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Column Experiments for Radionuclide Adsorption Studies of the Culebra Dolomite: Retardation Parameter Estimation for Non-Eluted Actinide Species

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Column Experiments for Radionuclide Adsorption Studies of the Culebra Dolomite: Retardation Parameter Estimation for Non-Eluted Actinide Species

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ABSTRACT

The U.S. Department of Energy (DOE) has been developing a nuclear waste disposal facility, the Waste Isolation Pilot Plant (WIPP), located approximately 42 km east of Carlsbad, New Mexico. The WIPP is designed to demonstrate the safe disposal of transuranic wastes produced by the defense nuclear-weapons program. Performance assessment analyses (U.S. DOE, 1996) indicate that human intrusion by inadvertent and intermittent drilling for resources provide the only credible mechanisms for significant releases of radionuclides from the disposal system. These releases may occur by five mechanisms: (1) cuttings, (2) cavings, (3) spallings, (4) direct brine releases, and (5) long-term brine releases. The first four mechanisms could result in immediate release of contaminant to the accessible environment. For the last mechanism, migration pathways through the permeable layers of rock above the Salado are important, and major emphasis is placed on the Culebra Member of the Rustler Formation because this is the most transmissive geologic layer in the disposal system. For reasons of initial quantity, half-life, and specific radioactivity, certain isotopes of Th, U, Am, and Pu would dominate calculated releases from the WIPP. In order to help quantify parameters for the calculated releases, radionuclide

transport experiments have been carried out using five intact-core columns obtained from the Culebra dolomite member of the Rustler Formation within the Waste Isolation Pilot Plant (WIPP) site in southeastern New Mexico. This report deals primarily with results of mathematical analyses related to the retardation of ^{228}Th, ^{241}Pu, and ^{241}Am in two of these cores (B-Core - VPX26-11A and C-Core - VPX28-6C). All B-Core transport experiments were done using Culebra-simulant brine relevant to the core recovery location (the WIPP air-intake shaft - AIS). Most experiments with C-Core were done with AIS brine with some admixture of a brine composition (ERDA-6) that simulated deeper formation brines. No significant changes in transport behavior were observed for changes in brine. Hydraulic characteristics (i.e., apparent porosity and apparent dispersion coefficient) for the cores were obtained via experiments using conservative tracer ^{22}Na. Elution experiments carried out over periods of a few days with tracers ^{232}U and ^{239}Np indicated that these tracers were weakly retarded as indicated by delayed elution of these species. Elution experiments with tracers ^{228}Th, ^{241}Pu, and ^{241}Am were performed, but no elution of any of these species was observed in any flow experiment to date, including experiments of up to two years duration. However, B-Core was subjected to tomographic analysis from which a retardation factor can be inferred for ^{228}Th. Moreover, the fact of non-elution for ^{241}Pu and ^{241}Am after more than two years brine flow through C-Core can be coupled with the minimum detectable activity for each of these species to compute minimum retardation factors in C-Core. The retardation factors for all three species can then be coupled with the apparent hydraulic characteristics to estimate an apparent minimum solution/rock distribution coefficient, K_d, for each actinide. The specific radionuclide isotopes used in these experiments were chosen to facilitate analysis. Even though these isotopes are not necessarily the same as those that are most important to WIPP performance, they are isotopes of the same elements, and their chemical and transport properties are therefore identical to those of isotopes in the WIPP inventory. The retardation factors and K_d values deduced from experimental results strongly support the contention that sorption in the Culebra provides an effective barrier to release of Th, Pu, and Am during the regulatory period.

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INTRODUCTION

Under the authorization of Public Law 96-164 (1979), the U.S. Department of Energy (DOE) has been developing a nuclear waste disposal facility, the Waste Isolation Pilot Plant (WIPP), located approximately 42 km east of Carlsbad, New Mexico. The WIPP is designed to demonstrate the safe disposal of transuranic wastes produced by the defense nuclear-weapons program. Transuranic waste is defined as waste contaminated with radionuclides having an atomic number greater than 92, a half-life greater than 20 years and a concentration greater than 100 nCi/g (U.S. EPA, 1993). This radioactive waste is regulated by U.S. Environmental Protection Agency regulations 40 CFR Part 191 (U.S. EPA, 1993). The regulation sets limits on cumulative radioactive release to the accessible environment over 10,000 years and requires that Performance Assessment (PA) analyses be performed to demonstrate WIPP facility compliance with the regulations.

Performance assessment analyses (U.S. DOE, 1996) indicate that human intrusion by inadvertent and intermittent drilling for resources provide the only credible mechanisms for significant releases of radionuclides from the disposal system. These releases may occur by five mechanisms: (1) cuttings, (2) cavings, (3) spallings, (4) direct brine releases, and (5) long-term brine releases. The first four mechanisms could result in immediate release of contaminant to the accessible environment. For the last mechanism, migration pathways through the permeable layers of rock above the Salado are important, and major emphasis is placed on the Culebra Member of the Rustler Formation because this is by far the most transmissive geologic layer in the disposal system. Considerable empirical and conceptual modeling work has been done on the hydrology (Meigs *et al.*, 1997) and contaminant-transport (Brush, 1998; Holt, 1997) characteristics of the Culebra dolomite.

The rationale for selection of certain isotopes of Th, U, Am, and Pu for Culebra transport calculations in performance assessment is given in the WIPP Compliance Certification Application (CCA, U.S. DOE, 1996, Appendix WCA). For reasons of initial quantity, half-life, and specific radioactivity, the isotopes listed in the CCA would dominate calculated releases from the WIPP. The rationale for the specific isotopes used in the intact-core column experiments has to do with radiolytic analysis of the species and is discussed in detail by Lucero *et al.* (1998).

Empirical batch sorption experiments have provided most of the actinide-dolomite sorption values submitted for performance assessment calculations (Brush, 1998). However, flow experiments with intact rock columns of Culebra dolomite have also been used to demonstrate actinide retardation. The intact-core column flow experiments provide information on the effects of advective fluid flow on sorption behavior in the Culebra dolomite at small scale. The technical scope and requirements for these experiments are described in a test plan (Lucero *et al.*, 1995) and in a report on the work (Lucero *et al.*, 1998). In the experiments, steady state flows of Culebra-relevant brine were first established in several intact-core columns that had been recovered from the Culebra at the location of the WIPP Air-Intake Shaft. At various times after steady-state flow was established in a given core, relatively small pulses of brine containing one or more dissolved radioactive species were injected into the general flow at the upstream

end of the column. The effluent brine was then analyzed as a function of time by either γ-ray spectroscopy or liquid scintillation counting for each of the injected species. Selection criteria for isotopes used in the intact-core column experiments included half-life, nature of decay emission, and possible interference from radioactive daughter products. Lucero *et al.* (1998) discusses experimental isotope selection in detail.

Experimental results indicate that the species ^{3}H (as tritiated water) and $^{22}Na^{+}$ are "conservative tracers" that are not significantly retarded by surface-chemical interactions with the rock. As described by Lucero *et al.* (1998), elution times for ^{3}H and $^{22}Na^{+}$ were used to estimate core hydraulic characteristics such as apparent porosity and apparent dispersion coefficient. In addition, ^{22}Na is a positron emitter, and the resulting 0.51 MeV γ-ray emission can be used in γ-ray emission tomography to estimate the degree of brine access to the core porosity (Behl and Lucero, 1996). The actinide species $^{232}UO_2^{++}$ and $^{239}NpO_2^{+}$ have been observed to elute with some degree of retardation from all columns into which they were introduced. On the other hand, none of the species ^{241}Am, ^{241}Pu, and ^{228}Th has been observed to elute from any of the columns into which they were introduced.

Transport retardation characteristics of each eluted radioactive species were inferred from species elution time dependence using computer code COLUMN, a one-dimensional transport code, with single-porosity and dual-porosity capabilities, that was first developed in the C++ programming language by Budge (1996) for use on UNIX workstations. The UNIX version (COLUMN 1.3) was relatively difficult to use because of the somewhat awkward input files required. Brown *et al.* (1997) developed a Windows version (COLUMN 1.4) that uses a Microsoft Visual Basic interface to simplify input. COLUMN 1.4 is designed to run under any of the Microsoft Windows 95, Windows NT 3.51, and Windows NT 4.0 operating systems. Both versions of COLUMN have been approved for use under quality assurance procedures relevant to the WIPP Project (Sandia National Laboratories, 1996, 1997). COLUMN 1.4 has been used to infer retardation parameters from radionuclide elution data for a large number of experiments (Lucero *et al.*, 1998).

Holt (1997) used a multi-rate dual-porosity model to interpret results of field conservative tracer tests at the WIPP site (Meigs *et al.*, 1997). Holt (1997) argues that, for the small geometry of the intact-core column experiments with the conservative tracer Na^{+} and the weakly retarded tracers U(VI) and Np(V), only the advective porosity is accessed by the tracer during the short transit times characteristic of these experiments. Since only a fraction of the total porosity is involved in the experiments, the single-porosity treatment of the small-scale intact rock-column elution experiments will tend to provide low values for retardation factors calculated for the weakly-retarded species.

The objective of the present report is to provide estimates of retardation parameters for ^{228}Th, ^{241}Pu, and ^{241}Am as determined from the results of brine-flow experiments with intact-core columns obtained from the Culebra dolomite member of the Rustler formation near the WIPP site in southeastern New Mexico. These estimates can then be compared to values obtained in other ways. One can also describe the impact of actinide retardation on possible actinide transport from the repository to the general environment.

Computerized γ-ray emission tomography of some of the ^{228}Th decay daughter products permits determination, with approximately 1-centimeter resolution, of ^{228}Th location in a core after a period of brine flow. For ^{241}Pu and ^{241}Am, estimates of minimum retardation parameters can be obtained from core hydraulic characteristics, total flow duration (volume), and non-elution of the actinides above the minimum detectable activity for each actinide.

FLOW EXPERIMENTS

Figure 1 shows a schematic diagram of the apparatus used for intact-core column flow and transport experiments. Detailed information on test materials, equipment and procedures for the intact-core column flow experiments are presented in Behl and Lucero (1996), Lucero *et al.* (1998), and WIPP Laboratory Notebooks (Lucero, 1995-1996). The pumping system shown in Figure 1 can be used to provide a constant flow rate of a given brine composition through an intact-core column. In addition, there is provision to inject a relatively small volume of radioisotope-doped brine at the injection end of the column. Finally, the experimenters can collect fractions of the effluent brine at the outlet end of the column. The detection equipment used to perform γ-ray emission tomography is not shown in Figure 1. This equipment is described briefly in the test plan (Behl and Lucero, 1996) and more fully in laboratory notebooks (Lucero, 1995-1996).

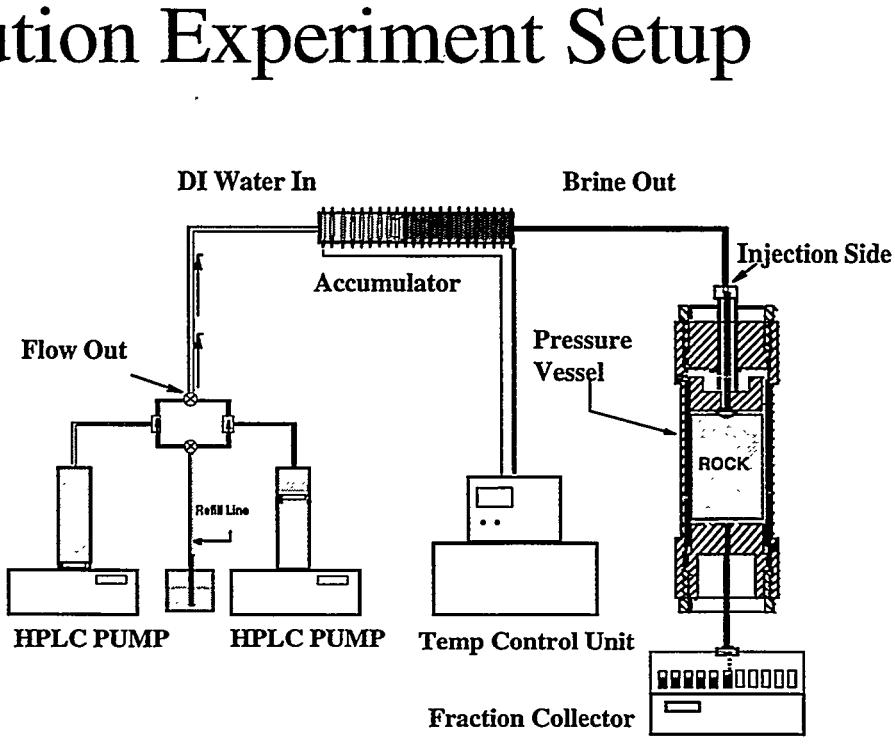

Figure 1. Schematic diagram of the apparatus used for intact-core column flow and transport experiments.

The sections below summarize procedures and parameters specific to intact-core columns discussed in this report.

Core Properties

Table 1 gives a description of the VPX26 and VPX28 bore holes from which B-Core and C-Core were recovered, and Table 2 summarizes the physical dimensions and estimated hydraulic properties of the cores. The porosity estimates given in Table 2 were calculated by Lucero *et al.* (1998) and represent the estimated total porosity available in each core.

Table 1. Borehole properties.

Borehole	VPX 26	VPX 28
Depth below surface (m)	218.2	219.9
Side of AIS	North	South
Borehole flow (L/min)	0.16	0.16
pH	7.69	8.09
Temperature (°C)	20.9	20.1

Table 2. Test sample core properties.

Series	B	C
Core: VPX	26-11A	28-6C
Cut core measures		
Length (cm)	50.9	10.2
Diameter (cm)	14.5	14.5
Volume (cm^3)	8404	1666
Wet weight (gm)	20,900	4146
Estimated Properties		
Dry bulk density (gm/cm^3)	2.40	2.40
Porosity	0.14	0.14

Injection and Flow Conditions

Table 3 summarizes the test information for the flow experiments performed on B- and C-Cores. All experiments except C-5 and C-7 were carried out using air-intake shaft (AIS) brine. Experiments C-5 and C-7 were performed using ERDA-6 brine (which is typical of the Salado formation). Lucero *et al.* (1998) observed no significant impact of brine composition on actinide retardation. One notes from Table 3 that ^{228}Th was injected only once into B-Core (Experiment B-3), and that a solution spike containing ^{241}Pu and ^{241}Am was injected only once into C-Core (Experiment C-3).

γ-Ray Emission Tomography Experiments

The purpose of the γ-ray tomography experiments was to attempt formation of a three-dimensional image of radioisotopes within a core. As defined in Behl and Lucero (1996), the spatial resolution for location of γ emitter was about 1 cm. Thus, although one could obtain a qualitative image, quantification of the image was limited in resolution. The main use of tomography was with the 0.51-MeV signature of ^{22}Na. However, it was possible to study the location of ^{228}Th in the core as well.

Table 3. Summary of B- and C-Core flow experiments

Test Number (Start Date)	Tracer	Spike Volume (mL)	Pump Speed (mL/min)	Test Objective
B-1 (9/6/95)	0.246 μCi ^{3}H	13	0.1	Porosity measurement
B-2 (9/22/95)	8.69 μCi ^{22}Na 375 μCi ^{239}Np	18	0.1	γ-Tomography; Np Retardation
B-3 (10/4/95)	8.23 μCi ^{22}Na 70.7 μCi ^{232}U 70.7 μCi ^{228}Th	13.7	0.1	γ-Tomography, U and Th Retardation
B-4 (11/6/95)	300 μCi ^{22}Na	2000	0.1	γ-Tomography
B-5 (12/7/95)	274 μCi ^{22}Na	2000	0.05	γ-Tomography
B-6 (1/30/96)	4.22 μCi ^{22}Na 5.94μCi ^{232}U	17	0.05	U Retardation
B-7 (4/16/96)	9.0 μCi ^{22}Na 4.28 μCi ^{232}U	18	0.5	U Retardation
B-8 (4/23/96)	220 μCi ^{22}Na	2000	0.5	γ-Tomography
C-1 (5/1/95)	1μCi ^{22}Na 10μCi ^{3}H	20	0.1	Porosity
C-2 (6/19/95)	3.7μCi ^{22}Na 10μCi ^{232}U 10μCi ^{228}Th	20	0.1	U and Th Retardation
C-3 (7/10/95)	3.3μCi ^{22}Na 20μCi ^{241}Pu 5.6μCi ^{241}Am	20	0.1	Pu and Am Retardation
C-4 (7/26/95)	11.5μCi ^{22}Na 78.3μCi ^{239}Np	10	0.1	Np Retardation
C-5 * (9/13/95)	3.4μCi ^{22}Na 26.8μCi ^{239}Np 4.8μCi ^{232}U 4.8μCi ^{228}Th	10	0.1	Evaluate Brine Effects on Np, U and Th Retardation
C-6 (10/18/95)	5.3μCi ^{22}Na 175μCi ^{239}Np	8.5	0.1	Duplicate Np Retardation
C-7 * (11/17/95)	6.83μCi ^{22}Na 327μCi ^{239}Np 50μCi ^{232}U	10	0.1	Duplicate Brine Effects
Pause (4/9/96)				
Restart (6/4/96)			0.05	
End (9/2/97)				

* All experiments except C-5 and C-7 were carried out using air-intake shaft (AIS) brine. Experiments C-5 and C-7 were performed using ERDA-6 brine (typical of the Salado formation). Lucero *et al.* (1998) observed no significant impact of brine composition on retardation of eluted actinides ^{232}U and ^{239}Np.

After injection of ^{228}Th into B-Core, brine flow was maintained at 0.1 mL/min for the following 64 days. The flow rate was then reduced to 0.05 mL/min, the rate that was maintained for the following 131 days.

Although ^{228}Th is itself primarily an α-particle emitter, its decay chain includes the isotopes ^{224}Ra ($t_{1/2}$ = 3.7 d, 241 keV γ) and ^{212}Pb ($t_{1/2}$ = 10.6 h, 239 keV γ). The half-lives of both these daughter products are significantly less than that of ^{228}Th (1.9 a), so the daughters grow rapidly into equilibrium with the decaying ^{228}Th.

Figure 2 shows results of 240-keV γ-ray emission tomography of the B-Core taken at various depths below the brine inlet as functions of time for about one month after initial ^{228}Th injection. Within 200 hours, the daughters appear to have reached steady state, which is consistent with their short half-life values. More interesting, however, is the fact that the signal drops off rapidly with distance from the inlet. Figure 3 shows γ-ray emission tomography data for the same experiment as a function of distance from the inlet at various times after injection. The 192-day tomography was performed 128 days after the flow rate was reduced to 0.05 mL/min.

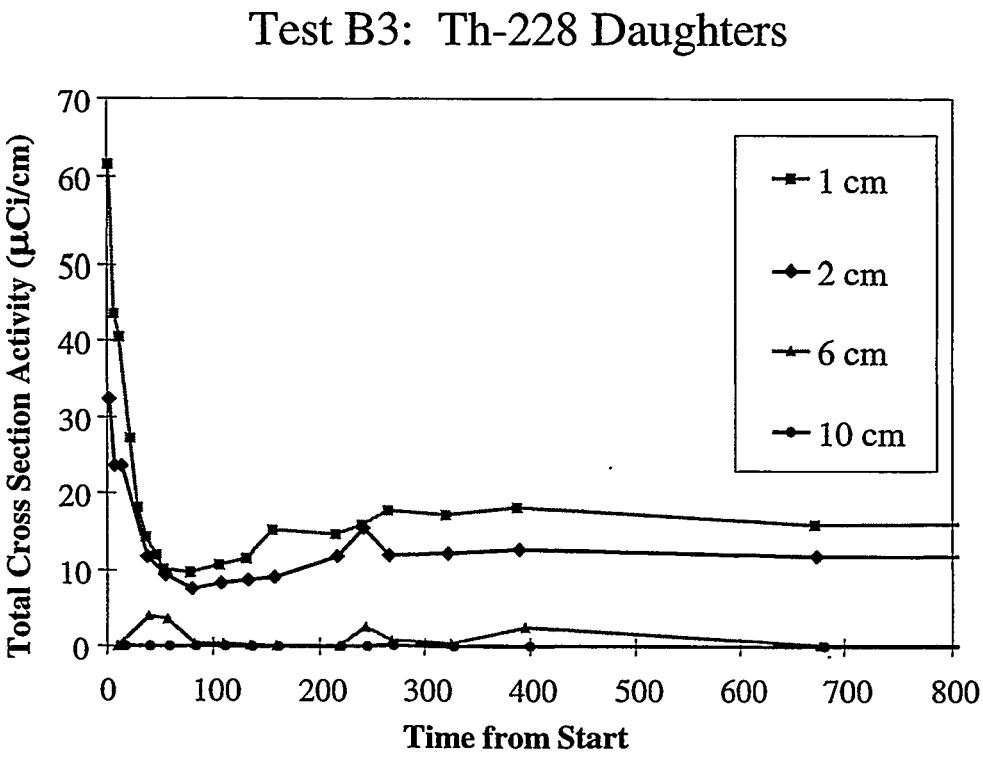

Figure 2. Total cross section activity for ^{228}Th daughters ^{224}Ra and ^{212}Pb (at 240 keV) as a function of time at various depths below the brine inlet in B-Core.

Test B3: Th-228 Daughters

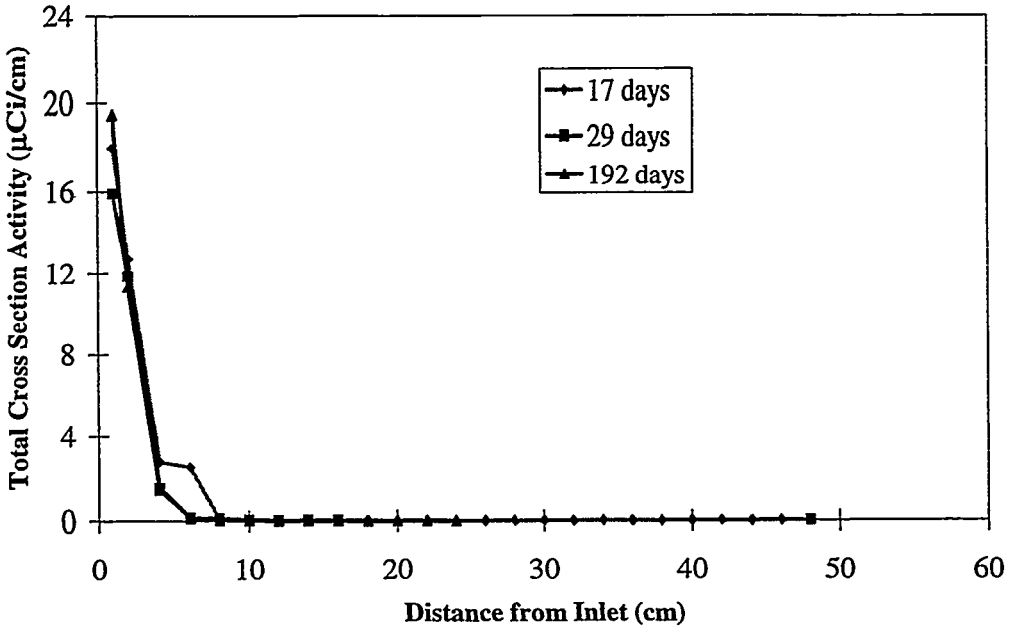

Figure 3. Total cross section activity for ^{228}Th daughters ^{224}Ra and ^{212}Pb (at 240 keV) as a function of depth below the brine inlet in B-Core at various times.

Elution Experiments with ^{241}Pu and ^{241}Am

The purpose of the ^{241}Pu and ^{241}Am elution experiment with C-Core (Test Number C-3) was to determine retardation parameters for these isotopes by measuring breakthrough of the isotopes at the outlet end of C-Core. In fact, breakthrough was never observed for either isotope. Based on this fact and on the known minimum detectable activity for each isotope, it is possible to estimate minimum values for the retardation parameters.

After injection of ^{241}Am and ^{241}Pu on 7/10/95, brine flow was maintained at 0.1 mL/min until 4/9/96, for 274 calendar days. However, Lucero (1995-1996) reports only 269 flow days due to a five-day flow interruption during December 1995. Flow was interrupted from 4/9/96 until 6/4/96, when flow was re-initiated at the reduced rate of 0.05 mL/min. The 0.05 mL/min flow rate was maintained from 6/4/96 until 9/2/97, on which date the C-Core experiments were suspended. Total flow time at the reduced rate was 455 days. A plot of cumulative flow vs. time is given in Figure 5. The total brine flow volume from the injection of ^{241}Am and ^{241}Pu to final experiment suspension was 71.5 L.

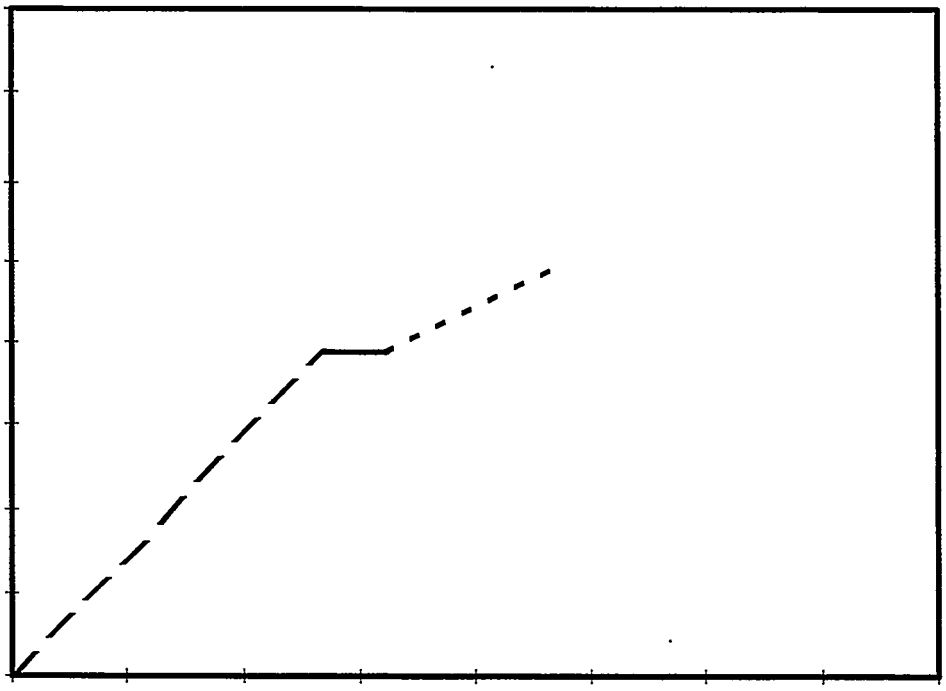

Figure 5. Effluent volume vs. time for C-Core experiments with ^{241}Pu and ^{241}Am.

ESTIMATION OF RETARDATION PARAMETERS

Estimation of ^{228}Th Retardation Parameter from γ-Ray Emission Tomography

Any attempt to estimate a ^{228}Th retardation parameter with the computational tool available (the COLUMN code) from the experimental data of Figures 2 and 3 is complicated by the change in flow rate 64 days after initial ^{228}Th injection. However, because the single-porosity transport model is linear and because the experimental observations indicate very little migration of the ^{228}Th, it seems reasonable to use brine volume, rather than time, as the independent variable for comparing experimental results to model predictions. Parker and van Genuchten (1984) defined a transformation of variables that permits one to use pore volumes rather than time as the independent variable for the linear equilibrium single-porosity transport equation. This transformation of variables for both B-Core and C-Core experiments is discussed in Appendix A. We can use the transformed variables and parameters in COLUMN 1.4 to account for the change in flow rate and to calculate ^{228}Th depth profiles as functions of retardation coefficient R. Using transformed variables, the COLUMN 1.4 output provides *dissolved* actinide concentration as a function of fractional distance through the intact-core column. The experimental activity data of Figure 3 are proportional to ^{228}Th concentration per unit volume of rock plotted as a function of depth in centimeters. Thus, comparison of the calculation results with the data of Figure 3 requires transformations of the calculated

depth and concentration variables. By Equation A-3, the depth variable used for calculation was Z, units of core lengths. Thus, the depth in centimeters is z = L Z, where L = 50.9 cm. Dissolved concentration, C_{sol}, can be converted to concentration in the rock, C_T, via the formula in Equation 1, which is derived in Appendix B.

$$C_T = \theta C_{sol} R \quad (1)$$

In Equation 1, θ is the porosity used for the calculations, C_{sol} is the calculated dissolved concentration, and R is the apparent retardation factor.

COLUMN 1.4 uses or creates two input files and generates one or two output files. The first input file is a "*.inp" file that contains two columns. The first column gives z values at which dissolved actinide concentration is to be calculated, and the second column gives a time value for the calculation. Variable z implies fixed time, and variable time implies fixed z. Appendix C contains a listing of the file "Th_vs_Z_Vol.inp." The first column of the listing gives depths Z at which dissolved ^{228}Th concentration was to be calculated (in units of core length). The second column gives the time at which the calculations were to be performed (in units of pore volume).

The second COLUMN 1.4 input file is a "*.col" file that contains control information for the calculations to be performed. This information includes a run title, input and output file names, model identification, curve type, parameter values, and information on input spikes. For this report, three calculations were performed for thorium, at retardation values of 5,000, 10,000, and 50,000. The three corresponding "*.col" files are listed in Appendix D.

The two COLUMN 1.4 output files are "*.log" and "*.out" files. The "*.log" file contains run identification information from the input "*.col" file as well as computational results. Thus, only the "*.log" files for the three ^{228}Th calculations are listed in Appendix E.

Finally, Microsoft Excel 97 spreadsheet software was used to transform several of the COLUMN 1.4 output variables for comparison with experimentally observed data. First, depth Z was converted from dimensionless units of core length to depth z in centimeters. Second, calculated solution concentration for each of the three retardation values was converted to concentration in the rock via Equation (1). Third, each calculated total concentration value for a given retardation value was divided by the maximum calculated concentration value for that retardation value to obtain a relative calculated concentration profile. Finally, each observed value of total ^{228}Th daughter activity was divided by the maximum observed total ^{228}Th daughter activity to obtain a relative observed activity profile. The Microsoft Excel 97 chart capability was then used to co-plot the relative calculated ^{228}Th concentration profiles with the observed relative total ^{228}Th daughter activity profile. Appendix F contains: a) the Microsoft Excel 97 spreadsheet with the computational results; b) a spreadsheet that reports formulas that were used to generate the computational results; and c) an Excel 97 chart that depicts the relation of calculated to observed concentration profiles. Row and column indices are included in the two spreadsheets, which allows for connection between the computational results and the formulas used to compute them. The graphical data are also included as Figure 4. It is obvious from Figure 4 that there is rather good agreement between the observed relative

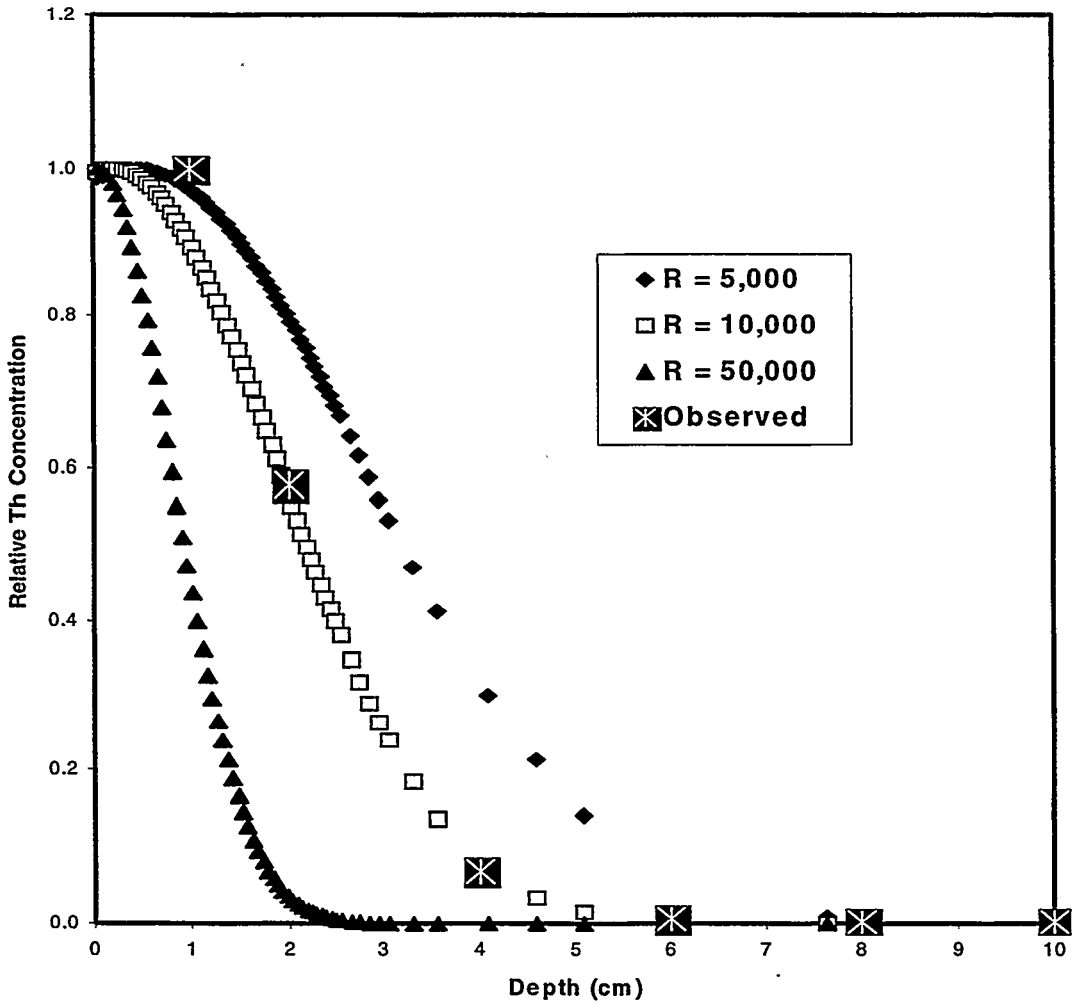

Figure 4. Comparison of relative observed total cross section activity for ^{228}Th daughters ^{224}Ra and ^{212}Pb with relative total concentration of ^{228}Th in B-Core, calculated for three different retardation values, R = 5,000, 10,000, and 50,000.

concentration profile and the relative concentration profile calculated for retardation parameter R(^{228}Th) = 10,000.

Estimation of ^{241}Pu and ^{241}Am Retardation Parameters

For the C-Core experiments, there are no data regarding a concentration profile of either ^{241}Pu or ^{241}Am. However, one can use the fact that no elution of either isotope has been observed above its minimum detectable activity (MDA) to estimate minimum retardation parameters for the isotopes.

As was true for ^{228}Th, attempts to model transport of ^{241}Pu and ^{241}Am using the code COLUMN 1.4 are complicated by the pause in flow and the change in flow rate for the C-Core experiments. However, it again seems reasonable to use effluent brine volume as the independent variable for modeling calculations. The Parker and van Genuchten

(1984) variable transformations for ^{241}Pu and ^{241}Am are discussed in Appendix A. Unlike the case with ^{228}Th, we do not seek to match a measured concentration depth profile. Rather, we seek to estimate the minimum retardation parameter R that can be used to explain the fact that actinide elution has not been observed even for very large brine-flow volume.

We use the transformed variables and parameters in COLUMN 1.4 to account for changes in the flow rate and to calculate effluent ^{241}Pu and ^{241}Am concentrations as functions of time (eluted volume) and retardation coefficient R. The eluted volume for experiment C-3 is calculated in Appendix A. The most common use of COLUMN 1.4 is to calculate actinide concentration in effluent brine at the outlet of an intact-core column. Our strategy for estimating the retardation parameter is to carry out a series of calculations at different values of R, seeking the minimum R value for which we would predict observable actinide breakthrough at the known total effluent volume.

It is convenient to scale actinide concentrations as multiples of the minimum detectable activity for each actinide. COLUMN 1.4 can then be used for a given R-value to calculate scaled eluted concentration as a function of effluent volume. At the critical R-value for a given actinide, a plot of calculated scaled eluted concentration should achieve the value 1.0 for effluent volume equal to the total observed effluent volume.

Before the calculations can be carried out, however, it is necessary to examine critically the ^{241}Pu and ^{241}Am input concentrations listed in Table 3. Appendix A contains detailed discussion of the saturated concentrations used in the calculations and the rationale used for developing input parameters for the COLUMN 1.4 calculations. Briefly, using minimum saturated concentrations reported by Craft and Siegel (1998), we deduce that the initial ^{241}Am spike was probably supersaturated by a factor of 52.4. The ^{241}Pu spike was probably not supersaturated, whether the ^{241}Pu was present as $^{241}Pu^{4+}$ or $^{241}Pu^{5+}$. Thus, for ^{241}Pu, calculations were carried out using input parameters derived from the data in Table 3. For ^{241}Am, which almost certainly was present as $^{241}Am^{3+}$, calculations were carried out using parameters derived directly from the data in Table 3 and also for a saturated solution of $^{241}Am^{3+}$.

For the calculations carried out for ^{241}Pu and ^{241}Am, COLUMN 1.4 uses only the "*.col" file, which contains control information for the calculations to be performed. This information includes a run title, input and output file names, model identification, curve type, parameter values, information on input spikes, and distance-time specifications for the calculations. For both ^{241}Pu and ^{241}Am, the distance was fixed at 1.0 (units of column length), and the maximum "time" was set at 1,290 (units of pore volume). Calculations were done for pore-volume increments of 12.9 to generate 100-point plots.

Three calculations were performed for ^{241}Pu, at retardation values of 20,000, 20,500, and 21,000. The three corresponding "*.col" files are listed in Appendix H, and the three corresponding "*.log" files (output) are listed in Appendix I.

Microsoft Excel 97 spreadsheet software was used to transform several of the COLUMN 1.4 output variables for ^{241}Pu to a format that could be plotted conveniently. Effluent volume was converted from dimensionless units of pore volume to volume in liters. The calculated solution concentration for each of the three retardation values was left in terms

of multiples of the minimum detectable activity per unit volume to facilitate visual inspection of the plotted values. The Microsoft Excel 97 chart capability was used to co-plot the calculated ^{241}Pu eluted relative concentrations as functions of effluent volume for each of the three retardation values. Appendix J contains: a) the Microsoft Excel 97 spreadsheet with the computational results; b) a spreadsheet that reports formulas that were used to generate the computational results; and c) an Excel 97 chart that depicts the calculated eluted ^{241}Pu concentration as a function of effluent volume. Row and column indices are included in the two spreadsheets, which allows for connection between the computational results and the formulas used to compute them. The graphical data are also included as Figure 6. If detectable ^{241}Pu breakthrough had been observed just before flow was stopped at 71.7 L, we would conclude that $20{,}000 < R < 21{,}000$. Since detectable ^{241}Pu breakthrough was not observed, we conclude $R \geq 2 \times 10^4$ for ^{241}Pu in these experiments.

