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# Tank Characterization Report for Single-Shell Tank 241-B-109

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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-B-109. This report supports the requirements of the Tri-Party Agreement Milestone M-44-10.



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# Tank Characterization Report for Single-Shell Tank 241-B-109

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Assistant Secretary for Environmental Management

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## LIST OF TERMS

| | |
|---|---|
| 1C | first-cycle decontamination waste |
| ANOVA | analysis of variance |
| Btu/hr | British thermal units per hour |
| BSltCk | saltcake waste |
| Ci | curie |
| Ci/L | curies per liter |
| cm | centimeter |
| CW | aluminum cladding waste |
| CWP | PUREX cladding waste |
| CWP2 | PUREX process aluminum cladding waste |
| DQO | data quality objective |
| DSC | differential scanning calorimetry |
| EB | evaporator bottoms (slurry product from evaporators) |
| ft | feet |
| g | gram |
| $g/cm^3$ | grams per cubic centimeter |
| g/gal | grams per gallon |
| g/L | grams per liter |
| g/mL | grams per milliliter |
| g/$\mu$g | grams per microgram |
| HDW | Hanford defined waste |
| HTCE | historical tank content estimate |
| IC | ion chromatography |
| ICP | inductively coupled plasma spectroscopy |
| in. | inch |
| J/g | joules per gram |
| kg | kilogram |
| kgal | kilogallon |
| kg/L | kilograms per liter |
| kL | kiloliter |
| L/kL | liters per kiloliter |
| LFL | lower flammability limit |
| LL | lower limit |
| m | meter |
| mm | millimeter |
| *M* | moles per liter |
| mrad/hr | millirads per hour |
| n/a | not applicable |
| n/r | not reported |
| PHMC | Project Hanford Management Contractor |
| ppm | parts per million |

## LIST OF TERMS (Continued)

| | |
|---|---|
| PUREX | plutonium-uranium extraction (plant) |
| QC | quality control |
| REML | restricted maximum likelihood estimation |
| RPD | relative percent difference |
| SACS | Surveillance Analysis Computer System |
| SL | sludge waste |
| SMM | supernatant mixing model |
| SU | supernatant waste |
| SWLIQ | dilute, noncomplexed waste from single-shell tanks |
| T22 | waste from in-tank scavenging with FeCN |
| TCP | tank characterization plan |
| TGA | thermogravimetric analysis |
| TIC | total inorganic carbon |
| TLM | tank layer model |
| TOC | total organic carbon |
| TWRS | Tank Waste Remediation System |
| UL | upper limit |
| UNK | unknown waste origin |
| UR | uranium recovery |
| W | watt |
| WSTRS | Waste Status and Transaction Record Summary |
| wt% | weight percent |
| °C | degrees Celsius |
| °F | degrees Fahrenheit |
| μCi/g | microcuries per gram |
| μCi/gal | microcuries per gallon |
| μCi/mL | microcuries per milliliter |
| μeg/g | microequivalents per gram |
| μg/g | micrograms per gram |

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# 1.0 INTRODUCTION

One major function of the Tank Waste Remediation System (TWRS) is to characterize wastes in support of waste management and disposal activities at the Hanford Site. Analytical data from sampling and analysis, and other available information about a tank are compiled and maintained in a tank characterization report. This report and its appendixes serve as the tank characterization report for single-shell tank 241-B-109.

The objectives of this report are: 1) to use characterization data in response to technical issues associated with tank 241-B-109 waste, and 2) to provide a standard characterization of this waste in terms of a best-basis inventory estimate. Section 2.0 summarizes the response to technical issues, Section 3.0 provides the best-basis inventory estimate, and Section 4.0 provides recommendations about safety status and additional sampling needs. The appendixes contain supporting data and information. This report also supports the requirements of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), Milestone M-44-10.

## 1.1 SCOPE

The characterization information in this report originated from sample analyses and known historical sources. Although only the results of recent sample events will be used to fulfill the requirements of the data quality objectives (DQOs), other information can be used to support (or question) conclusions derived from these results. Appendix A contains historical information for tank 241-B-109 including surveillance information, records pertaining to waste transfers and tank operations, and expected tank contents derived from a process knowledge model.

Appendix B summarizes the recent sampling events listed in Table 1-1, sample data obtained before 1989, and sampling results. The results of the 1996 sampling event, reported in the laboratory data package (Nuzum 1997), satisfied the data requirements specified in the tank characterization plan (TCP) (Winkelman 1996) for this tank. The statistical analysis and numerical manipulation of data used in issue resolution are reported in Appendix C. Appendix D contains the evaluation to establish the best basis for the inventory estimate and the statistical analysis performed for this evaluation. Appendix E is a bibliography resulting from an in depth literature search of all known information sources applicable to tank 241-B-109 and its respective waste types. The reports listed in Appendix E can be found in the Tank Characterization Resource Center.

Table 1-1. Summary of Recent Sampling.

| Sample/Date | Phase | Location | Segmentation | % Recovery[1] |
|---|---|---|---|---|
| Core 169 (August 1996) | Solid | Riser 7 | Half segment | Segment 1 31<br>Segment 2 63<br>Segment 3 0 |
| Core 170 (August 1996) | Solid | Riser 4 | Half segment, Quarter segment | Segment 1 50<br>Segment 2 95<br>Segment 3 17 |
| Vapor (August 1996) | Gas | Tank headspace | n/a | n/a |

Notes:

n/a = not applicable

[1]The percent recoveries were estimated by dividing the recovered sample lengths by the expected sample length taken from the chain-of-custody records in Nuzum 1997. Expected sample lengths ranged from 1.5 to 19 in.

## 1.2 TANK BACKGROUND

Tank 241-B-109 is located in the 200 East Area B Tank Farm on the Hanford Site. It is the last tank in a three cascade series, which includes tanks B-107 and B-108. The tank went into service in 1946 and initially received first cycle decontamination waste (1C) waste through the cascade from tank 241-B-108 (Agnew et al. 1997b). The cascade continued until the tank was filled in April 1946. After several waste transfers, the cascade was reactivated in the third quarter of 1963 and PUREX cladding waste (CWP) was added to the tank. The cascade ended in the fourth quarter of 1963. The tank was declared inactive in 1978 and underwent interim stabilization in 1985. Intrusion prevention was completed in 1985. For detailed waste transfer information, see Section A3.1 and Appendix A (see Table A3-1).

Table 1-2 summarizes the description of tank 241-B-109. The tank has an operating capacity of 2,010 kL (530 kgal), and presently contains a total volume of 481 kL (127 kgal) of waste, which is equivalent to 105 cm (41.5 in.) of waste as measured from the tank baseline (Hanlon 1997). Tank 241-B-109 is not on a Watch List (Public Law 101-510).

Table 1-2. Description of Tank 241-B-109.

| | |
|---|---|
| **TANK DESCRIPTION** | |
| Type | Single-shell |
| Constructed | 1943 to 1944 |
| In service | 1946 |
| Diameter | 22.9 m (75 ft) |
| Operating depth | 5.2 m (17 ft) |
| Capacity | 2,010 kL (530 kgal) |
| Bottom shape | Dish |
| Ventilation | Passive |
| **TANK STATUS** | |
| Waste classification | Noncomplexed |
| Total waste volume[1] | 481 kL (127 kgal) |
| Supernatant volume | 0 kL (0 kgal) |
| Saltcake volume[2] | 0 kL (0 kgal) |
| Sludge volume[2] | 481 kL (127 kgal) |
| Drainable interstitial liquid volume | 30 kL (8 kgal) |
| Waste surface level (October 3, 1996) | 105 cm (41.5 in.) |
| Temperature (April 1974 to July 1996) | 12 °C (53 °F) to 33 °C (91 °F) |
| Integrity | Sound |
| Watch List | None |
| **SAMPLING DATE** | |
| Tank headspace gas sampling | August 1996 |
| Push mode core sampling | August 1996 |
| **SERVICE STATUS** | |
| Declared inactive | 1978 |
| Interim stabilization | 1985 |
| Intrusion prevention | 1985 |

Notes:

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

[2]Although Hanlon (1997) reports that the tank contains all sludge waste, it is evident from the transfer history (Agnew et al. 1997b) and the push mode core samples (Nuzum 1997) that the majority of the waste is probably saltcake.

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# 2.0 RESPONSE TO TECHNICAL ISSUES

Three technical issues have been identified for tank 241-B-109 (Brown et al. 1996).

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

The TCP (Winkelman 1996) provides the types of sampling and analysis used to address the safety screening issue. Data from the recent analysis of two push mode core samples and tank headspace flammability measurements provided the means to respond to this issue. Vapor sampling is scheduled for Fiscal Year 1998 and will provide results that will address the remaining two technical issues. See Appendix B for sample and analysis data for tank 241-B-109.

## 2.1 SAFETY SCREENING

The data needed to screen the waste in tank 241-B-109 are documented in the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). Potential safety problems include exothermic conditions in the waste, flammable gases in the waste and/or tank headspace, and criticality conditions in the waste. Each condition is addressed separately.

### 2.1.1 Exothermic Conditions (Energetics)

The first requirement in Dukelow et al. (1995) is to ensure exothermic constituents (organic or ferrocyanide) in tank 241-B-109 do not pose a safety hazard. The safety screening DQO requires that waste sample profiles be tested for energetics every 24 cm (half segment) to determine whether the energetics exceed the safety threshold limit. The threshold limit for energetics is 480 J/g on a dry weight basis. Results obtained using differential scanning calorimetry (DSC) indicated no exotherms exceeded the threshold limit in any segment of either core. In addition, the calculated upper limits of the one-sided 95 percent confidence intervals for each sample result was less than the threshold limit.

### 2.1.2 Flammable Gas

The tank headspace was sampled and analyzed for the presence of flammable gases in August 1996, before the push code core sampling. Results indicated no flammable gas was detected (0 percent of the lower flammability limit [LFL]). Appendix B contains measurement data.

### 2.1.3 Criticality

The safety threshold limit is 1 g $^{239}$Pu per liter of waste. Assuming that all total alpha activity is from $^{239}$Pu and using the highest measured density of 1.94 g/mL, 1 g/L of $^{239}$Pu is equivalent to 31.7 $\mu$Ci/g of alpha activity. By using the highest density result, the lowest threshold limit in $\mu$Ci/g was obtained, thereby providing the most conservative estimate with respect to criticality evaluation. The highest core sample result for total alpha activity was 0.136 $\mu$Ci/g, well below this limit. Additionally, as required by the DQO, the upper limit (UL) of the one-sided 95 percent confidence interval for these results was 0.186 $\mu$Ci/g, far less than 1 g/L; therefore, criticality is not an issue for this tank. Appendix C contains the method used to calculate confidence limits and values.

## 2.2 HAZARDOUS VAPOR SAFETY SCREENING

The data required to support vapor screening are documented in *Data Quality Objective for Tank Hazardous Vapor Safety Screening* (Osborne and Buckley 1995). The vapor screening DQO addresses two issues: 1) does the vapor headspace exceed 25 percent of the LFL? If so, what are the principal fuel components, and 2) does the potential exist for worker hazards associated with the toxicity of constituents in any fugitive vapor emissions from these tanks?

### 2.2.1 Flammable Gas

This is the same requirement as the safety screening flammability requirement. As noted previously, flammable gas was not detected in the tank headspace (0 percent of the LFL) before sampling.

### 2.2.2 Toxicity

The vapor screening DQO requires the analysis of ammonia, carbon dioxide ($CO_2$), carbon monoxide (CO), nitric oxide (NO), nitrous oxide ($N_2O$), and nitrogen dioxide ($NO_2$) from a sample. The vapor screening DQO specifies a threshold limit for each of these compounds. The tank is scheduled to be vapor sampled in 1998. However, the toxicity issue has been closed for all tanks (Hewitt 1996).

## 2.3 ORGANIC SOLVENTS

The data required to support the organic solvent screening issues are documented in the *Recommendation 93-5 Implementation Plan* (DOE-RL 1996). A new DQO is being developed to address the organic solvent issue. In the interim, tanks are to be sampled for total nonmethane hydrocarbon to determine whether an organic extractant pool greater than 1 $m^2$ exists (Cash 1996). The purpose of this assessment is to ensure that the organic solvent pool is sufficiently small to ensure that an organic solvent pool fire or ignition of organic solvents cannot occur. The size of the organic extractant pool will be determined by the organics program based on the vapor data, tank headspace temperature, and the ventilation rate. Vapor samples to support this issue are scheduled for 1998.

## 2.4 OTHER TECHNICAL ISSUES

Heat generation and waste temperature are factors in assessing tank safety. Because the waste in tank 241-B-109 is radioactive, it generates heat through radioactive decay. An estimate of the tank heat load based on the 1996 sample event was not possible because radionuclide analyses were not required. However, the heat load estimate based on process history was 211 W (720 Btu/hr) (Agnew et al. 1997a). The heat load estimate based on the tank headspace temperature was 527 W (1,800 Btu/hr) (Kummerer 1995). Both estimates are below the limit of 11,700 W (40,000 Btu/hr) that separates high- and low-heat load tanks (Smith 1986).

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

| Analyte | Total Inventory (Ci) | Watts/Ci[2] | Watts |
|---|---|---|---|
| $^{90}Sr$ | 8,530 | 0.00669 | 57.1 |
| $^{137}Cs$ | 31,700 | 0.00472 | 149.6 |
| $^{239}Pu$ | 144 | 0.0306 | 4.4 |
| Total | | | 211.1 |

Notes:
[1]Agnew et al. (1997a)
[2]Kirkpatrick and Brown (1984)

## 2.5 SUMMARY

The results from analyses performed to address potential safety issues showed that no primary analyte exceeded safety decision threshold limits. Table 2-2 summarizes the analyses' results.

Table 2-2. Summary of Safety Screening Results.

| Issue | Sub-issue | Result |
|---|---|---|
| Safety screening | Energetics | No exotherms were observed in any sample. |
| | Flammable gas | A combustible gas meter reported 0 percent of the LFL. |
| | Criticality | All analyses were less than 0.5 $\mu$Ci/g, well below 31.5 $\mu$Ci/g total alpha (within 95 percent confidence limit on each sample). |

## 3.0 BEST-BASIS STANDARD INVENTORY ESTIMATE

Information about chemical, radiological, and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessments associated with waste management activities, and to address regulatory issues. Waste management activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes, and facilities for retrieving wastes and processing them into a form suitable for long-term storage.

Chemical and radiological inventory information are generally derived using three approaches: 1) component inventories are estimated using results of sample analyses, 2) component inventories are estimated using a model based on process knowledge and historical information, or 3) a tank-specific process estimate is made based on process flowsheets, reactor fuel data, essential material usage, and other operating data. The information derived from these different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as the standard characterization for the various waste management activities (Hodgson and LeClair 1996). As part of this effort an evaluation of chemical information for tank 241-B-109 was performed, including the following:

- Analytical data from two push mode 1996 core samples (see Appendix B)
- An inventory estimate generated by the Hanford Defined Waste (HDW) model (Agnew et al. 1997a)
- Comparing the sum of individual waste types and total waste concentrations to similar 241-B Tank Farm tank samples.

Based on this evaluation, a best-basis inventory was developed for tank 241-B-109 (see Tables D4-1 and D4-2). The evaluation used sample-based analytical data to define the best-basis inventory for the following reasons:

- The concentrations of waste components in the saltcake portions of tank 241-B-109 core sample 170 are comparable to those for tank 241-B-108. Both tanks were concluded to have received saltcake from the final pass of highly concentrated waste liquors from 1C and/or uranium recovery (UR) supernatants through the 242-B Evaporator.
- No methodology is available to fully predict 242-B Evaporator saltcake from process flowsheets or historical records.

- The relative concentrations of key components in tank 241-B-109, core 169, are consistent with those expected from waste resulting from aluminum decladding waste.

- The solubility data in Agnew et al. (1997a) for several chemical components in saltcake waste (BSltCk) are not consistent with the sample-based data for tanks 241-B-108 and 241-B-109.

Radionuclide inventories for $^{137}Cs$ were estimated based on tank 241-B-108 analyses because tank 241-B-109 analyses were unavailable. Hanford Defined Waste model bases were used as best-basis in Tables 3-1 and 3-2 where poor (or no) sample data existed.

Table 3-1. Best-Basis Inventory Estimate for Nonradioactive Components in Tank 241-B-109 (Effective January 31, 1997). (2 Sheets)

| Analyte | Total Inventory (kg) | Basis (S, M, or E)[1] | Comment |
|---|---|---|---|
| Al | 57,000 | S | |
| Bi | 2,860 | S | |
| Ca | <1,710 | S | |
| Cl | 750 | S | |
| TIC as $CO_3$ | 6,870 | S | |
| Cr | 1,770 | S | |
| F | 23,900 | S | |
| Fe | 3,740 | S | |
| Hg | 59.9 | M | No sample basis |
| K | 459 | M | No sample basis |
| La | 0.05 | M | No sample basis |
| Mn | <328 | S | Near detection limit |
| Na | 179,000 | S | |
| Ni | 174 | M | Poor sample basis |
| $NO_2$ | 7,130 | S | |
| $NO_3$ | 82,800 | S | |
| OH | 89,000 | C | Total oxide as hydroxide |
| Pb | <1,630 | S | |
| $PO_4$ | 73,200 | S | ICP basis |

Table 3-1. Best-Basis Inventory Estimate for Nonradioactive Components in Tank 241-B-109 (Effective January 31, 1997). (2 Sheets)

| Analyte | Total Inventory (kg) | Basis (S, M, or E)[1] | Comment |
|---|---|---|---|
| Si | 2,880 | S | IC basis |
| S as $SO_4$ | 84,300 | S | |
| Sr | 0 | M | Poor sample basis |
| TOC | 1,080 | S | |
| $U_{TOTAL}$ | 13,800 | S | Near detection limit |
| Zr | 4.9 | M | No sample basis |

Notes:

C = calculated by charge balance
IC = ion chromatography
ICP = inductively coupled plasma
TIC = total inorganic carbon
TOC = total organic carbon

[1]S = sample-based, M = HDW model-based, and E = engineering assessment-based.

Table 3-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-B-109, Decayed to January 1, 1994 (Effective January 31, 1997). (2 sheets)

| Analyte | Total inventory (Ci) | Basis (S, M, or E)[1] | Comment |
|---|---|---|---|
| $^{90}Sr$ | 8,530 | M | Poor sample basis |
| $^{90}Y$ | 8,530 | M | Based on $^{90}Sr$ |
| $^{137}Cs$ | 17,000 | E | Based on tank 241-B-108 |
| $^{137m}Ba$ | 16,000 | E | Based on $^{137}Cs$ |
| $^{239/240}Pu$ | 144 | M | Poor sample basis |

Note:

[1]S = sample-based, M = HDW model-based, and E = engineering assessment-based.

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# 4.0 RECOMMENDATIONS

All analytical results for the safety screening DQO (Dukelow et al. 1995) were well within the safety notification limits. The tank can be classified as safe. A characterization best-basis inventory was developed for the tank contents.

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

Table 4-1. Acceptance of Tank 241-B-109 Sampling and Analysis.

| Issue | Sampling and Analyses Performed | TWRS[1] Program Acceptance |
|---|---|---|
| Safety screening DQO | Yes | Yes |
| Hazardous vapor | No | N/R |
| Organic solvents | No | N/R |

Note:

[1]PHMC Program Office

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

Tank 241-B-109 is considered safe and does not require resampling. All analytical results from this sampling event were well below the threshold limits identified in Dukelow et al. (1995). There is no criticality concern for this tank.

Table 4-2. Acceptance of Evaluation of Characterization Data and Information for Tank 241-B-109.

| Issue | Evaluation Performed | TWRS Program Acceptance[1] |
|---|---|---|
| Safety categorization (tank is safe) | Yes | N/R |
| Hazardous vapor | No | N/R |
| Organic solvents | No | N/R |

Note:
[1]PHMC Program Office

# 5.0 REFERENCES


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# APPENDIX A

# HISTORICAL TANK INFORMATION

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# APPENDIX A

# HISTORICAL TANK INFORMATION

Appendix A describes tank 241-B-109 based on historical information. For this report, historical information includes information about the fill history, waste types, surveillance, or modeling data about the tank. This information is necessary to provide a balanced assessment of the sampling and analytical results.

This appendix contains the following information:

- **Section A1**: Current status of tank 241-B-109, including current waste levels and stabilization and isolation status.
- **Section A2**: Information about the tank design.
- **Section A3**: Process knowledge of the tank, that is, the waste transfer history and the estimated contents of the tank based on modeling data.
- **Section A4**: Surveillance data, including surface-level readings, temperatures, and a description of the waste surface based on photographs.
- **Section A5**: References for Appendix A.

Appendix B contains historical sampling results (results from samples obtained before 1989).

## A1.0 CURRENT TANK STATUS

As of October 31, 1996, tank 241-B-109 contained an estimated 481 kL (127 kgal) of noncomplexed waste (Hanlon 1997). The waste volumes were estimated using a manual tape surface level gauge. The solid waste volume was updated on April 8, 1985. Table A1-1 shows the volume estimates of the waste phases found in the tank.

Tank 241-B-109 was removed from service in 1978. It was interim stabilized in 1985; intrusion prevention (interim isolation) was completed in 1985. The tank is passively ventilated and is not on the Watch List (Public Law 101-510). All monitoring systems were in compliance with documented standards as of October 31, 1996 (Hanlon 1997).

