Strontium Distribution Coefficients of Surficial Sediment Samples from the Idaho National Engineering Laboratory, Idaho

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CONVERSION FACTORS AND ABBREVIATED UNITS

Multiply	By	To obtain
cubic centimeter (cm^3)	0.06102	cubic inch
gram (g)	0.03527	ounce
kilogram (kg)	2.205	pound
kilometer (km)	0.6215	mile
square kilometer (km^2)	0.3861	square mile
meter (m)	3.281	foot
millimeter (mm)	0.03937	inches
becquerel per liter (Bq/L)	27	picocuries per liter
terra becquerel (TBq)	27	curies

For temperature, degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by using the formula °F=(1.8)(°C) + 32.

Abbreviated units used in report: K_d (distribution coefficient), mg/L (milligrams per liter), ml/g, (milliliters per gram), mg/kg (milligrams per kilogram).

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Abstract

Strontium distribution coefficients (K_d's) were measured for 20 surficial sediment samples collected from selected sites at the Idaho National Engineering Laboratory (INEL). The measurements were made to help assess the variability of strontium K_d's found at the INEL as part of an ongoing investigation of strontium chemical transport properties of surficial and interbedded sediments at the INEL. The investigation is being conducted by the U.S. Geological Survey and Idaho State University in cooperation with the U.S. Department of Energy. Batch experimental techniques were used to determine K_d's of surficial sediments using a synthesized aqueous solution representative of wastewater in waste disposal ponds at the INEL. Strontium K_d's of the 20 surficial sediments ranged from 36±1 to 275±6 milliliters per gram. These results indicate significant variability in the strontium sorptive capacities of surficial sediments at the INEL. Some of this variability can be attributed to physical and chemical properties of the sediment itself; however, the remainder of the variability may be due to compositional changes in the equilibrated solutions after being mixed with the sediment.

INTRODUCTION

The transport and fate of waste constituents in geologic media is dependent on physical and chemical processes that govern the distribution of constituents between the solid geologic stationary phase and an aqueous mobile phase. This distribution often is quantified, at thermodynamic equilibrium, by an empirically determined parameter called the distribution coefficient (K_d). K_d's can be used effectively to summarize the net chemical factors that affect transport efficiency of ground-water constituents. Many transport models for radionuclides use K_d's to predict the extent to which the migration of the constituent will be lessened relative to the mean ground-water velocity (Sposito, 1989, p. 150-155; Bohn, 1985, p. 153-207; Fetter, 1993, p. 117-127).

The U.S. Geological Survey (USGS) and Idaho State University, in cooperation with the U.S. Department of Energy (DOE), are conducting a study to determine geochemical properties affecting strontium transport in surficial sediment at the Idaho National Engineering Laboratory (INEL), Idaho. The purpose of the study is to determine the fate and transport behavior of chemical constituents in wastewater discharged to the unsaturated zone and the Snake River Plain aquifer at the INEL. Study objectives include assessing the variability of strontium K_d's in surficial and interbedded sediments at the INEL.

This report presents experimentally derived K_d's of 20 surficial sediment samples collected from selected sites at the INEL. Sediment samples were mixed with a synthesized aqueous solution using batch experimental techniques to determine the strontium distribution between the solid and aqueous phases. The synthesized aqueous solutions were representative of wastewater in waste disposal ponds at the INEL with respect to major cations and pH. Strontium concentrations in the solution were varied to define strontium sorption isotherms. Strontium K_d's were derived from the isotherms using the linear sorption isotherm model described by Fetter (1993, p. 117-119).

Background

The INEL comprises 2,300 km^2 of the eastern Snake River Plain in southeastern Idaho (fig. 1). The INEL was established in 1949 by the DOE for the development of peacetime atomic energy applications such as nuclear safety research, defense programs, and advanced energy concepts. More than 50 nuclear reactors have been operated at the INEL since its inception. Facilities at the INEL also are used to store nuclear waste, such as spent fuel rods from the U.S. Navy's nuclear fleet and other DOE sites, and wastes generated onsite.

Aqueous chemical and radiochemical wastes, including strontium-90 (^{90}Sr), have been discharged to waste disposal ponds and disposal wells at the INEL since 1952. Prior to 1983, much of the wastewater was injected directly into the Snake River Plain aquifer through deep injection wells. Since 1983, most of the wastewater has been discharged to unlined waste disposal ponds. Some chemical constituents from wastewater may enter the aquifer indirectly following percolation from the waste disposal ponds through sediments in the unsaturated zone (Pittman and others, 1988). Disposal of radioactive wastewater to the Test Reactor Area (TRA) waste disposal pond ceased in August of 1993 and the pond was remediated (Chew, U.S. Department of Energy, written commun., 1995). Radioactive wastewater at the TRA is now (1996) discharged to a lined evaporation pond.

^{90}Sr is a radionuclide produced by the fission of uranium, has a half-life of 28.8 years, and decays through beta emission (Eisenbud, 1973, p. 83-97). The deposition of ^{90}Sr is well documented globally (Eisenbud, 1973, p. 320-331). This radionuclide is present in ground water and was introduced to the environment from fallout of nuclear explosions and as a result of the waste disposal practices used in the nuclear industry. Because of the toxicity of ^{90}Sr and its tendency to concentrate uniformly throughout mineral bone tissues, the maximum contaminant level allowable in drinking water is 0.3 Bq/L (U.S. Environmental Protection Agency, 1989, p. 551). (Note: All radioactivity concentrations and associated uncertainties in this report have been converted from units reported by the laboratory (pCi/L) to SI units (Bq/L). No judgement was made relative to the precision of the conversions.)

Approximately 4.8 TBq of ^{90}Sr was discharged to the subsurface at the INEL from the early 1950's to 1991, primarily at the Idaho Chemical Processing Plant (ICPP) and TRA facilities (Bartholomay and others, 1995, p. 26). Documented disposals include:

- Approximately 1.2 TBq of ^{90}Sr discharged into a pit at the ICPP during 1962-63 (Robertson and others, 1974, p. 119).
- Approximately 0.6 TBq of ^{90}Sr discharged to a disposal well and waste disposal ponds at the ICPP (fig. 2) from 1961-91, of which approxi-mately 0.25 Ci were discharged to the waste disposal ponds (Bartholomay and others, 1995, p. 26).
- Approximately 2.9 TBq of ^{90}Sr discharged to waste disposal ponds at the TRA (fig. 2) from 1952-91 (Bartholomay and others, 1995, p. 26).

Concentrations of ^{90}Sr in perched-water zones beneath the ICPP ranged from 0 to 11±0.4 Bq/L during 1990 through 1995. Concentrations of ^{90}Sr in perched-water zones beneath the TRA ranged from 0 to 185±5 Bq/L for the same period. Disposal of ^{90}Sr has resulted in a 10-km^2 plume within the eastern Snake River Plain aquifer beneath the ICPP (Bartholomay and others, 1995, p. 28) with concentrations greater than 0.3 Bq/L. Concentrations of ^{90}Sr in water from wells completed in the Snake River Plain aquifer have been as large as 0.07 Bq/L in recent years (well 47 on October 24, 1991; fig. 2). ^{90}Sr has not yet been detected within the eastern Snake River Plain aquifer beneath the TRA. This may, in part, be explained by the exclusive use of waste disposal ponds rather than disposal wells at this facility from its inception. Sorption processes in the unsaturated and perched-water zones beneath the waste disposal ponds have likely lessened ^{90}Sr migration at the TRA. In addition, stratigraphy beneath the TRA may be different from that beneath the ICPP (Anderson, 1991, p. 22-28).

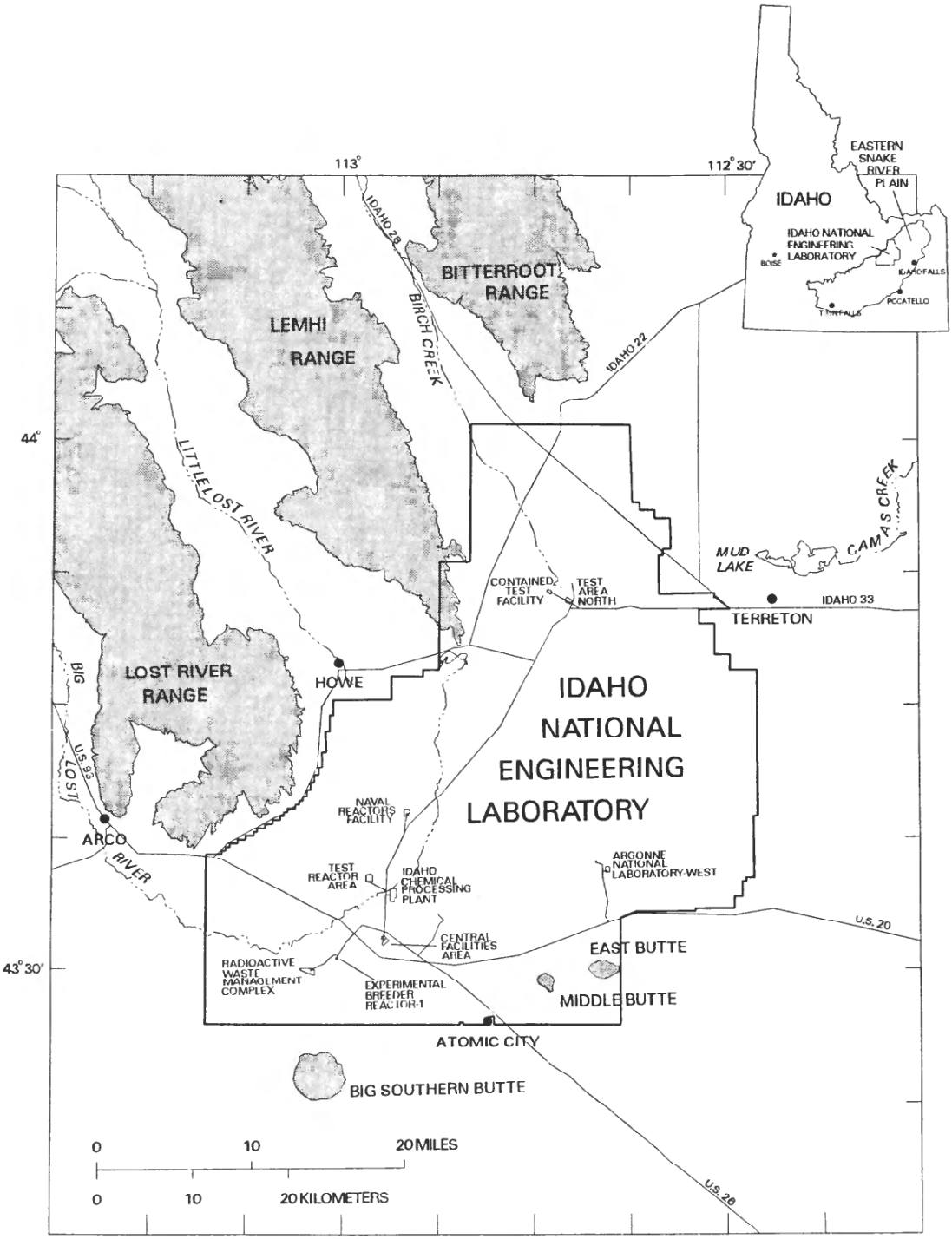

Figure 1. Location of the Idaho National Engineering Laboratory and selected facilities.

