

REPORT No.  
NRL-F 33

DEPARTMENT OF HEALTH



ANNUAL SUMMARY 1968

# ENVIRONMENTAL RADIOACTIVITY IN NEW ZEALAND

AND

RESULTS OF EXTENDED MONITORING OF FALLOUT  
FROM FRENCH NUCLEAR TESTS IN THE PACIFIC

NATIONAL RADIATION LABORATORY  
P.O. BOX 1456, CHRISTCHURCH, NEW ZEALAND

## SYMBOLS      UNITS      AND      EQUIVALENTS

## UNITS OF RADIOACTIVITY

Ci	..	..	Curie	..	..	..	..	..	..	..	..	3.7 x 10 <sup>10</sup>	disintegrations per second
mCi	..	..	millicurie	..	..	10 <sup>-3</sup>	Curies						
pCi	..	..	picocurie	..	..	10 <sup>-12</sup>	Curies	..	..	2.22	disintegrations per minute		

## UNITS OF LENGTH, AREA, VOLUME AND MASS AND THEIR EQUIVALENTS IN THE IMPERIAL SYSTEM

cm <sup>2</sup>	.. .. .	centimetre	.. .. .	0.394	inches
km <sup>2</sup>	.. .. .	square kilometre	.. .. .	0.386	square miles
m <sup>3</sup>	.. .. .	cubic metre	.. .. .	35.31	cubic feet
litre	.. .. .	litre	.. .. .	0.880	quart
g	.. .. .	gram	.. .. .	0.0353	ounce

## NOTES

1. Unless otherwise noted, all times given in this report are New Zealand Standard time i.e. G.M.T. + 12 hours.
2. Radioactive fallout in rain is expressed as:
  - (a) Deposition - millicuries per square kilometre (mCi/km<sup>2</sup>)
  - (b) Concentration - picocuries per litre (pCi/litre)

$$\text{Concentration (pCi/litre)} = \frac{\text{deposition (mCi/km}^2\text{)}}{\text{rainfall (cm)}} \times 100$$

Multiply  $\text{mCi/km}^2$  by 2.59 to obtain  $\text{mCi/sq. mile}$ .

3. The levels of strontium-90 contamination in food and bone are given in "Strontium Units" i.e. picocuries strontium-90 per gram of calcium .....pCi Sr<sup>90</sup>/g Ca.

Similarly caesium-137 results are given as picocuries of caesium-137 per gram of potassium.....pCi Cs<sup>137</sup>/g K.

One litre of whole milk contains approximately:

1.2 g of calcium

1.4 g of potassium.

## CONTENTS

	PAGE
SYMBOLS UNITS AND EQUIVALENTS .. .. .	1
CONTENTS .. .. .	2
POTENTIAL HEALTH HAZARD - PERMISSIBLE LEVELS OF RADIOACTIVITY ..	3
GENERAL STATEMENT OF RESULTS .. .. .	4
LOCATION OF COLLECTING STATIONS IN NEW ZEALAND FIG. 1a .. .. .	5
LOCATION OF MONITORING AND COLLECTING STATIONS IN THE PACIFIC FIG. 1b	6
 <u>SECTION A - GENERAL INFORMATION, SAMPLE COLLECTION AND EVALUATION ..</u>	 7
1. Portable Gamma Ray Survey Meters .. .. .	8
2. Air Sampling .. .. .	8
3. Rainwater .. .. .	8
4. Milk .. .. .	9
5. Animal Thyroids .. .. .	10
6. Human Bone .. .. .	10
7. Soil .. .. .	10
 <u>SECTION B - RESULTS OF ROUTINE MEASUREMENTS</u>	
1. Fission Products in Air .. .. .	12
2. Fission Products in Rain .. .. .	12
3. Strontium-90 in Rain .. .. .	12
4. Strontium-90 Cumulative Deposition .. .. .	15
5. Strontium-90 in Soil .. .. .	16
6. Strontium-90 in Milk .. .. .	18
7. Caesium-137 in Milk .. .. .	22
 <u>SECTION C - RESULTS OF EXTENDED MONITORING OF FALLOUT</u> <u>FROM FRENCH NUCLEAR TESTS IN THE PACIFIC</u>	
1. Gamma Ray Radiation Monitoring .. .. .	25
2. Fission Products in Air .. .. .	25
3. Fission Products in Rain .. .. .	30
4. Strontium-89 in Rain .. .. .	32
5. Iodine-131 in Milk and Cattle Thyroid .. .. .	34
 <u>SECTION D - SPECIAL SURVEYS AND MISCELLANEOUS MEASUREMENTS</u>	
1. Caesium-137, Individual Milk Stations, Taranaki .. .. .	37
2. Caesium-137 to Strontium-90 Ratios in Milk .. .. .	38
3. Lead-210 in Rain .. .. .	40
4. Strontium-90, Radium-226 and Lead-210 in Human Bone .. .. .	42
 <u>ACKNOWLEDGEMENT</u> .. .. .	 44

## POTENTIAL HEALTH HAZARD

The significance of the levels of radioactivity in environmental samples published in this Report may be understood more readily by comparing these levels with the following "permissible levels for the general population" which have been adopted for use in New Zealand.

These levels have been set as a guide to limit the controlled release of radioactive substances into the environment by licensed users in New Zealand.

They are levels which individually would not require remedial or preventive action and have been chosen to protect the most sensitive age group in the population. It is considered that any risk associated with these levels is exceedingly small and that levels many times as great would involve a hazard which is small compared to commonly accepted risks of life.

### "Permissible levels" of Radioactivity

These levels were derived so as to ensure that the dose to any member of the public arising from the controlled use of radioactive materials does not exceed the Dose Limit recommended by the International Commission on Radiological Protection.

#### Strontium-90

In Milk: 270 Strontium Units - maintained indefinitely in the milk.  
In Bone: 67 Strontium Units.

#### Caesium-137

In Milk: 7,000 pCi/g K - maintained indefinitely in the milk.

#### Iodine-131

In Milk: 200 pCi/litre - as an average intake over one year.

#### Total Beta Activity of Mixed Fission Products Between 10 and 80 Days Old

In Air: 300 pCi/m<sup>3</sup> - for continuous breathing.  
In Rainwater: 6,000 pCi/litre - for continuous consumption.

## GENERAL STATEMENT OF RESULTS

In this Report a distinction is made between the levels of radioactivity due to long-lived radionuclides (which have been of major significance in assessing health hazards), and short-lived radionuclides from recent nuclear tests which, although showing increased levels of radioactivity during limited periods, have been of less significance in assessing health hazards.

### LONG LIVED FISSION PRODUCTS

The deposition on New Zealand of long lived bomb products, such as strontium-90 and caesium-137, from delayed stratospheric fallout, continues to decrease. During 1968 the country-wide deposition of strontium-90 was less than one quarter of that during 1964, the year of peak deposition. During 1966 and 1967 only a fraction of the deposition originated from the nuclear tests conducted by France in the Pacific, the majority still originating from nuclear tests conducted prior to 1963. In 1968, however, a larger proportion of the strontium-90 derived from the French tests, mainly as a result of decreasing stratospheric fallout of strontium-90 from past tests.

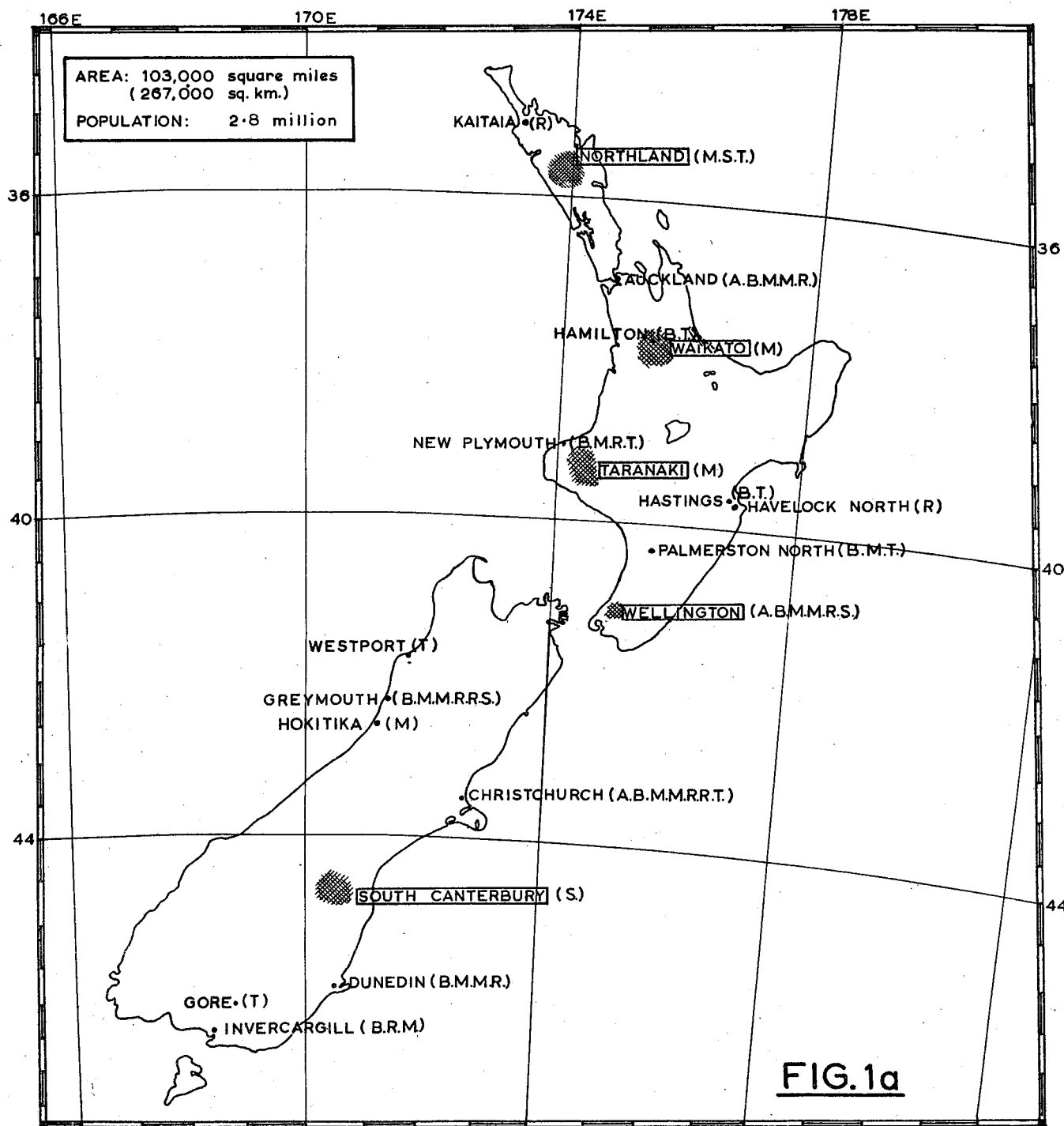
The levels of strontium-90 and caesium-137 in milk have also decreased during 1968 to less than one half of the peak levels in 1965. The slower rate of decrease in this case being due to continuing uptake by grass of the accumulated deposit in the soil. The levels in milk averaged over several years are only a small fraction of the maximum permissible levels for continuous consumption.

### SHORT LIVED FISSION PRODUCTS

During 1968 the third consecutive series of nuclear tests was conducted in the Pacific Area culminating in the testing of two hydrogen bombs in August and September. The Laboratory's extended monitoring of fallout during 1968 has again measured increased levels of radioactivity due to short lived fission products in air, rainwater and milk at all New Zealand and Pacific Island stations.

The inclusion of the two hydrogen bombs in the five nuclear devices tested in 1968 did not result in levels of environmental radioactivity greater than those in 1966 when five atomic bombs were tested.

The levels of radioactivity measured during the extended monitoring period are a small fraction of permissible levels for continuous consumption and do not constitute a health hazard.



LOCATION OF COLLECTING STATIONS ESTABLISHED BY THE NATIONAL RADIATION LABORATORY FOR AIR (A), BONE (B), MILK (M), RAINWATER (R), SOIL (S), AND THYROIDS (T) SAMPLES IN NEW ZEALAND. Where more than one type of collection is performed (e.g. weekly and monthly rainwater collection) the appropriate symbol is shown twice. Collection areas not confined to a single location but extending over part of a province or district are shown thus [NAME]

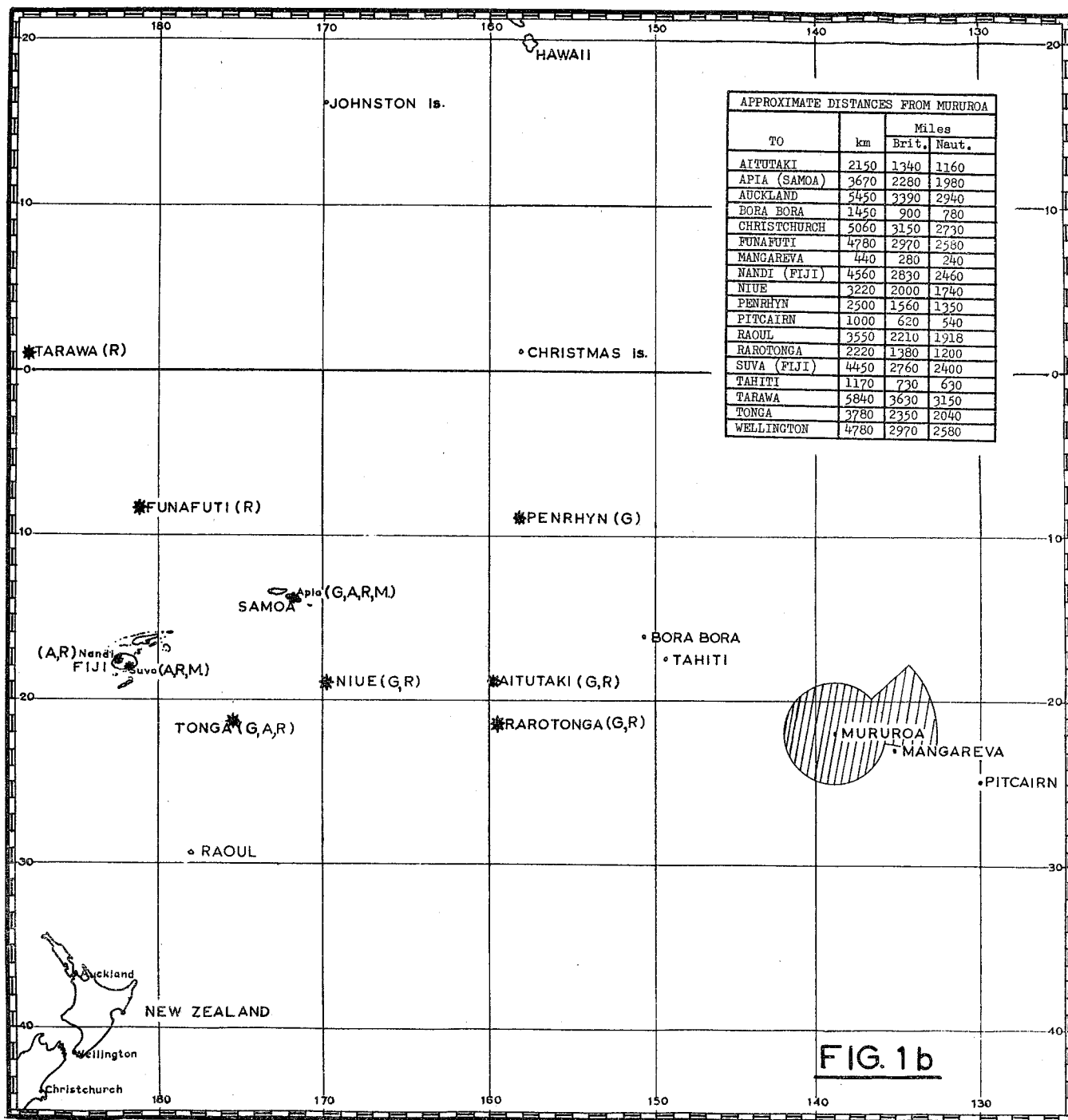


FIG. 1b

LOCATION OF MONITORING AND COLLECTING STATIONS ESTABLISHED BY THE NATIONAL RADIATION LABORATORY ON PACIFIC ISLANDS. GAMMA RADIATION MONITORING STATIONS (G), AND COLLECTING STATIONS FOR AIR (A), AND RAINWATER (R), AND MILK (M) SAMPLES ARE MARKED THUS \* Officially proclaimed danger zone shown thus

SECTION A  
GENERAL INFORMATION

In September 1957 the New Zealand Department of Health was charged, under a Cabinet directive, with the responsibility for the monitoring of environmental radioactive contamination in New Zealand and the Pacific areas with which it is associated. Subsequently the network of collecting stations shown in Fig. 1a and b has been established to provide the necessary samples of air, rain, water, soil, animal thyroid, milk, and human bone. The collections and measurements are being made on a routine basis and the results are published in a series of Quarterly Reports ("Fallout in New Zealand", DXRL-F1 to F9 and NRL-F10 to F18; and "Environmental Radioactivity in New Zealand", NRL-F19 onwards).

