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Preliminary Tank Characterization Report for Single-Shell Tank 241-BY-101: Best-Basis Inventory

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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-BY-101 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-BY-101: BEST-BASIS INVENTORY

July 1997

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PRELIMINARY TANK CHARACTERIZATION REPORT FOR SINGLE-SHELL TANK 241-BY-101: BEST-BASIS INVENTORY

This document is a preliminary Tank Characterization Report (TCR) and contains only the current best-basis inventory (Appendix D) for tank 241-BY-101. No TCRs have been previously issued for this tank. Consequently, the best-basis inventory is based on an engineering assessment of waste type, process flow sheet data, early sample data, and 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, B. C. Simpson, 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-BY-101

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-BY-101

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-BY-101 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

There is no previous Tank Characterization Report (TCR) for this tank. Available waste (chemical) information for tank 241-BY-101 included the following:

- The inventory estimate for this tank (Agnew et al. 1996) generated from the Hanford Defined Waste model (HDW), which is also referred to as the Los Alamos National Laboratory (LANL) model and also referred to as the Historical Tank Content Estimate (HTCE). The HDW term will be used in this Appendix.

- Tank Characterization Reports (TCRs) from other tanks with the same salt cake waste generated from in-tank solidification units 1 and 2 between 1965 and 1974 (BY SltCk) and ferrocyanide sludge produced by in-plant scavenging of waste from uranium recovery (PFeCN) waste types in the BY Tank Farm and the Best-Basis analysis for tank 241-BX-112 (Winkelman and Morris, 1997) for the sludge waste types from the first decontamination cycle of the bismuth phosphate process (1C) and cladding waste (CW) (1C/CW) .

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

The HDW model inventories, generated by the HDW model, are listed in Tables D2-1 and D2-2. Table D2-1 lists nonradioactive components on a kilogram (kg) basis, and Table D2-2 lists the radioactive components on a curie basis. The tank volume used to generate the engineering assessment is 1,464.8 kL (387 kgal) total waste with a sludge layer of 412.6 kL (109 kgal), 1,052.2 kL (278 kgal) of salt cake, and no supernatant (Hanlon 1996). Agnew et al. (1996) in the HDW model reports 1,464.8 kL (387 kgal) of total waste, 140 kL (37 kgal) of metal waste (MW) sludge, 1,324.8 kL (350 kgal) of salt cake, and no supernatant. The mean sludge density, that includes interstitial liquid, used to calculate the engineering estimate component inventories was 1.71 g/mL (Section D3-3), and the HDW model density for the total solid waste is estimated to be 1.63 g/mL. The chemical species are reported without charge designation per the best-basis inventory convention.

Table D2-1. Hanford Defined Waste-Based Inventory Estimates for Nonradioactive Components in Tank 241-BY-101.

Analyte[a]	HDW inventory estimate[b] (kg)	Analyte[a]	HDW inventory estimate[b] (kg)
Al	76,700	NO_3	527,000
Bi	249	OH	236,000
Ca	4,370	oxalate	0.322
Cl	5,970	Pb	1,560
Cr^{+3}	3,500	P as PO_4	13,900
F	1,500	Si	2,920
Fe	2,120	S as SO_4	25,400
Hg	9.63	Sr	0.417
K	1,950	TIC as CO_3	55,700
La	0.594	TOC	9,680
Mn	237	U_{TOTAL}	74,400
Na	394,000	Zr	35.9
NH_4	232	H_2O (wt%)	38.1
Ni	1,050	density (kg/L)	1.63
NO_2	106,000		

HDW = Hanford Defined Waste
[a] No sample-based data
[b] Agnew et al. (1996), decayed to January 1, 1994.

Table D2-2. Hanford Defined Waste Inventory Estimates for Radioactive Components in Tank 241-BY-101.

Analyte[a]	HDW inventory estimate[b] (Ci)	Analyte[a]	HDW inventory estimate[b] (Ci)
^{90}Sr	167,000	$^{239/240}Pu$	230
^{137}Cs	335,000		

HDW = Hanford Defined Waste
[a] No sample-based data
[b] Agnew et al. (1996), decayed to January 1, 1994.

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 HDW model component inventories.

Waste History Tank 241-BY-101

Tank 241-BY-101 filled with metal waste from the tank 241-BX-103 cascade overflow between March 1950 and the first quarter of 1951. The tank contained MW (waste type definitions are in D3.1) from 1950 until it was transferred to tank 241-BY-103 in the first quarter of 1954. The tank was then sluiced and was emptied in May 1954. The PFeCN was transferred into and out of the tank from the first quarter of 1955 until the end of 1960. The tank received PFeCN and 1C/CW from the first quarter of 1961 until 1964. At that time it had 140 kL (37 kgal) of stored solids. In tank solidification occurred from 1964 through 1967.

