

## TANK 4 BWR COMPLETE DETERMINATION

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## 1.0 Purpose

The purpose of this report is to provide chronology of Bulk Waste Removal (BWR) efforts and document the determination of Waste Tank 4 BWR completion.

## 2.0 Background

### 2.1 Tank 4 History

Tank 4 is Type I waste tank placed in service at the Savannah River Site (SRS) as fresh High Heat Waste (HW) receiver from the Purex process in F Canyon in April 1961. About 60% of supernate was decanted in February 1971. Tank 4 then began receiving Evaporator bottoms. During the period of evaporator bottom's receipt, about 34,000 gallons of soft salt accumulated on the top of the sludge. A hard layer of salt was encountered in late 2004 during installation of waste removal equipment. This hard layer was determined to be Berkeite Salt<sup>2</sup> and needed to be dissolved prior to initiation of bulk sludge mixing. The hard layer of Burkeit was estimated to be 6 inches thick on the top of 6.6 inches of common salt waste layer and 33.5 inches of sludge layer. The total waste at the beginning of the BWR was estimated to be 125Kgallons which includes approximately 16.3Kgallons of Berkeit, 17.9Kgallons of common salt waste and 90.8Kgallons of sludge. The Burkeit dissolution and removal was completed in September 2007<sup>3</sup>. The remaining common salt waste was dissolved and transferred to Tank 33 in late 2007. The sludge mixing and transfer campaign were initiated in mid 2009 and continued until March 2011. Table-1 depicts the timeline for the Burkeit, salt and sludge removal efforts.

### 2.2 Burkite and Salt Waste Removal

Riser mining in late 2004 was unable to penetrate a hard layer at approximately 44 inches from the tank bottom. A high pressure hydro lance tool with simulated caisson was utilized in March 2005, but was again unable to penetrate the hard layer. The subsequent analysis revealed that the portion of the salt waste had transformed into a hard layer known as Burkeit. Tank 4 contained approximately 350Kgallon (130 inches) of superante on the top of the Burkeit, common salt and sludge layer. The dissolution flowsheet<sup>4</sup> estimated that approximately 165,000 gallons of Inhibited Water (IW) would require to dissolve 6 inch Burkeit layer and approximately 43,000 gallons of IW to dissolve the 6.6 inch salt layer. Accordingly the supernate was transferred to Tank 8 and three batches of Burkeit dissolution, each with 55Kgal-60Kgal and 42Kgal of IW respectively dissolved all Burkiet and was transferred to Tank 33. The last dissolution batch in late 2007 used 46Kgallons of IW and dissolved a 6" layer of salt. The solution was transferred to tank 33 leaving a 33.5 inch layer of sludge.

Table – 1 Tank 4 Bulk Waste Removal chronology

Date Transfer	Transfer Tank	Initial Level	Final Level	Volume Transfer	Initial SpG	Receipt Tank	Initial Level	Final Level	Transferred material
		in	in	gal			in	in	
5/17/2007	4	76.5	56.1	55409	1.21	33	279.8	295.34	Burkite removal
6/24/2007	4	73.7	51.3	60162	1.21	33	294.3	311.63	Burkite removal
7/28/2007	4	68.3	53	41624	1.20	33	311.14	323.29	Burkite removal
9/2/2007	4	71.4	55.1	44569	1.28	33	323.24	336.44	Salt removal
10/4/2009	4	158.9	111.48	135500	1.31	51	105.9	143.5	Sludge slurry transfer # 1
9/18/2010	4	135.8	62	196555	1.21	51	174.9	232.9	Sludge Slurry Transfer # 2
11/8/2010	4	140.3	60.5	214903	1.18	7	108.3	186.35	Sludge Slurry Recycle transfer
11/14/2010	4	144.6	62.3	222762	1.16	7	103.54	186.36	Sludge Slurry Recycle transfer
11/22/2010	4	144.3	90.3	146069	1.16	7	104.48	157.77	Sludge Slurry Recycle transfer
2/10/2011	4	145.8	60.5	228453	1.16	7	109.9	193.49	Sludge Slurry Recycle transfer
3/1/2011	4	96	21.8	207857	1.15	7	109.93	185.79	Sludge Slurry Recycle transfer

