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Small Column Ion Exchange Testing of Superlig 644 for Removal of ^{137}Cs from Hanford Tank Waste Envelope C (Tank 241-AN-107)

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Summary

The current BNFL Inc. flowsheet for the pretreatment of the Hanford high-level tank wastes includes the use of Superlig® materials for removing ^{137}Cs from the aqueous fraction of the waste. The Superlig® materials applicable to cesium removal include the cesium-selective Superlig®632 and Superlig®644. These materials have been developed and supplied by IBC Advanced Technologies, Inc., American Fork, Utah.

This report describes the testing of the Superlig®644 ion exchange material in a small dual-column system. The bed volume of the lead column was 18.6 mL (L/D = 7), and the bed volume of the lag column was 15.9 mL (L/D=6) during the loading phase. The sample processed was approximately 1.6 L of diluted waste ($[Na^+]$ = 4.84 M) from Tank 241-AN-107 (Envelope C). This sample had been previously treated for removal of Sr/transuranic (TRU) values and clarified in a single tube cross-flow filtration unit. All ion exchange process steps were tested, including resin-bed preparation, loading, feed displacement, water rinse, elution, eluant rinse, and resin regeneration.

A summary of performance measures for both columns is shown in Table S1. The Cs λ values represent a measure of the effective capacity of the SL-644 resin. The Cs λ of 20 for the lead column is much lower than the estimated 150 obtained by the Savannah River Technology Center during Phase 1A testing. Equilibrium data obtained with batch contacts using the AN-107 Cs IX feed predicts a Cs λ of 183. A Cs λ for the lag column could not be determined due to insufficient breakthrough, but it appeared to work well and removed nearly all of the cesium not removed by the lead column. The low value for the lead column indicates that it did not perform as expected. This may have been due to air or gas in the bed that caused fluid channeling or blinding of the resin. The maximum decontamination factor (DF) for ^{137}Cs listed in Table S1 is based on ^{137}Cs concentration in the first samples collected from each column and the ^{137}Cs concentration in the feed. The composite DF for ^{137}Cs was 1760, which provided an effluent with a ^{137}Cs concentration of 8.7E-02 Ci/m^3. The ^{137}Cs concentration is below the basis of design limit and is 7.2% of the contract limit for ^{137}Cs.

Table S1. Summary of Performance Measures

Flow Rate (BV[a]/hr)	Cs λ		Composite DF	Maximum ^{137}Cs DF	
	Lead Column	Lag Column		Lead Column	Lag Column
4.6	20	--	1760	4.2	114,000

(a) BV = Bed Volume

The elution of both columns proceeded very well with the majority of the ^{137}Cs contained in 2.4 BVs of eluant (0.5 M nitric acid). The peak C/C_o values for ^{137}Cs were 34 for the lead column and 61 for the lag column.

Terms and Abbreviations

BNFL	BNFL, Inc; subsidiary of British Nuclear Fuels, Ltd.
BV	Bed Volume
C/C_0	analyte concentration in column effluent divided by analyte concentration in feed
DF	decontamination factor
DI	deionized water
DL	detection limit
E	elution
ER	elution rinse
F	feed
FD	feed displacement
GEA	gamma energy analysis
HLW	high-level waste
HLRF	High Level Radiation Facility
IC	ion chromatography
ICP AES	inductively coupled plasma/atomic emission spectrometry
ICP MS	inductively coupled plasma/mass spectrometry
LAW	low-activity waste
L/D	bed length (height) to diameter ratio
MDL	method detection limit
MRQ	minimum reportable quantity
NMRQ	no minimum reportable quantity
R	regeneration
SAL	Shielded Analytical Laboratory
SRTC	Savannah River Technology Center
TIC	total inorganic carbon
TOC	total organic carbon
TRU	transuranic

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1.0 Introduction

The current BNFL Inc. flow sheet for the pretreatment of the Hanford high-level tank wastes (HLWs) includes the use of Superlig® materials for removing ^{137}Cs from the aqueous fraction of the waste. The Superlig® materials applicable to cesium removal include the cesium selective Superlig®632 (SL-632) and Superlig®644 (SL-644). These materials have been developed and supplied by IBC Advanced Technologies, Inc., American Fork, Utah.

This report describes the small-column testing of the Superlig®644 ion exchange material.[a] The sample processed was approximately 1.6 L of diluted and treated waste (@ 4.84 M Na) from Tank 241-AN-107 (the 241 prefix, which is common to all Hanford tanks, will not be used hereafter). This waste had been previously treated for removal of Sr/transuranic (TRU) values and clarified in a single-tube cross-flow filtration unit (Hallen et al. 2000). The ion exchange process steps tested include resin-bed preparation, loading, feed displacement, water rinse, elution, and resin regeneration.

The objectives of this work were to:

- demonstrate the ^{137}Cs decontamination of Envelope C (Tank AN-107) and provide a cesium decontaminated sample for downstream process testing (i.e., ^{99}Tc removal, SO_4 removal, corrosion testing, low activity waste [LAW] melter feed testing and LAW vitrification)
- demonstrate the effectiveness of all SL-644 ion exchange process steps, including loading, feed displacement, deionized (DI) water washing, elution, and resin regeneration
- obtain process performance data for SL-644 at conditions different than those previously tested
- investigate exchanger/waste chemistry
- investigate the potential for exchanger fouling.

[a] The results presented in this report are based on work conducted under Test Plan TP-29953-3 Rev. 1 (November 1999), and test instructions BNFL-TI-29953-053, BNFL-TI-29953-062, BNFL-TI-29953-066. Some data are recorded in Laboratory Record Book BNW 13687. Conditions for conducting these tests were given in the "Ion Exchange Test Specification Rev 2," TSP-W375-99-00013 Rev 2.

2.0 Experimental

2.1 Ion Exchange Column System

A schematic of the ion exchange column system is shown in Figure 2.1. The system consists of two small columns containing the ion exchange material, a small metering pump, four valves, a pressure gauge, and a pressure relief valve. Valve 1 is a five-way valve that allows switching between the waste feed and various process solutions. Valves 2, 3, and 4 are three-way valves that can be turned to the flow position, sample position, or no-flow position. Valve 2 is placed at the outlet of the pump and is used to eliminate air from the system, purge the initial volume of the system, or isolate the columns from the pump. Valves 3 and 4 are primarily used for obtaining samples, and may also be used to isolate the columns from the rest of the system. The columns are Kontes Chromaflex chromatography columns made of glass with adjustable plungers on the bottom and the top. The inside diameter of the columns is 1.5 cm, which corresponds to a volume of 1.77 mL/cm of length. The connecting tubing is ¼-in. OD ($^1/_8$-in. ID) polyethylene. The columns are connected in series with the first column referred to as the lead column, and the second column referred to as the lag column. The pump is an FMI piston pump with the flow rate controlled from outside of the hot cell with an FMI stroke-rate controller. The pump was calibrated with the stroke-rate controller and can provide pumping rates from 0–152 mL/h. The volume actually pumped is determined using the mass of the fluid and the fluid density. The pressure relief valve is set at 40 psi, which is below the maximum operating pressure of 45 psi for the columns. The pressure indicated on the pressure gauge remained below 5 psi during the run. The total holdup volume of the Cs IX system was estimated to be 60 mL with the holdup volume to Valve 2 being 30 mL.

2.2 SL-644 Resin and Bed Preparation

Some properties of the as-received, hydrogen form of the SL-644 resin (Batch # = 644BZ) are shown in Table 2.1. The Battelle values at room temperature and at 85°C are duplicated from Kurath et al. (1999a) while all of the Savannah River Technology Center (SRTC) data are reproduced from Hassan et al. (1999). The F factor is the ratio of the dry mass of exchanger to the initial mass of the exchanger. This was obtained by drying approximately 0.5 g in an oven at the temperature of interest until there was no significant change in mass. The as-received bulk density was determined by weighing approximately 10 mL of exchanger in a 50-mL graduated cylinder. The dry bulk densities were obtained by multiplying the as-received bulk density by the appropriate f factor. A particle density of 1.611 g/mL was reported by Hassan et al. (1999).

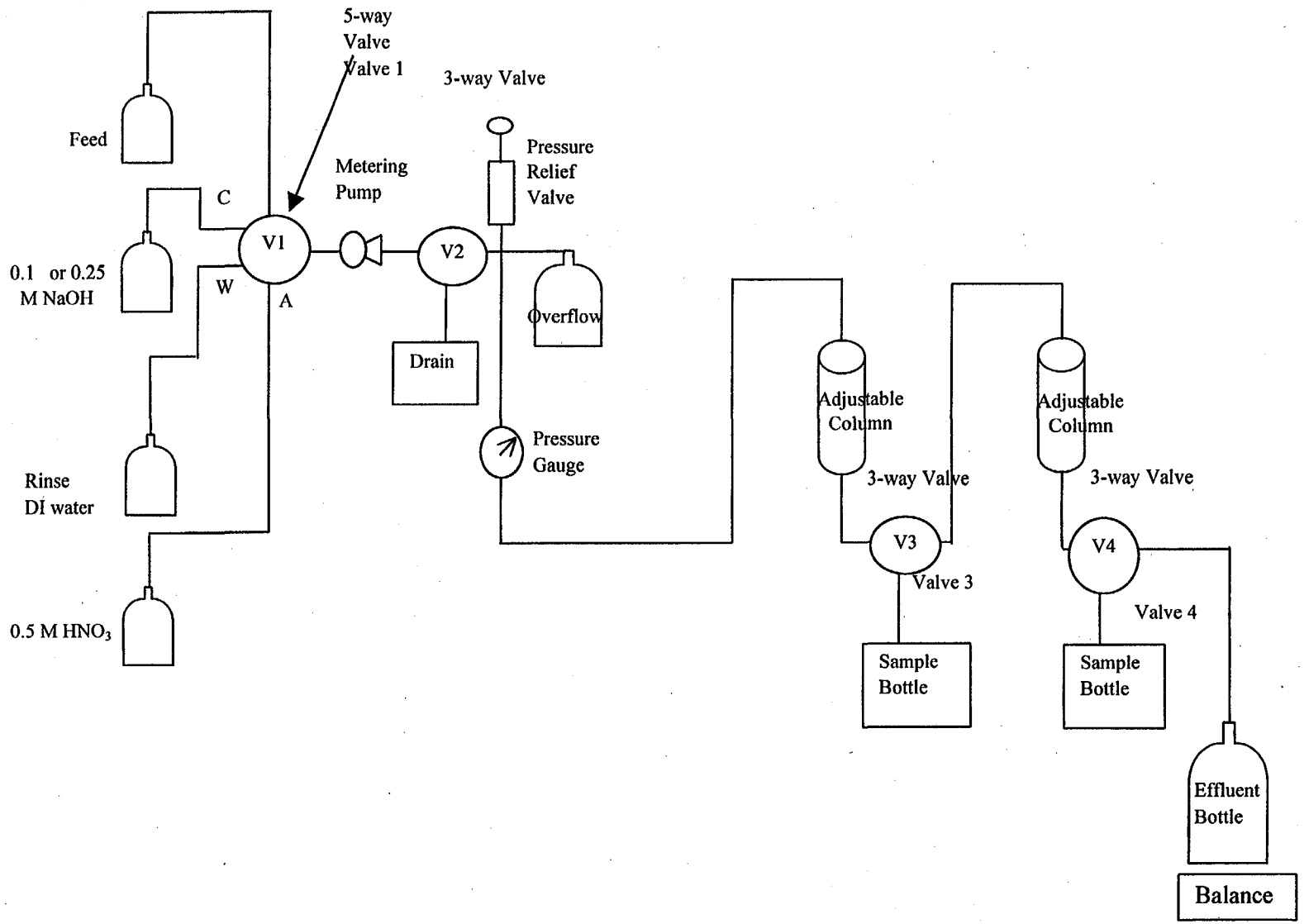


Figure 2.1. Cesium Ion Exchange Column System

Table 2.1. Physical Properties of the As-Received Hydrogen Form of SL-644

	Battelle	SRTC
as-received bulk density (room temperature)	0.86 g/mL	0.88
dry as received bulk density (85°C)	0.78 g/mL	-
dry as received bulk density (95°C)	0.69 g/mL	0.793 g/mL
F factor @ 85°C (% water)	0.907 (9.3%)	-
F factor @ 95°C (% water)	0.80 (20%)	0.9 (10%)

The particle size distribution for the as-received SL-644 resin subsample (Kurath et al. 1999a) is compared to the subsample used in column experiments by SRTC (Hassan et al. 1999) in Table 2.2. It is apparent that the average particle size of the Battelle subsample is smaller than that of the SRTC subsample. The data are not precise enough to allow an accurate estimate of the average particle diameter, but the average apparently lies between 210 and 425 microns with a rough estimate of 330 microns.

Table 2.2. Particle Size Distribution of the As-Received, Hydrogen Form of SL-644

Sieve Size	Size (μm)	Battelle Subsample (wt %)	Size (μm)	SRTC Subsample (wt%)
	>600	not measured	>600	14
40	>425	9.9	600–425	44
70	425–210	88	425–210	40
100	210–149	2.1	210–62	0
200	149–74	0		

The resin beds used in this experiment were previously used to remove cesium from a waste sample from Tank AW-101 (Envelope A) (Kurath et al. 2000). The initial SL-644 resin and bed preparation was performed using a procedure similar to that recommended by Hassan et al. (1999) with the exception that the solution volumes and flow rates were larger. Before packing the resin bed, two 7.9-g batches of the as-received SL-644 resin were placed in separate beakers. The resin was soaked in about 70 mL of 1 M NaOH with light agitation for 2.5 h. The NaOH was decanted, and the SL-644 was washed three times with 100 mL of DI water per wash. The resin was then slurried into the columns in DI water. The swollen resin volume was about 22 mL and was greater than required. Approximately 32% of the slurried resin volume was removed, leaving about 5.4 g of as-received resin per column. The F factor was determined to be 0.80 at 95°C so the amount of SL-644 in each column was about 4.3 g on a dry basis (Kurath et al. 2000). Before installing the system into the hot cell, both of the resin beds were cycled through the acid form with the solution amounts shown in Table 2.3. The solution volumes were significantly in excess of those planned for full-scale operation to ensure that the system was completely flushed and that the resin beds were fully conditioned. The total system hold-up volume was 60 mL.

Table 2.3. Shakedown Testing and Bed Conditioning Parameters

	Solution	Volume	Contact Time
Elution	0.5 M HNO_3	> 6 BV[(a)] (90 mL)	> 1 h
Eluant Rinse	DI water	> 6 BV (90 mL)	> 1 h
Regeneration	0.25 M NaOH	> 6 BV (90 mL)	> 1 h
DI Water Wash	DI water	> 6 BV (90 mL)	> 1 h

(a) BV = Bed Volume

A number of the resin bed properties determined during the testing discussed in this report are shown in Table 2.4. The bed-volume definition is based on the volume of the SL-644 resin in each column during the loading step. These BVs are slightly larger than the 15 mL determined during testing of the AW-101 sample (Kurath et al. 2000). The corresponding bed height and bed length (height) to diameter ratio (L/D) is also given. The expanded particle-size diameter was estimated on the basis of the bed-volume expansion relative to the as-received resin volume and the initial rough estimate of the average particle size of the resin (330 μm). The average number of resin particles per column diameter is greater than the 20–30 particle diameters commonly assumed necessary to prevent channeling.

Table 2.4. Resin Bed Properties

	Lead Column	Lag Column
BV, mL	18.6	15.9
Bed Height – cm	10.5	9
L/D	7.0	6.0
Expanded Particle Size Diameter – um	475	450
Resin Particles Per Column Diameter	32	33

2.3 Feed Preparation

A sample of the waste from Tank AN-107 (Envelope C) was received in the High Level Radiation Facility (HLRF) during the 4th quarter of 1998. The homogenization, dilution, caustic adjustment, and subsampling of this sample is described in Urie (1999). The diluted AN-107 sample was then processed for Sr/TRU removal with a precipitation process. The precipitate and entrained solids were removed with a single-tube cross-flow filter using a 0.1-micron sintered metal Mott filter (Hallen 2000). The clarified AN-107 sample was then transferred in two containers from the HLRF to the shielded analytical laboratory (SAL) hot cells. The total volume transferred was about 1.8 L. The contents of the two transfer containers where combined and homogenized and subsampled leaving a total of about 1740 mL of feed. The density of the cesium ion exchange feed was determined with a 25-mL volumetric flask and a 4-place analytical balance.

2.4 Column Run Experimental Procedure and Conditions

The experimental conditions for each process step are shown in Table 2.5. The BVs and flow rates are somewhat different from the target values (BNFL-TP-29953-003 Rev 1) because the experiment was planned on the assumption that the BV was 15 mL, which was the volume during the loading phase for the treatment of the AW-101 sample. The BVs during the loading phase in this run were larger—18.6 mL for the lead column and 15.9 mL for the lag column. Since the BVs were larger than anticipated, the flow rates in BVs per hour are lower than the target values. The actual volumes of the bed conditioning, feed displacement, and DI-water rinse solutions were increased relative to the runs with the AW-101 sample to ensure that the system was adequately flushed. The bed conditioning was performed within 12 h of initiating the column run. Before the bed conditioning, the beds had been stored in 0.25 M NaOH since the end of the AW-101 column runs (approximately 15 weeks). The bed conditioning, loading, feed displacement, and DI water rinse steps were conducted by passing these solutions through both resin beds connected in series. The elution, elution rinse, and the regeneration steps were conducted on each column separately.

The adjustable plungers at the top of each column were used to minimize the volume of solution above each of the resin beds. The BVs changed dramatically from a minimum volume in the acid form during elution to a maximum volume in the sodium form in contact with water. The plungers were moved downward at the end of each process step in which the resin beds shrank and were moved upward periodically as the bed expanded. The plungers did not constrain or compress the resin bed. The height of liquid above the beds was kept to less than 1 cm (about 1.8 mL).

Table 2.5. Experimental Conditions for Column Run

Process Step	Solution	Total Volume, BV[a] (mL)	Flow rate BV/h (mL/h)	Time (h)
Bed Conditioning	DI water	12.6 (235)	5.6 (104)	2.25
Bed Conditioning	0.5 M nitric	14.1 (260)	6.5 (122)	2.17
Bed Conditioning	DI water	8.6 (160)	8.0 (147)	1.1
Bed Conditioning	0.25 M NaOH	8.3 (155)	8.3 (155)	1
Loading Based on Lead Column	AN-107 Feed	88.6 (1649)	4.6 (86)	19.2
Loading Based on Lag Column [b]	AN-107 Feed	102.1 (1623)	5.3 (85)	19.2
Feed Displacement	0.1 M NaOH	6.3 (117)	3.4 (63)	1.8
DI Water Rinse	DI water	5.2 (97)	2.6 (48)	2.0
Elution of Lead Column				
Elution (lead col)	0.5 M HNO_3	10.5 (195)	0.84 (15)	12.6
Eluant Rinse (lead)	DI water	4.2 (77)	2.9 (53)	1.5
Regeneration (lead)	0.25 M NaOH	6.9 (128)	5.4 (100)	1.3

Elution of Lag Column [b]				
DI Water Rinse (lag column)	DI water	5.2 (97)	2.6 (48)	2.0
Elution (lag column)	0.5 M HNO_3	13.3 (210)	0.94 (15)	14.1
Eluant Rinse (lag column)	DI water	6.4 (104)	3.6 (58)	1.8
Regeneration (lag column)	0.25 M NaOH	6.9 (109)	3 (47)	2.3

Notes:

(a) The column volume is based on the volume in the columns during the loading step. The BV in the lead column was 18.6 mL with a height of 10.5-cm. The BV in the lag column was 15.9 mL with a bed height of 9 cm. Unless otherwise indicated, values are based on the BV in the lead column.

(b) The column volume of the lag column is used for the elution volumes of the lag column and for the loading data of the lag column. The feed volume through the lag column is reduced because of sampling from the lead column.

The sampling and analysis protocol is shown in Table 2.6. The ^{137}Cs content was determined in most of the samples using a portable gamma energy analysis (GEA) instrument. This allowed near real-time analysis of the samples. The response time was limited by the rate at which samples could be removed from the hot cell and was often on the order of hours. Due to the dose rate from ^{137}Cs, many of the samples required dilution before removal from the hot cell. Samples were diluted in either 0.25 M NaOH or 0.5 M HNO_3. The extent of dilution was determined by mass difference on a 4-place analytical balance. The samples that required dilution included the feed sample, the effluent samples from the last half of the loading phase, and most of the eluate samples. The ^{137}Cs results from the portable GEA instrument were confirmed by analyzing selected samples with the GEA instrument in the analytical laboratory. The sodium and other metal concentrations were determined with inductively coupled plasma-atomic emission spectroscopy (ICP-AES). The OH^- concentration was determined by titration with hydrochloric acid.

During the loading phase, the treated effluent was collected in one of two effluent bottles, except for the small (2 mL) analytical samples that were taken. A composite sample from each of the two loading effluent bottles was taken for analysis by GEA. Another loading effluent composite sample was taken for analysis once the contents of the two loading effluent bottles were combined for Tc ion exchange. The samples for the other process steps were collected in approximately 0.8-BV aliquots. Once the GEA results were confirmed for the eluate, all of the eluate samples were composited, and a sample of the composite was submitted for GEA, ICP-AES, total organic carbon (TOC), ion chromatography (IC), total alpha, ^{90}Sr, and inductively coupled plasma-mass spectrometry (ICP-MS) for ^{99}Tc.

Table 2.6. Sampling Interval and Analyses

Process Step	Lead Column BV	Lag Column BV	Approximate Sample Size (mL)	Analyses
Bed conditioning	-	-	-	-
Bed conditioning	-	-	-	-
Bed conditioning	-	-	-	-
Loading	Every 8 BV	Every 16 BV	2	GEA
Feed displacement	-	Every 0.8 BV	15	ICP, GEA, OH-
DI water rinse	-	Every 0.8 BV	15	ICP, GEA, OH-
Elution	Every 0.8 BV	-	15	GEA
Eluant rinse	Every 0.8 BV	-	15	GEA
Regeneration	1 composite	-	128	ICP, GEA, OH-
Composite Samples				
Effluent – 1			2	GEA
Effluent – 2			2	GEA
Eluate	1 Composite	-	2	ICP-AES, GEA, TOC, IC, Sr-90, total alpha ICP-MS (Tc)

2.5 Batch Contacts

A number of batch contacts between the SL-644 and subsamples of the AN-107 feed were conducted to obtain equilibrium data. Portions of the subsamples were spiked with 0.1 M $CsNO_3$ stock solutions to obtain additional concentrations of cesium. The initial cesium concentrations in the AN-107 subsamples are given in Table 2.7. The purpose of these spikes was to ensure that the equilibrium composition of the solutions bracketed the cesium feed concentration.

Table 2.7. Initial Cs Concentrations in the AN-107 Solutions Used for the Batch Kd Tests

Waste	Solution	Initial Cs Conc. [M]	Initial Na/Cs (a)	Initial K/Cs (a)
AN-107	Un-spiked	5.25E-5	92,130	360
(4.84 M Na^+)	Cs Spike 1	3.92E-4	12,300	49
(0.019 M K^+)	Cs Spike 2	9.26E-4	5,230	21

(a)Na^+ and K^+ are the primary cations that compete with Cs^+ for ion exchange with SL-644.

The batch Kd tests were performed at a phase ratio of approximately 100 mL/g (liquid volume to exchanger mass). Typically, 0.05 g of exchanger was contacted with 5 mL of solution. The exchanger mass was determined to an accuracy of 0.0001 g. The waste volume was transferred by pipette, and the actual volume was determined by mass difference with an accuracy of 0.0001 g and the solution density.

Agitation was provided by an orbital shaker set at 200 rpm for approximately 96 h. The temperature was not controlled, but was generally constant at 24°C during the 4 days of contact.

All K_d measurements were made in duplicate and blank samples (i.e., without the ion exchange resin) were used to determine the initial concentration of the species of interest. All initial and final solutions were analyzed by GEA to determine the ^{137}Cs concentration. The initial sodium and potassium concentrations were determined with ICP-AES.

The batch distribution coefficient, K_d (with units of mL/g), was determined using the following relationship:

$$K_d = \frac{(C_0 - C_1)}{C_1} * \frac{V}{M * F} \quad \textbf{(1)}$$

where C_0 and C_1 are the initial and final ^{137}Cs concentrations, respectively, V is the volume of the liquid sample (mL), M is the mass of the ion exchanger (g), and F is the mass of the dried resin divided by the mass of the as-received resin.

3.0 Results and Discussion

3.1 Feed Composition

The composition of the feed to the cesium ion exchange system is shown in Table 3.1. The concentrations of Na and Al were determined by ICP-AES, and are averages of the analyses for the filtrate from the Sr/TRU removal process, cesium IX feed, Tc IX feed, Tc IX effluent, and sulfate-removal feed. The concentrations of K, Cr, and P were also determined by ICP-AES and are averages of analyses for the filtrate from the Sr/TRU removal process and the cesium ion exchange feed. Additional compositional data for the individual analyses and standard deviations for averaged results may be found in Appendix A. The total cesium concentration was estimated using the GEA results for ^{137}Cs from six different subsamples, and the isotopic ratios were determined with thermal ionization mass spectroscopy and reported in Urie (1999). For the AN-107 sample, the ^{137}Cs:total cesium was 0.2455. The anion concentrations were obtained from analyses conducted on the feed and effluent samples from the Tc IX experiments. These results were assumed to be valid since the anion concentrations were not greatly affected by cesium and Tc removal. No residual solids were observed in the feed, which is not surprising since the sample had been refiltered approximately 2 weeks after the initial treatment for Sr/TRU removal.

3.2 Loading (^{137}Cs Breakthrough Curves), Feed Displacement, and Water Wash

After the resin beds were conditioned, the loading phase was initiated with the AN-107 sample. Collection of the effluent was initiated when the color of the AN-107 sample appeared in the effluent tube. Approximately 2.8 BVs[(a)] (52 mL) of 0.25 M NaOH were diverted to the waste bottle. This prevented most of the 0.25 M NaOH in the system from being mixed with the AN-107 effluent. Small samples (about 2 mL) were collected from the lead column every 8 BV of feed and from the lag column every 16 BV of feed. It had been planned to collect samples every 10 BVs, but this was based on the 15 mL BV obtained during the initial column loading with the AW-101 sample. Initial samples were collected from both columns soon after loading was initiated to obtain a determination of the maximum decontamination factors. The loading phase generally went well, except for some difficulty controlling the flow rate to a constant value.

The cesium effluent concentrations from the columns are shown in Figure 3.1 as C/C_o vs. the BVs of feed processed through each column. The Co value for ^{137}Cs was determined to be 153.0 μCi/mL. The C/C_o is plotted on a probability scale (i.e., gaussian distribution) since this tends to provide a straight-line breakthrough curve. The C/C_o values for the feed displacement (0.1 M NaOH) and DI water rinse are

(a) Many solution volumes given as bed volumes are based on the 18.6-mL BV of the lead column. Volumes associated with the lag column are based on the 15.9-mL BV of the lag column.

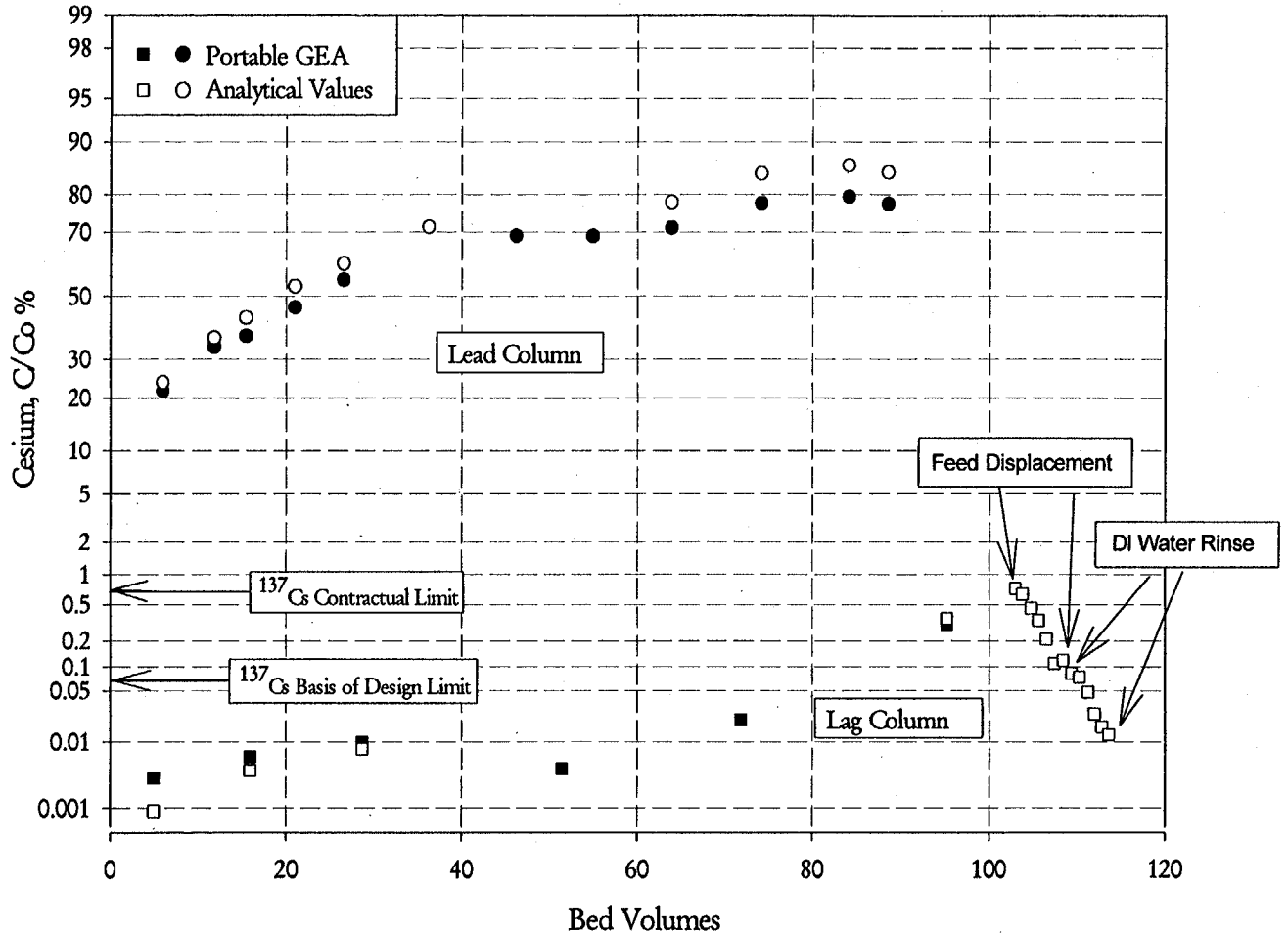
also shown in Figure 3.1. These exhibit a steadily decreasing concentration of ^{137}Cs. The C/C_o values were determined with a portable GEA instrument, and selected samples were independently analyzed with an analytical laboratory GEA instrument. The two analyses are generally in good agreement (within 10%). Raw analytical results and calculations are located in the appendix.

