

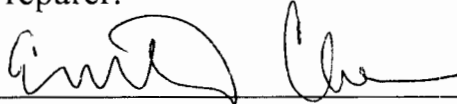
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**CHEMICAL INVENTORY COMPARISON (CIC)
BETWEEN the WASTE CHARACTERIZATION SYSTEM
(WCS) AND SAVANNAH RIVER NATIONAL
LABORATORY (SRNL) REPORTS
for TANKS 5, 18, and 19**

PREPARED BY:
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REVIEWS AND APPROVALS

Preparer:

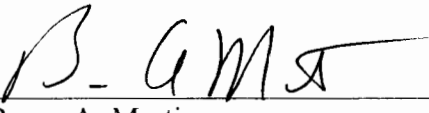

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Objective:

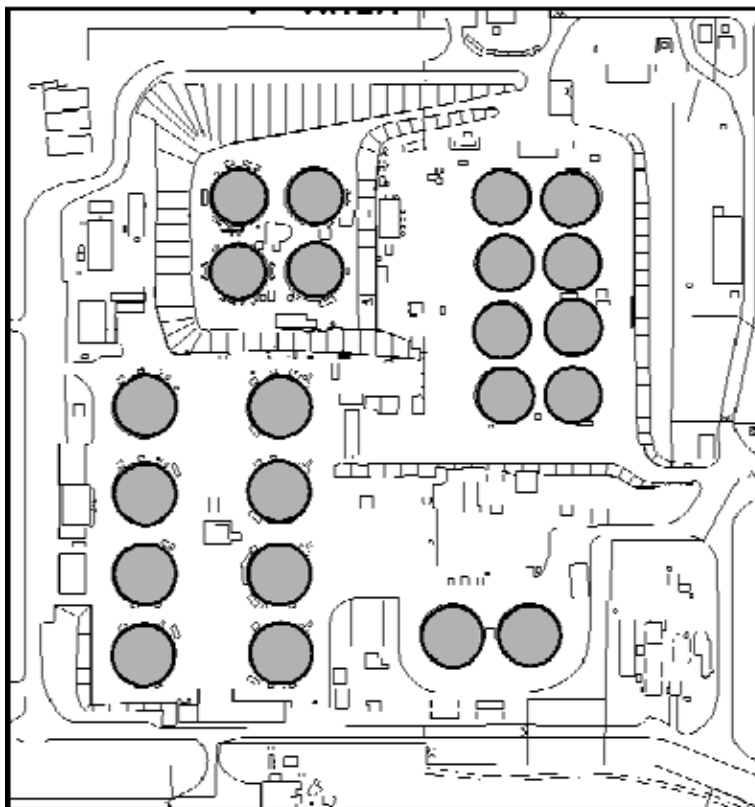
The objective of this report is to compare the chemical inventories of Tanks 5, 18, and 19 as determined by sample analysis at SRNL to the estimates of these inventories as listed in the Waste Characterization System (WCS).

Background:

The Savannah River Site (SRS) F-Area Tank Farm (FTF) contains twenty-two high-level aqueous waste tanks, all of which were constructed from carbon steel and reinforced concrete in a series of non-continuous construction projects that lasted from 1952-1980. The layout of the FTF is shown in Figure 1. There are four primary types of tanks in FTF: Tanks 1-8 are Type I tanks, Tanks 17-20 are Type IV tanks, Tanks 25-28 and 44-47 are Type IIIA tanks, and Tanks 33-34 are Type III tanks. The capacity of the tanks ranges from 750,000 to 1,300,000 gallons. Their primary function is to house the radiological aqueous waste produced by various SRS operations. [1].

In the 1990's, the SRS shifted its focus from production of nuclear materials to cleanup and long-term storage of nuclear waste. This includes the removal of waste from the tanks and vitrification of the waste into a borosilicate glass. Thus far, Tanks 17 and 20, both FTF tanks, have been closed [1]. The tanks next scheduled for closure are 18, 19, 5, and 6.

Figure 1: Layout of the F-Area Tank Farm



This report was generated in response to an NRC question asked about the accuracy of the closure concentrations. It was requested by the NRC that tank sample data be used to make a comparison to the residual concentration predicted by the WCS. The only tank samples available to allow for a comparison to the predictions are from Tanks 5, 18, and 19.

Data Collection and Analysis (Procedure):

Over the past six years, sludge, core, and supernate samples have been taken from Tanks 5, 18, and 19. The samples were transported to the shielded cells at the Savannah River National Lab (SRNL) for analysis, and the results are documented in the SRS archives.

The chemical inventory results used for comparison with WCS were obtained from analysis of sludge samples only. These samples were studied in two different media--sodium peroxide and a mix of hydrochloric and nitric acids (called an aqua regia dissolution). In order to account for all the species and to separate all the radionuclides in each sludge sample, a variety of spectral methods were used for analysis post-dissolution. A more detailed list of procedure can be found in each report [2, 3, 4].

The results of the SRNL analysis were compared to the predicted values listed in WCS. This comparison was done individually by dissolution method (sodium peroxide and aqua regia) and as a whole tank comparison. All estimates from both sources were converted into parts per million for comparison (mg/kg for non-radiological species, mCi/kg for radionuclides). Since the WCS has been updated to reflect sample results from SRNL for Tanks 18 and 19, the original WCS values which were in place before the incorporation of the SRNL data were used in this comparison in order to make a true determination of the validity of the WCS predictions. In the rare case that more than one type of spectroscopy had been used to measure the concentration of a single species, the spectroscopy result giving the highest concentration of that species was used in the comparison. This was done in order to provide the most rigorous test of WCS values.

