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IT CORP, ABSORPTION OF SELECT METALS AND RADIO-NUCLIDES ON GLACIAL OVERBURDEN PRESENT AT THE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT SITE - (USED AS A REFERENCE IN OU5 RI REPORT)

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REPORT

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Adsorption of Select Metals and Radionuclides on Glacial Overburden Present at the Fernald Environmental Management Project Site

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1.0 INTRODUCTION

This document describes the procedures, methodology, and results of the adsorption tests conducted by the Environmental and Waste Technology Center at Brookhaven National Laboratory (BNL). BNL was retained by the Fernald Environmental Management Project (FEMP) to measure adsorption ratios by the batch method (American Society for Testing and Materials, 1983) as part of the investigation into the performance of a proposed on-site disposal cell. Adsorption ratios were determined for barium, lead, molybdenum, radium, technetium, uranium, and vanadium using perched groundwater and cement leachate contact solutions and site specific soils. These seven constituents were selected for study because the concentrations of the indicated constituents in leachate derived from Operable Unit 1 (OU1) cemented waste forms exceeded their background concentrations in perched groundwater.

Results presented in this document will focus on the adsorption of metals and radionuclides on weathered and unweathered glacial overburden from perched groundwater contact solution. These results can be used to calculate retardation coefficients for all groundwater models currently active in evaluating contaminant migration in the FEMP glacial overburden because the mineralogy of glacial overburden and major cation and anion concentrations in perched groundwater are similar across the site. Of particular importance are the presented adsorption ratios for radium and uranium, which are about an order of magnitude greater than the adsorption ratios used in the past. A summary of the constituent adsorption ratios for cement leachate and a cement leachate/perched groundwater mixture is also given, but these results only pertain to migration of contaminants from leached cement waste forms.

1.1 Conceptual Model of the Experimental Matrix

Adsorption batch tests were carried out at BNL to evaluate the retardation of contaminants by engineered and natural barrier materials below a proposed mixed waste on-site disposal cell (OSDC) holding cement-treated waste forms. The conceptual model of this facility is shown on Figure 1. Cement leachate was generated for these contact experiments from a deionized water leach of cement-treated waste forms using a modified 90-day leach test (American Nuclear Society, 1986). The use of deionized water instead of rainwater makes no difference in the final leachate composition because the solute concentrations in rainwater are very low and insufficient to buffer the solution pH. The phases present in the cement paste (principally portlandite), the waste, and any added pozzolanic materials will control the pH and solute concentrations in the final leachate. A description of the various cement formulas tested, the 90-day leach procedure, and all experimental results can be found in "Technical Report 5.1B, Site Characterization/Geological Report for On-Site Disposal" (issued to FERMCO in February, 1993). The EWMF project is now known as the OSDC, although both acronyms refer to the same facility design being proposed to house cement-treated waste forms.

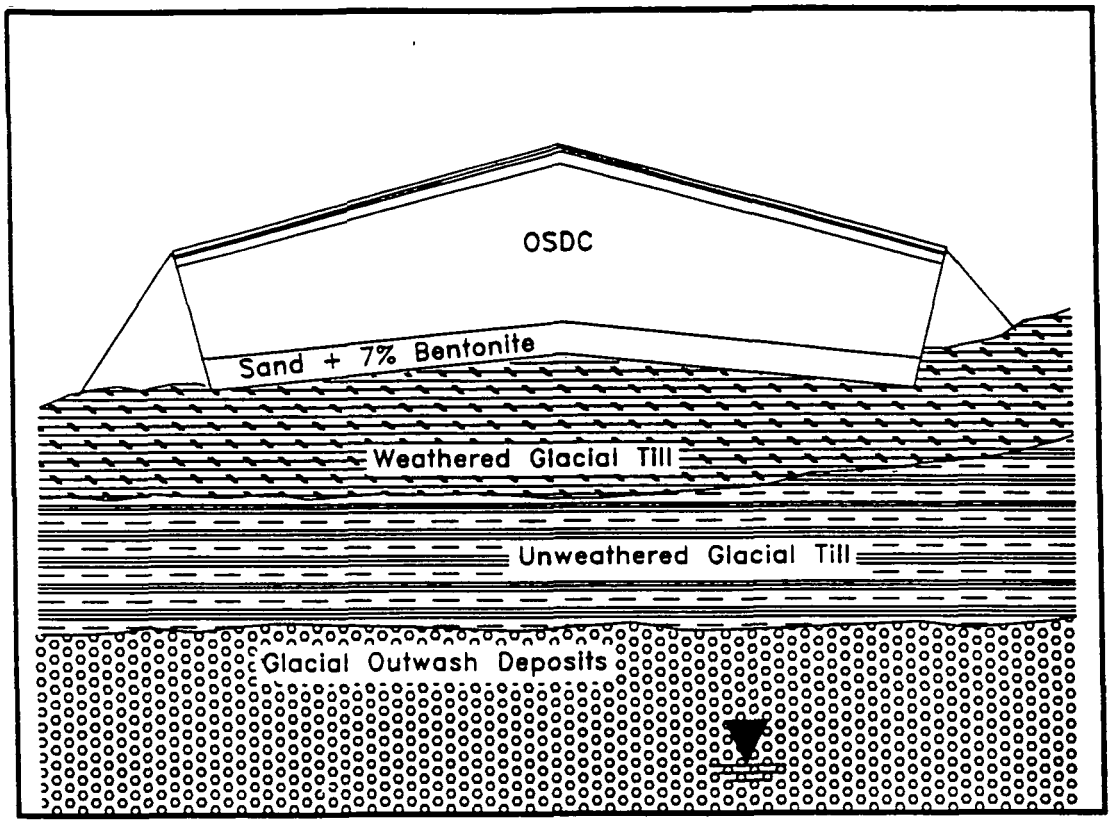

FIGURE 1

Conceptual Model of the OSDC used to Develop the Experimental Matrix

Leaching results for the three most promising cement waste forms are given in Table 1. The pH values of the leachates are all near 12, suggesting the leachate pH is controlled by the solubility of the cement paste phase porlandite ($Ca(OH)_2$). Variations in solute concentrations reflect different materials in the cement formulations (i.e., 1046-18 contained portland cement, flyash, and waste; 1046-30 contained portland cement, flyash, sodium silicate, and waste; 1046-46 contained portland cement and waste).

Cement leachate (hereafter referred to as leachate) derived from the 90-day leach test is assumed to represent the leachate that may migrate from the proposed facility. Contaminants in leachate that are present in concentrations above background values in site perched groundwater were selected for the batch tests. The contaminants and their background concentrations are: barium (Ba=0.069 mg/L); lead (Pb=0.003 mg/L); molybdenum (Mo<0.02 mg/L); vanadium (V=0.02 mg/L); radium (Ra<1.02E-09 mg/L); technetium (Tc<1.77E-06 mg/L); and uranium (U=0.0016 mg/L). The background concentrations are reported in Table 15-1 of the draft Groundwater Report, FMPC (United States Department of Energy, 1990).

Three distinct solutions were contacted with up to three different solids to simulate the range of fluid and solid compositions below the disposal facility (Figure 1). The solutions were leachate derived from cement-treated waste, a leachate/perched groundwater mix (1:1 by volume), and perched groundwater in equilibrium with carbonate minerals present in the glacial till. Solids consisted of sand with 7 percent sodium bentonite (the engineered barrier), a weathered glacial till, and an unweathered glacial till. Measured surface areas of the solids are 3 meters squared per gram (m^2/g), 117 m^2/g, and 13 m^2/g, respectively; as determined by the BET isotherm method (Brunauer et al., 1938).

An experimental matrix for the solids and solutions is given in Table 2. Leachate was contacted with all solids, but the leachate/groundwater mix and groundwater were only contacted with the weathered and unweathered till. This matrix simulates the migration of leachate through the engineered barrier and into the glacial till (CS, CW, CU in Table 2), were it begins to mix with groundwater (MW and MU in Table 2) and, with time, becomes extensively diluted by the perched groundwater (PW and PU in Table 2).

1.2 Adsorption Ratio versus Distribution Coefficient

The adsorption ratio (R_a) measurements in this study differ from the distribution coefficient (K_d) in that R_a predicts the adsorbed mass of contaminants by a solid medium and K_d implies that the contaminant adsorption predicted by R_a is fully reversible (i.e., adsorption ratio = desorption ratio). In general, the longer a contaminant remains adsorbed to the surface of a solid the probability increases for surface reactions to incorporate the adsorbed contaminant

TABLE 1

Analytical Results for 90-Day Leaching of Cemented OU1 Waste Forms

	Cement Leachate Samples		
Parameter (units)	**1046-18**	**1046-30**	**1046-46**
pH (std. units)	11.95	11.99	12.36
Eh (millivolts)	200	198	161
Ammonium (mg/L)	17.8	19.8	24.6
Carbonate (mg/L)	3.6	1.0	1.1
Chloride (mg/L)	92.6	79.3	69.5
Nitrate (mg/L)	1,487	1,209	1,248
Phosphate (mg/L)	1.23	0.93	1.8
Sulfate (mg/L)	5.2	2.0	9.5
Barium (mg/L)	1.82	0.764	5.89
Calcium (mg/L)	174	93.4	674
Lead (mg/L)	0.003	0.002	0.010
Magnesium (mg/L)	0.2	0.131	0.406
Molybdenum (mg/L)	0.232	0.513	0.125
Potassium (mg/L)	239	242	275
Sodium (mg/L)	131	224	105
Vanadium (mg/L)	0.021	0.058	0.01
^{99}Technetium (pCi/L (mg/L))	1,555 (9.2E-5)	2,100 (1.2E-4)	1,329 (7.8E-5)
^{226}Radium (pCi/L (mg/L))	34.6 (3.5E-8)	12.7 (1.3E-8)	86.8 (8.8E-8)
^{238}Uranium (pCi/L (mg/L))	4.95 (1.5E-2)	3.06 (9.1E-3)	16.0 (4.8E-2)

TABLE 2

Experimental Matrix for the Adsorption Experiments

	Cement Leachate	Mixture (1:1) Leachate:Groundwater	Perched Groundwater
Sand + 7% Bentonite	CS Tests	No Tests Performed	No Tests Performed
Weathered Glacial Till	CW Tests	MW Tests	PW Tests
Unweathered Glacial Till	CU Tests	MU Tests	PU Tests

Key: CS = cement leachate/sand+bentonite system;
CW = cement leachate/weathered till system;
CU = cement leachate/unweathered till system;
MW = mixture/weathered till system;
MU = mixture/unweathered till system;
PW = perched groundwater/weathered till system; and
PU = perched groundwater/unweathered till system.

into the solid, where it is no longer available for desorption. Therefore, desorption ratios are generally not equal to adsorption ratios and such limitations must be clearly stated when R_a is used to estimate K_d. For example, using R_a to calculate retardation coefficients used in fate and transport models may lead to estimates of contaminant concentrations at receptors that are too high, although this estimate will be a conservative estimate. However, using R_a to estimate the time required to remediate a contaminated aquifer may lead to underestimating the time and cost required for the remedial activity (i.e., a nonconservative estimate).

Adsorption ratios are strongly dependent on the composition and pH of the contact solution and the surface area and mineralogy of the solid. For instance, the concentration of major cations (e.g., Ca^{+2}, Na^{+}, etc) and anions (e.g., SO_4^{-2}, CO_3^{-2}, etc) in solution will compete for available adsorption sites, and the anions may also play a role in complexing metal contaminants (e.g., $UO_2(CO_3)_2^{-2}$). The surface area and mineralogy of the solid material will control the number of available sorption sites. Therefore, site-specific groundwater (obtained from well 1024) and soils (sample locations and physical and chemical parameters are given Technical Report 5.1B; FERMCO, 1993) were used along with cement leachate prepared from a recipe derived from analytical results on leachate obtained from cement monoliths containing OU1 waste. The decision to prepare the leachate contact solution by means of a recipe was dictated by the small volume of leachate generated by the 90-day leaching of cement-treated OU1 waste forms.

1.3 Description of a Batch Test

A batch test is run by placing solid and contact solution in a container and measuring the concentration of the solution as a function of time. The initial contact solution is spiked with contaminants of concern prior to contacting the solids, with care taken to ensure that contaminant concentrations in the initial contact solution do not exceed solubility limits for known contaminant solids (e.g., the initial lead concentration must be low enough to avoid precipitation of $PbCO_3$ when the initial contact solution is spiked with lead). The solubilities of common metal and radionuclide solids were evaluated with the EQ3/6 code (Wolery, 1983; Wolery and Daveler, 1989) to develop estimates on the maximum solution concentration for constituents of concern.

After preparing the initial spiked solution, the solids and spiked solution are contacted and sampled at established time intervals. These kinetic experiments are run to determine the time period required to reach steady-state conditions, prior to starting the experiments of interest. Steady-state conditions are met when two successive samples have contaminant concentrations that are equal within the analytical uncertainty of the method. For most common laboratory analytical methods, the two successive samples would agree within 10

percent of each other. This uncertainty would be greater if the contaminant of interest is being examined at concentrations near the analytical detection limit.

Kinetic experiments are carried out with contaminant concentrations that equal or exceed the highest concentration range of interest. When steady-state conditions are achieved, the distribution ratio is calculated as follows:

$$R_a = \frac{\textit{micrograms of adsorbed contaminant per gram of solid}}{\textit{micrograms of contaminant per milliliter of solution}} = \frac{ml}{g}$$

where the micrograms of adsorbed contaminant per gram of waste is determined by difference between the initial and steady-state contaminant concentration in the contact solution, and micrograms of contaminant per milliliter of solution refers to the steady-state contaminant concentration in solution.

Adsorption ratios measured by the batch test method may be used to estimate K_d when contaminant migration is dominantly through granular porous material. In contrast, when contaminant migration is along joints and fractures, less surface area is exposed to the contaminated solution and less time may be available for adsorption reactions to occur. Therefore, the condition of joint and fracture flow is not reproduced by batch tests, and R_a measured by laboratory batch tests cannot be used to estimate K_d under this condition. It should be noted that the design of the OSDC eliminates consideration of joint and fracture flow (i.e., flow will be through granular porous material).

2.0 LABORATORY METHODS

This section describes the preparation of tracers and contact solutions, subsurface soil samples, reference and blank experiments, kinetic runs, and analytical instruments. The following procedures were carried out for each of the seven experimental cells indicated in Table 2.

2.1 Tracer and Contact Solutions

Four tracer solutions were prepared: barium (Ba), molybdenum (Mo), and vanadium (V) were present in one solution; technetium-99 (^{99}Tc) in a second; uranium (U) and lead (Pb) in a third; and radium-226 (^{226}Ra) in a fourth. Each of the tracers had to be used in a unique set of experiments to allow for proper analysis of the final solutions. Barium, Mo, and V concentrations are determined by ICP, ^{99}Tc activity by liquid scintillation, and ^{210}Pb, ^{226}Ra,

and ^{232}U activity by gamma spectrometry. For the gamma spectrometry analysis, ^{226}Ra had to be separated from ^{210}Pb and ^{232}U due to ingrowth of ^{226}Ra daughters that interfered with the gamma spectrum in the region of interest for ^{210}Pb and ^{232}U.

The Ba, Mo, and V tracers used in this study were prepared from commercial 1000 part-per-million (ppm) standards used for atomic adsorption spectroscopy. These strongly acid solutions were neutralized with NaOH and diluted with distilled/deionized water. The ^{99}Tc tracer was a carrier free solution of NH_4TcO_4 in water, with a radionuclide purity of greater than 99 percent. An original ^{99}Tc concentration of 434.8 microcuries per milliliter (mCi/mL) was diluted with distilled/deionized water to obtain the desired activities. The U tracer was a solution of ^{232}U as UO_2Cl_2 in 2 Normal HCl, with a specific activity of 22.4 mCi/mg of U. To obtain the required concentrations of total U, a carrier of natural U was added to the tracer solution. A lead tracer was prepared from a solution of ^{210}Pb and nonradioactive lead carrier. The radioactive tracer was a carrier-free solution of ^{210}Pb as $Pb(NO_3)_2$ in 1 Normal HNO_3, while the Pb carrier solution was a dilution of a commercial 1000 ppm Pb atomic adsorption standard. Lead and U tracers were combined for use in the same batch experiments. A tracer of Ra was prepared using carrier-free ^{226}Ra as $Ra(NO_3)_2$ in 0.1 Normal HNO_3.

Three spiked contact solutions were prepared to simulate the leachate and groundwater solution compositions expected below the proposed disposal cell. Contact solutions (Table 3) consisted of site-specific perched groundwater, a simulated cement leachate, and a solution consisting of a 1:1 mixture of the two. Tracers were added to the contact solutions to achieve concentrations for constituents of concern that were about 0.2, 1, and 5 times their reported concentrations in Table 1. However, the very low concentration observed in the leachate for ^{226}Ra and V made measurement of adsorption ratios impossible, due to detection limit problems. Therefore, it was necessary to use greater concentrations of ^{226}Ra and V than originally planned. Concentrations of the tracers in the contact solutions are given in Table 4.

2.2 Experimental Setup

Site-specific soils containing the minerals given in Table 5 were air dried and lightly ground to pass through a 1.7 mm sieve. Two gram (radionuclide experiments) and five gram (metal experiments) samples were weighed and placed into polyethylene centrifuge tubes. The soil samples were then contacted with site-specific groundwater for one day to reequilibrate the adsorption sites. The mass of contact solution was equal to four times the mass of the soil. After one day, the tubes were centrifuged, decanted and reweighed to obtain the mass and volume of pore water present in each tube. The pore volume is required to correct observed concentrations to the total volume of liquid in each experiment.

TABLE 3

Composition of Contact Solutions for Adsorption Experiments

Perched Groundwater		Leachate Recipe (2 liters)	
Parameter (units)	**Well 1024**	**Component**	**Mass Added**
pH (std. units)	7.2	$NaHCO_3$	3.02 mg/2 L
Eh (millivolts)	250 mV	KNO_3	910 mg/2 L
Ammonium (mg/L)	0.35	$CaCl_2$	222 mg/2 L
Bicarbonate (mg/L)	425	CaO	146 mg/2 L
Chloride (mg/L)	5.7	K_3PO_4	4.03 mg/2 L
Nitrate (mg/L)	0.05	KOH	277 mg/2 L
Phosphate (mg/L)	0.25	NaOH*	366 mg/2 L
Sulfate (mg/L)	84.3	*Leachate solution adjusted to a pH of 12 with NaOH	
Barium (mg/L)	0.093		
Calcium (mg/L)	98.3		
Lead (mg/L)	0.005		
Magnesium (mg/L)	40.0		
Molybdenum (mg/L)	0.014		
Potassium (mg/L)	1.7		
Sodium (mg/L)	15.2		
Vanadium (mg/L)	0.023		
^{99}Technetium (mg/L)	< 8.8E-8		
^{226}Radium (mg/L)	5.1E-10		
Uranium (mg/L)	0.001		

TABLE 4

Initial Tracer Concentrations[a] in Adsorption Experiments

Experiment	Ba (ng/mL)	Mo (ng/mL)	V (ng/mL)	^{226}Ra (ng/mL)	^{99}Tc (ng/mL)	Pb (ng/mL)	U (ng/mL)
0.2x	135	82	470	2.78	0.53	1.96	4.84
1x	660	460	2,310	10.25	1.8	4.10	21.7
5x	3,120	2,370	12,190	33.68	8.9	12.4	107

[a] Tracer concentrations plus existing contaminant concentrations in the contact solution equal the initial contaminant concentration in the contact solution. These combined concentrations are indicated by analytical results for reference tubes (Appendix B).

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TABLE 5

Composition of Subsurface Soil Samples used in Adsorption Experiments

Mineral - Ideal Formula	Average Modal Percent	Standard Deviation
Calcite - $CaCO_3$	25.75	11.62
Dolomite - $Ca_{0.5}Mg_{0.5}CO_3$	20.77	10.53
Quartz - SiO_2	18.03	8.58
Feldspar - $KAlSi_3O_8$	14.76	6.49
Illite - $KAl_5Si_7O_{22}:2H_2O$	9.15	17.37
Corrensite - $Na_{0.5}Ca_{0.5}Mg_4Fe_{2.5}Al_{2.5}Si_7O_{25}:5H_2O$	4.27	8.30
Chlorite - $Mg_7Fe_4Al_2Si_7O_{28}:8H_2O$	1.13	1.50
Iron Oxide - Fe_2O_3	0.83	0.72
Hornblende - $KCa_2Mg_2Fe_2Al_2Si_6O_{22}:H_2O$	0.95	0.72
Biotite - $K_2Mg_2Fe_2TiAl_2Si_6O_{22}:2H_2O$	0.04	0.09
Organic Material	3.49	3.68

After determining the pore volumes, the contact solutions were added to the centrifuge tubes and the tubes were reweighed. Tracer was added to each of the triplicate samples containing soil and to a reference and blank tube. Reference and blank tubes accompanied each set of triplicate tubes and consisted of, respectively, contact solution and tracer with no soil and deionized water and tracer with no soil. The blank solution is the same for each of the seven cells in each experimental set (i.e., the 1x concentration experimental set for U contains 7 blank solutions that are the same), and these blank tubes provide statistical data on pipetting and analytical errors. Comparison of tracer concentrations in the blank and reference solutions provides data to assess reactions (e.g., precipitation, adsorption to tube surface) that may take place between the contact solution and constituents of concern in the absence of soil. A summary of the amount of soil, solution, and tracer added to each experimental set is given in Table 6.

2.3 Kinetic Experiments

Prior to the initiation of the full-scale batch tests, a set of kinetic experiments were conducted for each experimental tracer set shown in Table 6, using 5x concentrations for the initial solutions. The kinetic experiments consisted of batch runs with 20 grams of soil and 80 grams of contact solution containing the appropriate tracer. These runs were sampled periodically, filtered through a 0.45 micron (um) cellulose acetate syringe filter and analyzed to determine the minimum time required for the isotherm experiments to attain steady-state conditions. Based on the kinetic data, Ba, Mo, and V samples were allowed to run for 20 days, Tc samples for 7 days, Ra samples for 5 days, and Pb and U experiments required up to 70 days to reach steady-state concentrations. It is noted that U concentrations were still decreasing slightly after 70-days, but the decision was made to terminate the experiments to avoid further delay in the completion of this work. Figure 2 summarizes the PW kinetic data, which are representative of the time range covered by all kinetic experiments. A summary of all kinetic data can be found in Appendix A.