Table 3.1. Composition of Envelope C (AN-107) Cs IX Column Feed[(a)]

Cations, M	
Na^+	4.84
K^+	0.019
Cs^+	5.25E-5
Na/Cs mole ratio	92,130
K/Cs mole ratio	360
Anions, M	
AlO_2^- [(b)]	0.087
Cl^-	0.014
$CO3_2^-$	0.57
CrO_4^{-2} [(b)]	8.8E-04
NO_2^-	0.62
NO_3^-	1.82
OH^-	0.8 (estimated)
PO_4^{-3} [(b)]	0.01
SO_4^{-2}	0.042
Oxalate	0.016
TOC	13.6 g/L
Radionuclides, (μCi/mL)	
Total alpha	9.8E-03
^{60}Co	6.1E-02
^{90}Sr	5.9E-01
^{99}Tc (μg/mL)	3.37 μg/mL
^{137}Cs	153.0
^{154}Eu	3.8E-02
Solution Density, g/mL	1.2414

(a) The analytical results for various samples that contribute to the values in Table 3.1 may be found in the appendix.

(b) Al, Cr, and P determined by ICP-AES. The anionic form is assumed on the basis of waste chemistry.



Conditions: Temperature = 26 °C, Feed Rate = 86 mL/h, Lead column BV = 18.6 mL, lag column BV = 15.9 mL, SL-644 batch # = 644BZ, ^{137}Cs Co = 153 µCi/mL, AN-107 Na concentration = 4.84 M.

Figure 3.1. ^{137}Cs Breakthrough Curves, Feed Displacement and Water Washing for AN-107 Sample

Two ^{137}Cs-removal limits are also shown in Figure 3.1. The higher C/C_o value of 0.79% corresponds to the contractual limit of 3 Ci/m^3 for ^{137}Cs in the low-activity waste (LAW) glass, and the lower C/C_o value of 7.9E-02% corresponds to the basis of design limit of 0.3 Ci/m^3 for ^{137}Cs in the LAW glass, which is 10 times less than the contractual limit. The C/C_o values corresponding to these limits are determined using the sodium concentration of 4.84 M in the AN-107 sample, the ^{137}Cs feed concentration of 153 μCi/mL, a 14 wt% total Na_2O loading in the glass, and a glass product density of 2.66 g/mL.

Volume corrections have been made in the analysis of the data so that the indicated data points correspond to the BVs that have actually passed through each column at the time of sampling. These volumes are different from the amount of feed pumped from the feed container because of the holdup volume. The BVs actually pumped from the feed vessel can be estimated by adding 1.6 BVs for the lead column (30 mL) and 3.8 BVs (60 mL) for the lag column.

The Cs λ value is about 20 for the lead column, and there is insufficient data for an estimate of the Cs λ for the lag column. The Cs λ value is the point at which the C/C_o value is 50% (0.5) and is normally a direct indicator of the effective capacity of the resin. The Cs λ value of 20 for the lead column is very much lower than the estimated Cs λ of 145–150 obtained during Phase IA testing (Hassan and McCabe 1997). The very low value for the lead column indicates that this resin bed was not functioning properly.

The cause of the relatively poor performance of the lead column is not known, but could have been due to fluid channeling caused by air in the resin bed, although care was taken to ensure that this did not happen, and air bubbles were not observed during the loading phase. Air (or some kind of gas) was observed during elution of the lead column. Also, the bed height in the lead column was larger than the bed height in the lag column whereas the bed heights of the two columns had been the same during previous runs. This supports the theory that there was unobserved air in the lead column during the loading phase. Another possible explanation for the poor performance could be improper bed conditioning since the SL-644 resin has been shown to be sensitive to the bed-conditioning process before initiating the loading (McCabe et al. 1997). This explanation seems unlikely since the lag column appeared to perform well.

Several decontamination factors for various samples are shown in Table 3.2. These may be compared to the contractual limit for cesium removal of C/C_o = 0.79% (decontamination factor [DF] = 127) and the basis of design limit of C/C_o = 7.9E-02% (DF= 1270). In all cases, sufficient cesium was removed that the contractual limit for cesium removal was met. The final sample from the lag column and the effluent collected in Bottle 2 did not meet the basis of design limit. Significantly, the ^{137}Cs in the composite effluent met the basis of design limit, even though the lead column was not functioning properly.

Table 3.2. Decontamination Factors for ^{137}Cs

	Processed Volume, BV (mL)	^{137}Cs Concentration µCi/mL	C/C_o, %	DF
First Sample From Lag Column	5.9 (110)	1.3E-3	8.8E-04	114,000
Final Sample From Lag Column	81 (1513)	5.4E-01	3.5E-01	284
Effluent Bottle-1	61 (1134)	5.9E-03	3.86E-03	25,900
Effluent Bottle-2	26 (476)	2.89E-01	1.89E-01	530
Composite Effluent	87 (1610)	8.71E-02	5.69E-02	1760

The concentrations of sodium, potassium, Al, and hydroxide in the feed displacement and DI water rinse solutions are shown in Figure 3.2. The concentrations of the sodium, potassium, and Al are indicated on the left hand axis while the hydroxide concentration is shown on the right hand axis. Both Y axes are logarithmic scales to clearly show the roughly 100-fold decrease in concentrations. The samples were taken from the effluent line following the lag column, after the solutions had passed sequentially through both columns. Analytical results and calculations are located in the appendix.

Due to the holdup volume in the system, there was a delay between the introduction of the feed displacement and DI water wash solutions and the collection of these samples from the effluent line. Approximately 29 mL of cesium-decontaminated AN-107 was collected as effluent before starting the feed-displacement sampling. Since the sample size was about 15 mL and the holdup volume was 60 mL, the first two feed-displacement samples largely consisted of AN-107 effluent.

The concentrations given in Figures 3.1 and 3.2 indicate that washing was nearing completion at the fifth and sixth samples. The slight rise in concentrations in the middle of the DI water rinse step has not been explained, but it is probably not due to analytical dilution errors since independent analytical results all show the same rise, and the sample density also increases (indicates more dissolved solids). The required volume of feed displacement and DI water rinse solutions could be significantly reduced with a smaller holdup volume in the system and may not reflect the performance of a large-scale system

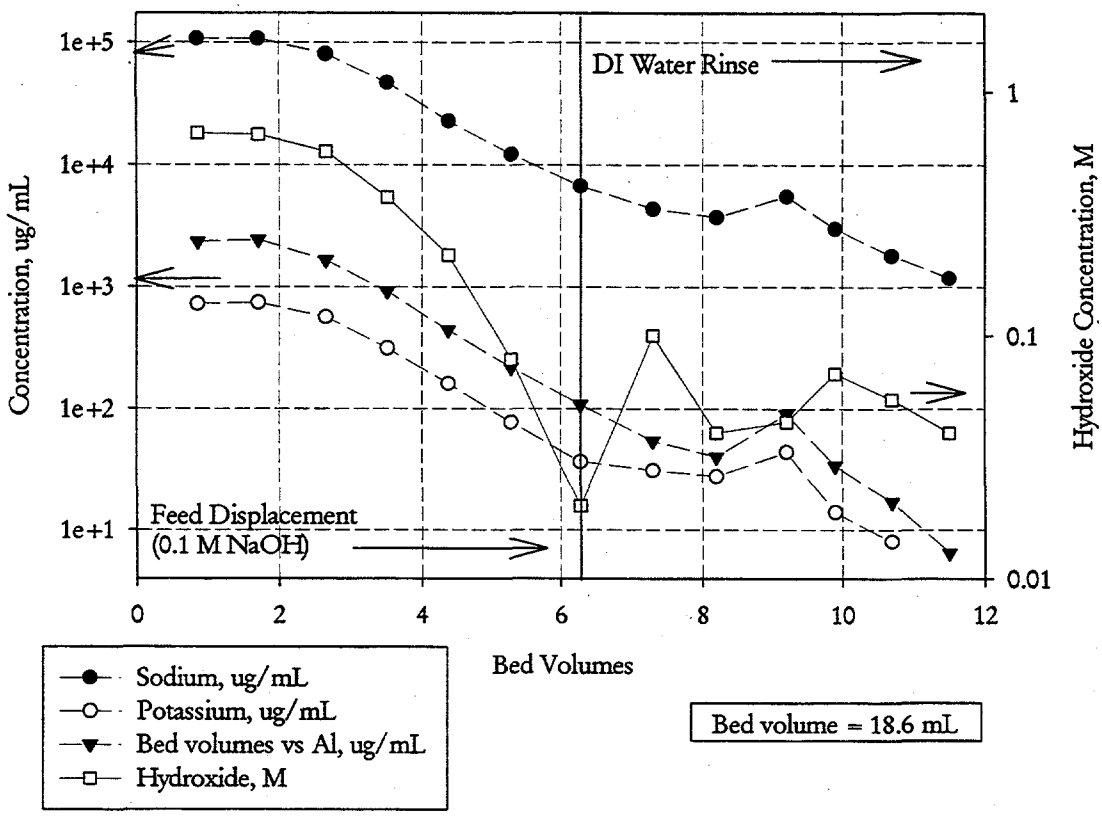


Figure 3.2. Component Concentrations in Feed Displacement and DI Water Rinse Solutions

3.3 Elution, Eluant Rinse, and Regeneration

At the completion of the DI water wash, elution of the lead and lag columns was initiated by pumping 0.5 M nitric acid into each column. Elution of each column was performed separately (i.e., the columns were not connected in series as they were for loading). Samples of the eluate and the eluant rinse were collected in approximately 0.8-BV increments while the regeneration solution was collected as a single composite. The ^{137}Cs content of these samples was determined with the portable GEA instrument and confirmed with analysis in the analytical laboratory instrument. Due to holdup in the system, the first couple of BVs probably contained a substantial amount of the DI water rinse that preceded the elution.

The elution generally went well, except for a short downtime ($\approx$ 5 min) during collection of sample # 8 from the lead column to remove an air bubble from the resin bed. The source of this air is probably due to in-leakage, although the resin bed was covered with liquid. The air was removed from the bed by tapping the column and moving the plunger on top of the column until the bubble migrated to the top of the resin and into the headspace above the bed. The elution was resumed and completed without further difficulties.

The lead column C/C_o[(a)] values for ^{137}Cs are shown in Figure 3.3 for the elution, the eluant rinse, and the regeneration steps. The Y axis is a logarithmic scale to clearly show the large range of C/C_o values. The majority of the ^{137}Cs was contained in Samples #4, #5, and #6. The peak value of C/C_o was found to be 31. The elution cutoff of $C/C_o = 0.01$ was reached at sample #10 (8 BV), but elution was continued slightly beyond this due to the lag between sample collection and the determination of the cesium concentration. The C/C_o values for the eluant rinse indicate a rise in ^{137}Cs concentration. This is probably because column operations were shut down overnight before the elution rinse was initiated the following morning. This downtime allowed more of the ^{137}Cs to ion exchange out of the resin and into the eluate. At the end of the eluant rinse, the ^{137}Cs concentration had dropped to a relatively low value.

The lag column C/C_o values for ^{137}Cs are shown in Figure 3.4 for the elution step. The majority of the ^{137}Cs was contained in Samples #4, #5, and #6. The peak value of C/C_o was found to be 61. The elution cutoff of $C/C_o = 0.01$ was reached at Sample #13 (12 BV).

(a) The C_o refers to the ^{137}Cs concentration in the AN-107 sample fed to the lead column. For elution, the C/C_o value is an indication of the extent to which ^{137}Cs is concentrated relative to the feed. It is an indirect measure of the extent to which the resin is actually eluted.

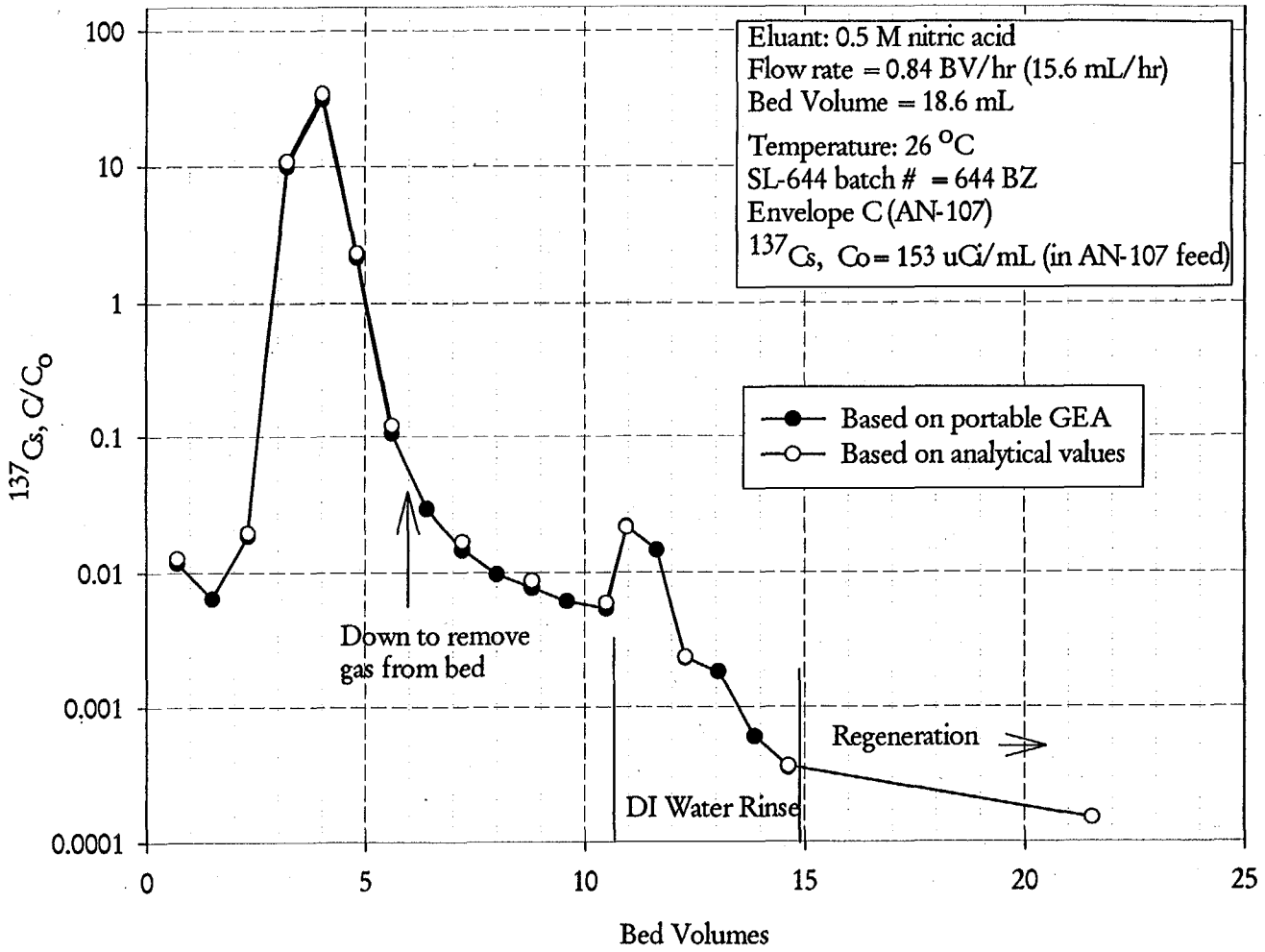


Figure 3.3. Elution, Eluant Rinse, and Regeneration of the Lead Column

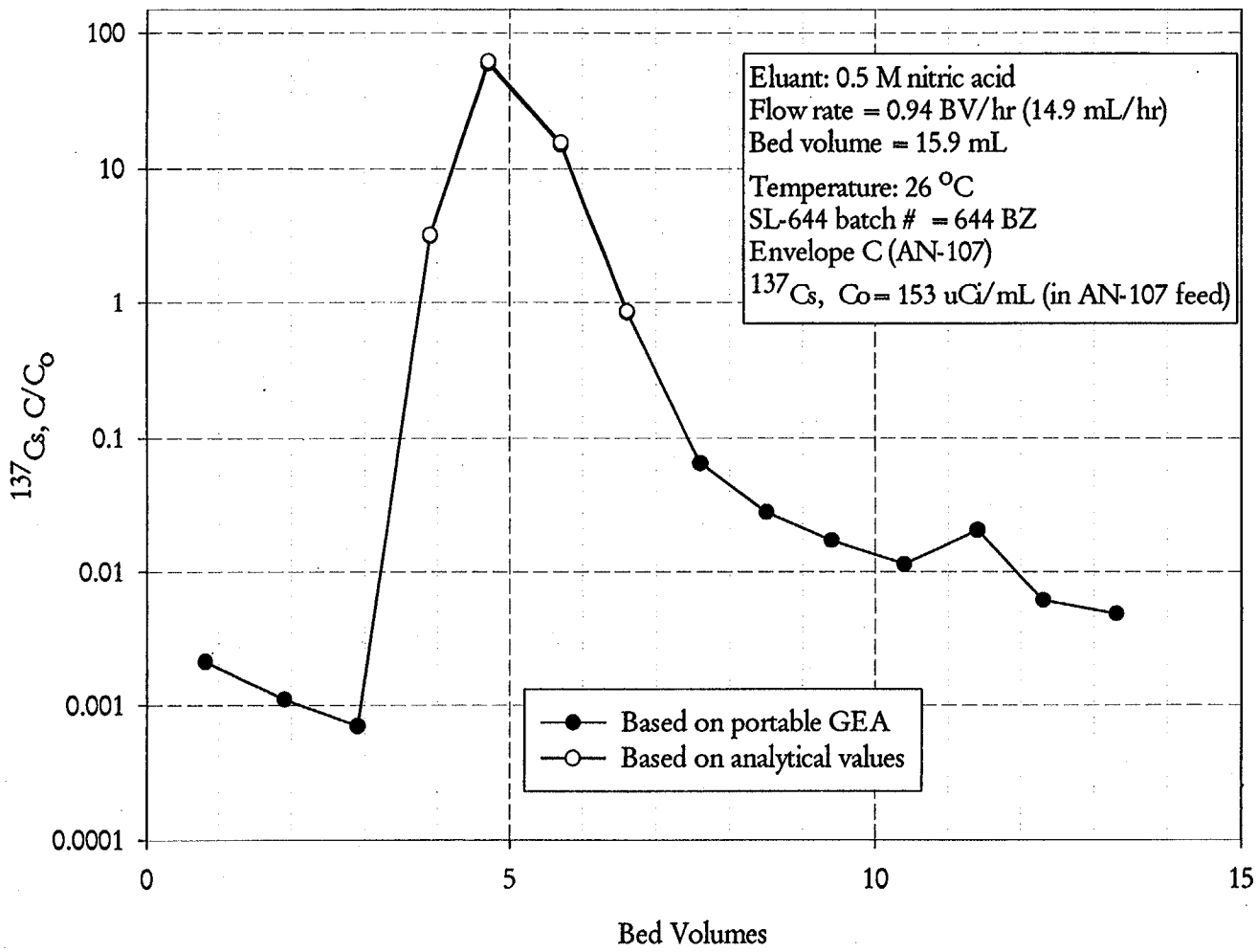


Figure 3.4. Elution, Eluant Rinse, and Regeneration of the Lag Column

The composition of the regeneration composite sample collected during the regeneration of the lead column is shown in Table 3.3.

Table 3.3. Composition of Regeneration Solution

	Concentration, µg/mL	BNFL MRQ	Concentration, M
Al	0.9	-	3.3E-5
B	3.8	-	3.5E-04
Cr	0.25	-	4.8E-06
Cu	0.28	-	4.4E-06
Fe	0.49	-	8.8E-06
Na^+	1790	75	0.08
K^+	DL = 2	-	-
Ni	[0.1]	-	1.7E-06
Si	18.9	-	6.7E-04
Zn	0.5	-	7.6E-06
OH-	580	17	0.034
^{137}Cs	2.29E-02 µCi/mL	9	-
Total cesium	-	-	7.9E-09
Density, g/mL	-	-	1.0025

Notes: MRQ is minimum reportable quantity. DL = detection limit; component not detected. The overall error is estimated to be within +/-15%. Values in brackets are within 10 times the detection limit, and errors are likely to exceed +/-15%

The eluate samples from each column were composited separately, and a sample of each composite was submitted to the analytical laboratory for analysis with ICP-AES, IC (anions), GEA, total alpha, ^{90}Sr, TOC, and ICP-MS to determine the ^{99}Tc content. The results are shown in Tables 3.4 and 3.5. Sodium was the dominant component detected with ICP-AES, although a number of other metals were also detected. Many of the same metals detected by ICP-AES were also found in the eluate from the AW-101 testing (Kurath et al. 2000) and include Cr, Cu, Fe, Na, Ni, K, Pb, U, and Zn. Many of these same components were also detected during the analysis of the spent resin (Kurath and Wagner 2000) and include Ca, Co, Cr, Cu, Fe, Na, Ni, Pb, Sr, Zn and Zr. As expected, ^{137}Cs was the dominant radionuclide detected. The only anion detected was nitrate, which is not surprising since the eluant was 0.5 M nitric acid. A small amount of total organic carbon was detected, but it is not known if this is from residual waste in the column system or from organic materials leaching from the resin.

Most of the BNFL-specified minimum reportable quantity (MRQ) levels were met with some exceptions. The large amount of ^{137}Cs prevented the detection limits for ^{241}Am, ^{154}Eu, and ^{155}Eu from meeting the MRQ levels. Relatively high ^{137}Cs activity increases the gamma background level in the detectors due to Compton scattering, thereby making it difficult to detect lower concentrations of other gamma emitters. The large amount of nitrate prevented the detection limit for Cl from meeting the MRQ

levels. The large concentration of nitrate requires large sample dilutions and increases the method detection limit (MDL) for the other components. In any case, the anion concentrations other than nitrate are expected to be small. This is somewhat confirmed by the fact that no P was detected with the ICP-AES analysis. The total inorganic carbon (TIC) analysis was not completed because carbonate is known to evolve as CO_2 in acidic solutions.

Table 3.4. Analysis of the Lead Column Eluate Composite and Minimum Reportable Quantities

ICP-AES Components		**BNFL MRQ**	**Anions**		**BNFL MRQ**
	µg/mL	µg/mL		µg/mL	µg/mL
Al	[3.6]	7.50E+01	TOC	151	1.50E+03
Ba	DL=0.1	7.80E+01	TIC	NA	1.5E+02
Ca	DL=2.6	1.50E+02	Br^-	DL=100	NMRQ
Cd	[0.5]	7.50E+00	Cl^-	DL=100	3.0E+00
Co	DL=0.52	3.00E+01	F^-	DL=100	1.5E+02
Cr	5.25	1.50E+01	NO_2^-	DL=200	NMRQ
Cu	20.3	1.70E+01	NO_3^-	24,500	3.0E+03
Fe	7.23	1.50E+02	PO_4^{-3}	DL=200	2.5E+03
K	DL=20.7	7.50E+01	SO_4^{-2}	DL=200	2.3E+03
La	DL=0.52	3.50E+01	oxalate	DL=200	NMRQ
Mg	DL=1.0	1.50E+02			
Mn	DL=0.52	1.50E+02	Radionuclides		MRQ
Mo	DL=0.52	9.00E+01		µCi/mL	µCi/mL
Na	920	7.50E+01	^{134}Cs	DL=2E-02	NMRQ
Ni	67.5	3.00E+01	^{137}Cs	4.74E+02	9.00E+00
Pb	[7.7]	3.00E+02	^{90}Sr	4.16E-2	1.50E-01
Si	[15]	1.70E+02	^{99}Tc	3.8E-4 (2.23E-2 ug/mL)	1.50E-03
Sn	DL=15.5	1.50E+03	^{241}Am	DL=6E-1	7.20E-04
Ti	DL=0.26	1.70E+01	^{154}Eu	DL=4E-2	2.00E-03
U	[87]	6.00E+02	^{155}Eu	DL=6E-1	9.00E-02
Zn	[0.84]	1.65E+01	Total alpha	1.22E-04	2.30E-01
B	12.5	NMRQ	Total volume = 173 mL		
P	DL=1.0	NMRQ	Total mass = 176 g		
Sr	[0.84]	NMRQ	Density = 1.015 g/mL		

Notes: MRQ is minimum reportable quantity. NMRQ is no minimum reportable quantity. NA = not analyzed. DL = detection limit; component not detected. The overall error is estimated to be within +/- 15%. Values in brackets are within 10 times the detection limit, and errors are likely to exceed +/-15%

Table 3.5. Analysis of the Lag Column Eluate Composite and Minimum Reportable Quantities

ICP-AES Components		BNFL MRQ	Anions		BNFL MRQ
	µg/mL	µg/mL		µg/mL	µg/mL
Al	[4.6]	7.50E+01	TOC	196	1.50E+03
Ba	DL= 0.1	7.80E+01	TIC	NA	1.5E+02
Ca	[5.3]	1.50E+02	Br^-	DL=100	NMRQ
Cd	[0.59]	7.50E+00	Cl^-	DL=100	3.0E+00
Co	DL=0.52	3.00E+01	F^-	DL=100	1.5E+02
Cr	5.29	1.50E+01	NO_2^-	DL=200	NMRQ
Cu	39.3	1.70E+01	NO_3^-	26,300	3.0E+03
Fe	7.63	1.50E+02	PO_4^{-3}	DL=200	2.5E+03
K	DL=20.7	7.50E+01	SO_4^{-2}	DL=200	2.3E+03
La	DL=0.52	3.50E+01	oxalate	DL=200	NMRQ
Mg	DL=1.0	1.50E+02			
Mn	DL=0.52	1.50E+02	Radionuclides		MRQ
Mo	DL=0.52	9.00E+01		µCi/mL	µCi/mL
Na	1630	7.50E+01	^{134}Cs	DL=3E-02	NMRQ
Ni	36.7	3.00E+01	^{137}Cs	7.16E+02	9.00E+00
Pb	[10]	3.00E+02	^{90}Sr	5.68E-2	1.50E-01
Si	[39]	1.70E+02	^{99}Tc	2.59E-04 (1.52E-2 µg/mL)	1.50E-03
Sn	DL=15.5	1.50E+03	^{241}Am	DL=7E-1	7.20E-04
Ti	DL=0.26	1.70E+01	^{154}Eu	DL=4E-2	2.00E-03
U	[170]	6.00E+02	^{155}Eu	DL=7E-1	9.00E-02
Zn	5.4	1.65E+01	Total alpha	1.0E-04	2.30E-01
B	13.8	NMRQ	Total volume = 212 mL		
P	DL=1.0	NMRQ	Total mass = 215 g		
Sr	[0.49]	NMRQ	Density = 1.015 g/mL		

Notes: MRQ is minimum reportable quantity. NMRQ is no minimum reportable quantity. NA = not analyzed. DL = detection limit; component not detected. The overall error is estimated to be within +/- 15%. Values in brackets are within 10 times the detection limit, and errors are likely to exceed +/-15%.

3.4 Mass Balance for ^{137}Cs

A mass balance for ^{137}Cs was completed to compare the ^{137}Cs recovered in various process streams to the ^{137}Cs present in the feed sample (Table 3.6). As expected, the majority (96.6%) of the ^{137}Cs was found in the eluate streams. Nearly 97.8% of the ^{137}Cs present in the feed sample was accounted for in the samples and process streams, indicating that the integrity of the experiment was fairly good.

Table 3.6. Mass Balance for ^{137}Cs

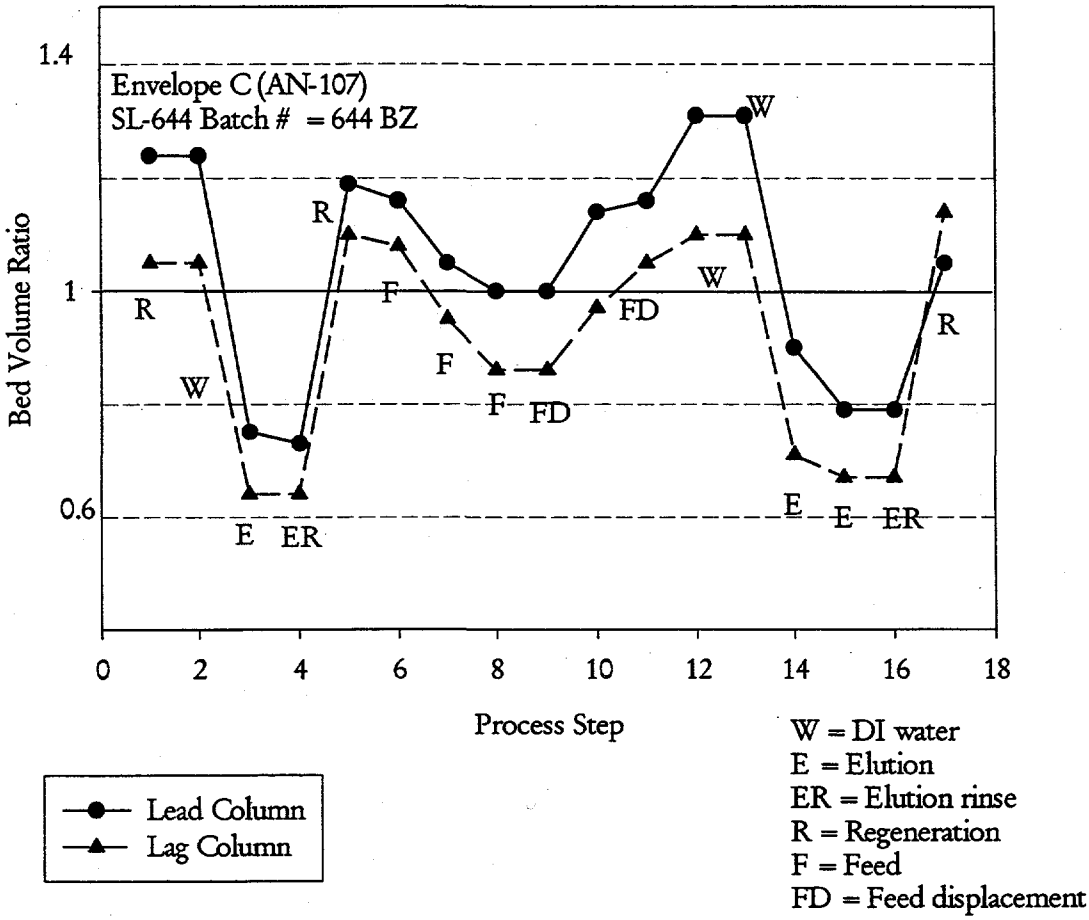
	^{137}Cs, μCi	% of ^{137}Cs in Feed Sample
Feed Sample	252,300	100
Effluent	140	0.05
Load samples	2,600	1.0
Feed displacement	65	0.03
DI Water Rinse	7	0.00
Column #1 Eluate	92,400	36.6
Column #1 DI water rinse	69	0.03
Column #1 regeneration	3	0.00
Column #2 Eluate	151,300	60.0
Total ^{137}Cs Recovery	246,600	97.8

3.5 SL-644 Resin Volume Changes

The SL-644 resin is known to change in volume as a function of the solution pH and ionic strength (Hassan et al. 1999). The variation in BV as a function of the process steps for both columns is shown in Figure 3.5 as a ratio of BV to the baseline value of 18.6 mL. In this case, the baseline value was chosen as the volume of the bed in the lead column after several BVs of feed had passed through the column and the BV reached a steady value. Two process cycles are shown with the first cycle consisting of the bed conditioning steps and the second cycle consisting of the actual process test. Each process step is denoted with a letter defined as follows: W (DI water), E (elution with 0.5 M nitric acid), ER (elution rinse with DI water), R (regeneration with 0.25 M NaOH), F (feed), and FD (feed displacement with 0.1 M NaOH).

