



DEPARTMENT OF HEALTH
NEW ZEALAND

ENVIRONMENTAL RADIOACTIVITY
ANNUAL REPORT

1978

NATIONAL RADIATION LABORATORY
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The Environmental Radioactivity Section of the Laboratory organised the monitoring operations and analysed the samples. The Officer in Charge of this section, Mr L. P. Gregory, was responsible for reporting and interpreting results. He was assisted professionally by Dr K. M. Matthews, and technically by Mr G. N. Connor and Miss M. Roberts.

for H. R. Atkinson
(Director)

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UNITS AND REFERENCE LEVELS

Units

The unit of radioactivity, the "Curie" (Ci), equal to 3.7×10^{10} disintegrations per second, is too large for environmental levels, and subdivisions are used in this report: the millicurie (mCi) = 10^{-3} Ci, and the picocurie (pCi) = 10^{-12} Ci or 2.22 disintegrations per minute.

Deposition of radioactivity is given as millicuries per square kilometre (mCi/km²)

Concentration of radioactivity

in air: is given as picocuries per cubic metre (pCi/m³)

in rain: is given as picocuries per litre (pCi/l) and is derived from the relationship:

$$\text{pCi/l} = \frac{\text{mCi/km}^2 \times 1000}{\text{millimetres of rain}}$$

in milk: strontium-90 (⁹⁰Sr) concentration is given as picocuries per gram of calcium (pCi/gCa)

caesium-137 (¹³⁷Cs) concentration is given as picocuries per gram of potassium (pCi/gK)

(One litre of milk contains about 1.2 g of calcium and about 1.4 g of potassium)

Reference Levels

The following reference levels, against which measured levels reported herein may be compared, have been adopted for New Zealand:

Mixed fission products between 10 and 80 days old (Total Beta Activity)

in air: 300 pCi/m³

in rain: 6000 pCi/l

strontium-90 in milk: 270 pCi/gCa

caesium-137 in milk: 7000 pCi/gK

SUMMARY

During 1978 the deposition of strontium-90 at nine New Zealand stations averaged less than 0.1 millicuries per square kilometre. This was the lowest deposition since measurements commenced in 1960.

During 1964 a maximum deposition (averaging 3.6 mCi/km^2 for the New Zealand stations), resulted from the large scale USSR and USA atmospheric nuclear tests of 1961-62. Subsequently annual depositions decreased. During French atmospheric tests in the South Pacific from 1966 to 1974 average depositions in New Zealand ranged from 0.3 to 1.4 mCi/km^2 per year.

The concentrations of strontium-90 and caesium-137 in New Zealand milk have reflected the changes in fallout deposition. The average concentrations during 1978 were the lowest recorded since measurements commenced.

French underground nuclear tests in the South Pacific commenced in mid-1975. Since then continuous monitoring has also been conducted at five Pacific Island stations. No fresh fission products, from possible venting during underground tests, have been detected since this programme started.

The levels recorded during 1978 were very small fractions of the reference levels and thus do not constitute a public health hazard. Moreover, the radiation dose to the general population resulting from the long-term average levels, summarised herein, is small compared not only with the dose from the natural background but also with that from common variations in the natural background.

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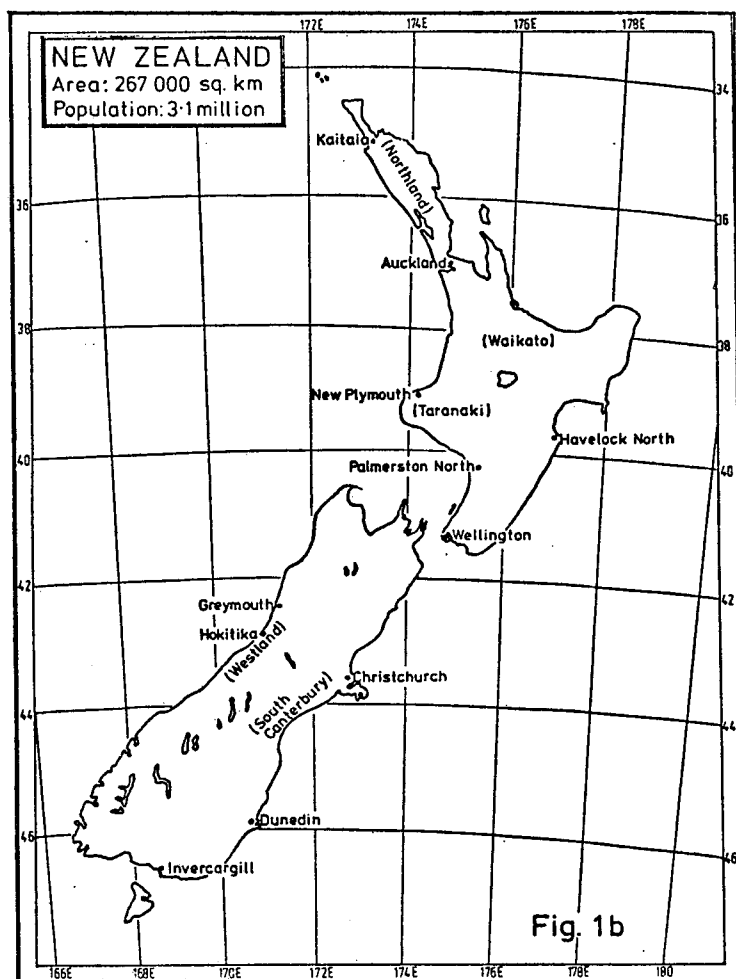
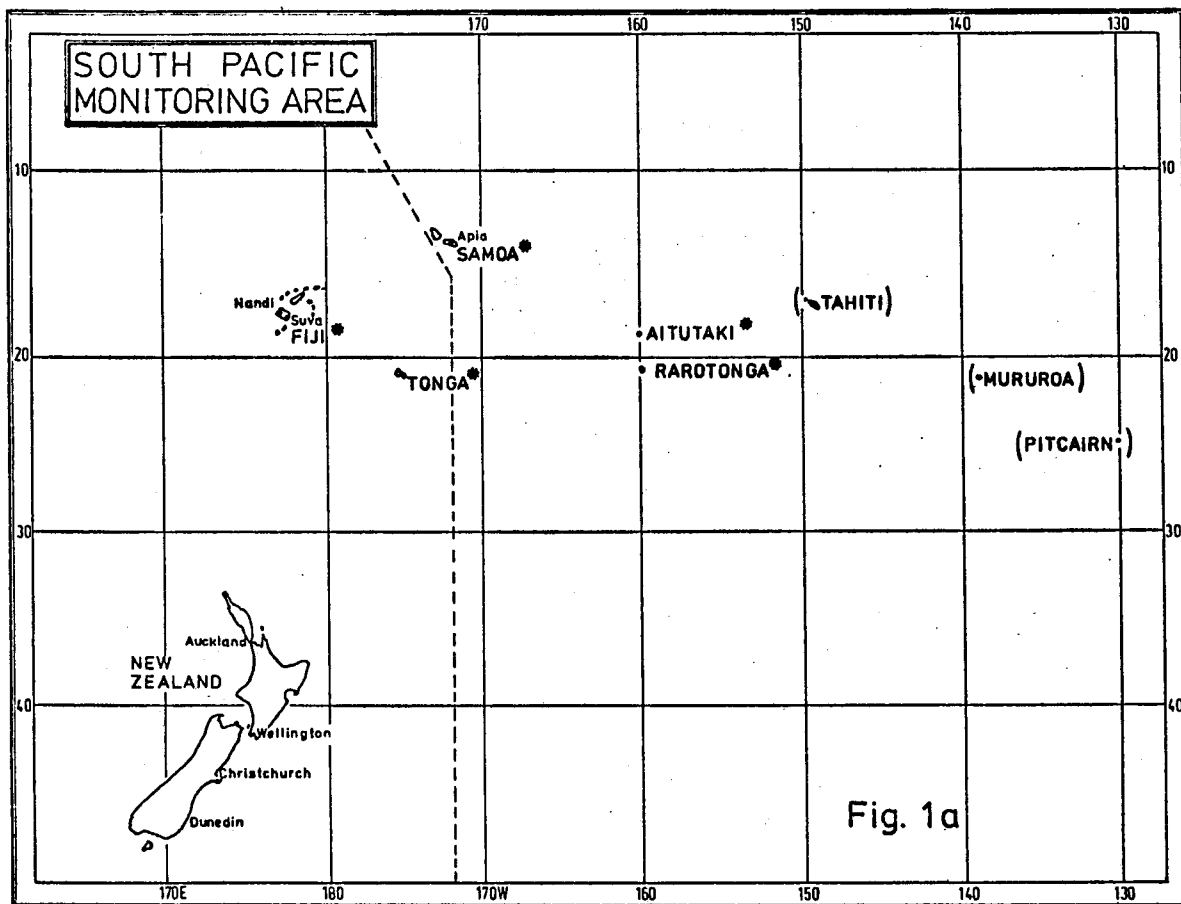


