ENGINEERING DOCUMENT CHANGE CONTROL

Change Identification

21. Release:

SEP 26 2002
DATE:
STA: 5
HANFORD RELEASE
12
ID:

1. Change Category:
☐ Direct Revision ☐ Supplemental Change ☐ Page Change
☐ Supersedure ☐ Cancel/Void ☒ New

2. Classification of Change:
☒ Major ☐ Minor ☐ Conf Baseline

3. Date: 09/25/02

4. Originator's Name, Organization, MSIN, and Telephone No.:
D. L. Herting, Technology Project Management, T6-07, 373-2532

5. USQ Required? ☐ Yes ☒ No
USQ No.: N/A
CX No.: N/A

6. Technical Authority: D. L. Herting

7. Project/Program (WMP, FFTF, etc.): TFA

8. Area:

9. Building:

10. Reviewer Designator: N/A

11. Plan: N/A

12. Criteria: N/A

13. Change Description:
new document

14. Documents Issued or Changed by this EDC:

Document	Page	Revision	Comments
HNF-12145		0	new document

15. Technical Justification (Need):
fulfills milestone #544-311 in Technical Task Plan RL08WT41

Evaluation and Coordination

16. Change Impact: N/A

17. Affected Documents: N/A

Document Number	Page	Revision	Person Notified/Comments

ENGINEERING DOCUMENT CHANGE CONTROL (continued)

Verification

18. Verification: N/A

19. Approvals/Reviews:

Initials, Last Name, Date, MSIN	Initials, Last Name, Date, MSIN
Technical Authority: D. L. Herting 9/25/02 T6-07	Technical Authority Manager: L. L. Lockrem 9/25/02 T6-07
Reviewer (Title): (peer reviewer) J. C. Person 9/25/02 T6-07	Reviewer (Title):
Reviewer (Title):	Reviewer (Title):
Reviewer (Title):	Reviewer (Title):
Reviewer (Title):	Reviewer (Title):

Solution

20. Change Description (Solution) - Continuation Sheet:

N/A

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	Technology Project Management	Date 09/25/02
Project Title/Work Order		EDT No. HNF-EDC02-12375
HNF-12145, Saltcake Dissolution FY 2002 Status Report		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
Barton, W.B.	R2-11	X			
Cooke, G.A.	T6-07	X			
Hardy, D.B.	T6-14	X			
Herting, D.L.	T6-07	X			
Huckaby, J.L.	K7-15	X			
Lockrem, L.L.	T6-07	X			
Mahoney, L.A.	K7-15	X			
Person, J.C.	T6-07	X			
Place, D.E.	R3-73	X			
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HNF-12145
Revision 0

Saltcake Dissolution FY 2002 Status Report

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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Richland, Washington

Approved for public release; further dissemination unlimited.

HNF-12145
Revision 0

HNF-EDC-02-12375

Saltcake Dissolution FY 2002 Status Report

Document Type: TR

Herting, D.L.
Fluor Hanford

Date Published
September 2002
Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
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Release Approval 9/26/02 Date

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Total Pages 53

Printed in the United States of America

SALTCAKE DISSOLUTION FY 2002 STATUS REPORT

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ACRONYMS AND ABBREVIATIONS

ChargeBal	charge balance (ratio of cation equivalents to anion equivalents)
CSol	centrifuged solids
EDS	energy dispersive x-ray spectrometer
ESP	Environmental Simulation Program
FY	fiscal year
GEA	gamma energy analysis
IC	ion chromatography
ICP	inductively coupled plasma spectroscopy
kgal	kilogallons (thousand gallons)
MassBal	mass balance
ML	mega-liters (million liters)
PLM	polarized light microscope (or microscopy)
RPP	River Protection Project
SEM/EDS	scanning electron microscopy with energy dispersive x-ray spectroscopy
TGA	thermogravimetric analysis
TIC	total inorganic carbon
TOC	total organic carbon
Vol	volume
Wt	weight
Wt%	weight percent
XRD	x-ray diffraction

1.0 INTRODUCTION AND EXECUTIVE SUMMARY

Laboratory tests were completed on the dissolution characteristics of Hanford saltcake waste from single-shell waste tanks 241-B-109 and 241-SX-101 (henceforth referred to as B-109 and SX-101). This work was funded by the Department of Energy's Tanks Focus Area (EM-50) under Technical Task Plan Number RL0-8-WT-41, "PHMC Pretreatment – Saltcake Dissolution". The tests performed were similar in scope to those completed in previous years on waste from tanks A-101, B-106, BY-102, BY-106, BY-109, S-102, S-110, TX-113, and U-107 (Herting 1998, 1999, 2000, 2001).

The River Protection Project (RPP) is tasked with retrieving waste from double-shell and single-shell tanks to provide feed for vitrification. The RPP organization needs chemical and physical data to evaluate technologies for retrieving the waste. Little relevant laboratory testing has been done to evaluate in-tank dissolution parameters for the various types of saltcake wastes that exist in single-shell tanks.

A computer modeling program known as the Environmental Simulation Program (ESP), produced by OLI Systems, Inc. of Morris Plains, New Jersey, is being used by the RPP organization to predict solubilities during dilution and retrieval of all tank waste types. Data from this task are provided to ESP users to support evaluation, refinement, and validation of the ESP model.

1.1 RESULTS SUMMARY

Cascade (or "stepwise") dissolution tests were performed on composite saltcake samples from both tanks. The purpose of these tests is to evaluate the solid/liquid phase distribution of chemicals and radionuclides during tank waste retrieval operations. Solid phase identification tests were also performed on saltcake from both tanks.

Weight percent (wt%) dilution is defined in this report as 100 times the weight of diluent (water or 2 M NaOH solution) divided by the weight of undiluted saltcake composite sample. A 50% dilution, for example, would be 50 g of H_2O (or 50 g of 2 M NaOH) added to 100 g of undiluted composite sample. Volume percent (Vol%) dilution is defined as 100 times the volume of diluent divided by the calculated volume of undiluted sample. Weight percent dilutions are measured directly by weighing the undiluted sample and diluent. Volume percent dilutions are estimated from the known volume of diluent and calculated volume of undiluted sample.

1.1.1 Cascade Dissolution Tests

The Cascade dissolution test is a very small scale, batch-wise representation of a continuous in-tank retrieval process. A single saltcake sample is contacted several times with fresh water, removing the equilibrated liquid phase after each contact. Progress of the saltcake dissolution is followed through volume/weight measurements and chemical analysis of the removed liquid samples. See Section 2.2 for a detailed procedure description.

Some of the dissolution data for tanks B-109 and SX-101 are plotted in Figure 4-1 as Wt% Centrifuged Solids vs. Cumulative Wt% Dilution. The amount of water required to dissolve B-109 saltcake is relatively large, but most of the saltcake does eventually dissolve, leaving a water-insoluble residue of 11% of the original sample weight. By comparison, the SX-101 saltcake dissolves with far less water added, but leaves a much larger residue of approximately 25% of the original sample weight. In both tanks, heating the samples to 50 °C resulted in some improvement in dissolution. The improvement was dramatic for SX-101 saltcake at 50% dilution. Changing the diluent from water to 2 M NaOH resulted in only a small incremental dissolution for the SX-101 saltcake. The NaOH was ineffective in dissolving additional B-109 saltcake (data not shown in the figure).

Data are presented in Section 5 that explain the gross dissolution behavior in terms of solubilities of individual components in the waste. Evidence is provided there of the importance of double salts (sodium fluoride sulfate and others) in controlling the equilibrium concentrations of sulfate, phosphate, and fluoride in the dissolved waste solutions. Identification of solid phases in equilibrium with the ions in solution is important for computer modeling of the thermodynamics of the system.

ESP computer simulations of the cascade dissolution tests on tanks B-109 and SX-101 were conducted by investigators at Mississippi State University Diagnostic Instrumentation and Analysis Laboratory (MSU/DIAL). Tank B-109 saltcake contained significantly more sulfate (24.8 wt%) than any saltcake examined previously (range from below detection limit to ~ 17 wt%). It also contains a significant amount of fluoride (6.08 wt%). The sodium fluoride sulfate double salt is predicted to be completely dissolved only upon cumulative diluent addition in excess of 400 wt%, in good agreement with the experimental results (see Section 5.1.5). The high levels of sulfate and fluoride will make retrieval of this saltcake difficult due to the large amount of diluent required to dissolve the material. Major trends observed in the experimental anion concentration profiles for B-109 saltcake were observed in the simulation results at both ambient temperature and 50 °C. Results of ESP modeling of B-109 and SX-101 saltcakes will be documented in a separate technical report in preparation by MSU/DIAL.

1.1.2 Solid Phase Identification

Accurate chemical modeling of the tank waste systems (e.g., with ESP) depends in part on proper identification of the solid phases in equilibrium with the ions in solution. Analysis of solids from tanks B-109 and SX-101 were performed this fiscal year using the three-pronged approach of polarized light microscopy (PLM), scanning electron microscopy with energy dispersive x-ray spectroscopy (SEM/EDS), and x-ray diffraction (XRD).

The major solid phases identified in B-109 saltcake included (in very approximate order of abundance): Na_3FSO_4, $Na_7F(PO_4)_2 \cdot 19H_2O$, $NaNO_3$, $Al(OH)_3$ (gibbsite and amorphous forms), $Na_2U_2O_7$ (sodium diuranate), and an unidentified phase rich in bismuth, iron, chromium, and phosphate.

The major solid phases identified in SX-101 saltcake included (in very approximate order of abundance): $NaNO_3$, $NaAl(OH)_4$ (sodium aluminate), $Na_2C_2O_4$ (sodium oxalate), $NaNO_2$, $Na_2U_2O_7$, and NaCl. There was also an unidentified phase with cubic morphology and very complex composition, being rich in calcium, iron, aluminum, strontium, manganese, lanthanum, and neodymium.

1.2 COMPOSITION OF TANK WASTES

All of the tests described in this report were performed on composite saltcake samples made from archived core segment samples. One composite sample was prepared for each tank, and tests were performed on aliquots taken from the composite samples. Tables 5-1 and 5-2 show the overall composition of the composite sample from each tank. The total sodium content of both tanks was similar, but there were major differences in the anions associated with the sodium cations.

1.2.1 Tank B-109

Two core samples (cores 169 and 170) were taken from Tank B-109 in 1996. Only one archived sample with a significant amount of material was available from core 169, and it was known (DOE 2002) to contain mainly aluminum decladding waste not suitable for saltcake dissolution testing. (The sample contained 12 wt% Al, with Na and nitrate levels much lower than typical saltcake.) Several archived samples were available from core 170, and while the nitrate level in those samples was still low, the aluminum level was much lower, the sodium level was more typical of saltcake, and other water-soluble sodium salt anions were present (fluoride, sulfate, phosphate). Therefore, the composite sample was created by mixing aliquots of the archived segment samples from core 170 only.

The composite sample was light brown, and very dry, with no apparent liquid phase. The notable features of the chemical make-up of the composite sample (Table 5-1) are the very high fluoride and sulfate levels and low nitrate level.

1.2.2 Tank SX-101

Two core samples (cores 225 and 227) were taken from Tank SX-101 in late 1997 and early 1998. Physical appearance and chemical analyses of the individual segments (DOE 2002) showed wide variations between segments within each core. The composite sample was created by mixing representative segment samples from both cores.

The composite sample was very dark brown and wet, resembling used coffee grounds. The notable features of the chemical make-up of the composite sample (Table 5-1) are the high nitrate level, relatively high Cr, Al, and hydroxide levels (compared to typical or average saltcakes), and low levels of most other analytes.

It might be noted that the B-109 composite sample was described as "very dry" and the SX-101 composite as "wet", but the percent water (reported in Table 5-1) is higher for B-109 (17.35%) than for SX-101 (14.45%). This apparent discrepancy is due to the finding that most or all of the water in the B-109 sample is tied up as waters of hydration, mainly in the double salt $Na_7F(PO_4)_2 \cdot 19H_2O$, while SX-101 contains little hydrated salt.

2.0 DESCRIPTION OF LABORATORY STUDIES

Composite samples of tank waste were prepared in a hotcell, and most of the dissolution tests were carried out in a hotcell. The procedures, data, and observations are recorded in controlled laboratory notebook HNF-N-70-3. The procedures are described in this section, and the raw data are shown in the following section (3.0).

All dissolution tests were done on composite samples made by combining representative core segment samples from each tank. Details of the composite preparation are given in Section 2.1.

Cascade dissolution tests (also called stepwise dissolution tests) were done to determine the solubility characteristics of the saltcake. Details of the cascade test procedure are provided in Section 2.2.

Solid phase identification tests were performed on both saltcakes. Information about solid phase speciation is needed to improve the input data to ESP. These tests are described in section 2.3.

2.1 PREPARATION OF COMPOSITE SAMPLES

The saltcake composite samples were made by combining archived fractions of individual core segment samples into a single composite jar for each tank. The waste in the completed composite jar was mixed thoroughly before taking subsamples for the individual tests. Weights of individual core segment samples used for each composite sample are shown in Tables 2-1 and 2-2. One aliquot of each composite sample was analyzed for percent water by thermogravimetric analysis (TGA) and total inorganic carbon/total organic carbon (TIC/TOC). A second aliquot of each composite sample was subjected to a water digest, followed by analysis for free hydroxide and for anions by ion chromatography (IC). A third aliquot was subjected to a potassium hydroxide fusion digest, followed by analysis for metals by inductively coupled plasma spectroscopy (ICP) and for radionuclides by various methods. Results of these analyses are shown in Tables 5-1 and 5-2.

Table 2-1. Segment Samples Used to Create B-109 Core Composite Sample

Core	Segment[a]	Jar #	Weight, g
170	1	11488	25
170	2A	11364	8
170	2B	11390	100
170	2B	18295	120
170	2C	11363	32
170	2D	11360	14
	Composite	Total Wt =	299

[a] Segment 1 is at top of waste; A – D are quarter-segments.

Table 2-2. Segment Samples Used to Create SX-101 Core Composite Sample

Core	Segment[a]	Jar #	Weight, g
227	1	13636	54
225	2	11845	49
225	5	13667	68
227	5A	12973	58
225	6	13662	74
227	6	12965	63
227	6	14002	50
225	7	13656	68
225	7A	12931	25
227	7	14009	42
	Composite	Total Wt =	551

[a] Segments 5A and 7A are re-take samples.