The following qualitative observations are made on the BV changes:

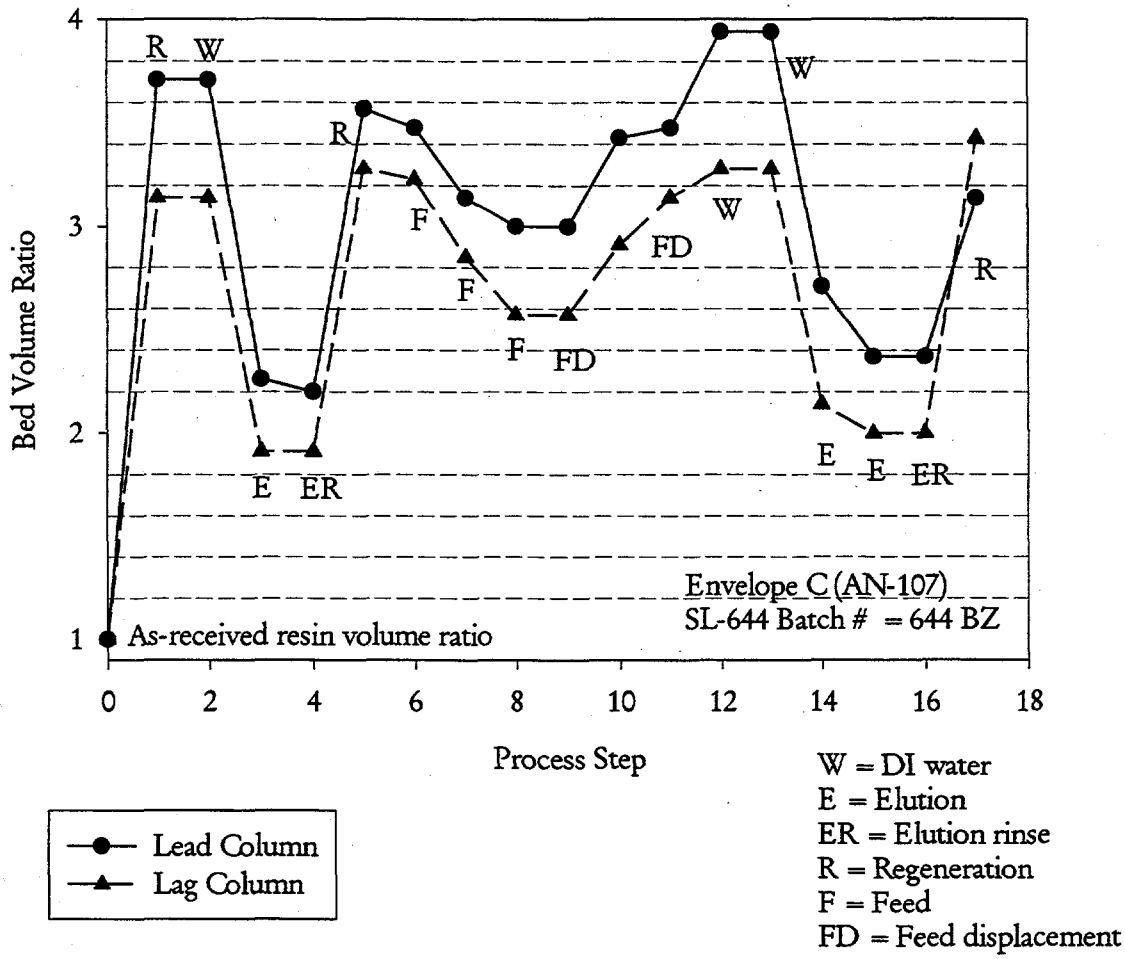
- Both columns reached minimum volumes in the hydrogen form (after elution) and maximum volumes in the sodium form after contact with dilute caustic (0.1 M) and water.
- Except for the final end state, the resin bed in the lead column was significantly larger than the bed in the lag column, even though the same amount of resin had been added to the columns initially. At the end of the previous process test with AW-101 (Envelope A), it was noted that the resin bed in the lead column was about 10% larger than the bed in the second column, although the beds had been the same size during the loading phase.
- Since both columns exhibited similar qualitative volume changes, it seems unlikely that the volume change contributed to the early breakthrough of ^{137}Cs for the first column.



Note: Bed volume ratios are referenced to the bed volume of the lead column during the loading phase.

Figure 3.5. Bed Volume Ratio for Lead and Lag Columns During Processing

The variation in bed volume as a function of the process steps for both columns is shown in Figure 3.6 as a ratio of BV to the estimated as-received resin volume (6.2 mL). The initial volume of the as-received resin added to each column was estimated from the as-received mass of 5.6 g and the as-received resin density of 0.86 g/mL. The initial BV of as-received resin was not measured since the resin preparation procedure required preconditioning in a beaker. It can be seen that the resin expands by as much as a factor of 4 relative to the initial volume.



Note: Bed volume ratios are referenced to the bed volume of the as-received resin.

Figure 3.6. Bed Volume Ratio for Lead and Lag Columns During Processing

3.6 Batch Contact Results

The ^{137}Cs distribution coefficients (Kds) are shown in Figure 3.7 for the SL-644 resin in contact with the AN-107 column feed. The Kd values were calculated using Equation 1 (page 2.8) and are based on the ^{137}Cs concentrations as measured by GEA. The Na/Cs ratio is calculated from the individual sodium and cesium concentrations. The sodium concentrations are based on an analysis of the initial feed as prepared for the column run and is assumed to be constant for the batch contacts. Since the quantity of H^+ added with the resins is small relative to the moles of Na^+ and OH^- (phase ratio of 100 mL of solution: gram of exchanger), this is a reasonable assumption. In these experiments, the waste solutions were estimated to have 4 meq of OH^- and 25.8 meq of Na^+, while the resin had 0.005 meq of H^+. The total cesium was based on the ^{137}Cs concentrations, and the ratio of ^{137}Cs:total cesium was determined for the unspiked and spiked solutions.

The Kd at the AN-107 feed conditions can be estimated at 790 mL/g from the point at which the Kd plot crosses the Na/Cs mole ratio (92,130) for the AN-107 sample. The column distribution ratio can be determined from the Kd and the appropriate bed density using the following relationship

$$C_s\lambda = Kd * \rho_b \qquad (2)$$

where $C_s\lambda$ is the column distribution ratio, and ρ_b is the dry bed density.

In this case, the dry-bed density is 0.231 g/mL, which is determined from the dry (@ 95 °C) mass of exchanger (4.3 g) divided by the expanded BV in the lead column of 18.6 mL. The Cs λ is then determined to be 183. This value is the approximate point at which the Cs breakthrough curve would have passed through C/C_o = 50% if the lead column had been functioning properly.

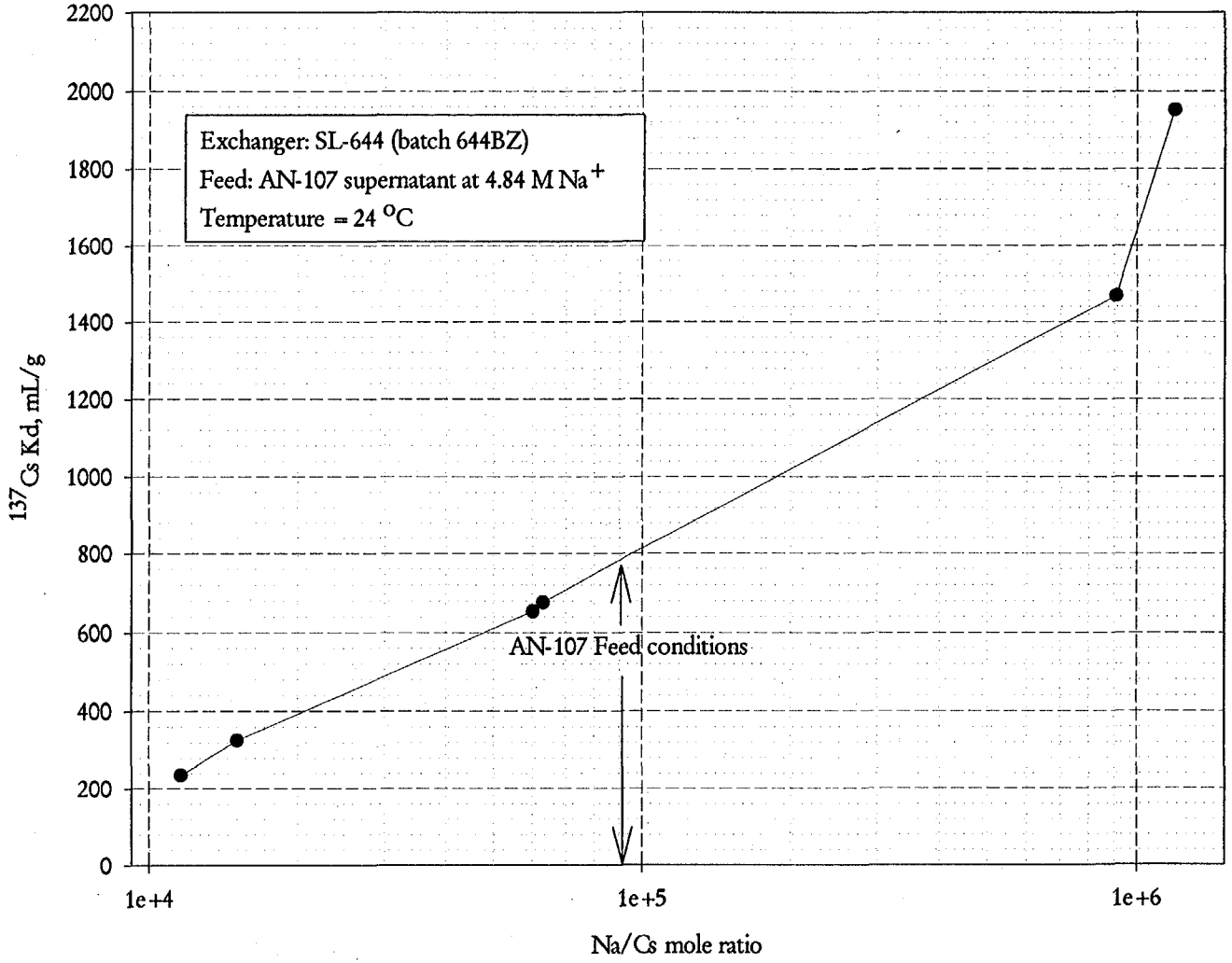


Figure 3.7. ^{137}Cs Distribution Coefficients (Kd) for AN-107 Feed

4.0 Conclusions and Recommendations

- Small-column testing with SL-644 indicates that sufficient decontamination of ^{137}Cs can be obtained with waste from Tank 241-AN-107 (Envelope C) to allow the LAW glass product to meet the basis of design limit for ^{137}Cs removal, which is a factor of 10 less than the contractual limit. An overall decontamination factor of 1760 was obtained providing a cesium-decontaminated effluent with a ^{137}Cs concentration of 8.7E-02 Ci/m^3. This is 7.2% of the contract limit.
- The Cs λ value for the lead column was estimated to be about 20, which is much lower than the 150 that was expected based on prior testing (Hassan, et al 1997). This low value indicates that the lead column was not functioning properly. The poor performance of the lead column was possibly caused by fluid channeling or blinding of the resin due to gas or air in the bed. The lag column functioned well and provided excellent decontamination of the ^{137}Cs, but breakthrough of ^{137}Cs was insufficient to allow an estimate of the Cs λ for this column.
- Batch contacts were conducted to obtain equilibrium data in the form of batch distribution coefficients (Kds). These equilibrium data predict a Cs λ of 183.
- The feed displacement (0.1 M NaOH) volume of 6.3 BV followed by 5.2 BV of DI water rinse was sufficient to adequately flush feed and residual caustic from the columns before the start of elution. While these volumes are larger than the assumed flowsheet volumes, it should be noted that the test system has a total system holdup in the pumps, valves, and tubing equal to 3.2 BVs of resin (60 mL). A smaller holdup volume would likely allow a reduction in the required amount of feed displacement and DI water-rinse solutions.
- The cesium-loaded columns are efficiently eluted with 0.5 M nitric acid. The majority of the ^{137}Cs is eluted from the column in 2.4 BVs of eluate, although a total of 8 and 13 BVs of eluant were required to reach the elution end point of a $C/C_o = 0.01$ for Columns 1 and 2, respectively. The peak C/C_o values for ^{137}Cs were 34 for the lead column and 61 for the lag column.
- The SL-644 was adequately regenerated with 6.9 BVs of 0.25 M NaOH. The average ^{137}Cs concentration in the regeneration solution was 2.3E-2 $\mu Ci/mL$ and a C/C_o of 1.5E-04.
- Fouling of the resin beds or exchanger was not observed.

5.0 References

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Appendix A: Analytical Results

Sample Identification

Sample ID	Description
C1-Cs-0AR	Initial feed sample - AN-107 Cs IX
C1-Cs-ICP	Additional feed sample - AN-107 Cs IX
C1-Cs-L1 through L12	Loading samples from lead column - AN-107 Cs IX
C1-Cs-P1 through P6	Loading samples from lag column - AN-107 Cs IX
Effluent – 1D	Effluent composite container 1 - AN-107 Cs IX
Effluent – 2D	Effluent composite container 2 - AN-107 Cs IX
AN-107-TcIX	Cs IX effluent which is also the Tc IX feed
C1-Cs-FD1 through FD7	Feed displacement samples - AN-107 Cs IX
C1-Cs-PR1 through PR6	DI water rinse samples - AN-107 Cs IX
C1-Cs-E1-1 through E1-13	Eluate samples from lead column - AN-107 Cs IX
C1-Cs-E1-R1 through R6	Eluant rinse samples from lead column - AN-107 Cs IX
Regeneration	Regeneration composite for lead column - AN-107 Cs IX
C1-Cs-E2-1 through E2-13	Eluate samples from lag column - AN-107 Cs IX
C1-CA	AN-107 feed control for batch contacts
C1-S1A	AN-107 spike 1 feed control for batch contacts
C1-S2A	AN-107 spike 2 feed control for batch contacts
C1-44A, C1-44-D-A	Batch contact with unspiked AN-107 sample
C1-44-S1-A, C1-44-S1-D-A	Batch contact with spike 1 AN-107 sample
C1-44-S2-A, C1-44-S2-D-A	Batch contact with spike 2 AN-107 sample
C1-Cs-E1-composite	Eluate composite from column 1, AN-107 run
C1-Cs-E2-composite	Eluate composite from column 2, AN-107 run
N7-Tc-0	Tc IX feed which is also Cs IX effluent composite
AN-107-TcIX	AN-107 Tc IX feed sample

Notes: 1) The letter A, B, C or D after the sample ID indicates that the original sample was diluted and/or transferred to a new, uncontaminated vial for loading out from the hot cell.

Sample Identification Continued

The following sample results are included in the appendix since they were reported with the AN-107 Cs IX samples. Samples from other work were batched to reduce cost and duration (schedule). These results are discussed in other reports.

A1-Cs-E2-CO	Eluate composite from second column, Cs IX, run 1 with AW-101
A1-Cs-E2-comp	Cs IX eluant composite from elution of lag column loaded with AW-101 sample, Run 1
A1R-Cs-0	Feed sample for Run 2, Cs IX, AW-101
A1R-Cs-E-comp	Cs IX eluant composite from elution of both columns loaded with AW-101 sample, Run 2
A1R-Cs-L1 through L2	Loading samples from lead column, Run 2, Cs IX, AW-101
A1R-Cs-P1 through P7	Loading samples from lag column, Run 2 Cs IX, AW-101
A1-Tc-EC1	Eluate composite from Tc IX/AW-101
A1-Tc-LC	Tc IX load effluent from AW-101 sample
N7-Tc-Elu-Comp	Tc IX eluant composite from elution of lead column loaded with AN-107 sample
N7-Tc-PW1 – PW7	Feed displacement samples from Tc IX, AN-107 run
N7-Tc-PR1 –PR2	Rinse samples from Tc IX, AN-107 run

AN-107 Column Run Analytical Results

Battelle PNNL/325 Bldg/RPG/Inorganic Analysis ...
ICPAES Data Report

Project: 29953
Client: D. Kurath

ACL Number(s): 00-0295 through 00-0348

Client ID: "C1-Cs-ICP" through "A1-Tc-EC1"

proj. 29953
T2.8.3.3
Task 2.8
p 1/12

ASR Number: 5571

Total Samples: 16

Procedure: PNL-ALO-211, "Determination of Elements by Inductively Coupled Argon Plasma Atomic Emission Spectrometry" (ICP-AES).

Analyst: D.R. Sanders

Analysis Date (Filename): 12-02-99 (A0563)

See Chemical Measurement Center 98620: ICP-325-405-1 File for Calibration and Maintenance Records.

M&TE Number: ICPAES instrument -- WB73520
Mettler AT400 Balance -- Ser.No. 360-06-01-029

Jerry Wagner 12-15-99
Reviewed by

12-16-99
Concur

Battelle PNNL/325 Bldg/RPG/Inorganic Analysis ...
ICPAES Data Report

Sixteen radioactive liquid samples, C1-Cs-ICP through A1-Tc-EC1 (ACL# 00-0295 through 00-0348), were analyzed by ICPAES after preparation by the Sample Receiving and Preparation Lab (SRPL). All samples except ACL# 00-0295, 00-0331 and 00-0348 were prepared by SRPL using PNL-ALO-128 acid digestion procedure. Approximately 2 to 4 ml of sample (weighed) was processed and diluted to a final volume of approximately 10ml. Density of the final solution will be determined using a 1ml aliquot taken from each processed sample, weighed and the density estimated by dividing the aliquot weight by the weight of water using the same pipette. The final volume of each processed sample may then be calculated using the final weight of processed sample divided by the estimated density. Results of the density estimates for the samples will be sent as a separate report. Several samples required analytical dilution of 5-fold or more because of high sodium concentration. Concentration for samples ACL# 00-0306 through 00-0318 are reported in **ug/ml** and corrected for analytical dilution and sample processing (diluted by mass: weight of final solution divided by weight of sample aliquot).

Sample ACL# 00-0295 was not processed, only diluted about 10-fold before analysis using 2% v/v nitric acid. Also samples ACL# 00-0331 and 00-0348 were not processed and analyzed as received except for analytical dilution analysis using 2% v/v nitric acid as needed. Concentration for samples ACL# 00-0295, 00-0331, 00-0348 are reported in **ug/g** and corrected for dilution (final solution volume divided by weight of sample aliquot).

Volumes and weights have been recorded on bench sheets and included with this report. Specific analytes of interest requested in table 6-1 attached to ASR-5571 include: Al, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, La, Mg, Mn, Mo, Na, Ni, Pb, Si, Sn, Ti, U, and Zn.

Most of samples contained high concentrations of sodium. A few samples had moderately high concentrations of aluminum. All other analytes measured were much lower in concentration. Please note that sample C1-Cs-PR3-A (ACL# 00-0315) appears to be quite different than those in the series of six samples C1-Cs-PR1-A through C1-Cs-PR6-A (ACL# 00-0313 through 00-0318). Several analytes such as aluminum, cadmium, sodium, phosphorus, lead, and strontium are higher in concentration than those in the previous or later sample series.

Quality control check-standard results met tolerance requirements for all analytes of interest except as noted below. Following is a list of quality control measurement results relative to ICPAES analysis tolerance requirements under MCS-033.

Five fold serial dilution:

(Aqueous samples) All results for analytes of interest were within tolerance limit of ≤ 10% after correcting for dilution.

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Duplicate RPD (Relative Percent Difference):

(Aqueous samples) All analytes of interest were recovered within tolerance limit of ≤ 20% relative percent difference (RPD) except for barium and zinc. The original sample aliquot did not have any significant amount (detectable but below EQL) of either barium or zinc. However the replicate processed sample had about twice as much zinc and thirty times more barium than the original sample. Also noted was the concentration of barium and zinc in the process blank. Only sample "C1-Cs-PR4-A" (ACL# 00-0316) had as much barium as the process blank. It appears that the preparation blank had become contaminated during sample processing.

Post-Spiked Samples (Group A):

(Aqueous samples) All analytes of interest were recovered within tolerance of 75% to 125%.

Post-Spiked Samples (Group B):

(Aqueous samples) All analytes of interest were recovered within tolerance of 75% to 125%.

Blank Spike:

(Aqueous samples) None prepared.

Matrix Spiked Sample:

(Aqueous samples) None prepared.

Quality Control Check Standards (aqueous samples):

Concentration of all analytes of interest was within tolerance limit of ± 10% accuracy in standards: QC_MCVA, QC_MCVB, and QC_SSTMCV. Calibration Blank (ICP98.0) concentration was acceptable, less than two times IDL.

High Calibration Standard Check (aqueous samples):

Verification of the high-end calibration concentration for all analytes of interest is within tolerance of ± 5% accuracy except nickel. Nickel was slightly low (6.4%) at the end of the run in QC_SST however it was within 5% (low) when measured at the start of the run.

Battelle PNNL/325 Bldg/RPG/Inorganic Analysis ...
ICPAES Data Report

Process Blank:

(Aqueous samples) All analytes of interest were within tolerance limit of ≤ EQL or < 5% of sample concentration except barium. As noted above for the %RPD quality control check, barium was above EQL (0.5 ug/ml) and appeared to be about the same concentration as that measured in the replicate sample (ACL# 00-0313REP) and (ACL# 00-316). It would appear that the process blank was contaminated during sample processing.

Laboratory Control Standard (LCS):

(Aqueous samples) No LCS was prepared for PNL-ALO-128 acid digested samples.

Analytes other than those requested by the client are for information only. Please note bracketed values listed in the data report are within ten times instrument detection limit and have a potential uncertainty much greater than 15%.

Comments:

1) "Final Results" have been corrected for all laboratory dilution performed on the sample during processing and analysis unless specifically noted.

2) Detection limits (DL) shown are for acidified water. Detection limits for other matrices may be determined if requested.

3) Routine precision and bias is typically ± 15% or better for samples in dilute, acidified water (e.g. 2% v/v HNO_3 or less) at analyte concentrations greater than ten times detection limit up to the upper calibration level. This also presumes that the total dissolved solids concentration in the sample is less than 5000 µg/mL (0.5 per cent by weight).

4) Absolute precision, bias and detection limits may be determined on each sample if required by the client.

5) The maximum number of significant figures for all ICP measurements is 2.

Battelle PNNL/RPG/Inorganic Analysis ... ICPAES Data Report

Det. Limit (ug/mL)	Multiplier= / ALO#= / Client ID= / Run Date= (Analyte)	5.0 PROCESS BLANK 00-0295 series 12/2/99 ug/mL	20.6 00-0306 @5 C1-Cs-FD1-B 12/2/99 ug/mL	20.3 00-0307 @5 C1-Cs-FD2-B 12/2/99 ug/mL	20.5 00-0308 @5 C1-Cs-FD3-B 12/2/99 ug/mL	21.6 00-0309 @5 C1-Cs-FD4-B 12/2/99 ug/mL
0.025	Ag	--	--	--	--	--
0.060	Al	--	2,020	2,080	1,480	854
0.250	As	--	--	--	--	--
0.050	B	--	24.6	26.0	21.8	18.5
0.010	Ba	3.50	--	--	--	--
0.010	Be	--	--	--	--	--
0.100	Bi	--	--	--	--	--
0.250	Ca	--	144	151	111	57.2
0.015	Cd	--	23.7	24.9	28.6	20.9
0.200	Ce	--	--	--	--	--
0.050	Co	--	[1.8]	[1.8]	[1.9]	[1.5]
0.020	Cr	--	36.0	36.5	23.6	12.7
0.025	Cu	--	14.7	15.3	20.2	18.4
0.050	Dy	--	--	--	--	--
0.100	Eu	--	--	--	--	--
0.025	Fe	[0.14]	7.98	8.23	5.18	[2.7]
2.000	K	--	624	631	503	[290]
0.050	La	--	--	--	--	--
0.030	Li	--	--	--	--	--
0.100	Mg	--	--	--	--	--
0.050	Mn	--	[1.3]	[1.3]	[1.5]	[1.2]
0.050	Mo	--	12.5	12.8	[8.8]	[4.8]
0.150	Na	--	92,100	91,900	71,900	43,800
0.100	Nd	--	[2.1]	--	--	--
0.030	Ni	[0.68]	183	192	226	185
0.100	P	--	257	262	229	155
0.100	Pb	--	53.5	55.8	80.8	77.5
0.750	Pd	--	--	--	--	--
0.300	Rh	--	--	--	--	--
1.100	Ru	--	--	--	--	--
0.500	Sb	--	--	--	--	--
0.250	Se	--	--	--	--	--
0.500	Si	--	[50]	[50]	[49]	[43]
1.500	Sn	--	--	--	--	--
0.015	Sr	--	109	114	84.8	43.8
1.500	Te	--	--	--	--	--
1.000	Th	--	--	--	--	--
0.025	Ti	--	--	--	--	--
0.500	Tl	--	--	--	--	--
2.000	U	--	--	--	--	--
0.050	V	--	--	--	--	--
2.000	W	--	[64]	[65]	[45]	--
0.050	Y	--	--	[1.0]	--	--
0.050	Zn	[1.3]	[5.6]	[5.6]	[6.4]	[4.4]
0.050	Zr	--	[1.7]	[1.8]	--	--

Note: 1) Overall error greater than 10-times detection limit is estimated to be within +/- 15%.

2) Values in brackets [] are within 10-times detection limit with errors likely to exceed 15%.

3) "--" indicate measurement is below detection. Sample detection limit may be found by multiplying "det. limit" (far left column) by "multiplier" (top of each column).

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Battelle PNNL/RPG/Inorganic Analysis ... ICPAES Data Report

Det. Limit (ug/mL)	Multiplier= / ALO#= / Client ID= / Run Date= (Analyte)	4.7 / 00-0310 / C1-Cs-FD5-B / 12/2/99 ug/mL	5.0 / 00-0311 / C1-Cs-FD6-B / 12/2/99 ug/mL	5.1 / 00-0312 / C1-Cs-FD7-B / 12/2/99 ug/mL	3.3 / 00-0313 / C1-Cs-PR1-A / 12/2/99 ug/mL	3.3 / 00-0313-REP / C1-Cs-PR1-A / 12/2/99 ug/mL
0.025	Ag	--	--	--	--	--
0.060	Al	429	215	110	55.8	56.7
0.250	As	--	--	--	--	--
0.050	B	15.2	12.2	10.6	4.41	4.51
0.010	Ba	[0.13]	[0.081]	--	[0.11]	3.36
0.010	Be	--	--	--	--	--
0.100	Bi	--	--	--	--	--
0.250	Ca	28.8	21.2	[7.6]	[3.4]	[3.0]
0.015	Cd	11.9	6.68	3.82	1.84	1.89
0.200	Ce	--	--	--	--	--
0.050	Co	[1.0]	[0.62]	[0.41]	[0.23]	[0.25]
0.020	Cr	6.50	3.36	1.83	0.899	0.916
0.025	Cu	13.3	8.56	6.54	3.99	4.03
0.050	Dy	--	--	--	--	--
0.100	Eu	--	--	--	--	--
0.025	Fe	1.56	[1.0]	[0.73]	[0.49]	[0.42]
2.000	K	157	[77]	[37]	[28]	[36]
0.050	La	--	--	--	--	--
0.030	Li	--	--	--	--	--
0.100	Mg	--	--	--	--	--
0.050	Mn	[0.68]	[0.39]	--	[0.19]	--
0.050	Mo	[2.3]	[1.1]	[0.50]	[0.22]	[0.23]
0.150	Na	22,500	12,100	6,820	4,530	4,440
0.100	Nd	--	--	--	--	--
0.030	Ni	119	80.2	58.2	34.6	35.0
0.100	P	70.1	34.2	16.3	6.11	6.37
0.100	Pb	56.9	41.6	23.4	10.2	10.6
0.750	Pd	--	--	--	--	--
0.300	Rh	--	--	--	--	--
1.100	Ru	--	--	--	--	--
0.500	Sb	--	--	--	--	--
0.250	Se	--	--	--	--	--
0.500	Si	35.4	25.8	[24]	[15]	[11]
1.500	Sn	--	--	--	--	--
0.015	Sr	21.3	10.6	4.92	1.57	1.60
1.500	Te	--	--	--	--	--
1.000	Th	--	--	--	--	--
0.025	Ti	--	--	--	--	--
0.500	Tl	--	--	--	--	--
2.000	U	--	--	--	--	--
0.050	V	--	--	--	--	--
2.000	W	[12]	--	--	--	--
0.050	Y	--	--	--	--	--
0.050	Zn	2.87	[1.9]	[1.3]	[0.82]	1.93
0.050	Zr	[0.26]	--	--	--	--

Note: 1) Overall error greater than 10-times detection limit is estimated to be within +/- 15%.

2) Values in brackets [] are within 10-times detection limit with errors likely to exceed 15%.

3) "--" indicate measurement is below detection. Sample detection limit may be found by multiplying "det. limit" (far left column) by "multiplier" (top of each column).