FIG. 1 MONITORING AND COLLECTING STATIONS ON PACIFIC ISLANDS AND IN NEW ZEALAND.

INTRODUCTION

This report continues the series of annual reports on levels of environmental radioactivity in New Zealand and in the South Pacific area.

In September 1974 France terminated the series of atmospheric nuclear tests which had been conducted in the Tuamotu Archipelago in the South Pacific, and in June 1975 commenced underground testing in the same area. Consequently the Laboratory's monitoring programme was modified in mid-1975. During 1978 this programme, designed to detect any venting to the atmosphere of fission products from underground tests, consisted of continuous collection of air filter and rainwater samples from five Pacific Island and four New Zealand stations. The samples were sent to the Laboratory for measurement of total beta activity.

The routine programme for measurement of long-term radioactive fallout from the earlier atmospheric tests was also continued during 1978. In this programme emphasis is given to the measurement of the two most potentially hazardous long-lived radionuclides, strontium-90 and caesium-137. Monthly depositions of strontium-90 in rain were measured at nine New Zealand and two Pacific Island stations. (Naturally-occurring lead-210 was also evaluated concurrently.) Strontium-90 and caesium-137 concentrations were measured in milk from nine New Zealand stations.

Monitoring and sample collecting stations are shown in Figs. 1 a and b.

Fallout levels during recent years and particularly since 1976 have been very low and reports covering this period have been considerably shortened.

The reader is referred to the earlier annual reports (1), and the special reports (2) on monitoring of French atmospheric nuclear tests (1966-1974). These give additional information on terms of reference, potential health hazard, adoption of reference levels, and technical information on procedures. They also include graphical presentations of results allowing historical and geographical comparisons.

(1) "Environmental Radioactivity":

Annual Report 1971, Report No. NRL-F/48, June	1972
Annual Report 1972, Report No. NRL-F/50, April	1973
Annual Report 1973, Report No. NRL-F/52, June	1974
Annual Report 1974, Report No. NRL-F/54, June	1975
Annual Report 1975, Report No. NRL-F/55, June	1976
Annual Report 1976, Report No. NRL-F/56, April	1977 (shortened version)
Annual Report 1977, Report No. NRL-F/57, April	1978 (shortened version)

(2) "Environmental Radioactivity. Fallout from Nuclear Weapons Tests Conducted by France in the South Pacific . . . and comparisons with previous test series." Report Nos: NRL-F/47, March 1972 (Summarising all previous monitoring results since 1966); NRL-F/49, October 1972; NRL-F/51, November 1973, and NRL-F/53, November 1974.

TOTAL BETA ACTIVITY IN AIR AND RAIN

Normally the short-lived decay products of naturally-occurring radon account for most of the beta activity in air. Ground level air over continents has a beta activity commonly ranging between 60 and 600 picocuries per cubic metre, but under certain conditions the beta activity may be up to ten times the upper value of this range.

Air filter and rainwater samples are measured four days after collection. After this delay the naturally-occurring beta activity has decayed and the residual beta activity, from radioactive fallout, may be assessed. Hereafter the term "total beta activity" refers to this residual fission product radioactivity in the sample and excludes naturally-occurring radioactivity.

1. Fission Products in Air

During 1978 air was monitored continuously at the New Zealand and Pacific Island stations listed in Table 1 below. The filters, which were changed three times each week, were measured for total beta activity at the Laboratory. Average levels each month during 1978 did not exceed the limit of detection at any station. Therefore the individual results and monthly averages are not tabulated in the Appendix. However, the 1978 results are included in Table 1 for comparison with annual averages obtained previously.

TABLE 1 - Total Beta Activity in Air - Annual Averages (pCi/m³)

	New Zealand				Pacific Islands				
	AK	WN	HK	CH	FJ	SM	TO	AI	RA
1966	0.14	(0.10)		0.11					
1967	0.08	0.05		0.06					
1968	0.12	0.10		0.07					
1969	0.12	0.09		0.07					
1970	0.16	0.12	(0.12)	0.10					
1971	0.21	0.12	0.16	0.15					
1972	0.06	0.05	0.05	0.05					
1973	0.02	0.01	0.02	0.02					
1974	0.08	0.05	0.07	0.05					
1975	0.03	0.03	0.03	0.02	<0.01	<0.01	0.01	<0.01	0.01
1976	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1977	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.02	<0.02	<0.01
1978	<0.01	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02

- Notes:
1. The stations are: Auckland, Wellington, Hokitika, Christchurch, Fiji, Samoa, Tonga, Aitutaki, and Rarotonga.
 2. Values in parenthesis are estimates: At Wellington measurements commenced 12 July 1966; at Hokitika, 1 May 1970.
 3. At the Pacific Islands the 1975 results are for June-Dec. only (during this period the New Zealand results were similar, averaging 0.01 pCi/m³).
 4. Starting 1977 the limit of detection is either 0.01 or 0.02 pCi/m³ depending on the air sampling equipment in use.

It can be seen that levels in New Zealand have been latitude dependent during the period of French atmospheric tests (1966-1974). For example, levels at Auckland are higher in most cases than those at Christchurch. Moreover, levels at the Pacific Islands, during the 3-6 month special monitoring programmes covering these tests, were significantly higher than New Zealand levels, averaging from 0.04 to 6.22 pCi/m³, depending on the locality monitored, the extent of nuclear testing, and meteorological conditions.

Since mid-1975, about nine months after the termination of the French atmospheric nuclear tests, levels have not exceeded the limit of detection at any station. There has been no indication of fresh fission products in the atmosphere from venting of underground tests.

All levels of fission products in air tabulated here and particularly those during recent years have been very small fractions of the reference levels.

2. Fission Products in Rain

During 1978 weekly funnel and bottle collections of rainwater were made at the same stations providing air filter samples. The rainwater samples were despatched to the Laboratory where they were processed and measured for total beta activity. The annual totals, since measurements started, are listed for each station in Table 2 below. (Individual weekly results during 1978 are given in Table 7 Appendix.)

