Savannah River Remediation
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INTEROFFICE MEMORANDUM

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Revision 0
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3/31/2016–March 2016 Curie and Volume Inventory Report

Introduction

The Waste Characterization System (WCS) is an electronic information system that tracks waste tank data—including projected radionuclide inventories—based on sample analyses, process histories, composition studies, and theoretical relationships. In addition, several recent studies have established characterization methodologies that expand on the information found in WCS. This information is used to aid the planning and scheduling of SRR activities. The purpose of this memorandum is to document the information as of March 2016 for the curie inventory phase partition (supernate, sludge, salt) for radionuclides tracked in waste (including phase subtotals). This information is provided in Table A1 and reflects the tank farm inventories as of 4/04/2016 Phase curies and volume inventories reported by tanks are provided in Tables A2 and A3 respectively. General methods and computations performed within WCS used to generate curie inventory projections are documented in References 1 and 2.

Inputs and Assumptions

1. Reference date for sludge decay calculations: 4/04/2016
2. Tank Farm Transfer Receipt Sludge 1.5 Update Status:

   Tank 22: 2/07/2016

   Tank 39: 9/11/2015
3. Tank Farm Effluent Transfer Sludge 1.5 Update Status:

   Tank 40: 3/06/2016
4. Morning Report reference date for tank levels: 04/04/2016

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5. Evaporator Tanks (30, 32, 37, 38, and 43) assumed to be at level when samples were taken for Curie inventory estimates. Total supernate Curie inventory is affected accordingly due to the level changes in the tanks.
6. The Closed Tanks (5, 6, 12, 16, 17, 18, 19, and 20) Sludge Volumes are not included in Phase Volume Sludge Total. These curies are no longer tracked in this document.
7. Zeolite, coal, and sand volumes are not accounted for in volumes (impacts Supernate Total). Interstitial Supernate Volumes are accounted for in Sludge/Salt Volumes, Salt Volume for Salt Ci content calculations, and in Total Supernate Volume for Supernate Ci content calculations.
8. Algorithms from Reference 3 are used to estimate the supernate inventories of ^{14}C, ^{60}Co, ^{63}Ni, ^{90}Sr, and ^{90}Y, except for the values of Tanks 21, 23, and 49 (Salt Batch 8 and 9 qualification sample results are used), for which the results of supernate sample analysis and evaluation are used (Ref. 4, 5, and 6) and Tank 50 for which results of Tank 50 material balance are used (Tank 50 material balance Tab in WCS 1.5) . These algorithms project conservative (high) estimates for supernate inventory of these isotopes.
9. ^{3}H curies inventories are estimated in Reference 7 except for Tanks 21, 49 and 50. Tank 21and Tank 49 values are from References 4 and 6 respectively. Tank 50 values are from the Tank 50 material balance.
10. Additional sludge inventories are identified for ^{151}Sm, ^{152}Eu, ^{155}Eu, ^{243}Am, and ^{243}Cm (Ref. 8). An assumed 30 year-old waste is utilized in the inventory estimates.
11. Additional sludge inventories are identified for ^{126}Sb, ^{126m}Sb, and ^{125m}Te (Ref. 8). ^{126m}Sb is set equal to ^{126}Sn. ^{125m}Te and ^{126}Sb are proportional to ^{125}Sb and ^{126m}Sb respectively.
12. ^{244}Pu inventory is set equal to ^{242}Pu (Ref. 9).
13. ^{129}I Supernate inventory for ^{129}I is a constant fraction of ^{137}Cs supernate inventory. The average fraction for the two radionuclides from supernate samples was 1.57E-7 calculated in Reference 10. The constant fraction used in this report is 3.14E-7 (twice of 1.57E-7) to account for the decay of ^{137}Cs in 30 years.
14. Supernate inventory for ^{79}Se is 8.9E+01 curies (Ref. 11).
15. Supernate inventory for ^{99}Tc is a constant fraction of ^{137}Cs supernate inventory. The average fraction for the two radionuclides from supernate samples was 1.95E-4 (Ref. 12). The constant fraction used in this report is 3.90E-4 (twice of 1.95E-4) to account for the decay of ^{137}Cs in 30 years.
16. ^{242}Cm inventory is set equal to the corresponding ^{242m}Am inventory according to the decay chain of ^{242m}Am (Ref. 8).
17. ^{246}Cm sludge inventory is determined in Reference 13.
18. New isotopes inventories are distributed to each tank as detailed in Reference 12.
19. Supernate ^{137}Cs inventory was decayed according to the latest sample dates from HLW Tank Chemistry database (Ref. 14), with the exception of Tank 49 which has its Cs inventory taken from Salt Batch 8.
20. To determine supernate inventories for isotopes listed in **Table 1**, the solubility factor is multiplied by the corresponding total tank farm sludge inventory. Since the chemistry of the transplutonium elements is very similar to the rare earths (Ref. 15), their solubility factor is assumed to be 0.001.