A separate set of kinetic experiments were run to monitor pH change as a function of time. Figure 3 summarizes the results for the PW and PU tubes. The pH is observed to rise throughout the duration of the experiment, suggesting bicarbonate ion breaks down to carbon dioxide and hydroxide ion (i.e., $HCO_3^- <-> CO_2 + OH^-$) in response to consumption of CO_2 by microbial organisms present in the soil. If this mechanism controls the drift in pH with time, final pH measurements in the adsorption experiments may differ due to variation in the rate of microbial activity. In all experiments where pH was measured, tubes containing the contact solutions and soils were shaken and the pH probe inserted into the suspension until a consistent reading was obtained.

TABLE 6

Content of Triplicate Tubes used in Adsorption Experiments

Experiment	Dry Soil (grams)	Contact Solution (milliliters)	Tracer (milliliters)
Ba, Mo, V	5	19	1.0
^{99}Tc	5	19	0.5
^{210}Pb, ^{232}U	2	8	0.5
^{226}Ra	2	8	1.0, 0.5

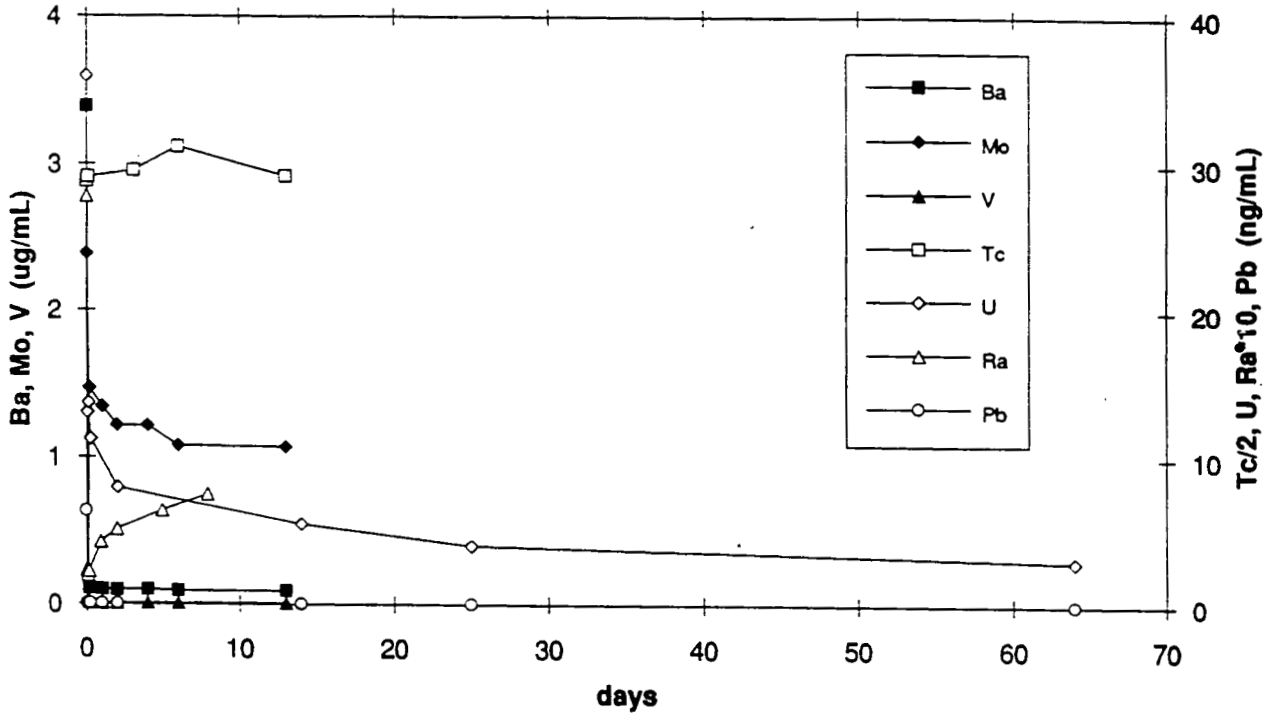

FIGURE 2

Kinetic Experiments for PW Cell

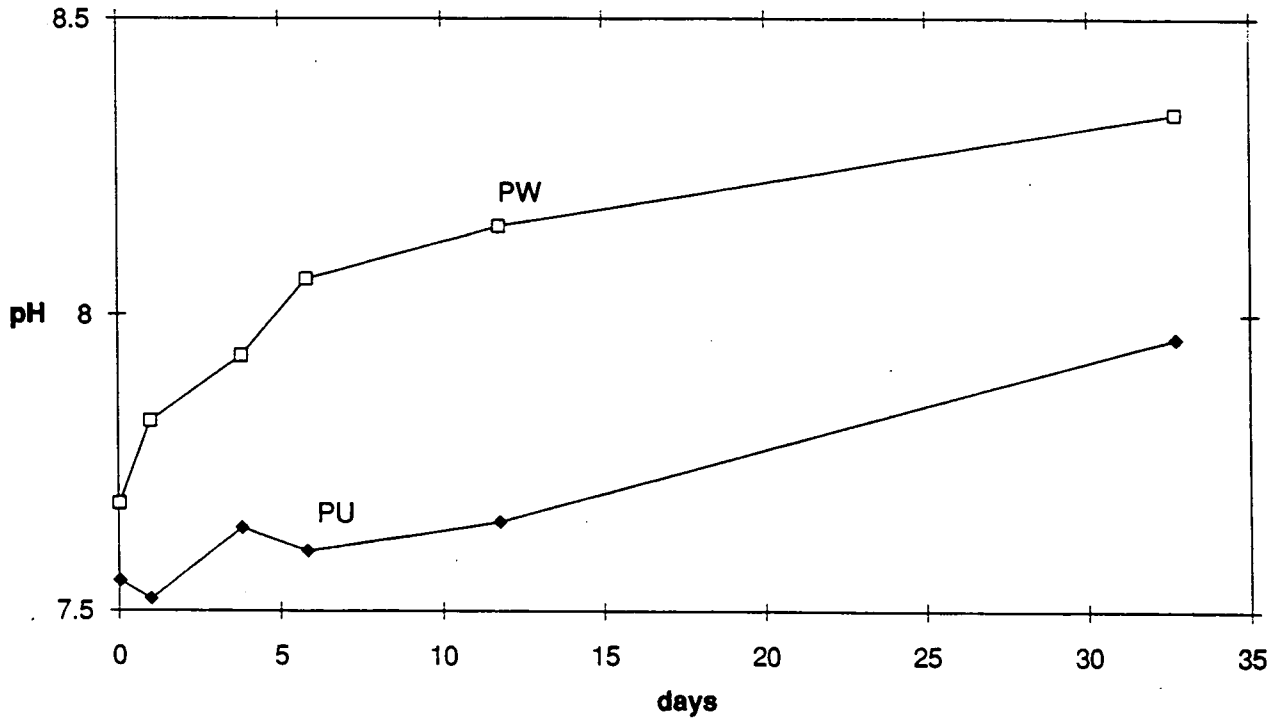

FIGURE 3

Kinetic Experiments for pH

2.4 Analytical Instruments

All samples were recovered from the centrifuge tubes through 0.45 um cellulose acetate syringe filters. Samples for ^{99}Tc were analyzed by liquid scintillation counting and were prepared by mixing 2 or 4 mL of sample with 10 mL of scintillation fluid. The counting efficiency of the scintillation instrument is 95 percent, as determined by a sealed carbon-14 standard. Barium, Mo, and V samples were acidified with ultrex acid and analyzed by ICP techniques on a Varian Liberty 100 instrument. Commercial multielement standards were used to calibrate the ICP instrument before Ba, Mo, and V samples were run. Analysis for ^{210}Pb, ^{226}Ra, and ^{232}U was done by gamma spectroscopy on an intrinsic germanium gamma/x-ray detector and a Canberra System 100 analysis package. Instrument calibration was carried out with mixed-gamma standard NBS 4276-108. Counts for ^{210}Pb, ^{226}Ra, and ^{232}U were taken at the 46.5 keV gamma, 185.7 keV gamma, and 57.6 keV gamma peaks, respectively. Sample volumes used for gamma counting were 4 mL, except 2 mL was used for CS series due to a limited amount of contact solution in the centrifuge tubes.

Analytical precision for ICP measurements is better than one percent for Mo, two percent for Ba, and three percent for V, as determined by statistical reduction of six analyses of the calibration standards. Instrument precision is dependent on the analyte concentration, and the precision can be as poor as 50 percent when analytes are near the detection limit. ICP detection limits for Ba, Mo, and V are, repectively, 0.1, 20, and 20 micrograms per liter.

3.0 RESULTS

This section presents the experimental data, data analysis, and discussion of the adsorption experiments. Raw data generated from the adsorption experiments are given in Appendix B, and tables and figures are used throughout this section to summarize the data given in Appendix B. A discussion of the raw data will be presented first, followed by a detailed analysis of the adsorption results for the perched groundwater cells and a concluding discussion section.

3.1 Experimental Data

Adsorption data received from BNL are reported in Appendix B for each of the adsorption experiments indicated in Table 6. Data reported in Appendix B were collected at the last time interval indicated on Figure 2, that is the last time point sampled for the kinetic experiments. Each experiment was performed three times using the tracer concentrations reported in Table 4. Therefore, Appendix B contains three data sheets for each set of tracers, and these are identified as 0.2x, 1x, and 5x. Barium, Mo, and V are reported together and the radionuclides are reported separately.

Analytical results for Ba, Mo, and V are reported as ug/mL (Appendix B) and than corrected for pore volume prior to determining the mass lost from solution. Corrected concentrations are obtained by multiplying the reported analytical concentration by the ratio of total water in the triplicate tube divided by the total water in the blank tube:

$$C_c = C_m * (W_s/W_b)$$

where C_c = corrected concentration in ug/mL, C_m is the measured concentration in ug/mL, W_s is grams of water in the sample of interest, and W_b grams of water in the blank. This correction allows direct comparison of the triplicate sample tubes with the blank tube and must be done to calculate the constituent mass removed from solution.

Constituent mass removed from solution is obtained by calculating the average concentration of the constituent in all blank tubes (7 total) and subtracting the corrected concentration:

$$C_r = ((C_{PWb} + C_{PUb} + C_{MWb} + C_{MUb} + C_{CWb} + C_{CUb} + C_{CSb})/7) - C_c$$

where C_r = mass removed from solution in ug/mL, C_{PWb}, C_{PUb}, ... C_{CSb} are the respective concentrations in the PW, PU, ... CS blank tubes, and C_c is the corrected concentration in ug/mL.

After the constituent mass removed from solution is obtained, the mass of adsorbed constituent present on the solid is calculated by multiplying the mass removed by the total volume present and dividing by the mass of dry soil:

$$M_a = C_r * V_b/M_s$$

where M_a = mass adsorbed on the soil in ug/g, C_r = mass removed from solution in ug/mL, V_b refers to volume of blank solution in mL, and M_s is grams of dry soil.

Adsorption ratios can now be calculated using the adsorbed mass and measured solution concentration as follows:

$$R_a = M_a/C_m$$

where R_a is the adsorption ratio in mL/g, M_a = mass adsorbed on the soil in ug/g, and C_m is the measured concentration in ug/mL.

Shaded cells in the data sheets presented in Appendix B indicate that:

- Experimental problems resulted in a loss of data for the 0.2x CS cell,
- Instrument detection limits were encountered for 0.2x and 1x V experiments, and some Mo experiments, and data calculations could not be performed, and
- The average blank concentration was larger than the corrected concentration, resulting in a negative value for the mass removed from solution (see 0.2x sheet for CU cell Mo results).

Analytical results for radionuclides (Appendix B) are reported as counts per minute (cpm) per 4 or 2 mL. The raw counts are corrected for background counts to obtain the sample activity as follows:

$$A_s = A_r - A_b$$

where A_s = sample activity in cpm/4 mL, A_r = raw counts in cpm/4 mL, and A_b = background counts in cpm/4 mL.

Using the sample activity, a pore water correction is made to compare the triplicate tubes with the volume of contact solution in the reference cells. A corrected activity is calculated as follows:

$$A_c = (A_s/4) * (W_s/W_r)$$

where A_c = corrected activity in cpm/mL, A_s is the sample activity in cpm/4 mL, 4 is the normalizing constant to get cpm/mL, W_s is grams of water in the sample of interest, and W_r grams of water in the reference tube. This correction allows direct comparison of the triplicate sample tubes with the reference tube and must be done to calculate the constituent mass removed from solution. Reference tubes were used to correct radionuclides, rather than blank tubes, due to the low solubility of Pb and U in the contact solutions. That is, precipitation of Pb and U occurred when the tracers were added to the contact solutions and the precipitated mass is accounted for by using the reference tube concentration instead of the blank tube concentration.

The radionuclide activity removed from solution is obtained by calculating the average activity of the constituent in the reference cells containing the same contact solution (e.g., PU_r

and PW_r) and subtracting the corrected activity for the PW or PU triplicates:

$$A_r = ((A_{PWr} + A_{PUr}/2) - A_c$$

where A_r = activity removed from solution in cpm/mL for the PW or PU triplicates, A_{PWr} and A_{PUr} are the respective activities in the PW and PU reference tubes, and A_c is the corrected activity in cpm/mL for the PU and PW triplicates.

After the radionuclide activity removed from solution is obtained, the activity adsorbed on the solid is calculated by multiplying the activity removed by the total volume of the reference tube and dividing by the mass of dry soil:

$$A_a = A_r * V_r/M_s$$

where A_a = activity adsorbed on the soil in cpm/g, A_r = activity removed from solution in cpm/mL, V_r is the volume of the reference solution in mL, and M_s is grams of dry soil.

Adsorption ratios can now be calculated using the adsorbed activity and measured solution activity as follows:

$$R_a = A_a/(A_m/4)$$

where R_a is the adsorption ratio in mL/g, A_a = activity adsorbed on the soil in cpm/g, and A_m is the measured activity in cpm/4 mL, and 4 is the normalizing constant for the measured activity.

Shaded cells in the data sheets presented in Appendix B indicate that:

- Experimental problems resulted in a loss of data for the 0.2x Tc PW_{ref} and MU_{ref} tubes, the 1x Ra CU_{blank} tube, and the 1x U CW_3 and CU_{blank} tubes,

- Raw sample counts were less than background counts resulting in negative values for corrected activities, and further data calculations could not be performed,

- Activity measurements in the reference cell were below background counts, indicating the radionuclide had precipitated when the tracer was mixed with the contact solution (see Pb sheets in Appendix B),

- The radionuclide solubility is pH sensitive and pH differences between the reference tube and triplicate tubes prohibited calculation of adsorption ratios (e.g., 0.2x U sheet, Appendix B: CWref pH = 11.5, CW1 pH = 8.0, CW2 pH = 8.0, and CW3 pH = 8.2. Note U has disappeared from CWref tube due to U precipitation at high pH. Therefore, the reference tube cannot be used to correct CW1, CW2, and CW3 tubes with pH near 8).

3.2 Data Analysis

Using the data in Appendix B for the PW and PU cells, regression analysis was conducted to determine the shape of the adsorption isotherms. The regression analysis used final solution concentration and adsorbed mass to calculate a fit to a linear, logarithmic, and exponential regression equation, as measured by the R^2 value (R^2 = 1 indicates a perfect fit) returned for each of the indicated regression equations. Activities reported in Appendix B were converted to mass using the conversion factors given on the data sheets.

Adsorption isotherms for Ba are illustrated on Figure 4. The isotherms are linear with slopes (i.e., slope = adsorption ratio) of 128 mL/g and 66 mL/g for the PW and PU cells, respectively. R^2 values of 0.96 (PW cell) and 0.94 (PU cell) indicate the data are a very good fit to the linear regression model. Linear behavior indicates the solid has an unlimited supply of Ba adsorption sites over the concentration range studied. That is, the adsorbed mass of Ba continues to increase as the contaminant solution concentration increases.

Figure 5 illustrates the adsorption isotherms for Mo. The isotherms fit a logarithmic regression equation, suggesting the data exhibit Langmuir behavior over the concentration range studied. R^2 values of 0.96 (PW cell) and 0.90 (PU cell) indicate the data are a very good to good fit to the logarithmic regression model. Langmuir behavior indicates the solid has a limited number of Mo adsorption sites over the concentration range studied. As solution concentrations increase, the adsorbed mass of Mo approaches a steady-state value. The steady-state value, or maximum mass of Mo that can be adsorbed by the solid, can be calculated from the Langmuir isotherm equation:

$$M_a = (K_L * M_{max} * C_f)/(1 + K_L * C_f)$$

where M_a = the mass adsorbed at equilibrium for gram of solid (ug/g), K_L = the Langmuir adsorption constant (mL/ug), M_{max} = the maximum adsorption capacity of the solid (ug/g), and C_f = the final solution concentration at equilibrium (ug/mL).

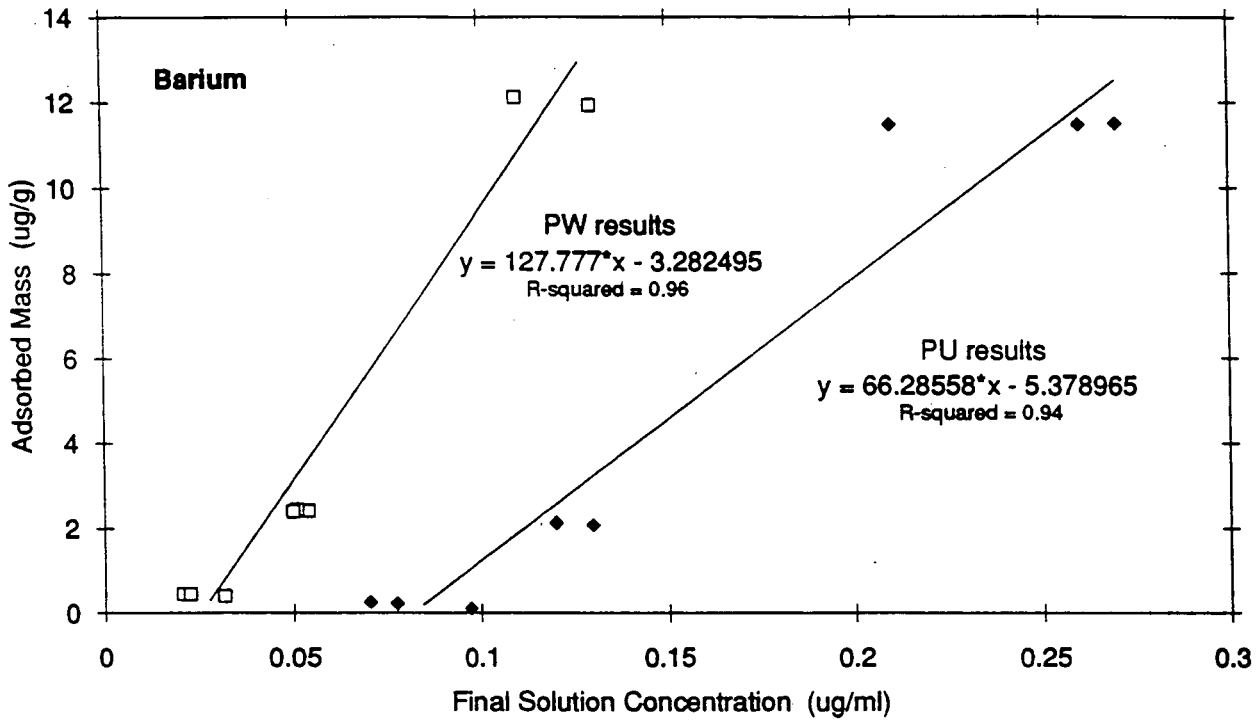

FIGURE 4

Adsorption Isotherms for Barium

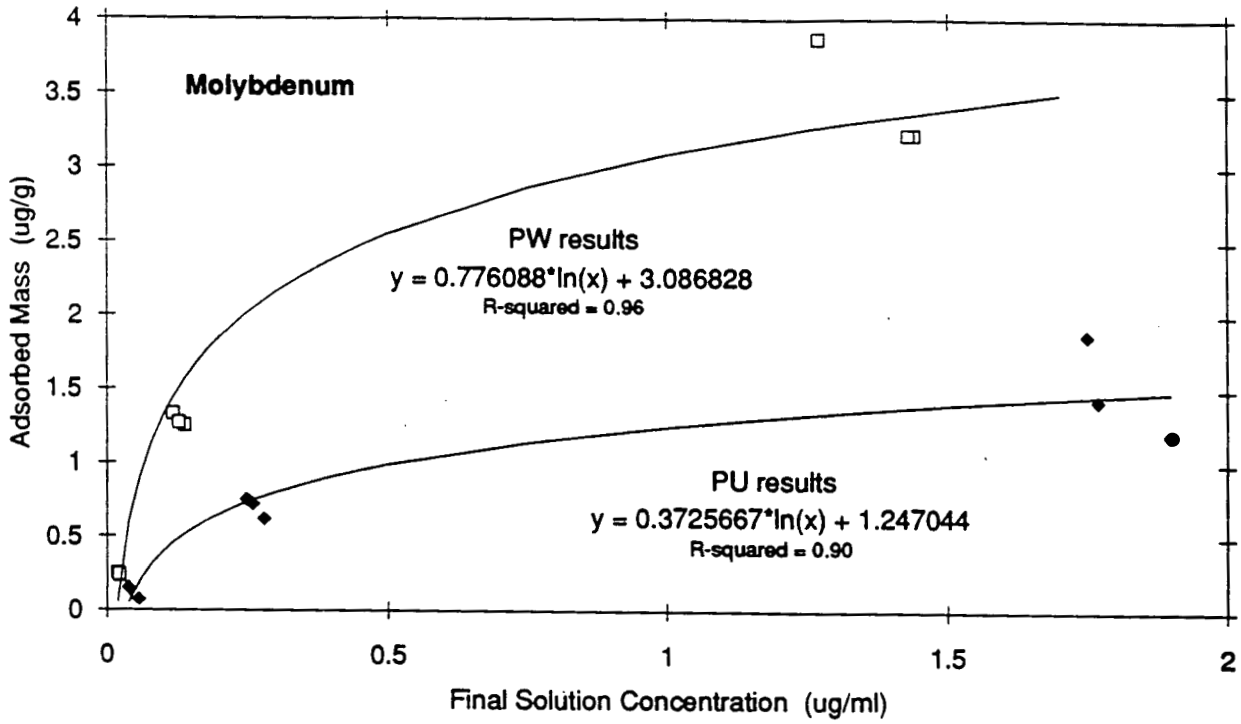

FIGURE 5

Adsorption Isotherms for Molybdenum

To calculate the maximum mass of Mo that can be adsorbed by the solid, the Langmuir isotherm equation can be rearranged to give:

$$C_f/M_a = (1/M_{max})*C_f + 1/K_L*M_{max}$$

This is an equation of a straight line that yields a slope of $1/M_{max}$ and an intercept of $1/K_L*M_{max}$ when C_f/M_a is plotted against C_f. A linear regression of the C_f/M_a and C_f data presented for Mo in Appendix B indicates the unweathered and weathered till have a maximum adsorption capacity of 4.2 and 2.0 micrograms of Mo per gram of soil, respectively. Molybdenum adsorption ratios calculated from data on individual tubes in Appendix B vary from 0.6 to 11.9 mL/g.