TABLE 2 - Total Beta Activity in Rain - Weekly Depositions Summed Annually
(mCi/km²)

	New Zealand				Pacific Islands				
	AK	WN	HK	CH	FJ	SM	TO	AI	RA
1963				28					
1964				15					
1965				17					
1966			106	32					
1967			77	14					
1968			205	28					
1969			61	18					
1970	101	75	133	26					
1971	98	80	99	32					
1972	25	22	33	15					
1973	5	7	8	4					
1974	59	60	42	22					
1975	9	13	19	13	3	4	2	3	4
1976	3	3	4	2	3	3	4	4	3
1977	2	3	3	2	3	5	4	4	4
1978	3	3	5	2	4	6	6	6	6

- Notes:
1. See Table 1 (Note 1) for station names.
 2. Measurements commenced in Westland at Greymouth in July 1966 (the first result is for July-Dec. 1966 only). The station was transferred to Hokitika starting Jan. 1976.
 3. Measurement commenced at AK and WN in May 1970 (the first results are for May-Dec. only).
 4. At the Pacific Islands the 1975 results are for June-Dec. only (during this period the New Zealand results were similar, averaging about 4 mCi/km²).

Since 1976 the annual depositions have ranged from 2 to 6 mCi/km² and have been the lowest recorded since measurements started. The average concentrations have ranged from 2 to 4 pCi/l (see Table 7 Appendix). These concentrations are very small fractions of the reference level.

STRONTIUM-90 DEPOSITION

1. Routine Measurement

The measurement of strontium-90 deposition started at 6 stations in New Zealand in 1960, and at Suva in 1961. Since 1963 measurements have been made continuously at 9 New Zealand stations, and since 1967 at Rarotonga also. Collections are made

each month in high walled stainless steel pots. The collected rainwater is passed through a column of cation exchange resin at the collecting site. The resin is then mailed to the Laboratory for measurement of strontium-90.

Annual depositions at each station since measurements commenced are listed in Table 3 below. The average deposition at the New Zealand stations is also listed for each year. (Individual results, aggregated quarterly during 1978, are given in Table 8 Appendix.)

TABLE 3 - Annual Deposition of Strontium-90 (mCi/km^2), Mean Annual Rainfall (mm)

	New Zealand Stations										Pacific Islands	
	KA	AK	NP	HN	WN	HK	CH	DN	IN	Average	SU	RA
1960		1.2		0.7	0.8	1.5	0.5		0.5	0.9		
1961		1.1		0.8	1.1	2.2	0.7		1.2	1.2	1.0	
1962		1.8		1.0	1.8	2.8	0.7		1.2	1.6	1.6	
1963	1.8	2.0	2.0	1.0	2.0	3.7	1.2	1.0	1.7	1.8	2.4	
1964	4.1	4.0	5.3	1.6	3.4	7.8	1.3	1.8	3.0	3.6	2.5	
1965	3.1	2.9	4.2	1.7	3.9	5.9	1.7	2.0	2.8	3.1	2.0	
1966	1.6	1.3	1.9	0.8	1.6	2.2	0.7	0.7	1.1	1.3	1.2	
1967	1.0	0.9	1.3	0.5	1.0	1.7	0.4	0.6	0.9	0.9	0.8	(0.9)
1968	0.9	0.7	1.0	0.6	0.9	1.4	0.4	0.4	0.5	0.8	1.0	0.7
1969	1.5	1.3	1.5	0.7	1.1	2.2	0.7	0.7	1.2	1.2	1.3	0.7
1970	1.0	0.9	1.2	0.6	1.2	2.1	0.5	0.5	0.7	1.0	0.9	1.0
1971	2.0	1.3	1.9	1.0	1.2	2.5	0.7	0.8	1.1	1.4	(1.5)	(0.9)
1972	0.9	0.7	0.9	0.5	0.8	1.8	0.4	0.6	0.9	0.8	0.9	0.8
1973	0.4	0.3	0.3	0.2	0.4	0.6	0.2	0.2	0.3	0.3	0.4	0.6
1974	0.3	0.2	0.3	0.2	0.3	0.5	0.2	0.2	0.2	0.3	0.3	0.3
1975	0.3	0.2	0.3	0.2	0.3	0.6	0.2	0.2	0.3	0.3	0.2	0.1
1976	0.1	0.1	0.1	<0.1	0.2	0.2	<0.1	<0.1	<0.1	0.1	0.1	0.1
1977	<0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1978	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Rain-fall	1362	1148	1482	779	1380	2436	632	642	1029		3063	2068

- Notes: 1. The New Zealand stations are: Kaitaia, Auckland, New Plymouth, Havelock North, Wellington, Hokitika, Christchurch, Dunedin, and Invercargill.
The Pacific Island stations are: Suva (Fiji), and Rarotonga
2. The station in Westland (HK) was at Greymouth from 1960-1975 inclusive and was resited at Hokitika starting Jan. 1976.
3. Values in parenthesis are estimates.
4. The mean annual rainfall is for 1963 to 1978 inclusive (at Rarotonga for 1967-1978). At Westland annual rainfalls at the actual collecting sites were used to obtain the mean.

The large scale Northern Hemisphere (USSR) and Pacific area (USA) nuclear tests, which were conducted in 1961 and 1962 before the signing of the Partial Test Ban Treaty, resulted in a delayed stratospheric fallout over New Zealand. Maximum annual depositions (exceeding a station average of $3 \text{ mCi}/\text{km}^2$) occurred in New Zealand in 1964 and 1965, (the peak occurring in the last half 1964 and first quarter 1965). Annual depositions then decreased steadily until 1968.

During the years 1966 to 1974 a series of smaller scale nuclear tests was conducted by France in the South Pacific each year except 1969. Each series, lasting from one to three months and comprising from three to eight nuclear explosions, has taken place during the Southern Hemisphere winter. During these tests a total of 41 nuclear devices was reported to have been exploded in the atmosphere, most of them being in the low to medium power (kiloton) range. However, megaton explosions were reported to have occurred twice in 1968, twice in

1970, and once in 1971 (2). The annual deposition of strontium-90 in New Zealand increased again during the period 1969 to 1971 reaching a second maximum in 1971 which, however, was less than one-half of the 1964 maximum. Since then the annual depositions have again decreased.

During 1976 monthly results were nearing the limit of detection. Therefore monthly samples collected since 1977 have been aggregated on a quarterly basis in order to obtain sufficient analytical sensitivity. The annual depositions during the last three years have been the lowest recorded since this programme started.

Estimates of the French nuclear tests' contribution to the total strontium-90 deposition in New Zealand, and also comparisons of New Zealand and Northern Hemisphere depositions were made in earlier reports (1).

Unlike the deposition of fresh fission products from the troposphere after the French Southern Hemisphere tests, the long term strontium-90 deposition, which includes a significant stratospheric component, has shown no latitude dependence within New Zealand. The deposition, however, is rainfall dependent and high rainfall areas such as Greymouth or Hokitika in Westland have shown elevated values compared to low rainfall areas such as Christchurch on the east coast: excluding the last three years of minimal fallout, the mean annual deposition (normalised for rainfall) at the nine New Zealand stations during 1963-1975 inclusive was 1.08 ± 0.06 mCi/km² per 1000 mm of rain.

In 1964, the year of maximum strontium-90 fallout, the deposition at Suva, however, was less than that in New Zealand despite the much higher rainfall at Suva. This demonstrates a characteristic feature of stratospheric fallout, namely that the tropics receive less stratospheric fallout than mid-latitudes. Since then depositions at the two Pacific Islands have been similar to the average depositions in New Zealand. It seems that during the period of French Pacific nuclear testing, the smaller stratospheric component and larger tropospheric component of the fallout at the Pacific Islands resulted in depositions similar to those in New Zealand where the relative contribution of the two components was reversed.