In the third quarter of 1967 the tank had 413 kL (109 kgal) of solids. The reported solids level varied around 1,136 kL (300 kgal) the next two years with no reported transfers. Hanlon (1996) uses the 413 kL (109 kgal) as the sludge value. From 1967 to 1976 evaporator bottoms (EB) was recycled through the tank. The tank was salt well pumped in the first and second quarters of 1977, and was declared inactive in the first quarter of 1978. Primary stabilization was completed in May 1980 and a level adjustment was made in April 1982.

The tank was salt well pumped, was declared interim stabilized, and had a level adjustment made in May 1984. Liquid observation well data, that represent interstitial levels, have been plotted. An engineering assumption was made before March 1986. This assumption was that after interim stabilization pumping, the interstitial liquid equalizes in the tank and is relatively consistent through the waste matrix. In 1985, 216 kL (57 kgal) of liquid was transferred through salt well pumping to tank 241-AW-105. In 1992, 15 kL (4 kgal) of liquid was transferred through salt well pumping to tank 241-AW-106. This left the present volume of 1,465 kL (387 kgal).

D3.1 EXPECTED TYPE OF WASTE BASED ON THIS EVALUATION

Agnew et al. (1996): MW, BY SltCk
Hill et al. (1995): TBP-F, EB-ITS, CW, 1C

1C	=	$BiPO_4$ First decontamination cycle waste
CW	=	$BiPO_4$ First decontamination cladding waste (1C and CW were handled as waste together) so 1C = 1C/CW
PFeCN	=	Ferrocyanide sludge produced by in-plant scavenging of waste from uranium recovery (UR)
BY SltCk	=	a mixture of supernatants from other waste types that have been blended to create a new waste type through concentration as a salt cake
TBP-F	=	Tributyl phosphate-ferrocyanide scavenged UR (TBP) supernatants (equivalent to PFeCN)
EB-ITS	=	Evaporator bottoms (EB) - In tank solidification (ITS) (equivalent in this tank to BY SltCk)
MW	=	Metal waste

Agnew et al. (1996) provides estimated volumes for these waste types as does Hanlon (1996) and these are addressed in Section D2.0. Agnew et al. projects 140 kL (37 kgal) bottom layer of MW. The Hanlon estimates includes a sludge layer of 413 kL (109 kgal). Neither Anderson (1990) nor the left hand columns of Agnew et al. (1995) show MW in solids in this tank in the 1950's. This tank farm was sluiced for MW in the mid 1950's and no mention of this tank was made in Rodenhizer (1987). Rodenhizer shows the sluicing of MW from several BY Tank Farm tanks and from other farms. The MW was valuable and 140 kL (37 kgal) would not have been passed by. Grigsby et al. (1992) discusses this tank and could be used for further information, as Gamma and Neutron scans suggest a solids type change at about 379 to 454 kL (100 to 120 kgal). Anderson shows that 413 kL (109 kgal) of combined PFeCN and 1C/CW sludge waste solids were in this tank in 1967, before BY SltCk was added. Since Hanlon reports this amount of sludge, the engineering assessment is using this as the combined sludge volume. There is no way to accurately break down the sludge layer into the two types; therefore, based on an evaluation of Anderson (1990) and Agnew et al. (1996), PFeCN has been assigned to 189 kL (50 kgal) and 1C/CW has been assigned to 223 kL (59 kgal) of the sludge waste. The other 1,052 kL (278 kgal) of waste was assigned to BY SltCk salt cake.

D3.2 INVENTORY EVALUATION

The following evaluation provides an engineering assessment of tank 241-BY-101 contents. For this evaluation, the following assumptions and observations are made:

- Tank waste mass is calculated using the measured density and the tank volume listed in Hanlon (1996). The different sludge and salt cake volumes reported by Agnew et al. (1996) and the different density used would make a significant difference in the final inventories. As a result, inventory comparisons are not all made on the same volume or mass basis for sludge or salt cake. However, the total volumes are the same.

- Only the BY SltCk waste stream and the PFeCN and 1C/CW sludge waste streams contributed to solids formation.

- The salt cake and sludge compositions can be estimated by using inventories from similar wastes for calculating the predicted engineering data set.

- No radiolysis of NO_3 to NO_2 and no additions of NO_2 to the waste for corrosion purposes are factored into this evaluation.

D3.3 BASIS FOR CALCULATIONS USED IN THIS ENGINEERING EVALUATION

Table D3-1 shows the engineering evaluation approaches used on tank 241-BY-101.

Table D3-1. Engineering Evaluation Approaches Used On Tank 241-BY-101. (2 Sheets)

Type of waste	How calculated	Check method
Supernatant	No supernatant predicted	NA
Salt cake BY SltCk Volume = 1,052 kL (278 kgal) Density = 1.71 g/mL	Used sample-based average concentrations for other 241-BY Tank Farm tanks, multiplied by salt cake total mass in tank 241-BY-101. The density used was the average density of the tanks for which the concentrations were derived (1.71 g/mL) (see Table D3-3).	Sample concentrations from other tanks with BY SltCk were used to predict the salt cake inventories. Waste records indicate that the salt cake in this tank should be similar to those used to predict the inventories. There are no sampling-based inventories for this tank to use for further comparisons.