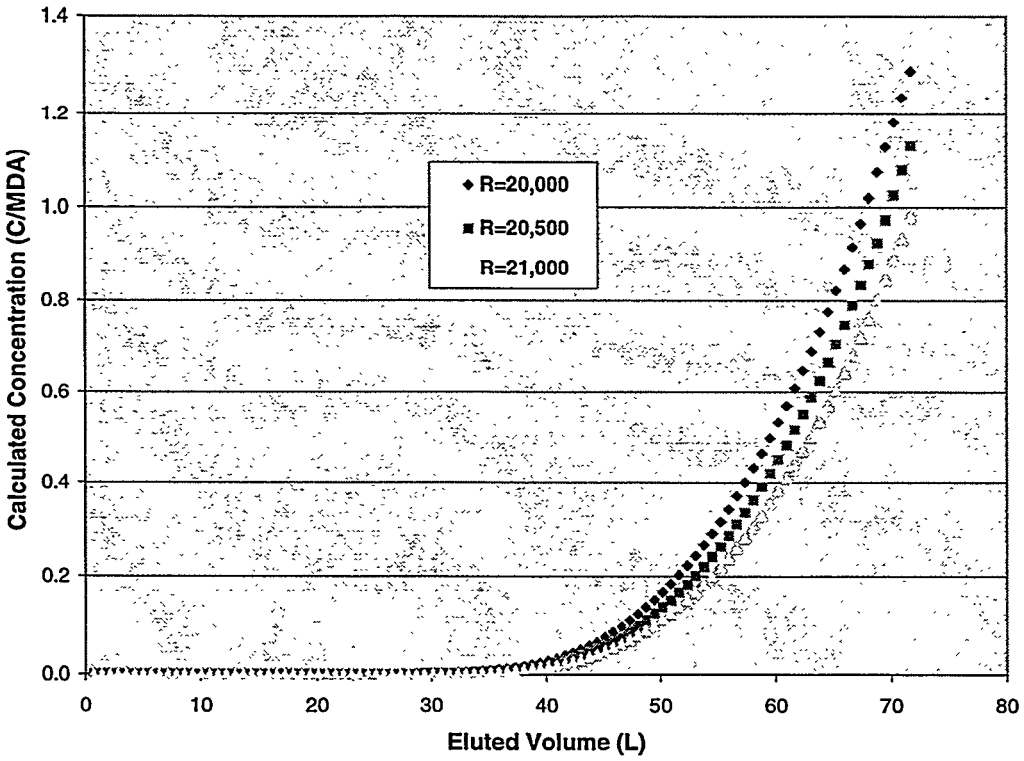

Figure 6. Calculated relative eluted concentration vs. effluent volume for ^{241}Pu elution through C-Core.

Nine calculations were performed for ^{241}Am. The first three calculations were performed assuming a 20-mL input spike at the full concentration reported in Table 3 for Test C-3 (0.28 µCi/mL). Calculations were done at retardation values of 25,500, 26,000, and 26,500. The three corresponding "*.col" files are listed in Appendix K, and the three corresponding "*.log" files (output) are listed in Appendix L. Appendix M contains: a) a Microsoft Excel 97 spreadsheet with the computational results for the three R values; b) a

spreadsheet that reports formulas used to generate the computational results; and c) an Excel 97 chart that depicts the calculated eluted ^{241}Am relative concentration as a function of effluent volume. The graphical data are also included as Figure 7. If all injected ^{241}Am remained in solution, and detectable ^{241}Am breakthrough had been observed just before flow was stopped at 71.7 L, we might conclude that $25{,}500 < R < 26{,}500$ (or that the retardation is $R \geq 2.6 \times 10^4$). However, it is unlikely that all injected ^{241}Am remained in solution.

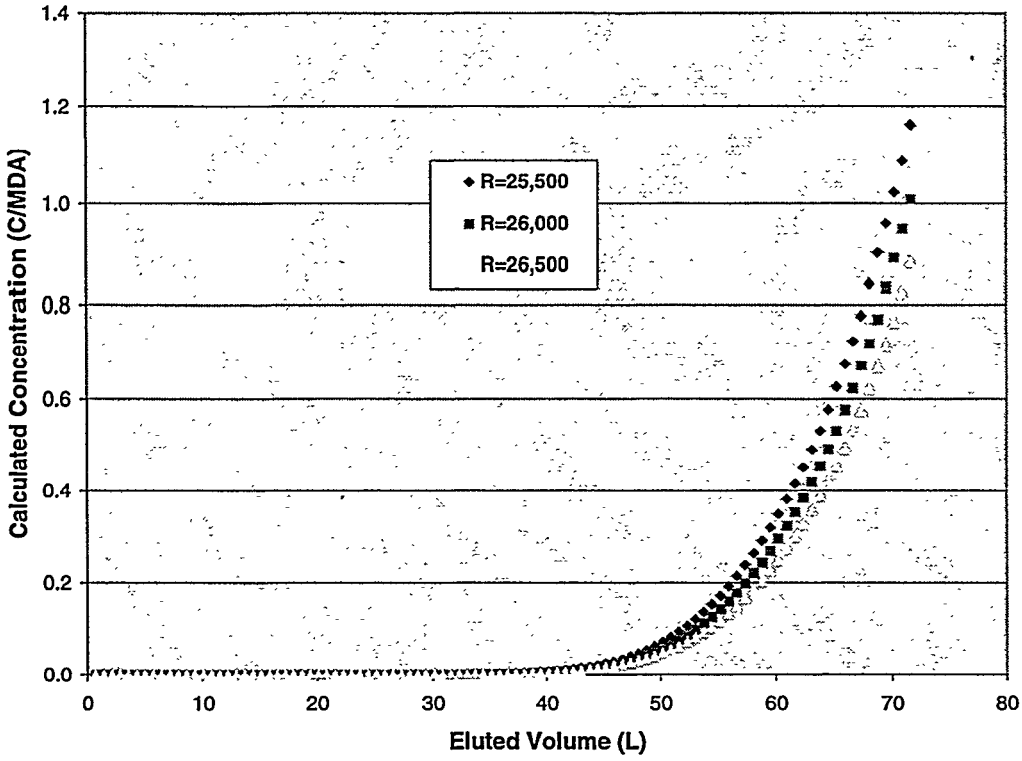

Figure 7. Calculated relative eluted concentration vs. effluent volume for ^{241}Am elution through C-Core. This calculation assumes that all injected ^{241}Am remains in solution until it can interact by sorption on surfaces in the core.

The second set of three calculations for ^{241}Am was performed assuming a saturation-concentration (5.3×10^{-3} μCi/mL) input spike with spike volume of 1,048 mL. This set of assumptions is based on the idea that, even though most of the ^{241}Am initially precipitated, adequate solvent flow occurs to dissolve the precipitate. The extended spike volume is only 1.5% of the total effluent used in this experiment. Calculations were done at retardation values of 25,000, 25,500, and 26,000. The three corresponding "*.col" files are listed in Appendix N, and the three corresponding "*.log" files (output) are listed in Appendix O. Appendix P contains: a) a Microsoft Excel 97 spreadsheet with the computational results for the three R values; b) a spreadsheet that reports formulas used

to generate the computational results; and c) an Excel 97 chart that depicts the calculated eluted ^{241}Am relative concentration as a function of effluent volume. The graphical data are also included as Figure 8. These calculations assume that most of the injected ^{241}Am initially precipitated but was subsequently dissolved due to introduction of additional brine. If, then, detectable ^{241}Am breakthrough had been observed just before flow was stopped at 71.7 L, we might conclude that $25{,}000 < R < 26{,}000$ (or that the retardation is $R \geq 2.6 \times 10^4$). This scenario is more likely than the one in which the entire ^{241}Am spike remained in solution. Even so, the retardation values calculated for these two scenarios are nearly identical because for either scenario, the total volume of the input spike is still a small fraction of the total flow volume.

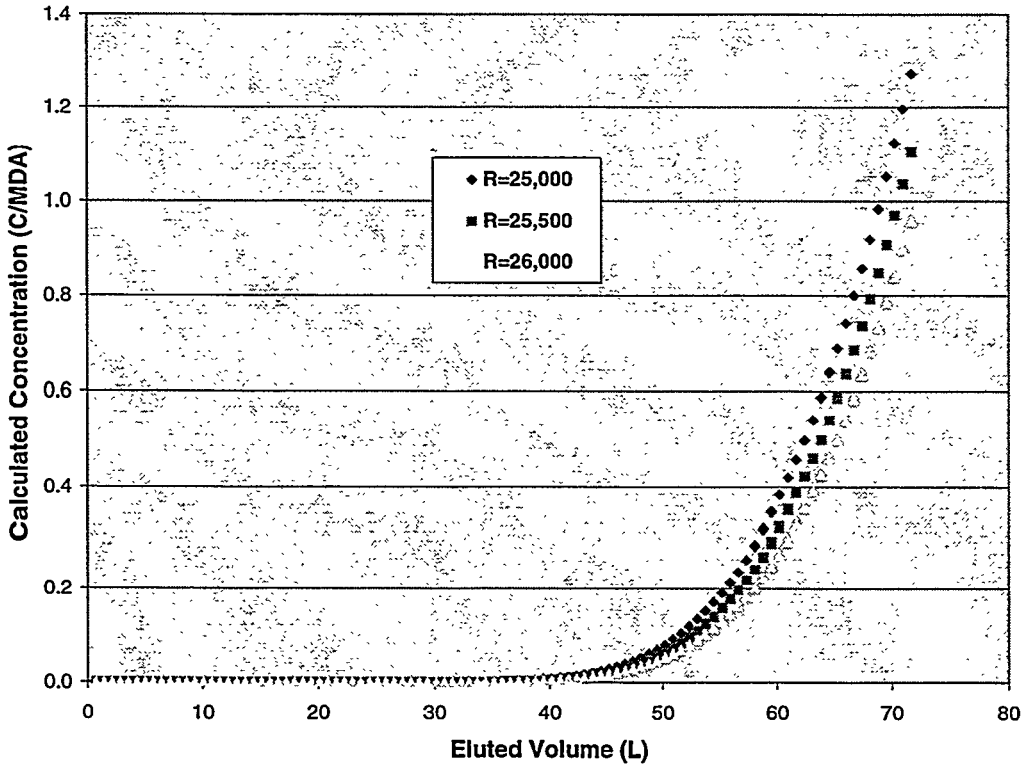

Figure 8. Calculated relative eluted concentration vs. effluent volume for ^{241}Am elution through C-Core. This calculation assumes that only the saturated concentration of ^{241}Am remains in solution initially but that the precipitated ^{241}Am subsequently dissolved due to solvent flow.

The final set of three calculations for ^{241}Am was performed using the quite conservative assumption that all the ^{241}Am except the saturation concentration (5.3×10^{-3} μCi/mL) precipitates irreversibly. Thus, the input spike volume was 20 mL, and no re-dissolution of the precipitate occurred. Calculations were performed at retardation values of 11,000, 11,500, and 12,000. The three corresponding "*.col" files are listed in Appendix Q, and the three corresponding "*.log" files (output) are listed in Appendix R. Appendix S

contains: a) a Microsoft Excel 97 spreadsheet with the computational results for the three R values; b) a spreadsheet that reports formulas used to generate the computational results; and c) an Excel 97 chart that depicts the calculated eluted ^{241}Am relative concentration as a function of effluent volume. The graphical data are also included as Figure 9. These calculations assume that most of the injected ^{241}Am initially precipitated irreversibly and was not subsequently dissolved. If, then, detectable ^{241}Am breakthrough had been observed just before flow was stopped at 71.7 L, we might conclude that 11,000 $< R <$ 12,000 (or that the retardation is $R \geq 1.1 \times 10^4$). This scenario is considerably more pessimistic than the one in which the precipitated ^{241}Am was dissolved. The retardation value calculated for this scenario is considerably lower than for the other two scenarios. The true situation is probably intermediate between the second and third scenarios.

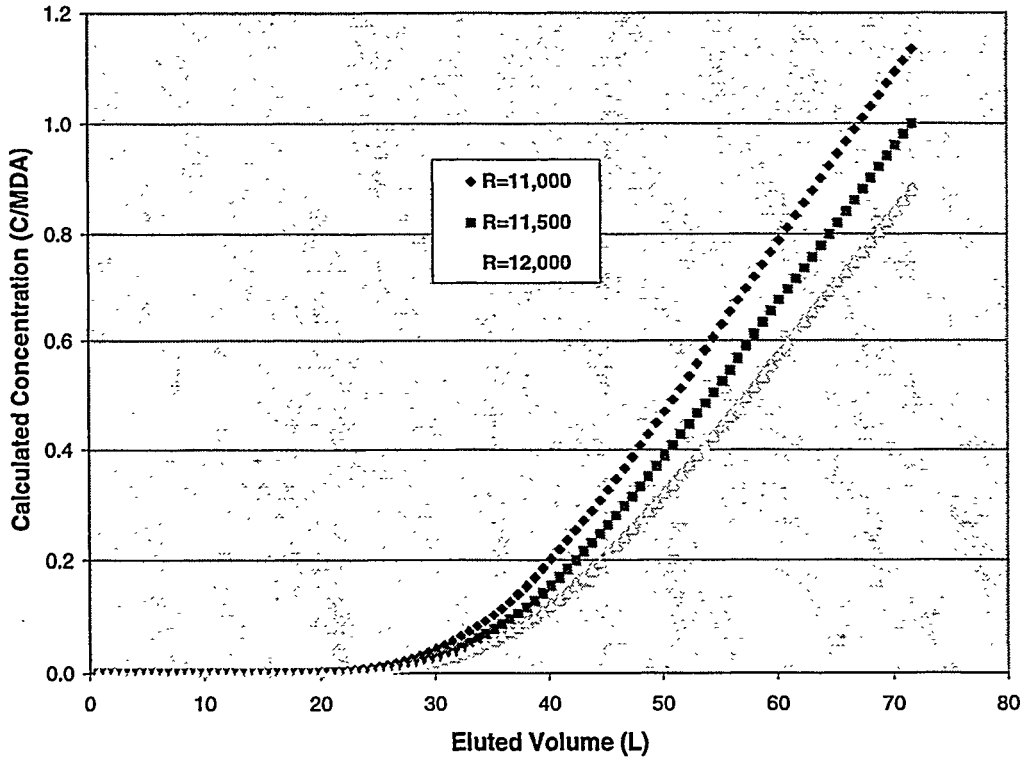

Figure 9. Calculated relative eluted concentration vs. effluent volume for ^{241}Am elution through C-Core. This calculation assumes that only the saturated concentration of ^{241}Am remains in solution and that the precipitated ^{241}Am remains insoluble.

DISCUSSION

The comparison of calculated and experimental concentration profiles for ^{228}Th in B-Core for an extended flow indicates that the retardation $R \approx 10^4$. For the linear adsorption isotherm approximation, R is defined (e.g., by Fetter, 1993) by the formula

$$R = 1 + (\rho_b K_d/\theta), \qquad (2)$$

where ρ_b is the rock bulk density (about 2.4 g cm^{-3} for Culebra dolomite), K_d is the distribution coefficient between dissolved and sorbed actinide (cm^3 g^{-1}), and θ is the dimensionless advective porosity. For a given R-value, the solution-surface distribution coefficient can be calculated via

$$K_d = (R - 1)\ \theta / \rho_b \qquad (3)$$

For B-Core, Lucero *et al.* (1998) report $\theta \approx 0.09$ (the mean result of fitting data from six elution experiments using conservative tracer ^{22}Na). This value is less than the estimated bulk porosity (≈ 0.14) probably because the ^{22}Na elution experiments sample only the advective porosity, rather than the total porosity, of the column. For all cores used in these experiments, $\rho_b \approx 2.4$ g cm^{-3}. Thus, for $R \approx 10^4$ for ^{228}Th translates into $K_d(^{228}Th) \approx 375$, which is of the same order of magnitude as the lower end of the Th(IV) K_d range determined by batch sorption (Lucero, *et al.*, 1998 – Appendix D, Table 1).

Lucero *et al.* (1998) use $\theta \approx 0.033$ for their C-Core fitting calculations. If we use this value of θ and $\rho_b \approx 2.4$ g cm^{-3}, calculation of K_d for ^{241}Pu and ^{241}Am is straightforward. Results of the calculations are summarized in Table 4. The ^{228}Th results are included in Table 4 for completeness.

Table 4. Estimated R and K_d Values for Actinides

Isotope	Concentration Assumption	Estimated R Value	Estimated K_d (cm^3/g)
^{228}Th	As dissolved	10,000	375
^{241}Pu	As dissolved	20,000	275
^{241}Am	As dissolved	26,000	357
^{241}Am	Equilibrium Saturation with Re-dissolution	25,000	344
^{241}Am	Equilibrium Saturation NO Re-dissolution	11,000	151

It is worth emphasizing that the estimated R and K_d values for Pu and Am are based on assuming breakthrough on the day that the experiment was retired. Since breakthrough was **NOT** observed, we conclude that the values estimated are smaller than the actual values would be.

Blaine (1997) performed sensitivity analyses for actinide retardation in the Culebra formation and found that, even for worst-case scenarios, K_d values greater than 3 are adequate to prevent violation of the EPA standards for release of radionuclides to the accessible environment during the regulatory 10,000-year life of the repository. Every K_d value reported in Table 4 is at least a factor of 50 greater than 3, from which we conclude that the results reported here strongly support the effectiveness of sorption in the Culebra as a barrier to release of Th, Pu, and Am during the WIPP regulatory life.

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APPENDIX A.

DIMENSIONLESS FORM OF LINEAR-EQUILIBRIUM TRANSPORT EQUATION FOR ANALYSIS OF B-CORE AND C-CORE NON-ELUTION RESULTS

Development of Dimensionless Equations

The basic linear-equilibrium transport equation is

$$R\,\partial C/\partial t = D\,\partial^2 C/\partial z^2 - v\,\partial C/\partial z, \tag{A-1}$$

where C is the concentration of solute in brine solution, R is the solute retardation coefficient as defined, for example, by Fetter (1993), D is the dispersion coefficient for transport in the medium, t is time, z is distance, $v = q/\theta$ is the average pore water velocity, q is the specific discharge (volumetric flow rate divided by cross-sectional area), and θ is the porosity. For the experiments described here, the initial condition is $C(z,0) = 0$, the boundary condition for $t = 0$, $z = 0$ is a spike of concentration C_0 for duration t_0, and brine flow is maintained for a time t_{end}. For a column of length L, following Parker and van Genuchten (1984), we define dimensionless variables

$$T = v\,t/L \text{ (units of pore volumes)} \tag{A-2}$$

$$Z = z/L \text{ (units of core lengths).} \tag{A-3}$$

Now,

$$\partial C/\partial t = (\partial T/\partial t)\,(\partial C/\partial T) = (v/L)\,(\partial C/\partial T),$$

$$\partial C/\partial z = (1/L)\,(\partial C/\partial Z),$$

and

$$\partial^2 C/\partial z^2 = (1/L^2)\,(\partial^2 C/\partial Z^2).$$

Thus, the transport equation (A-1) becomes

$$R\,(v/L)\,(\partial C/\partial T) = (D/L^2)\,(\partial^2 C/\partial Z^2) - (v/L)\,(\partial C/\partial Z), \tag{A-4}$$

or

$$R\,(\partial C/\partial T) = (1/L)\,(D/v)\,(\partial^2 C/\partial Z^2) - (\partial C/\partial Z), \tag{A-5}$$

which is in the same form as Eq. (A-1) if the initial parameters are replaced as follows.

$$R^* = R \tag{A-6}$$

$$D^* = (1/L)\,(D/v) = (D\,\theta)/(q\,L) \tag{A-7}$$

$$v^* = 1 \tag{A-8}$$

$$q^* = \theta^* \tag{A-9}$$

$$\theta^* = \theta \tag{A-10}$$

$$C_0^* = C_0 \tag{A-11}$$

$$T_0 = (q/\theta L)\,t_0 \tag{A-12}$$

$$T_{end} = (q/\theta L)\, t_{end} \qquad \text{(A-13)}$$

Dimensionless Parameter Values for ^{228}Th in B-Core

For B-Core (see Table 3), ^{228}Th was first introduced in a 13.7 mL spike at 0.1 mL/min flow rate. The measured and fitted core parameters reported by Lucero *et al.* (1998) were:

R = retardation coefficient (parameter to be fitted)

$q = 1.009 \times 10^{-5}$ cm/s (0.1 mL/min flow rate divided by cross-sectional area)

L = 50.9 cm

D = 0.0013 cm^2/s (average of fitting parameters for two experiments with ^{22}Na)

$\theta = 0.09$ (average of fitting parameters for two experiments with ^{22}Na)

$t_0 = 8{,}820$ s (corresponding to volume: 13.7 mL)

$C_0 = 5.16$ μCi/mL

Elapsed-Time Calculation

The parameter t_{end} is estimated based on the flow history of the core. The time from first injection of ^{228}Th to the change in flow rate was 64 days, and the time from change in flow rate to the last ^{228}Th tomography was 128 days. For conversion to pore volumes as the independent variable, the total flow time is taken as:

$t_{end} = [(64 + 128/2)\ \text{day}]\ [86{,}400\ \text{s/day}] = 1.11 \times 10^7$ s.

This set of parameters transforms to

$R^* = R$

$D^* = [(0.0013)\ (0.09)] / [(1.009 \times 10^{-5})\ (50.9)] = 0.23$

$\theta^* = \theta = 0.09$

$q^* = \theta = 0.09$

$L^* = 50.9/50.9 = 1.0$

$T_0 = \{(1.009 \times 10^{-5})/[(0.09)\ (50.9)]\}\ t_0 = 2.20 \times 10^{-6}\ t_0 = 0.019$

$T_{end} = 2.20 \times 10^{-6}\ t_{end} = 24.4$ (pore volumes).

Conversion from pore volumes to total volume requires multiplication by core volume and porosity to yield

$$V_{tot} = \pi\ (7.25)^2\ (50.9)\ (0.09)\ T_{end} = 18.5\ \text{L}.$$

This result is in good agreement with the total volume computed from flow rate and time (18.4 L).

Saturated Activity Calculation

Craft and Siegel (1998) calculate saturation solubilities of Th^{4+} in VPX-28 brine at atmospheric CO_2 pressure. The saturated solubility ranges from 1.9×10^{-7} M (pmH =

7.73, without dolomite equilibrium) to 1.57×10^{-7} M (pmH = 7.64, with dolomite equilibrium). Lucero *et al.* (1998) reported the conversion factor: 5.35×10^{-6} mole/Ci for ^{228}Th. The lower value for the $^{228}Th^{4+}$ saturated concentration (1.57×10^{-7} mole/L) thus corresponds to saturated activity 29.3 μCi/mL. The input ^{228}Th spike activity for test B3 (see Table 3) was 5.16 μCi/mL, roughly a factor of six less that the saturated activity. It is thus unlikely that the injected ^{228}Th precipitated.

Dimensionless Parameter Values for ^{241}Pu and ^{241}Am in C-Core

For C-Core (see Table 3), ^{241}Am and ^{241}Pu were first introduced in a 20.0 mL spike at 0.1 mL/min flow rate. The measured and fitted core parameters reported by Lucero *et al.* (1998) were:

R = retardation coefficient (parameter to be estimated)

$q = 1.009 \times 10^{-5}$ cm/s (0.1 mL/min flow rate divided by cross-sectional area)

L = 10.2 cm

D = 0.0020 cm^2/s (fitting parameter for experiment C-3 with ^{22}Na)

$\theta = 0.033$ (fitting parameter for experiment C-3 with ^{22}Na)

t_0 = 12,000 s (for 20.0 mL spike volume at 0.1 mL/min flow rate)

C_0 = 0.28 μCi/mL (or variable – see below) for ^{241}Am spike

= 1.0 μCi/mL for ^{241}Pu spike

Elapsed-Time Calculations

The parameter t_{end} can be estimated based on the flow history of the core. For C-Core, ^{241}Pu and ^{241}Am were first injected in a 20-mL spike on 7/10/95, and brine flow continued at 0.1 mL/min through 4/9/96. Actual calendar days from 7/10/95 to 4/9/96 inclusive are 274 days, but Lucero (1995-1996) reports 269 days of flow (due to a five-day interruption in December 1995). As of 4/9/96, neither ^{241}Am nor ^{241}Pu had been observed above minimum detectable activity (MDA) in the effluent. Flow was interrupted from 4/9/96 until 6/4/96, when flow was resumed at the reduced rate of 0.05 mL/min. The 0.05 mL/min flow rate was maintained from 6/4/96 until 9/2/97, on which date the C-Core experiments were suspended. Total flow time at the reduced rate was 455 days. Again, as of 9/2/97, neither ^{241}Am nor ^{241}Pu had been observed above minimum detectable activity (MDA) in the effluent.

The total time at an equivalent flow rate of 0.1 mL/min was

$$t_{end} = \{[269 + 0.5\ (455)]\text{day}\}\ \{86{,}400\ \text{s/day}\} = 4.29 \times 10^7\ \text{s},$$

which corresponds to a total flow volume of

$$V_{tot} = (496.5\ \text{day})\ (1{,}440\ \text{min/day})\ (0.1\ \text{mL/min}) = 71.5 \times 10^3\ \text{mL} = 71.5\ \text{L}.$$

For analysis of the experiments, it is convenient to express time in terms of pore volumes using Eq. (A-13). Given $t_{end} = 4.29 \times 10^7$ s, and $T_{end} = (q/\theta L)\ t_{end}$, then

$$T_{end} = \{1.009 \times 10^{-5}/[(0.033)(10.2)]\}\ 4.29 \times 10^7 = 1.29 \times 10^3 \text{ pore volumes}.$$

As a check on arithmetic, conversion of pore volumes to total eluted volume requires multiplication by the core volume and porosity to yield

$$V_{tot} = \pi\,(7.25)^2\,(10.2)\,(0.033)\,T_{end} = 71.7 \times 10^3\ mL = 71.7\ L,$$

which is in good agreement with effluent volume calculated above using elapsed time and flow rate.

Saturated Activity Calculations for ^{241}Am and ^{241}Pu

Craft and Siegel (1998) calculated the saturated solubility of Am^{3+} in VPX-28 brine at atmospheric CO_2 pressure. The saturated solubility ranges from 6.46×10^{-9} M (pmH = 7.73, without dolomite equilibrium) to 9.63×10^{-9} M (pmH = 7.64, with dolomite equilibrium). Lucero *et al.* (1998) reported the conversion factor: 1.21×10^{-3} mole/Ci for ^{241}Am. The lower value for the $^{241}Am^{3+}$ saturated concentration (6.46×10^{-9} mole/L) thus corresponds to saturated ^{241}Am activity

$$(6.46 \times 10^{-9}\ \text{mole/L}) / (1.21 \times 10^{-3}\ \text{mole/Ci}) = 5.34\ \mu\text{Ci/L} = 5.34 \times 10^{-3}\ \mu\text{Ci/mL}.$$

The input ^{241}Am spike activity for test C3 was 0.28 μCi/mL. The $^{241}Am^{3+}$ input spike for experiment C3 was supersaturated by a factor of $(0.28)/(5.34 \times 10^{-3}) = 52.4$. It is thus likely that the ^{241}Am precipitated at or near the inlet surface of C-Core.

Although the ^{241}Am almost certainly dissolved as $^{241}Am^{3+}$, the valence of the dissolved ^{241}Pu is not so well known. A ^{241}Pu solution was submitted to the Los Alamos National Laboratory Chemical Science and Technology Division for oxidation-state determination in December 1994. The response from Los Alamos is included as Appendix G. From the discussion in the Los Alamos report, it could be argued that ^{241}Pu might have been present as either Pu^{4+} or Pu^{5+} or as a mixture of these oxidation states. One would expect the solubility of Pu^{5+} to be similar to that for Np^{5+}, reported by Craft and Siegel (1998) as 7.84×10^{-6} M (pmH = 7.72, without dolomite equilibrium) and 1.1×10^{-5} M (pmH = 7.64, with dolomite equilibrium). Similarly, one would expect the solubility of Pu^{4+} to be similar to that for Th^{4+}, reported by Craft and Siegel (1998) as 1.9×10^{-7} M (pmH = 7.73, without dolomite equilibrium) and 1.57×10^{-7} M (pmH = 7.64, with dolomite equilibrium). Thus, the minimum estimated ^{241}Pu saturated solubility is 1.57×10^{-7} M. Lucero *et al.* (1998) reported the conversion factor: 4.03×10^{-5} mole/Ci for ^{241}Pu. The minimum estimated ^{241}Pu saturated solubility thus corresponds to saturated activity

$$(1.57 \times 10^{-7}\ \text{mole/L}) / (4.03 \times 10^{-5}\ \text{mole/Ci}) = 3.9 \times 10^{-3}\ \text{Ci/L} = 3.9\ \mu\text{Ci/mL}.$$

The input spike ^{241}Pu activity for test C3 was 1.0 μCi/mL. Thus, it is likely that the injected ^{241}Pu remained in solution, whether it was dissolved as Pu^{4+}, Pu^{5+}, or as a mixture.

For the simplest case (no precipitation), the parameters for equation A-5 are then

$R^* = R$ (to be estimated)

$D^* = [(0.0020)\,(0.033)] / [(1.009 \times 10^{-5})\,(10.2)] = 0.64$

$\theta^* = \theta = 0.033$

$q^* = \theta = 0.033$

$L^* = 10.2/10.2 = 1.0$

$T_0 = \{(1.009 \times 10^{-5})/[(0.033)\ (10.2)]\}\ t_0 = 3.00 \times 10^{-5}\ t_0 = 0.36$ (pore volumes)

$T_{end} = 3.00 \times 10^{-5}\ t_{end} = 1.29 \times 10^{3}$ (pore volumes).

We can attempt to represent the effects of ^{241}Am precipitation by reducing the input spike concentration and increasing the input spike duration accordingly. Calculations indicate that the initial ^{241}Am concentration was supersaturated by a factor of 52.4. Assuming the solution equilibrated rapidly with the dolomite, the actual injected solution concentration could then be lower by roughly this factor. If the precipitated ^{241}Am then dissolved as more brine flowed, the apparent input-spike duration would be increased by the same factor as the decrease in concentration. Thus, the ^{241}Am transport parameters for saturation concentration can be estimated as

$$C_{sat} = C_0/52.4,$$

and

$$T_{0sat} = 52.4\ T_0 = (52.4)\ (0.36) = 18.9 \text{ pore volumes.}$$

Note that T_{0sat} is only a small fraction (~ 1.5%) of the total brine flow for C-Core.

A more conservative analysis could be based on assuming that any precipitated ^{241}Am is never again dissolved, so $T_{0sat} = 0.36$ even for $C_{sat} = C_0/52.4$. The main text contains discussion of retardation values estimated for the three different ^{241}Am-input scenarios described here.

Concentration Scaling using Minimum Detectable Activities for ^{241}Pu and ^{241}Am

The effluent brine from C-Core experiments was analyzed for both ^{241}Pu and ^{241}Am using liquid scintillation counting (LSC). Using this technique, the minimum detectable activity (MDA) for ^{241}Am is 1×10^{-7} µCi/mL, and the MDA for ^{241}Pu is 1.5×10^{-6} µCi/mL (Lucero *et al.*, 1998). In order to compare effluent concentrations with actinide MDA values, the input-spike actinide concentrations can be scaled by the appropriate MDA values. Thus,

$C_0^*(^{241}Pu) = C_0(^{241}Pu)/(1.5 \times 10^{-6}) = 1.0/(1.5 \times 10^{-6}) = 6.7 \times 10^{5}$;

$C_0^*(^{241}Am) = C_0(^{241}Am)/(1 \times 10^{-7}) = 0.28/(1 \times 10^{-7}) = 2.8 \times 10^{6}$;

$C_{0sat}^*(^{241}Am) = C_{0sat}(^{241}Am)/(1 \times 10^{-7}) = 0.28/(52.4 \times 10^{-7}) = 5.3 \times 10^{4}$.

Clearly, the inlet actinide concentrations are significantly greater than the MDA values.

APPENDIX B.

DERIVATION OF RELATION BETWEEN DISSOLVED ACTINIDE CONCENTRATION AND TOTAL ACTINIDE CONCENTRATION IN THE ROCK

As was stated in the main text, COLUMN 1.4 calculates actinide concentrations in solution, not on the solid. However, for comparison of calculation with the results of destructive analysis, it is necessary to calculate the total concentration of actinide both in solution and sorbed on the rock surfaces. For the approximations is used in this report (i.e., single-porosity and linear sorption isotherm), the sorbed concentration (per unit rock mass) is related to dissolved concentration by the equation

$$S = K_d C_{sol}, \quad \text{(B-1)}$$

where K_d is given in mL/g, and C_{sol} is the dissolved concentration (e.g., μCi/mL). The total volume concentration of actinide (per unit volume of rock) is then

$$C_T = \rho_b S + \theta C_{sol}, \quad \text{(B-2)}$$

where θ is the porosity. Inserting Equation (B-1) into Equation B-2 yields

$$C_T = \rho_b K_d C_{sol} + \theta C_{sol} = \theta C_{sol} [1 + (\rho_b K_d/\theta)]. \quad \text{(B-3)}$$

Note that the factor $[1 + (\rho_b K_d/\theta)]$ is just the definition of the retardation factor R. Thus,

$$C_T = \theta C_{sol} R, \quad \text{(B-4)}$$

which, given θ and R, provides a straightforward conversion from dissolved concentration to total concentration in the solid.

APPENDIX C.

LISTING OF POSITION-TIME INPUT FILE (*.INP) FOR ^{228}Th COLUMN 1.4 CALCULATION

Th_vs_Z_Vol.inp

```
0.001 24.4
0.002 24.4
0.003 24.4
0.004 24.4
0.005 24.4
0.006 24.4
0.007 24.4
0.008 24.4
0.009 24.4
0.010 24.4
0.011 24.4
0.012 24.4
0.013 24.4
0.014 24.4
0.015 24.4
0.016 24.4
0.017 24.4
0.018 24.4
0.019 24.4
0.020 24.4
0.021 24.4
0.022 24.4
0.023 24.4
0.024 24.4
0.025 24.4
0.026 24.4
0.027 24.4
0.028 24.4
0.029 24.4
0.030 24.4
0.031 24.4
0.032 24.4
0.033 24.4
0.034 24.4
0.035 24.4
0.036 24.4
0.037 24.4
0.038 24.4
0.039 24.4
0.040 24.4
0.041 24.4
0.042 24.4
0.043 24.4
0.044 24.4
0.045 24.4
0.046 24.4
0.047 24.4
0.048 24.4
0.049 24.4
0.050 24.4
0.052 24.4
0.054 24.4
0.056 24.4
```

Th_vs_Z_Vol.inp

```
0.058 24.4
0.060 24.4
0.065 24.4
0.070 24.4
0.080 24.4
0.090 24.4
0.100 24.4
0.150 24.4
0.200 24.4
0.300 24.4
0.400 24.4
0.500 24.4
0.600 24.4
0.700 24.4
0.800 24.4
0.900 24.4
1.000 24.4
```

APPENDIX D.

LISTINGS OF PARAMETER INPUT FILES (*.COL) FOR THREE ^{228}Th COLUMN 1.4 CALCULATIONS AT RETARDATION VALUES 5,000, 10,000, & 50,000

Th5000_vs_Z_Vol.col

```
[Wcolumn]
Date=4/29/98 2:53:30 PM
Title=Th vs. Depth at R=5,000
LogFile=Th5000_vs_Z_Vol.log
OutputFile=Th5000_vs_Z_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=RESIDENT
Bootstrap=

[DistanceAndTimeSpec.]
Set=File
FileName=Th_vs_Z_Vol.inp

[ParameterValues]
R=5000
theta=0.09
D=0.23
mu=0
gamma=0
q=0.09
t0=0.019
c0=5.16
```

Th10000_vs_Z_Vol.col

```
[Wcolumn]
Date=4/29/98 2:53:18 PM
Title=Th vs. Depth at R=10,000
LogFile=Th10000_vs_Z_Vol.log
OutputFile=Th10000_vs_Z_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=RESIDENT
Bootstrap=

[DistanceAndTimeSpec.]
Set=File
FileName=Th_vs_Z_Vol.inp

[ParameterValues]
R=10000
theta=0.09
D=0.23
mu=0
gamma=0
q=0.09
t0=0.019
c0=5.16
```

Th50000_vs_Z_Vol.col

```
[Wcolumn]
Date=4/29/98 2:54:30 PM
Title=Th vs. Depth at R=50,000
LogFile=Th50000_vs_Z_Vol.log
OutputFile=Th50000_vs_Z_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=RESIDENT
Bootstrap=

[DistanceAndTimeSpec.]
Set=File
FileName=Th_vs_Z_Vol.inp

[ParameterValues]
R=50000
theta=0.09
D=0.23
mu=0
gamma=0
q=0.09
t0=0.019
c0=5.16
```

APPENDIX E.

