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Tank 18 Residual Characterization Report

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1.0 SUMMARY

This document develops the characterization for Tank 18 residual material. Samples of the residual material have been taken at various locations within the tank to ensure the residual material was adequately represented. These samples were analyzed to determine the composition of the various material populations. Each population's inventory was developed and totaled to determine the complete Tank 18 inventory.

The approach taken developed three inventories with different levels of conservatism. The multiple characterizations allow the end use to drive the appropriate characterization chosen (e.g. deterministic model fate and transport analysis or probabilistic uncertainty analysis). The three characterizations developed were Average, Best Estimate and Reasonably Conservative. The purpose of the various characterizations was to provide a range of conservatisms starting with a slight conservatism level (Average). Then a second level was to provide a moderate level of conservatism (Best Estimate). Lastly, an upper conservative level was set as one that reaches the upper level of practicality (Reasonably Conservative) without reaching an unrealistic or bounding level.

When developing each characterization, the various population inventories were developed using values at that characterization's conservatism level. This approach was used for both the floor and the wall inventories and provided a consistent level of conservatism throughout the entire characterization.

2.0 APPROACH

The methodology used to develop the characterization summed the inventory from discrete areas of the waste tank. The inventory for each area was determined by taking the material concentration and multiplying it by the corresponding volume (or surface area). This was repeated for each constituent (radionuclides and non-radionuclides).

$$T_j = \sum (V_i \times c_{ij})$$

Where: T_j = Total Inventory for constituent j

V_i = Volume of area i

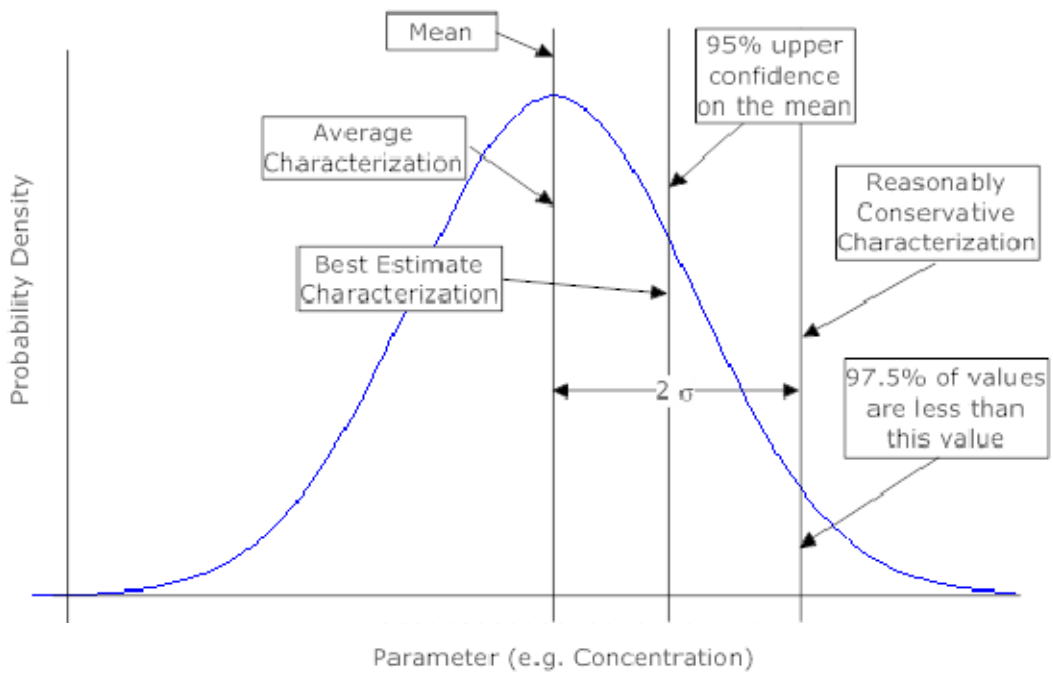
c_{ij} = Concentration of constituent, j, in area, i

This methodology was repeated to develop three types of residual inventory characterizations. The first inventory characterization is described as an "Average" inventory. The second characterization is described as the "Best Estimate" inventory. The Best Estimate represents the nominal Tank 18 inventory at closure. The third inventory characterization is described as "Reasonably Conservative". This characterization provides more conservatism by increasing the inventory quantities. This varied approach provides multiple Tank 18 inventory characterizations which can be used as appropriate for different performance assessment modeling scenarios or other evaluations.

For the Best Estimate characterization, values which reflect the uncertainty were used. Values reflecting the expected inventory (with a moderate level of conservatism) were desired with this characterization. For this reason, values representing the 95% confidence on the mean were used. This approach reflects the desire to add some conservatism over the average values. For components where an explicit confidence value could not be determined, a value approximating this level of conservatism was chosen.

For the Reasonably Conservative characterization, additional conservatism was used. This characterization increased the margin provided over the Best Estimate characterization, but does not reach a physically bounding level of conservatism. Figure 2.0-1 illustrates the various levels conservatisms and the approaches used in this document.

Figure 2.0-1: Illustration of various levels of conservatism



Although there are three types of characterizations, the methodology used to determine each characterization is the same. The differences are in the specific values used in the methodology.

3.0 DISCRETE AREA INVENTORIES

As described above, the methodology used to develop the characterizations sums the inventories from discrete areas of the waste tank. The discrete areas to be determined are listed below.

- Waste tank floor
- Waste tank wall
- Other potential equipment hold-up – e.g. pumps

3.1 Tank Floor

The floor residual inventory was developed using the residual floor volume and the concentrations for both radionuclides and non-radionuclides.

The floor inventory was determined by multiplying the floor volume by the concentration (for each constituent). Samples were taken of the residual material on the floor and analyzed to determine the concentrations. These concentrations were in terms of dried solids mass; therefore, conversion to a volume basis was needed. For this reason, the density and solids content (dry solids to wet solids) were also measured.

3.1.1 Concentration

Working with statistical experts in the Applied Computational Engineering and Statistics Group in the Savannah River National Laboratory, a basis was developed for the number of locations and quantity of residual samples required to sufficiently characterize the residuals. [SRNL-STI-2009-00782] The sampling strategy used the tank waste removal history as a guide when developing the sampling basis. Previous samples and analyses, showed the possibility of two different populations. With a basis of three samples to characterize a population being used and to allow for the possibility of two populations, two sets of three samples were recommended. This would provide three samples per population should two populations be found. If only one population was found, the six samples could be combined into one data set which would decrease the uncertainty and improve the confidence limits.

The sample locations were chosen to ensure that the different regions of the tank floor were represented and took into account the configuration of the residual material. The tank was partitioned into six equal sectors and a sample was taken from each of these sectors. To assess the location of different populations, the sample locations were chosen to distinguish between possible different tank halves and to distinguish between differences in the center region of the tank from the outer region near the tank wall. It was also recommended that an additional two samples be obtained as archive samples to provide contingency. For more information, refer to Recommendations for Sampling of Tank 18 in F Tank Farm. [SRNL-STI-2009-00782] Figure 3.1-1 illustrates the sample locations.

As discussed later, the sample results show the material to be similar enough to be characterized as one population. This analysis provides high confidence that more than enough samples were taken to represent the residual material and characterize the inventory.

The six samples were analyzed by SRNL to characterize the constituents listed in Table 3.1-1. [SRNL-STI-2010-00386] Each sample was analyzed for the target analytes. A majority of the analytes was digested in triplicate and each resulting solution analyzed for the requested constituents. For a few constituents, it was recognized that reaching the target detection limits was going to be challenging and thus, new or modified analytical methods and/or additional sample material were required to achieve these detection limit values. Special emphasis was placed on achieving these target detection limits for at least one sample location. Also, there were a set of constituents where the purpose of the analysis was to confirm that the constituent was not present or present only in extremely low concentrations. These analyses were also expected to be challenging. Only one replicate per sample was

performed for these analytes. For additional details on the sample analyses, refer to SRNL-STI-2010-00386.

