when its sample bottle broke during the sampling operation. No sample-handling anomalies were noted in the chain-of-custody forms. No cooling water was added to tank 241-C-106 during the February/March 1996 sampling period.

Schofield (1996) notes a number of inconsistencies among the depths recorded in the work packages, particularly for samples 6C-96-10 through 6C-96-16. Schofield (1996) presents the best estimates of the correct sample depths based on the work package records, field sampling procedures, and operations knowledge. While these sample depths and elevations were accepted as correct, some of the sample inconsistencies discussed further in this section may be explained if the sample elevations were not correct.

The primary inconsistency in the samples is that supernate was collected when sludge was the expected sample type. Hanlon (1996) lists the total waste volume for tank 241-C-106 as 867 kL (229 kgal) with a sludge volume of 746 kL (197 kgal). The sludge volume was calculated based on a sludge measurement obtained on April 28, 1982, and was reconfirmed in 1994 based on an in-tank video of the tank waste (Bander 1995). These values convert to an elevation[1] of 2.3 m (91 in.) to the top of the supernate layer and an elevation of 2.0 m (79 in.) to the top of the sludge layer (Brevick et al. 1994b). *Assuming a flat and even interface between the sludge and supernate layers*, any samples collected at sample elevations less than 2.0 m should have been sludge samples.

Table 3-2 tabulates the grab sample numbers and sample elevations, and Table 3-3 lists the sample type (supernate or sludge) for each grab sample. Because all the samples were drawn from elevations less than 2.0 m, all the samples, ideally, should have been sludge samples. However, Table 3-3 lists six samples as primarily supernate samples. These are samples (with sample elevations in parentheses) 6C-96-1 (1.68 m), 6C-96-2 (1.68 m), 6C-96-5 (1.88 m), 6C-96-12 (1.65 m), 6C-96-15 (1.23 m), and 6C-96-16 (1.17 m). The fact that supernate was collected when sludge was expected may indicate one or more of three possibilities: (1) the sample elevations were in error, (2) the grab sampling method was biased, or (3) the samples were from the waste at the indicated sample elevations, and the assumptions regarding sludge location are incorrect.

The first possibility, that the sample elevations were incorrect, may explain some of the supernate samples, especially those from the higher elevations. However, based on Schofield (1996) the sample elevations were assumed to be correct.

There is evidence to support the second possibility that at least some of the samples were biased and did not accurately represent the waste at the indicated sample elevations. The evidence is that replicate samples from the same riser and elevation yielded supernate in one instance and sludge in another. Table 3-2 lists the sample elevation for riser 1 samples 6C-96-5 and 6C-96-6 as 1.88 m (74 in.). However, Table 3-3 indicates sample 6C-96-5

[1]Sample elevation is defined as the vertical distance from the tank bottom centerline to the mouth of the sample bottle.

contained only 20 percent solids and was classified a supernate sample, while sample 6C-96-6 contained 80 percent solids and was classified a sludge sample. Similarly, samples 6C-96-13 through 6C-96-16 were all drawn from riser 7 at elevations of 1.17 to 1.23 m (46 to 48 in.). Samples 6C-96-13 and 6C-96-14 were 100 percent sludge, while samples 6C-96-15 and 6C-96-16 contained less than 15 percent solids and were classified as supernate samples. Any systematic bias in the analytical results introduced as a result of sampling is unknown.

Previous samplings at a given sample elevation may have been one cause of the observed inconsistency in sample types. Such prior sampling may have provided a pathway down which portions of sludge and supernate from shallower levels could have travelled and thus contaminated not only the target sample point but the intervening layers of waste as well. Subsequent grab sampling might then have yielded samples contaminated by supernate (or sludge) from the shallower regions. This explanation is supported by the fact that for those sample elevations that yielded both sludge and supernate samples, the sludge sample was collected first. That is, sample 6C-96-6 (sludge) was collected before sample 6C-96-5 (supernate) and samples 6C-96-13 and 6C-96-14 (both sludge) were collected before samples 6C-96-15 and 6C-96-16 (both supernate). The work package for samples 6C-96-5 through 6C-96-10 (WHC 1996b) indicates that samples 6C-96-5 through 6C-96-10 were acquired in reverse numerical order with sample 6C-96-10 being acquired first. This sampling order implies that the deepest portions of the tank waste were sampled first, disturbing the waste above.

The way the grab samples were obtained may have been an additional cause of inconsistent sample types. During sampling, the wide-mouth sample bottle was stoppered until it reached the desired sample depth. The sampling operator then pulled the stopper by means of a lanyard attached to the stopper and waited about 10 seconds for the sample bottle to fill. The operator then pulled the sampler from the tank; there was no provision for restoppering the sample bottle prior to pulling the sample. Because the sample bottle could not be restoppered prior to removing it from the sampled layer, it is conceivable that the grab samples could have been contaminated with intervening layers of sludge or supernate.

The third possibility is that the samples were from the indicated sample elevations, but that the sludge surface is irregular. Bander (1995) and Schofield (1996) indicate that a 1994 in-tank video of tank 241-C-106 showed the sludge surface to be extremely uneven. If the interface between the supernate and sludge layers were sufficiently uneven, then supernate samples could have been obtained in regions where sludge samples were expected. No attempt was made to relate any surface features in the sludge, especially depressions, with the probable sampling locations under risers 1 and 7. Therefore it is difficult to determine how likely supernate might have been obtained instead of sludge. Furthermore, riser 7 had been used for the cooling water additions to the tank (WHC 1996g), although cooling water was not added to the tank during the February/March 1996 sampling period. It is conceivable that the addition of water through this riser may have altered the surface level of the sludge immediately under the riser, possibly causing a depression in the sludge in which supernate could accumulate.

In addition to the uneven interface between the sludge and supernate, there may have been layers or pockets of supernate within the sludge layers. Bander (1995) indicates that best-fit thermal-hydraulic models of the sludge in tank 241-C-106 were generated when the model included the formation of voids in the sludge. The modeled voids occurred as the result of water converting to steam in the thermally hot sludge. If voids formed in the actual sludge, and if the voids subsequently filled with interstitial liquid or supernate, then pockets of solution might reside within the sludge. The size and stability of any such pockets are unknown.

After the samples were received at the laboratory, Esch (1996) states that the samples were to be maintained at about 55 °C (130 °F) to keep the samples in a state as similar to the original tank waste as possible. A water bath was used to keep the samples at approximately 55 °C (130 °F) in the hot cell. While samples 6C-96-1 through 6C-96-4 were in the water bath, the water bath went dry and overheated the samples to an estimated 200 °C (approximately 400 °F). Upon overheating, the containers for supernate samples 6C-96-1 and 6C-96-2 cracked and those samples evaporated to dryness and were lost; the container for sludge sample 6C-96-3 also cracked and the sludge dried out. The container for sample 6C-96-4 remained intact, and this sample was analyzed as planned. Therefore, there are no results for samples 6C-96-1 and 6C-96-2, and the results for sample 6C-96-3 should be used with caution because that sample was subjected to an uncontrolled step during the preparation procedure. While sample 6C-96-4 appeared to remain sealed and intact when accidentally overheated, it is possible that this sample may also have been altered by the uncontrolled overheating.

Because the sludge samples were centrifuged in a heated centrifuge, some evaporation of water from the sludge samples may have occurred. This water loss may introduce an overall high bias in the analytical results because the sample constituents would tend to concentrate as water was lost from the sample. In addition, centrifugation may have caused some stratification in the solid phase of the sludge samples. If stratification occurred and the solid phase was not well homogenized prior to subsampling, then unknown biases could exist in the centrifuged solids, control sample, and filtered centrifuged solids fractions.

5.1.1.2 Field Observations for the March 1996 Vapor Samples. No additional details other than those presented in Section 3.2.1 were available regarding field observations for these samples. However, see the discussion in Section 5.1.1.3 regarding the possible effects that sampling from the tank exhauster may have had on the vapor samples.

5.1.1.3 Field Observations for the February 1994 Vapor Samples. Bratzel and Huckaby (1995) report a number of observations that may affect the interpretation of the vapor samples from both the February 1994 and March 1996 vapor sampling events.

The February 1994 and March 1996 vapor samples were both collected from a port on the exhaust header while the exhauster was operating. Sampling the tank vapor at the exhaust header may affect how representative the samples are of the tank headspace for two reasons. First, sampling from the exhauster does not take into account the possible variability of vapor concentrations in the tank headspace. Therefore, the tank headspace was assumed to be homogeneous. This is a reasonable assumption because the tank is actively ventilated.

Second, the active ventilation system of tank 241-C-106 is connected via a cascade line to tank 241-C-105, which is in turn connected via a cascade line to tank 241-C-104. Consequently, gases and vapors from waste stored in tanks 241-C-104 and 241-C-105 may also be drawn into the tank 241-C-106 headspace. Thus, when considering the relationship between the waste in tank 241-C-106 and the gases and vapors in the exhaust from that tank, it should be kept in mind that some vapor constituents may actually be coming from tanks 241-C-104 and 241-C-105. Results of gas and vapor samples from tanks 241-C-104 and 241-C-105 provide evidence that tank 241-C-104 has vented through its cascade line to tank 241-C-105 (Huckaby and Bratzel 1995). In spite of these uncertainties, the exhaust header was deemed the best place to vapor sample the tank to reduce the exposure risks to tank farm workers.

The February 1994 vapor sampling of tank 241-C-106 was only the second use of the vapor sampling system; the sampling occurred only three weeks after the first use of the vapor sampling system on a tank. Because the methods and equipment were relatively new, problems with sample handling (e.g., chain-of-custody and shipping) were encountered. Sorbent trap collection problems noted in a subsequent sampling event appear to have affected several of the inorganic compound samples. In particular, for tank 241-C-106, one valve on the sorbent trap station of the vapor sampling system may have not opened properly during the sampling event.

5.1.2 Quality Control Assessment

The usual quality control assessment includes an evaluation of the appropriate standard recoveries, matrix spike recoveries, duplicate analyses, and method blanks that are performed in conjunction with the chemical analyses. All of the pertinent quality control tests were conducted on the 1996 grab samples, allowing a full assessment regarding the accuracy and precision of the data. The quality control (QC) criteria were specified by the laboratory for standard recoveries and matrix spike recoveries, while the duplicate analyses and method blanks were governed by the *Hanford Analytical Services Quality Assurance Plan* (DOE 1995). Quality control results outside these criteria are identified by superscripts in the Appendix A tables for all analytes. A summary of the QC results for several major analytes related to tank safety issues (e.g., DSC, TGA, total alpha activity, TOC, ^{90}Sr, and ^{137}Cs) is presented below.

The standard and spike recovery results provide an estimate of the accuracy of the analysis. If a standard or spike recovery is above or below the given criterion, then the analytical results may be biased. All standard recoveries were within the defined criteria with the exception of two of 25 standards run with the TGA analyses. One of these results was slightly below the criteria and the other was slightly above. None of the spike recoveries for total alpha activity, TOC, ^{90}Sr, or ^{137}Cs were outside their criteria.

Analytical precision is estimated by the RPD, which is defined as the absolute value of the difference between the primary and duplicate samples, divided by their mean, times one hundred. One or more RPDs were above the criteria for all six analyses. Including solid and liquid results, ten of 39 RPDs were above the limit for DSC, five of 41 for TGA, four of 14 for total alpha activity, two of 17 for TOC, four of 19 for ^{90}Sr, and four of 21 for ^{137}Cs. Because the sludge samples were observed to contain pieces of material that appeared to be crystals, the RPD deviations were attributed to heterogeneous samples. Reruns were not requested for most samples; reruns would not have substantially improved the results because of the difficulty in obtaining representative samples of the crystalline material (Esch 1996). The preparation blanks for TOC and ^{90}Sr showed some results above the detection limit. However, the level of analyte concentration in the blanks was inconsequential when compared to the sample results (Esch 1996). Thus, the low level of contamination did not impact data quality for either of these analytes.

In summary, practically all of the QC results for the six analyses were within the boundaries specified by the laboratory and in DOE (1995). The few discrepancies noted should not impact either the validity or use of the data for those analyses.

5.1.3 Data Consistency Checks

Comparing the results from different analytical methods helps in assessing data consistency and quality. Several comparisons within the data set provided by the grab samples are discussed below. They include comparing phosphorus and sulfur as analyzed by ICP with phosphate and sulfate as analyzed by IC, comparing total alpha activity with the sum of alpha emitters, comparing TOC results for two analytical methods, comparing percent water as analyzed by TGA and gravimetry, comparing percent water analyzed by TGA under nitrogen and air, and calculating a mass and charge balance to help assess the overall data consistency.

5.1.3.1 Comparison of Results from Different Analytical Methods. The following data consistency checks compare the results from two or more analytical methods for a given analyte. Close agreement between the two methods can strengthen the credibility of both results; poor agreement may bring into question the reliability of the data or the assumptions about the waste. All analytical mean results were taken from Tables 4-2 and 4-3.

Table 5-1 presents a comparison of ICP-determined phosphorous and sulfur results to the corresponding IC-determined phosphate and sulfate results. The analytical phosphorus mean result in the supernate as determined by ICP of acid-diluted samples (ICP:A) was 286 μg/mL which converts to 875 μg/mL of phosphate (assuming that all the phosphorous is present as phosphate). This is in reasonable agreement with the IC phosphate mean result of

862 μg/mL. The ratio of IC to ICP results typically indicates the degree of solubility for the analyte because the sample preparation method used for ICP can render some forms of insoluble phosphorous into soluble forms that can be subsequently detected by the ICP. In the supernate, all the phosphorous appears to be present as phosphate.

For the sludge, the results indicated that the phosphate was present mostly in insoluble form. The analytical phosphorus mean result in the sludge, as determined by ICP:A, was 2,370 μg/mL which converts to 7,270 μg/mL of phosphate. Compared with the IC phosphate mean result of 1,530 μg/mL, the ICP result suggests that most phosphate in this waste is insoluble. This observation prompted the assumption in the mass and charge balance calculations that most of the phosphate in the sludge layer was insoluble (see Section 5.1.3.2).

The ICP sulfur value in the supernate of 2,580 μg/mL converts to 7,740 μg/mL of sulfate (assuming all the sulfur is present as sulfate). This compares closely with the IC sulfate result of 7,360 μg/g. The RPD between the two sulfate estimates was 4.9 percent, meaning that almost all of the sulfur appears to be present as sulfate. The ICP:A sulfur value in the sludge of 2,420 μg/mL converts to 7,250 μg/mL of sulfate. This compared reasonably well with the IC sulfate result of 6,960 μg/mL. The RPD between these two sulfate estimates was 4.2 percent. In this case, the sulfur/sulfate in the sludge is entirely soluble.

Table 5-1. Comparison of Phosphate/Phosphorous and Sulfate/Sulfur Concentrations by Different Methods.

Supernate				Sludge			
ICP:A	IC			ICP:A	IC		
PO_4^{3-} (μg/mL)	PO_4^{3-} (μg/mL)	Solubility (IC/ICP)	RPD	PO_4^{3-} (μg/mL)	PO_4^{3-} (μg/mL)	Solubility (IC/ICP)	RPD
875	862	98.5%	1.5%	7,270	1,530	21.2%	130%
SO_4^{2-} (μg/mL)	SO_4^{2-} (μg/mL)	Solubility (IC/ICP)	RPD	SO_4^{2-} (μg/mL)	SO_4^{2-} (μg/mL)	Solubility (IC/ICP)	RPD
7,740	7,360	95.1%	4.9%	7,250	6,960	95.9%	4.2%

Notes:

ICP:A = Inductively coupled plasma - acid prepared sample result
IC = Ion chromatography result

A limited comparison was made between the gross alpha activities for the supernate and the sum of the individual alpha emitters for the supernate. A similar comparison was not performed for the sludge because alpha activities were not determined on all the sludge subsamples. Hence, overall activities could not be reconstructed for all the alpha emitters in the sludge. The sum of the activities of the individual alpha emitters was determined by adding the ^{241}Am and $^{239/240}Pu$ activities. The comparison of total alpha activity with the sum of the activities of the alpha emitters that were determined is reasonably good for the low levels of alpha activity observed, with an RPD of 26.4 percent. Table 5-2 shows the results of this comparison.

Table 5-2. Tank 241-C-106 Comparison of Gross Alpha Activity with the Total of the Individual Activities.

Analyte	Supernate Overall Mean (μCi/mL)
^{241}Am	0.013
$^{239/240}Pu$	0.745
Sum of alpha emitters	0.758
Gross alpha	1.03
Relative percent difference	26.4%

Five liquid samples were analyzed for TOC by both persulfate oxidation and furnace oxidation methods. Two of the samples were supernate and three were interstitial or drainable liquid. A comparison of the results for these two analytical methods is included in Table 5-3. In general, the results show that the TOC results by the furnace oxidation method are consistently slightly higher than by the persulfate oxidation method. This is expected because furnace oxidation is a more rigorous oxidation method.

Table 5-3. Comparison of TOC Results by Persulfate and Furnace Oxidation.

Sample Type	Laboratory Number	Sample Number	Persulfate Oxidation TOC (μg C/mL)	Furnace Oxidation TOC (μg C/mL)
Supernate	S96T000538	6C-96-5	2,240	3,300
Supernate	S96T001023	6C-96-12	2,030	2,520
Drainable Liquid	S96T001544	6C-96-4	1,680	2,320
Drainable Liquid	S96T000563	6C-96-7	2,320	2,440
Drainable Liquid	S96T001681	6C-96-11	1,630	2,070

Twelve samples were analyzed for percent water by both TGA and gravimetric analysis. Two of these samples were supernate, five were filtered centrifuged solids and five were centrifuged solids. Table 5-4 lists the results for these two analytical methods, and Appendix C provides the statistical comparison of the two methods. The statistical analyses indicated that, at the 0.05 significance level, the two methods gave significantly different answers for the filtered centrifuged solids but not for supernate and centrifuged solids. In general, for the filtered centrifuged solids, the percent water results by gravimetric analysis are consistently greater than the TGA method. This is expected, because the gravimetric method used larger samples and a constant drying temperature of 105 °C for 18 hours, which could potentially drive off more water from the solid samples. As well, the TGA results are based only on the first weight loss transition. Some of the weight loss in the second transition may be attributed to water. Therefore, the gravimetry results were used because they are thought to more accurately represent the water content.

Table 5-4. Comparison of Percent Water by Thermogravimetric and Gravimetric Analyses. (2 sheets)

Laboratory Number[1]	Sample Number	Thermogravimetric Analysis (% water)	Gravimetric Analysis (% water)
Supernate			
S96T000538	6C-96-5	80.88	81.4
S96T001023	6C-96-12	79.27	79.0
Filtered Centrifuged Solids			
S96T001537/ S96T001539	6C-96-4	24.10	25.1
S96T000567/ S96T000569	6C-96-7	25.74	26.8
S96T000551/ S96T000553	6C-96-10	12.78	19.05
S96T001685/ S96T001687	6C-96-11	31.92	34.1
S96T001559/ S96T001561	6C-96-13	23.7	26.3
Centrifuged Solids			
S96T001527	6C-96-4	3.58	5.75
S96T000542	6C-96-7	8.28	9.9

Table 5-4. Comparison of Percent Water by Thermogravimetric and Gravimetric Analyses. (2 sheets)

Laboratory Number[1]	Sample Number	Thermogravimetric Analysis (% water)	Gravimetric Analysis (% water)
Centrifuged Solids (continued)			
S96T000558	6C-96-10	12.86	17.1
S96T001674	6C-96-11	9.03	11.65
S96T001030	6C-96-13	9.36	20.85

Note:

[1]In cases where two sample numbers are given, the parent sample is the same and the two sample are sister samples.

Two samples were analyzed for percent water by thermogravimetric analysis under two different atmospheric conditions, nitrogen and air. Both of the samples analyzed were sludge samples. Table 5-5 compares the results for these two methods, and Appendix C contains the statistical analysis of these data. The statistical analysis indicated that the analyses for percent water by TGA run under different atmospheric conditions do not give significantly different answers at the 0.05 significance level.

Table 5-5. Comparison of TGA Results under Nitrogen and Air.

Laboratory Number[1]	Sample Number	TGA - Nitrogen (% water)	TGA - Air (% water)
S96T002021/ S96T002042	6C-96-8	52.88	57.9
S96T002350/ S96T002351	6C-96-14	64.16	55.3

Note:

[1]In cases where two sample numbers are given, the parent sample is the same and the two samples are sister samples.

5.1.3.2 Mass and Charge Balance. The principal objective in performing a mass and charge balance is to determine whether the analytical results were consistent. In calculating the balances, only those analytes listed in Tables 4-2 and 4-3 that were detected at a concentration of 1,500 μg/g or greater were considered.

For sludges, with the exception of sodium, the cations listed in Table 5-6 were assumed to be in their most common oxide/hydroxide form, as an insoluble phosphate, or as an insoluble oxalate. The concentrations of the assumed species were calculated stoichiometrically. Because precipitates are neutral species, all positive charge was attributed to sodium.

Carbonate concentration was derived from the total inorganic carbon. The total organic carbon was considered to be oxalate. The other anions listed in Table 5-7 were assumed to be present as sodium salts and were expected to balance the positive charge of sodium ion. Sulfur is considered to be present as the sulfate ion and is assumed to be completely water soluble. The water soluble phosphate was included in the anion mass and charge data, and subtracted from the total phosphate calculated from the ICP. The insoluble phosphate was combined stoichiometrically with calcium, sodium, and lead. Iron was combined with hydroxide. The concentrations of the cations in Table 5-6, the anions in Table 5-7, and the percent water were ultimately used to calculate the mass balance. The uncertainty estimates (RSDs) associated with each analyte are given in the tables.

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

Mass balance = % Water + 0.0001 x {Total Analyte Concentration} = % Water + 0.0001 x $\{Al(OH)_3 + FeO(OH) + Ca_3(PO_4)_2 + Na_3PO_4 + PbHPO_4 + SiO_2 + Na^+ + CO_3^{-2} + {}^{-}NO_3^- + NO_2^- + (COO)_2^{-2} + PO_4^{-3} + SO_4^{-2}\}$

The mass balance is evaluated in several steps. First, the individual contributions of the anions and cations are calculated, and species assumed. The total analyte concentration calculated from the above equation was 500,000 μg/g. Then, the weight percent water is added. The mean weight percent water obtained from gravimetric analysis reported in Table 4-3 is 47.2 percent. The mass balance resulting from adding the percent water to the total analyte concentration is 97.2 percent (see Table 5-8).

The following equations are the derivation of total cations and total anions.

Total cations (microequivalents) = $Na^+/23.0$ = 4,876 microequivalents

Total anions (microequivalents) = $CO_3^{-2}/30.0 + NO_3^-/62.0 + NO_2^-/46.0 + (COO)_2^{-2}/44.0 + PO_4^{-3}/31.7 + SO_4^{-2}/48.1$ = -5,544 microequivalents

Table 5-6. Tank 241-C-106 Sludge Cation Mass and Charge Data.

Analyte	Concentration (μg/g)	Assumed Species	Concentration of Assumed Species (μg/g)	Charge (μeq/g)
Aluminum	31,000	$Al(OH)_3$	89,600	0.00
Calcium	851	$Ca_3(PO_4)_2$	2,200	0.00
Iron	40,300	FeO(OH)	64,100	0.00
Lead	1,500	$PbHPO_4$	2,190	0.00
Phosphorous (net)	4,660		with Ca, Na & Pb	
Silicon	15,800	SiO_2	33,800	0.00
Sodium	114,000	Na^+ Na_3PO_4	113,000 4,540	4,876 0
Totals			309,000	4,876

Table 5-7. Tank 241-C-106 Sludge Anion Mass and Charge Data.

Analyte	Concentration (μg/g)	Species	Concentration of Assumed Species (μg/g)	Charge (μeq/g)
TIC	23,300	CO_3^{-2}	115,900	-3,863
Nitrate	1,540	NO_3^-	1,540	-25
Nitrite	15,900	NO_2^-	15,900	-346
Oxalate	52,200	$C_2O_4^{-2}$	52,200	-1,186
Phosphate	988	PO_4^{-3}	988	-318
Sulfate	4,490	SO_4^{-2}	4,490	-93
Totals			191,000	-5,544

The charge balance is 0.88. The charge balance is the absolute value of the total cations divided by the total anions. The net charge is -669 microequivalents. Boundary conditions for the mass balance are 1,000,000 μg/g and 1.00 for the charge balance, with no net charge remaining. Table 5-8 provides a summary of the mass and charge calculations for the sludge.

Table 5-8. Tank 241-C-106 Sludge Mass and Charge Balance Totals.

	Concentrations (µg/g)	Charge (µeq/g)
Total from Table 5-6	309,000	4,876
Total from Table 5-7	191,000	-5,544
Water (gravimetric)	472,000	0
Total	972,000	-668

In summary, the above calculations yield a reasonable mass balance of 97.2 percent and a charge balance value of 0.88, indicating that the mean analytical results for the sludge samples were an adequate description of the sludge layers that were sampled.

For the supernate, sodium was the only cation present in appreciable concentration. The mass and charge values for sodium are listed in Table 5-9. All positive charge was attributed to sodium ion. The formate and carbonate data were derived from the total organic carbon and total inorganic carbon analyses, respectively. Because of the high levels of beta and gamma radiation, formate was the species assumed for the TOC present. The other anions listed in Table 5-10 were assumed to be present as sodium salts and were expected to balance the positive charge from sodium ion.

Sulfur is considered to be present as the sulfate ion and phosphorus as the phosphate ion. Both species are assumed to be completely water soluble. The concentrations of the cations in Table 5-9, the anions in Table 5-10, and the percent water were used to calculate the mass balance.

Table 5-9. Tank 241-C-106 Supernate Cation Mass and Charge Data.

Analyte	Concentration (µg/g)	Assumed Species	Concentration of Assumed Species (µg/g)	Charge (µeq/g)
Sodium	90,100	Na^+	90,100	3,920
Totals			90,100	3,920

Table 5-10. Tank 241-C-106 Supernate Anion Mass and Charge Data.

Analyte	Concentration (μg/g)	Assumed Species	Concentration of Assumed Species	Charge (μeq/g)
TOC	2,490	HCO_2^-	9,340	-208
TIC	19,000	CO_3^{2-}	95,000	-3,167
Nitrate	1,130	NO_3^-	1,130	-18
Nitrite	23,800	NO_2^-	23,800	-517
Oxalate	2,900	$C_2O_4^{2-}$	2,900	-66
Phosphate	739	PO_4^{3-}	739	-23
Sulfate	6,300	SO_4^{2-}	6,300	-131
Totals			139,000	-4,130

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 { $Na^+ + HCO_2^- + CO_3^{-2} + NO_3^- + NO_2^- + (COO)_2^{-2} + PO_4^{-3} + SO_4^{-2}$}

The mass balance is evaluated in several steps. First, the individual contributions of the anions and cations are calculated, and species assumed. The total analyte concentrations calculated from the above equation is 229,000 μg/g. Then, the weight percent water is added. The mean weight percent water obtained from gravimetric analysis is 80.2 percent. The mass balance resulting from adding the percent water to the total analyte concentration is 103.1 percent (see Table 5-11).

The following equations are the derivation of total cations and total anions.

Total cations (microequivalents) = $Na^+/23.0$ = 3,920 microequivalents

Total anions (microequivalents) = $+HCO_2^-/45.0 + CO_3^{-2}/30.0 + NO_3^-/62.0 + NO_2^-/46.0 + (COO)_2^{-2}/44.0 + PO_4^{-3}/31.7 + SO_4^{-2}/48.1$ = -4,130 microequivalents

The charge balance for the supernate is 0.95. The charge balance is the absolute value of the total cations divided by the total anions. The net charge is -210 microequivalents. Boundary conditions for the mass balance are 1,000,000 μg/g and 1.00 for the charge balance, with no net charge remaining. Table 5-11 provides a summary of the mass and charge calculations for the supernate.

Table 5-11. Tank 241-C-106 Supernate Mass and Charge Balance Totals.

	Concentrations (μg/g)	Charge (μeq/g)
Total from Table 5-9 (cations)	90,100	3,920
Total from Table 5-10 (anions)	139,000	-4,130
Water (grav.)	802,000	0
Total	1,031,000	-210

In summary, the above calculations yield reasonable mass and charge balance values (approximately 103 percent for the mass balance and 0.95 for the charge balance), indicating that the mean analytical results for the supernate were an adequate description of the tank contents sampled. With the uncertainty regarding these measurements, the mass and charge balance calculations can be considered to be consistent.

5.2 COMPARISON OF SAMPLING EVENTS

Two sample events were compared with the 1996 grab samples. These include a 1986 sludge core composite and drainable liquid samples, and a 1980 sludge core composite. Radioisotope concentrations for the historical samples are decayed to 1996 values. As shown in Table 5-12, there is generally good comparison between the 1996 supernate samples and the 1986 drainable liquid samples. The only substantial difference in the sample results are for ^{137}Cs and ^{90}Sr. The supernate samples from the 1996 grab sampling event have five times more ^{137}Cs and a third as much ^{90}Sr as in the 1986 drainable liquid samples. Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), laboratory results prior to 1989 are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

Table 5-12. Comparison of 1996 Supernate Analyses with 1986 Sample Results for Tank 241-C-106[1]. (2 sheets)

Analyte	1996 Supernate	1986 Drainable Liquid[2]
METALS (μg/mL)		
Aluminum	<30	<34
Barium	<30	<5
Boron	<30	10.4
Cadmium	<3	<25
Calcium	<60	11
Chromium	<6	6
Copper	<6	3
Iron	<30	12
Lanthanum	<30	n/a
Lead	<60	<82
Magnesium	<60	13
Manganese	<6	<200
Nickel	16	72
Phosphorous	286	344
Potassium	658	422
Silicon	<30	105
Silver	8	<10
Sodium	1.05E05	9.5E04
Titanium	<6	n/a
Uranium	1,680	n/a
Zirconium	381	293
ANIONS (μg/mL)		
F^-	244	458
NO_3^-	1,320	1,408
SO_4^{-2}	7,360	6,470

Table 5-12. Comparison of 1996 Supernate Analyses with 1986 Sample Results for Tank 241-C-106[1]. (2 sheets)

Analyte	1996 Supernate	1986 Drainable Liquid[2]
RADIONUCLIDES (μCi/mL)[3]		
^{241}Am	0.013	<0.014
^{137}Cs	108	22.1
$^{239/240}$Pu	0.74	0.98
^{90}Sr	0.42	1.29
PHYSICAL PROPERTIES		
Percent Water	80.1%	79.7%
CARBON (μg C/mL)		
Total Organic Carbon	2,910	2,520

Notes:

[1]1996 analytical data are from Appendix A; 1986 data are from Appendix D.

[2]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

[3]Radionuclide values are decayed from the sample date to 1996.

However, Table 5-13 shows substantial differences between sludge results for the 1996, 1986 and 1980 sample events. These differences may be attributed in large part to the different types of samples that were obtained during the different sampling events. The 1980 and 1986 composite samples were prepared from multiple subsamples from each segment of full-depth cores, while the 1996 mean concentrations were based on multiple grab samples from the top 60% of the sludge, the results of which were then averaged together. The sludge analyses from the 1996 grab samples showed twice as much ^{137}Cs and one-fourth the ^{90}Sr compared to the 1986 composite sample. Most other species were comparable, with a few exceptions such as magnesium, silicon, and TOC. The lower TOC value for the 1986 composite sample is likely due to the dilution effect caused by mixing low TOC segments with higher TOC segments. The 1980 composite sample analyses showed much higher amounts of chloride, nitrate, phosphate, and TIC. There was also about three times less ^{137}Cs, and twelve times more ^{90}Sr in the 1980 composite sample as compared to the 1996 analytical results. The high ^{90}Sr results for the 1980 and 1986 samples may be the result of sampling lower waste layers that have higher ^{90}Sr concentrations.

Table 5-13. Comparison of 1996 Sludge Analyses with 1986 Sample Results for Tank 241-C-106.[1] (2 sheets)

Analyte	1996 Sludge Grab Sample	1986 Core Composite Sample[2]	1980 Core Composite Sample[2,3]
METALS (μg/mL)			
Aluminum	48,200	58,487	40,950
Barium	292	6,993	n/a
Boron	66.3	28	n/a
Cadmium	32.4	529	287
Calcium	1,310	17,017	n/a
Chromium	636	1,407	1,843
Copper	105	183	n/a
Iron	62,800	74,503	87,496
Lanthanum	71.2	n/a	8,135
Lead	2,330	3,446	2,300
Magnesium	254	9,381	792
Manganese	2,160	2,631	19,246
Nickel	607	1,391	1,215
Phosphorous	2,370	4,161	n/a
Potassium	932	2,102	n/a
Silicon	24,600	101,530	28,119
Silver	1,870	756	n/a
Sodium	177,000	167,310	106,334
Strontium	40.2	147	n/a
Uranium	1,610	n/a	n/a
Zinc	63.4	66	n/a
Zirconium	725	3,103	1,003
ANIONS (μg/mL)			
Cl^-	384	365 [1,*]	4,786
F^-	324	1,030	413
NO_3^-	2,360	1,327	21,430
NO_2^-	24,600	37,600 [1,*]	n/a
PO_4^{-3}	1,530	1,670 [1,*]	127,900
SO_4^{-2}	6,960	6,936	4,805

Table 5-13. Comparison of 1996 Sludge Analyses with 1986 Sample Results for Tank 241-C-106.[1] (2 sheets)

Analyte	1996 Sludge Grab Sample	1986 Core Composite Sample[2]	1980 Core Composite Sample[2,3]
RADIONUCLIDES (µCi/mL) [4]			
^{137}Cs	654	375	231
$^{239/240}Pu$	1.67	4.4	7.5
^{90}Sr	546	2,212	6,901
PHYSICAL PROPERTIES			
Percent Water	47.2	52.5	n/a
CARBON (µg C/mL)			
Total Inorganic Carbon	36,000	n/a	125,444
Total Organic Carbon	20,000	6,607	27,300

Notes:

n/a = not available

[1]1996 analytical data are from Appendix A; 1986 data are from Pauly and Torgerson (1987), except where denoted by an asterisk. Asterisk data are from McCown (1988).

[2]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

[3]1980 grab samples included a water soluble and a water insoluble fraction. The higher of these two results are reported here.

[4]Radionuclide values are decayed from the sample date to 1996.

5.3 TANK WASTE PROFILE

One objective of the 1996 grab sampling event was to obtain a vertical profile of the waste from two or more widely-spaced risers (Schreiber 1996a). Vertical profiles were obtained from riser 1 and riser 7. However, these were only obtained from the supernate and top 60 percent of the sludge. As a result, statistical results presented in this section apply only to the supernate and upper 60 percent of the sludge in tank 241-C-106.

Historical information on the vertical disposition of the waste was available from the TLM (see Figure 2-3). According to the TLM, the total waste profile is composed of six layers. Two layers of unknown waste make up the top 30 percent of waste in the tank, and are estimated to be half washed PUREX sludge (AR) and half B-Plant low level (BL) waste (Agnew et al. 1996). Below the unknown waste is a thin layer of BL waste, followed by a layer of AR waste in the middle third of the tank. The bottom two tank layers are cladding PUREX (CWP1) waste and a thin layer of uranium recovery (UR) waste. These predicted layers indicate that tank contents are expected to be vertically heterogeneous.

The fact that two risers were sampled at different depths enabled an analysis of variance (ANOVA) to be conducted on the February/March 1996 grab samples to further determine whether significant horizontal or vertical differences in analyte concentrations existed. The ANOVA generates a p-value that is compared to a standard significance level ($\alpha = 0.05$). If a p-value is below 0.05, there is sufficient evidence to conclude that the sample means are significantly different. A two-tailed statistical test was used in all cases.

A random-effects nested model was used initially to assess horizontal and vertical heterogeneity. The results from fitting this model to the data showed that there were no statistically significant difference between the risers, with all p-values greater than 0.05. As a result, vertical heterogeneity for all analytes was assessed using a one-way random-effects nested model. This model was further segregated into supernate and centrifuged solids waste phases. The ANOVA analyses were calculated only for analytes which had more than half of their individual measurements above the detection limit.

Results from the one-way random-effects nested model showed that supernate analytes had 14 of 30 analytes with p-values less than 0.05. These analytes included radionuclides, anions, and metals. Similar results were obtained for the centrifuged solids, with six of nine analytes showing p-values less than 0.05. This indicates that the composition of the supernate and top 60 percent of the sludge depends heavily on vertical position.

Restricted maximum likelihood estimates of the mean and RSD of the mean for the data set as a whole and for the designated supernate and sludge samples are included in Appendix A. Additional statistical evaluations are in Appendix C.

In summary, the supernate and top 60 percent of the sludge vary substantially with depth but not with horizontal position. The evidence of vertical heterogeneity supports observations and the TLM qualitative description.

5.4 COMPARISON OF ANALYTICAL AND TRANSFER DATA

Tables 5-14 and 5-15 compare the analytical results for the supernate and sludge from the February/March 1996 grab samples of tank 241-C-106 to the historical tank content estimate and HDW estimates. The comparison is for information only. The HTCE values are generated from a combination of inputs from the WSTRS (Agnew et al. 1995), the Hanford Defined Wastes, and the TLM (Agnew et al. 1996). Each input contains assumptions and/or other factors that may impact the HTCE numbers (such as transfers of an unknown waste type into the tank). Because the HTCE values have not been validated, they should be used with caution.

Table 5-14 compares the analytical results from the February/March 1996 grab samples to the HTCE prediction for tank 241-C-106 supernate. In general, the predicted supernate values compare very poorly with the analytical results. In particular, the HTCE model predicts the sodium concentration to be an order of magnitude lower than actually observed. The model also does not predict the analytical results showing nitrite with a greater concentration than nitrate, nor that the TIC value is greater than the TOC value. Comparing the analytical results to the HDW models for AR and BL supernates shows that the AR model tends to predict the anion and ^{137}Cs analytical values better than the BL supernate model. In contrast, the BL model better predicts the potassium, sodium, uranium, physical properties, TOC, and TIC values. Neither model predicts the aluminum, iron, or silicon values very well, possibly because these species have precipitated out as hydroxides and have caused the supernate to become caustic deficient.

Sludge comparisons (Table 5-15) show general agreement within an order of magnitude between the 1996 analyses and HTCE predictions with the exceptions of calcium, manganese, nickel, uranium, fluoride, ^{90}Sr, and ^{137}Cs.

One of the primary concerns regarding tank 241-C-106 involves the distribution of ^{90}Sr in the tank waste. During fiscal year 1997, sluicing a portion of the waste to tank 241-AY-102 is planned in order to remove a significant amount of the ^{90}Sr (the primary heat-generating species in the waste) from the tank and thus mitigate the high-heat load in the tank. However, the bottommost layer in the tank according to the TLM -- the "hardpan" -- will not be retrieved during this project. Therefore, it is important to determine whether or not the ^{90}Sr activity generating the high-heat load in this tank resides in the hardpan.

There is compelling evidence that the bulk of the radioactivity is not located in the hardpan. The historical transfer records for tank 241-C-106 are the main support for this contention. The tank was placed into use in 1947, and it received uranium recovery waste and cladding waste between 1955 and 1960. These two waste types combined to form the layer of hardpan waste (Agnew 1995). The tank layer model estimates the volume of this layer at 57 kL (15 kgal) (Agnew et al. 1996) which converts to an elevation of 0.33 m (12.9 in.).

During the late 1960s, a sludge washing/decanting process occurred in the 244-AR vault and involved washing slurry with water to remove soluble constituents. Originally, the wash solution was to be decanted to tank 241-C-106 after the solids settled. However, the decanting step was ineffective, and strontium solids were inadvertently transferred with the wash solution into the tank, where the solids accumulated. During 1971, temperatures in excess of 100 °C (212 °F) were observed in tank 241-C-106 and it became apparent that large quantities of strontium had been transferred during the process (Bander 1995). Therefore, since the elevated tank waste temperatures did not appear until the AR waste (AR) was transferred to the tank, it is reasonable to conclude that the bulk of the ^{90}Sr resides in the AR layer rather than in the hardpan layer.

For the sludge, the tank layer model predicts two AR layers from 0.64 to 1.23 m (25.3 to 48.5 in.) elevation and 1.71 to 2.01 m (67.5 to 79.1 in.) elevation. B-Plant low-level waste

(BL) is predicted to reside from 1.23 to 1.71 m (48.5 to 67.5 in.) elevation. From Table 3-2, sludge samples 6C-96-6 and -11 should have originated in the upper AR layer while sludge samples 6C-96-4, -13, and -14 should have come from the lower AR layer. Samples 6C-96-7, -8, and -10 should have originated from the BL layer. The TLM predicts that both waste types should contain a significant amount of ^{90}Sr with the AR layer containing almost twice as much as the BL layer. The analytical value for ^{90}Sr in Table 5-15 is approximately an order of magnitude lower than those values predicted by the TLM. The ^{90}Sr data in Appendix A for the sludge samples do seem to indicate a general trend of increasing ^{90}Sr concentrations with decreasing sample elevation; the TLM does predict this trend through the AR layer.

