

Keywords: Salt, Oxalic
Acid, leaching test

Retention: Permanent

Characterization of Tank 16H Annulus Samples Part II: Leaching Results

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June 2012

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Prepared for the U.S. Department of Energy under
contract number DE-AC09-08SR22470.



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Printed in the United States of America

**Prepared for
U.S. Department of Energy**

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EXECUTIVE SUMMARY

The closure of Tank 16H will require removal of material from the annulus of the tank. Samples from Tank 16H annulus were characterized and tested to provide information to evaluate various alternatives for removing the annulus waste.

The analysis found all four annulus samples to be composed mainly of Si, Na, and Al and lesser amounts of other elements. The XRD data indicate quartz (SiO_2) and sodium aluminum nitrate silicate hydrate ($\text{Na}_8(\text{Al}_6\text{Si}_6\text{O}_{24})(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$) as the predominant crystalline mineral phases in the samples. The XRD data also indicate the presence of crystalline sodium nitrate (NaNO_3), sodium nitrite (NaNO_2), gibbsite ($\text{Al}(\text{OH})_3$), hydrated sodium bicarbonate ($\text{Na}_3\text{H}(\text{CO}_3)_2 \cdot 2\text{H}_2\text{O}$), and muscovite ($\text{KAl}_2(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$).

Based on the weight of solids remaining at the end of the test, the water leaching test results indicate 20-35% of the solids dissolved after three contacts with an approximately 3:1 volume of water at 45 °C. The chemical analysis of the leachates and the XRD results of the remaining solids indicate sodium salts of nitrate, nitrite, sulfate, and possibly carbonate/bicarbonate make up the majority of the dissolved material. The majority of these salts were dissolved in the first water contact and simply diluted with each subsequent water contact. The water leaching removed large amounts of the uranium in two of the samples and approximately 1/3 of the ^{99}Tc from all four samples. Most of the other radionuclides analyzed showed low solubility in the water leaching test.

The oxalic acid leaching test result indicate approximately 34-47% of the solids in the four annulus samples will dissolve after three contacts with an approximately 3:1 volume of acid to solids at 45 °C. The same sodium salts found in the water leaching test comprise the majority of dissolved material in the oxalic acid leaching test. However, the oxalic acid was somewhat more effective in dissolving radionuclides than the water leach. In contrast to the water leaching results, most constituents continued to dissolve during subsequent cycles of oxalic acid leaching.

The somewhat higher dissolution found in the oxalic acid leaching test versus the water leaching test might be offset by the tendency of the oxalic acid solutions to take on a gel-like consistency. The filtered solids left behind after three oxalic acid contacts were sticky and formed large clumps after drying. These two observations could indicate potential processing difficulties with solutions and solids from oxalic acid leaching. The gel formation might be avoided by using larger volumes of the acid. Further testing would be recommended before using oxalic acid to dissolve the Tank 16H annulus waste to ensure no processing difficulties are encountered in the full scale process.

TABLE OF CONTENTS

LIST OF TABLES	vi
LIST OF FIGURES	viii
LIST OF ABBREVIATIONS.....	ix
1.0 Introduction.....	10
2.0 Experimental.....	10
2.1 Sample Description.....	10
2.2 Sample Preparation and Analysis	10
2.3 Water and Oxalic Acid Leaching Tests.....	11
3.0 Analytical Results and Discussion.....	13
3.1 General Information	13
3.2 Water Leached Solids Results	14
3.3 Oxalic Acid Leachate Results.....	14
3.4 Oxalic Acid Leached Solids Results	15
4.0 Modeling Summary and Recommendations.....	61
5.0 Conclusions.....	64
6.0 Recommendation	67
7.0 References.....	68
Appendix A.....	69

LIST OF TABLES

Table 2-1.	Sampling Locations of Tank 16H Annulus Samples	12
Table 2-2.	Composition of the Analytical Reference Glass-1 Standard.	12
Table 3-1.	Abbreviations for Analytical Methods used in Data Tables	14
Table 3-2.	Composition of the Water Leached Solids from Tank 16H Annulus Sample HTF-16-E-2.....	17
Table 3-3.	Composition of the Water Leached Solids from Tank 16H Annulus Sample HTF-16-N-1	20
Table 3-4.	Composition of the Water Leached Solids from Tank 16H Annulus Sample HTF-16-S-2.....	23
Table 3-5.	Composition of the Water Leached Solids from Tank 16H Annulus Sample HTF-16-W-1	26
Table 3-6.	Composition of the Oxalic Acid Leachates from Tank 16H Annulus Sample HTF-16-E-2 from Three Leaching Cycles.....	29
Table 3-7.	Composition of the Oxalic Acid Leachates from Tank 16H Annulus Sample HTF-16-N-1 from Three Leaching Cycles	32
Table 3-8.	Composition of the Oxalic Acid Leachates from Tank 16H Annulus Sample HTF-16-S-2 from Three Leaching Cycles.....	35
Table 3-9.	Composition of the Oxalic Acid Leachates from Tank 16H Annulus Sample HTF-16-W-1 from Three Leaching Cycles	38
Table 3-10.	Composition of the Oxalic Acid Leached Solids from Tank 16H Annulus Sample HTF-16-E-2.....	41
Table 3-11.	Composition of the Oxalic Acid Leached Solids from Tank 16H Annulus Sample HTF-16-N-1	44
Table 3-12.	Composition of the Oxalic Acid Leached Solids from Tank 16H Annulus Sample HTF-16-S-2.....	47
Table 3-13.	Composition of the Oxalic Acid Leached Solids from Tank 16H Annulus Sample HTF-16-W-1	50
Table 3-14.	XRD Result for the Oxalic Acid Leached Solids from the Tank 16H Annulus Samples-Estimated Mineral Phase Composition	56
Table 4-1.	Species Chosen for the ESP Chemistry Model of Tank 16 Annulus Solids	61

Table 5-1.	Summary of the Composition of the As-Received, Water Leached, and Oxalic Acid Leached Solids from Tank 16H Annulus Samples (Wt% Total Dried Solids)	64
Table 5-2.	Estimated Percent of Solids Dissolved in the Water Leaching and Oxalic Acid Leaching Tests on Tank 16H Annulus Samples	65
Table 5-3.	Summary of the Estimated Percentage Dissolved for each Radionuclide from the Water Leaching Test on Tank 16H Annulus Samples	66
Table 5-4.	Summary of the Estimated Percentage Dissolved for each Radionuclide from the Oxalic Acid Leaching Test on Tank 16H Annulus Samples	66
Table A-1.	Composition of Blanks and Standards for the Water Leached Solids from Tank 16H Annulus Sample	70
Table A-2.	Composition of Blanks and Standards for the Oxalic Acid Leached Solids from Tank 16H Annulus Sample	73

LIST OF FIGURES

Figure 3-1	Oxalic Acid Leached Solids from the Tank 16H Annulus Samples.....	53
Figure 3-2	Oxalic Acid Leached Solids from Tank 16H Annulus Sample HTF 16-E-2	54
Figure 3-3	Oxalic Acid Leached Solids from Tank 16H Annulus Sample HTF 16-N-1	54
Figure 3-4	Oxalic Acid Leached Solids from Tank 16H Annulus Sample HTF 16-S-255	
Figure 3-5	Oxalic Acid Leached Solids from Tank 16H Annulus Sample HTF 16-W-1	55
Figure 3-6	XRD Results of the Oxalic Acid Leached Solids for HTF-16E2-1	57
Figure 3-7	XRD Results of the Oxalic Acid Leached Solids for HTF-16E2-2.....	57
Figure 3-8	XRD Results of the Oxalic Acid Leached Solids for HTF-16N1-1	58
Figure 3-9	XRD Results of the Oxalic Acid Leached Solids for HTF-16N1-2	58
Figure 3-10	XRD Results of the Oxalic Acid Leached Solids for HTF-16S2-1	59
Figure 3-11	XRD Results of the Oxalic Acid Leached Solids for HTF-16S2-2.....	59
Figure 3-12	XRD Results of the Oxalic Acid Leached Solids for HTF-16W1-1	60
Figure 3-13	XRD Results of the Oxalic Acid Leached Solids for HTF-16W1-2	60

LIST OF ABBREVIATIONS

AD	Analytical Development
BS	Beta Spectroscopy
ESP	Environmental Simulation Program
GS	Gamma Spectroscopy
IC	Ion Chromatography
IE	Inductively Coupled Plasma-Emission Spectroscopy
IM	Inductively Coupled Plasma-Mass Spectrometry
MSE	Mixed Solvent Electrolyte
MSEPUB	Mixed Solvent Electrolyte Public Database
SA	Separation/Alpha Spectroscopy
SRNL	Savannah River National Laboratory
SRR	Savannah River Remediation
TH	Titration for Free Hydroxide
TTR	Technical Task Request
XRD	X-Ray Diffraction

1.0 Introduction

The closure of Tank 16H requires removal of material from the annulus of the tank. Savannah River Remediation (SRR) requested that the Savannah River National Laboratory (SRNL) provide information to evaluate various alternatives for removing the annulus waste. Samples from Tank 16H annulus were obtained and sent to SRNL to determine the chemical and radiochemical composition and to determine the leaching characteristics of the material. The work was conducted as stated in the task plan¹ developed from the Technical Task Request (TTR).² The results from the analysis of the initial as-received solids, the duct sample ¹³⁷Cs concentration, results of the water leachate analysis, and annulus cleaning recommendations were previously reported.³ This report documents the composition of the oxalic acid leachates, the composition of the solids remaining after water and oxalic acid leaching, and provides recommendations for the chemical species to use for thermodynamic modeling. Several other reports provide additional characterization information on the material in the Tank 16H annulus.^{4,5,6}

2.0 Experimental

2.1 Sample Description

A total of four samples were obtained from the Tank 16H annulus. Table 2-1 provides the riser sampling location in the annulus and the dates the samples were received at SRNL. The material obtained for each of the four samples appeared to be very dry and powdery and ranged in color from light grey to dark grey. Additional details on the samples can be found in a previous report.³

2.2 Sample Preparation and Analysis

For analysis by X-ray Diffraction (XRD), small amounts of the solids were placed in a shielded bottle and sent to Analytical Development (AD). Samples for XRD were analyzed in duplicate. The initial as-received solids were not washed, dried, or ground prior to sub-sampling for XRD analysis. Solids from the water and oxalic acid leaching tests were rinsed on the filter three times with small amounts of water to replace the interstitial liquid and dried in an oven at 110 °C to constant weight before XRD analysis.

After drying to constant weight in an oven at 110 °C, the solids from the leaching tests were prepared for analysis using two methods. An aqua regia digestion and a standard fusion digestion with sodium peroxide followed by uptake in nitric acid were used to dissolve the dried solids from the samples. The digested solids from each method were diluted to reduce activity and allow removal from the Shielded Cells. All sample preparations were conducted in duplicate. A digestion of a glass standard containing many of the elements found in tank samples was prepared concurrently with the sample digestions. Table 2-2 lists the composition of the Analytical Reference Glass-1 glass

standard.⁷ A reagent blank was prepared concurrently with the sample preparations consisting of the digestion reagents using the same manipulations and dilutions conducted on the sample.

2.3 Water and Oxalic Acid Leaching Tests

Leaching tests were conducted on the Tank 16H annulus samples to determine the solubility of the sample material in water and 4 wt% oxalic acid. Approximately 50 grams of the as-received solids from each sample were contacted with 150 mL of leaching solution for ~24 hours. The tests were conducted in a shaker oven maintained at 45 °C throughout the duration of the test. After ~24 hours with moderate agitation, the shaker was switched off and the solids allowed to settle. The liquid was decanted from the bottle as close to the settled solids interface as possible without disturbing the solids. Another 150 mL of leaching solution was then added to the solids and the mixtures agitated at 45 °C for another 24 hours. A third contact was conducted in the same manner.

All of the decanted solutions were filtered through a 0.45µm nylon filter to remove fines carried over during the decanting. Single aliquots of each decanted liquid from the leaching tests were removed without dilution and sent to AD for analysis.

The solids remaining from the leaching tests were filtered through a 0.45µm nylon filter and rinsed on the filter with three 30 mL portions of de-ionized water to remove the interstitial liquid. The solids were dried in a 110 °C oven overnight and prepared for analysis in the same manner as the as-received solids. Small portions of the dried solids were also submitted for analysis by XRD.

Table 2-1. Sampling Locations of Tank 16H Annulus Samples

Sample ID	Sample Location	Date Received	Total Weight of Sample Received
HTF-16-N-1	N (North)	11/14/2011	162.1 g
HTF-16-S-1	S (South)*	9/13/2011	-
HTF-16-E-1	E (East)*	10/3/2011	-
HTF-16-W-1	W (West)	12/1/2011	234.8 g
HTF-16-S-2	S (South)	11/21/2011	208.8 g
HTF-16-E-2	E (East)	11/7/2011	144.4 g

* An insufficient quantity of material was obtained in the initial samples from the South and East risers, so additional samples were obtained from each of these locations.

Table 2-2. Composition of the Analytical Reference Glass-1 Standard.

Element	mg/kg in Glass
Al	2.50E+04
B	2.69E+04
Ba	7.88E+02
Ca	1.02E+04
Cr	6.36E+02
Cu	3.20E+01
Fe	9.79E+04
K	2.25E+04
Li	1.49E+04
Mg	5.19E+03

Element	mg/kg in Glass
Mn	1.46E+04
Na	8.53E+04
Ni	8.25E+03
P	9.60E+02
Si	2.24E+05
Sr	3.13E+01
Ti	6.89E+03
Zn	1.61E+02
Zr	9.63E+02

3.0 Analytical Results and Discussion

3.1 General Information

Tables 3-2 through 3-13 provide analytical results on the chemical composition of the water leached solids, the oxalic acid leachates, and oxalic acid leached solids from the leaching tests. Figures 3-1 through 3-5 provide photographs of the remaining solids from the oxalic acid leaching test. Table 3-14 and Figures 3-6 through 3-13 provide the results of the XRD analysis of the oxalic acid leached solids. Analytical results for the digested solids use units of mg/kg and dpm/g of dried solids. Analytical results for leachate solutions use units of mg/L and dpm/mL. Values in italics were not used in the calculation of the average due to the unreliability of the values. The unreliability may be due to the presence of the analyte in the blank/standard or the unsuitability of the digestion method for that analyte. Additionally, the detection limits for the peroxide fusion data in the ICP-ES were generally much higher than for the aqua regia digestion and were not included in determining the less than value for the analyte. The results of the reagent blanks and glass standards prepared concurrently with the sample preparations can be found in the appendix.

For waste tank sample characterization, an uncertainty of approximately +/- 15% has been found to be the normal range for the combined sampling and analytical uncertainty.⁸ For the Tank 16H samples, the percent relative standard deviation (%RSD) presented in the tables only includes the uncertainty associated with sub-sampling in the Shielded Cells and the uncertainty of the analytical method. It should be noted that the samples represent a small amount of material from four small areas in the tank annulus.

The column headings in the data tables indicate the dissolution method used to dissolve the samples ("Aqua Regia" and "Per Fusion"). The data tables also indicate the analytical method used to measure each analyte. Table 3-1 shows the abbreviations used for each analytical method:

Table 3-1. Abbreviations for Analytical Methods used in Data Tables

Analytical Method	Abbreviation in Tables
Inductively Coupled Plasma-Emission Spectroscopy	IE
Inductively Coupled Plasma-Mass Spectrometry	IM
Ion Chromatography	IC
Titration for Free Hydroxide	TH
Separation/Alpha Spectroscopy	SA
Gamma Spectroscopy	GS
Beta Spectroscopy	BS

3.2 Water Leached Solids Results

Table 3-2 through 3-5 shows the analytical results of the water leached solids for the four samples. The results show Si, Na, Al, and Fe remain as the most abundant elements in all four samples after water leaching. The heterogeneous nature of the material and difficulties in sub-sampling the solids may contribute to the higher %RSD's found in some of the results. For both digestion methods, the results of the glass standards show close agreement with the expected concentrations and the reagent blanks show no significant contamination (see Table A-1).

The results from the XRD analysis of the water leached solids were previously reported.³ The XRD results largely agree with the chemical analysis showing the predominant crystalline mineral phase is either quartz (SiO_2) or sodium aluminum nitrate silicate hydrate ($\text{Na}_8(\text{Al}_6\text{Si}_6\text{O}_{24})(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$) in all four samples.

Based on the weight of solids remaining, the water leaching test dissolved 20-35% of the solids after three contacts with an approximately 3:1 volume of water at 45 °C. The chemical analysis of the leachates, along with the XRD results and analysis of the remaining solids, indicate sodium salts of nitrate, nitrite, sulfate, and possibly carbonate/bicarbonate make up the majority of the dissolved material. Based on the results of the leachate analysis, the majority of these salts were dissolved in the first water contact and simply diluted with each subsequent water contact.³

3.3 Oxalic Acid Leachate Results

Tables 3-6 through 3-9 provide the chemical composition of the decanted leachates from the oxalic acid leaching test. All of the decanted leachates indicate the presence of

soluble sodium salts of NO_2^- and NO_3^- as the species of highest concentration with substantial concentrations of aluminum.

The tables also show two columns labeled “Decant 2/Decant 1” and “Decant 3/Decant 2”. The values in the columns represent the fraction from dividing the concentrations in the labeled decant solutions by one another. These columns provide an indication of how material is dissolving from the solids during each oxalic acid contact in the leaching test. Since the leaching test decanted the first contact solution to approximately 50 mL and then added an additional 150 mL of oxalic acid for the next contact, simple dilution should give a factor of 0.25 (i.e., $50/(50 + 150) = 0.25$) for the ratio of concentrations between contacts. In other words, if all of the material that will be dissolved was dissolved in the first oxalic acid contact, the addition of oxalic acid in second contact merely serves to dilute the concentrations of species in solution from the first contact. In that case, the ratio of the concentration in the second oxalic acid contact to the concentration in the first contact should be ~ 0.25 . However, since the solutions were decanted to the level of the settled solids during the leaching test, sometimes less and sometimes more than 50 mL of solution was left behind. Therefore, assuming the volume left after decanting was between 35-65 mL, a ratio of between ~ 0.2 to ~ 0.3 indicates simple dilution between oxalic acid contacts. A value larger than ~ 0.3 indicates that material is still dissolving between each solution contact. A value smaller than ~ 0.2 for the ratio of concentrations between oxalic acid contacts may indicate precipitation of the analyte from solution. The values in the tables are nearly all above 0.3 indicating continued dissolution of the analyte with each oxalic acid contact.

Completing a clean separation of the liquid from the solids during the oxalic acid leaching tests proved difficult due to the presence of fine particulates that did not settle within a 24 hour period. One of the samples (HTF-16-S-2) showed the formation of a gel in the bottom of the bottle on the first oxalic acid contact. All of the samples showed gel formation in the 2nd and 3rd oxalic acid contacts. All of the decanted solutions required filtration to remove the fines. The amount of material removed by filtration was miniscule, barely coating the surface of the filter. Figures 3-1 through 3-5 show the appearance of the solids after oxalic acid leaching (beaker dimensions, 3 7/8” tall, 2” wide at base, 2 1/4” wide at top). The solids were difficult to filter and formed gummy clumps on the filter. After drying, the solids appear swollen relative to the water leached solids and formed large clumps.

3.4 Oxalic Acid Leached Solids Results

Tables 3-10 through 3-13 show the analytical results of the oxalic acid leached solids for the four samples. The results show Si, Na, Al, and Fe remain as the most abundant elements in all four samples after leaching. The heterogeneous nature of the material and difficulties in sub-sampling the solids may contribute to the higher %RSD's found in some of the results. For both digestion methods the results of the glass standards show close agreement with the expected concentrations and the reagent blanks show little contamination (see Table A-2).

Table 3-14 shows a summary of the results from the XRD analysis and the estimated percentages of each crystalline mineral phase present in the samples. Figures 3-6 through 3-13 show the individual spectra for each sample in duplicate. All four samples after oxalic acid leaching show the presence of quartz (SiO_2) and/or sodium aluminum nitrate silicate hydrate ($\text{Na}_8(\text{Al}_6\text{Si}_6\text{O}_{24})(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$) crystalline phases except for HTF-16S2 that still contains some gibbsite ($\text{Al}(\text{OH})_3$). These results agree well with the chemical analysis of the remaining solids after oxalic acid leaching.