Figure 3.1-1: Tank 18 Floor Sample Locations

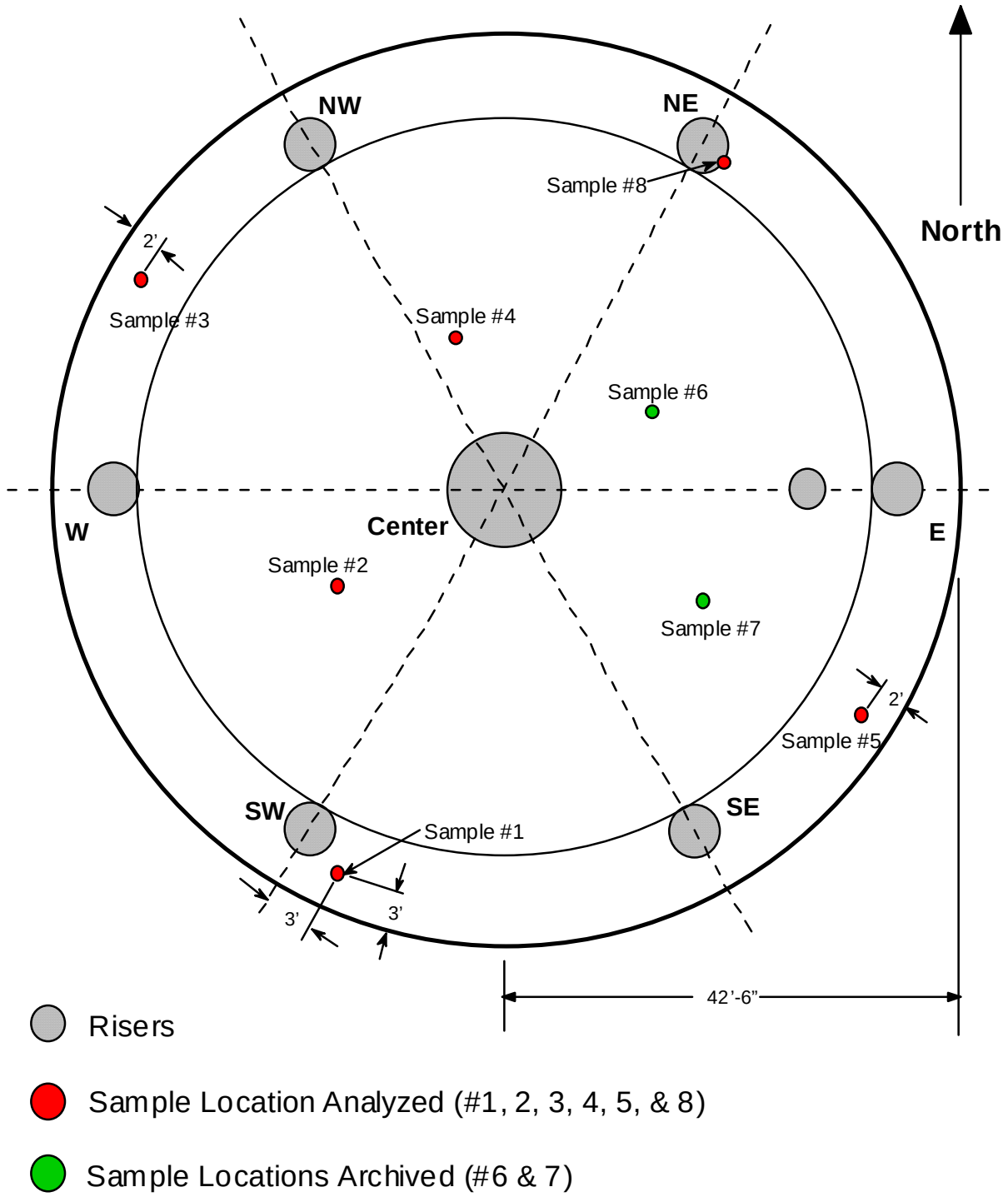
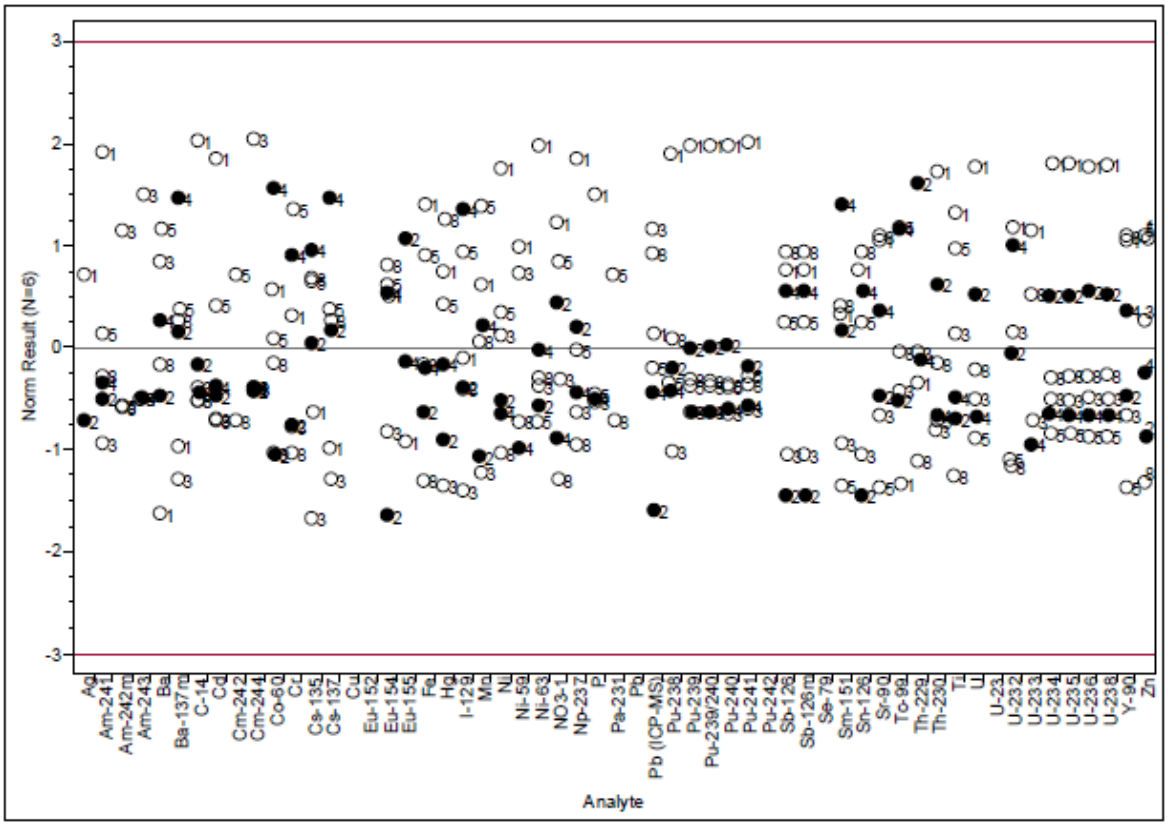


Table 3.1-1: Tank 18 Floor Constituents

Ac-227	Cm-243	Eu-154	Pa-231	Ra-226	Th-230	Ag	Mn
Al-26	Cm-244	H-3	Pd-107	Sb-126	U-232	As	Ni
Am-241	Cm-245	I-129	Pt-193	Sb-126m	U-233	Ba	NO_2
Am-242m	Cm-247	K-40	Pu-238	Se-79	U-234	Cd	NO_3
Am-243	Cm-248	Nb-93m	Pu-239	Sm-151	U-235	Cr	Pb
Ba-137m	Co-60	Nb-94	Pu-240	Sn-126	U-236	Cu	Sb
C-14	Cs-135	Ni-59	Pu-241	Sr-90	U-238	F	Se
Cf-249	Cs-137	Ni-63	Pu-242	Tc-99	Y-90	Fe	U
Cl-36	Eu-152	Np-237	Pu-244	Th-229	Zr-93	Hg	Zn

A statistical study of the sampling results was performed and demonstrated the ability to characterize the tank as one population. [SRNL-STI-2010-00401] The study showed that a comparison of the range of relative standard deviations to the mean fell within a three sigma limit. Figure 3.1-2 shows the relative standard deviation for each sample. Each data point was calculated by subtracting the average and dividing by the standard deviation. The data proves to be well behaved since all fit within a range of plus and minus three standard deviations in as shown Figure 3.1-2. This is also important because it provides high confidence that the number of samples analyzed was more than enough to characterize the residual material on the floor. For additional details, refer to the Statistical Analysis of Tank 18F Floor Sample Results. [SRNL-STI-2010-00401]

Figure 3.1-2: Relative Standard Deviations for the Tank 18 Sample Results



This study proceeded to determine the means, standard deviations, and upper 95% confidence limits for those constituents where sample analyses provide measured results. This included constituents where the sample results were mixed with measured values and detection limits. For these constituents, only the measured values were used to calculate the statistics. The 95% upper confidence limits were used to determine the Best Estimate inventory. For the Reasonably Conservative inventory, the concentration used was determined by adding two times the standard deviation to the average sample result. For a subset of these Reasonably Conservative concentrations, an adjustment was needed. In some cases the number of measured results was minimal. Since only the measured values were used to determine the statistical parameters, the statistical analysis of this subset was affected by the limited number of measured results and resulted in increasing the variance and the 95% confidence limit significantly. When the 95% confidence limits were compared to the 'average plus two sigma' value, the 95% confidence limit was greater than the average plus two sigma values. In these cases, the Reasonably Conservative value used the 95% confidence limit (the larger concentration) as the value for its concentration.

There were some constituents that were not detected in any of the samples and results returned only detection limits. In this case, there was no statistical analysis performed. The analysis of constituents with very low concentrations reached the limits of the analytical equipment and procedures. Based on many factors, such as interference from other radionuclides, the reported detection limit can differ between sample analyses. For the Best Estimate characterization, the lowest detection limit reached was chosen as the concentration for the tank. The highest detection limit was chosen for the Reasonably Conservative characterization.

For two radionuclides (Cl-36 and Ra-226), additional efforts were taken to measure to lower concentrations. In both of these analyses, the radionuclides were first measured in all the samples. Then one sample was selected and additional work and time was taken to measure to lower concentrations. This resulted in detection limits significantly lower than the first set of detection limits reached. Since there was a significant difference between the detection limits, using the highest detection limit for the Reasonably Conservative characterization was not considered to be appropriate. Therefore, conservatism was added to the low detection limit to represent the Reasonably Conservative characterization. This conservatism was one order of magnitude greater than the low detection limit used in the Best Estimate characterization.