The fact that the TLM predicts much more ^{90}Sr than actually observed may indicate one or more of three explanations: (1) the ^{90}Sr concentration in the AR layer is actually less than predicted by the model, (2) the grab samples were biased and did not obtain representative samples from the sludge layers in the tank, or (3) the location of the AR layer is at a lower elevation in the tank than predicted by the model and the grab samples did not penetrate deeply enough to sample the layer (this situation also constitutes a form of sampling bias). With regard to the first explanation, models of the tank heat load (see Section 5.5) indicate that a larger inventory of ^{90}Sr than that calculated from the analytical results is required to account for the tank heat load. The second explanation -- that the grab samples were biased -- is more likely. However, the extent of any bias due to sampling remains unknown. Finally, the third explanation -- that the ^{90}Sr is located deeper in the tank than predicted by the TLM -- provides a rationale for why the grab samples did not contain sufficient ^{90}Sr to account for the observed heat load in the tank.

Therefore based on the grab samples and the waste transfer history, the bulk of the ^{90}Sr in the waste probably lies below about 0.91 m (36 in.) elevation -- the elevation of the deepest grab sample retrieved from tank 241-C-106 -- and above 0.33 m (13 in.) -- the elevation to the top of the hardpan layer.

In summary, the HTCE predicts the composition of the supernate layer poorly; the HDW models of AR and BL supernates predict portions of the analytical results to a limited extent. The HTCE models the sludge layer to a reasonable degree. Discrepancies between the model and the analytical results may be attributed in part to biases in the grab samples.

Table 5-14. Comparison of Historical Inventory With 1996 Analytically Derived Inventory for Tank 241-C-106 (Supernate).[1,2] (2 sheets)

Analyte	1996 Supernate Analytes	HTCE Supernate Analytes	HDW PUREX, AR Waste	HDW B-Plant Low Level Waste
METALS (μg/mL)				
Aluminum	< 30	2,220	591	14,090
Calcium	< 60	56.9	361	361

Table 5-14. Comparison of Historical Inventory With 1996 Analytically Derived Inventory for Tank 241-C-106 (Supernate).[1,2] (2 sheets)

Analyte	1996 Supernate Analytes	HTCE Supernate Analytes	HDW PUREX, AR Waste	HDW B-Plant Low Level Waste
METALS (μg/mL) (continued)				
Iron	< 30	17.9	112	112
Lead	< 60	0	12.4	0
Nickel	16.1	16.6	106	106
Potassium	658	83.3	290	528
Silicon	< 30	150	956	955
Sodium	105,000	12,300	31,000	78,500
Uranium	1,680	150	690	952
ANIONS (μg/mL)				
Cl^-	318	347	634	2,200
NO_3^-	1,320	15,900	19,900	101,000
NO_2^-	27,800	686	20,600	4,360
PO_4^{-3}	862	150	2,230	953
SO_4^{-2}	7,360	667	7,860	4,240
RADIONUCLIDES (μCi/mL)				
^{137}Cs	108	0.0003	276	0
$^{239/240}Pu$	0.745	.0005	31.6	34.9
^{90}Sr	0.423	5.35	34.0	34.0
PHYSICAL PROPERTIES				
Percent Water	80.1	95.7	90.7	77.5
Specific Gravity	1.17	1.03	1.05	1.16
CARBON (μg/mL)				
Total Organic Carbon	2,910	93,200	0	5,900
Total Inorganic Carbon/ CO_3^{-2}	22,300	2,540	8,750	16,200

Notes:

n/a = not available

[1]1996 analytical data are from Appendix A; HTCE and HDW data are from Agnew et al. (1996).

[2]Because the HTCE values have not been validated, they should be used with caution.

Table 5-15. Comparison of Historical Inventory With 1996 Analytically Derived Inventory for Tank 241-C-106 (Sludge).[1,2] (2 sheets)

Analyte	1996 Sludge Analytes	HTCE Prediction for C-106 Sludge	HDW PUREX, AR Waste	HDW B-Plant Low Level Waste
METALS (μg/mL)				
Aluminum	48,200	68,300	1,920	164,000
Calcium	1,310	6,170	247	8,150
Chromium	636	395	738	0.01
Iron	62,800	76,500	72,700	123,000
Lead	2,330	4,210	10.2	0
Manganese	2,160	59	6,020	0
Nickel	607	22,700	8,160	70,900
Potassium	932	253	241	304
Silicon	24,600	48,900	63,700	67,000
Sodium	177,000	117,000	129,000	154,000
Strontium	40.2	0	194	0
Uranium	1,610	42,100	571	154,000
ANIONS (μg/mL)				
Cl^-	384	876	526	1,270
F^-	324	3.0	6.3	0
NO_3^-	2,360	16,400	0	53
NO_2^-	24,600	33,000	29,400	45,700
ANIONS (continued) (μg/mL)				
PO_4^{-3}	1,530	1,910	1,850	548
SO_4^{-2}	6,960	4,950	6,530	2,440
RADIONUCLIDES (μCi/mL)				
^{137}Cs	654	112	230	0
$^{239/240}Pu$	1.67	6.12	9.46	5.19
^{90}Sr	546	7,010	11,800	4,700
PHYSICAL PROPERTIES				
Percent Water	50.6	54.4	69.3	33.6
Bulk Density (g/mL)	1.55	1.50	1.30	1.99

Table 5-15. Comparison of Historical Inventory With 1996 Analytically Derived Inventory for Tank 241-C-106 (Sludge).[1,2] (2 sheets)

Analyte	1996 Sludge Analytes	HTCE Prediction for C-106 Sludge	HDW PUREX, AR Waste	HDW B-Plant Low Level Waste
CARBON (μg C/mL)				
Total Organic Carbon	20,000	89,400	0	3,390
Total Inorganic Carbon/CO_3^{-2}	36,000	15,700	13,400	21,200

Notes:

n/a = not available

[1]1996 analytical data are from Appendix A; HTCE and HDW data are from Agnew et al. (1996).

[2]Because the HTCE values have not been validated, they should be used with caution.

5.5 EVALUATION OF PROGRAM REQUIREMENTS

An evaluation of the analytical results from the February/March 1996 grab samples was made according to the safety screening (Dukelow et al. 1995) and waste compatibility DQOs (Fowler 1995). The safety screening DQO lists requirements for examining the waste in Hanford's high-level underground storage tanks to identify safety problems and to evaluate the tank for placement on a Watch List. The compatibility DQO identifies potential safety and operational problems which may be encountered when combining waste from two or more sources, e.g., the saltwell liquor from a single-shell tank with the waste in a receiving double-shell tank. This section discusses the requirements of each DQO and compares the analytical data to defined concentration limits.

5.5.1 Safety Screening Evaluation

Requirements and criteria identified in the safety screening DQO were used to assess the safety of the waste in tank 241-C-106. The requirement that vertical profiles of the waste (or grab samples from multiple depths) be obtained from at least two widely spaced risers was met for the supernate layer and the top approximately 60 percent of the sludge layer. Of the five primary analyses required by the safety screening DQO, three have decision thresholds which, if exceeded, could warrant further investigation to ensure tank safety. These three analyses include DSC (to measure the fuel content), a measurement of the total alpha activity (to determine the criticality potential), and a determination of the flammability of the tank headspace vapors. Table 5-16 lists the applicable safety issues, decision variables, and thresholds of the safety screening DQO along with the mean analytical results from the grab samples.

Table 5-16. Safety Screening Data Quality Objective Criteria. (2 sheets)

Safety Issue	Primary Decision Variable	Decision Threshold Value	Analytical Result
Ferrocyanide/ organics	Total fuel content	-480 J/g (dry weight)	2 out of 32 samples or subsamples exceeded the threshold (largest exotherm = -681 J/g). 6 samples had 95% confidence interval upper limits above threshold (largest 95% exotherm = -1,340 J/g).
Criticality	Total alpha activity	1 g/L[1] (supernate = 61.5 μCi/mL)	Mean supernate alpha activity = 1.03 μCi/mL (95% upper limit = 1.79 μCi/mL)
		1 g/L[1] (sludge = 39.8 μCi/g)	Maximum sludge subsample alpha activity = 4.38 μCi/g (95% upper limit = 16.7 μCi/g)[2]
Ferrocyanide/ organics	TOC	3 wt% (dry weight) (30,000 μg C/g)	Mean supernate TOC (dry weight) = 12,700 μg C/g; 95% upper confidence limit = 29,200 μg C/g[3]
			Mean sludge TOC (dry weight) = 23,500 μg C/g; 95% upper confidence limit = 29,300 μg C/g[4]
Flammable gas	Flammable gas	25% of the LFL	0% of LFL

Table 5-16. Safety Screening Data Quality Objective Criteria. (2 sheets)

Notes:

[1]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 activity for the sludge samples into a number more readily usable by the laboratory, it was assumed that all alpha decay originates from ^{239}Pu. The 39.8 μCi/g notification limit for the sludge is derived using the overall mean sludge density of 1.55 g/mL and the specific activity of ^{239}Pu (0.0615 Ci/g). The following equation was used to derive the notification limit:

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

[2]Because an overall mean total alpha activity value could not be computed for the raw sludge, the highest total alpha activity value and its 95 percent upper confidence limit for any sludge subsample is reported here instead; the value shown is for sample S96T001036 from sludge sample 6C-96-13.

[3]The overall supernate dry-weight TOC value is the average of the dry-weight TOC values individually computed for each supernate sample.

[4]The overall sludge dry-weight TOC value is the average of the dry-weight TOC values individually computed for each sludge sample. The larger gravimetric weight percent water values were used in computing the individual dry-weight TOC values instead of the smaller TGA-determined values for a more conservative comparison of the dry-weight TOC value to the decision threshold value.

The safety screening DQO has established a decision criteria threshold of -480 J/g (dry-weight basis) for the DSC analyses (Dukelow et al. 1995). Fifteen of the 32 samples or subsamples displayed exothermic reactions; two of these exceeded the DQO decision threshold of -480 J/g, and six had upper limits to a one-sided 95% confidence interval on the mean exceeding the threshold. The largest individual sample exotherm was -681 J/g (dry weight) from the Potential Organic Layer (S96T001553) of sample 6C-96-13, and the largest upper limit to a one-sided 95% confidence interval on the mean for an exotherm was -1,340 J/g (dry weight) for the Potential Organic Layer (S96T001567) of sample 6C-96-10. While the mean dry-weight exotherms for the Centrifuged Solids and Interstitial Liquid fractions of sample 6C-96-13 did not exceed the threshold value, the upper limit to a one-sided 95% confidence interval on the mean for these samples did exceed the threshold value.

Although the overheating of samples 6C-96-1 through 6C-96-4 was unplanned, a key observation was garnered from this "experiment" regarding the behavior of the tank 241-C-106 waste. Specifically, the samples were heated to approximately 200 °C (approximately 400 °F) without an observed runaway exothermic reaction. This result is consistent with the DSC results for the sludge samples -- no exotherms below 200 °C were observed in the DSC results.

The TOC and total cyanide tests were to be performed as secondary analyses if the DSC notification limit was exceeded. The results of these analyses help to determine if the tank should be placed on either the organic or ferrocyanide Watch Lists. Because the DSC exotherms were attributed to the presence of organic carbon in the samples, the total cyanide determinations were not performed.

The organic safety program has established a dry-weight TOC concentration limit of 3 weight percent, or 30,000 μg C/g. The mean TOC result (wet weight) for the February/March 1996 supernate samples was 2,910 μg C/mL, while the mean wet-weight TOC result from the sludge samples was 20,000 μg C/mL. The corresponding dry weights were 12,700 μg C/g with a upper limit to a one-sided 95% confidence interval on the mean of 29,200 μg C/g for the supernate and 23,500 μg C/g for the sludge with a upper limit to a one-sided 95% confidence interval on the mean of 29,300 μg C/g. The dry-weight TOC values were computed using the larger, gravimetrically determined weight percent water values instead of the smaller, TGA-determined values. This was done in order to generate larger dry-weight values that are more conservative from a safety viewpoint. The dry-weight upper limits to a one-sided 95% confidence interval on the mean for neither the supernate nor the sludge exceeded the organic DQO decision threshold of 30,000 μg C/g.

To investigate the relationship between DSC and the TOC content, the DSC dry-weight results for those samples that had exothermic reactions were compared with the corresponding dry-weight TOC results and the TOC energy equivalents in Table 5-17. This comparison may be biased since DSC reports net enthalpy change; if endotherms are present, they could mask the full extent of the actual exothermic reactions. The TOC data were converted to their energy equivalents using the following equation.

$$\textbf{Energy Equivalent (J/g)} = -\ \textbf{wt\% TOC (dry weight)} \left(\frac{1200\ \text{J/g}}{4.5\ \text{wt\% TOC}}\right)$$

The 1200 J/g value is the theoretical energy equivalent of one gram of sample that is 4.5 weight percent TOC (Turner et al. 1995); the TOC is assumed to be supplied by sodium acetate and the balance of the sample is sodium nitrate. Assuming that all of the TOC is present as sodium acetate will produce a high bias in the computed energy equivalent.

Table 5-17. Comparison of DSC Analytical Results with Theoretical TOC Energy Equivalents (Dry Weight Basis).[1] (2 sheets)

Grab Sample	Sample Number	Subsample	Mean TOC Analytical Result	TOC Energy Equivalent	Mean DSC Analytical Result
			μg C/g	J/g	J/g
6C-96-4	S96T001538 (S96T001537)[2]	Filtered Centrifuged Solids	20,600	-548	0
	S96T001544	Interstitial Liquid	3,240	-86	0
	S96T001544	Interstitial Liquid	4,450	-119	0
6C-96-5	S96T000538	Supernate	10,100	-270	0
	S96T000538[3]	Supernate	14,900	-398	0
6C-96-7	S96T000563	Interstitial Liquid	4,880	-130	0
	S96T000563[3]	Interstitial Liquid	5,140	-137	0
	S96T000568 (S96T000567)[2]	Filtered Centrifuged Solids	30,500	-813	-111
6C-96-10	S96T000545	Interstitial Liquid	3,260	-87	0
	S96T000552 (S96T000551)[2]	Filtered Centrifuged Solids	30,900	-824	-325
	S96T001567	Potential Organic Layer	108,000	-2,870	-587
6C-96-11	S96T001679	Potential Organic Layer	33,400	-890	0
	S96T001681	Interstitial Liquid	2,550	-68	-10
	S96T001681[3]	Interstitial Liquid	3,240	-86	-10
	S96T001686 (S96T001685)[2]	Filtered Centrifuged Solids	27,400	-731	0
6C-96-12	S96T001023	Supernate	8,280	-221	0
	S96T001023[3]	Supernate	10,300	-274	0
6C-96-13	S96T001560 (S96T001559)[2]	Filtered Centrifuged Solids	19,300	-516	0
	S96T001566	Interstitial Liquid	6,380	-170	-445

Table 5-17. Comparison of DSC Analytical Results with Theoretical TOC Energy Equivalents (Dry Weight Basis).[1] (2 sheets)

Note:

[1]All values listed in table are on a dry-weight basis. TOC values were determined by the persulfate method (LA-342-100) unless otherwise noted and were corrected for water content using the TGA-determined weight percent water values. Aqueous samples were converted from μg C/mL to μg C/g using the specific gravity either for that sample or for a closely related liquid fraction from the same sample. The density of the Potential Organic Layers was assumed to be equal to 1 g/mL.

[2]TOC was determined on the first sample listed; DSC and TGA were performed on the samples listed in parentheses.

[3]TOC was determined by the furnace method (LA-344-105).

A regression analysis was performed on the data in Table 5-17 with dry-weight TOC (persulfate-determined values only) as the independent variable and the dry-weight DSC results as the dependent variable. The regression equation is:

$$\textbf{Estimated Energy Equivalent (J/g)} = 2.05 - 0.00488(\textbf{dry-weight TOC } \mu\textbf{g C/g})$$

and the square of the correlation coefficient is 0.4546. This indicates that there is at least a moderate correlation between the TOC and DSC results. The slope term from the regression equation, -0.00488 J/μg C/g, may be compared to the theoretical value of -(1200 J/45,000 μg C/g) = -0.0267 J/μg C/g. The regression slope is approximately one-fifth the value of the theoretical slope.

The poor match between the energy values calculated from the TOC results and the actual DSC results may be attributed to the two assumptions that no endotherms in the DSC mask the onset of the exotherms from the organic components, and that the organic components have an energy equivalent similar to the theoretical value of 4.5 weight percent TOC (sodium acetate) in sodium nitrate. The organic analyses of the samples indicated that oxalate constitutes about 32 percent of the TOC in the supernate and nearly 100 percent of the TOC in the sludge portion of the tank waste. The theoretical energy equivalent value for 4.5 weight percent TOC (sodium oxalate) in sodium nitrate is 310 J/g of sample (Wahl et al. 1996). Wahl et al. (1996) also note that the relationship between TOC and DSC results is highly variable and is dependent on the identity of the organic compounds present. For instance, bis(2-ethylhexyl)phosphate is a major component of the Potential Organic Layers.

The potential for criticality can be assessed from the total alpha activity data. The safety screening decision threshold is 1 g/L, or 61.5 μCi/mL for the supernate. The overall supernate mean was 1.03 μCi/mL and the upper limit to a one-sided 95% confidence interval on the mean was 1.79 μCi/mL; both values are well below the DQO decision threshold. For the sludge, the 1 g/L decision threshold was converted to 39.8 μCi/g using the mean sludge density of 1.546 g/mL, as shown in Note 1 of Table 5-16. Because there were gaps in the total alpha analyses for several of the sludge subsamples, an overall mean for the sludge total alpha could not be calculated. Reported instead is the largest total alpha activity value for any sludge subsample (S96T001036, sample 6C-96-13) the value of which was 4.38 μCi/g with a upper limit to a one-sided 95% confidence interval on the mean of 16.7 μCi/g; both values are well below the decision threshold.

The overall mean weight percent water (as determined by TGA) for the supernate was 80.1 with an upper limit to a one-sided 95% confidence interval on the mean of 75.2. For the sludge the overall mean percent water (TGA) was 36.3 with a 95 percent lower confidence limit on the mean of 24.0. Therefore, both percent water values were well above 17 weight percent, the minimum amount of moisture needed to prevent a propagating exothermic reaction (Turner et al. 1995). Sample 6C-96-3 (S96T001526) had a TGA-determined mean percent water value of only 3.2. This value was low because sample 6C-96-3 dried out when inadvertently overheated during sample preparation.

The flammability of the gas in the tank headspace is an additional safety screening DQO consideration. The safety screening DQO notification limit for the flammable gas concentration is 25 percent of the LFL. The reported result of 0 percent of the LFL was well below the safety screening notification limit. The results of the tank headspace vapor samples taken from the tank exhauster port in February 1994 and March 1996 and analyzed for flammable gases support the combustible gas meter results. The concentration of any single flammable species in the headspace vapor samples was less than 10 parts-per-million by volume (ppmv). Hydrogen itself was measured at less than 10 ppmv; this value is far below 25 percent of the lower flammability limit (10,000 ppmv) for hydrogen in air.

Another factor in assessing the safety of tank waste is the heat generation from radioactive decay. The waste in tank 241-C-106 is known to have an elevated temperature because of the large radionuclide content in the waste, and the tank is the only tank listed on the High-Heat Load Watch List. The heat load limit that separates high-heat load from low-heat load tanks is 11,700 W (40,000 Btu/hr) (Bergmann 1991). Historically, heat dissipation from tank 241-C-106 has been aided by evaporative cooling from the addition of water to the tank.

The heat-load value calculated using the supernate data from the February/March 1996 grab samples was 5,130 W (17,500 Btu/hr), as shown in Table 5-18. Bander (1993a) lists the value of 32,200 ± 5,900 W (110,000 ± 20,000 Btu/hr), Agnew et al. (1996) estimates a value of 35,600 W (121,000 Btu/hr), and Ogden et al. (1996) gives a value of 38,700 W (132,000 Btu/hr). Appendix E contains additional heat-load calculations based on the 1996 grab sample results. The disparity between the values calculated from the February/March 1996 grab samples and the other values suggests that the bulk of the heat-generating radionuclides may reside in the lower 40 percent of the sludge, or may have not been captured in the samples obtained.

Table 5-18. Tank 241-C-106 Projected Heat Load.

Radionuclide	Tank Inventory	Decay Heat[1]	Heat Load from Radioactive Decay
	Ci	W/Ci	W
^{90}Sr	4.07E+05	6.69E-03[3]	2.72E+03
^{99}Tc	2.48E+01[2]	5.01E-04	1.24E-02[2]
^{137}Cs	5.01E+05	4.72E-03[4]	2.36E+03
$^{239/240}Pu$	1.33E+03	3.05E-02	4.06E+01
^{241}Am	1.51E+00[2]	3.28E-02	4.95E-02[2]
Total			5.13E+03

Notes:

[1]Kirkpatrick and Brown (1984)

[2]Based only on the supernate since these radionuclides were not analyzed in all subsamples of the sludge.

[3]Includes the contribution from ^{90}Y.

[4]Includes the contribution from ^{137}Ba.

5.5.2 Waste Compatibility Evaluation

In accordance with Fowler (1995), tank 241-C-106 was analyzed to assess the safety and operational implications of combining the wastes in the tank and the double-shell tank system. Safety considerations include criticality, flammable gas generation and accumulation, energetics, corrosion and leakage, and unwanted chemical reactions. Operational considerations include plugged pipelines and equipment, TRU segregation, complexant waste segregation, and heat load limits of the receiving tank. Not all of the safety and operational considerations are within the scope of this report, notably the potential chemical reactivity of the waste in a variety of different situations, and the tendency of the waste to plug piping and equipment.

Table 5-19 presents the analyses used to evaluate the waste in terms of the safety and operational considerations that are within the scope of this report. The primary decision variable, the decision threshold, and the analytical results from the February/March 1996 grab samples are listed for each safety and operational issue.

Table 5-19. Decision Variables and Criteria for the Waste Compatibility Data Quality Objective. (2 sheets)

Compatibility Issue	Primary Decision Variable	Decision Threshold	Mean Analytical Result	
			Supernate	Sludge
Safety				
Criticality	$^{239/240}Pu$	> 0.013 g/L (> 0.800 μCi/mL)[1]	0.745 μCi/mL	1.67 μCi/mL
Flammable gas	Specific gravity	> 1.41	1.17	1.55
Ferrocyanide/ organics	Total fuel content	For thermal analysis < 500 °C (932 °F), the absolute value of exotherm/endotherm ratio ≥ 1	All exotherm/ endotherm ratios < 1	All exotherm/ endotherm ratios < 1[2]
Corrosion and leakage	OH^-	< 170 or > 170,000 μg/mL	2.49 μg/mL[3]	n/a
	NO_3^-	> 341,000 μg/mL	1,320 μg/mL	2,360 μg/mL
	NO_2^-	< 506 or > 253,000 μg/mL	27,800 μg/mL	24,600 μg/mL
Operations				
TRU segregation	TRU elements	$^{239/240}Pu$, ^{238}Pu, ^{241}Am, $^{243/244}Cm$, ^{237}Np total concentration > 0.1 μCi/g	0.648 μCi/g[4]	1.08 μCi/g[5]
Complexant segregation	Determined by selected analyte concentration using PREDICT[6], or by performing a boildown test in the laboratory.			
Heat load	Heat generation rate from radioactive decay	≥ 205,000 W (700,000 Btu/hr)	32,200 to 38,700 W (110,000 to 132,000 Btu/hr)[7]	

Table 5-19. Decision Variables and Criteria for the Waste Compatibility Data Quality Objective. (2 sheets)

Notes:

n/a = not available

[1]Although the actual decision criterion listed in the DQO was 0.013 g/L, $^{239/240}Pu$ was measured in μCi/mL rather than g/L. The following equation converts the decision threshold into the same units as the laboratory used. The 0.0615 Ci/g term is the specific activity of ^{239}Pu. The decision criterion was converted to 0.800 μCi/mL.

$$\left(\frac{0.013\ g}{L}\right)\left(\frac{1\ L}{10^3\ mL}\right)\left(\frac{0.0615\ Ci}{1\ g}\right)\left(\frac{10^6\ \mu Ci}{1\ Ci}\right) = 0.800\ \frac{\mu Ci}{mL}$$

[2]One DSC duplicate run for a Centrifuged Solids sample (S96T001527) generated an exotherm/endotherm ratio of 2.92, but this run failed the QC criterion for RPD value.

[3]Calculated from the supernate pH overall mean value of 10.2

[4]Includes $^{239/240}Pu$ and ^{241}Am only

[5]Includes $^{239/240}Pu$ only

[6]Allison (1984)

[7]Estimates are from Bander (1993a) and Ogden et al. (1996).

The waste compatibility criticality decision threshold value is 0.013 g/L $^{239/240}Pu$; this value was converted to 0.800 μCi/mL using the equation in Note 1 of Table 5-19 in order to compare the threshold value to the analytical units. The analytical means for $^{239/240}Pu$ shown in Table 5-19 approach or exceed the decision threshold. Flammable gases may accumulate in wastes with convective (supernate) layers having a specific gravity > 1.41. The mean specific gravity for the February/March grab sample supernates was 1.17 and was well below the decision threshold. For energetics, the exotherm/endotherm ratio must be < 1 for all reactions below 500 °C (932 °F). All exotherm/endotherm ratios were below the given criterion of 1 (with one exception; see Note 2 of Table 5-19).

The concentrations of the corrosion-inhibiting species nitrate and nitrite were within the limits imposed by the compatibility DQO. The hydroxide value for the supernate was estimated to be 2.49 μg/mL based on the supernate overall mean pH value of 10.2. This value is below the lower decision threshold of 170 μg/mL hydroxide and thus fails to meet the corrosion control criterion. Herting (1996) reports the results for caustic demand studies performed on aliquots of sludge samples 6C-96-8 and 6C-96-14. The results showed the sludge can absorb significant amounts of hydroxide with a corresponding dissolution of aluminum from the sludge.

Operations issues are based on the policy of segregating TRU and complexant wastes, avoiding excess heat in the tanks, and ensuring pumpability of the source waste to the receiving tank. The total concentration of TRU elements was calculated by converting the values to a per-weight basis from the per-volume basis by dividing the analytical result for each radionuclide from each phase by the mean density for that phase, then summing the per-weight results. The total was then compared to the 0.1 μCi/g standard for segregating TRU waste from non-TRU. The results showed the concentration of TRU elements exceeded the limit of 0.1 μCi/g. Finally, the heat load estimate for the tank based on the 1996 grab samples was 5,130 W (17,500 Btu/hr); this estimate is undoubtedly biased low because the lower 40 percent of the tank sludge was not sampled. Other heat-load estimates range from 23,300 W (79,800 Btu/hr) (Babad et al. 1996) to 38,700 W (132,000 Btu/hr) (Ogden et al. 1996) but do not exceed the waste compatibility heat-load decision threshold of 205,000 W (700,000 Btu/hr) for tank 241-AY-102.

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6.0 CONCLUSIONS AND RECOMMENDATIONS

The waste in tank 241-C-106 has been evaluated according to the requirements listed in the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995), the *Data Quality Objectives for Tank Farms Waste Compatibility Program* (Fowler 1995), the *Tank 241-C-106 Grab Sample — Technical Letter of Instruction* (Cash and Babad 1996), the *Tank C-106 Flammable Vapor Sampling and Analysis Plan* (Homi 1996), and *Data Quality Objectives for Generic In-Tank Health and Safety Vapor Issues Resolution* (Osborne et al. 1994). As of April 30, 1996, tank 241-C-106 was the only tank listed on the High-Heat Load Watch List (Hanlon 1996). Results from the February/March 1996 grab sampling event, and the February 1994 and March 1996 vapor sampling events were used in the characterization of the tank waste.

The safety screening requirement to obtain two vertical profiles of the tank waste from widely spaced risers was met for the supernate and the upper 60 percent of the sludge. To assess tank safety, the safety screening DQO required analyses for energetics, weight percent water, density, total alpha activity, a visual inspection for a separable organics layer, and the flammability of gases in the tank headspace. To examine possible waste compatibility problems, the waste compatibility DQO required analyses for energetics, percent water, TIC, TOC, density, pH, selected metals, anions, and radionuclides. The grab sample analyses were performed at the Westinghouse Hanford Company 222-S Laboratory and at the Pacific Northwest National Laboratory. Because there is some question regarding how well the samples represent the depths at which the tank was sampled, there may be unknown biases in the analytical results.

The DSC results for two out of 32 samples or subsamples exceeded the safety screening exothermic threshold of -480 J/g on a dry-weight basis while six samples had upper limits to a one-sided 95 percent confidence interval on the mean that exceeded the threshold. However, the overall mean weight percent water (as determined by TGA) for the supernate was 80.1 with a lower limit to a one-sided 95 percent confidence interval on the mean of 75.2. For the sludge the overall mean weight percent water (TGA) was 36.3 with a lower limit to a one-sided 95 percent confidence interval on the mean of 24.0. Therefore, both percent water values were well above 17 weight percent, the minimum amount of moisture needed to prevent a propagating exothermic reaction (Turner et al. 1995).

The TOC results were compared with the organic DQO limit of 3.0 weight percent (30,000 μg C/g) on a dry weight basis (Turner et al. 1995). The overall mean result for the supernate was 12,700 μg C/g and was 23,500 μg C/g for the sludge. The upper limit to a one-sided 95 percent confidence interval on the mean for the supernate was 29,200 μg C/g, and the sludge was 29,300 μg C/g. The upper limit to the 95 percent confidence interval on the mean dry-weight TOC values for the supernate and the sludge did not exceed the 30,000 μg C/g decision threshold.

During the preparation of the sludge samples for analysis, a second liquid phase was discovered and reported. This phase was designated a potential organic layer and constituted approximately 0.5 to 3 percent of the tank volume. Babad et al. (1996) reports that this layer consisted largely of bis(2-ethylhexyl)phosphate. When subjected to propagating reaction tests, bis(2-ethylhexyl)phosphate did not exhibit a propagating exothermic reaction.

All remaining requirements of the safety screening DQO were satisfied. The total alpha activity overall mean for the supernate was 1.03 μCi/mL with an upper limit to a one-sided 95 percent confidence interval on the mean of 1.79 μCi/mL. Both values were less than the decision threshold value of 61.5 μCi/mL. An overall mean total alpha value could not be calculated for the sludge, but the highest sludge subsample total alpha value was 4.38 μCi/g with an upper limit to a one-sided 95 percent confidence interval on the mean of 16.7 μCi/g; both values were less than the decision threshold value of 39.8 μCi/g.

Finally, the flammability of gases in the tank headspace was 0 percent of the lower flammability limit. The results of the vapor characterization indicated that there was no hazard posed from ammonia or organic vapors in the dome space or breathing zone of the tank.

The waste compatibility evaluation revealed other issues that may impact waste management decisions. Because significant amounts of organic carbon were found in the tank 241-C-106 waste, the waste in the tank may need to be segregated from non-complexant waste types when transferred to the double-shell tank system.

The waste compatibility criticality decision threshold value was 0.800 μCi/mL $^{239/240}$Pu. The overall mean $^{239/240}$Pu value for the supernate was 0.745 μCi/mL, nearly equalling the threshold value; the overall mean $^{239/240}$Pu value for the sludge was 1.67 μCi/mL and exceeded the threshold value. The overall mean TRU content of the waste was found to be 0.648 μCi/g for the supernate and 1.08 μCi/g for the sludge; both values exceed the 0.1 μCi/g TRU limit in the DQO.

The supernate overall mean pH of 10.2 and the caustic demand results of Herting (1996) indicate that the waste is very caustic deficient, which could lead to potential corrosion problems. However, prior to sluicing activities, caustic additions will be made to tank 241-AY-102. These caustic additions may mitigate the caustic deficiency of the waste.

Finally, the heat load estimates for the tank (Bander 1993a, Ogden et al. 1996) do not exceed the decision threshold of 205,000 W (700,000 Btu/hr) (Fowler 1995). Radionuclide data were used to calculate an estimate of 5,130 W (17,500 Btu/hr) for the tank heat load. In contrast, Bander (1993b) lists the value of 32,200 $\pm$ 5,900 W (110,000 $\pm$ 20,000 Btu/hr), Agnew et al. (1996) estimates a value of 35,600 W (12,100 Btu/hr), and Ogden et al. (1996) gives a value of 38,700 W (132,000 Btu/hr). The disparity between the values calculated from the February/ March 1996 grab samples and the other values most likely indicates that the bulk of the heat-generating radionuclides may reside in the lower 40 percent of the sludge. Evidence exists from the historical transfer records that the high ^{90}Sr is not located in the hardpan layer; therefore, it is believed that the bulk of the radionuclides may reside in this layer. Additional information regarding the heat load for tank 241-C-106 may be found in Appendix E.

Based on these results and the amount of TOC found, those portions of the tank waste that were sampled should be considered "safe" from an energetics perspective. However, the addition of water to tank 241-C-106 is still necessary to maintain evaporative cooling and prevent the waste from exceeding the tank temperature operating limit of 149 °C (300 °F), which would compromise the tank integrity.

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APPENDIX A

TANK 241-C-106 FEBRUARY/MARCH 1996 GRAB SAMPLE ANALYTICAL RESULTS

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APPENDIX A NOTES:

Sample Mean is the average of Result value and Duplicate value for the given Sample Number.

Overall Mean is the REML mean concentration of all the results for the given analyte and matrix (sludge or supernate).

Notes:

Overall Mean reported as μg/mL; to obtain μg/g divide by the density

Potential Organic Layer represented only 0.5-3% of the total sample volume and, therefore, the results for these samples were not included in sample mean calculations or inventory projections.

Overall Mean for Total Organic Carbon derived from persulfate oxidation results only.

Overall Means were not calculated for ^{241}Am, ^{99}Tc, and total alpha activity because not all of the sample fractions were analyzed for these assays.

Sample Portion Descriptors:

CS:	Centrifuged Solids from Raw Sludge.
C:	Control Sludge Sample.
D:	Dried Sludge.
DS:	Decanted Supernate from Raw Sludge (units in μg/mL).
FCS:	Filtered Centrifuged Solids from Raw Sludge.
IL:	Interstitial Liquid from Raw Sludge (units in μg/mL).
POL:	Potential Organic Layer from Raw Sludge (units in μg/mL).
RS:	Raw Sludge.
S:	Supernate.

QC Footnotes:

a -- indicates that the standard recovery was below the QC range.
b -- indicates that the standard recovery was above the QC range.
c -- indicates that the spike recovery was below the QC range.
d -- indicates that the spike recovery was above the QC range.
e -- indicates that the RPD was greater than the QC limit range.
f -- indicates that there was blank contamination.

Other Notes:

n/a:	not available.
Furn:	Furnace Oxidation Procedure for Total Organic Carbon.
Pers:	Persulfate Oxidation Procedure for Total Organic Carbon.