Prior to December 1967 the fourth quarterly results and annual summary were published in a single Report. Since then, however, the Annual Summary Report has been published separately. Individual results, therefore, are not given in this report, these having been published in the four preceding quarterly reports for 1968 (NRL-F29 to F32).

SAMPLE COLLECTION AND EVALUATION

The selection of rainwater collecting stations in New Zealand was based on the requirement that an adequate geographical coverage of the country must be made, taking account of natural features, such as mountain ranges which, particularly in the South Island, account for the extremes in rainfall. Furthermore, proximity of rainwater collecting sites to milk producing areas is desirable, so that comparisons between levels of contamination in rain and milk can be made.

The selection of milk producing areas was based not only on geographical coverage and routine availability of samples but also on population distribution, so that the average result of all stations would be representative of the contamination in the average New Zealand diet.

During the period of nuclear testing which started in the Christmas Island area in April 1962, the routine monitoring operations conducted by this Laboratory were extended within New Zealand, and a new network of monitoring and collection stations was established throughout the Pacific area. The extent of these monitoring operations and the results of the measurements have been published in previous issues of the Laboratory's Quarterly Reports. (See particularly DXRL-F5, DXRL-F7, and DXRL-F8).

After the conclusion of the 1962 Pacific test series, the monitoring activities of the Laboratory reverted to the established routine pattern. However, in preparation for the French series of nuclear tests in the Pacific, which commenced in July 1966, and were continued in 1967 and 1968, the monitoring operations of the Laboratory were again extended. The results of the extended monitoring operations during 1966 and 1967 were given in the Annual Summary Report NRL-F23 and NRL-F28.



The following information lists the type and extent of sample collection and measurement undertaken by the Laboratory during its routine operations as well as during the 1968 nuclear tests. The procedures for radiochemical separations and measurement of radioactivity were described in detail in the Annual Summary for 1966 (NRL-F23) and are only briefly referred to here. The procedures for the measurement of strontium-90 have been modified recently and are being prepared for publication. A copy of these may be obtained from this Laboratory on request.

### 1. PORTABLE GAMMA RAY SURVEY METERS

Duplicate sets of gamma radiation monitors have been provided on the following 6 Pacific Islands stations for monitoring of the gamma radiation dose rate during the 1968 extended monitoring programme.

Penrhyn	Aitutaki	Rarotonga	Apia(Samoa)	Niue	Tonga
---------	----------	-----------	-------------	------	-------

The most sensitive range on these instruments is 0-0.5 mR/hr, enabling significant readings to be made even on natural background radiation. Any increase in the gamma radiation dose rate on any of the islands monitored can thus be detected long before it reaches levels indicating a possible health hazard. Gamma radiation dose rate measurements are made several times each day by observers of the New Zealand Meteorological Service concurrently with their meteorological observations. Readings are made at a fixed position 3 feet (91 cm) above the ground. Only readings exceeding 0.3 mR/hr will be reported.

### 2. AIR SAMPLING (For Measurement of Total Beta Activity)

Routinely, air filter samples are collected continually at Auckland, Wellington and Christchurch. Sampling involves the collection of particulates in ground level air by drawing the air through 11 cm diameter filters using positive displacement pumps. The filters are changed three times weekly. During extended monitoring, however, daily air filter samples were collected at the following 7 stations:

Auckland	Wellington	Christchurch	Nandi(Fiji)	Suva(Fiji)	Apia(Samoa)	Tonga
----------	------------	--------------	-------------	------------	-------------	-------

The air filter samples are collected by pumping about 100m<sup>3</sup> of air in 24 hours through a glass fibre filter of 11 cm diameter (Whatman GF/A). The air filters are airmailed to Christchurch and the total beta activity of the entire filter is measured using a 5 inch beta detector. Measurement is made four days after the end of collection to allow for the decay of natural atmospheric radioactivity.

### 3. RAINWATER

#### (a) MONTHLY COLLECTION (For Measurement of Strontium-90, Strontium-89 and Lead-210).

Rainwater is routinely collected by exposing a stainless steel pot of 30 cm diameter and 30 cm height, at ground level, for 1 month at each of the following 11 collecting sites:

Site	Rainfall (during year 1968 in cm)	Site	Rainfall (during year 1968 in cm)
Kaitaia	168	Christchurch	74
Auckland	125	Dunedin	75
New Plymouth	151	Invercargill	108
Havelock North	81		
Wellington	159	Suva, Fiji*	212
Greymouth	276	Rarotonga**	172

\*Normally a 3-monthly collection changed to monthly collections from June 1966.

\*\*Monthly collections started June 1966.

The appropriate carriers are added to the collecting pots before despatch to the collecting sites. A supply of distilled water is maintained at the site and is added to the pot when necessary to prevent the contents from evaporating to dryness during dry periods. On arrival at the Laboratory the carriers are separated by ion exchange elution chromatography. Strontium-89 is determined by beta counting and subtracting the contributions from Strontium-90 and Yttrium-90. Strontium-90 is determined by measurements of its daughter Yttrium-90 and lead-210 by measurement of its ingrowing daughter bismuth-210.

(b) WEEKLY COLLECTION (For Measurement of Total Beta Activity)

Samples of rainwater, collected each week by means of a polythene funnel and bottle collector from the 11 stations listed below, are returned to Christchurch for processing and measurement of total beta activity.

LOCATION OF 11 RAINWATER STATIONS MAKING WEEKLY COLLECTIONS			
Tarawa	Suva (Fiji)	Tonga	Greymouth
Funafuti	Apia (Samoa)	Aitutaki	Christchurch
Nandi (Fiji)	Niue	Rarotonga	

The collecting bottles contain carrier solution for fission products, and the funnels have a diameter of 9.9 cm for Pacific Island stations and 17.0 cm for New Zealand stations. The collected rainwater samples are evaporated to dryness and counted in 4.5 inch planchettes using a 5 inch beta detector.

#### 4. MILK

(a) MONTHLY COLLECTION (For Measurement of Strontium-90 and Caesium-137)

Representative milk samples are obtained in New Zealand each month from the following 9 urban centres or provinces:

Northland	Taranaki	Greymouth*
Auckland	Palmerston North	Christchurch
Waikato	Wellington	Dunedin

\* Sampling of fresh milk at Greymouth was changed to dried milk sampling at Hokitika from October 1968 with the start of milk drying operations on the West Coast.

Monthly composite samples of milk from each of the sampling areas are measured for caesium-137 and potassium-40 by gamma spectrometry. Liquid milk samples are dried and powdered before measurement.

Because of the general decrease in strontium-90 levels over the past few years, aliquots of the dried milk samples which were aggregated on a two-monthly basis for each station for ashing and measurement of strontium-90 content, are now aggregated on a three-monthly basis starting at the third quarter 1968.

Strontium carrier is separated from other milk ash constituents with nitric acid followed by ion exchange elution chromatography. Strontium-90 is then measured by the methods already referred to under subsection 3, Rainwater.

(b) SPECIAL COLLECTION (For Measurement of Iodine-131)

During the period of extended monitoring, representative samples of fresh milk were despatched to Christchurch on Mondays, Wednesdays and Fridays of each week from the following 7 New Zealand town milk supplies:

Auckland	New Plymouth	Wellington	Greymouth	Christchurch	Dunedin	Invercargill
----------	--------------	------------	-----------	--------------	---------	--------------

Twice weekly collections were also obtained at 

Suva(Fiji)	Apia(Samoa)
------------	-------------

Iodine-131 is separated from fresh milk by absorption on anion exchange resin and measured by gamma spectrometry of the resin. At the two Pacific Island Stations the separation was made locally and the resin was airmailed to Christchurch for measurement.

5. ANIMAL THYROIDS (For Measurement of Iodine-131)

Sampling of cattle thyroids is carried out once each week at the following 8 stations:

Northland (Moerewa)	Palmerston North (Longburn)
Hamilton (Horotiu)	Westport
New Plymouth (Waitara)	Christchurch (Islington)
Hastings (Tomoana)	Gore

Radioiodine was measured by gamma spectrometry of the thyroids.

6. HUMAN BONE (For Measurement of Strontium-90, Radium-226 and Lead-210)

Post mortem samples of human bone are obtained whenever possible. Samples have been collected at Auckland, Hamilton, Hastings, Napier, New Plymouth, Palmerston North, Wellington, Nelson, Greymouth, Christchurch, Dunedin, Invercargill and from some provincial areas.

7. SOIL (For Measurement of Strontium-90)

Soil is sampled annually from the following 4 districts: Northland, Wellington, Greymouth and South Canterbury. Samples were taken at Campbell Island (52.5°S 169.0°E) up to February 1965.

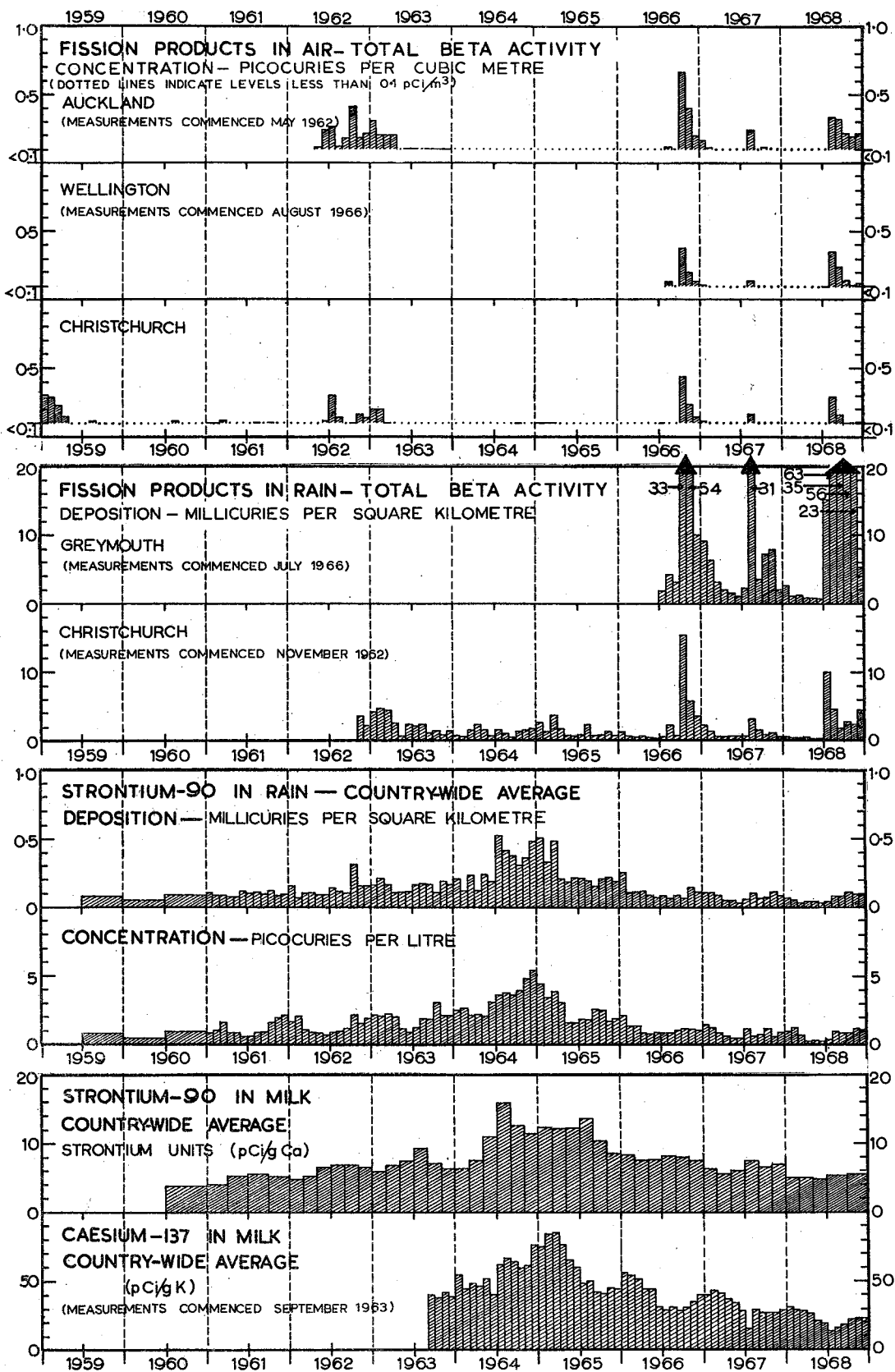


FIG. 2

SUMMARY OF LONG TERM MEASUREMENTS

SECTION B  
RESULTS OF ROUTINE MEASUREMENTS

1. FISSION PRODUCTS IN AIR

Over the last decade the levels of total beta activity in air due to fission products have usually been less than  $0.1 \text{ pCi/m}^3$ . Transient increases, which are of negligible health concern, have resulted, however, particularly from nuclear testing in the Pacific Area. During the latter halves of 1966, 1967 and 1968 transient increases in air radioactivity have again been observed following the French nuclear testing programme in the Pacific.

The results of measurements of individual air filter samples have been averaged for each month for Auckland, Wellington and Christchurch and these average levels are shown in Fig. 2. The highest average monthly levels recorded during each of the nuclear test series were:

$0.66 \text{ pCi/m}^3$  at Auckland during October 1966  
 $0.24 \text{ pCi/m}^3$  at Auckland during August 1967  
 $0.35 \text{ pCi/m}^3$  at Wellington during August 1968

The results of air monitoring are given in greater detail in SECTION C.

2. FISSION PRODUCTS IN RAIN

Increases in the levels of fission products in rainwater collected at Greymouth and Christchurch also occurred concurrently with increases in air radioactivity during 1966, 1967 and 1968. The highest levels were measured in Greymouth rainwater with maximum depositions of  $54 \text{ mCi/km}^2$  in November 1966,  $31 \text{ mCi/km}^2$  in August 1967, and  $63 \text{ mCi/km}^2$  in August 1968. These levels, which are not of health concern, are shown in Fig. 2 and in greater detail in SECTION C.

3. STRONTIUM-90 IN RAIN

Country-wide average values for deposition and concentration are shown in Fig. 2 and individual station values for deposition and rainfall are shown in Fig. 3. Strontium-90 deposition on New Zealand reached a maximum during the latter half of 1964 and the first quarter of 1965, mainly from delayed stratospheric fallout from nuclear testing in 1961 and 1962. Levels have steadily decreased since then. Table 1 lists the annual deposition at individual stations and the country-wide average deposition since 1960. The annual rainfall listed is the mean over the past 6 years i.e. 1963-1968 inclusive.

TABLE 1		ANNUAL DEPOSITION OF STRONTIUM-90 $\text{mCi/km}^2$								
NEW ZEALAND STATIONS	ANNUAL RAINFALL (cm)	1960	1961	1962	1963	1964	1965	1966	1967	1968
Kaitaia	137				1.8	4.1	3.1	1.6	1.1	0.9
Auckland	132	1.2	1.1	1.8	2.0	4.0	2.9	1.3	0.9	0.7
New Plymouth	153				2.0	5.3	4.2	1.9	1.3	0.9
Havelock North	73	0.7	0.8	1.0	1.0	1.6	1.7	0.8	0.5	0.6
Wellington	140	0.8	1.1	1.8	2.0	3.4	3.9	1.6	1.0	0.9
Greymouth	257	1.5	2.2	2.8	3.7	7.8	5.9	2.2	1.7	1.4
Christchurch	61	0.5	0.7	0.7	1.2	1.3	1.7	0.7	0.4	0.5
Dunedin	59				1.0	1.8	2.0	0.7	0.7	0.4
Invercargill	105	0.5	1.2	1.2	1.7	3.0	2.8	1.1	0.9	0.5
Country-Wide Average		0.9	1.2	1.6	1.8	3.6	3.1	1.3	0.9	0.8
Suva, Fiji	268		1.0	1.6	2.4	2.5	2.0	1.2	0.6	1.0

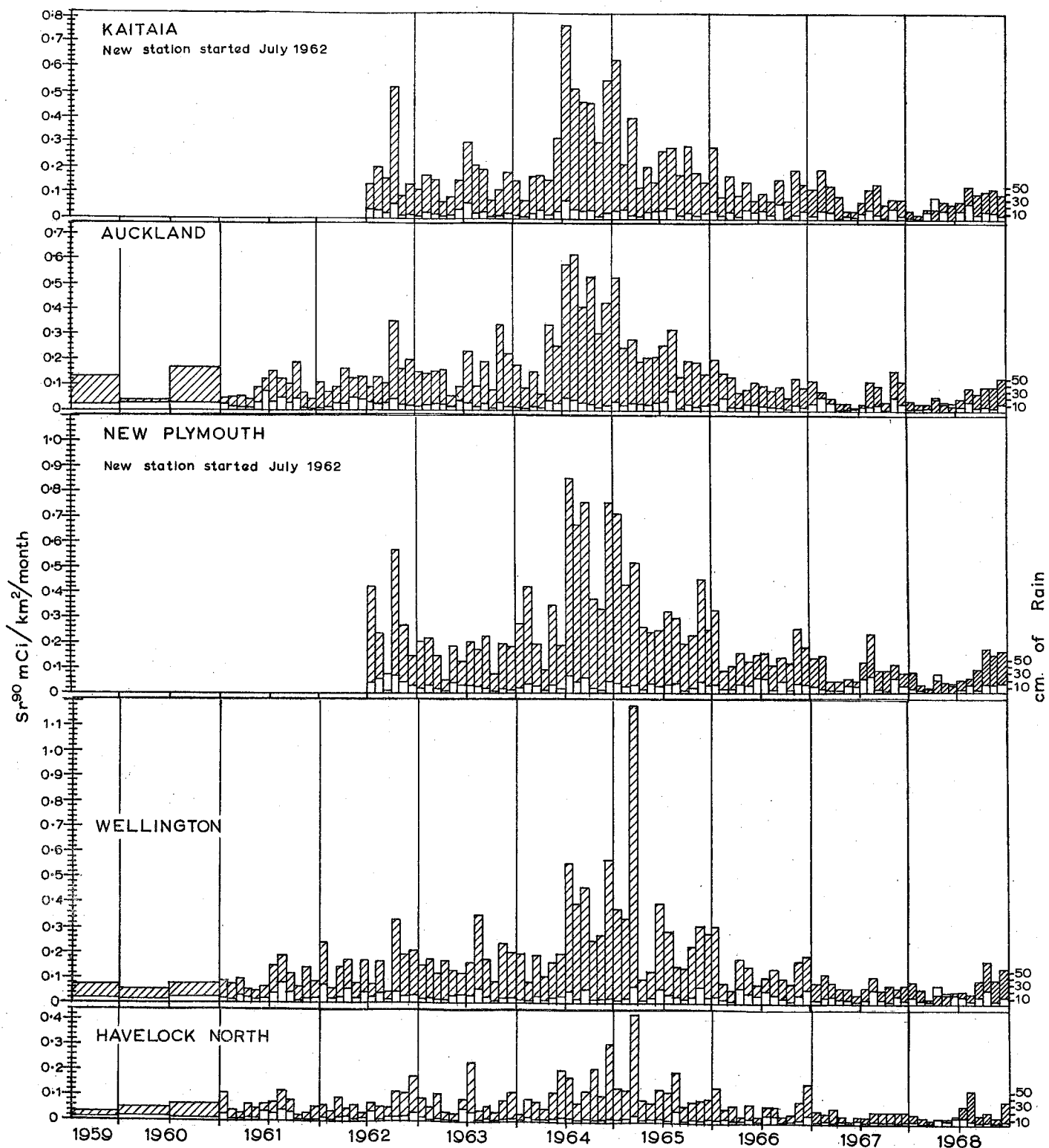




FIG. 3 STRONTIUM 90 IN RAIN

 Millicuries Sr per square kilometre per month. Lefthand scale.  
 Centimetres of rain per month. Righthand scale.

