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Small-Column Cesium Ion Exchange Elution Testing of Spherical Resorcinol-Formaldehyde

GN Brown
RL Russell

RA Peterson

October 2011



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Test Specification: 24590-PTF-TSP-RT-09-002 Rev 0

Work Authorization: WA#2009-035

Test Plan: TP-WTPSP-002, Rev. 1.0

Test Exceptions: 24590-PTF-TEF-RT-10-00001, Rev 000
24590-PTF-TEF-RT-10-00002, Rev 1

R&T Focus Area: Pretreatment

Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

COMPLETENESS OF TESTING

This report describes the results of work and testing specified by Test Specification 24590-PTF-TSP-RT-09-002, Rev 0 "RF Resin Cesium Removal with Expanded Load and Elution Conditions" and Test Plan TP-WTPSP-002, Rev 1.0 "Cesium Ion Exchange Simulant Testing in Support of M-6." The work and any associated testing followed the quality assurance requirements outlined in the Test Specification/Plan. The descriptions provided in this test report are an accurate account of both the conduct of the work and the data collected. Test plan results are reported. Also reported are any unusual or anomalous occurrences that are different from expected results. The test results and this report have been reviewed and verified.

Approved:

Dean E. Kurath
Dean E. Kurath, Manager
WTP R&T Support Project

10/21/11
Date

Testing Summary

Ion exchange using the Spherical Resorcinol-Formaldehyde (SRF) resin has been selected by the U.S. Department of Energy's Office of River Protection (DOE-ORP) for use in the Pretreatment Facility (PTF) of the Hanford Tank Waste Treatment and Immobilization Plant (WTP) and for potential application in an at-tank deployment. Numerous studies have shown the SRF resin to be effective for removing ^{137}Cs from a wide variety of actual and simulated tank waste supernatants (Adamson et al. 2006; Blanchard et al. 2008; Burgeson et al. 2004; Duignan and Nash 2009; Fiskum et al. 2006a; Fiskum et al. 2006b; Fiskum et al. 2006c; Fiskum et al. 2007; Hassan and Adu-Wusu 2003; King et al. 2004; Nash et al. 2006; Thorson and Gilbert 2007). Much of the prior work at Pacific Northwest National Laboratory (PNNL) in this area focused primarily on the loading behavior for 4 to 6 M sodium (Na) solutions at 25°C to 45°C and the eluting behavior of the loaded SRF resin with virgin 0.5 M HNO_3 . In addition, various alternative acid concentrations and elution strategies have been investigated (Taylor and Johnson 2009; Burgeson et al. 2004). Recent proposed changes to the WTP ion exchange process baseline indicate that loading may include a broader range of sodium molarities (2 to 8 M) and higher temperatures (50°C) to alleviate post-filtration precipitation issues. In addition, elution will likely use variable-strength recycled nitric acid containing trace impurities of ^{137}Cs .

This report summarizes the work performed to evaluate multiple, cesium loading, and elution cycles for small columns containing SRF resin using a simple, high-level waste (HLW) simulant. Cesium ion exchange loading and elution curves were generated for a nominal 5 M Na, $2.4\text{E-}05$ M Cs, 0.115 M Al loading solution traced before beginning testing with ^{134}Cs . This was followed by elution with variable HNO_3 (0.02, 0.07, 0.15, 0.23, and 0.28 M) containing variable CsNO_3 ($5.0\text{E-}09$, $5.0\text{E-}08$, and $5.0\text{E-}07$ M) and traced before beginning testing with ^{137}Cs . The use of two separate cesium process tracers (^{134}Cs and ^{137}Cs) facilitated the monitoring of cesium behavior from multiple sources (e.g., from the loading and elution solution, respectively). The ion exchange system consisted of a pump, tubing, process solutions, and a single, small (~15.7 mL) bed of SRF resin with a water-jacketed column for temperature-control. The columns were loaded with approximately 250 bed volumes (BVs) of feed solution at 45°C and at 1.5 to 12 BV per hour (0.15 to 1.2 cm/min). The columns were then eluted with 29+ BVs of HNO_3 processed at 25°C and at 1.4 BV/h. The two independent tracers allowed analysis of the on-column cesium interaction between the loading and elution solutions. The objective of these tests was to improve the correlation between the spent resin cesium content and cesium leached out of the resin in subsequent loading cycles (cesium leakage) to help establish acid strength and purity requirements.

S.1 Objective

The test objectives were to:

- Determine the impact of residual ^{137}Cs in the nitric acid elution feed on the Cs elution profile of the SRF resin.
- Determine the completeness of SRF resin elution as a function of nitric acid concentration to help establish acid strength and purity requirements.
- Improve the correlation between eluted resin cesium content and the amount of cesium leached out of the resin during subsequent loading cycles.

Table S.1 provides the objectives that applied to the small-column elution testing task. Other objectives identified in Test Plan TP-WTPSP-002¹ did not apply to this activity but instead apply to the ion exchange loading kinetics testing task that will be discussed in a future report.

Table S.1. Summary of Test Objectives and Results

Test Objective	Objective Met?	Discussion
Determine the impact of residual ¹³⁷Cs in the nitric acid elution feed on the Cs elution profile of the SRF resin.	Yes	Cesium ion exchange loading and elution curves were generated for multiple cycles using a 15.7 mL bed of SRF resin. The columns were loaded with 250 BV (~87 μmol Cs) of a solution containing 2.4E-05 <u>M</u> Cs, 0.115 <u>M</u> Al and 5 <u>M</u> Na and traced with ¹³⁴ Cs.
Determine the completeness of SRF resin elution as a function of nitric acid concentration to help establish acid strength and purity requirements.	Yes	Depending upon cycle number and column, breakthrough ranged from ~2% to 14% C/C ₀ ¹³⁴ Cs. The columns were neutralized with 3 BV of 0.5 <u>M</u> HNO ₃ and eluted with 29+ BV of variable HNO ₃ (0.02, 0.07, 0.15, 0.23, and 0.28 <u>M</u>) containing variable CsNO ₃ (5.0E-09, 5.0E-08, and 5.0E-07 <u>M</u>) and traced with ¹³⁷ Cs.
Improve the correlation between eluted resin cesium content and the amount of cesium leached out of the resin during subsequent loading cycles.	Yes	Integration of the elution samples indicated from 91% to 122% of the loaded cesium was removed. The residual cesium content on the column after elution was estimated by gamma counting the column and ranged from approximately 0.006% (after elution with 0.07 <u>M</u> to 0.28 <u>M</u> HNO ₃) to 0.5% (after elution with 0.02 <u>M</u> HNO ₃) of the loaded cesium.

S.2 Test Exceptions

The Test Exceptions that were applicable to the Test Plan TP-WTPSP-002 are presented in Table S.2. Neither Test Exception was applicable to the small-column elution testing task but instead apply to the ion exchange loading kinetics testing task that will be discussed in a future report.

Table S.2. Test Exceptions

Test Exceptions	Description of Test Exceptions
24590-WTP-TEF-RT-10-00001 Rev 0	1. Not applicable to the small-column elution testing task.
24590-WTP-TEF-RT-10-00002 Rev 1	2. Not applicable to the small-column elution testing task.

S.3 Results and Performance Against Success Criteria

The Research and Technology (R&T) success criterion for achieving the test objective is discussed in Table S.3. Only the success criterion for the small-column elution testing task is addressed in the table. The success criteria for the ion exchange loading kinetic testing portion of Test Plan TP-WTPSP-002 are not shown in this table and will be discussed in a future report.

¹ Russell RL, GN Brown, and RA Peterson. 2010. *Cesium Ion Exchange Simulant Testing in Support of M-6*. TP-WTPSP-002, Rev 1.0, Pacific Northwest National Laboratory, Richland, Washington.

Table S.3. Success Criteria for Small-Column Elution Testing

Success Criteria	How Testing Did or Did Not Meet Success Criteria
Provide data that quantifies the impact of eluate acid conditions (strength and Cs impurity level) on the Cs elution profile, completeness of elution, and subsequent ion exchange loading (cesium removal performance) of the SRF resin in order to determine suitable acid strength and purity requirements for elution in the ion exchange process.	These success criteria were met. The small-column elution testing task generated a series of cesium ion exchange loading and elution curves for two 15.7-mL columns of SRF resin. The columns were loaded with a simple simulant (5 <u>M</u> Na, 0.115 <u>M</u> Al and 2.4E-05 <u>M</u> Cs), partially eluted with 3 BV 0.5 <u>M</u> HNO ₃ and then eluted with 29+ BV of various HNO ₃ solutions (0.02, 0.07, 0.15, 0.23, and 0.28 <u>M</u>) containing variable CsNO ₃ (5.0E-09, 5.0E-08, and 5.0E-07 <u>M</u>). Each column was loaded and eluted six times. The data collected were used to quantify the completeness of elution as a function of acid and cesium concentration. Effective elution [Decontamination Factor (DF) >1000] was achieved using 25 BV of all acids except 0.02 <u>M</u> HNO ₃ . The cesium content of the acid had no impact. The data also provide an indication of resin degradation during multiple loading cycles.

S.4 Quality Requirements

The PNNL Quality Assurance (QA) Program is based upon the requirements defined in the U.S. Department of Energy Order 414.1C, *Quality Assurance*, and 10 CFR 830, *Energy/Nuclear Safety Management*, and Subpart A—*Quality Assurance Requirements* (a.k.a. the Quality Rule). PNNL has chosen to implement the following consensus standards in a graded approach:

- ASME NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications*, Part 1, Requirements for Quality Assurance Programs for Nuclear Facilities.
- ASME NQA-1-2000, Part II, Subpart 2.7, *Quality Assurance Requirements for Computer Software for Nuclear Facility Applications*.
- ASME NQA-1-2000, Part IV, Subpart 4.2, *Graded Approach Application of Quality Assurance Requirements for Research and Development*.

The procedures necessary to implement the requirements are documented through PNNL's "How Do I...?" (HDI¹).

The Waste Treatment Plant Support Project (WTPSP) implements an NQA-1-2000 Quality Assurance Program, graded on the approach presented in NQA-1-2000, Part IV, Subpart 4.2. The WTPSP Quality Assurance Manual (QA-WTPSP-0002) describes the technology life cycle stages under the WTPSP Quality Assurance Plan (QA-WTPSP-0001). The technology life cycle includes the progression of technology development, commercialization, and retirement in process phases of basic and applied research and development (R&D), engineering and production and operation until process completion. The life cycle is characterized by flexible and informal quality assurance activities in basic research, which becomes more structured and formalized through the applied R&D stages.

The work described in this report has been completed under the QA technology level of applied research. WTPSP addresses internal verification and validation activities by conducting an Independent Technical Review of the final data report in accordance with WTPSP's procedure QA-WTPSP-601, Document Preparation and Change. This review verifies that the reported results are traceable, that

¹ System for managing the delivery of PNNL policies, requirements, and procedures.

inferences and conclusions are soundly based, and that the reported work satisfies the Test Plan objectives.

S.5 R&T Test Conditions

This report summarizes the ion exchange removal of cesium from a simple waste simulant using Microbeads SRF resin, Lot 5E-370/641. The resin was sub-sampled from existing stock that had been stored under nitrogen at PNNL for more than 4 years in the H^+ -form. The resin was bulk pretreated with de-ionized (DI) water, 1 M NaOH, and 0.5 M HNO_3 to cycle between Na^+ and H^+ -forms. The resin was then further pretreated in the column with another acid/base cycle prior to simulant loading. Dry resin density was determined by drying duplicate samples under vacuum at 50°C to constant mass.

All test conditions delineated by the Test Plan and Test Exceptions were met. A summary of test conditions is provided in Table S.4. In summary, two nominal 15-mL columns of SRF resin were loaded with a simple simulant (5 M Na, 0.115 M Al and 2.4E-05 M Cs), partially eluted with 3 BV 0.5 M HNO_3 , and then eluted with 29+ BV of various HNO_3 solutions (0.02, 0.07, 0.15, 0.23, and 0.28 M) containing variable $CsNO_3$ (5.0E-09, 5.0E-08, and 5.0E-07 M).

Table S.4. Summary of R&T Test Conditions

R&T Test Condition	Discussion
Prepare a simple simulant containing nominally 5 <u>M</u> Na, 0.115 <u>M</u> Al, 2.4E-05 <u>M</u> Cs, and 1.55 <u>M</u> Free OH.	These conditions were met. The simulant was prepared in a single 50-L batch and analyzed prior to use as described in Section 3.1.
Select a sub-sample of SRF resin from Microbeads Lot 5E-370/641.	These conditions were met. The resin was removed from an existing 2-L container that had been purged with inert gas prior to extended (>4 year) storage. Upon opening the container, the top layer of resin (~3 mm) was removed by vacuum sluicing and disposed of without use due to visible darkening of this material. The remaining resin was thoroughly mixed, and a representative sample was removed for use in the experiment as discussed in Section 3.4.
Determine the dry H^+ -form density.	These conditions were met and the dry H^+ -form density was estimated to be 0.456 g/mL (mass of dried H^+ -form resin per mL of settled H^+ -form resin under water in a 25-mL graduated cylinder).
Precondition SRF resin per previous protocols (Fiskum et al. 2006).	These conditions were met. The SRF resin was preconditioned with multiple acid/base conversions in bulk and in column as prescribed and discussed in Section 3.5.
Utilize similar columns as previous testing (Fiskum et al. 2006).	These conditions were met. Existing equipment was used with minor modifications (e.g., water-jacketed ion exchange columns were added) as discussed in Section 3.6.
Complete six load-elute cycles on two columns of SRF resin at 45°C and one cycle on new resin at 25°C.	These conditions were met. The columns were eluted with various HNO_3 solutions (0.02, 0.07, 0.15, 0.23, and 0.28 <u>M</u>) containing variable $CsNO_3$ (5.0E-09, 5.0E-08, and 5.0E-07 <u>M</u>) as defined in the Test Plan and discussed in Section 4.0.
Analyze each column after each elution cycle for residual cesium.	These conditions were met. The columns were eluted, rinsed with water, removed from fume hood and analyzed by gamma spectroscopy as discussed in Section 4.5. Residual Cs ranged from 4.88E-03 to 5.73E-05 ^{134}Cs C/C ₀ .

S.6 Simulant Use

The small-column elution testing task was performed using a nonradioactive aqueous solution that had been traced with a small amount of ^{134}Cs prior to beginning testing. This simple simulant composition was provided by Bechtel National, Inc. (BNI) as documented in Test Specification *RF Resin Cesium Removal with Expanded Load and Elution Conditions*.¹ The sodium, cesium, aluminum and hydroxide concentrations were within the ranges expected for aqueous waste feeds to the PTF. The nominal sodium concentration was specified to be 5 M and the nominal cesium concentration was specified to be 2.4E-05 M. No potassium was included in the simulant. The nominal free hydroxide concentration was specified to be 1.55 M and the nominal aluminum concentration was specified to be 0.115 M, approximately 90% of the solubility limit. The simulant was not selected to represent any particular Hanford tank waste type.

S.7 Discrepancies and Follow-on Tests

Complete cesium loading curves (e.g., breakthrough exceeding 0.5 C/C_0) were not observed during the experimental cycles as anticipated. Since the simulant solution did not contain potassium, the cesium loading (e.g., volume to 0.5 C/C_0) for the current experiment was more than anticipated based on literature reports for similar solutions (e.g., simulants containing 5 M Na and approximately 0.05 M K). The primary objective of the current testing was to evaluate elution of the SRF resin as a function of acid and cesium concentration. The lack of a full loading curve did not impact this objective. However, additional testing with a potassium-containing simulant (e.g., AN-105) may be warranted to evaluate the impact that potassium-loaded SRF resin might have on the elution profile.

¹ Lehrman S and M Thorson. 2010. *RF Resin Cesium Removal with Expanded Load and Elution Conditions*, 24590-PTF-TSP-RT-09-002, Rev 0, Bechtel National, Inc., Richland, Washington.

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Acronyms and Abbreviations

ASO	Analytical Support Operations
ASR	Analytical Service Request
AV	apparatus volume
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BNI	Bechtel National Incorporated
BV	bed volume
DI	de-ionized
DF	Decontamination Factor
DOE	U.S. Department of Energy
GEA	Gamma Energy Analysis
GGRF	Ground Gel Resorcinol-Formaldehyde Ion Exchange Resin
HDI	“How Do I,” the standards-based management system for PNNL
HLW	low-volume high-activity waste
HPGe	High-Purity Germanium
IC	Ion Chromatography
ICP	Inductively Coupled Plasma
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
LAW	high-volume low-activity waste
LRB	Laboratory Record Book
MDL	Method Detection Limit
ORP	DOE Office of River Protection
PNNL	Pacific Northwest National Laboratory
PNWD	Battelle—Pacific Northwest Division
PTF	Pretreatment Facility
QA	Quality Assurance
QAM	Quality Assurance Manual
QAP	Quality Assurance Plan
QARD	Quality Assurance Requirements and Descriptions
RF	Resorcinol-Formaldehyde Ion Exchange Resin
RPL	Radiochemical Processing Laboratory
RPP-WTP	River Protection Project – Waste Treatment Plant
RV	resin volume
R&T	Research and Technology
SRF	Spherical Resorcinol-Formaldehyde Ion Exchange Resin
SwRI	Southwest Research Institute
TRU	transuranic
WSRC	Westinghouse Savannah River Company
WTP	Hanford Tank Waste Treatment and Immobilization Plant
WTPSP	Waste Treatment Plant Support Project

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1.0 Introduction

The U.S. Department of Energy (DOE) Hanford Site contains more than 53 million gallons of legacy waste generated as a byproduct of plutonium production and reprocessing operations. The wastes are a complex mixture composed mostly of sodium nitrate, nitrite, hydroxide, aluminate, phosphate, and sulfate, with a number of minor and trace metals, organics, and radionuclides stored in underground waste tanks. The DOE Office of River Protection (ORP) has contracted Bechtel National Incorporated (BNI) to build a pretreatment facility, the River Protection Project-Waste Treatment Plant (RPP-WTP), that will separate long-lived transuranics (TRU) and highly radioactive components (specifically ^{137}Cs and, in selected cases, ^{90}Sr) from the bulk (nonradioactive) constituents and immobilize the wastes by vitrification. The plant is designed to produce two waste streams: a high-volume low-activity waste (LAW) and a low-volume high-activity waste (HLW).

Ion exchange using the spherical resorcinol-formaldehyde (SRF) resin has been selected by BNI and approved by DOE ORP for use in the Pretreatment Facility (PTF) of the RPP-WTP. The SRF resin is an engineered spherical form of the older ground gel resorcinol-formaldehyde (GGRF) resin, also termed resorcinol-formaldehyde (RF), which was developed and evaluated at the Westinghouse Savannah River Company (WSRC) in the 1980s (Ebra and Wallace 1983; Bibler et al. 1989). Numerous studies at Hanford and other DOE sites have shown the GGRF and SRF resins to be effective for removing ^{137}Cs from a wide variety of simulated and actual tank waste supernatants and for achieving less than the proposed spent waste classification criteria of $<100\text{ nCi TRU}$ and $<60\text{ }\mu\text{Ci }^{137}\text{Cs}$ per gram of spent resin (Adamson et al. 2006; Blanchard et al. 2008; Burgeson et al. 2004; Duignan and Nash 2009; Fiskum et al. 2006a; Fiskum et al. 2006b; Fiskum et al. 2006c; Fiskum et al. 2007; Hassan and Adu-Wusu 2003; King et al. 2004; Kurath et al. 1994; Nash et al. 2006).

Much of the prior work focused on loading behavior for 4 to 6 M sodium (Na) solutions at 25°C to 45°C and the eluting behavior of the loaded SRF resin with fresh 0.5 M HNO_3 . Some alternative acid concentrations and elution strategies have also been investigated previously (Taylor and Johnson 2009; Burgeson et al. 2004). Recent proposed changes to the process baseline indicate that a broader range of sodium molarities (2 to 8 M) and higher temperatures (50°C) may be required to alleviate post-filtration precipitation issues during loading. In addition, recycled nitric acid from the eluate evaporator that will be used for subsequent elution is expected to contain variable strength acid with trace ^{137}Cs .

The objective of this report is to provide additional information on resin behavior during elution with 0.02 M to 0.28 M HNO_3 containing trace levels of residual cesium ($5.0\text{E-}09$ to $5.0\text{E-}07$ M). Of particular interest is cesium carryover after elution into subsequent loading cycles and the minimum acid concentration needed to effectively elute the resin.

Section 1.0 of this report provides a brief historical background for HLW, cesium ion exchange, and the test design. Section 2.0 details the basis of the PNNL Quality Assurance (QA) Program as applied to the RPP-WTP quality requirements. Section 3.0 describes the test design, solution and resin preparations, equipment, process steps, and chemical and radiochemical analyses. Section 4.0 provides a summary of the experimental data and includes a discussion of the relevance of these results as applied to multiple load-elute cycle profiles, post-cycle leakage, and column residuals. Section 5.0 summarizes the testing results, Section 6.0 provides a list of pertinent references, Appendix A lists supplemental data plots, Appendix B displays the unprocessed analytical data, and Appendix C lists all data and calculations.

2.0 Quality Assurance

The PNNL Quality Assurance (QA) Program is based upon the requirements defined in the U.S. Department of Energy Order 414.1C, *Quality Assurance*, and 10 CFR 830, *Energy/Nuclear Safety Management*, and Subpart A—*Quality Assurance Requirements* (a.k.a. the Quality Rule). PNNL has chosen to implement the following consensus standards in a graded approach:

- ASME NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications*, Part 1, Requirements for Quality Assurance Programs for Nuclear Facilities.
- ASME NQA-1-2000, Part II, Subpart 2.7, *Quality Assurance Requirements for Computer Software for Nuclear Facility Applications*.
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¹ System for managing the delivery of PNNL policies, requirements, and procedures.

3.0 Experimental

This section summarizes the SRF resin, resin preparation, simple simulant preparation, ion exchange system, and solution processing. Detailed laboratory test instructions were provided by internal documentation.¹ Data and observations were recorded on photocopied datasheets, the printed test instruction, and in a Laboratory Record Book (LRB).² Supplemental data plots, unprocessed analytical data, and tables of all data calculations are provided in Appendix A, Appendix B, and Appendix C, respectively.

3.1 Loading Solution Preparation

The small-column elution testing task was performed using a nonradioactive aqueous solution traced with a small amount of ¹³⁴Cs prior to beginning testing. This loading simulant composition (Table 3.1) was provided by BNI as documented in Test Specification *RF Resin Cesium Removal with Expanded Load and Elution Conditions*.³ The sodium, cesium, aluminum, and hydroxide concentrations were within the ranges expected for aqueous waste feeds to the PTF. The nominal sodium concentration was specified to be 5 M, and the nominal cesium concentration was specified to be 2.4E-05 M. No potassium was included in the simulant. The nominal free hydroxide concentration was specified to be 1.55 M, and the aluminum concentration was specified to be 0.115 M, approximately 90% of the solubility limit. This simple, loading simulant was not selected to represent any particular Hanford tank waste type.

Approximately 49 liters of the simple, loading simulant solution was prepared in a single 50-liter carboy to ensure solution consistency for the thirteen column runs. All chemicals (Fisher Scientific, Pittsburgh, PA), except cesium, were added to the container based on weight (± 0.1 g) and were within $\pm 0.1\%$ of the target. For increased accuracy, 156.2 mL of a certified 1000-ppm cesium standard (Ricca Chemical Company, Arlington, TX) was added by volume to the stock solution. Unfortunately, a balance with sufficient capacity to accurately weigh the entire 49-liter solution was not readily available. Therefore, the DI water was added to the carboy to an approximate volume of 49 liters and the solution was mixed with an overhead stirrer for a minimum of 4 hours. The exact volume of stock solution produced is uncertain since the carboy was only coarsely calibrated. However, the total volume is expected to be accurate to $\pm 5\%$. A 2-liter sample of the stock solution was collected and its density determined to be 1.206 g/mL using a volumetric flask. A second sample of the stock solution was sent to Southwest Research Institute (SwRI) for density determination and chemical analysis using Inductively Coupled Plasma (ICP), Ion Chromatography (IC), and titration. SwRI reported a density of 1.194 g/mL.

Chemical analysis of the simulant solution is summarized in the right-most column of Table 3.1. The analytical results were all slightly lower than the preparation targets. The aluminum, sodium, cesium, and chloride results were 2.6%, 8.6%, 27.1%, and 8.5% below target, respectively. Other than the cesium result, the data are well within common ($\pm 10\%$) analytical uncertainty. It is not uncommon to obtain low sodium results during ICP analysis of such high sodium level simulants. A certified 1000-ppm Cesium standard was used during solution preparation and was analyzed by Inductively Coupled Plasma Mass

¹ Brown GN. 2010. *Small Column SRF Ion Exchange With Cesium-Contaminated Nitric Acid*, TI-WTPSP-025, Rev 0, Pacific Northwest National Laboratory, Richland, Washington.

² Brown GN. 2010. BNW-60702, Pacific Northwest National Laboratory, Richland, Washington.

³ Lehrman S and M Thorson. 2010. *RF Resin Cesium Removal with Expanded Load and Elution Conditions*, 24590-PTF-TSP-RT-09-002, Rev 0, Bechtel National, Inc., Richland, Washington.

Spectrometry (ICP-MS), independent of the other metals. No definitive conclusion can be made regarding the discrepancy between the measured and targeted concentrations.

Table 3.1. Planned Stock Simulant Solutions for Cesium Ion Exchange Loading

Stock ID No. ^(a)	Solution 5B17 ^(b)	SwRI Results
Species (g/L):		
NaOH (s)	80.497	NA ⁱ
Al(NO ₃) ₃ •9H ₂ O (s)	43.254	NA
NaNO ₃ (s)	112.260	NA
NaCl (s)	97.403	NA
CsNO ₃ (s)	0.0047	NA
Species (<u>M</u>):		
NaOH (aq)	2.013	NA
Al(NO ₃) ₃ •9H ₂ O (aq)	0.115	NA
NaNO ₃ (aq)	1.321	NA
NaCl (aq)	1.667	NA
CsNO ₃ (aq)	2.4E-05	NA
Composition (<u>M</u>):		
Na ^(c)	5.000	4.568
Al ^(d)	0.115	0.112
Cs ^(e)	2.4E-05	1.75E-05
OH-Total ^(f)	2.013	1.605
OH-Free ^(f)	1.551	1.465
NO ₃ ^(g)	1.667	1.585
Cl ^(h)	1.667	1.526
Ratios (mol/mol):		
Initial Na/Cs	2.08E+05	2.61E+05
Na/Al	43.365	40.758
Na/NO ₃	3.000	2.882
Na/OH _{Total}	2.484	2.846
Na/OH _{Free}	3.223	3.118

- | | | | |
|-----|--|---------------------------|--|
| (a) | Stock Solution ID Code: | 1 st Position: | Initial Na <u>M</u> (5=5.00 <u>M</u> Na) |
| | | 2 nd Position: | Initial Cs <u>M</u> (B=2.4E-05) |
| | | 3 rd Position: | NaOH <u>M</u> Before Gibbsite (17=1.67) |
| (b) | Solution 5B17 was used for Cs impurity column tests. | | |
| (c) | [Na] _{Total} = 5 <u>M</u> was used for Cs impurity column tests. | | |
| (d) | Aluminum is at 90% of the solubility limit as calculated from hydroxide (Li et al. 2005). | | |
| (e) | Cesium was added from a certified 1000 ppm stock solution. | | |
| (f) | [OH] _{Total} = 1.67 <u>M</u> was used for Cs impurity column tests. | | |
| (g) | Nitrate varied to keep Na:NO ₃ ratio constant at 3.00, similar to waste tank AP-101. | | |
| (h) | Chloride was correlated with the amount of NaNO ₃ added to keep sodium at the prescribed level. | | |
| (i) | Not applicable | | |

The total and free hydroxide results were 20% and 5.5% below target, respectively. The reported nitrate results are highly suspect and have been combined with the reported nitrite results to yield a total

that is 4.9% below target. No nitrite was added to this simulant and approximately 1.667 M NO_3^- was added to the simulant, yet SwRI reported 0.7568 M NO_2^- and 0.8282 M NO_3^- . It is possible that redox changes may have occurred during analysis. However, similar solutions were analyzed under the ion exchange loading kinetic testing task¹ without observing such anomalous nitrite levels. Presumably, the nitrate and nitrite analytical data are incorrect.

The 49-liter stock solution was dispensed by weight ($4523.2 \pm 0.1 \text{ g}$) into thirteen separate 3750-mL aliquots. Before use each aliquot was traced with $\sim 0.375 \text{ mCi } ^{134}\text{Cs}$ (Eckert & Ziegler Isotope Products, Valencia, CA) to produce a level of $0.103 \pm 0.006 \text{ }\mu\text{Ci/mL}$. The specific activity of the ^{134}Cs ($t_{1/2} = 2.065 \text{ y}$) was approximately 50.4 Ci/g at the beginning of the test. The experimental phase of the column loading and elution test was completed in 3 months and all results were decay-corrected to August 15, 2010.

3.2 Elution Solution Preparation

Elution solutions ($0.02, 0.07, 0.15, 0.23, 0.28 \text{ M HNO}_3$) and acid conversion solutions (0.5 M HNO_3) were prepared by volumetric dilution of certified 2.0 M HNO_3 (Ricca Chemical Company, Arlington, TX). Nonradioactive cesium was added to the acid solutions by volumetric dilution of a 1000 ppm cesium standard (Ricca Chemical Company, Arlington, TX). Chemical analysis by SwRI (San Antonio, TX) confirmed that the concentrations were within $\pm 1\%$ of the targeted amount. The experimental design called for a range of cesium concentrations in the acid. Since all of the solutions were traced with ^{137}Cs ($t_{1/2} = 30.17 \text{ y}$) before use, the amount of added nonradioactive cesium was adjusted for the ^{137}Cs contribution assuming a specific activity of 86.5 Ci/g . For the $5.00\text{E-}09 \text{ M Cs}$ solution, only radioactive ^{137}Cs was added. The percentage of ^{137}Cs in the cesium was approximately 26% for the $1.90\text{E-}08 \text{ M Cs}$ solution, 3.6% for the $1.40\text{E-}07 \text{ M Cs}$ solution, and 1.0% for the $5.00\text{E-}07 \text{ M Cs}$ solution. Most aliquots were traced with $\sim 0.032 \text{ mCi } ^{137}\text{Cs}$ (in-house) to produce a level of $0.063 \pm 0.009 \text{ }\mu\text{Ci/mL}$. In order to consume the ^{137}Cs stock, aliquots for columns E1, E2, E3, E4 and E5 were traced at $0.073 \pm 0.01 \text{ }\mu\text{Ci/mL}$.

3.3 Sodium Hydroxide (NaOH) Solution Preparation

Sodium hydroxide solutions for SRF resin pretreatment (1.0 M), regeneration (0.50 M), and feed displacement (0.10 M) were prepared by weighing ($\pm 0.1 \text{ g}$) 98% NaOH pellets (Fisher Scientific, Pittsburgh, PA) into volumetric flasks and diluting to volume. ICP analysis by SwRI (San Antonio, TX) indicated that the sodium concentrations were 8.65% to 14.3% below the targeted amount. Independent titration analysis by SwRI indicated that the hydroxide concentrations for the same solutions were only about 5% below the targeted amount. This suggests that these ICP results, as well as those for the loading simulant stock solution reported in Section 3.1, may be biased slightly low. The slightly low hydroxide result also suggests possible carbonate formation by the neutralization reaction with carbon dioxide. The low results were deemed inconsequential since an excess of each solution is used during column operations.

¹ Russell RL. 2010. *Small Column SRF Ion Exchange Kinetics Testing*, TI-WTPSP-026, Rev 0, Pacific Northwest National Laboratory, Richland, Washington.

3.4 Spherical RF Resin

The SRF resin used in these tests was from existing stock (Microbeads, Skedsmokorset, Norway, Lot Number 5E-370/641) that had been stored at PNNL for more than 4 years. The resin had been stored in the H-form in water under nitrogen in sealed 2-L plastic bottles. A small (~3 mm) layer of the resin was dark brown, indicating possible oxidative degradation, in contrast to the orange color of the remaining bulk. Upon opening the container, the top layer of resin was removed by vacuum sluicing and disposed of without use. The remaining resin was thoroughly mixed, and a representative sample was removed for use in the experiment using a coring technique consistent with the American Society for Testing and Materials (ASTM) Method 2687, *Standard Practice for Sampling Particulate Ion-Exchange Materials* (ASTM 2001). Even after vacuum sluicing of the top, darker brown layer and mixing the remaining material, a small fraction (<1%) of the sampled resin still exhibited the darker brown color as is shown in Figure 3.1. The small fraction was deemed inconsequential and no further separation was attempted. As a comparison to previous historical work (Bibler et al. 1989; Kurath et al. 1994), Figure 3.2 displays examples of visible light microscopy images of the SRF and older GGRF resins (Fiskum et al. 2004).



Figure 3.1. Representative SRF Resin Sample Showing Darkened Resin Beads

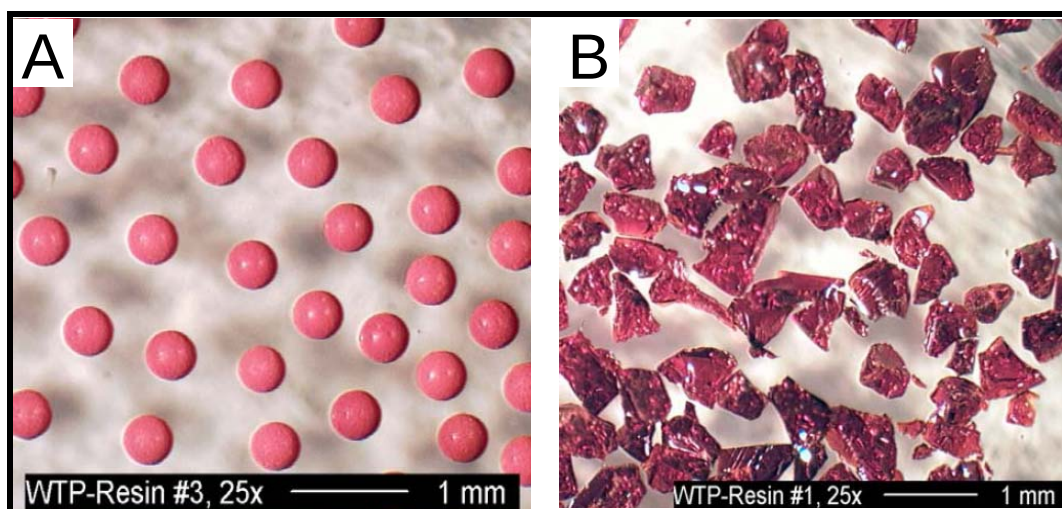


Figure 3.2. Spherical (SRF) and Ground Gel Resorcinol-Formaldehyde (GGRF) Resins

3.5 Resin Pretreatment Processing

Approximately 10.7 mL of the SRF resin (H⁺-form) was dispensed into seven 25-mL graduated cylinders and allowed to settle for more than 30 minutes to a constant volume during tapping/vibration. The resin sub-samples were then transferred into 100-mL glass beakers. Three of the samples were pretreated as described below and used during the column experiments. The remaining four sub-samples, two in the H⁺-form and two that had been converted to the Na⁺-form, were dried to a constant mass at 50°C in a vacuum oven. Constant mass was defined as <0.1% mass variation over two consecutive measurements taken at an interval of at least 7 hours. The average density was calculated to be 0.456 g/mL (mass of dried H⁺-form resin per mL of settled H⁺-form resin under water in a 25-mL graduated cylinder) and is consistent with values reported previously (Fiskum et al. 2006b; Fiskum et al. 2006c).

Figure 3.3 displays a comparison of the H⁺- and Na⁺-forms of the SRF resin. The left-most cylinder contains the orange-colored, H⁺-form of the resin (~10.7 mL), while the three right-most cylinders contain the final, dark black/brown-colored, pretreated Na⁺-form of the resin (~15.7 mL). The volume of initial H⁺-form resin aliquot expanded slightly more than the targeted 15-mL volume that was based on previous reports (Fiskum et al. 2006b; Fiskum et al. 2006c). Since the resin was being stored as an aqueous slurry and should not be dried prior to use, this method was chosen to yield a reproducible amount of dispensed resin without weighing. The slight increase (e.g., 4.7%) in resin volume as compared to the experimental plan was deemed inconsequential to the main experimental objectives.

The overall resin bulk pretreatment and column pretreatment steps are shown in Table 3.2 and are consistent with previous testing¹ (Arm and Blanchard 2004; Fiskum et al. 2006b; Fiskum et al. 2006c). The bulk pretreatment processes utilized a full resin expansion/contraction cycle in an open beaker format, which allows for full expansion of the resin without being constrained inside the ion exchange column (Fiskum et al. 2007).

¹ Nash CA and CE Duffey. August 17, 2004. *Hanford RPP-WTP Alternate Resin Program -Protocol P1-RF: Spherical Resin Sampling from Containers, Resin Pretreatment, F-Factor, and Resin Loading to Column*, WTP 097893, Savannah River National Laboratory.

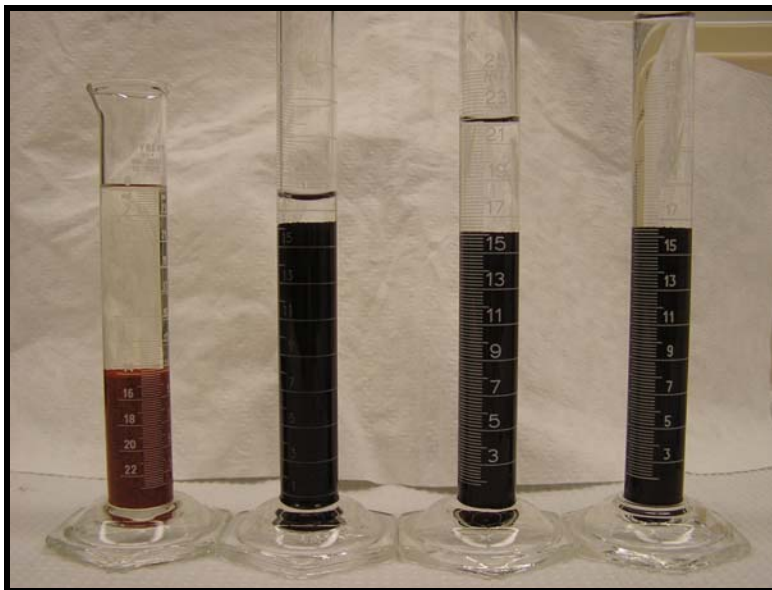


Figure 3.3. SRF Resin Dispensed for Column Experiments

Following bulk pretreatment, the Na-form resin was slurry transferred into the ion exchange column, rinsed with DI water, and converted into the H-form with down-flow 0.5 M HNO₃ (Figure 3.4B). The resin was then re-converted back into the Na-form with down-flow 0.5 M NaOH. Because “fingering” (Figure 3.4C) was observed during this initial down-flow, in-column, resin expansion, all subsequent post-elution regeneration was completed using up-flow NaOH solutions. The WTP flowsheet proposes up-flow regeneration of the SRF resin and is the planned operational mode.

Figure 3.4D displays the SRF column several days after the regeneration process had completely converted the resin back into the Na-form. There is a slightly tinted orange color clearly visible in the headspace solution above the resin. This color was observed in the headspace solution after each regeneration cycle as well as in the first few loading samples. Similar observations have been reported previously (Fiskum et al. 2006b; Fiskum et al. 2006c).

3.6 Ion Exchange Column System

The ion exchange column system is based on (and used some of the equipment from) prior work (Fiskum et al. 2006b; Fiskum et al. 2006c) at PNNL. The current system (Figure 3.4, Figure 3.5) utilized water-jacketed columns (CHROMAFLEX®, Kimble-Chase, Vineland, NJ) with 2-cm internal diameter, variable-speed pumps (QVG50, Fluid Metering Inc., Syosset, NY), 1/16” i.d. Teflon® tubing, and various fittings, pressure-relief valves, pressure gauges, tube-in-tube heat exchangers constructed in-house, and 3-way valves (<http://www.swagelok.com>). The resin bed was supported inside the column with a 100-mesh, stainless steel, screen tack welded to a stainless steel ring and fitted with a Viton® O-ring. To reduce the dead volume between the screen and the column end fitting, the space was filled with 3-mm glass spheres. The total apparatus volume (AV) of the current system was approximately 42 mL from the solution reservoir to the sample vial. The sodium-form resin bed volume (BV) was approximately 15.7 mL. The previous PNNL work (Fiskum et al. 2006b; Fiskum et al. 2006c) was completed at room temperature and hence used columns that were not water-jacketed for temperature control.

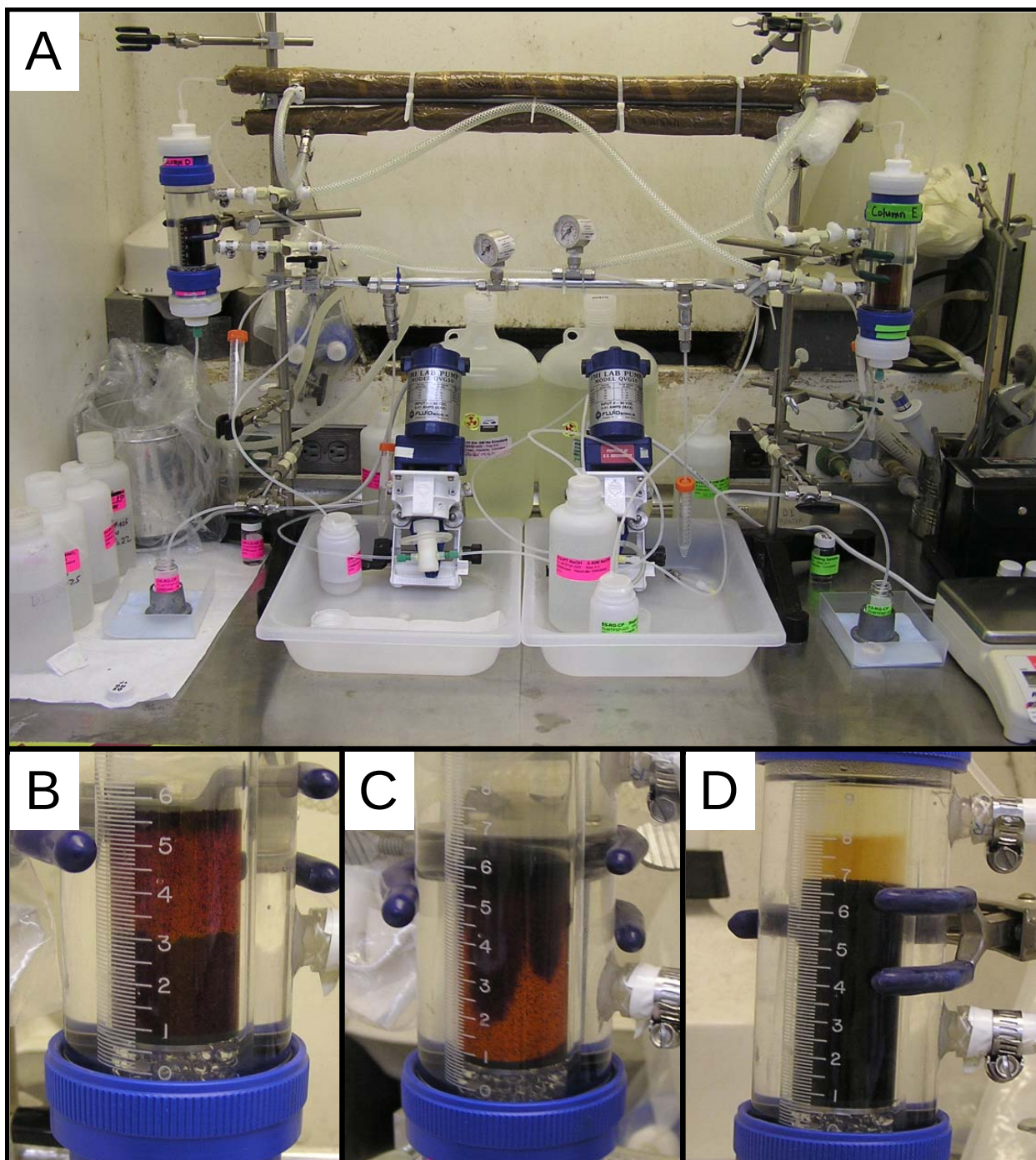


Figure 3.4. Ion Exchange Column System with Close-up View of SRF Resin in Column

Temperature testing of a mock-up ion exchange system confirmed that injecting room temperature solution into a small ion exchange column that was water-jacketed at 45°C was sufficient to create a measurable temperature gradient (e.g., >10°C) across the bed length. Therefore, in order to ameliorate the formation of a temperature gradient during column operations, several modifications to the system were evaluated. The best remedy involved heating the feed solution by passing it through a tube-in-tube heat exchanger just prior to injecting the solution into the top of the ion exchange column. The heat

exchanger consisted of two concentric stainless steel tubes (1/8" i.d. and 3/8" i.d. by 20" length) with Swagelok® tees on either end. Mock-up testing confirmed that the temperature of the feed solution, constant temperature water bath, and resin bed was increased to 45±2°C. No appreciable temperature gradient (<2°C) was observed across the resin bed. Direct temperature measurement of the solution feed or resin bed during the thirteen loading and elution cycles was not completed due to the possibility of probe-induced channeling of the resin bed. However, the temperature of the water bath was periodically monitored and remained at the specified level (±2°C) throughout the entire experiment.

Table 3.2. Ion Exchanger Pretreatment and Process Steps

Process/Pretreatment Step	Solution	Volume	Time	Mixing	Flowrate
Bulk Pretreatment					
Water Rinse	DI Water	5 RV ^(a)	30 min	Swirl ^(b)	NA ^(c)
Resin Expansion	1 <u>M</u> NaOH	5 RV	1 h	Swirl	NA
Resin Expansion	1 <u>M</u> NaOH	5 RV	>12 h	Soak	NA
Water Rinse – 1 st	DI Water	3RV	30 min	Swirl	NA
Water Rinse – 2 nd	DI Water	3RV	30 min	Swirl	NA
Water Rinse – 3 rd	DI Water	3RV	30 min	Swirl	NA
Resin Conversion	0.5 <u>M</u> HNO ₃	10 RV	2 h	Swirl	NA
Water Rinse – 4 th	DI Water	3 RV	1 min	Swirl	NA
Resin Expansion	1 <u>M</u> NaOH	10 RV	1 h	Swirl	NA
Water Rinse – 5 th	DI Water	10 RV	1 min	Swirl	NA
Column Pretreatment					
Water Rinse	DI Water	7.5 BV ^(d)	2.5 h	Flow	3 BV/h
Acid Rinse	0.5 <u>M</u> HNO ₃	8 BV	2.7 h	Flow	3 BV/h
Water Rinse	DI Water	3 BV	1 h	Flow	3 BV/h
Feed Prep	0.5 <u>M</u> NaOH	6 BV	2 h	Flow	3 BV/h
Column Loading/Elute					
Simulant ^(e)	Simulant	12 BV	8 h	Flow	1.5 BV/h
Simulant ^(f)	Simulant	≥200 BV	≥16 h	Flow	≥12 BV/h
Feed Displaced	0.1 <u>M</u> NaOH	7.5 BV	2.5 h	Flow	3 BV/h
Water Rinse	DI Water	7.5 BV	2.5 h	Flow	3 BV/h
Neutralization ^(g)	0.5 <u>M</u> HNO ₃	3 BV	2.1 h	Flow	1.4 BV/h
Acid Elution ^(h)	Variable	≥25 BV	≥17.9 h	Flow	1.4 BV/h
Water Rinse	DI Water	3 BV	2.1 h	Flow	1.4 BV/h
Regeneration	0.5 <u>M</u> NaOH	6 BV	4.2 h	Flow	1.4 BV/h

(a) Resin volume (RV).

(b) Gently swirling by hand every 10 minutes.

(c) Not applicable (NA).

(d) Bed volume (BV).

(e) Column loading was at 1.5 BV/h for the first 8 h and ≥12 BV/h until the feed solution was exhausted.

(f) Column loading was expected to require ~200 BV to achieve full loading (e.g., $C/C_0 > 0.95$).

(g) Elution with variable HNO₃ commenced after 3BV 0.5 M HNO₃ was passed through the column.

(h) Elution was expected to require <25 BV but was continued until the acid solution was exhausted, typically after 21 h (29 BV) has been reached.

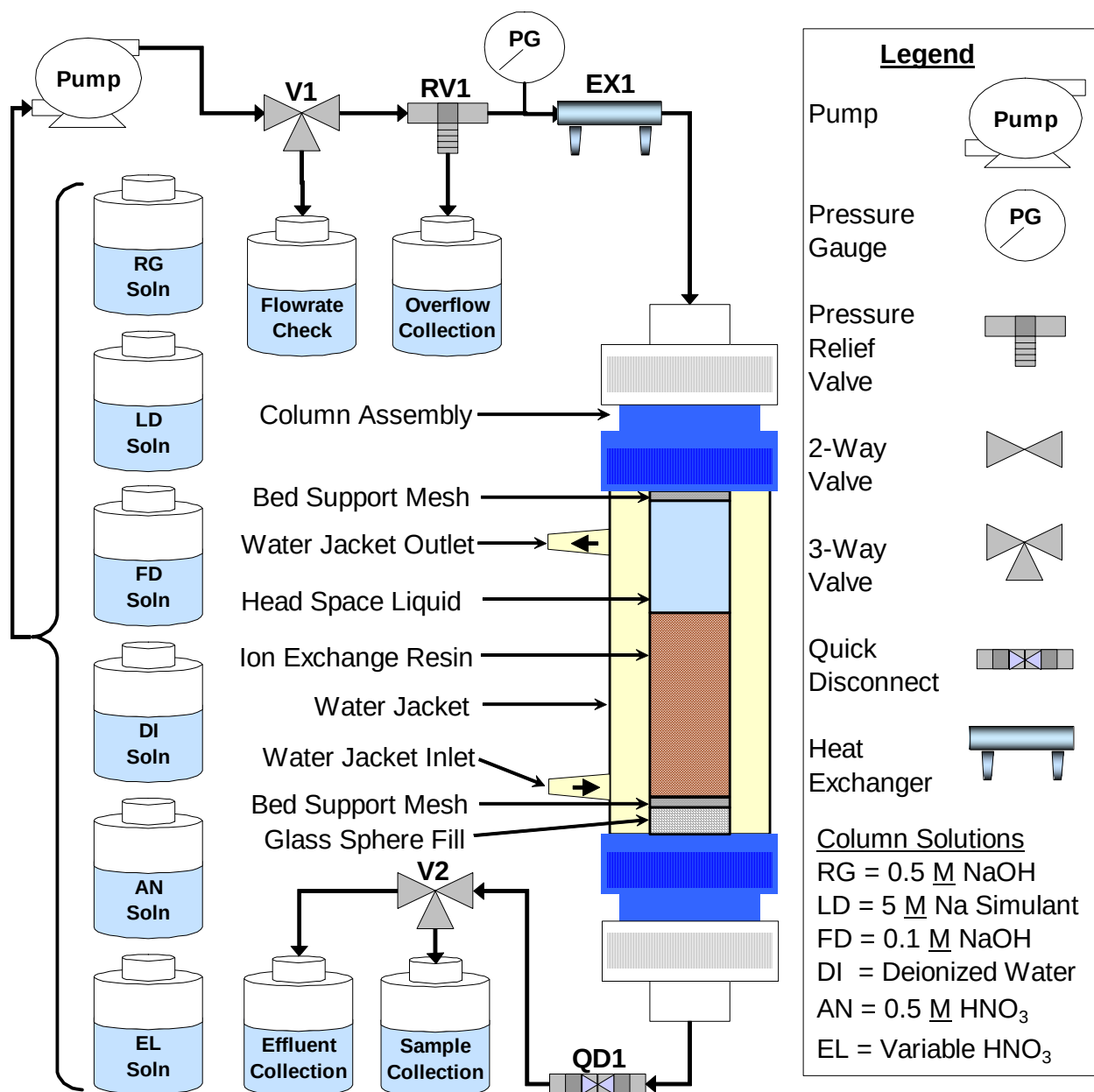


Figure 3.5. Schematic Diagram of Ion Exchange Column System

3.7 Column Processing

A series of thirteen column loading and elution cycles was completed as detailed in Table 3.3. The columns (D, E, and F) were loaded with the simple simulant that was described in Section 3.1. The general column processing steps (e.g., pretreatment, loading, feed displacement, rinsing, elution, rinsing, regeneration) are described in Table 3.2. There were two independent column systems (Figure 3.5) operated in parallel to save time. Each of the two columns (D and E) was filled with SRF resin and then six sequential loading and elution cycles were completed using the same resin, new loading solution, and different elution solutions, for a total of twelve experimental tests. The final, thirteenth, test was a single loading and elution cycle with fresh resin (column F) as a comparison to previous work.

Table 3.3. Cesium Residue Elution Experimental Design

Run ID	Ion Exchange Column Loading Conditions							Column Elution Conditions				
	h (a)	T °C	BV (b)	$\frac{BV}{h}$	Na <u>M</u>	OH <u>M</u>	Initial Cs, <u>M</u>	T °C	BV (c)	$\frac{BV}{h}$	HNO ₃ <u>M</u> ^(d)	Cs <u>M</u> in HNO ₃
Test-3-D-1	24	45	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.15	5.00E-08
Test-3-D-2	24	45	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.02	5.00E-08
Test-3-D-3	24	45	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.28	5.00E-08
Test-3-D-4	24	45	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.15	5.00E-07
Test-3-D-5	24	45	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.15	5.00E-09
Test-3-D-6	24	45	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.15	5.00E-07
Test-3-E-1	24	45	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.15	5.00E-08
Test-3-E-2	24	45	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.07	1.40E-07
Test-3-E-3	24	45	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.23	1.90E-08
Test-3-E-4	24	45	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.23	1.40E-07
Test-3-E-5	24	45	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.07	1.90E-08
Test-3-E-6	24	45	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.15	5.00E-08
Test-3-F-1 ^(e)	24	25	250	12	5.0	1.67	2.4E-05	25	25	1.4	0.28	0.00E-00

(a) Column loading was completed over a 24- to 28-h period using a fluid flow rate of 1.5 ± 0.1 BV/h for the first 8 h and >12 BV/h thereafter until the feed solution was exhausted. Samples were collected hourly for the first 8 h to define the initial cesium breakthrough curve and at 250 BV to confirm loading.

(b) BV = Bed Volume. Column loading was expected to require ~ 200 BV to achieve full loading of the cesium solution (e.g., Cs $C/C_0 > 0.95$). Each column BV was approximately 15.7 mL.

(c) Column elution was expected to require <25 BV but was continued until the acid solution was exhausted, typically after 21 h (29 BV) has been reached.

(d) Elution with variable HNO₃ commenced after feed displacement (7.5 BV 0.1 M NaOH), a water rinse (7.5 BV DI Water) and resin neutralization (3BV 0.5 M HNO₃) solutions had passed through the column. Samples were collected hourly for the first 8 h, every 2 h for the next 4 h, and every 3 h thereafter until the acid solution was exhausted, typically after 21 h (29 BV) has been reached.

(e) The final column (Test 3-F-1) served as a comparison to prior ion exchange testing at 25°C (e.g., Burgeson et al. 2004, Fiskum et al. 2006a, Fiskum et al. 2006b, Fiskum et al. 2006c).

The ion exchange columns were loaded with approximately 250 BVs (3750 mL) of simulant feed solution at $45 \pm 2^\circ\text{C}$. The solution was processed at approximately 1.5 ± 0.1 BV/h for the first 8 h and then at >12 BV/h for the remaining 16 h. The objective of the experiment was to evaluate elution conditions, not loading, and therefore the flow rate could be increased to reduce run times, while not impacting the results. Following loading, the feed solution was displaced with 7.5 BVs of 0.1 M NaOH at 3 BV/h, rinsed with 7.5 BVs of DI water at 3 BV/h, and the resin was neutralized with 3 BVs of 0.5 M HNO₃ at 1.4 ± 0.1 BV/h as outlined in Table 3.2. Approximately 3 to 4 BV of 0.5 M HNO₃ are required to acid neutralize (titrate) the SRF resin, thereby exchanging protons for sodium, cesium, and other cations. For this work, the lower 3 BV value was used, thus minimizing the possibility of removing cesium during the titration step and allowing observation of the cesium elution profile peak.

The ion exchange columns were eluted with 29+ BVs of HNO₃ processed at 25°C and at ~ 1.4 BV/h. As is shown in Table 3.3, the elution solutions for each cycle were variable acid strength (0.02, 0.07, 0.15, 0.23, or 0.28 M) and contained variable CsNO₃ (5.0E-09, 1.9E-08, 5.0E-08, 1.4E-07, or 5.0E-07 M). The

elution solutions were prepared as described in Section 3.2. Following elution, the columns were rinsed with 3 BVs of DI water at ~1.4 BV/h and regenerated up-flow with 6 BVs 0.5 M NaOH at ~1.4 BV/h.

The variable strength acid solutions described above, each containing variable levels of cesium impurities, comprise the basis for the overall experimental approach. WTP operations are anticipated to require large amounts of nitric acid during cesium ion exchange which may impact the downstream pretreatment processes. The objective of this test is to determine the minimum acid strength needed to elute the SRF resin. In addition, the use of recycled nitric acid during WTP operations has been proposed in order to minimize acid consumption. However, the recycled acid may contain trace ¹³⁷Cs impurities which could impact the subsequent elution of the SRF resin. Thus, this experimental design comprises a plausible range of acid strengths and cesium impurity levels in order to evaluate elution completeness.

The NaOH regeneration process was completed at the end of each weekly loading and elution processing cycle, with the next cycle typically beginning on the following Monday or Tuesday. The brownish orange discoloration visible in the head space liquid (Figure 3.4D) was not visible during the regeneration process, but formed over the course of several days (weekend) and was visible in the first several samples collected during the loading phase.

3.8 Gamma Energy Analysis

High-Purity Germanium (HPGe) Gamma Energy Analysis (GEA) of the loading and elution samples was completed by the Analytical Support Operations (ASO) in PNNL's Radiochemical Processing Laboratory (RPL). The data were collected under Analytical Service Request (ASR) 8700 and are displayed in Appendix B. All samples were analyzed to determine the concentration of the ¹³⁴Cs and ¹³⁷Cs tracers remaining after the ion exchange test. These tracers were added prior to beginning the ion exchange process testing and therefore are used to evaluate the bulk cesium behavior during the ion exchange process. The column effluent samples submitted to the ASO were counted directly with no further processing. Because of the direct counting analysis, there was no post-testing sample preparation performed on the samples or classic analytical recoveries reported (e.g., sample dilution, concentration, separation, matrix spike, blank spike, post process spike, analytical duplicates, percent recoveries). Subsequent data analysis normalized each sample's cesium result to the initial (C_0) sample result. The ¹³⁴Cs data for the loading (LD) cycle were normalized to the initial feed ¹³⁴Cs concentration of that cycle (e.g., nn-LD-0 samples). The ¹³⁷Cs data for subsequent loading (LD) cycles were normalized to the initial ¹³⁷Cs concentration in the "previous" cycle's acid eluent (e.g., nn-EL-00 samples). Most sample GEA results were reported within $\pm 3\%$ counting uncertainty. For the 1st cycle, the initial loading samples (<10 hours) were often below the Method Detection Limit (MDL). Intermediate loading samples (11 to 15 hours) had higher counting uncertainties (e.g., up to $\pm 20\%$).

4.0 Results and Discussion

4.1 1st Cycle Column Loading

In all 13 test cycles, the SRF resin was loaded with ~3750 mL (250 BV) of the simple simulant feed solution (5 M Na, $2.4\text{E-}05$ M Cs). The solution was processed at approximately 1.5 ± 0.1 BV/h for the first 8 h and then at >12 BV/h for the remaining 16 h. Columns D and E were each loaded at 45°C and eluted at 25°C a total of six times, while Column F was loaded and eluted at 25°C once. Hourly samples were collected during the first loading cycle as is shown for Column D1 in Figure 4.1. The results for Columns D1 and E1 show good duplication (Figure 4.2). Column F1, however, demonstrates the slower kinetics and higher estimated loading expected at 25°C when compared to 45°C (Figure 4.2). Although full of uncertainty, extrapolating Figure 4.3 to 0.5 C/C_0 suggests a loading capacity of 450 BV at 45°C and 700 BV at 25°C .

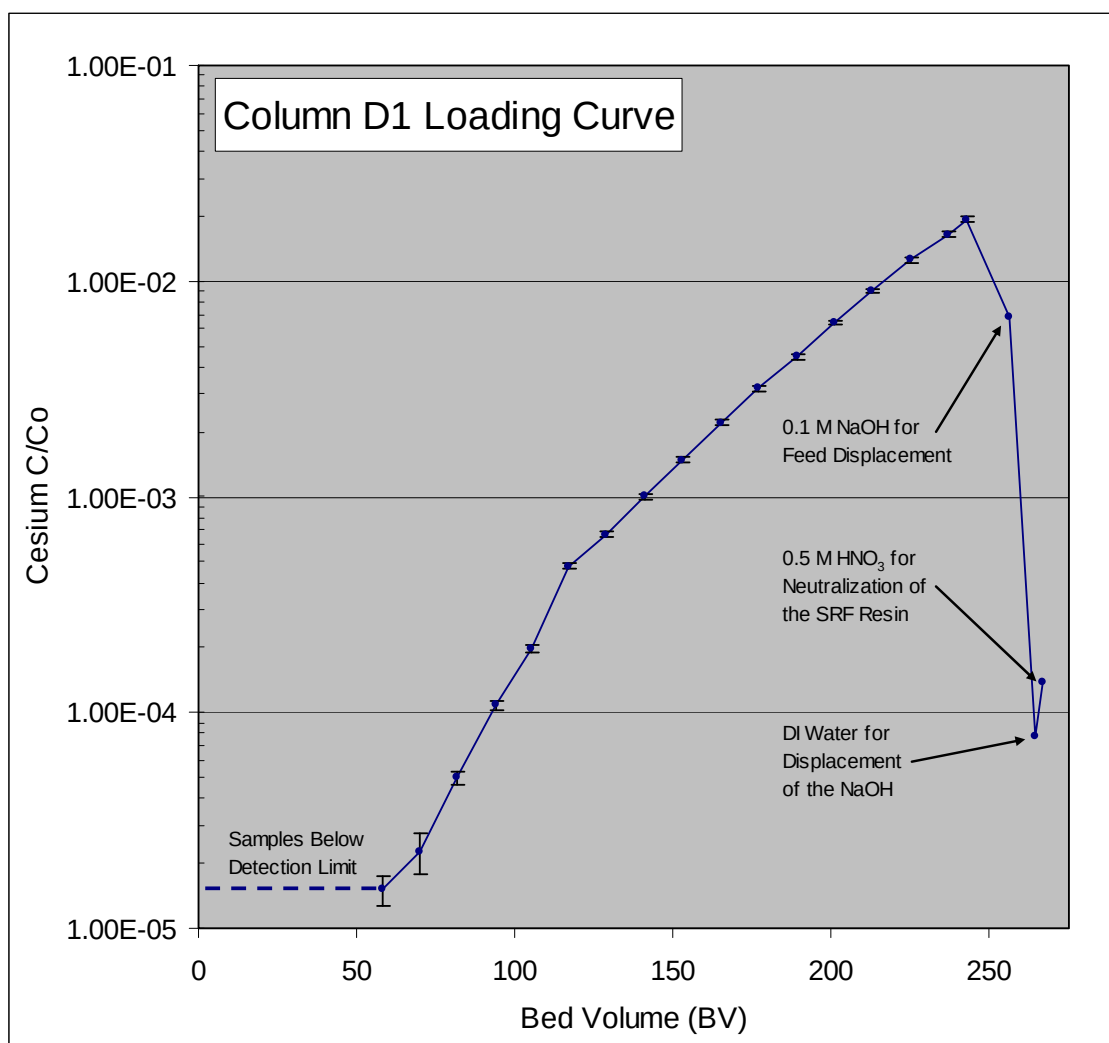


Figure 4.1. Column D1 Cesium Loading Profile

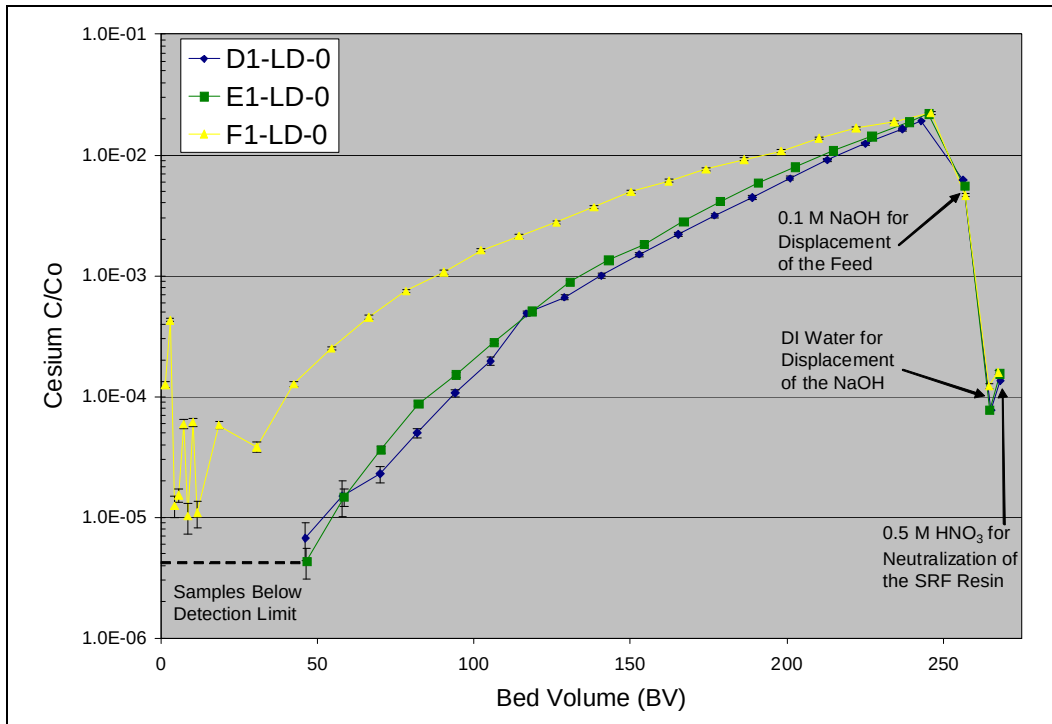


Figure 4.2. Comparison of Column D1, E1, and F1 Cesium Loading Profiles

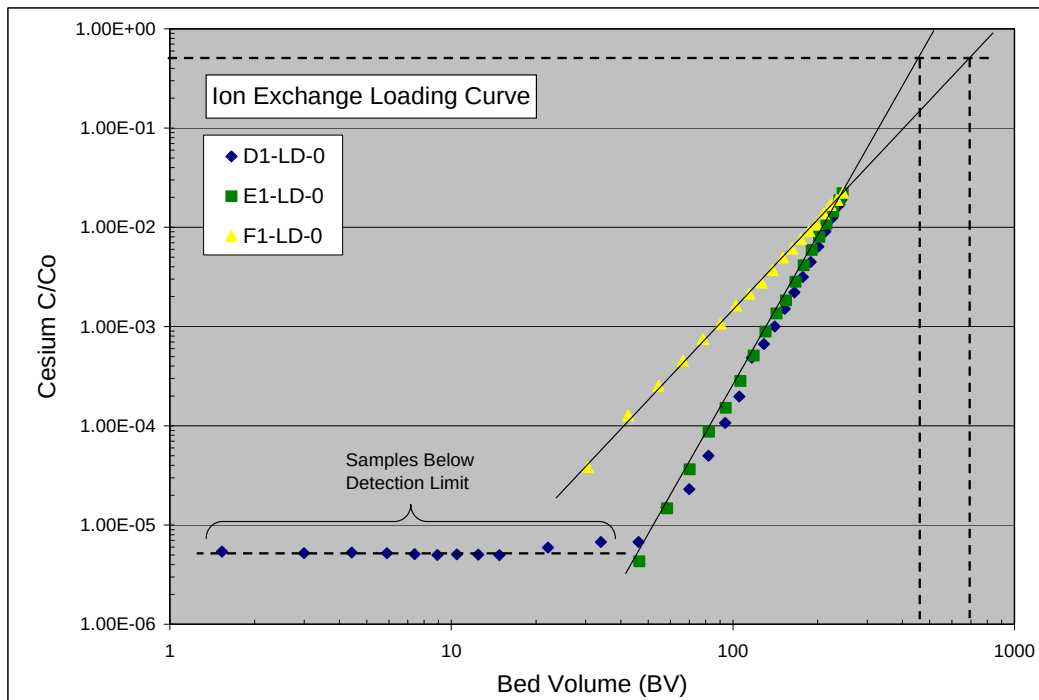


Figure 4.3. Comparison of Column D1, E1, and F1 Cesium Loading Profiles

The original experimental design called for achieving a minimum of 50% breakthrough (e.g., full loading) during each of the loading cycles. Preliminary loading calculations were based on previous experimental results for Hanford Tank AN-105 (Burgeson et al. 2004). Unfortunately, the simple

simulant used in the current column tests did not contain potassium, while the AN-105 waste in the referenced experiment contained $\sim 0.1 \text{ M K}^+$. The difference in K^+ concentration was enough to increase the estimated 50% breakthrough point from approximately 220 BV (AN-105) to approximately 450 BV (extrapolated for the simple simulant). Therefore, the columns in the current experiment were loaded significantly less than expected (2% - 13% C/C_0). It is anticipated that the lower Cs loading of the SRF resin should not significantly impact the corresponding elution results reported herein or the objective of this test, which focused primarily on the elution as a function of acid and cesium concentration.

The loading curve for Column F1 (Figure 4.2) also demonstrates the carryover of contamination associated with the previously spent SRF resin. After the sixth processing cycle (Column D6), the spent SRF resin was removed by vacuum sluicing until no visible resin beads remained. The column was partially disassembled, rinsed lightly with DI water, reassembled, and recharged with fresh SRF resin. No attempt was made to “scrub” the column clean or quantify the contamination remaining. The newly filled column system became Column F1, and the SRF resin was pretreated as described in Table 3.2. The Column F1 data are above the MDL and indicate that achieving a decontamination factor (DF) of 10^5 for the initial breakthrough samples may be difficult following replacement of the spent SRF resin.

