USGS-474-225

USGS-474-225

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Federal Center, Lakewood, Colorado 80225

RADIOCHEMICAL MONITORING OF WATER AFTER THE CANNIKIN EVENT, AMCHITKA ISLAND, ALASKA, AUGUST 1974 AND CHEMICAL MONITORING FROM JULY 1972 TO JUNE 1974

(Amchitka-44)
Date Published: March 1976

Prepared Under
Agreement No. E(29-2)-474

for the

Nevada Operations Office
U.S. Energy Research and Development Administration

Printed in the United States of America
Available from
U.S. Department of Commerce
National Technical Information Service
Springfield, Virginia 22161
Price: Printed Copy $____*; Microfiche $2.25

*Pages	NTIS Selling Price
1-50	$ 4.00
51-150	$ 5.45
151-325	$ 7.60
326-500	$10.60
501-1000	$13.60

Amchitka-44
1976

USGS-474-225

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Federal Center, Lakewood, Colorado 80225

RADIOCHEMICAL MONITORING OF WATER AFTER THE CANNIKIN EVENT, AMCHITKA ISLAND, ALASKA, AUGUST 1974 AND CHEMICAL MONITORING FROM JULY 1972 TO JUNE 1974

By

William Thordarson and Wilbur C. Ballance

CONTENTS

ILLUSTRATIONS

TABLES

Amchitka-44
1976

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

USGS-474-225

Federal Center, Lakewood, Colorado 80225

RADIOCHEMICAL MONITORING OF WATER AFTER THE CANNIKIN EVENT, AMCHITKA ISLAND, ALASKA, AUGUST 1974 AND CHEMICAL MONITORING FROM JULY 1972 TO JUNE 1974

By

William Thordarson and Wilbur C. Ballance

ABSTRACT

Radiochemical data from the Amchitka Island study area were obtained from water samples collected by the U.S. Geological Survey during August 1974. Tritium determinations were made on 18 samples, and gross alpha and gross beta/gamma determinations were made on 12 samples. No appreciable differences were found between the data obtained during August 1974 and the data obtained before the Cannikin event.

Chemical analyses were made on 4 samples collected in 1971, on 15 samples in 1972, on 11 samples in 1973, and 7 samples in 1974. Comparison of these analyses to analyses of samples collected before the Cannikin event indicates no changes outside of the seasonal range normally found at the sampling locations.

INTRODUCTION

Amchitka Island, Alaska, was the site for three underground nuclear detonations. The Long Shot event was conducted on October 29, 1965, the Milrow event on October 2, 1969, and the Cannikin event on November 6, 1971.

The U.S. Geological Survey on behalf of the U.S. Energy Research and Development Administration (formerly the U.S. Atomic Energy Commission) started water sampling of wells, streams, and springs on Amchitka Island in 1965 in order to establish background levels of radioactivity before initiation of nuclear explosion experiments. A long-term, water-sampling network was developed in 1967 in order to observe possible effects of the nuclear explosions on the island. This network was expanded to a total of 72 stations in September 1971 to include the drainage area surrounding the final nuclear explosion, the Cannikin event, and included 13 offshore stations. At the request of the Energy Research and Development Administration, this network was reduced to 16 stations in July 1974 and the 13 offshore stations were excluded. Water samples were collected by personnel of Teledyne Isotopes and the Geological Survey from 1967 through September 1971. The Geological Survey has done the water sampling since September 1971.

The network stations were sampled in 1971 in September, November, and December; in 1972 in January, April, and October; in 1973 in August; and in 1974 in May and August. The Energy Research and Development Administration has announced that the Geological Survey will no longer be involved with the long-term, water-sampling network on Amchitka Island.

The techniques and procedures used by the Geological Survey for collecting, identifying, and analyzing water samples are described by Beetem and others, 1971a, 1971b; Schroder, 1971.

Radiochemical data obtained by the Geological Survey from 1965 through May 1974 were presented in previous reports (Beetem and others, 1971a; Schroder and Ballance, 1972a, 1972b, 1973a, 1973b, 1973c; Ballance, 1974; Thordarson and Ballance, 1976). Chemical data through June 1972 were presented in previous reports (Beetem and others, 1971b; Schroder and Ballance, 1973b). This report presents the radiochemical data from water samples collected in August 1974 and chemical data from water samples collected during 1971-1974. Also included are the chemical analyses of six precipitation samples collected at the South Hanger in fiscal year 1972.

WATER-SAMPLING NETWORK

Freshwater samples were collected from precipitation, wells, streams, lakes, and springs. Seawater samples were collected at the shoreline.

Figures 1, 2, and 3 show the locations of the sampling points in the present modified water-sampling network. The radiochemical-sampling stations and types of radiochemical analyses performed on the freshwater samples and the shoreline seawater samples are listed in table 1. The sampling points in figures 1, 2, and 3 have reference numbers that are listed in the tables.