Table D3-1. Engineering Evaluation Approaches Used On Tank 241-BY-101. (2 Sheets)

Type of waste	How calculated	Check method
Sludge PFeCN Volume = 189 kL (50 kgal) Density = 1.71 g/mL	Used the average total analyte concentrations and inventories from other 241-BY Tank Farm tanks with PFeCN waste to calculate the PFeCN sludge portion of the waste.	There are no sample-based inventories for this tank to use for further comparison.
1C/CW Volume = 223 kL (59 kgal) Density = Not used in calculations, compared total inventory ratios	Used the total 1C/CW sludge waste volume of tank 241-BY-101, 223 kL (59 kgal) divided by the total 1C/CW sludge volume of tank 241-BX-112, 625 kL (165 kgal), which is 0.358, multiplied by the total inventory values for tank 241-BX-112 to obtain the total sludge inventories for tank 241-BY-101.	

TCR = Tank Characterization Reports

BY SltCk = A mixture of supernatants from other waste types that have been blended to create a new waste type through concentration as a salt cake

PFeCN = Ferrocyanide sludge produced by in-plant scavenging of waste from uranium recovery

1C/CW = $BiPO_4$ First decontamination cycle waste/$BiPO_4$ First decontamination cladding waste.

D3.3.1 Basis for Salt Cake Calculations Used in this Engineering Evaluation

For this evaluation the sample-based comparisons developed for BY SltCk were used. This is based on comparing data sets from BY Tank Farm TCRs for six tanks and are shown in Table D3-2. Each of these tanks have been recently sampled and TCRs are available. The "SC" columns defines the BY SltCk average concentration in the respective tank. The "Total" column defines both the combined sludge and salt cake concentrations which could not be separated out because of mixed layers. The "SL" columns define the PFeCN sludge average concentration for the respective tank. This table is not used for the calculations but presents an overall presentation of the data. In Table D3-3, Tanks 241-BY-105, 241-BY-106, and 241-BY-110 were used to produce the average salt cake analyte concentrations for this comparison. Tank 241-BY-102 was not used in this comparison because it operated with an in-tank heater which resulted in higher analytical concentrations for some analytes. Tanks 241-BY-104 and 241-BY-108 were not included because the salt cake portion of the waste was not differentiated from the total waste. The average concentrations were multiplied by the average density (1.71 g/mL), the tank salt cake waste volume, and the conversion factors. These inventories were added to the sludge inventories to produce the total analyte inventories for tank 241-BY-101.

Table D3-2. BY Tank Average Concentrations[g]. (3 Sheets)
(Not used for calculations, see Tables D3-3 and D3-4 for the calculations)

Element	BY-102[a] (SC) (µg/g)	BY-104[b] (total) (µg/g)	BY-105[c] (SC) (µg/g)	BY-106[d] (SC) (µg/g)	BY-110[e] (SC) (µg/g)	BY-108[f] (total) (µg/g)	BY-106 (SL)[g] (µg/g)	BY-110 (SL) (µg/g)
Al	14,600	30,100	18,400	20,400	14,100	39,800	30,800	28,300
As	<2,030	<62.4	NR	NR	NR	<116	NR	NR
Sb	<1,220	<37.5	NR	NR	NR	<186	NR	NR
Ba	<1,010	<69.1	NR	NR	NR	124	NR	NR
Be	<101	<3.16	NR	NR	NR	<6.73	NR	NR
Bi	<2,030	<285	55.6	NR	NR	<495	NR	NR
B	<101	<45	NR	113	92.3	250	NR	39.8
Br	<854	NR	NR	NR	NR	NR	NR	NR
Cd	<101	16.1	6.54	8.25	21.1	<16.3	NR	7.4
Ca	<2,110	1,240	216	308	400	3,370	8,150	14,200
Ce	<2,030	<62.4	NR	NR	NR	<123	NR	NR
Cl	1,220	2,320	897	2,060	2,250	1,540	NR	3,570
Cr	1,870	4,580	321	855	2,900	255	1,120	2,220
Co	<406	<15.2	8.75	NR	NR	34.2	NR	NR
Cu	<210	<8.25	7.57	NR	NR	<45.9	NR	NR
F	18,000	4,630	4,100	5,130	5,420	6,610	NR	4,220
Fe	1,860	4,090	476	215	924	7,190	33,000	20,000
La	<1,010	<36.8	NR	NR	NR	<67.4	NR	NR
Pb	<2,030	190	50.3	64.5	130	439	NR	1,880
Li	<203	NR	NR	NR	NR	NR	NR	NR
Mg	<2,030	<165	NR	NR	NR	447	NR	NR
Mn	372	77.1	54.8	9.57	52.8	209	NR	228
Mo	<1,010	36.5	NR	NR	NR	<54.1	NR	NR
Nd	<2,030[a]	<71.2	NR	NR	NR	<119	NR	NR
Ni	4,820	1,160	75.9	47.9	193	2,510	6,960	6,670
NO_3	95,000	261,000	491,000	329,000	184,000	201,000	NR	111,000
NO_2	13,900	34,900	9,410	32,100	30,600	27,300	NR	43,200
Oxalate	19,300	13,100	11,300	8,990	13,600	7,500	NR	5,870