The cumulative deposition of strontium-90 at selected sites, and the special "profile survey" conducted during 1976 were discussed in the 1977 report (1).

LEAD-210 DEPOSITION

Lead-210 is a naturally-occurring radionuclide produced in the atmosphere by decay of gaseous radon which is exhaled from land surfaces. Like strontium-90 the subsequent deposition of lead-210 is rainfall dependent and high rainfall areas such as Hokitika show elevated values compared to low rainfall areas such as Christchurch.

Measurement of lead-210 deposition was continued during 1978. Evaluation was made in the same monthly rainwater samples collected for strontium-90 measurement. Earlier results, including higher levels during 1965 at four stations, and also levels in milk, were discussed in the 1971 annual report (1). Annual depositions at each station since 1968 are listed in Table 4 below. The average annual depositions at the New Zealand stations is also listed. (Individual monthly results during 1978 are given in Table 9 Appendix.)

During the last 11 years the annual deposition in New Zealand has averaged about 1.4 mCi/km². During the same period the annual deposition of weapons test strontium-90 at the same stations has averaged about 0.6 mCi/km². At the Pacific Island stations lead-210 depositions at Suva are generally somewhat higher, and at Rarotonga generally somewhat lower, than those in New Zealand.

Since 1967, there does not appear to have been any marked seasonable variation nor, unlike strontium-90, any significant change in the average annual deposition.

TABLE 4 - Annual Deposition of Lead-210 (mCi/km²)

	New Zealand Stations										Pacific Islands	
	KA	AK	NP	HN	WN	HK	CH	DN	IN	Average	SU	RA
1967*	0.62	1.15	1.72	0.73	1.02	2.38	0.36	0.56	0.99	1.06	1.25	0.60
1968	1.75	1.64	2.08	0.84	1.86	3.20	0.64	0.76	1.06	1.54	2.46	0.61
1969	1.83	1.33	1.54	0.88	1.20	3.94	0.56	0.92	1.29	1.50	1.91	0.98
1970	1.43	1.00	1.82	0.63	1.52	3.09	0.65	0.74	0.92	1.31	1.85	0.85
1971	2.07	1.04	0.96	0.65	1.26	2.34	0.52	0.74	1.09	1.19	1.83	-
1972	2.28	1.62	1.99	0.88	1.70	3.41	0.70	1.22	1.31	1.68	2.65	-
1973	1.92	1.42	2.29	0.80	1.80	3.31	0.48	0.67	0.81	1.50	2.11	-
1974	1.24	1.08	1.76	0.76	1.61	2.85	0.71	0.66	0.58	1.25	1.86	4.00
1975	1.61	1.51	1.81	1.12	1.97	3.94	0.92	0.91	1.11	1.66	2.91	1.40
1976	1.41	1.33	1.43	0.93	1.46	2.73	0.70	0.71	0.76	1.27	2.03	-
1977	1.33	1.10	1.68	0.75	1.55	2.61	0.63	0.74	1.09	1.27	1.68	-
1978	1.61	1.14	1.61	0.75	1.40	2.88	0.73	0.88	0.99	1.33	2.24	-

Note: See Table 3 (Notes 1 and 2) for station names and the re-siting of the Westland station. *1967 results are for May-Dec. only.

STRONTIUM-90 AND CAESIUM-137 IN MILK

Strontium-90 measurement in New Zealand milk started in 1961 and caesium-137 measurement in 1964. Since 1965 continuous measurements have been made in samples from nine collecting stations. Caesium-137 and potassium are determined directly in monthly samples by gamma spectroscopy. Samples are then aggregated quarterly for radiochemical analysis for strontium-90 and also for the determination of calcium.

1. Strontium-90

The annual average concentrations of strontium-90 in milk at individual collecting stations are listed in Table 5 below for each year since 1961. The all-station averages each year are also listed. (Individual quarterly results during 1978 are given in Table 10 Appendix.)

TABLE 5 - Strontium-90 in Milk - Annual Averages (pCi/gCa)

	ND	AK	WK	TA	PN	WN	WD	CH	DN	Average
1961	4.5		4.1	7.1			12.7	1.6		6.0
1962	6.3	5.5	4.9	9.4	4.3		13.5	2.1	3.0	6.1
1963	7.5	5.3	5.6	9.9	4.9		17.2	2.7	3.7	7.1
1964	11.2	9.1	9.5	17.1	7.1		26.0	2.6	4.1	10.8
1965	10.6	9.4	9.8	16.7	8.4	8.8	28.8	4.3	7.4	11.6
1966	6.5	6.1	6.3	12.5	4.8	6.1	22.7	2.4	4.0	7.9
1967	5.1	5.2	5.0	10.4	3.9	5.4	17.8	1.9	3.1	6.4
1968	4.1	3.8	4.1	8.0	3.6	4.8	14.0	1.6	2.4	5.2
1969	6.3	6.0	5.4	9.4	5.8	5.1	17.9	1.7	3.0	6.7
1970	5.2	5.1	5.2	9.7	3.6	4.7	21.0	2.2	2.5	6.6
1971	7.3	5.8	6.0	10.2	5.0	4.8	18.3	2.0	3.0	6.9
1972	4.8	4.6	4.4	8.2	5.0	4.1	14.7	1.9	3.1	5.6
1973	3.8	3.4	3.5	5.7	2.7	3.5	10.8	1.2	1.9	4.1
1974	3.3	3.0	2.7	5.4	2.5	3.0	8.8	1.3	1.9	3.5
1975	3.1	2.7	3.0	5.1	2.4	3.4	8.7	1.2	1.6	3.5
1976	2.6	2.4	2.5	3.5	1.6	2.4	6.1	1.1	1.1	2.6
1977	2.1	2.1	2.4	3.9	1.4	2.1	5.0	1.0	1.2	2.3
1978	1.7	2.1	2.2	2.9	1.5	2.1	3.9	1.0	1.1	2.1
Average	5.3	4.8	4.8	8.6	4.0	4.3	14.9	1.9	2.8	5.8

Note: The stations are: Northland, Auckland, Waikato, Taranaki, Palmerston North, Wellington, Westland, Christchurch, and Dunedin.

Average levels in New Zealand milk reached maximum values of 10.8 and 11.6 pCi/gCa during 1964 and 1965 when the rate of strontium-90 deposition was also a maximum. Milk levels then decreased steadily reaching a minimum of 5.2 pCi/gCa in 1968, about half the 1964-65 maximum. This indicated that the level in milk was dependent to a considerable extent on fallout rate. However, during the period 1965-68 milk levels decreased at a somewhat slower rate than the strontium-90 deposition, thus indicating some uptake by grass of the cumulative deposit in the soil. After the start of French Pacific nuclear tests in 1966, milk levels increased slightly during the period 1969-71. However, after the decrease in fallout deposition since 1973, milk levels decreased again. The average concentration during 1978, 2.1 pCi/gCa, was the lowest recorded since measurements commenced.

Milk samples from the lowest and highest rainfall stations, i.e., Christchurch and Westland, give the range of strontium-90 contamination in New Zealand milk. Generally the extent of this range is from about one-third to about $2\frac{1}{2}$ times the country-wide average.

2. Caesium-137

The annual average concentrations of caesium-137 in milk at individual collecting stations are listed in Table 6 below for each year since 1964. The all-station averages each year are also listed. (Individual monthly results during 1978 are given in Table 11 Appendix.)

