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ACKNOWLEDGEMENT

We gratefully acknowledge the assistance given by the staff of this and other Government Departments, especially the New Zealand Meteorological Service and the managers of milk processing plants. Without their co-operation the monitoring programme would not be possible. The Laboratory's Environmental Radioactivity Section organised the monitoring and analysed the samples. The Officer in Charge, Mr L.P. Gregory, was responsible for reporting and interpreting results. He was assisted professionally by Dr K.M. Matthews, and technically by Mrs M. Marsh.

for H.R. Atkinson
(Director)

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UNITS AND CONVERSION FACTORS

The International System of Units (SI) is used in this report. Conversion factors are given below for the relationship between SI units and those used prior to 1980. The SI unit of radioactivity, the becquerel (Bq), is 1 disintegration per second. The multiple of this unit used here is the megabecquerel (MBq) = 10^6 Bq, and the submultiple used is the millibecquerel (mBq) = 10^{-3} Bq.

Deposition — is given in megabecquerels per square kilometre (MBq/km^2).
To convert to mCi/km^2 multiply by 0.027.

Concentration

in air: is given in millibecquerels per cubic metre (mBq/m^3).
To convert to pCi/m^3 multiply by 0.027.

in rain: is given in becquerels per litre (Bq/l). It is calculated by dividing the deposition by the rainfall in millimetres.
To convert to pCi/l multiply by 27.

in milk: strontium-90 is given in becquerels per gram of calcium (Bq/gCa).
caesium-137 is given in becquerels per gram of potassium (Bq/gK).
To convert to pCi/gCa or pCi/gK multiply by 27.

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

LIMIT OF DETECTION AND PRECISION OF MEASUREMENT

In recent years some sample activities have been below the limit of detection. The detection limit (L_D counts) used here is calculated from the formula: $L_D = 4.65\sqrt{B}$, where B is the background counts during the counting interval (EML Procedures Manual, HASL-300, Section D-08. U.S. Dept of Energy). The limit of detection is given in appropriate units in a footnote to the tables where relevant.

The precision of measurement is based on a counting error of 2 Poisson standard deviations (95% confidence level).

REFERENCE LEVELS

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

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

in air: 11 000 mBq/m^3 in rain: 220 Bq/l

strontium-90 in milk: 10 Bq/gCa caesium-137 in milk: 260 Bq/gK

SUMMARY

During 1981 the average deposition of strontium-90 at New Zealand monitoring stations was less than 2 megabecquerels per square kilometre (MBq/km^2). This is the lowest annual deposition since monitoring commenced in 1960.

Large-scale nuclear weapons tests were conducted by the USSR and USA in 1961 and 1962. Subsequently average strontium-90 depositions at New Zealand stations increased to maximum values of 130 MBq/km^2 in 1964 and 110 MBq/km^2 in 1965. French atmospheric nuclear weapons tests were conducted in the South Pacific from 1966 to 1974. During this time average depositions ranged from 9.4 to 51 MBq/km^2. In 1975 these tests were replaced by underground tests and since then strontium-90 depositions have decreased significantly. Monitoring of total beta activity in air and rain at 5 Pacific Island stations continues. Fresh fission products from possible venting of underground tests have not been detected.

The concentrations of strontium-90 and caesium-137 in New Zealand milk reflect the changes in fallout deposition. Average concentrations during recent years are the lowest since measurements started.

The levels recorded during 1981 are 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.