Table D3-2. BY Tank Average Concentrations[g]. (3 Sheets)
(Not used for calculations, see Tables D3-3 and D3-4 for the calculations)

Element	BY-102[a] (SC) (μg/g)	BY-104[b] (total) (μg/g)	BY-105[c] (SC) (μg/g)	BY-106[d] (SC) (μg/g)	BY-110[e] (SC) (μg/g)	BY-108[f] (total) (μg/g)	BY-106 (SL)[g] (μg/g)	BY-110 (SL) (μg/g)
PO_4	27,000	11,200	4,890	5,270	14,200	26,000	NR	32,100
P	9,500	3,560	1,010	1,032	4,650	10,100	20,500	10,500
K	NR	3,390	712	2,470	1,930	2,650	NR	2,930
Sm	<2,030	<62.4	NR	NR	NR	<131	NR	NR
Se	<2,030	<62.8	NR	NR	NR	<135	NR	NR
Si	4,350	434	180	184	451	1,530	NR	1,190
Ag	<203	16.9	17.4	14.5	17.5	<49.9	NR	10.2
Na	267,000	220,000	198,000	203,000	237,000	163,000	130,000	161,000
Sr	<203	2,330	88.3	44.4	58.1	3,190	NR	6,840
SO_4	57,700	17,300	10,600	11,300	18,400	22,900	NR	18,400
S	17,300	4,420	3,140	3,280	5,950	6,960	NR	5,360
Tl	<4,060	<125	NR	NR	NR	<479	NR	NR
Ti	<203	<12.1	NR	NR	NR	74.9	NR	NR
TIC	27,800	14,800	NR	7,359	31,800	5,340	5,580	6,440
TOC	4,360	6,810	3,250	2,500	5,920	4,480	20,400	11,100
U	<10,100	3,270	261	164.2	697	9,470	NR	20,900
V	<1,010	<31.2	NR	NR	NR	<47.3	NR	NR
Zn	396	41	36.8	18.4	32.8	83.5	194	91.6
Zr	<203	13.2	5.23	6.28	14.4	<34.7	589	19.7
Density g/mL	1.5	1.75	NR	1.71	NR	NR	NR	NR
wt% H_2O	29.9	25.6	16.1	25.5	23.2	27.2	37.3	30.5

Table D3-2. BY Tank Average Concentrations[g]. (3 Sheets)
(Not used for calculations, see Tables D3-3 and D3-4 for the calculations)

Element	BY-102[a] (SC) (μg/g)	BY-104[b] (total) (μg/g)	BY-105[c] (SC) (μg/g)	BY-106[d] (SC) (μg/g)	BY-110[e] (SC) (μg/g)	BY-108[f] (total) (μg/g)	BY-106 (SL)[g] (μg/g)	BY-110 (SL) (μg/g)
Radionuclides[h] (μCi/g)								
^{137}Cs	NR	97	NR	106	60	258	508	140
^{60}Co	NR	<0.0149	NR	NR	NR	<0.00911	NR	NR
^{90}Sr	NR	391	NR	<4.26	22.5	143	763	348
$^{239/240}$Pu	NR	NR	NR	NR	0.0192	0.0459	0.0997	0.061
Total Alpha	0.089	0.179	0.0168	<0.00945	0.0434	0.0619	0.253	NR
Total Beta	NR	837	NR	<80.2	NR	549	NR	NR

NR = Not reported
SC = Salt cake
SL = Sludge
Total = Total inventory of all solids (salt cake and sludge) and interstitial liquids for the tank
[a] Sasaki et al., 1997
[b] Benar et al., 1996
[c] Simpson et al., 1996a
[d] Bell et al., 1996
[e] Simpson et al., 1996b
[f] Baldwin et al., 1996
[g] Tank 241-BY-106 sludge readings were called suspect in the TCR and should be used with caution. Only one sludge sample was retrieved from the three cores.
[h] Radionuclides are reported as of the date of sample analysis.

Table D3-3 shows the engineering assessment of BY SltCk, including the total tank salt cake inventories. Calculations for Table D3-3 are: (average concentration of analyte in μg/g) x (waste in kgal) x 3,785 L/kgal x 1,000 mL/L x (density in g/mL) x kg/(1 E+09) μg = total kg for this waste type in the tank.

