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DISTRIBUTION OF MOISTURE, TRITIUM, AND PLUTONIUM IN THE ALLUVIUM, AQUIFER, AND UNDERLYING TUFF IN MORTANDAD CANYON

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Funding Organization: Los Alamos National Laboratory

Introduction

Mortandad Canyon received industrial effluents containing trace amounts of radionuclides from the treatment plant at TA–50 (Fig. 19). The effluents and surface runoff recharge a shallow aquifer in the canyon. The shallow aquifer in the alluvium is perched (separated by about 290 m of unsaturated volcanics and sediments from the main aquifer) on the underlying tuff.[1] The aquifer is of limited extent as water in the aquifer is depleted by evapotranspiration and infiltration into the underlying tuff. This investigation was made to determine the distribution of infiltration (moisture) and radionuclides in the alluvium and underlying tuff in a section of Mortandad Canyon.

Concentrations of radionuclides in water of the shallow aquifer decrease downgradient in the canyon from the effluent outfall. This reduction is caused by adsorption or ion exchange of the radionuclides with silt or clay minerals in the alluvium or dilution of the effluent by storm runoff. The distribution of the radionuclides in the aquifer is monitored by seven observation wells.[2]

At observation Well MCO–6, three core holes were drilled at right angles to the stream channel. Two other holes were cored to obtain background information. Cores taken from five holes were analyzed to determine moisture content and concentrations of tritium and plutonium (Table XXII).

The alluvium in the canyon is derived from the weathering of the Bandelier Tuff. At Well MCO–6, the alluvium is thickest beneath the stream channel and thins away from the channel (Fig. 18). The alluvium is a silty sand that includes a thin layer of silty clay of weathered tuff at the base. The light pinkish gray tuff is moderately welded and is composed of quartz and sanidine crystals and crystal fragments, with small rock fragments of rhyolite, latite, and pumice in an ash

TABLE XXII. Distribution of Moisture, Tritium, and Plutonium from Core Holes in Mortandad Canyon