Data:

Two regions of Tank 18 were sampled—one from the southwest mound of the tank and one from the northeast mound. The sample results of each of these mounds is separately compared to the WCS. An overall comparison is included in the results section.

For non-radiological species, a “<” in the “SRNL Measurement” column indicates that measurement was not possible because the amount of species present was below minimum detectable limits. This indicates that the amount present in the sample is somewhere between zero and the minimum detectable limit. For radiological species, the “<” indicates either that counting was stopped after no amount of the species was detected at the minimum level of interest and/or that complete chemical separation of the radionuclide from other isotopes which would increase the count was not completed. In this last case, the number associated with the “<” is not a minimum detection limit, but a count of more than one species, and the “<” indicates that the count derived solely from the species of interest can be no greater than the count of combined species achieved in sampling.

Tank 5 data:

Table 1: Tank 5 Sodium Peroxide Data

Element	WCS Estimate (mg/kg)	SRNL Measurement (mg/kg)	Was our estimate conservative?	Sample : Prediction Ratio
Ag	1.58E+03	7.85E+02	Yes	5.00E-01
Al	2.01E+04	1.72E+04	No	8.60E-01
B	Not modeled	< 9.1E+02	Not applicable	Not calculable
Ba	2.90E+03	1.82E+03	Yes	6.30E-01
Ca	9.05E+05	5.10E+03	Yes	6.00E-03
Cd	Not modeled	< 6.0E+02	Not applicable	Not calculable
Ce	1.95E+03	5.42E+03	No	2.78E+00
Cr	2.48E+03	1.10E+03	Yes	4.40E-01
Cu	1.11E+03	6.42E+02	Yes	6.00E-01
Fe	2.19E+05	3.63E+05	No	1.75E+00
Gd	Not modeled	5.24E+02	Not applicable	Not calculable
K	1.85E+03	1.10E+04	No	5.90E+00
La	1.10E+03	1.93E+03	No	1.85E+00
Li	Not modeled	9.36E+02	Not applicable	Not calculable
Mg	1.46E+03	8.50E+02	Yes	5.80E-01
Mn	5.98E+04	6.79E+04	No	1.66E+00
Mo	Not modeled	< 3.1E+03	Not applicable	Not calculable
Ni	1.16E+05	4.27E+04	Yes	3.70E-01
P	Not modeled	< 3.6E+03	Not applicable	Not calculable
Pb	3.12E+04	5.80E+03	No	1.86E+00
S	Not modeled	< 6.2E+02	Not applicable	Not calculable
Sb	Not modeled	2.80E+04	Not applicable	Not calculable
Si	5.71E+03	1.18E+04	No	2.07E+00
Sn	Not modeled	8.18E+03	Not applicable	Not calculable
Sr	Not modeled	1.29E+03	Not applicable	Not calculable
Ti	0	5.20E+02	Not applicable	Not calculable
U	1.29E+05	9.29E+04	Yes	7.20E-01
V	Not modeled	< 2.9E+03	Not applicable	Not calculable
Zn	1.99E+03	1.20E+03	Yes	6.02E-01
	WCS Estimate (mCi/kg)	SRNL Measurement (mCi/kg)	Was our estimate conservative	Sample : Prediction Ratio
Pu-238	5.01E+01	1.88E+00	Yes	3.75E-02
Pu-239/240	1.04E+01	8.59E+00	Yes	8.26E-01
Pu-241	1.21E+01	7.73E+00	Yes	6.39E-01
U-233	0	9.45E-02	Not applicable	Not calculable
U-234	0	6.18E-02	Not applicable	Not calculable
U-235	1.82E-03	1.29E-03	Yes	7.10E-01
U-236	0	2.34E-03	Not applicable	Not calculable
U-238	4.30E-02	3.10E-02	Yes	7.20E-01

