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The chemical and radiochemical quality of surface and ground water at Los Alamos, New Mexico, July 1965 through June 1966

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Introduction

The U.S. Geological Survey in cooperation with the U.S. Atomic Energy Commission and the University of California, Los Alamos Scientific Laboratory, began in 1949 to monitor the chemical and radiochemical concentrations in surface and ground water in the Los Alamos area. Water samples for chemical and radiochemical analyses were collected down gradient from liquid waste treatment plants (fig. 1).

The purpose of obtaining this information is to determine if, or to what extent, low-level radioactive effluents and sewage effluents, from the operation of the Los Alamos Scientific Laboratory, contaminate surface and ground-water systems downgradient from Los Alamos and to synthesize these data into a single report.

This is the ninth in a series of reports describing monitoring of surface and ground water at Los Alamos and presents the data collected in the period July 1965 through June 1966. The first report of the series describes the disposal sites near Los Alamos and methods of radioactive waste disposal (Abrahams, 1963a). Others of the series are basic-data reports of the chemical and radiochemical analyses of water collected during the periods 1949-55 (Weir and others, 1962); 1956 through June 1957 (Abrahams, 1965b); July 1957 through June 1961 (Abrahams and Purtymun, 1965); July 1961 through June 1962 (Purtymun, 1965a); July 1962 through June 1963 (Purtymun, 1965b); July 1963 through June 1964 (Purtymun, 1965c) and July 1964 through June 1965 (Purtymun and Enyart, 1966).

Water samples collected were analyzed for radionuclides by H-6 Group of the Los Alamos Scientific Laboratory under the direction of William Kennedy, Group Leader. Chemical analyses of water samples were made by H-7 Group under the direction of C. W. Christenson, Group Leader.

Chemical and radiochemical quality of water

The chemical and radiochemical quality of water data is presented in four parts: (1) Pajarito Plateau which includes test, observation, and supply wells, surface water and springs, excluding data collected in the major waste disposal area of Mortandad Canyon; (2) Mortandad Canyon surface water and observation wells; (3) Rio Chama and Rio Grande; and (4) Tritium analyses from observation wells LAO-3 and MCO-7.

The word "contamination" is used in this report to signify a change in chemical or radiochemical quality of water by solutes induced from other than natural sources, but not necessarily hazardous to the health of an individual. Chemical contamination of water generally is indicated by sodium, chloride, nitrate , or fluoride concentrations in excess of that found in the natural waters in the area. Radiochemical contamination of water may be indicated by the presence of artificially created radionuclides (plutonium) or excessive concentrations of gross beta-gamma emitters. Uranium in water may be from radioactive wastes or may occur in small amounts as part of the natural environment. Maximum permissible concentrations (MPC) in water of plutonium are 3×10^5 d/m/l (disintegrations per minute per liter), uranium 4×10^4 μgr/l (micrograms per liter) and beta-gamma emitters 670 d/m/l (Dummer, 1958 and U.S. Dept of Comm., 1959).

Pajarito Plateau

Observation and test wells were constructed for the purpose of establishing a monitoring net on the plateau as well as to obtain geologic and hydrologic information. These wells are supplemented in the net by the supply wells, spring, and surface water sampling points (See note on figure 1 for well designation and aquifer).

The chemical quality of water from test wells (wells TW-1, TW-3, and TW-8) and the Los Alamos supply wells (wells LA-1B, LA-2, LA-3, LA-4, LA-6, G-1, G-2, G-3, G-4, G-5 and G-6) did not change significantly from previous analyses (table 1). The concentration of radionuclides were below MPC. Uranium reported from several of the wells was low, well below MPC and was of natural origin. The analyses, chemical and radiochemical, indicated no contamination by low-level radioactive effluents.