Table D3-3. Tank 241-BY-101 Salt Cake Calculations. (2 Sheets)

Element	241-BY-105[a] (SC) (μg/g)	241-BY-106[b] (SC) (μg/g)	241-BY-110[c] (SC) (μg/g)	Average Concentration (μg/g)	HDW Average Concentration (μg/g)	241-BY-101 SC (SC volume of 278 kgal) (kg)
Al	18,400	20,400	14,100	17,633	35,783	31,502
Bi	55.6	NR	NR	55.6	116.2	99
B	NR	113	92.3	103	NR	183
Cd	6.54	8.25	21.1	12	NR	21.4
Ca	216	308	400	308	1,817.9	550
Cl	897	2,060	2,250	1,736	2,784.3	3,101
Cr	321	855	2,900	1,359	1,628.7	2,427
Co	8.75	NR	NR	8.75	NR	15.6
Cu	7.57	NR	NR	7.57	NR	13.5
F	4,100	5,130	5,420	4,883	699.5	8,724
Fe	476	215	924	538	554.4	962
Pb	50.3	64.5	130	82	726.1	146
Mn	54.8	9.57	52.8	39.1	110.4	70
Ni	75.9	47.9	193	106	489.7	189
NO_3	491,000	329,000	184,000	334,667	245,767	597,875
NO_2	9,410	32,100	30,600	24,037	49,532	42,941
Oxalate	11,300	8,990	13,600	11,297	0.15	20,181
PO_4	4,890	5,270	14,200	8,120	4,023.3	14,506
P	1,010	1,032	4,650	2,231	NR	3,985
K	712	2,470	1,930	1,704	910.8	3,044
Si	180	184	451	272	1,359.2	485
Ag	17.4	14.5	17.5	16.5	NR	29.4
Na	198,000	203,000	237,000	212,667	176,264	379,924

Table D3-3. Tank 241-BY-101 Salt Cake Calculations. (2 Sheets)

Element	241-BY-105[a] (SC) (μg/g)	241-BY-106[b] (SC) (μg/g)	241-BY-110[c] (SC) (μg/g)	Average Concentration (μg/g)	HDW Average Concentration (μg/g)	241-BY-101 SC (SC volume of 278 kgal) (kg)
Sr	88.3	44.4	58.1	64	0.19	114
SO_4	10,600	11,300	18,400	13,433	11,357	23,998
S	3,140	3,280	5,950	4,123	NR	7,366
TIC	NR	7,359	31,800	19,580	3,720.6	34,978
TOC	3,250	2,500	5,920	3,890	NR	6,949
U	261	164.2	697	374	3793	668
Zr	5.23	6.28	14.4	8.64	16.7	15.4
Density (g/mL)	NR	1.71	NR	1.71	1.62	1.71
wt% H_2O	16.1	25.5	23.2	21.6	37.4	21.6
Radio-nuclides[d]	μCi/g	μCi/g	μCi/g	μCi/g	μCi/g	kCi
^{90}Sr	NR	<4.26	22.5[e]	22.5	80.3	24.1
^{137}Cs	NR	106	60	83	133.2	148.3
$^{239/240}Pu$	NR	NR	0.0192	0.0192	0.107	0.0343

HDW = Hanford Defined Waste (displayed for comparison only)
NR = Not reported
SC = Salt cake
[a] Simpson et al. (1996a)
[b] Bell et al. (1996)
[c] Simpson et al. (1996b)
[d] Radionuclides reported as of the sample analysis date
[e] Less than values are not included in average.

D3.3.2 Basis for Sludge Calculations used In This Engineering Evaluation

The average total analyte concentrations and inventories from other BY Tank Farm tanks with PFeCN waste (shown in Table D3-2) were used to calculate the PFeCN sludge portion of the waste as demonstrated in Table D3-4.

The 1C/CW engineering assessment was developed on tanks 241-T-104, and 241-T-107. The same waste type is found in tank 241-BX-112, with one difference being that both tanks 241-BX-112 and 241-BY-101 waste came from B Plant while the T Tank Farm waste came from T Plant. The engineering assessments show that the approximate same waste concentrations appear in each tank. The inventories for Tank 241-BX-112 were used to predict the 1C/CW inventories of tank 241-BY-101. The total 1C/CW sludge waste volume of tank 241-BY-101 (223 kL [59 kgal]) was divided by the total 1C/CW sludge volume of tank 241-BX-112 (625 kL [165 kgal]), which is 0.358, this was multiplied by the total inventory values for tank 241-BX-112 to obtain the total 1C/CW sludge inventories for tank 241-BY-101 (see Table D3-4 for the results). The two sludge inventories were added together to produce a tank sludge inventory. These predicted inventories were added to the predicted inventory for the salt cake to produce a total tank inventory and is shown in Table D3-5.

