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7. 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-101. This report supports the requirements of Tri-Party Agreement Milestone M-44-08.

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EXECUTIVE SUMMARY

This tank characterization report summarizes the information concerning the historical uses and present status of single-shell underground storage tank 241-C-101. It also presents information concerning sampling and analysis of the waste in the tank. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order* Milestone M-44-08 (Ecology et al. 1994).

Tank 241-C-101 is one of 16 underground storage tanks located in the C Tank Farm in the 200 East Area of the Hanford Site. The tank went into service in 1946 and received metal waste (MW) from the Bismuth Phosphate process at the B-Plant Facility. Other wastes routed to it include uranium recovery waste, and cladding waste. These waste types, along with waste of unknown composition, comprise the sludge currently remaining in the tank. The tank was declared an assumed leaker in 1980. Intrusion prevention measures were implemented in 1982. The tank was interim stabilized in 1983. The tank is not on a watch list and has no associated unreviewed safety questions.

A description of the tank and its status are summarized in Table ES-1 and Figures ES-1 and ES-2. The tank, which has an operating capacity of 2,010 kL (530 kgal), contains 333 kL (88 kgal) of non-complexed sludge, of which 11.4 kL (3 kgal) are interstitial liquid (Hanlon 1995). No supernatant remains.

Table ES-1. Description and Status of Tank 241-C-101.

Tank description	
Type	Single-Shell
Constructed	1943-1944
In-service	1946
Diameter	23 m (75 ft)
Usable depth	5.2 m (17 ft)
Capacity	2,010 kL (530 kgal)
Bottom shape	Dished
Ventilation	Passive
Tank status (as of April 1995)	
Total waste volume	330 kL (88 kgal)
Sludge volume	330 kL (88 kgal)
Interstitial liquid	11 kL (3 kgal)
Supernatant volume	0 kL (0 kgal)
Waste surface level (4/1/95)	58 cm (23 in.)
Temperature (1/74 - 1/94)	15 °C (55 °F) to 44 °C (111 °F)
Integrity	Assumed leaker
Watched list classification	Non-watch list
Waste classification	Non-complexed
Sampling dates	
Auger sampled	March 1995
Service status	
Removed from service	1976
Interim stabilized	1983
Intrusion prevention	1982

Notes:
m = meter.
ft = foot.
kL = kiloliter.
kgal = kilogallon.
mm = millimeter.
in = inch.
C = Celsius.
F = Fahrenheit.

[1]Hanlon, B. M., 1995, *Waste Tank Summary Report for Month Ending April 30, 1995*, WHC-EP-0182-80, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Figure ES-1. Tank 241-C-101.

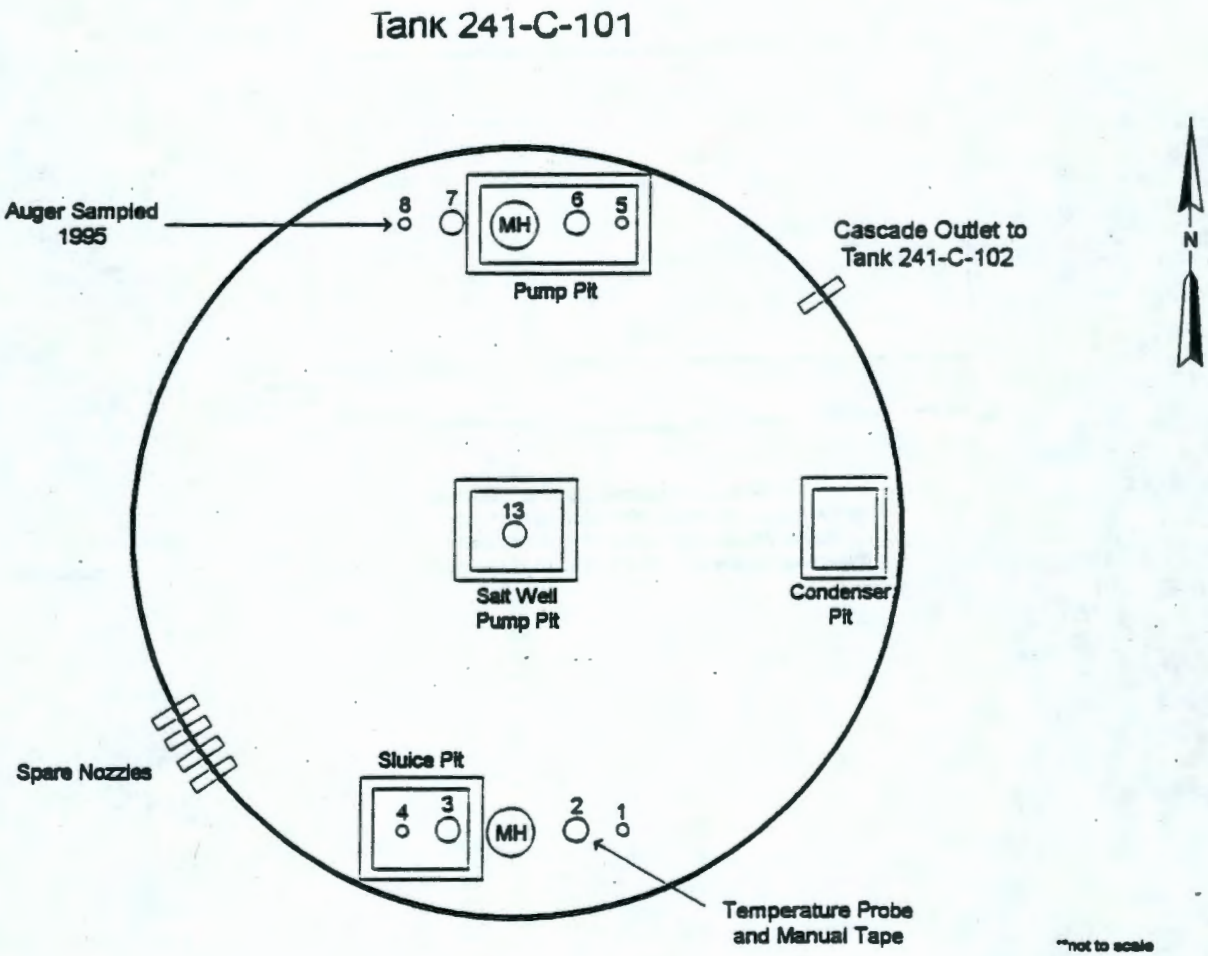
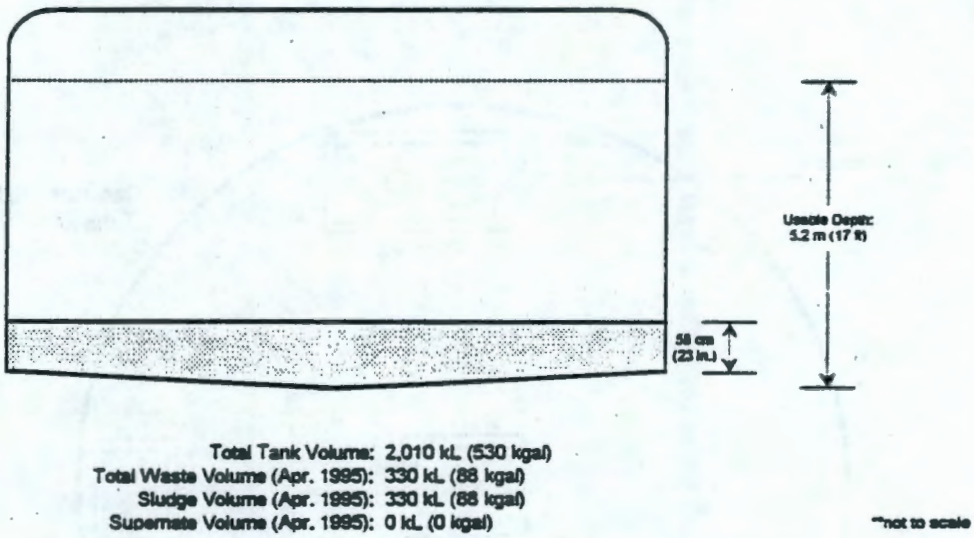


Figure ES-2. Waste Profile of Tank 241-C-101.



This report also summarizes the only available sampling event, an auger sample obtained in March 1995. Total alpha activity, percent water, and energetic properties of the measured in accordance with WHC-SD-WM-SP-004, *Tank Safety Screening Data Quality obtained in March Objective* (Babad and Redus 1994). In addition, Characterization Plant waste were Engineering and Characterization Process Control requested that measurements of pH, total organic carbon, total inorganic carbon, and bulk density be performed.

The waste subsamples, as measured by differential scanning calorimetry, exhibited no exothermic reactions. The percent water ranged from 15.4 to 33.9 percent for the solids phase of the waste. Values less than 17 percent are below the minimum required by the Tank Safety Screening Data Quality Objective. Proper notifications concerning the low percent water results were made on May 3, 1995 (Sasaki 1995). The total alpha activity ranged from 0.955 to 1.18 μCi/g, well below the maximum limit of 34.4 μCi/g. The maximum total organic carbon value from the drainable liquid phase of the auger sample was 3,990 μg C/g, well below the limit of 30,000 μg C/g specified in WHC-SD-WM-DQO-006, *Data Quality Objective to Support Resolution of the Organic Fuel Rich Tank Safety Issue* (Babad et al. 1994). The maximum weekly temperature readings in the tank since 1974 fluctuate between 13 °C (55 °F) and 44 °C (111 °F). The temperature readings indicate that the heat load in the tank is not excessive and is adequately dissipated. Vapor space sampling and analysis results will be included in future revisions to this report.

The waste characteristics, physical properties, best estimates for the chemical and radiochemical composition, and the total tank inventory are summarized in Table ES-2.

Table ES-2. Tank 241-C-101 Major Analytes and Inventory Estimates.

Physical properties	Results	
Total waste volume[a]	333 kL (88 kgal)	
Total waste mass[a]	5.96 E+05	
Density[a]	1.79 g/ml	
Percent water (by weight)[a]	24.0	
Heat load[b]	0.0110 kW (38 Btu/hr)	
Chemical constituents	Concentration	Inventory
Metals[b]	μg/g	kg
Aluminum	42,000	25,000
Iron	75,800	45,200
Sodium	52,800	31,500
Uranium	28,700	17,100
Anions[b]	μg/g	kg
Carbonate	10,300	6,140
Hydroxide	1.65 E+05	98,400
Nitrate	62,700	57,400
Sulfate	39,600	23,600
Organics[a]	μg C/ml	kg
Total organic carbon	1,260	420
Total inorganic carbon	3,990	1,330
Radionuclides	μCi/g	Ci
Total alpha[a]	1.09	650
Plutonium[b]	0.512	305 (4,920 kg)
Cesium[b]	0.856	415
Strontium[b]	2.78	1,350

Note: 1 Ci = 3.7 E+10 Bq.

[a]Results taken from analysis of March 1995 safety screening auger (Sasaki, L. M., 1995, *45-Day Safety Screen Results for Tank 241-C-101, Auger Sample 95-AUG-019*, WHC-SD-WM-DP-111, Westinghouse Hanford Company, Richland, Washington).

[b]Results taken from C. H. Brevick, L. A. Gaddis, and W. W. Pickett, 1994, *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 East Areas*, WHC-SD-WM-ER-349, Rev. 0, ICF Kaiser Hanford Company, Richland, Washington.

[c]Assumes all plutonium is ^{239}Pu isotope.

Based on the tank's waste transfer history, the sludge is projected to contain high concentrations of aluminum, hydroxide, iron, nitrate, sodium, and uranium (Brevick et al. 1995). The operating history of the tank includes receipt of cladding waste from PUREX, uranium recovery waste, and metal waste from B Plant. An estimated 17 percent of the tank's waste volume is of unknown origin according to the tank layer model (Agnew et al. 1994).