Table 1: Soluble Inventory Estimates Based on Solubility

Nuclide	Solubility Factor (Ref. 16)
Ni-59 (a)	-
Nb-94	1.00E-03
Ru-106	2.50E-01
Rh-106 (f)	2.50E-01
Sn-126 (b)	2.00E-01
Sb-125	5.00E-02
Sb-126 (c)	5.00E-02
Sb-126m (c)	5.00E-02
Te-125m (c)	5.00E-02
Cs-134 (d)	-
Cs-135(d)	-
Ce-144	1.00E-03
Pr-144 (g)	1.00E-03
Pm-147	1.00E-03
Eu-154	1.00E-03
Sm-151 (e)	1.00E-03
Eu-152 (e)	1.00E-03
Eu-155 (e)	1.00E-03
Am-243 (e)	1.00E-03
Cm-243 (e)	1.00E-03
Cm-244 (e)	1.00E-03
Cm-245 (e)	1.00E-03
Cm-246 (e)	1.00E-03

Note: (a) Based on ^{63}Ni ratio between sludge and supernate inventories
(b) Based on Reference 11
(c) Based on ^{125}Sb solubility
(d) Based on ^{137}Cs ratio between sludge and supernate inventories
(e) Based on rare earths solubility
(f) Assumed same as Ru-106
(g) Assumed same as Ce-144

21. For Tanks with Bulk Waste Removal Efforts (BWRE) declared complete or where sludge mapping has been completed with no sludge transfers into or out of the tanks, the sludge mapping will supercede any sludge soundings or turbidity measurements for the purpose of determing the sludge volume. This includes Tanks 4, 7, 8, 11 and 15.

22. Adjustments Made to Sludge 1.5:

- ^{63}Ni sludge inventory is added (Ref. 17). To be consistent with all other isotopes within PUREX waste, the mixed waste stream is assumed to be 50% LHW and 50% HHW.
- ^{94}Nb sludge inventory is added (Ref. 18).
- Activities of a transfer from Tank 13 to Tank 51 were subtracted from Tank 13, 7/5/2014.
- Activities of a transfer from Tank 41 to Tank 23 were subtracted from Tank 41, 8/08/2014.
- Activities of a transfer from Tank 23 to Tank 21 were deleted. For inventory purposes, it is assumed that no sludge was transferred from Tank 23 to Tank 21, 8/31/2014.
- Activities of a transfer from Tank 13 to Tank 22 were subtracted from Tank 13, 6/24/2014.
- Activities of three transfers from Tank 22 to Tank 43 were subtracted from Tank 22, 3/11/2014, 3/27/2014, 4/16/2014.
- Activities of a transfer from Tank 22 to Tank 13 were subtracted from Tank 22, 3/10/2014.

- Activities of a transfer from Tank 22 to Tank 23 were subtracted from Tank 22, 6/23/2013.
- Tank 48 Ci was decayed according to the date of the sample value used for each isotope. The sample dates were listed in Reference 19, Table 10.
- Tank 50 sludge inventories are set to zero because the solid material in Tank 50 is Low Level Solids, not sludge (Ref. 20).

23. Adjustments Made to WCS 1.5:

a) **Sludge Volume:** The values listed below reflect sludge volume corrections for the sludge volume equation. The Sludge Volume changes do not affect the total sludge curie inventory because those values are extracted directly from Sludge 1.5. Setting the Sludge User Input value to 0 or no value allows the software to use the latest sludge depth measurement recorded for a particulat tank (Ref. 21).

Tanks 5, 6, 12, 16, 17, 18, 19 and 20 (Set Sludge Level to 0) – These tanks are closed, this inventory report will no longer track the Tank's inventory. Curies remaining in the grouted tanks are described in Reference 22.

Tank 4– The current sludge volume 8,000 gallons as determined by Reference 23 as the "Bulk Waste Removal Complete" value per the latest mapping of this tank bottom.

Tank 7 (Sludge User input set to 13,600 gallons) – The current sludge volume was determined by Reference 24 as the "Bulk Waste Removal Complete" value per the latest mapping of this tank bottom.

Tank 8 (Sludge User input set to 4029 gallons) – The current sludge volume as determined by Reference 25 as the "Tank 8 Heel Removal" value per the latest mapping of this tank bottom.

Tank 11 The sludge volume 19,254 gallons was estimated by Reference 26 .

Tank 12 – Tank 12 is considered closed, this inventory report will no longer track the Tank's inventory. See note above.

