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Paul D. d'Entremont
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Characterization of Tank 20 Residual Waste

BY

P. D. d'ENTREMONT
J. R. HESTER

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Paul D. d'Entremont
P. D. d'Entremont, Author, HLWE — Date: 3/20/97

J. R. Hester
J. R. Hester, Author, HLWE — Date: 3/26/97

M. S. Hay
M. S. Hay, Technical Reviewer, SRTC-IWT — Date: 3/27/97

Michael C Chandler
M. C. Chandler, Manager, HLW Engineering Support — Date: 4/4/97

Michael C Chandler for BL Lewis
B. L. Lewis, Manager, HLW Engineering Support — Date: 4/4/97

T M Monahon
T. M. Monahon, Manager, HLW Engineering — Date: 4/8/97

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1. Introduction

Plans are to close Tank 20, a type IV Waste Tank in the F-area Tank Farm, by filling it with pumpable backfills. Most of the waste was removed from the Tank in 1988, so only residual waste remains. More details on the planned closure can be found in the Closure Plan for the HLW Tanks[1] and the specific closure module for Tank 20.[2]

To show that closure of the tanks is environmentally sound, a performance evaluation has been performed for Tank 20.[2] The performance evaluation projected the concentration of contaminants at various locations and times after closure.

This report documents the basis for the inventories of contaminants that were used in the Tank 20 performance evaluation.

2. Summary

Photographs of Tank 20 show that most of the tank is covered by a thin layer of brown solids. The volume of this solids layer is estimated to be approximately 1000 gallons, which is equivalent to about 1950 pounds of dried solids. The tank also contains a number of piles of white solids that have precipitated from the ballast water that has been left in the tank. The solids are a mixture of cryolite, sodium sulfate, and sludge. The volume of the white piles is estimated to be less than 50 gallons.

The composition of these two different types of solids has been estimated by two means: 1) predictions based on the knowledge that the material entering the tank was PUREX Low-Heat Waste, and 2) samples. The samples have shown that the predictions based on process knowledge were reasonable, although a few adjustments are in order. HLWE recommends that the process knowledge estimates of the inventory be used for all contaminants except for Tc-99 and Pu-238. For these two radionuclides, the inventory estimates should be raised to reflect what was learned from sample results.

The recommended inventories to be assumed for modeling purposes in Tank 20 are shown in Tables 1 and 2 at the end of the report.

The contaminants reported in Tables 1 and 2 are contained in the waste, which is primarily on the bottom of the tank. In addition, the risers on the top of the tank each contain lead. Based on the prints, a reasonable estimate is 500 pounds per riser, or 3000 pounds (1400 kg) of lead for the whole tank. Also, we recommend that an amount of waste be assumed to be outside of the tank to account for spills and other

equipment in the Tank 17-20 area, such as the 1F Evaporator and CTS. An allowance of 20% of the tank inventory in these four tanks should be sufficient to bound contributions from the other sources.

Plans are for the contaminants currently in Tank 20 to be left in the tank during the closure. However, if plans change, and more sludge is removed from Tank 20, the inventories of sludge and white solids should be re-evaluated to accurately estimate the inventory of contaminants.

3. Background

Tank 20 is a type IV waste tank in the F-area Tank Farm. The tank is an underground carbon steel waste tank, 85 feet in diameter, and has a working capacity of 1.3 million gallons. Tank 20 was placed into service in 1960 as an evaporator concentrate receipt tank. Concentrated waste in the form of saltcake was removed from the tank in several campaigns from 1980 to 1988. Waste removal, which included spray washing of the dome and sides with water, was completed in 1988.

A liquid heel of approximately 20,000 gallons of ballast water was added in 1990. The purpose of the heel was to prevent uplift of the bottom of the tank if water were to collect in the leak detection system underneath the tank. From 1990 to 1996, inhibitors (sodium nitrite and sodium hydroxide) were added to the tank to ensure that inhibitor concentrations stayed sufficiently high to prevent corrosion of the carbon steel wall.

4. Estimating the Mass of Residual Waste

Estimating the inventory of contaminants in Tank 20 required estimating 1) the mass of residual waste in the tank and 2) the concentration of contaminants in this waste. This section discusses the mass estimates. Section 5 discusses waste concentration estimates and inventories.

Photographs of the floor of Tank 20 taken after the ballast water was pumped out have shown that, except for a few small regions, the entire tank floor is covered by liquid approximately 1 inch high. The liquid is the remainder of the ballast water that was not picked up by the pump. Over the last 10 years, inhibitors have been added to protect the tank steel, so this ballast water contains inhibitors (sodium nitrite and sodium hydroxide) and other compounds that were in the waste, mainly sodium nitrate, carbonate, and sulfate.

Underneath the liquid are precipitated solids left after waste removal. Two areas of the tank appear to have no smearable solids (i.e. the floor of the tank as seen through the liquid appears to be clean). The rest of the tank contains predominantly brown solids, which have been shown to be similar in composition to PUREX low-heat waste sludge. The tank also contains a number of small deposits of white solids that have been shown to be primarily cryolite (see section 5.2, "Samples"). The mass of cryolite solids is small; however, because cryolite is over 50 wt% fluoride, these solids contribute significantly to the fluoride inventory in the tank.

The sections that follow describe the method of determining the volumes of precipitated solids in the tank.

4.1 Lifting Plates

The depth of the brown sludge on the floor of Tank 20 was estimated by observing the sludge relative to lifting plates that were placed on the tank floor during construction. The purpose of the plates was to allow the plates forming the floor of the tank to be butt-welded from both sides during construction. The procedure for constructing the tank bottom was as follows:

- The steel plates that formed the tank floor were placed on top of the concrete pad, the top half of all welds was completed, and the lifting plates with lugs were welded into place.
- Using a lifting frame (Print W164197, 2/16/56), the tank floor was lifted off the ground.
- The bottom half of each weld was completed by welders crawling underneath the lifted plates.
- The tank floor was lowered to the concrete pad, and the lifting lugs were ground off.

Although the lifting lugs were removed during construction, the lifting plates were left in place. Thus, they now provide convenient "depth gauges" for estimating the depth of solids on the tank floor.

Figure 1 shows the arrangement of lifting plates (print W164197). The lifting plates are 12 by 12 inches, 3/8 inches high, and have a 1/4-inch weld bead around their perimeter.

4.2 Estimating Sludge Volume

The depth of sludge at each point in the tank was estimated from photographs of the tank floor. Figure 2 shows the sludge and other equipment that was seen in the photographs. The photographs show a number of pieces of abandoned equipment in the tank, including a transfer jet, several pieces of rope, several pieces of conduit, and a number of steel tapes underneath the steel tape riser.

