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TRANSPORT OF PLUTONIUM IN SNOWMELT RUN-OFF

by

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ABSTRACT

Plutonium in treated low-level radioactive effluents released into intermittent streams is bound by ion exchange or adsorption to bed sediments in the stream channel. These sediments are subject to transport with summer and spring snowmelt run-off. A study was made of the transport of plutonium during seven spring run-off events (1975, 1979, 1980, 1982, 1983, 1985, and 1986) in Los Alamos and Pueblo canyons from the Laboratory boundary to Otowi on the Rio Grande. The melting of the snowpack during these years resulted in run-off that was large enough to reach the eastern edge of the Laboratory. Of these seven run-off events recorded at the Laboratory boundary, only five had sufficient flow to reach the Rio Grande. The volume of the five events that reached the river ranged from 5×10^3 m^3 to 104×10^3 m^3. The five run-off events carried 119×10^3 kg of suspended sediments and 1073×10^3 kg of bed sediments, and transported 598 µCi of plutonium to the river. Of the 598 µCi of plutonium, 3% was transported in solution, 57% with suspended sediments, and 40% with bed sediments.

I. INTRODUCTION

The Los Alamos National Laboratory is located on the Pajarito Plateau, which forms an apron around the eastern flanks of the Sierra de los Valles. The plateau slopes gently eastward until it terminates in cliffs and steep slopes above the Rio Grande. The surface of the plateau has been dissected into a number of narrow mesas by east-to-southeast–trending canyons cut by intermittent streams.

Precipitation on the flanks of the mountains and on the plateau produces two types of run-off in the intermittent streams: (1) run-off from summer thunderstorms and (2) run-off from the melting of spring snowpack.

Run-off from summer storms usually reaches a maximum discharge in less than 2 h, with total flow lasting less than 24 h. The high discharge results in transport of large masses of suspended sediments (concentrations as much as 40 000 mg/L) and large masses of bed sediments over long distances (Purtymun 1974).

Run-off from snowmelt in the spring usually occurs over a period of several weeks to several months with a low discharge. The low discharge results in transport of low concentrations of suspended sediments (less than 1000 mg/L); however, the long duration of flow moves large masses of suspended and bed sediments.

Two canyons that received treated low-level radioactive effluent are Acid and DP canyons (Fig. 1). The release of effluent ended in Acid Canyon in 1964 and DP Canyon in 1986. The amount of plutonium released into the two canyons has been estimated to range from 150 to 3000 mCi in the sediments (Stoker 1981, Lane 1985). An inventory of plutonium in the sediments indicated that only 8% of the plutonium in the canyon was in the active channel; the remaining 92% was in the inactive channel and bank (Stoker 1981). A model (Lane 1985) placed 33% of the inventory in the active