Adsorption isotherms for V are illustrated on Figure 6. These isotherms were calculated using one-half the detection limit value for V reported on the 0.2x and 1x data sheets (Appendix B) and assuming all the V tracer was adsorbed by the solids. The isotherms are linear with slopes (i.e., slope = adsorption ratio) of 462 mL/g and 190 mL/g for the PW and PU cells, respectively. R^2 values of 0.96 (PW cell) and 0.95 (PU cell) indicate the data are a very good fit to the linear regression model. Linear behavior indicates the solid has an unlimited supply of V adsorption sites over the concentration range studied. That is, the adsorbed mass of V continues to increase as the contaminant solution concentration increases.

Radium isotherms are shown on Figure 7. The PW isotherm was calculated using one-half the detection limit value for Ra reported on the 0.2x data sheet (Appendix B) and assuming all the Ra tracer was adsorbed by the solids. Calculated isotherms are linear with slopes (i.e., slope = adsorption ratio) of 8,726 mL/g and 942 mL/g for the PW and PU cells, respectively. R^2 values of 0.89 (PW cell) and 0.99 (PU cell) indicate the data are a good to excellent fit to the linear regression model. Linear behavior indicates the solid has an unlimited supply of Ra adsorption sites over the concentration range studied. That is, the adsorbed mass of Ra continues to increase as the contaminant solution concentration increases.

Adsorption isotherms for Tc are illustrated on Figure 8. The isotherms are linear with slopes (i.e., slope = adsorption ratio) of 0.17 mL/g and 0.62 mL/g for the PW and PU cells, respectively. R^2 values of 0.88 (PW cell) and 0.99 (PU cell) indicate the data are a good to excellent fit to the linear regression model. Linear behavior indicates the solid has an unlimited supply of Tc adsorption sites over the concentration range studied. However, the adsorption ratios are less than one indicating that Tc is preferentially partitioned into the liquid phase.

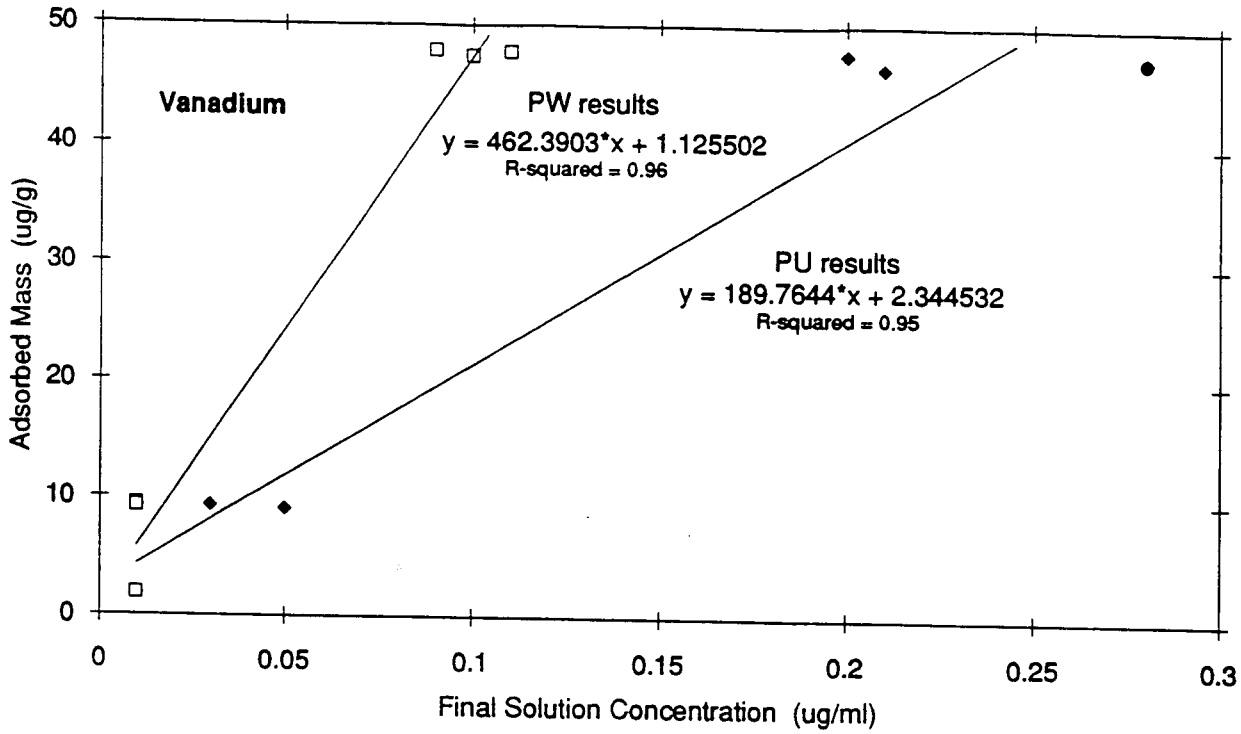

FIGURE 6

Adsorption Isotherms for Vanadium

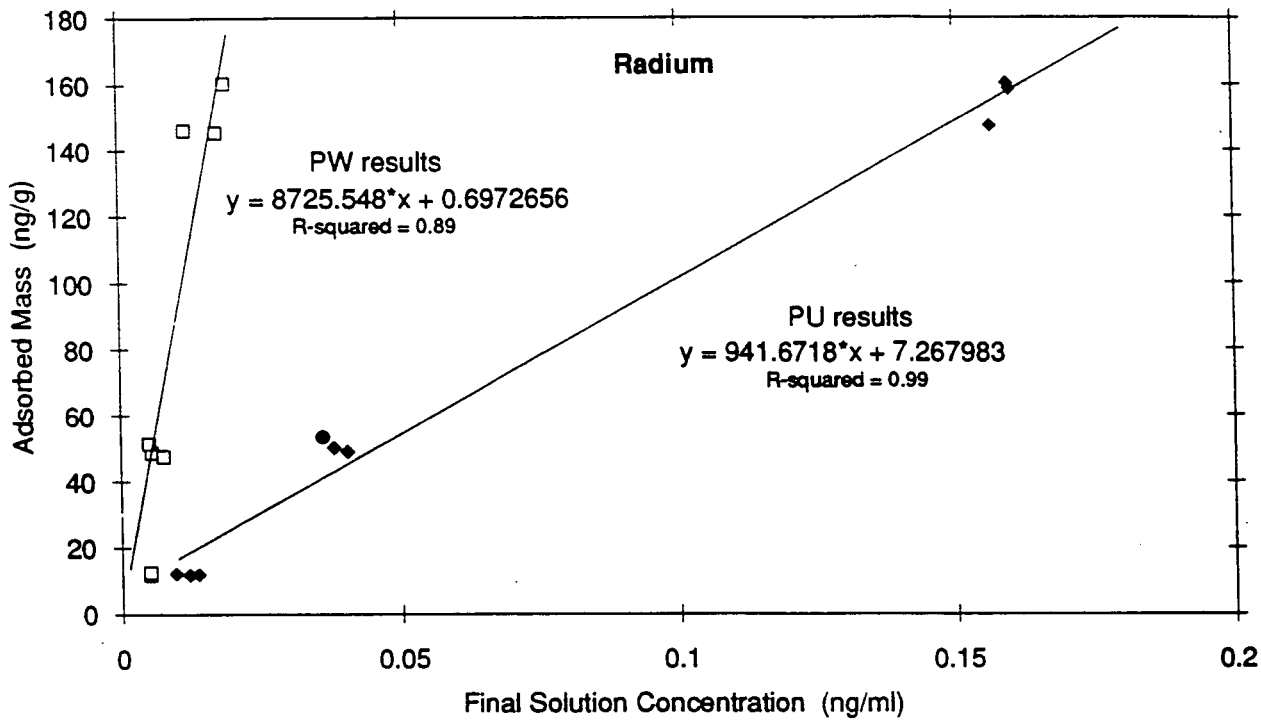

FIGURE 7

Adsorption Isotherms for Radium

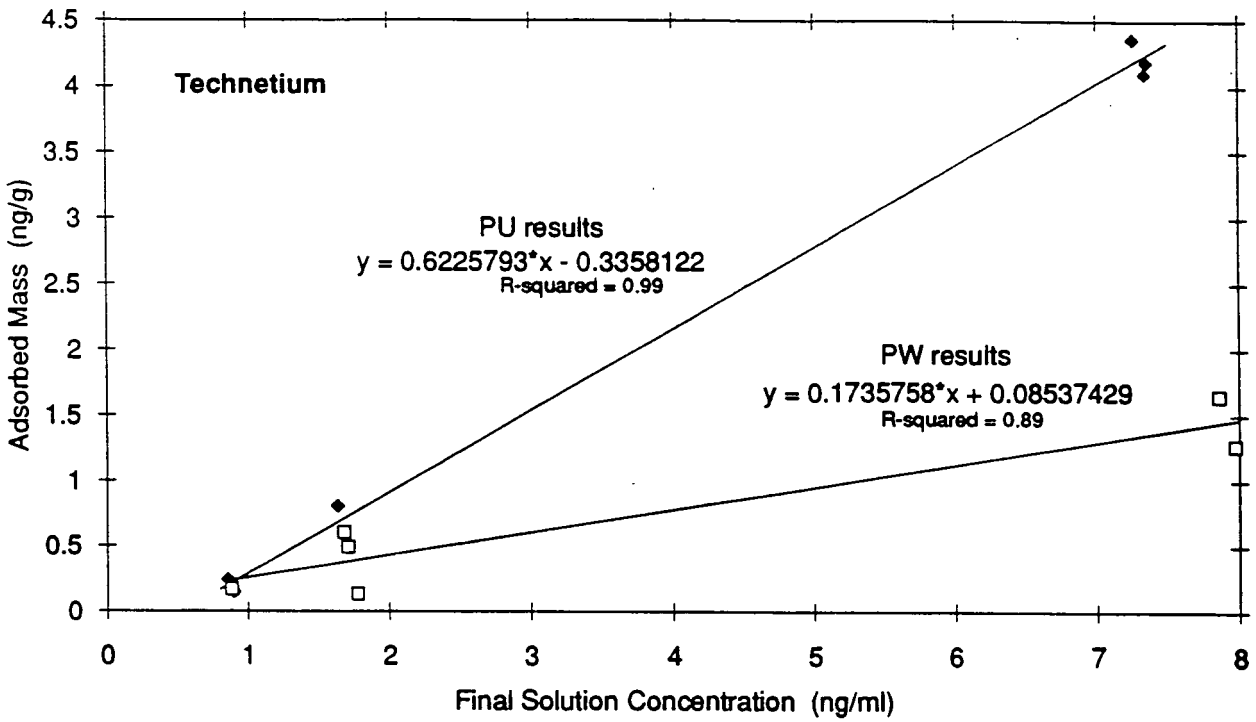

FIGURE 8

Adsorption Isotherms for Technetium

Figure 9 presents the adsorption isotherms for U. The isotherms are linear with slopes (i.e., slope = adsorption ratio) of 25 mL/g and 23 mL/g for the PW and PU cells, respectively. R^2 values of 0.97 (PW cell) and 0.96 (PU cell) indicate the data are a very good fit to the linear regression model. Linear behavior indicates the solid has an unlimited supply of U adsorption sites over the concentration range studied.

Adsorption isotherms for Pb were not calculated because the reference tubes in the PU and PW cells contained lead at levels that were less than or equal to background counts for ^{210}Pb. That is, lead concentrations in perched groundwater are controlled by the precipitation of $PbCO_3$ more so than by adsorption. Figure 10 plots Pb concentration as a function of pH and $PbCO_3$ solubility and shows the ^{210}Pb background concentration. The theoretical solubility curve suggests that Pb should be detected in the reference tubes, but measurable ^{210}Pb activities were less than or equal to the background activity. Activity measurements indicate that the theoretical solubility curve in Figure 10 must be lowered to account for the observed behavior of Pb in the perched groundwater.

A summary of all adsorption ratios obtained from BNL experiments is provided in Table 7. Adsorption ratios reported for the mixed (MW and MU cells) and cement leachate (CW, CU, and CS cells) contact solutions are only applicable to the migration of contaminants derived from cemented waste forms. The discussion of these data are beyond the scope of the present report.

3.3 Discussion

Adsorption isotherms presented on Figures 4 through 9 indicate that the weathered and unweathered glacial overburden have distinct affinities for the adsorption of metals and radionuclides, as evidenced by the difference in their surface areas (weathered = 117 m^2/g and unweathered = 13 m^2/g). Adsorption of Ba, Mo, V, and Ra (Figures 4 through 7) on weathered glacial overburden exceeds that on unweathered glacial overburden. Uranium adsorption (Figure 9) appears nearly independent of weathered versus unweathered glacial overburden. The adsorption of Tc (Figure 8) is best on unweathered glacial overburden.

The simplest model for the adsorption behavior of Ba, Mo, V, and Ra assumes that the surface area of the solid controls adsorption. This model is supported by mineralogical data that indicates the weathered and unweathered soil samples are similar in bulk composition. Surface area of the weathered glacial overburden is expected to exceed that of the unweathered soils because neutralization reactions between acid rainfall and the glacial overburden take place in the weathered zone. The principal neutralization reaction that increases surface area is the dissolution and pitting of carbonate minerals by rainfall with pH

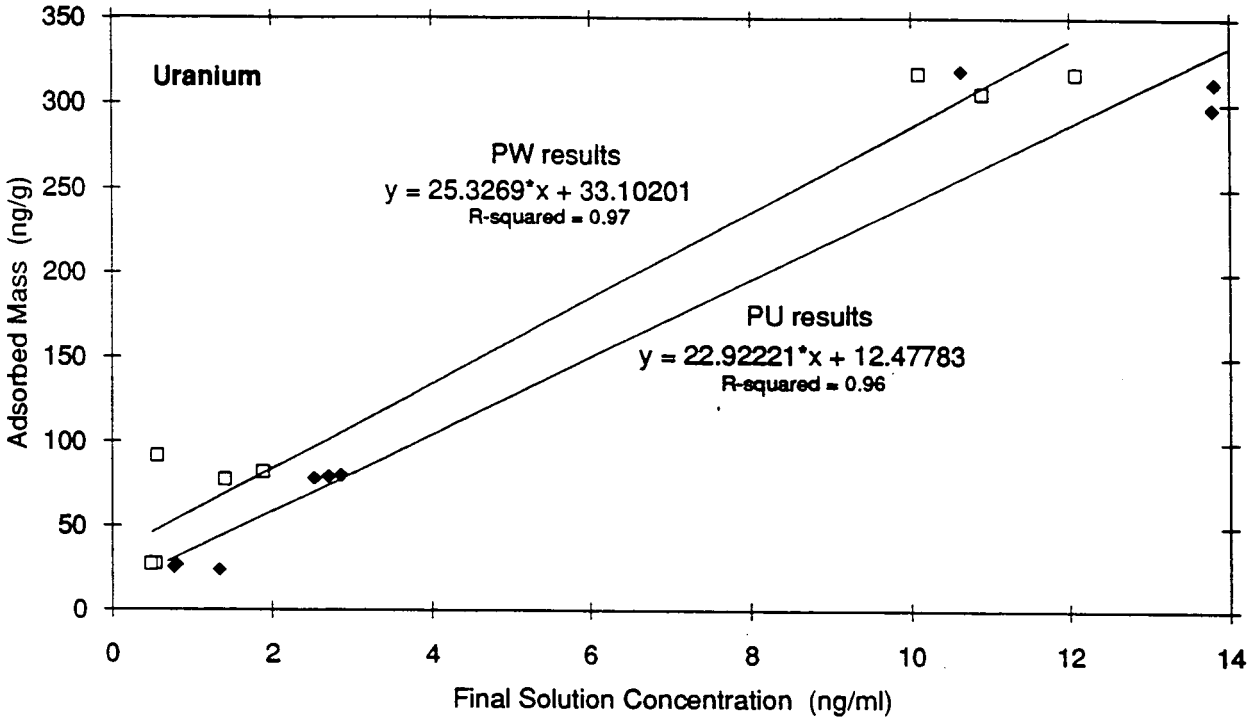

FIGURE 9

Adsorption Isotherms for Uranium

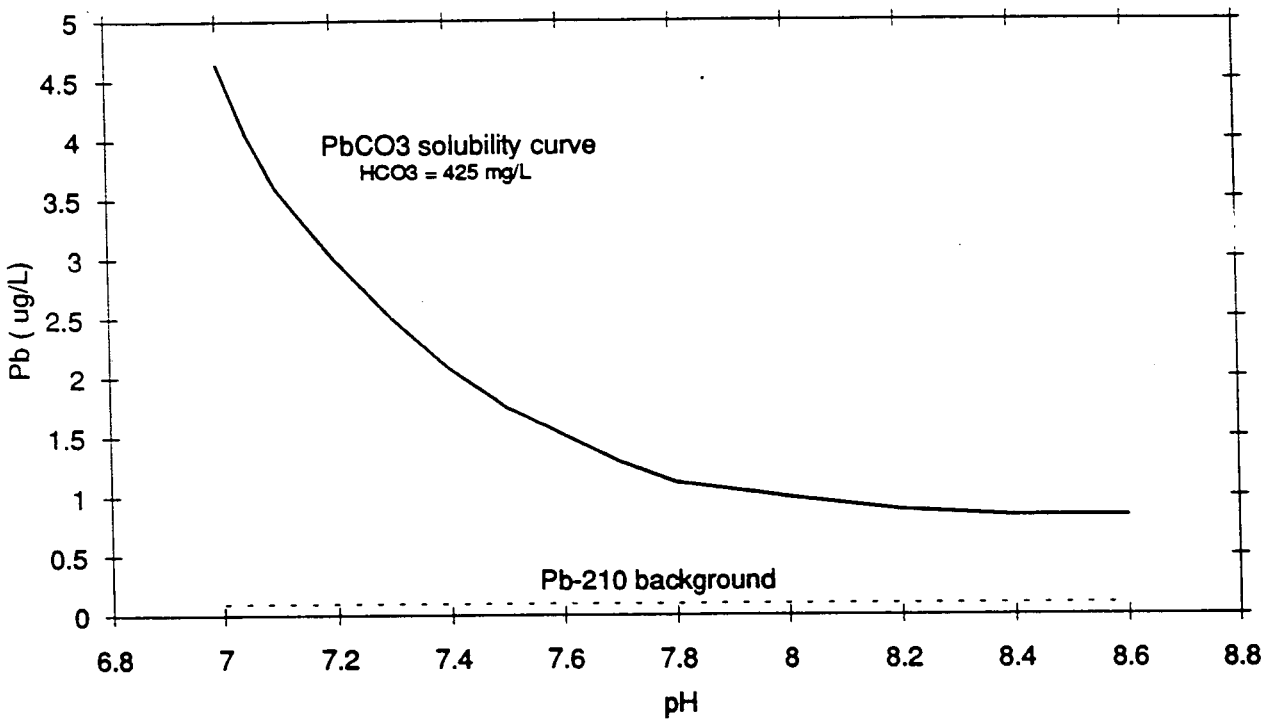

FIGURE 10

Solubility of $PbCO_3$ as a Function of pH

TABLE 7

Summary of Adsorption Ratios for All Experimental Cells Studied

	Adsorption Ratios (milliliter/gram)						
	PW Cell	**PU Cell**	**MW Cell**	**MU Cell**	**CW Cell**	**CU Cell**	**CS Cell**
Barium	128[a]	66[a]	20 - 101	0.3 - 43	16 - 85	0.1 - 42	49 - 120
Lead	NC	NC	NC	NC	NC	NC	NC
Molybdenum	2.2 - 11.9	0.6 - 3.8	1.3 - 4.4	0.2 - 2.4	0.1 - 2.7	0.1 - 0.2[b]	8.5 - 10.2[c]
Radium	8726[a]	942[a]	4268 - 6206[b]	212 - 534	3453 - 22493[b]	404 - 709	951 - 4002
Technetium	0.17[a]	0.62[a]	0.1 - 0.3[b]	0.001 - 0.4	0.09 - 0.9	0.05 - 0.4	0.01 - 1.1
Uranium	25[a]	23[a]	NC	NC	NC	NC	NC
Vanadium	462[a]	190[a]	591 - 599[c]	361 - 466[c]	585 - 684[c]	295 - 472[b]	4 - 87

NC No calculation performed to evaluate the adsorption ratio due to precipitation of phases in the reference cell and pH differences between the reference cell and the triplicate cells (see Appendix B).

[a] Single value for adsorption ratio calculated from linear regression data presented in Figures 4 through 9.

[b] Range of adsorption values includes only two of the three initial solution concentrations evaluated (see Appendix B).

[c] Range of adsorption values includes only one of the three initial solution concentrations evaluted (see Appendix B).