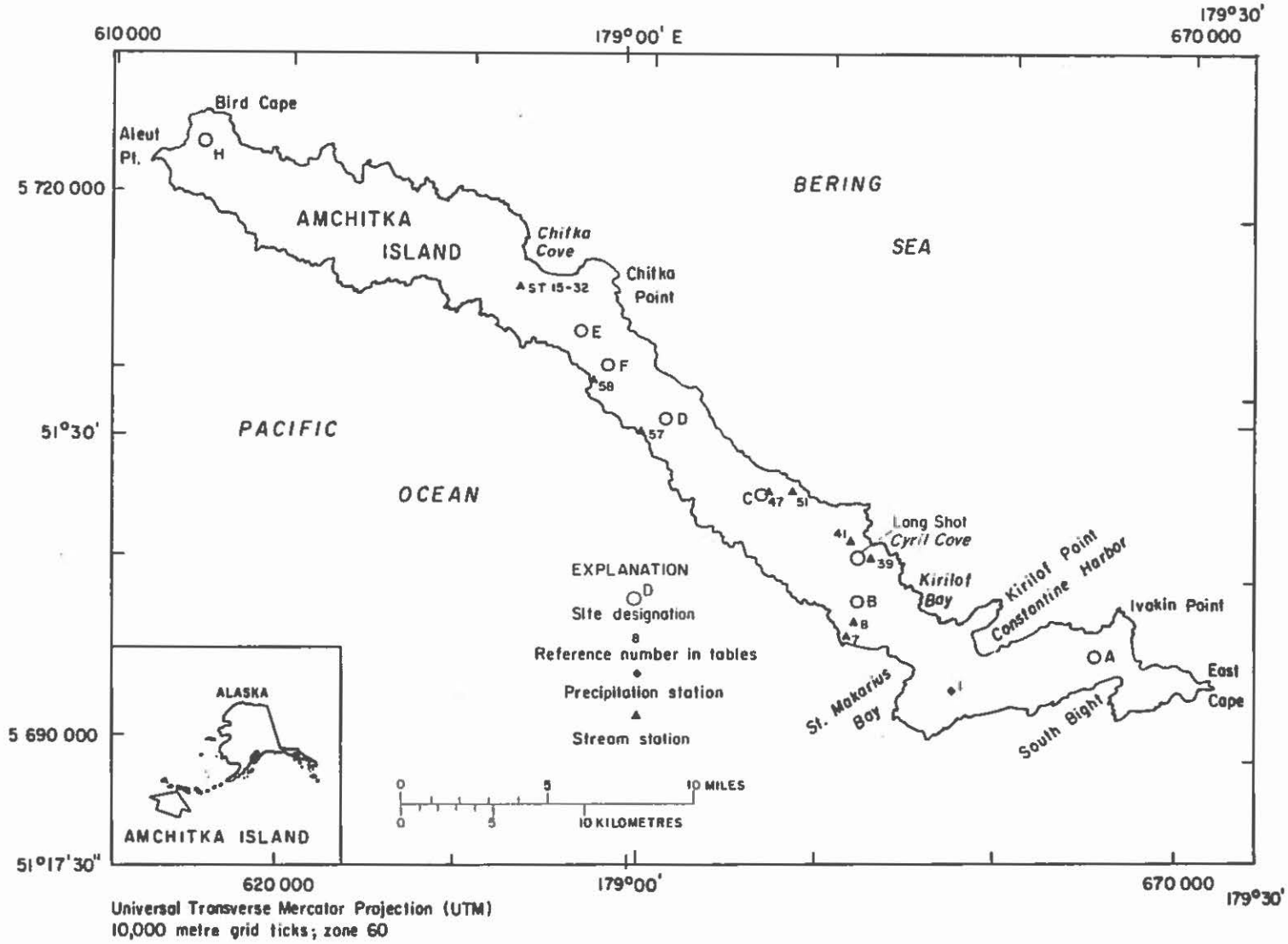

Figure 1.--Precipitation- and stream-sampling stations for chemical and radiochemical monitoring, Amchitka Island, Alaska.