Supply well PM-1 was completed February 1965 and was in service in June. There was a change in the chemical quality of the water when the well was put into service and pumpage increased. After four months of continuous pumpage (June to September) calcium increased from 8 ppm (parts per million) to 22 ppm. Magnesium increased from 0 to 9 ppm, and sodium increased from 9 to 13 ppm (table 1). This resulted in an increase of hardness from 20 ppm to 90 ppm. The cause of the change in chemical quality is due to continued development of the well which caused a proportionally higher yield of water from the Puye Conglomerate and basalts in the Tesuque Formation. The chemical and radiochemical quality of water from PM-1 show no indication of contamination.

Table 1.--Chemical and radiochemical quality of surface and ground water on the Pajarito Plateau - Concluded

Source	Date of collection	Chemical												Radiochemical		
		Parts per million										Conductivity (grains per gallon)	pH	Plutonium (disintegrations per minute per liter)	Uranium (micrograms per liter)	Beta (gamma) emitters (disintegrations per minute per liter; Bg: background)
		Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness					
Well LAO-2	4-13-66	16	1	65	0	140	64	15.6	7	440	45	22	7.8	<0.4	<0.5	74.4
Well LAO-3	4-13-66	21	5	49	0	124	44	10.2	5	335	72	17	7.9	<.4	<.5	58.0
Well LAO-4	4-13-66	26	7	49	0	142	39	.5	7	299	95	16	7.8	<.4	<.5	18.0
DP Canyon																
Near TW-3	9-23-65	17	3	92	0	205	48	12	7	545	54	25	7.9	0.8	<.5	<1.0
Acid Weir	9-23-65	22	4	38	0	136	14	1.7	1.0	246	73	13	7.6	<.4	1.6	26.0
Ancho Spring	9-28-65	13	3	7	0	53	3	.5	.5	124	44	5	7.7	<.4	<.5	<1.0
Basalt Spring	9-23-65	26	11	10	0	79	14	.2	3	201	108	10	7.8	<.4	.7	1.5
Doe Spring	7-2-65	21	15	13	3	159	5	.2	.1	218	115	12	7.8	<.4	<.5	8.2

Table 1.--Chemical and radiochemical quality of surface and ground water on the Pajarito Plateau

(Analyses by the Los Alamos Scientific Laboratory)

Source	Date of collection	Chemical: Parts per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness	Conductivity (grains per [illegible])	[illegible]	Radiochemical: Plutonium (disintegrations per minute per liter)	[illegible] (micromicrocuries per liter)	Beta (Sem.) (Sr-Y) [illegible]
Well TW-1	9-23-65	28	5	17	0	115	8	0.7	0.2	149	90	10	7.4	< 0.4	< 0.5	< 1.0
Well TW-3	9-23-65	17	7	10	0	78	6	.4	.2	124	70	7	7.9	< .4	< .5	< 1.0
Well TW-8	9-24-65	10	3	10	0	58	3	.2	.2	113	40	5	7.5	< .4	< .5	< 1.0
Well LA-1B	7-22-65	18	.7	145	0	286	14	3.1	.2	440	21	22	7.9	< .4	.8	3.2
Well LA-2	7-22-65	14	.5	65	3	124	13	2.2	.3	214	16	10	8.3	< .4	1.3	4.0
Well LA-3	7-22-65	31	.5	30	0	98	3	1.0	.4	147	33	7	8.1	< .4	1.6	3.2
Well LA-4	7-22-65	32	0	14	0	66	2	1.1	.3	97	32	5	8.0	< .4	< .5	8.1
Well LA-6	7-22-65	9	.5	100	8	220	4	3.0	.4	301	11	15	8.5	< .4	11.4	4.2
Well LA-6	9-23-65	3	1	102	4	198	4	1.8	.4	297	11	16	8.5	< .4	6.1	27.0
Well G-1	7-15-65	10	.5	21	4	101	6	.5	.3	160	28	7	8.2	< .4	< .5	6.0
Well G-1A	7-15-65	11	.5	18	3	79	3	.5	.4	159	29	6	8.2	< .4	< .5	10.0
Well G-2	7-15-65	10	.5	31	8	103	4	.4	.4	196	28	9	8.3	< .4	< .5	7.0
Well G-3	7-15-65	9	1	22	7	82	4	.2	.4	147	29	7	8.2	< .4	< .5	< 1.0
Well G-4	7-15-65	12	5	11	4	76	4	0	.5	151	52	6	8.0	< .4	.5	7.0
Well G-5	7-15-65	14	5	10	5	81	5	.2	.8	153	54	7	8.0	< .4	1.4	< 1.0
Well G-6	7-15-65	11	2	15	5	34	3	.2	.4	148	37	6	8.0	< .4	< .5	< 1.0
Well PM-1	7-15-65	17	9	18	7	115	9	.2	.4	123	79	10	7.9	< .4	< .5	2.4
Well PM-1	9-23-65	22	9	13	0	110	6	.2	.4	199	90	10	7.9	< .4	< .5	< 1.0
Well PM-2	7-15-65	9	3	11	0	59	4	.2	.1	158	35	5	7.6	< .4	< .5	1.6
Well LAO-1	4-13-66	16	3	44	0	74	44	.5	.5	257	53	13	7.7	< .4	< .5	22