4.2.1 Clean Regions

The regions underneath the southwest and center risers have no smearable solids contamination. This conclusion is based on 1) photographs, which show what appears to be oxidizded tank steel in these locations, and 2) an unsuccessful attempt to swipe contamination underneath the southwest riser. The attempt was made with an absorbent swipe wrapped around a weight. Although the swipe was dragged across the bottom of the tank repeatedly, no visible solids were collected.

Photographs of the area underneath the southwest riser and the center riser show circular regions on the floor underneath the risers (HLW File Photograph 1028:25). The location of the regions under spray washing nozzles suggest that they are clean regions where the sludge has been swept away by the spray washing nozzles. The regions are light brown, approximately 15 feet across, and are noticeably lighter in color than other parts of the tank floor, which range in color from medium brown to dark brown. The tops of the lifting plates in the clean regions are approximately the same color as the floor, unlike other regions of the tank, where the lifting plates are lighter in color than the floor, presumably because the tops of the lifting plates have a thinner layer of sludge than the surrounding floor.

Also, the edges of the clean regions have a "spoke" pattern of short, clean lines radiating outward from the centers of the regions. The "spokes" average about a foot in length. The pattern is the cleaning pattern of the spray nozzle. Each pass of the rotary spray nozzle created another clean "spoke" in the pattern.

Figure 1. Tank 20 Top and Floor

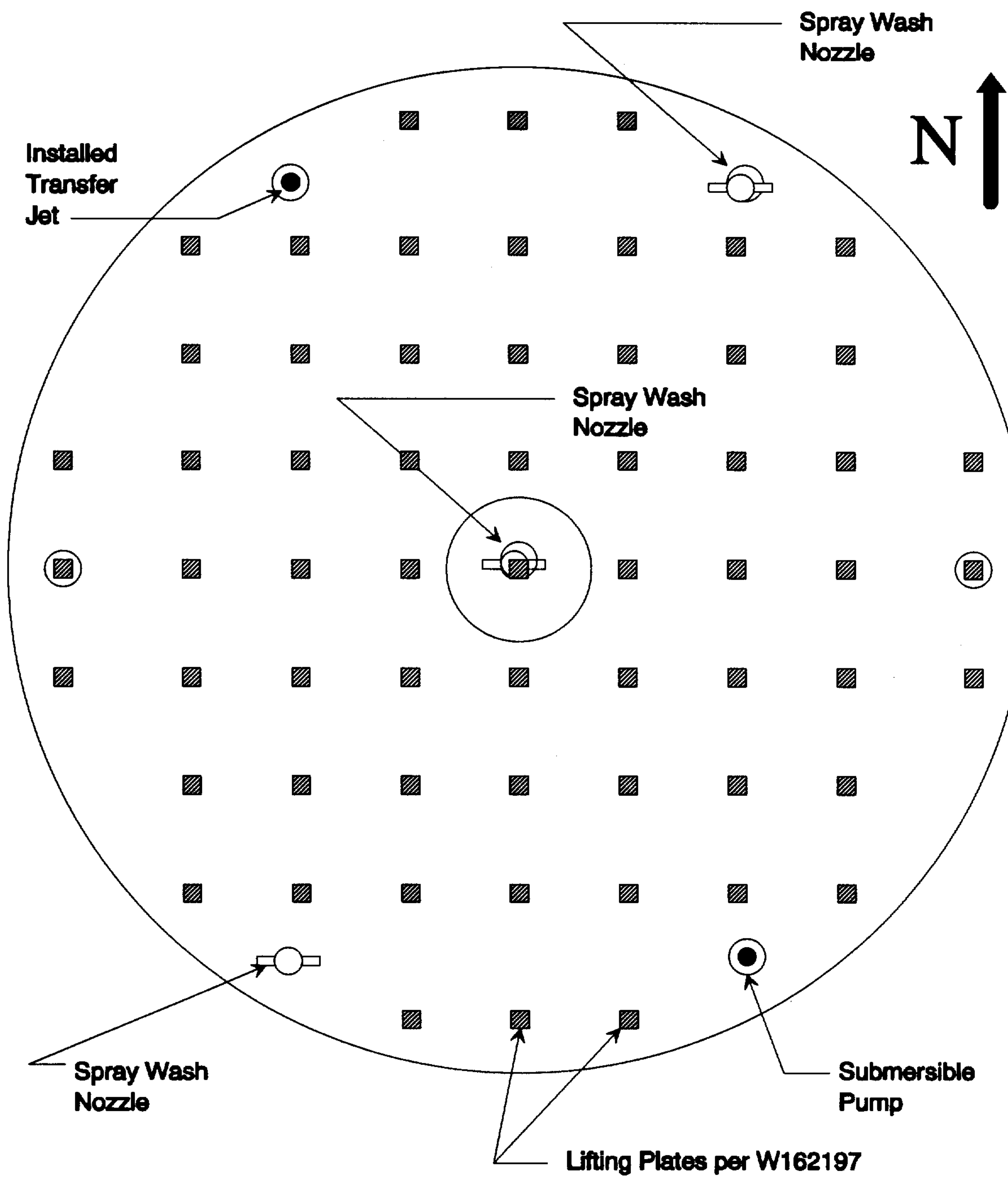
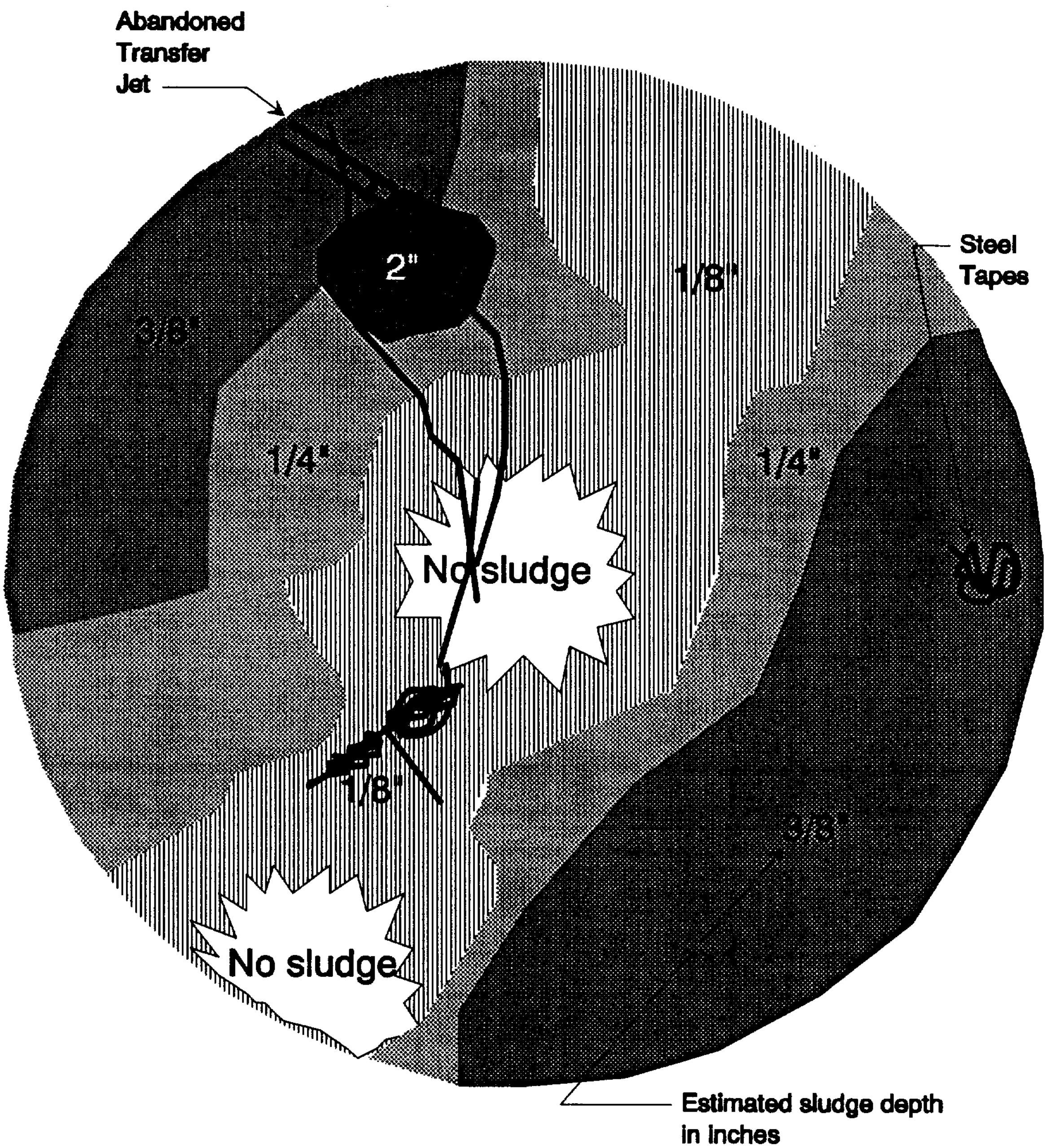