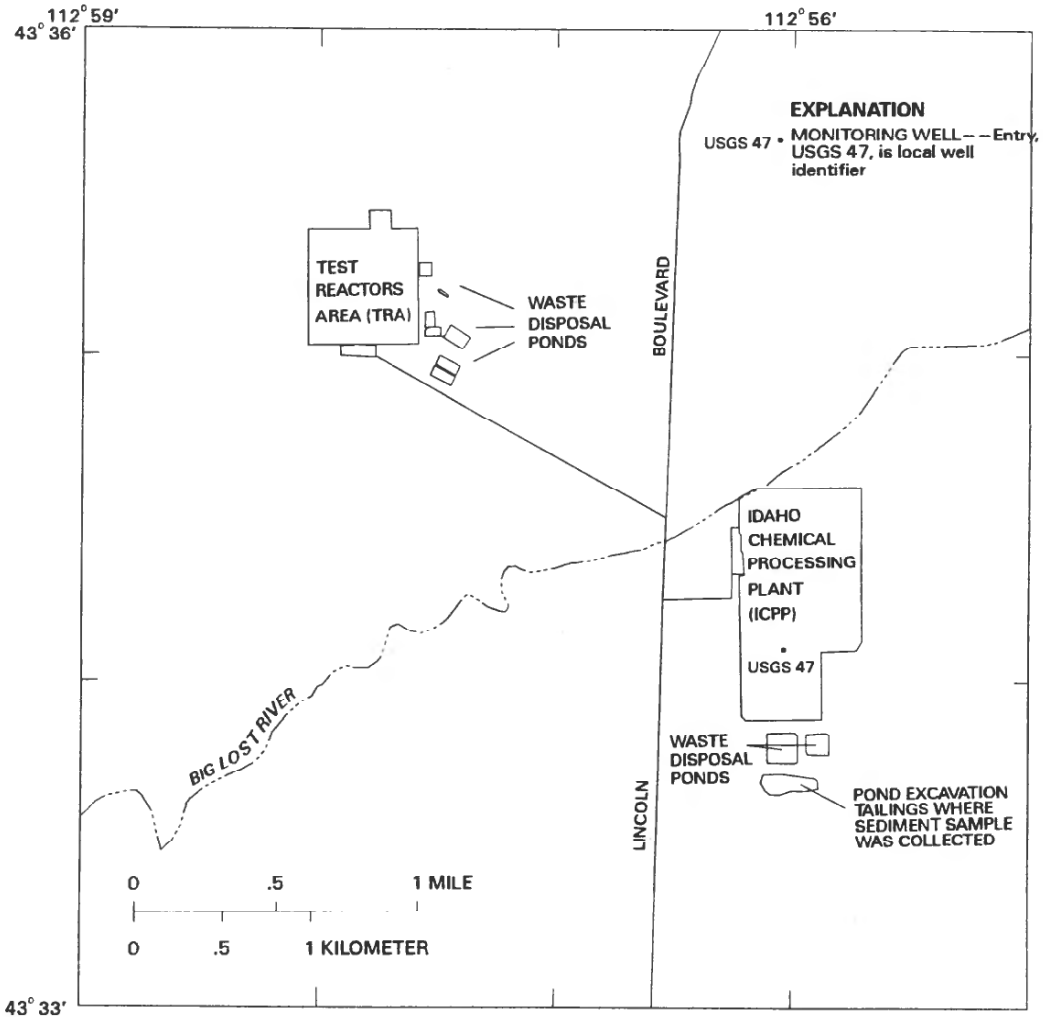

Figure 2. Location of the Idaho Chemical Processing Plant and Test Reactor Area with selected waste disposal ponds and monitoring well, Idaho National Engineering Laboratory.

Geohydrologic Setting

The eastern Snake River Plain is a northeast-trending structural basin about 125 km long and 30 to 40 km wide. The plain is underlain by a layered sequence of basaltic lava flows and cinder beds intercalated with alluvial and lakebed deposits. Individual flows range from 3 to 15 m in thickness, although the average thickness may be from 6 to 8 m (Mundorf and others, 1964, p. 143). The sedimentary deposits consist mainly of lenticular beds of sand, silt, and clay, and lesser amounts of gravel. Locally, rhyolitic lava flows and tuffs are exposed at the land surface or occur at depth. The basaltic lava flows and intercalated sedimentary deposits combine to form the framework for the Snake River Plain aquifer system, which is the main source of ground water on the plain. The depth to water in the aquifer system ranges from about 60 m below land surface in the northern part of the INEL to more than 275 m in the southern part (Orr and Cecil, 1991, p 25). The generalized direction of ground-water flow is from the northeast to the southwest. The INEL obtains its entire water supply from the Snake River Plain aquifer.

Previous Investigations

Strontium K_d's of sediment collected from the INEL have been reported by Hawkins and Short (1965), Schmalz (1972), Del Debbio and Thomas (1989), Bunde (U.S. Geological Survey, written commun., 1995), Hemming (U.S. Geological Survey, written commun., 1995), and Liszewski (U.S. Geological Survey, written commun., 1995). Additional strontium K_d's of sediment from nuclear facilities in the United States and Canada have been reported by Patterson and Spoel (1981), Jackson and Inch (1983), and Kipp and others (1986). A summary and review of available information on strontium and other radionuclide interactions with geologic media through 1976 has been compiled by Ames and Rai (1978).

Materials And Methods

Experiments for measuring K_d's required the collection and preparation of surficial sediment samples and the preparation of the synthesized aqueous solution. Once the samples and solution were prepared, they were combined in a reaction vessel and agitated using batch experimental techniques for a period of time sufficient for an apparent equilibrium to be reached. Solutions then were analyzed directly for dissolved strontium content. The amount of strontium sorbed to the sediment was calculated from the difference between the initial and equilibrium solution concentrations multiplied by the volume-to-mass ratio. Sorption isotherms and K_d's then were derived using the linear isotherm model (Fetter, 1993, p. 118).

Collection, description, and preparation of sediment samples

Surficial sediment samples for this study were collected from 20 selected sites at the INEL (fig. 3). Most of the sites were near the Radioactive Waste Management Complex (RWMC), ICPP, TRA, and the Test Area North (TAN) facilities, where waste is known to have been discharged to the subsurface. Additional samples were collected at sites remote from these facilities to expand the areal extent and range of sediment character included in the study. Sample sites were located near existing monitoring wells or study areas at the INEL.

Samples were collected by coring with a hand auger to a depth of 1 m, discarding the cored material, and then continuing to a depth sufficient to collect approximately 2 to 4 kg of sediment. The sediment was carefully removed from the auger into a plastic bag, which then was sealed, and placed in a tin can for storage. Samples that could not be obtained using the hand auger, typically those large in gravel and cobble content, were collected by digging with a shovel to a depth of 0.3 to 0.8 m. Approximately 2 to 4 kg of sample then was removed from the bottom of the small pit and placed, using the shovel, into the plastic bag. All of the samples were homogenized and split into approximately two equal parts. One part was archived for possible future work. The other part was passed through a 4.7-mm sieve, crushed to pass through a 2.0 mm sieve, and then air dried.

Sediment textures (from Folk, 1974, p. 28) were described on the basis of grain-size distribution of sediment samples; texures ranged from sandy gravel to gravelly sand (table 1). Grain-size

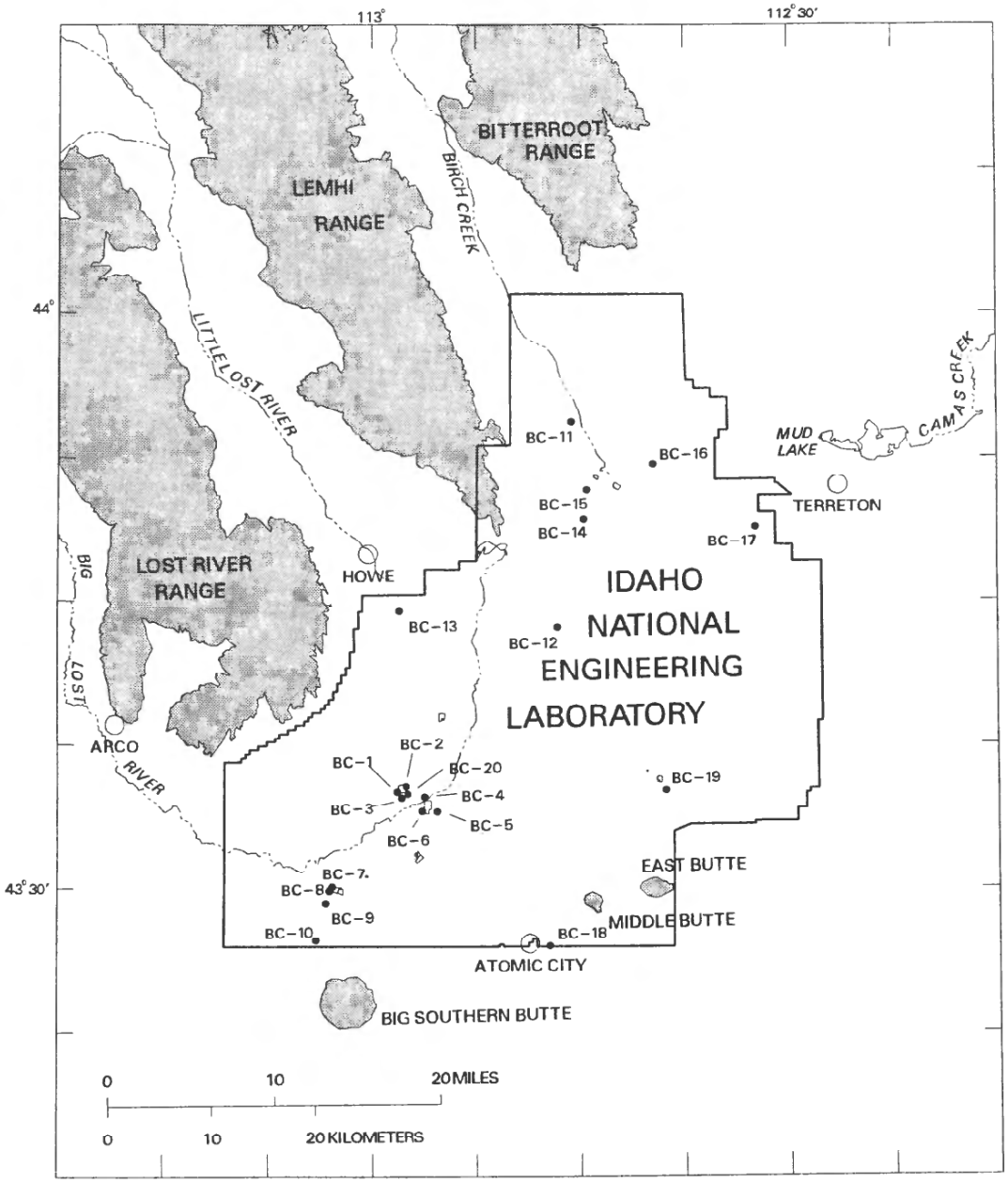

Figure 3. Location of sites where surficial sediment samples were collected, Idaho National Engineering Laboratory.