Table 2: Tank 5 Aqua Regia Data

Element	WCS Estimate (mg/kg)	SRNL Measurement (mg/kg)	Was our estimate conservative?	Sample : Prediction ratio
Ag	1.58E+03	4.86E+02	Yes	3.10E-01
Al	2.01E+04	1.43E+04	No	7.00E-01
B	Not modeled	< 9.2E+02	Not applicable	Not calculable
Ba	2.90E+03	1.81E+03	Yes	6.20E-01
Ca	9.05E+05	3.47E+03	Yes	4.00E-03
Cd	Not modeled	< 6.1E+02	Not applicable	Not calculable
Ce	1.95E+03	4.22E+03	No	2.16E+00
Cr	2.48E+03	1.10E+03	Yes	4.40E-01
Cu	1.11E+03	6.61E+02	Yes	6.00E-01
Fe	2.19E+05	3.83E+05	No	1.75E+00
Gd	Not modeled	< 5.1E+02	Not applicable	Not calculable
Hg	1.28E+03	1.29E+03	No	1.00E+00
K	1.85E+03	1.10E+04	No	5.90E+00
La	1.10E+03	1.78E+03	No	1.71E+00
Li	Not modeled	6.55E+02	Not applicable	Not calculable
Mg	1.46E+03	8.50E+02	Yes	5.80E-01
Mn	5.98E+04	6.90E+04	No	1.15E+00
Mo	Not modeled	< 3.1E+03	Not applicable	Not calculable
Na	4.89E+04	4.26E+04	Yes	8.70E-01
Ni	1.16E+05	4.62E+04	Yes	4.00E-01
P	Not modeled	< 3.6E+04	Not applicable	Not calculable
Pb	3.12E+03	5.80E+03	No	1.86E+00
S	Not modeled	< 6.2E+03	Not applicable	Not calculable
Sb	Not modeled	2.80E+04	Not applicable	Not calculable
Si	5.71E+03	7.30E+03	No	1.28E+00
Sn	Not modeled	5.67E+03	Not applicable	Not calculable
Sr	Not modeled	1.29E+03	Not applicable	Not calculable
Ti	0	7.30E+03	Not applicable	Not calculable
U	1.29E+05	9.93E+04	Yes	7.70E-01
V	Not modeled	< 2.9E+03	Not applicable	Not calculable
Zn	1.99E+03	1.20E+03	Yes	6.02E-01
Zr	3.90E+03	3.91E+03	No	1.00E+00
	WCS Estimate (mg/kg)	SRNL Measurement (mCi/kg)	Was our estimate conservative?	Sample : Prediction Ratio
Am-241	1.54E+02	5.07E+01	Yes	3.30E-01
Am-242	1.94E+00	1.47E-01	Yes	7.60E-01
Am-243	Not modeled	3.35E-01	Not applicable	Not calculable
Cm-242	Not modeled	1.21E-01	Not applicable	Not calculable
Cm-244	2.90E-02	3.86E+00	No	1.33E+02
Co-60	1.75E+01	1.39E+01	Yes	1.66E+00
Cs-137	3.01E+03	1.09E+03	Yes	3.62E-01
Eu-154	7.60E+01	3.03E+01	Yes	4.00E-01
Pu-238	5.01E+01	2.02E+00	Yes	4.03E-02

Table 2: Tank 5 Aqua Regia Data (Continued)

Pu-239/240	1.04E+01	8.37E+00	Yes	8.05E-01
Pu-241	1.21E+01	8.37E+00	Yes	6.92E-01
Sr-90	4.25E+03	3.70E+04	No	8.71E+00
U-233	0	9.64E-03	Not applicable	Not calculable
U-234	0	4.60E-02	Not applicable	Not calculable
U-235	1.82E-03	1.20E-03	Yes	6.60E-01
U-236	0	2.38E-03	Not applicable	Not calculable
U-238	4.30E-02	3.32E-02	Yes	7.70E-01

Tank 18 data:

Table 3: Tank 18 Northeast Mound Sodium Peroxide Data

Element	WCS estimate (mg/kg)	SRNL measurement (mg/kg)	Was our estimate conservative?	Sample : Prediction Ratio
Al	9.79E+04	1.30E+05	No	1.33E+00
As	Not modeled	< 5.01E+01	Not applicable	Not calculable
B	Not modeled	< 1.62E+04	Not applicable	Not calculable
Ba	3.00E+03	2.71E+02	Yes	9.04E-02
Ca	4.34E+04	3.01E+04	Yes	6.93E-01
Cd	Not modeled	6.21E+03	Not applicable	Not calculable
Ce	4.29E+03	< 2.48E+03	Yes	5.78E-01
C0-59	Not modeled	4.06E+01	Not applicable	Not calculable
Cr	3.62E+03	8.13E+02	Yes	2.25E-01
Cu	2.57E+03	3.10E+02	Yes	1.21E-01
Fe	4.15E+05	8.35E+04	Yes	2.01E-01
Gd	Not modeled	< 2.70E+02	Not applicable	Not calculable
La	2.57E+03	2.00E+02	Yes	7.78E-02
Li	Not modeled	8.51E+02	Not applicable	Not calculable
Mg	1.43E+03	1.06E+04	No	7.42E+00
Mn	1.94E+04	1.14E+04	Yes	5.87E-01
Mo	Not modeled	< 2.04E+03	Not applicable	Not calculable
Ni	0.00E+00	1.11E+03	No	Not calculable
P	Not modeled	< 4.86E+03	Not applicable	Not calculable
Pb	4.29E+03	< 2.46E+03	Yes	5.69E-01
S	Not modeled	< 3.79E+03	Not applicable	Not calculable
Sb	Not modeled	< 1.51E+03	Not applicable	Not calculable
Se	Not modeled	< 5.01E+01	Not applicable	Not calculable
Si	1.46E+04	6.12E+04	No	4.20E+00
Sn	Not modeled	< 2.45E+03	Not applicable	Not calculable
Sr	4.02E+05	6.20E+03	Yes	1.54E-02
Ti	0.00E+00	1.23E+02	Not applicable	Not calculable
U	9.26E+04	2.94E+04	Yes	3.17E-01
V	Not modeled	< 1.10 E+02	Not applicable	Not calculable