CONTENTS

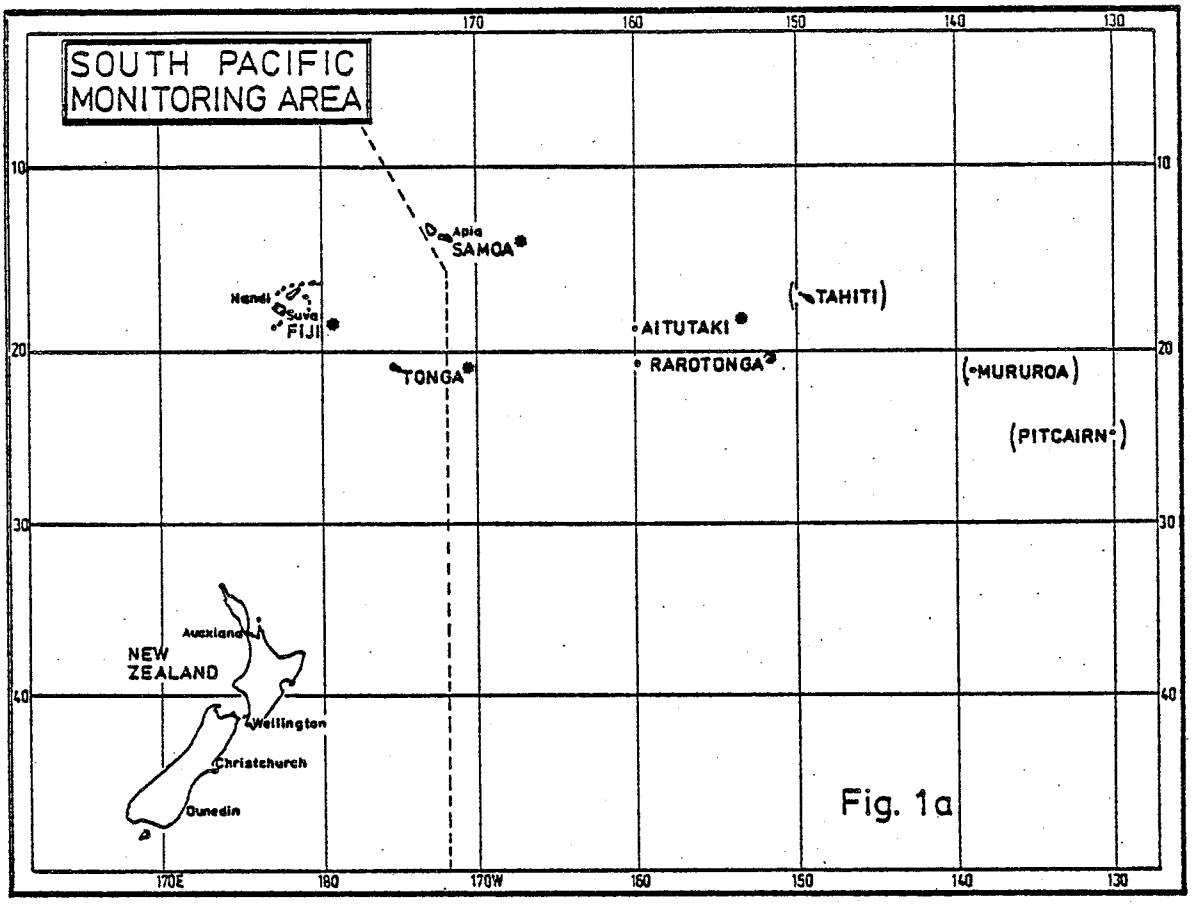

Fig. 1a

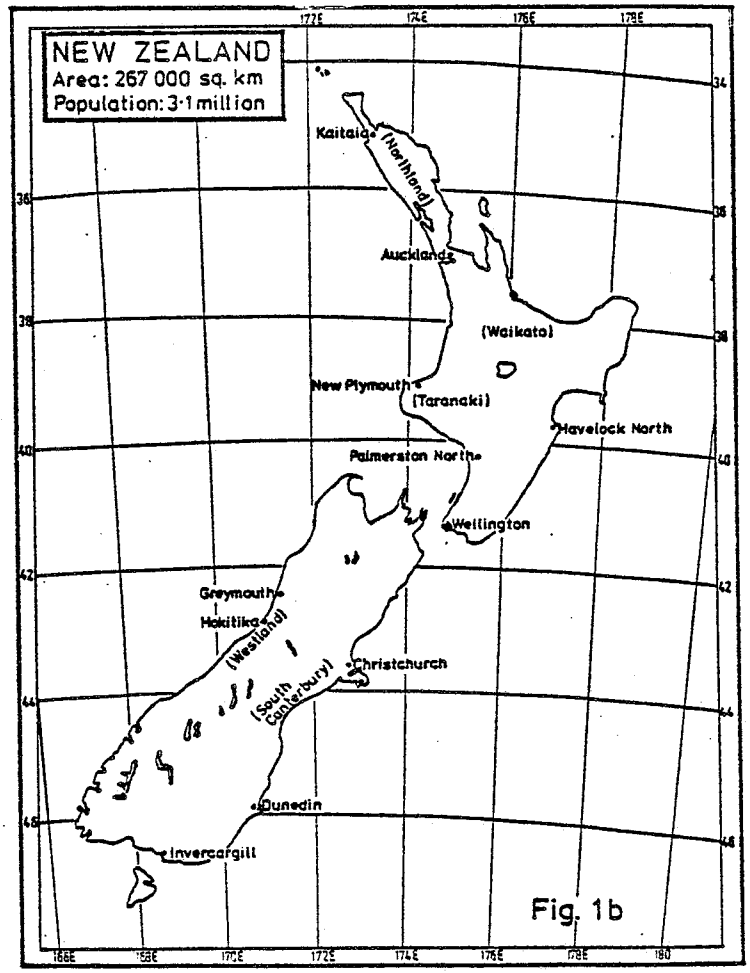

Fig. 1b

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

INTRODUCTION

This report continues the series of reports on environmental radioactivity monitoring in New Zealand, and in the South Pacific area, which have been published since 1961.

In September 1974 France terminated atmospheric nuclear testing which had been conducted in the Tuamotu Archipelago in the South Pacific since 1966, and in June 1975 commenced underground testing in the same area. The Laboratory's programme was changed to monitor any venting to the atmosphere of fission products from underground tests. The current programme consists of continuous air and rainwater monitoring at 5 Pacific island and 4 New Zealand stations. Samples are sent to the Laboratory for measurement of total beta activity.

The routine programme, monitoring long-term radioactive fallout from earlier atmospheric tests, was also continued during 1981. Here emphasis is given to the measurement of the two most potentially hazardous long-lived radionuclides, strontium-90 and caesium-137. Depositions of strontium-90 in rain are measured at 9 New Zealand and 2 Pacific island stations. (Naturally occurring lead-210 is also evaluated concurrently.) Strontium-90 and caesium-137 concentrations are measured in milk from 9 New Zealand stations.