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CONTENTS

1.0 INTRODUCTION 1-1
1.1 PURPOSE 1-1
1.2 SCOPE 1-1

2.0 HISTORICAL TANK INFORMATION 2-1
2.1 TANK STATUS 2-1
2.2 TANK DESIGN AND BACKGROUND 2-2
2.3 PROCESS KNOWLEDGE 2-6
2.3.1 Waste Transfer History 2-6
2.3.2 Historical Estimation of Tank Contents 2-10
2.4 SURVEILLANCE DATA 2-12
2.4.1 Surface Level Readings 2-12
2.4.2 Internal Tank Temperatures 2-14
2.4.3 Tank 241-C-101 Photographs 2-14

3.0 TANK SAMPLING OVERVIEW 3-1
3.1 DESCRIPTION OF 1995 AUGER SAMPLING EVENT 3-1
3.1.1 1995 Auger Sample Handling 3-1
3.1.2 1995 Auger Sample Analysis 3-1

4.0 ANALYTICAL RESULTS 4-1
4.1 OVERVIEW 4-1
4.2 DATA PRESENTATION 4-1
4.2.1 Total Alpha 4-1
4.2.2 Total Carbon 4-2
4.3 PHYSICAL MEASUREMENT RESULTS 4-3
4.3.1 Density and pH 4-3
4.3.2 Thermogravimetric Analysis 4-3
4.3.3 Differential Scanning Calorimetry 4-4

5.0 INTERPRETATION OF CHARACTERIZATION RESULTS 5-1
5.1 ASSESSMENT OF SAMPLING AND ANALYTICAL RESULTS 5-1
5.1.1 Field Observations 5-1
5.1.2 Quality Control Assessment 5-1
5.1.3 Data Consistency Checks 5-3
5.2 COMPARISON OF ANALYTICAL DATA 5-4
5.3 TANK WASTE PROFILE 5-4
5.4 COMPARISON OF ANALYTICAL AND HISTORICAL DATA 5-5
5.5 EVALUATION OF PROGRAM REQUIREMENTS 5-5
5.5.1 Safety Evaluation 5-6

CONTENTS (Continued)

6.0 CONCLUSIONS AND RECOMMENDATIONS 6-1

7.0 REFERENCES 7-1

APPENDIXES

A SURFACE LEVEL MEASUREMENTS FOR TANK 241-C-101 FROM 1991 THROUGH 1993 . . . . . A-1

B CALCULATION TO DETERMINE EQUILIBRIUM CONCENTRATION OF CO_2 IN THE VAPOR SPACE OF TANK 241-C-101 . . . . . B-1

LIST OF FIGURES

2-1 Riser Configuration of Tank 241-C-101 2-4

2-2 Tank 241-C-101 Configuration 2-5

2-3 Tank Level History 2-9

2-4 Tank Layer Model 2-11

2-5 Tank 241-C-101 2-15

2-6 Tank 241-C-101 Weekly High Temperature Plot 2-16

2-7 Photo Montage of Tank 241-C-101 Waste Surface 2-17

LIST OF TABLES

2-1 Summary Tank Contents Status 2-1

2-2 Tank 241-C-101 Risers 2-3

2-3 Tank 241-C-101 Waste Transfer History 2-7

2-4 Synopsis of Major Waste Types Transferred 2-10

2-5 Tank 241-C-101 Solids Composite Inventory Estimate 2-13

3-1 Analytical Methods and Procedures 3-3

4-1 Tank 241-C-101 Analytical Data for Total Alpha 4-2

4-2 Tank 241-C-101 Total Organic and Inorganic Carbon Analytical Data 4-2

4-3 Tank 241-C-101 Density and pH Analytical Results 4-3

4-4 Thermogravimetric Results for Tank 241-C-101 4-5

4-5 Differential Scanning Calorimetry Results for Tank 241-C-101 4-6

5-1 Quality Control Summary, 1994 Auger Samples. 5-2

LIST OF TABLES (Continued)

5-2 Comparison of the Solids Analytical Results and Historical Tank Content Estimate Estimates 5-5

5-3 Tank Safety Screening Data Quality Objective Decision Variables and Criteria for Tank 241-C-101 5-7

LIST OF TERMS

CWP	cladding waste from PUREX
DL	Detection Limit
DQO	data quality objective
DSC	differential scanning calorimetry
DW	Decontamination Waste
HTCE	Historical Tank Content Estimate
MW	metal waste
P	PUREX waste
PUREX	Plutonium-Uranium Extraction (Facility)
RPD	relative percent difference
SACS	Surveillance Analysis Computer System
SL	sludge
SU	supernatant
TCP	Tank Characterization Plan
TGA	thermogravimetric analysis
TIC	total inorganic carbon
TOC	total organic carbon
UR	uranium recovery waste
WHC	Westinghouse Hanford Company

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1.0 INTRODUCTION

This report presents an overview of single-shell tank 241-C-101 and its waste contents. It provides estimated concentrations and inventories for the waste components based on *Historical Tank Contents Estimate for the Northeast Quadrant of the Hanford 200 East Areas*, WHC-SD-WM-ER-349 (Brevick et al. 1995), and results of the most recent sampling event. In March 1995, one auger sample was obtained for analysis in accordance with *Tank Safety Screening Data Quality Objective*, WHC-WM-SD-SP-004 (Babad and Redus 1994). Auger samples from two different risers are required by the Data Quality Objective (DQO) (Babad and Redus 1994), but one of the risers specified in *Tank 241-C-101 Tank Characterization Plan*, WHC-SD-WM-TP-285 (Schreiber 1995), was not available for use when the samples were taken.

Tank 241-C-101 entered service in March 1946 as the first tank in a three-tank cascade. The tank began service by receiving metal waste from B Plant. The tank was full by May 1946 and began cascading waste to tank 241-C-102. The remainder of the history of the tank is a series of receipts and transfers, primarily of supernatant. The majority of the waste presently in the tank is composed of metal waste, cladding waste from the Plutonium-Uranium Extraction (PUREX) Facility, and uranium recovery waste. The tank was removed from service in 1976 and was declared an assumed leaker in 1980.

The concentration and inventory values reported in this document reflect the current best estimate of the composition of the waste based on the tank's waste transfer history. The composition is unlikely to change since all supernatant has been removed and the tank has been interim stabilized and has had intrusion prevention completed. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order* Milestone M-44-08 (Ecology et al. 1994).

1.1 PURPOSE

The primary purpose of this report is to summarize the information about the use and contents of tank 241-C-101. When possible, this information will be used to assess issues associated with safety, operations, environmental, and process development activities. This report also provides a reference point for more detailed information about tank 241-C-101.

1.2 SCOPE

The auger sample taken in 1995 was obtained in accordance with the *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994). Sampling and analysis activities are focused on either verification of the non-watch list tank status or identification of unknown safety issues associated with the tank. Therefore, weight percent water, energetics, and total alpha were evaluated. Additional analyses, including determinations of density,

pH, total organic carbon (TOC), and total inorganic carbon (TIC), were performed at the request of Characterization Plant Engineering and Characterization Process Control.

This report includes no information on vapor space sampling and analysis to determine the composition of the tank head space gases. The vapor space of the tank was recently sampled. Results of analyses on those samples are contained in Huckaby (1995). The vapor space data will be included and evaluated in a future revision to this report.

2.0 HISTORICAL TANK INFORMATION

This section describes tank 241-C-101 based on historical information. The first part of the section details the current condition of the tank, followed by discussions on the design and mission of the tank, its waste transfer history, and the 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 final part of the section details any surveillance data available for the tank. Solid and liquid level data are used to determine tank integrity and to provide clues to internal activity in the solid/crust layers of the tank (i.e., slurry growth from gas evolution with subsequent burping and collapse, or shrinkage caused by drying). Temperature data are provided to evaluate the heat generating characteristics of the waste.

2.1 TANK STATUS

According to the *Waste Tank Summary Report for Month Ending April 30, 1995*, WHC-EP-0182-80 (Hanlon 1995), tank 241-C-101 contains 333 kL (88 kgal) of non-complexed waste. Approximate volumes of the different waste phases as estimated by WHC-EP-0182-80, *Waste Tank Summary for Month Ending April 30, 1995*, (Hanlon 1995) are shown in Table 2-1.

Table 2-1. Summary Tank Contents Status.

Waste form	Volume kL (kgal)
Total waste	333 (88)
Supernatant	0 (0)
Drainable interstitial liquid	11.4 (3)
Drainable liquid remaining	11.4 (3)
Pumpable liquid	0 (0)
Sludge	333 (88)
Saltcake	0 (0)

Tank 241-C-101 is identified as a low-heat tank, is passively ventilated, and is categorized as an assumed leaker. The tank has been interim stabilized (1983) and has had intrusion prevention completed (1982). Based on process history the waste is made up of metal waste, uranium recovery waste, and PUREX cladding waste. Tank 241-C-101 is the

first tank in a three-tank cascade series (tanks 241-C-101, 241-C-102, and 241-C-103). Tank 241-C-101 is not on a watch list.

2.2 TANK DESIGN AND BACKGROUND

The C Tank Farm is a first generation tank farm, built between 1943 and 1944, consisting of twelve 2,010-kL (530-kgal) tanks and four 208-kL (55-kgal) tanks. These tanks were designed for nonboiling waste with a maximum fluid temperature of 104 °C (220 °F). Tank 241-C-101 is passively ventilated.

Tank 241-C-101 entered service in March 1946 and is first in a three-tank cascading series. The single-shell tank is constructed of 0.3-m- (1-ft-) thick reinforced concrete with a 6.4-mm (0.25-in.) mild carbon steel liner (ASTM A283 Grade C) on the bottom and sides and a 0.38-m- (1.25-ft-) thick domed concrete top. The tank has a dished bottom with a 1.2-m (4-ft) radius knuckle and a 5.18-m (17-ft) operating depth. The cascade overflow height is approximately 4.78 m (188 in.) from the tank bottom and 0.6 m (2 ft) below the top of the steel liner. The tank is set on a reinforced concrete foundation and covered with approximately 2.2 m (7.25 ft) of overburden.

As with all first generation tank farms, equipment to monitor the waste is limited. A typical C Farm tank contains 9 to 13 risers, ranging in size from 50 mm (2 in.) to 1.07 m (42 in.) in diameter, that provide surface-level access to the underground tank. Generally, there is one riser through the center of the tank dome and two groups of five each on opposite sides of the tank, with the remaining one to three scattered on the dome. Tank 241-C-101 has nine grade-level risers and two construction manholes. Riser 1, which is 100 mm (4 in.) in diameter, and riser 7, which is 300 mm (12 in.) in diameter, are available for use. If used as sampling ports, the risers give access to two opposite sides of the tank. A list of tank 241-C-101 risers, showing size and relative location, is provided in Table 2-2. A plan view that depicts the riser configuration is shown as Figure 2-1.

Waste surface level in the tank 241-C-101 is monitored through riser 2 with a manual tape. Liquid waste volume is determined by the manual tape surface level gauge, while solid waste volume is determined by a sludge level measurement device. Four tank inlets are available with one cascade overflow inlet at approximately 4.9 m (191.5 in.) from the tank bottom (as measured at the tank wall). Locations are shown on Figure 2-1. A tank cross-section showing the approximate waste level along with a schematic of the tank equipment is found in Figure 2-2.

Table 2-2. Tank 241-C-101 Risers.

Riser number	Diameter (in.)	Description and comments
R1	4	Flange, BM
R2	12	20- to 4-in. flange and temperature probe
R3	12	(Sluicing nozzle) WC (pit)
R4	4	(Drain) WC (pit)
R5	4	(Drain) WC (pit)
R6	12	(Pump) WC (pit)
R7	12	Flange/B-222 obsv port
R8	4	Breather filter
R13	12	Pump WC
N1	3	Spare nozzle
N2	3	Spare nozzle
N3	3	Spare nozzle
N4	3	Spare nozzle
N5	3	Outlet nozzle overflow

BM = bench mark.
OBSV = observation.
N = nozzle.
R = riser.
WC = weather-covered with urethane foam.

Figure 2-1. Riser Configuration of Tank 241-C-101.