The Tank 18 waste tank floor residual material was assumed to include two distinct regions, the southwest area of the waste tank and the remaining waste tank area based on previous sample analyses. [WSRC-TR-2003-00449] As shown in Figure 3.1-2, recent statistical analysis showed the samples analyzed are within three sigma limits and thus could be characterized as one population. [SRNL-STI-2010-00401] By characterizing Tank 18 as one population, an additional conservatism is statistically added to the conservatism already present in the Best Estimate characterization.

The Tank 18 concentrations were determined for each of the needed characterizations, Average, Best Estimate, and Reasonability Conservative. Table 3.1-2 lists the floor concentrations for these various characterizations.

Table 3.1-2: Tank 18 Floor Concentrations

Constituent	Units	Concentrations			Constituent	Units	Concentrations		
		Average	BE	RC			Average	BE	RC
Ac-227	µCi/g	<1.1E-05	<1.1E-05	<5.3E-04	Ra-226	µCi/g	<1.7E-04	<1.7E-04	<1.7E-04
Al-26	µCi/g	<9.6E-06	<9.6E-06	<6.7E-05	Sb-126	µCi/g	8.5E-05	9.1E-05	1.0E-04
Am-241	µCi/g	4.8E+00	6.1E+00	7.9E+00	Sb-126m	µCi/g	6.1E-04	6.5E-04	7.2E-04
Am-242m	µCi/g	6.0E-04	2.0E-03	2.2E-03	Se-79	µCi/g	<2.4E-05	<2.4E-05	<8.4E-05
Am-243	µCi/g	3.7E-02	1.2E-01	1.7E-01	Sm-151	µCi/g	1.6E+00	2.0E+00	2.5E+00
Ba-137m	µCi/g	3.0E+02	3.6E+02	4.5E+02	Sn-126	µCi/g	6.1E-04	6.5E-04	7.2E-04
C-14	µCi/g	2.2E-02	4.5E-02	7.8E-02	Sr-90	µCi/g	5.1E+01	6.1E+01	7.5E+01
Cf-249	µCi/g	<1.2E-04	<1.2E-04	<5.9E-03	Tc-99	µCi/g	3.9E-02	4.5E-02	5.5E-02
Cl-36	µCi/g	<1.4E-05	<1.4E-05	<1.4E-04	Th-229	µCi/g	2.6E-05	4.4E-05	6.4E-05
Cm-243	µCi/g	<1.2E-03	<1.2E-03	<1.7E-01	Th-230	µCi/g	6.5E-05	1.0E-04	1.6E-04
Cm-244	µCi/g	2.5E+00	7.2E+00	1.4E+01	U-232	µCi/g	2.4E-05	3.8E-05	5.9E-05
Cm-245	µCi/g	<5.9E-04	<5.9E-04	<1.3E-02	U-233	µCi/g	9.9E-04	1.3E-03	1.5E-03
Cm-247	µCi/g	<1.1E-07	<1.1E-07	<5.1E-06	U-234	µCi/g	8.4E-03	1.4E-02	2.3E-02
Cm-248	µCi/g	<4.8E-06	<4.8E-06	<2.3E-04	U-235	µCi/g	3.3E-04	5.6E-04	8.9E-04
Co-60	µCi/g	2.7E-02	3.3E-02	4.2E-02	U-236	µCi/g	2.8E-04	4.7E-04	7.3E-04
Cs-135	µCi/g	1.2E-03	1.5E-03	2.0E-03	U-238	µCi/g	8.3E-03	1.4E-02	2.2E-02
Cs-137	µCi/g	3.2E+02	3.8E+02	4.8E+02	Y-90	µCi/g	5.1E+01	6.1E+01	7.5E+01
Eu-152	µCi/g	<4.0E-04	<4.0E-04	<8.7E-04	Zr-93	µCi/g	2.5E-03	3.8E-03	6.3E-03
Eu-154	µCi/g	2.2E-02	2.4E-02	2.7E-02	Ag	wt%	1.9E-02	2.2E-02	2.6E-02
H-3	µCi/g	<7.2E-04	<7.2E-04	<3.1E-03	As	wt%	<4.3E-04	<4.3E-04	<6.0E-04
I-129	µCi/g	1.1E-05	1.3E-05	1.7E-05	Ba	wt%	2.3E-02	2.7E-02	3.3E-02
K-40	µCi/g	6.7E-04	8.1E-04	9.0E-04	Cd	wt%	6.8E-01	8.0E-01	9.8E-01
Nb-93m	µCi/g	2.5E-03	3.8E-03	6.3E-03	Cr	wt%	5.7E-02	6.1E-02	6.6E-02
Nb-94	µCi/g	<2.8E-05	<2.8E-05	<2.6E-04	Cu	wt%	<9.1E-03	<9.1E-03	<1.3E-02
Ni-59	µCi/g	1.2E-02	1.6E-02	2.0E-02	F	wt%	3.3E-02	4.2E-02	5.4E-02
Ni-63	µCi/g	6.8E-01	8.5E-01	1.1E+00	Fe	wt%	8.7E+00	9.5E+00	1.1E+01
Np-237	µCi/g	5.1E-03	7.0E-03	9.8E-03	Hg	wt%	6.2E-02	8.6E-02	1.2E-01
Pa-231	µCi/g	4.4E-04	2.3E-03	1.3E-03	Mn	wt%	1.1E+00	1.2E+00	1.4E+00
Pd-107	µCi/g	4.7E-03	6.2E-03	8.3E-03	Ni	wt%	1.0E-01	1.2E-01	1.4E-01
Pt-193	µCi/g	<2.1E-04	<2.1E-04	<2.9E-03	NO_3	wt%	3.2E-02	4.1E-02	5.3E-02
Pu-238	µCi/g	4.0E+00	4.8E+00	6.1E+00	NO_2	wt%	2.9E-02	4.8E-02	7.6E-02
Pu-239	µCi/g	9.6E+00	1.3E+01	1.7E+01	Pb	wt%	4.5E-02	5.8E-02	7.6E-02
Pu-240	µCi/g	2.2E+00	2.9E+00	3.8E+00	Sb	wt%	<4.4E-02	<4.4E-02	<9.5E-02
Pu-241	µCi/g	1.0E+01	1.3E+01	1.6E+01	Se	wt%	<8.6E-04	<8.6E-04	<2.0E-03
Pu-242	µCi/g	<5.9E-04	<5.9E-04	<3.0E-02	U	wt%	2.8E+00	4.5E+00	7.0E+00
Pu-244	µCi/g	<1.7E-07	<1.7E-07	<1.4E-04	Zn	wt%	1.8E-02	2.0E-02	2.1E-02

3.1.2 Density

The density was measured for each of the six samples to allow for the conversion from the volume of the residual material to a mass basis. The sample analyses resulted in little variation between the multiple density measurements. This resulted in the same value to two significant figures. Table 3.1-3 contains the density value used for the inventory determinations. For additional information, refer to the Characterization of Additional Tank 18F Samples. [SRNL-STI-2010-00386]

Table 3.1-3: Tank 18 Floor Density

Density (g/ml)	1.1

3.1.3 Solids Content

For the analysis of the residual samples, the material was dried to remove the water content. Due to this, the sample analysis returns concentrations in terms of dried solids. To adjust the measured concentrations to appropriate concentrations of the residual material, the percentage of solids in the residual material was measured (Table 3.1-4). For additional information, refer to the Characterization of Additional Tank 18F Samples. [SRNL-STI-2010-00386]

Table 3.1-4: Tank 18 Floor Solids

Average	92%
Best Estimate (95% confidence)	96%
Reasonably Conservative (2 sigma)	100%

3.1.4 Volume

Following the final waste removal operations, residual material mapping of the Tank 18 volume started. [U-ESR-F-00041] Material mapping is a method for determining the volume of materials inside of a waste tank. This method used video and still images to capture the relative depth of material in the tank in relation to known landmarks. Following material removal operations over 140 photographs were taken of the interior of Tank 18 using a high quality digital camera at various locations and elevations inside the tank. The pictures were inspected by a team for evidence of the lifting plates and other landmarks that could be used for depth measurements. These depths were then plotted over an area to determine the residual material volume. The method employed to develop the volume provided a slight conservatism based on the volume uncertainty developed in Tank 18 Volume Estimation Following Mantis Cleaning Operations. [U-ESR-F-00041] Based on this approach the volume of 3900 gal was used for the Best Estimate characterization. The level of conservatism was similar to that of the Best Estimate approach.

The uncertainty of the volume estimation process for the residual material on the floor was also assessed. To perform the assessment, ten areas (randomly selected) of the floor were chosen to be re-mapped. Video inspections and photographs for these areas were given to the mapping team, but the previous volume determinations for the specified areas were not provided. The mapping team was asked to provide a low end depth, a high end depth, and a "best" depth for each area. These depths were then converted into volumes based on the area reviewed.

The ten area volumes were added together. The new mapping "best" volume for the ten areas was within 3% of the original mapping volume for the same areas. The high volume was 35% more than the original volume and the low volume was 30% less than the original volume. The Reasonably Conservative value was determined by adding an uncertainty of 35% to the Best Estimate volume.

As an average value to use in calculations for a residual inventory, 3900 gal was chosen. This is the same value used in the Best Estimate characterization which adds conservatism to the Average characterization.