Sample	Depth (m)	Moisture (vol %)	^{3}H (10^{-6} μCi/mL)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)
Core Hole 1					
(In channel)	1.8	7	10 ± 0.8	0.001 ± 0.002	0.000 ± 0.003
	3.4	12	29 ± 1.4	–0.003 ± 0.004	0.016 ± 0.008
	4.9	12	21 ± 1.2	0.001 ± 0.002	0.004 ± 0.003
	6.4	12	14 ± 1.0	–0.001 ± 0.002	0.008 ± 0.006
	7.9	28	8.5 ± 0.8	0.006 ± 0.003	0.010 ± 0.004
	9.4	32	23 ± 1.2	0.000 ± 0.003	0.003 ± 0.004
	11.0	19	—	—	—
	12.5	20	150 ± 4.0	0.003 ± 0.003	0.002 ± 0.002
	14.0	27	391 ± 12	0.003 ± 0.003	0.004 ± 0.003
	15.2	18	106 ± 3.6	0.005 ± 0.003	0.000 ± 0.002
	15.5	17	101 ± 3.4	–0.001 ± 0.002	0.002 ± 0.002
	17.1	12	91 ± 3.0	0.003 ± 0.003	0.002 ± 0.003
	18.6	16	118 ± 3.8	0.001 ± 0.003	0.001 ± 0.002
	20.1	11	115 ± 3.8	–0.001 ± 0.001	0.004 ± 0.003
	21.6	14	107 ± 3.6	0.000 ± 0.002	0.000 ± 0.002
Summary: $\bar{x}$ ± 2s		17 ± 14	92 ± 198	0.001 ± 0.005	0.004 ± 0.009
Core Hole 2					
(6 m south of channel)	1.8	8	7.9 ± 0.8	–0.001 ± 0.000	0.010 ± 0.004
	3.4	4	—	0.002 ± 0.002	0.043 ± 0.008
	4.9	4	11 ± 1.0	–0.002 ± 0.004	0.020 ± 0.006
	6.4	6	16 ± 1.0	–0.001 ± 0.003	0.001 ± 0.003
	7.9	18	62 ± 2.2	0.001 ± 0.002	0.008 ± 0.004
	9.3	29	291 ± 10	0.000 ± 0.002	0.010 ± 0.004
	4	29	277 ± 8.0	–0.001 ± 0.002	0.035 ± 0.008
	11.0	19	169 ± 6.0	0.002 ± 0.004	0.006 ± 0.004
	12.5	25	138 ± 4.0	0.003 ± 0.003	0.010 ± 0.004
	14.0	14	541 ± 18	–0.001 ± 0.002	0.005 ± 0.003
	15.5	12	60 ± 2.2	–0.001 ± 0.002	0.004 ± 0.004
	17.1	11	34 ± 14	–0.001 ± 0.003	0.000 ± 0.002
	18.6	11	65 ± 2.4	–0.001 ± 0.002	0.002 ± 0.002
	20.1	10	80 ± 2.8	–0.001 ± 0.002	0.002 ± 0.003
	21.6	11	139 ± 4.0	–0.001 ± 0.003	0.002 ± 0.002
Summary: $\bar{x}$ ± 2s		14 ± 17	135 ± 296	0.000 ± 0.003	0.011 ± 0.025
Core Hole 3					
(12 m south of channel)	1.8	3	18 ± 1.0	0.004 ± 0.004	0.000 ± 0.004
	2.9	2	—	–0.002 ± 0.002	0.003 ± 0.003
	4.9	6	2.4 ± 0.8	–0.003 ± 0.003	–0.002 ± 0.003
	6.4	4	6.0 ± 1.2	–0.001 ± 0.002	–0.001 ± 0.003
	7.9	4	17 ± 1.0	0.000 ± 0.003	0.000 ± 0.003
	9.4	—	14 ± 1.0	0.000 ± 0.001	–0.001 ± 0.002
	11.0	7	13 ± 1.0	0.000 ± 0.004	0.017 ± 0.006
	12.5	8	13 ± 1.0	–0.002 ± 0.003	0.002 ± 0.004
	14.0	8	16 ± 1.0	0.000 ± 0.002	0.003 ± 0.004
	15.5	9	25 ± 1.2	–0.002 ± 0.001	0.015 ± 0.004
	17.1	9	35 ± 1.6	–0.003 ± 0.002	0.003 ± 0.004
	18.6	9	50 ± 2.0	–0.001 ± 0.001	0.010 ± 0.004
	20.1	10	44 ± 1.8	–0.001 ± 0.003	0.010 ± 0.004
	21.6	12	53 ± 2.0	–0.001 ± 0.001	0.022 ± 0.006
Summary: $\bar{x}$ ± 2s		7 ± 6	28 ± 39	–0.001 ± 0.003	0.006 ± 0.015
Core Hole 4					
(control)	1.8	5	4.5 ± 0.8	–0.002 ± 0.002	–0.002 ± 0.003
	3.4	5	1.6 ± 0.8	0.000 ± 0.003	–0.001 ± 0.003
	4.9	5	1.3 ± 0.6	—	—
	6.4	3	—	–0.001 ± 0.002	0.004 ± 0.003
Summary: $\bar{x}$ ± 2s		4 ± 2	2.5 ± 3.5	–0.001 ± 0.002	0.000 ± 0.006
Core Hole 5					
(Control)	1.8	3	6.0 ± 0.8	–0.002 ± 0.004	–0.004 ± 0.003
	3.4	3	1.7 ± 0.4	–0.002 ± 0.002	–0.001 ± 0.002
	4.9	2	—	0.000 ± 0.002	–0.001 ± 0.004
	6.4	5	3.8 ± 0.8	–0.001 ± 0.002	–0.003 ± 0.002
Summary: $\bar{x}$ ± 2s		3 ± 2	3.8 ± 4.3	–0.001 ± 0.002	–0.002 ± 0.003
Core Holes 4 and 5 (Control)					
Summary: $\bar{x}$ ± 2s		4 ± 2	3.0 ± 3.5	–0.001 ± 0.002	–0.001 ± 0.005

Notes: 1. One sample taken at each depth.

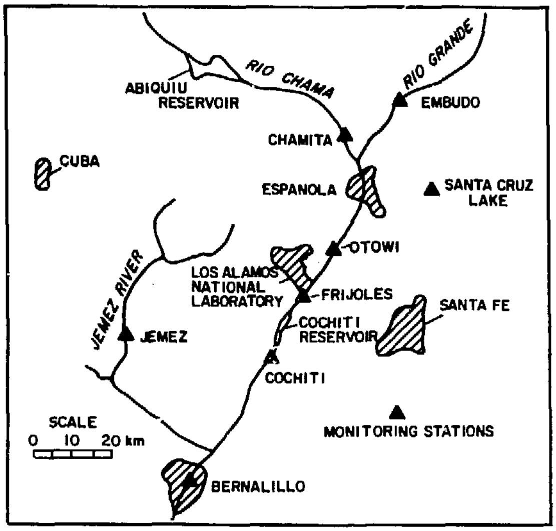
2. *The ± value is twice the uncertainty for that analysis.*