2.2 CASCADE DISSOLUTION TESTS

Cascade dissolution tests, which have also been called **stepwise** dissolution tests (Herting 1999, 2000), employ a single saltcake sample that is contacted multiple times with diluent (water or 2 M NaOH). The cascade test is a very small scale, batch-wise representation of a continuous in-tank retrieval process.

For each tank, a 40-gram aliquot of saltcake composite sample was placed into a tared 50-mL graduated centrifuge cone. The cone plus saltcake was weighed, then 20 g of water was added, and the cone was re-weighed. Then the cone was vortex-mixed, and placed on a tumbler to tumble end-over-end for at least 20 hours. After the mixing/equilibration period, each cone was centrifuged for 30 minutes. Total volume and centrifuged solids volume were recorded, and the liquid was decanted into a sample vial for analysis. (For the 50 °C tests, the liquid samples had to be diluted with water to prevent precipitation of salts when the samples cooled to room temperature.) The cone with residual solids was weighed to determine the weight of centrifuged solids and (by difference) the weight of solution decanted. Then a fresh portion of water was added (20 g or more) and the cycle of mixing/centrifuging/decanting was repeated.

Three runs were done on each saltcake. Run #1 was done at ambient hotcell temperature (23 °C) using water as the diluent. A total of six water contacts were made. Run #2 was done at 50 °C, again using water. Five water contacts were done on each saltcake. Run #3 was done at ambient hotcell temperature (24 °C) and taken to exhaustive dissolution with water, followed by attempted further dissolution using 2 M NaOH. For the B-109 saltcake there were nine water contacts followed by one NaOH contact. For the SX-101 saltcake there were four water contacts followed by five NaOH contacts.

The liquid samples were analyzed by ICP, IC, TIC/TOC, OH^-, $\%H_2O$ by oven drying, and density. Radionuclides were analyzed by GEA (^{60}Co, ^{125}Sb, ^{137}Cs, ^{154}Eu, ^{155}Eu, and ^{241}Am), and extraction ($^{89/90}Sr$ and ^{99}Tc). Not all analyses were performed in Run #3 due to budget constraints.

For the residual solids (following the final water or NaOH contact), one aliquot was analyzed for TIC/TOC and $\%H_2O$ by TGA. Fusion digest preparations of a second aliquot were analyzed for metals by ICP and radionuclides by the same methods listed for the liquid samples.

2.3 SOLID PHASE CHARACTERIZATION TESTS

The three-pronged approach of using polarized light microscopy (PLM), scanning electron microscopy with energy dispersive x-ray spectroscopy (SEM/EDS), and x-ray diffraction (XRD) was used to identify solid phases in untreated saltcake composite samples and in the residue remaining after Run #3. The specific instruments used were:

PLM – Leitz Laborlux® 12 polarized light microscope with Colorview 12 digital color camera.

SEM/EDS – Aspex® Personal Scanning Electron Microscope, Model II, with Noran Light Element EDS detector.

XRD – Rigaku® MiniFlex x-ray diffractometer.

Sample preparation methods and instrumental techniques are described in detail in a companion report to be published simultaneously with this one (Herting et al. 2002).

The following sub-sections describe the findings of each instrument as applied to each of the following samples:

- B-109 Original Saltcake is taken directly from the B-109 composite sample;
- B-109 Residue is the solid phase remaining after exhaustive dissolution in Run #3;
- SX-101 Original Saltcake is taken directly from the SX-101 composite sample;
- SX-101 Residue is the solid phase remaining after exhaustive dissolution in Run #3.
- Solids formed on cooling supernatant liquid from 50 °C to 24 °C (both tanks)

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2.3.1 Tank B-109 Original Saltcake

SEM/EDS: As judged by SEM/EDS, the sample consisted primarily of $NaNO_3$ (Figure 2-1) with lesser amounts of Na_3FSO_4 (Figure 2-2) and patches of $Na_7F(PO_4)_2 \cdot 19H_2O$. Minor amounts of $Al(OH)_3$ and $Na_2U_2O_7$ (sodium diurante) were also observed. There were also particles containing a mixture of bismuth, iron, chromium, and phosphate. The latter phases were more clearly evident in the B-109 residue sample.

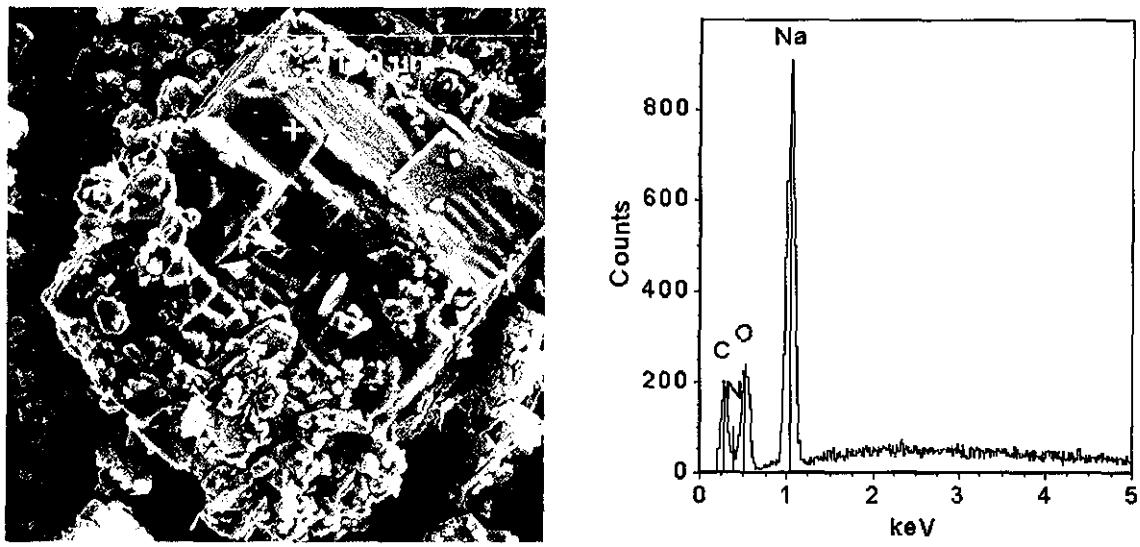


Figure 2-1. SEM Secondary Electron Image of $NaNO_3$ from B-109 Original Saltcake. (EDS spectrum is from spot marked with +.)

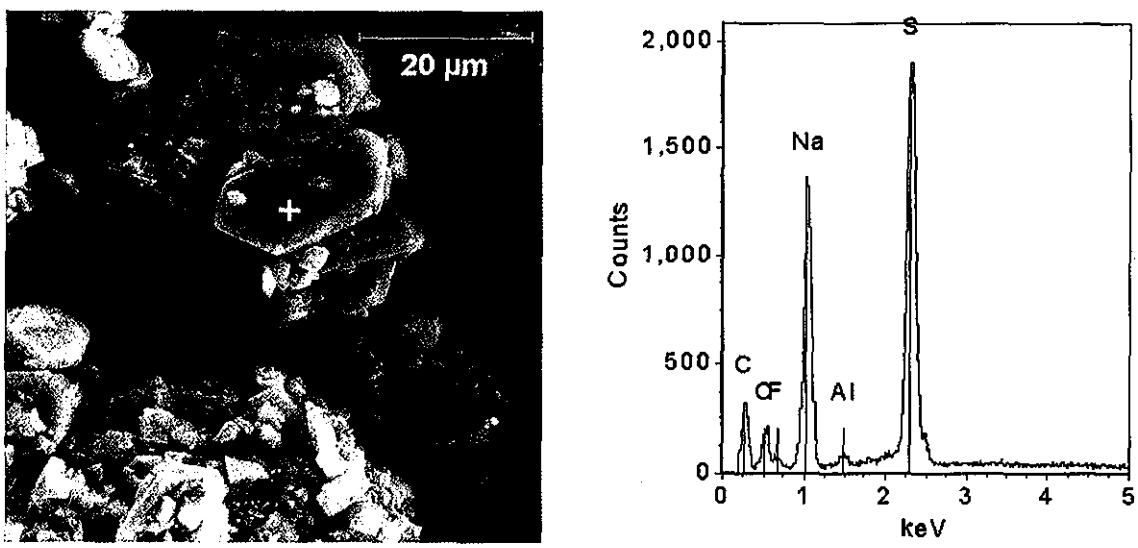


Figure 2-2. SEM Secondary Electron Image of Na_3FSO_4 from B-109 Original Saltcake. (EDS Spectrum is from spot marked with +.)

PLM: There were no phases in the B-109 original saltcake that could be unambiguously identified by PLM alone. There were many large isotropic crystals with irregular shapes, and many very small crystals with high birefringence and irregular shapes. These observations are consistent with the phases identified by SEM/EDS (above) and XRD (below), but differ in relative abundance. Based on the PLM, the major phase would be most likely $Na_7F(PO_4)_2 \cdot 19H_2O$, with Na_3FSO_4 and $NaNO_3$ being the minor phases. Based on the chemical analysis (Table 5-1), Na_3FSO_4 is the most likely major phase, with the other two phases being minor. In any case, it is clear that these three solid phases make up the majority of the saltcake from tank B-109.

XRD: The major phase in the B-109 original saltcake was identified by XRD as $NaNO_3$, with minor phases Na_3FSO_4 and $Na_7F(PO_4)_2 \cdot 19H_2O$.

2.3.2 Tank B-109 Residue

PLM: A PLM photograph of the B-109 residue is shown in Figure 2-3. The bulk of the material is made up of particles too small to resolve with the optical microscope (i.e, smaller than about 0.5 – 1.0 μm), and these particles appear in the photograph as a general fuzzy dullness in the background. However, there are also many larger crystalline particles that are consistent with the XRD assignment of gibbsite. There is another minor phase, just discernable in the photograph, comprised of small (2-3 μm) amber particles.

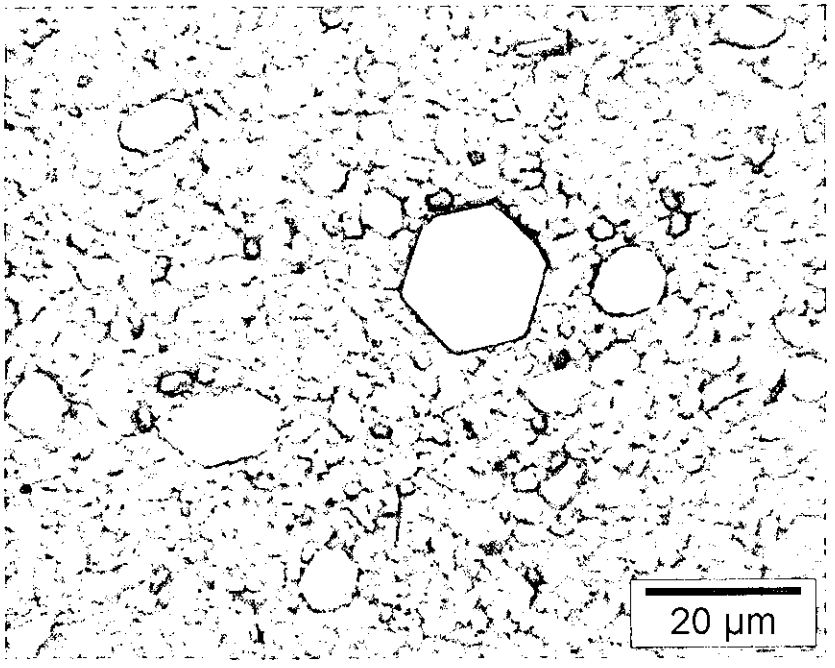


Figure 2-3. PLM Image of Tank B-109 Water-Insoluble Residue (uncrossed polars).

SEM/EDS: The B-109 residue consists primarily of aluminum hydroxide. Many of these particles are larger hexagonal plates (Figure 2-4) and columns, consistent with the large crystalline particles observed by PLM (Figure 2-3). Most of the finer particulate is aluminum-rich. The next most common phase (~ 20% by area) is the bismuth-rich phase described for the original saltcake sample, but with the phosphate apparently gone and with different morphology. It is likely that the dissolution steps dissolved the phosphate and replaced it with oxide/hydroxide. In addition, minor amounts of fine-grained $Na_2U_2O_7$ are easy to find.

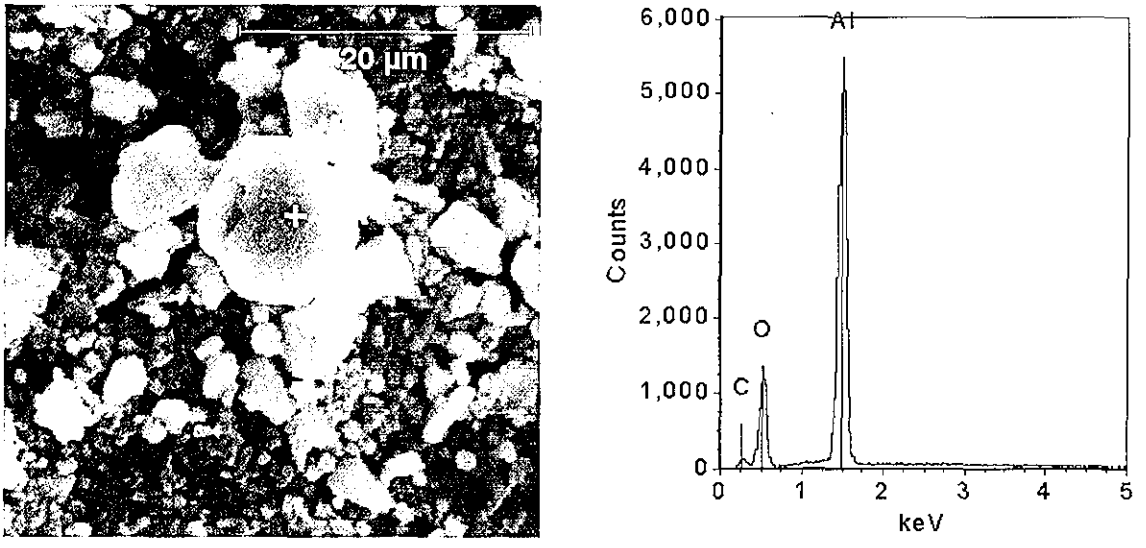


Figure 2-4. SEM Secondary Electron Image of $Al(OH)_3$ from B-109 Residue. (EDS Spectrum is from spot marked with +.)