### 2.3 Sludge Removal

The high pressure hydrolancing was performed in risers 3 and 8 in April 2005 to install waste removal equipment<sup>5</sup>. Interferences were observed in risers 6 and 8 during riser mining efforts in risers 3, 6 and 8. Based on the mining/probing results it was decided to install submersible mixing pumps (SMPs) in risers 3 and 8, and a submersible transfer pump (STP) in riser 6 without caisson. The SMPs were initially deployed at 40 inches from the tank bottom and STP was at 42 inches from the tank bottom. The SMPs were supported from the top and STP was on a mast structurally secured within the riser with air cylinders.

The mixing campaign started in April 2009 with SMPs at 40 inches in risers 3 and 8, and STP at 42 inches. The SMPs were operated for about 100 hours at 40 inch level. Next, both SMPs were lowered to 30 inches and operated for 100 hours.

Subsequently, SMP in riser 8 was lowered to 20 inches and in riser 3 to 22 inches from the tank bottom. The SMPs were operated at these levels for 140 hours when another attempt successfully lowered riser 8 SMP to 15 inch level. The slurry was transferred to Tank 51 in October 2009. Following the transfer, Riser 3 SMP was lowered to 13 inches. Two more mixing campaigns and one transfer were carried out and the mixed slurry was transferred to Tank 51.

A 3rd SMP in riser 1 was deployed in November 2010 to suspend and mix maximum volume of sludge in Tank 4. The SMP in riser 1 could be initially deployed at 8 inches, and after a pump run to 3 inches from the tank bottom. A waste recycling

concept was used between Tank 4 and Tank 7 wherein the sludge was mixed in Tank 4, transferred slurry to Tank 7 and returned supernate back to Tank 4 for further mixing. Total of 5 cycles of mixing and transfer were performed during "recycling" to transfer maximum waste out of Tank 4.

The STP failed after the 3<sup>rd</sup> campaign. Redesign of STP assembly allowed it to lower from 42 inches to 19 inches. The last 2 transfers were performed with STP at 19 inches. Cooling coil interferences with the STP were confirmed during mapping after campaign 5.

