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The chemical and radiochemical quality of surface and ground water at Los Alamos, New Mexico, July 1963 through June 1964

By

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The chemical and radiochemical quality of surface and ground water at Los Alamos, New Mexico, July 1963 through June 1964

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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 a program 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 downgradient from waste-disposal points, industrial-waste-treatment plants, and disposal pits (fig. 1).

Figure 1 (caption on next page) belongs near here.

The purpose of obtaining this information is to determine whether or not radioactive wastes discharged from the operation of the Los Alamos Scientific Laboratory become a source of contamination to the surface- and ground-water systems downgradient from Los Alamos.

Figure 1.--Map of the Los Alamos area, New Mexico, showing waste- and sewage-disposal sites and sampling points.

This is the seventh of a series of reports describing waste disposal monitoring at Los Alamos and presents data collected in the period July 1963 to June 1964. The first report described methods of waste disposal and disposal sites near Los Alamos (Abrahams, 1963a). Others of the series are basic-data reports of the chemical and radiochemical analyses of water collected during the period 1949-55 (Weir and others, 1962); January 1956 through June 1957 (Abrahams, 1965b); July 1957 through June 1961 (Abrahams and Purtymun, 1965); July 1961 through June 1962 (Purtymun, 1965a) and July 1962 through June 1963 (Purtymun, 1965b). This report also presents the results of tritium analyses of ground water collected in 1959.

Water samples were collected and analyzed for radionuclides by the 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 the H-7 Group under the direction of C. W. Christenson, Group Leader. The tritium analyses of ground water from a spring and four supply wells were made by the U. S. Geological Survey.

Chemical and radiochemical quality of water

Contamination of surface and ground water by industrial effluents (treated low-level, radioactive liquids) was confined to canyons which received the effluents. The chemical contamination of water generally is indicated by sodium, chloride, and nitrate contents in excess of that found in the natural water of the area. Chemical analyses during 1963-64 indicate that the water is generally acceptable for domestic use according to maximum limits as recommended by the U.S. Public Health Service, for drinking water.

Radiochemical contamination of water may be indicated by artificially created radionuclides (plutonium) or excessive concentration of gross beta-gamma emitters. Uranium may be from a source of contamination or may occur as part of the natural environment. Maximum permissible concentrations (MPC) of plutonium are 3×10^5 dml (desintegrations per minute per liter), uranium 4×10^4 μgl (micrograms per liter), and beta-gamma emitters 670 dml (Dummer, 1958). Radiochemical contamination reported in water outside canyons that receive industrial effluents may be due to fallout or rainout from reactor gases or past nuclear explosions. There is a possibility of contamination of the samples in the laboratory when they were analyzed. An example of this unknown contamination is the composite quaterly river sample of April-June 1964 from the Rio Chama at Chamita which was reported to contain minor amounts of plutonium. The sampling station at Chamita is upstream from and is not hydrologically connected to any of the disposal areas at Los Alamos, thus the plutonium content in the water sample is attributed to one of the above-listed possible sources of contamination.

Acid and Pueblo Canyons receive treated industrial effluents from an industrial-waste-treatment plant near the head of Acid Canyon and from a sewage-treatment plant on Pueblo Canyon (fig. 1). The total volume of industrial effluents discharged into Acid Canyon declined from about 10 million gallons in 1962-63 to about 304,000 gallons in 1963-64. The decline of effluents is due to the operation of a new treatment plant that discharges effluents into Mortandad Canyon (a study is being made of the movement of effluents in this new disposal system). About 163 million gallons of treated sewage effluents was discharged into Pueblo Canyon during 1963-64. The industrial and sewage effluents mix in Pueblo Canyon below the confluence with Acid Canyon (fig. 1). The varying proportions of industrial effluents, sewage effluents, and storm runoff result in a wide range of chemical composition of the composite water in the canyon.

The chemical quality of surface water (Acid Weir, Pueblo 1, 2, and 3) and ground water in the alluvium (wells AC-3, PC-4, PC-6, PC-9, PC-10, and PC-11, and Hamilton Bend Spring) in the canyons was good during 1963-64 with dissolved-solids content below 500 ppm (parts per million). (See table 1.) Individual chemical constituents were below the limits as described by the U.S. Public Health Service. In general, there was no significant change from 1962-63 to 1963-64 in the chemical quality of water; however, the decreased quantity of industrial effluents discharged into Acid Canyon resulted in a more chemically stable water in Acid Canyon (near neutral pH) with only minor chemical changes occurring in water downgradient in Pueblo Canyon below the confluence with Acid Canyon.

Surface water (Acid Weir) and ground water in the alluvium (well AC-3) in Acid Canyon contained some undesirable concentrations of radioactivity. The gross beta-gamma emitters in water from well AC-3 was 2,000 dml. This exceeds the MPC of 670 dml (Dunner, 1958).