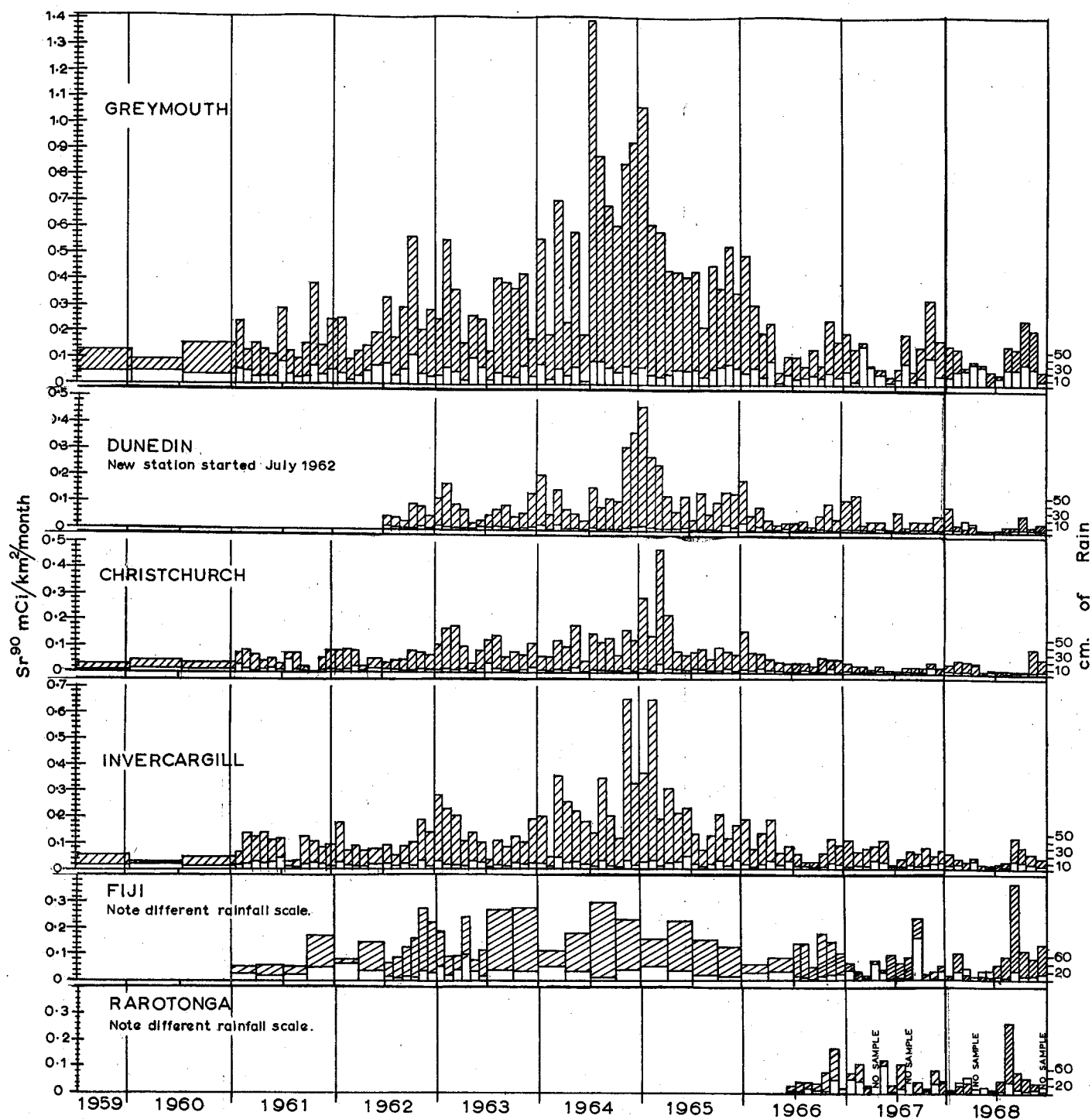


FIG. 3 STRONTIUM 90 IN RAIN

Millicuries  $\text{Sr}^{90}$  per square kilometre per month. Lefthand scale.  
 Centimetres of rain per month Righthand scale.

The annual depositions since 1954 at New York City and at Milford Haven in the United Kingdom are listed in Table 2. The New Zealand country-wide average depositions since 1960 are also listed for comparison. The values for New York City are taken from the Quarterly Summary Report (HASL-204 APP.) of the Health and Safety Laboratory, United States Atomic Energy Commission and the Milford Haven values have been taken from the United Kingdom Atomic Energy Authority's Report "Radioactive Fallout in Air and Rain: Results to the Middle of 1968" (AERE-R5899). Following the nuclear tests conducted in the Northern Hemisphere during 1961 and 1962, strontium-90 fallout reached a maximum in 1963 in the Northern Hemisphere and in 1964 in the Southern Hemisphere. Since then levels have fallen steadily.

TABLE 2 ANNUAL DEPOSITION OF STRONTIUM-90 mCi/km <sup>2</sup>			
YEAR	MILFORD HAVEN	NEW YORK CITY	NEW ZEALAND AVERAGE
1954	2.0 (up to end of 1954)	2.8 (Feb.-Dec. inc.)	
1955	2.4	3.6	
1956	2.5	4.4	
1957	2.6	4.4	
1958	5.4	6.2	
1959	5.7	8.7	
1960	1.8	1.6	0.9
1961	2.5	2.4	1.2
1962	9.3	12.3	1.6
1963	20.9	23.8	1.8
1964	11.7	15.9	3.6
1965	4.8	5.5	3.1
1966	3.1	2.4	1.3
1967	1.2	1.6	0.9
1968	0.7 (to end of June)	1.1 (to end of Aug.)	0.8

#### 4. STRONTIUM-90 CUMULATIVE DEPOSITION

The annual depositions in Table 2 have been totalled and corrected for radioactive decay and are presented graphically in Fig. 4 as cumulative deposition. The dotted portion of the curve for New Zealand is based on soil measurements undertaken by the U.S. Department of Agriculture on samples from three collecting sites. The part of the curve from July 1959 to July 1962 is derived from our measurements on rain samples from six collecting stations. From July 1962 the average result from our network of nine rainwater collecting stations has been used.



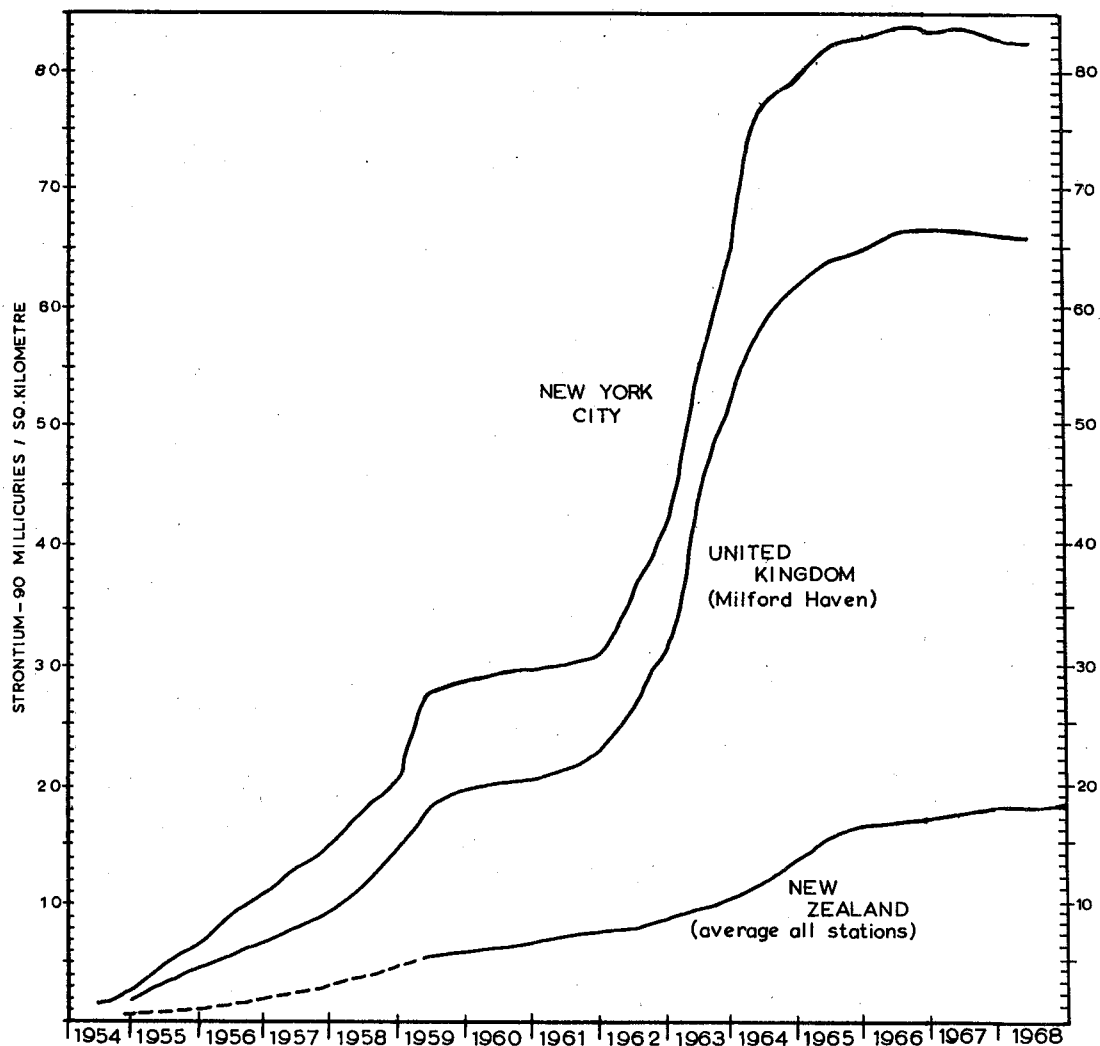


FIG. 4. TOTAL ACCUMULATION OF STRONTIUM-90 FROM RAIN

Due to the steadily decreasing levels of fallout since 1963, the situation was eventually reached during 1967 when the reduction of the accumulated strontium-90 by radioactive decay in the Northern Hemisphere was greater than the annual deposit. The total accumulation at June 1968 was therefore slightly less than that at the beginning of 1967.

In New Zealand, however, where the total accumulation is much less, reduction by radioactive decay has been of less significance. Interhemispheric transfer of strontium-90 and the injection of fresh fission material into the troposphere during the French nuclear tests have resulted in a continuing slight increase in the total accumulation of strontium-90.

##### 5. STRONTIUM-90 IN SOIL

Table 3 lists the results for strontium-90 in New Zealand soils. Measurements were initially undertaken by the Health and Safety Laboratory (HASL) of the U.S. Atomic Energy Commission for the U.S. Department of Agriculture. The 1963/1964 samples were also measured by this Laboratory (NRL) for intercomparison purposes and both sets of results are listed. Since then samples have been measured by this Laboratory.

TABLE 3 STRONTIUM-90 IN NEW ZEALAND SOILS - mCi/km <sup>2</sup>						
SAMPLING DATES	LABORATORY	NORTH AUCKLAND	WELLINGTON		GREYMOUTH	SOUTH CANTERBURY
			JUDEGFOR	TAITA		
Nov. 1953 - Jan. 1954	HASL	<0.1	<0.1			<0.1
Feb. 1955	HASL		0.7			
Apr. - May 1956	HASL	1.5	1.3			0.8
Mar. 1958	HASL	2.5	3.7			3.1
Jun. 1959	HASL	5.5	6.1			4.2
Dec. 1960 - Jan. 1961	HASL	5.2	7.8	5.1		4.6
Nov. 1963 - Feb. 1964	HASL	10.2	10.5	9.0	16.7	6.3
	NRL	9.9	10.3	8.8	16.8	5.9
Dec. 1965 - Jan. 1966	NRL	12.9		12.4	23.0	9.1
Dec. 1967 - Jan. 1968	NRL	14.1			20.8	8.4
Jul. 1968	NRL			11.2		

It is noted that results of soil analyses are generally lower than the corresponding results of cumulative deposition obtained from rainwater analyses. Also the values for three of the 1967/1968 soil samples listed in Table 3 are lower than those for the corresponding 1965/1966 samples. Soils are sampled to a depth of 8 inches and the possibility that significant penetration of strontium-90 below 8 inches may have occurred at some sites over the past few years should not be overlooked.

A final world-wide sampling of soil for measuring the distribution and cumulative deposit of strontium-90 was conducted from 1965 to 1967 by the Soil Survey Laboratory, U.S. Department of Agriculture and Health and Safety Laboratory, U.S. Atomic Energy Commission. The results were published in their report "Strontium-90 on the Earth's Surface IV": Report No. TID-24341. The average level of strontium-90 in New Zealand soils, of the order of 14 mCi/km<sup>2</sup> at the end of 1965, is in good agreement with their average soil values for 30° - 50° south latitude. This report also gives an average value of about 70 mCi/km<sup>2</sup> for 30° - 60° north latitude. Maximum depositions have occurred at these latitudes in each hemisphere with minimum depositions at polar and equatorial regions.

## 6. STRONTIUM-90 IN MILK

Country-wide average levels of strontium-90 in milk since about 1960 are shown in Fig. 2 and individual station levels in Fig. 5. The levels in New Zealand milk reached their maximum values during 1964 and 1965 when the deposition in rain was also a maximum. Although milk levels have decreased since then the decrease has been at a slower rate than the decrease in deposition because of the accumulating deposit of strontium-90 in soil and the continuing uptake from soil into grass.

During 1968 the country-wide average level was 5.2 Strontium Units, with individual station levels ranging from 1.6 Strontium Units at Christchurch to 14.0 Strontium Units at Greymouth. Table 4 lists the average levels at individual stations and the country-wide average levels since 1962.

TABLE 4 AVERAGE LEVELS OF STRONTIUM-90 IN MILK - STRONTIUM UNITS									
	1961	1962	1963	1964	1965	1966	1967	1968	Average 1962-1968
Northland	4.5	6.3	7.5	11.2	10.6	6.5	5.1	4.1	7.3
Auckland		5.5	5.3	9.1	9.4	6.1	5.2	3.8	6.3
Waikato	4.1	4.9	5.6	9.5	9.8	6.3	5.0	4.1	6.5
Taranaki	7.1	9.4	9.9	17.1	16.7	12.5	10.4	8.0	12.0
Palmerston North		4.3	4.9	7.1	8.4	4.8	3.9	3.6	5.3
Wellington					8.8	6.1	5.4	4.8	
Greymouth	12.7	13.5	17.2	26.0	28.8	22.7	17.8	14.0	20.0
Christchurch	1.6	2.1	2.7	2.6	4.3	2.4	1.9	1.6	2.5
Dunedin		3.0	3.7	4.1	7.4	4.0	3.1	2.4	4.0
Country-Wide Average		6.1	7.1	10.8	11.6	7.9	6.4	5.2	8.0

For health hazard assessment it is more significant to consider average levels over many years. If we postulate that the average levels in milk during the period 1962-1968 are maintained indefinitely in the diet as a whole, and if we accept the observed ratio of strontium-90 in bone to strontium-90 in diet as 1 to 4 then under these steady state conditions levels in the bones of New Zealanders would not exceed the levels listed in Table 5.