XRD: The only phase identifiable in the B-109 residue sample was gibbsite, $Al(OH)_3$. The spectral peaks were sharper (indicating a higher degree of crystallinity) than some of the residue samples that have been examined in other recent studies. There was still enough peak broadening to indicate the presence of a significant amount of amorphous phase.

2.3.3 Tank SX-101 Original Saltcake

XRD: The major phase identified by XRD in the SX-101 original saltcake was $NaNO_3$, with minor phases $NaAlO_2 \cdot 1.25H_2O$ (sodium aluminate), $Na_2C_2O_4$ (sodium oxalate), and $NaNO_2$ (sodium nitrite).

PLM: A PLM photograph of the SX-101 original saltcake is shown in Figure 2-5. As with the B-109 saltcake, the crystals were largely irregular in shape and difficult to identify. The dominant phase, though, was clearly $NaNO_3$, represented by the large, bright white/yellow crystals in Figure 2-5. Other phases are clearly present, represented by the large and small crystals with low birefringence (most notably the blue crystals in the photograph), but these phases were not identified by PLM.

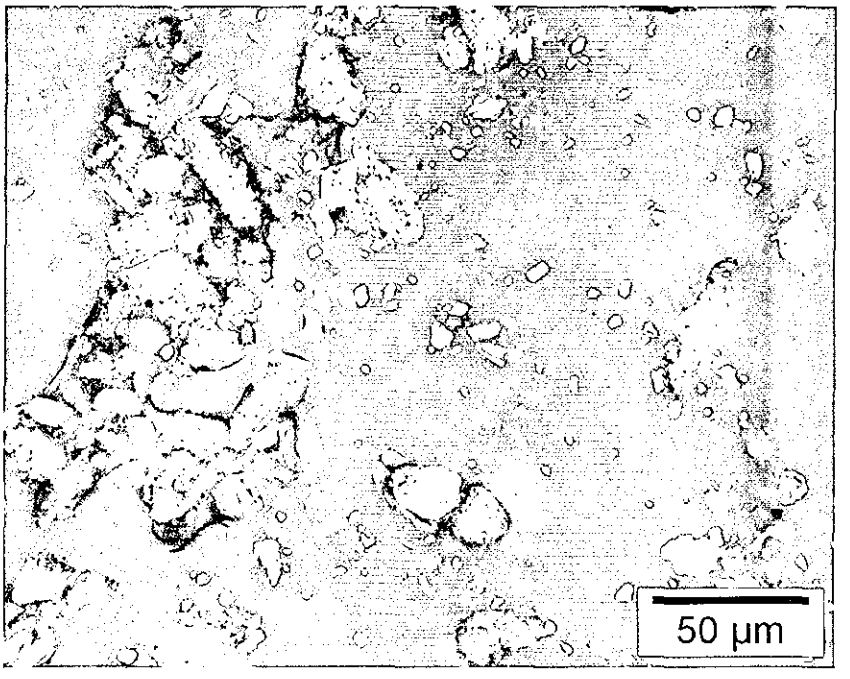


Figure 2-5. PLM Image of Tank SX-101 Original Saltcake (crossed polars with Red I compensator).

SEM/EDS: In agreement with XRD and PLM, the major phase found by SEM/XRD was $NaNO_3$, though it contained a continuous coating of aluminum hydroxide and/or sodium aluminate. Even particles with an obvious $NaNO_3$ morphology contained spots on the surface that were aluminum-rich. No evidence for significant amounts of Na_3FSO_4 or $Na_7F(PO_4)_2 \cdot 19H_2O$ was observed. Examination in backscatter mode revealed occasional particles of $Na_2U_2O_7$, some small cubic crystals of NaCl (sodium chloride), and an occasional cubic crystal of complex chemistry that will be shown and discussed with the SX-101 residue, below.

2.3.4 Tank SX-101 Residue

XRD: The only phases identifiable by XRD in the SX-101 residue sample were gibbsite and $Na_2U_2O_7$. As with the B-109 residue, the spectral peaks were sharper (indicating a higher degree of crystallinity) than some of the residue samples that have been examined in other recent studies. The XRD spectrum for the SX-101 residue is shown in Figure 2-6.

PLM: The SX-101 residue was very similar in appearance to the B-109 residue.

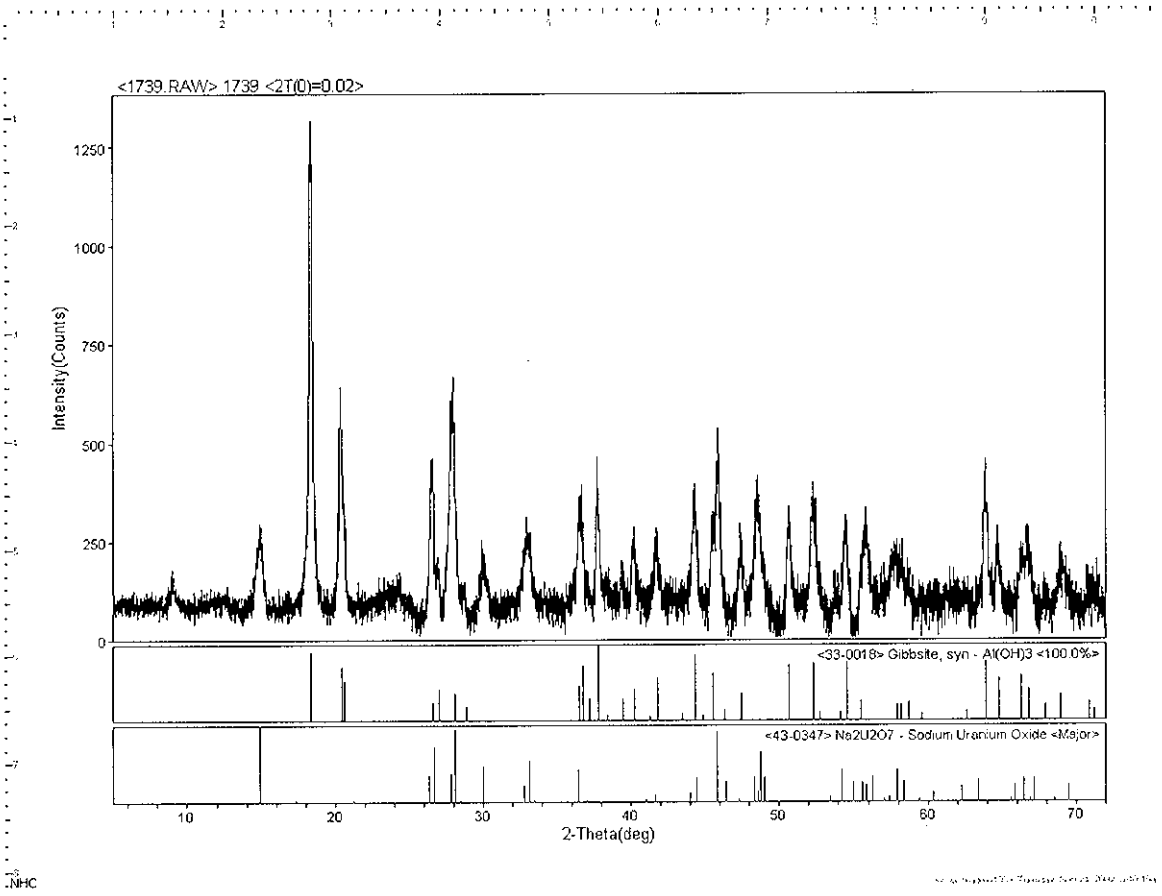


Figure 2-6. XRD Spectrum of Tank SX-101 Water-Insoluble Residue

SEM/XRD: As with the B-109 residue, the SX-101 residue was dominated by aluminum hydroxide, although it appeared to be finer-grained than in the B-109 residue. The finer-grained material had variable chromium content. Also as before, $Na_2U_2O_7$ could be found using backscatter imaging, always as particulate measuring 1 μm or less in diameter.

What was different with this sample (as compared to the B-109 residue) was the cubic crystal illustrated in Figure 2-7. These crystals were common, and had a reproducible, but complex, chemistry.

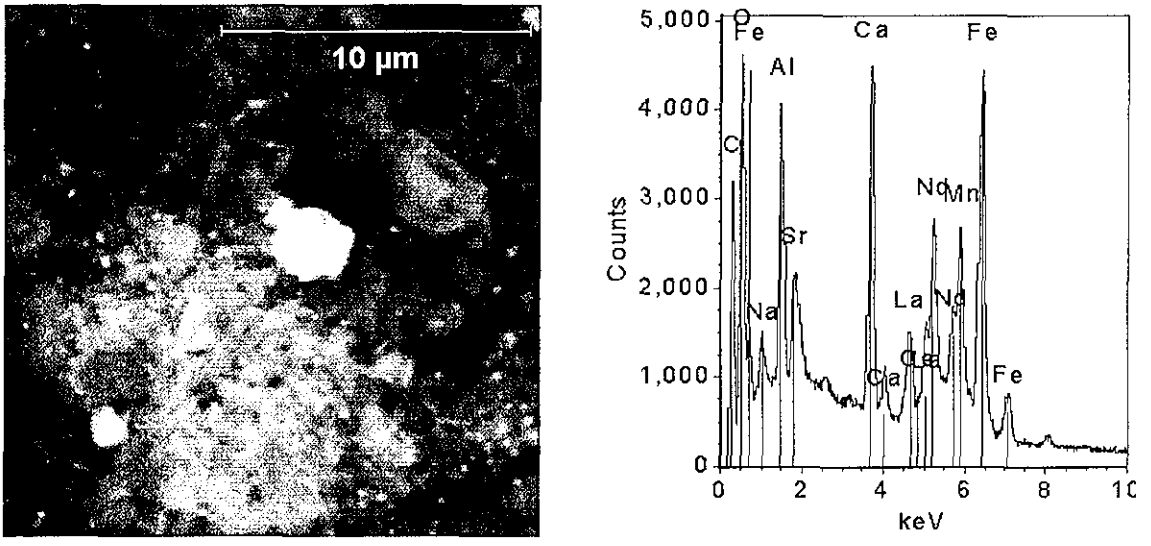


Figure 2-7. SEM Backscatter Image of Cubic Crystal from Tank SX-101 Residue. (EDS Spectrum is from spot marked with +.)

2.3.5 *Solids Formed on Cooling*

As mentioned in Section 2.2, the liquid samples resulting from dissolution of the saltcake at 50 °C (Run #2) had a tendency to form solids on cooling to ambient temperature. Dilutions were made on these liquid samples prior to analyzing the samples, to prevent the skewing of the analytical results that would have been caused by the precipitation. However, a small portion of each liquid sample was left undiluted to allow observation of the solids that formed. Samples from B-109 contacts 1, 2, and 3 were examined by PLM. The sample from SX-101 contact 1 was examined by PLM, SEM/EDS, and XRD. The other samples (B-109 contacts 4 and 5, SX-101 contacts 2-5) did not form an appreciable amount of solids on cooling.

The B-109 samples were all very similar, containing 99% or more $Na_7F(PO_4)_2 \cdot 19H_2O$ crystals, some of which were quite large (at least 1 mm in diameter).

The dominant phase in the SX-101 sample was gibbsite, as determined by all three instrumental techniques. The crystal habit was rather unique. Photos of this phase are shown in Figures 2-8 (PLM) and 2-9 (SEM/EDS). The XRD also identified $NaNO_3$ as a second phase in this sample.

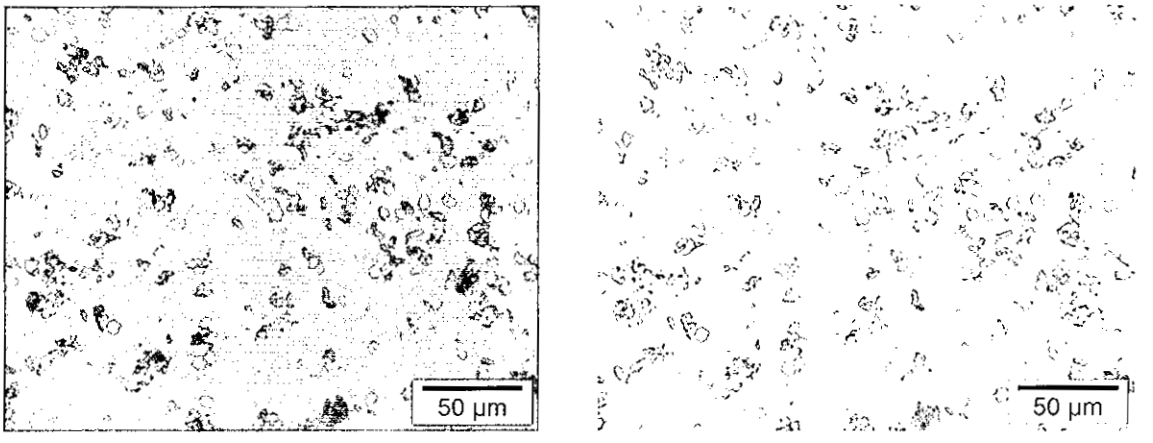


Figure 2-8. PLM Image of Gibbsite Solids that Formed on Cooling of SX-101 Contact #1 Liquid from 50 °C to ambient temperature. (left – crossed polars with Red I compensator; right – uncrossed polars)

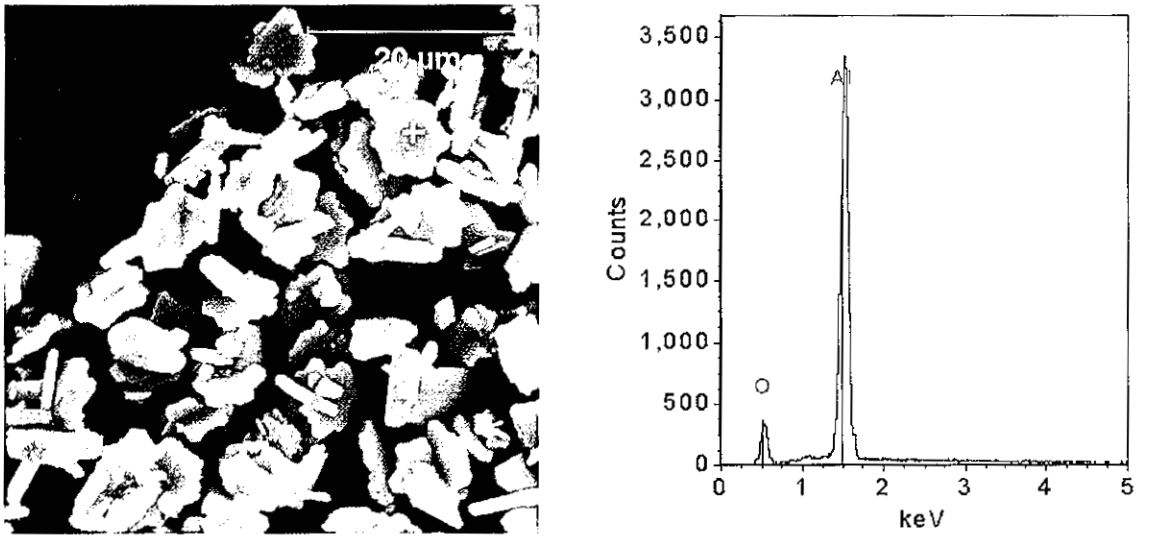


Figure 2-9. SEM Secondary Electron Image of Gibbsite Solids that Formed on Cooling of SX-101 Contact #1 Liquid from 50 °C to ambient temperature.