Table 3: Tank 18 Northeast Mound Sodium Peroxide Data

Zn	5.14E+03	< 5.50E+02	No	1.07E-01
	WCS estimate (mCi/kg)	SRNL measurement (mCi/kg)	Was our estimate conservative?	Sample : Prediction Ratio
Am-241	1.02E-01	3.80E+00	No	3.73E+01
Cs-137	2.81E+01	5.74E+02	No	2.04E+01
Np-237	0.00E+00	< 4.36E-03	Not applicable	Not calculable
Pu-238	5.47E+01	4.17E+00	Yes	7.63E-02
Pu-239/240	Not modeled	9.40E+00	Not applicable	Not calculable
Pu-239	9.45E+00	7.70E+00	Yes	8.15E-01
Pu-240	2.41E+00	1.78E+00	Yes	7.39E-01
Pu-241	3.50E+01	< 1.18E+01	No	3.37E-01
Pu-242	3.10E-03	< 2.10E-02	No	6.77E+00
Se-79	9.26E-03	< 1.18E-03	Yes	1.27E-01
Sr-90	4.02E+05	6.92E+01	Yes	1.72E-04
Tc-99	7.79E-03	9.40E-02	No	Not calculable
U-233	0.00E+00	< 5.31E-02	Not applicable	Not calculable
U-234	0.00E+00	< 3.43E-02	Not applicable	Not calculable
U-235	2.68E-04	4.08E-04	No	1.52E+00
U-236	0.00E+00	4.33E-04	Not applicable	Not calculable
U-238	1.55E-02	1.00E-02	Yes	6.45E-01

Table 4: Tank 18 Northeast Mound Aqua Regia Data

Element	WCS estimate (mg/kg)	SRNL average(mg/kg)	Was our estimate conservative?	Sample : Prediction Ratio
Ag	5.14E+03	< 1.50E+02	Yes	2.92E-02
Al	9.79E+04	1.56E+05	No	1.59E+00
As	Not modeled	< 4.97E+01	Not applicable	Not calculable
B	Not modeled	< 1.62E+04	Not applicable	Not calculable
Ba	3.00E+03	1.90E+02	Yes	6.33E-02
Ca	4.34E+04	2.46E+04	Yes	5.67E-01
Cd	Not modeled	6.12E+03	Not applicable	Not calculable
Ce	4.29E+03	< 2.47E+03	Yes	5.76E-01
Co-59	Not modeled	4.93E+01	Not applicable	Not calculable
Cr	3.62E+03	6.33E+02	Yes	1.75E-01
Cu	2.57E+03	< 3.09E+02	Yes	1.20E-01
Fe	4.15E+05	8.75E+04	Yes	2.11E-01
Gd	Not modeled	< 2.69E+02	Not applicable	Not calculable
Hg	1.06E+03	2.08E+02	Yes	1.97E-01
K	5.61E+03	1.78E+02	No	3.17E-02
La	2.57E+03	< 1.99E+02	Yes	7.74E-02
Li	Not modeled	< 8.47E+02	Not applicable	Not calculable
Mg	1.43E+03	1.79E+04	No	1.25E+01
Mn	1.94E+04	1.05E+04	Yes	5.40E-01
Mo	Not modeled	< 2.03E+03	Not applicable	Not calculable

Table 4: Tank 18 Northeast Mound Aqua Regia Data

Na	1.25E+05	4.70E+03	Yes	3.76E-02
Ni	0.00E+00	9.60E+02	No	Not calculable
P	Not modeled	< 4.83E+03	Not applicable	Not calculable
Pb	4.29E+03	< 2.45E+03	No	Not calculable
S	Not modeled	< 3.81E+03	Not applicable	Not calculable
Sb	Not modeled	< 1.51E+03	Not applicable	Not calculable
Se	Not modeled	< 4.97E+01	Not applicable	Not calculable
Sn	Not modeled	< 2.44E+03	No	Not calculable
Sr	4.02E+05	4.90E+03	No	1.22E-02
Ti	0.00E+00	7.39E+01	Not applicable	Not calculable
U	9.26E+04	9.77E+07	No	1.05E+03
V	Not modeled	< 1.09E+02	Not applicable	Not calculable
Zn	5.14E+03	< 5.48 E+02	Yes	1.07E-01
Zr	8.57E+03	1.19E+02	Yes	1.39E-02
	WCS estimate (mCi/kg)	SRNL average (mCi/kg)	Was our estimate conservative?	Sample : Prediction Ratio
Am-241	1.02E-01	<3.18 E+00	No	3.12E+01
Cs-137	2.81E+01	8.28E+02	No	2.94E+01
Np-237	0.00E+00	< 4.55E-03	Not applicable	Not calculable
Pu-238	5.47E+01	4.29E+00	Yes	7.85E-02
Pu-239/240	Not modeled	9.29E+00	Not applicable	Not calculable
Pu-239	9.45E+00	6.94E+00	Yes	7.34E-01
Pu-240	2.41E+00	1.55E+00	Yes	6.43E-01
Pu-241	3.50E+01	< 1.31E+01	Yes	3.71E-01
Pu-242	3.10E-03	< 2.06E-02	No	8.39E+00
Se-79	9.26E-03	< 6.30E-04	Yes	6.80E-02
Sr-90	4.02E+05	1.22E+02	Yes	3.03E-04
Tc-99	7.79E-03	< 7.45E-02	No	Not calculable
U-233	0.00E+00	5.57E-02	Not applicable	Not calculable
U-234	0.00E+00	3.59E-02	Not applicable	Not calculable
U-235	2.68E-04	4.10E-04	No	1.53E+00
U-236	0.00E+00	4.33E-04	Not applicable	Not calculable
U-238	1.55E-02	1.02E-02	Yes	6.58E-01