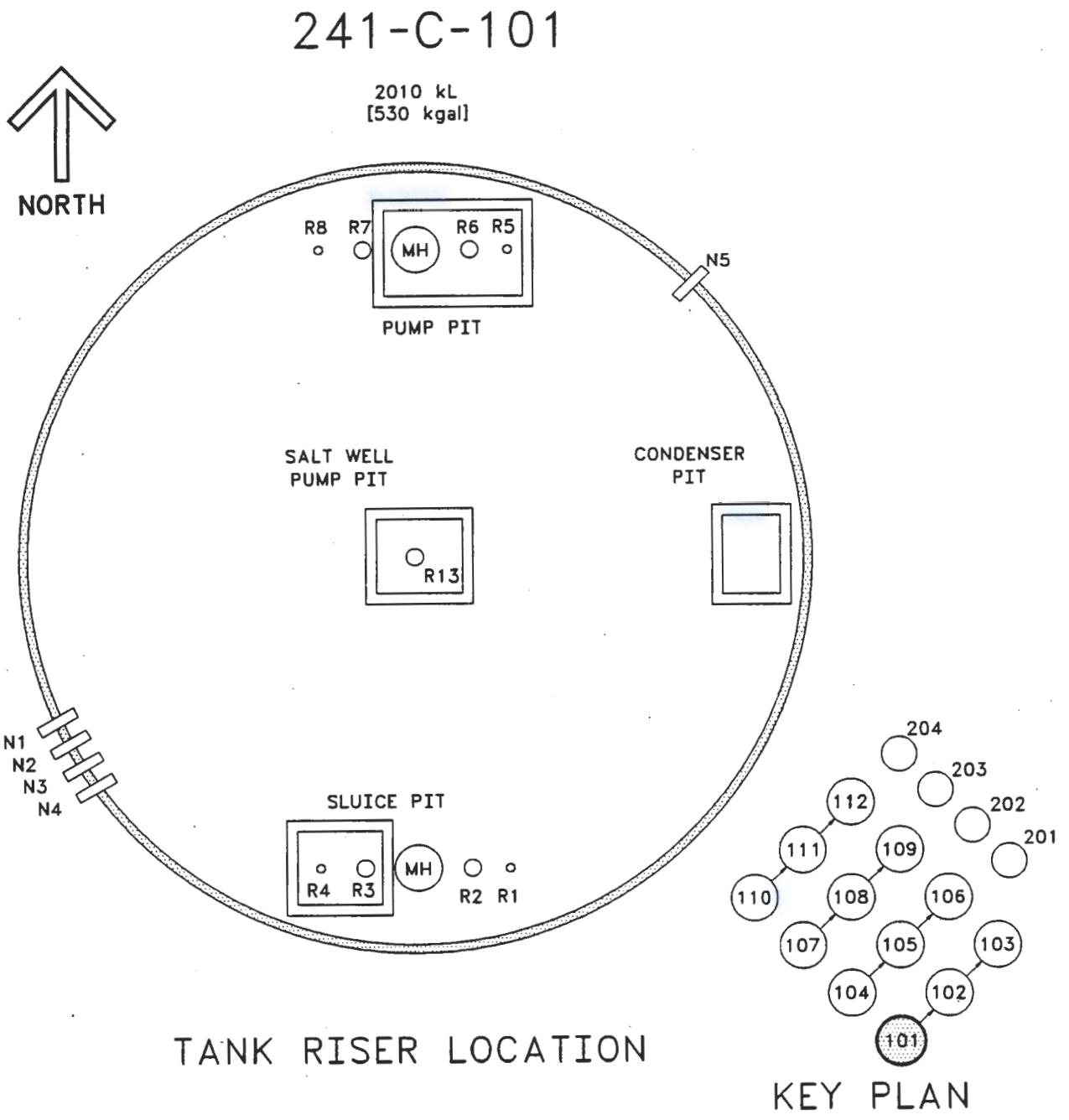
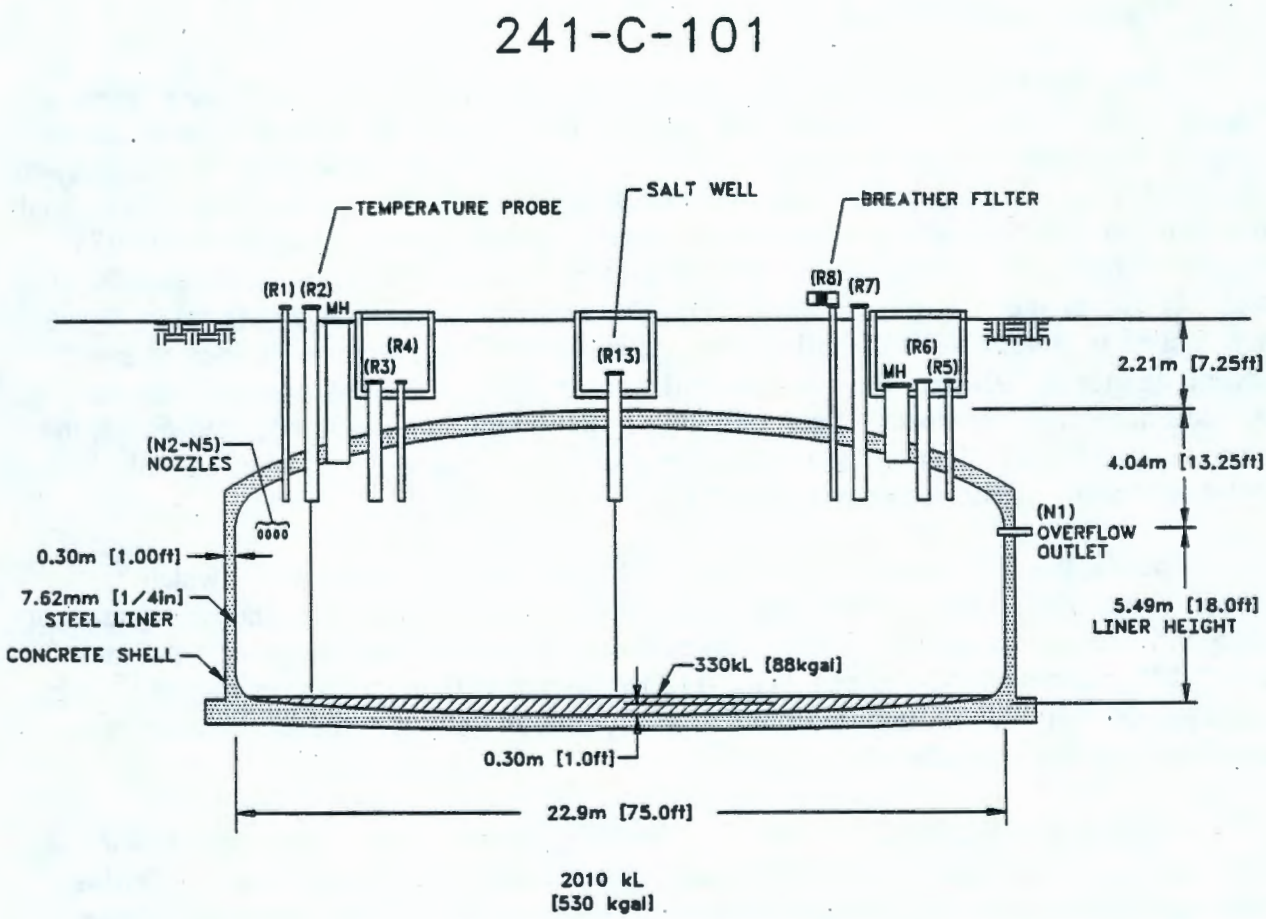


Figure 2-2. Tank 241-C-101 Configuration.



2.3 PROCESS KNOWLEDGE

These sections present the transfer history of tank 241-C-101 and describe the process wastes that made up the transfers. Section 2.3.1 and Table 2-3 present major transfers that involved tank 241-C-101 along with a narrative describing the transfers. A graphical representation of transfers to and from the tank is provided in Figure 2-3.

2.3.1 Waste Transfer History

Tank 241-C-101 began receiving metal waste from the bismuth phosphate process in March 1946. In May 1946, the tank was declared full. During the third and fourth quarters of 1946, additions of metal waste to tank 241-C-101 would continually exceed the capacity of the tank. Therefore, supernatant was cascaded to tank 241-C-102. Tank 241-C-101 received uranium recovery (UR) waste intermittently from U-Plant from the second quarter of 1953 until the fourth quarter of 1954. During the third quarter of 1953, supernatant cascaded to tank 241-C-102 and also to tank 241-C-103. This was the last cascade transfer of supernatant to tank 241-C-102 until the first quarter of 1961. It became apparent in the second quarter of 1954 that the overflow outlet of tank 241-C-101 was partially plugged. A small transfer of supernatant from tank 241-C-101 to tank 241-B-106 occurred during the first quarter of 1954. During the fourth quarter of 1954, most of the contents of tank 241-C-101 were transferred to tank 241-C-103.

During the first quarter of 1956, tank 241-C-101 received supernatant (which probably was tributyl phosphate waste) from tank 241-C-104. Also, from the first quarter of 1956 until the second quarter of 1957, supernatant was sporadically transferred from tank 241-C-101 to tanks 241-C-109 and 241-C-112 for in-tank settling and scavenging of ^{137}Cs by ferrocyanide. During the second quarter of 1957, tank 241-C-101 received waste of an unknown type from tank 241-BY-101.

Beginning in the fourth quarter of 1960 and intermittently until the second quarter of 1962, tank 241-C-101 received PUREX cladding waste from an unknown source. During the second quarter of 1962, the addition of the PUREX cladding waste exceeded the capacity of tank 241-C-101 and subsequently led to the cascade of supernatant to tank 241-C-102. During the third quarter of 1963, tank 241-C-101 received supernatant from tank 241-A-102, and supernatant was pumped from tank 241-C-101 to tank 241-B-107. In the first quarter of 1964 tank 241-C-101 received waste of unknown type from tank 241-A-103. In the second quarter of 1965, tank 241-C-101 received waste of an unknown type from the CR vault. The only other transfers for which the destination or the source are known are as follows:

- In the first quarter of 1964, tank 241-C-101 received waste of an unknown type from tank 241-A-103
- In the second quarter of 1965, tank 241-C-101 received waste of an unknown type from the CR vault

Table 2-3. Tank 241-C-101 Waste Transfer History.* (2 pages)

Year:Qtr	Transaction source or *destination*	Transaction amount, kL	Waste type	Tank total volume kL (kgal)	Comments
1946:1-4	B Plant *241-C-102*	6,019 *- 4,012*	MW *- SU*	2,007 (530)	Tank full *Cascade*
1952:4	*241-C-103*	*- 2,007*	*- SU and SL*	0 (0)	
1953:2-3	U Plant	2,877	UR	2,877 (760)	
1953:3	*241-C-102*	*- 871*	*- SU*	2,006 (530)	*Cascade*
1953:4	*241-C-103*	*- 1,166*	*- SU*	840 (222)	
1953:4	U Plant	1,116	UR	1956 (517)	
1954:1	*241-B-106*	*- 26*	*- SU*	1930 (510)	
1955:4	*Unknown*	*- 697*	*- SU*	1,233 (326)	
1956:1	241-C-104 *241-C-109*	1,420 *- 1,454*	SU *-SU*	1,199 (317)	*Pumped to 241-C-109 for in-tank scavenging with FeCN*
1956:3	Unknown *Unknown*	636 *- 1,226*	Unknown *- SU*	610 (161)	
1956:4	*241-C-112* *241-C-109* Unknown	*- 1,624* *- 42* 1,552	*- SU* *- SU* Unknown	496 (131)	*Tanks 241-C-112, 241-C-109 used for in-tank FeCN scavenging*
1957:1-4	*Unknown* 241-BY-101 *Unknown*	*- 125* 1,722 *- 1,597*	*- SU* SU *- SU*	496 (131)	*241-C-101 used as the feed tank for FeCN scavenging operation.*
1958:1-2	Unknown *Unknown*	72 *- 95*	Unknown *- SU*	473 (125)	Solids volume = 371 kL (98 kgal)
1959:2-3	Unknown	23	Unknown	496 (131)	
1960:4 - 1961:1	PUREX	1,673	CWP	2,169 (573)	
1961:1-2	*241-C-102* *Unknown*	*- 163* *- 76*	*- SU* *- SU*	1,930 (510)	*Overflow (cascade) to 241-C-102*
1962:2	PUREX *241-C-102* *Unknown*	810 *- 734* *- 23*	CWP *- SU* *- SU*	1,983 (524)	*Cascade* Solids volume = 413 kL (109 kgal)
1963:3-4	*241-B-107* 241-A-102 *Unknown*	*- 1,166* 1,045 *- 462*	*- SU* SU *- SU*	1,862 (492) 1,400 (370)	
1964:1-4	241-A-103	666	SU	2,066 (546)	Solids = 413 kL (109 kgal)
1965:2	CR Vault	106	DW	2,172 (574)	Solids = 193 kL (51 kgal)
1965:3-4	*Unknown*	*- 34*	*- SU*	2,138 (565)	
1966:1-4	*Unknown* Unknown Unknown *Unknown*	*- 8* 30 322 *- 352*	*- SU* Unknown Unknown *- SU*	2,130 (563)	

Table 2-3. Tank 241-C-101 Waste Transfer History.* (2 pages)

Year:Qtr	Transaction source or *destination*	Transaction amount, kL	Waste type	Tank total volume kL (kgal)	Comments
1967:1-4	*Unknown*	*- 53*	*- SU*	2,077 (549)	
1968:1-4	*Unknown*	*- 30*	*- SU*	2,047 (541)	
1969:1-4	*Unknown* *241-C-105* *Unknown*	*- 11* *- 1,529* *- 8*	*- SU* *- SU* *- SU*	499 (132)	Solids volume = 473 kL (125 kgal)
1970:1-4	Unknown	23	Unknown	522 (138)	Solids volume = 307 kL (81 kgal)
1971:1-4	*Unknown*	*- 42*	*- SU*	480 (127)	
1972:1-4	*Unknown*	*- 26*	*- SU*	454 (120)	
1973:4	Unknown	42	Unknown	496 (131)	241-C-101 designated suspect leaker
1974:1-4	*Unknown* *241-C-104* Unknown	*- 11* *- 185* 49	*- SU* *- SU* Unknown	485 (128) 349 (92)	 Solids volume =235 kL (62 kgal)
1976:2	*Unknown*	*- 72*	*- SU and possibly SL*	277 (73)	Solids volume = 276 kL (73 kgal). Removed from service; salt well pumped in 1976. Primary stabilized in 1978.
1993:2	Unknown	57	Unknown	334 (88)	Increase may be caused be level gauge adjustment (4/82).