LISTINGS OF OUTPUT FILES (*.LOG) FOR THREE ^{228}Th COLUMN 1.4 CALCULATIONS AT RETARDATION VALUES 5,000, 10,000, & 50,000

Th5000_vs_Z_vol.log

```
*******************************************************************************
*                                                                             *
*    Deterministic linear equilibrium absorption for pulse injection with     *
*    first-order decay                                                        *
*                                                                             *
*    Th vs. Depth at R=5,000                                                  *
*                                                                             *
*******************************************************************************
Model Name = Linear equilibrium
Calculation began 4/29/98 2:53:51 PM

Model parameters:
        R = 5000
    theta = 0.09
        D = 0.23
       mu = 0
    gamma = 0
        q = 0.09
       t0 = 0.019
       c0 = 5.16

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E-03  2.440000E+01  2.905809E-04
2.000000E-03  2.440000E+01  2.916264E-04
3.000000E-03  2.440000E+01  2.925291E-04
4.000000E-03  2.440000E+01  2.932882E-04
5.000000E-03  2.440000E+01  2.939029E-04
6.000000E-03  2.440000E+01  2.943720E-04
7.000000E-03  2.440000E+01  2.946961E-04
8.000000E-03  2.440000E+01  2.948755E-04
9.000000E-03  2.440000E+01  2.949101E-04
1.000000E-02  2.440000E+01  2.948005E-04
1.100000E-02  2.440000E+01  2.945472E-04
1.200000E-02  2.440000E+01  2.941509E-04
1.300000E-02  2.440000E+01  2.936126E-04
1.400000E-02  2.440000E+01  2.929336E-04
1.500000E-02  2.440000E+01  2.921150E-04
1.600000E-02  2.440000E+01  2.911584E-04
1.700000E-02  2.440000E+01  2.900656E-04
1.800000E-02  2.440000E+01  2.888384E-04
1.900000E-02  2.440000E+01  2.874789E-04
2.000000E-02  2.440000E+01  2.859892E-04
2.100000E-02  2.440000E+01  2.843717E-04
2.200000E-02  2.440000E+01  2.826290E-04
2.300000E-02  2.440000E+01  2.807637E-04
2.400000E-02  2.440000E+01  2.787787E-04
2.500000E-02  2.440000E+01  2.766769E-04
2.600000E-02  2.440000E+01  2.744614E-04
2.700000E-02  2.440000E+01  2.721353E-04
2.800000E-02  2.440000E+01  2.697021E-04
2.900000E-02  2.440000E+01  2.671652E-04
3.000000E-02  2.440000E+01  2.645280E-04
3.100000E-02  2.440000E+01  2.617942E-04
3.200000E-02  2.440000E+01  2.589675E-04
3.300000E-02  2.440000E+01  2.560518E-04
3.400000E-02  2.440000E+01  2.530508E-04
3.500000E-02  2.440000E+01  2.499685E-04
3.600000E-02  2.440000E+01  2.468089E-04
3.700000E-02  2.440000E+01  2.435760E-04
3.800000E-02  2.440000E+01  2.402739E-04
3.900000E-02  2.440000E+01  2.369067E-04
4.000000E-02  2.440000E+01  2.334785E-04
4.100000E-02  2.440000E+01  2.299934E-04
4.200000E-02  2.440000E+01  2.264556E-04
4.300000E-02  2.440000E+01  2.228693E-04
4.400000E-02  2.440000E+01  2.192386E-04
```

4.500000E-02	2.440000E+01	2.155677E-04
4.600000E-02	2.440000E+01	2.118606E-04
4.700000E-02	2.440000E+01	2.081214E-04
4.800000E-02	2.440000E+01	2.043542E-04
4.900000E-02	2.440000E+01	2.005631E-04
5.000000E-02	2.440000E+01	1.967519E-04
5.200000E-02	2.440000E+01	1.890850E-04
5.400000E-02	2.440000E+01	1.813842E-04
5.600000E-02	2.440000E+01	1.736788E-04
5.800000E-02	2.440000E+01	1.659971E-04
6.000000E-02	2.440000E+01	1.583657E-04
6.500000E-02	2.440000E+01	1.396690E-04
7.000000E-02	2.440000E+01	1.217873E-04
8.000000E-02	2.440000E+01	8.950334E-05
9.000000E-02	2.440000E+01	6.287055E-05
1.000000E-01	2.440000E+01	4.221640E-05
1.500000E-01	2.440000E+01	2.936390E-06
2.000000E-01	2.440000E+01	6.680018E-08
3.000000E-01	2.440000E+01	1.212198E-12
4.000000E-01	2.440000E+01	2.544797E-19
5.000000E-01	2.440000E+01	6.190085E-28
6.000000E-01	2.440000E+01	1.745844E-38
7.000000E-01	2.440000E+01	8.384744E-49
8.000000E-01	2.440000E+01	4.019795E-63
9.000000E-01	2.440000E+01	2.181311E-79
1.000000E+00	2.440000E+01	1.346290E-97

Th10000_vs_Z_vol.log

```
*******************************************************************************
*                                                                             *
*    Deterministic linear equilibrium absorption for pulse injection with     *
*    first-order decay                                                        *
*                                                                             *
*    Th vs. Depth at R=10,000                                                 *
*                                                                             *
*******************************************************************************
Model Name = Linear equilibrium
Calculation began 4/28/98 3:41:30 PM

Model parameters:
        R = 10000
    theta = 0.09
        D = 0.23
       mu = 0
    gamma = 0
        q = 0.09
       t0 = 0.019
       c0 = 5.16

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E-03  2.440000E+01  2.136653E-04
2.000000E-03  2.440000E+01  2.142840E-04
3.000000E-03  2.440000E+01  2.146964E-04
4.000000E-03  2.440000E+01  2.149019E-04
5.000000E-03  2.440000E+01  2.149013E-04
6.000000E-03  2.440000E+01  2.146952E-04
7.000000E-03  2.440000E+01  2.142849E-04
8.000000E-03  2.440000E+01  2.136720E-04
9.000000E-03  2.440000E+01  2.128589E-04
1.000000E-02  2.440000E+01  2.118485E-04
1.100000E-02  2.440000E+01  2.106440E-04
1.200000E-02  2.440000E+01  2.092494E-04
1.300000E-02  2.440000E+01  2.076689E-04
1.400000E-02  2.440000E+01  2.059074E-04
1.500000E-02  2.440000E+01  2.039701E-04
1.600000E-02  2.440000E+01  2.018625E-04
1.700000E-02  2.440000E+01  1.995908E-04
1.800000E-02  2.440000E+01  1.971613E-04
1.900000E-02  2.440000E+01  1.945807E-04
2.000000E-02  2.440000E+01  1.918561E-04
2.100000E-02  2.440000E+01  1.889947E-04
2.200000E-02  2.440000E+01  1.860042E-04
2.300000E-02  2.440000E+01  1.828922E-04
2.400000E-02  2.440000E+01  1.796667E-04
2.500000E-02  2.440000E+01  1.763357E-04
2.600000E-02  2.440000E+01  1.729076E-04
2.700000E-02  2.440000E+01  1.693906E-04
2.800000E-02  2.440000E+01  1.657931E-04
2.900000E-02  2.440000E+01  1.621234E-04
3.000000E-02  2.440000E+01  1.583899E-04
3.100000E-02  2.440000E+01  1.546011E-04
3.200000E-02  2.440000E+01  1.507651E-04
3.300000E-02  2.440000E+01  1.468901E-04
3.400000E-02  2.440000E+01  1.429844E-04
3.500000E-02  2.440000E+01  1.390557E-04
3.600000E-02  2.440000E+01  1.351120E-04
3.700000E-02  2.440000E+01  1.311607E-04
3.800000E-02  2.440000E+01  1.272093E-04
3.900000E-02  2.440000E+01  1.232648E-04
4.000000E-02  2.440000E+01  1.193344E-04
4.100000E-02  2.440000E+01  1.154244E-04
4.200000E-02  2.440000E+01  1.115414E-04
4.300000E-02  2.440000E+01  1.076914E-04
4.400000E-02  2.440000E+01  1.038802E-04
```

4.500000E-02	2.440000E+01	1.001132E-04
4.600000E-02	2.440000E+01	9.639555E-05
4.700000E-02	2.440000E+01	9.273207E-05
4.800000E-02	2.440000E+01	8.912723E-05
4.900000E-02	2.440000E+01	8.558519E-05
5.000000E-02	2.440000E+01	8.210975E-05
5.200000E-02	2.440000E+01	7.537222E-05
5.400000E-02	2.440000E+01	6.893845E-05
5.600000E-02	2.440000E+01	6.282705E-05
5.800000E-02	2.440000E+01	5.705160E-05
6.000000E-02	2.440000E+01	5.162097E-05
6.500000E-02	2.440000E+01	3.957223E-05
7.000000E-02	2.440000E+01	2.966233E-05
8.000000E-02	2.440000E+01	1.558181E-05
9.000000E-02	2.440000E+01	7.483238E-06
1.000000E-01	2.440000E+01	3.285368E-06
1.500000E-01	2.440000E+01	1.404748E-08
2.000000E-01	2.440000E+01	6.445210E-12
3.000000E-01	2.440000E+01	1.691134E-21
4.000000E-01	2.440000E+01	5.963787E-35
5.000000E-01	2.440000E+01	4.646280E-50
6.000000E-01	2.440000E+01	4.040352E-71
7.000000E-01	2.440000E+01	4.535086E-96
8.000000E-01	2.440000E+01	6.639537E-125
9.000000E-01	2.440000E+01	1.276811E-157
1.000000E+00	2.440000E+01	3.241275E-194

Th50000_vs_Z_vol.log

```
*****************************************************************************
*                                                                           *
*    Deterministic linear equilibrium absorption for pulse injection with   *
*    first-order decay                                                      *
*                                                                           *
*    Th vs. Depth at R=50,000                                               *
*                                                                           *
*****************************************************************************
Model Name = Linear equilibrium
Calculation began 4/29/98 2:54:17 PM

Model parameters:
        R = 50000
    theta = 0.09
        D = 0.23
       mu = 0
    gamma = 0
        q = 0.09
       t0 = 0.019
       c0 = 5.16

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E-03  2.440000E+01  1.004372E-04
2.000000E-03  2.440000E+01  1.001771E-04
3.000000E-03  2.440000E+01  9.945869E-05
4.000000E-03  2.440000E+01  9.829312E-05
5.000000E-03  2.440000E+01  9.669744E-05
6.000000E-03  2.440000E+01  9.469418E-05
7.000000E-03  2.440000E+01  9.231088E-05
8.000000E-03  2.440000E+01  8.957938E-05
9.000000E-03  2.440000E+01  8.653514E-05
1.000000E-02  2.440000E+01  8.321649E-05
1.100000E-02  2.440000E+01  7.966388E-05
1.200000E-02  2.440000E+01  7.591908E-05
1.300000E-02  2.440000E+01  7.202445E-05
1.400000E-02  2.440000E+01  6.802212E-05
1.500000E-02  2.440000E+01  6.395334E-05
1.600000E-02  2.440000E+01  5.985777E-05
1.700000E-02  2.440000E+01  5.577296E-05
1.800000E-02  2.440000E+01  5.173374E-05
1.900000E-02  2.440000E+01  4.777191E-05
2.000000E-02  2.440000E+01  4.391584E-05
2.100000E-02  2.440000E+01  4.019026E-05
2.200000E-02  2.440000E+01  3.661616E-05
2.300000E-02  2.440000E+01  3.321073E-05
2.400000E-02  2.440000E+01  2.998741E-05
2.500000E-02  2.440000E+01  2.695599E-05
2.600000E-02  2.440000E+01  2.412284E-05
2.700000E-02  2.440000E+01  2.149115E-05
2.800000E-02  2.440000E+01  1.906116E-05
2.900000E-02  2.440000E+01  1.683055E-05
3.000000E-02  2.440000E+01  1.479473E-05
3.100000E-02  2.440000E+01  1.294720E-05
3.200000E-02  2.440000E+01  1.127990E-05
3.300000E-02  2.440000E+01  9.783515E-06
3.400000E-02  2.440000E+01  8.447820E-06
3.500000E-02  2.440000E+01  7.261965E-06
3.600000E-02  2.440000E+01  6.214738E-06
3.700000E-02  2.440000E+01  5.294803E-06
3.800000E-02  2.440000E+01  4.490907E-06
3.900000E-02  2.440000E+01  3.792053E-06
4.000000E-02  2.440000E+01  3.187641E-06
4.100000E-02  2.440000E+01  2.667580E-06
4.200000E-02  2.440000E+01  2.222370E-06
4.300000E-02  2.440000E+01  1.843166E-06
4.400000E-02  2.440000E+01  1.521805E-06
```

Th50000_vs_Z_vol.log

4.500000E-02	2.440000E+01	1.250829E-06
4.600000E-02	2.440000E+01	1.023477E-06
4.700000E-02	2.440000E+01	8.336752E-07
4.800000E-02	2.440000E+01	6.760067E-07
4.900000E-02	2.440000E+01	5.456790E-07
5.000000E-02	2.440000E+01	4.384822E-07
5.200000E-02	2.440000E+01	2.792879E-07
5.400000E-02	2.440000E+01	1.746705E-07
5.600000E-02	2.440000E+01	1.072556E-07
5.800000E-02	2.440000E+01	6.465702E-08
6.000000E-02	2.440000E+01	3.826188E-08
6.500000E-02	2.440000E+01	9.744173E-09
7.000000E-02	2.440000E+01	2.189303E-09
8.000000E-02	2.440000E+01	7.913468E-11
9.000000E-02	2.440000E+01	1.831932E-12
1.000000E-01	2.440000E+01	2.715776E-14
1.500000E-01	2.440000E+01	2.428756E-26
2.000000E-01	2.440000E+01	3.148090E-43
3.000000E-01	2.440000E+01	5.735480E-89
4.000000E-01	2.440000E+01	2.059703E-156
5.000000E-01	2.440000E+01	2.998571E-243
6.000000E-01	2.440000E+01	0.000000E+00
7.000000E-01	2.440000E+01	0.000000E+00
8.000000E-01	2.440000E+01	0.000000E+00
9.000000E-01	2.440000E+01	0.000000E+00
1.000000E+00	2.440000E+01	0.000000E+00

APPENDIX F.

LISTINGS OF EXCEL 97 SPREADSHEETS AND CHARTS SHOWING RELATIVE CALCULATED VS. OBSERVED ^{228}Th CONCENTRATION AS FUNCTION OF DEPTH

R =	5,000	10,000	50,000										
Theta =	0.09												
L =	50.9												
		Calc.	Calc.	Calc.		Calc.		Calc.		Calc.		Total Th	
		Soln Th	Soln Th	Soln Th		Total Th	Relative	Total Th	Relative	Total Th	Relative	Daughter	Relative Th
		Conc.	Conc.	Conc.		Conc.	Total Th	Conc.	Total Th	Conc.	Total Th	Activity	Daughter
Depth	Pore	µCi/mL	µCi/mL	µCi/mL	Depth	µCi/mL	Conc.	µCi/mL	Conc.	µCi/mL	Conc.	µCi	Activity
Z = z/L	Volumes	R = 5,000	R = 10,000	R = 50,000	(cm)	R = 5,000	R = 5,000	R = 10,000	R = 10,000	R = 50,000	R = 50,000	Observed	Observed
0.001	24.4	2.91E-03	2.14E-03	1.00E-03	0.0509	0.131	0.99	0.192	0.99	0.45	1.00		
0.002	24.4	2.92E-03	2.14E-03	1.00E-03	0.1018	0.131	0.99	0.193	1.00	0.45	1.00		
0.003	24.4	2.93E-03	2.15E-03	9.95E-04	0.1527	0.132	0.99	0.193	1.00	0.45	0.99		
0.004	24.4	2.93E-03	2.15E-03	9.83E-04	0.2036	0.132	0.99	0.193	1.00	0.44	0.98		
0.005	24.4	2.94E-03	2.15E-03	9.67E-04	0.2545	0.132	1.00	0.193	1.00	0.44	0.96		
0.006	24.4	2.94E-03	2.15E-03	9.47E-04	0.3054	0.132	1.00	0.193	1.00	0.43	0.94		
0.007	24.4	2.95E-03	2.14E-03	9.23E-04	0.3563	0.133	1.00	0.193	1.00	0.42	0.92		
0.008	24.4	2.95E-03	2.14E-03	8.96E-04	0.4072	0.133	1.00	0.192	0.99	0.40	0.89		
0.009	24.4	2.95E-03	2.13E-03	8.65E-04	0.4581	0.133	1.00	0.192	0.99	0.39	0.86		
0.010	24.4	2.95E-03	2.12E-03	8.32E-04	0.5090	0.133	1.00	0.191	0.99	0.37	0.83		
0.011	24.4	2.95E-03	2.11E-03	7.97E-04	0.5599	0.133	1.00	0.190	0.98	0.36	0.79		
0.012	24.4	2.94E-03	2.09E-03	7.59E-04	0.6108	0.132	1.00	0.188	0.97	0.34	0.76		
0.013	24.4	2.94E-03	2.08E-03	7.20E-04	0.6617	0.132	1.00	0.187	0.97	0.32	0.72		
0.014	24.4	2.93E-03	2.06E-03	6.80E-04	0.7126	0.132	0.99	0.185	0.96	0.31	0.68		
0.015	24.4	2.92E-03	2.04E-03	6.40E-04	0.7635	0.131	0.99	0.184	0.95	0.29	0.64		
0.016	24.4	2.91E-03	2.02E-03	5.99E-04	0.8144	0.131	0.99	0.182	0.94	0.27	0.60		
0.017	24.4	2.90E-03	2.00E-03	5.58E-04	0.8653	0.131	0.98	0.180	0.93	0.25	0.56		
0.018	24.4	2.89E-03	1.97E-03	5.17E-04	0.9162	0.130	0.98	0.177	0.92	0.23	0.52		
0.019	24.4	2.87E-03	1.95E-03	4.78E-04	0.9671	0.129	0.97	0.175	0.91	0.21	0.48		
					1.0000							19.510	1.00
0.020	24.4	2.86E-03	1.92E-03	4.39E-04	1.0180	0.129	0.97	0.173	0.89	0.20	0.44		
0.021	24.4	2.84E-03	1.89E-03	4.02E-04	1.0689	0.128	0.96	0.170	0.88	0.18	0.40		
0.022	24.4	2.83E-03	1.86E-03	3.66E-04	1.1198	0.127	0.96	0.167	0.87	0.16	0.36		
0.023	24.4	2.81E-03	1.83E-03	3.32E-04	1.1707	0.126	0.95	0.165	0.85	0.15	0.33		
0.024	24.4	2.79E-03	1.80E-03	3.00E-04	1.2216	0.125	0.95	0.162	0.84	0.13	0.30		
0.025	24.4	2.77E-03	1.76E-03	2.70E-04	1.2725	0.125	0.94	0.159	0.82	0.12	0.27		
0.026	24.4	2.74E-03	1.73E-03	2.41E-04	1.3234	0.124	0.93	0.156	0.80	0.11	0.24		
0.027	24.4	2.72E-03	1.69E-03	2.15E-04	1.3743	0.122	0.92	0.152	0.79	0.10	0.21		

R =	5,000	10,000	50,000										
Theta =	0.09												
L =	50.9												
		Calc.	Calc.	Calc.		Calc.		Calc.		Calc.		Total Th	
		Sol'n Th	Sol'n Th	Sol'n Th		Total Th	Relative	Total Th	Relative	Total Th	Relative	Daughter	Relative Th
		Conc.	Conc.	Conc.		Conc.	Total Th	Conc.	Total Th	Conc.	Total Th	Activity	Daughter
Depth	Pore	µCi/mL	µCi/mL	µCi/mL	Depth	µCi/mL	Conc.	µCi/mL	Conc.	µCi/mL	Conc.	µCi	Activity
Z = z/L	Volumes	R = 5,000	R = 10,000	R = 50,000	(cm)	R = 5,000	R = 5,000	R = 10,000	R = 10,000	R = 50,000	R = 50,000	Observed	Observed
0.028	24.4	2.70E-03	1.66E-03	1.91E-04	1.4252	0.121	0.91	0.149	0.77	0.09	0.19		
0.029	24.4	2.67E-03	1.62E-03	1.68E-04	1.4761	0.120	0.91	0.146	0.75	0.08	0.17		
0.030	24.4	2.65E-03	1.58E-03	1.48E-04	1.5270	0.119	0.90	0.143	0.74	0.07	0.15		
0.031	24.4	2.62E-03	1.55E-03	1.29E-04	1.5779	0.118	0.89	0.139	0.72	0.06	0.13		
0.032	24.4	2.59E-03	1.51E-03	1.13E-04	1.6288	0.117	0.88	0.136	0.70	0.05	0.11		
0.033	24.4	2.56E-03	1.47E-03	9.78E-05	1.6797	0.115	0.87	0.132	0.68	0.04	0.10		
0.034	24.4	2.53E-03	1.43E-03	8.45E-05	1.7306	0.114	0.86	0.129	0.67	0.04	0.08		
0.035	24.4	2.50E-03	1.39E-03	7.26E-05	1.7815	0.112	0.85	0.125	0.65	0.03	0.07		
0.036	24.4	2.47E-03	1.35E-03	6.21E-05	1.8324	0.111	0.84	0.122	0.63	0.03	0.06		
0.037	24.4	2.44E-03	1.31E-03	5.29E-05	1.8833	0.110	0.83	0.118	0.61	0.02	0.05		
0.038	24.4	2.40E-03	1.27E-03	4.49E-05	1.9342	0.108	0.81	0.114	0.59	0.02	0.04		
0.039	24.4	2.37E-03	1.23E-03	3.79E-05	1.9851	0.107	0.80	0.111	0.57	0.02	0.04		
					2.0000							11.310	0.58
0.040	24.4	2.33E-03	1.19E-03	3.19E-05	2.0360	0.105	0.79	0.107	0.56	0.01	0.03		
0.041	24.4	2.30E-03	1.15E-03	2.67E-05	2.0869	0.103	0.78	0.104	0.54	0.01	0.03		
0.042	24.4	2.26E-03	1.12E-03	2.22E-05	2.1378	0.102	0.77	0.100	0.52	0.01	0.02		
0.043	24.4	2.23E-03	1.08E-03	1.84E-05	2.1887	0.100	0.76	0.097	0.50	0.00	0.02		
0.044	24.4	2.19E-03	1.04E-03	1.52E-05	2.2396	0.099	0.74	0.093	0.48	0.00	0.02		
0.045	24.4	2.16E-03	1.00E-03	1.25E-05	2.2905	0.097	0.73	0.090	0.47	0.00	0.01		
0.046	24.4	2.12E-03	9.64E-04	1.02E-05	2.3414	0.095	0.72	0.087	0.45	0.00	0.01		
0.047	24.4	2.08E-03	9.27E-04	8.34E-06	2.3923	0.094	0.71	0.083	0.43	0.00	0.00		
0.048	24.4	2.04E-03	8.91E-04	6.76E-06	2.4432	0.092	0.69	0.080	0.41	0.00	0.00		
0.049	24.4	2.01E-03	8.56E-04	5.46E-06	2.4941	0.090	0.68	0.077	0.40	0.00	0.00		
0.050	24.4	1.97E-03	8.21E-04	4.38E-06	2.5450	0.089	0.67	0.074	0.38	0.00	0.00		
0.052	24.4	1.89E-03	7.54E-04	2.79E-06	2.6468	0.085	0.64	0.068	0.35	0.00	0.00		
0.054	24.4	1.81E-03	6.89E-04	1.75E-06	2.7486	0.082	0.62	0.062	0.32	0.00	0.00		
0.056	24.4	1.74E-03	6.28E-04	1.07E-06	2.8504	0.078	0.59	0.057	0.29	0.00	0.00		
0.058	24.4	1.66E-03	5.71E-04	6.47E-07	2.9522	0.075	0.56	0.051	0.27	0.00	0.00		
0.060	24.4	1.58E-03	5.16E-04	3.83E-07	3.0540	0.071	0.54	0.046	0.24	0.00	0.00		

R =	5,000	10,000	50,000										
Theta =	0.09												
L =	50.9												
		Calc.	Calc.	Calc.		Calc.		Calc.		Calc.		Total Th	
		Sol'n Th	Sol'n Th	Sol'n Th		Total Th	Relative	Total Th	Relative	Total Th	Relative	Daughter	Relative Th
		Conc.	Conc.	Conc.		Conc.	Total Th	Conc.	Total Th	Conc.	Total Th	Activity	Daughter
Depth	Pore	µCi/mL	µCi/mL	µCi/mL	Depth	µCi/mL	Conc.	µCi/mL	Conc.	µCi/mL	Conc.	µCi	Activity
Z = z/L	Volumes	R = 5,000	R = 10,000	R = 50,000	(cm)	R = 5,000	R = 5,000	R = 10,000	R = 10,000	R = 50,000	R = 50,000	Observed	Observed
0.065	24.4	1.40E-03	3.96E-04	9.74E-08	3.3085	0.063	0.47	0.036	0.18	0.00	0.00		
0.070	24.4	1.22E-03	2.97E-04	2.19E-08	3.5630	0.055	0.41	0.027	0.14	0.00	0.00		
					4.0000	0.000						1.410	0.07
0.080	24.4	8.95E-04	1.56E-04	7.91E-10	4.0720	0.040	0.30	0.014	0.07	0.00	0.00		
0.090	24.4	6.29E-04	7.48E-05	1.83E-11	4.5810	0.028	0.21	0.007	0.03	0.00	0.00		
0.100	24.4	4.22E-04	3.29E-05	2.72E-13	5.0900	0.019	0.14	0.003	0.02	0.00	0.00		
					6.0000							0.130	0.00
0.150	24.4	2.94E-05	1.40E-07	2.43E-25	7.6350	0.001	0.00	0.000	0.00	0.00	0.00		
					8.0000							0.030	0.00
					10.0000							0.040	0.00
0.200	24.4	6.68E-07	6.45E-11	3.15E-42	10.1800	0.000	0.00	0.000	0.00	0.00	0.00		
					12.0000							0.020	0.00
					14.0000							0.007	0.00
0.300	24.4	1.21E-11	1.69E-20	5.74E-88	15.2700	0.000	0.00	0.000	0.00	0.00	0.00		
					16.0000							0.007	0.00
					18.0000							0.004	0.00
					20.0000							0.008	
0.400	24.4	2.54E-18	5.96E-34	2.06E-155	20.3600	0.000	0.00	0.000	0.00	0.00	0.00		
					22.0000							0.004	0.00
					24.0000							0.002	0.00
0.500	24.4	6.19E-27	4.65E-49	3.00E-242	25.4500	0.000	0.00	0.000	0.00	0.00	0.00		
0.600	24.4	1.75E-37	4.04E-70	0.00E+01	30.5400	0.000	0.00	0.000	0.00	0.00	0.00		
0.700	24.4	8.38E-48	4.54E-95	0.00E+01	35.6300	0.000	0.00	0.000	0.00	0.00	0.00		
0.800	24.4	4.02E-62	6.64E-124	0.00E+01	40.7200	0.000	0.00	0.000	0.00	0.00	0.00		
0.900	24.4	2.18E-78	1.28E-156	0.00E+01	45.8100	0.000	0.00	0.000	0.00	0.00	0.00		
1.000	24.4	1.35E-96	3.24E-193	0.00E+01	50.9000	0.000	0.00	0.000	0.00	0.00	0.00		
0.001	24.4	2.91E-03	2.14E-03	1.00E-03	0.0509	0.131	0.99	0.192	0.99	0.45	1.00		
0.002	24.4	2.92E-03	2.14E-03	1.00E-03	0.1018	0.131	0.99	0.193	1.00	0.45	1.00		

R =	5000	10000	50000					
Theta =	0.09							
L=	50.9							
		Calc.	Calc.	Calc.		Calc.		Calc.
		Sol'n Th	Sol'n Th	Sol'n Th		Total Th	Relative	Total Th
		Conc.	Conc.	Conc.		Conc.	Total Th	Conc.
Depth	Pore	µCi/mL	µCi/mL	µCi/mL	Depth	µCi/mL	Conc.	µCi/mL
Z = z/L	Volumes	R =5,000	R = 10,000	R =50,000	(cm)	R = 5,000	R = 5,000	R = 10,000
0.001	24.4	0.0002905809	0.0002136653	0.0001004372	=A11*$B$4	=$B$2*$B$3*C11	=G11/$G$19	=$C$2*$B$3*D11
0.002	24.4	0.0002916264	0.000214284	0.0001001771	=A12*$B$4	=$B$2*$B$3*C12	=G12/$G$19	=$C$2*$B$3*D12
0.003	24.4	0.0002925291	0.0002146964	0.00009945869	=A13*$B$4	=$B$2*$B$3*C13	=G13/$G$19	=$C$2*$B$3*D13
0.004	24.4	0.0002932882	0.0002149019	0.00009829312	=A14*$B$4	=$B$2*$B$3*C14	=G14/$G$19	=$C$2*$B$3*D14
0.005	24.4	0.0002939029	0.0002149013	0.00009669744	=A15*$B$4	=$B$2*$B$3*C15	=G15/$G$19	=$C$2*$B$3*D15
0.006	24.4	0.000294372	0.0002146952	0.00009469418	=A16*$B$4	=$B$2*$B$3*C16	=G16/$G$19	=$C$2*$B$3*D16
0.007	24.4	0.0002946961	0.0002142849	0.00009231088	=A17*$B$4	=$B$2*$B$3*C17	=G17/$G$19	=$C$2*$B$3*D17
0.008	24.4	0.0002948755	0.000213672	0.00008957938	=A18*$B$4	=$B$2*$B$3*C18	=G18/$G$19	=$C$2*$B$3*D18
0.009	24.4	0.0002949101	0.0002128589	0.00008653514	=A19*$B$4	=$B$2*$B$3*C19	=G19/$G$19	=$C$2*$B$3*D19
0.01	24.4	0.0002948005	0.0002118485	0.00008321649	=A20*$B$4	=$B$2*$B$3*C20	=G20/$G$19	=$C$2*$B$3*D20
0.011	24.4	0.0002945472	0.000210644	0.00007966388	=A21*$B$4	=$B$2*$B$3*C21	=G21/$G$19	=$C$2*$B$3*D21
0.012	24.4	0.0002941509	0.0002092494	0.00007591908	=A22*$B$4	=$B$2*$B$3*C22	=G22/$G$19	=$C$2*$B$3*D22
0.013	24.4	0.0002936126	0.0002076689	0.00007202445	=A23*$B$4	=$B$2*$B$3*C23	=G23/$G$19	=$C$2*$B$3*D23
0.014	24.4	0.0002929336	0.0002059074	0.00006802212	=A24*$B$4	=$B$2*$B$3*C24	=G24/$G$19	=$C$2*$B$3*D24
0.015	24.4	0.000292115	0.0002039701	0.00006395334	=A25*$B$4	=$B$2*$B$3*C25	=G25/$G$19	=$C$2*$B$3*D25
0.016	24.4	0.0002911584	0.0002018625	0.00005985777	=A26*$B$4	=$B$2*$B$3*C26	=G26/$G$19	=$C$2*$B$3*D26
0.017	24.4	0.0002900656	0.0001995908	0.00005577296	=A27*$B$4	=$B$2*$B$3*C27	=G27/$G$19	=$C$2*$B$3*D27
0.018	24.4	0.0002888384	0.0001971613	0.00005173374	=A28*$B$4	=$B$2*$B$3*C28	=G28/$G$19	=$C$2*$B$3*D28
0.019	24.4	0.0002874789	0.0001945807	0.00004777191	=A29*$B$4	=$B$2*$B$3*C29	=G29/$G$19	=$C$2*$B$3*D29
					1			
0.02	24.4	0.0002859892	0.0001918561	0.00004391584	=A31*$B$4	=$B$2*$B$3*C31	=G31/$G$19	=$C$2*$B$3*D31
0.021	24.4	0.0002843717	0.0001889947	0.00004019026	=A32*$B$4	=$B$2*$B$3*C32	=G32/$G$19	=$C$2*$B$3*D32
0.022	24.4	0.000282629	0.0001860042	0.00003661616	=A33*$B$4	=$B$2*$B$3*C33	=G33/$G$19	=$C$2*$B$3*D33
0.023	24.4	0.0002807637	0.0001828922	0.00003321073	=A34*$B$4	=$B$2*$B$3*C34	=G34/$G$19	=$C$2*$B$3*D34
0.024	24.4	0.0002787787	0.0001796667	0.00002998741	=A35*$B$4	=$B$2*$B$3*C35	=G35/$G$19	=$C$2*$B$3*D35
0.025	24.4	0.0002766769	0.0001763357	0.00002695599	=A36*$B$4	=$B$2*$B$3*C36	=G36/$G$19	=$C$2*$B$3*D36

R =	5000	10000	50000					
Theta =	0.09							
L=	50.9							
		Calc.	Calc.	Calc.		Calc.		Calc.
		Soil h Th	Soil h Th	Soil h Th		Total Th	Relative	Total Th
		Conc.	Conc.	Conc.		Conc.	Total Th	Conc.
Depth	Pore	µCi/mL	µCi/mL	µCi/mL	Depth	µCi/mL	Conc.	µCi/mL
Z = z/L	Volumes	R=5,000	R=10,000	R=50,000	(cm)	R=5,000	R=5,000	R=10,000
0.026	24.4	0.0002744614	0.0001729076	0.00002412284	=A37*$B$4	=$B$2*$B$3*C37	=G37/$G$19	=$C$2*$B$3*D37
0.027	24.4	0.0002721353	0.0001693906	0.00002149115	=A38*$B$4	=$B$2*$B$3*C38	=G38/$G$19	=$C$2*$B$3*D38
0.028	24.4	0.0002697021	0.0001657931	0.00001906116	=A39*$B$4	=$B$2*$B$3*C39	=G39/$G$19	=$C$2*$B$3*D39
0.029	24.4	0.0002671652	0.0001621234	0.00001683055	=A40*$B$4	=$B$2*$B$3*C40	=G40/$G$19	=$C$2*$B$3*D40
0.03	24.4	0.000264528	0.0001583899	0.00001479473	=A41*$B$4	=$B$2*$B$3*C41	=G41/$G$19	=$C$2*$B$3*D41
0.031	24.4	0.0002617942	0.0001546011	0.0000129472	=A42*$B$4	=$B$2*$B$3*C42	=G42/$G$19	=$C$2*$B$3*D42
0.032	24.4	0.0002589675	0.0001507651	0.0000112799	=A43*$B$4	=$B$2*$B$3*C43	=G43/$G$19	=$C$2*$B$3*D43
0.033	24.4	0.0002560518	0.0001468901	0.000009783515	=A44*$B$4	=$B$2*$B$3*C44	=G44/$G$19	=$C$2*$B$3*D44
0.034	24.4	0.0002530508	0.0001429844	0.00000844782	=A45*$B$4	=$B$2*$B$3*C45	=G45/$G$19	=$C$2*$B$3*D45
0.035	24.4	0.0002499685	0.0001390557	0.000007261965	=A46*$B$4	=$B$2*$B$3*C46	=G46/$G$19	=$C$2*$B$3*D46
0.036	24.4	0.0002468089	0.000135112	0.000006214738	=A47*$B$4	=$B$2*$B$3*C47	=G47/$G$19	=$C$2*$B$3*D47
0.037	24.4	0.000243576	0.0001311607	0.000005294803	=A48*$B$4	=$B$2*$B$3*C48	=G48/$G$19	=$C$2*$B$3*D48
0.038	24.4	0.0002402739	0.0001272093	0.000004490907	=A49*$B$4	=$B$2*$B$3*C49	=G49/$G$19	=$C$2*$B$3*D49
0.039	24.4	0.0002369067	0.0001232648	0.000003792053	=A50*$B$4	=$B$2*$B$3*C50	=G50/$G$19	=$C$2*$B$3*D50
					2			
0.04	24.4	0.0002334785	0.0001193344	0.000003187641	=A52*$B$4	=$B$2*$B$3*C52	=G52/$G$19	=$C$2*$B$3*D52
0.041	24.4	0.0002299934	0.0001154244	0.00000266758	=A53*$B$4	=$B$2*$B$3*C53	=G53/$G$19	=$C$2*$B$3*D53
0.042	24.4	0.0002264556	0.0001115414	0.00000222237	=A54*$B$4	=$B$2*$B$3*C54	=G54/$G$19	=$C$2*$B$3*D54
0.043	24.4	0.0002228693	0.0001076914	0.000001843166	=A55*$B$4	=$B$2*$B$3*C55	=G55/$G$19	=$C$2*$B$3*D55
0.044	24.4	0.0002192386	0.0001038802	0.000001521805	=A56*$B$4	=$B$2*$B$3*C56	=G56/$G$19	=$C$2*$B$3*D56
0.045	24.4	0.0002155677	0.0001001132	0.000001250829	=A57*$B$4	=$B$2*$B$3*C57	=G57/$G$19	=$C$2*$B$3*D57
0.046	24.4	0.0002118606	0.00009639555	0.000001023477	=A58*$B$4	=$B$2*$B$3*C58	=G58/$G$19	=$C$2*$B$3*D58
0.047	24.4	0.0002081214	0.00009273207	0.0000008336752	=A59*$B$4	=$B$2*$B$3*C59	=G59/$G$19	=$C$2*$B$3*D59
0.048	24.4	0.0002043542	0.00008912723	0.0000006760067	=A60*$B$4	=$B$2*$B$3*C60	=G60/$G$19	=$C$2*$B$3*D60
0.049	24.4	0.0002005631	0.00008558519	0.000000545679	=A61*$B$4	=$B$2*$B$3*C61	=G61/$G$19	=$C$2*$B$3*D61
0.05	24.4	0.0001967519	0.00008210975	0.0000004384822	=A62*$B$4	=$B$2*$B$3*C62	=G62/$G$19	=$C$2*$B$3*D62

R =	5000	10000	50000					
Theta =	0.09							
L=	50.9							
		Calc.	Calc.	Calc.		Calc.		Calc.
		Sol'n Th	Sol'n Th	Sol'n Th		Total Th	Relative	Total Th
		Conc.	Conc.	Conc.		Conc.	Total Th	Conc.
Depth	Pore	µCi/mL	µCi/mL	µCi/mL	Depth	µCi/mL	Conc.	µCi/mL
Z = z/L	Volumes	R =5,000	R = 10,000	R =50,000	(cm)	R = 5,000	R = 5,000	R = 10,000
0.052	24.4	0.000189085	0.00007537222	0.0000002792879	=A63*$B$4	=$B$2*$B$3*C63	=G63/$G$19	=$C$2*$B$3*D63
0.054	24.4	0.0001813842	0.00006893845	0.0000001746705	=A64*$B$4	=$B$2*$B$3*C64	=G64/$G$19	=$C$2*$B$3*D64
0.056	24.4	0.0001736788	0.00006282705	0.0000001072556	=A65*$B$4	=$B$2*$B$3*C65	=G65/$G$19	=$C$2*$B$3*D65
0.058	24.4	0.0001659971	0.0000570516	0.00000006465702	=A66*$B$4	=$B$2*$B$3*C66	=G66/$G$19	=$C$2*$B$3*D66
0.06	24.4	0.0001583657	0.00005162097	0.00000003826188	=A67*$B$4	=$B$2*$B$3*C67	=G67/$G$19	=$C$2*$B$3*D67
0.065	24.4	0.000139669	0.00003957223	0.000000009744173	=A68*$B$4	=$B$2*$B$3*C68	=G68/$G$19	=$C$2*$B$3*D68
0.07	24.4	0.0001217873	0.00002966233	0.000000002189303	=A69*$B$4	=$B$2*$B$3*C69	=G69/$G$19	=$C$2*$B$3*D69
					4	=$B$2*$B$3*C70		
0.08	24.4	0.00008950334	0.00001558181	0.00000000007913468	=A71*$B$4	=$B$2*$B$3*C71	=G71/$G$19	=$C$2*$B$3*D71
0.09	24.4	0.00006287055	0.000007483238	0.000000000001831932	=A72*$B$4	=$B$2*$B$3*C72	=G72/$G$19	=$C$2*$B$3*D72
0.1	24.4	0.0000422164	0.000003285368	2.715776E-14	=A73*$B$4	=$B$2*$B$3*C73	=G73/$G$19	=$C$2*$B$3*D73
					6			
0.15	24.4	0.00000293639	0.00000001404748	2.428756E-26	=A75*$B$4	=$B$2*$B$3*C75	=G75/$G$19	=$C$2*$B$3*D75
					8			
					10			
0.2	24.4	0.00000006680018	0.00000000000644521	3.14809E-43	=A78*$B$4	=$B$2*$B$3*C78	=G78/$G$19	=$C$2*$B$3*D78
					12			
					14			
0.3	24.4	0.000000000001212198	1.691134E-21	5.73548E-89	=A81*$B$4	=$B$2*$B$3*C81	=G81/$G$19	=$C$2*$B$3*D81
					16			
					18			
					20			
0.4	24.4	2.544797E-19	5.963787E-35	2.059703E-156	=A85*$B$4	=$B$2*$B$3*C85	=G85/$G$19	=$C$2*$B$3*D85
					22			
					24			
0.5	24.4	6.190085E-28	4.64628E-50	2.998571E-243	=A88*$B$4	=$B$2*$B$3*C88	=G88/$G$19	=$C$2*$B$3*D88