Table 5: Tank 18 Southwest Mound Sodium Peroxide Data

Element	WCS estimate (mg/kg)	SRNL average (mg/kg)	Was our estimate conservative?	Sample : Prediction ratio
Al	9.79E+04	1.20E+05	No	1.23E+00
As	Not modeled	< 4.99E+01	Not applicable	Not calculable
B	Not modeled	< 1.62E+04	Not applicable	Not calculable
Ba	3.00E+03	2.03E+02	Yes	6.77E-02
Ca	4.34E+04	2.72E+04	Yes	6.26E-01
Cd	Not modeled	7.11E+03	Not applicable	Not calculable
Ce	4.29E+03	< 2.48E+03	Yes	5.79E-01

Table 5: Tank 18 Southwest Mound Sodium Peroxide Data

C0-59	Not modeled	2.25E+01	Not applicable	Not calculable
Cr	3.62E+03	3.50E+02	Yes	9.67E-02
Cu	2.57E+03	< 3.09E+02	Yes	1.20E-01
Fe	4.15E+05	1.10E+05	Yes	2.65E-01
Gd	Not modeled	< 2.70E+02	Not applicable	Not calculable
La	2.57E+03	< 2.00E+02	Yes	7.78E-02
Li	Not modeled	< 8.49E+02	Not applicable	Not calculable
Mg	1.43E+03	2.72E+04	No	1.90E+01
Mn	1.94E+04	1.30E+04	Yes	6.69E-01
Mo	Not modeled	< 2.40E+03	Not applicable	Not calculable
Ni	0.00E+00	1.18E+03	Not applicable	Not calculable
P	Not modeled	< 4.84E+03	Not applicable	Not calculable
Pb	4.29E+03	< 2.46E+03	Yes	5.74E-01
S	Not modeled	< 3.81E+03	Not applicable	Not calculable
Sb	Not modeled	< 1.51E+03	Not applicable	Not calculable
Se	Not modeled	< 4.99E+01	Not applicable	Not calculable
Si	1.46E+04	5.79E+04	No	3.97E+00
Sn	Not modeled	< 2.45E+03	Not applicable	Not calculable
Sr	4.02E+05	6.21E+03	Yes	1.54E-02
Ti	0.00E+00	2.28E+02	Not applicable	Not calculable
U	9.26E+04	3.83E+04	Yes	4.13E-01
V	Not modeled	4.42E+02	Not applicable	Not calculable
Zn	5.14E+03	< 5.47E+02	Yes	1.06E-01
	WCS estimate (mCi/kg)	SRNL average (mCi/kg)	Was our estimate conservative?	Sample : Prediction ratio
Am-241	1.02E-01	5.75E+00	No	5.64E+01
Cs-137	2.81E+01	5.91E+02	No	2.10E+01
Np-237	0.00E+00	5.40E-03	Not applicable	Not calculable
Pu-238	5.47E+01	4.07E+00	Yes	7.44E-02
Pu-239/240	Not modeled	1.25E+01	Not applicable	Not calculable
Pu-239	9.45E+00	9.96E+00	No	1.05E+00
Pu-240	2.41E+00	2.28E+00	Yes	9.46E-01
Pu-241	3.50E+01	< 1.82E+01	Yes	5.20E-01
Pu-242	3.10E-03	2.80E-03	Yes	9.03E-01
Se-79	9.26E-03	< 1.21E-03	Yes	1.31E-01
Sr-90	4.02E+05	9.08E+01	Yes	2.26E-04
Tc-99	7.79E-03	8.43E-02	No	Not calculable
U-233	0.00E+00	< 5.81E-01	Not applicable	Not calculable
U-234	0.00E+00	1.32E-02	Not applicable	Not calculable
U-235	2.68E-04	4.93E-04	No	1.84E+00
U-236	0.00E+00	4.81E-04	Not applicable	Not calculable
U-238	1.55E-02	1.28E-02	Yes	8.26E-01

Table 6: Tank 18 Southwest Mound Aqua Regia Data

Element	WCS estimate (mg/kg)	SRNL average (mg/kg)	Was our estimate conservative?	Sample : Prediction Ratio
Ag	5.14E+03	< 1.97E+02	Yes	3.83E-02
Al	9.79E+04	1.30E+05	No	1.33E+00
As	Not modeled	< 1.98E+02	Not applicable	Not calculable
B	Not modeled	< 1.61E+04	Not applicable	Not calculable
Ba	3.00E+03	1.96E+02	Yes	6.53E-02
Ca	4.34E+04	2.83E+04	Yes	6.52E-01
Cd	Not modeled	7.84E+03	Not applicable	Not calculable
Ce	4.29E+03	< 2.46E+03	Yes	5.74E-01
C0-59	Not modeled	1.90E+01	Not applicable	Not calculable
Cr	3.62E+03	5.24E+02	Yes	1.45E-01
Cu	2.57E+03	< 3.08E+02	Yes	1.20E-01
Fe	4.15E+05	1.35E+04	Yes	3.25E-02
Gd	Not modeled	< 2.68E+02	Not applicable	Not calculable
Hg	1.06E+03	9.55E+00	Yes	9.04E-03
K	5.61E+03	< 1.49E+02	Yes	2.66E-02
La	2.57E+03	< 1.98E+02	Yes	7.70E-02
Li	Not modeled	< 8.44E+02	Not applicable	Not calculable
Mg	1.43E+03	3.09E+04	No	2.16E+01
Mn	1.94E+04	1.48E+04	Yes	7.62E-01
Mo	Not modeled	< 2.02E+03	Not applicable	Not calculable
Na	1.25E+05	4.63E+04	Yes	3.71E-01
Ni	0.00E+00	1.45E+03	Not applicable	Not calculable
P	Not modeled	< 4.81E+03	Not applicable	Not calculable
Pb	4.29E+03	< 2.44E+03	Yes	5.69E-01
S	Not modeled	< 3.79E+03	Not applicable	Not calculable
Sb	Not modeled	< 1.50E+03	Not applicable	Not calculable
Se	Not modeled	< 1.98E+02	Not applicable	Not calculable
Sn	Not modeled	< 2.43E+03	Not applicable	Not calculable
Sr	4.02E+05	6.23E+03	Yes	1.55E-02
Ti	0.00E+00	2.04E+03	Not applicable	Not calculable
U	9.26E+04	3.07E+04	Yes	3.31E-01
V	Not modeled	< 1.14E+02	Not applicable	Not calculable
Zn	5.14E+03	< 5.46E+02	Yes	1.06E-01
Zr	8.57E+03	< 1.19E+02	Yes	1.39E-02
	WCS estimate (mCi/kg)	SRNL average (mCi/kg)	Was our estimate conservative?	Sample : Prediction Ratio
Am-241	1.02E-01	4.91E+00	No	4.81E+01
Cs-137	2.81E+01	6.20E+02	No	2.20E+01
Np-237	0.00E+00	5.88E-03	Not applicable	Not calculable
Pu-238	5.47E+01	3.71E+00	Yes	6.79E-02
Pu-239/240	Not modeled	1.19E+01	Not applicable	Not calculable
Pu-239	9.45E+00	8.65E+00	Yes	9.15E-01