For additional information associated with the volume determination process, refer to Tank 18 Volume Estimation Following Mantis Cleaning Operations. [U-ESR-F-00041] Table 3.1-5 contains the different volume determinations.

Table 3.1-5: Tank 18 Floor Volume

Average	3900 gal
Best Estimate	3900 gal
Reasonably Conservative	5300 gal

3.2 Waste Tank Wall

The tank wall was sampled to validate previous estimates of the corrosion material composition. Inspection of the waste tank wall with high quality digital cameras for sampling activities found residual material, referred to as scale, adhered to the wall in specific locations in addition to the corrosion material expected. The scale build up covered only a portion of the wall, whereas the corrosion film was assumed to cover the entire wall surface. Samples were collected of these two material types. Two samples were collected of the corrosion film and one sample of the scale. [SRNS-STI-2009-00416]

For the corrosion film characterization, the concentration of material was measured in the samples and multiplied across the entire surface area of the wall. The characterization of the material used the collected sample surface area to define the units. This characterization was then projected around the entire wall surface area to determine the wall corrosion material inventory. The scale build up concentrations were multiplied by the scale volume to determine the scale inventory.

3.2.1 Wall Concentrations

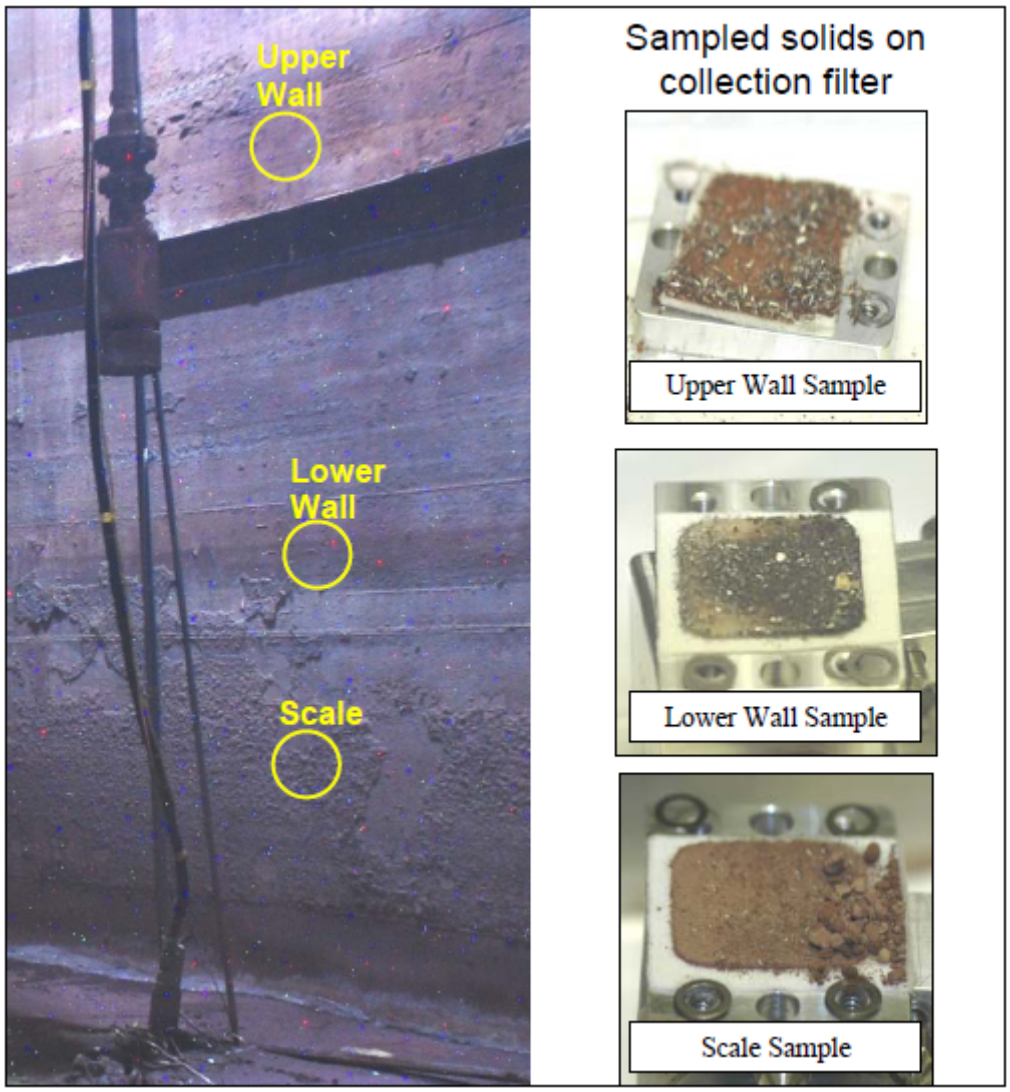
The three wall samples were taken by drilling into the wall material and using a device to capture the drilled material. [SRNS-STI-2009-00416] This captured material sample was then analyzed for the constituents listed in Table 3.2-1. The entire list of constituents analyzed in the floor samples was not analyzed in the wall samples due to analytical limitations in measuring very low concentrations.

Table 3.2-1: Tank 18 Wall Constituents

Am-241	Pu-239	U-233
Co-60	Pu-240	U-234
Cs-137	Pu-241	U-235
Np-237	Pu-242	U-236
Pu-238	Pu-244	U-238
	Sr-90	

The sampling of the wall resulted in two types of material. The first type (Upper and Lower Wall in Figure 3.2-1) was where the drill sampler collected both corrosion film and wall (steel) material. The drill sampler completely penetrated the material on the wall and into the steel at both of these locations. This was evident due to the metal shavings seen in the samples. The sample analysis determined the concentration for each constituent. Each sample area was inspected to determine the surface area associated with that sample. This surface area was then used to convert the concentrations from a mass basis to a surface area basis. This allowed the results to be projected around the entire tank wall surface and was independent of the amount of metal shavings collected with each sample.

Figure 3.2-1: Tank 18 Wall and Sampling Locations



The scale sample contained a limited amount of metal shavings. This was an indication that only the scale material was sampled. This allowed a concentration comparison to the material samples analyzed from the floor. Since the scale sample collection technique did not penetrate the tank wall, the same visual determination of the sample area used for the corrosion sample was not effective. Therefore, the sample analysis results were in terms of a mass basis concentration.

A statistical study was performed on the results of the wall samples analyses to determine the upper confidence limit on the concentrations for each analyzed constituent. The scale buildup radionuclide concentrations were found to compare reasonably well to the floor sample concentrations although the variance (difference between samples) measured did not match. [SRNL-STI-2010-00525] Since there were a limited numbers of scale samples to compare, the statistical study grouped all the wall samples (upper, lower, and scale) together to compare the concentrations and variances. The scale sample was composed of almost

entirely residual material, where the upper and lower wall samples contained significant portions of metal shavings. Therefore, it would be expected for there to be a greater variance in the wall samples, with different sample compositions, than in the floor samples, with similar sample compositions. Since the concentrations between the scale and floor samples were comparable, the floor sample concentrations statistics were used to determine for the scale inventory.

The statistical study also analyzed the non-radionuclide concentrations in the scale sample. For a number of the non-radionuclide concentrations, a difference was found when compared to the floor concentrations. A majority of the non-radionuclides where differences were found (e.g., Ba, Cr, Fe, Mg, Mn, Ni, Sr, and Zn), can be attributed to the constituents found in the tank wall steel and/or of the sampling equipment, specifically the drill bit. This brings into question the validity of the sample analysis results for those specific elements common to the residual material, the tank wall, and sample equipment. Without those common elements, the majority of the non-radionuclides concentrations match the residual floor material, except for those potentially impacted by the sampling technique. Therefore, the floor sample concentrations statistics were also applied to the scale non-radionuclide inventory.

As described above, in both the radionuclide and non-radionuclide inventories, the floor concentration statistics were used to determine the scale inventory. Application of the results using this approach has only a marginal impact on the inventory. The impact of the concentration statistics in the scale material is minimal due to the relative volume difference to the floor residual. In the Best Estimate characterization, the residual floor volume is 3900 gal as compared to 110 gal for the scale volume. The concentrations used for the scale material was the same as those for the floor material, Table 3.1-2.

For the upper and lower wall concentrations for the corrosion film material, the statistical analysis significantly increased the 95% confidence limits for the concentration, due to the limited number of samples. Due to the substantial additional conservatism, the same values were used for both the Best Estimate and Reasonably Conservative concentrations.

Since the complete list of constituents was not analyzed for these samples, the remaining constituent inventories needed to be determined. The floor sample results, for the specific constituent, were multiplied by the ratio of U-238 wall to floor results to determine the remaining constituents' wall concentrations. These concentrations were then multiplied by the upper and lower wall surface areas. Since the radionuclide concentrations were comparable to the floor concentrations for those radionuclides not measured, the ratio of floor concentrations to wall concentrations for U-238 was used. The basis for using U-238 as the constituent in this comparison was due to the confidence and ability to measure U-238. It is a prominent constituent in both the floor and wall samples which leads to the confidence in both measurements.

Table 3.2-2 lists the lower wall concentrations and Table 3.2-3 lists the upper wall concentrations used in determining the wall inventory.