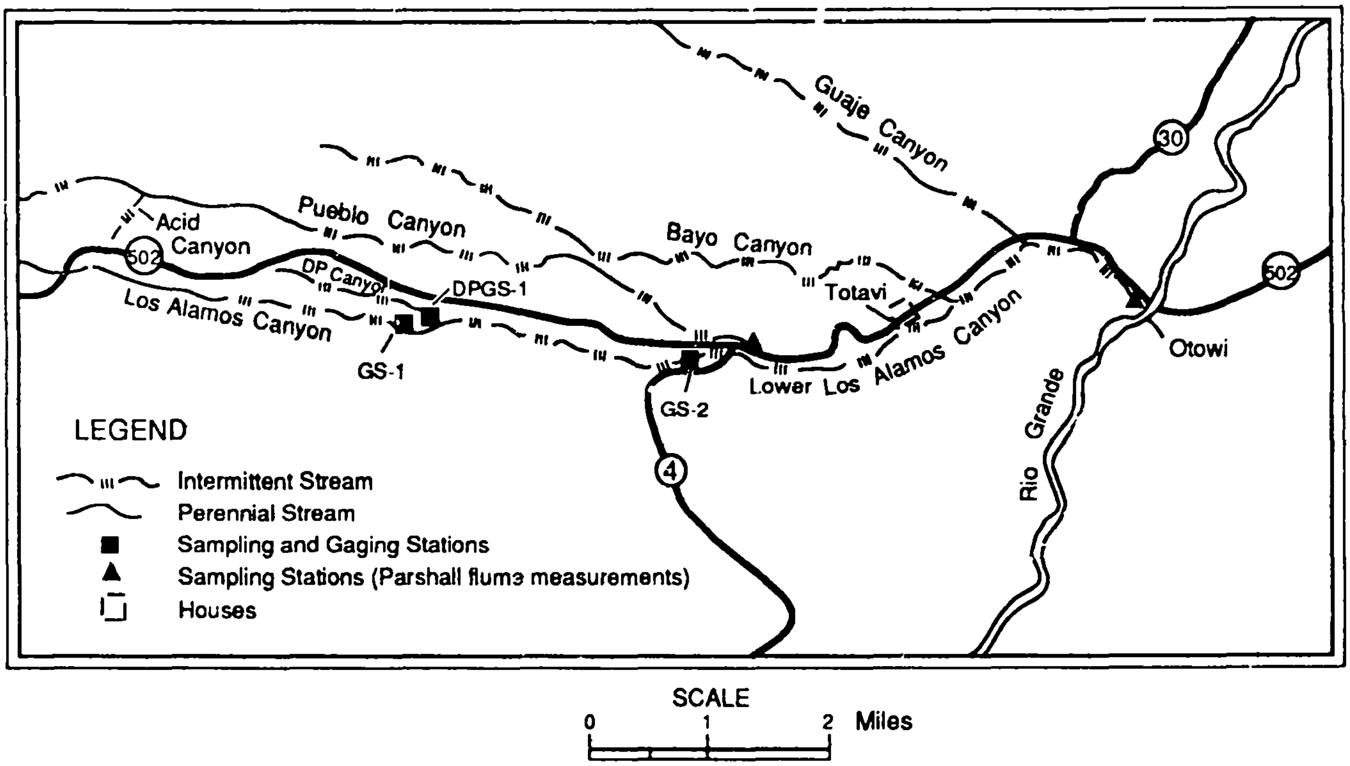

Fig. 1. Location of gaging and sampling stations in Pueblo and Los Alamos canyons.

channel and 67% in the inactive channel and on its banks.

The plutonium in the effluent becomes adsorbed or bound to sediments in the stream channel. The distribution of plutonium in the bed sediments is related to particle size. The highest plutonium concentrations are found in the fine-size fraction (clays and silts), with concentrations decreasing with increasing particle size. A large build-up of plutonium does not occur in the sediments at the effluent outfall, as the sediments and attached or bound plutonium are carried down gradient with the summer and spring run-off.

The active channel carries run-off from snowmelt and summer-storm small events. These events occur 2 to 10 times annually. Flow under these conditions may occur along short segments of the canyon, never reaching the Rio Grande; however, long periods of spring run-off saturates the alluvium and the flow reaches the Rio Grande.

During spring run-off, the transport of plutonium is confined to the inventory of plutonium in the active channel. Summer run-off with high discharge and a large suspended sediment load overflows the active channels onto the inactive channel and banks. The inactive channel above the active channel carries summer run-off 1 to 6 times annually; the overflow to the banks occurs once or twice every 2 years (ESG 1986).

Transport of radionuclides in summer run-off has been described for 17 run-off events in 1967 by Purtymun (1974); the distribution of radionuclides in a single summer event has been described by Hakonson (1976A). Distribution of radionuclides in channel sediments of canyon effluent areas has been investigated over the past years (Purtymun 1966 and 1971, Hakonson 1976B, Miera 1976, Nyhan 1980). A model for estimating surface run-off (combining spring and summer run-off) and contaminant transport was prepared in 1985 (Lane 1985).

This report describes the transport of plutonium in solution and in suspended and bed sediments for seven spring run-off events that reached the Laboratory boundary in the period 1975 through 1986. Of these seven events, only five had sufficient volume to reach Otowi and the Rio Grande. The two events that did not reach the river deposited sediments and plutonium east of the Laboratory boundary in the lower canyon (Fig. 1).

A. Methods of Study

Records were collected in the spring of 1973 and 1975 at gaging stations GS-1 in the midreach of Los Alamos Canyon and DPGS-4 in DP Canyon above the confluence with Los Alamos Canyon (Fig. 1). The records from a second station, GS-2 in Los Alamos Canyon at the eastern Laboratory boundary, were used to determine the flow into the lower canyon. The records on mean discharge and duration of run-off were used to determine the volume of flow for the run-off event. The volumes of run-off at the boundary in Pueblo Canyon and in Los Alamos Canyon at Otowi on the Rio Grande were determined from a number of measurements made using a Parshall flume (Fig. 2 and Appendix A).

A number of run-off samples were collected during the spring run-off. The samples were filtered through a 0.45-micron-millipore filter, and the data on the weight of the samples and the volume filtered were used to determine the concentration of the suspended sediment (milligrams per liter). The calculations of volume and average sediment concentration for the run-off event were used to determine the mass transport of suspended sediments through each station (Fig. 2 and Appendix A).

The estimate of bed sediment transported through each station was made using a model described by Leopold (1976) and using data on the mean diameter of the bed sediment, velocity of discharge, depth of run-off, slope of channel, and duration of run-off event. The model was calibrated using data for the spring run-off of 1973. From the volume and density of gravels removed within the active channel, it was estimated that 2880×10^3 kg of sediments were removed between GS-1 and GS-2. Leopold's model indicated that the amount of bed sediments removed from the station at GS-2 was 2665×10^3 kg. The difference between the measured and calculated transported bed sediments was about 10%. Leopold's model was used to calculate the bed sediment transported at each station for the seven spring run-off events that occurred from 1975 through 1986 (Fig. 2 and Appendix A).