Table A-1. Tank 241-C-106 Analytical Results: Aluminum (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						48,200	10.5	35,900
S96T001542A	6C-96-4	FCS	62,000	54,400	58,200			
S96T001544D	6C-96-4	IL	< 20.1	< 20.1	< 20.1			
S96T000572A	6C-96-7	FCS	51,800	60,800	56,300[QC:d]			
S96T000563D	6C-96-7	IL	< 20.1	< 20.1	< 20.1			
S96T000556A	6C-96-10	FCS	51,700	44,200	47,950[QC:d]			
Riser 7								
S96T001690A	6C-96-11	FCS	38,100	37,700	37,900[QC:d]			
S96T001681D	6C-96-11	IL	< 20.1	< 20.1	< 20.1			
S96T001564A	6C-96-13	FCS	62,100	64,500	63,300			
S96T001566D	6C-96-13	IL	48.1	66.9	57.5[QC:e]			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						<30	N/A	<3.63
S96T000538D	6C-96-5	S	< 20	< 20	< 20			
Riser 7								
S96T001023D	6C-96-12	S	< 30	< 30	< 30			
S96T001546D	6C-96-15	S	< 20.1	< 20.1	< 20.1			

Table A-2. Tank 241-C-106 Analytical Results: Antimony (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T001542A	6C-96-4	FCS	< 36.9	< 35.4	< 36.15			
S96T001544D	6C-96-4	IL	< 24.1	< 24.1	< 24.1			
S96T000572A	6C-96-7	FCS	95.4	< 59.1	< 77.25			
S96T000563D	6C-96-7	IL	< 24.1	< 24.1	< 24.1			
S96T000556A	6C-96-10	FCS	< 65.7	< 56.6	< 61.15			
Riser 7								
S96T001690A	6C-96-11	FCS	< 23	< 23.6	< 23.3			
S96T001681D	6C-96-11	IL	< 24.1	< 24.1	< 24.1			
S96T001564A	6C-96-13	FCS	< 25.3	< 25.1	< 25.2			
S96T001566D	6C-96-13	IL	< 24.1	< 24.1	< 24.1			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T000538D	6C-96-5	S	< 24.1	< 24.1	< 24.1			
Riser 7								
S96T001023D	6C-96-12	S	< 36.1	< 36.1	< 36.1			
S96T001546D	6C-96-15	S	< 24.1	< 24.1	< 24.1			

Table A-3. Tank 241-C-106 Analytical Results: Arsenic (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T001542A	6C-96-4	FCS	< 61.4	< 59.1	< 60.25			
S96T001544D	6C-96-4	IL	< 40.1	< 40.1	< 40.1			
S96T000572A	6C-96-7	FCS	< 84.3	< 98.6	< 91.45			
S96T000563D	6C-96-7	IL	< 40.1	< 40.1	< 40.1			
S96T000556A	6C-96-10	FCS	< 110	< 94.3	< 102.15			
Riser 7								
S96T001690A	6C-96-11	FCS	< 38.3	< 39.3	< 38.8			
S96T001681D	6C-96-11	IL	< 40.1	< 40.1	< 40.1			
S96T001564A	6C-96-13	FCS	< 42.2	< 41.8	< 42			
S96T001566D	6C-96-13	IL	< 40.1	< 40.1	< 40.1			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T000538D	6C-96-5	S	< 40.1	< 40.1	< 40.1			
Riser 7								
S96T001023D	6C-96-12	S	< 60.1	< 60.1	< 60.1			
S96T001546D	6C-96-15	S	< 40.1	< 40.1	< 40.1			

Table A-4. Tank 241-C-106 Analytical Results: Barium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1						292	9.5	217
S96T001542A	6C-96-4	FCS	379	330	354.5			
S96T001544D	6C-96-4	IL	< 20.1	< 20.1	< 20.1			
S96T000572A	6C-96-7	FCS	288	340	314			
S96T000563D	6C-96-7	IL	< 20.1	< 20.1	< 20.1			
S96T000556A	6C-96-10	FCS	304	260	282			
Riser 7								
S96T001690A	6C-96-11	FCS	222	219	220.5			
S96T001681D	6C-96-11	IL	< 20.1	< 20.1	< 20.1			
S96T001564A	6C-96-13	FCS	367	375	371			
S96T001566D	6C-96-13	IL	< 20.1	< 20.1	< 20.1			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						< 30	n/a	<3.63
S96T000538D	6C-96-5	S	< 20	< 20	< 20			
Riser 7								
S96T001023D	6C-96-12	S	< 30	< 30	< 30			
S96T001546D	6C-96-15	S	< 20.1	< 20.1	< 20.1			

Table A-5. Tank 241-C-106 Analytical Results: Beryllium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T001542A	6C-96-4	FCS	< 3.07	< 2.95	< 3.01			
S96T001544D	6C-96-4	IL	< 2	< 2	< 2			
S96T000572A	6C-96-7	FCS	< 4.22	< 4.93	< 4.575			
S96T000563D	6C-96-7	IL	< 2	< 2	< 2			
S96T000556A	6C-96-10	FCS	< 5.48	< 4.72	< 5.1			
Riser 7								
S96T001690A	6C-96-11	FCS	< 1.91	< 1.97	< 1.94			
S96T001681D	6C-96-11	IL	< 2	< 2	< 2			
S96T001564A	6C-96-13	FCS	< 2.11	< 2.09	< 2.1			
S96T001566D	6C-96-13	IL	< 2	< 2	< 2			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T000538D	6C-96-5	S	< 2	< 2	< 2			
Riser 7								
S96T001023D	6C-96-12	S	< 3	< 3	< 3			
S96T001546D	6C-96-15	S	< 2	< 2	< 2			

Table A-6. Tank 241-C-106 Analytical Results: Bismuth (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T001542A	6C-96-4	FCS	< 61.4	< 59.1	< 60.25			
S96T001544D	6C-96-4	IL	< 40.1	< 40.1	< 40.1			
S96T000572A	6C-96-7	FCS	< 84.3	< 98.6	< 91.45			
S96T000563D	6C-96-7	IL	< 40.1	< 40.1	< 40.1			
S96T000556A	6C-96-10	FCS	< 110	< 94.3	< 102.15			
Riser 7								
S96T001690A	6C-96-11	FCS	< 38.3	< 39.3	< 38.8			
S96T001681D	6C-96-11	IL	< 40.1	< 40.1	< 40.1			
S96T001564A	6C-96-13	FCS	< 42.2	< 41.8	< 42			
S96T001566D	6C-96-13	IL	< 40.1	< 40.1	< 40.1			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T000538D	6C-96-5	S	< 40.1	< 40.1	< 40.1			
Riser 7								
S96T001023D	6C-96-12	S	< 60.1	< 60.1	< 60.1			
S96T001546D	6C-96-15	S	< 40.1	< 40.1	< 40.1			

Table A-7. Tank 241-C-106 Analytical Results: Boron (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						66.3	14.1	49.4
S96T001542A	6C-96-4	FCS	59.2	72.1	65.65			
S96T001544D	6C-96-4	IL	< 20.1	< 20.1	< 20.1			
S96T000572A	6C-96-7	FCS	71.3	83	77.15			
S96T000563D	6C-96-7	IL	< 20.1	< 20.1	< 20.1			
S96T000556A	6C-96-10	FCS	< 54.8	< 47.2	< 51			
Riser 7								
S96T001690A	6C-96-11	FCS	25.8	30.7	28.25			
S96T001681D	6C-96-11	IL	< 20.1	< 20.1	< 20.1			
S96T001564A	6C-96-13	FCS	79.3	61.3	70.3[QC:e]			
S96T001566D	6C-96-13	IL	32.1	32.4	32.25			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						< 30	n/a	<3.63
S96T000538D	6C-96-5	S	< 20	< 20	< 20			
Riser 7								
S96T001023D	6C-96-12	S	< 30	< 30	< 30			
S96T001546D	6C-96-15	S	< 20.1	< 20.1	< 20.1			

Table A-8. Tank 241-C-106 Analytical Results: Cadmium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						32.4	13.1	24.2
S96T001542A	6C-96-4	FCS	37.9	33	35.45			
S96T001544D	6C-96-4	IL	< 2	< 2	< 2			
S96T000572A	6C-96-7	FCS	39.9	44.5	42.2			
S96T000563D	6C-96-7	IL	< 2	< 2	< 2			
S96T000556A	6C-96-10	FCS	33.3	27.1	30.2[QC:e]			
Riser 7								
S96T001690A	6C-96-11	FCS	23.9	24.8	24.35			
S96T001681D	6C-96-11	IL	< 2	< 2	< 2			
S96T001564A	6C-96-13	FCS	36.5	38.9	37.7			
S96T001566D	6C-96-13	IL	< 2	< 2	< 2			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						< 30	n/a	<3.63
S96T000538D	6C-96-5	S	< 2	< 2	< 2			
Riser 7								
S96T001023D	6C-96-12	S	< 3	< 3	< 3			
S96T001546D	6C-96-15	S	< 2	< 2	< 2			

Table A-9. Tank 241-C-106 Analytical Results: Calcium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1						1,310	17.3	974
S96T001542A	6C-96-4	FCS	1,170	1,180	1,175			
S96T001544D	6C-96-4	IL	< 40.1	< 40.1	< 40.1			
S96T000572A	6C-96-7	FCS	882	1,040	961			
S96T000563D	6C-96-7	IL	< 40.1	< 40.1	< 40.1			
S96T000556A	6C-96-10	FCS	1,330	1,120	1,225			
Riser 7								
S96T001690A	6C-96-11	FCS	2,650	2,500	2,575			
S96T001681D	6C-96-11	IL	< 40.1	< 40.1	< 40.1			
S96T001564A	6C-96-13	FCS	1,200	1,270	1,235			
S96T001566D	6C-96-13	IL	< 40.1	< 40.1	< 40.1			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						< 60.1	n/a	<7.28
S96T000538D	6C-96-5	S	< 40.1	< 40.1	< 40.1			
Riser 7								
S96T001023D	6C-96-12	S	< 60.1	< 60.1	< 60.1			
S96T001546D	6C-96-15	S	< 40.1	< 40.1	< 40.1			

Table A-10. Tank 241-C-106 Analytical Results: Cerium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						202	8.2	151
S96T001542A	6C-96-4	FCS	242	233	237.5			
S96T001544D	6C-96-4	IL	< 40.1	< 40.1	< 40.1			
S96T000572A	6C-96-7	FCS	206	199	202.5			
S96T000563D	6C-96-7	IL	< 40.1	< 40.1	< 40.1			
S96T000556A	6C-96-10	FCS	178	174	176			
Riser 7								
S96T001690A	6C-96-11	FCS	141	152	146.5			
S96T001681D	6C-96-11	IL	< 40.1	< 40.1	< 40.1			
S96T001564A	6C-96-13	FCS	213	251	232			
S96T001566D	6C-96-13	IL	< 40.1	< 40.1	< 40.1			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						< 60.1	n/a	<7.28
S96T000538D	6C-96-5	TOTAL	< 40.1	< 40.1	< 40.1			
Riser 7								
S96T001023D	6C-96-12	TOTAL	< 60.1	< 60.1	< 60.1			
S96T001546D	6C-96-15	TOTAL	< 40.1	< 40.1	< 40.1			

Table A-11. Tank 241-C-106 Analytical Results: Chromium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						636	12.7	474
S96T001542A	6C-96-4	FCS	730	660	695			
S96T001544D	6C-96-4	IL	< 4.01	< 4.01	< 4.01			
S96T000572A	6C-96-7	FCS	769	884	826.5			
S96T000563D	6C-96-7	IL	< 4.01	< 4.01	< 4.01			
S96T000556A	6C-96-10	FCS	645	552	598.5			
Riser 7								
S96T001690A	6C-96-11	FCS	528	538	533			
S96T001681D	6C-96-11	IL	< 4.01	< 4.01	< 4.01			
S96T001564A	6C-96-13	FCS	655	682	668.5			
S96T001566D	6C-96-13	IL	< 4.01	< 4.01	< 4.01			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						< 6.01	n/a	<0.73
S96T000538D	6C-96-5	S	< 4.01	< 4.01	< 4.01			
Riser 7								
S96T001023D	6C-96-12	S	< 6.01	< 6.01	< 6.01			
S96T001546D	6C-96-15	S	< 4.01	< 4.01	< 4.01			

Table A-12. Tank 241-C-106 Analytical Results: Cobalt (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1								
S96T001542A	6C-96-4	FCS	12.3	< 11.8	< 12.05	n/a	n/a	n/a
S96T001544D	6C-96-4	IL	< 8.02	< 8.02	< 8.02			
S96T000572A	6C-96-7	FCS	< 16.9	< 19.7	< 18.3			
S96T000563D	6C-96-7	IL	< 8.02	< 8.02	< 8.02			
S96T000556A	6C-96-10	FCS	< 21.9	< 18.9	< 20.4			
Riser 7								
S96T001690A	6C-96-11	FCS	< 7.66	8.35	< 8.005			
S96T001681D	6C-96-11	IL	< 8.02	< 8.02	< 8.02			
S96T001564A	6C-96-13	FCS	10.3	11.1	10.7			
S96T001566D	6C-96-13	IL	< 8.02	< 8.02	< 8.02			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1								
S96T000538D	6C-96-5	S	< 8.02	< 8.02	< 8.02	n/a	n/a	n/a
Riser 7								
S96T001023D	6C-96-12	S	< 12	< 12	< 12			
S96T001546D	6C-96-15	S	< 8.02	< 8.02	< 8.02			

Table A-13. Tank 241-C-106 Analytical Results: Copper (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						105	3.7	78.1
S96T001542A	6C-96-4	FCS	93.7	80.4	87.05			
S96T001544D	6C-96-4	IL	< 4.01	< 4.01	< 4.01			
S96T000572A	6C-96-7	FCS	84.4	96.4	90.4			
S96T000563D	6C-96-7	IL	< 4.01	< 4.01	< 4.01			
S96T000556A	6C-96-10	FCS	89.7	76.7	83.2			
Riser 7								
S96T001690A	6C-96-11	FCS	95.6	94.2	94.9			
S96T001681D	6C-96-11	IL	< 4.01	< 4.01	< 4.01			
S96T001564A	6C-96-13	FCS	104	108	106			
S96T001566D	6C-96-13	IL	< 4.01	< 4.01	< 4.01			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						< 6.01	n/a	<0.73
S96T000538D	6C-96-5	S	< 4.01	< 4.01	< 4.01			
Riser 7								
S96T001023D	6C-96-12	S	< 6.01	< 6.01	< 6.01			
S96T001546D	6C-96-15	S	< 4.01	< 4.01	< 4.01			

Table A-14. Tank 241-C-106 Analytical Results: Iron (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						62,800	11.5	46,800
S96T001542A	6C-96-4	FCS	83,100	71,500	77,300			
S96T001544D	6C-96-4	IL	< 20.1	< 20.1	< 20.1			
S96T000572A	6C-96-7	FCS	70,300	82,500	76,400[QC:e]			
S96T000563D	6C-96-7	IL	< 20.1	< 20.1	< 20.1			
S96T000556A	6C-96-10	FCS	68,700	58,600	63,650[QC:d]			
Riser 7								
S96T001690A	6C-96-11	FCS	45,900	57,400	51,650[QC:e]			
S96T001681D	6C-96-11	IL	< 20.1	< 20.1	< 20.1			
S96T001564A	6C-96-13	FCS	70,000	72,900	71,450			
S96T001566D	6C-96-13	IL	52.8	64.7	58.75[QC:e]			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 7						<30	n/a	<3.63
S96T000538D	6C-96-5	S	< 20	< 20	< 20			
Riser 7								
S96T001023D	6C-96-12	S	< 30	< 30	< 30			
S96T001546D	6C-96-15	S	< 20.1	< 20.1	< 20.1			

Table A-15. Tank 241-C-106 Analytical Results: Lanthanum (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1						71.2	8.8	53.1
S96T001542A	6C-96-4	FCS	80.3	72	76.15			
S96T001544D	6C-96-4	IL	< 20.1	< 20.1	< 20.1			
S96T000572A	6C-96-7	FCS	59.1	72.3	65.7[QC:e]			
S96T000563D	6C-96-7	IL	< 20.1	< 20.1	< 20.1			
S96T000556A	6C-96-10	FCS	74.8	60.5	67.65[QC:e]			
Riser 7								
S96T001690A	6C-96-11	FCS	49.6	47.8	48.7			
S96T001681D	6C-96-11	IL	< 20.1	< 20.1	< 20.1			
S96T001564A	6C-96-13	FCS	70.5	73.5	72			
S96T001566D	6C-96-13	IL	< 20.1	< 20.1	< 20.1			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						< 30	n/a	<3.63
S96T000538D	6C-96-5	S	< 20	< 20	< 20			
Riser 7								
S96T001023D	6C-96-12	S	< 30	< 30	< 30			
S96T001546D	6C-96-15	S	< 20.1	< 20.1	< 20.1			

Table A-16. Tank 241-C-106 Analytical Results: Lead (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						2,330	10.5	1,730
S96T001542A	6C-96-4	FCS	2,900	2,540	2,720[QC:c]			
S96T001544D	6C-96-4	IL	< 40.1	< 40.1	< 40.1			
S96T000572A	6C-96-7	FCS	2,550	2,970	2,760			
S96T000563D	6C-96-7	IL	< 40.1	< 40.1	< 40.1			
S96T000556A	6C-96-10	FCS	2,490	2,150	2,320[QC:d]			
Riser 7								
S96T001690A	6C-96-11	FCS	1,900	1,950	1,925			
S96T001681D	6C-96-11	IL	< 40.1	< 40.1	< 40.1			
S96T001564A	6C-96-13	FCS	2,810	2,850	2,830			
S96T001566D	6C-96-13	IL	< 40.1	< 40.1	< 40.1			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						< 60.1	n/a	<7.28
S96T000538D	6C-96-5	S	< 40.1	< 40.1	< 40.1			
Riser 7								
S96T001023D	6C-96-12	S	< 60.1	< 60.1	< 60.1			
S96T001546D	6C-96-15	S	< 40.1	< 40.1	< 40.1			

Table A-17. Tank 241-C-106 Analytical Results: Lithium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T001542A	6C-96-4	FCS	< 6.14	< 5.91	< 6.025			
S96T001544D	6C-96-4	IL	< 4.01	< 4.01	< 4.01			
S96T000572A	6C-96-7	FCS	< 8.43	< 9.86	< 9.145			
S96T000563D	6C-96-7	IL	< 4.01	< 4.01	< 4.01			
S96T000556A	6C-96-10	FCS	< 11	< 9.43	< 10.215			
Riser 7								
S96T001690A	6C-96-11	FCS	< 3.83	< 3.93	< 3.88			
S96T001681D	6C-96-11	IL	< 4.01	< 4.01	< 4.01			
S96T001564A	6C-96-13	FCS	4.9	5.09	4.995			
S96T001566D	6C-96-13	IL	< 4.01	< 4.01	< 4.01			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T000538D	6C-96-5	S	< 4.01	< 4.01	< 4.01			
Riser 7								
S96T001023D	6C-96-12	S	< 6.01	< 6.01	< 6.01			
S96T001546D	6C-96-15	S	< 4.01	< 4.01	< 4.01			

Table A-18. Tank 241-C-106 Analytical Results: Magnesium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1						254	3.9	190
S96T001542A	6C-96-4	FCS	321	283	302[QC:c]			
S96T001544D	6C-96-4	IL	< 40.1	< 40.1	< 40.1			
S96T000572A	6C-96-7	FCS	225	263	244			
S96T000563D	6C-96-7	IL	< 40.1	< 40.1	< 40.1			
S96T000556A	6C-96-10	FCS	219	187	203			
Riser 7								
S96T001690A	6C-96-11	FCS	250	264	257			
S96T001681D	6C-96-11	IL	< 40.1	< 40.1	< 40.1			
S96T001564A	6C-96-13	FCS	279	303	291			
S96T001566D	6C-96-13	IL	< 40.1	< 40.1	< 40.1			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						< 60.1	n/a	<7.28
S96T000538D	6C-96-5	S	< 40.1	< 40.1	< 40.1			
Riser 7								
S96T001023D	6C-96-12	S	< 60.1	< 60.1	< 60.1			
S96T001546D	6C-96-15	S	< 40.1	< 40.1	< 40.1			

Table A-19. Tank 241-C-106 Analytical Results: Manganese (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1						2,160	6.9	1,610
S96T001542A	6C-96-4	FCS	2,280	2,000	2,140[QC:c]			
S96T001544D	6C-96-4	IL	< 4.01	< 4.01	< 4.01			
S96T000572A	6C-96-7	FCS	1,750	2,050	1,900			
S96T000563D	6C-96-7	IL	< 4.01	< 4.01	< 4.01			
S96T000556A	6C-96-10	FCS	1,860	1,590	1,725[QC:d]			
Riser 7								
S96T001690A	6C-96-11	FCS	3,210	3,270	3,240			
S96T001681D	6C-96-11	IL	< 4.01	< 4.01	< 4.01			
S96T001564A	6C-96-13	FCS	3,010	3,120	3,065			
S96T001566D	6C-96-13	IL	< 4.01	< 4.01	< 4.01			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						< 6.01	n/a	<0.73
S96T000538D	6C-96-5	S	< 4.01	< 4.01	< 4.01			
Riser 7								
S96T001023D	6C-96-12	S	< 6.01	< 6.01	< 6.01			
S96T001546D	6C-96-15	S	< 4.01	< 4.01	< 4.01			

Table A-20. Tank 241-C-106 Analytical Results: Molybdenum (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T001542A	6C-96-4	FCS	< 30.7	< 29.5	< 30.1			
S96T001544D	6C-96-4	IL	22.3	21.6	21.95			
S96T000572A	6C-96-7	FCS	< 42.2	< 49.3	< 45.75			
S96T000563D	6C-96-7	IL	21.3	< 20.1	< 20.7			
S96T000556A	6C-96-10	FCS	< 54.8	< 47.2	< 51			
Riser 7								
S96T001690A	6C-96-11	FCS	< 19.1	< 19.7	< 19.4			
S96T001681D	6C-96-11	IL	< 20.1	< 20.1	< 20.1			
S96T001564A	6C-96-13	FCS	< 21.1	< 20.9	< 21			
S96T001566D	6C-96-13	IL	22.4	22.7	22.55			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T000538D	6C-96-5	S	29.3	25	27.15			
Riser 7								
S96T001023D	6C-96-12	S	< 30	< 30	< 30			
S96T001546D	6C-96-15	S	21.8	21.8	21.8			

Table A-21. Tank 241-C-106 Analytical Results: Neodymium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						164	6.9	122
S96T001542A	6C-96-4	FCS	192	176	184			
S96T001544D	6C-96-4	IL	< 40.1	< 40.1	< 40.1			
S96T000572A	6C-96-7	FCS	153	170	161.5			
S96T000563D	6C-96-7	IL	< 40.1	< 40.1	< 40.1			
S96T000556A	6C-96-10	FCS	139	127	133			
Riser 7								
S96T001690A	6C-96-11	FCS	128	125	126.5			
S96T001681D	6C-96-11	IL	< 40.1	< 40.1	< 40.1			
S96T001564A	6C-96-13	FCS	174	187	180.5			
S96T001566D	6C-96-13	IL	< 40.1	< 40.1	< 40.1			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						< 60.1	n/a	<7.28
S96T000538D	6C-96-5	S	< 40.1	< 40.1	< 40.1			
Riser 7								
S96T001023D	6C-96-12	S	< 60.1	< 60.1	< 60.1			
S96T001546D	6C-96-15	S	< 40.1	< 40.1	< 40.1			

Table A-22. Tank 241-C-106 Analytical Results: Nickel (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						607	9.8	453
S96T001542A	6C-96-4	FCS	770	694	732			
S96T001544D	6C-96-4	IL	14.8	15.6	15.2			
S96T000572A	6C-96-7	FCS	653	755	704			
S96T000563D	6C-96-7	IL	13.7	13.5	13.6			
S96T000556A	6C-96-10	FCS	645	550	597.5			
Riser 7								
S96T001690A	6C-96-11	FCS	515	518	516.5			
S96T001681D	6C-96-11	IL	11.5	11.3	11.4			
S96T001564A	6C-96-13	FCS	708	740	724			
S96T001566D	6C-96-13	IL	15.2	15	15.1			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						16.1	5.3	1.94
S96T000538D	6C-96-5	S	18.4	15.7	17.05			
Riser 7								
S96T001023D	6C-96-12	S	14	14.7	14.35			
S96T001546D	6C-96-15	S	16.4	17.1	16.75			

Table A-23. Tank 241-C-106 Analytical Results: Phosphorus (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						2,370	9.6	1,770
S96T001542A	6C-96-4	FCS	2,750	2,500	2,625[QC:c]			
S96T001544D	6C-96-4	IL	352	372	362			
S96T000572A	6C-96-7	FCS	2,220	2,600	2,410[QC:d]			
S96T000563D	6C-96-7	IL	371	375	373			
S96T000556A	6C-96-10	FCS	2,580	2,200	2,390[QC:d]			
Riser 7								
S96T001690A	6C-96-11	FCS	1,760	1,810	1,785			
S96T001681D	6C-96-11	IL	266	275	270.5			
S96T001564A	6C-96-13	FCS	2,710	2,740	2,725			
S96T001566D	6C-96-13	IL	368	393	380.5			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						286	6.5	34.6
S96T000538D	6C-96-5	S	324	300	312			
Riser 7								
S96T001023D	6C-96-12	S	253	247	250			
S96T001546D	6C-96-15	S	292	299	295.5			

Table A-24. Tank 241-C-106 Analytical Results: Potassium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1						932	6.3	695
S96T001542A	6C-96-4	FCS	905	644	774.5[QC:c,e]			
S96T001544D	6C-96-4	IL	592	566	579			
S96T000572A	6C-96-7	FCS	612	646	629			
S96T000563D	6C-96-7	IL	548	564	556			
S96T000556A	6C-96-10	FCS	643	588	615.5			
Riser 7								
S96T001690A	6C-96-11	FCS	553	514	533.5			
S96T001681D	6C-96-11	IL	541	533	537			
S96T001564A	6C-96-13	FCS	942	932	937			
S96T001566D	6C-96-13	IL	671	634	652.5			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						658	11.8	79.6
S96T000538D	6C-96-5	S	801	658	729.5[QC:c,e]			
Riser 7								
S96T001023D	6C-96-12	S	694	788	741			
S96T001546D	6C-96-15	S	508	496	502			

Table A-25. Tank 241-C-106 Analytical Results: Samarium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			**µg/g**	**µg/g**	**µg/g**	**µg/mL**	**%**	**kg**
Riser 1						n/a	n/a	n/a
S96T001542A	6C-96-4	FCS	< 61.4	< 59.1	< 60.25			
S96T001544D	6C-96-4	IL	< 40.1	< 40.1	< 40.1			
S96T000572A	6C-96-7	FCS	< 84.3	< 98.6	< 91.45			
S96T000563D	6C-96-7	IL	< 40.1	< 40.1	< 40.1			
S96T000556A	6C-96-10	FCS	< 110	< 94.3	< 102.15			
Riser 7								
S96T001690A	6C-96-11	FCS	< 38.3	< 39.3	< 38.8			
S96T001566D	6C-96-11	IL	< 40.1	< 40.1	< 40.1			
S96T001564A	6C-96-13	FCS	< 42.2	< 41.8	< 42			
S96T001681D	6C-96-13	IL	< 40.1	< 40.1	< 40.1			
Supernate			**µg/mL**	**µg/mL**	**µg/mL**	**µg/mL**	**%**	**kg**
Riser 1						n/a	n/a	n/a
S96T000538D	6C-96-5	S	< 40.1	< 40.1	< 40.1			
Riser 7								
S96T001023D	6C-96-12	S	< 60.1	< 60.1	< 60.1			
S96T001546D	6C-96-15	S	< 40.1	< 40.1	< 40.1			

Table A-26. Tank 241-C-106 Analytical Results: Selenium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1								
S96T001542A	6C-96-4	FCS	< 61.4	< 59.1	< 60.25	n/a	n/a	n/a
S96T001544D	6C-96-4	IL	< 40.1	< 40.1	< 40.1			
S96T000572A	6C-96-7	FCS	< 84.3	< 98.6	< 91.45			
S96T000563D	6C-96-7	IL	< 40.1	< 40.1	< 40.1			
S96T000556A	6C-96-10	FCS	< 110	< 94.3	< 102.15			
Riser 7								
S96T001690A	6C-96-11	FCS	< 38.3	< 39.3	< 38.8			
S96T001681D	6C-96-11	IL	< 40.1	< 40.1	< 40.1			
S96T001564A	6C-96-13	FCS	< 42.2	< 41.8	< 42			
S96T001566D	6C-96-13	IL	< 40.1	< 40.1	< 40.1			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1								
S96T000538D	6C-96-5	S	< 40.1	< 40.1	< 40.1	n/a	n/a	n/a
Riser 7								
S96T001023D	6C-96-12	S	< 60.1	< 60.1	< 60.1			
S96T001546D	6C-96-15	S	< 40.1	< 40.1	< 40.1			

Table A-27. Tank 241-C-106 Analytical Results: Silicon (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1								
S96T001542A	6C-96-4	FCS	38,100	21,900	30,000 QC:b,e	24,600	9.0	18,400
S96T001544D	6C-96-4	IL	< 20.1	< 20.1	< 20.1			
S96T000572A	6C-96-7	FCS	22,700	26,600	24,650 QC:b			
S96T000563D	6C-96-7	IL	25.8	26.9	26.35			
S96T000556A	6C-96-10	FCS	28,700	24,700	26,700 QC:d,b			
Riser 7								
S96T001690A	6C-96-11	FCS	21,600	20,500	21,050 QC:c,b			
S96T001681D	6C-96-11	IL	27.5	20.4	23.95 QC:e			
S96T001564A	6C-96-13	FCS	35,500	29,500	32,500 QC:b			
S96T001566D	6C-96-13	IL	118	124	121			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1								
S96T000538D	6C-96-5	S	26.2	23	24.6	<36.2	n/a	<3.63
Riser 7								
S96T001023D	6C-96-12	S	< 30	< 30	< 30			
S96T001546D	6C-96-15	S	< 20.1	< 20.1	< 20.1			

Table A-28. Tank 241-C-106 Analytical Results: Silver (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1						1,870	13.0	1,390
S96T001542A	6C-96-4	FCS	2,500	1,510	2,005[QC:e]			
S96T001544D	6C-96-4	IL	< 4.01	< 4.01	< 4.01			
S96T000572A	6C-96-7	FCS	1,420	1,660	1,540[QC:e]			
S96T000563D	6C-96-7	IL	< 4.01	< 4.01	< 4.01			
S96T000556A	6C-96-10	FCS	2,770	2,020	2,395[QC:e]			
Riser 7								
S96T001690A	6C-96-11	FCS	1,960	1,250	1,605[QC:d,e]			
S96T001681D	6C-96-11	IL	< 4.01	< 4.01	< 4.01			
S96T001564A	6C-96-13	FCS	1,810	3,330	2,570[QC:e]			
S96T001566D	6C-96-13	IL	8.51	9.27	8.89			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						8.01	25.2	0.97
S96T000538D	6C-96-5	S	11.2	9.69	10.445			
Riser 7								
S96T001023D	6C-96-12	S	9.21	9.93	9.57			
S96T001546D	6C-96-15	S	< 4.01	< 4.01	< 4.01			

Table A-29. Tank 241-C-106 Analytical Results: Sodium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						177,000	6.8	132,000
S96T001542A	6C-96-4	FCS	1.400E+05	1.290E+05	1.345E+05			
S96T001544D	6C-96-4	IL	1.100E+05	1.100E+05	1.100E+05[QC:d]			
S96T000572A	6C-96-7	FCS	1.190E+05	1.410E+05	1.300E+05[QC:d]			
S96T000563D	6C-96-7	IL	1.030E+05	1.010E+05	1.020E+05			
S96T000556A	6C-96-10	FCS	1.610E+05	1.370E+05	1.490E+05[QC:d]			
Riser 7								
S96T001690A	6C-96-11	FCS	1.080E+05	1.080E+05	1.080E+05			
S96T001681D	6C-96-11	IL	99,100	95,600	97,350			
S96T001564A	6C-96-13	FCS	1.410E+05	1.350E+05	1.380E+05			
S96T001566D	6C-96-13	IL	1.130E+05	1.100E+05	1.115E+05			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						105,000	1.8	12,800
S96T000538D	6C-96-5	S	1.070E+05	96,800	1.019E+05			
Riser 7								
S96T001023D	6C-96-12	S	1.080E+05	1.040E+05	1.060E+05			
S96T001546D	6C-96-15	S	1.100E+05	1.060E+05	1.080E+05			

Table A-30. Tank 241-C-106 Analytical Results: Strontium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1								
S96T001542A	6C-96-4	FCS	25.6	22.9	24.25	40.2	2.7	30.0
S96T001544D	6C-96-4	IL	< 4.01	< 4.01	< 4.01			
S96T000572A	6C-96-7	FCS	17.7	20.4	19.05			
S96T000563D	6C-96-7	IL	< 4.01	< 4.01	< 4.01			
S96T000556A	6C-96-10	FCS	21.1	17.9	19.5			
Riser 7								
S96T001690A	6C-96-11	FCS	20.1	20	20.05			
S96T001681D	6C-96-11	IL	< 4.01	< 4.01	< 4.01			
S96T001564A	6C-96-13	FCS	23.5	24.6	24.05			
S96T001566D	6C-96-13	IL	< 4.01	< 4.01	< 4.01			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1								
S96T000538D	6C-96-5	S	< 4.01	< 4.01	< 4.01	<6.01	n/a	<0.73
Riser 7								
S96T001023D	6C-96-12	S	< 6.01	< 6.01	< 6.01			
S96T001546D	6C-96-15	S	< 4.01	< 4.01	< 4.01			

Table A-31. Tank 241-C-106 Analytical Results: Sulfur (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						2,420	6.1	2,120
S96T001542A	6C-96-4	FCS	1,400	1,140	1,270[QC:c,e]			
S96T001544D	6C-96-4	IL	2,370	2,280	2,325[QC:c]			
S96T000572A	6C-96-7	FCS	1,130	1,320	1,225			
S96T000563D	6C-96-7	IL	2,480	2,500	2,490			
S96T000556A	6C-96-10	FCS	1,390	1,190	1,290[QC:d]			
Riser 7								
S96T001690A	6C-96-11	FCS	918	938	928			
S96T001681D	6C-96-11	IL	2,240	2,150	2,195			
S96T001564A	6C-96-13	FCS	1,670	1,510	1,590			
S96T001566D	6C-96-13	IL	2,730	2,710	2,720			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						2,580	6.0	313
S96T000538D	6C-96-5	S	3,060	2,710	2,885			
Riser 7								
S96T001023D	6C-96-12	S	2,490	2,450	2,470[QC:c]			
S96T001546D	6C-96-15	S	2,420	2,350	2,385[QC:c]			

Table A-32. Tank 241-C-106 Analytical Results: Thallium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T001542A	6C-96-4	FCS	< 123	< 118	< 120.5			
S96T001544D	6C-96-4	IL	< 80.2	< 80.2	< 80.2			
S96T000572A	6C-96-7	FCS	< 169	< 197	< 183			
S96T000563D	6C-96-7	IL	< 80.2	< 80.2	< 80.2			
S96T000556A	6C-96-10	FCS	< 219	< 189	< 204			
Riser 7								
S96T001690A	6C-96-11	FCS	< 76.6	< 78.7	< 77.65			
S96T001681D	6C-96-11	IL	< 80.2	< 80.2	< 80.2			
S96T001564A	6C-96-13	FCS	< 84.5	< 83.6	< 84.05			
S96T001566D	6C-96-13	IL	< 80.2	< 80.2	< 80.2			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T000538D	6C-96-5	S	< 80.2	< 80.2	< 80.2			
Riser 7								
S96T001023D	6C-96-12	S	< 120	< 120	< 120			
S96T001546D	6C-96-15	S	< 80.2	< 80.2	< 80.2			

Table A-33. Tank 241-C-106 Analytical Results: Titanium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1						129	9.7	9.60
S96T001542A	6C-96-4	FCS	139	122	130.5			
S96T001544D	6C-96-4	IL	< 4.01	< 4.01	< 4.01			
S96T000572A	6C-96-7	FCS	125	147	136			
S96T000563D	6C-96-7	IL	< 4.01	< 4.01	< 4.01			
S96T000556A	6C-96-10	FCS	120	102	111			
Riser 7								
S96T001690A	6C-96-11	FCS	87.4	87.5	87.45			
S96T001681D	6C-96-11	IL	< 4.01	< 4.01	< 4.01			
S96T001564A	6C-96-13	FCS	115	121	118			
S96T001566D	6C-96-13	IL	< 4.01	< 4.01	< 4.01			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						< 6.01	n/a	<0.73
S96T000538D	6C-96-5	S	< 4.01	< 4.01	< 4.01			
Riser 7								
S96T001023D	6C-96-12	S	< 6.01	< 6.01	< 6.01			
S96T001546D	6C-96-15	S	< 4.01	< 4.01	< 4.01			

Table A-34. Tank 241-C-106 Analytical Results: Total Uranium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						1,610	6.0	1,200
S96T001542A	6C-96-4	FCS	856	1,140	998[QC:e]			
S96T001544D	6C-96-4	IL	1,540	1,640	1,590			
S96T000572A	6C-96-7	FCS	707	890	798.5[QC:e]			
S96T000563D	6C-96-7	IL	1,560	1,570	1,565			
S96T000556A	6C-96-10	FCS	830	686	758			
Riser 7								
S96T001690A	6C-96-11	FCS	578	588	583			
S96T001681D	6C-96-11	IL	1,600	1,500	1,550			
S96T001564A	6C-96-13	FCS	1,060	927	993.5			
S96T001566D	6C-96-13	IL	1,870	1,830	1,850			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						1,680	7.0	204
S96T000538D	6C-96-5	S	1,870	1,770	1,820[QC:e]			
Riser 7								
S96T001023D	6C-96-12	S	1,480	1,410	1,445			
S96T001546D	6C-96-15	S	1,760	1,790	1,775			

Table A-35. Tank 241-C-106 Analytical Results: Vanadium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T001542A	6C-96-4	FCS	< 30.7	< 29.5	< 30.1			
S96T001544D	6C-96-4	IL	< 20.1	< 20.1	< 20.1			
S96T000572A	6C-96-7	FCS	< 42.2	< 49.3	< 45.75			
S96T000563D	6C-96-7	IL	< 20.1	< 20.1	< 20.1			
S96T000556A	6C-96-10	FCS	< 54.8	< 47.2	< 51			
Riser 7								
S96T001690A	6C-96-11	FCS	< 19.1	< 19.7	< 19.4			
S96T001681D	6C-96-11	IL	< 20.1	< 20.1	< 20.1			
S96T001564A	6C-96-13	FCS	< 21.1	< 20.9	< 21			
S96T001566D	6C-96-13	IL	< 20.1	< 20.1	< 20.1			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T000538D	6C-96-5	S	< 20	< 20	< 20			
Riser 7								
S96T001023D	6C-96-12	S	< 30	< 30	< 30			
S96T001546D	6C-96-15	S	< 20.1	< 20.1	< 20.1			

Table A-36. Tank 241-C-106 Analytical Results: Zinc (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						63.4	9.0	47.3
S96T001542A	6C-96-4	FCS	60.6	49.8	55.2			
S96T001544D	6C-96-4	IL	5.25	5.98	5.615			
S96T000572A	6C-96-7	FCS	40.3	44.6	42.45			
S96T000563D	6C-96-7	IL	< 4.01	< 4.01	< 4.01			
S96T000556A	6C-96-10	FCS	39.6	35.2	37.4			
Riser 7								
S96T001690A	6C-96-11	FCS	62.3	87.4	74.85[QC:e]			
S96T001681D	6C-96-11	IL	< 4.01	< 4.01	< 4.01			
S96T001564A	6C-96-13	FCS	53.5	58	55.75			
S96T001566D	6C-96-13	IL	< 4.01	< 4.01	< 4.01			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						< 4.92	11.4	0.543
S96T000538D	6C-96-5	S	5.09	4.05	4.57[QC:e]			
Riser 7								
S96T001023D	6C-96-12	S	< 6.01	< 6.01	< 6.01			
S96T001546D	6C-96-15	S	4.32	< 4.01	< 4.165			

Table A-37. Tank 241-C-106 Analytical Results: Zirconium (ICP).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: acid digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1								
S96T001542A	6C-96-4	FCS	942	1,380	1,161[QC:e]	725	25.4	540
S96T001544D	6C-96-4	IL	372	378	375			
S96T000572A	6C-96-7	FCS	755	890	822.5[QC:d]			
S96T000563D	6C-96-7	IL	336	336	336			
S96T000556A	6C-96-10	FCS	49.3	39.4	44.35[QC:d,e]			
Riser 7								
S96T001690A	6C-96-11	FCS	162	431	296.5[QC:e]			
S96T001681D	6C-96-11	IL	330	319	324.5			
S96T001564A	6C-96-13	FCS	452	1,100	776[QC:e]			
S96T001566D	6C-96-13	IL	379	375	377			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1								
S96T000538D	6C-96-5	S	445	404	424.5	381	6.5	46.1
Riser 7								
S96T001023D	6C-96-12	S	344	333	338.5			
S96T001546D	6C-96-15	S	381	377	379			

Table A-38. Tank 241-C-106 Analytical Results: Chloride (IC).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: water digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						384	21.2	286
S96T003178W	6C-96-3	RS	291.8	310	300.9			
S96T003179W	6C-96-4	FCS	636.4	261	448.7[QC:e]			
S96T001544	6C-96-4	IL	584.2	588	586.1			
S96T000574W	6C-96-7	FCS	147	133	140			
S96T000563	6C-96-7	IL	304.2	326	315.1			
S96T000557W	6C-96-10	FCS	171.9	169	170.45			
Riser 7								
S96T003180W	6C-96-11	FCS	155.7	153	154.35			
S96T002024	6C-96-11	DS	257.9	266	261.95			
S96T003181W	6C-96-13	FCS	155.9	197	176.45[QC:d,e]			
S96T002025	6C-96-13	DS	281.5	293	287.25			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						318	7.7	38.5
S96T000538	6C-96-5	S	247.8	428	337.9[QC:e]			
Riser 7								
S96T001023	6C-96-12	S	320.4	317	318.7			
S96T001546	6C-96-15	S	296.6	295	295.8			

Table A-39. Tank 241-C-106 Analytical Results: Fluoride (IC).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: water digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						324	9.6	242
S96T003178W	6C-96-3	RS	214.4	267	240.7[QC:e]			
S96T003179W	6C-96-4	FCS	494.6	142	318.3[QC:e]			
S96T001544	6C-96-4	IL	197.3	199	198.15			
S96T000574W	6C-96-7	FCS	194.4	195	194.7			
S96T000563	6C-96-7	IL	235.5	230	232.75			
S96T000557W	6C-96-10	FCS	209.1	198	203.55			
Riser 7								
S96T003180W	6C-96-11	FCS	112.4	344	228.2[QC:e]			
S96T002024	6C-96-11	DS	201.1	209	205.05[QC:d]			
S96T003181W	6C-96-13	FCS	401.6	119	260.3[QC:e]			
S96T002025	6C-96-13	DS	191.4	209	200.2			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						244	18.4	29.6
S96T000538	6C-96-5	S	317	347	332			
Riser 7								
S96T001023	6C-96-12	S	182.8	184	183.4			
S96T001546	6C-96-15	S	222.6	212	217.3[QC:d]			

Table A-40. Tank 241-C-106 Analytical Results: Nitrate (IC).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: water digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						2,360	14.6	1,760
S96T003178W	6C-96-3	RS	2,958	3,800	3,379[QC:e]			
S96T003179W	6C-96-4	FCS	3,077	4,310	3,693.5[QC:e]			
S96T001544	6C-96-4	IL	943	954	948.5			
S96T000574W	6C-96-7	FCS	1,834	978	1,406[QC:e]			
S96T000563	6C-96-7	IL	1,166	1,140	1,153			
S96T000557W	6C-96-10	FCS	1,267	1,250	1,258.5			
Riser 7								
S96T003180W	6C-96-11	FCS	2,646	2,350	2,498			
S96T002024	6C-96-11	DS	981.1	1,010	995.55			
S96T003181W	6C-96-13	FCS	988.7	1,940	1,464.35[QC:e]			
S96T002025	6C-96-13	DS	969	1,100	1,034.5			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						1,320	18.5	160
S96T000538	6C-96-5	S	2,044	1,580	1,812[QC:e]			
Riser 7								
S96T001023	6C-96-12	S	1,106	1,120	1,113			
S96T001546	6C-96-15	S	1,005	1,090	1,047.5			

Table A-41. Tank 241-C-106 Analytical Results: Nitrite (IC).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: water digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1						24,600	4.5	18,300
S96T003178W	6C-96-3	RS	13,160	14,300	13,730			
S96T003179W	6C-96-4	FCS	11,920	12,300	12,110			
S96T001544	6C-96-4	IL	25,860	26,200	26,030			
S96T000574W	6C-96-7	FCS	10,360	10,300	10,330			
S96T000563	6C-96-7	IL	29,080	28,300	28,690			
S96T000557W	6C-96-10	FCS	13,520	13,400	13,460			
Riser 7								
S96T003180W	6C-96-11	FCS	8,225	7,200	7,712.5			
S96T002024	6C-96-11	DS	25,940	27,900	26,920[QC:d]			
S96T003181W	6C-96-13	FCS	11,640	10,900	11,270			
S96T002025	6C-96-13	DS	27,410	30,500	28,955			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						27,800	6.8	3,360
S96T000538	6C-96-5	S	29,110	28,700	28,905			
Riser 7								
S96T001023	6C-96-12	S	24,180	24,000	24,090			
S96T001546	6C-96-15	S	30,150	30,400	30,275			

Table A-42. Tank 241-C-106 Analytical Results: Phosphate (IC).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: water digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						1,530	22.4	1,140
S96T003178W	6C-96-3	RS	1,658	<1,400	1,529			
S96T003179W	6C-96-4	FCS	1,599	1,980	1,789.5[QC:e]			
S96T001544	6C-96-4	IL	584.7	547	565.85			
S96T000574W	6C-96-7	FCS	3,525	1,010	2,267.5[QC:e]			
S96T000563	6C-96-7	IL	649	609	629			
S96T000557W	6C-96-10	FCS	929.1	985	957.05			
Riser 7								
S96T003180W	6C-96-11	FCS	829.3	< 415	< 622.15			
S96T002024	6C-96-11	DS	441.9	480	460.95			
S96T003181W	6C-96-13	FCS	924.1	1,080	1002.05			
S96T002025	6C-96-13	DS	487.6	558	522.8			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						862	23.1	104
S96T000538	6C-96-5	S	<1,213	<1,210	<1,211.5			
Riser 7								
S96T001023	6C-96-12	S	863	845	854			
S96T001546	6C-96-15	S	513.3	530	521.65			

Table A-43. Tank 241-C-106 Analytical Results: Sulfate (IC).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: water digest			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						6,960	4.9	5,190
S96T003178W	6C-96-3	RS	5,343	5,230	5,286.5			
S96T003179W	6C-96-4	FCS	4,064	3,850	3,957			
S96T001544	6C-96-4	IL	6,832	6,860	6,846			
S96T000574W	6C-96-7	FCS	3,322	3,310	3,316			
S96T000563	6C-96-7	IL	7,764	7,610	7,687			
S96T000557W	6C-96-10	FCS	4,115	4,110	4,112.5			
Riser 7								
S96T003180W	6C-96-11	FCS	2,533	2,280	2,406.5			
S96T002024	6C-96-11	DS	6,686	7,200	6,943			
S96T003181W	6C-96-13	FCS	3,525	3,120	3,322.5			
S96T002025	6C-96-13	DS	7,190	7,980	7,585			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						7,360	5.7	892
S96T000538	6C-96-5	S	7,464	7,860	7,662			
Riser 7								
S96T001023	6C-96-12	S	6,540	6,530	6,535			
S96T001546	6C-96-15	S	7,879	7,900	7,889.5			

Table A-44. Tank 241-C-106 Analytical Results: Oxalate (IC).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: water digest			μg/g	μg/g	μg/g	μg/mL	%	kg
Riser 1						80,200	17.7	59,800
S96T003178W	6C-96-3	RS	3.076E+05	3.190E+05	3.133E+05[QC:c]			
S96T003179W	6C-96-4	FCS	1.174E+05	43,000	80,200[QC:e]			
S96T001544	6C-96-4	IL	2,189	2,230	2,209.5			
S96T000574W	6C-96-7	FCS	68,950	68,300	68,625			
S96T000563	6C-96-7	IL	3,081	3,090	3,085.5			
S96T000557W	6C-96-10	FCS	77,960	77,000	77,480			
Riser 7								
S96T003180W	6C-96-11	FCS	78,150	2.260E+05	1.521E+05[QC:e]			
S96T002024	6C-96-11	DS	3,177	3,450	3,313.5			
S96T003181W	6C-96-13	FCS	24,980	82,500	53,740[QC:e]			
S96T002025	6C-96-13	DS	3,106	3,470	3,288			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						3,390	6.2	411
S96T000538	6C-96-5	S	3,654	3,700	3,677			
Riser 7								
S96T001023	6C-96-12	S	2,980	2,980	2,980			
S96T001546	6C-96-15	S	3,532	3,500	3,516			

Table A-45. Tank 241-C-106 Analytical Results: Total Inorganic Carbon.