For Pu-238, both the lower wall and the upper wall sample analyses returned unusually high concentration results. Due to the additional mass (metal shavings) in the wall samples, the

concentrations for all other radionuclides decreased relative to the floor samples. However, the Pu-238 concentration in the wall samples was higher than the floor samples. The concentrations of Pu-238 also showed an increase from the samples taken higher in the tank. This was unexpected and was not consistent with the sample analysis results for the other constituents.

Another anomaly was the different relative concentrations between the floor and the wall sample analyses for the Pu isotopes. For all the Pu isotopes, except Pu-238, the wall sample analyses were similar to the floor sample results for the same Pu isotopes. Since, chemically all the Pu isotopes behave the same, it is expected that all Pu isotopes, including Pu-238, have similar relative concentrations (floor versus wall concentrations).

Based on the rationale discussed above, the expected Pu-238 wall concentrations would be at least one order of magnitude less than the analytical value. Therefore, the measured concentrations are believed to be significantly conservative. While the use of the Pu-238 wall sample results is believed to be significantly conservative, these high concentrations results were used to determine the wall inventory characterizations due to the lack of any other objective data.

Table 3.2-2: Tank 18 Lower Wall Concentrations

Constituent	Units	Concentrations		Constituent	Units	Concentrations	
		Average	BE & RC			Average	BE & RC
Ac-227	Ci/ft^2	1.4E-09	2.4E-09	Ra-226	Ci/ft^2	2.2E-08	3.9E-08
Al-26	Ci/ft^2	1.3E-09	2.2E-09	Sb-126	Ci/ft^2	1.1E-08	2.1E-08
Am-241	Ci/ft^2	7.5E-04	2.6E-03	Sb-126m	Ci/ft^2	8.0E-08	1.5E-07
Am-242m	Ci/ft^2	7.9E-08	4.5E-07	Se-79	Ci/ft^2	3.2E-09	5.4E-09
Am-243	Ci/ft^2	4.9E-06	2.6E-05	Sm-151	Ci/ft^2	2.2E-04	4.5E-04
Ba-137m	Ci/ft^2	3.2E-01	1.5E+00	Sn-126	Ci/ft^2	8.0E-08	1.5E-07
C-14	Ci/ft^2	2.9E-06	1.0E-05	Sr-90	Ci/ft^2	7.7E-02	1.8E-01
Cf-249	Ci/ft^2	1.5E-08	2.6E-08	Tc-99	Ci/ft^2	5.1E-06	1.0E-05
Cl-36	Ci/ft^2	1.9E-09	3.2E-09	Th-229	Ci/ft^2	3.5E-09	1.0E-08
Cm-243	Ci/ft^2	1.5E-07	2.6E-07	Th-230	Ci/ft^2	8.6E-09	2.3E-08
Cm-244	Ci/ft^2	3.3E-04	1.6E-03	U-232	Ci/ft^2	3.1E-09	8.6E-09
Cm-245	Ci/ft^2	7.8E-08	1.3E-07	U-233	Ci/ft^2	7.1E-07	9.9E-07
Cm-247	Ci/ft^2	1.4E-11	2.4E-11	U-234	Ci/ft^2	3.5E-06	4.1E-06
Cm-248	Ci/ft^2	6.3E-10	1.1E-09	U-235	Ci/ft^2	4.6E-08	1.4E-07
Co-60	Ci/ft^2	2.0E-05	6.5E-05	U-236	Ci/ft^2	1.4E-07	1.8E-07
Cs-135	Ci/ft^2	1.6E-07	3.4E-07	U-238	Ci/ft^2	1.1E-06	3.2E-06
Cs-137	Ci/ft^2	3.4E-01	1.6E+00	Y-90	Ci/ft^2	7.7E-02	1.8E-01
Eu-152	Ci/ft^2	5.3E-08	9.1E-08	Zr-93	Ci/ft^2	3.3E-07	9.8E-07
Eu-154	Ci/ft^2	2.9E-06	5.5E-06	Ag	kg/ft^2	2.6E-06	5.1E-05
H-3	Ci/ft^2	9.5E-08	1.6E-07	As	kg/ft^2	5.7E-08	9.7E-07
I-129	Ci/ft^2	1.5E-09	3.1E-09	Ba	kg/ft^2	3.0E-06	6.1E-05
K-40	Ci/ft^2	8.9E-08	1.8E-07	Cd	kg/ft^2	8.9E-05	1.8E-03
Nb-93m	Ci/ft^2	3.3E-07	9.8E-07	Cr	kg/ft^2	7.5E-06	1.4E-04
Nb-94	Ci/ft^2	3.7E-09	6.3E-09	Cu	kg/ft^2	1.2E-06	2.1E-05
Ni-59	Ci/ft^2	1.5E-06	3.7E-06	F	kg/ft^2	4.3E-06	9.5E-05
Ni-63	Ci/ft^2	9.0E-05	1.9E-04	Fe	kg/ft^2	1.1E-03	2.2E-02
Np-237	Ci/ft^2	6.4E-07	1.5E-06	Hg	kg/ft^2	8.2E-06	1.9E-04
Pa-231	Ci/ft^2	5.8E-08	5.2E-07	Mn	kg/ft^2	1.4E-04	2.7E-03
Pd-107	Ci/ft^2	6.3E-07	1.4E-06	Ni	kg/ft^2	1.4E-05	2.7E-04
Pt-193	Ci/ft^2	2.8E-08	4.7E-08	NO_3	kg/ft^2	4.3E-06	9.3E-05
Pu-238	Ci/ft^2	9.1E-03	2.8E-02	NO_2	kg/ft^2	3.8E-06	1.1E-04
Pu-239	Ci/ft^2	1.1E-03	3.6E-03	Pb	kg/ft^2	6.0E-06	1.3E-04
Pu-240	Ci/ft^2	2.5E-04	7.9E-04	Sb	kg/ft^2	5.9E-06	1.0E-04
Pu-241	Ci/ft^2	3.5E-03	6.9E-03	Se	kg/ft^2	1.1E-07	1.9E-06
Pu-242	Ci/ft^2	1.7E-07	5.9E-07	U	kg/ft^2	3.7E-04	1.0E-02
Pu-244	Ci/ft^2	<1.9E-10	<1.9E-10	Zn	kg/ft^2	2.4E-06	4.4E-05

Table 3.2-3: Tank 18 Upper Wall Concentrations

Constituent	Units	Concentrations		Constituent	Units	Concentrations	
		Average	BE & RC			Average	BE & RC
Ac-227	Ci/ft^2	3.3E-09	5.6E-09	Ra-226	Ci/ft^2	5.3E-08	8.9E-08
Al-26	Ci/ft^2	3.0E-09	5.0E-09	Sb-126	Ci/ft^2	2.6E-08	4.8E-08
Am-241	Ci/ft^2	2.5E-03	8.7E-03	Sb-126m	Ci/ft^2	1.9E-07	3.4E-07
Am-242m	Ci/ft^2	1.8E-07	1.0E-06	Se-79	Ci/ft^2	7.4E-09	1.3E-08
Am-243	Ci/ft^2	1.1E-05	6.1E-05	Sm-151	Ci/ft^2	5.1E-04	1.0E-03
Ba-137m	Ci/ft^2	7.3E-02	3.4E-01	Sn-126	Ci/ft^2	1.9E-07	3.4E-07
C-14	Ci/ft^2	6.8E-06	2.4E-05	Sr-90	Ci/ft^2	1.1E-01	2.6E-01
Cf-249	Ci/ft^2	3.6E-08	6.1E-08	Tc-99	Ci/ft^2	1.2E-05	2.4E-05
Cl-36	Ci/ft^2	4.3E-09	7.4E-09	Th-229	Ci/ft^2	8.1E-09	2.3E-08
Cm-243	Ci/ft^2	3.6E-07	6.1E-07	Th-230	Ci/ft^2	2.0E-08	5.4E-08
Cm-244	Ci/ft^2	7.8E-04	3.8E-03	U-232	Ci/ft^2	7.3E-09	2.0E-08
Cm-245	Ci/ft^2	1.8E-07	3.1E-07	U-233	Ci/ft^2	1.9E-06	2.6E-06
Cm-247	Ci/ft^2	3.3E-11	5.6E-11	U-234	Ci/ft^2	9.1E-06	1.1E-05
Cm-248	Ci/ft^2	1.5E-09	2.5E-09	U-235	Ci/ft^2	1.1E-07	3.1E-07
Co-60	Ci/ft^2	2.5E-05	8.0E-05	U-236	Ci/ft^2	4.2E-07	6.3E-07
Cs-135	Ci/ft^2	3.7E-07	8.0E-07	U-238	Ci/ft^2	2.6E-06	7.4E-06
Cs-137	Ci/ft^2	7.7E-02	3.6E-01	Y-90	Ci/ft^2	1.1E-01	2.6E-01
Eu-152	Ci/ft^2	1.2E-07	2.1E-07	Zr-93	Ci/ft^2	7.8E-07	2.3E-06
Eu-154	Ci/ft^2	6.8E-06	1.3E-05	Ag	kg/ft^2	6.0E-06	1.2E-04
H-3	Ci/ft^2	2.2E-07	3.8E-07	As	kg/ft^2	1.3E-07	2.3E-06
I-129	Ci/ft^2	3.6E-09	7.2E-09	Ba	kg/ft^2	7.0E-06	1.4E-04
K-40	Ci/ft^2	2.1E-07	4.2E-07	Cd	kg/ft^2	2.1E-04	4.2E-03
Nb-93m	Ci/ft^2	7.8E-07	2.3E-06	Cr	kg/ft^2	1.7E-05	3.2E-04
Nb-94	Ci/ft^2	8.6E-09	1.5E-08	Cu	kg/ft^2	2.8E-06	4.8E-05
Ni-59	Ci/ft^2	3.6E-06	8.6E-06	F	kg/ft^2	1.0E-05	2.2E-04
Ni-63	Ci/ft^2	2.1E-04	4.5E-04	Fe	kg/ft^2	2.7E-03	5.0E-02
Np-237	Ci/ft^2	4.2E-06	1.0E-05	Hg	kg/ft^2	1.9E-05	4.5E-04
Pa-231	Ci/ft^2	1.4E-07	1.2E-06	Mn	kg/ft^2	3.2E-04	6.3E-03
Pd-107	Ci/ft^2	1.5E-06	3.3E-06	Ni	kg/ft^2	3.2E-05	6.2E-04
Pt-193	Ci/ft^2	6.5E-08	1.1E-07	NO_3	kg/ft^2	1.0E-05	2.2E-04
Pu-238	Ci/ft^2	5.7E-02	1.8E-01	NO_2	kg/ft^2	8.9E-06	2.5E-04
Pu-239	Ci/ft^2	3.0E-03	1.0E-02	Pb	kg/ft^2	1.4E-05	3.0E-04
Pu-240	Ci/ft^2	8.1E-04	2.6E-03	Sb	kg/ft^2	1.4E-05	2.3E-04
Pu-241	Ci/ft^2	1.4E-02	3.2E-02	Se	kg/ft^2	2.6E-07	4.5E-06
Pu-242	Ci/ft^2	6.8E-07	2.3E-06	U	kg/ft^2	8.6E-04	2.4E-02
Pu-244	Ci/ft^2	<4.3E-10	<4.3E-10	Zn	kg/ft^2	5.5E-06	1.0E-04

