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ENGINEERING CHANGE NOTICE

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13a. Description of Change 13b. Design Baseline Document? [] Yes [X] No

Add Appendix D, Evaluation to Establish Best-Basis Inventory for Single-Shell Tank 241-B-102.

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14a. Justification (mark one)

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14b. Justification Details

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-B-102 was performed, and a best-basis inventory was established. This work follows the methodology that was established by the standard inventory task.

15. Distribution (include name, MSIN, and no. of copies)

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Tank Characterization Report for Single-Shell Tank 241-B-102

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Lockheed Martin Hanford Corporation, Richland, WA 99352
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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-B-102

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-B-102

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-B-102 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

Results from the most recent sampling event for this tank are provided in Section 4.0. One auger sample was obtained in 1994 for safety screening. Analytical determinations from the 1994 sampling event were limited to total alpha, percent water, and differential scanning calorimetry for safety screening.

Component concentrations based on analytical data are available from core samples from tanks 241-B-104, 241-B-106, 241-B-108, and 241-B-109, which historically contain the same salt cake waste type as tank 241-B-102. The Hanford Defined Waste (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

Inventories derived from the tank 241-B-102 analytical concentration data and HDW model inventories (Agnew et al. 1997a) are compared in Tables D2-1 and D2-2. (The chemical species are reported without charge designation per the best-basis inventory convention.) Insufficient analyses were performed on the 1994 auger sample to allow a sample-based estimate of tank inventory. The tank volume used to generate these inventories is 121 kL (32 kgal). This volume is reported in Hanlon (1997) and is the same as that reported by Agnew et al. (1997a, 1997b).

Table D2-1. Sample-Based and Hanford Defined Waste-Based Inventory Estimates for Nonradioactive Components in Tank 241-B-102.

Analyte[a]	HDW model inventory estimate[b] (kg)	Analyte[a]	HDW model inventory estimate[b] (kg)
Al	712	NO_2	1,210
Bi	343	NO_3	49,700
Ca	348	PO_4	9,010
Cl	289	Pb	256
Cr	33.3	Si	40
F	183	SO_4	1;310
Fe	768	Sr	0
Hg	4.9	TIC as CO_3	2,440
K	58	TOC	14
La	0.001	U_{TOTAL}	6,310
Mn	0.34	Zr	1.28
Na	28,400	H_2O (wt%)	45.4
Ni	46		

HDW = Hanford Defined Waste
NR = Not reported
[a] No sample-based inventory estimate is available for these analytes
[b] Agnew et al. (1997a).

Table D2-2. Sample-Based and Hanford Defined Waste-Based Inventory Estimates for Radioactive Components in Tank 241-B-102 (Values Decayed to January 1, 1994).

Analyte[a]	HDW model inventory estimate[b] (Ci)
^{137}Cs	4,700
^{90}Sr	1,300
^{238}Pu	0.26
^{239}Pu	14.3
^{240}Pu	2.1
^{241}Am	0.15

HDW = Hanford Defined Waste
NR = Not reported
[a] No sample-based inventory estimate is available for these analytes
[b] Appendix E of Agnew et al. (1997a), 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 sample-based and HDW model component inventories.

D3.1 CONTRIBUTING WASTE TYPES

The following abbreviations were used to designate waste types:

MW	=	Metal waste from $BiPO_4$ process, operational 1944 to 1956
BSltCk	=	Salt cake from 242-B Evaporator operation, 1951 to 1953
EB	=	Evaporator bottoms. Slurry product from the evaporators. Comparable to BSltCk
CWP	=	PUREX aluminum cladding waste
BL	=	B Plant low-level waste.

D3.1.1 Waste Transaction History

Tank 241-B-102 was initially filled with metal waste (MW) from the B Plant bismuth phosphate process in 1945. The tank was nearly emptied in 1953 when the waste was sluiced for uranium recovery (UR). In 1953, tank 241-B-102 received evaporator bottoms (EB) from the 242-B Evaporator. In 1957, the supernatant was removed for ferrocyanide scavenging at the 244-CR vault. The remaining solids were recorded as 318 kL (84 kgal).

During 1963 through 1975, Plutonium-Uranium Extraction (PUREX) process supernatant cladding waste, B Plant supernatant high-level wastes, B Plant low-level and ion exchange wastes, and other SST supernatants were routed through tank 241-B-102 with observed reductions in the measured solids level to a final 106 kL (28 kgal). Also reported is 15 kL (4 kgal) of supernatant (Hanlon 1997). The effect of passing supernatants through tank 241-B-102 was to dissolve the soluble components of salt cake leaving behind a fraction enriched in aluminum, iron, etc., and the simultaneous deposition of insoluble sludges contained in the B Plant high-level and low-level wastes.