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						36,000	7.0	26,800
S96T001538	6C-96-4	FCS	25,400	25,300	25,350			
S96T000568	6C-96-7	FCS	29,300	25,600	27,450			
S96T000552	6C-96-10	FCS	25,600	27,600	26,600			
Riser 7								
S96T00686	6C-96-11	FCS	23,200	22,800	23,000			
S96T001560	6C-96-13	FCS	26,400	26,600	26,500			
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						22,300	9.8	2,700
S96T000538	6C-96-5	S	20,000	20,200	20,100			
Riser 7								
S96T001023	6C-96-12	S	24,300	24,600	24,450			

Table A-46. Tank 241-C-106 Analytical Results: Total Organic Carbon (Furnace and Persulfate Oxidation). (2 sheets)

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge			µg/g	µg/g	µg/g	µg/mL	%	kg
Riser 1						20,000	18.9	14,900
S96T001526 Pers	6C-96-3	RS	60,500	50,300	55,400			
S96T001538 Pers	6C-96-4	FCS	14,800	16,400	15,600			
S96T001544 Pers	6C-96-4	IL	1,870	1,500	1,685 QC:e			
S96T001544 Furn	6C-96-4	IL	2,320	2,310	2,315			
S96T000568 Pers	6C-96-7	FCS	20,400	24,900	22,650			
S96T000563 Pers	6C-96-7	IL	2,350	2,280	2,315			
S96T000563 Furn	6C-96-7	IL	2,440	2,440	2,440			
S96T000544 Furn	6C-96-7	DS	2,070	2,020	2,045			
S96T000854 Pers	6C-96-8	CS	13,400	9,320	11,360 QC:e			
S96T000552 Pers	6C-96-10	FCS	24,700	29,200	26,950			
S96T000545 Pers	6C-96-10	IL	2,420	2,430	2,425			
S96T001567 Pers	6C-96-10	POL	30,800	34,800	32,800			
Riser 7								
S96T001686 Pers	6C-96-11	FCS	20,000	17,300	18,650			
S96T001681 Pers	6C-96-11	IL	1,640	1,620	1,630			
S96T001681 Furn	6C-96-11	IL	2,060	2,080	2,070			

Table A-46. Tank 241-C-106 Analytical Results: Total Organic Carbon (Furnace and Persulfate Oxidation). (2 sheets)

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Riser 7 (Cont'd)						20,000	18.9	14,900
S96T001679^{Pers}	6C-96-11	POL	24,800	22,000	23,400			
S96T001560^{Pers}	6C-96-13	FCS	16,000	13,500	14,750			
S96T001566^{Pers}	6C-96-13	IL	1,860	1,830	1,845			
S96T002025^{Furn}	6C-96-13	DS	1,950	1,950	1,950			
S96T001551^{Pers}	6C-96-14	CS	29,700	28,500	29,100			
Supernate			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
Riser 1						2,910	13.5	352
S96T000538^{Pers}	6C-96-5	S	2,300	2,180	2,240			
S96T000538^{Furn}	6C-96-5	S	3,360	3,240	3,300			
Riser 7								
S96T001023^{Pers}	6C-96-12	S	1,970	2,090	2,030			
S96T001023^{Furn}	6C-96-12	S	2,490	2,540	2,515			

Table A-47. Tank 241-C-106 Analytical Results: Nonane (Volatile Organic Analysis).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T003134	6C-96-8	POL	< 1	n/a	< 1			
Riser 7								
S96T003230	6C-96-14	POL	< 1	n/a	< 1			

Table A-48. Tank 241-C-106 Analytical Results: Decane (Volatile Organic Analysis).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T003134	6C-96-8	POL	< 1	n/a	< 1			
Riser 7								
S96T003230	6C-96-14	POL	< 1	n/a	< 1			

Table A-49. Tank 241-C-106 Analytical Results: Undecane (Volatile Organic Analysis).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						2.83	n/a	0.343
S96T003134	6C-96-8	POL	1.59	n/a	1.59			
Riser 7								
S96T003230	6C-96-14	POL	4.07	n/a	4.07			

Table A-50. Tank 241-C-106 Analytical Results: Dodecane (Volatile Organic Analysis).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						18.6	n/a	2.25
S96T003134	6C-96-8	POL	10.1	n/a	10.1			
Riser 7								
S96T003230	6C-96-14	POL	27	n/a	27			

Table A-51. Tank 241-C-106 Analytical Results: Tridecane (Volatile Organic Analysis).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						82.3	n/a	9.97
S96T003134	6C-96-8	POL	45.6	n/a	45.6			
Riser 7								
S96T003230	6C-96-14	POL	119	n/a	119			

Table A-52. Tank 241-C-106 Analytical Results: Tetradecane (Volatile Organic Analysis).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						52.3	n/a	6.33
S96T003134	6C-96-8	POL	27.6	n/a	27.6			
Riser 7								
S96T003230	6C-96-14	POL	77	n/a	77			

Table A-53. Tank 241-C-106 Analytical Results: Pentadecane (Volatile Organic Analysis).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						4.32	n/a	0.52
S96T003134	6C-96-8	POL	2.37	n/a	2.37			
Riser 7								
S96T003230	6C-96-14	POL	6.27	n/a	6.27			

Table A-53. Tank 241-C-106 Analytical Results: Tributyl Phosphate (Semi-Volatile Organic Analysis).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						40.4	n/a	4.9
S96T003134	6C-96-8	POL	31.9	n/a	31.9			
Riser 7								
S96T003230	6C-96-14	POL	48.8	n/a	48.8			

Table A-54. Tank 241-C-106 Analytical Results: Bulk Density.

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Solid Portions			g/mL	g/mL	g/mL	g/mL	%	
Riser 1						n/a	n/a	n/a
S96T000532	6C-96-4	RS	n/a	n/a	1.495			
S96T001530	6C-96-4	C	n/a	n/a	1.735			
S96T000837	6C-96-7	RS	n/a	n/a	1.566			
S96T000543	6C-96-7	C	n/a	n/a	1.789			
S96T000531	6C-96-10	RS	n/a	n/a	1.6995			
S96T000560	6C-96-10	C	n/a	n/a	1.714			
Riser 7								
S96T001021	6C-96-11	RS	n/a	n/a	1.450			
S96T001676	6C-96-11	C	n/a	n/a	1.637			
S96T001675	6C-96-11	CS	1.153	1.138	1.1455[QC:b]			
S96T001026	6C-96-13	RS	n/a	n/a	1.523			
S96T001034	6C-96-13	C	n/a	n/a	1.740			

Table A-55. Tank 241-C-106 Analytical Results: Specific Gravity.

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Liquid Portions			unitless	unitless	unitless	unitless	%	
Riser 1						n/a	n/a	n/a
S96T001528	6C-96-4	DS	1.23	1.246	1.238			
S96T000538	6C-96-5	S	1.155	1.155	1.155			
S96T000544	6C-96-7	DS	1.2	1.194	1.197			
S96T002768	6C-96-8	DS	1.005	0.997	1.001			
S96T002771	6C-96-8	DS	1.002	0.991	0.9965			
S96T000559	6C-96-10	DS	1.156	1.15	1.153			
Riser 7								
S96T001528	6C-96-11	DS	1.23	1.246	1.238			
S96T002024	6C-96-11	DS	1.195	1.195	1.195			
S96T001023	6C-96-12	S	1.173	1.193	1.183			
S96T002826	6C-96-14	DS	0.988	0.972	0.98			
S96T002830	6C-96-14	DS	0.996	0.999	0.9975			

Table A-56. Tank 241-C-106 Analytical Results: pH Measurement.

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge			unitless	unitless	unitless	unitless	%	
Riser 1								
S96T001540	6C-96-4	FCS	10.21	10.18	10.195	n/a	n/a	n/a
S96T001544	6C-96-4	IL	10.1	n/a	10.1			
S96T000570	6C-96-7	FCS	10.56	10.54	10.55			
S96T000544	6C-96-7	DS	10.09	n/a	10.09			
S96T002768	6C-96-8	DS	11.1	n/a	11.1			
S96T002771	6C-96-8	DS	11.81	11.79	11.8			
S96T000554	6C-96-10	FCS	10.4	10.5	10.45			
Riser 7								
S96T001688	6C-96-11	FCS	10.42	n/a	10.42			
S96T002024	6C-96-11	DS	10.15	n/a	10.15			
S96T001562	6C-96-13	FCS	10.67	10.62	10.645			
S96T002025	6C-96-13	DS	10.09	n/a	10.09			
S96T002826	6C-96-14	DS	11.5	n/a	11.5			
S96T002830	6C-96-14	DS	11.91	11.9	11.905			
Supernate			unitless	unitless	unitless	unitless	%	
Riser 1								
S96T000538	6C-96-5	S	10.1	10.08	10.09	n/a	n/a	n/a
Riser 7								
S96T001023	6C-96-12	S	10.24	10.24	10.24			

Table A-57. Tank 241-C-106 Analytical Results: Americium-241 (AEA).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: fusion			µCi/g	µCi/g	µCi/g	µCi/mL	%	Ci
Riser 1						n/a	n/a	n/a
S96T001531F	6C-96-4	C	0.884	1.1	0.992[QC:e]			
S96T001541F	6C-96-4	FCS	1.15	1.56	1.355[QC:e]			
S96T000546F	6C-96-7	C	1.01	1.23	1.12			
S96T000571F	6C-96-7	FCS	0.532	1.56	1.046[QC:e]			
S96T002718F	6C-96-7	FCS	1.87	1.69	1.78			
S96T000555F	6C-96-10	FCS	1.33	1.22	1.275			
S96T000561F	6C-96-10	C	0.426	0.362	0.394			
Riser 7								
S96T001678F	6C-96-11	C	0.703	0.715	0.709			
S96T001689F	6C-96-11	FCS	1.03	0.98	1.005			
S96T001036F	6C-96-13	C	1.46	1.21	1.335			
S96T001563F	6C-96-13	FCS	1.59	1.63	1.61			
Supernate			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
Riser 1						n/a	n/a	n/a
S96T000539	6C-96-5	S	0.015	0.0121	0.01355[QC:e]			
Riser 7								
S96T001024	6C-96-12	S	< 0.0113	< 0.0128	< 0.01205			

Table A-58. Tank 241-C-106 Analytical Results: Cesium-137 (GEA). (2 sheets)

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: fusion			µCi/g	µCi/g	µCi/g	µCi/mL	%	Ci
Riser 1						654	7.5	488,000
S96T001531F	6C-96-4	C	661	625	643			
S96T001541F	6C-96-4	FCS	616.3	671	643.65			
S96T001544	6C-96-4	IL	159	157	158			
S96T000546F	6C-96-7	C	402.7	417	409.85			
S96T000571F	6C-96-7	FCS	204.6	531	367.8[QC:e]			
S96T002718F	6C-96-7	FCS	579.6	633	606.3			
S96T000563	6C-96-7	IL	154	153	153.5			
S96T000555F	6C-96-10	FCS	595.9	622	608.95			
S96T000561F	6C-96-10	C	197.7	170	183.85			
S96T000545	6C-96-10	IL	76.5	100	88.25[QC:e]			
Riser 7								
S96T001678F	6C-96-11	C	450.2	408	429.1			
S96T001689F	6C-96-11	FCS	482.7	509	495.85			
S96T001681	6C-96-11	IL	121	121	121			
S96T002024	6C-96-11	DS	128	127	127.5			
S96T001036F	6C-96-13	C	899.3	716	807.65[QC:e]			
S96T001563F	6C-96-13	FCS	888.5	892	890.25			

Table A-58. Tank 241-C-106 Analytical Results: Cesium-137 (GEA). (2 sheets)

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Riser 7 Cont'd								
S96T001566	6C-96-13	IL	135	170	152.5[QC:e]	654	7.5	488,000
S96T002025	6C-96-13	DS	104	105	104.5			
Supernate			μCi/mL	μCi/mL	μCi/mL	μCi/mL	%	Ci
Riser 1								
S96T000539	6C-96-5	S	108	107	107.5	108	0.7	131,000
Riser 7								
S96T001024	6C-96-12	S	108	110	109			

Table A-59. Tank 241-C-106 Analytical Results: Cobalt-60 (GEA). (2 sheets)

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: fusion			µCi/g	µCi/g	µCi/g	µCi/mL	%	Ci
Riser 1								
S96T001531F	6C-96-4	C	< 0.496	< 0.435	< 0.4655	n/a	n/a	n/a
S96T001541F	6C-96-4	FCS	< 0.5477	< 0.572	< 0.55985			
S96T001544	6C-96-4	IL	< 0.03379	< 0.0227	< 0.028245			
S96T000546F	6C-96-7	C	< 0.2329	< 0.227	< 0.22995			
S96T000571F	6C-96-7	FCS	< 0.1276	0.351	< 0.2393			
S96T002718F	6C-96-7	FCS	< 0.5331	< 0.423	< 0.47805			
S96T000563	6C-96-7	IL	< 0.008447	0.0124	< 0.0104235			
S96T000555F	6C-96-10	FCS	0	< 0.571	< 0.2855			
S96T000561F	6C-96-10	C	< 0.205	< 0.188	< 0.1965			
S96T000545	6C-96-10	IL	< 0.007503	0.0108	< 0.0091515			
Riser 7								
S96T001678F	6C-96-11	C	< 0.7173	< 0.587	< 0.65215			
S96T001689F	6C-96-11	FCS	< 0.3034	< 0.413	< 0.3582			
S96T001681	6C-96-11	IL	< 0.00505	< 0.0048	< 0.004925			
S96T002024	6C-96-11	DS	< 0.00463	< 0.00449	< 0.00456			
S96T001036F	6C-96-13	C	< 0.5751	< 0.558	< 0.56655			
S96T001563F	6C-96-13	FCS	< 0.6243	< 0.583	< 0.60365			

Table A-59. Tank 241-C-106 Analytical Results: Cobalt-60 (GEA). (2 sheets)

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Riser 7 Cont'd						n/a	n/a	n/a
S96T001566	6C-96-13	IL	< 0.006193	< 0.00713	< 0.0066615			
S96T002025	6C-96-13	DS	< 0.004027	< 0.00434	< 0.0041835			
Supernate			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
Riser 1						n/a	n/a	n/a
S96T000539	6C-96-5	S	< 0.005709	< 0.00613	< 0.0059195			
Riser 7								
S96T001024	6C-96-12	S	< 0.006189	< 0.00555	< 0.0058695			

Table A-60. Tank 241-C-106 Analytical Results: Total Alpha (Alpha).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: fusion			μCi/g	μCi/g	μCi/g	μCi/mL	%	Ci
Riser 1						n/a	n/a	n/a
S96T001531F	6C-96-4	C	2.63	2.57	2.6			
S96T001541F	6C-96-4	FCS	3.12	3.31	3.215			
S96T000546F	6C-96-7	C	2.88	2.57	2.725			
S96T000571F	6C-96-7	FCS	1.32	3.57	2.445[QC:e]			
S96T002718F	6C-96-7	FCS	3.5	3.64	3.57			
S96T000555F	6C-96-10	FCS	3.33	3.06	3.195			
S96T000561F	6C-96-10	C	1.56	1.15	1.355[QC:e]			
Riser 7								
S96T001678F	6C-96-11	C	1.5	1.62	1.56			
S96T001689F	6C-96-11	FCS	1.68	1.84	1.76			
S96T001036F	6C-96-13	C	6.33	2.42	4.375[QC:e]			
S96T001563F	6C-96-13	FCS	3.61	3.67	3.64			
Supernate			μCi/mL	μCi/mL	μCi/mL	μCi/mL	%	Ci
Riser 1						1.03	11.7	124
S96T000539	6C-96-5	S	1.15	1.14	1.145			
Riser 7								
S96T001024	6C-96-12	S	0.928	0.88	0.904			

Table A-61. Tank 241-C-106 Analytical Results: Plutonium-239/40 (PU239/240). (2 sheets)

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge			µCi/g	µCi/g	µCi/g	µCi/mL	%	Ci
Riser 1								
S96T001531F	6C-96-4	C	1.27	1.21	1.24	1.67	8.0	1,240
S96T001541F	6C-96-4	FCS	1.42	1.48	1.45			
S96T001544	6C-96-4	IL	0.867	0.839	0.853			
S96T001545	6C-96-4	POL	0.00426	0.00421	0.004235			
S96T000544	6C-96-7	DS	0.769	0.756	0.7625			
S96T000546F	6C-96-7	C	1.52	1.39	1.455			
S96T000571F	6C-96-7	FCS	< 0.0217	< 0.0279	< 0.0248			
S96T002718F	6C-96-7	FCS	1.52	1.53	1.525			
S96T000563	6C-96-7	IL	0.812	0.833	0.8225			
S96T000555F	6C-96-10	FCS	1.32	1.28	1.3			
S96T000561F	6C-96-10	C	< 0.062	< 0.0467	< 0.05435			
Riser 7								
S96T001678F	6C-96-11	C	0.775	0.765	0.77			
S96T001689F	6C-96-11	FCS	0.901	0.926	0.9135			
S96T001681	6C-96-11	IL	0.84	0.834	0.837			
S96T001036F	6C-96-13	C	1.2	0.895	1.0475[QC:e]			
S96T001563F	6C-96-13	FCS	1.65	1.54	1.595			
S96T002025	6C-96-13	DS	0.773	0.766	0.7695			

Table A-61. Tank 241-C-106 Analytical Results: Plutonium-239/40 (PU239/240). (2 sheets)

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Supernate			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
Riser 1								
S96T000539	6C-96-5	S	0.74	0.692	0.716	0.745	4.0	90.2
Riser 7								
S96T001024	6C-96-12	S	0.738	0.814	0.776			

Table A-62. Tank 241-C-106 Analytical Results: Strontium-89/90 (Sr). (2 sheets)

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: fusion			μCi/g	μCi/g	μCi/g	μCi/mL	%	Ci
Riser 1						546	8.2	407,000
S96T001531F	6C-96-4	C	603	589	596			
S96T001541F	6C-96-4	FCS	665	721	693			
S96T001544	6C-96-4	IL	0.84	0.782	0.811			
S96T000544	6C-96-7	DS	0.968	0.893	0.9305			
S96T000546F	6C-96-7	C	332	342	337			
S96T000571F	6C-96-7	FCS	186	517	351.5[QC:e]			
S96T002718F	6C-96-7	FCS	590	639	614.5			
S96T000563	6C-96-7	IL	1.23	0.635	0.9325[QC:e]			
S96T000555F	6C-96-10	FCS	519	523	521			
S96T000561F	6C-96-10	C	174	152	163			
Riser 7								
S96T001678F	6C-96-11	C	383	381	382			
S96T001689F	6C-96-11	FCS	487	523	505			
S96T001681	6C-96-11	IL	0.671	0.668	0.6695			
S96T001566	6C-96-13	IL	0.0639	0.0886	0.07625[QC:e]			
S96T001036F	6C-96-13	C	1,240	483	861.5[QC:e]			
S96T001563F	6C-96-13	FCS	638	683	660.5			

Table A-62. Tank 241-C-106 Analytical Results: Strontium-89/90 (Sr). (2 sheets)

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Supernate			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
Riser 1						0.423	13.6	51.2
S96T000539	6C-96-5	S	0.369	0.362	0.3655			
Riser 7								
S96T001024	6C-96-12	S	0.484	0.482	0.483			

Table A-63. Tank 241-C-106 Analytical Results: Technetium-99 (Tc).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Sludge: fusion			μCi/g	μCi/g	μCi/g	μCi/mL	%	Ci
Riser 1						n/a	n/a	n/a
S96T001531F	6C-96-4	C	< 0.0143	0.0174	< 0.01585			
S96T001541F	6C-96-4	FCS	< 0.0154	0.0175	< 0.01645			
S96T000546F	6C-96-7	C	0.0551	0.0448	0.04995[QC:e]			
S96T000571F	6C-96-7	FCS	< 0.0226	< 0.0274	< 0.025			
S96T002718F	6C-96-7	FCS	< 0.0352	< 0.037	< 0.0361			
S96T000555F	6C-96-10	FCS	0.0409	< 0.0353	< 0.0381			
S96T000561F	6C-96-10	C	< 0.0643	< 0.0553	< 0.0598			
Riser 7								
S96T001678F	6C-96-11	C	0.0193	0.0275	0.0234[QC:e]			
S96T001689F	6C-96-11	FCS	0.0297	0.504	0.26685[QC:e]			
S96T001036F	6C-96-13	C	0.0359	0.0241	0.03[QC:e]			
S96T001563F	6C-96-13	FCS	0.0411	0.0323	0.0367[QC:e]			
Supernate			μCi/mL	μCi/mL	μCi/mL	μCi/mL	%	Ci
Riser 1						0.205	56.1	24.8
S96T000539	6C-96-5	S	0.0852	0.0923	0.08875			
Riser 7								
S96T001024	6C-96-12	S	0.16	0.479	0.3195[QC:e]			

Table A-64. Tank 241-C-106 Analytical Results: Ammonium (Ion Selective Electrode (NH_4^+).

Sample Number	Grab Sample Number	Sample Portion	Result	Duplicate	Sample Mean	Overall Mean	RSD (Mean)	Projected Inventory
Supernate			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
Riser 1						n/a	n/a	n/a
S96T000538	6C-96-5	S	< 5	< 5	< 5			
Riser 7								
S96T001023	6C-96-12	S	< 5	< 5	< 5			

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APPENDIX B

TANK 241-C-106 GRAB SAMPLE BREAKDOWN FLOW CHARTS

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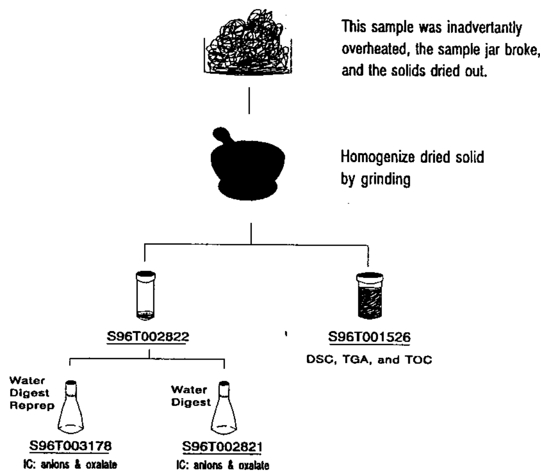
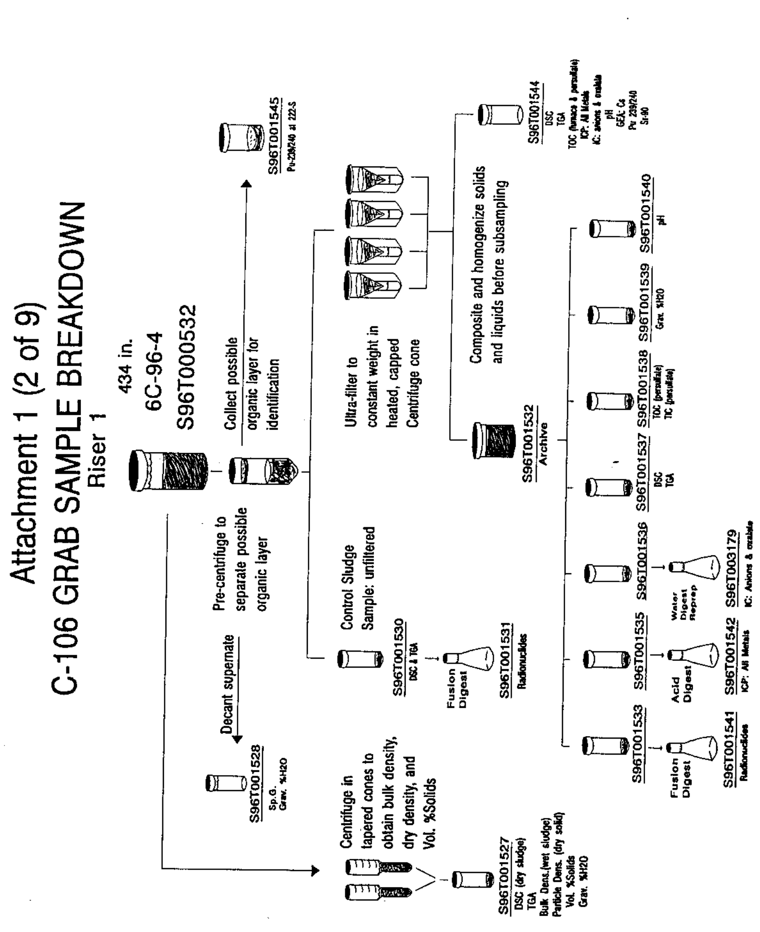
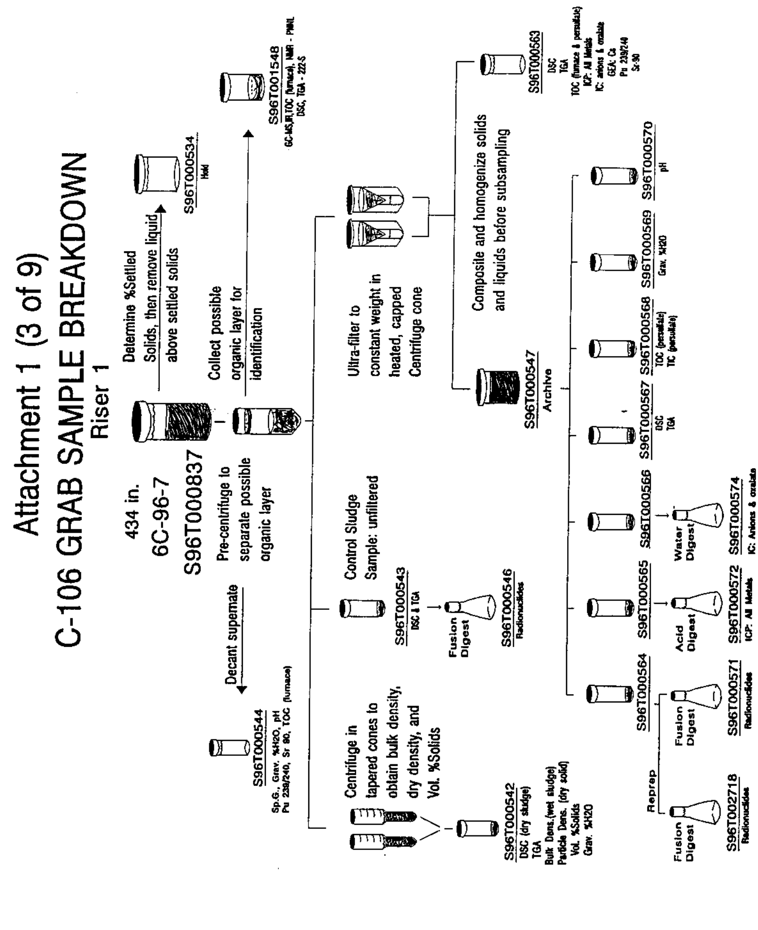
Attachment 1 (1 of 9)
C-106 GRAB SAMPLE BREAKDOWN
Riser 1

432 in.
6C-96-3
S96T000530

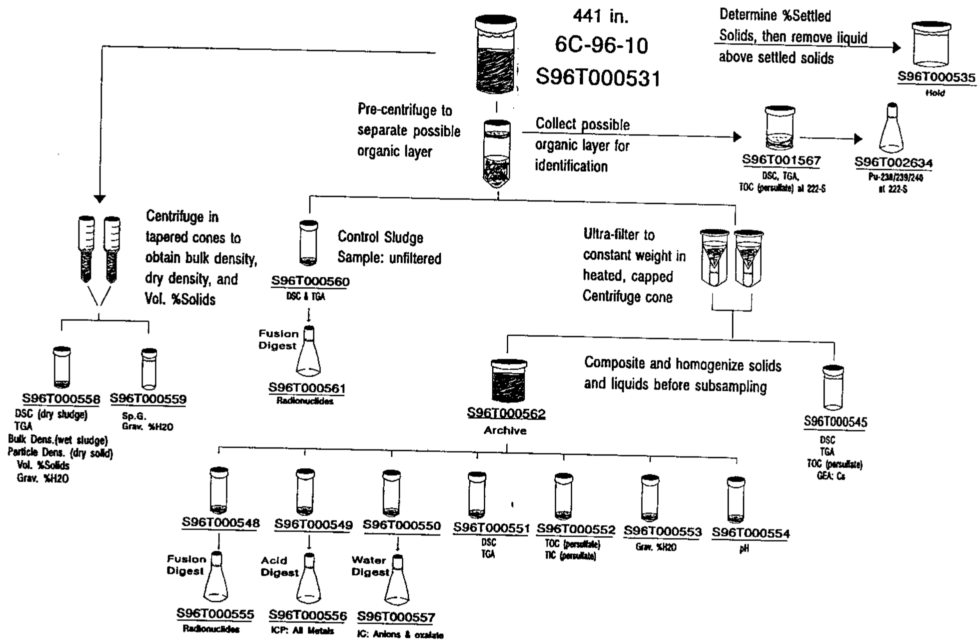




Attachment 1 (2 of 9)
C-106 GRAB SAMPLE BREAKDOWN
Riser 1
434 in.
6C-96-4
S96T000532
Decant supernate
Pre-centrifuge to separate possible organic layer
Collect possible organic layer for identification
S96T001545
Pu-239/240 at 22-S
S96T001528
Sp.G.
Grav. %H2O
Centrifuge in tapered cones to obtain bulk density, dry density, and Vol. %Solids
S96T001527
DSC (dry sludge)
TGA
Bulk Dens.(wet sludge)
Particle Dens. (dry solid)
Vol. %Solids
Grav. %H2O
Control Sludge Sample: unfiltered
S96T001530
DSC & TGA
Fusion Digest
S96T001531
Radionuclides
Ultra-filter to constant weight in heated, capped Centrifuge cone
Composite and homogenize solids and liquids before subsampling
S96T001532
Archive
S96T001544
DSC
TGA
pH
GEA: Cs
Pu 239/240
Sr-90
S96T001533
Fusion Digest
S96T001541
Radionuclides
S96T001535
Acid Digest
S96T001542
ICP: All Metals
S96T001536
Water Digest Reprep
S96T003179
IC: Anions & oxalate
S96T001537
DSC
TGA
S96T001538
TOC (persulfate)
TIC (persulfate)
S96T001539
Grav. %H2O
S96T001540
pH


Attachment 1 (3 of 9)
C-106 GRAB SAMPLE BREAKDOWN
Riser 1
434 in.
6C-96-7
S96T000837
Decant supernate
S96T000544
Sp.G., Grav. %H2O, pH
Pu 239/240, Sr 90, TOC (furnace)
Pre-centrifuge to separate possible organic layer
Determine %Settled Solids, then remove liquid above settled solids
S96T000534
Hold
Collect possible organic layer for identification
S96T001548
GC-MS,IR,TOC (furnace), NMR - PNNL
DSC, TGA - 222-S
Centrifuge in tapered cones to obtain bulk density, dry density, and Vol. %Solids
S96T000542
DSC (dry sludge)
TGA
Bulk Dens. (wet sludge)
Particle Dens. (dry solid)
Vol. %Solids
Grav. %H2O
Control Sludge Sample: unfiltered
S96T000543
DSC & TGA
Fusion Digest
S96T000546
Radionuclides
Ultra-filter to constant weight in heated, capped Centrifuge cone
Composite and homogenize solids and liquids before subsampling
S96T000563
DSC
TGA
TOC (furnace & persulfate)
ICP: All Metals
IC: anions & oxalate
GEA: Cs
Pu 239/240
Sr-90
S96T000547
Archive
S96T000564
Reprep
Fusion Digest
S96T002718
Radionuclides
Fusion Digest
S96T000571
Radionuclides
S96T000565
Acid Digest
S96T000572
ICP: All Metals
S96T000566
Water Digest
S96T000574
IC: Anions & oxalate
S96T000567
DSC
TGA
S96T000568
TOC (persulfate)
TIC (persulfate)
S96T000569
Grav. %H2O
S96T000570
pH

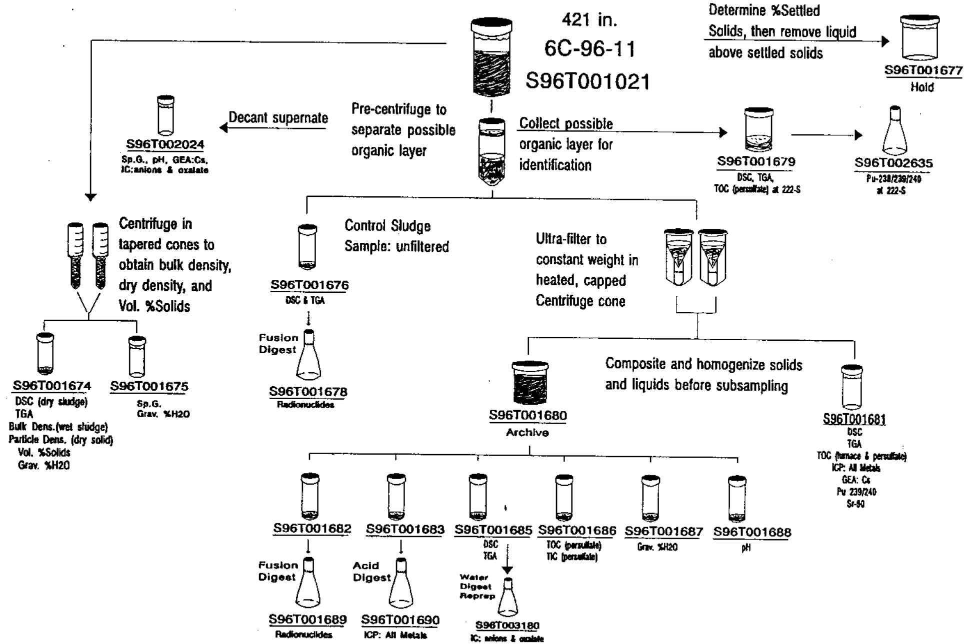
Attachment 1 (4 of 9)
C-106 GRAB SAMPLE BREAKDOWN
Riser 1



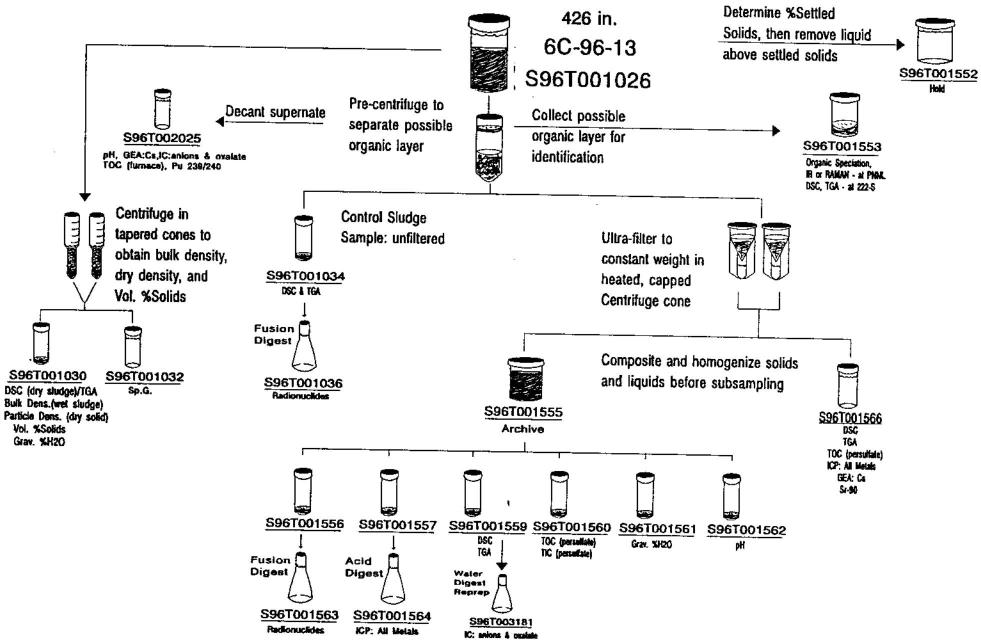
Attachment 1 (5 of 9)

C-106 GRAB SAMPLE BREAKDOWN

Riser 7



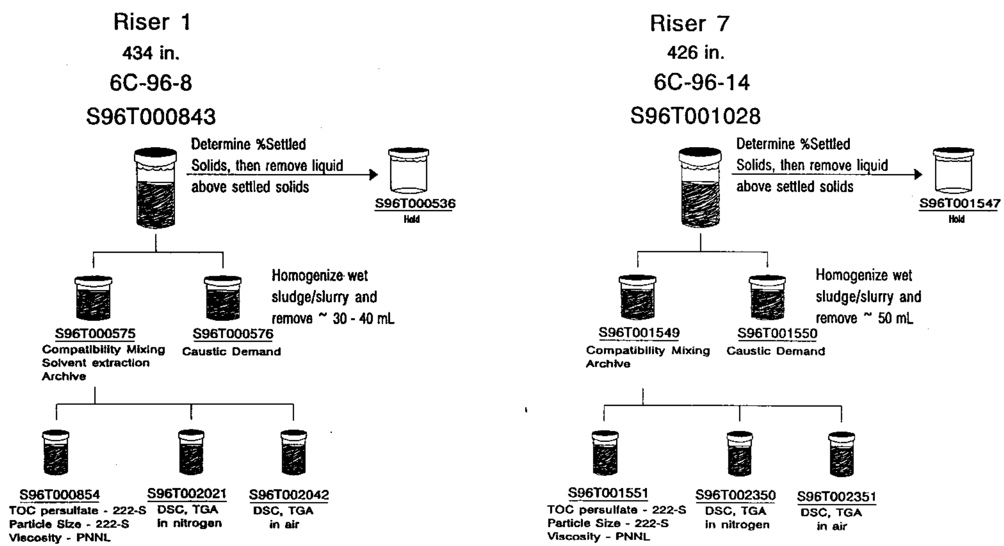
Attachment 1 (6 of 9)
C-106 GRAB SAMPLE BREAKDOWN
Riser 7



Attachment 1 (7 of 9)

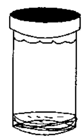
C-106 GRAB SAMPLE BREAKDOWN

For Caustic Demand, Particle Size, Viscosity, and Compatibility Mixing Studies on Sludge Samples

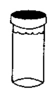


Attachment 1 (8 of 9)
C-106 GRAB SAMPLE BREAKDOWN
Riser 7

426 in.
6C-96-15
S96T001027



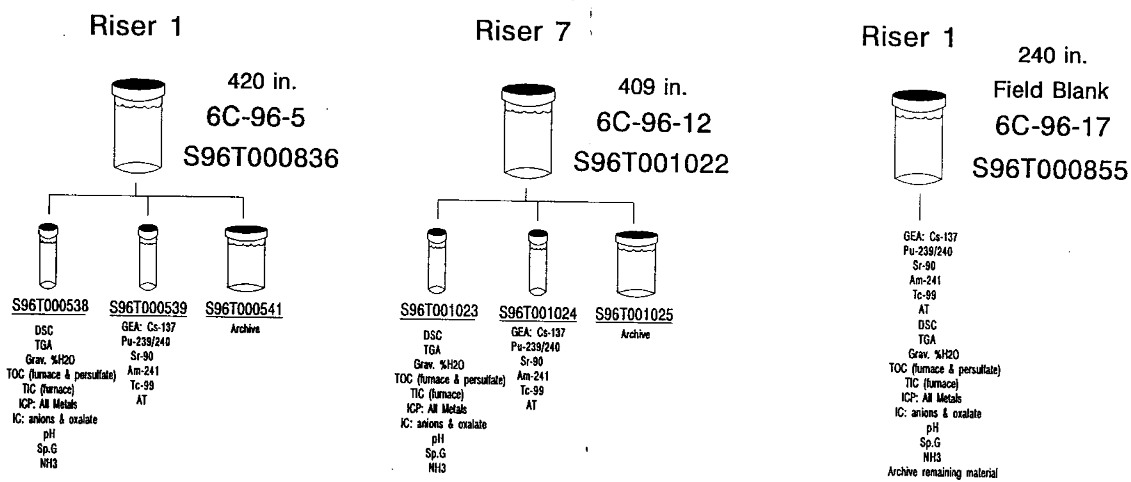
Determine %Settled Solids, then carefully remove liquid above settled solids



S96T001546

ICP: All Metals
IC: anions + oxalate

Attachment 1 (9 of 9)
C-106 GRAB SAMPLE BREAKDOWN



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APPENDIX C

STATISTICAL ANALYSIS OF TANK 241-C-106 GRAB SAMPLE RESULTS

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Westinghouse Hanford Company — Internal Memo

From:	Process Chemistry and Statistics	75764-PCS96-090
Phone:	373-4034 T6-07	
Date:	September 9, 1996	
Subject:	STATISTICAL ANALYSIS FOR SINGLE-SHELL TANK 241-C-106	

To: R. D. Schreiber R2-12

cc: J. G. Douglas L5-55
J. W. Hunt R2-12
J. R. Jewett T6-09
L. Jensen T6-07
RDC:TLW File/LB

References: (1) WHC-SD-WM-TI-756, Rev. 0-A, "Chemical and Chemically-Related Considerations Associated with Sluicing Tank C-106 Waste to Tank AY-102," H. Babad et al., dated July 15, 1996.