As previously stated, a number of run-off samples collected during the event were filtered. The concentration of the plutonium in solution was determined from the filtrate, and the concentration of the suspended solids was determined from the sediments on the filter. The transport of plutonium in solution and suspended sediments was determined using the average concentration of plutonium with the volume of run-off and mass of suspended sediment for each spring event (Appendixes B and C).

The bed sediments are sampled in the spring as part of the general surveillance of the Laboratory conducted by the Environmental Protection Group (HSE-8). The samples are collected to a depth of about 5 cm across the active channel (the channel occupied by snowmelt run-off). The plutonium concentrations of the bed sediments and the mass of bed sediments passing through the station were used to estimate the amount of plutonium transported with the bed sediments (Appendix D).

B. Run-Off Characteristics

Shallow ground water occurs in the ~3.5-m-thick alluvium, which is perched on the underlying tuff between GS-1 and GS-2. The alluvium is partly saturated, recharged from intermittent streamflow into the canyon. The streamflow records from gaging stations GS-1 and GS-2 in 1973 and 1975 were used to determine the surface water losses between the two stations. These losses, when the flow between the two stations stabilizes, reflect losses from the perched aquifer into the tuff.

The surface water losses during 1973 between GS-1 and GS-2 stabilized between May 3 and May 28 as the alluvium became saturated. Surface water losses ranged from 2.3×10^3 m^3/day to 2.5×10^3 m^3/day; the discharge at GS-1 was about 0.19 m^3/s.

During 1975, the surface water losses between the two stations stabilized between April 10 and May 12. The average daily loss between the two stations was 1.7×10^3 m^3; the discharge at GS-1 was about 0.10 m^3/s. The flow losses between the two stations decrease with a decrease in discharge at GS-1. As the discharge at GS-1 approaches 0.012 m^3/s with the alluvium saturated, the losses between GS-1 and GS-2 become about equal to the inflow at GS-1 and the discharge at GS-2 becomes intermittent.

The alluvium contains a large volume of unsaturated alluvium in the lower canyon from Totavi to Otowi (Fig. 1). In this section of the canyon, the alluvium thickens and the active channel widens and