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

| Waste Type | Volume | |
|---|---|---|
| | Kiloliters | Kilogallons |
| Total waste | 481 | 127 |
| Supernatant | 0 | 0 |
| Sludge | 481 | 127 |
| Saltcake | 0 | 0 |
| Drainable interstitial liquid | 30 | 8 |
| Drainable liquid remaining | 30 | 8 |
| Pumpable liquid remaining | 0 | 0 |

Note:

[1]For definitions and calculation methods, refer to Appendix C of Hanlon (1997).

## A2.0 TANK DESIGN AND BACKGROUND

Tank 241-B-109 was constructed during 1943 and 1944. It is one of twelve 2,010 kL (530 kgal) tanks in the B Tank Farm. The tank has a dished bottom with a 1.2-m (4-ft) radius knuckle. The tanks were designed for nonboiling waste with a maximum fluid temperature of 104 °C (220 °F) (Leach and Stahl 1996). Tank 241-B-109 has 11 risers ranging in size from 10 cm (4 in.) to 1.1 m (42 in.) in diameter that provide surface-level access to the underground tank (Alstad 1993).

Tank 241-B-109 entered service in 1946 as the third tank in a three-tank cascade that includes tanks 241-B-107 and 241-B-108. Many tanks in the Hanford Site tank farms are connected in cascades (groups of tanks that have overflow lines from one to another). Cascades served several functions in waste management operations. Cascaded tanks required fewer connections during waste disposal; consequently, all three tanks were usable without having to connect the active waste transfer line directly to each tank. In a cascade arrangement, most waste slurry solids, which were routed to the tanks, settled in the first tank, and the clarified liquids cascaded to other tanks in the series. Supernate from the final tank in the cascade series was sometimes routed to a disposal trench.

Tank 241-B-109 was designed with a primary mild steel liner (ASTM[1] A283 Grade C) and a concrete dome with various risers. The tank is set on a reinforced concrete foundation. The tank and foundation were waterproofed by a coating of tar covered by a three-ply,

[1]American Society for Testing and Materials

asphalt-impregnated, waterproofing fabric. The waterproofing was protected by welded wire reinforced gunite. Two coats of primer were sprayed on all exposed interior tank surfaces (Rogers and Daniels 1944). The tank ceiling dome was covered with three applications of magnesium zinc fluorosilicate wash. Lead flashing was used to protect the joint where the steel liner meets the concrete dome. Asbestos gaskets were used to seal the risers in the tank dome.

Tank 241-B-109 has 11 risers according to the drawings. Figure A2-1 shows the riser and nozzle configuration. Riser 4 (100 mm [4 in.] in diameter) and risers 2 and 7 (300 mm [12 in.] in diameter) are tentatively available for sampling (Lipnicki 1996). Table A2-1 shows numbers, diameters, and descriptions of the risers and the inlet, overflow, and spare nozzles. Figure A2-2 shows a tank cross section, the approximate waste level, and a schematic of the tank equipment.

Figure A2-1. Riser Configuration for Tank 241-B-109.

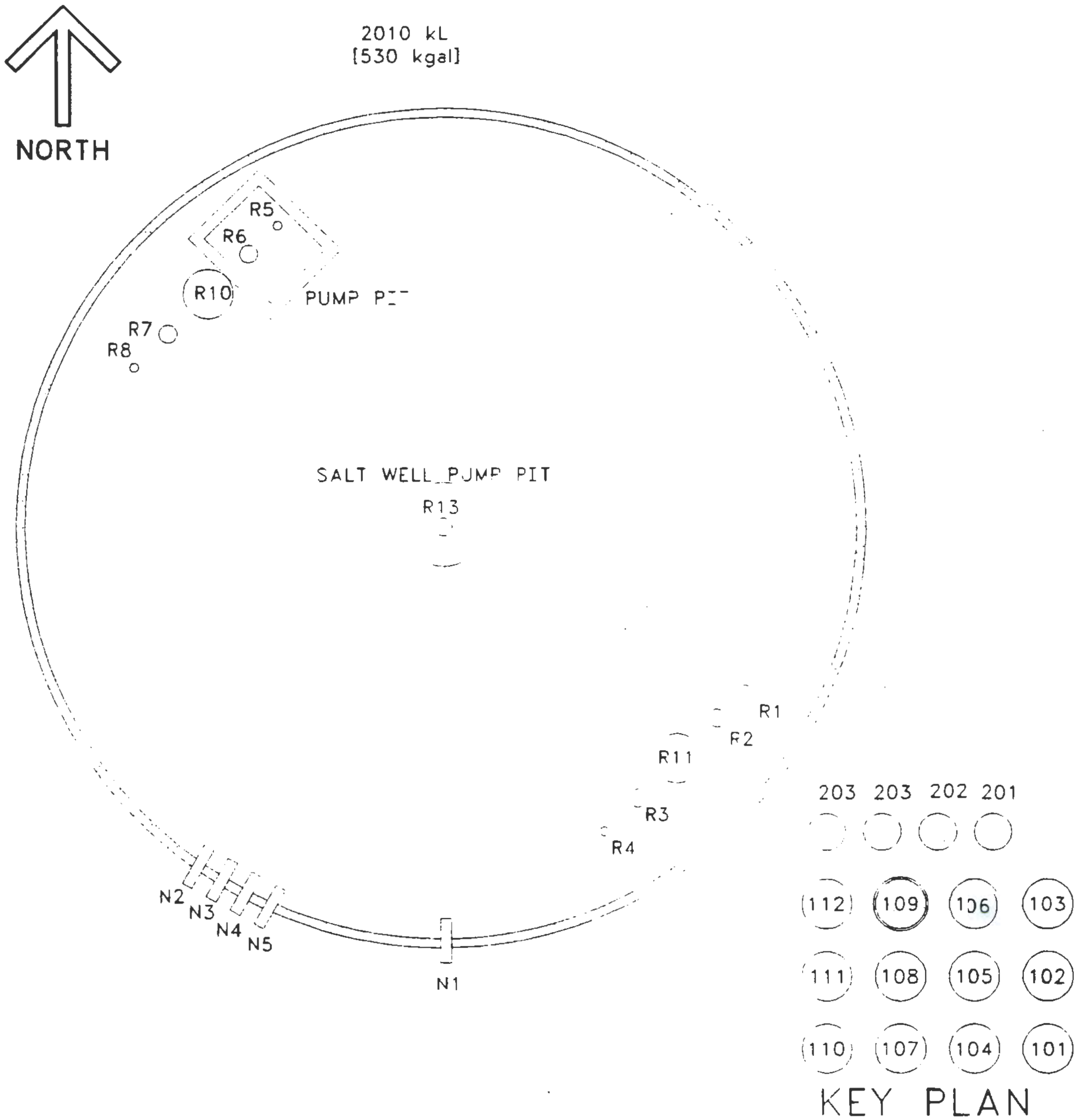


Table A2-1. Tank 241-B-109 Risers.[1, 2, 3]

| Number | Diameter (In.) | Description and Comments |
|---|---|---|
| 1 | 4 | Thermocouple tree, (bench mark CEO-37771 12/08/86) |
| 2[4] | 12 | Flange/B-222 observation port |
| 3 | 12 | Liquid level reel |
| 4[4] | 4 | Breather filter, G1 housing |
| 5 | 4 | Tank fill, weather covered |
| 6 | 12 | Pump, weather covered |
| 7[4] | 12 | Blind flange |
| 8 | 4 | Tank fill, below grade |
| 10 | 42 | Manhole, below grade |
| 11 | 42 | Manhole, below grade |
| 13 | 12 | Salt well screen, weather covered |
| N1 | 3 | Inlet |
| N2 | 3 | Spare |
| N3 | 3 | Spare |
| N4 | 3 | Spare |
| N5 | 3 | Spare |

Notes:

CEO = change engineering order

[1]Alstad (1993)
[2]Tran (1993)
[3]Vitro (1986)
[4]Denotes risers tentatively available for sampling (Lipnicki 1996).

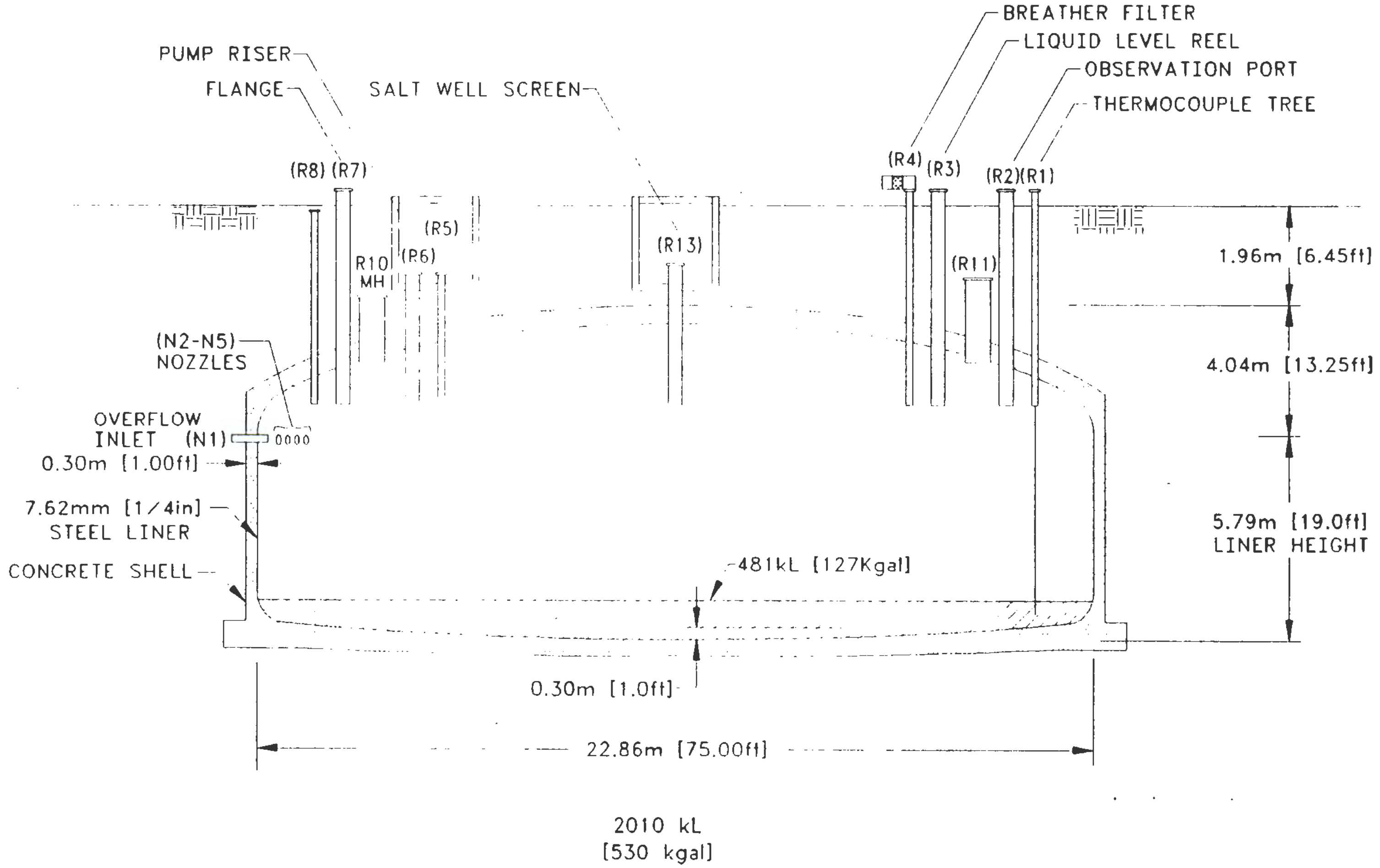



Figure A2-2. Tank 241-B-109 Cross Section and Schematic.

# A3.0 PROCESS KNOWLEDGE

This section provides information on the following: 1) the transfer history of tank 241-B-109, 2) the process wastes that made up the transfers, and 3) the estimate of the current tank contents based on transfer history.

## A3.1 WASTE TRANSFER HISTORY

Table A3-1 summarizes the waste transfer history of tank 241-B-109. The tank initially received 1C waste in January 1946 through the cascade from tank 241-B-108 (Agnew et al. 1997a). The cascade continued until the tank was filled in April 1946. Tank 241-B-109 was inactive until supernatant waste was sent to tank 241-B-106 in the first quarter of 1952 and in 1953. Sludge waste was transferred to tank 241-B-109 from tank 241-B-106 during the second and third quarters of 1952, 1953, and in the third quarter of 1954. During the third quarter of 1954, waste was sent to the B-037 crib. A transfer of waste from tank 241-B-109 to tank 241-C-111 occurred in the third quarter of 1955.

The tank was inactive again until the third quarter of 1963 when the cascade was reactivated and CWP was added to the tank. The cascade ended in the fourth quarter of 1963. Waste from tank 241-B-109 was sent to tank 241-A-102 in the fourth quarter of 1963. Tank 241-BY-101 sent waste to tank 241-B-109 during the fourth quarter of 1965. Waste from tank 241-B-109 was sent to tank 241-B-103 during the third quarter of 1969. Tank 241-B-109 received waste from tank 241-B-111 in the fourth quarter of 1969. Supernatant waste was sent to tank 241-B-109 from tank 241-B-103 in the first quarter of 1972 and received from tank 241-B-103 in the fourth quarter of 1973.

During the first quarter of 1974, tanks 241-B-201, -202, -203, and -204 sent supernatant waste to tank 241-B-109. Tank 241-B-201 sent additional supernatant waste until the third quarter of 1975. Tank 241-BY-107 sent waste to tank 241-B-109 during the second quarter of 1974. Waste was sent from tank 241-B-109 to tank 241-B-103 during the fourth quarter of 1975 and the first quarter of 1976. Also during that time, waste was received from tank 241-BY-112. Waste was received from tank 241-S-107 during the first quarter of 1976.

Tank 241-A-102 received waste from tank 241-B-109 during the second and third quarters of 1977. The final transfers of waste involving tank 241-B-109 were salt well pumping to tanks 241-AW-101 and 241-AW-106 in the first quarter of 1985 and the fourth quarter of 1992, respectively. Interim stabilization and intrusion prevention were completed on tank 241-B-109 in 1985. The most probable explanation for the tank 241-AW-106 transfer is that the salt well liquor was pumped from tank 241-B-109 to an interim storage vessel in 1985, then transferred to tank 241-AW-106 in 1992.

Table A3-1. Tank 241-B-109 Major Transfers.[1]

| Transfer Source | Transfer Destination | Waste Type | Time Period | Estimated Waste Volume | |
|---|---|---|---|---|---|
| | | | | kL | kgal |
| 241-B-108 | | IC | 1946 | 2010 | 530 |
| | 241-B-106 | SU | 1952 to 1953 | -3710 | -979 |
| 241-B-106 | | SL | 1952 to 1954 | 5008 | 1323 |
| | 241-B-037 Crib | SU | 1954 | -1440 | -380 |
| | 241-C-111 | T22 | 1955 | -1560 | -412 |
| 241-B-108 | | CWP | 1963 | 4342 | 1147 |
| | 241-A-102 | SU | 1963 | -4342 | -1147 |
| PUREX | | CWP | 1963 | 1730 | 457 |
| 241-BY-101 | | SU | 1965 | 125 | 33 |
| 241-B-111 | | SU | 1969 | 1390 | 367 |
| | 241-B-103 | SU | 1969, 1972 | -2750 | -726 |
| 241-B-103, 241-B-201, 241-B-202, 241-B-203, 241-B-204, 241-BY-107 | | SU | 1973 to 1975 | 776 | 205 |
| | 241-B-103 | SU | 1975, 1976 | -1170 | -309 |
| 241-BY-112 | | SU | 1975 to 1976 | 220 | 58 |
| 241-S-107 | | SU | 1976 | 386 | 102 |
| | 241-A-102 | SU | 1977 | -458 | -121 |
| | 241-AW-101 | SWLIQ | 1985 | -15 | -4 |
| | 241-AW-106 | SWLIQ | 1992[2] | -4 | -1 |

Notes:

SL = sludge waste
SU = supernatant waste
SWLIQ = dilute, noncomplexed waste from single-shell tanks
T22 = waste from in-tank scavenging with $Fe(CN)_6^{-4}$

[1]Waste volumes and types are best estimates based on historical data.

[2]This date is probably 1985 when tank 241-B-109 was interim stabilized (see Section A3.1).

## A3.2 HISTORICAL ESTIMATION OF TANK CONTENTS

The historical transfer data used for this estimate are from the following sources:

- The *Waste Status and transaction Record Summary: WSTRS, Rev. A*, (Agnew et al. 1997b) is a tank-by-tank quarterly summary spreadsheet of waste transactions.

- The *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 4*, (Agnew et al. 1997a contains the Hanford defined waste (HDW) list, the supernatant mixing model (SMM), the tank layer model (TLM), and the historical tank content estimate (HTCE).

- The HDW list is comprised of approximately 50 waste types defined by concentration for major analytes/compounds for sludge and supernatant layers.

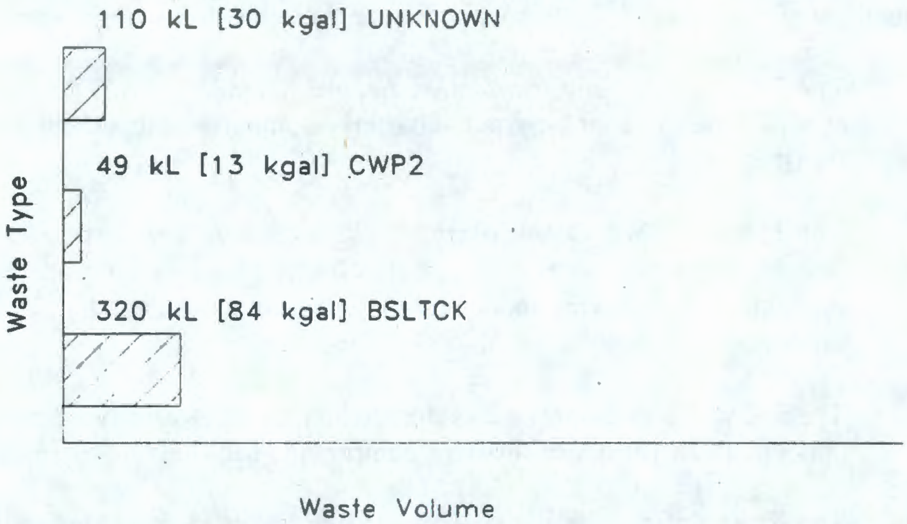
- The TLM defines the sludge and saltcake layers in each tank using waste composition and waste transfer information.

- The SMM is a subroutine within the HDW model that calculates the volume and composition of certin supernatant blens and concentrates.

Using these records, the TLM defines the sludge and saltcake layers in each tank. The SMM uses information from the WSTRS, the TLM, and the HDW list to describe the supernatants and concentrates in each tank. Together the WSTRS, TLM, SMM, and HDW list determine the inventory estimate for each tank. These model predictions are considered estimates that require further evaluation using analytical data.

Based on the TLM and the SMM, tank 241-B-109 contains 481 kL (127 kgal) of waste comprised of a bottom solids layer of 320 kL (84 kgal) of BSltCk, a middle layer of 49 kL (13 kgal) of PUREX process aluminum cladding waste (CWP2), and a top layer of 110 kL (30 kgal) of an unknown waste type. Figure A3-1 is a graph of the estimated waste types and volumes for the tank layer.

Figure A3-1. Tank Layer Model.




The BSltCk layer should contain, from highest concentration above one weight percent, the following constituents: nitrate, sodium, phosphate, and hydroxide. Additional constituents contained in this layer above a tenth of a weight percent are: sulfate, nitrite, carbonate, iron, bismuth, aluminum, calcium, chloride, and fluoride.

The CWP2 layer should contain, from highest concentration above one weight percent, the following constituents: hydroxide, aluminum, lead, uranium, nitrate, sodium, iron, and carbonate. Additional constituents contained in this layer above a tenth of a weight percent are: calcium and nitrite. Presently, data are unavailable on the exact contents of the unknown waste layer. Table A3-2 shows an estimate of the expected waste constituents and concentrations.