**Table 3-2. Composition of the Water Leached Solids from Tank 16H Annulus
Sample HTF-16-E-2**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Ag (IE)	<1.03E+02	<1.03E+02	<9.97E+02	<1.04E+03	<1.03E+02	-
Al (IE)	8.21E+04	1.05E+05	9.79E+04	1.04E+05	9.73E+04	11%
B (IE)	<1.45E+01	<1.45E+01	<1.40E+02	<1.46E+02	<1.45E+01	-
Ba (IE)	6.73E+01	7.18E+01	7.82E+01	8.48E+01	7.55E+01	10%
Be (IE)	<4.30E-01	<4.30E-01	<5.54E+00	<5.80E+00	<4.30E-01	-
Ca (IE)	1.70E+04	1.44E+04	1.75E+04	1.61E+04	1.57E+04	12%
Cd (IE)	3.80E+00	3.51E+00	<2.15E+01	<2.25E+01	3.66E+00	5.6%
Ce (IE)	5.93E+01	5.97E+01	<4.89E+02	<5.12E+02	5.95E+01	0.5%
Co (IE)	<6.95E+00	<6.95E+00	<6.71E+01	<7.03E+01	<6.95E+00	-
Cr (IE)	4.51E+02	4.34E+02	5.05E+02	6.83E+02	5.18E+02	22%
Cu (IE)	1.36E+02	1.24E+02	1.43E+02	1.53E+02	1.39E+02	8.8%
Fe (IE)	4.59E+04	2.56E+04	4.36E+04	3.20E+04	3.68E+04	26%
Gd (IE)	<1.54E+01	<1.54E+01	<1.49E+02	<1.56E+02	<1.54E+01	-
K (IE)	1.28E+03	1.54E+03	2.91E+03	4.20E+03	1.41E+03	13%
La (IE)	2.42E+01	2.78E+01	<4.64E+01	<4.86E+01	2.60E+01	9.8%
Li (IE)	<1.05E+01	<1.05E+01	<1.01E+02	<1.06E+02	<1.05E+01	-
Mg (IE)	1.13E+03	9.03E+02	1.83E+03	1.75E+03	1.40E+03	33%
Mn (IE)	3.31E+02	2.38E+02	3.56E+02	3.35E+02	3.15E+02	17%
Mo (IE)	<4.42E+01	<4.42E+01	<1.85E+02	<1.94E+02	<4.42E+01	-
Na (IE)	8.50E+04	1.05E+05	-	-	9.50E+04	15%
Ni (IE)	7.19E+01	6.00E+01	<3.15E+02	<3.30E+02	6.60E+01	13%
P (IE)	1.08E+02	1.04E+02	<5.99E+02	<6.28E+02	1.06E+02	2.7%
Pb (IE)	3.53E+02	3.71E+02	<4.96E+02	<5.19E+02	3.62E+02	3.5%
S (IE)	5.56E+02	<5.38E+02	<5.19E+03	<5.43E+03	5.56E+02	-
Sb (IE)	<9.15E+01	<9.15E+01	<7.38E+02	<7.72E+02	<9.15E+01	-
Si (IE)	-	-	2.04E+05	2.17E+05	2.11E+05	4.4%
Sn (IE)	<4.02E+01	<4.02E+01	<3.88E+02	<4.07E+02	<4.02E+01	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

Table 3-2. Composition of the Water Leached Solids from Tank 16H Annulus Sample HTF-16-E-2 (continued)

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Sr (IE)	5.30E+01	5.22E+01	<i>8.03E+01</i>	<i>8.15E+01</i>	5.26E+01	1.1%
Th (IE)	<3.84E+01	<3.84E+01	< <i>3.79E+02</i>	< <i>3.97E+02</i>	<3.84E+01	-
Ti (IE)	<i>1.05E+02</i>	<i>8.40E+01</i>	1.67E+02	2.00E+02	1.84E+02	13%
U (IE)	7.24E+02	6.21E+02	< <i>2.26E+03</i>	< <i>2.37E+03</i>	6.73E+02	11%
V (IE)	<3.37E+00	<3.37E+00	< <i>3.25E+01</i>	< <i>3.41E+01</i>	<3.37E+00	-
Zn (IE)	7.04E+02	7.53E+02	8.53E+02	1.00E+03	8.28E+02	16%
Zr (IE)	5.22E+01	5.71E+01	-	-	5.47E+01	6.3%
Hg (CV)	1.91E+03	1.78E+03	-	-	1.85E+03	5.0%
²³² Th (IM)	2.45E+00	1.77E+00	2.53E+00	2.88E+00	2.41E+00	19%
²³³ U (IM)	<8.91E-01	<8.96E-01	<8.65E-01	<9.06E-01	<8.89E-01	-
²³⁴ U (IM)	<8.91E-01	<8.96E-01	<8.65E-01	<9.06E-01	<8.89E-01	-
²³⁵ U (IM)	5.75E+00	6.49E+00	7.44E+00	6.75E+00	6.61E+00	11%
²³⁶ U (IM)	9.65E-01	9.25E-01	<1.73E+00	<1.81E+00	9.45E-01	3.0%
²³⁸ U (IM)	1.44E+02	1.56E+02	1.84E+02	1.91E+02	1.69E+02	13%
U-total (IM)	1.50E+02	1.63E+02	1.91E+02	1.98E+02	1.76E+02	13%
⁹⁰ Sr (BS)	3.70E+00	4.52E+00	4.81E+00	5.73E+00	4.69E+00	18%
¹³⁷ Cs (GS)	<8.91E-01	<8.96E-01	<1.73E+00	<1.81E+00	<1.33E+00	-
²³⁸ Pu (SA)	3.70E+00	4.52E+00	4.81E+00	5.73E+00	4.69E+00	18%
⁹⁹ Tc (IM)	7.97E+00	8.78E+00	1.01E+01	1.11E+01	9.48E+00	15%
²³⁷ Np (IM)	2.68E+00	2.89E+00	3.68E+00	2.75E+00	3.00E+00	15%
²³⁹ Pu (IM)	3.70E+00	4.52E+00	4.81E+00	5.73E+00	4.69E+00	18%
²⁴⁰ Pu (IM)	<8.91E-01	<8.96E-01	<1.73E+00	<1.81E+00	<1.33E+00	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-2. Composition of the Water Leached Solids from Tank 16H Annulus
Sample HTF-16-E-2 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (dpm/g)	Aqua Regia Replicate 2 (dpm/g)	Per Fusion Replicate 1 (dpm/g)	Per Fusion Replicate 2 (dpm/g)	Average (dpm/g)	%RSD
⁹⁰ Sr (BS)	1.29E+09	1.40E+09	1.27E+09	1.55E+09	1.38E+09	9.3%
¹³⁷ Cs (GS)	2.22E+09	2.45E+09	2.72E+09	2.52E+09	2.48E+09	8.3%
²³⁸ Pu (SA)	4.57E+06	4.81E+06	4.70E+06	6.16E+06	5.06E+06	15%
^{239/240} Pu (SA)	8.08E+05	7.81E+05	7.96E+05	1.08E+06	8.66E+05	16%
⁹⁹ Tc (IM)	3.00E+05	3.31E+05	3.79E+05	4.19E+05	3.57E+05	15%
²³² Th (IM)	5.99E-01	4.32E-01	6.17E-01	7.04E-01	5.88E-01	19%
²³³ U (IM)	<1.91E+04	<1.92E+04	<1.85E+04	<1.94E+04	<1.90E+04	-
²³⁴ U (IM)	<1.24E+04	<1.25E+04	<1.20E+04	<1.26E+04	<1.24E+04	-
²³⁵ U (IM)	2.76E+01	3.11E+01	3.57E+01	3.24E+01	3.17E+01	11%
²³⁶ U (IM)	1.39E+02	1.33E+02	<2.48E+02	<2.60E+02	1.36E+02	3.0%
²³⁷ Np (IM)	4.20E+03	4.51E+03	5.75E+03	4.30E+03	4.69E+03	15%
²³⁸ U (IM)	1.07E+02	1.16E+02	1.37E+02	1.43E+02	1.26E+02	13%
²³⁹ Pu (IM)	5.04E+05	6.16E+05	6.54E+05	7.80E+05	6.38E+05	18%
²⁴⁰ Pu (IM)	<4.46E+05	<4.49E+05	<8.66E+05	<9.07E+05	<6.67E+05	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-3. Composition of the Water Leached Solids from Tank 16H Annulus
Sample HTF-16-N-1**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Ag (IE)	<1.03E+02	<1.07E+02	<1.10E+03	<1.10E+03	<1.05E+02	-
Al (IE)	1.13E+05	1.08E+05	9.86E+04	5.90E+04	9.47E+04	26%
B (IE)	<1.45E+01	<1.50E+01	<1.55E+02	<1.55E+02	<1.48E+01	-
Ba (IE)	4.81E+01	3.10E+01	<3.98E+01	<3.98E+01	3.96E+01	31%
Be (IE)	<4.30E-01	<4.46E-01	<6.13E+00	<6.13E+00	<4.38E-01	-
Ca (IE)	2.70E+03	1.63E+03	5.83E+03	3.33E+03	2.17E+03	35%
Cd (IE)	<2.22E+00	<2.30E+00	<2.38E+01	<2.38E+01	<2.26E+00	-
Ce (IE)	<5.07E+01	<5.26E+01	<5.42E+02	<5.42E+02	<5.17E+01	-
Co (IE)	<6.95E+00	<7.21E+00	<7.43E+01	<7.43E+01	<7.08E+00	-
Cr (IE)	5.89E+01	4.39E+01	9.66E+01	8.70E+01	7.16E+01	34%
Cu (IE)	1.11E+02	8.89E+01	1.27E+02	7.89E+01	1.01E+02	21%
Fe (IE)	7.32E+03	9.87E+03	1.31E+04	1.09E+03	7.85E+03	65%
Gd (IE)	<1.54E+01	<1.60E+01	<1.65E+02	<1.65E+02	<1.57E+01	-
K (IE)	4.69E+02	2.80E+02	3.84E+03	3.14E+03	3.75E+02	36%
La (IE)	1.34E+01	7.06E+00	<5.13E+01	<5.13E+01	1.02E+01	44%
Li (IE)	<1.05E+01	<1.09E+01	<1.12E+02	<1.12E+02	<1.07E+01	-
Mg (IE)	7.12E+02	1.17E+02	5.15E+02	5.52E+02	4.74E+02	53%
Mn (IE)	7.89E+01	7.22E+01	1.03E+02	<1.61E+01	8.47E+01	19%
Mo (IE)	<4.42E+01	<4.59E+01	<2.05E+02	<2.05E+02	<4.51E+01	-
Na (IE)	1.11E+05	1.05E+05	-	-	1.08E+05	3.9%
Ni (IE)	<3.26E+01	<3.38E+01	<3.49E+02	<3.49E+02	<3.32E+01	-
P (IE)	<6.21E+01	<6.44E+01	<6.64E+02	<6.64E+02	<6.33E+01	-
Pb (IE)	3.76E+02	2.55E+02	<5.49E+02	<5.49E+02	3.16E+02	27%
S (IE)	<5.38E+02	<5.58E+02	<5.75E+03	<5.75E+03	<5.48E+02	-
Sb (IE)	<9.15E+01	<9.49E+01	<8.17E+02	<8.17E+02	<9.32E+01	-
Si (IE)	-	-	2.62E+05	2.39E+05	2.51E+05	6.5%
Sn (IE)	<4.02E+01	<4.17E+01	<4.30E+02	<4.30E+02	<4.10E+01	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-3. Composition of the Water Leached Solids from Tank 16H Annulus
Sample HTF-16-N-1 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Sr (IE)	9.96E+00	6.84E+00	<i>3.99E+01</i>	<i>3.38E+01</i>	8.40E+00	26%
Th (IE)	<3.84E+01	<3.98E+01	< <i>4.20E+02</i>	< <i>4.20E+02</i>	<3.91E+01	-
Ti (IE)	<i>9.41E+01</i>	<i>3.29E+01</i>	2.95E+02	3.15E+02	3.05E+02	4.6%
U (IE)	<2.34E+02	<2.43E+02	< <i>2.50E+03</i>	< <i>2.50E+03</i>	<2.39E+02	-
V (IE)	6.59E+00	<3.49E+00	<3.60E+01	<3.60E+01	6.59E+00	-
Zn (IE)	6.89E+02	6.98E+02	7.74E+02	1.65E+03	9.53E+02	49%
Zr (IE)	3.56E+01	1.46E+01	-	-	2.51E+01	59%
Hg (CV)	1.03E+03	4.27E+02	-	-	7.29E+02	59%
²³² Th (IM)	1.39E+00	9.29E-01	1.71E+00	1.53E+00	1.39E+00	24%
²³³ U (IM)	<8.96E-01	<9.29E-01	<9.58E-01	<9.58E-01	<9.35E-01	-
²³⁴ U (IM)	<8.96E-01	<9.29E-01	<9.58E-01	<9.58E-01	<9.35E-01	-
²³⁵ U (IM)	2.50E+00	<1.39E+00	1.44E+00	1.79E+00	1.91E+00	28%
²³⁶ U (IM)	<8.96E-01	<9.29E-01	<1.92E+00	<1.92E+00	<1.41E+00	-
²³⁸ U (IM)	4.88E+01	2.04E+01	1.49E+01	2.96E+01	2.84E+01	52%
U-total (IM)	5.13E+01	2.18E+01	1.63E+01	3.13E+01	3.02E+01	51%
⁹⁰ Sr (BS)	1.47E+00	7.98E-01	9.20E-01	3.14E-01	8.75E-01	54%
¹³⁷ Cs (GS)	1.80E+01	1.98E+01	1.46E+01	1.03E+01	1.57E+01	27%
²³⁸ Pu (SA)	4.89E-02	2.50E-02	3.03E-02	1.35E-02	2.94E-02	50%
⁹⁹ Tc (IM)	7.96E+00	4.66E+00	2.44E+00	5.46E+00	5.13E+00	44%
²³⁷ Np (IM)	<8.96E-01	<9.29E-01	<2.39E+00	<2.39E+00	<1.65E+00	-
²³⁹ Pu (IM)	1.90E+00	<1.86E+00	<9.58E-01	<9.58E-01	<1.42E+00	-
²⁴⁰ Pu (IM)	<8.96E-01	<9.29E-01	<1.92E+00	<1.92E+00	<1.41E+00	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-3. Composition of the Water Leached Solids from Tank 16H Annulus
Sample HTF-16-N-1 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (dpm/g)	Aqua Regia Replicate 2 (dpm/g)	Per Fusion Replicate 1 (dpm/g)	Per Fusion Replicate 2 (dpm/g)	Average (dpm/g)	%RSD
⁹⁰ Sr (BS)	4.46E+08	2.43E+08	2.80E+08	9.57E+07	2.66E+08	54%
¹³⁷ Cs (GS)	3.47E+09	3.81E+09	2.82E+09	1.98E+09	3.02E+09	27%
²³⁸ Pu (SA)	1.86E+06	9.52E+05	1.15E+06	5.14E+05	1.12E+06	50%
^{239/240} Pu (SA)	3.09E+05	1.50E+05	1.58E+05	7.94E+04	1.74E+05	55%
⁹⁹ Tc (IM)	3.00E+05	1.76E+05	9.18E+04	2.06E+05	1.93E+05	44%
²³² Th (IM)	3.38E-01	2.27E-01	4.18E-01	3.74E-01	3.39E-01	24%
²³³ U (IM)	<1.92E+04	<1.99E+04	<2.05E+04	<2.05E+04	<2.00E+04	-
²³⁴ U (IM)	<1.25E+04	<1.29E+04	<1.33E+04	<1.33E+04	<1.30E+04	-
²³⁵ U (IM)	1.20E+01	<6.68E+00	6.90E+00	8.56E+00	9.15E+00	28%
²³⁶ U (IM)	<1.29E+02	<1.33E+02	<2.75E+02	<2.75E+02	<2.03E+02	-
²³⁷ Np (IM)	<1.40E+03	<1.45E+03	<3.75E+03	<3.75E+03	<2.59E+03	-
²³⁸ U (IM)	3.64E+01	1.52E+01	1.11E+01	2.20E+01	2.12E+01	52%
²³⁹ Pu (IM)	2.59E+05	<2.53E+05	<1.30E+05	<1.30E+05	<1.93E+05	-
²⁴⁰ Pu (IM)	<4.49E+05	<4.65E+05	<9.59E+05	<9.59E+05	<7.08E+05	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-4. Composition of the Water Leached Solids from Tank 16H Annulus
Sample HTF-16-S-2**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Ag (IE)	<1.11E+02	<1.14E+02	<1.19E+03	<1.06E+03	<1.13E+02	-
Al (IE)	7.71E+04	8.75E+04	9.14E+04	6.61E+04	8.05E+04	14%
B (IE)	<1.55E+01	<1.60E+01	<1.66E+02	<1.49E+02	<1.58E+01	-
Ba (IE)	9.41E+01	1.68E+02	1.30E+02	1.23E+02	1.29E+02	24%
Be (IE)	<4.62E-01	<4.74E-01	<6.58E+00	<5.90E+00	<4.68E-01	-
Ca (IE)	2.60E+03	4.74E+03	6.44E+03	5.87E+03	3.67E+03	41%
Cd (IE)	4.31E+00	6.32E+00	<2.55E+01	<2.29E+01	5.32E+00	27%
Ce (IE)	8.20E+01	2.08E+02	<5.82E+02	<5.22E+02	1.45E+02	61%
Co (IE)	8.77E+00	1.06E+01	<7.98E+01	<7.16E+01	9.69E+00	13%
Cr (IE)	1.77E+02	2.70E+02	2.98E+02	1.71E+02	2.29E+02	28%
Cu (IE)	2.61E+02	4.40E+02	3.93E+02	1.81E+02	3.19E+02	37%
Fe (IE)	3.19E+04	2.70E+04	2.92E+04	2.53E+04	2.84E+04	10%
Gd (IE)	<1.65E+01	<1.70E+01	<1.77E+02	<1.59E+02	<1.68E+01	-
K (IE)	5.88E+02	6.13E+02	4.44E+03	3.75E+03	6.01E+02	2.9%
La (IE)	3.08E+01	8.43E+01	5.84E+01	<4.94E+01	5.78E+01	46%
Li (IE)	<1.12E+01	<1.52E+01	<1.20E+02	<1.08E+02	<1.52E+01	-
Mg (IE)	8.73E+03	6.94E+03	4.30E+03	9.00E+03	7.24E+03	30%
Mn (IE)	3.16E+02	3.05E+02	2.80E+02	2.14E+02	2.79E+02	16%
Mo (IE)	<4.75E+01	<4.88E+01	<2.21E+02	<1.98E+02	<4.82E+01	-
Na (IE)	6.57E+04	8.06E+04	-	-	7.32E+04	14%
Ni (IE)	1.11E+02	1.55E+02	<3.74E+02	<3.36E+02	1.33E+02	23%
P (IE)	8.42E+01	1.21E+02	<7.13E+02	<6.39E+02	1.03E+02	25%
Pb (IE)	8.18E+02	7.34E+02	8.38E+02	2.41E+03	1.20E+03	67%
S (IE)	1.20E+03	6.70E+02	<6.17E+03	<5.54E+03	9.35E+02	40%
Sb (IE)	<9.82E+01	<1.01E+02	<8.77E+02	<7.87E+02	<9.96E+01	-
Si (IE)	-	-	2.28E+05	1.83E+05	2.06E+05	15%
Sn (IE)	<4.32E+01	<4.43E+01	<4.62E+02	<4.14E+02	<4.38E+01	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-4. Composition of the Water Leached Solids from Tank 16H Annulus
Sample HTF-16-S-2 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Sr (IE)	3.62E+01	6.96E+01	<i>8.56E+01</i>	<i>6.57E+01</i>	5.29E+01	45%
Th (IE)	<4.12E+01	<4.23E+01	<i><4.51E+02</i>	<i><4.04E+02</i>	<4.18E+01	-
Ti (IE)	<i>9.54E+01</i>	<i>1.52E+02</i>	2.00E+02	1.51E+02	1.76E+02	20%
U (IE)	<i><2.51E+02</i>	4.72E+02	<i><2.69E+03</i>	<i><2.41E+03</i>	4.72E+02	-
V (IE)	3.49E+01	1.07E+01	<i><3.87E+01</i>	<i><3.47E+01</i>	2.28E+01	75%
Zn (IE)	4.20E+02	5.44E+02	6.71E+02	5.78E+02	5.53E+02	19%
Zr (IE)	9.89E+01	2.54E+02	-	-	1.76E+02	62%
Hg (CV)	2.47E+03	2.92E+03	-	-	2.70E+03	12%
²³² Th (IM)	1.58E+00	3.25E+00	2.92E+00	2.42E+00	2.54E+00	29%
²³³ U (IM)	<9.62E-01	<9.88E-01	<1.03E+00	<9.23E-01	<9.75E-01	-
²³⁴ U (IM)	<9.62E-01	<9.88E-01	<1.03E+00	<9.23E-01	<9.75E-01	-
²³⁵ U (IM)	4.33E+00	1.05E+01	8.76E+00	6.61E+00	7.55E+00	35%
²³⁶ U (IM)	<9.62E-01	<9.88E-01	<2.06E+00	<1.85E+00	<1.46E+00	-
²³⁸ U (IM)	9.51E+01	2.57E+02	2.24E+02	1.53E+02	1.82E+02	40%
U-total (IM)	9.94E+01	2.67E+02	2.33E+02	1.59E+02	1.90E+02	40%
⁹⁰ Sr (BS)	4.76E+00	1.06E+01	8.31E+00	5.88E+00	7.39E+00	35%
¹³⁷ Cs (GS)	1.43E+01	1.55E+01	1.43E+01	1.24E+01	1.41E+01	9.1%
²³⁸ Pu (SA)	7.08E-02	1.75E-01	1.24E-01	9.74E-02	1.17E-01	38%
⁹⁹ Tc (IM)	1.32E+01	1.88E+01	2.01E+01	1.29E+01	1.63E+01	23%
²³⁷ Np (IM)	1.56E+00	3.71E+00	3.03E+00	<2.31E+00	2.76E+00	40%
²³⁹ Pu (IM)	2.81E+00	5.44E+00	4.61E+00	3.55E+00	4.11E+00	28%
²⁴⁰ Pu (IM)	<9.62E-01	<9.88E-01	<2.06E+00	<1.85E+00	<1.46E+00	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-4. Composition of the Water Leached Solids from Tank 16H Annulus
Sample HTF-16-S-2 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (dpm/g)	Aqua Regia Replicate 2 (dpm/g)	Per Fusion Replicate 1 (dpm/g)	Per Fusion Replicate 2 (dpm/g)	Average (dpm/g)	%RSD
⁹⁰ Sr (BS)	1.45E+09	3.23E+09	2.53E+09	1.79E+09	2.25E+09	35%
¹³⁷ Cs (GS)	2.75E+09	2.99E+09	2.76E+09	2.39E+09	2.72E+09	9.1%
²³⁸ Pu (SA)	2.69E+06	6.66E+06	4.71E+06	3.70E+06	4.44E+06	38%
^{239/240} Pu (SA)	4.38E+05	1.16E+06	8.11E+05	6.69E+05	7.70E+05	39%
⁹⁹ Tc (IM)	4.97E+05	7.08E+05	7.58E+05	4.86E+05	6.13E+05	23%
²³² Th (IM)	3.86E-01	7.93E-01	7.13E-01	5.91E-01	6.21E-01	29%
²³³ U (IM)	<2.06E+04	<2.12E+04	<2.20E+04	<1.98E+04	<2.09E+04	-
²³⁴ U (IM)	<1.34E+04	<1.37E+04	<1.43E+04	<1.28E+04	<1.36E+04	-
²³⁵ U (IM)	2.08E+01	5.03E+01	4.20E+01	3.17E+01	3.62E+01	35%
²³⁶ U (IM)	<1.38E+02	<1.42E+02	<2.95E+02	<2.65E+02	<2.10E+02	
²³⁷ Np (IM)	2.43E+03	5.80E+03	4.74E+03	<3.61E+03	4.33E+03	40%
²³⁸ U (IM)	7.09E+01	1.92E+02	1.67E+02	1.14E+02	1.36E+02	40%
²³⁹ Pu (IM)	3.83E+05	7.41E+05	6.28E+05	4.84E+05	5.59E+05	28%
²⁴⁰ Pu (IM)	<4.82E+05	<4.95E+05	<1.03E+06	<9.24E+05	<7.33E+05	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-5. Composition of the Water Leached Solids from Tank 16H Annulus
Sample HTF-16-W-1**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Ag (IE)	<1.12E+02	<9.90E+01	<9.47E+02	<9.57E+02	<1.06E+02	-
Al (IE)	1.26E+05	1.04E+05	1.39E+05	1.24E+05	1.23E+05	12%
B (IE)	<1.57E+01	<1.39E+01	<1.33E+02	<1.34E+02	<1.48E+01	-
Ba (IE)	1.54E+02	1.46E+02	1.29E+02	1.25E+02	1.39E+02	10%
Be (IE)	<4.65E-01	<4.12E-01	<5.26E+00	<5.32E+00	<4.39E-01	-
Ca (IE)	1.41E+03	2.23E+04	3.14E+03	3.74E+03	1.19E+04	125%
Cd (IE)	5.58E+00	4.74E+00	<2.04E+01	<2.06E+01	5.16E+00	12%
Ce (IE)	2.23E+02	2.25E+02	<4.65E+02	<4.70E+02	2.24E+02	0.6%
Co (IE)	<7.52E+00	<6.67E+00	<6.38E+01	<6.45E+01	<7.10E+00	-
Cr (IE)	1.38E+02	2.04E+02	9.77E+01	1.07E+02	1.37E+02	35%
Cu (IE)	1.54E+02	1.29E+02	1.11E+02	1.20E+02	1.29E+02	14%
Fe (IE)	3.48E+04	2.76E+04	1.55E+04	2.04E+04	2.46E+04	34%
Gd (IE)	<1.67E+01	<1.48E+01	<1.41E+02	<1.43E+02	<1.58E+01	-
K (IE)	8.58E+02	7.23E+02	4.16E+03	3.77E+03	7.91E+02	12%
La (IE)	8.97E+01	8.82E+01	7.17E+01	7.51E+01	8.12E+01	11%
Li (IE)	<1.13E+01	<1.00E+01	<9.61E+01	<9.70E+01	<1.07E+01	-
Mg (IE)	2.80E+02	6.95E+03	2.38E+02	2.68E+02	1.93E+03	173%
Mn (IE)	2.88E+02	3.08E+02	2.00E+02	2.11E+02	2.52E+02	22%
Mo (IE)	<4.78E+01	<4.24E+01	<1.76E+02	<1.78E+02	<4.51E+01	-
Na (IE)	1.32E+05	1.10E+05	-	-	1.21E+05	13%
Ni (IE)	1.49E+02	1.82E+02	<2.99E+02	<3.02E+02	1.66E+02	14%
P (IE)	<6.71E+01	<5.95E+01	<5.70E+02	<5.75E+02	<6.33E+01	-
Pb (IE)	7.37E+02	5.99E+02	6.55E+02	5.48E+02	6.35E+02	13%
S (IE)	<5.81E+02	<5.15E+02	<4.93E+03	<4.98E+03	<5.48E+02	-
Sb (IE)	<9.90E+01	<8.78E+01	<7.01E+02	<7.08E+02	<9.34E+01	-
Si (IE)	-	-	1.74E+05	1.75E+05	1.75E+05	0.4%
Sn (IE)	<4.35E+01	<3.86E+01	<3.69E+02	<3.73E+02	<4.11E+01	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