Surface water and ground water in the alluvium in Pueblo Canyon contained minor concentrations of radioactivity that were well below the MPC. The minor concentrations of plutonium reported from water in the mid-reach (well PC-6) and lower reach (wells PC-10 and PC-11, Otowi Seep and Hamilton Bend Spring) of Pueblo Canyon indicate a possible release of radionuclides previously adsorbed by the alluvium near the area of effluent discharge in Acid Canyon.

The chemical quality of water from shallow wells in the fanglomerate member of the Puye Conglomerate (wells PO-1A, PO-3B, PO-4A, and PO-4B) and shallow test wells (wells TW-1A and TW-2A) in Pueblo Canyon did not change significantly from previous analyses. Concentrations of radioactivity were near background and were below MPC. Recharge to these wells is from streamflow in Pueblo Canyon.

The surface water flow in DP Canyon is composed of industrial effluents from the industrial-waste-treatment plant at DP West (fig. 1) and from storm runoff. Streamflow in the canyon is intermittent and reaches the confluence with Los Alamos Canyon only during excessive precipitation. The chemical quality of surface water from DP Canyon near well TW-3 varied but did not change significantly from previous analyses. The dissolved-solids content ranged from 621 to 781 ppm, which exceeds the MPC of 500 ppm. High sodium, chloride, and nitrate contents as well as traces of plutonium and above-background, gross beta-gamma emitters indicate some contamination by industrial effluents. The concentrations of radioactivity were well below the MPC.

The chemical quality of water from deep test wells (wells TW-1, TW-2, TW-3, and TW-4) and Los Alamos supply wells (wells LA-1B, LA-2, LA-3, LA-4, LA-5, LA-6, G-1, G-1A, G-2, G-3, G-4, and G-5) did not change significantly from previous analyses. The concentrations of radioactivity were below MPC. Uranium, reported in water from several of the wells, is natural and is not contamination. The chemical and radiochemical analyses indicate no contamination by industrial effluents.

Los Alamos supply well G-6 was constructed in the spring of 1964. The dissolved-solid content in water from the well ranged from 169 to 218 ppm. (See table 1.) A sample of water was collected at a depth of 630 feet during construction of the well; a second was collected when the well was completed at a depth of 1,520 feet, and is a composite of all water yielded to the well from the aquifer. The slight difference in chemical quality is due to separation of the aquifers which contain water of slightly different chemical quality. Concentrations of radioactivity were background. The minor amount of uranium reported is natural and is below MPC.

Wells DT-5A and DT-10 were sampled for the first time since 1960. The chemical quality of the water had not changed since previous analyses. Concentrations of radioactivity were background and indicate no contamination.

The chemical quality of water from Sacred, Indian, Los Alamos, Basalt, Ancho, Doe, and Sandia Springs and of surface water from Frijoles stream at Bandelier National Monument had not changed significantly from previous analyses. Concentrations of radioactivity were below MPC and indicate no contamination by industrial effluents. Uranium reported is natural.

The chemical quality of a sample of surface water collected from Guaje Canyon Reservoir is good and is low in dissolved solids. (See table 1.) The concentrations of radioactivity are background and indicate no contamination.

The chemical quality of surface water from the Rio Chama and Rio Grande vary seasonally as well as changes in discharge (fig. 2). Radiochemical analyses indicate minor amounts

Figure 2 (caption on next page) belongs near here.

of plutonium in water samples from the Rio Chama for April-June 1964 and beta-gamma emitters, above background, in water from the Rio Grande at Cochiti in the April-June 1964 sample. (See page 8). Minor amounts of uranium occur naturally in the water. The concentrations of radioactivity are below MPC.

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

Tritium age of ground water

The tritium content of water from Los Alamos Spring and supply wells LA-4, LA-6, G-1A, and G-5 at Los Alamos was determined to establish the age of the water (time in transit of the ground water from recharge to discharge). The recharge area for the spring and supply wells may be in areas receiving industrial and sewage effluents and the effluents may constitute part of the recharge to the spring and wells. Chemical and radiochemical contamination in the older water (longer time in movement through the aquifer) would be reduced or eliminated by by ion exchange and absorption of the harmful contaminates and by decay of the radionuclides. Los Alamos Spring is near supply well LA-4 in Los Alamos Canyon (fig. 1) and discharges about one-fourth gpm (gallon per minute) from a perched aquifer near the base of a basalt flow. Los Alamos supply wells LA-4 and LA-6, in Los Alamos Canyon, and G-1A and G-5, in Guaje Canyon, are finished in the zone of saturation, at depths ranging from 1,536 to 1,965 feet, within the Tesuque Formation which consists of siltstone and silty sandstone.

Tritium, a radioactive isotope of hydrogen with a half life of 12.26 years, occurs in precipitation, part of which infiltrates the rocks in the mantle of the earth to recharge the ground water. By use of half-life decay, the the tritium content in ground water can be used to compute the age of the water if the initial tritium content in the precipitation is known and if the water is assumed to have come from known areas of recharge (von Buttlar and Wendt, 1958).