*All information used in the table comes from S. F. Agnew, 1994, *Waste Status and Transaction Record Summary for the Northeast Quadrant*, WHC-SD-WM-TI-615, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

CW = cladding waste.
CWP = cladding waste PUREX.
DW = decontamination waste.
MW = metal waste.
P = PUREX waste.
PUREX = Plutonium-Uranium Extraction Facility.
SL = sludge.
SU = supernatant.
UR = uranium recovery waste.

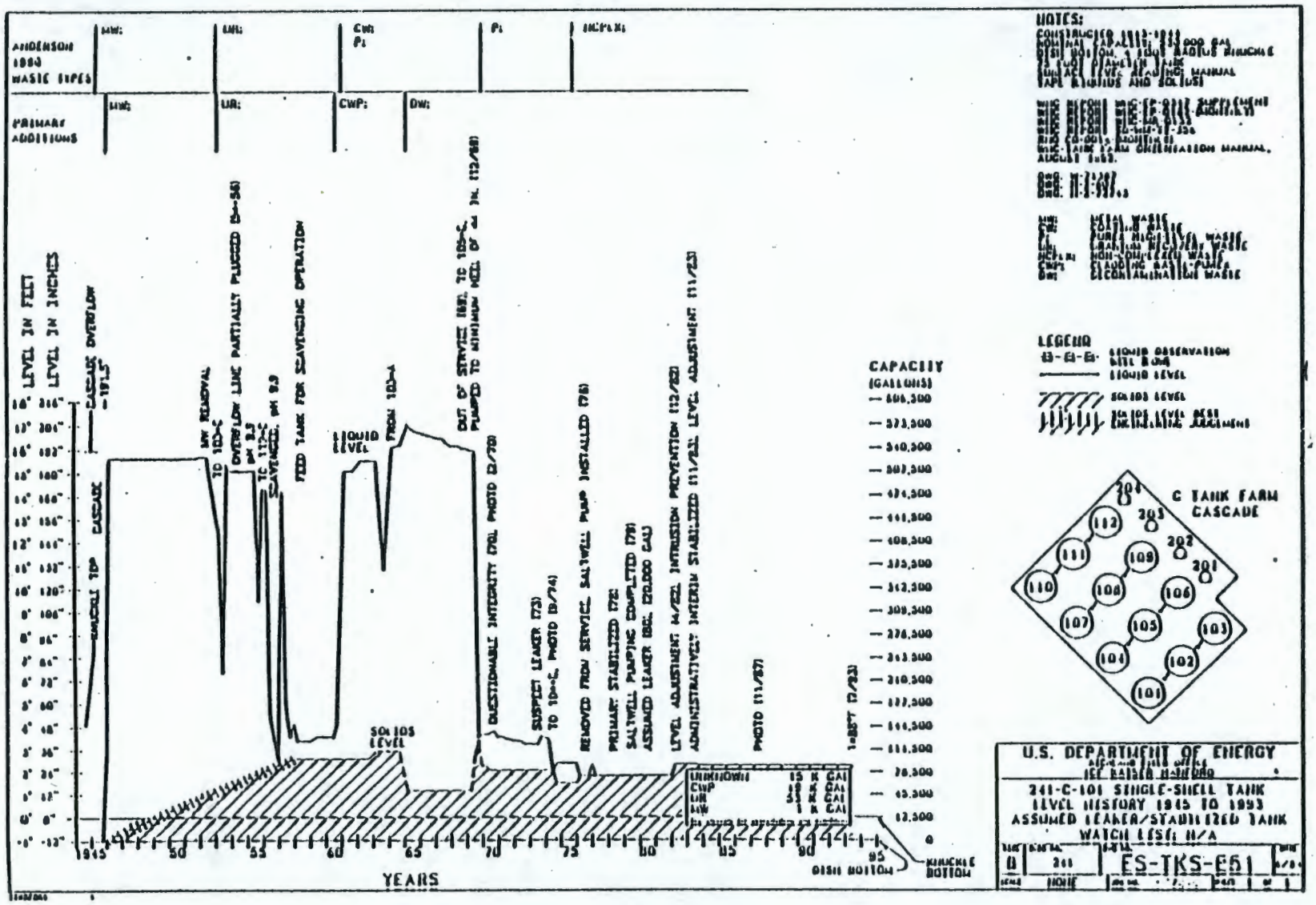


Figure 2-3. Tank Level History.

- In the fourth quarter of 1969, supernate was transferred out of tank 241-C-101 to tank 241-C-105

- In the third quarter of 1974, supernate was transferred out of tank 241-C-101 to tank 241-C-104.

Tank 241-C-101 was removed from service in the first quarter of 1976. It was categorized as an assumed leaker in 1980 with an approximate leak volume of 76 kL (20 kgal). Intrusion prevention has been completed (12/82) on tank 241-C-101, and the tank has been interim stabilized (11/83). Tank 241-C-101 waste is currently defined as non-complexed. A synopsis of the major waste types transferred through tank 241-C-101 is presented in Table 2-4. As Table 2-3 shows, the source or destination for many transfers is unknown. Based on solids level measurements however, most of the unknown waste transferred to tank 241-C-101 is believed to have been supernatant material from other tanks. Much of this supernatant material was subsequently removed or evaporated from the tank. The tank layer model (Agnew 1994) discussed in the next section provides an estimate of the fraction of sludge waste remaining in the tank that is of unknown origin.

Table 2-4. Synopsis of Major Waste Types Transferred.

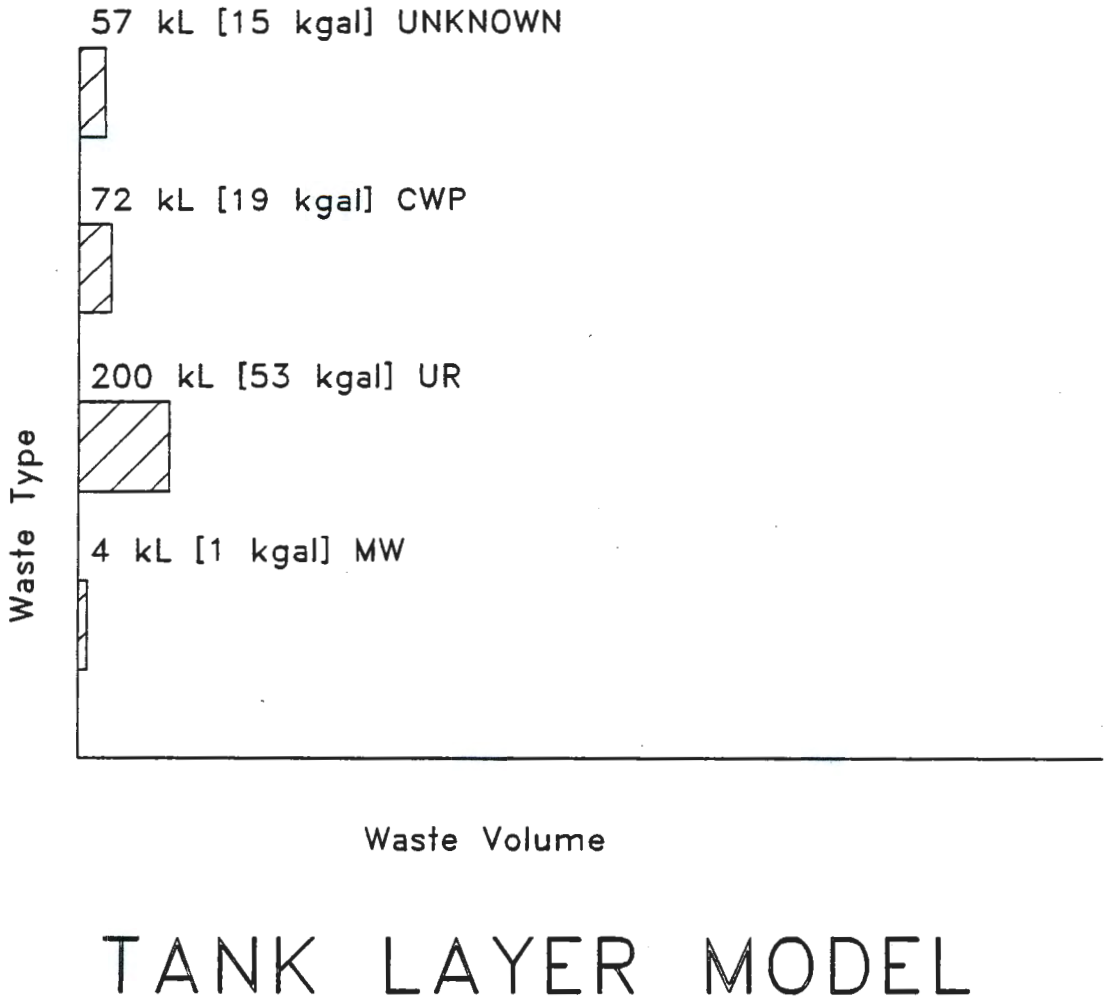
Transfer type	Volume kL (kgal)
Addition of metal waste	6,019 (1,590)
Addition of uranium recovery waste	3,993 (1,055)
Addition of unknown waste	2,806 (741)
Addition of PUREX cladding waste	2,483 (655)
Addition of decontamination waste	106 (28)
Addition of supernatant from other tanks	4,853 (1,282)
Transfer out of sludge	265 (70)
Transfer out of SU for FeCN scavenging	3,120 (824)
Transfer out of supernatant to other tanks	16,542 (4,370)

PUREX = Plutonium-Uranium Extraction Plant.
SU = Supernatant.

2.3.2 Historical Estimation of Tank Contents

Based on the Historical Tank Content Estimate (Brevick et al. 1995) and on *Tank Layer Model Spreadsheet: Northeast Quadrant, A, AX, B, BX, BY, C Farms* (Agnew 1994), tank 241-C-101 is estimated to contain 201 kL (53 kgal) of uranium recovery waste, 72 kL (19 kgal) of PUREX cladding waste, 57 kL (15 kgal) of an unknown waste type, and 4 kL (1 kgal) of metal waste. Figure 2-4 shows a graphical representation of the estimated waste type and volumes for the tank layers from the Tank Layer Model (Agnew 1994). Metal

Figure 2-4. Tank Layer Model.



waste is expected to comprise the bottom layer and should contain large amounts of sodium, uranium, carbonate, phosphate, sulfate and hydroxide. Uranium recovery waste (located directly above the metal waste) should contain large quantities of sodium, iron, nitrate, sulfate and uranium. Strontium and cesium should be present in larger quantities in the uranium recovery waste layer than in the other layers of waste in the tank. Therefore, the uranium recovery waste layer will have a higher heat load than the metal waste and PUREX cladding waste layers. The PUREX cladding waste layer is directly above the uranium recovery waste layer and should be rich in aluminum, sodium, nitrate, nitrite, and uranium. This layer will contain less uranium than both the uranium recovery and the metal waste layers. Cesium and strontium are present but in such quantities that the activity in the PUREX cladding waste layer will be the lowest of the three known layers. The PUREX cladding waste layer can be further distinguished from the other two layers by the absence of iron (found in the uranium recovery waste layer) and the presence of a significant amount of aluminum (absent in both uranium recovery and metal waste layers). The waste type in the top-most waste layer in tank 241-C-101 cannot presently be determined.

Table 2-5 shows an estimate of the expected waste constituents and their concentrations. The composite inventory estimates in Table 2-5 are based on waste transfer data, not actual characterization data. An estimated seventeen percent (by volume) of the waste is of unknown origin and is therefore not included in the inventory estimates.

2.4 SURVEILLANCE DATA

Tank 241-C-101 surveillance consists of surface level measurements (liquid and solid), temperature monitoring inside the tank (waste and vapor space), and leak detection well monitoring (drywell) for radioactivity outside the tank. Obtaining these data are significant because they provide the basis for determining tank integrity. No tanks in the C Tank Farm have liquid observation wells for monitoring interstitial liquid levels.

Surface level measurements provide an indication of any major leaks from or intrusions into, a tank and a basis from which to determine tank waste volumes. Solid level measurements provide an indication of physical changes and of the consistency of the solid layers in a tank. Drywells located around the perimeter of the tank may show increased radioactivity in the event of a leak to the soil.

2.4.1 Surface Level Readings

A graphical representation of the volume and waste level measurements over the entire transfer history of the tank was presented in Figure 2-3. Figure 2-3 indicates that the tank may have leaked up to 67 kL (20 kgal) of liquid waste in the 1970's. The tank was designated a suspected leaker in 1973 and an assumed leaker in 1980.

