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Preliminary Tank Characterization Report for Single-Shell Tank 241-AX-103: Best-Basis Inventory

S. L. Lambert and D. W. Hendrickson
SGN Eurisys Services Corporation, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

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Abstract: An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities. As part of this effort, an evaluation of available information for single-shell tank 241-AX-103 was performed, and a best-basis inventory was established. This work follows the methodology that was established by the standard inventory task.

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PRELIMINARY TANK CHARACTERIZATION REPORT FOR SINGLE-SHELL TANK 241-AX-103: BEST-BASIS INVENTORY

July 1997

S. L. Lambert
D. W. Hendrickson
SGN Eurisys Services Corporation
Richland, Washington

Prepared for
U.S. Department of Energy
Richland, Washington

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PRELIMINARY TANK CHARACTERIZATION REPORT FOR SINGLE-SHELL TANK 241-AX-103: BEST-BASIS INVENTORY

This document is a preliminary Tank Characterization Report (TCR). It only contains the current best-basis inventory (Appendix D) for single-shell tank 241-AX-103. No TCRs have been previously issued for this tank, and current core sample analyses are not available. The best-basis inventory, therefore, is based on an engineering assessment of waste type, process flowsheet data, early sample data, and/or other available information.

The *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes* (Kupfer et al. 1997) describes standard methodology used to derive the tank-by-tank best-basis inventories. This preliminary TCR will be updated using this same methodology when additional data on tank contents become available.

REFERENCE

Kupfer, M. J., A. L. Boldt, B. A. Higley, K. M. Hodgson, L. W. Shelton, and R. A. Watrous (LMHC), S. L. Lambert, and D. E. Place (SESC), R. M. Orme (NHC), G. L. Borsheim (Borsheim Associates), N. G. Colton (PNNL), M. D. LeClair (SAIC), R. T. Winward (Meier Associates), and W. W. Schulz (W^2S Corporation), 1997, *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes*, HNF-SD-WM-TI-740, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-AX-103

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-AX-103

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 single-shell tank 241-AX-103 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

A Tank Characterization Report (TCR) has not been prepared for this tank. Tank 241-AX-103 was sampled in September 1974, to determine the sludge composition prior to the 1976 sluicing campaign, and again in September 1980, to establish the tank supernate composition before deactivation of the tank in 1981. Samples obtained prior to 1976 are of only limited value because most of the material was removed from this tank during the 1976 sluicing campaign. Similarly, supernate samples from the post 1976 period are of little interest because the supernate was transferred to tank 241-A-102 during the fourth quarter of 1980, or removed via salt well pumping to tank 241-AN-101 in 1987.

The Hanford Defined Waste (HDW) model Rev. 4 (Agnew et al. 1997a) has generated an inventory for this tank, and an independent set of estimates can be generated for this tank based on process flowsheets and waste transaction records for this tank (Agnew et al. 1997b). Information obtained from tanks containing wastes from the same process, combined with assumptions regarding the waste volumes contributing to the inventory, can be used to calculate individual analyte inventories for this tank.

The waste history of this tank is provided in Anderson (1990). Tank 241-AX-103 was initially used as a Plutonium-Uranium Extraction (PUREX) waste receiver from the first quarter of 1965 until the second quarter of 1966, with large transfers of PUREX (P2) waste and intermittent transfers of PUREX organic wash (OWW2) waste. Other transfers of PUREX organic wash (OWW3) waste occurred in 1966 and 1967, followed by transfers of B Plant (B) waste, PUREX low-level (PL1) waste and supernate receipts from other tanks (241-A-104, 241-A-106, 241-AX-101, 241-AX-102, 241-AX-104 and 241-C-106). AR vault (AR) sludge was added in 1975, and the tank was sluiced from March 1976, until the beginning of 1977, removing about 310 kL (82 kgal) of sludge (Rodenhizer 1987). The tank was isolated and stabilized in early 1977 and deactivated in 1981, with the last salt well transfer occurring in 1987.

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D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

After the 1976 sluicing campaign, the residual sludge level was found to be 15.2 cm (6 in.) at riser 9B. This level was measured again in November 1979, after dilute evaporator wastes were added to the tank and found to be 7.6 cm (3 in.) and 25.4 cm (10 in.) at risers 9D and 9E (Bendixsen 1980). Based on these values, approximately 15.2 cm (6 in.) of residual sludge must have been left in the tank after the 1976 sluicing campaign. This level is equivalent to a residual sludge inventory of 62.5 kL (16.5 kgal) in the 22.86 m (75 ft) diameter, flat bottom tank. This estimate is somewhat larger than the residual inventories reported by Anderson (1990) (0 to 22.7 kL [0 to 6 kgal] of sludge in 1980) and later by Agnew et al. (1997a) (14 kgal of sludge), based on the historical records for this tank.

Approximately 1,635 kL (432 kgal) of 242-A Evaporator concentrates were added to this tank in 1980, increasing the sludge and salt cake inventory to about 458 kL (121 kgal) (Agnew et.al. 1997b). Because of salt well pumping, this inventory was later reduced to about 424 kL (112 kgal), which is consistent with the tank farm surveillance estimate 103.4 cm (40.7 in.) of solids, including 7.6 kL (2 kgal) of sludge and 416.4 kL (110 kgal of salt cake (Hanlon 1997). The Hanlon estimate is also consistent with current waste level measurements for this tank, 102.9 cm (40.5 in.) of waste as of January 1993, including a 2.54 cm (1 in.) offset for the FIC plummet (Swaney 1993). Based on the 1979 sludge level measurements, it appears the Hanlon sludge and salt cake estimates should be revised to match the 1979 sludge level data for this tank (62.5 kL [16.5 kgal] of sludge and 361.5 kL [95.5 kgal] of salt cake). The best-basis inventory will be developed from the tank farm surveillance waste inventory (424 kL [112 kgal]), with revised inventory estimates of 62.5 kL (16.5 kgal) of sludge and 361.5 kL (95.5 kgal) of salt cake.