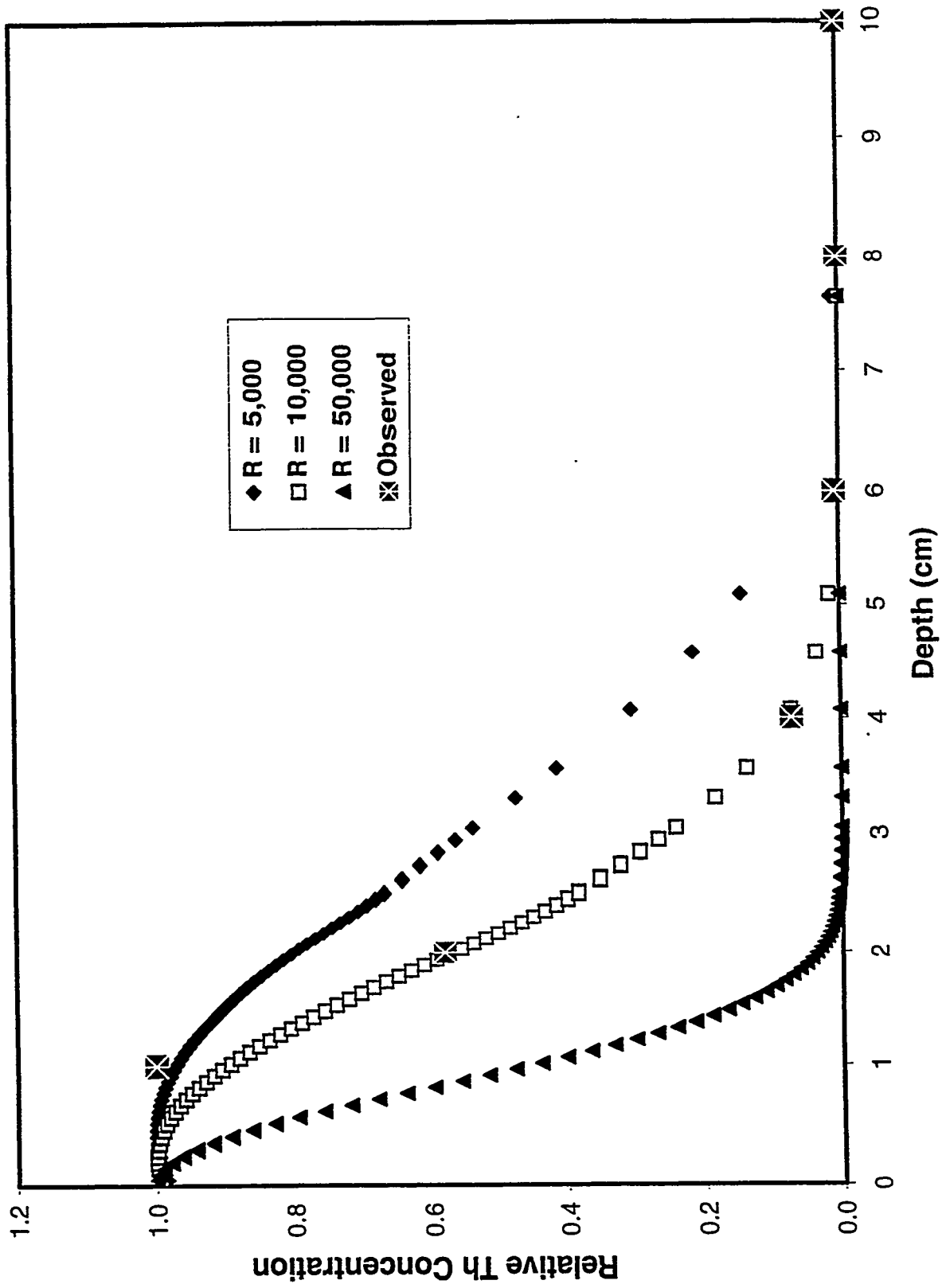
R =	5000	10000	50000					
Theta =	0.09							
L=	50.9							
		Calc.	Calc.	Calc.		Calc.		Calc.
		Soln Th	Soln Th	Soln Th		Total Th	Relative	Total Th
		Conc.	Conc.	Conc.		Conc.	Total Th	Conc.
Depth	Pore	µCi/mL	µCi/mL	µCi/mL	Depth	µCi/mL	Conc.	µCi/mL
Z = z/L	Volumes	R =5,000	R =10,000	R =50,000	(cm)	R = 5,000	R = 5,000	R = 10,000
0.6	24.4	1.745844E-38	4.040352E-71	0	=A89*$B$4	=$B$2*$B$3*C89	=G89/$G$19	=$C$2*$B$3*D89
0.7	24.4	8.384744E-49	4.535086E-96	0	=A90*$B$4	=$B$2*$B$3*C90	=G90/$G$19	=$C$2*$B$3*D90
0.8	24.4	4.019795E-63	6.639537E-125	0	=A91*$B$4	=$B$2*$B$3*C91	=G91/$G$19	=$C$2*$B$3*D91
0.9	24.4	2.181311E-79	1.276811E-157	0	=A92*$B$4	=$B$2*$B$3*C92	=G92/$G$19	=$C$2*$B$3*D92
1	24.4	1.34629E-97	3.241275E-194	0	=A93*$B$4	=$B$2*$B$3*C93	=G93/$G$19	=$C$2*$B$3*D93

	Calc.		Total Th	
Relative	Total Th	Relative	Daughter	Relative Th
Total Th	Conc.	Total Th	Activity	Daughter
Conc.	µCi/mL	Conc.	µCi	Activity
R = 10,000	R = 50,000	R = 50,000	Observed	Observed
=I11/$I$14	=$D$2*$B$3*E11	=K11/$K$11		
=I12/$I$14	=$D$2*$B$3*E12	=K12/$K$11		
=I13/$I$14	=$D$2*$B$3*E13	=K13/$K$11		
=I14/$I$14	=$D$2*$B$3*E14	=K14/$K$11		
=I15/$I$14	=$D$2*$B$3*E15	=K15/$K$11		
=I16/$I$14	=$D$2*$B$3*E16	=K16/$K$11		
=I17/$I$14	=$D$2*$B$3*E17	=K17/$K$11		
=I18/$I$14	=$D$2*$B$3*E18	=K18/$K$11		
=I19/$I$14	=$D$2*$B$3*E19	=K19/$K$11		
=I20/$I$14	=$D$2*$B$3*E20	=K20/$K$11		
=I21/$I$14	=$D$2*$B$3*E21	=K21/$K$11		
=I22/$I$14	=$D$2*$B$3*E22	=K22/$K$11		
=I23/$I$14	=$D$2*$B$3*E23	=K23/$K$11		
=I24/$I$14	=$D$2*$B$3*E24	=K24/$K$11		
=I25/$I$14	=$D$2*$B$3*E25	=K25/$K$11		
=I26/$I$14	=$D$2*$B$3*E26	=K26/$K$11		
=I27/$I$14	=$D$2*$B$3*E27	=K27/$K$11		
=I28/$I$14	=$D$2*$B$3*E28	=K28/$K$11		
=I29/$I$14	=$D$2*$B$3*E29	=K29/$K$11		
			19.51	=M30/$M$30
=I31/$I$14	=$D$2*$B$3*E31	=K31/$K$11		
=I32/$I$14	=$D$2*$B$3*E32	=K32/$K$11		
=I33/$I$14	=$D$2*$B$3*E33	=K33/$K$11		
=I34/$I$14	=$D$2*$B$3*E34	=K34/$K$11		
=I35/$I$14	=$D$2*$B$3*E35	=K35/$K$11		
=I36/$I$14	=$D$2*$B$3*E36	=K36/$K$11		

	Calc.		Total Th	
Relative	Total Th	Relative	Daughter	Relative Th
Total Th	Conc.	Total Th	Activity	Daughter
Conc.	µCi/mL	Conc.	µCi	Activity
R = 10,000	R = 50,000	R = 50,000	Observed	Observed
=I37/$I$14	=$D$2*$B$3*E37	=K37/$K$11		
=I38/$I$14	=$D$2*$B$3*E38	=K38/$K$11		
=I39/$I$14	=$D$2*$B$3*E39	=K39/$K$11		
=I40/$I$14	=$D$2*$B$3*E40	=K40/$K$11		
=I41/$I$14	=$D$2*$B$3*E41	=K41/$K$11		
=I42/$I$14	=$D$2*$B$3*E42	=K42/$K$11		
=I43/$I$14	=$D$2*$B$3*E43	=K43/$K$11		
=I44/$I$14	=$D$2*$B$3*E44	=K44/$K$11		
=I45/$I$14	=$D$2*$B$3*E45	=K45/$K$11		
=I46/$I$14	=$D$2*$B$3*E46	=K46/$K$11		
=I47/$I$14	=$D$2*$B$3*E47	=K47/$K$11		
=I48/$I$14	=$D$2*$B$3*E48	=K48/$K$11		
=I49/$I$14	=$D$2*$B$3*E49	=K49/$K$11		
=I50/$I$14	=$D$2*$B$3*E50	=K50/$K$11		
			11.31	=M51/$M$30
=I52/$I$14	=$D$2*$B$3*E52	=K52/$K$11		
=I53/$I$14	=$D$2*$B$3*E53	=K53/$K$11		
=I54/$I$14	=$D$2*$B$3*E54	=K54/$K$11		
=I55/$I$14	=$D$2*$B$3*E55	=K55/$K$11		
=I56/$I$14	=$D$2*$B$3*E56	=K56/$K$11		
=I57/$I$14	=$D$2*$B$3*E57	=K57/$K$11		
=I58/$I$14	=$D$2*$B$3*E58	=K58/$K$11		
=I59/$I$14	=$D$2*$B$3*E59	=K59/$K$11		
=I60/$I$14	=$D$2*$B$3*E60	=K60/$K$11		
=I61/$I$14	=$D$2*$B$3*E61	=K61/$K$11		
=I62/$I$14	=$D$2*$B$3*E62	=K62/$K$11		

	Calc.		Total Th	
Relative	Total Th	Relative	Daughter	Relative Th
Total Th	Conc.	Total Th	Activity	Daughter
Conc.	µCi/mL	Conc.	µCi	Activity
R = 10,000	R = 50,000	R = 50,000	Observed	Observed
=I63/$I$14	=$D$2*$B$3*E63	=K63/$K$11		
=I64/$I$14	=$D$2*$B$3*E64	=K64/$K$11		
=I65/$I$14	=$D$2*$B$3*E65	=K65/$K$11		
=I66/$I$14	=$D$2*$B$3*E66	=K66/$K$11		
=I67/$I$14	=$D$2*$B$3*E67	=K67/$K$11		
=I68/$I$14	=$D$2*$B$3*E68	=K68/$K$11		
=I69/$I$14	=$D$2*$B$3*E69	=K69/$K$11		
			1.41	=M70/$M$30
=I71/$I$14	=$D$2*$B$3*E71	=K71/$K$11		
=I72/$I$14	=$D$2*$B$3*E72	=K72/$K$11		
=I73/$I$14	=$D$2*$B$3*E73	=K73/$K$11		
			0.13	=M74/$M$30
=I75/$I$14	=$D$2*$B$3*E75	=K75/$K$11		
			0.03	=M76/$M$30
			0.04	=M77/$M$30
=I78/$I$14	=$D$2*$B$3*E78	=K78/$K$11		
			0.02	=M79/$M$30
			0.007	=M80/$M$30
=I81/$I$14	=$D$2*$B$3*E81	=K81/$K$11		
			0.007	=M82/$M$30
			0.004	=M83/$M$30
			0.008	
=I85/$I$14	=$D$2*$B$3*E85	=K85/$K$11		
			0.004	=M86/$M$30
			0.002	=M87/$M$30
=I88/$I$14	=$D$2*$B$3*E88	=K88/$K$11		

	Calc.		Total Th	
Relative	Total Th	Relative	Daughter	Relative Th
Total Th	Conc.	Total TH	Activity	Daughter
Conc.	µCi/mL	Conc.	µCi	Activity
R = 10,000	R = 50,000	R = 50,000	Observed	Observed
=I89/$I$14	=$D$2*$B$3*E89	=K89/$K$11		
=I90/$I$14	=$D$2*$B$3*E90	=K90/$K$11		
=I91/$I$14	=$D$2*$B$3*E91	=K91/$K$11		
=I92/$I$14	=$D$2*$B$3*E92	=K92/$K$11		
=I93/$I$14	=$D$2*$B$3*E93	=K93/$K$11		


R = 5,000
R = 10,000
R = 50,000
Observed
Relative Th Concentration
Depth (cm)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
1
2
3
4
5
6
7
8
9
10

APPENDIX G.

MEMORANDUM FROM
LOS ALAMOS NATIONAL LABORATORY
CHEMICAL SCIENCE AND TECHNOLOGY DIVISION

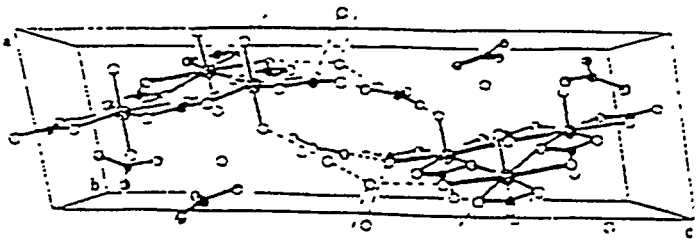
Discussion of analytical and oxidation state characterization on the 241 Actinide samples

By David L. Clark

David L. Clark
Chemical Science and Technology Division
Mail Stop G739

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545



Dan,

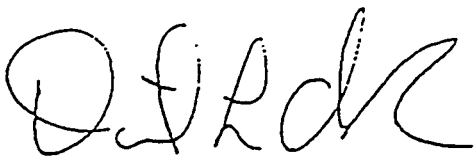
Here is a discussion of the analytical and oxidation state characterization on the 241Actinide samples.

(1) $^{241}Am(III)$ preparation and characterization.

LANL CST-7 prepared a sample of aqueous $^{241}Am^{3+}$ for assay and shipment to Sandia National Laboratory. Preparation and assay are recorded in LANL lab notebook LA-CST-NBK-95-028, pages 35-36, and 38-39. The results of the ^{241}Am assay are recorded on page 41. Approximately 0.025g of high purity $^{241}AmO_2$ (lot ID LRA03) was taken from Material Balance Area 528 and dissolved in 0.5mL 8M HNO_3 with a trace amount of HF. This solution was heated in a salt bath until the solid had dissolved to give a yellow solution. The ^{241}Am was precipitated from solution using 10.7M NaOH. The resulting $^{241}Am(OH)_3$ was removed via centrifugation, and washed three times with distilled water. The resulting precipitate was redissolved in 0.5mL of 1M $HClO_4$ to give a pink solution of $^{241}Am^{3+}$ aquo ion. An 0.025mL aliquot of this solution was added to 3.0 mL of 1M $HClO_4$ and added to a 2cm micro cell for assay using absorption spectroscopy. The absorption maximum at 503 nm was used to determine Am concentration, and to confirm that all Am was present in the trivalent oxidation state. Another aliquot was submitted for isotopic purity determination (Analytical Chemistry sample ID 200017115). Alpha spectroscopy showed only ^{241}Am, and total plutonium < 0.6% of alpha activity. The combined assays were used to prepare 5.0 mL of a solution containing 1.03×10^{-6}M $^{241}Am^{3+}$ in 0.1M HCl. This solution was packaged and shipped to Dan Lucero at SNL.

(2) ^{241}Pu sample analysis.

LANL CST-7 received a shipment of ^{241}Pu from Dan Lucero at SNL. This sample contained 19.91 µCi/g of ^{241}Pu in 1M HCl as of December 1, 1994. A simple calculation suggested that 19.60 µCi/g of ^{241}Pu in 1M HCl existed as of April 1, 1995. This activity corresponded to a concentration of 7.2×10^{-7}M, which is a the edge of our detection limits for oxidation state determination using PAS. Since this was the only ^{241}Pu available, the risk of losing sample via transfers, etc. was deemed too great, and we sent the sample back to SNL. The status of the oxidation state of the sample is unclear. Normally, in HCl solution, alpha radiolysis will keep the sample in the tetravalent oxidation state. However, ^{241}Pu is primarily a beta-emitting radionuclide, and the radiolysis effects from such a solution are not well understood. Plutonium samples in near-neutral solution under these concentrations are known to contain a large amount of the pentavalent oxidation state. Without further data in brine solution, one cannot say for sure what the predominant oxidation state will be.



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APPENDIX H.

LISTINGS OF PARAMETER INPUT FILES (*.COL) FOR THREE ^{241}Pu COLUMN 1.4 CALCULATIONS AT RETARDATION VALUES 20,000, 20,500, & 21,000

Pu_20000_Vol.col

```
[Wcolumn]
Date=5/7/98 1:41:36 PM
Title=Pu, 0.1 mL/min, 20 mL spike - Data through 9/2/97
LogFile=Pu_20000_Vol.log
OutputFile=Pu_20000_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=FLUX
Bootstrap=
[DistanceAndTimeSpec.]
Set=Formula
Fixed=Distance
Distance=1
Start=12.9
End=1290
Step=100
[ParameterValues]
R=20000
theta=0.033
D=0.64
mu=0
gamma=0
q=0.033
t0=0.36
c0=670000
```

Pu_20500_Vol.col

```
[Wcolumn]
Date=5/7/98 1:43:10 PM
Title=Pu, 0.1 mL/min, 20 mL spike - Data through 9/2/97
LogFile=Pu_20500_Vol.log
OutputFile=Pu_20500_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=FLUX
Bootstrap=
[DistanceAndTimeSpec.]
Set=Formula
Fixed=Distance
Distance=1
Start=12.9
End=1290
Step=100
[ParameterValues]
R=20500
theta=0.033
D=0.64
mu=0
gamma=0
q=0.033
t0=0.36
c0=670000
```

Pu_21000_Vol.col

```
[Wcolumn]
Date=5/7/98 1:42:19 PM
Title=Pu, 0.1 mL/min, 20 mL spike - Data through 9/2/97
LogFile=Pu_21000_Vol.log
OutputFile=Pu_21000_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=FLUX
Bootstrap=
[DistanceAndTimeSpec.]
Set=Formula
Fixed=Distance
Distance=1
Start=12.9
End=1290
Step=100
[ParameterValues]
R=21000
theta=0.033
D=0.64
mu=0
gamma=0
q=0.033
t0=0.36
c0=670000
```

APPENDIX I.

LISTINGS OF OUTPUT FILES (*.LOG) FOR THREE ^{241}Pu COLUMN 1.4 CALCULATIONS AT RETARDATION VALUES 20,000, 20,500, & 21,000

Pu_20000_Vol.log

```
*******************************************************************************
*                                                                             *
*    Deterministic linear equilibrium absorption for pulse injection with     *
*    first-order decay                                                        *
*                                                                             *
*    Pu, 0.1 mL/min, 20 mL spike - Data through 9/2/97                        *
*                                                                             *
*******************************************************************************
Model Name = Linear equilibrium
Calculation began 5/7/98 1:41:40 PM

Model parameters:
        R = 20000
    theta = 0.033
        D = 0.64
       mu = 0
    gamma = 0
        q = 0.033
       t0 = 0.36
       c0 = 670000

No fit performed; model calculation only

Calculated model curves:
Distance        Time            Model
1.000000E+00  1.290000E+01  1.610584E-259
1.000000E+00  2.580000E+01  7.245637E-128
1.000000E+00  3.870000E+01  5.245887E-84
1.000000E+00  5.160000E+01  3.868146E-62
1.000000E+00  6.450000E+01  4.613911E-49
1.000000E+00  7.740000E+01  2.255661E-40
1.000000E+00  9.030000E+01  6.911341E-34
1.000000E+00  1.032000E+02  2.922740E-29
1.000000E+00  1.161000E+02  1.130989E-25
1.000000E+00  1.290000E+02  8.229986E-23
1.000000E+00  1.419000E+02  1.779975E-20
1.000000E+00  1.548000E+02  1.551907E-18
1.000000E+00  1.677000E+02  6.734067E-17
1.000000E+00  1.806000E+02  1.690228E-15
1.000000E+00  1.935000E+02  2.739676E-14
1.000000E+00  2.064000E+02  3.114381E-13
1.000000E+00  2.193000E+02  2.644449E-12
1.000000E+00  2.322000E+02  1.761396E-11
1.000000E+00  2.451000E+02  9.565554E-11
1.000000E+00  2.580000E+02  4.368167E-10
1.000000E+00  2.709000E+02  1.719749E-09
1.000000E+00  2.838000E+02  5.957568E-09
1.000000E+00  2.967000E+02  1.846817E-08
1.000000E+00  3.096000E+02  5.195387E-08
1.000000E+00  3.225000E+02  1.342025E-07
1.000000E+00  3.354000E+02  3.214927E-07
1.000000E+00  3.483000E+02  7.203203E-07
1.000000E+00  3.612000E+02  1.520449E-06
1.000000E+00  3.741000E+02  3.042433E-06
1.000000E+00  3.870000E+02  5.802574E-06
1.000000E+00  3.999000E+02  1.059775E-05
1.000000E+00  4.128000E+02  1.861169E-05
1.000000E+00  4.257000E+02  3.154314E-05
1.000000E+00  4.386000E+02  5.175514E-05
1.000000E+00  4.515000E+02  8.244311E-05
1.000000E+00  4.644000E+02  1.278186E-04
1.000000E+00  4.773000E+02  1.933037E-04
1.000000E+00  4.902000E+02  2.857318E-04
1.000000E+00  5.031000E+02  4.135468E-04
1.000000E+00  5.160000E+02  5.869975E-04
1.000000E+00  5.289000E+02  8.183185E-04
1.000000E+00  5.418000E+02  1.121894E-03
1.000000E+00  5.547000E+02  1.514396E-03
1.000000E+00  5.676000E+02  2.014900E-03
```

1.000000E+00	5.805000E+02	2.644965E-03
1.000000E+00	5.934000E+02	3.428685E-03
1.000000E+00	6.063000E+02	4.392700E-03
1.000000E+00	6.192000E+02	5.566179E-03
1.000000E+00	6.321000E+02	6.980765E-03
1.000000E+00	6.450000E+02	8.670486E-03
1.000000E+00	6.579000E+02	1.067164E-02
1.000000E+00	6.708000E+02	1.302265E-02
1.000000E+00	6.837000E+02	1.576387E-02
1.000000E+00	6.966000E+02	1.893743E-02
1.000000E+00	7.095000E+02	2.258700E-02
1.000000E+00	7.224000E+02	2.675754E-02
1.000000E+00	7.353000E+02	3.149512E-02
1.000000E+00	7.482000E+02	3.684660E-02
1.000000E+00	7.611000E+02	4.285945E-02
1.000000E+00	7.740000E+02	4.958144E-02
1.000000E+00	7.869000E+02	5.706043E-02
1.000000E+00	7.998000E+02	6.534409E-02
1.000000E+00	8.127000E+02	7.447971E-02
1.000000E+00	8.256000E+02	8.451390E-02
1.000000E+00	8.385000E+02	9.549244E-02
1.000000E+00	8.514000E+02	1.074600E-01
1.000000E+00	8.643000E+02	1.204601E-01
1.000000E+00	8.772000E+02	1.345347E-01
1.000000E+00	8.901000E+02	1.497241E-01
1.000000E+00	9.030000E+02	1.660671E-01
1.000000E+00	9.159000E+02	1.836004E-01
1.000000E+00	9.288000E+02	2.023588E-01
1.000000E+00	9.417000E+02	2.223749E-01
1.000000E+00	9.546000E+02	2.437357E-01
1.000000E+00	9.675000E+02	2.663594E-01
1.000000E+00	9.804000E+02	2.903254E-01
1.000000E+00	9.933000E+02	3.156574E-01
1.000000E+00	1.006200E+03	3.423764E-01
1.000000E+00	1.019100E+03	3.705014E-01
1.000000E+00	1.032000E+03	4.000485E-01
1.000000E+00	1.044900E+03	4.310319E-01
1.000000E+00	1.057800E+03	4.634631E-01
1.000000E+00	1.070700E+03	4.973512E-01
1.000000E+00	1.083600E+03	5.327033E-01
1.000000E+00	1.096500E+03	5.695240E-01
1.000000E+00	1.109400E+03	6.078156E-01
1.000000E+00	1.122300E+03	6.475784E-01
1.000000E+00	1.135200E+03	6.888105E-01
1.000000E+00	1.148100E+03	7.315079E-01
1.000000E+00	1.161000E+03	7.756647E-01
1.000000E+00	1.173900E+03	8.212730E-01
1.000000E+00	1.186800E+03	8.683232E-01
1.000000E+00	1.199700E+03	9.168038E-01
1.000000E+00	1.212600E+03	9.667017E-01
1.000000E+00	1.225500E+03	1.018002E+00
1.000000E+00	1.238400E+03	1.070689E+00
1.000000E+00	1.251300E+03	1.124744E+00
1.000000E+00	1.264200E+03	1.180149E+00
1.000000E+00	1.277100E+03	1.236883E+00
1.000000E+00	1.290000E+03	1.294925E+00

Pu_20500_Vol.log

```
*****************************************************************************
*                                                                           *
*    Deterministic linear equilibrium absorption for pulse injection with   *
*    first-order decay                                                      *
*                                                                           *
*    Pu, 0.1 mL/min, 20 mL spike - Data through 9/2/97                      *
*                                                                           *
*****************************************************************************
Model Name = Linear equilibrium
Calculation began 5/7/98 1:43:15 PM

Model parameters:
        R = 20500
    theta = 0.033
        D = 0.64
       mu = 0
    gamma = 0
        q = 0.033
       t0 = 0.36
       c0 = 670000

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E+00  1.290000E+01  4.228522E-266
1.000000E+00  2.580000E+01  3.695017E-131
1.000000E+00  3.870000E+01  3.358754E-86
1.000000E+00  5.160000E+01  8.794973E-64
1.000000E+00  6.450000E+01  2.244162E-50
1.000000E+00  7.740000E+01  1.821160E-41
1.000000E+00  9.030000E+01  8.013552E-35
1.000000E+00  1.032000E+02  4.444981E-30
1.000000E+00  1.161000E+02  2.123951E-26
1.000000E+00  1.290000E+02  1.829576E-23
1.000000E+00  1.419000E+02  4.542512E-21
1.000000E+00  1.548000E+02  4.443045E-19
1.000000E+00  1.677000E+02  2.124890E-17
1.000000E+00  1.806000E+02  5.797068E-16
1.000000E+00  1.935000E+02  1.010032E-14
1.000000E+00  2.064000E+02  1.223085E-13
1.000000E+00  2.193000E+02  1.098088E-12
1.000000E+00  2.322000E+02  7.685708E-12
1.000000E+00  2.451000E+02  4.363094E-11
1.000000E+00  2.580000E+02  2.073551E-10
1.000000E+00  2.709000E+02  8.463697E-10
1.000000E+00  2.838000E+02  3.029825E-09
1.000000E+00  2.967000E+02  9.678005E-09
1.000000E+00  3.096000E+02  2.798392E-08
1.000000E+00  3.225000E+02  7.413537E-08
1.000000E+00  3.354000E+02  1.817882E-07
1.000000E+00  3.483000E+02  4.161974E-07
1.000000E+00  3.612000E+02  8.963027E-07
1.000000E+00  3.741000E+02  1.827310E-06
1.000000E+00  3.870000E+02  3.546335E-06
1.000000E+00  3.999000E+02  6.583429E-06
1.000000E+00  4.128000E+02  1.173982E-05
1.000000E+00  4.257000E+02  2.018437E-05
1.000000E+00  4.386000E+02  3.356848E-05
1.000000E+00  4.515000E+02  5.415833E-05
1.000000E+00  4.644000E+02  8.498265E-05
1.000000E+00  4.773000E+02  1.299929E-04
1.000000E+00  4.902000E+02  1.942319E-04
1.000000E+00  5.031000E+02  2.840073E-04
1.000000E+00  5.160000E+02  4.070631E-04
1.000000E+00  5.289000E+02  5.727469E-04
1.000000E+00  5.418000E+02  7.921651E-04
1.000000E+00  5.547000E+02  1.078324E-03
1.000000E+00  5.676000E+02  1.446251E-03
```

1.000000E+00	5.805000E+02	1.913092E-03
1.000000E+00	5.934000E+02	2.498186E-03
1.000000E+00	6.063000E+02	3.223106E-03
1.000000E+00	6.192000E+02	4.111679E-03
1.000000E+00	6.321000E+02	5.189972E-03
1.000000E+00	6.450000E+02	6.486247E-03
1.000000E+00	6.579000E+02	8.030895E-03
1.000000E+00	6.708000E+02	9.856335E-03
1.000000E+00	6.837000E+02	1.199689E-02
1.000000E+00	6.966000E+02	1.448867E-02
1.000000E+00	7.095000E+02	1.736935E-02
1.000000E+00	7.224000E+02	2.067807E-02
1.000000E+00	7.353000E+02	2.445517E-02
1.000000E+00	7.482000E+02	2.874203E-02
1.000000E+00	7.611000E+02	3.358085E-02
1.000000E+00	7.740000E+02	3.901443E-02
1.000000E+00	7.869000E+02	4.508595E-02
1.000000E+00	7.998000E+02	5.183877E-02
1.000000E+00	8.127000E+02	5.931618E-02
1.000000E+00	8.256000E+02	6.756123E-02
1.000000E+00	8.385000E+02	7.661651E-02
1.000000E+00	8.514000E+02	8.652396E-02
1.000000E+00	8.643000E+02	9.732467E-02
1.000000E+00	8.772000E+02	1.090587E-01
1.000000E+00	8.901000E+02	1.217651E-01
1.000000E+00	9.030000E+02	1.354812E-01
1.000000E+00	9.159000E+02	1.502434E-01
1.000000E+00	9.288000E+02	1.660861E-01
1.000000E+00	9.417000E+02	1.830422E-01
1.000000E+00	9.546000E+02	2.011427E-01
1.000000E+00	9.675000E+02	2.204169E-01
1.000000E+00	9.804000E+02	2.409475E-01
1.000000E+00	9.933000E+02	2.626514E-01
1.000000E+00	1.006200E+03	2.856047E-01
1.000000E+00	1.019100E+03	3.098283E-01
1.000000E+00	1.032000E+03	3.353415E-01
1.000000E+00	1.044900E+03	3.621609E-01
1.000000E+00	1.057800E+03	3.903013E-01
1.000000E+00	1.070700E+03	4.197754E-01
1.000000E+00	1.083600E+03	4.505937E-01
1.000000E+00	1.096500E+03	4.827647E-01
1.000000E+00	1.109400E+03	5.162946E-01
1.000000E+00	1.122300E+03	5.511880E-01
1.000000E+00	1.135200E+03	5.874471E-01
1.000000E+00	1.148100E+03	6.250725E-01
1.000000E+00	1.161000E+03	6.640626E-01
1.000000E+00	1.173900E+03	7.044144E-01
1.000000E+00	1.186800E+03	7.461227E-01
1.000000E+00	1.199700E+03	7.891808E-01
1.000000E+00	1.212600E+03	8.335804E-01
1.000000E+00	1.225500E+03	8.793116E-01
1.000000E+00	1.238400E+03	9.263629E-01
1.000000E+00	1.251300E+03	9.747214E-01
1.000000E+00	1.264200E+03	1.024373E+00
1.000000E+00	1.277100E+03	1.075302E+00
1.000000E+00	1.290000E+03	1.127492E+00

Pu_21000_Vol.log

```
*****************************************************************************
*                                                                           *
*    Deterministic linear equilibrium absorption for pulse injection with   *
*    first-order decay                                                      *
*                                                                           *
*    Pu, 0.1 mL/min, 20 mL spike - Data through 9/2/97                      *
*                                                                           *
*****************************************************************************
Model Name = Linear equilibrium
Calculation began 5/7/98 1:42:25 PM

Model parameters:
        R = 21000
    theta = 0.033
        D = 0.64
       mu = 0
    gamma = 0
        q = 0.033
       t0 = 0.36
       c0 = 670000

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E+00  1.290000E+01  1.110511E-272
1.000000E+00  2.580000E+01  1.884613E-134
1.000000E+00  3.870000E+01  2.150190E-88
1.000000E+00  5.160000E+01  1.999226E-65
1.000000E+00  6.450000E+01  1.091242E-51
1.000000E+00  7.740000E+01  1.469940E-42
1.000000E+00  9.030000E+01  9.288815E-36
1.000000E+00  1.032000E+02  6.758042E-31
1.000000E+00  1.161000E+02  3.987503E-27
1.000000E+00  1.290000E+02  4.066042E-24
1.000000E+00  1.419000E+02  1.158906E-21
1.000000E+00  1.548000E+02  1.271643E-19
1.000000E+00  1.677000E+02  6.702930E-18
1.000000E+00  1.806000E+02  1.987653E-16
1.000000E+00  1.935000E+02  3.722550E-15
1.000000E+00  2.064000E+02  4.801867E-14
1.000000E+00  2.193000E+02  4.558353E-13
1.000000E+00  2.322000E+02  3.352580E-12
1.000000E+00  2.451000E+02  1.989516E-11
1.000000E+00  2.580000E+02  9.840072E-11
1.000000E+00  2.709000E+02  4.164119E-10
1.000000E+00  2.838000E+02  1.540401E-09
1.000000E+00  2.967000E+02  5.070091E-09
1.000000E+00  3.096000E+02  1.506840E-08
1.000000E+00  3.225000E+02  4.094095E-08
1.000000E+00  3.354000E+02  1.027609E-07
1.000000E+00  3.483000E+02  2.404034E-07
1.000000E+00  3.612000E+02  5.282078E-07
1.000000E+00  3.741000E+02  1.097162E-06
1.000000E+00  3.870000E+02  2.166735E-06
1.000000E+00  3.999000E+02  4.088439E-06
1.000000E+00  4.128000E+02  7.402927E-06
1.000000E+00  4.257000E+02  1.291196E-05
1.000000E+00  4.386000E+02  2.176589E-05
1.000000E+00  4.515000E+02  3.556662E-05
1.000000E+00  4.644000E+02  5.648495E-05
1.000000E+00  4.773000E+02  8.739062E-05
1.000000E+00  4.902000E+02  1.319923E-04
1.000000E+00  5.031000E+02  1.949845E-04
1.000000E+00  5.160000E+02  2.821973E-04
1.000000E+00  5.289000E+02  4.007455E-04
1.000000E+00  5.418000E+02  5.591717E-04
1.000000E+00  5.547000E+02  7.675818E-04
1.000000E+00  5.676000E+02  1.037765E-03
```

1.000000E+00	5.805000E+02	1.383302E-03
1.000000E+00	5.934000E+02	1.819646E-03
1.000000E+00	6.063000E+02	2.364190E-03
1.000000E+00	6.192000E+02	3.036309E-03
1.000000E+00	6.321000E+02	3.857372E-03
1.000000E+00	6.450000E+02	4.850740E-03
1.000000E+00	6.579000E+02	6.041725E-03
1.000000E+00	6.708000E+02	7.457543E-03
1.000000E+00	6.837000E+02	9.127227E-03
1.000000E+00	6.966000E+02	1.108153E-02
1.000000E+00	7.095000E+02	1.335281E-02
1.000000E+00	7.224000E+02	1.597487E-02
1.000000E+00	7.353000E+02	1.898286E-02
1.000000E+00	7.482000E+02	2.241304E-02
1.000000E+00	7.611000E+02	2.630269E-02
1.000000E+00	7.740000E+02	3.068984E-02
1.000000E+00	7.869000E+02	3.561316E-02
1.000000E+00	7.998000E+02	4.111174E-02
1.000000E+00	8.127000E+02	4.722490E-02
1.000000E+00	8.256000E+02	5.399202E-02
1.000000E+00	8.385000E+02	6.145232E-02
1.000000E+00	8.514000E+02	6.964472E-02
1.000000E+00	8.643000E+02	7.860768E-02
1.000000E+00	8.772000E+02	8.837896E-02
1.000000E+00	8.901000E+02	9.899554E-02
1.000000E+00	9.030000E+02	1.104935E-01
1.000000E+00	9.159000E+02	1.229077E-01
1.000000E+00	9.288000E+02	1.362719E-01
1.000000E+00	9.417000E+02	1.506184E-01
1.000000E+00	9.546000E+02	1.659784E-01
1.000000E+00	9.675000E+02	1.823811E-01
1.000000E+00	9.804000E+02	1.998544E-01
1.000000E+00	9.933000E+02	2.184245E-01
1.000000E+00	1.006200E+03	2.381704E-01
1.000000E+00	1.019100E+03	2.590082E-01
1.000000E+00	1.032000E+03	2.810106E-01
1.000000E+00	1.044900E+03	3.041966E-01
1.000000E+00	1.057800E+03	3.285833E-01
1.000000E+00	1.070700E+03	3.541859E-01
1.000000E+00	1.083600E+03	3.810178E-01
1.000000E+00	1.096500E+03	4.090903E-01
1.000000E+00	1.109400E+03	4.384130E-01
1.000000E+00	1.122300E+03	4.689937E-01
1.000000E+00	1.135200E+03	5.008384E-01
1.000000E+00	1.148100E+03	5.339510E-01
1.000000E+00	1.161000E+03	5.683340E-01
1.000000E+00	1.173900E+03	6.039880E-01
1.000000E+00	1.186800E+03	6.409119E-01
1.000000E+00	1.199700E+03	6.791032E-01
1.000000E+00	1.212600E+03	7.185576E-01
1.000000E+00	1.225500E+03	7.592693E-01
1.000000E+00	1.238400E+03	8.012311E-01
1.000000E+00	1.251300E+03	8.444344E-01
1.000000E+00	1.264200E+03	8.888692E-01
1.000000E+00	1.277100E+03	9.345242E-01
1.000000E+00	1.290000E+03	9.813869E-01

APPENDIX J.