Table 2-5. Tank 241-C-101 Solids Composite Inventory Estimate.*

Physical properties			
Total solid waste	4.85 E+05 kg (88 kgal)		
Heat load	0.0110 kW (38 Btu/hr)		
Bulk density	1.45 (g/cc)		
Void fraction	0.731		
Water wt%	61.1		
TOC wt% C (wet)	0		
Chemical constituents	mole/L	ppm (μg/g)	kg
Na^{+}	3.34	52,800	25,600
Al^{+3}	2.27	42,000	20,400
Fe^{+3}	1.97	75,800	36,700
Cr^{+3}	0.00590	211	102
Ni^{+2}	0.0786	3,170	1,540
Ca^{+2}	0.164	4,510	2,180
OH^{-}	14.1	165,000	80,000
NO_3^{-}	1.47	62,700	30,400
NO_2^{-}	0.0838	2,650	1,280
CO_3^{-2}	0.250	10,300	5,000
PO_4^{-3}	0.0615	4,020	1,950
SO_4^{-2}	0.600	39,600	19,200
Si (SiO_3^{-2})	2.35E-05	0.454	0.220
Cl^{-}	0.0488	1,190	576
Radiological constituents			
Pu		0.512 (μCi/g)	248 Ci (4.13 kg)
U	0.176 (mole/L)	28,700 (μg/g)	13,900 (kg)
Cs	0.00125 (Ci/L)	0.856 (μCi/g)	415 (Ci)
Sr	0.00405 (Ci/L)	2.78 (μCi/g)	1,350 (Ci)

Notes: 1 Ci = 3.7 E+10 Bq.

*Composite inventory excludes supernatant, diatomaceous earth, and cement. Inventories are estimated from limited historical waste transfer information, not characterization data.

EDTA = ethylenediaminetetraacetic acid.
HEDTA = n hydroxy-ethylenediaminetriacetic acid.
NTA = nitrilotriacetic acid.
DBP = dibutyl phosphate.
NPH = normal paraffin hydrocarbon.

The surface level of tank 241-C-101 is currently monitored quarterly with a manual tape. The quarterly level measurements are entered into the Surveillance Analysis Computer System. As of April 1, 1995, the surface level measured 58.4 cm (23 in.) Other surface level readings between 1991 and 1994 are provided in Appendix A, Table A-1. A maximum increase of 5 cm (2 in.) above the 71.8 cm (28.3 in.) baseline is allowed before investigative action is taken. There is no decrease criterion for investigating tank behavior. There are two surface level data points in the 1991 to 1994 data (Table A-1) that are not consistent with the other data (Figure 2-5). One level measurement of 163.8 cm (64.5 in.) was attributed to an input error of the field data sheets into the Surveillance Analysis Computer System. Another reading of 40.0 cm (15.75 in.) was superseded by a rerun. Since January of 1991, the tank surface level readings have remained stable between 63.5 cm (25.0 in.) and 67.3 cm (26.5 in.).

2.4.2 Internal Tank Temperatures

Tank 241-C-101 has a single thermocouple tree with 14 thermocouple probes to monitor the waste temperature. Thermocouple 1 is located approximately 40.5 cm (1.33 ft) above the bottom of the tank. Thermocouples 1 through 9 are evenly spaced 60.0 cm (2 ft) apart; thermocouples 9 through 11 are spaced 1.2 m (4 ft) apart; elevation data are not available for thermocouples 12 through 14. Thermocouple 1 is the only thermocouple believed to be contained within the waste. The rest of the thermocouple probes are located in the tank's vapor space. All of the 14 thermocouples, however, have similar temperature readings. The vapor space and waste sludge temperatures trend together, likely because of the relatively small waste volume in the tank. Weekly temperature readings are available from 1983 through 1985 and from 1992 to the present. Plots of the individual thermocouple readings can be found in the Historical Tank Content Estimate (Brevick et al. 1994). A plot summarizing the weekly high thermocouple readings is provided in Figure 2-6. In the future, tank 241-C-101 is scheduled to have temperature data taken semi-annually, in January and July.

Maximum temperature readings for the tank range from 13 °C (55 °F) to 44 °C (111 °F). Much of the variation in the temperature data is likely caused by seasonal ambient temperature changes. The temperature readings indicate that the heat generated in the tank is not excessive and is adequately dissipated.

2.4.3 Tank 241-C-101 Photographs

The 1987 photographic montage of the tank 241-C-101 interior indicates a black and white sludge surface with no visible liquid. The montage is presented in Figure 2-7. The background in the picture is hazy, but some equipment in that area has been identified and labeled. The tank contains approximately 333 kL (88 kgal) of sludge, which is approximately 60.0 cm (2 ft) deep. There have been no changes in the tank that would affect the waste since the photographs were taken, so the picture should represent the current tank contents.

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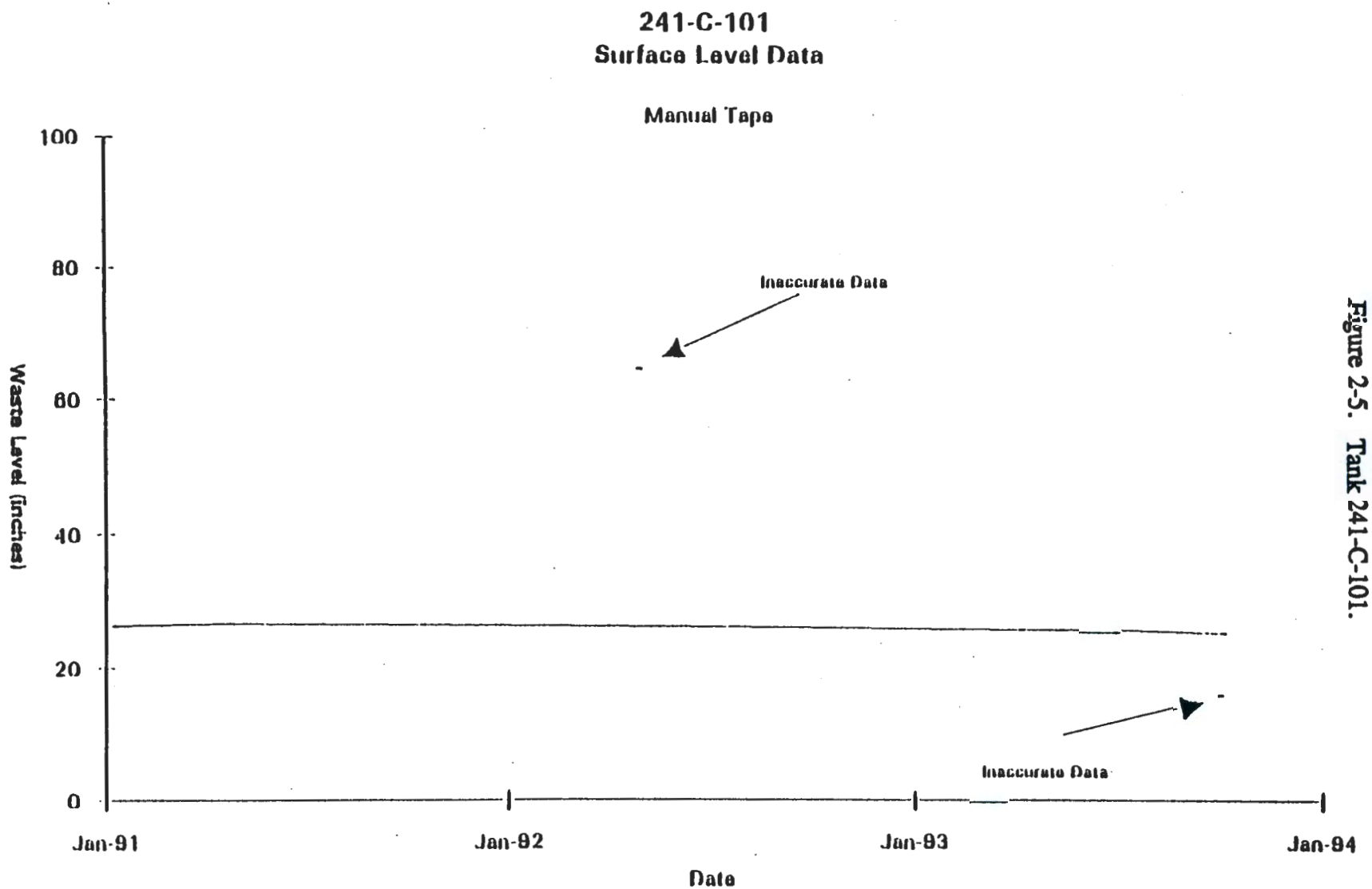
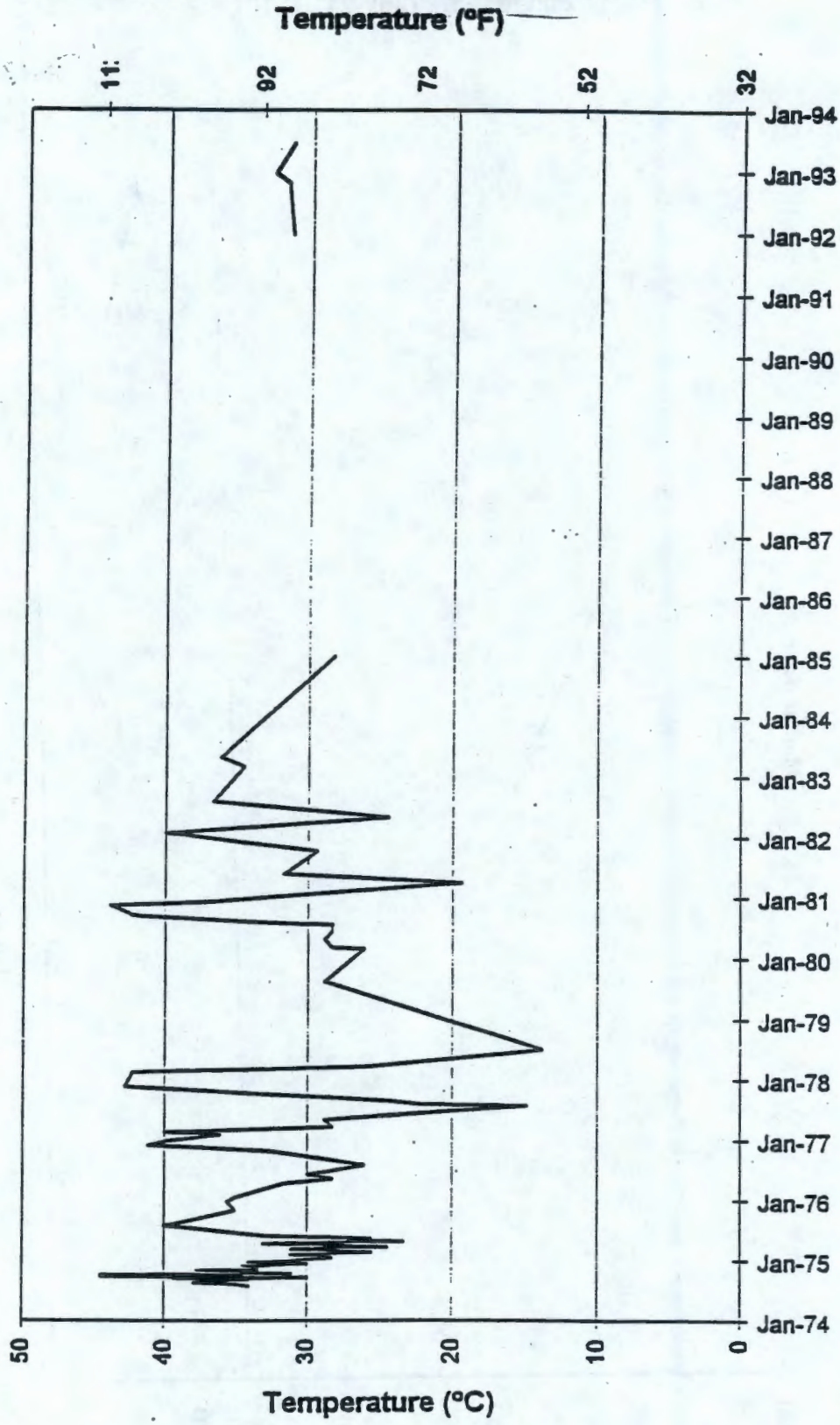


Figure 2-5. Tank 241-C-101.

Data obtained from WHC Surveillance Analysis Computer System (SACS), November 16, 1993.

Figure 2-6. Tank 241-C-101 Weekly High Temperature Plot.