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

| Total Inventory Estimate | | | |
|---|---|---|---|
| **Physical Properties** | | | |
| Total solid waste | 7.73E+05 kg (127 kgal) | | |
| Heat load | 0.206 kW (704 Btu/hr) | | |
| Bulk density | 1.61 (g/cm$^3$) | | |
| Water wt% | 41.7 | | |
| Total organic carbon wt% carbon (wet) | 0.162 | | |
| **Chemical Constituents** | ***M*** | **ppm** | **kg**[3] |
| $Na^{+}$ | 11.1 | 1.59E+05 | 1.23E+05 |
| $Al^{3+}$ | 1.05 | 1.77E+04 | 1.37E+04 |
| $Fe^{3+}$ (total Fe) | 0.125 | 4.34E+03 | 3.36E+03 |
| $Cr^{3+}$ | 2.36E-02 | 763 | 589 |
| $Bi^{3+}$ | 1.22E-02 | 1.59E+03 | 1.23E+03 |
| $La^{3+}$ | 7.33E-07 | 6.33E-02 | 4.89E-02 |
| $Hg^{2+}$ | 6.21E-04 | 77.5 | 59.9 |
| Zr (as $ZrO(OH)_2$) | 1.11E-04 | 6.32 | 4.88 |
| $Pb^{2+}$ | 3.38E-02 | 4.36E+03 | 3.37E+03 |
| $Ni^{2+}$ | 6.16E-03 | 225 | 174 |
| $Sr^{2+}$ | 0 | 0 | 0 |
| $Mn^{4+}$ | 1.16E-03 | 39.7 | 30.7 |
| $Ca^{2+}$ | 8.24E-02 | 2.05E+03 | 1.59E+03 |
| $K^{+}$ | 2.44E-02 | 594 | 459 |
| $OH^{-}$ | 4.90 | 5.18E+04 | 4.00E+04 |
| $NO_3^{-}$ | 6.57 | 2.53E+05 | 1.96E+05 |
| $NO_2^{-}$ | 0.779 | 2.23E+04 | 1.72E+04 |
| $CO_3^{2-}$ | 0.260 | 9.72E+03 | 7.51E+03 |
| $PO_4^{3-}$ | 0.680 | 4.02E+04 | 3.10E+04 |
| $SO_4^{2-}$ | 0.157 | 9.36E+03 | 7.23E+03 |
| Si (as $SiO_3^{2-}$) | 3.66E-02 | 639 | 494 |
| $F^{-}$ | 8.77E-02 | 1.04E+03 | 801 |
| $Cl^{-}$ | 0.104 | 2.29E+03 | 1.77E+03 |
| $C_6H_5O_7^{3-}$ | 8.56E-03 | 1.01E+03 | 778 |

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

| Total Inventory Estimate | | | |
|---|---|---|---|
| **Chemical Constituents (Continued)** | ***M*** | **ppm** | **kg** |
| $EDTA^{4-}$ | 1.92E-03 | 345 | 266 |
| $HEDTA^{3-}$ | 2.59E-04 | 44.2 | 34.2 |
| $glycolate^{-}$ | 6.03E-03 | 281 | 217 |
| $acetate^{-}$ | 1.14E-02 | 420 | 324 |
| $oxalate^{2-}$ | 9.60E-07 | 5.26E-02 | 4.06E-02 |
| DBP | 9.11E-03 | 1.19E+03 | 920 |
| Butanol | 9.11E-03 | 420 | 325 |
| $NH_3$ | 3.89E-02 | 411 | 318 |
| $Fe(CN)_6^{4-}$ | 0 | 0 | 0 |
| **Radiological Constituents** | | | |
| Cs-137 | 6.60E-02 (Ci/L) | 41.1 ($\mu$Ci/g) | 3.17E+04 (Ci) |
| Sr-90 | 1.77E+02 (Ci/L) | 11.0 ($\mu$Ci/g) | 8.53E+03 (Ci) |
| Pu | 5.04E-03 (g/L) | --- | 2.42 (kg) |
| U | 6.22E-02 (*M*) | 9.21E+03 ($\mu$g/g) | 7.11E+03 (kg) |

Notes:

[1]Agnew et al. (1997a)

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

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

# A4.0 SURVEILLANCE DATA

Tank 241-B-109 surveillance consists of surface-level measurements (liquid and solid), and temperature monitoring inside the tank (waste and headspace). Surveillance data provide the basis for determining tank integrity.

Liquid-level measurements can indicate if the tank has a major leak. Solid surface-level measurements indicate physical changes in and consistencies of the solid layers of a tank.

## A4.1 SURFACE-LEVEL READINGS

The waste surface level for tank 241-B-109 is measured by a manual tape in riser 3. On October 3, 1996, the waste surface level was 1.05 m (41.5 in.), as measured by the manual tape. Figure A4-1 is a level history graph of volume measurements.

Tank 241-B-109 has 3 dry wells; none have or had readings greater than background radiation (50 counts/second).

## A4.2 INTERNAL TANK TEMPERATURES

Tank 241-B-109 contains a single thermocouple tree, located in riser 1, with 14 thermocouples. The Surveillance Analysis Computer System (SACS) has data only from the first 12 thermocouples. The elevations of all thermocouples on this tree are available. Temperature data, recorded from April 1974 through July 1996, were obtained from SACS (LMHC 1996). The average temperature of the SACS data is 19.8 °C (67.7 °F), the minimum is 12 °C (53 °F), and the maximum is 33 °C (91 °F). The average temperature of the SACS data over the last year (December 1995 through December 1996) was 16.5 °C (61.7 °F), the minimum was 15.9 °C (60.7 °F), and the maximum was 17.3 °C (63.1 °F). The maximum temperature on July 1, 1996 was 17.3 °C (63.1 °F) on thermocouples 11 and 12 (located in the headspace), and the minimum was 15.9 °C (60.7 °F) on thermocouples 2 and 3 (located in the waste and headspace, respectively). Figure A4-2 shows a graph of the weekly high temperatures. Plots of individual thermocouple readings can be found in the B Tank Farm supporting document for the HTCE (Brevick et al. 1996b).

Figure A4-1. Tank 241-B-109 Level History.

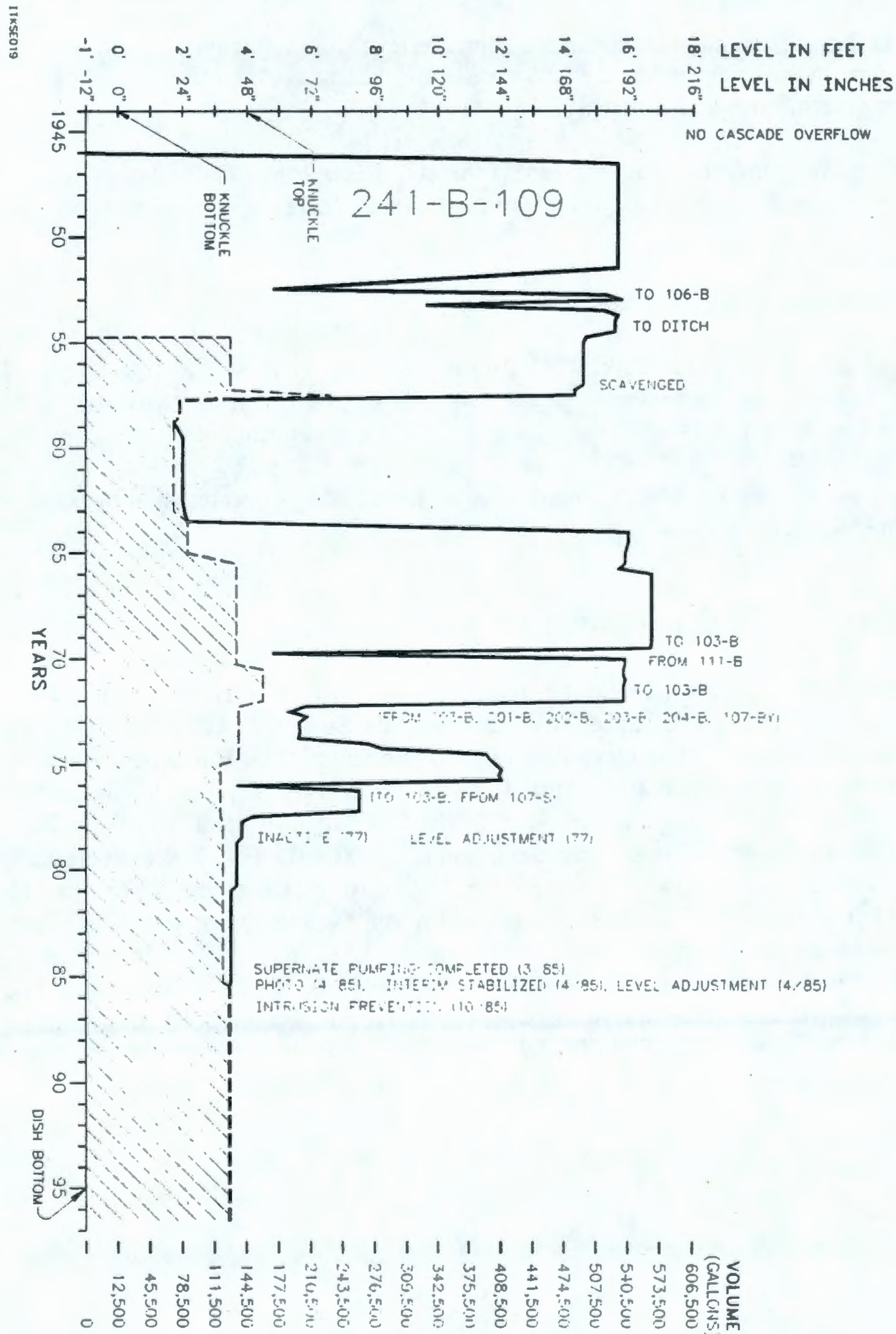
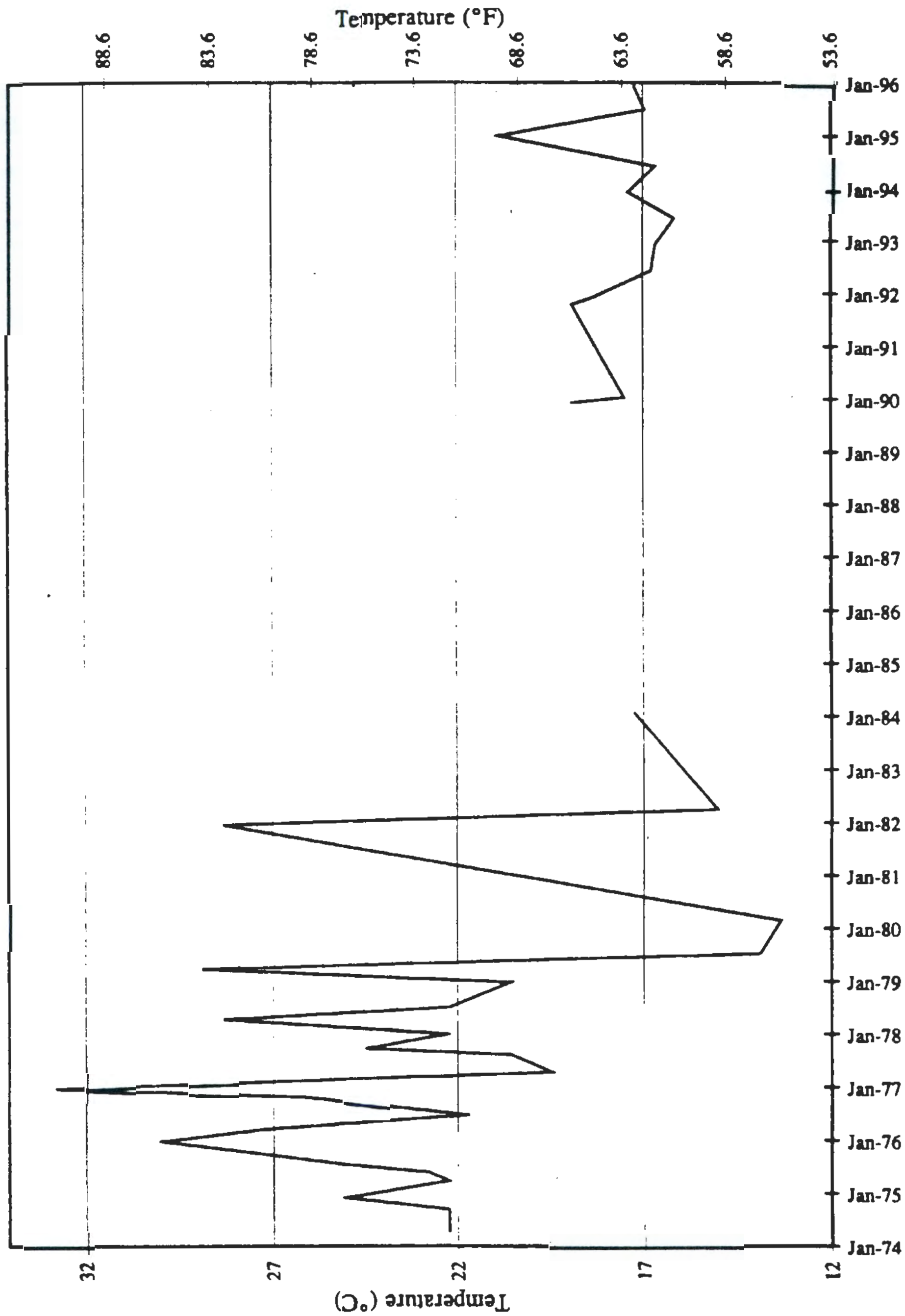


Figure A4-2. Tank 241-B-109 High Temperature Plot.



## A4.3 TANK 241-B-109 PHOTOGRAPHS

The April 1985 photographic montage (Brevick et al. 1996b) of the interior of tank 241-B-109 shows a dark dry solid surface with a ring of saltcake along the edge of the tank. Various pieces of equipment and risers have been identified and labeled. The waste level has not changed since the photographs were taken; therefore, the photographic montage should accurately represent the current appearance of the tank's waste.

## A5.0 APPENDIX A REFERENCES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# APPENDIX B

# SAMPLING OF TANK 241-B-109

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# APPENDIX B

# SAMPLING OF TANK 241-B-109

Appendix B provides sampling and analysis information for each known sampling event for tank 241-B-109 and assesses the core sampling results.

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

Future sampling of tank 241-B-109 will be appended to the above list.

## B1.0 TANK SAMPLING OVERVIEW

This section describes the August 1996 sampling and analysis for tank 241-B-109. Core samples and tank headspace gas samples were taken to satisfy the requirements of the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). The sampling and analyses were performed in accordance with the *Tank 241-B-109 Rotary Mode Sampling and Analysis Plan* (Benar 1997). Further discussions of the sampling and analysis procedures can be found in the *Tank Characterization Reference Guide* (DeLorenzo et al. 1994). A liquid sample was also taken from this tank in October 1975; this sample event is discussed in Section B1.4.

### B1.1 DESCRIPTION OF SAMPLING EVENT

Two cores, each consisting of 3 segments, were expected from tank 241-B-109. Core 169 consisted of 2 segments which were collected from riser 7 on August 22 and 23, 1996. Due to sampling problems, full recovery of segment 2 was not possible. A second attempt was made to recover segment 2 using a different sampler. A small amount of sample was obtained and was called segment 2A. The third segment from core 169 was not obtained.

Core 170 consisted of 3 segments that were collected from riser 4 from August 23 to 27, 1996. All samples were received and extruded by the 222-S Laboratory between September 6, 1996 and September 10, 1996.

A vertical profile is used to satisfy the safety screening data quality objective (DQO). Safety screening analyses include total alpha to determine criticality, differential scanning calorimetry (DSC) to ascertain the fuel energy value, and thermogravimetric analysis (TGA) to obtain the total moisture content. In addition, combustible gas meter readings in the tank headspace were taken to measure flammability. The current revision of the safety screening DQO (Dukelow et al. 1995) also requires bulk density measurements. Sampling and analytical requirements from the safety screening DQOs are summarized in Table B1-1.

Table B1-1. Integrated Data Quality Objective Requirements for Tank 241-B-109.[1]

| Sampling Event | Applicable DQOs | Sampling Requirements | Analytical Requirements |
|---|---|---|---|
| Core Sampling | Safety Screening | Core samples from a minimum of two risers separated radially to the maximum extent possible. | • Energetics<br>• Moisture content<br>• Total alpha |
| Combustible Gas Meter Reading | Safety Screening | Measurement in a minimum of one location within tank headspace. | • Flammable gas concentration |

Note:

[1]Benar 1997

## B1.2 SAMPLE HANDLING

The core 169 samples removed from riser 7 had a total weight of 165.6 grams of solids. Sample material from segment 1 was gray/black and resembled dry saltcake. Sample material from segment 2 was yellow/brown and resembled moist saltcake. The samples were homogenized and subsampled for further laboratory analyses and archiving. Segment 2A was not homogenized due to its small size. Sample recoveries ranged from 0 to 5.5 inches.

Core 170 samples removed from riser 4 had a total weight of 503.3 grams of solids. Sample material from segment 1 was pale yellow/brown and resembled dry saltcake. Solids from segment 2 were green and yellow/brown and resembled salt slurry and wet saltcake. Solids from segment 3 were light brown and resembled moist saltcake. Most of the samples were homogenized and subsampled for laboratory analyses and archiving. Segment 3 was not homogenized due to its small sample size. Sample recoveries ranged from 0.6 to 45.7 cm (0.25 to 18 in.) Table B1-2 gives the subsampling scheme and sample description.

Table B1-2. Tank 241-B-109 Subsampling Scheme and Sample Description.[1]

| Segment | Percent Recovery[2] | Sample Weights Solid (g) | Sample Weights Liquid (g) | Sample Portion | Sample Characteristics |
|---|---|---|---|---|---|
| **Core 169 Riser 7** | | | | | |
| 1 | 31% | 16.0 | 0 | Lower half | Gray-black dry saltcake |
| 2 | 63% | 142.5 | 0 | Lower half | Yellow-brown moist saltcake |
| 2A | n/a | 7.1 | 0 | Lower half | Light brown moist saltcake |
| 3 | 0% | | | | |
| **Core 170 Riser 4** | | | | | |
| 1 | 50% | 72.2 | 0 | Lower half | Pale yellow-brown dry saltcake |
| 2 | 95% | 22.1 | 0 | Quarter A | Light yellow wet saltcake |
| | | 281.0 | 0 | Quarter B | Yellow salt slurry |
| | | 71.6 | 0 | Quarter C | Dark brown wet saltcake |
| | | 50.2 | 0 | Quarter D | Light green wet saltcake |
| 3 | 17% | 6.2 | 0 | Upper half | Light brown moist saltcake |

Notes:

[1]Nuzum (1997)

[2]The percent recoveries were estimated by dividing the recovered sample lengths by the expected sample length taken from the chain-of-custody records in Nuzum 1997. Expected sample lengths ranged from 38 mm to 483 mm (1.5 to 19 in.).

## B1.3 SAMPLE ANALYSIS

The analyses performed on the core samples were limited to those required by the safety screening DQO. The analyses required by the safety screening DQO included analyses for thermal properties by DSC, moisture content by TGA, and content of fissile material by total alpha activity analysis. Analyses by ICP and IC were performed to determine if lithium and bromide were present in sufficient amounts to indicate contamination with hydrostatic head fluid.

All reported analyses were performed in accordance with approved laboratory procedures. A list of the sample numbers and applicable analyses is presented in Table B1-3.

Table B1-3. Tank 241-B-109 Sample Analysis Summary.[1] (2 sheets)

| Riser | Sample Identification | Sample Portion | Sample Number | Analyses |
|---|---|---|---|---|
| 7 | Segment 1 | Lower half | S96T005102 | DSC, TGA, TOC |
| | | | S96T005103 | Total alpha, ICP |
| | | | S96T005104 | IC |
| | Segment 2 | Lower half | S96T005107 | Bulk density |
| | | | S96T005108 | DSC, TGA, TOC |
| | | | S96T005109 | Total alpha, ICP |
| | | | S96T005110 | IC |
| | Segment 2A | Upper half[2] | S96T005112 | DSC, TGA, TOC |
| | | | S96T005113 | ICP |
| | | | S96T005114 | IC |
| 4 | Field Blank | | S96T005116 | Total alpha, ICP, IC, TOC, DSC, specific gravity, TGA |
| | Segment 1 | Lower half | S96T005119 | DSC, TGA, TOC |
| | | | S96T005121 | Total alpha, ICP |
| | | | S96T005122 | IC |
| | Segment 2 | Quarter A | S96T005131 | DSC, TGA, TOC |
| | | | S96T005139 | ICP |
| | | | S96T005143 | IC |
| | Segment 2 | Quarter B | S96T005132 | DSC, TGA, TOC |
| | | | S96T005140 | ICP |
| | | | S96T005144 | IC |
| | Segment 2 | Quarter C | S96T005129 | Bulk density |
| | | | S96T005135 | DSC, TGA, TOC |
| | | | S96T005141 | Total alpha, ICP |
| | | | S96T005145 | IC |

Table B1-3. Tank 241-B-109 Sample Analysis Summary.[1] (2 sheets)

| Riser | Sample Identification | Sample Portion | Sample Number | Analyses |
|---|---|---|---|---|
| 4 (Cont'd) | Segment 2 | Quarter D | S96T005130 | Bulk density |
| | | | S96T005136 | DSC, TGA, TOC |
| | | | S96T005142 | Total alpha, ICP |
| | | | S96T005146 | IC |
| | Segment 3 | Upper half[2] | S96T005124 | DSC, TGA, TOC |
| | | | S96T005125 | ICP |
| | | | S96T005126 | IC |

Notes:

[1]Nuzum (1997)

[2]The sample portion was not homogenized before subsampling.

## B1.4 DESCRIPTION OF HISTORICAL SAMPLING EVENT

Sampling data for one sample from tank 241-B-109 was obtained from historical records dated November 12, 1975. The sample was taken on October 6, 1975 (Wheeler 1975). The data are presented in Section B2.6. Pre-1989 analytical data have not been validated and should not be used as the sole source for tank characterization data.

No information was available regarding the handling of this sample. The purpose of the sample appears to be to check the compatibility of the waste contained in the tank with a noted cross-site transfer of waste from tank 241-S-107 that occurred in early 1976. The sample was reported as yellow with no solids (Brevick et al. 1996).