Figure 2. Sludge and Abandoned Equipment in Tank 20



4.2.2 Brown Solids

As mentioned previously, most of the floor of the tank is covered by brown solids. The solids range from very thin (the areas immediately surrounding the clean regions) to a fraction of an inch (underneath the northwest and southeast risers). Also, there is an "island" near the northwest riser that sticks above the water level and has sludge that is noticeably deeper than the rest of the tank.

Figure 2 shows the estimated depths at each spot in the tank. In estimating depths, the following guidelines were used:

- The light brown regions under the southwest and center spray wash nozzles were estimated to have no sludge, as explained in the previous section.
- In places where some sludge was evident on the floor (darker brown than the clean regions) but the tops of the lifting plates appeared to be free of sludge (as evidenced by the same light brown color as the clean regions), the sludge depth was estimated to be less than 1/8 inch sludge. Several plates with this appearance are located immediately at the periphery of the clean zones, indicating that this appearance signifies a thin layer of sludge.
- In places where the lifting plates were a darker color than the clear regions but are still noticeably lighter than the surrounding sludge, the sludge depth was estimated to be 1/4 inch of sludge. The depth in this region is obviously higher than the thin region (1/8 inch) but lower than the top of the lifting plate (3/8 inch), which is the basis for the estimate of 1/4 inch.
- In places where the lifting plates were not visible or only barely visible the sludge depth was estimated as 3/8 inch of sludge or more. In these places, the sludge has evidently partially covered or completely covered the lifting plates, which are 3/8 inch in height.
- The "island" between NW and NE risers was estimated as having 2 inches of sludge. In photographs taken immediately after the first pump-out operation, when the liquid level was about 1 1/2 inches, this region appeared to rise only slightly from the liquid.

The areas of the regions identified in Figure 2 were estimated using a manual grid technique, in which each region was overlaid with a grid pattern of known size. The number of grid squares within each region was manually counted, and the area of the region was estimated by multiplying the number of squares by the size of each square. The estimated areas of each region were then multiplied by the estimated depth to obtain an estimate of the volume of sludge in each region. The estimated volumes were then summed.

Results were as follows:

Sludge Depth (in.)	Estimated Area (Square feet)	Estimated Volume (cubic feet)	Estimated Volume (gallons)
0	369	0	0
0.125	1557	16	121
0.25	1475	31	230
0.375	2151	67	503
2	123	20	153
Totals	5675	135	1007

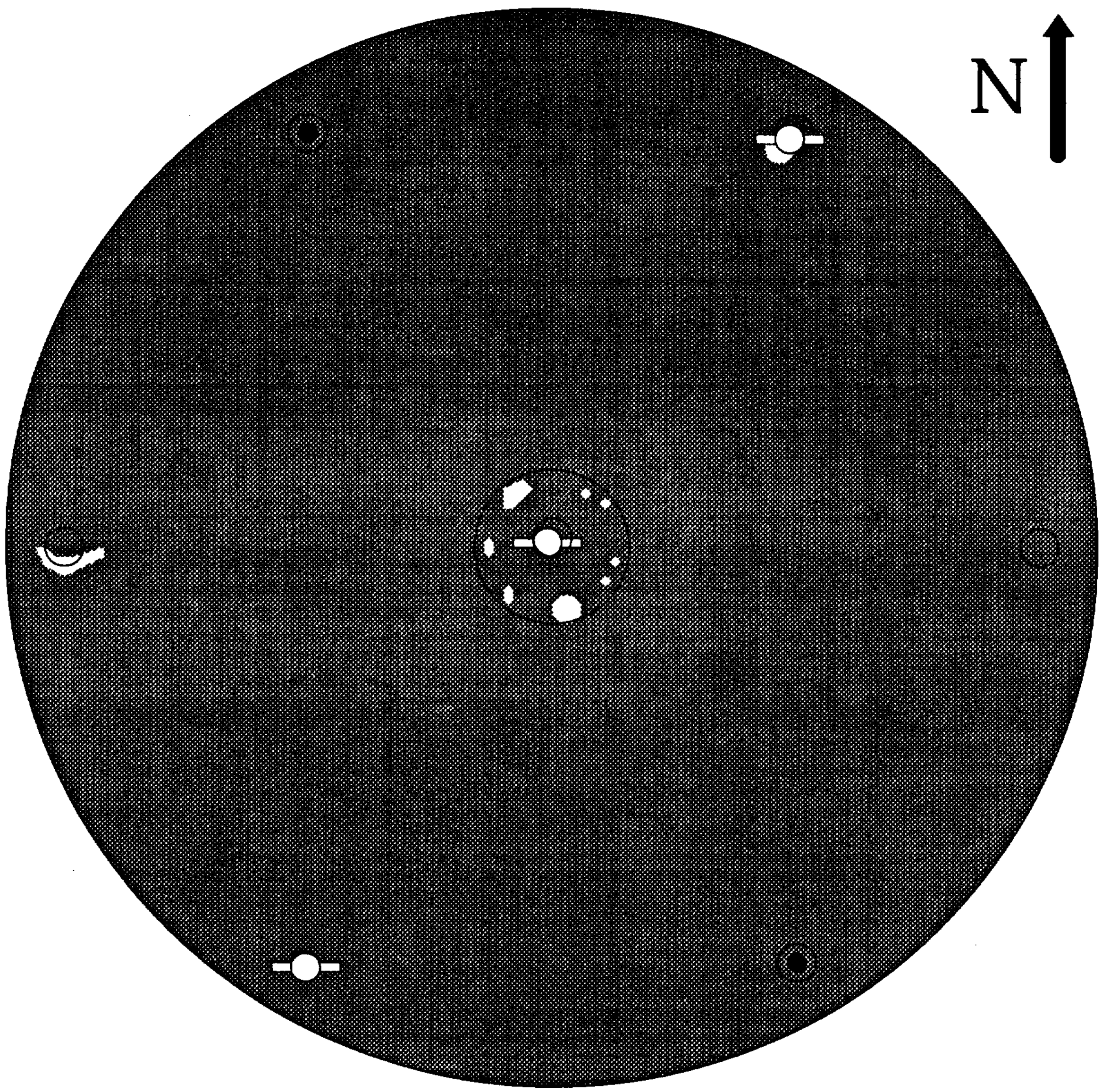
This is the basis for the estimate that the volume of sludge solids in Tank 20 is about 1000 gallons.