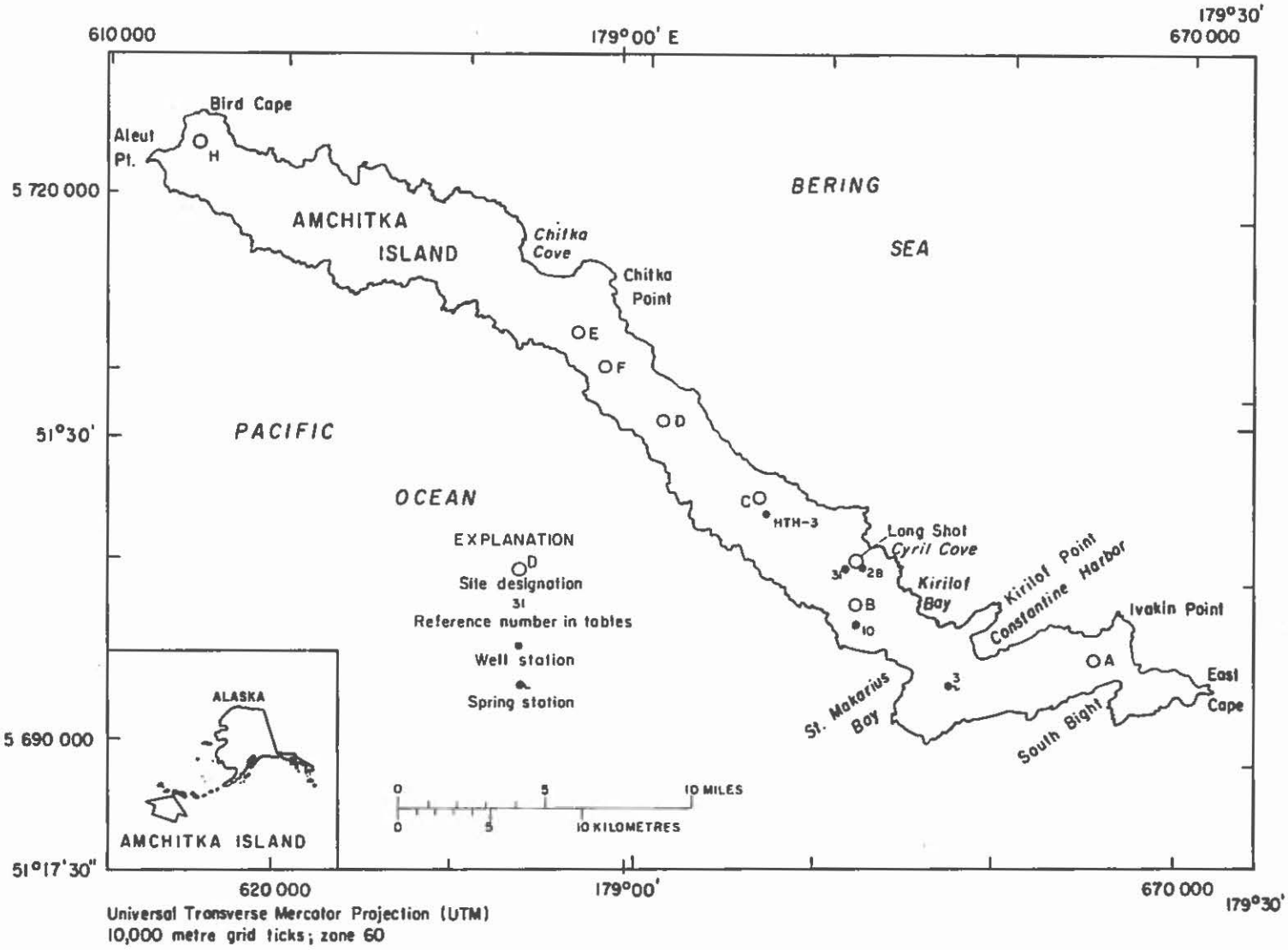

Figure 2.--Well- and spring-sampling stations for chemical and radiochemical monitoring, Amchitka Island, Alaska.