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

Fallout levels in recent years and particularly since 1976 have been very low and reports covering this period have been abbreviated. The reader is referred to the earlier annual reports (1), and special reports on French atmospheric nuclear tests (2). 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.

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 2 000 and 20 000 millibecquerels per cubic metre (mBq/m^3), but under certain conditions the beta activity may be up to ten times the upper value of this range.

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(1) "Environmental Radioactivity":

Annual Report 1971, Report No. NRL-F/48, June 1972 (summarising previous results)
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 (abridged)
Annual Report 1977, Report No. NRL-F/57, April 1978 (abridged)
Annual Report 1978, Report No. NRL-F/58, April 1979 (abridged)
Annual Report 1979, Report No. NRL-F/59, April 1980 (abridged)
Annual Report 1980, Report No. NRL-F/60, April 1981 (abridged)

(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.

Air filter and rainwater samples are measured 4 days after collection when naturally occurring beta activity has decayed and any residual beta activity from radioactive fallout can 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 1981 air was monitored continuously at the New Zealand and Pacific island stations listed in Table 1. The air filters were changed 3 times each week and were despatched to the Laboratory for measurement of total beta activity. Average concentrations each month during 1981 did not exceed the limit of detection at any station. Because the levels were so low, individual results are not tabulated in the Appendix. However, average concentrations during the year are included in Table 1 for comparison with those of previous years.

TABLE 1 - Total Beta Activity in Air: Average Concentrations (mBq/m^3)

	New Zealand Stations*				Pacific Island Stations*				
	AK	WN	HK	CH	FJ	SM	TO	AI	RA
1966	5.2	(3.7)		4.1	*1966 - 1974*				
1967	3.0	1.9		2.2					
1968	4.4	3.7		2.6	*(French atmospheric nuclear tests)*				
1969	4.4	3.3		2.6					
1970	5.9	4.4	(4.4)	3.7	*range: 1.5 - 230 mBq/m^3*				
1971	7.8	4.4	5.9	5.6	*at Pacific Islands during the*				
1972	2.2	1.9	1.9	1.9	*special monitoring programmes*				
1973	0.7	0.4	0.7	0.7					
1974	3.0	1.9	2.6	1.9					
1975	1.1	1.1	1.1	0.7	(<0.3)	(<0.3)	(0.4)	(<0.3)	(0.4)
1976	0.4	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
1977	<0.3	<1.1	<0.3	<0.3	<0.3	<0.3	<1.1	<1.1	<0.3
1978	<0.3	<0.3	<0.3	<0.3	<1.1	<1.1	<1.1	<1.1	<1.1
1979	<0.3	<0.3	<0.3	<0.3	<1.1	<1.1	<1.1	<1.1	<1.1
1980	<0.3	<0.3	<0.3	<0.3	<1.1	<1.1	<1.1	<1.1	<1.1
1981	<0.3	<0.3	<0.3	<0.3	<1.1	<1.1	<1.1	<1.1	<1.1

* *The stations are: Auckland, Wellington, Hokitika, and Christchurch; Fiji, Samoa, Tonga, Aitutaki, and Rarotonga.*

( ) *Incomplete year.*

The limit of detection is 0.3 or 1.1 mBq/m^3 depending on air samplers used.

The concentration of fission products in air at New Zealand stations was latitude dependent during the French South Pacific atmospheric tests (1966-1974). For example, concentrations were usually higher at Auckland than at Christchurch. Moreover, at the Pacific island stations concentrations were significantly higher, e.g., during the special monitoring programmes, lasting from 3 to 6 months, average concentrations ranged from 1.5 - 230 mBq/m^3 depending on the locality, the meteorological conditions, and the extent of nuclear testing (2).

Since mid-1975, about 9 months after the termination of the French atmospheric nuclear tests, concentrations have been near or below the limit of detection at all stations. No fresh fission products have been detected since underground testing started.

Concentrations of fission products in air tabulated here, particularly those during recent years, are very small fractions of the reference levels.

2. Fission Products in Rain

During 1981 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 for processing and measurement of total beta activity. Results are given in deposition units - megabecquerels per square kilometre (MBq/km^2). Quarterly cumulative results during 1981 are given in Table 7, Appendix. Annual totals, rounded to the nearest 10 MBq/km^2, are listed for each station in Table 2.

TABLE 2 - Total Beta Activity in Rain: Total Deposition (MBq/km^2)

	New Zealand Stations*				Pacific Island Stations*				
	AK	WN	HK	CH	FJ	SM	TO	AI	RA
1963				1040					
1964				560					
1965				630					
1966			(3920)†	1180					
1967			2850	520	*1966 - 1974*				
1968			7590	1040	*(French atmospheric nuclear tests)*				
1969			2260	670	*range: 100 - 20 000 MBq/km^2*				
1970	(3740)	(2780)	4920	960	*at Pacific Islands during the*				
1971	3630	2960	3660	1180	*special monitoring programmes*				
1972	930	810	1220	560					
1973	190	260	300	150					
1974	2180	2220	1550	810					
1975	340	470	710	460	(90)	(140)	(70)	(110)	(140)
1976	90	110	160	60	100	110	150	140	110
1977	70	100	120	60	110	170	130	140	150
1978	120	100	180	70	160	230	210	230	220
1979	100	110	190	60	120	120	250	220	190
1980	70	100	140	60	100	180	70	200	160
1981	100	110	220	80	170	210	180	180	190