TABLE 6 - Caesium-137 in Milk - Annual Averages (pCi/gK)

	ND	AK	WK	TA	PN	WN	WD	CH	DN	<u>Average</u>
1964	49	51	69	168	19		76	7	11	56
1965	54	53	84	185	26	29	77	11	18	60
1966	37	33	60	141	11	18	43	4	9	39
1967	26	26	48	123	7	13	33	3	5	31
1968	15	18	36	102	3	7	21	1	3	23
1969	27	26	41	101	5	9	38	2	4	28
1970	22	18	35	89	6	11	39	4	5	25
1971	23	18	36	80	7	9	30	3	5	23
1972	21	15	28	72	2	7	22	2	4	19
1973	14	9	21	49	3	4	14	1	2	13
1974	7	7	16	41	2	3	8	1	1	10
1975	9	7	14	34	1	3	8	1	1	9
1976	6	5	11	23	2	2	4	1	2	6
1977	6	4	12	29	1	2	6	1	1	7
1978	3	3	8	18	1	<1	4	<1	<1	4
Average	21	20	35	84	6	8	28	3	5	24

Note: See Table 5 for station names.

Again the highest levels were recorded in 1964 and 1965 when strontium-90 deposition and concentration in milk were at their highest. The levels have decreased steadily since then, except for a slight increase in 1969 and 1970. The average concentration during 1978 was 4 pCi/gK, the lowest recorded since measurements commenced. The higher levels at Taranaki, caused mainly by the "soil effect", were discussed in the 1977 annual report (1).

3. Comparison of Measured Levels with the Reference Levels

When comparing measured levels in milk with the reference levels, long-term averages are more meaningful. Since measurements commenced, the "country-wide" average levels of strontium-90 (5.8 pCi/gCa) and caesium-137 (24 pCi/gK), have been 2.1% and 0.3% of the reference levels respectively. At the stations with the highest levels of contamination the corresponding percentages are about 2.5 times higher for strontium-90 and about 3.5 times higher for caesium-137.

Thus the long-term average levels, even at the stations with highest concentrations, are very small fractions of the reference levels and do not constitute a public health hazard.

MISCELLANEOUS AND SPECIAL SURVEYS

1. International Intercomparison

During 1978 the Laboratory again participated successfully in the intercomparison of measurements on environmental samples:

The International Reference Centre, WHO, provided a sample of liquid milk for measurement of strontium-90, caesium-137, calcium and potassium, and also a seaweed sample for measurement of gamma emitters.

The U.S. Environmental Protection Agency provided water samples for measurement of radium-226, and also for radium-228. On a further two occasions water samples were provided for measurement of gross alpha and beta radioactivity. The Agency also provided a milk sample for measurement of strontium-90, strontium-89, caesium-137, iodine-131, barium-140, potassium and calcium.

2. Monitoring During the Visit of a Nuclear Powered Submarine

The environmental radioactivity section of the Laboratory participated in the special monitoring of harbour environs during the visit of the USS Pintado to Auckland in 1978. Pre-visit seawater samples were collected and then regular sampling downstream of the submarine was undertaken at each high tide. Sampling of bottom sediments from the berth used, and filter feeding molluscs from selected sites, was undertaken before the submarine's arrival and again after departure. All samples were airmailed to the Laboratory where they were evaluated by gamma spectroscopy. Measurements on the pre-visit samples established the background levels of radioactivity. All samples collected during and after the visit showed only those traces of natural radioactivity, and at the same levels, as were measured in the pre-visit samples.

Air sampling was conducted continuously during the visit at selected sites around the harbour. Sampling was by means of pumps each drawing 17 cubic metres of air per day through a special cartridge. The cartridges were made at the Laboratory from 25 mm diameter plastic cylinders containing a glass-fibre pre-filter for trapping particulates followed by a 35 mm bed of activated charcoal for trapping radioiodines. During routine monitoring, cartridges were changed each day and airmailed to the Laboratory for evaluation. Iodine-131 was below the limit of detection in all cartridges. The limit of detection was less than 1% of the dose limit for continuous exposure over one year for critical groups in the population, as set by the International Commission on Radiological Protection.

A full report on these monitoring operations has been published (3).

3. Potable Water Survey

During the year a nationwide radiological survey of drinking water was started. All supplies serving populations of 5000 or more are being measured for radon content and total alpha and beta radioactivity. By the end of the year 22 water supplies from 5 Health Districts had been measured. The survey is continuing and results will be published during 1979.

(3) "Report on Radioactive Monitoring During the Visit of a Nuclear Powered Submarine", National Radiation Laboratory, Department of Health, New Zealand, Report NPS-2, 7 April 1978.

4. Shellfish Farming Assessment of Water Quality

Measurement of radioactivity in shellfish, seawater, and sediments from harvest areas in the Whangarei, Takapuna, and Hamilton Health Districts have been made. Mussels from 12 farms in the Marlborough Sounds were also measured in a later survey. Only the expected traces of naturally-occurring potassium-40 were detected in all these samples.

5. Broadlands, Wairakei Radon Investigations

Air pollution by radon in geothermal steam was investigated at the Broadlands and Wairakei geothermal fields during the year. Radon levels in air and condensate, including radon daughter levels in air and lead-210 in soil, were measured. A report on this survey has been published (4).

(4) "Measurements of Air Pollution by Geothermal Radon." M.K. Robertson and K.M. Matthews, National Radiation Laboratory, Department of Health, New Zealand, Report NRL 1978/5.

APPENDIX

TABLE 7 - Total Beta Activity of Weekly Rainwater Samples 1978 : Deposition (mCi/km^2), Rainfall (mm)
The collection period is from the date shown to the start of the next collection.
N.S. No sample or no result available.