TABLE 5 STRONTIUM-90 HAZARD ASSESSMENT (1962-1968)		
STATION	STRONTIUM UNITS MILK BONE	% PERMISSIBLE LEVEL
Lowest Level (Christchurch)	2.5 0.6	0.9%
Highest Level (Greymouth)	20.0 5.0	7.4%
Country-wide Average	8.0 2.0	3%

Results of strontium-90 measurements in human bone samples are given in Table 14 Section D.

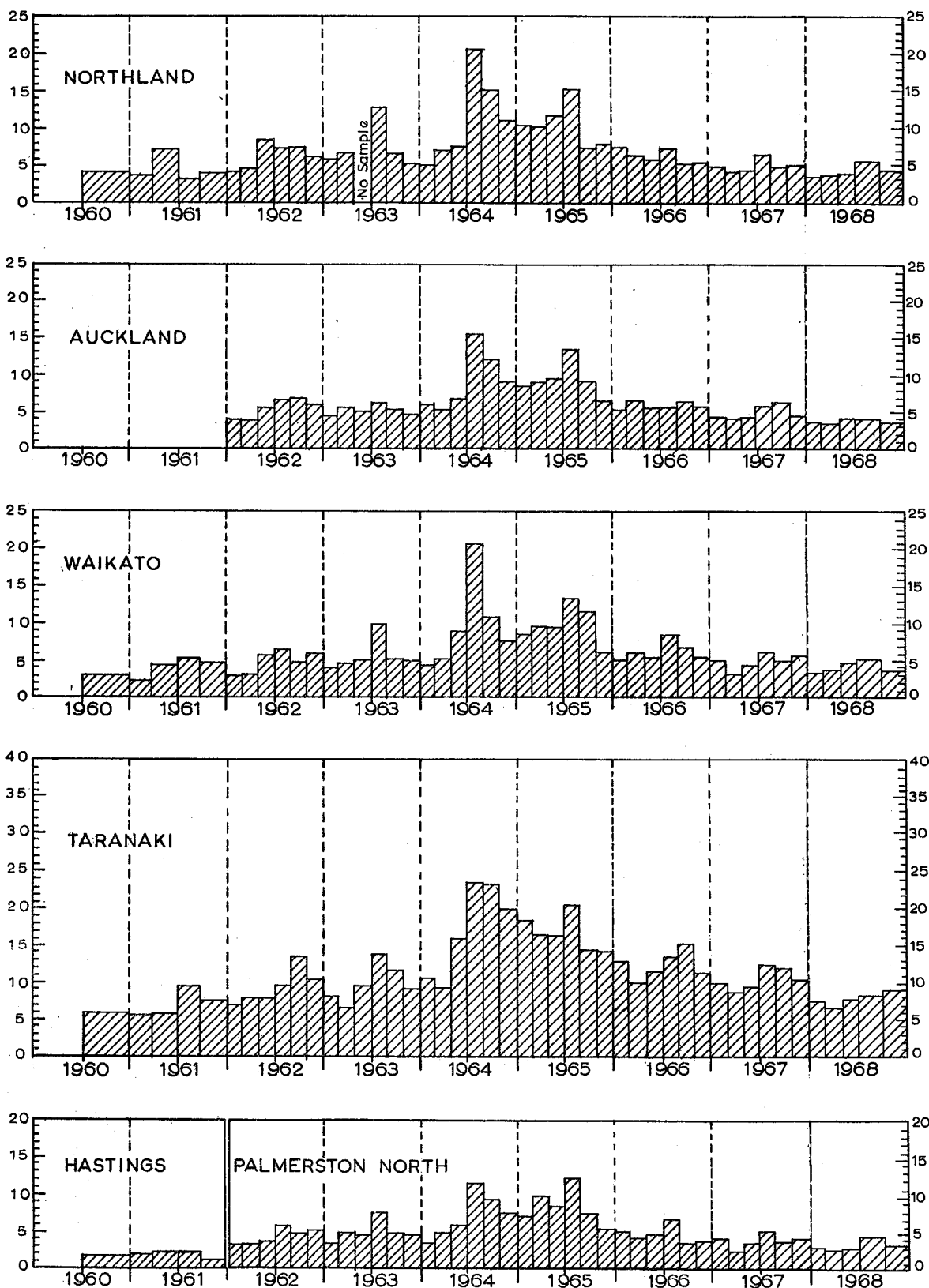


FIG. 5 STRONTIUM 90 IN MILK (Strontium Units = pCi Sr<sup>90</sup>/g calcium)

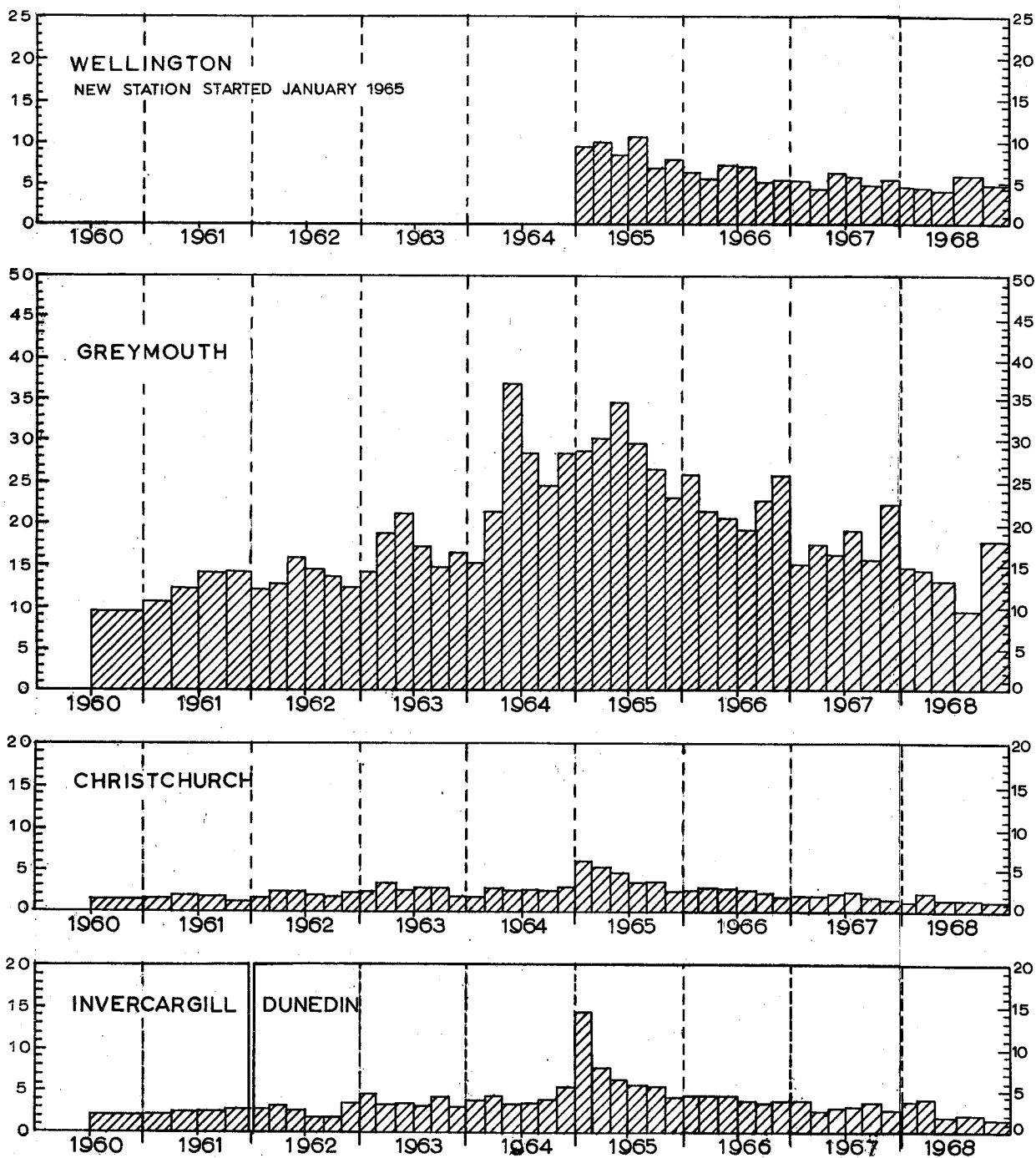
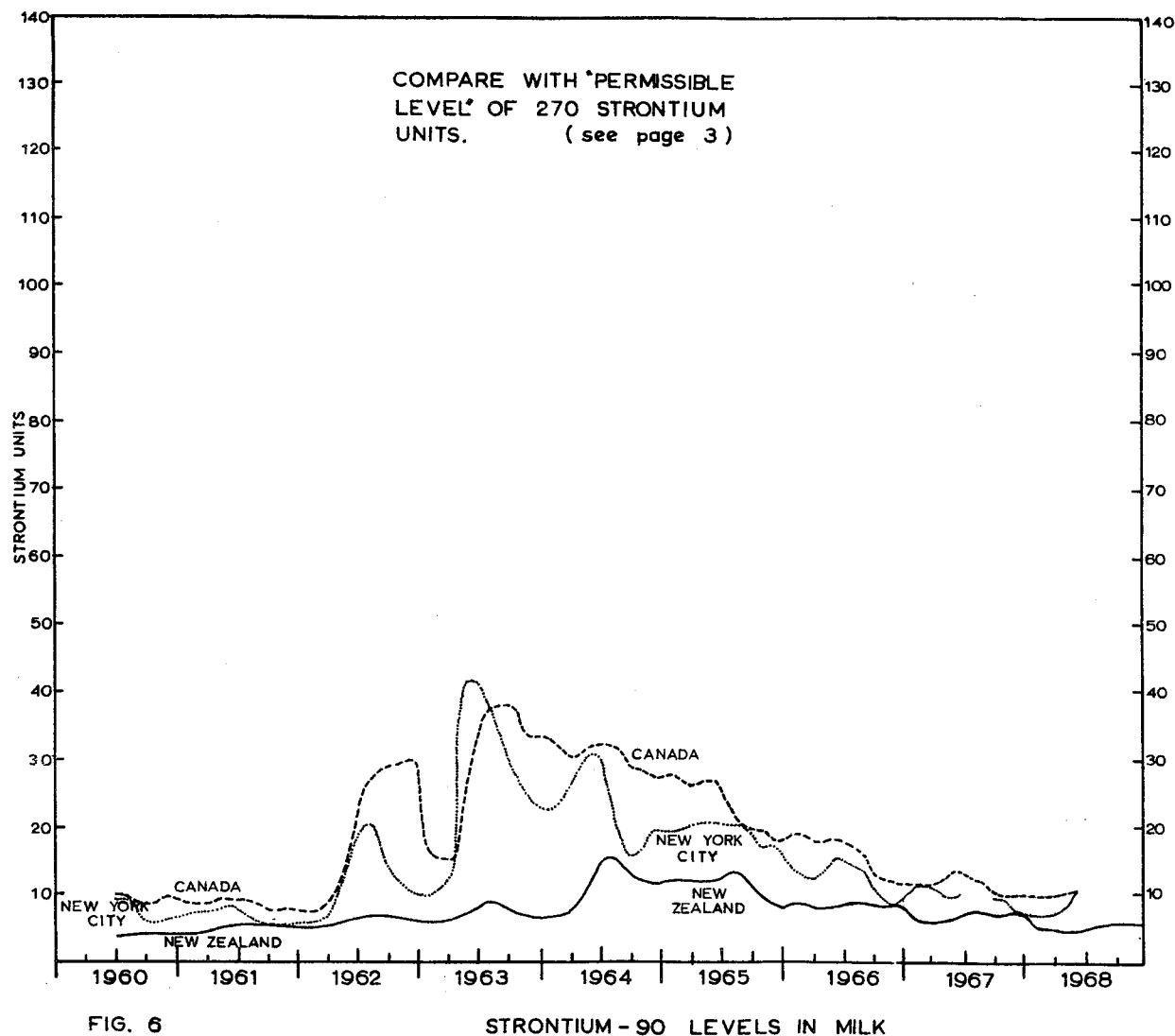


FIG. 5. STRONTIUM 90 IN MILK (Strontium Units= pCiSr<sup>90</sup>/g calcium)

In Fig. 6 a graphical comparison of the levels of strontium-90 in Canadian, New York City and New Zealand milk is given. The values shown for Canada and New Zealand are the averages of the results for all collecting stations. The Canadian values are taken from the monthly reports "Data from Radiation Protection Programs" of the Radiation Protection Division, Department of National Health and Welfare, Canada. The New York City values are the average of results from samples collected daily from the local milk supply, and are taken from the Fallout Program, Quarterly Summary Reports of the Health and Safety Laboratory, United States Atomic Energy Commission. For purposes of comparison the average level for each two monthly period is plotted for each locality.



## 7. CAESIUM-137 IN MILK

Country-wide average levels of caesium-137 in milk are shown in Fig. 2 and individual station levels in Fig. 7. The levels in New Zealand milk reached their maximum values during the first quarter 1965 and have subsequently decreased. Table 6 lists the average levels at individual stations and the country-wide average levels since measurements commenced.

TABLE 6	AVERAGE LEVELS OF CAESIUM-137 IN MILK - pCi/g K.					
	1964	1965	1966	1967	1968	Average 1964-1968
Northland	49	54	37	26	15	36
Auckland	51	53	33	26	18	36
Waikato	69	84	60	48	36	59
Taranaki	168	185	141	123	102	144
Palmerston North	19	26	11	7	3	13
Wellington	(25)*	29	18	13	7	18
Greymouth	76	77	43	33	21	50
Christchurch	7	11	4	3	1	5
Dunedin	11	18	9	5	3	9
Country-wide Average	53	60	39	31	23	41

\* estimated for averaging purposes.

During 1968 average levels ranged from 1 pCi/g K at Christchurch to 102 pCi/g K at Taranaki. The country-wide average level was 23 pCi/g K a decrease of about 26% on the level for the previous year.

For health hazard assessment average levels over longer periods are more significant. During the period 1964 - 1968 inclusive average station levels ranged from 5 pCi/g K at Christchurch (less than 0.1% of the permissible level) to 144 pCi/g K at Taranaki (about 2% of the permissible level). The country-wide average level over the same period was 41 pCi/g K which is about 0.6% of the permissible level for continuous consumption.

In Section D the results of the two special surveys which have been made over the past few years are again presented and brought up to date. These surveys are: (1) the levels of caesium-137 in milk from the five factories which constitute the Taranaki station, (2) the ratio of caesium-137 to strontium-90 in New Zealand milk.