3.2.2 Wall Area

The wall surface area was determined by using the dimensions of the waste tank, 85 feet in diameter and a height of 34 feet. [W167808, W163941] The upper wall surface area is 7,200 square feet and the lower wall surface area is 1,900 square feet. In determining the surface area of the tank, there is a slight conservatism added by using the total height. The

volume history of the tank shows a maximum volume of ~1350 kgal, which equates to ~32 ft. [WSRC-TR-2004-00284] Also, for the higher levels in the tank, the amount of time the tank level was at those heights was minimal.

3.2.3 Wall Scale Volume

As discussed earlier, there is residual material, scale, which has built up on the wall. Digital photographs were evaluated to determine the depth and coverage of the scale buildup. The scale buildup was determined to be 110 gallon. Also, an estimate of the uncertainty associated with the scale volume was developed. This uncertainty increased the scale volume to 280 gal. For more information on the determination of the wall scale volume, refer to Tank 18 Volume Estimation Following Mantis Cleaning Operations. [U-ESR-F-00041]

Table 3.2-4: Tank 18 Wall Scale Volume

Average	110 gal
Best Estimate	110 gal
Reasonably Conservative	282 gal

3.3 Equipment Build-up Inventory

Tank 18 houses various types of equipment used during the operational life of the tank and the waste removal process. This equipment includes several types of pumps, piping, and crawlers. There is potential for material build up in these equipment pieces and the amount of associated inventory has been determined. The inventory associated with the equipment was determined to be insignificant compared to the overall Tank 18 inventory.

3.3.1 Equipment Concentration

The equipment residual concentrations were assumed to be similar to the floor residuals. This equipment came in contact with similar material prior to completion of waste removal activities. The concentrations found in Table 3.1-2 were used to determine the inventory associated with residual buildup on the remaining equipment.

3.3.2 Equipment Volume

The potential buildup and residual volume was determined. [SRR-LWE-2010-00175] This evaluation determined differing levels of potential buildup and associated volume. In general the equipment was designed to drain and be free of material. For this reason, a negligible inventory of material was assumed for the Best Estimate case.

Table 3.3-1: Tank 18 Equipment Solids

Average	0 gal
Best Estimate	0 gal
Reasonably Conservative	1.85 gal

4.0 TOTAL RESIDUAL INVENTORIES

Each of the discrete inventories was totaled for the Average, Best Estimate, and Reasonably Conservative inventories. The inventories were decayed as needed to support Performance Assessment modeling. The decay period was based on the collection date for the samples, 2010,

and the planned closure date of F-Area Tank Farm, 2020. Table 4.0-1 presents the various inventory determinations for each of the characterizations.

Table 4.0-1: Tank 18 Residual Inventories

Constituent	Units	Average (2020)	Best Estimate (2010)	Best Estimate (2020)	Reasonably Conservative (2020)
Ac-227	Ci	1.3E-04	2.1E-04	1.5E-04	1.2E-02
Al-26	Ci	1.7E-04	1.9E-04	1.9E-04	2.1E-03
Am-241	Ci	8.9E+01	1.6E+02	1.6E+02	2.6E+02
Am-242m	Ci	9.8E-03	4.0E-02	3.8E-02	5.6E-02
Am-243	Ci	6.4E-01	2.3E+00	2.3E+00	4.4E+00
Ba-137m	Ci	4.4E+03	1.1E+04	8.7E+03	1.3E+04
C-14	Ci	3.8E-01	9.0E-01	9.0E-01	2.1E+00
Cf-249	Ci	2.0E-03	2.3E-03	2.3E-03	1.8E-01
Cl-36	Ci	2.4E-04	2.8E-04	2.8E-04	4.4E-03
Cm-243	Ci	1.6E-02	2.3E-02	1.8E-02	4.1E+00
Cm-244	Ci	3.0E+01	1.4E+02	9.8E+01	2.4E+02
Cm-245	Ci	1.0E-02	1.2E-02	1.2E-02	4.1E-01
Cm-247	Ci	1.8E-06	2.1E-06	2.1E-06	1.6E-04
Cm-248	Ci	8.2E-05	9.5E-05	9.5E-05	7.2E-03
Co-60	Ci	1.6E-01	1.2E+00	3.2E-01	4.5E-01
Cs-135	Ci	2.1E-02	3.0E-02	3.0E-02	5.7E-02
Cs-137	Ci	4.7E+03	1.2E+04	9.2E+03	1.4E+04
Eu-152	Ci	4.1E-03	8.0E-03	4.7E-03	1.6E-02
Eu-154	Ci	1.7E-01	4.8E-01	2.1E-01	3.0E-01
H-3	Ci	6.9E-03	1.4E-02	8.0E-03	5.5E-02
I-129	Ci	2.0E-04	2.7E-04	2.7E-04	4.9E-04
K-40	Ci	1.2E-02	1.6E-02	1.6E-02	2.1E-02
Nb-93m	Ci	4.3E-02	8.6E-02	8.6E-02	8.6E-02
Nb-94	Ci	4.8E-04	5.5E-04	5.5E-04	8.1E-03
Ni-59	Ci	2.0E-01	3.3E-01	3.3E-01	5.6E-01
Ni-63	Ci	1.1E+01	1.7E+01	1.6E+01	2.9E+01
Np-237	Ci	1.1E-01	1.9E-01	1.9E-01	3.1E-01
Pa-231	Ci	7.6E-03	4.6E-02	4.6E-02	4.6E-02
Pd-107	Ci	8.2E-02	1.2E-01	1.2E-01	1.5E-01
Pt-193	Ci	3.1E-03	4.2E-03	3.6E-03	7.9E-02
Pu-238	Ci	4.5E+02	1.4E+03	1.3E+03	1.4E+03
Pu-239	Ci	1.7E+02	2.8E+02	2.8E+02	4.9E+02
Pu-240	Ci	3.9E+01	6.5E+01	6.5E+01	1.1E+02
Pu-241	Ci	1.6E+02	4.4E+02	2.7E+02	3.9E+02
Pu-242	Ci	1.4E-02	2.7E-02	2.7E-02	7.4E-01
Pu-244	Ci	6.0E-06	6.2E-06	6.2E-06	3.4E-03