The tritium content of ground water being discharged from the spring and four supply wells indicates that the water was underground before the first hydrogen-bomb explosion, in 1952, which released 10 to 100 times more tritium into the atmosphere than is present naturally (von Buttlar and Wendt, 1958). Samples of rainfall at Los Alamos taken in June 1954, after the second hydrogen-bomb explosion, had 1,160 to 1,550 T-units (tritium units; one T-unit equals 1 atom of tritium per 10^{18} atoms of protium). The low tritium content of the water analyzed indicates that the water was not enriched in tritium by post-1952 local recharge.

Analyses of precipitation in the Chicago area prior to 1952 indicate that the concentration of tritium ranged from 8 T-units to 35 T-units (Kaufman and Libby, 1954, and von Buttlar and Libby, 1955). The tritium age of water from the spring and the four supply wells is based on 8 T-units, which is believed to be the average of the pre-bomb precipitation in the Southwest. If the concentration of tritium in pre-bomb precipitation in the Los Alamos area was greater than 8 T-units, the water is older than that indicated in the following table:

Source	Date collected	Date analyzed	Tritium units	Computed ages of samples (years)
Los Alamos Spring	5-20-59	6-28-60	2.5	22
Well LA-4	3-19-59	6-28-60	< .5	> 50
LA-6	3-19-59	6-28-60	< .5	> 50
G-1A	3-19-59	6-28-60	< .5	> 50
G-5	3-19-59	6-28-60	< .5	> 50

The computed ages of ground water from the spring and supply wells indicate that if the waste effluents constitute a part of the recharge, travel time in the aquifer is sufficient to eliminate or reduce contamination. Contributing to the likelihood of little contamination is the fact that the effluents are treated to below MPC of radioactivity before being discharged into the environment. Investigations in effluent disposal areas indicate that silt and clay retain, near points of discharge, most of the radionuclides carried in the effluents. There is ample opportunity for any contamination originally present in water, which is moving 600 to 1,200 feet vertically through unsaturated volcanic rock and sediment to the main ground-water body and 4 to 6 miles horizontally to the well fields, to be retained in the silt and clay before reaching the well fields. Dilution of the effluent by natural water would further reduce the concentration of contamination carried into the aquifers by the effluents.

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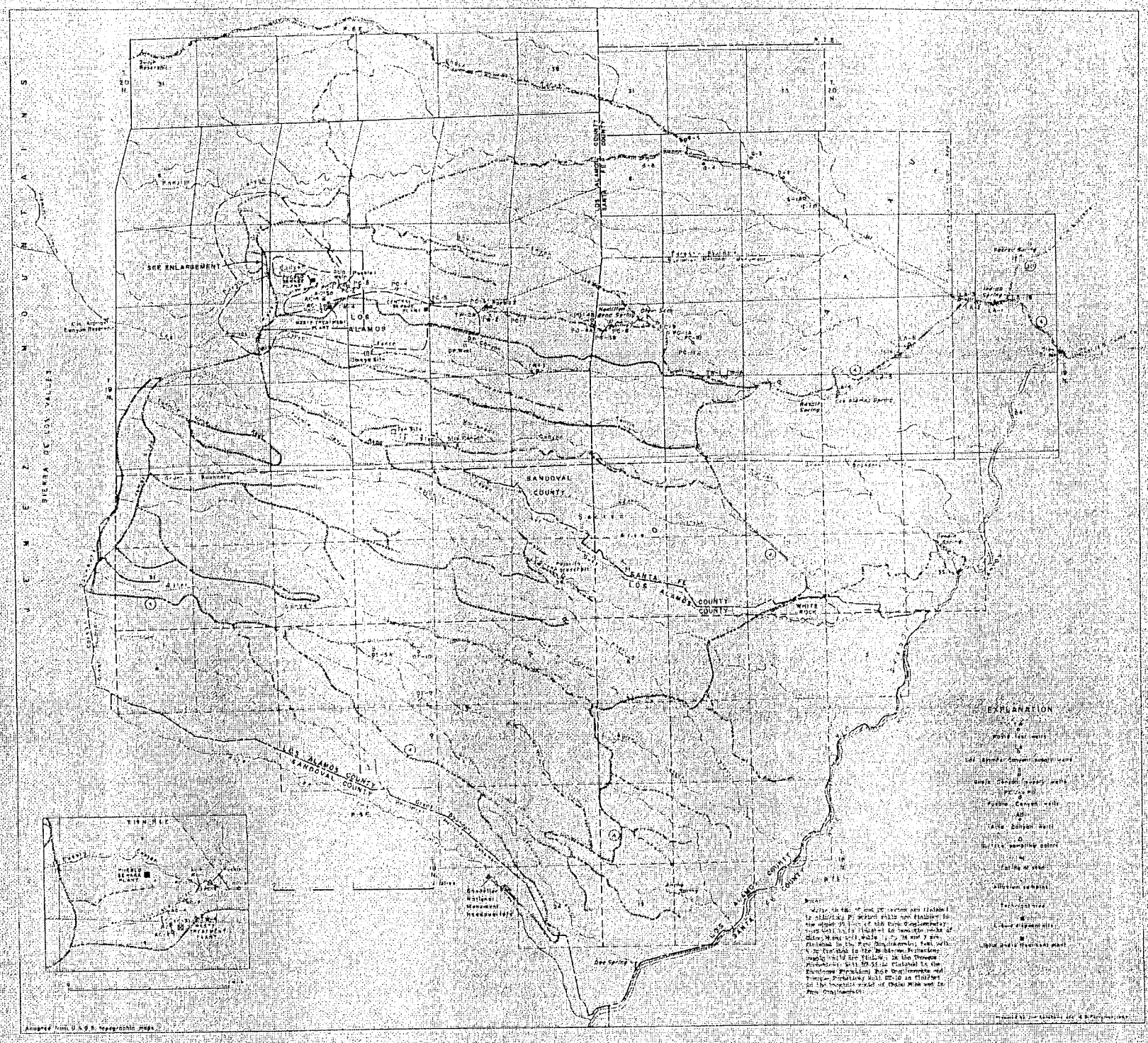