# B2.0 ANALYTICAL RESULTS

## B2.1 OVERVIEW

This section summarizes the sampling and analytical results associated with the August 1996 sampling and analysis of tank 241-B-109. The total alpha activity, percent water, bulk desnity, energetics, IC, ICP, and TOC analytical results associated with this tank are presented in Table B2-1. These results are documented in Nuzum (1997).

Table B2-1. Analytical Presentation Tables.

| Analysis | Table Number |
|---|---|
| Metals by ICP | B2-2 through B2-18 |
| Anions by IC | B2-19 through B2-26 |
| TIC/TOC | B2-27 and B2-28 |
| Total alpha activity | B2-29 |
| Bulk density | B2-30 |
| Percent water | B2-31 |
| Differential scanning calorimetry | B2-32 |
| Vapor phase measurements | B2-33 |

The four quality control (QC) parameters assessed in conjunction with the tank 241-B-109 samples were standard recoveries, spike recoveries, duplicate analyses (relative percent differences [RPDs]), and blanks. The QC criteria specified in the sampling and analysis plan (SAP) (Benar 1997) were 80 to 120 percent recovery for standards, 75 to 125 percent recovery for spikes and ≤ 20 percent for RPDs. These criteria applied to all of the analytes. The only QC parameter for which limits are not specified in the SAP is blank contamination. The limits for blanks are set forth in guidelines followed by the laboratory, and all data results presented in this report have met those guidelines. Sample and duplicate pairs in which any of the QC parameters were outside of these limits are footnoted in the sample mean column of the following data summary tables with an a, b, c, d, or e as follows:

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

## B2.2 INORGANIC ANALYSES

The ICP and IC analyses for anions and cations respectively were performed on the core samples. In the following sections below, a table is provided for each analyte.

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

### B2.2.1 Inductively Coupled Plasma

Samples were prepared by fusion digests before being subjected to ICP analyses. Although a full suite of analytes were reported, only lithium was required by the safety screening DQO. Results for antimony, arsenic, barium, beryllium, boron, cadmium, cerium, cobalt, copper, lanthanum, magnesium, molybdenum, neodymium, samarium, selenium, silver, strontium, thallium, vanadium, and zirconium are less than detection limits. Reports for aluminum, bismuth, calcium, chromium, iron, lithium, manganese, lead, phosphorus, sodium, sulfur, silicon, titanium, uranium, and zinc are above detection limits in some of the samples, and are shown in Tables B2-2 through B2-18. The potassium and nickel results should be disregarded, because the samples were prepared in a nickel crucible by fusion using potassium hydroxide. Quality control tests included standards, blanks, spikes, and duplicate analyses.

Table B2-2. Tank 241-B-109 Analytical Results: Aluminum (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| **Solids: fusion** | | | **µg/g** | **µg/g** | **µg/g** |
| S96T005103 | 169: 1 | Lower half | 15,400 | 28,700 | 22,050[QC:e] |
| S96T005109 | 169: 2 | Lower half | 1.220E+05 | 1.240E+05 | 1.230E+05 |
| S96T005113 | 169: 2A | Upper half | 1.010E+05 | 1.120E+05 | 1.065E+05 |
| S96T005121 | 170: 1 | Lower half | 82,500 | 81,300 | 81,900 |
| S96T005139 | 170: 2 | Quarter A | 37,900 | 37,300 | 37,600 |
| S96T005140 | | Quarter B | 3,100 | 2,830 | 2,965 |
| S96T005141 | | Quarter C | 3,920 | 5,790 | 4,855[QC:e] |
| S96T005142 | | Quarter D | 11,500 | 12,100 | 11,800 |
| S96T005125 | 170: 3 | Upper half | 4,670 | 7,570 | 6,120[QC:e] |

Table B2-3. Tank 241-B-109 Analytical Results: Bismuth (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | <1,930 | <1,880 | <1,905 |
| S96T005109 | 169: 2 | Lower half | <2,130 | <2,020 | <2,075 |
| S96T005113 | 169: 2A | Upper half | 2,580 | 3,830 | 3,205[QC:e] |
| S96T005121 | 170: 1 | Lower half | <1,990 | <1,970 | <1,980 |
| S96T005139 | 170: 2 | Quarter A | <1,970 | <1,950 | <1,960 |
| S96T005140 | | Quarter B | <1,970 | <2,000 | <1,985 |
| S96T005141 | | Quarter C | 7,170 | 8,150 | 7,660 |
| S96T005142 | | Quarter D | 12,600 | 13,600 | 13,100 |
| S96T005125 | 170: 3 | Upper half | 6,660 | 10,100 | 8,380[QC:e] |

Table B2-4. Tank 241-B-109 Analytical Results: Calcium (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | <1,930 | <1,880 | <1,905 |
| S96T005109 | 169: 2 | Lower half | <2,130 | <2,020 | <2,075 |
| S96T005113 | 169: 2A | Upper half | 2,810 | 3,340 | 3,075 |
| S96T005121 | 170: 1 | Lower half | <1,990 | <1,970 | <1,980 |
| S96T005139 | 170: 2 | Quarter A | <1,970 | <1,950 | <1,960 |
| S96T005140 | | Quarter B | <1,970 | <2,000 | <1,985 |
| S96T005141 | | Quarter C | <1,010 | <1,010 | <1,010 |
| S96T005142 | | Quarter D | <936 | <940 | <938 |
| S96T005125 | 170: 3 | Upper half | <1,000 | <978 | <989 |

Table B2-5. Tank 241-B-109 Analytical Results: Chromium (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | 4,770 | 6,710 | 5,740[QC:e] |
| S96T005109 | 169: 2 | Lower half | 2,400 | 2,770 | 2,585 |
| S96T005113 | 169: 2A | Upper half | 1,580 | 1,990 | 1,785[QC:e] |
| S96T005121 | 170: 1 | Lower half | 479 | 437 | 458 |
| S96T005139 | 170: 2 | Quarter A | 291 | 239 | 265 |
| S96T005140 | | Quarter B | 256 | 322 | 289[QC:e] |
| S96T005141 | | Quarter C | 3,530 | 3,700 | 3,615 |
| S96T005142 | | Quarter D | 1,110 | 1,090 | 1,100 |
| S96T005125 | 170: 3 | Upper half | 750 | 998 | 874[QC:e] |

Table B2-6. Tank 241-B-109 Analytical Results: Iron (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | 6,990 | 21,900 | 14,445[QC:e] |
| S96T005109 | 169: 2 | Lower half | 2,510 | 2,820 | 2,665 |
| S96T005113 | 169: 2A | Upper half | 6,550 | 8,670 | 7,610[QC:e] |
| S96T005121 | 170: 1 | Lower half | 2,280 | 2,090 | 2,185 |
| S96T005139 | 170: 2 | Quarter A | <985 | <976 | <980.5 |
| S96T005140 | | Quarter B | <986 | <1,000 | <993 |
| S96T005141 | | Quarter C | 14,100 | 15,000 | 14,550 |
| S96T005142 | | Quarter D | 5,710 | 5,610 | 5,660 |
| S96T005125 | 170: 3 | Upper half | 3,190 | 4,270 | 3,730[QC:e] |

Table B2-7. Tank 241-B-109 Analytical Results: Lead (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | <1,930 | <1,880 | <1,905 |
| S96T005109 | 169: 2 | Lower half | <2,130 | <2,020 | <2,075 |
| S96T005113 | 169: 2A | Upper half | <2,200 | <2,250 | <2,225 |
| S96T005121 | 170: 1 | Lower half | <1,990 | <1,970 | <1,980 |
| S96T005139 | 170: 2 | Quarter A | <1,970 | <1,950 | <1,960 |
| S96T005140 | | Quarter B | <1,970 | <2,000 | <1,985 |
| S96T005141 | | Quarter C | <1,010 | <1,010 | <1,010 |
| S96T005142 | | Quarter D | 1,360 | 1,410 | 1,385 |
| S96T005125 | 170: 3 | Upper half | <1,000 | 1,160 | <1,080 |

Table B2-8. Tank 241-B-109 Analytical Results: Lithium (ICP).[1]

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | <193 | <188 | <190.5 |
| S96T005109 | 169: 2 | Lower half | <213 | <202 | <207.5 |
| S96T005113 | 169: 2A | Upper half | <220 | 260 | <240 |
| S96T005121 | 170: 1 | Lower half | <199 | <197 | <198 |
| S96T005139 | 170: 2 | Quarter A | <197 | <195 | <196 |
| S96T005140 | | Quarter B | <197 | <200 | <198.5 |
| S96T005141 | | Quarter C | <101 | <101 | <101 |
| S96T005142 | | Quarter D | <93.6 | <94 | <93.8 |
| S96T005125 | 170: 3 | Upper half | <100 | <97.8 | <98.9 |

Note:

[1]Performed to confirm sample was not contaminated with hydrostatic head fluid.

Table B2-9. Tank 241-B-109 Analytical Results: Manganese (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | 270 | 534 | 402[QC:e] |
| S96T005109 | 169: 2 | Lower half | 538 | 638 | 588 |
| S96T005113 | 169: 2A | Upper half | 1,650 | 2,310 | 1,980[QC:e] |
| S96T005121 | 170: 1 | Lower half | < 199 | < 197 | < 198 |
| S96T005139 | 170: 2 | Quarter A | < 197 | < 195 | < 196 |
| S96T005140 | | Quarter B | < 197 | < 200 | < 198.5 |
| S96T005141 | | Quarter C | < 101 | < 101 | < 101 |
| S96T005142 | | Quarter D | < 93.6 | 95.7 | < 94.65 |
| S96T005125 | 170: 3 | Upper half | < 100 | < 97.8 | < 98.9 |

Table B2-10. Tank 241-B-109 Analytical Results: Nickel (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | 2,160 | 4,700 | 3,430[QC:e] |
| S96T005109 | 169: 2 | Lower half | 1,070 | 1,250 | 1,160 |
| S96T005113 | 169: 2A | Upper half | 6,070 | 6,550 | 6,310 |
| S96T005121 | 170: 1 | Lower half | 2,330 | 5,740 | 4,035[QC:e] |
| S96T005139 | 170: 2 | Quarter A | 2,190 | 2,240 | 2,215 |
| S96T005140 | | Quarter B | 3,000 | 1,010 | 2,005[QC:e] |
| S96T005141 | | Quarter C | 5,280 | 3,960 | 4,620[QC:e] |
| S96T005142 | | Quarter D | 5,960 | 5,540 | 5,750 |
| S96T005125 | 170: 3 | Upper half | 4,420 | 3,880 | 4,150 |

Note:

Nickel results should be disregarded because samples were prepared in a nickel crucible.

Table B2-11. Tank 241-B-109 Analytical Results: Phosphorus (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | 69,000 | 61,200 | 65,100 |
| S96T005109 | 169: 2 | Lower half | 24,100 | 18,200 | 21,150[QC:e] |
| S96T005113 | 169: 2A | Upper half | 39,200 | 28,100 | 33,650[QC:e] |
| S96T005121 | 170: 1 | Lower half | 51,300 | 52,800 | 52,050 |
| S96T005139 | 170: 2 | Quarter A | 57,600 | 59,800 | 58,700 |
| S96T005140 | | Quarter B | 11,700 | 9,030 | 10,365[QC:e] |
| S96T005141 | | Quarter C | 26,100 | 24,700 | 25,400 |
| S96T005142 | | Quarter D | 10,900 | 11,600 | 11,250 |
| S96T005125 | 170: 3 | Upper half | 15,000 | 15,300 | 15,150 |

Table B2-12. Tank 241-B-109 Analytical Results: Potassium (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Mean |
|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | 6.960E+06 | 6.960E+06 |
| S96T005109 | 169: 2 | Lower half | 7.340E+06 | 7.340E+06 |
| S96T005113 | 169: 2A | Upper half | 7.570E+06 | 7.570E+06 |
| S96T005121 | 170: 1 | Lower half | 6.550E+06 | 6.550E+06 |
| S96T005139 | 170: 2 | Quarter A | 5.430E+06 | 5.430E+06 |
| S96T005140 | | Quarter B | 5.780E+06 | 5.780E+06 |
| S96T005141 | | Quarter C | 4.960E+06 | 4.960E+06 |
| S96T005142 | | Quarter D | 4.890E+06 | 4.890E+06 |
| S96T005125 | 170: 3 | Upper half | 6.010E+06 | 6.010E+06 |

Note:

Potassium results should be disregarded because samples were prepared by fusion using potassium hydroxide.

Table B2-13. Tank 241-B-109 Analytical Results: Silicon (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | 2,770 | 6,250 | 4,510[QC:e] |
| S96T005109 | 169: 2 | Lower half | 4,540 | 5,030 | 4,785 |
| S96T005113 | 169: 2A | Upper half | 19,500 | 24,800 | 22,150[QC:e] |
| S96T005121 | 170: 1 | Lower half | 1,050 | 1,030 | 1,040 |
| S96T005139 | 170: 2 | Quarter A | <985 | <976 | <980.5 |
| S96T005140 | | Quarter B | <986 | <1,000 | <993 |
| S96T005141 | | Quarter C | 1,380 | 1,240 | 1,310 |
| S96T005142 | | Quarter D | 4,450 | 3,430 | 3,940[QC:e] |
| S96T005125 | 170: 3 | Upper half | 1,190 | 1,310 | 1,250 |

Table B2-14. Tank 241-B-109 Analytical Results: Sodium (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | 2.170E+05 | 1.990E+05 | 2.080E+05 |
| S96T005109 | 169: 2 | Lower half | 1.480E+05 | 1.380E+05 | 1.430E+05 |
| S96T005113 | 169: 2A | Upper half | 1.590E+05 | 1.400E+05 | 1.495E+05 |
| S96T005121 | 170: 1 | Lower half | 1.770E+05 | 1.810E+05 | 1.790E+05 |
| S96T005139 | 170: 2 | Quarter A | 2.080E+05 | 2.160E+05 | 2.120E+05 |
| S96T005140 | | Quarter B | 2.930E+05 | 2.760E+05 | 2.845E+05 |
| S96T005141 | | Quarter C | 2.160E+05 | 2.230E+05 | 2.195E+05[QC: d] |
| S96T005142 | | Quarter D | 2.440E+05 | 2.330E+05 | 2.385E+05[QC: c] |
| S96T005125 | 170: 3 | Upper half | 2.630E+05 | 2.300E+05 | 2.465E+05 |

Table B2-15. Tank 241-B-109 Analytical Results: Sulfur (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| **Solids: fusion** | | | **µg/g** | **µg/g** | **µg/g** |
| S96T005103 | 169: 1 | Lower half | <1,930 | <1,880 | <1,905 |
| S96T005109 | 169: 2 | Lower half | <2,130 | <2,020 | <2,075 |
| S96T005113 | 169: 2A | Upper half | <2,200 | <2,250 | <2,225 |
| S96T005121 | 170: 1 | Lower half | <1,990 | <1,970 | <1,980 |
| S96T005139 | 170: 2 | Quarter A | 4,910 | 4,700 | 4,805 |
| S96T005140 | | Quarter B | 83,600 | 82,900 | 83,250 |
| S96T005141 | | Quarter C | 40,700 | 43,700 | 42,200 |
| S96T005142 | | Quarter D | 49,900 | 51,400 | 50,650 |
| S96T005125 | 170: 3 | Upper half | 58,000 | 52,100 | 55,050 |

Table B2-16. Tank 241-B-109 Analytical Results: Titanium (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| **Solids: fusion** | | | **µg/g** | **µg/g** | **µg/g** |
| S96T005103 | 169: 1 | Lower half | <193 | <188 | <190.5 |
| S96T005109 | 169: 2 | Lower half | <213 | <202 | <207.5 |
| S96T005113 | 169: 2A | Upper half | 334 | 432 | 383[QC:e] |
| S96T005121 | 170: 1 | Lower half | <199 | <197 | <198 |
| S96T005139 | 170: 2 | Quarter A | <197 | <195 | <196 |
| S96T005140 | | Quarter B | <197 | <200 | <198.5 |
| S96T005141 | | Quarter C | <101 | <101 | <101 |
| S96T005142 | | Quarter D | <93.6 | <94 | <93.8 |
| S96T005125 | 170: 3 | Upper half | <100 | <97.8 | <98.9 |

Table B2-17. Tank 241-B-109 Analytical Results: Total Uranium (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | <9,660 | <9,420 | <9,540 |
| S96T005109 | 169: 2 | Lower half | 24,100 | 28,600 | 26,350 |
| S96T005113 | 169: 2A | Upper half | 24,200 | 36,600 | 30,400[QC:e] |
| S96T005121 | 170: 1 | Lower half | <9,970 | <9,830 | <9,900 |
| S96T005139 | 170: 2 | Quarter A | <9,850 | <9,760 | <9,805 |
| S96T005140 | | Quarter B | <9,860 | <10,000 | <9,930 |
| S96T005141 | | Quarter C | <5,060 | <5,070 | <5,065 |
| S96T005142 | | Quarter D | <4,680 | <4,700 | <4,690 |
| S96T005125 | 170: 3 | Upper half | <5,000 | <4,890 | <4,945 |

Table B2-18. Tank 241-B-109 Analytical Results: Zinc (ICP).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: fusion | | | µg/g | µg/g | µg/g |
| S96T005103 | 169: 1 | Lower half | <193 | <188 | <190.5 |
| S96T005109 | 169: 2 | Lower half | <213 | <202 | <207.5 |
| S96T005113 | 169: 2A | Upper half | <220 | 241 | <230.5 |
| S96T005121 | 170: 1 | Lower half | <199 | 582 | <390.5[QC:e] |
| S96T005139 | 170: 2 | Quarter A | 281 | 236 | 258.5 |
| S96T005140 | | Quarter B | <197 | 436 | <316.5[QC:e] |
| S96T005141 | | Quarter C | 412 | 436 | 424 |
| S96T005142 | | Quarter D | 581 | 768 | 674.5[QC:e] |
| S96T005125 | 170: 3 | Upper half | 360 | 638 | 499[QC:e] |

### B2.2.2 Ion Chromatography

Samples were prepared by water digests before being subjected to an IC analyses. Although a full suite of analytes were reported, only bromide was required by the safety screening DQO. Reports for bromide, chloride, fluoride, nitrate, nitrite, phosphate, sulfate, and oxalate are above detection limits in some of the samples. Quality control tests included standards, spikes, blanks, and duplicate analyses. The concentrations of metals in the samples are shown in Tables B2-19 through B2-26.