* *See Table 1 (footnote) for station names.*
( ) *Incomplete year.*
† *Commenced Greymouth Jul '66, transferred to Hokitika Jan '76.*

Levels of fisson products in rainwater samples have been very low at all stations during recent years. During the period 1976 to 1981 annual depositions ranged from 60 - 250 MBq/km^2 and average concentrations ranged from 0.03 - 0.15 becquerels per litre (Bq/l). These concentrations are very small fractions of the reference level.

STRONTIUM-90 DEPOSITION

1. Routine Measurement

Strontium-90 deposition measurements started at 6 stations in New Zealand in 1960, and at Suva in 1961. Since 1963 measurements have been made at 9 New Zealand stations, and since 1967 at Rarotonga also. Collections are made continuously in high-walled stainless steel pots which are changed each month. The rainwater sample is passed through a column of cation exchange resin on site. The resin is then mailed to the Laboratory for measurement of strontium-90. Because the deposition rates have been so low in recent years, samples collected since 1976 have been aggregated quarterly to obtain increased measurement sensitivity.

Quarterly results for deposition, concentration, and rainfall at each station during 1981 are given in Table 8, Appendix. Annual depositions at each station since measurements commenced are listed in Table 3.

TABLE 3 - Annual Deposition of Strontium-90 (MBq/km^2)

	New Zealand Stations*									NZ Av	Pacific Island Stations*	
	KA	AK	NP	HN	WN	HK	CH	DN	IN		SU	RA
1960		46		26	28	56	18		17	*32*		
1961		40		28	42	81	24		43	*43*	38	
1962		65		35	68	100	26		43	*56*	60	
1963	67	72	73	37	75	140	46	38	63	*68*	90	
1964	150	150	200	59	130	290	48	66	110	*130*	91	
1965	110	110	150	62	140	220	63	74	100	*110*	73	
1966	58	47	71	31	59	81	26	27	41	*49*	44	
1967	38	33	46	18	35	63	14	24	32	*34*	28	(33)
1968	33	27	35	21	32	53	16	15	20	*28*	38	24
1969	57	46	54	25	39	83	26	25	45	*44*	46	27
1970	37	32	45	22	45	79	19	20	25	*36*	33	35
1971	75	50	68	38	44	92	24	30	40	*51*	(56)	(12)
1972	33	27	32	18	30	65	16	21	32	*30*	35	28
1973	16	9.6	13	7.4	14	21	5.9	6.7	11	*12*	14	(21)
1974	13	8.5	11	5.6	10	17	6.3	5.9	7.0	*9.4*	11	11
1975	9.5	8.9	11	5.6	10	21	7.0	6.3	9.6	*9.9*	8.5	5.2
1976	4.1	3.7	4.8	2.6	5.6	7.0	3.3	3.0	3.3	*4.2*	4.4	4.4
1977	2.6	3.0	2.6	1.5	3.7	5.2	1.1	1.5	1.9	*2.6*	3.0	1.1
1978	3.0	1.9	2.2	1.9	2.2	5.6	1.1	1.9	1.5	*2.4*	3.0	1.5
1979	3.3	2.6	3.0	2.2	3.3	5.9	1.1	1.5	1.5	*2.7*	2.6	0.7
1980	2.5	1.9	2.3	1.7	2.6	4.6	1.2	1.2	1.7	*2.2*	1.7	2.0
1981	2.0	1.1	1.8	1.0	1.5	4.2	0.7	1.4	1.2	*1.7*	1.4	0.9
Annual Rainfall (mm)†												
	1440	1090	1450	830	1420	2600	650	680	1040		3240	1880

* *The New Zealand stations are: Kaitaia, Auckland, New Plymouth, Havelock North, Wellington, Hokitika (Greymouth before 1976), Christchurch, Dunedin and Invercargill. The Pacific island stations are: Suva (Fiji) and Rarotonga.*

† *Mean annual rainfall, since 1968, rounded to the nearest 10 mm.*

Values in parenthesis are estimates.

It is evident that the deposition of strontium-90 is rainfall dependent and high rainfall areas such as Hokitika show elevated values compared to low rainfall areas such as Christchurch.

The large-scale Northern Hemisphere (USSR) and Pacific area (USA) nuclear tests, 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 occurred in 1964 and 1965, exceeding a station average of 100 MBq/km^2. Annual depositions then decreased markedly.

From 1966 to 1974 smaller-scale atmospheric nuclear tests were conducted by France in the South Pacific each year except 1969. Each series, lasting from 1 to 3 months and comprising from 3 to 8 nuclear explosions, took place during the Southern Hemisphere winter. Forty-one nuclear devices were reported to have been exploded, most of them being in the low to medium power (kiloton) range. However, megaton explosions were reported to have taken place on 5 occasions (2). The annual deposition of strontium-90 in New Zealand increased again during the period 1969 to 1971 reaching a second smaller maximum in 1971, less than one-half of the 1964 maximum. Since then the annual depositions have decreased progressively and during the past 5 years have been the lowest recorded since this programme started.