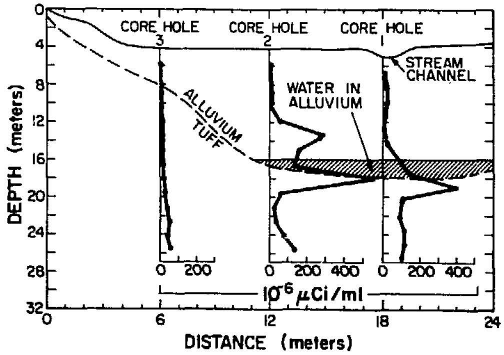
matrix. The tuff beneath the aquifer is weathered; the ash matrix contains some light brown silts and clays. The amount of silt and clays (degree of weathering) decreases at depth and with distance from the aquifer.

Moisture Distribution

The distribution of moisture in the alluvium and tuff is shown in Fig. 19. In core holes 1 and 2 the moisture content approaches 30% by volume from 1 to 3 m above the top of the aquifer. This anomaly above the aquifer is in a silty clay unit within the alluvium. The water table fluctuates twice a year because of seasonal runoff from snowmelt and summer precipitation. At the time the holes were cored, the water table was declining.

The moisture content of the aquifer material ranged from 20 to 25% by volume. There is some infiltration of water into the tuff beneath the aquifer. At core hole 1, the moisture content ranges from about 10 to 27% to a depth of 8 m below the base of the aquifer. At core hole 2, the moisture content is lower, ranging from 10 to 18% to a depth of 8 m below the aquifer. Core hole 3 indicates some horizontal component of movement of moisture from the aquifer only in the low-moisture range, greater than 5% by volume below a depth of 13 m (Fig. 20). Natural moisture content of the tuff is about 5% by volume.





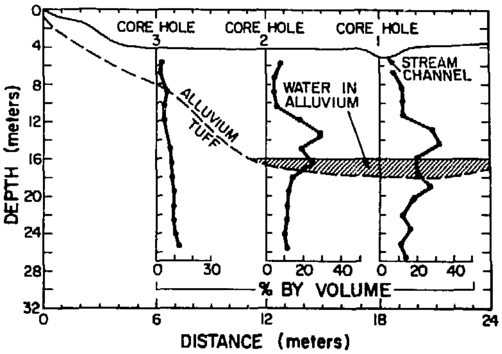


FIGURE 18 (top). Regional surface water, sediment, and soil sampling locations.

FIGURE 19 (left). Distribution of moisture in alluvium and tuff in Mortandad Canyon.

FIGURE 20 (right). Distribution of trituim in alluvium and tuff in Mortandad Canyon.

Tritium Distribution

Water distilled from the cores was analyzed for tritium (^3H). Tritium, a part of the water molecule, moves with the water and is not affected by adsorption or ion exchange with clay minerals. The average ^3H concentration in water in the aquifer (1978 when core was taken) at Well MCO-6 was 303×10^{-6} μCi/mL, having declined from a high of 1760×10^{-6} μCi/mL in 1976. The core from hole 1 contained a high of 400×10^{-6} μCi/mL about 1 m below the aquifer and was about 550×10^{-6} μCi/mL at the same depth below the aquifer in core hole 2 (Fig. 20). The ^3H concentrations generally decline with depth below the aquifer. The high concentrations in the tuff below the aquifer probably reflect the movement of tritium beneath the aquifer in the tuff, possibly from the high concentrations that occurred in 1976. At core hole 2, a high concentration of ^3H (290×10^{-6} μCi/mL) occurred in the silt and clay base alluvium at a depth of about 10 m. This is above the aquifer. The ^3H in core hole 3 increases slightly with depth and is above background (Table XXII). The concentrations are low, less than 50×10^{-6} μCi/mL, but the ^3H concentrations reflect the same pattern of the movement of moisture from the aquifer (Figs. 20 and 21).

Plutonium Distribution

Samples of water taken from observation wells were filtered through a 45-μm-pore membrane filter to remove fine sediments. The filtrate and the filter were analyzed for ^{238}Pu and $^{239,240}Pu$. The data indicated little, if any, plutonium was retained on the filter and most, if not all, of the plutonium was in solution. This is in direct contrast with what occurs in the channel when the effluent is released from the treatment plant. The plutonium in the effluent is readily adsorbed or attached to silt and clays in the alluvium in the channel. Concentrations in solution and on sediments decrease downgradient in the canyon.