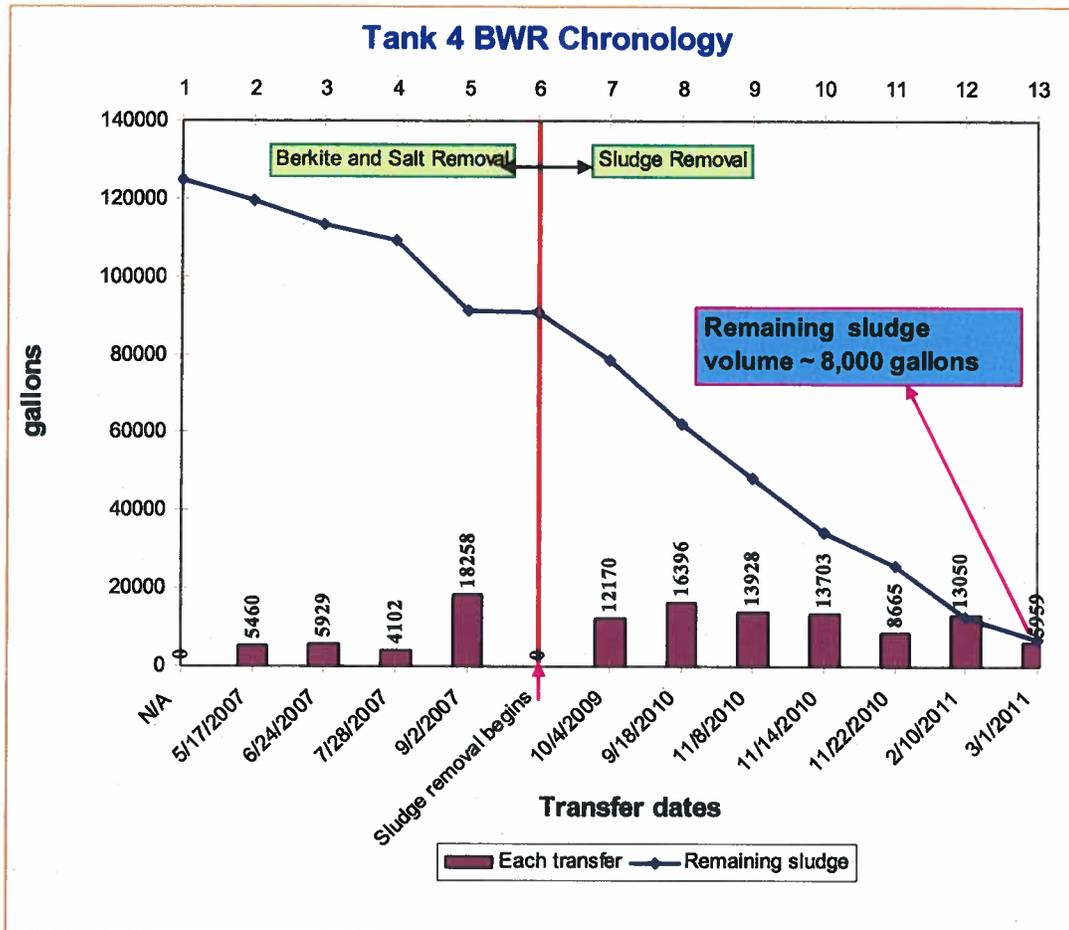
### 3.0 The BWR Process

The BWR process started in April 2005 and continued through March 2011. The process comprised primarily of three phases as

1. Berkeit dissolution and transfer
2. Salt dissolution and transfer
3. Sludge mixing and transfer

Total of 125Kgallons of waste was removed from Tank 4 in eleven transfers. Figure-1 depicts the volume of waste removed during each transfer and the volume of waste remaining in the tank after each transfer.

Figure -1 Tank 4 BWR Sludge Transfers



## 4.0 Sludge Mound Mapping

The mapping was performed in Tank 4 during and after the last transfer from Tank 4 to Tank 7 in late February 2011. The mapping results are documented in Reference 1. The sludge mapping was performed by monitoring Tank 4 during the transfer with one camera each in Riser 4 and the Center Riser. The height of the sludge mounds were assessed by obtaining liquid levels via the level monitoring radar device. Also, cooling coils, tank columns, slurry pump, and transfer pump screens were used as reference points to estimate liquid height as accurately as possible. The tank was monitored for sludge mounds approximately every thirty minutes. During the pump down no exposed mounds of sludge were observed. The transfer was completed at 21.8 inches as observed by tank landmarks. The final estimate of sludge volume was performed after waste settling. The sludge maps are shown in Figures 1 through 4.

### 4.1 Sludge Mapping Calculation Method

The waste was allowed to settle two days before performing a sludge height determination. The final waste liquid level, as observed from the Riser 4 camera, was determined to be 21.8 inches. This level could be accurately determined by comparing the suction screen detail to the known dimensions of the pump. The final sludge height is less than 3 inches since the lower cooling coil is clearly visible, the top of which is 3.2 inches off the floor. These visible features were repeatedly noticed in other areas during the tank inspection. This level of 3 inches appeared to be consistent across the observed areas of the tank. The inspection of the primary tank during and after the transfer did not show any sludge mounds remaining in Tank 4.