The residual sludge in tank 241-AX-103 is considered similar in composition to the residual sludge in tank 241-AX-104. Both tanks received PUREX high-level (P2) waste starting in 1965, while tank 241-AX-103 also received small transfers of PUREX organic wash (OWW2) waste during this period. Both tanks were sluiced in 1976 and 1977, leaving only a small heel of residual sludge (62.5 and 26.5 kL [16.5 and 7 kgal], respectively, in tanks 241-AX-103 and 241-AX-104). A small sample of residual sludge was obtained from tank 241-AX-104 after the 1976 sluicing campaign. The characteristics of this sludge were found to be consistent with the expected composition profile for PUREX P2 waste. (Best-basis inventory discussion for tank 241-AX-104 is included in Lambert and Hendrickson 1997.) Based on this analogy, it appears that this sample could also be used to estimate the residual waste composition profile for tank 241-AX-103, with appropriate adjustments for OWW2 waste.

According to the HDW model, 3.9 vol% of the P2 waste and 1.1 vol% of the OWW2 waste is expected to precipitate as sludge in the primary receiver tank (Agnew et al. 1997a). Based on the volume of such transfers in 1965 and 1966, it appears that PUREX P2 waste could makeup as much as 92 percent of the sludge and OWW2 waste 8 percent of the sludge

in tank 241-AX-103 (350 kL [92.5 kgal] of P2 sludge and 34.1 kL [9.0 kgal] of OWW2 sludge theoretically deposited in 1965 and 1966).

About 3,092 kL (817 kgal) of OWW2 waste were transferred to this tank in 1965 and 1966 (Agnew et.al. 1997b). OWW2 waste contained about 0.004 g moles/L of MnO_2 and 3.5 E-05 kg/L of uranium (Anderson 1990). Based on these values, about 680 kg of Mn and 111 kg of uranium must have been added with OWW2 waste in 1965 and 1966. Because all but 62.5 kL (16.5 kgal) of sludge were removed during the 1976 sluicing campaign, only about 16 percent of the OWW2 waste should be in the tank (62.5 kL/350 kL + 34.1 kL [16.5 kgal/92.5 kgal + 9 kgal]). Thus, 109 kg of Mn and 18 kg of uranium may have been added to the residual sludge layer from OWW2 waste.

Since the residual sludge layers in tanks 241-AX-103 and 241-AX-104 were derived from a common source, the 1977 grab sample from tank 241-AX-104 (Starr 1977) will be used in this analysis to estimate the waste composition profile for tank 241-AX-103. The tank 241-AX-104 1977 grab sample concentrations for both the washed sludge and the wash solution are listed in Tables D2-1 and D2-2 for nonradioactive and radioactive components, respectively. The tank 241-AX-104 grab sample concentrations are reported on a "per liter of sludge" basis. The tank 241-AX-103 sludge layer inventory, summarized in Tables D2-1 and D2-2, is calculated by multiplying the sum of the washed sludge and wash solution concentrations in tank 241-AX-104 sludge by the volume of the sludge in tank 241-AX-103 (62.6 kL [16.5 kgal]), with the indicated corrections for Mn and uranium from OWW2 waste. (The chemical species are reported without charge designation per the best-basis inventory convention.)

Table D2-1. Sludge Inventory Estimates for Nonradioactive Components in Tank 241-AX-104.

Component	Tank 241-AX-104 1977 washed sludge concentration (*M*)[a]	Tank 241-AX-104 1977 wash solution concentration (*M*)[b]	Tank 241-AX-103 sludge layer inventory (kg)[c]
Al	2.465	0.013	4,182
Ba	0.021	NR	180.4
Ca	0.642	NR	1608
Cd	0.015	NR	105.5
Cr	0.061	NR	198.4
Fe	5.31	NR	18,549
Mg	0.171	NR	260
Mn	0.0845	NR	399[d]
Na	2.99	0.337	4,784
Ni	0.26	NR	955
NO_2	NR	0.083	239
NO_3	<1.140	0.09	<4770
OH	NR	15.6	16,595
P as PO_4	0.11	NR	653
Si	2.485	NR	4,366
S as SO_4	0.125	0.01	811
Total U	1.79 E-05	NR	18.27[d]
H_2O	40.97	NR	46,162
Pu	0.213	NR	3,184
Volume (kL)	62.5		

NR = Not reported
OWW2 = PUREX organic wash waste generated between 1963 and 1967
PUREX = Plutonium-uranium extraction
[a]Average of two KOH fusion determinations from September 1977 grab sample of tank 241-AX-104 (Starr 1977)
[b]Wash solution composition is normalized to sludge volume (Starr 1977)
[c]Sludge inventory based on 62.5 kL (16.5 kgal) of sludge in tank 241-AX-103
[d]Includes 109 kg of Mn or 18 kg of U from OWW2 sludge.

Table D2-2. Sludge Inventory Estimates for Radioactive Components in Tank 241-AX-103 (Decayed January 1, 1994).

Component	Tank 241-AX-104 1977 washed sludge concentration (Ci/L)[a]	Tank 241-AX-104 1977 wash solution concentration (Ci/L)[b]	Tank 241-AX-103 sludge layer inventory (Ci)[c]
^{60}Co	0.0130	NR	816
^{90}Sr	59.4	0.0133	3.71 E+06
^{90}Y	59.4	0.0133	3.71 E+06
^{125}Sb	0.0106	NR	665
^{137}Cs	1.220	0.0086	76,661
^{137m}Ba	1.154	0.0081	72,521
^{154}Eu	0.0703	NR	4396
^{155}Eu	0.0672	NR	4204
$^{239/240}Pu$	0.013	NR	824

NR = Not reported

[a]Based on decayed mean of 1977 sludge sample (Starr 1977)

[b]Based on decayed mean of 1977 wash solution results normalized to sludge volume (Starr 1977)

[c]Sludge inventory based on 62.5 kL (16.5 kgal) of sludge in tank 241-AX-103.