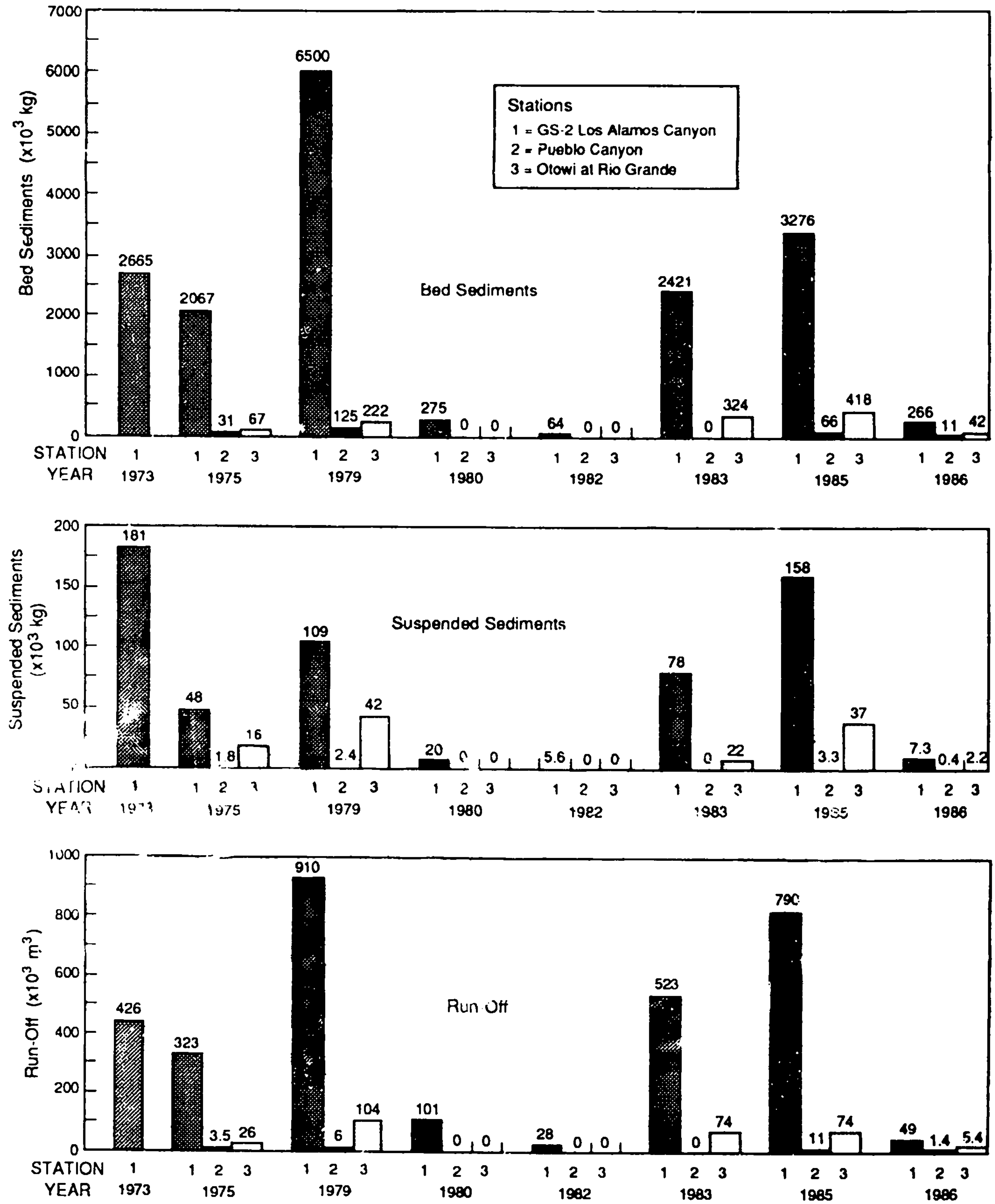

Fig. 2. Graph showing volume of run-off and amount of suspended and bed sediments at three stations for each event.

Table I. Run-Off in Lower Los Alamos Canyon.

Year	Volume (10^3 m^3) GS-2 and Pueblo	Otowi	Loss Lower Canyon	Percentage at Otowi
1973	426[a]	—	—	—
1975	326	26	300	8
1979	916	104	812	11
1980	101	—	101	—
1982	28	—	28	—
1983	523	74	449	14
1985	801	74	727	9
1986	50	5	45	10
Total	2745	283	2462	10

[a]Not included in total, as no measurements were taken at Pueblo and Otowi.

tends to braid out. Large losses of run-off occur in this section of the canyon.

The total spring run-off entering the lower canyon from 1975 through 1986 was $2745 \times 10^3 m^3$. Of this amount, $2462 \times 10^3 m^3$ were lost in the lower canyon, with only $283 \times 10^3 m^3$ reaching Otowi and the Rio Grande (Fig. 2 and Table I).

The concentration of suspended sediments in the run-off generally increases down gradient in the canyon as the run-off scours the finer material (clay, silt, very fine sands) from the active channel. However, the total suspended load decreases as the volume of run-off decreases down gradient in the canyon. The total mass of suspended sediments entering the lower canyon with spring run-off from 1975 through 1986 was 434 $\times 10^3$ kg. Of this amount, 315×10^3 kg were deposited in the lower canyon, with only 119×10^3 kg reaching Otowi and the Rio Grande (Fig. 2 and Table II).

Table II. Transport of Suspended Sediments in Lower Los Alamos Canyon.

Year	Weight (10^3 kg) GS-2 and Pueblo	Otowi	Deposited Lower Canyon	Percentage at Otowi
1973	181[a]	—	—	—
1975	50	16	34	32
1979	111	42	69	38
1980	20	—	20	—
1982	6	—	6	—
1983	78	22	56	28
1985	161	37	124	23
1986	8	2	6	25
Total	434	119	315	27

[a]Not included in total, as no measurements were taken at Otowi.

Table III. Transport of Bed Sediments in Lower Los Alamos Canyon.

Year	Weight (10^3 kg) GS-2 and Pueblo	Otowi	Deposited Lower Canyon	Percentage at Otowi
1973	2 665[a]	—	—	—
1975	2 098	67	2 031	3
1979	6 625	222	6 403	3
1980	275	—	275	—
1982	64	—	64	—
1983	2 421	324	2 097	13
1985	3 342	418	2 924	13
1986	277	42	235	15
Total	15 102	1 073	14 029	7

[a]Not included in total, as no measurements were taken at Otowi.

Bed sediments are deposited in the lower canyon as the flow velocity and run-off volume decrease eastward in the lower canyon. The mass of bed sediments entering the lower canyon with the seven spring events was 15 102 × 10^3 kg. Of this amount, 14 029 × 10^3 kg were deposited in the lower canyon, with only 1073 × 10^3 kg reaching Otowi and the Rio Grande (Fig. 2 and Table III).

II. DISTRIBUTION OF PLUTONIUM IN SNOWMELT RUN-OFF

As the plutonium is adsorbed or bound to the sediments in the channel, the spring run-off must interact with the sediments to resuspend the plutonium into solution (Table IV). As a result, the concentrations of plutonium in solution are low (ranging from <0.01 to 0.43 pCi/L) when compared with the total plutonium

Table IV. Average Total Plutonium Concentrations in Solution and in Suspended and Bed Sediments.