AUCKLAND			WELLINGTON			HOKITIKA			CHRISTCHURCH			FJJI			SAMOA			TONGA			AITUTAKI			RAROTONGA		
Date	mm	mCi/km^2	Date	mm	mCi/km^2	Date	mm	mCi/km^2	Date	mm	mCi/km^2	Date	mm	mCi/km^2	Date	mm	mCi/km^2	Date	mm	mCi/km^2	Date	mm	mCi/km^2	Date	mm	mCi/km^2
Dec 30	18	0.1	Dec 30	27	<0.1	Dec 30	12	<0.1	Dec 30	24	<0.1	Jan 4	96	<0.1	Dec 30	101	<0.1	Dec 30	3	0.1	Jan 3	19	<0.1	Jan 6	75	0.1
Jan 6	21	<0.1	Jan 6	12	<0.1	Jan 6	47	<0.1	Jan 6	7	<0.1	Jan 11	51	0.3	Jan 5	77	0.2	Jan 6	15	<0.1	Jan 9	29	0.1	Jan 14	74	<0.1
Jan 17	0	<0.1	Jan 13	281	0.3	Jan 13	281	0.3	Jan 13	17	<0.1	Jan 19	55	<0.1	Jan 13	171	0.2	Jan 13	12	0.3	Jan 16	113	0.2	Jan 20	46	0.2
Jan 20	<1	<0.1	Jan 20	0	<0.1	Jan 20	0	<0.1	Jan 20	10	<0.1	Jan 25	7	<0.1	Jan 20	11	<0.1	Jan 20	11	0.1	Jan 23	83	<0.1	Jan 27	72	<0.1
Jan 27	2	<0.1	Jan 27	<1	<0.1	Jan 27	<1	<0.1	Jan 27	1	<0.1	Jan 27	1	<0.1	Jan 27	310	<0.1	Jan 27	7	<0.1	Jan 27	83	<0.1	Jan 27	72	<0.1
Jan 41	0.2	0.2	Jan 50	50	0.2	Jan 340	340	0.4	Jan 59	0.1	0.1	Jan 209	209	0.3	Jan 670	670	0.5	Jan 48	0.6	0.6	Jan 244	244	0.3	Jan 267	267	0.3
Feb 3	<1	<0.1	Feb 3	32	<0.1	Feb 3	3	<0.1	Feb 3	16	<0.1	Feb 1	76	0.1	Feb 2	34	0.2	Feb 2	75	<0.1	Jan 30	34	<0.1	Jan 31	12	<0.1
Feb 10	6	<0.1	Feb 10	13	<0.1	Feb 10	27	<0.1	Feb 10	<1	<0.1	Feb 9	6	<0.1	Feb 10	154	0.2	Feb 10	2	<0.1	Feb 6	9	<0.1	Feb 10	12	0.1
Feb 17	20	0.1	Feb 17	<1	<0.1	Feb 17	46	0.1	Feb 17	<1	<0.1	Feb 15	26	<0.1	Feb 17	<1	<0.1	Feb 17	72	<0.1	Feb 13	142	0.4	Feb 17	83	0.1
Feb 24	-	N.S.	Feb 24	<1	<0.1	Feb 24	51	<0.1	Feb 24	<1	<0.1	Feb 22	<1	<0.1	Feb 24	22	<0.1	Feb 24	<1	<0.1	Feb 19	370	1.0	Feb 17	83	0.1
Feb 26	0.1	0.1	Feb 45	0.2	0.2	Feb 127	127	0.3	Feb 17	<0.1	<0.1	Feb 108	108	<0.1	Feb 210	210	0.4	Feb 149	0.2	0.2	Feb 555	555	1.5	Feb 107	107	0.3
Mar 3	10	<0.1	Mar 3	3	<0.1	Mar 3	7	<0.1	Mar 3	<1	<0.1	Mar 1	31	<0.1	Mar 3	58	<0.1	Mar 3	36	0.1	Feb 27	<1	<0.1	Mar 2	3	<0.1
Mar 10	0	<0.1	Mar 10	<1	<0.1	Mar 10	<1	<0.1	Mar 10	0	<0.1	Mar 8	62	0.2	Mar 10	248	0.2	Mar 10	12	<0.1	Mar 6	11	<0.1	Mar 10	52	0.2
Mar 17	<1	<0.1	Mar 17	20	<0.1	Mar 17	70	<0.1	Mar 17	12	<0.1	Mar 15	65	<0.1	Mar 17	361	0.5	Mar 17	125	<0.1	Mar 13	104	<0.1	Mar 17	114	<0.1
Mar 23	11	0.2	Mar 24	10	<0.1	Mar 24	57	<0.1	Mar 24	4	<0.1	Mar 22	12	<0.1	Mar 24	41	<0.1	Mar 22	81	0.1	Mar 20	7	<0.1	Mar 20	175	<0.1
Mar 21	0.2	0.2	Mar 33	<0.1	<0.1	Mar 134	134	0.2	Mar 16	<0.1	<0.1	Mar 170	170	0.5	Mar 708	708	0.8	Mar 257	0.3	0.3	Mar 197	197	0.2	Mar 344	344	0.3
Mar 31	4	<0.1	Mar 31	18	<0.1	Mar 31	63	<0.1	Mar 31	3	<0.1	Mar 29	5	0.1	Mar 31	20	<0.1	Mar 31	13	<0.1	Apr 3	72	<0.1	Apr 3	21	<0.1
Apr 7	2	<0.1	Apr 7	<1	<0.1	Apr 7	-	N.S.	Apr 7	3	<0.1	Apr 5	10	<0.1	Apr 7	30	<0.1	Apr 7	48	<0.1	Apr 10	-	N.S.	Apr 7	65	0.1
Apr 14	67	<0.1	Apr 14	144	0.1	Apr 14	10	<0.1	Apr 14	137	0.1	Apr 12	25	0.2	Apr 14	1	0.2	Apr 14	150	0.2	Apr 17	<1	0.2	Apr 14	83	0.3
Apr 21	7	<0.1	Apr 21	10	<0.1	Apr 21	102	<0.1	Apr 21	53	<0.1	Apr 19	39	0.1	Apr 21	2	0.2	Apr 21	59	<0.1	Apr 24	28	<0.1	Apr 21	56	0.3
Apr 80	<0.1	<0.1	Apr 172	0.2	0.2	Apr 175	175	0.2	Apr 196	0.1	0.1	Apr 79	79	0.4	Apr 53	53	0.4	Apr 250	0.4	0.4	Apr 100	100	0.3	Apr 225	225	0.7
Apr 28	68	0.1	Apr 28	67	0.1	Apr 28	17	<0.1	Apr 28	5	<0.1	Apr 27	0	0.3	Apr 28	65	0.2	Apr 28	11	0.1	May 3	23	0.2	Apr 28	7	<0.1
May 5	10	<0.1	May 5	6	<0.1	May 5	53	<0.1	May 5	2	<0.1	May 3	0	<0.1	May 5	-	N.S.	May 5	81	<0.1	May 15	8	0.1	May 5	10	0.3
May 12	29	0.1	May 12	145	0.2	May 12	110	0.2	May 12	20	<0.1	May 10	3	<0.1	May 12	19	0.1	May 12	35	<0.1	May 19	8	0.1	May 12	70	<0.1
May 19	4	<0.1	May 19	6	<0.1	May 19	0	<0.1	May 19	9	<0.1	May 17	51	0.2	May 19	8	0.1	May 19	85	0.2	May 26	85	0.2	May 19	<1	<0.1
May 26	<1	<0.1	May 26	17	<0.1	May 26	36	0.2	May 26	3	<0.1	May 26	18	<0.1	May 26	61	0.1	May 26	61	0.1	May 26	31	0.3	May 19	<1	<0.1
May 111	0.4	0.4	May 241	0.4	0.4	May 218	218	0.6	May 39	0.2	0.2	May 72	72	0.7	May 153	153	0.5	May 212	0.4	0.4	May 31	31	0.3	May 87	87	0.4
Jun 2	31	<0.1	Jun 2	30	<0.1	Jun 2	90	<0.1	Jun 2	5	<0.1	May 31	1	0.3	Jun 2	17	0.1	Jun 2	3	0.1	May 29	85	0.2	May 26	57	<0.1
Jun 9	3	<0.1	Jun 9	53	<0.1	Jun 9	14	<0.1	Jun 9	18	<0.1	Jun 8	0	0.2	Jun 9	16	0.2	Jun 9	<1	<0.1	Jun 5	187	<0.1	Jun 9	34	<0.1
Jun 16	52	0.1	Jun 16	19	0.1	Jun 16	<1	<0.1	Jun 16	18	<0.1	Jun 14	0	<0.1	Jun 16	40	<0.1	Jun 16	<1	<0.1	Jun 10	14	0.1	Jun 16	13	0.2
Jun 23	21	<0.1	Jun 23	58	0.1	Jun 23	3	<0.1	Jun 23	43	0.1	Jun 21	72	0.1	Jun 23	54	<0.1	Jun 23	37	0.2	Jun 12	75	<0.1	Jun 16	104	0.3
Jun 107	0.3	0.3	Jun 160	0.4	0.4	Jun 107	107	0.2	Jun 84	0.3	0.3	Jun 73	73	0.6	Jun 127	127	0.5	Jun 40	0.5	0.5	Jun 361	361	0.4	Jun 104	104	0.3

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TABLE 7 (contd.)