Key:
CS = cement leachate/sand+bentonite system;
CW = cement leachate/weathered till system;
CU = cement leachate/unweathered till system;
MW = mixture/weathered till system;
MU = mixture/unweathered till system;
PW = perched groundwater/weathered till system; and
PU = perched groundwater/unweathered till system.

of about 4.8 (e.g., $H^+ + CaCO_3 <-> HCO_3^- + Ca^{+2}$). Additionally, the oxidizing rainwater reacts with minerals containing ferrous iron (Fe^{+2}) and converts the iron to ferric iron (Fe^{+3}). The oxidation of iron will result in an increase in surface area as a primary mineral containing ferrous iron is converted to a low temperature iron oxyhydroxide mineral containing ferric iron.

Adsorption isotherms for U (Figure 9) indicate that the weathered and unweathered glacial overburden have similar affinities for the adsorption of U. If the surface-area model holds for differences observed in the adsorption behavior of Ba, Mo, V, and Ra, than the adsorption of U is not a strong function of surface area for these samples. Uranyl ion (UO_2^{+2}) is known to coprecipitate with calcium carbonate ($CaCO_3$) in the oceans, and the observed isotherms for U may reflect ion-exchange reactions with Ca present on carbonate mineral surfaces or the nucleation and precipitation of uranium-bearing calcite on the calcite and dolomite in the soil. Calcite and dolomite are the dominant mineral phases in both weathered and unweathered glacial overburden samples (Table 5). Evidence for control of uranium concentrations by a mechanism other than adsorption may be indicated by the 70-day time period required for U to reach steady-state conditions, as compared to less than 20 days for all other metals and radionuclides.

The adsorption behavior of Tc is the opposite of that observed for Ba, Mo, V, and Ra. That is, the unweathered soil samples have a greater affinity for Tc relative to the weathered samples. Again, if the surface-area model holds for differences observed in the adsorption behavior of Ba, Mo, V, and Ra, than the adsorption of Tc is not a strong function of surface area for these samples. A possible explanation for the Tc behavior may be tied to the oxidation-reduction potential (Eh) of the soil/water system. Technetium is generally present in mildly oxidizing soil/water systems as the TcO_4^- ion, but its mobility is sensitive to changes in the Eh of the system. The TcO_4^- ion, with Tc in the plus seven oxidation state (Tc^{+7}), can be reduced to Tc^{+4} or Tc^{+3} when Eh falls below about 200 millivolts. Reduction of Tc^{+7} to Tc^{+4} or Tc^{+3} results in the formation of TcO_2 or Tc_3O_4 oxides, which may be nucleated by surface kinetic reactions with ferrous iron. It is suggested that the unweathered soil/water interfaces adsorb Tc more readily because they have lower Eh than the weathered soil/water interfaces, due to a greater proportion of ferrous iron and organic material that has not reacted with oxidizing rainwater.

Reviewing the PW and PU adsorption ratios in Table 7 reveals another observation on the behavior of these metals and radionuclides in the perched groundwater/glacial overburden system. Radium, V, and Ba adsorption ratios are generally greater than 100, while U, Mo, and Tc adsorption ratios are much less than 100. This behavior is consistent with the

predicted aqueous form of the metals and radionulcides in perched groundwater (Table 8), except for V results.

In general, cations (i.e., Ba^{+2} and Ra^{+2}) adsorb more readily than anions (i.e, MoO_4^{-2}, TcO_4^-, and $UO_2(CO_3)_3^{-4}$) in soil/water systems with pH between 7 and 8 because most mineral/water interfaces in the soil have a net negative charge in this pH range. The affinity of an ion to adsorb to a mineral/water interface is dependent on the solution pH, solution composition, the ion charge and size, and the minerals zero point of charge (indicated as pH_{zpc}). For example, the pH_{zpc} for montmorillonite and kaolinite occur at pH of 2.5 and 4.6, respectively. When a solution contacting the mineral of interest has a pH above the mineral's pH_{zpc}, the mineral/water interface has a net negative charge that allows cations to adsorb. A few minerals, notably aluminum and iron oxyhydroxides (pH_{zpc} 8.2 and 8.5, respectively), have a net positive charge on their surface/water interface at near neutral pH because their pH_{zpc} is above the solution pH, and these minerals have the ability to adsorb anions from solution.

In applying the zero point of charge theory to minerals in the glacial overburden, it is noted that quartz, feldspar, illite, corrensite, chlorite, biotite, and hornblende (Table 5) have zero point of charge below a pH of 5, and iron oxide and iron oxyhydroxide minerals have zero point of charge between pH of 7 and 9. The zero point of charge for calcite and dolomite will depend on the Ca^{+2}, Mg^{+2}, and HCO_3^- concentrations in the groundwater, in addition to pH. Based on the concentrations of these three ions in groundwater from well 1024, calcite and dolomite are predicted to have a weak positive charge at their surface/water interface.

Applying the above knowledge to the PW and PU adsorption results, where the final soil/water pH is between 7.2 and 8.1, most minerals in the glacial overburden are predicted to have a net negative charge at their surface/water interface. That is, they are expected to adsorb Ba^{+2}, Ra^{+2}, and other cations. However, aluminum and iron oxyhydroxide minerals that form from the weathering of feldspar and iron-bearing minerals (e.g., biotite, hornblende, chlorite, corrensite) will create favorable surfaces for the adsorption of MoO_4^{-2}, TcO_4^-, $UO_2(CO_3)_3^{-4}$, and other anions. Because the aluminum and iron oxyhdroxide surface area in the glacial overburden is relatively small, adsorption of anions onto the glacial overburden is predicted to be limited. The observed isotherms are consistent with the predicted speciation for all metals and radionuclides studied, with the exception of V results.

Vanadium isotherms do not agree with the predicted anion forms for V in perched groundwater (Table 8). Like Tc, V may be reduced from its common plus five valence to plus four or plus three by interaction with ferrous iron or organic material. The plus four and and plus three ions of vanadium form V_2O_4 and V_2O_3 oxides, which may account for the

TABLE 8

Predicted Distribution of Aqueous Species in Perched Groundwater

Element	Specie	Molal Percent
Barium	Ba^{+2}	96.96
	$BaHCO_3^+$	2.97
Lead	Pb^{+2}	88.68
	$PbOH^+$	11.04
Molybdenum	MoO_4^{-2}	100.00
Radium	Ra^{+2}	100.00
Technetium	TcO_4^-	100.00
Uranium	$UO_2(CO_3)_3^{-4}$	52.24
	$UO_2(CO_3)_2^{-2}$	46.77
Vanadium	$H_2VO_4^-$	38.53
	VO_3OH^{-2}	32.12
	$VO_2(OH)_2^-$	23.46
	HVO_4^{-2}	5.87

removal of V from solution. It is noted that the reference cells for V (Appendix B) show no indication of V being lost from the soil-free perched groundwater tubes. This suggests that if V is precipitated in the soil/groundwater tubes the V is reduced by interaction with the solid medium. Alternatively, the predicted speciation for V may be incorrect.

Adsorption of lead has not been discussed because lead is removed from the PW and PU reference cells by precipitation of $PbCO_3$, as evidenced by counts on the reference tube perched groundwater that are less than or equal to background counts (Appendix B). Based on the background concentration of ^{210}Pb, which lies below the predicted $PbCO_3$ solubility curve (Figure 10), lead adsorption is predicted to occur, as represented by the space between the ^{210}Pb line and the solubility curve. However, ^{210}Pb counts in the reference tubes are equal to or less than the background counts, while counts in the blank tubes reflect the initial concentration of lead in the experiments (i.e., lead is not adsorbed to the tube wall in the blank runs). This implies that lead in the reference cell is removed by precipitation only, rather than a combination of precipitation and adsorption to the tube wall. Therefore, the predicted solubility curve for lead appears to overestimate the lead concentration in this system.

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APPENDIX A

Kinetic Results

TABLE A-1

Kinetic Experiments for pH

CS cell							
time	pH						
(hrs)							
1	10.82						
24	10.42						
92	10.24						
140	10.16						
284	9.62						
784	9.75						
CW cell			**MW cell**			**PW cell**	
time	pH		time	pH		time	pH
(hrs)			(hrs)			(hrs)	
1	9.8		1	8.5		1	7.68
24	9.22		24	8.26		24	7.82
92	9.16		92	8.26		92	7.93
140	9.04		140	8.26		140	8.06
284	8.83		284	8.14		284	8.15
784	8.85		784	8.12		784	8.34
CU cell			**MU cell**			**PU cell**	
time	pH		time	pH		time	pH
(hrs)			(hrs)			(hrs)	
1	10.06		1	8.28		1	7.55
24	9.27		24	8.05		24	7.52
92	8.94		92	7.93		92	7.64
140	8.8		140	7.93		140	7.6
284	8.56		284	7.89		284	7.65
784	8.31		784	8.07		784	7.96

TABLE A-2

Kinetic Experiments for Barium, Molybdenum, and Vanadium

CS cell			
time	Ba	Mo	V
(hrs)	(ug/mL)	(ug/mL)	(ug/mL)
0	3.514	2.363	0.242
4	0.029	1.885	0.090
24	0.049	1.960	0.075
48	0.047	1.979	0.066
96	0.050	2.002	0.046
144	0.049	1.938	0.044

CW cell				MW cell				PW cell			
time	Ba	Mo	V	time	Ba	Mo	V	time	Ba	Mo	V
(hrs)	(ug/mL)	(ug/mL)	(ug/mL)	(hrs)	(ug/mL)	(ug/mL)	(ug/mL)	(hrs)	(ug/mL)	(ug/mL)	(ug/mL)
0	3.579	2.406	0.246	0	3.229	2.245	0.226	0	3.392	2.384	0.231
4	0.080	1.857	0.210	4	0.105	1.637	<0.01	4	0.103	1.469	<0.01
24	0.083	1.783	<0.01	24	1.500	0.109	<0.01	24	0.101	1.342	<0.01
48	0.086	1.700	<0.01	48	1.354	0.099	<0.01	48	0.094	1.217	<0.01
96	0.085	1.522	<0.01	96	1.333	0.101	<0.01	96	0.101	1.217	<0.01
144	0.092	1.551	<0.01	144	1.228	0.093	<0.01	144	0.091	1.081	<0.01
312	0.084	1.405	<0.01	312	1.196	0.095	<0.01	312	0.092	1.07	<0.01

CU cell				MU cell				PU cell			
time	Ba	Mo	V	time	Ba	Mo	V	time	Ba	Mo	V
(hrs)	(ug/mL)	(ug/mL)	(ug/mL)	(hrs)	(ug/mL)	(ug/mL)	(ug/mL)	(hrs)	(ug/mL)	(ug/mL)	(ug/mL)
0	3.579	2.406	0.246	0	3.561	2.406	0.246	0	3.486	2.352	0.231
4	0.215	2.035	0.015	4	0.301	2.069	<0.01	4	0.305	1.806	<0.01
24	0.226	2.004	0.010	24	0.303	1.942	<0.01	24	0.273	1.699	<0.01
48	0.238	1.974	<0.01	48	0.306	1.942	<0.01	48	0.263	1.628	<0.01
96	0.241	1.933	<0.01	96	0.320	1.846	<0.01	96	0.252	1.554	<0.01
144	0.254	1.878	<0.01	144	0.295	1.722	<0.01	144	0.241	1.458	<0.01
312	0.267	1.815	<0.01	312	0.315	1.636	<0.01	312	0.252	1.356	<0.01

TABLE A-3

Kinetic Experiments for Technetium

CS cell		Tc: 1 cpm = 0.03 ng
time	Tc	Tc = 99Tc
(hrs)	(cpm/mL)	
0	2169	NOTE: Samples pulled at 2, 4, 24, and 48 hours were
2		modified by adsorption of Tc on nylon syringe filters.
4		Filters were changed to polyethylene prior to pulling
24		the remaining samples.
48		
74	2017	
144	2033	
312	2314	

CW cell		MW cell		PW cell	
time	Tc	time	Tc	time	Tc
(hrs)	(cpm/mL)	(hrs)	(cpm/mL)	(hrs)	(cpm/mL)
0	2132	0	1980	0	1918
2		2		2	
4		4		4	
24		24		24	
48		48		48	
74	1931	74	1980	74	1974
144	1999	144	1863	144	2079
312	2183	312	2141	312	1945

CU cell		MU cell		PU cell	
time	Tc	time	Tc	time	Tc
(hrs)	(cpm/mL)	(hrs)	(cpm/mL)	(hrs)	(cpm/mL)
0	2092	0	1960	0	1955
2		2		2	
4		4		4	
24		24		24	
48		48		48	
74	1926	74	1956	74	1974
144	1946	144	1884	144	1906
312	2106	312	1850	312	1752

TABLE A-4

Kinetic Experiments for Lead and Uranium

CS cell			Pb: 1 cpm = 0.3 ng	U: 1 cpm = 33 ng
time	Pb	U	Pb = 210Pb + Pb carrier	U = 232U + U carrier
(hrs)	(cpm/mL)	(cpm/mL)		
0	15.2	0.859		
1				
3				
6				
25				
49	0.295	0.015		
336	0.300	0.030		
600	0.325	0.025		
1536				

CW cell			MW cell			PW cell		
time	Pb	U	time	Pb	U	time	Pb	U
(hrs)	(cpm/mL)	(cpm/mL)	(hrs)	(cpm/mL)	(cpm/mL)	(hrs)	(cpm/mL)	(cpm/mL)
0	22.1	1.23	0	20.9	1.25	0	21.0	1.09
1			1			1	0.245	0.395
3			3			3	0.240	0.415
6			6			6	0.225	0.340
25			25			25	0.310	
49	0.305	0.001	49	0.330	0.34	49	0.235	0.240
336	0.300	0.009	336	0.265	0.030	336	0.300	0.165
600			600	0.265	0.015	600	0.260	0.120
1536			1536			1536	0.260	0.090

CU cell			MU cell			PU cell		
time	Pb	U	time	Pb	U	time	Pb	U
(hrs)	(cpm/mL)	(cpm/mL)	(hrs)	(cpm/mL)	(cpm/mL)	(hrs)	(cpm/mL)	(cpm/mL)
0	20.8	1.19	0	20.4	0.934	0	20.7	1.10
1			1			1		
3			3			3		
6			6			6		
25			25			25		
49	0.235	0.015	49	0.335	0.105	49	0.245	0.355
336	0.285	0.009	336	0.285	0.105	336	0.260	0.245
600	0.275	0.025	600	0.270	0.090	600	0.295	0.215
1536			1536			1536		0.190

TABLE A-5

Kinetic Experiments for Radium

CS cell			Ra: 1 cpm = 0.0005 ng
time	Ra		Ra = 226Ra
(hrs)	(cpm/mL)		
0	5100		NOTE: Kinetics experiments for Ra were counted by liquid
1	478		scintillation, rather than gamma spectroscopy. Therefore,
2	464		an increase in the cpm/mL for samples pulled after
4	467		2 hours reflects ingrowth of 226Ra daughters. This was
22.7	826		confirmed by gamma counting for 226Ra on 191 hour
47.2	942		samples. All sorption experiments for 226Ra reported in
119	1682		Appendix B were counted using gamma spectroscopy.
191	1910		

CW cell			MW cell			PW cell	
time	Ra		time	Ra		time	Ra
(hrs)	(cpm/mL)		(hrs)	(cpm/mL)		(hrs)	(cpm/mL)
0	5346		0	5410		0	5572
1	377		1	384		1	433
2	408		2	399		2	393
4	430		4	409		4	443
22.7	836		22.7	840		22.7	849
47.2	1161		47.2	1023		47.2	1023
119	1175		119	1428		119	1275
191	1676		191	1800		191	1494

CU cell			MU cell			PU cell	
time	Ra		time	Ra		time	Ra
(hrs)	(cpm/mL)		(hrs)	(cpm/mL)		(hrs)	(cpm/mL)
0	5690	0	0	5175		0	5564
1	436	1	1	482		1	483
2	440	2	2	381		2	478
4	456	4	4	421		4	420
22.7	874	23	22.7	951		22.7	826
47.2	1042	47	47.2	1172		47.2	945
119	1497	119	119	1236		119	1395
191	1912	191	191	1602		191	1404

APPENDIX B

Adsorption Results

TABLE B-1

Barium, Molybdenum, and Vanadium 0.2x Results

0.2x sample	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	total water (grams)	Mo (ug/mL)	Ba (ug/mL)	V (ug/mL)	corrected volumes Mo (ug/mL)	corrected volumes Ba (ug/mL)	corrected volumes V (ug/mL)	mass removed from solution blank - Mo (ug/mL)	mass removed from solution blank - Ba (ug/mL)	mass removed from solution blank - V (ug/mL)	mass on solids Mo (ug/g)	mass on solids Ba (ug/g)	mass on solids V (ug/g)	adsorption ratios Mo (mL/g)	adsorption ratios Ba (mL/g)	adsorption ratios V (mL/g)
CW1	6.32	11.31	13.40	4.99	2.09	22.09	0.078	0.023	<0.02	0.086	0.025	0.000	-0.005	0.110	0.460		0.439	1.844		19.10	
CW2	6.27	11.26	13.44	4.99	2.18	22.18	0.071	0.025	<0.02	0.079	0.028		0.002	0.107		0.009	0.430		0.13	17.20	
CW3	6.40	11.36	13.56	4.96	2.20	22.20	0.072	0.027	<0.02	0.080	0.030		0.001	0.105		0.004	0.424		0.06	15.69	
CWREF	6.26	6.26	6.26	0.00	0.00	20.00	0.082	0.132	0.450	0.082	0.132	0.450	-0.001	0.003	0.010						
CWBLANK	6.26	6.26	6.26	0.00	0.00	20.00	0.087	0.136	0.470	0.087	0.136	0.470	-0.006	-0.001	-0.010						
MW1	6.24	11.21	13.31	4.97	2.10	22.10	0.046	0.022	<0.02	0.051	0.024		0.030	0.111		0.121	0.445		2.64	20.25	
MW2	6.33	11.31	13.42	4.98	2.11	22.11	0.040	0.021	<0.02	0.044	0.023		0.037	0.112		0.148	0.449		3.69	21.38	
MW3	6.23	11.17	13.26	4.94	2.09	22.09	<0.02	0.022	<0.02		0.024			0.111							
MWREF	6.27	6.27	6.27	0.00	0.00	20.00	0.077	0.009	0.300	0.077	0.003	0.300	0.004	0.122	0.160						
MWBLANK	6.26	6.26	6.26	0.00	0.00	20.00	0.078	0.133	0.460	0.078	0.133	0.460	0.003	0.002	0.000						
PW1	6.25	11.20	13.36	4.95	2.16	22.16	0.020	0.032	<0.02	0.022	0.035		0.059	0.100		0.238	0.402		11.89	12.57	
PW2	6.30	11.30	13.48	5.00	2.18	22.18	0.024	0.021	<0.02	0.027	0.023		0.054	0.112		0.218	0.447		9.06	21.28	
PW3	6.28	11.29	13.45	5.01	2.16	22.16	0.022	0.023	<0.02	0.024	0.025		0.057	0.110		0.226	0.437		10.27	19.01	
PWREF	6.26	6.26	6.26	0.00	0.00	20.00	0.087	0.186	0.390	0.087	0.186	0.390	-0.006	-0.050	0.070						
PWBLANK	6.22	6.22	6.22	0.00	0.00	20.00	0.075	0.136	0.460	0.075	0.136	0.460	0.006	0.000	0.000						
CU1	6.23	11.22	13.20	4.99	1.98	21.98	0.112	0.133	<0.02	0.123	0.146		-0.042	-0.011							
CU2	6.27	11.26	13.30	4.99	2.04	22.04	0.106	0.117	<0.02	0.117	0.129		-0.036	0.006			0.024			0.21	
CU3	6.35	11.41	13.31	5.06	1.90	21.90	0.106	0.122	<0.02	0.116	0.134		-0.035	0.001			0.006			0.05	
CUREF	6.23	6.23	6.23	0.00	0.00	20.00	0.086	0.133	0.460	0.086	0.133	0.460	-0.007	0.002	0.000						
CUBLANK	6.27	6.27	6.27	0.00	0.00	20.00	0.080	0.136	0.470	0.080	0.136	0.470	0.001	-0.003	-0.010						
PU1	6.27	11.20	13.10	4.93	1.90	21.90	0.040	0.070	<0.02	0.044	0.077		0.037	0.058		0.151	0.237		3.77	3.38	
PU2	6.26	11.16	13.03	4.90	1.87	21.87	0.042	0.077	<0.02	0.046	0.084		0.035	0.051		0.143	0.207		3.41	2.69	
PU3	6.36	11.35	13.31	4.99	1.96	21.96	0.058	0.097	<0.02	0.064	0.107		0.017	0.028		0.069	0.114		1.20	1.18	
PUREF	6.25	6.25	6.25	0.00	0.00	20.00	0.104	0.167		0.104	0.167		-0.023	-0.062							
PUBLANK	6.25	6.25	6.25	0.00	0.00	20.00	0.086	0.133	0.460	0.086	0.133	0.460	-0.004	0.002	0.000						
MU1	6.24	11.24	13.21	5.00	1.97	21.97	0.062	0.111	<0.02	0.068	0.122		0.013	0.013		0.052	0.052		0.83	0.47	
MU2	6.21	11.12	13.01	4.91	1.89	21.89	0.048	0.111	<0.02	0.053	0.121		0.028	0.014		0.116	0.055		2.42	0.50	
MU3	6.24	11.24	13.15	5.00	1.91	21.91	0.067	0.116	<0.02	0.073	0.127		0.008	0.008		0.030	0.032		0.45	0.27	
MUREF	6.23	6.23	6.23	0.00	0.00	20.00	0.069	0.001	0.300	0.069	0.001	0.300	-0.008	0.134	0.160						
MUBLANK	6.22	6.22	6.22	0.00	0.00	20.00	0.082	0.135	0.470	0.082	0.135	0.470	-0.001	0.000	-0.010						
CS1	13.26	18.36	23.38	5.10	5.02	25.02	0.021	0.006	0.020	0.026	0.008	0.025	0.055	0.127	0.435	0.215	0.500	1.706	10.22	83.33	85.29
CS2	13.25	18.27	22.95	5.02	4.68	24.68	0.024	0.007	0.020	0.030	0.009	0.025	0.051	0.126	0.435	0.205	0.503	1.734	8.53	71.92	86.72
CS3	13.09	18.17	22.83	5.08	4.66	24.66															
CSREF	13.26	13.26	13.26	0.00	0.00	20.00															
CSBLANK	6.35	6.35	6.35	0.00	0.00	20.00															