Year	GS-2 Solution (pCi/L)	GS-2 Suspended Sediments (pCi/g)	GS-2 Bed Sediments (pCi/g)	Pueblo Solution (pCi/L)	Pueblo Suspended Sediments (pCi/g)	Pueblo Bed Sediments (pCi/g)	Otowi Solution (pCi/L)	Otowi Suspended Sediments (pCi/g)	Otowi Bed Sediments (pCi/g)
1975	0.03	1.16	0.18	0.43	5.73	0.35	0.42	2.73	0.11
1979	0.01	4.56	0.40	0.13	7.54	0.46	<0.01	3.96	0.32
1980	0.01	5.37	0.17	—	—	—	—	—	—
1982	0.05	11.1	0.31	—	—	—	—	—	—
1983	0.01	4.97	0.24	—	—	—	0.01	2.45	0.33
1985	0.03	5.47	0.82	0.03	4.65	0.61	0.03	1.95	0.13
1986	0.01	1.84	0.29	0.01	<0.01	0.43	0.01	1.50	0.09
Mean	0.03	4.92	0.34	0.15	4.48	0.46	0.10	2.52	0.20
Std dev	0.03	3.23	0.22	0.19	3.21	0.11	0.18	0.93	0.12

concentrations in the effluents, which could be as much as 10 pCi/L (ESG 1981). (In general, the concentrations of the plutonium in solution decrease in the lower canyon.)

The distribution of plutonium in the sediments finds the largest concentrations occurring in the suspended sediments, with lower concentrations in bed sediments. The plutonium has a greater affinity for the silts, clays, and fine sand in the suspended sediments than to the coarser sands and gravel that make up the bulk of the bed sediments. As a result, plutonium concentrations in the suspended sediments are more than a factor of 10 greater than concentrations occurring in the bed sediments. The plutonium concentrations of the suspended sediments range from <0.01 to 11.1 pCi/g, with a slight decrease in the concentrations from GS-2 and Pueblo to Otowi (Table IV).

The bed material is moved along the bottom of the channel, rolling and bouncing in the base of the run-off. The long period of discharge results in transport of a large mass of bed sediments.

The concentrations of plutonium in the bed sediments ranged from 0.11 to 0.82 pCi/g, with the concentrations decreasing in the lower canyon (Table IV). The range of mean plutonium concentration of the bed sediments in the active channel is similar to the model (Lane 1985) of 0.20 pCi/g. The concentrations are low and are not considered a health hazard (ESG 1985, 1986).

The distribution of plutonium transported in solution and in suspended and bed sediments varies somewhat, as indicated by the following data: 1 to 3% of the plutonium was transported in solution, 24 to 57% was transported in the suspended sediments, and 40 to 76% was transported with the bed sediments (Table V).

III. TRANSPORT OF PLUTONIUM IN SNOW-MELT RUN-OFF

The study evaluated the amounts of plutonium transported from the Laboratory at GS-2 and Pueblo Canyon into the lower canyon at Otowi on the Rio Grande (Fig. 3).

During the run-off event of 1973, no measurements or samples were collected at Otowi. There was about 2567 μCi of plutonium transported past GS-2 into the lower canyon (Table VI and Appendix E). A part of the plutonium transported during this run-off event probably reached the river. The rest was subject to transport, dispersion, and dilution by spring and summer run-off in the following years.

Table V. Distribution of Plutonium Transported in Solution and in Suspended and Bed Sediments.

	Plutonium (μCi)								
	GS-2			Pueblo			Otowi		
Year	Solution	Suspended Sediments	Bed Sediments	Solution	Suspended Sediments	Bed Sediments	Solution	Suspended Sediments	Bed Sediments
1975	10	56	372	2	10	11	11	44	7
1979	9	497	2600	<1	18	58	0	167	71
1980	1	107	47	—	—	—	—	—	—
1982	1	62	20	—	—	—	—	—	—
1983	5	387	580	—	—	—	<1	54	106
1985	24	864	2686	<1	15	40	2	73	54
1986	<1	14	77	<1	0	5	<1	3	4
Total	51	1987	6382	5	43	114	15	341	242
Percentage	<1	24	76	3	27	70	3	57	40