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Battelle PNNL/RPG/Inorganic Analysis ... ICPAES Data Report

Det. Limit (ug/mL)	Analyte	Multiplier= 3.4 ALO#= 00-0314 Client ID= C1-Cs-PR2-A Run Date= 12/2/99 ug/mL	Multiplier= 2.5 ALO#= 00-0315 Client ID= C1-Cs-PR3-A Run Date= 12/2/99 ug/mL	Multiplier= 5.0 ALO#= 00-0316 Client ID= C1-Cs-PR4-A Run Date= 12/2/99 ug/mL	Multiplier= 3.3 ALO#= 00-0317 Client ID= C1-Cs-PR5-A Run Date= 12/2/99 ug/mL	Multiplier= 3.3 ALO#= 00-0318 Client ID= C1-Cs-PR6-A Run Date= 12/2/99 ug/mL
0.025	Ag	--	--	--	--	--
0.060	Al	40.3	92.3	34.2	16.8	6.37
0.250	As	--	--	--	--	--
0.050	B	4.18	3.58	6.85	6.34	6.41
0.010	Ba	[0.26]	[0.092]	3.34	0.565	1.28
0.010	Be	--	--	--	--	--
0.100	Bi	--	--	--	--	--
0.250	Ca	[1.8]	[6.1]	[2.2]	[0.90]	--
0.015	Cd	0.939	1.89	0.785	[0.46]	[0.22]
0.200	Ce	--	--	--	--	--
0.050	Co	--	[0.17]	--	--	--
0.020	Cr	0.704	1.02	[0.54]	[0.36]	[0.27]
0.025	Cu	2.73	2.60	2.41	2.15	1.80
0.050	Dy	--	--	--	--	--
0.100	Eu	--	--	--	--	--
0.025	Fe	[0.31]	[0.52]	[1.0]	[0.23]	[0.19]
2.000	K	[28]	[44]	[14]	[8.3]	--
0.050	La	--	--	--	--	--
0.030	Li	--	--	--	--	--
0.100	Mg	--	--	--	--	--
0.050	Mn	--	[0.19]	--	--	--
0.050	Mo	--	[0.49]	--	--	--
0.150	Na	3,760	5,570	3,050	1,790	1,180
0.100	Nd	--	--	--	--	--
0.030	Ni	21.1	23.6	17.0	12.1	7.95
0.100	P	[2.6]	9.08	[2.2]	[0.99]	--
0.100	Pb	5.44	25.6	6.26	[2.7]	[0.67]
0.750	Pd	--	--	--	--	--
0.300	Rh	--	--	--	--	--
1.100	Ru	--	--	--	--	--
0.500	Sb	--	--	--	--	--
0.250	Se	--	--	--	--	--
0.500	Si	[14]	[10]	[19]	[4.9]	[11]
1.500	Sn	--	--	--	--	--
0.015	Sr	0.530	4.58	1.26	0.517	[0.15]
1.500	Te	--	--	--	--	--
1.000	Th	--	--	--	--	--
0.025	Ti	--	--	--	--	--
0.500	Tl	--	--	--	--	--
2.000	U	--	--	--	--	--
0.050	V	--	--	--	--	--
2.000	W	--	--	--	--	--
0.050	Y	--	--	--	--	--
0.050	Zn	[1.5]	1.35	2.97	2.62	[1.6]
0.050	Zr	--	--	--	--	--

Note: 1) Overall error greater than 10-times detection limit is estimated to be within +/- 15%.
2) Values in brackets [] are within 10-times detection limit with errors likely to exceed 15%.
3) "--" indicate measurement is below detection. Sample detection limit may be found by multiplying "det. limit" (far left column) by "multiplier" (top of each column).

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Battelle PNNL/RPG/Inorganic Analysis ... ICPAES Data Report

Det. Limit (ug/mL)	Multiplier= / ALO#= / Client ID= / Run Date= / (Analyte)	40.5 / 00-0295 @5 / C1-Cs-ICP / 12/2/99 / ug/g	1.0 / 00-0331 / Regeneration soln / 12/2/99 / ug/g	1.0 / 00-0348 / A1-Tc-EC1 / 12/2/99 / ug/g		
0.025	Ag	--	--	--	--	--
0.060	Al	1,960	0.870	7.46	--	--
0.250	As	--	--	--	--	--
0.050	B	28.8	3.74	8.41	--	--
0.010	Ba	--	--	[0.030]	--	--
0.010	Be	--	--	--	--	--
0.100	Bi	--	--	--	--	--
0.250	Ca	137	--	--	--	--
0.015	Cd	23.1	--	--	--	--
0.200	Ce	--	--	--	--	--
0.050	Co	--	--	--	--	--
0.020	Cr	36.6	0.252	1.51	--	--
0.025	Cu	15.5	0.282	--	--	--
0.050	Dy	--	--	--	--	--
0.100	Eu	--	--	--	--	--
0.025	Fe	[8.3]	0.488	10.7	--	--
2.000	K	[630]	--	23.8	--	--
0.050	La	--	--	--	--	--
0.030	Li	--	--	--	--	--
0.100	Mg	--	--	[0.13]	--	--
0.050	Mn	--	--	[0.15]	--	--
0.050	Mo	[12]	--	--	--	--
0.150	Na	90,100	1,790	108	--	--
0.100	Nd	--	--	--	--	--
0.030	Ni	188	[0.11]	1.34	--	--
0.100	P	249	--	[0.24]	--	--
0.100	Pb	53.0	--	--	--	--
0.750	Pd	--	--	--	--	--
0.300	Rh	--	--	--	--	--
1.100	Ru	--	--	--	--	--
0.500	Sb	--	--	--	--	--
0.250	Se	--	--	--	--	--
0.500	Si	[59]	18.8	16.7	--	--
1.500	Sn	--	--	--	--	--
0.015	Sr	107	--	--	--	--
1.500	Te	--	--	--	--	--
1.000	Th	--	--	--	--	--
0.025	Ti	--	--	--	--	--
0.500	Tl	--	--	--	--	--
2.000	U	--	--	--	--	--
0.050	V	--	--	--	--	--
2.000	W	--	--	--	--	--
0.050	Y	--	--	--	--	--
0.050	Zn	[5.4]	0.532	[0.12]	--	--
0.050	Zr	--	--	--	--	--

Note: 1) Overall error greater than 10-times detection limit is estimated to be within +/- 15%.

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3) "--" indicate measurement is below detection. Sample detection limit may be found by multiplying "det. limit" (far left column) by "multiplier" (top of each column).

8/17

CLI[redacted] Kenneth

ASR 5571 PRELIMINARY DATA FINAL REPORT TC FOLLOW

A[redacted] DIGEST METHOD 128

ANALYST MJ Steele [redacted] E 11/16/99

REVIEWER _____ DATE _____

Note: dilutions should be done by mass.

Sample ID		vial (g)	vial+ sample(g)	sample (g)	post digest(g) new vial	post digest(g) sample(g)	Vol wt.	final vol.(ml)	
C1-Cs-ICP	00-0295 ✓	8.2179	8.8352	0.6173	NA			5	
C1-Cs-FD1-B	00-0306 ✓	8.1289	10.6006	2.4717	6.8823	17.0703	10.188	10	
C1-Cs-FD2-B	00-0307 ✓	8.0605	10.5321	2.4716	6.9176	16.9577	10.0401	10	
C1-Cs-FD3-B	00-0308 ✓	8.3068	10.6631	2.3563	6.8334	16.5048	9.6714	10	
C1-Cs-FD4-B	00-0309 ✓	8.0952	10.3006	2.2054	6.9074	16.4375	9.5301	10	
C1-Cs-FD5-B	00-0310 ✓	8.2097	10.3261	2.1164	6.9218	16.8993	9.9775	10	
C1-Cs-FD6-B	00-0311 ✓	8.1188	10.1608	2.042	6.9653	17.128	10.1627	10	
C1-Cs-FD7-B	00-0312 ✓	7.939	9.9628	2.0238	6.9433	17.254	10.3107	10	
C1-Cs-PR1-A	00-0313 ✓	8.0484	11.067	3.0186	6.8496	16.8079	9.9583	10	
C1-Cs-PR2-A	00-0314 * ✓	8.1417 ~~8.417~~	11.1532	3.0115 ~~2.7362~~	6.8531	16.9523	10.0992	10	
C1-Cs-PR3-A	00-0315 * ✓	8.0273	12.087	4.0597	6.9087	17.1594	10.2507	10	
C1-Cs-PR4-A	00-0316 * ✓	8.1647	10.1648	2.0001	6.9281	16.9736	10.0455	10	
C1-Cs-PR5-A	00-0317 * ✓	8.0868	11.0747	2.9879	6.96	16.8984	9.9384	10	
C1-Cs-PR6-A	00-0318 * ✓	8.2479	11.2531	3.0052	6.9718	16.9131	9.9413	10	
regeneration soln	00-0331 ✓	8.0918	13.0325	4.9407	NA	NA		5	
A1-Tc-EC1	00-0348 ✓	8.0802	13.0584	4.9782	NA	NA		5	
C1-Cs-PR1-A	00-0313 REP ✓	8.1162	11.1307	3.0145	6.8343	16.865	10.0307	10	
ASR 5571	PROCESS BLANK ✓				6.9092	17.2599	10.3507	10	

*SAMPLE ABOUT 0.5 ML DIGEST = ABOUT 3 HOURS

0.5M HNO3

PRELIMINARY DATA FINAL REPORT TC FOLLOW

11/16

L:/IAG/PREP/ ASR5571.xls

Battelle Pacific Northwest Laboratories
Analytical Chemistry Laboratory
Sample Receiving and Prep Laboratory

DENSITY DETERMINATION

Client Name: Dean Kunath
Work Auth. Doc (WAD): ASR 5571
Tank/Core/Project:
Special Instructions:

Work Package Number: W48409
Project Number: 29953
PNL QA Plan: SBMS
Prep. Lab (SAL/SRPL/other): SRPL
Procedure ID:

#	ACL #	1st Sample Wt. (g)	2nd Sample Wt. (g)	3rd Sample Wt. (g)		1st Density (g/ml)	2nd Density (g/ml)	3rd Density (g/ml)	AVERAGE DENSITY (g/ml)	
	00-0295	1.0073	1.0055	N/A		1.0093	1.0075	N/A	~~1.0084~~	1.0104
	00-0306	1.0673	1.0702			1.0694	1.0723		~~1.0709~~	1.0730
	00-0307	1.0673	1.0726			1.0694	1.0747		~~1.0721~~	1.0742
	00-0308	1.0585	1.0678			1.0606	1.0699		~~1.0653~~	1.0674
	00-0309	1.0408	1.0374			1.0429	1.0395		~~1.0412~~	1.0433
	00-310	1.0375	1.0390			1.0396	1.0411		~~1.0404~~	1.0425
	00-0311	1.0246	1.0339		1.0267	~~1.0302~~	1.0360		1.0314	1.0385
	00-0312	1.0281	1.0329			1.0302	1.0350		1.0326	1.0347
	00-0313	1.0327	1.0378			1.0348	1.0399		1.0374	1.0395
	00-0314	1.0158	1.0167			1.0178	1.0187		1.0183	1.0203

COMMENTS: Pipette # 288618 @ 1.0 mL T = 23°C
(d = 0.9975415)

0.9909
0.9954
0.9976
0.9973
0.9964

x̄ = 0.9955 g. → V = 0.9955 g / 0.997541 g/mL = 0.9980 mL
sd = 0.0027
%RSD = 0.27127
Dev. = 0.9980 mL.

LPD 12-16-99

M&TE Number: 360-06-01-037

Analyst/Date: Lori P. Darnell 12-16-99
Reviewer/Date:

[redacted]ical Chemistry Laboratory
[redacted]ple Receiving and Prep Laboratory

DENSITY DETERMINATION

Name:
Work Package Number:
Work Auth. Doc (WAD):
Project Number:
Tank/Core/Project:
PNL QA Plan:
Special Instructions:
Prep. Lab (SAL/SRPL/other):
Procedure ID:

#	ACL #	1st Sample Wt. (g)	2nd Sample Wt. (g)	3rd Sample Wt. (g)		1st Density (g/ml)	2nd Density (g/ml)	3rd Density (g/ml)	AVERAGE DENSITY (g/ml)
	00-0315	1.0240	1.0268	N/A		1.0261	1.0289	N/A	1.0254
	00-0316	1.0036	1.0129			1.0056	1.0149		1.0083
	00-0317	0.9947	1.0041			0.9967	1.0061		0.9994
	00-0318	1.0031	1.0063			1.0051	1.0083		1.0047
	00-0331	0.9919	0.9951			0.9939	0.9971		0.9935
	00-0348	No Sample Material			See last page(3)				
	00-313R	1.0161	1.0164			1.0181	1.0184		1.0163
	P.B.	1.0141	1.0145			1.0161	1.0165		1.0143

1.0254 1.0083 0.9994 1.0047 0.9935 1.0163 1.0143

COMMENTS:
M&TE Number:

Analyst/Date: Lori P. Darnell 12-16-99
Reviewer/Date:

Analytical Chemistry Laboratory
Sample Receiving and Prep Laboratory

DENSITY DETERMINATION

Client Name: Dean Kurath	Work Package Number: W48409
Work Auth. Doc (WAD): ASR5571	Project Number: 29953
Tank/Core/Project:	PNL QA Plan: SIBMS
Special Instructions:	Prep. Lab (SAL/SRPL/other): SRPL
	Procedure ID:

#	ACL #	1st Sample Wt. (g)	2nd Sample Wt. (g)	3rd Sample Wt. (g)		1st Density (g/ml)	2nd Density (g/ml)	3rd Density (g/ml)	AVERAGE DENSITY (g/ml)
	00-0348	1.0141	1.0152	1.0132		1.0066	1.0076	1.0057	1.0066

COMMENTS: M&TE Number: 36-06-21-026

112498 Pipet # (1ml) T = 20.6°C. (used 21°C d = 0.7979955)

1.0014
1.0026 X = 1.0055 g
1.0092 S = 0.0041
1.0089 %RSD = 0.4078 %
Dens. = 1.0075

Analyst/D: MJ Steele 12-16-99 Reviewer/Date:

File: 00-0295.xls

Battelle Pacific Northwest Laboratory
Radiochemical Processing Group-325 Building
Radioanalytical Applications Team

12/6/1999

RECORD COPY

Client : Kurath

proj 29953
T 2.8.3.3
Task 2.8

Cognizant Scientist: L R Greenwood Date : 12/6/99

Concur : Richard T. R Date : 12/7/99

Procedure: PNL-ALO-450

1/5

Measured Activities (uCi/g) with 1-sigma error

ALO ID Client ID	Co-60 Error %	Rurh-106 Error %	Sb-125 Error %	SnSb-126 Error %	Cs-134 Error %	Cs-137 Error %	Eu-154 Error %	Eu-155 Error %	Am-241 Error %	Y-88 Error %	Tc-95 Error %	Tc-95M Error %	Co-57 Error %
00-00295 C1-Cs-ICP	4.86E-2 3%	<2.E-1	<2.E-1	<5.E-2	<4.E-3	1.26E+2 2%	3.24E-2 6%	<8.E-2	<7.E-2				
00-00296 C1-Cs-0A	7.10E-4 4%	<3.E-3	<2.E-3	<6.E-4	<6.E-5	1.60E+0 2%	3.39E-4 14%	<2.E-3	<2.E-3				
00-00297 C1-Cs-L1A	4.38E-2 2%	<2.E-2	<7.E-3	<3.E-3	2.93E-4 35%	2.93E+1 2%	2.80E-2 2%	1.67E-2 10%	9.77E-3 17%				
00-00298 C1-Cs-L3A	4.43E-2 2%	<9.E-2	<6.E-2	<3.E-2	<2.E-3	5.29E+1 2%	2.90E-2 5%	<4.E-2	<4.E-2				
00-00299 C1-Cs-L6A	4.69E-2 2%	<5.E-2	<3.E-2	<2.E-2	<1.E-3	8.81E+1 2%	2.85E-2 3%	<2.E-2	<2.E-2				
00-00300 C1-Cs-L9B	5.16E-4 6%	<5.E-3	<3.E-3	<1.E-3	<7.E-5	1.13E+0 2%	4.01E-4 12%	<2.E-3	<2.E-3				
00-00301 C1-Cs-L12B	5.40E-4 6%	<5.E-3	<3.E-3	<1.E-3	<7.E-5	1.16E+0 2%	4.94E-4 12%	<3.E-3	<2.E-3				
00-00302 C1-Cs-P1A	3.52E-2 2%	<8.E-4	2.98E-4 28%	3.20E-4 6%	<2.E-4	1.08E-3 5%	2.52E-2 2%	1.79E-2 3%	9.03E-4 5%				
00-00303 C1-Cs-P2A	4.00E-2 2%	<2.E-3	5.57E-4 25%	3.58E-4 8%	<2.E-4	4.70E-3 3%	2.83E-2 2%	1.96E-2 3%	1.03E-2 7%				

Measured Activities (uCi/g) with 1-sigma error

ALO ID Client ID	Co-60 Error %	Rurh-106 Error %	Sb-125 Error %	SnSb-126 Error %	Cs-134 Error %	Cs-137 Error %	Eu-154 Error %	Eu-155 Error %	Am-241 Error %	Y-88 Error %	Tc-95 Error %	Tc-95M Error %	Co-57 Error %
00-00304 C1-Cs-P3A	4.26E-2 2%	<2.E-3	7.81E-4 20%	2.82E-4 11%	<2.E-4	9.59E-3 2%	2.85E-2 2%	1.95E-2 3%	1.02E-2 7%				
00-00305 C1-Cs-P6A	4.47E-2 2%	<3.E-3	<1.E-3	<4.E-4	<3.E-4	4.34E-1 2%	2.79E-2 2%	2.04E-2 3%	1.04E-2 5%				
00-00306 C1-Cs-FD1-B	4.64E-2 2%	<3.E-3	<2.E-3	<5.E-4	<2.E-4	9.00E-1 2%	2.93E-2 2%	2.09E-2 3%	1.08E-2 5%				
00-00307 C1-Cs-FD2-B	4.50E-2 2%	<3.E-3	<2.E-3	<6.E-4	<2.E-4	7.96E-1 2%	2.72E-2 2%	1.99E-2 3%	1.08E-2 5%				
00-00308 C1-Cs-FD3-B	4.91E-2 2%	<2.E-3	<1.E-3	<4.E-4	<2.E-4	6.03E-1 2%	1.63E-2 2%	1.17E-2 3%	6.56E-3 6%				
00-00309 C1-Cs-FD4-B	4.06E-2 2%	<2.E-3	<1.E-3	<3.E-4	<2.E-4	4.69E-1 2%	8.21E-3 2%	5.97E-3 5%	3.27E-3 13%				
00-00310 C1-Cs-FD5-B	2.80E-2 2%	<2.E-3	<7.E-4	<3.E-4	<2.E-4	3.00E-1 2%	4.95E-3 2%	3.53E-3 4%	2.51E-3 8%				
00-00311 C1-Cs-FD6-B	1.77E-2 2%	<2.E-3	<6.E-4	<3.E-4	<2.E-4	1.65E-1 2%	3.15E-3 3%	2.16E-3 6%	1.24E-3 12%				
00-00312 C1-Cs-FD7-B	1.21E-2 2%	<9.E-4	<5.E-4	<2.E-4	<8.E-5	1.80E-1 2%	2.09E-3 3%	1.34E-3 8%	1.04E-3 17%				
00-00313 C1-Cs-PR1-A	6.71E-3 2%	<8.E-4	<5.E-4	<8.E-5	<6.E-5	1.26E-1 2%	9.12E-4 5%	6.53E-4 16%	6.95E-4 29%				
00-00314 C1-Cs-PR2-A	4.25E-3 2%	<5.E-4	<3.E-4	<3.E-4	<3.E-5	1.14E-1 2%	5.32E-4 4%	3.47E-4 11%	2.38E-4 22%				
00-00315 C1-Cs-PR3-A	4.67E-3 2%	<5.E-4	<3.E-4	<3.E-4	<4.E-5	7.31E-2 2%	1.28E-3 2%	9.27E-4 5%	5.50E-4 11%				
00-00316 C1-Cs-PR4-A	3.46E-3 2%	<3.E-4	<2.E-4	<3.E-5	<3.E-5	3.83E-2 2%	4.81E-4 4%	3.76E-4 9%	1.74E-4 26%				
00-00317 C1-Cs-PR5-A	2.71E-3 2%	<2.E-4	<2.E-4	<3.E-5	<2.E-5	2.51E-2 2%	3.18E-4 4%	2.05E-4 11%	1.32E-4 27%				

Measured Activities (uCi/g) with 1-sigma error

ALO ID Client ID	Co-60 Error %	Rurh-106 Error %	Sb-125 Error %	SnSb-126 Error %	Cs-134 Error %	Cs-137 Error %	Eu-154 Error %	Eu-155 Error %	Am-241 Error %	Y-88 Error %	Tc-95 Error %	Tc-95M Error %	Co-57 Error %
00-00318 C1-Cs-PR6-A	2.11E-3 2%	<2.E-4	<7.E-5	<2.E-5	<2.E-5	1.97E-2 2%	1.94E-4 4%	1.40E-4 10%	<3.E-5				
00-00319 C1-Cs-E1-1B	1.03E-4 6%	<9.E-4	<5.E-4	<5.E-4	<2.E-5	2.13E-1 2%	<5.E-5	<3.E-4	<3.E-4				
00-00320 C1-Cs-E1-3B	<2.E-5	<6.E-4	<4.E-4	<6.E-5	<3.E-5	5.41E-2 2%	<4.E-5	<3.E-4	<3.E-4				
00-00321 C1-Cs-E1-4B	<7.E-6	<7.E-4	<4.E-4	<2.E-4	<9.E-6	1.46E-1 3%	<2.E-5	<3.E-4	<3.E-4				
00-00322 C1-Cs-E1-5B	<7.E-6	<9.E-4	<6.E-4	<6.E-4	<2.E-5	3.41E-1 3%	<2.E-5	<3.E-4	<3.E-4				
00-00323 C1-Cs-E1-6B	<3.E-5	<2.E-3	<9.E-4	<2.E-4	<4.E-5	3.31E-1 2%	<6.E-5	<6.E-4	<7.E-4				
00-00324 C1-Cs-E1-7B	5.66E-5 8%	<9.E-4	<6.E-4	<9.E-5	<2.E-5	3.21E-1 2%	<4.E-5	<4.E-4	<4.E-4				
00-00325 C1-Cs-E1-9B	3.34E-4 5%	<2.E-3	<1.E-3	<4.E-4	<3.E-5	4.93E-1 2%	<7.E-5	<6.E-4	<6.E-4				
00-00326 C1-Cs-E1-11B	2.48E-4 5%	<2.E-3	<7.E-4	<2.E-4	<4.E-5	2.54E-1 2%	<6.E-5	<5.E-4	<6.E-4				
00-00327 C1-Cs-E1-13A	9.09E-4 3%	<3.E-3	<2.E-3	<3.E-4	<9.E-5	8.98E-1 2%	<2.E-4	<2.E-3	<2.E-3				
00-00328 C1-Cs-E1-R1A	1.55E-3 4%	<8.E-3	<5.E-3	<9.E-4	<3.E-4	3.32E+0 2%	<4.E-4	<4.E-3	<5.E-3				
00-00329 C1-Cs-E1-R3A	1.57E-3 2%	<2.E-3	<7.E-4	<3.E-4	<4.E-5	3.63E-1 2%	<6.E-5	<5.E-4	<5.E-4				
00-00330 C1-Cs-E1-R6A	1.78E-4 3%	<3.E-4	<2.E-4	<7.E-5	3.46E-5 12%	5.50E-2 2%	<2.E-5	<1.E-4	<1.E-4				

Measured Activities (uCi/g) with 1-sigma error

ALO ID Client ID	Co-60 Error %	Rurh-106 Error %	Sb-125 Error %	SnSb-126 Error %	Cs-134 Error %	Cs-137 Error %	Eu-154 Error %	Eu-155 Error %	Am-241 Error %	Y-88 Error %	Tc-95 Error %	Tc-95M Error %	Co-57 Error %
00-00331 Regeneration	4.56E-4 2%	<2.E-4	<8.E-5	<3.E-5	2.95E-5 10%	2.29E-2 2%	<2.E-5	<5.E-5	<5.E-5				
00-00332 C1-CA	2.98E-3 3%	<2.E-2	<7.E-3	<3.E-3	<3.E-4	7.41E+0 2%	6.04E-4 23%	<6.E-3	<5.E-3				
00-00333 C1-S1A	2.85E-3 3%	<2.E-2	<7.E-3	<3.E-3	<3.E-4	7.30E+0 2%	2.20E-3 7%	<6.E-3	<5.E-3				
00-00334 C1-S2A	2.86E-3 3%	<2.E-2	<7.E-3	<3.E-3	<3.E-4	7.29E+0 2%	1.78E-3 9%	<6.E-3	<5.E-3				
00-00335 C1-44A	2.45E-3 2%	<2.E-3	<2.E-3	<3.E-4	<7.E-5	7.16E-1 2%	1.65E-3 4%	1.43E-3 20%	<2.E-3				
00-00336 C1-44-D-A	2.50E-3 2%	<2.E-3	<2.E-3	<4.E-4	<6.E-5	5.49E-1 2%	1.67E-3 4%	8.36E-4 19%	7.47E-4 30%				
00-00337 C1-44-S1-A	2.51E-3 2%	<4.E-3	<3.E-3	<8.E-4	<8.E-5	1.40E+0 2%	1.73E-3 5%	<2.E-3	<2.E-3				
00-00338 C1-44-S1-D	2.52E-3 2%	<4.E-3	<3.E-3	<8.E-4	<8.E-5	1.49E+0 2%	1.64E-3 5%	1.12E-3 30%	<2.E-3				
00-00339 C1-44-S2-A	2.53E-3 3%	<7.E-3	<4.E-3	<2.E-3	<2.E-4	3.19E+0 2%	1.80E-3 5%	<3.E-3	<3.E-3				
00-00340 C1-44-S2-D	2.45E-3 3%	<6.E-3	<4.E-4	<2.E-3	<1.E-4	2.46E+0 2%	1.65E-3 6%	<3.E-3	<3.E-3				
00-00341 A1R-Cs-0	5.14E-4 5%	<1.E-2	<6.E-3	<6.E-3	3.45E-3 4%	2.09E+1 2%	<3.E-4	<4.E-3	<4.E-3				
00-00342 A1R-Cs-L1	2.91E-4 2%	<3.E-4	<2.E-4	1.82E-4 10%	4.92E-5 10%	2.11E-1 2%	3.36E-5 20%	<2.E-4	<2.E-4				
00-00343 A1R-Cs-L2	3.03E-4 2%	<4.E-4	<3.E-4	1.61E-4 4%	6.19E-5 6%	3.12E-1 2%	3.23E-5 18%	<2.E-4	<2.E-4				
00-00344 A1R-Cs-P1	2.79E-4 2%	3.40E-4 10%	8.60E-5 19%	2.12E-4 3%	1.62E-5 15%	1.85E-2 2%	1.72E-5 24%	<5.E-5	<5.E-5				

Measured Activities (uCi/g) with 1-sigma error

ALO ID Client ID	Co-60 Error %	Rurh-106 Error %	Sb-125 Error %	SnSb-126 Error %	Cs-134 Error %	Cs-137 Error %	Eu-154 Error %	Eu-155 Error %	Am-241 Error %	Y-88 Error %	Tc-95 Error %	Tc-95M Error %	Co-57 Error %
00-00345 A1R-Cs-P2	3.08E-4 2%	2.78E-4 12%	9.85E-5 17%	2.18E-4 2%	4.91E-5 7%	1.97E-2 2%	2.87E-5 15%	<6.E-5	<7.E-5				
00-00346 A1R-Cs-P7	2.77E-4 2%	2.30E-4 14%	6.97E-5 24%	1.77E-4 3%	7.31E-6 37%	2.91E-2 2%	1.78E-5 21%	<5.E-5	<7.E-5				
00-00347 A1-Cs-E2-CO	<1.E-5	<2.E-3	<7.E-4	<2.E-4	6.76E-5 22%	4.54E-1 2%	<5.E-5	<5.E-4	<6.E-4				
00-00348* A1-Tc-EC1	<2.E-6	<2.E-4	<6.E-5	<2.E-5	<2.E-5	6.61E-5 10%	<5.E-6	<7.E-5	<6.E-5	9.93E-6 7%	4.61E-3 2%	9.76E-2 2%	
00-00349** A1-Tc-LC	2.88E-4 2%	2.83E-4 8%	8.48E-5 20%	2.04E-4 4%	9.00E-6 16%	5.89E-2 2%	2.33E-5 8%	<4.E-5	<6.E-5	2.14E-5 4%	8.52E-5 4%	1.80E-3 2%	6.84E-5 38%
00-00365 C1-Cs-OAR	7.29E-3 3%	<3.E-2	<2.E-2	<6.E-3	<6.E-4	1.81E+1 2%	4.65E-3 8%	<1.E-2	<9.E-3				

*Sample activity of Tc-95m as of 11/17/99 at 15:00
**Sample activity of Tc-95m as of 11/18/99 at 14:30