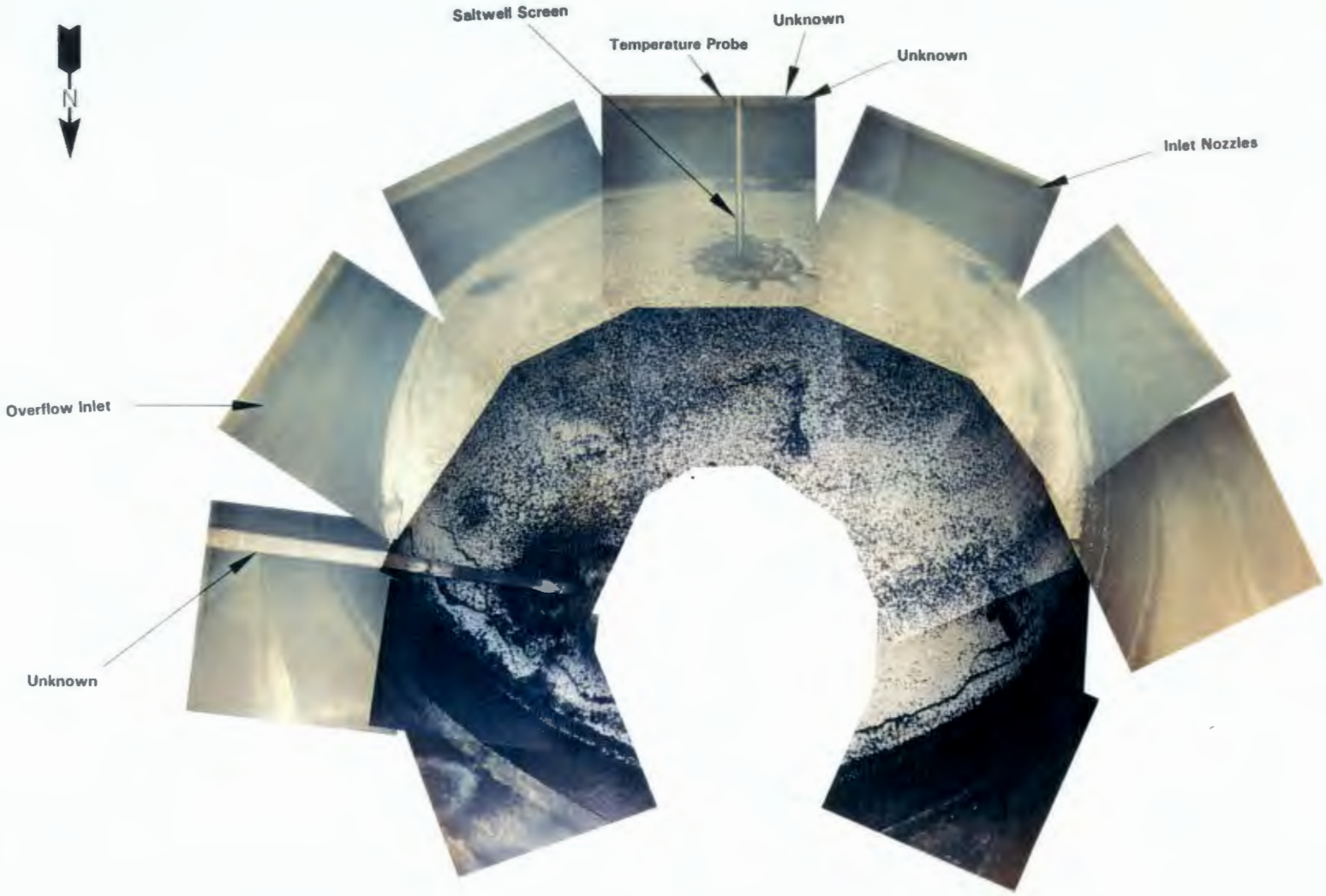


Figure 2-7. Photo Montage of Tank 241-C-101 Waste Surface.

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3.0 TANK SAMPLING OVERVIEW

This section describes the March 1995 sampling and analysis event for tank 241-C-101. A 2-segment auger sample was taken to satisfy the requirements of WHC-SD-WM-SP-004, *Tank Safety Screening Data Quality Objective* (Babad and Redus 1994). The sampling and analysis were performed in accordance with WHC-SD-WM-TP-285 (Schreiber 1995). Additional analyses were requested by Characterization Plant Engineering and Characterization Process Control. Further discussion of the sampling and analysis procedures can found in WHC-SD-WM-TI-648, *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

3.1 DESCRIPTION OF 1995 AUGER SAMPLING EVENT

On March 29, 1995, an auger sample was obtained from riser number 8 of tank 241-C-101. Risers 1 and 8 were scheduled to be used for sampling (Schreiber 1995), but a presampling walkdown of the tank revealed that only riser 8 was available for sampling. Two auger segments, 25.4 cm and 50.8 cm in length, were scheduled to be taken from riser 8, but errors during sampling resulted in the auger penetrating the full depth of the waste. For this reason, any stratification of the waste in the auger sample cannot be assumed to be representative of the waste stratification in the tank (Sasaki 1995).

3.1.1 1995 Auger Sample Handling

The riser 8 auger sample was received by the 222-S Laboratory on March 30, 1995, and extruded on April 14, 1995. The outside of the sample liner and the inside of the shipping cask were found to be contaminated. Special procedures were developed to allow the safe loading of the cask into the hot cell.

The sampler was full of sample material. The sample solids were thick, mud-like, and dark brown in color. The lower flutes of the auger contained waste that was firmly packed and damp. The waste on the upper flutes was drier and contained off-white material mixed in with the dark brown solids. Flutes 1 through 4 contained some crust-like material. Of a total of 592 g of waste, 15.5 g were labeled as crust, 190 g as upper half solids, and 387 g as lower half solids. In addition, 32.2 g of drainable liquid were recovered from the liner. The crust, upper half solids, and lower half solids subsamples were each homogenized prior to analysis.

3.1.2 1995 Auger Sample Analysis

All analyses were performed at the 222-S Laboratory. The crust, upper half solids, and lower half solids subsamples were each analyzed for percent water using TGA, for

energetics using DSC, and for fissile content using total alpha analysis. The drainable liquid subsample was similarly analyzed using TGA and DSC, and in addition was analyzed for pH, TOC content and TIC content. Bulk densities were determined on the upper half solids and lower half solids subsamples.

The TGA, DSC, and total alpha analyses were performed to satisfy the safety screening requirements. The TOC, TIC, pH, and bulk density analyses were performed at the request of Characterization Plant Engineering and Characterization Process Control. The pH, TOC, and TIC analyses were requested in order to resolve a reported high carbon dioxide reading in the vapor space of the tank. Bulk densities on the solids subsamples were requested to resolve a question regarding the capacity of the waste transfer cask.

The analytical procedures used for each analysis are identified in Table 3-1. The TGA and DSC analyses were both conducted under a nitrogen blanket, and both used a combination of Mettler and Perkin-Elmer instruments. Total alpha activity was determined using an alpha proportional counter. Before the total alpha analysis could be performed, the solid subsamples had to be dissolved. This was accomplished by fusing the solid aliquot portion (0.2 g - 0.5 g) of the homogenized subsample with potassium hydroxide and dissolving the flux in hydrochloric acid. The TOC values on the drainable liquid subsample were determined using persulfate-ultraviolet oxidation. In this method, the organic carbon is oxidized to carbon dioxide in the presence of ultraviolet light. The sample is then analyzed directly by a nondispersive infrared analyzer, reduced to methane, and measured by a flame ionization detector, or chemically reduced. TIC is determined by subtracting the TOC value from the total carbon value. The total carbon values on the drainable liquid subsample were determined using combustion-infrared analysis. In combustion-infrared analysis, the carbon in the sample is oxidized, aided by a catalyst, then measured by a nondispersive infrared analyzer. Further details on analytical methods can be found in the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

Duplicate analyses and appropriate standards, blanks, and spikes were performed for quality control purposes, in accordance with the Tank Characterization Plan (TCP) for tank 241-C-101 (Schreiber 1995). The results of analyses are summarized in Section 4.0. The quality control checks, and their implications on the analytical results, are discussed in Section 5.0.

Table 3-1. Analytical Methods and Procedures.

Analyte	Method	Procedure
Energetics	Differential scanning calorimetry	LA-514-113 (Mettler) LA-514-114 (Perkin-Elmer)
Percent water	Thermogravimetric analysis	LA-560-112 (Mettler) LA-514-114 (Perkin-Elmer)
Total alpha	Alpha proportional counting	LA-508-101
Total organic carbon	Persulfate-ultraviolet oxidation	LA-344-105
Total carbon	Combustion-infrared	LA-622-102
Bulk density	Mass/volume	LO-160-103
pH	pH meter	LA-212-102

4.0 ANALYTICAL RESULTS

4.1 OVERVIEW

The purpose of this section is to summarize the sampling and analytical results from the March 29, 1995, sampling event for tank 241-C-101. This sampling and analysis event was performed for evaluation of safety screening criteria defined in the Tank Safety Screening DQO (Babad and Redus 1994). The DQO stipulates that TGA for weight percent water, DSC for evaluation of fuel content and thermal output, and total alpha analyses for criticality evaluation are required for tank 241-C-101. The DQO also stipulates that the vapor space of the tank should be sampled for flammable gas content. The results of recent vapor space sampling and analysis will be incorporated in the next revision to this document.

In addition to the safety screening analyses, bulk density was requested by Characterization Plant Engineering. TOC, TIC, and pH analyses were requested by Characterization Process Control. These analyses, along with the safety screening analysis results reported in WHC-SD-WM-DP-111, *45-Day Safety Screen Results for Tank 241-C-101, Auger Sample 95-AUG-019* (Sasaki 1995), are summarized in the following sections.

4.2 DATA PRESENTATION

4.2.1 Total Alpha

Total alpha measurements were performed on the three samples from riser 8 (crust, upper half of the auger, and lower half of the auger). Each sample was run in duplicate and analyzed for total alpha according to procedure number LA-508-101. The results of these analyses are summarized in Table 4-1.

The fifth column of the table provides the mean of the two runs performed on each portion of the auger sample. The last column of the table provides the simple mean of all the results (i.e., total of all primary and duplicate results divided by the number of results).

Table 4-1. Tank 241-C-101 Analytical Data for Total Alpha.

Laboratory sample number	Sample location	Run	Total alpha activity, μCi/g	Sample mean, μCi/g	Overall mean, μCi/g
S95T000824	Crust	1	0.986	1.18	1.09
		2	1.37		
S95T000828	Upper 1/2 of auger	1	0.869	0.955	
		2	1.04		
S95T000832	Lower 1/2 of auger	1	1.05	1.14	
		2	1.23		

4.2.2 Total Organic Carbon and Total Inorganic Carbon

The total organic carbon content and total inorganic carbon content of the waste were requested by Characterization Process Control because of high carbon dioxide readings in the vapor space above the waste.

TOC was determined by persulfate ultraviolet oxidization using procedure LA-622-102. TIC was determined by subtracting the TOC value from the total carbon value. Total carbon was analyzed by coulometric furnace oxidation procedure LA-344-105. By this method, the sample is oxidized with an oxidative catalyst then measured by a nondispersive infrared analyzer. The TOC and TIC values for tank 241-C-101 were derived from the drainable liquid phase of the waste and are presented in Table 4-2. The values listed in the table represent the average of the primary sample and its respective duplicate sample.

Table 4-2. Tank 241-C-101 Total Organic and Inorganic Carbon Analytical Data.

Analysis	Sample number	Sample type	Mean sample result μg C/ml
Total organic carbon	S95T000906	Drainable liquid	1,260
Total inorganic carbon			3,990

4.3 PHYSICAL MEASUREMENT RESULTS

The only physical requirements requested in the Tank Safety Screening DQO (Babad and Redus 1994), are TGA weight percent water and DSC to determine the energy content. In addition to the safety screening requirements, bulk density and pH were also requested and performed. The results of these analyses are summarized in the following sections.

4.3.1 Density and pH

The density measurements were performed on the upper and lower half of the auger segment, and each sample was measured once (without duplicates). The pH measurement was determined from the drainable liquid portion of the sample and included a duplicate analysis. The results for density and pH are given in Table 4-3.

Table 4-3. Tank 241-C-101 Density and pH Analytical Results.

Analysis	Sample number	Sample location or type	Sample result	Mean
Bulk density	S95T000826	Upper ½ of auger	1.84 g/ml	1.79 g/ml
	S95T000830	Lower ½ of auger	1.73 g/ml	
pH	S95T000906	Drainable liquid	10.7	

4.3.2 Thermogravimetric Analysis

Thermogravimetric analysis measures the mass of a sample as the temperature of the sample is increased at a constant rate. Nitrogen gas is passed over the sample during heating to inert the sample chamber and to ensure no gas-phase induced oxidation occurs. Any decrease in the weight of the sample represents a loss of gaseous matter from the sample either through evaporation or through a reaction that forms gas-phase products.

The weight percent water by TGA was performed under a nitrogen purge using either procedure LA-560-112, on a Mettler TG 50 instrument (drainable liquid and lower half of auger), or procedure LA-514-114, on a Perkin-Elmer TGA 7 instrument (crust and upper half of auger). The analyses were run in duplicate. The TGA results for tank 241-C-101 are presented in Table 4-4. The recorded weight losses are relative to the original weight of the sample.

The TGA results associated with the drainable liquid sample displayed only one broad transition, ranging from ambient temperature to 155 °C. The loss of sample weight within this temperature range is attributed to the evaporation of free and interstitial water.

Table 4-4. Thermogravimetric Results for Tank 241-C-101.