Table 3-5. Composition of the Water Leached Solids from Tank 16H Annulus Sample HTF-16-W-1 (continued)

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Sr (IE)	5.36E+01	5.40E+01	<i>7.14E+01</i>	<i>7.08E+01</i>	5.38E+01	0.5%
Th (IE)	<4.15E+01	<3.68E+01	<i><3.61E+02</i>	<i><3.64E+02</i>	<3.92E+01	-
Ti (IE)	<i>4.77E+01</i>	<i>8.12E+01</i>	7.43E+01	7.22E+02	3.98E+02	115%
U (IE)	3.39E+02	1.08E+03	<i><2.15E+03</i>	<i><2.17E+03</i>	7.10E+02	74%
V (IE)	<3.64E+00	<3.23E+00	<i><3.09E+01</i>	<i><3.12E+01</i>	<3.44E+00	-
Zn (IE)	4.43E+02	2.92E+02	3.30E+02	4.33E+02	3.75E+02	20%
Zr (IE)	2.65E+02	2.58E+02	-	-	2.62E+02	1.9%
Hg (CV)	2.69E+03	2.37E+03	-	-	2.53E+03	9%
²³² Th (IM)	1.55E+00	1.61E+00	1.99E+00	1.44E+00	1.65E+00	15%
²³³ U (IM)	<9.69E-01	<8.59E-01	<8.22E-01	<8.31E-01	<8.70E-01	-
²³⁴ U (IM)	<9.69E-01	<8.59E-01	<8.22E-01	<8.31E-01	<8.70E-01	-
²³⁵ U (IM)	1.07E+01	9.85E+00	1.21E+01	1.05E+01	1.08E+01	8.8%
²³⁶ U (IM)	<9.69E-01	<1.43E+00	<1.64E+00	<1.66E+00	<1.43E+00	-
²³⁸ U (IM)	2.67E+02	2.69E+02	3.04E+02	2.72E+02	2.78E+02	6.3%
U-total (IM)	2.77E+02	2.78E+02	3.16E+02	2.83E+02	2.89E+02	6.4%
⁹⁰ Sr (BS)	6.47E+00	8.31E+00	6.70E+00	8.12E+00	7.40E+00	13%
¹³⁷ Cs (GS)	2.13E+01	1.79E+01	2.37E+01	2.18E+01	2.11E+01	11%
²³⁸ Pu (SA)	1.71E-01	1.81E-01	1.63E-01	1.54E-01	1.67E-01	6.9%
⁹⁹ Tc (IM)	2.46E+01	2.18E+01	2.46E+01	2.24E+01	2.33E+01	6.3%
²³⁷ Np (IM)	2.82E+00	2.95E+00	3.75E+00	3.58E+00	3.27E+00	14%
²³⁹ Pu (IM)	6.39E+00	6.66E+00	6.88E+00	6.56E+00	6.62E+00	3.1%
²⁴⁰ Pu (IM)	<9.69E-01	<8.59E-01	<1.64E+00	<1.66E+00	<1.28E+00	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-5. Composition of the Water Leached Solids from Tank 16H Annulus
Sample HTF-16-W-1 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (dpm/g)	Aqua Regia Replicate 2 (dpm/g)	Per Fusion Replicate 1 (dpm/g)	Per Fusion Replicate 2 (dpm/g)	Average (dpm/g)	%RSD
⁹⁰ Sr (BS)	1.97E+09	2.53E+09	2.04E+09	2.47E+09	2.25E+09	13%
¹³⁷ Cs (GS)	4.10E+09	3.44E+09	4.56E+09	4.19E+09	4.07E+09	11%
²³⁸ Pu (SA)	6.50E+06	6.88E+06	6.21E+06	5.85E+06	6.36E+06	6.9%
^{239/240} Pu (SA)	1.23E+06	1.28E+06	1.15E+06	1.03E+06	1.17E+06	9.3%
⁹⁹ Tc (IM)	9.25E+05	8.22E+05	9.28E+05	8.42E+05	8.79E+05	6.3%
²³² Th (IM)	3.78E-01	3.94E-01	4.87E-01	3.50E-01	4.02E-01	15%
²³³ U (IM)	<2.08E+04	<1.84E+04	<1.76E+04	<1.78E+04	<1.86E+04	-
²³⁴ U (IM)	<1.35E+04	<1.19E+04	<1.14E+04	<1.15E+04	<1.21E+04	-
²³⁵ U (IM)	5.14E+01	4.72E+01	5.81E+01	5.04E+01	5.18E+01	8.8%
²³⁶ U (IM)	<1.39E+02	<2.05E+02	<2.36E+02	<2.38E+02	<2.05E+02	-
²³⁷ Np (IM)	4.41E+03	4.62E+03	5.87E+03	5.60E+03	5.12E+03	14%
²³⁸ U (IM)	1.99E+02	2.00E+02	2.27E+02	2.03E+02	2.07E+02	6.3%
²³⁹ Pu (IM)	8.70E+05	9.06E+05	9.37E+05	8.93E+05	9.02E+05	3.1%
²⁴⁰ Pu (IM)	<4.85E+05	<4.30E+05	<8.24E+05	<8.32E+05	<6.43E+05	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-6. Composition of the Oxalic Acid Leachates from Tank 16H Annulus
Sample HTF-16-E-2 from Three Leaching Cycles**

Analyte (Method)	Decant 1 (mg/L)	Decant 2 (mg/L)	Decant 3 (mg/L)	<u>Decant 2</u> Decant 1	<u>Decant 3</u> Decant 2
F ⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
CH ₂ O ⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
Cl ⁻ (IC)	4.17E+02	1.75E+02	<1.00E+02	0.42	-
NO ₂ ⁻ (IC)	5.60E+03	<1.00E+02	<1.00E+02	-	-
Br ⁻ (IC)	<1.00E+03	<1.00E+03	<1.00E+03	-	-
NO ₃ ⁻ (IC)	1.24E+04	9.68E+03	3.20E+03	0.78	0.33
PO ₄ ³⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
SO ₄ ²⁻ (IC)	<1.20E+03	<1.20E+03	<1.20E+03	-	-
C ₂ O ₄ ²⁻ (IC)	3.89E+04	3.83E+04	3.67E+04	0.98	0.96
Ag (IE)	<1.46E+00	<1.46E+00	<1.46E+00	-	-
Al (IE)	4.27E+03	4.39E+03	2.16E+03	1.03	0.49
B (IE)	<2.02E+00	<2.02E+00	<2.02E+00	-	-
Ba (IE)	1.50E+00	2.44E+00	2.35E+00	1.63	0.96
Be (IE)	<6.00E-02	<6.00E-02	<6.00E-02	-	-
Ca (IE)	3.52E+01	6.08E+01	4.65E+01	1.73	0.76
Cd (IE)	<6.40E-01	<6.40E-01	<6.40E-01	-	-
Ce (IE)	<7.07E+00	<7.07E+00	<7.07E+00	-	-
Co (IE)	<9.70E-01	<9.70E-01	<9.70E-01	-	-
Cr (IE)	1.48E+01	2.73E+01	1.97E+01	1.84	0.72
Cu (IE)	8.59E+00	8.57E+00	4.66E+00	1.00	0.54
Fe (IE)	1.38E+02	1.87E+02	3.97E+02	1.36	2.12
Gd (IE)	<7.80E-01	<7.80E-01	<7.80E-01	-	-
K (IE)	1.64E+02	1.40E+02	7.41E+01	0.85	0.53
La (IE)	<6.70E-01	<6.70E-01	<6.70E-01	-	-
Li (IE)	1.77E+00	<1.46E+00	<1.46E+00	-	-
Mg (IE)	3.41E+01	3.94E+01	3.02E+01	1.16	0.77
Mn (IE)	5.50E+00	6.64E+00	5.70E+00	1.21	0.86
Mo (IE)	<6.17E+00	<6.17E+00	<6.17E+00	-	-

**Table 3-6. Composition of the Oxalic Acid Leachates from Tank 16H Annulus
Sample HTF-16-E-2 from Three Leaching Cycles (continued)**

Analyte (Method)	Decant 1 (mg/L)	Decant 2 (mg/L)	Decant 3 (mg/L)	<u>Decant 2</u> Decant 1	<u>Decant 3</u> Decant 2
Na (IE)	1.71E+04	1.19E+04	5.69E+03	0.70	0.48
Ni (IE)	<4.55E+00	<4.55E+00	<4.55E+00	-	-
P (IE)	<8.66E+00	<8.66E+00	<8.66E+00	-	-
Pb (IE)	<7.16E+00	<7.16E+00	<7.16E+00	-	-
S (IE)	3.33E+02	2.04E+02	1.18E+02	0.61	0.58
Sb (IE)	<1.07E+01	<1.07E+01	<1.07E+01	-	-
Si (IE)	9.39E+01	5.64E+02	2.72E+02	6.01	0.48
Sn (IE)	<5.61E+00	<5.61E+00	<5.61E+00	-	-
Sr (IE)	7.50E-01	6.00E-01	6.20E-01	0.80	1.03
Th (IE)	<2.68E+00	<2.68E+00	<2.68E+00	-	-
Ti (IE)	<1.30E-01	1.60E-01	8.10E-01	-	-
U (IE)	<3.27E+01	<3.27E+01	<3.27E+01	-	-
V (IE)	<4.70E-01	<4.70E-01	<4.70E-01	-	-
Zn (IE)	4.58E+01	4.58E+01	2.39E+01	1.00	0.52
Zr (IE)	8.80E-01	1.36E+00	2.27E+00	1.55	1.67
Hg (CV)	3.37E+01	4.11E+01	2.36E+01	1.22	0.57
²³² Th (IM)	7.50E-02	7.50E-02	3.00E-02	1.00	0.40
²³³ U (IM)	<5.00E-02	<5.00E-02	<2.00E-02	-	-
²³⁴ U (IM)	<5.00E-02	<5.00E-02	<2.00E-02	-	-
²³⁵ U (IM)	1.13E+00	8.58E-01	3.35E-01	0.76	0.39
²³⁶ U (IM)	1.07E-01	8.17E-02	3.65E-02	0.76	0.45
²³⁸ U (IM)	2.97E+01	2.22E+01	8.62E+00	0.75	0.39
U-total (IM)	3.09E+01	2.31E+01	9.00E+00	0.75	0.39
¹³⁷ Cs (GS)	3.17E-01	4.89E-01	4.73E-01	1.54	0.97
⁹⁹ Tc (IM)	9.49E-01	6.19E-01	2.33E-01	0.65	0.38
²³⁷ Np (IM)	1.51E-01	1.48E-01	4.12E-02	0.98	0.28
²³⁹ Pu (IM)	7.18E-02	7.91E-02	5.75E-02	1.10	0.73
²⁴⁰ Pu (IM)	<5.00E-02	<5.00E-02	<2.00E-02	-	-
pH (pH units)	5.06	4.38	1.29	-	-

**Table 3-6. Composition of the Oxalic Acid Leachates from Tank 16H Annulus
Sample HTF-16-E-2 from Three Leaching Cycles (continued)**

Analyte (Method)	Decant 1 (dpm/ml)	Decant 2 (dpm/ml)	Decant 3 (dpm/ml)	<u>Decant 2</u> Decant 1	<u>Decant 3</u> Decant 2
¹³⁷ Cs (GS)	6.10E+07	9.42E+07	9.11E+07	1.54	0.97
⁹⁹ Tc (IM)	3.58E+04	2.33E+04	8.77E+03	0.65	0.38
²³² Th (IM)	1.83E-02	1.83E-02	7.33E-03	1.00	0.40
²³³ U (IM)	<1.07E+03	<1.07E+03	<4.28E+02	-	-
²³⁴ U (IM)	<6.95E+02	<6.95E+02	<2.78E+02	-	-
²³⁵ U (IM)	5.43E+00	4.11E+00	1.61E+00	0.76	0.39
²³⁶ U (IM)	1.53E+01	1.17E+01	5.24E+00	0.76	0.45
²³⁷ Np (IM)	2.36E+02	2.32E+02	6.44E+01	0.98	0.28
²³⁸ U (IM)	2.21E+01	1.66E+01	6.43E+00	0.75	0.39
²³⁹ Pu (IM)	9.77E+03	1.08E+04	7.83E+03	1.10	0.73
²⁴⁰ Pu (IM)	<2.50E+04	<2.50E+04	<1.00E+04	-	-

Table 3-7. Composition of the Oxalic Acid Leachates from Tank 16H Annulus Sample HTF-16-N-1 from Three Leaching Cycles

Analyte (Method)	Decant 1 (mg/L)	Decant 2 (mg/L)	Decant 3 (mg/L)	<u>Decant 2</u> Decant 1	<u>Decant 3</u> Decant 2
F ⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
CH ₂ O ⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
Cl ⁻ (IC)	1.97E+02	<1.00E+02	<1.00E+02	-	-
NO ₂ ⁻ (IC)	1.09E+04	<1.00E+02	<1.00E+02	-	-
Br ⁻ (IC)	<1.00E+03	<1.00E+03	<1.00E+03	-	-
NO ₃ ⁻ (IC)	1.27E+04	8.08E+03	4.56E+03	0.64	0.56
PO ₄ ³⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
SO ₄ ²⁻ (IC)	<1.20E+03	<1.20E+03	<1.20E+03	-	-
C ₂ O ₄ ²⁻ (IC)	3.59E+04	3.46E+04	3.82E+04	0.96	1.10
Ag (IE)	<1.46E+00	<1.46E+00	<1.46E+00	-	-
Al (IE)	3.80E+03	2.94E+03	3.59E+03	0.77	1.22
B (IE)	<2.02E+00	<2.02E+00	<2.02E+00	-	-
Ba (IE)	8.90E-01	1.41E+00	1.82E+00	1.58	1.29
Be (IE)	<6.00E-02	<6.00E-02	<6.00E-02	-	-
Ca (IE)	9.68E+00	2.56E+01	6.67E+01	2.64	2.61
Cd (IE)	<6.40E-01	<6.40E-01	<6.40E-01	-	-
Ce (IE)	<7.07E+00	<7.07E+00	<7.07E+00	-	-
Co (IE)	<9.70E-01	<9.70E-01	<9.70E-01	-	-
Cr (IE)	5.08E+00	7.52E+00	5.67E+00	1.48	0.75
Cu (IE)	3.78E+01	2.74E+01	1.48E+01	0.72	0.54
Fe (IE)	3.40E+01	7.99E+01	1.46E+02	2.35	1.83
Gd (IE)	<7.80E-01	<7.80E-01	<7.80E-01	-	-
K (IE)	1.08E+02	5.28E+01	3.36E+01	0.49	0.64
La (IE)	<6.70E-01	<6.70E-01	<6.70E-01	-	-
Li (IE)	<1.46E+00	<1.46E+00	<1.46E+00	-	-
Mg (IE)	1.78E+01	2.22E+01	3.77E+01	1.25	1.70
Mn (IE)	1.35E+00	1.80E+00	2.31E+00	1.33	1.28
Mo (IE)	<6.17E+00	<6.17E+00	<6.17E+00	-	-

Table 3-7. Composition of the Oxalic Acid Leachates from Tank 16H Annulus Sample HTF-16-N-1 from Three Leaching Cycles (continued)