During the second and third quarters of 1980, approximately 1,635 kL (432 kgal) of evaporator concentrates were added to tank 241-AX-103 from the 242-A Evaporator-crystallizer. After this transfer, the waste inventory increased to 458 kL (121 kgal), and later because of salt well pumping, gradually decreased to the present inventory of 424 kL (112 kgal) (Agnew et al. 1997a, Hanlon 1997, Swaney 1993). Some 361.4 kL (95.5 kgal) of this inventory is due to the accumulation of salt cake from the 242-A Evaporator. This salt cake is also known as SMMA1 salt cake in the HDW model. While salt cake compositions probably varied from batch to batch (depending on the source of concentrated supernate), large volumes of salt cake were also added to tanks 241-A-102 and 241-A-103 during this same time period. These tanks are of interest because both tanks were sluiced in 1976 to a residual inventory of only 4 to 11 kL (1 to 3 kgal) of sludge and both were sampled after receiving large volumes of 242-A Evaporator salt cake in 1977 to 1980.

Tank 241-A-102 was sluiced in 1964, 1972 to 1974, and once again in 1976 to a residual heel of about 11 kL (3 kgal) of strontium recovery (SRR) sludge (Anderson 1990, Agnew et al. 1997a). Based on the HDW model, this tank currently contains 11 kL (3 kgal) of SRR sludge and 128.7 kL (34 kgal) of SMMA1 salt cake, values which are generally consistent with the current inventory estimates for this tank (147.6 kL or 39 kgal according to Swaney 1993 and 155 kL or 41 kgal according to Hanlon 1997). Thus, 92 percent of this

waste apparently consists of 242-A Evaporator salt cake. Two full-depth core samples were obtained from riser 4 in 1986 and two auger samples, the first from riser 19 in June 1995 and the second from riser 5 in March 1996, were also obtained for safety screening analysis. Core segment recoveries were determined to be nearly 100 percent for each core. Composite samples from the two 1986 cores and 1996 auger sample were analyzed to determine the chemical and radionuclide composition of the waste. The analytical results are summarized in the TCR (Morris 1996).

Table D2-3 shows the projected inventory of key components in the residual SRR sludge layer in tank 241-A-102, based on the HDW model. This model assumes that 11.3 kL (3 kgal) of SRR sludge were left in this tank, and this sludge has an average density of 1.322 kg/L.

Table D2-3. Projected Inventory of Strontium Recovery Sludge in Tank 241-A-102 Waste and Percent of Tank 241-A-102 Inventory Attributed to Strontium Recovery Sludge.

Analyte	Average concentration[a] (μg/g)	Projected inventory in SRR sludge[b] (kg)	Sample-based inventory in tank 241-A-102[c] (kg)	Percent tank 241-A-102 inventory due to SRR sludge (%)
Ca	4,146	62	410	15.1
CO_3	15,490	232	5,724	4.1
Fe	53,951	809	4,358	18.6
NO_3	19,406	291	21,949	1.3
Si	14,075	211	2,563	8.2
Na	112,406	1,687	40,087	4.2

PUREX = Plutonium-uranium extraction

SRR = Strontium recovery

[a]Based on the concentration of SRR sludge in the HDW model (Agnew et al. 1997a)

[b]Based on 11.3 kL (3 kgal) of waste with an average density of 1.322 kg/L (Agnew et al. 1997a)

[c]Based on average analyte concentrations from 1986 core samples and 1996 auger sample, with a total waste inventory of 139.7 kL (37 kgal) and average waste density of 1.645 kg/L.

Tank 241-A-103 was also sluiced in the 1960's, in 1974, and once again in 1976, to a residual sludge heel of 11.3 kL (3 kgal) of AR vault (AR) sludge (Anderson 1990, Agnew et al. 1997b). According to the HDW model (Agnew, 1997a), this tank currently contains 11 kL (3 kgal) of AR sludge and 1,374 kL (363 kgal) of SMMA1 salt cake from the 242-A Evaporator, values which are generally consistent with current inventory projections for this

tank (1,430 kL or 378 kgal based on Swaney 1993 and 1,404 kL or 371 kgal based on Hanlon 1997). Consequently, about 99.2 percent of this waste apparently consists of 242-A Evaporator salt cake. Two full-depth core samples were taken from risers 12 and 17 of this tank in March 1986. Excellent recoveries were obtained for each core. Composite samples from each core were analyzed to determine chemical and radionuclide composition of the waste, with the results being summarized in the data transmittal package for this tank (Weiss and Schull 1988a).

It appears, based on the HDW model (Agnew, 1997a), that 53 percent of the Ni and virtually all of the Fe are due to the residual AR sludge in this tank (92 out of 173 kg of Ni and 825 out of 663 kg of Fe). Apparently, these are the only components in the AR sludge likely to have any affect on the composition of the SMMA1 salt cake in tank 241-A-103.

Table D2-4 summarizes the SMMA1 salt cake compositions derived from tanks 241-A-102 and 241-A-103. These estimates have been corrected for the amount of Fe, Si, and CO_3 in tank 241-A-102 SRR sludge, and the fractional inventories of Fe and Ni in tank 241-A-103 AR sludge, based on SRR and AR sludge compositions and volumes in the HDW model (Agnew et al. 1997a). This table provides source data and the average analyte concentrations for SMMA1 salt cake, corrected to a common 40.2 percent moisture content. This moisture value was arbitrarily selected to match the tank 241-A-103 data, but is generally consistent with the 43.1 percent moisture value used for tank 241-AX-103 SMMA1 salt cake in the HDW model. Salt cake inventory estimates for tank 241-AX-103 are based on 361.5 kL (95.5 kgal) of salt cake, with an average density of 1.495 kg/L from sample data. This estimate is reasonably consistent with the average density of 1.513 derived from the HDW model for SMMA1 salt cake in tanks 241-A-102, 241-A-103, and 241-AX-103.