Corrected volumes are obtained by multiplying total water volume by measured concentration and dividing by 20 mL to allow direct comparison with 20 mL blank and reference samples
[e.g., for Mo CW2: ((22.18 mL * 0.071 ug/mL)/20 mL) = corrected volume concentration of 0.079 ug/mL]
Mass removed from solution is obtained by taking the volume corrected, blank average for all cells and subtracting the concentration entered for the corrected volumes
[e.g., for Mo CW2: ((0.087 ug/mL + 0.078 ug/mL + 0.075 ug/mL + 0.080 ug/mL + 0.085 ug/mL + 0.082 ug/mL)/6) - 0.079 ug/mL = 0.002 ug/mL]
Mass on solids is obtained by multiplying the mass removed from solution by 20 mL of solution and dividing by the reported dry soil mass
[e.g., for Mo CW2: ((0.002 ug/mL * 20 mL)/4.99 g) = 0.009 ug/g]
Adsorption ratio is obtained by dividing the mass on solids by the concentration reported for the uncorrected volume
[e.g., for Mo CW2: (0.009 ug/g)/(0.071 ug/mL) = 0.13 mL/g]

TABLE B-2

Barium, Molybdenum, and Vanadium 1x Results

1x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	total water (grams)	Mo (ug/mL)	Ba (ug/mL)	V (ug/mL)	corrected volumes Mo (ug/mL)	corrected volumes Ba (ug/mL)	corrected volumes V (ug/mL)	mass removed from solution blank - Mo (ug/mL)	mass removed from solution blank - Ba (ug/mL)	mass removed from solution blank - V (ug/mL)	mass on solids Mo (ug/g)	mass on solids Ba (ug/g)	mass on solids V (ug/g)	adsorption ratios Mo (mL/g)	adsorption ratios Ba (mL/g)	adsorption ratios V (mL/g)
CW1	6.28	11.28	13.35	5.00	2.07	22.07	0.280	0.058	<0.02	0.309	0.064		0.152	0.592		0.608	2.368		2.17	40.83	
CW2	6.31	11.30	13.34	4.99	2.04	22.04	0.260	0.055	<0.02	0.287	0.061		0.174	0.595		0.699	2.386		2.69	43.39	
CW3	6.24	11.25	13.36	5.01	2.11	22.11	0.280	0.056	<0.02	0.310	0.062		0.151	0.594		0.605	2.372		2.16	42.35	
CWREF	6.28	6.28	6.28	0.00	0.00	20.00	0.450	0.636	2.310	0.450	0.636	2.310	0.011	0.020	0.000						
CWBLANK	6.23	6.23	6.23	0.00	0.00	20.00	0.440	0.653	2.300	0.440	0.653	2.300	0.021	0.003	0.010						
MW1	6.27	11.28	13.27	5.01	1.99	21.99	0.220	0.042	<0.02	0.242	0.046		0.219	0.610		0.875	2.434		3.98	57.96	
MW2	6.22	11.20	13.16	4.98	1.95	21.95	0.220	0.042	<0.02	0.241	0.046		0.220	0.610		0.882	2.449		4.01	58.32	
MW3	6.28	11.24	13.21	4.96	1.97	21.97	0.210	0.042	<0.02	0.231	0.046		0.230	0.610		0.929	2.459		4.42	58.55	
MWREF	6.28	6.28	6.28	0.00	0.00	20.00	0.470	0.180	0.990	0.470	0.180	0.990	-0.009	0.476	1.320						
MWBLANK	6.25	6.25	6.25	0.00	0.00	20.00	0.460	0.647	2.300	0.460	0.647	2.300	0.001	0.009	0.010						
PW1	6.24	11.19	13.18	4.95	1.99	21.99	0.120	0.054	<0.02	0.132	0.059		0.329	0.597		1.330	2.411		11.08	44.64	
PW2	6.26	11.18	13.18	4.92	2.00	22.00	0.140	0.051	<0.02	0.154	0.056		0.307	0.600		1.248	2.439		8.91	47.82	
PW3	6.30	11.32	13.29	5.02	1.97	21.97	0.130	0.050	<0.02	0.143	0.055		0.318	0.601		1.268	2.395		9.75	47.89	
PWREF	6.27	6.27	6.27	0.00	0.00	20.00	0.460	0.614	2.130	0.460	0.614	2.130	0.001	0.042	0.160						
PWBLANK	6.20	6.20	6.20	0.00	0.00	20.00	0.450	0.655	2.270	0.450	0.655	2.270	0.011	0.001	0.040						
CU1	6.26	11.26	13.18	5.00	1.92	21.92	0.400	0.156	<0.02	0.438	0.171		0.023	0.485		0.090	1.940		0.23	12.44	
CU2	6.27	11.12	12.98	4.85	1.84	21.84	0.430	0.146	0.020	0.470	0.159	0.022	-0.009	0.497	2.288		2.048	9.436		14.03	471.79
CU3	6.19	11.37	13.27	5.18	1.90	21.90	0.410	0.143	<0.02	0.449	0.157		0.012	0.499		0.047	1.928		0.11	13.48	
CUREF	6.20	6.20	6.20	0.00	0.00	20.00	0.460	0.640	2.350	0.460	0.640	2.350	0.001	0.016	-0.040						
CUBLANK	6.23	6.23	6.23	0.00	0.00	20.00	0.450	0.631	2.240	0.450	0.631	2.240	0.011	0.025	0.070						
PU1	6.24	11.23	13.15	4.99	1.92	21.92	0.250	0.127	0.050	0.274	0.139	0.055	0.187	0.517	2.255	0.749	2.071	9.039	3.00	16.31	180.78
PU2	6.27	11.18	13.11	4.91	1.93	21.93	0.260	0.122	0.030	0.285	0.134	0.033	0.176	0.522	2.277	0.717	2.127	9.275	2.76	17.44	309.18
PU3	6.26	11.22	13.17	4.96	1.95	21.95	0.280	0.118	<0.02	0.307	0.130		0.154	0.526		0.620	2.123		2.21	17.99	
PUREF	6.28	6.28	6.28	0.00	0.00	20.00	0.470	0.606	2.230	0.470	0.606	2.230	-0.009	0.151	0.080						
PUBLANK	6.24	6.24	6.24	0.00	0.00	20.00	0.450	0.636	2.260	0.450	0.636	2.260	0.011	0.020	0.060						
MU1	6.25	11.23	13.07	4.98	1.84	21.84	0.370	0.161	<0.02	0.404	0.176		0.057	0.480		0.229	1.928		0.62	11.98	
MU2	6.32	11.40	13.35	5.08	1.95	21.95	0.370	0.157	<0.02	0.406	0.172		0.055	0.484		0.216	1.904		0.58	12.13	
MU3	6.26	11.14	13.08	4.88	1.94	21.94	0.370	0.157	<0.02	0.406	0.172		0.055	0.484		0.226	1.983		0.61	12.63	
MUREF	6.21	6.21	6.21	0.00	0.00	20.00	0.470	0.184	1.020	0.470	0.184	1.020	-0.009	0.472	1.290						
MUBLANK	6.28	6.28	6.28	0.00	0.00	20.00	0.470	0.658	2.350	0.470	0.658	2.350	-0.009	-0.002	-0.040						
CS1	13.28	18.41	22.74	5.13	4.33	24.33	0.440	0.022	0.780	0.535	0.027	0.949	-0.074	0.629	1.361		2.453	5.307		111.51	6.80
CS2	13.07	18.00	22.41	4.93	4.41	24.41	0.490	0.049	0.900	0.598	0.060	1.098	-0.137	0.596	1.212		2.419	4.915		49.36	5.46
CS3	13.61	18.60	22.92	4.99	4.32	24.32	0.430	0.021	0.840	0.523	0.026	1.021	-0.062	0.630	1.289		2.527	5.165		120.33	6.15
CSREF	13.07	13.07	13.07	0.00	0.00	20.00	0.500	0.687	2.400	0.500	0.687	2.400	-0.039	-0.031	-0.090						
CSBLANK	6.24	6.24	6.24	0.00	0.00	20.00	0.510	0.712	2.420	0.510	0.712	2.420	-0.049	-0.056	-0.110						

Corrected volumes are obtained by multiplying total water volume by measured concentration and dividing by 20 mL to allow direct comparison with 20 mL blank and reference samples
[e.g., for Mo CW1: ((22.07 mL * 0.280 ug/mL)/20 mL) = corrected volume concentration of 0.309 ug/mL]
Mass removed from solution is obtained by taking the volume corrected, blank average for all cells and subtracting the concentration entered for the corrected volumes
[e.g., for Mo CW1: ((0.44 ug/mL + 0.48 ug/mL + 0.45 ug/mL + 0.45 ug/mL + 0.45 ug/mL + 0.47 ug/mL + 0.51 ug/mL)/7) - 0.309 ug/mL = 0.152 ug/mL]
Mass on solids is obtained by multiplying the mass removed from solution by 20 mL of solution and dividing by the reported dry soil mass
[e.g., for Mo CW1: ((0.152 ug/mL * 20 mL)/5.0 g) = 0.608 ug/g]
Adsorption ratio is obtained by dividing the mass on solids by the concentration reported for the uncorrected volume
[e.g., for Mo CW1: (0.608 ug/g)/(0.280 ug/mL) = 2.17 mL/g]

TABLE B-3

Barium, Molybdenum, and Vanadium 5x Results

5x sample	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	total water (grams)	Mo (ug/mL)	Ba (ug/mL)	V (ug/mL)	corrected volumes Mo (ug/mL)	corrected volumes Ba (ug/mL)	corrected volumes V (ug/mL)	mass removed from solution: blank - Mo (ug/mL)	mass removed from solution: blank - Ba (ug/mL)	mass removed from solution: blank - V (ug/mL)	mass on solids Mo (ug/g)	mass on solids Ba (ug/g)	mass on solids V (ug/g)	adsorption ratios Mo (mL/g)	adsorption ratios Ba (mL/g)	adsorption ratios V (mL/g)
CW1	6.25	11.32	13.16	5.07	1.84	21.84	1.860	0.150	0.080	2.031	0.164	0.087	0.339	2.956	11.863	1.337	11.662	46.795	0.72	77.74	584.94
CW2	6.23	11.19	13.03	4.96	1.84	21.84	1.810	0.140	0.070	1.977	0.153	0.076	0.393	2.967	11.874	1.587	11.964	47.877	0.88	85.46	683.96
CW3	6.26	11.25	13.17	4.99	1.92	21.92	1.860	0.150	0.080	2.039	0.164	0.088	0.331	2.956	11.862	1.328	11.846	47.544	0.71	78.97	594.30
CWREF	6.24	6.24	6.24	0.00	0.00	20.00	2.390	3.250	20.370	2.390	3.250	20.370	-0.020	-0.130	-6.420						
CWBLANK	6.26	6.26	6.26	0.00	0.00	20.00	2.320	3.320	12.100	2.320	3.320	12.100	0.050	-0.200	-0.150						
MW1	6.26	11.21	13.18	4.95	1.97	21.97	1.600	0.120	0.080	1.758	0.132	0.088	0.612	2.988	11.862	2.474	12.073	47.928	1.55	100.61	599.10
MW2	6.28	11.29	13.26	5.01	1.97	21.97	1.660	0.120	0.080	1.824	0.132	0.088	0.546	2.988	11.862	2.182	11.929	47.354	1.31	99.41	591.92
MW3	6.27	11.29	13.36	5.02	2.07	22.07	1.670	0.120	0.080	1.843	0.132	0.088	0.527	2.988	11.862	2.100	11.903	47.258	1.26	99.19	590.72
MWREF	6.27	6.27	6.27	0.00	0.00	20.00	2.310	2.000	9.070	2.310	2.000	9.070	0.080	1.120	2.880						
MWBLANK	6.27	6.27	6.27	0.00	0.00	20.00	2.380	3.130	13.130	2.390	3.130	13.130	-0.020	-0.010	-1.180						
PW1	6.37	11.32	13.16	4.95	1.84	21.84	1.440	0.110	0.110	1.572	0.120	0.120	0.798	3.000	11.830	3.222	12.121	47.797	2.24	110.19	434.52
PW2	6.23	11.18	13.18	4.95	2.00	22.00	1.430	0.110	0.090	1.573	0.121	0.099	0.797	2.999	11.851	3.220	12.117	47.883	2.25	110.16	532.03
PW3	6.27	11.26	13.37	4.99	2.11	22.11	1.270	0.130	0.100	1.404	0.144	0.111	0.966	2.976	11.839	3.872	11.929	47.453	3.05	91.76	474.53
PWREF	6.29	6.23	6.23	0.00	0.00	20.00	2.410	3.220	12.010	2.410	3.220	12.010	-0.040	-0.100	-0.060						
PWBLANK	6.27	6.27	6.27	0.00	0.00	20.00	2.370	3.120	11.960	2.370	3.120	11.960	0.000	0.000	0.000						
CU1	6.27	11.26	13.04	4.99	1.78	21.78	2.150	0.280	0.110	2.341	0.305	0.120	0.029	2.815	11.830	0.115	11.283	47.416	0.05	40.30	431.05
CU2	6.25	11.28	13.10	5.03	1.82	21.82	2.120	0.270	0.140	2.313	0.295	0.153	0.057	2.825	11.797	0.227	11.234	46.908	0.11	41.61	335.05
CU3	6.22	11.21	12.91	4.99	1.70	21.70	2.160	0.280	0.160	2.344	0.304	0.174	0.026	2.816	11.776	0.106	11.287	47.200	0.05	40.31	295.00
CUREF	6.28	6.28	6.28	0.00	0.00	20.00	2.410	3.080	11.770	2.410	3.080	11.770	-0.040	0.040	0.180						
CUBLANK	6.27	6.27	6.27	0.00	0.00	20.00	2.270	2.980	11.250	2.270	2.980	11.250	0.100	0.160	0.700						
PU1	6.26	11.30	13.06	5.04	1.76	21.76	1.900	0.210	0.210	2.067	0.228	0.228	0.303	2.892	11.722	1.202	11.474	46.514	0.63	54.64	221.50
PU2	6.29	11.20	13.05	4.91	1.85	21.85	1.750	0.270	0.260	1.912	0.295	0.306	0.458	2.825	11.644	1.866	11.507	47.430	1.07	42.62	169.39
PU3	6.26	11.18	13.99	4.92	2.81	22.81	1.770	0.260	0.200	2.019	0.297	0.228	0.351	2.823	11.722	1.428	11.478	47.650	0.81	44.14	238.25
PUREF	6.27	6.27	6.27	0.00	0.00	20.00	2.440	3.070	12.360	2.440	3.070	12.360	-0.070	0.050	-0.430						
PUBLANK	6.24	6.24	6.24	0.00	0.00	20.00	2.370	3.050	11.940	2.370	3.050	11.940	0.000	0.070	0.010						
MU1	6.28	11.36	13.26	5.08	1.90	21.90	2.050	0.260	0.100	2.245	0.285	0.110	0.125	2.835	11.841	0.493	11.163	46.616	0.24	42.93	466.16
MU2	6.25	11.28	13.15	5.03	1.87	21.87	2.070	0.270	0.130	2.264	0.295	0.142	0.106	2.825	11.808	0.423	11.232	46.950	0.20	41.60	361.15
MU3	6.24	11.31	13.15	5.07	1.84	21.84	2.090	0.270	0.120	2.282	0.295	0.131	0.088	2.825	11.819	0.346	11.145	46.623	0.17	41.28	388.53
MUREF	6.25	6.25	6.25	0.00	0.00	20.00	2.430	2.010	9.700	2.430	2.010	9.700	-0.060	1.110	2.250						
MUBLANK	6.26	6.26	6.26	0.00	0.00	20.00	2.420	3.110	12.330	2.420	3.110	12.330	-0.060	0.010	-0.380						
CS1	6.24	11.21	16.27	4.97	5.06	25.06	2.090	0.120	5.070	2.619	0.150	6.353	-0.249	2.970	5.597		11.950	22.524		99.59	4.44
CS2	6.26	11.17	16.07	4.91	4.90	24.90	2.060	0.120	4.920	2.565	0.149	6.125	-0.195	2.971	5.825		12.100	23.725		100.84	4.82
CS3	6.27	11.11	16.00	4.84	4.89	24.89	2.090	0.130	4.840	2.601	0.162	6.023	-0.231	2.958	5.927		12.224	24.490		94.03	5.06
CSREF	6.24	6.24	6.24	0.00	0.00	20.00	2.460	2.180	11.190	2.460	2.180	11.190	-0.090	0.940	0.760						
CSBLANK	6.27	6.27	6.27	0.00	0.00	20.00	2.430	3.120	11.920	2.430	3.120	11.920	-0.060	0.000	0.030						

Corrected volumes are obtained by multiplying total water volume by measured concentration and dividing by 20 mL to allow direct comparison with 20 mL blank and reference samples
[e.g., for Mo CW1: ((21.84 mL*1.860 ug/mL)/20 mL) = corrected volume concentration of 2.031 ug/mL]
Mass removed from solution is obtained by taking the volume corrected, blank average for all cells and subtracting the concentration entered for the corrected volumes
[e.g., for Mo CW1: ((2.32 ug/mL + 2.39 ug/mL + 2.37 ug/mL + 2.27 ug/mL + 2.37 ug/mL + 2.42 ug/mL + 2.43 ug/mL)/7) - 2.031 ug/mL = 0.339 ug/mL]
Mass on solids is obtained by multiplying the mass removed from solution by 20 mL of solution and dividing by the reported dry soil mass
[e.g., for Mo CW1: ((0.339 ug/mL * 20 mL)/5.07 g) = 1.3437ug/g]
Adsorption ratio is obtained by dividing the mass on solids by the concentration reported for the uncorrected volume
[e.g., for Mo CW1: (1.337 ug/g)/(1.860 ug/mL) = 0.72 mL/g]

020090

TABLE B-4

Lead 0.2x Results

Counting done on 4 mL samples, Pb-210 background for 4 mL sample is 0.599 cpm

1 CPM = 0.018 ng Pb

0.2x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	Pb-210 (cpm/4 mL)	Pb-210 - bgrd (cpm/4 mL)	tube + soil + water (grams)	total water (grams)	corrected Pb-210 (cpm/mL)	ref - Pb-210 (cpm/mL)	Pb-210 (cpm/g)	adsorption ratio (mL/g)	pH (std. units)	Pb-210 (pCi/ml)
CW 1	13.80	15.72	16.58	1.92	0.86	0.46	-0.14	24.56	9.34	-0.0388				8.02	-4.24
CW2	13.86	15.95	16.88	2.09	0.93	0.47	-0.13	24.88	9.43	-0.0355				8.00	-3.88
CW3	13.87	15.72	16.59	1.85	0.87	0.51	-0.09	24.58	9.36	-0.0245				8.16	-2.68
CWREF	13.79	13.79	13.79	0	0	160.19	159.59	21.80	8.51	39.9447				11.50	4367.26
CWBLANK	13.74	13.74	13.74	0	0	461.77	461.17	21.71	8.47	114.8858					12560.77
MW1	13.79	15.73	16.60	1.94	0.87	0.49	-0.11	24.67	9.44	-0.0303				7.86	-3.31
MW2	13.97	15.99	16.88	2.02	0.89	0.51	-0.09	24.96	9.47	-0.0248				7.80	-2.71
MW3	13.74	15.65	16.47	1.91	0.82	0.55	-0.05	24.47	9.32	-0.0137				7.78	-1.50
MWREF	13.83	13.83	13.83	0	0	10.19	9.59	21.94	8.61	2.4288				8.66	265.54
MWBLANK	13.77	13.77	13.77	0	0	463.91	463.31	21.83	8.56	116.6454					12753.14
PW1	13.68	15.75	16.65	2.07	0.90	0.47	-0.13	24.75	9.50	-0.0360				7.46	-3.94
PW2	13.79	15.86	16.77	2.07	0.91	0.63	0.03	24.92	9.56	0.0090				7.43	0.98
PW3	13.89	16.00	16.94	2.11	0.94	0.52	-0.08	24.98	9.48	-0.0220				7.48	-2.41
PWREF	13.80	13.80	13.80	0	0	0.00	-0.60	21.95	8.65	-0.1524				8.02	-16.66
PWBLANK	13.72	13.72	13.72	0	0	465.92	465.32	21.84	8.62	117.9726					12898.25
CU1	13.83	15.76	16.55	1.93	0.79	0.70	0.10	24.52	9.26	0.0275				7.68	3.01
CU2	13.76	15.86	16.70	2.10	0.84	0.71	0.11	24.69	9.33	0.0305				7.71	3.33
CU3	13.79	15.91	16.76	2.12	0.85	0.57	-0.03	24.71	9.30	-0.0079				7.67	-0.87
CUREF	13.78	13.78	13.78	0	0		-0.60	21.69	8.41	-0.1482				11.40	-16.20
CUBLANK	13.78	13.78	13.78	0	0	457.02	456.42	21.77	8.49	113.9710					12460.75
PU1	13.76	15.92	16.81	2.16	0.89	0.45	-0.15	24.95	9.53	-0.0415				7.64	-4.53
PU2	13.70	15.75	16.57	2.05	0.82	2.57	1.97	24.80	9.55	0.5528				7.72	60.44
PU3	13.64	15.66	16.49	2.02	0.83	0.51	-0.09	24.59	9.43	-0.0240				7.70	-2.63
PUREF	13.78	13.78	13.78	0	0	0.34	-0.26	21.94	8.66	-0.0661				8.15	-7.22
PUBLANK	13.90	13.90	13.90	0	0	471.15	470.55	21.88	8.48	117.3610					12831.38
MU1	13.76	15.73	16.61	1.97	0.88	0.47	-0.13	24.70	9.47	-0.0371				7.60	-4.06
MU2	13.84	15.81	16.70	1.97	0.89	0.39	-0.21	24.74	9.43	-0.0580				7.50	-6.34
MU3	13.76	15.93	16.89	2.17	0.96	0.47	-0.13	24.92	9.49	-0.0360				7.55	-3.94
MUREF	13.83	13.83	13.83	0	0	5.50	4.90	21.94	8.61	1.2411				9.38	135.69
MUBLANK	13.79	13.79	13.79	0	0	471.09	470.49	21.79	8.50	117.6228					12860.01
CS counting samples only contain 2 mL															
CS1	13.86	15.86	16.97	2.00	1.11	0.53	-0.07	24.97	9.61	-0.0209				9.68/9.64	-1.96
CS2	13.80	15.80	16.90	2.00	1.10	0.58	-0.02	24.92	9.62	-0.0055				8.82/8.80	-0.52
CS3	14.05	16.05	17.18	2.00	1.13	0.51	-0.09	25.17	9.62	-0.0242				9.80	-2.27
CSREF	13.65	13.65	13.65	0	0	80.50	79.90	21.62	8.47	19.9045				11.48	1867.91
CSBLANK	13.84	13.84	13.84	0	0	261.35	260.75	21.81	8.47	64.9577					6095.88