Interpretation of the long-term results summarised in Table 3 and commentary on the origin of the strontium-90, fallout mechanism, latitudinal effect and rainfall dependence, were made in earlier reports (1).

LEAD-210 DEPOSITION

Lead-210 is a naturally occurring radionuclide produced in the atmosphere by decay of gaseous radon exhaled from land surfaces. Lead-210 deposition is measured along with strontium-90 in the same monthly rainwater collections.

Individual monthly depositions during 1981 are given in Table 9, Appendix. Annual depositions at each station since 1968 are listed in Table 4.

TABLE 4 - Annual Deposition of Lead-210 (MBq/km^2)

	New Zealand Stations*										Pacific Island Stations*	
	KA	AK	NP	HN	WN	HK	CH	DN	IN	*NZ Av*	SU	RA
1967†	23	43	64	27	38	88	13	21	37	*39*	46	22
1968	65	61	77	31	69	118	24	28	39	*57*	91	23
1969	68	49	57	33	44	146	21	34	48	*56*	71	36
1970	53	37	67	23	56	114	24	27	34	*48*	68	31
1971	77	38	36	24	47	87	19	27	40	*44*	68	-
1972	84	60	74	33	63	126	26	45	48	*62*	98	-
1973	71	53	85	30	67	122	18	25	30	*56*	78	-
1974	46	40	65	28	60	105	26	24	21	*46*	69	148
1975	60	56	67	41	73	146	34	34	41	*61*	108	52
1976	52	49	53	34	54	101	26	26	28	*47*	75	-
1977	49	41	62	28	57	97	23	27	40	*47*	62	-
1978	60	42	60	28	52	107	27	33	37	*50*	83	-
1979	70	56	70	38	76	167	27	34	38	*64*	79	-
1980	74	49	66	34	68	144	26	41	48	*61*	74	-
1981	61	40	61	28	61	146	18	27	34	*53*	-	-

* *See Table 3 for station names.*
† *May-December only.*

The deposition of lead-210 is rainfall dependent like strontium-90. However, unlike strontium-90 there is little significant change in the New Zealand station average annual deposition which is consistently about 50 MBq/km^2. Because of the current low strontium-90 deposition, lead-210 deposition is now nearly 30 times higher.

STRONTIUM-90 AND CAESIUM-137 IN MILK

Monitoring of strontium-90 in New Zealand milk started in 1961, and caesium-137 in 1964. Since 1965 measurements have been made on milk samples from 9 collecting stations. Caesium-137 and potassium are determined monthly by gamma spectroscopy. Samples are then aggregated quarterly for strontium-90 and calcium determinations.

1. Strontium-90

Quarterly average concentrations of strontium-90 in milk at each station during 1981 are given in Table 10, Appendix. Annual average concentrations at each station since 1961 are listed in Table 5.

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

	Collecting Stations*									
	ND	AK	WK	TA	PN	WN	WD	CH	DN	*Average*
1961	0.17		0.15	0.26			0.47	0.059		*0.22*
1962	0.23	0.20	0.18	0.35	0.16		0.50	0.078	0.11	*0.23*
1963	0.28	0.20	0.21	0.37	0.18		0.64	0.10	0.14	*0.26*
1964	0.41	0.34	0.35	0.63	0.26		0.96	0.096	0.15	*0.40*
1965	0.39	0.35	0.36	0.62	0.31	0.33	1.07	0.16	0.27	*0.43*
1966	0.24	0.23	0.23	0.46	0.18	0.23	0.84	0.089	0.15	*0.29*
1967	0.19	0.19	0.19	0.38	0.14	0.20	0.66	0.070	0.11	*0.24*
1968	0.15	0.14	0.15	0.30	0.13	0.18	0.52	0.059	0.089	*0.19*
1969	0.23	0.22	0.20	0.35	0.21	0.19	0.66	0.063	0.11	*0.25*
1970	0.19	0.19	0.19	0.36	0.13	0.17	0.78	0.081	0.093	*0.24*
1971	0.27	0.21	0.22	0.38	0.19	0.18	0.68	0.074	0.11	*0.26*
1972	0.18	0.17	0.16	0.30	0.19	0.15	0.54	0.070	0.11	*0.21*
1973	0.14	0.13	0.13	0.21	0.10	0.13	0.40	0.044	0.070	*0.15*
1974	0.12	0.11	0.10	0.20	0.093	0.11	0.33	0.048	0.070	*0.13*
1975	0.11	0.10	0.11	0.19	0.089	0.13	0.32	0.044	0.059	*0.13*
1976	0.096	0.089	0.093	0.13	0.059	0.089	0.23	0.041	0.041	*0.096*
1977	0.078	0.078	0.089	0.14	0.052	0.078	0.19	0.037	0.044	*0.087*
1978	0.063	0.078	0.081	0.11	0.056	0.078	0.14	0.037	0.041	*0.076*
1979	0.059	0.067	0.093	0.16	0.056	0.070	0.14	0.037	0.033	*0.079*
1980	0.059	0.060	0.088	0.14	0.049	0.066	0.13	0.032	0.035	*0.073*
1981	0.053	0.054	0.074	0.12	0.043	0.054	0.12	0.027	0.027	*0.063*
Average	*0.18*	*0.16*	*0.16*	*0.29*	*0.13*	*0.14*	*0.49*	*0.064*	*0.093*	*0.20*