Table B2-19. Tank 241-B-109 Analytical Results: Bromide (IC).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| **Solids: water digest** | | | **μg/g** | **μg/g** | **μg/g** |
| S96T005104 | 169: 1 | Lower half | <564.5 | <558 | <561.25 |
| S96T005110 | 169: 2 | Lower half | <520.6 | <527 | <523.8 |
| S96T005114 | 169: 2A | Upper half | 1,458 | 1,530 | 1,494 |
| S96T005122 | 170: 1 | Lower half | <1,002 | <1,010 | <1,006 |
| S96T005143 | 170: 2 | Quarter A | <1,006 | <1,020 | <1,013 |
| S96T005144 | | Quarter B | <1,016 | <1,030 | <1,023 |
| S96T005145 | | Quarter C | <2,491 | <2,500 | <2,495.5 |
| S96T005146 | | Quarter D | <1,227 | <1,250 | <1,238.5 |
| S96T005126 | 170: 3 | Upper half | <2,448 | <2,490 | <2,469 |

Table B2-20. Tank 241-B-109 Analytical Results: Chloride (IC).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| **Solids: water digest** | | | **µg/g** | **µg/g** | **µg/g** |
| S96T005104 | 169: 1 | Lower half | 655.3 | 620 | 637.65 |
| S96T005110 | 169: 2 | Lower half | 929.4 | 796 | 862.7 |
| S96T005114 | 169: 2A | Upper half | 200.4 | 249 | 224.7[QC:e] |
| S96T005122 | 170: 1 | Lower half | 461.6 | 409 | 435.3 |
| S96T005143 | 170: 2 | Quarter A | 582.7 | 586 | 584.35 |
| S96T005144 | | Quarter B | 968.3 | 1,050 | 1,009.15 |
| S96T005145 | | Quarter C | 1,081 | 897 | 989 |
| S96T005146 | | Quarter D | 1,026 | 1,110 | 1,068 |
| S96T005126 | 170: 3 | Upper half | 1,144 | 1,150 | 1,147 |

Table B2-21. Tank 241-B-109 Analytical Results: Fluoride (IC).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| **Solids: water digest** | | | **µg/g** | **µg/g** | **µg/g** |
| S96T005104 | 169: 1 | Lower half | 5,458 | 7,190 | 6,324[QC:e] |
| S96T005110 | 169: 2 | Lower half | 6,171 | 6,560 | 6,365.5 |
| S96T005114 | 169: 2A | Upper half | 10,560 | 12,100 | 11,330 |
| S96T005122 | 170: 1 | Lower half | 11,570 | 12,000 | 11,785 |
| S96T005143 | 170: 2 | Quarter A | 25,310 | 26,500 | 25,905 |
| S96T005144 | | Quarter B | 65,730 | 63,100 | 64,415 |
| S96T005145 | | Quarter C | 44,840 | 47,500 | 46,170 |
| S96T005146 | | Quarter D | 48,520 | 50,100 | 49,310 |
| S96T005126 | 170: 3 | Upper half | 47,000 | 47,200 | 47,100 |

Table B2-22. Tank 241-B-109 Analytical Results: Nitrate (IC).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: water digest | | | µg/g | µg/g | µg/g |
| S96T005104 | 169: 1 | Lower half | 24,750 | 23,300 | 24,025 |
| S96T005110 | 169: 2 | Lower half | 69,000 | 59,600 | 64,300 |
| S96T005114 | 169: 2A | Upper half | 11,770 | 12,000 | 11,885 |
| S96T005122 | 170: 1 | Lower half | 29,050 | 26,400 | 27,725 |
| S96T005143 | 170: 2 | Quarter A | 48,460 | 49,200 | 48,830 |
| S96T005144 | | Quarter B | 1.193E+05 | 1.300E+05 | 1.247E+05 |
| S96T005145 | | Quarter C | 1.444E+05 | 1.510E+05 | 1.477E+05 |
| S96T005146 | | Quarter D | 3.403E+05 | 3.430E+05 | 3.417E+05 |
| S96T005126 | 170: 3 | Upper half | 2.539E+05 | 2.590E+05 | 2.565E+05 |

Table B2-23. Tank 241-B-109 Analytical Results: Nitrite (IC).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: water digest | | | µg/g | µg/g | µg/g |
| S96T005104 | 169: 1 | Lower half | 9,797 | 9,570 | 9,683.5 |
| S96T005110 | 169: 2 | Lower half | 12,790 | 11,300 | 12,045 |
| S96T005114 | 169: 2A | Upper half | 2,786 | 3,040 | 2,913 |
| S96T005122 | 170: 1 | Lower half | 3,438 | 3,210 | 3,324 |
| S96T005143 | 170: 2 | Quarter A | 2,810 | 2,940 | 2,875 |
| S96T005144 | | Quarter B | 4,940 | 5,180 | 5,060 |
| S96T005145 | | Quarter C | 5,446 | 5,590 | 5,518 |
| S96T005146 | | Quarter D | 4,291 | 4,420 | 4,355.5 |
| S96T005126 | 170: 3 | Upper half | 5,483 | 5,840 | 5,661.5 |

Table B2-24. Tank 241-B-109 Analytical Results: Phosphate (IC).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: water digest | | | µg/g | µg/g | µg/g |
| S96T005104 | 169: 1 | Lower half | 1.942E+05 | 2.070E+05 | 2.006E+05[QC: c] |
| S96T005110 | 169: 2 | Lower half | 55,530 | 59,400 | 57,465 |
| S96T005114 | 169: 2A | Upper half | 1.024E+05 | 1.150E+05 | 1.087E+05 |
| S96T005122 | 170: 1 | Lower half | 1.590E+05 | 1.680E+05 | 1.635E+05 |
| S96T005143 | 170: 2 | Quarter A | 2.128E+05 | 2.170E+05 | 2.149E+05 |
| S96T005144 | | Quarter B | 27,220 | 29,500 | 28,360 |
| S96T005145 | | Quarter C | 79,900 | 70,100 | 75,000 |
| S96T005146 | | Quarter D | 15,300 | 16,300 | 15,800 |
| S96T005126 | 170: 3 | Upper half | 25,420 | 24,400 | 24,910 |

Table B2-25. Tank 241-B-109 Analytical Results: Sulfate (IC).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: water digest | | | µg/g | µg/g | µg/g |
| S96T005104 | 169: 1 | Lower half | 839.1 | 800 | 819.55 |
| S96T005110 | 169: 2 | Lower half | 2,191 | 1,720 | 1,955.5[QC:e] |
| S96T005114 | 169: 2A | Upper half | <632.8 | <620 | <626.4 |
| S96T005122 | 170: 1 | Lower half | 1,362 | 1,440 | 1,401 |
| S96T005143 | 170: 2 | Quarter A | 12,510 | 12,900 | 12,705 |
| S96T005144 | | Quarter B | 2.988E+05 | 2.880E+05 | 2.934E+05 |
| S96T005145 | | Quarter C | 1.342E+05 | 1.530E+05 | 1.436E+05 |
| S96T005146 | | Quarter D | 2.058E+05 | 2.110E+05 | 2.084E+05 |
| S96T005126 | 170: 3 | Upper half | 1.903E+05 | 1.890E+05 | 1.897E+05 |

Table B2-26. Tank 241-B-109 Analytical Results: Oxalate (IC).

| Sample Number | Core Segment | Segment Portion | Result | Duplicate | Mean |
|---|---|---|---|---|---|
| Solids: water digest | | | µg/g | µg/g | µg/g |
| S96T005104 | 169: 1 | Lower half | 1,044 | 1,630 | 1,337[QC:e] |
| S96T005110 | 169: 2 | Lower half | 9,428 | 9,400 | 9,414 |
| S96T005114 | 169: 2A | Upper half | 17,140 | 11,700 | 14,420[QC:e] |
| S96T005122 | 170: 1 | Lower half | <841.6 | <845 | <843.3 |
| S96T005143 | 170: 2 | Quarter A | <844.9 | <860 | <852.45 |
| S96T005144 | | Quarter B | <853.5 | <862 | <857.75 |
| S96T005145 | | Quarter C | <2,092 | <2,100 | <2,096 |
| S96T005146 | | Quarter D | <1,030 | <1,050 | <1,040 |
| S96T005126 | 170: 3 | Upper half | <2,056 | <2,090 | <2,073 |

## B2.3 CARBON ANALYSES

Results for TOC and TIC are obtained during the same analysis; therefore, the discussion of the analytical method for the 2 analytes has been combined. TIC/TOC analyses were performed on all nine solid samples from tank 241-B-109.

Table B2-27. Tank 241-B-109 Analytical Results: Total Organic Carbon (TIC/TOC).

| Sample Number | Sample Location | Sample Portion | Result | Duplicate | Triplicate | Mean |
|---|---|---|---|---|---|---|
| Solids | | | µg/g | µg/g | µg/g | µg/g |
| S96T005102 | 169: 1 | Lower half | 1,460 | 1,460 | | 1,460 |
| S96T005108 | 169: 2 | Lower half | 2,260 | 2,390 | | 2,325 |
| S96T005112 | 169: 2A | Upper half | 5,360 | 3,120 | 7,000 | 5,160[QC:e] |
| S96T005119 | 170: 1 | Lower half | 251 | 271 | | 261 |
| S96T005131 | 170: 2 | Quarter A | 78.4 | 64.9 | | 71.65[QC:f] |
| S96T005132 | | Quarter B | 98.4 | 99.7 | | 99.05[QC:f] |
| S96T005135 | | Quarter C | 177 | 195 | | 186 |
| S96T005136 | | Quarter D | 150 | 209 | | 179.5[QC:e] |
| S96T005124 | 170: 3 | Upper half | 253 | 263 | | 258 |

Table B2-28. Tank 241-B-109 Analytical Results: Total Inorganic Carbon (TIC/TOC).

| Sample Number | Sample Location | Sample Portion | Result | Duplicate | Triplicate | Mean |
|---|---|---|---|---|---|---|
| **Solids** | | | **μg/g** | **μg/g** | **μg/g** | **μg/g** |
| S96T005102 | 169: 1 | Lower half | 4,340 | 4,800 | | 4,570 |
| S96T005108 | 169: 2 | Lower half | 2,270 | 2,390 | | 2,330 |
| S96T005112 | 169: 2A | Upper half | 2,510 | 2,430 | 1,940 | 2,293.33 |
| S96T005119 | 170: 1 | Lower half | 602 | 465 | | 533.5[QC:e] |
| S96T005131 | 170: 2 | Quarter A | 517 | 489 | | 503 |
| S96T005132 | | Quarter B | 202 | 204 | | 203 |
| S96T005135 | | Quarter C | 337 | 359 | | 348 |
| S96T005136 | | Quarter D | 240 | 264 | | 252 |
| S96T005124 | 170: 3 | Upper half | 407 | 378 | | 392.5 |

## B2.4 TOTAL ALPHA ACTIVITY

Analyses for total alpha activity were performed on the samples that were prepared by fusion digestion. Two fusions were prepared per sample (for duplicate results). Quality control tests included standards, spikes, blanks, and duplicate analyses. The sample results for total alpha are given in Table B2-29.

Table B2-29. Tank 241-B-109 Total Alpha Activity.

| Sample Number | Segment Portion | | Result (μCi/g) | Duplicate (μCi/g) | Sample Mean (μCi/g) |
|---|---|---|---|---|---|
| **Core 169** | | | | | |
| S96T005103 | Segment 1 | Lower half | 0.0647 | 0.0795 | 0.0721[QC:e,c] |
| S96T005109 | Segment 2 | Lower half | 0.117 | 0.136 | 0.1265[QC:c] |
| **Core 170** | | | | | |
| S96T005121 | Segment 1 | Lower half | 0.022 | 0.0216 | 0.0218[QC:c] |
| S96T005141 | Segment 2 | Quarter C | 0.0132 | 0.0163 | 0.0148[QC:e,c] |
| S95T001619 | Segment 2 | Quarter D | 0.0445 | 0.0492 | 0.04685 |

## B2.5 BULK DENSITY

Bulk density measurements were performed on three of the nine solid subsamples. As directed by the sampling and analysis plan (Benar 1997), bulk density was performed only on the lower half segments. Subsegment 2 of core 170 was subsampled in quarter segments so bulk density measurements were performed on the lower two subsegments (quarters C and D). Bulk density was not deteremined for segment 1 of core 170 because of sample dryness. Segment 1 of core 169 did not have enough sample to perform bulk density measurements.

Table B2-30. Tank 241-B-109 Analytical Results: Bulk Density.

| Sample Number | Sample Location | Sample Portion | Result | Duplicate | Triplicate | Mean |
|---|---|---|---|---|---|---|
| Solids | | | g/mL | g/mL | g/mL | g/mL |
| S96T005107 | 169: 2 | Lower half | 1.85 | n/a | n/a | 1.85 |
| S96T005129 | 170: 2 | Quarter C | 1.83 | n/a | n/a | 1.83 |
| S96T005130 | | Quarter D | 1.94 | n/a | n/a | 1.94 |

## B2.6 THERMODYNAMIC ANALYSES

As required by the safety screening DQO, TGA and DSC were performed on the solids. No other physical tests were required or performed.

### B2.6.1 Thermogravimetric Analysis

Thermogravimetric analysis measures the mass of a sample while its temperature is increased at a constant rate. Nitrogen is passed over the sample during heating to remove any released gases. Any decrease in the weight of a sample during TGA represents a loss of gaseous matter from the sample, either through evaporation or through a reaction that forms gas phase products. The moisture content is estimated by assuming that all TGA sample weight loss up to a certain temperature (typically 150 to 200 °C [302 to 392 °F]) is due to water evaporation. The temperature limit for moisture loss is chosen by the operator at an inflection point on the TGA plot. Other volatile matter fractions can often be differentiated by inflection points as well.

TGA was performed in duplicate on direct subsamples from tank 241-B-109. Results are presented in Table B2-31.

Table B2-31. Percent Water by Thermogravimetric Analysis.[1]

| Sample Number | Segment Level | Sample Portion | Result % $H_2O$ | Duplicate % $H_2O$ | Mean % $H_2O$ |
|---|---|---|---|---|---|
| **Core 169** | | | | | |
| S96T005102 | Segment 1 | Lower half | 44.45 | 44.79 | 44.62 |
| S96T005108[3] | Segment 2 | Lower half | 44.81 | 46.8 | 45.81 |
| S96T005108 | Segment 2 | Lower half | 65.41 | 43.79 | 54.6[QC:e] |
| S96T005112[2] | Segment 2A | Upper half | 14.27 | 20.96 | 17.6[QC:e] |
| **Core 170** | | | | | |
| S96T005119 | Segment 1 | Lower half | 40.79 | 39.11 | 39.95 |
| S96T005131 | Segment 2 | Quarter A | 44.85 | 44.25 | 44.55 |
| S96T005132 | Segment 2 | Quarter B | 43.63 | 49.35 | 46.49 |
| S96T005135 | Segment 2 | Quarter C | 47.64 | 41.66 | 44.65 |
| S96T005136 | Segment 2 | Quarter D | 23.81 | 28.44 | 26.13 |
| S96T005124[2] | Segment 3 | Upper half | 25.76 | 22.68 | 24.22 |

Notes:

[1]Nuzum (1997)

[2]Sample was not homogenized due to its small size.

[3]This sample is a rerun.

### B2.6.2 Differential Scanning Calorimetry

In a DSC analysis, heat absorbed or emitted by a substance is measured while the temperature of the sample is heated at a constant rate. Nitrogen is passed over the sample material to remove any gases being released. The onset temperature for an endothermic or exothermic event is determined graphically. Quality control tests included performing the analyses in duplicate, and the use of standards.

The DSC analyses was performed on all tank 241-B-109 subsamples. None of the subsamples submitted for analysis exceeded the safety screening notification limit. Samples exhibiting exotherms are presented in Table B2-32.

Table B2-32. Differential Scanning Calorimetry.[1]

| Sample Number | Segment Level | Transition 1 (Exotherms) | | | |
|---|---|---|---|---|---|
| | | Sample Portion | Result (J/g) | Duplicate (J/g) | Mean (J/g) |
| S96T005102 | Segment 1 | Lower half | 49.4 | 46 | 47.7 |
| S96T005112 | Segment 2A | Upper half | 90.9 | 89.6 | 90.25 |

Note:

[1]Nuzum (1997)

## B2.7 VAPOR PHASE MEASUREMENT

Before the August 23-27 core sampling of tank 241-B-109, a tank headspace vapor phase measurement was taken. These measurements supported the safety screening DQO (Dukelow et al. 1995). The vapor phase screening was taken for flammability issues. The vapor phase measurements were taken 6096 mm (20 ft) below riser 6 in the dome space of the tank and results were obtained in the field (that is, no gas sample was sent to the laboratory for analysis). The results of the vapor phase measurements are provided in Table B2-33.

Table B2-33. Results of Vapor Phase Measurements of Tank 241-B-109.

| Measurement | Result | |
|---|---|---|
| | August 22, 1996 | August 27, 1996 |
| Total organic carbon (TOC) | 2 ppm | 5 ppm |
| Lower flammability limit (LFL) | 0.0% of LFL | 0.0% of LFL |
| Oxygen | 20.8% | 20.8% |
| Ammonia | 40 ppm | 60 ppm |

## B2.8 HISTORICAL SAMPLE RESULTS

Analytical results for the one historical sample from tank 241-B-109 are shown in Table B2-34. It appears the sample was taken to determine compatibility of waste before a cross-site transfer was to occur from tank 241-S-107 in early 1976. Because the sample is a liquid and the tank has since had all liquids removed, this sample no longer represents the tank contents. The lack of information regarding the reported historical sample limits the viability of the analytical results. The sample was 79.62 percent water, and contained primarily sodium, nitrate, and nitrite. The radionuclides tested were cesium and strontium. These data have not been validated and should be used with caution.

Table B2-34. Supernatant Sample.[1,2]

| Component | Lab Value | Lab Unit |
|---|---|---|
| **Physical Data** | | |
| **Sample description** | **Yellow, no solids. 700 mrad/hr.** | |
| pH | 12.50 | |
| Specific gravity | 1.282 | |
| Water | 79.62 | % |
| **Chemical Analysis** | | |
| OH | 1.29 | *M* |
| Al | 0.667 | *M* |
| Na | 4.77 | *M* |
| $NO_2$ | 1.14 | *M* |
| $NO_3$ | 2.48 | *M* |
| Cl | 6.26E-02 | *M* |
| $SO_4$ | Canceled | *M* |
| $PO_4$ | 2.09E-02 | *M* |
| F | 2.44E-04 | *M* |
| $CO_3$ | 3.17E-04 | *M* |
| **Radiological Analysis** | | |
| Pu | 1.10E-05 | g/gal |
| $^{89,90}Sr$ | 2.18E-01 | $\mu$Ci/gal |
| GEA: $^{134}Cs$ | 3.60E+03 | $\mu$Ci/gal |
| GEA: $^{137}Cs$ | 6.39E+05 | $\mu$Ci/gal |

Notes:

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

[2]Wheeler 1975

## B3.0 ASSESSMENT OF CHARACTERIZATION RESULTS

The purpose of this chapter is to discuss the overall quality and consistency of the current sampling results for tank 241-B-109, and to present the results of the calculation of an analytical-based inventory.

This section also evaluates sampling and analysis factors that may impact interpretation of the data. These factors are used to assess the overall quality and consistency of the data and to identify any limitations in the use of the data.

### B3.1 FIELD OBSERVATIONS

Two cores, three segments each, were expected from this tank. Sampling problems prevented the acquisition of complete cores. Some segments were not homogenized due to insufficient amount of sample and were analyzed in their entirety.

### B3.2 QUALITY CONTROL ASSESSMENT

The usual quality control assessment includes an evaluation of the appropriate standard recoveries, spike recoveries, duplicate analyses, and blanks that are performed in conjunction with the chemical analyses. All the pertinent quality control tests were conducted on the 1996 core samples, allowing a full assessment regarding the accuracy and precision of the data. The SAP (Benar 1997) established the specific criteria for all analytes. Sample and duplicate pairs that had one or more QC results outside the specified criteria were identified by footnotes in the data summary tables.

The standard and spike recovery results provide an estimate of the accuracy of the analysis. If a standard or spike recovery is above or below the given criterion, the analytical results may be biased high or low, respectively. The precision is estimated by the relative percent difference (RPD), which is defined as the absolute value of the difference between the primary and duplicate samples, divided by their mean, times one hundred.

The RPD between sample and duplicate exceeded 20 percent for 2 of 10 subsamples submitted for TIC/TOC analyses and on 2 of 10 samples submitted for TGA. This was attributed to sample heterogeneity. Sample S96T005108 was rerun for TGA and the RPD improved significantly. The RPDs exceeded 20 percent for 2 of 6 subsamples submitted for total alpha analyses. Reruns indicated high RPDs were due to low alpha activity and sample heterogeneity. Low spike recoveries for total alpha were reported for 3 of 5 subsamples, and were attributed to self-absorption by solids left on the planchet after drying. Second analysis of these subsamples did not improve spike recovery. Additional reruns were not requested (Nuzum 1997).

In summary, the majority of the QC results were within the boundaries specified in the tank sampling and analysis plan (Benar 1997). The discrepancies mentioned here are footnoted in the data summary tables and should not impact data validity or use.

## B3.3 DATA CONSISTENCY CHECKS

Comparisons of different analytical methods for the same analyte can help to assess the consistency and quality of the data. A comparison was made of phosphorous and sulfur as analyzed by ICP with phosphate and sulfate as analyzed by IC. In addition, mass and charge balances were calculated to help assess the overall data consistency.

### B3.3.1 Comparison of Results from Different Analytical Methods

The following data consistency checks compare the results from two different analytical methods. Close agreement between the two methods strengthens the credibility of both results, whereas a poor agreement brings the reliability of the data into question. This comparison also gives an indication of chemical speciation. For example, if the IC determination of phosphate from water digestion agrees with the phosphorus by ICP on the fusion digestion, it indicates that the phosphorus is present as soluble phosphate. If the ICP result is significantly higher it may indicate the presence of insoluble phosphate. All analytical mean results were taken from Table B3-6.

The analytical phosphorous mean result as determined by ICP was 32,500 $\mu$g/g, which converts to 99,600 $\mu$g/g of phosphate. This compared well with the IC phosphate mean result of 98,800 $\mu$g/g. These numbers agreed quite well as evidenced by the ratio of 1.0. This suggests that the phosphate is mostly soluble.

Table B3-1. Tank 241-B-109 Comparison of Phosphorus Concentration with the Equivalent Concentration of Phosphate.

| Analyte | Overall Mean (ug/g) |
|---|---|
| Measured mean phosphate concentration by IC | 98,800 |
| Phosphate concentration from phosphorus by ICP | 99,600 |
| Ratio | 1.00 |

The IC sulfate value of 76,900 $\mu$g/g, which represents soluble sulfur in the form of sulfate, is equivalent to 25,600 $\mu$g/g of sulfur. The ICP result for sulfur is 22,400 $\mu$g/g (ratio of 0.88). These results indicate the sulfates are soluble. The lower than expected ratio may be the result of measurement uncertainty.

Table B3-2. Tank 241-B-109 Comparison of Sulfur Concentration with the Equivalent Concentration of Sulfate.

| Analyte | Overall Mean (ug/g) |
|---|---|
| Measured mean sulfur concentration by ICP | 22,400 |
| Sulfur concentration from sulfate by IC | 25,600 |
| Ratio | 0.88 |

### B3.3.2 Mass and Charge Balance

The principal objective in performing mass and charge balances is to determine whether the measurements are consistent. In calculating the balances, only analytes listed in Table B3-6 detected at a concentration of 1000 $\mu$g/g (0.1 weight percent) or greater were considered.

Except sodium, all cations listed in Table B3-3 were assumed to be in their most common hydroxide or oxide form, and the concentrations of the assumed species were calculated stoichiometrically. Because precipitates are neutral species, all positive charge was attributed to the sodium cation. The anions listed in Table B3-4 were assumed to be present as sodium and/or potassium salts and were expected to balance the positive charge exhibited by the cations. Phosphorus and sulfur were assumed to be present primarily as the soluble phosphate and sulfate ions. The acetate and carbonate data were derived from the TOC and TIC analyses, respectively. The concentrations of cationic species in Table B3-3, the anionic species in Table B3-4, and the percent water were used to calculate the mass balance.