Table D3-4. Tank 241-BY-101 Sludge Engineering Assessment Calculations for PFeCN and 1C/CW. (2 Sheets)

Element	241-BY-106[a] (SL) (μg/g)	241-BY-110[b] (SL) (μg/g)	Average conc. PFeCN (μg/g)	241-BY-101 SL (SL volume of PFeCN 50 kgal) (kg)	241-BX-112[c] SL volume 1C/CW (kg)	241-BY-101 1C/CW 59/165 = 0.358 (kg)	241-BY-101 Total sludge PFeCN and 1C/CW (kg)
Al	30,800	28,300	29,550	9,495	11,000	3,930	13,420
B	NR	39.8	39.8	13	NR	NR	13
Bi	NR	NR	NR	NR	14,000	5,010	5,010
Cd	NR	7.4	7.4	2	NR	NR	2
Ca	8,150	14,200	11,175	3,591	2,000	715	4,310
Cl	NR	3,570	3,570	1,147	850	304	1,450
Cr	1,120	2,220	1,670	537	1,000	358	895
F	NR	4,220	4,220	1,356	8,700	3,110	4,470
Fe	33,000	20,000	26,500	8,515	7,700	2,750	11,260
Pb	NR	1,880	1,880	604	1.0	0.4	604
Mn	NR	228	228	73	280	100	173
Ni	6,960	6,670	6,815	2,190	97	35	2,220
NO_3	NR	111,000	111,000	35,665	61,000	21,810	57,480
NO_2	NR	43,200	43,200	13,881	21,000	7,520	21,400
Oxalate	NR	5,870	5,870	1,886	NR	NR	1,890

Table D3-4. Tank 241-BY-101 Sludge Engineering Assessment Calculations for PFeCN and 1C/CW. (2 Sheets)

Element	241-BY-106[a] (SL) (μg/g)	241-BY-110[b] (SL) (μg/g)	Average conc. PFeCN (μg/g)	241-BY-101 SL (SL volume of PFeCN 50 kgal) (kg)	241-BX-112[c] SL volume 1C/CW (kg)	241-BY-101 1C/CW 59/165 = 0.358 (kg)	241-BY-101 Total sludge PFeCN and 1C/CW (kg)
PO_4	NR	32,100	32,100	10,314	49,000	17,520	27,830
P	20,500	10,500	15,500	4,980	NR	NR	4,980
K	NR	2,930	2,930	941	380	136	1,080
Si	NR	1,190	1,190	382	6,800	2,430	2,810
Ag	NR	10.2	10.2	3	NR	NR	3
Na	130,000	161,000	145,500	46,750	67,000	23,960	70,710
Sr	NR	6,840	6,840	2,198	110	39	2,240
SO_4	NR	18,400	18,400	5,912	5,300	1,900	7,810
S	NR	5,360	5,360	1,722	NR	NR	1,722
TIC	5,580	6,430	6,005	1,929	1,760	630	2,560
TOC	20,400	11,100	15,750	5,061	780	279	5,340
U	NR	20,900	20,900	6,715	850	304	7,020
Zr	589	19.7	304.35	98	160	57	155
Density (g/mL)	NR	NR	NR	1.71	NR	NR	NR
wt% H_2O	37.3	30.5	33.9	11	NR	NR	11
Radio-nuclides	μCi/g	μCi/g	μCi/g	kCi	kCi	kCi	kCi
^{90}Sr	763	348	555.5	178	4.2	1.5	180
^{137}Cs	508	140	324	104	40	14	118
$^{239/240}Pu$	0.0997	0.061	0.08035	0.026	0.013	.005	0.031

NR = Not reported
[a]Bell at al. (1996)
[b]Simpson et al. (1996b)
[c]Winkelman and Morris (1996)
[d]Radionuclides are reported as of the sample analysis date.

Table D3-5 shows the individual waste type and total tank inventories for tank 241-BY-101.

Table D3-5. Tank 241-BY-101 Engineering Assessment Total Inventory Calculations. (2 Sheets)

Element	241-BY-101 SC (SC volume of 278 kgal) (kg)	241-BY-101 SL (SL volume of 50 kgal PFeCN) (kg)	241-BY-101 SL (SL volume of 59 kgal 1C/CW) (kg)	Total Inventory for tank 241-BY-101 (kg)
Al	31,502	9,495	3,930	44,930
Bi	99	0	5,010	5,110
B	183	13	NR	196
Cd	21.4	2.0	NR	23.4
Ca	550	3,591	715	4,860
Cl	3,101	1,147	304	4,550
Cr	2,427	537	358	3,320
Co	15.6	0	NR	15.6
Cu	13.5	0	NR	13.5
F	8,724	1,356	3,110	13,190
Fe	962	8,515	2,750	12,230
Pb	146	604	0.4	750
Mn	70	73	100	243
Ni	189	2,190	35	2,410
NO_3	597,875	35,665	21,810	655,400
NO_2	42,941	13,881	7,520	64,340
Oxalate	20,181	1,886	NR	22,070
PO_4	14,506	10,314	17,520	42,340
P	3,985	4,980	NR	8,965
K	3,044	941	136	4,120
Si	485	382	2,430	3,300
Ag	29.4	3.0	NR	32
Na	379,924	46,750	23,960	450,630
Sr	114	2,198	39	2,350