Analyte (Method)	Decant 1 (mg/L)	Decant 2 (mg/L)	Decant 3 (mg/L)	<u>Decant 2</u> Decant 1	<u>Decant 3</u> Decant 2
Na (IE)	2.30E+04	1.08E+04	7.42E+03	0.47	0.69
Ni (IE)	<4.55E+00	<4.55E+00	<4.55E+00	-	-
P (IE)	<8.66E+00	<8.66E+00	<8.66E+00	-	-
Pb (IE)	<7.16E+00	1.16E+01	1.25E+01	-	-
S (IE)	3.95E+02	1.61E+02	1.10E+02	0.41	0.68
Sb (IE)	<1.07E+01	<1.07E+01	<1.07E+01	-	-
Si (IE)	8.09E+01	8.03E+02	7.49E+02	9.93	0.93
Sn (IE)	<5.61E+00	<5.61E+00	<5.61E+00	-	-
Sr (IE)	2.80E-01	2.50E-01	4.00E-01	0.89	1.60
Th (IE)	<2.68E+00	<2.68E+00	<2.68E+00	-	-
Ti (IE)	3.40E-01	6.10E-01	7.60E-01	-	-
U (IE)	<3.27E+01	<3.27E+01	<3.27E+01	-	-
V (IE)	<4.70E-01	<4.70E-01	<4.70E-01	-	-
Zn (IE)	7.97E+01	3.10E+01	3.18E+01	0.39	1.03
Zr (IE)	4.50E-01	8.30E-01	9.10E-01	1.84	1.10
Hg (CV)	1.39E+01	8.74E+00	1.31E+01	0.63	1.50
²³² Th (IM)	3.00E-02	2.91E-02	2.60E-02	0.97	0.89
²³³ U (IM)	<2.00E-02	<1.00E-02	<1.00E-02	-	-
²³⁴ U (IM)	<2.00E-02	1.01E-02	<1.00E-02	-	-
²³⁵ U (IM)	4.37E-01	2.30E-01	1.19E-01	0.53	0.52
²³⁶ U (IM)	5.40E-02	2.53E-02	1.65E-02	0.47	0.65
²³⁸ U (IM)	1.04E+01	5.72E+00	2.86E+00	0.55	0.50
U-total (IM)	1.09E+01	5.98E+00	3.00E+00	0.55	0.50
¹³⁷ Cs (GS)	3.07E-01	5.19E-01	6.49E-01	1.69	1.25
⁹⁹ Tc (IM)	8.38E-01	4.34E-01	2.53E-01	0.52	0.58
²³⁷ Np (IM)	1.10E-01	6.13E-02	3.12E-02	0.56	0.51
²³⁹ Pu (IM)	8.50E-02	5.90E-02	4.01E-02	0.69	0.68
²⁴⁰ Pu (IM)	2.25E-02	1.15E-02	<1.00E-02	0.51	-
pH (pH units)	6.85	1.82	1.36	-	-

**Table 3-7. Composition of the Oxalic Acid Leachates from Tank 16H Annulus
Sample HTF-16-N-1 from Three Leaching Cycles (continued)**

Analyte (Method)	Decant 1 (dpm/ml)	Decant 2 (dpm/ml)	Decant 3 (dpm/ml)	<u>Decant 2</u> Decant 1	<u>Decant 3</u> Decant 2
¹³⁷ Cs (GS)	5.91E+07	1.00E+08	1.25E+08	1.69	1.25
⁹⁹ Tc (IM)	3.16E+04	1.63E+04	9.51E+03	0.52	0.58
²³² Th (IM)	7.33E-03	7.12E-03	6.35E-03	0.97	0.89
²³³ U (IM)	<4.28E+02	<2.14E+02	<2.14E+02	-	-
²³⁴ U (IM)	<2.78E+02	1.40E+02	<1.39E+02	-	-
²³⁵ U (IM)	2.10E+00	1.10E+00	5.70E-01	0.53	0.52
²³⁶ U (IM)	7.76E+00	3.63E+00	2.37E+00	0.47	0.65
²³⁷ Np (IM)	1.72E+02	9.59E+01	4.88E+01	0.56	0.51
²³⁸ U (IM)	7.79E+00	4.26E+00	2.13E+00	0.55	0.50
²³⁹ Pu (IM)	1.16E+04	8.03E+03	5.45E+03	0.69	0.68
²⁴⁰ Pu (IM)	1.13E+04	5.75E+03	<5.01E+03	0.51	-

**Table 3-8. Composition of the Oxalic Acid Leachates from Tank 16H Annulus
Sample HTF-16-S-2 from Three Leaching Cycles**

Analyte (Method)	Decant 1 (mg/L)	Decant 2 (mg/L)	Decant 3 (mg/L)	<u>Decant 2</u> Decant 1	<u>Decant 3</u> Decant 2
F ⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
CH ₂ O ⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
Cl ⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
NO ₂ ⁻ (IC)	1.96E+04	<1.00E+02	<1.00E+02	-	-
Br ⁻ (IC)	<1.00E+03	<1.00E+03	<1.00E+03	-	-
NO ₃ ⁻ (IC)	1.94E+04	1.18E+04	4.09E+03	0.61	0.35
PO ₄ ³⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
SO ₄ ²⁻ (IC)	<1.20E+03	<1.20E+03	<1.20E+03	-	-
C ₂ O ₄ ²⁻ (IC)	3.59E+04	3.70E+04	3.69E+04	1.03	1.00
Ag (IE)	<1.46E+00	<1.46E+00	<1.46E+00	-	-
Al (IE)	2.71E+03	3.40E+03	1.67E+03	1.25	0.49
B (IE)	<2.02E+00	<2.02E+00	<2.02E+00	-	-
Ba (IE)	1.22E+00	3.50E+00	2.57E+00	2.87	0.73
Be (IE)	<6.00E-02	<6.00E-02	<6.00E-02	-	-
Ca (IE)	3.85E+00	4.65E+00	3.59E+01	1.21	7.72
Cd (IE)	<6.40E-01	<6.40E-01	<6.40E-01	-	-
Ce (IE)	<7.07E+00	<7.07E+00	<7.07E+00	-	-
Co (IE)	<9.70E-01	<9.70E-01	<9.70E-01	-	-
Cr (IE)	3.53E+00	8.52E+00	5.11E+00	2.41	0.60
Cu (IE)	2.25E+01	1.59E+01	7.94E+00	0.71	0.50
Fe (IE)	3.80E+01	1.77E+02	1.89E+02	4.66	1.07
Gd (IE)	<7.80E-01	<7.80E-01	<7.80E-01	-	-
K (IE)	2.12E+02	1.12E+02	4.06E+01	0.53	0.36
La (IE)	<6.70E-01	<6.70E-01	<6.70E-01	-	-
Li (IE)	<1.46E+00	<1.46E+00	<1.46E+00	-	-
Mg (IE)	2.20E+01	3.39E+01	4.45E+01	1.54	1.31
Mn (IE)	2.20E+00	4.41E+00	3.95E+00	2.00	0.90
Mo (IE)	<6.17E+00	<6.17E+00	<6.17E+00	-	-

**Table 3-8. Composition of the Oxalic Acid Leachates from Tank 16H Annulus
Sample HTF-16-S-2 from Three Leaching Cycles (continued)**

Analyte (Method)	Decant 1 (mg/L)	Decant 2 (mg/L)	Decant 3 (mg/L)	<u>Decant 2</u> Decant 1	<u>Decant 3</u> Decant 2
Na (IE)	2.94E+04	1.40E+04	6.05E+03	0.48	0.43
Ni (IE)	<4.55E+00	<4.55E+00	<4.55E+00	-	-
P (IE)	<8.66E+00	<8.66E+00	<8.66E+00	-	-
Pb (IE)	9.43E+00	2.19E+01	1.99E+01	-	-
S (IE)	5.50E+02	2.44E+02	1.13E+02	0.44	0.46
Sb (IE)	<1.07E+01	<1.07E+01	<1.07E+01	-	-
Si (IE)	5.86E+01	1.67E+03	3.83E+02	28.5	0.23
Sn (IE)	<5.61E+00	<5.61E+00	<5.61E+00	-	-
Sr (IE)	2.10E-01	6.10E-01	6.20E-01	2.90	1.02
Th (IE)	<2.68E+00	<2.68E+00	<2.68E+00	-	-
Ti (IE)	2.40E-01	7.10E-01	7.50E-01	2.96	1.06
U (IE)	<3.27E+01	<3.27E+01	<3.27E+01	-	-
V (IE)	<4.70E-01	<4.70E-01	<4.70E-01	-	-
Zn (IE)	1.42E+01	1.81E+01	1.12E+01	1.27	0.62
Zr (IE)	1.15E+00	3.32E+00	3.32E+00	2.89	1.00
Hg (CV)	1.13E+01	5.80E+00	5.29E+00	0.51	0.91
²³² Th (IM)	3.00E-02	3.00E-02	2.12E-02	1.00	0.71
²³³ U (IM)	<2.00E-02	<2.00E-02	<1.00E-02	-	-
²³⁴ U (IM)	2.12E-02	<2.00E-02	<1.00E-02	-	-
²³⁵ U (IM)	6.65E-01	4.50E-01	1.65E-01	0.68	0.37
²³⁶ U (IM)	6.34E-02	3.64E-02	1.52E-02	0.57	0.42
²³⁸ U (IM)	1.62E+01	1.16E+01	4.35E+00	0.72	0.38
U-total (IM)	1.69E+01	1.21E+01	4.53E+00	0.71	0.38
¹³⁷ Cs (GS)	5.19E-01	7.48E-01	3.96E-01	1.44	0.53
⁹⁹ Tc (IM)	1.75E+00	7.48E-01	2.65E-01	0.43	0.35
²³⁷ Np (IM)	1.62E-01	1.04E-01	4.91E-02	0.64	0.47
²³⁹ Pu (IM)	1.05E-01	1.16E-01	6.87E-02	1.10	0.59
²⁴⁰ Pu (IM)	<2.00E-02	<2.00E-02	1.14E-02	-	-
pH (pH units)	7.23	2.90	1.26	-	-

**Table 3-8. Composition of the Oxalic Acid Leachates from Tank 16H Annulus
Sample HTF-16-S-2 from Three Leaching Cycles (continued)**

Analyte (Method)	Decant 1 (dpm/ml)	Decant 2 (dpm/ml)	Decant 3 (dpm/ml)	<u>Decant 2</u> Decant 1	<u>Decant 3</u> Decant 2
¹³⁷ Cs (GS)	9.99E+07	1.44E+08	7.62E+07	1.44	0.53
⁹⁹ Tc (IM)	6.60E+04	2.82E+04	9.98E+03	0.43	0.35
²³² Th (IM)	7.33E-03	7.33E-03	5.17E-03	1.00	0.71
²³³ U (IM)	<4.28E+02	<4.28E+02	<2.14E+02	-	-
²³⁴ U (IM)	2.95E+02	<2.78E+02	<1.39E+02	-	-
²³⁵ U (IM)	3.19E+00	2.16E+00	7.93E-01	0.68	0.37
²³⁶ U (IM)	9.11E+00	5.23E+00	2.18E+00	0.57	0.42
²³⁷ Np (IM)	2.53E+02	1.62E+02	7.69E+01	0.64	0.47
²³⁸ U (IM)	1.20E+01	8.65E+00	3.24E+00	0.72	0.38
²³⁹ Pu (IM)	1.43E+04	1.57E+04	9.36E+03	1.10	0.59
²⁴⁰ Pu (IM)	<1.00E+04	<1.00E+04	5.70E+03	-	-

**Table 3-9. Composition of the Oxalic Acid Leachates from Tank 16H Annulus
Sample HTF-16-W-1 from Three Leaching Cycles**

Analyte (Method)	Decant 1 (mg/L)	Decant 2 (mg/L)	Decant 3 (mg/L)	<u>Decant 2</u> Decant 1	<u>Decant 3</u> Decant 2
F ⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
CH ₂ O ⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
Cl ⁻ (IC)	1.64E+02	<1.00E+02	<1.00E+02	-	-
NO ₂ ⁻ (IC)	1.92E+04	<1.00E+02	<1.00E+02	-	-
Br ⁻ (IC)	<1.00E+03	<1.00E+03	<1.00E+03	-	-
NO ₃ ⁻ (IC)	1.84E+04	1.23E+04	5.09E+03	0.67	0.41
PO ₄ ³⁻ (IC)	<1.00E+02	<1.00E+02	<1.00E+02	-	-
SO ₄ ²⁻ (IC)	<1.20E+03	<1.20E+03	<1.20E+03	-	-
C ₂ O ₄ ²⁻ (IC)	3.63E+04	3.60E+04	3.63E+04	0.99	1.01
Ag (IE)	<1.46E+00	<1.46E+00	<1.46E+00	-	-
Al (IE)	3.77E+03	3.67E+03	2.33E+03	0.97	0.63
B (IE)	<2.02E+00	<2.02E+00	<2.02E+00	-	-
Ba (IE)	2.62E+00	3.05E+00	2.55E+00	1.16	0.84
Be (IE)	<6.00E-02	<6.00E-02	<6.00E-02	-	-
Ca (IE)	2.73E+00	9.60E+00	2.50E+01	3.52	2.60
Cd (IE)	<6.40E-01	<6.40E-01	<6.40E-01	-	-
Ce (IE)	<7.07E+00	<7.07E+00	<7.07E+00	-	-
Co (IE)	<9.70E-01	<9.70E-01	<9.70E-01	-	-
Cr (IE)	3.42E+00	4.76E+00	3.12E+00	1.39	0.66
Cu (IE)	2.91E+00	3.56E+00	2.29E+00	1.22	0.64
Fe (IE)	3.82E+01	1.29E+02	1.44E+02	3.38	1.12
Gd (IE)	<7.80E-01	<7.80E-01	<7.80E-01	-	-
K (IE)	2.90E+02	1.54E+02	6.74E+01	0.53	0.44
La (IE)	7.20E-01	<6.70E-01	1.78E+00	-	-
Li (IE)	<1.46E+00	<1.46E+00	<1.46E+00	-	-
Mg (IE)	1.25E+01	1.12E+01	6.78E+00	0.90	0.61
Mn (IE)	3.35E+00	4.32E+00	3.89E+00	1.29	0.90
Mo (IE)	<6.17E+00	<6.17E+00	<6.17E+00	-	-

**Table 3-9. Composition of the Oxalic Acid Leachates from Tank 16H Annulus
Sample HTF-16-W-1 from Three Leaching Cycles (continued)**

Analyte (Method)	Decant 1 (mg/L)	Decant 2 (mg/L)	Decant 3 (mg/L)	<u>Decant 2</u> Decant 1	<u>Decant 3</u> Decant 2
Na (IE)	2.65E+04	1.39E+04	7.32E+03	0.52	0.53
Ni (IE)	<4.55E+00	<4.55E+00	<4.55E+00	-	-
P (IE)	<8.66E+00	<8.66E+00	<8.66E+00	-	-
Pb (IE)	<7.16E+00	<7.16E+00	9.59E+00	-	-
S (IE)	3.80E+02	1.82E+02	1.38E+02	0.48	0.76
Sb (IE)	<1.07E+01	<1.07E+01	<1.07E+01	-	-
Si (IE)	7.21E+01	1.25E+03	3.71E+02	17.34	0.30
Sn (IE)	<5.61E+00	<5.61E+00	<5.61E+00	-	-
Sr (IE)	1.96E+00	1.43E+00	1.19E+00	0.73	0.83
Th (IE)	<2.68E+00	<2.68E+00	<2.68E+00	-	-
Ti (IE)	<1.30E-01	1.50E-01	3.20E-01	-	-
U (IE)	<3.27E+01	<3.27E+01	<3.27E+01	-	-
V (IE)	<4.70E-01	<4.70E-01	<4.70E-01	-	-
Zn (IE)	1.71E+01	1.43E+01	8.14E+00	0.84	0.57
Zr (IE)	2.01E+00	3.46E+00	3.80E+00	1.72	1.10
Hg (CV)	1.78E+01	1.11E+01	1.05E+01	0.62	0.95
²³² Th (IM)	7.50E-02	7.50E-02	3.00E-02	1.00	0.40
²³³ U (IM)	<5.00E-02	<5.00E-02	<2.00E-02	-	-
²³⁴ U (IM)	<5.00E-02	<5.00E-02	<2.00E-02	-	-
²³⁵ U (IM)	1.00E+00	7.85E-01	3.27E-01	0.78	0.42
²³⁶ U (IM)	7.98E-02	6.92E-02	3.22E-02	0.87	0.47
²³⁸ U (IM)	2.48E+01	1.97E+01	8.32E+00	0.79	0.42
U-total (IM)	2.59E+01	2.05E+01	8.67E+00	0.79	0.42
¹³⁷ Cs (GS)	4.42E-01	6.85E-01	4.45E-01	1.55	0.65
⁹⁹ Tc (IM)	2.44E+00	9.88E-01	4.08E-01	0.41	0.41
²³⁷ Np (IM)	2.05E-01	1.71E-01	9.23E-02	0.83	0.54
²³⁹ Pu (IM)	1.60E-01	1.41E-01	8.51E-02	0.88	0.60
²⁴⁰ Pu (IM)	<5.00E-02	<5.00E-02	<2.00E-02	-	-
pH (pH units)	6.43	2.71	1.30	-	-

**Table 3-9. Composition of the Oxalic Acid Leachates from Tank 16H Annulus
Sample HTF-16-W-1 from Three Leaching Cycles (continued)**

Analyte (Method)	Decant 1 (dpm/ml)	Decant 2 (dpm/ml)	Decant 3 (dpm/ml)	<u>Decant 2</u> Decant 1	<u>Decant 3</u> Decant 2
¹³⁷ Cs (GS)	8.52E+07	1.32E+08	8.57E+07	1.55	0.65
⁹⁹ Tc (IM)	9.18E+04	3.72E+04	1.54E+04	0.41	0.41
²³² Th (IM)	1.83E-02	1.83E-02	7.33E-03	1.00	0.40
²³³ U (IM)	<1.07E+03	<1.07E+03	<4.28E+02	-	-
²³⁴ U (IM)	<6.95E+02	<6.95E+02	<2.78E+02	-	-
²³⁵ U (IM)	4.80E+00	3.76E+00	1.57E+00	0.78	0.42
²³⁶ U (IM)	1.15E+01	9.93E+00	4.62E+00	0.87	0.47
²³⁷ Np (IM)	3.21E+02	2.67E+02	1.44E+02	0.83	0.54
²³⁸ U (IM)	1.85E+01	1.47E+01	6.20E+00	0.79	0.42
²³⁹ Pu (IM)	2.17E+04	1.92E+04	1.16E+04	0.88	0.60
²⁴⁰ Pu (IM)	<2.50E+04	<2.50E+04	<1.00E+04	-	-

**Table 3-10. Composition of the Oxalic Acid Leached Solids from Tank 16H
Annulus Sample HTF-16-E-2**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Ag (IE)	<1.13E+02	<1.10E+02	<1.04E+03	<9.63E+02	<1.12E+02	-
Al (IE)	6.32E+04	6.42E+04	7.47E+04	7.08E+04	6.82E+04	8.0%
B (IE)	<1.58E+01	<1.54E+01	<1.46E+02	<1.35E+02	<1.56E+01	-
Ba (IE)	5.51E+01	6.60E+01	1.38E+02	7.29E+01	6.06E+01	13%
Be (IE)	<4.71E-01	<4.58E-01	<5.78E+00	<5.35E+00	<4.65E-01	-
Ca (IE)	1.41E+04	1.74E+04	1.93E+04	1.12E+04	1.58E+04	15%
Cd (IE)	3.14E+00	3.59E+00	<2.24E+01	<2.07E+01	3.37E+00	9.5%
Ce (IE)	6.43E+01	<5.40E+01	<5.10E+02	<4.73E+02	6.43E+01	-
Co (IE)	<7.61E+00	<7.40E+00	<6.14E+01	<5.69E+01	<7.51E+00	-
Cr (IE)	2.62E+02	2.49E+02	3.15E+02	2.27E+02	2.63E+02	14%
Cu (IE)	7.77E+01	7.47E+01	1.00E+02	1.02E+02	8.86E+01	16%
Fe (IE)	3.22E+04	2.54E+04	4.01E+04	4.12E+04	3.47E+04	21%
Gd (IE)	<1.69E+01	<1.64E+01	<1.55E+02	<1.44E+02	<1.67E+01	-
K (IE)	8.93E+02	8.24E+02	3.50E+03	3.93E+03	8.59E+02	5.7%
La (IE)	2.22E+01	2.47E+01	7.51E+01	<4.48E+01	4.07E+01	73%
Li (IE)	<1.15E+01	<1.11E+01	<1.05E+02	<9.77E+01	<1.13E+01	-
Mg (IE)	5.72E+02	8.10E+02	1.15E+03	2.10E+03	1.16E+03	58%
Mn (IE)	2.25E+02	2.10E+02	3.00E+02	8.26E+02	3.90E+02	75%
Mo (IE)	<4.84E+01	<4.71E+01	<1.94E+02	<1.79E+02	<4.78E+01	-
Na (IE)	4.90E+04	4.66E+04	-	-	4.78E+04	3.6%
Ni (IE)	4.70E+01	6.30E+01	<3.29E+02	<3.04E+02	5.50E+01	21%
P (IE)	9.20E+01	1.06E+02	<1.18E+03	<1.10E+03	9.90E+01	10%
Pb (IE)	3.06E+02	3.20E+02	<5.17E+02	<4.79E+02	3.13E+02	3.2%
S (IE)	<5.88E+02	6.30E+02	<5.42E+03	<5.02E+03	6.30E+02	-
Sb (IE)	<1.00E+02	<9.75E+01	<7.70E+02	<7.13E+02	<9.88E+01	-
Si (IE)	-	-	2.27E+05	2.43E+05	2.35E+05	4.8%
Sn (IE)	<4.40E+01	<4.28E+01	<4.05E+02	<3.75E+02	<4.34E+01	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-10. Composition of the Oxalic Acid Leached Solids from Tank 16H
Annulus Sample HTF-16-E-2 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Sr (IE)	4.66E+01	5.15E+01	<i>1.06E+02</i>	<i>6.76E+01</i>	4.91E+01	7.1%
Th (IE)	<4.20E+01	<4.08E+01	<i><1.94E+02</i>	<i><1.79E+02</i>	<4.14E+01	-
Ti (IE)	<i>7.76E+01</i>	<i>9.53E+01</i>	2.04E+02	2.01E+02	2.03E+02	1.0%
U (IE)	6.41E+02	6.94E+02	<i><2.36E+03</i>	<i><2.18E+03</i>	6.68E+02	5.6%
V (IE)	<3.69E+00	<3.59E+00	<i><3.39E+01</i>	<i><3.14E+01</i>	<3.64E+00	-
Zn (IE)	3.79E+02	3.60E+02	5.99E+02	6.07E+02	4.86E+02	28%
Zr (IE)	5.27E+01	6.38E+01	-	-	5.83E+01	13%
Hg (CV)	1.39E+03	1.14E+03	-	-	1.27E+03	14%
²³² Th (IM)	3.28E-01	3.44E-01	8.90E-01	4.42E-01	5.01E-01	53%
²³³ U (IM)	<1.96E-01	<1.91E-01	<1.81E+00	<6.69E-01	<7.15E-01	-
²³⁴ U (IM)	<1.96E-01	<1.91E-01	<1.81E+00	<6.69E-01	<7.15E-01	-
²³⁵ U (IM)	2.95E+00	3.31E+00	1.08E+01	3.33E+00	5.09E+00	74%
²³⁶ U (IM)	4.02E-01	4.06E-01	<1.81E+00	<6.69E-01	4.04E-01	0.7%
²³⁸ U (IM)	7.76E+01	8.43E+01	2.95E+02	7.48E+01	1.33E+02	81%
U-total (IM)	8.09E+01	8.80E+01	3.06E+02	7.81E+01	1.38E+02	81%
⁹⁰ Sr (BS)	2.88E+00	3.03E+00	7.33E+00	2.95E+00	4.05E+00	54%
¹³⁷ Cs (GS)	1.18E+01	1.14E+01	1.44E+01	1.21E+01	1.24E+01	11%
²³⁸ Pu (SA)	9.81E-02	1.11E-01	1.91E-01	6.66E-02	1.17E-01	45%
⁹⁹ Tc (IM)	7.20E+00	7.87E+00	1.91E+01	7.51E+00	1.04E+01	56%
²³⁷ Np (IM)	1.53E+00	1.86E+00	4.20E+00	1.45E+00	2.26E+00	58%
²³⁹ Pu (IM)	3.08E+00	3.65E+00	<4.51E+00	<1.67E+00	3.37E+00	12%
²⁴⁰ Pu (IM)	4.71E-01	4.88E-01	<1.81E+00	<6.69E-01	4.80E-01	2.5%