4.2 2nd Cycle Column Loading

During subsequent loading cycles (e.g., 2-6), hourly samples were only collected during the first 8 hours to assess initial breakthrough, followed by a single sample at the end of the loading process (~ 28 hours or 250 BV). This greatly simplified the experiment while still obtaining and confirming the level of cesium breakthrough on subsequent loading cycles. In addition, since the loading solution was traced with ^{134}Cs and the elution solution was traced with ^{137}Cs prior to beginning the ion exchange process, both tracers could be monitored for breakthrough using HPGe GEA.

Figure 4.4 and Figure 4.5, respectively, display Column D2 and E2 (2nd cycle) loading profiles for both ^{134}Cs (breakthrough from the 2nd cycle loading solution) and ^{137}Cs (carryover from the previous 1st cycle acid elution). These two loading cycles are essentially process duplicates, having identical loading solutions for the first two cycles and identical 1st cycle elution solutions ($5.00\text{E-}08 \text{ M Cs}$ and $1.50\text{E-}01 \text{ M HNO}_3$). The ^{134}Cs data (blue diamonds) are normalized to the initial cesium concentration in the loading solution, and the ^{137}Cs data (pink squares) are normalized to the initial cesium concentration in the previous cycle's elution solution. The first data point on each graph (1.5 BV) demonstrates a slightly higher cesium breakthrough value than subsequent data points (3 to 12 BV). However, the data also show a relatively constant cesium breakthrough ($1\text{E-}03 \text{ }^{137}\text{Cs C/C}_0$ and $1\text{E-}04 \text{ }^{134}\text{Cs C/C}_0$) from 3 to 12 BV. In addition, the amount of ^{134}Cs carryover (from the previous cycle's loading solution) is always at least an order of magnitude less than the ^{137}Cs carryover (from the current cycle's elution solution).

The final cesium C/C_0 data points at 250 BV in Figure 4.4 and Figure 4.5 confirm the expected ($\sim 2\%$) ^{134}Cs breakthrough without a significant increase in the ^{137}Cs leakage. It is important to remember that there are no data displayed between 12 BV and 250 BV since no samples were collected in this period. However, it is expected that the result would be similar to data in the first loading cycle (Figure 4.3). In this range the ^{134}Cs breakthrough data increase almost 500-fold (from about $4\text{E-}05$ to $2\text{E-}02$) while the ^{137}Cs leakage data only increase less than 2-fold (from about $2\text{E-}03$ to $3\text{E-}03$). Essentially, this means that most of the cesium that exists on the column after acid elution, DI water rinsing, and regeneration with NaOH will continue to remain fixed on the column during the next process loading cycle.

During subsequent loading cycles (e.g., 3-6), similar data were collected and, hence, similar plots were generated for both Column D and Column E. For clarity, since no additional information was obtained by visual examination, these individual plots are displayed in Appendix A.

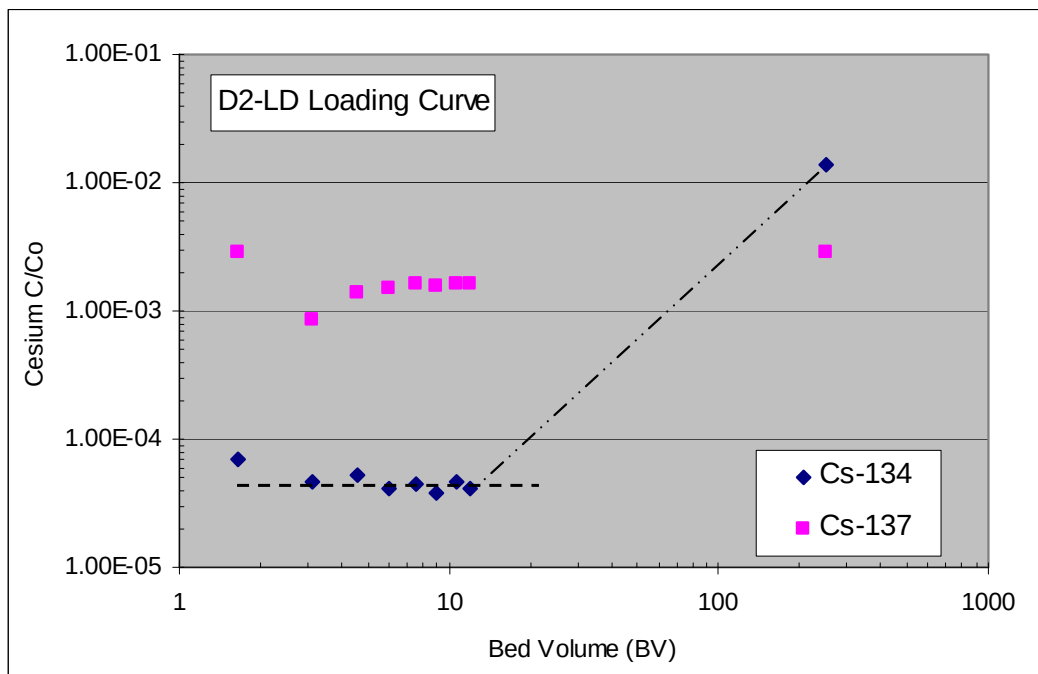


Figure 4.4. Column D2 Cesium (^{134}Cs and ^{137}Cs) Loading Profiles

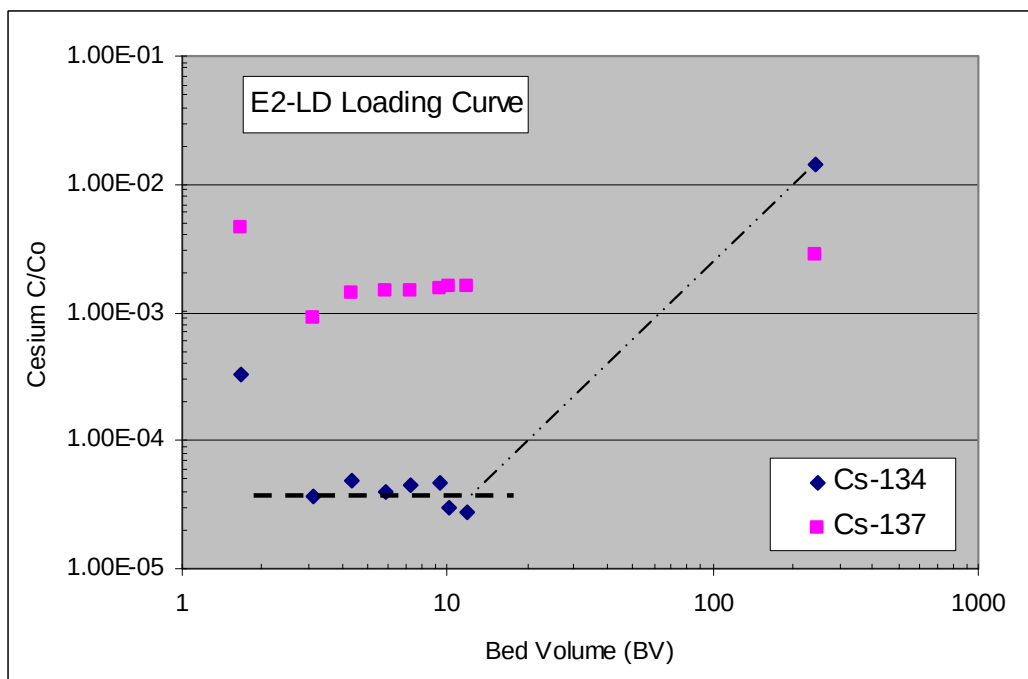


Figure 4.5. Column E2 Cesium (^{134}Cs and ^{137}Cs) Loading Profiles

4.3 Comparison of Loading Breakthrough at 250 BV

A comparison of each column cycle's ^{134}Cs C/C_0 breakthrough at the end of loading (250 BV) is shown in Figure 4.6. Columns D and E were loaded at 45°C while column F was loaded at 25°C . The Column E breakthrough is stable ($2.0 \pm 0.4\%$) for the first four cycles, but then increases dramatically in cycles five (6%) and six (11%). Column D shows increases starting in the third cycle and reaching greater breakthrough during the sixth cycle (13%). These data seem to indicate that the SRF resin was degrading with each load/elute cycle. It is possible that experimental problems (e.g., the liquid level accidentally decreased, exposing the Na-form of the SRF resin to oxygen) during column loading contributed to this degradation. The length of time the resins were exposed varied from minutes to nearly 10 hours but the greatest exposure occurred during the 2nd and 4th cycles. Column D went dry during loading cycles 2, 3, 4, and 6. Column E went dry during cycles 2, 4, and 6. Previous researchers have indicated that oxidative resin degradation is most prevalent when the resin's Na-form is exposed to oxygen or air. Alternatively, the chemical composition of the simple simulant (e.g., lack of nitrite as compared to previous simulants) may provide additional oxidative/reductive degradation pathways. In contrast to the current results, Fiskum et al. (2006a) reported $\sim 7\%$ loss in cesium loading capacity over 16 process cycles and virtually identical breakthrough on the 1st and 17th cycles.

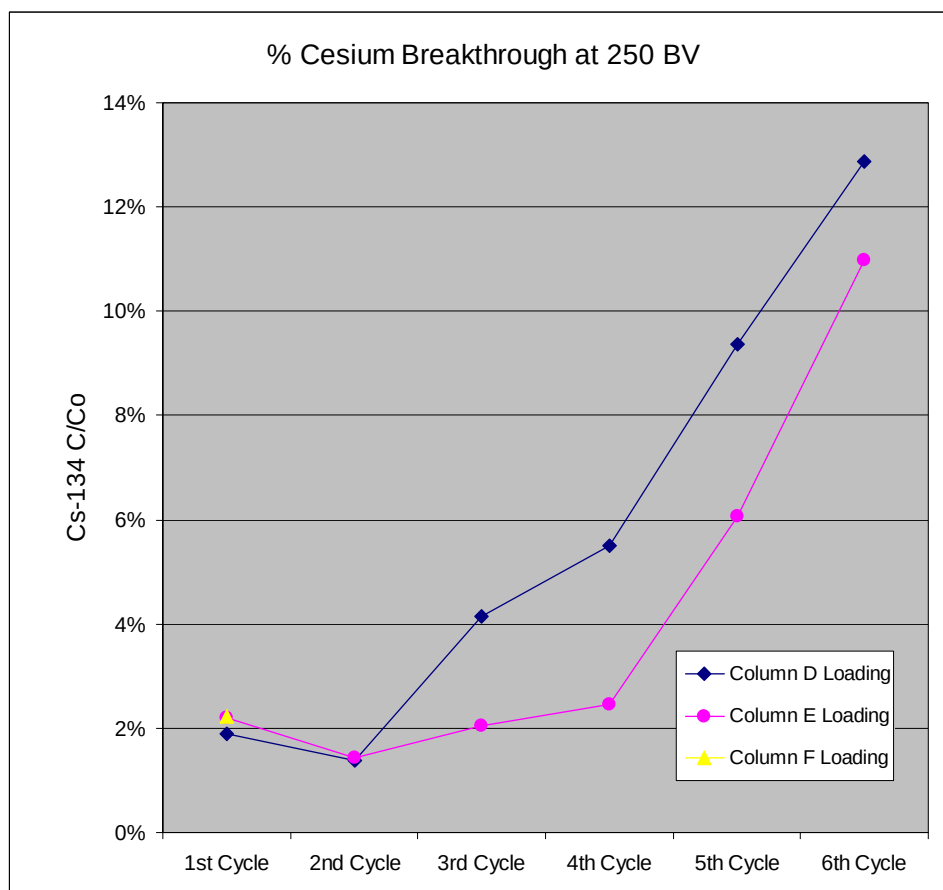


Figure 4.6. Comparison of ^{134}Cs % C/C_0 Breakthrough at Final Loading Volume (250 BV)

4.4 Column Elution

After the SRF resin had been loaded with ~3750 mL (250 BV) of the simple simulant feed solution as described in Sections 4.1 and 4.2, each column was rinsed with 7.5 BV 0.1 M NaOH, 7.5 BV DI water, and partially neutralized or titrated with 3 BV 0.5 M HNO₃ as described in Table 3.2. Each column was then eluted at 25°C with the variable acid and cesium composition described in the experimental design (Table 3.3). Hourly samples were collected for the first 8 hours, and every 2 to 3 hours thereafter until the acid solution was consumed, typically after the 21-hour sample (29 BV) had been collected. Data sheets with the actual data collected for each of the test runs are displayed in Appendix C.

The results for Columns D1 and E1 (Figure 4.7) show good duplication, as expected, since these two elution cycles are essentially process duplicates and have identical loading (simple simulant) and elution (5.00E-08 M Cs and 1.50E-01 M HNO₃) solutions. The ¹³⁴Cs data (blue diamonds, left axis) are normalized to the initial cesium concentration in the loading solution, and the ¹³⁷Cs data (red open circles, right axis) are normalized to the initial cesium concentration in the elution acid solution. The semi-log plots show the amount of cesium in the column effluent as a function of BV of acid eluant. The 3 BV of 0.5 M HNO₃ that was used to partially neutralize and titrate the SRF resin is not displayed in these plots (e.g., would be from -3 to 0 BV). The ¹³⁴Cs elution profile shown in the graphs exhibit a similar exponential decrease as those produced by other researchers in the past two decades. The ¹³⁷Cs data show that the cesium in the acid eluant appears to load onto the column initially, quickly reaches equilibrium (~10 BV) and begins passing through the SRF column unimpeded. The latter data should be important in defining recycled acid purity specifications for use during WTP operations.

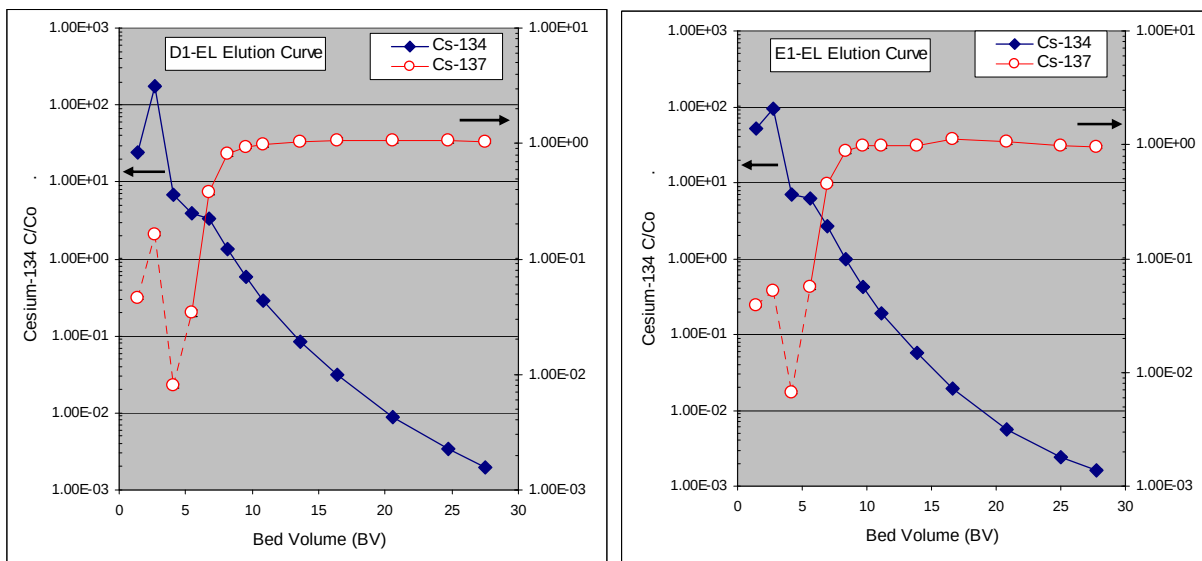


Figure 4.7. Column D1 and E1 Cesium (¹³⁴Cs and ¹³⁷Cs) Elution Profiles

During subsequent elution cycles (e.g., 2-6) with different cesium and acid concentrations, similar data were collected and, hence, similar plots were generated for Columns D, E, and F. For clarity, since very little additional information was obtained by visual examination of the individual plots, the data are

displayed in Appendix A. However, a comparison of selected plots (Columns D1, D2, and D3) reveals the importance of acid concentration during elution (Figure 4.8). As expected, the 0.28 M HNO₃ is capable of reducing the ¹³⁴Cs concentration more quickly than the 0.15 or 0.02 M HNO₃. After 21 BV (sample nn-EL-15), the highest strength acid generates ~0.1% ¹³⁴Cs C/C₀ while the 0.15 M HNO₃ generates a level of ~0.9% ¹³⁴Cs C/C₀. Eluting with 0.02 M HNO₃, however, does not achieve an acceptable Cs concentration even after 40 BV (sample nn-EL-30). For the 0.02 M HNO₃, the ¹³⁷Cs C/C₀ values do not approach unity until ~30 BV have been processed (sample D2-EL-21), indicating extended ¹³⁷Cs retention on the column and perhaps incomplete titration or neutralization of the SRF resin.

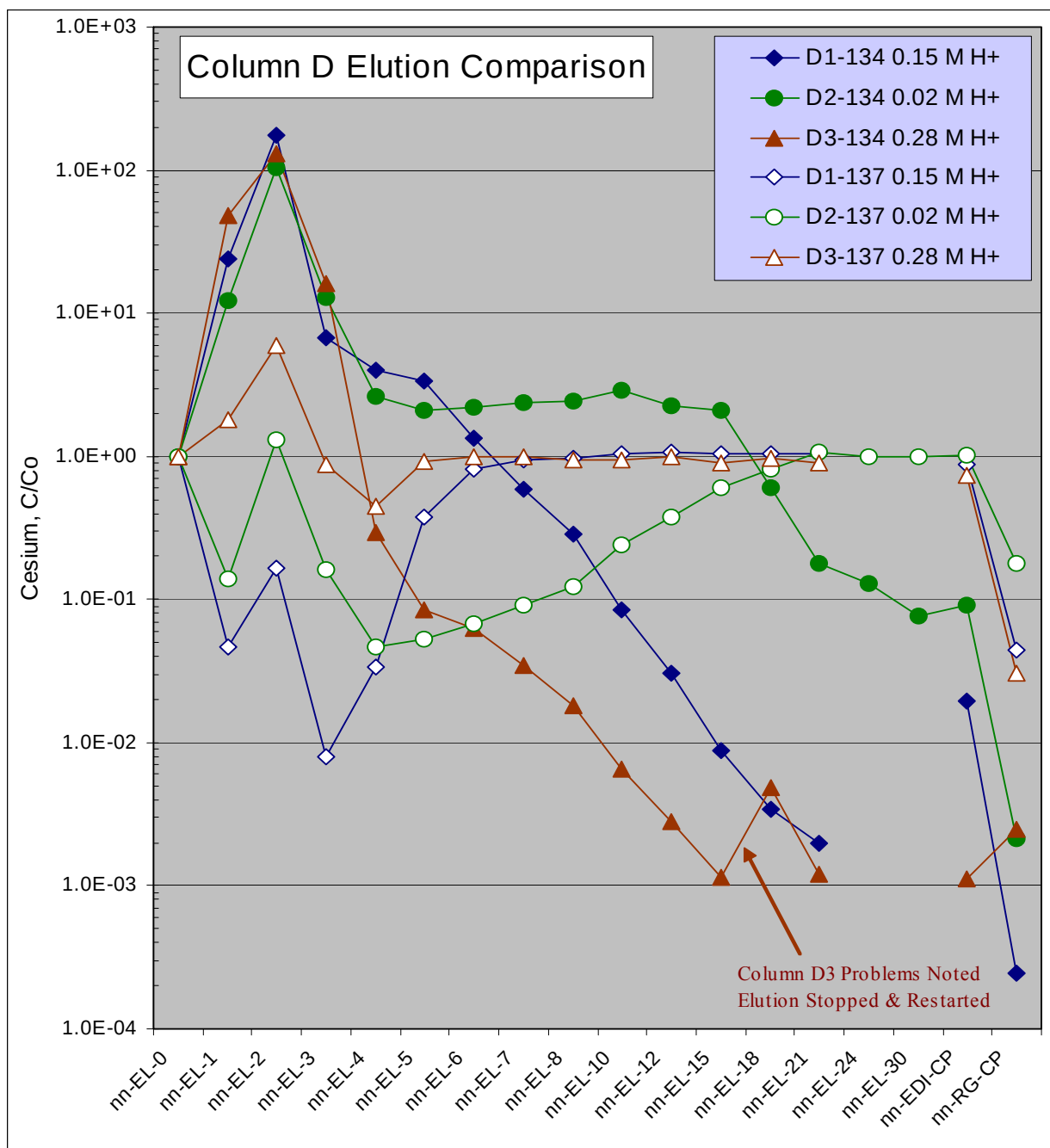


Figure 4.8. Column D1, D2, and D3 Cesium (¹³⁴Cs and ¹³⁷Cs) Elution Profiles

A single graph comparison of all thirteen normalized column ^{134}Cs elution profiles is shown in Figure 4.9. This plot is filled with more data than the previous plots and makes the visual comparisons more difficult. There appears to be a rapid elution of cesium in the first few samples (up to nn-EL-6) followed by a slower, extended elution with slightly reduced slope (between nn-EL-6 and nn-EL-12). This may indicate a mechanistic change in the elution process (e.g., diffusion). Although the trend of stronger acid improving elution is still visible, the plot shows the wide data variability within the experimental results. In addition, at times, a stronger acid does not always produce more complete elution than a weaker acid. The reason for this variability is not known, but does not appear to correlate with cesium impurity levels in the eluting acid.

Approximately 3 to 4 BV of 0.5 M HNO_3 are required to acid neutralize (titrate) the SRF resin, thereby exchanging protons for sodium, cesium, and other cations. For this work, the lower 3 BV value was used, thus minimizing the possibility of removing cesium during the titration step and allowing observation of the cesium elution profile peak (e.g., data points nn-EL-2 in Figure 4.9). On the basis of total acid consumption, the results for the 0.07 M HNO_3 test compare favorably with the stepped elution method (Taylor and Johnson 2009). In retrospect, using the larger 4 BV of 0.5 M HNO_3 might have allowed more complete elution of the SRF resin when eluting with 0.02 M HNO_3 .

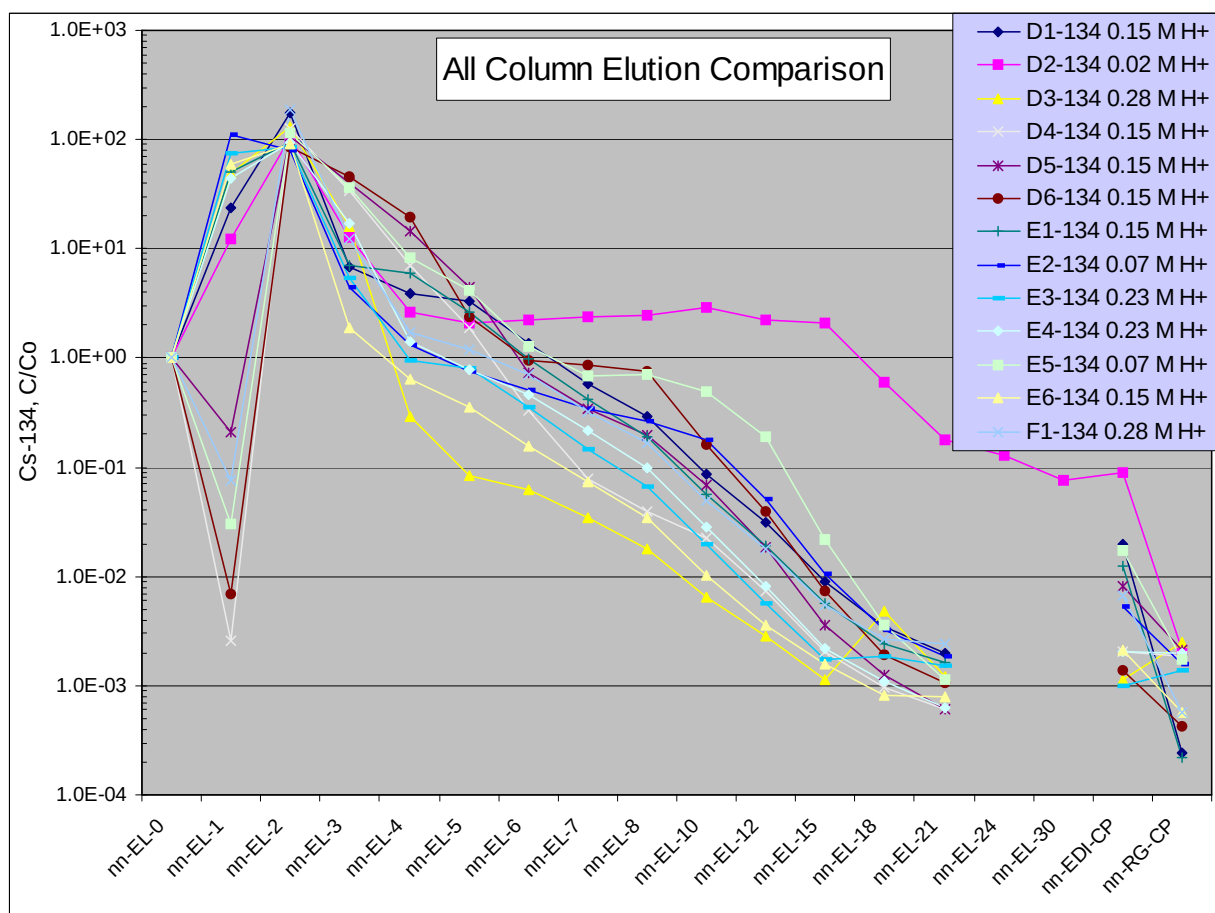


Figure 4.9. Comparison of All Column ^{134}Cs Elution Profiles

4.5 Column Residue after Elution

Following acid elution (Section 4.4), each column was rinsed with 3 BV DI water, disconnected from the ion exchange system, sealed, double-bagged, and removed from the contamination area fume hood. The columns were then placed into a shielded “track” system and analyzed for residual ^{134}Cs and ^{137}Cs by GEA. The GEA system had been calibrated for a standard glass scintillation vial (e.g., not the same geometry as the column and SRF resin). For this reason, the column residual results are only approximate and cannot be validated for accuracy. The results (normalized to the total amount of ^{134}Cs or ^{137}Cs in the loading or elution solution, respectively) are presented in the two right-most columns of Table 4.1 and graphically in Figure 4.10. Prior researchers (Fiskum et al. 2006c) have estimated that $\leq 0.1\% \text{ C/C}_0$ [decontamination factor (DF) ≥ 1000] will be required to meet waste loading criteria for similar Hanford tank wastes. The results from this test indicate that nearly all elution conditions (except Column D2) were sufficient to achieve a DF greater than 1000 (e.g., $< 1.0\text{E-}03 \text{ }^{134}\text{Cs C/C}_0$). The ^{137}Cs results for Column E2 suggest that at lower (0.07 M HNO_3) acid strength, as much as 14% of the cesium in the eluting acid (e.g., if recycled during WTP operations) could remain on the column after each elution cycle. This emphasizes the importance of well-defined specifications for the recycled acid eluant.

Table 4.1. Summary of Column Leakage and Column Residue Results

Column ID	Elution Content		Next-Load Cycle Leakage		Post-Elute Column Residue	
	[Cs], M	[H+], M	$^{134}\text{Cs C/C}_0$	$^{137}\text{Cs C/C}_0$	$^{134}\text{Cs C/C}_0$	$^{137}\text{Cs C/C}_0$
D1	5.00E-08	1.50E-01	4.43E-05	1.45E-03	1.53E-04	9.32E-02
D2	5.00E-08	2.00E-02	1.43E-03	7.85E-03	4.88E-03	2.64E-01
D3	5.00E-08	2.80E-01	1.76E-05	7.66E-04	5.73E-05	3.54E-02
D4	5.00E-07	1.50E-01	5.06E-05	1.41E-03	7.42E-05	7.77E-02
D5	5.00E-09	1.50E-01	5.92E-05	1.44E-03	7.35E-05	6.00E-02
D6	5.00E-07	1.50E-01	NA	NA	7.22E-05	5.04E-02
E1	5.00E-08	1.50E-01	4.46E-05	1.26E-03	1.22E-04	9.00E-02
E2	1.40E-07	7.00E-02	3.93E-05	1.20E-03	1.44E-04	1.38E-01
E3	1.90E-08	2.30E-01	4.23E-05	1.22E-03	7.89E-05	5.04E-02
E4	1.40E-07	2.30E-01	2.87E-05	1.06E-03	6.62E-05	5.77E-02
E5	1.90E-08	7.00E-02	7.25E-05	1.79E-03	7.76E-05	1.04E-01
E6	5.00E-08	1.50E-01	NA	NA	7.16E-05	5.30E-02
F1	0.00E+00	2.80E-01	NA	NA	1.59E-04	6.48E-02

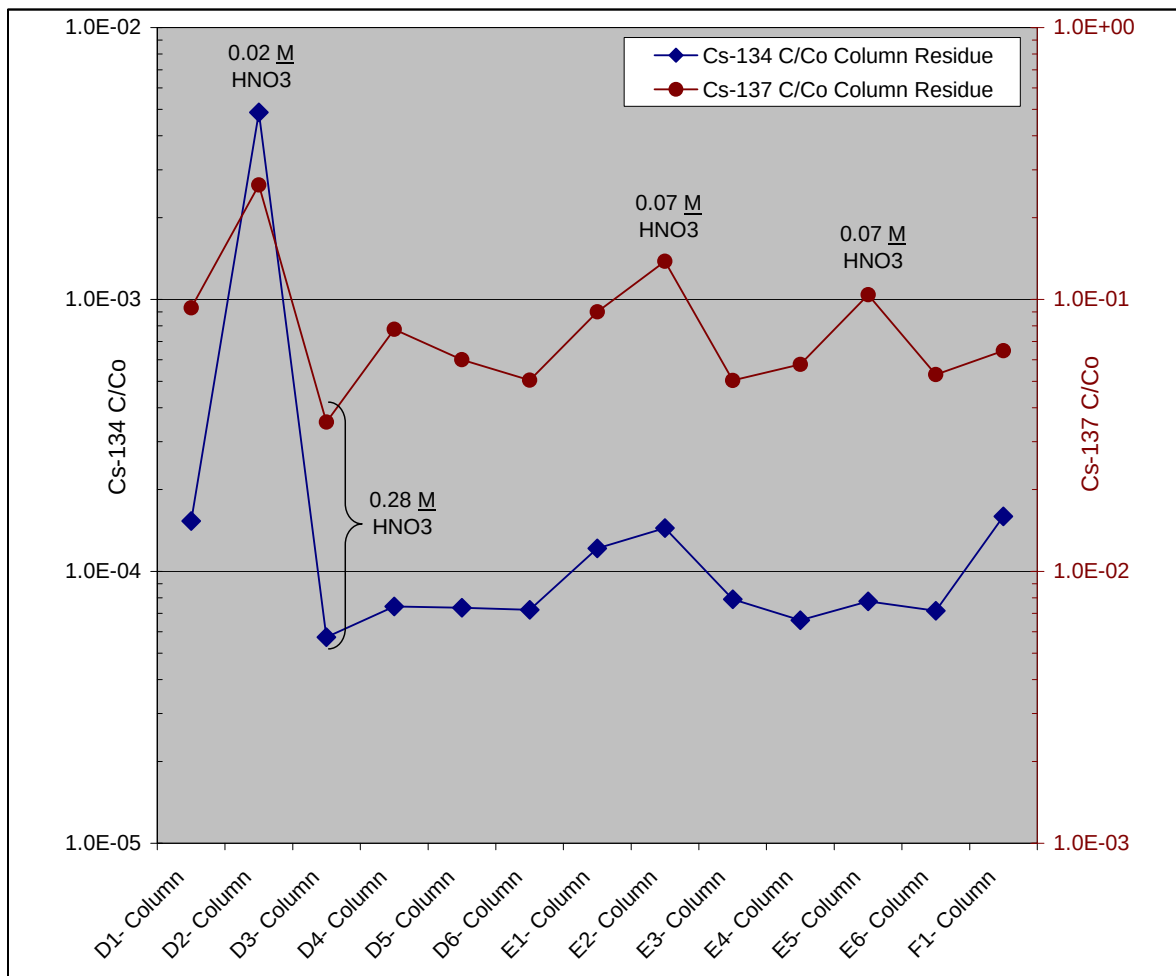


Figure 4.10. Column Cesium (^{134}Cs and ^{137}Cs) Residue After Elution Cycle

One experimental test objective was to evaluate the effect of acid strength and cesium impurity concentration on the elution process. The ^{134}Cs data from Figure 4.10 are re-plotted as a function of cesium concentration in Figure 4.11. As expected, the 0.02 M HNO_3 experiment (upper point) shows as an obvious anomaly due to incomplete titration/elution of the SRF resin. The remaining data points spread horizontally around $1.0\text{E-}04$ ^{134}Cs C/C_0 . Therefore, over the range evaluated ($5\text{E-}09$ to $5\text{E-}07$ M Cs), the cesium impurity concentration in the elution acid does not affect the elution process. The effect of acid strength and an approximate estimate of the experimental variation are also shown in Figure 4.11. At every cesium concentration, the higher acid concentration resulted in a lower ^{134}Cs C/C_0 residue on the SRF column. The data observed at 0.15 M HNO_3 and $5\text{E-}08$ M Cs provide an approximate estimate of the experimental variation.

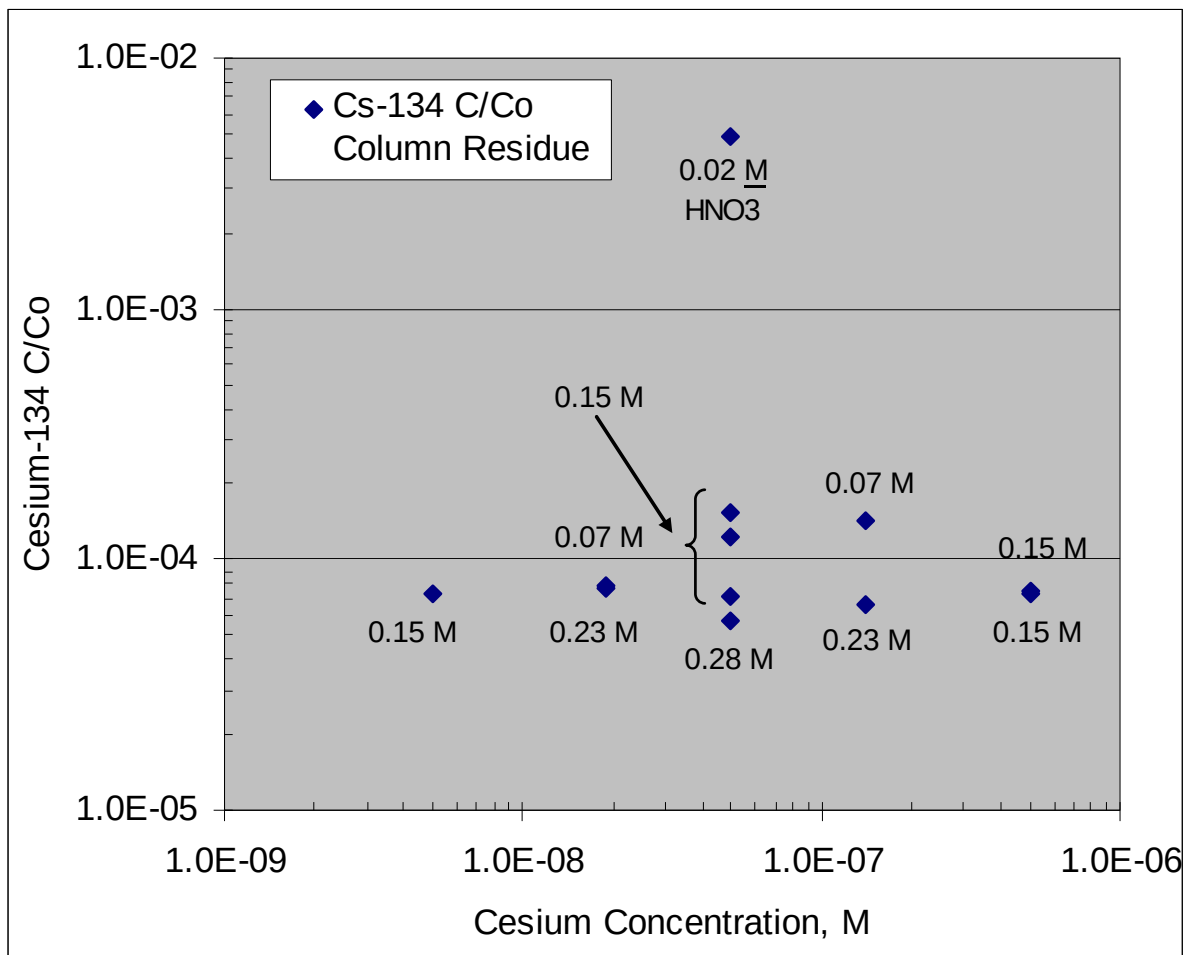


Figure 4.11. Column Cesium (^{134}Cs Only) Residue After Elution Cycle

4.6 Average Column Carryover

Another objective of the elution testing was to evaluate the amount of cesium “leakage” or carryover during subsequent loading cycles. This can be quantified by evaluating the first few data points collected on each cycle loading (e.g., Figure 4.4 and Figure 4.5) as previously discussed in Section 4.2. The data for seven of the first eight samples in each loading cycle were averaged to generate a numerical estimate of the cesium leakage. The first data point in each graph appeared to be anomalous and was not used in the calculation. The average cycle leakage results (center columns in Table 4.1) are shown graphically in Figure 4.12. The results indicate that the average “leakage” or breakthrough during the first 8-hour period (12 BV) is typically less than 0.006% ^{134}Cs C/C₀ (cesium in loading solution) and 0.2% ^{137}Cs C/C₀ (cesium in recycled elution acid). The test following elution with 0.02 M HNO₃ showed nearly 0.14% ^{134}Cs and 0.8% ^{137}Cs breakthrough, indicating insufficient cesium removal during the previous elution cycle. These results (except column test D2, 0.02 M HNO₃) indicate that there was sufficient acid strength for cesium elution and reducing carryover (“leakage”) to subsequent process cycles.

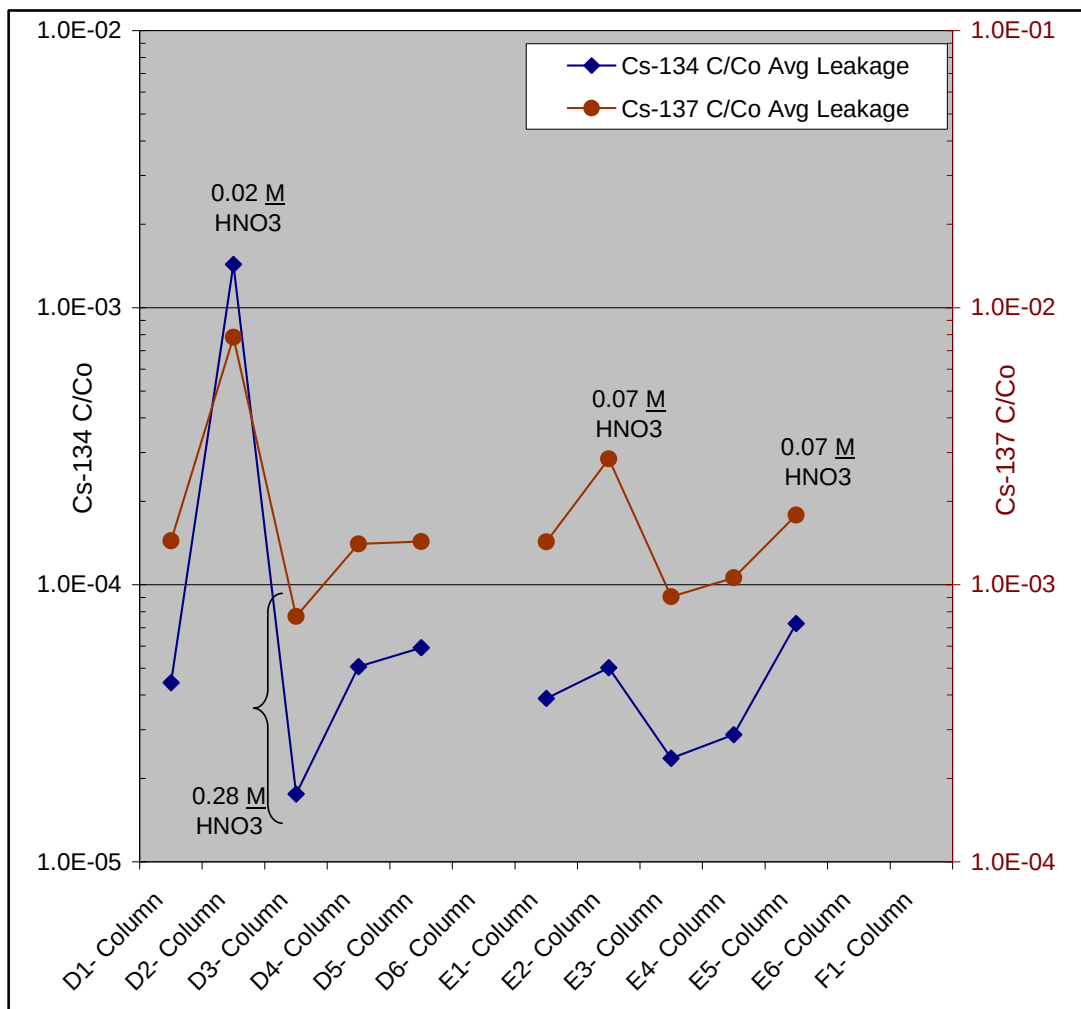


Figure 4.12. Average Column Next Cycle Leakage Cesium (^{134}Cs and ^{137}Cs)

The ^{134}Cs data from Figure 4.12 are re-plotted as a function of cesium concentration in Figure 4.13. As expected, the 0.02 M HNO_3 experiment (upper point) shows as an obvious anomaly due to incomplete titration/elution of the SRF resin. The remaining data points spread horizontally around $4.0\text{E-}05$ ^{134}Cs C/C_0 . Therefore, over the range evaluated ($5\text{E-}09$ to $5\text{E-}07$ M Cs), the cesium impurity concentration in the elution acid does not affect the average next cycle cesium leakage. The effect of acid strength is also shown in Figure 4.13. At every cesium concentration, the higher acid resulted in a lower ^{134}Cs C/C_0 residue on the SRF column. These data are in agreement with the column residue results shown in Figure 4.11 and suggest that the two data sets produce similar or correlated information.

One of the test objectives was to improve the correlation between eluted resin cesium content and the amount of cesium leached out of the resin during subsequent loading cycles. These data are available in Table 4.1 and are displayed graphically in Figure 4.14. As has been described above, the 0.02 M HNO_3 elution of column D2 was incomplete and therefore is a significant outlier when compared to all other tests. The highest acid solutions (0.23 and 0.28 M) are highlighted in Figure 4.14 in the lower left blue circle. The upper yellow and right purple shaded data have "medium" acid strength (0.07 and 0.15 M). The level of cesium impurities seem to be higher in the purple shaded data set on the right vs. the upper yellow data set (except test D4). It is unknown whether this effect is related to experimental scatter.

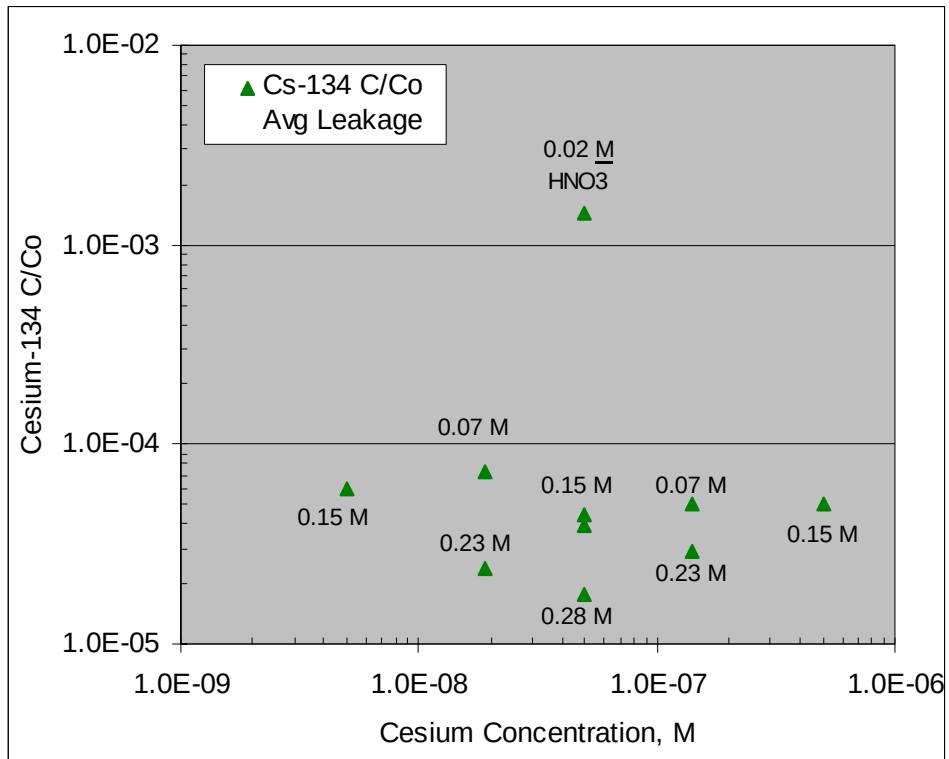


Figure 4.13. Average Column Next Cycle Leakage Cesium (^{134}Cs)

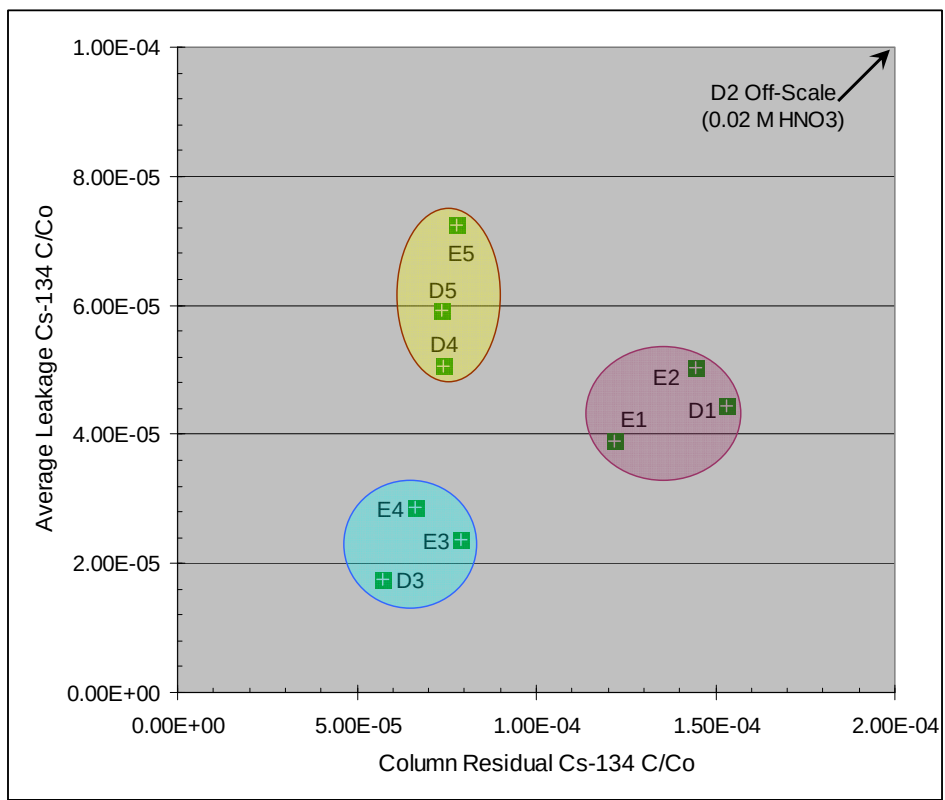


Figure 4.14. Average Next Cycle Leakage vs. Column Residual ^{134}Cs C/Co

4.7 Estimated Cesium Residue During Elution

The amount of cesium remaining on the SRF resin at any point during the elution process has been estimated by mathematically adding the amount of cesium removed in each elution sample to the amount of cesium residue present at the end of each cycle (Section 4.5). The results, reported as total Cs (μg) per gram of dry H^+ -form SRF resin, are displayed in Figure 4.15. These results may be useful in estimating when the elution process might be terminated while still meeting operating specifications. In addition, the data demonstrate the variation in acid volume required to achieve a certain residue level. For example, approximately 10 BV of 0.28 M HNO_3 (Column D3) are needed to achieve a level of 10 μg Cs per gram of SRF resin. In contrast, only 20 BV of 0.07 M HNO_3 (Column E2) are needed to achieve the same level, a significant reduction in the amount of acid required, but at the expense of larger volumes and longer processing time. Figure 4.15 also demonstrates similar curve-to-curve variability as is shown in Figure 4.9.

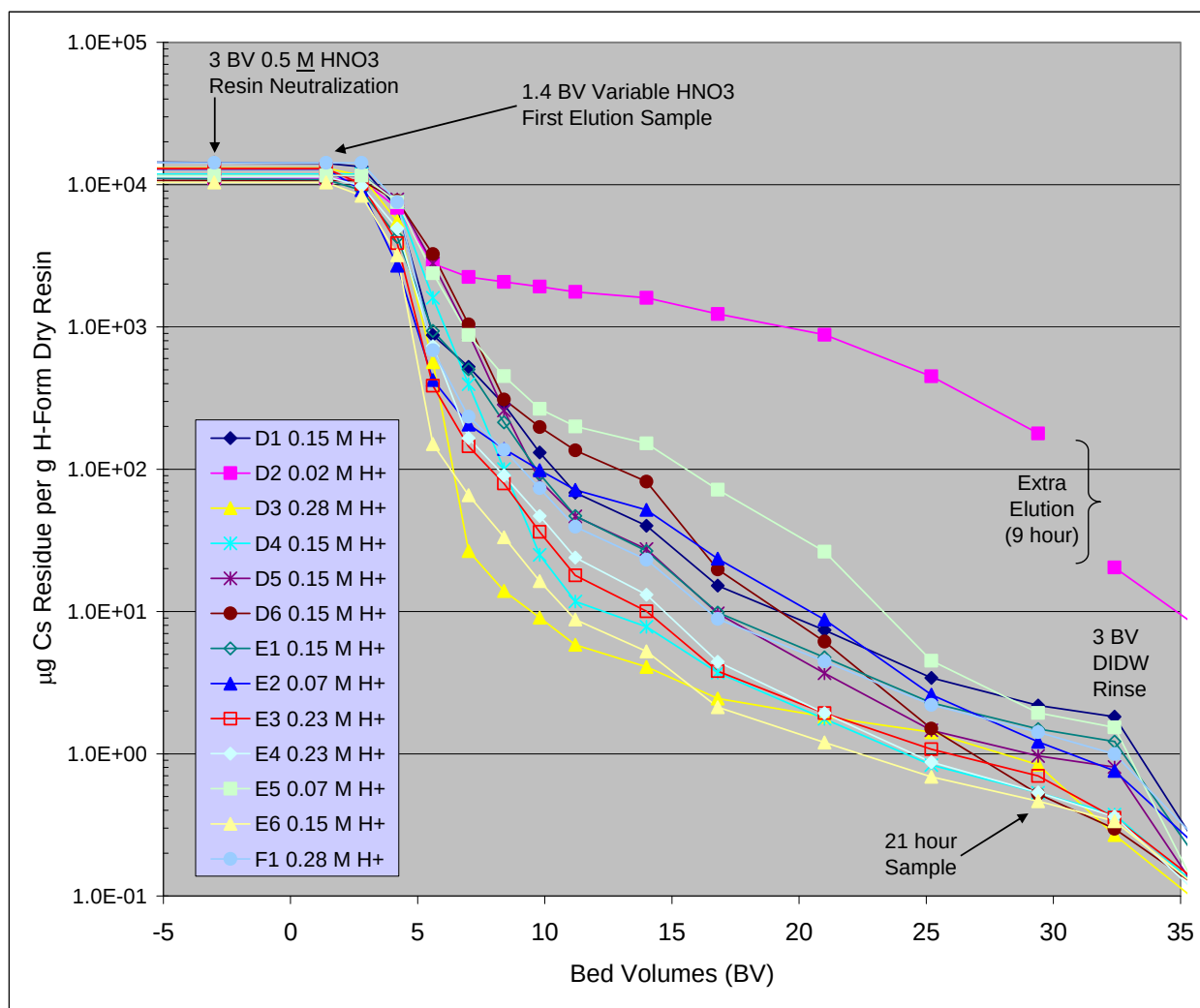


Figure 4.15. Estimated Cesium Residue

5.0 Conclusions

The test objectives were to:

- Determine the impact of residual cesium (^{137}Cs) in the nitric acid elution feed on the Cs elution profile of the SRF resin.

Over the range evaluated (5E-09 to 5E-07 M Cs), the cesium impurity concentration in the elution acid did not appear to affect the average next cycle cesium leakage or the amount of residual cesium remaining on the column after elution (Figure 4.11, Figure 4.13).

- Determine the completeness of SRF resin elution as a function of nitric acid concentration to help establish acid strength and purity requirements.

The results indicate that nearly all HNO_3 concentrations (e.g., 0.07, 0.15, 0.23 and 0.28 M with the exception of 0.02 M for Column D2) were sufficient to elute to less than $1.0\text{E-}03$ ^{134}Cs C/C₀ (Figure 4.9).

- Improve the correlation between eluted resin cesium content and the amount of cesium leached out of the resin during subsequent loading cycles.

Over the range evaluated (5E-09 to 5E-07 M Cs), the cesium impurity concentration in the elution acid did not appear to affect the average next cycle cesium leakage or the amount of residual cesium remaining on the column after elution (Figure 4.11, Figure 4.13). A direct plot of the average column leakage as a function of residual cesium on each column is shown in Figure 4.14.

The small SRF columns (~15.7 mL) were loaded with 250 BV of a simple simulant traced with ^{134}Cs and containing nominally 5 M Na, $2.4\text{E-}05$ M Cs, 0.115 M Al, and 1.55 M free OH. Effective removal of cesium from the SRF resin has been demonstrated using 3 BV of 0.5 M HNO_3 followed by ~29 BV of dilute HNO_3 (e.g., 0.07 to 0.28 M) and traced with ^{137}Cs . As expected from previous work (Burgeson et al. 2004; Taylor and Johnson 2009), the higher acid concentration was more effective at eluting the SRF resin. However, in the current study, effective elution to 0.001 C/C₀ (DF=1000) was still observed after 20 BV of 0.07 M HNO_3 . In contrast, the WTP baseline pretreatment process calls for 15 BV of 0.5 M HNO_3 . The use of more dilute nitric acid may minimize acid consumption and facilitate the use of a broader range of acid concentrations recycled from the evaporator. Under the conditions evaluated during this test ($5.00\text{E-}09$ M to $5.00\text{E-}07$ M Cs), the level of residual cesium impurity in the eluting acid did not affect the elution process (e.g., the amount of residual cesium remaining in the column post-elution or the amount of Cs leakage during subsequent loading cycles).

Approximately 3 to 4 BV of 0.5 M HNO_3 are required to acid neutralize (titrate) the SRF resin, thereby exchanging protons for sodium, cesium, and other cations. For this work, the lower 3 BV value was used, thus minimizing the possibility of removing cesium during the titration step and allowing observation of the cesium elution profile peak. On the basis of total acid consumption, the results for the 0.07 M HNO_3 test compare favorably with the stepped elution method (Taylor and Johnson 2009). In retrospect, using the larger 4 BV of 0.5 M HNO_3 might have allowed more complete elution of the SRF resin when eluting with 0.02 M HNO_3 .

During each cycle's loading phase, cesium breakthrough and carryover (except the first loading cycle) were measured for both ^{134}Cs (from the loading solution) and ^{137}Cs (from the previous cycle's elution acid). Initial breakthrough during the first 10 BV averaged approximately $4\text{E-}05\text{ C/C}_0$ for ^{134}Cs and $2\text{E-}03\text{ C/C}_0$ for ^{137}Cs . The ^{134}Cs values provide an indication of leakage that may be attributed to residual cesium remaining on the SRF resin after the previous elution cycle. The ^{137}Cs values provide an indication of the column rinsing efficiency and any cesium impurities that may be present in the recycled acid (e.g., the ^{137}Cs on the column from the eluting acid is reduced by ~ 500 -fold during the DI water rinsing and NaOH regeneration process).

During each cycle's elution phase, classical cesium elution curves were generated using the ^{134}Cs tracer data. As has been reported by other researchers over the past two decades, the peak typically approached 200 C/C_0 followed by a pseudo-exponential decrease to approximately $1\text{E-}03\text{ C/C}_0$ after 25 to 30 BV. In contrast, the ^{137}Cs tracer data provided an indication of acid displacement. The $^{137}\text{Cs}\text{ C/C}_0$ increased to unity after about 10 BV, indicating that cesium impurities in the eluting acid initially loaded on the SRF resin and then subsequently passed through the column unimpeded.