Table 1. Sample depth, texture, and distribution coefficient of surficial sediment samples from the Idaho National Engineering Laboratory (fig. 4).

[Depth is the approximate depth below land surface at which the sample was collected. Abbreviations: m, meter; K_d, distribution coefficient; ml/g, milliliters per gram. Texture descriptions are from Folk (1974, p. 28). K_d uncertainties are the standard error of the linear regression used to calculate the K_d]

Sample name	Depth (m)	Texture	K_d (ml/g)
BC-1	0.7	Sandy gravel	68±3
BC-2	0.8	Sandy gravel	94±2
BC-3	1	Sandy gravel	66±3
BC-4	1	Gravelly sand	97±3
BC-5	1	Gravelly sand	61±3
BC-6	1	Gravelly sand	134±4
BC-7	1	Gravelly sand	204±6
BC-8	1	Slightly gravelly muddy sand	266±6
BC-9	1	Gravelly sand	275±6
BC-10	1	Sandy gravel	167±2
BC-11	0.7	Sandy gravel	36±1
BC-12	1	Gravelly sand	89±2
BC-13	1	Gravelly muddy sand	208±4
BC-14	1	Gravelly sand	118±3
BC-15	1	Gravelly sand	157±2
BC-16	1	Gravelly sand	203±5
BC-17	1	Gravelly sand	96±3
BC-18	1	Gravelly muddy sand	209±5
BC-19	1	Gravelly muddy sand	88±3
BC-20	0.3	Sandy gravel	67±1

analysis techniques described by Bartholomay (1990, p. 58) were used to determine the grain-size distribution of sediment samples (table 2). Bulk mineralogy of the samples was determined using X-ray diffraction techniques (Reed, 1994, p. 5-6) and was variable; quartz, calcite, and feldspar generally were the most abundant (table 3). As can be seen from tables 1 through 3, a wide range of sedimentary characteristics was represented in the 20 samples.

Preparation of the synthesized aqueous solution

A synthesized aqueous solution that chemically represented wastewater in the ICPP waste disposal ponds was prepared because of the difficulty in obtaining wastewater in the field and potential chemical changes associated with the long-term storage of wastewater. The synthesized aqueous solution contained dissolved calcium, chloride, magnesium, potassium, sodium, strontium, silica, and carbonate alkalinity. The pH of the synthesized aqueous solution was fixed at 8.0±0.1. The use of a synthesized aqueous solution allowed for the control of experimental variables, addressed potential saturation problems and chemical phase modifications, and provided a constant supply of solution.

A concentrated stock solution containing 1,000 mg/L of calcium, 200 mg/L of magnesium, and 200 mg/L of potassium was prepared by adding American Chemical Society (ACS) certified reagents of calcium carbonate, magnesium carbonate, and potassium chloride to deionized water. A concentrated stock solution containing 1,000 mg/L of stable strontium was prepared separately by adding ACS-certified strontium carbonate to deionized water. Stable strontium was substituted for the radioactive ^{90}Sr isotope so that no special handling was required. Stable strontium is assumed to behave geochemically in the same manner as ^{90}Sr. Concentrated trace-metal-grade hydrochloric acid was added to the stock solutions to enhance stability of the concentrated solutions and to evolve carbon dioxide. The resulting pH of the concentrated stock solutions was less than 2.0.

Four volumetric flasks of synthesized aqueous solution were prepared by first volumetrically diluting the concentrated stock solution of calcium, magnesium, and potassium with deionized water. Solution in each of the flasks then was spiked with different concentrations of strontium using the strontium concentrate. Next, silica, in the form of sodium silicate, was added directly to the solution using a Fisher Scientific 1,000-mg/L atomic-absorption reference standard. The pH then was adjusted to 8.0±0.1 by adding 1.0 molar sodium hydroxide and hydrochloric acid. Sodium then was added to the synthesized aqueous solution in the form of solid sodium bicarbonate and the pH was readjusted to 8.0. Finally, the solution was equilibrated with atmospheric gases by leaving the flasks open to the atmosphere overnight and then adjusting the pH again if necessary.

Two batches of the synthesized aqueous solution were prepared and spiked with strontium (table 4). Small variations between constiuent concentrations in the two batches were due to inconsistencies in the preparation. Also, because the strontium concentrate used for spiking was acidified, each of the spiked solutions required different amounts of sodium hydroxide and hydrochloric acid for pH adjustment. The different amounts of sodium hydroxide and hydrochloric acid added for pH adjustment caused slight variations in the concentrations of sodium and chloride. These slight variations were not expected to affect strontium sorption to a measurable degree. Chloride concentrations were not determined analytically. Concentrations of calcium, magnesium, potassium, silica, sodium, and pH of the synthesized aqueous solution were based upon typical concentrations of these constituents in historical samples from ICPP waste disposal ponds (table 5). Alkalinity concentrations were not adjustable directly and were dependent on the amount of sodium bicarbonate added to the solution as described above.

Experimental methods and results of analyses

The sorption studies were carried out using batch experimental techniques in 50-cm^3 polyethylene centrifuge tubes. Batch experimental techniques were used because they are relatively simple and inexpensive, and many experiments can be done simultaneously. The dried sediments were homogenized and split into nominal 1-g subsamples using a riffler to minimize bias. The

Table 2. Grain-size distribution of surficial sediment samples from the Idaho National Engineering Laboratory.

[All size intervals are in millimeters. Grain-size distribution determined using grain-size analysis techniques described by Bartholomay (1990). Abbreviations: >, greater than; <, less than]

Sample name	Grain size distribution, in weight percent								
	>4.75	4.75-4.00	4.00-2.00	2.00-1.00	1.00-0.500	0.500-0.250	0.250-0.125	0.125-0.063	<0.063
BC-1	46.1	4.5	11.0	6.4	5.9	10.6	6.7	6.1	2.7
BC-2	30.7	2.9	7.6	4.9	4.5	13.7	18.1	10.8	6.9
BC-3	41.8	3.5	8.4	5.1	6.7	18.8	6.8	6.0	2.8
BC-4	0.0	2.0	13.2	11.3	14.4	30.2	18.2	8.8	2.0
BC-5	45.3	3.1	7.5	4.0	5.1	22.0	9.6	2.7	0.7
BC-6	36.0	2.5	5.6	5.3	11.2	25.6	8.0	4.5	1.3
BC-7	0.0	8.4	29.9	22.8	20.6	16.7	1.3	0.2	0.0
BC-8	1.4	0.3	1.9	7.3	11.2	10.5	13.3	38.3	16.0
BC-9	0.0	4.5	18.3	19.0	19.6	15.0	11.5	10.0	2.1
BC-10	0.0	6.5	30.9	24.0	25.5	10.9	1.6	0.6	0.1
BC-11	55.4	3.6	9.6	5.9	4.5	11.2	5.4	2.8	1.7
BC-12	0.0	0.7	14.5	14.4	11.9	14.2	25.8	13.2	5.3
BC-13	0.7	0.7	10.5	11.0	10.5	9.0	16.7	26.0	14.9
BC-14	0.0	1.2	11.1	9.7	8.0	11.3	37.3	18.0	3.4
BC-15	0.0	0.8	15.2	21.6	18.8	13.2	12.7	16.5	1.0
BC-16	0.0	2.7	18.1	22.2	19.0	13.2	11.4	10.0	3.3
BC-17	0.0	2.7	19.2	25.9	20.8	12.3	7.1	8.9	3.1
BC-18	1.6	1.4	12.3	13.3	12.8	10.8	11.9	18.0	18.0
BC-19	6.2	1.4	12.6	15.2	13.5	9.7	14.1	17.8	9.5
BC-20	48.5	3.7	10.8	8.6	8.9	12.6	4.5	1.3	1.0

Table 3. Bulk mineralogy of surficial sediment samples from the Idaho National Engineering Laboratory.

[Bulk mineralogy determined using X-ray diffraction techniques (Reed and others, 1994, p. 5-6). Abbreviations: Qz, quartz; Pg, plagioclase feldspar; Ksp, potassium feldspar; Cc, calcite; Tc, total clay minerals; Dol, dolomite; Py, pyroxene]

Sample name	Bulk mineralogy, in weight percent						
	Qz	Pg	Ksp	Cc	Tc	Dol	Py
BC-1	48	13	9	11	7	0	9
BC-2	51	24	5	7	10	0	2
BC-3	63	22	0	16	0	0	0
BC-4	56	19	0	3	22	0	0
BC-5	41	21	12	12	0	0	14
BC-6	41	18	13	8	21	0	0
BC-7	42	24	0	5	21	0	8
BC-8	39	15	0	15	10	7	15
BC-9	45	18	0	11	26	0	0
BC-10	52	16	0	25	0	6	0
BC-11	26	0	0	69	0	5	0
BC-12	29	17	0	27	15	12	0
BC-13	25	14	0	51	0	10	0
BC-14	30	6	0	52	0	12	0
BC-15	27	0	0	41	24	9	0
BC-16	21	4	10	42	17	6	0
BC-17	28	12	0	35	19	7	0
BC-18	41	13	0	28	10	8	0
BC-19	33	7	0	40	13	7	0
BC-20	47	30	0	4	4	7	9

Table 4. Concentrations of alkalinity, calcium, magnesium, potassium, silica, sodium, and strontium, and pH in the two batches of synthesized aqueous solutions used in the strontium batch experiments.

[Alkalinity was determined using a Hach digital titrator. Calcium, magnesium, potassium, sodium, and strontium concentrations determined by assay using atomic absorption spectroscopy. Silica concentration determined by calculation on the basis of the amount added. pH was measured using an Orion Research model 231 pH meter. Sodium concentrations include sodium additions from sodium bicarbonate, sodium hydroxide, and sodium silicate. Abbreviations: mg/L, milligrams per liter; $CaCO_3$, calcium carbonate; SiO_2, silicon dioxide; <, less than.]

Batch number	Alkalinity (mg/L as $CaCO_3$)	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Silica (mg/L as SiO_2)	Sodium (mg/L)	Strontium (mg/L)	pH
1	95	11	1.9	1.9	21	109	<0.02	7.95
	96	11	1.9	1.9	21	104	1.1	7.94
	96	11	1.9	1.9	21	122	2.5	7.94
	95	11	1.9	1.9	21	115	5.4	7.92
2	99	11	1.9	1.9	21	84	<.02	8.04
	98	11	1.9	1.9	21	86	1.1	8.10
	100	11	1.9	1.9	21	92	2.7	8.08
	96	12	1.9	1.9	21	104	5.4	8.06

Table 5. Concentrations of alkalinity, calcium, magnesium, potassium, silica, sodium, and strontium, and pH in samples collected from waste disposal ponds at the Idaho Chemical Processing Plant.