Table D2-4. SMMA1 Salt Cake Composition and Inventory Projections for Tank 241-AX-103 Based on Core Samples from Tanks 241-A-102 and 241-A-103 and Auger Samples From Tank 241-A-102. (2 Sheets)

Analyte	Tank 241-A-102 sample data[a]		Tank 241-A-103 core sample data[b]	Average analyte concentration in SMMA1 salt cake[h]	Estimated inventory of SMMA1 salt cake in tank 241-AX-103[i]
	1986 core sample (μg/g)	1996 auger sample (μg/g)	μg/g	μg/g	kg
Density	1.59	1.7	1.345	1.495	1.495
Ag	199	317	24.7	141	76
Al	19,980	27,048	16,570	20,042	10,831
B	12.3	NR	22.2	17.3	9.3
Ba	750	119	575	505	273
Bi	1,440	287	176	520	281
Ca	2,184	589	1,716	1,551	838
Cd	54	NR	80	67	36
TIC as CO_3	NR	18,515[c]	NR	18,515	10,006
Cr	5,362	7,508	1,531	3,983	2,153
Cu	67	NR	12.3	40	22
F	NR	<236	NR	<236	<128
Fe	8,938[d]	13,586[d]	0[f]	5,631	3,043
K	2,448	2,628	2,534	2,536	1,370
La	NR	88	NR	88	47
Mg	1,166	NR	795	981	530
Mn	1,724	2,884	124	1,214	656
Na	164,484	110,067	208,605	172,940	93,464
Ni	461	352	44[g]	225	122
NO_2	NR	70,989	NR	70,989	38,366
NO_3	162,012	77,047	113,500	116,515	62,970
Pb	947	1,203	364	719	389
P as PO_4	14,198	4,186	6,655	7,923	4,282
Si	12,830	1,130	11,025	9,005	4,876
S as SO_4	NR	3,822[e]	NR	3,822	2,066

Table D2-4. SMMA1 Salt Cake Composition and Inventory Projections for Tank 241-AX-103 Based on Core Samples from Tanks 241-A-102 and 241-A-103 and Auger Samples From Tank 241-A-102. (2 Sheets)

Analyte	Tank 241-A-102 sample data[a]		Tank 241-A-103 core sample data[b]	Average analyte concentration in SMMA1 salt cake[h]	Estimated inventory of SMMA1 salt cake in tank 241-AX-103[i]
	1986 core sample (μg/g)	1996 auger sample (μg/g)	μg/g	μg/g	kg
Sr	93	26.9	12.0	35.8	19.4
TOC	6,566	12,671	7,885	8,752	4,730
U_{TOTAL}	762	30,119	1,435	8,438	4,560
Zn	107	NR	54	80	43
Zr	1,169	NR	209	689	372
H_2O	402,000	402,000	402,000	402,000	217,258

HDW = Hanford Defined Waste

NR = Not reported

SMMA1 = Salt cake from the 242-A Evaporator as predicted by the Supernatant Mixing Model (Agnew et al. 1997a)

[a]Based on the TCR (Morris 1996)

[b]Based on mean of two composite core samples from tank 241-A-103 (Weiss and Schull 1988b)

[c]Composition estimates adjusted to show only the amount of CO_3 in SMMA1 salt cake. Approximately 4.05 percent of the CO_3 in tank 241-A-102 waste due to SRR sludge (Table D2-3)

[d]Composition estimates adjusted to show only the amount of Fe in SMMA1 salt cake. Approximately 18.76 percent of the Fe in tank 241-A-102 waste due to SRR sludge (Table D2-3)

[e]Composition estimates adjusted to show only the amount of Si in SMMA1 salt cake. Approximately 8.2 percent of the Si in tank 241-A-102 waste due to SRR sludge (Table D2-3)

[f]Composition estimates adjusted to show only the amount of Fe in SMMA1 salt cake. Approximately 100 percent of the Fe in tank 241-A-103 waste due to AR sludge

[g]Composition estimates adjusted to show only the amount of Ni in SMMA1 salt cake. Approximately 53 percent of the Ni in tank 241-A-103 waste due to AR sludge

[h]Average analyte concentrations referenced to 40.2 percent moisture and calculated by averaging the tank 241-A-102 core and auger sample concentrations, and then averaging the results for tanks 241-A-102 and 241-A-103

[i]Based on 361,500 L (95.5 kgal) of SMMA1 salt cake, with an average density of 1.495 kg/L.

Table D2-5 summarizes the mean radionuclide concentrations and tank inventory estimates for SMMA1 salt cake based on core and auger samples from tanks 241-A-102 and 241-A-103. Radionuclide results in Table D2-5 have been decayed to January 1, 1994. The original analytical values for tank 241-A-102 may be found in the tank characterization report (Morris 1996), and for tank 241-A-103, in the data transmittal package for this tank (Weiss and Schull 1988a).