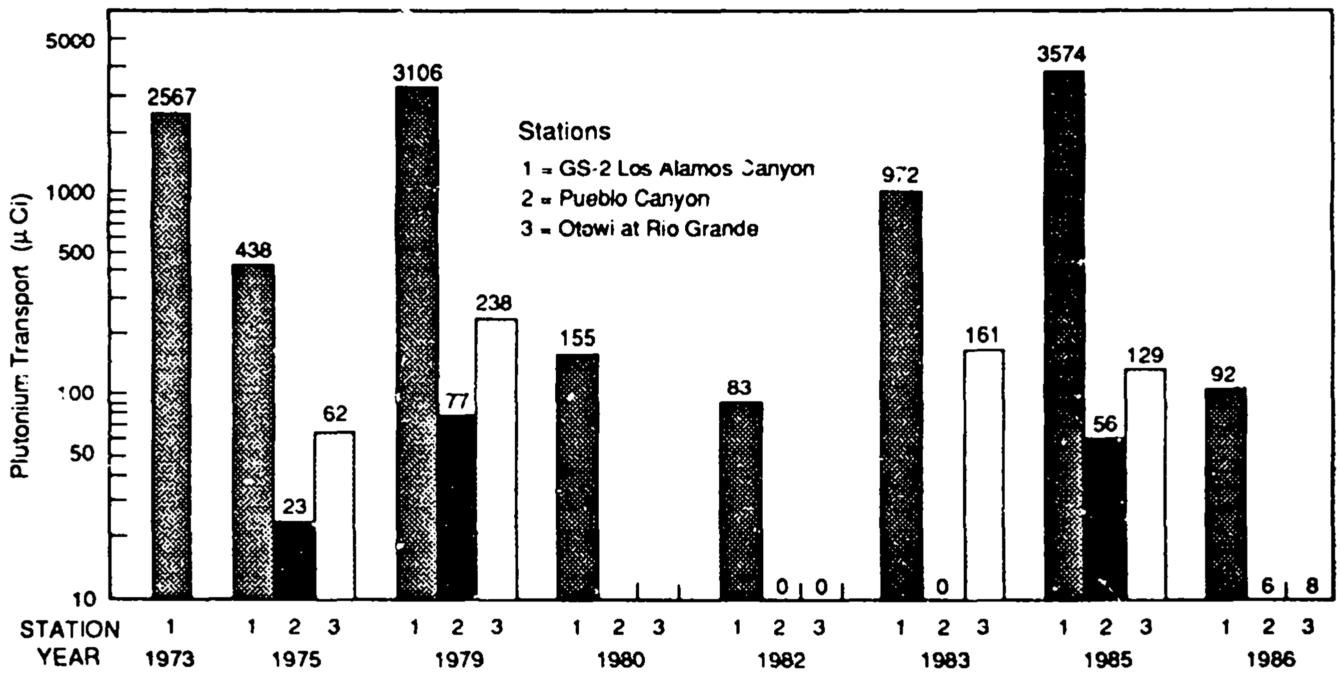

Fig. 3. Graph showing amount of plutonium transported with snowmelt run-off.

Five of the seven snowmelt run-off events (1975 through 1986) reached Otowi and the Rio Grande. The two events that did not reach Otowi deposited sediments and plutonium in the lower canyon. These sediments and plutonium in turn were flushed out with succeeding spring or summer run-off events.

The total amount of plutonium entering the upper canyon from the seven events was 8582 μCi. Of that amount, 598 μCi reached Otowi and the Rio Grande and 7984 μCi were deposited in the lower canyon (Table VI). The amount of plutonium deposited in the lower canyon ranged from 83 to 3501 μCi during the seven events.

Table VI. Transport of Total Plutonium in the Lower Los Alamos Canyon.

	Plutonium (μCi)			
Year	**GS-2 and Pueblo**	**Otowi**	**Deposited Lower Canyon**	**Percentage at Otowi**
1973	2 567[a]	—	—	—
1975	461	62	399	14
1979	3 183	238	2 945	7
1980	155	—	155	—
1982	83	—	83	—
1983	972	161	811	17
1985	3 630	129	3 501	4
1986	98	8	90	8
Total	8 582	598	7984	7

[a]Not included in total, as no measurements were taken at Otowi.

The amount of plutonium estimated in the sediments of the canyons available for transport during spring run-off to the Rio Grande ranged from 150 to 3000 mCi. The amount of plutonium reaching the Rio Grande with the five events from 1975 through 1986 was less than 1% of the estimated average of 1500 mCi (150 to 3000 mCi) available for transport by storm run-off. The small percentage of plutonium transported, combined with the large deposition of bed sediments and plutonium in the lower canyon during spring run-off, suggests that the largest amounts of plutonium are transported in the summer run-off. The summer run-off events scour the canyon, transporting a large amount of plutonium with the suspended and bed sediments to the Rio Grande.

IV. CONCLUSIONS

A study was made of seven spring snowmelt run-off events that reached the Laboratory boundary during the period 1975 through 1986. Of these seven events, only five had sufficient flow to reach Otowi and the Rio Grande. Trace amounts of plutonium bound to sediments in the active channels of Pueblo and Los Alamos canyons are subject to transport with spring run-off in solution and with suspended and bed sediments.

Of the five events, only a small amount of plutonium (15 µCi) in solution was transported to Otowi and the Rio Grande. The amount of plutonium transported into the Rio Grande with the bed sediments (242 µCi) was less than that transported in the suspended sediments (341 µCi). The loss of run-off in the lower canyon resulted in the deposition of suspended and bed sediments along with the plutonium bound to the sediments. These sediments and plutonium (7984 µCi) were and are subject to transport during spring and summer run-off.