(2) WHC-SD-WM-TP-430, Rev. 1, "Sample Preparation of Tank 241-C-106 Samples and Testing and Testing for Compatibility with Tank 241-AY-102 Supernate," B. A. Crawford, dated May 9, 1996.

(3) Book, Statistical Sciences, Inc. *S-PLUS Reference Manual, Version 3.2*, Seattle: StatSci, a division of MathSoft, Inc., 1993.

(4) Book, Snedecor, G. W., and W. G. Cochran, 1980, *Statistical Methods*, 7th Edition, Iowa State University Press, Ames, Iowa.

(5) Harville, D. A., 1977, "Maximum Likelihood Approaches to Variance Component Estimation and to Related Problems," *Journal of the American Statistical Association*, pp. 320-340.

Summary

The Statistics Team was asked to provide mean concentration estimates, relative standard deviations (RSDs), and 95% confidence intervals (CIs) on the mean for the analytical results from single-shell tank 241-C-106 (C-106) samples. In addition, the differential scanning calorimetry (DSC) and total alpha (AT) analytical results were evaluated according to the safety screening data quality objectives. A comparison was performed between the two different measurement techniques for percent water. A comparison between the DSC results based on the atmosphere surrounding the sample was also performed. The data used in the statistical analysis can be provided upon request.

Samples

Grab samples were obtained from tank C-106 in the Spring of 1996. The grab samples were subsamples and analyzed in accordance with reference 2. The data and resolution of safety issues regarding this tank are presented in reference 1.

Statistical Analysis - Mean Tank Concentration

The analytical data, separated into supernate results and sludge results, were evaluated using two different statistical models. The first model (Model 1) was a nested analysis of variance. The second model (Model 2) was a one-way analysis of variance. The technical details associated with Model 1 and Model 2 are given in Attachment 1.

The ANOVA results using Model 1 indicated that the spatial variability due to risers was not significantly different than zero for the majority of the analytes (see Tables 4A, 4B, and 6 of Attachment 1). Therefore, the ANOVA results from Model 2 are more applicable. The results of the statistical analyses (Model 2 only) are listed in Table 1 for the supernate data and Table 2 for the sludge data. The Model 1 statistical results are provided in Tables 1 and 2 of Attachment 1 for information only.

The sludge concentrations were calculated using the equations provided in Attachment 2. For some analytes, the sludge concentrations were calculated using two different methodologies. The first method used the centrifuged analytical results from the "control samples" (CNTR) while the second method used the analytical results from the filtered centrifuged samples.

Tables 1 and 2 (supernate and sludge, respectively) list the estimates of the mean concentration ($\hat{\mu}$), the estimates of the standard deviation associated with the mean ($\hat{\sigma}_{\hat{\mu}}$), the relative standard deviation of the mean [RSD($\hat{\mu}$)], the degrees of freedom (*df*), and the limits to the two sided 95% confidence interval on the mean concentration. The RSD($\hat{\mu}$), as a percent, is the standard deviation associated with the mean divided by the mean times 100. The limits to a two-sided 95% confidence interval for the mean are

$$LL, UL = \hat{\mu} \pm t_{(df,0.975)} \times \hat{\sigma}_{\hat{\mu}}.$$

In this equation, LL is the lower limit, UL is the upper limit, and $t_{(df,0.975)}$ is the quantile from the Student's t distribution with *df* degrees of freedom for a two sided 95 % confidence interval, The details associated with $\hat{\mu}$, $\hat{\sigma}_{\hat{\mu}}$, and *df* are explained in Attachment 1.

Words of caution are needed. If the data are unbalanced (e.g. one sample location from one riser and two sample locations from another riser), then the *df* are estimated using Satterthwaite's approximation. Since the *df* are approximated, the p-values are also approximated. The analytes with a balanced data set are marked with a ϕ in the tables. The use of less-than values in the statistical analysis add a bias (with unknown magnitude) to the estimate of the mean concentration and to the estimate of the standard deviation.

Table 1. Summary Statistics - Supernate Data (Model 2). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %	df	95% LL	95% UL
Aluminum *	μg/mL	3.00E+01	NA	NA	NA	NA	NA
Barium *	μg/mL	3.00E+01	NA	NA	NA	NA	NA
Boron *	μg/mL	3.00E+01	NA	NA	NA	NA	NA
Cadmium *	μg/mL	3.00E+00	NA	NA	NA	NA	NA
Calcium *	μg/mL	6.01E+01	NA	NA	NA	NA	NA
Cerium *	μg/mL	6.01E+01	NA	NA	NA	NA	NA
Chromium *	μg/mL	6.01E+00	NA	NA	NA	NA	NA
Copper *	μg/mL	6.01E+00	NA	NA	NA	NA	NA
Iron *	μg/mL	3.00E+01	NA	NA	NA	NA	NA
Lanthanum *	μg/mL	3.00E+01	NA	NA	NA	NA	NA
Lead *	μg/mL	6.01E+01	NA	NA	NA	NA	NA
Magnesium *	μg/mL	6.01E+01	NA	NA	NA	NA	NA
Manganese *	μg/mL	6.01E+00	NA	NA	NA	NA	NA
Neodymium *	μg/mL	6.01E+01	NA	NA	NA	NA	NA
Nickel	μg/mL	1.61E+01	8.54E-01	5.3	2	1.24E+01	1.97E+01
Phosphorus	μg/mL	2.86E+02	1.85E+01	6.5	2	2.06E+02	3.66E+02
Potassium	μg/mL	6.58E+02	7.78E+01	11.8	2	3.23E+02	9.92E+02
Silicon *	μg/mL	3.00E+01	NA	NA	NA	NA	NA
Silver *	μg/mL	8.01E+00	2.02E+00	25.2	2	0.00E+00	1.67E+01
Sodium	μg/mL	1.05E+05	1.89E+03	1.8	2	9.72E+04	1.13E+05
Strontium *	μg/mL	6.01E+00	NA	NA	NA	NA	NA
Sulfur	μg/mL	2.58E+03	1.54E+02	6.0	2	1.92E+03	3.24E+03
Titanium *	μg/mL	6.01E+00	NA	NA	NA	NA	NA
Uranium	μg/mL	1.68E+03	1.18E+02	7.0	2	1.17E+03	2.19E+03
Zinc *	μg/mL	4.92E+00	5.60E-01	11.4	2	2.51E+00	7.32E+00
Zinc $	μg/mL	4.49E+00	3.12E-01	6.9	1	5.28E-01	8.45E+00
Zirconium	μg/mL	3.81E+02	2.48E+01	6.5	2	2.74E+02	4.88E+02
^{137}Cs ϕ	μCi/mL	1.08E+02	7.50E-01	0.7	1	9.87E+01	1.18E+02
^{241}Am *ϕ	μCi/mL	1.25E-02	2.50E-03	20.0	1	0.00E+00	4.43E-02
$^{239/240}$Pu ϕ	μCi/mL	7.45E-01	3.00E-02	4.0	1	3.64E-01	1.13E+00
$^{89/90}$Sr ϕ	μCi/mL	4.23E-01	5.75E-02	13.6	1	0.00E+00	1.15E+00
^{99}Tc ϕ	μCi/mL	2.05E-01	1.15E-01	56.1	1	0.00E+00	1.67E+00
AT ϕ	μCi/mL	1.03E+00	1.20E-01	11.7	1	0.00E+00	2.55E+00
water (TGA) ϕ	g/mL	9.36E-01	4.38E-03	0.5	1	8.80E-01	9.92E-01
TIC ϕ	μg/mL	2.23E+04	2.18E+03	9.8	1	0.00E+00	4.99E+04

Table 1. Summary Statistics - Supernate Data (Model 2). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %	df	95% LL	95% UL
TOC ϕ	$\mu g/mL$	2.91E+03	3.93E+02	13.5	1	0.00E+00	7.89E+03
Fluoride	$\mu g/mL$	2.44E+02	4.49E+01	18.4	2	5.11E+01	4.38E+02
Chloride	$\mu g/mL$	3.18E+02	2.45E+01	7.7	2	2.12E+02	4.23E+02
Nitrate	$\mu g/mL$	1.32E+03	2.44E+02	18.5	2	2.73E+02	2.37E+03
Nitrite	$\mu g/mL$	2.78E+04	1.88E+03	6.8	2	1.97E+04	3.58E+04
Oxalate	$\mu g/mL$	3.39E+03	2.10E+02	6.2	2	2.49E+03	4.29E+03
Phosphate *	$\mu g/mL$	8.62E+02	1.99E+02	23.1	2	6.50E+00	1.72E+03
Phosphate $	$\mu g/mL$	6.88E+02	1.66E+02	24.2	1	0.00E+00	2.80E+03
Sulfate	$\mu g/mL$	7.36E+03	4.19E+02	5.7	2	5.56E+03	9.16E+03
water ϕ (Gravimetric)	g/mL	9.37E-01	3.45E-03	0.4	1	8.93E-01	9.81E-01
SpG ϕ	---	1.17E+00	1.00E-02	0.9	1	1.04E+00	1.30E+00

Notes:

* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.
NA = Not available
ϕ = Balanced data set.

Table 2. Summary Statistics - Sludge Data (Model 2). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %	df	95% LL	95% UL
Aluminum *	µg/mL	4.82E+04	5.04E+03	10.5	4	3.42E+04	6.22E+04
Barium *	µg/mL	2.92E+02	2.76E+01	9.5	4	2.15E+02	3.68E+02
Boron *	µg/mL	6.63E+01	9.33E+00	14.1	4	4.04E+01	9.22E+01
Cadmium *	µg/mL	3.24E+01	4.22E+00	13.1	4	2.07E+01	4.41E+01
Calcium *	µg/mL	1.31E+03	2.25E+02	17.3	4	6.81E+02	1.93E+03
Cerium *	µg/mL	2.02E+02	1.66E+01	8.2	4	1.56E+02	2.48E+02
Chromium *	µg/mL	6.36E+02	8.05E+01	12.7	4	4.13E+02	8.60E+02
Copper *	µg/mL	1.05E+02	3.91E+00	3.7	4	9.39E+01	1.16E+02
Iron *	µg/mL	6.28E+04	7.24E+03	11.5	4	4.27E+04	8.29E+04
Lanthanum *	µg/mL	7.12E+01	6.24E+00	8.8	4	5.39E+01	8.85E+01
Lead *	µg/mL	2.33E+03	2.43E+02	10.5	4	1.65E+03	3.00E+03
Magnesium *	µg/mL	2.54E+02	9.92E+00	3.9	4	2.27E+02	2.82E+02
Manganese *	µg/mL	2.16E+03	1.48E+02	6.9	4	1.75E+03	2.57E+03
Neodymium *	µg/mL	1.64E+02	1.12E+01	6.9	4	1.32E+02	1.95E+02
Nickel	µg/mL	6.07E+02	5.93E+01	9.8	4	4.43E+02	7.72E+02
Phosphorus	µg/mL	2.37E+03	2.28E+02	9.6	4	1.74E+03	3.01E+03
Potassium	µg/mL	9.32E+02	5.83E+01	6.3	4	7.70E+02	1.09E+03
Silicon *	µg/mL	2.46E+04	2.21E+03	9.0	4	1.85E+04	3.07E+04
Silver *	µg/mL	1.87E+03	2.42E+02	13.0	4	1.20E+03	2.54E+03
Sodium	µg/mL	1.77E+05	1.21E+04	6.8	4	1.44E+05	2.11E+05
Strontium *	µg/mL	4.02E+01	1.07E+00	2.7	4	3.72E+01	4.31E+01
Sulfur	µg/mL	2.42E+03	1.47E+02	6.1	4	2.01E+03	2.83E+03
Titanium *	µg/mL	1.29E+02	1.25E+01	9.7	4	9.39E+01	1.64E+02
Uranium	µg/mL	1.61E+03	9.62E+01	6.0	4	1.34E+03	1.87E+03
Zinc *	µg/mL	6.34E+01	5.68E+00	9.0	4	4.76E+01	7.92E+01
Zirconium	µg/mL	7.25E+02	1.84E+02	25.4	4	2.13E+02	1.24E+03
^{137}Cs	µCi/mL	6.54E+02	4.92E+01	7.5	4	5.18E+02	7.91E+02
^{137}Cs CNTR	µCi/mL	5.60E+02	8.83E+01	15.8	4	3.15E+02	8.06E+02
$^{239/240}$Pu	µCi/mL	1.67E+00	1.34E-01	8.0	4	1.30E+00	2.04E+00
$^{239/240}$Pu CNTR *	µCi/mL	1.25E+00	3.08E-01	24.6	4	3.98E-01	2.11E+00
$^{239/240}$Pu CNTR $	µCi/mL	1.52E+00	2.06E-01	13.6	3	8.62E-01	2.18E+00
$^{89/90}$Sr	µCi/mL	5.46E+02	4.47E+01	8.2	4	4.22E+02	6.70E+02
$^{89/90}$Sr CNTR	µCi/mL	4.82E+02	9.28E+01	19.3	4	2.24E+02	7.39E+02
water (TGA)	g/mL	5.63E-01	6.89E-02	12.3	4	3.72E-01	7.54E-01
water (TGA) CNTR	g/mL	5.65E-01	7.96E-02	14.1	4	3.44E-01	7.86E-01

Table 2. Summary Statistics - Sludge Data (Model 2). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %	df	95% LL	95% UL
TIC	μg/mL	3.60E+04	2.53E+03	7.0	4	2.90E+04	4.30E+04
TOC	μg/mL	2.00E+04	3.77E+03	18.9	4	9.50E+03	3.05E+04
Fluoride	μg/mL	3.24E+02	3.11E+01	9.6	4	2.38E+02	4.11E+02
Chloride	μg/mL	3.84E+02	8.13E+01	21.2	4	1.58E+02	6.09E+02
Nitrate	μg/mL	2.36E+03	3.44E+02	14.6	4	1.41E+03	3.32E+03
Nitrite	μg/mL	2.46E+04	1.10E+03	4.5	4	2.15E+04	2.76E+04
Oxalate	μg/mL	8.02E+04	1.42E+04	17.7	4	4.08E+04	1.20E+05
Phosphate *	μg/mL	1.53E+03	3.44E+02	22.4	4	5.79E+02	2.49E+03
Phosphate $	μg/mL	1.63E+03	3.32E+02	20.3	4	7.14E+02	2.56E+03
Sulfate	μg/mL	6.96E+03	3.40E+02	4.9	4	6.01E+03	7.90E+03
water (Gravimetric)	g/mL	7.20E-01	3.28E-02	4.6	4	6.29E-01	8.11E-01

Notes:

* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.
CNTR = Sludge results calculated using control sample results.

Tank Inventory Estimates

The tank inventory estimate for each analyte was calculated using the following equation.

$$\text{Tk Inv} = \hat{\mu}_{supernate} \times \text{Volume}_{supernate} + \hat{\mu}_{sludge} \times \text{Volume}_{sludge}$$

where $\hat{\mu}_{supernate}$ is the mean supernate concentration in μg/mL (see Table 1),

$\text{Volume}_{supernate}$ = 32,000 gallons (121,132,800 mL = 32,000 gal x 3.7854 L/gal x 1000 mL/L),

$\hat{\mu}_{sludge}$ (calculated using the equations in Attachment 2) is the mean sludge concentration in μg/mL (see Table 2), and

Volume_{sludge} = 197,000 gallons (745,723,800 mL = 197,000 gal x 3.7854 L/gal x 1000 mL/L).

The tank inventory estimates are provided in Table 3, where $\hat{\mu}_{supernate}$ and $\hat{\mu}_{sludge}$ were determined using Model 2. The tank inventory estimates, where $\hat{\mu}_{supernate}$ and $\hat{\mu}_{sludge}$, where $\hat{\mu}_{supernate}$ and $\hat{\mu}_{sludge}$ were determined using Model 1, are provided for information only in Table 3, Attachment 1.

Table 3. Tank Inventory based on Model 2 mean concentrations. (2 sheets)

Analyte	Concentration (per mL)	Gallons	Concentration (per mL)	Gallons	Supernate	Sludge	Tank
	Supernate	Supernate	Sludge	Sludge	Total	Total	Total
Aluminum *	3.00E+01	32000	4.82E+04	197000	3.63E+03 g	3.59E+07 g	3.60E+07 g
Barium *	3.00E+01	32000	2.92E+02	197000	3.63E+03 g	2.17E+05 g	2.21E+05 g
Boron *	3.00E+01	32000	6.63E+01	197000	3.63E+03 g	4.94E+04 g	5.30E+04 g
Cadmium *	3.00E+00	32000	3.24E+01	197000	3.63E+02 g	2.42E+04 g	2.45E+04 g
Calcium *	6.01E+01	32000	1.31E+03	197000	7.28E+03 g	9.74E+05 g	9.81E+05 g
Cerium *	6.01E+01	32000	2.02E+02	197000	7.28E+03 g	1.51E+05 g	1.58E+05 g
Chromium *	6.01E+00	32000	6.36E+02	197000	7.28E+02 g	4.74E+05 g	4.75E+05 g
Copper *	6.01E+00	32000	1.05E+02	197000	7.28E+02 g	7.81E+04 g	7.88E+04 g
Iron *	3.00E+01	32000	6.28E+04	197000	3.63E+03 g	4.68E+07 g	4.68E+07 g
Lanthanum *	3.00E+01	32000	7.12E+01	197000	3.63E+03 g	5.31E+04 g	5.67E+04 g
Lead *	6.01E+01	32000	2.33E+03	197000	7.28E+03 g	1.73E+06 g	1.74E+06 g
Magnesium *	6.01E+01	32000	2.54E+02	197000	7.28E+03 g	1.90E+05 g	1.97E+05 g
Manganese *	6.01E+00	32000	2.16E+03	197000	7.28E+02 g	1.61E+06 g	1.61E+06 g
Neodymium *	6.01E+01	32000	1.64E+02	197000	7.28E+03 g	1.22E+05 g	1.29E+05 g
Nickel	1.61E+01	32000	6.07E+02	197000	1.94E+03 g	4.53E+05 g	4.55E+05 g
Phosphorus	2.86E+02	32000	2.37E+03	197000	3.46E+04 g	1.77E+06 g	1.80E+06 g
Potassium	6.58E+02	32000	9.32E+02	197000	7.96E+04 g	6.95E+05 g	7.74E+05 g
Silicon *	3.00E+01	32000	2.46E+04	197000	3.63E+03 g	1.84E+07 g	1.84E+07 g
Silver *	8.01E+00	32000	1.87E+03	197000	9.70E+02 g	1.39E+06 g	1.39E+06 g
Sodium	1.05E+05	32000	1.77E+05	197000	1.28E+07 g	1.32E+08 g	1.45E+08 g
Strontium *	6.01E+00	32000	4.02E+01	197000	7.28E+02 g	3.00E+04 g	3.07E+04 g
Sulfur	2.58E+03	32000	2.42E+03	197000	3.13E+05 g	1.80E+06 g	2.12E+06 g
Titanium *	6.01E+00	32000	1.29E+02	197000	7.28E+02 g	9.60E+04 g	9.67E+04 g
Uranium	1.68E+03	32000	1.61E+03	197000	2.04E+05 g	1.20E+06 g	1.40E+06 g
Zinc *	4.92E+00	32000	6.34E+01	197000	5.95E+02 g	4.73E+04 g	4.79E+04 g
Zinc $	4.49E+00	32000	6.34E+01	197000	5.43E+02 g	4.73E+04 g	4.78E+04 g
Zirconium	3.81E+02	32000	7.25E+02	197000	4.61E+04 g	5.40E+05 g	5.87E+05 g
^{137}Cs	1.08E+02	32000	6.54E+02	197000	1.31E+04 Ci	4.88E+05 Ci	5.01E+05 Ci
^{137}Cs CNTR	1.08E+02	32000	5.60E+02	197000	1.31E+04 Ci	4.18E+05 Ci	4.31E+05 Ci
^{241}Am *	1.25E-02	32000	NA	197000	1.51E+00 Ci	NA	NA
$^{239/240}$Pu	7.45E-01	32000	1.67E+00	197000	9.02E+01 Ci	1.24E+03 Ci	1.33E+03 Ci
$^{239/240}$Pu CNTR *	7.45E-01	32000	1.25E+00	197000	9.02E+01 Ci	9.36E+02 Ci	1.03E+03 Ci
$^{239/240}$Pu CNTR $	7.45E-01	32000	1.52E+00	197000	9.02E+01 Ci	1.13E+03 Ci	1.22E+03 Ci

Table 3. Tank Inventory based on Model 2 mean concentrations. (2 sheets)

Tank Inventory							
Analyte	Concentration (per mL)	Gallons	Concentration (per mL)	Gallons	Supernate	Sludge	Tank
	Supernate	Supernate	Sludge	Sludge	Total	Total	Total
$^{89/90}Sr$	4.23E-01	32000	5.46E+02	197000	5.12E+01 Ci	4.07E+05 Ci	4.07E+05 Ci
$^{89/90}Sr$ CNTR	4.23E-01	32000	4.82E+02	197000	5.12E+01 Ci	3.59E+05 Ci	3.59E+05 Ci
^{99}Tc *	2.05E-01	32000	NA	197000	2.48E+01 Ci	NA	NA
AT	1.03E+00	32000	NA	197000	1.24E+02 Ci	NA	NA
water (TGA)	9.36E-01	32000	5.63E-01	197000	1.13E+08 g	4.20E+08 g	5.33E+08 g
water (TGA) CNTR	9.36E-01	32000	5.65E-01	197000	1.13E+08 g	4.21E+08 g	5.35E+08 g
TIC	2.23E+04	32000	3.60E+04	197000	2.70E+06 g	2.68E+07 g	2.95E+07 g
TOC	2.91E+03	32000	2.00E+04	197000	3.52E+05 g	1.49E+07 g	1.52E+07 g
Fluoride	2.44E+02	32000	3.24E+02	197000	2.96E+04 g	2.42E+05 g	2.71E+05 g
Chloride	3.18E+02	32000	3.84E+02	197000	3.85E+04 g	2.86E+05 g	3.25E+05 g
Nitrate	1.32E+03	32000	2.36E+03	197000	1.60E+05 g	1.76E+06 g	1.92E+06 g
Nitrite	2.78E+04	32000	2.46E+04	197000	3.36E+06 g	1.83E+07 g	2.17E+07 g
Oxalate	3.39E+03	32000	8.02E+04	197000	4.11E+05 g	5.98E+07 g	6.02E+07 g
Phosphate *	8.62E+02	32000	1.53E+03	197000	1.04E+05 g	1.14E+06 g	1.25E+06 g
Phosphate $	6.88E+02	32000	1.63E+03	197000	8.33E+04 g	1.22E+06 g	1.30E+06 g
Sulfate	7.36E+03	32000	6.96E+03	197000	8.92E+05 g	5.19E+06 g	6.08E+06 g
water (Gravimetric)	9.37E-01	32000	7.20E-01	197000	1.14E+08 g	5.37E+08 g	6.51E+08 g

Notes:

*	=	Less than values were used in the data analysis.
NA	=	Not available.
$	=	Less than values were deleted in the data analysis.
CNTR	=	Sludge results calculated using control sample results.

The statistical results listed in Tables 1 and 2 were obtained using two different statistical models which account for the spatial (riser and/or location) variability and the measurement variability. The two models, Model 1 and Model 2, are explained in Attachment 1. Variance components were determined from ANOVA techniques. These variance components (spatial and analytical) from which the standard deviation associated with the mean concentration were calculated are provided in Tables 4A, 4B, 5A, 5B, 6, and 7 of Attachment 1.

A statistical test (F-Test) was performed to determine if each of the variance components were significantly different from zero. The p-values are the attained level of significance of the statistical test. A p-value less than 0.05 indicates that the variance component is significantly different from zero at the 0.05 level of significance. A word of caution is needed. If the data are unbalanced, then the *df* are estimated using Satterthwaite's approximation. Since the *df* are approximated, the p-value is also approximated. The balanced data are marked with a ϕ in the tables.

Supernate Concentrations

During the sampling event which occurred in the Spring of 1996, three of the grab samples were supernate only. One of the grab samples was obtained from riser one, and the other two were obtained from riser seven. The three supernate grab samples were not analyzed for all analytes. Therefore, for most of the analytes, the data are unbalanced.

For the data analyzed using Model 1, the p-values from the F-test on riser-to-riser variability [σ^2(R)] were less than 0.05 for zero of 16 tests. The p-values from the F-test on the location within riser variability [σ^2(L)] were less than 0.05 for nine of the 16 tests. For the remaining 13 tests, the riser and location variabilities are confounded (one location from each of the risers); if the variability is significantly different than zero, it could be due to either the location or the riser. Five of these 13 tests had p-values less than 0.05. The variance component estimates and p-values from the F-Tests for the supernate data (Model 1) are given in Tables 4A and 4B, Attachment 1.

For the data analyzed using Model 2, the p-values from the F-test on location-to-location variability [σ^2(L)] were less than 0.05 for 16 of the 30 tests. This F-test compares the location-to-location variability against the analytical variability. The variance component estimates and p-values from the F-Tests are given in Tables 5A and 5B, Attachment 1.

Sludge Calculations

During the sampling event which occurred in the Spring of 1996, five of the grab samples consisted of sludge. Three of the grab samples were obtained from riser one, and the other two were obtained from riser seven. The five grab samples were separated into interstitial liquid samples, decanted liquid samples, filtered centrifuged solids samples, and control centrifuged samples. Each of these separated fractions were not analyzed for all analytes. However, interstitial liquid and decanted liquid analytical results were assumed to be from the same population. All of the analytes have unbalanced data.

The statistical analyses were performed on the "sludge" data. The sludge concentrations (see Table 2) were calculated using

- decanted supernate/interstitial analytical results, control sample results, specific gravity results, bulk density from the control samples, and the volume fraction of centrifuged solids or

- decanted supernate/interstitial analytical results, filtered centrifuged sample results, specific gravity results, mass fraction of filtered centrifuged solids, bulk density from the control samples, and the volume fraction of the centrifuged solids.

The equations, representing these two methodologies, are provided in Attachment 2.

For the data analyzed using Model 1, the p-values from the F-test on riser-to-riser variability [$\sigma^2(R)$] were less than 0.05 for four out of 41 tests. The p-values from the F-test on the location within riser variability [$\sigma^2(L)$] were less than 0.05 for 23 of the 41 tests. The variance component estimates and p-values from the F-Tests are given in Table 6, Attachment 1.

For the data analyzed using Model 2, the p-values from the F-test on location-to-location variability [$\sigma^2(L)$] were less than 0.05 for 31 of the 41 tests. This F-test compares the location-to-location variability against the analytical variability. The variance component estimates and p-values from the F-Tests are given in Table 7, Attachment 1.

Less than values were present in the data for the majority of the analytes. The analytes where less than values were used in the statistical analyses are marked with a * in the tables. If less than values were deleted in the statistical analysis, the analytes are marked with a $ in the tables.

Safety Screening DQO

Safety screening data were obtained from the analysis of the C-106 grab samples. The safety screening data consists of total alpha and differential scanning calorimeter (DSC) analytical results. From the duplicate analytical results for each sample, a one-sided 95% confidence interval for the mean was calculated and compared to the safety screening data quality objective (DQO) limit.

For total alpha, there were no upper limits for the 95% confidence interval above 41 μCi/g (the safety screen DQO limit). For DSC there were five samples where the upper limits for the 95% confidence interval (centrifuged solids grab samples 6C-96-4 and 6C-96-13, interstitial liquid grab sample 6C-96-13, and sludge grab samples 6C-96-8 and 6C-96-14) were above 480 Joules/g (the safety screen DQO limit). The summary statistics along with the confidence intervals for the safety screening data are presented in Tables 1 and 2, Attachment 3.

Percent Water Comparison

Thermographic analysis (TGA) uses two different methods for controlling the atmosphere when measuring percent water. The first method purges the sample with nitrogen and minimizes the oxygen available to the sample. The second method purges the sample with air. The TGA comparison was performed to determine whether the two different atmospheres surrounding the sample give equivalent results. A randomized complete block design was used to analyze the data (see Reference 4 for details).

The C-106 grab samples were subsampled into several different types. Percent water analyses were completed for three of the subsample types; filtered centrifuged solids, centrifuged solids, and supernate. The statistical analysis was performed for each type separately. The statistical analyses indicated that the two atmospheres give significantly different answers for the filtered centrifuged solids but not for supernate and centrifuged solids. The statistical analysis output is provided in Attachment 4.

Thermographic Analysis Comparison

Thermographic analysis (TGA) uses two different methods for controlling the atmosphere when measuring percent water. The first method purges the sample with nitrogen and minimizes the oxygen available to the sample. The second method purges the sample with air. The TGA comparison was performed to determine whether the two atmospheres surrounding the sample give equivalent results. A randomized complete block design was used to analyze the data (see Reference 4 for details).

The two different TGA methods were used for analyzing centrifuged solids subsamples only. The statistical analysis indicated that the two methods do not give significantly different answers for the centrifuged solids. The statistical analysis output is provided in Attachment 4.

If there are questions, call Terri Welsh at 373-2475 or Ryan Cromar at 373-4034.

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rdc
Attachments 4

75764-PCS96-090
ATTACHMENT 1
(17 sheets)

Statistical Analysis

The first statistical model used to describe the structure of the data is

$$Y_{ijkl} = \mu + R_i + L_{ij} + A_{ijk}, \quad \text{(Model 1)}$$

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

where

y_{ijk}	=	concentration from the k^{th} analytical result of the j^{th} location sample from the i^{th} riser
μ	=	the grand mean
R_i	=	the effect of the i^{th} riser
L_{ij}	=	the effect of the j^{th} location from the i^{th} riser
A_{ijk}	=	the effect of the k^{th} analytical result from the j^{th} location from the i^{th} riser
a	=	the number of risers sampled
b_i	=	the number of locations taken from the i^{th} riser
n_{ij}	=	the number of analytical results in the j^{th} core from the i^{th} riser.

The variables R_i and L_{ij} are assumed to be random effects. These variables, as well as A_{ijk}, are assumed to be uncorrelated and normally distributed with means zero and variances $\sigma^2(R)$, $\sigma^2(L)$, and $\sigma^2(A)$, respectively. Estimates of $\sigma^2(R)$, $\sigma^2(L)$, and $\sigma^2(A)$ were obtained using Restricted Maximum Likelihood Estimation (REML) techniques. This method applied to variance component estimation is described in Reference 5. The results using the REML techniques were obtained using the statistical analysis package S-PLUS (see Reference 3).

The second statistical model used to describe the structure of the data is

$$Y_{ij} = \mu + L_i + A_{ij}, \quad \text{(Model 2)}$$

$i=1,\ldots a$, $j=1,\ldots n_i$,

where

Y_{ij}	=	concentration from the j^{th} analytical result from the i^{th} location
μ	=	the grand mean
L_i	=	the effect of the i^{th} location
A_{ij}	=	the effect of the j^{th} analytical result from the i^{th} location
a	=	the number of locations sampled
n_i	=	the number of analytical results from the i^{th} location

The variable L_i is assumed to be random effects. This variable, as well as A_{ij}, are assumed to be uncorrelated and normally distributed with means zero and variances $\sigma^2(L)$ and $\sigma^2(A)$, respectively. Estimates of $\sigma^2(L)$ and $\sigma^2(A)$ were obtained using Restricted Maximum Likelihood Estimation (REML) techniques. This method applied to variance component estimation is described in Reference 5. The results using the REML techniques were obtained using the statistical analysis package S-PLUS (see Reference 3).

The following paragraphs describe how the mean ($\hat{\mu}$), standard deviation of the mean ($\hat{\sigma}_{\hat{\mu}}$), and the degrees of freedom (*df*) were determined using the results from the statistical models fit to the data.

Mean

The estimator of $\hat{\mu}$ is the maximum likelihood estimate of the mean. This estimator was determined by the structure of the data reflected by the statistical model. The estimate of $\hat{\mu}$ was obtained using Restricted Maximum Likelihood Estimation (REML) techniques in S-PLUS.

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Standard Deviation of the Mean

The estimated standard deviation of the mean, $\hat{\sigma}_{\hat{\mu}}$, is the square root of a linear combination of the variance estimates:

Model 1: $\sigma^2(R)$, $\sigma^2(L)$, and $\sigma^2(A)$

Model 2: $\sigma^2(L)$ and $\sigma^2(A)$.

These estimates were obtained using the Restricted Maximum Likelihood Estimation (REML) techniques. For unbalanced data, $\hat{\sigma}_{\hat{\mu}}$ is a more complicated linear combination of these variances.

$\hat{\sigma}_{\hat{\mu}}$ is the standard deviation of the mean associated with the maximum likelihood estimate of the mean.

Degrees of Freedom

The degrees of freedom (*df*) are dependent on the data structure or the statistical model used. The *df* associated with C-106 data are either the number of risers minus one (Model 1) or the number of locations minus one (Model 2).

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Table 1. Supernate Data - Model 1. (2 sheets)

Analyte	units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %	df	95% LL	95% UL
Aluminum *	μg/mL	3.00E+01	NA	NA	NA	NA	NA
Barium *	μg/mL	3.00E+01	NA	NA	NA	NA	NA
Boron *	μg/mL	3.00E+01	NA	NA	NA	NA	NA
Cadmium *	μg/mL	3.00E+00	NA	NA	NA	NA	NA
Calcium *	μg/mL	6.01E+01	NA	NA	NA	NA	NA
Cerium *	μg/mL	6.01E+01	NA	NA	NA	NA	NA
Chromium *	μg/mL	6.01E+00	NA	NA	NA	NA	NA
Copper *	μg/mL	6.01E+00	NA	NA	NA	NA	NA
Iron *	μg/mL	3.00E+01	NA	NA	NA	NA	NA
Lanthanum *	μg/mL	3.00E+01	NA	NA	NA	NA	NA
Lead *	μg/mL	6.01E+01	NA	NA	NA	NA	NA
Magnesium *	μg/mL	6.01E+01	NA	NA	NA	NA	NA
Manganese *	μg/mL	6.01E+00	NA	NA	NA	NA	NA
Neodymium *	μg/mL	6.01E+01	NA	NA	NA	NA	NA
Nickel	μg/mL	1.61E+01	8.54E-01	5.3	1	5.19E+00	2.69E+01
Phosphorus	μg/mL	2.86E+02	1.85E+01	6.5	1	5.03E+01	5.21E+02
Potassium	μg/mL	6.58E+02	7.78E+01	11.8	1	0.00E+00	1.65E+03
Silicon *	μg/mL	3.00E+01	NA	NA	NA	NA	NA
Silver *	μg/mL	8.01E+00	2.02E+00	25.2	1	0.00E+00	3.36E+01
Sodium	μg/mL	1.05E+05	2.51E+03	2.4	1	7.30E+04	1.37E+05
Strontium *	μg/mL	6.01E+00	NA	NA	NA	NA	NA
Sulfur	μg/mL	2.65E+03	2.29E+02	8.6	1	0.00E+00	5.56E+03
Titanium *	μg/mL	6.01E+00	NA	NA	NA	NA	NA
Uranium	μg/mL	1.68E+03	1.18E+02	7.0	1	1.78E+02	3.18E+03
Zinc *	μg/mL	4.92E+00	5.60E-01	11.4	1	0.00E+00	1.20E+01
Zinc $	μg/mL	4.49E+00	3.12E-01	6.9	1	5.28E-01	8.45E+00
Zirconium	μg/mL	3.89E+02	3.27E+01	8.4	1	0.00E+00	8.04E+02

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Table 1. Supernate Data - Model 1. (2 sheets)

Analyte	units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %	df	95% LL	95% UL
^{137}Cs ϕ	μCi/mL	1.08E+02	7.50E-01	0.7	1	9.87E+01	1.18E+02
^{241}Am * ϕ	μCi/mL	1.25E-02	2.50E-03	20.0	1	0.00E+00	4.43E-02
$^{239/240}Pu$ ϕ	μCi/mL	7.45E-01	3.00E-02	4.0	1	3.64E-01	1.13E+00
$^{89/90}Sr$ ϕ	μCi/mL	4.23E-01	5.75E-02	13.6	1	0.00E+00	1.15E+00
^{99}Tc ϕ	μCi/mL	2.05E-01	1.15E-01	56.1	1	0.00E+00	1.67E+00
AT ϕ	μCi/mL	1.03E+00	1.20E-01	11.7	1	0.00E+00	2.55E+00
water (TGA) ϕ	g/mL	9.36E-01	4.38E-03	0.5	1	8.80E-01	9.92E-01
TIC ϕ	μg/mL	2.23E+04	2.18E+03	9.8	1	0.00E+00	4.99E+04
TOC ϕ	μg/mL	2.91E+03	3.93E+02	13.5	1	0.00E+00	7.89E+03
Fluoride	μg/mL	2.65E+02	6.57E+01	24.8	1	0.00E+00	1.10E+03
Chloride	μg/mL	3.18E+02	2.45E+01	7.7	1	6.49E+00	6.29E+02
Nitrate	μg/mL	1.44E+03	3.65E+02	25.3	1	0.00E+00	6.08E+03
Nitrite	μg/mL	2.78E+04	1.88E+03	6.8	1	3.91E+03	5.16E+04
Oxalate	μg/mL	3.39E+03	2.10E+02	6.2	1	7.20E+02	6.06E+03
Phosphate *	μg/mL	9.22E+02	2.60E+02	28.2	1	0.00E+00	4.22E+03
Phosphate $	μg/mL	6.88E+02	1.66E+02	24.2	1	0.00E+00	2.80E+03
Sulfate	μg/mL	7.36E+03	4.19E+02	5.7	1	2.04E+03	1.27E+04
water (Gravimetric) ϕ	g/mL	9.37E-01	3.45E-03	0.4	1	8.93E-01	9.81E-01
SpG ϕ	---	1.17E+00	1.00E-02	0.9	1	1.04E+00	1.30E+00

Notes:

* = Less than values were used in the data analysis.
NA = Not available
$ = Less than values were deleted in the data analysis.
ϕ = Balanced data set.