Based on this process history, the solids expected in tank 241-B-102 include salt cake solids (EB or BSltCk) from the 242-B Evaporator (that have been partially redissolved and overlaid with sludges from PUREX cladding waste) and B Plant high-level and low-level wastes on top of the salt cake. Additional detail relevant to the waste transfer history is provided in Section 2.0 of this report.

D3.1.2 Predicted Current Waste Types and Volumes

Information concerning the waste types presently contained in tank 241-B-102 is inconsistent. The HDW model (Agnew et al. 1997b) predicts the following waste types.

Waste Type	Waste Volume - kL (kgal)
MW	11 (3)
BSltCk	91 (24)
CWP2	4 (1)
Supernatants	15 (4)
Total	121 (32)

The Sort on Radioactive Waste Type (SORWT) model (Hill et al. 1995) lists EB, CW, and BL as the primary, secondary, and tertiary waste types, respectively. Hill et al. (1995), Hanlon (1997), and Agnew et al. (1997b) report the total waste volume as 121 kL (32 kgal). Hill et al. reports that the waste consists entirely of sludge. Hanlon credits 38 kL (10 kgal) to salt cake, 68 kL (18 kgal) to sludge, and 15 kL (4 kgal) to supernatants. Agnew et al. (1997b) credits 91 kL (24 kgal) to salt cake, 15 kL (4 kgal) to sludge, and 15 kL (4 kgal) to supernatants.

D3.2 BASIS FOR ASSESSING INVENTORIES IN 241-B-102

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 as they cooled. Agnew et al. provides a single average composition for the BSltCk defined waste. However, historical records (Anderson 1990, Agnew et al. 1997b) indicate that supernatants from the first cycle Bismuth Phosphate process (1C waste), as well as supernatants from the UR process were evaporated in 242-B and transferred to several tanks in the 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 salt cake 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 salt cake 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), 241-B-108 (Schreiber 1997), and 241-B-109 (Benar 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. Also shown for comparison are data for core 170 from tank 241-B-109. The core 169 data are not shown since 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, i.e., 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 Salt Cake (Water-Free Basis). (2 Sheets)

Analyte	241-B-104[a] (μg/g)	241-B-106[b] (μg/g)	241-B-108[c] (μg/g)	241-B-109[d] (μg/g)	Average (μg/g)	HDW model BSltCk[e] (μg/g)
Al	3,471	6,925	40,400	40,380	22,800	432
Bi	21,516	7,238	<3,130	6,808	<9,670	3,818
Ca	618	4,499	<3,020	<2,950	<2,770	2,894
Cr	966	666	355	1,420	852	290
Fe	19,857	35,011	<1,570	5,908	15,590	6,666
K	NR	315	1,900	NR	1,110	599
La	NR	<73	<1,570	<1,475	<1,040	0.00
Mn	NR	403	<302	<295	<333	0.00
Na	220,620	228,337	343,560	417,902	302,600	295,250
Ni	NR	129	8,961	5,544	4,880	500
Pb	NR	741	<3,020	<3,023	<2,260	0.00
Si	10,729	4,092	2,051	2,236	4,780	1,170
Sr	NR	911	<302	<295	<500	0.00
U	3,616	27,821	1,930	<14,750	<12,000	NR
Zr	NR	<73	<302	<295	<223	13.9
CO_3^{2-}	NR	1,625	6,925	NR	4,280	11,480
Cl^-	3,974	3,334	1,471	1,495	2,569	3,030
F^-	6,516	5,632	61,280	79,614	38,260	1,979
NO_3^-	546,139	409,639	114,590	219,962	322,600	547,100
NO_2^-	4,614	16,044	19,275	7,907	11,960	11,150
PO_4^{3-}	43,879	66,436	182,070	125,628	104,500	95,690
SO_4^{2-}	41,153	31,312	183,700	316,880	143,000	12,770

Table D3-1. Composition of 242-B Evaporator Salt Cake (Water-Free Basis). (2 Sheets)

Analyte	241-B-104[a] (μg/g)	241-B-106[b] (μg/g)	241-B-108[c] (μg/g)	241-B-109[d] (μg/g)	Average (μg/g)	HDW model BSltCk[e] (μg/g)
Radionuclide[f] (μCi/g)						
^{137}Cs	NR	50.5	23.5	NR	37.0	49
^{90}Sr	NR	149	3.3	NR	76.2	12.5
$^{239/240}Pu$	NR	NR	NR	NR	NR	0.053

HDW = Hanford Defined Waste
NR = Not reported
[a] Field (1996)
[b] McCain (1996)
[c] Schreiber (1997); data from upper half of segment 1 from cores 172 and 173 are not included since these partial segments contain primarily cladding waste
[d] Benar (1997); core 170. Core 169 data are not shown since this core contained primarily cladding waste
[e] Agnew et al. (1997a), radionuclides decayed to January 1, 1994
[f] Sample radionuclides reported as of the analyses date.