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APPENDIX A

HYDROLOGIC CHARACTERISTICS OF SPRING SNOWMELT RUN-OFF

	Duration of Flow (Days)	Duration of Flow (10^6 s)	Mean Discharge (m^3/s)	Volume (10^3 m^3)	Suspended Sediments (mg/L)	Suspended Sediments (10^3 kg)	Bed Sediments (10^3 kg)
1973							
GS-1	93	8.0	0.077	616	300	185	1870
DP (inflow)	26	2.2	0.007	15	400	6	200
GS-2	48	4.1	0.104	426	425	181	2665
1975							
GS-1	86	7.4	0.059	437	125	55	1488
DP (inflow)	35	3.0	0.005	15	200	3	39
GS-2	61	5.3	0.061	323	150	48	2067
Pueblo (inflow)	6	0.5	0.007	3.5	500	1.8	31
Otowi	19	1.6	0.016	26	600	16	67
1979							
GS-2	116	10	0.091	910	120	109	6500
Pueblo (inflow)	35	3.0	0.002	6.0	400	2.4	125
Otowi	52	4.5	0.023	104	400	42	222
1980							
GS-2	30	2.6	0.039	101	200	20	275
Pueblo (inflow)	0	—	—	—	—	—	—
Otowi	0	—	—	—	—	—	—
1982							
GS-2	22	1.9	0.015	28	200	5.6	64
Pueblo (inflow)	0	—	—	—	—	—	—
Otowi	0	—	—	—	—	—	—
1983							
GS-2	78	6.7	0.078	523	150	78	2421
Pueblo (inflow)	0	—	—	—	—	—	—
Otowi	45	3.9	0.019	74	300	22	324
1985							
GS-2	121	10	0.079	790	200	158	3276
Pueblo (inflow)	21	1.8	0.006	11	300	3.3	66
Otowi	78	6.7	0.011	74	500	37	418
1986							
GS-2	48	4.1	0.012	49	150	7.3	266
Pueblo (inflow)	8	0.7	0.002	1.4	300	0.4	11
Otowi	11	0.9	0.006	5.4	400	2.2	42

APPENDIX B

TRANSPORT OF PLUTONIUM IN SOLUTION IN SPRING SNOWMELT RUN-OFF

	Volume	Mean Concentration		Plutonium Transported		
		^{238}Pu	$^{239,240}Pu$	^{238}Pu	$^{239,240}Pu$	Total
	(10^3 m^3)	(pCi/L)	(pCi/L)	(μCi)	(μCi)	(μCi)
1973						
GS-1	616	0.02		12		12
DP (inflow)	15	0.32		5		5
GS-2	426	0.07		30		30
1975						
GS-1	437	0.01	0.02	4.4	8.7	13
DP (inflow)	15	0.08	0.24	1.2	3.6	5
GS-2	323	0.00	0.03	0	9.7	10
Pueblo (inflow)	3.5	0.01	0.42	<0.1	1.5	2
Otowi	26	0.09	0.33	2.3	8.6	11
1979						
GS-2	910	0.00	0.01	0	9.1	9
Pueblo (inflow)	6.0	0.00	0.13	0	0.8	<1
Otowi	104	0.00	0.00	0	0	0
1980						
GS-2	101	0.00	0.01	0	1.0	1
Pueblo (inflow)	—	—	—	—	—	—
Otowi	—	—	—	—	—	—
1982						
GS-2	28	0.02	0.03	0.6	0.8	1
Pueblo (inflow)	—	—	—	—	—	—
Otowi	—	—	—	—	—	—
1983						
GS-2	523	0.00	0.01	0	5.2	5
Pueblo (inflow)	—	—	—	—	—	—
Otowi	74	0.00	0.01	0	0.7	<1
1985						
GS-2	790	0.00	0.03	0	24	24
Pueblo (inflow)	11	0.01	0.02	0.1	0.2	<1
Otowi	74	0.00	0.03	0	2.2	2
1986						
GS-2	49	0.00	0.01	0	0.5	<1
Pueblo (inflow)	1.4	0.00	0.01	0	<0.1	<1
Otowi	5.4	0.00	0.01	0	<0.1	<1