Figure 1.--Map of the Los Alamos area, New Mexico, showing waste and sewage disposal sites and sampling points.

Table 1.--Chemical and radiochemical quality of surface and ground water in the Los Alamos area, New Mexico, July 1963 through June 1964

(Analyses by the Los Alamos Scientific Laboratory)

Source	Date of collection	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	Plutonium (disintegrations per minute per liter)	Uranium (micrograms per liter)	Beta (gross) emitters (disintegrations per minute per liter; less background)
		Chemical: Parts per million												Radiochemical		
Well AO-3	3-16-63	31	4	58	0	162	18	1.2	6.5	192	144	15	7.4	23.8	46.0	1,300
Do. PO-4	3-18-63	14	2	62	0	34	29	2.8	7.3	264	34	15	7.2	<.6	.7	16
Do. PO-6	9-13-63	18	5	39	0	116	30	.4	.3	348	44	15	7.1	<.4	<.5	33
Do. PO-8	3-13-64	21	10	44	0	177	34	1.6	1.1	409	72	17	7.1	<.4	<.5	17
Do. PO-8	9-25-63	13	4	87	0	163	30	1.1	.5	373	33	17	7.1	<.4	<.5	34
Do. PO-9	4-16-64	14	7	73	0	174	30	.8	.8	363	70	17	7.4	<.4	<.5	28
Do. PO-10	9-13-63	14	3	64	0	92	26	.4	.6	301	49	17	6.8	.3	<.5	30
Do. PO-10	12-19-63	7	6	70	0	202	12	1.3	5.1	186	48	17	7.0	<.4	<.5	14
Do. PO-10	4-16-64	8	16	63	0	142	34	2.0	2.8	456	22	28	7.5	<.4	<.5	29
Do. PC-12	5-14-64	16	10	100	0	138	32	1.6	7.6	363	84	17	7.7	1.8	<.5	18
Do. PO-11	9-23-63	17	3	89	0	91	28	1.1	22.0	494	78	22	6.3	<.4	<.5	25
Do. PO-11	12-23-63	8	7	41	0	96	31	1.4	7.1	349	52	15	7.0	<.4	<.5	12
Do. PO-11	4-16-64	13	6	60	0	124	29	.8	3.3	298	63	16	7.1	<.4	.3	124
Do. PO-11	5-24-64	10	8	32	0	127	31	1.6	5.6	260	34	18	7.2	3.4	<.5	15
Do. TW-1A	11-29-63	18	13	60	0	90	27	1.2	14.0	308	97	15	7.0	<.4	<.5	14
Do. TW-1A	1-23-64	17	9	51	0	102	29	1.2	2.6	336	80	15	7.1	<.4	<.5	14
Do. TW-1A	3-16-64	14	13	56	0	100	30	1.2	14.0	281	58	16	7.0	<.4	<.5	15
Do. TW-2A	7-9-63	13	7	29	5	39	15	.4	4.2	102	60	5	7.5	<1	<.5	<10
Do. TW-2A	9-25-63	13	7	30	5	48	15	.4	3.5	230	71	5	7.7	<.4	<.5	10
Do. TW-2A	1-22-64	12	4	13	0	44	16	.4	3.3	122	60	5	7.8	<.4	<.5	4
Do. TW-2A	3-16-64	13	6	19	5	79	16	.4	1.4	135	45	7	8.1	<.4	<.5	9
Do. TW-1	11-14-63	23	5	34	0	134	5	.4	.8	144	93	9	7.3	<.4	.7	6
Do. TW-2	7-8-63	11	3	8	2	65	2	.4	.2	105	46	6	8.1	<1	<.5	<10
Do. TW-2	10-10-63	14	5	10	5	68	2	.4	.3	102	55	6	7.3	<.4	1.4	4
Do. TW-2	11-27-63	13	4	11	0	62	2	.4	.4	150	51	3	8.0	.4	.2	10
Do. TW-2	4-16-64	13	5	12	0	55	4	.4	.8	135	52	3	7.7	<.4	<.5	<1
Do. TW-3	10-10-63	15	2	12	26	35	7	.4	.6	200	82	8	7.4	<.4	5.8	2
Do. TW-3	1-27-64	17	7	11	0	91	5	.4	.1	207	73	7	7.9	<.4	<.5	3
Do. TW-4	7-8-63	10	6	12	1	79	3	.4	.6	253	52	6	7.9	<1	<.5	<10
Do. TW-4	9-24-63	10	7	12	0	68	2	.4	.4	150	35	6	7.8	<.4	<.5	3
Do. TW-4	1-27-64	13	4	3	0	71	2	.4	.8	111	32	4	7.8	<.4	1.2	<1
Do. TW-4	3-16-64	12	6	4	0	73	2	.4	4.5	150	34	6	7.9	<.4	<.5	5
Do. PO-1A	4-20-64	11	8	73	0	148	36	.4	.8	137	42	17	7.3	<.4	<.5	40