Supply well PM-2 was completed in July 1965 and was sampled when test pumped. The well was not in service in June 1966. The chemical quality of the water collected in July 1965 was good (158 ppm dissolved solids). The concentrations of radionuclides in the water were no greater than background.

Six observation wells (wells LAO-1, LAO-2, LAO-3, LAO-4, LAO-5, and LAO-6) were drilled and cased in February 1966 (fig. 1). The wells, in Los Alamos Canyon, are constructed through the alluvium into the underlying tuff. They are perforated in the alluvium and are used to collect samples of water moving through the alluvium. Water in the alluvium is perched on the tuff and is recharged from periodic surface flow in Los Alamos and DP Canyons. Water samples were collected in April 1965 when wells LAO-5 and LAO-6 were dry.

The concentration of chloride, fluoride, and nitrate in water from wells LAO-1, LAO-2, LAO-3, and LAO-4 were abnormally high for water of this area and indicate contamination. The concentration of beta-gamma emitters was slightly higher than normal for ground water.

The contamination in water from well LAO-1 (chloride and beta-gamma emitters) is probably from sewage or cooling effluents from TA-2 or TA-41. Some residual beta-gamma emitter may remain from wastes dumped in the canyon near the well prior to 1961. The contamination of water from wells LAO-2, LAO-3, and LAO-4 may be due in part to wastes from TA-2 and TA-41, and due in part from low-level radioactive effluents from the waste treatment plant at TA-21 which are discharged into DP Canyon that is confluent with Los Alamos Canyon near well LAO-2 (fig. 1). The concentration of nitrate and fluoride in surface water from DP Canyon near well TW-3 (table 1) is similar to that in water from wells LAO-2 and LAO-3 which are near or below the confluence of DP and Los Alamos Canyons. The fluoride concentrations at these sites are higher (10.2 to 15.6 ppm) than recommended for domestic use; however, other chemical and radiochemical constituents are below maximum permissible concentrations for domestic use (U.S. Public Health Service, 1962).

The chemical quality of surface water in Acid Canyon at Acid Weir (fig. 1) has changed from September 1964 to September 1965. Sodium concentrations decreased from 87 ppm to 38 ppm. Chloride concentrations decreased from 20 ppm to 14 ppm, dissolved solid concentrations decreased from 357 ppm to 246 ppm and the conductivity decreased from 19 gpg (grains per gallon) to 13 gpg during the one year period. Plutonium concentration decreased from 4 d/m/l to <0.4, uranium from 57 μgr/l to 1.6 μgr/l, and beta-gamma emitters from 235 d/m/l to 26 d/m/l during the period. The discharge of low-level radioactive effluents into the canyon was discontinued in June 1964. The decrease in contamination is due to the absence of effluent and to the recharge and dilution of the contaminated water in the alluvium by storm runoff.

The chemical and radiochemical quality of water from Ancho, Basalt, and Doe Springs has not changed from previous years. The water is of good quality (below 500 ppm dissolved solids) and contains only background amounts of radionuclides (table 1).