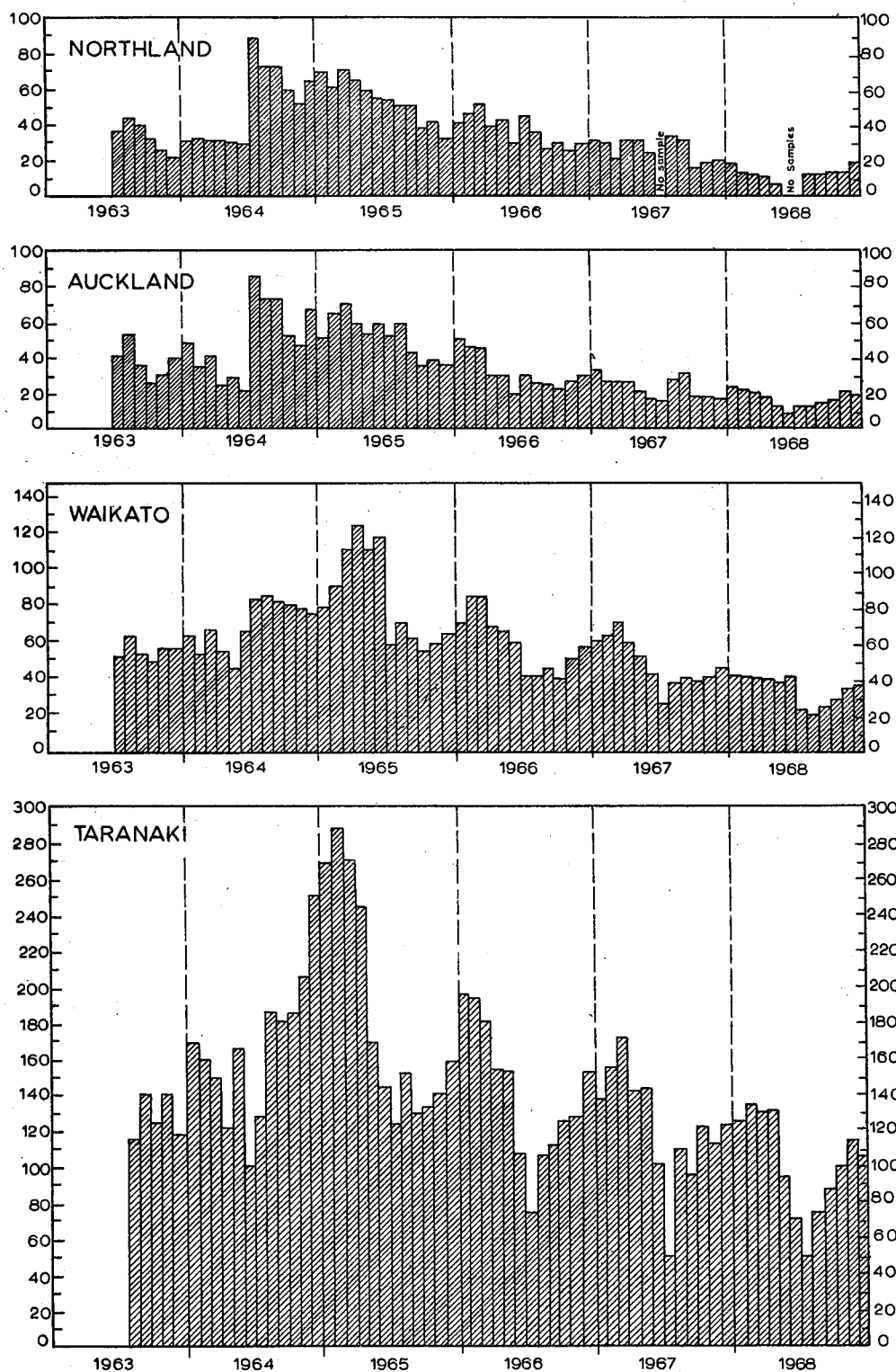


FIG. 7 CESIUM-137 IN MILK (pCi Cs<sup>137</sup>/g potassium)



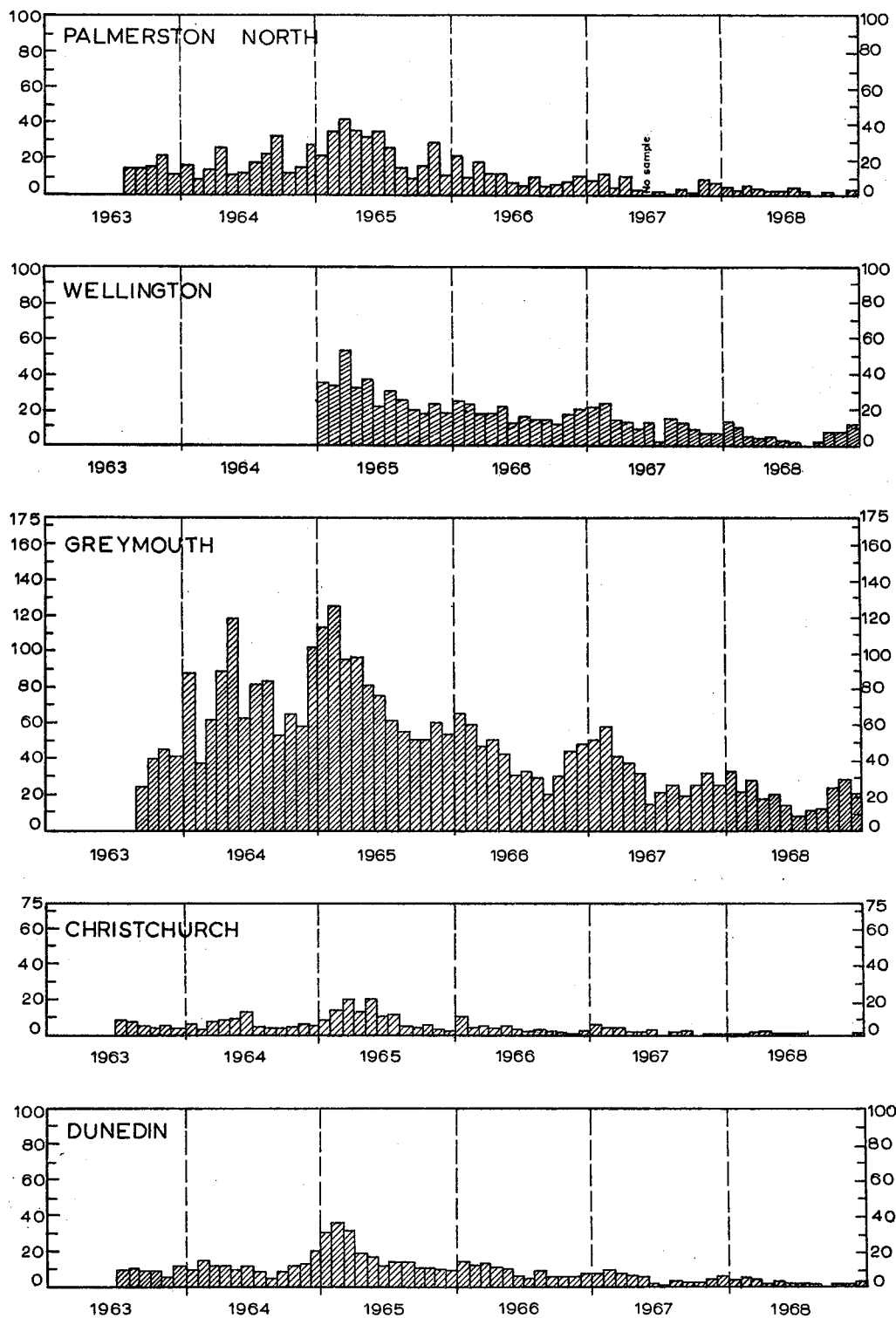


FIG. 7 CESIUM-137 IN MILK (pCi Cs<sup>137</sup>/g potassium)

## SECTION C

### RESULTS OF EXTENDED MONITORING OF FALLOUT FROM FRENCH NUCLEAR TESTS IN THE PACIFIC

During 1968 the third consecutive series of atmospheric nuclear tests in the Pacific Area was conducted by France at Islands in the Tuamotu Archipelago. Five nuclear devices, including for the first time two hydrogen bombs, were detonated between 8 July and 9 September 1968. (New Zealand Standard Time, i.e. G.M.T. + 12 hours). The New Zealand programme for monitoring the environmental radioactive contamination resulting from these tests commenced on 4 July and continued until the end of November.

Table 7 lists the dates and any information we have on yields of the nuclear tests in the Pacific during the past 3 years.

TABLE 7			NUCLEAR TESTS IN THE PACIFIC AREA		
1966			1967	1968	
3 July	25-30	Kiloton	6 June low yield	8 July	medium power
20 July	70-80	Kiloton	28 June low yield	16 July	medium power
12 Sept.	About 120	Kiloton	3 July low yield	4 Aug.	medium energy
25 Sept.	About 150	Kiloton		25 Aug.	Hydrogen bomb (2 megaton)
5 Oct.	200-300	Kiloton		9 Sept.	Hydrogen bomb

#### 1. GAMMA RAY RADIATION MONITORING

No gamma ray radiation readings exceeding 0.3 mR/hr (the lowest reporting level set for this monitoring service) were reported from any of the six Pacific Islands listed on page 8.

#### 2. FISSION PRODUCTS IN AIR

a) 1968 - The results of total beta activity measurements on daily air filter samples are shown in Fig. 8. Transient increases in air radioactivity have again been detected at all stations during the monitoring period. The daily results have been averaged over each calendar month for each station and are listed in Table 8.

TABLE 8					
1968 AVERAGE MONTHLY AIR ACTIVITY - pCi/m <sup>3</sup>					
	July	August	September	October	November
Nandi, Fiji	0.33	2.27	0.90	0.73	0.64
Suva, Fiji	0.51	2.64	1.24	0.98	(0.71)
Apia, Samoa	0.41	3.48	1.65	0.55	0.43
Tonga	0.18	1.60	0.97	0.69	0.61
Auckland	0.04	0.33	0.32	0.22	0.19
Wellington	0.10	0.35	0.24	0.14	0.11
Christchurch	0.04	0.29	0.16	0.10	0.09

b) Comparison 1966-1968. In Fig. 9 average monthly levels during the monitoring periods of the past 3 years are compared for each station.

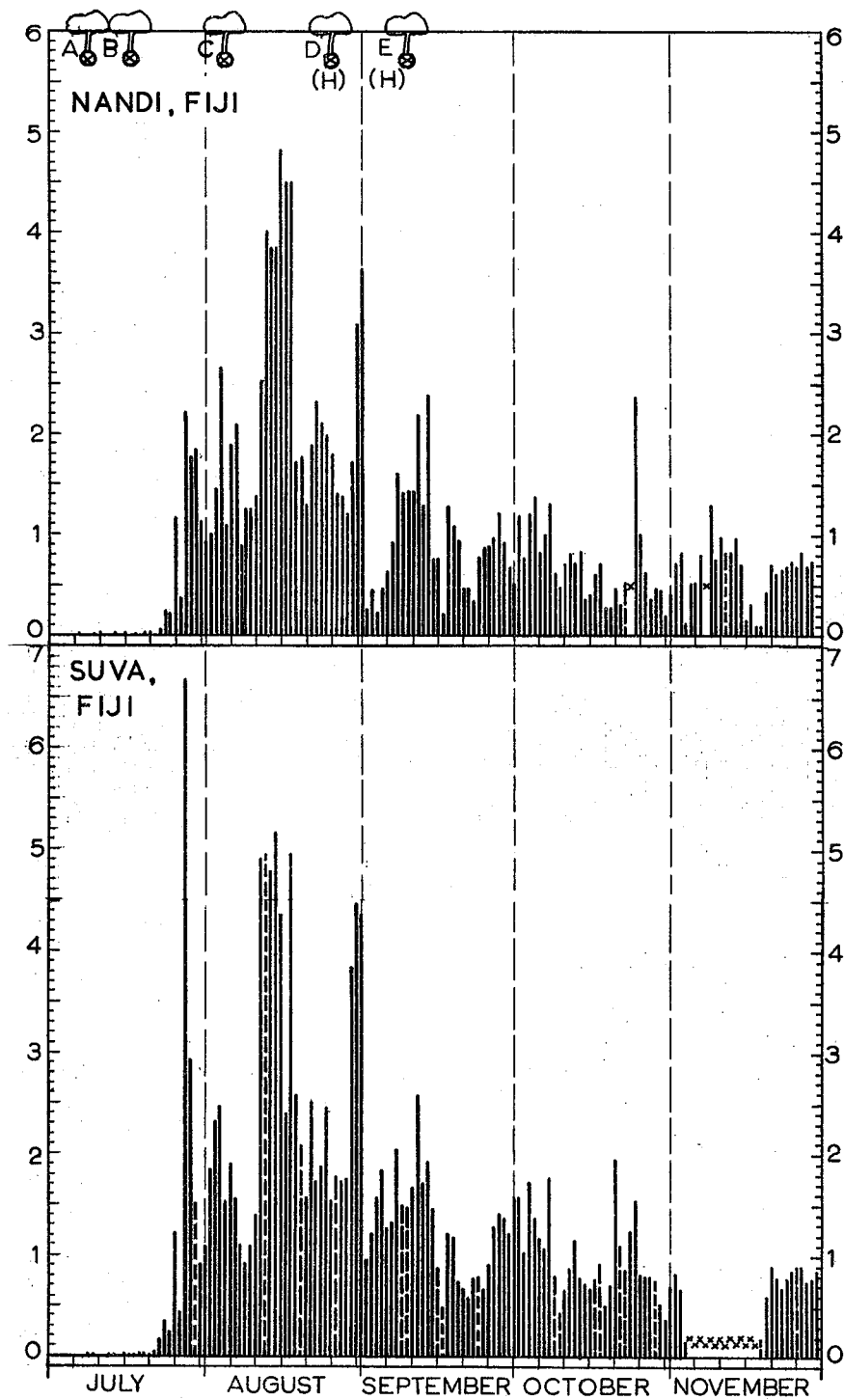


FIG. 8 TOTAL BETA ACTIVITIES OF  
DAILY AIR FILTER SAMPLES  
Stated in  $\text{pCi}/\text{m}^3$  at time of measurement

The interval between collection  
and measurement is shown thus:

x Indicates no sample received

3-5 6-9 10-15 >15  
days

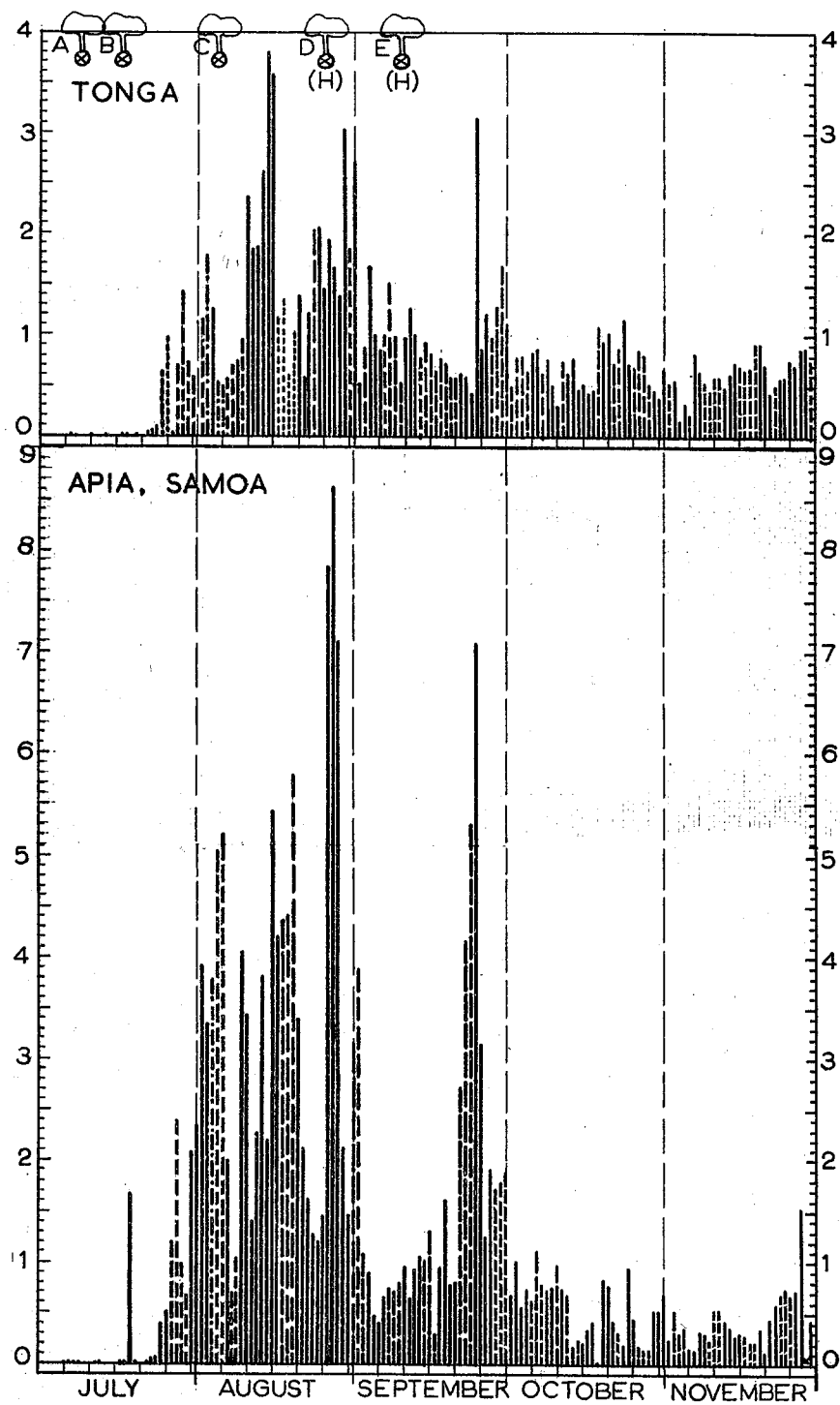


FIG. 8 TOTAL BETA ACTIVITIES OF  
DAILY AIR FILTER SAMPLES  
Stated in  $\text{pCi}/\text{m}^3$  at time of measurement