Tank 15 The current sludge volume of Tank 15 is 187,000 gallons as mapping in Reference 27.

Tank 21 (Sludge User Input to 0) – The most current sludge level of 18.85 (Ref. 21) is used in volume determination, and Sludge User Input is set to 0. For inventory purposes, Tank 23 to Tank 21 transfer is assumed to contain no sludge since the transfer pump suction of Tank 23 is at 60 inches.

Tank 22 (33.20 inches to 18.99 inches and Sludge User Input to 0) – The most current sludge level of 18.99 inches is taken from the average of four recent sludge soundings (Ref. 21) and Sludge User Input is set to 0.

Tank 23 – Sludge volume of 112,223 gallons is taken from Reference. 28. This volume corresponds to 31.7 inches.

Tank 40 (70.30 inches to 120.6 inches and Sludge User Input to 0) – Tank 40 level of 120.6 inches on 4/4/2016 is used for sludge level to account for recent sludge transfer to DWPF. The entire liquid inventory of Tank 40 is considered a sludge slurry for sludge volume reporting.

Tank 41 (Sludge User Input set to 0 gallons) – All the Sludge volume and curies in Tank 41 are assumed to be transferred into Tank 23 (Ref. 28). For inventory purposes, the volume is subtracted from Tank 41 inventory.

Tank 50 (4.5 inches to 0 inches) – Tank 50 contains only insoluble solids not sludge (Ref. 20).

b) **Salt Volume:** Changes in Salt Volume will change the corresponding insoluble curies inventory. However, additional salt formation from reducing evaporator tank supernate volumes is not accounted for.

Tank 41 (Salt User Input set to 0) – The average of two recent measurements of salt level of 111.05 inches is recorded in Reference 21 is used.

c) **Tank 48** – The tank sludge curie contents are accounted for as sludge in Sludge 1.5. Although the sludge curie inventory will be shown, the total volume will be treated as free supernate for volume inventory and supernate curie calculation. Reference 29 lists the curie concentration of Tank 48 supernate.

d) **Tank 21** – Supernate concentration is taken from ISDP B9 Tank 21 qualification sample results (Ref. 4).

e) **Tank 23** – Supernate sample data from a recent analysis is used in place of WCS assumptions (Ref. 5) except for ^{137}Cs.

f) **Tank 49** – Sample data for Salt Batch 8 (Ref. 6) is used in place of WCS assumptions.

g) **Tank 50** – Data is derived from WCS 1.5, Tank 50 material balance Tab.

h) **When available** – ^{137}Cs concentration of tanks supernate is taken from HLW Tank Chemistry (Ref. 14).

Appendix A Table A1: March 2015 Curie Inventory

Nuclide Data	Supernate Total (Ci)	Sludge Total (Ci)	Insolubles Total (Ci)
H-3	2,426	100.5	
C-14	149.2	2.604	364.0
Na-22	2,054	8.592	2,997
Al-26	13.03	4.830	11.53
Co-60	83.22	95,820	
Ni-59	2.454	2,199	
Ni-63	202.2	181,300	
Se-79	89.00	1,114	
Sr-90	18,700	54,340,000	5,665,000
Y-90	18,700	54,340,000	5,665,000
Nb-94	0.0004948	0.4943	
Tc-99	23,030	18,670	
Ru-106	258.9	776.6	
Rh-106	258.9	776.6	
Sn-126	361.8	1,447	
Sb-125	1,030	19,570	
Sb-126	10.66	202.6	
Sb-126m	76.17	1,447	
Te-125m	251.5	4,778	
I-129	18.54	0.2638	
Cs-134	36,340	2,635	
Cs-135	180.5	13.09	
Cs-137	58,840,000	4,267,000	253,100
Ba-137m	55,660,000	3,872,000	239,500
Ce-144	0.8365	835.7	
Pr-144	0.7561	755.4	
Pm-147	632.2	631,600	
Sm-151	4,296	4,291,000	
Eu-152	20.76	20,740	
Eu-154	365.7	365,400	
Eu-155	242.9	242,700	
Ra-226	12.11	124.9	
Ra-228	0.1947	2.046	
Ac-227	0.5143	1.672	
Th-229	12.68	99.22	
Th-230	12.03	124.1	
Th-232	0.1947	2.046	
Pa-231	0.5143	1.672	
U-232	0.06391	0.3374	
U-233	12.10	94.66	
U-234	8.344	86.07	
U-235	0.5143	1.672	0.2230
U-236	0.4117	7.723	
U-238	16.72	52.12	5.003
Np-237	8.654	176.7	
Pu-238	83,480	1,696,000	72,320
Pu-239	6,390	40,370	2,411
Pu-240	1,686	17,790	
Pu-241	37,050	731,100	
Pu-242	2.131	35.68	
Pu-244	0.009741	0.1631	
Am-241	13,730	249,900	
iAm-241	3,744	77,880	
Am-242m	7.387	129.2	
Am-243	0.06947	69.40	
Cm-242	7.387	129.2	
Cm-243	0.04066	40.62	
Cm-244	193.6	193,400	
Cm-245	0.5844	583.8	
Cm-246	0.00001284	0.01283	
Subtotal	114,800,000	125,700,000	11,900,000
Total		252,400,000	