### 4.2 Volume of sludge remaining in tank

Based on the mapping video, the bottom of the lower horizontal coil which is 1.5 inches from the tank bottom is visible hence the sludge layer could be less than 1.5 inches in some areas. However, it is conservatively assumed that all the material below 3 inches is settled sludge. The 3 inch level for Type-I Waste Tank equates to approximately 8000 gallons of sludge. Landmark photos from various locations inside Tank 4 support this determination and are included in the attachment.

## 5.0 Summary

Due to the inability to accurately determine settled sludge heights below the supernate, it is conservatively estimated that approximately **8,000 gallons** of sludge remain in the tank. Based on all of the bulk sludge needed for the sludge batches has been removed and the low residual from mapping it is concluded that BWR is complete in Tank 4. With the completion of BWR, the Heel removal will be initiated.

## 6.0 References

1. SRR-LWE-2011-00076, Revision 0, "Estimation of Tank 4 Wet Sludge Volume", J.L. Clark, March 9, 2011
2. WSRC-TR-2005-0441,"Charecterization of core samples from hardened crust layer in Tank 4" M.J. Hay, September 16, 2005
3. LWO-LWE-2007-00190, Revision 0,"Tank 4 probing results and completion of Burkeit removal process" V.A. Chander, September 16, 2007
4. CBU-PIT-2006-00088,"Tank 4 Dissolution Batch 4", Q.L. Nguyen, May 18, 2006
5. CBU-LTS-2005-00118,"Tank 4 Riser interference path forward" J.E. Hurbert, May 25, 2005