As shown in Table D3-1, the concentrations of most components in tank 241-B-104 (with the exception of Bi and PO_4) 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. 1997a) indicate that tank 241-B-109 was the last tank to receive 242-B Evaporator bottoms. The records indicate that evaporated 1C waste and probably evaporated UR waste were transferred to tank 241-B-109. The high concentrations of F^-, SO_4^{2-}, and PO_4^{3-} in tanks 241-B-108 and 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 tank 241-B-102. 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 that, like tank 241-B-109, also received highly concentrated salt liquors from 242-B Evaporator operations. This difference suggests a phasing and distribution issue. 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.

Analyses for tank 241-B-102 samples were limited to safety screening requirements. Analyses useful for the best-basis inventory are water content and total alpha measurements. No analyte analyses were performed on samples from tank 241-B-102. The concentrations of analytes are estimated using the average concentrations on a water-free basis for the four 241-B Evaporator salt cake tanks presented in Table D3-1. The analyte concentrations are adjusted for a water content of 18.5 wt%. The value of 18.5 wt% is the average of the water results for the tank 241-B-102 sample. The inventories of analytes are calculated using a solids volume of 106 kL (28 kgal) and a solids density of 1.65 g/cc established by the HDW model (Agnew et al. 1997a). It is assumed that inventory contributions from 15 kL (4 kgal) of supernatant are negligible and equal to zero in the engineering assessment.

There are no or poor sample bases for mercury and total organic carbon from Table D3-1. The values provided by the HDW model (Agnew et al. 1997a) are used for the best-basis inventory for these analytes.

Radionuclide analysis for tank 241-B-102 sample was limited to total alpha measurements. The total alpha determination was less than 0.36 μCi/g. The HDW model (Agnew et al. 1997a) inventories are used for radionuclides.

D3.3 COMPARISON OF INVENTORY ESTIMATES

Estimated inventories from this evaluation are compared with the HDW model-based inventories (Agnew et al. 1997a) in Table D3-2. The inventories from this evaluation differ significantly from the HDW inventories. Table D3-1 shows the high variability of 242-B Evaporator salt cake by comparison of analyses from four different tanks. The concentration of analytes determined by this evaluation are the average of sample based concentrations presented in Table D3-1. The variability of analytes (Al, Bi, Fe, F, PO_4, and SO_4) for BSltCk wastes is a function of the type of wastes being processed by the 242-B Evaporator and if the salt produced was early or late in the evaporation campaign.

Table D3-2. Engineering Assessment-Based and Hanford Defined Waste-Based Inventory Estimates for Nonradioactive Components in Tank 241-B-102.

Analyte	Engineering assessment inventory estimate (kg)	HDW model inventory estimate[a] (kg)	Analyte	Engineering assessment inventory estimate (kg)	HDW model inventory estimate[a] (kg)
Al	3,250	712	NO_2	1,700	1,210
Bi	<1,380	343	NO_3	46,000	49,700
Ca	<395	348	PO_4	14,900	9,010
Cl	366	289	Pb	<322	256
Cr	121	33.3	Si	681	40
F	5,450	183	SO_4	20,400	1,310
Fe	2,220	768	Sr	<72	0
Hg	NR	4.9	TIC as CO_3	4,280	2,440
K	158	58	TOC	NR	14
La	<148	0.001	U_{TOTAL}	<1,710	6,310
Mn	<48	0.34	Zr	<32	1.28
Na	43,100	28,400	H_2O (wt%)	18.5	45.4
Ni	695	46			

HDW = Hanford Defined Waste
NR = Not reported
[a] 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 assessment associated with waste management activities, as well as 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/disposal.