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using analytical techniques prescribed by Fishman and Friedman (1989), and Fishman (1993). Abbreviations: mg/L, milligrams per liter; $CaCO_3$, calcium carbonate; SiO_2, silicon dioxide. Location of ponds shown on fig. 2]

Date sampled	Alkalinity (mg/L as $CaCO_3$)	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Silica (mg/L as SiO_2)	Sodium (mg/L)	Strontium (mg/L)	pH
10/27/86	158	3.7	1.2	1.2	21	87	0.017	8.30
01/28/87	159	5.7	1.4	2.5	21	84	.029	8.29
10/26/87	150	9.7	2.5	1.6	21	88	.051	8.50
01/25/88	125	2.5	0.65	0.90	24	87	.012	8.00
04/26/88	103	67	29	2.8	21	92	.34	7.20
07/28/88	137	260	53	1.5	24	340	1.3	8.00
10/31/88	145	11	3.0	1.1	22	98	.057	8.00

nominal 1-g sub-samples were equilibrated with 20.0 ml of the synthesized aqueous solution at 30°C in a constant temperature shaker (Fisher Scientific Versa-Bath S Model 236) at a setting of 70 cycles per minute for 144 hours. The 1 to 20 mass-to-volume ratio, time of equilibration, and the agitation rate were selected to be consistent with those in previous investigations performed by Del Debbio and Thomas (1989). The time of equilibration was demonstrated to be sufficient by work performed by Bunde (U.S. Geological Survey, written commun., 1995). The aqueous phase was separated from the solid phase at the end of the experiment by centrifugation for 10 minutes at 3,500 revolutions per minute. The supernatant samples were preserved by adding several drops of trace-metal-grade concentrated nitric acid.

Sorption isotherms for each surficial sediment were determined from strontium distribution data at four initial solution concentrations of strontium (table 4). Strontium linear sorption isotherms and K_d's were derived from the least squares regression of equilibrium concentrations of strontium sorbed to the sediment as a function of dissolved strontium in solution (Fetter, 1993, p. 118). Concentrations of dissolved strontium were measured directly by atomic absorption spectroscopy. Concentrations of sorbed strontium were calculated as the difference between the initial and equilibrium concentrations of dissolved strontium multiplied by the volume-to-mass ratio. Initial concentrations were determined on the basis of the concentration in control samples measured at the conclusion of the experiment. Control samples consisted of reaction vessels containing synthesized aqueous solution with no sediment. This determination assumed that any changes that occurred during the experiments in the solution concentrations of the control samples also occurred in the samples. To best represent field conditions in the unsaturated and perched ground-water zones, the sediment was not pre-treated with the simulated wastewater solution before experimentation.

Experiments were grouped into sets consisting of 12 sediment samples mixed with synthesized aqueous solution in centrifuge tubes, three tubes at each of the four strontium concentrations. Additionally, an experimental blank and four control samples were included in each experimental set. The blank consisted of a centrifuge tube containing only deionized water, and control samples consisted of centrifuge tubes containing only synthesized aqueous solution, one at each of the four strontium concentrations. Blanks and controls provided experimental evidence that the constituents in these experiments did not adsorb onto or desorb from the reaction vessel walls or experimental apparatus. The first batch of synthesized aqueous solution (table 4) was used for sample sets BC-1 through BC-6 (table 6) and the second batch was used for BC-7 through BC-20.

The synthesized aqueous solution, controls, and blanks were analyzed for concentrations of alkalinity, calcium, magnesium, potassium, sodium, strontium, and pH before equilibration with the sediment and for calcium, magnesium, strontium, and pH after equilibration with the sediment. Cation concentrations were determined on a Thermo Jarrell Ash Smith-Hieftje 1,000 flame atomic absorption spectrometer with AA/ThermoSPEC version 3.01 software; pH was measured with an Orion Research model 231 pH meter, and alkalinity was determined with a Hach digital titrator. Historical pond water analyses (table 5) presented as supporting data in this report were done by the U.S. Geological Survey's National Water Quality Laboratory using analytical techniques prescribed by Fishman and Friedman (1989), and Fishman (1993).

Derivation of the strontium distribution coefficient using the linear isotherm model

The distribution coefficient is defined as:

$$K_d = [Sr]_s / [Sr]_{eq} \qquad [1]$$

(Kipp and others, 1986, p. 523)

where:

K_d is measured in milliliters per gram,

$[Sr]_s$ = concentration of sorbed constituent per unit mass of sediment, in milligram per kilogram, and

$[Sr]_{eq}$ = concentration of dissolved constituent in the equilibrated solution, in milligram per liter.

Equilibrium sorption of solutes on sedimentary material is commonly described by the linear isotherm model where the K_d is equal to the slope

of a least squares fit between sorbed and aqueous strontium concentrations at thermodynamic equilibrium (Fetter, 1993, p. 118). Plots of isotherms for the sediments used in the study indicated that the sediments conformed to the linear isotherm model based on examination of plots of their respective isotherms. Therefore, the slopes of the linear sorption isotherms were used as the K_d's in this study.

Experimentally observed values of $[Sr]_s$ were obtained through assayed concentrations of aqueous strontium and ratios of solution to sediment used in experimentation:

$$[Sr]_s = \{[Sr]_i - [Sr]_{eq}\} V/M \qquad [2]$$

where

$[Sr]_i$ = initial concentration of aqueous strontium in the solution before equilibration with the sediment, in mg/L,

V = volume of solution, in ml, and

M = mass of sediment, in grams.

STRONTIUM DISTRIBUTION COEFFICIENTS OF SURFICIAL SEDIMENTS

Strontium K_d's, textures, and sampling depths of 20 surficial sediment samples are listed in table 1. K_d's also are shown on fig. 4. Sediment mass and initial and final concentrations of dissolved calcium, magnesium, strontium, and pH, and initial concentrations of dissolved potassium, sodium, and alkalinity, for the samples, controls, and blanks are listed in table 6. Concentrations of all dissolved constituents in the control samples and blanks were generally close to expected amounts. However, final concentrations of dissolved strontium in 12 blanks ranged from 0.02 to 0.05 mg/L. These concentrations probably were the result of a small amount of carryover from one sample to another due to incomplete flushing of the aspirator chamber during analysis, and analytical uncertainty. These strontium concentrations are considered too small to have any effect on the reported K_d's but may indicate that the reporting level for strontium is too small.

Strontium K_d's of the 20 surficial sediment samples ranged from 36±1 to 275±6 ml/g (table 1, fig. 4). K_d uncertainties are equal to the standard error of the linear regression used to calculate the K_d's. In general, K_d's were larger from samples collected near the RWMC (204±6 to 275±6 ml/g) and lowest from samples near the TRA (66±3 to 94±2 ml/g). One exception was sample BC-11 at the north end of the site, which had a K_d of 36±1 ml/g. K_d's for samples collected near the ICPP and TAN facilities ranged from 61±3 to 134±4 ml/g and 118±3 to 203±5 ml/g, respectively. K_d's from samples collected remote from facilities ranged from 36±1 to 209±5 ml/g.

These results indicate that significant variability exists in strontium K_d's of surficial sediment at the INEL. Some of this variability can be attributed to physical and chemical properties of the sediment itself; however, the remainder of the variability may be due to compositional changes in the equilibrated solutions after being mixed with the sediment (Bunde, U.S. Geological Survey, written commun., 1995). The synthesized aqueous solution reacted with the sediment by dissolving mineral phases and desorbing mineral surface constituents to establish a new chemical equilibrium between the solid and liquid phases. Dissolution of, and desorption from, solid phases caused detectable changes in solution composition relative to major ions and other constituents in this study. For example, initial concentrations of dissolved calcium and magnesium ranged from 10 to 12 and 1.8 to 2.1 mg/L, respectively; however, the final concentration of these two constituents ranged from 8.7 to 84 and 1.2 to 15 mg/L, respectively (table 6, located at end of report). The extent to which variability in strontium K_d's can be explained by differing properties of either the sediment or solution is as yet unquantified and is the subject of future study.

The variability in strontium K_d's determined in this study has important implications relative to the transport of strontium beneath waste disposal ponds at the INEL. Sediment beneath waste disposal ponds having large K_d's, such as that near the RWMC, can be expected to effectively lessen strontium movement relative to sediment having small K_d's, such as that near the TRA, other factors that affect transport being equal. The results of this study should be used with caution when applied to radioactive strontium, which normally is present at