3.0 RESULTS – RAW DATA

"Raw data" include values of net weight, volume, and chemical and physical analyses of the samples. Visual observations of the test materials are also presented in this section. The raw data provide a reference record of the tests. However, sample-to-sample comparisons of raw data generally should not be made because of variations in initial sample weights and volumes. Comparisons based on normalized data, accounting for initial volume and weight differences, are presented in later sections of the report.

3.1 CASCADE DISSOLUTION TESTS

The procedure for the Cascade dissolution tests was described in Section 2.2. Weights, volumes, and analytical sample identification numbers of the various fractions for the Run #1 ambient temperature tests are shown in Table 3-1, with sample analytical results shown in Tables 3-4 through 3-7. Corresponding data for the Run #2 tests at 50 °C are shown in Tables 3-2 and 3-8 through 3-11, respectively. Data for the Run #3 tests at ambient temperature are shown in Tables 3-3 and 3-12 through 3-13, respectively.

Mass balance and charge balance calculations can be done on the supernatant liquid fractions, because all of the known components of the liquid were analyzed. The mass balance formula is:

$$\text{MassBal} = \%H_2O + (\Sigma_i C_i + 3C_{TOC} + 5C_{TIC} + 2.2C_{Al})/(10 \times \text{Density})$$

where the C_i values are concentrations expressed in g/L as shown in Table 3-4 and subsequent tables; Density is in g/mL; and i = OH^-, Cr, K, Na, F^-, Cl^-, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}. The TOC concentration is multiplied by 3 to account for the mass of oxygen, nitrogen, and hydrogen associated with the carbon in typical organic complexants. This is an approximate factor. For the centrifuged solids samples in which virtually all of the TOC comes from oxalate, the oxalate concentration is used instead of the TOC in the mass balance calculation. (The same is true for the liquid samples in which oxalate can be shown to represent all or nearly all of the TOC.) The TIC concentration is multiplied by 5 and the Al concentration is multiplied by 2.2 to account for the mass of oxygen in carbonate and aluminate (AlO_2^-), respectively. These are known factors. The aluminate is used as the anhydrous AlO_2^- rather than the hydrated $Al(OH)_4^-$ because the hydration water is included in the $\%H_2O$ factor.

The charge balance formula, showing the ratio of cation equivalents to anion equivalents, is:

$$\text{ChargeBal } (+/-) = \Sigma_+(C_+/W_+)/\Sigma_-(C_-Z_-/W_-)$$

where the C_+ values are the concentrations of Na and K in g/L; W_+ are the respective atomic weights; C_- are the concentrations of anionic species (OH^-, TOC, TIC, Al, F^-, Cl^-, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}); Z_- are the charges on the respective anions; and W_- are the formula weights of the anions. The Z_- for TOC is taken to be 0.5, assuming a typical mixture of organic compounds in solution that have an average of two carbon atoms per negative charge (e.g., acetate). The Z_- for TIC is 2. Aluminum is assumed to be present

in the liquid phase as aluminate ion, $Al(OH)_4^-$, but 27 is used as the formula weight because the concentration is expressed in the tables as Al, not $Al(OH)_4^-$.

Table 3-1. Raw Data, Cascade Dissolution Test Run #1 at 23 °C.
(weights in grams, volumes in mL)

	B-109	SX-101
Composite Sample Wt, g	40.020	39.938
Wt H_2O Added (1st wash)	21.287	20.666
Total Vol, mL	40.0	38.5
CSol[a] Vol	22.5	18.5
CSol Wt	41.158	32.170
Wt H_2O Added (2nd wash)	19.842	19.956
Total Vol, mL	42.5	37.5
CSol Vol	22.5	10.0
CSol Wt	37.375	15.009
Wt H_2O Added (3rd wash)	23.478	20.018
Total Vol, mL	45.0	29.5
CSol Vol	19.0	9.5
CSol Wt	31.753	13.558
Wt H_2O Added (4th wash)	28.495	19.326
Total Vol, mL	47.0	29.0
CSol Vol	16.0	10.0
CSol Wt	26.020	12.965
Wt H_2O Added (5th wash)	25.355	20.707
Total Vol	40.0	30.0
CSol Vol	12.5	10.0
CSol Wt	20.523	12.583
Wt H_2O Added (6th wash)	22.829	20.874
Total Vol	35.0	30.0
CSol Vol	9.0	10.0
CSol Wt	15.424	12.405

[a] CSol = centrifuged solids

Table 3-2. Raw Data, Cascade Dissolution Test Run #2 at 50 °C.
(weights in grams, volumes in mL)

	B-109	SX-101
Composite Sample Wt, g	40.271	39.928
Wt H_2O Added (1st wash)	19.896	20.687
Total Vol, mL	38.5	39.0
CSol Vol	20.0	10.0
CSol Wt	37.480	17.568
Wt H_2O Added (2nd wash)	19.430	19.952
Total Vol, mL	40.0	29.0
CSol Vol	19.0	7.5
CSol Wt	33.422	11.410
Wt H_2O Added (3rd wash)	21.255	19.992
Total Vol, mL	39.5	25.0
CSol Vol	16.0	7.0
CSol Wt	27.753	10.156
Wt H_2O Added (4th wash)	26.280	29.270
Total Vol, mL	42.0	35.0
CSol Vol	13.0	7.0
CSol Wt	21.986	9.569
Wt H_2O Added (5th wash)	32.407	37.495
Total Vol	44.5	44.0
CSol Vol	8.5	7.0
CSol Wt	15.331	9.317

Table 3-3. Raw Data, Cascade Dissolution Test Run #3 at 24 °C, page 1 of 2.
(weights in grams, volumes in mL)

	B-109	SX-101
Composite Sample Wt, g	40.005	40.099
Diluent for 1st wash	H_2O	H_2O
Wt Diluent Added	20.379	19.702
Total Vol, mL	38.0	37.5
CSol Vol	22.5	22.0
CSol Wt	40.650	38.571
Diluent for 2nd wash	H_2O	H_2O
Wt Diluent Added	20.482	20.327
Total Vol, mL	42.5	41.5
CSol Vol	21.5	10.5
CSol Wt	36.955	18.233
Diluent for 3rd wash	H_2O	H_2O
Wt Diluent Added	24.389	32.950
Total Vol, mL	45.0	43.0
CSol Vol	18.0	10.0
CSol Wt	32.049	14.950
Diluent for 4th wash	H_2O	H_2O
Wt Diluent Added	22.415	34.358
Total Vol, mL	40.0	44.5
CSol Vol	15.0	10.0
CSol Wt	27.192	14.270
Diluent for 5th wash	H_2O	2 M NaOH
Wt Diluent Added	29.378	37.105
Total Vol, mL	45.0	44.5
CSol Vol	12.5	9.5
CSol Wt	20.894	13.502

Table 3-3 continued. Raw Data, Cascade Dissolution Test Run #3 at 24 °C, page 2 of 2.
(weights in grams, volumes in mL)

	B-109	SX-101
Diluent for 6th wash	H_2O	2 M NaOH
Wt Diluent Added	32.860	39.566
Total Vol, mL	44.5	45.5
CSol Vol	9.0	8.0
CSol Wt	13.928	12.437
Diluent for 7th wash	H_2O	2 M NaOH
Wt Diluent Added	38.301	39.433
Total Vol, mL	46.0	45.0
CSol Vol	5.0	8.0
CSol Wt	7.921	11.525
Diluent for 8th wash	H_2O	2 M NaOH
Wt Diluent Added	40.570	41.446
Total Vol, mL	45.0	45.5
CSol Vol	4.0	7.5
CSol Wt	5.268	10.592
Diluent for 9th wash	H_2O	2 M NaOH
Wt Diluent Added	41.690	39.987
Total Vol, mL	45.0	44.5
CSol Vol	3.0	7.0
CSol Wt	4.601	9.683
Diluent for 10th wash	2 M NaOH	H_2O
Wt Diluent Added	41.340	33.272
Total Vol, mL	41.5	39.5
CSol Vol	3.5	7.5
CSol Wt	4.563	9.523

Table 3-4. Chemical Analyses, Tank B-109 Run #1, 23 °C.
(Chemical analytes in g/L for liquids, g/kg for solids)

Analyte	H_2O Contact						Residual Solids
	1	2	3	4	5	6	
Wt% Diln	53	103	161	233	296	353	--
Sample ID	B109C1	B109C2	B109C3	B109C4	B109C5	B109C6	B109SOL
S02T000...	827	828	829	833	834	835	869/70
Density (g/mL)	1.208	1.143	1.131	1.108	1.106	1.113	--
Al	< 0.01	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	38.8
Bi	< 0.02	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	5.87
Cr	0.28	0.10	0.038	0.013	0.007	0.004	1.37
Fe	< 0.01	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6.92
K	0.27	< 0.20	< 0.20	0.21	< 0.20	< 0.20	--
Na	77.0	64.3	55.5	49.7	58.2	53.2	181
P	3.32	3.50	3.66	2.75	2.73	2.31	14.8
S	7.96	16.1	19.2	20.2	24.9	23.1	69.2
Si	0.12	0.13	0.17	0.12	0.09	0.09	1.85
F^-	4.27	9.56	11.8	12.0	11.9	12.9	--
Cl^-	1.40	0.60	0.23	< 0.07	< 0.07	< 0.09	--
NO_2^-	5.35	1.64	< 1.1	0.68	< 0.45	< 0.56	--
NO_3^-	160	49.7	14.7	3.34	0.90	< 0.72	--
PO_4^{3-}	9.73	9.53	10.1	7.43	6.38	5.78	--
SO_4^{2-}	19.0	41.4	50.2	53.9	59.3	59.3	--
$C_2O_4^{2-}$	< 1.1	< 1.1	< 1.1	< 0.4	< 0.4	< 0.5	--
TIC	2.22	0.80	0.26	0.077	0.032	0.032	0.05
TOC	0.16	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.04
OH^-	< 0.04	0.20	0.36	0.80	0.72	0.80	--
$\%H_2O$	73.8	83.3	86.8	87.9	88.3	88.3	58.0
MassBal	98.2	99.9	100.4	100.2	102.3	101.2	--
ChargeBal	0.80	0.97	0.96	0.94	1.00	0.96	--

Table 3-5. Chemical Analyses, Tank SX-101 Run #1, 23 °C.
(Chemical analytes in g/L except as noted)

Analyte	H_2O Contact						Residual Solids
	1	2	3	4	5	6	
Wt% Diln	52	102	152	200	252	304	--
Sample ID	SX101C1	SX101C2	SX101C3	SX101C4	SX101C5	SX101C6	SX101SOL
S02T000...	830	831	832	841	842	843	873/74
Density (g/mL)	1.417	1.313	1.097	1.022	1.001	0.982	--
Al	27.1	8.99	1.29	0.37	0.14	0.08	134
Cr	5.04	1.78	0.64	0.21	0.07	0.03	21.5
Fe	< 0.02	< 0.02	< 0.005	< 0.005	< 0.001	< 0.001	10.3
K	0.86	0.34	0.088	< 0.025	0.006	0.003	--
Mn	< 0.004	< 0.004	< 0.001	< 0.001	< 0.001	< 0.001	5.89
Na	211	153	39.3	10.7	3.04	1.07	9.82
P	0.76	0.54	0.13	0.038	0.015	0.010	< 2.0
S	1.13	0.38	0.10	0.033	0.015	0.009	< 1.0
Si	0.26	0.089	0.023	0.012	0.009	0.014	1.96
U	< 0.10	< 0.10	< 0.025	< 0.025	< 0.003	< 0.001	8.16
F^-	< 0.12	< 0.12	< 0.12	< 0.01	0.004	0.002	--
Cl^-	8.23	3.07	1.25	0.19	0.053	0.015	--
NO_2^-	20.5	7.22	2.05	0.41	0.10	0.024	--
NO_3^-	249	272	69.7	16.7	4.19	0.98	--
PO_4^{3-}	1.97	1.52	< 1.2	< 0.13	0.044	0.026	--
SO_4^{2-}	2.46	< 1.4	< 1.4	< 0.15	0.035	0.022	--
$C_2O_4^{2-}$	< 1.1	< 1.1	4.3	1.0	0.26	0.065	--
TIC	2.70	1.11	0.42	0.12	0.048	0.019	0.16
TOC	0.077	< 0.04	1.37	0.22	0.22	0.20	0.40
OH^-	32.7	14.6	4.53	1.58	0.63	0.34	--
$\%H_2O$	54.5	62.8	88.1	96.6	99.1	99.8	57.5
MassBal	97.8	99.6	99.8	99.8	100.0	100.1	--
ChargeBal	1.09	1.08	0.98	1.04	0.94	0.81	--

Table 3-6. Radionuclide Analyses, Tank B-109 Run #1, 23 °C.
(Radionuclides in µCi/mL liquid or µCi/g solid)