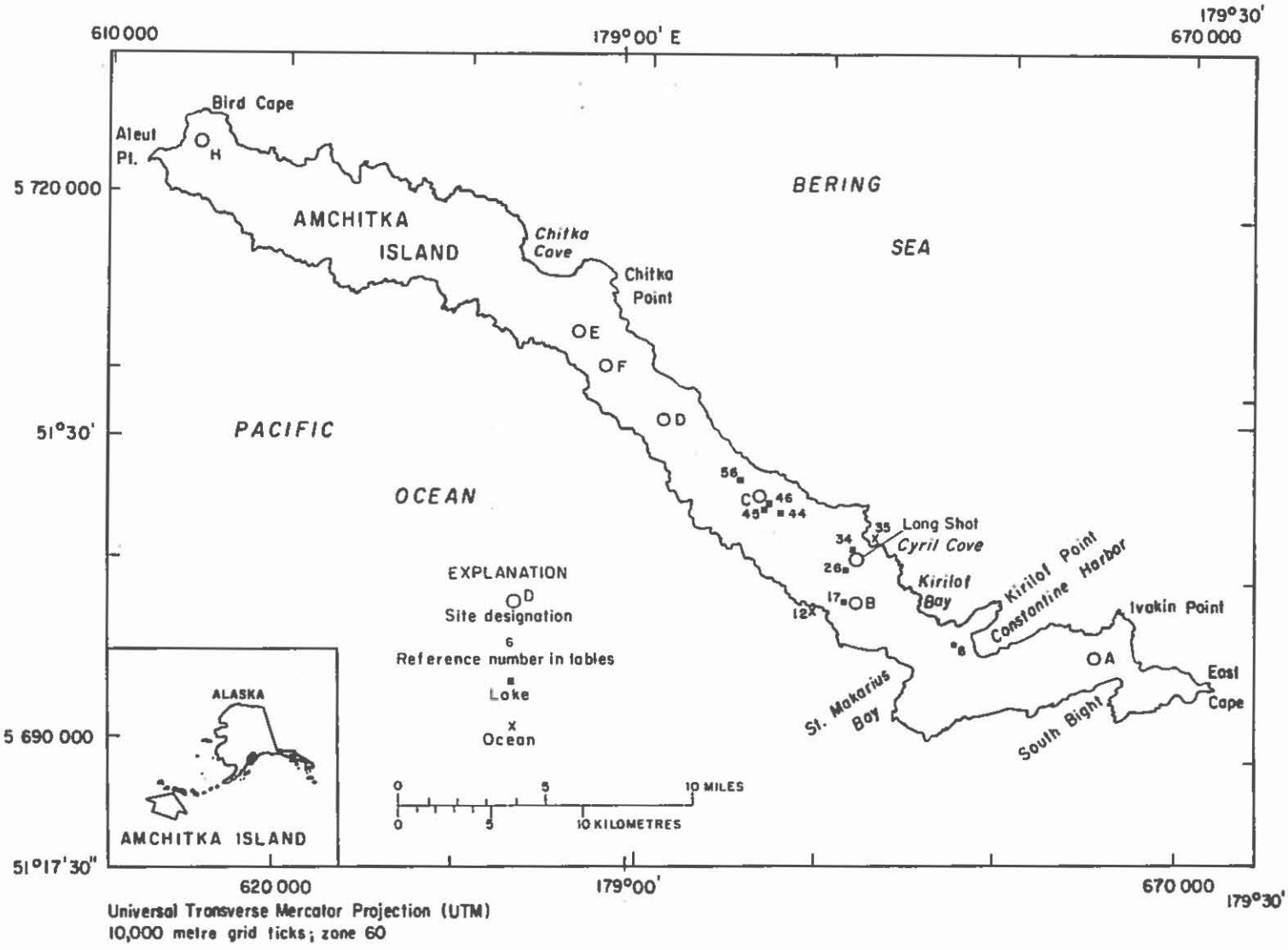

Figure 3.--Lake- and sea-sampling stations for chemical and radiochemical monitoring, Amchitka Island, Alaska.

Table 1.--Radiochemical-sampling stations, Amchitka Island, Alaska, August 1974

(A, analyzed for gross alpha, gross beta/gamma, and tritium; T, analyzed for tritium only)

Ident. no.	Ref. no.	Other identifying name	Type of analysis
PR93-57	1	Precipitation at South Hanger	T
SP94-56	3	Constantine Spring	A
LK96-57	6	Jones Lake	A
ST96-51	7	Clevenger Creek at road	A
WE97-51	10	Well W-13	A
OP97-50	12	Pacific Ocean	T
LK98-51B	17	Lake B-3	A
LK00-51B	26	Lake A-6	A
WE00-51E	28	Well No. 10C	T
WE00-51F	31	Well No. 8A	T
LK00-51D	34	Long Shot mudpit, A-3	A
OB01-52A	35	Bering Sea (F-11)	T
ST01-52	39	Stream at weir 1	A
LK04-46C	45	Lake	A
ST04-47A	47	White Alice Creek	A
LK05-45	56	Lake	A
WE03-46		HTH-3	T
ST15-32		Culvert northwest of site E	A

RESULTS

Chemical Data

Table 2 presents results of chemical analysis of 4 samples collected during 1971, 15 samples collected during 1972, 11 samples collected during 1973, and 7 samples collected during 1974. Comparison of these analyses to analyses of samples collected before the Cannikin event indicates no changes outside of the seasonal range normally found at the sampling locations.

The eight analyses of precipitation are presented to show the wide range in values of the dissolved chemical constituents. This wide range is attributed principally both to salts accumulation from sea spray before precipitation and to sea spray blown by the wind during precipitation.

Gross Alpha

In 12 freshwater samples, the dissolved gross alpha activity, reported as natural uranium equivalent in micrograms per litre (μg/l) was less than 3.9 μg/l for the August 1974 sampling (table 3). Before the Cannikin event, a range from less than 0.4 to 70 μg/l was found in samples from 54 freshwater stations on Amchitka (Beetem and others, 1971a). Five of the freshwater stations sampled during August 1974 were also sampled prior to the Cannikin event. The August 1974 samples from these five stations had values less than 2.5 μg/l in dissolved gross alpha activity. Before the Cannikin event, samples from these same five stations ranged from less than 0.7 to 3.3 μg/l (Beetem and others, 1971a).