Do. PO-3B	7-3-63	15	11	18	0	58	15	.4	1.5	160	88	8	7.4	<1	1.2	<10
Do. PO-3B	4-17-64	15	7	17	0	39	28	.4	3.3	204	67	8	7.8	<.4	<.5	16
Do. PO-4A	4-17-64	2	12	56	0	188	30	1.2	3.4	302	56	15	6.8	<.4	<.5	34
Do. PO-4B	4-17-64	18	12	38	0	187	32	.8	.4	342	93	13	7.2	<.4	1.8	21
Do. DT-5A	11-13-63	8	2	13	0	33	1	.4	.2	183	31	4	7.7	<.4	.3	2
Do. DT-10	11-13-63	12	3	14	0	41	3	.4	.2	185	42	4	7.8	<.4	.7	4
Do. LA-1B	8-19-63	8	1	130	0	325	15	2.4	.3	457	28	26	7.3	<.4	<.5	4
Do. LA-1B	1-14-64	8	1	126	0	280	15	2.0	.6	490	23	23	8.2	<.4	2.0	3
Do. LA-2	8-19-63	8	0	32	0	112	10	1.6	.0	174	21	10	8.1	<.4	1.9	2
Do. LA-3	8-19-63	14	1	30	0	81	1	.4	.3	128	37	7	7.8	<.4	.3	6
Do. LA-3	2-14-64	13	1	34	2	92	3	.4	.4	137	35	4	8.2	<.4	4.0	2
Do. LA-4	8-19-63	13	0	22	0	67	0	.8	.0	109	33	4	7.9	<.4	<.5	4
Do. LA-4	2-14-64	13	0	18	0	68	3	.4	.2	116	33	5	8.3	<.4	1.1	2
Do. LA-5	8-15-63	10	1	22	0	72	1	.4	.0	118	22	5	7.8	<.4	<.5	4
Do. LA-5	3-14-64	10	0	24	0	74	2	.4	.2	119	26	4	8.7	<.4	1.0	2
Do. LA-6	8-19-63	4	7	90	4	220	3	2.0	.8	314	37	12	8.4	<.4	19.8	7
Do. LA-6	11-29-63	4	0	104	5	201	4	2.0	.6	335	10	13	8.6	<.4	16.0	10
Do. LA-6	3-14-64	3	1	51	14	156	4	2.0	.4	294	10	12	8.4	<.4	1.7	3
Do. G-1	7-16-63	10	0	36	2	60	3	.8	.1	156	26	7	8.2	<2	<.5	<10
Do. G-1	1-17-64	13	1	20	20	74	3	.4	.2	126	36	4	7.8	<.4	<.5	4
Do. G-1	5-24-64	13	0	22	0	74	3	.4	.1	168	29	6	7.8	<.4	<.5	9
Do. G-1A	7-16-63	13	0	24	2	74	3	.4	.2	139	32	7	8.2	<1	<.5	<10
Do. G-1A	1-17-64	13	1	20	2	74	1	.4	.1	194	37	6	7.8	<.4	<.5	5
Do. G-1A	5-26-64	13	.3	22	0	78	3	.4	.2	183	33	3	7.9	1.5	<.5	5
Do. G-2	7-16-63	12	2	33	1	35	3	.4	.2	210	31	6	8.1	<1	1.1	<10
Do. G-2	1-17-64	13	1	31	0	98	4	.4	.0	213	35	6	8.1	<.4	.4	2
Do. G-2	5-24-64	12	.3	37	0	102	3	.4	.2	187	33	7	8.0	1.3	<.5	2
Do. G-3	7-16-63	10	2	27	2	84	2	.4	.2	145	31	7	8.1	<1	<.5	<10
Do. G-3	1-17-64	11	1	26	0	84	3	.4	.2	135	33	4	8.0	<.4	<.5	<1
Do. G-3	6-12-64	10	5	29	0	86	2	.4	.3	135	31	6	8.0	.6	<.5	4
Do. G-4	7-16-63	14	4	11	0	74	2	.4	.1	132	30	7	8.1	<1	.4	<10
Do. G-4	1-17-64	12	3	10	0	76	[illegible]	[illegible]	.2	140	38	7	[illegible]	<.4	.05	<1
Do. G-4	5-26-64	18	3	14	0	75	2	.4	.4	125	32	6	7.8	<.4	<.5	4
Do. G-5	7-16-63	14	3	12	2	73	2	.4	.3	143	37	7	8.1	<1	<.5	<10
Do. G-5	1-17-64	16	3	10	0	74	4	.4	.2	133	41	4	8.1	<.4	.7	3
Do. G-5	6-17-64	18	4	13	0	76	2	.4	.3	136	34	4	8.2	.4	<.5	9
Do. G-6 (630 ft.)	12-18-63	21	5	14	0	93	5	.4	.2	162	33	4	8.0	<.4	.4	4
Do. G-6 (1,520 ft.)	3-24-64	3	.3	11	1	49	4	.4	.2	218	41	4	8.4	<.4	4.1	1
Sacred Spring	11-5-63	21	8	15	0	92	3	.4	.6	128	56	4	7.1	<.4	1.3	6
Indian Spring	11-5-63	22	3	25	0	98	2	.4	.2	154	68	3	7.7	<.4	1.6	4
Los Alamos Spring	8-18-63	28	13	19	1	90	19	.3	1.1	217	125	12	8.3	<.4	.4	2
Do.	2-19-64	30	11	21	0	88	20	.2	[illegible]	209	119	12	7.7	<.4	1.2	4
Basalt Spring	8-14-63	30	12	22	0	82	18	.2	2.4	204	123	11	7.5	<.4	1.5	13