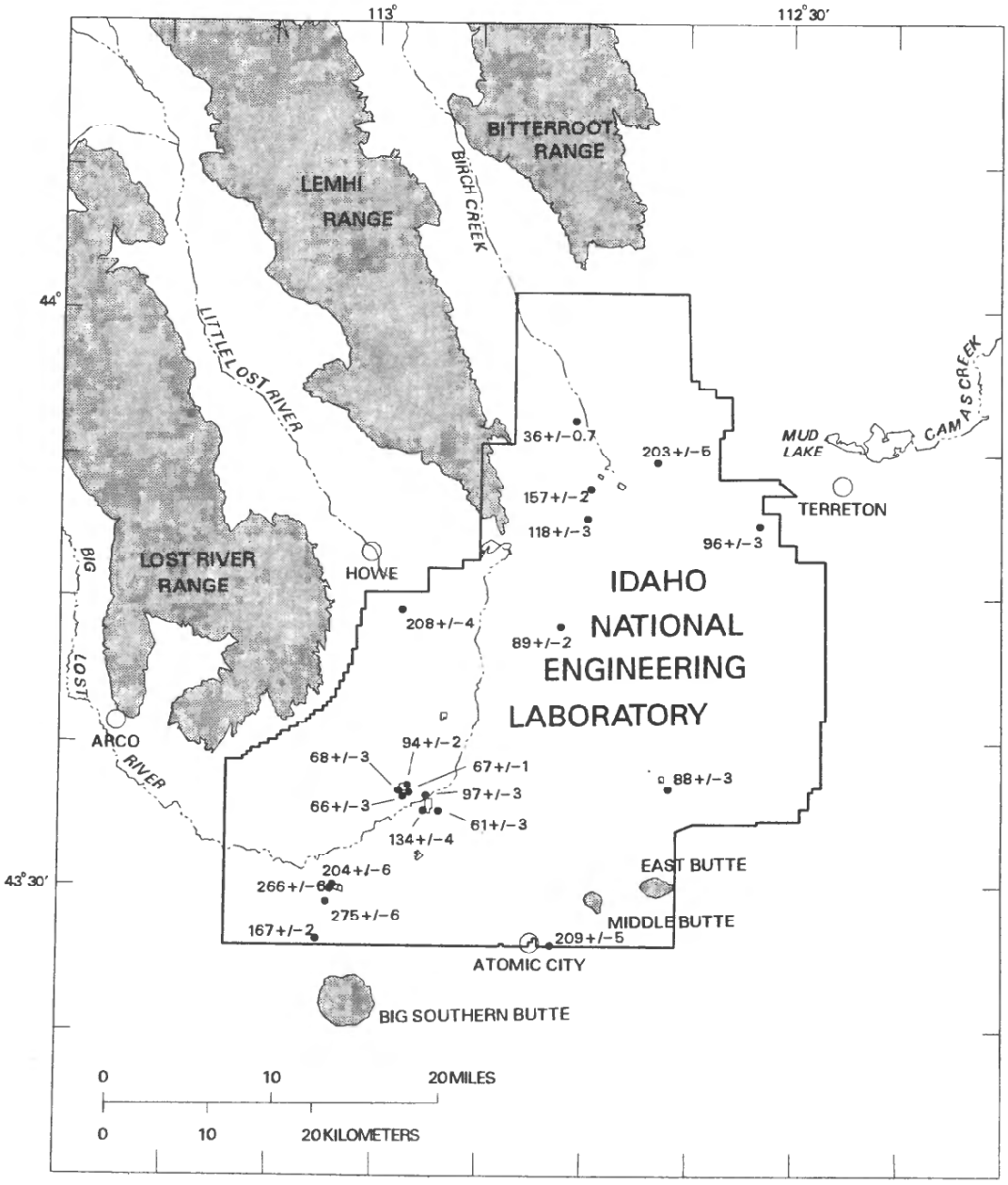

Figure 4. Strontium distribution coefficients of surficial sediment samples collected from selected sites at the Idaho National Engineering Laboratory.

concentrations far less than the concentration of stable strontium used in this study.

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Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions

[Sample set refers to all the samples associated with the determination of a single distribution coefficient. Sample numbers 1-3, 5-7, 9-11, and 13-15 represent triplicate experiments at each of 4 strontium concentrations. Sample type 1 refers to regular samples containing sediment and synthesized aqueous solution, type 2 refers to control samples containing only synthesized aqueous solution without sediment, and type 3 (sample number 17) refers to a blank sample containing only deionized water. Sediment mass is the mass of sediment mixed with 20.0 milliliters of synthesized aqueous solution. Initial concentrations are concentrations of each constituent in the synthesized aqueous solution before mixing with the sediment. Initial concentrations for sample numbers, 4, 8, 12, and 16 (control samples) are those determined for the synthesized aqueous solution before experiments began. Initial concentrations for potassium and sodium for sample numbers 1-3, 5-7, 9-11, and 13-15 (regular samples) are those determined for the synthesized aqueous solution before experiments began. Initial concentrations for calcium, magnesium, and strontium for sample numbers 1-3, 5-7, 9-11, and 13-15 (regular samples) were determined on the basis of the final concentrations of the control samples measured after the conclusion of the experiments. This determination assumes that any changes in solution concentrations that occurred during the experiments in the control samples also occurred in the regular samples. Final concentrations are of dissolved constituents after being equilibrated with the sediment for a period of 144 hours. Alkalinity is reported as mass equivalents of calcium carbonate. Calcium, magnesium, potassium, strontium, and sodium concentrations were determined by assay using atomic absorption spectroscopy. pH was measured using an Orion Research model 231 pH meter. Alkalinity was determined using a Hach digital titrator. Abbreviations: mg/L, milligrams per liter; <, less than; --, data not available]

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-1	1	1	1.169	12	36	1.9	6.5	<0.02	0.18	1.9	110	95	8.18	7.79
BC-1	2	1	1.260	12	38	1.9	6.7	<.02	.19	1.9	110	95	8.18	8.23
BC-1	3	1	1.025	12	32	1.9	6.0	<.02	.17	1.9	110	95	8.18	8.11
BC-1	5	1	1.024	11	34	2.0	6.3	1.1	.40	1.9	100	96	8.30	8.13
BC-1	6	1	.945	11	30	2.0	5.9	1.1	.42	1.9	100	96	8.30	8.21
BC-1	7	1	1.088	11	38	2.0	6.5	1.1	.42	1.9	100	96	8.30	8.25
BC-1	9	1	1.082	11	33	1.9	6.2	2.6	.75	1.9	120	96	8.21	8.23
BC-1	10	1	.907	11	33	1.9	5.9	2.6	.78	1.9	120	96	8.21	8.30
BC-1	11	1	1.164	11	36	1.9	6.5	2.6	.72	1.9	120	96	8.21	7.97
BC-1	13	1	1.072	11	35	1.9	6.8	5.3	1.4	1.9	120	95	8.27	8.21
BC-1	14	1	.875	11	31	1.9	6.1	5.3	1.4	1.9	120	95	8.27	8.20
BC-1	15	1	.836	11	30	1.9	5.8	5.3	1.5	1.9	120	95	8.27	8.21
BC-1	4	2	none	11	12	1.9	1.9	<.02	<.02	1.9	110	95	8.18	8.18
BC-1	8	2	none	11	11	1.9	2.0	1.1	1.1	1.9	100	96	8.30	8.30

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-1	12	2	none	11	11	1.9	1.9	2.5	2.6	1.9	120	96	8.21	8.21
BC-1	16	2	none	11	11	1.9	1.9	5.4	5.3	1.9	120	95	8.27	8.27
BC-1	17	3	none	<.06	<.06	<.05	<.05	<.02	.02	.0	.0	--	--	6.82
BC-2	1	1	1.211	11	25	1.8	4.4	.0	.12	1.9	110	95	8.26	8.06
BC-2	2	1	.904	11	23	1.8	3.9	.0	.11	1.9	110	95	8.26	8.00
BC-2	3	1	1.104	11	25	1.8	4.2	.0	.12	1.9	110	95	8.26	8.15
BC-2	5	1	1.156	11	24	1.8	4.3	1.0	.28	1.9	100	96	8.22	7.87
BC-2	6	1	1.052	11	24	1.8	4.2	1.0	.30	1.9	100	96	8.22	7.95
BC-2	7	1	1.079	11	25	1.8	4.2	1.0	.29	1.9	100	96	8.22	8.18
BC-2	9	1	1.058	10	24	1.9	4.3	2.5	.55	1.9	120	96	8.24	7.79
BC-2	10	1	.957	10	24	1.9	4.3	2.5	.58	1.9	120	96	8.24	8.08
BC-2	11	1	1.183	10	25	1.9	4.5	2.5	.54	1.9	120	96	8.24	8.09
BC-2	13	1	1.065	11	26	1.9	4.5	5.5	1.1	1.9	120	95	8.27	7.99
BC-2	14	1	1.040	11	26	1.9	4.6	5.5	1.1	1.9	120	95	8.27	8.03
BC-2	15	1	.974	11	24	1.9	4.3	5.5	1.1	1.9	120	95	8.27	8.14
BC-2	4	2	none	11	11	1.9	1.8	<.02	<.02	1.9	110	95	8.26	8.26
BC-2	8	2	none	11	11	1.9	1.8	1.1	1.1	1.9	100	96	8.22	8.22
BC-2	12	2	none	11	10	1.9	1.9	2.5	2.6	1.9	120	96	8.24	8.24
BC-2	16	2	none	11	11	1.9	1.9	5.4	5.5	1.9	120	95	8.27	8.27
BC-2	17	3	none	<.06	.17	<.05	<.05	<.02	.03	<.1	<.1	--	--	6.05

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-3	1	1	.957	11	28	1.9	5.9	<.02	.16	1.9	110	95	8.05	8.11
BC-3	2	1	1.037	11	37	1.9	6.2	<.02	.17	1.9	110	95	8.05	8.31
BC-3	3	1	1.090	11	28	1.9	6.2	<.02	.16	1.9	110	95	8.05	8.31
BC-3	5	1	1.181	11	37	1.9	6.4	1.1	.37	1.9	100	96	8.11	8.19
BC-3	6	1	1.080	11	40	1.9	6.3	1.1	.36	1.9	100	96	8.11	8.36
BC-3	7	1	1.049	11	38	1.9	6.2	1.1	.37	1.9	100	96	8.11	8.29
BC-3	9	1	1.147	10	37	1.8	6.4	2.7	.68	1.9	120	96	8.20	8.11
BC-3	10	1	1.039	10	42	1.8	6.6	2.7	.70	1.9	120	96	8.20	8.31
BC-3	11	1	1.180	10	46	1.8	7.0	2.7	.70	1.9	120	96	8.20	8.35
BC-3	13	1	1.170	11	44	1.9	7.2	5.2	1.31	1.9	120	95	8.21	8.32
BC-3	14	1	1.055	11	43	1.9	6.9	5.2	1.36	1.9	120	95	8.21	8.27
BC-3	15	1	.895	11	38	1.9	6.4	5.2	1.36	1.9	120	95	8.21	8.3
BC-3	4	2	none	11	11	1.9	1.9	<.02	<.02	1.9	110	95	8.05	8.05
BC-3	8	2	none	11	11	1.9	1.9	1.1	1.1	1.9	100	96	8.11	8.11
BC-3	12	2	none	11	10	1.9	1.8	2.5	2.7	1.9	120	96	8.20	8.20
BC-3	16	2	none	11	11	1.9	1.9	5.4	5.2	1.9	120	95	8.21	8.21
BC-3	17	3	none	<.06	.13	<.05	<.05	<.02	<.02	<.1	<.1	--	--	5.92
BC-4	1	1	.898	11	34	1.9	5.7	<.02	.14	1.9	110	95	8.17	7.95
BC-4	2	1	.946	11	35	1.9	5.9	<.02	.16	1.9	110	95	8.17	8.08
BC-4	3	1	1.098	11	39	1.9	6.6	<.02	.17	1.9	110	95	8.17	8.23
BC-4	5	1	0.971	11	36	1.9	6.1	1.0	0.32	1.9	100	96	8.19	8.19