GEA PREP SHEET

CLIENT D. Kurath

ASR 5571

$\rho = \frac{1.2328\,g}{0.9927\,mL} = 1.2411\,g/mL$

ANALYST MJ Stile DATE 11/5/99

REVIEWER _____ DATE _____

ilutions should be done by mass.		VIAL	VIAL+ SAMPLE	MASS	VIAL + SAMPLE + DDI	DILUTION	GEA GEOMETRY	Minimum reportable quantities (MRQ)	Notes
Sample ID									
C1-Cs-ICP	00-0295	16.7602	17.9922	1.232	18.9798	1.80	2	Cs-137; 9 uCi/mL, Na, K (75 ug.mL)	
C1-Cs-0A	00-0296	16.7755	17.7844	1.0089	18.7732	1.98	2	Cs-137; 9 uCi/mL	extra long count for minor radionuclides requested
C1-Cs-L1A	00-0297	16.7903	18.0211	1.2308	19.0117	1.80	2	Cs-137; 9 uCi/mL	extra long count for minor radionuclides requested
C1-Cs-L3A	00-0298	16.6708	19.143	2.4722			2	Cs-137; 9 uCi/mL	
C1-Cs-L6A	00-0299	16.658	19.1424	2.4844			2	Cs-137; 9 uCi/mL	
C1-Cs-L9B	00-0300	16.9888	22.0289	5.0401	26.9407	1.97	10	Cs-137; 9 uCi/mL	
C1-Cs-L12B	00-0301	16.9657	22.0073	5.0416	26.9156	1.97	10	Cs-137; 9 uCi/mL	
C1-Cs-P1A	00-0302	16.7541	19.2027	2.4486			2	Cs-137; 9 uCi/mL	extra long count for minor radionuclides requested
C1-Cs-P2A	00-0303	16.7488	17.9864	1.2376	18.9755	1.80	2	Cs-137; 9 uCi/mL	extra long count for minor radionuclides requested
C1-Cs-P3A	00-0304	16.782	18.0306	1.2486	19.021	1.79	2	Cs-137; 9 uCi/mL	extra long count for minor radionuclides requested
C1-Cs-P6A	00-0305	16.9608	18.2027	1.2419	19.1875	1.79	2	Cs-137; 9 uCi/mL	
C1-Cs-FD1-B	00-0306	16.808	19.2878	2.4798			2	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	Need to load out undiluted sample
C1-Cs-FD2-B	00-0307	16.948	19.4158	2.4678			2	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	Need to load out undiluted sample
C1-Cs-FD3-B	00-0308	16.9552	19.3009	2.3457			2	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	Need to load out undiluted sample
C1-Cs-FD4-B	00-0309	16.7455	18.9407	2.1952			2	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	Need to load out undiluted sample
C1-Cs-FD5-B	00-0310	16.683	18.7853	2.1023			2	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	Need to load out undiluted sample
C1-Cs-FD6-B	00-0311	16.9792	19.0251	2.0459			2	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	Need to load out undiluted sample
C1-Cs-FD7-B	00-0312	16.9417	18.9551	2.0134			2	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	Need to load out undiluted sample

filename = ASR5571.xls

GEA SHEET

CLIENT Kuwait

ASR 5571

ANALYST MJ Steele DATE 11/5/99

REVIEWER _____ DATE _____

ilutions should be done by mass.		VIAL	VIAL+ SAMPLE	MASS	VIAL + SAMPLE + DDI	DILUTION	GEA GEOMETRY	Minimum reportable quantities (MRQ)	Notes
Sample ID									
C1-Cs-PR1-A	00-0313	16.6851	26.7142	10.0291			10	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	
C1-Cs-PR2-A	00-0314	17.0297	27.0518	10.0221			10	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	
C1-Cs-PR3-A	00-0315	16.7783	26.8425	10.0642			10	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	
C1-Cs-PR4-A	00-0316	16.9674	26.9676	10.0002			10	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	
C1-Cs-PR5-A	00-0317	16.7893	26.7803	9.991			10	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	
C1-Cs-PR6-A	00-0318	16.7316	26.6941	9.9625			10	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	
C1-Cs-E1-1B	00-0319	16.7099	18.7458	2.0359			2	Cs-137; 9 uCi/mL	
C1-Cs-E1-3B	00-0320	16.7883	18.8182	2.0299			2	Cs-137; 9 uCi/mL	
C1-Cs-E1-4B2	00-0321	16.6441	21.7182	5.0741			10	Cs-137; 9 uCi/mL	
C1-Cs-E1-5B2	00-0322	16.8426	21.878	5.0354			10	Cs-137; 9 uCi/mL	
C1-Cs-E1-6B2	00-0323	16.7339	18.7569	2.023			2	Cs-137; 9 uCi/mL	
C1-Cs-E1-7B1	00-0324	16.7446	18.7761	2.0315			2	Cs-137; 9 uCi/mL	
C1-Cs-E1-9B1	00-0325	16.6514	18.6798	2.0284			2	Cs-137; 9 uCi/mL	
C1-Cs-E1-11B1	00-0326	16.7359	18.7691	2.0332			2	Cs-137; 9 uCi/mL	
C1-Cs-E1-13A	00-0327	16.7129	26.8081	10.0952			10	Cs-137; 9 uCi/mL	
C1-Cs-E1-R1-A	00-0328	16.8581	18.8788	2.0207			2	Cs-137; 9 uCi/mL	
C1-Cs-E1-R3-A	00-0329	16.8183	26.9791	10.1608			10	Cs-137; 9 uCi/mL	
C1-Cs-E1-R6-A	00-0330	16.727	26.7102	9.9832			10	Cs-137; 9 uCi/mL	
regeneration soln	00-0331	16.7578	26.7397	9.9819			10	Cs-137; 9 uCi/mL, Na, K (75 ug.mL), OH (17 ug/mL)	
C1-CA	00-0332	16.7378	21.794	5.0562	26.6989	1.97	10		
C1-S1A	00-0333	16.6398	21.6825	5.0427	26.571	1.97	10		
C1-S2A	00-0334	16.6644	21.7125	5.0481	26.6167	1.97	10		
C1-44A	00-0335	16.6225	21.6696	5.0471	26.5551	1.97	10		
C1-44-D-A	00-0336	16.8092	21.8543	5.0451	26.7674	1.97	10		
C1-44-S1-A	00-0337	16.7603	21.7962	5.0359	26.7005	1.97	10		

filename = ASR5571.xls

GEA PREP SHEET

CLIENT Kuralth

ASR 5571

ANALYST MJ Steele DATE 11/5/99

REVIEWER _____ DATE _____

ilutions should be done by mass.		VIAL	VIAL+ SAMPLE	MASS	VIAL + SAMPLE + DDI	DILUTION	GEA GEOMETRY	Minimum reportable quantities (MRQ)	Notes
Sample ID									
C1-44-S1-D-A	00-0338	16.6993	21.7415	5.0422	26.6497	1.97	10		
C1-44-S2-A	00-0339	16.7008	21.749	5.0482	26.6393	1.97	10		
C1-44-S2-D-A	00-0340	16.81	21.8646	5.0546	26.7551	1.97	10		
A1R-Cs-0	00-0341	16.7654	18.0063	1.2409	18.9992	1.80	2		extra long count for minor radionuclides requested (stored in RMA in 410), some solids in vial, mix up a bit before using
A1R-Cs-L1	00-0342	16.7184	19.1763	2.4579			2		extra long count for minor radionuclides requested (stored in RMA in 410), some solids in vial, mix up a bit before using
A1R-Cs-L2	00-0343	16.8217	19.2722	2.4505			2		extra long count for minor radionuclides requested (stored in RMA in 410), some solids in vial, mix up a bit before using
A1R-Cs-P1	00-0344	16.8819	19.3285	2.4466			2		extra long count for minor radionuclides requested (stored in RMA in 410), some solids in vial, mix up a bit before using
A1R-Cs-P2	00-0345	16.7088	19.1687	2.4599			2		extra long count for minor radionuclides requested (stored in RMA in 410), some solids in vial, mix up a bit before using
A1R-Cs-P7	00-0346	16.1667	19.0743	2.9076			2		extra long count for minor radionuclides requested (stored in RMA in 410), some solids in vial, mix up a bit before using
A1-Cs-E2-CO	00-0347	16.7207	18.7355	2.0148			2		Cs is main rad of interest but report others if detected (RMA in 410)
A1-Tc-EC1	00-0348	16.7414	26.8372	10.0958			10	see table 6-1	Extra long count for minor radionuclides requested
A1-Tc-LC	00-0349	16.6691	28.8807	12.2116			10		Extra long count for minor radionuclides requested
C1-CS-0AR	00-0365	16.7944	18.8635	2.0691			2		

filename = ASR5571.xls

Radiochemistry Bench Sheet

Client: D Knuath
Work Order #: 5571
ASR:
Procedure: Prep

GEA + ICP
Prep

Balance: 360-06-01-02B

T = 19°C

Sample ID	Dilutions and Aliquot Sizes	Pipet ID Numbers / Pipet Checks
	ρ_{water} @ 19°C = 0.99840 g/mL	#07544 0.5ml 0.4993 0.4967 0.4972 0.4987 ave = 0.49830 g V = 0.4988 mL
		#L05722N 10ml 9.9691 9.9576 9.9510 9.9462 9.9560 g V = 9.9719 mL
		5ml 4.9507 4.9302 4.9317 4.9251 ave = 4.93194 V = 4.9423 mL
		#126886 1ml 0.9942 0.9918 0.9907 0.9897 ave = 0.99114 V = 0.9927

Spike, Tracer ID
Isotope
Concentration
Ref Date

Analyst/Date: MJ Steele 11/4/99

Reviewer/Date:

Battelle Pacific Northwest Laboratory
Radiochemical Processing Group-325 Building
Radioanalytical Applications Team

00-1040

2/4/00

Client : Kurath

Cognizant Scientist: J R Greenwood Date : 2/4/00

Concur : T Trang-Le Date : 2/4/00

Procedure: PNL-ALO-450

RECORD COPY

proj 29953
T2.8.3.3
Task 2.8
P 1/2

Measured Activities (uCi/g) with 1-sigma error

ALO ID Client ID	Co-60 Error %	Sb-125 Error %	SnSb-126 Error %	Cs-137 Error %	Eu-154 Error %	Eu-155 Error %	Am-241 Error %
00-1040 AN-107-TclX	4.21E-2 2%	<4.13E-4	2.77E-4 10%	7.01E-2 2%	2.74E-2 2%	1.90E-2 3%	9.37E-3 10%
00-1041 Effluent-1D	4.07E-2 2%	5.59E-4 29%	3.12E-4 12%	4.76E-3 3%	2.66E-2 2%	1.88E-2 3%	9.37E-3 11%
00-1042 Effluent-2D	4.50E-2 2%	<9.83E-4	3.14E-4 17%	2.33E-1 2%	2.82E-2 2%	2.05E-2 3%	9.55E-3 11%
00-1043 C1-Cs-E2-4c2	<9.89E-5	<3.46E-3	<9.89E-4	1.79E+0 2%	<1.48E-4	<2.97E-3	<3.95E-3
00-1044 C1-Cs-E2-5c2	<9.87E-5	<4.93E-3	<1.48E-3	3.31E+0 2%	<1.97E-4	<3.95E-3	<4.93E-3
00-1045 C1-Cs-E2-6c2	<9.90E-5	<9.90E-3	<1.49E-3	4.32E+0 2%	<2.48E-4	<4.46E-3	<9.90E-3
00-1046 C1-Cs-E2-7c	8.68E-5 16%	<2.98E-3	<9.92E-4	2.47E+0 2%	<1.49E-4	<2.48E-3	<2.98E-3

Radiochemistry Bench Sheet

RECORD COPY

Proj 29953
Task 2.8
T 2.8.3.3
P2/2

Client Kuraath CMC
Work Order #
ASR

Geometry = 2 ml

Balance 360-06-01-036426

Procedure GEA – see ASR for isotopes of interest

Sample ID	Dilutions and Aliquot Sizes	Vial +026	Vial + Sample DDI added	Mass Sample	T = 20.2°C Pipet ID Numbers / Pipet Checks
00-1040	~~17.5339~~ 17.5339	19.9574		2.4255 #	126086
00-1041	~~17.0308~~	17.4470 *	18.9319 (1.4849)	0.5ml **	0.9901
00-1042	~~17.1413~~	17.513 *	19.0009 (1.4878)	0.5ml **	0.9887 X = 0.9927 ml
00-1043	17.1371	19.1599		2.0228	0.9920
00-1044	17.0892	19.116		2.0269	0.9973
00-1045	16.9234	18.9433		2.0199	0.9952
00-1046	17.0288	19.0448		2.0160	

** Dot from Dean Kuraath

* Vial + sample as rec'd 0.5ml added 1.5 H_2O for 2ml Geometry

Spike, Tracer ID
Isotope
Concentration
Ref Date

Analyst/Date MJ Steele 1/27/00 Reviewer/Date JR Hammond 2/4/00

Battelle Pacific Northwest Laboratory 00-1073
Radiochemical Processing Group-325 Building
Radioanalytical Applications Team

Client : Kurath

Cognizant Scientist: L R Greenwood Date: 2/4/00

Concur : T Trang-Le Date: 2/4/00

Procedure: PNL-ALO-450

Measured Activities (uCi/ml) with 1-sigma error

ALO ID Client ID	Co-60 Error %	Cs-137 Error %	Eu-154 Error %
00-1073 C1-Cs L2	4.21E-2 2%	4.31E+1 2%	2.66E-2 4%
00-1074* C1-Cs L4	6.14E-2 3%	8.99E+1 3%	4.47E-2 6%
00-1075* C1-Cs L5	4.15E-2 3%	6.84E+1 3%	2.54E-2 6%
00-1076 C1-Cs 8A	4.43E-3 3%	8.95E+0 2%	3.19E-3 6%
00-1077 C1-Cs 10A	5.17E-3 3%	1.09E+1 2%	3.43E-3 7%
00-1078 C1-Cs 11A	4.24E-3 3%	9.67E+0 2%	2.83E-3 8%
00-1079 C1-Cs 10B	5.31E-4 3%	1.17E+0 2%	3.51E-4 8%
00-1080 C1-Cs 11B	2.62E-3 3%	6.11E+0 2%	1.58E-3 9%

RECORD COPY

proj 29953
T2.8.3.3
Task 2.8
P 1/1

*Note: These 2 samples contained very high activity; thus a ~1% bias (low) can be expected with the reported activities. This bias is included with the reported uncertainties.

Battelle Pacific Northwest Laboratory 00-1073
Radiochemical Processing Group-325 Building
Radioanalytical Applications Team

Client : Kurath

Cognizant Scientist: _____ Date: _____

Concur : _____ Date: _____

proj 29953
Task 28
T2.8.3.3
P1/1

Procedure: PNL-ALO-450

Measured Activities (uCi/ml) with 1-sigma error

ALO ID Client ID	Co-60 Error %	Cs-137 Error %	Eu-154 Error %	Volume ml	Mass g
00-1073 C1-Cs L2	4.21E-2 2%	4.31E+1 2%	2.66E-2 4%	2.00	1.9219
00-1074* C1-Cs L4	6.14E-2 3%	8.99E+1 3%	4.47E-2 6%	2.00	2.7406
00-1075* C1-Cs L5	4.15E-2 3%	6.84E+1 3%	2.54E-2 6%	2.00	1.8372
00-1076 C1-Cs 8A	4.43E-3 3%	8.95E+0 2%	3.19E-3 6%	2.00	2.1057
00-1077 C1-Cs 10A	5.17E-3 3%	1.09E+1 2%	3.43E-3 7%	2.00	2.1177
00-1078 C1-Cs 11A	4.24E-3 3%	9.67E+0 2%	2.83E-3 8%	2.00	2.0709
00-1079 C1-Cs 10B	5.31E-4 3%	1.17E+0 2%	3.51E-4 8%	10.00	10.1596
00-1080 C1-Cs 11B	2.62E-3 3%	6.11E+0 2%	1.58E-3 9%	2.00	10.2126

Note: These 2 samples contained very high activity; thus a ~1% bias (low) can be expected with the reported activities. This bias is included with the reported uncertainties.

Battelle PNNL/RPG/Inorganic Analysis --- TOC/TIC Report

Client: D. Blanchard
Charge Code: 75%/25% W48409/W48414
Project: 29953
ACL Numbers: 00-0615 to 00-0619
ASR Number: 5626
Analyst: MJ Steele
Analysis Date: January 7, 2000

Procedure: PNL-ALO-381, "Direct Determination of TC, TOC, and TIC in Radioactive Sludges and Liquids by Hot Persulfate Method"
M&TE: Carbon System (WA92040); Balance (360-06-01-023).

proj 29953
Task 2.8
T2.8.3.3
1/2

Final Results:

Lab Number	Sample ID	Vol ml	TOC µg C/ml	TOC RPD %
00-0615	N7-Tc-Elu-Comp	0.3000	<60	
00-0615 Dup	N7-Tc-Elu-Comp Rep	1.0000	<20	n/a
00-0615 Spike	N7-Tc-Elu-Comp MS	1.0000	104%	
00-0616	A1-Cs-E2-Comp	0.3000	80	
00-0616 Dup	A1-Cs-E2-Comp Rep	1.0000	<20	n/a
00-0617	A1R-Cs-E-Comp	1.0000	<20	
00-0617 Dup	A1R-Cs-E-Comp Rep	1.0000	<20	n/a
00-0618	C1-Cs-E1-Comp	1.0000	150	
00-0618 Dup	C1-Cs-E1-Comp Rep	1.0000	150	0
00-0619	C1-Cs-E2-Comp	1.0000	200	
00-0619 Dup	C1-Cs-E2-Comp Rep	1.0000	190	5

RPD = Relative Percent Difference (between sample and duplicate/replicate)
n/a = Not applicable; either sample or duplicate result is <5 times MDL

The analysis of the subject samples submitted under ASR 5626 were performed by the hot persulfate wet oxidation method. The hot persulfate method uses acid decomposition for TIC and acidic potassium persulfate oxidation at 92-95°C for TOC, all on the same sample, with TC being the sum of the TIC and TOC. Per the ASR and since the samples were acidic, only TIC analyses were performed on these samples.

The table above shows the results, rounded to one to two significant figures. The result for A1-Cs-E2-Comp (i.e., 80 µg/ml) is only marginally above the method detection limit for the 0.3 ml sample size analyzed (i.e., 60 µg/ml) and should be considered qualitative. The raw data bench sheets and calculation work sheets showing all calculations are attached. All sample results are corrected for average percent recovery of system calibration standards and are also corrected for contribution from the blank

Q.C. Comments:

The TIC standard is calcium carbonate and TOC standard is α-Glucose (the certificates of purity are attached). The standard materials were used in solid form for system calibration standards as well as matrix spikes. TIC and TOC percent recovery are determined using the appropriate standard (i.e., calcium carbonate for TIC or glucose for TOC).

The QC for the methods involves calibration blanks, system calibration standards, sample duplicates, and one matrix spike per matrix type.

Calibration Standards: The QC system calibration standards were all within acceptance criteria, with the average recovery being 98.4% for TIC and 98.1% for TOC.

Calibration Blanks: The three calibration blanks run at the beginning and middle of the analysis run were acceptable, averaging 13.9 µgC TIC and 454.7 µgC TOC.

Duplicates: No actual sample duplicates were provided to the laboratory for analysis. However, each sample was analyzed in replicate and the relative percent differences (RPD) between replicates are within the acceptance criteria of 20% for all values measured above the EQL (i.e., 5 times the method detection limit).

Matrix Spike: The accuracy of the carbon measurements can be estimated by the recovery results from the matrix spike. A matrix spike was prepared from sample 00-0615 (N7-Tc-Elu-Comp) with the TOC spike recovery being 103.8%, well within the 75% to 125% recovery acceptance criteria.

General Comments:

- The reported "Final Results" have been corrected for all dilution performed on the sample during processing or analysis.
- Routine precision and bias are typically ±15% or better for non-complex samples that are free of interferences.
- The estimated quantitation limit (EQL) is defined as 5 times the MDL. Results less than 5 times the MDL have higher uncertainties, and RPDs are not calculated for any results less than 5 times the MDL.
- Some results may be reported as less than ("<") values. These less than values represent the sample MDL (method detection limit), which is the system MDL adjusted for the volume of sample used for the analysis. The system MDL is based on the attached pooled historical blank data. The evaluation and calculation of the system MDL is included in the data package.

Report Prepared by: _____ **Date** 1-11-00

Review/Approval by: _____ **Date** 1-17-00

Archive Information:

Files: ASR 5626 Blanchard.doc	ASR 5478 5626 Liq+Solids.xls

Eluate Composite Analytical Results

Battelle PNNL/325 Bldg/RPG/Inorganic Analysis ...
ICPAES Data Report

Project: 29953
Client: D. Blanchard

proj 29953
Task 2.8
T2.8.3.3

ACL Number(s): 00-0615 to 00-0619
&
00-0626 to 00-0664

Client ID: "N7-Tc-Elu-Comp" to "C1-Cs-E2-Composite"
&
"N7-Tc-0" to "N7-Tc-R01"

~~Elu~~ Eluate composite

ASR Number: 5626 & 5628

Total Samples: 13

Procedure: PNL-ALO-211, "Determination of Elements by Inductively Coupled Argon Plasma Atomic Emission Spectrometry" (ICP-AES).

Analyst: D.R. Sanders

Analysis Date (Filename): 12-16-99 (A0570) & 12-17-99 (A0571)

See Chemical Measurement Center 98620: ICP-325-405-1 File for Calibration and Maintenance Records.

M&TE Number: ICPAES instrument -- WB73520
Mettler AT400 Balance -- Ser.No. 360-06-01-029

Jerry Wagner 12-29-99
Reviewed by

MD Thun 1-4-00
Concur

Battelle PNNL/325 Bldg/RPG/Inorganic Analysis ...
ICPAES Data Report

Five radioactive liquid samples, N7-Tc-Elu-Comp to C1-Cs-E2-Composite (ACL# 00-0615 to 00-0619), were analyzed by ICPAES after each sample was diluted using dilute nitric acid by the Sample Receiving and Preparation Laboratory (SRPL). Final sample volume was 25ml (weighed). Concentration was adjusted for dilution using the weight of final solution divided by sample weight.

Eight radioactive liquid samples, N7-Tc-0 to N7-Tc-R01 (ACL# 00-0626 to 00-0664), were analyzed by ICPAES after samples were prepared by SRPL using PNL-ALO-128 acid digestion procedure. Approximately 3ml of sample (weighed) was digested and diluted to a final volume of approximately 10ml (weighed). Concentration was adjusted for dilution from processing using the weight of final solution divided by sample weight.

Measurement results reported have been corrected for preparation and analytical dilution. All results reported are in µg/ml for liquid samples. Weights have been recorded on bench sheets and included with this report.

Liquid samples contained low to high concentrations of sodium (<0.1% to about 10%). All other analytes measured were typically much lower in concentration.

Quality control check-standard results met tolerance requirements except as noted below. Following is a list of quality control measurement results relative to ICPAES analysis tolerance requirements under MCS-033.

Five fold serial dilution:

(Aqueous samples) All results for analytes of interest were within tolerance limit of ≤ 10% after correcting for dilution.

Duplicate RPD (Relative Percent Difference):

(Aqueous samples) All analytes of interest were recovered within tolerance limit of ≤ 20% relative percent difference (RPD).

Post-Spiked Samples (Group A):

(Aqueous samples) All analytes of interest were recovered within tolerance of 75% to 125%.

Post-Spiked Samples (Group B):

(Aqueous samples) All analytes of interest were recovered within tolerance of 75% to 125%.

Blank Spike:
(Aqueous samples) None required or prepared.

Matrix Spiked Sample:
(Aqueous samples) None required or prepared.

Quality Control Check Standards (aqueous samples):
Concentration of all analytes was within tolerance limit of ± 10% accuracy in the standards: QC_MCVA, QC_MCVB, ICP98.0 and QC_SSTMCV except as follows. Tin and palladium was low by as much as 23% in QC_MCVB check standard measurements. Single element standards of tin at 2 µg/ml and palladium 2 µg/ml measured were well within the tolerance limit thus confirming calibration check for these two analytes.

High Calibration Standard Check (aqueous samples):
Verification of the high-end calibration concentration for all analytes is within tolerance of ± 5% accuracy.

Process Blank:
(Aqueous samples) All analytes are within tolerance limit of ≤ EQL or < 5% of sample concentration.

Laboratory Control Standard (LCS):
(Aqueous samples) No LCS was prepared for PNL-ALO-128 acid digested samples.

Please note bracketed values listed in the data report are within ten times instrument detection limit and have a potential uncertainty much greater than 15%.

Comments:

1) "Final Results" have been corrected for all laboratory dilution performed on the sample during processing and analysis unless specifically noted.

2) Detection limits (DL) shown are for acidified water. Detection limits for other matrices may be determined if requested.

3) Routine precision and bias is typically ± 15% or better for samples in dilute, acidified water (e.g. 2% v/v HNO_3 or less) at analyte concentrations greater than ten times detection limit up to the upper calibration level. This also presumes that the total dissolved solids concentration in the sample is less than 5000 µg/mL (0.5 per cent by weight).

4) Absolute precision, bias and detection limits may be determined on each sample if required by the client.

5) The maximum number of significant figures for all ICP measurements is 2.

Battelle PNNL/RPG/Inorganic Analysis ... ICPAES Data Report

Det. Limit (ug/mL)	Multiplier= / Run Date= (Analyte)	1.0 00-0615-DB Dilution Blank 12/16/99 ug/mL	5.2 00-0615 N7-Tc-Elu-Comp 12/16/99 ug/mL	5.2 00-0615-DUP N7-Tc-Elu-Comp 12/16/99 ug/mL	10.3 00-0616 A1-Cs-E2-Comp 12/16/99 ug/mL	10.3 00-0617 A1R-Cs-E-Comp 12/16/99 ug/mL
0.025	Ag	--	--	--	--	--
0.060	Al	--	[0.47]	[0.44]	[1.3]	[6.1]
0.250	As	--	--	--	--	--
0.050	B	--	10.5	10.5	7.78	7.42
0.010	Ba	--	[0.11]	[0.096]	[0.23]	--
0.010	Be	--	--	--	--	--
0.100	Bi	--	--	--	--	--
0.250	Ca	--	[1.9]	--	[3.3]	[2.9]
0.015	Cd	--	--	--	[0.34]	[0.23]
0.200	Ce	--	--	--	--	--
0.050	Co	--	--	--	--	--
0.020	Cr	--	--	--	6.54	3.25
0.025	Cu	--	--	--	12.7	7.13
0.050	Dy	--	--	--	--	--
0.100	Eu	--	--	--	--	--
0.025	Fe	--	--	--	12.8	8.09
2.000	K	--	--	--	[190]	[210]
0.050	La	--	--	--	--	--
0.030	Li	--	--	--	--	--
0.100	Mg	--	--	--	--	--
0.050	Mn	--	--	--	--	--
0.050	Mo	--	--	--	--	--
0.150	Na	--	105	105	698	1,150
0.100	Nd	--	--	--	--	--
0.030	Ni	[0.044]	[0.18]	--	[2.8]	5.69
0.100	P	--	--	--	--	--
0.100	Pb	--	--	--	12.8	[9.9]
0.750	Pd	--	--	--	--	--
0.300	Rh	--	--	--	--	--
1.100	Ru	--	--	--	--	--
0.500	Sb	--	--	--	--	--
0.250	Se	--	--	--	--	--
0.500	Si	--	[23]	[22]	[6.5]	[6.3]
1.500	Sn	--	--	--	--	--
0.015	Sr	--	--	--	--	--
1.500	Te	--	--	--	--	--
1.000	Th	--	--	--	--	--
0.025	Ti	--	--	--	--	--
0.500	Tl	--	--	--	--	--
2.000	U	--	--	--	--	--
0.050	V	--	--	--	--	--
2.000	W	--	--	--	--	--
0.050	Y	--	--	--	--	--
0.050	Zn	--	--	--	6.20	--
0.050	Zr	--	--	--	--	--

Note: 1) Overall error greater than 10-times detection limit is estimated to be within +/- 15%.

2) Values in brackets [] are within 10-times detection limit with errors likely to exceed 15%.

3) "--" indicate measurement is below detection. Sample detection limit may be found by multiplying "det. limit" (far left column) by "multiplier" (top of each column).

Battelle PNNL/RPG/Inorganic Analysis ... ICPAES Data Report

Det. Limit (ug/mL)	Multiplier= / ALO#= / Client ID= / Run Date= / (Analyte)	10.3 00-0618 C1-Cs-E1-Composite 12/16/99 ug/mL	10.4 00-0619 C1-Cs-E2-Composite 12/16/99 ug/mL	1.0 00-0626-BLK1 Process Blank-1 12/16/99 ug/mL	15.1 00-0626 @5 N7-Tc-0 12/16/99 ug/mL	14.6 00-0641 @5 N7-Tc-PW1 12/16/99 ug/mL
0.025	Ag	--	--	--	--	--
0.060	Al	[3.6]	[4.6]	--	2,070	1,920
0.250	As	--	--	--	--	--
0.050	B	12.5	13.8	--	25.4	33.5
0.010	Ba	--	--	--	--	--
0.010	Be	--	--	--	--	--
0.100	Bi	--	--	--	--	--
0.250	Ca	--	[5.3]	[0.34]	146	141
0.015	Cd	[0.50]	[0.59]	--	24.2	22.8
0.200	Ce	--	--	--	--	--
0.050	Co	--	--	--	[1.8]	[1.8]
0.020	Cr	5.25	5.29	--	37.2	35.3
0.025	Cu	20.3	39.3	--	11.9	11.3
0.050	Dy	--	--	--	--	--
0.100	Eu	--	--	--	--	--
0.025	Fe	7.23	7.63	--	7.35	7.00
2.000	K	--	--	--	641	620
0.050	La	--	--	--	--	--
0.030	Li	--	--	--	--	--
0.100	Mg	--	--	--	--	--
0.050	Mn	--	--	--	[1.1]	[1.0]
0.050	Mo	--	--	--	14.1	13.5
0.150	Na	920	1,630	--	99,600	90,500
0.100	Nd	--	--	--	[2.1]	[2.7]
0.030	Ni	67.5	36.7	[0.047]	181	174
0.100	P	--	--	--	266	245
0.100	Pb	[7.7]	[10]	--	52.2	50.7
0.750	Pd	--	--	--	--	--
0.300	Rh	--	--	--	--	--
1.100	Ru	--	--	--	--	--
0.500	Sb	--	--	--	--	--
0.250	Se	--	--	--	--	--
0.500	Si	[15]	[39]	--	[65]	85.7
1.500	Sn	--	--	--	--	--
0.015	Sr	[0.84]	[0.49]	--	115	110
1.500	Te	--	--	--	--	--
1.000	Th	--	--	--	--	--
0.025	Ti	--	--	--	--	--
0.500	Tl	--	--	--	--	--
2.000	U	[87]	[170]	--	--	--
0.050	V	--	--	--	--	--
2.000	W	--	--	--	[66]	[63]
0.050	Y	--	--	--	[1.0]	[0.98]
0.050	Zn	[0.84]	5.40	[0.13]	[5.7]	[5.8]
0.050	Zr	--	--	--	[2.1]	[1.1]

Note: 1) Overall error greater than 10-times detection limit is estimated to be within +/- 15%.

2) Values in brackets [] are within 10-times detection limit with errors likely to exceed 15%.

3) "--" indicate measurement is below detection. Sample detection limit may be found by multiplying "det. limit" (far left column) by "multiplier" (top of each column).