LISTINGS OF EXCEL 97 SPREADSHEETS AND CHARTS SHOWING RELATIVE CALCULATED ^{241}Pu CONCENTRATION AS FUNCTION OF EFFLUENT BRINE VOLUME AT RETARDATION VALUES 20,000, 20,500, & 21,000

Pu_Calculations.xls - Pu vs Eluted Volume Numbers

theta 0.033		R 20,000	R 20,500	R 21,000
Eluted Pore Volumes	Eluted Volume (L)	Relative Eluted Conc. (C/MDA) R=20,000	Relative Eluted Conc. (C/MDA) R=20,500	Relative Eluted Conc. (C/MDA) R=21,000
12.9	0.72	0.00	0.00	0.00
25.8	1.43	0.00	0.00	0.00
38.7	2.15	0.00	0.00	0.00
51.6	2.87	0.00	0.00	0.00
64.5	3.59	0.00	0.00	0.00
77.4	4.30	0.00	0.00	0.00
90.3	5.02	0.00	0.00	0.00
103.2	5.74	0.00	0.00	0.00
116.1	6.45	0.00	0.00	0.00
129.0	7.17	0.00	0.00	0.00
141.9	7.89	0.00	0.00	0.00
154.8	8.60	0.00	0.00	0.00
167.7	9.32	0.00	0.00	0.00
180.6	10.04	0.00	0.00	0.00
193.5	10.76	0.00	0.00	0.00
206.4	11.47	0.00	0.00	0.00
219.3	12.19	0.00	0.00	0.00
232.2	12.91	0.00	0.00	0.00
245.1	13.62	0.00	0.00	0.00
258.0	14.34	0.00	0.00	0.00
270.9	15.06	0.00	0.00	0.00
283.8	15.77	0.00	0.00	0.00
296.7	16.49	0.00	0.00	0.00
309.6	17.21	0.00	0.00	0.00
322.5	17.93	0.00	0.00	0.00
335.4	18.64	0.00	0.00	0.00
348.3	19.36	0.00	0.00	0.00
361.2	20.08	0.00	0.00	0.00
374.1	20.79	0.00	0.00	0.00
387.0	21.51	0.00	0.00	0.00
399.9	22.23	0.00	0.00	0.00
412.8	22.94	0.00	0.00	0.00
425.7	23.66	0.00	0.00	0.00
438.6	24.38	0.00	0.00	0.00
451.5	25.10	0.00	0.00	0.00
464.4	25.81	0.00	0.00	0.00
477.3	26.53	0.00	0.00	0.00
490.2	27.25	0.00	0.00	0.00
503.1	27.96	0.00	0.00	0.00
516.0	28.68	0.00	0.00	0.00
528.9	29.40	0.00	0.00	0.00
541.8	30.11	0.00	0.00	0.00
554.7	30.83	0.00	0.00	0.00
567.6	31.55	0.00	0.00	0.00
580.5	32.27	0.00	0.00	0.00

theta		R	R	R
0.033		20,000	20,500	21,000
Eluted Pore Volumes	Eluted Volume (L)	Relative Eluted Conc. (C/MDA) R=20,000	Relative Eluted Conc. (C/MDA) R=20,500	Relative Eluted Conc. (C/MDA) R=21,000
593.4	32.98	0.00	0.00	0.00
606.3	33.70	0.00	0.00	0.00
619.2	34.42	0.01	0.00	0.00
632.1	35.13	0.01	0.01	0.00
645.0	35.85	0.01	0.01	0.00
657.9	36.57	0.01	0.01	0.01
670.8	37.28	0.01	0.01	0.01
683.7	38.00	0.02	0.01	0.01
696.6	38.72	0.02	0.01	0.01
709.5	39.44	0.02	0.02	0.01
722.4	40.15	0.03	0.02	0.02
735.3	40.87	0.03	0.02	0.02
748.2	41.59	0.04	0.03	0.02
761.1	42.30	0.04	0.03	0.03
774.0	43.02	0.05	0.04	0.03
786.9	43.74	0.06	0.05	0.04
799.8	44.46	0.07	0.05	0.04
812.7	45.17	0.07	0.06	0.05
825.6	45.89	0.08	0.07	0.05
838.5	46.61	0.10	0.08	0.06
851.4	47.32	0.11	0.09	0.07
864.3	48.04	0.12	0.10	0.08
877.2	48.76	0.13	0.11	0.09
890.1	49.47	0.15	0.12	0.10
903.0	50.19	0.17	0.14	0.11
915.9	50.91	0.18	0.15	0.12
928.8	51.63	0.20	0.17	0.14
941.7	52.34	0.22	0.18	0.15
954.6	53.06	0.24	0.20	0.17
967.5	53.78	0.27	0.22	0.18
980.4	54.49	0.29	0.24	0.20
993.3	55.21	0.32	0.26	0.22
1006.2	55.93	0.34	0.29	0.24
1019.1	56.64	0.37	0.31	0.26
1032.0	57.36	0.40	0.34	0.28
1044.9	58.08	0.43	0.36	0.30
1057.8	58.80	0.46	0.39	0.33
1070.7	59.51	0.50	0.42	0.35
1083.6	60.23	0.53	0.45	0.38
1096.5	60.95	0.57	0.48	0.41
1109.4	61.66	0.61	0.52	0.44
1122.3	62.38	0.65	0.55	0.47
1135.2	63.10	0.69	0.59	0.50
1148.1	63.81	0.73	0.63	0.53
1161.0	64.53	0.78	0.66	0.57

Pu_Calculations.xls - Pu vs Eluted Volume Numbers (continued)

theta		R	R	R
0.033		20,000	20,500	21,000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA) R=20,000**	**Relative Eluted Conc. (C/MDA) R=20,500**	**Relative Eluted Conc. (C/MDA) R=21,000**
1173.9	65.25	0.82	0.70	0.60
1186.8	65.97	0.87	0.75	0.64
1199.7	66.68	0.92	0.79	0.68
1212.6	67.40	0.97	0.83	0.72
1225.5	68.12	1.02	0.88	0.76
1238.4	68.83	1.07	0.93	0.80
1251.3	69.55	1.12	0.97	0.84
1264.2	70.27	1.18	1.02	0.89
1277.1	70.98	1.24	1.08	0.93
1290.0	71.70	1.29	1.13	0.98

Pu_Calculations.xls - Pu vs Eluted Volume Formulas

theta 0.033		R 20000	R 20500	R 21000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
12.9	=PI()*(7.25)^2*10.2*$A$3*A6/1000	1.610584E-259	4.228522E-266	1.110511E-272
25.8	=PI()*(7.25)^2*10.2*$A$3*A7/1000	7.245637E-128	3.695017E-131	1.884613E-134
38.7	=PI()*(7.25)^2*10.2*$A$3*A8/1000	5.245887E-84	3.358754E-86	2.15019E-88
51.6	=PI()*(7.25)^2*10.2*$A$3*A9/1000	3.868146E-62	8.794973E-64	1.999226E-65
64.5	=PI()*(7.25)^2*10.2*$A$3*A10/1000	4.613911E-49	2.244162E-50	1.091242E-51
77.4	=PI()*(7.25)^2*10.2*$A$3*A11/1000	2.255661E-40	1.82116E-41	1.46994E-42
90.3	=PI()*(7.25)^2*10.2*$A$3*A12/1000	6.911341E-34	8.013552E-35	9.288815E-36
103.2	=PI()*(7.25)^2*10.2*$A$3*A13/1000	2.92274E-29	4.444981E-30	6.758042E-31
116.1	=PI()*(7.25)^2*10.2*$A$3*A14/1000	1.130989E-25	2.123951E-26	3.987503E-27
129	=PI()*(7.25)^2*10.2*$A$3*A15/1000	8.229986E-23	1.829576E-23	4.066042E-24
141.9	=PI()*(7.25)^2*10.2*$A$3*A16/1000	1.779975E-20	4.542512E-21	1.158906E-21
154.8	=PI()*(7.25)^2*10.2*$A$3*A17/1000	1.551907E-18	4.443045E-19	1.271643E-19
167.7	=PI()*(7.25)^2*10.2*$A$3*A18/1000	6.734067E-17	2.12489E-17	6.70293E-18
180.6	=PI()*(7.25)^2*10.2*$A$3*A19/1000	1.690228E-15	5.797068E-16	1.987653E-16
193.5	=PI()*(7.25)^2*10.2*$A$3*A20/1000	2.739676E-14	1.010032E-14	3.72255E-15
206.4	=PI()*(7.25)^2*10.2*$A$3*A21/1000	0.0000000000003114381	0.0000000000001223085	4.801867E-14
219.3	=PI()*(7.25)^2*10.2*$A$3*A22/1000	0.000000000002644449	0.000000000001098088	0.0000000000004558353
232.2	=PI()*(7.25)^2*10.2*$A$3*A23/1000	0.00000000001761396	0.00000000007685708	0.00000000000335258
245.1	=PI()*(7.25)^2*10.2*$A$3*A24/1000	0.00000000009565554	0.00000000004363094	0.00000000001989516
258	=PI()*(7.25)^2*10.2*$A$3*A25/1000	0.0000000004368167	0.0000000002073551	0.00000000009840072
270.9	=PI()*(7.25)^2*10.2*$A$3*A26/1000	0.000000001719749	0.0000000008463697	0.0000000004164119
283.8	=PI()*(7.25)^2*10.2*$A$3*A27/1000	0.000000005957568	0.000000003029825	0.000000001540401
296.7	=PI()*(7.25)^2*10.2*$A$3*A28/1000	0.00000001846817	0.000000009678005	0.000000005070091
309.6	=PI()*(7.25)^2*10.2*$A$3*A29/1000	0.00000005195387	0.00000002798392	0.0000000150684
322.5	=PI()*(7.25)^2*10.2*$A$3*A30/1000	0.0000001342025	0.00000007413537	0.00000004094095
335.4	=PI()*(7.25)^2*10.2*$A$3*A31/1000	0.0000003214927	0.0000001817882	0.0000001027609
348.3	=PI()*(7.25)^2*10.2*$A$3*A32/1000	0.0000007203203	0.0000004161974	0.0000002404034
361.2	=PI()*(7.25)^2*10.2*$A$3*A33/1000	0.000001520449	0.0000008963027	0.0000005282078
374.1	=PI()*(7.25)^2*10.2*$A$3*A34/1000	0.000003042433	0.00000182731	0.000001097162
387	=PI()*(7.25)^2*10.2*$A$3*A35/1000	0.000005802574	0.000003546335	0.000002166735

Pu_Calculations.xls - Pu vs Eluted Volume Formulas (continued)

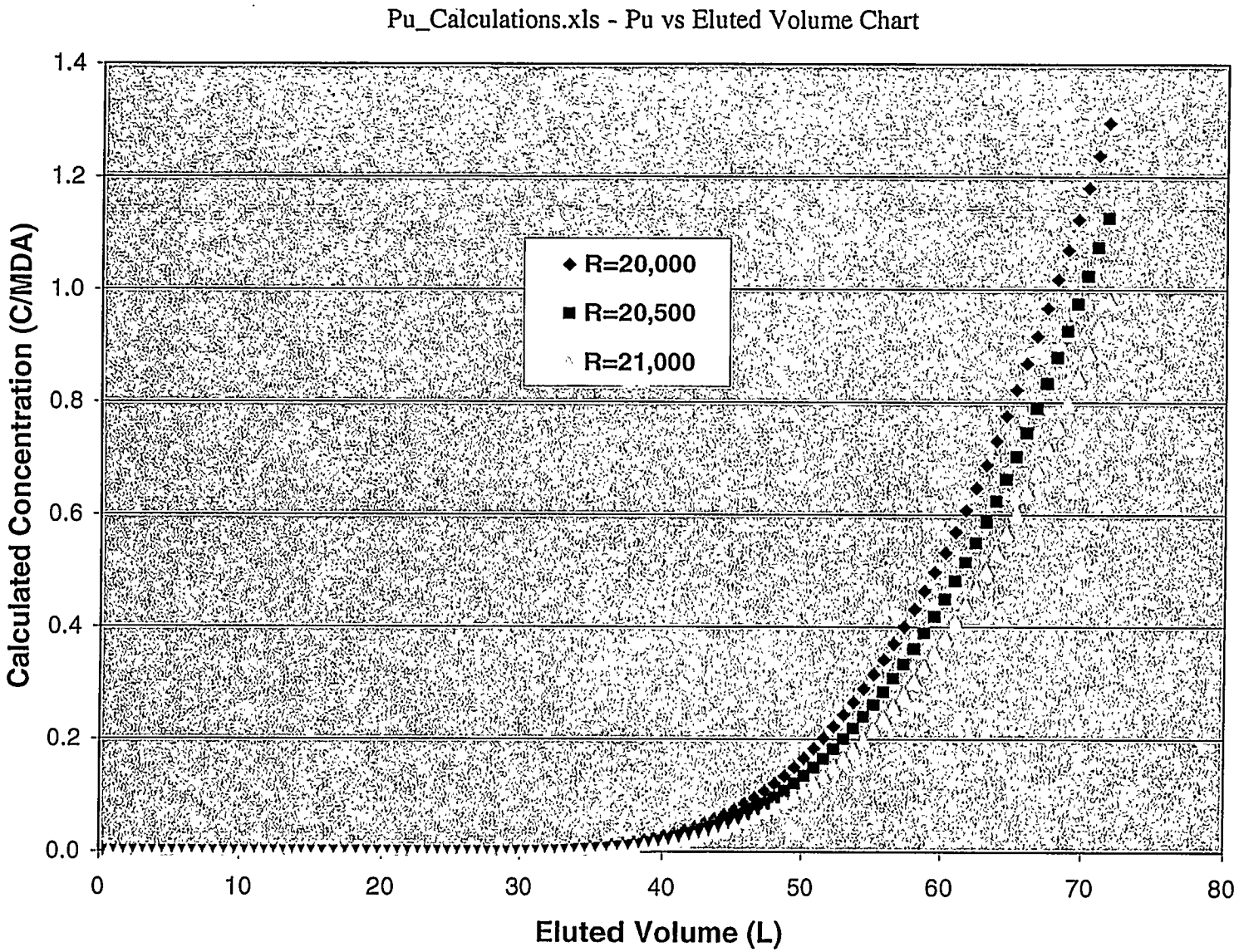
theta 0.033		R 20000	R 20500	R 21000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
399.9	=PI()*(7.25)^2*10.2*$A$3*A36/1000	0.00001059775	0.000006583429	0.000004088439
412.8	=PI()*(7.25)^2*10.2*$A$3*A37/1000	0.00001861169	0.00001173982	0.000007402927
425.7	=PI()*(7.25)^2*10.2*$A$3*A38/1000	0.00003154314	0.00002018437	0.00001291196
438.6	=PI()*(7.25)^2*10.2*$A$3*A39/1000	0.00005175514	0.00003356848	0.00002176589
451.5	=PI()*(7.25)^2*10.2*$A$3*A40/1000	0.00008244311	0.00005415833	0.00003556662
464.4	=PI()*(7.25)^2*10.2*$A$3*A41/1000	0.0001278186	0.00008498265	0.00005648495
477.3	=PI()*(7.25)^2*10.2*$A$3*A42/1000	0.0001933037	0.0001299929	0.00008739062
490.2	=PI()*(7.25)^2*10.2*$A$3*A43/1000	0.0002857318	0.0001942319	0.0001319923
503.1	=PI()*(7.25)^2*10.2*$A$3*A44/1000	0.0004135468	0.0002840073	0.0001949845
516	=PI()*(7.25)^2*10.2*$A$3*A45/1000	0.0005869975	0.0004070631	0.0002821973
528.9	=PI()*(7.25)^2*10.2*$A$3*A46/1000	0.0008183185	0.0005727469	0.0004007455
541.8	=PI()*(7.25)^2*10.2*$A$3*A47/1000	0.001121894	0.0007921651	0.0005591717
554.7	=PI()*(7.25)^2*10.2*$A$3*A48/1000	0.001514396	0.001078324	0.0007675818
567.6	=PI()*(7.25)^2*10.2*$A$3*A49/1000	0.0020149	0.001446251	0.001037765
580.5	=PI()*(7.25)^2*10.2*$A$3*A50/1000	0.002644965	0.001913092	0.001383302
593.4	=PI()*(7.25)^2*10.2*$A$3*A51/1000	0.003428685	0.002498186	0.001819646
606.3	=PI()*(7.25)^2*10.2*$A$3*A52/1000	0.0043927	0.003223106	0.00236419
619.2	=PI()*(7.25)^2*10.2*$A$3*A53/1000	0.005566179	0.004111679	0.003036309
632.1	=PI()*(7.25)^2*10.2*$A$3*A54/1000	0.006980765	0.005189972	0.003857372
645	=PI()*(7.25)^2*10.2*$A$3*A55/1000	0.008670486	0.006486247	0.00485074
657.9	=PI()*(7.25)^2*10.2*$A$3*A56/1000	0.01067164	0.008030895	0.006041725
670.8	=PI()*(7.25)^2*10.2*$A$3*A57/1000	0.01302265	0.009856335	0.007457543
683.7	=PI()*(7.25)^2*10.2*$A$3*A58/1000	0.01576387	0.01199689	0.009127227
696.6	=PI()*(7.25)^2*10.2*$A$3*A59/1000	0.01893743	0.01448867	0.01108153
709.5	=PI()*(7.25)^2*10.2*$A$3*A60/1000	0.022587	0.01736935	0.01335281
722.4	=PI()*(7.25)^2*10.2*$A$3*A61/1000	0.02675754	0.02067807	0.01597487
735.3	=PI()*(7.25)^2*10.2*$A$3*A62/1000	0.03149512	0.02445517	0.01898286
748.2	=PI()*(7.25)^2*10.2*$A$3*A63/1000	0.0368466	0.02874203	0.02241304
761.1	=PI()*(7.25)^2*10.2*$A$3*A64/1000	0.04285945	0.03358085	0.02630269
774	=PI()*(7.25)^2*10.2*$A$3*A65/1000	0.04958144	0.03901443	0.03068984

Pu_Calculations.xls - Pu vs Eluted Volume Formulas (continued)

theta 0.033		R 20000	R 20500	R 21000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
786.9	=PI()*(7.25)^2*10.2*$A$3*A66/1000	0.05706043	0.04508595	0.03561316
799.8	=PI()*(7.25)^2*10.2*$A$3*A67/1000	0.06534409	0.05183877	0.04111174
812.7	=PI()*(7.25)^2*10.2*$A$3*A68/1000	0.07447971	0.05931618	0.0472249
825.6	=PI()*(7.25)^2*10.2*$A$3*A69/1000	0.0845139	0.06756123	0.05399202
838.5	=PI()*(7.25)^2*10.2*$A$3*A70/1000	0.09549244	0.07661651	0.06145232
851.4	=PI()*(7.25)^2*10.2*$A$3*A71/1000	0.10746	0.08652396	0.06964472
864.3	=PI()*(7.25)^2*10.2*$A$3*A72/1000	0.1204601	0.09732467	0.07860768
877.2	=PI()*(7.25)^2*10.2*$A$3*A73/1000	0.1345347	0.1090587	0.08837896
890.1	=PI()*(7.25)^2*10.2*$A$3*A74/1000	0.1497241	0.1217651	0.09899554
903	=PI()*(7.25)^2*10.2*$A$3*A75/1000	0.1660671	0.1354812	0.1104935
915.9	=PI()*(7.25)^2*10.2*$A$3*A76/1000	0.1836004	0.1502434	0.1229077
928.8	=PI()*(7.25)^2*10.2*$A$3*A77/1000	0.2023588	0.1660861	0.1362719
941.7	=PI()*(7.25)^2*10.2*$A$3*A78/1000	0.2223749	0.1830422	0.1506184
954.6	=PI()*(7.25)^2*10.2*$A$3*A79/1000	0.2437357	0.2011427	0.1659784
967.5	=PI()*(7.25)^2*10.2*$A$3*A80/1000	0.2663594	0.2204169	0.1823811
980.4	=PI()*(7.25)^2*10.2*$A$3*A81/1000	0.2903254	0.2409475	0.1998544
993.3	=PI()*(7.25)^2*10.2*$A$3*A82/1000	0.3156574	0.2626514	0.2184245
1006.2	=PI()*(7.25)^2*10.2*$A$3*A83/1000	0.3423764	0.2856047	0.2381704
1019.1	=PI()*(7.25)^2*10.2*$A$3*A84/1000	0.3705014	0.3098283	0.2590082
1032	=PI()*(7.25)^2*10.2*$A$3*A85/1000	0.4000485	0.3353415	0.2810106
1044.9	=PI()*(7.25)^2*10.2*$A$3*A86/1000	0.4310319	0.3621609	0.3041966
1057.8	=PI()*(7.25)^2*10.2*$A$3*A87/1000	0.4634631	0.3903013	0.3285833
1070.7	=PI()*(7.25)^2*10.2*$A$3*A88/1000	0.4973512	0.4197754	0.3541859
1083.6	=PI()*(7.25)^2*10.2*$A$3*A89/1000	0.5327033	0.4505937	0.3810178
1096.5	=PI()*(7.25)^2*10.2*$A$3*A90/1000	0.569524	0.4827647	0.4090903
1109.4	=PI()*(7.25)^2*10.2*$A$3*A91/1000	0.6078156	0.5162946	0.438413
1122.3	=PI()*(7.25)^2*10.2*$A$3*A92/1000	0.6475784	0.551188	0.4689937
1135.2	=PI()*(7.25)^2*10.2*$A$3*A93/1000	0.6888105	0.5874471	0.5008384
1148.1	=PI()*(7.25)^2*10.2*$A$3*A94/1000	0.7315079	0.6250725	0.533951
1161	=PI()*(7.25)^2*10.2*$A$3*A95/1000	0.7756647	0.6640626	0.568334

Pu_Calculations.xls - Pu vs Eluted Volume Formulas (continued)

theta 0.033		R 20000	R 20500	R 21000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
1173.9	=PI()*(7.25)^2*10.2*$A$3*A96/1000	0.821273	0.7044144	0.603988
1186.8	=PI()*(7.25)^2*10.2*$A$3*A97/1000	0.8683232	0.7461227	0.6409119
1199.7	=PI()*(7.25)^2*10.2*$A$3*A98/1000	0.9168038	0.7891808	0.6791032
1212.6	=PI()*(7.25)^2*10.2*$A$3*A99/1000	0.9667017	0.8335804	0.7185576
1225.5	=PI()*(7.25)^2*10.2*$A$3*A100/1000	1.018002	0.8793116	0.7592693
1238.4	=PI()*(7.25)^2*10.2*$A$3*A101/1000	1.070689	0.9263629	0.8012311
1251.3	=PI()*(7.25)^2*10.2*$A$3*A102/1000	1.124744	0.9747214	0.8444344
1264.2	=PI()*(7.25)^2*10.2*$A$3*A103/1000	1.180149	1.024373	0.8888692
1277.1	=PI()*(7.25)^2*10.2*$A$3*A104/1000	1.236883	1.075302	0.9345242
1290	=PI()*(7.25)^2*10.2*$A$3*A105/1000	1.294925	1.127492	0.9813869


Pu_Calculations.xls - Pu vs Eluted Volume Chart
Calculated Concentration (C/MDA)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
R=20,000
R=20,500
R=21,000
0
10
20
30
40
50
60
70
80
Eluted Volume (L)

APPENDIX K.

LISTINGS OF PARAMETER INPUT FILES (*.COL) FOR THREE ^{241}Am COLUMN 1.4 CALCULATIONS AT RETARDATION VALUES 25,500, 26,000, & 26,500 (For Full Injection Concentration, 20-mL Spike)

Am_25500_Vol.col

```
[Wcolumn]
Date=5/7/98 12:50:19 PM
Title=Am, 0.1 mL/min, 20 mL spike - Data through 9/2/97
LogFile=Am_25500_Vol.log
OutputFile=Am_25500_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=FLUX
Bootstrap=
[DistanceAndTimeSpec.]
Set=Formula
Fixed=Distance
Distance=1
Start=12.9
End=1290
Step=100
[ParameterValues]
R=25500
theta=0.033
D=0.64
mu=0
gamma=0
q=0.033
t0=0.36
c0=2800000
```

Am_26000_Vol.col

```
[Wcolumn]
Date=5/7/98 11:56:27 AM
Title=Am, 0.1 mL/min, 20 mL spike - Data through 9/2/97
LogFile=Am_26000_Vol.log
OutputFile=Am_26000_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=FLUX
Bootstrap=
[DistanceAndTimeSpec.]
Set=Formula
Fixed=Distance
Distance=1
Start=12.9
End=1290
Step=100
[ParameterValues]
R=26000
theta=0.033
D=0.64
mu=0
gamma=0
q=0.033
t0=0.36
c0=2800000
```

Am_26500_Vol.col

```
[Wcolumn]
Date=5/7/98 12:51:08 PM
Title=Am, 0.1 mL/min, 20 mL spike - Data through 9/2/97
LogFile=Am_26500_Vol.log
OutputFile=Am_26500_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=FLUX
Bootstrap=
[DistanceAndTimeSpec.]
Set=Formula
Fixed=Distance
Distance=1
Start=12.9
End=1290
Step=100
[ParameterValues]
R=26500
theta=0.033
D=0.64
mu=0
gamma=0
q=0.033
t0=0.36
c0=2800000
```

APPENDIX L.

LISTINGS OF OUTPUT FILES (*.LOG) FOR THREE ^{241}Am COLUMN 1.4 CALCULATIONS AT RETARDATION VALUES 25,500, 26,000, & 26,500

(For Full Injection Concentration, 20-mL Spike)

Am_25500_Vol.log

```
*****************************************************************************
*                                                                           *
*    Deterministic linear equilibrium absorption for pulse injection with   *
*    first-order decay                                                      *
*                                                                           *
*    Am, 0.1 mL/min, 20 mL spike - Data through 9/2/97                      *
*                                                                           *
*****************************************************************************
Model Name = Linear equilibrium
Calculation began 5/7/98 12:50:23 PM

Model parameters:
        R = 25500
    theta = 0.033
        D = 0.64
       mu = 0
    gamma = 0
        q = 0.033
       t0 = 0.36
       c0 = 2800000

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E+00  1.290000E+01  0.000000E+00
1.000000E+00  2.580000E+01  1.852375E-163
1.000000E+00  3.870000E+01  1.615454E-107
1.000000E+00  5.160000E+01  1.342021E-79
1.000000E+00  6.450000E+01  6.860640E-63
1.000000E+00  7.740000E+01  8.836412E-52
1.000000E+00  9.030000E+01  7.276447E-44
1.000000E+00  1.032000E+02  1.212172E-37
1.000000E+00  1.161000E+02  4.773791E-33
1.000000E+00  1.290000E+02  2.221768E-29
1.000000E+00  1.419000E+02  2.192480E-26
1.000000E+00  1.548000E+02  6.770733E-24
1.000000E+00  1.677000E+02  8.564868E-22
1.000000E+00  1.806000E+02  5.378047E-20
1.000000E+00  1.935000E+02  1.929633E-18
1.000000E+00  2.064000E+02  4.396175E-17
1.000000E+00  2.193000E+02  6.893203E-16
1.000000E+00  2.322000E+02  7.919698E-15
1.000000E+00  2.451000E+02  7.004705E-14
1.000000E+00  2.580000E+02  4.961496E-13
1.000000E+00  2.709000E+02  2.905678E-12
1.000000E+00  2.838000E+02  1.444222E-11
1.000000E+00  2.967000E+02  6.224894E-11
1.000000E+00  3.096000E+02  2.368841E-10
1.000000E+00  3.225000E+02  8.079567E-10
1.000000E+00  3.354000E+02  2.501611E-09
1.000000E+00  3.483000E+02  7.107869E-09
1.000000E+00  3.612000E+02  1.870596E-08
1.000000E+00  3.741000E+02  4.596376E-08
1.000000E+00  3.870000E+02  1.061830E-07
1.000000E+00  3.999000E+02  2.320151E-07
1.000000E+00  4.128000E+02  4.820469E-07
1.000000E+00  4.257000E+02  9.567199E-07
1.000000E+00  4.386000E+02  1.821275E-06
1.000000E+00  4.515000E+02  3.337569E-06
1.000000E+00  4.644000E+02  5.906675E-06
1.000000E+00  4.773000E+02  1.012409E-05
1.000000E+00  4.902000E+02  1.684922E-05
1.000000E+00  5.031000E+02  2.729042E-05
1.000000E+00  5.160000E+02  4.310657E-05
1.000000E+00  5.289000E+02  6.652534E-05
1.000000E+00  5.418000E+02  1.004781E-04
1.000000E+00  5.547000E+02  1.487506E-04
1.000000E+00  5.676000E+02  2.161476E-04
```

1.000000E+00	5.805000E+02	3.086694E-04
1.000000E+00	5.934000E+02	4.336987E-04
1.000000E+00	6.063000E+02	6.001929E-04
1.000000E+00	6.192000E+02	8.188795E-04
1.000000E+00	6.321000E+02	1.102452E-03
1.000000E+00	6.450000E+02	1.465760E-03
1.000000E+00	6.579000E+02	1.925992E-03
1.000000E+00	6.708000E+02	2.502849E-03
1.000000E+00	6.837000E+02	3.218698E-03
1.000000E+00	6.966000E+02	4.098716E-03
1.000000E+00	7.095000E+02	5.171004E-03
1.000000E+00	7.224000E+02	6.466685E-03
1.000000E+00	7.353000E+02	8.019980E-03
1.000000E+00	7.482000E+02	9.868250E-03
1.000000E+00	7.611000E+02	1.205202E-02
1.000000E+00	7.740000E+02	1.461496E-02
1.000000E+00	7.869000E+02	1.760389E-02
1.000000E+00	7.998000E+02	2.106867E-02
1.000000E+00	8.127000E+02	2.506215E-02
1.000000E+00	8.256000E+02	2.964006E-02
1.000000E+00	8.385000E+02	3.486086E-02
1.000000E+00	8.514000E+02	4.078562E-02
1.000000E+00	8.643000E+02	4.747781E-02
1.000000E+00	8.772000E+02	5.500316E-02
1.000000E+00	8.901000E+02	6.342943E-02
1.000000E+00	9.030000E+02	7.282618E-02
1.000000E+00	9.159000E+02	8.326459E-02
1.000000E+00	9.288000E+02	9.481717E-02
1.000000E+00	9.417000E+02	1.075576E-01
1.000000E+00	9.546000E+02	1.215604E-01
1.000000E+00	9.675000E+02	1.369007E-01
1.000000E+00	9.804000E+02	1.536542E-01
1.000000E+00	9.933000E+02	1.718964E-01
1.000000E+00	1.006200E+03	1.917030E-01
1.000000E+00	1.019100E+03	2.131493E-01
1.000000E+00	1.032000E+03	2.363100E-01
1.000000E+00	1.044900E+03	2.612590E-01
1.000000E+00	1.057800E+03	2.880693E-01
1.000000E+00	1.070700E+03	3.168124E-01
1.000000E+00	1.083600E+03	3.475589E-01
1.000000E+00	1.096500E+03	3.803773E-01
1.000000E+00	1.109400E+03	4.153346E-01
1.000000E+00	1.122300E+03	4.524960E-01
1.000000E+00	1.135200E+03	4.919243E-01
1.000000E+00	1.148100E+03	5.336804E-01
1.000000E+00	1.161000E+03	5.778225E-01
1.000000E+00	1.173900E+03	6.244067E-01
1.000000E+00	1.186800E+03	6.734864E-01
1.000000E+00	1.199700E+03	7.251124E-01
1.000000E+00	1.212600E+03	7.793325E-01
1.000000E+00	1.225500E+03	8.363823E-01
1.000000E+00	1.238400E+03	8.959313E-01
1.000000E+00	1.251300E+03	9.582017E-01
1.000000E+00	1.264200E+03	1.023230E+00
1.000000E+00	1.277100E+03	1.091050E+00
1.000000E+00	1.290000E+03	1.161692E+00

Am_26000_Vol.log

```
*******************************************************************************
*                                                                             *
*    Deterministic linear equilibrium absorption for pulse injection with     *
*    first-order decay                                                        *
*                                                                             *
*    Am, 0.1 mL/min, 20 mL spike - Data through 9/2/97                        *
*                                                                             *
*******************************************************************************
Model Name = Linear equilibrium
Calculation began 5/7/98 11:56:35 AM

Model parameters:
        R = 26000
    theta = 0.033
        D = 0.64
       mu = 0
    gamma = 0
        q = 0.033
       t0 = 0.36
       c0 = 2800000

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E+00  1.290000E+01  0.000000E+00
1.000000E+00  2.580000E+01  9.462060E-167
1.000000E+00  3.870000E+01  1.033304E-109
1.000000E+00  5.160000E+01  3.045184E-81
1.000000E+00  6.450000E+01  3.329075E-64
1.000000E+00  7.740000E+01  7.116542E-53
1.000000E+00  9.030000E+01  8.414529E-45
1.000000E+00  1.032000E+02  1.838688E-38
1.000000E+00  1.161000E+02  8.941403E-34
1.000000E+00  1.290000E+02  4.926081E-30
1.000000E+00  1.419000E+02  5.580411E-27
1.000000E+00  1.548000E+02  1.933288E-24
1.000000E+00  1.677000E+02  2.695402E-22
1.000000E+00  1.806000E+02  1.839628E-20
1.000000E+00  1.935000E+02  7.094989E-19
1.000000E+00  2.064000E+02  1.721866E-17
1.000000E+00  2.193000E+02  2.854706E-16
1.000000E+00  2.322000E+02  3.446453E-15
1.000000E+00  2.451000E+02  3.186473E-14
1.000000E+00  2.580000E+02  2.348891E-13
1.000000E+00  2.709000E+02  1.426186E-12
1.000000E+00  2.838000E+02  7.325121E-12
1.000000E+00  2.967000E+02  3.253310E-11
1.000000E+00  3.096000E+02  1.272498E-10
1.000000E+00  3.225000E+02  4.451253E-10
1.000000E+00  3.354000E+02  1.410726E-09
1.000000E+00  3.483000E+02  4.095816E-09
1.000000E+00  3.612000E+02  1.099738E-08
1.000000E+00  3.741000E+02  2.753164E-08
1.000000E+00  3.870000E+02  6.471993E-08
1.000000E+00  3.999000E+02  1.437401E-07
1.000000E+00  4.128000E+02  3.032403E-07
1.000000E+00  4.257000E+02  6.105428E-07
1.000000E+00  4.386000E+02  1.178077E-06
1.000000E+00  4.515000E+02  2.186554E-06
1.000000E+00  4.644000E+02  3.916493E-06
1.000000E+00  4.773000E+02  6.789726E-06
1.000000E+00  4.902000E+02  1.142241E-05
1.000000E+00  5.031000E+02  1.869089E-05
1.000000E+00  5.160000E+02  2.981143E-05
1.000000E+00  5.289000E+02  4.643445E-05
1.000000E+00  5.418000E+02  7.075343E-05
1.000000E+00  5.547000E+02  1.056282E-04
1.000000E+00  5.676000E+02  1.547214E-04
```

1.000000E+00	5.805000E+02	2.226478E-04
1.000000E+00	5.934000E+02	3.151324E-04
1.000000E+00	6.063000E+02	4.391780E-04
1.000000E+00	6.192000E+02	6.032367E-04
1.000000E+00	6.321000E+02	8.173844E-04
1.000000E+00	6.450000E+02	1.093494E-03
1.000000E+00	6.579000E+02	1.445406E-03
1.000000E+00	6.708000E+02	1.889089E-03
1.000000E+00	6.837000E+02	2.442794E-03
1.000000E+00	6.966000E+02	3.127194E-03
1.000000E+00	7.095000E+02	3.965505E-03
1.000000E+00	7.224000E+02	4.983598E-03
1.000000E+00	7.353000E+02	6.210081E-03
1.000000E+00	7.482000E+02	7.676365E-03
1.000000E+00	7.611000E+02	9.416713E-03
1.000000E+00	7.740000E+02	1.146825E-02
1.000000E+00	7.869000E+02	1.387099E-02
1.000000E+00	7.998000E+02	1.666774E-02
1.000000E+00	8.127000E+02	1.990416E-02
1.000000E+00	8.256000E+02	2.362859E-02
1.000000E+00	8.385000E+02	2.789201E-02
1.000000E+00	8.514000E+02	3.274792E-02
1.000000E+00	8.643000E+02	3.825222E-02
1.000000E+00	8.772000E+02	4.446304E-02
1.000000E+00	8.901000E+02	5.144059E-02
1.000000E+00	9.030000E+02	5.924698E-02
1.000000E+00	9.159000E+02	6.794605E-02
1.000000E+00	9.288000E+02	7.760315E-02
1.000000E+00	9.417000E+02	8.828494E-02
1.000000E+00	9.546000E+02	1.000592E-01
1.000000E+00	9.675000E+02	1.129946E-01
1.000000E+00	9.804000E+02	1.271604E-01
1.000000E+00	9.933000E+02	1.426264E-01
1.000000E+00	1.006200E+03	1.594626E-01
1.000000E+00	1.019100E+03	1.777391E-01
1.000000E+00	1.032000E+03	1.975257E-01
1.000000E+00	1.044900E+03	2.188918E-01
1.000000E+00	1.057800E+03	2.419063E-01
1.000000E+00	1.070700E+03	2.666371E-01
1.000000E+00	1.083600E+03	2.931513E-01
1.000000E+00	1.096500E+03	3.215147E-01
1.000000E+00	1.109400E+03	3.517920E-01
1.000000E+00	1.122300E+03	3.840461E-01
1.000000E+00	1.135200E+03	4.183383E-01
1.000000E+00	1.148100E+03	4.547284E-01
1.000000E+00	1.161000E+03	4.932739E-01
1.000000E+00	1.173900E+03	5.340305E-01
1.000000E+00	1.186800E+03	5.770516E-01
1.000000E+00	1.199700E+03	6.223884E-01
1.000000E+00	1.212600E+03	6.700898E-01
1.000000E+00	1.225500E+03	7.202024E-01
1.000000E+00	1.238400E+03	7.727699E-01
1.000000E+00	1.251300E+03	8.280214E-01
1.000000E+00	1.264200E+03	8.856279E-01
1.000000E+00	1.277100E+03	9.458060E-01
1.000000E+00	1.290000E+03	1.008589E+00

Am_26500_Vol.log

```
*******************************************************************************
*                                                                             *
*    Deterministic linear equilibrium absorption for pulse injection with     *
*    first-order decay                                                        *
*                                                                             *
*    Am, 0.1 mL/min, 20 mL spike - Data through 9/2/97                        *
*                                                                             *
*******************************************************************************
Model Name = Linear equilibrium
Calculation began 5/7/98 12:51:11 PM

Model parameters:
        R = 26500
    theta = 0.033
        D = 0.64
       mu = 0
    gamma = 0
        q = 0.033
       t0 = 0.36
       c0 = 2800000

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E+00  1.290000E+01  0.000000E+00
1.000000E+00  2.580000E+01  4.833967E-170
1.000000E+00  3.870000E+01  6.609116E-112
1.000000E+00  5.160000E+01  6.908933E-83
1.000000E+00  6.450000E+01  1.615150E-65
1.000000E+00  7.740000E+01  5.730430E-54
1.000000E+00  9.030000E+01  9.728889E-46
1.000000E+00  1.032000E+02  2.788510E-39
1.000000E+00  1.161000E+02  1.674434E-34
1.000000E+00  1.290000E+02  1.092004E-30
1.000000E+00  1.419000E+02  1.420091E-27
1.000000E+00  1.548000E+02  5.519207E-25
1.000000E+00  1.677000E+02  8.480970E-23
1.000000E+00  1.806000E+02  6.291500E-21
1.000000E+00  1.935000E+02  2.608240E-19
1.000000E+00  2.064000E+02  6.742831E-18
1.000000E+00  2.193000E+02  1.182008E-16
1.000000E+00  2.322000E+02  1.499529E-15
1.000000E+00  2.451000E+02  1.449269E-14
1.000000E+00  2.580000E+02  1.111812E-13
1.000000E+00  2.709000E+02  6.998791E-13
1.000000E+00  2.838000E+02  3.714618E-12
1.000000E+00  2.967000E+02  1.699954E-11
1.000000E+00  3.096000E+02  6.834339E-11
1.000000E+00  3.225000E+02  2.451855E-10
1.000000E+00  3.354000E+02  7.953964E-10
1.000000E+00  3.483000E+02  2.359715E-09
1.000000E+00  3.612000E+02  6.464222E-09
1.000000E+00  3.741000E+02  1.648794E-08
1.000000E+00  3.870000E+02  3.944019E-08
1.000000E+00  3.999000E+02  8.903428E-08
1.000000E+00  4.128000E+02  1.907226E-07
1.000000E+00  4.257000E+02  3.895517E-07
1.000000E+00  4.386000E+02  7.618853E-07
1.000000E+00  4.515000E+02  1.432213E-06
1.000000E+00  4.644000E+02  2.596385E-06
1.000000E+00  4.773000E+02  4.552667E-06
1.000000E+00  4.902000E+02  7.742000E-06
1.000000E+00  5.031000E+02  1.279874E-05
1.000000E+00  5.160000E+02  2.061292E-05
1.000000E+00  5.289000E+02  3.240490E-05
1.000000E+00  5.418000E+02  4.981274E-05
1.000000E+00  5.547000E+02  7.499245E-05
1.000000E+00  5.676000E+02  1.107306E-04
```

1.000000E+00	5.805000E+02	1.605684E-04
1.000000E+00	5.934000E+02	2.289364E-04
1.000000E+00	6.063000E+02	3.212973E-04
1.000000E+00	6.192000E+02	4.442958E-04
1.000000E+00	6.321000E+02	6.059121E-04
1.000000E+00	6.450000E+02	8.156179E-04
1.000000E+00	6.579000E+02	1.084530E-03
1.000000E+00	6.708000E+02	1.425564E-03
1.000000E+00	6.837000E+02	1.853574E-03
1.000000E+00	6.966000E+02	2.385492E-03
1.000000E+00	7.095000E+02	3.040454E-03
1.000000E+00	7.224000E+02	3.839905E-03
1.000000E+00	7.353000E+02	4.807699E-03
1.000000E+00	7.482000E+02	5.970177E-03
1.000000E+00	7.611000E+02	7.356224E-03
1.000000E+00	7.740000E+02	8.997313E-03
1.000000E+00	7.869000E+02	1.092752E-02
1.000000E+00	7.998000E+02	1.318355E-02
1.000000E+00	8.127000E+02	1.580466E-02
1.000000E+00	8.256000E+02	1.883268E-02
1.000000E+00	8.385000E+02	2.231192E-02
1.000000E+00	8.514000E+02	2.628912E-02
1.000000E+00	8.643000E+02	3.081329E-02
1.000000E+00	8.772000E+02	3.593570E-02
1.000000E+00	8.901000E+02	4.170964E-02
1.000000E+00	9.030000E+02	4.819037E-02
1.000000E+00	9.159000E+02	5.543491E-02
1.000000E+00	9.288000E+02	6.350192E-02
1.000000E+00	9.417000E+02	7.245148E-02
1.000000E+00	9.546000E+02	8.234493E-02
1.000000E+00	9.675000E+02	9.324471E-02
1.000000E+00	9.804000E+02	1.052141E-01
1.000000E+00	9.933000E+02	1.183172E-01
1.000000E+00	1.006200E+03	1.326184E-01
1.000000E+00	1.019100E+03	1.481825E-01
1.000000E+00	1.032000E+03	1.650745E-01
1.000000E+00	1.044900E+03	1.833591E-01
1.000000E+00	1.057800E+03	2.031009E-01
1.000000E+00	1.070700E+03	2.243641E-01
1.000000E+00	1.083600E+03	2.472121E-01
1.000000E+00	1.096500E+03	2.717075E-01
1.000000E+00	1.109400E+03	2.979120E-01
1.000000E+00	1.122300E+03	3.258863E-01
1.000000E+00	1.135200E+03	3.556896E-01
1.000000E+00	1.148100E+03	3.873799E-01
1.000000E+00	1.161000E+03	4.210133E-01
1.000000E+00	1.173900E+03	4.566447E-01
1.000000E+00	1.186800E+03	4.943270E-01
1.000000E+00	1.199700E+03	5.341110E-01
1.000000E+00	1.212600E+03	5.760459E-01
1.000000E+00	1.225500E+03	6.201785E-01
1.000000E+00	1.238400E+03	6.665538E-01
1.000000E+00	1.251300E+03	7.152142E-01
1.000000E+00	1.264200E+03	7.663781E-01
1.000000E+00	1.277100E+03	8.197345E-01
1.000000E+00	1.290000E+03	8.754901E-01

APPENDIX M.