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-4	6	1	.862	11	34	1.9	5.6	1.0	.31	1.9	100	96	8.19	8.24
BC-4	7	1	1.033	11	36	1.9	6.2	1.0	.32	1.9	100	96	8.19	8.17
BC-4	9	1	1.312	10	40	1.8	7.2	2.7	.52	1.9	120	96	8.17	7.91
BC-4	10	1	1.163	10	39	1.8	6.8	2.7	.54	1.9	120	96	8.17	8.09
BC-4	11	1	1.153	10	38	1.8	6.8	2.7	.53	1.9	120	96	8.17	8.07
BC-4	13	1	1.051	11	36	1.9	6.7	5.1	.97	1.9	120	95	8.28	8.17
BC-4	14	1	1.170	11	37	1.9	7.0	5.1	.97	1.9	120	95	8.28	8.11
BC-4	15	1	1.053	11	36	1.9	6.6	5.1	.95	1.9	120	95	8.28	8.19
BC-4	4	2	none	11	11	1.9	1.9	<.02	<.02	1.9	110	95	8.17	8.17
BC-4	8	2	none	11	11	1.9	1.9	1.1	1.0	1.9	100	96	8.19	8.19
BC-4	12	2	none	11	10	1.9	1.8	2.5	2.7	1.9	120	96	8.17	8.17
BC-4	16	2	none	11	11	1.9	1.9	5.4	5.1	1.9	120	95	8.28	8.28
BC-4	17	3	none	<.06	.15	<.05	<.05	<.02	<.02	<.1	<.1	--	--	6.02
BC-5	1	1	.915	11	17	2.0	5.8	<.02	.12	1.9	110	95	8.12	7.91
BC-5	2	1	1.170	11	18	2.0	6.2	<.02	.12	1.9	110	95	8.12	8.37
BC-5	3	1	1.033	11	18	2.0	5.9	<.02	.12	1.9	110	95	8.12	8.36
BC-5	5	1	1.574	11	19	2.0	6.8	1.0	.28	1.9	100	96	8.17	8.26
BC-5	6	1	1.378	11	19	2.0	6.6	1.0	.30	1.9	100	96	8.17	8.37
BC-5	7	1	1.113	11	18	2.0	6.1	1.0	.32	1.9	100	96	8.17	8.41
BC-5	9	1	1.213	10	18	1.9	6.4	2.5	0.59	1.9	120	96	8.01	8.30
BC-5	10	1	1.016	10	16	1.9	5.9	2.5	.62	1.9	120	96	8.01	8.37

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-5	11	1	1.133	10	17	1.9	6.2	2.5	.62	1.9	120	96	8.01	8.41
BC-5	13	1	1.122	11	16	1.9	6.4	4.7	1.2	1.9	120	95	8.30	8.32
BC-5	14	1	1.424	11	18	1.9	6.9	4.7	1.0	1.9	120	95	8.30	8.31
BC-5	15	1	1.239	11	18	1.9	6.5	4.7	1.1	1.9	120	95	8.30	8.33
BC-5	4	2	none	11	11	1.9	2.0	<.02	<.02	1.9	110	95	8.12	8.12
BC-5	8	2	none	11	11	1.9	2.0	1.1	.98	1.9	100	96	8.17	8.17
BC-5	12	2	none	11	10	1.9	1.9	2.5	2.5	1.9	120	96	8.01	8.01
BC-5	16	2	none	11	11	1.9	1.9	5.4	4.7	1.9	120	95	8.30	8.30
BC-5	17	3	none	<.06	.17	<.05	<.05	<.02	<.02	<.1	<.1	--	--	5.87
BC-6	1	1	1.151	11	32	1.9	6.9	<.02	.14	1.9	110	95	8.08	8.19
BC-6	2	1	1.076	11	37	1.9	7.2	<.02	.15	1.9	110	95	8.08	8.16
BC-6	3	1	.987	11	32	1.9	6.7	<.02	.14	1.9	110	95	8.08	8.37
BC-6	5	1	.898	11	30	1.9	6.4	1.0	.26	1.9	100	96	7.89	8.27
BC-6	6	1	.945	11	28	1.9	6.4	1.0	.25	1.9	100	96	7.89	8.30
BC-6	7	1	.957	11	30	1.9	6.6	1.0	.26	1.9	100	96	7.89	8.35
BC-6	9	1	1.051	11	28	1.9	6.8	2.7	.41	1.9	120	96	8.19	8.19
BC-6	10	1	1.058	11	33	1.9	7.0	2.7	.44	1.9	120	96	8.19	8.26
BC-6	11	1	1.093	11	32	1.9	7.1	2.7	.42	1.9	120	96	8.19	8.40
BC-6	13	1	0.975	11	34	1.9	7.5	5.2	0.82	1.9	120	95	8.22	8.32
BC-6	14	1	.898	11	30	1.9	7.1	5.2	.87	1.9	120	95	8.22	8.27
BC-6	15	1	1.086	11	34	1.9	7.1	5.2	.75	1.9	120	95	8.22	8.47

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-6	4	2	none	11	11	1.9	1.9	<.02	<.02	1.9	110	95	8.08	8.08
BC-6	8	2	none	11	11	1.9	1.9	1.1	1.03	1.9	100	96	7.89	7.89
BC-6	12	2	none	11	11	1.9	1.9	2.5	2.7	1.9	120	96	8.19	8.19
BC-6	16	2	none	11	11	1.9	1.9	5.4	5.2	1.9	120	95	8.22	8.22
BC-6	17	3	none	<.06	.17	<.05	<.05	<.02	<.02	<.1	<.1	--	--	5.83
BC-7	1	1	.936	11	19	1.9	4.5	.03	.08	1.9	84	99	8.30	8.04
BC-7	2	1	.944	11	19	1.9	4.5	.03	.08	1.9	84	99	8.30	8.13
BC-7	3	1	1.052	11	19	1.9	4.6	.03	.09	1.9	84	99	8.30	8.19
BC-7	5	1	1.053	11	20	1.9	4.9	1.0	.19	1.9	86	98	8.27	8.15
BC-7	6	1	1.007	11	20	1.9	4.8	1.0	.18	1.9	86	98	8.27	8.15
BC-7	7	1	.953	11	20	1.9	4.8	1.0	.19	1.9	86	98	8.27	8.27
BC-7	9	1	1.001	11	20	2.0	4.9	2.5	.28	1.9	92	100	8.23	8.27
BC-7	10	1	.938	11	20	2.0	4.8	2.5	.28	1.9	92	100	8.23	8.30
BC-7	11	1	1.028	11	21	2.0	5.0	2.5	.29	1.9	92	100	8.23	8.21
BC-7	13	1	1.063	11	22	2.0	5.3	5.0	.50	1.9	100	96	8.25	8.19
BC-7	14	1	.986	11	21	2.0	5.2	5.0	.53	1.9	100	96	8.25	8.22
BC-7	15	1	1.033	11	21	2.0	5.2	5.0	.52	1.9	100	96	8.25	8.21
BC-7	4	2	none	11	11	1.9	1.9	<.02	0.03	1.9	84	99	8.30	8.30
BC-7	8	2	none	11	11	1.9	1.9	1.1	1.05	1.9	86	98	8.27	8.27
BC-7	12	2	none	11	11	1.9	2.0	2.7	2.50	1.9	92	100	8.23	8.23
BC-7	16	2	none	12	11	1.9	2.0	5.4	4.96	1.9	100	96	8.25	8.25

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-7	17	3	none	<.06	.10	<.05	<.05	<.02	.02	<.1	<.1	--	--	6.29
BC-8	1	1	1.090	11	10	1.9	5.8	<.02	.09	1.9	84	99	8.11	8.52
BC-8	2	1	1.093	11	10	1.9	5.6	<.02	.09	1.9	84	99	8.11	8.46
BC-8	3	1	.964	11	10	1.9	6.0	<.02	.10	1.9	84	99	8.11	8.47
BC-8	5	1	.919	11	9.7	2.0	5.8	1.0	.17	1.9	86	98	8.17	8.54
BC-8	6	1	.996	11	9.9	2.0	6.0	1.0	.17	1.9	86	98	8.17	8.51
BC-8	7	1	1.074	11	10	2.0	5.9	1.0	.16	1.9	86	98	8.17	8.56
BC-8	9	1	1.093	11	9.9	2.0	6.0	2.5	.24	1.9	92	100	8.17	8.54
BC-8	10	1	1.150	11	9.7	2.0	5.8	2.5	.23	1.9	92	100	8.17	8.61
BC-8	11	1	.998	11	9.3	2.0	5.8	2.5	.25	1.9	92	100	8.17	8.58
BC-8	13	1	.881	11	8.7	2.0	6.2	5.2	.50	1.9	100	96	8.25	8.41
BC-8	14	1	1.049	11	9.2	2.0	6.3	5.2	.44	1.9	100	96	8.25	8.57
BC-8	15	1	1.010	11	9.0	2.0	6.4	5.2	.44	1.9	100	96	8.25	8.57
BC-8	4	2	none	11	11	1.9	1.9	<.02	<.02	1.9	84	99	8.11	8.11
BC-8	8	2	none	11	11	1.9	2.0	1.1	1.0	1.9	86	98	8.17	8.17
BC-8	12	2	none	11	11	1.9	2.0	2.7	2.5	1.9	92	100	8.17	8.17
BC-8	16	2	none	12	11	1.9	2.0	5.4	5.2	1.9	100	96	8.25	8.25
BC-8	17	3	none	<.06	.13	<.05	<.05	<.02	.02	.0	.0	--	--	6.38
BC-9	1	1	1.004	11	11	2.1	7.1	<.02	.10	1.9	84	99	8.30	8.41
BC-9	2	1	.937	11	10	2.1	6.4	<.02	.10	1.9	84	99	8.30	8.43

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-9	3	1	.973	11	12	2.1	7.2	<.02	.10	1.9	84	99	8.30	8.44
BC-9	5	1	.965	11	12	2.1	7.4	1.0	.16	1.9	86	98	8.32	8.41
BC-9	6	1	.984	11	12	2.1	7.4	1.0	.16	1.9	86	98	8.32	8.43
BC-9	7	1	.888	11	11	2.1	7.0	1.0	.17	1.9	86	98	8.32	8.44
BC-9	9	1	.861	11	11	2.1	7.1	2.5	.27	1.9	92	100	8.27	8.40
BC-9	10	1	.949	11	12	2.1	7.5	2.5	.26	1.9	92	100	8.27	8.39
BC-9	11	1	.975	11	12	2.1	7.4	2.5	.27	1.9	92	100	8.27	8.32
BC-9	13	1	.920	11	12	2.1	7.9	5.2	.47	1.9	100	96	8.19	8.38
BC-9	14	1	.980	11	12	2.1	7.8	5.2	.45	1.9	100	96	8.19	8.37
BC-9	15	1	1.077	11	12	2.1	8.0	5.2	.44	1.9	100	96	8.19	8.27
BC-9	4	2	none	11	11	1.9	2.1	<.02	<.02	1.9	84	99	8.30	8.30
BC-9	8	2	none	11	11	1.9	2.1	1.1	1.0	1.9	86	98	8.32	8.32
BC-9	12	2	none	11	11	1.9	2.1	2.7	2.5	1.9	92	100	8.27	8.27
BC-9	16	2	none	12	11	1.9	2.1	5.4	5.2	1.9	100	96	8.19	8.19
BC-9	17	3	none	<.06	.10	<.05	<.05	<.02	<.02	<.1	<.1	--	--	6.20
BC-10	1	1	1.039	10	21	1.9	5.7	<.02	.07	1.9	84	99	8.23	8.29
BC-10	2	1	.984	10	21	1.9	5.5	<.02	.07	1.9	84	99	8.23	8.27
BC-10	3	1	.924	10	20	1.9	5.4	<.02	.08	1.9	84	99	8.23	8.28
BC-10	5	1	.930	11	20	2.0	5.7	1.0	.18	1.9	86	98	8.16	8.24
BC-10	6	1	.951	11	22	2.0	5.8	1.0	.18	1.9	86	98	8.16	8.25
BC-10	7	1	.946	11	21	2.0	5.8	1.0	.19	1.9	86	98	8.16	8.21