Table D3-5. Tank 241-BY-101 Engineering Assessment Total Inventory Calculations. (2 Sheets)

Element	241-BY-101 SC (SC volume of 278 kgal) (kg)	241-BY-101 SL (SL volume of 50 kgal PFeCN) (kg)	241-BY-101 SL (SL volume of 59 kgal 1C/CW) (kg)	Total Inventory for tank 241-BY-101 (kg)
SO_4	23,998	5,912	1,900	31,810
S	7,366	1,722	NR	9,090
TIC	34,978	1,929	630	37,540
TOC	6,949	5,061	279	12,290
U	668	6,715	304	7,690
Zr	15.4	98	57	170
Radionuclides[a] (kCi)				
^{90}Sr	40.2	178	1.5	220
^{137}Cs	148.3	104	14	266
$^{239/240}Pu$	0.0343	0.026	.005	0.065

SC = Salt cake
SL = Sludge
Solids = All solids; no distinction made from SC or SL
[a]Radionuclides are reported as of the sample analysis date.

The engineering assessment-based inventory values and the HDW model values are compared in Table D3-6. No values are shown in the sample-based column because no sample-based values were determined for this tank.

Table D3-6. Comparison of Selected Component Inventory Estimates for Tank 241-BY-101 Waste. (2 Sheets)

Component	Engineering assessment[a] (kg)	HDW estimated[b] (kg)
Al	44,930	76,700
Bi	5,110	249
Ca	4,860	4,370
Cl	4,550	5,970
Cr	3,320	3,500

Table D3-6. Comparison of Selected Component Inventory Estimates for Tank 241-BY-101 Waste. (2 Sheets)

Component	Engineering assessment[a] (kg)	HDW estimated[b] (kg)
F	13,190	1,500
Fe	12,230	2,120
K	4,120	1,950
Ni	2,410	1,050
NO_2	64,340	106,000
NO_3	655,400	527,000
Mn	243	237
Na	450,630	394,000
Oxalate	22,070	0.322
Pb	750	1,560
PO_4	42,340	13,900
Si	3,300	2,920
SO_4	31,810	25,400
Sr	2,350	0.417
TIC as CO_3	187,700	55,700
TOC	12,290	9,680
U	7,690	74,400
Zr	170	35.9
Radionuclide[c] (Ci)		
^{90}Sr	220,000	167,000
^{137}Cs	266,000	335,000
$^{239/240}Pu$	65	230

HDW = Hanford Defined Waste
[a]From Table D3-5
[b]Agnew et al. (1996), radionuclides decayed to January 1, 1994
[c]Engineering assessment radionuclides are reported as of the sample analysis date.

Several problems exist in trying to compare individual analyte inventories between the engineering assessment and the HDW model. At this time, there is no way to accurately predict the salt cake analytical values through an engineering assessment, other than by using analytical data from other tanks containing BY SltCk. The majority of this tank's inventory is from BY SltCk with contributions from PFeCN sludge and 1C/CW sludge. Best-basis evaluations dealing with different sludge waste types, have shown that the solubilities of some analytes determined from flowsheet and sample data do not agree with the HDW model treatment of solubilities. The best-basis inventory analyses of tanks with 1C waste and waste from second decontamination cycle of the bismuth phosphate process (2C) types discuss these disagreements in detail. Solubility assumptions affect salt cake predications because flowsheet analytes not found in the sludge are placed by the HDW model in the salt cakes. Specific problems cannot be fully isolated at this time. The analytes with the most striking difference are bismuth, nitrite, phosphate, fluoride, aluminum, uranium, strontium, iron, TIC, and oxalate. The HDW model also used a different sludge waste type and volumes of waste types for tank 241-BY-101 than is found in Hanlon (1996) and this evaluation. If the HDW model input is changed to reflect the same waste types, volumes, and densities, a better comparison can be made.

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

Key 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 that is suitable for long-term storage/disposal. Information about chemical, radiological and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessment associated with these activities.

Chemical and radiological inventory information are generally derived using three approaches: (1) component inventories are estimated using the results of sample analyses, (2) component inventories are predicted using the HDW model, 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.

As part of this effort, an evaluation of available chemical information for tank 241-BY-101 was performed, including the following:

- An inventory estimate generated by the HDW model (Agnew et al. 1996)
- An engineering evaluation which produced a predicted BY SltCk and PFeCN sludge inventory based on comparisons developed by evaluation of similar BY Tank Farm tanks and an engineering evaluation of 1C/CW sludge based on sample-based data from tank 241-BX-112.