LISTINGS OF EXCEL 97 SPREADSHEETS AND CHARTS SHOWING RELATIVE CALCULATED ^{241}Am CONCENTRATION AS FUNCTION OF EFFLUENT BRINE VOLUME AT RETARDATION VALUES 25,500, 26,000, & 26,500 (For Full Injection Concentration, 20-mL Spike)

Am_Calculations_1.xls - Am vs Eluted Volume Numbers

theta 0.033		R 25,500	R 26,000	R 26,500
Eluted Pore Volumes	Eluted Volume (L)	Relative Eluted Conc. (C/MDA) R=25,500	Relative Eluted Conc. (C/MDA) R=26,000	Relative Eluted Conc. (C/MDA) R=26,500
12.9	0.72	0.00	0.00	0.00
25.8	1.43	0.00	0.00	0.00
38.7	2.15	0.00	0.00	0.00
51.6	2.87	0.00	0.00	0.00
64.5	3.59	0.00	0.00	0.00
77.4	4.30	0.00	0.00	0.00
90.3	5.02	0.00	0.00	0.00
103.2	5.74	0.00	0.00	0.00
116.1	6.45	0.00	0.00	0.00
129.0	7.17	0.00	0.00	0.00
141.9	7.89	0.00	0.00	0.00
154.8	8.60	0.00	0.00	0.00
167.7	9.32	0.00	0.00	0.00
180.6	10.04	0.00	0.00	0.00
193.5	10.76	0.00	0.00	0.00
206.4	11.47	0.00	0.00	0.00
219.3	12.19	0.00	0.00	0.00
232.2	12.91	0.00	0.00	0.00
245.1	13.62	0.00	0.00	0.00
258.0	14.34	0.00	0.00	0.00
270.9	15.06	0.00	0.00	0.00
283.8	15.77	0.00	0.00	0.00
296.7	16.49	0.00	0.00	0.00
309.6	17.21	0.00	0.00	0.00
322.5	17.93	0.00	0.00	0.00
335.4	18.64	0.00	0.00	0.00
348.3	19.36	0.00	0.00	0.00
361.2	20.08	0.00	0.00	0.00
374.1	20.79	0.00	0.00	0.00
387.0	21.51	0.00	0.00	0.00
399.9	22.23	0.00	0.00	0.00
412.8	22.94	0.00	0.00	0.00
425.7	23.66	0.00	0.00	0.00
438.6	24.38	0.00	0.00	0.00
451.5	25.10	0.00	0.00	0.00
464.4	25.81	0.00	0.00	0.00
477.3	26.53	0.00	0.00	0.00
490.2	27.25	0.00	0.00	0.00
503.1	27.96	0.00	0.00	0.00
516.0	28.68	0.00	0.00	0.00

Am_Calculations_1.xls - Am vs Eluted Volume Numbers (continued)

theta		R	R	R
0.033		25,500	26,000	26,500
Eluted Pore Volumes	Eluted Volume (L)	Relative Eluted Conc. (C/MDA) R=25,500	Relative Eluted Conc. (C/MDA) R=26,000	Relative Eluted Conc. (C/MDA) R=26,500
528.9	29.40	0.00	0.00	0.00
541.8	30.11	0.00	0.00	0.00
554.7	30.83	0.00	0.00	0.00
567.6	31.55	0.00	0.00	0.00
580.5	32.27	0.00	0.00	0.00
593.4	32.98	0.00	0.00	0.00
606.3	33.70	0.00	0.00	0.00
619.2	34.42	0.00	0.00	0.00
632.1	35.13	0.00	0.00	0.00
645.0	35.85	0.00	0.00	0.00
657.9	36.57	0.00	0.00	0.00
670.8	37.28	0.00	0.00	0.00
683.7	38.00	0.00	0.00	0.00
696.6	38.72	0.00	0.00	0.00
709.5	39.44	0.01	0.00	0.00
722.4	40.15	0.01	0.00	0.00
735.3	40.87	0.01	0.01	0.00
748.2	41.59	0.01	0.01	0.01
761.1	42.30	0.01	0.01	0.01
774.0	43.02	0.01	0.01	0.01
786.9	43.74	0.02	0.01	0.01
799.8	44.46	0.02	0.02	0.01
812.7	45.17	0.03	0.02	0.02
825.6	45.89	0.03	0.02	0.02
838.5	46.61	0.03	0.03	0.02
851.4	47.32	0.04	0.03	0.03
864.3	48.04	0.05	0.04	0.03
877.2	48.76	0.06	0.04	0.04
890.1	49.47	0.06	0.05	0.04
903.0	50.19	0.07	0.06	0.05
915.9	50.91	0.08	0.07	0.06
928.8	51.63	0.09	0.08	0.06
941.7	52.34	0.11	0.09	0.07
954.6	53.06	0.12	0.10	0.08
967.5	53.78	0.14	0.11	0.09
980.4	54.49	0.15	0.13	0.11
993.3	55.21	0.17	0.14	0.12
1006.2	55.93	0.19	0.16	0.13
1019.1	56.64	0.21	0.18	0.15
1032.0	57.36	0.24	0.20	0.17

Am_Calculations_1.xls - Am vs Eluted Volume Numbers (continued)

theta 0.033		R 25,500	R 26,000	R 26,500
Eluted Pore Volumes	Eluted Volume (L)	Relative Eluted Conc. (C/MDA) R=25,500	Relative Eluted Conc. (C/MDA) R=26,000	Relative Eluted Conc. (C/MDA) R=26,500
1044.9	58.08	0.26	0.22	0.18
1057.8	58.80	0.29	0.24	0.20
1070.7	59.51	0.32	0.27	0.22
1083.6	60.23	0.35	0.29	0.25
1096.5	60.95	0.38	0.32	0.27
1109.4	61.66	0.42	0.35	0.30
1122.3	62.38	0.45	0.38	0.33
1135.2	63.10	0.49	0.42	0.36
1148.1	63.81	0.53	0.45	0.39
1161.0	64.53	0.58	0.49	0.42
1173.9	65.25	0.62	0.53	0.46
1186.8	65.97	0.67	0.58	0.49
1199.7	66.68	0.73	0.62	0.53
1212.6	67.40	0.78	0.67	0.58
1225.5	68.12	0.84	0.72	0.62
1238.4	68.83	0.90	0.77	0.67
1251.3	69.55	0.96	0.83	0.72
1264.2	70.27	1.02	0.89	0.77
1277.1	70.98	1.09	0.95	0.82
1290.0	71.70	1.16	1.01	0.88

Am_Calculations_1.xls - Am vs Eluted Volume Formulas

theta 0.033		R 25500	R 26000	R 26500
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
		R=25,500	**R=26,000**	**R=26,500**
12.9	=PI()*(7.25)^2*10.2*$A$3*A7/1000	0	0	0
25.8	=PI()*(7.25)^2*10.2*$A$3*A8/1000	1.852375E-163	9.46206E-167	4.833967E-170
38.7	=PI()*(7.25)^2*10.2*$A$3*A9/1000	1.615454E-107	1.033304E-109	6.609116E-112
51.6	=PI()*(7.25)^2*10.2*$A$3*A10/1000	1.342021E-79	3.045184E-81	6.908933E-83
64.5	=PI()*(7.25)^2*10.2*$A$3*A11/1000	6.86064E-63	3.329075E-64	1.61515E-65
77.4	=PI()*(7.25)^2*10.2*$A$3*A12/1000	8.836412E-52	7.116542E-53	5.73043E-54
90.3	=PI()*(7.25)^2*10.2*$A$3*A13/1000	7.276447E-44	8.414529E-45	9.728889E-46
103.2	=PI()*(7.25)^2*10.2*$A$3*A14/1000	1.212172E-37	1.838688E-38	2.78851E-39
116.1	=PI()*(7.25)^2*10.2*$A$3*A15/1000	4.773791E-33	8.941403E-34	1.674434E-34
129	=PI()*(7.25)^2*10.2*$A$3*A16/1000	2.221768E-29	4.926081E-30	1.092004E-30
141.9	=PI()*(7.25)^2*10.2*$A$3*A17/1000	2.19248E-26	5.580411E-27	1.420091E-27
154.8	=PI()*(7.25)^2*10.2*$A$3*A18/1000	6.770733E-24	1.933288E-24	5.519207E-25
167.7	=PI()*(7.25)^2*10.2*$A$3*A19/1000	8.564868E-22	2.695402E-22	8.48097E-23
180.6	=PI()*(7.25)^2*10.2*$A$3*A20/1000	5.378047E-20	1.839628E-20	6.2915E-21
193.5	=PI()*(7.25)^2*10.2*$A$3*A21/1000	1.929633E-18	7.094989E-19	2.60824E-19
206.4	=PI()*(7.25)^2*10.2*$A$3*A22/1000	4.396175E-17	1.721866E-17	6.742831E-18
219.3	=PI()*(7.25)^2*10.2*$A$3*A23/1000	6.893203E-16	2.854706E-16	1.182008E-16
232.2	=PI()*(7.25)^2*10.2*$A$3*A24/1000	7.919698E-15	3.446453E-15	1.499529E-15
245.1	=PI()*(7.25)^2*10.2*$A$3*A25/1000	7.004705E-14	3.186473E-14	1.449269E-14
258	=PI()*(7.25)^2*10.2*$A$3*A26/1000	0.000000000004961496	0.000000000002348891	0.000000000001111812
270.9	=PI()*(7.25)^2*10.2*$A$3*A27/1000	0.00000000002905678	0.00000000001426186	0.00000000006998791
283.8	=PI()*(7.25)^2*10.2*$A$3*A28/1000	0.00000000001444222	0.00000000007325121	0.00000000003714618
296.7	=PI()*(7.25)^2*10.2*$A$3*A29/1000	0.00000000006224894	0.0000000000325331	0.00000000001699954
309.6	=PI()*(7.25)^2*10.2*$A$3*A30/1000	0.0000000002368841	0.0000000001272498	0.00000000006834339
322.5	=PI()*(7.25)^2*10.2*$A$3*A31/1000	0.0000000008079567	0.0000000004451253	0.0000000002451855
335.4	=PI()*(7.25)^2*10.2*$A$3*A32/1000	0.000000002501611	0.000000001410726	0.0000000007953964
348.3	=PI()*(7.25)^2*10.2*$A$3*A33/1000	0.000000007107869	0.000000004095816	0.000000002359715
361.2	=PI()*(7.25)^2*10.2*$A$3*A34/1000	0.00000001870596	0.00000001099738	0.000000006464222
374.1	=PI()*(7.25)^2*10.2*$A$3*A35/1000	0.00000004596376	0.00000002753164	0.00000001648794

Am_Calculations_1.xls - Am vs Eluted Volume Formulas (continued)

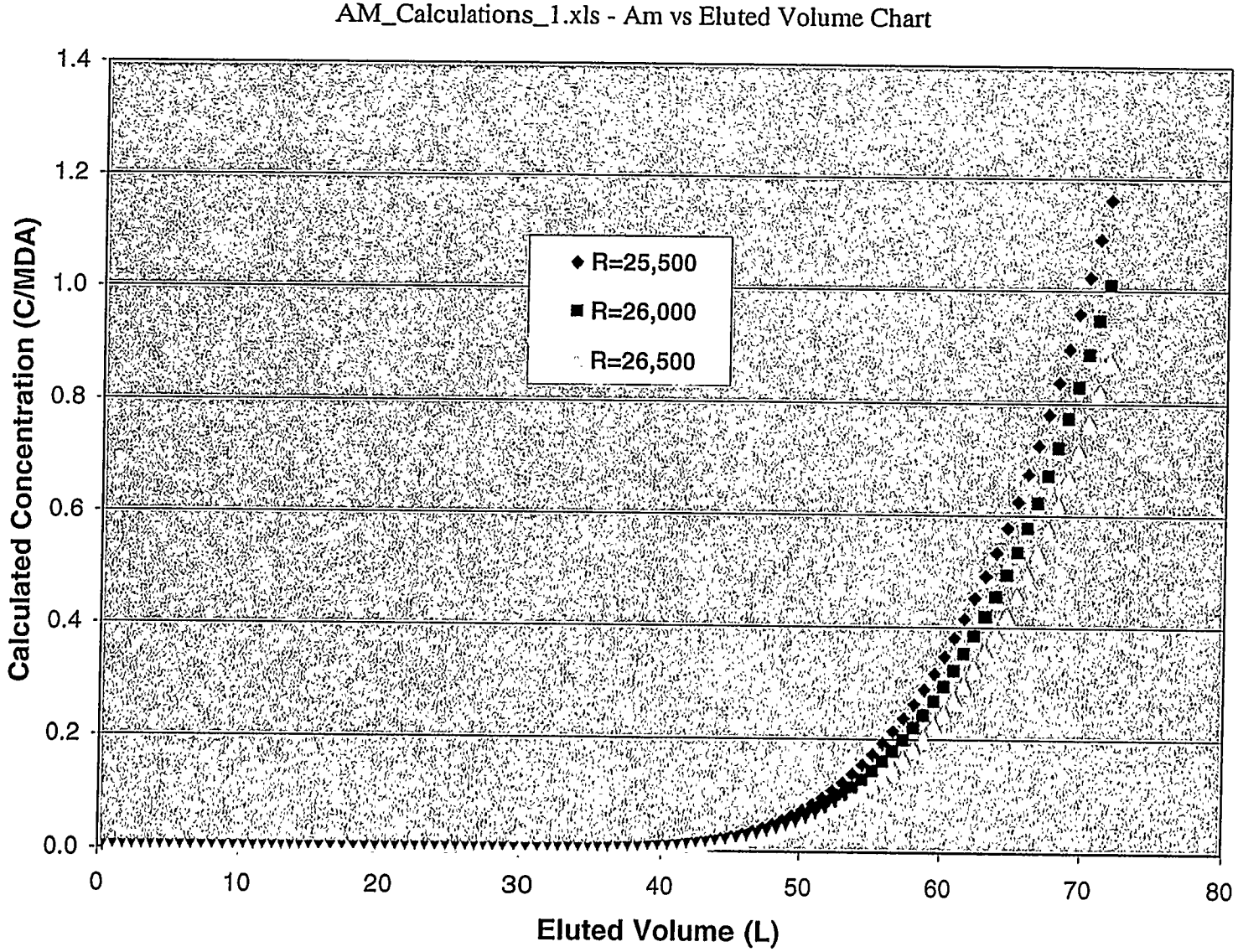
theta 0.033		R 25500	R 26000	R 26500
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
		R=25,500	**R=26,000**	**R=26,500**
387	=PI()*(7.25)^2*10.2*$A$3*A36/1000	0.000000106183	0.00000006471993	0.00000003944019
399.9	=PI()*(7.25)^2*10.2*$A$3*A37/1000	0.0000002320151	0.0000001437401	0.00000008903428
412.8	=PI()*(7.25)^2*10.2*$A$3*A38/1000	0.0000004820469	0.0000003032403	0.0000001907226
425.7	=PI()*(7.25)^2*10.2*$A$3*A39/1000	0.0000009567199	0.0000006105428	0.0000003895517
438.6	=PI()*(7.25)^2*10.2*$A$3*A40/1000	0.000001821275	0.000001178077	0.0000007618853
451.5	=PI()*(7.25)^2*10.2*$A$3*A41/1000	0.000003337569	0.000002186554	0.000001432213
464.4	=PI()*(7.25)^2*10.2*$A$3*A42/1000	0.000005906675	0.000003916493	0.000002596385
477.3	=PI()*(7.25)^2*10.2*$A$3*A43/1000	0.00001012409	0.000006789726	0.000004552667
490.2	=PI()*(7.25)^2*10.2*$A$3*A44/1000	0.00001684922	0.00001142241	0.000007742
503.1	=PI()*(7.25)^2*10.2*$A$3*A45/1000	0.00002729042	0.00001869089	0.00001279874
516	=PI()*(7.25)^2*10.2*$A$3*A46/1000	0.00004310657	0.00002981143	0.00002061292
528.9	=PI()*(7.25)^2*10.2*$A$3*A47/1000	0.00006652534	0.00004643445	0.0000324049
541.8	=PI()*(7.25)^2*10.2*$A$3*A48/1000	0.0001004781	0.00007075343	0.00004981274
554.7	=PI()*(7.25)^2*10.2*$A$3*A49/1000	0.0001487506	0.0001056282	0.00007499245
567.6	=PI()*(7.25)^2*10.2*$A$3*A50/1000	0.0002161476	0.0001547214	0.0001107306
580.5	=PI()*(7.25)^2*10.2*$A$3*A51/1000	0.0003086694	0.0002226478	0.0001605684
593.4	=PI()*(7.25)^2*10.2*$A$3*A52/1000	0.0004336987	0.0003151324	0.0002289364
606.3	=PI()*(7.25)^2*10.2*$A$3*A53/1000	0.0006001929	0.000439178	0.0003212973
619.2	=PI()*(7.25)^2*10.2*$A$3*A54/1000	0.0008188795	0.0006032367	0.0004442958
632.1	=PI()*(7.25)^2*10.2*$A$3*A55/1000	0.001102452	0.0008173844	0.0006059121
645	=PI()*(7.25)^2*10.2*$A$3*A56/1000	0.00146576	0.001093494	0.0008156179
657.9	=PI()*(7.25)^2*10.2*$A$3*A57/1000	0.001925992	0.001445406	0.00108453
670.8	=PI()*(7.25)^2*10.2*$A$3*A58/1000	0.002502849	0.001889089	0.001425564
683.7	=PI()*(7.25)^2*10.2*$A$3*A59/1000	0.003218698	0.002442794	0.001853574
696.6	=PI()*(7.25)^2*10.2*$A$3*A60/1000	0.004098716	0.003127194	0.002385492
709.5	=PI()*(7.25)^2*10.2*$A$3*A61/1000	0.005171004	0.003965505	0.003040454
722.4	=PI()*(7.25)^2*10.2*$A$3*A62/1000	0.006466685	0.004983598	0.003839905
735.3	=PI()*(7.25)^2*10.2*$A$3*A63/1000	0.00801998	0.006210081	0.004807699
748.2	=PI()*(7.25)^2*10.2*$A$3*A64/1000	0.00986825	0.007676365	0.005970177

Am_Calculations_1.xls - Am vs Eluted Volume Formulas (continued)

theta 0.033		R 25500	R 26000	R 26500
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
		R=25,500	R=26,000	R=26,500
761.1	=PI()*(7.25)^2*10.2*$A$3*A65/1000	0.01205202	0.009416713	0.007356224
774	=PI()*(7.25)^2*10.2*$A$3*A66/1000	0.01461496	0.01146825	0.008997313
786.9	=PI()*(7.25)^2*10.2*$A$3*A67/1000	0.01760389	0.01387099	0.01092752
799.8	=PI()*(7.25)^2*10.2*$A$3*A68/1000	0.02106867	0.01666774	0.01318355
812.7	=PI()*(7.25)^2*10.2*$A$3*A69/1000	0.02506215	0.01990416	0.01580466
825.6	=PI()*(7.25)^2*10.2*$A$3*A70/1000	0.02964006	0.02362859	0.01883268
838.5	=PI()*(7.25)^2*10.2*$A$3*A71/1000	0.03486086	0.02789201	0.02231192
851.4	=PI()*(7.25)^2*10.2*$A$3*A72/1000	0.04078562	0.03274792	0.02628912
864.3	=PI()*(7.25)^2*10.2*$A$3*A73/1000	0.04747781	0.03825222	0.03081329
877.2	=PI()*(7.25)^2*10.2*$A$3*A74/1000	0.05500316	0.04446304	0.0359357
890.1	=PI()*(7.25)^2*10.2*$A$3*A75/1000	0.06342943	0.05144059	0.04170964
903	=PI()*(7.25)^2*10.2*$A$3*A76/1000	0.07282618	0.05924698	0.04819037
915.9	=PI()*(7.25)^2*10.2*$A$3*A77/1000	0.08326459	0.06794605	0.05543491
928.8	=PI()*(7.25)^2*10.2*$A$3*A78/1000	0.09481717	0.07760315	0.06350192
941.7	=PI()*(7.25)^2*10.2*$A$3*A79/1000	0.1075576	0.08828494	0.07245148
954.6	=PI()*(7.25)^2*10.2*$A$3*A80/1000	0.1215604	0.1000592	0.08234493
967.5	=PI()*(7.25)^2*10.2*$A$3*A81/1000	0.1369007	0.1129946	0.09324471
980.4	=PI()*(7.25)^2*10.2*$A$3*A82/1000	0.1536542	0.1271604	0.1052141
993.3	=PI()*(7.25)^2*10.2*$A$3*A83/1000	0.1718964	0.1426264	0.1183172
1006.2	=PI()*(7.25)^2*10.2*$A$3*A84/1000	0.191703	0.1594626	0.1326184
1019.1	=PI()*(7.25)^2*10.2*$A$3*A85/1000	0.2131493	0.1777391	0.1481825
1032	=PI()*(7.25)^2*10.2*$A$3*A86/1000	0.23631	0.1975257	0.1650745
1044.9	=PI()*(7.25)^2*10.2*$A$3*A87/1000	0.261259	0.2188918	0.1833591
1057.8	=PI()*(7.25)^2*10.2*$A$3*A88/1000	0.2880693	0.2419063	0.2031009
1070.7	=PI()*(7.25)^2*10.2*$A$3*A89/1000	0.3168124	0.2666371	0.2243641
1083.6	=PI()*(7.25)^2*10.2*$A$3*A90/1000	0.3475589	0.2931513	0.2472121
1096.5	=PI()*(7.25)^2*10.2*$A$3*A91/1000	0.3803773	0.3215147	0.2717075
1109.4	=PI()*(7.25)^2*10.2*$A$3*A92/1000	0.4153346	0.351792	0.297912
1122.3	=PI()*(7.25)^2*10.2*$A$3*A93/1000	0.452496	0.3840461	0.3258863

Am_Calculations_1.xls - Am vs Eluted Volume Formulas (continued)

theta 0.033		R 25500	R 26000	R 26500
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
		R=25,500	R=26,000	R=26,500
1135.2	=PI()*(7.25)^2*10.2*$A$3*A94/1000	0.4919243	0.4183383	0.3556896
1148.1	=PI()*(7.25)^2*10.2*$A$3*A95/1000	0.5336804	0.4547284	0.3873799
1161	=PI()*(7.25)^2*10.2*$A$3*A96/1000	0.5778225	0.4932739	0.4210133
1173.9	=PI()*(7.25)^2*10.2*$A$3*A97/1000	0.6244067	0.5340305	0.4566447
1186.8	=PI()*(7.25)^2*10.2*$A$3*A98/1000	0.6734864	0.5770516	0.494327
1199.7	=PI()*(7.25)^2*10.2*$A$3*A99/1000	0.7251124	0.6223884	0.534111
1212.6	=PI()*(7.25)^2*10.2*$A$3*A100/1000	0.7793325	0.6700898	0.5760459
1225.5	=PI()*(7.25)^2*10.2*$A$3*A101/1000	0.8363823	0.7202024	0.6201785
1238.4	=PI()*(7.25)^2*10.2*$A$3*A102/1000	0.8959313	0.7727699	0.6665538
1251.3	=PI()*(7.25)^2*10.2*$A$3*A103/1000	0.9582017	0.8280214	0.7152142
1264.2	=PI()*(7.25)^2*10.2*$A$3*A104/1000	1.02323	0.8856279	0.7663781
1277.1	=PI()*(7.25)^2*10.2*$A$3*A105/1000	1.09105	0.945806	0.8197345
1290	=PI()*(7.25)^2*10.2*$A$3*A106/1000	1.161692	1.008589	0.8754901


AM_Calculations_1.xls - Am vs Eluted Volume Chart
Calculated Concentration (C/MDA)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
R=25,500
R=26,000
R=26,500
0
10
20
30
40
50
60
70
80
Eluted Volume (L)

APPENDIX N.

LISTINGS OF PARAMETER INPUT FILES (*.COL) FOR THREE ^{241}Am COLUMN 1.4 CALCULATIONS AT RETARDATION VALUES 25,000, 25,500, & 26,000 (FOR EQUILIBRIUM SATURATION CONCENTRATION, WITH RE-DISSOLUTION OF PRECIPITATED ^{241}Am)

Am_Sat_25000_Vol.col

```
[Wcolumn]
Date=5/7/98 11:28:04 AM
Title=Am (sat), 0.1 mL/min, 20 mL spike - Data through 9/2/97
LogFile=Am_Sat_25000_Vol.log
OutputFile=Am_Sat_25000_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=FLUX
Bootstrap=
[DistanceAndTimeSpec.]
Set=Formula
Fixed=Distance
Distance=1
Start=12.9
End=1290
Step=100
[ParameterValues]
R=25000
theta=0.033
D=0.64
mu=0
gamma=0
q=0.033
t0=18.9
c0=53000
```

Am_Sat_25500_Vol.col

```
[Wcolumn]
Date=5/7/98 11:32:56 AM
Title=Am (sat), 0.1 mL/min, 20 mL spike - Data through 9/2/97
LogFile=Am_Sat_25500_Vol.log
OutputFile=Am_Sat_25500_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=FLUX
Bootstrap=
[DistanceAndTimeSpec.]
Set=Formula
Fixed=Distance
Distance=1
Start=12.9
End=1290
Step=100
[ParameterValues]
R=25500
theta=0.033
D=0.64
mu=0
gamma=0
q=0.033
t0=18.9
c0=53000
```

Am_Sat_26000_Vol.col

```
[Wcolumn]
Date=5/7/98 11:32:00 AM
Title=Am (sat), 0.1 mL/min, 20 mL spike - Data through 9/2/97
LogFile=Am_Sat_26000_Vol.log
OutputFile=Am_Sat_26000_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=FLUX
Bootstrap=
[DistanceAndTimeSpec.]
Set=Formula
Fixed=Distance
Distance=1
Start=12.9
End=1290
Step=100
[ParameterValues]
R=26000
theta=0.033
D=0.64
mu=0
gamma=0
q=0.033
t0=18.9
c0=53000
```

APPENDIX O.

LISTINGS OF OUTPUT FILES (*.LOG) FOR RETARDATION VALUES 25,000, 25,500, & 26,000 (FOR EQUILIBRIUM SATURATION CONCENTRATION, WITH RE-DISSOLUTION OF PRECIPITATED ^{241}Am)

Am_Sat_25000_Vol.log

```
*******************************************************************************
*                                                                             *
*    Deterministic linear equilibrium absorption for pulse injection with     *
*    first-order decay                                                        *
*                                                                             *
*    Am (sat), 0.1 mL/min, 20 mL spike - Data through 9/2/97                  *
*                                                                             *
*******************************************************************************
Model Name = Linear equilibrium
Calculation began 5/7/98 11:49:29 AM

Model parameters:
        R = 25000
    theta = 0.033
        D = 0.64
       mu = 0
    gamma = 0
        q = 0.033
       t0 = 18.9
       c0 = 53000

No fit performed; model calculation only

Calculated model curves:
Distance       Time           Model
1.000000E+00  1.290000E+01  0.000000E+00
1.000000E+00  2.580000E+01  6.897497E-162
1.000000E+00  3.870000E+01  5.271070E-107
1.000000E+00  5.160000E+01  1.520109E-79
1.000000E+00  6.450000E+01  4.664175E-63
1.000000E+00  7.740000E+01  4.648147E-52
1.000000E+00  9.030000E+01  3.376817E-44
1.000000E+00  1.032000E+02  5.340010E-38
1.000000E+00  1.161000E+02  2.084632E-33
1.000000E+00  1.290000E+02  9.875618E-30
1.000000E+00  1.419000E+02  1.008611E-26
1.000000E+00  1.548000E+02  3.257614E-24
1.000000E+00  1.677000E+02  4.337545E-22
1.000000E+00  1.806000E+02  2.876908E-20
1.000000E+00  1.935000E+02  1.091731E-18
1.000000E+00  2.064000E+02  2.629534E-17
1.000000E+00  2.193000E+02  4.351698E-16
1.000000E+00  2.322000E+02  5.263344E-15
1.000000E+00  2.451000E+02  4.885302E-14
1.000000E+00  2.580000E+02  3.618776E-13
1.000000E+00  2.709000E+02  2.208496E-12
1.000000E+00  2.838000E+02  1.139861E-11
1.000000E+00  2.967000E+02  5.084470E-11
1.000000E+00  3.096000E+02  1.995980E-10
1.000000E+00  3.225000E+02  7.002015E-10
1.000000E+00  3.354000E+02  2.223725E-09
1.000000E+00  3.483000E+02  6.464607E-09
1.000000E+00  3.612000E+02  1.736755E-08
1.000000E+00  3.741000E+02  4.347487E-08
1.000000E+00  3.870000E+02  1.021262E-07
1.000000E+00  3.999000E+02  2.265342E-07
1.000000E+00  4.128000E+02  4.770788E-07
1.000000E+00  4.257000E+02  9.584793E-07
1.000000E+00  4.386000E+02  1.844776E-06
1.000000E+00  4.515000E+02  3.414246E-06
1.000000E+00  4.644000E+02  6.096461E-06
1.000000E+00  4.773000E+02  1.053361E-05
1.000000E+00  4.902000E+02  1.765803E-05
1.000000E+00  5.031000E+02  2.878743E-05
1.000000E+00  5.160000E+02  4.573884E-05
1.000000E+00  5.289000E+02  7.096176E-05
1.000000E+00  5.418000E+02  1.076900E-04
1.000000E+00  5.547000E+02  1.601113E-04
1.000000E+00  5.676000E+02  2.335528E-04
```

1.000000E+00	5.805000E+02	3.346801E-04
1.000000E+00	5.934000E+02	4.717066E-04
1.000000E+00	6.063000E+02	6.546093E-04
1.000000E+00	6.192000E+02	8.953474E-04
1.000000E+00	6.321000E+02	1.208080E-03
1.000000E+00	6.450000E+02	1.609379E-03
1.000000E+00	6.579000E+02	2.118427E-03
1.000000E+00	6.708000E+02	2.757210E-03
1.000000E+00	6.837000E+02	3.550683E-03
1.000000E+00	6.966000E+02	4.526923E-03
1.000000E+00	7.095000E+02	5.717252E-03
1.000000E+00	7.224000E+02	7.156336E-03
1.000000E+00	7.353000E+02	8.882257E-03
1.000000E+00	7.482000E+02	1.093655E-02
1.000000E+00	7.611000E+02	1.336423E-02
1.000000E+00	7.740000E+02	1.621374E-02
1.000000E+00	7.869000E+02	1.953693E-02
1.000000E+00	7.998000E+02	2.338899E-02
1.000000E+00	8.127000E+02	2.782829E-02
1.000000E+00	8.256000E+02	3.291632E-02
1.000000E+00	8.385000E+02	3.871746E-02
1.000000E+00	8.514000E+02	4.529885E-02
1.000000E+00	8.643000E+02	5.273018E-02
1.000000E+00	8.772000E+02	6.108343E-02
1.000000E+00	8.901000E+02	7.043271E-02
1.000000E+00	9.030000E+02	8.085395E-02
1.000000E+00	9.159000E+02	9.242467E-02
1.000000E+00	9.288000E+02	1.052237E-01
1.000000E+00	9.417000E+02	1.193310E-01
1.000000E+00	9.546000E+02	1.348271E-01
1.000000E+00	9.675000E+02	1.517932E-01
1.000000E+00	9.804000E+02	1.703108E-01
1.000000E+00	9.933000E+02	1.904611E-01
1.000000E+00	1.006200E+03	2.123253E-01
1.000000E+00	1.019100E+03	2.359837E-01
1.000000E+00	1.032000E+03	2.615160E-01
1.000000E+00	1.044900E+03	2.890009E-01
1.000000E+00	1.057800E+03	3.185155E-01
1.000000E+00	1.070700E+03	3.501358E-01
1.000000E+00	1.083600E+03	3.839356E-01
1.000000E+00	1.096500E+03	4.199873E-01
1.000000E+00	1.109400E+03	4.583607E-01
1.000000E+00	1.122300E+03	4.991238E-01
1.000000E+00	1.135200E+03	5.423418E-01
1.000000E+00	1.148100E+03	5.880775E-01
1.000000E+00	1.161000E+03	6.363910E-01
1.000000E+00	1.173900E+03	6.873395E-01
1.000000E+00	1.186800E+03	7.409775E-01
1.000000E+00	1.199700E+03	7.993539E-01
1.000000E+00	1.212600E+03	8.567179E-01
1.000000E+00	1.225500E+03	9.187276E-01
1.000000E+00	1.238400E+03	9.836137E-01
1.000000E+00	1.251300E+03	1.051415E+00
1.000000E+00	1.264200E+03	1.122166E+00
1.000000E+00	1.277100E+03	1.195900E+00
1.000000E+00	1.290000E+03	1.272646E+00

Am_Sat_25500_Vol.log

```
*****************************************************************************
*                                                                           *
*    Deterministic linear equilibrium absorption for pulse injection with   *
*    first-order decay                                                      *
*                                                                           *
*    Am (sat), 0.1 mL/min, 20 mL spike - Data through 9/2/97                *
*                                                                           *
*****************************************************************************
Model Name = Linear equilibrium
Calculation began 5/7/98 11:50:00 AM

Model parameters:
        R = 25500
    theta = 0.033
        D = 0.64
       mu = 0
    gamma = 0
        q = 0.033
       t0 = 18.9
       c0 = 53000

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E+00  1.290000E+01  0.000000E+00
1.000000E+00  2.580000E+01  3.521102E-165
1.000000E+00  3.870000E+01  3.355792E-109
1.000000E+00  5.160000E+01  3.417646E-81
1.000000E+00  6.450000E+01  2.235640E-64
1.000000E+00  7.740000E+01  3.690549E-53
1.000000E+00  9.030000E+01  3.844850E-45
1.000000E+00  1.032000E+02  7.968372E-39
1.000000E+00  1.161000E+02  3.838747E-34
1.000000E+00  1.290000E+02  2.151751E-30
1.000000E+00  1.419000E+02  2.521951E-27
1.000000E+00  1.548000E+02  9.135696E-25
1.000000E+00  1.677000E+02  1.340502E-22
1.000000E+00  1.806000E+02  9.663588E-21
1.000000E+00  1.935000E+02  3.942214E-19
1.000000E+00  2.064000E+02  1.011692E-17
1.000000E+00  2.193000E+02  1.770909E-16
1.000000E+00  2.322000E+02  2.251760E-15
1.000000E+00  2.451000E+02  2.185975E-14
1.000000E+00  2.580000E+02  1.686200E-13
1.000000E+00  2.709000E+02  1.067588E-12
1.000000E+00  2.838000E+02  5.697720E-12
1.000000E+00  2.967000E+02  2.620593E-11
1.000000E+00  3.096000E+02  1.058100E-10
1.000000E+00  3.225000E+02  3.809330E-10
1.000000E+00  3.354000E+02  1.239104E-09
1.000000E+00  3.483000E+02  3.683055E-09
1.000000E+00  3.612000E+02  1.010094E-08
1.000000E+00  3.741000E+02  2.577539E-08
1.000000E+00  3.870000E+02  6.164453E-08
1.000000E+00  3.999000E+02  1.390531E-07
1.000000E+00  4.128000E+02  2.974896E-07
1.000000E+00  4.257000E+02  6.065760E-07
1.000000E+00  4.386000E+02  1.183829E-06
1.000000E+00  4.515000E+02  2.219919E-06
1.000000E+00  4.644000E+02  4.013285E-06
1.000000E+00  4.773000E+02  7.015967E-06
1.000000E+00  4.902000E+02  1.189246E-05
1.000000E+00  5.031000E+02  1.959309E-05
1.000000E+00  5.160000E+02  3.144317E-05
1.000000E+00  5.289000E+02  4.924858E-05
1.000000E+00  5.418000E+02  7.541802E-05
1.000000E+00  5.547000E+02  1.131014E-04
1.000000E+00  5.676000E+02  1.663437E-04
```

