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Savannah River Company
Aiken, SC 29808

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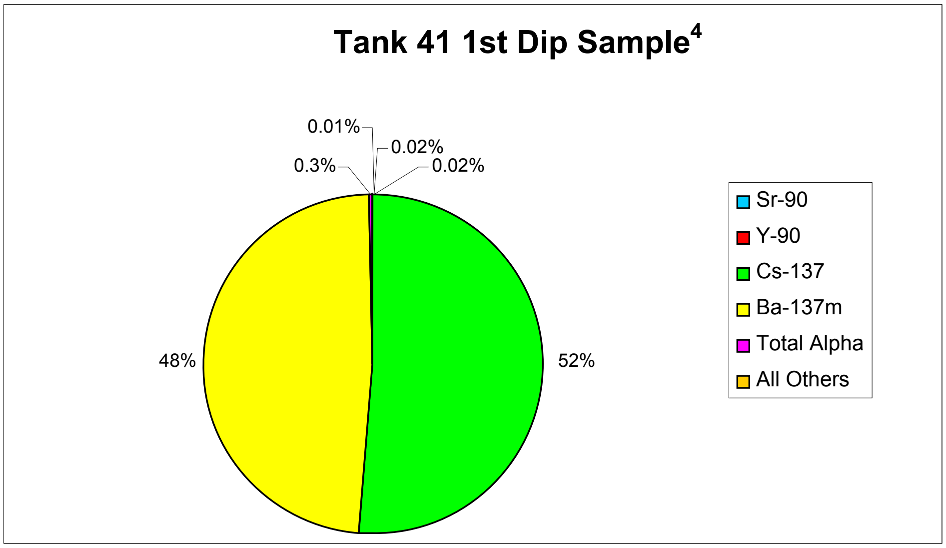
Subject: Curie Calculation Basis for Salt Strategies

This memo explains the basis used in developing the total Curie (Ci) values processed in support of the salt strategies. A model has been developed to estimate the Cs-137 concentration that will be present from residual interstitial liquid (IL) in the saltcake after the creation of approximately 1,000,000 gal macrobatches of salt solution. Using current Cs-137 concentrations and salt levels, the effect of multiple dissolutions can be predicted. This allows both the Cs-137 inventory and the volume to be tracked for both the tank and the drained salt solution. Cs-137 concentration data for the model is taken from varied sources:

1) Drained saltcake dissolved into solution and processed as LCS through ARP/CSSX uses WCS[1] data (8/01 baseline):
   Tank 25: 4.29 Ci/gal
   Tank 28: 4.47 Ci/gal
   Tank 41: 2.52 Ci/gal
2) Supernate removed as feed for ARP/CSSX uses tank sample data[2] because the WCS data gives an abnormally low value of 0.27 Ci/gal:
   Tank 38: 0.73 Ci/gal
3) Tank 48 for TPB removal uses tank sample data[3]:
   Tank 48: 1.72 Ci/gal

The total Curie content is assumed to be twice (2x) the Cs-137 concentration because Cs-137 comprises approximately 50% of the Curies in the supernate. Figure 1 shows the radionuclide division in Tank 41 supernate and drained saltcake. In the supernate Cs-137 accounts for 52% of the total Curies. Because the estimated value is actually slightly higher (~4%) than the total Curie content, it is a conservative approximation for estimating purposes. In the drained saltcake, the