Based on this evaluation, a best-basis inventory was developed for tank 241-BY-101 for which sampling information was not available. The engineering evaluation inventory was chosen as the best basis for those analytes for which sample-based analytical values were available from similar BY Tank Farm tanks, and tank 241-BX-112, for the following reasons:

- The sample-based inventory analytical concentrations of the other BY Tank Farm tanks compared favorably with each other for BY SltCk.
- No methodology is available to fully predict BY SltCk from process flowsheet or historical records.
- Waste transfer records demonstrate that 1C/CW sludge is similar to that found in tank 241-BX-112 (or other tanks containing 1C/CW waste).
- The engineering assessment supports the assumption that the sample-based data appear reasonable and could be substituted for the absent sample-based data for this tank.

- For those few analytes where no values were available from the sample-based inventory of similar tanks, the HDW model values were used.

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, significant figures are retained. No such adjustments were necessary in this tank. This charge balance approach is consistent with that used by (Agnew et al. 1997).

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. 1997). 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.

Best-basis tables for chemicals and only four radionuclides (^{90}Sr, ^{137}Cs, Pu and U) were being generated in 1996, using values derived from an earlier version (Rev. 3) of the HDW model. When values for all 46 radionuclides became available in Rev. 4 of the HDW model, they were merged with draft best-basis chemical inventory documents. Defined scope of work in FY 1997 did not permit HDW Rev. 3 chemical values to be updated to HDW Rev. 4 chemical values.

The best-basis inventory for tank 241-BY-101 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-BY-101 (Effective January 31, 1997).

Analyte	Total inventory (kg)	Basis (S, M, C, or E)[1]	Comment
Al	44,900	E	
Bi	5,110	E	
Ca	4,860	E	
Cl	4,550	E	
TIC as CO_3	187,700	E	
Cr	3,320	E	
F	13,190	E	
Fe	12,230	E	
Hg	9.63	M	
K	4,120	E	
La	0.594	M	
Mn	243	E	
Na	450,000	E	
Ni	2,410	E	
NO_2	64,340	E	
NO_3	655,000	E	
OH_{TOTAL}	78,000	C	
Pb	750	E	
P as PO_4	42,300	E	
Si	3,300	E	
S as SO_4	31,800	E	
Sr	2,350	E	
TOC	12,300	E	
U_{TOTAL}	7,690	E	
Zr	170	E	

[1]S = Sample-based
M = Hanford Defined Waste model-based, Agnew et al. (1996)
E = Engineering assessment-based
C = Calculated by charge balance; includes oxides as hydroxides, not including CO_3, NO_3, NO_2, PO_4, SO_4 and SiO_3.

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-BY-101 Decayed to January 1, 1994 (Effective January 31, 1997). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	173	M	
^{14}C	45.4	M	
^{59}Ni	4.82	M	
^{60}Co	42.2	M	
^{63}Ni	478	M	
^{79}Se	3.79	M	
^{90}Sr	228,000	E	
^{90}Y	228,000	E	Referenced to ^{90}Sr.
^{93}Zr	18.3	M	
^{93m}Nb	13.2	M	
^{99}Tc	251	M	
^{106}Ru	0.00841	M	
^{113m}Cd	96.7	M	
^{125}Sb	189	M	
^{126}Sn	5.66	M	
^{129}I	0.486	M	
^{134}Cs	2.05	M	
^{137}Cs	260,000	E	
^{137m}Ba	246,000	E	Referenced to ^{137}Cs.
^{151}Sm	13,100	M	
^{152}Eu	5.93	M	
^{154}Eu	711	M	
^{155}Eu	360	M	
^{226}Ra	2.01E-04	M	
^{227}Ac	0.00262	M	
^{228}Ra	2.25	M	
^{229}Th	0.0520	M	
^{231}Pa	0.0133	M	

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-BY-101 Decayed to January 1, 1994 (Effective January 31, 1997). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{232}Th	0.0832	M	
^{232}U	12.6	M	
^{233}U	48.1	M	
^{234}U	22.7	M	
^{235}U	0.992	M	
^{236}U	0.236	M	
^{237}Np	0.843	M	
^{238}Pu	3.36	M	
^{238}U	26.6	M	
$^{239/240}Pu$	65	E	
^{241}Am	59.0	M	
^{241}Pu	242	M	
^{242}Cm	7.94 E-04	M	
^{242}Pu	0.00116	M	
^{243}Am	0.00204	M	
^{243}Cm	1.60 E-05	M	
^{244}Cm	2.71 E-04	M	

[1]S = Sample-based
M = Hanford Defined Waste model-based, Agnew et al. (1997)
E = Engineering assessment-based.

D5.0 APPENDIX D REFERENCES

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