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-10	9	1	1.003	11	21	2.0	5.8	2.5	.34	1.9	92	100	8.31	8.27
BC-10	10	1	1.038	11	21	2.0	5.9	2.5	.34	1.9	92	100	8.31	8.29
BC-10	11	1	.930	11	20	2.0	5.7	2.5	.36	1.9	92	100	8.31	8.30
BC-10	13	1	.862	11	21	2.0	5.7	5.2	.70	1.9	100	96	8.25	8.30
BC-10	14	1	1.112	11	23	2.0	6.4	5.2	.60	1.9	100	96	8.25	8.24
BC-10	15	1	.893	11	20	2.0	5.9	5.2	.68	1.9	100	96	8.25	8.26
BC-10	4	2	none	11	10	1.9	1.9	<.02	<.02	1.9	84	99	8.23	8.23
BC-10	8	2	none	11	11	1.9	2.0	1.1	.98	1.9	86	98	8.16	8.16
BC-10	12	2	none	11	11	1.9	2.0	2.7	2.5	1.9	92	100	8.31	8.31
BC-10	16	2	none	12	11	1.9	2.0	5.4	5.2	1.9	100	96	8.25	8.25
BC-10	17	3	none	<.06	.11	<.05	<.05	<.02	.03	<.1	<.1	--	--	6.31
BC-11	1	1	1.100	10	35	1.9	7.3	<.02	.09	1.9	84	99	8.29	8.21
BC-11	2	1	.923	10	32	1.9	6.3	<.02	.08	1.9	84	99	8.29	8.35
BC-11	3	1	1.091	10	33	1.9	6.9	<.02	.09	1.9	84	99	8.29	8.32
BC-11	5	1	0.891	11	30	2.0	6.1	1.0	0.42	1.9	86	98	8.26	8.29
BC-11	6	1	.918	.11	31	2.0	6.1	1.0	.42	1.9	86	98	8.26	8.30
BC-11	7	1	.931	11	30	2.0	6.0	1.0	.42	1.9	86	98	8.26	8.28
BC-11	9	1	.959	11	32	2.0	6.5	2.4	.91	1.9	92	100	8.27	8.30
BC-11	10	1	1.139	11	34	2.0	7.1	2.4	.91	1.9	92	100	8.27	8.29
BC-11	11	1	1.039	11	34	2.0	6.9	2.4	.89	1.9	92	100	8.27	8.30
BC-11	13	1	1.139	11	36	2.0	7.4	4.9	1.7	1.9	100	96	8.24	8.29

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-11	14	1	1.123	11	34	2.0	7.2	4.9	1.7	1.9	100	96	8.24	8.31
BC-11	15	1	1.097	11	35	2.0	7.2	4.9	1.8	1.9	100	96	8.24	8.34
BC-11	4	2	none	11	10	1.9	1.9	<.02	<.02	1.9	84	99	8.29	8.29
BC-11	8	2	none	11	11	1.9	2.0	1.1	.98	1.9	86	98	8.26	8.26
BC-11	12	2	none	11	11	1.9	2.0	2.7	2.4	1.9	92	100	8.27	8.27
BC-11	16	2	none	12	11	1.9	2.0	5.4	4.9	1.9	100	96	8.24	8.24
BC-11	17	3	none	<.06	.09	<.05	<.05	<.02	.02	<.1	<.1	--	--	6.21
BC-12	1	1	1.044	11	23	2.0	12.0	<.02	.25	1.9	84	99	8.31	8.31
BC-12	2	1	.957	11	22	2.0	11.0	<.02	.24	1.9	84	99	8.31	8.31
BC-12	3	1	1.015	11	22	2.0	11.2	<.02	.24	1.9	84	99	8.31	8.32
BC-12	5	1	1.032	10	23	2.0	11.9	1.0	.42	1.9	86	98	8.22	8.35
BC-12	6	1	.998	10	25	2.0	12.6	1.0	.45	1.9	86	98	8.22	8.30
BC-12	7	1	1.063	10	25	2.0	12.7	1.0	.44	1.9	86	98	8.22	8.24
BC-12	9	1	0.971	11	23	2.1	11.8	2.5	0.71	1.9	92	100	8.28	8.31
BC-12	10	1	.966	11	22	2.1	11.7	2.5	.70	1.9	92	100	8.28	8.30
BC-12	11	1	.912	11	22	2.1	11.4	2.5	.69	1.9	92	100	8.28	8.34
BC-12	13	1	1.035	11	24	2.1	12.3	5.1	1.2	1.9	100	96	8.31	8.33
BC-12	14	1	1.016	11	24	2.1	12.3	5.1	1.2	1.9	100	96	8.31	8.33
BC-12	15	1	.955	11	23	2.1	12.1	5.1	1.2	1.9	100	96	8.31	8.31
BC-12	4	2	none	11	11	1.9	2.0	<.02	<.02	1.9	84	99	8.31	8.31
BC-12	8	2	none	11	10	1.9	2.0	1.1	.99	1.9	86	98	8.22	8.22

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-12	12	2	none	11	11	1.9	2.1	2.7	2.5	1.9	92	100	8.28	8.28
BC-12	16	2	none	12	11	1.9	2.1	5.4	5.1	1.9	100	96	8.31	8.31
BC-12	17	3	none	<.06	.11	<.05	<.05	<.02	.02	<.1	<.1	--	--	6.13
BC-13	1	1	.942	10	81	1.8	6.6	<.02	.11	1.9	84	99	8.40	8.57
BC-13	2	1	1.042	10	75	1.8	6.1	<.02	.11	1.9	84	99	8.40	8.62
BC-13	3	1	.972	10	75	1.8	6.2	<.02	.11	1.9	84	99	8.40	8.58
BC-13	5	1	.993	10	84	1.8	6.5	1.0	.20	1.9	86	98	8.36	8.57
BC-13	6	1	.991	10	74	1.8	5.8	1.0	.20	1.9	86	98	8.36	8.51
BC-13	7	1	.971	10	73	1.8	5.7	1.0	.18	1.9	86	98	8.36	8.57
BC-13	9	1	1.069	11	65	1.9	4.3	2.4	.30	1.9	92	100	8.31	8.49
BC-13	10	1	.970	11	62	1.9	4.3	2.4	.32	1.9	92	100	8.31	8.53
BC-13	11	1	.978	11	66	1.9	4.0	2.4	.31	1.9	92	100	8.31	8.53
BC-13	13	1	0.998	11	52	1.9	5.5	5.2	0.54	1.9	100	96	8.34	8.51
BC-13	14	1	.992	11	51	1.9	5.8	5.2	.58	1.9	100	96	8.34	8.5
BC-13	15	1	.978	11	53	1.9	5.6	5.2	.58	1.9	100	96	8.34	8.47
BC-13	4	2	none	11	10	1.9	1.8	<.02	<.02	1.9	84	99	8.40	8.4
BC-13	8	2	none	11	10	1.9	1.8	1.1	.98	1.9	86	98	8.36	8.36
BC-13	12	2	none	11	11	1.9	1.9	2.7	.24	1.9	92	100	8.31	8.31
BC-13	16	2	none	12	11	1.9	1.9	5.4	5.2	1.9	100	96	8.34	8.34
BC-13	17	3	none	<.06	.15	<.05	<.05	<.02	.04	<.1	<.1	--	--	6.46

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-14	1	1	1.095	12	22	1.9	5.8	<.02	.12	1.9	84	99	8.23	8.20
BC-14	2	1	.930	12	22	1.9	5.7	<.02	.12	1.9	84	99	8.23	8.33
BC-14	3	1	1.007	12	21	1.9	5.4	<.02	.11	1.9	84	99	8.23	8.27
BC-14	5	1	.971	12	23	2.0	5.7	1.0	.28	1.9	86	98	8.31	8.25
BC-14	6	1	.873	12	22	2.0	5.5	1.0	.28	1.9	86	98	8.31	8.30
BC-14	7	1	1.017	12	24	2.0	5.7	1.0	.26	1.9	86	98	8.31	8.27
BC-14	9	1	.996	12	22	2.0	5.6	2.5	.47	1.9	92	100	8.29	8.41
BC-14	10	1	.935	12	22	2.0	5.6	2.5	.51	1.9	92	100	8.29	8.35
BC-14	11	1	.988	12	22	2.0	5.7	2.5	.51	1.9	92	100	8.29	8.29
BC-14	13	1	.833	12	20	2.0	5.6	5.4	1.0	1.9	100	96	8.32	8.29
BC-14	14	1	1.028	12	23	2.0	6.1	5.4	.92	1.9	100	96	8.32	8.31
BC-14	15	1	1.030	12	22	2.0	5.9	5.4	.84	1.9	100	96	8.32	8.30
BC-14	4	2	none	11	12	1.9	1.9	<.02	<.02	1.9	84	99	8.23	8.23
BC-14	8	2	none	11	12	1.9	2.0	1.1	1.0	1.9	86	98	8.31	8.31
BC-14	12	2	none	11	12	1.9	2.0	2.7	2.48	1.9	92	100	8.29	8.29
BC-14	16	2	none	12	12	1.9	2.0	5.4	5.38	1.9	100	96	8.32	8.32
BC-14	17	3	none	<.06	0.12	<.05	<.05	<.02	.03	<.1	<.1	--	--	6.35
BC-15	1	1	1.059	11	19	2.0	3.9	<.02	.08	1.9	84	99	8.41	8.29
BC-15	2	1	.865	11	17	2.0	3.8	<.02	.08	1.9	84	99	8.41	8.30
BC-15	3	1	.927	11	17	2.0	3.8	<.02	.08	1.9	84	99	8.41	8.31
BC-15	5	1	1.036	11	18	2.0	4.0	1.0	.19	1.9	86	98	8.40	8.33