Mortandad Canyon

Mortandad Canyon is the disposal area for the low-level radioactive effluents processed at the waste treatment plant at TA-50. The plant removes most of the radionuclides before the effluent is released into the canyon. The effluent in the canyon is further diluted by storm runoff and coolant water from other technical areas. As the effluent, storm runoff, and coolant water moves eastward by surface flow they infiltrate into the alluvium on the canyon floor to form a perched water body that is temporarily retained on the underlying tuff.

The amount of surface water (effluents, storm runoff or coolant) entering the disposal area is obtained from records of gaging station 1 (figure 1). Seven shallow observation wells east of gaging station 1 are used to monitor the chemical and radiochemical changes of the water as it moves eastward through the alluvium.

The effluents from TA-50 have averaged about 1 million gallons a month from January 1965 to June 1966. The amount of storm runoff and coolant water varies (table 2). Surface water generally infiltrates into the alluvium between gaging station 1 and well MCO-4. Only for a brief period during a summer thunderstorm did surface flow reach well MCO-7 during the period July 1965 to June 1966.

Table 2.--Surface water entering the disposal area in Mortandad by sources from January 1965 to June 1966.

Month and year	Storm runoff and coolant water (1,000 of gallons)	Industrial effluent from TA-50 (1,000 of gallons)	Total surface water entering the disposal area (1,000 of gallons)
1965			
January	3,516	922	4,438
February	2,591	1,063	3,654
March	2,389	1,135	3,524
April	2,297	852	3,149
May	2,107	989	3,096
June	2,025	1,002	3,035
July	1,584	1,010	2,594
August	3,059	1,163	4,222
September	1,496	1,342	2,838
October	683	1,175	1,858
November	671	1,152	1,823
December	a/	1,222	a/
1966			
January	a/	1,189	a/
February	a/	1,019	a/
March	a/	1,155	a/
April	498	1,088	1,586
May	539	1,245	1,784
June	420	1,045	1,465

a/ No record, gage well frozen.

Surface water samples collected in September 1965 (gaging station 1, MCS-3.8, and MCS-3.9) were of coolant water and return flow from bank storage. Radiochemical analyses indicated very little contamination (table 3). Water samples collected in November 1965 (gaging stations 1 and 2) and April 1966 (gaging station 1) were a mixture of industrial effluents and cooling water. Chemical analyses indicate chloride and nitrate concentrations slightly above that which would be expected in natural water. Radiochemical analyses indicated minor amounts of plutonium and uranium. Beta-gama emitters exceeded the MPC (670 d/m/l) in samples collected in November 1965 at gaging station 1 (5,801 d/m/l) and gaging station 2 (1,240 d/m/l) and in April 1966 at gaging station 1 (1,995 d/m/l).

Table 3.--Chemical and radiochemical quality of surface and ground water in the disposal area of Mortandad Canyon (Analyses by the Los Alamos Scientific Laboratory)