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 the HDW 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-102 was performed, including the following:

- Data from one 1994 auger sample (Section 4.0)
- An inventory estimate generated by the HDW model (Agnew et al. 1997a)
- Comparing 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-102 (Tables D4-1 and D4-2). The evaluation used the sample-based analytical data from tanks 241-B-104, 241-B-106, 241-B-108, and 241-B-109, which historically contain the salt cake waste type similar to that of tank 241-B-102, to define the best-basis inventory for the following reasons:

- No methodology is available to fully predict 242-B Evaporator salt cake from process flowsheets or historical records.
- Waste transfer records are not complete and not always accurate.
- The solubility data in Agnew et al. (1997a) for several chemical components in BSltCk are not consistent with the sample-based data for tanks 241-B-108 and 241-B-109.

The inventories shown in Table D4-1 are categorized as engineering assessment-based rather the sample-based. The analytical data from four other BSltCk tanks were used for analytes where there were no tank 241-B-102 sample analyses and were the primary basis used for deriving the inventories in Table D4-1. Tank 241-B-102 composition may be closer to tanks 241-B-104 and 241-B-106 or tanks 241-B-108 and 241-B-109 but there is not sufficient historical evidence to state a preference.

The inventories of analytes are calculated using a solids volume of 106 kL (28 kgal) and a solids density of 1.65 g/cc established by the HDW model (Agnew et al. 1997a). It is assumed that inventory contributions from 15 kL (4 kgal) of supernatant are negligible and equal to zero in the engineering assessment. HDW model bases were used as best-basis where there were poor (or no) sample bases. Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valences of other analytes. This charge balance approach is consistent with that used by Agnew et al. (1997a).

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.

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.

Table D4-1. Best-Basis Inventory Estimate for Nonradioactive Components in Tank 241-B-102 (Effective May 31, 1997).

Analyte	Total Inventory (kg)	Basis (S, M, C, or E)[1]	Comment
Al	3,250	E	
Bi	<1,380	E	
Ca	<395	E	
Cl	366	E	
TIC as CO_3	4,280	E	
Cr	121	E	
F	5,450	E	
Fe	2,220	E	
Hg	4.9	M	No sample basis
K	158	E	
La	<148	E	
Mn	<48	E	
Na	43,100	E	
Ni	695	E	
NO_2	1,700	E	
NO_3	46,000	E	
OH	5,490	C	
Pb	<322	E	
PO_4	14,900	E	
Si	681	E	
SO_4	20,400	E	
Sr	<72	E	
TOC	14	M	No sample basis
U_{TOTAL}	1,710	E	
Zr	<32	E	

[1]S = Sample-based
M = Hanford Defined Waste model-based, Agnew et al. (1997a)
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 Estimate for Radioactive Components in Tank 241-B-102, Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M,or E)[1]	Comment
^{3}H	0.617	M	
^{14}C	0.134	M	
^{59}Ni	0.0619	M	
^{60}Co	0.0805	M	
^{63}Ni	5.59	M	
^{79}Se	0.0153	M	
^{90}Sr	11,600	E	
^{90}Y	11,600	E	Referenced to ^{90}Sr.
^{93m}Nb	0.0593	M	
^{93}Zr	0.0733	M	
^{99}Tc	0.759	M	
^{106}Ru	1.10 E-05	M	
^{113m}Cd	0.244	M	
^{125}Sb	0.327	M	
^{126}Sn	0.0229	M	
^{129}I	0.00145	M	
^{134}Cs	0.00344	M	
^{137m}Ba	5,280	E	Referenced to ^{137}Cs.
^{137}Cs	5,580	E	
^{151}Sm	56	M	
^{152}Eu	0.0157	M	
^{154}Eu	1.15	M	
^{155}Eu	1.16	M	
^{226}Ra	4.65 E-06	M	
^{227}Ac	6.44 E-04	M	
^{228}Ra	0.00139	M	
^{229}Th	1.20 E-04	M	
^{231}Pa	9.68 E-04	M	
^{232}Th	9.95 E-05	M	
^{232}U	0.0157	M	

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-B-102, Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M,or E)[1]	Comment
^{233}U	0.0605	M	
^{234}U	2.08	M	
^{235}U	0.0932	M	
^{236}U	0.016	M	
^{237}Np	0.00354	M	
^{238}Pu	0.261	M	
^{238}U	2.11	M	
^{239}Pu	14.3	M	
^{240}Pu	2.1	M	
^{241}Am	0.154	M	
^{241}Pu	19.8	M	
^{242}Cm	3.97 E-04	M	
^{242}Pu	5.74 E-05	M	
^{243}Am	3.21 E-06	M	
^{243}Cm	2.71 E-05	M	
^{244}Cm	1.90 E-04	M	

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

D5.0 APPENDIX D REFERENCES

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