Table D2-5. Analytical Results and Tank Inventory Estimates for Radioactive Components in SMMA1 Salt Cake in Tank 241-AX-103 Based on Core Samples from Tanks 241-A-102 and 241-A-103. (Decayed to January 1, 1994)

Analyte	Tank 241-A-102 sample data		Tank 241-A-103 core sample data	Average analyte concentration in SMMA1 salt cake[a]	Estimated inventory of SMMA1 salt cake in tank 241-AX-103[b]
	1986 core sample	1996 auger sample			
	μCi/g	μCi/g	μCi/g	μCi/g	Ci
^{14}C	0.0011	NR	0.0026	0.0018	0.98
^{60}Co	0.078	NR	0.033	0.055	30.0
^{90}Sr	333	NR	40.6	187	101,006
^{90}Y	333	NR	40.6	187	101,006
^{99}Tc	0.089	NR	0.117	0.103	55.8
^{129}I	3.47 E-05	NR	9.50 E-06	2.7 E-05	0.015
^{137}Cs	44.1	NR	169	107	57,557
^{137m}Ba	41.7	NR	160	101	54,449
$^{239/240}Pu$	1.713	NR	0.130	0.921	498
^{241}Am	0.882	NR	0.120	0.501	271

NR = Not reported

SMMA1 = Salt cake from the 242-A Evaporator as predicted by the Supernatant Mixing Model (Agnew et al. 1997a)

[a]Average radionuclide concentrations referenced to 40.2 percent moisture and calculated by averaging the tank 241-A-102 core and auger sample concentrations, and then averaging the results for tanks 241-A-102 and 241-A-103. All radionuclides have been decayed to January 1, 1994

[b]Based on 361,500 L (95.5 kgal) of SMMA1 salt cake, with an average density of 1.495 kg/L. This estimate was derived by using the average analyte concentrations in the SMMA1 salt cake.

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D3.0 COMPONENT INVENTORY EVALUATION

Engineering assessment-based estimates developed from analytical data (Section D2.0), and the HDW model estimates developed by Agnew et al. (1997a) are both potentially useful for estimating component inventories in the tank. The HDW model is mainly based on process production waste compositions, waste transaction records for each tank, and assumed solubilities for key components. Primary wastes are process wastes initially added to tank 241-AX-103, while secondary wastes are transferred from another tank. A review of these records shows that tank 241-AX-103 received the following wastes (Agnew et al. 1997b):

- 8,974 kL (2,371 kgal) of primary PUREX high-level (P2) waste, most of which was later sluiced to B Plant for strontium recovery during the 1976 sluicing campaign.
- 4,004 kL (1,058 kgal) of PUREX organic wash (OWW2 and OWW3) waste, almost all of which was later sluiced to B Plant for strontium recovery during the 1976 sluicing campaign.
- 37.9 kL (10 kgal) of low level B Plant (BL) waste added in 1968, all of which was later sluiced to B Plant for strontium recovery during the 1976 sluicing campaign.
- 53 kL (14 kgal) of high-level B Plant (B) waste added in 1969 and 1972, all of which was later sluiced to B Plant for strontium recovery during the 1976 sluicing campaign.
- 746 kL (197 kgal) of PUREX low-level (PL) waste, all of which was later sluiced to B Plant for strontium recovery during the 1976 sluicing campaign.
- 1,487 kL (393 kgal) of B Plant AR vault sludge added in 1975, all of which was later sluiced to B Plant for strontium recovery during the 1976 sluicing campaign.
- 1,635 kL (432 kgal) of 242-A Evaporator concentrates added in 1980.
- Plus various supernate transfers from the A and AX tank farms and tanks 241-AY-102 and 241-C-106.

The HDW model (Agnew et al. 1997a) assumes that 53 kL (14 kgal) of PUREX high-level (P2) sludge were left in this tank after the 1976 sluicing campaigns and 371 kL (98 kgal) of SMMA1 salt cake were later added from the 242-A Evaporator. The total waste volumes identified in this model are consistent with the January 1993, waste level measurements and the tank farm surveillance sludge data for this tank (Swaney 1993, Hanlon 1997). Table D3-1 compares the engineering assessment-based and HDW model estimates

for chemical components, while Table D3-2 provides a similar comparison for radioactive components in tank 241-AX-103.

Table D3-1. Comparison of Engineering Assessment-Based and Hanford Defined Waste Inventory Estimates for Nonradioactive Components in Tank 241-AX-103. (2 Sheets)

Analyte	HDW model[a] (kg)	Engineering assessment (kg)[b]
Density	1.46	1.54
Heat load (kW)	6.56	3.84[e]
Heat load calculated (kW)[c]	5.57	22.77
Al	13,800	15,000
Bi	76.4	281
Ca	854	2,450
Cl	2,550	NR
TIC as CO_3	10,200	10,000
Cr	1,850	2,350
F	378	<128
Fe	8,910	21,600
Hg	0.589	NR
K	775	1,370
La	0.904	47.5
Mn	74.5	1,060
Na	98,700	98,250
Ni	272	1,080
NO_2	35,200	38,600
NO_3	80,200	63,000
OH_{TOTAL}	57,300	16,600
Pb	82.5	389
P as PO_4	2,620	4,940
Si	2,910	9,240
S as SO_4	8,810	2,880
Sr[d]	6.55	19.4
TOC	6,250	4,730
U_{TOTAL}	594	4,580

Table D3-1. Comparison of Engineering Assessment-Based and Hanford Defined Waste Inventory Estimates for Nonradioactive Components in Tank 241-AX-103. (2 Sheets)

Analyte	HDW model[a] (kg)	Engineering assessment (kg)[b]
Zr	4.14	372
H_2O	280,400	263,400
Volume (kL)	424.0	424.0

HDW = Hanford Defined Waste
NR = Not Reported
[a]Agnew et al. (1997a)
[b]Sum of Inventories in Tables D2-1 and D2-4
[c]Based on major heat emitting isotopes
[d]HDW value based on ^{90}Sr only; engineering assessment value based on SMMA1 salt cake analysis.
[e]Kummer (1995)

Table D3-2. Comparison of Engineering Assessment-Based and Hanford Defined Waste Inventory Estimates for Radioactive Components in Tank 241-AX-103.