6.0 References

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Appendix A

Supplemental Plots

Appendix A

Supplemental Plots

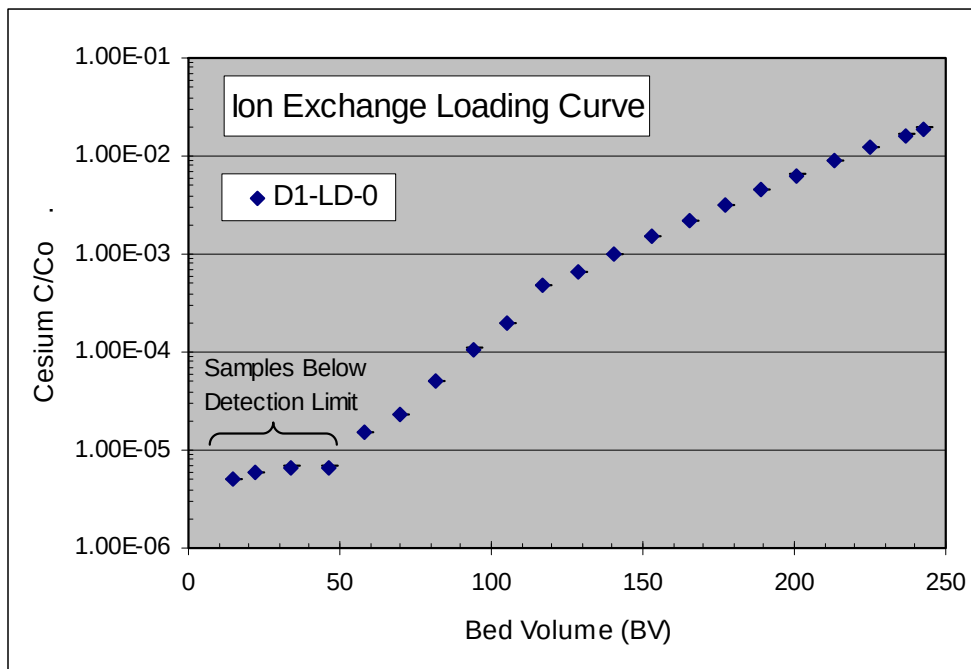


Figure A.1. Column D1 Cesium (^{134}Cs only) Loading Profiles

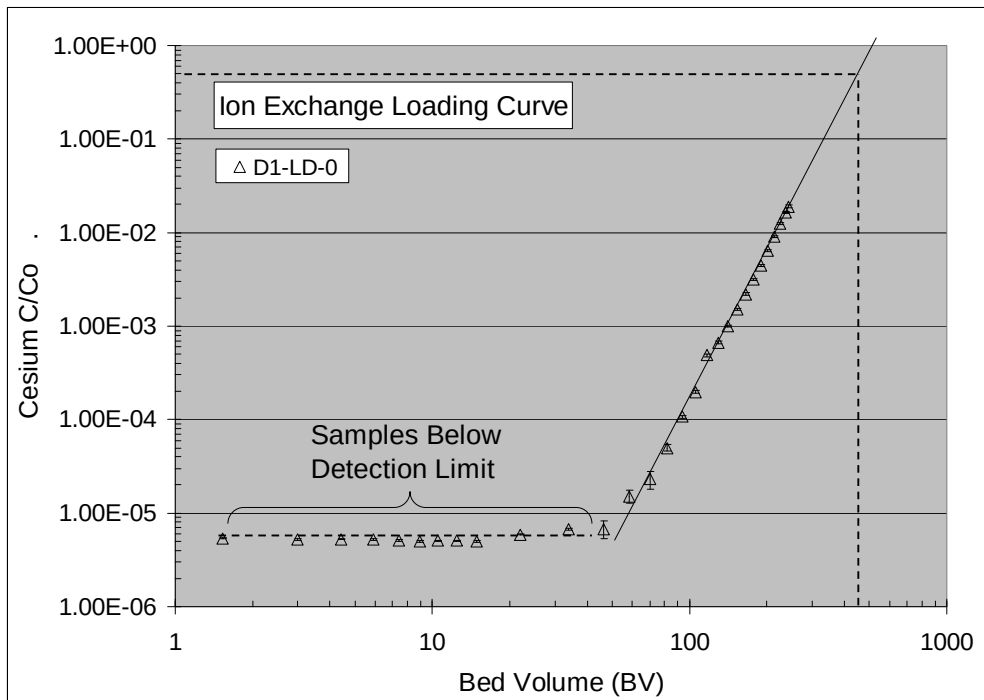


Figure A.2. Column D1 Cesium (^{134}Cs only) Loading Profiles

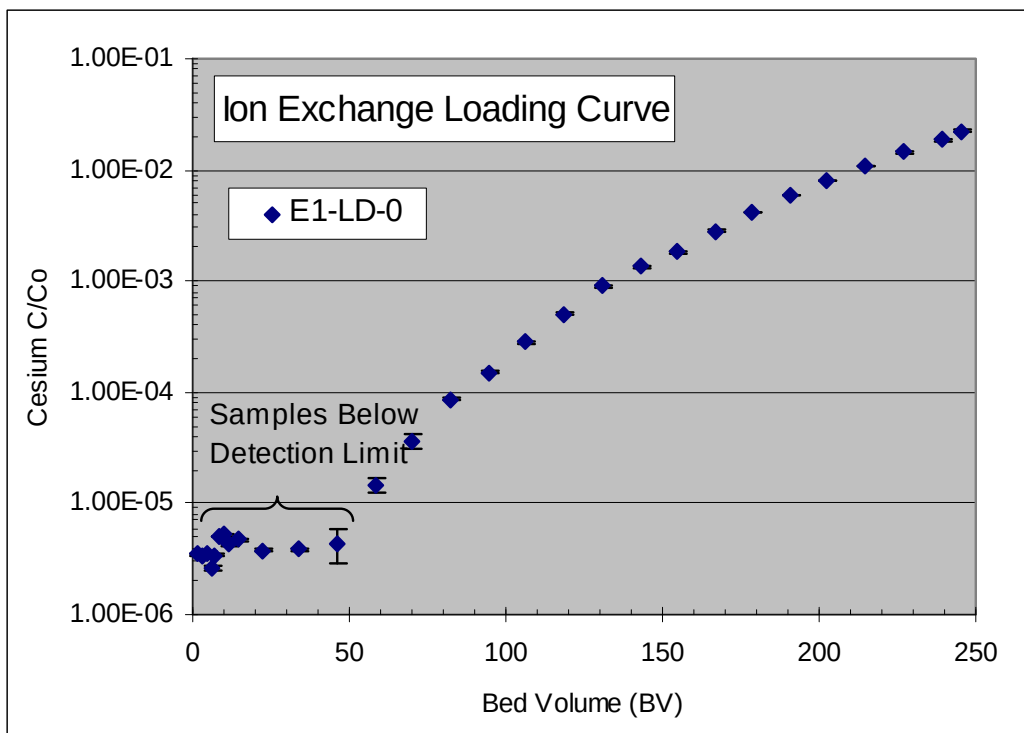


Figure A.3. Column E1 Cesium (^{134}Cs only) Loading Profiles

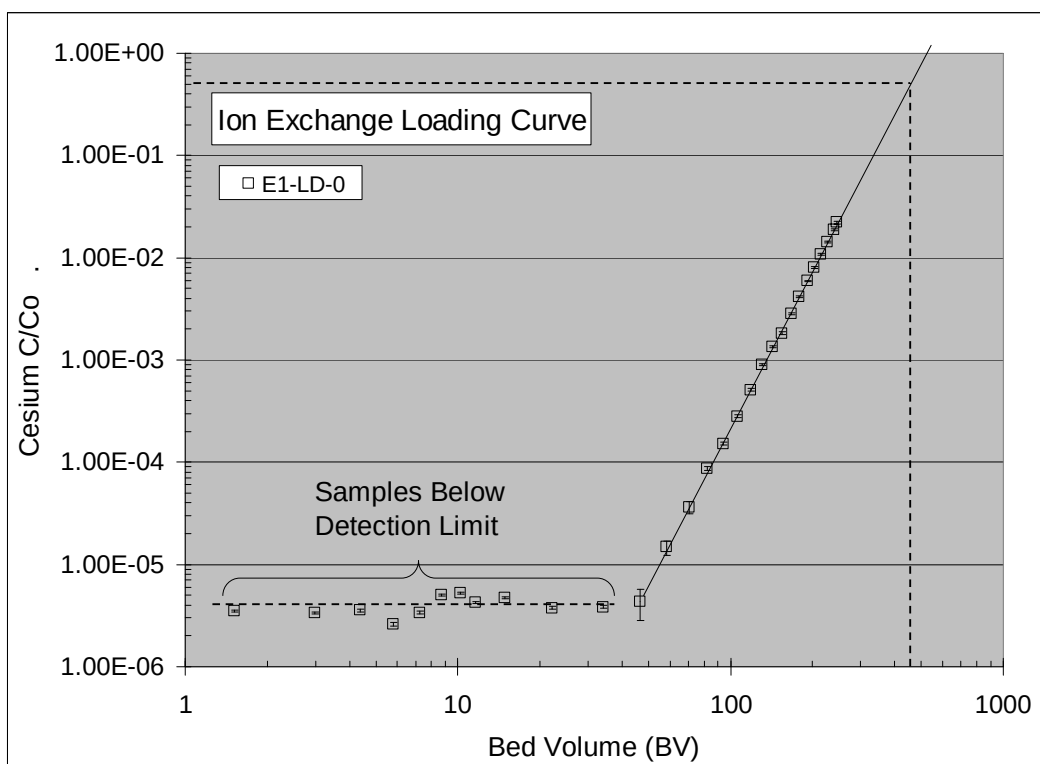


Figure A.4. Column E1 Cesium (^{134}Cs only) Loading Profiles

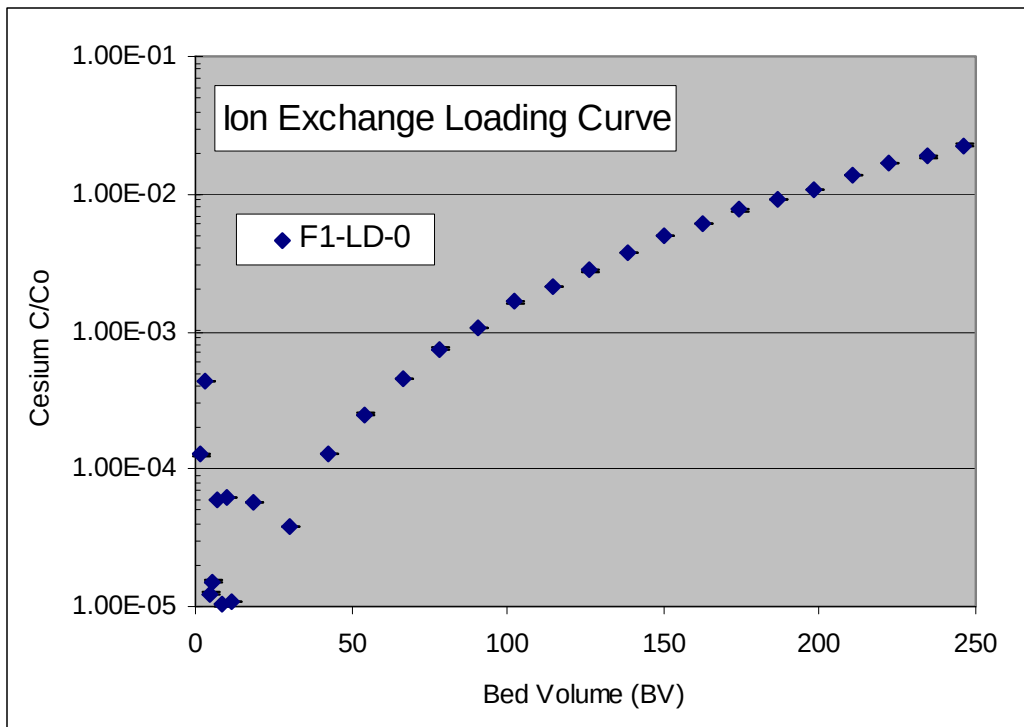


Figure A.5. Column F1 Cesium (^{134}Cs only) Loading Profiles

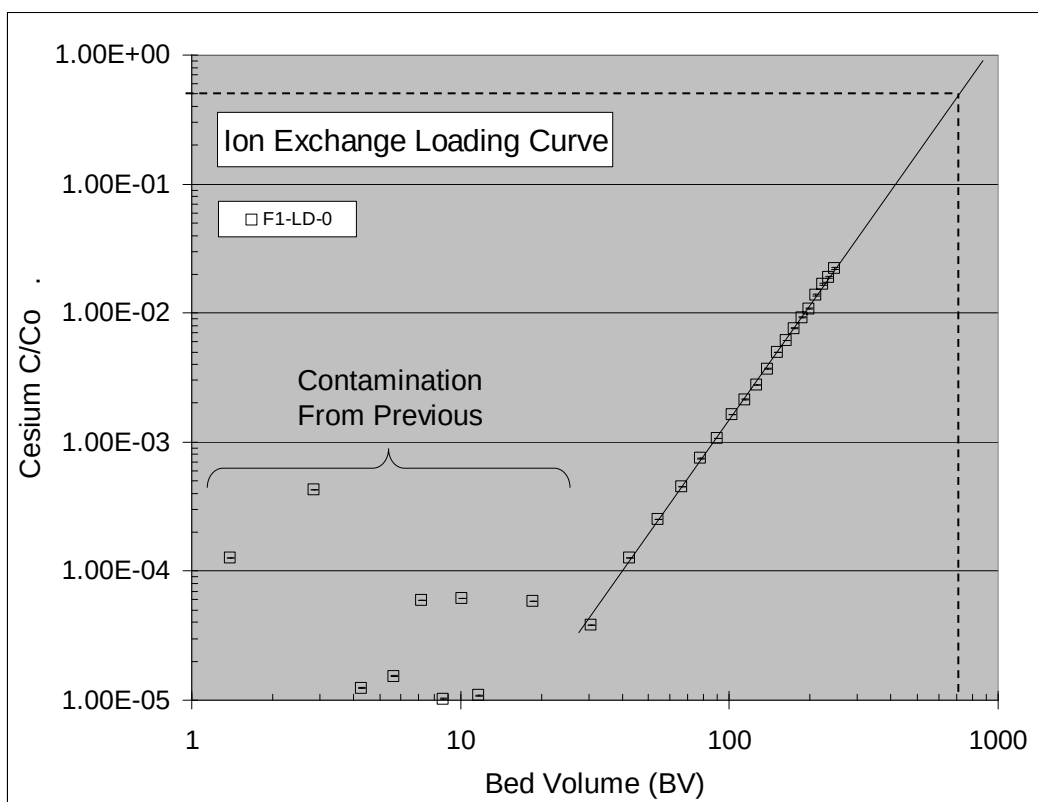


Figure A.6. Column F1 Cesium (^{134}Cs only) Loading Profiles

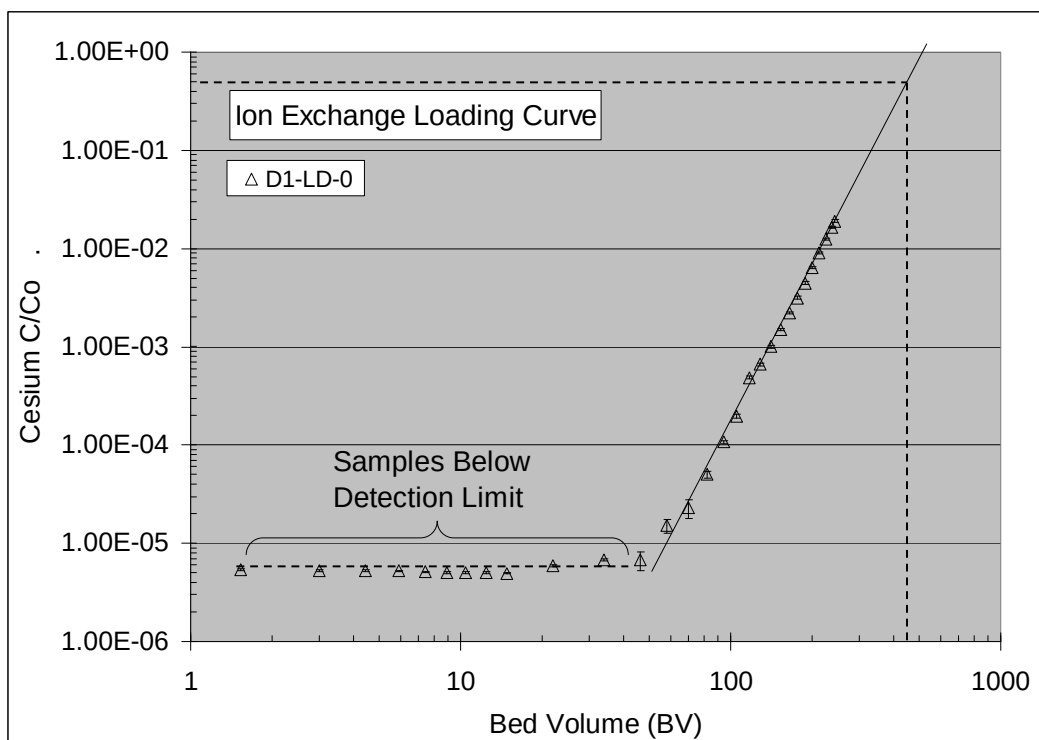


Figure A.7. Column D1 Cesium (^{134}Cs only) Loading Profiles

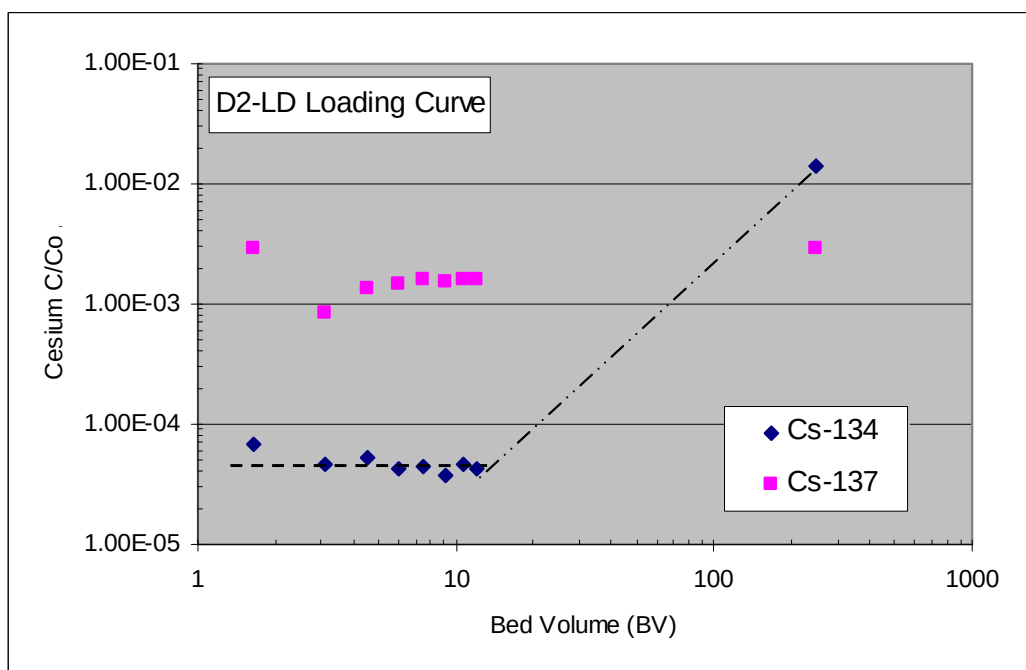


Figure A.8. Column D2 Cesium (^{134}Cs and ^{137}Cs) Loading Profiles

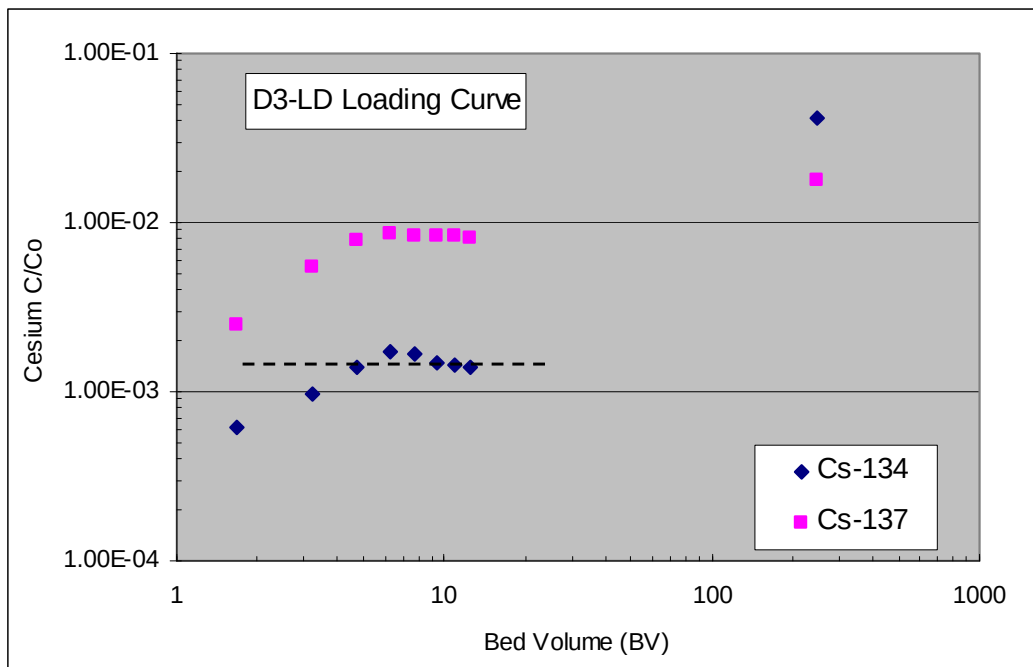


Figure A.9. Column D3 Cesium (^{134}Cs and ^{137}Cs) Loading Profiles

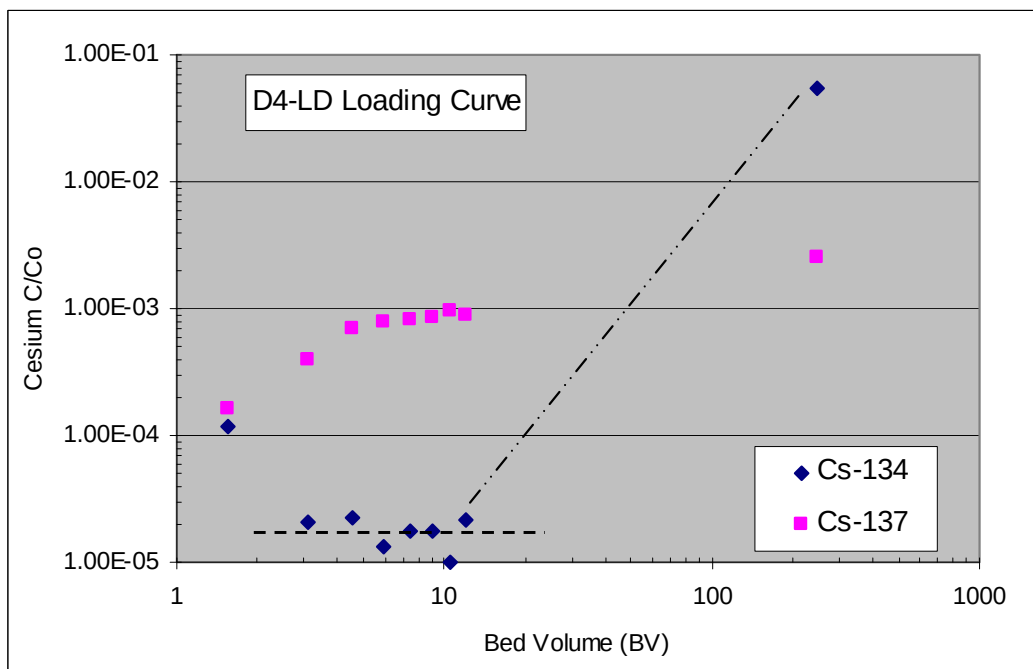


Figure A.10. Column D4 Cesium (^{134}Cs and ^{137}Cs) Loading Profiles

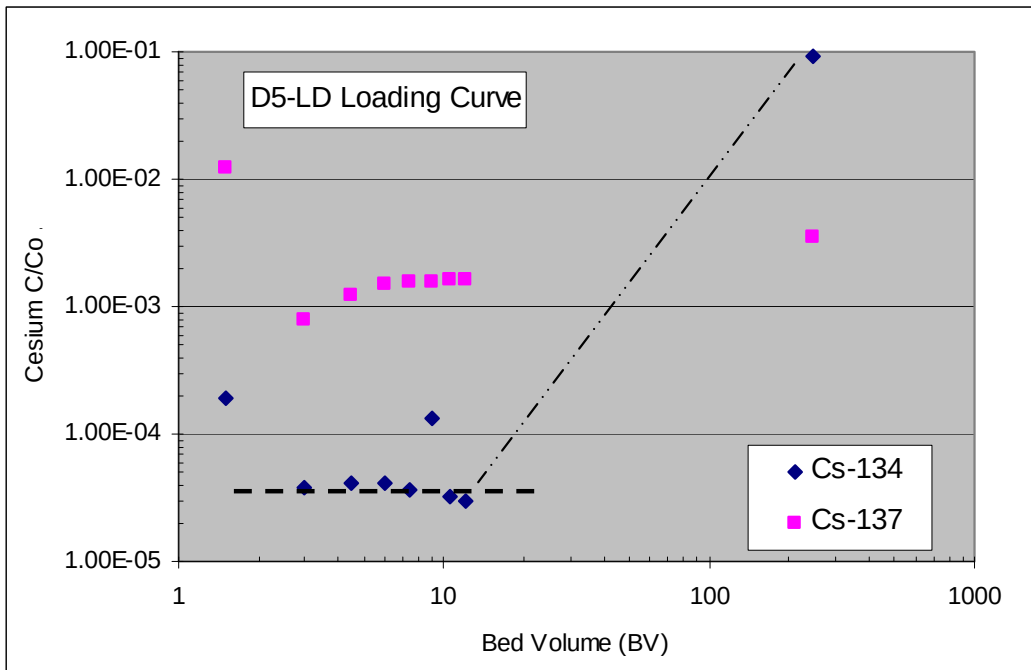


Figure A.11. Column D5 Cesium (^{134}Cs and ^{137}Cs) Loading Profiles

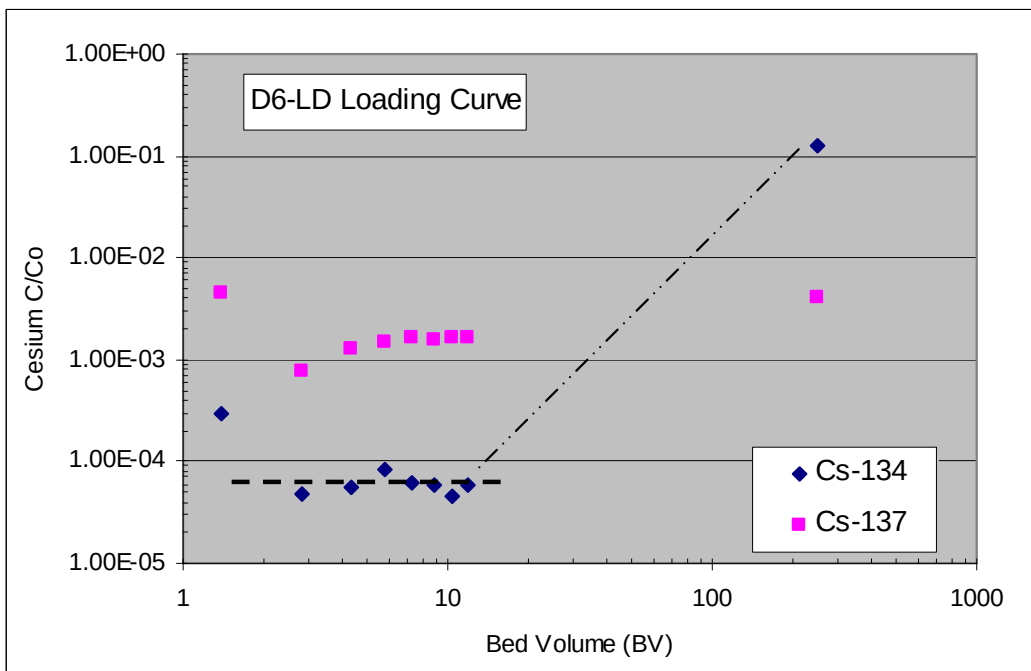


Figure A.12. Column D6 Cesium (^{134}Cs and ^{137}Cs) Loading Profiles

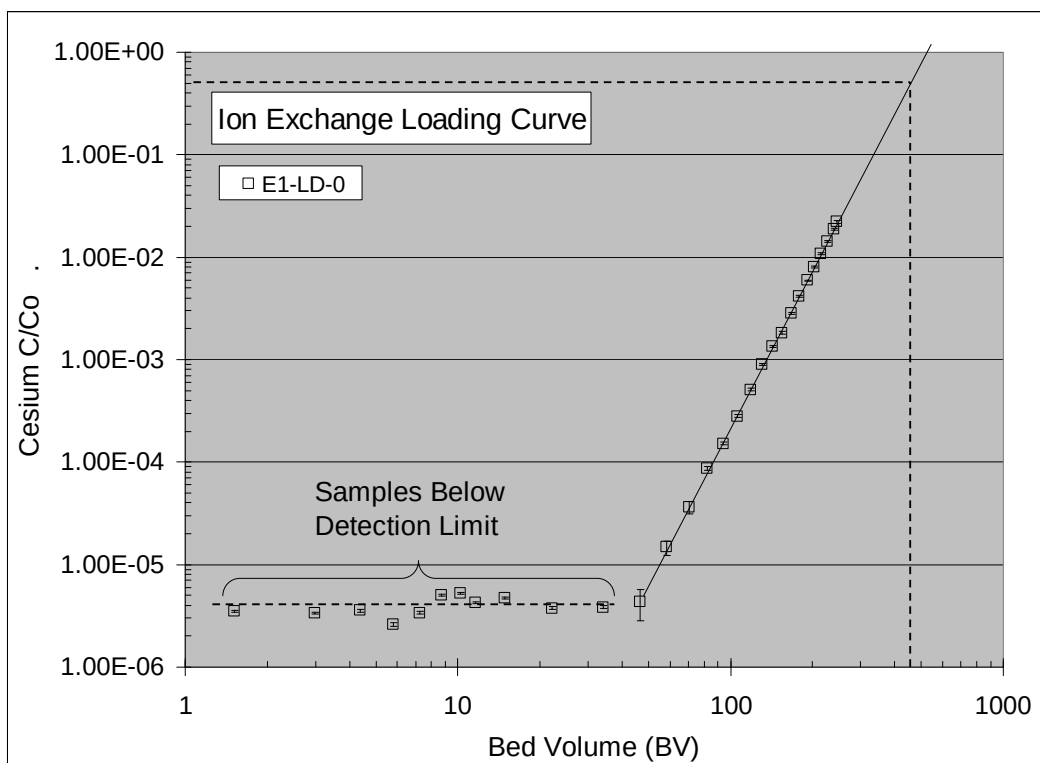


Figure A.13. Column E1 Cesium (^{134}Cs only) Loading Profiles

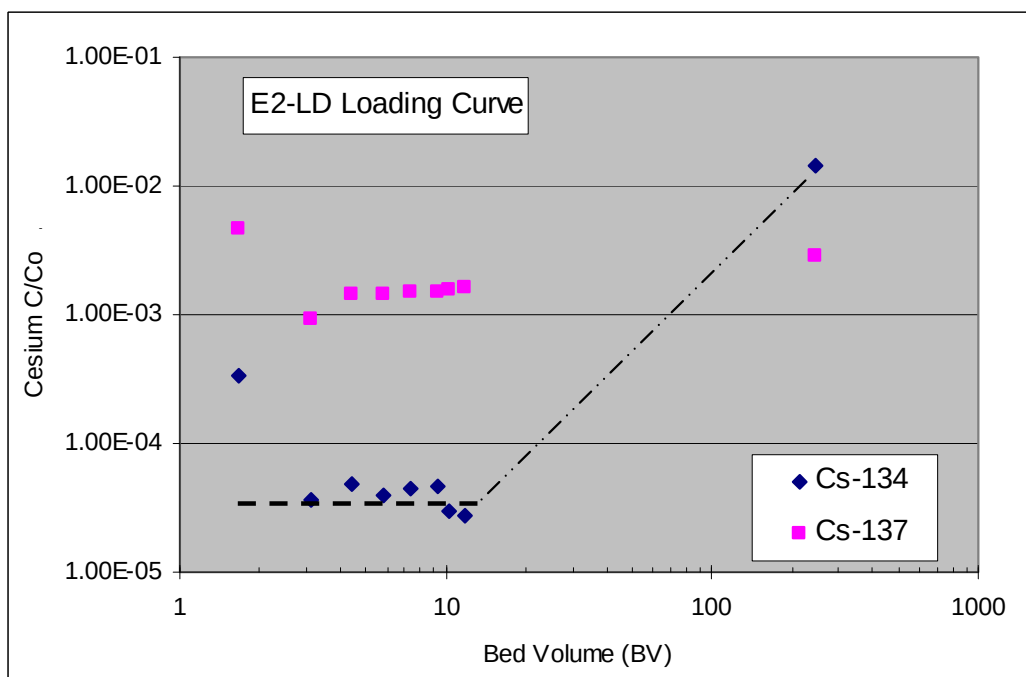


Figure A.14. Column E2 Cesium (^{134}Cs and ^{137}Cs) Loading Profiles

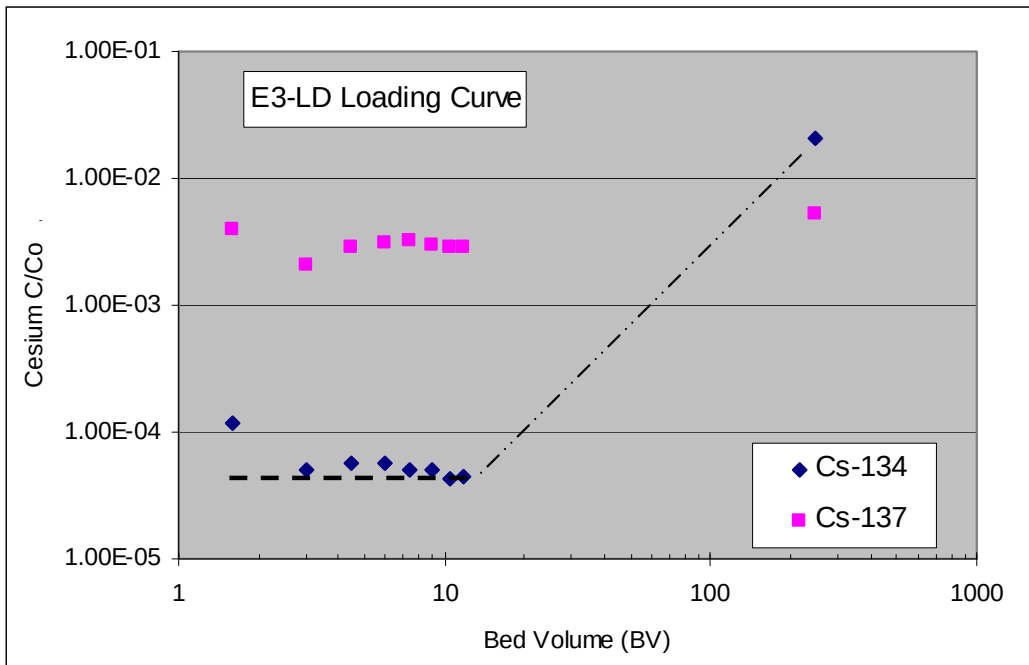


Figure A.15. Column E3 Cesium (^{134}Cs and ^{137}Cs) Loading Profiles

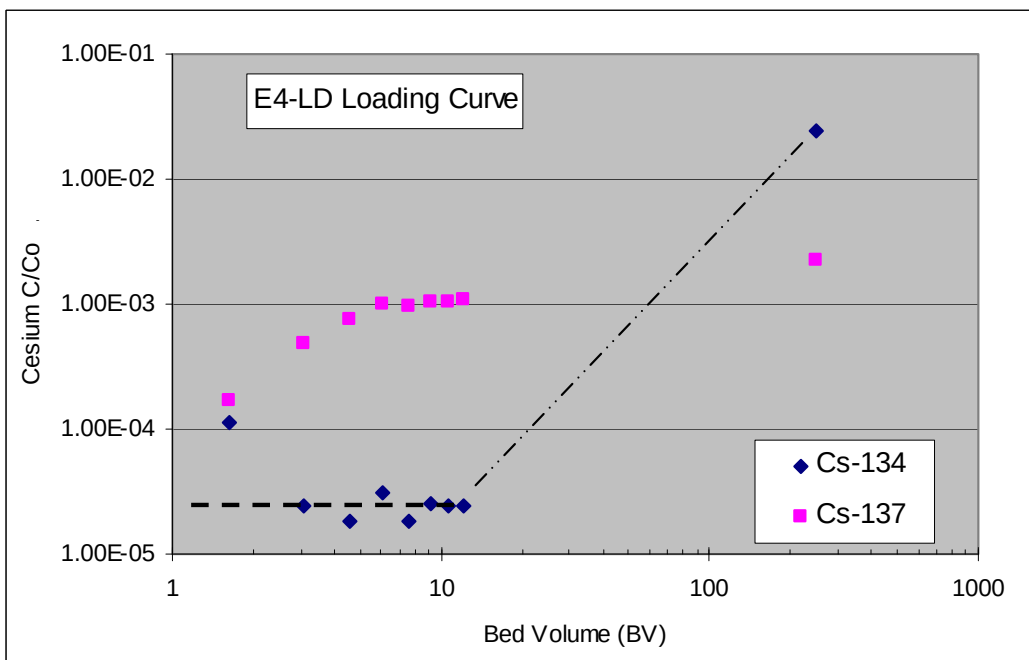


Figure A.16. Column E4 Cesium (^{134}Cs and ^{137}Cs) Loading Profiles

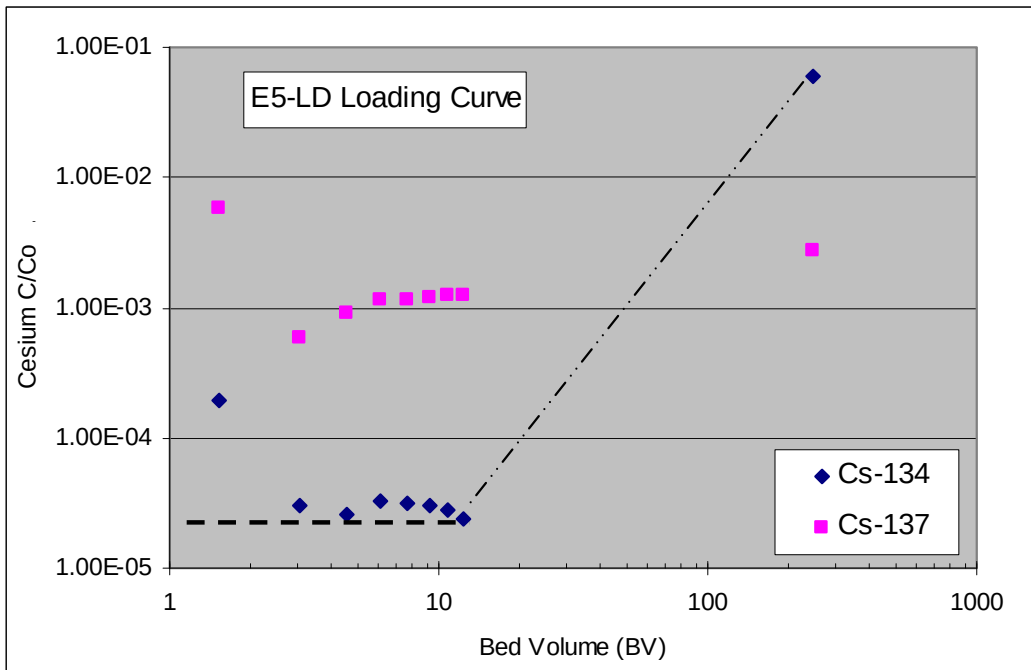


Figure A.17. Column E5 Cesium (^{134}Cs and ^{137}Cs) Loading Profiles

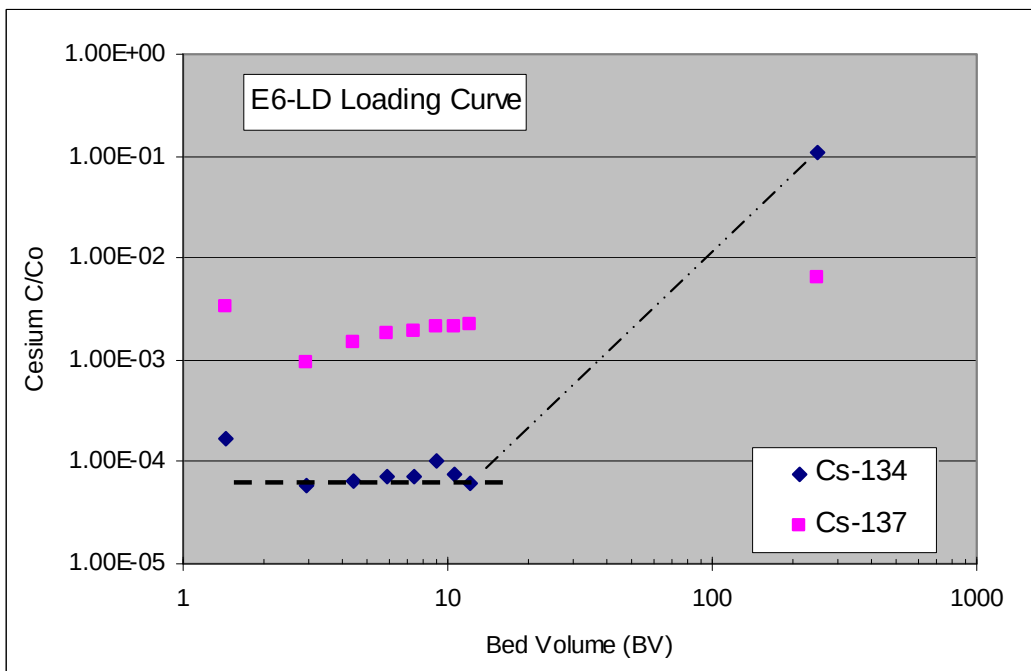


Figure A.18. Column E6 Cesium (^{134}Cs and ^{137}Cs) Loading Profiles

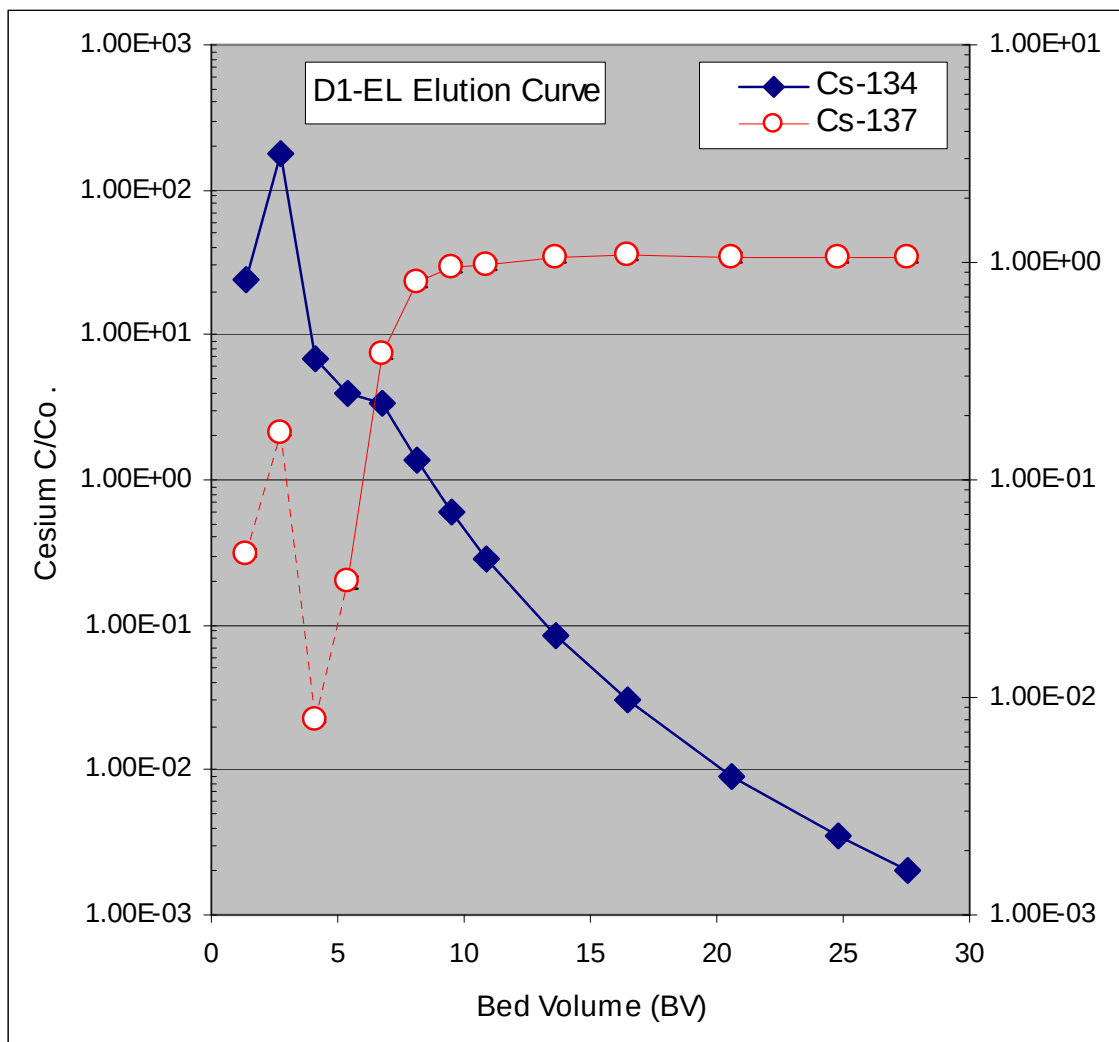


Figure A.19. Column D1 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

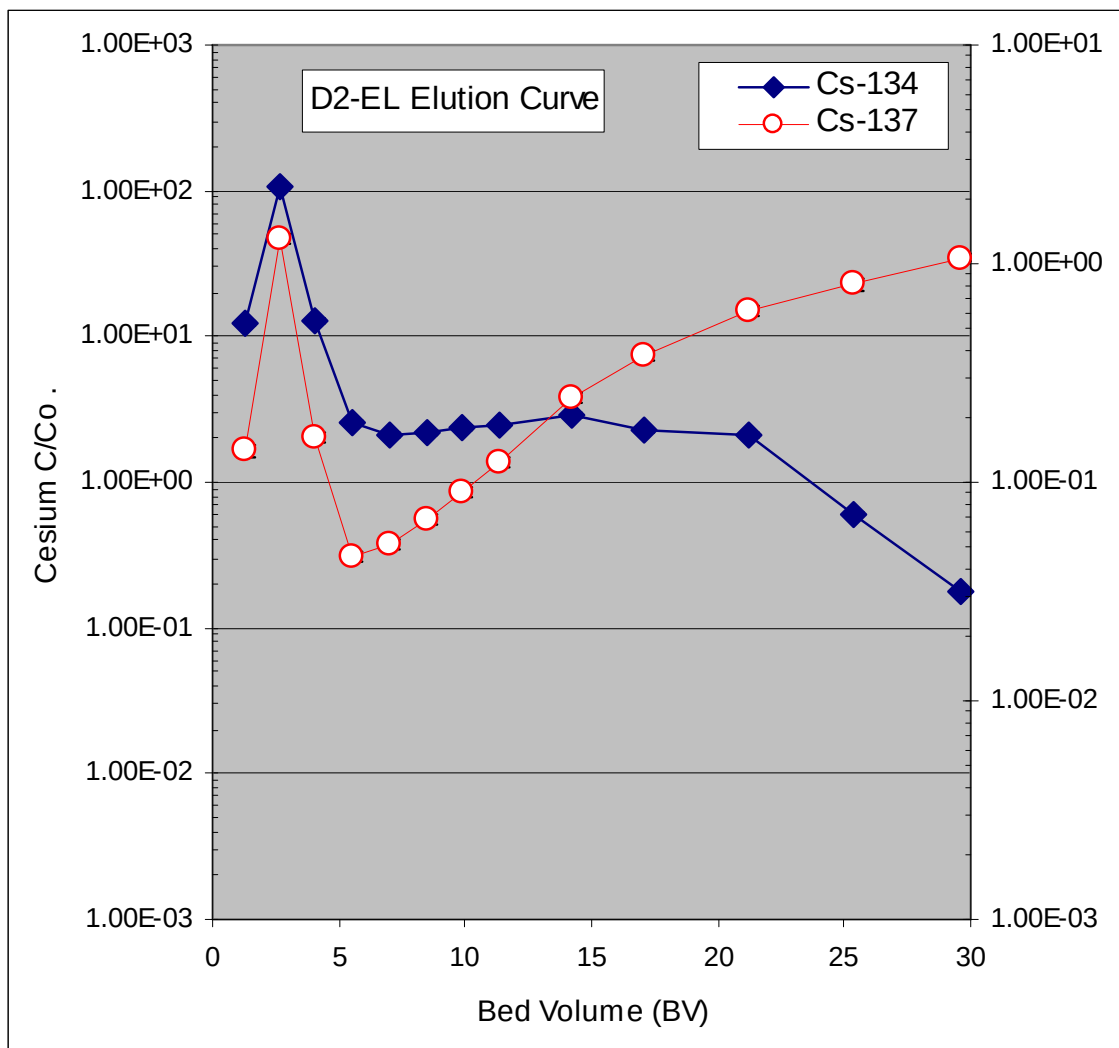


Figure A.20. Column D2 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

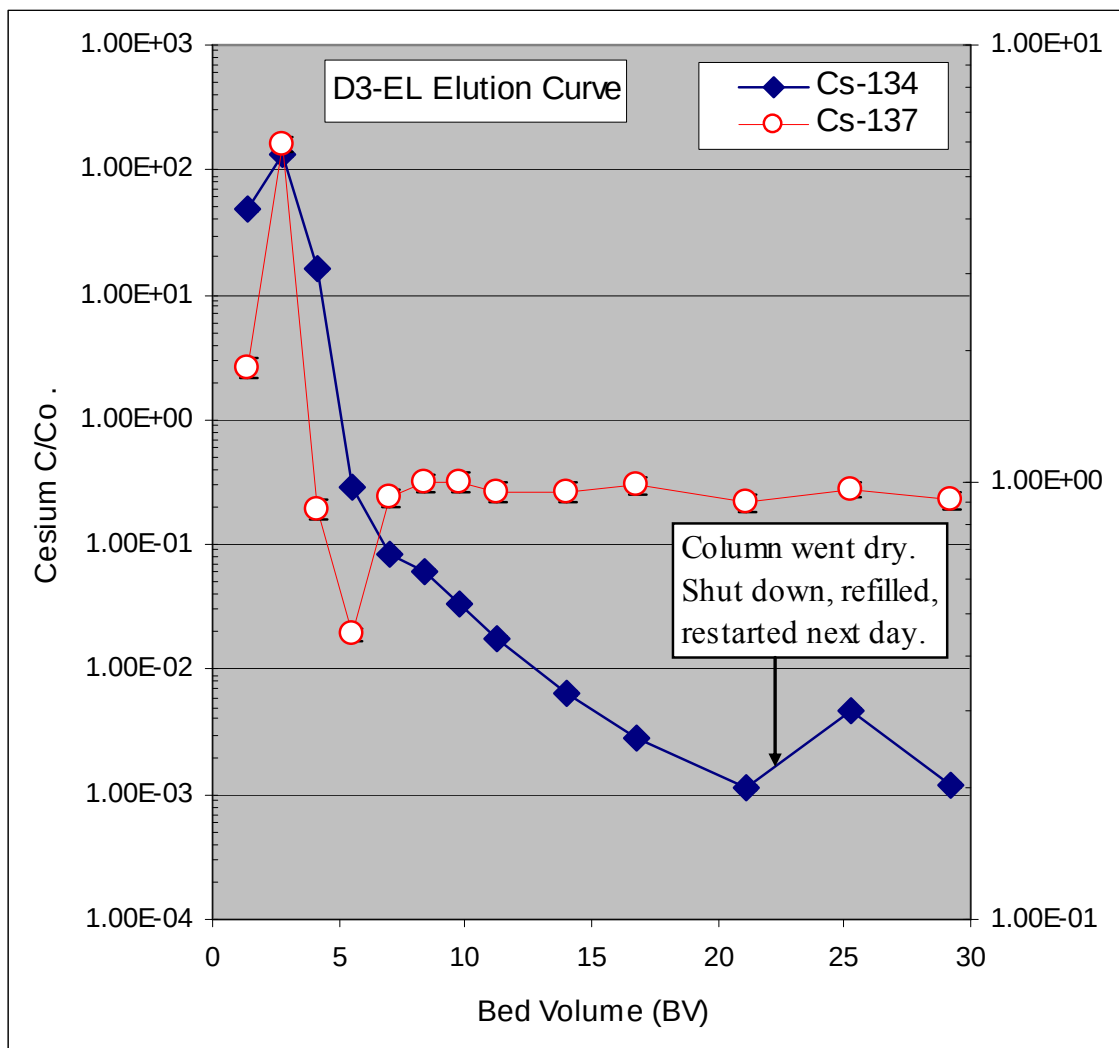


Figure A.21. Column D3 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

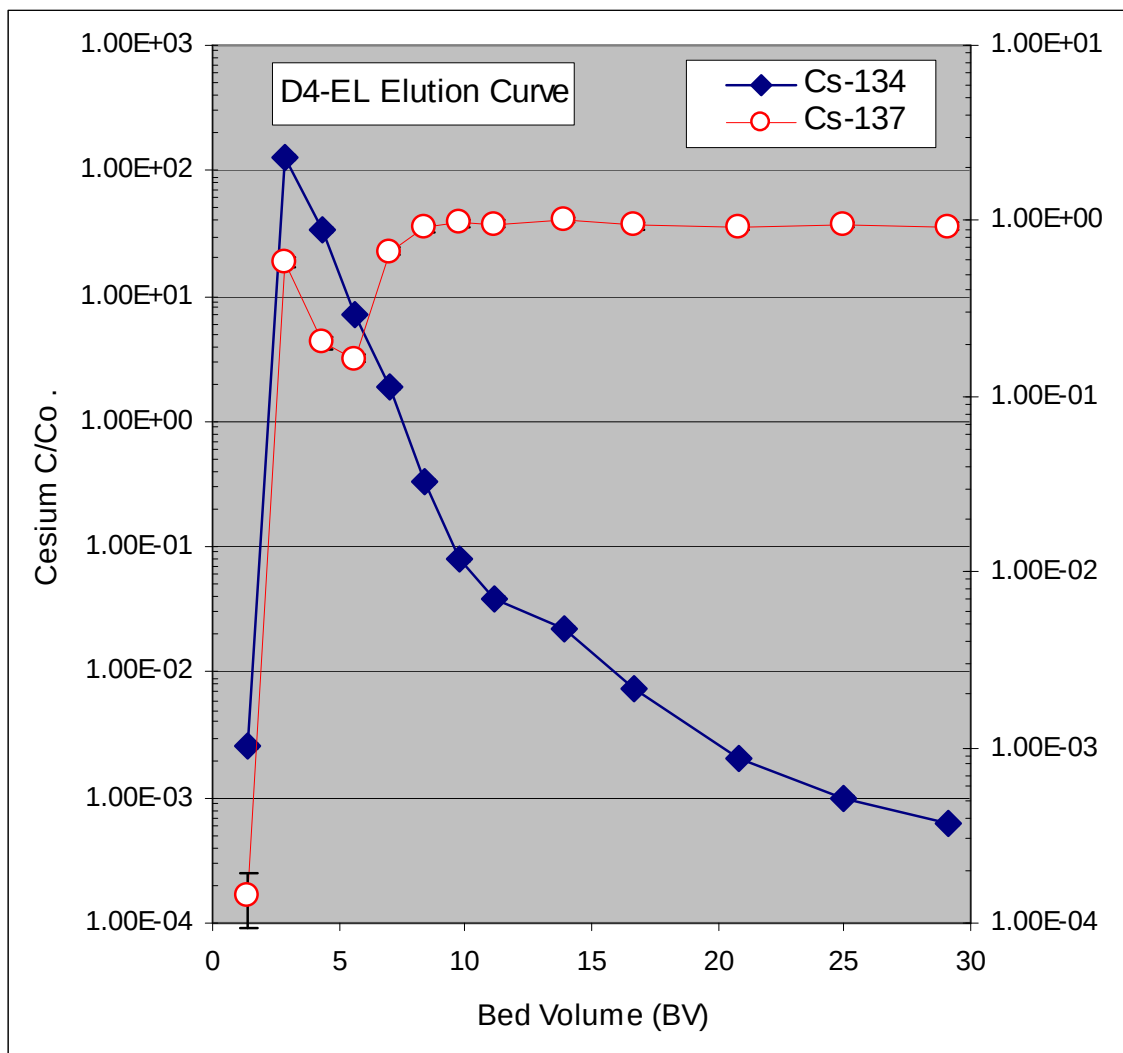


Figure A.22. Column D4 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

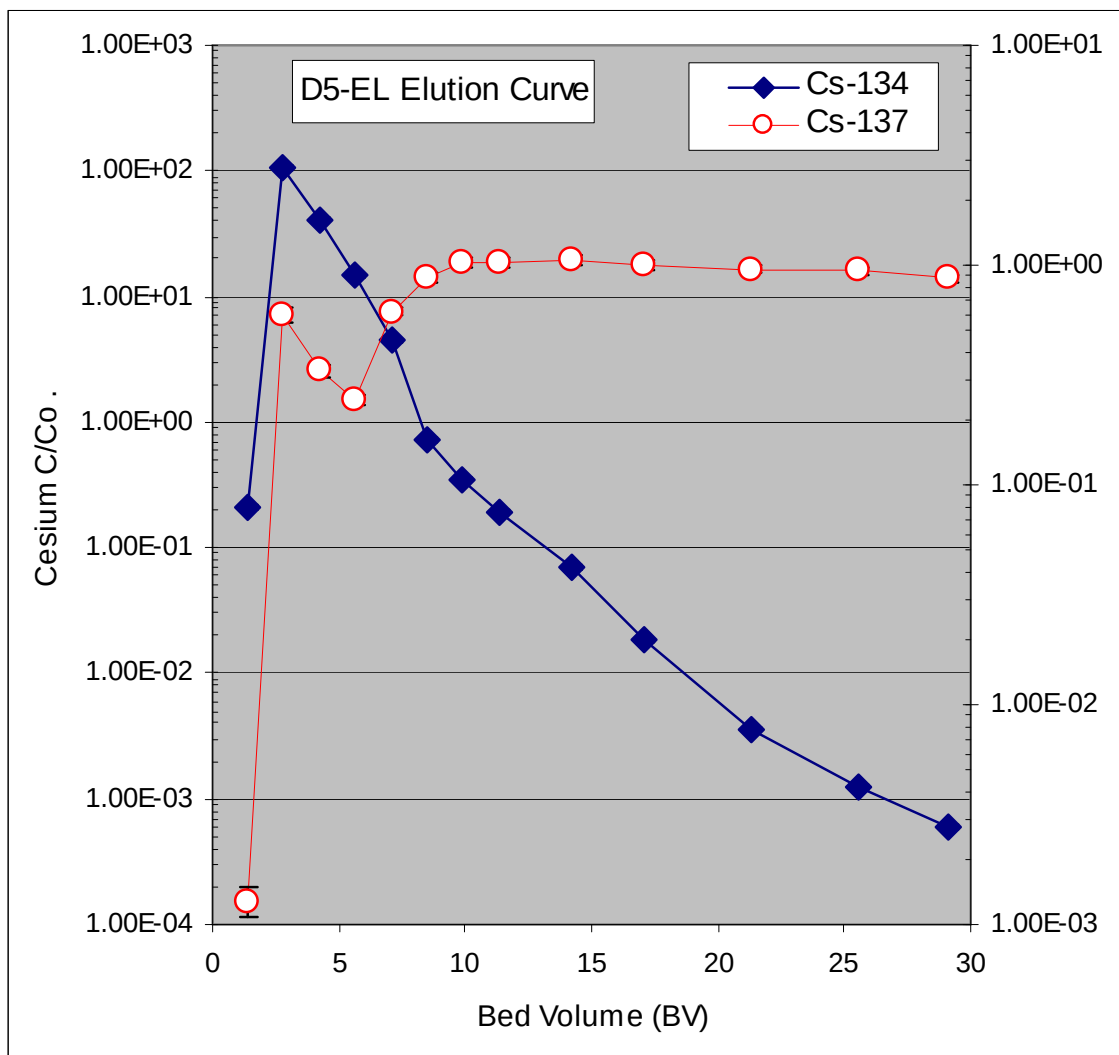


Figure A.23. Column D5 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

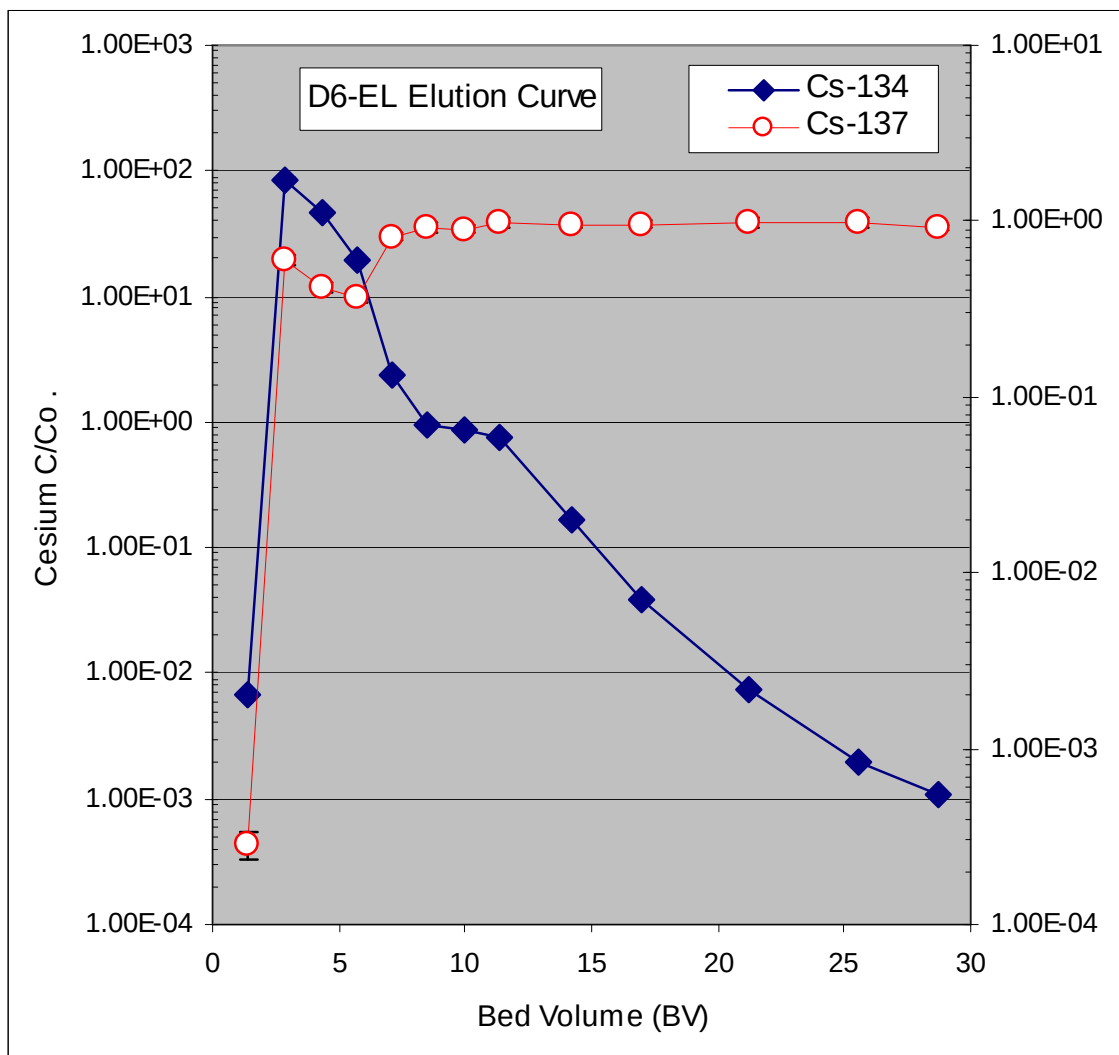


Figure A.24. Column D6 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

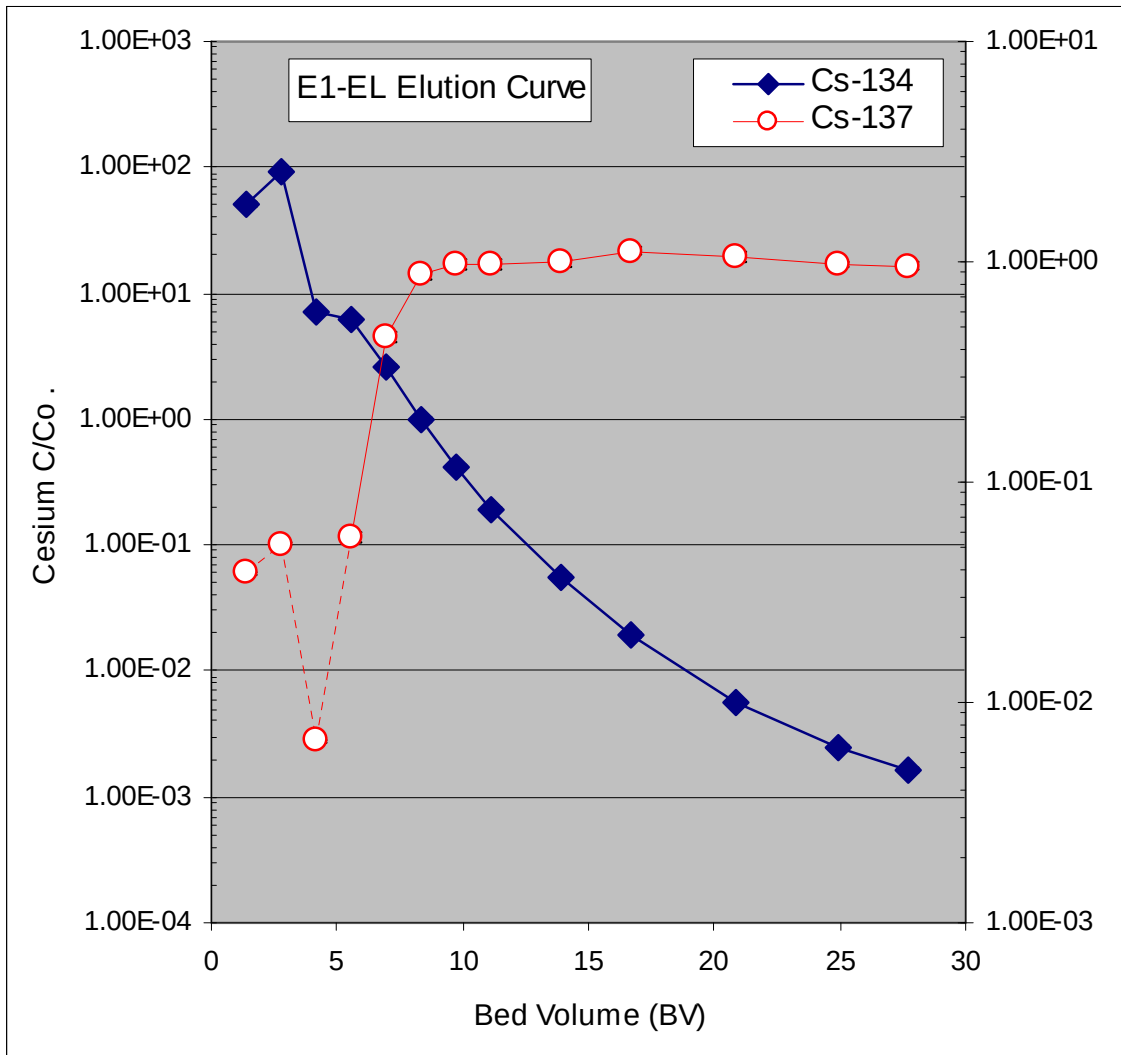


Figure A.25. Column E1 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

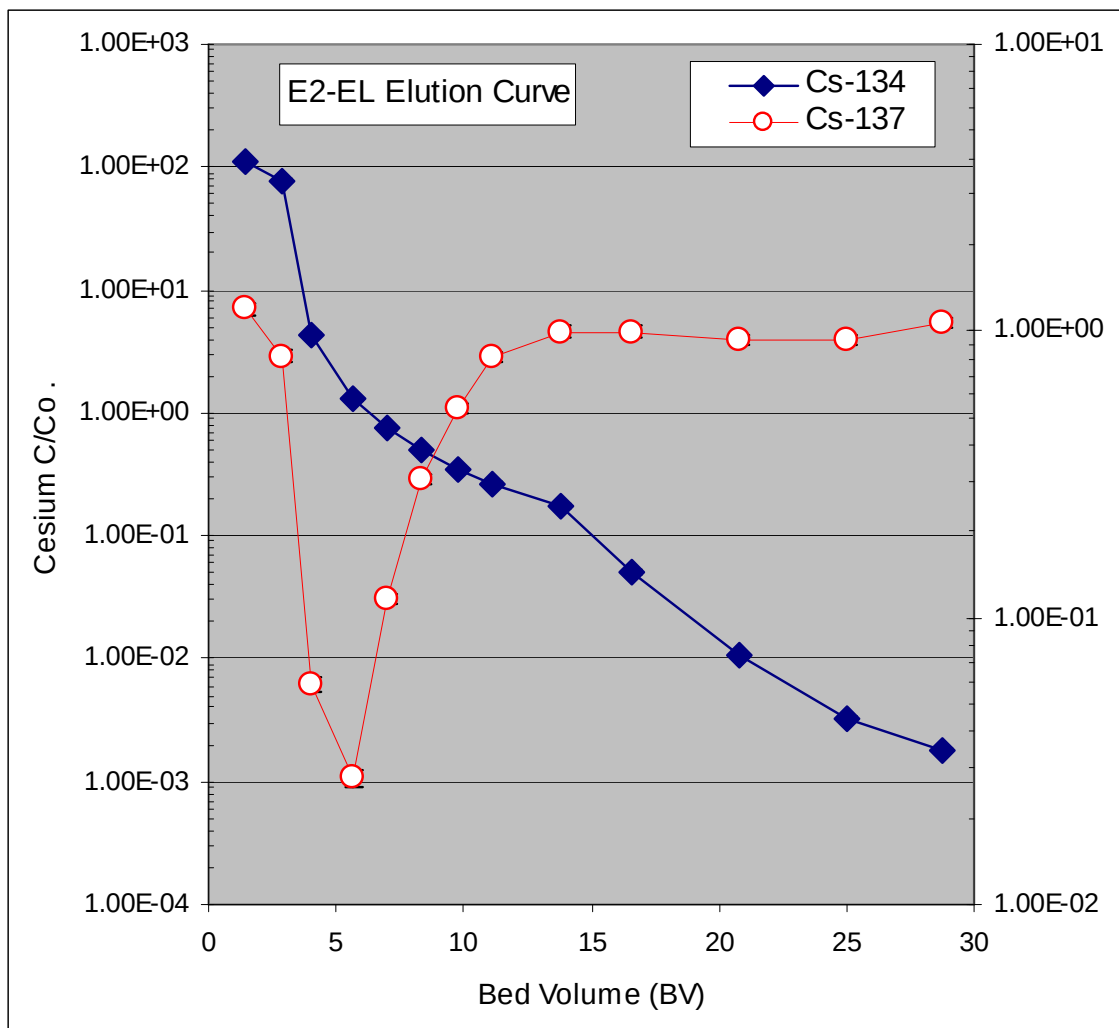


Figure A.26. Column E2 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

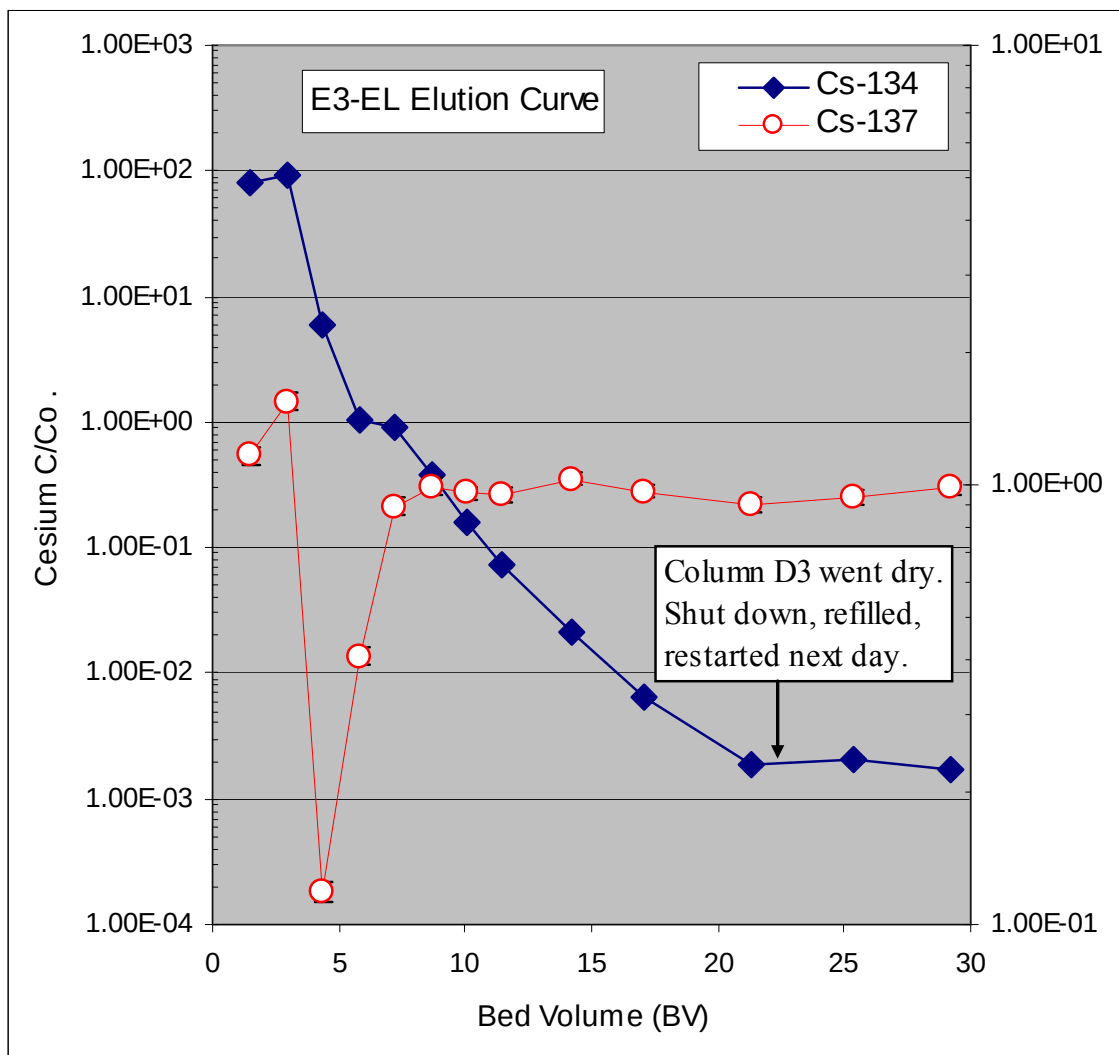


Figure A.27. Column E3 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

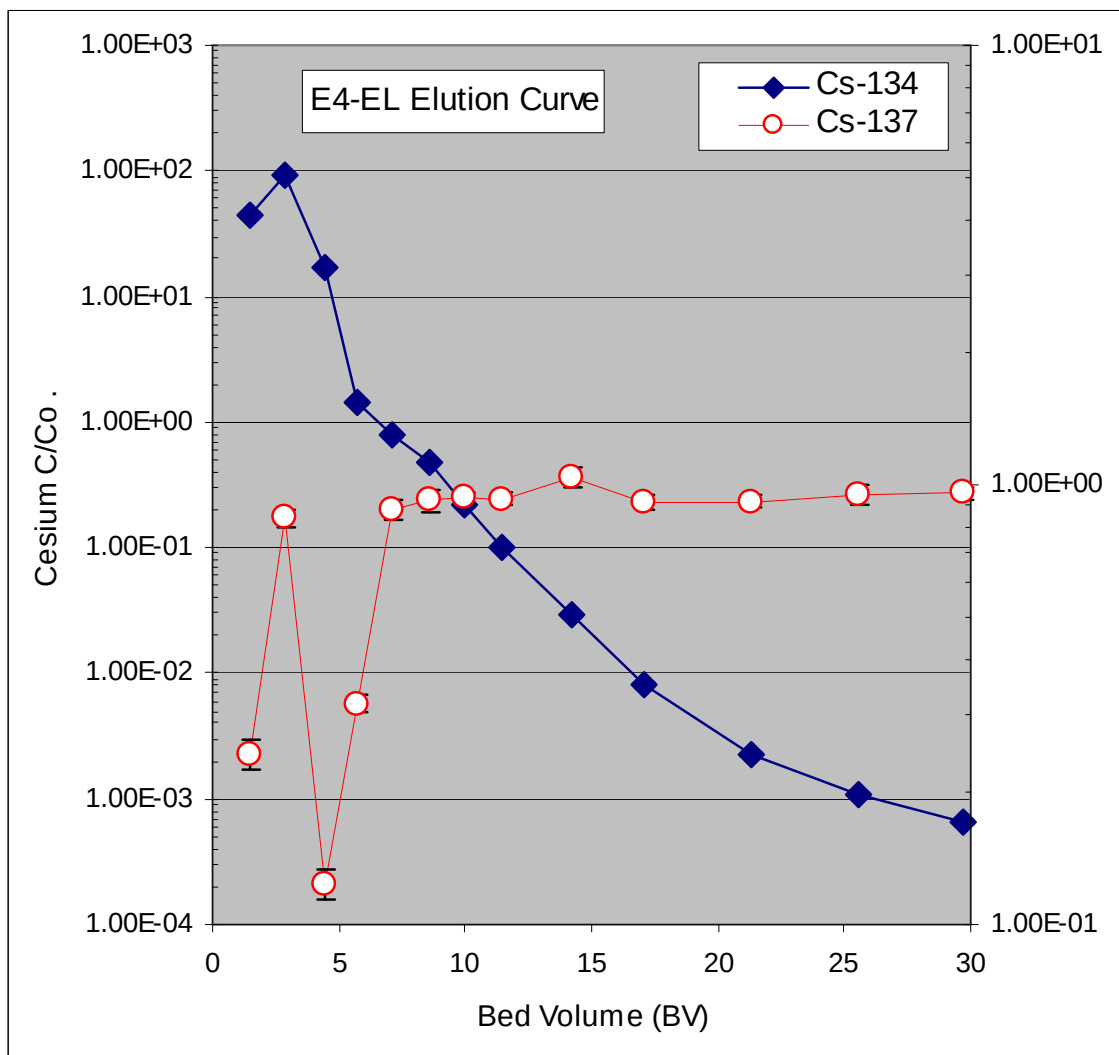


Figure A.28. Column E4 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

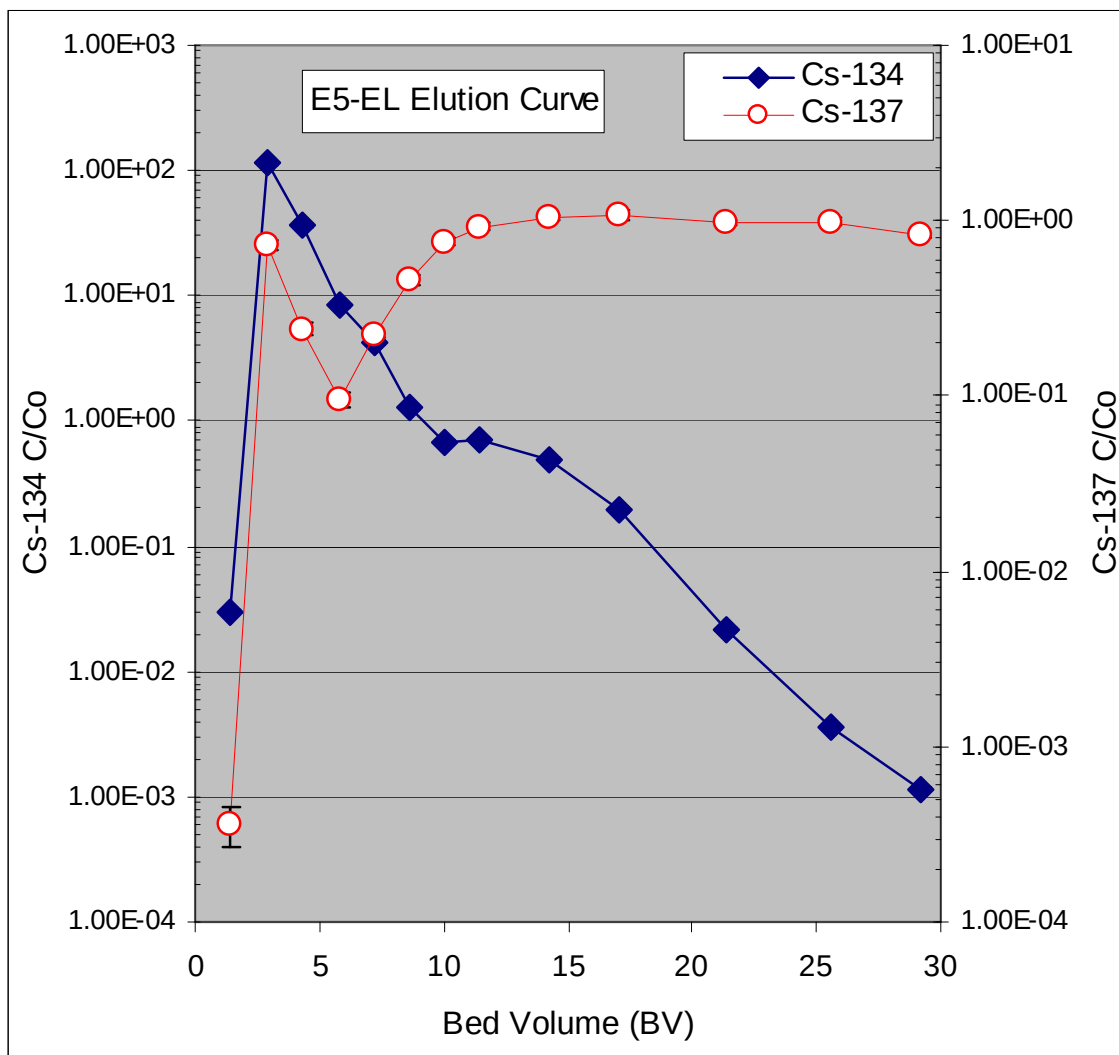


Figure A.29. Column E5 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

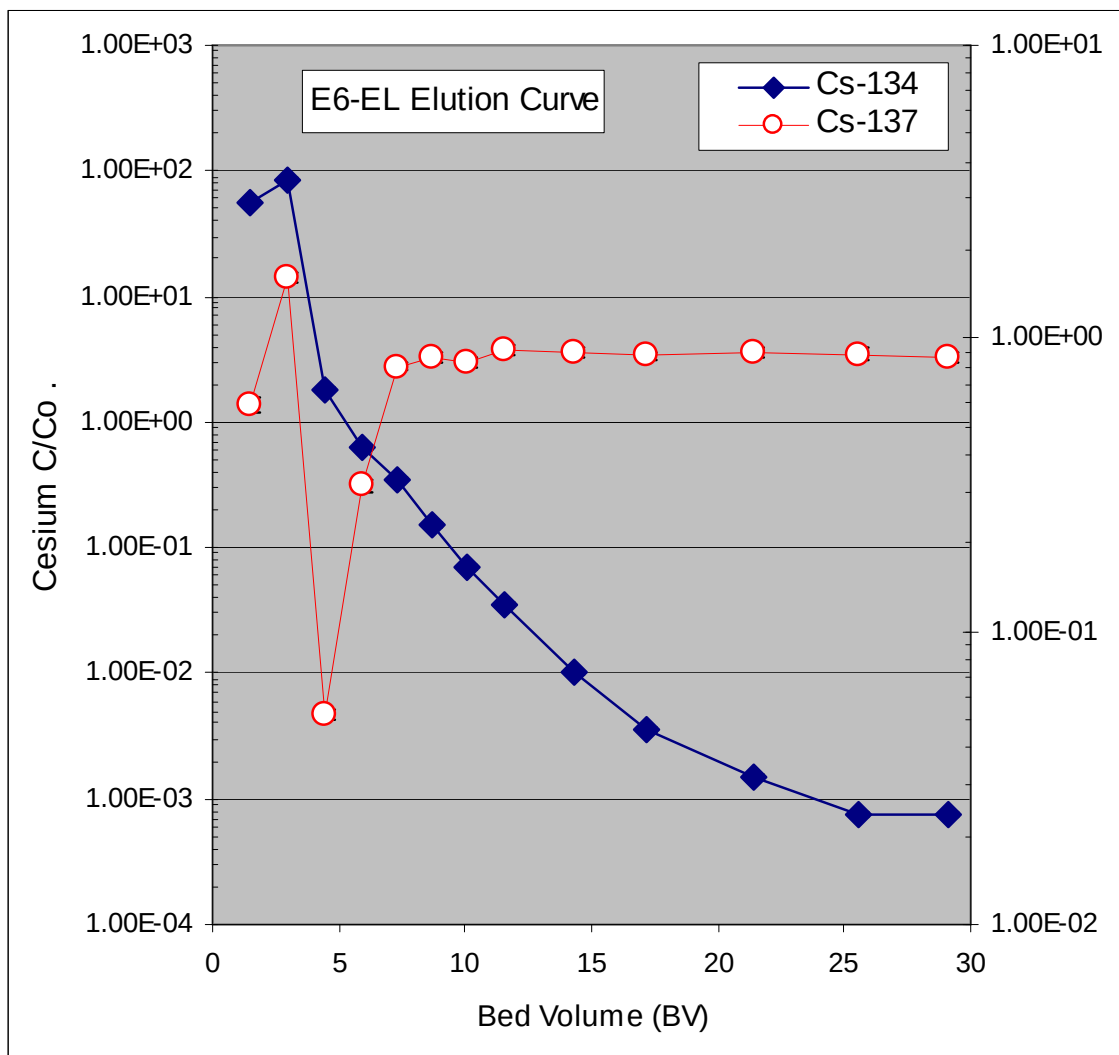


Figure A.30. Column E6 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

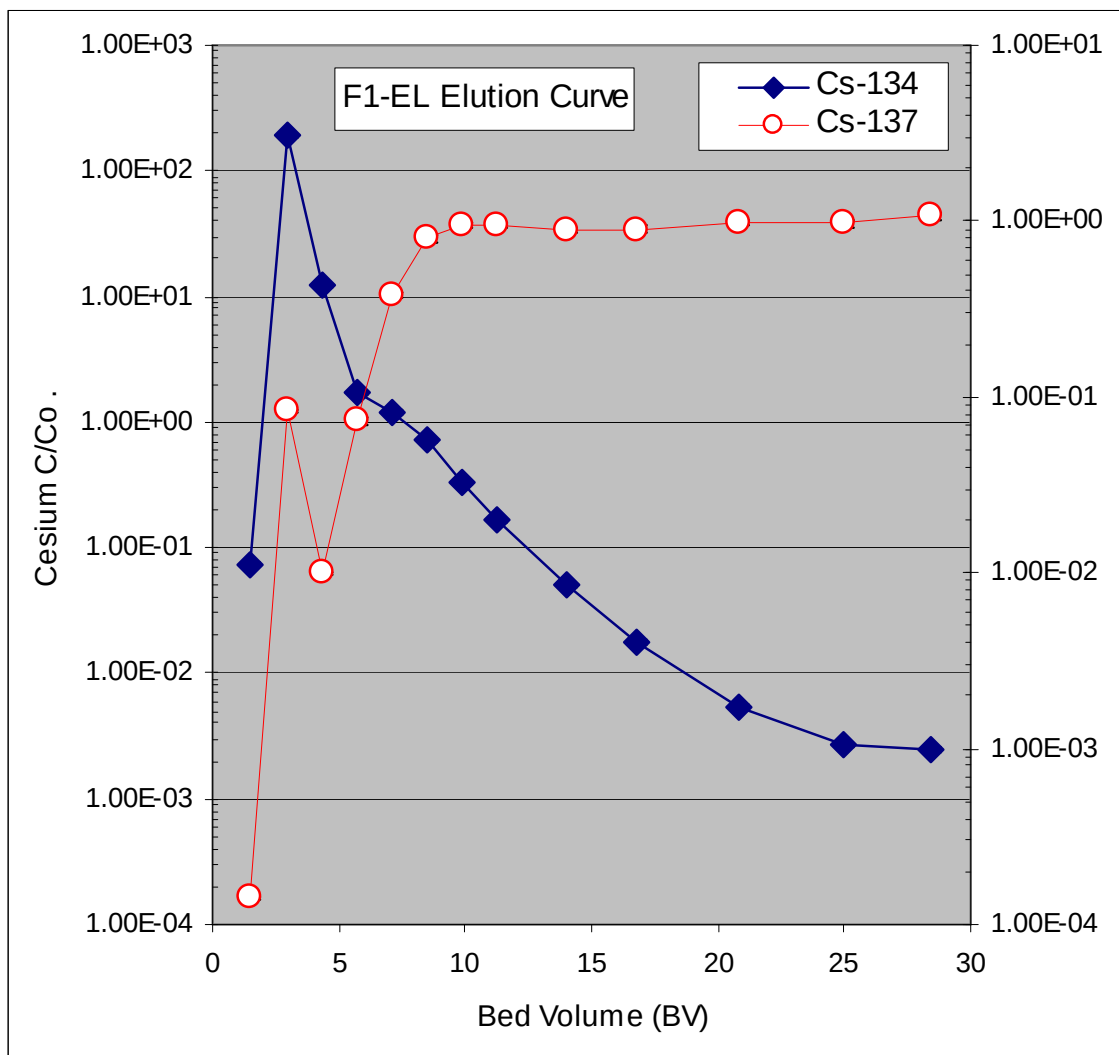


Figure A.31. Column F1 Cesium (^{134}Cs and ^{137}Cs) Elution Profiles

Appendix B

Analytical

Appendix B

Analytical

SOUTHWEST RESEARCH INSTITUTE SAMPLE ANALYSIS DATA SHEET

010003

Lab Name: Southwest Research Institute

Lab Code: SwRI

Matrix: Aqueous

Task Order #: 100907-9

Lab System ID: 445606

Sample ID
5B17 5M Feed Simulant

Client: Battelle Memorial PNNL

Project No.: 15973.01.00X

Date Received: 09/07/10

SRR #: 42378

Analysis	Sample Result (mg/L)	Reporting Limit (mg/L)	Date Analyzed	Instrument
Aluminum	3020	50	09/10/10	ICP-AES
Cesium	2.33	0.01	09/10/10	ICPMS
Sodium	105000	500	09/10/10	ICP-AES