Table 4.0-1: Tank 18 Residual Inventories, continued

Constituent	Units	Average (2020)	Best Estimate (2010)	Best Estimate (2020)	Reasonably Conservative (2020)
Ra-226	Ci	2.9E-03	3.4E-03	3.4E-03	5.3E-03
Sb-126	Ci	1.5E-03	1.8E-03	1.8E-03	3.1E-03
Sb-126m	Ci	1.0E-02	1.3E-02	1.3E-02	2.2E-02
Se-79	Ci	4.1E-04	4.8E-04	4.8E-04	2.6E-03
Sm-151	Ci	2.6E+01	4.0E+01	3.7E+01	6.7E+01
Sn-126	Ci	1.0E-02	1.3E-02	1.3E-02	2.2E-02
Sr-90	Ci	1.3E+03	3.2E+03	2.5E+03	3.2E+03
Tc-99	Ci	6.7E-01	9.0E-01	9.0E-01	1.6E+00
Th-229	Ci	4.5E-04	8.9E-04	8.9E-04	1.7E-03
Th-230	Ci	1.1E-03	2.1E-03	2.1E-03	4.3E-03
U-232	Ci	3.7E-04	7.6E-04	6.9E-04	1.4E-03
U-233	Ci	2.8E-02	4.0E-02	4.0E-02	5.6E-02
U-234	Ci	2.0E-01	3.1E-01	3.1E-01	6.3E-01
U-235	Ci	5.7E-03	1.1E-02	1.1E-02	2.4E-02
U-236	Ci	7.4E-03	1.2E-02	1.2E-02	2.3E-02
U-238	Ci	1.4E-01	2.8E-01	2.8E-01	6.0E-01
Y-90	Ci	1.3E+03	3.2E+03	2.5E+03	3.2E+03
Zr-93	Ci	4.3E-02	8.6E-02	8.6E-02	8.6E-02
Ag	kg	2.9E+00	3.5E+00	3.5E+00	6.4E+00
As	kg	6.4E-02	6.7E-02	6.7E-02	1.5E-01
Ba	kg	3.4E+00	4.3E+00	4.3E+00	8.0E+00
Cd	kg	1.0E+02	1.3E+02	1.3E+02	2.4E+02
Cr	kg	8.5E+00	9.5E+00	9.5E+00	1.6E+01
Cu	kg	1.4E+00	1.4E+00	1.4E+00	3.2E+00
F	kg	4.9E+00	6.6E+00	6.6E+00	8.0E+00
Fe	kg	1.3E+03	1.5E+03	1.5E+03	2.6E+03
Hg	kg	9.3E+00	1.4E+01	1.4E+01	2.9E+01
Mn	kg	1.6E+02	1.9E+02	1.9E+02	3.3E+02
Ni	kg	1.5E+01	1.9E+01	1.9E+01	3.4E+01
NO_3	kg	4.9E+00	6.5E+00	6.5E+00	1.3E+01
NO_2	kg	4.3E+00	7.6E+00	7.6E+00	7.6E+00
Pb	kg	6.8E+00	9.1E+00	9.1E+00	1.1E+01
Sb	kg	6.7E+00	7.0E+00	7.0E+00	2.3E+01
Se	kg	1.3E-01	1.4E-01	1.4E-01	4.9E-01
U	kg	4.2E+02	7.1E+02	7.1E+02	1.7E+03
Zn	kg	2.7E+00	3.1E+00	3.1E+00	5.2E+00

5.0 INVENTORY MULTIPLIERS

Inventory multipliers were developed for the radionuclide inventories to represent the uncertainty associated with the inventory determinations. This allows the inventories to be represented by probability distributions instead of the single value characteristics such as the different characterizations discussed above. These distributions can be used in probabilistic analyses to assess the impact of the inventory uncertainties.

The statistical analysis results provided the basis for the development of the radionuclide inventory multipliers. Multipliers have been used in modeling as an adjustment to the Best Estimate inventory. For this reason, the multipliers were determined using the Best Estimate inventory as the basis inventory. This resulted in a unitless multiplier that can be inserted into the modeling where the inventory is used as an adjustment in the probabilistic analysis. All the probability distributions were based on a normal distribution. This in turn resulted in the final inventory probability distributions and multipliers returning normal distributions.

The uncertainties from the three significant inventory areas were used to develop the inventory distribution. The floor, lower wall, and upper wall inventory probability distributions were taken and added together to determine the overall inventory probability distribution.

Each area's probability distribution was developed using the concentrations uncertainty and concentration basis quantity uncertainty. For the floor inventory uncertainty, both the floor residual concentrations and floor residual volume probability distributions were included. So, distribution parameters were developed for both the floor residual concentrations and the floor residual volume. These distributions were then multiplied together using the probabilistic simulation capabilities of GoldSim.

For the wall inventories, only the concentrations involved probability distributions. The wall surface area was constant. Therefore, the walls' concentration distributions were multiplied by the constant of the wall surface area to determine the wall inventory distribution.

Once these three areas inventory probability distributions were developed, they were then added together to determine the overall tank inventory distribution. Then a ratio (inventory multiplier) of the probability distribution parameters (mean and standard deviation) to the Best Estimate inventory for each radionuclide was determined.

5.1 Floor Inventory Distribution

Both the floor concentration and volume probability distributions were determined using the information previously discussed. Then floor inventory probability distributions were developed by multiplying the floor concentration distributions by the floor volume distribution.

5.1.1 Floor Concentration Distribution

The average concentrations and standard deviations were taken from the statistical study, as described in Section 4.2.1, and converted to a volume basis using the density and the sample solids content results. The probability distribution parameters of each radionuclide are presented in Table 5.1-1.

Table 5.1-1: Tank 18 Floor Concentration Distributions – Means and Standard Deviations

Radionuclide	Units	Mean	Standard Deviation	Radionuclide	Units	Mean	Standard Deviation
Am-241	Ci/gal	2.1E-02	6.7E-03	Pu-239	Ci/gal	4.2E-02	1.6E-02
Am-242m	Ci/gal	2.5E-06	3.4E-06	Pu-240	Ci/gal	9.5E-03	3.4E-03
Am-243	Ci/gal	1.6E-04	2.9E-04	Pu-241	Ci/gal	2.7E-02	8.1E-03
C-14	Ci/gal	9.6E-05	1.2E-04	Sm-151	Ci/gal	6.6E-03	1.7E-03
Cm-244	Ci/gal	7.4E-03	1.7E-02	Sn-126	Ci/gal	2.6E-06	2.5E-07
Co-60	Ci/gal	3.1E-05	8.7E-06	Sr-90	Ci/gal	1.7E-01	4.1E-02
Cs-135	Ci/gal	5.2E-06	1.7E-06	Tc-99	Ci/gal	1.7E-04	3.5E-05
Cs-137	Ci/gal	1.1E+00	2.7E-01	Th-229	Ci/gal	1.1E-07	8.3E-08
Eu-154	Ci/gal	4.2E-05	5.1E-06	Th-230	Ci/gal	2.8E-07	2.0E-07
I-129	Ci/gal	5.0E-08	1.2E-08	U-232	Ci/gal	9.2E-08	6.9E-08
K-40	Ci/gal	2.9E-06	4.9E-07	U-233	Ci/gal	3.8E-06	1.3E-06
Ni-59	Ci/gal	5.0E-05	1.7E-05	U-234	Ci/gal	3.7E-05	3.1E-05
Ni-63	Ci/gal	2.8E-03	8.4E-04	U-235	Ci/gal	1.4E-06	1.2E-06
Np-237	Ci/gal	2.2E-05	1.0E-05	U-236	Ci/gal	1.2E-06	9.9E-07
Pa-231	Ci/gal	1.9E-06	1.8E-06	U-238	Ci/gal	3.6E-05	3.0E-05
Pd-107	Ci/gal	2.1E-05	7.7E-06	Zr-93	Ci/gal	1.1E-05	8.2E-06
Pu-238	Ci/gal	1.6E-02	4.1E-03				

5.1.2 Floor Volume Distribution

The floor volume probability distribution parameters were determined by using the Average and the Reasonably Conservative volume values for both the floor and wall scale volumes, Tables 3.1-5 and 3.2-4. A normal distribution was fit using the Reasonably Conservative value as the 95% cumulative probability value. The floor and scale distribution parameters are listed in Table 5.1-2.

Table 5.1-2: Tank 18 Floor and Scale Volume – Mean and Standard Deviation

	Mean	Standard Deviation
Floor Volume	3900 gal	850 gal
Scale Volume	110 gal	105 gal

5.2 Upper Wall Inventory Distribution

The upper wall probability distribution parameters were developed using the sample analysis results as the mean parameter. The standard deviation was determined by dividing the ratio of the "t" statistic times the standard error to the mean by the "t" statistic found in Table 6 of SRNL-STI-2010-00525. This resulting ratio was then multiplied by the sample analysis result to determine the absolute standard deviation. The upper wall probability distribution parameters are listed in Table 5.2-1.

Table 5.2-1: Tank 18 Upper Wall Concentration Distributions – Means and Standard Deviations

Radionuclide	Units	Mean	Standard Deviation	Radionuclide	Units	Mean	Standard Deviation
Am-241	Ci/ft^2	2.5E-03	2.1E-03	Pu-239	Ci/ft^2	3.0E-03	2.5E-03
Am-242m	Ci/ft^2	1.8E-07	1.2E-07	Pu-240	Ci/ft^2	8.1E-04	6.1E-04
Am-243	Ci/ft^2	1.1E-05	7.4E-06	Pu-241	Ci/ft^2	1.4E-02	6.1E-03
C-14	Ci/ft^2	6.8E-06	4.4E-06	Sm-151	Ci/ft^2	5.1E-04	3.3E-04
Cm-244	Ci/ft^2	7.8E-04	5.0E-04	Sn-126	Ci/ft^2	1.9E-07	1.2E-07
Co-60	Ci/ft^2	2.5E-05	1.9E-05	Sr-90	Ci/ft^2	1.1E-01	5.1E-02
Cs-135	Ci/ft^2	3.7E-07	2.4E-07	Tc-99	Ci/ft^2	1.2E-05	7.7E-06
Cs-137	Ci/ft^2	7.7E-02	9.8E-02	Th-229	Ci/ft^2	8.1E-09	5.2E-09
Eu-154	Ci/ft^2	6.8E-06	4.4E-06	Th-230	Ci/ft^2	2.0E-08	1.3E-08
I-129	Ci/ft^2	3.6E-09	2.3E-09	U-232	Ci/ft^2	7.3E-09	4.7E-09
K-40	Ci/ft^2	2.1E-07	1.3E-07	U-233	Ci/ft^2	1.9E-06	2.5E-07
Ni-59	Ci/ft^2	3.6E-06	2.3E-06	U-234	Ci/ft^2	9.1E-06	5.4E-07
Ni-63	Ci/ft^2	2.1E-04	1.4E-04	U-235	Ci/ft^2	1.1E-07	6.9E-08
Np-237	Ci/ft^2	4.2E-06	2.0E-06	U-236	Ci/ft^2	4.2E-07	6.0E-08
Pa-231	Ci/ft^2	1.4E-07	8.7E-08	U-238	Ci/ft^2	2.6E-06	1.7E-06
Pd-107	Ci/ft^2	1.5E-06	9.4E-07	Zr-93	Ci/ft^2	7.8E-07	5.0E-07
Pu-238	Ci/ft^2	5.7E-02	4.1E-02				