Do.	2-19-64	30	10	20	0	43	30	.2	2.4	229	114	12	7.7	<.4	1.0	10
Apache Spring	11-13-63	12	4	11	0	60	3	.4	.4	124	44	5	7.8	1.0	3.1	11
Bear Spring	11-7-63	10	5	10	0	58	2	.4	.1	125	48	3	7.5	<.4	1.2	4
Sandia Spring	11-11-63	22	13	10	0	120	4	.4	.1	120	108	10	7.7	<.4	1.7	6
Hamilton Bend Spring	9-25-63	12	6	19	0	104	33	1.2	2.4	376	56	17	7.1	<.4	<.5	18
Do.	3-19-64	11	7	19	0	120	30	1.2	2.6	154	56	15	7.5	1.5	<.5	13
[illegible] Seep	9-23-63	10	5	67	0	112	30	1.0	4.0	379	38	16	7.3	<.4	<.5	37
Do. 1/	3-17-64	3	6	53	4	119	32	1.5	4.5	346	49	14	7.2	40.5	<.5	15
Acid Canyon at Acid Weir	9-26-63	16	4	87	0	193	20	1.4	1.3	337	75	19	7.3	4.0	35.8	234
Pueblo Canyon at Pueblo 1	9-26-63	14	3	65	0	106	30	1.0	6.3	376	48	12	7.2	<.4	<.5	28
Pueblo Canyon at Pueblo 2	9-23-63	12	2	65	0	91	28	1.0	6.3	353	44	14	7.2	1.6	<.5	37
Do.	11-20-63	14	8	82	0	183	29	.4	12.0	464	67	19	7.4	<.4	<.5	12
Do.	1-16-64	14	5	33	0	161	33	1.0	7.3	394	56	20	7.3	<.4	<.5	34
Pueblo Canyon at Pueblo 3 1/	9-25-63	14	3	65	0	113	28	1.6	2.3	362	50	18	7.5	<.4	<.5	38
Do.	3-19-64	16	5	52	0	152	33	1.0	2.8	403	58	18	7.7	<.4	<.5	52
Frijoles Stream at Bandelier Natl. Mon. Hdqrs.	9-4-63	6	1	13	0	58	3	.4	.2	119	31	3	8.0	<1	<.5	<10
Do.	5-13-64	3	3	15	0	53	1	.4	.9	168	42	6	7.8	<.4	1.6	11
DP Canyon near [illegible]	9-26-63	16	4	121	0	248	91	20.0	6.2	330	86	34	7.4	1.6	<.5	210
Do.	1-23-64	25	8	106	0	210	98	3.4	11.0	421	47	32	7.5	<.4	<.5	160
Do.	3-12-64	24	7	90	0	240	132	5.4	16.4	383	97	40	7.7	4.7	<.5	181
Guaje Canyon at reservoir	4-17-64	7	2	10	0	40	0	.4	.2	83	25	3	7.4	.8	<.5	8
Rio Chama at Chamita 2/	June, Aug., Sept., 1963	15	18	79	0	132	8	.4	.9	423	114	16	7.5	<.4	1.3	14
Do.	Oct.-Nov., 1963	28	26	38	0	140	23	.4	.1	441	136	23	7.8	<.4	3.8	14
Do.	Jan.-Mar., 1964	19	32	46	0	147	18	.4	.0	377	141	25	7.8	<.4	2.6	12
Do.	Apr.-June, 1964	18	23	29	0	111	4	.4	.1	262	134	15	7.7	2.3	<.5	18
Rio Grande at Embudo 2/	July-Sept., 1963	23	8	34	0	104	3	.4	.05	186	97	9	7.5	<.4	.5	18
Do.	Oct.-Dec., 1963	27	10	23	0	111	11	.6	.2	219	104	11	7.6	<.4	1.0	8
Do.	Mar., 1964	25	14	14	2	109	23	.8	.8	223	94	11	7.2	<.4	.8	17
Do.	May, June, 1964	26	12	21	0	112	4	.4	.0	140	112	12	8.2	<.4	<.5	32
Rio Grande at Otowi 2/	June-Sept., 1963	12	24	32	0	128	4	.8	.1	254	130	12	7.6	<.4	4.5	36
Do.	Oct.-Dec., 1963	17	25	33	0	137	11	.4	.1	225	146	15	7.7	<.4	2.4	13
Do.	Jan.-Mar., 1964	15	8	34	0	138	8	.4	.2	253	72	13	7.3	<.4	1.7	18
Do.	Apr.-June, 1964	13	14	36	0	103	4	.4	.3	204	111	12	8.2	<.4	<.5	30
Rio Grande at Bandelier 2/	July-Sept., 1963	5	16	42	0	135	7	.8	.3	306	85	13	7.4	<.4	2.3	20
Do.	Oct.-Dec., 1963	19	23	37	0	88	15	.4	.8	234	154	15	7.5	<.4	6.0	13
Do.	Jan.-Mar., 1964	25	26	37	0	123	8	.4	.8	287	132	13	7.8	<.4	1.5	17
Do.	Apr.-June, 1964	5	28	30	5	140	4	.4	.3	276	104	15	7.7	<.4	<.5	100