SOUTHWEST RESEARCH INSTITUTE DUPLICATE SUMMARY

010004

Lab Name: Southwest Research Institute

Lab Code: SwRI

Matrix: Aqueous

Task Order #: 100907-9

Lab System ID: 445606D

Sample ID
5B17 5M Feed Simulant

Client: Battelle Memorial PNNL

Project No.: 15973.01.00X

Date Received: 09/07/10

SRR #: 42378

Analysis	Orig. Sample Result (mg/L)	Duplicate Result (mg/L)	RPD	Date Analyzed	Instrument
Aluminum	3020	3020	0.00%	09/10/10	ICP-AES
Cesium	2.33	2.33	0.00%	09/10/10	ICPMS
Sodium	105000	106000	0.95%	09/10/10	ICP-AES

SOUTHWEST RESEARCH INSTITUTE . 020003

SAMPLE ANALYSIS DATA SHEET

Lab Name: Southwest Research Institute

Client: Battelle Memorial PNNL

Lab Code: SwRI

Project No.: 15973.01.00X

Matrix: Aqueous

Date Received: 09/07/10

Task Order #: 100907-8

SRR #: 42378

Sample ID	Lab System ID	Acid Titration Results	Units	Date Analyzed
Prep Blank	icb	<0.001	mol/L	09/10/10
Lab Control	icv	1.03	mol/L	09/10/10
True Value	----	1.00	----	----
Recovery	----	103%	----	----
H02D2 HNO3 Stock Soln	445607	0.020	mol/L	09/10/10
H07E2 HNO3 Stock Soln	445608	0.070	mol/L	09/10/10
H07E5 HNO3 Stock Soln	445609	0.070	mol/L	09/10/10
H15D1 HNO3 Stock Soln	445610	0.150	mol/L	09/10/10
Duplicate result	445610D	0.150	mol/L	09/10/10
RPD	----	0.00%	----	----
Spike result	445610S	0.252	mol/L	09/10/10
Spike added	----	0.100	----	----
Recovery	----	102%	----	----
H15D4 HNO3 Stock Soln	445611	0.150	mol/L	09/10/10
H15D5 HNO3 Stock Soln	445612	0.150	mol/L	09/10/10
H15D6 HNO3 Stock Soln	445613	0.150	mol/L	09/10/10
H15E1 HNO3 Stock Soln	445614	0.150	mol/L	09/10/10
H15E6 HNO3 Stock Soln	445615	0.149	mol/L	09/10/10
H23E3 HNO3 Stock Soln	445616	0.229	mol/L	09/10/10
H23E4 HNO3 Stock Soln	445617	0.231	mol/L	09/10/10
H28D3 HNO3 Stock Soln	445618	0.280	mol/L	09/10/10
H28F1 HNO3 Stock Soln	445619	0.279	mol/L	09/10/10

Reporting Limit:

0.001 mol/L

SOUTHWEST RESEARCH INSTITUTE

SAMPLE ANALYSIS DATA SHEET

AA 12.16.10
020005
020004

Lab Name: Southwest Research Institute

Client: Battelle Memorial PNNL

Lab Code: SwRI

Project No.: 15973.01.00X

Matrix: Aqueous

Date Received: 09/07/10

Task Order #: 100907-8

SRR #: 42378

Sample ID	Lab System ID	Cesium Results	Units	Date Analyzed
Prep Blank	pbwj08ke1	<0.0000200	mg/L	09/10/10
Lab Control	lcswj08ke1	0.523	mg/L	09/10/10
True Value	----	0.500	----	----
Recovery	----	104.6%	----	----
H02D2 HNO3 Stock Soln	445607	0.00611	mg/L	09/10/10
Duplicate result	445607D	0.00607	mg/L	09/10/10
RPD	----	0.66%	----	----
Spike result	445607S	0.539	mg/L	09/10/10
Spike added	----	0.500	----	----
Recovery	----	106.6%	----	----
Spike Dup result	445607SD	0.532	mg/L	09/10/10
Spike added	----	0.500	----	----
Recovery	----	105.2%	----	----
H07E2 HNO3 Stock Soln	445608	0.0183	mg/L	09/10/10
H07E5 HNO3 Stock Soln	445609	0.00190	mg/L	09/10/10
H15D1 HNO3 Stock Soln	445610	0.00589	mg/L	09/10/10
H15D4 HNO3 Stock Soln	445611	0.0659	mg/L	09/10/10
H15D5 HNO3 Stock Soln	445612	<0.0000200	mg/L	09/10/10
H15D6 HNO3 Stock Soln	445613	0.0643	mg/L	09/10/10
H15E1 HNO3 Stock Soln	445614	0.00598	mg/L	09/10/10
H15E6 HNO3 Stock Soln	445615	0.00598	mg/L	09/10/10
H23E3 HNO3 Stock Soln	445616	0.00188	mg/L	09/10/10
H23E4 HNO3 Stock Soln	445617	0.0185	mg/L	09/10/10
H28D3 HNO3 Stock Soln	445618	0.00605	mg/L	09/10/10
H28F1 HNO3 Stock Soln	445619	<0.0000200	mg/L	09/10/10

Reporting Limit:

0.00002 mg/L

SOUTHWEST RESEARCH INSTITUTE

SAMPLE ANALYSIS DATA SHEET

~~M12.16.10~~
~~020006~~
020005

Lab Name: Southwest Research Institute	Sample ID 5B17 5M Feed Simulant
Lab Code: SwRI	Client: Battelle Memorial PNNL
Matrix: Aqueous	Project No.: 15973.01.00X
Task Order #: 100907-9	Date Received: 09/07/10
Lab System ID: 445606	SRR #: 42378

Analysis	Sample Result	Reporting Limit	Units	Date Analyzed	Method
Total Inorganic Carbon	55.2	0.2	mg/L	09/26/10	SW846 9060M
Chloride	54100	500	mg/L	09/13/10	SW846 9056
Nitrate-N	11600	500	mg/L	09/13/10	SW846 9056
Nitrite-N	10600	500	mg/L	09/13/10	SW846 9056
Base Titration					
1st EQP	1.47	0.5	meq/L	09/14/10	SW846 9060M
2nd EQP	1.60	0.5	meq/L	09/14/10	SW846 9060M

SOUTHWEST RESEARCH INSTITUTE

DUPLICATE SUMMARY

~~M12.16.10~~
~~020007~~
020006

Lab Name: Southwest Research Institute	Sample ID 5B17 5M Feed Simulant
Lab Code: SwRI	Client: Battelle Memorial PNNL
Matrix: Aqueous	Project No.: 15973.01.00X
Task Order #: 100907-9	Date Received: 09/07/10
Lab System ID: 445606D	SRR #: 42378

Analysis	Orig. Sample Result	Duplicate Result	RPD	Units	Date Analyzed
Total Inorganic Carbon	55.2	69.1	22.4%	mg/L	09/26/10
Chloride	54100	53900	0.37%	mg/L	09/13/10
Nitrate-N	11600	11600	0.00%	mg/L	09/13/10
Nitrite-N	10600	10600	0.00%	mg/L	09/13/10
Base Titration					
1st EQP	1.47	1.46	0.68%	meq/L	09/14/10
2nd EQP	1.60	1.61	0.62%	meq/L	09/14/10

SOUTHWEST RESEARCH INSTITUTE

SAMPLE ANALYSIS DATA SHEET

M^{12.16.10}
~~020011~~
 020010

Lab Name: Southwest Research Institute

Client: Battelle Memorial PNNL

Lab Code: SwRI

Project No.: 15973.01.00X

Matrix: Aqueous

Date Received: 09/07/10

Task Order #: 100907-10

SRR #: 42378

Sample ID	Lab System ID	Acid Titration Results	Units	Date Analyzed
Prep Blank	icb	<0.001	mol/L	09/10/10
Lab Control	icv	1.03	mol/L	09/10/10
True Value	----	1.00	----	----
Recovery	----	103%	----	----
H50M-1 HNO3 Stock Soln	445620	0.500	mol/L	09/10/10
Duplicate result	445620D	0.500	mol/L	09/10/10
RPD	----	0.00%	----	----
Spike result	445620S	0.806	mol/L	09/10/10
Spike added	----	0.300	----	----
Recovery	----	102%	----	----
H50M-2 HNO3 Stock Soln	445621	0.501	mol/L	09/10/10
H50M-3 HNO3 Stock Soln	445622	0.496	mol/L	09/10/10

Reporting Limit:

0.001 mol/L

SOUTHWEST RESEARCH INSTITUTE

SAMPLE ANALYSIS DATA SHEET

11/2/16
~~020012~~
020011

Lab Name: Southwest Research Institute

Client: Battelle Memorial PNNL

Lab Code: SwRI

Project No.: 15973.01.00X

Matrix: Aqueous

Date Received: 09/07/10

Task Order #: 100907-10

SRR #: 42378

Sample ID	Lab System ID	Base Titration Results	Units	Date Analyzed
Prep Blank	icb	<0.001	mol/L	09/14/10
Lab Control	icv	0.993	mol/L	09/14/10
True Value	----	1.00	----	----
Recovery	----	99.3%	----	----
NaI.00M NaOH Stock Soln	445623	0.944	mol/L	09/14/10
Na0.50M#1 NaOH Stock Soln	445624	0.476	mol/L	09/14/10
Duplicate result	445624D	0.478	mol/L	09/14/10
RPD	----	0.419%	----	----
Spike result	445624S	0.771	mol/L	09/14/10
Spike added	----	0.300	----	----
Recovery	----	98.3%	----	----
Na0.10M NaOH Stock Soln	445625	0.095	mol/L	09/14/10
Na0.50M#2 NaOH Stock Soln	445626	0.475	mol/L	09/14/10

Reporting Limit:

0.5 mg/L

SOUTHWEST RESEARCH INSTITUTE

SAMPLE ANALYSIS DATA SHEET

11/2/16
~~020012~~
020012

Sample ID

H50M-1 HNO3 Stock Soln

Lab Name: Southwest Research Institute

Client: Battelle Memorial PNNL

Lab Code: SwRI

Project No.: 15973.01.00X

Matrix: Aqueous

Date Received: 09/07/10

Task Order #: 100907-10

SRR #: 42378

Lab System ID: 445620

Analysis	Sample Result (mg/L)	Reporting Limit (mg/L)	Date Analyzed	Instrument
Cesium	<0.0000200	0.00002	09/10/10	ICPMS
Sodium	<1.25	1.25	09/09/10	ICP-AES

SOUTHWEST RESEARCH INSTITUTE

DUPLICATE SUMMARY

020013

Lab Name: Southwest Research Institute
 Lab Code: SwRI
 Matrix: Aqueous
 Task Order #: 100907-10
 Lab System ID: 445620D

Sample ID
 H50M-1 HNO3 Stock Soln

Client: Battelle Memorial PNNL
 Project No.: 15973.01.00X
 Date Received: 09/07/10
 SRR #: 42378

Analysis	Orig. Sample Result (mg/L)	Duplicate Result (mg/L)	RPD	Date Analyzed	Instrument
Cesium	<0.0000200	<0.0000200	0.00%	09/10/10	ICPMS
Sodium	<1.25	<1.25	0.00%	09/09/10	ICP-AES

SOUTHWEST RESEARCH INSTITUTE

SAMPLE ANALYSIS DATA SHEET

020016

Lab Name: Southwest Research Institute
 Lab Code: SwRI
 Matrix: Aqueous
 Task Order #: 100907-10
 Lab System ID: 445621

Sample ID
 H50M-2 HNO3 Stock Soln

Client: Battelle Memorial PNNL
 Project No.: 15973.01.00X
 Date Received: 09/07/10
 SRR #: 42378

Analysis	Sample Result (mg/L)	Reporting Limit (mg/L)	Date Analyzed	Instrument
Cesium	<0.0000200	0.00002	09/10/10	ICPMS
Sodium	<1.25	1.25	09/09/10	ICP-AES

SOUTHWEST RESEARCH INSTITUTE

SAMPLE ANALYSIS DATA SHEET

020019

Lab Name: Southwest Research Institute

Lab Code: SwRI

Matrix: Aqueous

Task Order #: 100907-10

Lab System ID: 445622

Sample ID
H50M-3 HNO3 Stock Soln

Client: Battelle Memorial PNNL

Project No.: 15973.01.00X

Date Received: 09/07/10

SRR #: 42378

Analysis	Sample Result (mg/L)	Reporting Limit (mg/L)	Date Analyzed	Instrument
Cesium	<0.0000200	0.00002	09/10/10	ICPMS
Sodium	<1.25	1.25	09/09/10	ICP-AES

SOUTHWEST RESEARCH INSTITUTE

SAMPLE ANALYSIS DATA SHEET

020020

Lab Name: Southwest Research Institute

Lab Code: SwRI

Matrix: Aqueous

Task Order #: 100907-10

Lab System ID: 445623

Sample ID
Na1.00M NaOH Stock Soln

Client: Battelle Memorial PNNL

Project No.: 15973.01.00X

Date Received: 09/07/10

SRR #: 42378

Analysis	Sample Result (mg/L)	Reporting Limit (mg/L)	Date Analyzed	Instrument
Cesium	<0.000200	0.0002	09/10/10	ICPMS
Sodium	21000	25	09/09/10	ICP-AES

SOUTHWEST RESEARCH INSTITUTE

SAMPLE ANALYSIS DATA SHEET

020021

Lab Name: Southwest Research Institute

Lab Code: SwRI

Matrix: Aqueous

Task Order #: 100907-10

Lab System ID: 445624

Sample ID

Na0.50M#1 NaOH Stock Soln

Client: Battelle Memorial PNNL

Project No.: 15973.01.00X

Date Received: 09/07/10

SRR #: 42378

Analysis	Sample Result (mg/L)	Reporting Limit (mg/L)	Date Analyzed	Instrument
Cesium	<0.000200	0.0002	09/10/10	ICPMS
Sodium	10100	25	09/09/10	ICP-AES

SOUTHWEST RESEARCH INSTITUTE

SAMPLE ANALYSIS DATA SHEET

020024

Lab Name: Southwest Research Institute

Lab Code: SwRI

Matrix: Aqueous

Task Order #: 100907-10

Lab System ID: 445625

Sample ID

Na0.10M NaOH Stock Soln

Client: Battelle Memorial PNNL

Project No.: 15973.01.00X

Date Received: 09/07/10

SRR #: 42378

Analysis	Sample Result (mg/L)	Reporting Limit (mg/L)	Date Analyzed	Instrument
Cesium	<0.0000400	0.00004	09/10/10	ICPMS
Sodium	1970	25	09/10/10	ICP-AES

SOUTHWEST RESEARCH INSTITUTE

SAMPLE ANALYSIS DATA SHEET

020027

Lab Name: Southwest Research Institute

Lab Code: SwRI

Matrix: Aqueous

Task Order #: 100907-10

Lab System ID: 445626

Sample ID
Na0.50M#2 NaOH Stock Soln

Client: Battelle Memorial PNNL

Project No.: 15973.01.00X

Date Received: 09/07/10

SRR #: 42378

Analysis	Sample Result (mg/L)	Reporting Limit (mg/L)	Date Analyzed	Instrument
Cesium	<0.000200	0.0002	09/10/10	ICPMS
Sodium	10200	25	09/10/10	ICP-AES

Southwest Research Institute Base Titration

*✓ RSPis
9/29/10*

Client: Battelle PNNL
Project #: 15973.01.006
TO #: 100907-10, 100907-9
Method: 9060M

Date: 09/14/10
Analyst: Monica Mendoza
RL = 0.5 mg/l
Sig Figs: 3

Titrant : 0.1036 N HCl Inorg # 8487
ICV /CCV : 1.00 N NaOH Inorg # 8484
ICB : Deionized water

445606S = (0.3ml x 1N NaOH) / 0.2ml = 0.15 meq/L

SwRI Sample ID	Client ID	Initial Sample Wt/Vol (g or mL)	Final Wt/Vol (g or mL)	Sample Volume Titrated (mL)	Titrant Vol. to 1st EQP (mL)	Titrant Vol. to 2nd EQP (mL)	Titrant Vol. to 3rd EQP (mL)	meq/mL to 1st EQP	meq/mL to 2nd EQP	meq/mL to 3rd EQP	%Rec %RPD
ICV		0.300	50	0.300	2.88			0.994	0.000	0.000	99.4%
ICB		20.0	50	20.0	0.00			<0.001	0.000	0.000	
445623	Na1.00M NaOH Stock soln	0.500	50	0.50	4.56			0.944	0.000	0.000	
445624	Na0.50M#1 NaOH stock soln	1.00	50	1.00	4.60			0.476	0.000	0.000	
445624D	Na0.50M#1 NaOH stock soln	1.00	50	1.00	4.61			0.478	0.000	0.000	0.419% RPD
445624S	Na0.50M#1 NaOH stock soln	1.00	50	1.00	7.44			0.771	0.000	0.000	98.3%
445625	Na0.10M NaOH Stock soln	5.00	50	5.00	4.60			0.095	0.000	0.000	
445626	Na0.50M#2 NaOH stock soln	1.00	50	1.00	4.58			0.474	0.000	0.000	
CCV		0.300	50	0.300	2.87			0.990	0.000	0.000	99.0%
CCB		20.0	50	20.0	0.00			<0.001	0.000	0.000	
445606	5B17 5M Feed Simulant	0.200	50	0.200	2.83	3.09		1.47	1.60	0.000	
445606D	5B17 5M Feed Simulant	0.200	50	0.200	2.83	3.10		1.46	1.61	0.000	0.683% / 0.623 RPD
445606S	5B17 5M Feed Simulant	0.200	50	0.200	5.72	6.02		2.96	3.12	0.000	97.3% / 101%
CCV		0.300	50	0.300	2.90			1.00	0.000	0.000	100%
CCB		20.0	50	20.0	0.00			<0.001	0.000	0.000	

Sample calc 445606 EQP1 =

$$\frac{2.83 \text{ mL} \times 0.1036 \text{ N}}{0.2 \text{ mL}} = 1.47 \text{ N} = 1.47 \text{ meq/mL}$$

020065

Southwest Research Institute

Base Titration

Revised 9/29/10 029127

Client: Battelle PNNL
Project: 15973.01.006
TO#: 100907-10
Method: 6090M

Date: 09/14/10
Analyst: M. Mendoza mm
RL= 0.5 mg/L
Sig Figs: 3

Titrant : 0.1036 N HCL
ICV /CCV : 1.00 N NaOH
ICB : Deionized Water
Notes: Epp:1000-C

Inorg # 8487
Inorg # 8484

Sample ID	Client ID	NaOH (M)	Comments
ICV		0.993	99.3% TV=1.00
ICB		<0.001	
445623 *	Na1.00M NaOH Stock Soln	0.944	
445624	Na0.50M#1 NaOH Stock Soln	0.476	
445624D	Na0.50M#1 NaOH Stock Soln	0.478	0.419% RPD
445624S	Na0.50M#1 NaOH Stock Soln	0.771	98.3% TV=0.3N
445625	Na0.10M NaOH Stock Soln	0.095	
445626	Na0.50M#2 NaOH Stock Soln	0.475	
CCV		0.990	99.0% TV=1.00
CCB		<0.001	

* See raw data for calculation information:

Sample calc: 445623

$$\frac{4.556 \text{ mL} \times 0.1036 \text{ N}}{0.5 \text{ mL}} = 0.944 \text{ M}$$

Southwest Research Institute

Acid Titration

020189

Client: Battelle PNNL
Project: 15973.01.006
TO#: 100907-8, 100907-10
Method: 6090M

Date: 09/10/10
Analyst: M. Mendoza *mm*
RL= 0.5 mg/L
Sig Figs: 3

Titrant : 0.1N NaOH
ICV /CCV : 1.00 N HNO3
ICB : Deionized Water
Notes: Epp: 5000-C, 1000-M

Inorg # 8485
Inorg # 8540

Sample ID	Client ID	HNO3 (M)	Comments
ICV		1.03	103% TV=1.00
ICB		<0.001	
445607	H02D2 HNO3 Stock Soln	0.020	
445608	H07E2 HNO3 Stock Soln	0.070	
445609	H07E5 HNO3 Stock Soln	0.070	
445610	H15D1 HNO3 Stock Soln	0.150	
445610D	H15D1 HNO3 Stock Soln	0.150	0.00% RPD
445610S	H15D1 HNO3 Stock Soln	0.252	102% TV=0.1N
445611	H15D4 HNO3 Stock Soln	0.150	
CCV		1.03	103% TV=1.00
CCB		<0.001	
445612	H15D5 HNO3 Stock Soln	0.150	
445613	H15D6 HNO3 Stock Soln	0.150	
445614	H15E1 HNO3 Stock Soln	0.150	
445615	H15E6 HNO3 Stock Soln	0.149	
445616	H23E3 HNO3 Stock Soln	0.229	
445617	H23E4 HNO3 Stock Soln	0.231	
445618	H28D3 HNO3 Stock Soln	0.280	
CCV		1.03	103% TV=1.00
CCB		<0.001	
445619	H28F1 HNO3 Stock Soln	0.279	
445620	H50M-1 HNO3 Stock Soln	0.500	
445620D	H50M-1 HNO3 Stock Soln	0.500	0.00% RPD
445620S	H50M-1 HNO3 Stock Soln	0.806	102% TV=0.3N
445621	H50M-2 HNO3 Stock Soln	0.501	
445622	H50M-3 HNO3 Stock Soln	0.496	
CCV		1.03	103% TV=1.00
CCB		<0.001	

Sample calc: 445607
See raw data for calc.
information.

$$\frac{4.038 \text{ mL} \times 0.1 \text{ N}}{20 \text{ mL}} = 0.02 \text{ N}$$

Battelle, Pacific Northwest National Laboratory
PO Box 999
Richland, WA
Radiochemical Sciences and Engineering Group

filename: 10-1060_Brown

Previously reported on 9/20/2010

Client: G. Brown
ASR: 8700

Prepared by:

C. Soderquist 12-17-2010

Concur:

T Trang-le 12-17-2010

Procedures: RPG-CMC-450, Rev. 1 Gamma Energy Analysis (GEA)
and Low-Energy Photon Spectrometry (LEPS)

M & TE: Gamma Detector T

Reference Date: August 15, 2010 @ noon

<u>Measured Activities, $\mu\text{Ci}/\text{sample}$ with 1-sigma uncertainty</u>			
<u>Sample ID</u>	<u>RPL ID</u>	<u>Cs-134</u>	<u>Cs-137</u>
D1- Column	10-1060	5.91E-2 $\pm$ 2%	2.46E+0 $\pm$ 3%
E1- Column	10-1061	4.80E-2 $\pm$ 2%	2.78E+0 $\pm$ 3%

The samples were counted on the T detector for 1 hour. Uncertainties only reflect counting statistics and absolute uncertainties are higher since the sample did not match one of our calibrated counting geometries.

Battelle, Pacific Northwest National Laboratory
PO Box 999
Richland, WA
Radiochemical Sciences and Engineering Group

filename: 10-1060_Brown

Previously reported on 10/4/2010

Client: G. Brown
ASR: 8700

Procedures: RPG-CMC-450, Rev. 1 Gamma Energy Analysis (GEA)
and Low-Energy Photon Spectrometry (LEPS)
M & TE: Gamma Detectors T
Reference Date: August 15, 2010 @ noon

<u>Measured Activities, $\mu\text{Ci}/\text{sample}$ with 1-sigma uncertainty</u>			
<u>Sample ID</u>	<u>RPL ID</u>	<u>Cs-134</u>	<u>Cs-137</u>
D2- Column	10-1062	1.85E+0 $\pm$ 2%	9.66E+0 $\pm$ 3%
E2- Column	10-1063	5.53E-2 $\pm$ 2%	4.33E+0 $\pm$ 3%

The samples were counted on the T detector. Uncertainties only reflect counting statistics and absolute uncertainties are higher since the sample did not match one of our calibrated counting geometries.

Battelle, Pacific Northwest National Laboratory
PO Box 999
Richland, WA
Radiochemical Sciences and Engineering Group

filename: 10-1060_Brown

Previously reported on 10/14/2010

Client: G. Brown
ASR: 8700

Procedures: RPG-CMC-450, Rev. 1 Gamma Energy Analysis (GEA)
and Low-Energy Photon Spectrometry (LEPS)
M & TE: Gamma Detectors T
Reference Date: August 15, 2010 @ noon

<u>Measured Activities, $\mu\text{Ci}/\text{sample}$ with 1-sigma uncertainty</u>			
<u>Sample ID</u>	<u>RPL ID</u>	<u>Cs-134</u>	<u>Cs-137</u>
D3- Column	10-1064	2.19E-2 $\pm$ 2%	1.00E+0 $\pm$ 3%
E3- Column	10-1065	3.00E-2 $\pm$ 2%	1.63E+0 $\pm$ 3%
D4- Column	10-1066	2.84E-2 $\pm$ 2%	2.16E+0 $\pm$ 3%
E4- Column	10-1067	2.63E-2 $\pm$ 2%	1.90E+0 $\pm$ 3%

The samples were counted on the T detector. Uncertainties only reflect counting statistics and absolute uncertainties are higher since the sample did not match one of our calibrated counting geometries.

11/5/2010

Battelle, Pacific Northwest National Laboratory
PO Box 999
Richland, WA
Radiochemical Sciences and Engineering Group

Client: Brown
ASR: 8700

Prepared by:

Concur:

T Trang-le 11/5/10
C. Soderquist 11-11-10

Procedures: RPG-CMC-450, Rev. 1 Gamma Energy Analysis (GEA) and Low-Energy Photon Spectrometry (LEPS)

M & TE: Gamma Detectors T

Reference Date: August 15, 2010 @ noon

Measured Activities, $\mu\text{Ci/sample}$ with 1-sigma uncertainty

Sample ID	RPL ID	Cs-134	Cs-137
D5- Column	10-1068	2.85E-2 $\pm$ 2%	1.71E+0 $\pm$ 3%
E5- Column	10-1069	3.02E-2 $\pm$ 2%	3.40E+0 $\pm$ 3%
D6- Column	10-1070	2.63E-2 $\pm$ 2%	1.39E+0 $\pm$ 3%
E6- Column	10-1071	2.78E-2 $\pm$ 2%	1.58E+0 $\pm$ 3%
F1- Column	10-1072	6.09E-2 $\pm$ 2%	1.82E+0 $\pm$ 3%

The samples were counted on the T detector. Uncertainties only reflect counting statistics and absolute uncertainties are higher since the sample did not match one of our calibrated counting geometries.

Pacific Northwest National Laboratory
PO Box 999
Richland, WA 99354
Radiochemical Sciences and Engineering Group

filename: 10-1060_Brown
12/10/2010
Revision 1

This revision includes several recounts. The other data unchanged from the original version of the report.

Client: G. Brown
ASR: 8700

Prepared by:

T Trang-le 12-10-10

Concur:

C. Soderquist 12-10-10

Procedures: RPG-CMC-450, Rev. 1 Gamma Energy Analysis (GEA) and Low-Energy Photon Spectrometry (LEPS)
M & TE: Gamma Detectors C, D, E, G, K
Reference Date: August 15, 2010

Measured Activities, $\mu\text{Ci/sample}$ with 1-sigma uncertainty

Sample ID	RPL ID	Cs-134	Cs-137	Recounts done on December 9, 2010	
				Cs-134	Cs-137
D1-EL-00	10-1073	<4.E-6	6.31E-2 $\pm$ 3%	<7.E-6	5.85E-2 $\pm$ 4%
D2-EL-00	10-1074	<4.E-6	6.02E-2 $\pm$ 3%		
D3-EL-00	10-1075	<4.E-6	5.89E-2 $\pm$ 3%		
D4-EL-00	10-1076	<4.E-6	6.11E-2 $\pm$ 3%		
D5-EL-00	10-1077	<5.E-6	6.39E-2 $\pm$ 3%		
D6-EL-00	10-1078	<4.E-6	6.12E-2 $\pm$ 3%		
E1-EL-00	10-1079	<4.E-6	7.34E-2 $\pm$ 2%		
E2-EL-00	10-1080	<5.E-6	7.29E-2 $\pm$ 2%		
E3-EL-00	10-1081	<4.E-6	7.38E-2 $\pm$ 2%		
E4-EL-00	10-1082	<4.E-6	7.40E-2 $\pm$ 2%		
E5-EL-00	10-1083	<4.E-6	6.81E-2 $\pm$ 2%		
E6-EL-00	10-1084	<4.E-6	6.31E-2 $\pm$ 2%		
F1-EL-00	10-1085	<7.E-6	6.37E-2 $\pm$ 2%		
D1-LD-00	10-1086	1.03E+0 $\pm$ 2%	<9.E-4	<4.E-6	1.04E-5 $\pm$ 18%
D1-LD-01	10-1087	<6.E-6	1.18E-5 $\pm$ 29%		
D1-LD-02	10-1088	<6.E-6	<7.E-6		
D1-LD-03	10-1089	<6.E-6	<6.E-6		
D1-LD-04	10-1090	<6.E-6	<6.E-6		
D1-LD-05	10-1091	<6.E-6	<6.E-6		
D1-LD-06	10-1092	<6.E-6	<6.E-6		
D1-LD-07	10-1093	<6.E-6	<6.E-6		
D1-LD-08	10-1094	<6.E-6	<6.E-6		
D1-LD-09	10-1095	<6.E-6	<6.E-6		
D1-LD-10	10-1096	<6.E-6	<6.E-6		
D1-LD-11	10-1097	<7.E-6	<6.E-6		
D1-LD-12	10-1098	<7.E-6	<5.E-6		
D1-LD-13	10-1099	1.56E-5 $\pm$ 15%	<6.E-6		
D1-LD-14	10-1100	2.32E-5 $\pm$ 21%	<6.E-6		
D1-LD-15	10-1101	5.13E-5 $\pm$ 7%	<4.E-6		
D1-LD-16	10-1102	1.11E-4 $\pm$ 4%	<4.E-6		
D1-LD-17	10-1103	2.04E-4 $\pm$ 3%	<4.E-6		
D1-LD-18	10-1104	4.92E-4 $\pm$ 2%	<6.E-6		
D1-LD-19	10-1105	6.87E-4 $\pm$ 2%	<6.E-6		
D1-LD-20	10-1106	1.04E-3 $\pm$ 2%	<7.E-6		
D1-LD-21	10-1107	1.53E-3 $\pm$ 2%	<9.E-6		
D1-LD-22	10-1108	2.28E-3 $\pm$ 2%	<1.E-5		
D1-LD-23	10-1109	3.28E-3 $\pm$ 2%	<1.E-5		
D1-LD-24	10-1110	4.60E-3 $\pm$ 2%	<1.E-5		
D1-LD-25	10-1111	6.60E-3 $\pm$ 2%	<1.E-5		
D1-LD-26	10-1112	9.27E-3 $\pm$ 2%	<2.E-5		
D1-LD-27	10-1113	1.29E-2 $\pm$ 2%	<2.E-5		
D1-LD-28	10-1114	1.70E-2 $\pm$ 2%	<2.E-5		

Measured Activities, $\mu\text{Ci}/\text{sample}$ with 1-sigma uncertainty

Sample ID	RPL ID	Recounts done on December 9, 2010			
		Cs-134	Cs-137	Cs-134	Cs-137
D1-LD-29	10-1115	1.98E-2 $\pm$ 2%	<3.E-5		
D1-LD-CP	10-1116	3.38E-3 $\pm$ 2%	<1.E-5		
D1-FD-CP	10-1117	7.09E-3 $\pm$ 2%	<2.E-5		
D1-FDI-CP	10-1118	8.06E-5 $\pm$ 4%	<4.E-6		
D1-AN-CP	10-1119	1.42E-4 $\pm$ 3%	<5.E-6		
D1-EL-01	10-1120	2.60E+0 $\pm$ 2%	<3.E-3		
D1-EL-02	10-1121	1.77E+1 $\pm$ 2%	<1.E-2		
D1-EL-03	10-1122	7.08E-1 $\pm$ 2%	<5.E-4		
D1-EL-04	10-1123	4.09E+0 $\pm$ 2%	2.12E-2 $\pm$ 6%		
D1-EL-05	10-1124	3.55E+0 $\pm$ 2%	2.39E-1 $\pm$ 3%		
D1-EL-06	10-1125	1.44E+0 $\pm$ 2%	5.24E-1 $\pm$ 4%		
D1-EL-07	10-1126	6.30E-1 $\pm$ 2%	6.06E-1 $\pm$ 4%		
D1-EL-08	10-1127	3.02E-1 $\pm$ 2%	6.10E-1 $\pm$ 4%		
D1-EL-10	10-1128	9.23E-2 $\pm$ 2%	6.74E-1 $\pm$ 3%		
D1-EL-12	10-1129	3.35E-2 $\pm$ 2%	7.45E-1 $\pm$ 3%	3.38E-2 $\pm$ 2%	6.97E-1 $\pm$ 4%
D1-EL-15	10-1130	9.70E-3 $\pm$ 2%	6.90E-1 $\pm$ 3%		
D1-EL-18	10-1131	3.78E-3 $\pm$ 2%	6.91E-1 $\pm$ 3%		
D1-EL-21	10-1132	2.21E-3 $\pm$ 3%	6.97E-1 $\pm$ 3%		
D1-EL-CP	10-1133	6.34E+0 $\pm$ 2%	5.05E-1 $\pm$ 3%		
D1-EDI-CP	10-1134	2.11E-2 $\pm$ 2%	5.78E-1 $\pm$ 3%	2.08E-2 $\pm$ 2%	5.69E-1 $\pm$ 3%
D1-RG-CP	10-1135	2.70E-4 $\pm$ 5%	2.95E-2 $\pm$ 2%		
E1-LD-00	10-1136	1.66E-1 $\pm$ 2%	<3.E-5	1.05E+0 $\pm$ 2%	<6.E-4
E1-LD-01	10-1137	<4.E-6	5.51E-6 $\pm$ 37%	<6.E-6	<7.E-6
E1-LD-02	10-1138	<4.E-6	<4.E-6		
E1-LD-03	10-1139	<4.E-6	<4.E-6		
E1-LD-04	10-1140	<3.E-6	<4.E-6		
E1-LD-05	10-1141	<4.E-6	<3.E-6		
E1-LD-06	10-1142	<6.E-6	<6.E-6		
E1-LD-07	10-1143	<6.E-6	<6.E-6		
E1-LD-08	10-1144	<5.E-6	<6.E-6		
E1-LD-09	10-1145	<6.E-6	<5.E-6		
E1-LD-10	10-1146	<4.E-6	<3.E-6		
E1-LD-11	10-1147	<4.E-6	<4.E-6		
E1-LD-12	10-1148	4.52E-6 $\pm$ 28%	<3.E-6		
E1-LD-13	10-1149	1.56E-5 $\pm$ 16%	<4.E-6		
E1-LD-14	10-1150	3.81E-5 $\pm$ 7%	<4.E-6		
E1-LD-15	10-1151	9.20E-5 $\pm$ 4%	<4.E-6		
E1-LD-16	10-1152	1.61E-4 $\pm$ 4%	<4.E-6		
E1-LD-17	10-1153	3.01E-4 $\pm$ 3%	<5.E-6		
E1-LD-18	10-1154	5.51E-4 $\pm$ 3%	<8.E-6		
E1-LD-19	10-1155	9.43E-4 $\pm$ 3%	<9.E-6		
E1-LD-20	10-1156	1.42E-3 $\pm$ 2%	<8.E-6		
E1-LD-21	10-1157	1.94E-3 $\pm$ 2%	<8.E-6		
E1-LD-22	10-1158	2.99E-3 $\pm$ 2%	<1.E-5		
E1-LD-23	10-1159	4.44E-3 $\pm$ 2%	<1.E-5		
E1-LD-24	10-1160	6.24E-3 $\pm$ 2%	<1.E-5		
E1-LD-25	10-1161	8.43E-3 $\pm$ 2%	<2.E-5		
E1-LD-26	10-1162	1.14E-2 $\pm$ 2%	<2.E-5		
E1-LD-27	10-1163	1.54E-2 $\pm$ 2%	<2.E-5		
E1-LD-28	10-1164	1.98E-2 $\pm$ 2%	<3.E-5		
E1-LD-29	10-1165	2.33E-2 $\pm$ 2%	<3.E-5		
E1-LD-CP	10-1166	4.09E-3 $\pm$ 2%	<1.E-5		
E1-FD-CP	10-1167	6.42E-3 $\pm$ 2%	<2.E-5		
E1-FDI-CP	10-1168	8.25E-5 $\pm$ 5%	<4.E-6		
E1-AN-CP	10-1169	1.64E-4 $\pm$ 3%	<4.E-6		

The original results for sample E1-LD-00, shaded in this report, were incorrectly calculated using the wrong counting position. The recount is correct.

Measured Activities, $\mu\text{Ci}/\text{sample}$ with 1-sigma uncertainty

Sample ID	RPL ID	Cs-134	Cs-137	Recounts done on December 9, 2010	
				Cs-134	Cs-137
E1-EL-01	10-1170	5.80E+0 $\pm$ 2%	<3.E-3		
E1-EL-02	10-1171	1.02E+1 $\pm$ 2%	<4.E-3		
E1-EL-03	10-1172	7.62E-1 $\pm$ 2%	<5.E-4		
E1-EL-04	10-1173	6.65E+0 $\pm$ 2%	4.25E-2 $\pm$ 5%		
E1-EL-05	10-1174	2.87E+0 $\pm$ 2%	3.40E-1 $\pm$ 4%		
E1-EL-06	10-1175	1.08E+0 $\pm$ 2%	6.54E-1 $\pm$ 4%		
E1-EL-07	10-1176	4.62E-1 $\pm$ 2%	7.34E-1 $\pm$ 4%		
E1-EL-08	10-1177	2.09E-1 $\pm$ 2%	7.24E-1 $\pm$ 4%		
E1-EL-10	10-1178	6.30E-2 $\pm$ 2%	7.54E-1 $\pm$ 4%		
E1-EL-12	10-1179	2.15E-2 $\pm$ 2%	8.49E-1 $\pm$ 4%		
E1-EL-15	10-1180	6.17E-3 $\pm$ 2%	7.91E-1 $\pm$ 4%		
E1-EL-18	10-1181	2.67E-3 $\pm$ 3%	7.33E-1 $\pm$ 3%		
E1-EL-21	10-1182	1.83E-3 $\pm$ 3%	7.28E-1 $\pm$ 3%		
E1-EL-CP	10-1183	7.69E+0 $\pm$ 2%	5.80E-1 $\pm$ 3%		
E1-EDI-CP	10-1184	1.33E-2 $\pm$ 2%	6.61E-1 $\pm$ 3%		
E1-RG-CP	10-1185	2.34E-4 $\pm$ 6%	3.70E-2 $\pm$ 2%		
D2-LD-00	10-1186	1.07E+0 $\pm$ 2%	<6.E-4		
D2-LD-01	10-1187	7.87E-5 $\pm$ 7%	2.01E-3 $\pm$ 4%		
D2-LD-02	10-1188	5.53E-5 $\pm$ 7%	6.22E-4 $\pm$ 2%		
D2-LD-03	10-1189	5.69E-5 $\pm$ 6%	9.07E-4 $\pm$ 2%		
D2-LD-04	10-1190	4.88E-5 $\pm$ 7%	1.06E-3 $\pm$ 2%		
D2-LD-05	10-1191	4.63E-5 $\pm$ 8%	1.05E-3 $\pm$ 2%		
D2-LD-06	10-1192	4.47E-5 $\pm$ 11%	1.09E-3 $\pm$ 2%		
D2-LD-07	10-1193	4.94E-5 $\pm$ 8%	1.06E-3 $\pm$ 3%		
D2-LD-08	10-1194	4.42E-5 $\pm$ 9%	1.04E-3 $\pm$ 3%		
D2-LD-24	10-1195	1.36E-2 $\pm$ 2%	1.73E-3 $\pm$ 3%		
D2-LD-CP	10-1196	2.12E-3 $\pm$ 2%	1.14E-3 $\pm$ 2%		
D2-FD-CP	10-1197	4.49E-3 $\pm$ 3%	6.78E-4 $\pm$ 3%		
D2-FDI-CP	10-1198	8.93E-5 $\pm$ 5%	1.62E-5 $\pm$ 14%		
D2-AN-CP	10-1199	1.40E-4 $\pm$ 5%	3.27E-5 $\pm$ 11%		
D2-EL-01	10-1200	1.29E+0 $\pm$ 2%	8.31E-3 $\pm$ 5%		
D2-EL-02	10-1201	1.20E+1 $\pm$ 2%	8.34E-2 $\pm$ 4%		
D2-EL-03	10-1202	1.35E+0 $\pm$ 2%	9.56E-3 $\pm$ 5%		
D2-EL-04	10-1203	2.91E+0 $\pm$ 2%	2.92E-2 $\pm$ 4%		
D2-EL-05	10-1204	2.33E+0 $\pm$ 2%	3.32E-2 $\pm$ 4%		
D2-EL-06	10-1205	2.43E+0 $\pm$ 2%	4.19E-2 $\pm$ 4%		
D2-EL-07	10-1206	2.61E+0 $\pm$ 2%	5.65E-2 $\pm$ 4%		
D2-EL-08	10-1207	2.69E+0 $\pm$ 2%	7.74E-2 $\pm$ 4%		
D2-EL-10	10-1208	3.16E+0 $\pm$ 2%	1.50E-1 $\pm$ 4%		
D2-EL-12	10-1209	2.41E+0 $\pm$ 2%	2.31E-1 $\pm$ 5%		
D2-EL-15	10-1210	2.29E+0 $\pm$ 2%	3.72E-1 $\pm$ 6%		
D2-EL-18	10-1211	6.60E-1 $\pm$ 2%	4.96E-1 $\pm$ 5%		
D2-EL-21	10-1212	1.90E-1 $\pm$ 2%	6.47E-1 $\pm$ 3%		
D2-EL-24	10-1213	1.41E-1 $\pm$ 2%	6.03E-1 $\pm$ 3%		
D2-EL-30	10-1214	8.33E-2 $\pm$ 2%	6.05E-1 $\pm$ 3%		
D2-EL-CP	10-1215	5.22E+0 $\pm$ 2%	4.69E-1 $\pm$ 3%		
D2-EDI-CP	10-1216	9.84E-2 $\pm$ 2%	6.28E-1 $\pm$ 3%		
D2-RG-CP	10-1217	2.33E-3 $\pm$ 2%	1.11E-1 $\pm$ 3%		
--	10-1218	[no sample assigned to this number]			
--	10-1219	[no sample assigned to this number]			
E2-LD-00	10-1220	1.09E+0 $\pm$ 2%	<6.E-4		
E2-LD-01	10-1221	3.61E-4 $\pm$ 3%	3.53E-3 $\pm$ 4%		
E2-LD-02	10-1222	4.52E-5 $\pm$ 10%	7.98E-4 $\pm$ 4%		

$\sim 3\%$ lower
 $\sim 11\%$
 $\sim 11\%$ lower

Measured Activities, $\mu\text{Ci}/\text{sample}$ with 1-sigma uncertainty

Sample ID	RPL ID	Recounts done on December 9, 2010			
		Cs-134	Cs-137	Cs-134	Cs-137
E2-LD-03	10-1223	5.11E-5 $\pm$ 8%	1.06E-3 $\pm$ 4%		
E2-LD-04	10-1224	4.69E-5 $\pm$ 10%	1.21E-3 $\pm$ 4%		
E2-LD-05	10-1225	4.93E-5 $\pm$ 9%	1.12E-3 $\pm$ 4%		
E2-LD-06	10-1226	5.23E-5 $\pm$ 8%	1.19E-3 $\pm$ 2%		
E2-LD-07	10-1227	3.28E-5 $\pm$ 10%	1.19E-3 $\pm$ 2%		
E2-LD-08	10-1228	2.94E-5 $\pm$ 14%	1.19E-3 $\pm$ 3%		
E2-LD-24	10-1229	1.39E-2 $\pm$ 3%	1.90E-3 $\pm$ 2%		
E2-LD-CP	10-1230	2.21E-3 $\pm$ 2%	1.24E-3 $\pm$ 4%		
E2-FD-CP	10-1231	3.92E-3 $\pm$ 2%	6.83E-4 $\pm$ 3%		
E2-FDI-CP	10-1232	7.13E-5 $\pm$ 6%	1.78E-5 $\pm$ 14%		
E2-AN-CP	10-1233	9.27E-5 $\pm$ 6%	2.65E-5 $\pm$ 9%		
E2-EL-01	10-1234	1.15E+1 $\pm$ 2%	8.66E-2 $\pm$ 4%		
E2-EL-02	10-1235	8.39E+0 $\pm$ 2%	6.08E-2 $\pm$ 5%		
E2-EL-03	10-1236	4.64E-1 $\pm$ 2%	4.32E-3 $\pm$ 5%		
E2-EL-04	10-1237	1.39E+0 $\pm$ 2%	2.06E-2 $\pm$ 6%		
E2-EL-05	10-1238	7.99E-1 $\pm$ 2%	8.66E-2 $\pm$ 4%		
E2-EL-06	10-1239	5.23E-1 $\pm$ 2%	2.23E-1 $\pm$ 4%		
E2-EL-07	10-1240	3.61E-1 $\pm$ 2%	3.93E-1 $\pm$ 3%		
E2-EL-08	10-1241	2.80E-1 $\pm$ 2%	5.95E-1 $\pm$ 4%		
E2-EL-10	10-1242	1.87E-1 $\pm$ 2%	7.36E-1 $\pm$ 5%		
E2-EL-12	10-1243	5.52E-2 $\pm$ 2%	7.52E-1 $\pm$ 5%		
E2-EL-15	10-1244	1.20E-2 $\pm$ 2%	7.38E-1 $\pm$ 3%		
E2-EL-18	10-1245	3.67E-3 $\pm$ 2%	7.30E-1 $\pm$ 4%		
E2-EL-21	10-1246	2.05E-3 $\pm$ 3%	8.34E-1 $\pm$ 3%		
E2-EL-24	10-1247				
E2-EL-CP	10-1248	6.53E+0 $\pm$ 2%	6.37E-1 $\pm$ 3%		
E2-EDI-CP	10-1249	5.71E-3 $\pm$ 2%	5.27E-1 $\pm$ 4%		
E2-RG-CP	10-1250	1.70E-3 $\pm$ 3%	1.43E-1 $\pm$ 3%		
D3-LD-00	10-1251	1.10E+0 $\pm$ 2%	<6.E-4		
D3-LD-01	10-1252	7.34E-4 $\pm$ 2%	1.71E-3 $\pm$ 2%		
D3-LD-02	10-1253	1.18E-3 $\pm$ 2%	3.75E-3 $\pm$ 2%		
D3-LD-03	10-1254	1.66E-3 $\pm$ 2%	5.24E-3 $\pm$ 2%		
D3-LD-04	10-1255	2.06E-3 $\pm$ 2%	5.86E-3 $\pm$ 2%		
D3-LD-05	10-1256	2.01E-3 $\pm$ 2%	5.77E-3 $\pm$ 2%		
D3-LD-06	10-1257	1.81E-3 $\pm$ 2%	5.76E-3 $\pm$ 2%		
D3-LD-07	10-1258	1.78E-3 $\pm$ 2%	5.82E-3 $\pm$ 2%		
D3-LD-08	10-1259	1.75E-3 $\pm$ 2%	5.70E-3 $\pm$ 2%		
D3-LD-24	10-1260	4.27E-2 $\pm$ 3%	1.05E-2 $\pm$ 2%		
D3-LD-CP	10-1261	8.07E-3 $\pm$ 2%	5.87E-3 $\pm$ 3%		
D3-FD-CP	10-1262	1.31E-2 $\pm$ 2%	4.03E-3 $\pm$ 3%		
D3-FDI-CP	10-1263	2.72E-4 $\pm$ 3%	1.05E-4 $\pm$ 5%		
D3-AN-CP	10-1264	3.41E-4 $\pm$ 3%	1.33E-4 $\pm$ 4%		
D3-EL-01	10-1265	4.85E+0 $\pm$ 2%	1.13E-1 $\pm$ 4%		
D3-EL-02	10-1266	1.40E+1 $\pm$ 2%	3.91E-1 $\pm$ 3%		
D3-EL-03	10-1267	1.71E+0 $\pm$ 2%	5.74E-2 $\pm$ 4%		
D3-EL-04	10-1268	3.16E-2 $\pm$ 3%	2.96E-2 $\pm$ 2%		
D3-EL-05	10-1269	9.20E-2 $\pm$ 2%	6.19E-1 $\pm$ 4%		
D3-EL-06	10-1270	6.75E-2 $\pm$ 2%	6.67E-1 $\pm$ 4%		
D3-EL-07	10-1271	3.73E-2 $\pm$ 2%	6.70E-1 $\pm$ 4%		
D3-EL-08	10-1272	1.96E-2 $\pm$ 2%	6.39E-1 $\pm$ 4%		
D3-EL-10	10-1273	6.74E-3 $\pm$ 2%	6.06E-1 $\pm$ 4%		
D3-EL-12	10-1274	3.08E-3 $\pm$ 3%	6.66E-1 $\pm$ 4%		
D3-EL-15	10-1275	1.33E-3 $\pm$ 4%	6.39E-1 $\pm$ 3%		
D3-EL-18	10-1276	5.54E-3 $\pm$ 2%	6.85E-1 $\pm$ 3%		

Measured Activities, $\mu\text{Ci}/\text{sample}$ with 1-sigma uncertainty

Sample ID	RPL ID	Recounts done on December 9, 2010			
		Cs-134	Cs-137	Cs-134	Cs-137
D3-EL-21	10-1277	1.33E-3 $\pm$ 3%	6.21E-1 $\pm$ 3%		
D3-EL-CP	10-1278	6.23E+0 $\pm$ 2%	7.12E-1 $\pm$ 3%		
D3-EDI-CP	10-1279	1.19E-3 $\pm$ 4%	4.83E-1 $\pm$ 3%		
D3-RG-CP	10-1280	2.81E-3 $\pm$ 2%	2.16E-2 $\pm$ 4%	2.23E-3 $\pm$ 2%	1.91E-2 $\pm$ 2%
E3-LD-00	10-1281	9.77E-1 $\pm$ 2%	<6.E-4		
E3-LD-01	10-1282	1.30E-4 $\pm$ 5%	3.14E-3 $\pm$ 4%		
E3-LD-02	10-1283	5.81E-5 $\pm$ 9%	1.70E-3 $\pm$ 4%		
E3-LD-03	10-1284	6.27E-5 $\pm$ 9%	2.33E-3 $\pm$ 4%		
E3-LD-04	10-1285	6.54E-5 $\pm$ 9%	2.49E-3 $\pm$ 4%		
E3-LD-05	10-1286	5.84E-5 $\pm$ 9%	2.58E-3 $\pm$ 4%		
E3-LD-06	10-1287	5.83E-5 $\pm$ 8%	2.45E-3 $\pm$ 4%		
E3-LD-07	10-1288	4.90E-5 $\pm$ 11%	2.37E-3 $\pm$ 4%		
E3-LD-08	10-1289	5.11E-5 $\pm$ 11%	2.34E-3 $\pm$ 4%		
E3-LD-24	10-1290	2.10E-2 $\pm$ 2%	3.83E-3 $\pm$ 4%		
E3-LD-CP	10-1291	2.98E-3 $\pm$ 2%	2.33E-3 $\pm$ 2%		
E3-FD-CP	10-1292	5.81E-3 $\pm$ 2%	1.27E-3 $\pm$ 2%		
E3-FDI-CP	10-1293	1.03E-4 $\pm$ 3%	3.61E-5 $\pm$ 6%		
E3-AN-CP	10-1294	1.53E-4 $\pm$ 3%	5.66E-5 $\pm$ 6%		
E3-EL-01	10-1295	8.74E+0 $\pm$ 2%	8.98E-2 $\pm$ 4%		
E3-EL-02	10-1296	1.03E+1 $\pm$ 2%	1.23E-1 $\pm$ 4%		
E3-EL-03	10-1297	6.48E-1 $\pm$ 2%	9.30E-3 $\pm$ 5%		
E3-EL-04	10-1298	1.10E-1 $\pm$ 2%	3.16E-2 $\pm$ 4%		
E3-EL-05	10-1299	9.64E-1 $\pm$ 2%	7.03E-1 $\pm$ 4%		
E3-EL-06	10-1300	4.13E-1 $\pm$ 2%	7.73E-1 $\pm$ 4%		
E3-EL-07	10-1301	1.71E-1 $\pm$ 2%	7.42E-1 $\pm$ 3%		
E3-EL-08	10-1302	7.93E-2 $\pm$ 2%	7.45E-1 $\pm$ 3%		
E3-EL-10	10-1303	2.00E-2 $\pm$ 2%	6.95E-1 $\pm$ 3%		
E3-EL-12	10-1304	6.78E-3 $\pm$ 2%	7.52E-1 $\pm$ 3%		
E3-EL-15	10-1305	2.12E-3 $\pm$ 3%	7.35E-1 $\pm$ 3%		
E3-EL-18	10-1306	2.19E-3 $\pm$ 3%	7.28E-1 $\pm$ 3%		
E3-EL-21	10-1307	1.91E-3 $\pm$ 3%	8.09E-1 $\pm$ 3%		
E3-EL-CP	10-1308	6.27E+0 $\pm$ 2%	7.28E-1 $\pm$ 3%		
E3-EDI-CP	10-1309	1.23E-3 $\pm$ 3%	3.61E-1 $\pm$ 3%		
E3-RG-CP	10-1310	1.72E-3 $\pm$ 2%	2.89E-2 $\pm$ 4%		
D4-LD-00	10-1311	1.04E+0 $\pm$ 2%	<6.E-4		
D4-LD-01	10-1312	1.37E-4 $\pm$ 5%	1.17E-4 $\pm$ 6%		
D4-LD-02	10-1313	2.50E-5 $\pm$ 10%	2.96E-4 $\pm$ 3%		
D4-LD-03	10-1314	2.53E-5 $\pm$ 10%	4.81E-4 $\pm$ 2%		
D4-LD-04	10-1315	1.44E-5 $\pm$ 27%	5.17E-4 $\pm$ 3%		
D4-LD-05	10-1316	2.02E-5 $\pm$ 14%	5.65E-4 $\pm$ 2%		
D4-LD-06	10-1317	1.92E-5 $\pm$ 20%	5.73E-4 $\pm$ 4%		
D4-LD-07	10-1318	1.11E-5 $\pm$ 33%	6.60E-4 $\pm$ 2%		
D4-LD-08	10-1319	2.38E-5 $\pm$ 11%	6.01E-4 $\pm$ 3%		
D4-LD-24	10-1320	5.68E-2 $\pm$ 2%	1.57E-3 $\pm$ 4%		
D4-LD-CP	10-1321	8.85E-3 $\pm$ 2%	7.67E-4 $\pm$ 4%		
D4-FD-CP	10-1322	2.20E-2 $\pm$ 3%	7.33E-4 $\pm$ 3%		
D4-FDI-CP	10-1323	2.87E-4 $\pm$ 3%	1.73E-5 $\pm$ 20%		
D4-AN-CP	10-1324	1.93E-4 $\pm$ 3%	1.50E-5 $\pm$ 14%		
D4-EL-01	10-1325	2.86E-4 $\pm$ 3%	9.69E-6 $\pm$ 34%		
D4-EL-02	10-1326	1.35E+1 $\pm$ 2%	3.74E-2 $\pm$ 6%		
D4-EL-03	10-1327	3.61E+0 $\pm$ 2%	1.30E-2 $\pm$ 9%		
D4-EL-04	10-1328	7.35E-1 $\pm$ 2%	1.03E-2 $\pm$ 4%		

Measured Activities, $\mu\text{Ci}/\text{sample}$ with 1-sigma uncertainty

Sample ID	RPL ID	Recounts done on December 9, 2010	
		Cs-134	Cs-137
—	10-1329	[skipped this number]	
D4-EL-05	10-1330	2.02E+0 $\pm$ 2%	4.35E-1 $\pm$ 5%
D4-EL-06	10-1331	3.65E-1 $\pm$ 2%	6.09E-1 $\pm$ 3%
D4-EL-07	10-1332	8.22E-2 $\pm$ 2%	6.18E-1 $\pm$ 3%
D4-EL-08	10-1333	4.21E-2 $\pm$ 2%	6.25E-1 $\pm$ 3%
D4-EL-10	10-1334	2.36E-2 $\pm$ 2%	6.55E-1 $\pm$ 3%
D4-EL-12	10-1335	7.82E-3 $\pm$ 2%	6.07E-1 $\pm$ 3%
D4-EL-15	10-1336	2.17E-3 $\pm$ 3%	5.94E-1 $\pm$ 3%
D4-EL-18	10-1337	1.03E-3 $\pm$ 4%	6.08E-1 $\pm$ 3%
D4-EL-21	10-1338	6.82E-4 $\pm$ 4%	6.29E-1 $\pm$ 3%
D4-EL-CP	10-1339	7.05E+0 $\pm$ 2%	5.53E-1 $\pm$ 3%
D4-EDI-CP	10-1340	2.21E-3 $\pm$ 3%	4.38E-1 $\pm$ 3%
D4-RG-CP	10-1341	2.03E-3 $\pm$ 3%	1.05E-1 $\pm$ 3%
E4-LD-00	10-1342	1.06E+0 $\pm$ 2%	<9.E-4
E4-LD-01	10-1343	1.39E-4 $\pm$ 4%	1.45E-4 $\pm$ 4%
E4-LD-02	10-1344	2.86E-5 $\pm$ 9%	4.02E-4 $\pm$ 2%
E4-LD-03	10-1345	2.17E-5 $\pm$ 14%	6.16E-4 $\pm$ 2%
E4-LD-04	10-1346	3.49E-5 $\pm$ 11%	7.85E-4 $\pm$ 4%
E4-LD-05	10-1347	2.15E-5 $\pm$ 12%	8.00E-4 $\pm$ 2%
E4-LD-06	10-1348	2.90E-5 $\pm$ 10%	8.07E-4 $\pm$ 3%
E4-LD-07	10-1349	2.76E-5 $\pm$ 10%	8.24E-4 $\pm$ 2%
E4-LD-08	10-1350	2.77E-5 $\pm$ 14%	8.44E-4 $\pm$ 4%
E4-LD-24	10-1351	2.59E-2 $\pm$ 3%	1.67E-3 $\pm$ 2%
E4-LD-CP	10-1352	3.74E-3 $\pm$ 2%	9.64E-4 $\pm$ 3%
E4-FD-CP	10-1353	8.60E-3 $\pm$ 2%	6.91E-4 $\pm$ 3%
E4-FDI-CP	10-1354	1.48E-4 $\pm$ 4%	2.19E-5 $\pm$ 14%
E4-AN-CP	10-1355	1.72E-4 $\pm$ 4%	2.06E-5 $\pm$ 20%
E4-EL-01	10-1356	4.89E+0 $\pm$ 2%	1.84E-2 $\pm$ 8%
E4-EL-02	10-1357	1.05E+1 $\pm$ 2%	6.52E-2 $\pm$ 4%
E4-EL-03	10-1358	1.97E+0 $\pm$ 2%	9.79E-3 $\pm$ 8%
E4-EL-04	10-1359	1.58E-1 $\pm$ 2%	2.45E-2 $\pm$ 4%
E4-EL-05	10-1360	8.77E-1 $\pm$ 2%	6.89E-1 $\pm$ 5%
E4-EL-06	10-1361	5.47E-1 $\pm$ 2%	7.49E-1 $\pm$ 5%
E4-EL-07	10-1362	2.47E-1 $\pm$ 2%	7.30E-1 $\pm$ 3%
E4-EL-08	10-1363	1.11E-1 $\pm$ 2%	7.26E-1 $\pm$ 3%
E4-EL-10	10-1364	3.21E-2 $\pm$ 2%	8.11E-1 $\pm$ 5%
E4-EL-12	10-1365	9.22E-3 $\pm$ 2%	7.22E-1 $\pm$ 3%
E4-EL-15	10-1366	2.53E-3 $\pm$ 3%	7.23E-1 $\pm$ 3%
E4-EL-18	10-1367	1.25E-3 $\pm$ 4%	7.47E-1 $\pm$ 5%
E4-EL-21	10-1368	5.47E-4 $\pm$ 4%	5.64E-1 $\pm$ 3%
E4-EL-CP	10-1369	7.08E+0 $\pm$ 2%	6.62E-1 $\pm$ 3%
E4-EDI-CP	10-1370	2.29E-3 $\pm$ 3%	3.34E-1 $\pm$ 3%
E4-RG-CP	10-1371	2.27E-3 $\pm$ 2%	6.04E-2 $\pm$ 4%
D5-LD-00	10-1372	1.03E+0 $\pm$ 2%	<8.E-4
D5-LD-01	10-1373	2.31E-4 $\pm$ 5%	8.84E-3 $\pm$ 4%
D5-LD-02	10-1374	4.42E-5 $\pm$ 8%	5.47E-4 $\pm$ 3%
D5-LD-03	10-1375	4.78E-5 $\pm$ 8%	8.59E-4 $\pm$ 3%
D5-LD-04	10-1376	4.69E-5 $\pm$ 8%	1.02E-3 $\pm$ 3%
D5-LD-05	10-1377	4.10E-5 $\pm$ 9%	1.03E-3 $\pm$ 3%
D5-LD-06	10-1378	1.52E-4 $\pm$ 4%	1.05E-3 $\pm$ 3%
D5-LD-07	10-1379	3.59E-5 $\pm$ 9%	1.07E-3 $\pm$ 3%

Pacific Northwest National Laboratory
PO Box 999
Richland, WA 99354
Radiochemical Sciences and Engineering Group

filename: 10-1060_Brown
12/10/2010
Revision 1

In this revision, one recount is reported. The original data is unchanged from the previous version of the report.