AUCKLAND			WELLINGTON			HOKITIKA			CHRISTCHURCH			FIJI			SAMOA			TONGA			AITUTAKI			RAROTONGA		
Date	mm	mCi/km ²	Date	mm	mCi/km ²	Date	mm	mCi/km ²	Date	mm	mCi/km ²	Date	mm	mCi/km ²	Date	mm	mCi/km ²	Date	mm	mCi/km ²	Date	mm	mCi/km ²	Date	mm	mCi/km ²
Jul 3	13	<0.1	Jun 30	24	<0.1	Jun 30	72	<0.1	Jun 30	2	<0.1	Jun 25	1	<0.1	Jun 30	14	<0.1	Jun 30	2	<0.1	Jul 3	42	0.3	Jun 30	38	0.3
Jul 7	44	0.4	Jul 7	54	N.S.	Jul 7	64	0.1	Jul 7	93	0.1	Jul 5	<1	<0.1	Jul 7	0	<0.1	Jul 7	8	<0.1	Jul 10	1	0.2	Jul 7	13	0.2
Jul 14	57	0.1	Jul 14	30	<0.1	Jul 14	-	N.S.	Jul 14	32	<0.1	Jul 12	51	0.2	Jul 14	60	0.3	Jul 14	22	0.2	Jul 17	15	<0.1	Jul 14	-	N.S.
Jul 21	38	<0.1	Jul 21	19	0.1	Jul 21	145	0.2	Jul 21	5	<0.1	Jul 21	0	<0.1	Jul 21	21	0.3	Jul 21	44	0.2	Jul 24	7	<0.1	Jul 16	44	0.3
Jul 28	20	<0.1	Jul 28	26	<0.1	Jul 28	33	<0.1	Jul 28	12	<0.1	Jul 28	14	<0.1	Jul 28	5	0.2	Jul 28	55	<0.1						
Jul	172	0.6	Jul	153	0.2	Jul	314	0.4	Jul	144	0.2	Jul	66	0.4	Jul	100	0.8	Jul	131	0.7	Jul	65	0.5	Jul	95	0.8
Aug 4	2	<0.1	Aug 4	22	<0.1	Aug 4	91	0.4	Aug 4	5	<0.1	Aug 2	1	0.2	Aug 4	118	0.1	Aug 4	53	<0.1	Jul 31	2	<0.1	Jul 31	276	0.3
Aug 11	34	<0.1	Aug 11	13	0.2	Aug 11	55	0.1	Aug 11	0	<0.1	Aug 9	<1	<0.1	Aug 11	29	0.2	Aug 11	26	<0.1	Aug 7	92	0.4	Aug 11	36	0.3
Aug 18	25	<0.1	Aug 18	14	<0.1	Aug 18	35	<0.1	Aug 18	25	<0.1	Aug 17	-	N.S.	Aug 18	14	0.2	Aug 18	80	0.2	Aug 14	13	<0.1	Aug 18	5	0.2
Aug 25	33	0.2	Aug 25	53	<0.1	Aug 25	14	<0.1	Aug 25	22	<0.1	Aug 31	-	N.S.	Aug 25	56	0.2	Aug 25	41	0.4	Aug 21	7	0.1	Aug 25	39	0.2
Aug	94	0.3	Aug	102	0.3	Aug	195	0.6	Aug	52	0.1	Aug	1	0.2	Aug	217	0.7	Aug	200	0.6	Aug	114	0.5	Aug	356	1.0
Sep 1	6	<0.1	Sep 8	115	0.1	Sep 1	24	0.1	Sep 1	1	<0.1	Sep 1	-	N.S.	Sep 1	20	0.2	Sep 1	76	0.3	Aug 28	40	<0.1	Sep 1	136	0.1
Sep 8	20	<0.1	Sep 15	15	<0.1	Sep 8	112	0.3	Sep 8	10	<0.1	Sep 7	-	N.S.	Sep 8	16	<0.1	Sep 8	21	0.1	Sep 4	122	0.2	Sep 8	53	0.2
Sep 15	51	<0.1	Sep 22	53	<0.1	Sep 15	<1	<0.1	Sep 15	47	<0.1	Sep 13	0	0.2	Sep 15	3	0.1	Sep 15	-	N.S.	Sep 15	4	0.3	Sep 15	2	0.2
Sep 22	37	0.1				Sep 22	79	0.2	Sep 22	29	<0.1	Sep 20	0	<0.1	Sep 22	17	<0.1	Sep 22	-	N.S.	Sep 25	71	0.2	Sep 22	46	0.3
Sep	114	0.3	Sep	183	0.2	Sep	215	0.6	Sep	87	0.2	Sep	0	0.2	Sep	56	0.4	Sep	97	0.4	Sep	237	0.7	Sep	237	0.8
Sep 29	2	<0.1	Sep 29	4	0.1	Sep 29	11	<0.1	Sep 29	<1	<0.1	Sep 27	96	0.2	Sep 29	23	0.2	Sep 29	61	0.1	Oct 2	59	0.2	Sep 29	48	0.1
Oct 6	6	0.1	Oct 6	3	<0.1	Oct 6	29	0.2	Oct 6	2	<0.1	Oct 11	80	0.2	Oct 6	112	0.1	Oct 4	30	0.2	Oct 9	20	0.2	Oct 6	23	<0.1
Oct 13	47	0.1	Oct 13	66	<0.1	Oct 13	154	0.1	Oct 13	14	<0.1	Oct 18	1	<0.1	Oct 14	65	<0.1	Oct 13	4	0.1	Oct 16	<1	0.1	Oct 13	<1	<0.1
Oct 20	8	<0.1	Oct 20	25	0.1	Oct 20	19	<0.1	Oct 20	31	<0.1	Oct 25	6	0.1	Oct 20	128	0.3	Oct 20	62	0.2	Oct 23	25	0.2	Oct 20	1	0.2
Oct 27	7	<0.1	Oct 27	<1	<0.1	Oct 27	34	0.1	Oct 27	1	<0.1	Nov 1	5	<0.1	Oct 27	83	0.3	Oct 27	105	0.1	Oct 30	12	<0.1	Oct 27	104	0.1
Oct	70	0.4	Oct	98	0.3	Oct	247	0.5	Oct	48	0.2	Oct	188	0.6	Oct	411	0.9	Oct	262	0.7	Oct	116	0.7	Oct	176	0.5
Nov 3	2	<0.1	Nov 3	<1	<0.1	Nov 3	27	<0.1	Nov 3	6	<0.1	Nov 8	3	<0.1	Nov 8	232	0.1	Nov 3	6	<0.1	Nov 6	40	<0.1	Nov 10	6	<0.1
Nov 10	78	0.2	Nov 10	54	<0.1	Nov 10	53	0.1	Nov 10	23	<0.1	Nov 15	19	<0.1	Nov 15	123	<0.1	Nov 10	4	<0.1	Nov 13	21	0.3	Nov 17	58	<0.1
Nov 17	<1	<0.1	Nov 17	2	<0.1	Nov 17	92	0.2	Nov 17	0	<0.1	Nov 22	48	<0.1	Nov 19	60	<0.1	Nov 17	52	<0.1	Nov 20	95	0.3	Nov 24	80	<0.1
Nov 24	<1	<0.1	Nov 24	4	<0.1	Nov 24	12	<0.1	Nov 24	0	<0.1	Nov 29	42	<0.1	Nov 23	25	<0.1	Nov 24	166	0.3	Nov 27	29	<0.1	Nov 27	125	0.1
Nov	80	0.2	Nov	60	0.1	Nov	184	0.4	Nov	29	0.1	Nov	112	0.1	Nov	440	0.2	Nov	228	0.4	Nov	183	0.6	Nov	269	0.2
Dec 1	9	0.1	Dec 8	63	0.1	Dec 1	54	0.2	Dec 1	10	<0.1	Dec 6	0	0.1	Dec 1	30	0.1	Dec 1	44	0.1	Dec 4	0	0.2	Dec 1	18	0.2
Dec 8	36	0.1	Dec 15	34	<0.1	Dec 8	68	<0.1	Dec 8	98	0.1	Dec 13	23	0.1	Dec 8	93	0.1	Dec 8	3	<0.1	Dec 11	4	<0.1	Dec 8	<1	<0.1
Dec 15	17	<0.1	Dec 22	23	0.1	Dec 15	71	0.1	Dec 18	43	<0.1	Dec 20	1	<0.1	Dec 15	136	<0.1	Dec 15	4	<0.1	Dec 18	46	<0.1	Dec 15	6	<0.1
Dec 22	13	<0.1				Dec 22	12	<0.1	Dec 22	3	<0.1	Dec 27	3	<0.1	Dec 25	118	<0.1	Dec 24	38	0.2	Dec 25	38	<0.1	Dec 22	6	<0.1
Dec	75	0.2	Dec	120	0.2	Dec	205	0.4	Dec	154	0.2	Dec	27	0.3	Dec	377	0.2	Dec	89	0.4	Dec	88	0.3	Dec	30	0.3
TOTAL	991	3.2	TOTAL	1417	2.7	TOTAL	2461	4.8	TOTAL	925	1.8	TOTAL	1105	4.4	TOTAL	3522	6.3	TOTAL	1963	5.6	TOTAL	2291	6.3	TOTAL	2297	5.9
Average Concentration (pCi/l)																										
3			2			2			2			4			2			3			3			3		