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

$$\text{Mass balance} = \%\ \text{Water} + 0.0001 \times \{\text{Total Analyte Concentration}\}$$

$$= \%\ \text{Water} + 0.0001 \times \{Al(OH)_3 + Cr(OH)_3 + FeO(OH) + Na^+ + C_2H_3O_2^- + CO_3^{-2} + F^- + NO_3^- + NO_2^- + PO_4^{-3} + SO_4^{-2} + SiO_3^{-2}\}$$

The total analyte concentrations calculated from the above equation is 717,700 $\mu$g/g. The mean weight percent water obtained from thermogravimetric analyses reported in Table B3-6 is 37.7 percent, or 377,000 $\mu$g/g. The mass balance resulting from adding the percent water to the total analyte concentration is 109.5 percent (Table B3-5).

The following equations demonstrate the derivation of total cations and total anions; the charge balance is the ratio of these two values.

Total cations ($\mu$eq/g) = $[Na^+]/23.0 = 8{,}609\ \mu eq/g$

Total anions ($\mu$eq/g) = $[C_2H_3O_2^-]/59.0 + [CO_3^{-2}]/30.0 + [F^-]/19.0 + [NO_3^-]/62.0 + [NO_2^-]/46.0 + [PO_4^{-3}]/31.7 + [SO_4^{-2}]/48.1 + [SiO_3^{-2}]/38$
= $8{,}549\ \mu eq/g$

The charge balance obtained by dividing the sum of the positive charge by the sum of the negative charge was 1.01.

In summary, the above calculations yield mass and charge balance values close to 1.00 for charge balance and 100 percent for mass balance, indicating that the analytical results are consistent.

Table B3-3. Cation Mass and Charge Data.

| Analyte | Concentration ($\mu$g/g) | Assumed Species | Concentration of Assumed Species ($\mu$g/g) | Charge ($\mu$eq/g) |
|---|---|---|---|---|
| Aluminum | 58,500 | $Al(OH)_3$ | 169,000 | --- |
| Chromium | 2,150 | $Cr(OH)_3$ | 4,259 | --- |
| Iron | 5,870 | FeO(OH) | 9,340 | --- |
| Sodium | 198,000 | $Na^+$ | 198,000 | 8,609 |
| Total | | | 380,600 | 8,609 |

Table B3-4. Anion Mass and Charge Data.

| Analyte | Concentration ($\mu g/g$) | Assumed Species | Concentration of Assumed Species ($\mu g/g$) | Charge ($\mu eq/g$) |
|---|---|---|---|---|
| TOC | 1,610 | $C_2H_3O_2^-$ | 3,400 | 57.6 |
| TIC | 1,740 | $CO_3^{-2}$ | 8,700 | 290 |
| Fluoride | 23,900 | $F^-$ | 23,900 | 1,258 |
| Nitrate | 103,000 | $NO_3^-$ | 103,000 | 1,661 |
| Nitrite | 6,330 | $NO_2^-$ | 6,330 | 137.6 |
| Phosphate | 98,800 | $PO_4^{-3}$ | 98,800 | 3120 |
| Sulfate | 76,900 | $SO_4^{-2}$ | 76,900 | 1602 |
| Silicon | 5,920 | $SiO_3^{-2}$ | 16,070 | 422.9 |
| Total | | | 337,100 | 8,549 |

Table B3-5. Mass Balance Totals.

| Totals | Concentrations ($\mu g/g$) | Charge $\mu eq/g$ |
|---|---|---|
| Cation total from Table B3-3 | 380,600 | 8609 |
| Anion total from Table B3-4 | 337,100 | 8549 |
| Water | 377,000 | 0 |
| Grand total | 1,094,700 | 60 |

## B3.4 MEAN CONCENTRATIONS AND CONFIDENCE INTERVALS

The following evaluation was performed on the analytical data from the samples from tank 241-B-109.

Because an inventory estimate is needed without comparing it to a threshold value, two-sided 95 percent confidence intervals on the mean inventory are computed. This was done with only segment-level data. The lower and upper limits (LL and UL) to a two-sided 95 percent confidence interval for the mean are

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

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

The mean, $\hat{\mu}$, and the standard deviation, $\hat{\sigma}_{\hat{\mu}}$, were estimated using restricted maximum likelihood estimation (REML) methods. The degrees of freedom (df), for tank 241-B-109, is the number of cores sampled minus one.

### B3.4.1 Solid Segment Means

Standard statistical analysis of variance (ANOVA) models were fit to the analytical data from the 1996 sampling of tank 241-B-109. All analytes that had at least 50 percent of reported values above the detection limit were used in the computations. The detection limit was used as the value for nondetected results. The arithmetic means were computed for analytes with less than 50 percent detected values.

The results given below in Table B3-6 are ANOVA estimates. The lower limit, LL, to a 95 percent confidence interval can be negative. Because an actual concentration of less than zero is not possible, the lower limit is reported as zero, whenever this occurred.

Table B3-6. Analysis of Variance Estimates for Tank 241-B-109. (3 sheets)

| | **Mean µg/g** | **Standard Deviation** | **Degrees of Freedom** | **Lower Limit** | **Upper Limit** |
|---|---|---|---|---|---|
| **Analyte** | $\hat{\mu}$ | $\hat{\sigma}_{\hat{\mu}}$ | **df** | **LL** | **UL** |
| ICP(f) Al | 5.85E+04 | 2.52E+04 | 1 | 0.00E+00 | 3.78E+05 |
| ICP(f) Sb[1] | <1.00E+03 | n/a | n/a | n/a | n/a |
| ICP(f) As[1] | <1.67E+03 | n/a | n/a | n/a | n/a |
| ICP(f) Ba[1] | <8.38E+02 | n/a | n/a | n/a | n/a |
| ICP(f) Be[1] | <8.38E+01 | n/a | n/a | n/a | n/a |
| ICP(f) Bi[1] | <4.69E+03 | n/a | n/a | n/a | n/a |
| ICP(f) B[1] | <8.38E+02 | n/a | n/a | n/a | n/a |

Table B3-6. Analysis of Variance Estimates for Tank 241-B-109. (3 sheets)

| | Mean µg/g | Standard Deviation | Degrees of Freedom | Lower Limit | Upper Limit |
|---|---|---|---|---|---|
| Bulk density[2] | 1.87E+00 | 3.38E-02 | 2 | 1.73E+00 | 2.02E+00 |
| Bromide[1] | <1.31E+03 | n/a | n/a | n/a | n/a |
| ICP(f)Cd[1] | <8.38E+01 | n/a | n/a | n/a | n/a |
| ICP(f)Ca[1] | <1.77E+03 | n/a | n/a | n/a | n/a |
| ICP(f)Ce[1] | <1.67E+03 | n/a | n/a | n/a | n/a |
| Chloride | 7.20E+02 | 1.34E+02 | 1 | 0.00E+00 | 2.42E+03 |
| ICP(f)Cr | 2.15E+03 | 1.13E+03 | 1 | 0.00E+00 | 1.65E+04 |
| ICP(f)Co[1] | <3.35E+02 | n/a | n/a | n/a | n/a |
| ICP(f)Cu[1] | <1.67E+02 | n/a | n/a | n/a | n/a |
| DSC | 3.14E+01 | 3.26E+01 | 1 | 0.00E+00 | 4.45E+02 |
| Fluoride | 2.39E+04 | 1.54E+04 | 1 | 0.00E+00 | 2.19E+05 |
| Alpha | 6.28E-02 | 3.64E-02 | 1 | 0.00E+00 | 5.25E-01 |
| ICP(f)Fe[3] | 5.87E+03 | 1.78E+03 | 1 | 0.00E+00 | 2.85E+04 |
| ICP(f)La[1] | <8.38E+02 | n/a | n/a | n/a | n/a |
| ICP(f)Pb[1] | <1.73E+03 | n/a | n/a | n/a | n/a |
| ICP(f)Li[1] | <1.69E+02 | n/a | n/a | n/a | n/a |
| ICP(f)Mg[1] | <1.67E+03 | n/a | n/a | n/a | n/a |
| ICP(f)Mn[1] | <4.29E+02 | n/a | n/a | n/a | n/a |
| ICP(f)Mo[1] | <8.38E+02 | n/a | n/a | n/a | n/a |
| ICP(f)Nd[1] | <1.67E+03 | n/a | n/a | n/a | n/a |
| ICP(f)Ni | 3.74E+03 | 5.74E+02 | 1 | 0.00E+00 | 1.10E+04 |
| Nitrate | 1.03E+05 | 6.18E+04 | 1 | 0.00E+00 | 8.88E+05 |
| Nitrite | 6.33E+03 | 1.87E+03 | 1 | 0.00E+00 | 3.01E+04 |
| Oxalate[1] | <3.66E+03 | n/a | n/a | n/a | n/a |
| % Water | 3.77E+01 | 3.92E+00 | 1 | 0.00E+00 | 8.75E+01 |
| Phosphate | 9.88E+04 | 2.57E+04 | 1 | 0.00E+00 | 4.26E+05 |
| ICP(f)P | 3.25E+04 | 7.03E+03 | 1 | 0.00E+00 | 1.22E+05 |
| ICP(f)Sm[1] | <1.67E+03 | n/a | n/a | n/a | n/a |
| ICP(f)Se[1] | <1.67E+03 | n/a | n/a | n/a | n/a |
| ICP(f)Si[3] | 5.92E+03 | 4.56E+03 | 1 | 0.00E+00 | 6.38E+04 |

Table B3-6. Analysis of Variance Estimates for Tank 241-B-109. (3 sheets)

| | Mean μg/g | Standard Deviation | Degrees of Freedom | Lower Limit | Upper Limit |
|---|---|---|---|---|---|
| ICP(f)Ag[1] | <1.71E+02 | n/a | n/a | n/a | n/a |
| ICP(f)Na | 1.98E+05 | 2.99E+04 | 1 | 0.00E+00 | 5.78E+05 |
| ICP(f)Sr[1] | <1.67E+02 | n/a | n/a | n/a | n/a |
| Sulfate[3] | 7.69E+04 | 7.00E+04 | 1 | 0.00E+00 | 9.66E+05 |
| ICP(f)S[3] | 2.24E+04 | 1.87E+04 | 1 | 0.00E+00 | 2.60E+05 |
| ICP(f)Tl[1] | <3.35E+03 | n/a | n/a | n/a | n/a |
| ICP(f)Ti[1] | <1.85E+02 | n/a | n/a | n/a | n/a |
| TIC | 1.74E+03 | 1.32E+03 | 1 | 0.00E+00 | 1.85E+04 |
| TOC[4] | 1.61E+03 | 1.40E+03 | 1 | 0.00E+00 | 1.94E+04 |
| ICP(f)U[1] | <1.23E+04 | n/a | n/a | n/a | n/a |
| ICP(f)V[1] | <8.38E+02 | n/a | n/a | n/a | n/a |
| ICP(f)Zn[3] | 3.24E+02 | 1.09E+02 | 1 | 0.00E+00 | 1.71E+03 |
| ICP(f)Zr[1] | <1.67E+02 | n/a | n/a | n/a | n/a |

Notes:

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

[2]Only three sample results were obtained for bulk density. Therefore, the statistical model fit to the other analytes could not be fit to the bulk density data.

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

[4]Wet basis

**B3.4.2 Analysis of Variance Model**

A statistical model is needed to account for the spatial and measurement variability in $\hat{\sigma}_{\hat{\mu}}$. This cannot be done using an ordinary standard deviation of the data (Cochran et al. 1980). The statistical model fit to the solid segment sample data is

$$Y_{ijkm} = \mu + C_i + S_{ij} + L_{ijk} + A_{ijkm},$$

$$i=1,\ldots,a,\ j=1,\ldots,b_i,\ k=1,\ldots,c_{ij},\ m=1,\ldots,d_{ijk}$$

where

$Y_{ijkm}$=laboratory results from the m$^{th}$ duplicate in the k$^{th}$ location in the j$^{th}$ segment in the i$^{th}$ core
in the tank,

$\mu$ = the grand mean

$C_i$ = the effect of the i$^{th}$ core

$S_{ij}$ = the effect of the j$^{th}$ segment from the i$^{th}$ core

$L_{ijk}$ = the effect of the k$^{th}$ location in the j$^{th}$ segment in the i$^{th}$ core

$A_{ijkm}$ = the effect of the m$^{th}$ analytical result from the k$^{th}$ location in the j$^{th}$ segment in the i$^{th}$ core

a = the number of cores

$b_i$ = the number of segments in the i$^{th}$ core

$c_{ij}$ = the number of locations from the j$^{th}$ segment in the i$^{th}$ core

$d_{ijk}$ = the number of analytical results from the k$^{th}$ location in the j$^{th}$ segment in the i$^{th}$ core.

The variable $C_i$, $S_{ij}$, and $L_{ijk}$ are assumed to be random effects. These variables and $A_{ijkm}$ are assumed to be not correlated and normally distributed with means zero and variances $\sigma^2(C)$, $\sigma^2(S)$, $\sigma^2(L)$, and $\sigma^2(A)$, respectively. Estimates of $\sigma^2(C)$, $\sigma^2(S)$, $\sigma^2(L)$, and $\sigma^2(A)$ were obtained using Restricted Maximum Likelihood Estimation (REML) techniques. This method, applied to variance component estimation, is described in Harville (1977). The statistical results were obtained using statistical analysis package S-PLUS[2] (Statistical Science 1993).

[2]S-PLUS is a trademark of Statistical Sciences Incorporated, Seattle, Washington.

### B3.4.3 Inventory

After the sample means are calculated for the tank for each analyte, the sampling based inventory may be calculated by multiplying the results in Table B3-6 by the density and volume. Because the analyte concentrations above are presented in terms of a mass basis concentration, the total mass of waste in the tank is needed to estimate inventories. The total mass of waste is derived from the tank volume (from surveillance) and the estimated tank solids density. The tank volume for solids is 423 kL (Hanlon 1997). The density used for this estimate is 1.87 g/mL for solid segment sample data. The inventory of each of the analytes is presented in Table B3-7 for solid segment sample data.

Table B3-7. Analytical-Based Inventory for Solid Segment Sample Data for Tank 241-B-109. (2 sheets)

| Analyte | Inventory (kg or Ci) | LL | UL |
|---|---|---|---|
| ICP(f)Al | 5.27E+04 | 0.00E+00 | 3.41E+05 |
| ICP(f)Sb | <9.05E+02 | n/a | n/a |
| ICP(f)As | <1.51E+03 | n/a | n/a |
| ICP(f)Ba | <7.55E+02 | n/a | n/a |
| ICP(f)Be | <7.55E+01 | n/a | n/a |
| ICP(f)Bi | <4.23E+03 | n/a | n/a |
| ICP(f)B | <7.55E+02 | n/a | n/a |
| Bromide | <1.18E+03 | n/a | n/a |
| ICP(f)Cd | <7.55E+01 | n/a | n/a |
| ICP(f)Ca | <1.59E+03 | n/a | n/a |
| ICP(f)Ce | <1.51E+03 | n/a | n/a |
| Chloride | 6.48E+02 | 0.00E+00 | 2.18E+03 |
| ICP(f)Cr | 1.93E+03 | 0.00E+00 | 1.49E+04 |
| ICP(f)Co | <3.02E+02 | n/a | n/a |
| ICP(f)Cu | <1.51E+02 | n/a | n/a |
| Fluoride | 2.15E+04 | 0.00E+00 | 1.98E+05 |
| Alpha | 5.66E+01 | 0.00E+00 | 4.73E+02 |
| ICP(f)Fe | 5.29E+03 | 0.00E+00 | 2.57E+04 |
| ICP(f)La | <7.55E+02 | n/a | n/a |
| ICP(f)Pb | <1.56E+03 | n/a | n/a |
| ICP(f)Li | <1.53E+02 | n/a | n/a |

Table B3-7. Analytical-Based Inventory for Solid Segment Sample Data for Tank 241-B-109. (2 sheets)

| Analyte | Inventory (kg or Ci) | LL | UL |
|---|---|---|---|
| $^{ICP(f)}$Mg | <1.51E+03 | n/a | n/a |
| $^{ICP(f)}$Mn | <3.86E+02 | n/a | n/a |
| $^{ICP(f)}$Mo | <7.55E+02 | n/a | n/a |
| $^{ICP(f)}$Nd | <1.51E+03 | n/a | n/a |
| $^{ICP(f)}$Ni | 3.37E+03 | 0.00E+00 | 9.95E+03 |
| Nitrate | 9.26E+04 | 0.00E+00 | 8.00E+05 |
| Nitrite | 5.70E+03 | 0.00E+00 | 2.71E+04 |
| Oxalate | <3.30E+03 | n/a | n/a |
| % Water | 3.40E+05 | 0.00E+00 | 7.88E+05 |
| Phosphate | 8.90E+04 | 0.00E+00 | 3.84E+05 |
| $^{ICP(f)}$P | 2.93E+04 | 0.00E+00 | 1.10E+05 |
| $^{ICP(f)}$Sm | <1.51E+03 | n/a | n/a |
| $^{ICP(f)}$Se | <1.51E+03 | n/a | n/a |
| $^{ICP(f)}$Si | 5.33E+03 | 0.00E+00 | 5.75E+04 |
| $^{ICP(f)}$Ag | <1.54E+02 | n/a | n/a |
| $^{ICP(f)}$Na | 1.78E+05 | 0.00E+00 | 5.21E+05 |
| $^{ICP(f)}$Sr | <1.51E+02 | n/a | n/a |
| Sulfate | 6.93E+04 | 0.00E+00 | 8.70E+05 |
| $^{ICP(f)}$S | 2.02E+04 | 0.00E+00 | 2.35E+05 |
| $^{ICP(f)}$Tl | <3.02E+03 | n/a | n/a |
| $^{ICP(f)}$Ti | <1.67E+02 | n/a | n/a |
| TIC | 1.57E+03 | 0.00E+00 | 1.67E+04 |
| TOC | 1.45E+03 | 0.00E+00 | 1.75E+04 |
| $^{ICP(f)}$U | <1.11E+04 | n/a | n/a |
| $^{ICP(f)}$V | <7.55E+02 | n/a | n/a |
| $^{ICP(f)}$Zn | 2.92E+02 | 0.00E+00 | 1.54E+03 |
| $^{ICP(f)}$Zr | <1.51E+02 | n/a | n/a |

## B4.0 APPENDIX B REFERENCES


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# APPENDIX C

# STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

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# APPENDIX C

# STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

## C1.0 STATISTICS FOR SAFETY SCREENING DQO

The safety screening DQO (Dukelow et al. 1995) defines acceptable decision confidence limits in terms of one-sided 95 percent confidence intervals. In this appendix, one-sided confidence limits supporting the safety screening DQO are calculated for tank 241-B-109. All data in this section are from the final laboratory data package for the 1996 core sampling event for tank 241-B-109 (Nuzum 1997).

Confidence intervals were computed for each sample number from tank 241-B-109 analytical data. The sample numbers and confidence intervals are provided in Table C1-1 for alpha and Table C1-2 for DSC.

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

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

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

For the tank 241-B-109 data (per sample number), df equals the number of observations minus one.

The upper limit of the 95 percent confidence interval for each sample number based on alpha data is listed in Table C1-1. Each confidence interval can be used to make the following statement. If the upper limit is less than 31.5 $\mu$Ci/g, then one would reject the null hypothesis that the alpha is greater than or equal to 31.5 $\mu$Ci/g at the 0.05 level of significance.

The upper limit of the 95 percent confidence interval for each sample number based on DSC data is listed in Table C1-2. Each confidence interval can be used to make the following statement. If the upper limit is less than 480 J/g, then one would reject the null hypothesis that DSC is greater than or equal to 480 J/g at the 0.05 level of significance.

Table C1-1. 95 Percent Confidence Interval Upper Limits for Alpha for Tank 241-B-109. (Units are $\mu$Ci/g or $\mu$Ci/mL)

| Sample Number | Sample Description | $\hat{\mu}$ | $\hat{\sigma}_{\hat{\mu}}$ | UL |
|---|---|---|---|---|
| S96T005103 | Core 169, segment 1, lower half | 7.21E-02 | 7.40E-03 | 1.19E-01 |
| S96T005109 | Core 169, segment 2, lower half | 1.27E-01 | 9.50E-03 | 1.86E-01 |
| S96T005121 | Core 170, segment 1, lower half | 2.18E-02 | 2.00E-04 | 2.31E-02 |
| S96T005141 | Core 170, segment 2, quarter C | 1.48E-02 | 1.55E-03 | 2.45E-02 |
| S96T005142 | Core 170, segment 2, quarter D | 4.69E-02 | 2.35E-03 | 6.17E-02 |

Table C1-2. 95 Percent Confidence Interval Upper Limits for Differential Scanning Calorimetry for Tank 241-B-109. (Units are J/g-Dry)

| Sample Number | Sample Description | $\hat{\mu}$ | $\hat{\sigma}_{\hat{\mu}}$ | UL |
|---|---|---|---|---|
| S96T005102 | Core 169, segment 1, lower half | 8.62E+01 | 3.05E+00 | 1.05E+02 |
| S96T005108 | Core 169, segment 2, lower half | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| S96T005112 | Core 169, segment 2A, upper half | 1.10E+02 | 5.00E-01 | 1.13E+02 |
| S96T005119 | Core 170, segment 1, lower half | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| S96T005124 | Core 170, segment 3, upper half | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| S96T005131 | Core 170, segment 2, quarter A | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| S96T005132 | Core 170, segment 2, quarter B | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| S96T005135 | Core 170, segment 2, quarter C | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| S96T005136 | Core 170, segment 2, quarter D | 0.00E+00 | 0.00E+00 | 0.00E+00 |

## C2.0 APPENDIX C REFERENCES

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# APPENDIX D

# EVALUATION TO ESTABLISH BEST-BASIS STANDARD INVENTORY FOR TANK 241-B-109

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# APPENDIX D

# EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR TANK 241-B-109

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available information for tank 241-B-109 was performed, and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

## D1.0 CHEMICAL INFORMATION SOURCES

Characterization results from the most recent sampling event for this tank are provided in Appendix B. Two core samples (cores 169 and 170) were obtained in 1996 from two different risers. The component concentrations are based on segment means from which a core mean and overall tank mean were derived. The analytical data from core samples from tanks 241-B-104, 241-B-106, and 241-B-108, which process records indicate contain the same saltcake waste type as tank 241-B-109, provided useful comparison information. The HDW model (Agnew et al. 1997a) also provides tank content estimates in terms of component concentrations and inventories.