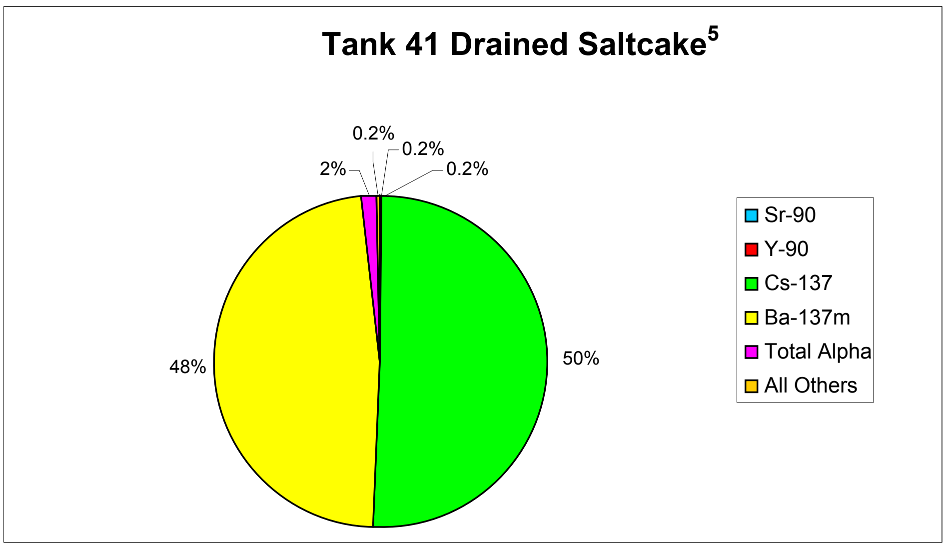
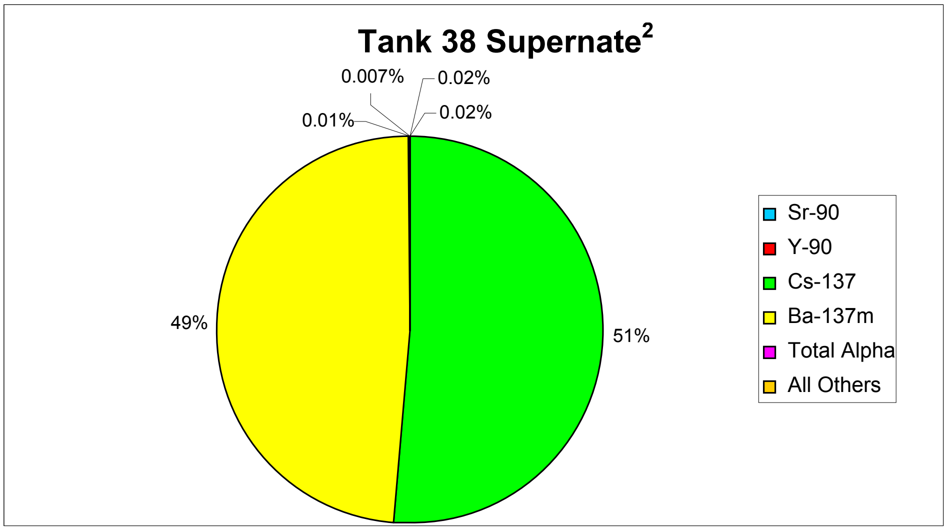


Figure 1. Division of Radionuclides in Tank 41

other radiological sources, e.g. Sr-90, are nearly all insoluble (as evidenced by the increased % Activity by a factor of 10 between the saltcake and supernate). Most of the insoluble activity that is transferred with the salt solution is captured through settling/filtration and not sent on as LCS.

This effect is more pronounced in tanks with higher concentrations of other radionuclides, such as Tank 38 (Figure 2). In the undrained dissolved saltcake, Sr-90 and Y-90 comprise 12% of the total activity. However, because they are insoluble, they will remain while Cs-137 and Ba-137m are drained and their % Activity in the saltcake will increase. Discounting the insoluble activity, the Cs-137 again accounts for approximately 50% of the Curies. If the actual draining does not correspond with the model and the activity of the macrobatch is greater than predicted, the batch will not be processed as LCS. This will result in a slower reclamation of tank space due to alternative treatment rather than a situation where the Saltstone Waste Acceptance Criteria is exceeded.



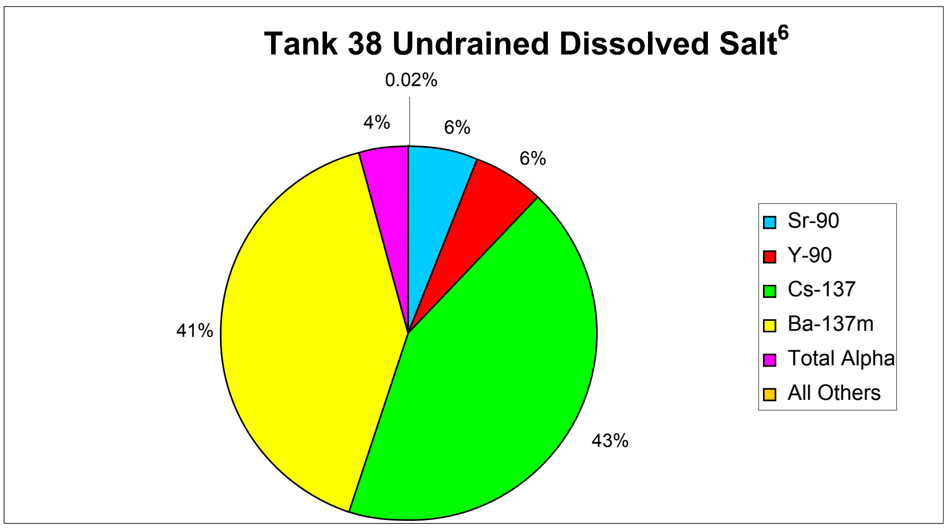


Figure 2. Division of Radionuclides in Tank 38

The model is based on the following assumptions about the physical properties of the saltcake:

- Saltcake contains 40 volume% void space made up of 10 volume% gas and 30 volume% IL
- Saltcake above 56” (196.6 kgals) is considered ‘drainable’ and the residual IL in the saltcake is reduced by 50%, leaving 15 volume% IL.
- The bottom 56” of saltcake is considered ‘saturated’ and the residual IL in the saltcake is the full 30 volume% IL.
- Each dissolution batch is homogeneously mixed so that radionuclide and chemical components are distributed evenly throughout all the liquid in the tank.