Table 2.--Chemical analyses of water

(Chemical analyses in milligrams

Source and identification number	Ref. no. 1/	Latitude N.			Longitude E.			Date of Collection	Dissolved Silica (SiO_2)	Dissolved Aluminum (Al)	Dissolved Iron (Fe)	Dissolved Manganese (Mn)	Dissolved Magnesium (Mg)	Dissolved Calcium (Ca)	Dissolved Strontium (Sr)
		Deg.	Min.	Sec.	Deg.	Min.	Sec.	M D Y							
PR93-57 2/	1	51	22	25	179	15	48	08-19-71	--	--	--	--	0.4	1.1	--
PR93-57 2/	1	51	22	25	179	15	48	09-01-71	--	--	--	--	.2	.9	--
PR93-57 2/	1	51	22	25	179	15	48	11-13-71	--	--	--	--	3.0	1.9	--
PR93-57 2/	1	51	22	25	179	15	48	12-09-71	--	--	--	--	.8	1.7	--
PR93-57 2/	1	51	22	25	179	15	48	01-16-72	--	--	--	--	20	8.2	--
PR93-57 2/	1	51	22	25	179	15	48	01-18-72	--	--	--	--	1.3	1.0	--
SP94-56	3	51	22	43	179	14	59	07-13-72	17	0.01	0.01	0.02	2.8	2.0	0.03
SP94-56	3	51	22	43	179	14	59	08-21-73	16	.01	.05	<.001	3.1	2.2	.01
SP94-56	3	51	22	43	179	14	59	05-21-74	16	.01	.01	<.001	2.0	2.8	<.001
LK96-57	6	51	24	11	179	16	09	07-13-72	1.8	.03	.07	.03	2.5	2.5	.02
LK96-57	6	51	24	11	179	16	09	8-21-73	2.3	.04	.17	<.001	2.4	2.4	.02
LK96-57	6	51	24	11	179	16	09	05-21-74	1.5	.02	.08	<.001	2.7	3.2	.01
ST97-51	8	51	24	35	179	11	00	07-14-72	17	<.001	.04	.02	4.0	6.9	.03
ST97-51	8	51	24	35	179	11	00	05-23-74	15	.01	80	.07	3.8	7.1	.01
ST01-51A	41	51	26	54	179	10	57	07-14-72	23	.01	.11	.03	5.7	9.2	.03
ST01-51A	41	51	26	54	179	10	57	08-23-73	6.4	.10	.29	.01	2.8	6.7	.02
ST01-51A	41	51	26	54	179	10	57	05-22-74	18	.02	.15	.07	5.1	8.2	.02
LK03-47	44	51	28	08	179	07	12	01-19-73	--	--	--	--	3.8	6.3	--
LK04-46C	45	51	28	12	179	06	42	07-14-72	20	.13	.34	.03	4.2	13	.09
LK04-46C	45	51	28	12	179	06	42	08-23-73	15	<.001	.27	<.001	3.2	8.4	.07
LK04-46D	46	51	28	14	179	06	46	07-14-72	2.6	.04	.07	<.001	3.8	8.6	.08
LK04-46D	46	51	28	14	179	06	46	10-14-72	19	.04	.15	<.001	4.4	9.9	.10
ST04-47	51	51	28	41	179	07	34	07-16-72	24	.01	.04	.02	6.5	7.7	.03
ST04-47	51	51	28	41	179	07	34	08-24-73	14	.07	.51	.05	3.6	8.3	.04
ST04-47	51	51	28	41	179	07	34	05-23-74	27	.01	.03	.05	4.7	6.3	.02
ST07-40	57	51	30	04	179	01	01	07-16-72	32	.01	.03	<.001	5.2	5.4	.02
ST07-40	57	51	30	04	179	01	01	08-23-73	17	.04	.16	.01	3.2	6.9	.02
ST07-40	57	51	30	04	179	01	01	05-23-74	12	.01	.02	.05	3.2	6.6	.01
ST09-36	58	51	31	32	178	58	24	07-15-72	29	.02	.05	<.001	3.9	4.6	.03
ST09-36	58	51	31	32	178	58	24	08-23-73	15	.06	.14	.01	2.7	6.6	.02
ST09-36	58	51	31	32	178	58	24	05-23-74	25	.02	.04	.02	3.8	4.4	.01
HTH-3		51	28	08	179	06	45	11-03-72	--	--	--	--	1.1	4.0	--
HTH-3 3/		51	28	08	179	06	45	11-03-72	--	--	--	--	1.7	7.0	--
HTH-3		51	28	08	179	06	45	11-05-72	17	--	--	--	.6	1.2	<.01
HTH-3		51	28	08	179	06	45	01-19-73	--	--	--	--	.4	1.3	--
S Station 2/		51	26	52	179	11	41	04-27-73	--	--	--	--	22	17	--
S Station 2/		51	26	52	179	11	41	05-06-73	--	--	--	--	3.8	3.3	--

1/ Reference numbers and Station names not listed in Table 1 are: 8, Clevenger Creek at gage; 41, Bridge at gage; 58, Limpet Creek at gage.