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

Average concentrations of strontium-90 in New Zealand milk reached maximum values of 0.40 and 0.43 Bq/gCa during 1964 and 1965 when the rate of strontium-90 deposition was also a maximum. Levels then decreased, reaching a minimum of 0.19 Bq/gCa in 1968, indicating that levels in milk are dependent on the rate of fallout. However, during the period 1965-68 strontium-90 in milk decreased at a slower rate than strontium-90 deposition, indicating some uptake by grass of the cumulative deposit in the soil. After the start of French Pacific nuclear tests in 1966, concentrations increased slightly during the period 1969-71. However, with decreasing fallout depositions since 1973, concentrations in milk decreased again. The average concentration during 1981, 0.063 Bq/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 two and a half times the country-wide average.

2. Caesium-137

Monthly average concentrations of caesium-137 in milk at each station during 1981 are given in Table 11, Appendix. Annual average concentrations at each station since 1964 are listed in Table 6.

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

	Collecting Stations*									
	ND	AK	WK	TA	PN	WN	WD	CH	DN	*Average*
1964	1.8	1.9	2.6	6.2	0.7		2.8	0.2	0.4	*2.1*
1965	2.0	2.0	3.1	6.9	1.0	1.1	2.9	0.4	0.7	*2.2*
1966	1.4	1.2	2.2	5.2	0.4	0.7	1.6	0.1	0.3	*1.5*
1967	1.0	1.0	1.8	4.6	0.3	0.5	1.2	0.1	0.2	*1.2*
1968	0.6	0.7	1.3	3.8	0.1	0.3	0.8	<0.1	0.1	*0.9*
1969	1.0	1.0	1.5	3.7	0.2	0.3	1.4	0.1	0.1	*1.0*
1970	0.8	0.7	1.3	3.3	0.2	0.4	1.4	0.1	0.2	*0.9*
1971	0.9	0.7	1.3	3.0	0.3	0.3	1.1	0.1	0.2	*0.9*
1972	0.8	0.6	1.0	2.7	0.1	0.3	0.8	0.1	0.1	*0.7*
1973	0.5	0.3	0.8	1.8	0.1	0.1	0.5	<0.1	0.1	*0.5*
1974	0.3	0.3	0.6	1.5	0.1	0.1	0.3	<0.1	<0.1	*0.4*
1975	0.3	0.3	0.5	1.3	<0.1	0.1	0.3	<0.1	<0.1	*0.3*
1976	0.2	0.2	0.4	0.9	0.1	0.1	0.1	<0.1	0.1	*0.2*
1977	0.2	0.1	0.4	1.1	<0.1	0.1	0.2	<0.1	<0.1	*0.3*
1978	0.1	0.1	0.3	0.7	<0.1	<0.1	0.1	<0.1	<0.1	*0.2*
1979	0.1	0.1	0.4	1.2	<0.1	<0.1	0.1	<0.1	<0.1	*0.2*
1980	0.2	0.2	0.4	1.0	<0.1	<0.1	0.2	<0.1	<0.1	*0.2*
1981	<0.1	<0.1	0.2	0.9	<0.1	<0.1	<0.1	<0.1	<0.1	*0.1*
Average	*0.7*	*0.6*	*1.1*	*2.8*	*0.2*	*0.3*	*0.9*	*0.1*	*0.2*	*0.8*

* *See Table 5 for station names.*

The highest concentrations of caesium-137 in milk were recorded in 1964 and 1965 when strontium-90 deposition and concentration in milk were also at their highest. Concentrations have decreased steadily since then. During the last 4 years average concentrations have not exceeded 0.2 Bq/l, the lowest recorded since measurements commenced.

The "soil effect" leading to high caesium-137 concentrations in milk at Taranaki, and to a lesser extent at Waikato and Auckland, has been the subject of a special survey (Annual Report 1977 (1)).

3. Comparison of Measured Levels with the Reference Levels

When measured levels in milk are compared with the reference levels, long-term averages are more meaningful. Since measurements commenced, the country-wide average levels of strontium-90 (0.20 Bq/gCa) and caesium-137 (0.8 Bq/gK) have been 2% and 0.3% of the reference levels respectively. The stations with the highest levels of contamination have corresponding percentages about 2.5 times and 3.5 times higher respectively.

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.