Previous studies have demonstrated that there are approximately 1.95 pounds of dry sludge solids per gallons of settled sludge.[3] The solids density of the solids in the bottom of Tank 20 is not known, but it is expected that the density of a thin layer of solids left after waste removal should be less than deep sludge in a waste tank, which is compacted due to compressive settling. Therefore, 1.95 pounds of dry sludge solids per gallon is probably a reasonable upper bound for the solids density in Tank 20. This is equivalent to an estimated 1,950 pounds of dry sludge solids in Tank 20.

4.2.3 White Solids

In addition to the brown solids in Tank 20, the tank also contained a number of piles of white solids. The piles have been determined to be primarily cryolite and sodium sulfate (see "Samples" section). Figure 3 shows the locations of the piles of white solids in Tank 20 as recorded in file photographs 1028:24 through 1028:29. At the time the photographs were taken, there were ten piles of white solids in the tank. The size of the white piles was significantly reduced between the initial inspection of the tank and later inspections.

Figure 3.
Location of White Solids



The location of the piles and the fact that they decreased in size between the two inspections suggests that they were formed in locations where rainwater dripped into the tank. Each of the piles is at a spot below a riser where water could have dripped into the tank. The piles underneath the center riser are near the periphery of the riser, where the riser plugs meets the riser, which is the location that rainwater could leak in. Also, inspections of the center riser show small "stalactites," perhaps a couple of inches long at the bottom of the riser, confirming that liquid entered the tank through this riser. Such stalactites are routinely found in the tank farm underneath risers that have experienced rainwater inleakage. There are also piles of white solids underneath the slurry pump in the west riser and the spray wash jet in the northeast riser; both are spots where water could leak in the tank.

Further evidence that dripping caused the piles is the appearance of the piles at the time during the second inspection. A number of piles had localized craters, which appear to have been formed when liquid dripped into the pile and dissolved the white solids. There were hard rains between the two inspections, which is consistent with the hypothesis that rainwater leaking in caused the craters.

The main compound in these piles was identified to be cryolite (See section 5.2, "Samples"). The evidence suggests that this compound became supersaturated in the ballast water. Between 1990 and 1996, the sodium concentration in the tank climbed slowly as sodium hydroxide and sodium nitrite were added to maintain inhibitor concentrations in the tank. Apparently, at some time during this period the solution exceeded the solubility product for cryolite, became supersaturated in cryolite, and the cryolite precipitated. The location of the piles suggests that they precipitated in spots where the solution was disturbed by dripping water. When the ballast water was pumped out the tank, and the piles were exposed to unsaturated rainwater, the solids dissolved.

The volume of white solids in the tank is estimated to be less than 50 gallons, with a total dry solids weight of less than 100 pounds. This estimate was derived as follows. The seven piles of solids underneath the center riser are all estimated to be much less than 2 feet in diameter and 4 inches tall. The piles underneath the northeast riser and the west riser are larger than the piles underneath the center riser, but the volume of all of the piles can be conservatively estimated as 10 piles of solids with a diameter of 2 feet and height of 4 inches. For the purposes of estimation, the surface of the pile is assumed to be roughly spherical in shape. The volume of a spherical section with a height of 4 inches and a circular base two feet in diameter is computed as follows:

Volume of a Spherical Dome = $\pi \cdot h \cdot \left(\frac{c^2}{8} + \frac{h^2}{6}\right)$ Reference: Machinery's Handbook, p. 16

Where: c = diameter of the base of the dome (2 feet)
h = height of the dome (4")

$$\pi \cdot \left(\frac{4}{12} \cdot ft\right) \cdot \left[\frac{(2 \cdot ft)^2}{8} + \frac{\left(\frac{4}{12} \cdot ft\right)^2}{6}\right] = 0.543 \cdot ft^3$$

This is equivalent to about 4 gallons per pile, or, conservatively, about 50 gallons for 10 piles. Assuming that the material has the same density as ordinary sludge (1.95 pounds of dried solid per gallon of settled sludge), this is approximately 100 pounds of dry white solids in the tank.

5. Waste Composition and Inventory

As mentioned previously, most of the solids in Tank 20 appear to be sludge solids, even though the tank was never a sludge receiver. Apparently, the sludge entered the tank entrained in the concentrated salt solution. Previous samples of supernate and salt have shown that all supernate and salt contains small quantities of sludge that have not completely settled out of the liquid.[4] When supernate is evaporated, the entrained sludge is carried into the evaporator system and is deposited into the concentrate receiver tank.

The residual waste at the bottom of a waste tank (either a sludge tank or salt tank) at the end of waste removal is always expected to be primarily sludge. The concentration of entrained sludge in salt, as deposited by evaporation, is small. However, the sludge in a salt tank will be concentrated during waste removal. The reason for this is that hydraulic slurrying techniques are more effective at removing salt than sludge. Salt readily dissolves and is easily removed from the tank. Sludge is not soluble, and so it must be suspended by the slurry pumps. Even if the sludge can be completely suspended, when the sludge slurry is pumped from the tank it begins to settle when the slurry pumps are turned off (The slurry pumps must be turned off during transfers to prevent the pumps from sucking air, which causes accelerated wear). Thus, no matter how good the suspension, some sludge is always left behind at the end of the transfer. If the slurry pumps are not able to suspend some spots in the tank, due to their distance from the pumps, then even more sludge is left in these spots.