2/ Precipitation samples.

3/ Bromide equals 2.8 mg/l. Water plus added potassium bromide was used for the drilling fluid.

samples collected on Amchitka Island, Alaska

per litre, <, less than)

Dissolved Lithium (Li)	Dissolved Sodium (Na)	Dissolved Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Dissolved Sulfate (SO_4)	Dissolved Chloride (Cl)	Dissolved Fluoride (F)	Dissolved Nitrate (NO_3)	Dissolved Ortho Phosphate (PO_4)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos/cm at 25°C)	pH (Units)
											Calcium, magnesium	Noncarbonate		
--	9.8	0.5	6	0	7.3	10	--	--	--	--	4	0	64	5.6
--	4.0	.2	8	0	1.2	3.4	--	--	--	--	3	0	28	6.4
--	31	1.3	9	0	11	49	--	--	--	--	17	10	206	6.6
--	8.0	.5	13	0	3.2	10	--	--	--	--	8	0	60	6.7
--	190	6.8	5	0	55	310	--	--	--	--	100	99	1,150	6.4
--	10	0.4	3	0	6.6	18	--	--	--	--	8	5	80	6.6
0.01	59	4.5	96	0	9.5	40	0.4	0.1	0.29	230	17	0	307	7.5
<.001	58	4.5	99	0	8.6	40	.4	.4	.95	174	18	0	302	7.9
.01	53	4.7	94	0	8.8	40	.5	.04	.29	179	15	0	298	8.0
<.001	68	2.6	114	0	10	51	.4	.00	.01	252	17	0	368	7.5
<.001	64	2.5	99	0	9.1	43	.3	.04	.28	175	16	0	319	7.6
<.001	52	2.5	81	0	9.3	45	.4	.09	.03	169	19	0	303	7.6
.01	130	3.3	202	0	34	77	.2	.00	.07	418	34	0	630	7.7
<.001	110	3.2	174	0	28	68	.4	.04	.21	321	33	0	554	7.9
.01	35	2.3	77	0	6.8	42	.1	.00	.02	218	46	0	270	7.7
<.001	19	1.3	30	0	5.1	24	.1	.04	.09	--	36	11	134	7.2
<.001	30	2.3	58	0	6.3	40	.0	.09	.01	143	42	0	239	7.4
<.001	69	1.2	78	--	22	63	--	--	--	--	31	--	427	7.5
<.001	40	1.7	73	0	14	43	.3	.04	.28	194	50	0	292	7.0
<.001	33	1.5	85	0	34	81	.8	1.5	.21	287	34	0	486	7.5
<.001	31	1.5	22	0	22	42	.2	5.3	.34	137	37	19	245	7.4
<.001	66	4.0	47	0	45	70	.4	1.9	.21	252	43	4	425	7.3
<.001	42	3.0	86	0	6.2	44	.1	.04	.01	212	46	0	294	7.2
<.001	92	1.5	86	0	36	83	.5	.00	.15	330	28	0	485	7.4
<.001	28	2.9	42	0	7.7	42	.1	.04	.09	147	35	1	227	7.5
.01	33	3.4	51	0	8.0	43	.0	.00	.03	206	35	0	243	7.3
<.001	22	1.8	30	0	6.4	31	.1	.00	.12	114	30	6	161	7.2
<.001	93	1.1	77	0	40	97	.6	.04	.03	309	30	0	537	7.5
.01	28	2.4	34	0	8.0	42	.0	.00	.02	186	28	0	210	7.7
<.001	20	1.5	23	0	5.6	30	.1	.00	.21	104	28	9	146	7.1
<.001	25	2.4	28	0	7.2	40	.1	.04	.06	128	27	4	198	7.3
<.001	94	7.7	134	--	17	78	--	--	--	--	15	0	480	7.8
<.001	120	1.8	155	--	21	110	--	--	--	--	24	0	629	7.2
<.01	110	.7	188	14	11	42	.2	.00	.34	326	5	0	477	8.5
.01	99	.6	188	--	14	40	--	--	--	--	5	--	440	7.8
--	170	9.1	--	--	61	310	--	--	--	--	130	--	1,140	--
--	30	1.6	15	--	9.0	52	--	--	--	--	24	12	213	7.3

Creek at gage; 44, Lake (unnamed); 46, Lake (unnamed); 51, White Alice Creek at gage; 57, Falls Creek

Table 3.--Radiochemical analyses of water samples collected on Amchitka Island, Alaska, August 1974

(Gross beta/gamma as cesium-137 in picocuries per litre, gross alpha as natural uranium equivalent in micrograms per litre, tritium in picocuries per litre; <, less than)