Table A2: March 2015 Waste Tanks Curie Inventory

Tank	Total Supernate Curies (Ci)*	Sludge Curies (Ci)	Insolubles Curies (Ci)
1	3,559,000	888,400	358,700
2	1,423,000	121,700	400,700
3	1,439,000	106,800	400,700
4	123,300	429,100	-
5		-	
6		-	
7	262,500	570,400	-
8	436,500	2,674,000	-
9	819,600	131,100	410,200
10	79,210	13,670	143,100
11	26,200	1,209,000	-
12	-	-	-
13	1,092,000	1,568,000	-
14	1,902,000	298,900	96,800
15	95,650	11,410,000	-
16		-	
17		-	
18		-	
19		-	
20		-	
21	2,135,000	3,367,000	2,646
22	173,700	2,994,000	-
23	737,000	425,800	-
24	13,820,000	-	-
25	3,199,000	-	375,800
26	2,954,000	323,900	-
27	3,051,000	-	866,100
28	3,626,000	-	769,800
29	1,299,000	-	764,800
30	11,370,000	68,660	238,200
31	6,065,000	-	926,200
32	5,869,000	16,480,000	196,800
33	4,470,000	14,820,000	209,100
34	7,692,000	12,720,000	143,000
35	3,108,000	14,810,000	-
36	11,900,000	16,560	856,900
37	3,628,000	-	649,100
38	335,600	569,200	603,400
39	531,300	24,100,000	-
40	109,000	5,994,000	-
41	62,010	-	291,400
42	2,597,000	1,407,000	-
43	370,600	3,306,000	-
44	2,400,000	-	754,300
45	2,525,000	-	924,800
46	3,407,000	-	935,600
47	5,130,000	248,200	578,100
48	20,170	937,400	-
49	786,700	-	5,247
50	8,143	-	-
51	118,400	3,683,000	-
Phase total	**114,800,000**	**125,700,000**	**11,900,000**
Total		**252,400,000**	

*Total supernate curies include interstitial supernate.

Table A3: March 2015 Waste Tank Phase Volume Inventory

Tank	Free Supernate Volume (gal)	Sludge Volume (incl. Interstitial Liquid) (gal) (*)	Salt Volume (incl. Interstitial Liquid) (gal)
1	-	7,050	480,000
2	-	4,070	536,000
3	-	4,070	536,000
4	112,000	8,000	-
5		-	
6		-	
7	285,000	13,600	-
8	544,000	4,030	-
9	-	2,710	549,000
10	13,500	2,710	191,000
11	116,000	19,300	-
12	-	-	-
13	582,000	16,600	-
14	-	28,000	130,000
15	112,000	187,000	-
16		-	
17		-	
18		-	
19		-	
20		-	
21	1,150,000	66,700	3,540
22	986,000	67,200	-
23	588,000	112,000	-
24	1,210,000	3,540	-
25	553,000	-	503,000
26	748,000	288,000	-
27	79,300	3,860	1,160,000
28	183,000	-	1,030,000
29	74,100	-	1,020,000
30	817,000	617	319,000
31	5,970	-	1,240,000
32	506,000	104,000	263,000
33	857,000	98,300	280,000
34	927,000	12,600	191,000
35	912,000	71,600	-
36	109,000	186	1,150,000
37	377,000	-	868,000
38	409,000	-	807,000
39	723,000	198,000	-
40	-	423,000	-
41	319,000	-	390,000
42	1,220,000	17,600	-
43	868,000	241,000	-
44	229,000	-	1,010,000
45	2,460	-	1,240,000
46	1,370	-	1,250,000
47	224,000	248,000	773,000
48	247,000	-	-
49	749,000	-	7,020
50	541,000	-	-
51	107,000	162,000	-
Phase Totals	17,500,000	2,440,000	15,900,000
Interstitial Total	-	1,710,000	4,780,000
Total Volume		**35,840,000**	
F Tank Farm Total	**4,740,000**	**711,000**	**8,990,000**
H Tank Farm Total	**12,700,000**	**1,720,000**	**6,940,000**

* Slurry volume

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