## D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

Sample-based inventories derived from the analytical concentration data and HDW model inventories (Agnew et al. 1997a), are compared in Tables D2-1 and D2-2. The tank volume used to generate these inventories is 481 kL (127 kgal). This volume, which is reported in Hanlon (1997), is the same as that reported by Agnew et al. (1997a). The density used to calculate the component inventories is 1.87 g/mL based on sample measurements, which is higher than the value reported in Agnew et al. (1997a). The HDW model estimates the density to be 1.61 g/mL. This difference in density provides an RPD of 15 percent for analytes with roughly the same concentrations. Note that the sample-based and HDW model inventories differ significantly for several components; e.g., Al, $Cl^-$, $F^-$, $NO_3^-$, $PO_4^{3-}$, and $SO_4^{2-}$.

A list of references used in this evaluation is provided in Section D5.0.

Table D2-1. Sample-Based and Hanford Defined Waste-Based Inventory Estimates for Nonradioactive Components in Tank 241-B-109.

| Analyte | Sampling Inventory Estimate[1] (kg) | HDW Model Inventory Estimate[2] (kg) | Analyte | Sampling Inventory Estimate[1] (kg) | HDW Model Inventory Estimate[2] (kg) |
|---|---|---|---|---|---|
| Al | 52,700 | 13,700 | $NO_2^-$ | 5,700 | 17,200 |
| Bi | <4,200 | 1,230 | $NO_3^-$ | 92,600 | 196,000 |
| Ca | <1,590 | 1,590 | P as $PO_4^{3-}$ | 89,000 | 31,000 |
| $Cl^-$ | 648 | 0.32 | Pb | <1,560 | 3,370 |
| Cr | 1,930 | 589 | Si | 5,330 | 494 |
| $F^-$ | 21,500 | 801 | S as $SO_4^{2-}$ | 69,300 | 7,230 |
| Fe | 5,290 | 3,360 | Sr | <150 | 0 |
| Hg | n/r | 59.9 | TIC as $CO_3^{2-}$ | 7,850 | 7,510 |
| K | n/r | 459 | TOC | 1,450 | 1,250 |
| La | <755 | 0.049 | $U_{TOTAL}$ | <11,000 | 7,100 |
| Mn | <386 | 30.7 | Zr | <150 | 4.9 |
| Na | 178,000 | 123,000 | $H_2O$ (wt%) | 37.7 | 41.7 |
| Ni | n/r | 174 | | | |

Notes:

n/r = not reported

[1]Appendix B, Section B3.4.3
[2]Agnew et al. (1997a)

Table D2-2. Sample-Based and Hanford Defined Waste-Based Inventory Estimates for Radioactive Components in Tank 241-B-109 (Curie Values Decayed to January 1, 1994).

| Analyte | Sampling Inventory Estimate (Ci) | HDW Model Inventory Estimate[1] (Ci) |
|---|---|---|
| $^{137}Cs$ | n/r | 31,700 |
| $^{90}Sr$ | n/r | 8,530 |
| $^{239}Pu$ | n/r | 144 |

Note:

[1]Appendix E, Agnew (1997a)

## D3.0 COMPONENT INVENTORY EVALUATION

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

### D3.1 CONTRIBUTING WASTE TYPES

Tank 241-B-109 is the last tank in a cascade that includes tank 241-B-107 and 241-B-108. In 1946, tank 241-B-109 began receiving 1C waste cascaded from tank 241-B-108 (Agnew et al. 1997b). Tank 241-B-109 was filled by the second quarter of 1946.

Significant amounts of 1C solids are not expected to have cascaded to tank 241-B-109. The tank was nearly emptied in 1952 when the waste was transferred to the 242-B feed tank (tank 241-B-106). In 1952, tank 241-B-109 began receiving salt liquors from tank 241-B-106, which was the 242-B evaporator feed tank. In 1954, re-evaporated 1C bottoms were received from tank 241-B-105, which was the active bottoms tank. From 1963 until approximately 1965, PUREX process aluminum cladding waste was transferred to tank 241-B-109 (Agnew et al. 1997b).

Based on this process history, the majority of the solids expected in tank 241-B-109 included saltcake solids (evaporator bottoms [EB],or BSltCk) from the 242-B Evaporator, and aluminum cladding waste from PUREX process operation. Additional detail relevant to the waste transfer history is provided in Appendix A of this report.

### D3.1.1 Predicted Current Waste Types and Volumes

Information concerning the waste types presently contained in tank 241-B-109 is inconsistent. The HDW model (Agnew et al. 1997a) predicts the following waste types.

| Waste Type | Waste Volume - kL (kgal) |
|---|---|
| BSltCk | 318 (84) |
| CWP2 | 49 (13) |
| Unknown waste origin (UNK) | 113 (30) |
| Total | 480 (127) |

However, Agnew et al. (1997a) assumes that the chemical composition of the UNK waste is the same as BSltCk. The HDW model prediction for waste volumes is thus equivalent to the following:

| Waste Type | Waste Volume - kL (kgal) |
|---|---|
| BSltCk | 431 (114) |
| CWP2 | 49 (13) |
| Total | 480 (127) |

### D3.1.2 Evaluation of Segment-Level Data

The sort on radioactive waste type model (Hill et al. 1995) lists 1C, EB, and aluminum cladding waste (CW) as the primary, secondary, and tertiary waste types, respectively. Hill et al. (1995) and Hanlon (1997) both report the total waste volume as 480 kL (127 kgal), which is consistent with Agnew et al. (1997a). Both Hill and Hanlon, however, report that the waste consists entirely of sludge, whereas Agnew et al. (1997a) credits at least 318 kL (84 kgal) to saltcake.

Evaluation of segment-level core sample data indicates considerable vertical and horizontal nonuniformity for concentrations of most major analytes. The analyte concentrations differ vastly between the two core samples (see Appendix B, Section B3.0). Core 169 contains significant concentrations of Al (approximately 7.0*M*) which is likely indicative of aluminum cladding waste as predicted by Agnew et al. (1997a). The concentration of $PO_4^{3-}$ in core 169 ranges from 1 to 4*M*, which indicates mixing of up to 50 volume percent 242-B Evaporator saltcake with the cladding waste.

Segment-level analyses for core sample 170 indicate unexpectedly high concentrations of $SO_4^{2-}$ and $F^-$ (approximately 4.0*M* in segment 2), whereas $SO_4^{2-}$ and $F^-$ concentrations in core 169 are only approximately 0.03 and 0.6, respectively. The $PO_4$ concentration in core 170 is similar to that for core 169 (1 to 4*M*). The chemical composition of core 170 reflects components that would be expected from evaporation of $BiPO_4^{3-}$ process 1C waste (Schneider 1951), although with unexpectedly high concentrations for the noted anions.

Evaluation of segment-level data for cores 169 and 170 shows no indication of the 1C sludge layer predicted by Hill et al. (1995). The core samples from tank 241-B-109 thus indicate the presence of both cladding waste (core 169) and 242-B Evaporator saltcake (core 170).

As previously noted, Agnew et al. (1997a) assumes that the composition of the 113 kL (30 kgal) UNK waste in tank 241-B-109 is the same as BSltCk, which proportions the total waste volume as 49 kL (13 kgal) CWP2 and 431 kL (114 kgal) BSltCk. However, the high concentration of Al in both segments of core 169 could indicate significantly more than 49 kL (13 kgal) CWP2. This engineering evaluation assumes that cores 169 and 170 each represent half of the waste volume in the tank. Because core 169 is estimated to consist of approximately 50 volume percent CW and 50 volume percent BSltCk, and core 170 consists of essentially 100 percent BSltCk, the following approximate volumes for these waste types are assumed in this evaluation:

| **Waste Type** | **Waste Volume - kL (kgal)** |
|---|---|
| 242-B Evaporator saltcake | 360 (95) |
| Cladding waste | 120 (32) |
| Total | 480 (127) |

## D3.2 BASIS FOR ASSESSING SALTCAKE INVENTORIES IN 241-B-109

BSltCk, the abbreviation used by Agnew et al. (1997a) is representative of salt waste supernatants that were evaporated and concentrated in the 242-B Evaporator until they were largely solidified. Agnew et al. (1997a) provides a single average composition for the BSltCk defined waste. However, historical records (Anderson 1990, Agnew et al. 1997a) indicate that supernatants from the first cycle bismuth phosphate process (1C waste), as well as supernatants from the uranium recovery (UR) process were evaporated in the 242-B Evaporator and transferred to several tanks in the 241-B Tank Farm. The chemical compositions of the dilute supernatants from these processes differed. Because the supernatants were not all blended together before evaporation, the saltcake compositions resulting from evaporation of these wastes are also expected to differ, both as a function of position within a tank, and as a function of which tank was used as a receiver at a particular time.

Because of the complicated waste supernatant transfer history of feed to the 242-B Evaporator and the lack of a flowsheet basis for the waste, it is difficult to perform an independent assessment to estimate the saltcake composition that can be compared to the model-based BSltCk composition. However, waste samples from a limited number of B Tank Farm tanks expected to contain BSltCk have been analyzed and reported. The composition data for tanks 241-B-104 (Field 1996), 241-B-106 (McCain 1996) and 241-B-108 (Schreiber 1997), are summarized in Table D3-1. The analytical results for these tanks were evaluated at the core segment level to identify the areas representing BSltCk. For comparison, data for core 170 from tank 241-B-109 are shown. The core 169 data are not shown because this core is assumed to contain primarily cladding waste. The analytical results for tank 241-B-109 were averaged based on the weight of a full-core segment. The full-core segment weight was derived by correcting for the reported segment volume percent recovery.

To provide a common basis for comparison of the data in Table D3-1, the reported water mass was removed from the results; that is, the results are all compared on a water-free basis. The HDW model composition for BSltCk (also on a water-free basis) is included in Table D3-1 for comparison.

Table D3-1. Composition of 242-B Evaporator Saltcake (Water-Free Basis). (2 sheets)

| Analyte | 241-B-104 | 241-B-106 | 241-B-108 | 241-B-109 | HDW Model[3] BSltCk |
|---|---|---|---|---|---|
| | µg/g | µg/g | µg/g[1] | µg/g[2] | µg/g |
| Al | 3,471 | 6,925 | 40,400 | 40,380 | 432 |
| Bi | 21,516 | 7,238 | <3,130 | 6,808 | 3,818 |
| Ca | 618 | 4,499 | <3,020 | <2,950 | 2,894 |
| Cr | 966 | 666 | 355 | 1,420 | 290 |
| Fe | 19,857 | 35,011 | <1,570 | 5,908 | 6,666 |
| K | n/r | 315 | 1,900 | n/r | 599 |
| La | n/r | <73 | <1,570 | <1,475 | 0 |
| Mn | n/r | 403 | <302 | <295 | 0 |
| Na | 220,620 | 228,337 | 343,560 | 417,902 | 295,250 |
| Ni | n/r | 129 | n/r | n/r | 500 |
| Pb | n/r | 741 | <3,020 | <3,023 | 0 |
| Si | 10,729 | 4,092 | 2,051 | 2,236 | 1,170 |
| Sr | n/r | 911 | <302 | <295 | 0 |
| U | 3,616 | 27,821 | 1,930 | <14,750 | n/r |
| Zr | n/r | <73 | <302 | <295 | 139 |

Table D3-1. Composition of 242-B Evaporator Saltcake (Water-Free Basis). (2 sheets)

| Analyte | 241-B-104 µg/g | 241-B-106 µg/g | 241-B-108 µg/g[1] | 241-B-109 µg/g[2] | HDW Model[3] BSltCk µg/g |
|---|---|---|---|---|---|
| $CO_3^{2-}$ | n/r | 1,625 | 6,925 | n/r | 11,480 |
| $Cl^-$ | 3,974 | 3,334 | 1,471 | 1,495 | 3,030 |
| $F^-$ | 6,516 | 5,632 | 61,280 | 79,614 | 1,979 |
| $NO_3^-$ | 546,139 | 409,639 | 114,590 | 219,962 | 547,100 |
| $NO_2^-$ | 4,614 | 16,044 | 19,275 | 7,907 | 11,150 |
| $PO_4^{3-}$ | 43,879 | 66,436 | 182,070 | 125,628 | 95,690 |
| $SO_4^{2-}$ | 41,153 | 31,312 | 183,700 | 316,880 | 12,770 |
| **Radionuclide** | **µCi/g** | **µCi/g** | **µCi/g** | **µCi/g** | **µCi/g** |
| $^{137}Cs$ | n/r | 50.5 | 23.5 | n/r | 29.3 |
| $^{90}Sr$ | n/r | 149 | 3.3 | n/r | 7.5 |
| $^{239/240}Pu$ | n/r | n/r | n/r | n/r | 0.029 |

Notes:

[1]Data from upper half segment 1 from cores 172 and 173 are not included because these partial segments contained primarily CW.

[2]Core 170. Core 169 data are not shown because this core contained primarily CW.

[3]Agnew et al. (1997b)

As shown in Table D3-1, the concentrations of most components in tank 241-B-104 (with the exception of Bi and $PO_4^{3-}$) agree quite well with those for tank 241-B-106. Similarly, the concentration of components in tank 241-B-108 agree quite well with those for tank 241-B-109 (core 170). However, the component concentrations in tanks 241-B-104 and 241-B-106 differ markedly from those in tank 241-B-108 and 241-B-109.

Transfer records (Agnew et al. 1997b) indicate that tank 241-B-109 was the last tank to receive evaporator bottoms from tank 241-B-105. Tank 241-B-105 was the active bottoms tank at that time. The records indicate that both evaporated 1C waste and probably evaporated UR waste was transferred from tank 241-B-105 to 241-B-109. The high concentrations of $F^-$, $SO_4^{2-}$, and $PO_4^{3-}$ in tank 241-B-109 may reflect precipitation of those components from highly concentrated residual liquors that resulted from the final pass through the 242-B Evaporator.

The analyte concentrations for core 170 from tank 241-B-109 are considered an appropriate basis for estimating the inventory of chemical components for the fraction of BSltCk waste in this tank. The component concentrations are not consistent with two other tanks (241-B-104 and 241-B-106) believed to contain BSltCk. However, they are consistent with those for tank 241-B-108, which (like tank 241-B-109) also received highly concentrated salt liquors from 242-B Evaporator operations. This difference suggests a phasing and distribution issue. Perhaps earlier evaporator concentrates derived from 1C waste were placed in tanks 241-B-108 and 241-B-109, and later concentrates derived from UR waste were placed in tanks 241-B-104 and 241-B-106.

The inventory for BSltCk components was calculated as the product of the core 170, tank 241-B-109 component concentrations in Table D3-1 (corrected to include 41.7 weight percent $H_2O$), a waste volume of 240 kL (63.5 kgal) and the core 170 sample measured density of 1.885 g/mL (see Appendix B). As previously noted, core 170 is assumed to account for half of the tank chemical inventory. The inventory for the remaining BSltCk (and CWP) estimated to be in the tank is accounted for from core 169 (see Section D3.3).

An example calculation for the Al content in the BSltCk in tank 241-B-109 is shown below:

$$40{,}380\ \mu g/g \times (1-.417) \times 1.0E\text{-}06\ g/\mu g \times 1.885\ kg/L \times 240\ kL \times 1{,}000\ L/kL = 10{,}650\ kg\ Al$$

## D3.3 BASIS FOR ASSESSING CLADDING WASTE INVENTORY IN TANK 241-B-109

Matheison and Nicholson (1968) provide the PUREX process flowsheet basis for the neutralized aluminum cladding waste. The major components include Na, Al, Si, $NO_2^-$, and $NO_3^-$. Table D3-2 shows the analyte concentrations (on a water-free basis) for core 169 from tank 241-B-109. Also shown for comparison is the defined waste composition for CWP2 from the HDW model. The high Al and Si concentrations in the sample indicate that the sample data are consistent with the flowsheet basis for cladding waste. The presence of significant amounts of uranium suggests that some fuel core material also is present. The high concentration of Al in this sample is comparable to that for the HDW-model-defined waste. However, the core 169 sample also contains an estimated 50 volume percent BSltCk, which increases component concentrations in particular for Na, $NO_3^-$, $PO_4^{3-}$, and $F^-$. The HDW model CWP2 defined waste does not indicate Si, whereas significant concentrations of Si were found in the core sample. The presence of Si in aluminum cladding waste is expected because the decladding process attacks the Al-Si alloy bonding. It is not clear why the HDW model does not indicate Si for the defined waste.

The analytical data for core 169 are considered an appropriate basis for estimating the inventory of components for the cladding waste/BSltCk mixture in tank 241-B-109. This core sample is assumed to represent 240 kL (63 kgal) of waste, which accounts for the approximately 120 kL (32 kgal) of cladding waste estimated to be in the tank, and for

120 kL of the total of 360 kL (95 kgal) of 242-B evaporator saltcake estimated to be in the tank (Section D3.1).

The inventory for the cladding waste/saltcake mixture was calculated as the product of the component concentrations from Table D3-2 (corrected to include 44.9 weight percent $H_2O$), a waste volume of 240 kL (63 kgal), and the core 169 sample measured density of 1.85 g/mL (Appendix B).

An example calculation for the Al content in the cladding waste in tank 241-B-109 follows:

$$189{,}264\ \mu g/g \times (1-.449) \times 1.0E\text{-}06\ g/\mu g \times 1.85\ kg/L \times 240\ kL \times 1{,}000\ L/kL = 46{,}300\ kg\ Al.$$

Table D3-2. Chemical Compositions of Cladding Wastes (Water-Free Basis). (2 sheets)

| Analyte | 241-B-109[1] ($\mu$g/g) | HDW Model CWP2[2] ($\mu$g/g) |
|---|---|---|
| Al | 189,264 | 213,700 |
| Bi | <3,720 | 0 |
| Ca | <3,650 | 17,410 |
| Cr | 5,692 | 164 |
| Fe | 8,962 | 13,990 |
| K | n/r | 101 |
| La | <1,664 | 0 |
| Mn | 1,069 | 0 |
| Na | 281,149 | 38,430 |
| Ni | n/r | 93 |
| Pb | <3,320 | 91,250 |
| Si | 9,378 | 0 |
| Sr | <331 | 0 |
| U | 42,586 | n/r |
| Zr | <331 | 0 |
| $CO_3$ | n/r | 0 |
| Cl | 1,463 | 422 |
| $F^-$ | 11,762 | 0 |

Table D3-2. Chemical Compositions of Cladding Wastes (Water-Free Basis). (2 sheets)

| Anions | µg/g | µg/g |
|---|---|---|
| $NO_3^-$ | 101,069 | 43,320 |
| $NO_2^-$ | 20,668 | 13,950 |
| $PO_4^{3-}$ | 163,691 | 0 |
| $SO_4^{2-}$ | 3,115 | 1,249 |

Notes:

[1]Core 169
[2]Agnew et al. (1997a)

## D3.4 COMPARISON OF INVENTORY ESTIMATES

Estimated inventories from this evaluation for selected components are compared with the HDW model-based inventories in Table D3-3. Estimated inventories for the saltcake component (Section D3.2) and cladding waste component (Section D3.3) were added together to provide the total tank inventory estimate. It should be noted that although the inventory estimate in Table D3-3 is based primarily on the tank 241-B-109 core sample analyses, it differs from the sample-based inventory shown in Table D2-1 and Appendix B (Section B3.4). This is because the component concentrations for the two core samples were calculated for this assessment by correcting for the reported waste recoveries. The mean concentrations in Appendix B were derived using ANOVA techniques.

Comments and observations regarding these inventories are provided by component in the following text.