APPENDIX

TABLE 7 - Total Beta Activity in Rain 1981 (Weekly Collections):

Cumulative Rainfall (mm)
Cumulative Deposition (MBq/km^2)
Average Concentration (Bq/l)

New Zealand Stations	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	*1981*
Auckland					
mm	92	352	297	191	*932*
MBq/km^2	15 ± 7	33 ± 8	23 ± 7	32 ± 7	*103 ± 15*
Bq/l	0.16 ± 0.08	0.09 ± 0.02	0.08 ± 0.02	0.17 ± 0.04	*0.11 ± 0.02*
Wellington					
mm	99	461	396	317	*1273*
MBq/km^2	11 ± 7	32 ± 7	32 ± 7	34 ± 7	*109 ± 14*
Bq/l	0.11 ± 0.07	0.07 ± 0.02	0.08 ± 0.02	0.11 ± 0.02	*0.09 ± 0.01*
Hokitika					
mm	776	896	685	891	*3248*
MBq/km^2	35 ± 7	70 ± 8	48 ± 7	68 ± 8	*221 ± 15*
Bq/l	0.05 ±<0.01	0.08 ±<0.01	0.07 ± 0.01	0.08 ±<0.01	*0.07 ±<0.01*
Christchurch					
mm	70	211	174	123	*578*
MBq/km^2	20 ± 7	27 ± 7	26 ± 7	11 ± 7	*84 ± 14*
Bq/l	0.29 ± 0.10	0.13 ± 0.03	0.15 ± 0.04	0.09 ± 0.06	*0.15 ± 0.02*
Average					
MBq/km^2	*20*	*41*	*32*	*36*	*129*
Bq/l	*0.15*	*0.09*	*0.10*	*0.11*	*0.11*
Pacific Island Stations					
Nandi, Fiji					
mm	384	588	274	325	*1571*
MBq/km^2	28 ± 15	55 ± 19	25 ± 19	65 ± 20	*173 ± 37*
Bq/l	0.07 ± 0.04	0.09 ± 0.03	0.09 ± 0.07	0.20 ± 0.06	*0.11 ± 0.02*
Samoa					
mm	1265		330	1143	*2738*
MBq/km^2	97 ± 26	N.S.	35 ± 19	77 ± 25	*209 ± 41*
Bq/l	0.08 ± 0.02		0.11 ± 0.06	0.07 ± 0.02	*0.08 ± 0.01*
Tonga					
mm	350	281	207	346	*1184*
MBq/km^2	38 ± 20	42 ± 17	44 ± 20	55 ± 21	*179 ± 39*
Bq/l	0.11 ± 0.06	0.15 ± 0.06	0.21 ± 0.10	0.16 ± 0.06	*0.15 ± 0.03*
Aitutaki					
mm	781	406	278	831	*2296*
MBq/km^2	28 ± 25	66 ± 21	37 ± 19	45 ± 24	*176 ± 45*
Bq/l	0.04 ± 0.03	0.16 ± 0.05	0.13 ± 0.07	0.05 ± 0.03	*0.08 ± 0.02*
Rarotonga					
mm	538	477	585	627	*2227*
MBq/km^2	58 ± 24	34 ± 19	59 ± 22	38 ± 19	*189 ± 42*
Bq/l	0.11 ± 0.04	0.07 ± 0.04	0.10 ± 0.04	0.06 ± 0.03	*0.08 ± 0.02*

N.S. *No Samples obtainable*
The error term is ±2 standard deviations

TABLE 8 - Strontium-90 in Rain 1981:

Rainfall (mm)
Deposition (MBq/km^2)
Concentration (Bq/l)

New Zealand Stations		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	*Total*	*Av*
Kaitaia	mm	278	391	505	343	*1517*	
	MBq/km^2	0.4	0.4	0.6	0.6	*2.0*	
	Bq/l	0.001	<0.001	0.001	0.002		*0.001*
Auckland	mm	92	337	310	191	*930*	
	MBq/km^2	0.1	0.4	0.3	0.3	*1.1*	
	Bq/l	0.001	0.001	0.001	0.001		*0.001*
New Plymouth	mm	118*	407	488	171*	*1184*	
	MBq/km^2	0.3*	0.6	0.6	0.3*	*1.8*	
	Bq/l	0.002	0.002	0.001	0.002		*0.002*
Havelock North	mm	116	332	294	153	*895*	
	MBq/km^2	0.2	0.2	0.3	0.3	*1.0*	
	Bq/l	0.002	<0.001	<0.001	0.002		*0.001*
Wellington	mm	107*	450	381	326	*1264*	
	MBq/km^2	0.2*	0.3	0.4	0.6	*1.5*	
	Bq/l	0.002	<0.001	0.001	0.002		*0.001*
Hokitika	mm	771	887	1354	1045	*4057*	
	MBq/km^2	1.2	1.0	0.7	1.3	*4.2*	
	Bq/l	0.002	0.001	<0.001	0.001		*0.001*
Christchurch	mm	69	184	110*	124	*487*	
	MBq/km^2	0.3	0.3	<0.1*	0.1	*0.7*	
	Bq/l	0.004	0.002	<0.001	0.001		*0.002*
Dunedin	mm	178	92	213	137	*620*	
	MBq/km^2	0.6	0.2	0.2	0.4	*1.4*	
	Bq/l	0.003	0.002	<0.001	0.003		*0.002*
Invercargill	mm	189	280	311	297	*1077*	
	MBq/km^2	0.4	0.3	0.3	0.2	*1.2*	
	Bq/l	0.002	<0.001	<0.001	<0.001		*0.001*
Average	*mm*	*213*	*373*	*441*	*310*	*1337*	
	MBq/km^2	*0.4*	*0.4*	*0.4*	*0.5*	*1.7*	
	Bq/l	*0.002*	*0.001*	*<0.001*	*0.002*		*0.001*
Pacific Island Stations							
Suva, Fiji	mm	971	695	384	1135	3185	
	MBq/km^2	0.4	0.1	0.4	0.5	1.4	
	Bq/l	<0.001	<0.001	<0.001	<0.001		*<0.001*
Rarotonga	mm	542	107*	335*	498	1482	
	MBq/km^2	0.2	0.2*	0.2*	0.3	0.9	
	Bq/l	<0.001	0.002	<0.001	<0.001		*<0.001*