Figure - 2 Tank 4 Tank Bottom View

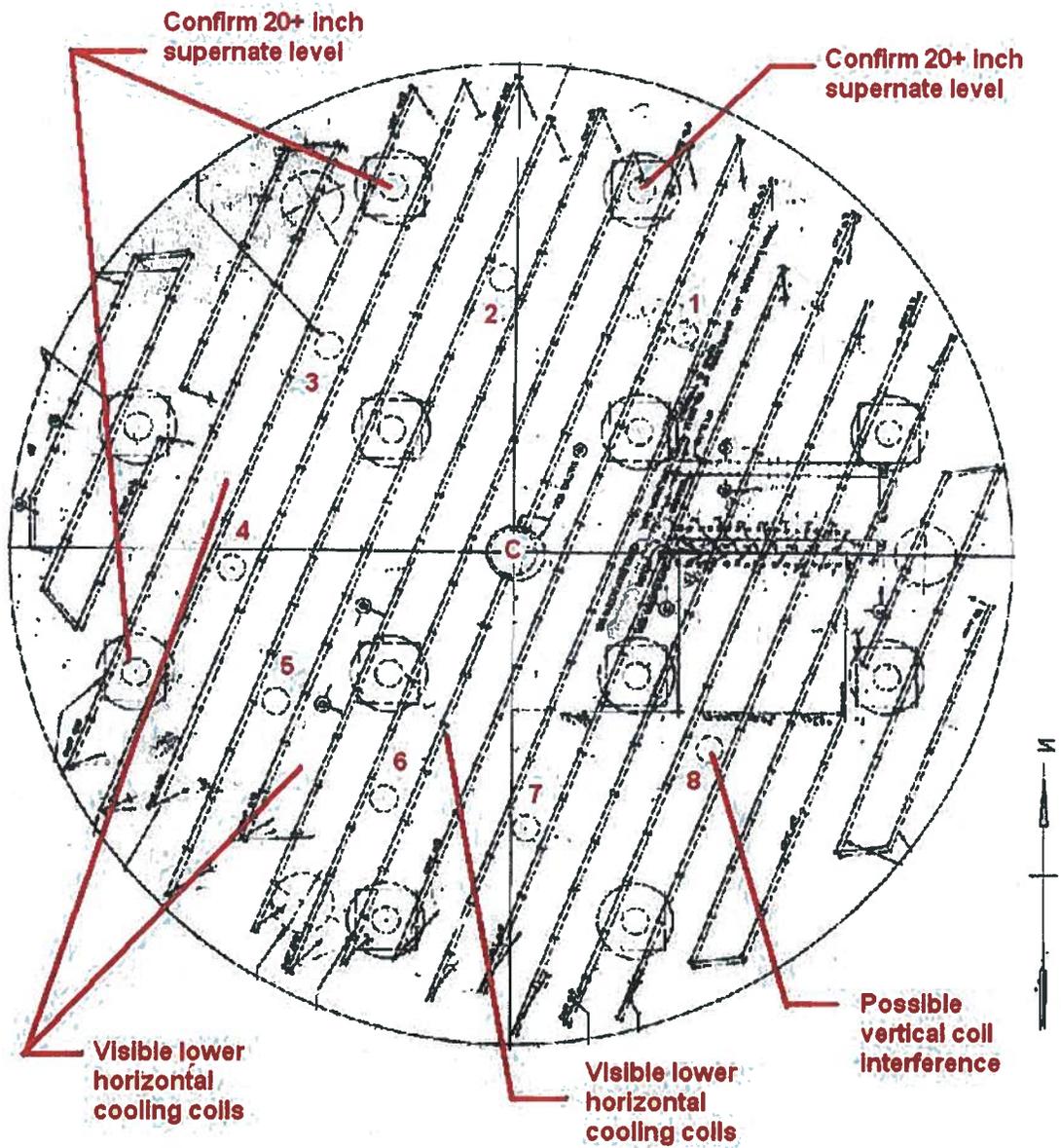




Figure 3 - Tank 4 overview

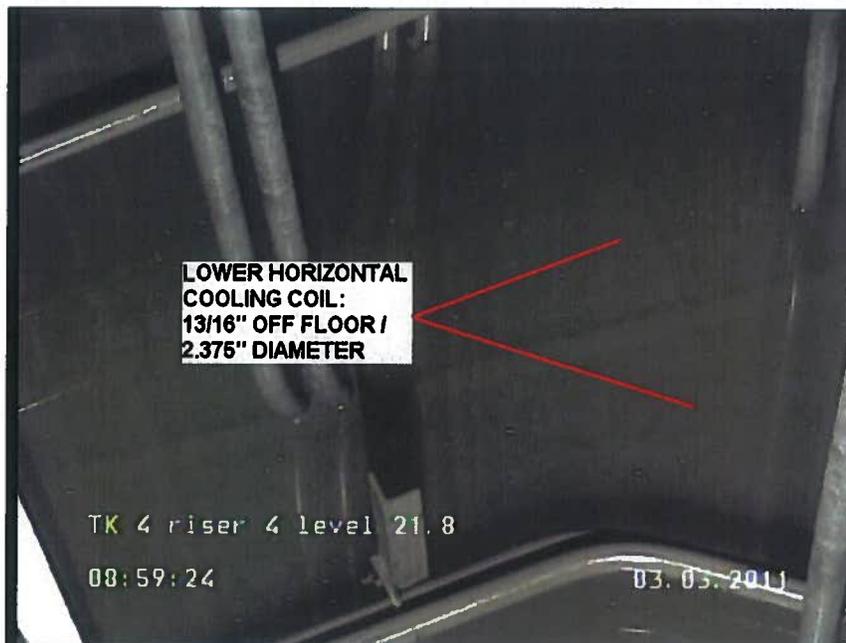


Figure - 4 Visible lower horizontal cooling coil



Figure - 5 Valvehouse