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-15	6	1	1.065	11	18	2.0	4.1	1.0	.18	1.9	86	98	8.40	8.34
BC-15	7	1	.971	11	18	2.0	3.9	1.0	.19	1.9	86	98	8.40	8.36
BC-15	9	1	1.004	12	20	2.0	4.1	2.5	.37	1.9	92	100	8.41	8.33
BC-15	10	1	.986	12	19	2.0	4.0	2.5	.35	1.9	92	100	8.41	8.35
BC-15	11	1	1.041	12	19	2.0	4.1	2.5	.34	1.9	92	100	8.41	8.34
BC-15	13	1	.962	12	20	2.0	4.3	5.2	.70	1.9	100	96	8.35	8.33
BC-15	14	1	.971	12	20	2.0	4.2	5.2	.68	1.9	100	96	8.35	8.33
BC-15	15	1	1.030	12	20	2.0	4.3	5.2	.65	1.9	100	96	8.35	8.33
BC-15	4	2	none	11	11	1.9	2.0	<.02	<.02	1.9	84	99	8.41	8.41
BC-15	8	2	none	11	11	1.9	2.0	1.1	1.0	1.9	86	98	8.40	8.40
BC-15	12	2	none	11	12	1.9	2.0	2.7	2.5	1.9	92	100	8.41	8.41
BC-15	16	2	none	12	12	1.9	2.0	5.4	5.2	1.9	100	96	8.35	8.35
BC-15	17	3	none	<.06	0.12	<.05	<.05	<.02	<.02	<.1	<.1	--	--	6.39
BC-16	1	1	1.114	12	16	2.0	4.2	<.02	.11	1.9	84	99	8.34	8.34
BC-16	2	1	.911	12	15	2.0	4.0	<.02	.11	1.9	84	99	8.34	8.41
BC-16	3	1	.978	12	16	2.0	4.2	<.02	.11	1.9	84	99	8.34	8.38
BC-16	5	1	1.070	13	16	2.1	4.3	1.1	.20	1.9	86	98	8.37	8.41
BC-16	6	1	1.100	13	17	2.1	4.5	1.1	.21	1.9	86	98	8.37	8.37
BC-16	7	1	.894	13	16	2.1	4.3	1.1	.21	1.9	86	98	8.37	8.4
BC-16	9	1	.923	12	16	2.0	4.3	2.5	.38	1.9	92	100	8.39	8.41
BC-16	10	1	.967	12	16	2.0	4.3	2.5	.36	1.9	92	100	8.39	8.41

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-16	11	1	.907	12	15	2.0	4.2	2.5	.36	1.9	92	100	8.39	8.44
BC-16	13	1	1.015	12	16	2.0	4.4	5.4	.59	1.9	100	96	8.37	8.41
BC-16	14	1	.864	12	16	2.0	4.4	5.4	.65	1.9	100	96	8.37	8.41
BC-16	15	1	1.010	12	16	2.0	4.5	5.4	.59	1.9	100	96	8.37	8.39
BC-16	4	2	none	11	12	1.9	2.0	<.02	<.02	1.9	84	99	8.34	8.34
BC-16	8	2	none	11	13	1.9	2.1	1.1	1.1	1.9	86	98	8.37	8.37
BC-16	12	2	none	11	12	1.9	2.0	2.7	2.5	1.9	92	100	8.39	8.39
BC-16	16	2	none	12	12	1.9	2.0	5.4	5.4	1.9	100	96	8.37	8.37
BC-16	17	3	none	<.06	0.15	<.05	<.05	<.02	<.02	<.1	<.1	--	--	6.33
BC-17	1	1	0.979	12	30	2.0	1.9	<.02	.25	1.9	84	99	8.37	8.24
BC-17	2	1	.935	12	28	2.0	1.4	<.02	.24	1.9	84	99	8.37	8.26
BC-17	3	1	1.008	12	32	2.0	11.8	<.02	.27	1.9	84	99	8.37	8.23
BC-17	5	1	.987	12	29	2.0	1.7	1.0	.41	1.9	86	98	8.40	8.22
BC-17	6	1	.911	12	29	2.0	1.6	1.0	.42	1.9	86	98	8.40	8.25
BC-17	7	1	1.018	12	31	2.0	11.3	1.0	.41	1.9	86	98	8.40	8.24
BC-17	9	1	.991	12	31	2.0	11.4	2.5	.71	1.9	92	100	8.37	8.28
BC-17	10	1	.965	12	31	2.0	11.1	2.5	.71	1.9	92	100	8.37	8.27
BC-17	11	1	1.061	12	33	2.0	12.1	2.5	.73	1.9	92	100	8.37	8.25
BC-17	13	1	.966	12	35	2.0	12.4	5.5	1.3	1.9	100	96	8.34	8.25
BC-17	14	1	.961	12	32	2.0	11.7	5.5	1.2	1.9	100	96	8.34	8.26
BC-17	15	1	.977	12	31	2.0	11.5	5.5	1.2	1.9	100	96	8.34	8.26

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-17	4	2	none	11	12	1.9	2.0	<.02	<.02	1.9	84	99	8.37	8.37
BC-17	8	2	none	11	12	1.9	2.0	1.1	.99	1.9	86	98	8.40	8.40
BC-17	12	2	none	11	12	1.9	2.0	2.7	2.5	1.9	92	100	8.37	8.37
BC-17	16	2	none	12	12	1.9	2.0	5.4	5.5	1.9	100	96	8.34	8.34
BC-17	17	3	none	<.06	0.12	<.05	<.05	<.02	.02	<.1	<.1	--	--	6.37
BC-18	1	1	.898	12	22	2.0	7.6	<.02	.11	1.9	84	99	8.40	8.45
BC-18	2	1	1.019	12	25	2.0	7.9	<.02	.12	1.9	84	99	8.40	8.50
BC-18	3	1	.949	12	27	2.0	7.6	<.02	.12	1.9	84	99	8.40	8.51
BC-18	5	1	0.985	12	24	2.0	8.0	1.0	0.20	1.9	86	98	8.41	8.51
BC-18	6	1	.953	12	22	2.0	8.0	1.0	.21	1.9	86	98	8.41	8.52
BC-18	7	1	1.072	12	22	2.0	8.4	1.0	.21	1.9	86	98	8.41	8.52
BC-18	9	1	.940	12	23	2.0	8.2	2.4	.35	1.9	92	100	8.40	8.54
BC-18	10	1	.936	12	22	2.0	8.1	2.4	.35	1.9	92	100	8.40	8.54
BC-18	11	1	.902	12	21	2.0	7.8	2.4	.36	1.9	92	100	8.40	8.52
BC-18	13	1	.965	12	20	2.0	8.5	5.4	.59	1.9	100	96	8.39	8.53
BC-18	14	1	.966	12	20	2.0	8.5	5.4	.58	1.9	100	96	8.39	8.52
BC-18	15	1	1.056	12	21	2.0	8.7	5.4	.59	1.9	100	96	8.39	8.51
BC-18	4	2	none	11	12	1.9	2.0	<.02	<.02	1.9	84	99	8.40	8.40
BC-18	8	2	none	11	12	1.9	2.0	1.1	1.0	1.9	86	98	8.41	8.41
BC-18	12	2	none	11	12	1.9	2.0	2.7	2.5	1.9	92	100	8.40	8.40
BC-18	16	2	none	12	12	1.9	2.0	5.4	5.4	1.9	100	96	8.39	8.39

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-18	17	3	none	<.06	0.13	<.05	<.05	<.02	<.02	<.1	<.1	--	--	6.55
BC-19	1	1	.973	10	18	1.8	11	.1	.25	1.9	84	99	8.19	8.01
BC-19	2	1	1.074	10	23	1.8	13	.1	.29	1.9	84	99	8.19	8.01
BC-19	3	1	.988	10	19	1.8	12	.1	.28	1.9	84	99	8.19	8.22
BC-19	5	1	1.027	10	24	1.8	14	1.0	.47	1.9	86	98	8.07	8.25
BC-19	6	1	.961	10	29	1.8	13	1.0	.45	1.9	86	98	8.07	8.16
BC-19	7	1	.993	10	19	1.8	12	1.0	.45	1.9	86	98	8.07	8.05
BC-19	9	1	1.007	10	21	1.9	13	2.6	0.70	1.9	92	100	8.19	8.28
BC-19	10	1	1.053	10	20	1.9	13	2.6	.68	1.9	92	100	8.19	8.06
BC-19	11	1	1.066	10	23	1.9	14	2.6	.77	1.9	92	100	8.19	8.32
BC-19	13	1	1.116	10	22	1.9	14	4.9	1.0	1.9	100	96	8.22	8.21
BC-19	14	1	1.033	10	24	1.9	14	4.9	1.1	1.9	100	96	8.22	8.18
BC-19	15	1	1.028	10	25	1.9	15	4.9	1.2	1.9	100	96	8.22	8.17
BC-19	4	2	none	11	10	1.9	1.8	<.02	.06	1.9	84	99	8.19	8.19
BC-19	8	2	none	11	10	1.9	1.8	1.1	.99	1.9	86	98	8.07	8.07
BC-19	12	2	none	11	10	1.9	1.9	2.7	2.6	1.9	92	100	8.19	8.19
BC-19	16	2	none	12	10	1.9	1.9	5.4	4.9	1.9	100	96	8.22	8.22
BC-19	17	3	none	<.06	0.13	<.05	<.05	<.02	.02	<.1	<.1	--	--	6.91
BC-20	1	1	1.024	10	15	1.9	2.0	<.02	.05	1.9	84	99	8.15	8.01
BC-20	2	1	.991	10	15	1.9	2.0	<.02	.07	1.9	84	99	8.15	8.17

Table 6. Sediment mass; initial and final calcium, magnesium, and strontium concentrations; initial potassium, sodium, and alkalinity concentrations; and initial and final pH of synthesized aqueous solutions—continued

Sample set	Sample number	Sample type	Sediment mass (grams)	Initial calcium (mg/L)	Final calcium (mg/L)	Initial magnesium (mg/L)	Final magnesium (mg/L)	Initial strontium (mg/L)	Final strontium (mg/L)	Initial potassium (mg/L)	Initial sodium (mg/L)	Initial alkalinity (mg/L)	Initial pH (pH units)	Final pH (pH units)
BC-20	3	1	.991	10	14	1.9	2.0	<.02	.08	1.9	84	99	8.15	8.20
BC-20	5	1	.982	10	11	1.9	1.4	.9	.28	1.9	86	98	8.17	8.13
BC-20	6	1	.991	10	16	1.9	2.1	.9	.31	1.9	86	98	8.17	8.21
BC-20	7	1	.964	10	16	1.9	2.1	.9	.29	1.9	86	98	8.17	8.16
BC-20	9	1	.976	10	16	1.9	2.1	2.5	.63	1.9	92	100	8.05	8.01
BC-20	10	1	1.012	10	17	1.9	2.1	2.5	.64	1.9	92	100	8.05	8.05
BC-20	11	1	.999	10	16	1.9	2.1	2.5	.60	1.9	92	100	8.05	8.10
BC-20	13	1	1.022	10	18	1.9	2.3	5.2	1.2	1.9	100	96	8.24	8.17
BC-20	14	1	.987	10	18	1.9	2.4	5.2	1.3	1.9	100	96	8.24	8.06
BC-20	15	1	.944	10	17	1.9	2.3	5.2	1.3	1.9	100	96	8.24	8.15
BC-20	4	2	none	11	10	1.9	1.9	<.02	<.02	1.9	84	99	8.15	8.15
BC-20	8	2	none	11	10	1.9	1.9	1.1	.94	1.9	86	98	8.17	8.17
BC-20	12	2	none	11	10	1.9	1.9	2.7	2.5	1.9	92	100	8.05	8.05
BC-20	16	2	none	12	10	1.9	1.9	5.4	5.2	1.9	100	96	8.24	8.24
BC-20	17	3	none	<.06	0.13	<.05	<.05	<.02	.05	<.1	<.1	--	--	6.80