Analyte	HDW model[a, b] (Ci)	Engineering Assessment[b, c] (Ci)
^{14}C	12.6	0.98
^{60}Co	16.2	846
^{90}Sr	892,000	3.82 E+06
^{90}Y	892,000	3.82 E+06
^{99}Tc	95.4	55.8
^{125}Sb	72.4	665
^{129}I	0.184	0.015
^{137}Cs	117,000	134,000
^{137m}Ba	110,000	127,000
^{154}Eu	612	4,396
^{155}Eu	590	4,204
$^{239/240}Pu$	171	1,322
^{241}Am	222	271

HDW = Hanford Defined Waste
NR = Not reported
[a]Agnew et al. (1997a)
[b]Decayed to January 1, 1994
[b]Sum of inventories derived from Tables D2-2 and D2-5 where applicable.

The engineering assessment-based and HDW model-based estimates closely match for many of the salt cake components, including Al, Cl, CO_3, Cr, NO_3, NO_2, and Na. For components that are normally enriched in the sludge, such as Ca, Fe, Mn, Ni, Si, U, and Zr, the level of agreement is much less satisfactory, indicating perhaps a deficiency in the HDW model for these components. While the predicted values for ^{137}Cs are reasonably close, significant differences were noted in the estimates for all of the other radionuclides. In the following section flowsheets, process samples, and comparable sludge samples from other tanks will be used to independently evaluate the credibility of the engineering assessment and HDW model-based estimates for this waste.

D3.1 WASTE TYPES

Only seven different types of waste were added to tank 241-AX-103. The most important from a volume perspective are primary PUREX high-level (P2) waste, PUREX organic wash (OWW2 and OWW3) waste, and (SMMA1) salt cake from the 242-A Evaporator. Because of the sluicing campaign conducted in 1976, only a small volume of P2 and OWW2 waste is currently in the tank, together with a substantial volume of SMMA1 salt cake from the 242-A Evaporator.

D3.1.1 PUREX High-Level (P2) Waste

Approximately 8,974 kL (2,371 kgal) of P2 waste were added to this tank in 1965 and 1966. According to the HDW model, 3.9 vol% of this waste would have precipitated as sludge in the primary receiver tank (Agnew et al. 1997a). Based on this estimate, approximately 350 kL (92.5 kgal) of P2 sludge would have precipitated in this tank from 1965 to 1966. This model also assumes that 1.1 vol% of the PUREX organic wash (OWW2) waste and 0.6 percent of the OWW3 waste (from 1965 to 1968), 1.7 percent of the B Plant low-level (BL) waste (in 1968), 2.2 vol% of the PUREX low-level (PL) waste (in 1968 and 1969), 0.5 vol% of the B Plant (B) waste (in 1969 and 1972), and 3.1 vol% of the B Plant AR vault (AR) waste (in 1975) precipitated.

Altogether, some 454.8 kL (120.1 kgal) of sludge would have precipitated in this tank before the 1976 sluicing campaign, with 77 percent of this inventory consisting of PUREX high-level (P2) waste. About 310 kL (82 kgal) of waste were removed from this tank during the 1976 sluicing campaign, leaving some 39.7 kL (10.5 kgal) of sludge in the tank (Rodenhizer 1987). This inventory is equivalent to 9.7 cm (3.8 in.) of sludge, compared to 15.2 cm (6 in.) of sludge that was previously found during the 1979 survey from risers 9D and 9E. In all likelihood, these values represent the range of uncertainty in the predicted sludge inventory in this tank (from 39.6 kL to 62.5 kL).

The high-level waste stream from PUREX (HAW) was not recycled in the plant. This stream is the main source of high-level waste from this process. The HAW stream was directed to the 1WW concentrator where most of the nitric acid was recovered. The product stream from the concentrator (1WW) was the main source of denitrated acid waste (PAW), neutralized acid waste (PNW), and in the underground storage tanks, PUREX high-level (P2) waste.

While impurity concentrations may have varied from batch to batch, the composition of the 1WW stream can be estimated from samples taken during 1958 (Van Tuyl 1958 and Allen 1976). The 1WW sample data were normalized to the amount of Fe in tank 241-AX-104 and used as such to evaluate other components in this waste. The 1WW composition estimates are summarized in Table D3-3, together with 1WW component inventory estimates normalized to the amount of Fe in this waste.

Table D3-3. Comparison of 1WW Estimates to Sludge Inventory Estimates for Tank 241-AX-103 Based Upon Tank 241-AX-104 Sample Analysis.

Analyte	1WW composition[a] (*M*)	1WW-based inventory[b] (kg)	Tank 241-AX-103 sludge inventory estimated from tank 241-AX-104 sludge analysis[c] (kg)
Al	0.10	4,483	4,182
Cr	0.01	865	198
Fe	0.20	18,549	18,549
Na	0.80	30,557	4,784
Ni	0.01	977	955
NO_2	NR	NR	239
NO_3	7.00	721,339	<4770
OH_{TOTAL}	NR	NR	16,595
Pb	NR	NR	NR
P as PO_4	0.01	1,578	653
Si	NR	NR	4,366
S as SO_4	NR	NR	811
U_{TOTAL}	0.01	3,951	18[d]
H_2O	NR	NR	46,162

1WW = Product stream from the "1WW" concentrator
NR = Not reported
OWW2 = PUREX organic wash waste generated between 1963 and 1967
[a]Estimated composition of the 1WW waste (Van Tuyl 1958 and Allen 1976)
[b]Based on estimated composition of 1WW waste normalized to the amount of Fe in tank 241-AX-103 waste
[c]Based on the estimated sludge inventory in tank 241-AX-103 waste (from Table D2-1)
[d]Includes 18 kg of U from OWW2 waste.