Client: G. Brown
ASR: 8700

Prepared by:

Concur:

T. Trang-le 12-10-10
C. Soderquist 12-10-10

Procedures: RPG-CMC-450, Rev. 1 Gamma Energy Analysis (GEA) and Low-Energy Photon Spectrometry (LEPS)
M & TE: Gamma Detectors C, D, E, G, K
Reference Date: August 15, 2010

Measured Activities, $\mu\text{Ci}/\text{sample}$ with 1-sigma uncertainty

Sample ID	RPL ID	Cs-134	Cs-137	Recount	
				Cs-134	Cs-137
D5-LD-08	10-1380	3.32E-5 $\pm$ 11%	1.08E-3 $\pm$ 3%		
D5-LD-24	10-1381	1.02E-1 $\pm$ 2%	2.24E-3 $\pm$ 4%		
D5-LD-CP	10-1382	1.86E-2 $\pm$ 2%	1.16E-3 $\pm$ 4%		
D5-FD-CP	10-1383	3.27E-2 $\pm$ 2%	8.47E-4 $\pm$ 5%		
D5-FDI-CP	10-1384	5.62E-4 $\pm$ 3%	2.03E-5 $\pm$ 20%		
D5-AN-CP	10-1385	6.07E-4 $\pm$ 3%	2.51E-5 $\pm$ 13%		
D5-EL-01	10-1386	2.16E-2 $\pm$ 2%	8.09E-5 $\pm$ 15%		
D5-EL-02	10-1387	1.09E+1 $\pm$ 2%	3.75E-2 $\pm$ 6%		
D5-EL-03	10-1388	4.11E+0 $\pm$ 2%	2.06E-2 $\pm$ 6%		
D5-EL-04	10-1389	1.48E+0 $\pm$ 2%	1.54E-2 $\pm$ 5%		
D5-EL-05	10-1390	4.60E+0 $\pm$ 2%	3.89E-1 $\pm$ 3%		
D5-EL-06	10-1391	7.47E-1 $\pm$ 2%	5.63E-1 $\pm$ 4%		
D5-EL-07	10-1392	3.58E-1 $\pm$ 2%	6.51E-1 $\pm$ 4%		
D5-EL-08	10-1393	2.12E-1 $\pm$ 2%	6.92E-1 $\pm$ 4%		
D5-EL-10	10-1394	7.18E-2 $\pm$ 2%	6.67E-1 $\pm$ 4%		
D5-EL-12	10-1395	1.94E-2 $\pm$ 2%	6.53E-1 $\pm$ 4%		
D5-EL-15	10-1396	3.66E-3 $\pm$ 2%	6.04E-1 $\pm$ 3%		
D5-EL-18	10-1397	1.31E-3 $\pm$ 4%	6.00E-1 $\pm$ 3%		
D5-EL-21	10-1398	6.26E-4 $\pm$ 5%	5.57E-1 $\pm$ 3%		
D5-EL-CP	10-1399	7.34E+0 $\pm$ 2%	5.33E-1 $\pm$ 3%		
D5-EDI-CP	10-1400	8.44E-3 $\pm$ 2%	5.14E-1 $\pm$ 3%		
D5-RG-CP	10-1401	2.24E-3 $\pm$ 2%	1.56E-2 $\pm$ 2%		
E5-LD-00	10-1402	1.03E+0 $\pm$ 2%	<8.E-4		
E5-LD-01	10-1403	2.46E-4 $\pm$ 3%	5.18E-3 $\pm$ 2%		
E5-LD-02	10-1404	3.65E-5 $\pm$ 9%	4.88E-4 $\pm$ 2%		
E5-LD-03	10-1405	3.05E-5 $\pm$ 15%	7.54E-4 $\pm$ 2%		
E5-LD-04	10-1406	3.66E-5 $\pm$ 10%	9.10E-4 $\pm$ 2%		
E5-LD-05	10-1407	3.62E-5 $\pm$ 8%	9.46E-4 $\pm$ 2%		
E5-LD-06	10-1408	3.46E-5 $\pm$ 11%	9.90E-4 $\pm$ 2%		
E5-LD-07	10-1409	3.21E-5 $\pm$ 12%	1.01E-3 $\pm$ 2%		
E5-LD-08	10-1410	2.77E-5 $\pm$ 11%	1.02E-3 $\pm$ 2%		
E5-LD-24	10-1411	6.56E-2 $\pm$ 2%	2.11E-3 $\pm$ 2%		
E5-LD-CP	10-1412	1.32E-2 $\pm$ 2%	1.20E-3 $\pm$ 4%		
E5-FD-CP	10-1413	2.03E-2 $\pm$ 2%	7.40E-4 $\pm$ 5%		
E5-FDI-CP	10-1414	3.30E-4 $\pm$ 3%	1.23E-5 $\pm$ 23%		
E5-AN-CP	10-1415	3.43E-4 $\pm$ 3%	2.24E-5 $\pm$ 12%		
E5-EL-01	10-1416	3.25E-3 $\pm$ 2%	2.73E-5 $\pm$ 26%		
E5-EL-02	10-1417	1.19E+1 $\pm$ 2%	5.44E-2 $\pm$ 5%		

Measured Activities, $\mu\text{Ci}/\text{sample}$ with 1-sigma uncertainty

Sample ID	RPL ID	Recount			
		Cs-134	Cs-137	Cs-134	Cs-137
E5-EL-03	10-1418	3.65E+0 $\pm$ 2%	1.75E-2 $\pm$ 7%		
E5-EL-04	10-1419	8.42E-1 $\pm$ 2%	6.93E-3 $\pm$ 8%		
E5-EL-05	10-1420	4.38E+0 $\pm$ 2%	1.66E-1 $\pm$ 3%		
E5-EL-06	10-1421	1.30E+0 $\pm$ 2%	3.38E-1 $\pm$ 5%		
E5-EL-07	10-1422	7.01E-1 $\pm$ 2%	5.58E-1 $\pm$ 5%		
E5-EL-08	10-1423	7.61E-1 $\pm$ 2%	7.18E-1 $\pm$ 5%		
E5-EL-10	10-1424	5.03E-1 $\pm$ 2%	7.62E-1 $\pm$ 3%		
E5-EL-12	10-1425	2.01E-1 $\pm$ 2%	8.10E-1 $\pm$ 5%		
E5-EL-15	10-1426	2.25E-2 $\pm$ 2%	7.22E-1 $\pm$ 3%		
E5-EL-18	10-1427	3.67E-3 $\pm$ 2%	7.25E-1 $\pm$ 5%		
E5-EL-21	10-1428	1.19E-3 $\pm$ 3%	6.14E-1 $\pm$ 3%		
E5-EL-CP	10-1429	7.21E+0 $\pm$ 2%	5.97E-1 $\pm$ 3%		
E5-EDI-CP	10-1430	1.83E-2 $\pm$ 2%	5.05E-1 $\pm$ 4%		
E5-RG-CP	10-1431	1.84E-3 $\pm$ 2%	1.08E-2 $\pm$ 2%		
D6-LD-00	10-1432	9.83E-1 $\pm$ 2%	<8.E-4		
D6-LD-01	10-1433	3.17E-4 $\pm$ 3%	3.09E-3 $\pm$ 4%		
D6-LD-02	10-1434	5.06E-5 $\pm$ 10%	5.38E-4 $\pm$ 4%		
D6-LD-03	10-1435	5.58E-5 $\pm$ 8%	8.37E-4 $\pm$ 2%		
D6-LD-04	10-1436	9.04E-5 $\pm$ 5%	1.06E-3 $\pm$ 2%		
D6-LD-05	10-1437	6.39E-5 $\pm$ 7%	1.12E-3 $\pm$ 4%		
D6-LD-06	10-1438	6.13E-5 $\pm$ 8%	1.08E-3 $\pm$ 4%		
D6-LD-07	10-1439	4.89E-5 $\pm$ 9%	1.12E-3 $\pm$ 4%		
D6-LD-08	10-1440	6.32E-5 $\pm$ 8%	1.13E-3 $\pm$ 4%		
D6-LD-24	10-1441	1.36E-1 $\pm$ 2%	2.89E-3 $\pm$ 6%		
D6-LD-CP	10-1442	2.36E-2 $\pm$ 2%	1.48E-3 $\pm$ 3%		
D6-FD-CP	10-1443	4.76E-2 $\pm$ 2%	1.39E-3 $\pm$ 3%		
D6-FDI-CP	10-1444	7.46E-4 $\pm$ 3%	3.51E-5 $\pm$ 14%		
D6-AN-CP	10-1445	7.75E-4 $\pm$ 3%	2.66E-5 $\pm$ 13%		
D6-EL-01	10-1446	6.92E-4 $\pm$ 2%	1.86E-5 $\pm$ 18%		
D6-EL-02	10-1447	8.69E+0 $\pm$ 2%	3.95E-2 $\pm$ 6%		
D6-EL-03	10-1448	4.46E+0 $\pm$ 2%	2.62E-2 $\pm$ 6%		
D6-EL-04	10-1449	1.89E+0 $\pm$ 2%	2.30E-2 $\pm$ 4%		
D6-EL-05	10-1450	2.34E+0 $\pm$ 2%	5.17E-1 $\pm$ 4%		
D6-EL-06	10-1451	9.49E-1 $\pm$ 2%	5.85E-1 $\pm$ 5%		
D6-EL-07	10-1452	8.59E-1 $\pm$ 2%	5.78E-1 $\pm$ 5%		
D6-EL-08	10-1453	7.47E-1 $\pm$ 2%	6.33E-1 $\pm$ 5%		
D6-EL-10	10-1454	1.60E-1 $\pm$ 2%	5.96E-1 $\pm$ 3%		
D6-EL-12	10-1455	3.85E-2 $\pm$ 2%	6.08E-1 $\pm$ 3%		
D6-EL-15	10-1456	7.57E-3 $\pm$ 2%	6.50E-1 $\pm$ 5%		
D6-EL-18	10-1457	1.97E-3 $\pm$ 3%	6.40E-1 $\pm$ 5%		
D6-EL-21	10-1458	1.14E-3 $\pm$ 3%	6.31E-1 $\pm$ 3%		
D6-EL-CP	10-1459	7.06E+0 $\pm$ 2%	5.42E-1 $\pm$ 3%		
D6-EDI-CP	10-1460	1.34E-3 $\pm$ 3%	5.82E-1 $\pm$ 3%		
D6-RG-CP	10-1461	4.23E-4 $\pm$ 3%	1.92E-3 $\pm$ 3%		
E6-LD-00	10-1462	8.61E+0 $\pm$ 2%	3.98E-2 $\pm$ 5%	1.03E+0 $\pm$ 2%	<6.E-4
E6-LD-01	10-1463	1.91E-4 $\pm$ 4%	2.72E-3 $\pm$ 3%		
E6-LD-02	10-1464	6.63E-5 $\pm$ 6%	7.53E-4 $\pm$ 3%		
E6-LD-03	10-1465	6.86E-5 $\pm$ 8%	1.13E-3 $\pm$ 3%		
E6-LD-04	10-1466	8.15E-5 $\pm$ 6%	1.45E-3 $\pm$ 3%		
E6-LD-05	10-1467	7.83E-5 $\pm$ 7%	1.57E-3 $\pm$ 3%		
E6-LD-06	10-1468	1.16E-4 $\pm$ 6%	1.71E-3 $\pm$ 4%		
E6-LD-07	10-1469	8.66E-5 $\pm$ 6%	1.72E-3 $\pm$ 4%		
E6-LD-08	10-1470	6.86E-5 $\pm$ 8%	1.78E-3 $\pm$ 4%		
E6-LD-24	10-1471	1.23E-1 $\pm$ 2%	5.23E-3 $\pm$ 4%		

The original result is quite different from recount.

Measured Activities, $\mu\text{Ci/sample}$ with 1-sigma uncertainty

Sample ID	RPL ID	Cs-134	Cs-137	Recount	
				Cs-134	Cs-137
E6-LD-CP	10-1472	1.77E-2 $\pm$ 2%	2.41E-3 $\pm$ 2%		
E6-FD-CP	10-1473	1.35E-2 $\pm$ 2%	6.80E-4 $\pm$ 3%		
E6-FDI-CP	10-1474	5.24E-4 $\pm$ 2%	4.56E-5 $\pm$ 8%		
E6-AN-CP	10-1475	6.64E-4 $\pm$ 2%	6.99E-5 $\pm$ 5%		
E6-EL-01	10-1476	6.23E+0 $\pm$ 2%	4.36E-2 $\pm$ 5%		
E6-EL-02	10-1477	9.43E+0 $\pm$ 2%	1.17E-1 $\pm$ 4%		
E6-EL-03	10-1478	1.87E-1 $\pm$ 2%	3.54E-3 $\pm$ 4%		
E6-EL-04	10-1479	6.54E-2 $\pm$ 2%	2.18E-2 $\pm$ 5%		
E6-EL-05	10-1480	3.63E-1 $\pm$ 2%	5.51E-1 $\pm$ 3%		
E6-EL-06	10-1481	1.60E-1 $\pm$ 2%	5.99E-1 $\pm$ 3%		
E6-EL-07	10-1482	7.39E-2 $\pm$ 2%	5.78E-1 $\pm$ 3%		
E6-EL-08	10-1483	3.73E-2 $\pm$ 2%	6.28E-1 $\pm$ 4%		
E6-EL-10	10-1484	1.05E-2 $\pm$ 2%	6.18E-1 $\pm$ 3%		
E6-EL-12	10-1485	3.76E-3 $\pm$ 2%	6.09E-1 $\pm$ 3%		
E6-EL-15	10-1486	1.64E-3 $\pm$ 3%	6.44E-1 $\pm$ 4%		
E6-EL-18	10-1487	8.24E-4 $\pm$ 4%	6.31E-1 $\pm$ 5%		
E6-EL-21	10-1488	7.98E-4 $\pm$ 4%	6.14E-1 $\pm$ 3%		
E6-EL-CP	10-1489	7.17E+0 $\pm$ 2%	5.81E-1 $\pm$ 3%		
E6-EDI-CP	10-1490	2.21E-3 $\pm$ 3%	3.82E-1 $\pm$ 4%		
E6-RG-CP	10-1491	5.99E-4 $\pm$ 2%	7.07E-3 $\pm$ 2%		
F1-LD-00	10-1492	1.23E+0 $\pm$ 2%	<6.E-4		
F1-LD-01	10-1493	1.35E-4 $\pm$ 5%	6.49E-3 $\pm$ 2%		
F1-LD-02	10-1494	4.37E-4 $\pm$ 2%	2.45E-5 $\pm$ 13%		
F1-LD-03	10-1495	1.33E-5 $\pm$ 20%	6.59E-6 $\pm$ 23%		
F1-LD-04	10-1496	1.62E-5 $\pm$ 13%	7.83E-6 $\pm$ 26%		
F1-LD-05	10-1497	6.28E-5 $\pm$ 8%	<6.E-6		
F1-LD-06	10-1498	1.10E-5 $\pm$ 29%	5.06E-6 $\pm$ 40%		
F1-LD-07	10-1499	6.66E-5 $\pm$ 7%	<6.E-6		
F1-LD-08	10-1500	1.19E-5 $\pm$ 25%	<6.E-6		
F1-LD-09	10-1501	6.11E-5 $\pm$ 7%	<6.E-6		
F1-LD-10	10-1502	4.07E-5 $\pm$ 10%	<6.E-6		
F1-LD-11	10-1503	1.34E-4 $\pm$ 4%	<7.E-6		
F1-LD-12	10-1504	2.65E-4 $\pm$ 3%	<5.E-6		
F1-LD-13	10-1505	4.85E-4 $\pm$ 3%	<6.E-6		
F1-LD-14	10-1506	7.68E-4 $\pm$ 3%	7.89E-6 $\pm$ 39%		
F1-LD-15	10-1507	1.13E-3 $\pm$ 3%	<7.E-6		
F1-LD-16	10-1508	1.68E-3 $\pm$ 3%	<9.E-6		
F1-LD-17	10-1509	2.20E-3 $\pm$ 3%	<9.E-6		
F1-LD-18	10-1510	2.84E-3 $\pm$ 2%	<1.E-5		
F1-LD-19	10-1511	3.74E-3 $\pm$ 2%	<1.E-5		
F1-LD-20	10-1512	5.07E-3 $\pm$ 2%	<1.E-5		
F1-LD-21	10-1513	6.32E-3 $\pm$ 2%	<2.E-5		
F1-LD-22	10-1514	7.93E-3 $\pm$ 2%	<2.E-5		
F1-LD-23	10-1515	9.60E-3 $\pm$ 2%	<2.E-5		
F1-LD-24	10-1516	1.11E-2 $\pm$ 2%	<2.E-5		
F1-LD-25	10-1517	1.42E-2 $\pm$ 2%	<2.E-5		
F1-LD-26	10-1518	1.73E-2 $\pm$ 2%	<3.E-5		
F1-LD-27	10-1519	1.92E-2 $\pm$ 2%	<3.E-5		
F1-LD-28	10-1520	2.28E-2 $\pm$ 2%	<3.E-5		
F1-LD-CP	10-1521	6.42E-3 $\pm$ 2%	<2.E-5		
F1-FD-CP	10-1522	5.24E-3 $\pm$ 2%	<2.E-5		
F1-FDI-CP	10-1523	1.30E-4 $\pm$ 5%	<6.E-6		
F1-AN-CP	10-1524	1.71E-4 $\pm$ 4%	<8.E-6		
F1-EL-01	10-1525	8.28E-2 $\pm$ 2%	<1.E-4		

Measured Activities, $\mu\text{Ci}/\text{sample}$ with 1-sigma uncertainty

Sample ID	RPL ID	Cs-134	Cs-137	Recount	
				Cs-134	Cs-137
F1-EL-02	10-1526	2.16E+1 $\pm$ 2%	<6 E-3		
F1-EL-03	10-1527	1.37E+0 $\pm$ 2%	<7 E-4		
F1-EL-04	10-1528	1.78E-1 $\pm$ 2%	4.80E-3 $\pm$ 4%		
F1-EL-05	10-1529	1.26E-1 $\pm$ 2%	2.53E-2 $\pm$ 3%		
F1-EL-06	10-1530	7.63E-1 $\pm$ 2%	5.35E-1 $\pm$ 5%		
F1-EL-07	10-1531	3.51E-1 $\pm$ 2%	6.43E-1 $\pm$ 3%		
F1-EL-08	10-1532	1.77E-1 $\pm$ 2%	6.45E-1 $\pm$ 3%		
F1-EL-10	10-1533	5.18E-2 $\pm$ 2%	5.87E-1 $\pm$ 3%		
F1-EL-12	10-1534	1.82E-2 $\pm$ 2%	5.89E-1 $\pm$ 3%		
F1-EL-15	10-1535	5.53E-3 $\pm$ 2%	6.36E-1 $\pm$ 4%		
F1-EL-18	10-1536	2.75E-3 $\pm$ 3%	6.29E-1 $\pm$ 4%		
F1-EL-21	10-1537	2.63E-3 $\pm$ 3%	7.24E-1 $\pm$ 4%		
F1-EL-CP	10-1538	6.97E+0 $\pm$ 2%	5.17E-1 $\pm$ 3%		
F1-EDI-CP	10-1539	7.03E-3 $\pm$ 2%	6.18E-1 $\pm$ 4%		
F1-RG-CP	10-1540	6.29E-4 $\pm$ 2%	6.41E-3 $\pm$ 2%		

Appendix C

Supplemental Data Tables

Appendix C

Supplemental Data Tables

Table C.1. Column D1 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
D1-PT-DIW1	250 mL	25	192	12:45	15:15	6.0	Blk	20.4	66.22	175.9	109.7	0.0000	0.000	0.000
D1-PT-ACID	200 mL	25	193	15:15	18:07	5.8	Blk	25.1	66.22	301.3	125.4	0.0000	0.000	0.000
D1-PT-DIW2	250 mL	25	193	20:00	21:00	5.1	Org	24.4	66.22	346.8	45.5	0.0000	0.000	0.000
D1-PT-NaOH	200 mL	25	193	21:02	23:02	6.0	Blk	24.4	66.22	434.0	87.2	0.0000	0.000	0.000
D1-LD-0	4-L	45	193	NA	NA	NA	NA	NA	NA	NA	NA	17.4800	29.500	12.020
Loading (LD) Phase Start Date/Time:				23:30										
D1-LD-1	4-L	45	109	0:00	00:30	6.0	Blk	46.0	355.8	368.3	12.5	17.4720	28.500	11.028
D1-LD-2	4-L	45	109	01:00	01:30	6.2	Blk	46.0	355.8	380.4	12.1	17.5045	29.900	12.396
D1-LD-3	4-L	45	109	02:00	02:30	6.3	Blk	46.0	355.8	393.0	12.6	17.4269	30.700	13.273
D1-LD-4	4-L	45	109	03:00	03:30	6.3	Blk	46.0	355.8	406.3	13.3	17.4573	30.900	13.443
D1-LD-5	4-L	45	109	04:00	04:30	6.2	Blk	46.0	355.8	419.7	13.4	17.4293	31.200	13.771
D1-LD-6	4-L	45	109	05:00	05:30	6.2	Blk	46.0	355.8	433.0	13.3	17.2931	31.300	14.007
D1-LD-7	4-L	45	109	06:00	06:30	6.2	Blk	46.0	355.8	447.1	14.1	17.2432	31.100	13.857
D1-LD-8	4-L	45	109	07:00	07:30	6.2	Blk	46.0	355.8	469.3	22.2	17.5166	31.400	13.883
D1-LD-9	4-L	45	732	09:00	09:30	6.3	Blk	46.0	355.8	497.8	28.5	17.3045	31.400	14.096
D1-LD-10	4-L	45	732	10:00	10:08	6.3	Blk	46.0	355.8	600.7	102.9	17.6568	45.700	28.043
D1-LD-11	4-L	45	732	11:00	11:08	6.3	Blk	46.0	355.8	787.8	187.1	17.3705	46.200	28.830
D1-LD-12	4-L	45	732	12:00	12:08	6.3	Blk	46.0	355.8	981.0	193.2	17.3827	44.900	27.517
D1-LD-13	4-L	45	732	13:00	13:08	6.3	Blk	46.0	355.8	1167.6	186.6	17.4507	45.100	27.649
D1-LD-14	4-L	45	732	14:00	14:08	NR	NR	NR	355.8	1364.3	196.7	17.7256	36.700	18.974
D1-LD-15	4-L	45	732	15:00	15:05	6.3	Blk	46.0	355.8	1560.9	196.7	17.5332	36.600	19.067
D1-LD-16	4-L	45	732	16:00	16:05	6.3	Blk	46.0	355.8	1760.5	199.6	17.3964	35.900	18.504

C.1

Table C.1. (contd)

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
D1-LD-17	4-L	45	732	17:00	17:05	6.3	Blk	46.0	355.8	1948.9	188.4	17.4069	36.000	18.593
D1-LD-18	4-L	45	732	18:00	18:05	6.4	Blk	46.0	355.8	2137.2	188.4	17.7220	36.600	18.878
D1-LD-19	4-L	45	732	19:00	19:05	6.3	Blk	46.0	355.8	2338.3	201.1	17.4367	36.000	18.563
D1-LD-20	4-L	45	732	20:00	20:05	6.3	Blk	46.0	355.8	2533.4	195.1	17.3992	35.900	18.501
D1-LD-21	4-L	45	732	21:00	21:05	6.3	Blk	46.0	355.8	2731.7	198.3	17.6495	36.100	18.451
D1-LD-22	4-L	45	732	22:01	22:06	6.3	Blk	46.0	355.8	2939.3	207.6	17.4276	36.100	18.672
D1-LD-23	4-L	45	732	23:00	23:05	6.3	Blk	46.0	355.8	3132.4	193.1	17.3740	36.000	18.626
D1-LD-24	4-L	45	732	00:00	00:05	6.3	Blk	46.0	355.8	3330.7	198.3	17.5052	35.900	18.395
D1-LD-25	4-L	45	732	01:00	01:05	6.3	Blk	46.0	355.8	3530.5	199.8	17.4737	35.100	17.626
D1-LD-26	4-L	45	732	02:00	02:05	6.3	Blk	46.0	355.8	3730.1	199.6	17.5829	35.200	17.617
D1-LD-27	4-L	45	732	03:00	03:05	6.4	Blk	46.0	355.8	3929.5	199.4	17.3514	35.900	18.549
D1-LD-28	4-L	45	732	04:00	04:05	6.3	Blk	46.0	355.8	4127.7	198.2	17.4466	35.900	18.453
D1-LD-29	4-L	45	732	04:30	04:35	6.3	Blk	46.0	355.8	4217.7	90.0	17.3520	35.800	18.448
D1-LD-CP	4-L	45	Mix	23:30	05:03	Mix	Blk	46.0	355.8	4317.7	3961.9	17.4621	29.500	12.038
D1-FD-CP	4-L	45	193	05:11	07:42	6.3	Blk	46.0	25.39	138.0	112.61	17.4097	29.500	12.090
D1-FDI-CP	4-L	25	193	07:46	10:45	6.1	Blk	25.0	25.38	147.0	121.6	17.3500	27.400	10.050
D1-AN-CP	4-L	25	103	10:45	13:00	5.7	Mix	25.0	12.82	50.3	37.5	17.3800	27.500	10.120

Table C.1. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
D1-PT-DIW1	109.85	7.32	0.73	2.93	0.73	2.93	NA	NA	NA	NA	NA	NA
D1-PT-ACID	123.92	8.26	0.72	2.88	0.73	2.91	NA	NA	NA	NA	NA	NA
D1-PT-DIW2	45.57	3.04	0.76	3.04	0.74	2.95	NA	NA	NA	NA	NA	NA
D1-PT-NaOH	85.12	5.67	0.71	2.84	0.73	2.92	NA	NA	NA	NA	NA	NA
D1-LD-0	NA	NA	NA	NA	NA	NA	9.9653	10-1086	1.03E+00	± 2%	<9.0E-04	NA
D1-LD-1	22.97	1.53	0.38	1.53	0.38	1.53	10.7650	10-1087	<6.0E-06	NA	<1.2E-05	NA
D1-LD-2	21.96	1.46	0.37	1.46	0.37	1.50	11.1140	10-1088	<6.0E-06	NA	<7.0E-06	NA
D1-LD-3	21.45	1.43	0.36	1.43	0.37	1.48	11.0042	10-1089	<6.0E-06	NA	<6.0E-06	NA
D1-LD-4	22.17	1.48	0.37	1.48	0.37	1.48	11.1448	10-1090	<6.0E-06	NA	<6.0E-06	NA
D1-LD-5	22.53	1.50	0.38	1.50	0.37	1.48	11.4167	10-1091	<6.0E-06	NA	<6.0E-06	NA
D1-LD-6	22.64	1.51	0.38	1.51	0.37	1.49	11.6126	10-1092	<6.0E-06	NA	<6.0E-06	NA
D1-LD-7	23.18	1.55	0.39	1.55	0.37	1.49	11.4881	10-1093	<6.0E-06	NA	<6.0E-06	NA
D1-LD-8	29.92	1.99	0.50	1.99	0.39	1.56	11.5102	10-1094	<6.0E-06	NA	<6.0E-06	NA
D1-LD-9	35.31	2.35	0.29	1.18	0.37	1.48	11.6860	10-1095	<6.0E-06	NA	<6.0E-06	NA
D1-LD-10	108.56	7.24	2.86	11.43	2.86	11.43	9.8187	10-1096	<6.0E-06	NA	<6.0E-06	NA
D1-LD-11	179.02	11.93	2.98	11.93	2.93	11.74	10.0561	10-1097	<7.0E-06	NA	<6.0E-06	NA
D1-LD-12	182.99	12.20	3.05	12.20	2.98	11.91	10.0460	10-1098	<7.0E-06	± 21%	<5.0E-06	NA
D1-LD-13	177.63	11.84	2.96	11.84	2.97	11.89	9.9896	10-1099	1.56E-05	± 15%	<6.0E-06	NA
D1-LD-14	178.77	11.92	2.98	11.92	2.97	11.90	9.7617	10-1100	2.32E-05	± 21%	<6.0E-06	NA
D1-LD-15	178.84	11.92	3.14	12.55	3.00	12.01	9.9212	10-1101	5.13E-05	± 7%	<4.0E-06	NA
D1-LD-16	180.82	12.05	3.01	12.05	3.00	12.02	10.0346	10-1102	1.11E-04	± 4%	<4.0E-06	NA
D1-LD-17	171.57	11.44	2.86	11.44	2.99	11.94	10.0259	10-1103	2.04E-04	± 3%	<4.0E-06	NA
D1-LD-18	171.80	11.45	2.86	11.45	2.97	11.88	9.7647	10-1104	4.92E-04	± 2%	<6.0E-06	NA
D1-LD-19	182.11	12.14	3.04	12.14	2.98	11.91	10.0012	10-1105	6.87E-04	± 2%	<6.0E-06	NA
D1-LD-20	177.09	11.81	2.95	11.81	2.98	11.90	10.0323	10-1106	1.04E-03	± 2%	<7.0E-06	NA

Table C.1. (contd)

Sample ID No.	Instant. Volume mL BV		Instant. Flow mL/min BV/hr		Average Flow mL/min BV/hr		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
D1-LD-21	179.70	11.98	2.99	11.98	2.98	11.91	9.8248	10-1107	1.53E-03	± 2%	<9.0E-06	NA
D1-LD-22	187.59	12.51	3.08	12.30	2.98	11.94	10.0087	10-1108	2.28E-03	± 2%	<1.0E-05	NA
D1-LD-23	175.53	11.70	2.98	11.90	2.98	11.94	10.0532	10-1109	3.28E-03	± 2%	<1.0E-05	NA
D1-LD-24	179.65	11.98	2.99	11.98	2.98	11.94	9.9444	10-1110	4.60E-03	± 2%	<1.0E-05	NA
D1-LD-25	180.26	12.02	3.00	12.02	2.99	11.94	9.9705	10-1111	6.60E-03	± 2%	<1.5E-05	NA
D1-LD-26	180.09	12.01	3.00	12.01	2.99	11.95	9.8800	10-1112	9.27E-03	± 2%	<1.8E-05	NA
D1-LD-27	180.69	12.05	3.01	12.05	2.99	11.95	10.0719	10-1113	1.29E-02	± 2%	<2.0E-05	NA
D1-LD-28	179.62	11.97	2.99	11.97	2.99	11.95	9.9930	10-1114	1.70E-02	± 2%	<2.0E-05	NA
D1-LD-29	89.91	5.99	3.00	11.99	2.99	11.96	10.0714	10-1115	1.98E-02	± 2%	<3.0E-05	NA
D1-LD-CP	3732.13	248.81	NA	NA	NA	NA	9.9801	10-1116	3.38E-03	± 2%	<1.0E-05	NA
D1-FD-CP	112.99	7.53	0.75	2.99	0.75	2.99	10.9551	10-1117	7.09E-03	± 2%	<2.0E-05	NA
D1-FDI-CP	131.70	8.78	0.74	2.94	0.74	2.94	10.0526	10-1118	8.06E-05	± 4%	<4.0E-06	NA
D1-AN-CP	47.35	3.16	0.35	1.40	0.35	1.40	10.0678	10-1119	1.42E-04	± 3%	<5.0E-06	NA

Table C.1. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	Loading meq/g
D1-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D1-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D1-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D1-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D1-LD-0	1.03E-01	2.07E-03	<9.0E-05	NA	NA	100.0%	1.00E+00	2.83E-02	NA	NA	NA	NA	NA	NA
D1-LD-1	<5.57E-07	NA	<1.1E-06	NA	1.53	0.00%	5.39E-06	NA	NA	NA	NA	5.51E-04	5.51E-04	8.06E-05
D1-LD-2	<5.40E-07	NA	<6.3E-07	NA	3.00	0.00%	5.22E-06	NA	NA	NA	NA	5.27E-04	1.08E-03	1.58E-04
D1-LD-3	<5.45E-07	NA	<5.5E-07	NA	4.43	0.00%	5.28E-06	NA	NA	NA	NA	5.15E-04	1.59E-03	2.33E-04
D1-LD-4	<5.38E-07	NA	<5.4E-07	NA	5.90	0.00%	5.21E-06	NA	NA	NA	NA	5.32E-04	2.13E-03	3.11E-04
D1-LD-5	<5.26E-07	NA	<5.3E-07	NA	7.41	0.00%	5.08E-06	NA	NA	NA	NA	5.41E-04	2.67E-03	3.90E-04
D1-LD-6	<5.17E-07	NA	<5.2E-07	NA	8.91	0.00%	5.00E-06	NA	NA	NA	NA	5.43E-04	3.21E-03	4.69E-04
D1-LD-7	<5.22E-07	NA	<5.2E-07	NA	10.46	0.00%	5.05E-06	NA	NA	NA	NA	5.56E-04	3.77E-03	5.51E-04
D1-LD-8	<5.21E-07	NA	<5.2E-07	NA	12.45	0.00%	5.04E-06	NA	NA	NA	NA	7.18E-04	4.48E-03	6.55E-04
D1-LD-9	<5.13E-07	NA	<5.1E-07	NA	14.81	0.00%	4.97E-06	NA	NA	NA	NA	8.48E-04	5.33E-03	7.79E-04
D1-LD-10	<6.11E-07	NA	<6.1E-07	NA	22.05	0.00%	5.91E-06	NA	NA	NA	NA	2.61E-03	7.94E-03	1.16E-03
D1-LD-11	<6.96E-07	NA	<6.0E-07	NA	33.98	0.00%	6.73E-06	NA	NA	NA	NA	4.30E-03	1.22E-02	1.79E-03
D1-LD-12	6.97E-07	1.50E-07	<5.0E-07	NA	46.18	0.00%	6.74E-06	1.45E-06	NA	NA	NA	4.39E-03	1.66E-02	2.43E-03
D1-LD-13	1.56E-06	2.39E-07	<6.0E-07	NA	58.02	0.00%	1.51E-05	2.33E-06	NA	NA	NA	4.26E-03	2.09E-02	3.05E-03
D1-LD-14	2.38E-06	5.10E-07	<6.1E-07	NA	69.94	0.00%	2.30E-05	4.96E-06	NA	NA	NA	4.29E-03	2.52E-02	3.68E-03
D1-LD-15	5.17E-06	3.60E-07	<4.0E-07	NA	81.86	0.01%	5.00E-05	3.63E-06	NA	NA	NA	4.29E-03	2.95E-02	4.31E-03
D1-LD-16	1.11E-05	4.15E-07	<4.0E-07	NA	93.92	0.01%	1.07E-04	4.55E-06	NA	NA	NA	4.34E-03	3.38E-02	4.94E-03
D1-LD-17	2.03E-05	6.06E-07	<4.0E-07	NA	105.35	0.02%	1.97E-04	7.06E-06	NA	NA	NA	4.12E-03	3.79E-02	5.54E-03
D1-LD-18	5.04E-05	1.22E-06	<6.1E-07	NA	116.81	0.05%	4.87E-04	1.53E-05	NA	NA	NA	4.12E-03	4.20E-02	6.15E-03
D1-LD-19	6.87E-05	1.58E-06	<6.0E-07	NA	128.95	0.07%	6.65E-04	2.03E-05	NA	NA	NA	4.37E-03	4.64E-02	6.79E-03
D1-LD-20	1.04E-04	2.25E-06	<7.0E-07	NA	140.75	0.10%	1.00E-03	2.96E-05	NA	NA	NA	4.25E-03	5.07E-02	7.41E-03

Table C.1. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	meq/g
D1-LD-21	1.56E-04	3.21E-06	<9.2E-07	NA	152.73	0.15%	1.51E-03	4.32E-05	NA	NA	NA	4.31E-03	5.50E-02	8.04E-03
D1-LD-22	2.28E-04	4.52E-06	<1.0E-06	NA	165.24	0.22%	2.20E-03	6.21E-05	NA	NA	NA	4.49E-03	5.95E-02	8.69E-03
D1-LD-23	3.26E-04	6.36E-06	<9.9E-07	NA	176.94	0.32%	3.16E-03	8.81E-05	NA	NA	NA	4.20E-03	6.37E-02	9.31E-03
D1-LD-24	4.62E-04	8.77E-06	<1.0E-06	NA	188.92	0.45%	4.47E-03	1.23E-04	NA	NA	NA	4.30E-03	6.80E-02	9.94E-03
D1-LD-25	6.62E-04	1.09E-05	<1.5E-06	NA	200.94	0.64%	6.40E-03	1.66E-04	NA	NA	NA	4.30E-03	7.23E-02	1.06E-02
D1-LD-26	9.38E-04	1.53E-05	<1.8E-06	NA	212.94	0.91%	9.08E-03	2.34E-04	NA	NA	NA	4.29E-03	7.66E-02	1.12E-02
D1-LD-27	1.28E-03	2.07E-05	<2.0E-06	NA	224.99	1.24%	1.24E-02	3.19E-04	NA	NA	NA	4.29E-03	8.08E-02	1.18E-02
D1-LD-28	1.70E-03	3.40E-05	<2.0E-06	NA	236.96	1.64%	1.64E-02	4.65E-04	NA	NA	NA	4.25E-03	8.51E-02	1.24E-02
D1-LD-29	1.97E-03	3.94E-05	<3.0E-06	NA	242.96	1.91%	1.91E-02	5.39E-04	NA	NA	NA	2.12E-03	8.72E-02	1.28E-02
D1-LD-CP	3.39E-04	6.78E-06	<1.0E-06	NA	248.81	0.33%	3.28E-03	9.28E-05	NA	NA	NA	8.90E-02	8.90E-02	1.30E-02
D1-FD-CP	6.47E-04	1.29E-05	<1.8E-06	NA	256.34	0.63%	6.26E-03	1.77E-04	NA	NA	NA	2.43E-03	8.96E-02	1.31E-02
D1-FDI-CP	8.01E-06	3.21E-07	<4.0E-07	NA	265.12	0.01%	7.75E-05	3.47E-06	NA	NA	NA	2.92E-03	9.26E-02	1.35E-02
D1-AN-CP	1.41E-05	4.23E-07	<5.0E-07	NA	268.28	0.01%	1.36E-04	4.91E-06	NA	NA	NA	8.95E-04	9.35E-02	1.37E-02

Table C.2. Column D2 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
D2-PT-DIW1	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2-PT-ACID	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2-PT-DIW2	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2-PT-NaOH	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2-LD-0	4-L	45										17.4325	30.100	12.668
Loading (LD) Phase Start Date/Time:				06:00										
D2-LD-1	4-L	45	109	06:30	07:00	6.2	Blk	46.0	355.9	369.7	13.8	17.3968	28.800	11.403
D2-LD-2	4-L	45	109	07:30	08:00	6.2	Blk	46.0	355.9	381.5	11.8	17.5024	30.500	12.998
D2-LD-3	4-L	45	109	08:30	09:00	6.2	Blk	46.0	355.9	394.7	13.2	17.5463	30.500	12.954
D2-LD-4	4-L	45	109	09:30	10:00	6.2	Blk	46.0	355.9	407.2	12.5	17.5143	31.300	13.786
D2-LD-5	4-L	45	109	10:30	11:00	6.2	Blk	46.0	355.9	420.9	13.7	17.4964	30.000	12.504
D2-LD-6	4-L	45	109	11:30	12:00	6.2	Blk	46.0	355.9	435.5	14.6	17.4737	31.300	13.826
D2-LD-7	4-L	45	109	12:36	13:05	6.2	Blk	46.0	355.9	451.4	15.9	17.5421	30.300	12.758
D2-LD-8	4-L	45	109	13:30	14:00	6.2	Blk	46.0	355.9	463.3	11.9	17.4811	30.000	12.519
D2-LD-24	4-L	45	109	17:15	05:44	6.2	Blk	46.0	355.9	4721.5	4258.2	17.3941	29.000	11.606
D2-LD-CP	4-L	45	Mix	NA	NA	6.2	Blk	46.0	355.9	4721.5	4365.6	17.0476	29.500	12.452
D2-FD-CP	4-L	45	174	06:00	08:35	6.2	Blk	46.0	25.37	151.1	125.7	17.4388	29.500	12.061
D2-FDI-CP	4-L	25	174	09:00	11:30	6.2	Blk	31.0	25.31	114.1	88.8	17.4544	29.500	12.046
D2-AN-CP	4-L	25	87	12:00	14:06	6.2	Mix	25.6	12.89	68.7	55.8	17.5990	29.500	11.901

Table C.2. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
D2-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2-LD-0	NA	NA	NA	NA	NA	NA	10.5021	10-1186	1.07E+00	± 2%	6.31E-02	± 3%
D2-LD-1	24.60	1.640	0.410	1.640	0.410	1.640	11.1312	10-1187	7.87E-05	± 7%	2.01E-03	± 4%
D2-LD-2	22.23	1.482	0.371	1.482	0.390	1.561	11.6538	10-1188	5.53E-05	± 7%	6.22E-04	± 2%
D2-LD-3	21.68	1.446	0.361	1.446	0.381	1.523	10.7394	10-1189	5.69E-05	± 6%	9.07E-04	± 2%
D2-LD-4	21.79	1.453	0.363	1.453	0.376	1.505	11.4292	10-1190	4.88E-05	± 7%	1.06E-03	± 2%
D2-LD-5	21.72	1.448	0.362	1.448	0.373	1.494	10.3662	10-1191	4.63E-05	± 8%	1.05E-03	± 2%
D2-LD-6	23.57	1.571	0.393	1.571	0.377	1.507	11.4628	10-1192	4.47E-05	± 11%	1.09E-03	± 2%
D2-LD-7	23.76	1.584	0.366	1.462	0.375	1.500	10.5771	10-1193	4.94E-05	± 8%	1.06E-03	± 3%
D2-LD-8	20.24	1.350	0.368	1.472	0.374	1.497	10.3789	10-1194	4.42E-05	± 9%	1.04E-03	± 3%
D2-LD-24	3539.92	235.99	3.750	15.000	3.750	15.00	9.6220	10-1195	1.36E-02	± 2%	1.73E-03	± 3%
D2-LD-CP	3724.47	248.30	NA	NA	NA	NA	10.3238	10-1196	2.12E-03	± 2%	1.14E-03	± 2%
D2-FD-CP	113.92	7.595	0.735	2.940	0.735	2.940	10.9287	10-1197	4.49E-03	± 3%	6.78E-04	± 3%
D2-FDI-CP	88.81	5.921	0.592	2.368	0.592	2.368	12.0487	10-1198	8.93E-05	± 5%	1.62E-05	± 14%
D2-AN-CP	55.52	3.701	0.441	1.763	0.441	1.763	11.8396	10-1199	1.40E-04	± 5%	3.27E-05	± 11%

Table C.2. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	meq/g
D2-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D2-LD-0	1.02E-01	2.04E-03	6.23E-02	1.87E-03	NA	100.00%	1.00E+00	2.83E-02	100.00%	100.00%	4.24E-02	NA	NA	NA
D2-LD-1	7.07E-06	4.95E-07	1.80E-04	7.22E-06	1.64	0.01%	6.94E-05	5.05E-06	0.29%	2.90E-03	1.45E-04	5.90E-04	5.90E-04	8.63E-05
D2-LD-2	4.75E-06	3.32E-07	5.34E-05	1.07E-06	3.12	0.00%	4.66E-05	3.39E-06	0.09%	8.57E-04	3.09E-05	5.34E-04	1.12E-03	1.64E-04
D2-LD-3	5.30E-06	3.18E-07	8.45E-05	1.69E-06	4.57	0.01%	5.20E-05	3.29E-06	0.14%	1.36E-03	4.89E-05	5.20E-04	1.64E-03	2.40E-04
D2-LD-4	4.27E-06	2.99E-07	9.27E-05	1.85E-06	6.02	0.00%	4.19E-05	3.05E-06	0.15%	1.49E-03	5.37E-05	5.23E-04	2.17E-03	3.17E-04
D2-LD-5	4.47E-06	3.57E-07	1.01E-04	2.03E-06	7.47	0.00%	4.39E-05	3.62E-06	0.16%	1.63E-03	5.87E-05	5.21E-04	2.69E-03	3.93E-04
D2-LD-6	3.90E-06	4.29E-07	9.54E-05	1.91E-06	9.04	0.00%	3.83E-05	4.28E-06	0.15%	1.53E-03	5.52E-05	5.66E-04	3.25E-03	4.76E-04
D2-LD-7	4.67E-06	3.74E-07	1.00E-04	3.01E-06	10.62	0.00%	4.58E-05	3.78E-06	0.16%	1.61E-03	6.83E-05	5.70E-04	3.82E-03	5.59E-04
D2-LD-8	4.26E-06	3.83E-07	1.00E-04	3.01E-06	11.97	0.00%	4.18E-05	3.86E-06	0.16%	1.61E-03	6.83E-05	4.86E-04	4.31E-03	6.30E-04
D2-LD-24	1.41E-03	2.83E-05	1.80E-04	5.39E-06	247.97	1.39%	1.39E-02	3.93E-04	0.29%	2.89E-03	1.23E-04	8.44E-02	8.87E-02	1.30E-02
D2-LD-CP	2.05E-04	4.10E-06	1.10E-04	2.20E-06	248.30	0.20%	2.01E-03	5.70E-05	0.18%	1.77E-03	6.38E-05	8.90E-02	8.90E-02	1.30E-02
D2-FD-CP	4.11E-04	1.23E-05	6.20E-05	1.86E-06	255.89	0.40%	4.03E-03	1.45E-04	0.10%	9.96E-04	4.23E-05	2.72E-03	9.14E-02	1.34E-02
D2-FDI-CP	7.41E-06	3.71E-07	1.34E-06	1.88E-07	261.81	0.01%	7.28E-05	3.92E-06	0.00%	2.15E-05	3.08E-06	2.13E-03	9.35E-02	1.37E-02
D2-AN-CP	1.18E-05	5.90E-07	2.77E-06	3.04E-07	265.52	0.01%	1.16E-04	6.23E-06	0.00%	4.44E-05	5.06E-06	1.33E-03	9.49E-02	1.39E-02

Table C.3. Column D3 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
D3-PT-DIW1	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3-PT-ACID	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3-PT-DIW2	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3-PT-NaOH	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3-LD-0	4-L	45										17.4056	30.400	12.994
Loading (LD) Phase Start Date/Time:				09:00										
D3-LD-1	4-L	45	101	09:30	10:00	6.4	Blk	46.0	387.4	401.0	13.6	17.3610	29.400	12.039
D3-LD-2	4-L	45	101	10:30	11:00	6.8	Blk	46.0	387.4	413.3	12.3	17.4659	30.800	13.334
D3-LD-3	4-L	45	101	11:30	12:00	6.7	Blk	46.0	387.4	426.3	13.0	17.4812	31.500	14.019
D3-LD-4	4-L	45	101	12:30	13:00	6.7	Blk	46.0	387.4	439.7	13.4	17.5013	31.800	14.299
D3-LD-5	4-L	45	101	13:30	14:00	6.7	Blk	46.0	387.4	453.4	13.7	17.6155	32.000	14.385
D3-LD-6	4-L	45	101	14:30	15:00	6.7	Blk	46.0	387.4	467.1	13.7	17.4753	32.100	14.625
D3-LD-7	4-L	45	101	15:30	16:00	6.7	Blk	46.0	387.4	480.8	13.7	17.4955	32.200	14.705
D3-LD-8	4-L	45	101	16:30	17:00	6.7	Blk	46.0	387.4	494.4	13.6	17.3987	32.000	14.601
D3-LD-24	4-L	45	640	12:30	12:36	6.7	Blk	46.0	387.4	4723.9	4229.5	17.3520	29.500	12.148
D3-LD-CP	4-L	45	Mix	09:00	12:45	6.7	Blk	46.0	387.4	4768.0	4380.6	17.4650	28.500	11.035
D3-FD-CP	4-L	45	174	13:00	15:30	6.6	Blk	46.0	25.38	143.8	118.4	17.4690	28.500	11.031
D3-FDI-CP	4-L	25	174	15:30	18:00	6.6	Blk	28.1	25.35	136.7	111.4	17.2811	28.500	11.219
D3-AN-CP	4-L	25	174	18:05	19:05	5.9	Mix	25.0	12.89	57.6	44.7	17.4162	28.500	11.084

Table C.3. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
D3-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3-LD-0	NA	NA	NA	NA	NA	NA	10.7731	10-1251	1.10E+00	± 2%	6.02E-02	± 3%
D3-LD-1	25.03	1.668	0.417	1.668	0.417	1.668	11.7518	10-1252	7.34E-04	± 2%	1.71E-03	± 2%
D3-LD-2	22.98	1.532	0.383	1.532	0.400	1.600	11.9555	10-1253	1.18E-03	± 2%	3.75E-03	± 2%
D3-LD-3	22.40	1.493	0.373	1.493	0.391	1.565	11.6224	10-1254	1.66E-03	± 2%	5.24E-03	± 2%
D3-LD-4	22.96	1.531	0.383	1.531	0.389	1.556	11.8545	10-1255	2.06E-03	± 2%	5.86E-03	± 2%
D3-LD-5	23.28	1.552	0.388	1.552	0.389	1.555	11.9256	10-1256	2.01E-03	± 2%	5.77E-03	± 2%
D3-LD-6	23.48	1.566	0.391	1.566	0.389	1.557	12.1248	10-1257	1.81E-03	± 2%	5.76E-03	± 2%
D3-LD-7	23.55	1.570	0.392	1.570	0.390	1.559	12.1909	10-1258	1.78E-03	± 2%	5.82E-03	± 2%
D3-LD-8	23.38	1.559	0.390	1.559	0.390	1.559	12.1054	10-1259	1.75E-03	± 2%	5.70E-03	± 2%
D3-LD-24	3516.58	234.44	2.990	11.961	2.990	11.96	10.0714	10-1260	4.27E-02	± 3%	1.05E-02	± 2%
D3-LD-CP	3743.86	249.59	NA	NA	NA	NA	9.1487	10-1261	8.07E-03	± 2%	5.87E-03	± 3%
D3-FD-CP	107.30	7.153	0.715	2.861	0.715	2.861	9.9953	10-1262	1.31E-02	± 2%	4.03E-03	± 3%
D3-FDI-CP	111.38	7.425	0.743	2.970	0.743	2.970	11.2218	10-1263	2.72E-04	± 3%	1.05E-04	± 5%
D3-AN-CP	44.48	2.965	0.741	2.965	0.741	2.965	11.0266	10-1264	3.41E-04	± 3%	1.33E-04	± 4%

Table C.3. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	meq/g
D3-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D3-LD-0	1.02E-01	2.04E-03	5.78E-02	1.74E-03	NA	100.00%	1.00E+00	2.83E-02	100.00%	100.00%	4.24E-02	NA	NA	NA
D3-LD-1	6.24E-05	1.25E-06	1.45E-04	2.90E-06	1.67	0.06%	6.11E-04	1.73E-05	0.25%	2.51E-03	9.04E-05	6.00E-04	6.00E-04	8.78E-05
D3-LD-2	9.87E-05	1.97E-06	3.14E-04	6.27E-06	3.20	0.10%	9.66E-04	2.73E-05	0.54%	5.42E-03	1.96E-04	5.51E-04	1.15E-03	1.68E-04
D3-LD-3	1.42E-04	2.85E-06	4.51E-04	9.02E-06	4.69	0.14%	1.40E-03	3.95E-05	0.78%	7.80E-03	2.81E-04	5.37E-04	1.69E-03	2.47E-04
D3-LD-4	1.74E-04	3.47E-06	4.94E-04	9.89E-06	6.23	0.17%	1.70E-03	4.81E-05	0.85%	8.55E-03	3.08E-04	5.50E-04	2.24E-03	3.27E-04
D3-LD-5	1.69E-04	3.37E-06	4.84E-04	9.68E-06	7.78	0.17%	1.65E-03	4.67E-05	0.84%	8.36E-03	3.02E-04	5.58E-04	2.80E-03	4.09E-04
D3-LD-6	1.50E-04	2.99E-06	4.75E-04	9.50E-06	9.34	0.15%	1.47E-03	4.15E-05	0.82%	8.21E-03	2.96E-04	5.63E-04	3.36E-03	4.91E-04
D3-LD-7	1.46E-04	2.92E-06	4.77E-04	9.55E-06	10.91	0.14%	1.43E-03	4.04E-05	0.83%	8.25E-03	2.98E-04	5.64E-04	3.92E-03	5.74E-04
D3-LD-8	1.44E-04	2.88E-06	4.71E-04	9.42E-06	12.47	0.14%	1.41E-03	3.99E-05	0.81%	8.14E-03	2.93E-04	5.60E-04	4.48E-03	6.56E-04
D3-LD-24	4.24E-03	1.27E-04	1.04E-03	2.09E-05	246.91	4.15%	4.15E-02	1.50E-03	1.80%	1.80E-02	6.50E-04	8.26E-02	8.71E-02	1.27E-02
D3-LD-CP	8.82E-04	1.76E-05	6.42E-04	1.92E-05	249.59	0.86%	8.64E-03	2.44E-04	1.11%	1.11E-02	4.71E-04	8.89E-02	8.89E-02	1.30E-02
D3-FD-CP	1.31E-03	2.61E-05	4.03E-04	1.21E-05	256.74	1.28%	1.28E-02	3.62E-04	0.70%	6.96E-03	2.95E-04	2.54E-03	8.96E-02	1.31E-02
D3-FDI-CP	2.43E-05	7.28E-07	9.39E-06	4.70E-07	264.17	0.02%	2.38E-04	8.57E-06	0.02%	1.62E-04	9.47E-06	2.67E-03	9.23E-02	1.35E-02
D3-AN-CP	3.09E-05	9.28E-07	1.20E-05	4.81E-07	267.13	0.03%	3.03E-04	1.09E-05	0.02%	2.08E-04	1.04E-05	1.07E-03	9.34E-02	1.36E-02

Table C.4. Column D4 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
D4-PT-DIW1	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4-PT-ACID	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4-PT-DIW2	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4-PT-NaOH	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4-LD-0	4-L	45										17.4391	29.700	12.261
Loading (LD) Phase Start Date/Time:				05:30										
D4-LD-1	4-L	45	101	06:00	06:30	6.8	Blk	46.0	387.4	399.6	12.2	17.4856	29.200	11.714
D4-LD-2	4-L	45	101	07:00	07:30	6.8	Blk	46.0	387.4	411.7	12.1	17.4363	30.600	13.164
D4-LD-3	4-L	45	101	08:00	08:30	6.8	Blk	46.0	387.4	424.4	12.7	17.4189	30.800	13.381
D4-LD-4	4-L	45	101	09:00	09:28	6.8	Blk	46.0	387.4	437.7	13.3	17.2835	30.000	12.717
D4-LD-5	4-L	45	101	10:00	10:28	6.8	Blk	46.0	387.4	451.9	14.2	17.5552	30.900	13.345
D4-LD-6	4-L	45	101	11:00	11:28	6.8	Blk	46.0	387.4	465.9	14.0	17.4779	30.400	12.922
D4-LD-7	4-L	45	101	12:00	12:28	6.8	Blk	46.0	387.4	480.6	14.7	17.3909	30.500	13.109
D4-LD-8	4-L	45	101	13:00	13:28	6.8	Blk	46.0	387.4	495.2	14.6	17.4446	30.700	13.255
D4-LD-24	4-L	45	640	09:00	09:06	6.8	Blk	46.0	387.4	4746.6	4251.4	17.3637	29.500	12.136
D4-LD-CP	4-L	45	Mix	05:30	09:16	6.8	Blk	46.0	387.4	4773.4	4386.0	17.4352	29.500	12.065
D4-FD-CP	4-L	45	174	09:30	12:00	6.7	Blk	46.0	25.35	150.1	124.8	17.2771	29.500	12.223
D4-FDI-CP	4-L	25	174	12:00	14:30	6.6	Blk	25.0	25.18	136.7	111.5	17.4613	29.000	11.539
D4-AN-CP	4-L	25	95	14:30	16:36	6.6	Mix	25.0	12.75	57.0	44.3	17.3374	29.000	11.663

Table C.4. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
D4-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4-LD-0	NA	NA	NA	NA	NA	NA	10.1650	10-1311	1.04E+00	± 2%	5.89E-02	± 3%
D4-LD-1	23.34	1.556	0.389	1.556	0.389	1.556	11.4350	10-1312	1.37E-04	± 5%	1.17E-04	± 6%
D4-LD-2	22.65	1.510	0.378	1.510	0.383	1.533	11.8027	10-1313	2.50E-05	± 10%	2.96E-04	± 3%
D4-LD-3	21.62	1.442	0.360	1.442	0.376	1.503	11.0937	10-1314	2.53E-05	± 10%	4.81E-04	± 2%
D4-LD-4	21.57	1.438	0.372	1.488	0.375	1.499	10.5427	10-1315	1.44E-05	± 27%	5.17E-04	± 3%
D4-LD-5	22.84	1.522	0.381	1.522	0.376	1.504	11.0636	10-1316	2.02E-05	± 14%	5.65E-04	± 2%
D4-LD-6	22.32	1.488	0.372	1.488	0.375	1.501	10.7132	10-1317	1.92E-05	± 20%	5.73E-04	± 4%
D4-LD-7	23.06	1.537	0.384	1.537	0.377	1.506	10.8682	10-1318	1.11E-05	± 33%	6.60E-04	± 2%
D4-LD-8	23.09	1.540	0.385	1.540	0.378	1.510	10.9895	10-1319	2.38E-05	± 11%	6.01E-04	± 3%
D4-LD-24	3534.73	235.65	3.001	12.002	3.001	12.00	10.0617	10-1320	5.68E-02	± 2%	1.57E-03	± 4%
D4-LD-CP	3742.22	249.48	NA	NA	NA	NA	10.0024	10-1321	8.85E-03	± 2%	7.67E-04	± 4%
D4-FD-CP	113.04	7.536	0.754	3.014	0.754	3.014	11.0753	10-1322	2.20E-02	± 3%	7.33E-04	± 3%
D4-FDI-CP	111.55	7.437	0.744	2.975	0.744	2.975	11.5417	10-1323	2.87E-04	± 3%	1.73E-05	± 20%
D4-AN-CP	44.02	2.935	0.349	1.398	0.349	1.398	11.6024	10-1324	1.93E-04	± 3%	1.50E-05	± 14%

Table C.4. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	meq/g
D4-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D4-LD-0	1.02E-01	2.05E-03	6.27E-02	1.88E-03	NA	100.00%	1.00E+00	2.83E-02	100.00%	100.00%	4.24E-02	NA	NA	NA
D4-LD-1	1.20E-05	5.98E-07	1.02E-05	6.13E-07	1.56	0.01%	1.17E-04	6.29E-06	0.02%	1.63E-04	1.09E-05	5.60E-04	5.60E-04	8.19E-05
D4-LD-2	2.12E-06	2.12E-07	2.51E-05	7.53E-07	3.07	0.00%	2.07E-05	2.11E-06	0.04%	4.00E-04	1.70E-05	5.44E-04	1.10E-03	1.61E-04
D4-LD-3	2.28E-06	2.28E-07	4.34E-05	8.68E-07	4.51	0.00%	2.23E-05	2.28E-06	0.07%	6.92E-04	2.49E-05	5.19E-04	1.62E-03	2.37E-04
D4-LD-4	1.37E-06	3.70E-07	4.90E-05	1.47E-06	5.95	0.00%	1.34E-05	3.63E-06	0.08%	7.81E-04	3.31E-05	5.18E-04	2.14E-03	3.13E-04
D4-LD-5	1.82E-06	2.55E-07	5.11E-05	1.02E-06	7.47	0.00%	1.78E-05	2.52E-06	0.08%	8.14E-04	2.94E-05	5.48E-04	2.69E-03	3.93E-04
D4-LD-6	1.79E-06	3.59E-07	5.35E-05	2.14E-06	8.96	0.00%	1.75E-05	3.52E-06	0.09%	8.53E-04	4.27E-05	5.36E-04	3.22E-03	4.71E-04
D4-LD-7	1.02E-06	3.38E-07	6.07E-05	1.21E-06	10.49	0.00%	1.00E-05	3.31E-06	0.10%	9.68E-04	3.49E-05	5.53E-04	3.78E-03	5.52E-04
D4-LD-8	2.17E-06	2.38E-07	5.47E-05	1.64E-06	12.03	0.00%	2.12E-05	2.37E-06	0.09%	8.72E-04	3.70E-05	5.54E-04	4.33E-03	6.33E-04
D4-LD-24	5.64E-03	1.13E-04	1.56E-04	6.24E-06	247.68	5.51%	5.51E-02	1.56E-03	0.25%	2.49E-03	1.24E-04	8.25E-02	8.68E-02	1.27E-02
D4-LD-CP	8.85E-04	1.77E-05	7.67E-05	3.07E-06	249.48	0.86%	8.65E-03	2.45E-04	0.12%	1.22E-03	6.11E-05	8.88E-02	8.88E-02	1.30E-02
D4-FD-CP	1.98E-03	5.95E-05	6.62E-05	1.99E-06	257.02	1.94%	1.94E-02	6.99E-04	0.11%	1.06E-03	4.48E-05	2.66E-03	8.95E-02	1.31E-02
D4-FDI-CP	2.48E-05	7.45E-07	1.50E-06	3.00E-07	264.45	0.02%	2.43E-04	8.75E-06	0.00%	2.39E-05	4.83E-06	2.68E-03	9.22E-02	1.35E-02
D4-AN-CP	1.66E-05	4.99E-07	1.29E-06	1.81E-07	267.39	0.02%	1.62E-04	5.86E-06	0.00%	2.06E-05	2.95E-06	1.06E-03	9.32E-02	1.36E-02

Table C.5. Column D5 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
D5-PT-DIW1	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D5-PT-ACID	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D5-PT-DIW2	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D5-PT-NaOH	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D5-LD-0	4-L	45				6.8	Blk					17.5066	29.500	11.993
Loading (LD) Phase Start Date/Time:				10:00										
D5-LD-1	4-L	45	101	10:30	11:00	6.9	Blk	46.0	387.4	398.6	11.2	17.5908	29.500	11.909
D5-LD-2	4-L	45	101	11:30	12:00	6.8	Blk	46.0	387.4	410.9	12.3	17.3174	29.700	12.383
D5-LD-3	4-L	45	101	12:30	13:00	6.8	Blk	46.0	387.4	424.3	13.4	17.4044	30.900	13.496
D5-LD-4	4-L	45	101	13:30	14:00	6.8	Blk	46.0	387.4	437.9	13.6	17.4304	30.600	13.170
D5-LD-5	4-L	45	101	14:30	15:00	6.8	Blk	46.0	387.4	452.7	14.8	17.2488	30.300	13.051
D5-LD-6	4-L	45	101	15:30	16:00	6.8	Blk	46.0	387.4	467.5	14.8	17.4090	30.500	13.091
D5-LD-7	4-L	45	101	16:30	17:00	6.8	Blk	46.0	387.4	482.3	14.8	17.3608	30.400	13.039
D5-LD-8	4-L	45	101	17:30	18:00	6.8	Blk	46.0	387.4	497.2	14.9	17.3420	30.500	13.158
D5-LD-24	4-L	45	800	09:30	09:33	6.8	Blk	46.0	387.4	4719.3	4222.1	17.3559	30.000	12.644
D5-LD-CP	4-L	45	Mix	10:00	09:45	6.8	Blk	46.0	387.4	4771.6	4384.2	17.3835	30.000	12.617
D5-FD-CP	4-L	45	174	10:00	12:35	6.8	Blk	46.0	25.31	151.0	125.7	17.5404	29.500	11.960
D5-FDI-CP	4-L	25	174	12:40	15:10	6.7	Blk	25.0	25.14	137.6	112.5	17.4727	28.500	11.027
D5-AN-CP	4-L	25	86	15:15	17:25	6.2	Mix	25.0	12.80	59.2	46.4	17.5300	28.000	10.470

Table C.5. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
D5-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D5-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D5-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D5-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D5-LD-0	NA	NA	NA	NA	NA	NA	9.9432	10-1372	1.03E+00	± 2%	6.11E-02	± 3%
D5-LD-1	22.56	1.504	0.376	1.504	0.376	1.504	11.6251	10-1373	2.31E-04	± 5%	8.84E-03	± 4%
D5-LD-2	22.13	1.475	0.369	1.475	0.372	1.490	11.1024	10-1374	4.42E-05	± 8%	5.47E-04	± 3%
D5-LD-3	22.30	1.487	0.372	1.487	0.372	1.489	11.1887	10-1375	4.78E-05	± 8%	8.59E-04	± 3%
D5-LD-4	22.19	1.480	0.370	1.480	0.372	1.486	10.9184	10-1376	4.69E-05	± 8%	1.02E-03	± 3%
D5-LD-5	23.09	1.539	0.385	1.539	0.374	1.497	10.8202	10-1377	4.10E-05	± 9%	1.03E-03	± 3%
D5-LD-6	23.12	1.542	0.385	1.542	0.376	1.504	10.8532	10-1378	1.52E-04	± 4%	1.05E-03	± 3%
D5-LD-7	23.08	1.539	0.385	1.539	0.377	1.509	10.8103	10-1379	3.59E-05	± 9%	1.07E-03	± 3%
D5-LD-8	23.26	1.551	0.388	1.551	0.379	1.514	10.9088	10-1380	3.32E-05	± 11%	1.08E-03	± 3%
D5-LD-24	3510.86	234.06	3.763	15.052	3.763	15.05	10.4827	10-1381	1.02E-01	± 2%	2.24E-03	± 4%
D5-LD-CP	3741.35	249.42	NA	NA	NA	NA	10.4598	10-1382	1.86E-02	± 2%	1.16E-03	± 4%
D5-FD-CP	113.89	7.593	0.735	2.939	0.735	2.939	10.8367	10-1383	3.27E-02	± 2%	8.47E-04	± 5%
D5-FDI-CP	112.49	7.499	0.750	3.000	0.750	3.000	11.0302	10-1384	5.62E-04	± 3%	2.03E-05	± 20%
D5-AN-CP	46.16	3.077	0.355	1.420	0.355	1.420	10.4159	10-1385	6.07E-04	± 3%	2.51E-05	± 13%

Table C.5. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	meq/g
D5-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D5-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D5-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D5-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D5-LD-0	1.04E-01	2.07E-03	6.21E-02	1.86E-03	NA	100.00%	1.00E+00	2.83E-02	100.00%	100.00%	4.24E-02	NA	NA	NA
D5-LD-1	1.98E-05	9.91E-07	7.61E-04	3.04E-05	1.50	0.02%	1.91E-04	1.03E-05	1.23%	1.23E-02	6.13E-04	5.41E-04	5.41E-04	7.91E-05
D5-LD-2	3.98E-06	3.18E-07	4.93E-05	1.48E-06	2.98	0.00%	3.84E-05	3.17E-06	0.08%	7.94E-04	3.37E-05	5.31E-04	1.07E-03	1.57E-04
D5-LD-3	4.27E-06	3.42E-07	7.68E-05	2.30E-06	4.47	0.00%	4.12E-05	3.40E-06	0.12%	1.24E-03	5.25E-05	5.35E-04	1.61E-03	2.35E-04
D5-LD-4	4.30E-06	3.44E-07	9.34E-05	2.80E-06	5.95	0.00%	4.15E-05	3.42E-06	0.15%	1.50E-03	6.39E-05	5.33E-04	2.14E-03	3.13E-04
D5-LD-5	3.79E-06	3.41E-07	9.53E-05	2.86E-06	7.48	0.00%	3.66E-05	3.37E-06	0.15%	1.53E-03	6.51E-05	5.54E-04	2.69E-03	3.94E-04
D5-LD-6	1.40E-05	5.61E-07	9.67E-05	2.90E-06	9.03	0.01%	1.35E-04	6.05E-06	0.16%	1.56E-03	6.61E-05	5.55E-04	3.25E-03	4.75E-04
D5-LD-7	3.32E-06	2.98E-07	9.93E-05	2.98E-06	10.56	0.00%	3.20E-05	2.95E-06	0.16%	1.60E-03	6.79E-05	5.54E-04	3.80E-03	5.56E-04
D5-LD-8	3.05E-06	3.35E-07	9.90E-05	2.97E-06	12.12	0.00%	2.94E-05	3.29E-06	0.16%	1.59E-03	6.77E-05	5.58E-04	4.36E-03	6.38E-04
D5-LD-24	9.72E-03	1.94E-04	2.14E-04	8.55E-06	246.17	9.38%	9.38E-02	2.65E-03	0.34%	3.44E-03	1.72E-04	8.03E-02	8.47E-02	1.24E-02
D5-LD-CP	1.78E-03	3.56E-05	1.11E-04	4.44E-06	249.42	1.72%	1.72E-02	4.87E-04	0.18%	1.79E-03	8.93E-05	8.80E-02	8.80E-02	1.29E-02
D5-FD-CP	3.01E-03	6.03E-05	7.81E-05	3.91E-06	257.02	2.91%	2.91E-02	8.23E-04	0.13%	1.26E-03	7.34E-05	2.65E-03	8.73E-02	1.28E-02
D5-FDI-CP	5.09E-05	1.53E-06	1.84E-06	3.68E-07	264.51	0.05%	4.92E-04	1.77E-05	0.00%	2.96E-05	6.00E-06	2.70E-03	9.00E-02	1.32E-02
D5-AN-CP	5.83E-05	1.75E-06	2.40E-06	3.13E-07	267.59	0.06%	5.63E-04	2.03E-05	0.00%	3.87E-05	5.17E-06	1.11E-03	9.11E-02	1.33E-02