APPENDIX C

TRANSPORT OF PLUTONIUM IN SUSPENDED SEDIMENTS IN SPRING SNOWMELT RUN-OFF

	Suspended Sediments (10^3 kg)	Mean Concentration ^{238}Pu (pCi/g)	Mean Concentration $^{239,240}Pu$ (pCi/g)	Plutonium Transported ^{238}Pu (μCi)	Plutonium Transported $^{239,240}Pu$ (μCi)	Plutonium Transported Total (μCi)
1973						
GS-1	185	0.15		—	—	28
DP (inflow)	6	2.5		—	—	15
GS-2	181	1.5		—	—	272
1975						
GS-1	55	0.02	0.59	1.1	32	33
DP (inflow)	3	0.83	3.8	2.4	11	13
GS-2	48	0.06	1.1	2.9	53	56
Pueblo (inflow)	1.8	0.03	5.7	<0.1	10	10
Otowi	16	0.03	2.7	0.5	43	44
1979						
GS-2	109	0.56	4.0	61	436	497
Pueblo (inflow)	2.4	0.04	7.5	<0.1	18	18
Otowi	42	0.16	3.8	6.7	160	167
1980						
GS-2	20	0.27	5.1	5.4	102	107
Pueblo (inflow)	0	—	—	—	—	—
Otowi	0	—	—	—	—	—
1982						
GS-2	5.6	1.4	9.7	7.8	54	62
Pueblo (inflow)	0	—	—	—	—	—
Otowi	0	—	—	—	—	—
1983						
GS-2	78	0.27	4.7	21	366	387
Pueblo (inflow)	0	—	—	—	—	—
Otowi	22	0.15	2.3	3.3	51	54
1985						
GS-2	158	0.67	4.8	106	758	864
Pueblo (inflow)	3.3	0.05	4.6	0.2	15	15
Otowi	37	0.15	1.8	5.6	67	73
1986						
GS-2	7.3	0.24	1.6	1.7	12	14
Pueblo (inflow)	0.4	0.00	0.00	0	0	0
Otowi	2.2	0.00	1.5	0	3.3	3

APPENDIX D

TRANSPORT OF PLUTONIUM IN BED SEDIMENTS IN SPRING SNOWMELT RUN-OFF

	Bed Sediments (10^3 kg)	Mean Concentration		Plutonium Transported		
		^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{238}Pu (μCi)	$^{239,240}Pu$ (μCi)	Total (μCi)
1973						
GS-1	1870	0.00	0.11	0	206	206
DP (inflow)	200	0.21	1.4	42	280	322
GS-2	2665	0.00	0.85	0	2265	2265
1975						
GS-1	1488	0.00	0.08	0	119	119
DP (inflow)	39	0.10	0.50	4	20	24
GS-2	2067	0.00	0.18	0	372	372
Pueblo (inflow)	31	0.00	0.35	0	11	11
Otowi	67	0.00	0.11	0	7	7
1979						
GS-2	6500	0.06	0.34	390	2210	2600
Pueblo (inflow)	125	0.00	0.46	0	58	58
Otowi	222	0.00	0.32	0	71	71
1980						
GS-2	275	0.02	0.15	6	41	47
Pueblo (inflow)	0	—	—	—	—	—
Otowi	0	—	—	—	—	—
1982						
GS-2	64	0.04	0.27	3	17	20
Pueblo (inflow)	0	—	—	—	—	—
Otowi	0	—	—	—	—	—
1983						
GS-2	2421	0.04	0.20	96	484	580
Pueblo (inflow)	0	—	—	—	—	—
Otowi	324	0.02	0.31	6	100	106
1985						
GS-2	3276	0.12	0.70	393	2293	2686
Pueblo (inflow)	66	0.00	0.61	0	40	40
Otowi	418	0.00	0.13	0	54	54
1986						
GS-2	266	0.06	0.23	16	61	77
Pueblo (inflow)	11	0.00	0.43	0	5	5
Otowi	42	0.00	0.09	0	4	4

APPENDIX E

TRANSPORT OF PLUTONIUM IN SOLUTION AND IN SUSPENDED AND BED SEDIMENTS IN SPRING SNOWMELT RUN-OFF

	Plutonium Transported				Distribution of Transport		
	Solution (μCi)	Suspended Sediments (μCi)	Bed Sediments (μCi)	Total (μCi)	Solution (%)	Suspended Sediments (%)	Bed Sediments (%)
1973							
GS-1	12	28	206	246	5	11	84
DP (inflow)	5	15	322	342	1	4	95
GS-2	30	272	2265	2567	1	11	88
1975							
GS-1	13	33	119	165	8	20	72
DP (inflow)	5	13	24	42	12	31	57
GS-2	10	56	372	438	2	13	85
Pueblo (inflow)	2	10	11	23	8	44	48
Otowi	11	44	7	62	18	71	11
1979							
GS-2	9	497	2600	3106	1	16	83
Pueblo (inflow)	<1	18	58	77	1	24	75
Otowi	0	167	71	238	<1	70	29
1980							
GS-2	1	107	47	155	<1	69	30
Pueblo (inflow)	0	0	0	0	0	0	0
Otowi	0	0	0	0	0	0	0
1982							
GS-2	1	62	20	83	1	75	24
Pueblo (inflow)	—	—	—	—	—	—	—
Otowi	—	—	—	—	—	—	—
1983							
GS-2	5	387	580	972	1	39	60
Pueblo (inflow)	—	—	—	—	—	—	—
Otowi	<1	54	106	161	1	33	66
1985							
GS-2	24	864	2686	3574	1	24	75
Pueblo (inflow)	<1	15	40	56	2	27	71
Otowi	2	73	54	129	1	57	42
1986							
GS-2	<1	14	77	92	1	15	84
Pueblo (inflow)	<1	0	5	6	17	0	83
Otowi	<1	3	4	8	13	37	50