Battelle PNNL/RPG/Inorganic Analysis ... ICPAES Data Report

Det. Limit (ug/mL)	Multiplier= / ALO#= / Client ID= / Run Date= / (Analyte)	14.7 / 00-0642 @5 / N7-Tc-PW3 / 12/16/99 / ug/mL	16.4 / 00-0643 @5 / N7-Tc-PW5 / 12/16/99 / ug/mL	3.4 / 00-0644 / N7-Tc-PW7 / 12/16/99 / ug/mL	3.4 / 00-0645 / N7-Tc-PR1 / 12/16/99 / ug/mL	3.8 / 00-0646 / N7-Tc-PR2 / 12/16/99 / ug/mL
0.025	Ag	--	--	--	--	--
0.060	Al	1,870	398	21.1	13.5	8.37
0.250	As	--	--	--	--	--
0.050	B	34.1	26.8	19.3	18.7	22.4
0.010	Ba	--	--	[0.041]	--	--
0.010	Be	--	--	--	--	--
0.100	Bi	--	--	--	--	--
0.250	Ca	134	[31]	[3.0]	[2.2]	[1.4]
0.015	Cd	22.1	4.72	[0.24]	[0.14]	--
0.200	Ce	--	--	--	--	--
0.050	Co	[1.8]	--	--	--	--
0.020	Cr	34.5	7.59	[0.39]	1.17	[0.69]
0.025	Cu	10.9	[2.3]	[0.16]	[0.14]	--
0.050	Dy	--	--	--	--	--
0.100	Eu	--	--	--	--	--
0.025	Fe	6.81	[1.6]	[0.44]	[0.25]	[0.81]
2.000	K	613	[100]	[14]	[9.9]	[7.6]
0.050	La	--	--	--	--	--
0.030	Li	--	--	--	--	--
0.100	Mg	--	--	--	--	--
0.050	Mn	[0.95]	--	--	[0.24]	--
0.050	Mo	13.2	[2.7]	--	--	--
0.150	Na	91,500	31,100	3,420	2,920	2,740
0.100	Nd	[2.7]	--	--	--	--
0.030	Ni	168	38.2	2.22	1.63	[0.66]
0.100	P	245	73.5	5.49	4.63	[1.8]
0.100	Pb	49.1	[11]	[0.71]	--	--
0.750	Pd	--	--	[2.9]	[2.9]	[3.0]
0.300	Rh	--	--	--	--	--
1.100	Ru	--	--	--	--	--
0.500	Sb	--	--	--	--	--
0.250	Se	--	--	--	--	--
0.500	Si	90.1	142	107	123	155
1.500	Sn	--	--	--	--	--
0.015	Sr	106	24.0	1.31	[0.34]	--
1.500	Te	--	--	--	--	--
1.000	Th	--	--	--	--	--
0.025	Ti	--	--	--	--	--
0.500	Tl	--	--	--	--	--
2.000	U	--	--	--	--	--
0.050	V	--	--	--	--	--
2.000	W	[61]	--	--	--	--
0.050	Y	[0.93]	--	--	--	--
0.050	Zn	[5.2]	[1.6]	[0.45]	[0.43]	[0.35]
0.050	Zr	[2.1]	--	--	--	--

Note: 1) Overall error greater than 10-times detection limit is estimated to be within +/- 15%.

2) Values in brackets [] are within 10-times detection limit with errors likely to exceed 15%.

3) "--" indicate measurement is below detection. Sample detection limit may be found by multiplying "det. limit" (far left column) by "multiplier" (top of each column).

Battelle PNNL/RPG/Inorganic Analysis ... ICPAES Data Report

Det. Limit (ug/mL)	Multiplier= / ALO#= / Client ID= / Run Date= (Analyte)	16.9 / 00-0664 @5 / N7-Tc-R01 / 12/16/99 ug/mL				
0.025	Ag	--	--	--	--	--
0.060	Al	11.2	--	--	--	--
0.250	As	--	--	--	--	--
0.050	B	34.7	--	--	--	--
0.010	Ba	--	--	--	--	--
0.010	Be	--	--	--	--	--
0.100	Bi	--	--	--	--	--
0.250	Ca	--	--	--	--	--
0.015	Cd	--	--	--	--	--
0.200	Ce	--	--	--	--	--
0.050	Co	--	--	--	--	--
0.020	Cr	--	--	--	--	--
0.025	Cu	--	--	--	--	--
0.050	Dy	--	--	--	--	--
0.100	Eu	--	--	--	--	--
0.025	Fe	[0.44]	--	--	--	--
2.000	K	--	--	--	--	--
0.050	La	--	--	--	--	--
0.030	Li	--	--	--	--	--
0.100	Mg	--	--	--	--	--
0.050	Mn	--	--	--	--	--
0.050	Mo	--	--	--	--	--
0.150	Na	19,200	--	--	--	--
0.100	Nd	--	--	--	--	--
0.030	Ni	--	--	--	--	--
0.100	P	--	--	--	--	--
0.100	Pb	--	--	--	--	--
0.750	Pd	--	--	--	--	--
0.300	Rh	--	--	--	--	--
1.100	Ru	--	--	--	--	--
0.500	Sb	--	--	--	--	--
0.250	Se	--	--	--	--	--
0.500	Si	310	--	--	--	--
1.500	Sn	--	--	--	--	--
0.015	Sr	[0.38]	--	--	--	--
1.500	Te	--	--	--	--	--
1.000	Th	--	--	--	--	--
0.025	Ti	--	--	--	--	--
0.500	Tl	--	--	--	--	--
2.000	U	--	--	--	--	--
0.050	V	--	--	--	--	--
2.000	W	--	--	--	--	--
0.050	Y	--	--	--	--	--
0.050	Zn	--	--	--	--	--
0.050	Zr	--	--	--	--	--

Note: 1) Overall error greater than 10-times detection limit is estimated to be within +/- 15%.
2) Values in brackets [] are within 10-times detection limit with errors likely to exceed 15%.
3) "--" indicate measurement is below detection. Sample detection limit may be found by multiplying "det. limit" (far left column) by "multiplier" (top of each column).

Battelle PNNL/RPG/Inorganic Analysis --- IC Report

Client: D Blanchard **Charge Code/Project:** W48409/29953-75%
W48414/29953-25%

ACL Numbers: 00-0615 to 00-0619, 00-0626 **ASR Number:** 5626 and 5628
Analyst: MJ Steele **Analysis Date:** December 18-20, 1999

Procedure: PNL-ALO-212, "Determination of Inorganic Anions by Ion Chromatography"
M&TE: IC system (WD25214); Balance (360-06-01-031) --- See Chemical Measurement Center 98620 RIDS IC File for Calibration, Standards Preparations, and Maintenance Records.

proj 29953
Task 2.8
T2.8.3.3

Final Results:

Lab ID	Sample ID	(1) F ug/ml	Cl ug/ml	NO2 ug/ml	Br ug/ml	NO3 ug/ml	PO4 ug/ml	SO4 ug/ml	C2O4 ug/ml
00-00615	N7-Tc-Elu-Comp	< 0.3	15	8	< 0.3	19	< 0.5	1	< 0.5
00-00615 MS	N7-Tc-Elu-Comp MS Rec	94%	OvrRng	101%	103%	103%	103%	103%	101%
00-00616	A1-Cs-E2-Comp	< 100	< 100	< 200	< 100	31,400	< 200	< 200	< 200
00-00616	A1-Cs-E2-Comp Dup	< 100	< 100	< 200	< 100	31,600	< 200	< 200	< 200
	RSD	n/a	n/a	n/a	n/a	1%	n/a	n/a	n/a
00-00617	A1R-Cs-E-Comp	< 100	< 100	< 200	< 100	26,500	< 200	< 200	< 200
00-00618	C1-Cs-E1-Composite	< 100	< 100	< 200	< 100	24,500	< 200	< 200	< 200
00-00619	C1-Cs-E2-Composite	< 100	< 100	< 200	< 100	26,300	< 200	< 200	< 200
00-00626	N7-Tc-0	3,200	480	27,900	< 250	110,000	1,100	3,800	1,400
00-00626 MS	N7-Tc-0 MS Rec	112%	105%	122%	108%	OvrRng	111%	114%	111%

RPD = Relative Percent Difference (between sample and duplicate/replicate)
MS Rec = Matrix Spike Standard % recovery
(1) Fluoride is most likely formate or acetate due to slight peak shift and broadening

The samples were analyzed by ion chromatography (IC) for inorganic anions as specified in the governing ASR. The liquid samples were diluted at the IC workstation up to 4,000-fold to ensure that all anions were within the calibration range.

Q.C. Comments:

Duplicates: No actual sample duplicates were provided to the laboratory for analysis. However, the sample, A1-Cs-E2-Comp (00-0616), was split at the IC workstation and analyzed as two samples (replicate). For anions above the estimated quantitation level (i.e., the lowest calibration standard), the Relative Percent Difference (RPD) is will within the acceptance criteria of 20%.

Matrix Spike: Two matrix spikes were prepared from samples submitted. The recoveries for all anions were within the 75% to 125% recovery acceptance criteria for those anions measured within the calibration range.

Blank Spike: No blank spikes were analyzed within the analytical runs.

System Blank/Processing Blanks: Twelve system blanks were process during the analysis of the samples. No anions were detected in the system blanks above the estimate quantitation level.

Quality Control Calibration Verification Check Standards: Seven mid-range verification standards were analyzed throughout the analysis runs. Except for only two oxalate values, the reported results for all anions of interest were recovered within the acceptance criteria of ±10% for the verification standard.

General Comments:

- The reported "Final Results" have been corrected for all dilution performed on the sample during processing or analysis.
- The low calibration standards are defined as the estimated quantitation limit (EQL) for the reported results and assume non-complex aqueous matrices. Actual detection limits or quantitation limits for specific sample matrices may be determined, if requested.
- Routine precision and bias are typically ±15% or better for non-complex aqueous samples that are free of interference and have similar concentrations as the measured anions.

Analyst: M J Steele **Date** 1/13/00

Approval: M W Min **Date** 1/14/00

Archive Information:

Files: ASR 5626 5628 Blanchard.doc	ASR 5606 5626 5642.xls

Battelle Pacific Northwest Laboratory
Radiochemical Processing Group-325 Building

12/22/1999

Client : Blanchard/Kurath

Cognizant Scientist: L R Greenwood Date : 12/22/99

Concur : T Trang-Le Date : 12/28/99

Procedure: PNL-ALO-450 *Gamma Energy Analysis*

Measured Activities (uCi/g) with 1-σ error

ALO ID Client ID	Tc-95m* Error %	Cs-134 Error %	Cs-137 Error %	Eu-154 Error %	Eu-155 Error %	Am-241 Error %
00-0615 N7-Tc-Elu-Comp	4.44E-1 2%	<2.E-4	<3.E-4	<9.E-5	<7.E-4	<7.E-4
00-0615 Dup N7-Tc-Elu-Comp	4.55E-1 2%	<2.E-4	<3.E-4	<1.E-4	<7.E-4	<7.E-4
00-0616 A1-Cs-E2-Comp	<6.E-2	3.99E-2 7%	2.38E+2 2%	<7.E-3	<2.E-1	<2.E-1
00-0617 A1R-Cs-E-Comp	<5.E-2	2.39E-2 8%	1.45E+2 2%	<6.E-3	<9.E-2	<9.E-2
00-0618 C1-Cs-E1-Composite	<3.E-1	<2.E-2	4.67E+2 2%	<4.E-2	<6.E-1	<6.E-1
00-0619 C1-Cs-E2-Composite	<4.E-1	<3.E-2	7.05E+2 2%	<4.E-2	<7.E-1	<7.E-1

* Tc-95m values are reported as of December 17, 1999 at 8:00 am PST.

proj 29953
Task 2.8
T2.8.3.3

Battelle Pacific Northwest Laboratory
Radiochemical Processing Group-325 Building

1/18/2000

Client : Blanchard/Kurath

Cognizant Scientist: L R Greenwood Date : 1/18/00

Concur : T Trang - le Date : 1/18/2000

Procedure: PNL-ALO-420/421

Measured Activities (uCi/g) with 1-σ error

ALO ID Client ID	Alpha Error +/-	Sr-90 Error +/-
00-0615 N7-Tc-Elu-Comp	5.73E-6 43%	8.70E-4 5%
00-0616 A1-Cs-E2-Comp	<2.E-5	2.40E-1 4%
00-0617 A1R-Cs-E-Comp	1.62E-5 38%	8.43E-2 3%
00-0618 C1-Cs-E1-Composite	1.20E-4 10%	4.10E-2 8%
00-0619 C1-Cs-E2-Composite	9.86E-5 11%	5.60E-2 9%
00-0619 DUP C1-Cs-E2-Composite		1.41E-1 6%
RPD		86%
Matrix Spike	98%	105%
Blank Spike	108%	103%
Blank	<2.E-5	<7.E-5

proj 29953
Task 2.8
T2.8.3.3

Battelle
Pacific Northwest Laboratories

Project Number

Internal Distribution

329/4 File
Mike Urie

Date December 21, 1999

To Dave Blanchard

From Tom Farmer Thomas Farmer

Subject ICP/MS Analysis of Submitted Samples
(ACL #00-0615 through 00-0619)

Pursuant to your request, the 7 samples that you submitted for analysis were analyzed by ICPMS for ^{99}Tc. The results of this analysis are reported on the attached page.

An Amersham ^{99}Tc standard was used to generate the calibration curve and an independent Amersham ^{99}Tc standard was used as the continuing calibration verification (CCV) standard. The 1% high-purity nitric acid solution used to dilute the standards and samples was used as a reagent blank. The samples were diluted an extra 10x from the dilutions received. The results include your dilutions and are reported in ng analyte/ g (ppb) of original sample ± one standard deviation.

The ^{99}Tc values reported assume that the Ru present is exclusively fission-product Ru, and therefore does not have an isotope at m/z 99; i.e., everything observed at m/z 99 is due to ^{99}Tc. The fingerprint we're seeing for Ru is obviously not natural, and is consistent with that observed in previous tank waste analyses. Semiquantitative Ru concentrations, corrected for sample dilution, are provided for your information.

If you have any questions regarding this analysis, feel free to call me at 372-0700 or James Bramson at 372-0624.

45R 5626

project 29953
Task 2.8
T2.8.3.3
Eluate composites

Kurath/Blanchard Tc-99 Analysis

December 21, 1999

Results are reported in ng/g (ppb) of original sample.

Sample ID	Client Number	ICP/MS Number	Tc-99 ng/g ± 1SD	Ru-101/ Ru-102	†Ru-101 ng/g
1%HNO3		9c17a7	0.035±0.005		
1%HNO3		9c17a1	<0.024		
1%HNO3		9c17a18	<0.024		
00-00615DB	Dilution Blank	9c17a8	<1.0	1.0303	0.6
00-00615	N7-Tc-Elu-Comp	9c17a15	3600±170	0.7692	4
00-00615DUP	N7-Tc-Elu-Comp	9c17a16	3510±160	3.2727	8
00-00616	A1-Cs-E2-Comp	9c17a11	27±6	0.0242	0.8
00-00617	A1R-Cs-E-Comp	9c17a12	15±4	0.9706	1
00-00618	C1-Cs-E1-Comp	9c17a13	22±4	0.7927	6
00-00619	C1-Cs-E2-Comp	9c17a14	15±4	1.2948	16
00-00619 + spike	C1-Cs-E2-Comp	9c17a17	547±21		
Spike Recovery			**103%**		
CCV results are reported in ng/ml (ppb)					
5ppb Tc-99		9c17a5	4.72±0.15		
5ppb Tc-99		9c17a19	5.13±0.03		

†Based on response from indium

DATA REVIEW

Reviewed by: O.J. Farmer III

Date: 30Dec99 Page 1 of 1

Appendix B: Spreadsheet Calculations

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	Loading of SL-644 with AW-101 feed																					
2	Loading																					
3			Start Date and Time:		10/12/99	2:46																
4			Bed volume col 1=		18.6	mL																
5			Bed volume col 2=		15.9	mL																
6			Empty Eff Btl - 1 w/ cap(w / holes) + plastic w				386.7	g														
7			Empty Eff Btl -2 w/ cap(w / holes) + plastic wr				262.2	g														
8			Bed volumes diverted to waste =			3.75																
9			Supernate Density =				1.2414	(g/ml)														
10			Co (ave) =		cnts/g of sample =		323535	cnts/g of waste/min		401637	cnts/mL of waste/minute											
11			regeneration and diluent (0.25 M NaOH) density @ 25 °C					1.008	g/mL													
12			density of 0.1 M NaOh @ 25 °C =																			
13			eluant density (0.5 M nitric acid) @ 25 °C =					1.014	g/mL													
14			Feed analyses: Cs-137, uCi/mL							Cs-134												
15			Date	sample	uCi/mL					uCi/mL												
16																						
17			Oct-99	DF-20	154.5					<6E-3												
18			Oct-99	DF-21	151.0					<6E-3												
19			Oct-99	C1-CA	152.2	Batch contacts with AN-107 feed and SL-64				<6.2E-3												
20			Oct-99	C1-S1-A	152.4	Batch contacts with AN-107 feed and SL-64				<6.2E-3												
21			Oct-99	C1-S2-A	151.4	Batch contacts with AN-107 feed and SL-64				<6.2E-3												
22			Oct-99	C1-Cs-ICP	156.4	Column run feed analysis				<4E-3												
23			average		153.0	uCi/mL																
24																						
25			The effluent volume on which the bed volumes is based was determined by estimating the total mass and volume of waste pumped through the columns at																			
26			the time of sampling. For column #1 this includes the mass of the waste in the effluent bottle + the samples taken from column # 1 and # 2 prior to the																			
27			sample of interest (the mass of the effluent bottle was recorded during each sample event). For column # 2 the effluent volume includes the mass of the waste																			
28			in the effluent bottle + the samples taken from column #2 prior to the the sample of interest (samples taken from column # 1 did not go through column #																			
29			2). A hold up volume of 1.6 bed volumes (30 mL) is added for column # 1. This is the system volume between the end of the effluent line and valve 3. This																			
30			is actually added in the bed volume column in the spreadsheet. The holdup between the bottom of column # 2 and the effluent bottle was not accounted for																			
31			as it is limited to several mL.																			
32																						
33			Since the run started with 0.25 M caustic in the system, approximately 2.8 bed volumes (52 mL) of solution were diverted to the waste jug. Effluent																			
34			collection therefore started about the time the waste began exiting the system. This was determined by observing the time at which the relatively dark color																			
35			of the AN-107 was observed exiting the system.																			
36																						

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP
1	Loading of SL-																				
2	Loading																				
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					
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36																					

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
37	Vial	ACL #	sample time	elapsed time	sample mass taken	mass of diluent	volume of diluent	mass of sample pipetted for dilution	mass of sample + diluent	mass of sample + diluent transferred	sample mass counted	sample volume counted	count time	net area	back ground	Tot cts-bck	counts/g of sample/min	^{137}Cs analytical value	mass of submitted sample counted	mass of waste counted	^{137}Cs per g of waste	^{137}Cs
38			(hr:mm:s)	(hr)	(g)	(g)	(mL)	(g)	(g)	(g)	(g)	(mL)	(min)	(counts)	(counts)	(counts)		(uCi/g)	(g)	(g)	(uCi/g)	(uCi)
39	C1-Cs-0AR (cnt 1)				0.3203	2.0413	2.0251	0.3203	2.3616	2.3616	0.3203	0.2580	5	518142	0	518142	323535	126.0				
40	C1-Cs-0A	00-295																1.60				
41	start		2:46:00	0.000																		
42	C1-Cs-L1 (1)	00-296	3:42:00	0.933	2.3135	na	na	na	na	na	2.1346	1.7195	3	448058	0	448058	69968	29.3	-	-	29.3	67.8
43	C1-Cs-L2 (1)	-	5:32:00	2.767	2.1740	na	na	na	na	na	1.9219	1.5482	3	627955	0	627955	108912	44.9	-	-	44.9	97.6
44	C1-Cs-L3 (1)	00-297	6:53:00	4.117	3.0069	na	na	na	na	na	2.8248	2.2755	3	1015325	0	1015325	119811	52.9	-	-	52.9	159.1
45	C1-Cs-L4 (1)	-	8:31:00	5.750	3.0009	na	na	na	na	na	2.7406	2.2077	3	1229551	0	1229551	149548	65.6	-	-	65.6	196.9
46	C1-Cs-L5 (1)	-	10:11:00	7.417	2.0109	na	na	na	na	na	1.8372	1.4799	3	984922	0	984922	178700	74.5	-	-	74.5	149.8
47	C1-Cs-L6 (1)	00-299	11:55:00	9.150	3.8480	na	na	na	na	na	3.6730	2.9588	3		0	0	0	88.1	-	-	88.1	339.0
49	C1-Cs-L7 B	-	13:41:00	10.917	2.0639	10.0758	9.9958	0.1090	10.1848	na	0.1090	0.0878	3	72923	23	72900	222936		-	-	-	217.6
51	C1-Cs-L8 B	-	15:35:00	12.817	2.1186	10.0916	10.0115	0.1209	10.2125	na	0.1209	0.0974	3	80725	23	80702	222503		-	-	-	222.9
53	C1-Cs-L9 B	00-300	17:19:00	14.550	2.7615	10.0447	9.9650	0.1192	10.1639	na	0.1192	0.0960	3	82342	23	82319	230199	1.13			96.4	266.1
55	C1-Cs-L10 B	-	19:09:00	16.383	3.5148	10.0474	9.9677	0.1122	10.1596	na	0.1122	0.0904	3	84838	23	84815	251976	1.15		-	104.1	366.0
57	C1-Cs-L11 B	-	20:53:00	18.117	2.5267	10.0971	10.0170	0.1155	10.2126	na	0.1155	0.0930	3	88990	23	88967	256759	1.2	-	-	106.1	268.1
59	C1-Cs-L12 B	00-301	21:56:00	19.167	2.3639	10.1035	10.0233	0.1135	10.2170	na	0.1135	0.0914	3	85538	23	85515	251145	1.16			104.4	246.8
60	stop		22:17:00	19.517	31.7036																	2597.7
61			(1) Initial samples were removed from hot cell without dilution. Since the Cs-137																			
62			concentration was relatively low, the dose was also low.																			
63			2) diluent was 0.25 M NaOH for load samples.																			
64																						
65																						
66																						
67																						
68																						
69	Vial	ACL #	sample time	elapsed time	sample mass taken	mass of diluent	volume of diluent	mass of sample pipetted for dilution	mass of sample + diluent	mass of sample + diluent transferred	sample mass counted	sample volume counted	count time, min	net counts	back ground	Tot cts-bck	counts/g of sample counted/min	^{137}Cs analytical value	mass of sample counted	mass of waste counted	^{137}Cs per g of waste	^{137}Cs
70			(hr:mm:s)	(hr)	(g)	(g)	(mL)	(g)	(g)	(g)	(g)	(mL)	(min)	(counts)	(counts)	(counts)		(uCi/g)	(g)	(g)	(uCi/g)	(uCi)
71	start		2:46:00	0.000																		
72	C1-Cs-P1	00-302	3:45:00	0.983	2.9569	na	na	na	na	na	2.7412	2.2082	3	83	0	83	9	1.08E-03	-	-	1.08E-03	3.19E-03
73	C1-Cs-P2	00-303	6:56:00	4.167	2.1957	na	na	na	na	na	2.057	1.6570	3	128	0	128	19	4.70E-03	-	-	4.70E-03	1.03E-02
74	C1-Cs-P3	00-304	10:13:00	7.450	2.4443	na	na	na	na	na	3.0457	2.4534	3	236	0	236	32	9.59E-03	-	-	9.59E-03	2.34E-02
75	C1-Cs-P4	-	13:45:00	10.983	3.5915	na	na	na	na	na	3.4058	2.7435	3	140	0	140	13	-	-	-	-	2.21E-02
76	C1-Cs-P5	-	17:28:00	14.700	2.0353	na	na	na	na	na	1.8545	1.4939	3	403	0	403	66	-	-	-	-	6.35E-02
77	C1-Cs-P6	00-305	20:46:00	18.000	2.5125	na	na	na	na	na	2.3585	1.8999	3	7407	0	7407	983	4.34E-01	-	-	4.34E-01	1.09E+00
78			total samples taken =		15.7	g			total samples (5) =		15.5	12.5										1.21E+00
79			total samples taken =		12.7	mL			(5) some sample was lost in transfer to clean vials for loadout from													
80									hot cells.													
81																						
82																						
83																						
84																						

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP
37	Vial	^{137}Cs per mL of waste	C/Co, portable GEA	C/Co, analytical (3)	analytical/ portable	Eff Btl Mas	Effluent Mass+ samples (4)	Collected Eff Vol (4)	Bed volumes (4)	Flow Rate											
38		(uCi/mL)				(g)	(g)	(mL)	(BV)	(BV/hr)											
39	C1-Cs-0AR (cnt 1)	1.56E+02																			
40	C1-Cs-0A																				
41	start					258.4	0	0.0	0.0												
42	C1-Cs-L1 (1)	36.4	21.63%	23.78%	1.10	352.4	99.3	80.0	5.9	4.18											
43	C1-Cs-L2 (1)	55.7	33.66%	36.43%	1.08	486.5	235.5	189.7	11.8	3.22											
44	C1-Cs-L3 (1)	65.7	37.03%	42.93%	1.16	566.9	319.0	256.9	15.4	2.68											
45	C1-Cs-L4 (1)	81.4	46.22%	53.23%	1.15	688.9	446.1	359.4	20.9	3.37											
46	C1-Cs-L5 (1)	92.5	55.23%	60.45%	1.09	815.5	574.8	463.0	26.5	3.34											
47	C1-Cs-L6 (1)	109.4	-	71.49%	-	1032.6	798.2	642.9	36.2	5.58											
49	C1-Cs-L7 B	-	68.91%	-	-	1262	1029.6	829.4	46.2	5.67											
51	C1-Cs-L8 B	-	68.77%	-	-	1456.3	1229.6	990.5	54.9	4.56											
53	C1-Cs-L9 B	119.6	71.15%	78.19%	1.10	1661.6	1437.7	1158.1	63.9	5.20											
55	C1-Cs-L10 B	129.3	77.88%	84.50%	1.08	1891.8	1673.4	1348.0	74.1	5.57											
57	C1-Cs-L11 B	131.7	79.36%	86.10%	1.08	2121.2	1905.4	1534.9	84.1	5.79											
59	C1-Cs-L12 B	1.30E+02	77.63%	84.73%	1.09	2217.1	2006.1	1616.0	88.5	4.16											
60	stop							ave=	4.62	BV/hr	based on loading phase column #1 bed volume										
61								ave=	4.54	BV/hr	based on loading phase + additional feed collected during feed displacement										
62		total amount of sample processed through column 1 =				2046.8		g =	88.6	BV =	1648.8	mL									
63		total amount of sample processed through column 2 =				2015.1		g =	102.1	BV =	1623.3	mL									
64																					
65		(3) The analytical value from cell U36 is used for Co.																			
66		(4) Bed volumes are the volume of feed that has passed through the column(s). For column #1, this requires that the mass of samples from both columns be added to the mass of effluent in the effluent bottle. The																			
67		volume is determined by dividing the effluent mass by the density. Approximately, 1.6 bed volumes are added to account for the 30 mL holdup between the bottom of column 1 and the effluent bottle.																			
68		Collection of effluent was started after 31 minutes of pumping (approximately 47 mL pumped into system) when it looked like the AN-107 sample color started to exit the effluent tube. This volume is less than the estimated system holdup volume of 60 mL. The bed volume of colume #1 is used and is 18.9 mL.																			
69	Vial	^{137}Cs per mL of waste	portable GEA C/Co	C/Co, analytical	analytical/ portable	DF based on analytical	Eff Btl Mass	Effluent Mass+ sample	Eff Vol (6)	Bed Volumes (6)	low rate (6)										
70		(uCi/mL)					(g)	(g)	(mL)		(BV/hr)										
71	start						258.4	-	-	-											
72	C1-Cs-P1	1.3E-03	0.0029%	0.00088%	0.30	1.14E+05	352.4	97.0	78.1	4.9	5.00										
73	C1-Cs-P2	5.8E-03	0.0060%	0.0038%	0.64	2.62E+04	566.9	313.7	252.7	15.9	3.45										
74	C1-Cs-P3	1.2E-02	0.0099%	0.0078%	0.78	1.29E+04	815.5	564.7	454.9	28.6	3.87										
75	C1-Cs-P4	-	0.0040%	-	-	-	1262	1014.8	817.5	51.4	6.45										
76	C1-Cs-P5	-	0.0204%	-	-	-	1661.6	1416.4	1141.0	71.8	5.47										
77	C1-Cs-P6	5.4E-01	0.3037%	0.3522%	1.16	2.84E+02	2121.2	1878.5	1513.2	95.2	7.09										
78										ave=	5.3	BV/hr	based on loading phase column #2 bed volume of 15.9 mL								
79		(6) Bed volumes are the volume of feed that has passed through the column(s). For column #2,																			
80		this requires that the mass of sample from column #2 be added to the mass of effluent in the																			
81		effluent bottle. The volume is determined by dividing by the density. Holdup between the																			
82		bottom of column 2 and the effluent bottle is small and not accounted for. The bed volume																			
83		used is the bed volume of the lag column which = 15.9 mL																			
84																					