Table C.6. Column D6 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
D6-PT-DIW1	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D6-PT-ACID	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D6-PT-DIW2	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D6-PT-NaOH	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D6-LD-0	4-L	45	NA	NA	NA	NA	NA	NA	NA	NA	NA	17.3232	29.500	12.177
Loading (LD) Phase Start Date/Time:				09:00										
D6-LD-1	4-L	45	101	09:30	09:58	6.9	Blk	46.0	387.4	397.8	10.4	17.5241	28.600	11.076
D6-LD-2	4-L	45	101	10:30	10:58	6.7	Blk	46.0	387.4	410.0	12.2	17.3712	29.300	11.929
D6-LD-3	4-L	45	101	11:30	11:58	6.8	Blk	46.0	387.4	424.4	14.4	17.5205	30.100	12.580
D6-LD-4	4-L	45	101	12:30	12:58	6.8	Blk	46.0	387.4	438.5	14.1	17.4229	30.600	13.177
D6-LD-5	4-L	45	101	13:30	13:58	6.8	Blk	46.0	387.4	453.0	14.5	17.4384	30.300	12.862
D6-LD-6	4-L	45	101	14:30	14:58	6.8	Blk	46.0	387.4	467.5	14.5	17.3241	30.300	12.976
D6-LD-7	4-L	45	101	15:30	15:58	6.8	Blk	46.0	387.4	482.1	14.6	17.4154	30.500	13.085
D6-LD-8	4-L	45	101	16:30	16:58	6.8	Blk	46.0	387.4	496.3	14.2	17.4371	30.500	13.063
D6-LD-24	4-L	45	800	08:45	08:48	6.8	Blk	46.0	387.4	4771.7	4275.4	17.5013	30.600	13.099
D6-LD-CP	4-L	45	Mix	09:00	08:48	6.6	Blk	46.0	387.4	4771.7	4384.3	17.4330	30.500	13.067
D6-FD-CP	4-L	45	174	09:00	11:30	6.7	Blk	46.0	25.27	150.9	125.6	17.3371	29.500	12.163
D6-FDI-CP	4-L	25	174	11:30	14:00	6.7	Blk	46.0	25.37	137.4	112.0	17.5438	28.000	10.456
D6-AN-CP	4-L	25	95	14:00	16:10	6.1	Mix	25.0	12.81	59.6	46.8	17.3692	27.500	10.131

Table C.6. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
	mL	BV	mL/min	BV/hr	mL/min	BV/hr						
D6-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D6-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D6-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D6-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D6-LD-0	NA	NA	NA	NA	NA	NA	10.0953	10-1432	9.83E-01	± 2%	6.39E-02	± 3%
D6-LD-1	20.96	1.398	0.361	1.446	0.361	1.446	10.8117	10-1433	3.17E-04	± 3%	3.09E-03	± 4%
D6-LD-2	21.63	1.442	0.361	1.442	0.361	1.444	10.6955	10-1434	5.06E-05	± 10%	5.38E-04	± 4%
D6-LD-3	22.37	1.491	0.373	1.491	0.365	1.460	10.4292	10-1435	5.58E-05	± 8%	8.37E-04	± 2%
D6-LD-4	22.61	1.508	0.377	1.508	0.368	1.472	10.9246	10-1436	9.04E-05	± 5%	1.06E-03	± 2%
D6-LD-5	22.68	1.512	0.378	1.512	0.370	1.480	10.6630	10-1437	6.39E-05	± 7%	1.12E-03	± 4%
D6-LD-6	22.78	1.519	0.380	1.519	0.372	1.487	10.7578	10-1438	6.13E-05	± 8%	1.08E-03	± 4%
D6-LD-7	22.95	1.530	0.383	1.530	0.373	1.493	10.8479	10-1439	4.89E-05	± 9%	1.12E-03	± 4%
D6-LD-8	22.60	1.507	0.377	1.507	0.374	1.495	10.8299	10-1440	6.32E-05	± 8%	1.13E-03	± 4%
D6-LD-24	3555.42	237.03	3.743	14.970	3.743	14.97	10.8596	10-1441	1.36E-01	± 2%	2.89E-03	± 6%
D6-LD-CP	3740.06	249.34	NA	NA	NA	NA	10.8333	10-1442	2.36E-02	± 2%	1.48E-03	± 3%
D6-FD-CP	113.83	7.589	0.759	3.036	0.759	3.036	11.0209	10-1443	4.76E-02	± 2%	1.39E-03	± 3%
D6-FDI-CP	112.06	7.471	0.747	2.988	0.747	2.988	10.4589	10-1444	7.46E-04	± 3%	3.51E-05	± 14%
D6-AN-CP	46.55	3.103	0.358	1.432	0.358	1.432	10.0785	10-1445	7.75E-04	± 3%	2.66E-05	± 13%

Table C.6. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	meq/g
D6-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D6-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D6-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D6-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D6-LD-0	9.74E-02	1.95E-03	6.39E-02	1.92E-03	NA	100.00%	1.00E+00	2.83E-02	100.00%	100.00%	4.24E-02	NA	NA	NA
D6-LD-1	2.93E-05	8.80E-07	2.86E-04	1.14E-05	1.40	0.03%	3.01E-04	1.09E-05	0.45%	4.47E-03	2.24E-04	5.03E-04	5.03E-04	7.35E-05
D6-LD-2	4.73E-06	4.73E-07	5.03E-05	2.01E-06	2.84	0.00%	4.86E-05	4.96E-06	0.08%	7.87E-04	3.93E-05	5.19E-04	1.02E-03	1.49E-04
D6-LD-3	5.35E-06	4.28E-07	8.03E-05	1.61E-06	4.33	0.01%	5.50E-05	4.53E-06	0.13%	1.26E-03	4.53E-05	5.37E-04	1.56E-03	2.28E-04
D6-LD-4	8.28E-06	4.14E-07	9.70E-05	1.94E-06	5.84	0.01%	8.50E-05	4.58E-06	0.15%	1.52E-03	5.48E-05	5.43E-04	2.10E-03	3.07E-04
D6-LD-5	5.99E-06	4.19E-07	1.05E-04	4.20E-06	7.35	0.01%	6.15E-05	4.48E-06	0.16%	1.64E-03	8.22E-05	5.44E-04	2.65E-03	3.87E-04
D6-LD-6	5.70E-06	4.56E-07	1.00E-04	4.02E-06	8.87	0.01%	5.85E-05	4.82E-06	0.16%	1.57E-03	7.86E-05	5.47E-04	3.19E-03	4.67E-04
D6-LD-7	4.50E-06	4.05E-07	1.03E-04	4.13E-06	10.40	0.00%	4.63E-05	4.26E-06	0.16%	1.62E-03	8.08E-05	5.51E-04	3.74E-03	5.47E-04
D6-LD-8	5.83E-06	4.67E-07	1.04E-04	4.17E-06	11.91	0.01%	5.99E-05	4.94E-06	0.16%	1.63E-03	8.16E-05	5.42E-04	4.29E-03	6.27E-04
D6-LD-24	1.25E-02	2.50E-04	2.66E-04	1.60E-05	248.93	12.86%	1.29E-01	3.64E-03	0.42%	4.17E-03	2.79E-04	7.98E-02	8.41E-02	1.23E-02
D6-LD-CP	2.18E-03	4.36E-05	1.37E-04	4.10E-06	249.34	2.24%	2.24E-02	6.33E-04	0.21%	2.14E-03	9.07E-05	8.75E-02	8.75E-02	1.28E-02
D6-FD-CP	4.32E-03	8.63E-05	1.26E-04	3.79E-06	256.93	4.43%	4.43E-02	1.25E-03	0.20%	1.98E-03	8.39E-05	2.61E-03	8.67E-02	1.27E-02
D6-FDI-CP	7.14E-05	2.14E-06	3.36E-06	4.70E-07	264.40	0.07%	7.33E-04	2.64E-05	0.01%	5.25E-05	7.52E-06	2.69E-03	8.94E-02	1.31E-02
D6-AN-CP	7.68E-05	2.31E-06	2.64E-06	3.43E-07	267.50	0.08%	7.89E-04	2.85E-05	0.00%	4.13E-05	5.51E-06	1.12E-03	9.05E-02	1.32E-02

Table C.7. Column E1 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
E1-PT-DIW1	250 mL	25	163	12:45	15:15	6.0	Blk	20.4	65.92	177.2	111.3	0.0000	0.000	0.000
E1-PT-ACID	200 mL	25	164	15:15	18:00	5.8	Blk	25.1	65.92	300.0	122.8	0.0000	0.000	0.000
E1-PT-DIW2	250 mL	25	160	20:00	21:00	5.1	Org	24.4	65.92	333.1	33.1	0.0000	0.000	0.000
E1-PT-NaOH	200 mL	25	160	21:02	23:02	6.0	Blk	24.4	65.92	420.0	86.9	0.0000	0.000	0.000
E1-LD-0	4-L	45	160	NA	NA	NA	NA	NA	NA	NA	NA	17.3029	29.300	11.997
Loading (LD) Phase Start Date/Time:				23:30										
E1-LD-1	4-L	45	93	0:00	00:30	6.0	Blk	46.0	356.9	369.2	12.3	17.7305	28.800	11.070
E1-LD-2	4-L	45	93	01:00	01:30	6.1	Blk	46.0	356.9	381.0	11.8	17.3212	29.900	12.579
E1-LD-3	4-L	45	93	02:00	02:30	6.2	Blk	46.0	356.9	393.3	12.3	17.5526	30.400	12.847
E1-LD-4	4-L	45	93	03:00	03:30	6.2	Blk	46.0	356.9	406.1	12.8	17.3910	30.500	13.109
E1-LD-5	4-L	45	93	04:00	04:30	6.2	Blk	46.0	356.9	418.9	12.8	17.5174	31.000	13.483
E1-LD-6	4-L	45	93	05:00	05:30	6.2	Blk	46.0	356.9	432.0	13.1	17.5443	31.100	13.556
E1-LD-7	4-L	45	93	06:00	06:30	6.2	Blk	46.0	356.9	445.5	13.5	17.4108	30.500	13.089
E1-LD-8	4-L	45	93	07:00	07:30	6.2	Blk	46.0	356.9	458.3	12.8	17.3299	30.700	13.370
E1-LD-9	4-L	45	93	09:00	09:30	6.3	Blk	46.0	356.9	501.1	42.8	17.4002	31.900	14.500
E1-LD-10	4-L	45	621	10:00	10:08	6.3	Blk	46.0	356.9	607.0	105.9	17.3497	45.500	28.150
E1-LD-11	4-L	45	621	11:00	11:08	6.3	Blk	46.0	356.9	795.4	188.4	17.5703	46.500	28.930
E1-LD-12	4-L	45	621	12:00	12:08	6.3	Blk	46.0	356.9	990.5	195.1	17.5152	44.900	27.385
E1-LD-13	4-L	45	621	13:00	13:08	6.4	Blk	46.0	356.9	1177.7	187.2	17.4203	45.200	27.780
E1-LD-14	4-L	45	621	14:00	14:08	6.3	Blk	46.0	356.9	1374.4	196.7	17.5115	36.100	18.589
E1-LD-15	4-L	45	621	15:00	15:05	6.3	Blk	46.0	356.9	1571.0	196.7	17.4230	35.900	18.477
E1-LD-16	4-L	45	621	16:00	16:05	6.3	Blk	46.0	356.9	1770.9	199.9	17.3305	35.500	18.170
E1-LD-17	4-L	45	621	17:00	17:05	6.3	Blk	46.0	356.9	1972.8	201.9	17.3306	34.400	17.069
E1-LD-18	4-L	45	621	18:00	18:05	6.3	Blk	46.0	356.9	2174.6	201.9	17.1528	35.300	18.147
E1-LD-19	4-L	45	621	19:00	19:05	6.3	Blk	46.0	356.9	2375.9	201.3	17.4162	35.800	18.384
E1-LD-20	4-L	45	621	20:00	20:05	6.3	Blk	46.0	356.9	2580.1	204.2	17.5487	35.900	18.351

Table C.7. (contd)

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
E1-LD-21	4-L	45	621	21:00	21:05	6.3	Blk	46.0	356.9	2768.1	188.0	17.3599	35.500	18.140
E1-LD-22	4-L	45	621	22:01	22:06	6.3	Blk	46.0	356.9	2977.1	209.0	17.3912	36.000	18.609
E1-LD-23	4-L	45	621	23:00	23:05	6.3	Blk	46.0	356.9	3171.1	194.0	17.2850	35.900	18.615
E1-LD-24	4-L	45	621	00:00	00:05	6.3	Blk	46.0	356.9	3370.3	199.2	17.4148	36.100	18.685
E1-LD-25	4-L	45	621	01:00	01:05	6.3	Blk	46.0	356.9	3569.0	198.7	17.4621	35.400	17.938
E1-LD-26	4-L	45	621	02:00	02:05	6.3	Blk	46.0	356.9	3770.8	201.8	17.4715	35.400	17.929
E1-LD-27	4-L	45	621	03:00	03:05	6.3	Blk	46.0	356.9	3972.4	201.6	17.2430	36.000	18.757
E1-LD-28	4-L	45	621	04:00	04:05	6.3	Blk	46.0	356.9	4173.2	200.8	17.4659	36.200	18.734
E1-LD-29	4-L	45	621	04:30	04:35	6.3	Blk	46.0	356.9	4264.0	90.8	17.4443	36.200	18.756
E1-FD-CP	4-L	45	Mix	05:11	07:42	6.2	Blk	46.0	25.00	150.0	125.0	17.4241	29.500	12.076
E1-FDI-CP	4-L	25	160	07:46	10:45	6.0	Blk	25.0	25.00	145.1	120.1	17.4900	27.600	10.110
E1-AN-CP	4-L	25	88	10:45	13:00	5.5	Mix	25.0	12.80	60.8	48.0	17.3500	27.400	10.050

Table C.7. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
E1-PT-DIW1	111.46	7.430	0.743	2.972	0.743	2.972	NA	NA	NA	NA	NA	NA
E1-PT-ACID	121.35	8.090	0.735	2.942	0.739	2.957	NA	NA	NA	NA	NA	NA
E1-PT-DIW2	33.15	2.210	0.553	2.210	0.677	2.708	NA	NA	NA	NA	NA	NA
E1-PT-NaOH	84.83	5.655	0.707	2.828	0.684	2.738	NA	NA	NA	NA	NA	NA
E1-LD-0	NA	NA	NA	NA	NA	NA	9.9463	10-1136	1.05E+00	± 2%	<9.0E-05	NA
E1-LD-1	22.81	1.521	0.380	1.521	0.380	1.521	10.8055	10-1137	<4.0E-06	NA	<5.5E-06	NA
E1-LD-2	21.86	1.457	0.364	1.457	0.372	1.489	11.2783	10-1138	<4.0E-06	NA	<4.0E-06	NA
E1-LD-3	20.85	1.390	0.347	1.390	0.364	1.456	10.6513	10-1139	<4.0E-06	NA	<4.0E-06	NA
E1-LD-4	21.48	1.432	0.358	1.432	0.362	1.450	10.8681	10-1140	<3.0E-06	NA	<4.0E-06	NA
E1-LD-5	21.79	1.453	0.363	1.453	0.363	1.451	11.1779	10-1141	<4.0E-06	NA	<3.0E-06	NA
E1-LD-6	22.10	1.473	0.368	1.473	0.364	1.454	11.2385	10-1142	<6.0E-06	NA	<6.0E-06	NA
E1-LD-7	22.04	1.470	0.367	1.470	0.364	1.456	10.8517	10-1143	<6.0E-06	NA	<6.0E-06	NA
E1-LD-8	21.70	1.446	0.362	1.446	0.364	1.455	11.0846	10-1144	<5.0E-06	NA	<6.0E-06	NA
E1-LD-9	47.50	3.167	0.396	1.583	0.370	1.481	12.0212	10-1145	<6.0E-06	NA	<5.0E-06	NA
E1-LD-10	111.14	7.409	2.925	11.698	0.522	2.089	10.0733	10-1146	<4.0E-06	NA	<3.0E-06	NA
E1-LD-11	180.18	12.012	3.003	12.012	3.003	12.012	9.8904	10-1147	<4.0E-06	NA	<4.0E-06	NA
E1-LD-12	184.45	12.297	3.074	12.297	3.039	12.154	9.9361	10-1148	4.52E-06	± 28%	<3.0E-06	NA
E1-LD-13	178.23	11.882	2.971	11.882	3.016	12.064	10.0148	10-1149	1.56E-05	± 16%	<4.0E-06	NA
E1-LD-14	178.45	11.896	2.974	11.896	3.005	12.022	9.9392	10-1150	3.81E-05	± 7%	<4.0E-06	NA
E1-LD-15	178.35	11.890	3.129	12.516	3.029	12.117	10.0126	10-1151	9.20E-05	± 4%	<4.0E-06	NA
E1-LD-16	180.79	12.053	3.013	12.053	3.026	12.106	10.0892	10-1152	1.61E-04	± 4%	<4.0E-06	NA
E1-LD-17	181.50	12.100	3.025	12.100	3.026	12.105	10.0892	10-1153	3.01E-04	± 3%	<5.0E-06	NA
E1-LD-18	182.39	12.159	3.040	12.159	3.028	12.112	10.2366	10-1154	5.51E-04	± 3%	<8.0E-06	NA
E1-LD-19	182.13	12.142	3.036	12.142	3.029	12.115	10.0182	10-1155	9.43E-04	± 3%	<9.0E-06	NA
E1-LD-20	184.51	12.301	3.075	12.301	3.033	12.134	9.9083	10-1156	1.42E-03	± 2%	<8.0E-06	NA

Table C.7. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr	Vol, mL	ID No.	uCi Tot	Uncert	uCi Tot	Uncert
E1-LD-21	170.90	11.393	2.848	11.393	3.017	12.066	10.0649	10-1157	1.94E-03	± 2%	<8.0E-06	NA
E1-LD-22	188.70	12.580	3.093	12.374	3.023	12.092	10.0389	10-1158	2.99E-03	± 2%	<1.0E-05	NA
E1-LD-23	176.27	11.751	2.988	11.951	3.020	12.082	10.1270	10-1159	4.44E-03	± 2%	<1.0E-05	NA
E1-LD-24	180.64	12.043	3.011	12.043	3.020	12.079	10.0194	10-1160	6.24E-03	± 2%	<1.0E-05	NA
E1-LD-25	179.61	11.974	2.993	11.974	3.018	12.072	9.9801	10-1161	8.43E-03	± 2%	<2.0E-05	NA
E1-LD-26	182.17	12.145	3.036	12.145	3.019	12.076	9.9723	10-1162	1.14E-02	± 2%	<2.0E-05	NA
E1-LD-27	182.69	12.179	3.045	12.179	3.021	12.082	10.1618	10-1163	1.54E-02	± 2%	<2.0E-05	NA
E1-LD-28	182.01	12.134	3.033	12.134	3.021	12.085	9.9770	10-1164	1.98E-02	± 2%	<3.0E-05	NA
E1-LD-29	90.83	6.055	3.028	12.110	3.021	12.086	9.9949	10-1165	2.33E-02	± 2%	<3.0E-05	NA
E1-FD-CP	113.26	7.55	0.75	3.00	0.75	3.000	10.9421	10-1167	6.42E-03	± 2%	<2.0E-05	NA
E1-FDI-CP	120.13	8.009	0.671	2.684	0.671	2.684	10.1126	10-1168	8.25E-05	± 5%	<4.0E-06	NA
E1-AN-CP	47.70	3.180	0.353	1.413	0.353	1.413	9.9981	10-1169	1.64E-04	± 3%	<4.0E-06	NA

Table C.7. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated mmol Cs	Loading meq/g
E1-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E1-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E1-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E1-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E1-LD-0	1.06E-01	2.11E-03	<9.0E-06	NA	NA	100.0%	1.00E+00	2.83E-02	NA	NA	NA	NA	NA	NA
E1-LD-1	3.70E-07	NA	<5.1E-07	NA	1.52	0.00%	3.51E-06	NA	NA	NA	NA	5.47E-04	5.47E-04	8.00E-05
E1-LD-2	3.55E-07	NA	<3.5E-07	NA	2.98	0.00%	3.36E-06	NA	NA	NA	NA	5.25E-04	1.07E-03	1.57E-04
E1-LD-3	3.76E-07	NA	<3.8E-07	NA	4.37	0.00%	3.56E-06	NA	NA	NA	NA	5.00E-04	1.57E-03	2.30E-04
E1-LD-4	2.76E-07	NA	<3.7E-07	NA	5.80	0.00%	2.61E-06	NA	NA	NA	NA	5.16E-04	2.09E-03	3.05E-04
E1-LD-5	3.58E-07	NA	<2.7E-07	NA	7.25	0.00%	3.39E-06	NA	NA	NA	NA	5.23E-04	2.61E-03	3.82E-04
E1-LD-6	5.34E-07	NA	<5.3E-07	NA	8.73	0.00%	5.06E-06	NA	NA	NA	NA	5.30E-04	3.14E-03	4.59E-04
E1-LD-7	5.53E-07	NA	<5.5E-07	NA	10.20	0.00%	5.24E-06	NA	NA	NA	NA	5.29E-04	3.67E-03	5.37E-04
E1-LD-8	4.51E-07	NA	<5.4E-07	NA	11.64	0.00%	4.27E-06	NA	NA	NA	NA	5.21E-04	4.19E-03	6.13E-04
E1-LD-9	4.99E-07	NA	<4.2E-07	NA	14.81	0.00%	4.73E-06	NA	NA	NA	NA	1.14E-03	5.33E-03	7.79E-04
E1-LD-10	3.97E-07	NA	<3.0E-07	NA	22.22	0.00%	3.76E-06	NA	NA	NA	NA	2.67E-03	8.00E-03	1.17E-03
E1-LD-11	4.04E-07	NA	<4.0E-07	NA	34.23	0.00%	3.83E-06	NA	NA	NA	NA	4.32E-03	1.23E-02	1.80E-03
E1-LD-12	4.55E-07	1.27E-07	<3.0E-07	NA	46.53	0.00%	4.31E-06	1.21E-06	NA	NA	NA	4.43E-03	1.67E-02	2.45E-03
E1-LD-13	1.55E-06	2.49E-07	<4.0E-07	NA	58.41	0.00%	1.47E-05	2.37E-06	NA	NA	NA	4.28E-03	2.10E-02	3.07E-03
E1-LD-14	3.84E-06	2.69E-07	<4.0E-07	NA	70.31	0.00%	3.63E-05	2.65E-06	NA	NA	NA	4.28E-03	2.53E-02	3.70E-03
E1-LD-15	9.19E-06	3.68E-07	<4.0E-07	NA	82.20	0.01%	8.71E-05	3.89E-06	NA	NA	NA	4.28E-03	2.96E-02	4.33E-03
E1-LD-16	1.60E-05	6.40E-07	<4.0E-07	NA	94.25	0.02%	1.52E-04	6.78E-06	NA	NA	NA	4.34E-03	3.39E-02	4.96E-03
E1-LD-17	2.98E-05	8.94E-07	<5.0E-07	NA	106.35	0.03%	2.82E-04	1.02E-05	NA	NA	NA	4.35E-03	3.83E-02	5.60E-03
E1-LD-18	5.39E-05	1.62E-06	<7.8E-07	NA	118.51	0.05%	5.10E-04	1.84E-05	NA	NA	NA	4.38E-03	4.27E-02	6.24E-03
E1-LD-19	9.41E-05	2.82E-06	<9.0E-07	NA	130.65	0.09%	8.92E-04	3.21E-05	NA	NA	NA	4.37E-03	4.70E-02	6.88E-03
E1-LD-20	1.43E-04	2.86E-06	<8.1E-07	NA	142.95	0.14%	1.35E-03	3.83E-05	NA	NA	NA	4.42E-03	5.15E-02	7.52E-03

Table C.7. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	meq/g
E1-LD-21	1.93E-04	3.86E-06	<7.9E-07	NA	154.34	0.18%	1.83E-03	5.17E-05	NA	NA	NA	4.10E-03	5.55E-02	8.12E-03
E1-LD-22	2.98E-04	5.96E-06	<1.0E-06	NA	166.92	0.28%	2.82E-03	7.99E-05	NA	NA	NA	4.52E-03	6.01E-02	8.78E-03
E1-LD-23	4.38E-04	8.76E-06	<9.9E-07	NA	178.68	0.42%	4.15E-03	1.17E-04	NA	NA	NA	4.22E-03	6.43E-02	9.40E-03
E1-LD-24	6.23E-04	1.25E-05	<1.0E-06	NA	190.72	0.59%	5.90E-03	1.67E-04	NA	NA	NA	4.31E-03	6.86E-02	1.00E-02
E1-LD-25	8.45E-04	1.69E-05	<2.0E-06	NA	202.69	0.80%	8.01E-03	2.26E-04	NA	NA	NA	4.28E-03	7.29E-02	1.07E-02
E1-LD-26	1.15E-03	2.29E-05	<2.0E-06	NA	214.84	1.09%	1.09E-02	3.07E-04	NA	NA	NA	4.33E-03	7.72E-02	1.13E-02
E1-LD-27	1.52E-03	3.04E-05	<2.0E-06	NA	227.02	1.44%	1.44E-02	4.07E-04	NA	NA	NA	4.33E-03	8.15E-02	1.19E-02
E1-LD-28	1.98E-03	3.97E-05	<3.0E-06	NA	239.15	1.88%	1.88E-02	5.31E-04	NA	NA	NA	4.30E-03	8.58E-02	1.25E-02
E1-LD-29	2.33E-03	4.66E-05	<3.0E-06	NA	245.20	2.21%	2.21E-02	6.24E-04	NA	NA	NA	2.14E-03	8.80E-02	1.29E-02
E1-FD-CP	5.87E-04	1.17E-05	<1.8E-06	NA	256.81	0.56%	5.56E-03	1.57E-04	NA	NA	NA	2.70E-03	9.07E-02	1.33E-02
E1-FDI-CP	8.16E-06	4.08E-07	<4.0E-07	NA	264.82	0.01%	7.73E-05	4.16E-06	NA	NA	NA	2.88E-03	9.36E-02	1.37E-02
E1-AN-CP	1.64E-05	4.92E-07	<4.0E-07	NA	268.00	0.02%	1.55E-04	5.60E-06	NA	NA	NA	1.14E-03	9.47E-02	1.38E-02

Table C.8. Column E2 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
E2-PT-DIW1	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E2-PT-ACID	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E2-PT-DIW2	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E2-PT-NaOH	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E2-LD-0	4-L	45										17.5475	30.100	12.553
Loading (LD) Phase Start Date/Time:				06:00										
E2-LD-1	4-L	45	93	06:30	07:00	6.2	Blk	46.0	357.3	372.3	15.0	17.2946	28.000	10.705
E2-LD-2	4-L	45	93	07:30	08:00	6.2	Blk	46.0	357.3	383.5	11.2	17.2375	30.600	13.363
E2-LD-3	4-L	45	93	08:30	09:00	6.2	Blk	46.0	357.3	394.0	10.5	17.5232	29.800	12.277
E2-LD-4	4-L	45	93	09:30	10:00	6.2	Blk	46.0	357.3	406.2	12.2	17.3075	31.100	13.793
E2-LD-5	4-L	45	93	10:30	11:00	6.2	Blk	46.0	357.3	420.0	13.8	17.5052	30.000	12.495
E2-LD-6	4-L	45	93	11:30	12:00	6.2	Blk	46.0	357.3	444.2	24.2	17.4240	30.500	13.076
E2-LD-7	4-L	45	93	12:36	13:05	6.2	Blk	46.0	357.3	447.2	3.0	17.4816	30.000	12.518
E2-LD-8	4-L	45	93	13:30	14:00	6.2	Blk	46.0	357.3	463.9	16.7	17.6009	30.000	12.399
E2-LD-24	4-L	45	635	17:15	05:40	6.2	Blk	46.0	357.3	4646.0	4182.1	17.5497	28.800	11.250
E2-LD-CP	4-L	45	Mix	NA	NA	6.2	Blk	46.0	357.3	4646.0	4288.7	17.6588	29.500	11.841
E2-FD-CP	4-L	45	163	06:00	08:35	6.2	Blk	46.0	25.41	149.4	124.0	17.4185	28.500	11.082
E2-FDI-CP	4-L	25	163	09:00	11:30	6.2	Blk	31.0	25.36	134.4	109.0	17.3854	28.500	11.115
E2-AN-CP	4-L	25	95	12:00	14:06	5.8	Mix	25.6	12.66	61.4	48.7	17.3864	28.500	11.114

Table C.8. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
E2-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E2-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E2-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E2-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E2-LD-0	NA	NA	NA	NA	NA	NA	10.4068	10-1220	1.09E+00	± 2%	7.34E-02	± 2%
E2-LD-1	25.09	1.673	0.418	1.673	0.418	1.673	10.4501	10-1221	3.61E-04	± 3%	3.53E-03	± 4%
E2-LD-2	22.02	1.468	0.367	1.468	0.393	1.571	11.9810	10-1222	4.52E-05	± 10%	7.98E-04	± 4%
E2-LD-3	18.88	1.259	0.315	1.259	0.367	1.467	10.1782	10-1223	5.11E-05	± 8%	1.06E-03	± 4%
E2-LD-4	21.55	1.437	0.359	1.437	0.365	1.459	11.4348	10-1224	4.69E-05	± 10%	1.21E-03	± 4%
E2-LD-5	21.80	1.453	0.363	1.453	0.364	1.458	10.3589	10-1225	4.93E-05	± 9%	1.12E-03	± 4%
E2-LD-6	30.90	2.060	0.515	2.060	0.390	1.558	10.8408	10-1226	5.23E-05	± 8%	1.19E-03	± 2%
E2-LD-7	12.87	0.858	0.198	0.792	0.360	1.441	10.3785	10-1227	3.28E-05	± 10%	1.19E-03	± 2%
E2-LD-8	24.12	1.608	0.439	1.755	0.369	1.477	10.2796	10-1228	2.94E-05	± 14%	1.19E-03	± 3%
E2-LD-24	3476.54	231.77	3.698	14.794	3.698	14.79	9.3272	10-1229	1.39E-02	± 3%	1.90E-03	± 2%
E2-LD-CP	3658.16	243.88	NA	NA	NA	NA	9.8171	10-1230	2.21E-03	± 2%	1.24E-03	± 4%
E2-FD-CP	112.35	7.490	0.725	2.899	0.725	2.899	10.0410	10-1231	3.92E-03	± 2%	6.83E-04	± 3%
E2-FDI-CP	109.07	7.271	0.727	2.908	0.727	2.908	11.1175	10-1232	7.13E-05	± 6%	1.78E-05	± 14%
E2-AN-CP	48.49	3.233	0.385	1.539	0.385	1.539	11.0562	10-1233	9.27E-05	± 6%	2.65E-05	± 9%

Table C.8. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	meq/g
E2-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E2-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E2-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E2-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E2-LD-0	1.05E-01	2.09E-03	7.25E-02	1.45E-03	NA	100.00%	1.00E+00	2.83E-02	100.00%	100.00%	2.83E-02	NA	NA	NA
E2-LD-1	3.46E-05	1.04E-06	3.38E-04	1.35E-05	1.67	0.03%	3.30E-04	1.19E-05	0.47%	4.67E-03	2.09E-04	6.02E-04	6.02E-04	8.80E-05
E2-LD-2	3.77E-06	3.77E-07	6.66E-05	2.67E-06	3.14	0.00%	3.60E-05	3.67E-06	0.09%	9.19E-04	4.11E-05	5.28E-04	1.13E-03	1.65E-04
E2-LD-3	5.02E-06	4.02E-07	1.04E-04	4.16E-06	4.40	0.00%	4.79E-05	3.95E-06	0.14%	1.43E-03	6.41E-05	4.53E-04	1.58E-03	2.32E-04
E2-LD-4	4.10E-06	4.10E-07	1.06E-04	4.23E-06	5.84	0.00%	3.92E-05	3.99E-06	0.15%	1.46E-03	6.53E-05	5.17E-04	2.10E-03	3.07E-04
E2-LD-5	4.76E-06	4.29E-07	1.08E-04	4.33E-06	7.29	0.00%	4.55E-05	4.19E-06	0.15%	1.49E-03	6.68E-05	5.23E-04	2.62E-03	3.84E-04
E2-LD-6	4.83E-06	3.86E-07	1.10E-04	2.20E-06	9.35	0.00%	4.61E-05	3.80E-06	0.15%	1.51E-03	4.28E-05	7.42E-04	3.37E-03	4.92E-04
E2-LD-7	3.16E-06	3.16E-07	1.15E-04	2.29E-06	10.21	0.00%	3.02E-05	3.07E-06	0.16%	1.58E-03	4.47E-05	3.09E-04	3.67E-03	5.37E-04
E2-LD-8	2.86E-06	4.00E-07	1.16E-04	3.47E-06	11.82	0.00%	2.73E-05	3.86E-06	0.16%	1.60E-03	5.76E-05	5.79E-04	4.25E-03	6.22E-04
E2-LD-24	1.49E-03	4.48E-05	2.04E-04	4.07E-06	243.59	1.43%	1.43E-02	5.14E-04	0.28%	2.81E-03	7.95E-05	8.28E-02	8.71E-02	1.27E-02
E2-LD-CP	2.25E-04	4.49E-06	1.27E-04	5.06E-06	243.88	0.21%	2.15E-03	6.07E-05	0.17%	1.75E-03	7.81E-05	8.74E-02	8.74E-02	1.28E-02
E2-FD-CP	3.90E-04	7.80E-06	6.81E-05	2.04E-06	251.37	0.37%	3.72E-03	1.05E-04	0.09%	9.39E-04	3.39E-05	2.69E-03	8.98E-02	1.31E-02
E2-FDI-CP	6.41E-06	3.85E-07	1.60E-06	2.25E-07	258.64	0.01%	6.12E-05	3.87E-06	0.00%	2.21E-05	3.13E-06	2.62E-03	9.24E-02	1.35E-02
E2-AN-CP	8.38E-06	5.03E-07	2.40E-06	2.16E-07	261.87	0.01%	8.00E-05	5.06E-06	0.00%	3.31E-05	3.05E-06	1.16E-03	9.36E-02	1.37E-02

Table C.9. Column E3 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
E3-PT-DIW1	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E3-PT-ACID	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E3-PT-DIW2	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E3-PT-NaOH	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E3-LD-0	4-L	45										17.4081	29.000	11.592
Loading (LD) Phase Start Date/Time:				09:00										
E3-LD-1	4-L	45	93	09:30	10:00	6.5	Blk	46.0	395.2	408.4	13.2	17.3842	28.700	11.316
E3-LD-2	4-L	45	93	10:30	11:00	6.5	Blk	46.0	395.2	420.1	11.7	17.3976	30.000	12.602
E3-LD-3	4-L	45	93	11:30	12:00	6.6	Blk	46.0	395.2	432.8	12.7	17.3703	30.700	13.330
E3-LD-4	4-L	45	93	12:30	13:00	6.6	Blk	46.0	395.2	445.7	12.9	17.4022	31.000	13.598
E3-LD-5	4-L	45	93	13:30	14:00	6.6	Blk	46.0	395.2	458.7	13.0	17.4388	31.000	13.561
E3-LD-6	4-L	45	93	14:30	15:00	6.6	Blk	46.0	395.2	471.8	13.1	17.4666	31.200	13.733
E3-LD-7	4-L	45	93	15:30	16:00	6.6	Blk	46.0	395.2	484.8	13.0	17.4135	31.100	13.687
E3-LD-8	4-L	45	93	16:30	17:00	6.6	Blk	46.0	395.2	498.0	13.2	17.4043	31.100	13.696
E3-LD-24	4-L	45	626	12:30	12:36	6.8	Blk	46.0	395.2	4731.2	4233.2	17.3612	29.500	12.139
E3-LD-CP	4-L	45	Mix	NA	12:47	6.8	Blk	46.0	395.2	4783.8	4388.6	17.3802	28.500	11.120
E3-FD-CP	4-L	45	164	13:00	15:30	6.7	Blk	46.0	25.33	148.8	123.5	17.5420	28.500	10.958
E3-FDI-CP	4-L	25	164	15:30	18:00	6.7	Blk	28.1	25.45	141.2	115.8	17.5671	28.500	10.933
E3-AN-CP	4-L	25	164	18:05	19:05	5.9	Mix	25.0	12.80	59.1	46.3	17.7346	28.500	10.765

Table C.9. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
E3-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E3-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E3-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E3-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E3-LD-0	NA	NA	NA	NA	NA	NA	9.6104	10-1281	9.77E-01	± 2%	7.29E-02	± 2%
E3-LD-1	23.93	1.595	0.399	1.595	0.399	1.595	11.0459	10-1282	1.30E-04	± 5%	3.14E-03	± 4%
E3-LD-2	21.79	1.453	0.363	1.453	0.381	1.524	11.2995	10-1283	5.81E-05	± 9%	1.70E-03	± 4%
E3-LD-3	21.58	1.439	0.360	1.439	0.374	1.496	11.0511	10-1284	6.27E-05	± 9%	2.33E-03	± 4%
E3-LD-4	21.97	1.465	0.366	1.465	0.372	1.488	11.2734	10-1285	6.54E-05	± 9%	2.49E-03	± 4%
E3-LD-5	22.02	1.468	0.367	1.468	0.371	1.484	11.2430	10-1286	5.84E-05	± 9%	2.58E-03	± 4%
E3-LD-6	22.25	1.483	0.371	1.483	0.371	1.484	11.3858	10-1287	5.83E-05	± 8%	2.45E-03	± 4%
E3-LD-7	22.12	1.475	0.369	1.475	0.371	1.482	11.3469	10-1288	4.90E-05	± 11%	2.37E-03	± 4%
E3-LD-8	22.30	1.487	0.372	1.487	0.371	1.483	11.3546	10-1289	5.11E-05	± 11%	2.34E-03	± 4%
E3-LD-24	3519.64	234.64	2.993	11.972	2.993	11.97	10.0638	10-1290	2.10E-02	± 2%	3.83E-03	± 4%
E3-LD-CP	3745.18	249.68	NA	NA	NA	NA	9.2190	10-1291	2.98E-03	± 2%	2.33E-03	± 2%
E3-FD-CP	111.88	7.458	0.746	2.983	0.746	2.983	9.9291	10-1292	5.81E-03	± 2%	1.27E-03	± 2%
E3-FDI-CP	115.78	7.719	0.772	3.087	0.772	3.087	10.9357	10-1293	1.03E-04	± 3%	3.61E-05	± 6%
E3-AN-CP	46.06	3.071	0.768	3.071	0.768	3.071	10.7098	10-1294	1.53E-04	± 3%	5.65E-05	± 6%

Table C.9. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	meq/g
E3-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E3-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E3-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E3-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E3-LD-0	1.02E-01	2.03E-03	7.23E-02	1.45E-03	NA	100.00%	1.00E+00	2.83E-02	100.00%	100.00%	2.83E-02	NA	NA	NA
E3-LD-1	1.17E-05	5.87E-07	2.84E-04	1.14E-05	1.60	0.01%	1.15E-04	6.22E-06	0.39%	3.93E-03	1.76E-04	5.74E-04	5.74E-04	8.40E-05
E3-LD-2	5.14E-06	4.63E-07	1.50E-04	6.02E-06	3.05	0.01%	5.06E-05	4.66E-06	0.21%	2.08E-03	9.30E-05	5.23E-04	1.10E-03	1.60E-04
E3-LD-3	5.67E-06	5.11E-07	2.11E-04	8.42E-06	4.49	0.01%	5.58E-05	5.15E-06	0.29%	2.91E-03	1.30E-04	5.18E-04	1.62E-03	2.36E-04
E3-LD-4	5.80E-06	5.22E-07	2.21E-04	8.83E-06	5.95	0.01%	5.71E-05	5.26E-06	0.31%	3.05E-03	1.37E-04	5.27E-04	2.14E-03	3.13E-04
E3-LD-5	5.19E-06	4.67E-07	2.29E-04	9.18E-06	7.42	0.01%	5.11E-05	4.71E-06	0.32%	3.17E-03	1.42E-04	5.28E-04	2.67E-03	3.90E-04
E3-LD-6	5.12E-06	4.09E-07	2.15E-04	8.61E-06	8.90	0.01%	5.04E-05	4.15E-06	0.30%	2.97E-03	1.33E-04	5.34E-04	3.20E-03	4.69E-04
E3-LD-7	4.32E-06	4.75E-07	2.09E-04	8.35E-06	10.38	0.00%	4.25E-05	4.75E-06	0.29%	2.89E-03	1.29E-04	5.31E-04	3.74E-03	5.46E-04
E3-LD-8	4.50E-06	4.95E-07	2.06E-04	8.25E-06	11.86	0.00%	4.43E-05	4.95E-06	0.28%	2.85E-03	1.27E-04	5.35E-04	4.27E-03	6.24E-04
E3-LD-24	2.08E-03	4.17E-05	3.81E-04	1.52E-05	246.51	2.05%	2.05E-02	5.80E-04	0.53%	5.26E-03	2.35E-04	8.36E-02	8.79E-02	1.28E-02
E3-LD-CP	3.23E-04	6.46E-06	2.53E-04	5.05E-06	249.68	0.32%	3.18E-03	8.99E-05	0.35%	3.49E-03	9.88E-05	8.94E-02	8.94E-02	1.31E-02
E3-FD-CP	5.85E-04	1.17E-05	1.28E-04	2.56E-06	257.14	0.58%	5.76E-03	1.63E-04	0.18%	1.77E-03	5.00E-05	2.67E-03	9.05E-02	1.32E-02
E3-FDI-CP	9.42E-06	2.83E-07	3.30E-06	1.98E-07	264.86	0.01%	9.26E-05	3.34E-06	0.00%	4.56E-05	2.89E-06	2.78E-03	9.33E-02	1.36E-02
E3-AN-CP	1.43E-05	4.29E-07	5.28E-06	3.17E-07	267.93	0.01%	1.41E-04	5.07E-06	0.01%	7.29E-05	4.61E-06	1.11E-03	9.44E-02	1.38E-02

Table C.10. Column E4 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
E4-PT-DIW1	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E4-PT-ACID	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E4-PT-DIW2	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E4-PT-NaOH	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E4-LD-0	4-L	45										17.3222	29.400	12.078
Loading (LD) Phase Start Date/Time:				05:30										
E4-LD-1	4-L	45	93	06:00	06:30	6.5	Blk	46.0	395.2	408.0	12.8	17.4963	29.600	12.104
E4-LD-2	4-L	45	93	07:00	07:30	6.5	Blk	46.0	395.2	420.3	12.3	17.6947	30.100	12.405
E4-LD-3	4-L	45	93	08:00	08:30	6.5	Blk	46.0	395.2	433.4	13.1	17.5666	31.100	13.533
E4-LD-4	4-L	45	93	09:00	09:30	6.5	Blk	46.0	395.2	447.1	13.7	17.5176	30.500	12.982
E4-LD-5	4-L	45	93	10:00	10:30	6.5	Blk	46.0	395.2	461.7	14.6	17.5269	31.000	13.473
E4-LD-6	4-L	45	92	11:00	11:30	6.5	Blk	46.0	395.2	475.8	14.1	17.8236	30.700	12.876
E4-LD-7	4-L	45	92	12:00	12:30	6.5	Blk	46.0	395.2	490.5	14.7	17.4084	30.300	12.892
E4-LD-8	4-L	45	92	13:00	13:30	6.5	Blk	46.0	395.2	504.9	14.4	17.5354	30.400	12.865
E4-LD-24	4-L	45	626	09:00	09:06	6.5	Blk	46.0	395.2	4764.0	4259.1	17.5123	29.500	11.988
E4-LD-CP	4-L	45	Mix	05:30	09:15	6.5	Blk	46.0	395.2	4788.9	4393.7	17.4093	29.500	12.091
E4-FD-CP	4-L	45	164	09:30	12:00	6.5	Blk	46.0	25.28	151.4	126.1	17.3674	29.500	12.133
E4-FDI-CP	4-L	25	164	12:00	14:38	6.4	Blk	25.0	25.32	139.9	114.6	17.5596	29.000	11.440
E4-AN-CP	4-L	25	87	14:38	16:45	6.4	Mix	25.0	12.75	57.5	44.8	17.3357	29.000	11.664

Table C.10. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
E4-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E4-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E4-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E4-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E4-LD-0	NA	NA	NA	NA	NA	NA	10.0132	10-1342	1.06E+00	± 2%	7.38E-02	± 2%
E4-LD-1	24.31	1.621	0.405	1.621	0.405	1.621	11.8150	10-1343	1.39E-04	± 4%	1.45E-04	± 4%
E4-LD-2	22.15	1.477	0.369	1.477	0.387	1.549	11.1227	10-1344	2.86E-05	± 9%	4.02E-04	± 2%
E4-LD-3	22.08	1.472	0.368	1.472	0.381	1.523	11.2200	10-1345	2.17E-05	± 14%	6.16E-04	± 2%
E4-LD-4	22.12	1.475	0.369	1.475	0.378	1.511	10.7632	10-1346	3.49E-05	± 11%	7.85E-04	± 4%
E4-LD-5	23.27	1.552	0.388	1.552	0.380	1.519	11.1700	10-1347	2.15E-05	± 12%	8.00E-04	± 2%
E4-LD-6	22.37	1.491	0.373	1.491	0.379	1.514	10.6753	10-1348	2.90E-05	± 10%	8.07E-04	± 3%
E4-LD-7	22.88	1.525	0.381	1.525	0.379	1.516	10.6879	10-1349	2.76E-05	± 10%	8.24E-04	± 2%
E4-LD-8	22.60	1.507	0.377	1.507	0.379	1.515	10.6655	10-1350	2.77E-05	± 14%	8.44E-04	± 4%
E4-LD-24	3540.99	236.07	3.011	12.044	3.011	12.04	9.9385	10-1351	2.59E-02	± 3%	1.67E-03	± 2%
E4-LD-CP	3748.10	249.87	NA	NA	NA	NA	10.0239	10-1352	3.74E-03	± 2%	9.64E-04	± 3%
E4-FD-CP	114.28	7.619	0.762	3.047	0.762	3.047	10.9934	10-1353	8.60E-03	± 2%	6.91E-04	± 3%
E4-FDI-CP	114.61	7.641	0.725	2.902	0.725	2.902	11.4434	10-1354	1.48E-04	± 4%	2.19E-05	± 14%
E4-AN-CP	44.52	2.968	0.351	1.402	0.351	1.402	11.6041	10-1355	1.72E-04	± 4%	2.06E-05	± 20%

Table C.10. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	meq/g
E4-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E4-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E4-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E4-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E4-LD-0	1.06E-01	2.12E-03	7.38E-02	1.48E-03	NA	100.0%	1.00E+00	2.83E-02	100.0%	100.0%	2.83E-02	NA	NA	NA
E4-LD-1	1.18E-05	4.72E-07	1.23E-05	4.91E-07	1.62	0.01%	1.11E-04	4.98E-06	0.02%	1.66E-04	7.43E-06	5.83E-04	5.83E-04	8.53E-05
E4-LD-2	2.57E-06	2.31E-07	3.62E-05	7.23E-07	3.10	0.00%	2.42E-05	2.24E-06	0.05%	4.90E-04	1.39E-05	5.32E-04	1.11E-03	1.63E-04
E4-LD-3	1.93E-06	2.70E-07	5.49E-05	1.10E-06	4.57	0.00%	1.82E-05	2.57E-06	0.07%	7.44E-04	2.10E-05	5.30E-04	1.64E-03	2.40E-04
E4-LD-4	3.24E-06	3.56E-07	7.29E-05	2.92E-06	6.04	0.00%	3.05E-05	3.41E-06	0.10%	9.88E-04	4.42E-05	5.31E-04	2.18E-03	3.18E-04
E4-LD-5	1.92E-06	2.31E-07	7.16E-05	1.43E-06	7.60	0.00%	1.81E-05	2.20E-06	0.10%	9.70E-04	2.74E-05	5.59E-04	2.73E-03	4.00E-04
E4-LD-6	2.72E-06	2.72E-07	7.56E-05	2.27E-06	9.09	0.00%	2.56E-05	2.61E-06	0.10%	1.02E-03	3.69E-05	5.37E-04	3.27E-03	4.78E-04
E4-LD-7	2.58E-06	2.58E-07	7.71E-05	1.54E-06	10.61	0.00%	2.43E-05	2.48E-06	0.10%	1.04E-03	2.95E-05	5.49E-04	3.82E-03	5.58E-04
E4-LD-8	2.60E-06	3.64E-07	7.91E-05	3.16E-06	12.12	0.00%	2.45E-05	3.47E-06	0.11%	1.07E-03	4.79E-05	5.42E-04	4.36E-03	6.38E-04
E4-LD-24	2.61E-03	7.82E-05	1.68E-04	3.36E-06	248.18	2.46%	2.46E-02	8.86E-04	0.23%	2.28E-03	6.45E-05	8.39E-02	8.83E-02	1.29E-02
E4-LD-CP	3.74E-04	7.47E-06	9.61E-05	2.88E-06	249.87	0.35%	3.52E-03	9.96E-05	0.13%	1.30E-03	4.69E-05	8.94E-02	8.94E-02	1.31E-02
E4-FD-CP	7.83E-04	1.57E-05	6.29E-05	1.89E-06	257.49	0.74%	7.38E-03	2.09E-04	0.09%	8.51E-04	3.07E-05	2.72E-03	9.10E-02	1.33E-02
E4-FDI-CP	1.29E-05	5.16E-07	1.92E-06	2.68E-07	265.13	0.01%	1.22E-04	5.44E-06	0.00%	2.60E-05	3.67E-06	2.75E-03	9.38E-02	1.37E-02
E4-AN-CP	1.48E-05	5.91E-07	1.78E-06	3.55E-07	268.10	0.01%	1.39E-04	6.23E-06	0.00%	2.40E-05	4.83E-06	1.07E-03	9.48E-02	1.39E-02

Table C.11. Column E5 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
E5-PT-DIW1	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E5-PT-ACID	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E5-PT-DIW2	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E5-PT-NaOH	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E5-LD-0	4-L	45	NA	NA	NA	NA	NA	NA	NA	NA	NA	17.5562	29.500	11.944
Loading (LD) Phase Start Date/Time:				10:00										
E5-LD-1	4-L	45	92	10:30	11:00	6.6	Blk	46.0	395.2	406.4	11.2	17.2594	29.500	12.241
E5-LD-2	4-L	45	92	11:30	12:00	6.6	Blk	46.0	395.2	419.0	12.6	17.6936	30.500	12.806
E5-LD-3	4-L	45	92	12:30	13:00	6.6	Blk	46.0	395.2	433.0	14.0	17.7563	31.500	13.744
E5-LD-4	4-L	45	92	13:30	14:00	6.6	Blk	46.0	395.2	446.8	13.8	17.4514	30.600	13.149
E5-LD-5	4-L	45	92	14:30	15:00	6.6	Blk	46.0	395.2	461.9	15.1	17.4684	30.800	13.332
E5-LD-6	4-L	45	92	15:30	16:00	6.6	Blk	46.0	395.2	477.0	15.1	17.3730	30.900	13.527
E5-LD-7	4-L	45	92	16:30	17:00	6.6	Blk	46.0	395.2	492.3	15.3	17.7311	31.200	13.469
E5-LD-8	4-L	45	92	17:30	18:00	6.6	Blk	46.0	395.2	507.6	15.3	17.5178	31.000	13.482
E5-LD-24	4-L	45	800	09:26	09:29	6.5	Blk	46.0	395.2	4765.1	4257.5	17.5571	30.100	12.543
E5-LD-CP	4-L	45	Mix	10:00	09:30	6.5	Blk	46.0	395.2	4777.6	4382.4	17.5871	30.000	12.413
E5-FD-CP	4-L	45	164	10:00	12:35	6.5	Blk	46.0	25.31	153.7	128.4	17.3851	29.500	12.115
E5-FDI-CP	4-L	25	164	12:40	15:10	6.5	Blk	25.0	25.32	139.9	114.6	17.5391	28.500	10.961
E5-AN-CP	4-L	25	95	15:15	17:21		Mix	25.0	12.68	59.5	46.8	17.4075	27.600	10.193

Table C.11. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
E5-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E5-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E5-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E5-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E5-LD-0	NA	NA	NA	NA	NA	NA	9.9021	10-1402	1.03E+00	± 2%	7.40E-02	± 2%
E5-LD-1	22.88	1.525	0.381	1.525	0.381	1.525	11.9486	10-1403	2.46E-04	± 3%	5.18E-03	± 2%
E5-LD-2	22.78	1.519	0.380	1.519	0.381	1.522	11.4824	10-1404	3.65E-05	± 9%	4.88E-04	± 2%
E5-LD-3	23.00	1.533	0.383	1.533	0.381	1.526	11.3943	10-1405	3.05E-05	± 15%	7.54E-04	± 2%
E5-LD-4	22.34	1.489	0.372	1.489	0.379	1.517	10.9010	10-1406	3.66E-05	± 10%	9.10E-04	± 2%
E5-LD-5	23.57	1.571	0.393	1.571	0.382	1.528	11.0527	10-1407	3.62E-05	± 8%	9.46E-04	± 2%
E5-LD-6	23.73	1.582	0.396	1.582	0.384	1.537	11.2147	10-1408	3.46E-05	± 11%	9.90E-04	± 2%
E5-LD-7	23.85	1.590	0.398	1.590	0.386	1.544	11.1665	10-1409	3.21E-05	± 12%	1.01E-03	± 2%
E5-LD-8	23.86	1.591	0.398	1.591	0.388	1.550	11.1776	10-1410	2.77E-05	± 11%	1.02E-03	± 2%
E5-LD-24	3540.12	236.01	3.811	15.243	3.811	15.24	10.3988	10-1411	6.56E-02	± 2%	2.11E-03	± 2%
E5-LD-CP	3741.63	249.44	NA	NA	NA	NA	10.2910	10-1412	1.32E-02	± 2%	1.20E-03	± 4%
E5-FD-CP	116.34	7.756	0.751	3.002	0.751	3.002	10.9774	10-1413	2.03E-02	± 2%	7.40E-04	± 5%
E5-FDI-CP	114.61	7.641	0.764	3.056	0.764	3.056	10.9637	10-1414	3.30E-04	± 3%	1.23E-05	± 23%
E5-AN-CP	46.58	3.105	0.370	1.479	0.370	1.479	10.1399	10-1415	3.43E-04	± 3%	2.24E-05	± 12%

Table C.11. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	meq/g
E5-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E5-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E5-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E5-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E5-LD-0	1.04E-01	2.08E-03	7.39E-02	1.48E-03	NA	100.00%	1.00E+00	2.83E-02	100.00%	100.00%	2.83E-02	NA	NA	NA
E5-LD-1	2.05E-05	6.16E-07	4.34E-04	8.68E-06	1.53	0.02%	1.98E-04	7.12E-06	0.59%	5.87E-03	1.66E-04	5.49E-04	5.49E-04	8.03E-05
E5-LD-2	3.18E-06	2.86E-07	4.25E-05	8.51E-07	3.04	0.00%	3.06E-05	2.82E-06	0.06%	5.76E-04	1.63E-05	5.47E-04	1.10E-03	1.60E-04
E5-LD-3	2.68E-06	4.01E-07	6.61E-05	1.32E-06	4.58	0.00%	2.57E-05	3.89E-06	0.09%	8.95E-04	2.53E-05	5.52E-04	1.65E-03	2.41E-04
E5-LD-4	3.35E-06	3.35E-07	8.35E-05	1.67E-06	6.07	0.00%	3.22E-05	3.29E-06	0.11%	1.13E-03	3.20E-05	5.36E-04	2.18E-03	3.19E-04
E5-LD-5	3.28E-06	2.62E-07	8.56E-05	1.71E-06	7.64	0.00%	3.15E-05	2.60E-06	0.12%	1.16E-03	3.28E-05	5.66E-04	2.75E-03	4.02E-04
E5-LD-6	3.09E-06	3.40E-07	8.83E-05	1.77E-06	9.22	0.00%	2.97E-05	3.32E-06	0.12%	1.19E-03	3.38E-05	5.70E-04	3.32E-03	4.85E-04
E5-LD-7	2.88E-06	3.45E-07	9.04E-05	1.81E-06	10.81	0.00%	2.77E-05	3.37E-06	0.12%	1.22E-03	3.46E-05	5.72E-04	3.89E-03	5.69E-04
E5-LD-8	2.48E-06	2.73E-07	9.11E-05	1.82E-06	12.40	0.00%	2.39E-05	2.67E-06	0.12%	1.23E-03	3.49E-05	5.73E-04	4.46E-03	6.53E-04
E5-LD-24	6.31E-03	1.26E-04	2.03E-04	4.06E-06	248.41	6.07%	6.07E-02	1.72E-03	0.28%	2.75E-03	7.78E-05	8.24E-02	8.68E-02	1.27E-02
E5-LD-CP	1.28E-03	2.56E-05	1.17E-04	4.66E-06	249.44	1.23%	1.23E-02	3.48E-04	0.16%	1.58E-03	7.06E-05	8.84E-02	8.84E-02	1.29E-02
E5-FD-CP	1.85E-03	3.70E-05	6.74E-05	3.37E-06	257.20	1.78%	1.78E-02	5.03E-04	0.09%	9.12E-04	4.91E-05	2.74E-03	8.96E-02	1.31E-02
E5-FDI-CP	3.01E-05	9.03E-07	1.12E-06	2.57E-07	264.84	0.03%	2.89E-04	1.04E-05	0.00%	1.51E-05	3.50E-06	2.75E-03	9.23E-02	1.35E-02
E5-AN-CP	3.38E-05	1.02E-06	2.21E-06	2.65E-07	267.94	0.03%	3.25E-04	1.17E-05	0.00%	2.99E-05	3.64E-06	1.12E-03	9.35E-02	1.37E-02

Table C.12. Column E6 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
E6-PT-DIW1	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E6-PT-ACID	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E6-PT-DIW2	250 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E6-PT-NaOH	200 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E6-LD-0	4-L	45	NA	NA	NA	NA	NA	NA	NA	NA	NA	17.4131	29.500	12.087
Loading (LD) Phase Start Date/Time:				09:00										
E6-LD-1	4-L	45	92	09:30	09:58	6.8	Blk	46.0	395.2	406.2	11.0	17.4207	28.600	11.179
E6-LD-2	4-L	45	92	10:30	10:58	6.7	Blk	46.0	395.2	419.4	13.2	17.3735	29.400	12.027
E6-LD-3	4-L	45	92	11:30	11:58	6.7	Blk	46.0	395.2	433.4	14.0	17.4245	30.100	12.676
E6-LD-4	4-L	45	92	12:30	12:58	6.7	Blk	46.0	395.2	448.0	14.6	17.5191	30.600	13.081
E6-LD-5	4-L	45	92	13:30	13:58	6.7	Blk	46.0	395.2	462.7	14.7	17.3061	30.400	13.094
E6-LD-6	4-L	45	92	14:30	14:58	6.7	Blk	46.0	395.2	477.7	15.0	17.3889	30.600	13.211
E6-LD-7	4-L	45	92	15:30	15:58	6.7	Blk	46.0	395.2	492.5	14.8	17.6625	30.900	13.238
E6-LD-8	4-L	45	92	16:30	16:58	6.7	Blk	46.0	395.2	506.8	14.3	17.3930	30.600	13.207
E6-LD-24	4-L	45	800	08:45	08:48	6.8	Blk	46.0	395.2	4825.5	4318.7	17.4673	30.600	13.133
E6-LD-CP	4-L	45	Mix	09:00	08:48	6.8	Blk	46.0	395.2	4825.5	4430.3	17.4823	30.500	13.018
E6-FD-CP	4-L	45	164	09:00	11:30	6.8	Blk	46.0	25.36	144.4	119.0	17.6662	29.500	11.834
E6-FDI-CP	4-L	25	164	11:30	14:00	6.6	Blk	38.0	25.28	138.5	113.2	17.4670	28.000	10.533
E6-AN-CP	4-L	25	88	14:00	16:10	6.2	Mix	25.0	12.75	61.3	48.6	17.5285	27.900	10.372

Table C.12. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
E6-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E6-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E6-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E6-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E6-LD-0	NA	NA	NA	NA	NA	NA	10.0208	10-1462	1.03E+00	± 2%	6.81E-02	± 2%
E6-LD-1	21.65	1.443	0.373	1.493	0.373	1.493	10.9127	10-1463	1.91E-04	± 4%	2.72E-03	± 3%
E6-LD-2	22.62	1.508	0.377	1.508	0.375	1.501	10.7831	10-1464	6.63E-05	± 6%	7.53E-04	± 3%
E6-LD-3	22.12	1.474	0.369	1.474	0.373	1.492	10.5087	10-1465	6.86E-05	± 8%	1.13E-03	± 3%
E6-LD-4	22.95	1.530	0.382	1.530	0.375	1.501	10.8448	10-1466	8.15E-05	± 6%	1.45E-03	± 3%
E6-LD-5	23.04	1.536	0.384	1.536	0.377	1.508	10.8556	10-1467	7.83E-05	± 7%	1.57E-03	± 3%
E6-LD-6	23.39	1.559	0.390	1.559	0.379	1.517	10.9528	10-1468	1.16E-04	± 6%	1.71E-03	± 4%
E6-LD-7	23.24	1.550	0.387	1.550	0.380	1.522	10.9747	10-1469	8.66E-05	± 6%	1.72E-03	± 4%
E6-LD-8	22.80	1.520	0.380	1.520	0.380	1.521	10.9494	10-1470	6.86E-05	± 8%	1.78E-03	± 4%
E6-LD-24	3591.35	239.42	3.780	15.121	3.780	15.12	10.8878	10-1471	1.23E-01	± 2%	5.23E-03	± 4%
E6-LD-CP	3778.99	251.93	NA	NA	NA	NA	10.7925	10-1472	1.77E-02	± 2%	2.41E-03	± 2%
E6-FD-CP	107.86	7.191	0.719	2.876	0.719	2.876	10.7227	10-1473	1.35E-02	± 2%	6.80E-04	± 3%
E6-FDI-CP	113.25	7.550	0.755	3.020	0.755	3.020	10.5357	10-1474	5.24E-04	± 2%	4.56E-05	± 8%
E6-AN-CP	48.30	3.220	0.372	1.486	0.372	1.486	10.3180	10-1475	6.64E-04	± 2%	6.99E-05	± 5%

Table C.12. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Loading mmol Cs	meq/g
E6-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E6-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E6-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E6-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E6-LD-0	1.03E-01	2.06E-03	7.44E-02	1.49E-03	NA	100.0%	1.00E+00	2.83E-02	100.0%	100.00%	2.83E-02	NA	NA	NA
E6-LD-1	1.75E-05	7.01E-07	2.50E-04	7.49E-06	1.44	0.02%	1.70E-04	7.62E-06	0.34%	3.35E-03	1.21E-04	5.20E-04	5.20E-04	7.60E-05
E6-LD-2	6.15E-06	3.69E-07	6.98E-05	2.09E-06	2.95	0.01%	5.98E-05	3.78E-06	0.09%	9.37E-04	3.38E-05	5.43E-04	1.06E-03	1.55E-04
E6-LD-3	6.53E-06	5.22E-07	1.08E-04	3.24E-06	4.43	0.01%	6.35E-05	5.24E-06	0.14%	1.45E-03	5.23E-05	5.31E-04	1.59E-03	2.33E-04
E6-LD-4	7.51E-06	4.51E-07	1.34E-04	4.01E-06	5.96	0.01%	7.31E-05	4.62E-06	0.18%	1.80E-03	6.48E-05	5.51E-04	2.14E-03	3.13E-04
E6-LD-5	7.21E-06	5.05E-07	1.45E-04	4.34E-06	7.49	0.01%	7.02E-05	5.11E-06	0.19%	1.94E-03	7.00E-05	5.53E-04	2.70E-03	3.94E-04
E6-LD-6	1.06E-05	6.38E-07	1.56E-04	6.24E-06	9.05	0.01%	1.03E-04	6.54E-06	0.21%	2.09E-03	9.37E-05	5.61E-04	3.26E-03	4.76E-04
E6-LD-7	7.89E-06	4.73E-07	1.57E-04	6.26E-06	10.60	0.01%	7.68E-05	4.85E-06	0.21%	2.10E-03	9.40E-05	5.58E-04	3.82E-03	5.58E-04
E6-LD-8	6.26E-06	5.01E-07	1.63E-04	6.50E-06	12.12	0.01%	6.09E-05	5.02E-06	0.22%	2.18E-03	9.77E-05	5.47E-04	4.36E-03	6.38E-04
E6-LD-24	1.13E-02	2.26E-04	4.80E-04	1.92E-05	251.54	10.99%	1.10E-01	3.11E-03	0.65%	6.45E-03	2.89E-04	8.15E-02	8.58E-02	1.25E-02
E6-LD-CP	1.64E-03	3.28E-05	2.23E-04	4.46E-06	251.93	1.60%	1.60E-02	4.51E-04	0.30%	3.00E-03	8.48E-05	8.90E-02	8.90E-02	1.30E-02
E6-FD-CP	1.26E-03	2.52E-05	6.34E-05	1.90E-06	259.12	1.22%	1.22E-02	3.46E-04	0.09%	8.52E-04	3.07E-05	2.56E-03	8.84E-02	1.29E-02
E6-FDI-CP	4.97E-05	9.94E-07	4.33E-06	3.46E-07	266.67	0.05%	4.84E-04	1.37E-05	0.01%	5.82E-05	4.80E-06	2.72E-03	9.11E-02	1.33E-02
E6-AN-CP	6.43E-05	1.29E-06	6.78E-06	3.39E-07	269.89	0.06%	6.26E-04	1.77E-05	0.01%	9.10E-05	4.90E-06	1.16E-03	9.22E-02	1.35E-02

Table C.13. Column F1 Loading Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
F1-PT-DIW1	250 mL	25	174	10:30	13:00	6.3	Blk	25	25.35	140.1	114.8	0.0000	0.000	0.000
F1-PT-ACID	200 mL	25	174	13:00	15:42	5.2	Org	25	25.32	147.4	122.1	0.0000	0.000	0.000
F1-PT-DIW2	250 mL	25	174	15:42	16:42	5.2	Org	25	25.28	73.2	47.9	0.0000	0.000	0.000
F1-PT-NaOH	200 mL	25	174	16:42	18:43	5.8	Blk	25	25.32	122.5	97.2	0.0000	0.000	0.000
F1-LD-0	4-L	45	174	NA	NA	NA	NA	NA	NA	NA	NA	17.4398	29.500	12.060
Loading (LD) Phase Start Date/Time:				19:00										
F1-LD-1	4-L	45	101	19:30	19:58	6.0	Blk	25.0	346.4	357.1	10.7	17.5182	28.200	10.682
F1-LD-2	4-L	45	101	20:30	20:58	6.1	Blk	25.0	346.4	370.3	13.2	17.6094	28.700	11.091
F1-LD-3	4-L	45	101	21:30	21:58	6.2	Blk	25.0	346.4	383.3	13.0	17.5835	30.300	12.717
F1-LD-4	4-L	45	101	22:30	22:58	6.2	Blk	25.0	346.4	396.2	12.9	17.5064	30.000	12.494
F1-LD-5	4-L	45	101	23:30	23:58	6.2	Blk	25.0	346.4	410.4	14.2	17.5819	30.100	12.518
F1-LD-6	4-L	45	101	00:30	00:58	6.2	Blk	25.0	346.4	424.7	14.3	17.6726	30.400	12.727
F1-LD-7	4-L	45	101	01:30	01:58	6.2	Blk	25.0	346.4	439.0	14.3	17.6930	30.500	12.807
F1-LD-8	4-L	45	101	02:30	02:58	6.2	Blk	25.0	346.4	453.6	14.6	17.5650	30.400	12.835
F1-LD-9	4-L	45	101	03:30	03:33	6.2	Blk	25.0	346.4	565.8	112.2	17.7436	30.200	12.456
F1-LD-10	4-L	45	640	04:30	04:33	6.2	Blk	25.0	346.4	769.7	203.9	17.5807	30.100	12.519
F1-LD-11	4-L	45	640	05:30	05:33	6.2	Blk	25.0	346.4	973.7	204.0	17.5426	30.000	12.457
F1-LD-12	4-L	45	640	06:30	06:33	6.2	Blk	25.0	346.4	1178.1	204.4	17.5249	30.000	12.475
F1-LD-13	4-L	45	640	07:30	07:33	6.2	Blk	25.0	346.4	1382.1	204.0	17.4171	30.100	12.683
F1-LD-14	4-L	45	640	08:30	08:33	6.2	Blk	25.0	346.4	1586.1	204.0	17.5720	29.700	12.128
F1-LD-15	4-L	45	640	09:30	09:33	6.2	Blk	25.0	346.4	1790.2	204.1	17.5037	30.000	12.496
F1-LD-16	4-L	45	640	10:30	10:33	6.2	Blk	25.0	346.4	1994.1	203.9	17.4987	29.700	12.201
F1-LD-17	4-L	45	640	11:30	11:33	6.2	Blk	25.0	346.4	2199.0	204.9	17.6253	29.800	12.175
F1-LD-18	4-L	45	640	12:30	12:33	6.2	Blk	25.0	346.4	2404.0	205.0	17.6573	29.800	12.143
F1-LD-19	4-L	45	640	13:30	13:33	6.2	Blk	25.0	346.4	2609.4	205.4	17.6742	29.600	11.926
F1-LD-20	4-L	45	640	14:30	14:33	6.2	Blk	25.0	346.4	2814.0	204.6	17.5349	29.600	12.065

Table C.13. (contd)

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Sampling Time		Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
				Start	Stop				Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
F1-LD-21	4-L	45	640	15:30	15:33	6.2	Blk	25.0	346.4	3018.2	204.2	17.4927	29.700	12.207
F1-LD-22	4-L	45	640	16:30	16:33	6.2	Blk	25.0	346.4	3222.9	204.7	17.7034	30.000	12.297
F1-LD-23	4-L	45	640	17:30	17:33	6.2	Blk	25.0	346.4	3429.3	206.4	17.4952	29.800	12.305
F1-LD-24	4-L	45	640	18:30	18:33	6.2	Blk	25.0	346.4	3631.8	202.5	17.6714	29.800	12.129
F1-LD-25	4-L	45	640	19:30	19:33	6.2	Blk	25.0	346.4	3836.4	204.6	17.6240	29.800	12.176
F1-LD-26	4-L	45	640	20:30	20:33	6.2	Blk	25.0	346.4	4040.4	204.0	17.4904	29.700	12.210
F1-LD-27	4-L	45	640	21:30	21:33	6.2	Blk	25.0	346.4	4248.0	207.6	17.5458	29.600	12.054
F1-LD-28	4-L	45	640	22:30	22:33	6.2	Blk	25.0	346.4	4448.8	200.8	17.6295	29.700	12.071
F1-FD-CP	4-L	45	174	09:08	11:38	6.1	Blk	25.0	25.30	152.2	126.9	17.4904	29.700	12.210
F1-FDI-CP	4-L	25	174	11:38	14:08	6.0	Blk	25.0	25.35	138.4	113.1	17.5500	28.000	10.450
F1-AN-CP	4-L	25	94	14:08	16:14	5.6	Mix	25.0	12.79	60.5	47.7	17.4005	28.000	10.600