1.000000E+00	5.805000E+02	2.402515E-04
1.000000E+00	5.934000E+02	3.411722E-04
1.000000E+00	6.063000E+02	4.768802E-04
1.000000E+00	6.192000E+02	6.567697E-04
1.000000E+00	6.321000E+02	8.920486E-04
1.000000E+00	6.450000E+02	1.195932E-03
1.000000E+00	6.579000E+02	1.583828E-03
1.000000E+00	6.708000E+02	2.073520E-03
1.000000E+00	6.837000E+02	2.685330E-03
1.000000E+00	6.966000E+02	3.442268E-03
1.000000E+00	7.095000E+02	4.370171E-03
1.000000E+00	7.224000E+02	5.497809E-03
1.000000E+00	7.353000E+02	6.856977E-03
1.000000E+00	7.482000E+02	8.482558E-03
1.000000E+00	7.611000E+02	1.041257E-02
1.000000E+00	7.740000E+02	1.268815E-02
1.000000E+00	7.869000E+02	1.535360E-02
1.000000E+00	7.998000E+02	1.845628E-02
1.000000E+00	8.127000E+02	2.204658E-02
1.000000E+00	8.256000E+02	2.617783E-02
1.000000E+00	8.385000E+02	3.090618E-02
1.000000E+00	8.514000E+02	3.629045E-02
1.000000E+00	8.643000E+02	4.239200E-02
1.000000E+00	8.772000E+02	4.927455E-02
1.000000E+00	8.901000E+02	5.700397E-02
1.000000E+00	9.030000E+02	6.564812E-02
1.000000E+00	9.159000E+02	7.527657E-02
1.000000E+00	9.288000E+02	8.596044E-02
1.000000E+00	9.417000E+02	9.777212E-02
1.000000E+00	9.546000E+02	1.107850E-01
1.000000E+00	9.675000E+02	1.250735E-01
1.000000E+00	9.804000E+02	1.407122E-01
1.000000E+00	9.933000E+02	1.577764E-01
1.000000E+00	1.006200E+03	1.763412E-01
1.000000E+00	1.019100E+03	1.964817E-01
1.000000E+00	1.032000E+03	2.182725E-01
1.000000E+00	1.044900E+03	2.417877E-01
1.000000E+00	1.057800E+03	2.671004E-01
1.000000E+00	1.070700E+03	2.942827E-01
1.000000E+00	1.083600E+03	3.234057E-01
1.000000E+00	1.096500E+03	3.545386E-01
1.000000E+00	1.109400E+03	3.877492E-01
1.000000E+00	1.122300E+03	4.231037E-01
1.000000E+00	1.135200E+03	4.606661E-01
1.000000E+00	1.148100E+03	5.004982E-01
1.000000E+00	1.161000E+03	5.426599E-01
1.000000E+00	1.173900E+03	5.872084E-01
1.000000E+00	1.186800E+03	6.341987E-01
1.000000E+00	1.199700E+03	6.836832E-01
1.000000E+00	1.212600E+03	7.357114E-01
1.000000E+00	1.225500E+03	7.923460E-01
1.000000E+00	1.238400E+03	8.477751E-01
1.000000E+00	1.251300E+03	9.077125E-01
1.000000E+00	1.264200E+03	9.703646E-01
1.000000E+00	1.277100E+03	1.035767E+00
1.000000E+00	1.290000E+03	1.103951E+00

Am_Sat_26000_Vol.log

```
*****************************************************************************
*                                                                           *
*    Deterministic linear equilibrium absorption for pulse injection with   *
*    first-order decay                                                      *
*                                                                           *
*    Am (sat), 0.1 mL/min, 20 mL spike - Data through 9/2/97                *
*                                                                           *
*****************************************************************************
Model Name = Linear equilibrium
Calculation began 5/7/98 11:50:26 AM

Model parameters:
        R = 26000
    theta = 0.033
        D = 0.64
       mu = 0
    gamma = 0
        q = 0.033
       t0 = 18.9
       c0 = 53000

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E+00  1.290000E+01  0.000000E+00
1.000000E+00  2.580000E+01  1.797832E-168
1.000000E+00  3.870000E+01  2.136852E-111
1.000000E+00  5.160000E+01  7.685327E-83
1.000000E+00  6.450000E+01  1.071795E-65
1.000000E+00  7.740000E+01  2.930791E-54
1.000000E+00  9.030000E+01  4.378588E-46
1.000000E+00  1.032000E+02  1.189265E-39
1.000000E+00  1.161000E+02  7.070182E-35
1.000000E+00  1.290000E+02  4.689217E-31
1.000000E+00  1.419000E+02  6.307102E-28
1.000000E+00  1.548000E+02  2.562490E-25
1.000000E+00  1.677000E+02  4.143488E-23
1.000000E+00  1.806000E+02  3.246536E-21
1.000000E+00  1.935000E+02  1.423723E-19
1.000000E+00  2.064000E+02  3.892851E-18
1.000000E+00  2.193000E+02  7.207280E-17
1.000000E+00  2.322000E+02  9.634013E-16
1.000000E+00  2.451000E+02  9.781625E-15
1.000000E+00  2.580000E+02  7.857000E-14
1.000000E+00  2.709000E+02  5.160598E-13
1.000000E+00  2.838000E+02  2.847938E-12
1.000000E+00  2.967000E+02  1.350595E-11
1.000000E+00  3.096000E+02  5.608687E-11
1.000000E+00  3.225000E+02  2.072201E-10
1.000000E+00  3.354000E+02  6.903778E-10
1.000000E+00  3.483000E+02  2.098079E-09
1.000000E+00  3.612000E+02  5.873926E-09
1.000000E+00  3.741000E+02  1.527961E-08
1.000000E+00  3.870000E+02  3.720392E-08
1.000000E+00  3.999000E+02  8.534176E-08
1.000000E+00  4.128000E+02  1.854750E-07
1.000000E+00  4.257000E+02  3.838111E-07
1.000000E+00  4.386000E+02  7.595606E-07
1.000000E+00  4.515000E+02  1.443132E-06
1.000000E+00  4.644000E+02  2.641480E-06
1.000000E+00  4.773000E+02  4.672203E-06
1.000000E+00  4.902000E+02  8.007997E-06
1.000000E+00  5.031000E+02  1.333292E-05
1.000000E+00  5.160000E+02  2.161169E-05
1.000000E+00  5.289000E+02  3.417304E-05
1.000000E+00  5.418000E+02  5.280739E-05
1.000000E+00  5.547000E+02  7.987916E-05
1.000000E+00  5.676000E+02  1.184530E-04
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1.000000E+00	5.805000E+02	1.724331E-04
1.000000E+00	5.934000E+02	2.467136E-04
1.000000E+00	6.063000E+02	3.473392E-04
1.000000E+00	6.192000E+02	4.816721E-04
1.000000E+00	6.321000E+02	6.585635E-04
1.000000E+00	6.450000E+02	8.885271E-04
1.000000E+00	6.579000E+02	1.183910E-03
1.000000E+00	6.708000E+02	1.559059E-03
1.000000E+00	6.837000E+02	2.030480E-03
1.000000E+00	6.966000E+02	2.616986E-03
1.000000E+00	7.095000E+02	3.339831E-03
1.000000E+00	7.224000E+02	4.222827E-03
1.000000E+00	7.353000E+02	5.292447E-03
1.000000E+00	7.482000E+02	6.577906E-03
1.000000E+00	7.611000E+02	8.111215E-03
1.000000E+00	7.740000E+02	9.927223E-03
1.000000E+00	7.869000E+02	1.206363E-02
1.000000E+00	7.998000E+02	1.456098E-02
1.000000E+00	8.127000E+02	1.746263E-02
1.000000E+00	8.256000E+02	2.081467E-02
1.000000E+00	8.385000E+02	2.466590E-02
1.000000E+00	8.514000E+02	2.906769E-02
1.000000E+00	8.643000E+02	3.407388E-02
1.000000E+00	8.772000E+02	3.974063E-02
1.000000E+00	8.901000E+02	4.612630E-02
1.000000E+00	9.030000E+02	5.329127E-02
1.000000E+00	9.159000E+02	6.129772E-02
1.000000E+00	9.288000E+02	7.020954E-02
1.000000E+00	9.417000E+02	8.009203E-02
1.000000E+00	9.546000E+02	9.101174E-02
1.000000E+00	9.675000E+02	1.030363E-01
1.000000E+00	9.804000E+02	1.162341E-01
1.000000E+00	9.933000E+02	1.306741E-01
1.000000E+00	1.006200E+03	1.464258E-01
1.000000E+00	1.019100E+03	1.635588E-01
1.000000E+00	1.032000E+03	1.821425E-01
1.000000E+00	1.044900E+03	2.022463E-01
1.000000E+00	1.057800E+03	2.239391E-01
1.000000E+00	1.070700E+03	2.472888E-01
1.000000E+00	1.083600E+03	2.723630E-01
1.000000E+00	1.096500E+03	2.992279E-01
1.000000E+00	1.109400E+03	3.279485E-01
1.000000E+00	1.122300E+03	3.585886E-01
1.000000E+00	1.135200E+03	3.912104E-01
1.000000E+00	1.148100E+03	4.258743E-01
1.000000E+00	1.161000E+03	4.626390E-01
1.000000E+00	1.173900E+03	5.015613E-01
1.000000E+00	1.186800E+03	5.426958E-01
1.000000E+00	1.199700E+03	5.860950E-01
1.000000E+00	1.212600E+03	6.318092E-01
1.000000E+00	1.225500E+03	6.798863E-01
1.000000E+00	1.238400E+03	7.303716E-01
1.000000E+00	1.251300E+03	7.853415E-01
1.000000E+00	1.264200E+03	8.389251E-01
1.000000E+00	1.277100E+03	8.968902E-01
1.000000E+00	1.290000E+03	9.574203E-01

APPENDIX P.

LISTINGS OF EXCEL 97 SPREADSHEETS AND CHARTS SHOWING RELATIVE CALCULATED ^{241}Am CONCENTRATION AS FUNCTION OF EFFLUENT BRINE VOLUME AT RETARDATION VALUES 25,000, 25,500, & 26,000 (FOR EQUILIBRIUM SATURATION CONCENTRATION, WITH RE-DISSOLUTION OF PRECIPITATED ^{241}Am)

Am_Calculations_2.xls - Am vs Eluted Volume Numbers

theta		R	R	R
0.033		25,000	25,500	26,000
Eluted Pore Volumes	Eluted Volume (L)	Relative Eluted Conc. (C/MDA)	Relative Eluted Conc. (C/MDA)	Relative Eluted Conc. (C/MDA)
		R=25,000	R=25,500	R=26,000
12.9	0.72	0.00	0.00	0.00
25.8	1.43	0.00	0.00	0.00
38.7	2.15	0.00	0.00	0.00
51.6	2.87	0.00	0.00	0.00
64.5	3.59	0.00	0.00	0.00
77.4	4.30	0.00	0.00	0.00
90.3	5.02	0.00	0.00	0.00
103.2	5.74	0.00	0.00	0.00
116.1	6.45	0.00	0.00	0.00
129.0	7.17	0.00	0.00	0.00
141.9	7.89	0.00	0.00	0.00
154.8	8.60	0.00	0.00	0.00
167.7	9.32	0.00	0.00	0.00
180.6	10.04	0.00	0.00	0.00
193.5	10.76	0.00	0.00	0.00
206.4	11.47	0.00	0.00	0.00
219.3	12.19	0.00	0.00	0.00
232.2	12.91	0.00	0.00	0.00
245.1	13.62	0.00	0.00	0.00
258.0	14.34	0.00	0.00	0.00
270.9	15.06	0.00	0.00	0.00
283.8	15.77	0.00	0.00	0.00
296.7	16.49	0.00	0.00	0.00
309.6	17.21	0.00	0.00	0.00
322.5	17.93	0.00	0.00	0.00
335.4	18.64	0.00	0.00	0.00
348.3	19.36	0.00	0.00	0.00
361.2	20.08	0.00	0.00	0.00
374.1	20.79	0.00	0.00	0.00
387.0	21.51	0.00	0.00	0.00
399.9	22.23	0.00	0.00	0.00
412.8	22.94	0.00	0.00	0.00
425.7	23.66	0.00	0.00	0.00
438.6	24.38	0.00	0.00	0.00
451.5	25.10	0.00	0.00	0.00
464.4	25.81	0.00	0.00	0.00
477.3	26.53	0.00	0.00	0.00
490.2	27.25	0.00	0.00	0.00
503.1	27.96	0.00	0.00	0.00
516.0	28.68	0.00	0.00	0.00

theta 0.033		R 25,000	R 25,500	R 26,000
Eluted Pore Volumes	Eluted Volume (L)	Relative Eluted Conc. (C/MDA) R=25,000	Relative Eluted Conc. (C/MDA) R=25,500	Relative Eluted Conc. (C/MDA) R=26,000
528.9	29.40	0.00	0.00	0.00
541.8	30.11	0.00	0.00	0.00
554.7	30.83	0.00	0.00	0.00
567.6	31.55	0.00	0.00	0.00
580.5	32.27	0.00	0.00	0.00
593.4	32.98	0.00	0.00	0.00
606.3	33.70	0.00	0.00	0.00
619.2	34.42	0.00	0.00	0.00
632.1	35.13	0.00	0.00	0.00
645.0	35.85	0.00	0.00	0.00
657.9	36.57	0.00	0.00	0.00
670.8	37.28	0.00	0.00	0.00
683.7	38.00	0.00	0.00	0.00
696.6	38.72	0.00	0.00	0.00
709.5	39.44	0.01	0.00	0.00
722.4	40.15	0.01	0.01	0.00
735.3	40.87	0.01	0.01	0.01
748.2	41.59	0.01	0.01	0.01
761.1	42.30	0.01	0.01	0.01
774.0	43.02	0.02	0.01	0.01
786.9	43.74	0.02	0.02	0.01
799.8	44.46	0.02	0.02	0.01
812.7	45.17	0.03	0.02	0.02
825.6	45.89	0.03	0.03	0.02
838.5	46.61	0.04	0.03	0.02
851.4	47.32	0.05	0.04	0.03
864.3	48.04	0.05	0.04	0.03
877.2	48.76	0.06	0.05	0.04
890.1	49.47	0.07	0.06	0.05
903.0	50.19	0.08	0.07	0.05
915.9	50.91	0.09	0.08	0.06
928.8	51.63	0.11	0.09	0.07
941.7	52.34	0.12	0.10	0.08
954.6	53.06	0.13	0.11	0.09
967.5	53.78	0.15	0.13	0.10
980.4	54.49	0.17	0.14	0.12
993.3	55.21	0.19	0.16	0.13
1006.2	55.93	0.21	0.18	0.15
1019.1	56.64	0.24	0.20	0.16
1032.0	57.36	0.26	0.22	0.18

Am_Calculations_2.xls - Am vs Eluted Volume Numbers (continued)

theta 0.033		R 25,000	R 25,500	R 26,000
Eluted Pore Volumes	Eluted Volume (L)	Relative Eluted Conc. (C/MDA) R=25,000	Relative Eluted Conc. (C/MDA) R=25,500	Relative Eluted Conc. (C/MDA) R=26,000
1044.9	58.08	0.29	0.24	0.20
1057.8	58.80	0.32	0.27	0.22
1070.7	59.51	0.35	0.29	0.25
1083.6	60.23	0.38	0.32	0.27
1096.5	60.95	0.42	0.35	0.30
1109.4	61.66	0.46	0.39	0.33
1122.3	62.38	0.50	0.42	0.36
1135.2	63.10	0.54	0.46	0.39
1148.1	63.81	0.59	0.50	0.43
1161.0	64.53	0.64	0.54	0.46
1173.9	65.25	0.69	0.59	0.50
1186.8	65.97	0.74	0.63	0.54
1199.7	66.68	0.80	0.68	0.59
1212.6	67.40	0.86	0.74	0.63
1225.5	68.12	0.92	0.79	0.68
1238.4	68.83	0.98	0.85	0.73
1251.3	69.55	1.05	0.91	0.79
1264.2	70.27	1.12	0.97	0.84
1277.1	70.98	1.20	1.04	0.90
1290.0	71.70	1.27	1.10	0.96

Am_Calculations_2.xls - Am vs Eluted Volume Formulas

theta 0.033		R 25000	R 25500	R 26000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
		R=25,000	**R=25,500**	**R=26,000**
12.9	=PI()*(7.25)^2*10.2*$A$3*A7/1000	0	0	0
25.8	=PI()*(7.25)^2*10.2*$A$3*A8/1000	6.897497E-162	3.521102E-165	1.797832E-168
38.7	=PI()*(7.25)^2*10.2*$A$3*A9/1000	5.27107E-107	3.355792E-109	2.136852E-111
51.6	=PI()*(7.25)^2*10.2*$A$3*A10/1000	1.520109E-79	3.417646E-81	7.685327E-83
64.5	=PI()*(7.25)^2*10.2*$A$3*A11/1000	4.664175E-63	2.23564E-64	1.071795E-65
77.4	=PI()*(7.25)^2*10.2*$A$3*A12/1000	4.648147E-52	3.690549E-53	2.930791E-54
90.3	=PI()*(7.25)^2*10.2*$A$3*A13/1000	3.376817E-44	3.84485E-45	4.378588E-46
103.2	=PI()*(7.25)^2*10.2*$A$3*A14/1000	5.34001E-38	7.968372E-39	1.189265E-39
116.1	=PI()*(7.25)^2*10.2*$A$3*A15/1000	2.084632E-33	3.838747E-34	7.070182E-35
129	=PI()*(7.25)^2*10.2*$A$3*A16/1000	9.875618E-30	2.151751E-30	4.689217E-31
141.9	=PI()*(7.25)^2*10.2*$A$3*A17/1000	1.008611E-26	2.521951E-27	6.307102E-28
154.8	=PI()*(7.25)^2*10.2*$A$3*A18/1000	3.257614E-24	9.135696E-25	2.56249E-25
167.7	=PI()*(7.25)^2*10.2*$A$3*A19/1000	4.337545E-22	1.340502E-22	4.143488E-23
180.6	=PI()*(7.25)^2*10.2*$A$3*A20/1000	2.876908E-20	9.663588E-21	3.246536E-21
193.5	=PI()*(7.25)^2*10.2*$A$3*A21/1000	1.091731E-18	3.942214E-19	1.423723E-19
206.4	=PI()*(7.25)^2*10.2*$A$3*A22/1000	2.629534E-17	1.011692E-17	3.892851E-18
219.3	=PI()*(7.25)^2*10.2*$A$3*A23/1000	4.351698E-16	1.770909E-16	7.20728E-17
232.2	=PI()*(7.25)^2*10.2*$A$3*A24/1000	5.263344E-15	2.25176E-15	9.634013E-16
245.1	=PI()*(7.25)^2*10.2*$A$3*A25/1000	4.885302E-14	2.185975E-14	9.781625E-15
258	=PI()*(7.25)^2*10.2*$A$3*A26/1000	0.000000000003618776	0.00000000000016862	0.00000000000007857
270.9	=PI()*(7.25)^2*10.2*$A$3*A27/1000	0.000000000002208496	0.000000000001067588	0.000000000005160598
283.8	=PI()*(7.25)^2*10.2*$A$3*A28/1000	0.00000000001139861	0.00000000000569772	0.000000000002847938
296.7	=PI()*(7.25)^2*10.2*$A$3*A29/1000	0.0000000000508447	0.00000000002620593	0.00000000001350595
309.6	=PI()*(7.25)^2*10.2*$A$3*A30/1000	0.000000000199598	0.00000000010581	0.00000000005608687
322.5	=PI()*(7.25)^2*10.2*$A$3*A31/1000	0.0000000007002015	0.000000000380933	0.0000000002072201
335.4	=PI()*(7.25)^2*10.2*$A$3*A32/1000	0.000000002223725	0.000000001239104	0.0000000006903778
348.3	=PI()*(7.25)^2*10.2*$A$3*A33/1000	0.000000006464607	0.000000003683055	0.000000002098079
361.2	=PI()*(7.25)^2*10.2*$A$3*A34/1000	0.00000001736755	0.00000001010094	0.000000005873926
374.1	=PI()*(7.25)^2*10.2*$A$3*A35/1000	0.00000004347487	0.00000002577539	0.00000001527961

Am_Calculations_2.xls - Am vs Eluted Volume Formulas (continued)

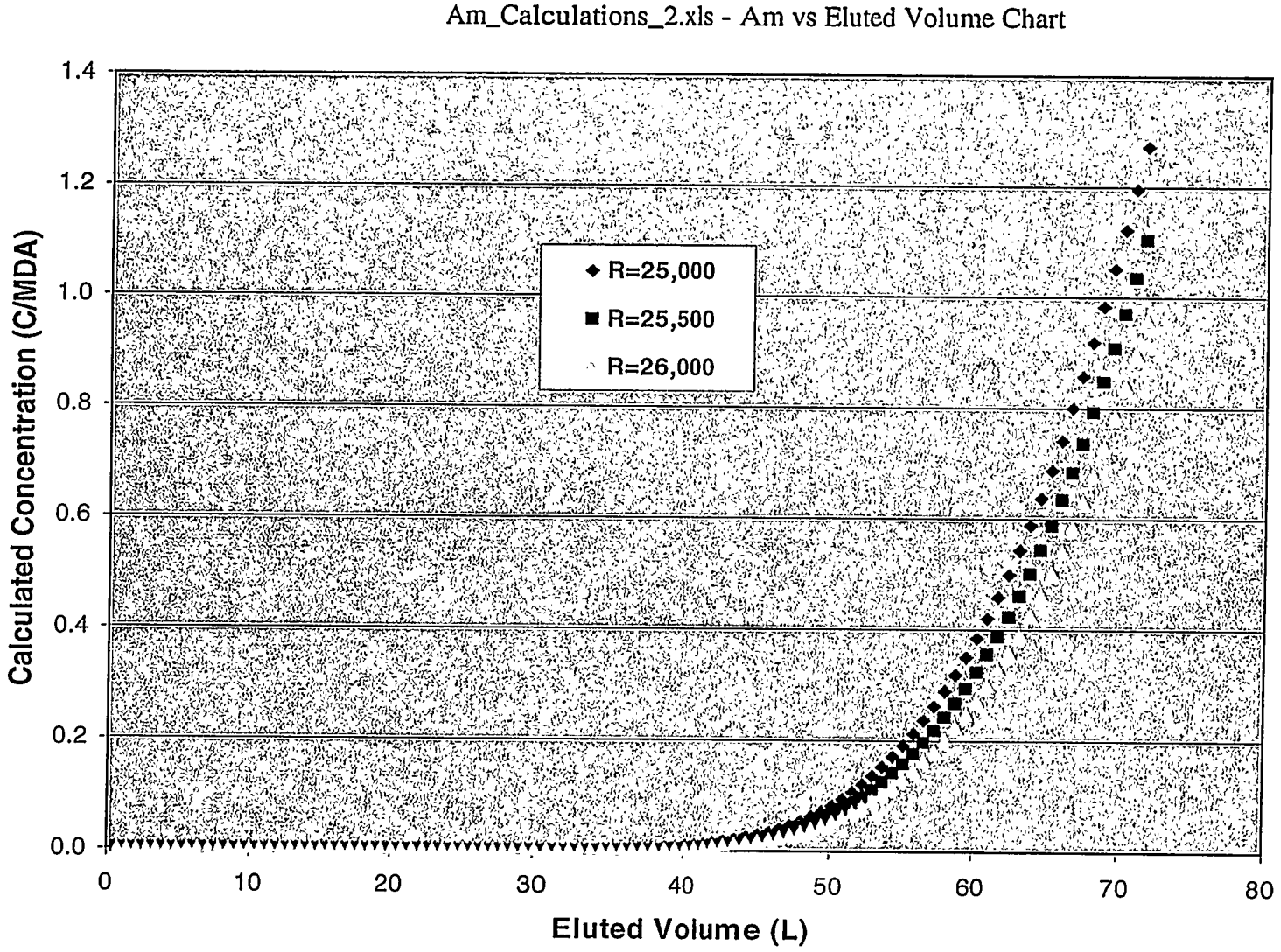
theta 0.033		R 25000	R 25500	R 26000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
		R=25,000	**R=25,500**	**R=26,000**
387	=PI()*(7.25)^2*10.2*$A$3*A36/1000	0.0000001021262	0.00000006164453	0.00000003720392
399.9	=PI()*(7.25)^2*10.2*$A$3*A37/1000	0.0000002265342	0.0000001390531	0.00000008534176
412.8	=PI()*(7.25)^2*10.2*$A$3*A38/1000	0.0000004770788	0.0000002974896	0.000000185475
425.7	=PI()*(7.25)^2*10.2*$A$3*A39/1000	0.0000009584793	0.000000606576	0.0000003838111
438.6	=PI()*(7.25)^2*10.2*$A$3*A40/1000	0.000001844776	0.000001183829	0.0000007595606
451.5	=PI()*(7.25)^2*10.2*$A$3*A41/1000	0.000003414246	0.000002219919	0.000001443132
464.4	=PI()*(7.25)^2*10.2*$A$3*A42/1000	0.000006096461	0.000004013285	0.00000264148
477.3	=PI()*(7.25)^2*10.2*$A$3*A43/1000	0.00001053361	0.000007015967	0.000004672203
490.2	=PI()*(7.25)^2*10.2*$A$3*A44/1000	0.00001765803	0.00001189246	0.000008007997
503.1	=PI()*(7.25)^2*10.2*$A$3*A45/1000	0.00002878743	0.00001959309	0.00001333292
516	=PI()*(7.25)^2*10.2*$A$3*A46/1000	0.00004573884	0.00003144317	0.00002161169
528.9	=PI()*(7.25)^2*10.2*$A$3*A47/1000	0.00007096176	0.00004924858	0.00003417304
541.8	=PI()*(7.25)^2*10.2*$A$3*A48/1000	0.00010769	0.00007541802	0.00005280739
554.7	=PI()*(7.25)^2*10.2*$A$3*A49/1000	0.0001601113	0.0001131014	0.00007987916
567.6	=PI()*(7.25)^2*10.2*$A$3*A50/1000	0.0002335528	0.0001663437	0.000118453
580.5	=PI()*(7.25)^2*10.2*$A$3*A51/1000	0.0003346801	0.0002402515	0.0001724331
593.4	=PI()*(7.25)^2*10.2*$A$3*A52/1000	0.0004717066	0.0003411722	0.0002467136
606.3	=PI()*(7.25)^2*10.2*$A$3*A53/1000	0.0006546093	0.0004768802	0.0003473392
619.2	=PI()*(7.25)^2*10.2*$A$3*A54/1000	0.0008953474	0.0006567697	0.0004816721
632.1	=PI()*(7.25)^2*10.2*$A$3*A55/1000	0.00120808	0.0008920486	0.0006585635
645	=PI()*(7.25)^2*10.2*$A$3*A56/1000	0.001609379	0.001195932	0.0008885271
657.9	=PI()*(7.25)^2*10.2*$A$3*A57/1000	0.002118427	0.001583828	0.00118391
670.8	=PI()*(7.25)^2*10.2*$A$3*A58/1000	0.00275721	0.00207352	0.001559059
683.7	=PI()*(7.25)^2*10.2*$A$3*A59/1000	0.003550683	0.00268533	0.00203048
696.6	=PI()*(7.25)^2*10.2*$A$3*A60/1000	0.004526923	0.003442268	0.002616986
709.5	=PI()*(7.25)^2*10.2*$A$3*A61/1000	0.005717252	0.004370171	0.003339831
722.4	=PI()*(7.25)^2*10.2*$A$3*A62/1000	0.007156336	0.005497809	0.004222827
735.3	=PI()*(7.25)^2*10.2*$A$3*A63/1000	0.008882257	0.006856977	0.005292447
748.2	=PI()*(7.25)^2*10.2*$A$3*A64/1000	0.01093655	0.008482558	0.006577906

Am_Calculations_2.xls - Am vs Eluted Volume Formulas (continued)

theta 0.033		R 25000	R 25500	R 26000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
		R=25,000	**R=25,500**	**R=26,000**
761.1	=PI()*(7.25)^2*10.2*$A$3*A65/1000	0.01336423	0.01041257	0.008111215
774	=PI()*(7.25)^2*10.2*$A$3*A66/1000	0.01621374	0.01268815	0.009927223
786.9	=PI()*(7.25)^2*10.2*$A$3*A67/1000	0.01953693	0.0153536	0.01206363
799.8	=PI()*(7.25)^2*10.2*$A$3*A68/1000	0.02338899	0.01845628	0.01456098
812.7	=PI()*(7.25)^2*10.2*$A$3*A69/1000	0.02782829	0.02204658	0.01746263
825.6	=PI()*(7.25)^2*10.2*$A$3*A70/1000	0.03291632	0.02617783	0.02081467
838.5	=PI()*(7.25)^2*10.2*$A$3*A71/1000	0.03871746	0.03090618	0.0246659
851.4	=PI()*(7.25)^2*10.2*$A$3*A72/1000	0.04529885	0.03629045	0.02906769
864.3	=PI()*(7.25)^2*10.2*$A$3*A73/1000	0.05273018	0.042392	0.03407388
877.2	=PI()*(7.25)^2*10.2*$A$3*A74/1000	0.06108343	0.04927455	0.03974063
890.1	=PI()*(7.25)^2*10.2*$A$3*A75/1000	0.07043271	0.05700397	0.0461263
903	=PI()*(7.25)^2*10.2*$A$3*A76/1000	0.08085395	0.06564812	0.05329127
915.9	=PI()*(7.25)^2*10.2*$A$3*A77/1000	0.09242467	0.07527657	0.06129772
928.8	=PI()*(7.25)^2*10.2*$A$3*A78/1000	0.1052237	0.08596044	0.07020954
941.7	=PI()*(7.25)^2*10.2*$A$3*A79/1000	0.119331	0.09777212	0.08009203
954.6	=PI()*(7.25)^2*10.2*$A$3*A80/1000	0.1348271	0.110785	0.09101174
967.5	=PI()*(7.25)^2*10.2*$A$3*A81/1000	0.1517932	0.1250735	0.1030363
980.4	=PI()*(7.25)^2*10.2*$A$3*A82/1000	0.1703108	0.1407122	0.1162341
993.3	=PI()*(7.25)^2*10.2*$A$3*A83/1000	0.1904611	0.1577764	0.1306741
1006.2	=PI()*(7.25)^2*10.2*$A$3*A84/1000	0.2123253	0.1763412	0.1464258
1019.1	=PI()*(7.25)^2*10.2*$A$3*A85/1000	0.2359837	0.1964817	0.1635588
1032	=PI()*(7.25)^2*10.2*$A$3*A86/1000	0.261516	0.2182725	0.1821425
1044.9	=PI()*(7.25)^2*10.2*$A$3*A87/1000	0.2890009	0.2417877	0.2022463
1057.8	=PI()*(7.25)^2*10.2*$A$3*A88/1000	0.3185155	0.2671004	0.2239391
1070.7	=PI()*(7.25)^2*10.2*$A$3*A89/1000	0.3501358	0.2942827	0.2472888
1083.6	=PI()*(7.25)^2*10.2*$A$3*A90/1000	0.3839356	0.3234057	0.272363
1096.5	=PI()*(7.25)^2*10.2*$A$3*A91/1000	0.4199873	0.3545386	0.2992279
1109.4	=PI()*(7.25)^2*10.2*$A$3*A92/1000	0.4583607	0.3877492	0.3279485
1122.3	=PI()*(7.25)^2*10.2*$A$3*A93/1000	0.4991238	0.4231037	0.3585886

Am_Calculations_2.xls - Am vs Eluted Volume Formulas (continued)

theta 0.033		R 25000	R 25500	R 26000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
		R=25,000	**R=25,500**	**R=26,000**
1135.2	=PI()*(7.25)^2*10.2*$A$3*A94/1000	0.5423418	0.4606661	0.3912104
1148.1	=PI()*(7.25)^2*10.2*$A$3*A95/1000	0.5880775	0.5004982	0.4258743
1161	=PI()*(7.25)^2*10.2*$A$3*A96/1000	0.636391	0.5426599	0.462639
1173.9	=PI()*(7.25)^2*10.2*$A$3*A97/1000	0.6873395	0.5872084	0.5015613
1186.8	=PI()*(7.25)^2*10.2*$A$3*A98/1000	0.7409775	0.6341987	0.5426958
1199.7	=PI()*(7.25)^2*10.2*$A$3*A99/1000	0.7993539	0.6836832	0.586095
1212.6	=PI()*(7.25)^2*10.2*$A$3*A100/1000	0.8567179	0.7357114	0.6318092
1225.5	=PI()*(7.25)^2*10.2*$A$3*A101/1000	0.9187276	0.792346	0.6798863
1238.4	=PI()*(7.25)^2*10.2*$A$3*A102/1000	0.9836137	0.8477751	0.7303716
1251.3	=PI()*(7.25)^2*10.2*$A$3*A103/1000	1.051415	0.9077125	0.7853415
1264.2	=PI()*(7.25)^2*10.2*$A$3*A104/1000	1.122166	0.9703646	0.8389251
1277.1	=PI()*(7.25)^2*10.2*$A$3*A105/1000	1.1959	1.035767	0.8968902
1290	=PI()*(7.25)^2*10.2*$A$3*A106/1000	1.272646	1.103951	0.9574203


Am_Calculations_2.xls - Am vs Eluted Volume Chart
Calculated Concentration (C/MDA)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
R=25,000
R=25,500
R=26,000
0
10
20
30
40
50
60
70
80
Eluted Volume (L)

APPENDIX Q.

LISTINGS OF PARAMETER INPUT FILES (*.COL) FOR THREE ^{241}Am COLUMN 1.4 CALCULATIONS AT RETARDATION VALUES 11,000, 11,500, & 12,000 (FOR EQUILIBRIUM SATURATION CONCENTRATION, WITHOUT RE-DISSOLUTION OF PRECIPITATED ^{241}Am)

Am_Sat_11000_Short_Vol.col

```
[Wcolumn]
Date=5/26/98 11:26:02 AM
Title=Am (sat), 0.1 mL/min, 20 mL spike ONLY - Data through 9/2/97
LogFile=Am_Sat_11000_Short_Vol.log
OutputFile=Am_Sat_11000_Short_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=FLUX
Bootstrap=
[DistanceAndTimeSpec.]
Set=Formula
Fixed=Distance
Distance=1
Start=12.9
End=1290
Step=100
[ParameterValues]
R=11000
theta=0.033
D=0.64
mu=0
gamma=0
q=0.033
t0=0.36
c0=53000
```

Am_Sat_11500_Short_Vol.col

```
[Wcolumn]
Date=5/26/98 11:26:02 AM
Title=Am (sat), 0.1 mL/min, 20 mL spike ONLY - Data through 9/2/97
LogFile=Am_Sat_11500_Short_Vol.log
OutputFile=Am_Sat_11500_Short_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=FLUX
Bootstrap=
[DistanceAndTimeSpec.]
Set=Formula
Fixed=Distance
Distance=1
Start=12.9
End=1290
Step=100
[ParameterValues]
R=11500
theta=0.033
D=0.64
mu=0
gamma=0
q=0.033
t0=0.36
c0=53000
```

Am_Sat_12000_Short_Vol.col

```
[Wcolumn]
Date=5/26/98 11:26:02 AM
Title=Am (sat), 0.1 mL/min, 20 mL spike ONLY - Data through 9/2/97
LogFile=Am_Sat_12000_Short_Vol.log
OutputFile=Am_Sat_12000_Short_Vol.out
Model=Linear equilibrium
TracerSpikeType=Single
CurveType=Theoretical Curve
Normalization=FLUX
Bootstrap=
[DistanceAndTimeSpec.]
Set=Formula
Fixed=Distance
Distance=1
Start=12.9
End=1290
Step=100
[ParameterValues]
R=12000
theta=0.033
D=0.64
mu=0
gamma=0
q=0.033
t0=0.36
c0=53000
```

APPENDIX R.

LISTINGS OF OUTPUT FILES (*.LOG) FOR THREE ^{241}Am COLUMN 1.4 CALCULATIONS AT RETARDATION VALUES 11,000, 11,500, & 12,000 (FOR EQUILIBRIUM SATURATION CONCENTRATION, WITHOUT RE-DISSOLUTION OF PRECIPITATED ^{241}Am)

Am_Sat_12000_Short_Vol.log

```
*****************************************************************************
*                                                                           *
*    Deterministic linear equilibrium absorption for pulse injection with   *
*    first-order decay                                                      *
*                                                                           *
*    Am (sat), 0.1 mL/min, 20 mL spike ONLY - Data through 9/2/97           *
*                                                                           *
*****************************************************************************
Model Name = Linear equilibrium
Calculation began 5/26/98 11:30:44 AM

Model parameters:
        R = 11000
    theta = 0.033
        D = 0.64
       mu = 0
    gamma = 0
        q = 0.033
       t0 = 0.36
       c0 = 53000

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E+00  1.290000E+01  3.914634E-142
1.000000E+00  2.580000E+01  1.071041E-69
1.000000E+00  3.870000E+01  1.209628E-45
1.000000E+00  5.160000E+01  2.161157E-33
1.000000E+00  6.450000E+01  2.909448E-26
1.000000E+00  7.740000E+01  1.549026E-21
1.000000E+00  9.030000E+01  3.531041E-18
1.000000E+00  1.032000E+02  1.130299E-15
1.000000E+00  1.161000E+02  9.813081E-14
1.000000E+00  1.290000E+02  3.426648E-12
1.000000E+00  1.419000E+02  6.180909E-11
1.000000E+00  1.548000E+02  6.802202E-10
1.000000E+00  1.677000E+02  5.124052E-09
1.000000E+00  1.806000E+02  2.867850E-08
1.000000E+00  1.935000E+02  1.266326E-07
1.000000E+00  2.064000E+02  4.614196E-07
1.000000E+00  2.193000E+02  1.435834E-06
1.000000E+00  2.322000E+02  3.918649E-06
1.000000E+00  2.451000E+02  9.578717E-06
1.000000E+00  2.580000E+02  2.132539E-05
1.000000E+00  2.709000E+02  4.383170E-05
1.000000E+00  2.838000E+02  8.409817E-05
1.000000E+00  2.967000E+02  1.520039E-04
1.000000E+00  3.096000E+02  2.607891E-04
1.000000E+00  3.225000E+02  4.274210E-04
1.000000E+00  3.354000E+02  6.728054E-04
1.000000E+00  3.483000E+02  1.021825E-03
1.000000E+00  3.612000E+02  1.503200E-03
1.000000E+00  3.741000E+02  2.149181E-03
1.000000E+00  3.870000E+02  2.995100E-03
1.000000E+00  3.999000E+02  4.078795E-03
1.000000E+00  4.128000E+02  5.439970E-03
1.000000E+00  4.257000E+02  7.119485E-03
1.000000E+00  4.386000E+02  9.158647E-03
1.000000E+00  4.515000E+02  1.159850E-02
1.000000E+00  4.644000E+02  1.447915E-02
1.000000E+00  4.773000E+02  1.783916E-02
1.000000E+00  4.902000E+02  2.171499E-02
1.000000E+00  5.031000E+02  2.614053E-02
1.000000E+00  5.160000E+02  3.114671E-02
1.000000E+00  5.289000E+02  3.676952E-02
1.000000E+00  5.418000E+02  4.301716E-02
1.000000E+00  5.547000E+02  4.991769E-02
1.000000E+00  5.676000E+02  5.748785E-02
```

1.000000E+00	5.805000E+02	6.574057E-02
1.000000E+00	5.934000E+02	7.468507E-02
1.000000E+00	6.063000E+02	8.432691E-02
1.000000E+00	6.192000E+02	9.466810E-02
1.000000E+00	6.321000E+02	1.057073E-01
1.000000E+00	6.450000E+02	1.174399E-01
1.000000E+00	6.579000E+02	1.298584E-01
1.000000E+00	6.708000E+02	1.429525E-01
1.000000E+00	6.837000E+02	1.567093E-01
1.000000E+00	6.966000E+02	1.711136E-01
1.000000E+00	7.095000E+02	1.861480E-01
1.000000E+00	7.224000E+02	2.017935E-01
1.000000E+00	7.353000E+02	2.180293E-01
1.000000E+00	7.482000E+02	2.348331E-01
1.000000E+00	7.611000E+02	2.521816E-01
1.000000E+00	7.740000E+02	2.700504E-01
1.000000E+00	7.869000E+02	2.884141E-01
1.000000E+00	7.998000E+02	3.072471E-01
1.000000E+00	8.127000E+02	3.265228E-01
1.000000E+00	8.256000E+02	3.462148E-01
1.000000E+00	8.385000E+02	3.662960E-01
1.000000E+00	8.514000E+02	3.867396E-01
1.000000E+00	8.643000E+02	4.075188E-01
1.000000E+00	8.772000E+02	4.286069E-01
1.000000E+00	8.901000E+02	4.499774E-01
1.000000E+00	9.030000E+02	4.716044E-01
1.000000E+00	9.159000E+02	4.934622E-01
1.000000E+00	9.288000E+02	5.155257E-01
1.000000E+00	9.417000E+02	5.377702E-01
1.000000E+00	9.546000E+02	5.601718E-01
1.000000E+00	9.675000E+02	5.827071E-01
1.000000E+00	9.804000E+02	6.053534E-01
1.000000E+00	9.933000E+02	6.280886E-01
1.000000E+00	1.006200E+03	6.508916E-01
1.000000E+00	1.019100E+03	6.737418E-01
1.000000E+00	1.032000E+03	6.966194E-01
1.000000E+00	1.044900E+03	7.195053E-01
1.000000E+00	1.057800E+03	7.423814E-01
1.000000E+00	1.070700E+03	7.652300E-01
1.000000E+00	1.083600E+03	7.880344E-01
1.000000E+00	1.096500E+03	8.107787E-01
1.000000E+00	1.109400E+03	8.334476E-01
1.000000E+00	1.122300E+03	8.560266E-01
1.000000E+00	1.135200E+03	8.785019E-01
1.000000E+00	1.148100E+03	9.008605E-01
1.000000E+00	1.161000E+03	9.230899E-01
1.000000E+00	1.173900E+03	9.451785E-01
1.000000E+00	1.186800E+03	9.671152E-01
1.000000E+00	1.199700E+03	9.888896E-01
1.000000E+00	1.212600E+03	1.010492E+00
1.000000E+00	1.225500E+03	1.031913E+00
1.000000E+00	1.238400E+03	1.053145E+00
1.000000E+00	1.251300E+03	1.074179E+00
1.000000E+00	1.264200E+03	1.095008E+00
1.000000E+00	1.277100E+03	1.115624E+00
1.000000E+00	1.290000E+03	1.136023E+00

Am_Sat_11500_Short_Vol.log