7414

TABLE B-5

Lead 1x Results

Counting done on 4 mL samples, Pb-210 background for 4 mL sample is 0.599 cpm

1 CPM = 0.13 ng Pb

1x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	Pb-210 (cpm/4 mL)	Pb-210 - bgrd (cpm/4 mL)	tube + soil + water (grams)	total water (grams)	corrected Pb-210 (cpm/mL)	ref - Pb-210 (cpm/mL)	Pb-210 (cpm/g)	adsorption ratio (mL/g)	pH (std. units)	Pb-210 (pCi/ml)
CW 1	13.86	15.87	16.87	2.01	1.00	0.59	-0.01	24.89	9.52	-0.0020				8.59	-0.22
CW2	13.78	15.85	16.83	2.07	0.98	0.61	0.01	24.82	9.47	0.0031				8.54	0.34
CW3	13.66	15.74	16.69	2.08	0.95	0.55	-0.05	24.65	9.41	-0.0130				8.62	-1.42
CWREF	13.88	13.88	13.88	0	0	288.69	288.09	21.77	8.39	72.0228				11.55	7874.44
CWBLANK	13.77	13.77	13.77	0	0	503.28	502.68	21.77	8.50	127.3179					13920.00
MW1	13.98	15.93	16.95	1.95	1.02	0.54	-0.06	24.97	9.54	-0.0164				7.91	-1.80
MW2	13.80	15.64	16.50	1.84	0.86	0.72	0.12	24.58	9.44	0.0333				8.00	3.64
MW3	14.05	16.07	17.06	2.02	0.99	0.62	0.02	25.16	9.59	0.0067				8.01	0.73
MWREF	13.75	13.75	13.75	0	0	1.10	0.50	21.82	8.57	0.1248				10.13	13.64
MWBLANK	13.86	13.86	13.86	0	0	479.56	478.96	21.83	8.47	118.3430					12938.76
PW1	13.74	15.70	16.66	1.96	0.96	0.69	0.09	24.82	9.62	0.0258				8.18	2.82
PW2	13.76	15.97	17.04	2.21	1.07	0.52	-0.08	25.09	9.62	-0.0208				7.99	-2.27
PW3	13.86	15.89	16.93	2.03	1.04	0.51	-0.09	25.06	9.67	-0.0248				7.09	-2.71
PWREF	13.66	13.66	13.66	0	0	0.00	-0.60	21.84	8.68	-0.1498				6.00	-16.37
PWBLANK	13.86	13.86	13.86	0	0	455.94	455.34	21.83	8.47	111.0812				3.80	12144.80
CU1	13.74	15.80	16.77	2.06	0.97	0.60	0.00	24.72	9.42	0.0011				8.45	0.12
CU2	13.85	15.86	16.70	2.01	0.84	0.56	-0.04	24.72	9.36	-0.0120				8.62	-1.31
CU3	14.07	16.00	16.96	1.93	0.96	0.62	0.02	24.94	9.44	0.0068				8.65	0.74
CUREF	13.92	13.92	13.92	0	0	267.69	267.09	21.81	8.39	68.7703				11.54	7300.17
CUBLANK	13.90	13.90	13.90	0	0	513.24	512.64		8.50	129.8405					14195.81
PU1	13.93	15.94	16.80	2.01	0.86	0.48	-0.12	25.01	9.57	-0.0342				7.83	0.00
PU2	13.79	15.76	16.67	1.97	0.91	0.52	-0.08	24.88	9.62	-0.0219				7.81	-2.40
PU3	13.79	15.84	16.88	2.05	1.04	0.42	-0.18	25.09	9.75	-0.0503				7.90	-5.50
PUREF	13.79	13.79	13.79	0	0	0.00	-0.60	21.96	8.67	-0.1498					-16.37
PUBLANK	13.65	13.65	13.65	0	0	453.47	452.87	21.68	8.53	111.3896					12178.51
MU1	13.78	15.87	16.85	2.09	0.98	0.74	0.14	24.80	9.43	0.0387				7.63	4.24
MU2	13.76	15.73	16.64	1.97	0.91	0.61	0.01	24.70	9.47	0.0019				7.73	0.21
MU3	13.80	15.89	16.90	2.09	1.01	0.59	-0.01	24.92	9.53	-0.0025				7.73	-0.27
MUREF	13.87	13.87	13.87	0	0	0.87	0.27	21.95	8.58	0.0678				10.03	7.41
MUBLANK	13.86	13.86	13.86	0	0	479.36	478.76	21.87	8.51	118.7138				3.60	12979.29
CS1	13.86	15.86	17.54	2.00	1.68	0.67	0.07	25.40	9.54	0.0428				9.94	4.01
CS2	13.76	15.76	17.32	2.00	1.56	0.56	-0.04	25.64	9.88	-0.0243				9.74	-2.28
CS3	13.78	15.78	16.96	2.00	1.18	0.55	-0.05	24.88	9.10	-0.0282				10.17	-2.64
CSREF	13.92	13.92	13.92	0	0	143.44	142.84	21.84	7.92	71.4205				11.61	6702.37
CSBLANK	13.98	13.98	13.98	0	0	301.35	300.75	21.94	7.96	151.1350					14183.09

TABLE B-6

Lead 5x Results

Counting done on 4 mL samples, Pb-210 background for 4 mL sample is 0.599 cpm

1 CPM = 0.101 ng Pb

5x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	Pb-210 (cpm/4 mL)	Pb-210 - bgrd (cpm/4 mL)	tube + soil + water (grams)	total water (grams)	corrected Pb-210 (cpm/mL)	ref - Pb-210 (cpm/mL)	Pb-210 (cpm/g)	adsorption ratio (mL/g)	pH (std. units)	Pb-210 (pCi/ml)
CW 1	13.75	15.83	16.81	2.08	0.98	0.65	0.06	24.82	9.49	0.017				8.59	1.85
CW2	13.97	16.08	17.09	2.11	1.01	0.53	-0.06	25.08	9.50	-0.017				8.59	-1.85
CW3	13.81	15.95	16.98	2.14	1.03	0.62	0.03	24.98	9.53	0.008				8.56	0.93
CWREF	13.74	13.74	13.74	0	0	183.23	182.64	21.65	8.41	45.660				11.49	4992.13
CWBLANK	13.76	13.76	13.76	0	0	532.60	532.01	21.74	8.48	134.110					14662.55
MW1	13.79	15.80	16.90	2.01	1.10	0.55	-0.04	24.97	9.67	-0.01128				8.08	-1.23
MW2	13.86	15.95	16.91	2.09	0.96	0.61	0.02	24.96	9.51	0.00555				8.06	0.61
MW3	13.80	15.77	16.61	1.97	0.84	0.62	0.03	24.70	9.43	0.00825				8.06	0.90
MWREF	13.76	13.76	13.76	0	0	1.61	1.02	21.83	8.57	0.25500				10.06	27.88
MWBLANK	13.86	13.86	13.86	0	0	525.22	524.63	21.82	8.46	129.47403					14155.74
PW1	14.01	16.16	17.13	2.15	0.97	0.65	0.06	25.21	9.55	0.016				7.21	1.80
PW2	13.81	15.84	16.81	2.03	0.97	0.33	-0.26	25.02	9.68	-0.072				7.26	-7.91
PW3	13.80	15.89	16.89	2.09	1.00	0.37	-0.22	25.08	9.69	-0.061				7.29	-6.70
PWREF	13.83	13.83	13.83	0	0	0.37	-0.22	22.03	8.70	-0.056				7.90	-6.12
PWBLANK	13.75	13.75	13.75	0	0	448.40	447.81	21.74	8.49	109.250					11944.61
CU1	13.78	15.75	16.61	1.97	0.86	0.63	0.04	24.60	9.35	0.011				8.77	1.22
CU2	13.96	16.07	17.05	2.11	0.98	0.52	-0.07	25.03	9.46	-0.021				8.61	-2.28
CU3	13.80	15.93	16.90	2.13	0.97	0.51	-0.08	24.89	9.46	-0.022				8.60	-2.41
CUREF	13.97	13.97	13.97	0	0	193.34	192.75	21.86	8.39	48.188				11.54	5268.47
CUBLANK	13.98	13.98	13.98	0	0	446.04	445.45	21.96	8.48	112.557					12306.16
PU1	13.88	15.89	16.73	2.01	0.84	0.38	-0.21	24.96	9.57	-0.057				7.42	-6.21
PU2	13.87	15.98	16.92	2.11	0.94	0.48	-0.11	25.10	9.62	-0.030				7.41	-3.24
PU3	13.65	15.71	16.66	2.06	0.95	0.40	-0.19	24.88	9.67	-0.053				7.44	-5.82
PUREF	13.84	13.84	13.84	0	0	469.67	469.08	22.02	8.68	117.270				8.02	12821.44
PUBLANK	13.86	13.86	13.86	0	0			21.85	8.49						
MU1	13.86	15.90	16.80	2.04	0.90	0.44	-0.15	24.84	9.44	-0.04111				7.88	-4.50
MU2	13.98	15.90	16.76	1.92	0.86	0.33	-0.26	24.92	9.52	-0.07270				7.88	-7.95
MU3	13.79	15.95	16.88	2.16	0.93	0.68	0.09	24.94	9.49	0.02480				7.85	2.71
MUREF	13.70	13.70	13.70	0	0	1.89	1.30	21.81	8.61	0.32500				10.18	35.53
MUBLANK	13.96	13.96	13.96	0	0	531.84	531.25	21.96	8.50	131.11571					14335.23
CS counting samples only contain 2 mL															
CS1	13.71	15.71	17.19	2.00	1.48	0.51	-0.08	25.12	9.91	0.000				10.06	0.00
CS2	13.78	15.78	16.84	2.00	1.06	0.64	0.05	24.79	9.51	0.027				10.44	2.52
CS3	13.75	15.75	17.05	2.00	1.30	0.64	0.05	25.00	9.75	0.030				10.17	2.80
CSREF	13.97	13.97	13.97	0	0	128.70	128.11	21.90	8.43	63.527				11.59	5961.66
CSBLANK	13.86	13.86	13.86	0	0	320.57	319.98	21.84	8.48	159.614					14978.75

TABLE B-7

Radium 0.2x Results

Counting done on 4 mL samples, Ra-226 background for 4 mL sample is 1.12 cpm

1 CPM = 0.202 ng Ra-226

0.2x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	Ra-226 (cpm/4 mL)	Ra-226 - bgrd (cpm/4 mL)	tube + soil + water (grams)	total water (grams)	corrected Ra-226 (cpm/mL)	ref - Ra-226 (cpm/mL)	Ra-226 (cpm/g)	adsorption ratio (mL/g)	pH (std. units)	Ra-226 (pCi/ml)
CW 1	13.80	15.89	16.77	2.09	0.88	1.12	0.00	24.78	9.39	0.0000	14.6763	60.1094		8.02	0.00
CW2	13.79	15.70	16.51	1.91	0.81	1.11	-0.01	24.52	9.32	-0.0030				7.95	-0.60
CW3	14.03	16.13	16.98	2.10	0.85	1.02	-0.10	24.97	9.34	-0.0265				7.93	-5.34
CWREF	13.73	13.73	13.73	0	0	61.93	60.81	21.79	8.56	15.2025	-0.5262			11.31	3070.29
CWBLANK	13.82	13.82	13.82	0	0	1.23	0.11	21.84	8.52	0.0274	14.6489				5.53
MW1	13.75	15.78	16.52	2.03	0.74	0.92	-0.20	24.49	9.21	-0.0533				7.79	-10.76
MW2	13.73	15.67	16.47	1.94	0.80	0.84	-0.28	24.48	9.31	-0.0771				7.80	-15.58
MW3	13.84	15.87	16.73	2.03	0.86	0.99	-0.13	24.72	9.35	-0.0363				7.71	-7.32
MWREF	14.02	14.02	14.02	0	0	18.14	17.02	22.03	8.51	4.2550	1.7413			9.87	859.34
MWBLANK	13.84	13.84	13.84	0	0	44.43	43.31	21.82	8.48	10.7893	-4.7931				2179.01
PW1	13.88	15.95	16.88	2.07	0.93	1.12	0.00	25.08	9.63	0.0000	14.0325	58.7060		7.63	0.00
PW2	13.89	15.87	16.68	1.98	0.81	1.08	-0.04	24.82	9.45	-0.0109				7.63	-2.20
PW3	13.82	15.78	16.56	1.96	0.78	1.05	-0.07	24.64	9.36	-0.0189				7.66	-3.82
PWREF	13.85	13.85	13.85	0	0	53.48	52.36	22.01	8.66	13.0000	0.9425			8.27	2643.65
PWBLANK	13.79	13.79	13.79	0	0	23.94	22.82	21.82	8.53	5.6194	8.4131				1134.88
CU1	13.79	15.81	16.62	2.02	0.81	1.47	0.35	24.60	9.29	0.0966	14.5797	61.2780	694	7.85	19.50
CU2	13.79	15.87	16.68	2.08	0.81	1.52	0.40	24.68	9.31	0.1097	14.5666	59.4569	595	7.74	22.15
CU3	13.72	15.66	16.56	1.94	0.90	1.48	0.36	24.45	9.29	0.0985	14.5778	63.7965	709	7.80	19.89
CUREF	13.85	13.85	13.85	0	0	57.72	56.60	21.84	8.49	14.1500	0.5262			11.28	2857.73
CUBLANK	13.89	13.89	13.89	0	0	24.06	22.93	21.89	8.50	5.7393	8.9370			7.70	1159.10
PU1	14.05	16.05	16.80	2.00	0.75	1.31	0.19	24.93	9.38	0.0518	13.9807	59.8374	1260	7.31	10.46
PU2	13.77	15.81	16.61	2.04	0.80	1.36	0.24	24.79	9.48	0.0661	13.9664	58.6039	977	7.33	13.36
PU3	13.98	16.00	16.77	2.02	0.77	1.39	0.27	24.85	9.35	0.0734	13.9591	59.1535	876	7.40	14.82
PUREF	13.90	13.90	13.90	0	0	61.02	59.90	21.96	8.56	14.9750	-0.9425			8.09	3024.34
PUBLANK	13.66	13.66	13.66	0	0	40.87	39.75	21.68	8.52	9.8911	4.1414				1997.59
MU1	13.81	15.80	16.58	1.99	0.78	1.46	0.34	24.57	9.27	0.0926	5.9037	25.2463	297	7.42	18.70
MU2	13.85	15.80	16.53	1.95	0.73	1.53	0.41	24.53	9.23	0.1112	5.8851	25.6831	251	7.62	22.45
MU3	13.78	15.88	16.65	2.10	0.77	1.57	0.45	24.63	9.25	0.1223	5.8740	23.8036	212	7.57	24.70
MUREF	13.83	13.83	13.83	0	0	32.07	30.95	21.84	8.51	7.7375	-1.7413			9.84	1562.66
MUBLANK	13.85	13.85	13.85	0	0	52.72	51.60	21.87	8.52	12.9152	-6.9189				2608.34
CS counting samples only contain 2 mL															
CS1	13.79	15.79	17.27	2.00	1.48	1.23	0.11	25.27	9.98	0.0650	18.9250	79.8634	1452	9.54	21.27
CS2	13.73	15.73	17.43	2.00	1.70	1.02	-0.10	25.46	10.23	-0.0588				8.74	-19.22
CS3	14.05	16.05	17.51	2.00	1.46	1.16	0.04	25.52	9.97	0.0236	18.9664	80.0381	4002	9.46	7.73
CSREF	13.82	13.82	13.82	0	0	39.10	37.98	21.76	8.44	18.9900	0.0000			11.31	6209.39
CSBLANK	13.88	13.88	13.88	0	0	20.25	19.13	21.90	8.52	9.6557	9.3343				3157.23

Corrected volumes are obtained using Ra-226 minus background counts, dividing by 4 mL, multiplying the result by total water volume (assuming 1 gram = 1 mL), and dividing by the total water volume for the reference cell [e.g., for CU1: ((0.35 cpm/4 mL)*9.29 mL)/8.49 mL) = corrected volume activity of 0.0966 cpm/mL]

CPM removed from solution is obtained by taking the volume corrected, reference average for CUref and CWref cells and subtracting the activity entered for the corrected volumes [e.g., for CU1: ((14.15 cpm/mL + 15.2025 cpm/mL)/2) - 0.0966 cpm/mL = 14.5797 cpm/mL]

CPM on solids is obtained by multiplying the CPM removed from solution by the total water in the reference cell and dividing by the reported dry soil mass [e.g., for CU1: ((14.5797 cpm/mL * 8.49 mL)/2.02 g) = 61.278 cpm/g]

Adsorption ratio is obtained by dividing the CPM on solids by the CPM reported for Ra-226 minus background normalized to 1 mL [e.g., for CU1: (61.278 cpm/g)/(0.35 cpm/4 mL) = 694 mL/g]

TABLE B-8

Radium 1x Results

Counting done on 4 mL samples, Ra-226 background for 4 mL sample is 1.12 cpm

1 CPM = 0.202 ng Ra-226

1x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	Ra-226 (cpm/4 mL)	Ra-226 - bgrd (cpm/4 mL)	tube + soil + water (grams)	total water (grams)	corrected Ra-226 (cpm/mL)	ref - Ra-226 (cpm/mL)	Ra-226 (cpm/g)	adsorption ratio (mL/g)	pH (std. units)	Ra-226 (pCi/ml)
CW 1	13.78	15.96	16.88	2.18	0.92	1.36	0.24	24.87	9.41	0.0669	53.5106	207.1695	3453	7.90	13.51
CW2	13.78	15.90	16.83	2.12	0.93	1.34	0.22	24.83	9.43	0.0615	53.5160	213.0545	3874	8.23	12.41
CW3	13.74	15.75	16.59	2.01	0.84	1.16	0.04	24.65	9.40	0.0111	53.5664	224.9254	22493	8.11	2.25
CWREF	14.03	14.03	14.03	0	0	215.13	214.01	21.97	8.44	53.5025	0.0750			11.30	10805.34
CWBLANK	13.77	13.77	13.77	0	0	85.36	84.24	21.79	8.52	21.2596	32.3179				4293.58
MW1	13.80	15.75	16.58	1.95	0.83	1.28	0.16	24.85	9.60	0.0441	38.2209	170.7201	4268	7.85	8.90
MW2	13.85	15.89	16.69	2.04	0.80	1.21	0.09	24.94	9.55	0.0247	38.2403	163.2712	7256	7.81	4.98
MW3	13.75	15.74	16.50	1.99	0.76	1.27	0.15	24.77	9.53	0.0410	38.2240	167.3019	4461	7.83	8.29
MWREF	13.85	13.85	13.85	0	0	152.45	151.33	22.06	8.71	37.8325	0.4325			10.19	7640.63
MWBLANK	13.90	13.90	13.90	0	0	109.59	108.47	21.91	8.51	26.4948	11.7702				5350.88
PW1	13.80	15.90	16.79	2.10	0.89	1.23	0.11	25.02	9.62	0.0301	57.6637	241.3636	8777	8.18	6.08
PW2	13.84	15.83	16.67	1.99	0.84	0.74	-0.38	24.91	9.58	-0.1035				8.03	-20.91
PW3	14.02	16.18	17.11	2.16	0.93	1.27	0.15	25.31	9.63	0.0411	57.6527	234.6143	6256	8.03	8.30
PWREF	13.92	13.92	13.92	0	0	239.24	238.12	22.21	8.79	59.5300	-1.8363			8.32	12022.65
PWBLANK	13.80	13.80	13.80	0	0	94.82	93.70	21.85	8.55	22.7854	34.9063				4601.73
CU1	13.75	15.74	16.51	1.99	0.77	3.29	2.17	24.48	9.24	0.5932	52.9843	224.9835	415	8.21	119.81
CU2	13.86	15.92	16.68	2.06	0.76	3.02	1.90	24.67	9.25	0.5200	53.0575	217.6389	458	8.13	105.01
CU3	13.78	15.73	16.54	1.95	0.81	2.82	1.70	24.59	9.36	0.4694	53.1081	230.1352	543	8.06	94.80
CUREF	14.04	14.04	14.04	0	0	215.73	214.61	21.99	8.45	53.6525	-0.0750			11.24	10835.63
CUBLANK	13.97	13.97	13.97	0	0			21.95	8.48						0.00
PU1	13.75	15.85	16.62	2.10	0.77	1.92	0.80	24.75	9.40	0.2124	57.4813	242.2427	1211	7.99	42.90
PU2	13.74	15.66	16.43	1.92	0.77	1.83	0.71	24.55	9.39	0.1883	57.5054	265.0640	1493	7.85	38.04
PU3	13.79	15.84	16.62	2.05	0.78	1.87	0.75	24.71	9.37	0.1985	57.4952	248.2111	1324	7.76	40.09
PUREF	13.73	13.73	13.73	0	0	224.55	223.43	22.06	8.85	55.8575	1.8363			8.31	11280.96
PUBLANK	13.70	13.70	13.70	0	0	82.05	80.93	21.73	8.53	19.5009	38.1928			8.87	3938.40
MU1	13.80	15.74	16.52	1.94	0.78	2.39	1.27	24.69	9.45	0.3457	37.9193	169.6597	534	7.94	69.81
MU2	13.82	15.88	16.73	2.06	0.85	2.60	1.48	24.92	9.54	0.4067	37.8583	159.5196	431	7.62	82.13
MU3	13.76	15.70	16.50	1.94	0.80	2.70	1.58	24.68	9.48	0.4325	37.8325	169.2712	427	7.64	87.35
MUREF	13.98	13.98	13.98	0	0	155.91	154.79	22.16	8.68	38.6975	-0.4325			9.13	7815.33
MUBLANK	13.75	13.75	13.75	0	0	130.52	129.40	21.76	8.51	31.7164	6.5486				6405.43
CS counting samples only contain 2 mL															
CS1	13.82	15.82	17.29	2.00	1.47	1.61	0.49	25.27	9.95	0.2865	61.5235	261.7827	1069	8.73	93.67
CS2	13.86	15.86	17.27	2.00	1.41	1.67	0.55	25.31	9.95	0.3215	61.4885	261.6334	951	8.73	105.14
CS3	13.97	15.97	17.72	2.00	1.75	1.33	0.21	25.70	10.23	0.1262	61.6838	262.4645	2500	9.44	41.27
CSREF	13.82	13.82	13.82	0	0	124.74	123.62	21.83	8.51	61.8100	0.0000			11.29	20210.76
CSBLANK	13.82	13.82	13.82	0	0	28.85	27.73	21.79	8.47	13.7998	48.0102				4512.30