The interval between collection and measurement is shown thus:

x Indicates no sample received	3-5	6-9	10-15	>15
	days			

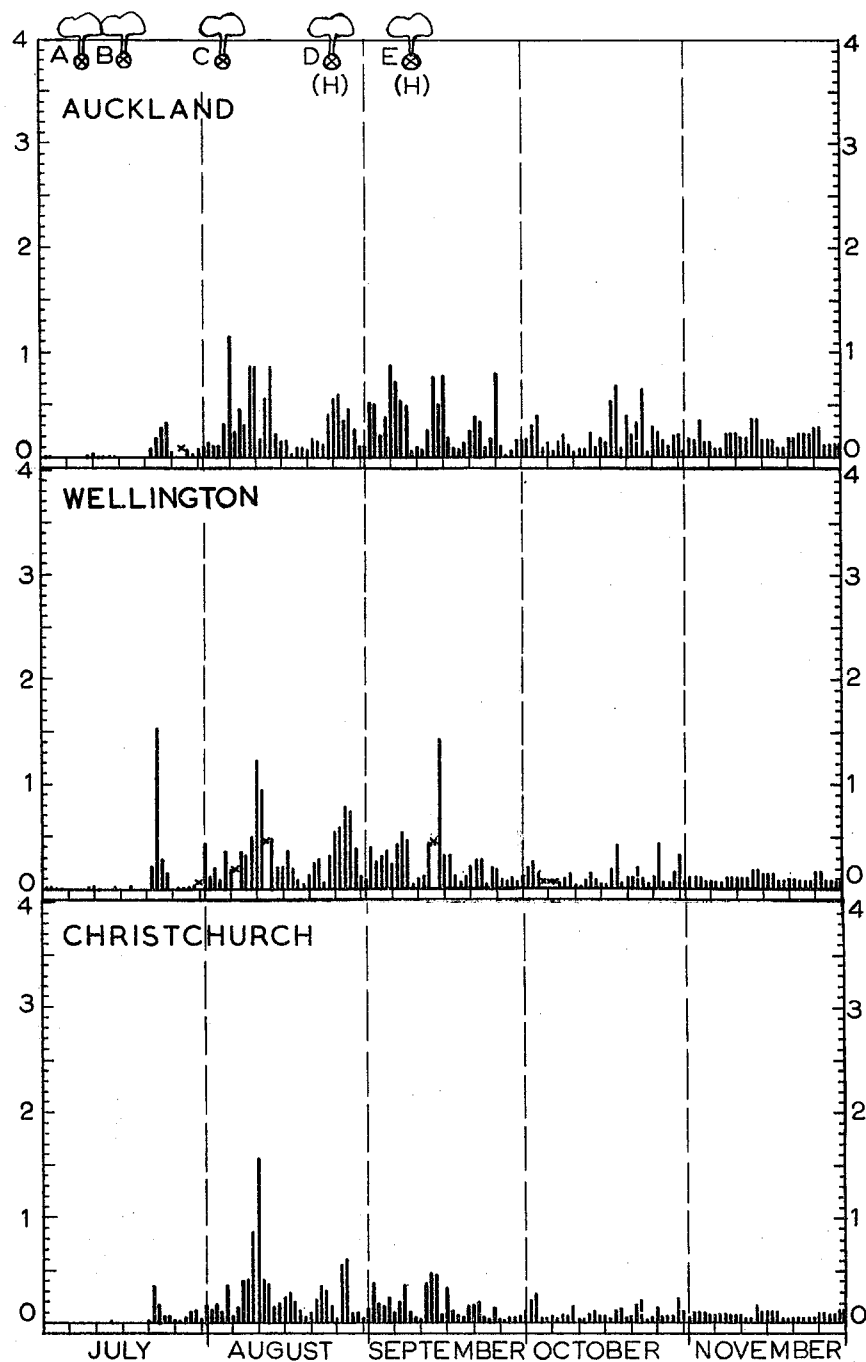


FIG. 8 TOTAL BETA ACTIVITIES OF  
DAILY AIR FILTER SAMPLES  
Stated in  $\text{pCi/m}^3$  at time of measurement

The interval between collection  
and measurement is shown thus:

x Indicates no sample received

3-5	6-9	10-15	>15
	days		

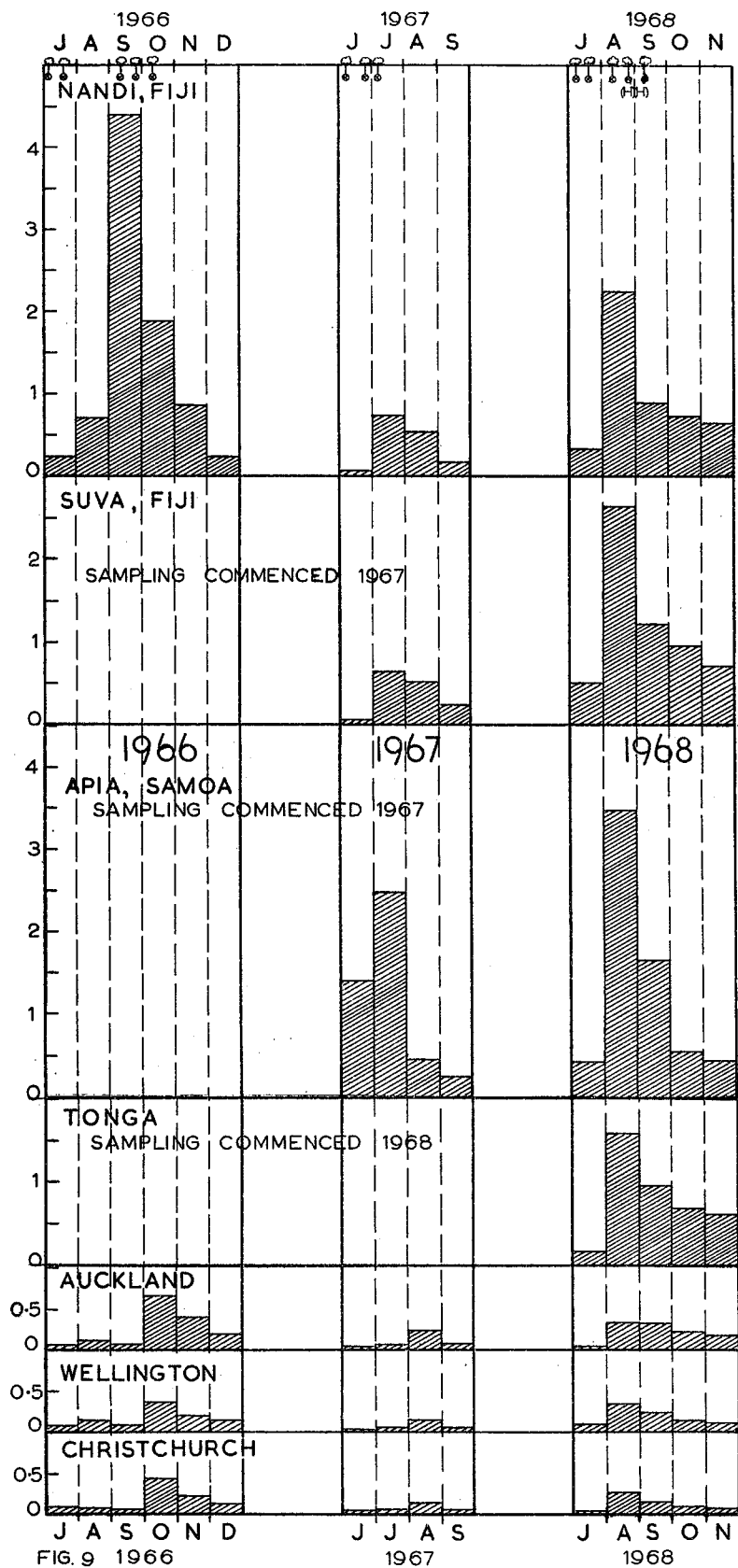


FIG. 9 1966 1967 1968  
TOTAL BETA ACTIVITY OF AIR FILTER SAMPLES  
 $\text{pCi/m}^3$  MONTHLY AVERAGES DURING EXTENDED  
MONITORING PROGRAMMES 1966-1968

Because each monitoring period started early in the month of the first explosion of each test series and continued until about 3 months after the last explosion of each test series, average levels for each monitoring period are also of interest for comparison purposes. These levels are listed for each station in Table 9.

TABLE 9 AIR ACTIVITY - pCi/m <sup>3</sup> AVERAGE FOR THE MONITORING PERIOD			
	1966 July-Dec.	1967 June-Sept.	1968 July-Nov.
Nandi, Fiji	1.39	0.38	0.97
Suva, Fiji		0.37	1.22
Apia, Samoa		1.15	1.30
Tonga			0.81
Auckland	0.26	0.11	0.22
Wellington	0.17	0.07	0.19
Christchurch	0.18	0.08	0.14

These results show that the inclusion of two hydrogen bombs in the five nuclear devices tested in the 1968 test series did not result in higher fission product contamination of air at our monitoring stations. The levels in 1968 were in general somewhat lower than levels in 1966 when five atomic devices were tested. The lower levels in 1967 reflect the smaller number of devices tested.

Apia, Samoa was the station with the highest average level during the 1968 monitoring period i.e. 1.30 pCi/m<sup>3</sup>. This level is less than 0.5% of the permissible level for continuous breathing by the general population.

### 3. FISSION PRODUCTS IN RAIN

The results of measurements of total beta activity of weekly rain samples are shown in Fig. 10 for the three monitoring periods during 1966-1968.

NOTE: The results shown are for the level of radioactivity on the day of measurement and are not adjusted for radioactive decay since collection. The degree of adjustment required will depend on the age of the fission products at collection and the time delay until measurement. Some time delay due to transport of samples is unavoidable and this is relatively more important for those stations not on a regular air service, i.e. Niue, Aitutaki and Rarotonga. More detailed information on collection and measurement dates is given with the results tabled and graphed in the quarterly reports over the past three years. During 1968 the following approximate correction factors would apply in most cases:

STATIONS	LEVEL AT MID-COLLECTION TIME
Niue, Aitutaki, Rarotonga	= 2-5 times the level at measurement time
Other Pacific Islands	= 1.5-2.3 times the level at measurement time

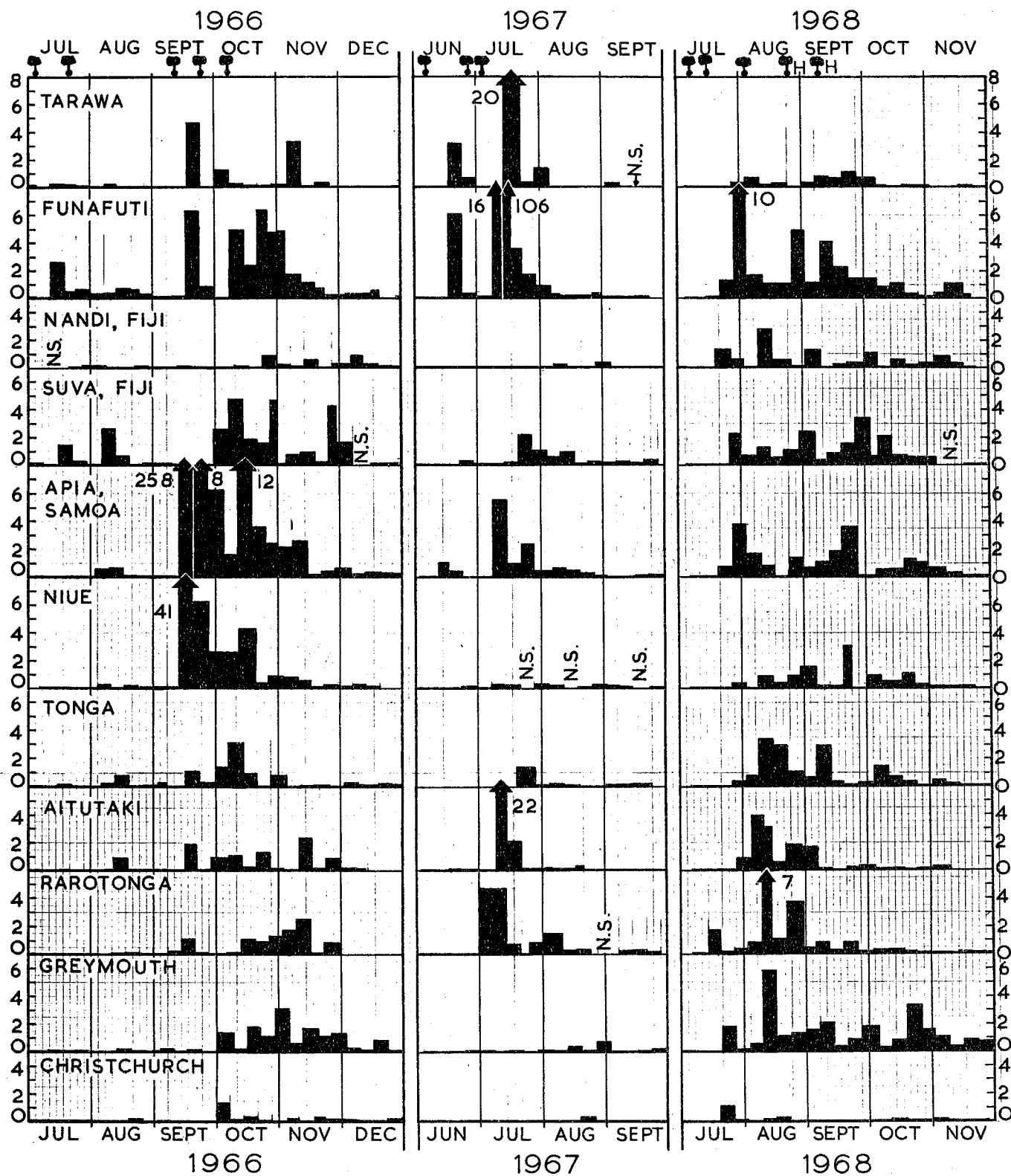


FIG. 10 TOTAL BETA ACTIVITIES OF RAINWATER SAMPLES AT TIME OF MEASUREMENT

Average daily deposition mCi/km<sup>2</sup> during periods shown

N.S.= NO SAMPLE



In Table 10 the concentration of fission products in rainwater at the collecting station of highest fallout is given for each monitoring period. The values of concentration are calculated from the total deposition and total rainfall during the monitoring period and are used for hazard assessment by comparing them with permissible levels in drinking water for mixed fission products between 10 and 80 days old.

TABLE 10 CONCENTRATION OF FISSION PRODUCTS IN RAIN 1966-1968					
MONITORING PERIOD	STATION	HIGHEST LEVELS		AVERAGE FOR MONITORING PERIOD	
		COLLECTION PERIOD	AVERAGE pCi/litre	pCi/litre	% PERMISSIBLE LEVEL FOR CONTINUOUS DRINKING
1966 July-Dec.	Samoa	30 Aug.-27 Sep.	11,800	1,530	25%
1967 June-Sep.	Funafuti	1 July-29 July	1,530	530	9%
1968 July-Nov.	Funafuti*	3 Aug.-2 Sep.	507	211	4%

\* Although Funafuti is listed as the station of highest fallout level for 1968, the levels were in fact fairly typical of levels at several islands during the monitoring period.

Summing up, it may be said that levels were generally lower in 1967 although peak levels were lower in 1968 than in the preceding two years.

#### 4. STRONTIUM-89 IN RAIN

The routine measurements of strontium-90 in monthly rainwater collections have been extended since June 1966 to include the measurement of the relatively short-lived strontium-89 (half-life 50 days). These measurements have indicated the presence of fresh fission debris from the French Nuclear Tests in the Pacific, and the ratio of strontium-89 to strontium-90 indicates the contribution made to the deposit of strontium-90 by current nuclear testing.

In 1966 strontium-89 was first detected in the July rainwater collections at all New Zealand stations, Suva and Rarotonga, following the first nuclear explosion of 3 July. Levels reached their maximum values in the October and November collections following the final three tests of the 1966 series. By May 1967 levels had fallen nearly to the limit of detection.

In June 1967 levels started to increase following the first test of the 1967 series on 6 June. Maximum levels for 1967 occurred in July at the two Pacific Island stations and in August at the New Zealand stations. By December 1967 levels had again fallen nearly to the limit of detection.

In July 1968 levels again increased following the first test on 8 July. Maximum levels in 1968 occurred in July and August at the Pacific Islands and in August at the New Zealand stations.