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Table 2. Summary Statistics - Sludge Data (Model 1). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %	df	95% LL	95% UL
Aluminum *	μg/mL	4.69E+04	8.23E+03	17.6	1	0.00E+00	1.51E+05
Barium *	μg/mL	2.84E+02	4.67E+01	16.5	1	0.00E+00	8.77E+02
Boron *	μg/mL	6.53E+01	1.14E+01	17.5	1	0.00E+00	2.11E+02
Cadmium *	μg/mL	3.15E+01	6.41E+00	20.4	1	0.00E+00	1.13E+02
Calcium *	μg/mL	1.31E+03	2.25E+02	17.3	1	0.00E+00	4.17E+03
Cerium *	μg/mL	1.97E+02	2.92E+01	14.8	1	0.00E+00	5.67E+02
Chromium *	μg/mL	6.16E+02	1.28E+02	20.8	1	0.00E+00	2.24E+03
Copper *	μg/mL	1.05E+02	3.91E+00	3.7	1	5.50E+01	1.54E+02
Iron *	μg/mL	6.03E+04	1.32E+04	21.9	1	0.00E+00	2.28E+05
Lanthanum *	μg/mL	6.91E+01	1.13E+01	16.4	1	0.00E+00	2.13E+02
Lead *	μg/mL	2.26E+03	4.13E+02	18.3	1	0.00E+00	7.50E+03
Magnesium *	μg/mL	2.51E+02	1.75E+01	7.0	1	2.95E+01	4.73E+02
Manganese *	μg/mL	2.20E+03	2.48E+02	11.3	1	0.00E+00	5.35E+03
Neodymium *	μg/mL	1.60E+02	1.95E+01	12.2	1	0.00E+00	4.08E+02
Nickel	μg/mL	5.88E+02	1.06E+02	18.0	1	0.00E+00	1.94E+03
Phosphorus	μg/mL	2.31E+03	3.89E+02	16.9	1	0.00E+00	7.25E+03
Potassium	μg/mL	9.32E+02	5.83E+01	6.3	1	1.91E+02	1.67E+03
Silicon *	μg/mL	2.40E+04	3.54E+03	14.7	1	0.00E+00	6.90E+04
Silver *	μg/mL	1.87E+03	2.42E+02	13.0	1	0.00E+00	4.94E+03
Sodium	μg/mL	1.74E+05	1.82E+04	10.4	1	0.00E+00	4.05E+05
Strontium *	μg/mL	4.02E+01	1.07E+00	2.7	1	2.66E+01	5.38E+01
Sulfur	μg/mL	2.42E+03	1.47E+02	6.1	1	5.46E+02	4.29E+03
Titanium *	μg/mL	1.25E+02	2.25E+01	18.1	1	0.00E+00	4.11E+02
Uranium	μg/mL	1.61E+03	9.62E+01	6.0	1	3.83E+02	2.83E+03
Zinc *	μg/mL	6.48E+01	8.95E+00	13.8	1	0.00E+00	1.79E+02
Zirconium	μg/mL	7.25E+02	1.84E+02	25.4	1	0.00E+00	3.06E+03
^{137}Cs	μCi/mL	6.54E+02	4.97E+01	7.6	1	2.21E+01	1.29E+03

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Table 2. Summary Statistics - Sludge Data (Model 1). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %	df	95% LL	95% UL
^{137}Cs CNTR	μCi/mL	5.60E+02	8.83E+01	15.8	1	0.00E+00	1.68E+03
$^{239/240}$Pu	μCi/mL	1.64E+00	2.14E-01	13.1	1	0.00E+00	4.35E+00
$^{239/240}$Pu CNTR *	μCi/mL	1.26E+00	3.08E-01	24.6	1	0.00E+00	5.17E+00
$^{239/240}$Pu CNTR $	μCi/mL	1.52E+00	3.16E-01	20.8	1	0.00E+00	5.54E+00
$^{89/90}$Sr	μCi/mL	5.30E+02	8.43E+01	15.9	1	0.00E+00	1.60E+03
$^{89/90}$Sr CNTR	μCi/mL	4.82E+02	9.28E+01	19.3	1	0.00E+00	1.66E+03
water (TGA)	g/mL	5.63E-01	6.89E-02	12.3	1	0.00E+00	1.44E+00
water (TGA) CNTR	g/mL	5.65E-01	7.96E-02	14.1	1	0.00E+00	1.58E+00
TIC	μg/mL	3.54E+04	3.88E+03	11.0	1	0.00E+00	8.48E+04
TOC	μg/mL	1.95E+04	4.85E+03	24.9	1	0.00E+00	8.11E+04
Fluoride	μg/mL	3.24E+02	3.11E+01	9.6	1	0.00E+00	7.19E+02
Chloride	μg/mL	3.84E+02	8.13E+01	21.2	1	0.00E+00	1.42E+03
Nitrate	μg/mL	2.36E+03	3.44E+02	14.6	1	0.00E+00	6.73E+03
Nitrite	μg/mL	2.46E+04	1.10E+03	4.5	1	1.06E+04	3.85E+04
Oxalate	μg/mL	8.02E+04	1.42E+04	17.7	1	0.00E+00	2.60E+05
Phosphate *	μg/mL	1.46E+03	5.24E+02	35.9	1	0.00E+00	8.11E+03
Phosphate $	μg/mL	1.55E+03	4.65E+02	29.9	1	0.00E+00	7.47E+03
Sulfate	μg/mL	6.92E+03	4.28E+02	6.2	1	1.48E+03	1.24E+04
water (Gravimetric)	g/mL	7.26E-01	4.49E-02	6.2	1	1.55E-01	1.30E+00

Notes:

* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.
CNTR = Sludge results calculated using control sample results.

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Table 3. Tank Inventory based on Model 1 mean concentrations. (2 sheets)

Tank Inventory							
Analyte	Concentration (µg/mL or µCi/mL)	Gallons	Concentration (µg/mL or µCi/mL)	Gallons	Supernate	Sludge	Tank
	Supernate	Supernate	Sludge	Sludge	Total	Total	Total
Aluminum *	3.00E+01	32000	4.69E+04	197000	3.63E+03 g	3.49E+07 g	3.50E+07 g
Barium *	3.00E+01	32000	2.84E+02	197000	3.63E+03 g	2.12E+05 g	2.15E+05 g
Boron *	3.00E+01	32000	6.53E+01	197000	3.63E+03 g	4.87E+04 g	5.23E+04 g
Cadmium *	3.00E+00	32000	3.15E+01	197000	3.63E+02 g	2.35E+04 g	2.38E+04 g
Calcium *	6.01E+01	32000	1.31E+03	197000	7.28E+03 g	9.74E+05 g	9.81E+05 g
Cerium *	6.01E+01	32000	1.97E+02	197000	7.28E+03 g	1.47E+05 g	1.54E+05 g
Chromium *	6.01E+00	32000	6.16E+02	197000	7.28E+02 g	4.59E+05 g	4.60E+05 g
Copper *	6.01E+00	32000	1.05E+02	197000	7.28E+02 g	7.81E+04 g	7.88E+04 g
Iron *	3.00E+01	32000	6.03E+04	197000	3.63E+03 g	4.50E+07 g	4.50E+07 g
Lanthanum *	3.00E+01	32000	6.91E+01	197000	3.63E+03 g	5.15E+04 g	5.52E+04 g
Lead *	6.01E+01	32000	2.26E+03	197000	7.28E+03 g	1.68E+06 g	1.69E+06 g
Magnesium *	6.01E+01	32000	2.51E+02	197000	7.28E+03 g	1.87E+05 g	1.95E+05 g
Manganese *	6.01E+00	32000	2.20E+03	197000	7.28E+02 g	1.64E+06 g	1.64E+06 g
Neodymium *	6.01E+01	32000	1.60E+02	197000	7.28E+03 g	1.19E+05 g	1.27E+05 g
Nickel	1.61E+01	32000	5.88E+02	197000	1.94E+03 g	4.39E+05 g	4.41E+05 g
Phosphorus	2.86E+02	32000	2.31E+03	197000	3.46E+04 g	1.72E+06 g	1.75E+06 g
Potassium	6.58E+02	32000	9.32E+02	197000	7.96E+04 g	6.95E+05 g	7.74E+05 g
Silicon *	3.00E+01	32000	2.40E+04	197000	3.63E+03 g	1.79E+07 g	1.79E+07 g
Silver *	8.01E+00	32000	1.87E+03	197000	9.70E+02 g	1.39E+06 g	1.39E+06 g
Sodium	1.05E+05	32000	1.74E+05	197000	1.27E+07 g	1.30E+08 g	1.43E+08 g
Strontium *	6.01E+00	32000	4.02E+01	197000	7.28E+02 g	3.00E+04 g	3.07E+04 g
Sulfur	2.65E+03	32000	2.42E+03	197000	3.21E+05 g	1.80E+06 g	2.12E+06 g
Titanium *	6.01E+00	32000	1.25E+02	197000	7.28E+02 g	9.30E+04 g	9.37E+04 g
Uranium	1.68E+03	32000	1.61E+03	197000	2.04E+05 g	1.20E+06 g	1.40E+06 g
Zinc *	4.92E+00	32000	6.48E+01	197000	5.95E+02 g	4.83E+04 g	4.89E+04 g
Zinc $	4.49E+00	32000	6.48E+01	197000	5.43E+02 g	4.83E+04 g	4.89E+04 g
Zirconium	3.89E+02	32000	7.25E+02	197000	4.71E+04 g	5.40E+05 g	5.88E+05 g

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Table 3. Tank Inventory based on Model 1 mean concentrations. (2 sheets)

Tank Inventory							
Analyte	Concentration (µg/mL or µCi/mL)	Gallons	Concentration (µg/mL or µCi/mL)	Gallons	Supernate	Sludge	Tank
^{137}Cs	1.08E+02	32000	6.54E+02	197000	1.31E+04 Ci	4.88E+05 Ci	5.01E+05 Ci
^{137}Cs CNTR	1.08E+02	32000	5.60E+02	197000	1.31E+04 Ci	4.18E+05 Ci	4.31E+05 Ci
^{241}Am *	1.25E-02	32000	NA	197000	1.51E+00 Ci	NA	NA
$^{239/240}$Pu	7.45E-01	32000	1.64E+00	197000	9.02E+01 Ci	1.22E+03 Ci	1.31E+03 Ci
$^{239/240}$Pu CNTR *	7.45E-01	32000	1.26E+00	197000	9.02E+01 Ci	9.36E+02 Ci	1.03E+03 Ci
$^{239/240}$Pu CNTR $	7.45E-01	32000	1.52E+00	197000	9.02E+01 Ci	1.13E+03 Ci	1.22E+03 Ci
$^{89/90}$Sr	4.23E-01	32000	5.30E+02	197000	5.12E+01 Ci	3.95E+05 Ci	3.95E+05 Ci
$^{89/90}$Sr CNTR	4.23E-01	32000	4.82E+02	197000	5.12E+01 Ci	3.59E+05 Ci	3.59E+05 Ci
^{99}Tc *	2.05E-01	32000	NA	197000	2.48E+01 Ci	NA	NA
AT	1.03E+00	32000	NA	197000	1.24E+02 Ci	NA	NA
water (TGA) (g/mL)	9.36E-01	32000	5.63E-01	197000	1.13E+08 g	4.20E+08 g	5.33E+08 g
water (TGA) CNTR (g/mL)	9.36E-01	32000	5.65E-01	197000	1.13E+08 g	4.21E+08 g	5.35E+08 g
TIC	2.23E+04	32000	3.54E+04	197000	2.70E+06 g	2.64E+07 g	2.91E+07 g
TOC	2.91E+03	32000	1.95E+04	197000	3.52E+05 g	1.45E+07 g	1.49E+07 g
Fluoride	2.65E+02	32000	3.24E+02	197000	3.21E+04 g	2.42E+05 g	2.74E+05 g
Chloride	3.18E+02	32000	3.84E+02	197000	3.85E+04 g	2.86E+05 g	3.25E+05 g
Nitrate	1.44E+03	32000	2.36E+03	197000	1.74E+05 g	1.76E+06 g	1.94E+06 g
Nitrite	2.78E+04	32000	2.46E+04	197000	3.36E+06 g	1.83E+07 g	2.17E+07 g
Oxalate	3.39E+03	32000	8.02E+04	197000	4.11E+05 g	5.98E+07 g	6.02E+07 g
Phosphate *	9.22E+02	32000	1.46E+03	197000	1.12E+05 g	1.09E+06 g	1.20E+06 g
Phosphate $	6.88E+02	32000	1.55E+03	197000	8.33E+04 g	1.16E+06 g	1.24E+06 g
Sulfate	7.36E+03	32000	6.92E+03	197000	8.92E+05 g	5.16E+06 g	6.05E+06 g
water (Gravimetric) (g/mL)	9.37E-01	32000	7.26E-01	197000	1.14E+02 g	5.41E+08 g	5.41E+08 g

Notes:

* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.
CNTR = Sludge results calculated using control sample results.

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Table 4A. Variance Component Estimates - Supernate Data (Model 1).

Analyte	Units	$\hat{\sigma}^2(R)$	Test: $\sigma^2(R)=0$ p-value	$\hat{\sigma}^2(L)$	Test: $\sigma^2(L)=0$ p-value	$\hat{\sigma}^2(A)$
Chloride	µg/mL	1.41E-18	0.3596	1.75E-23	0.7795	3.59E+03
Fluoride	µg/mL	8.21E+03	0.1402	4.93E+02	0.0800	1.70E+02
Nickel	µg/mL	2.37E-27	0.6020	1.50E+00	0.1335	1.38E+00
Nitrate	µg/mL	2.56E+05	0.0527	4.67E-22	0.7388	2.87E+04
Nitrite	µg/mL	8.13E-15	0.8048	1.06E+07	0.0001	4.00E+04
Oxalate	µg/mL	1.68E-09	0.5256	1.32E+05	0.0002	5.67E+02
Phosphate *	µg/mL	9.49E+04	0.3208	5.52E+04	0.0001	1.02E+02
Phosphorus	µg/mL	4.26E-11	0.5012	9.76E+02	0.0226	1.10E+02
Potassium	µg/mL	1.79E-18	0.6938	1.57E+04	0.0421	4.90E+03
Silver *	µg/mL	6.65E-22	0.5867	1.19E+01	0.0039	4.66E-01
Sodium	µg/mL	6.25E+06	0.2084	8.89E-28	0.7027	1.80E+07
Sulfate	µg/mL	3.89E-16	0.7681	5.12E+05	0.0037	2.68E+04
Sulfur	µg/mL	9.79E+04	0.1016	2.77E-14	0.6028	1.79E+04
Uranium	µg/mL	7.42E-14	0.5966	4.06E+04	0.0076	2.63E+03
Zinc *	µg/mL	1.12E-17	0.8006	8.42E-01	0.0252	1.96E-01
Zirconium	µg/mL	1.55E+03	0.3120	6.69E+02	0.1025	3.03E+02

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Table 4B. Variance Component Estimates - Supernate Data (Model 1).

Analyte #	Units	$\hat{\sigma}^2(R)$	Test: $\sigma^2(R)=0$ p-value	$\hat{\sigma}^2(A)$
water (TGA) ϕ	g/mL	9.38E-33	0.8022	7.67E-05
water (Gravimetric) ϕ	g/mL	4.36E-23	0.5397	4.76E-05
AT ϕ	μCi/mL	2.85E-02	0.0111	6.50E-04
^{241}Am *ϕ	μCi/mL	3.40E-10	0.4226	2.50E-05
^{137}Cs ϕ	μCi/mL	5.00E-01	0.3118	1.25E+00
$^{239/240}$Pu ϕ	μCi/mL	8.75E-04	0.2978	1.85E-03
SpG ϕ	---	1.50E-04	0.1835	1.00E-04
$^{89/90}$Sr ϕ	μCi/mL	6.60E-03	0.0019	2.50E-05
TIC ϕ	μg/mL	9.45E+06	0.0017	3.25E+04
TOC ϕ	μg/mL	3.06E+05	0.0068	4.23E+03
^{99}Tc ϕ	μCi/mL	1.37E-02	0.2871	2.56E-02
Phosphate $	μg/mL	5.52E+04	0.0014	1.53E+02
Zinc $	μg/mL	1.04E-18	0.8276	2.91E-01

Notes:

- \# = The riser and location variabilities (only 1 sample from each riser) are confounded.
- * = Less than values were used in the data analysis.
- $ = Less than values were deleted from the data analysis.
- ϕ = Balanced data set.

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Table 5A. Variance Component Estimates - Supernate Data (Model 2).

Analyte	Units	$\hat{\sigma}^2(L)$	Test: $\sigma^2(L)=0$ p-value	$\hat{\sigma}^2(A)$
Chloride	μg/mL	6.36E-26	0.8562	3.59E+03
Fluoride	μg/mL	5.97E+03	0.0030	1.70E+02
Nickel	μg/mL	1.50E+00	0.1816	1.38E+00
Nitrate	μg/mL	1.61E+05	0.0486	3.66E+04
Nitrite	μg/mL	1.06E+07	0.0002	4.00E+04
Oxalate	μg/mL	1.32E+05	0.0002	5.67E+02
Phosphate *	μg/mL	1.19E+05	0.0001	1.02E+02
Phosphorus	μg/mL	9.76E+02	0.0202	1.10E+02
Potassium	μg/mL	1.57E+04	0.0691	4.90E+03
Silver *	μg/mL	1.19E+01	0.0047	4.66E-01
Sodium	μg/mL	2.90E-11	0.5090	2.13E+07
Sulfate	μg/mL	5.12E+05	0.0070	2.68E+04
Sulfur	μg/mL	6.08E+04	0.0788	2.15E+04
Uranium	μg/mL	4.06E+04	0.0095	2.63E+03
Zinc *	μg/mL	8.42E-01	0.0498	1.96E-01
Zirconium	μg/mL	1.70E+03	0.0362	3.03E+02

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Table 5B. Variance Component Estimates - Supernate Data (Model 2).

Analyte	Units	$\hat{\sigma}^2(L)$ &	Test: $\sigma^2(L)=0$ p-value	$\hat{\sigma}^2(A)$
water (TGA) ϕ	g/mL	9.38E-33	0.8022	7.67E-05
water (Gravimetric) ϕ	g/mL	4.36E-23	0.5397	4.76E-05
AT ϕ	μCi/mL	2.85E-02	0.0111	6.50E-04
^{241}Am *ϕ	μCi/mL	3.40E-10	0.4226	2.50E-05
^{137}Cs ϕ	μCi/mL	5.00E-01	0.3118	1.25E+00
$^{239/240}$Pu ϕ	μCi/mL	8.75E-04	0.2978	1.85E-03
Silver $	μg/mL	3.30E-02	0.4053	7.00E-01
SpG ϕ	---	1.50E-04	0.1835	1.00E-04
$^{89/90}$Sr ϕ	μCi/mL	6.60E-03	0.0019	2.50E-05
TIC ϕ	μg/mL	9.45E+06	0.0017	3.25E+04
TOC ϕ	μg/mL	3.06E+05	0.0068	4.23E+03
^{99}Tc ϕ	μCi/mL	1.37E-02	0.2871	2.56E-02
Phosphate $	μg/mL	5.52E+04	0.0014	1.53E+02
Zinc $	μg/mL	1.04E-18	0.8276	2.91E-01

Notes:

& = These are the same values as Table 4B, since the riser and location variabilities are confounded.
* = Less than values were used in the data analysis.
$ = Less than values were deleted from the data analysis.
ϕ = Balanced data set.

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Table 6. Variance Component Estimates - Sludge Data (Model 1). (2 sheets)

Analyte	Units	$\hat{\sigma}^2(R)$	Test: $\sigma^2(R)=0$ p-value	$\hat{\sigma}^2(L)$	Test: $\sigma^2(L)=0$ p-value	$\hat{\sigma}^2(A)$
water (TGA)	g/mL	1.80E-17	0.3955	2.34E-02	0.0002	7.21E-04
Aluminum *	µg/mL	1.10E+08	0.1033	5.00E+07	0.0451	2.12E+07
Barium *	µg/mL	3.70E+03	0.0824	1.21E+03	0.0759	7.42E+02
Boron *	µg/mL	1.13E+02	0.2793	3.41E+02	0.0775	5.32E+01
Cadmium *	µg/mL	6.05E+01	0.1481	4.80E+01	0.0121	9.58E+00
Calcium *	µg/mL	2.99E-15	0.5104	2.48E+05	0.0003	1.05E+04
Cerium *	µg/mL	1.50E+03	0.0622	4.35E+02	0.0147	9.62E+01
Chloride	µg/mL	2.74E-06	0.4130	2.82E+04	0.0308	9.72E+03
Chromium *	µg/mL	2.58E+04	0.1197	1.54E+04	0.0121	3.07E+03
Copper *	µg/mL	-3.28E-15	0.4489	5.04E+01	0.1266	5.24E+01
^{137}Cs	µCi/mL	1.39E+02	0.3853	1.16E+04	0.0010	7.31E+02
Fluoride	µg/mL	1.52E-22	0.3191	1.43E-27	0.9526	9.64E+03
water (Gravimetric)	g/mL	2.42E-03	0.2131	3.88E-03	0.0001	8.98E-05
Iron *	µg/mL	3.21E+08	0.0400	4.45E+07	0.1483	4.95E+07
Lanthanum *	µg/mL	2.34E+02	0.0434	2.78E+01	0.2255	5.29E+01
Lead *	µg/mL	2.91E+05	0.0804	9.85E+04	0.0507	4.51E+04
Magnesium *	µg/mL	5.26E+02	0.0597	9.90E-12	0.5676	4.05E+02
Manganese *	µg/mL	1.04E+05	0.0876	3.41E+04	0.1017	2.64E+04
Neodymium *	µg/mL	6.61E+02	0.0689	1.95E+02	0.0426	7.98E+01
Nickel	µg/mL	2.03E+04	0.0507	3.96E+03	0.0940	2.87E+03
Nitrate	µg/mL	1.53E-18	0.6790	4.73E+05	0.0389	2.39E+05
Nitrite	µg/mL	4.41E-16	0.5425	5.82E+06	0.0012	4.50E+05
Oxalate	µg/mL	1.38E-43	0.8732	6.05E-04	0.3691	2.01E+09
Phosphate *	µg/mL	3.98E+05	0.1905	3.69E-17	0.5890	7.31E+05
Phosphate $	µg/mL	2.39E+05	0.0785	5.20e-13	0.0556	8.19E+05
Phosphorus	µg/mL	2.59E+05	0.1649	8.47E+04	0.4922	4.13E+04

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Table 6. Variance Component Estimates - Sludge Data (Model 1). (2 sheets)

Analyte	Units	$\hat{\sigma}^2(R)$	Test: $\sigma^2(R)=0$ p-value	$\hat{\sigma}^2(L)$	Test: $\sigma^2(L)=0$ p-value	$\hat{\sigma}^2(A)$
Potassium	μg/mL	3.52E-14	0.7709	1.47E+04	0.0164	4.60E+03
$^{239/240}$Pu	μCi/mL	7.18E-02	0.1197	4.64E-02	0.0002	1.35E-03
Silicon *	μg/mL	1.99E+07	0.1150	4.53E+05	0.4514	2.39E+07
Silver *	μg/mL	2.38E-02	0.4389	1.41E+05	0.2267	3.02E+05
Sodium	μg/mL	4.77E+08	0.1546	3.69E+08	0.0414	1.48E+08
$^{89/90}$Sr	μCi/mL	1.34E+04	0.0252	1.62E+03	0.0452	6.89E+02
Strontium *	μg/mL	7.45E-24	0.9417	4.33E+00	0.0489	2.78E+00
Sulfate	μg/mL	1.72E+05	0.2653	4.52E+05	0.0033	4.78E+04
Sulfur	μg/mL	2.43E-21	0.9354	1.02E+05	0.0028	1.35E+04
TIC	μg/mL	2.26E+07	0.1415	1.74E+07	0.0043	2.09E+06
Titanium *	μg/g	9.15E+02	0.0490	1.75E+02	0.0888	1.21E+02
TOC	μg/g	2.38E+07	0.2517	5.39E+07	0.0037	6.02E+06
Uranium	μg/mL	2.41E-12	0.9477	4.11E+04	0.0105	1.04E+04
Zinc *	μg/mL	1.25E+02	0.1251	5.79E+01	0.1316	5.70E+01
Zirconium	μg/mL	8.53E-18	0.6706	1.49E+05	0.0147	4.19E+04

Notes:

* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.

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Table 7. Variance Component Estimates - Sludge Data (Model 2). (2 sheets)

Analyte	Units	$\hat{\sigma}^2(L)$	Test: $\sigma^2(L)=0$ p-value	$\hat{\sigma}^2(A)$
water (TGA)	g/mL	2.34E-02	0.0002	7.21E-04
Aluminum *	μg/mL	1.16E+08	0.0090	2.12E+07
Barium *	μg/mL	3.44E+03	0.0125	7.42E+02
Boron *	μg/mL	4.08E+02	0.0045	5.32E+01
Cadmium *	μg/mL	8.42E+01	0.0033	9.58E+00
Calcium *	μg/mL	2.48E+05	0.0004	1.05E+04
Cerium *	μg/mL	1.34E+03	0.0012	9.62E+01
Chloride	μg/mL	2.82E+04	0.0295	9.72E+03
Chromium *	μg/mL	3.09E+04	0.0025	3.07E+03
Copper *	μg/mL	5.04E+01	0.1351	5.24E+01
^{137}Cs	μCi/mL	1.17E+04	0.0009	7.31E+02
Fluoride	μg/mL	7.35E-23	0.9703	9.64E+03
water (Gravimetric)	g/mL	5.33E-03	0.0001	8.98E-05
Iron *	μg/mL	2.37E+08	0.0117	4.95E+07
Lanthanum *	μg/mL	1.68E+02	0.0252	5.29E+01
Lead *	μg/mL	2.73E+05	0.0073	4.51E+04
Magnesium *	μg/mL	2.68E+02	0.2048	4.47E+02
Manganese *	μg/mL	9.63E+04	0.0197	2.64E+04
Neodymium *	μg/mL	5.92E+02	0.0048	7.98E+01
Nickel	μg/mL	1.61E+04	0.0086	2.87E+03
Nitrate	μg/mL	4.73E+05	0.0545	2.39E+05
Nitrite	μg/mL	5.82E+06	0.0014	4.50E+05
Oxalate	μg/mL	1.56E-09	0.4894	2.01E+09
Phosphate *	μg/mL	2.15E+05	0.4931	7.52E+05
Phosphate $	μg/mL	5.24E+04	0.0080	8.92E+05
Phosphorus	μg/mL	2.40E+05	0.3123	4.13E+04
Potassium	μg/mL	1.47E+04	0.0249	4.60E+03

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Table 7. Variance Component Estimates - Sludge Data (Model 2). (2 sheets)

Analyte	Units	$\hat{\sigma}^2(L)$	Test: $\sigma^2(L)=0$ p-value	$\hat{\sigma}^2(A)$
$^{239/240}Pu$	µCi/mL	8.94E-02	0.0001	1.35E-03
Silicon *	µg/mL	1.24E+07	0.2274	2.39E+07
Silver *	µg/mL	1.41E+05	0.2429	3.02E+05
Sodium	µg/mL	6.55E+08	0.0137	1.48E+08
$^{89/90}Sr$	µCi/mL	9.66E+03	0.0012	6.89E+02
Strontium *	µg/mL	4.33E+00	0.0764	2.78E+00
Sulfate	µg/mL	5.55E+05	0.0018	4.78E+04
Sulfur	µg/mL	1.02E+05	0.0047	1.35E+04
TIC	µg/mL	3.09E+07	0.0010	2.09E+06
Titanium *	µg/g	7.24E+02	0.0075	1.21E+02
TOC	µg/g	6.82E+07	0.0019	6.02E+06
Uranium	µg/mL	4.11E+04	0.0171	1.04E+04
Zinc *	µg/mL	1.33E+02	0.0424	5.70E+01
Zirconium	µg/mL	1.49E+05	0.0207	4.19E+04

* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.

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EQUATIONS

(A) Determination of centrifuged sludge concentration before filter treatment.

Let
- IL = interstitial liquid analytical results
- FCS = filtered centrifuged solids analytical results
- SpG = density of the interstitial liquid samples
- msf = mass fraction of filtered centrifuged solids
- PRE = centrifuged solids sample results before filtering

$$PRE = \frac{IL}{SpG} \times (1-msf) + FCS \times msf \qquad (1)$$

$$PRE(\frac{\mu g}{g}) = (\frac{\mu g}{mL}) \times (\frac{mL}{g}) \times (1-msf) + (\frac{\mu g}{g}) \times (msf). \qquad (2)$$

In the above equation, the units, μg/g and μg/mL, change to μCi/g and μCi/mL for the radionuclide data. Since the reported units for percent water data were weight percent (g/g * 100), the above equations were modified to the following.

$$PRE = (\frac{IL\ wt\%}{100}) \times (1-msf) + (\frac{FCS\ wt\%}{100}) \times (msf) \qquad (3)$$

$$PRE\ (\frac{g}{g}) = (\frac{g}{g}) \times (1-msf) + (\frac{g}{g}) \times (msf) \qquad (4)$$

Interstitial liquid analytical results were not available for each of the five "sludge" grab samples. For those samples without interstitial liquid analytical data, decanted supernate data were used to represent the interstitial liquid results for that sample. If both interstitial liquid and decanted supernate analytical results were not available for a grab sample, the average interstitial liquid analytical result from the remaining interstitial liquid sample results was used to represent that sample's concentration.

For many of the ICP analytes, the interstitial liquid analytical results were "less-than" values. In most cases, the filtered centrifuged solids analytical results (which were associated with the larger mass fraction) were at least an order of magnitude larger. Therefore, the use of the "less-than" value would not significantly change the PRE determination of the concentration.

The estimate of the mean concentration ($\hat{\mu}$), the estimate of the standard deviation associated with the mean concentration ($\hat{\sigma}_{\hat{\mu}}$), and the relative standard deviation of the mean (RSD) ($\hat{\sigma}_{\hat{\mu}}/\hat{\mu}$) for the PRE data are listed in Table 1A (Model 1) and Table 1B (Model 2) of this Attachment. The variance components from the ANOVA for Model 1 and Model 2 are listed in Tables 2A and 2B of this Attachment.

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Table 1A. Pre-Filtered Sample Data (Model 1). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %
Aluminum *	μg/g	4.34E+04	3.66E+03	8.4
Barium *	μg/g	2.56E+02	2.15E+01	8.4
Boron *	μg/g	5.17E+01	7.48E+00	14.5
Cadmium *	μg/g	2.83E+01	2.77E+00	9.8
Calcium *	μg/g	1.23E+03	3.32E+02	27.1
Cerium *	μg/g	1.69E+02	1.37E+01	8.1
Chromium *	μg/g	5.54E+02	4.68E+01	8.5
Copper *	μg/g	8.29E+01	5.65E+00	6.8
Iron *	μg/g	5.59E+04	4.43E+03	7.9
Lanthanum *	μg/g	5.71E+01	3.79E+00	6.6
Lead *	μg/g	2.07E+03	1.47E+02	7.1
Magnesium *	μg/g	2.20E+02	1.44E+01	6.6
Manganese *	μg/g	2.09E+03	5.12E+02	24.5
Neodymium *	μg/g	1.35E+02	9.60E+00	7.1
Nickel	μg/g	5.41E+02	3.58E+01	6.6
Phosphorus	μg/g	2.01E+03	1.29E+02	6.4
Potassium	μg/g	6.60E+02	5.95E+01	9.0
Silicon *	μg/g	2.22E+04	1.47E+03	6.6
Silver *	μg/g	1.66E+03	1.60E+02	9.7
Sodium	μg/g	1.24E+05	5.95E+03	4.8
Strontium *	μg/g	2.35E+01	9.89E-01	4.2
Sulfur	μg/g	1.40E+03	1.04E+02	7.4
Titanium *	μg/g	1.01E+02	9.54E+00	9.5
Uranium	μg/g	9.24E+02	7.13E+01	7.7
Zinc *	μg/g	5.00E+01	9.66E+00	19.3
Zirconium	μg/g	5.66E+02	1.62E+02	28.7
^{137}Cs	μCi/g	5.53E+02	5.21E+01	9.4

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Table 1A. Pre-Filtered Sample Data (Model 1). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %
$^{239/240}Pu$	µCi/g	1.24E+00	9.98E-02	8.1
$^{89/90}Sr$	µCi/g	4.93E+02	3.09E+01	6.3
water (TGA)	g/g	2.78E-01	3.83E-02	13.0
TIC	µg/g	2.47E+04	1.05E+03	4.3
TOC	µg/g	1.65E+04	2.01E+03	12.2
Fluoride	µg/g	2.29E+02	3.29E+01	14.4
Chloride	µg/g	2.33E+02	5.57E+01	23.9
Nitrate	µg/g	1.85E+03	3.70E+02	20.0
Nitrite	µg/g	1.31E+04	9.56E+02	7.3
Oxalate	µg/g	7.18E+04	1.46E+04	20.4
Phosphate *	µg/g	1.14E+03	3.66E+02	32.2
Phosphate $	µg/g	1.24E+03	3.04E+02	24.6
Sulfate	µg/g	3.84E+03	3.76E+02	9.8
water (Gravimetric)	g/g	3.60E-01	2.58E-02	7.2

Notes:

* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.

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Table 1B. Pre-Filtered Sample Data (Model 2). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %
Aluminum *	µg/g	4.34E+04	3.66E+03	8.4
Barium *	µg/g	2.56E+02	2.15E+01	8.4
Boron *	µg/g	5.17E+01	7.48E+00	14.5
Cadmium *	µg/g	2.83E+01	2.77E+00	9.8
Calcium *	µg/g	1.19E+03	2.48E+02	20.8
Cerium *	µg/g	1.69E+02	1.37E+01	8.1
Chromium *	µg/g	5.54E+02	4.68E+01	8.5
Copper *	µg/g	8.20E+01	3.37E+00	4.1
Iron *	µg/g	5.61E+04	4.13E+03	7.4
Lanthanum *	µg/g	5.72E+01	3.60E+00	6.3
Lead *	µg/g	2.07E+03	1.47E+02	7.1
Magnesium *	µg/g	2.20E+02	1.44E+01	6.6
Manganese *	µg/g	2.00E+03	2.61E+02	13.1
Neodymium *	µg/g	1.35E+02	9.60E+00	7.1
Nickel	µg/g	5.41E+02	3.58E+01	6.6
Phosphorus	µg/g	2.01E+03	1.29E+02	6.4
Potassium	µg/g	6.60E+02	5.95E+01	9.0
Silicon *	µg/g	2.22E+04	1.47E+03	6.6
Silver *	µg/g	1.66E+03	1.60E+02	9.7
Sodium	µg/g	1.24E+05	5.45E+03	4.4
Strontium *	µg/g	2.35E+01	9.89E-01	4.2
Sulfur	µg/g	1.40E+03	1.04E+02	7.4
Titanium *	µg/g	1.02E+02	7.38E+00	7.2
Uranium	µg/g	9.24E+02	7.13E+01	7.7
Zinc *	µg/g	4.84E+01	5.67E+00	11.7
Zirconium	µg/g	5.66E+02	1.62E+02	28.7
^{137}Cs	µCi/g	5.53E+02	5.21E+01	9.4
$^{239/240}$Pu	µCi/g	1.24E+00	9.98E-02	8.1

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Table 1B. Pre-Filtered Sample Data (Model 2). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %
$^{89/90}Sr$	μCi/g	4.93E+02	3.09E+01	6.3
water (TGA)	g/g	2.93E-01	3.03E-02	10.4
TIC	μg/g	2.48E+04	8.50E+02	3.4
TOC	μg/g	1.66E+04	1.86E+03	11.2
Fluoride	μg/g	2.29E+02	3.29E+01	14.4
Chloride	μg/g	2.33E+02	5.57E+01	23.9
Nitrate	μg/g	1.85E+03	3.70E+02	20.0
Nitrite	μg/g	1.31E+04	9.29E+02	7.1
Oxalate	μg/g	7.18E+04	1.46E+04	20.4
Phosphate *	μg/g	1.18E+03	2.64E+02	22.4
Phosphate $	μg/g	1.27E+03	2.54E+02	20.1
Sulfate	μg/g	3.89E+03	2.73E+02	7.0
water (Gravimetric)	g/g	3.56E-01	1.57E-02	4.4

Notes:

* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.

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Table 2A. Variance Component Estimates - Pre-Filtered Sample Data (Model 1).
(2 sheets)

Centrifuged Solids						
Analyte	Units	$\hat{\sigma}^2(R)$	Test: $\sigma^2(R)=0$ p-value	$\hat{\sigma}^2(L)$	Test: $\sigma^2(L)=0$ p-value	$\hat{\sigma}^2(A)$
Aluminum *	μg/g	2.75E-08	0.7470	6.00E+07	0.0093	1.38E+07
Barium *	μg/g	4.59E-14	0.7474	2.06E+03	0.0099	4.86E+02
Boron *	μg/g	1.23E-14	0.5012	2.56E+02	0.0084	4.79E+01
Cadmium *	μg/g	5.42E-28	0.5392	3.54E+01	0.0064	5.98E+00
Calcium *	μg/g	1.26E+05	0.2253	2.27E+05	0.0002	6.55E+03
Cerium *	μg/g	4.35E-15	0.6996	8.80E+02	0.0030	1.13E+02
Chromium *	μg/g	8.28E-15	0.4311	1.00E+04	0.0101	1.91E+03
Copper *	μg/g	5.35E+01	0.0886	7.71E+00	0.3330	3.41E+01
Iron *	μg/g	6.45E+06	0.3551	6.33E+07	0.0696	3.63E+07
Lanthanum *	μg/g	3.41E+00	0.3658	4.74E+01	0.0834	3.11E+01
Lead *	μg/g	8.37E-21	0.6124	9.28E+04	0.0191	2.92E+04
Magnesium *	μg/g	2.50E-25	0.5641	8.83E+02	0.0257	3.18E+02
Manganese *	μg/g	5.11E+05	0.0091	2.59E+04	0.0860	1.75E+04
Neodymium *	μg/g	6.26E-23	0.8379	4.31E+02	0.0031	5.91E+01
Nickel	μg/g	6.47E-22	0.5929	5.50E+03	0.0208	1.79E+03
Phosphorus	μg/g	8.02E-25	0.5677	7.14E+04	0.0233	2.44E+04
Potassium	μg/g	2.68E-15	0.7188	1.54E+04	0.0158	4.62E+03
Silicon *	μg/g	4.93E-56	0.9560	8.13E-08	0.3646	2.17E+07
Silver *	μg/g	5.48E-33	0.7909	1.25E-19	0.4805	2.57E+05
Sodium	μg/g	1.42E+07	0.3463	9.80E+07	0.1146	8.45E+07
Strontium *	μg/g	7.20E-16	0.7111	4.02E+00	0.0299	1.74E+00
Sulfur	μg/g	3.05E-12	0.9872	4.81E+04	0.0095	1.16E+04
Titanium *	μg/g	9.39E+01	0.2482	1.77E+02	0.0478	7.79E+01

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Table 2A. Variance Component Estimates - Pre-Filtered Sample Data (Model 1).
(2 sheets)

Centrifuged Solids						
Analyte	Units	$\hat{\sigma}^2(R)$	Test: $\sigma^2(R)=0$ p-value	$\hat{\sigma}^2(L)$	Test: $\sigma^2(L)=0$ p-value	$\hat{\sigma}^2(A)$
Uranium	μg/g	6.20E-14	0.8319	2.07E+04	0.0304	9.48E+03
Zinc *	μg/g	1.60E+02	0.0786	3.68E+01	0.1941	5.64E+01
Zirconium	μg/g	1.76E-15	0.7620	1.08E+05	0.0283	4.63E+04
water (TGA)	g/g	1.42E-03	0.2605	3.49E-03	0.0059	4.87E-04
Chloride	μg/g	4.08E-15	0.4940	1.09E+04	0.0961	9.27E+03
^{137}Cs	μCi/g	1.36E-17	0.6383	1.33E+04	0.0002	5.22E+02
Fluoride	μg/g	3.71E-45	0.9242	8.42E-23	0.8734	1.08E+04
water (Gravimetric)	g/g	1.10E-03	0.0989	5.15E-04	0.0149	1.15E-04
Nitrate	μg/g	9.30E-22	0.9226	5.74E+05	0.0226	2.23E+05
Nitrite	μg/g	1.28E+05	0.3766	4.22E+06	0.0001	5.35E+04
Oxalate	μg/g	1.02E-40	0.5007	6.66E+06	0.4230	2.12E+09
Phosphate *	μg/g	1.65E+05	0.2060	2.00E+02	0.4646	4.99E+05
Phosphate $	μg/g	5.79E+04	0.2740	7.21E-13	0.5659	5.51E+05
$^{239/240}$Pu	μCi/g	2.22E-41	0.5397	4.92E-02	0.0001	1.20E-03
$^{89/90}$Sr	μCi/g	7.97E-13	0.7844	4.48E+03	0.0031	6.10E+02
Sulfate	μg/g	1.72E+05	0.2100	2.65E+05	0.0002	8.90E+03
TIC	μg/g	9.85E+05	0.2740	2.36E+06	0.0063	1.31E+06
TOC	μg/g	1.41E+06	0.3523	1.45E+07	0.0209	3.88E+06

Notes:
* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.