Source	Date of collection	Chemical: Parts per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness	Conductivity (grains per gallon)	pH	Radiochemical: Plutonium (disintegrations per minute per liter)	Uranium (micrograms per liter)	Beta (gamma) emitters (disintegrations per minute per liter; Bg: background)
Surface water																
Gaging Station 1	9- 1-65	12	0	63	36	202	6	1.2	0.4	297	32	13	9.2	< 0.4	< 0.5	1.5
Gaging Station 1	11-22-65	34	1	167	234	291	17	1.0	11	645	89	46	11.4	11.9	2.1	5,800.9
Gaging Station 1	4- 1-66	13	0	173	248	292	18	2.8	13	583	32	56	11.5	8.6	< .5	1,994.6
MCS - 3.8	9- 1-65	11	1	117	0	258	15	2.2	1.0	574	31	23	8.2	.7	.7	2.0
MCS - 3.9	9- 1-65	15	1	117	0	264	18	1.8	7.5	591	43	24	7.9	< .4	< .5	< 1.0
Gaging Station 2	11-22-65	11	1	167	102	212	20	1.3	10	552	30	27	10.2	3.8	< .5	1,240.5
Observation wells																
Well MCO-3	9- 1-65	8	0	87	4	193	12	1.7	1.0	408	20	17	8.8	1.4	0.8	8.0
Well MCO-3	11-22-65	6	1	142	16	148	31	1.3	7.0	452	20	21	8.9	.5	2.5	381.4
Well MCO-3	4- 1-66	4	.4	63	0	148	7	1.5	5	360	12	14	8.9	1.4	< .5	230.4
Well MCO-4	9- 1-65	11	3	117	0	252	15	1.4	7.5	521	42	24	7.7	< .4	< .5	< 1.0
Well MCO-4	11-22-65	12	5	160	2	214	29	.8	11	558	51	26	8.0	1.1	< .5	273.2
Well MCO-4	4- 1-66	6	1.0	105	0	164	13	1.3	9	432	20	18	8.3	2.8	1.0	166.6
Well MCO-5	9- 1-65	15	3	80	0	163	17	0	11	430	52	19	7.5	< .4	< .5	< 1.0
Well MCO-5	11-22-65	19	4	118	4	174	19	0	9	394	65	19	7.4	< .4	< .5	68
Well MCO-5	4- 1- 66	14	4	100	0	160	19	.2	12	398	54	20	8.0	< .4	< .5	72
Well MCO-6	9- 1-65	13	2	80	0	153	16	0	13	491	47	18	7.9	< .4	< .5	1.3
Well MCO-6	11-22-65	15	4	124	9	186	15	0	6	397	53	19	7.6	< .4	< .5	67.8
Well MCO-6	4- 1-66	14	4	115	0	188	21	0	10	479	50	21	7.9	< .4	< .5	56

Table 3.--Chemical and radiochemical quality of surface and ground water in the disposal area of Mortandad Canyon - Concluded

Observation wells																
Well MCO-7	9- 1-65	14	4	34	0	100	10	0.2	4	238	50	10	7.7	< 0.4	<0.5	2.0
Well MCO-7	11-22-65	18	5	60	2	105	11	0	5	232	63	12	7.2	< .4	< .5	36.6
Well MCO-7	4- 1-66	22	6	52	0	152	15	0	4	300	82	16	7.6	< .4	< .5	48
Well MCO-7.5	9- 1-65	30	6	39	0	108	17	0	12	373	102	16	7.2	< .4	< .5	< 1.0
Well MCO-7.5	11-22-65	26	8	67	2	101	16	0	9	306	98	13	7.1	.5	< .5	40.6
Well MCO-7.5	4- 1-66	27	6	51	0	150	16	0	6	373	94	18	7.5	< .4	< .5	40.2
Well MCO-8	9- 1-65	31	7	20	0	83	14	.5	14	283	109	12	7.2	< .4	< .5	< 1.0
Well MCO-8	11-22-65	32	8	38	4	82	13	.2	11	274	111	12	7.1	< .4	< .5	21.4
Well MCO-8	4- 1-66	29	9	30	0	100	14	0	8	283	110	13	7.4	< .4	< .5	15.2

The chemical and radiochemical quality of water in the alluvium varied from sample to sample from the individual observation wells. This is due to eastward movement of water in the alluvium and the amount of mixing of the effluent with storm runoff and coolant water when the sample was collected. In general, the chemical constituents sodium and bicarbonate decreased downgradient eastward (from well MCO-3 to MCO-8). Total dissolved solids, conductivity and pH also decrease eastward; however, calcium and magnesium concentrations increase eastward (table 3).

Radiochemical contamination decreases downgradient in the alluvium. Plutonium and uranium were reported from wells MCO-3 and MCO-4 in various analyses. The plutonium and uranium were very low, just above background. Significant concentrations of beta-gamma emitters were reported from most samples; however, all were well below MPC.