Figure 3 shows the evolution of the draining and dissolution process as used in the model. Tank A contains fully saturated salt with free supernate above the saltcake. The tank is first drained (Tank B) to remove any existing free supernate and to extract as much interstitial liquid as possible. Above 56”, 50% of the IL is assumed to be drained, while below 56” the IL is unaffected. To create the salt solution batches the tanks are then filled with IW (Tank C) so that approximately 24” of salt solution will exist above the salt level (Tank D). This refills the drained void space, both the 15% that formerly contained IL and the 10% that was formerly gas, saturating the saltcake. Below 56” the saltcake that was not drained is also saturated to 40% liquid. The initially salt-free IW dissolves a portion of the saltcake and is drained as before (Tank E), reducing the liquid volume and recreating open void space. The salt solution (free liquid, 25% (40% void - 15% residual) of the salt cake above 56”, and none below 56”) is drained and stored as the dissolution process repeats 4-5 times (Tank F) until sufficient volume (~1,000,000 gal) has accumulated to create the batch.

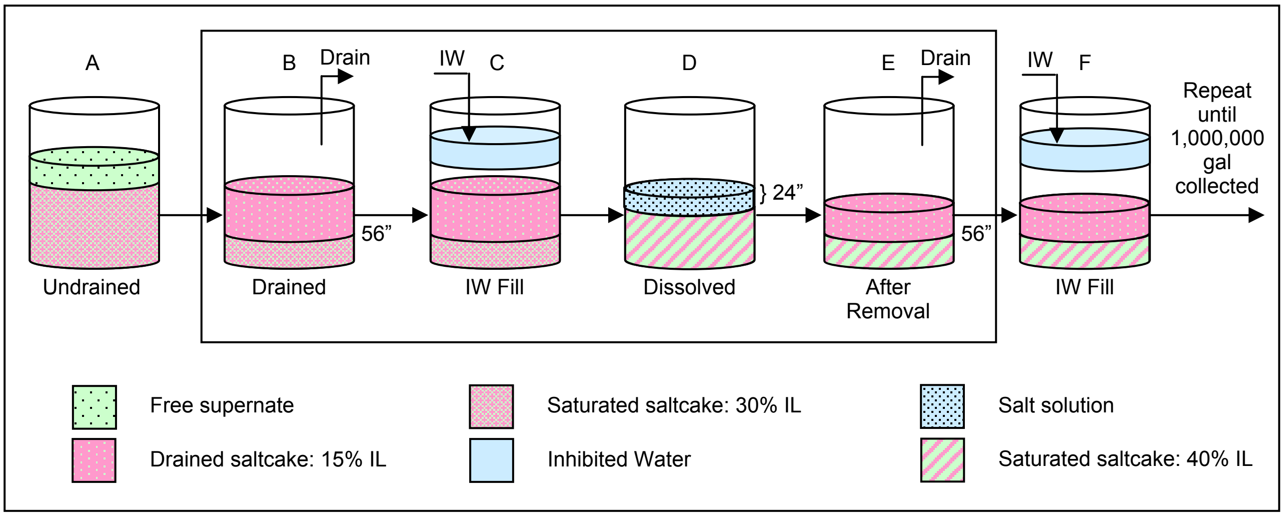


Figure 3. Draining and subsequent dissolution of waste tanks

Figure 4 shows the effect of the dissolution process on Curie content during the first dissolution of Tank 41. In Tank B the total residual IL is the combination of the IL in saturated salt (56” * 3510 gal/in * 30%[†]) and in the drained salt ([salt height - 56”] * 3510 gal/in * 15%). Total Curies are then the product of the total residual IL volume and the tank Cs-137 concentration. Sludge carryover is excluded because the Cs-137 concentration in sludge contributes 0.06% - 0.41% of the total value and is deemed negligible. After filling with IW (Tank C), the evacuated void space is replaced with Curie-free liquid to dilute the solution. The total number of Curies from the residual IL is distributed evenly throughout the liquid, decreasing the Cs-137 concentration. The dissolution of a portion of the saltcake (Tank D) increases the liquid volume, further diluting the Curie content. The tank is then drained (Tank E), reducing the total number of Curies. The Cs-137 concentration remains the same as before draining throughout the IL although the total number of Curies is reduced proportionately with the volume during draining. The dissolution process repeats, further reducing the Cs-137 concentration with each iteration.