5.1 Process Knowledge Estimates

Estimates of the residual sludge in Tank 20 were derived from the Waste Characterization System (WCS).[5]

The estimated composition of Tank 19 sludge was used as the estimate for the composition of the residual sludge in Tank 20. As explained in the previous section, the sludge in Tank 20 probably entered the tank entrained in supernate that passed through the evaporator system. Tank 19 received sludge derived from the same type of waste (Purex low-heat waste) as in Tank 20. Therefore, the composition of sludge in both tanks should be similar, and the estimated composition of Tank 19 sludge, which has been derived from production records, is a reasonable estimate of the residual sludge composition in Tank 20.

The inventories and compositions of major sludge constituents in WCS are based on tank fill histories. WCS sludge inventories are based on sludge transfers from the canyons to the tank farms and between tanks. WCS contains the following information about each sludge transfer:

- Date
- Source - canyon or tank
- Destination - tank
- Process - PUREX or H Modified (HM)
- Stream - High Heat Waste (HHW), Low Heat Waste (LHW), or Mixed
- Volume
- Major chemical compound weights - $Fe(OH)_3$, $NaAlO_2$, $Ni(OH)_2$, and MnO_2
- Major actinide weights - Th-232, U-233, U-234, U-235, U-236, U-238, Np-237, Pu-238, Pu-239, Pu-240, Pu-241, and Pu-242

5.1.1 Chemical Contaminants

For each transfer, WCS keeps track of which tank received the waste and how much of each compound was in the transfer. For major chemical compounds (the four listed above) the information comes directly from canyon records. These four compounds account for about 80% of the weight of SRS sludge. The minor compounds are estimated by multiplying the weight of $Fe(OH)_3$ by the flowsheet ratio of that constituent to $Fe(OH)_3$. WCS computes the inventory of chemical contaminants that were received in each waste tank by simply summing up the quantity of chemicals in each transfer.

To determine the concentration of each compound, the inventory of that compound is divided by the calculated total mass of sludge in the waste tank. In the case of Tank 20, the concentration of each compound in the Tank 19 sludge was computed. These concentrations were then multiplied by the estimated mass of sludge in Tank 20 (1950 pounds) to derive an estimate of the total chemical inventory in the tank, which is reported in Table 2.

5.1.2 Radionuclides

The radionuclide inventory was estimated only for the sludge because the primary salt radionuclide, Cs-137, would have been preferentially washed out during spray washing.

WCS computes the inventory of fission and activation products (H-3 through Eu-155 in Table 1) using concentrations based on yield distributions in SRS reactor assemblies and solubility data. The concentrations predicted by WCS were used to estimate the inventory in Tank 20, with the exception of Tc-99, which is discussed in the section below.

WCS computes the inventory of sludge actinides (U-232 through Cm-245 in Table 1) using a combination of techniques used for chemicals and fission and activation products. The mass of major actinides in each transfer are known from canyon accountability records or process records. The concentration of minor actinides was estimated from yield distributions in SRS reactor assemblies.

Similar to the treatment for chemical constituents, the concentration of each radionuclide in Tank 20 was computed by dividing the estimated inventory in Tank 19 by the estimated total mass of sludge in Tank 19. Each of these concentrations was them multiplied by the estimated mass of sludge remaining in Tank 20 to derive the inventories that are reported in Table 1.

5.1.3 Tc-99

The process knowledge inventory reported in Table 1 for Tc-99 is based on a concentration that is 13.5 times the concentration reported by WCS. This is the only nuclide for which the process knowledge concentration has been adjusted. The value for this radionuclide was adjusted for two reasons:

- The performance evaluation predicts that the dose at the seepline will be predominantly due to Tc-99. Therefore, it is important to estimate this radionuclide conservatively.

- Sample results indicate that the concentration of Tc-99 in the residual sludge in Tank 20 is elevated relative to the concentration predicted by WCS for the bulk sludge. In particular, the ratio of Tc-99 to iron (iron is an indicator for sludge) is extremely high in the white deposits in Tank 20. The presence of highly enriched Tc-99 in these deposits suggests that the Tc-99 might have precipitated in the cryolite, so that the residual deposits have a higher amount of Tc-99 than the bulk sludge.

The adjustment factor of 13.5 was chosen in September 1996. At that time the Tc-99 concentration predicted for Tank 20 by process knowledge was 6.95 E-05 Ci/kg, whereas the measured concentration in the Tank 20 sludge is 0.94 microCi/gm, which is equivalent to 9.4 E-04 Ci/kg.[6] Since that time, the process knowledge estimate has changed slightly due to refinements in the method of calculation. WCS currently predicts that the sludge in Tank 20 should have a concentration of 6.252 E-05 Ci of Tc-99 per kg. Thus, the appropriate adjustment factor to be used in the performance evaluation should have been be 15 (9.2 E-04 divided by 6.252 E-05), about 11% higher. However, the error introduced by using the old adjustment factor is small, and there are no plans to revise the Tank 20 performance evaluation.

5.2 Samples

There were four sampling attempts made in Tank 20 to validate the estimates obtained from process knowledge. For the purposes of this report, the samples will be referred to as Samples 1, 2, 3, 4. The location that each of these samples is indicated in Figure 4. The samples were as follows.

Sample	Location	Description
1	Southeast riser	Mudsnapper* sample of white solids underneath riser
2	Southeast riser	Absorbent swipe of brown solids a few inches northwest of riser
3	Southwest riser	Absorbent swipe of bottom. No solids were collected on the swipe
4	North of Southwest riser	Scrape sample of brown solids to the north of the riser

*The mudsnapper was a spring-loaded, clam-shell sampler that was used to collect thick solids beneath the southeast riser.