Table 6: Tank 18 Southwest Mound Aqua Regia Data

Pu-240	2.41E+00	1.90E+00	Yes	7.88E-01
Pu-241	3.50E+01	< 20.3E+01	Yes	5.80E-01
Pu-242	3.10E-03	4.96E-03	No	1.60E+00
Se-79	9.26E-03	< 2.17E-03	Yes	2.34E-01
Tc-99	7.79E-03	7.14E-02	No	Not calculable
U-233	0.00E+00	< 1.26E-03	Not applicable	Not calculable
U-234	0.00E+00	1.21E-02	Not applicable	Not calculable
U-235	2.68E-04	4.89E-04	No	1.82E+00
U-236	0.00E+00	4.96E-04	Not applicable	Not calculable
U-238	1.55E-02	1.34E-02	Yes	8.65E-01

Tank 19 data:

Table 7: Tank 19 Sodium Peroxide Data

Element	WCS Estimate (mg/kg)	SRNL Measurement (mg/kg)	Was our estimate conservative?	Sample : Prediction Ratio
Al	9.80E+02	1.34E+01	Yes	1.37E-02
B	Not modeled	< 7.02E-3	Not applicable	Not calculable
Ba	3.45E+01	8.67E-02	Yes	2.51E-03
Ca	4.99E+02	9.80E-01	Yes	1.96E-03
Cd	Not modeled	8.96E-03	Not applicable	Not calculable
Ce	4.93E+01	< 3.74E-01	Yes	7.59E-03
Co	2.63E+00	< 1.83E-02	Yes	6.96E-03
Cr	4.16E+01	3.59E-02	Yes	8.64E-04
Cu	2.96E+01	< 4.17E-03	Yes	1.41E-04
Fe	4.77E+03	1.85E+00	Yes	3.87E-04
La	2.96E+01	< 1.12E-01	Yes	3.78E-03
Li	Not modeled	< 7.83E-03	Not applicable	Not calculable
Mg	1.64E+01	2.40E-01	Yes	1.46E-02
Mn	2.20E+02	1.28E-01	Yes	5.84E-04
Mo	Not modeled	< 9.02E-03	Not applicable	Not calculable
Ni	0.00E+00	< 2.84E-02	No	Not calculable
P	Not modeled	< 7.34E-02	Not applicable	Not calculable
Pb	4.93E+01	< 2.47E-01	Yes	5.01E-03
Se	Not modeled	Not measured	Not applicable	Not calculable
Si	1.77E+02	1.01E+01	Yes	5.72E-02
Sn	Not modeled	< 4.57E-01	Not applicable	Not calculable
Sr	1.27E+01	2.17E-02	Yes	1.70E-03
Ti	0.00E+00	5.58E-02	No	Not calculable
V	Not modeled	< 1.08E-02	Not applicable	Not calculable
Zn	5.91E+01	< 7.37E-03	Yes	1.25E-04
	WCS Estimate (mCi/kg)	SRNL Measurement (mCi/kg)	Was our estimate conservative?	Sample : Prediction Ratio
Am-241	0.00E+00	1.53E-01	No	Not calculable
Cs-137	1.97E-01	8.09E+02	No	4.11E+03
Np-237	0.00E+00	< 7.72E-04	No	Not calculable

Table 7: Tank 19 Sodium Peroxide Data

Pu-238	4.62E-01	5.64E-01	No	1.22E+00
Pu-239	6.60E-02	3.04E-01	No	4.61E+00
Pu-240	1.47E-02	< 2.49E-01	No	1.69E+01
Pu-241	1.52E+00	< 1.07E+00	Yes	7.04E-01
Pu-242	3.60E-05	< 4.18E-03	No	1.16E+02
Sr-90	2.82E+00	< 7.04E-01	Yes	2.50E-01
Tc-99	1.07E-03	1.05E-01	No	9.79E+01
U-233	0.00E+00	< 1.06E-02	No	Not calculable
U-234	0.00E+00	< 6.84E-03	No	Not calculable
U-235	0.00E+00	1.77E-05	No	Not calculable
U-236	0.00E+00	< 6.99E-05	No	Not calculable
U-238	1.09E-03	6.15E-04	Yes	5.65E-01