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-10. Composition of the Oxalic Acid Leached Solids from Tank 16H
Annulus Sample HTF-16-E-2 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (dpm/g)	Aqua Regia Replicate 2 (dpm/g)	Per Fusion Replicate 1 (dpm/g)	Per Fusion Replicate 2 (dpm/g)	Average (dpm/g)	%RSD
⁹⁰ Sr (BS)	8.78E+08	9.23E+08	2.23E+09	8.99E+08	1.23E+09	54%
¹³⁷ Cs (GS)	2.27E+09	2.19E+09	2.78E+09	2.33E+09	2.39E+09	11%
²³⁸ Pu (SA)	3.73E+06	4.23E+06	7.25E+06	2.53E+06	4.44E+06	45%
^{239/240} Pu (SA)	5.95E+05	7.58E+05	1.24E+06	4.43E+05	7.59E+05	46%
⁹⁹ Tc (IM)	2.71E+05	2.96E+05	7.19E+05	2.83E+05	3.92E+05	56%
²³² Th (IM)	3.28E-01	3.44E-01	8.90E-01	4.42E-01	5.01E-01	53%
²³³ U (IM)	<4.20E+03	<4.09E+03	<3.87E+04	<1.43E+04	<1.53E+04	-
²³⁴ U (IM)	<2.72E+03	<2.65E+03	<2.51E+04	<9.30E+03	<9.94E+03	-
²³⁵ U (IM)	1.42E+01	1.59E+01	5.16E+01	1.60E+01	2.44E+01	74%
²³⁶ U (IM)	5.77E+01	5.83E+01	<2.59E+02	<9.60E+01	5.80E+01	0.7%
²³⁷ Np (IM)	2.39E+03	2.91E+03	6.56E+03	2.27E+03	3.54E+03	58%
²³⁸ U (IM)	5.79E+01	6.29E+01	2.20E+02	5.58E+01	9.92E+01	81%
²³⁹ Pu (IM)	4.20E+05	4.97E+05	<6.14E+05	<2.28E+05	4.58E+05	12%
²⁴⁰ Pu (IM)	2.36E+05	2.44E+05	<9.04E+05	<3.35E+05	2.40E+05	2.5%

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-11. Composition of the Oxalic Acid Leached Solids from Tank 16H
Annulus Sample HTF-16-N-1**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Ag (IE)	<1.08E+02	<1.06E+02	<1.05E+03	<1.13E+03	<1.07E+02	-
Al (IE)	6.62E+04	8.20E+04	1.19E+05	1.14E+05	9.53E+04	27%
B (IE)	<1.51E+01	<1.49E+01	<1.47E+02	<1.58E+02	<1.50E+01	-
Ba (IE)	3.71E+01	4.09E+01	1.41E+02	7.58E+01	3.90E+01	6.9%
Be (IE)	<4.49E-01	<4.41E-01	<5.84E+00	<6.25E+00	<4.45E-01	-
Ca (IE)	3.07E+03	4.23E+03	6.66E+03	5.06E+03	3.65E+03	22%
Cd (IE)	<2.32E+00	<2.28E+00	<2.26E+01	<2.42E+01	<2.30E+00	-
Ce (IE)	<5.30E+01	<5.20E+01	<5.16E+02	<5.52E+02	<5.25E+01	-
Co (IE)	<7.27E+00	<7.13E+00	<6.20E+01	<6.64E+01	<7.20E+00	-
Cr (IE)	8.85E+01	1.51E+02	8.76E+01	<6.41E+01	1.09E+02	33%
Cu (IE)	9.01E+01	1.15E+02	7.52E+01	6.80E+01	8.71E+01	24%
Fe (IE)	1.09E+04	1.15E+04	2.50E+04	4.84E+03	1.31E+04	65%
Gd (IE)	<1.61E+01	<1.58E+01	<1.57E+02	<1.68E+02	<1.60E+01	-
K (IE)	<1.92E+02	2.48E+02	3.89E+03	4.26E+03	2.20E+02	18%
La (IE)	1.39E+01	1.67E+01	<4.89E+01	<5.23E+01	1.53E+01	13%
Li (IE)	<1.09E+01	<1.07E+01	<1.07E+02	<1.14E+02	<1.08E+01	-
Mg (IE)	2.53E+02	4.25E+02	2.18E+02	2.48E+02	2.86E+02	33%
Mn (IE)	6.79E+01	9.29E+01	1.23E+02	4.77E+01	8.29E+01	39%
Mo (IE)	<4.62E+01	<4.54E+01	<1.96E+02	<2.09E+02	<4.58E+01	-
Na (IE)	4.84E+04	5.41E+04	-	-	5.13E+04	7.9%
Ni (IE)	<3.41E+01	<3.35E+01	<3.32E+02	<3.55E+02	<3.38E+01	-
P (IE)	<6.49E+01	<6.37E+01	<1.20E+03	<1.28E+03	<6.43E+01	-
Pb (IE)	3.55E+02	3.63E+02	5.52E+02	6.32E+02	4.76E+02	29%
S (IE)	<5.62E+02	5.78E+02	<5.47E+03	<5.86E+03	5.70E+02	2.0%
Sb (IE)	<9.57E+01	<9.39E+01	<7.78E+02	<8.33E+02	<9.48E+01	-
Si (IE)	-	-	2.19E+05	2.11E+05	2.15E+05	2.6%
Sn (IE)	<4.20E+01	<4.13E+01	<4.09E+02	<4.38E+02	<4.17E+01	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-11. Composition of the Oxalic Acid Leached Solids from Tank 16H
Annulus Sample HTF-16-N-1 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Sr (IE)	1.23E+01	1.30E+01	<i>3.94E+01</i>	<i>3.75E+01</i>	1.27E+01	3.9%
Th (IE)	<4.01E+01	<3.93E+01	<i><1.96E+02</i>	<i><2.09E+02</i>	<3.97E+01	-
Ti (IE)	<i>9.78E+01</i>	<i>1.53E+02</i>	4.33E+02	3.21E+02	3.77E+02	21%
U (IE)	<2.45E+02	2.56E+02	<i><2.38E+03</i>	<i><2.55E+03</i>	2.56E+02	-
V (IE)	6.44E+00	8.82E+00	<i><3.43E+01</i>	<i><3.67E+01</i>	7.63E+00	22%
Zn (IE)	3.07E+02	3.37E+02	6.16E+02	3.90E+02	4.13E+02	34%
Zr (IE)	2.80E+01	3.51E+01	-	-	3.16E+01	16%
Hg (CV)	1.27E+03	1.73E+03	-	-	1.50E+03	22%
²³² Th (IM)	2.05E+00	1.94E+00	2.71E+00	1.40E+00	2.03E+00	26%
²³³ U (IM)	<1.87E-01	<1.84E-01	<7.30E-01	<7.81E-01	<4.71E-01	-
²³⁴ U (IM)	<1.87E-01	<1.84E-01	<7.30E-01	<7.81E-01	<4.71E-01	-
²³⁵ U (IM)	1.04E+00	1.01E+00	1.53E+00	1.91E+00	1.37E+00	31%
²³⁶ U (IM)	<1.87E-01	<1.84E-01	<7.30E-01	<7.81E-01	<4.71E-01	-
²³⁸ U (IM)	2.19E+01	2.20E+01	2.36E+01	2.63E+01	2.34E+01	8.8%
U-total (IM)	2.29E+01	2.30E+01	2.51E+01	2.82E+01	2.48E+01	10%
⁹⁰ Sr (BS)	1.44E+00	1.40E+00	1.17E+00	8.94E-01	1.23E+00	21%
¹³⁷ Cs (GS)	1.37E+01	1.76E+01	2.31E+01	2.29E+01	1.93E+01	24%
²³⁸ Pu (SA)	3.37E-02	4.13E-02	3.63E-02	3.05E-02	3.55E-02	13%
⁹⁹ Tc (IM)	7.96E+00	1.17E+01	7.34E+00	6.18E+00	8.28E+00	29%
²³⁷ Np (IM)	3.45E-01	4.14E-01	<7.30E-01	<7.81E-01	3.80E-01	13%
²³⁹ Pu (IM)	9.50E-01	1.20E+00	<1.82E+00	<1.95E+00	1.08E+00	17%
²⁴⁰ Pu (IM)	<1.87E-01	<1.84E-01	<7.30E-01	<7.81E-01	<4.71E-01	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-11. Composition of the Oxalic Acid Leached Solids from Tank 16H
Annulus Sample HTF-16-N-1 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (dpm/g)	Aqua Regia Replicate 2 (dpm/g)	Per Fusion Replicate 1 (dpm/g)	Per Fusion Replicate 2 (dpm/g)	Average (dpm/g)	%RSD
⁹⁰ Sr (BS)	4.39E+08	4.27E+08	3.57E+08	2.72E+08	3.74E+08	21%
¹³⁷ Cs (GS)	2.63E+09	3.39E+09	4.44E+09	4.41E+09	3.72E+09	24%
²³⁸ Pu (SA)	1.28E+06	1.57E+06	1.38E+06	1.16E+06	1.35E+06	13%
^{239/240} Pu (SA)	1.76E+05	2.35E+05	2.05E+05	1.77E+05	1.98E+05	14%
⁹⁹ Tc (IM)	3.00E+05	4.39E+05	2.76E+05	2.33E+05	3.12E+05	29%
²³² Th (IM)	5.02E-01	4.74E-01	6.62E-01	3.43E-01	4.95E-01	26%
²³³ U (IM)	<4.01E+03	<3.94E+03	<1.56E+04	<1.67E+04	<1.01E+04	-
²³⁴ U (IM)	<2.60E+03	<2.55E+03	<1.01E+04	<1.09E+04	<6.54E+03	-
²³⁵ U (IM)	4.97E+00	4.86E+00	7.36E+00	9.15E+00	6.58E+00	31%
²³⁶ U (IM)	<2.69E+01	<2.64E+01	<1.05E+02	<1.12E+02	<6.76E+01	-
²³⁷ Np (IM)	5.40E+02	6.48E+02	<1.14E+03	<1.22E+03	5.94E+02	13%
²³⁸ U (IM)	1.63E+01	1.64E+01	1.76E+01	1.96E+01	1.75E+01	8.8%
²³⁹ Pu (IM)	1.29E+05	1.63E+05	<2.48E+05	<2.66E+05	1.46E+05	17%
²⁴⁰ Pu (IM)	<9.38E+04	<9.21E+04	<3.66E+05	<3.91E+05	<2.36E+05	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-12. Composition of the Oxalic Acid Leached Solids from Tank 16H
Annulus Sample HTF-16-S-2**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Ag (IE)	<9.93E+01	<1.04E+02	<1.04E+03	<1.06E+03	<1.02E+02	-
Al (IE)	4.03E+04	7.18E+04	4.41E+04	5.15E+04	5.19E+04	27%
B (IE)	<1.39E+01	<1.45E+01	<1.46E+02	<1.49E+02	<1.42E+01	-
Ba (IE)	7.89E+01	1.11E+02	1.08E+02	1.76E+02	9.50E+01	24%
Be (IE)	<4.14E-01	<4.32E-01	<5.80E+00	<5.90E+00	<4.23E-01	-
Ca (IE)	3.79E+03	3.95E+03	5.78E+03	8.18E+03	3.87E+03	2.9%
Cd (IE)	4.69E+00	3.60E+00	<2.25E+01	<2.29E+01	4.15E+00	19%
Ce (IE)	1.13E+02	1.09E+02	<5.12E+02	<5.22E+02	1.11E+02	2.5%
Co (IE)	<6.69E+00	<6.98E+00	<6.16E+01	<6.27E+01	<6.84E+00	-
Cr (IE)	1.16E+02	2.04E+02	1.75E+02	2.44E+02	1.85E+02	29%
Cu (IE)	1.27E+02	1.77E+02	1.02E+02	1.05E+02	1.28E+02	27%
Fe (IE)	2.41E+04	3.42E+04	1.51E+04	1.77E+04	2.28E+04	37%
Gd (IE)	<1.48E+01	<1.55E+01	<1.56E+02	<1.59E+02	<1.52E+01	-
K (IE)	2.30E+02	2.21E+02	4.23E+03	5.40E+03	2.26E+02	2.8%
La (IE)	4.69E+01	4.71E+01	4.93E+01	9.59E+01	5.98E+01	40%
Li (IE)	<1.01E+01	<1.05E+01	1.07E+02	<1.08E+02	<1.03E+01	-
Mg (IE)	1.42E+03	1.51E+03	4.23E+03	8.00E+03	3.79E+03	82%
Mn (IE)	1.56E+02	2.39E+02	1.25E+02	1.73E+02	1.73E+02	28%
Mo (IE)	<4.26E+01	<4.44E+01	<1.94E+02	<1.98E+02	<4.35E+01	-
Na (IE)	3.33E+04	3.29E+04	-	-	3.31E+04	0.9%
Ni (IE)	5.79E+01	8.17E+01	<3.30E+02	<3.36E+02	6.98E+01	24%
P (IE)	<5.97E+01	6.69E+01	<1.19E+03	<1.21E+03	6.69E+01	-
Pb (IE)	8.25E+02	2.89E+03	1.27E+03	6.61E+03	2.90E+03	91%
S (IE)	1.10E+03	3.70E+03	<5.43E+03	<5.54E+03	2.40E+03	77%
Sb (IE)	<8.81E+01	<9.19E+01	<7.72E+02	<7.87E+02	<9.00E+01	-
Si (IE)	-	-	1.97E+05	2.07E+05	2.02E+05	3.5%
Sn (IE)	<3.87E+01	<4.04E+01	<4.07E+02	<4.14E+02	<3.96E+01	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-12. Composition of the Oxalic Acid Leached Solids from Tank 16H
Annulus Sample HTF-16-S-2 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Sr (IE)	3.87E+01	3.98E+01	<i>5.94E+01</i>	<i>6.79E+01</i>	3.93E+01	2.0%
Th (IE)	<3.69E+01	<3.85E+01	< <i>1.94E+02</i>	< <i>1.98E+02</i>	<3.77E+01	-
Ti (IE)	<i>6.37E+01</i>	<i>7.47E+01</i>	1.75E+02	3.16E+02	2.46E+02	41%
U (IE)	<2.25E+02	<2.35E+02	< <i>2.37E+03</i>	< <i>2.41E+03</i>	<2.30E+02	-
V (IE)	7.17E+00	8.27E+00	< <i>3.41E+01</i>	< <i>3.47E+01</i>	7.72E+00	10%
Zn (IE)	2.77E+02	4.59E+02	3.94E+02	4.47E+02	3.94E+02	21%
Zr (IE)	1.24E+02	1.29E+02	-	-	1.27E+02	2.8%
Hg (CV)	2.41E+03	5.03E+03	-	-	3.72E+03	50%
²³² Th (IM)	1.34E+00	1.92E+00	3.24E+00	3.24E+00	2.43E+00	39%
²³³ U (IM)	<1.72E-01	<1.80E-01	<7.25E-01	<1.85E+00	<7.30E-01	-
²³⁴ U (IM)	<1.72E-01	<1.80E-01	<7.25E-01	<1.85E+00	<7.30E-01	-
²³⁵ U (IM)	1.44E+00	1.85E+00	4.67E+00	3.93E+00	2.97E+00	53%
²³⁶ U (IM)	<1.72E-01	2.59E-01	<7.25E-01	<1.85E+00	<7.50E-01	-
²³⁸ U (IM)	4.01E+01	4.92E+01	9.08E+01	1.02E+02	7.05E+01	43%
U-total (IM)	4.15E+01	5.13E+01	9.54E+01	1.06E+02	7.35E+01	43%
⁹⁰ Sr (BS)	5.55E+00	5.22E+00	5.42E+00	4.99E+00	5.30E+00	4.6%
¹³⁷ Cs (GS)	1.12E+01	1.22E+01	1.14E+01	8.98E+00	1.09E+01	12%
²³⁸ Pu (SA)	7.47E-02	8.79E-02	7.81E-02	8.39E-02	8.12E-02	7.2%
⁹⁹ Tc (IM)	1.65E+01	1.79E+01	2.53E+01	2.09E+01	2.01E+01	19%
²³⁷ Np (IM)	8.38E-01	1.04E+00	1.48E+00	<1.85E+00	1.30E+00	35%
²³⁹ Pu (IM)	2.30E+00	2.47E+00	<1.81E+00	<4.61E+00	2.39E+00	5.0%
²⁴⁰ Pu (IM)	3.29E-01	3.40E-01	<7.25E-01	<1.85E+00	3.35E-01	2.3%

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-12. Composition of the Oxalic Acid Leached Solids from Tank 16H
Annulus Sample HTF-16-S-2 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (dpm/g)	Aqua Regia Replicate 2 (dpm/g)	Per Fusion Replicate 1 (dpm/g)	Per Fusion Replicate 2 (dpm/g)	Average (dpm/g)	%RSD
⁹⁰ Sr (BS)	1.69E+09	1.59E+09	1.65E+09	1.52E+09	1.61E+09	4.6%
¹³⁷ Cs (GS)	2.16E+09	2.34E+09	2.20E+09	1.73E+09	2.11E+09	12%
²³⁸ Pu (SA)	2.84E+06	3.34E+06	2.97E+06	3.19E+06	3.09E+06	7.2%
^{239/240} Pu (SA)	4.84E+05	4.97E+05	5.12E+05	5.61E+05	5.14E+05	6.6%
⁹⁹ Tc (IM)	6.20E+05	6.75E+05	9.54E+05	7.85E+05	7.59E+05	19%
²³² Th (IM)	3.28E-01	4.68E-01	7.91E-01	7.91E-01	5.94E-01	39%
²³³ U (IM)	<3.69E+03	<3.85E+03	<1.55E+04	<3.95E+04	<1.56E+04	-
²³⁴ U (IM)	<2.40E+03	<2.50E+03	<1.01E+04	<2.56E+04	<1.02E+04	-
²³⁵ U (IM)	6.91E+00	8.87E+00	2.24E+01	1.89E+01	1.43E+01	53%
²³⁶ U (IM)	<2.48E+01	3.72E+01	<1.04E+02	<2.65E+02	<1.08E+02	-
²³⁷ Np (IM)	1.31E+03	1.62E+03	2.32E+03	<2.89E+03	1.75E+03	29%
²³⁸ U (IM)	2.99E+01	3.67E+01	6.77E+01	7.59E+01	5.26E+01	43%
²³⁹ Pu (IM)	3.13E+05	3.36E+05	<2.47E+05	<6.28E+05	3.25E+05	5.0%
²⁴⁰ Pu (IM)	1.65E+05	1.70E+05	<3.63E+05	<9.24E+05	1.68E+05	2.3%