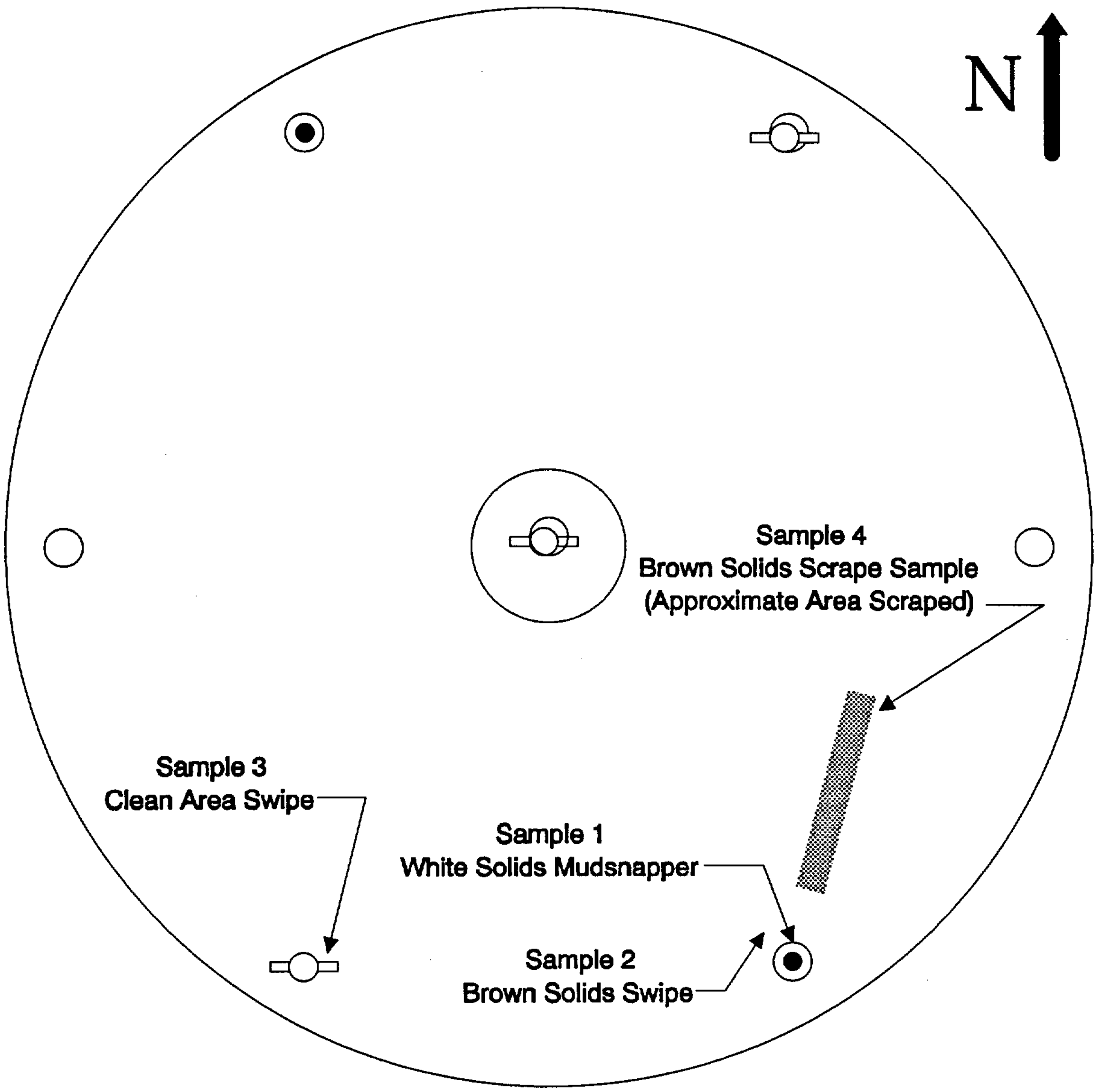
Each of these samples was transported to SRTC for analysis. The analyses performed and results are documented in Reference 7.

A summary of the sample results is as follows:

Sample 1 was a mixture of cryolite, sodium sulfate, and sludge. The cryolite (Na_3AlF_6), which comprises about 60% of the sample, was identified by X-ray diffraction. Also the ratio of Al to F in the sample is consistent with the formula for cryolite, although the sample has an excess of sodium relative to Al and F. Excess sodium is to be expected because sodium is also the main cation for the other anions found in the sample.

As mentioned previously, the cryolite was deposited in locations where water dripped into the tank. Apparently, the solution in the tank became supersaturated with cryolite because of sodium additions. The location of the piles suggests that they precipitated in spots where the solution was disturbed by dripping water.

Figure 4
Locations of Samples from Tank 20



Sample 2 was a swipe of the brown solids. It was not possible to quantitatively analyze the sample because the sample was entrained in the swipe material. Therefore, the entire swipe was dissolved in aqua regia, so it was not possible to measure the actual weight of the dry solids collected. The ratios of sludge constituents were compared to ratios in known sludge and shown to be comparable, but no quantitative information on contaminant concentration was obtained from this sample.

Sample 3 had no observable solids (because the area underneath the southwest riser is clean) and was not analyzed.

Sample 4 was a sample of brown solids that was scraped from the floor. The composition of the sample was similar to sludge, although it also contained about 8% sulfate and 15% oxalate, which is not characteristic of sludge. Apparently, these two salts precipitated out of the ballast water. The sample results are shown in Tables 1 and 2.

5.3 Estimated Inventories

The estimated inventories of contaminants in Tank 20 are reported in Tables 1 and 2.

5.3.1 Radionuclide Inventories

Table 1 shows the radionuclide contaminants. Columns 2 and 3 show the inventories predicted from process knowledge, as discussed previously. Columns 4 and 6 show the concentrations in Samples 1 and 4, respectively. Column 8 shows the inventory predicted from sample results, using the assumption of 50 gallons of white solids and 1000 gallons of brown solids.

The predicted inventory of Se-79, 0.003 Ci, is below the detection limit for Se-79, so the result of less than 0.9 microcuries per gram was expected. However, Se-79 is a fission product, so the inventory predicted from fission product yields should be reasonably accurate.

The inventories of Cs-137 and Pu-239 were below the predictions.

Tc-99, Pu-238, and Np-237 were notably higher than predictions. As noted previous, the concentration of Tc-99 was sufficiently high that the process knowledge estimate was adjusted upward by a factor of 13.5.

Eight curies of Pu-238 were found in Tank 20, although none were predicted. Production records do not indicate that any Pu-238 went to Tank 20, which contains Purex Low-Heat Waste. It had long been recognized that some small amount of Pu-238 would be present in Purex Low-Heat Waste, but the amount was expected to be small enough to be neglected. The sample result from Tank 20 shows that this assumption is not correct, because Pu-238 is, in fact, the alpha radionuclide that is present in highest concentration.

For the performance evaluation, Pu-238 is not a concern because it is relatively immobile in the environment and has a half life of only 86 years. Therefore, virtually no Pu-238 will travel through the environment and outcrop at the seepline. However, the Pu-238 is a concern because of its Class C implications (see next section). Plans are to revise the assumptions in the WCS to specify that some fraction of the Pu-238 goes to Low-Heat Waste.