Sample number	Sample location or type	Run	Transition 1			Transition 2		
			Temperature range (°C)	Sample result (wt% loss)	Mean (wt% loss)	Temperature range (°C)	Sample result (wt% loss)	Mean (wt% loss)
S95T000820	Drainable liquid	1	Ambient to 155	73.8	73.8	--	--	--
		2	Ambient to 155	73.8		--	--	
S95T000823	Crust	1	Ambient to 118	10.5[1]	15.4	249 to 348	18.8	18.2
		2	Ambient to 120	20.4		247 to 350	17.6	
S95T000827	Upper half	1	Ambient to 118	23.4	22.6	248 to 348	16.6	17.0
		2	Ambient to 123	21.8		245 to 343	17.3	
S95T000831	Lower half	1	Ambient to 140	33.6	33.9	242 to 335	11.3	11.2
		2	Ambient to 109	34.2		242 to 335	11.1	

[1]Rerun gave 19.8%.

The solid samples displayed two distinct transitions. The first transition occurred between ambient temperature and approximately 140 °C and is attributed to the evaporation process described for the drainable liquid sample. The second transition occurs at much higher temperatures, 242 °C to 350 °C. This second loss may be due to the dehydration of aluminum hydroxide or to the melting of sodium nitrate that occurs near 300 °C.

The drainable liquid sample averaged 73.8 wt% water. The solid samples averaged from 15.4 wt% for the crust to 33.9 wt% water for the lower half solids. The results of the crust sample were 10.5 wt% for the primary sample and 20.4 wt% water for the duplicate. The average of the primary sample and its duplicate was 15.4 wt%. The TGA result for the crust sample is less than the DQO threshold of 17 wt% water (Babad and Redus 1994). According to the DQO, notification is required if the sample analyzed yields a result that is less than this limit; therefore, verbal and written notifications were made on May 3, 1995. A rerun of the crust sample yielded a weight percent of 19.8, indicating that the sample may, however, have sufficient moisture.

4.3.3 Differential Scanning Calorimetry

In a DSC analysis, heat absorbed or emitted by a substance is measured as the substance is exposed to a linear increase in temperature. While the substance is being heated, nitrogen gas is passed over the waste material to inert the sample chamber.

Analyses for DSC were performed using procedure LA-514-113. The DSC analyses were performed in duplicate (run 1 and run 2). No exothermic reactions were observed in any of the samples or their respective duplicates.

The DSC results for tank 241-C-101 are given in Table 4-5. The onset temperature and the magnitude of the enthalpy change are provided for each transition. The first transition represents the endothermic reaction for the evaporation of free and interstitial water. The second transition probably represents the energy (heat) required to remove the bound water from hydrated compounds such as aluminum hydroxide or to melt salts such as sodium nitrate.

Table 4-5. Differential Scanning Calorimetry Results for Tank 241-C-101.

Sample number	Sample location or type	Run	Sample weight (mg)	Transition 1		Transition 2	
				Onset temp (°C)	ΔH (J/g)	Onset temp (°C)	ΔH (J/g)
S95T000823	Crust	1	21.4	36.1	472	261	472
		2	29.6	36.3	474	264	498
S95T000827	Upper ½	1	24.3	101	672	260	476
		2	17.8	35.1	641	258	496
S95T000831	Lower ½	1	29.3	115	787	289	356
		2	29.1	111	801	289	319
S95T000820	Drainable liquid	1	12.4	107	1,500	219	16.0
		2	12.7	107	1,350	219	15.5

ΔH = change in enthalpy.
J = Joules.

5.0 INTERPRETATION OF CHARACTERIZATION RESULTS

The purpose of this chapter is to evaluate the overall quality and consistency of the available results for tank 241-C-101 and to assess and compare these results against historical information and program requirements.

5.1 ASSESSMENT OF SAMPLING AND ANALYTICAL RESULTS

This section evaluates sampling and analysis factors that may impact interpretation of the data. These factors are used to assess the overall quality and consistency of the data and to identify any limitations in the use of the data. Because of the limited sampling and analysis for tank 241-C-101, evaluation of many of the items for data consistency is not possible.

5.1.1 Field Observations

Two events associated with the sampling of tank 241-C-101 occurred that could impact the quality of the analytical data: one riser was sampled instead of the two required in the Tank Characterization Plan (Schreiber 1995), and an error was made during the sampling operation that resulted in the first auger sampling the full height of the waste in the tank. These two conditions primarily impact any interpretation of the heterogeneity or stratification of the waste, the first because only one point was sampled and the second because the entire waste column of approximately 76.2 cm became distributed on the 50.8-cm length of the auger sampler. According to Sasaki (1995), off-white material was mixed with the dark brown material of the upper segment half on the top four auger flutes.

5.1.2 Quality Control Assessment

Blanks, duplicates, spikes, and standards for quality control were performed, where appropriate, on most of the 1995 auger sampling analyses. Table 5-1 summarizes the quality control data for the tank 241-C-101 analyses. The Tank Characterization Plan (Schreiber 1995) established a criteria of $\pm$ 10 percent for the accuracy and precision of the data.

Standards are used to estimate the accuracy of the analytical method and are evaluated prior to and concurrent with sample analysis. Standards contain the analytes of interest at known concentrations. The criterion for standard recovery is 100 $\pm$ 10 percent. If a standard is above or below the criterion, then the analytical results can be concluded to be high or low, respectively. All of the standards conducted on percent water, DSC, TIC, and TOC were in the acceptable range. However, the only standard run for total alpha activity was slightly below the criterion (83.1 percent), indicating that the analytical results for total

Table 5-1. Quality Control Summary, 1994 Auger Samples.

Sample ID number	Analyte	RPD %[a]	Standard %[b]	Blank	Spike recovery %[b]
S95T000823	$ water, crust	64.1	97.64	NA	NA
S95T000827	% water, upper half solids	7.08	97.64	NA	NA
S95T000831	% water, lower half solids	1.77	99.49	NA	NA
S95T000820	% water, drainable liquid	0	99.51	NA	NA
S95T000823	DSC, crust	NA	100.4	NA	NA
S95T000827	DSC, upper half solids	NA	100.4	NA	NA
S95T000831	DSC, lower half solids	NA	95.25	NA	NA
S95T000820	DSC, drainable liquid	NA	109.7	NA	NA
S95T000823	Total, alpha, crust	32.6	83.11	< DL	80.80
S95T000828	Total alpha, upper half solids	17.9	83.11	< DL	85.10
S95T000832	Total alpha, lower half solids	15.8	83.11	< DL	88.90
S95T000906	Total organic carbon	2.39	99.67	< DL	110.0
S95T000906	Total inorganic carbon	2.51	97.33	< DL	96.6
S95T000906	pH, drainable liquid	0.10	NA	NA	NA

[a]10% limit.
[b]Range = 90-110%.
DL = detection limit.
DSC = differential scanning calorimetry.
RPD = relative percent difference.

alpha may be biased low. Standards are not applicable to bulk density and were not performed for the pH analyses.

Matrix spikes are used to estimate the bias of the analytical method caused by matrix interferences. Spike samples are prepared by splitting a sample into two aliquot portions and adding a known amount of a particular analyte to one aliquot portion to calculate a percent recovery. The quality control criterion for matrix spike is, as with standards, 100 $\pm$ 10 percent recovery. One spike each was conducted on the TIC and TOC analyses, and both were within the criterion. All three of the spikes conducted on the total alpha results (80.8, 85.1, and 88.9 percent), were below the criterion again indicating that the total alpha analytical results may be biased low. The low spike values are most likely caused by absorption of alpha particles by the solids in the sample. Spikes are not applicable to the bulk density, pH, DSC, and TGA methods.

Blanks are used to determine whether contamination results from the analytical process. Blanks are prepared by filling sample containers with deionized, distilled water. The blanks are carried through the complete sample preparation and analytical procedure, and all reagents used in sample processing are added in the same volumes. Evaluation of blanks is only applicable to the total alpha, TIC, and TOC analyses. All blanks were below the detection limit, indicating that contamination was not a problem for these analytes.

The precision requirements are calculated by determining the relative percent difference (RPD) between primary and duplicate samples. The RPD is defined as the absolute difference between duplicate results, divided by the mean. The Tank Characterization Plan for tank 241-C-101 (Schreiber 1995) set the duplicate precision acceptance criterion at 10 RPD. No RPDs were calculated for DSC because no exothermic reactions were detected, and the bulk density had no RPDs because no duplicates were performed. The RPDs for TIC, TOC, and pH met the criteria. One of four RPDs for percent water (64.1 percent) exceeded the criteria, but the rerun of this sample resulted in an acceptable RPD. As with the spikes, all three of the RPDs for total alpha (32.6, 17.9, and 15.8 percent), were outside the limits but no reruns were requested as the analytical results were less than 5 percent of the Tank Safety Screening DQO limit (Sasaki 1995).

In summary, the total alpha results may be suspect because of the low standard and spike recoveries as well as the high RPD results. The quality control information for the remainder of the analytes indicates that the analytical results are reasonably consistent.

5.1.3 Data Consistency Checks

Comparisons of different analytical methods, such as the comparison of phosphorus and phosphate results, the mass and charge balance, or the comparison of total alpha and the sum of the individual radionuclide activities, are not possible with the data available.

5.2 COMPARISON OF ANALYTICAL DATA

The vapor space of tank 241-C-101 was recently sampled to help determine the potential risks of fugitive emissions to tank farm workers. The average of three analyses for vapor sample CO_2 concentration was found to be 1,426 ppm (Huckaby 1995), higher than any other tank that has been sampled. As discussed in Section 3, TIC and TOC analyses were conducted on the drainable liquid fraction of the 1994 auger sample to help determine the origin of the high CO_2 concentration measured in the vapor samples.

Appendix B contains a calculation that predicts the theoretical equilibrium concentration of $CO_2(g)$ that could be expected in the vapor space of tank 241-C-101 based on the TIC results from the 1994 auger sample. The calculation predicts an equilibrium concentration of $CO_2(g)$ of 23,400 ppm--well above the 1,426 ppm measured in the vapor space samples. The high $CO_2(g)$ readings in the vapor space can thus be accounted for by the inorganic content of the waste. The TOC results on the drainable liquid portion of the auger sample were relatively low compared to other sampled tanks--well below the organics safety program limit of 30,000 μg C/ml. Based on the calculation in Appendix B and the measured TOC content of the waste, there is little reason to suspect that the high CO_2 readings in the tank 241-C-101 vapor space are due to decomposition of organics within tank 241-C-101.

The tank 241-C-101 vapor space is connected via cascade lines to tanks 241-C-102 and 241-C-103. The vapor spaces of all three tanks are passively ventilated through a riser on tank 241-C-102 (Conrad 1994). Constituents detected in the headspace of tank 241-C-101, because it may be breathing via tank 241-C-102, may actually have originated from the waste in tanks 241-C-102 or 241-C-103. Tank 241-C-103 is known to have a layer of semivolatile organic liquid floating on the aqueous waste (Pool and Bean 1994). Tank 241-C-102 is known to have contained bulk quantities of the same semivolatile organic liquid (Carothers 1988), and its presence is still evident in auger samples (Campbell et al., 1995). To confidently determine the origin of the high CO_2 concentrations measured in Tank 241-C-101, detailed analyses of the liquids and solids layers in all three tanks need to be performed. The extent to which the three tanks in the cascade exchange gases must also be determined.

5.3 TANK WASTE PROFILE

As mentioned in Section 5.1.1, only one auger sample was taken from tank 241-C-101, preventing any horizontal comparisons in the waste disposition. Vertically, 76 cm (30 in.) of waste was mistakenly sampled by one 51-cm (20-in.) auger, possibly mixing the waste from different depths. For these reasons, any attempt to interpret or infer an analyte profile could not be justified. Also, due to the limited amount of data, a statistical evaluation of the results was not attempted.

5.4 COMPARISON OF ANALYTICAL AND HISTORICAL DATA

Because of the limited analytical requirements stipulated by the safety screening characterization (Babad and Redus 1994), few comparisons are possible between the analytical results from the 1995 sampling event and the historical transfers and estimated inventories. There are no TOC, pH or DSC data listed in the Historical Tank Content Estimate (Brevick et al. 1994); however, historical estimates for bulk density and percent water are available (see Table 2-5). Total alpha activity can also be estimated from the historical plutonium activity in Table 2-5. Table 5-2 compares the historical and analytical data for bulk density, water content, and total alpha. The analytical weight percent water value in Table 5-2 corresponds to the weight-weighted average of the results reported in Table 4-4 (transition 1) for the crust, upper half solids, and lower half solids, and drainable liquid samples. There was no Historical Tank Content Estimate (Brevick et al. 1994) available for the supernatant TIC, but the analytical result of 3,990 μg C/ml can be compared with the uranium recovery waste supernatant prediction of 10,500 μg C/ml in WHC-SD-WM-TI-629, *Hanford Defined Wastes: Chemical and Radionuclide Compositions* (Agnew 1995).