Rio Chama and Rio Grande

Surface water samples are collected from the Rio Chama at Chamita and from the Rio Grande at Embudo, Otowi and Cochiti (fig. 2). The chemical quality of water varies with amount of flow in the rivers at the time the samples are collected (table 4). Change in flow is due to storm runoff or released storage water from El Vado or Abiquiu Dams on the Rio Chama. Radiochemical analyses indicated a minor amount of plutonium (1 d/m/l) in water from Rio Chama for Jan. - Mar. 1966 (table 4). The plutonium is not the result of radioactive effluent discharged at Los Alamos as the station (Chamita) is upstream and not hydrologically connected with any of the disposal areas at Los Alamos. The plutonium content could result from use of a contaminated sample bottle or glass-ware in the laboratory. Beta-gamma emitters were at background concentrations and the minor amounts of uranium are due to the solution of uranium minerals in the rocks.

Table 4.--Chemical and radiochemical quality of surface water from the Rio Chama and Rio Grande

(Analysis by the Los Alamos Scientific Laboratory)

Source	Date of collection	Chemical												Radiochemical		
		Parts per million										Conductivity (grains per gallon)	pH	Plutonium (disintegrations per minute per liter)	Uranium (micrograms per liter)	Beta (gamma) emitters (disintegrations per minute per liter; Bg: background)
		Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness					
Rio Chama at Chamita	July - Sept. 1965	48	25	41	0	117	6.5	0.8	0.2	402	224	9	7.2	< 0.4	2.1	7.9
Rio Chama at Chamita	Oct. - Dec. 1965	46	12	24	0	104	6	.3	.7	282	163	14	7.9	< .4	< .5	10
Rio Chama at Chamita	Jan. - Mar. 1966	63	26	40	0	138	16	.1	1.0	477	264	22	7.7	1.2	< .5	9
Rio Chama at Chamita	Apr. - June 1966	31	5	17	0	90	6	.1	.1	292	98	8	7.8	< .4	.5	17
Rio Grande at Embudo	July - Sept. 1965	34	10	27	0	103	4	.4	.1	219	126	12	7.1	< .4	.7	12
Rio Grande at Embudo	Jan. - Mar. 1966	25	15	15	0	84	3	0	.3	172	88	8	7.7	< .4	< .5	10.2
Rio Grande at Embudo	Apr. - June 1966	37	8	25	0	90	12	.4	.2	406	125	12	7.4	< .4	1.4	19
Rio Grande at Otowi	July - Sept. 1965	41	8	29	1.0	96	5	0	0	240	136	12	8.0	< .4	< 2.0	4.3
Rio Grande at Otowi	Oct. - Dec. 1965	38	22	21	0	94	6	.3	.3	233	130	12	8.4	< .4	1.3	8.0
Rio Grande at Otowi	Mar. - June 1966	32	7	25	0	82	14	.3	.1	362	109	11	7.6	< .4	2.4	8
Rio Grande at Cochiti	July - Sept. 1965	39	37	30	0	113	5.5	.2	.1	267	352	14	7.4	< .4	2.0	7.8
Rio Grande at Cochiti	Oct. - Nov. 1965	34	6	17	0	96	3	0	.3	202	113	10	8.1	< .4	1.5	6.0
Rio Grande at Cochiti	Jan. - Mar. 1966	46	14	24	0	126	7	0	1	305	172	15	7.8	< .7	< .5	12.1
Rio Grande at Cochiti	Apr. - June 1966	46	7	27	0	130	16	.3	.5	356	146	13	7.8	< .4	1.6	15

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Conclusions

As in previous reports, analyses of water samples collected at Los Alamos during 1965-66 show that chemical and radiochemical contamination is confined to surface and ground water in the alluvium of canyons receiving low-level radioactive effluents (DP, Los Alamos, and Mortandad Canyons) or canyons that have received low-level radioactive effluents in the past (Acid Canyon). The chemical contamination was generally low, with most analyses indicating that water is acceptable for domestic use according to the limits recommended by U.S. Public Health Service. Radiochemical analyses show that plutonium, and uranium were below MPC. Beta-gamma emitters were also below MPC except in surface water in Mortandad Canyon. The degree of contamination decreases downgradient in the canyon. The results of tritium analyses indicate that the tritium content of water in the alluvium of Los Alamos and Mortandad Canyons is near the maximum permissible concentrations. Further investigations are being made to determine the extent and amounts of tritium contamination.