Tank 241-AX-103 sludge inventory estimates for Al and Ni are in good agreement with 1WW derived estimates (Table D3-3) for these components, normalized to the amount of Fe in this waste. For other components, such as Cr, NO_3, PO_4, Na, and U, the level of agreement is generally poor because these components are soluble and apparently not well represented in the precipitated sludge layer in tank 241-AX-103. The tank 241-AX-103 inventory is also lower than the 1WW inventory for these components, which is the trend that one might expect for the soluble components in the 1WW waste. This comparison,

together with the best-basis analysis of tank 241-AX-104, shows that sludge samples from tank 241-AX-104 (and corresponding sludge layer in tank 241-AX-103) generally fit the expected composition profile of PUREX high-level waste from Al-clad fuel.

D3.2 CESIUM AND STRONTIUM

Tank 241-AX-103 has an estimated heat load of 13,101 BTU/h or 3,840 watts (Kummerer 1995). This heat load corresponds to an upper bounding inventory of 813,900 Ci of ^{137}Cs or 574,000 Ci of ^{90}Sr, values that are well outside of the range of the analytical data. The sample data are consistent with a projected heat load of 22,800 watts, which is 6 times the indicated load from the thermal model. Similar discrepancies also have been identified for many other tanks. Table D3-4 summarizes these data by providing a comparison between the estimated heat loads, based on ^{90}Sr and ^{137}Cs inventories in the waste, and the thermal modelling results for these tanks.

Table D3-4 clearly shows large discrepancies between the sample-based heat load estimates and thermal modelling results for most tanks in this list. Thermal modelling results are apparently too high for six of ten tanks in this population, and too low for 3 others, with a reasonable match (to within +/- 50 percent) only being found for one tank, tank 241-C-104. This comparison suggests that the thermal modelling results may not be reliable enough at this time to generate acceptable estimates for ^{90}Sr and ^{137}Cs. In view of the indicated discrepancies in this model, sample results will be used in this analysis to develop the best-basis estimates for ^{90}Sr and ^{137}Cs.

Table D3-4. Comparison of Estimated Heat Loads to Thermal Modelling Results for Various Tanks. (2 Sheets)

Tanks	^{137}Cs (Ci)	^{90}Sr (Ci)	Estimated heat load (watts)	Thermal modelling results[j] (watts)
241-AX-103	134,220	3,820,000	22,770	3,840
241-AX-104	32,600[a]	1,580,000	9,270	4,218
241-C-102	24,800[b]	NR	117	3,790
241-C-102[c]	62,500[c]	182,000[b]	1,219	3,790
241-C-103	78,000[d]	1,980,000	13,634	5,332
241-C-104	123,000[e]	624,000	4,761	3,344
241-C-105	125,000[f]	365,000	3,035	7,327
241-C-106	501,000[g]	2,110,000	16,501	32,241
241-C-110	19,300[h]	4,880	124	932

Table D3-4. Comparison of Estimated Heat Loads to Thermal Modelling Results for Various Tanks. (2 Sheets)

Tanks	^{137}Cs (Ci)	^{90}Sr (Ci)	Estimated heat load (watts)	Thermal modelling results[j] (watts)
241-TY-101	171[i]	7,320	50	918

NR = Not reported
PUREX = Plutonium-uranium extraction
[a]Lambert and Hendrickson (1997)
[b]Lambert (1997a)
[c]Estimate for tank 241-C-102 based on the volume of PUREX coating waste added to tank 241-C-102 divided by the volume of similar waste added to tank 241-C-105 multiplied by the ^{90}Sr and ^{137}Cs values for tank 241-C-105
[d]Lambert (1997b)
[e]Baldwin et al. (1997)
[f]Lambert (1997c)
[g]Lambert (1997d)
[h]Benar et al. (1997)
[i]Lambert (1997e)
[j]Thermal modelling results from (Kummerer 1995).

D3.3 SUMMARY

The sample-based inventories that were developed for tank 241-AX-103 sludge appear to be consistent and in good agreement with the Al and Ni estimates developed from process samples of 1WW waste, normalized to the amount of Fe in tank 241-AX-103. Acceptable matches were also obtained between sample-based and HDW model-based estimates for many of the salt cake components, including Al, Cl, CO_3, Cr, NO_3, NO_2, and Na. For components that are normally enriched in the sludge, such as Ca, Fe, Mn, Ni, Si, U, and Zr, the level of agreement is much less satisfactory, indicating perhaps a deficiency in the HDW model for these components. From comparisons shown in Table D3-4, the thermal modelling results do not appear to be reliable enough at this time to generate acceptable estimates for ^{90}Sr and ^{137}Cs. The full-depth core samples (of SMMA1 salt cake) from tanks 241-A-102 and 241-A-103, together with the 1977 sample (of PUREX P2 sludge) from tank 241-AX-104, were used to generate tank inventory estimates, not only for ^{90}Sr and ^{137}Cs, but also for all of the chemical components in this waste.

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

Chemical and radionuclide inventory estimates are generally derived from one of three sources of information: (1) sample analysis and sample derived inventory estimates, (2) component inventories predicted by the HDW model based on process knowledge and historical tank transfer information, or (3) a tank-specific process estimate based on process flowsheets, reactor fuel data, essential materials records, or comparable sludge layers and sample information from other tanks.

An effort is currently underway to provide waste inventory estimates that will serve as the standard characterization data for various waste management activities. As part of this effort, a survey and analysis of various sources of information relating to the chemical and radionuclide component inventories in tank 241-AX-103 was performed, including the following:

1. Data from a 1977 grab sample of tank 241-AX-104 waste (PUREX P2 waste) obtained after the last sluicing campaign (Starr 1977)

2. Analytical data from two full-depth core samples and two auger samples (of SMMA1 salt cake) in tank 241-A-102 (Morris 1996)

3. Analytical data from two full-depth core samples (of SMMA1 salt cake) from tank 241-A-103 (Weiss and Schull 1988a)

4. Component inventory estimates provided by the HDW model (Agnew et al. 1997a)

5. Evaluation of the PUREX high-level (P2) sludge and PUREX organic wash (OWW2) sludge based on process samples (of 1WW waste), normalized to the amount of Fe in tank 241-AX-103, and process flowsheet estimates for the OWW stream (Anderson 1990)

6. Evaluation of the estimated thermal loads provided by the sample-based inventories of ^{90}Sr and ^{137}Cs relative to thermal modelling results for this tank.