The last nuclide that occurred higher than its predicted concentration was Np-237. Similar to Pu-238, Np-237 was thought to be present in low enough concentrations that it could be neglected. The inventory estimated of Np-237 in Tank 20, 5.5 E-04 Ci, is low. However, of the nuclides of concern in Tank 20, Np-237 is unique in that it has a high ingestion dose conversion factor, a long half life, and travels through the environment relatively easily (Most nuclides with high dose conversion factors, such as Pu-239, are relatively immobile). Therefore, it is important to estimate Np-237 conservatively.

For the purposes of Tank 20, Np-237 can be neglected. For example, a performance evaluation was done for Tank 17, which has about 20 times the Np-237 as Tank 20 (The estimated quantity is 0.013 Ci in Tank 17). The Tank 17 performance evaluation showed the concentration at the seepline to be a small fraction of the limit for alpha-emitting nuclides. Therefore, there are no plans to revise the performance evaluation for Tank 20. However, as a result of the discovery of Np-237 in Tank 20 and 17, plans are to revise the WCS to account for Np-237 in Low-Heat Waste. It appears likely that Np-237 may be a significant dose contributor to the performance evaluation for some tanks.

5.3.2 Class C Calculation

The rightmost five columns of Table 1 include a Class C calculation for the waste in Tank 20. The column entitled "Class C Upper Limit" shows the Class C limit for each radionuclide. The units for the value in the column are shown in the next column, entitled "Class C Units." The next column, "Tank 20 Concentration in Class Units," shows the computed concentration of the Tank 20 sludge converted to the appropriate units.

In the column "Factor relative to Class C Limit" the computed concentration in Tank 20 is divided by the limit to obtain a Class C factor for each radionuclide. To be within the Class C designation the sum of all of these factors must be less than or equal to 1. As can be seen from the sum at the bottom of the column, the sludge in Tank 20 is currently 174 times the upper limit for Class C.

The last column, "Factor with 7.196 inches of backfill," shows the factors if one takes credit for the mass of 7.196 inches of grout covering the entire tank floor in computing the radionuclide concentration. The grout is assumed to have a specific gravity of 1.6, which is equivalent to light CLSM. Plans are to pour reducing grout in Tank 20, which has a specific gravity of 2.4, so this calculation incorporates a safety factor of 50%. As can be seen from the summation at the bottom of the column, 7.2 inches of grout is sufficient to bring the sum of the Class C factors down to 1.000. Thus, if one takes credit for the mass of 7.2 inches or more of grout covering the entire tank floor, the concentration of the waste plus grout in Tank 20 will be less than the upper limit for Class C.

5.3.3 Chemical Inventories

Table 2 shows the chemical contaminants. Column 2 shows the inventories predicted by WCS. Also shown are the concentrations measured in the tank, and the estimated inventories based on the samples.

Table 1
Radionuclide Inventories in Tank 20 Solids

Nuclide	Concentration from WCS (10/31/96) (Ci/kg)	Tank Inventory based on 1000 gal	Sample 1 Mudsnapper white solids (microCi/gm)	Inventory based on 50 gal of white solids (Ci)	Sample 4 Scrape Sample of brown solids (microCi/gm)	Inventory based on 1000 gal of brown solids (Ci)	Total inventory estimated from Samples (Ci)	Conservative Estimate (Highest of WCS and samples) (Ci)	Class C Upper Limit	Class C Units	Tank 20 concentration in Class C units	Factor Relative to Class C limit	Factor with 7.196 inches of backfill (SpG=1.6)
H-3	0.00E+00	0.00E+00						0	None	NA			
C-14	7.411E-07	6.56E-04						6.6E-04	8.000E+00	Ci/m^3	0.00017	2.16E-05	8.5E-07
Ni-59	4.357E-05	3.85E-02						3.9E-02	2.200E+02	Ci/m^3	0.010	4.62E-05	1.817E-06
Co-60	7.552E-04	6.68E-01	0.1	0.0044	0.116	0.103	0.107	6.7E-01	None	NA			
Se-79	3.604E-06	3.19E-03	<0.9	<0.04				3.2E-03	None	NA			
Sr-90	2.148E-01	1.90E+02	12.8	0.567	44.6	39.5	40.1	1.9E+02	7.000E+03	Ci/m^3	50.2	0.00717	0.0002816
Y-90	2.148E-01	1.90E+02						1.9E+02	None	NA			
Tc-99	6.252E-05	*7.47E-01	0.34	0.0151	0.94	0.83	0.85	8.5E-01	3.000E+00	Ci/m^3	0.22	0.0747	0.0029331
Ru-106	4.889E-07	4.32E-04						4.3E-04	None	NA			
Rh-106	4.889E-07	4.32E-04						4.3E-04	None	NA			
Sb-125	5.118E-04	4.53E-01						4.5E-01	None	NA			
Sn-126	6.696E-06	5.92E-03						5.9E-03	None	NA			
I-129	2.967E-10	2.62E-07						2.6E-07	8.000E-02	Ci/m^3	6.93E-08	8.66E-07	3.403E-08
Cs-134	2.274E-06	2.01E-03						2.0E-03	None	NA			
Cs-135	4.126E-08	3.65E-05						3.6E-05	None	NA			
Cs-137	1.478E-02	1.31E+01	37.6	1.666	44.3	39.3	40.9	4.1E+01	4.600E+03	Ci/m^3	10.83	0.0023	9.246E-05
Ce-144	1.994E-08	1.76E-05						1.8E-05	None	NA			

* The inventory reported for Tc-99 is computed assuming a concentration 13.5 times that reported in WCS. See section 5.3, "Tc-99."