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
85	Bottle		mass of bottle	final mass of bottle + effluent	mass of effluent	volume of effluent	mass of sample vial + cap	mass of sample vial + cap + sample	mass of sample	mass of analytical vial + cap	mass of analytical vial + cap + sample	mass of sample counted	count time	Tot Cts	back ground	Tot cts-bck	counts/g of sample counted	C/Co	mass of waste counted	^{137}Cs quantity (ACL)	^{137}Cs per g of waste (ACL)	^{137}Cs per mL of waste (ACL)
86		ACL #	g	g	g	mL	g	g	g	g	g	g	min	cnts	cnts	cnts	cnts/g		g	uCi	uCi/g	uCi/mL
87	Effluent bottle	00-1041	258.4	1666.6	1408.2	1134	16.8310	17.4361	0.6051	-	-	0.6051	3			0	0		0.6051	2.88E-03	4.76E-03	5.91E-03
88																						
89	Effluent bottle	00-1042	262.9	854.1	591.2	476	16.8902	17.5008	0.6106	-	-	0.6106	3			0	0		0.6106	1.42E-01	2.33E-01	2.89E-01
90	total (AN-107-TcIX feed)	00-1040			1999.4	1611			2.4235			2.4235							2.4235	0.17	7.01E-02	8.71E-02
91																						
92																						
93																						
94																						
95																						
96	**Feed Displacement: 0.1 M NaOH**																					
97																						
98			Start Date and Time:		10/12/99	20:21																
99			Density of 0.1 M NaO		1.001	g/mL																
100	Vial/Bottle	ACL #	sample start time	sample finish time	processing time	sum of processing time	mass of vial + cap	mass of vial + cap + sample	mass of sample collected	mass of analytical vial + cap (tare)	mass of waste counted (ACL)	volume	density	^{137}Cs per g of sample	Cs-137	^{137}Cs per mL of sample	C/Co based on analytical	volume passed through column 1	cumulative volume passed through column 1	Bed Volumes	cumulative BV's	Flow rate
101			hr:min	hr:min	hr	hr	g	g	g	g	g	mL	g/mL	uCi/g	uCi	uCi/mL		mL	mL	BV	BV	BV/hr
102	C1-Cs-FD1	00-306	22:21	22:38	0.283	0.283	16.899	37.0284	20.129	16.899	2.4798	2	1.240	0.9	18.1	1.12	0.73%	16.2	16.2	0.87	0.87	3.1
103	C1-Cs-FD2	00-307	22:43	22:53	0.167	0.450	16.897	36.0265	19.130	16.827	2.4678	2	1.234	0.796	15.2	0.98	0.64%	15.5	31.7	0.83	1.71	5.0
104	C1-Cs-FD3	00-308	23:01	23:17	0.267	0.717	16.8381	37.4767	20.639	16.6848	2.3457	2	1.173	0.603	12.4	0.71	0.46%	17.6	49.3	0.95	2.65	3.5
105	C1-Cs-FD4	00-309	23:22	23:35	0.217	0.933	16.8554	34.3318	17.476	16.8926	2.1952	2	1.098	0.469	8.2	0.51	0.34%	15.9	65.3	0.86	3.51	4.0
106	C1-Cs-FD5	00-310	23:39	23:56	0.283	1.217	16.6985	33.7255	17.027	16.8097	2.1023	2	1.051	0.3	5.1	0.32	0.21%	16.2	81.5	0.87	4.38	3.1
107	C1-Cs-FD6	00-311	23:59	0:16	0.283	1.500	16.7676	33.9701	17.203	16.7501	2.0459	2	1.023	0.165	2.8	0.17	0.11%	16.8	98.3	0.90	5.28	3.2
108	C1-Cs-FD7	00-312	6:15	6:35	0.333	1.833	16.8609	35.4864	18.626	16.8781	2.0134	2	1.007	0.18	3.4	0.18	0.12%	18.5	116.8	0.99	6.28	3.0
109																					Ave =	3.42
110	DI water rinse							Note: GEA analyses using the portable instrument were not conducted.														
111																						
112																						
113			start date and time		10/13/99	6:45																
114																						
115	Vial/Bottle	ACL #	sample start time (hr:mm:s)	sample finish time	Elapsed time	cumulative time	mass of vial + cap	mass of vial + cap + sample	mass of sample collected	mass of analytical vial + cap (tare)	mass of analytical vial + cap + waste (tare)	mass of sample counted	count time, min	background	Net area (counts)	total cnts - bckg	net cnts per g of sample per min	net cnts per mL of sample	C/Co	mass of sample counted (ACL)	volume	density
116			hr:mm:s	hr:min	hr	hr	g	g	g	g	g	g	min	cnts	cnts	cnts	cnts/g	cnts/mL/min		g	mL	g/mL
117	A1-Cs-PR1	00-313	6:45	7:05	0.333	0.333	16.843	35.0918	18.249	17.0477	34.9393	17.892	3	42	17449	17407	324	325	0.0810%	10.0291	10	1.003
118	A1-Cs-PR2	00-314	7:17	7:37	0.333	0.667	16.889	34.2659	17.377	16.8751	33.8790	17.004	3	42	14382	14340	281	282	0.0701%	10.0221	10	1.002
119	A1-Cs-PR3	00-315	7:44	8:04	0.333	1.000	16.8509	34.9592	18.108	16.8936	34.6943	17.801	3	42	10150	10108	189	190	0.0474%	10.0642	10	1.006
120	A1-Cs-PR4	00-316	8:05	8:25	0.333	1.333	16.767	30.0563	13.290	16.7804	29.5857	12.805	3	42	3891	3849	100	100	0.0249%	10.0002	10	1.000
121	A1-Cs-PR5	00-317	8:25	8:47	0.367	1.700	16.801	31.8663	15.066	16.8993	31.6690	14.770	3	42	3106	3064	69	69	0.0172%	9.991	10	0.999
122	A1-Cs-PR6	00-318	8:47	9:07	0.333	2.033	16.785	31.4758	14.691	17.0435	31.3116	14.268	3	42	2280	2238	52	52	0.0130%	9.9625	10	0.996
123																						
124																						

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP
85	Bottle	C/Co based on analytical	DF based on analytical																		
86																					
87	Effluent bottle	3.86E-05	2.59E+04																		
88																					
89	Effluent bottle	1.89E-03	5.30E+02																		
90	total (AN-107-TcIX feed)	5.69E-04	1.76E+03																		
91																					
92																					
93																					
94																					
95																					
96	**Feed Displacement: 0.1 M NaOH**																				
97																					
98																					
99																					
100	Vial/Bottle	cumulative BV's after loading																			
101		BV																			
102	C1-Cs-FD1	102.97																			
103	C1-Cs-FD2	103.80																			
104	C1-Cs-FD3	104.75																			
105	C1-Cs-FD4	105.60																			
106	C1-Cs-FD5	106.47																			
107	C1-Cs-FD6	107.38																			
108	C1-Cs-FD7	108.37																			
109																					
110	DI water rinse																				
111																					
112																					
113																					
114																					
115	Vial/Bottle	^{137}Cs per g of sample	^{137}Cs	^{137}Cs per mL of sample	C/Co based on analytical	analytical C/Co/portable GEA C/Co	volume passed through column 1	cumulative volume passed through column 1	Bed Volumes	cumulative BV's	Flow rate	cumulative BV's after feed displacement	cumulative BV's after feed displacement (col 2)								
116		uCi/g	uCi	uCi/mL			mL	mL	BV	BV	BV/hr	BV	BV								
117	A1-Cs-PR1	0.126	2.30	1.26E-01	0.0826%	1.02	18.2	1.0	0.98	0.98	2.9	7.3	109.3								
118	A1-Cs-PR2	0.114	1.98	1.14E-01	0.0747%	1.06	17.3	2.1	0.93	1.91	2.8	8.2	110.3								
119	A1-Cs-PR3	7.31E-02	1.32	7.36E-02	0.0481%	1.01	18.0	3.1	0.97	2.88	2.9	9.2	111.2								
120	A1-Cs-PR4	3.83E-02	0.51	3.83E-02	0.0250%	1.00	13.3	4.1	0.71	3.59	2.1	9.9	112.0								
121	A1-Cs-PR5	2.51E-02	0.38	2.51E-02	0.0164%	0.95	15.1	5.1	0.81	4.40	2.2	10.7	112.8								
122	A1-Cs-PR6	1.97E-02	0.29	1.96E-02	0.0128%	0.99	14.7	6.0	0.79	5.20	2.4	11.5	113.6								
123									ave =	2.56											
124																					

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
125	Elution - 1st Column																					
126																						
127			Start Date and Time:		10/13/99	9:20																
128			eluant (0.5 M nitric) density @ 25 °C =				1.014	g/mL														
129			diluent (0.6 M nitric) density @ 25 °C =				1.017	g/mL														
130	Vial/Bottle	ACL #	sample start time	sample finish time	Elapsed time	cumulative time	mass of vial + cap	mass of vial + cap + sample	mass of sample	volume of eluant	first dilution mass of dilution vial + cap	first dilution mass of diluent vial + cap + diluent	first dilution mass of diluent	volume of first diluent	first dilution mass of eluant transferred	volume of eluant from first dilution	total volume eluant + diluent: first dilution	second dilution diluent mass	second dilution diluent volume	first dilution mass transferred in second dilution	first dilution volume transferred in second dilution	mass of eluant counted
131			hr:min	hr:min	hr	hr	g	g	g	mL	g	g	g	mL	g	mL	mL	g	mL	g	mL	g
132	C1-Cs-E1-1	00-319	9:20	10:20	1.000	1.000	16.9983	29.4282	12.430	12.258	16.8204	21.4770	4.657	4.579	0.5787	0.5707	5.1495	-	na	-	-	0.579
133	C1-Cs-E1-2	-	10:21	11:22	1.017	2.017	16.9222	33.1573	16.235	16.011	16.7126	21.3736	4.661	4.583	0.4885	0.4818	5.0648	-	na	-	-	0.488
134	C1-Cs-E1-3	00-320	11:23	12:20	0.950	2.967	16.8529	31.335	14.482	14.282	16.6978	21.7401	5.042	4.958	0.0932	0.0919	5.0499	-	na	-	-	0.093
135	C1-Cs-E1-4	00-321	12:21	13:21	1.000	3.967	16.8804	33.6539	16.774	16.542	16.8168	26.9346	10.118	9.949	0.0951	0.0938	10.0425	10.1811	10.0109	0.0998	0.0981	9.165E-04
136	C1-Cs-E1-5	00-322	13:23	14:20	0.950	4.917	16.8675	32.0303	15.163	14.953	16.8044	26.9746	10.170	10.000	0.0711	0.0701	10.0703	10.1786	10.0085	0.0983	0.0967	6.730E-04
137	C1-Cs-E1-6	00-323	14:22	15:19	0.950	5.867	16.8665	32.4081	15.542	15.327	16.7138	26.8904	10.177	10.006	0.0971	0.0958	10.1022	4.5765	4.5000	0.509	0.500	4.740E-03
138	C1-Cs-E1-7	00-324	15:25	16:19	0.900	6.767	16.7743	31.9223	15.148	14.939	16.8479	21.9396	5.092	5.007	0.0923	0.0910	5.0976	-	na	-	-	0.092
139	C1-Cs-E1-8	-	16:23	17:20	0.950	7.717	16.8487	31.111	14.262	14.065	16.8346	20.9653	4.131	4.062	0.9917	0.9780	5.0397	-	na	-	-	0.992
140	C1-Cs-E1-9	00-325	17:23	18:20	0.950	8.667	16.9381	32.2915	15.353	15.141	16.7673	20.9417	4.174	4.105	0.9988	0.9850	5.0896	-	na	-	-	0.999
141	C1-Cs-E1-10	-	18:23	19:20	0.950	9.617	16.8285	32.3301	15.502	15.288	16.7553	20.9061	4.151	4.081	0.9990	0.9852	5.0666	-	na	-	-	0.999
142	C1-Cs-E1-11	00-326	19:23	20:20	0.950	10.567	16.9401	32.2341	15.294	15.083	16.8199	20.9460	4.126	4.057	1.0027	0.9889	5.0460	-	na	-	-	1.003
143	C1-Cs-E1-12	-	20:23	21:20	0.950	11.517	16.8741	31.8959	15.022	14.814	16.7131	20.8559	4.143	4.074	1.0056	0.9917	5.0653	-	na	-	-	1.006
144	C1-Cs-E1-13	00-327	21:28	22:30	1.033	12.550	16.9753	33.4675	16.492	16.264	na	na	na	na	na	na	na	-	na	-	-	16.236
145																						
146																						
147	Elution rinse DI water																					
148			Start Date and Time		10/14/99	8:33																
149	Vial/Bottle	ACL #	sample start time	sample finish time	Elapsed time	cumulative time	mass of vial + cap	mass of vial + cap + sample	mass of sample	volume of sample	mass of sample transferred to analytical vial	mass of sample counted	count time	background	Net area	total cnts - bckg	net cnts per g of sample	net cnts/ mL of sample/ minute	sample density	^{137}Cs analytical value	^{137}Cs analytical value	^{137}Cs
150			hr:min	hr:min	hr	hr	g	g	g	mL	g	g	min	cnts	cnts	cnts	cnts/g	cnts/mL/min	g/mL	uCi/g	uCi/mL	uCi
151	C1-Cs-E1-R1	00-328	8:33	8:38	0.083	0.083	16.985	25.9415	8.957	8.957	5.909	5.909	3	42	154994	154952	26222	8896	1.018	3.320	3.320	29.7
152	C1-Cs-E1-R2	-	13:00	13:15	0.250	0.333	16.795	29.3845	12.589	12.589	12.274	12.274	3	42	217446	217404	17712	5904	-	-	-	28.3
153	C1-Cs-E1-R3	00-329	13:17	13:33	0.267	0.600	16.7099	28.9816	12.272	12.272	11.888	11.888	3	42	32906	32864	2764	939	1.019	0.363	0.363	4.5
154	C1-Cs-E1-R4	-	13:36	13:52	0.267	0.867	16.624	30.7008	14.076	14.076	13.843	13.843	3	42	30963	30921	2234	745	-	-	-	4.0
155	C1-Cs-E1-R5	-	13:54	14:12	0.300	1.167	16.720	31.8108	15.091	15.091	14.737	14.737	3	42	10539	10497	712	237	-	-	-	1.4
156	C1-Cs-E1-R6	00-330	14:14	14:31	0.283	1.450	16.621	30.913	14.292	14.292	14.034	14.034	3	42	6019	5977	426	142	1.003	0.055	0.055	0.8
157																						
158	Regeneration (0.25 M NaOH)																					
159			Start Date and Time		10/14/99	2:41																
160	Vial/Bottle	ACL #	sample start time (hr:mm:s)	sample finish time	Elapsed time	mass of vial + cap	mass of vial + cap + sample	mass of analytical vial + cap (tare)	mass of analytical vial + cap + waste (tare)	mass of sample counted	count time, min	background	Total counts	total cnts - bckg	net cnts per g of sample	net cnts/ mL of sample/ minute	C/Co based on portable GEA	sample density	137Cs analytical value	137Cs analytical value	C/Co based on analytical data	analytical C/Co/ portable GEA C/Co
161			hr:min	hr:min	hr	g	g	g	mL	g	g	min	cnts	cnts	cnts	cnts/mL/min		g/mL	uCi/g	uCi/mL		
162	Regeneration	00-331	14:41	15:58	1.283	-	-	-	-	-	-	-	-	-	-	-	-	1.001	2.29E-02	2.29E-02	1.50E-04	-

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP
125	**Elution - 1st Column**																				
126																					
127																					
128																					
129																					
130	Vial/Bottle	count time	back ground	Total net counts	total cnts - bckg	net cnts per g of sample	net counts/ mL of sample/ minute	^{137}Cs analytical value	^{137}Cs analytical value	mass of sample counted (ACL)	volume of sample (ACL)	density of sample	^{137}Cs per g of eluant	Cs-137	^{137}Cs per mL of eluant	C/Co based on portable GEA	C/Co based on analytical data	analytical C/Co/ portable GEA C/Co	Bed volumes of eluant (7)	Cumulative bed volumes (7)	Flow rate
131		min	cnts	cnts	cnts	cnts/g	cnts/mL/min	uCi/g	uCi/mL	g	mL	g/mL	uCi/g	uCi	uCi/mL				BV	BV	BV/hr
132	C1-Cs-E1-1	3	23	8106	8083	13968	4721	2.13E-01	0.2184	2.0359	1.985	1.0254	1.93	24	1.97	0.0118	0.0129	1.10	0.66	0.7	
133	C1-Cs-E1-2	3	23	3759	3736	7648	2585	-	-	-	-	-	-	16	-	0.0064	-	-	0.86	1.5	0.8
134	C1-Cs-E1-3	3	23	2120	2097	22500	7605	5.41E-02	0.0553	2.0299	1.985	1.0224	2.98	43	3.04	0.0189	0.0199	1.05	0.77	2.3	0.8
135	C1-Cs-E1-4	3	23	10846	10823	11809611	3991649	1.46E-01	0.1499	5.0741	4.942	1.0267	1600	26829	1653	9.938	10.808	1.09	0.89	3.2	0.9
136	C1-Cs-E1-5	3	23	24934	24911	37014340	12510847	3.41E-01	0.3474	5.0354	4.942	1.0188	5086	77118	5217	31.150	34.099	1.09	0.80	4.0	0.8
137	C1-Cs-E1-6	3	23	12130	12107	2554485	863416	3.31E-01	0.3373	2.0230	1.985	1.0189	315	4899	356	2.150	2.326	1.08	0.82	4.8	0.9
138	C1-Cs-E1-7	3	343	11799	11456	124117	41952	3.21E-01	0.3285	2.0315	1.985	1.0232	18.03	273	18.39	0.1045	0.1202369	1.15	0.80	5.6	0.9
139	C1-Cs-E1-8	3	343	35386	35043	35336	11944	-	-	-	-	-	-	65	-	0.0297	-	-	0.76	6.4	0.8
140	C1-Cs-E1-9	3	343	17963	17620	17641	5963	4.93E-01	0.5037	2.0284	1.985	1.0217	2.55	39	2.60	1.48E-02	1.70E-02	1.15	0.81	7.2	0.9
141	C1-Cs-E1-10	3	343	11841	11498	11510	3890	-	-	-	-	-	-	23	-	9.69E-03	-	-	0.82	8.0	0.9
142	C1-Cs-E1-11	3	343	9478	9135	9110	3079	2.54E-01	0.2601	2.0332	1.985	1.0241	1.30	20	1.33	7.67E-03	8.68E-03	1.13	0.81	8.8	0.9
143	C1-Cs-E1-12	3	343	7647	7304	7263	2455	-	-	-	-	-	-	14	-	6.11E-03	-	-	0.80	9.6	0.8
144	C1-Cs-E1-13	5	70	174494	174424	10743	2179	8.98E-01	0.9091	10.0952	9.972	1.0124	0.898	15	9.09E-01	5.42E-03	5.94E-03	1.10	0.87	10.5	0.8
145																					
146																				ave =	0.84
147	**Elution rinse DI water**																				
148																					
149	Vial/Bottle	C/Co based on portable GEA	C/Co based on analytical data	analytical C/Co/ portable GEA C/Co	Bed volumes of sample	cumulative BV's of elution rinse	cumulative BV's of elution rinse + eluant	Flow rate													
150					BV	BV	BV	BV/hr													
151	C1-Cs-E1-R1	2.21E-02	2.17E-02	0.98	0.48	0.48	10.96	5.8													
152	C1-Cs-E1-R2	1.47E-02	-	-	0.68	1.16	11.64	2.7													
153	C1-Cs-E1-R3	2.34E-03	2.37E-03	1.01	0.66	1.82	12.30	2.5													
154	C1-Cs-E1-R4	1.85E-03	-	-	0.76	2.57	13.06	2.8													
155	C1-Cs-E1-R5	5.91E-04	-	-	0.81	3.39	13.87	2.7													
156	C1-Cs-E1-R6	3.54E-04	3.60E-04	1.01	0.77	4.15	14.64	2.7													
157							average	2.87													
158	**Regeneration (0.25 M NaOH)**																				
159																					
160	Vial/Bottle	Bed volumes of regenerati on soln	cumulativ e BV's of elution rinse + eluant + regen soln	Flow rate																	
161		BV	BV	BV/hr																	
162	Regeneration	6.9	21.55	5.4																	

(7) sampling initiated immediately after starting to pump nitric acid. The first 1 or 2 column volumes were likely water. Density measurements indicate sample (column volume) # 2 was nitric acid.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
163																						
164	Determination of supplemental Co																					
165	Vial		sample time	elapsed time	sample mass taken	mass of diluent	volume of diluent	mass of sample pipetted for dilution	mass of sample + diluent	mass of sample + diluent transferred in ACL	sample mass counted	sample volume counted	count time, min	net area, counts	back ground	Tot cts-bck	counts/mL of sample/min	^{137}Cs analytical value	mass of sample counted	mass of waste counted	^{137}Cs per g of waste	^{137}Cs per mL of waste
166			(hr:mm:s)	(hr)	g	g	mL	g	g	g	g	mL						uCi/g	g	g	uCi/g	uCi/mL
167	C1-Cs-0AR (cnt 1)	00-365	-	-	0.3203	2.0413	2.0251	0.3203	2.3616	2.0691	0.2806	0.2261	3	355732	75	355657	524433					
168																						
169			Sample 00-365 was recounted in lab 410 on 1/21/00 to determine a supplemental Co count																			
170			value. This was done so that C/Co could be determined for supplemental samples C1-Cs-																			
171			E2-4C2, 5C2, 6C2, 7C and AN-107 Tc IX Feed (which is also the composite effluent from																			
172																						
173	Elution - 2nd Column																					
174			Start Date and Time:		10/19/99	7:17																
175			eluant (0.5 M nitric) density @ 25 °C =				1.014	g/mL														
176			diluent (0.6 M nitric) density @ 25 °C =				1.017	g/mL														
177	Vial/Bottle	ACL #	sample start time	sample finish time	Elapsed time	cumulative time	mass of vial + cap	mass of vial + cap + sample	mass of sample	volume of eluant	first dilution mass of dilution vial + cap	first dilution mass of diluent vial + cap + diluent	first dilution mass of diluent vial + cap + diluent + sample	first dilution mass of diluent	volume of first diluent	first dilution mass of eluant transferred	volume of eluant from first dilution	total volume eluant + diluent: first dilution	second dilution diluent mass	second dilution diluent volume	first dilution mass transferred in second dilution	first dilution volume transferred in second dilution
178			hr:min	hr:min	hr	hr	g	g	g	mL	g	g	g	g	mL	g	mL	mL	g	mL	g	mL
179	C1-Cs-E2-1	-	7:17	8:17	1.000	1.000	16.7138	29.7723	13.059	12.878	16.6691	21.3602	21.8056	4.691	4.613	0.4454	0.5000	5.1127	-	-	-	-
180	C1-Cs-E2-2	-	8:18	9:18	1.000	2.000	16.7324	34.7166	17.984	17.736	16.7777	21.4792	21.8679	4.702	4.623	0.3887	0.5000	5.1229	-	-	-	-
181	C1-Cs-E2-3	-	9:20	10:19	0.983	2.983	16.6114	32.5916	15.980	15.760	16.6986	21.8035	21.8310	5.105	5.020	0.0275	0.1000	5.1196	-	-	-	-
183	C1-Cs-E2-4C	00-1043	10:21	11:21	1.000	3.983	16.6485	33.0836	16.435	16.208	17.2149	22.2214	5.2072	5.007	4.923	0.2007	0.1979	5.1207	4.7254	4.6602	0.5013	0.4944
185	C1-Cs-E2-5C	00-1040	11:22	12:22	1.000	4.983	16.7249	29.6613	12.936	12.758	17.3862	22.5117	5.2250	5.126	5.040	0.0995	0.0981	5.1379	5.1221	5.0514	0.0990	0.0976
187	C1-Cs-E2-6C	00-1045	12:23	13:23	1.000	5.983	16.6480	31.3909	14.7430	14.5390	17.3384	22.4436	5.2046	5.105	5.020	0.0994	0.0980	5.1179	4.6971	4.6322	0.506	0.4991
189	C1-Cs-E2-7C	00-1046	13:24	14:25	1.017	7.000	16.6257	31.3757	14.7500	14.5460	14.6500	19.7702	5.2199	5.120	5.035	0.0997	0.0983	5.1329	-	-	-	-
190	C1-Cs-E2-8	-	14:27	15:32	1.083	8.083	16.6669	32.9002	16.233	16.009	16.7504	20.9238	21.8523	4.173	4.104	0.9285	1.0000	5.1036	-	-	-	-
191	C1-Cs-E2-9	-	15:34	16:35	1.017	9.100	16.5651	31.659	15.094	14.886	16.8994	21.0784	21.9813	4.179	4.109	0.9029	1.0000	5.1091	-	-	-	-
192	C1-Cs-E2-10	-	16:36	17:37	1.017	10.117	16.7385	31.4657	14.727	14.524	16.6387	20.8208	21.7583	4.182	4.112	0.9375	1.0000	5.1122	-	-	-	-
193	C1-Cs-E2-11	-	17:38	18:39	1.017	11.133	16.6045	32.151	15.547	15.332	16.7774	20.9592	21.8713	4.182	4.112	0.9121	1.0000	5.1119	-	-	-	-
194	C1-Cs-E2-12	-	18:40	19:41	1.017	12.150	16.7450	32.428	15.683	15.466	16.9070	21.0844	22.0145	4.177	4.108	0.9301	1.0000	5.1076	-	-	-	-
195	C1-Cs-E2-13	-	19:43	20:44	1.017	13.167	16.8837	32.6554	15.772	15.554	16.8935	21.0703	21.9536	4.177	4.107	0.8833	1.0000	5.1070	-	-	-	-
196	C1-Cs-E2-14	-	20:45	21:45	1.000	14.167	16.8127	32.1275	15.315	15.103	16.926	21.115	22.057	4.189	4.119	0.9423	1.000	5.1189	-	-	-	-
197																						

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP
163																					
164	Determination																				
165	Vial	C/Co, portable GEA	C/Co, analytical (5)	analytical / portable																	
166																					
167	C1-Cs-0AR (cnt 1)																				
168																					
169																					
170																					
171																					
172																					
173	Elution - 2nd Column																				
174																					
175																					
176																					
177	Vial/Bottle	volume of eluate counted	count time	back ground	Total net counts	total net cnts - bckg	total net counts/ mL of sample/ minute	C/Co based on portable GEA	volume of eluate counted in ACL	^{137}Cs (ACL)	^{137}Cs per mL of sample (ACL)	^{137}Cs	C/Co based on analytical values	Bed volumes of eluant (8)	Cumulative bed volumes (8)	Flow rate					
178		mL	min	cnts	cnts	cnts	cnts/mL/min		mL	uCi	uCi/mL	uCi		BV	BV	BV/hr					
179	C1-Cs-E2-1	0.500	3	136	1421	1285	857	0.0021	-	-	-	4.2	-	0.81	0.8	0.8					
180	C1-Cs-E2-2	0.500	3	136	811	675	450	0.0011	-	-	-	3.0	-	1.12	1.9	1.1					
181	C1-Cs-E2-3	0.100	3	136	220	84	280	0.0007	-	-	-	1.7	-	0.99	2.9	1.0					
183	C1-Cs-E2-4C	1.91E-02	3	75	94442	94367	1646124	3.14	7.40E-03	3.630	490.8	7955.7	3.21	1.02	3.9	1.0					
185	C1-Cs-E2-5C	1.86E-03	3	75	170844	170769	30527780	58.21	7.24E-04	6.710	9269.6	118259.3	60.59	0.80	4.7	0.8					
187	C1-Cs-E2-6C	9.56E-03	3	75	224138	224063	7812554	14.90	3.71E-03	8.720	2349.6	34161.4	15.36	0.91	5.7	0.9					
189	C1-Cs-E2-7C	0.098	3	75	129011	128936	437115	0.83	3.80E-02	4.970	130.9	1903.8	0.86	0.91	6.6	0.9					
190	C1-Cs-E2-8	1.000	3	136	78383	78247	26082	0.0649	-	-	-	159.0	-	1.01	7.6	0.9					
191	C1-Cs-E2-9	1.000	3	136	34123	33987	11329	2.82E-02	-	-	-	64.2	-	0.94	8.5	0.9					
192	C1-Cs-E2-10	1.000	3	136	21117	20981	6994	1.74E-02	-	-	-	38.7	-	0.91	9.4	0.9					
193	C1-Cs-E2-11	1.000	3	136	13876	13740	4580	1.14E-02	-	-	-	26.7	-	0.96	10.4	0.9					
194	C1-Cs-E2-12	1.000	3	136	25077	24941	8314	2.07E-02	-	-	-	49.0	-	0.97	11.4	1.0					
195	C1-Cs-E2-13	1.000	3	136	7382	7246	2415	6.01E-03	-	-	-	14.3	-	0.98	12.3	1.0					
196	C1-Cs-E2-14	1.000	3	136	5856	5720	1907	4.75E-03	-	-	-	11.0	-	0.95	13.3	0.9					
197															ave =	0.94					

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
198	Decontamination of non cesium radionuclides																					
199																						
200				Co-60	Sb-125	SnSb-126	Eu-154	Eu-155	Am-241				Co-60	Sb-125	SnSb-126	Eu-154	Eu-155	Am-241				
201				uCi/mL	uCi/mL	uCi/mL	uCi/mL	uCi/mL	uCi/mL				uCi/g	uCi/g	uCi/g	uCi/g	uCi/g	uCi/g				
202	C1-Cs-ICP	00-0295	Cs IX feed sample	6.03E-02	<2.5E-01	<6.2E-02	4.02E-02	<1E-01	<8.7E-02		C1-Cs-ICP	Cs IX feed sample	4.86E-02	<2E-1	<5E-2	3.24E-02	<8E-2	<7E-2				
203	C1-Cs-P1	00-0302	lag col #1	4.37E-02	3.70E-04	3.97E-04	3.13E-02	2.22E-02	1.12E-03		C1-Cs-P1	lag col #1	3.52E-02	2.98E-04	3.20E-04	2.52E-02	1.8E-02	9.03E-04				
204	C1-Cs-P2	00-0303	lag col #2	4.97E-02	6.91E-04	4.44E-04	3.51E-02	2.43E-02	1.28E-02		C1-Cs-P2	lag col #2	4.00E-02	5.57E-04	3.58E-04	2.83E-02	2.0E-02	1.03E-02				
205	C1-Cs-P3	00-0304	lag col #3	5.29E-02	9.70E-04	3.50E-04	3.54E-02	2.42E-02	1.27E-02		C1-Cs-P3	lag col #3	4.26E-02	7.81E-04	2.82E-04	2.85E-02	2.0E-02	1.02E-02				
206	C1-Cs-P6	00-0305	lag col #6	5.55E-02			3.46E-02	2.53E-02	1.29E-02		C1-Cs-P6	lag col #6	4.47E-02			2.79E-02	2.0E-02	1.04E-02				
207	Effluent-1	00-1041	effluent #1	5.05E-02	6.94E-04	3.87E-04	3.30E-02	2.33E-02	1.16E-02		Effluent-1	effluent #1	4.07E-02	5.59E-04	3.12E-04	2.66E-02	1.9E-02	9.37E-03				
208	Effluent-2	00-1042	effluent #2	5.59E-02		3.90E-04	3.50E-02	2.54E-02	1.19E-02		Effluent-2	effluent #2	4.50E-02		3.14E-04	2.82E-02	2.1E-02	9.55E-03				
209	An-107-TcIX	00-1040	Tc IX feed	5.23E-02	<5.1E-04	3.44E-04	3.40E-02	2.36E-02	1.16E-02		An-107-TcI	Tc IX feed	4.21E-02	<4.13E-04	2.77E-04	2.74E-02	1.9E-02	9.37E-03				
210	maximum DF			1.38E+00			1.29E+00															
211	DF			1.15E+00			1.18E+00															
212	P6/P1			1.27	0.00	0.00	1.11	1.14	11.52													
213	P3/P1				2.62	0.88																
214																						
215	Cs-137 Mass Balance																					
216																						
217	Cs-137 at start		mass of feed, g	volume of feed, mL	Cs-137, uCi/mL	Cs-137, u Ci																
218			2047.00	1649	153	252258																
219																						
220	^{137}Cs recovered		mass	volume	Cs-137	Cs-137 (7)	% of original (7)	Cs-137 (8)	% of original (8)													
221			g	mL	u Ci/mL	u Ci		u Ci														
222	Effluent		1999	1611	0.087	140.3	0.06%	140.3	0.06%													
223	load samples # 1		32	26	--	2597.7	1.03%	2597.7	1.03%													
224	load samples # 2		16	13	--	1.2	0.00%	1.2	0.00%													
225	Feed displacement		130.2	116.8	--	65.3	0.03%	65.3	0.03%													
226	DI water rinse		96.8	96.6	--	6.8	0.00%	6.8	0.00%													
227	Elution, 1st Col:		197.7	195.0	474.0	92415	36.64%	109378	43.36%													
228	DI water rinse col # 1		77.3	77.3	--	68.6	0.03%	68.6	0.03%													
229	regeneration solution #1		128.7	128.6	0.023	2.9	0.00%	2.9	0.00%													
230	Elution, 2nd Col:		214.258	211.299	716.0	151290	59.97%	162652	64.48%													
231	DI water rinse #2		data not taken ---------->																			
232	regeneration solution #2		data not taken ---------->																			
233	left on resin			34.500	2.460	84.9	0.03%	84.9	0.03%													
234	Total:					246673	97.79%	274997	109.01%													

(7) Cesium content in eluants is based on concentration in composite samples.
(8) Cesium content in eluants is based on summation of individual samples.