Table C.13. (contd)

Sample ID No.	Instant. Volume mL BV		Instant. Flow mL/min BV/hr		Average Flow mL/min BV/hr		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
F1-PT-DIW1	114.93	7.662	0.766	3.065	0.766	3.065	NA	NA	NA	NA	NA	NA
F1-PT-ACID	120.64	8.043	0.745	2.979	0.755	3.022	NA	NA	NA	NA	NA	NA
F1-PT-DIW2	48.00	3.200	0.800	3.200	0.770	3.081	NA	NA	NA	NA	NA	NA
F1-PT-NaOH	94.86	6.324	0.784	3.136	0.774	3.095	NA	NA	NA	NA	NA	NA
F1-LD-0	NA	NA	NA	NA	NA	NA	12.0475	10-1492	1.23E+00	± 2%	<6.0E-04	NA
F1-LD-1	20.87	1.391	0.360	1.439	0.360	1.439	10.4270	10-1493	1.35E-04	± 5%	6.49E-03	± 2%
F1-LD-2	21.78	1.452	0.363	1.452	0.361	1.446	9.9440	10-1494	4.37E-04	± 2%	2.45E-05	± 13%
F1-LD-3	21.32	1.421	0.355	1.421	0.359	1.438	10.5427	10-1495	1.33E-05	± 20%	6.59E-06	± 23%
F1-LD-4	21.05	1.404	0.351	1.404	0.357	1.429	10.3579	10-1496	1.62E-05	± 13%	7.83E-06	± 26%
F1-LD-5	22.15	1.477	0.369	1.477	0.360	1.439	10.3783	10-1497	6.28E-05	± 8%	<6.0E-06	NA
F1-LD-6	22.41	1.494	0.373	1.494	0.362	1.448	10.5518	10-1498	1.10E-05	± 29%	5.06E-06	± 40%
F1-LD-7	22.47	1.498	0.375	1.498	0.364	1.455	10.6178	10-1499	6.66E-05	± 7%	<6.0E-06	NA
F1-LD-8	22.75	1.516	0.379	1.516	0.366	1.463	10.6410	10-1500	1.19E-05	± 25%	<6.0E-06	NA
F1-LD-9	103.35	6.890	2.925	11.700	2.925	11.700	10.3271	10-1501	6.11E-05	± 7%	<6.0E-06	NA
F1-LD-10	179.42	11.962	2.990	11.962	2.966	11.865	10.3792	10-1502	4.07E-05	± 10%	<6.0E-06	NA
F1-LD-11	179.46	11.964	2.991	11.964	2.991	11.964	10.3279	10-1503	1.34E-04	± 4%	<7.0E-06	NA
F1-LD-12	179.80	11.987	2.997	11.987	2.994	11.975	10.3426	10-1504	2.65E-04	± 3%	<5.0E-06	NA
F1-LD-13	179.64	11.976	2.994	11.976	2.994	11.976	10.5149	10-1505	4.85E-04	± 3%	<6.0E-06	NA
F1-LD-14	179.18	11.946	2.986	11.946	2.992	11.968	10.0548	10-1506	7.68E-04	± 3%	7.89E-06	± 39%
F1-LD-15	179.57	11.971	2.993	11.971	2.992	11.969	10.3602	10-1507	1.13E-03	± 3%	<7.0E-06	NA
F1-LD-16	179.16	11.944	2.986	11.944	2.991	11.965	10.1156	10-1508	1.68E-03	± 3%	<9.0E-06	NA
F1-LD-17	179.97	11.998	2.999	11.998	2.992	11.969	10.0936	10-1509	2.20E-03	± 3%	<9.0E-06	NA
F1-LD-18	180.02	12.002	3.000	12.002	2.993	11.973	10.0670	10-1510	2.84E-03	± 2%	<1.0E-05	NA
F1-LD-19	180.18	12.012	3.003	12.012	2.994	11.978	9.8872	10-1511	3.74E-03	± 2%	<1.0E-05	NA
F1-LD-20	179.63	11.975	2.994	11.975	2.994	11.977	10.0027	10-1512	5.07E-03	± 2%	<1.0E-05	NA

Table C.13. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Sample Vol, mL	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
	mL	BV	mL/min	BV/hr	mL/min	BV/hr						
F1-LD-21	179.41	11.961	2.990	11.961	2.994	11.976	10.1206	10-1513	6.32E-03	± 2%	<2.0E-05	NA
F1-LD-22	179.90	11.994	2.998	11.994	2.994	11.977	10.1946	10-1514	7.93E-03	± 2%	<2.0E-05	NA
F1-LD-23	181.32	12.088	3.022	12.088	2.996	11.986	10.2014	10-1515	9.60E-03	± 2%	<2.0E-05	NA
F1-LD-24	177.94	11.863	2.966	11.863	2.994	11.977	10.0553	10-1516	1.11E-02	± 2%	<2.0E-05	NA
F1-LD-25	179.72	11.981	2.995	11.981	2.994	11.977	10.0946	10-1517	1.42E-02	± 2%	<2.0E-05	NA
F1-LD-26	179.25	11.950	2.988	11.950	2.994	11.976	10.1225	10-1518	1.73E-02	± 2%	<3.0E-05	NA
F1-LD-27	182.11	12.140	3.035	12.140	2.996	11.985	9.9937	10-1519	1.92E-02	± 2%	<3.0E-05	NA
F1-LD-28	176.48	11.765	2.941	11.765	2.993	11.973	10.0072	10-1520	2.28E-02	± 2%	<3.0E-05	NA
F1-FD-CP	114.99	7.67	0.77	3.07	0.77	3.066	11.0632	10-1522	5.24E-03	± 2%	<2.0E-05	NA
F1-FDI-CP	113.08	7.539	0.754	3.015	0.754	3.015	10.4527	10-1523	1.30E-04	± 5%	<6.0E-06	NA
F1-AN-CP	47.46	3.164	0.377	1.507	0.377	1.507	10.5448	10-1524	1.71E-04	± 4%	<8.0E-06	NA

Table C.14. Column F1 Loading Data Table

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated mmol Cs	Elution meq/g
F1-PT-DIW1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F1-PT-ACID	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F1-PT-DIW2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F1-PT-NaOH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F1-LD-0	1.02E-01	2.04E-03	<5.0E-05	0.00E+00	NA	100.0%	1.00E+00	2.83E-02	NA	NA	NA	NA	NA	NA
F1-LD-1	1.29E-05	6.45E-07	6.2E-04	1.24E-05	1.39	0.01%	1.26E-04	6.81E-06	NA	NA	NA	5.01E-04	5.01E-04	7.32E-05
F1-LD-2	4.40E-05	8.79E-07	2.5E-06	3.20E-07	2.84	0.04%	4.31E-04	1.22E-05	NA	NA	NA	5.23E-04	1.02E-03	1.50E-04
F1-LD-3	1.27E-06	2.53E-07	6.3E-07	1.44E-07	4.26	0.00%	1.24E-05	2.49E-06	NA	NA	NA	5.12E-04	1.54E-03	2.24E-04
F1-LD-4	1.56E-06	2.03E-07	7.6E-07	1.97E-07	5.67	0.00%	1.53E-05	2.01E-06	NA	NA	NA	5.05E-04	2.04E-03	2.98E-04
F1-LD-5	6.05E-06	4.84E-07	<5.8E-07	NA	7.15	0.01%	5.93E-05	4.89E-06	NA	NA	NA	5.32E-04	2.57E-03	3.76E-04
F1-LD-6	1.04E-06	3.02E-07	4.8E-07	1.92E-07	8.64	0.00%	1.02E-05	2.97E-06	NA	NA	NA	5.38E-04	3.11E-03	4.55E-04
F1-LD-7	6.27E-06	4.39E-07	<5.7E-07	NA	10.14	0.01%	6.14E-05	4.47E-06	NA	NA	NA	5.39E-04	3.65E-03	5.33E-04
F1-LD-8	1.11E-06	2.79E-07	<5.6E-07	NA	11.65	0.00%	1.09E-05	2.74E-06	NA	NA	NA	5.46E-04	4.19E-03	6.13E-04
F1-LD-9	5.91E-06	4.14E-07	<5.8E-07	NA	18.54	0.01%	5.79E-05	4.22E-06	NA	NA	NA	2.48E-03	6.68E-03	9.76E-04
F1-LD-10	3.92E-06	3.72E-07	<5.8E-07	NA	30.50	0.00%	3.84E-05	3.73E-06	NA	NA	NA	4.31E-03	1.10E-02	1.61E-03
F1-LD-11	1.30E-05	5.20E-07	<6.8E-07	NA	42.47	0.01%	1.27E-04	5.69E-06	NA	NA	NA	4.31E-03	1.53E-02	2.24E-03
F1-LD-12	2.57E-05	7.70E-07	<4.8E-07	NA	54.46	0.03%	2.51E-04	9.06E-06	NA	NA	NA	4.31E-03	1.96E-02	2.87E-03
F1-LD-13	4.61E-05	1.38E-06	<5.7E-07	NA	66.43	0.05%	4.52E-04	1.63E-05	NA	NA	NA	4.31E-03	2.39E-02	3.50E-03
F1-LD-14	7.64E-05	2.29E-06	7.8E-07	3.06E-07	78.38	0.07%	7.49E-04	2.70E-05	NA	NA	NA	4.30E-03	2.82E-02	4.12E-03
F1-LD-15	1.09E-04	3.28E-06	<6.8E-07	NA	90.35	0.11%	1.07E-03	3.86E-05	NA	NA	NA	4.31E-03	3.25E-02	4.75E-03
F1-LD-16	1.66E-04	4.99E-06	<8.9E-07	NA	102.29	0.16%	1.63E-03	5.87E-05	NA	NA	NA	4.29E-03	3.68E-02	5.38E-03
F1-LD-17	2.18E-04	6.55E-06	<8.9E-07	NA	114.29	0.21%	2.14E-03	7.71E-05	NA	NA	NA	4.31E-03	4.11E-02	6.01E-03
F1-LD-18	2.83E-04	5.65E-06	<9.9E-07	NA	126.29	0.28%	2.77E-03	7.83E-05	NA	NA	NA	4.31E-03	4.54E-02	6.64E-03
F1-LD-19	3.78E-04	7.56E-06	<1.0E-06	NA	138.30	0.37%	3.70E-03	1.05E-04	NA	NA	NA	4.31E-03	4.97E-02	7.27E-03
F1-LD-20	5.07E-04	1.01E-05	<1.0E-06	NA	150.28	0.50%	4.96E-03	1.40E-04	NA	NA	NA	4.29E-03	5.40E-02	7.90E-03

Table C.14. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 % C/C ₀	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 % C/C ₀	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution mmol Cs	meq/g
F1-LD-21	6.25E-04	1.25E-05	<2.0E-06	NA	162.24	0.61%	6.12E-03	1.73E-04	NA	NA	NA	4.28E-03	5.83E-02	8.53E-03
F1-LD-22	7.78E-04	1.56E-05	<2.0E-06	NA	174.23	0.76%	7.62E-03	2.15E-04	NA	NA	NA	4.29E-03	6.26E-02	9.15E-03
F1-LD-23	9.41E-04	1.88E-05	<2.0E-06	NA	186.32	0.92%	9.22E-03	2.61E-04	NA	NA	NA	4.32E-03	6.69E-02	9.78E-03
F1-LD-24	1.10E-03	2.21E-05	<2.0E-06	NA	198.18	1.08%	1.08E-02	3.06E-04	NA	NA	NA	4.23E-03	7.11E-02	1.04E-02
F1-LD-25	1.41E-03	2.82E-05	<2.0E-06	NA	210.17	1.38%	1.38E-02	3.90E-04	NA	NA	NA	4.26E-03	7.54E-02	1.10E-02
F1-LD-26	1.71E-03	3.42E-05	<3.0E-06	NA	222.12	1.67%	1.67E-02	4.74E-04	NA	NA	NA	4.24E-03	7.96E-02	1.16E-02
F1-LD-27	1.92E-03	3.85E-05	<3.0E-06	NA	234.26	1.88%	1.88E-02	5.33E-04	NA	NA	NA	4.29E-03	8.39E-02	1.23E-02
F1-LD-28	2.28E-03	4.56E-05	<3.0E-06	NA	246.02	2.23%	2.23E-02	6.31E-04	NA	NA	NA	4.15E-03	8.81E-02	1.29E-02
F1-FD-CP	4.74E-04	9.48E-06	<1.8E-06	NA	257.12	0.46%	4.64E-03	1.31E-04	NA	NA	NA	2.75E-03	9.08E-02	1.33E-02
F1-FDI-CP	1.25E-05	6.23E-07	<5.7E-07	NA	264.66	0.01%	1.22E-04	6.57E-06	NA	NA	NA	2.71E-03	9.35E-02	1.37E-02
F1-AN-CP	1.63E-05	6.50E-07	<7.6E-07	NA	267.82	0.02%	1.59E-04	7.12E-06	NA	NA	NA	1.14E-03	9.47E-02	1.38E-02

Table C.15. Column D1 Elution Data Table

[illegible]

Table C.15. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Dilute	Vial	Aliquot	Diluent	Total	Dilution	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr	Y/N	Tare, g	Net, g	Net, g	Gross, g	Factor	ID No.	uCi Tot	Uncert	uCi Tot	Uncert
D1-EL-0	NA	NA	NA	NA	NA	NA	Y	17.3550	1.0125	9.1380	27.5055	10.0252	10-1073	1.03E+00	± 2%	6.31E-02	± 3%
D1-EL-1	20.20	1.347	0.354	1.418	0.354	1.42	Y	17.5232	1.0000	9.1334	27.6566	10.1334	10-1120	2.60E+00	± 2%	<3.0E-03	NA
D1-EL-2	20.44	1.363	0.341	1.363	0.347	1.39	Y	17.4798	1.0000	9.1216	27.6014	10.1216	10-1121	1.77E+01	± 2%	<1.0E-02	NA
D1-EL-3	20.57	1.371	0.343	1.371	0.346	1.38	Y	17.6049	1.0000	9.1131	27.7180	10.1131	10-1122	7.08E-01	± 2%	<5.0E-04	NA
D1-EL-4	20.35	1.357	0.339	1.357	0.344	1.38	N	17.3300	9.9700	NA	27.3000	1.0000	10-1123	4.09E+00	± 2%	2.12E-02	± 6%
D1-EL-5	20.50	1.367	0.342	1.367	0.344	1.37	N	17.4800	10.2200	NA	27.7000	1.0000	10-1124	3.55E+00	± 2%	2.39E-01	± 3%
D1-EL-6	20.46	1.364	0.341	1.364	0.343	1.37	N	17.4200	10.2800	NA	27.7000	1.0000	10-1125	1.44E+00	± 2%	5.24E-01	± 4%
D1-EL-7	20.20	1.347	0.337	1.347	0.342	1.37	N	17.5800	10.3200	NA	27.9000	1.0000	10-1126	6.30E-01	± 2%	6.06E-01	± 4%
D1-EL-8	20.26	1.351	0.338	1.351	0.342	1.37	N	17.5200	10.0800	NA	27.6000	1.0000	10-1127	3.02E-01	± 2%	6.10E-01	± 4%
D1-EL-10	41.55	2.770	0.346	1.385	0.343	1.37	N	17.6100	10.3900	NA	28.0000	1.0000	10-1128	9.23E-02	± 2%	6.74E-01	± 3%
D1-EL-12	41.82	2.788	0.349	1.394	0.344	1.37	N	17.4400	10.4600	NA	27.9000	1.0000	10-1129	3.35E-02	± 2%	6.97E-01	± 3%
D1-EL-15	62.55	4.170	0.348	1.390	0.344	1.38	N	17.5900	10.5100	NA	28.1000	1.0000	10-1130	9.70E-03	± 2%	6.90E-01	± 3%
D1-EL-18	62.61	4.174	0.348	1.391	0.345	1.38	N	17.3300	10.5700	NA	27.9000	1.0000	10-1131	3.78E-03	± 2%	6.91E-01	± 3%
D1-EL-21	41.80	2.787	0.348	1.393	0.345	1.38	N	17.3600	10.7400	NA	28.1000	1.0000	10-1132	2.21E-03	± 2%	6.97E-01	± 3%
D1-EL-CP	423.93	28.26	0.354	1.417	0.354	1.42	N	17.5000	10.5000	NA	28.0000	1.0000	10-1133	6.34E+00	± 2%	5.05E-01	± 3%
D1-EDI-CP	45.42	3.028	0.349	1.398	0.349	1.40	N	17.5000	10.5000	NA	28.0000	1.0000	10-1134	2.11E-02	± 2%	5.78E-01	± 3%
D1-RG-CP	45.32	3.021	0.349	1.395	0.349	1.39	N	17.3055	10.6945	NA	28.0000	1.0000	10-1135	2.70E-04	± 2%	2.95E-02	± 2%
D1-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1060	5.91E-02	± 2%	2.46E+0	± 3%

Table C.15. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution mmol Cs	meq/g
D1-EL-0	1.03E-01	2.07E-03	6.23E-02	1.87E-03	NA	1.00E+00	2.83E-02	1.00E+00	4.24E-02	NA	NA	NA
D1-EL-1	2.49E+00	4.97E-02	<2.87E-03	NA	1.347	2.40E+01	6.80E-01	4.61E-02	1.38E-03	5.83E-03	5.83E-03	8.52E-04
D1-EL-2	1.82E+01	3.63E-01	<1.03E-02	NA	2.709	1.76E+02	4.97E+00	1.65E-01	4.94E-03	4.90E-02	5.48E-02	8.01E-03
D1-EL-3	7.02E-01	1.40E-02	<4.96E-04	NA	4.081	6.79E+00	1.92E-01	7.96E-03	2.39E-04	4.50E-02	9.98E-02	1.46E-02
D1-EL-4	4.10E-01	8.20E-03	2.12E-03	1.27E-04	5.438	3.97E+00	1.12E-01	3.41E-02	2.29E-03	2.63E-03	1.02E-01	1.50E-02
D1-EL-5	3.47E-01	6.94E-03	2.34E-02	7.01E-04	6.804	3.36E+00	9.50E-02	3.75E-01	1.59E-02	1.80E-03	1.04E-01	1.52E-02
D1-EL-6	1.40E-01	2.80E-03	5.09E-02	2.04E-03	8.168	1.35E+00	3.83E-02	8.18E-01	4.09E-02	1.16E-03	1.05E-01	1.54E-02
D1-EL-7	6.10E-02	1.22E-03	5.87E-02	2.35E-03	9.515	5.90E-01	1.67E-02	9.42E-01	4.71E-02	4.71E-04	1.06E-01	1.55E-02
D1-EL-8	2.99E-02	5.99E-04	6.05E-02	2.42E-03	10.866	2.90E-01	8.19E-03	9.71E-01	4.86E-02	2.14E-04	1.06E-01	1.55E-02
D1-EL-10	8.87E-03	1.77E-04	6.48E-02	1.94E-03	13.636	8.58E-02	2.43E-03	1.04E+00	4.42E-02	1.87E-04	1.06E-01	1.55E-02
D1-EL-12	3.20E-03	6.40E-05	6.66E-02	2.00E-03	16.424	3.09E-02	8.75E-04	1.07E+00	4.54E-02	5.86E-05	1.06E-01	1.55E-02
D1-EL-15	9.22E-04	1.84E-05	6.56E-02	1.97E-03	20.594	8.92E-03	2.52E-04	1.05E+00	4.47E-02	2.99E-05	1.06E-01	1.56E-02
D1-EL-18	3.57E-04	7.15E-06	6.53E-02	1.96E-03	24.768	3.46E-03	9.78E-05	1.05E+00	4.45E-02	9.30E-06	1.06E-01	1.56E-02
D1-EL-21	2.06E-04	4.12E-06	6.48E-02	1.95E-03	27.555	1.99E-03	5.63E-05	1.04E+00	4.42E-02	2.73E-06	1.06E-01	1.56E-02
D1-EL-CP	6.03E-01	1.21E-02	4.81E-02	1.44E-03	28.262	5.84E+00	1.65E-01	7.72E-01	3.27E-02	5.79E-02	1.09E-01	1.59E-02
D1-EDI-CP	2.01E-03	4.02E-05	5.51E-02	1.65E-03	31.290	1.94E-02	5.50E-04	8.84E-01	3.75E-02	1.17E-05	1.09E-01	1.59E-02
D1-RG-CP	2.49E-05	4.99E-07	2.73E-03	5.45E-05	34.312	2.41E-04	6.83E-06	4.38E-02	1.58E-03	1.07E-05	1.09E-01	1.59E-02
D1-Column	NA	NA	NA	NA	NA	1.53E-04	4.33E-06	9.32E-02	3.36E-03	NA	NA	NA

Table C.16. Column D2 Elution Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Start Time	Stop Time	Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
									Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
D2-EL-0	400 mL	25										17.5000	28.000	10.500
Elution (EL) Phase Start Date/Time:				11:45										
D2-EL-1	400 mL	25	95	12:30	13:00	5.9	Org	25.0	32.05	41.0	9.0	17.4663	27.900	10.434
D2-EL-2	400 mL	25	95	13:30	14:00	5.9	Org	25.0	32.05	50.1	9.1	17.7149	29.000	11.285
D2-EL-3	400 mL	25	95	14:30	15:00	5.7	Org	25.0	32.05	61.4	11.3	17.4445	27.800	10.356
D2-EL-4	400 mL	25	95	15:30	16:00	5.7	Org	24.6	32.05	72.3	10.9	17.4542	28.400	10.946
D2-EL-5	400 mL	25	95	16:30	17:00	5.6	Org	24.9	32.05	83.4	11.1	17.4842	28.400	10.916
D2-EL-6	400 mL	25	95	17:30	18:00	5.6	Org	25.0	32.05	94.4	11.0	17.5097	28.300	10.790
D2-EL-7	400 mL	25	95	18:30	19:00	5.6	Org	25.0	32.05	105.4	11.0	17.3785	28.100	10.722
D2-EL-8	400 mL	25	95	19:30	20:00	5.5	Org	25.0	32.05	116.1	10.7	17.3584	28.200	10.842
D2-EL-10	400 mL	25	95	21:30	22:00	5.5	Org	25.0	32.05	148.6	32.5	17.4388	28.100	10.661
D2-EL-12	400 mL	25	95	23:30	0:00	5.5	Org	25.0	32.05	180.7	32.1	17.4238	27.900	10.476
D2-EL-15	400 mL	25	95	2:30	3:00	5.5	Org	24.8	32.05	232.1	51.4	17.3869	28.000	10.613
D2-EL-18	400 mL	25	95	5:30	6:00	5.5	Org	25.0	32.05	283.9	51.8	17.3523	28.000	10.648
D2-EL-21	400 mL	25	95	8:25	8:55	5.5	Org	25.1	32.05	337.6	53.7	17.4866	28.000	10.513
D2-EL-24	400 mL	25	95	12:35	13:05	5.4	Org	24.8	54.67	161.2	85.4	17.5258	28.100	10.574
D2-EL-30	400 mL	25	95	17:00	17:30	5.4	Org	24.6	54.67	243.4	82.2	17.4666	28.100	10.633
D2-EL-CP	400 mL	25	95	11:45	17:30	5.4	Org	25.0	54.67	237.1	473.2	17.5232	28.900	11.377
D2-EDI-CP	100 mL	25	93	17:30	19:36	5.4	Org	24.7	12.79	57.3	44.5	17.3949	28.100	10.705
D2-RG-CP	100 mL	25	93	15:15	19:30	5.4	Mix	24.8	25.00	115.0	90.0	17.8589	28.500	10.641

Table C.16. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Dilute	Vial	Aliquot	Diluent	Total	Dilution	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr	Y/N	Tare, g	Net, g	Net, g	Gross, g	Factor	ID No.	uCi Tot	Uncert	uCi Tot	Uncert
D2-EL-0	NA	NA	NA	NA	NA	NA	Y	17.3148	1.0045	9.1397	27.4590	10.0988	10-1074	1.07E+00	± 2%	6.02E-02	± 3%
D2-EL-1	19.26	1.284	0.257	1.027	0.257	1.03	Y	17.5232	1.0000	9.1334	27.6566	10.1334	10-1200	1.29E+00	± 2%	8.31E-03	± 5%
D2-EL-2	20.37	1.358	0.339	1.358	0.294	1.17	Y	17.4798	1.0000	9.1216	27.6014	10.1216	10-1201	1.20E+01	± 2%	8.34E-02	± 4%
D2-EL-3	21.64	1.442	0.361	1.442	0.314	1.26	Y	17.6049	1.0000	9.1131	27.7180	10.1131	10-1202	1.35E+00	± 2%	9.56E-03	± 5%
D2-EL-4	21.83	1.455	0.364	1.455	0.326	1.30	N	17.4542	10.9458	NA	28.4000	1.0000	10-1203	2.91E+00	± 2%	2.92E-02	± 4%
D2-EL-5	22.00	1.466	0.367	1.466	0.334	1.33	N	17.4842	10.9158	NA	28.4000	1.0000	10-1204	2.33E+00	± 2%	3.32E-02	± 4%
D2-EL-6	21.77	1.451	0.363	1.451	0.338	1.35	N	17.5097	10.7903	NA	28.3000	1.0000	10-1205	2.43E+00	± 2%	4.19E-02	± 4%
D2-EL-7	21.70	1.447	0.362	1.447	0.342	1.37	N	17.3785	10.7215	NA	28.1000	1.0000	10-1206	2.61E+00	± 2%	5.65E-02	± 4%
D2-EL-8	21.52	1.435	0.359	1.435	0.344	1.37	N	17.3584	10.8416	NA	28.2000	1.0000	10-1207	2.69E+00	± 2%	7.74E-02	± 4%
D2-EL-10	43.12	2.875	0.359	1.437	0.347	1.39	N	17.4388	10.6612	NA	28.1000	1.0000	10-1208	3.16E+00	± 2%	1.50E-01	± 4%
D2-EL-12	42.54	2.836	0.354	1.418	0.348	1.39	N	17.4238	10.4762	NA	27.9000	1.0000	10-1209	2.41E+00	± 2%	2.31E-01	± 5%
D2-EL-15	61.96	4.130	0.344	1.377	0.347	1.39	N	17.3869	10.6131	NA	28.0000	1.0000	10-1210	2.29E+00	± 2%	3.72E-01	± 5%
D2-EL-18	62.39	4.159	0.347	1.386	0.347	1.39	N	17.3523	10.6477	NA	28.0000	1.0000	10-1211	6.60E-01	± 2%	4.96E-01	± 5%
D2-EL-21	64.15	4.277	0.367	1.466	0.350	1.40	N	17.4866	10.5134	NA	28.0000	1.0000	10-1212	1.90E-01	± 2%	6.47E-01	± 3%
D2-EL-24	95.93	6.395	0.384	1.535	0.355	1.42	N	17.5258	10.5742	NA	28.1000	1.0000	10-1213	1.41E-01	± 2%	6.03E-01	± 3%
D2-EL-30	92.75	6.183	0.350	1.400	0.355	1.42	N	17.4666	10.6334	NA	28.1000	1.0000	10-1214	8.33E-02	± 2%	6.05E-01	± 3%
D2-EL-CP	632.91	42.194	0.355	1.418	0.355	1.42	N	17.5232	11.3768	NA	28.9000	1.0000	10-1215	5.22E+00	± 2%	4.69E-01	± 3%
D2-EDI-CP	44.52	2.968	0.353	1.413	0.353	1.41	N	17.3949	10.7051	NA	28.1000	1.0000	10-1216	9.84E-02	± 2%	6.28E-01	± 3%
D2-RG-CP	88.98	5.932	0.349	1.396	0.349	1.40	N	17.8589	10.6411	NA	28.5000	1.0000	10-1217	2.33E-03	± 2%	1.11E-01	± 3%
D2-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1062	1.85E+00	± 2%	9.66E+00	± 3%

Table C.16. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution mmol Cs	meq/g
D2-EL-0	1.02E-01	2.04E-03	5.78E-02	1.74E-03	NA	1.00E+00	2.83E-02	1.00E+00	4.24E-02	NA	NA	NA
D2-EL-1	1.25E+00	2.50E-02	8.06E-03	4.03E-04	1.284	1.23E+01	3.47E-01	1.39E-01	8.13E-03	2.84E-03	2.84E-03	4.15E-04
D2-EL-2	1.08E+01	2.15E-01	7.47E-02	2.99E-03	2.642	1.06E+02	2.99E+00	1.29E+00	6.46E-02	2.88E-02	3.16E-02	4.63E-03
D2-EL-3	1.32E+00	2.63E-02	9.33E-03	4.66E-04	4.084	1.29E+01	3.66E-01	1.61E-01	9.40E-03	3.08E-02	6.24E-02	9.12E-03
D2-EL-4	2.66E-01	5.31E-03	2.67E-03	1.07E-04	5.539	2.61E+00	7.37E-02	4.61E-02	2.30E-03	4.07E-03	6.65E-02	9.72E-03
D2-EL-5	2.13E-01	4.27E-03	3.04E-03	1.22E-04	7.005	2.09E+00	5.92E-02	5.25E-02	2.63E-03	1.24E-03	6.77E-02	9.90E-03
D2-EL-6	2.25E-01	4.50E-03	3.88E-03	1.55E-04	8.457	2.21E+00	6.25E-02	6.71E-02	3.35E-03	1.12E-03	6.88E-02	1.01E-02
D2-EL-7	2.43E-01	4.86E-03	5.26E-03	2.11E-04	9.904	2.39E+00	6.75E-02	9.10E-02	4.55E-03	1.20E-03	7.00E-02	1.02E-02
D2-EL-8	2.48E-01	4.96E-03	7.13E-03	2.85E-04	11.338	2.43E+00	6.88E-02	1.23E-01	6.17E-03	1.24E-03	7.13E-02	1.04E-02
D2-EL-10	2.96E-01	5.92E-03	1.41E-02	5.62E-04	14.213	2.91E+00	8.22E-02	2.43E-01	1.22E-02	2.76E-03	7.40E-02	1.08E-02
D2-EL-12	2.30E-01	4.60E-03	2.20E-02	1.10E-03	17.049	2.26E+00	6.38E-02	3.81E-01	2.22E-02	2.64E-03	7.67E-02	1.12E-02
D2-EL-15	2.16E-01	4.31E-03	3.50E-02	1.75E-03	21.179	2.12E+00	5.98E-02	6.05E-01	3.53E-02	3.25E-03	7.99E-02	1.17E-02
D2-EL-18	6.19E-02	1.24E-03	4.65E-02	2.33E-03	25.339	6.08E-01	1.72E-02	8.05E-01	4.69E-02	2.04E-03	8.20E-02	1.20E-02
D2-EL-21	1.81E-02	3.61E-04	6.15E-02	1.84E-03	29.615	1.77E-01	5.01E-03	1.06E+00	4.51E-02	6.04E-04	8.26E-02	1.21E-02
D2-EL-24	1.33E-02	2.66E-04	5.70E-02	1.71E-03	36.011	1.31E-01	3.70E-03	9.85E-01	4.18E-02	3.55E-04	8.29E-02	1.21E-02
D2-EL-30	7.83E-03	1.57E-04	5.68E-02	1.71E-03	42.194	7.68E-02	2.17E-03	9.83E-01	4.17E-02	2.31E-04	8.31E-02	1.22E-02
D2-EL-CP	4.58E-01	9.17E-03	4.12E-02	1.24E-03	42.194	4.50E+00	1.27E-01	7.12E-01	3.02E-02	6.84E-02	1.28E-01	1.87E-02
D2-EDI-CP	9.19E-03	1.84E-04	5.87E-02	1.76E-03	45.162	9.02E-02	2.55E-03	1.01E+00	4.30E-02	8.93E-05	1.28E-01	1.88E-02
D2-RG-CP	2.16E-04	4.33E-06	1.03E-02	3.09E-04	51.094	2.12E-03	6.01E-05	1.78E-01	7.56E-03	9.86E-05	1.28E-01	1.88E-02
D2-Column	NA	NA	NA	NA	NA	4.88E-03	1.38E-04	2.64E-01	9.51E-03	NA	NA	NA

C.5.5

[illegible]

Table C.17. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Dilute	Vial	Aliquot	Diluent	Total	Dilution	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr	Y/N	Tare, g	Net, g	Net, g	Gross, g	Factor	ID No.	uCi Tot	Uncert	uCi Tot	Uncert
D3-EL-0	NA	NA	NA	NA	NA	NA	Y	17.3980	0.9379	9.1334	27.4693	10.7381	10-1075	1.10E+00	± 2%	5.89E-02	± 3%
D3-EL-1	20.50	1.366	0.360	1.438	0.360	1.44	Y	17.0547	1.0000	9.1266	27.1813	10.1266	10-1265	4.85E+00	± 2%	1.13E-01	± 4%
D3-EL-2	21.07	1.405	0.351	1.405	0.355	1.42	Y	17.0270	1.0000	9.1422	27.1692	10.1422	10-1266	1.40E+01	± 2%	3.91E-01	± 3%
D3-EL-3	21.20	1.414	0.353	1.414	0.355	1.42	Y	16.9570	1.0000	9.1474	27.1044	10.1474	10-1267	1.71E+00	± 2%	5.74E-02	± 4%
D3-EL-4	20.83	1.389	0.347	1.389	0.353	1.41	Y	17.0212	1.0000	9.1450	27.1662	10.1450	10-1268	3.16E-02	± 3%	2.96E-02	± 2%
D3-EL-5	21.06	1.404	0.351	1.404	0.352	1.41	N	17.5640	10.6360	NA	28.2000	1.0000	10-1269	9.20E-02	± 2%	6.19E-01	± 4%
D3-EL-6	21.12	1.408	0.352	1.408	0.352	1.41	N	17.4025	10.5975	NA	28.0000	1.0000	10-1270	6.75E-02	± 2%	6.67E-01	± 4%
D3-EL-7	21.14	1.409	0.352	1.409	0.352	1.41	N	17.6828	10.6172	NA	28.3000	1.0000	10-1271	3.73E-02	± 2%	6.70E-01	± 4%
D3-EL-8	21.19	1.413	0.353	1.413	0.352	1.41	N	17.3294	10.6706	NA	28.0000	1.0000	10-1272	1.96E-02	± 2%	6.39E-01	± 4%
D3-EL-10	42.06	2.804	0.351	1.402	0.352	1.41	N	17.4770	10.1230	NA	27.6000	1.0000	10-1273	6.74E-03	± 2%	6.06E-01	± 4%
D3-EL-12	42.05	2.803	0.350	1.402	0.352	1.41	N	17.3940	10.7060	NA	28.1000	1.0000	10-1274	3.08E-03	± 3%	6.66E-01	± 4%
D3-EL-15	65.00	4.333	0.361	1.444	0.354	1.41	N	17.4471	11.2529	NA	28.7000	1.0000	10-1275	1.33E-03	± 4%	6.39E-01	± 3%
D3-EL-18	61.26	4.084	0.340	1.361	0.351	1.41	N	17.4189	11.2811	NA	28.7000	1.0000	10-1276	5.54E-03	± 2%	6.85E-01	± 3%
D3-EL-21	59.80	3.986	0.332	1.329	0.349	1.39	N	17.3916	10.8084	NA	28.2000	1.0000	10-1277	1.33E-03	± 3%	6.21E-01	± 3%
D3-EL-CP	450.55	30.036	0.358	1.434	0.358	1.43	N	17.3775	10.5225	NA	27.9000	1.0000	10-1278	6.23E+00	± 2%	7.12E-01	± 3%
D3-EDI-CP	45.61	3.041	0.351	1.403	0.351	1.40	N	17.1310	10.3690	NA	27.5000	1.0000	10-1279	1.19E-03	± 4%	4.83E-01	± 3%
D3-RG-CP	45.50	3.033	0.350	1.400	0.350	1.40	N	17.3626	11.1374	NA	28.5000	1.0000	10-1280	2.81E-03	± 2%	2.16E-02	± 4%
D3-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1064	2.19E-02	± 2%	1.00E+00	± 3%

Table C.17. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution mmol Cs	Elution meq/g
D3-EL-0	1.02E-01	2.04E-03	6.27E-02	1.88E-03	NA	1.00E+00	2.83E-02	100%	4.24E-02	NA	NA	NA
D3-EL-1	4.90E+00	9.80E-02	1.14E-01	4.57E-03	1.366	4.80E+01	1.36E+00	1.82E+00	9.10E-02	1.18E-02	1.18E-02	1.73E-03
D3-EL-2	1.33E+01	2.67E-01	3.73E-01	1.12E-02	2.771	1.31E+02	3.70E+00	5.94E+00	2.52E-01	4.52E-02	5.70E-02	8.33E-03
D3-EL-3	1.63E+00	3.25E-02	5.46E-02	2.18E-03	4.185	1.59E+01	4.51E-01	8.70E-01	4.35E-02	3.73E-02	9.43E-02	1.38E-02
D3-EL-4	2.99E-02	8.98E-04	2.81E-02	5.61E-04	5.574	2.93E-01	1.06E-02	4.48E-01	1.61E-02	4.06E-03	9.83E-02	1.44E-02
D3-EL-5	8.57E-03	1.71E-04	5.77E-02	2.31E-03	6.977	8.40E-02	2.37E-03	9.20E-01	4.60E-02	9.53E-05	9.84E-02	1.44E-02
D3-EL-6	6.32E-03	1.26E-04	6.24E-02	2.50E-03	8.385	6.19E-02	1.75E-03	9.95E-01	4.98E-02	3.69E-05	9.85E-02	1.44E-02
D3-EL-7	3.48E-03	6.97E-05	6.26E-02	2.50E-03	9.794	3.41E-02	9.65E-04	9.98E-01	4.99E-02	2.43E-05	9.85E-02	1.44E-02
D3-EL-8	1.82E-03	3.64E-05	5.94E-02	2.38E-03	11.207	1.78E-02	5.05E-04	9.47E-01	4.73E-02	1.32E-05	9.85E-02	1.44E-02
D3-EL-10	6.60E-04	1.32E-05	5.94E-02	2.37E-03	14.011	6.47E-03	1.83E-04	9.46E-01	4.73E-02	1.23E-05	9.85E-02	1.44E-02
D3-EL-12	2.85E-04	8.56E-06	6.17E-02	2.47E-03	16.814	2.79E-03	1.01E-04	9.84E-01	4.92E-02	4.67E-06	9.85E-02	1.44E-02
D3-EL-15	1.17E-04	4.69E-06	5.63E-02	1.69E-03	21.147	1.15E-03	5.13E-05	8.98E-01	3.81E-02	3.07E-06	9.85E-02	1.44E-02
D3-EL-18	4.87E-04	9.74E-06	6.02E-02	1.81E-03	25.231	4.77E-03	1.35E-04	9.60E-01	4.07E-02	4.35E-06	9.85E-02	1.44E-02
D3-EL-21	1.22E-04	3.66E-06	5.70E-02	1.71E-03	29.218	1.19E-03	4.31E-05	9.08E-01	3.85E-02	4.28E-06	9.85E-02	1.44E-02
D3-EL-CP	5.87E-01	1.17E-02	6.71E-02	2.01E-03	30.036	5.75E+00	1.63E-01	1.07E+00	4.54E-02	6.07E-02	1.14E-01	1.66E-02
D3-EDI-CP	1.14E-04	4.57E-06	4.64E-02	1.39E-03	33.077	1.12E-03	5.01E-05	7.40E-01	3.14E-02	1.27E-06	1.14E-01	1.66E-02
D3-RG-CP	2.49E-04	4.99E-06	1.92E-03	7.67E-05	36.110	2.44E-03	6.91E-05	3.06E-02	1.53E-03	1.95E-06	1.14E-01	1.66E-02
D3-Column	NA	NA	NA	NA	NA	5.73E-05	1.62E-06	3.54E-02	1.28E-03	NA	NA	NA

Table C.18. Column D3 Elution Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Start Time	Stop Time	Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
									Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
D4-EL-0	400 mL	25										17.3550	27.506	10.151
Elution (EL) Phase Start Date/Time:				05:00										
D4-EL-1	400 mL	25	94	05:30	06:00	6.1	Mix	25.0	31.92	42.3	10.4	17.3819	28.400	11.018
D4-EL-2	400 mL	25	94	6:30	7:00	5.8	Mix	25.0	31.92	53.0	10.7	17.5378	28.000	10.462
D4-EL-3	400 mL	25	94	7:30	8:00	5.6	Mix	25.0	31.92	65.4	12.4	17.4639	28.000	10.536
D4-EL-4	400 mL	25	94	8:30	9:00	5.6	Mix	25.0	31.92	73.5	8.1	17.3485	27.700	10.352
D4-EL-5	400 mL	25	94	9:30	10:00	5.6	Org	25.0	31.92	83.8	10.3	17.4744	27.900	10.426
D4-EL-6	400 mL	25	95	10:30	11:00	5.6	Org	25.0	31.92	94.3	10.5	17.4627	28.200	10.737
D4-EL-7	400 mL	25	95	11:30	12:00	5.6	Org	25.0	31.92	104.3	10.0	17.4908	27.700	10.209
D4-EL-8	400 mL	25	95	12:30	13:00	5.6	Org	25.0	31.92	114.9	10.6	17.4436	27.900	10.456
D4-EL-10	400 mL	25	95	14:30	15:00	5.6	Org	25.0	31.92	146.2	31.3	17.3543	27.700	10.346
D4-EL-12	400 mL	25	95	16:30	17:00	5.6	Org	25.0	31.92	177.3	31.1	17.3613	27.800	10.439
D4-EL-15	400 mL	25	95	19:30	20:00	5.6	Org	25.0	31.92	228.9	51.6	17.5016	27.900	10.398
D4-EL-18	400 mL	25	95	22:30	23:00	5.6	Org	25.0	32.00	84.0	52.0	17.4148	27.700	10.285
D4-EL-21	400 mL	25	95	1:30	2:00	5.5	Org	25.0	32.00	136.0	52.0	17.3010	28.200	10.899
D4-EL-CP	400 mL	25	95	5:00	2:00	5.6	Org	25.0	32.00	136.0	301.0	17.4165	28.000	10.584
D4-EDI-CP	100 mL	25	95	8:15	11:00	5.5	Org	25.0	12.50	70.0	57.5	17.4577	28.000	10.542
D4-RG-CP	100 mL	25	95	14:50	20:16	7.0	Blk	25.0	25.00	140.0	115.0	17.3769	28.000	10.623

Table C.18. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Dilute	Vial	Aliquot	Diluent	Total	Dilution	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr	Y/N	Tare, g	Net, g	Net, g	Gross, g	Factor	ID No.	uCi Tot	Uncert	uCi Tot	Uncert
D4-EL-0	NA	NA	NA	NA	NA	NA	Y	17.3835	0.9769	9.1067	27.4671	10.3220	10-1076	1.04E+00	± 2%	6.11E-02	± 3%
D4-EL-1	21.26	1.417	0.354	1.417	0.354	1.42	Y	16.9617	1.0000	9.1214	27.0831	10.1214	10-1325	2.86E-04	± 3%	9.69E-06	± 34%
D4-EL-2	21.14	1.410	0.352	1.410	0.353	1.41	Y	16.9703	1.0000	9.1462	27.1165	10.1462	10-1326	1.35E+01	± 2%	3.74E-02	± 6%
D4-EL-3	22.91	1.528	0.382	1.528	0.363	1.45	Y	16.9804	1.0000	9.1451	27.1255	10.1451	10-1327	3.61E+00	± 2%	1.30E-02	± 9%
D4-EL-4	18.43	1.229	0.307	1.229	0.349	1.40	Y	17.0111	1.0000	9.1639	27.1750	10.1639	10-1328	7.35E-01	± 2%	1.03E-02	± 4%
D4-EL-5	20.71	1.380	0.345	1.380	0.348	1.39	N	17.4744	10.4256	NA	27.9000	1.0000	10-1330	2.02E+00	± 2%	4.35E-01	± 5%
D4-EL-6	21.22	1.415	0.354	1.415	0.349	1.40	N	17.4627	10.7373	NA	28.2000	1.0000	10-1331	3.65E-01	± 2%	6.09E-01	± 3%
D4-EL-7	20.19	1.346	0.337	1.346	0.347	1.39	N	17.4908	10.2092	NA	27.7000	1.0000	10-1332	8.22E-02	± 2%	6.18E-01	± 3%
D4-EL-8	21.04	1.402	0.351	1.402	0.348	1.39	N	17.4436	10.4564	NA	27.9000	1.0000	10-1333	4.21E-02	± 2%	6.25E-01	± 3%
D4-EL-10	41.61	2.774	0.347	1.387	0.348	1.39	N	17.3543	10.3457	NA	27.7000	1.0000	10-1334	2.36E-02	± 2%	6.55E-01	± 3%
D4-EL-12	41.50	2.767	0.346	1.383	0.347	1.39	N	17.3613	10.4387	NA	27.8000	1.0000	10-1335	7.82E-03	± 2%	6.07E-01	± 3%
D4-EL-15	61.94	4.129	0.344	1.376	0.347	1.39	N	17.5016	10.3984	NA	27.9000	1.0000	10-1336	2.17E-03	± 3%	5.94E-01	± 3%
D4-EL-18	62.23	4.148	0.346	1.383	0.346	1.39	N	17.4148	10.2852	NA	27.7000	1.0000	10-1337	1.03E-03	± 4%	6.08E-01	± 3%
D4-EL-21	62.84	4.189	0.349	1.396	0.347	1.39	N	17.3010	10.8990	NA	28.2000	1.0000	10-1338	6.82E-04	± 4%	6.29E-01	± 3%
D4-EL-CP	447.71	29.847	0.355	1.421	0.355	1.42	N	17.4165	10.5835	NA	28.0000	1.0000	10-1339	7.05E+00	± 2%	5.53E-01	± 3%
D4-EDI-CP	57.52	3.835	0.349	1.394	0.349	1.39	N	17.4577	10.5423	NA	28.0000	1.0000	10-1340	2.21E-03	± 3%	4.38E-01	± 3%
D4-RG-CP	113.70	7.580	0.349	1.395	0.349	1.40	N	17.3769	10.6231	NA	28.0000	1.0000	10-1341	2.03E-03	± 3%	1.05E-01	± 3%
D4-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1066	2.84E-02	± 2%	2.16E+00	± 3%

Table C.18. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution	
											mmol Cs	meq/g
D4-EL-0	1.02E-01	2.05E-03	6.21E-02	1.86E-03	NA	1.00E+00	2.83E-02	100%	4.24E-02	NA	NA	NA
D4-EL-1	2.63E-04	7.88E-06	8.90E-06	3.02E-06	1.417	2.57E-03	9.25E-05	1.43E-04	4.89E-05	6.55E-07	6.55E-07	9.57E-08
D4-EL-2	1.31E+01	2.62E-01	3.63E-02	2.18E-03	2.827	1.28E+02	3.62E+00	5.84E-01	3.92E-02	3.25E-02	3.25E-02	4.75E-03
D4-EL-3	3.47E+00	6.95E-02	1.25E-02	1.13E-03	4.355	3.39E+01	9.60E-01	2.01E-01	1.91E-02	4.45E-02	7.70E-02	1.13E-02
D4-EL-4	7.21E-01	1.44E-02	1.01E-02	4.04E-04	5.584	7.04E+00	1.99E-01	1.63E-01	8.14E-03	9.07E-03	8.61E-02	1.26E-02
D4-EL-5	1.94E-01	3.87E-03	4.17E-02	2.08E-03	6.964	1.89E+00	5.35E-02	6.72E-01	3.92E-02	2.22E-03	8.83E-02	1.29E-02
D4-EL-6	3.40E-02	6.79E-04	5.67E-02	1.70E-03	8.378	3.32E-01	9.39E-03	9.13E-01	3.87E-02	5.66E-04	8.89E-02	1.30E-02
D4-EL-7	8.04E-03	1.61E-04	6.05E-02	1.81E-03	9.724	7.86E-02	2.22E-03	9.74E-01	4.13E-02	9.95E-05	8.90E-02	1.30E-02
D4-EL-8	4.02E-03	8.05E-05	5.97E-02	1.79E-03	11.127	3.93E-02	1.11E-03	9.62E-01	4.08E-02	2.98E-05	8.90E-02	1.30E-02
D4-EL-10	2.28E-03	4.56E-05	6.33E-02	1.90E-03	13.901	2.23E-02	6.30E-04	1.02E+00	4.32E-02	3.08E-05	8.90E-02	1.30E-02
D4-EL-12	7.48E-04	1.50E-05	5.81E-02	1.74E-03	16.667	7.32E-03	2.07E-04	9.36E-01	3.97E-02	1.47E-05	8.91E-02	1.30E-02
D4-EL-15	2.09E-04	6.26E-06	5.71E-02	1.71E-03	20.797	2.04E-03	7.36E-05	9.19E-01	3.90E-02	6.95E-06	8.91E-02	1.30E-02
D4-EL-18	1.00E-04	4.01E-06	5.91E-02	1.77E-03	24.945	9.80E-04	4.38E-05	9.52E-01	4.04E-02	2.26E-06	8.91E-02	1.30E-02
D4-EL-21	6.25E-05	2.50E-06	5.76E-02	1.73E-03	29.135	6.11E-04	2.73E-05	9.28E-01	3.94E-02	1.20E-06	8.91E-02	1.30E-02
D4-EL-CP	6.66E-01	1.33E-02	5.22E-02	1.57E-03	29.847	6.51E+00	1.84E-01	8.41E-01	3.57E-02	6.83E-02	1.28E-01	1.87E-02
D4-EDI-CP	2.10E-04	6.29E-06	4.16E-02	1.25E-03	33.682	2.05E-03	7.38E-05	6.69E-01	2.84E-02	1.84E-06	1.28E-01	1.87E-02
D4-RG-CP	1.89E-04	5.68E-06	9.79E-03	2.94E-04	41.262	1.85E-03	6.67E-05	1.58E-01	6.69E-03	5.32E-06	1.28E-01	1.87E-02
D4-Column	NA	NA	NA	NA	NA	7.42E-05	2.10E-06	7.77E-02	2.80E-03	NA	NA	NA

Table C.19. Column D5 Elution Data Table

[illegible]

Table C.19. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Dilute Y/N	Vial	Aliquot	Diluent	Total	Dilution Factor	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr		Tare, g	Net, g	Net, g	Gross, g		ID No.	uCi Tot	Uncert	uCi Tot	Uncert
D5-EL-0	NA	NA	NA	NA	NA	NA	Y	17.5630	0.9977	9.1381	27.6988	10.1592	10-1077	1.03E+00	± 2%	6.39E-02	± 3%
D5-EL-1	20.45	1.363	0.353	1.410	0.353	1.41	Y	16.9617	1.0000	9.1214	27.0831	10.1214	10-1386	2.16E-02	± 2%	8.09E-05	± 15%
D5-EL-2	21.49	1.433	0.358	1.433	0.355	1.42	Y	16.9703	1.0000	9.1462	27.1165	10.1462	10-1387	1.09E+01	± 2%	3.75E-02	± 6%
D5-EL-3	21.63	1.442	0.361	1.442	0.357	1.43	Y	16.9804	1.0000	9.1451	27.1255	10.1451	10-1388	4.11E+00	± 2%	2.06E-02	± 6%
D5-EL-4	21.35	1.423	0.356	1.423	0.357	1.43	Y	17.0111	1.0000	9.1639	27.1750	10.1639	10-1389	1.48E+00	± 2%	1.54E-02	± 5%
D5-EL-5	21.20	1.413	0.353	1.413	0.356	1.42	N	17.4830	9.9170	NA	27.4000	1.0000	10-1390	4.60E+00	± 2%	3.89E-01	± 3%
D5-EL-6	21.13	1.408	0.352	1.408	0.355	1.42	N	17.6548	9.9452	NA	27.6000	1.0000	10-1391	7.47E-01	± 2%	5.63E-01	± 4%
D5-EL-7	21.39	1.426	0.357	1.426	0.356	1.42	N	17.5881	9.9119	NA	27.5000	1.0000	10-1392	3.58E-01	± 2%	6.51E-01	± 4%
D5-EL-8	22.00	1.466	0.367	1.466	0.357	1.43	N	17.3822	10.5178	NA	27.9000	1.0000	10-1393	2.12E-01	± 2%	6.92E-01	± 4%
D5-EL-10	42.07	2.805	0.351	1.402	0.356	1.42	N	17.3927	9.9073	NA	27.3000	1.0000	10-1394	7.18E-02	± 2%	6.67E-01	± 4%
D5-EL-12	42.77	2.851	0.356	1.426	0.356	1.42	N	17.3890	10.2110	NA	27.6000	1.0000	10-1395	1.94E-02	± 2%	6.53E-01	± 4%
D5-EL-15	63.59	4.239	0.353	1.413	0.355	1.42	N	17.4496	9.8504	NA	27.3000	1.0000	10-1396	3.66E-03	± 2%	6.04E-01	± 3%
D5-EL-18	63.77	4.251	0.354	1.417	0.355	1.42	N	17.2753	9.9247	NA	27.2000	1.0000	10-1397	1.31E-03	± 4%	6.00E-01	± 3%
D5-EL-21	53.54	3.569	0.357	1.428	0.355	1.42	N	17.3129	9.9871	NA	27.3000	1.0000	10-1398	6.26E-04	± 5%	5.57E-01	± 3%
D5-EL-CP	446.52	29.768	0.364	1.454	0.364	1.45	N	17.4500	10.0500	NA	27.5000	1.0000	10-1399	7.34E+00	± 2%	5.33E-01	± 3%
D5-EDI-CP	48.87	3.258	0.376	1.504	0.376	1.50	N	17.4238	10.0762	NA	27.5000	1.0000	10-1400	8.44E-03	± 2%	5.14E-01	± 3%
D5-RG-CP	87.86	5.857	0.351	1.406	0.351	1.41	N	17.4348	10.0652	NA	27.5000	1.0000	10-1401	2.24E-03	± 2%	1.56E-02	± 2%
D5-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1068	2.85E-02	± 2%	1.71E+00	± 3%

Table C.19. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution mmol Cs	Elution meq/g
D5-EL-0	1.04E-01	2.07E-03	6.39E-02	1.92E-03	NA	1.00E+00	2.83E-02	100%	4.24E-02	NA	NA	NA
D5-EL-1	2.16E-02	4.33E-04	8.11E-05	1.22E-05	1.363	2.09E-01	5.91E-03	1.27E-03	1.94E-04	5.12E-05	5.12E-05	7.49E-06
D5-EL-2	1.10E+01	2.21E-01	3.80E-02	2.28E-03	2.796	1.07E+02	3.01E+00	5.94E-01	3.99E-02	2.75E-02	2.76E-02	4.03E-03
D5-EL-3	4.23E+00	8.46E-02	2.12E-02	1.27E-03	4.238	4.08E+01	1.16E+00	3.32E-01	2.22E-02	3.83E-02	6.59E-02	9.63E-03
D5-EL-4	1.51E+00	3.01E-02	1.57E-02	7.84E-04	5.662	1.46E+01	4.12E-01	2.45E-01	1.43E-02	1.42E-02	8.01E-02	1.17E-02
D5-EL-5	4.64E-01	9.27E-03	3.92E-02	1.18E-03	7.075	4.47E+00	1.27E-01	6.14E-01	2.60E-02	4.84E-03	8.49E-02	1.24E-02
D5-EL-6	7.50E-02	1.50E-03	5.66E-02	2.26E-03	8.483	7.24E-01	2.05E-02	8.85E-01	4.43E-02	1.32E-03	8.62E-02	1.26E-02
D5-EL-7	3.61E-02	7.23E-04	6.56E-02	2.62E-03	9.909	3.49E-01	9.86E-03	1.03E+00	5.13E-02	2.75E-04	8.65E-02	1.26E-02
D5-EL-8	2.02E-02	4.04E-04	6.58E-02	2.63E-03	11.376	1.95E-01	5.51E-03	1.03E+00	5.15E-02	1.43E-04	8.66E-02	1.27E-02
D5-EL-10	7.24E-03	1.45E-04	6.73E-02	2.69E-03	14.180	6.99E-02	1.98E-03	1.05E+00	5.27E-02	1.34E-04	8.68E-02	1.27E-02
D5-EL-12	1.90E-03	3.80E-05	6.39E-02	2.55E-03	17.032	1.84E-02	5.19E-04	1.00E+00	5.00E-02	4.53E-05	8.68E-02	1.27E-02
D5-EL-15	3.71E-04	7.43E-06	6.12E-02	1.84E-03	21.271	3.58E-03	1.01E-04	9.58E-01	4.06E-02	1.67E-05	8.68E-02	1.27E-02
D5-EL-18	1.31E-04	5.25E-06	6.04E-02	1.81E-03	25.522	1.27E-03	5.67E-05	9.45E-01	4.01E-02	3.71E-06	8.68E-02	1.27E-02
D5-EL-21	6.26E-05	3.13E-06	5.57E-02	1.67E-03	29.091	6.04E-04	3.26E-05	8.71E-01	3.70E-02	1.20E-06	8.68E-02	1.27E-02
D5-EL-CP	7.30E-01	1.46E-02	5.30E-02	1.59E-03	29.768	7.05E+00	1.99E-01	8.30E-01	3.52E-02	7.38E-02	1.38E-01	2.02E-02
D5-EDI-CP	8.38E-04	1.68E-05	5.10E-02	1.53E-03	33.026	8.09E-03	2.29E-04	7.98E-01	3.39E-02	5.10E-06	1.38E-01	2.02E-02
D5-RG-CP	2.20E-04	4.39E-06	1.53E-03	3.07E-05	38.883	2.12E-03	6.00E-05	2.40E-02	8.66E-04	1.08E-05	1.38E-01	2.02E-02
D5-Column	NA	NA	NA	NA	NA	7.35E-05	2.08E-06	6.00E-02	2.16E-03	NA	NA	NA

Table C.20. Column D5 Elution Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Start Time	Stop Time	Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
									Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
D6-EL-0	400 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	17.3550	27.506	10.151
Elution (EL) Phase Start Date/Time:				09:30										
D6-EL-1	400 mL	25	95	10:00	10:29	6.1	Mix	25.0	55.20	66.2	11.0	17.6267	28.100	10.473
D6-EL-2	400 mL	25	95	11:00	11:29	5.8	Mix	25.0	55.20	77.5	11.3	17.8032	28.400	10.597
D6-EL-3	400 mL	25	94	12:00	12:29	5.6	Mix	25.0	55.20	88.6	11.1	17.5181	27.800	10.282
D6-EL-4	400 mL	25	94	13:00	13:29	5.6	Org	25.0	55.20	99.6	11.0	17.3330	27.500	10.167
D6-EL-5	400 mL	25	94	14:00	14:29	5.6	Org	25.0	55.20	110.6	11.0	17.4190	27.600	10.181
D6-EL-6	400 mL	25	94	15:00	15:29	5.6	Org	25.0	55.20	121.6	11.0	17.7410	27.900	10.159
D6-EL-7	400 mL	25	94	16:00	16:29	5.6	Org	25.0	55.20	132.8	11.2	17.4453	27.700	10.255
D6-EL-8	400 mL	25	94	17:00	17:29	5.6	Org	25.0	55.20	143.5	10.7	17.4859	27.700	10.214
D6-EL-10	400 mL	25	94	19:00	19:29	5.6	Org	24.4	55.20	176.1	32.6	17.4710	27.500	10.029
D6-EL-12	400 mL	25	94	21:00	21:29	5.6	Org	24.2	55.20	207.9	31.8	17.5783	27.700	10.122
D6-EL-15	400 mL	25	94	0:00	0:29	5.6	Org	23.6	55.20	260.1	52.2	17.4379	28.000	10.562
D6-EL-18	400 mL	25	94	3:00	3:29	5.6	Org	25.0	55.20	315.8	55.7	17.4282	27.900	10.472
D6-EL-21	400 mL	25	94	5:25	5:54	5.5	Org	25.0	55.20	352.1	36.3	17.4622	28.400	10.938
D6-EL-CP	400 mL	25	94	9:30	5:54	5.5	Org	25.0	55.20	352.1	296.9	17.3487	27.500	10.151
D6-EDI-CP	100 mL	25	94	6:00	8:06	5.5	Org	25.0	12.73	56.7	44.0	17.6405	27.700	10.060
D6-RG-CP	100 mL	25	94	16:00	20:12	7.1	Blk	25.0	24.99	112.0	87.0	17.4152	27.500	10.085

Table C.20. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Dilute	Vial	Aliquot	Diluent	Total	Dilution	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr	Y/N	Tare, g	Net, g	Net, g	Gross, g	Factor	ID No.	uCi Tot	Uncert	uCi Tot	Uncert
D6-EL-0	NA	NA	NA	NA	NA	NA	Y	17.7255	0.9731	9.1183	27.8169	10.3704	10-1078	9.83E-01	± 2%	6.12E-02	± 3%
D6-EL-1	21.34	1.422	0.362	1.446	0.362	1.45	Y	17.7846	1.0000	9.1521	27.9367	10.1521	10-1446	6.92E-04	± 2%	1.85E-05	± 18%
D6-EL-2	21.88	1.458	0.365	1.458	0.363	1.45	Y	17.5840	1.0000	9.1428	27.7268	10.1428	10-1447	8.69E+00	± 2%	3.95E-02	± 5%
D6-EL-3	21.36	1.424	0.356	1.424	0.361	1.44	Y	17.4597	1.0000	9.3276	27.7873	10.3276	10-1448	4.46E+00	± 2%	2.62E-02	± 6%
D6-EL-4	21.15	1.410	0.352	1.410	0.359	1.43	Y	17.5757	1.0000	9.1384	27.7141	10.1384	10-1449	1.89E+00	± 2%	2.30E-02	± 4%
D6-EL-5	21.16	1.411	0.353	1.411	0.357	1.43	N	17.4190	10.1810	NA	27.6000	1.0000	10-1450	2.34E+00	± 2%	5.17E-01	± 4%
D6-EL-6	21.14	1.409	0.352	1.409	0.357	1.43	N	17.7410	10.1590	NA	27.9000	1.0000	10-1451	9.49E-01	± 2%	5.85E-01	± 5%
D6-EL-7	21.43	1.429	0.357	1.429	0.357	1.43	N	17.4453	10.2547	NA	27.7000	1.0000	10-1452	8.59E-01	± 2%	5.78E-01	± 5%
D6-EL-8	20.89	1.393	0.348	1.393	0.356	1.42	N	17.4859	10.2141	NA	27.7000	1.0000	10-1453	7.47E-01	± 2%	6.33E-01	± 5%
D6-EL-10	42.59	2.839	0.355	1.420	0.355	1.42	N	17.4710	10.0290	NA	27.5000	1.0000	10-1454	1.60E-01	± 2%	5.96E-01	± 3%
D6-EL-12	41.88	2.792	0.349	1.396	0.354	1.42	N	17.5783	10.1217	NA	27.7000	1.0000	10-1455	3.85E-02	± 2%	6.08E-01	± 3%
D6-EL-15	62.70	4.180	0.348	1.393	0.353	1.41	N	17.4379	10.5621	NA	28.0000	1.0000	10-1456	7.57E-03	± 2%	6.50E-01	± 5%
D6-EL-18	66.11	4.407	0.367	1.469	0.356	1.42	N	17.4282	10.4718	NA	27.9000	1.0000	10-1457	1.97E-03	± 3%	6.40E-01	± 5%
D6-EL-21	47.19	3.146	0.325	1.302	0.352	1.41	N	17.4622	10.9378	NA	28.4000	1.0000	10-1458	1.14E-03	± 3%	6.31E-01	± 3%
D6-EL-CP	441.09	29.406	0.360	1.441	0.360	1.44	N	17.3487	10.1513	NA	27.5000	1.0000	10-1459	7.06E+00	± 2%	5.42E-01	± 3%
D6-EDI-CP	43.98	2.932	0.349	1.396	0.349	1.40	N	17.6405	10.0595	NA	27.7000	1.0000	10-1460	1.34E-03	± 3%	5.82E-01	± 3%
D6-RG-CP	86.03	5.735	0.341	1.366	0.341	1.37	N	17.4152	10.0848	NA	27.5000	1.0000	10-1461	4.23E-04	± 3%	1.92E-03	± 3%
D6-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1070	2.63E-02	± 2%	1.39E+00	± 3%

Table C.20. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated mmol Cs	Elution meq/g
D6-EL-0	9.74E-02	1.95E-03	6.25E-02	1.87E-03	NA	1.00E+00	2.83E-02	100%	4.24E-02	NA	NA	NA
D6-EL-1	6.70E-04	1.34E-05	1.79E-05	3.22E-06	1.422	6.88E-03	1.95E-04	2.86E-04	5.22E-05	1.76E-06	1.76E-06	2.58E-07
D6-EL-2	8.31E+00	1.66E-01	3.78E-02	1.89E-03	2.881	8.53E+01	2.41E+00	6.05E-01	3.52E-02	2.24E-02	2.24E-02	3.28E-03
D6-EL-3	4.48E+00	8.95E-02	2.63E-02	1.58E-03	4.305	4.60E+01	1.30E+00	4.21E-01	2.83E-02	3.37E-02	5.61E-02	8.20E-03
D6-EL-4	1.88E+00	3.76E-02	2.29E-02	9.17E-04	5.715	1.93E+01	5.47E-01	3.67E-01	1.84E-02	1.66E-02	7.26E-02	1.06E-02
D6-EL-5	2.30E-01	4.60E-03	5.07E-02	2.03E-03	7.126	2.36E+00	6.68E-02	8.12E-01	4.06E-02	5.51E-03	7.81E-02	1.14E-02
D6-EL-6	9.33E-02	1.87E-03	5.76E-02	2.88E-03	8.535	9.58E-01	2.71E-02	9.21E-01	5.37E-02	8.42E-04	7.90E-02	1.15E-02
D6-EL-7	8.36E-02	1.67E-03	5.63E-02	2.81E-03	9.964	8.59E-01	2.43E-02	9.01E-01	5.25E-02	4.67E-04	7.94E-02	1.16E-02
D6-EL-8	7.31E-02	1.46E-03	6.19E-02	3.10E-03	11.357	7.50E-01	2.12E-02	9.91E-01	5.78E-02	4.03E-04	7.99E-02	1.17E-02
D6-EL-10	1.60E-02	3.19E-04	5.93E-02	1.78E-03	14.196	1.64E-01	4.64E-03	9.50E-01	4.03E-02	4.67E-04	8.03E-02	1.17E-02
D6-EL-12	3.80E-03	7.61E-05	6.00E-02	1.80E-03	16.988	3.91E-02	1.11E-03	9.61E-01	4.08E-02	1.02E-04	8.04E-02	1.18E-02
D6-EL-15	7.16E-04	1.43E-05	6.15E-02	3.07E-03	21.169	7.36E-03	2.08E-04	9.84E-01	5.74E-02	3.49E-05	8.05E-02	1.18E-02
D6-EL-18	1.87E-04	5.62E-06	6.11E-02	3.05E-03	25.576	1.93E-03	6.94E-05	9.78E-01	5.70E-02	7.36E-06	8.05E-02	1.18E-02
D6-EL-21	1.04E-04	3.12E-06	5.76E-02	1.73E-03	28.722	1.07E-03	3.85E-05	9.22E-01	3.91E-02	1.69E-06	8.05E-02	1.18E-02
D6-EL-CP	6.95E-01	1.39E-02	5.34E-02	1.60E-03	29.406	7.14E+00	2.02E-01	8.55E-01	3.63E-02	7.38E-02	1.38E-01	2.02E-02
D6-EDI-CP	1.34E-04	4.01E-06	5.78E-02	1.74E-03	32.338	1.37E-03	4.95E-05	9.26E-01	3.93E-02	1.29E-06	1.38E-01	2.02E-02
D6-RG-CP	4.15E-05	1.24E-06	1.88E-04	5.65E-06	38.074	4.26E-04	1.54E-05	3.01E-03	1.28E-04	1.86E-06	1.38E-01	2.02E-02
D6-Column	NA	NA	NA	NA	NA	7.22E-05	2.04E-06	5.04E-02	1.82E-03	NA	NA	NA

Table C.21. Column E1 Elution Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Start Time	Stop Time	Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
									Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
E1-EL-0	400 mL	25										17.3550	27.506	10.151
Elution (EL) Phase Start Date/Time:				13:03										
E1-EL-1	400 mL	25	88	13:30	14:00	5.3	Org	25.0	31.72	41.7	10.0	17.4300	28.300	10.870
E1-EL-2	400 mL	25	88	14:30	15:00	5.2	Org	25.0	31.72	52.4	10.7	17.5000	28.000	10.500
E1-EL-3	400 mL	25	88	15:30	16:00	5.2	Org	25.0	31.72	62.9	10.5	17.3800	27.800	10.420
E1-EL-4	400 mL	25	88	16:30	17:00	5.2	Org	25.0	31.72	73.4	10.5	17.4200	27.800	10.380
E1-EL-5	400 mL	25	88	17:30	18:00	5.2	Org	25.0	31.72	84.0	10.6	17.4100	27.700	10.290
E1-EL-6	400 mL	25	88	18:30	19:00	5.2	Org	25.0	31.72	94.5	10.5	17.3700	27.700	10.330
E1-EL-7	400 mL	25	88	19:30	20:00	5.2	Org	25.0	31.72	104.5	10.0	17.3300	27.700	10.370
E1-EL-8	400 mL	25	88	20:30	21:00	5.2	Org	25.0	31.72	114.9	10.4	17.4200	27.700	10.280
E1-EL-10	400 mL	25	88	22:30	23:00	5.1	Org	25.0	31.72	146.7	31.8	17.4800	28.000	10.520
E1-EL-12	400 mL	25	88	0:30	1:00	5.1	Org	25.0	31.72	177.9	31.2	17.3400	27.800	10.460
E1-EL-15	400 mL	25	88	3:30	4:00	5.1	Org	25.0	31.72	229.7	51.8	17.6100	28.000	10.390
E1-EL-18	400 mL	25	88	6:30	7:00	5.1	Org	25.0	31.72	281.3	51.6	17.5300	27.900	10.370
E1-EL-21	400 mL	25	88	8:30	9:00	5.1	Org	25.0	31.72	312.5	31.2	17.4800	28.000	10.520
E1-EL-CP	400 mL	25	88	13:03	9:00	5.1	Org	25.0	31.72	312.5	280.8	17.5000	27.500	10.000
E1-EDI-CP	100 mL	25	88	9:25	11:35	5.1	Org	25.0	12.68	57.3	44.6	17.4280	27.500	10.072
E1-RG-CP	100 mL	25	88	11:40	13:50	5.1	Org	25.0	25.32	70.9	45.6	17.6628	27.700	10.037