Cores taken through the alluvium, aquifer, and into the underlying tuff were analyzed for plutonium to determine if there was any transport or buildup of plutonium in silts and clays beneath the channel in the alluvium, aquifer, or tuff. When the cores were taken in 1978, the alluvium in the channel contained about 2.7 pCi/g of ^{238}Pu and 4.0 pCi/g of $^{239,240}Pu$. Water in the

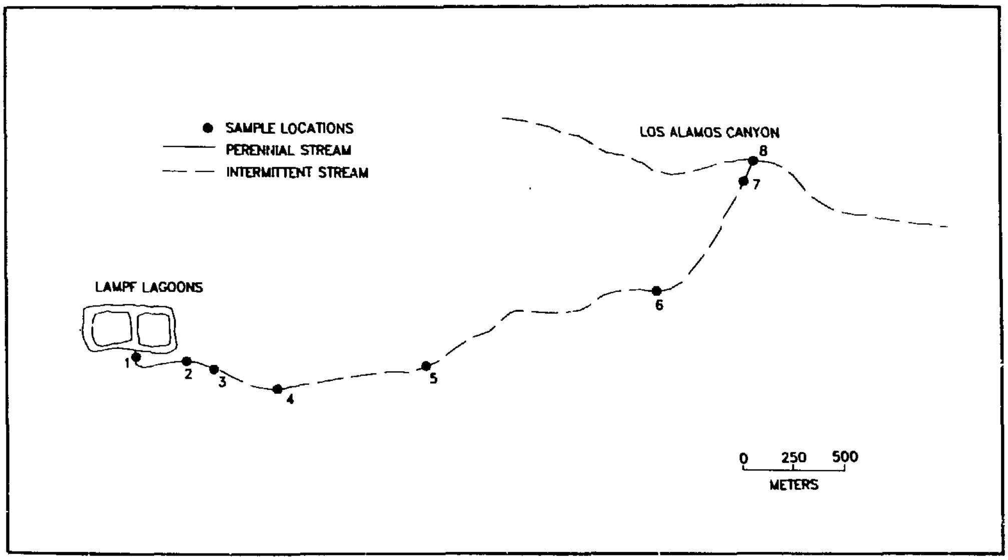


FIGURE 21. **Sampling locations in vicinity of the Los Alamos Meson Physics Facility's lagoons.**

aquifer contained an average of 2.2×20^{-6} μCi/mL of ^{238}Pu and 0.28×10^{-6} μCi/mL of ^{239,240}Pu at Well MCO-6. Results of the analyses of cores indicate no significant concentrations of ^{238}Pu in silts and clay of the alluvium aquifer or underlying tuff (Table XXIII). A comparison of the ^{239,240}Pu concentrations are low, being much lower than those found in solution in the aquifer or attached to sediments in the stream channel.

TABLE XXIII. Average Plutonium Concentration in Soil Cores from Mortandad Canyon

	$\bar{x}+2$ s	
Location	**^{238}Pu (pCi/g)**	**^{239}Pu (pCi/g)**
Core Hole 1	0.001 ± 0.005	0.004 ± 0.009
Core Hole 2	0.0000 ± 0.003	0.011 ± 0.025
Core Hole 3	−0.001 ± 0.003	0.006 ± 0.015
Core Hole 4 (Control)	−0.001 ± 0.002	0.000 ± 0.006
Core Hole 5 (Control)	−0.001 ± 0.002	−0.002 ± 0.003

Summary

In summary, a study of the distribution of moisture, tritium, and plutonium in the Mortandad Canyon aquifer indicates some infiltration of water into the underlying tuff. This infiltration was accompanied by similar movement of tritium. The concentrations of plutonium on the sediments in the aquifer were low when compared with the high concentrations in solution in an ionic complex that does not readily exchange or is adsorbed by clay minerals in the alluvium.

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TRANSPORT OF RADIONUCLIDES FROM THE LAMPF LAGOONS

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Monitoring of the discharge water from the Los Alamos Meson Physics Facility lagoons continued during 1983. Sampling frequency has been reduced to twice a year, in June and December. The list of radionuclides being monitored has been expanded so that it now includes ^{7}Be, ^{57}Co, ^{134}Cs, ^{3}H, ^{54}Mn, ^{22}Na, and ^{83}Rb. The sampling locations are shown in Fig. 21 and the data