5.3 Lower Wall Inventory Distribution

The lower wall probability distribution parameters were developed in the same way the upper wall parameters were developed, using the sample analysis results as the mean parameter. The standard deviation was determined by dividing the ratio of the "t" statistic times the standard error to the mean by the t statistic found in Table 6 of SRNL-STI-2010-00525. This resulting ratio was then multiplied by the sample analysis result to determine the absolute standard deviation. The upper wall probability distribution parameters are listed in Table 5.3-1.

Table 5.3-1: Tank 18 Lower Wall Concentration Distributions – Averages and Standard Deviations

Radionuclide	Units	Mean	Standard Deviation	Radionuclide	Units	Mean	Standard Deviation
Am-241	Ci/ft^2	7.5E-04	6.3E-04	Pu-239	Ci/ft^2	1.1E-03	8.6E-04
Am-242m	Ci/ft^2	8.0E-08	5.1E-08	Pu-240	Ci/ft^2	2.5E-04	1.9E-04
Am-243	Ci/ft^2	5.0E-06	3.2E-06	Pu-241	Ci/ft^2	3.5E-03	1.5E-03
C-14	Ci/ft^2	2.9E-06	1.9E-06	Sm-151	Ci/ft^2	2.2E-04	1.4E-04
Cm-244	Ci/ft^2	3.4E-04	2.2E-04	Sn-126	Ci/ft^2	8.1E-08	5.2E-08
Co-60	Ci/ft^2	2.0E-05	1.5E-05	Sr-90	Ci/ft^2	7.7E-02	3.4E-02
Cs-135	Ci/ft^2	1.6E-07	1.0E-07	Tc-99	Ci/ft^2	5.2E-06	3.3E-06
Cs-137	Ci/ft^2	3.4E-01	4.4E-01	Th-229	Ci/ft^2	3.5E-09	2.3E-09
Eu-154	Ci/ft^2	2.9E-06	1.9E-06	Th-230	Ci/ft^2	8.7E-09	5.6E-09
I-129	Ci/ft^2	1.5E-09	9.9E-10	U-232	Ci/ft^2	3.1E-09	2.0E-09
K-40	Ci/ft^2	9.0E-08	5.8E-08	U-233	Ci/ft^2	7.1E-07	9.0E-08
Ni-59	Ci/ft^2	1.5E-06	9.9E-07	U-234	Ci/ft^2	3.5E-06	2.1E-07
Ni-63	Ci/ft^2	9.1E-05	5.9E-05	U-235	Ci/ft^2	4.6E-08	2.8E-08
Np-237	Ci/ft^2	6.4E-07	3.1E-07	U-236	Ci/ft^2	1.4E-07	1.9E-08
Pa-231	Ci/ft^2	5.8E-08	3.8E-08	U-238	Ci/ft^2	1.1E-06	7.1E-07
Pd-107	Ci/ft^2	6.3E-07	4.1E-07	Zr-93	Ci/ft^2	3.3E-07	2.2E-07
Pu-238	Ci/ft^2	9.1E-03	6.5E-03				

5.4 Total Inventory Distribution Multipliers

Using the concentration and floor probability distributions and the fixed areas of the tank upper and lower walls, a probabilistic analysis was run using GoldSim. The analysis used 10,000 realizations to develop the probability distributions for each radionuclide. The parameters for each radionuclide inventory distribution were divided by the Best Estimate for that radionuclide inventory. The resulting ratio represents the inventory multiplier for those radionuclides.

The radionuclides that reached the detection limit capabilities needed to be provided probability distributions. First, the distribution curve was chosen to represent the probability distribution of radionuclides that reached the detection limits. For simplicity, a normal distribution was chosen. It is probable that the expected value will decrease from the detection limit; therefore the distribution was truncated at the mean. This allows the distribution curve to be at a maximum at the mean and decrease as the value moves away from the mean. Also, since the Best Estimate inventories for these radionuclides was based on the detection limit and the multipliers are ratios to the Best Estimate inventory, a mean of 1 was set for the detection limit radionuclides. To allow the values to curve significantly away from the mean, a standard deviation of 0.5 was chosen.

The inventory multipliers developed for both the radionuclides with detectable sample results and radionuclides based on detection limit sample analysis are presented in Table 5.4-1.

Table 5.4-1: Tank 18 Inventory Multipliers

Radionuclide	Average	Standard Deviation	Radionuclide	Average	Standard Deviation
Ac-227 [(a)]	1	0.5	Pa-231	0.24	0.14
Al-26 [(a)]	1	0.5	Pd-107	0.79	0.30
Am-241	0.68	0.22	Pt-193 [(a)]	1	0.5
Am-242m	0.45	0.29	Pu-238	0.40	0.19
Am-243	0.56	0.38	Pu-239	0.72	0.27
Ba-137m	0.63	0.17	Pu-240	0.71	0.26
C-14	0.69	0.44	Pu-241	0.67	0.18
Cf-249 [(a)]	1	0.5	Pu-242 [(a)]	1	0.5
Cl-36 [(a)]	1	0.5	Pu-244 [(a)]	1	0.5
Cm-243 [(a)]	1	0.5	Ra-226 [(a)]	1	0.5
Cm-244	0.74	0.51	Sb-126	0.92	0.20
Cm-245 [(a)]	1	0.5	Sb-126m	0.92	0.20
Cm-247 [(a)]	1	0.5	Se-79 [(a)]	1	0.5
Cm-248 [(a)]	1	0.5	Sm-151	0.84	0.25
Co-60	0.60	0.17	Sn-126	0.92	0.20
Cs-135	0.79	0.28	Sr-90	0.60	0.15
Cs-137	0.63	0.17	Tc-99	0.87	0.23
Eu-152 [(a)]	1	0.5	Th-229	0.66	0.35
Eu-154	0.94	0.21	Th-230	0.68	0.37
H-3 [(a)]	1	0.5	U-232	0.70	0.38
I-129	0.84	0.25	U-233	0.75	0.16
K-40	0.87	0.21	U-234	0.81	0.36
Nb-93m [(a)]	1	0.5	U-235	0.68	0.38
Nb-94 [(a)]	1	0.5	U-236	0.74	0.29
Ni-59	0.71	0.26	U-238	0.68	0.39
Ni-63	0.82	0.27	Y-90	0.60	0.15
Np-237	0.64	0.25	Zr-93	0.66	0.36

Note: – All inventory multipliers were based on a normal distribution.
– All distributions should be truncated at zero.
– All statistics are based on a decay date of 2020.
(a) These distributions were based on detection limits and should be truncated at a maximum of 1.

6.0 REFERENCES

SRNS-STI-2009-00416, Leisher, R. A., *Tank 18 and Tank 19 Wall Sampler Performance*, Savannah River Site, Aiken, SC, Rev. 0, January 12, 2010.

SRNL-STI-2009-00782, Shine, E, P., *Recommendations for Sampling of Tank 18 in F Tank Farm*, Savannah River Site, Aiken, SC, Rev. 0, December 14, 2009.

SRNL-STI-2009-00802, Hay, M. S., et. al., *Characterization of Tank 18F Wall and Scale Samples*, Savannah River Site, Aiken, SC, Rev. 0, March, 2010.

SRNL-STI-2010-00386, Oji, L. N., et. al., *Characterization of Additional Tank 18F Samples*, Savannah River Site, Aiken, SC, Rev. 0, September 2, 2010.

SRNL-STI-2010-00401, Harris, S. P., *Statistical Analysis of Tank 18F Floor Sample Results*, Savannah River Site, Aiken, SC, Rev. 0, September 2, 2010.

SRNL-STI-2010-00525, Shine, E. P., *Recommendations for Assessing the Uncertainty in Tank 18-F Wall Samples*, Savannah River Site, Aiken, SC, Rev. 0, September 2, 2010.

U-ESR-F-00041, Thaxton, G. D., et. al., *Tank 18 Volume Estimation Following Mantis Cleaning Operations*, Savannah River Site, Aiken, SC, Rev. 1, September 1, 2010.

WSRC-TR-2003-00449, Swingle, R. F., *Characterization of the Tank 18F Closure Samples*, Savannah River Site, Aiken, SC, Rev. 0, October 8, 2002.

WSRC-TR-2004-00284, Thomas, J. L., *Tanks 17 – 20 Volume Histories*, Savannah River Site, Aiken, SC, Rev. 1, September 16, 2004.