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Table 2B. Variance Component Estimates - Pre-Filtered Sample Data (Model 2). (2 sheets)

Centrifuged Solids				
Analyte	Units	$\hat{\sigma}^2(L)$	Test: $\sigma^2(L)=0$ p-value	$\hat{\sigma}^2(A)$
Aluminum *	μg/g	6.01E+07	0.0141	1.38E+07
Barium *	μg/g	2.06E+03	0.0149	4.86E+02
Boron *	μg/g	2.56E+02	0.0094	4.79E+01
Cadmium *	μg/g	3.54E+01	0.0077	5.98E+00
Calcium *	μg/g	3.03E+05	0.0001	6.55E+03
Cerium *	μg/g	8.80E+02	0.0043	1.13E+02
Chromium *	μg/g	1.00E+04	0.0098	1.91E+03
Copper *	μg/g	3.98E+01	0.1093	3.41E+01
Iron *	μg/g	6.72E+07	0.0600	3.63E+07
Lanthanum *	μg/g	4.94E+01	0.0746	3.11E+01
Lead *	μg/g	9.28E+04	0.0253	2.92E+04
Magnesium *	μg/g	8.83E+02	0.0319	3.18E+02
Manganese *	μg/g	3.32E+05	0.0006	1.75E+04
Neodymium *	μg/g	4.31E+02	0.0050	5.91E+01
Nickel	μg/g	5.50E+03	0.0268	1.79E+03
Phosphorus	μg/g	7.14E+04	0.0291	2.44E+04
Potassium	μg/g	1.54E+04	0.0232	4.62E+03
Silicon *	μg/g	3.96E-10	0.4878	2.17E+07
Silver *	μg/g	1.25E-19	0.6043	2.57E+05
Sodium	μg/g	1.07E+08	0.0999	8.45E+07
Strontium *	μg/g	4.02E+00	0.0431	1.74E+00
Sulfur	μg/g	4.81E+04	0.0156	1.16E+04
Titanium *	μg/g	2.33E+02	0.0279	7.79E+01
Uranium	μg/g	2.07E+04	0.0469	9.48E+03

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Table 2B. Variance Component Estimates - Pre-Filtered Sample Data (Model 2). (2 sheets)

Centrifuged Solids				
Analyte	Units	$\hat{\sigma}^2(L)$	Test: $\sigma^2(L)=0$ p-value	$\hat{\sigma}^2(A)$
Zinc *	µg/g	1.33E+02	0.0418	5.64E+01
Zirconium	µg/g	1.08E+05	0.0422	4.63E+04
water (TGA)	g/g	4.34E-03	0.0032	4.87E-04
Chloride	µg/g	1.09E+04	0.1090	9.27E+03
^{137}Cs	µCi/g	1.33E+04	0.0003	5.22E+02
Fluoride	µg/g	8.54E-23	0.9438	1.08E+04
water (Gravimetric)	g/g	1.17E-03	0.0024	1.15E-04
Nitrate	µg/g	5.74E+05	0.0361	2.23E+05
Nitrite	µg/g	4.29E+06	0.0001	5.35E+04
Oxalate	µg/g	6.60E+06	0.4832	2.12E+09
Phosphate *	µg/g	9.94E+04	0.3551	4.99E+05
Phosphate $	µg/g	2.22E+03	0.5387	5.78E+05
$^{239/240}Pu$	µCi/g	4.92E-02	0.0001	1.20E-03
$^{89/90}Sr$	µCi/g	4.48E+03	0.0049	6.10E+02
Sulfate	µg/g	3.68E+05	0.0001	8.90E+03
TIC	µg/g	2.96E+06	0.0444	1.31E+06
TOC	µg/g	1.54E+07	0.0169	3.88E+06

Notes:
* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.

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Centrifuged Solids - without filtering

The grab sample portion that was called "control" sample also represents the centrifuged solids. Only a limited number of analytical determinations were performed on the control samples. The mean, standard deviation of the mean and the RSD of the mean for the control sample data are listed in Table 3A (Model 1) and Table 3B (Model 2) of this Attachment. The variance components from the ANOVA for Model 1 and Model 2 are listed in Tables 4A and 4B of this Attachment.

Table 3A. Control Sample Data - Model 1.

Centrifuged solids				
Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %
^{137}Cs	µCi/g	4.95E+02	1.07E+02	21.6
^{241}Am	µCi/g	9.10E-01	1.64E-01	18.0
$^{239/240}$Pu *	µCi/g	9.15E-01	2.42E-01	26.5
$^{239/240}$Pu $	µCi/g	1.13E+00	2.18E-01	19.3
$^{89/90}$Sr	µCi/g	4.71E+02	1.26E+02	26.8
^{99}Tc *	µCi/g	3.60E-02	8.28E-03	23.0
AT	µCi/g	2.52E+00	5.37E-01	21.3
water (TGA)	g/g	2.99E-01	4.62E-02	15.5

Notes:
* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.

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Table 3B. Control Sample Data - Model 2.

Centrifuged solids				
Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$) %
^{137}Cs	μCi/g	4.95E+02	1.07E+02	21.6
^{241}Am	μCi/g	9.10E-01	1.64E-01	18.0
$^{239/240}$Pu *	μCi/g	9.15E-01	2.42E-01	26.5
$^{239/240}$Pu $	μCi/g	1.13E+00	1.44E-01	12.8
$^{89/90}$Sr	μCi/g	4.68E+02	1.20E+02	25.7
^{99}Tc *	μCi/g	3.60E-02	8.28E-03	23.0
^{99}Tc $	μCi/g	3.22E-02	6.62E-03	20.6
AT	μCi/g	2.52E+00	5.37E-01	21.3
water (TGA)	g/g	2.98E-01	4.37E-02	14.7

Notes:

* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.

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Table 4A. Variance Component Estimates - Control Sample Data (Model 1).

Centrifuged Solids						
Analyte	Units	$\hat{\sigma}^2(R)$	Test: $\sigma^2=0$ p-value	$\hat{\sigma}^2(L)$	Test: $\sigma^2=0$ p-value	$\hat{\sigma}^2(A)$
water (TGA)	g/g	5.73E-04	0.3623	9.18E-03	0.0001	1.04E-04
AT	μCi/g	5.51E-22	0.5781	6.64E-01	0.2078	1.56E+00
^{241}Am	μCi/g	8.40E-23	0.6476	1.26E-01	0.0032	1.65E-02
^{137}Cs	μCi/g	2.94E-15	0.4215	5.51E+04	0.0011	3.75E+03
$^{239/240}$Pu *	μCi/g	3.51E-26	0.9946	2.88E-01	0.0002	1.11E-02
$^{239/240}$Pu $	μCi/g	7.94E-02	0.1303	2.36E-02	0.0974	1.38E-02
$^{89/90}$Sr	μCi/g	3.72E+03	0.3662	4.13E+04	0.1799	5.74E+04
^{99}Tc *	μCi/g	7.93E-31	0.4822	2.93E-04	0.0266	1.00E-04
^{99}Tc $	μCi/g	2.63E-21	0.6401	8.80E-05	0.2708	1.47E-04

Notes:
* = Less than values were used in the data analysis.
$ = Less than values were deleted from the data analysis.

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Table 4B. Variance Component Estimates - Control Sample Data (Model 2).

Centrifuged Solids				
Analyte	Units	$\hat{\sigma}^2(L)$	Test: $\sigma^2=0$ p-value	$\hat{\sigma}^2(A)$
water (TGA)	g/g	9.52E-03	0.0001	1.04E-04
AT	μCi/g	6.64E-01	0.2569	1.56E+00
^{241}Am	μCi/g	1.26E-01	0.0045	1.65E-02
^{137}Cs	μCi/g	5.51E+04	0.0011	3.75E+03
$^{239/240}$Pu *	μCi/g	2.88E-01	0.0003	1.11E-02
$^{239/240}$Pu $	μCi/g	4.35E+04	0.1694	5.74E+04
$^{89/90}$Sr	μCi/g	2.92E-04	0.0291	1.00E-04
^{99}Tc *	μCi/g	7.65E-02	0.0179	1.38E-02
^{99}Tc $	μCi/g	8.80E-05	0.2939	1.47E-04

Notes:

* = Less than values were used in the data analysis.
$ = Less than values were deleted from the data analysis.

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(B) Determination of Sludge Concentrations using the PRE centrifuged solids data.

Let DC = decanted supernate analytical results
PRE = centrifuged solids analytical results
BDC = bulk density of the centrifuged samples
Vfs = volume fraction of centrifuged solids

$$\text{Sludge} = \text{liquid} + \text{solids} \quad (5)$$

$$\text{Sludge} = \text{DC} \times (1-\text{Vfs}) + \text{PRE} \times \text{BDC} \times \text{Vfs} \quad (6)$$

$$\text{Sludge}\left(\frac{\mu g}{mL}\right) = \frac{\mu g}{mL} \times (1 - \text{Vfs}) + \left(\frac{\mu g}{g}\right) \times \left(\frac{g}{mL}\right)(\text{Vfs}) \quad (7)$$

In the above equation, the units μg/g and μg/mL, change to μCi/g and μCi/mL for the radionuclide data. Since the reported units for percent water data were weight percent (g/g * 100), the above equation was modified to the following.

$$\text{Sludge}\left(\frac{g}{mL}\right) = \text{DC}\left(\frac{g}{g}\right) \times \left(\frac{g}{mL}\right) \times (1 - \text{Vfs}) + \text{PRE}\left(\frac{g}{g}\right) \times \left(\frac{g}{mL}\right) \times (\text{Vfs}) \quad (8)$$

If the decanted supernate results were not available for each "sludge" grab sample, either (1) the interstitial liquid analytical results were used or (2) the mean of the other decanted supernate results was used for the concentration of the sample. If the decanted supernate analytical result was a "less-than" value, the value itself was used to represent the concentration of the sample.

The mean, standard deviation associated with the mean and the RSD of the mean for the sludge data using the PRE centrifuged solids results are listed in Table 5A (Model 1) and Table 5B (Model 2) of this Attachment. The variance components from the ANOVA for Model 1 and Model 2 are listed in Tables 6 and 7, Attachment 1, respectively.

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Table 5A. Summary Statistics - Sludge Data (Model 1). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$)%
Aluminum *	μg/mL	4.69E+04	8.23E+03	17.6
Barium *	μg/mL	2.84E+02	4.67E+01	16.5
Boron *	μg/mL	6.53E+01	1.14E+01	17.5
Cadmium *	μg/mL	3.15E+01	6.41E+00	20.4
Calcium *	μg/mL	1.31E+03	2.25E+02	17.3
Cerium *	μg/mL	1.97E+02	2.92E+01	14.8
Chromium *	μg/mL	6.16E+02	1.28E+02	20.8
Copper *	μg/mL	1.05E+02	3.91E+00	3.7
Iron *	μg/mL	6.03E+04	1.32E+04	21.9
Lanthanum *	μg/mL	6.91E+01	1.13E+01	16.4
Lead *	μg/mL	2.26E+03	4.13E+02	18.3
Magnesium *	μg/mL	2.51E+02	1.75E+01	7.0
Manganese *	μg/mL	2.20E+03	2.48E+02	11.3
Neodymium *	μg/mL	1.60E+02	1.95E+01	12.2
Nickel	μg/mL	5.88E+02	1.06E+02	18.0
Phosphorus	μg/mL	2.31E+03	3.89E+02	16.9
Potassium	μg/mL	9.32E+02	5.83E+01	6.3
Silicon *	μg/mL	2.40E+04	3.54E+03	14.7
Silver *	μg/mL	1.87E+03	2.42E+02	13.0
Sodium	μg/mL	1.74E+05	1.82E+04	10.4
Strontium *	μg/mL	4.02E+01	1.07E+00	2.7
Sulfur	μg/mL	2.42E+03	1.47E+02	6.1
Titanium *	μg/mL	1.25E+02	2.25E+01	18.1
Uranium	μg/mL	1.61E+03	9.62E+01	6.0
Zinc *	μg/mL	6.48E+01	8.95E+00	13.8
Zirconium	μg/mL	7.25E+02	1.84E+02	25.4
^{137}Cs	μCi/mL	6.54E+02	4.97E+01	7.6
^{137}Cs CNTR	μCi/mL	5.60E+02	8.83E+01	15.8

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Table 5A. Summary Statistics - Sludge Data (Model 1). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$)%
Aluminum *	µg/mL	4.69E+04	8.23E+03	17.6
$^{239/240}Pu$	µCi/mL	1.64E+00	2.14E-01	13.1
$^{239/240}Pu$ CNTR *	µCi/mL	1.26E+00	3.08E-01	24.6
$^{239/240}Pu$ CNTR $	µCi/mL	1.52E+00	3.16E-01	20.8
$^{89/90}Sr$	µCi/mL	5.30E+02	8.43E+01	15.9
$^{89/90}Sr$ CNTR	µCi/mL	4.82E+02	9.28E+01	19.3
water (TGA)	g/mL	5.63E-01	6.89E-02	12.3
water (TGA) CNTR	g/mL	5.65E-01	7.96E-02	14.1
TIC	µg/mL	3.54E+04	3.88E+03	11.0
TOC	µg/mL	1.95E+04	4.85E+03	24.9
Fluoride	µg/mL	3.24E+02	3.11E+01	9.6
Chloride	µg/mL	3.84E+02	8.13E+01	21.2
Nitrate	µg/mL	2.36E+03	3.44E+02	14.6
Nitrite	µg/mL	2.46E+04	1.10E+03	4.5
Oxalate	µg/mL	8.02E+04	1.42E+04	17.7
Phosphate *	µg/mL	1.46E+03	5.24E+02	35.9
Phosphate $	µg/mL	1.55E+03	4.65E+02	29.9
Sulfate	µg/mL	6.92E+03	4.28E+02	6.2
water (Gravimetric)	g/mL	7.26E-01	4.49E-02	6.2

Notes:

* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.

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Table 5B. Summary Statistics - Sludge Data (Model 2). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$)%
Aluminum *	μg/mL	4.82E+04	5.04E+03	10.5
Barium *	μg/mL	2.92E+02	2.76E+01	9.5
Boron *	μg/mL	6.63E+01	9.33E+00	14.1
Cadmium *	μg/mL	3.24E+01	4.22E+00	13.1
Calcium *	μg/mL	1.31E+03	2.25E+02	17.3
Cerium *	μg/mL	2.02E+02	1.66E+01	8.2
Chromium *	μg/mL	6.36E+02	8.05E+01	12.7
Copper *	μg/mL	1.05E+02	3.91E+00	3.7
Iron *	μg/mL	6.28E+04	7.24E+03	11.5
Lanthanum *	μg/mL	7.12E+01	6.24E+00	8.8
Lead *	μg/mL	2.33E+03	2.43E+02	10.5
Magnesium *	μg/mL	2.54E+02	9.92E+00	3.9
Manganese *	μg/mL	2.16E+03	1.48E+02	6.9
Neodymium *	μg/mL	1.64E+02	1.12E+01	6.9
Nickel	μg/mL	6.07E+02	5.93E+01	9.8
Phosphorus	μg/mL	2.37E+03	2.28E+02	9.6
Potassium	μg/mL	9.32E+02	5.83E+01	6.3
Silicon *	μg/mL	2.46E+04	2.21E+03	9.0
Silver *	μg/mL	1.87E+03	2.42E+02	13.0
Sodium	μg/mL	1.77E+05	1.21E+04	6.8
Strontium *	μg/mL	4.02E+01	1.07E+00	2.7
Sulfur *	μg/mL	2.42E+03	1.47E+02	6.1
Titanium *	μg/mL	1.29E+02	1.25E+01	9.7
Uranium	μg/mL	1.61E+03	9.62E+01	6.0
Zinc *	μg/mL	6.34E+01	5.68E+00	9.0
Zirconium	μg/mL	7.25E+02	1.84E+02	25.4
^{137}Cs	μCi/mL	6.54E+02	4.92E+01	7.5
^{137}Cs CNTR	μCi/mL	5.60E+02	8.83E+01	15.8

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Table 5B. Summary Statistics - Sludge Data (Model 2). (2 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	RSD($\hat{\mu}$)%
$^{239/240}$Pu	μCi/mL	1.67E+00	1.34E-01	8.0
$^{239/240}$Pu CNTR *	μCi/mL	1.25E+00	3.08E-01	24.6
$^{239/240}$Pu CNTR $	μCi/mL	1.52E+00	2.06E-01	13.6
$^{89/90}$Sr	μCi/mL	5.46E+02	4.47E+01	8.2
$^{89/90}$Sr CNTR	μCi/mL	4.82E+02	9.28E+01	19.3
water (TGA)	g/mL	5.63E-01	6.89E-02	12.3
water (TGA) CNTR	μg/mL	5.65E-01	7.96E-02	14.1
TIC	μg/mL	3.60E+04	2.53E+03	7.0
TOC	μg/mL	2.00E+04	3.77E+03	18.9
Fluoride	μg/mL	3.24E+02	3.11E+01	9.6
Chloride	μg/mL	3.84E+02	8.13E+01	21.2
Nitrate	μg/mL	2.36E+03	3.44E+02	14.6
Nitrite	μg/mL	2.46E+04	1.10E+03	4.5
Oxalate	μg/mL	8.02E+04	1.42E+04	17.7
Phosphate *	μg/mL	1.53E+03	3.44E+02	22.4
Phosphate $	μg/mL	1.63E+03	3.32E+02	20.3
Sulfate	μg/mL	6.96E+03	3.40E+02	4.9
water (Gravimetric)	g/mL	7.20E-01	3.28E-02	4.6

Notes:

* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.

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(C) Determination of the Sludge Concentration using the control sample centrifuged solids data.

Let DC = decanted supernate analytical results
CNTR = centrifuged solids analytical results
BDC = bulk density of the centrifuged samples
Vfs = volume fraction of the centrifuged solids

$$\text{Sludge} = \text{liquid} + \text{solids} \tag{9}$$

$$\text{Sludge} = DC \times (1 - Vfs) + CNTR \times BDC \times Vfs \tag{10}$$

$$\text{Sludge}\,\left(\frac{\mu g}{mL}\right) = \frac{\mu g}{mL} \times (1 - Vfs) + \left(\frac{\mu g}{g}\right) \times \left(\frac{g}{mL}\right) \times Vfs \tag{11}$$

In the above equation, the units μg/g and μg/mL change to μCi/g and μCi/mL for the radionuclide data. Since the reported units for percent water data were weight percent (g/g * 100), the above equation was modified to the following.

$$\text{Sludge}\left(\frac{g}{mL}\right) = DC\left(\frac{g}{g}\right) \times \left(\frac{g}{mL}\right) \times (1 - Vfs) + CNTR\left(\frac{g}{g}\right) \times \left(\frac{g}{mL}\right) \times Vfs \tag{12}$$

If the decanted supernate results were not available for each "sludge" grab sample, either (1) the interstitial liquid analytical results were used, or (2) the mean of the other decanted supernate results was used for the concentration of the sample. If the decanted supernate analytical result was a "less-than" value, the value itself was used to represent the concentration of the sample.

The mean, standard deviation associated with the mean and the RSD of the mean for the sludge data using the CNTR centrifuged solids results are listed in Table 5A (Model 1) and Table 5B (Model 2) of this Attachment. The variance components from the ANOVA for Model 1 and Model 2 are listed in Tables 6 and 7, Attachment 1, respectively.

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(D) Reporting the sludge data in units of μg/g or μCi/g.

$$\text{Sludge}\left(\frac{\mu g}{g}\right) = \left(\frac{\mu g}{mL}\right) \times \left(\frac{mL}{g}\right) \tag{13}$$

where mL/g is the inverse of the sludge density. A similar equation in terms of μCi/g can be written for the radionuclide data.

The mean concentrations for the sludge data, both sets of units, are provided in Table 6A (Model 1) and Table 6B (Model 2) of this Attachment.

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Table 6A. Sludge Data - Model 1. (2 sheets)

Analyte	Sludge Units	
	μg/mL or μCi/mL	μg/g or μCi/g
Aluminum *	4.69E+04	3.03E+04
Barium *	2.84E+02	1.84E+02
Boron *	6.53E+01	4.24E+01
Cadmium *	3.15E+01	2.04E+01
Calcium *	1.31E+03	8.51E+02
Cerium *	1.97E+02	1.28E+02
Chromium *	6.16E+02	3.99E+02
Copper *	1.05E+02	6.77E+01
Iron *	6.03E+04	3.90E+04
Lanthanum *	6.91E+01	4.47E+01
Lead *	2.26E+03	1.46E+03
Magnesium *	2.51E+02	1.65E+02
Manganese *	2.20E+03	1.44E+03
Neodymium *	1.60E+02	1.04E+02
Nickel	5.88E+02	3.81E+02
Phosphorus	2.31E+03	1.49E+03
Potassium	9.32E+02	6.03E+02
Silicon *	2.40E+04	1.56E+04
Silver *	1.87E+03	1.19E+03
Sodium	1.74E+05	1.13E+05
Strontium *	4.02E+01	2.61E+01
Sulfur	2.42E+03	1.56E+03
Titanium *	1.25E+02	8.08E+01
Uranium	1.61E+03	1.04E+03
Zinc *	6.48E+01	4.25E+01
Zirconium	7.25E+02	4.75E+02
^{137}Cs	6.54E+02	4.22E+02

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Table 6A. Sludge Data - Model 1. (2 sheets)

Analyte	Sludge Units	
	µg/mL or µCi/mL	µg/g or µCi/g
^{137}Cs CNTR	5.60E+02	3.67E+02
$^{239/240}$Pu	1.64E+00	1.06E+00
$^{239/240}$Pu CNTR *	1.26E+00	8.24E-01
$^{239/240}$Pu CNTR $	1.52E+00	1.00E+00
$^{89/90}$Sr	5.30E+02	3.44E+02
$^{89/90}$Sr CNTR	4.82E+02	3.15E+02
water (TGA) (g/mL or g/g)	5.63E-01	3.65E-01
water (TGA) CNTR (g/mL or g/g)	5.65E-01	3.68E-01
TIC	3.54E+04	2.29E+04
TOC	1.95E+04	1.25E+04
Fluoride	3.24E+02	2.10E+02
Chloride	3.84E+02	2.50E+02
Nitrate	2.36E+03	1.54E+03
Nitrite	2.46E+04	1.59E+04
Oxalate	8.02E+04	5.22E+04
Phosphate *	1.46E+03	9.45E+02
Phosphate $	1.55E+03	1.01E+03
Sulfate	6.92E+03	4.49E+03
water (Gravimetric) (g/mL or g/g)	7.26E-01	4.75E-01

Notes:
* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.

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Table 6B. Sludge Data - Model 2. (2 sheets)

Analyte	Sludge Units	
	μg/mL or μCi/mL	μg/g or μCi/g
Aluminum *	4.82E+04	3.10E+04
Barium *	2.92E+02	1.88E+02
Boron *	6.63E+01	4.26E+01
Cadmium *	3.24E+01	2.08E+01
Calcium *	1.31E+03	8.51E+02
Cerium *	2.02E+02	1.30E+02
Chromium *	6.36E+02	4.09E+02
Copper *	1.05E+02	6.77E+01
Iron *	6.28E+04	4.03E+04
Lanthanum *	7.12E+01	4.58E+01
Lead *	2.33E+03	1.50E+03
Magnesium *	2.54E+02	1.65E+02
Manganese *	2.16E+03	1.40E+03
Neodymium *	1.64E+02	1.06E+02
Nickel	6.07E+02	3.91E+02
Phosphorus	2.37E+03	1.52E+03
Potassium	9.32E+02	6.03E+02
Silicon *	2.46E+04	1.58E+04
Silver *	1.87E+03	1.19E+03
Sodium	1.77E+05	1.14E+05
Strontium *	4.02E+01	2.61E+01
Sulfur	2.42E+03	1.56E+03
Titanium *	1.29E+02	8.29E+01
Uranium	1.61E+03	1.04E+03
Zinc *	6.34E+01	4.13E+01
Zirconium	7.25E+02	4.75E+02
^{137}Cs	6.54E+02	4.22E+02

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Table 6B. Sludge Data - Model 2. (2 sheets)

Analyte	Sludge Units	
	μg/mL or μCi/mL	μg/g or μCi/g
^{137}Cs CNTR	5.60E+02	3.67E+02
$^{239/240}$Pu	1.67E+00	1.08E+00
$^{239/240}$Pu CNTR *	1.25E+00	8.24E-01
$^{239/240}$Pu CNTR $	1.52E+00	1.00E+00
$^{89/90}$Sr	5.46E+02	3.52E+02
$^{89/90}$Sr CNTR	4.82E+02	3.15E+02
water (TGA) (g/mL or g/g)	5.63E-01	3.63E-01
water (TGA) CNTR (g/mL or g/g)	5.65E-01	3.67E-01
TIC	3.60E+04	2.32E+04
TOC	2.00E+04	1.27E+04
Fluoride	3.24E+02	2.10E+02
Chloride	3.84E+02	2.50E+02
Nitrate	2.36E+03	1.54E+03
Nitrite	2.46E+04	1.59E+04
Oxalate	8.02E+04	5.22E+04
Phosphate *	1.53E+03	9.88E+02
Phosphate $	1.63E+03	1.05E+03
Sulfate	6.96E+03	4.49E+03
water (Gravimetric) (g/mL or g/g)	7.20E-01	4.72E-01

Notes:
* = Less than values were used in the data analysis.
$ = Less than values were deleted in the data analysis.

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(E) Reporting the supernate data in units of μg/mL or μCi/mL.

The supernate grab samples analytical results were usually reported as either μg/mL or μCi/mL. The units are changed to μg/g or μCi/g using the following equation.

$$\text{Supernate}\left(\frac{\mu g}{mL}\right) = \left(\frac{\mu g}{mL}\right) \times \left(\frac{mL}{g}\right) \qquad (14)$$

where mL/g is the inverse of the supernate density.

The mean concentration for the supernate data, using both sets of units, are provided in Table 7A (Model 1) and Table 7B (Model 2) of this Attachment.

Table 7A. Supernate Data - Model 1. (3 sheets)

Analyte	Supernate Units	
	Concentration μg/mL or μCi/mL	Concentration μg/g or μCi/g
Aluminum *	3.00E+01	2.5E+01
Barium *	3.00E+01	2.5E+01
Boron *	3.00E+01	2.5E+01
Cadmium *	3.00E+00	3.0E+00
Calcium *	6.01E+01	5.1E+01
Cerium *	6.01E+01	5.1E+01
Chromium *	6.01E+00	5.0E+00
Copper *	6.01E+00	5.0E+00
Iron *	3.00E+01	2.5E+01
Lanthanum *	3.00E+01	2.5E+01
Lead *	6.01E+01	5.1E+01
Magnesium *	6.01E+01	5.1E+01
Manganese *	6.01E+00	5.0E+00
Neodymium *	6.01E+01	5.1E+01

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Table 7A. Supernate Data - Model 1. (3 sheets)

Analyte	Supernate Units	
	Concentration μg/mL or μCi/mL	Concentration μg/g or μCi/g
Nickel	1.61E+01	1.37E+01
Phosphorus	2.86E+02	2.45E+02
Potassium	6.58E+02	5.62E+02
Silicon *	3.00E+01	2.5E+01
Silver *	8.01E+00	6.85E+00
Sodium	1.05E+05	9.01E+04
Strontium *	6.01E+00	5.0E+00
Sulfur	2.65E+03	2.28E+03
Titanium *	6.01E+00	5.0E+00
Uranium	1.68E+03	1.44E+03
Zinc *	4.92E+00	4.20E+00
Zinc $	4.49E+00	3.87E+00
Zirconium	3.89E+02	3.33E+02
^{137}Cs φ	1.08E+02	9.26E+01
^{241}Am *φ	1.25E-02	1.10E-02
$^{239/240}$Pu φ	7.45E-01	6.38E-01
$^{89/90}$Sr φ	4.23E-01	3.62E-01
^{99}Tc φ	2.05E-01	1.73E-01
AT φ	1.03E+00	8.78E-01
water (TGA) φ (g/mL or g/g)	9.36E-01	8.01E-01
TIC φ	2.23E+04	1.90E+04
TOC φ	2.91E+03	2.49E+03
Fluoride	2.65E+02	2.28E+02
Chloride	3.18E+02	2.72E+02

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Table 7A. Supernate Data - Model 1. (3 sheets)

Analyte	Supernate Units	
	Concentration μg/mL or μCi/mL	Concentration μg/g or μCi/g
Nitrate	1.44E+03	1.24E+03
Nitrite	2.78E+04	2.38E+04
Oxalate	3.39E+03	2.90E+03
Phosphate *	9.22E+02	7.95E+02
Phosphate $	6.88E+02	5.87E+02
Sulfate	7.36E+03	6.30E+03
water (Gravimetric) ϕ (g/mL or g/g)	9.37E-01	8.02E-01

Notes:
- * = Less than values were used in the data analysis.
- $ = Less than values were deleted in the data analysis.
- ϕ = Balanced data set.

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Table 7B. Supernate Data - Model 2. (2 sheets)

Analyte	Supernate Units	
	Concentration µg/mL or µCi/mL	Concentration µg/g or µCi/g
Aluminum *	3.00E+01	2.5E+01
Barium *	3.00E+01	2.5E+01
Boron *	3.00E+01	2.5E+01
Cadmium *	3.00E+00	3.0E+00
Calcium *	6.01E+01	5.1E+01
Cerium *	6.01E+01	5.1E+01
Chromium *	6.01E+00	5.0E+00
Copper *	6.01E+00	5.0E+00
Iron *	3.00E+01	2.5E+01
Lanthanum *	3.00E+01	2.5E+01
Lead *	6.01E+01	5.1E+01
Magnesium *	6.01E+01	5.1E+01
Manganese *	6.01E+00	5.0E+00
Neodymium *	6.01E+01	5.1E+01
Nickel	1.61E+01	1.37E+01
Phosphorus	2.86E+02	2.45E+02
Potassium	6.58E+02	5.62E+02
Silicon *	3.00E+01	2.5E+01
Silver *	8.01E+00	6.85E+00
Sodium	1.05E+05	9.01E+04
Strontium *	6.01E+00	5.0E+00
Sulfur	2.65E+03	2.21E+03
Titanium *	6.01E+00	5.0E+00
Uranium	1.68E+03	1.44E+03
Zinc *	4.92E+00	4.20E+00

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Table 7B. Supernate Data - Model 2. (2 sheets)

Analyte	Supernate Units	
	Concentration $\mu g/mL$ or $\mu Ci/mL$	Concentration $\mu g/g$ or $\mu Ci/g$
Zinc $	4.49E+00	3.87E+00
Zirconium	3.89E+02	3.26E+02
^{137}Cs ϕ	1.08E+02	9.26E+01
^{241}Am *ϕ	1.25E-02	1.10E-02
$^{239/240}Pu$ ϕ	7.45E-01	6.38E-01
$^{89/90}Sr$ ϕ	4.23E-01	3.62E-01
^{99}Tc ϕ	2.05E-01	1.73E-01
AT ϕ	1.03E+00	8.78E-01
water (TGA) ϕ (g/mL or g/g)	9.36E-01	8.01E-01
TIC ϕ	2.23E+04	1.90E+04
TOC ϕ	2.91E+03	2.49E+03
Fluoride	2.65E+02	2.10E+02
Chloride	3.18E+02	2.72E+02
Nitrate	1.44E+03	1.13E+03
Nitrite	2.78E+04	2.38E+04
Oxalate	3.39E+03	2.90E+03
Phosphate *	9.22E+02	7.39E+02
Phosphate $	6.88E+02	5.87E+02
Sulfate	7.36E+03	6.30E+03
water (Gravimetric) ϕ (g/mL or g/g)	9.37E-01	8.02E-01

Notes:
- * = Less than values were used in the data analysis.
- $ = Less than values were deleted in the data analysis.
- ϕ = Balanced data set.

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(F) Tank inventory calculation

The tank inventory for each analyte was calculated using the following equation where Conc represents concentration, Vol represents volume, liq represents supernate, and sldg represents sludge. The volume of the supernate is 32,000 gallons and the volume of the sludge is 197,000 gallons.

$$TK\ INV = (Conc_{liq}) \times (Vol_{liq}) + (Conc_{sldg}) \times (Vol_{sldg}) \qquad (15)$$

$$TK\ INV\ (g) = [(\frac{\mu g}{mL}) \times (mL) + (\frac{\mu g}{mL}) \times (mL)] \times \frac{g}{1000000 \mu g} \qquad (16)$$

$$mL = (gal) \times (\frac{3.7854\ L}{gal}) \times (\frac{1000\ mL}{L}) \qquad (17)$$

In the equation above, the units μg/mL change to μCi/mL for the radionuclide data. The tank inventory units then become Curies. The mean concentration for the tank inventory data are provided in Table 3 of this internal memo for Model 2 and Table 3, Attachment 1, for Model 1.

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Evaluation for Safety Screening DQO

The tank safety screening DQO specifies that an 95% upper confidence value will be computed for the average value from the data collected for each analyte. This upper limit is then compared to the decision threshold to classify a tank as "safe", "conditionally safe", or "not safe". The analytes of interest for C-106 are AT and DSC. The decision threshold value for AT is 41 μCi/g. The decision threshold value for DSC is 480 Joules/g.

The upper limit of a one-sided confidence interval for the mean for safety screening data is

$$\hat{\mu} + t_{(df,0.95)} * \hat{\sigma}_{\hat{\mu}}$$

For this equation, $\hat{\mu}$ is the arithmetic mean of the data, $\hat{\sigma}_{\hat{\mu}}$ is the standard deviation of the mean, and $t_{(df,0.95)}$ is a quantile from Student's t distribution with *df* degrees of freedom and 0.95 confidence level.

For total alpha (AT) data, the upper limit will be used to test the null hypothesis that the mean concentration is greater than or equal to 41 μCi/g. If the upper limit is less than 41 μCi/g then the null hypothesis that the mean total alpha is greater than or equal to 41 μCi/g is rejected at the 0.05 level of significance. The summary statistics for the AT data are listed in Table 1 of this Attachment.

For DSC data, the upper limit will be used to test the null hypothesis that the mean concentration is greater than or equal to 480 Joules/g. If the upper limit is less than 480 Joules/g, then the null hypothesis that the mean DSC is greater than or equal to 480 Joules/g is rejected at the 0.05 level of significance. The summary statistics for the DSC data are listed in Table 2 of this Attachment.

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Table 1. AT (μCi/g) Summary Statistics.

Analyte	Portion	Riser	Grab Sample #	Labcore Sample #	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	95% UL
AT	Control Sample	1	6C-96-4	S96T001531	2.60E+00	3.00E-02	2.79E+00
AT	Control Sample	1	6C-96-7	S96T000546	2.73E+00	1.55E-01	3.70E+00
AT	Control Sample	1	6C-96-10	S96T000561	1.36E+00	2.05E-01	2.65E+00
AT	Control Sample	7	6C-96-11	S96T001678	1.56E+00	6.00E-02	1.94E+00
AT	Control Sample	7	6C-96-13	S96T001036	4.38E+00	1.96E+00	1.67E+01
AT	Filtered Centrifuged Solids	1	6C-96-4	S96T001541	3.22E+00	9.50E-02	3.81E+00
AT	Filtered Centrifuged Solids	1	6C-96-7	S96T000555	3.20E+00	1.35E-01	4.05E+00
AT	Filtered Centrifuged Solids	1	6C-96-10	S96T002718	3.57E+00	7.00E-02	4.01E+00
AT	Filtered Centrifuged Solids	7	6C-96-11	S96T001689	1.76E+00	8.00E-02	2.27E+00
AT	Filtered Centrifuged Solids	7	6C-96-13	S96T001563	3.64E+00	3.00E-02	3.83E+00
AT	Supernate	1	6C-96-5	S96T000539	1.15E+00	5.00E-03	1.18E+00
AT	Supernate	7	6C-96-12	S96T001024	9.04E-01	2.40E-02	1.06E+00

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Table 2. DSC (Joules/g Dry) Summary Statistics. (2 sheets)

Analyte	Portion	Riser	Grab Sample #	Labcore Sample #	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	95% UL
DSC	Centrifuged Solids	1	6C-96-4	S96T001527	2.70E+02	2.57E+02	8.74E+02
DSC	Centrifuged Solids	1	6C-96-7	S96T000542	1.10E+02	1.24E+01	1.88E+02
DSC	Centrifuged Solids	1	6C-96-10	S96T000558	0.00E+00	0.00E+00	0.00E+00
DSC	Centrifuged Solids	7	6C-96-11	S96T001674	7.11E+01	4.94E+01	3.83E+02
DSC	Centrifuged Solids	7	6C-96-13	S96T001030	2.43E+02	4.28E+01	5.13E+02
DSC	Control Sample	1	6C-96-4	S96T001530	0.00E+00	0.00E+00	0.00E+00
DSC	Control Sample	1	6C-96-7	S96T000543	0.00E+00	0.00E+00	0.00E+00
DSC	Control Sample	1	6C-96-10	S96T000560	0.00E+00	0.00E+00	0.00E+00
DSC	Control Sample	7	6C-96-11	S96T001676	2.35E+02	7.10E+00	2.80E+02
DSC	Control Sample	7	6C-96-13	S96T001034	1.12E+02	1.51E+01	2.07E+02
DSC	Filtered Centrifuged Solids	1	6C-96-4	S96T001537	0.00E+00	0.00E+00	0.00E+00
DSC	Filtered Centrifuged Solids	1	6C-96-7	S96T000551	3.25E+02	4.05E+00	3.51E+02
DSC	Filtered Centrifuged Solids	1	6C-96-10	S96T000567	1.11E+02	1.68E+01	2.17E+02
DSC	Filtered Centrifuged Solids	7	6C-96-11	S96T001685	0.00E+00	0.00E+00	0.00E+00
DSC	Filtered Centrifuged Solids	7	6C-96-13	S96T001559	0.00E+00	0.00E+00	0.00E+00
DSC	Interstitial Liquid	1	6C-96-4	S96T001544	0.00E+00	0.00E+00	0.00E+00
DSC	Interstitial Liquid	1	6C-96-7	S96T000545	0.00E+00	0.00E+00	0.00E+00
DSC	Interstitial Liquid	1	6C-96-10	S96T000563	0.00E+00	0.00E+00	0.00E+00
DSC	Interstitial Liquid	7	6C-96-11	S96T001681	1.03E+01	0.00E+00	1.03E+01
DSC	Interstitial Liquid	7	6C-96-13	S96T001566	4.45E+02	4.54E+01	7.31E+02
DSC	Potential Organic Layer	1	6C-96-7	S96T001548	0.00E+00	0.00E+00	0.00E+00
DSC	Potential Organic Layer	1	6C-96-10	S96T001567	5.87E+02	1.19E+02	1.34E+03
DSC	Potential Organic Layer	7	6C-96-11	S96T001679	0.00E+00	0.00E+00	0.00E+00
DSC	Potential Organic Layer	7	6C-96-13	S96T001553	6.81E+02	7.29E+01	1.14E+03
DSC	Sludge	1	6C-96-3	S96T001526	0.00E+00	0.00E+00	0.00E+00
DSC (N)	Sludge	1	6C-96-8	S96T002021	1.42E+02	7.12E+01	5.92E+02

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Table 2. DSC (Joules/g Dry) Summary Statistics. (2 sheets)

Analyte	Portion	Riser	Grab Sample #	Labcore Sample #	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	95% UL
DSC (Air)	Sludge	1	6C-96-8	S96T002042	0.00E+00	0.00E+00	0.00E+00
DSC (N)	Sludge	7	6C-96-14	S96T002350	1.27E+02	4.37E+01	4.03E+02
DSC (Air)	Sludge	7	6C-96-14	S96T002351	4.46E+02	4.20E+01	7.11E+02
DSC	Supernate	1	6C-96-5	S96T000538	0.00E+00	0.00E+00	0.00E+00
DSC	Supernate	7	6C-96-12	S96T001023	0.00E+00	0.00E+00	0.00E+00

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DATA COMPARISON - RANDOMIZED COMPLETE BLOCK DESIGN

Percent Water Comparison

Percent Water measurements were obtained from C-106 samples using two different analytical procedures (TGA and gravimetry). In order to determine if the two procedures give equivalent results, the percent water data were analyzed using a randomized complete block design, where the grab samples are the blocks. The methods associated with the randomized complete block design are extensions of the paired t-test.