Corrected volumes are obtained using Ra-226 minus background counts, dividing by 4 mL, multiplying the result by total water volume (assuming 1 gram = 1 mL), and dividing by the total water volume for the reference cell [e.g., for CU1: ((2.17 cpm/4 mL)*9.24 mL)/8.45 mL) = corrected volume activity of 0.5932 cpm/mL]

CPM removed from solution is obtained by taking the volume corrected, reference average for CUref and CWref cells and subtracting the activity entered for the corrected volumes [e.g., for CU1: ((53.5025 cpm/mL + 53.6525 cpm/mL)/2) - 0.5932 cpm/mL = 52.9843 cpm/mL]

CPM on solids is obtained by multiplying the CPM removed from solution by the total water in the reference cell and dividing by the reported dry soil mass [e.g., for CU1: ((52.9843 cpm/mL * 8.45 mL)/1.99g) = 224.9835 cpm/g]

Adsorption ratio is obtained by dividing the CPM on solids by the CPM reported for Ra-226 minus background normalized to 1 mL [e.g., for CU1: (224.9835 cpm/g)/(2.17 cpm/4 mL) = 415 mL/g]

TABLE B-9

Radium 5x Results

Counting done on 4 mL samples, Ra-226 background for 4 mL sample is 1.12 cpm

1 CPM = 0.202 ng Ra-226

5x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	Ra-226 (cpm/4 mL)	Ra-226 - bgrd (cpm/4 mL)	tube + soil + water (grams)	total water (grams)	corrected Ra-226 (cpm/mL)	ref - Ra-226 (cpm/mL)	Ra-226 (cpm/g)	adsorption ratio (mL/g)	pH (std. units)	Ra-226 (pCi/ml)
CW 1	13.88	15.89	16.75	2.01	0.86	1.76	0.64	24.77	9.38	0.1768	166.8820	704.8895	4406	8.05	35.70
CW2	13.77	15.78	16.71	2.01	0.93	1.60	0.48	24.69	9.41	0.1330	166.9257	705.0744	5876	8.24/8.21	26.86
CW3	13.79	15.82	16.70	2.03	0.88	1.58	0.46	24.70	9.38	0.1271	166.9317	698.1528	6071	8.11	25.66
CWREF	13.80	13.80	13.80	0	0	633.93	632.81	21.79	8.49	158.2025	8.8563			10.31	31950.50
CWBLANK	13.81	13.81	13.81	0	0	597.45	596.33	21.75	8.44	148.2045	18.8542			7.70	29931.31
MW1	13.65	15.69	16.53	2.04	0.84	1.55	0.43	24.50	9.31	0.1182	145.3031	603.2927	5612	7.55	23.86
MW2	13.76	15.76	16.56	2.00	0.80	1.65	0.53	24.54	9.28	0.1438	145.2774	615.2500	4688	7.61	29.04
MW3	13.97	16.02	16.91	2.05	0.89	1.51	0.39	24.89	9.37	0.1070	145.3142	600.3958	6206	7.62	21.62
MWREF	13.94	13.94	13.94	0	0	577.05	575.93	21.91	8.47	143.9625	1.4388			10.06	29078.63
MWBLANK	13.84	13.84	13.84	0	0	605.26	604.14	21.78	8.44	150.5000	-5.0788				30394.91
PW1	13.79	15.94	16.86	2.15	0.92	1.47	0.35	24.84	9.40	0.0963	182.7312	719.8760	8298	7.85	19.44
PW2	13.80	15.94	16.87	2.14	0.93	1.36	0.24	24.88	9.44	0.0669	182.7606	723.3563	12056	8.00	13.51
PW3	13.80	15.75	16.54	1.95	0.79	1.50	0.38	24.46	9.21	0.1033	182.7242	793.6790	8355	7.86	20.86
PWREF	13.83	13.83	13.83	0	0	757.92	756.20	21.80	8.47	189.0500	-6.2225			8.40	38180.44
PWBLANK	13.77	13.77	13.77	0	0	543.91	542.79	21.73	8.46	135.5373	47.2902				27373.04
CU1	13.82	15.88	16.69	2.06	0.81	5.96	4.84	24.68	9.30	1.3254	165.7333	683.0465	565	8.00	267.69
CU2	13.75	15.76	16.52	2.01	0.76	6.86	5.74	24.49	9.23	1.5601	165.4987	699.0466	487	8.06	315.07
CU3	13.86	15.90	16.72	2.04	0.82	7.92	6.80	24.72	9.32	1.8662	165.1926	687.4925	404	7.98	376.90
CUREF	13.74	13.74	13.74	0	0	704.78	703.66	21.73	8.49	175.9150	-8.8563			11.28	35527.70
CUBLANK	13.78	13.78	13.78	0	0	556.01	554.89	21.87	8.59	140.3565	26.7023				28346.32
PU1	13.77	15.74	16.45	1.97	0.71	4.29	3.17	24.50	9.26	0.8634	181.9641	785.1245	991	7.55	174.36
PU2	13.76	15.88	16.65	2.12	0.77	4.22	3.10	24.61	9.23	0.8416	181.9859	729.6606	941	7.70	169.96
PU3	13.76	15.71	16.50	1.95	0.79	4.28	3.16	24.45	9.24	0.8588	181.9687	793.1970	1004	7.67	173.44
PUREF	13.92	13.92	13.92	0	0	707.54	706.42	21.92	8.50	176.6050	6.2225			8.31	35667.06
PUBLANK	13.79	13.79	13.79	0	0	554.23	553.11	21.85	8.56	139.2536	43.5739				28123.58
MU1	13.89	15.84	16.54	1.95	0.70	6.64	5.52	24.52	9.18	1.4939	143.9273	625.8994	454	7.78	301.71
MU2	13.76	15.77	16.54	2.01	0.77	6.41	5.29	24.52	9.25	1.4426	143.9787	607.4324	459	7.83	291.34
MU3	13.94	15.99	16.79	2.05	0.80	7.10	5.98	24.77	9.28	1.6360	143.7852	594.7798	398	7.84	330.41
MUREF	13.79	13.79	13.79	0	0	588.56	587.44	21.77	8.48	146.8600	-1.4388			10.23	29659.77
MUBLANK	13.84	13.84	13.84	0	0	576.64	575.52	21.81	8.47	143.7103	1.7109			8.20	29023.67
CS counting samples only contain 2 mL															
CS1	13.78	15.78	17.78	2.00	2.00	2.22	1.10	25.76	10.48	0.6757	203.4043	867.5192	1577	9.21	220.95
CS2	13.78	15.78	17.41	2.00	1.63	2.43	1.31	25.42	10.14	0.7786	203.3014	867.0804	1324	9.18	254.60
CS3	13.78	15.78	17.05	2.00	1.27	2.38	1.26	25.05	9.77	0.7216	203.3584	867.3237	1377	9.75	235.94
CSREF	13.81	13.81	13.81	0	0	409.28	408.16	21.84	8.53	204.0800	0.0000			11.30	66730.49
CSBLANK	13.90	13.90	13.90	0	0	260.94	259.82	21.96	8.56	130.3669	73.7131				42627.63

Corrected volumes are obtained using Ra-226 minus background counts, dividing by 4 mL, multiplying the result by total water volume (assuming 1 gram = 1 mL), and dividing by the total water volume for the reference cell [e.g., for CU1: ((4.84 cpm/4 mL)*9.30mL)/8.49 mL) = corrected volume activity of 1.3254 cpm/mL]

CPM removed from solution is obtained by taking the volume corrected, reference average for CUref and CWref cells and subtracting the activity entered for the corrected volumes [e.g., for CU1: ((158.2025 cpm/mL + 175.915 cpm/mL)/2) - 1.3254 cpm/mL = 165.7333 cpm/mL]

CPM on solids is obtained by multiplying the CPM removed from solution by the total water in the reference cell and dividing by the reported dry soil mass [e.g., for CU1: ((165.7333 cpm/mL * 8.49 mL)/2.06 g) = 683.0465 cpm/g]

Adsorption ratio is obtained by dividing the CPM on solids by the CPM reported for Ra-226 minus background normalized to 1 mL [e.g., for CU1: (683.0465 cpm/g)/(4.84 cpm/4 mL) = 565 mL/g]

TABLE B-10

Technetium 0.2x Results

Counting done on 2 mL samples, Tc-99 background for 2 mL sample is 91.2 cpm

1 CPM = 0.02777 ng Tc-99

0.2x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	Tc-99 (cpm/2 mL)	Tc-99 - bgrd (cpm/2 mL)	total water (grams)	corrected Tc-99 (cpm/mL)	ref - Tc-99 (cpm/mL)	Tc-99 (cpm/g)	adsorption ratio (mL/g)
CW1	13.65	18.63	20.79	4.98	2.16	209	117.8	21.66	32.71			
CW2	13.8	18.64	20.83	4.84	2.19	163	71.8	21.69	19.97			
CW3	13.81	18.44	20.63	4.63	2.19	151	59.8	21.69	16.63	3.07	12.93	0.865
CWREF	13.78	13.78	13.78	0	0	173	81.8	19.50	20.45	-0.75		
CWBLANK	13.82	13.82	13.82	0	0	167	75.8	19.50	18.95	0.75		
MW1	13.79	18.66	20.82	4.87	2.16	169	77.8	21.66	21.60			
MW2	13.96	18.84	21.05	4.88	2.21	157	65.8	21.71	18.31	0.39	1.54	0.094
MW3	13.84	18.89	21.05	5.05	2.16	163	71.8	21.66	19.94			
MWREF	13.84	13.84	13.84	0	0	166	74.8	19.50	18.70	0.00		
MWBLANK	13.86	13.86	13.86	0	0	170	78.8	19.50	19.70	-1.00		
PW1	13.76	18.63	20.86	4.87	2.23	164	72.8	21.73	20.28			
PW2	13.93	18.69	20.89	4.76	2.2	155	63.8	21.70	17.75	1.45	5.94	0.373
PW3	13.91	18.82	21.11	4.91	2.29	161	69.8	21.79	19.50			
PWREF	13.88	13.88	13.88	0	0							
PWBLANK	13.84	13.84	13.84	0	0	165	73.8	19.50	18.45	0.75		
CU1	14.02	19.06	21.07	5.04	2.01	179	87.8	21.51	24.21			
CU2	13.76	18.83	20.79	5.07	1.96	157	65.8	21.46	18.10	1.60	6.14	0.373
CU3	13.82	18.77	20.72	4.95	1.95	160	68.8	21.45	18.92	0.78	3.07	0.179
CUREF	13.76	13.76	13.76	0	0	167	75.8	19.50	18.95	0.75		
CUBLANK	13.8	13.8	13.8	0	0	167	75.8	19.50	18.95	0.75		
PU1	13.85	18.75	20.75	4.9	2	153	61.8	21.50	17.03	2.17	8.62	0.558
PU2	13.77	18.76	20.73	4.99	1.97	156	64.8	21.47	17.84	1.36	5.33	0.329
PU3	13.79	18.69	20.67	4.9	1.98	156	64.8	21.48	17.84	1.36	5.39	0.333
PUREF	13.89	13.89	13.89	0	0	168	76.8	19.50	19.20	0.00		
PUBLANK	13.96	13.96	13.96	0	0	165	73.8	19.50	18.45	0.75		
MU1	13.65	18.56	20.47	4.91	1.91	157	65.8	21.41	18.06	0.64	2.54	0.154
MU2	13.8	18.77	20.68	4.97	1.91	153	61.8	21.41	16.96	1.74	6.81	0.441
MU3	13.77	18.65	20.53	4.88	1.88	159	67.8	21.38	18.58	0.12	0.46	0.027
MUREF	13.77	13.77	13.77	0	0							
MUBLANK	13.74	13.74	13.74	0	0	167	75.8	19.50	18.95	-0.25		
CS1	13.79	18.83	22.94	5.04	4.11	155	63.8	23.61	19.31	1.39	5.37	0.337
CS2	13.77	18.75	23.05	4.98	4.3	155	63.8	23.80	19.47	1.23	4.83	0.303
CS3	13.64	18.67	22.8	5.03	4.13	147	55.8	23.63	16.90	3.80	14.71	1.055
CSREF	13.94	13.94	13.94	0	0	174	82.8	19.50	20.70	0.00		
CSBLANK	13.85	13.85	13.85	0	0	166	74.8	19.50	18.70	2.00		

Corrected volumes are obtained using Tc-99 minus background counts, dividing by 2 mL, multiplying the result by total water volume (assuming 1 g = 1 mL), and dividing by the total water volume for the reference cell [e.g., for CW3: ((59.8 cpm/2 mL)*21.69 mL)/19.5 mL) = corrected volume activity of 16.63 cpm/mL]

CPM removed from solution is obtained by taking the volume corrected, reference average for CWref and CUref cells and subtracting the activity entered for the corrected volumes [e.g., for CW3: ((20.45 cpm/mL + 18.95 cpm/mL)/2) - 16.63 cpm/mL = 3.07 cpm/mL]

CPM on solids is obtained by multiplying the CPM removed from solution by the total water in the reference cell and dividing by the reported dry soil mass [e.g., for CW3: ((3.07 cpm/mL * 19.50 mL)/4.63g) = 12.93 cpm/g]

Adsorption ratio is obtained by dividing the CPM on solids by the CPM reported for Tc-99 minus background normalized to 1 mL [e.g., for CW3: (12.93 cpm/g)/(59.8 cpm/2 mL) = 0.865 mL/g]

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TABLE B-11

Technetium 1x Results

Counting done on 2 mL samples, Tc-99 background for 2 mL sample is 81.3 cpm

1 CPM = 0.02777 ng Tc-99

1x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	Tc-99 (cpm/2 mL)	Tc-99 - bgrd (cpm/2 mL)	total water (grams)	corrected Tc-99 (cpm/mL)	ref - Tc-99 (cpm/mL)	Tc-99 (cpm/g)	adsorption ratio (mL/g)
CW1	13.74	18.7	20.89	4.96	2.19	198	116.7	21.69	64.9	6.95	27.31	0.468
CW2	13.8	18.75	21.06	4.95	2.31	203	121.7	21.81	68.1	3.79	14.94	0.245
CW3	13.84	18.91	21.19	5.07	2.28	202	120.7	21.78	67.4	4.44	17.09	0.283
CWREF	13.73	13.73	13.73	0	0	231	149.7	19.5	74.9	-3.00		
CWBLANK	13.86	13.86	13.86	0	0	210	128.7	19.5	64.4	7.50		
MW1	13.78	18.76	20.98	4.98	2.22	201	119.7	21.72	66.7	1.94	7.58	0.127
MW2	13.81	18.82	21.28	5.01	2.46	211	129.7	21.96	73.0			
MW3	14.02	18.97	21.34	4.95	2.37	197	115.7	21.87	64.9	3.72	14.65	0.253
MWREF	13.87	13.87	13.87	0	0	217	135.7	19.5	67.9	0.75		
MWBLANK	13.81	13.81	13.81	0	0	218	136.7	19.5	68.4	0.25		
PW1	13.8	18.82	20.97	5.02	2.15	202	120.7	21.65	67.0	5.60	21.74	0.360
PW2	13.97	18.91	21.06	4.94	2.15	204	122.7	21.65	68.1	4.49	17.71	0.289
PW3	13.75	18.79	21.09	5.04	2.3	209	127.7	21.8	71.4	1.22	4.72	0.074
PWREF	13.89	13.89	13.89	0	0	220	138.7	19.5	69.4	3.25		
PWBLANK	13.8	13.8	13.8	0	0	210	128.7	19.5	64.4	8.25		
CU1	13.72	18.81	20.73	5.09	1.92	202	120.7	21.42	66.3	5.56	21.29	0.353
CU2	13.79	18.77	20.71	4.98	1.94	220	138.7	21.44	76.2			
CU3	13.81	18.75	20.74	4.94	1.99	204	122.7	21.49	67.6	4.24	16.73	0.273
CUREF	13.78	13.78	13.78	0	0	219	137.7	19.5	68.9	3.00		
CUBLANK	13.88	13.88	13.88	0	0	212	130.7	19.5	65.4	6.50		
PU1	13.78	18.76	20.81	4.98	2.05	224	142.7	21.55	78.9			
PU2	13.79	18.84	20.86	5.05	2.02	247	165.7	21.52	91.4			
PU3	13.78	18.82	20.9	5.04	2.08	199	117.7	21.58	65.1	7.47	28.91	0.491
PUREF	13.86	13.86	13.86	0	0	233	151.7	19.5	75.9	-3.25		
PUBLANK	13.85	13.85	13.85	0	0	224	142.7	19.5	71.4	1.25		
MU1	13.8	18.71	20.66	4.91	1.95	206	124.7	21.45	68.6	0.02	0.06	0.001
MU2	13.8	18.68	20.59	4.88	1.91	207	125.7	21.91	70.6			
MU3	13.8	18.75	20.73	4.95	1.98	207	125.7	21.48	69.2			
MUREF	13.8	13.8	13.8	0	0	220	138.7	19.5	69.4	-0.75		
MUBLANK	13.8	13.8	13.8	0	0	213	131.7	19.5	65.9	2.75		
CS1	13.79	18.79	22.48	5	3.69	204	122.7	23.19	73.0			
CS2	13.73	18.61	22.26	4.88	3.65	223	141.7	23.15	84.1			
CS3	13.83	18.87	23.05	5.04	4.18	185	103.7	23.68	63.0	4.89	18.90	0.365
CSREF	13.81	13.81	13.81	0	0	217	135.7	19.5	67.9	0.00		
CSBLANK	13.88	13.88	13.88	0	0	211	129.7	19.5	64.9	3.00		

Corrected volumes are obtained using Tc-99 minus background counts, dividing by 2 mL, multiplying the result by total water volume (assuming 1 g = 1 mL), and dividing by the total water volume for the reference cell [e.g., for CW3: ((120.7 cpm/2mL)*21.78 mL)/19.5 mL) = corrected volume activity of 67.4 cpm/mL]

CPM removed from solution is obtained by taking the volume corrected, reference average for CWref and CUref cells and subtracting the activity entered for the corrected volumes [e.g., for CW3: ((74.9 cpm/mL + 68.9 cpm/mL)/2) - 67.4 cpm/mL = 4.44 cpm/mL]

CPM on solids is obtained by multiplying the CPM removed from solution by the total water in the reference cell and dividing by the reported dry soil mass [e.g., for CW3: ((4.44 cpm/mL * 19.50 mL)/5.07 g) = 17.09 cpm/g]

Adsorption ratio is obtained by dividing the CPM on solids by the CPM reported for Tc-99 minus background normalized to 1 mL [e.g., for CW3: (17.09 cpm/g)/(120.7 cpm/2mL) = 0.283 mL/g]