Ident. no.	Ref. no.	Latitude N.			Longitude E.			Date			Time	Gross beta/gamma	Gross alpha	Tritium
		Deg.	Min.	Sec.	Deg.	Min.	Sec.	Mo.	Da.	Yr.				
1/ PR93-57	1	51	22	25	179	15	48	08	27	74	1535	--	--	<480
1/ SP94-56	3	51	22	43	179	14	59	08	26	74	1630	5.1	<2.2	<480
1/ LK96-57	6	51	24	11	179	16	09	08	28	74	1100	4.5	<2.0	<480
1/ ST96-51	7	51	24	16	179	10	19	08	26	74	1645	7.7	<2.5	<480
WE97-51	10	51	24	50	179	10	58	08	26	74	1710	4.0	<2.2	<480
1/ OP97-50	12	51	24	52	179	09	44	08	30	74	0900	--	--	<480
1/ LK98-51B	17	51	25	01	179	10	51	08	26	74	1705	4.3	<.6	<480
LK00-51B	26	51	26	12	179	10	47	08	26	74	1730	4.0	<.5	$<480_5$
WE00-51E	28	51	26	15	179	10	59	08	28	74	0845	--	--	1.3×10^3
WE00-51F	31	51	26	17	179	10	58	08	28	74	0900	--	--	8.7×10^3
LK00-51D	34	51	26	18	179	11	01	08	28	74	0820	3.3	<2.7	3.2×10^3
OB01-52A	35	51	26	22	179	11	59	08	30	74	0800	--	--	<480
1/ ST01-52	39	51	26	45	179	11	32	08	27	74	1055	4.1	<1.2	<480
LK04-46C	45	51	28	12	179	06	42	08	27	74	1000	3.0	<3.8	<480
ST04-47A	47	51	28	21	179	06	59	08	27	74	0805	2.9	<3.9	<480
LK05-45	56	51	29	01	179	05	55	08	28	74	0930	5.1	1.1	<480
WE03-46	HTH-3	51	28	08	179	06	45	08	28	74	0950	--	--	<480
ST15-32		51	34	29	178	54	45	08	27	74	1300	2.4	<.8	<480

1/ Stations sampled in August 1974 and prior to Cannikin event (Beetem and others, 1971a).

Gross Beta/Gamma

The dissolved gross beta/gamma activity, reported as Cs-137 equivalent in picocuries per litre (pCi/l), ranged from 2.4 to 7.7 pCi/l for 12 freshwater samples from the August 1974 sampling (table 3). Before the Cannikin event, a range of less than 1.0 to 36 pCi/l was found in samples from 54 freshwater stations on Amchitka (Beetem and others, 1971a). The August 1974 samples from five freshwater stations ranged from 4.1 to 7.7 pCi/l in dissolved gross beta/gamma activity. Before the Cannikin event samples from the same five stations ranged from 1.2 to 16 pCi/l (Beetem and others, 1971a).

Tritium

Tritium analyses of water samples were made using the liquid scintillation counting technique. The minimum tritium-detection level using this method is 480 pCi/l.

Water samples having detectable (greater than 480 pCi/l) tritium activity were those collected at the Long Shot site (reference numbers 28, 31, and 34, table 3). The tritium activity found in water at the Long Shot site is consistent with data obtained prior to the Cannikin event. The greatest tritium values at the Long Shot site prior to the Cannikin event (Beetem and others, 1971a) ranged from 7,400 pCi/l, February 1970, in a mudpit at the site to 300,000 pCi/l, August 1970, in a drill hole at the site. Corresponding tritium activities in water samples from these locations in August 1974 are 3,200 and 130,000 pCi/l, respectively.

REFERENCES

Ballance, W. C., 1974, Radiochemical monitoring of water after the Cannikin event, Amchitka Island, Alaska, August 1973: U.S. Geol. Survey rept. USGS-474-205, 16 p.; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22161.

Beetem, W. A., Washington, C. L., Janzer, V. J., and Schroder, L. J., 1971a, Radiochemical analyses of water samples collected on Amchitka Island, Alaska: U.S. Geol. Survey rept. USGS-474-123, 34 p.; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22161.

Beetem, W. A., Young, R. A., Washington, C. L., and Schroder, L. J., 1971b, Chemical analyses of water samples collected on Amchitka Island, Alaska: U.S. Geol. Survey rept. USGS-474-135, 18 p.; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22161.

Schroder, L. J., 1971, Determination of tritium in water by the U.S. Geological Survey, Denver, Colorado: U.S. Geol. Survey rept. USGS-474-134, 18 p.; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22161.

Schroder, L. J., and Ballance, W. C., 1972a, Radiochemical monitoring of water for the Cannikin event, in Geologic and hydrologic effects of the Cannikin underground nuclear explosion, Amchitka Island, Aleutian Islands, Alaska: U.S. Geol. Survey rept. USGS-474-148, p. 68-81; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22161.