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-13. Composition of the Oxalic Acid Leached Solids from Tank 16H
Annulus Sample HTF-16-W-1**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Ag (IE)	<1.10E+02	<1.10E+02	<1.05E+03	<1.04E+03	<1.10E+02	-
Al (IE)	1.06E+05	9.39E+04	9.49E+04	8.95E+04	9.61E+04	7.3%
B (IE)	<1.55E+01	<1.54E+01	<1.48E+02	<1.46E+02	<1.55E+01	-
Ba (IE)	1.20E+02	1.05E+02	1.61E+02	1.14E+02	1.13E+02	9.4%
Be (IE)	<4.60E-01	<4.56E-01	<5.86E+00	<5.78E+00	<4.58E-01	-
Ca (IE)	4.80E+02	1.39E+03	3.33E+03	3.68E+03	9.35E+02	69%
Cd (IE)	2.38E+00	2.81E+00	<2.27E+01	<2.24E+01	2.60E+00	12%
Ce (IE)	2.03E+02	1.66E+02	<5.18E+02	<5.10E+02	1.85E+02	14%
Co (IE)	<7.43E+00	<7.38E+00	<6.23E+01	<6.14E+01	<7.41E+00	-
Cr (IE)	8.17E+01	7.95E+01	1.59E+02	1.74E+02	1.24E+02	40%
Cu (IE)	6.67E+01	7.41E+01	6.89E+01	4.77E+01	6.44E+01	18%
Fe (IE)	1.07E+04	1.19E+04	2.65E+04	2.00E+04	1.73E+04	43%
Gd (IE)	<1.65E+01	<1.63E+01	<1.58E+02	<1.55E+02	<1.64E+01	-
K (IE)	5.08E+02	4.22E+02	4.22E+03	4.02E+03	4.65E+02	13%
La (IE)	7.46E+01	6.75E+01	9.38E+01	6.71E+01	7.58E+01	17%
Li (IE)	<1.12E+01	<1.11E+01	<1.07E+02	<1.05E+02	<1.12E+01	-
Mg (IE)	1.41E+02	1.39E+02	1.88E+02	1.33E+02	1.50E+02	17%
Mn (IE)	1.27E+02	1.32E+02	2.29E+02	1.86E+02	1.69E+02	29%
Mo (IE)	<4.73E+01	<4.69E+01	<1.96E+02	<1.94E+02	<4.71E+01	-
Na (IE)	9.68E+04	8.81E+04	-	-	9.25E+04	6.7%
Ni (IE)	9.95E+01	1.32E+02	<3.33E+02	<3.29E+02	1.16E+02	20%
P (IE)	<6.64E+01	<6.59E+01	<1.20E+03	<1.18E+03	<6.62E+01	-
Pb (IE)	5.66E+02	5.18E+02	9.66E+02	8.93E+02	7.36E+02	31%
S (IE)	8.46E+02	<5.70E+02	<5.49E+03	<5.42E+03	8.46E+02	-
Sb (IE)	<9.79E+01	<9.71E+01	<7.81E+02	<7.70E+02	<9.75E+01	-
Si (IE)	-	-	2.39E+05	2.84E+05	2.62E+05	12%
Sn (IE)	<4.30E+01	<4.27E+01	<4.11E+02	<4.05E+02	<4.29E+01	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-13. Composition of the Oxalic Acid Leached Solids from Tank 16H
Annulus Sample HTF-16-W-1 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (mg/kg)	Aqua Regia Replicate 2 (mg/kg)	Per Fusion Replicate 1 (mg/kg)	Per Fusion Replicate 2 (mg/kg)	Average (mg/kg)	%RSD
Sr (IE)	2.87E+01	2.83E+01	<i>5.86E+01</i>	<i>5.27E+01</i>	2.85E+01	1.0%
Th (IE)	<4.10E+01	<4.07E+01	<i><1.96E+02</i>	<i><1.94E+02</i>	<4.09E+01	-
Ti (IE)	<i>3.72E+01</i>	<i>3.33E+01</i>	1.07E+02	7.36E+01	9.03E+01	26%
U (IE)	<2.50E+02	<2.48E+02	<i><2.39E+03</i>	<i><2.36E+03</i>	<2.49E+02	-
V (IE)	<3.60E+00	<3.57E+00	<i><3.44E+01</i>	<i><3.39E+01</i>	<3.59E+00	-
Zn (IE)	2.30E+02	3.03E+02	3.27E+02	2.73E+02	2.83E+02	15%
Zr (IE)	2.47E+02	2.06E+02	-	-	2.27E+02	13%
Hg (CV)	1.89E+03	2.00E+03	-	-	1.95E+03	4.0%
²³² Th (IM)	6.66E-01	7.22E-01	2.00E+00	1.10E+00	1.12E+00	55%
²³³ U (IM)	<1.92E-01	<1.90E-01	<7.33E-01	<7.22E-01	<4.59E-01	-
²³⁴ U (IM)	<1.92E-01	<1.90E-01	<7.33E-01	<7.22E-01	<4.59E-01	-
²³⁵ U (IM)	3.99E+00	3.32E+00	4.91E+00	3.29E+00	3.88E+00	20%
²³⁶ U (IM)	3.23E-01	3.94E-01	<7.33E-01	<7.22E-01	3.59E-01	14%
²³⁸ U (IM)	1.02E+02	8.68E+01	1.09E+02	7.19E+01	9.24E+01	18%
U-total (IM)	1.07E+02	9.05E+01	1.14E+02	7.52E+01	9.65E+01	18%
⁹⁰ Sr (BS)	5.45E+00	5.16E+00	5.68E+00	4.57E+00	5.22E+00	9.3%
¹³⁷ Cs (GS)	2.09E+01	1.92E+01	2.17E+01	1.82E+01	2.00E+01	7.9%
²³⁸ Pu (SA)	1.53E-01	1.19E-01	1.52E-01	9.34E-02	1.29E-01	22%
⁹⁹ Tc (IM)	1.74E+01	1.96E+01	3.36E+01	2.42E+01	2.37E+01	30%
²³⁷ Np (IM)	1.37E+00	1.17E+00	1.91E+00	1.24E+00	1.42E+00	24%
²³⁹ Pu (IM)	4.66E+00	3.94E+00	<1.83E+00	<1.81E+00	4.30E+00	12%
²⁴⁰ Pu (IM)	6.12E-01	5.05E-01	8.13E-01	<7.22E-01	6.43E-01	24%

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

**Table 3-13. Composition of the Oxalic Acid Leached Solids from Tank 16H
Annulus Sample HTF-16-W-1 (continued)**

Analyte (Method)	Aqua Regia Replicate 1 (dpm/g)	Aqua Regia Replicate 2 (dpm/g)	Per Fusion Replicate 1 (dpm/g)	Per Fusion Replicate 2 (dpm/g)	Average (dpm/g)	%RSD
⁹⁰ Sr (BS)	1.66E+09	1.57E+09	1.73E+09	1.39E+09	1.59E+09	9.3%
¹³⁷ Cs (GS)	4.02E+09	3.69E+09	4.18E+09	3.51E+09	3.85E+09	7.9%
²³⁸ Pu (SA)	5.80E+06	4.53E+06	5.78E+06	3.55E+06	4.92E+06	22%
^{239/240} Pu (SA)	1.11E+06	8.51E+05	1.11E+06	6.57E+05	9.32E+05	24%
⁹⁹ Tc (IM)	6.57E+05	7.38E+05	1.26E+06	9.11E+05	8.93E+05	30%
²³² Th (IM)	1.63E-01	1.76E-01	4.88E-01	2.69E-01	2.74E-01	55%
²³³ U (IM)	<4.10E+03	<4.07E+03	<1.57E+04	<1.55E+04	<9.83E+03	-
²³⁴ U (IM)	<2.66E+03	<2.64E+03	<1.02E+04	<1.00E+04	<6.38E+03	-
²³⁵ U (IM)	1.91E+01	1.59E+01	2.36E+01	1.58E+01	1.86E+01	20%
²³⁶ U (IM)	4.64E+01	5.66E+01	<1.05E+02	<1.04E+02	5.15E+01	14%
²³⁷ Np (IM)	2.14E+03	1.84E+03	2.99E+03	1.94E+03	2.22E+03	24%
²³⁸ U (IM)	7.62E+01	6.48E+01	8.11E+01	5.36E+01	6.89E+01	18%
²³⁹ Pu (IM)	6.34E+05	5.36E+05	<2.49E+05	<2.46E+05	5.85E+05	12%
²⁴⁰ Pu (IM)	3.07E+05	2.53E+05	4.07E+05	<3.62E+05	3.22E+05	24%

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

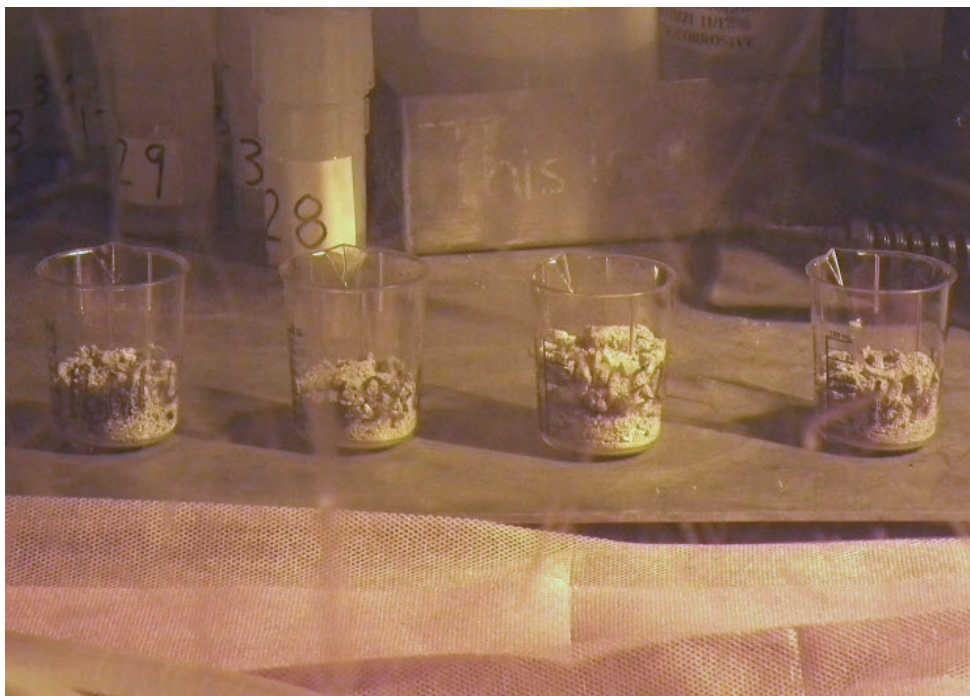


Figure 3-1 Oxalic Acid Leached Solids from the Tank 16H Annulus Samples

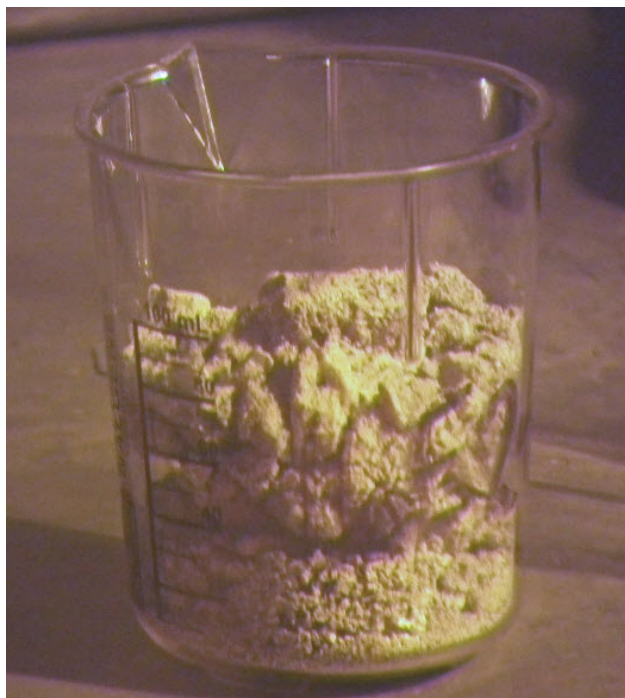


Figure 3-2 Oxalic Acid Leached Solids from Tank 16H Annulus Sample HTF 16-E-2

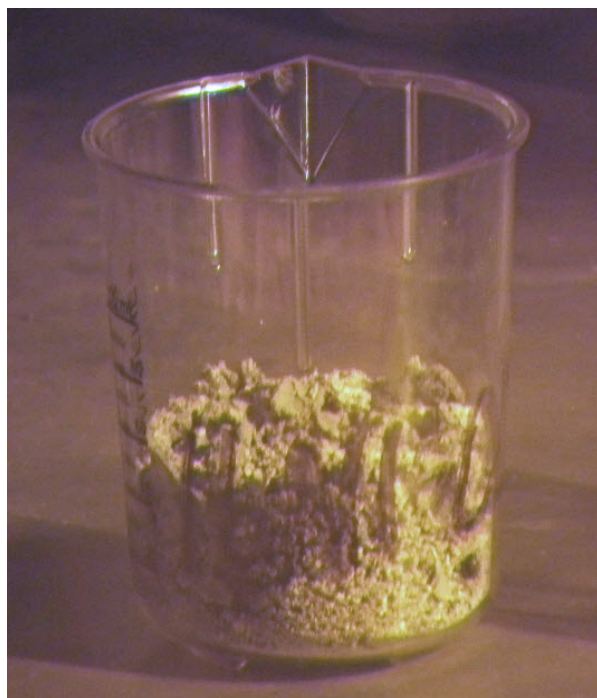


Figure 3-3 Oxalic Acid Leached Solids from Tank 16H Annulus Sample HTF 16-N-1

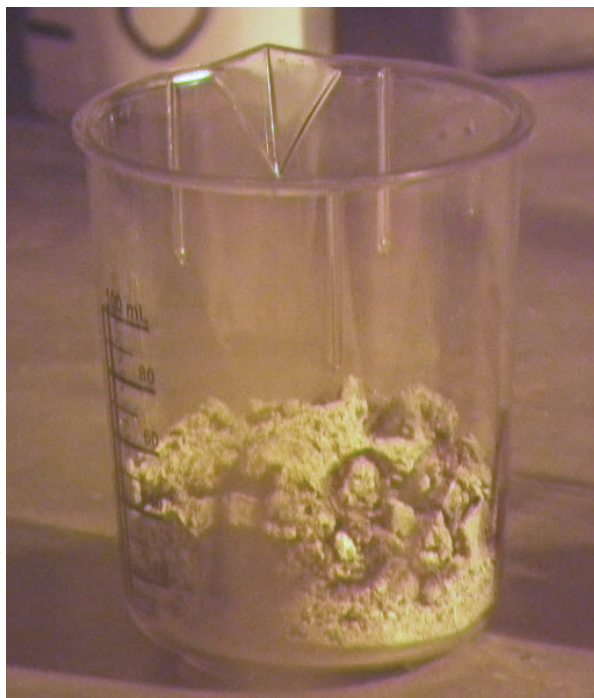


Figure 3-4 Oxalic Acid Leached Solids from Tank 16H Annulus Sample HTF 16-S-2

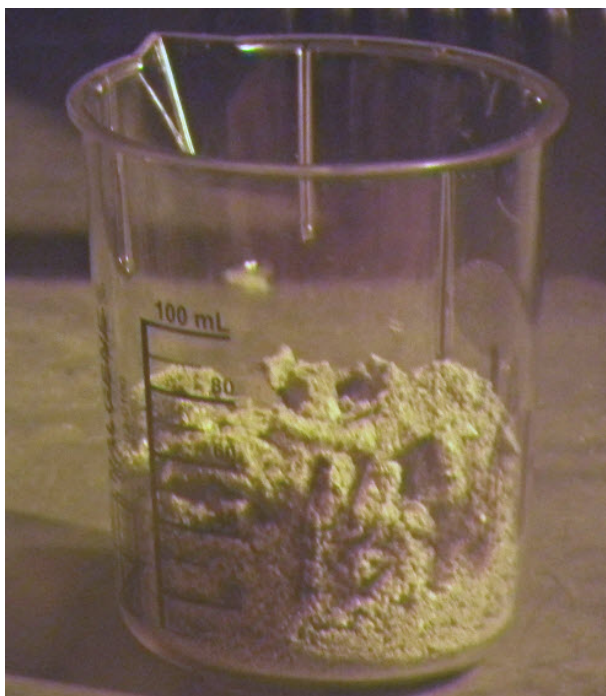


Figure 3-5 Oxalic Acid Leached Solids from Tank 16H Annulus Sample HTF 16-W-1

Table 3-14. XRD Result for the Oxalic Acid Leached Solids from the Tank 16H Annulus Samples-Estimated Mineral Phase Composition

Crystalline Phase	HTF-16E2 Replicate 1	HTF-16E2 Replicate 2	HTF-16N1 Replicate 1	HTF-16N1 Replicate 2	HTF-16S2 Replicate 1	HTF-16S2 Replicate 2	HTF-16W1 Replicate 1	HTF-16W1 Replicate 2
Amorphous	45%	47%	10%	24%	37%	45%	39%	34%
SiO ₂	30%	5%	78%	36%	23%	35%	-	-
Na ₈ (Al ₆ Si ₆ O ₂₄)(NO ₃) ₂ ·4H ₂ O	20%	44%	10%	35%	37%	13%	61%	66%
Al(OH) ₃	-	-	-	-	2%	5%	-	-