TABLE B-12

Technetium 5x Results

Counting done on 2 mL samples, Tc-99 background for 2 mL sample is 81.3 cpm

1 CPM = 0.02777 ng Tc-99

5x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	Tc-99 (cpm/2 mL)	Tc-99 - bgrd (cpm/2 mL)	total water (grams)	corrected Tc-99 (cpm/mL)	ref - Tc-99 (cpm/mL)	Tc-99 (cpm/g)	adsorption ratio (mL/g)
CW1	13.79	18.8	20.86	5.01	2.06	698	617	21.56	341			
CW2	13.81	18.83	20.87	5.02	2.04	653	572	21.54	316	6.6	25.6	0.089
CW3	13.85	18.81	20.79	4.96	1.98	655	574	21.48	316	6.4	25.0	0.087
CWREF	13.74	13.74	13.74	0	0	714	633	19.5	317	6.0		
CWBLANK	13.83	13.83	13.83	0	0	677	596	19.5	298	24.5		
MW1	13.8	18.78	20.85	4.98	2.07	697	616	21.57	341			
MW2	13.96	18.93	21.05	4.97	2.12	694	613	21.62	340			
MW3	13.85	18.84	20.93	4.99	2.09	1013	932	21.59	516			
MWREF	13.78	13.78	13.78	0	0	687	606	19.5	303	2.3		
MWBLANK	13.91	13.91	13.91	0	0	686	605	19.5	303	2.8		
PW1	13.8	18.85	20.9	5.05	2.05	655	574	21.55	317	11.8	45.7	0.159
PW2	13.8	18.77	20.85	4.97	2.08	711	630	21.58	349			
PW3	13.99	19	21.12	5.01	2.12	647	566	21.62	314	15.2	59.3	0.210
PWREF	13.77	13.77	13.77	0	0	764	683	19.5	342	-12.5		
PWBLANK	13.95	13.95	13.95	0	0	689	608	19.5	304	25.0		
CU1	13.8	18.79	20.68	4.99	1.89	662	581	21.39	319	3.8	15.0	0.052
CU2	13.76	18.79	20.65	5.03	1.86	663	582	21.36	319	3.7	14.5	0.050
CU3	13.68	18.63	20.51	4.95	1.88	649	568	21.38	311	11.1	43.8	0.154
CUREF	13.8	13.8	13.8	0	0	738	657	19.5	329	-6.0		
CUBLANK	13.75	13.75	13.75	0	0	948	867	19.5	434	-111.0		
PU1	13.82	18.77	20.66	4.95	1.89	611	530	21.39	291	38.3	150.9	0.570
PU2	13.95	19.03	21.01	5.08	1.98	604	523	21.48	288	40.9	157.2	0.601
PU3	13.79	18.83	20.77	5.04	1.94	610	529	21.44	291	38.2	147.7	0.559
PUREF	14.04	14.04	14.04	0	0	714	633	19.5	317	12.5		
PUBLANK	13.79	13.79	13.79	0	0	670	589	19.5	295	34.5		
MU1	13.77	18.74	20.68	4.97	1.94	633	552	21.44	303	1.8	7.0	0.023
MU2	13.78	18.79	20.66	5.01	1.87	641	560	21.37	307			
MU3	13.84	18.9	20.85	5.06	1.95	643	562	21.45	309			
MUREF	13.73	13.73	13.73	0	0	696	615	19.5	308	-2.3		
MUBLANK	13.74	13.74	13.74	0	0	675	594	19.5	297	8.3		
CS1	13.65	18.67	23.96	5.02	5.29	583	502	24.79	319	5.9	23.0	0.072
CS2	13.87	18.89	23.13	5.02	4.24	584	503	23.74	306	18.8	73.1	0.239
CS3	13.73	18.75	23.17	5.02	4.42	609	528	23.92	324	1.2	4.5	0.014
CSREF	13.9	13.9	13.9	0	0	730	649	19.5	325	0.5		
CSBLANK	13.98	13.98	13.98	0	0	695	614	19.5	307	18.0		

Corrected volumes are obtained using Tc-99 minus background counts, dividing by 2 mL, multiplying the result by total water volume (assuming 1 g = 1 mL), and dividing by the total water volume for the reference cell [e.g., for CW3: ((574 cpm/2mL)*21.48 mL)/19.5 mL) = corrected volume activity of 316 cpm/mL]

CPM removed from solution is obtained by taking the volume corrected, reference average for CWref and CUref cells and subtracting the activity entered for the corrected volumes [e.g., for CW3: ((317 cpm/mL + 329 cpm/mL)/2) - 317 cpm/mL = 6.4 cpm/mL]

CPM on solids is obtained by multiplying the CPM removed from solution by the total water in the reference cell and dividing by the reported dry soil mass [e.g., for CW3: ((6.4 cpm/mL * 19.50 mL)/4.96 g) = 25.0 cpm/g]

Adsorption ratio is obtained by dividing the CPM on solids by the CPM reported for Tc-99 minus background normalized to 1 mL [e.g., for CW3: (25.0 cpm/g)/(574 cpm/2mL) = 0.087 mL/g]

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TABLE B-13

Uranium 0.2x Results

Counting done on 4 mL samples, U-232 background for 4 mL sample is 0 cpm
1 CPM = 0.64 ng U

0.2x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	U-232 (cpm/4 mL)	U-232 - bgrd (cpm/4 mL)	tube + soil + water (grams)	total water (grams)	corrected U-232 (cpm/mL)	ref - U-232 (cpm/mL)	U-232 (cpm/g)	adsorption ratio (mL/g)	pH (std. units)	U-232 (pCi/ml)
CW 1	13.80	15.72	16.58	1.92	0.86	0.93	0.93	24.56	9.34	0.2542				8.02	436.23
CW2	13.86	15.95	16.88	2.09	0.93	0.81	0.81	24.88	9.43	0.2238				8.00	384.06
CW3	13.87	15.72	16.59	1.85	0.87	1.61	1.61	24.58	9.36	0.4416				8.16	757.79
CWREF	13.79	13.79	13.79	0	0	0.00	0.00	21.80	8.51	0.0000				11.50	0.00
CWBLANK	13.74	13.74	13.74	0	0	29.73	29.73	21.71	8.47	7.3981					12695.09
MW1	13.79	15.73	16.60	1.94	0.87	1.52	1.52	24.67	9.44	0.4166				7.86	714.94
MW2	13.97	15.99	16.88	2.02	0.89	1.47	1.47	24.96	9.47	0.4042				7.80	693.62
MW3	13.74	15.65	16.47	1.91	0.82	2.53	2.53	24.47	9.32	0.6847				7.78	1174.87
MWREF	13.83	13.83	13.83	0	0	4.54	4.54	21.94	8.61	1.1350				8.66	1947.66
MWBLANK	13.77	13.77	13.77	0	0	25.50	25.50	21.83	8.56	6.3380					10875.98
PW1	13.68	15.75	16.65	2.07	0.90	3.25	3.25	24.75	9.50	0.8915	10.2448	42.8103	52.74	7.46	1529.75
PW2	13.79	15.86	16.77	2.07	0.91	3.40	3.40	24.92	9.56	0.9394	10.1968	42.6099	50.13	7.43	1612.05
PW3	13.89	16.00	16.94	2.11	0.94	3.08	3.08	24.98	9.48	0.8439	10.2924	42.1938	54.80	7.48	1448.11
PWREF	13.80	13.80	13.80	0	0	44.91	44.91	21.95	8.65	11.2275	-0.0912			8.02	19266.41
PWBLANK	13.72	13.72	13.72	0	0	0.30	0.30	21.84	8.62	0.0756	11.0607				129.71
CU1	13.83	15.76	16.55	1.93	0.79	3.67	3.67	24.52	9.26	1.0102				7.68	1733.56
CU2	13.76	15.86	16.70	2.10	0.84	3.25	3.25	24.69	9.33	0.9014				7.71	1546.77
CU3	13.79	15.91	16.76	2.12	0.85	3.46	3.46	24.71	9.30	0.9565				7.67	1641.42
CUREF	13.78	13.78	13.78	0	0	0.00	0.00	21.69	8.41	0.0000				11.40	0.00
CUBLANK	13.78	13.78	13.78	0	0	32.05	32.05	21.77	8.49	8.0687					13880.26
PU1	13.76	15.92	16.81	2.16	0.89	4.91	4.91	24.95	9.53	1.3509	9.7853	39.2319	31.96	7.64	2318.19
PU2	13.70	15.75	16.57	2.05	0.82	8.46	8.46	24.80	9.55	2.3321	8.8041	37.1921	17.59	7.72	4001.91
PU3	13.64	15.66	16.49	2.02	0.83	5.07	5.07	24.59	9.43	1.3796	9.7566	41.8280	33.01	7.70	2367.40
PUREF	13.78	13.78	13.78	0	0	44.18	44.18	21.94	8.66	11.0450	0.0912			8.15	18953.24
PUBLANK	13.90	13.90	13.90	0	0	31.60	31.60	21.88	8.48	7.7351	3.4012				13273.38
MU1	13.76	15.73	16.61	1.97	0.88	3.40	3.40	24.70	9.47	0.9338				7.60	1602.40
MU2	13.84	15.81	16.70	1.97	0.89	3.39	3.39	24.74	9.43	0.9282				7.50	1592.82
MU3	13.76	15.93	16.89	2.17	0.96	3.35	3.35	24.92	9.49	0.9231				7.55	1584.04
MUREF	13.83	13.83	13.83	0	0	1.13	1.13	21.94	8.81	0.2825				9.38	484.77
MUBLANK	13.79	13.79	13.79	0	0	31.78	31.78	21.79	8.50	7.8435					13459.45
CS counting samples only contain 2 mL															
CS1	13.86	15.86	16.97	2.00	1.11	0.30	0.30	24.97	9.61	0.0850				9.68/9.64	128.45
CS2	13.80	15.80	16.90	2.00	1.10	2.59	2.59	24.92	9.62	0.7348				8.82/8.80	1109.99
CS3	14.05	16.05	17.18	2.00	1.13	0.16	0.16	25.17	9.62	0.0451				9.80	68.15
CSREF	13.65	13.65	13.65	0	0	0.35	0.35	21.62	8.47	0.0873				11.48	131.80
CSBLANK	13.84	13.84	13.84	0	0	15.13	15.13	21.81	8.47	3.7825					5713.71

Corrected volumes are obtained using U-232 minus background counts, dividing by 4 mL, multiplying the result by total water volume (assuming 1 gram = 1 mL), and dividing by the total water volume for the reference cell [e.g., for PW1: ((3.25 cpm/4 mL)*9.50 mL)/8.65 mL) = corrected volume activity of 0.8915 cpm/mL]

CPM removed from solution is obtained by taking the volume corrected, reference average for PUref and PWref cells and subtracting the activity entered for the corrected volumes [e.g., for PW1: ((11.2275 cpm/mL + 11.0450 cpm/mL)/2) - 0.8915 cpm/mL = 10.2448 cpm/mL]

CPM on solids is obtained by multiplying the CPM removed from solution by the total water in the reference cell and dividing by the reported dry soil mass [e.g., for PW1: ((10.2448 cpm/mL * 8.65 mL)/2.07 g) = 42.8103 cpm/g]

Adsorption ratio is obtained by dividing the CPM on solids by the CPM reported for U-232 minus background normalized to 1 mL [e.g., for PW1: (42.8103 cpm/g)/(3.25 cpm/4 mL) = 52.7416 mL/g]

TABLE B-14

Uranium 1x Results

Counting done on 4 mL samples, U-232 background for 4 mL sample is 0 cpm

1 CPM = 1.98 ng U

1x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	U-232 (cpm/4 mL)	U-232 - bgrd (cpm/4 mL)	tube + soil + water (grams)	total water (grams)	corrected U-232 (cpm/mL)	ref - U-232 (cpm/mL)	U-232 (cpm/g)	adsorption ratio (mL/g)	pH (std. units)	U-232 (pCi/ml)
CW 1	13.86	15.87	16.87	2.01	1.00	0.23	0.23	24.89	9.52	0.0663				8.59	113.77
CW2	13.78	15.85	16.83	2.07	0.98	0.24	0.24	24.82	9.47	0.0676				8.54	116.08
CW3	13.66	15.74	16.69	2.08	0.95			24.65	9.41					8.62	
CWREF	13.88	13.88	13.88	0	0	0.13	0.13	21.78	8.40	0.0325				11.55	55.77
CWBLANK	13.77	13.77	13.77	0	0	44.28	44.28	21.77	8.50	11.2018					19222.28
MW1	13.98	15.93	16.95	1.95	1.02	1.57	1.57	24.97	9.54	0.4369				7.91	749.76
MW2	13.80	15.64	16.50	1.84	0.86	1.61	1.61	24.58	9.44	0.4434				8.00	760.81
MW3	14.05	16.07	17.06	2.02	0.99	1.43	1.43	25.16	9.59	0.4000				8.01	686.49
MWREF	13.75	13.75	13.75	0	0	5.52	5.52	21.82	8.57	1.3810				10.13	2369.80
MWBLANK	13.86	13.86	13.86	0	0	41.37	41.37	21.83	8.47	10.2218					17540.66
PW1	13.74	15.70	16.66	1.96	0.96	1.15	1.15	24.82	9.62	0.3186	10.4514	46.2846	160.99	8.18	546.78
PW2	13.76	15.97	17.04	2.21	1.07	2.88	2.88	25.09	9.62	0.7980	9.9720	39.1662	54.40	7.99	1369.32
PW3	13.86	15.89	16.93	2.03	1.04	3.83	3.83	25.06	9.67	1.0667	9.7033	41.4899	43.33	7.99	1830.47
PWREF	13.66	13.66	13.66	0	0	42.76	42.76	21.84	8.58	10.6900	0.0800			8.00	18344.06
PWBLANK	13.86	13.86	13.86	0	0	34.53	34.53	21.83	8.47	8.4236	2.3464			3.80	14455.00
CU1	13.74	15.80	16.77	2.06	0.97	2.62	2.62	24.72	9.42	0.5356				8.45	919.09
CU2	13.85	15.86	16.70	2.01	0.84	1.35	1.35	24.72	9.36	0.2742				8.62	470.56
CU3	14.07	16.00	16.96	1.93	0.96	1.53	1.53	24.94	9.44	0.3134				8.65	537.86
CUREF	13.92	13.92	13.92	0	0	0.60	0.60	24.94	11.52	0.1500				11.54	257.40
CUBLANK	13.90	13.90	13.90	0	0	50.99	50.99								
PU1	13.93	15.94	16.80	2.01	0.86	5.43	5.43	25.01	9.57	1.4984	9.2716	39.9924	29.46	7.83	2571.29
PU2	13.79	15.76	16.67	1.97	0.91	5.75	5.75	24.88	9.62	1.5950	9.1750	40.3793	28.09	7.81	2737.04
PU3	13.79	15.84	16.88	2.05	1.04	5.07	5.07	25.09	9.75	1.4254	9.3446	39.5209	31.18	7.90	2445.97
PUREF	13.79	13.79	13.79	0	0	43.40	43.40	21.96	8.67	10.8500	-0.0800				18618.62
PUBLANK	13.65	13.65	13.65	0	0	33.19	33.19	21.68	8.53	8.1635	2.6065				14008.61
MU1	13.78	15.87	16.85	2.09	0.98	3.83	3.83	24.80	9.43	1.0524				7.63	1805.85
MU2	13.76	15.73	16.64	1.97	0.91	3.97	3.97	24.70	9.47	1.0955				7.73	1879.80
MU3	13.80	15.89	16.90	2.09	1.01	4.13	4.13	24.92	9.53	1.1468				7.73	1967.95
MUREF	13.87	13.87	13.87	0	0	5.77	5.77	21.96	8.58	1.4425				10.03	2475.33
MUBLANK	13.86	13.86	13.86	0	0	46.56	46.56	21.87	8.51	11.5450				3.60	19811.30
CS counting samples only contain 2 mL															
CS1	13.86	15.86	17.54	2.00	1.68	0.18	0.18	25.40	10.04	0.1091				9.94	164.81
CS2	13.76	15.76	17.32	2.00	1.56	0.28	0.28	25.64	10.38	0.1751				9.74	264.43
CS3	13.78	15.78	16.96	2.00	1.18	0.10	0.10	24.88	9.60	0.0553				10.17	83.53
CSREF	13.92	13.92	13.92	0	0	0.40	0.40	21.84	8.42	0.2000				11.61	302.11
CSBLANK	13.96	13.96	13.96	0	0	26.93	26.93	21.94	8.46	13.5290					20436.38

Corrected volumes are obtained using U-232 minus background counts, dividing by 4 mL, multiplying the result by total water volume (assuming 1 gram = 1 mL), and dividing by the total water volume for the reference cell [e.g., for PW1: ((1.15 cpm/4 mL)*9.62mL)/8.68 mL) = corrected volume activity of 0.3186 cpm/mL]

CPM removed from solution is obtained by taking the volume corrected, reference average for PUref and PWref cells and subtracting the activity entered for the corrected volumes [e.g., for PW1: ((10.69 cpm/mL + 10.85 cpm/mL)/2) - 0.3186 cpm/mL = 10.4514 cpm/mL]

CPM on solids is obtained by multiplying the CPM removed from solution by the total water in the reference cell and dividing by the reported dry soil mass [e.g., for PW1: ((10.4514 cpm/mL * 8.68 mL)/1.96 g) = 46.2846 cpm/g]

Adsorption ratio is obtained by dividing the CPM on solids by the CPM reported for U-232 minus background normalized to 1 mL [e.g., for PW1: (46.2846 cpm/g)/(1.15 cpm/4 mL) = 160.99 mL/g]

TABLE B-15

Uranium 5x Results

Counting done on 4 mL samples, U-232 background for 4 mL sample is 0 cpm
1 CPM = 9.8 ng U

5x samples	empty tube (grams)	tube + soil dry (grams)	tube + soil wet (grams)	dry soil (grams)	pore water (grams)	U-232 (cpm/4 mL)	U-232 - bgrd (cpm/4 mL)	tube + soil + water (grams)	total water (grams)	corrected U-232 (cpm/mL)	ref - U-232 (cpm/mL)	U-232 (cpm/g)	adsorption ratio (mL/g)	pH (std. units)	U-232 (pCi/ml)
CW 1 5X	13.75	15.83	16.81	2.08	0.98	0.31	0.31	24.82	9.49	0.0875				8.59	150.07
CW2	13.97	16.08	17.09	2.11	1.01	0.20	0.20	25.08	9.50	0.0568				8.59	97.41
CW3	13.81	15.95	16.98	2.14	1.03	0.17	0.17	24.98	9.53	0.0482				8.56	82.64
CWREF	13.74	13.74	13.74	0	0	0.99	0.99	21.65	8.41	0.2475				11.49	424.71
CWBLANK	13.76	13.76	13.76	0	0	51.52	51.52	21.74	8.48	12.9872					22286.07
MW1	13.79	15.80	16.90	2.01	1.10	2.27	2.27	24.97	9.67	0.6403				8.08	1098.83
MW2	13.86	15.95	16.91	2.09	0.96	2.16	2.16	24.96	9.51	0.5992				8.06	1028.28
MW3	13.80	15.77	16.61	1.97	0.84	1.87	1.87	24.70	9.43	0.5144				8.06	882.73
MWREF	13.76	13.76	13.76	0	0	12.29	12.29	21.83	8.57	3.0725				10.06	5272.42
MWBLANK	13.86	13.86	13.86	0	0	45.82	45.82	21.82	8.46	11.3080					19404.50
PW1	14.01	16.16	17.13	2.15	0.97	4.45	4.45	25.21	9.55	1.2212	7.7076	31.1887	28.03	7.21	2095.57
PW2	13.81	15.84	16.81	2.03	0.97	4.93	4.93	25.02	9.68	1.3713	7.5574	32.3889	26.28	7.26	2353.21
PW3	13.80	15.89	16.89	2.09	1.00	4.12	4.12	25.08	9.69	1.1472	7.7815	32.3921	31.45	7.29	1968.61
PWREF	13.83	13.83	13.83	0	0	35.19	35.19	22.03	8.70	8.7975	0.1313			7.90	15096.53
PWBLANK	13.75	13.75	13.75	0	0	33.56	33.56	21.74	8.49	8.1875	0.7413				14049.73
CU1	13.78	15.75	16.61	1.97	0.86	1.64	1.64	24.60	9.35	0.4569				8.77	784.06
CU2	13.96	16.07	17.05	2.11	0.98	1.46	1.46	25.03	9.46	0.4115				8.61	706.22
CU3	13.80	15.93	16.90	2.13	0.97	1.73	1.73	24.89	9.46	0.4877				8.60	836.82
CUREF	13.97	13.97	13.97	0	0	0.25	0.25	21.86	8.39	0.0625				11.54	107.25
CUBLANK	13.98	13.98	13.98	0	0	44.25	44.25	21.96	8.48	11.1812					19188.90
PU1	13.88	15.89	16.73	2.01	0.84	5.64	5.64	24.96	9.57	1.5546	7.3742	31.8447	22.58	7.42	2667.65
PU2	13.87	15.98	16.92	2.11	0.94	5.63	5.63	25.10	9.62	1.5599	7.3688	30.3135	21.54	7.41	2676.83
PU3	13.65	15.71	16.66	2.06	0.95	4.34	4.34	24.88	9.67	1.2088	7.7200	32.5289	29.98	7.44	2074.22
PUREF	13.84	13.84	13.84	0	0	36.24	36.24	22.02	8.68	9.0600	-0.1313			8.02	15546.98
PUBLANK	13.86	13.86	13.86	0	0	41.68	41.68	21.85	8.49	10.1919	-1.2632				17489.34
MU1	13.86	15.90	16.80	2.04	0.90	4.65	4.65	24.84	9.44	1.2746				7.88	2187.15
MU2	13.98	15.90	16.76	1.92	0.86	4.66	4.66	24.92	9.52	1.2881				7.88	2210.43
MU3	13.79	15.95	16.88	2.16	0.93	4.45	4.45	24.94	9.49	1.2262				7.85	2104.17
MUREF	13.70	13.70	13.70	0	0	11.71	11.71	21.81	8.61	2.9275				10.18	5023.60
MUBLANK	13.96	13.96	13.96	0	0	46.65	46.65	21.96	8.50	11.5135					19757.19
CS counting samples only contain 2 mL															
CS1	13.71	15.71	17.19	2.00	1.48	0.16	0.16	25.12	9.91	0.0343				10.06	51.79
CS2	13.78	15.78	16.84	2.00	1.06	0.06	0.06	24.79	9.51	0.0127				10.44	19.24
CS3	13.75	15.75	17.05	2.00	1.30	0.06	0.06	25.00	9.75	0.0131				10.17	19.73
CSREF	13.97	13.97	13.97	0	0	0.46	0.46	21.90	8.43	0.0866				11.59	130.75
CSBLANK	13.86	13.86	13.86	0	0	28.53	28.53	21.84	8.48	5.4003					8157.54

Corrected volumes are obtained using U-232 minus background counts, dividing by 4 mL, multiplying the result by total water volume (assuming 1 gram = 1 mL), and dividing by the total water volume for the reference cell [e.g., for PW1: ((4.45 cpm/4 mL)*9.55 mL)/8.7 mL) = corrected volume activity of 1.2212 cpm/mL]

CPM removed from solution is obtained by taking the volume corrected, reference average for PUref and PWref cells and subtracting the activity entered for the corrected volumes [e.g., for PW1: ((8.7975 cpm/mL + 9.0600 cpm/mL)/2) - 1.2212 cpm/mL = 7.7076 cpm/mL]

CPM on solids is obtained by multiplying the CPM removed from solution by the total water in the reference cell and dividing by the reported dry soil mass [e.g., for PW1: ((7.7076 cpm/mL * 8.70 mL)/2.15 g) = 31.1887 cpm/g]

Adsorption ratio is obtained by dividing the CPM on solids by the CPM reported for U-232 minus background normalized to 1 mL [e.g., for PW1: (31.1887 cpm/g)/(4.45 cpm/4 mL) = 28.0348 mL/g]