Schroder, L. J., and Ballance, W. C., 1972b, Radiochemical monitoring of water after the Cannikin event, Amchitka Island, Alaska, January 13-April 5, 1972: U.S. Geol. Survey rept. USGS-474-159, 13 p.; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22161.

_____1973a, Radiochemical monitoring of water after the Cannikin event, Amchitka Island, Alaska, July 1972: U.S. Geol. Survey rept. USGS-474-166, 11 p.; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22161.

_____1973b, Summary of chemical and radiochemical monitoring of water for the Cannikin event, Amchitka Island, Alaska, fiscal year 1972: U.S. Geol. Survey rept. USGS-474-167, 35 p.; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22161.

_____1973c, Radiochemical monitoring of water after the Cannikin event, Amchitka Island, Alaska, October 1972: U.S. Geol. Survey rept. USGS-474-169, 11 p.; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22161.

Thordarson, William, and Ballance, W. C., 1976, Radiochemical monitoring of water after the Cannikin event, Amchitka Island, Alaska, May 1974: U.S. Geol. Survey rept. USGS-474-226, 19 p.; available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service, Springfield, Va. 22161.

Distribution

U.S. Energy Research & Development Administration, Nevada Operations Office, Las Vegas, NV:

Elaine Bickerstaff (3)
E. M. Douthett (3)
M. E. Gates, c/o R. R. Loux (2)
D. G. Jackson
R. R. Loux (10)
Roger Ray
A. J. Whitman

U.S. Energy Research & Development Administration, Nevada Test Site Support Office, Mercury, NV:

J. O. Cummings

U.S. Energy Research & Development Administration, Mercury, NV:

CETO Library

U.S. Energy Research & Development Administration, Washington, DC:

M. B. Biles (2)
Ernest Graves (2)
J. L. Liverman
Office of Public Affairs
W. H. Pennington

U.S. Energy Research & Development Administration, Technical Information Center, Oak Ridge, TN: (27)

Defense Nuclear Agency:

Field Command, DNA, FCTD-T2 (Attn: Benton L. Tibbetts), Kirtland AFB, NM
Director (Attn: SPSS, David Oakley, Eugene Sevin, Clifton MacFarland), Washington, DC
O-I-C Liaison Office, Las Vegas, NV

Los Alamos Scientific Laboratory, Los Alamos, NM:

R. B. Brownlee
E. A. Bryant
R. H. Campbell
J. W. House
K. H. Olsen
R. R. Sharp
E. J. Sowder

Lawrence Livermore Laboratory, Livermore, CA:

J. E. Carothers
L. S. Germain
R. S. Guido
N. W. Howard
Roger Ide
A. E. Lewis
L. D. Ramspott
D. L. Springer
Technical Information Division

Lawrence Livermore Laboratory, Mercury, NV:

W. B. McKinnis

Sandia Laboratories, Albuquerque, NM:

J. R. Banister
C. D. Broyles
M. L. Merritt
W. C. Vollendorf
W. D. Weart

Defense Advanced Research Projects Agency, Arlington, VA:

G. H. Heilmeier

Battelle Columbus Laboratories:

R. S. Davidson, Columbus, OH
V. Q. Hale, Columbus, OH
J. B. Kirkwood, Duxbury, MA

CIRES, University of Colorado, Boulder, CO:

E. R. Engdahl

Desert Research Institute, Reno, NV:

P. R. Fenske
G. B. Maxey

Environmental Protection Agency:

Attn: Water Branch, Seattle, WA

Environmental Protection Agency, National Environmental Research Center, Las Vegas, NV:

D. S. Barth

Fenix & Scisson, Inc.:

Grant Bruesch, Mercury, NV
M. H. May, Las Vegas, NV

Holmes & Narver, Inc., Las Vegas, NV:

F. M. Drake

National Oceanic and Atmospheric Administration, Air Resources Laboratory, Las Vegas, NV:

H. F. Mueller

National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Auke Bay, AK:

T. R. Merrell, Jr.

University of Washington, Seattle, WA:

E. E. Held
J. S. Isakson

U.S. Army Corps of Engineers, Alaska District, Anchorage, AK:

District Engineer, Attn: A. C. Mathews

U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS:

Library

U.S. Bureau of Mines, Denver, CO:

P. L. Russell

U.S. Department of Interior, Fish and Wildlife Service, Anchorage, AK:

C. E. Abegglen

U.S. Geological Survey:

Geologic Data Center, Mercury, NV (15)
K. W. King, Las Vegas, NV
Library, Denver, CO
Library, Menlo Park, CA

U.S. Geological Survey, Reston, VA:

Chief Hydrologist, WRD (Attn: Radiohydrology Section)
Library
Military Geology Unit
J. C. Reed, Jr.