Table C.21. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Dilute	Vial	Aliquot	Diluent	Total	Dilution	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr	Y/N	Tare, g	Net, g	Net, g	Gross, g	Factor	ID No.	uCi Tot	Uncert	uCi Tot	Uncert
E1-EL-0	NA	NA	NA	NA	NA	NA	Y	17.3487	1.0088	9.1115	27.4690	10.0320	10-1079	1.05E+00	± 2%	7.34E-02	± 2%
E1-EL-1	20.72	1.381	0.363	1.454	0.363	1.45	Y	17.5232	1.0000	9.1334	27.6566	10.1334	10-1170	5.80E+00	± 2%	<3.0E-03	NA
E1-EL-2	21.18	1.412	0.353	1.412	0.358	1.43	Y	17.4798	1.0000	9.1216	27.6014	10.1216	10-1171	1.02E+01	± 2%	<4.0E-03	NA
E1-EL-3	20.90	1.393	0.348	1.393	0.355	1.42	Y	17.6049	1.0000	9.1131	27.7180	10.1131	10-1172	7.62E-01	± 2%	<5.0E-04	NA
E1-EL-4	20.86	1.391	0.348	1.391	0.353	1.41	N	17.4200	10.3800	NA	27.8000	1.0000	10-1173	6.65E+00	± 2%	4.25E-02	± 5%
E1-EL-5	20.87	1.391	0.348	1.391	0.352	1.41	N	17.4100	10.2900	NA	27.7000	1.0000	10-1174	2.87E+00	± 2%	3.40E-01	± 4%
E1-EL-6	20.81	1.387	0.347	1.387	0.351	1.40	N	17.3700	10.3300	NA	27.7000	1.0000	10-1175	1.08E+00	± 2%	6.54E-01	± 4%
E1-EL-7	20.35	1.357	0.339	1.357	0.349	1.40	N	17.3300	10.3700	NA	27.7000	1.0000	10-1176	4.62E-01	± 2%	7.34E-01	± 4%
E1-EL-8	20.66	1.377	0.344	1.377	0.349	1.39	N	17.4200	10.2800	NA	27.7000	1.0000	10-1177	2.09E-01	± 2%	7.24E-01	± 4%
E1-EL-10	42.28	2.819	0.352	1.409	0.349	1.40	N	17.4800	10.5200	NA	28.0000	1.0000	10-1178	6.30E-02	± 2%	7.54E-01	± 4%
E1-EL-12	41.62	2.775	0.347	1.387	0.349	1.40	N	17.3400	10.4600	NA	27.8000	1.0000	10-1179	2.15E-02	± 2%	8.49E-01	± 4%
E1-EL-15	62.13	4.142	0.345	1.381	0.348	1.39	N	17.6100	10.3900	NA	28.0000	1.0000	10-1180	6.17E-03	± 2%	7.91E-01	± 4%
E1-EL-18	61.91	4.128	0.344	1.376	0.348	1.39	N	17.5300	10.3700	NA	27.9000	1.0000	10-1181	2.67E-03	± 3%	7.33E-01	± 3%
E1-EL-21	41.68	2.779	0.347	1.389	0.348	1.39	N	17.4800	10.5200	NA	28.0000	1.0000	10-1182	1.83E-03	± 3%	7.28E-01	± 3%
E1-EL-CP	426.08	28.406	0.356	1.424	0.356	1.42	N	17.5000	10.0000	NA	27.5000	1.0000	10-1183	7.69E+00	± 2%	5.80E-01	± 3%
E1-EDI-CP	44.63	2.976	0.343	1.373	0.343	1.37	N	17.4280	10.0720	NA	27.5000	1.0000	10-1184	1.33E-02	± 2%	6.61E-01	± 3%
E1-RG-CP	45.06	3.004	0.347	1.387	0.347	1.39	N	17.6628	10.0372	NA	27.7000	1.0000	10-1185	2.34E-04	± 6%	3.70E-02	± 2%
E1-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1061	4.80E-02	± 2%	2.78E+00	± 3%

Table C.21. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution mmol Cs meq/g	
E1-EL-0	1.06E-01	2.11E-03	7.25E-02	1.45E-03	NA	1.00E+00	2.83E-02	100%	2.83E-02	NA	NA	NA
E1-EL-1	5.40E+00	1.08E-01	<2.79E-03	NA	1.381	5.12E+01	1.45E+00	3.86E-02	7.71E-04	1.27E-02	1.27E-02	1.86E-03
E1-EL-2	9.82E+00	1.96E-01	<3.81E-03	NA	2.793	9.31E+01	2.63E+00	5.26E-02	1.05E-03	3.67E-02	4.94E-02	7.22E-03
E1-EL-3	7.39E-01	1.48E-02	<4.85E-04	NA	4.186	7.00E+00	1.98E-01	6.69E-03	1.34E-04	2.51E-02	7.45E-02	1.09E-02
E1-EL-4	6.40E-01	1.28E-02	4.09E-03	2.05E-04	5.577	6.06E+00	1.71E-01	5.64E-02	3.04E-03	3.27E-03	7.77E-02	1.14E-02
E1-EL-5	2.79E-01	5.57E-03	3.30E-02	1.32E-03	6.969	2.64E+00	7.47E-02	4.55E-01	2.04E-02	2.18E-03	7.99E-02	1.17E-02
E1-EL-6	1.04E-01	2.09E-03	6.33E-02	2.53E-03	8.356	9.89E-01	2.80E-02	8.73E-01	3.90E-02	9.06E-04	8.08E-02	1.18E-02
E1-EL-7	4.45E-02	8.90E-04	7.07E-02	2.83E-03	9.713	4.22E-01	1.19E-02	9.76E-01	4.36E-02	3.45E-04	8.12E-02	1.19E-02
E1-EL-8	2.03E-02	4.06E-04	7.04E-02	2.81E-03	11.090	1.92E-01	5.44E-03	9.71E-01	4.34E-02	1.52E-04	8.13E-02	1.19E-02
E1-EL-10	5.98E-03	1.20E-04	7.16E-02	2.86E-03	13.909	5.67E-02	1.60E-03	9.88E-01	4.42E-02	1.26E-04	8.15E-02	1.19E-02
E1-EL-12	2.05E-03	4.11E-05	8.11E-02	3.24E-03	16.684	1.95E-02	5.50E-04	1.12E+00	5.00E-02	3.80E-05	8.15E-02	1.19E-02
E1-EL-15	5.93E-04	1.19E-05	7.61E-02	3.04E-03	20.826	5.62E-03	1.59E-04	1.05E+00	4.69E-02	1.87E-05	8.15E-02	1.19E-02
E1-EL-18	2.57E-04	7.72E-06	7.06E-02	2.12E-03	24.953	2.44E-03	8.79E-05	9.74E-01	3.51E-02	5.98E-06	8.15E-02	1.19E-02
E1-EL-21	1.74E-04	5.21E-06	6.91E-02	2.07E-03	27.732	1.65E-03	5.94E-05	9.54E-01	3.44E-02	2.04E-06	8.15E-02	1.19E-02
E1-EL-CP	7.68E-01	1.54E-02	5.79E-02	1.74E-03	28.406	7.28E+00	2.06E-01	8.00E-01	2.88E-02	7.27E-02	1.36E-01	1.99E-02
E1-EDI-CP	1.32E-03	2.64E-05	6.56E-02	1.97E-03	31.381	1.25E-02	3.54E-04	9.06E-01	3.27E-02	7.58E-06	1.36E-01	1.99E-02
E1-RG-CP	2.30E-05	1.38E-06	3.65E-03	7.29E-05	34.386	2.18E-04	1.38E-05	5.03E-02	1.42E-03	1.16E+04	1.16E+04	1.70E+03
E1-Column	NA	NA	NA	NA	NA	1.22E-04	3.44E-06	9.00E-02	3.25E-03	NA	NA	NA

Table C.22. Column E2 Elution Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Start Time	Stop Time	Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
									Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
E2-EL-0	400 mL	25										17.3550	27.506	10.151
Elution (EL) Phase Start Date/Time:				11:45										
E2-EL-1	400 mL	25	87	12:30	13:00	5.4	Org	25.0	32.03	43.0	11.0	17.6485	28.200	10.552
E2-EL-2	400 mL	25	87	13:30	14:00	5.4	Org	25.0	32.03	54.3	11.3	17.3241	27.700	10.376
E2-EL-3	400 mL	25	87	14:30	15:00	5.3	Org	25.0	32.03	61.3	7.0	17.4885	27.800	10.312
E2-EL-4	400 mL	25	87	15:30	16:00	5.3	Org	25.0	32.03	75.2	13.9	17.5026	27.800	10.297
E2-EL-5	400 mL	25	87	16:30	17:00	5.3	Org	25.0	32.03	85.7	10.5	17.5090	27.800	10.291
E2-EL-6	400 mL	25	87	17:30	18:00	5.3	Org	25.0	32.03	96.1	10.4	17.4019	27.500	10.098
E2-EL-7	400 mL	25	87	18:30	19:00	5.3	Org	25.0	32.03	106.3	10.2	17.4340	27.500	10.066
E2-EL-8	400 mL	25	87	19:30	20:00	5.3	Org	25.0	32.03	116.5	10.2	17.7444	27.900	10.156
E2-EL-10	400 mL	25	87	21:30	22:00	5.3	Org	25.0	32.03	146.9	30.4	17.6948	27.900	10.205
E2-EL-12	400 mL	25	87	23:30	0:00	5.3	Org	25.0	32.03	177.6	30.7	17.4579	27.900	10.442
E2-EL-15	400 mL	25	87	2:30	3:00	5.3	Org	25.0	32.03	230.2	52.6	17.3759	28.300	10.924
E2-EL-18	400 mL	25	87	5:30	6:00	5.3	Org	25.0	32.03	283.0	52.8	17.4005	28.200	10.800
E2-EL-21	400 mL	25	87	8:25	8:55	5.3	Org	25.0	32.03	329.0	46.0	17.4308	28.200	10.769
E2-EL-CP	400 mL	25	87	11:45	8:55	5.3	Org	25.0	32.03	319.2	287.2	17.3580	28.000	10.642
E2-EDI-CP	100 mL	25	90	9:25	11:35	5.3	Org	25.0	12.52	58.5	46.0	17.5188	28.100	10.581
E2-RG-CP	100 mL	25	90	11:40	13:50	5.3	Org	25.0	25.32	71.1	45.8	17.6373	28.000	10.363

Table C.22. (contd)

Sample ID No.	Instant. Volume mL BV		Instant. Flow mL/min BV/hr		Average Flow mL/min BV/hr		Dilute Y/N	Vial Tare, g	Aliquot Net, g	Diluent Net, g	Total Gross, g	Dilution Factor	ASO ID No.	Cs-134 uCi Tot	Cs-134 Uncert	Cs-137 uCi Tot	Cs-137 Uncert
E2-EL-0	NA	NA	NA	NA	NA	NA	Y	17.4272	1.0053	9.1312	27.5637	10.0831	10-1080	1.09E+00	± 2%	7.29E-02	± 2%
E2-EL-1	21.38	1.426	0.285	1.140	0.285	1.14	Y	17.1578	1.0000	9.4988	27.6566	10.4988	10-1234	1.15E+01	± 2%	8.66E-02	± 4%
E2-EL-2	21.66	1.444	0.361	1.444	0.319	1.28	Y	17.4957	1.0000	9.1057	27.6014	10.1057	10-1235	8.39E+00	± 2%	6.08E-02	± 5%
E2-EL-3	17.30	1.153	0.288	1.153	0.309	1.24	Y	17.5641	1.0000	9.1539	27.7180	10.1539	10-1236	4.64E-01	± 2%	4.32E-03	± 5%
E2-EL-4	24.17	1.612	0.403	1.612	0.331	1.33	N	17.5026	10.2974	NA	27.8000	1.0000	10-1237	1.39E+00	± 2%	2.06E-02	± 6%
E2-EL-5	20.77	1.385	0.346	1.385	0.334	1.34	N	17.5090	10.2910	NA	27.8000	1.0000	10-1238	7.99E-01	± 2%	8.66E-02	± 4%
E2-EL-6	20.48	1.365	0.341	1.365	0.335	1.34	N	17.4019	10.0981	NA	27.5000	1.0000	10-1239	5.23E-01	± 2%	2.23E-01	± 4%
E2-EL-7	20.25	1.350	0.337	1.350	0.336	1.34	N	17.4340	10.0660	NA	27.5000	1.0000	10-1240	3.61E-01	± 2%	3.93E-01	± 3%
E2-EL-8	20.34	1.356	0.339	1.356	0.336	1.34	N	17.7444	10.1556	NA	27.9000	1.0000	10-1241	2.80E-01	± 2%	5.95E-01	± 4%
E2-EL-10	40.57	2.705	0.338	1.352	0.336	1.35	N	17.6948	10.2052	NA	27.9000	1.0000	10-1242	1.87E-01	± 2%	7.36E-01	± 5%
E2-EL-12	41.10	2.740	0.343	1.370	0.337	1.35	N	17.4579	10.4421	NA	27.9000	1.0000	10-1243	5.52E-02	± 2%	7.52E-01	± 5%
E2-EL-15	63.47	4.231	0.353	1.410	0.340	1.36	N	17.3759	10.9241	NA	28.3000	1.0000	10-1244	1.20E-02	± 2%	7.38E-01	± 3%
E2-EL-18	63.54	4.236	0.353	1.412	0.342	1.37	N	17.4005	10.7995	NA	28.2000	1.0000	10-1245	3.67E-03	± 2%	7.30E-01	± 4%
E2-EL-21	56.72	3.781	0.324	1.296	0.340	1.36	N	17.4308	10.7692	NA	28.2000	1.0000	10-1246	2.05E-03	± 3%	8.34E-01	± 3%
E2-EL-CP	432.70	28.846	0.341	1.363	0.341	1.36	N	17.3580	10.6420	NA	28.0000	1.0000	10-1248	6.53E+00	± 2%	6.37E-01	± 3%
E2-EDI-CP	45.99	3.066	0.354	1.415	0.354	1.42	N	17.5188	10.5812	NA	28.1000	1.0000	10-1249	5.71E-03	± 2%	5.27E-01	± 4%
E2-RG-CP	45.26	3.018	0.348	1.393	0.348	1.39	N	17.6373	10.3627	NA	28.0000	1.0000	10-1250	1.70E-03	± 3%	1.43E-01	± 3%
E2-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1063	5.53E-02	± 2%	4.33E+00	± 3%

Table C.22. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution mmol Cs	Elution meq/g
E2-EL-0	1.05E-01	2.09E-03	7.23E-02	1.45E-03	NA	1.00E+00	2.83E-02	100%	2.83E-02	NA	NA	NA
E2-EL-1	1.14E+01	2.29E-01	8.61E-02	3.44E-03	1.426	1.09E+02	3.09E+00	1.19E+00	5.32E-02	2.80E-02	2.80E-02	4.09E-03
E2-EL-2	8.16E+00	1.63E-01	5.92E-02	2.96E-03	2.869	7.79E+01	2.20E+00	8.18E-01	4.40E-02	4.86E-02	7.66E-02	1.12E-02
E2-EL-3	4.56E-01	9.13E-03	4.25E-03	2.13E-04	4.022	4.36E+00	1.23E-01	5.87E-02	3.16E-03	1.71E-02	9.37E-02	1.37E-02
E2-EL-4	1.35E-01	2.70E-03	2.00E-03	1.20E-04	5.634	1.29E+00	3.64E-02	2.76E-02	1.75E-03	1.64E-03	9.53E-02	1.39E-02
E2-EL-5	7.76E-02	1.55E-03	8.41E-03	3.36E-04	7.019	7.41E-01	2.09E-02	1.16E-01	5.20E-03	5.06E-04	9.59E-02	1.40E-02
E2-EL-6	5.17E-02	1.03E-03	2.21E-02	8.83E-04	8.384	4.94E-01	1.40E-02	3.05E-01	1.36E-02	3.03E-04	9.62E-02	1.41E-02
E2-EL-7	3.58E-02	7.17E-04	3.90E-02	1.17E-03	9.734	3.42E-01	9.68E-03	5.39E-01	1.94E-02	2.03E-04	9.64E-02	1.41E-02
E2-EL-8	2.75E-02	5.51E-04	5.85E-02	2.34E-03	11.090	2.63E-01	7.44E-03	8.09E-01	3.62E-02	1.48E-04	9.65E-02	1.41E-02
E2-EL-10	1.83E-02	3.66E-04	7.21E-02	3.60E-03	13.794	1.75E-01	4.94E-03	9.96E-01	5.36E-02	2.13E-04	9.67E-02	1.41E-02
E2-EL-12	5.28E-03	1.06E-04	7.19E-02	3.60E-03	16.534	5.04E-02	1.43E-03	9.94E-01	5.36E-02	1.11E-04	9.68E-02	1.42E-02
E2-EL-15	1.10E-03	2.19E-05	6.75E-02	2.02E-03	20.765	1.05E-02	2.96E-04	9.33E-01	3.36E-02	4.64E-05	9.69E-02	1.42E-02
E2-EL-18	3.40E-04	6.79E-06	6.75E-02	2.70E-03	25.001	3.24E-03	9.17E-05	9.33E-01	4.17E-02	1.05E-05	9.69E-02	1.42E-02
E2-EL-21	1.90E-04	5.71E-06	7.74E-02	2.32E-03	28.783	1.82E-03	6.55E-05	1.07E+00	3.86E-02	3.44E-06	9.69E-02	1.42E-02
E2-EL-CP	6.13E-01	1.23E-02	5.98E-02	1.79E-03	28.846	5.85E+00	1.66E-01	8.27E-01	2.98E-02	5.93E-02	1.11E-01	1.63E-02
E2-EDI-CP	5.40E-04	1.08E-05	4.98E-02	1.99E-03	31.913	5.15E-03	1.46E-04	6.89E-01	3.08E-02	3.85E-06	1.11E-01	1.63E-02
E2-RG-CP	1.62E-04	4.87E-06	1.36E-02	4.09E-04	34.930	1.55E-03	5.58E-05	1.89E-01	6.80E-03	3.64E-06	1.11E-01	1.63E-02
E2-Column	NA	NA	NA	NA	NA	1.44E-04	4.08E-06	1.38E-01	4.99E-03	NA	NA	NA

Table C.23. Column E3 Elution Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Start Time	Stop Time	Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
									Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
E3-EL-0	400 mL	25										17.5000	27.500	10.000
Elution (EL) Phase Start Date/Time:				05:03										
E3-EL-1	400 mL	25	87	05:30	06:00	5.8	Org	25.0	31.85	43.1	11.25	17.4074	28.000	10.593
E3-EL-2	400 mL	25	87	6:30	7:00	5.5	Org	25.0	31.85	54.4	11.3	17.2661	28.200	10.934
E3-EL-3	400 mL	25	87	7:30	8:00	5.5	Org	25.0	31.85	65.5	11.1	17.5837	28.300	10.716
E3-EL-4	400 mL	25	86	8:30	9:00	5.5	Org	25.0	31.85	76.3	10.8	17.2525	27.900	10.648
E3-EL-5	400 mL	25	86	9:30	10:00	5.5	Org	25.0	31.85	87.0	10.7	17.4334	28.100	10.667
E3-EL-6	400 mL	25	86	10:30	11:00	5.5	Org	25.0	31.85	97.7	10.7	17.4662	28.000	10.534
E3-EL-7	400 mL	25	86	11:30	12:00	5.5	Org	25.0	31.85	108.3	10.6	17.6995	28.200	10.501
E3-EL-8	400 mL	25	86	12:30	13:00	5.5	Org	25.0	31.85	118.9	10.6	17.3579	28.000	10.642
E3-EL-10	400 mL	25	86	14:30	15:00	5.5	Org	25.0	31.85	151.1	32.2	17.3880	26.500	9.112
E3-EL-12	400 mL	25	86	16:30	17:00	5.5	Org	25.0	31.85	183.0	31.9	17.4780	28.000	10.522
E3-EL-15	400 mL	25	86	19:30	20:00	5.4	Org	25.0	31.85	236.8	53.8	17.2780	28.300	11.022
E3-EL-18	400 mL	25	86	22:30	23:00	5.4	Org	25.0	55.70	105.7	50.0	17.4452	27.900	10.455
E3-EL-21	400 mL	25	86	7:50	10:50	5.4	Org	25.0	55.70	152.0	46.3	17.5734	28.700	11.127
E3-EL-CP	400 mL	25	86	5:03	2:00	5.4	Org	25.0	55.70	152.0	301.3	17.5537	28.600	11.046
E3-EDI-CP	100 mL	25	86	9:40	12:00	5.4	Org	25.0	12.82	62.0	49.2	17.2992	28.500	11.201
E3-RG-CP	100 mL	25	86	16:00	18:10	5.4	Org	25.0	25.33	71.1	45.8	17.4359	28.500	11.064

Table C.23. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Dilute	Vial	Aliquot	Diluent	Total	Dilution	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr	Y/N	Tare, g	Net, g	Net, g	Gross, g	Factor	ID No.	uCi Tot	Uncert	uCi Tot	Uncert
E3-EL-0	NA	NA	NA	NA	NA	NA	Y	17.6011	1.0116	9.1174	27.7301	10.0129	10-1081	9.77E-01	± 2%	7.38E-02	± 2%
E3-EL-1	21.70	1.447	0.381	1.523	0.381	1.52	Y	16.9778	1.0000	9.1431	27.1209	10.1431	10-1295	8.74E+00	± 2%	8.98E-02	± 4%
E3-EL-2	22.21	1.481	0.370	1.481	0.375	1.50	Y	17.0080	1.0000	9.1400	27.1480	10.1400	10-1296	1.03E+01	± 2%	1.23E-01	± 4%
E3-EL-3	21.80	1.453	0.363	1.453	0.371	1.49	Y	17.0107	1.0000	9.1536	27.1643	10.1536	10-1297	6.48E-01	± 2%	9.30E-03	± 5%
E3-EL-4	21.43	1.429	0.357	1.429	0.368	1.47	Y	16.9979	1.0000	9.1532	27.1511	10.1532	10-1298	1.10E-01	± 2%	3.16E-02	± 4%
E3-EL-5	21.35	1.423	0.356	1.423	0.365	1.46	N	17.4334	10.6666	NA	28.1000	1.0000	10-1299	9.64E-01	± 2%	7.03E-01	± 4%
E3-EL-6	21.21	1.414	0.354	1.414	0.363	1.45	N	17.4662	10.5338	NA	28.0000	1.0000	10-1300	4.13E-01	± 2%	7.73E-01	± 4%
E3-EL-7	21.08	1.405	0.351	1.405	0.362	1.45	N	17.6995	10.5005	NA	28.2000	1.0000	10-1301	1.71E-01	± 2%	7.42E-01	± 3%
E3-EL-8	21.22	1.415	0.354	1.415	0.361	1.44	N	17.3579	10.6421	NA	28.0000	1.0000	10-1302	7.93E-02	± 2%	7.45E-01	± 3%
E3-EL-10	41.27	2.752	0.344	1.376	0.357	1.43	N	17.3880	9.1120	NA	26.5000	1.0000	10-1303	2.00E-02	± 2%	6.95E-01	± 3%
E3-EL-12	42.38	2.826	0.353	1.413	0.357	1.43	N	17.4780	10.5220	NA	28.0000	1.0000	10-1304	6.78E-03	± 2%	7.52E-01	± 3%
E3-EL-15	64.76	4.317	0.360	1.439	0.357	1.43	N	17.2780	11.0220	NA	28.3000	1.0000	10-1305	2.12E-03	± 3%	7.35E-01	± 3%
E3-EL-18	60.40	4.027	0.336	1.342	0.354	1.41	N	17.4452	10.4548	NA	27.9000	1.0000	10-1306	2.19E-03	± 3%	7.26E-01	± 3%
E3-EL-21	57.37	3.825	0.183	0.733	0.335	1.34	N	17.5734	11.1266	NA	28.7000	1.0000	10-1307	1.91E-03	± 3%	8.09E-01	± 3%
E3-EL-CP	438.31	29.221	0.349	1.395	0.349	1.39	N	17.5537	11.0463	NA	28.6000	1.0000	10-1308	6.27E+00	± 2%	7.28E-01	± 3%
E3-EDI-CP	49.20	3.280	0.351	1.406	0.351	1.41	N	17.2992	11.2008	NA	28.5000	1.0000	10-1309	1.23E-03	± 3%	3.61E-01	± 3%
E3-RG-CP	45.25	3.017	0.348	1.392	0.348	1.39	N	17.4359	11.0641	NA	28.5000	1.0000	10-1310	1.72E-03	± 2%	2.89E-02	± 4%
E3-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1065	3.00E-02	± 2%	1.63E+00	± 3%

Table C.23. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution mmol Cs	Elution meq/g
E3-EL-0	1.02E-01	2.03E-03	7.38E-02	1.48E-03	NA	1.00E+00	2.83E-02	100%	2.83E-02	NA	NA	NA
E3-EL-1	8.36E+00	1.67E-01	8.59E-02	3.44E-03	1.447	8.22E+01	2.33E+00	1.16E+00	5.20E-02	2.14E-02	2.14E-02	3.13E-03
E3-EL-2	9.57E+00	1.91E-01	1.14E-01	4.56E-03	2.928	9.41E+01	2.66E+00	1.54E+00	6.90E-02	4.70E-02	6.84E-02	1.00E-02
E3-EL-3	6.13E-01	1.23E-02	8.81E-03	4.40E-04	4.381	6.03E+00	1.71E-01	1.19E-01	6.42E-03	2.62E-02	9.46E-02	1.38E-02
E3-EL-4	1.05E-01	2.10E-03	3.01E-02	1.20E-03	5.809	1.03E+00	2.92E-02	4.08E-01	1.82E-02	1.82E-03	9.65E-02	1.41E-02
E3-EL-5	9.03E-02	1.81E-03	6.58E-02	2.63E-03	7.232	8.88E-01	2.51E-02	8.92E-01	3.99E-02	4.92E-04	9.70E-02	1.42E-02
E3-EL-6	3.92E-02	7.84E-04	7.33E-02	2.93E-03	8.647	3.85E-01	1.09E-02	9.93E-01	4.44E-02	3.24E-04	9.73E-02	1.42E-02
E3-EL-7	1.63E-02	3.25E-04	7.06E-02	2.12E-03	10.052	1.60E-01	4.53E-03	9.56E-01	3.45E-02	1.38E-04	9.74E-02	1.42E-02
E3-EL-8	7.44E-03	1.49E-04	6.99E-02	2.10E-03	11.467	7.32E-02	2.07E-03	9.47E-01	3.42E-02	5.94E-05	9.75E-02	1.43E-02
E3-EL-10	2.19E-03	4.38E-05	7.62E-02	2.29E-03	14.219	2.15E-02	6.09E-04	1.03E+00	3.72E-02	4.69E-05	9.75E-02	1.43E-02
E3-EL-12	6.44E-04	1.29E-05	7.14E-02	2.14E-03	17.044	6.33E-03	1.79E-04	9.67E-01	3.49E-02	1.42E-05	9.75E-02	1.43E-02
E3-EL-15	1.92E-04	5.76E-06	6.66E-02	2.00E-03	21.361	1.89E-03	6.82E-05	9.02E-01	3.25E-02	6.39E-06	9.75E-02	1.43E-02
E3-EL-18	2.09E-04	6.28E-06	6.94E-02	2.08E-03	25.388	2.06E-03	7.42E-05	9.40E-01	3.39E-02	2.86E-06	9.75E-02	1.43E-02
E3-EL-21	1.72E-04	5.15E-06	7.26E-02	2.18E-03	29.213	1.69E-03	6.08E-05	9.84E-01	3.55E-02	2.58E-06	9.75E-02	1.43E-02
E3-EL-CP	5.67E-01	1.13E-02	6.58E-02	1.98E-03	29.221	5.58E+00	1.58E-01	8.92E-01	3.22E-02	5.87E-02	1.10E-01	1.61E-02
E3-EDI-CP	1.10E-04	3.30E-06	3.22E-02	9.67E-04	32.501	1.08E-03	3.90E-05	4.37E-01	1.57E-02	1.63E-06	1.10E-01	1.61E-02
E3-RG-CP	1.54E-04	3.08E-06	2.58E-03	1.03E-04	35.518	1.51E-03	4.28E-05	3.50E-02	1.56E-03	1.41E-06	1.10E-01	1.61E-02
E3-Column	NA	NA	NA	NA	NA	7.89E-05	2.23E-06	5.04E-02	1.82E-03	NA	NA	NA

Table C.24. Column E4 Elution Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Start Time	Stop Time	Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
									Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
E4-EL-0	400 mL	25										17.5000	27.500	10.000
Elution (EL) Phase Start Date/Time:				05:00										
E4-EL-1	400 mL	25	86	05:30	06:00	5.6	Mix	25.0	31.94	43.3	11.4	17.4485	27.800	10.352
E4-EL-2	400 mL	25	85	6:30	7:00	5.5	Mix	25.0	31.94	54.5	11.2	17.5229	28.200	10.677
E4-EL-3	400 mL	25	84	7:36	8:06	5.5	Org	25.0	31.94	67.2	12.7	17.4272	28.300	10.873
E4-EL-4	400 mL	25	84	8:30	9:00	5.5	Org	25.0	31.94	75.6	8.4	17.5121	28.100	10.588
E4-EL-5	400 mL	25	84	9:30	10:00	5.4	Org	25.0	31.94	86.3	10.7	17.6241	28.200	10.576
E4-EL-6	400 mL	25	84	10:30	11:00	5.4	Org	25.0	31.94	97.1	10.8	17.6040	28.600	10.996
E4-EL-7	400 mL	25	84	11:30	12:00	5.5	Org	25.0	31.94	107.5	10.4	17.4293	28.000	10.571
E4-EL-8	400 mL	25	84	12:30	13:00	5.4	Org	25.0	31.94	118.2	10.7	17.4414	28.000	10.559
E4-EL-10	400 mL	25	84	14:30	15:00	5.4	Org	25.0	31.94	150.3	32.1	17.5688	28.100	10.531
E4-EL-12	400 mL	25	84	16:30	17:00	5.4	Org	25.0	31.94	182.2	31.9	17.4190	28.100	10.681
E4-EL-15	400 mL	25	84	19:30	20:00	5.4	Org	25.0	31.94	235.4	53.2	17.5523	28.200	10.648
E4-EL-18	400 mL	25	84	22:30	23:00	5.4	Org	25.0	32.00	85.4	53.4	17.3358	28.000	10.664
E4-EL-21	400 mL	25	84	1:30	2:00	5.4	Org	25.0	32.00	139.1	53.7	17.5259	25.500	7.974
E4-EL-CP	400 mL	25	84	5:00	2:00	5.4	Org	25.0	32.00	139.1	310.6	17.5902	28.000	10.410
E4-EDI-CP	100 mL	25	84	8:15	11:00	5.4	Org	25.0	12.80	70.0	57.2	17.4506	28.000	10.549
E4-RG-CP	100 mL	25	84	16:00	20:16	6.8	Org	25.0	25.30	115.0	89.7	17.2751	28.000	10.725

Table C.24. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Dilute	Vial	Aliquot	Diluent	Total	Dilution	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr	Y/N	Tare, g	Net, g	Net, g	Gross, g	Factor	ID No.	uCi Tot	Uncert	uCi Tot	Uncert
E4-EL-0	NA	NA	NA	NA	NA	NA	Y	17.0767	1.0118	9.1003	27.1888	9.9942	10-1082	1.06E+00	± 2%	7.40E-02	± 2%
E4-EL-1	21.57	1.438	0.360	1.438	0.360	1.44	Y	16.9382	1.0000	9.1854	27.1236	10.1854	10-1356	4.89E+00	± 2%	1.84E-02	± 8%
E4-EL-2	21.86	1.457	0.364	1.457	0.362	1.45	Y	17.0175	1.0000	9.1725	27.1900	10.1725	10-1357	1.05E+01	± 2%	6.52E-02	± 4%
E4-EL-3	23.55	1.570	0.357	1.427	0.360	1.44	Y	16.8880	1.0000	9.1408	27.0288	10.1408	10-1358	1.97E+00	± 2%	9.79E-03	± 8%
E4-EL-4	18.97	1.265	0.351	1.405	0.358	1.43	Y	16.9886	1.0000	9.1581	27.1467	10.1581	10-1359	1.58E-01	± 2%	2.45E-02	± 4%
E4-EL-5	21.26	1.417	0.354	1.417	0.357	1.43	N	17.6241	10.5759	NA	28.2000	1.0000	10-1360	8.77E-01	± 2%	6.89E-01	± 5%
E4-EL-6	21.78	1.452	0.363	1.452	0.358	1.43	N	17.6040	10.9960	NA	28.6000	1.0000	10-1361	5.47E-01	± 2%	7.49E-01	± 5%
E4-EL-7	20.95	1.397	0.349	1.397	0.357	1.43	N	17.4293	10.5707	NA	28.0000	1.0000	10-1362	2.47E-01	± 2%	7.30E-01	± 3%
E4-EL-8	21.24	1.416	0.354	1.416	0.357	1.43	N	17.4414	10.5586	NA	28.0000	1.0000	10-1363	1.11E-01	± 2%	7.26E-01	± 3%
E4-EL-10	42.59	2.839	0.355	1.420	0.356	1.43	N	17.5688	10.5312	NA	28.1000	1.0000	10-1364	3.21E-02	± 2%	8.11E-01	± 5%
E4-EL-12	42.54	2.836	0.355	1.418	0.356	1.42	N	17.4190	10.6810	NA	28.1000	1.0000	10-1365	9.22E-03	± 2%	7.22E-01	± 3%
E4-EL-15	63.79	4.253	0.354	1.418	0.356	1.42	N	17.5523	10.6477	NA	28.2000	1.0000	10-1366	2.53E-03	± 3%	7.23E-01	± 3%
E4-EL-18	64.00	4.267	0.356	1.422	0.356	1.42	N	17.3358	10.6642	NA	28.0000	1.0000	10-1367	1.25E-03	± 4%	7.47E-01	± 5%
E4-EL-21	61.62	4.108	0.342	1.369	0.354	1.41	N	17.5259	7.9741	NA	25.5000	1.0000	10-1368	5.47E-04	± 4%	5.64E-01	± 3%
E4-EL-CP	445.83	29.722	0.354	1.415	0.354	1.42	N	17.5902	10.4098	NA	28.0000	1.0000	10-1369	7.08E+00	± 2%	6.62E-01	± 3%
E4-EDI-CP	57.22	3.815	0.347	1.387	0.347	1.39	N	17.4506	10.5494	NA	28.0000	1.0000	10-1370	2.29E-03	± 3%	3.34E-01	± 3%
E4-RG-CP	88.69	5.912	0.346	1.386	0.346	1.39	N	17.2751	10.7249	NA	28.0000	1.0000	10-1371	2.27E-03	± 2%	6.04E-02	± 4%
E4-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1067	2.63E-02	± 2%	1.90E+00	± 3%

Table C.24. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution mmol Cs	Elution meq/g
E4-EL-0	1.06E-01	2.12E-03	7.39E-02	1.48E-03	NA	1.00E+00	2.83E-02	100%	2.83E-02	NA	NA	NA
E4-EL-1	4.81E+00	9.61E-02	1.81E-02	1.45E-03	1.438	4.53E+01	1.28E+00	2.45E-01	2.02E-02	1.17E-02	1.17E-02	1.72E-03
E4-EL-2	9.99E+00	2.00E-01	6.21E-02	2.48E-03	2.895	9.42E+01	2.67E+00	8.40E-01	3.76E-02	3.66E-02	4.83E-02	7.07E-03
E4-EL-3	1.84E+00	3.67E-02	9.12E-03	7.30E-04	4.465	1.73E+01	4.90E-01	1.23E-01	1.02E-02	3.15E-02	7.99E-02	1.17E-02
E4-EL-4	1.51E-01	3.03E-03	2.35E-02	9.39E-04	5.730	1.43E+00	4.04E-02	3.18E-01	1.42E-02	4.27E-03	8.41E-02	1.23E-02
E4-EL-5	8.28E-02	1.66E-03	6.51E-02	3.25E-03	7.147	7.81E-01	2.21E-02	8.81E-01	4.74E-02	5.63E-04	8.47E-02	1.24E-02
E4-EL-6	4.97E-02	9.94E-04	6.81E-02	3.40E-03	8.599	4.69E-01	1.33E-02	9.21E-01	4.96E-02	3.27E-04	8.50E-02	1.24E-02
E4-EL-7	2.33E-02	4.67E-04	6.90E-02	2.07E-03	9.996	2.20E-01	6.23E-03	9.34E-01	3.37E-02	1.73E-04	8.52E-02	1.25E-02
E4-EL-8	1.05E-02	2.11E-04	6.87E-02	2.06E-03	11.412	9.93E-02	2.81E-03	9.30E-01	3.35E-02	8.14E-05	8.53E-02	1.25E-02
E4-EL-10	3.05E-03	6.09E-05	7.70E-02	3.85E-03	14.251	2.87E-02	8.12E-04	1.04E+00	5.61E-02	6.54E-05	8.53E-02	1.25E-02
E4-EL-12	8.62E-04	1.72E-05	6.75E-02	2.03E-03	17.087	8.13E-03	2.30E-04	9.14E-01	3.30E-02	1.88E-05	8.54E-02	1.25E-02
E4-EL-15	2.37E-04	7.12E-06	6.78E-02	2.04E-03	21.340	2.24E-03	8.07E-05	9.18E-01	3.31E-02	7.93E-06	8.54E-02	1.25E-02
E4-EL-18	1.17E-04	4.68E-06	7.00E-02	3.50E-03	25.607	1.10E-03	4.94E-05	9.47E-01	5.10E-02	2.57E-06	8.54E-02	1.25E-02
E4-EL-21	6.85E-05	2.74E-06	7.07E-02	2.12E-03	29.714	6.46E-04	2.89E-05	9.56E-01	3.45E-02	1.29E-06	8.54E-02	1.25E-02
E4-EL-CP	6.80E-01	1.36E-02	6.36E-02	1.91E-03	29.722	6.41E+00	1.81E-01	8.60E-01	3.10E-02	6.86E-02	1.29E-01	1.88E-02
E4-EDI-CP	2.17E-04	6.51E-06	3.17E-02	9.50E-04	33.537	2.05E-03	7.38E-05	4.29E-01	1.55E-02	1.85E-06	1.29E-01	1.88E-02
E4-RG-CP	2.10E-04	4.19E-06	5.57E-03	2.23E-04	39.449	1.98E-03	5.59E-05	7.54E-02	3.37E-03	4.28E-06	1.29E-01	1.88E-02
E4-Column	NA	NA	NA	NA	NA	6.62E-05	1.87E-06	5.77E-02	2.08E-03	NA	NA	NA

Table C.25. Column E5 Elution Data Table

Sample ID No.	Bottle Size	Temp °C	Pump Setting	Start Time	Stop Time	Resin Height	Resin Color	Temp °C	Effluent Bottle Weights			Sample Vial Weights		
									Tare, g	Gross, g	Net, g	Tare, g	Gross, g	Net, g
E5-EL-0	400 mL	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	17.5000	27.500	10.000
Elution (EL) Phase Start Date/Time:				09:00										
E5-EL-1	400 mL	25	86	09:30	09:58	5.6	Mix	25.0	54.50	65.7	11.2	17.5581	28.000	10.442
E5-EL-2	400 mL	25	86	10:30	10:58	5.6	Mix	25.0	54.50	77.8	12.1	17.4803	27.700	10.220
E5-EL-3	400 mL	25	84	11:30	11:58	5.5	Org	25.0	54.50	89.5	11.7	17.4844	27.400	9.916
E5-EL-4	400 mL	25	85	12:30	12:58	5.4	Org	25.0	54.50	100.9	11.4	17.4666	27.400	9.933
E5-EL-5	400 mL	25	85	13:30	13:58	5.4	Org	25.0	54.50	112.3	11.4	17.3391	27.300	9.961
E5-EL-6	400 mL	25	85	14:30	14:58	5.4	Org	25.0	54.50	123.6	11.3	17.3908	27.300	9.909
E5-EL-7	400 mL	25	85	15:30	15:58	5.4	Org	25.0	54.50	135.0	11.4	17.3599	27.200	9.840
E5-EL-8	400 mL	25	85	16:30	16:58	5.4	Org	25.0	54.50	146.4	11.4	17.4037	27.800	10.396
E5-EL-10	400 mL	25	85	18:30	18:58	5.4	Org	25.0	54.50	178.5	32.1	17.5181	27.400	9.882
E5-EL-12	400 mL	25	85	20:30	20:58	5.4	Org	25.0	54.50	210.4	31.9	17.4144	27.500	10.086
E5-EL-15	400 mL	25	85	23:30	23:58	5.4	Org	25.0	54.50	264.7	54.3	17.3257	27.300	9.974
E5-EL-18	400 mL	25	85	2:30	2:58	5.4	Org	25.0	54.50	318.7	54.0	17.3935	27.300	9.907
E5-EL-21	400 mL	25	85	5:00	5:28	5.4	Org	25.0	54.50	362.7	44.0	17.6228	27.500	9.877
E5-EL-CP	400 mL	25	85	9:00	5:28	5.4	Org	25.0	54.50	362.7	308.2	17.4167	27.500	10.083
E5-EDI-CP	100 mL	25	85	5:35	7:45	5.4	Org	25.0	12.81	59.9	47.1	17.4246	27.500	10.075
E5-RG-CP	100 mL	25	85	14:55	19:05	7.0	Blk	25.0	25.32	111.9	86.6	17.4466	27.500	10.053

Table C.25. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Dilute	Vial	Aliquot	Diluent	Total	Dilution	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr	Y/N	Tare, g	Net, g	Net, g	Gross, g	Factor	ID No.	uCi Tot	Uncert	uCi Tot	Uncert
E5-EL-0	NA	NA	NA	NA	NA	NA	Y	17.4640	0.9157	9.1044	27.4841	10.9426	10-1083	1.03E+00	± 2%	6.81E-02	± 2%
E5-EL-1	21.50	1.434	0.371	1.483	0.371	1.48	Y	17.0781	1.0000	9.1603	27.2384	10.1603	10-1416	3.25E-03	± 2%	2.73E-05	± 26%
E5-EL-2	22.30	1.487	0.372	1.487	0.371	1.48	Y	16.8798	1.0000	9.1784	27.0582	10.1784	10-1417	1.19E+01	± 2%	5.44E-02	± 5%
E5-EL-3	21.60	1.440	0.360	1.440	0.367	1.47	Y	17.0325	1.0000	9.1643	27.1968	10.1643	10-1418	3.65E+00	± 2%	1.75E-02	± 7%
E5-EL-4	21.31	1.421	0.355	1.421	0.364	1.46	Y	16.9337	1.0000	9.1759	27.1096	10.1759	10-1419	8.42E-01	± 2%	6.93E-03	± 8%
E5-EL-5	21.34	1.423	0.356	1.423	0.363	1.45	N	17.3391	9.9609	NA	27.3000	1.0000	10-1420	4.38E+00	± 2%	1.66E-01	± 3%
E5-EL-6	21.19	1.413	0.353	1.413	0.361	1.44	N	17.3908	9.9092	NA	27.3000	1.0000	10-1421	1.30E+00	± 2%	3.38E-01	± 5%
E5-EL-7	21.22	1.415	0.354	1.415	0.360	1.44	N	17.3599	9.8401	NA	27.2000	1.0000	10-1422	7.01E-01	± 2%	5.58E-01	± 5%
E5-EL-8	21.78	1.452	0.363	1.452	0.360	1.44	N	17.4037	10.3963	NA	27.8000	1.0000	10-1423	7.61E-01	± 2%	7.18E-01	± 5%
E5-EL-10	41.94	2.796	0.350	1.398	0.358	1.43	N	17.5181	9.8819	NA	27.4000	1.0000	10-1424	5.03E-01	± 2%	7.62E-01	± 3%
E5-EL-12	41.95	2.796	0.350	1.398	0.357	1.43	N	17.4144	10.0856	NA	27.5000	1.0000	10-1425	2.01E-01	± 2%	8.10E-01	± 5%
E5-EL-15	64.21	4.281	0.357	1.427	0.357	1.43	N	17.3257	9.9743	NA	27.3000	1.0000	10-1426	2.25E-02	± 2%	7.22E-01	± 3%
E5-EL-18	63.85	4.256	0.355	1.419	0.356	1.43	N	17.3935	9.9065	NA	27.3000	1.0000	10-1427	3.67E-03	± 2%	7.25E-01	± 5%
E5-EL-21	53.83	3.588	0.359	1.435	0.357	1.43	N	17.6228	9.8772	NA	27.5000	1.0000	10-1428	1.19E-03	± 3%	6.14E-01	± 3%
E5-EL-CP	438.14	29.209	0.357	1.427	0.357	1.43	N	17.4167	10.0833	NA	27.5000	1.0000	10-1429	7.21E+00	± 2%	5.97E-01	± 3%
E5-EDI-CP	47.11	3.140	0.362	1.449	0.362	1.45	N	17.4246	10.0754	NA	27.5000	1.0000	10-1430	1.83E-02	± 2%	5.05E-01	± 4%
E5-RG-CP	85.60	5.707	0.342	1.370	0.342	1.37	N	17.4466	10.0534	NA	27.5000	1.0000	10-1431	1.84E-03	± 2%	1.08E-02	± 2%
E5-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1069	3.02E-02	± 2%	3.40E+00	± 3%

Table C.25. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution mmol Cs	meq/g
E5-EL-0	1.04E-01	2.08E-03	7.44E-02	1.49E-03	NA	1.00E+00	2.83E-02	100%	2.83E-02	NA	NA	NA
E5-EL-1	3.16E-03	6.32E-05	2.65E-05	6.90E-06	1.434	3.04E-02	8.59E-04	3.56E-04	9.30E-05	7.83E-06	7.83E-06	1.15E-06
E5-EL-2	1.18E+01	2.37E-01	5.41E-02	2.70E-03	2.920	1.14E+02	3.22E+00	7.26E-01	3.91E-02	3.05E-02	3.05E-02	4.46E-03
E5-EL-3	3.74E+00	7.48E-02	1.79E-02	1.26E-03	4.360	3.60E+01	1.02E+00	2.41E-01	1.75E-02	3.88E-02	6.93E-02	1.01E-02
E5-EL-4	8.62E-01	1.72E-02	7.09E-03	5.67E-04	5.781	8.28E+00	2.34E-01	9.53E-02	7.86E-03	1.13E-02	8.06E-02	1.18E-02
E5-EL-5	4.39E-01	8.79E-03	1.66E-02	4.99E-04	7.204	4.22E+00	1.19E-01	2.24E-01	8.06E-03	3.20E-03	8.38E-02	1.23E-02
E5-EL-6	1.31E-01	2.62E-03	3.41E-02	1.70E-03	8.616	1.26E+00	3.57E-02	4.58E-01	2.46E-02	1.39E-03	8.52E-02	1.25E-02
E5-EL-7	7.12E-02	1.42E-03	5.67E-02	2.83E-03	10.031	6.84E-01	1.94E-02	7.61E-01	4.10E-02	4.95E-04	8.57E-02	1.25E-02
E5-EL-8	7.31E-02	1.46E-03	6.90E-02	3.45E-03	11.483	7.03E-01	1.99E-02	9.27E-01	4.99E-02	3.63E-04	8.61E-02	1.26E-02
E5-EL-10	5.09E-02	1.02E-03	7.70E-02	2.31E-03	14.279	4.89E-01	1.38E-02	1.03E+00	3.73E-02	6.00E-04	8.67E-02	1.27E-02
E5-EL-12	1.99E-02	3.98E-04	8.02E-02	4.01E-03	17.075	1.91E-01	5.41E-03	1.08E+00	5.80E-02	3.42E-04	8.70E-02	1.27E-02
E5-EL-15	2.25E-03	4.51E-05	7.23E-02	2.17E-03	21.356	2.17E-02	6.13E-04	9.71E-01	3.50E-02	1.64E-04	8.72E-02	1.27E-02
E5-EL-18	3.70E-04	7.40E-06	7.31E-02	3.65E-03	25.613	3.56E-03	1.01E-04	9.82E-01	5.29E-02	1.93E-05	8.72E-02	1.27E-02
E5-EL-21	1.20E-04	3.61E-06	6.21E-02	1.86E-03	29.201	1.16E-03	4.17E-05	8.34E-01	3.01E-02	3.05E-06	8.72E-02	1.27E-02
E5-EL-CP	7.14E-01	1.43E-02	5.92E-02	1.77E-03	29.209	6.87E+00	1.94E-01	7.95E-01	2.86E-02	7.22E-02	1.35E-01	1.98E-02
E5-EDI-CP	1.82E-03	3.63E-05	5.01E-02	1.75E-03	32.349	1.75E-02	4.94E-04	6.73E-01	2.71E-02	1.05E-05	1.35E-01	1.98E-02
E5-RG-CP	1.81E-04	3.61E-06	1.06E-03	2.12E-05	38.056	1.74E-03	4.91E-05	1.43E-02	4.04E-04	1.97E-05	1.35E-01	1.98E-02
E5-Column						7.76E-05	2.19E-06	1.04E-01	3.76E-03			

Table C.26. Column E6 Elution Data Table

[illegible]

Table C.26. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Dilute Y/N	Vial	Aliquot	Diluent	Total	Dilution Factor	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr		Tare, g	Net, g	Net, g	Gross, g		ID No.	uCi Tot	Uncert	uCi Tot	Uncert
E6-EL-0	NA	NA	NA	NA	NA	NA	Y	17.5010	1.0058	9.0826	27.5894	10.0302	10-1083	1.03E+00	± 2%	6.81E-02	± 2%
E6-EL-1	22.24	1.483	0.377	1.508	0.377	1.51	Y	16.9541	1.0000	9.1635	27.1176	10.1635	10-1476	6.23E+00	± 2%	4.36E-02	± 5%
E6-EL-2	22.69	1.513	0.378	1.513	0.378	1.51	Y	16.9918	1.0000	9.1510	27.1428	10.1510	10-1477	9.43E+00	± 2%	1.17E-01	± 4%
E6-EL-3	21.69	1.446	0.361	1.446	0.372	1.49	Y	16.9597	1.0000	9.3346	27.2943	10.3346	10-1478	1.87E-01	± 2%	3.54E-03	± 4%
E6-EL-4	21.62	1.441	0.360	1.441	0.369	1.48	Y	17.0482	1.0000	9.1614	27.2096	10.1614	10-1479	6.54E-02	± 2%	2.18E-02	± 5%
E6-EL-5	20.85	1.390	0.347	1.390	0.365	1.46	N	17.4338	10.0662	NA	27.5000	1.0000	10-1480	3.63E-01	± 2%	5.51E-01	± 3%
E6-EL-6	21.16	1.410	0.353	1.410	0.363	1.45	N	17.3240	10.1760	NA	27.5000	1.0000	10-1481	1.60E-01	± 2%	5.99E-01	± 3%
E6-EL-7	21.36	1.424	0.356	1.424	0.362	1.45	N	17.4241	10.2759	NA	27.7000	1.0000	10-1482	7.39E-02	± 2%	5.78E-01	± 3%
E6-EL-8	20.93	1.395	0.349	1.395	0.360	1.44	N	17.4555	10.1445	NA	27.6000	1.0000	10-1483	3.73E-02	± 2%	6.28E-01	± 4%
E6-EL-10	42.60	2.840	0.355	1.420	0.359	1.44	N	17.3640	10.1360	NA	27.5000	1.0000	10-1484	1.05E-02	± 2%	6.18E-01	± 3%
E6-EL-12	42.42	2.828	0.353	1.414	0.358	1.43	N	17.4439	10.2561	NA	27.7000	1.0000	10-1485	3.76E-03	± 2%	6.09E-01	± 3%
E6-EL-15	63.54	4.236	0.353	1.412	0.357	1.43	N	17.6022	10.5978	NA	28.2000	1.0000	10-1486	1.64E-03	± 3%	6.44E-01	± 4%
E6-EL-18	62.20	4.147	0.346	1.382	0.355	1.42	N	17.4392	10.4608	NA	27.9000	1.0000	10-1487	8.24E-04	± 4%	6.31E-01	± 5%
E6-EL-21	53.47	3.565	0.369	1.475	0.357	1.43	N	17.3805	10.4195	NA	27.8000	1.0000	10-1488	7.98E-04	± 4%	6.14E-01	± 3%
E6-EL-CP	436.87	29.125	0.364	1.456	0.364	1.46	N	17.3993	10.1007	NA	27.5000	1.0000	10-1489	7.17E+00	± 2%	5.81E-01	± 3%
E6-EDI-CP	45.69	3.046	0.363	1.451	0.363	1.45	N	17.7279	10.0721	NA	27.8000	1.0000	10-1490	2.21E-03	± 3%	3.82E-01	± 4%
E6-RG-CP	88.64	5.909	0.352	1.407	0.352	1.41	N	17.6235	9.8765	NA	27.5000	1.0000	10-1491	5.99E-04	± 2%	7.07E-03	± 2%
E6-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1071	2.78E-02	± 2%	1.58E+00	± 3%

Table C.26. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution mmol Cs	Elution meq/g
E6-EL-0	1.03E-01	2.06E-03	6.82E-02	1.36E-03	NA	1.00E+00	2.83E-02	100%	2.83E-02	NA	NA	NA
E6-EL-1	5.81E+00	1.16E-01	4.06E-02	2.03E-03	1.483	5.65E+01	1.60E+00	5.95E-01	3.21E-02	1.51E-02	1.51E-02	2.21E-03
E6-EL-2	8.84E+00	1.77E-01	1.10E-01	4.39E-03	2.996	8.60E+01	2.43E+00	1.61E+00	7.19E-02	3.88E-02	5.39E-02	7.88E-03
E6-EL-3	1.87E-01	3.74E-03	3.55E-03	1.42E-04	4.442	1.82E+00	5.15E-02	5.20E-02	2.32E-03	2.29E-02	7.68E-02	1.12E-02
E6-EL-4	6.42E-02	1.28E-03	2.14E-02	1.07E-03	5.883	6.24E-01	1.77E-02	3.14E-01	1.69E-02	6.35E-04	7.74E-02	1.13E-02
E6-EL-5	3.60E-02	7.21E-04	5.47E-02	1.64E-03	7.273	3.51E-01	9.92E-03	8.02E-01	2.89E-02	2.44E-04	7.77E-02	1.14E-02
E6-EL-6	1.57E-02	3.14E-04	5.88E-02	1.76E-03	8.683	1.53E-01	4.31E-03	8.61E-01	3.11E-02	1.28E-04	7.78E-02	1.14E-02
E6-EL-7	7.19E-03	1.44E-04	5.62E-02	1.69E-03	10.107	6.99E-02	1.98E-03	8.24E-01	2.97E-02	5.70E-05	7.78E-02	1.14E-02
E6-EL-8	3.67E-03	7.34E-05	6.19E-02	2.17E-03	11.502	3.57E-02	1.01E-03	9.07E-01	3.66E-02	2.65E-05	7.79E-02	1.14E-02
E6-EL-10	1.04E-03	2.08E-05	6.09E-02	1.83E-03	14.341	1.01E-02	2.86E-04	8.93E-01	3.22E-02	2.34E-05	7.79E-02	1.14E-02
E6-EL-12	3.66E-04	7.33E-06	5.93E-02	1.78E-03	17.169	3.56E-03	1.01E-04	8.70E-01	3.14E-02	6.95E-06	7.79E-02	1.14E-02
E6-EL-15	1.55E-04	4.64E-06	6.07E-02	2.13E-03	21.405	1.51E-03	5.43E-05	8.90E-01	3.59E-02	3.87E-06	7.79E-02	1.14E-02
E6-EL-18	7.87E-05	3.15E-06	6.03E-02	3.02E-03	25.552	7.65E-04	3.42E-05	8.84E-01	4.76E-02	1.70E-06	7.79E-02	1.14E-02
E6-EL-21	7.65E-05	3.06E-06	5.89E-02	1.77E-03	29.117	7.44E-04	3.33E-05	8.63E-01	3.11E-02	9.69E-07	7.79E-02	1.14E-02
E6-EL-CP	7.09E-01	1.42E-02	5.75E-02	1.72E-03	29.125	6.90E+00	1.95E-01	8.42E-01	3.04E-02	7.23E-02	1.36E-01	1.98E-02
E6-EDI-CP	2.19E-04	6.58E-06	3.79E-02	1.33E-03	32.171	2.13E-03	7.69E-05	5.56E-01	2.24E-02	1.58E-06	1.36E-01	1.98E-02
E6-RG-CP	6.00E-05	1.20E-06	7.08E-04	1.42E-05	38.080	5.84E-04	1.65E-05	1.04E-02	2.93E-04	2.89E-06	1.36E-01	1.98E-02
E6-Column	NA	NA	NA	NA	NA	7.16E-05	2.02E-06	5.30E-02	1.91E-03	NA	NA	NA

Table C.27. Column F1 Elution Data Table

[illegible]

Table C.27. (contd)

Sample ID No.	Instant. Volume		Instant. Flow		Average Flow		Dilute Y/N	Vial	Aliquot	Diluent	Total	Dilution	ASO	Cs-134	Cs-134	Cs-137	Cs-137
	mL	BV	mL/min	BV/hr	mL/min	BV/hr		Tare, g	Net, g	Net, g	Gross, g	Factor	ID No.	uCi Tot	Uncert	uCi Tot	Uncert
F1-EL-0	NA	NA	NA	NA	NA	NA	Y	17.4462	0.9997	9.1968	27.6427	10.1996	10-1085	1.23E+00	± 2%	6.37E-02	± 2%
F1-EL-1	22.09	1.472	0.368	1.472	0.368	1.47	N	17.4965	10.8035	NA	28.3000	1.0000	10-1525	8.28E-02	± 2%	<1.0E-04	NA
F1-EL-2	22.23	1.482	0.364	1.458	0.366	1.47	Y	17.4594	1.0000	9.1142	27.5736	10.1142	10-1526	2.16E+01	± 2%	<6.0E-03	NA
F1-EL-3	21.27	1.418	0.367	1.467	0.366	1.47	Y	17.4667	1.0000	9.1044	27.5711	10.1044	10-1527	1.37E+00	± 2%	<7.0E-04	NA
F1-EL-4	20.27	1.352	0.338	1.352	0.359	1.44	Y	17.4599	1.0000	9.1185	27.5784	10.1185	10-1528	1.78E-01	± 2%	4.80E-03	± 4%
F1-EL-5	21.00	1.400	0.350	1.400	0.357	1.43	Y	17.5701	1.0000	9.1087	27.6788	10.1087	10-1529	1.26E-01	± 2%	2.53E-02	± 3%
F1-EL-6	20.90	1.394	0.348	1.394	0.356	1.42	N	17.5182	10.3818	NA	27.9000	1.0000	10-1530	7.63E-01	± 2%	5.35E-01	± 5%
F1-EL-7	20.60	1.373	0.343	1.373	0.354	1.42	N	17.5282	10.4718	NA	28.0000	1.0000	10-1531	3.51E-01	± 2%	6.43E-01	± 3%
F1-EL-8	20.71	1.380	0.345	1.380	0.353	1.41	N	17.6169	10.3831	NA	28.0000	1.0000	10-1532	1.77E-01	± 2%	6.45E-01	± 3%
F1-EL-10	41.49	2.766	0.346	1.383	0.352	1.41	N	17.4579	10.0421	NA	27.5000	1.0000	10-1533	5.18E-02	± 2%	5.87E-01	± 3%
F1-EL-12	40.79	2.719	0.340	1.360	0.350	1.40	N	17.4596	10.0404	NA	27.5000	1.0000	10-1534	1.82E-02	± 2%	5.89E-01	± 3%
F1-EL-15	61.43	4.096	0.341	1.365	0.348	1.39	N	17.5407	9.9593	NA	27.5000	1.0000	10-1535	5.53E-03	± 2%	6.36E-01	± 4%
F1-EL-18	61.29	4.086	0.340	1.362	0.347	1.39	N	17.4907	10.0093	NA	27.5000	1.0000	10-1536	2.75E-03	± 3%	6.29E-01	± 4%
F1-EL-21	51.81	3.454	0.432	1.727	0.355	1.42	N	17.5489	10.4511	NA	28.0000	1.0000	10-1537	2.63E-03	± 3%	7.24E-01	± 4%
F1-EL-CP	436.03	29.069	0.363	1.453	0.363	1.45	N	17.4042	10.1958	NA	27.6000	1.0000	10-1538	6.97E+00	± 2%	5.17E-01	± 3%
F1-EDI-CP	49.20	3.280	0.342	1.367	0.342	1.37	N	17.5397	10.2603	NA	27.8000	1.0000	10-1539	7.03E-03	± 2%	6.18E-01	± 4%
F1-RG-CP	80.42	5.361	0.318	1.271	0.318	1.27	N	17.3945	10.6055	NA	28.0000	1.0000	10-1540	6.29E-04	± 2%	6.41E-03	± 2%
F1-Column	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10-1072	6.09E-02	± 2%	1.82E+00	± 3%

Table C.27. (contd)

Sample ID No.	Cs-134 uCi/mL	Cs-134 Uncert	Cs-137 uCi/mL	Cs-137 Uncert	Cumulative Vol. (BV)	Cs-134 C/C ₀	Cs-134 Uncert	Cs-137 C/C ₀	Cs-137 Uncert	Instant. mmol Cs	Integrated Elution mmol Cs	meq/g
F1-EL-0	1.02E-01	2.04E-03	6.44E-02	1.29E-03	NA	1.00E+00	2.83E-02	100%	2.83E-02	NA	NA	NA
F1-EL-1	7.60E-03	1.52E-04	9.18E-06	NA	1.472	7.44E-02	2.10E-03	1.42E-04	2.85E-06	1.97E-05	1.97E-05	2.88E-06
F1-EL-2	1.93E+01	3.87E-01	5.36E-03	NA	2.955	1.89E+02	5.35E+00	8.32E-02	1.66E-03	5.05E-02	5.05E-02	7.39E-03
F1-EL-3	1.25E+00	2.50E-02	6.40E-04	NA	4.373	1.22E+01	3.46E-01	9.94E-03	1.99E-04	5.15E-02	1.02E-01	1.49E-02
F1-EL-4	1.74E-01	3.49E-03	4.70E-03	1.88E-04	5.724	1.71E+00	4.83E-02	7.30E-02	3.26E-03	3.39E-03	1.05E-01	1.54E-02
F1-EL-5	1.22E-01	2.43E-03	2.44E-02	7.33E-04	7.125	1.19E+00	3.37E-02	3.79E-01	1.37E-02	7.31E-04	1.06E-01	1.55E-02
F1-EL-6	7.29E-02	1.46E-03	5.11E-02	2.55E-03	8.518	7.14E-01	2.02E-02	7.93E-01	4.27E-02	4.78E-04	1.07E-01	1.56E-02
F1-EL-7	3.32E-02	6.65E-04	6.09E-02	1.83E-03	9.891	3.26E-01	9.21E-03	9.45E-01	3.41E-02	2.57E-04	1.07E-01	1.56E-02
F1-EL-8	1.69E-02	3.38E-04	6.15E-02	1.85E-03	11.272	1.66E-01	4.68E-03	9.55E-01	3.44E-02	1.22E-04	1.07E-01	1.56E-02
F1-EL-10	5.11E-03	1.02E-04	5.80E-02	1.74E-03	14.038	5.01E-02	1.42E-03	9.00E-01	3.24E-02	1.07E-04	1.07E-01	1.57E-02
F1-EL-12	1.80E-03	3.59E-05	5.82E-02	1.74E-03	16.757	1.76E-02	4.98E-04	9.03E-01	3.26E-02	3.31E-05	1.07E-01	1.57E-02
F1-EL-15	5.51E-04	1.10E-05	6.33E-02	2.21E-03	20.853	5.40E-03	1.53E-04	9.82E-01	3.96E-02	1.70E-05	1.07E-01	1.57E-02
F1-EL-18	2.72E-04	8.16E-06	6.23E-02	2.18E-03	24.938	2.66E-03	9.61E-05	9.67E-01	3.90E-02	5.93E-06	1.07E-01	1.57E-02
F1-EL-21	2.49E-04	7.48E-06	6.87E-02	2.40E-03	28.392	2.44E-03	8.80E-05	1.07E+00	4.30E-02	3.17E-06	1.07E-01	1.57E-02
F1-EL-CP	6.78E-01	1.36E-02	5.02E-02	1.51E-03	29.069	6.64E+00	1.88E-01	7.80E-01	2.81E-02	6.79E-02	1.27E-01	1.86E-02
F1-EDI-CP	6.82E-04	1.36E-05	6.00E-02	2.10E-03	32.348	6.68E-03	1.89E-04	9.32E-01	3.76E-02	5.39E-06	1.27E-01	1.86E-02
F1-RG-CP	5.87E-05	1.17E-06	5.98E-04	1.20E-05	37.710	5.75E-04	1.63E-05	9.28E-03	2.62E-04	7.01E-06	1.27E-01	1.86E-02
F1-Column	NA	NA	NA	NA	NA	1.59E-04	4.51E-06	6.48E-02	2.34E-03	NA	NA	NA

Table C.28. Solution Density Data Table

Solution ID No.	Method Type	Balance ID No.	Pipette ID No.	Set (mL)	Repetitive Mass (g)					Avg (g)	Temp (°C)	Avg (mL)	1 σ SD	% RSD	Density g/mL
					1st	2nd	3rd	4th	5th						
H50M-1	Pipette	N04143	K0203515E	1.000	1.0109	1.0106	1.0102	1.0112	1.0113	1.0108	18.9	1.0124	0.0005	0.04%	1.0124
H50M-2	Pipette	N04143	K0203515E	1.000	1.0114	1.0110	1.0108	1.0121	1.0115	1.0114	18.9	1.0130	0.0005	0.05%	1.0130
H50M-3	Pipette	N04143	K0203515E	1.000	1.0097	1.0095	1.0095	1.0077	1.0080	1.0089	18.9	1.0105	0.0010	0.09%	1.0105
2.0 M HNO ₃	Pipette	N04143	K0203515E	1.000	1.0638	1.0660	1.0653	1.0708	1.0605	1.0653	18.9	1.0670	0.0037	0.35%	1.0670
0.1 M NaOH	Pipette	N04143	K0203515E	1.000	0.9942	1.0015	0.9997	1.0009	1.0011	0.9995	18.9	1.0011	0.0030	0.30%	1.0011
0.5 M NaOH	Pipette	N04143	K0203515E	1.000	1.0262	1.0209	1.0193	1.0183	1.0182	1.0206	18.9	1.0222	0.0033	0.33%	1.0222
0.5 M NaOH	Pipette	N04143	K0203515E	1.000	1.0379	1.0199	1.0207	1.0206	1.0262	1.0251	18.9	1.0267	0.0076	0.74%	1.0267
1.0 M NaOH	Pipette	N04143	K0203515E	1.000	1.0363	1.0370	1.0373	1.0374	1.0350	1.0366	18.9	1.0382	0.0010	0.10%	1.0382
H15D1	Pipette	N04143	K0203515E	1.000	0.9856	0.9998	0.9953	0.9954	0.9929	0.9938	18.9	0.9954	0.0052	0.52%	0.9954
H02D2	Pipette	N04143	K0203515E	1.000	0.9975	0.9978	0.9986	0.9979	1.0013	0.9986	18.9	1.0002	0.0016	0.16%	1.0002
H28D3	Pipette	N04143	K0203515E	1.000	1.0066	1.0075	1.0064	1.0058	1.0096	1.0072	18.9	1.0088	0.0015	0.15%	1.0088
H15D4	Pipette	N04143	K0203515E	1.000	0.9817	0.9903	0.9909	0.9942	0.9815	0.9877	18.9	0.9893	0.0058	0.59%	0.9893
H15D5	Pipette	N04143	K0203515E	1.000	0.9873	0.9869	1.0005	1.0247	0.9986	0.9996	18.9	1.0012	0.0154	1.54%	1.0012
H15D6	Pipette	N04143	K0203515E	1.000	0.9942	0.9941	0.9968	0.9825	0.9899	0.9915	18.9	0.9931	0.0056	0.57%	0.9931
H15E1	Pipette	N04143	K0203515E	1.000	0.9913	1.0114	0.9926	0.9990	0.9975	0.9984	18.9	0.9999	0.0080	0.80%	0.9999
H07E2	Pipette	N04143	K0203515E	1.000	1.0021	1.0026	1.0018	1.0029	1.0024	1.0024	18.9	1.0039	0.0004	0.04%	1.0039
H23E3	Pipette	N04143	K0203515E	1.000	0.9972	0.9961	0.9964	1.0025	1.0029	0.9990	18.9	1.0006	0.0034	0.34%	1.0006
H23E4	Pipette	N04143	K0203515E	1.000	1.0060	1.0046	1.0036	1.0027	1.0054	1.0045	18.9	1.0060	0.0013	0.13%	1.0060
H07E5	Pipette	N04143	K0203515E	1.000	0.9989	1.0032	1.0023	1.0062	1.0052	1.0032	18.9	1.0047	0.0028	0.28%	1.0047
H15E6	Pipette	N04143	K0203515E	1.000	0.9988	1.0035	0.9994	0.9917	1.0007	0.9988	18.9	1.0004	0.0044	0.44%	1.0004
H28F1	Pipette	N04143	K0203515E	1.000	1.0062	1.0074	1.0062	1.0075	1.0075	1.0070	18.9	1.0085	0.0007	0.07%	1.0085
Feed #5B17	Flask	1125202532	NA	2000	2410.2	NA	NA	NA	NA	2410.2	18.9	1998.2	NA	NA	1.2062
					All Variable HNO3					0.9994	18.9	1.0009	0.0077	0.77%	1.0009
					All 0.50 M HNO3					1.0104	18.9	1.0120	0.0013	0.13%	1.0120
					Dupl 0.5 M NaOH					1.0228	18.9	1.0244	0.0060	0.59%	1.0244

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