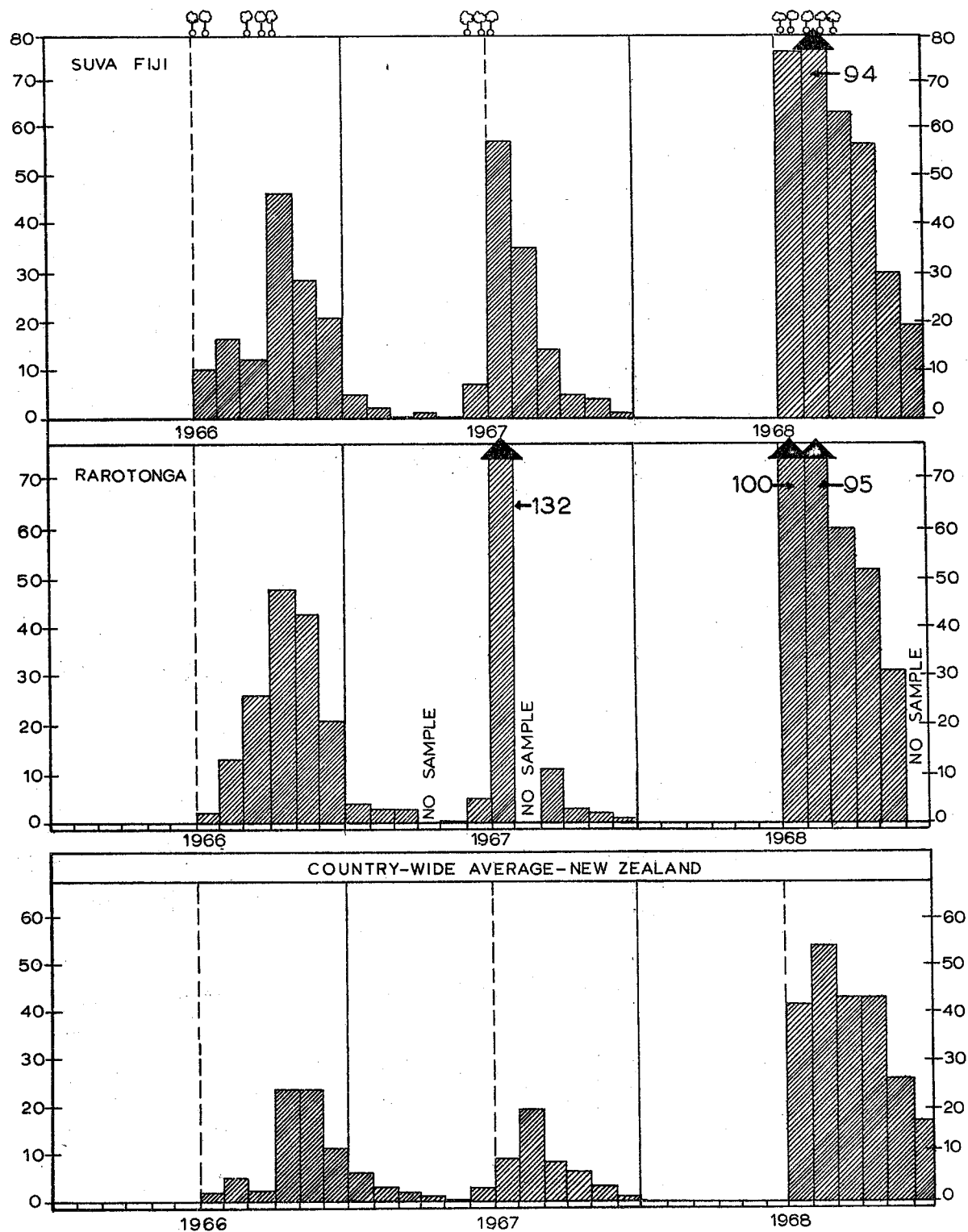


FIG. 11 RATIO STRONTIUM-89 TO STRONTIUM-90 IN RAINWATER SAMPLES

In Fig. 11 the ratio of strontium-89 to strontium-90 is shown for Suva (Fiji) and Rarotonga and the country-wide average ratio is shown for New Zealand. Values of this ratio indicate that in New Zealand the deposition of strontium-90 (see Section B) during 1966 and 1967 resulted largely from delayed global fallout from nuclear tests prior to 1963. In 1968 a larger proportion of the strontium-90 deposit derived from the French tests mainly as a result of decreasing stratospheric fallout of strontium-90 from past tests.

The higher values of the ratio for Suva and Rarotonga compared with those for New Zealand reflect the higher fallout of fresh fission debris at latitudes of the recent nuclear tests as well as the lower levels of stratospheric fallout of strontium-90, from past nuclear tests, at regions nearer the equator.

#### 5. IODINE-131 IN MILK AND CATTLE THYROIDS

Even though iodine-131 has a very short half-life of 8 days, its high yield in nuclear explosions, and its property of concentrating in thyroid make it the radionuclide of most health concern amongst the shorter-lived fission debris. Iodine-131 is present in milk within one day of pasture contamination. After each cessation of nuclear tests in the atmosphere, iodine-131 in the environment is reduced by radioactive decay to negligible proportions within a month or two.

The maximum permissible level in milk is based on the most critical age group (young children) and is 200 pCi/litre as an average intake over one year, or higher concentrations for correspondingly shorter times. During the 1966-1968 monitoring programmes, milk from seven New Zealand stations and two Pacific Islands has been measured for radioiodine. In addition, because of the enhanced sensitivity of detection of iodine-131 in animal thyroids, these samples have been used as an indicator of the arrival of iodine-131 in New Zealand.

##### (a) MILK

Iodine-131 levels in New Zealand milk were higher in 1966 than in the following two years. In 1966 the country-wide average level was about 7 pCi/litre during the monitoring period. Averaged over the year this reduces to about 4 pCi/litre or about 2% of the "permissible level". For 1967 and 1968 the levels were <1% and 1% of "permissible levels" respectively.

In Suva and Samoa levels were significantly higher ranging from about 25% of permissible level at Suva during 1966 to 4% of permissible level at Suva during 1967.

Table 11 summarizes the results of measurements and compares the levels with permissible levels.

TABLE 11				IODINE-131 IN MILK 1966-1968								
Stations	pCi/litre									% of Maximum Permissible Level		
	Maximum Level for Individual Sample			Average Level for Monitoring Period			Average Level for Year					
	1966	1967	1968	1966	1967	1968	1966	1967	1968	1966	1967	1968
New Zealand (country-wide average)	36	14	50	7	<5	5	~4	~1	~2	2%	<1%	1%
Suva, Fiji	*	151	135	*	23	36	(50)	8	12	(25%)	4%	6%
Apia, Samoa	*	708	91	*	68	28	(40)	23	9	(20%)	11%	5%

\* It was not originally intended to include milk from the Pacific Islands in this monitoring programme because of the small production and consumption of fresh milk in the Islands. After the increase in air radioactivity at Fiji on 17 September 1966, and in rainwater from Samoa collected during the week 13-20 September 1966 (See Report NRL-F23) it was decided to obtain milk samples for measurement of radioiodine. The first samples were collected at Suva on 8 October and at Apia on 6 October 1966, and an attempt has been made to assess the levels existing during the three weeks prior to collection by extrapolation of measured values back to 17 September. The bracketed values for the 1966 average level and the percentage of maximum permissible level at Suva, and Apia are based on these calculations and are only approximate. They are probably correct to within a factor of two.

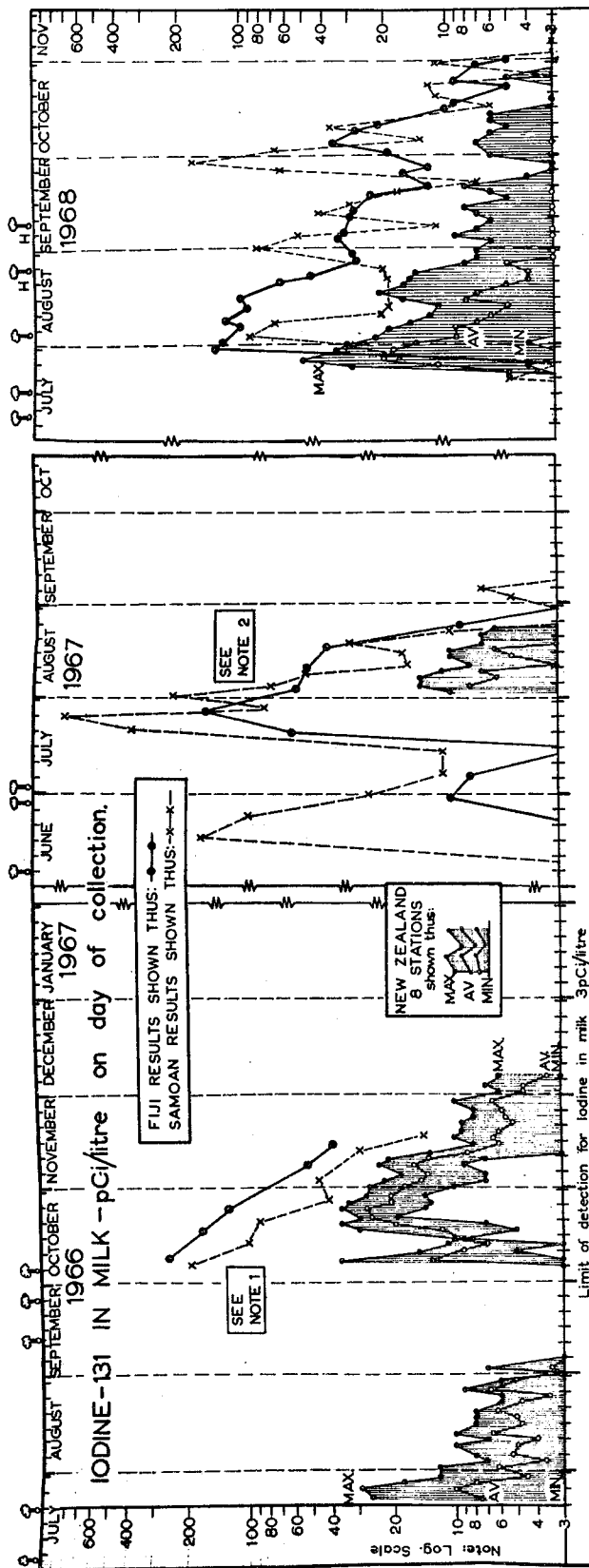
#### (b) CATTLE THYROIDS

During 1966 iodine-131 reached a maximum country-wide average level of 320 pCi/g of thyroid, and highest individual station level of 726 pCi/g at Gore, from cattle slaughtered on 31 October.

During 1967 the levels were lower. The maximum country-wide average level was 55 pCi/g and the highest individual station level 169 pCi/g at Westport, from cattle slaughtered on 14 August.

During 1968 the levels increased again. The highest country-wide average level was 139 pCi/g towards the end of July and the highest individual station level was 356 pCi/g at Palmerston North from cattle slaughtered on 12 August.

The results of the measurements of iodine-131 in milk and cattle thyroid are shown graphically in Fig. 12. While there is some obvious correlation between the two (i.e. the average concentration in milk expressed as pCi/litre is approximately equal to one-tenth the average concentration in thyroid expressed as pCi/g) the peak activities do not coincide in time, the rise and fall of the thyroid activity lagging slightly behind that of milk.



Note 1 Not originally part of monitoring programme - measurements commenced following rainfall at Samoa.

Note 2 Varying levels at Samoa due to random sampling from 3 separate herds.

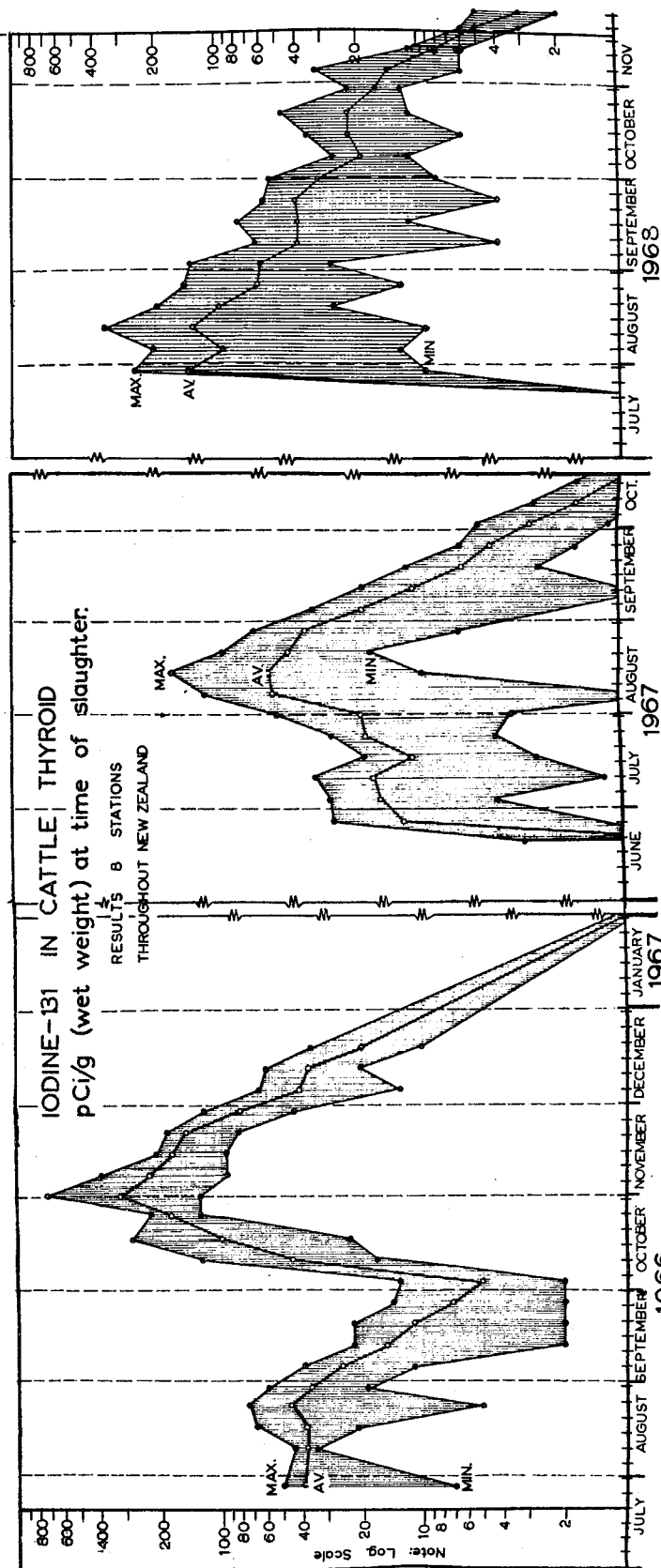
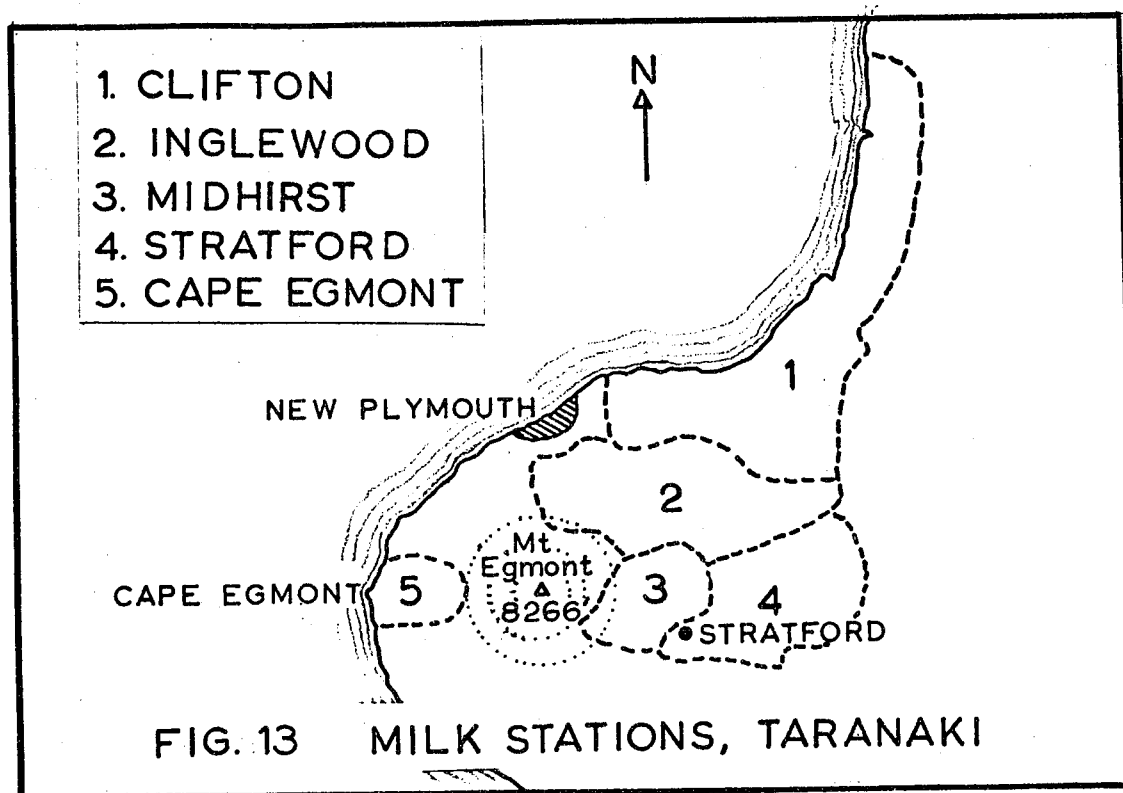


FIG.12 IODINE 131 IN MILK AND CATTLE THYROIDS

SECTION D  
SPECIAL SURVEYS AND MISCELLANEOUS MEASUREMENTS

1. CAESIUM-137, INDIVIDUAL MILK STATIONS, TARANAKI

Throughout the year separate analyses were again made on the monthly milk samples from the 5 factories which constitute the Taranaki station in our milk network. Their collection areas are indicated in Fig. 13. Previous values were given on page 32 of NRL-F28.



The previously determined pattern of high values in late summer and low values in late winter is apparent, and this seasonal variation is least for Cape Egmont, Clifton, and Inglewood and most marked for Midhirst.

These results conclude the survey of caesium-137 levels in milk from individual milk stations in Taranaki.

TABLE 12 CAESIUM-137 IN MILK TARANAKI PROVINCE 1968												
STATION	pCi/g K											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Clifton	96	99	72	73	126	NS	46	59	86	65	95	73
Inglewood	NS	211	197	163	188	70	90	NS	NS	147	147	NS
Midhirst	203	195	197	198	32	NS	NS	128	141	142	155	175
Stratford	115	109	112	109	76	74	24	80	71	NS	79	112
Cape Egmont	75	67	79	70	71	67	36	51	56	44	62	74

NS: No Sample received.

## 2. CAESIUM-137 TO STRONTIUM-90 RATIOS IN MILK

The evaluation of the Caesium-137 unit to Strontium-90 unit ratios ( $\text{pCi Cs}^{137}/\text{g K}$  to  $\text{pCi Sr}^{90}/\text{g Ca}$ ) for the New Zealand milk network has been continued through 1968 and the pattern of results is similar to that found in previous years.