```
*******************************************************************************
*                                                                             *
*    Deterministic linear equilibrium absorption for pulse injection with     *
*    first-order decay                                                        *
*                                                                             *
*    Am (sat), 0.1 mL/min, 20 mL spike ONLY - Data through 9/2/97             *
*                                                                             *
*******************************************************************************
Model Name = Linear equilibrium
Calculation began 5/26/98 11:31:06 AM

Model parameters:
        R = 11500
    theta = 0.033
        D = 0.64
       mu = 0
    gamma = 0
        q = 0.033
       t0 = 0.36
       c0 = 53000

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E+00  1.290000E+01  1.017716E-148
1.000000E+00  2.580000E+01  5.457844E-73
1.000000E+00  3.870000E+01  7.797658E-48
1.000000E+00  5.160000E+01  4.958098E-35
1.000000E+00  6.450000E+01  1.428777E-27
1.000000E+00  7.740000E+01  1.263021E-22
1.000000E+00  9.030000E+01  4.134750E-19
1.000000E+00  1.032000E+02  1.736133E-16
1.000000E+00  1.161000E+02  1.861306E-14
1.000000E+00  1.290000E+02  7.694130E-13
1.000000E+00  1.419000E+02  1.593246E-11
1.000000E+00  1.548000E+02  1.967076E-10
1.000000E+00  1.677000E+02  1.633190E-09
1.000000E+00  1.806000E+02  9.935523E-09
1.000000E+00  1.935000E+02  4.715848E-08
1.000000E+00  2.064000E+02  1.830481E-07
1.000000E+00  2.193000E+02  6.022783E-07
1.000000E+00  2.322000E+02  1.727270E-06
1.000000E+00  2.451000E+02  4.413622E-06
1.000000E+00  2.580000E+02  1.022638E-05
1.000000E+00  2.709000E+02  2.179209E-05
1.000000E+00  2.838000E+02  4.320726E-05
1.000000E+00  2.967000E+02  8.047193E-05
1.000000E+00  3.096000E+02  1.419104E-04
1.000000E+00  3.225000E+02  2.385397E-04
1.000000E+00  3.354000E+02  3.843528E-04
1.000000E+00  3.483000E+02  5.964888E-04
1.000000E+00  3.612000E+02  8.952776E-04
1.000000E+00  3.741000E+02  1.304153E-03
1.000000E+00  3.870000E+02  1.849441E-03
1.000000E+00  3.999000E+02  2.560039E-03
1.000000E+00  4.128000E+02  3.467003E-03
1.000000E+00  4.257000E+02  4.603064E-03
1.000000E+00  4.386000E+02  6.002108E-03
1.000000E+00  4.515000E+02  7.698621E-03
1.000000E+00  4.644000E+02  9.727150E-03
1.000000E+00  4.773000E+02  1.212177E-02
1.000000E+00  4.902000E+02  1.491558E-02
1.000000E+00  5.031000E+02  1.814027E-02
1.000000E+00  5.160000E+02  2.182570E-02
1.000000E+00  5.289000E+02  2.599957E-02
1.000000E+00  5.418000E+02  3.068713E-02
1.000000E+00  5.547000E+02  3.591905E-02
1.000000E+00  5.676000E+02  4.169960E-02
```

1.000000E+00	5.805000E+02	4.805298E-02
1.000000E+00	5.934000E+02	5.499296E-02
1.000000E+00	6.063000E+02	6.253033E-02
1.000000E+00	6.192000E+02	7.067286E-02
1.000000E+00	6.321000E+02	7.942539E-02
1.000000E+00	6.450000E+02	8.878992E-02
1.000000E+00	6.579000E+02	9.876574E-02
1.000000E+00	6.708000E+02	1.093495E-01
1.000000E+00	6.837000E+02	1.205356E-01
1.000000E+00	6.966000E+02	1.323158E-01
1.000000E+00	7.095000E+02	1.446802E-01
1.000000E+00	7.224000E+02	1.576167E-01
1.000000E+00	7.353000E+02	1.711115E-01
1.000000E+00	7.482000E+02	1.851492E-01
1.000000E+00	7.611000E+02	1.997132E-01
1.000000E+00	7.740000E+02	2.147855E-01
1.000000E+00	7.869000E+02	2.303470E-01
1.000000E+00	7.998000E+02	2.463778E-01
1.000000E+00	8.127000E+02	2.628572E-01
1.000000E+00	8.256000E+02	2.797640E-01
1.000000E+00	8.385000E+02	2.970765E-01
1.000000E+00	8.514000E+02	3.147723E-01
1.000000E+00	8.643000E+02	3.328294E-01
1.000000E+00	8.772000E+02	3.512250E-01
1.000000E+00	8.901000E+02	3.699368E-01
1.000000E+00	9.030000E+02	3.889422E-01
1.000000E+00	9.159000E+02	4.082190E-01
1.000000E+00	9.288000E+02	4.277449E-01
1.000000E+00	9.417000E+02	4.474983E-01
1.000000E+00	9.546000E+02	4.674574E-01
1.000000E+00	9.675000E+02	4.876013E-01
1.000000E+00	9.804000E+02	5.079092E-01
1.000000E+00	9.933000E+02	5.283608E-01
1.000000E+00	1.006200E+03	5.489365E-01
1.000000E+00	1.019100E+03	5.696170E-01
1.000000E+00	1.032000E+03	5.903837E-01
1.000000E+00	1.044900E+03	6.112184E-01
1.000000E+00	1.057800E+03	6.321038E-01
1.000000E+00	1.070700E+03	6.530227E-01
1.000000E+00	1.083600E+03	6.739591E-01
1.000000E+00	1.096500E+03	6.948971E-01
1.000000E+00	1.109400E+03	7.158217E-01
1.000000E+00	1.122300E+03	7.367184E-01
1.000000E+00	1.135200E+03	7.575734E-01
1.000000E+00	1.148100E+03	7.783733E-01
1.000000E+00	1.161000E+03	7.991055E-01
1.000000E+00	1.173900E+03	8.197580E-01
1.000000E+00	1.186800E+03	8.403192E-01
1.000000E+00	1.199700E+03	8.607782E-01
1.000000E+00	1.212600E+03	8.811247E-01
1.000000E+00	1.225500E+03	9.013487E-01
1.000000E+00	1.238400E+03	9.214410E-01
1.000000E+00	1.251300E+03	9.413929E-01
1.000000E+00	1.264200E+03	9.611961E-01
1.000000E+00	1.277100E+03	9.808427E-01
1.000000E+00	1.290000E+03	1.000326E+00

Am_Sat_12000_Short_Vol.log

```
*****************************************************************************
*                                                                           *
*    Deterministic linear equilibrium absorption for pulse injection with   *
*    first-order decay                                                      *
*                                                                           *
*    Am (sat), 0.1 mL/min, 20 mL spike ONLY - Data through 9/2/97           *
*                                                                           *
*****************************************************************************
Model Name = Linear equilibrium
Calculation began 5/26/98 11:31:24 AM

Model parameters:
        R = 12000
    theta = 0.033
        D = 0.64
       mu = 0
    gamma = 0
        q = 0.033
       t0 = 0.36
       c0 = 53000

No fit performed; model calculation only

Calculated model curves:
Distance      Time          Model
1.000000E+00  1.290000E+01  2.648306E-155
1.000000E+00  2.580000E+01  2.780618E-76
1.000000E+00  3.870000E+01  5.022797E-50
1.000000E+00  5.160000E+01  1.136463E-36
1.000000E+00  6.450000E+01  7.009943E-29
1.000000E+00  7.740000E+01  1.028850E-23
1.000000E+00  9.030000E+01  4.837072E-20
1.000000E+00  1.032000E+02  2.664142E-17
1.000000E+00  1.161000E+02  3.527070E-15
1.000000E+00  1.290000E+02  1.725965E-13
1.000000E+00  1.419000E+02  4.102939E-12
1.000000E+00  1.548000E+02  5.682949E-11
1.000000E+00  1.677000E+02  5.200437E-10
1.000000E+00  1.806000E+02  3.438779E-09
1.000000E+00  1.935000E+02  1.754496E-08
1.000000E+00  2.064000E+02  7.254581E-08
1.000000E+00  2.193000E+02  2.523870E-07
1.000000E+00  2.322000E+02  7.606071E-07
1.000000E+00  2.451000E+02  2.031695E-06
1.000000E+00  2.580000E+02  4.899159E-06
1.000000E+00  2.709000E+02  1.082389E-05
1.000000E+00  2.838000E+02  2.217687E-05
1.000000E+00  2.967000E+02  4.256051E-05
1.000000E+00  3.096000E+02  7.714549E-05
1.000000E+00  3.225000E+02  1.329954E-04
1.000000E+00  3.354000E+02  2.193517E-04
1.000000E+00  3.483000E+02  3.478546E-04
1.000000E+00  3.612000E+02  5.326814E-04
1.000000E+00  3.741000E+02  7.905913E-04
1.000000E+00  3.870000E+02  1.140872E-03
1.000000E+00  3.999000E+02  1.605196E-03
1.000000E+00  4.128000E+02  2.207384E-03
1.000000E+00  4.257000E+02  2.973109E-03
1.000000E+00  4.386000E+02  3.929532E-03
1.000000E+00  4.515000E+02  5.104909E-03
1.000000E+00  4.644000E+02  6.528168E-03
1.000000E+00  4.773000E+02  8.228486E-03
1.000000E+00  4.902000E+02  1.023487E-02
1.000000E+00  5.031000E+02  1.257575E-02
1.000000E+00  5.160000E+02  1.527863E-02
1.000000E+00  5.289000E+02  1.836972E-02
1.000000E+00  5.418000E+02  2.187367E-02
1.000000E+00  5.547000E+02  2.581331E-02
1.000000E+00  5.676000E+02  3.020944E-02
```

1.000000E+00	5.805000E+02	3.508849E-02
1.000000E+00	5.934000E+02	4.045174E-02
1.000000E+00	6.063000E+02	4.632030E-02
1.000000E+00	6.192000E+02	5.270562E-02
1.000000E+00	6.321000E+02	5.961675E-02
1.000000E+00	6.450000E+02	6.706028E-02
1.000000E+00	6.579000E+02	7.504046E-02
1.000000E+00	6.708000E+02	8.355921E-02
1.000000E+00	6.837000E+02	9.261627E-02
1.000000E+00	6.966000E+02	1.022092E-01
1.000000E+00	7.095000E+02	1.123337E-01
1.000000E+00	7.224000E+02	1.229834E-01
1.000000E+00	7.353000E+02	1.341505E-01
1.000000E+00	7.482000E+02	1.458252E-01
1.000000E+00	7.611000E+02	1.579965E-01
1.000000E+00	7.740000E+02	1.706520E-01
1.000000E+00	7.869000E+02	1.837782E-01
1.000000E+00	7.998000E+02	1.973605E-01
1.000000E+00	8.127000E+02	2.113832E-01
1.000000E+00	8.256000E+02	2.258300E-01
1.000000E+00	8.385000E+02	2.406839E-01
1.000000E+00	8.514000E+02	2.559272E-01
1.000000E+00	8.643000E+02	2.715419E-01
1.000000E+00	8.772000E+02	2.875095E-01
1.000000E+00	8.901000E+02	3.038114E-01
1.000000E+00	9.030000E+02	3.204286E-01
1.000000E+00	9.159000E+02	3.373423E-01
1.000000E+00	9.288000E+02	3.545333E-01
1.000000E+00	9.417000E+02	3.719827E-01
1.000000E+00	9.546000E+02	3.896718E-01
1.000000E+00	9.675000E+02	4.075818E-01
1.000000E+00	9.804000E+02	4.256943E-01
1.000000E+00	9.933000E+02	4.439910E-01
1.000000E+00	1.006200E+03	4.624542E-01
1.000000E+00	1.019100E+03	4.810662E-01
1.000000E+00	1.032000E+03	4.998099E-01
1.000000E+00	1.044900E+03	5.186685E-01
1.000000E+00	1.057800E+03	5.376256E-01
1.000000E+00	1.070700E+03	5.566653E-01
1.000000E+00	1.083600E+03	5.757722E-01
1.000000E+00	1.096500E+03	5.949312E-01
1.000000E+00	1.109400E+03	6.141278E-01
1.000000E+00	1.122300E+03	6.333480E-01
1.000000E+00	1.135200E+03	6.525782E-01
1.000000E+00	1.148100E+03	6.718054E-01
1.000000E+00	1.161000E+03	6.910170E-01
1.000000E+00	1.173900E+03	7.102009E-01
1.000000E+00	1.186800E+03	7.293456E-01
1.000000E+00	1.199700E+03	7.484400E-01
1.000000E+00	1.212600E+03	7.674734E-01
1.000000E+00	1.225500E+03	7.864357E-01
1.000000E+00	1.238400E+03	8.053173E-01
1.000000E+00	1.251300E+03	8.241090E-01
1.000000E+00	1.264200E+03	8.428019E-01
1.000000E+00	1.277100E+03	8.613878E-01
1.000000E+00	1.290000E+03	8.798588E-01

APPENDIX S.

LISTINGS OF EXCEL 97 SPREADSHEETS AND CHARTS SHOWING RELATIVE CALCULATED ^{241}Am CONCENTRATION AS FUNCTION OF EFFLUENT BRINE VOLUME AT RETARDATION VALUES 11,000, 11,500, & 12,000 (FOR EQUILIBRIUM SATURATION CONCENTRATION, WITHOUT RE-DISSOLUTION OF PRECIPITATED ^{241}Am)

Am_Calculations_3.xls - Am vs Eluted Volume Numbers

theta 0.033		R 11,000	R 11,500	R 12,000
Eluted Pore Volumes	Eluted Volume (L)	Relative Eluted Conc. (C/MDA) R=11,000	Relative Eluted Conc. (C/MDA) R=11,500	Relative Eluted Conc. (C/MDA) R=12,000
12.9	0.72	0.00	0.00	0.00
25.8	1.43	0.00	0.00	0.00
38.7	2.15	0.00	0.00	0.00
51.6	2.87	0.00	0.00	0.00
64.5	3.59	0.00	0.00	0.00
77.4	4.30	0.00	0.00	0.00
90.3	5.02	0.00	0.00	0.00
103.2	5.74	0.00	0.00	0.00
116.1	6.45	0.00	0.00	0.00
129.0	7.17	0.00	0.00	0.00
141.9	7.89	0.00	0.00	0.00
154.8	8.60	0.00	0.00	0.00
167.7	9.32	0.00	0.00	0.00
180.6	10.04	0.00	0.00	0.00
193.5	10.76	0.00	0.00	0.00
206.4	11.47	0.00	0.00	0.00
219.3	12.19	0.00	0.00	0.00
232.2	12.91	0.00	0.00	0.00
245.1	13.62	0.00	0.00	0.00
258.0	14.34	0.00	0.00	0.00
270.9	15.06	0.00	0.00	0.00
283.8	15.77	0.00	0.00	0.00
296.7	16.49	0.00	0.00	0.00
309.6	17.21	0.00	0.00	0.00
322.5	17.93	0.00	0.00	0.00
335.4	18.64	0.00	0.00	0.00
348.3	19.36	0.00	0.00	0.00
361.2	20.08	0.00	0.00	0.00
374.1	20.79	0.00	0.00	0.00
387.0	21.51	0.00	0.00	0.00
399.9	22.23	0.00	0.00	0.00
412.8	22.94	0.01	0.00	0.00
425.7	23.66	0.01	0.00	0.00
438.6	24.38	0.01	0.01	0.00
451.5	25.10	0.01	0.01	0.01
464.4	25.81	0.01	0.01	0.01
477.3	26.53	0.02	0.01	0.01
490.2	27.25	0.02	0.01	0.01
503.1	27.96	0.03	0.02	0.01
516.0	28.68	0.03	0.02	0.02

theta		R	R	R
0.033		11,000	11,500	12,000
Eluted Pore Volumes	Eluted Volume (L)	Relative Eluted Conc. (C/MDA) R=11,000	Relative Eluted Conc. (C/MDA) R=11,500	Relative Eluted Conc. (C/MDA) R=12,000
528.9	29.40	0.04	0.03	0.02
541.8	30.11	0.04	0.03	0.02
554.7	30.83	0.05	0.04	0.03
567.6	31.55	0.06	0.04	0.03
580.5	32.27	0.07	0.05	0.04
593.4	32.98	0.07	0.05	0.04
606.3	33.70	0.08	0.06	0.05
619.2	34.42	0.09	0.07	0.05
632.1	35.13	0.11	0.08	0.06
645.0	35.85	0.12	0.09	0.07
657.9	36.57	0.13	0.10	0.08
670.8	37.28	0.14	0.11	0.08
683.7	38.00	0.16	0.12	0.09
696.6	38.72	0.17	0.13	0.10
709.5	39.44	0.19	0.14	0.11
722.4	40.15	0.20	0.16	0.12
735.3	40.87	0.22	0.17	0.13
748.2	41.59	0.23	0.19	0.15
761.1	42.30	0.25	0.20	0.16
774.0	43.02	0.27	0.21	0.17
786.9	43.74	0.29	0.23	0.18
799.8	44.46	0.31	0.25	0.20
812.7	45.17	0.33	0.26	0.21
825.6	45.89	0.35	0.28	0.23
838.5	46.61	0.37	0.30	0.24
851.4	47.32	0.39	0.31	0.26
864.3	48.04	0.41	0.33	0.27
877.2	48.76	0.43	0.35	0.29
890.1	49.47	0.45	0.37	0.30
903.0	50.19	0.47	0.39	0.32
915.9	50.91	0.49	0.41	0.34
928.8	51.63	0.52	0.43	0.35
941.7	52.34	0.54	0.45	0.37
954.6	53.06	0.56	0.47	0.39
967.5	53.78	0.58	0.49	0.41
980.4	54.49	0.61	0.51	0.43
993.3	55.21	0.63	0.53	0.44
1006.2	55.93	0.65	0.55	0.46
1019.1	56.64	0.67	0.57	0.48
1032.0	57.36	0.70	0.59	0.50

Am_Calculations_3.xls - Am vs Eluted Volume Numbers (continued)

theta		R	R	R
0.033		11,000	11,500	12,000
Eluted Pore Volumes	Eluted Volume (L)	Relative Eluted Conc. (C/MDA) R=11,000	Relative Eluted Conc. (C/MDA) R=11,500	Relative Eluted Conc. (C/MDA) R=12,000
1044.9	58.08	0.72	0.61	0.52
1057.8	58.80	0.74	0.63	0.54
1070.7	59.51	0.77	0.65	0.56
1083.6	60.23	0.79	0.67	0.58
1096.5	60.95	0.81	0.69	0.59
1109.4	61.66	0.83	0.72	0.61
1122.3	62.38	0.86	0.74	0.63
1135.2	63.10	0.88	0.76	0.65
1148.1	63.81	0.90	0.78	0.67
1161.0	64.53	0.92	0.80	0.69
1173.9	65.25	0.95	0.82	0.71
1186.8	65.97	0.97	0.84	0.73
1199.7	66.68	0.99	0.86	0.75
1212.6	67.40	1.01	0.88	0.77
1225.5	68.12	1.03	0.90	0.79
1238.4	68.83	1.05	0.92	0.81
1251.3	69.55	1.07	0.94	0.82
1264.2	70.27	1.10	0.96	0.84
1277.1	70.98	1.12	0.98	0.86
1290.0	71.70	1.14	1.00	0.88

Am_Calculations_3.xls - Am vs Eluted Volume Formulas

theta		R	R	R
0.033		11000	11500	12000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
		R=11,000	R=11,500	R=12,000
12.9	=PI()*(7.25)^2*10.2*$A$3*A7/1000	3.914634E-142	1.017716E-148	2.648306E-155
25.8	=PI()*(7.25)^2*10.2*$A$3*A8/1000	1.071041E-69	5.457844E-73	2.780618E-76
38.7	=PI()*(7.25)^2*10.2*$A$3*A9/1000	1.209628E-45	7.797658E-48	5.022797E-50
51.6	=PI()*(7.25)^2*10.2*$A$3*A10/1000	2.161157E-33	4.958098E-35	1.136463E-36
64.5	=PI()*(7.25)^2*10.2*$A$3*A11/1000	2.909448E-26	1.428777E-27	7.009943E-29
77.4	=PI()*(7.25)^2*10.2*$A$3*A12/1000	1.549026E-21	1.263021E-22	1.02885E-23
90.3	=PI()*(7.25)^2*10.2*$A$3*A13/1000	3.531041E-18	4.13475E-19	4.837072E-20
103.2	=PI()*(7.25)^2*10.2*$A$3*A14/1000	1.130299E-15	1.736133E-16	2.664142E-17
116.1	=PI()*(7.25)^2*10.2*$A$3*A15/1000	9.813081E-14	1.861306E-14	3.52707E-15
129	=PI()*(7.25)^2*10.2*$A$3*A16/1000	0.000000000003426648	0.000000000000769413	0.000000000001725965
141.9	=PI()*(7.25)^2*10.2*$A$3*A17/1000	0.00000000006180909	0.00000000001593246	0.00000000004102939
154.8	=PI()*(7.25)^2*10.2*$A$3*A18/1000	0.0000000006802202	0.0000000001967076	0.00000000005682949
167.7	=PI()*(7.25)^2*10.2*$A$3*A19/1000	0.000000005124052	0.00000000163319	0.0000000005200437
180.6	=PI()*(7.25)^2*10.2*$A$3*A20/1000	0.0000000286785	0.000000009935523	0.000000003438779
193.5	=PI()*(7.25)^2*10.2*$A$3*A21/1000	0.0000001266326	0.00000004715848	0.00000001754496
206.4	=PI()*(7.25)^2*10.2*$A$3*A22/1000	0.0000004614196	0.0000001830481	0.00000007254581
219.3	=PI()*(7.25)^2*10.2*$A$3*A23/1000	0.000001435834	0.0000006022783	0.000000252387
232.2	=PI()*(7.25)^2*10.2*$A$3*A24/1000	0.000003918649	0.00000172727	0.0000007606071
245.1	=PI()*(7.25)^2*10.2*$A$3*A25/1000	0.000009578717	0.000004413622	0.000002031695
258	=PI()*(7.25)^2*10.2*$A$3*A26/1000	0.00002132539	0.00001022638	0.000004899159
270.9	=PI()*(7.25)^2*10.2*$A$3*A27/1000	0.0000438317	0.00002179209	0.00001082389
283.8	=PI()*(7.25)^2*10.2*$A$3*A28/1000	0.00008409817	0.00004320726	0.00002217687
296.7	=PI()*(7.25)^2*10.2*$A$3*A29/1000	0.0001520039	0.00008047193	0.00004256051
309.6	=PI()*(7.25)^2*10.2*$A$3*A30/1000	0.0002607891	0.0001419104	0.00007714549
322.5	=PI()*(7.25)^2*10.2*$A$3*A31/1000	0.000427421	0.0002385397	0.0001329954
335.4	=PI()*(7.25)^2*10.2*$A$3*A32/1000	0.0006728054	0.0003843528	0.0002193517
348.3	=PI()*(7.25)^2*10.2*$A$3*A33/1000	0.001021825	0.0005964888	0.0003478546
361.2	=PI()*(7.25)^2*10.2*$A$3*A34/1000	0.0015032	0.0008952776	0.0005326814
374.1	=PI()*(7.25)^2*10.2*$A$3*A35/1000	0.002149181	0.001304153	0.0007905913

Am_Calculations_3.xls - Am vs Eluted Volume Formulas (continued)

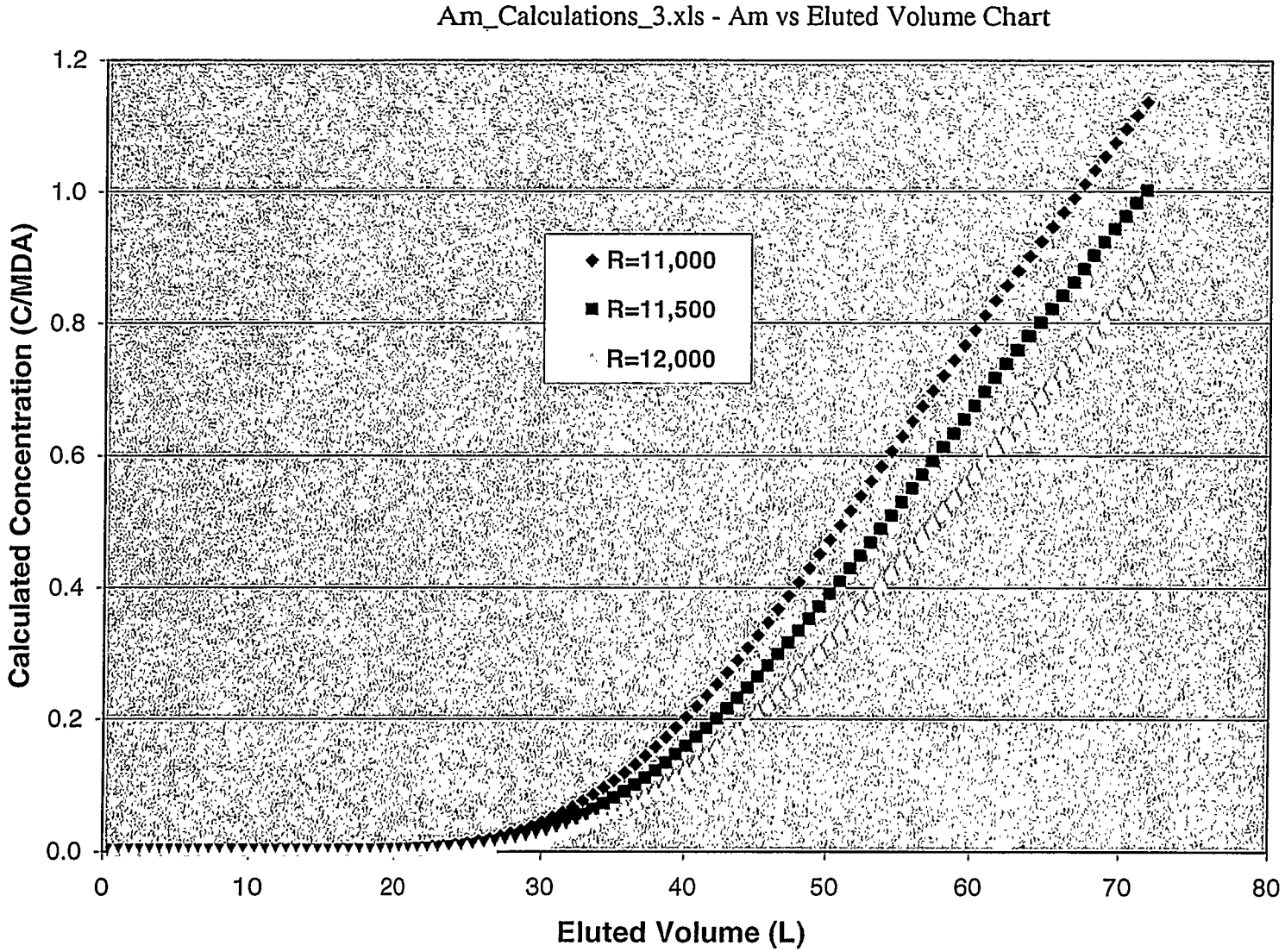
theta 0.033		R 11000	R 11500	R 12000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
		R=11,000	R=11,500	R=12,000
387	=PI()*(7.25)^2*10.2*$A$3*A36/1000	0.0029951	0.001849441	0.001140872
399.9	=PI()*(7.25)^2*10.2*$A$3*A37/1000	0.004078795	0.002560039	0.001605196
412.8	=PI()*(7.25)^2*10.2*$A$3*A38/1000	0.00543997	0.003467003	0.002207384
425.7	=PI()*(7.25)^2*10.2*$A$3*A39/1000	0.007119485	0.004603064	0.002973109
438.6	=PI()*(7.25)^2*10.2*$A$3*A40/1000	0.009158647	0.006002108	0.003929532
451.5	=PI()*(7.25)^2*10.2*$A$3*A41/1000	0.0115985	0.007698621	0.005104909
464.4	=PI()*(7.25)^2*10.2*$A$3*A42/1000	0.01447915	0.00972715	0.006528168
477.3	=PI()*(7.25)^2*10.2*$A$3*A43/1000	0.01783916	0.01212177	0.008228486
490.2	=PI()*(7.25)^2*10.2*$A$3*A44/1000	0.02171499	0.01491558	0.01023487
503.1	=PI()*(7.25)^2*10.2*$A$3*A45/1000	0.02614053	0.01814027	0.01257575
516	=PI()*(7.25)^2*10.2*$A$3*A46/1000	0.03114671	0.0218257	0.01527863
528.9	=PI()*(7.25)^2*10.2*$A$3*A47/1000	0.03676952	0.02599957	0.01836972
541.8	=PI()*(7.25)^2*10.2*$A$3*A48/1000	0.04301716	0.03068713	0.02187367
554.7	=PI()*(7.25)^2*10.2*$A$3*A49/1000	0.04991769	0.03591905	0.02581331
567.6	=PI()*(7.25)^2*10.2*$A$3*A50/1000	0.05748785	0.0416996	0.03020944
580.5	=PI()*(7.25)^2*10.2*$A$3*A51/1000	0.06574057	0.04805298	0.03508849
593.4	=PI()*(7.25)^2*10.2*$A$3*A52/1000	0.07468507	0.05499296	0.04045174
606.3	=PI()*(7.25)^2*10.2*$A$3*A53/1000	0.08432691	0.06253033	0.0463203
619.2	=PI()*(7.25)^2*10.2*$A$3*A54/1000	0.0946681	0.07067286	0.05270562
632.1	=PI()*(7.25)^2*10.2*$A$3*A55/1000	0.1057073	0.07942539	0.05961675
645	=PI()*(7.25)^2*10.2*$A$3*A56/1000	0.1174399	0.08878992	0.06706028
657.9	=PI()*(7.25)^2*10.2*$A$3*A57/1000	0.1298584	0.09876574	0.07504046
670.8	=PI()*(7.25)^2*10.2*$A$3*A58/1000	0.1429525	0.1093495	0.08355921
683.7	=PI()*(7.25)^2*10.2*$A$3*A59/1000	0.1567093	0.1205356	0.09261627
696.6	=PI()*(7.25)^2*10.2*$A$3*A60/1000	0.1711136	0.1323158	0.1022092
709.5	=PI()*(7.25)^2*10.2*$A$3*A61/1000	0.186148	0.1446802	0.1123337
722.4	=PI()*(7.25)^2*10.2*$A$3*A62/1000	0.2017935	0.1576167	0.1229834
735.3	=PI()*(7.25)^2*10.2*$A$3*A63/1000	0.2180293	0.1711115	0.1341505
748.2	=PI()*(7.25)^2*10.2*$A$3*A64/1000	0.2348331	0.1851492	0.1458252

Am_Calculations_3.xls - Am vs Eluted Volume Formulas (continued)

theta 0.033		R 11000	R 11500	R 12000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
		R=11,000	**R=11,500**	**R=12,000**
761.1	=PI()*(7.25)^2*10.2*$A$3*A65/1000	0.2521816	0.1997132	0.1579965
774	=PI()*(7.25)^2*10.2*$A$3*A66/1000	0.2700504	0.2147855	0.170652
786.9	=PI()*(7.25)^2*10.2*$A$3*A67/1000	0.2884141	0.230347	0.1837782
799.8	=PI()*(7.25)^2*10.2*$A$3*A68/1000	0.3072471	0.2463778	0.1973605
812.7	=PI()*(7.25)^2*10.2*$A$3*A69/1000	0.3265228	0.2628572	0.2113832
825.6	=PI()*(7.25)^2*10.2*$A$3*A70/1000	0.3462148	0.279764	0.22583
838.5	=PI()*(7.25)^2*10.2*$A$3*A71/1000	0.366296	0.2970765	0.2406839
851.4	=PI()*(7.25)^2*10.2*$A$3*A72/1000	0.3867396	0.3147723	0.2559272
864.3	=PI()*(7.25)^2*10.2*$A$3*A73/1000	0.4075188	0.3328294	0.2715419
877.2	=PI()*(7.25)^2*10.2*$A$3*A74/1000	0.4286069	0.351225	0.2875095
890.1	=PI()*(7.25)^2*10.2*$A$3*A75/1000	0.4499774	0.3699368	0.3038114
903	=PI()*(7.25)^2*10.2*$A$3*A76/1000	0.4716044	0.3889422	0.3204286
915.9	=PI()*(7.25)^2*10.2*$A$3*A77/1000	0.4934622	0.408219	0.3373423
928.8	=PI()*(7.25)^2*10.2*$A$3*A78/1000	0.5155257	0.4277449	0.3545333
941.7	=PI()*(7.25)^2*10.2*$A$3*A79/1000	0.5377702	0.4474983	0.3719827
954.6	=PI()*(7.25)^2*10.2*$A$3*A80/1000	0.5601718	0.4674574	0.3896718
967.5	=PI()*(7.25)^2*10.2*$A$3*A81/1000	0.5827071	0.4876013	0.4075818
980.4	=PI()*(7.25)^2*10.2*$A$3*A82/1000	0.6053534	0.5079092	0.4256943
993.3	=PI()*(7.25)^2*10.2*$A$3*A83/1000	0.6280886	0.5283608	0.443991
1006.2	=PI()*(7.25)^2*10.2*$A$3*A84/1000	0.6508916	0.5489365	0.4624542
1019.1	=PI()*(7.25)^2*10.2*$A$3*A85/1000	0.6737418	0.569617	0.4810662
1032	=PI()*(7.25)^2*10.2*$A$3*A86/1000	0.6966194	0.5903837	0.4998099
1044.9	=PI()*(7.25)^2*10.2*$A$3*A87/1000	0.7195053	0.6112184	0.5186685
1057.8	=PI()*(7.25)^2*10.2*$A$3*A88/1000	0.7423814	0.6321038	0.5376256
1070.7	=PI()*(7.25)^2*10.2*$A$3*A89/1000	0.76523	0.6530227	0.5566653
1083.6	=PI()*(7.25)^2*10.2*$A$3*A90/1000	0.7880344	0.6739591	0.5757722
1096.5	=PI()*(7.25)^2*10.2*$A$3*A91/1000	0.8107787	0.6948971	0.5949312
1109.4	=PI()*(7.25)^2*10.2*$A$3*A92/1000	0.8334476	0.7158217	0.6141278
1122.3	=PI()*(7.25)^2*10.2*$A$3*A93/1000	0.8560266	0.7367184	0.633348

Am_Calculations_3.xls - Am vs Eluted Volume Formulas (continued)

theta		R	R	R
0.033		11000	11500	12000
Eluted Pore Volumes	**Eluted Volume (L)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**	**Relative Eluted Conc. (C/MDA)**
		R=11,000	**R=11,500**	**R=12,000**
1135.2	=PI()*(7.25)^2*10.2*$A$3*A94/1000	0.8785019	0.7575734	0.6525782
1148.1	=PI()*(7.25)^2*10.2*$A$3*A95/1000	0.9008605	0.7783733	0.6718054
1161	=PI()*(7.25)^2*10.2*$A$3*A96/1000	0.9230899	0.7991055	0.691017
1173.9	=PI()*(7.25)^2*10.2*$A$3*A97/1000	0.9451785	0.819758	0.7102009
1186.8	=PI()*(7.25)^2*10.2*$A$3*A98/1000	0.9671152	0.8403192	0.7293456
1199.7	=PI()*(7.25)^2*10.2*$A$3*A99/1000	0.9888896	0.8607782	0.74844
1212.6	=PI()*(7.25)^2*10.2*$A$3*A100/1000	1.010492	0.8811247	0.7674734
1225.5	=PI()*(7.25)^2*10.2*$A$3*A101/1000	1.031913	0.9013487	0.7864357
1238.4	=PI()*(7.25)^2*10.2*$A$3*A102/1000	1.053145	0.921441	0.8053173
1251.3	=PI()*(7.25)^2*10.2*$A$3*A103/1000	1.074179	0.9413929	0.824109
1264.2	=PI()*(7.25)^2*10.2*$A$3*A104/1000	1.095008	0.9611961	0.8428019
1277.1	=PI()*(7.25)^2*10.2*$A$3*A105/1000	1.115624	0.9808427	0.8613878
1290	=PI()*(7.25)^2*10.2*$A$3*A106/1000	1.136023	1.000326	0.8798588


Am_Calculations_3.xls - Am vs Eluted Volume Chart
Calculated Concentration (C/MDA)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
R=11,000
R=11,500
R=12,000
0
10
20
30
40
50
60
70
80
Eluted Volume (L)

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Office of Waste Accept., Stor., & Tran.
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Washington, DC 20585

Yucca Mountain Site Characterization Office
Director, RW-3
Office of Quality Assurance
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Fuel Processing & Waste Mgmt. Division
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Idaho Falls, ID 83402

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Washington, DC 20460

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