[†] Note that in all but the first batch the residual IL in the bottom 56” of saltcake will be based on 40 volume% filled void space

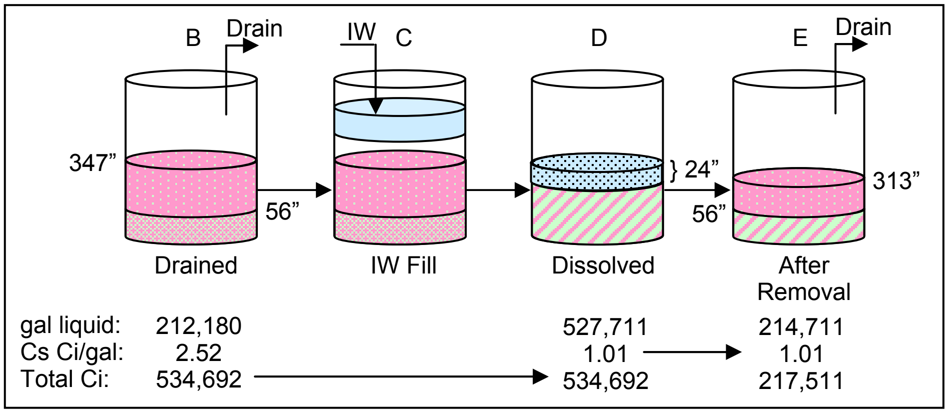


Figure 4. Changes in Curie content as a result of dissolution (Tank 41 Example)

The tank farm inventory baseline as described in the 8/01 WCS is based on different inputs and assumptions than are utilized in this model. Void fractions are assumed to be 30% in WCS, comprised of 8% gas and 22% IL. Using this value, previous draining models assumed 70% of the interstitial liquid was drainable.

Table 1. Residual IL volume difference between draining models

Tank	Salt height (in)	IL volume (gal) at 22% void fraction and 30% IL remaining[7] (WCS model)	IL volume (gal) at 30% void fraction and 50%-100% remaining above/below 56" (current model)	% Difference
25	316	73,200	195,860	167.6%
27	294	68,110	184,280	170.6%
38	258	59,770	165,320	176.6%
41	347	80,390	212,180	163.9%

The new draining model shows that there is significantly more residual IL, and therefore a higher Cs-137 concentration in the saltcake, than estimated by the bulk tank average model which used the WCS baseline and different assumptions. The difference is larger for tanks with shorter saltcake heights since the ratio of drained salt to undrained salt decreases. There are also differences in salt radionuclide concentrations between those values predicted by WCS and those that have been obtained from tank sampling data (i.e. Tanks 38, 48). Sample data values that are higher than WCS predicted values are used in place of WCS values. Table 2 shows Cs-137 sample data compared with predicted values from WCS and Spaceman. Cs-137 values under the “Selected” column represent the values used for salt strategies.

Table 2. Selection of data source for Cs-137 concentrations (Ci/gal)

	WCS	Spaceman	Sample	Selected	Explanation of selection
Tank 25	4.29	3.38	N/A	4.29	WCS highest
Tank 28	4.47	4.15	N/A	4.47	WCS highest
Tank 37	15.2	11.8	N/A	15.2	WCS highest
Tank 38	0.27	0.55	0.65 – 0.73[2]	0.73	Sample 33% - 130% higher
Tank 41	2.52	N/A	N/A	2.52	No sample data prior to draining
Tank 48	1.61	N/A	1.38 - 1.7[3]	1.7	Sample 6% higher

References:

1. J. R. Hester, "High Level Waste Characterization System (WCS)", WSRC-TR-96-0264, Rev. 0, December 1996.

2. C. J. Martino, "Initial Results of the Tank 38H Saltcake Core Sample Analysis", SRT-LWP-2003-00095, Rev. 1, November 5, 2003.

3. D. P. Lambert, "Analysis of Tank 48H Samples HTF-E-03-73 (June 03, 2003) and HTF-E-03-127 (September 17, 2003)", WSRC-TR-2003-00720, Rev. 0, January 20, 2004.

4. C. J. Martino, "Tank 41H Dissolved Saltcake Sample (HTF-E-03-91 – 92) Saltstone Waste Acceptance Criteria Analysis", WSRC-TR-2003-00380, Rev. 1, September 22, 2003.

5. C. J. Martino, "Tank 41H Drained Saltcake Core Sample Analysis (HTF-E-03-033 – HTF-E-03-035)", WSRC-TR-2003-00227, Rev. 0, December 16, 2003.

6. C. J. Martino, "Initial Results of the Tank 2F, 29H, and 38H Supernate Sample Analysis", SRT-LWP-2003-00092, Rev. 0, October 9, 2003.

7. M. D. Drumm, "Feed Basis for Processing Relatively Low Radioactivity Waste Tanks", WSRC-TR-2001-00059, Rev. 3, June 11, 2003.

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