Table 8: Tank 19 Aqua Regia Data

Element	WCS Estimate (mg/kg)	SRNL Measurement (mg/kg)	Was our estimate conservative?	Sample : Prediction Ratio
Ag	5.92E+01	1.09E-02	Yes	1.84E-04
Al	9.80E+02	1.36E+01	Yes	1.39E-02
As	Not modeled	< 1.08E-03	Not applicable	Not calculable
B	Not modeled	< 4.05E-03	Not applicable	Not calculable
Ba	3.45E+01	9.38E-02	Yes	2.72E-03
Ca	4.99E+02	8.38E-01	Yes	1.68E-03
Cd	Not modeled	1.26E-02	Not applicable	Not calculable
Ce	4.93E+01	<3.04E-01	Yes	6.17E-03
Co	2.63E+00	8.22E-03	Yes	3.13E-03
Cr	4.16E+01	3.49E-02	Yes	8.39E-04
Cu	2.96E+01	< 3.59E-03	Yes	1.21E-04
Fe	4.77E+03	1.97E+00	Yes	4.14E-04
Hg	1.22E+01	< 6.40E-03	Yes	5.24E-04
K	6.45E+01	< 1.11E-02	Yes	1.72E-04
La	2.96E+01	< 1.46E-02	Yes	4.93E-04
Li	Not modeled	< 3.07E-03	Not applicable	Not calculable
Mg	1.64E+01	2.63E-01	Yes	1.60E-02
Mn	2.20E+02	1.44E-01	Yes	6.56E-04
Mo	Not modeled	9.38E-03	Not applicable	Not calculable
Na	1.59E+03	1.68E+01	Yes	1.06E-02
Ni	0.00E+00	1.41E-02	No	Not calculable
P	Not modeled	< 3.66E-02	Not applicable	Not calculable
Pb	4.93E+01	< 4.84E-02	Yes	9.82E-04
Se	Not modeled	< 1.09E-03	Not applicable	Not calculable
Sn	Not modeled	< 2.31E-02	Not applicable	Not calculable
Sr	1.27E+01	1.94E-02	Yes	1.53E-03
Ti	0.00E+00	5.78E-02	No	Not calculable
V	Not modeled	8.79E-03	Not applicable	Not calculable
Zn	5.91E+01	< 5.41E-03	Yes	9.15E-05








Table 8: Tank 19 Aqua Regia Data

Zr	9.85E+01	1.62E-02	Yes	1.65E-04
	WCS Estimate (mCi/kg)	SRNL Measurement (mCi/kg)	Was our estimate conservative?	Sample : Prediction Ratio
Am-241	0.00E+00	1.29E-01	No	Not calculable
Cs-137	1.97E-01	8.40E+02	No	4.26E+03
Np-237	0.00E+00	< 6.66E-04	No	Not calculable
Pu-238	4.62E-01	4.58E-01	Yes	9.92E-01
Pu-239	6.60E-02	2.40E-01	No	3.63E+00
Pu-240	1.47E-02	< 2.24E-01	No	1.52E+01
Pu-241	1.52E+00	< 4.22E+00	No	2.78E+00
Pu-242	3.60E-05	< 3.47E-03	No	9.40E+01
Se-79	5.44E-05	< 6.54E-04	No	1.20E+01
Sr-90	2.82E+00	< 6.30E+00	No	2.23E+00
Tc-99	1.07E-03	8.48E-02	No	7.93E+01
U-233	0.00E+00	< 8.83E-03	No	Not calculable
U-234	0.00E+00	< 5.69E-03	No	Not calculable
U-235	0.00E+00	1.63E-05	No	Not calculable
U-236	0.00E+00	< 6.87E-05	No	Not calculable
U-238	1.09E-03	5.13E-04	Yes	4.72E-01

Results:

The results captured in this section reflect whole tank comparisons including both methods of dissolution used at SRNL. Unless otherwise noted, the color key for the figures and Tables in this section is as follows:

Figure 2: Color Key for Results Section

	WCS conservatively models this species
	WCS does not conservatively model this species
	WCS does not model this species, but it was measured at SRNL
	WCS models conservatively against sodium peroxide measurements only
	WCS models conservatively against aqua regia measurements only
	(For Tank 18 only) WCS provides mixed results between mounds
	This species was neither modeled by WCS nor measured by SRNL

Tank 5 results:

Figure 3: Tank 5 Non-radiological Species

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu				
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr				

Note: Mercury and sodium were only measured in aqua regia dissolution for Tank 5.

Table 9: Tank 5 Nuclides of Radiological Interest

Co	60				
Se	79				
Sr	90				
Tc	99				
Cs	137				
Eu	154				
U	233	234	235	236	238
Np	237				
Pu	238	239	240	241	242
Am	241	242	243	244	
Cm	242	244			

Note: Curium, cobalt, strontium, cesium, and americium were only measured in aqua regia solutions.

Tank 18 results:

Figure 4: Tank 18 Southwest Mound Non-radiological Species

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu				
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr				

Note: Sodium, potassium, zirconium, silver, and mercury were not measured in sodium peroxide solution. Silicon was not measured in aqua regia solution.