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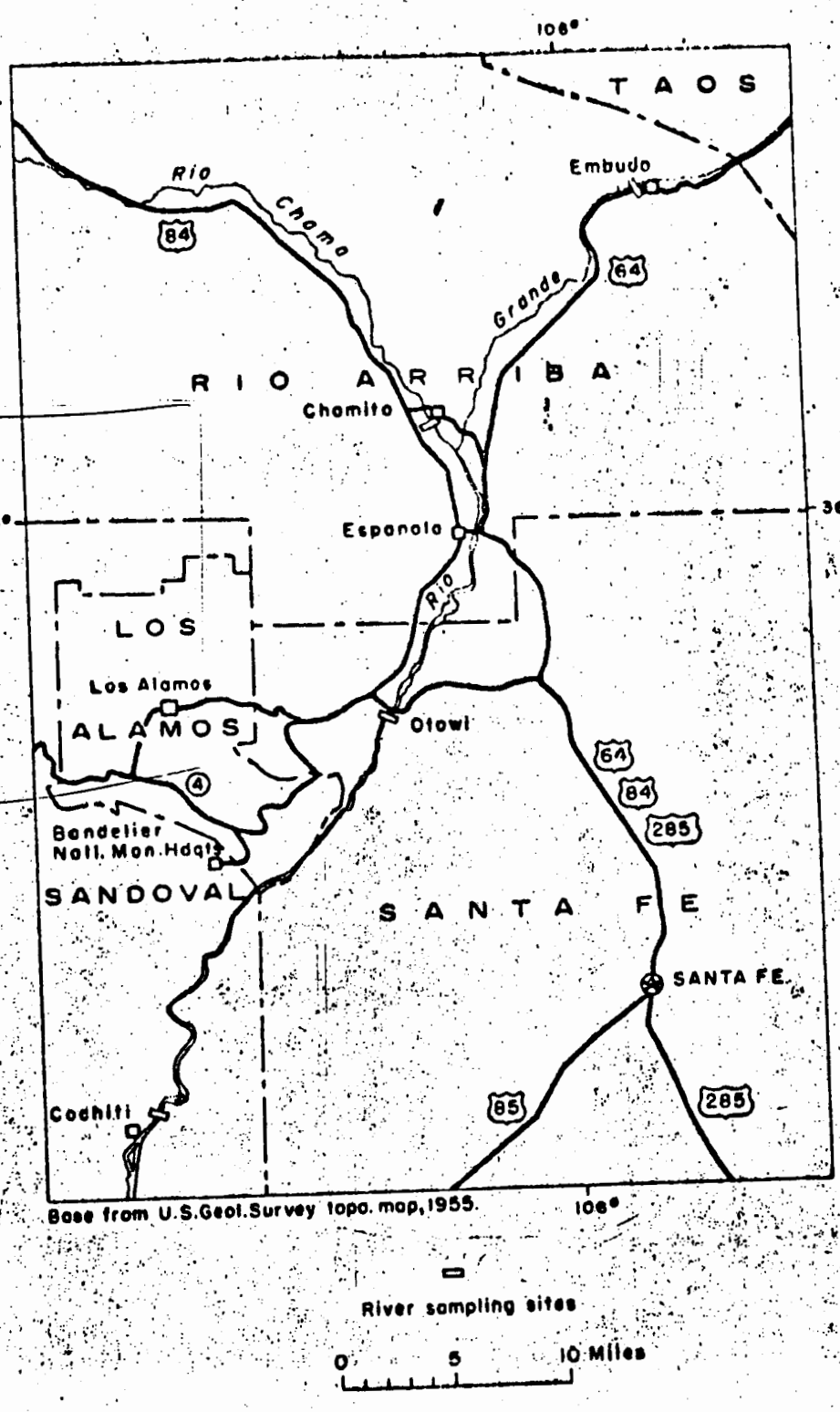

Figure 2.--River-sampling sites on the Rio Chama and Rio Grande