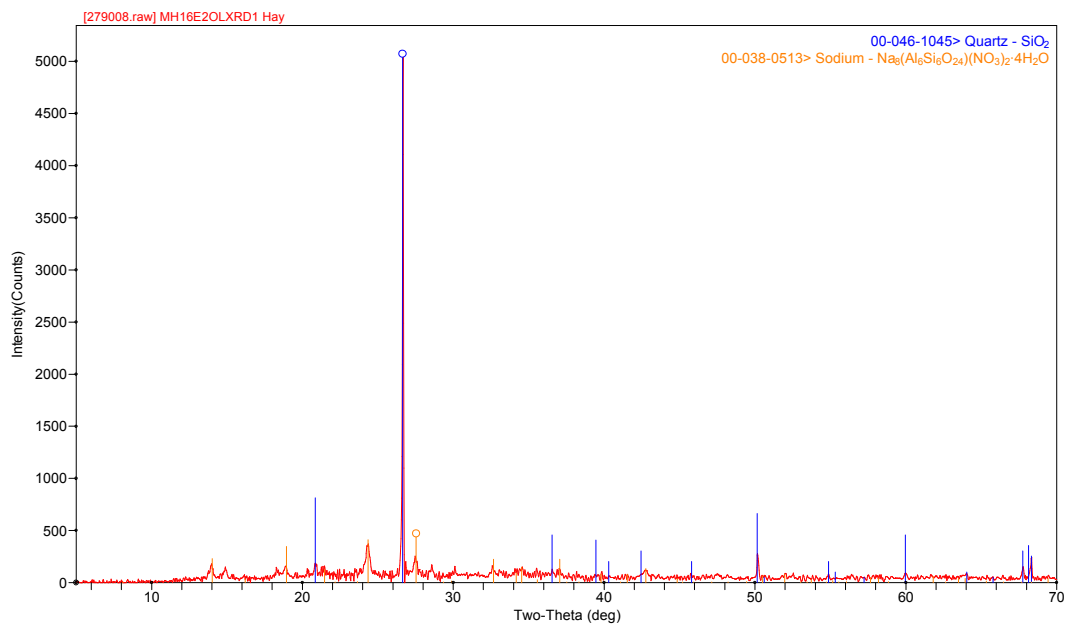


Figure 3-6 XRD Results of the Oxalic Acid Leached Solids for HTF-16E2-1

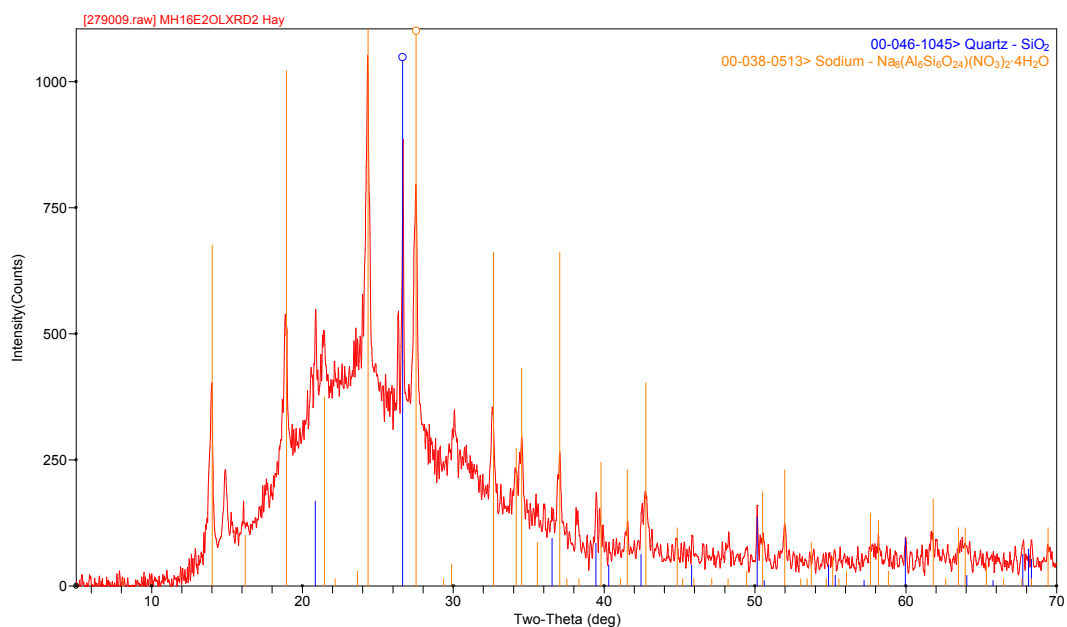


Figure 3-7 XRD Results of the Oxalic Acid Leached Solids for HTF-16E2-2

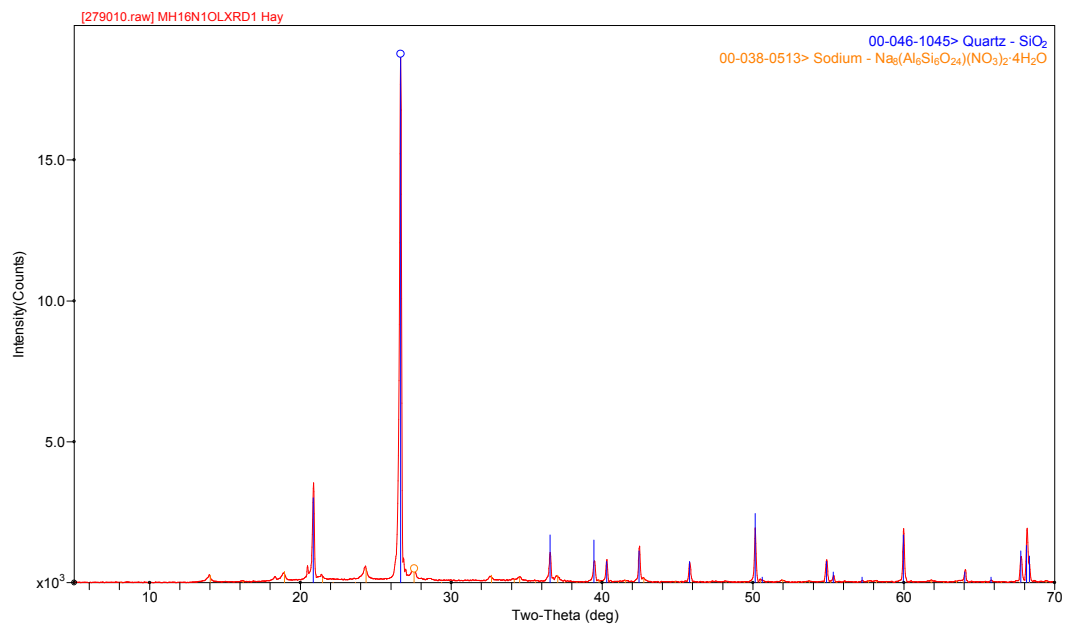


Figure 3-8 XRD Results of the Oxalic Acid Leached Solids for HTF-16N1-1

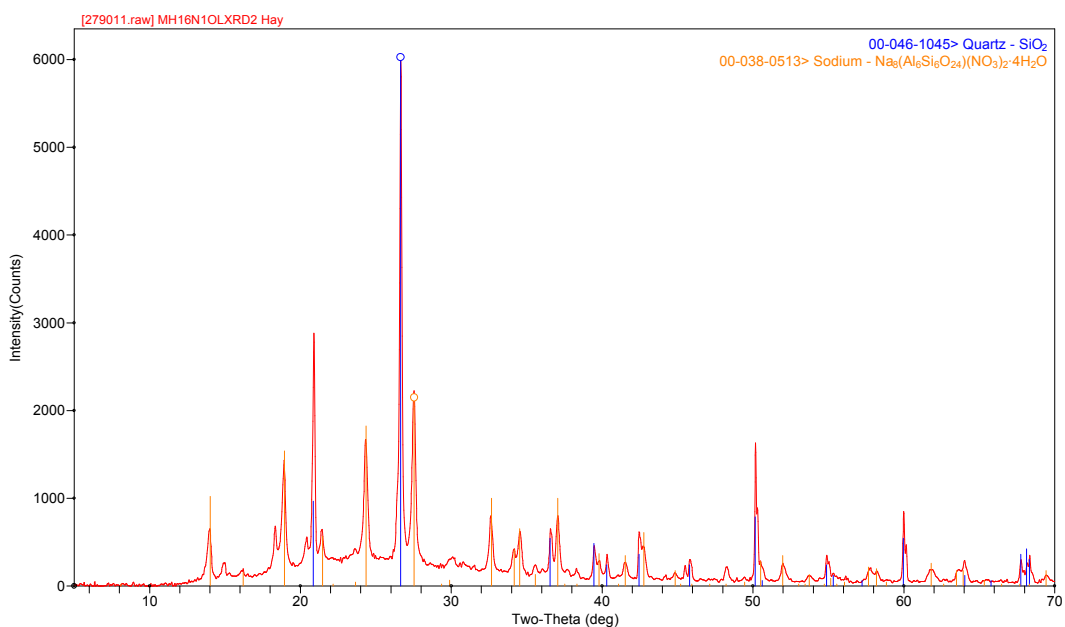


Figure 3-9 XRD Results of the Oxalic Acid Leached Solids for HTF-16N1-2

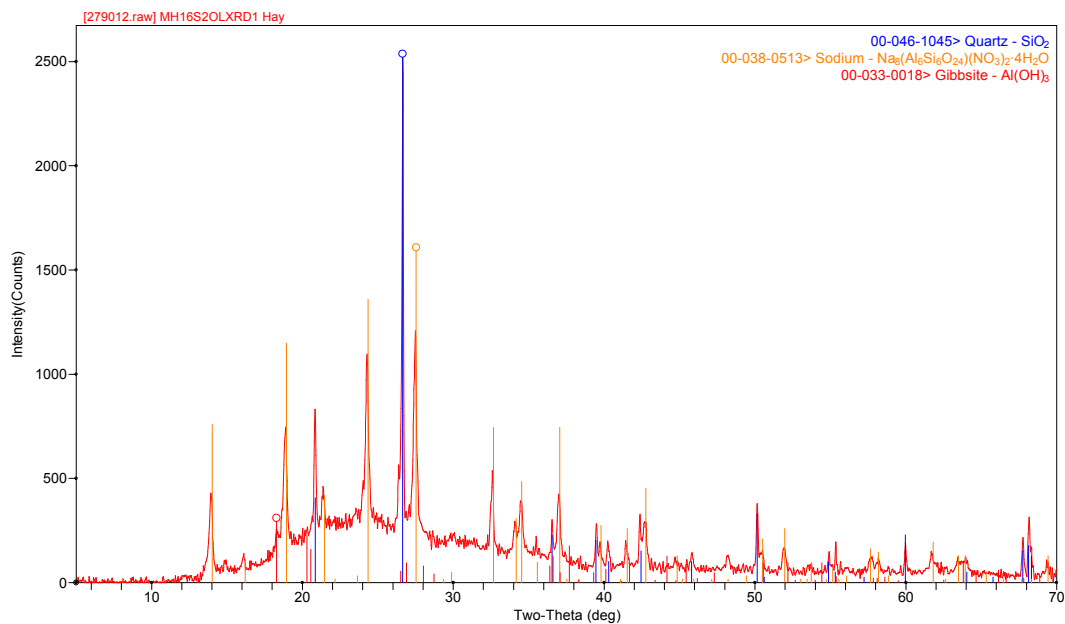


Figure 3-10 XRD Results of the Oxalic Acid Leached Solids for HTF-16S2-1

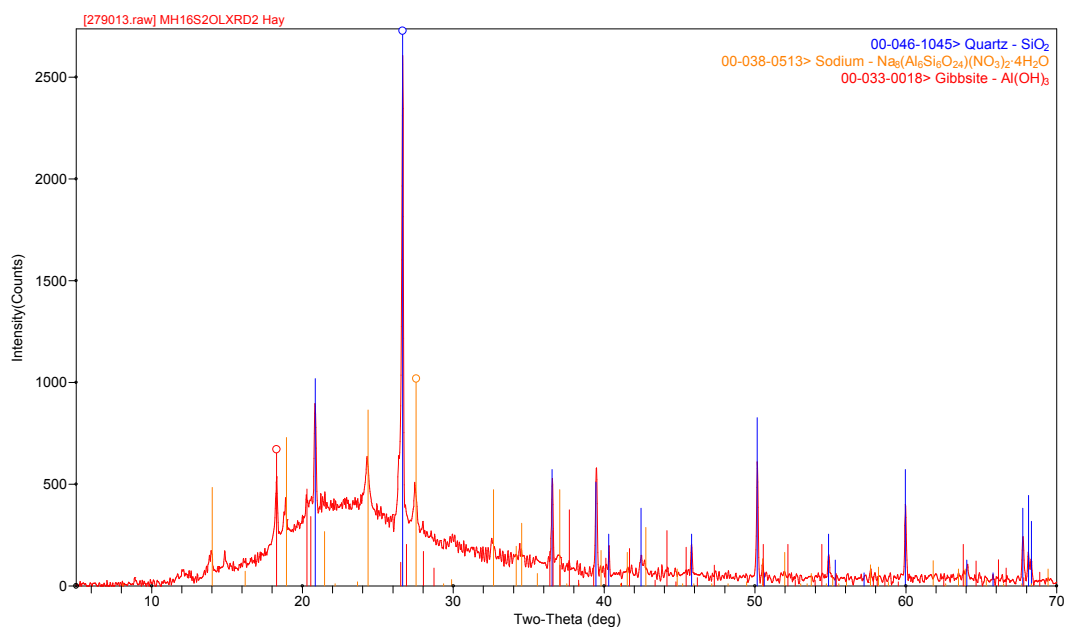


Figure 3-11 XRD Results of the Oxalic Acid Leached Solids for HTF-16S2-2

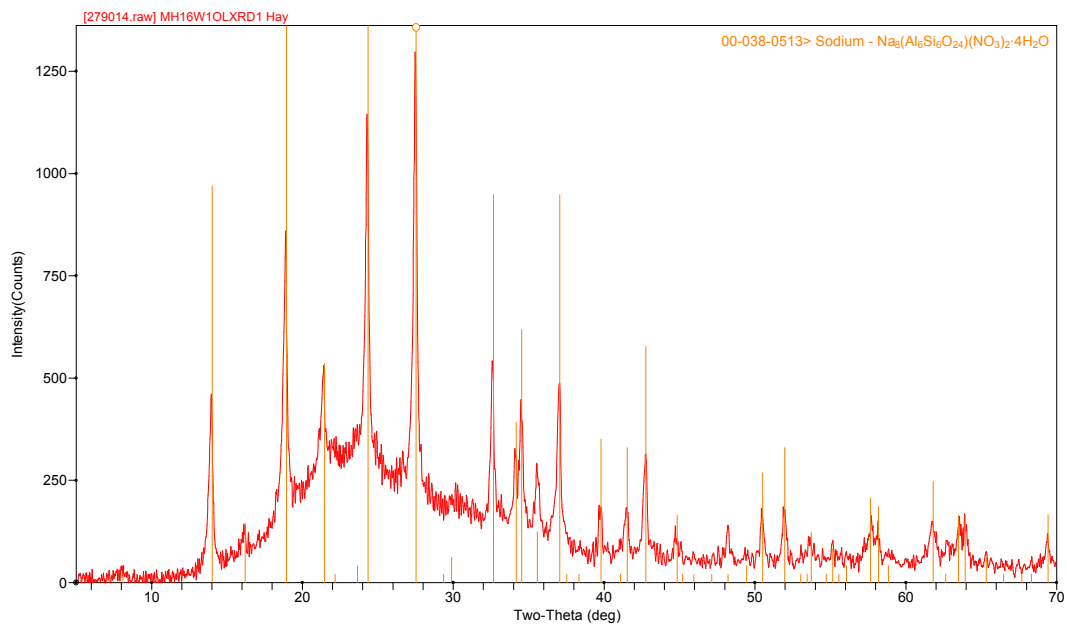


Figure 3-12 XRD Results of the Oxalic Acid Leached Solids for HTF-16W1-1

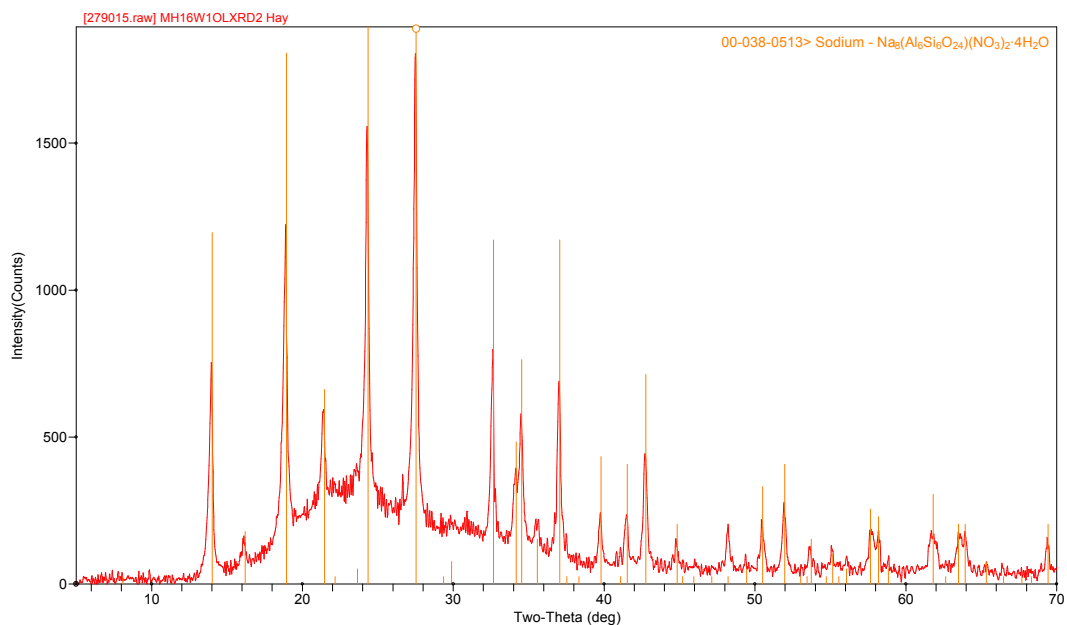


Figure 3-13 XRD Results of the Oxalic Acid Leached Solids for HTF-16W1-2

4.0 Modeling Summary and Recommendations

A simple, single leaching cycle model was developed using the OLI Systems Inc, Environmental Simulation Program (ESP), version 8.3, to develop recommendations on the choice of species from the thermodynamic database to represent Tank 16 Annulus solids. The simple model contained a single Mix block to combine a solids only stream of species representing the annulus solids with an aqueous stream representing the leaching solution (either water or 4 wt% oxalic acid). The chemistry model containing the species shown in Table 4-1 was developed using the Mixed Solvent Electrolyte (MSE) framework. All of the species in the chemistry model were contained in the Mixed Solvent Electrolyte Public (MSEPUB) database.

The MSEPUB database does not contain the sodium aluminum nitrate silicate hydrate ($\text{Na}_8(\text{Al}_6\text{Si}_6\text{O}_{24})(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$) or the muscovite ($\text{KAl}_2(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$) identified in the XRD results of the as-received Tank 16 Annulus solids. However, the MSEPUB database does contain the compounds cancrinite dihydrate ($\text{Na}_8(\text{Al}_6\text{Si}_6\text{O}_{24})(\text{CO}_3)_2 \cdot 2\text{H}_2\text{O}$) and hydroxysodalite dihydrate ($\text{Na}_8\text{Al}_6\text{Si}_6\text{O}_{24}(\text{OH})_2 \cdot 2\text{H}_2\text{O}$) that have similar chemical formulas. Using the simple ESP model, the hydroxysodalite dihydrate was found to better predict the solubility of silicon measured in the water and oxalic acid leaching tests on Tank 16 annulus solids.

Table 4-1. Species Chosen for the ESP Chemistry Model of Tank 16 Annulus Solids

H_2O	$\text{Na}_3\text{H}(\text{CO}_3)_2 \cdot 2\text{H}_2\text{O}$
SiO_2	Na_2CO_3
$\text{Na}_8\text{Al}_6\text{Si}_6\text{O}_{24}(\text{OH})_2 \cdot 2\text{H}_2\text{O}$	Na_2SO_4
$\text{Al}(\text{OH})_3$	NaNO_3
Fe_2O_3	NaNO_2
$\text{Ca}(\text{OH})_2$	KNO_3
CaSO_4	K_2CO_3
CaCO_3	$\text{Mg}(\text{OH})_2$
Hg	$\text{H}_2\text{C}_2\text{O}_4$
HgO	NaOH

The model predicts that all of the sodium nitrite, sodium nitrate, sodium sulfate, sodium carbonate, and sodium bicarbonate dihydrate (trona) will be completely soluble in water

using a 3:1 ratio of water volume to solids mass. This prediction agrees well with the water leaching test results. However, comparing the final water leach solution concentrations for the first water contact with the model predictions showed the model was over-predicting the sulfate concentration by 40-50%. This indicates the annulus samples may have some percentage of sulfate that is not soluble in water.

The simple model predictions for the solubility of Hg and Si in water match the measured values from the leaching test because the ratios of the more soluble and less soluble forms of Hg and Si in the model were adjusted to yield values that matched solubilities measured in the water leaching tests. As it turned out, that division of the Si between the more water soluble hydroxysodalite and the less water soluble silicon dioxide for each sample composition was similar to the percentages of each observed in the XRD results of the as-received solids. The total Hg concentration of the sample was divided between the more water soluble HgO and the less water soluble elemental Hg. The model does poorly predicting the solubility of Al, Fe, Ca, K, and Mg with differences of greater than +/- 2X compared to the solution concentrations from the leaching test results. However, the model predictions closely matched the total amount of material dissolved in the water leaching test.

The simple model predictions of the oxalic acid leaching test showed large deviations (greater than +/- 2X) from the measured solution concentrations in the oxalic acid leaching tests. This difference may result from a thermodynamics issue and the simple model only containing one leaching cycle. The thermodynamic modeling software takes all reactions to equilibrium. However, some of the dissolution reactions of the Tank 16 annulus solids in oxalic acid may require more than the 24 hour time period used in the leaching test to reach equilibrium. The results from the leaching tests indicate more material continued to dissolve from the annulus solids with each oxalic acid contact. Both of these issues indicate the simple model will not be sufficient for predicting the amount of Tank 16 annulus solids dissolved by oxalic acid leaching.

A larger model with three successive leaching/decant steps was developed to better evaluate the ability of the software to predict the leaching test results. This model used the same Mix block followed by a Filter block that allows partitioning of the liquid phase. The slurry output from the Filter block feeds the next Mix block.

The larger, three leaching cycle ESP model appears to predict the dissolution of water soluble components from the Tank 16 Annulus solids with reasonable accuracy but shows large deviations (greater than +/- 2X) from the measured solution concentrations for the components with low water solubility. However, since very little of these low water solubility components dissolved in the water leaching test, the large deviations from the measured solution concentrations may be less important than the generalized prediction of low solubility by the model. The model accurately predicted (<20% difference) the total amount of material dissolved from the annulus solids after three leaching cycles.

In modeling the oxalic acid leaching test results, the larger model showed large deviations (greater than $\pm 2X$) from the measured solution concentrations for each leaching cycle even for the most water soluble components. However, the model correctly predicted which components would exhibit high and low solubility in the oxalic acid and predicted the total amount of material dissolved from the annulus solids within 20% for the one sample examined.

Even given the inaccuracies in the model, it can be of some benefit in planning and evaluating processing options. Recommendations for modeling the leaching of Tank 16 Annulus solids include;

- Use the species shown in Table 4-1 for the chemistry model and the MSE framework. However, evaluation of other Hg species may provide better results for Hg solubility predictions.
- Develop a model construction that allows the simulation of three successive oxalic acid contacts since the tests showed that additional material will dissolve from the Tank 16 Annulus solids with each contact.

5.0 Conclusions

Table 5-1 summarizes the composition of the major components of the as-received annulus samples, the water leached solids, and the oxalic acid leached solids. The analysis found all four annulus samples to be composed mainly of Si, Na, Al, and Fe and lesser amounts of other elements both before and after leaching with either water or oxalic acid. The solid-phase sodium concentration decreases with both water and oxalic acid leaching, due to dissolution of dominant sodium salts such as NaNO_3 and NaNO_2 . The silicon concentration in the solids remaining after leaching increases substantially since very little of the silicon containing compounds dissolve in either leaching solution. With water leaching, the data indicate that most of the material that will be leached dissolves in the first water contact. Subsequent water contacts merely serve to dilute the concentrations of the dissolved solids in the interstitial liquid.³ The oxalic acid leaching results indicate that material from the annulus continues to dissolve with each new contact. The pH of the solution drops with each addition of oxalic acid persuading more material to dissolve.

Table 5-1. Summary of the Composition of the As-Received, Water Leached, and Oxalic Acid Leached Solids from Tank 16H Annulus Samples (Wt% Total Dried Solids)

Sample ID	Si wt%	Na wt%	Al wt%	Fe wt%	Ca wt%	S wt%	Hg wt%
HTF-16-E-2	17.0%	12.1%	6.62%	6.54%	1.58%	0.14%	0.21%
HTF-16-E-2 WL	21.1%	9.50%	9.73%	3.68%	1.57%	0.06%	0.18%
HTF-16-E-2 OAL	23.5%	4.78%	6.82%	3.47%	1.58%	0.06%	0.13%
HTF-16-N-1	21.1%	12.1%	7.27%	1.12%	0.61%	0.16%	0.10%
HTF-16-N-1 WL	25.1%	10.8%	9.47%	0.79%	0.22%	<0.05%	0.07%
HTF-16-N-1 OAL	21.5%	5.13%	9.53%	1.31%	0.37%	0.06%	0.16%
HTF-16-S-2	17.1%	15.9%	4.20%	2.01%	0.47%	0.55%	0.35%
HTF-16-S-2 WL	20.6%	7.32%	8.05%	2.84%	0.37%	0.09%	0.27%
HTF-16-S-2 OAL	20.2%	3.31%	5.19%	2.28%	0.39%	0.24%	0.37%
HTF-16-W-1	11.7%	17.9%	8.35%	3.58%	0.14%	0.14%	0.26%
HTF-16-W-1 WL	17.5%	12.1%	12.30%	2.46%	1.19%	<0.05%	0.25%
HTF-16-W-1 OAL	26.2%	9.25%	9.61%	1.73%	0.09%	0.09%	0.20%

Sample ID's ending in -WL are from the water leach and those ending in -OAL are from the oxalic acid leach./

Based on the weight of solids used in each test and the weight of solids remaining at the end of the test, Table 5-2 indicates 20-35% of the solids dissolved after three water contacts with an approximately 3:1 volume of water to solids at 45 °C. The oxalic acid leaching tests dissolved slightly more material ranging from 34%-47% with an approximately 3:1 volume of oxalic acid to solids at 45 °C. With both leaching solutions sample HTF-16-E-2 showed the least dissolution and samples HTF-16-S-2 and HTF-16-W-1 showed the highest percentage dissolution.