Table D3-3. Estimated Chemical Inventory for Tank 241-B-109. (2 sheets)

| Analyte | 241-B-109 Sample-Based (kg) | HDW Model Inventory (kg) |
|---|---|---|
| Al | 57,000 | 13,700 |
| Bi | <2,860 | 1,230 |
| Cr | 1,770 | 589 |
| Fe | 3,740 | 3,360 |
| Si | 2,880 | 494 |
| Na | 179,000 | 123,000 |
| U | <13,800 | 7,100 |
| F | 23,900 | 801 |
| $NO_3^-$ | 82,800 | 196,000 |

Table D3-3. Estimated Chemical Inventory for Tank 241-B-109. (2 sheets)

| Analyte | 241-B-109 Sample-Based (kg) | HDW Model Inventory (kg) |
|---|---|---|
| $NO_2^-$ | 7,130 | 17,200 |
| $PO_4^{3-}$ | 73,200 | 31,000 |
| $SO_4^{2-}$ | 84,300 | 7,230 |

**Aluminum**. The sample-based aluminum inventory estimate is over four times that predicted by the HDW model. This assessment assumes a larger contribution of cladding waste in this tank, which increases the Al content by approximately 50 percent over that predicted by the model. In addition, however, the Al concentration in tank 241-B-109 saltcake (and also tank 241-B-108 saltcake) is approximately 100-fold higher than predicted by the HDW model. The HDW model assumes a low solubility for Al in salt supernatants before evaporation to saltcake. This assumption appears to be incorrect.

**Bismuth**. The total Bi inventory for both estimates is low, which indicates that essentially no $BiPO_4$ process 1C sludge is present in tank 241-B-109. The small amount of Bi is likely present as soluble species in the BSltCk, and is from very minor amounts of 1C sludge.

**Iron and Chromium**. The sample-based Cr inventory is three-fold higher than predicted by the HDW model. The sample-based and model-based Fe inventories are comparable. The HDW model predicts Fe concentrations in cladding waste and 242-B saltcake close to those observed for the tank 241-B-109 core samples. However, consistently higher Cr concentrations were found in the 241-B-109 saltcake (as well as the other 241-B Tank Farm saltcake comparison tanks) than predicted by the HDW model.

**Silicon**. The Si inventory estimated by this assessment is six-fold higher than the HDW model inventory. The largest contribution of Si is from the cladding waste (observed for core 169). The presence of Si in aluminum cladding waste is expected because the decladding process attacks the Al-Si alloy bonding. The HDW model apparently does not account for dissolution of Si as part of the decladding mechanism, suggesting a missing or incomplete source term.

**Sodium**. The Na inventory estimate is approximately 50 percent higher than predicted by the HDW model. The 242-B Evaporator saltcake in both tanks 241-B-108 and 241-B-109 exhibits significantly higher Na concentrations than were found in the other 242-B Evaporator saltcake tanks. This assessment concludes that the higher concentrations for Na (as well as $F^-$ and $SO_4^{2-}$) are characteristic of some saltcakes resulting from the final pass of highly concentrated supernatants through the 242-B Evaporator.

**Fluoride and Sulfate**. The $F^-$ and $SO_4^{2-}$ inventories estimated by this evaluation are 30 times and 12 times higher, respectively, than predicted by the HDW model. The $F^-$ and $SO_4^{2-}$ concentrations in both 241-B-108 and 241-B-109 tank samples were significantly higher than found in the other 242-B saltcake comparison tank samples. Furthermore, none of the analytes that correlate with elevated concentrations (Si, Zn, or La) were observed. It is concluded that the tank 241-B-109 samples are characteristic of saltcake resulting from the final pass of highly concentrated supernatants through the 242-B Evaporator.

**Nitrate**. The $NO_3^-$ inventory estimate is about half of that predicted by the HDW model. As evidenced by the saltcake samples from tanks 241-B-108 and 241-B-109, it is thought that less soluble components, e.g., $F^-$ and $SO_4^{2-}$, precipitated preferentially from highly concentrated residual liquors during the final pass through the 242-B Evaporator.

**Hydroxide**. Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the other ionic species. In some cases, this approach requires that other cation or anion (e.g., sodium or nitrate) inventories be adjusted to achieve the charge balance. During such adjustments, significant figures are retained. This charge balance approach is consistent with that used by Agnew et al. (1997a).

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

Information about chemical, radiological, and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessments associated with waste management activities, as well as to address regulatory issues. These activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes, and facilities for retrieving wastes and processing them into a form that is suitable for long-term storage.

Chemical and radiological inventory information is generally derived using three approaches: 1) component inventories are estimated using results of sample analyses; 2) component inventories are estimated using HDW model-based process knowledge and historical information; or 3) a tank-specific process estimate is made based on process flowsheets, reactor fuel data, essential material usage, and other operating data. Not surprisingly, the information derived from these different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as the standard characterization for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of chemical information for tank 241-B-109 was performed that used:

- Analytical data from two push mode 1996 core samples (Appendix B)
- An inventory estimate generated by the HDW model (Agnew et al. 1997a)
- A comparison of the summation of individual waste types and total waste concentrations with similar 241-B Tank Farm tank samples.

Based on this evaluation, a best-basis inventory was developed for tank 241-B-109 (Tables D4-1 and D4-2). The evaluation used the sample-based analytical data to define the best-basis inventory. Factors considered were:

- The concentrations of waste components in the saltcake portions of the 241-B-109 core sample 170 are comparable to those for tank 241-B-108. Both tanks were concluded to have received saltcake from the final pass of highly concentrated waste liquors from 1C and/or UR supernatants through the 242-B Evaporator.
- No methodology is available to fully predict 242-B Evaporator saltcake from process flowsheets or historical records.
- The relative concentrations of key components in the tank 241-B-109 core 169 are consistent with those expected from waste resulting from aluminum decladding waste.
- The solubility data in Agnew et al. (1997a) for several chemical components in BSltCk are not consistent with the sample-based data for tanks 242-B-108 and 241-B-109.

Radionuclide inventories for $^{137}Cs$ were estimated based on tank 241-B-108 analyses because tank 241-B-109 analyses were unavailable. Hanford defined waste model bases were used as best-basis in Tables D4-1 and D4-2 where there were poor (or no) sample bases.

Table D4-1. Best-Basis Inventory Estimate for Nonradioactive Components in Tank 241-B-109 (Effective January 31, 1997).

| Analyte | Total Inventory (kg) | Basis (S, M, or E)[1] | Comment |
|---|---|---|---|
| Al | 57,000 | S | |
| Bi | <2,860 | S | |
| Ca | <1,710 | S | |
| Cl | 750 | S | |
| TIC as $CO_3$ | 6,870 | S | |
| Cr | 1,770 | S | |
| F | 23,900 | S | |
| Fe | 3,740 | S | |
| Hg | 59.9 | M | No sample basis |
| K | 459 | M | No sample basis |
| La | 0.05 | M | No sample basis |
| Mn | <328 | S | Near detection limit |
| Na | 179,000 | S | |
| Ni | 174 | M | Poor sample basis |
| $NO_2$ | 7,130 | S | |
| $NO_3$ | 82,800 | S | |
| OH | 89,000 | C | Total oxide as hydroxide |
| Pb | <1,630 | S | |
| $PO_4$ | 73,200 | S | ICP basis |
| Si | 2,880 | S | IC basis |
| S as $SO_4$ | 84,300 | S | |
| Sr | 0 | M | Poor sample basis |
| TOC | 1,080 | S | |
| $U_{TOTAL}$ | <13,800 | S | Near detection limit |
| Zr | 4.9 | M | No sample basis |

Notes:

[1]S = Sample-based (see Appendix B), M = HDW model-based, E = Engineering assessment-based, C = Calculated by charge balance

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-B-109, Decayed to January 1, 1994 (Effective January 31, 1997). (2 sheets)

| Analyte | Total Inventory (Ci) | Basis (S, M, or E)[1] | Comment |
|---|---|---|---|
| $^{3}H$ | n/r | | |
| $^{14}C$ | n/r | | |
| $^{59}Ni$ | n/r | | |
| $^{60}Co$ | n/r | | |
| $^{63}Ni$ | n/r | | |
| $^{79}Se$ | n/r | | |
| $^{90}Sr$ | 8,530 | M | Poor sample basis |
| $^{90}Y$ | 8,530 | M | Based on $^{90}Sr$ |
| $^{93}Zr$ | n/r | | |
| $^{93m}Nb$ | n/r | | |
| $^{99}Tc$ | n/r | | |
| $^{106}Ru$ | n/r | | |
| $^{113m}Cd$ | n/r | | |
| $^{125}Sb$ | n/r | | |
| $^{126}Sn$ | n/r | | |
| $^{129}I$ | n/r | | |
| $^{134}Cs$ | n/r | | |
| $^{137}Cs$ | 17,000 | E | Based on tank 241-B-108 |
| $^{137m}Ba$ | 16,000 | E | Based on $^{137}Cs$ |
| $^{151}Sm$ | n/r | | |
| $^{152}Eu$ | n/r | | |
| $^{154}Eu$ | n/r | | |
| $^{155}Eu$ | n/r | | |
| $^{226}Ra$ | n/r | | |
| $^{227}Ac$ | n/r | | |
| $^{228}Ra$ | n/r | | |
| $^{229}Th$ | n/r | | |
| $^{231}Pa$ | n/r | | |
| $^{232}Th$ | n/r | | |

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-B-109, Decayed to January 1, 1994 (Effective January 31, 1997). (2 sheets)

| Analyte | Total Inventory (Ci) | Basis (S, M, or E)[1] | Comment |
|---|---|---|---|
| $^{232}U$ | n/r | | |
| $^{233}U$ | n/r | | |
| $^{234}U$ | n/r | | |
| $^{235}U$ | n/r | | |
| $^{236}U$ | n/r | | |
| $^{237}Np$ | n/r | | |
| $^{238}Pu$ | n/r | | |
| $^{238}U$ | n/r | | |
| $^{239/240}Pu$ | 144 | M | Poor sample basis |
| $^{241}Am$ | n/r | | |
| $^{241}Pu$ | n/r | | |
| $^{242}Cm$ | n/r | | |
| $^{242}Pu$ | n/r | | |
| $^{243}Am$ | n/r | | |
| $^{243}Cm$ | n/r | | |
| $^{244}Cm$ | n/r | | |

Note:

[1]S = Sample-based, M = Hanford Defined Waste model-based, E = Engineering assessment-based.

## D5.0 APPENDIX D REFERENCES

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

Agnew, S. F., P. Baca, R. A. Corbin, T. B. Duran, and K. A. Jurgensen, 1997b, *Waste Status and Transaction Record Summary (WSTRS Rev. 4)*, LA-UR-97-311, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

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

Field, J. G., 1996, *Tank Characterization Report for Single-Shell Tank 241-B-104*, WHC-SD-WM-ER-552, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Hanlon, B. M., 1997, *Waste Tank Summary Report for Month Ending October 31, 1996*, WHC-EP-0182-103, Lockheed Martin Hanford Company, Richland, Washington

Hill, J. G., G. S. Anderson, and B. C. Simpson, 1995, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*, PNL-9814, Rev. 2, Pacific Northwest Laboratory, Richland, Washington.

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

Matheison, W. E., and G. A. Nicholson, 1968, *PUREX Chemical Flowsheet Processing of Aluminum-Clad Uranium Fuels*, ARH-214 DEL, Atlantic Richfield Hanford Company, Richland, Washington.

McCain, D. J., 1996, *Tank Characterization Report for Single-Shell Tank 241-B-106*, WHC-SD-WM-ER-601, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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

Schreiber, R. D., 1997, *Tank Characterization Report for Single-Shell Tank 241-B-108*, HNF-SD-WM-ER-674 Rev. 0, Draft, Lockheed Martin Hanford Corporation, Richland, Washington.

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# APPENDIX E

# BIBLIOGRAPHY FOR TANK 241-B-109

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# APPENDIX E

## BIBLIOGRAPHY FOR TANK 241-B-109

Appendix E provides a bibliography of information that supports the characterization of tank 241-B-109. This bibliography represents an in-depth literature search of all known information sources that provide sampling, analysis, surveillance, and modeling information, as well as processing occurrences associated with tank 241-B-109 and its respective waste types.

The references in this bibliography are separated into three broad categories containing references broken down into subgroups. These categories and their subgroups are listed below.

**I. NON-ANALYTICAL DATA**

- Ia. Models/Waste Type Inventories/Campaign Information
- Ib. Fill History/Waste Transfer Records
- Ic. Surveillance/Tank Configuration
- Id. Sample Planning/Tank Prioritization
- Ie. Data Quality Objectives/Customers of Characterization Data

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

- IIa. Sampling of Tank 241-B-109
- IIb. Sampling of Similar Waste Types

**III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA**

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

This bibliography is broken down into the appropriate sections of material to use, with an annotation at the end of each reference, or set of references, describing the information source. Where possible, a reference is provided for information sources. A majority of the information listed below may be found in the Lockheed Martin Hanford Corporation Tank Characterization Resource Center.

# I. NON-ANALYTICAL DATA

## Ia. Models/Waste Type Inventories/Campaign Information

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

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

Jungfleisch, F. M., and B. C. Simpson, 1993, *Preliminary Estimation of the Waste Inventories in Hanford Tanks Through 1980*, WHC-SD-WM-TI-057, Rev. 0A, Westinghouse Hanford Company, Richland, Washington.

- Describes a model for estimating tank waste inventories using process knowledge, radioactive decay estimates using ORIGEN, and assumptions about waste types, solubility, and constraints.

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

- Contains compositions of process stream waste before transfer to 200 Area waste tanks.

## Ib. Fill History/Waste Transfer Records

Agnew, S. F., P. Baca, R. A. Corbin, T. B. Duran, and K. A. Jurgensen, 1997, *Waste Status and Transaction Record Summary (WSTRS Rev. 4)*, LA-UR-97-311, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Contains spreadsheets depicting all known tank additions/transfers.

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

- Contains tank fill histories and primary campaign/waste type information up to 1981.

## Ic. Surveillance/Tank Configuration

Alstad, A. T., 1993, *Riser Configuration Document for Single-Shell Waste Tanks*, WHC-SD-WM-TI-053, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Shows riser location in relation to tank aerial view as well as a description of each riser and its contents.

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

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

Tran, T. T., 1993, *Thermocouple Status Single-Shell & Double-Shell Waste Tanks*, WHC-SD-WM-TI-553, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Provides thermocouple location and status information for double- and single-shell tanks.

Welty, R. K., 1988, *Waste Storage Tank Status and Leak Detection Criteria*, WHC-SD-WM-TI-356, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Provides leak detection information for all single- and double-shell tanks. Liquid level, liquid observation well, and drywell readings are included.

## Id. Sample Planning/Tank Prioritization

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

- Establishes an approach to determine the priority for tank sampling and characterization and identifies high-priority tanks for sampling.

Mulkey, C. H., 1996, *Single-Shell Tank System Waste Analysis Plan*, WHC-EP-0356, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Waste analysis plan for single-shell tanks as required by WAC-173-303 and 40 CFR Part 265.

Stanton, G. A., 1996, *Baseline Sampling Schedule, Change 96-04*, (internal letter 75610-96-11 to Distribution, August 22), Westinghouse Hanford Company, Richland, Washington.

- Provides a tank waste sampling schedule through fiscal year 2002 and lists samples taken since 1994.

Winkelman, W. D., 1996, *Tank 241-B-109 Tank Characterization Plan*, WHC-SD-WM-TP-505, Rev. 1, Lockheed Martin Hanford Corporation, Richland, Washington.

- Discusses all relevant DQOs and how their requirements will be met for tank 241-B-109.

Benar, C. J., 1997, *Tank 241-B-109 Rotary Mode Core Sampling and Analysis Plan*, WHC-SD-WM-TSAP-108, Rev. 0A, Lockheed Martin Hanford Corporation, Richland, Washington.

- Contains detailed sampling and analysis scheme for core samples to be taken from tank 241-B-109 to address applicable DQOs.

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

- Contains *Hanford Federal Facility Agreement and Consent Order* requirement-driven TWRS characterization program information and a list of tanks addressed in fiscal year 1997.

## Ie. Data Quality Objectives/Customers of Characterization Data

Dukelow, G. T., J. W. Hunt, H. Babad, and J. E. Meacham, 1995, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- DQO used to determine if tanks are under safe operating conditions.

Osborne, J. W. and L. L. Buckley, 1995, *Data Quality Objective for Tank Hazardous Vapor Safety Screening*, WHC-SD-WM-DQO-002, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- DQO used to determine if tank headspaces contain potentially hazardous gases and vapors.

Simpson, B. C. and D. J. McCain, 1996, *Historical Model Evaluation Data Requirements*, WHC-SD-WM-DQO-018, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Identifies analytical parameters to characterize waste into one of five waste types.

Turner, D. A., H. Babad, L. L. Buckley, and J. E. Meacham, 1995, *Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue*, WHC-SD-WM-DQO-006, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- DQO used to categorize organic tanks as "safe," "conditionally safe," or "unsafe" based on fuel and moisture concentrations and to support resolution of the safety issue.

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

### IIa. Sampling of Tank 241-B-109

Nuzum, J. L., 1997, *Tank 241-B-109, Cores 169 and 170 Analytical Results for the Final Report*, HNF-SD-WM-DP-201, Rev. 1, Rust Federal Services of Hanford, Inc., Richland, Washington.

- Contains analytical results from August 1996 push-mode core sampling event.

Wheeler, R. E., 1975, *Analysis of Tank Farm Samples, Sample: T-8578, Tank: 109-B, Received: October 6, 1975*, (internal memorandum to R. L. Walser, November 12), Atlantic Richfield Hanford Company Operations, Richland, Washington.

- Contains historical sample analysis results.

### IIb. Sampling of Similar Waste Types

Remund, K. M., S. A. Hartley, J. J. Toth, J. M. Tingey, P. G. Heasler, F. M. Ryan, and B. C. Simpson, 1994, *Tank Characterization Report for Single-Shell Tank T-102*, PNL-10101, Pacific Northwest Laboratory, Richland, Washington.

- Contains information on PUREX cladding waste type.

## III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

### IIIa. Inventories using both Campaign and Analytical Information

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

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

Agnew, S. F., R. A. Corbin, J. Boyer, T. B. Duran, K. A. Jurgensen, T. P. Ortiz, B. L. Young, R. Anema, and C. Ungerecht, 1996, *History of Organic Carbon in Hanford HLW Tanks: HDW Model Rev. 3*, LA-UR-96-989, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Attempts to account for the disposition of soluble organics and provides estimates of TOC content for each tank.

Allen, G. K., 1976, *Estimated Inventory of Chemicals Added to Underground Waste Tanks, 1944 - 1975*, ARH-CD-601B, Rev. 0, Atlantic Richfield Hanford Company, Richland, Washington.

- Contains major components for waste types and some assumptions. Purchase records are used to estimate chemical inventories.

Allen, G. K., 1975, *Hanford Liquid Waste Inventory as of September 30, 1974*, ARH-CD-229, Rev. 0, Atlantic Richfield Company, Richland, Washington.

- Contains major components for waste types and some assumptions.

Geier, R. G., 1976, *Estimated Hanford Liquid Wastes Chemical Inventory as of June 30, 1976*, ARH-CD-768, Rev. 0, Atlantic Richfield Hanford Company, Richland, Washington.

- Contains nominal concentrations of various analytes for the liquid waste in some of the waste tanks.

Klem, M. J., 1988, *Inventory of Chemicals Used at Hanford Production Plants and Support Operations (1944 - 1980)*, WHC-EP-0172, Westinghouse Hanford Company, Richland, Washington.

- Provides a list of chemicals used in production facilities and support operations that sent wastes to the single-shell tanks. List is based on chemical process flowsheets, essential materials consumption records, letters, reports, and other historical data.

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

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

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

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

## IIIb. Compendium of Existing Physical and Chemical Documented Data Sources

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

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

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

- Contains summary information for tanks in A, B, BX, BY, and C Tank Farms as well as in-tank photo collages and inventory estimates.

Brevick, C. H., R. L. Newell, and J. W. Funk, 1996, *Supporting Document for the Northeast Quadrant Historical Tank Content Estimate Report for B Tank Farm*, WHC-SD-WM-ER-310, Rev. 1A, Westinghouse Hanford Company, Richland, Washington.

- Contains summary information for tanks in the B Tank Farm, and appendixes containing more detailed information including tank waste level history, tank temperature history, cascade and dry well charts, riser information, in-tank photo collages, and tank layer model bar chart and spreadsheet.

Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1996, *Tank Waste Source Term Inventory Validation, Vol I, II, and III*, WHC-SD-WM-ER-400, Rev. 0A, Westinghouse Hanford Company, Richland, Washington.

- Contains a quick reference to sampling information in spreadsheet or graphical form for 24 chemicals and 11 radionuclides for all the tanks.

Hanlon, B. M., 1997, *Waste Tank Summary Report for Month Ending October 31, 1996*, HNF-EP-0182-103, Lockheed Martin Hanford Company, Richland, Washington.

- This document, updated monthly, is a summary of: tank waste volumes, Watch List tanks, occurrences, tank integrity information, equipment readings, tank location, leak volumes, and other miscellaneous tank information.

Hill, J. G., G. S. Anderson, and B. C. Simpson, 1995, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*, PNL-9814, Rev. 2, Pacific Northwest Laboratory, Richland, Washington.

- Describes a system of sorting single-shell tanks into groups based on the major waste types contained in each tank.

Husa, E. I., 1993, *Hanford Site Waste Storage Tank Information Notebook*, WHC-EP-0625, Westinghouse Hanford Company, Richland, Washington.

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

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

- Gives an assessment of the relative dryness of tank wastes.

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

- Contains a tank inventory estimate based on analytical information.

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

- Contains a tank inventory estimate based on analytical information.

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

- Contains a tank inventory estimate based on analytical information.

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

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

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