* *Results for 2 months only.*

The counting error for deposition results is about ±0.08 MBq/km^2

TABLE 9 - Lead-210 in Rain 1981: Deposition (MBq/km^2)

New Zealand Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	*Total*
Kaitaia	3.0	2.3	5.4	3.9	3.5	6.6	8.0	7.5	6.4	2.0	9.0	3.0	*60.6*
Auckland	1.8	1.4	1.4	4.0	3.7	6.3	5.3	3.7	4.5	1.6	3.1	2.7	*39.5*
New Plymouth	2.3	1.9	(2.8)	7.7	2.7	11.8	5.0	5.5	8.5	4.5	3.3	(5.1)	*61.1*
Havelock North	2.4	2.3	1.5	2.0	3.2	4.4	2.4	3.5	1.1	1.5	2.6	1.1	*28.0*
Wellington	1.9	(1.6)	2.7	3.9	7.6	4.9	6.6	1.8	8.3	8.9	3.9	8.8	*60.9*
Hokitika	6.3	12.1	12.2	14.6	8.6	18.6	13.0	6.0	9.8	14.8	17.6	11.9	*145.5*
Christchurch	1.7	1.4	2.5	1.2	ND	1.1	(1.4)	2.0	1.2	2.9	1.6	(0.8)	*17.8*
Dunedin	4.2	4.1	2.7	2.5	0.5	1.8	2.0	1.0	1.7	2.6	1.7	2.6	*27.4*
Invercargill	3.1	3.4	2.7	3.1	1.7	1.9	1.5	1.4	4.5	5.2	2.2	3.2	*33.9*
Average	*3.0*	*3.4*	*3.8*	*4.8*	*3.5*	*6.4*	*5.0*	*3.6*	*5.1*	*4.9*	*5.0*	*4.4*	*52.7*
Pacific Island Stations													
Suva, Fiji	12.0	4.8	3.9	5.2	6.3	4.0	5.9	4.3	5.9	8.5	NS	4.4	-
Rarotonga	5.0	3.1	1.4	NS	2.3	0.8	4.4	2.5	NS	4.9	1.7	6.0	-

ND *Not detected. The limit of detection is about 0.17 MBq/km^2.*
NS *No result available.*
( ) *Estimate.*
The counting error is less than 0.3 MBq/km^2 (less than 0.2 for most results).

TABLE 10 - Strontium-90 in Milk 1981: (Bq/gCa)

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Av
Northland	0.051	0.050	0.058	0.054	*0.053*
Auckland	0.050	0.046	0.062	0.056	*0.054*
Waikato	0.076	0.070	0.081	0.070	*0.074*
Taranaki	0.098	0.093	0.145	0.129	*0.116*
Palmerston North	0.038	0.037	0.052	0.046	*0.043*
Wellington	0.054	0.055	0.056	0.052	*0.054*
Westland	0.144	0.122	0.109	0.114	*0.122*
Christchurch	0.026	0.024	0.028	0.029	*0.027*
Dunedin	0.026	0.027	0.031	0.024	*0.027*
Average	*0.063*	*0.058*	*0.069*	*0.064*	*0.063*

The counting error is about ± 0.002 Bq/gCa

TABLE 11 - Caesium-137 in Milk 1981: (Bq/gK)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Av
Northland	0.22	0.15	0.30	ND	ND	ND	-	-	ND	ND	ND	ND	*<0.1*
Auckland	0.15	ND	ND	-	ND	ND	ND	-	ND	ND	ND	ND	*<0.1*
Waikato	0.42	0.51	0.49	0.39	0.14	0.13	ND	-	ND	ND	0.27	0.30	*0.24*
Taranaki	0.90	1.06	1.36	1.11	0.69	0.57	0.91	0.67	0.69	0.69	1.11	1.11	*0.91*
Palmerston North	0.04	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	*<0.1*
Wellington	0.11	ND	0.10	ND	ND	ND	ND	ND	ND	ND	ND	ND	*<0.1*
Westland	0.30	0.16	0.14	ND	ND	ND	-	ND	ND	ND	0.09	0.12	*0.1*
Christchurch	ND	ND	ND	ND	ND	ND	-	-	ND	ND	ND	ND	*<0.1*
Dunedin	ND	0.16	0.07	ND	ND	ND	-	-	ND	ND	ND	ND	*<0.1*
												Average	*0.1*

ND *Not detected. The limit of detection is about ± 0.1 Bq/gK.*
\- *Not determined.*
The counting error is about ± 0.07 Bq/gK.