Table 5-2. Comparison of the Solids Analytical Results and Historical Tank Content Estimate Estimates.*

Analyte	Analytical result	HTCE result
Bulk density (g/ml)	1.79	1.45
Percent water (by weight)	33.8	61.1
Total alpha (μCi/g)	1.09	0.512 (Pu only)

Note: 1 Ci = 3.7 E+10 Bq.

*C. H. Brevick, L. A. Gaddis, and W. W. Pickett, 1994, *Historical Tank Content Estimate for the Northeast Quadrant of the Hanford 200 East Areas*, WHC-SD-WM-ER-349, Rev. 0, ICF Kaiser Hanford Company, Richland, Washington.

5.5 EVALUATION OF PROGRAM REQUIREMENTS

This section details the data needs as defined in the Tank Safety Screening DQO (Babad and Redus 1994) and investigates whether tank 241-C-101 has been appropriately categorized concerning safety issues. The DQO establishes decision criteria or notification limits for concentrations of analytes of concern. If results from one of the primary analyses exceed any of the decision criteria, the tank is not classified as "safe" and further analyses are conducted to ensure the safety of the tank (Babad and Redus 1994). There are insufficient data available to assess impacts on operational, environmental, or process development programs.

5.5.1 Safety Evaluation

The primary analytical requirements identified in the Tank Safety Screening DQO (Babad and Redus 1994) are energetics, total alpha activity, moisture content, and flammable gas concentration. TOC was analyzed on the drainable liquid sample for tank 241-C-101 at the request of Characterization Process Control. The 1995 auger sampling event failed to meet all the requirements of the Tank Safety Screening DQO. The specific requirement that a horizontal profile of the tank be obtained from the tank from two widely spaced risers was not met. One riser was sampled rather than two, because of a lack of riser availability. One 50.4-cm auger sample was used to sample the entire 76.2-cm waste column, making decisions based on tank stratification difficult or impossible. Table 5-3 lists the DQO-required analytes, their notification limits, and their analytical results.

The waste fuel energy value was determined by DSC. No exotherms were observed on the 1995 auger sample. Another indicator of fuel content is TOC concentration. The analytical TOC result for the drainable liquid was 1,260 μg C/ml, which is well below the Organics Safety Program limit of 30,000 μg C/ml (Babad et al. 1994). The DSC and TOC results indicate that tank 241-c-101 waste does not contain excessive amounts of fuel.

Large amounts of moisture reduce the potential for propagating exothermic reactions in the waste. The percent water content of the waste was determined by TGA. All samples except the original sample of the crust material were above the notification limit of 17 percent. However, the implications for tank safety are probably minimal, given the endothermic DSC results. In addition, the average of the two crust sample analyses was above the notification limit indicating that the original crust analysis may be anomalous.

Another factor in assessing the safety of tank waste is the heat generation and temperature of the waste. Heat is generated in the tanks primarily from radioactive decay. No radiological results were obtained, but the Historical Tank Content Estimate of 11 W (38 British thermal units/hours [Btu/hr]) was well below the 40,000 Btu/hr threshold which separates high heat tanks from low heat tanks (Brevick et al. 1994). Thermocouple readings (Section 2.4.2) indicate that the radioactive decay heat in the tank is adequately dissipated throughout the year.

The potential for criticality can be assessed from the total alpha data. None of the individual subsamples from the 1995 auger sample contained alpha activity greater than 1.37 μCi/g, and the mean result was 1.09 μCi/g. This was well below the notification limit of 1 g/L (or 34.4 μCi/g) as specified in the Tank Safety Screening DQO (Babad and Redus 1994) (see footnote b of Table 5-2).

The flammability of the gas in the head space of the tank is another safety screening consideration. The results of recent vapor space sampling analyses (Huckaby 1995) will be included in a future revision to this tank characterization report.

Table 5-3. Tank Safety Screening Data Quality Objective Decision Variables and Criteria for Tank 241-C-101.

Safety issue	Primary decision variable	Decision criteria threshold	Analytical value
Ferrocyanide/organic	Total fuel content	481 J/g (115 cal/g) dry weight basis	No exotherms observed
Organic	Percent moisture	17 wt%	10.5 wt%[a]
Criticality	Total alpha	34.4 μCi/g 1 g/L)[b]	1.37 μCi/g[c]
Flammable gas	Flammable gas	L 25% LFL for all flammable gases	Not included

[a]Represents the minimum crust result (Table 4-4). The duplicate and rerun results on the crust were 20.4 wt% and 19.8 wt%, respectively.

[b]Although the actual decision criterion listed in the DQO is 1g/L, total alpha is measured in μCi/g rather than g/L. To convert the notification limit for total alpha into a number more readily usable by the laboratory, it was assumed that all alpha decay originates from ^{239}Pu. Using the average bulk density value from Table 4-3 of 1.79 g/ml, the decision criterion may be converted to 34.4 μCi/g as shown:

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

[c]Maximum taken from Table 4-1. </spctable>
</spc>

[d]Vapor space sampling results will be provided in future revisions to this tank characterization report.
J = Joules.

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6.0 CONCLUSIONS AND RECOMMENDATIONS

Tank 241-C-101 is a non-watch list tank; is an assumed leaker that was removed from service in 1976. The only recorded sampling event for tank 241-C-101 is a single segment auger sample taken in March of 1995. This event was governed by the Tank Safety Screening DQO (Babad and Redus 1994). A second intended auger sample could not be taken because of an unavailable riser. Analysis of the auger sample taken was directed primarily at safety screening criteria TIC, TOC, pH, and bulk density were also measured to help interpret the origin of high CO_2 concentrations found in the vapor space. The chemical and radiochemical composition of the waste must be estimated solely from tank waste history. During sampling, the 51-cm auger penetrated the entire 76-cm depth of the waste. The waste sample removed with the auger is thus not representative of the vertical disposition of waste in the tank. Because only a single auger sample was taken and because this auger sample is not representative of the vertical disposition of the waste, no conclusions regarding the horizontal or vertical disposition of the waste can be drawn. Should a better understanding of the waste content and disposition be desired, further sampling and analysis should be performed. However, adequate data are available from the 1995 sampling and analysis event to support the current non-watch list status of this tank.

The 1995 auger sampling did not fully comply with the Tank Safety Screening DQO (Babad and Redus 1994) because a single sample was taken from one riser instead of the required two samples from different risers. The analytical results fell within the safety screening criteria with the exception of an individual result for percent water. However, the rerun of this sample met the criteria. No exothermic reactions were exhibited by the DSC analysis, indicating that the fuel content of the tank is not excessive. The TOC content of the drainable liquid from the 1995 auger sample was found to be well below the safety program limit of 30,000 μg c/mL. In addition, the historical estimate of the tank heat load and tank temperatures do not indicate that excessive heat is being generated in the waste. The DSC results, low TOC results, and tank temperature readings indicate that the potential for runaway reactions in the waste is remote. The single low wt% water result is of low concern given the DSC, TOC, and temperature measurements.

The tank history indicates that the major waste types present are metal waste uranium recovery waste, and PUREX cladding waste. These waste types are known to have high aluminum, iron, sodium, sulfate, hydroxide, and nitrate. The major radionuclides are cesium and strontium. The water content and bulk density of the waste as estimated from the 1995 analytical data do not compare well with the Historical Tank Content Estimate (Brevick et al. 1994a). The chemical and radiochemical content estimates in the HTCE cannot be validated with the 1995 sample analysis results.

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APPENDIX A

SURFACE LEVEL MEASUREMENTS FOR TANK 241-C-101 FROM 1991 THROUGH 1993

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Table A-1. Tank 241-C-101 Surface Level Data Manual Tape*.

Year	Month	Day	Hour	Minutes	Surface level cm (in.)
1991	1	7	14	33	66.7 (26.25)
1991	4	23	14	52	66.7 (26.5)
1991	10	14	0	42	67.3 (26.25)
1992	4	27	22	5	67.7 (64.5)
1993	4	7	8	4	163.8 (25.5)
1993	7	1	11	14	65.0 (25.5)
1993	10	1	15	43	40.0 (15.75)
1993	10	3	13	0	63.5 (25)

*Data obtained from WHC Surveillance Analysis Computer System (SACS), November 16, 1993.

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APPENDIX B

CALCULATION TO DETERMINE EQUILIBRIUM CONCENTRATION OF CO_2 IN THE VAPOR SPACE OF TANK 241-C-101

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APPENDIX B

CALCULATION TO DETERMINE EQUILIBRIUM CONCENTRATION OF CO_2 IN THE VAPOR SPACE OF TANK 241-C-101

This calculation determines the theoretical equilibrium concentration of carbon dioxide gas above the tank 241-C-101 waste, based on the total inorganic content (TIC) of the waste as measured from the 1995 auger sample.

DATA

Mean TIC result on auger sample drainable liquid = 3,990 μg C/mL (Table 4-2).

Molarity of inorganic carbon in aqeous phase of the waste = [TIC]
= (3,990 μg C/mL)(1 mol C/1.2 x 10^7 μg)(1,000 mL/L) = 0.3225 M.

pH of auger sample drainable liquid = 10.2 (Table 4-3).

EQUATIONS

pH = -log[H^+], where [H^+] = concentration of H^+ ion
K = equilbrium or dissociation constant = Π (products)/Π (reactants)

CO_2 (g) $\rightleftarrows$ CO_2 (gas)

$$K_1(35\ °C) = [CO_2(aq)]/[CO_2(g)] \tag{B-1}$$

$K_1(35\ °C)$ = 0.027416 (interpolated from data in EPRI [1969])

$CO_2(aq) + H_2O \rightleftarrows H^+ + HCO_3^-$

$$K_2(35\ °C) = [H^+][HCO_3^-]/[CO_2(aq)] \tag{B-2}$$

$K_2(35\ °C)$ = 4.529 x 10^{-7} (interpolated from data in EPRI [1969])

$HCO_3^- \rightleftarrows H^+ + CO_3^{-2}$

$$K_3(35\ °C) = [H^+][CO_3^{-2}]/[HCO_3^-] \quad \text{(B-3)}$$

$K_3(35\ °C) = 5.4075 \times 10^{-11}$ (interpolated from data in EPRI [1969])

SOLUTION

From equation B-3,

$$[CO_3^{-2}] = 5.4075 \times 10^{-11}[HCO_3^-]/[H^+].$$

From Table 4-3,

$$pH = 10.2.$$

Therefore,

$$[H^+] = 10^{(-10.2)} = 6.31 \times 10^{-11}$$

and,

$$[CO_3^{-2}] = 5.4075 \times 10^{-11}[HCO_3^-]/6.31 \times 10^{-11} = 0.857[HCO_3^-] \quad \text{(B-4)}$$

$$[TIC] = [CO_3^{-2}] + [HCO_3^-] = 0.3225\ M \text{ (from Data Section)}$$

Solving for $[HCO_3^-]$ using equation B-4

$$0.857[HCO_3^-] + [HCO_3^-] = 0.3325$$

$$[HCO_3^-] = 0.3325/1.857 = \underline{0.1791\ M}$$

Solve for $[CO_3^{-2}]$ based on [TIC]

$$[CO_3^-] = 0.3325\ M - 0.1791\ M = \underline{0.1534\ M}$$

Solve for $[CO_2(aq)]$ using B-2:

$$[CO_2(aq)] = [H^+][HCO_3^-]/K_2$$

$$[CO_2(aq)] = (6.31 \times 10^{-11})(0.1791)/(4.529 \times 10^{-7}) = \underline{2.50 \times 10^{-5}\ M}$$

Solve for $[CO_2(g)]$ using equation B-1:

$$[CO_2(g)] = [CO_2(aq)]/K_1 = 2.50 \times 10^{-5}/0.027416 = \underline{9.12 \times 10^{-4}\ M}$$

Convert vapor space $CO_2(g)$ molarity to ppm using ideal gas law. First determine number of moles of ideal gas in one liter volume:

$$n = PV/RT$$

where

n = moles of ideal gas
P = 1 atm
V = 1 L basis
R = 0.08206 (L)(atm)/[(mol)(K)]
T = temperature of vapor space, assumed to be 313 K (35 °C)

$$n = (1\ atm)(1\ L)/[(0.08206)(313)] = 3.893 \times 10^{-2}\ mol$$

Divide $[CO_2(g)]$ by n above to determine $CO_2(g)$ concentration on a volume fraction basis:

$$CO_2(g)\ volume\ fraction = 9.12 \times 10^{-4}\ M/3.893 \times 10^{-2} = 2.34 \times 10^{-2}$$

Multiply by 1×10^6 to convert to ppm:

$$CO_2(g)\ concentration = \underline{23{,}400\ ppm}$$

REFERENCE

EPRI, 1969, *High Temperature Thermodynamic Data for Species in Aqueous Solution*, EPRI NP-2400, Project 1167-1, Electric Power Research Institute, San Diego State University Foundation, San Diego, California.

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