Filtered Centrifuged Solids

Both analytical procedures were used to obtain percent water measurements for five filtered centrifuged solids samples (6C-96-4, 6C-96-7, 6C-96-10, 6C-96-11, and 6C-96-13). The ANOVA results (the model is $y_{ijk} = \mu + S_i + M_j + SM_{ij} + E_{ijk}$, where S is sample and M is method) for these data are presented in Table 1 of this Attachment.

Table 1. Percent Water Comparison: Filtered Centrifuged Solids (full model).

Source	DF	Type III SS	Mean Square	Expected Mean Square
S	4	593.88628	148.47157	$\sigma^2(E) + 4\,\sigma^2(S)$
M	1	34.37442	34.37442	$\sigma^2(E) + 2\,\sigma^2(MS) + 10\,\sigma^2(M)$
MS	4	18.63848	4.65962	$\sigma^2(E) + 2\,\sigma^2(MS)$
ERROR	10	51.77720	5.17772	$\sigma^2(E)$

From the ANOVA results (see expected mean square), the following can be tested.

- $\sigma^2(MS) = 0$
- $\sigma^2(M) = 0$
- $\sigma^2(S) = 0$

The test for $\sigma^2(M) = 0$ is used to determine if the two analytical procedures give equivalent results. The test statistic is computed by dividing mean square (method) by mean square (method by sample). For this set of data, the test statistic is 7.38 which has a p-value of

0.0533. This indicates that the two procedures are not significantly different at the 0.05 level of significance, but that the two procedures are significantly different at the 0.06 level of significance.

The test statistic to determine if $\sigma^2(MS) = 0$ is calculated by dividing the mean square (method by sample) by the mean square (error). This test statistic is 0.90 which has a p-value of 0.4994. This indicates that $\sigma^2(MS)$ is not significant. Therefore, the interaction term (MS) was deleted from the model.

The ANOVA results (model is $y_{ijk} = \mu + S_i + M_j + E_{ijk}$, where S is sample and M is method) for these data are presented in Table 2 of this Attachment. The test for $\sigma^2(M) = 0$ is used to determine if the two analytical procedures give equivalent results. The test statistic is computed by dividing mean square (method) by mean square (error). For this set of data, the test statistic is 6.83 which has a p-value of 0.0204. This indicates that the two procedures are significantly different from each other at the 0.05 level of significance.

Table 2. Percent Water Comparison: Filtered Centrifuged Solids (edited model).

Source	DF	Type III SS	Mean Square	Expected Mean Square
S	4	593.88628	148.47157	$\sigma^2(E) + 4\ \sigma^2(S)$
M	1	34.37442	34.37442	$\sigma^2(E) + 10\ \sigma^2(M)$
ERROR	14	70.41568	5.02969	$\sigma^2(E)$

Figure 1 of this Attachment illustrates the difference between the two analytical procedures for percent water.

Centrifuged Solids

Both analytical procedures were used to obtain percent water measurements for five centrifuged solids samples (6C-96-4, 6C-96-7, 6C-96-10, 6C-96-11, and 6C-96-13). The ANOVA results (the model is $y_{ijk} = \mu + S_i + M_j + SM_{ij} + E_{ijk}$, where S is sample and M is method) for these data are presented in Table 3 of this Attachment.

Table 3. Percent Water Comparison - Centrifuged Solids (full model).

Source	DF	Type III SS	Mean Square	Expected Mean Square
S	4	306.92017	76.73004	$\sigma^2(E) + 4\ \sigma^2(S)$
M	1	98.08020	98.08020	$\sigma^2(E) + 2\ \sigma^2(MS) + 10\ \sigma^2(M)$
MS	4	66.15217	16.53804	$\sigma^2(E) + 2\ \sigma^2(MS)$
ERROR	10	9.50035	0.95003	$\sigma^2(E)$

The test for $\sigma^2(M) = 0$ is used to determine if the two analytical procedures give equivalent results. The test statistic is computed by dividing mean square (method) by mean square (method by sample). For this set of data, the test statistic is 5.93 which has a p-value of 0.0716. This indicates that the two procedures are not significantly different at the 0.05 level of significance, but that the two procedures are significantly different at the 0.08 level of significance.

The test statistic to determine if $\sigma^2(MS) = 0$ is calculated by dividing the mean square (method by sample) by the mean square (error). This test statistic is 17.41 which has a p-value of 0.0002. This indicates that $\sigma^2(MS)$ is significant. Therefore, the interaction term (MS) was not deleted from the model.

Figure 2 of this Attachment illustrates the differences between the two analytical procedures for percent water.

<u>Supernate</u>

Both analytical procedures were used to obtain percent water measurements for two supernate samples (6C-96-5 and 6C-96-12). The ANOVA results (the model is $y_{ijk} = \mu + S_i + M_j + SM_{ij} + E_{ijk}$, where S is sample and M is method) for these data are presented in Table 4 of this Attachment.

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Table 4. Percent Water Comparison - Supernate (full model).

Source	DF	Type III SS	Mean Square	Expected Mean Square
S	1	8.0200125	8.0200125	$\sigma^2(E) + 4\ \sigma^2(S)$
M	1	0.0325125	0.0325125	$\sigma^2(E) + 2\ \sigma^2(MS) + 10\ \sigma^2(M)$
MS	1	0.3160125	0.3160125	$\sigma^2(E) + 2\ \sigma^2(MS)$
ERROR	4	0.0992500	0.0248125	$\sigma^2(E)$

The test for $\sigma^2(M) = 0$ is used to determine if the two analytical procedures give equivalent results. The test statistic is computed by dividing mean square (method) by mean square (method by sample). For this set of data, the test statistic is 0.10 which has a p-value of 0.8024. This indicates that the two procedures are not significantly different.

The test statistic to determine if $\sigma^2(MS) = 0$ is calculated by dividing the mean square (method by sample) by the mean square (error). This test statistic is 12.74 which has a p-value of 0.0234. This indicates that $\sigma^2(MS)$ is significant. Therefore, the interaction term (MS) was not deleted from the model.

Figure 3 of this Attachment illustrates the differences between the two analytical procedures for percent water.

Thermogravimetric Analysis Comparison

Thermogravimetric analysis can use two different atmospheres when measuring percent water. The first purges the sample with nitrogen and minimizes the oxygen available to the sample. The second method purges the sample with air. In order to determine if the two analysis methods give equivalent results, the TGA percent water data were analyzed using a randomized complete block design, where the grab samples are the blocks. The methods associated with the randomized complete block design are extensions of the paired t-test.

Sludge Samples

Both atmospheres were used to obtain TGA percent water measurements for two sludge samples (6C-96-8 and 6C-96-14). The ANOVA results (the model is $y_{ijk} = \mu + S_i + M_j + SM_{ij} + E_{ijk}$, where S is sample and M is method) for these data are presented in Table 5 of this Attachment.

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Table 5. TGA Nitrogen vs. Air Comparison - Sludge (full model).

Source	DF	Type III SS	Mean Square	Expected Mean Squares
S	1	42.95366	42.95366	$\sigma^2(E) + Q\sigma^2(S)$
M	1	8.42606	8.42606	$\sigma^2(E) + 2.2857\ \sigma^2(MS) + 4.5714\ \sigma^2(M)$
MS	1	110.08823	110.08823	$\sigma^2(E) + 2.2857\ \sigma^2(MS)$
ERROR	6	121.32430	20.22072	$\sigma^2(E)$

The test for $\sigma^2(M) = 0$ is used to determine if the two analytical procedures give equivalent results. The test statistic is computed by dividing mean square (method) by mean square (method by sample). For this set of data, the test statistic is 0.08 which has a p-value of 0.8269. This indicates that the two procedures are not significantly different.

The test statistic to determine if $\sigma^2(MS) = 0$ is calculated by dividing the mean square (method by sample) by the mean square (error). This test statistic is 5.44 which has a p-value of 0.0584. This indicates that $\sigma^2(MS)$ is not significant at the 0.05 level. Therefore, the interaction term (MS) was deleted from the model.

The ANOVA results (model is $y_{ijk} = \mu + S_i + M_j + E_{ijk}$, where S is sample and M is method) for these data are presented in Table 6 of this Attachment. The test for $\sigma^2(M) = 0$ is used to determine if the two analytical procedures give equivalent results. The test statistic is computed by dividing mean square (method) by mean square (error). For this set of data, the test statistic is 0.06 which has a p-value of 0.8122. This indicates that the two procedures are not significantly different from each other at the 0.05 level of significance.

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Table 6. TGA Nitrogen vs. Air Comparison - Sludge (edited model).

Source	DF	Type III SS	Mean Square	Expected Mean Square
S	1	26.085430	26.085430	$\sigma^2(E) + Q\sigma^2(S)$
M	1	2.011905	2.011905	$\sigma^2(E) + 4.5714\ \sigma^2(M)$
ERROR	7	231.412529	33.058933	

Figure 4 of this Attachment illustrates the difference between the two atmospheres for TGA percent water.

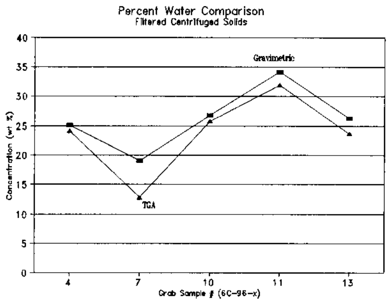

Figure 1 - Filtered Centrifuged Solids

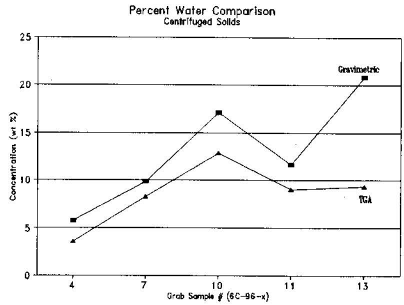

Figure 2 - Centrifuged Solids

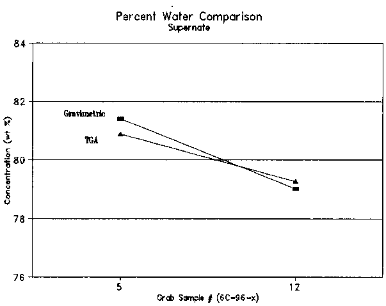

Figure 3 - Supernate

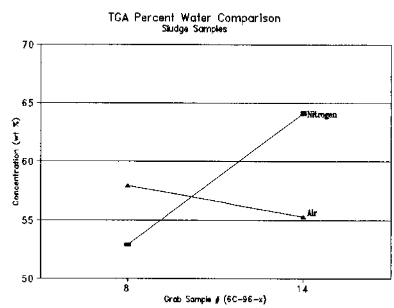

Figure 4 - TGA (Nitrogen vs. Air)

APPENDIX D

TANK 241-C-106 HISTORICAL ANALYTICAL RESULTS

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Table D-1. Sample from Tank 241-C-106.[1,2] (3 sheets)

Waste Tank 241-C-106		
Inorganic Analysis (KOH fusion)		
Component	Lab Value	Lab Unit
Ag	2,100	mg/kg
Al	115,000	mg/kg
As	390	mg/kg
B	350	mg/kg
Ba	350	mg/kg
Ca	1,900	mg/kg
Cd	n/a	mg/kg
Ce	490	mg/kg
Cr	1,750	mg/kg
Cu	300	mg/kg
Fe	82,400	mg/kg
Mg	420	mg/kg
Mn	4,500	mg/kg
Mo	n/a	mg/kg
Na	156,000	mg/kg
Nd	560	mg/kg
P	7,300	mg/kg
Pb	2,500	mg/kg
Sb	2,900	mg/kg
Se	1,400	mg/kg
Si	26,000	mg/kg
Sr	110	mg/kg
Ti	330	mg/kg
Tl	1,200	mg/kg

Table D-1. Sample from Tank 241-C-106.[1,2] (3 sheets)

U	944		mg/kg	
V	n/a		mg/kg	
Zn	n/a		mg/kg	
Zr	600		mg/kg	
Radionuclide Analysis				
Component	KOH fusion		Na_2O_2 fusion	
	Lab Value	Lab Unit	Lab Value	Lab Unit
Total α	4.13 x 10^3	nCi/g	3.99 x 10^3	nCi/g
Total ß as $^{90}Sr/^{90}Y$	8.83 x 10^6 8.56 x 10^6	nCi/g	8.56 x 10^6 8.15 x 10^6 8.34 x 10^6	nCi/g
^{137}Cs	4.82 x 10^5	nCi/g	5.04 x 10^5	nCi/g
^{60}Co	1.16 x 10^3	nCi/g	7.88 x 10^2	nCi/g
^{154}Eu	5.40 x 10^3	nCi/g	7.97 x 10^3	nCi/g
^{125}Sb	n/a	n/a	5.68 x 10^3	nCi/g
Component	Lab Value		Lab Unit	
^{227}Ac	<0.9		nCi/g	
^{242}Am	2,824 ± 98		nCi/g	
^{243}Am	19.2 ± 2.1		nCi/g	
^{242}Cm	10.5 ± 0.7		nCi/g	
^{244}Cm	129 ± 5		nCi/g	
^{238}Pu	422 ± 11		nCi/g	
^{239}Pu	2,340 ± 57		nCi/g	
^{242}Pu	<0.4		nCi/g	
^{135}Cs	n/a		nCi/g	
^{59}Ni	68 ± 14		nCi/g	
^{63}Ni	7,770 ± 1,508		nCi/g	
^{94}Nb	n/a		nCi/g	

Table D-1. Sample from Tank 241-C-106.[1,2] (3 sheets)

^{231}Pa	n/a	nCi/g
^{210}Pb	<0.3	nCi/g
^{210}Po	<0.002	nCi/g
^{226}Ra	<5	nCi/g
^{228}Ra	n/a	nCi/g
^{79}Se	0.95, 0.53 (replicate)	nCi/g
^{151}Sm	n/a	nCi/g

Note:

[1]Thomas et al. (1991)

[2]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

Table D-2. Sample from Tank 241-C-106.[1,2] (3 sheets)

SST Sample Characterization Results			
Analyzed August 24-25, 1988			
Physical Data			
Measurement	Sample		Blank
pH	10.47		8.46
% Solids	77.59		n/a
Chemical Analysis			
Component	Sample		Blank
	Lab Value	Lab Unit	
F	205	mg/kg	<3
Cl	255	mg/kg	<3
NO_2	26,320	mg/kg	6
NO_3	1,690	mg/kg	<26
PO_4	1,170	mg/kg	<13
SO_4	5,170	mg/kg	<26
Total Inorganic Carbon	18,900	mg/kg	178
Total Organic Carbon	7,500	mg/kg	385
Radiological Analysis			
Measurement	Lab Value		Lab Unit
Total α	7.8		μCi/kg
Total ß	9,330		μCi/kg
^{60}Co	1.15		μCi/kg
^{125}Sb	6.49		μCi/kg
^{137}Cs	536		μCi/kg
^{154}Eu	14.4		μCi/kg
^{99}Tc	0.055		μCi/kg
^{90}Sr	4,030		μCi/kg

Table D-2. Sample from Tank 241-C-106.[1,2] (3 sheets)

Cations by ICP (1.068 g, acid digestion to 200 mLs)			
Measurement	Sample		Blank
	Lab Value	Lab Unit	
Ag	104	mg/kg	5
Al	110	mg/kg	<1 g/kg
Ba	345	mg/kg	7
Ca	1,480	mg/kg	53
Cd	48	mg/kg	<2
Co	9.7	mg/kg	<5
Cr	1,560	mg/kg	<2
Cu	227	mg/kg	<5
Fe	78.2	g/kg	<0.1 g/kg
Mg	372	mg/kg	<29
Mn	4,130	mg/kg	<2
Na	16.1	g/kg	0.4 g/kg
Ni	1,450	mg/kg	<7
Si	2,580	mg/kg	116
V	12	mg/kg	<5
Zn	113	mg/kg	7
Zr	33.8	mg/kg	<5
Cations by GFAA (1.077 g, acid digestion to 200 mLs)			
Measurement	Sample		Blank
	Lab Value	Lab Unit	
As	37	mg/kg	<10
Be	0.72	mg/kg	<0.2
Pb	2,750	mg/kg	<200
Sb	<50	mg/kg	<50

Table D-2. Sample from Tank 241-C-106.[1,2] (3 sheets)

Se	<10	mg/kg	<1	
Tl	<10	mg/kg	<10	
Hg by AA (0.1831 g and 0.2139 g)				
Measurement	Sample		Blank	
	Lab Value	Lab Unit		
Hg	327	mg/kg	<1	
	42	mg/kg	4	
CN	60	mg/kg	Absorbance (0.029) zeroed out before std and sample run.	
Cations by ICP after EPA TOX (10.036 and 10.016 g + H.Ac → 201 mLs)				
Measurement	Sample		Sample + Sp (duplicate)	
	Lab Value	Lab Unit	Lab Value	Lab Unit
Ag	27	mg/kg	12	mg/kg
As	25	mg/kg	24	mg/kg
Ba	25	mg/kg	25	mg/kg
Cd	2	mg/kg	1	mg/kg
Cr	28	mg/kg	30	mg/kg
Hg	93	mg/kg	89	mg/kg
Ni	83	mg/kg	83	mg/kg
Pb	5	mg/kg	5	mg/kg
Se	<6	mg/kg	<6	mg/kg
Tl	15	mg/kg	15	mg/kg

Note:

[1]McCown (1988)

[2]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

Table D-3. Sample from Tank 241-C-106.[1,2] (4 sheets)

Analysis of Tank 106-C Core Sample		
Sample Received May 19, 1986		
Liquid Composite Sample		
Physical Data		
Component	Lab Value	Lab Unit
Visual	Dark gold	
pH	9.81	
Water loss	Room temp to 400°C	79.7%
	400°C to 1,000°C	2.45%
Volume (total)	80	mL
Density	1.22	g/mL
Viscosity	3.66	cP
Chemical Analysis		
Ag	10.1	mg/L
Al	34.3	mg/L
Ba	5	mg/L
Bi	111	mg/L
Bo	10.4	mg/L
Ca	11.4	mg/L
Cd	25.2	mg/L
Cr	6.2	mg/L
Cu	3.3	mg/L
Fe	12.4	mg/L
K	422	mg/L
Mg	12.8	mg/L
Mn	202	mg/L
Na	94,900	mg/L
Ni	71.5	mg/L
NO_3	0.023	moles/L
P	344	mg/L
Pb	81.8	mg/L

Table D-3. Sample from Tank 241-C-106.[1,2] (4 sheets)

Si	105	mg/L
Total organic carbon	2,520	mg/L
Zr	293	mg/L
Radiological Analysis		
Radiation	100	mR/hr
Total Gamma	27,800	μCi/L
U	958	mg/L
$^{239/240}Pu$	978	μCi/L
^{14}C	0.35	μCi/L
^{90}Sr	1,650	μCi/L
^{99}Tc	141	μCi/L
^{241}Am	13.9	μCi/L
^{60}Co	12.7	μCi/L
^{137}Cs	27,800	μCi/L
Solid Composite Sample		
Physical Data		
Bulk Density	1.55 g/mL	
Radiation	10,000 mR/hr	
Specific Heat	Nondetectable	
Softening Point	Nondetectable	
Particle Size	9.0 μm mean population; 75.4μm at 50% of total by volume	
Viscosity	Analysis not obtained	
Component	**Water Soluble**	**Maximum Total**
Visual	Clear, bright yellow	Brown solids
Total Mass	n/a	1,220 g
Mass Loss: Room to 400°C	n/a	52.5%
Mass Loss: 400°C to 1000°C	n/a	7.24%

Table D-3. Sample from Tank 241-C-106.[1,2] (4 sheets)

Component	Water Soluble		Maximum Total	
	Lab Value	Lab Unit	Lab Value	Lab Unit
Chemical Analysis				
Ag	529	μg/g	529	μg/g
Al	40,900	μg/g	40,900	μg/g
Ba	4,890	μg/g	4,890	μg/g
B	19.5	μg/g	19.5	μg/g
Bi	52.7	μg/g	501	μg/g
Ca	11,900	μg/g	11,900	μg/g
Cd	12.0	μg/g	370	μg/g
Co	4.81	μg/g	4.81	μg/g
Cr	984	μg/g	984	μg/g
Cu	128	μg/g	128	μg/g
Fe	52,100	μg/g	52,100	μg/g
K	1,470	μg/g	1,470	μg/g
Mg	6,560	μg/g	6,560	μg/g
Mn	1,840	μg/g	1,840	μg/g
Na	117,000	μg/g	117,000	μg/g
Ni	973	μg/g	973	μg/g
NO_3	928	μg/g	928	μg/g
P	2,910	μg/g	2,910	μg/g
Pb	1,060	μg/g	1,060	μg/g
Si	71,000	μg/g	71,000	μg/g
Sr	103	μg/g	103	μg/g
Total organic carbon	4,620	μg/g	4,620	μg/g
U	409	μg/g	409	μg/g
Zn	46.3	μg/g	46.3	μg/g
Zr	2,170	μg/g	2,170	μg/g
Radiological Analysis				
Total Gamma	363	μCi/g	363	μCi/g
$^{239/240}Pu$	3.05	μCi/g	3.05	μCi/g

Table D-3. Sample from Tank 241-C-106.[1,2] (4 sheets)

^{14}C	0.0002	μCi/g	0.0002	μCi/g
^{90}Sr	1,980	μCi/g	1,980	μCi/g
^{99}Tc	0.14	μCi/g	0.14	μCi/g
^{241}Am	Analysis not obtained		1.05	μCi/g
^{60}Co	0.56	μCi/g	0.88	μCi/g
^{137}Cs	330	μCi/g	330	μCi/g
^{129}I	0.00008	μCi/g	0.00008	μCi/g

Note:

[1]Pauly and Torgerson (1987)

[2]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

Table D-4. Characteristics of Tank C-106 Wastes.[1,2] (2 sheets)

Waste Tank 241-C-106		
Received January 1980		
Sampling		
Waste Group Number	9	
Primary Waste Source	Purex	
Date Sampled	1/80	
Depth of Waste in Tank	185 cm	
Depth of Waste Recovered	46 cm	
Analysis (wt% of total sample, unless otherwise noted)		
Ion/Radionuclide	Water Soluble	Water Insoluble
Al	n/a	3.00
Bi	0.200	7.68×10^{-2}
Cd	n/a	2.10×10^{-2}
Cl	<0.65 5.12×10^{-2}	n/a
CO_3	9.19	n/a
Cr	3.32×10^{-2}	0.135
F	7.20×10^{-3} 5.33×10^{-2}	8.58×10^{-3}
Fe	n/a	6.41
Hg	Deleted	Deleted
La	n/a	0.596
Mn	n/a	1.41
Na	7.60×10^{-4}	3.58
Ni	8.90×10^{-2}	$<6.79 \times 10^{-2}$
NO_3	1.57	<0.133
OH	n/a	n/a
Pb	<0.168	n/a
PO_4	1.11 0.291	9.37 0.160
SO_4	0.352	9.36×10^{-2}

Table D-4. Characteristics of Tank C-106 Wastes.[1,2] (2 sheets)

Si	0.258	2.06
Zr	n/a	<7.35 x 10^{-2}
Mg	n/a	4.61 x 10^{-2} 6.99 x 10^{-2}
Organic Carbon, g/g	2.00 x 10^{-2}	Deleted
^{241}Am, g/g	n/a	n/a
^{137}Cs, µCi/g	97.9	2.13 x 10^{2}
Pu, g/g	2.24 x 10^{-7}	8.90 x 10^{-5}
$^{89+90}$Sr, µCi/g	1.33 x 10^{2}	6.47 x 10^{3}
U, g/g	1.62 x 10^{-2}	8.8 x 10^{-8}

Physical Properties of Tank C-106 Wastes

Analysis	Segment				Composite
	1	2	3	4	
Sample Amount	200 mL liquid, 25 cm sludge	1 mL liquid, 20 cm sludge	5 cm sludge		
Percent Water (wt%)	45.0	45.5	40.8	38.6	45.3
Bulk Density (g/cm^3)	1.220	1.324	1.579	1.485	1.365
Particle Density (g/cm^3)	0.727	1.082	1.495	1.140	1.121
Water Solubility (wt%)	48.7	83.9	50.7	38.4	69.4

Note:

[1]Jungfleisch (1980) and Bratzel (1980)

[2]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

Table D-5. Sludge Sample from Tank 241-C-106.[1,2] (2 sheets)

Waste Tank 241-C-106		
Sample Received January 24, 1977		
Physical Data		
Component	Lab Value	Lab Unit
Bulk Density	2.44	g/cc
Particle Density	1.47	g/cc
$\%H_2O$	39.0	
Chemical Analysis		
Al	3.5	moles/L
Cr	0.2	moles/L
Ba	<0.04	moles/L
Fe	2.2	moles/L
NO_3	<0.7	moles/L
Cd	<0.01	moles/L
Na	4.9	moles/L
Ni	0.4	moles/L
Mg	0.06	moles/L
Mn	0.2	moles/L
Si	1.7	moles/L
PO_4	1.9	moles/L
SO_4	<0.8	moles/L
Radiological Analysis		
U	0.004	g/L
Pu	0.06	g/L
$^{89+90}Sr$	1.21×10^7	μCi/L
^{137}Cs	5.45×10^5	μCi/L
^{125}Sb	1.26×10^5	μCi/L
^{144}Ce	1.97×10^5	μCi/L
^{155}Eu	1.23×10^5	μCi/L
Particle Size Distribution		

Table D-5. Sludge Sample from Tank 241-C-106.[1,2] (2 sheets)

Particle Size (μm)	Average Diameter (μm)	Weight Percent
5-10	8.25	36.0
10-15	12.98	11.0
15-20	17.85	5.0
20-25	22.8	12.0
25-30	27.7	4.0
30-35	32.7	0.8
35-40	37.7	8.0
45-45	42.7	10.8
45-50	47.6	7.4
50-55	52.6	6.1
55-60	57.6	0
60-65	62.6	0
65-70	67.6	0

Note:

[1]Horton (1977)

[2]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

Table D-6. Sample from Tank 241-C-106.[1,2] (2 sheets)

Waste Tank 241-C-106		
Sample T-3294, Received March 15, 1976		
Physical Data		
Vis-OTR	Dark brown, 1% solids, 1500 mr/hr	
DTA	No exotherm below 200°C, exotherm at 255°C	
pH	10.1	
SpG	1.162	
% Water	77.43	
Chemical Analysis		
Component	Lab Value	Lab Unit
OH	0.324	moles/L
NO_3	1.67	moles/L
NO_2	6.49×10^{-2}	moles/L
CO_3	0.310	moles/L
PO_4	cancelled	n/a
SO_4	unable to run	n/a
Cl	4.15×10^{-3}	moles/L
F	1.67×10^{-3}	moles/L
Al	8.35×10^{-3}	moles/L
Na	5.54	moles/L
Cu	2.65×10^{-4}	moles/L
Pb	6.90×10^{-4}	moles/L
Hg	1.02×10^{-4}	moles/L
Pu	1.06×10^{-3}	g/gal
Radiological Analysis		
$^{89+90}Sr$	2.54×10^{5}	µCi/gal
^{134}Cs	4.43×10^{3}	µCi/gal
^{137}Cs	4.03×10^{5}	µCi/gal
^{60}Co	1.21×10^{4}	µCi/gal
^{154}Eu	3.53×10^{4}	µCi/gal

Table D-6. Sample from Tank 241-C-106.[1,2] (2 sheets)

^{125}Sb	2.17×10^4	µCi/gal
^{144}Ce	3.26×10^5	µCi/gal
^{144}Pr	3.44×10^5	µCi/gal
^{155}Eu	9.29×10^4	µCi/gal

Note:

[1]ARHCO (1976)

[2]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

Table D-7. Sample from Tank 241-C-106.[1,2] (2 sheets)

Waste Tank 241-C-106		
Sample T-8059, Received September 15, 1976		
Physical Data		
Vis-OTR	Dark brown, cruddy, 350 mr/hr	
DTA	No exotherm below 200°C, started up at 185°C, exotherms at 225°C and 255°C	
pH	10.7	
SpG	1.180 @ 62°C	
Chemical Analysis		
Component	Lab Value	Lab Units
OH	$<2.85 \times 10^{-2}$	moles/L
Al	1.86×10^{-2}	moles/L
Na	3.54	moles/L
NO_2	0.288	moles/L
NO_3	1.81	moles/L
SO_4	cancelled	n/a
PO_4	8.90×10^{-3}	moles/L
Cl	2.26×10^{-2}	moles/L
F	7.83×10^{-4}	moles/L
CO_3	0.564	moles/L
Pu	1.74×10^{-3}	g/gal
Radiological Analysis		
^{60}Co	5.48×10^{3}	µCi/gal
^{125}Sb	1.13×10^{4}	µCi/gal
$^{144}CePr$	5.15×10^{5}	µCi/gal
^{134}Cs	4.69×10^{3}	µCi/gal

Table D-7. Sample from Tank 241-C-106.[1,2] (2 sheets)

^{137}Cs	6.36 x 10^5	μCi/gal
^{155}Eu	1.38 x 10^4	μCi/gal

Note:

[1]Wheeler (1976a)

[2]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

Table D-8. Sample from Tank 241-C-106.[1,2]

Waste Tank 241-C-106		
Sample T-7808, Received September 8, 1975		
Physical Data		
Vis-OTR	Brown, cruddy, 20% solids, 1 rad/hr	
DTA	No exotherm below 200°C, medium exotherm from 200°C to 375°C	
pH	10.4	
SpG	1.140 @ 64°C	
Chemical Analysis		
Component	Lab Value	Lab Unit
OH	<2.85 x 10^{-2}	moles/L
Al	1.18 x 10^{-2}	moles/L
Na	3.21	moles/L
NO_2	0.283	moles/L
NO_3	1.66	moles/L
PO_4	1.38 x 10^{-2}	moles/L
Cl	2.12 x 10^{-2}	moles/L
F	8.40 x 10^{-4}	moles/L
CO_3	0.585	moles/L
Pu	2.69 x 10^{-3}	g/gal
Radiological Analysis		
^{60}Co	4.76 x 10^{3}	µCi/gal
^{125}Sb	2.67 x 10^{4}	µCi/gal
^{134}Cs	4.72 x 10^{3}	µCi/gal
^{137}Cs	6.76 x 10^{5}	µCi/gal
^{144}CePr	1.10 x 10^{5}	µCi/gal
^{154}Eu	1.26 x 10^{4}	µCi/gal
$^{89+90}$Sr	8.82 x 10^{5}	µCi/gal

Note:

[1]Wheeler (1976b)

[2]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

Table D-9. Sludge Sample from Tank 241-C-106.[1,2] (3 sheets)

Waste Tank 241-C-106		
Received: October 10, 1974		
Chemical Analysis of 106-C "As Received" Sludge		
Component	Lab Value	Lab Unit
Si	0.136	moles/L
Fe	1.78	moles/L
Mn	0.55	moles/L
Mg	0.09	moles/L
Ca	0.20	moles/L
Ba	<0.04	moles/L
Al	34.02	moles/L
Sr[M]	0.006	moles/L
Pu	0.06	g/L
$^{89+90}Sr$	1.88×10^7	µCi/L
^{137}Cs	8.62×10^5	µCi/L
Particle Size Distribution		
Particle size (µm)	Average Diameter (µm)	Weight Percent
5 - 10	8.25	12.4
10 - 15	12.98	21.3
15 - 20	17.85	22.5
20 - 25	22.8	18.1
25 - 30	27.7	8.6
30 - 35	32.7	3.1
35 - 40	37.7	1.8
40 - 45	42.7	1.7
45 - 50	47.6	1.0
50 - 55	52.6	1.7
55 - 60	57.6	0.6
60 - 65	62.6	2.2
65 - 70	67.6	0.7

Table D-9. Sludge Sample from Tank 241-C-106.[1,2] (3 sheets)

70 - 75	72.6	0.9
75 - 80	77.6	2.2
80 - 90	85.3	0.3
90 - 100	95.3	0.4
Analysis of 106-C Supernate		
Component	Lab Value	Lab Unit
%H_2O	74.6	wt%
Density	1.21	g/mL
$NaNO_2$	0.42	moles/L
$NaNO_3$	1.51	moles/L
Na_2CO_3	0.43	moles/L
NaOH	0.52	moles/L
$NaAlO_2$	2.31×10^{-2}	moles/L
Fe	4.41×10^{-2}	moles/L
Na_3PO_4	4.28×10^{-2}	moles/L
Si	1.41×10^{-3}	moles/L
$^{89+90}Sr$	4.60×10^{5}	μCi/L
^{137}Cs	2.40×10^{4}	μCi/L
^{134}Cs	1.41×10^{2}	μCi/L
^{154}Eu	1.32×10^{2}	μCi/L
^{60}Co	34.1	μCi/L
Analysis of 106-C PAS		
Component	Lab Value	Lab Unit
Si	0.11	moles/L
$^{89+90}Sr$	5.38×10^{6}	μCi/L
^{137}Cs	1.25×10^{5}	μCi/L
^{134}Cs	1.48×10^{3}	μCi/L
^{154}Eu	6.64×10^{3}	μCi/L

Table D-9. Sludge Sample from Tank 241-C-106.[1,2] (3 sheets)

Location of Strontium in PAS-Caustic Acid and Solids Fusion		
	$^{89+90}Sr$ (μCi/L)	Curies (percent)
Total	7.98 x 10^4	100
PAS	6.46 x 10^4	81.0
Caustic Acid Liquid	8.25 x 10^3	10.3
Solids Fusion	6.98 s 10^3	8.7

Note:

[1]Horton (1975) and Horton (1977)

[2]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

APPENDIX E

COMPARISON OF TANK 241-C-106 GRAB SAMPLES WITH 1986 CORE SAMPLE AND THERMAL MODELING

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The February/March 1996 grab samples from tank 241-C-106 have been analyzed for ^{90}Sr and ^{137}Cs content. A comparison of the total heat source estimates based on these samples, the sample taken in 1986, and the value used in the thermal modeling has been done. This comparison is shown in the tables below.

The total heat source estimates used in the thermal modeling are based on two main sources of measured data. An estimate of 32,200 ± 5,900 W (110,000 ± 20,000 Btu/hr) was calculated using the temperature data obtained during the ventilation outage in 1992 (Bander 1993a). A more recent estimate of 38,700 W (132,000 Btu/hr) was calculated using the surface level and temperature data obtained during and following the 1994 process test (Ogden et al. 1996). The thermal models assume three layers of sludge, which have different thermal properties and concentrations of heat generation radionuclides.

The grab samples of the sludge were taken primarily from depths above 104 cm. (41 in.) below the surface of the waste. This region is part of the top layer of sludge used in the thermal modeling which was formed from the noncomplexed waste added to the tank between 1977 and 1979. This layer consists of relatively low amounts of heat generation materials compared to the amounts in the two layers below it, as used in the thermal models.

Since there is some uncertainty in the representativeness of the grab samples, three possible cases were assumed for determining the total heat load in tank 241-C-106. The three cases were assessed separately for the two risers from which the grab samples were taken. The concentrations of ^{137}Cs and ^{90}Sr were assumed to have the following distributions in the three layers used in the thermal models. Calculations are presented for both the maximum and average measured values in the first case, and for the maximum measured values in the second and third cases.

Case 1: Both radionuclides are uniformly distributed in the three layers of sludge using the measured values.

Case 2: The ^{137}Cs is uniformly distributed in the three layers of sludge using the measured values. The ^{90}Sr is uniformly distributed using the measured values in the top layer and 4.2 times the measured values in the bottom two layers ("homogenized" values for ^{90}Sr in Tables E-1 and E-2).

Case 3: Both radionuclides are uniformly distributed using the measured values in the top layer and 4.2 times the measured values in the bottom two layers ("homogenized" values for ^{137}Cs and ^{90}Sr in Tables E-1 and E-2).

Case 2 was considered because ^{137}Cs is more soluble in liquid than ^{90}Sr. Case 3 is the distribution determined from the thermal modeling (Bander 1993b).

The core sample taken in 1986 from riser #1 was analyzed after homogenizing the entire sample. Therefore in order to compare the 1996 samples and the 1986 homogenized sample an estimate of the strontium and cesium concentrations for a homogenized sample of the

1996 samples was done. The calculations of homogenized concentrations for the 1996 samples assume that the ratio of the radionuclide concentrations between the bottom two layers and the top layer is the same as that used in the thermal modeling (a ratio of 4.2). The volumes of the sludge layers assumed in calculating homogenized 1996 concentrations are those used in the thermal model (400 kL [105 kgal] in the bottom two layers and 350 kL [92 kgal] in the top layer).

Table E-1 shows concentrations of ^{90}Sr and ^{137}Cs for the three cases described above using the maximum measured values of the 1996 samples and the 1986 "homogenized" values. The concentration of ^{90}Sr in the 1986 sample compared to the 1996 samples is higher for case 1 and lower for cases 2 and 3. The ^{137}Cs comparison indicates much higher concentrations in the 1996 samples compared to the 1986 sample.

Table E-1 Maximum value of Strontium and Cesium for 1996 samples (1986 sample decayed to 1996).

	1996 samples				1986 sample[1]	
	Riser #1		Riser #7		Riser #1	
	^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs
case 1						
sludge (μCi/g)	693	644	862	890	1611	269
liquid (μCi/mL)	0.932	158	0.669	128.5	1.34	22.6
case 2						
sludge (μCi/g)	1878	644	2336	890	1611	269
liquid (μCi/mL)	2.53	158	1.81	128.5	1.34	22.6
case 3						
sludge (μCi/g)	1878	1745	2336	2412	1611	269
liquid (μCi/mL)	2.53	428	1.81	348	1.34	22.6

Notes:

case 1: Uniform concentration of ^{137}Cs and ^{90}Sr throughout waste.
case 2: Uniform concentration of ^{137}Cs throughout waste and "homogenized" concentration of ^{90}Sr.
case 3: "Homogenized" concentration of ^{137}Cs and ^{90}Sr throughout waste.

[1]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

Table E-2 shows concentrations of ^{90}Sr and ^{137}Cs for the three cases described above using the average of the measured values of the 1996 samples and the 1986 "homogenized" values. The concentration of ^{90}Sr in the 1986 sample compared to the 1996 samples is higher for case 1 and about equal for cases 2 and 3. The ^{137}Cs comparison again indicates much higher concentrations in the 1996 samples compared to the 1986 sample.

Table E-2. Average value of Strontium and Cesium for 1996 samples (1986 sample decayed to 1996).

	1996 samples				1986 sample[1]	
	Riser #1		Riser #7		Riser #1	
	^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs	^{90}Sr	^{137}Cs
case 1						
sludge (μCi/g)	488	516	603	656	1611	269
liquid (μCi/mL)	0.760	127	0.413	121	1.34	22.6

Notes:

[1]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

Table E-3 shows the total heat source calculated for the three cases described above using the maximum measured values and the average of the measured values compared to the total heat source calculated from the 1986 sample and the thermal model (Bander 1993a). The total heat source calculations for cases 1 and 2 fall below the value used in the thermal model, with up to a factor of 4 difference. Only the calculation of case 3 from riser #7 is higher than the thermal model value. If the most recent estimate of the total heat load in tank 241-C-106 was used (Ogden et al. 1996) then all the total heat load estimates calculated from the samples would fall below the thermal model.

Table E-3. Total Heat Source (W [Btu/hr]) (1986 sample and thermal model decayed to 1996)

	1996 samples		1986 sample[1]	thermal model (32,200 [110,000] in 1992)
	Riser #1	Riser #7	Riser #1	
Maximum of measured values				
case 1	9,200 (31,500)	12,000 (41,000)	14,500 (49,600)	29,200 (99,800)
case 2	18,900 (64,400)	23,900 (81,700)	14,500 (49,600)	29,200 (99,800)
case 3	25,200 (86,000)	32,620 (111,400)	14,500 (49,600)	29,200 (99,800)
Average of measured values				
case 1	6,880 (23,500)	8,610 (29,400)	14,500 (49,600)	29,200 (99,800)

Notes:

[1]Because data generated before 1989 may not be considered valid for some applications under the constraints of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), these results are presented merely as supporting evidence; no direct conclusions are to be drawn based solely on these results.

The variability in the sample values and the uncertainties in the radionuclide distribution both vertically and horizontally in the sludge can account for the differences in the estimates of total heat source from the 1996 samples, the 1986 sample, and the thermal modeling. Also, there is the question of how representative the small volume of samples obtained is of the total volume of waste. The comparison of temperature measurements and especially the rate of water loss used in the thermal models is more representative of the total heat source in tank 241-C-106.

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