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP
198	Decontamination of non cesium radionuclides																				
199																					
200																					
201																					
202	C1-Cs-ICP																				
203	C1-Cs-P1																				
204	C1-Cs-P2																				
205	C1-Cs-P3																				
206	C1-Cs-P6																				
207	Effluent-1																				
208	Effluent-2																				
209	An-107-TcIX																				
210	maximum DF																				
211	DF																				
212	P6/P1																				
213	P3/P1																				
214																					
215	Cs-137 Mass Balance																				
216																					
217	Cs-137 at start																				
218																					
219																					
220	^{137}Cs recovered																				
221																					
222	Effluent																				
223	load samples # 1																				
224	load samples # 2																				
225	Feed displacement																				
226	DI water rinse																				
227	Elution, 1st Col:																				
228	DI water rinse col # 1																				
229	regeneration solution #1																				
230	Elution, 2nd Col:																				
231	DI water rinse #2																				
232	regeneration solution #2																				
233	left on resin																				
234	Total:																				

AN-107 Feed composition					ASR 5571				ASR 5571	ASR 5571	ASR 5571	ASR 5628	ASR 5582	ASR 5582	ASR 5582
	00-0072	00-0072 DUP	00-0073		00-00295				00-0332	00-0333	00-0334	00-0626	00-0380	00-0380	00-0380
	DF-20	DF-20	DF-21	average of DF 20,21	C1-Cs-IC	ratio col. F/E			C1-C-A	C1-S1-A	C1-S2-A	N7-Tc-0	N7-Tc-Eff-com	N7-Tc-Eff-com	N7-Tc-Eff-com
	Sr/TRU filtrate	Sr/TRU filtrate	Sr/TRU filtrate	Sr/TRU filtrate	Cs IX feed		average or best values	std. Dev.	Cs IX feed batch contact	Cs IX feed batch contact	Cs IX feed batch contacts	Tc IX feed	SO4 feed 11/11/99 @250	SO4 feed 11/11/99 @50	SO4 feed 11/17/99 @250
	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL		ug/mL					ug/mL	ug/mL	ug/mL	ug/mL
Al	2470	2545	2408	2458	2433	0.990	2343	158	-	-	-	2070	2460	2360	2420
Ba	-	-	-	-	-	-	-		-	-	-	0.10	-	-	-
Ca	174	179	163	169	170	1.004	162	11	-	-	-	146	140	159	150
Cd	-	30	28	29	28.7	0.989	27	2	-	-	-	24.2	24	27.1	28
Co	3	3	2	3	-	-	3	-	-	-	-	1.8	-	-	-
Cr	46	47	45	46	45.4	0.989	46	0	-	-	-	37.2	47	44.5	46
Cu	20	21	20	20	19.2	0.944	20	1	-	-	-	11.9	6.8	12.8	8.6
Fe	12	11	11	11	10.3	0.931	11	1	-	-	-	7.35	6.5	8.6	7.6
K	777	787	763	773	782	1.012	777	7	-	-	-	641	700	740	730
La	-	-	-	-	-	-	-	-	-	-	-	--	-	-	-
Mg	-	-	-	-	-	-	-	-	-	-	-	--	-	-	-
Mn	3	3	3	3	-	-	2.9	-	-	-	-	1.1	-	-	-
Mo	16	16	16	16	14.9	0.943	15.5	1	-	-	-	14.1	16	17	17
Na	126623	136554	114085	122837	111850	0.911	111307	8259	-	-	-	99600	114423	-	110073
Ni	241	248	232	238	233	0.979	237	7	-	-	-	181	224	216	226
Pb	68	70	67	68	65.8	0.969	67.2	2	-	-	-	52.2	56	60	60
Si	35	31	40	36	73.2	2.017	48.6	19	-	-	-	65	-	-	-
Sn	-	-	-	-	-	-	-	-	-	-	-	--	-	-	-
Ti	-	-	-	-	-	-	-	-	-	-	-	--	-	-	-
U	48	-	-	48	-	-	48.4	-	-	-	-	--	-	-	-
Zn	7	7	6	7	6.70	0.995	6.7	1	-	-	-	5.7	-	9.3	-
									-	-	-	--		-	
B	-	-	-	-	35.75	-	35.8	-	-	-	-	25.4	-	16	-
P	314	322	307	312	309.1	0.990	311	7	-	-	-	266	308	300	302
Nd	3	3	3	3	-	-	3.4	-	-	-	-	2.1	-	-	-
Sr	140	146	133	138	132.8	0.962	136	7	-	-	-	115	149	141	137
W	-	-	-	-	-	-	-	-	-	-	-	66	-	-	-
Y	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Zr	3	3	2	3	-	-	2.5	-	-	-	-	2.1	-	3.1	-

Note: [<##] indicates detection limit; -- indicates below detection limit

					ASR 5571		average or best values	std dev	ASR 5571	ASR 5571	ASR 5571	ASR 5628	ASR 5582	ASR 5582	ASR 5582
	00-0072	00-0072 DUP	00-0073		00-00295				00-0332	00-0333	00-0334	00-0626	00-0380	00-0380	00-0380
	DF-20	DF-20	DF-21	average	C1-Cs-ICP				C1-C-A	C1-S1-A	C1-S2-A	N7-Tc-0	N7-Tc-Eff-com	N7-Tc-Eff-com	N7-Tc-Eff-com
	Sr/TRU filtrate	Sr/TRU filtrate	Sr/TRU filtrate	Sr/TRU filtrate	ug/mL		ug/mL (1)					ug/mL	ug/mL (1)	ug/mL (1)	ug/mL (1)
TOC	14000	-	13200	13600			13600	-	-	-	-				
TIC	6800	-	6850	6825			6825	-	-	-	-		7940	7940	
Br							<250	-	-	-	-	<250	<500	<500	<500
Cl							480	-	-	-	-	480	<500	<500	<500
F									-	-	-	3200	3700	3400	3200
NO2							28392	507	-	-	-	27900	29000	28500	26600
NO3							112500	-	-	-	-	110000	97600	96300	92900
oxalate							1375	106	-	-	-	1400	1400	1300	1200
PO4							1250	-	-	-	-	1100	<1000	<1000	<1000
SO4							4008	59	-	-	-	3800	4100	4100	3700
OH									-	-	-	Notes: 1) F content is probably due to organic interferen 1.5 times the highest standard and linear extrapolation low.			

					ASR 5571		average or		ASR 5571	ASR 5571	ASR 5571	ASR 5628	ASR 5582	ASR 5582	ASR 5582
	00-0072	00-0072 DUP	00-0073		00-00295		best values		00-0332	00-0333	00-0334	00-0626	00-0380	00-0380	00-0380
	DF-20	DF-20	DF-21	average of DF 20,21	C1-Cs-IC	ratio col. F/E			C1-C-A	C1-S1-A	C1-S2-A	N7-Tc-0	N7-Tc-Eff-com	N7-Tc-Eff-com	N7-Tc-Eff-com
	Sr/TRU filtrate	Sr/TRU filtrate	Sr/TRU filtrate	Sr/TRU filtrate	Cs IX feed				Cs IX feed	Cs IX feed	Cs IX feed	Tc IX feed	SO4 feed	SO4 feed	SO4 feed
					uCi/mL		uCi/mL		uCi/mL	uCi/mL	uCi/mL				uCi/mL
Co-60	6.39E-02	6.48E-02	5.96E-02	6.20E-02	6.03E-02		6.07E-02		6.12E-02	5.95E-02	5.94E-02				
Nb-95**	--	--	--	--	-										
Y-88	--	--	--	--	-										
Sn-113	--	--	--	--	-										
Sb-125	--	--	--	--	<2.5E-1		<0.144	-	<0.144	<0.144	<0.144				
SnSb-126	--	--	--	--	<6.2E-2		<6.2E-2	-	<6.2E-2	<6.2E-2	<6.2E-2				
Cs-134	<7.4E-3	<7.4E-3	<7.4E-3	<7.4E-3	<5E-3		<6.2E-3	-	<6.2E-3	<6.2E-3	<6.2E-3				
Cs-137	1.54E+02	1.55E+02	1.51E+02	1.53E+02	156.4		153.0	-	152.2	152.4	151.4				
Eu-154	3.67E-02	7.71E-02	3.39E-02	4.54E-02	4.02E-02		3.77E-02	1.93E-02	1.24E-02	4.59E-02	3.69E-02				
Eu-155	<9.9E-2	<1.1E-2	<9.9E-2	<9.9E-2	<9.9E-2		<9.9E-2	-	<0.123	<0.123	<0.123				
Am-241	<9.9E-2	<9.9E-2	<9.9E-2	<9.9E-2	<8.7E-2		<8.7E-2	-	<0.1	<0.1	<0.1				
	ug/mL	ug/mL	ug/mL	ug/mL			ug/mL								
Tc-99	3.22	3.18	3.55	3.37			3.37	2.05E-01	-	-	-	3.34			
Np-237									-	-	-				
Pu-239									-	-	-				
	uCi/mL	uCi/mL	uCi/mL	uCi/mL			uCi/mL								
Tc -99	5.47E-02	5.40E-02	6.04E-02	5.73E-02			5.73E-02	3.49E-03	-	-	-	5.67E-02			
Np-237									-	-	-				
Pu-239									-	-	-				
Sr-90	5.82E-01	5.93E-01	5.97E-01	5.92E-01			5.92E-01	7.77E-03	-	-	-				
Pu									-	-	-				
Am/Cm									-	-	-				
Pu-238	2.07E-04	2.14E-04	2.06E-04	2.08E-04			2.08E-04	4.36E-06	-	-	-				
Pu-239/240	8.05E-04	7.96E-04	7.67E-04	7.84E-04			7.84E-04	1.99E-05	-	-	-				
Cm-242	3.06E-05	2.12E-05	3.00E-05	2.79E-05			2.79E-05	5.25E-06	-	-	-				
Cm243,244	2.98E-04	2.26E-04	2.43E-04	2.52E-04			2.52E-04	3.74E-05	-	-	-				
U									-	-	-				
Se-79									-	-	-				
Total alpha	1.02E-02	1.00E-02	9.58E-03	9.84E-03			9.84E-03	3.16E-04	-	-	-				
Volume, mL					1820										
Mass, g					2260										
density, g/mL	1.2414	1.2414	1.2414	1.2414	1.2414		1.2414		1.2414	1.2414	1.2414	1.24	1.2311		
temp, oC					26		26					est	23.7		

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AN-107 Feed c														
	ASR 5582	ASR 5582	ASR 5600	ASR 5600	ASR 5600		ASR 5600	ASR 5600	ASR 5600	ASR 5600	ASR 5600	ASR 5600	ASR 5600	
	00-0380	00-0380	00-461	00-462			00-463	00-464		00-473	00-473 REP	00-474	average	
	N7-Tc-Eff-com	N7-Tc-Eff-comp												MRQ
	SO4 feed	SO4 feed	sulfate removal feed/Tc effluent			Tc Effluent/vit feed	sulfate removal after Ca carbonate precip			sulfate removal effuent/vitrification feed				
	11/17/99	average			average	average			average				average	
	@50													
	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL
Al	2400	2410	2380	2310	2345	2378	852	849	850.5	793	788	746	768	75
Ba	-	-	--	--	--	--	--	--	--	--	--	--	--	78
Ca	172	155	168	175	171.5	163	975	907	941	922	919	851	886	150
Cd	27.8	26.7	27.4	26.7	27.1	26.9	25.1	24.9	25	22.9	22.8	21.5	22.2	7.5
Co	-	-	2.1		2.1	2.1	--	1.8	1.8	1.7	--	1.6	1.7	30
Cr	45.1	45.7	43.1	42.8	43.0	44.3	36.9	35.7	36.3	6.57	6.7	6.16	6.4	15
Cu	14	10.6	13.5	12	12.8	11.7	11.0	12.3	11.65	11.2	10	10.6	10.6	17
Fe	10	8.18	8.98	8.6	8.8	8.5	3.1	3.4	3.25	3	3	2.6	2.8	150
K	740	728	716	690	703	715	630.0	662.0	646	773	760	736	751	75
La	-	-	--	--	--	--	--	--	--	--	--	--	--	35
Mg	-	-	--	--	--	--	--	--	--	--	--	--	--	150
Mn	-	-	1.4	--	1.4	1.4	--	--	--	--	--	--	--	150
Mo	17	16.8	16.2	16	16.1	16.4	15	14.7	14.85	13.6	14	12.7	13.3	90
Na	-	112248	110000	110000	110000	111124	103000	104000	103500	95900	99200	91800	94675	75
Ni	220	222	208	207	207.5	214.5	199	192	195.5	181	184	169	176	30
Pb	61.4	59.4	58.2	57.9	58.05	58.7	25	24.4	24.7	23	23	21.6		300
Si	-	-	32	31	31.5	31.5	--	--	--	--	--	--	--	170
Sn	-	-	--	--	--	--	--	--	--	--	--	--	--	1500
Ti	-	-	--	--	--	--	--	--	--	--	--	--	--	17
U	-	-	--	--	--	--	--	--	--	--	--	--	--	600
Zn	8.8	9.1	6.5	7.2	6.9	8.0	4.8	4.6	4.7	4.4	5	4	4.4	16.5
	--	--	--	--	--	--	--	--	--	--	--	--	--	
B	16	16.0	19.4	18	18.7	17.4	--	1.8	1.8	1.3	--	1.1	1.2	NMRQ
P	307	304	306	297	301.5	303	50	47.7	48.85	43.5	44	41.3	42.5	NMRQ
Nd	--	--	--	--	--	--	--	--	--	--	--	--	--	NMRQ
Sr	134	140.25	131	129	130	135	--	0.78	0.78	7.31	7.3	6.68	7.0	NMRQ
W	--	--	76		76	76	--	65	65	60		56	43.0	NMRQ
Y	--	--	--	--	--	--	--	--	--	--	--	--	--	NMRQ
Zr	3	3.05	3	2.6	2.8	2.9	--	--	--	--	--	--	--	NMRQ
Note: [<##] indi														

file: AN-107.feedco[redacted]umn.xls
sheet: a[redacted]tical data

		ASR 5582	ASR 5600	ASR 5600	ASR 5600		ASR 5600	ASR 5600	ASR 5600	ASR 5600	ASR 5600	ASR 5600	ASR 5600	
		00-0380	00-461	00-462	average	Tc Effluent/vit feed	00-463	00-464	average	00-473	00-473 REP	00-474	average	
		N7-Tc-Eff-com	sulfate removal feed/Tc effluent			average	sulfate removal after Ca carbonate precip			sulfate removal effuent/vitrification feed				MRQ
		ug/mL (1)	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	mg/mL
TOC						13600								1500
TIC		7940				7940								150
Br		<500	< 500	< 500	< 500	< 500	<500	<500	<500	< 500		< 500	< 500	NMRQ
Cl		<500	< 500	< 500	< 500	< 500	<500	<500	<500	< 500		< 500	< 500	3
F		3433	3600	3500	3550	3492	3000	3000	3000	3000		3000	3000	150
NO2		28033	28700	28800	28750	28392	25800	26000	25900	29600		29500	29550	NMRQ
NO3		95600	113000	112000	112500	112500	197000	199000	198000	174000		172000	173000	3000
oxalate		1300	1400	1500	1450	1375	<1000	<1000	<1000	<1000		<1000	<1000	
PO4		<1000	1400	1400	1400	1400	<1000	<1000	<1000	<1000		<1000	<1000	2500
SO4		3967	4100	4000	4050	4008	3300	3300	3300	970		970	970	2300
OH	. Nitrate results are y be biased 10-20%													NMRQ
														MRQ

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	ASR 5582	ASR 5582	ASR 5600	ASR 5600	ASR 5600		ASR 5600	ASR 5600	ASR 5600	ASR 5600	ASR 5600	ASR 5600	ASR 5600	
	00-0380	00-0380	00-461	00-462			00-463	00-464		00-473	00-473 REP	00-474	ave	
	N7-Tc-Eff-com	N7-Tc-Eff-comp				Tc Effluent/vit feed								
	SO4 feed	SO4 feed	sulfate removal feed/Tc effluent			average	sulfate removal after Ca carbonate precip			sulfate removal effuent/vitrification feed				
			uCi/mL		uCi/mL	uCi/mL								uCi/mL
Co-60			4.97E-02	--	4.97E-02	4.97E-02	4.12E-02	--	4.12E-02	3.96E-02	--	--	3.96E-02	NMRQ
Nb-95**			1.38E-03	--	1.38E-03	1.38E-03	1.26E-03	--	1.26E-03	1.09E-03	--	--	1.09E-03	NMRQ
Y-88			8.29E-04	--	8.29E-04	8.29E-04	2.02E-04	--	2.02E-04	<2.4e-4	--	--	<2.4e-4	NMRQ
Sn-113			5.06E-04	--	5.06E-04	5.06E-04	--	--	--	5.59E-05	--	--	5.59E-05	NMRQ
Sb-125			6.03E-04	--	6.03E-04	6.03E-04	<3.6E-4	--	<3.6E-4	<8.4e-5	--	--	<8.4e-5	NMRQ
SnSb-126			3.82E-04	--	3.82E-04	3.82E-04	<2.4E-4	--	<2.4E-4	<3.6e-5	--	--	<3.6e-5	NMRQ
Cs-134														
Cs-137			8.26E-02	--	8.26E-02	8.26E-02	7.36E-02	--	7.36E-02	7.33E-02	--	--	7.33E-02	9.00E+00
Eu-154			3.27E-02	--	3.27E-02	3.27E-02	6.01E-03	--	6.01E-03	3.10E-03	--	--	3.10E-03	2.00E-03
Eu-155			2.33E-02	--	2.33E-02	2.33E-02	4.41E-03	--	4.41E-03	2.17E-03	--	--	2.17E-03	9.00E-02
Am-241			1.19E-02	--	1.19E-02	1.19E-02	2.08E-03	--	2.08E-03	1.35E-03	--	--	1.35E-03	7.75E-04
			ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	ug/mL	
Tc-99			3.45	3.49	3.47	3.47E+00	3.08	3.40	3.24	2.86	2.77	2.95	2.88	--
Np-237			6.01E-02	5.81E-02	5.91E-02	5.91E-02	3.15E-02	3.41E-02	3.28E-02	1.70E-02	1.80E-02	1.70E-02	1.73E-02	--
Pu-239			2.40E-02	2.40E-02	2.40E-02	2.40E-02	1.10E-02	1.10E-02	1.10E-02	4.40E-03	6.60E-03	7.00E-03	6.25E-03	--
			uCi/mL	uCi/mL	uCi/mL	uCi/mL	uCi/mL	uCi/mL	uCi/mL	uCi/mL	uCi/mL	uCi/mL	uCi/mL	
Tc-99			5.87E-02	5.93E-02	5.90E-02	5.90E-02	5.24E-02	5.78E-02	5.51E-02	0.04862	0.04709	0.05015	0.049003	1.50E-03
Np-237			4.24E-05	4.10E-05	4.17E-05	4.17E-05	2.22E-05	2.40E-05	2.31E-05	1.20E-05	1.27E-05	1.20E-05	1.22E-05	7.75E-04
Pu-239			1.49E-03	1.49E-03	1.49E-03	1.49E-03	6.82E-04	6.82E-04	6.82E-04	2.73E-04	4.09E-04	4.34E-04	3.88E-04	7.75E-04
Sr-90														3.00E-01
Pu														
Am/Cm														
Pu-238														
Pu-239/240														
Cm-242														
Cm243,244														7.75E-04
U														
Se-79														1.00E-04
Total alpha														7.75E-04
Volume, mL										484.4				
Mass, g										584.4				
density, g/mL			1.2311				1.2089			1.2064				
temp, oC														

file: AN-107.feedcon[redacted]umn.xls
sheet: a[redacted]ical data

AN-107 Cs IX

Composition Estimate for Column Run

[redacted]sity =	1.2414	g/mL @		°C					
Note: Independently verfied as Tc IX feed at 1.24 g/mL									
		MW	concentration	charge concentration					
Cations	µg/mL	g/mole	M	M					
Na^+	111307	23	4.839	4.839					
K^+	777	40	0.019	0.019					
Cs^+			5.25E-05	5.25E-05					
		Sum of cation charge =		4.859					
Na/Cs mole ratio			92128						
K/Cs mole ratio			370						
	ug/mL								
B	35.8								
Ca	162								
Cd	27.1								
Co	2.5								
Cr	45.7								
Cu	19.8								
Fe	10.7								
K	777								
Mn	2.9								
Mo	15.5								
Na	111307								
Ni	237								
Nd	3.4								
Pb	67.2								
[redacted]Si	48.6								
Sr	136								
U	48								
Zn	6.7								
Zr	2.5								
Anions		MW	concentration	charge concentration					
	µg/mL								
$AlO_2^{-(a)}$	2343	26.98	0.087	0.087					
Cl^-	480	35.45	0.014	0.014					
$CO_3^{-2(b)}$	6825	12	0.569	1.14					
$CrO_4^{2-(a)}$	45.7	52	8.79E-04	1.76E-03					
F^-	0	19	0.000		probably due to organic interference				
NO_2^-	28392	46	0.617	0.617					
NO_3^-	112500	62	1.815	1.815					
OH^- M		17	0.000	0.800	estimated				
PO_4^{-3} (a)	311	30.97	0.010	0.030					
SO_4^{-2}	4008	96.06	0.042	0.083					
oxalate	1375	88.04	0.016	0.031					
TOC, (b,c)	13600	12	1.133	1.102					
			Sum of anion charge =		5.718				
			cation - anion =		-0.859				

(a) analytical concentrations are for Al, P, Cr from ICP
(b) MW = 12 is for carbon only.
[redacted]TOC species unknown but assumed to be oxalate (2 carbons and a -2 charge)

Filename =AN-107.feedcomp.column.xls
sheet: feed composition

Radionuclides	µCi/mL								
total α	9.84E-03								
total β									
Co60	6.07E-02								
Sr-90	5.92E-01								
Tc-99, ug/mL	3.37E+00								
Ru/Rh-106									
Sb-125	<0.144								
Sn/Sb-126	<6.2E-2								
Cs-134	<6.2E-3								
Cs-137	153.0								
Eu-154	3.77E-02								
Eu-155	<9.9E-2								
Am-241	<8.7E-2								

Filename =AN-107.feedcomp.column.xls
sheet: feed composition

waste density by vol flask =			1.2414	g/mL	Resin batch number: 644BZ, std Kd= 570 mL/g				
					As received resin density =		0.86	g/mL	
Feed analyses: Cs-137, uCi/mL									
Date	sample	uCi/mL			f factor @ = 95 °C		0.776		
					dry density =		0.667	g/mL	
Oct-99	DF-20	154.5							
Oct-99	DF-21	151							
Oct-99	C1-CA	152.24	Batch contacts with AN-107 feed and SL-644						
Oct-99	C1-S1-A	152.43	Batch contacts with AN-107 feed and SL-644						
Oct-99	C1-S2-A	151.35	Batch contacts with AN-107 feed and SL-644						
Oct-99	C1-Cs-ICP	156.4	Column run feed analysis			Average Cs-137 concentration		153.0	uCi/mL
Oct-99			Column run feed analysis			Average Cs-134 concentration		<6.2e-3	uCi/mL
average		153.0	uCi/mL						
Sample ID's						ACL number			
C1-44-A	contact: unspiked				ASR 5571	00-0335			
C1-44-D-A	contact: unspiked duplicate				ASR 5571	00-0336			
C1-44-S1-A	contact: feed spiked with 50.9 uL of 0.1 M Cs nitrate				ASR 5571	00-0337			
C1-44-S1-D-A	contact: feed spiked with 50.9 uL of 0.1 M Cs nitrate				ASR 5571	00-0338			
C1-44-S2-A	contact: feed spiked with 132.3 uL of 0.1 M Cs nitrate				ASR 5571	00-0339			
C1-44-S2-D-A	contact: feed spiked with 132.3 uL of 0.1 M Cs nitrate				ASR 5571	00-0340			
C1-S1-A	control: feed spiked with 50.9 uL of 0.1 M Cs nitrate				ASR 5571	00-0333			
C1-S2-A	control: feed spiked with 132.3 uL of 0.1 M Cs nitrate				ASR 5571	00-0334			
C1-C-A	unspiked control				ASR 5571	00-0332			

Analytical Sample ID	C1-44A	C1-44-D-A	C1-44-S1-A	C1-44-S1-D-A	C1-44-S2-A	C1-44-S2-D-A	C1-S1-A	C1-S2-A	C1-C-A
analytical Cs-137, uCi/g of sample submitted	0.716	0.549	1.4	1.49	3.19	2.46	7.3	7.29	7.41
net waste added to analytical vial, g	0.5886	0.5917	0.5922	0.6007	0.5872	0.588	0.6088	0.6102	0.6183
mass of vial + 0.25 M NaOH	26.4523	26.3376	26.3312	26.2967	26.2739	26.3996	26.2894	26.2898	26.2628
Tare, g	16.7448	16.6543	16.7235	16.7029	16.6668	16.7912	16.6581	16.6952	16.6482
diluent mass, g	9.7075	9.6833	9.6077	9.5938	9.6071	9.6084	9.6313	9.5946	9.6146
mass dilution factor, total mass:waste mass	17.49	17.37	17.22	16.97	17.36	17.34	16.82	16.72	16.55
Cs-137, concentration, uCi/g of waste	12.52	9.53	24.11	25.29	55.38	42.66	122.79	121.92	122.64
Cs-137, concentration, uCi/mL of waste	15.55	11.83	29.93	31.39	68.75	52.96	152.43	151.35	152.24
Cs-137, waste concentration, M	1.31E-06	9.98E-07	2.52E-06	2.65E-06	5.79E-06	4.46E-06	1.28E-05	1.28E-05	1.28E-05
total cesium after contact	5.34E-06	4.06E-06	7.66E-05	8.04E-05	4.16E-04	3.21E-04	3.90E-04	9.16E-04	5.23E-05
Kd's based on average Cs 137									
contact waste mass, g	6.3406	6.2472	6.1814	6.2237	6.1463	6.1907	6.1917	6.4586	4.8510
contact waste volume, mL	5.11	5.03	4.98	5.01	4.95	4.99	4.99	5.20	3.91
resin mass	0.0503	0.05	0.0507	0.0499	0.0479	0.051			

f factor @ 95 °C	0.776	0.776	0.776	0.776	0.776	0.776			
Kd, mL/g (Cs-137)	**1467.79**	**1952.00**	**676.54**	**653.96**	**234.80**	**325.96**			
sodium concentration	4.84	4.84	4.84	4.84	4.84	4.84	4.84	4.84	4.84
Na/Cs mole ratio	**9.07E+05**	**1.19E+06**	**6.31E+04**	**6.02E+04**	**1.16E+04**	**1.51E+04**	**1.24E+04**	**5.28E+03**	**9.26E+04**
Kd @ feed conditions =		790	mL/g						
dry resin density in contact with feed =		0.2312	g/mL of expanded bed						
lambda @ feed conditions =		182.6							

Note: total cesium in waste is based on Cs-137 concentration and the TIMS results which indicate that the Cs-137 mole fraction is 0.2455. The spikes are adjusted for the addition of 0.1 M cesium nitrate. See Cs spike prep sheet.

	density of 0.1 M Cs nitrate	1.0126	g/mL	waste density =		1.2414	g/mL
Dispense 50 uL of water		density of water at 21 °C =		0.99754	g/mL		
	mass dispensed,	mL	uL				
	0.0531	0.05323	53.231				
	0.0527	0.05283	52.830				
	0.0525	0.05263	52.629				
	0.052	0.05213	52.128				
	0.052	0.05213	52.128				
	ave =	0.05259	52.589				
spike vial preparation							
tare	vial + 50 uL of 0.1 M Cs nitrate	mass added g	volume, uL				
16.5742	16.6257	0.0515	50.86				
Nonrad Cs added in spike 1 =		5.086E-06	moles				
			tare, g	mass, g	waste mass	waste volume	
			g	g	g	mL	
waste added to spike vial 1 (C1-S1)=			16.6252	35.2387	18.6135	14.9940	
incremental cesium concentration =			3.39E-04	M			
initial Cs-137 concentration =			153.0	uCi/mL			
initial Cs-137 concentration =			1.29E-05	M			
initial Cs-137 =			1.93E-07	moles			
initial total Cs concentration =			5.25E-05	M			
initial total Cs in sample =			7.88E-07	moles			
total Cs in spiked sample =			5.87E-06	moles			
concentration of total Cs in spiked sample			3.92E-04	M			
Cs-137: total Cs in spiked waste =			3.29E-02				
Dispense 135 uL of water		density of water at 23 °C =		0.99754	g/mL		
start	mass dispensed,	mL	uL				
	0.1314	0.13172	131.724				
	0.1321	0.13243	132.426				
	0.1327	0.13303	133.027				
	0.133	0.13333	133.328				
	0.133	0.13333	133.328				
	ave =	0.13303	133.027				
spike 2 vial preparation							
tare of spike vial	vial + 135 uL of 0.1 M Cs nitrate	mass added g	volume, uL				
16.7356	16.8696	0.134	132.33				
Nonrad Cs added in spike 2 =		1.323E-05	moles				
			tare, g	mass, g	waste mass	waste volume	
			g	g	g	mL	
waste added to spike vial 2 (C1-S2)=			16.8695	35.6782	18.8087	15.1512	
incremental cesium concentration =			8.73E-04	M			
initial Cs-137 concentration =			153.0	uCi/mL			
initial Cs-137 concentration =			1.29E-05	M			
initial Cs-137 =			1.95E-07	moles			
initial total Cs concentration =			5.25E-05	M			
initial total Cs in unspiked sample =			7.96E-07	moles			
total Cs in spiked sample =			1.40E-05	moles			
concentration of total Cs in spiked sample			9.26E-04	M			
Cs-137: total Cs in spiked waste =			1.39E-02				

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