Analyte	H_2O Contact						Residual Solids
	1	2	3	4	5	6	
Wt% Diln	53	103	161	233	296	353	--
^{60}Co	< 3.1E-4	< 2.7E-4	< 2.1E-4	< 2.7E-4	< 3.0E-4	< 2.7E-4	< 4.5E-3
$^{89/90}Sr$	3.7E-3	1.7E-3	1.1E-3	9.3E-4	8.1E-4	7.1E-4	1.9
^{99}Tc	1.2E-2	4.6E-3	1.5E-3	3.6E-4	8.4E-5	2.0E-5	< 2.8E-3
^{125}Sb	< 1.6E-2	< 9.5E-3	< 5.6E-3	< 2.5E-3	< 1.6E-3	< 1.1E-3	< 1.4E-2
^{137}Cs	17.8	6.40	2.20	0.55	0.18	0.07	0.74
^{154}Eu	< 1.6E-3	< 7.8E-4	< 5.9E-4	< 8.5E-4	< 8.9E-4	< 8.7E-4	< 1.4E-2
^{155}Eu	< 9.2E-3	< 5.5E-3	< 3.2E-3	< 7.6E-4	< 5.7E-4	< 4.9E-4	< 1.1E-2
^{241}Am	< 2.3E-2	< 1.4E-2	< 8.0E-3	< 6.9E-4	< 5.1E-4	< 4.6E-4	< 3.0E-2
Total Alpha	6.1E-4	2.3E-4	3.1E-4	1.6E-4	9.5E-5	< 9.8E-5	3.1E-2

Table 3-7. Radionuclide Analyses, Tank SX-101 Run #1, 23 °C.
(Radionuclides in µCi/mL liquid or µCi/g solid)

Analyte	H_2O Contact						Residual Solids
	1	2	3	4	5	6	
Wt% Diln	52	102	152	200	252	304	--
^{60}Co	< 1.1E-3	< 3.1E-4	< 3.0E-4	< 9.1E-4	< 8.9E-4	< 9.6E-4	< 1.3E-1
$^{89/90}Sr$	1.7E-2	1.1E-1	3.7E-2	4.0E-3	2.0E-3	1.1E-2	585
^{99}Tc	8.2E-2	2.9E-2	6.1E-3	1.9E-3	4.5E-4	1.2E-4	< 3.4E-2
^{125}Sb	< 3.5E-2	< 2.0E-2	< 1.0E-2	< 9.9E-3	< 7.0E-3	< 5.6E-3	< 3.8E-1
^{137}Cs	77	29	7.65	2.27	1.07	0.62	10.3
^{154}Eu	< 7.2E-3	< 2.4E-3	< 8.7E-4	< 2.8E-3	< 2.8E-3	< 2.8E-3	1.5
^{155}Eu	< 1.9E-2	< 1.2E-2	< 6.0E-3	< 3.2E-3	< 2.6E-3	< 2.3E-3	< 5.8E-1
^{241}Am	< 4.8E-2	< 2.9E-2	< 1.5E-2	< 2.7E-3	< 2.2E-3	< 1.9E-3	< 2.5
Total Alpha	< 2.8E-3	< 2.8E-4	< 2.9E-4	< 7.4E-5	< 3.4E-5	1.9E-4	2.77

Table 3-8. Chemical Analyses, Tank B-109 Run #2, 50 °C.
(Dilution-corrected chemical analytes in g/L for liquids, g/kg for solids)

Analyte	H_2O Contact					Residual Solids
	1	2	3	4	5	
Wt% Diln	49	98	150	216	296	--
Sample ID	50B1	50B2	50B3	50B4	50B5	50B9SOL
S02T000...	836	837	838	839	840	871/72
Density (g/mL)	1.23	1.12	1.15	1.11	1.09	--
Al	< 0.021	< 0.020	< 0.018	< 0.016	< 0.014	55.5
Bi	< 0.042	< 0.039	< 0.036	< 0.032	< 0.027	7.57
Cr	0.23	0.080	0.029	0.011	0.006	2.01
Fe	< 0.021	< 0.020	< 0.018	< 0.016	< 0.014	9.45
K	< 0.21	< 0.20	< 0.18	< 0.16	< 0.14	--
Na	107	65.6	53.3	50.8	46.2	180
P	10.4	6.68	4.51	3.83	1.98	3.14
S	7.20	13.6	17.5	19.8	20.3	80.0
Si	0.15	0.15	0.15	0.21	0.11	1.90
U	0.58	0.16	< 0.089	< 0.079	< 0.068	< 0.42
F^-	4.80	9.06	10.7	10.7	12.8	--
Cl^-	1.03	0.52	< 0.13	< 0.06	< 0.10	--
NO_2^-	4.01	1.27	< 0.82	< 0.38	< 0.65	--
NO_3^-	168	53.1	15.8	3.85	0.84	--
PO_4^{3-}	31.2	19.8	12.8	11.1	5.8	--
SO_4^{2-}	18.2	37.6	48.3	57.4	59.8	--
$C_2O_4^{2-}$	< 0.94	< 0.87	< 0.80	< 0.37	< 0.63	--
TIC	2.10	0.84	0.31	0.12	0.08	0.12
TOC	0.30	0.16	0.15	< 0.13	< 0.11	< 0.04
OH^-	< 0.18	< 0.16	< 0.15	0.15	< 0.11	--
$\%H_2O$	--	--	--	--	--	75.2
ChargeBal	0.95	0.94	0.95	0.96	0.92	--

Table 3-9. Chemical Analyses, Tank SX-101 Run #2, 50 °C.
(Dilution-corrected chemical analytes in g/L for liquids, g/kg for solids)

Analyte	H_2O Contact					Residual Solids
	1	2	3	4	5	
Wt% Diln	52	102	152	225	319	--
Sample ID	50SX1	50SX2	50SX3	50SX4	50SX5	50SX1SOL
S02T000...	844	845	846	847	848	875/76
Density (g/mL)	1.48	1.21	1.18	1.07	1.02	--
Al	32.9	5.11	1.08	0.22	0.08	152
Cr	4.30	1.12	0.40	0.22	0.06	28.8
Fe	< 0.06	< 0.02	< 0.01	< 0.01	< 0.01	14.6
K	0.92	0.18	< 0.02	0.01	0.005	--
Mn	< 0.01	< 0.004	< 0.004	< 0.004	< 0.004	7.76
Na	239	83.6	22.4	4.01	0.70	9.04
P	0.90	0.17	0.023	0.004	0.009	< 2.2
S	1.02	0.26	0.091	0.038	0.020	< 2.1
Si	0.20	0.046	0.021	0.009	0.015	2.77
U	< 0.31	< 0.088	< 0.025	< 0.004	0.008	11.6
F^-	< 0.38	< 0.09	< 0.10	< 0.003	< 0.003	--
Cl^-	7.75	2.01	0.48	0.075	0.018	--
NO_2^-	19.0	4.41	0.99	0.15	< 0.03	--
NO_3^-	383	168	42.0	5.79	0.64	--
PO_4^{3-}	< 3.8	< 0.9	< 1.0	< 0.04	0.11	--
SO_4^{2-}	< 4.4	< 1.0	< 1.2	0.08	0.05	--
$C_2O_4^{2-}$	< 3.4	1.61	3.85	0.54	0.07	--
TIC	2.45	0.83	0.39	0.12	< 0.01	0.22
TOC	0.24	0.31	0.98	0.36	0.10	0.57
OH^-	21.5	9.06	2.54	0.53	0.14	--
$\%H_2O$	--	--	--	--	--	51.2
ChargeBal	1.04	0.95	0.90	0.91	1.02	--

Table 3-10. Radionuclide Analyses, Tank B-109 Run #2, 50 °C.
(Radionuclides in µCi/mL liquid or µCi/g solid)

Analyte	H_2O Contact					Residual Solids
	1	2	3	4	5	
Wt% Diln	49	98	150	216	296	--
^{60}Co	< 1.1E-3	< 1.1E-3	< 9.0E-4	< 9.0E-4	< 1.0E-4	< 3.6E-2
$^{89/90}Sr$	8.8E-4	1.6E-4	8.9E-5	7.3E-5	3.3E-3	2.56
^{99}Tc	1.1E-2	3.4E-3	1.1E-3	2.5E-4	4.6E-5	< 2.8E-3
^{125}Sb	< 2.4E-2	< 1.4E-2	< 7.9E-3	< 4.4E-3	< 9.0E-4	< 9.1E-2
^{137}Cs	13.4	4.57	1.54	0.43	0.11	0.66
^{154}Eu	< 3.7E-3	< 3.2E-3	< 3.4E-3	< 2.7E-3	< 5.0E-4	< 1.1E-1
^{155}Eu	< 6.7E-3	< 3.9E-3	< 2.5E-3	< 1.7E-3	< 3.0E-4	< 7.7E-2
^{241}Am	< 5.9E-2	< 3.6E-3	< 2.3E-3	< 1.5E-3	< 3.0E-4	< 1.9E-1
Total Alpha	5.0E-4	2.0E-4	1.0E-4	3.0E-5	2.0E-5	2.7E-2

Table 3-11. Radionuclide Analyses, Tank SX-101 Run #2, 50 °C.
(Radionuclides in µCi/mL liquid or µCi/g solid)

Analyte	H_2O Contact					Residual Solids
	1	2	3	4	5	
Wt% Diln	52	102	152	225	319	--
^{60}Co	< 9.0E-4	< 8.0E-4	< 2.0E-4	< 1.0E-4	< 1.0E-4	< 4.7
$^{89/90}Sr$	2.0E-4	1.1E-3	3.7E-4	1.3E-3	7.4E-3	786
^{99}Tc	6.1E-2	1.7E-2	4.2E-3	6.6E-4	7.2E-5	< 3.6E-3
^{125}Sb	< 6.0E-2	< 3.0E-2	< 8.0E-3	< 4.0E-3	< 2.0E-3	< 11
^{137}Cs	76.6	17.9	5.4	1.8	0.6	< 12
^{154}Eu	< 6.9E-3	< 2.7E-3	< 6.0E-4	< 4.0E-4	< 3.0E-4	< 14
^{155}Eu	< 3.5E-2	< 1.7E-2	< 5.0E-3	< 2.0E-3	< 1.0E-3	< 11
^{241}Am	< 8.5E-2	< 4.2E-2	< 1.2E-2	< 6.0E-3	< 3.0E-3	< 26
Total Alpha	< 2.0E-3	< 4.0E-4	< 2.0E-5	< 2.0E-5	1.4E-4	3.62

Table 3-12. Chemical Analyses, Tank B-109 Run #3, 24 °C.
(Chemical analytes in g/L for liquids, g/kg for solids)

Analyte	Contact #										Resid[1] Solids
	1	2	3	4	5	6	7	8	9	10	
Diluent	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	NaOH	--
Wt% Diln	51	102	163	219	293	375	470	572	676	779	--
S02T000	1718	1719	1720	1721	1722	1723	1724	1725	1726	1746	1727
Density (g/mL)	1.27	1.15	1.09	1.09	1.10	1.12	1.08	1.05	1.01	1.09	--
Al	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	0.03	0.36	0.01	1.16	176
Cr	0.25	0.09	0.03	0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03	5.6
Fe	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	27.7
K	0.27	0.11	0.05	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	--
Na	100	62.0	50.0	47.2	45.8	46.8	28.4	12.4	1.17	41.0	24.6
P	2.96	3.16	2.84	2.53	2.31	2.12	3.64	4.01	0.21	0.81	1.2
S	8.85	15.6	19.2	20.5	21.0	21.7	10.2	0.84	0.06	0.04	< 0.3
Si	0.01	0.14	0.16	0.18	0.33	0.11	0.07	0.02	0.01	0.90	5.2
U	0.96	0.26	0.04	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	4.6
F^-	4.77	8.93	11.7	12.3	13.2	13.6	8.81	3.96	0.37	4.13	--
Cl^-	1.35	0.40	< 0.09	< 0.09	< 0.09	< 0.09			< 0.01	< 0.04	--
NO_2^-	4.84	0.94	0.80	< 0.6	< 0.6	< 0.6			< 0.02	< 0.3	--
NO_3^-	241	77.4	15.8	4.49	1.01	< 0.7			< 0.03	< 0.3	--
PO_4^{3-}	8.05	8.41	7.92	7.16	6.42	6.03	10.9	11.9	0.66	2.43	3.5
SO_4^{2-}	22.9	43.2	54.3	62.0	59.9	63.4	27.6	2.12	0.17	< 0.3	< 0.8
$C_2O_4^{2-}$	< 1.1	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6			< 0.02	< 0.3	--
TIC	2.01	0.65	0.22	0.08	0.04	0.03	--	--	--	--	0.68
TOC	0.21	0.07	< 0.04	< 0.04	< 0.04	< 0.04	--	--	--	--	0.80

[1]Residual solids after 10th contact; solids were 51.2% H_2O

Table 3-13. Chemical Analyses, Tank SX-101 Run #3, 24 °C.
(Chemical analytes in g/L for liquids, g/kg for solids)

Analyte	Contact #						Residual Solids[1]
	1	2	3	4	5	6	
Diluent	H_2O	H_2O	H_2O	H_2O	NaOH	NaOH	--
Wt% Diln	49	100	182	268	360	459	--
Sample ID	SX1EC1	SX1EC2	SX1EC3	SX1EC4	SX1EC51	SX1EC6	SX1ESOL
S02T000...	1730	1731	1732	1733	1734	1735	1739/40
Density (g/mL)	1.37	1.31	1.10	1.02	1.08	1.08	--
Al	30.6	9.12	1.22	0.25	4.68	5.04	108.0
Cr	4.98	2.02	0.44	0.10	0.19	0.07	28.3
Fe	< 0.02	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	14.3
K	0.70	0.35	0.06	0.01	< 0.05	< 0.05	--
Mn	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	8.5
Na	191	150	30.9	6.16	36.5	42.2	14.9
P	0.66	0.52	0.10	0.02	< 0.02	< 0.02	< 0.5
S	1.09	0.44	0.09	0.02	< 0.01	< 0.01	< 0.2
Si	0.20	0.07	0.02	0.01	0.04	0.04	2.0
U	< 0.1	< 0.1	< 0.03	< 0.01	< 0.03	< 0.03	11.4
F^-	< 0.12	< 0.12	< 0.06	< 0.01	< 0.01	< 0.01	--
Cl^-	9.05	3.50	0.77	0.12	< 0.01	< 0.01	--
NO_2^-	23.4	8.50	1.73	0.27	0.15	< 0.04	--
NO_3^-	211	280	58.1	9.93	1.82	0.28	--
PO_4^{3-}	1.74	1.49	< 0.6	< 0.06	0.07	0.06	--
SO_4^{2-}	2.96	1.30	< 0.7	< 0.07	< 0.02	< 0.06	--
$C_2O_4^{2-}$	< 0.11	< 0.11	2.74	0.44	0.09	< 0.04	--
TIC	3.49	1.41	0.42	0.09	0.05	0.04	1.07
TOC	0.29	0.18	0.91	0.18	< 0.04	< 0.04	0.88

[1]Residual solids after 10th contact; solids were 66.5% H_2O; contacts 7-10 liquid samples were not analyzed due to lack of apparent dissolution, based on lack of change in wt% centrifuged solids.