Table 10: Tank 18 Southwest Mound Nuclides of Radiological Interest

Co	60				
Se	79				
Sr	90				
Tc	99				
Cs	137				
Eu	154				
U	233	234	235	236	238
Np	237				
Pu	238	239	240	241	242
Am	241	242	243	244	
Cm	242	244			

Figure 5: Tank 18 Northeast Mound Non-radiological Species

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu				
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr				

Note: Sodium, potassium, zirconium, silver, and mercury were not measured in sodium peroxide solution. Silicon was not measured in the aqua regia solution

Table 11: Tank 18 Northeast Mound Nuclides of Radiological Interest

Co	60				
Se	79				
Sr	90				
Tc	99				
Cs	137				
Eu	154				
U	233	234	235	236	238
Np	237				
Pu	238	239	240	241	
Am	241	242	243	244	
Cm	242	244			

Figure 6: Tank 18 Combination of Both Mounds Non-radiological Species

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu				
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr				

Note: Cobalt was only modeled in the southwest mound, and titanium was only modeled in the northeast mound. Both of these elements, when modeled, were modeled non-conservatively.

Table 12: Tank 18 Combination of Both Mounds Nuclides of Radiological Interest

Co	60																		
Se	79																		
Sr	90																		
Tc	99																		
Cs	137																		
Eu	154																		
U	233	234	235	236	238														
Np	237																		
Pu	238	239	240	241	242														
Am	241	242	243	244															
Cm	242	244																	

Tank 19:

Figure 7: Tank 19 Non-radiological Species

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu				
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr				

Table 13: Tank 19 Nuclides of Radiological Interest

Co	60				
Se	79				
Sr	90				
Tc	99				
Cs	137				
Eu	154				
U	233	234	235	236	238
Np	237				
Pu	238	239	240	241	242
Am	241	242	243	244	
Cm	242	244			

Conclusion:

It is important to consider data such as sample results when using WCS to predict residual tank inventory. In Tank 19, only ^{238}U was conservatively estimated in both types of solution (16% conservative estimations against both types of solution combined). In Tank 5, the WCS estimated radioactive species conservatively 52% of the time. Tank 18 radionuclides were estimated conservatively in 44% of measurements in the northeast mound and in 41% of measurements in the southwest mound (42% percent of radionuclides overall). Table & shows a predicted

The precision of the analytical techniques used to evaluate tank samples should also be considered when comparing the WCS against sample data. Each value in the "SRNL measurement" column presented in Tables 1-8 represents an average of three measurements taken by the lab. While most measures of relative standard deviation were under 20%, for a few species, the relative standard deviation ranged as high as 153% (for Sr-90 in Tank 18, SW mound) [3].

As discussed in the data section of this report, the concentration of some species was below minimum detection limits. Since the concentration of these species is only known to be within a range and is not a pinpointed value, it is difficult to compare the concentration of these species to the WCS values with confidence in the validity of these comparisons.

Homogeneity and sampling issues provide a third consideration with respect to the accuracy of this inventory comparison. Tanks 18 and 19 have been slurried to homogenize their contents, so it is likely that samples from these tanks will be similar and that fewer samples would be needed in order to accurately characterize their contents. Tank 5 has undergone two mixing campaigns, but its contents may not have not been thoroughly slurried. Therefore, it cannot be assumed that the sample from Tank 5 is homogeneous or that one sample taken from the tank could accurately characterize the overall contents.

The chemical inventory comparison between the WCS and sample data still has worth to our evaluation of the WCS's predictive value. While the precision of the sample results prevents an exact number-by-number comparison of the WCS and the data, for data points which are known above the minimum detection limit, a valid comparison between samples and the WCS can be made on the order of magnitude.

In this inventory comparison, for species present above minimum detection limits, if the WCS value is more than one order of magnitude greater than the sample results, the WCS can be considered a conservative estimate of that species. For a species where the WCS is more than an order of magnitude below the sample concentration average, the WCS can be considered non-conservative. When the WCS and the sample average are on the same order of magnitude, the WCS can be considered a relatively accurate estimate. For species not present above the minimum detection limit, no accurate comparison between the WCS and the concentration of that species can be made, unless the WCS prediction is higher than the minimum detection limit. In this case, the WCS makes a conservative estimate of that species. The degree to which the WCS and sample data are in alignment for each species of each tank are shown in Tables 1-8.

Recommendations:

The following is a list of recommendations on how to improve further comparisons of sample data and the WCS:

- 1) When cost-effective, additional sampling can provide improved characterization of tank contents. If additional sampling is pursued, samples should only be taken after the tank has been slurried. This will ensure that the contents of the tank are as homogenous as possible before sampling and characterization.
- 2) In order to improve the characterization of the samples, minimum detection limits should be decreased where possible. This would increase analytical costs, but would allow for a more precise and accurate sample characterization, which creates better datapoints for comparison to our model. Additionally, if the current samples are still available, recharacterizing them would be less expensive than resampling the tanks.
- 3) Species which have been found in the samples but modeled as zero in the WCS should be remodeled. This will require backfitting sample results to determine the amount of these species present, but it will improve the WCS's ability to predict the inventory of the tanks.
- 4) Recognizing that the WCS was originally designed to monitor the tank farms primarily for criticality concerns, it is highly recommended that efforts to update the design of this model be continued. Though this is an expensive, time-consuming option, forty-nine out of fifty-one tanks remain to be closed. This process will undoubtedly take many years, but the usefulness of a more accurate tank inventory model would improve confidence in predicted closure inventories.

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