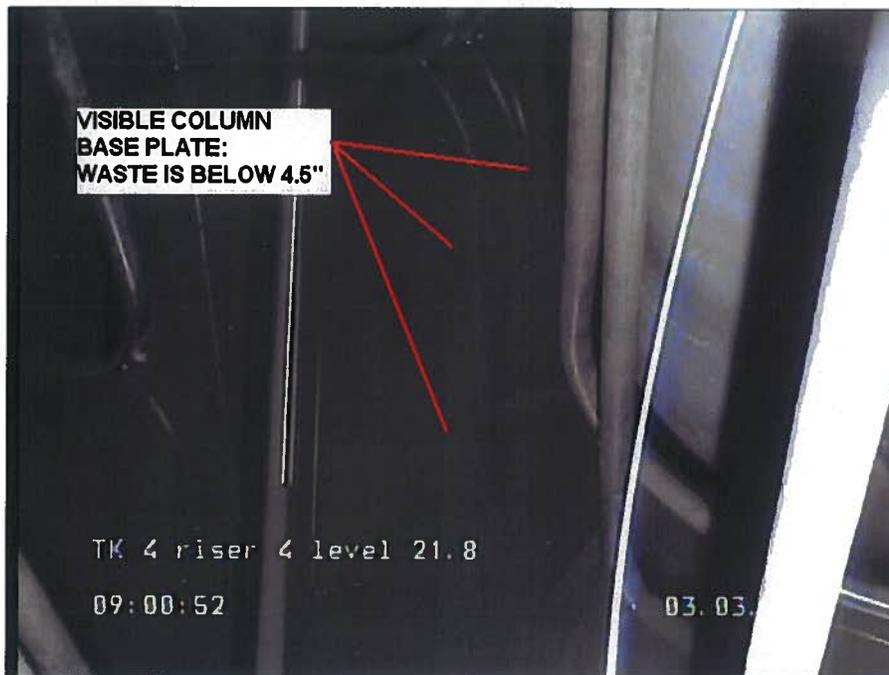


Figure -6 Column with visible base plate

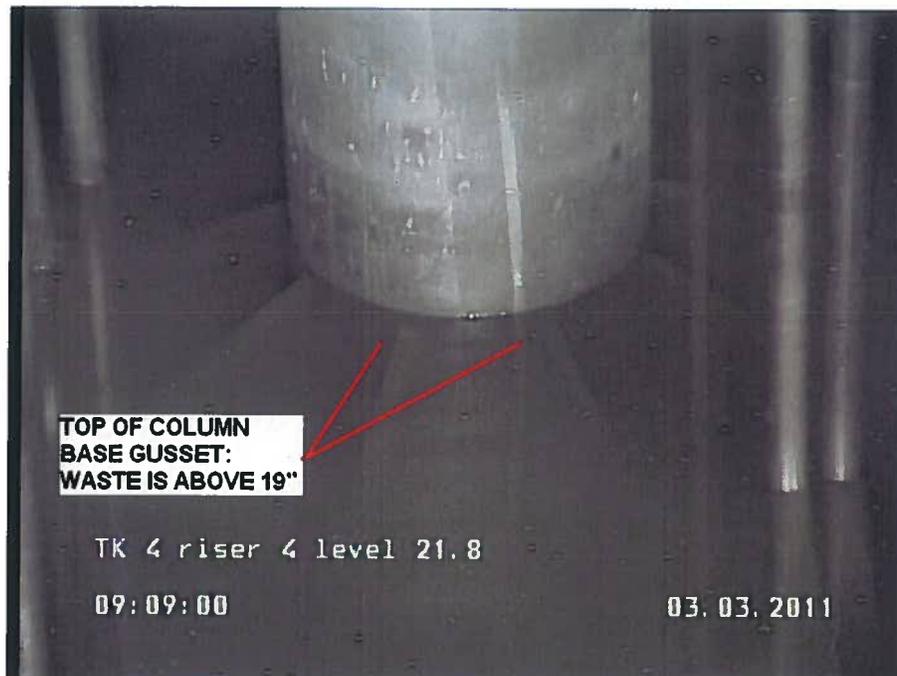


Figure – 7 Column base



Figure – 8 Riser 3 SMP – used to determine liquid level