4.0 DILUTION RESULTS, VOLUME AND WEIGHT MEASUREMENTS

All results quoted in Sections 4 and 5 have been "normalized" to a common basis for comparison. The common basis is defined in each sub-section as appropriate.

One way to measure the effectiveness of the dissolution brought about by the stepwise addition of water to the saltcake is to measure the weight percent of centrifuged solids remaining after each dissolution contact. The weight of centrifuged solids relative to the original sample weight gives the "Wt% CSol" values presented in Tables 4-1 and 4-2 for the three cascade dissolution tests (Runs #1 - 3). The "Cumulative Wt% Dilution" is the sum of the weights of diluent added relative to the original sample weight. The data are plotted in Figure 4-1.

The graphs in Figure 4-1 can be used to predict how much saltcake can be retrieved for a given amount of diluent. For example, assume that tank B-109 contains 360 kL (95 kgal) of saltcake at a density of 1.87 kg/L, or 673,000 kg of saltcake (Benar 1997). Then, addition of 2 million kg (530 kgal) of water (300 wt% dilution) would dissolve about half of the saltcake at 23 °C, or about 60% of the saltcake at 50 °C. It would take at least twice that much water to dissolve all of the soluble fluoride, phosphate, and sulfate in the saltcake.

In the corresponding calculation for tank SX-101, assume that the tank contains 1.05 ML (277 kgal) of saltcake at a density of 1.905 kg/L, or 2 million kg of saltcake (Hu 1998). Addition of an equal weight of water (100 wt% dilution, or 530 kgal water) would dissolve about 60% of the saltcake at 23 °C or 70% at 50 °C. More water would provide only a little additional dissolution.

Table 4-1. Dissolution Profiles, Tank B-109, H_2O Diluent Except as Noted
[all values in wt% (weight percent); CSol = centrifuged solids]

Contact	Run #1, 23 °C		Run #2, 50 °C		Run #3, 24 °C	
	Dilution	CSol	Dilution	CSol	Dilution	CSol
1	53	102.8	49	93.1	51	101.6
2	103	93.4	98	83.0	102	92.4
3	161	79.3	150	68.9	163	80.1
4	233	65.0	216	54.6	219	68.0
5	296	51.3	296	38.1	293	52.2
6	353	38.5	--	--	375	34.8
7	--	--	--	--	470	19.8
8	--	--	--	--	572	13.2
9	--	--	--	--	676	11.5
10	--	--	--	--	779[a]	11.4[a]

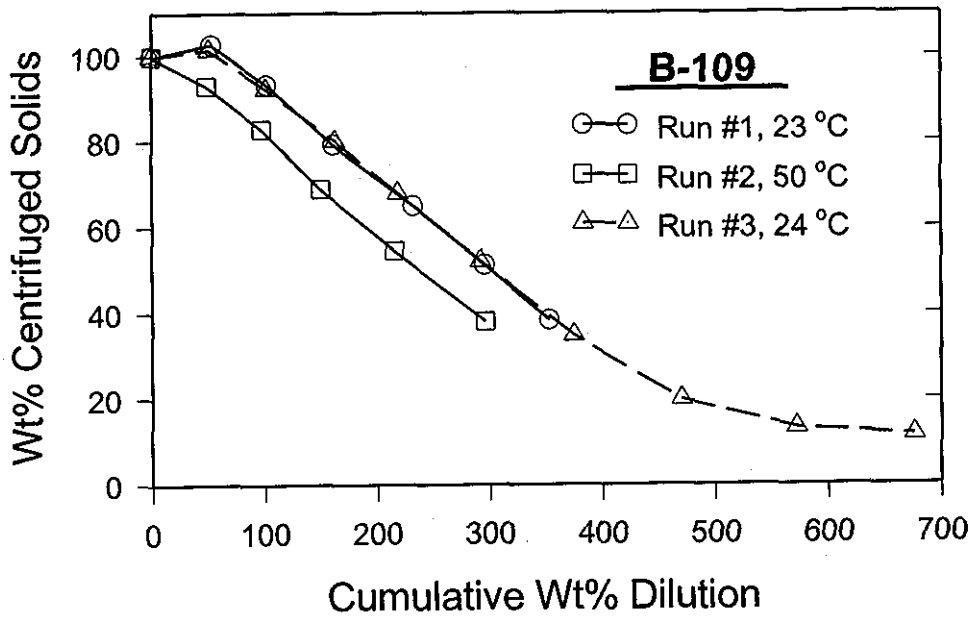
[a] 2 M NaOH diluent

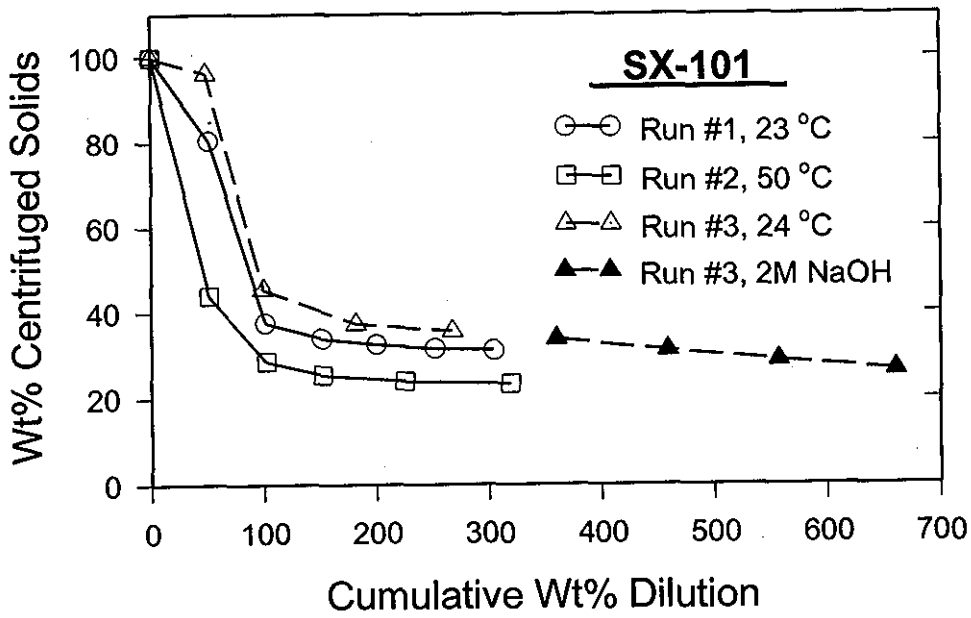
Table 4-2. Dissolution Profiles, Tank SX-101, H_2O Diluent Except as Noted
[all values in wt% (weight percent); CSol = centrifuged solids]

Contact	Run #1, 23 °C		Run #2, 50 °C		Run #3, 24 °C	
	Dilution	CSol	Dilution	CSol	Dilution	CSol
1	52	80.5	52	44.0	49	96.2
2	102	37.6	102	28.6	100	45.5
3	152	33.9	152	25.4	182	37.3
4	200	32.5	225	24.0	268	35.6
5	252	31.5	319	23.3	360[a]	33.7[a]
6	304	31.1	--	--	459[a]	31.0[a]
7	--	--	--	--	557[a]	28.7[a]
8	--	--	--	--	661[a]	26.4[a]
9	--	--	--	--	760[a]	24.1[a]
10	--	--	--	--	843	23.7

[a] 2 M NaOH diluent

Figure 4-1. Amount of Saltcake Dissolved as a Function of Temperature and Volume of Diluent Added





5.0 CHEMICAL COMPOSITION TRENDS

The gross sample behavior explored in the previous section (i.e., wt% centrifuged solids as a function of dilution) can be understood in terms of what happens to individual saltcake components. These trends are discussed in Section 5.

The overall composition of the composite sample from each tank was determined by direct analysis of the solid plus water-digest and fusion-digest preparations. The results are summarized in Tables 5-1 (chemical) and 5-2 (radionuclides).

Each of the saltcakes has its unique characteristics. Tank B-109 saltcake is unusually low in nitrate and high in fluoride and sulfate. Tank SX-101 saltcake is high in nitrate and unremarkable in all other anions. Tank SX-101 saltcake contains much higher radioactivity levels than B-109 saltcake, especially for those isotopes that are relatively insoluble in water.

5.1 LIQUID PHASE COMPOSITION TRENDS

Figure 5-1 (tank B-109) and Figure 5-2 (tank SX-101) show the dissolution behaviors of the major analytes of interest. These are plots of the analytical data from Tables 3-8 (run #2) and 3-12 (run #3) for Figure 5-1, and Tables 3-5 (run #1)and 3-9 (run #2) for Figure 5-2. Run #3 is used for Figure 5-1 in preference to run #1 because of the more extensive dissolution in run #3.

5.1.1 Nitrite, Chloride, Carbonate

The amount of nitrite, chloride, and carbonate in both of the saltcake samples was so low that they were completely dissolved at the lowest dilution level in all cases. Their concentrations in the liquid phase during the cascade dissolution tests fit the standard dilution pattern of a soluble salt that is completely dissolved at the lowest dilution. In subsequent dilutions, the only source of nitrite, chloride, and carbonate is the interstitial liquid remaining with the centrifuged solids from the previous dilution. Therefore, no new information about these analytes is learned from these tanks. Figure 5-2 shows the nitrite data for tank SX-101, which is typical of all of the data for these analytes.

Table 5-1. Overall Composition (in wt%) of Composite Saltcake Samples (average of duplicate samples)

Analyte	Sample Prep	B-109	SX-101
Al	fusion[a]	1.94	6.23
Bi	fusion	0.25	< 0.20
Cr	fusion	0.097	1.02
Fe	fusion	0.40	0.33
Na	fusion	26.8	22.2
P	fusion	1.86	< 0.40
S	fusion	8.38	< 0.20
Si	fusion	< 0.10	0.10
U	fusion	< 0.50	< 0.50
F^-	water digest[b]	6.08	< 0.02
Cl^-	water digest	0.16	0.67
NO_2^-	water digest	0.42	1.76
NO_3^-	water digest	10.2	39.4
PO_4^{3-} by IC	water digest	5.82	0.20
PO_4^{3-} by ICP[c]	fusion	5.72	< 1.2
SO_4^{2-} by IC	water digest	24.8	< 0.27
SO_4^{2-} by ICP[c]	fusion	25.1	< 0.60
$C_2O_4^{2-}$	water digest	< 0.20	0.27
CO_3^{2-}	direct	0.77	1.00
"acetate"[d]	calculation	0.052	0.08
OH^-	water digest	< 0.80	1.24
H_2O	direct	17.35	14.45
MassBal[d]		97.2	95.3
ChargeBal (+/-)[d]		0.90	1.21

[a] fusion = result from analysis of KOH fusion digest preparation.
[b] water digest = result from analysis of water digest preparation.
[c] calculated from fusion digest ICP result
[d] see Section 3.1 for definitions of "acetate", MassBal, and ChargeBal (+/-)

Table 5-2. Radionuclide Activities (in μCi/g) of Composite Saltcake Samples (average of duplicate samples)

	Sample Prep	B-109	SX-101
^{60}Co	fusion	< 0.008	< 0.035
$^{89/90}Sr$	fusion	0.90	172
^{99}Tc	fusion	0.0063	0.061
^{125}Sb	fusion	< 0.075	< 0.20
^{137}Cs	fusion	10.8	71.4
^{137}Cs	water digest	10.4	66.1
^{154}Eu	fusion	< 0.03	0.48
^{155}Eu	fusion	< 0.02	0.24
^{241}Am	fusion	< 0.02	0.69
Total Alpha	fusion	0.017	0.86

5.1.2 Nitrate

The concentration of nitrate follows a simple dilution pattern for tank B-109 (Figure 5-1). The reason for the discrepancy between the 24 and 50 °C curves is probably either analytical error or sample inhomogeneity (see Section 5.2 for further discussion). If the 24 °C data were taken from Table 3-4 (run #1) rather than Table 3-12 (run #3), then the discrepancy between the temperatures would be much smaller.

For tank SX-101 (Figure 5-2), the apparent discrepancy between the 23 °C curve and the 50 °C curve is explainable. At 50 °C, all of the nitrate is in solution at the lowest dilution level, and the nitrate concentration in the liquid phase for subsequent dilutions follows the usual dilution pattern. At 23 °C, some of the nitrate remains in the solid phase at the lowest dilution, so the second dilution shows a concentration much higher than what would otherwise result from simply the contribution from the interstitial liquid. Thus, the nitrate concentration at 23 °C is lower than at 50 °C for the first dilution (at about 50 wt% dilution), and higher for the second (at about 100 wt% dilution).