Table 5-2. Estimated Percent of Solids Dissolved in the Water Leaching and Oxalic Acid Leaching Tests on Tank 16H Annulus Samples

Sample ID	Estimated Percent Dissolved in Water Leach	Estimated Percent Dissolved in Oxalic Acid Leach
HTF-16-E-2	20%	34%
HTF-16-N-1	29%	38%
HTF-16-S-2	35%	46%
HTF-16-W-1	33%	47%

Tables 5-3 and 5-4 provide summaries of the leaching behavior of the radionuclides analyzed in the samples from the water leaching and oxalic acid leaching tests. The estimated percent removal values were calculated from the concentration of the radionuclide in the as-received solids minus the estimated amount removed in each leaching cycle. The percentage removal values can only be estimated since the amount decanted varied based on the settling characteristics of the sample. For the calculations, 100 mL of the first decant and 150 mL of the second and third decants were assumed to be removed. The estimated values from the water leaching differ slightly from the previously reported values because they include material from all three water contacts instead of just the first water contact. The values for the estimated percent of solids dissolved in the water leaching presented in the previous report only included the material removed in the first leaching cycle.³ The total strontium results from the ICP-ES method provide insight into the behavior for ⁹⁰Sr. The oxalic acid leach was somewhat more effective at removing the radionuclides from the annulus solids than the water leach.

Table 5-3. Summary of the Estimated Percentage Dissolved for each Radionuclide from the Water Leaching Test on Tank 16H Annulus Samples

Radionuclide	HTF-16-E-2	HTF-16-N-1	HTF-16-S-2	HTF-16-W-1
Cs-137	2.8%	3.1%	5.7%	3.6%
Sr	<0.2%	<0.9%	<0.5%	0.7%
Tc-99	35%	32%	34%	29%
U-235	56%	52%	16%	8.1%
U-238	53%	58%	16%	7.9%
Np-237	31%	16%	<8.5%	7.5%
Pu-239	20%	4.1%	<1.9%	<0.4%

Table 5-4. Summary of the Estimated Percentage Dissolved for each Radionuclide from the Oxalic Acid Leaching Test on Tank 16H Annulus Samples

Radionuclide	HTF-16-E-2	HTF-16-N-1	HTF-16-S-2	HTF-16-W-1
Cs-137	34%	38%	57%	31%
Sr	11%	21%	15%	29%
Tc-99	38%	54%	49%	40%
U-235	67%	98%	67%	67%
U-238	64%	103%	72%	64%
Np-237	35%	58%	49%	53%
Pu-239	15%	46%	34%	22%

The chemical analysis of the leachates and the XRD results of the remaining solids indicate sodium salts of nitrate, nitrite, sulfate, and possibly carbonate/bicarbonate make up the majority of the dissolved material with both leaching solutions. The oxalic acid leach also dissolved some fraction of the aluminum in the samples. Based on the results of the leachate analysis, the majority of these salts were dissolved in the first water contact and simply diluted with each subsequent water contact. However, in the oxalic acid leach, material continued to dissolve with each subsequent contact. The pH of the oxalic acid solutions continued to drop with each contact. Solution concentrations from water and oxalic acid leaching in the annulus can be expected to be lower than found in these small scale tests due to the monolithic structure of the waste in the annulus resulting in lower available surface area.

The somewhat higher dissolution found in the oxalic acid leaching test versus the water leaching test might be offset by the tendency of the oxalic acid solutions to take on a gel-like consistency. The filtered solids left behind after three oxalic acid contacts were sticky and formed large clumps after drying. These two observations could indicate potential processing difficulties with solutions and solids from oxalic acid leaching. The gel formation might be avoided by using larger volumes of the acid.

6.0 Recommendation

Further testing would be recommended before using oxalic acid to dissolve the Tank 16H annulus waste to ensure no processing difficulties are encountered in the full scale process.

7.0 References

1. M. S. Hay, S. H. Reboul, "Task Technical and Quality Assurance Plan for the Analysis of Tank 16 Annulus Process Samples", SRNL-RP-2011-01169, Rev. 1, November 14, 2011.
2. Technical Task Request, HLE-TTR-2011-010, C. B. Sherburne. November 14, 2011.
3. M. S. Hay, S. H. Reboul, "Characterization of Tank 16 Annulus Samples", SRNL-STI-2012-00178, Rev. 0, April, 2012.
4. M. S. Hay, "Characterization of Samples from Tank 16H Annulus", WSRC-STI-2008-00203, Rev. 0, May 2008.
5. M. S. Hay, "Results of the Characterization and Dissolution Tests of Samples from Tank 16H", WSRC-RP-99-00124, Rev. 0, January 19, 1999.
6. L. Reynolds, "Summary of Current Data on Tank 16H Annulus Samples", DPST-79-360, January 9, 1979.
7. C. J. Coleman, R. A. Dewberry, M. F. Bryant, J. J. Gemmill, "SRL's Performance in Round Robin #6 - Analysis of Simulated Defense Waste Glass", WSRC-TR-91-187, Rev. 0, May 31, 1991.
8. M. S. Hay, T. B. Edwards, "Statistical Analysis of ESP Verification Test Samples", WSRC-RP-94-1224, Rev. 0, November 4, 1994.

Appendix A

Table A-1. Composition of Blanks and Standards for the Water Leached Solids from Tank 16H Annulus Sample

Analyte (Method)	Aqua Regia Blank (mg/kg)	Per Fusion Blank (mg/kg)	Aqua Regia Glass Std (mg/kg)	Per Fusion Glass Std (mg/kg)	Glass Std Composition (mg/kg)
Ag (IE)	<1.15E+02	<1.15E+03	<1.12E+02	<1.15E+03	-
Al (IE)	5.11E+01	2.98E+02	2.44E+04	2.52E+04	2.50E+04
B (IE)	<1.62E+01	<1.62E+02	2.63E+04	2.54E+04	2.69E+04
Ba (IE)	<4.16E+00	<4.16E+01	8.27E+02	7.99E+02	7.88E+02
Be (IE)	<4.80E-01	<6.40E+00	2.19E+01	2.40E+01	-
Ca (IE)	3.82E+01	3.49E+03	1.08E+04	1.33E+04	1.02E+04
Cd (IE)	<2.48E+00	<2.48E+01	4.44E+00	<2.48E+01	-
Ce (IE)	<5.66E+01	<5.66E+02	<5.50E+01	<5.66E+02	-
Co (IE)	<7.76E+00	<7.76E+01	6.54E+01	<7.76E+01	-
Cr (IE)	<6.56E+00	<8.16E+01	7.23E+02	6.49E+02	6.36E+02
Cu (IE)	<5.04E+00	<5.04E+01	1.87E+01	7.20E+01	3.20E+01
Fe (IE)	1.84E+02	2.65E+02	9.89E+04	9.74E+04	9.79E+04
Gd (IE)	<1.72E+01	<1.72E+02	<1.67E+01	<1.72E+02	-
K (IE)	<2.05E+02	3.93E+03	2.13E+04	2.65E+04	2.25E+04
La (IE)	<5.36E+00	<5.36E+01	6.30E+00	<5.36E+01	-
Li (IE)	<1.17E+01	<1.17E+02	1.46E+04	1.44E+04	1.49E+04
Mg (IE)	6.16E+00	1.84E+01	5.19E+03	5.28E+03	5.19E+03
Mn (IE)	<4.24E+00	<1.68E+01	1.46E+04	1.44E+04	1.46E+04
Mo (IE)	<4.94E+01	<2.14E+02	<4.80E+01	<2.14E+02	-
Na (IE)	<5.90E+02	-	8.30E+04	-	8.53E+04
Ni (IE)	<3.64E+01	<3.64E+02	7.89E+03	7.99E+03	8.25E+03
P (IE)	<6.93E+01	<6.93E+02	1.10E+03	1.03E+03	9.60E+02
Pb (IE)	<5.73E+01	<5.73E+02	<5.57E+01	<5.73E+02	-
S (IE)	<6.00E+02	<6.00E+03	6.44E+02	<6.00E+03	-
Sb (IE)	<1.02E+02	<8.53E+02	1.52E+02	<8.53E+02	-
Si (IE)	-	<7.82E+02	-	2.33E+05	2.24E+05
Sn (IE)	<4.49E+01	<4.49E+02	7.55E+01	<4.49E+02	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

Table A-1. Composition of Blanks and Standards for the Water Leached Solids from Tank 16H Annulus Sample (continued)

Analyte (Method)	Aqua Regia Blank (mg/kg)	Per Fusion Blank (mg/kg)	Aqua Regia Glass Std (mg/kg)	Per Fusion Glass Std (mg/kg)	Glass Std Composition (mg/kg)
Sr (IE)	<4.00E-01	3.52E+01	3.21E+01	6.72E+01	3.13E+01
Th (IE)	<4.28E+01	<4.38E+02	<4.16E+01	<4.38E+02	-
Ti (IE)	<1.04E+00	<3.04E+01	5.37E+03	6.76E+03	6.89E+03
U (IE)	<2.61E+02	<2.61E+03	<2.54E+02	<2.61E+03	-
V (IE)	<3.76E+00	<3.76E+01	1.11E+02	1.03E+02	-
Zn (IE)	<7.36E+00	<7.36E+01	1.74E+02	1.96E+02	1.61E+02
Zr (IE)	<4.40E+00	-	6.25E+02	-	9.63E+02
Hg (CV)	<4.40E+01	-	<4.28E+01	-	-
²³² Th (IM)	<1.00E+00	<1.00E+00	1.83E+00	2.99E+00	-
²³³ U (IM)	<1.00E+00	<1.00E+00	<9.73E-01	<1.00E+00	-
²³⁴ U (IM)	<1.00E+00	<1.00E+00	<9.73E-01	<1.00E+00	-
²³⁵ U (IM)	<1.50E+00	<1.00E+00	<1.46E+00	<1.00E+00	-
²³⁶ U (IM)	<1.00E+00	<2.00E+00	<9.73E-01	<2.00E+00	-
²³⁸ U (IM)	<1.00E+00	1.38E+00	6.30E+00	7.31E+00	-
U-total (IM)	<1.00E+00	1.38E+00	7.76E+00	7.31E+00	-
⁹⁰ Sr (BS)	<5.82E-03	<5.95E-03	<7.52E-03	<6.90E-03	-
¹³⁷ Cs (GS)	<3.20E-02	<3.41E-02	<3.72E-02	<3.99E-02	-
²³⁸ Pu (SA)	<9.08E-05	<4.42E-05	<7.18E-05	9.34E-05	-
⁹⁹ Tc (IM)	<1.00E+00	<1.00E+00	<9.73E-01	<1.00E+00	-
²³⁷ Np (IM)	<1.00E+00	<2.50E+00	<9.73E-01	<2.50E+00	-
²³⁹ Pu (IM)	<2.00E+00	<1.00E+00	<1.95E+00	<1.00E+00	-
²⁴⁰ Pu (IM)	<1.00E+00	<2.00E+00	<9.73E-01	<2.00E+00	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

Table A-1. Composition of Blanks and Standards for the Water Leached Solids from Tank 16H Annulus Sample (continued)

Analyte (Method)	Aqua Regia Blank (dpm/g)	Per Fusion Blank (dpm/g)	Aqua Regia Glass Std (dpm/g)	Per Fusion Glass Std (dpm/g)	Glass Std Composition (dpm/g)
⁹⁰ Sr (BS)	<1.77E+06	<1.81E+06	<2.29E+06	<2.10E+06	-
¹³⁷ Cs (GS)	<6.16E+06	<6.56E+06	<7.16E+06	<7.68E+06	-
²³⁸ Pu (SA)	<3.45E+03	<1.68E+03	<2.73E+03	3.55E+03	-
^{239/240} Pu (SA)	<3.94E+03	<2.84E+03	<1.18E+03	<3.06E+03	-
⁹⁹ Tc (IM)	<3.77E+04	<3.77E+04	<3.66E+04	<3.77E+04	-
²³² Th (IM)	<2.44E-01	<2.44E-01	4.46E-01	7.31E-01	-
²³³ U (IM)	<2.14E+04	<2.14E+04	<2.08E+04	<2.14E+04	-
²³⁴ U (IM)	<1.39E+04	<1.39E+04	<1.35E+04	<1.39E+04	-
²³⁵ U (IM)	<7.19E+00	<4.80E+00	<7.00E+00	<4.80E+00	-
²³⁶ U (IM)	<1.44E+02	<2.87E+02	<1.40E+02	<2.87E+02	-
²³⁷ Np (IM)	<1.56E+03	<3.91E+03	<1.52E+03	<3.91E+03	-
²³⁸ U (IM)	<7.46E-01	1.03E+00	4.70E+00	5.45E+00	-
²³⁹ Pu (IM)	<2.72E+05	<1.36E+05	<2.65E+05	<1.36E+05	-
²⁴⁰ Pu (IM)	<5.01E+05	<1.00E+06	<4.87E+05	<1.00E+06	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

Table A-2. Composition of Blanks and Standards for the Oxalic Acid Leached Solids from Tank 16H Annulus Sample

Analyte (Method)	Aqua Regia Blank (mg/kg)	Per Fusion Blank (mg/kg)	Aqua Regia Glass Std (mg/kg)	Per Fusion Glass Std (mg/kg)	Glass Std Composition (mg/kg)
Ag (IE)	<1.15E+02	<1.15E+03	<1.07E+02	<1.05E+03	-
Al (IE)	5.42E+01	2.31E+03	2.40E+04	2.46E+04	2.50E+04
B (IE)	<1.62E+01	<1.62E+02	2.62E+04	2.49E+04	2.69E+04
Ba (IE)	<4.16E+00	1.26E+02	8.04E+02	8.21E+02	7.88E+02
Be (IE)	<4.80E-01	<6.40E+00	2.13E+01	2.69E+01	-
Ca (IE)	3.73E+01	3.53E+03	1.08E+04	1.29E+04	1.02E+04
Cd (IE)	<2.48E+00	<2.48E+01	3.57E+00	<2.25E+01	-
Ce (IE)	<5.66E+01	<5.66E+02	<5.26E+01	<5.14E+02	-
Co (IE)	<7.76E+00	<6.80E+01	6.22E+01	8.29E+01	-
Cr (IE)	<6.56E+00	<6.56E+01	7.08E+02	6.73E+02	6.36E+02
Cu (IE)	<5.04E+00	<5.04E+01	1.53E+01	<4.58E+01	3.20E+01
Fe (IE)	2.48E+01	2.54E+02	9.78E+04	9.60E+04	9.79E+04
Gd (IE)	<1.72E+01	<1.72E+02	<1.60E+01	<1.56E+02	-
K (IE)	<2.05E+02	<2.05E+03	2.25E+04	2.42E+04	2.25E+04
La (IE)	<5.36E+00	<5.36E+01	<4.98E+00	<4.87E+01	-
Li (IE)	<1.17E+01	<1.17E+02	1.46E+04	1.40E+04	1.49E+04
Mg (IE)	4.84E+00	1.28E+01	5.24E+03	5.12E+03	5.19E+03
Mn (IE)	<4.24E+00	<1.68E+01	1.44E+04	1.41E+04	1.46E+04
Mo (IE)	<4.94E+01	<2.14E+02	<4.59E+01	<1.95E+02	-
Na (IE)	8.77E+02	-	8.52E+04	-	8.53E+04
Ni (IE)	<3.64E+01	<3.64E+02	8.06E+03	7.82E+03	8.25E+03
P (IE)	<6.93E+01	<1.31E+03	1.11E+03	1.27E+03	9.60E+02
Pb (IE)	<5.73E+01	<5.73E+02	<5.32E+01	<5.21E+02	-
S (IE)	<6.00E+02	<6.00E+03	<5.58E+02	<5.45E+03	-
Sb (IE)	<1.02E+02	<8.53E+02	1.63E+02	<7.75E+02	-
Si (IE)	-	<3.51E+02	-	1.57E+05	2.24E+05
Sn (IE)	<4.49E+01	<4.49E+02	6.30E+01	<4.08E+02	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

Table A-2. Composition of Blanks and Standards for the Oxalic Acid Leached Solids from Tank 16H Annulus Sample (continued)

Analyte (Method)	Aqua Regia Blank (mg/kg)	Per Fusion Blank (mg/kg)	Aqua Regia Glass Std (mg/kg)	Per Fusion Glass Std (mg/kg)	Glass Std Composition (mg/kg)
Sr (IE)	<4.00E-01	3.60E+01	3.25E+01	5.89E+01	3.13E+01
Th (IE)	<4.28E+01	<2.14E+02	<3.98E+01	<1.95E+02	-
Ti (IE)	<1.04E+00	<1.04E+01	4.50E+03	6.76E+03	6.89E+03
U (IE)	<2.61E+02	<2.61E+03	<2.43E+03	<2.37E+03	-
V (IE)	<3.76E+00	<3.76E+01	1.09E+02	1.03E+02	-
Zn (IE)	1.31E+01	<5.28E+01	1.67E+02	2.29E+02	1.61E+02
Zr (IE)	6.56E+00	-	4.09E+02	-	9.63E+02
Hg (CV)	<4.40E+01	-	<4.01E+01	-	-
²³² Th (IM)	<2.00E-01	<1.20E+00	1.48E+00	2.09E+00	-
²³³ U (IM)	<2.00E-01	<8.00E-01	<1.86E-01	<7.27E-01	-
²³⁴ U (IM)	<2.00E-01	<8.00E-01	<1.86E-01	<7.27E-01	-
²³⁵ U (IM)	<2.00E-01	<8.00E-01	<1.86E-01	<7.27E-01	-
²³⁶ U (IM)	<2.00E-01	<8.00E-01	<1.86E-01	<7.27E-01	-
²³⁸ U (IM)	<5.00E-01	<1.20E+00	4.84E+00	5.49E+00	-
U-total (IM)	<1.30E+00	<4.40E+00	4.84E+00	5.49E+00	-
⁹⁰ Sr (BS)	<7.03E-03	<6.08E-03	<5.42E-03	<6.47E-03	-
¹³⁷ Cs (GS)	<3.74E-02	<2.53E-02	<3.79E-02	<3.00E-02	-
²³⁸ Pu (SA)	<2.18E-04	<8.95E-05	<7.18E-05	7.47E-05	-
⁹⁹ Tc (IM)	<3.00E-01	<8.00E-01	<2.79E-01	7.27E-01	-
²³⁷ Np (IM)	<2.00E-01	<8.00E-01	<1.86E-01	<7.27E-01	-
²³⁹ Pu (IM)	<2.00E-01	<2.00E+00	<1.86E-01	<1.82E+00	-
²⁴⁰ Pu (IM)	<2.00E-01	<8.00E-01	<1.86E-01	<7.27E-01	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.

Table A-2. Composition of Blanks and Standards for the Oxalic Acid Leached Solids from Tank 16H Annulus Sample (continued)

Analyte (Method)	Aqua Regia Blank (dpm/g)	Per Fusion Blank (dpm/g)	Aqua Regia Glass Std (dpm/g)	Per Fusion Glass Std (dpm/g)	Glass Std Composition (dpm/g)
⁹⁰ Sr (BS)	<2.14E+06	<1.85E+06	<1.65E+06	<1.97E+06	-
¹³⁷ Cs (GS)	<7.20E+06	<4.88E+06	<7.29E+06	<5.78E+06	-
²³⁸ Pu (SA)	<8.29E+03	<3.40E+03	<2.73E+03	<2.84E+03	-
^{239/240} Pu (SA)	2.89E+03	<3.85E+03	<2.63E+03	<2.49E+03	-
⁹⁹ Tc (IM)	<1.13E+04	<3.01E+04	<1.05E+04	2.74E+04	-
²³² Th (IM)	<4.88E-02	<2.93E-01	3.62E-01	5.11E-01	-
²³³ U (IM)	<4.28E+03	<1.71E+04	<3.98E+03	<1.56E+04	-
²³⁴ U (IM)	<2.78E+03	<1.11E+04	<2.58E+03	<1.01E+04	-
²³⁵ U (IM)	<9.59E-01	<3.84E+00	<8.91E-01	<3.49E+00	-
²³⁶ U (IM)	<2.87E+01	<1.15E+02	<2.67E+01	<1.04E+02	-
²³⁷ Np (IM)	<3.13E+02	<1.25E+03	<2.91E+02	<1.14E+03	-
²³⁸ U (IM)	<3.73E-01	<8.95E-01	3.61E+00	4.09E+00	-
²³⁹ Pu (IM)	<2.72E+04	<2.72E+05	<2.53E+04	<2.48E+05	-
²⁴⁰ Pu (IM)	<1.00E+05	<4.01E+05	<9.31E+04	<3.64E+05	-

Values in italics were not used in calculating the average. Divide mg/kg values by 1E+04 to convert to wt % basis.