1/ Sampling point at end of surface flow between PO-9 and PO-11. 2/ Composite of samples collected in months indicated.

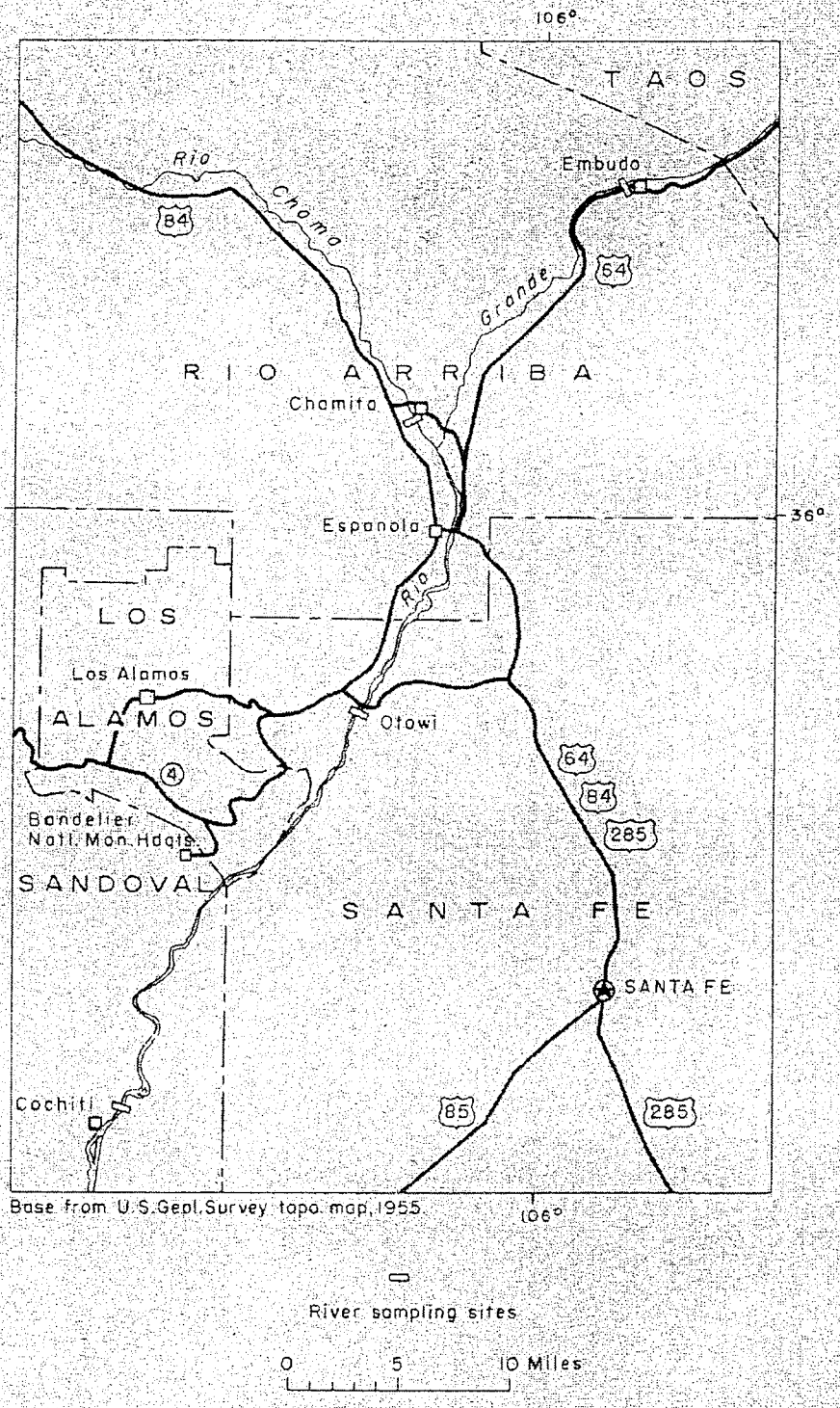

Figure 2.--River-sampling sites on the Rio Chama and Rio Grande

State of New Mexico
ENVIRONMENT DEPARTMENT
DOE OVERSIGHT BUREAU
P.O. Box 1663 MS J993
Los Alamos, NM 87545
Telephone (505) 672-0443 Fax (505) 672-0466

GARY JOHNSON
GOVERNOR

JOHN R. D'ANTONIO JR
SECRETARY

FACSIMILE TRANSMITTAL SHEET

To: Darlene	**Date:** 11-20-02
Company/Department: HWB	
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Company/Department: NMED/DOE OB – White Rock Office	
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Message or Instructions

If you did not receive all the pages or if any of the pages are illegible, please contact our office between 8:00 Am and 4:00 PM Monday through Friday at (505)672-0443. Thank you.

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

P. O. Box 4217
Albuquerque, New Mexico
February 2, 1966

Dr. T. L. Shipman
H Division Leader
Los Alamos Scientific Laboratory
P. O. Box 1663
Los Alamos, New Mexico

Dear Dr. Shipman:

Enclosed are three copies of each of the following reports:

(1) "The hydrology and the chemical and radiochemical quality of surface and ground water at Los Alamos, New Mexico, January 1956 through June 1957," by John H. Abrahams, Jr.

(2) "The hydrology and chemical and radiochemical quality of surface and ground water at Los Alamos, New Mexico, July 1957 through June 1961," by John H. Abrahams, Jr. and William D. Purtymun.

(3) "The chemical and radiochemical quality of surface and ground water at Los Alamos, New Mexico, July 1961 through June 1962," by William D. Purtymun

(4) "The chemical and radiochemical quality of surface and ground water at Los Alamos, New Mexico, July 1962 through June 1963," by William D. Purtymun.

(5) "The chemical and radiochemical quality of surface and ground water at Los Alamos, New Mexico, July 1963 through June 1964," by William D. Purtymun.

(6) "Physical characteristics of the Tshirege Member of the Bandelier Tuff with reference to use as a building and ornamental stone," by W. D. Purtymun and F. C. Koopman.