Table 1 Continued
Radionuclide Inventories in Tank 20 Solids

Nuclide	Concentration from WCS (10/31/96) (Ci/kg)	Tank Inventory based on 1000 gal	Sample 1 Mudsnapper white solids (microCi/gm)	Inventory based on 50 gal of white solids (Ci)	Sample 4 Scrape Sample of brown solids (microCi/gm)	Inventory based on 1000 gal of brown solids (Ci)	Total inventory estimated from Samples (Ci)	Conservative Estimate (Highest of WCS and samples) (Ci)	Class C Upper Limit	Class C Units	Tank 20 concentration in Class C units	Factor Relative to Class C limit	Factor with 7.196 inches of backfill (SpG=1.6)
Pr-144	1.994E-08	1.76E-05						1.8E-05	None	NA			
Pm-147	8.666E-03	7.66E+00						7.7E+00	None	NA			
Eu-154	1.167E-03	1.03E+00	<0.3	<0.01				1.0E+00	None	NA			
Eu-155	0.00E+00	0.00E+00						0.0E+00	None	NA			
U-232	1.149E-08	1.02E-05						1.0E-05	100	nCi/gm	0.011	0.00011	6.59E-07
U-233	0.00E+00	0.00E+00						0.0E+00	100	nCi/gm	0	0	
U-234	0.00E+00	0.00E+00						0.0E+00	100	nCi/gm	0	0	
U-235	7.235E-08	6.40E-05	8.30E-06	3.68E-07	2.10E-05	1.86E-05	1.90E-05	6.4E-05	100	nCi/gm	0.072	0.000724	4.149E-06
U-236	0.00E+00	0.00E+00	1.30E-05	5.76E-07	3.00E-05	2.66E-05	2.72E-05	2.7E-05	100	nCi/gm	0.03	0.00031	1.761E-06
U-238	6.609E-06	5.85E-03	2.40E-04	1.06E-05	6.17E-04	5.47E-04	5.58E-04	5.8E-03	100	nCi/gm	6.6	0.066	0.000379
Np-237	0.00E+00	0.00E+00	0.0038	1.68E-04	6.18E-04	5.48E-04	5.48E-04	7.16E-04	100	nCi/gm	0	0	0
Pu-238	0.00E+00	0.00E+00			8.3	7.36E+00	7.356818	8	100	nCi/gm	9025	90.26	0.5186632
Pu-239	3.872E-03	3.42E+00	0.44	0.0195	0.941	0.834068	0.853568	3.5	100	nCi/gm	3950	39.48	0.2269152
Pu-240	8.639E-04	7.64E-01			0.2	1.77E-01	0.177273	7.64E-01	100	nCi/gm	862	8.62	0.0495417
Pu-241	5.625E-02	4.98E+01						5.0E+01	3500	nCi/gm	56100	16.04	0.0921653
Pu-242	1.782E-06	1.58E-03						1.6E-03	100	nCi/gm	1.778	0.017	0.0001022
Am-241	0.00E+00	0.00E+00			1.9	1.68E+00	1.684091	1.7E+00	100	nCi/gm	1895	18.95	0.1089193
Cm-244	1.954E-07	1.73E-04						1.7E-04	100	nCi/gm	0.195	0.0020	1.121E-05
Cm-245	1.032E-13	9.13E-11						9.1E-11	100	nCi/gm	1.03E-07	1.03E-09	5.919E-12
Total alpha emitting nuclides with half lives greater than 5 years								1.4E+01					
									Sum of Class C Factors			174	1.0000

Table 2
Chemical Inventories in Tank 20 Solids

	Inventory from WCS (10/31/96) based on 1000 gal (kg)	Sample 1 ~~Mudsnapper~~ White Solids (wt%)	Estimated White solids Inventory Based on 50 gal (kg)	Sample 4 Scrape Brown solids (wt%)	Estimated Brown solids Inventory Based on 1000 gal (kg)	Estimated Total Inventory based on samples (kg)
			50.0		1000.0	
Silver	3.068375	<0.02				
Aluminum	50.86222	8.2	3.6	3.0	26.9	30.5
Barium	1.789763					
Fluoride	1.619407	33.0	14.6	1.0	8.9	23.5
Chromium	2.159336	0.1	0.0	0.3	2.5	2.5
Copper	1.53426	0.0	0.0			0.0
Iron	247.4876	2.7	1.2	7.9	70.0	71.2
Mercury	0.630674					
Nitrate	16.62612					
Manganese	11.41312	0.4	0.2	1.3	11.7	11.9
Nickel	0	0.0	0.0	0.1	0.8	0.8
Lead	2.556964	<0.05				0.0
Uranium	17.41831					
Zinc	3.067194					
Sodium	33.8	30.0	13.3	27.8	246.4	259.7
Silicon	7.6	0.8	0.3	0.5	4.8	5.2
Boron		<0.02				
Calcium	22.5	0.5	0.2	1.4	12.2	12.4
Lithium		<0.008				
Magnesium	0.7	0.1	0.1	0.5	4.3	4.3
Molybdenum		<0.003				
Titanium		<0.005		0.0	0.1	0.1
Zirconium	4.4	<0.019				
Cadmium		0.1	0.0	0.2	1.7	1.8
Phosphate	1.0	0.1	0.1			0.1
Chloride	10.8					
Sulfate	6.1	13.0	5.8	8.0	70.9	76.7
Oxalate	0.0			15.0	133.0	133.0

5.4 Other Contaminants

The risers in Tank 20 contain lead, which was intended to act as radiation shielding. Plans are to leave these risers in place when the tank is closed. The estimated mass of lead is approximated 500 pounds per riser. There are six risers on the tank, for an estimated total of 3000 pounds of lead.

In addition to the contaminants in Tanks 17-20, there will be contamination in other equipment in the area, such as the 1F Evaporator, the 1F Concentration Transfer System, ventilation systems, and transfer piping. The inventory of contaminants in these locations is expected to be small relative to the amount of contamination in the tanks.

To account for contamination outside of the tank, we recommend that an inventory of contaminants equal to 20% of the waste inside the tank be added to the performance evaluation for each waste tank (i.e. performance modeling of the Tank 17-20 area should add 20% of the inventory in these four tanks). Based on engineering judgment, this 20% should bound the contamination in these locations. As closure modules are prepared for these locations, the modules will show that the contamination left behind is smaller than this estimate, or the estimate will be revised and the performance evaluation repeated.

6. References

[1] "Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tanks," Rev. 1, 10 July 1996
[2] "Industrial Wastewater Closure Module for the High-Level Waste Tank 20 System," Rev. 1, 8 January 1997
[3] L. F. Landon and T. T. Thompson, "Technical Data Summary for the Defense Waste Processing Facility, Stage 2," DPSTD-80-39-2, December 1980
[4] J. R. Fowler, "Analysis of Tank 20 Saltcake," DPST-80-424, 16 June 1980
[5] J. R. Hester, "High Level Waste Characterization System," WSRC-TR-96-0264, December 1996
[6] P. D. d'Entremont and D. T. Bignell, "Options for Meeting Class C Criteria During HLW Tank Closure," WSRC-TR-96-0327, 16 October 1996
[7] M. S. Hay, "Analysis of Samples for Tank 20 Closure," WSRC-TR-97-XXXX (in draft)

Distribution for WSRC-TR-96-0267, "Characterization of Tank 20 Residual Waste,"
17 March 1997

DOE

L. T. Ling, 703-H
D. J. Blake, 703-H
G. R. Hannah, 703-H
T. T. Henderson, 703-H

WSRC

J. W. French, 703-H
K. D. Wilson, 241-121H
M. R. Wilson, 241-154H
K. A. Hauer, 241-100F
S. L. Marra, 703-H
J. L. Newman, 703-H
W. E. Stevens, 703-H
M. S. Hay, 773-A
B. T. Butcher, 773-43A
T. M. Monahon, 703-H
V. G. Dickert, 703-H
E. Saldivar, 742-4G
T. B. Caldwell, 742-4G
B. L. Lewis, 703-H
M. C. Chandler, 703-H
J. R. Hester, 703-H

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