Figure 5-1. Concentrations in Supernatant Liquid, Tank B-109
(open symbols 24 °C, filled symbols 50 °C)

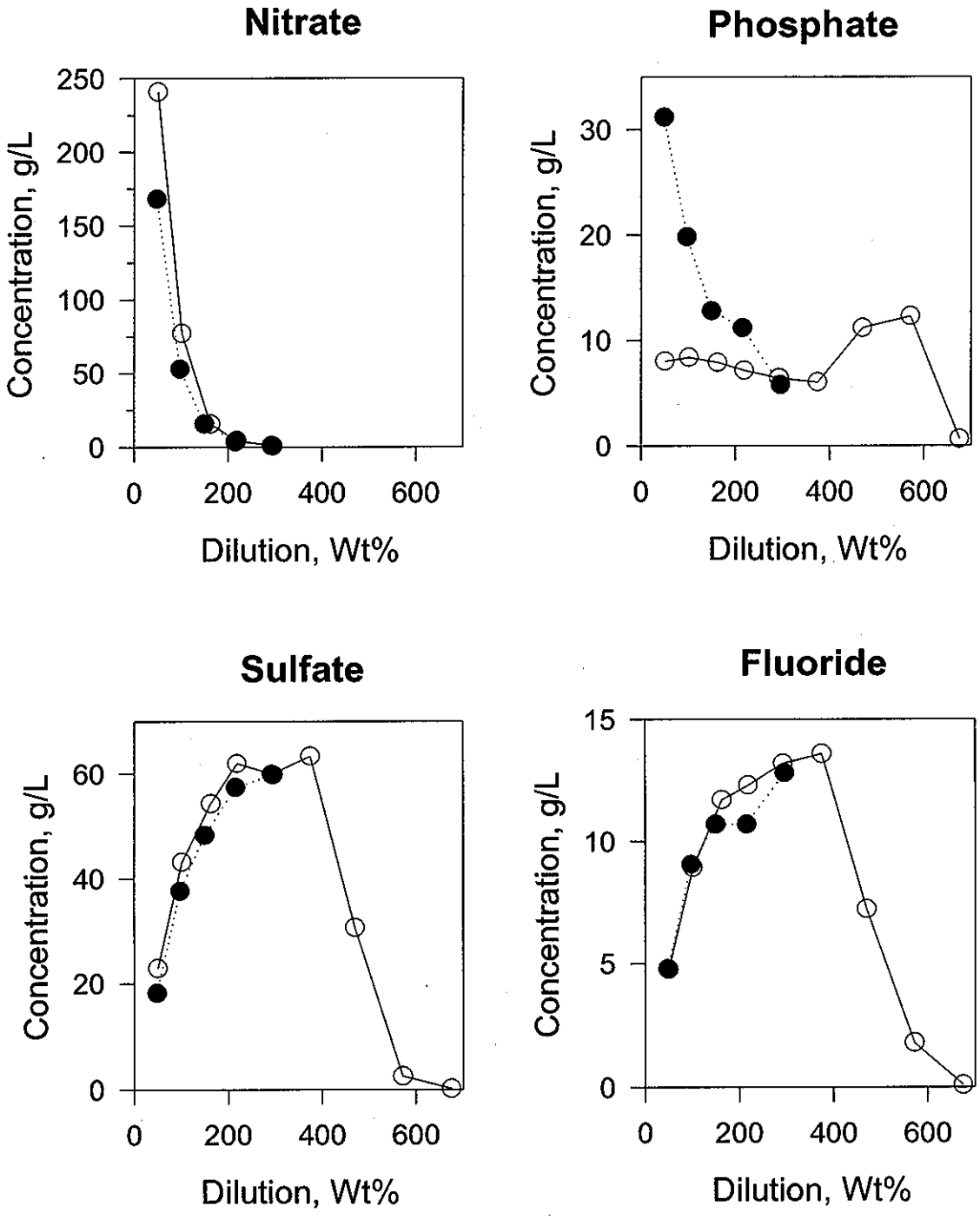
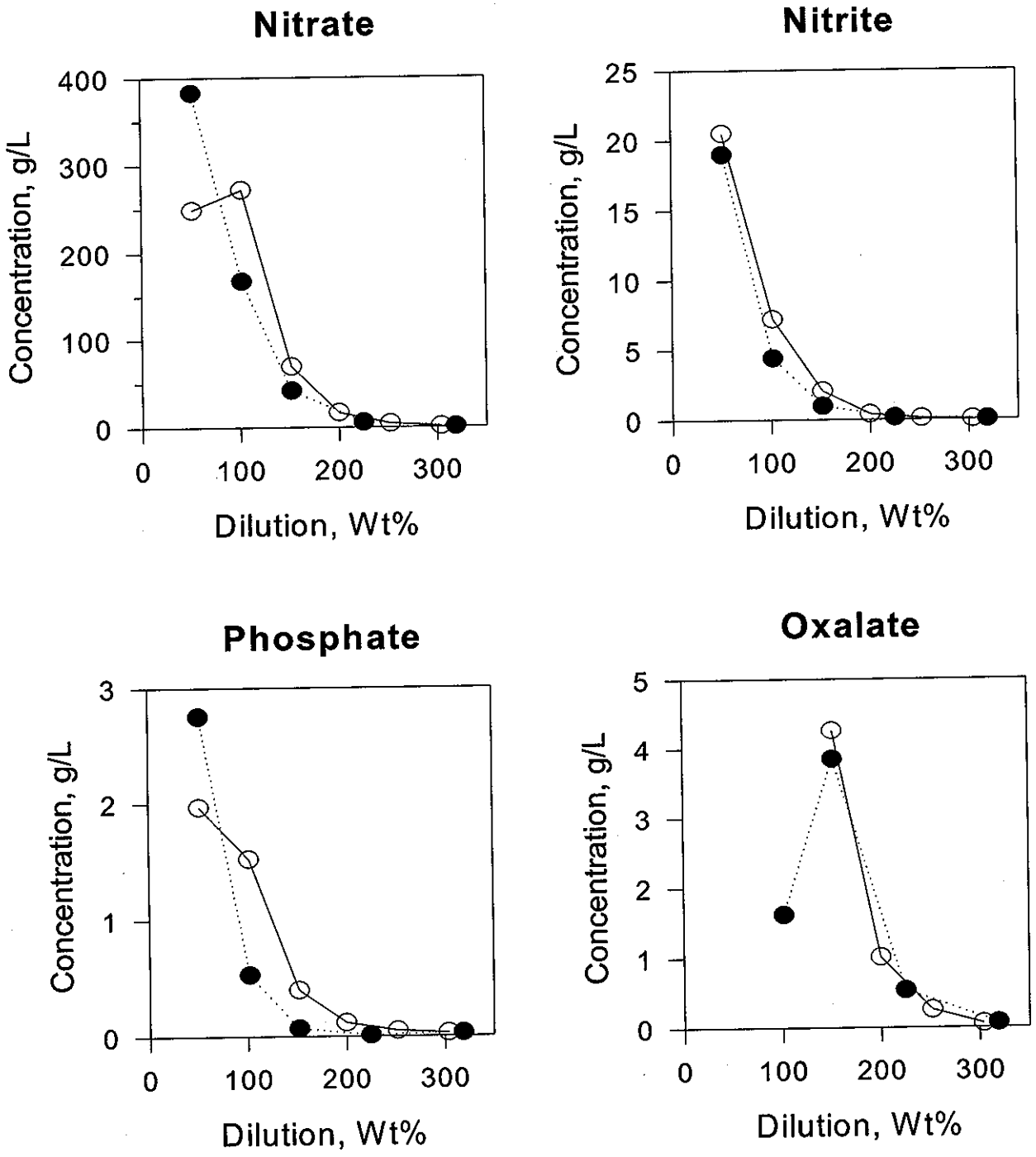


Figure 5-2. Concentrations in Supernatant Liquid, Tank SX-101
(open symbols 23 °C, filled symbols 50 °C)



5.1.3 Fluoride

As indicated in Table 5-1, fluoride is a significant contributor only to the saltcake from tank B-109. Solid phase analyses (Section 5.2) show that the major solid phases in tank B-109 saltcake are the sodium fluoride sulfate double salt, Na_3FSO_4, and sodium fluoride phosphate double salt, $Na_7F(PO_4)_2 \cdot 19H_2O$. Figure 5-1 gives the impression that the fluoride concentration in the liquid phase is closely parallel to the sulfate concentration. Actually, for all but the last few contacts in Run #3, the fluoride concentration is very close to the amount that would be predicted from the stoichiometric sum of the contributions from the sulfate and phosphate double salts. In other words, the fluoride concentration is very close to the prediction based on the equation (brackets { } indicate concentrations in g/L):

$$\{F^-\} = \{SO_4^{2-}\}(19/96) + \{PO_4^{3-}\}(19/190)$$

where 19 is the atomic weight of fluoride, 96 is the formula weight of sulfate, and 190 is twice the formula weight of phosphate.

For the last few contacts in Run #3, the observed $\{F^-\}$ is higher than that predicted by the above equation, indicating the probably presence of a third fluoride-containing phase, possibly NaF. The tenth and final contact in Run #3 (see Table 3-12), which was done with 2 M NaOH instead of H_2O as the diluent, shows an abrupt increase in $\{F^-\}$, implying a possible fourth fluoride-containing phase, one which is more soluble in 2 M NaOH than in water.

Fluoride was not detected in tank SX-101, except in trace amounts in a couple of the dilute solutions. It is not a significant factor in the chemistry of SX-101 saltcake.

5.1.4 Phosphate

Phosphate is a major component of the saltcake from tank B-109, where it is present as the sodium fluoride phosphate double salt, $Na_7F(PO_4)_2 \cdot 19H_2O$. The solubility of the double salt is strongly temperature dependent, and dissolves much more readily at 50 °C than at 24 °C (Figure 5-1). At ambient temperature, the salt is very persistent, not even dissolving completely at 600 wt% dilution.

Phosphate is a minor component in tank SX-101, where, due to the absence of fluoride, it is presumably present in the solid phase as $Na_3PO_4 \cdot 12H_2O$. Even though there is very little phosphate in the saltcake, it is still saturated at ambient temperature and 50 wt% dilution (Figure 5-2), due to the very high ionic strength of the solution at that point. At 50 °C, the salt is completely dissolved at 50 wt% dilution, and behaves like the nitrite and chloride discussed above.

5.1.5 Sulfate

Sulfate is the dominant anion in tank B-109 saltcake, on a weight percent basis, more prevalent even than nitrate. It is present as the sodium fluoride sulfate double salt, as mentioned previously. Its concentration in the liquid phase increases steadily with dilution up to about 400 wt% (Figure 5-1), at which point it is completely dissolved. The salt is slightly more soluble at 24 °C than at 50 °C.

Tank SX-101 contains only a trace amount of sulfate (Table 3-5), and it behaves like nitrite and chloride (completely soluble at the lowest dilution level).

5.1.6 Oxalate

Oxalate was not detected at all in tank B-109. It is a small but significant component in tank SX-101 (Table 5-1). Its solubility is highly dependant on ionic strength. The oxalate plot in Figure 5-2 shows that the salt dissolves after the nitrate has been depleted, and is completely dissolved at about 150 wt% dilution.

Tests performed on other tanks in previous years (specifically, tanks BY-109 and S-110, Herting 2001) have shown that the solubility of sodium oxalate is also temperature dependent. In those tests, oxalate was much more abundant than in the current test, so the data are more extensive and reliable.

5.1.7 Metals

Aluminum accounts for 1.94% of the B-109 saltcake and 6.23% of the SX-101 saltcake (Table 5-1). In tank B-109, virtually all of the aluminum is present as relatively insoluble aluminum oxide/hydroxide. In fact, aluminum was below detection limit in the liquid in almost all of the dissolution samples. Aluminum oxide/hydroxide was by far the most abundant component of the residual solids after exhaustive dissolution (see Residual Solids column in Table 3-12). Aluminum oxide/hydroxide also dominated the residual solids in tank SX-101 (Table 3-13), but there was also a soluble component (identified by XRD as sodium aluminate) that behaved like nitrite and chloride, being completely soluble at the lowest dilution level. More information on the soluble/insoluble distribution of aluminum is given in Section 5.2.

Switching the diluent from H_2O to 2 M NaOH had only a very small effect on the aluminum in B-109 (increasing the liquid phase Al concentration from about 0.01 g/L to 1.2 g/L, dissolving only a tiny fraction of the remaining aluminum), and was only modestly effective in dissolving the aluminum residue in SX-101 (increasing the liquid phase Al concentration from 0.25 g/L to about 5 g/L, improving the overall aluminum recovery from 32% to 46% – see Figure 5-4).

Most of what was said about aluminum could also be said about chromium (which represents 0.097% of B-109 saltcake and 1.02% of SX-101 saltcake), with one minor exception. Chromium was detected in the liquid phase in the B-109 tests, where aluminum was not detected. The solution-phase chromium in those samples was almost certainly the chromate ion, CrO_4^{2-}. Switching the diluent from H_2O to 2 M NaOH had very little effect on Cr dissolution.

Several metals, including Bi, Fe, Mn, and U, were near or below detection limits in all liquid samples, but made substantial contributions to the residual solids. These metals were not affected by the switch from H_2O to 2 M NaOH.

5.1.8 Radionuclides

Most of the ^{137}Cs behaved like nitrite and chloride, but there was a significant water-insoluble fraction of the isotope in both tanks. (See Section 5.2 for more information on solid/liquid phase distributions.) There was no detectable amount of ^{99}Tc in the residue from either tank. It behaved like nitrite and chloride in all respects.

Total alpha and $^{89/90}Sr$ in tank B-109 behaved like Cr, i.e., there was a small component that was completely soluble at the first dilution level and a much larger component that was insoluble. Total alpha was not detected in any liquid samples in SX-101, while $^{89/90}Sr$ in that tank behaved similar to nitrate at 24 °C – it was more soluble at the second dilution level than at the first level, and then fell as expected with further dilution. Increasing the temperature from ambient to 50 °C caused about an order-of-magnitude drop in $^{89/90}Sr$ in the liquid phase in both tanks (compare results in Tables 3-6 and 3-10 for B-109, and Tables 3-7 and 3-11 for SX-101). There was no such corresponding drop for total alpha.

No other radionuclides were consistently above detection limits in either the liquid samples or residual solids.

5.2 DISTRIBUTION BY FRACTION

In the Cascade dissolution tests, each composite saltcake sample was dissolved by contacting it repeatedly with water, decanting the liquid phase after each contact. This was a batch-wise approximation of a continuous in-tank retrieval process. The progress of the dissolution was followed by performing chemical analyses of each 'fraction' resulting from the test, i.e., the liquid phase from each contact plus the residual solids at the end of the dissolution.

The fractional dissolution gives a good initial understanding of the saltcake dissolution process achieved by the stepwise addition of water. Multiplication of the analyte concentration or activity (Tables 3-4 through 3-13) by the volume of solution (or

weight of residual solids) gives the total number of grams or microcuries of analyte in each fraction.

Table 5-3 shows the amount (grams or μCi) of each component in each fraction from the B-109 cascade test at 23 °C (Run #1). The column labeled "Total" is the sum of the seven fractions. The column labeled "Percent Dissolved" is 100 times the sum of the six liquid samples divided by the total. Calculations for the other five tests (Runs #1-3 for SX-101 and Runs #2-3 for B-109) are not shown, but the results are summarized in Table 5-4.