(7) "Geology and hydrology of White Rock Canyon from Otowi to the confluence of Frijoles Canyon, Los Alamos and Santa Fe Counties, New Mexico," by William D. Purtymun.

(8) "Geology and hydrology of Area "G" Mesita del Buey, Los Alamos County, New Mexico," by William D. Purtymun.

(9) "Equipment used to study the movement of water in the Bandelier Tuff at Los Alamos, New Mexico," by John H. Abrahams, Jr.

(10) "Movement of water and radionuclides in a tile field waste-disposal system at Jackass Flats, Nevada Test Site: Infiltration studies October 1959 through December 1960," by John H. Abrahams, Jr.

All of these reports have been reviewed by the USGS editors and have been approved for Administrative release to the AEC and LASL. They have also been reviewed by the AEC and Group H-6 of LASL and were revised according to the suggestions presented by Mr. Kennedy (H-6) and Mr. Christenson (H-7). Also, they have all been cleared through Security, D Division of LASL.

Mr. Ted Russo, Engineering 3, has requested that the transparancies for all these reports be loaned to his office for reproduction so that requests for copies of the reports can be filled there. The transparancies will be returned to this office.

Report No. 6 was prepared for the President's Community Action Program at Santa Clara Indian Pueblo. The information contained in this report was abstracted from reports in the files of the USGS which were prepared for and in cooperation with the AEC and LASL. The cost of preparing this report was absorbed by the general fund. It is included in this group for your reference.

We did not use an actual photograph for figure 6 in Rept. No. 9 because we did not have a negative available. You may wish to remove the photograph from your superseded copies before they are destroyed.

These reports are in final form and any review copies you have could now be destroyed.

Very truly yours,

F. C. Koopman

F. C. Koopman
Hydraulic Engineer

for: W. E. Hale
District Chief, WRD

cc: Ted Russo
Alfred Clebsch, Jr., Washington, D. C.