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TABLE 8 - Strontium-90 in Rain 1978: Rainfall (mm), Deposition (mCi/km²), Concentration (pCi/l)

Station		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total	Av
Kaitaia	Rainfall	202	463	512	211	1388	
	Deposition	0.01	0.01	0.03	0.03	0.08	
	Concentration	<0.1	<0.1	<0.1	0.1		<0.1
Auckland	Rainfall	71	312	367	222	972	
	Deposition	<0.01	0.01	0.02	0.02	0.05	
	Concentration	<0.1	<0.1	<0.1	0.1		<0.1
New Plymouth	Rainfall	104	462	459	340	1365	
	Deposition	<0.01	0.01	0.03	0.02	0.06	
	Concentration	<0.1	<0.1	<0.1	<0.1		<0.1
Havelock North	Rainfall	115	212	200	85	612	
	Deposition	0.01	0.01	0.01	0.02	0.05	
	Concentration	<0.1	<0.1	<0.1	0.2		<0.1
Wellington	Rainfall	105	475	456	341	1377	
	Deposition	0.01	0.01	0.02	0.02	0.06	
	Concentration	0.1	<0.1	<0.1	<0.1		<0.1
Hokitika	Rainfall	636	572	925	689	2822	
	Deposition	0.03	0.02	0.03	0.07	0.15	
	Concentration	<0.1	<0.1	<0.1	0.1		<0.1
Christchurch	Rainfall	73	373	283	236	965	
	Deposition	<0.01	<0.01	0.01	0.01	0.03	
	Concentration	<0.1	<0.1	<0.1	<0.1		<0.1
Dunedin	Rainfall	86	187	288	257	818	
	Deposition	0.01	0.01	0.01	0.02	0.05	
	Concentration	0.1	<0.1	<0.1	<0.1		<0.1
Invercargill	Rainfall	188	162	208	310	868	
	Deposition	<0.01	0.01	0.01	0.02	0.04	
	Concentration	<0.01	<0.01	<0.01	<0.01		<0.1
New Zealand Country-wide Average	Rainfall	176	357	411	299	1243	
	Deposition	0.01	0.01	0.02	0.02	0.06	
	Concentration	<0.1	<0.1	<0.1	<0.1		<0.1
Suva, Fiji	Rainfall	1023	717	429	634	2803	
	Deposition	0.01	0.02	0.03	0.02	0.08	
	Concentration	<0.1	<0.1	<0.1	<0.1		<0.1
Rarotonga	Rainfall	595	485	646	429	2155	
	Deposition	<0.01	0.01	0.02	N.S.	0.04	
	Concentration	<0.1	<0.1	<0.1	-		<0.1

N.S. No Sample

TABLE 9 - Lead-210 in Rain 1978: Deposition (mCi/km²)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
KA	0.09	0.12	0.11	0.09	0.08	0.17	0.18	0.16	0.19	0.17	(0.11)	0.14	1.61
AK	0.04	0.07	0.05	0.09	0.08	0.11	0.14	0.09	0.11	(0.09)	0.14	0.13	1.14
NP	0.10	0.10	(0.10)	0.11	0.07	0.11	0.34	0.10	0.11	0.16	(0.15)	0.16	1.61
HN	0.04	0.09	0.05	0.06	0.07	0.06	0.07	0.05	0.06	0.09	0.04	0.07	0.75
WN	0.04	0.04	0.07	0.13	0.12	0.10	0.15	0.11	0.32	0.08	0.13	0.11	1.40
HK	0.36	0.10	0.25	0.27	0.21	0.11	0.34	0.25	0.17	0.25	0.31	0.26	2.88
CH	0.05	0.04	0.03	0.10	0.04	0.06	0.08	0.04	0.08	0.04	0.07	0.10	0.73
DN	0.07	0.04	0.03	0.08	0.07	0.06	0.07	0.08	0.07	0.18	0.04	(0.09)	0.88
IN	0.05	0.07	0.09	0.07	0.09	0.05	0.05	0.07	0.07	0.23	0.05	0.10	0.99
NZ Av	0.09	0.07	0.09	0.11	0.09	0.09	0.16	0.11	0.13	0.14	0.12	0.13	1.33
SU	0.15	0.17	0.21	0.19	0.19	0.11	0.18	0.19	0.14	0.30	0.19	0.22	2.24
RA	0.13	N.S.	0.05	N.S.	N.S.	0.10	0.06	0.14	0.19	N.S.	N.S.	N.S.	-

N.S. No result available. () Estimate.

The station names are abbreviated and in the same sequence as in Table 8.

APPENDIX

TABLE 10 - Strontium-90 in Milk 1978: (pCi/gCa)

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	<u>Average</u>
Northland	1.5	1.4	1.9	2.0	1.7
Auckland	2.0	1.5	1.5	3.5	2.1
Waikato	2.0	2.1	2.3	2.5	2.2
Taranaki	1.8	3.1	3.5	3.1	2.9
Palmerston North	1.4	1.3	1.7	1.5	1.5
Wellington	2.3	1.7	2.2	2.0	2.1
Westland	4.5	4.2	3.9	3.0	3.9
Christchurch	0.8	0.8	1.1	1.1	1.0
Dunedin	1.0	1.0	1.3	1.1	1.1
NZ Average	1.9	1.9	2.2	2.2	2.1

TABLE 11 - Caesium-137 in Milk 1978: (pCi/gK)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	<u>Av</u>
Northland	4	3	4	3	4	3	N.S.	3	2	1	2	4	3
Auckland	4	4	3	3	2	4	3	<1	<1	1	7	3	3
Waikato	10	7	11	10	9	7	11	5	4	7	7	8	8
Taranaki	15	20	15	29	22	19	15	18	16	14	19	12	18
Palmerston North	<1	<1	1	<1	<1	1	4	<1	1	<1	1	<1	1
Wellington	<1	<1	<1	2	<1	<1	N.S.	<1	<1	<1	<1	1	<1
Westland	4	5	4	3	7	3	8	2	1	2	7	2	4
Christchurch	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2	<1	<1
Dunedin	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1
NZ Average	4	4	4	6	5	4	6	3	3	3	5	4	4

N.S. No Sample