Table 5-3. Distribution by Fraction in Tank B-109 at 23 °C (Run #1)
(total undiluted sample weight 40.020 g)
(chemicals in grams, radionuclides in μCi)

Analyte	Liquid Samples						Residual Solids	Total	Percent Dissolved
	1st Contact	2nd Contact	3rd Contact	4th Contact	5th Contact	6th Contact			
F^-	0.075	0.19	0.31	0.37	0.33	0.34	0.83[a]	1.61	66
Cl^-	0.025	0.011	0.006	0.002	0.001	--	--	0.044	100
NO_2^-	0.094	0.033	0.015	0.021	0.006	0.002	--	0.17	100
NO_3^-	2.80	0.99	0.38	0.10	0.025	0.009	--	4.31	100
PO_4^{3-}	0.17	0.19	0.26	0.23	0.18	0.15	0.70[b]	1.88	63
SO_4^{2-}	0.33	0.83	1.31	1.67	1.63	1.54	3.20[b]	10.5	70
CO_3^{2-}	0.19	0.080	0.034	0.012	0.004	0.004	0.004	0.33	99
Cr	0.005	0.002	0.001	0.0004	0.0002	0.0001	0.021	0.030	29
Na	1.35	1.29	1.44	1.54	1.60	1.38	2.79	11.4	76
P	0.058	0.070	0.095	0.085	0.075	0.060	0.23	0.67	66
S	0.14	0.32	0.50	0.63	0.68	0.60	1.07	3.94	73
$^{89/90}Sr$	0.065	0.034	0.029	0.029	0.022	0.018	29.3	29.5	0.7
^{99}Tc	0.210	0.092	0.039	0.011	0.002	0.001	< 0.04	0.35	100
^{137}Cs	312	128	57	17	5.0	1.8	11	532	97.9

[a] calculated value based on composition shown in Table 5-1 minus sum of liquid fractions.
[b] calculated from ICP result for P or S.

Table 5-4. Distribution by Fraction Summary
(percent dissolved at end of dissolution)

Analyte	B-109			SX-101		
	23 °C Run#1 at 353% diln	50 °C Run#2 at 296% diln	24 °C Run#3 at 779% diln	23 °C Run#1 at 304% diln	50 °C Run#2 at 319% diln	24 °C Run#3 at 459% diln
F^-	66	53	100	--	--	--
Cl^-	100	100	100	100	100	100
NO_2^-	100	100	100	100	100	100
NO_3^-	100	100	100	100	100	100
PO_4^{3-}	63	92	99	100	100	100
SO_4^{2-}	70	62	100	100	100	100
$C_2O_4^{2-}$	--	--	--	86	86	100
CO_3^{2-}	99	97	95	89	98	90
Al	--	--	--	33	44	46
Cr	29	19	26	39	38	32
Fe	0	0	0	0	0	0
Na	76	74	99	99	99	98
P	66	93	99	100	100	100
S	73	64	100	100	100	100
$^{89/90}Sr$	0.7	0.4	--	0.06	0.005	--
^{99}Tc	100	100	--	100	100	--
^{137}Cs	97.9	97.5	--	95.3	100	--

Dividing the number in the Total column in Table 5-3 by the undiluted sample weight shown in the table heading gives the weight percent of each analyte (or μCi/g for radionuclides) in the original composite sample, as determined by the sum of fractions. This value can be compared to the composition determined by direct analysis of the composite sample. The comparison is made in Table 5-5 for tank B-109 and Table 5-6 for tank SX-101. If all of the analyses had zero analytical error, and if all of the hotcell volumes were measured correctly after centrifuging the samples, and if the composite sample were perfectly homogeneous, these numbers would match perfectly. Considering the number of potential errors, the numbers match remarkably well. The low values for fluoride and phosphate in Run #1 and #2 are due to incomplete dissolution of the fluoride phosphate double salt in those runs.

Table 5-5. Comparison of Sum of Fractions to Direct Analysis, Tank B-109 (chemicals in grams, radionuclides in HCi)

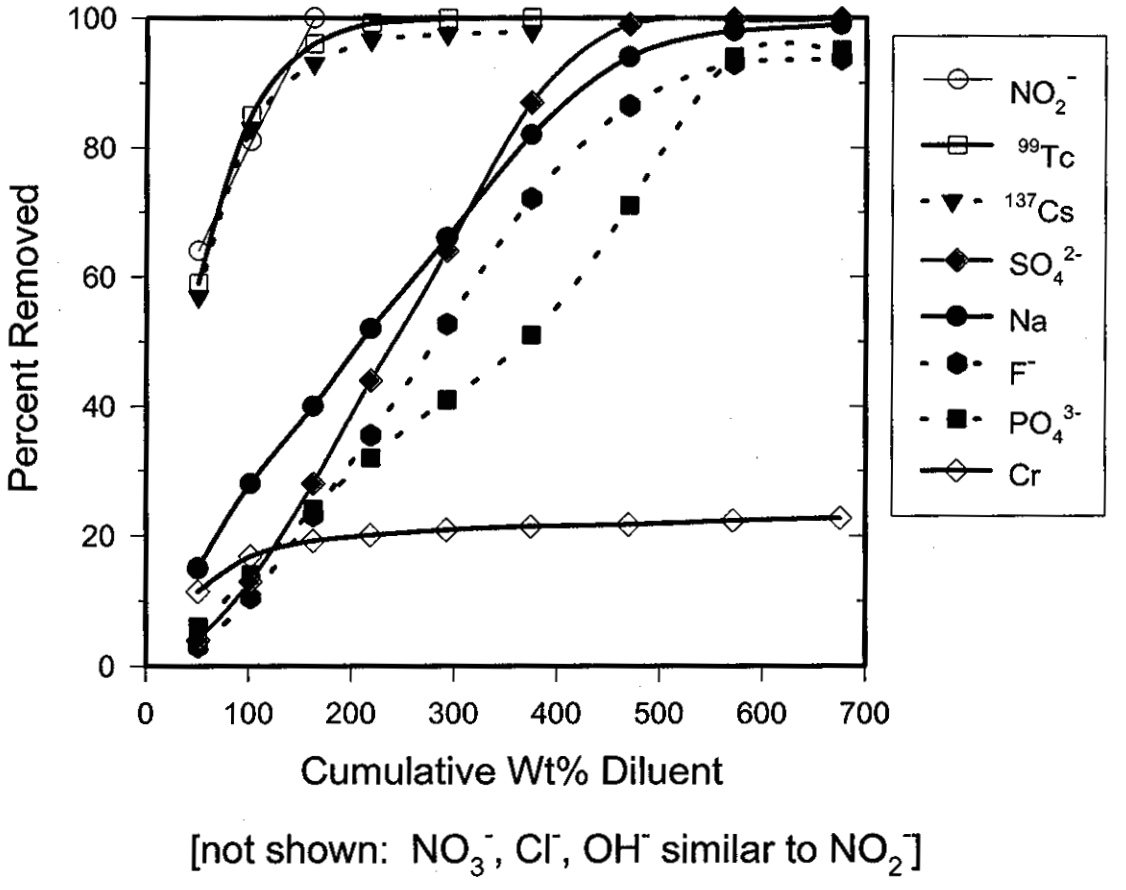
Analyte	Run#1 23 °C	Run#2 50 oC	Run#3 24 °C	Direct Analysis[1]
F^-	4.01	3.23	6.24	6.09
Cl^-	0.11	0.09	0.07	0.16
NO_2^-	0.43	0.29	0.29	0.42
NO_3^-	10.8	11.8	14.8	10.2
PO_4^{3-}	4.70	4.90	5.47	5.82
SO_4^{2-}	26.3	24.2	24.3	24.8
CO_3^{2-}	0.85	0.90	0.75	0.75
Al	1.50	2.11	2.16	1.95
Bi	0.23	0.29	0.24	0.25
Cr	0.07	0.09	0.09	0.10
Fe	0.27	0.36	0.32	0.40
Na	28.5	26.1	25.9	26.8
P	1.68	1.66	1.90	1.87
S	9.85	8.35	8.51	8.38
$^{89/90}Sr$	0.74	0.98	--	0.90
^{99}Tc	0.009	0.007	--	0.006
^{137}Cs	13.3	10.1	--	10.8

Table 5-6. Comparison of Sum of Fractions to Direct Analysis, Tank SX-101 (chemicals in grams, radionuclides in HCi)

Analyte	Run#1 23 °C	Run#2 50 oC	Run#3 24 °C	Direct Analysis[1]
Cl^-	0.70	0.70	0.71	0.67
NO_2^-	1.65	1.67	1.75	1.76
NO_3^-	35.7	39.2	35.6	39.5
PO_4^{3-}	0.23	0.24	0.23	< 0.24
SO_4^{2-}	0.22	0.29	0.25	< 0.27
$C_2O_4^{2-}$	0.32	0.35	0.27	0.27
CO_3^{2-}	1.25	1.25	1.65	1.00
Al	6.23	6.30	6.24	6.23
Cr	1.09	1.08	1.29	1.02
Fe	0.32	0.34	0.44	0.33
Mn	0.18	0.18	0.26	--
Na	24.1	23.5	22.5	22.2
P	0.08	0.08	0.08	< 0.36
S	0.09	0.10	0.09	< 0.18
Si	0.08	0.08	0.08	0.10
$^{89/90}Sr$	182	183	--	172
^{99}Tc	0.065	0.056	--	0.061
^{137}Cs	67.5	69.4	--	71.4

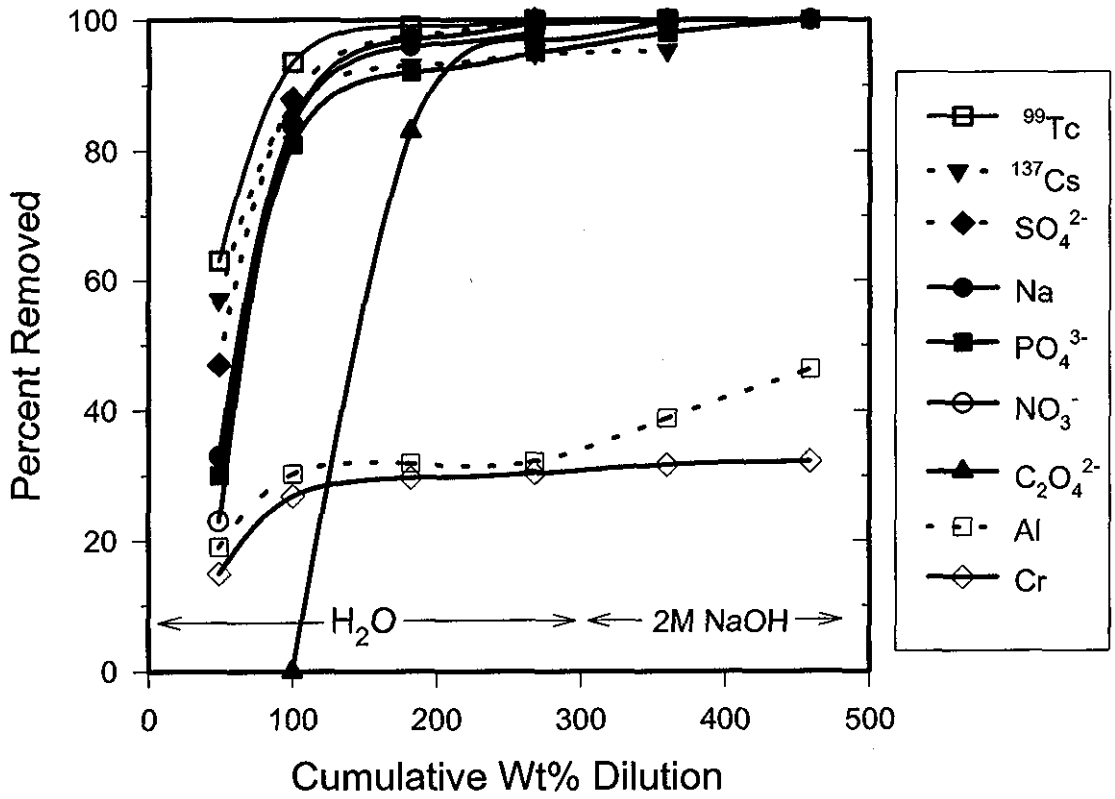
Figures 5-3 and 5-4 are called "dissolution profile" plots. They show the "Percent Removed" on the y-axis, defined as 100 times the cumulative weight of constituent removed in the decanted liquid phase divided by the total amount present (liquid and solid phases) in the undiluted sample. The "Percent Removed" at the highest dilution point matches the "Percent Dissolved" in the preceding tables. The legend for each figure follows the order of dissolution, with the components with the highest percent removed listed at the top of the legend.

Figure 5-3. Tank B-109 Dissolution Profile, 24 °C



In tank B-109 (Figure 5-3, above), a dilution of about 200 wt% would be sufficient to dissolve and remove from the tank all of the very soluble salts, including sodium nitrate, nitrite, hydroxide, and chloride. (Only the nitrite is shown in the figure.) At that point, though, only about 50% of the soluble sodium has been removed. The amount of sodium removed continues to increase almost linearly until the fluoride sulfate double salt is dissolved at about 500 wt% dilution. The sodium removal continues to rise as the last of the fluoride phosphate double salt dissolves at about 600 wt% dilution.

Figure 5-4. Tank SX-101 Dissolution Profile, 24 °C



In tank SX-101 (Figure 5-4, above), a dilution of 150 wt% would be sufficient to dissolve and remove almost the entire sodium inventory from the tank. All of the major salts have dissolved, and the remaining Al and Cr will not dissolve further regardless of dilution (with water). The only component still dissolving beyond 150 wt% dilution is the minor component sodium oxalate, which contributes less than one percent of the total sodium inventory. Nitrate, in this case, is not among the components that are completely dissolved at the lowest dilution, but it is completely dissolved at less than 150% dilution.

All of the water-soluble aluminum has also been removed by 150 wt% dilution. Changing the diluent from water to 2 M NaOH results in a little more aluminum removal, as seen in the upward sloping line for Al in the figure above. A similar effect occurs for Cr, but it is much less pronounced.

6.0 ACKNOWLEDGEMENTS

This work was funded by the U. S. Department of Energy Tanks Focus Area (EM-50) under Technical Task Plan Number RL0-8-WT-41, "PHMC Pretreatment – Saltcake Dissolution".

The author is indebted to a host of people who worked on the project. Mr. Wayne Edmonson performed most of the hotcell work and hood work with the radioactive saltcake samples. He also assisted with the preparation of slides for polarized light microscopy analysis. Mr. Gary Cooke performed the scanning electron microscopy analyses, with assistance from Mr. John Smith in sample preparation. Dr. Wade Warrant performed the x-ray diffraction analyses, also with assistance from Mr. Smith.

Chemical analyses were provided by the staff at the 222-S Laboratory. Detailed and helpful reviews of the document were provided by Dr. Jim Person.

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