Based on this analysis, a best-basis inventory was developed. The full-depth core samples and auger samples (of SMMA1 salt cake) from tanks 241-A-102 and 241-A-103, together with the 1977 sample (of PUREX P2 waste) from tank 241-AX-104 were used to generate estimates for the chemical and radionuclide components in this waste. This waste mostly consists of SMMA1 salt cake from the 242-A Evaporator and a small volume of PUREX high-level (P2) sludge and PUREX organic wash (OWW2) sludge waste from Al-clad fuel.

Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valences of other analytes. In some cases, this approach requires that other analyte (e.g., sodium or nitrate) inventories be adjusted to achieve the charge balance. During such adjustments, the number of significant figures is not increased. This charge balance approach is consistent with that used by Agnew et al. (1997a).

Best-basis tank inventory values are derived for 46 key radionuclides (as defined in Section 3.1 of Kupfer et al. 1997), all decayed to a common report date of January 1, 1994. Often, waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, and total uranium (or total beta and total alpha), while other key radionuclides such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, etc., have been infrequently reported. For this reason it has been necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions. (These computer models are described in Kupfer et al. 1997, Section 6.1 and in Watrous and Wootan 1997.) Model generated values for radionuclides in any of 177 tanks are reported in the HDW Rev. 4 model results (Agnew et al. 1997a). The best-basis value for any one analyte may be either a model result or a sample or engineering assessment-based result if available. (No attempt has been made to ratio or normalize model results for all 46 radionuclides when values for measured radionuclides disagree with the model.) For a discussion of typical error between model derived values and sample derived values, see Kupfer et al. 1997, Section 6.1.10.

The best-basis inventory for tank 241-AX-103 is presented in Tables D4-1 and D4-2. The inventory values reported in Tables D4-1 and D4-2 are subject to change. Refer to the Tank Characterization Database (TCD) for the most current inventory values.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-AX-103 (Effective May 30, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E or C)[1]	Comment
Al	15,000	E	Based on Tank Characterization Report for tank 241-A-102, core samples from tank 241-A-103, and the 1977 grab sample from 241-AX-104.
Bi	281	E	
Ca	2,450	E	
Cl	2,550	M	Agnew et al. 1997a
TIC as CO_3	10,000	E	
Cr	2,350	E	
F	128	E	
Fe	21,600	E	
Hg	0.589	M	
K	1,370	E	
La	47.5	E	
Mn	1,060	E	
Na	98,250	E	
Ni	1,080	E	
NO_2	38,600	E	
NO_3	63,000	E	
OH_{TOTAL}	74,500	C	Overall Charge Balance
Pb	389	E	
P as PO_4	4,940	E	
Si	9,240	E	
S as SO_4	2,880	E	
Sr	19.4	E	
TOC	4,730	E	
U_{TOTAL}	4,580	E	

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-AX-103 (Effective May 30, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E or C)[1]	Comment
Zr	372	E	

[1]S = Sample-based
M = Hanford Defined Waste model-based
E = Engineering assessment-based
C = Calculated by charge balance; includes oxides as hydroxides, not including CO_3, NO_2, NO_3, PO_4, SO_4, and SiO_3.

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-AX-103 (Effective May 30, 1997) (Decayed January 1, 1994). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	79.8	M	Agnew et al. 1997a
^{14}C	0.98	E	Based on the Tank Characterization Report for tank 241-A-102, core samples from tank 241-A-103, and the 1977 grab sample from 241-AX-104.
^{59}Ni	6.83	M	
^{60}Co	846	E	
^{63}Ni	685	M	
^{79}Se	7.04	M	
^{90}Sr	3.82 E+06	E	
^{90}Y	3.82 E+06	E	Referenced to ^{90}Sr.
^{93m}Nb	24.4	M	
^{93}Zr	32.7	M	
^{99}Tc	55.8	E	
^{106}Ru	0.028	M	
^{113m}Cd	147	M	
^{125}Sb	665	E	
^{126}Sn	10.9	M	
^{129}I	0.015	E	
^{134}Cs	1.60	M	
^{137}Cs	134,000	E	
^{137m}Ba	127,000	E	Referenced to ^{137}Cs.
^{151}Sm	26,000	M	
^{152}Eu	8.21	M	
^{154}Eu	4,400	E	
^{155}Eu	4,200	E	
^{226}Ra	4.36 E-04	M	
^{227}Ac	0.0024	M	

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-AX-103 (Effective May 30, 1997) (Decayed January 1, 1994). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{228}Ra	0.11	M	
^{229}Th	0.003	M	
^{231}Pa	0.006	M	
^{232}Th	0.012	M	
^{232}U	0.34	M	
^{233}U	1.31	M	
^{234}U	0.22	M	
^{235}U	0.009	M	
^{236}U	0.007	M	
^{237}Np	0.32	M	
^{238}Pu	5.45	M	
^{238}U	0.305	M	
$^{239/240}Pu$	1,320	E	
^{241}Am	271	E	
^{241}Pu	387	M	
^{242}Cm	0.24	M	
^{242}mAm	NR	M	
^{242}Pu	0.0022	M	
^{243}Am	0.007	M	
^{243}Cm	0.019	M	
^{244}Cm	0.48	M	

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

D5.0 APPENDIX D REFERENCES

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