Table 13 lists the annual averages of the ratio since 1963 for the stations of the New Zealand milk network and Fig. 14 shows the seasonal variation of the ratio for the stations of special interest i.e. Taranaki and Waikato.

TABLE 13 CAESIUM-137/STRONTIUM-90 RATIOS IN MILK - ANNUAL AVERAGES ( $\text{pCiCs}^{137}$ per g K/ $\text{pCiSr}^{90}$ per g Ca)						
	1963	1964	1965	1966	1967	1968
Taranaki	12.8	10.8	11.2	11.7	12.2	13.0
Waikato	9.6	9.0	9.0	9.9	10.8	9.2
Auckland	6.7	5.7	5.9	5.6	5.2	4.9
Northland	5.5	4.6	5.3	5.7	5.1	3.6
Remaining Stations	2.5-3.4	2.5-3.0	2.4-3.3	1.9-3.0	1.6-2.5	0.8-1.5
Average All Stations	5.8	5.1	5.1	5.0	4.8	4.1
Average excluding Taranaki and Waikato	4.0	3.5	3.6	3.3	2.8	2.1

Caesium-137 fallout in New Zealand was a maximum during the latter half of 1964 and first quarter of 1965. Levels in milk were a maximum during 1965 and have steadily decreased since then. Values of the ratio have also decreased since 1965 except for Taranaki and Waikato. In Taranaki milk, the ratio was still increasing slightly up to and including 1968. In Waikato milk the ratio increased from 1965 to 1967 but decreased in 1968.

The marked seasonal variation in the ratio has recurred each year from 1963 through to 1968. The variation is particularly noticeable for Taranaki and Waikato where the summer value is about twice as high as the winter value.

The normal range of the ratio is from 1.0 - 5.0, although it has been established that in certain areas (notably Florida, Jamaica and at certain special sites in England), the ratio has a value very similar to that found in Taranaki and Waikato, and undergoes a similar seasonal variation.

The high values of the ratio in New Zealand appear to be typical of a particular geographical area of the North Island with highest values at Taranaki on the western side of the island and progressively decreasing values towards the north, i.e. Waikato, Auckland and Northland. Stations to the east

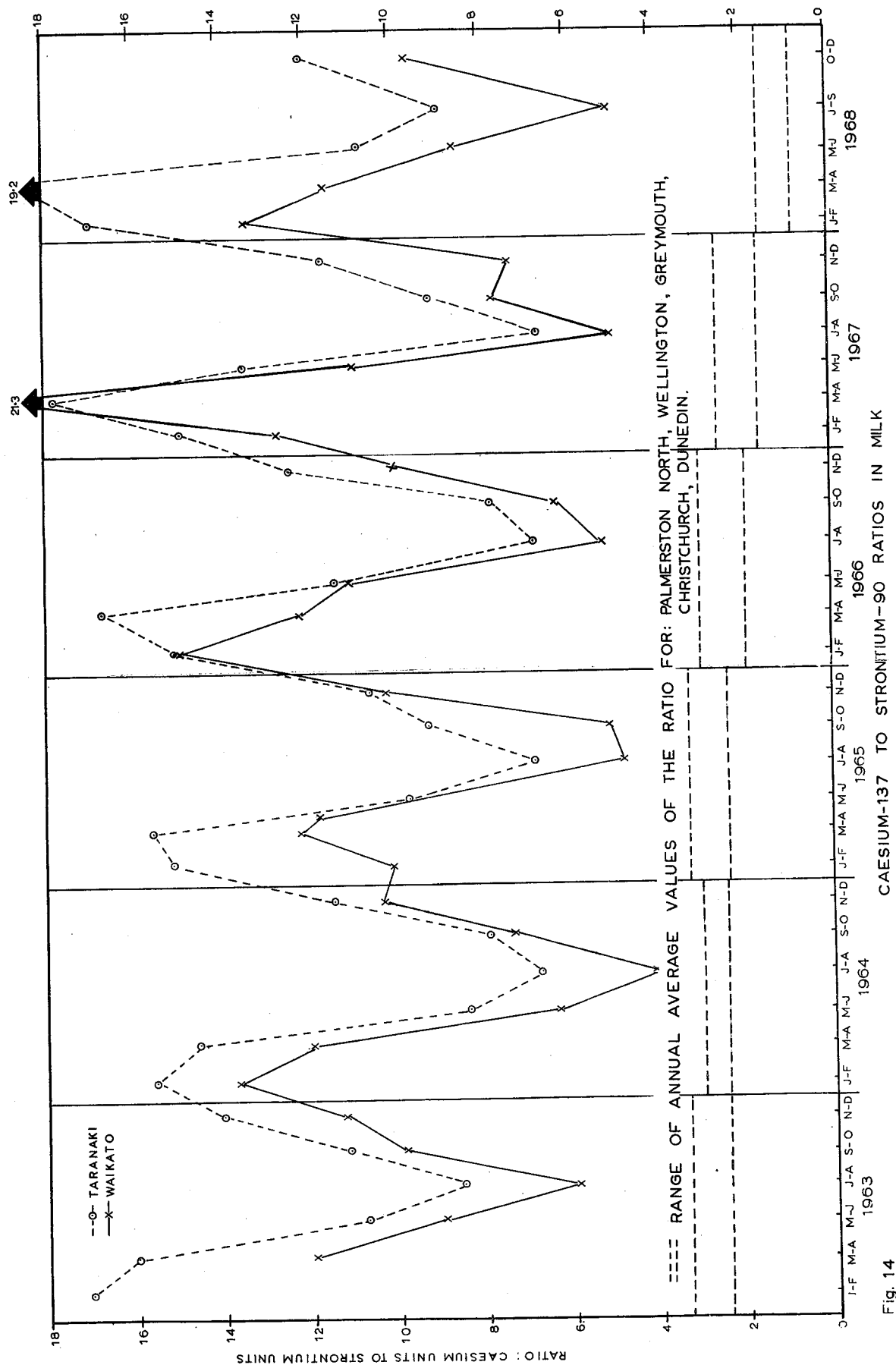


Fig. 14



and south of Taranaki and all South Island stations give "normal" values of the ratio. The soils of Taranaki and Waikato are distinguished from other New Zealand soils being classified as yellow brown loams derived from recent and holocene volcanic ash.

The exchange capacity for caesium and strontium of representative soils from the milk station districts has been investigated during the year. The results indicate, without exception, that high values of the ratio arise from those soils which have a relatively low ability to fix caesium thus making it more available for uptake by grass.

### 3. LEAD-210 IN RAIN

Lead-210 is produced in the atmosphere by decay of radon-222 diffusing from land surfaces. The resulting "natural fallout" of lead-210 is of health interest. During 1965 and 1966 a special survey was conducted at four sites selected from the network of rainwater stations which supply regular monthly samples for strontium-90 determination. The results of this survey were published in our Annual Summary 1967, Report No. NRL-F28. The results showed that lead-210 deposition in 1965 had been about twice that in 1966 and the possibility of lead-210 having been formed artificially in one or more of the explosions during the 1961 and 1962 test series was mentioned.

In May 1967 this survey was re-started at all collecting stations and the results for monthly collections up to December 1968 are shown in Fig. 15. During this period the country-wide average deposition of lead-210 has ranged from 0.08-0.26 mCi/km<sup>2</sup>/month, with a mean value of 0.13 mCi/km<sup>2</sup>/month i.e. about the same as in 1966.

During the course of this survey it was noticed that in about one sample in every twelve chemical recoveries of added lead carrier were in excess of 100% i.e. stable lead was also being collected along with the rain sample in these cases. Enquiries were made at the collecting stations, which in most cases were meteorological compounds at airports, and it became evident that the lead deposit derived from piston engined aircraft using leaded petrols. It was not considered desirable or practicable in most cases to change the location of the collecting sites, which have been established for many years for strontium-90 monitoring, in order to overcome this effect. In the case of Rarotonga, however, the collector was removed further from the runway.

All rainwater collections are made for one calendar month in 30 cm diameter pots. The sample containing the most deposited lead (25 mg of lead) was collected at Rarotonga. For New Zealand samples giving lead recoveries greater than 100% the stable lead deposited ranged from at least 0.2 mg to at least 15 mg per month with a mean value of at least 3.4 mg per month.

The uncertainty about the amount of stable lead deposited will give a low bias to the results shown in Fig. 15. It is estimated that results should be increased by up to 10% in many cases and perhaps in a few cases by 20% or more.

This survey is being continued during 1969. The effect of stable lead deposition is being minimized by increasing the amount of lead carrier used and by altering the procedures so that the daughter nuclide Bismuth-210 is separated for measurement.

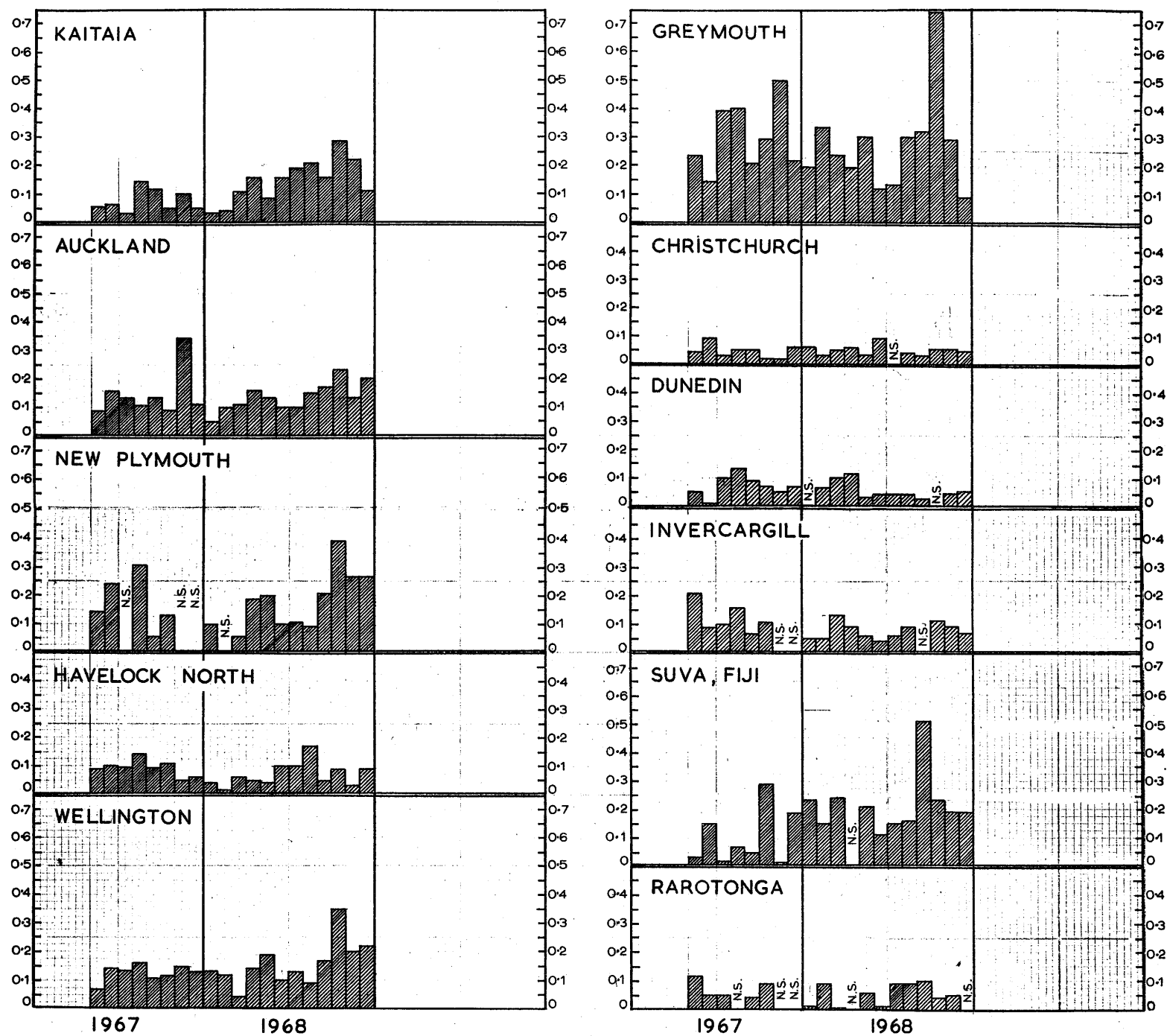


FIG. 15 LEAD-210 IN RAIN  $\text{mCi/km}^2/\text{month}$   
N.S. - NO SAMPLE

#### 4. STRONTIUM-90, RADIUM-226 AND LEAD-210 IN HUMAN BONE

Table 14 summarizes all the results of measurements of long-lived artificial and natural radionuclides that have been made on New Zealand samples. Previously published results (see REPORTS DXRL-F7 and F8, and NRL-F11, 13, 14, 23 and 28) are included in this table.

The areas from which human bone samples have been obtained within New Zealand are classified according to mean annual rainfall as follows:

Low rainfall	up to 100 cm per year
Medium rainfall	100 - 150 cm per year
High rainfall	over 150 cm per year

TABLE 14 RADIONUCLIDES IN HUMAN BONE							
Sample No.	Rainfall Area	Date of Death	Age at Death	Bone	RADIONUCLIDE LEVELS		
					ARTIFICIAL	NATURAL	
					Strontium-90 pCi/g Ca	Radium-226 pCi/g ash	Lead-210 pCi/g ash
3	Low	7/61	5m	F,V,R	0.9	0.016	0.044
4	"	7/61	9y	F,V	0.6	0.011	0.048
7*	"	9/61	23y	F,V	0.7	0.214	0.340
1	"	6/61	53y	F	<0.1	0.026	0.093
2	"	7/61	60y	F	<0.1	0.011	0.089
33	"	9/61	78y	H	0.2	0.012	0.046
34	"	9/61	79y	H	0.1	0.013	0.035
29	"	2/61	83y	H	0.1	0.017	0.043
5	High	9/61	68y	F	0.2	0.012	0.073
31	"	11/61	68y	H	0.3	0.010	0.063
8	"	10/61	80y	F	<0.1	0.040	0.098
6	"	9/61	85y	F	<0.1	0.010	0.099
10	Low	5/62	7y	F	0.5	0.020	0.086
36	"	1/62	56y	H	0.3	0.009	0.100
32	Medium	2/62	53y	H	0.3	0.046	0.168
30	"	2/62	67y	H	0.2	-	-
19	High	12/62	9m	F	3.2	0.036	0.075
11	"	11/62	1y	F	2.1	-	-
12	"	11/62	2y 6m	F	1.2	0.020	0.056
23	"	12/62	8y	F	1.6	0.026	0.070
9	"	5/62	16y	F	1.4	0.017	0.136
15	"	11/62	16y	F	0.6	0.013	0.053
14	"	11/62	19y	V,R	0.9	0.013	0.174
13	"	11/62	72y	V	0.9	0.021	0.159

Continued on Page 43

TABLE 14 (continued)

Sample No.	Rainfall Area	Date of Death	Age at Death	Bone	Strontium-90 pCi/g Ca	Radium-226 pCi/g ash	Lead-210 pCi/g ash
16	Low	11/63	4y	F	2.3	{0.009	{0.088
"				V	2.5		
35	Medium	6/63	84y	H	0.3	0.041	0.072
17	High	8/63	1y 3m	F	2.1	0.026	0.091
27	"	12/63	3y 9m	L	2.2	0.012	0.076
18	"	8/63	5y	F	1.3	0.010	0.071
22	"	7/63	5y 6m	F	1.4	0.008	0.045
21	"	1/63	7y	F	0.9	0.026	0.139
20	"	2/63	19y	F	1.4	0.023	0.068
25	Low	4/64	SB	L	1.0	-	-
"				R	1.0	-	-
"				V	0.9	-	-
26	"	4/64	SB	L	0.6	-	-
"				R	0.9	-	-
"				V	0.8	-	-
"				S	0.7	-	-
24	"	4/64	6y	F	1.2	{0.021	{0.064
"				V	1.0		
28	High	2/64	6y	L	1.4	0.008	0.052
46	Low	7/66	7y	F	1.8	0.009	0.093
42	"	6/66	16y 6m	F	1.0	0.074	0.095
43	"	6/66	19y	F	0.5	0.010	0.054
49	**	9/66	18y	F	0.5		
52	Medium	8/66	3y	F	2.1		
41	"	6/66	3y 6m	F	2.4	0.020	0.065
44	"	6/66	7y	F	1.9	0.006	0.045
47	"	7/66	7y	F	2.2	0.013	0.035
53	"	8/66	9y	F	1.2		
51	"	8/66	14y	F	1.1		
87	"	12/66	14y 7m	F	1.0		
78	"	12/66	15y	F	1.7		
30	"	10/66	16y	F	0.9		
38	"	6/66	17y	F	1.0	0.021	0.044
45	"	6/66	20y	F	0.9	0.010	0.044
48	"	8/66	22y	F	0.6		
40	"	6/66	24y	F	0.5	0.012	0.069
54	"	8/66	25y	F	0.4		
39	"	6/66	31y	F	0.5	0.016	0.085
37	High	5/66	17y	F	1.0	0.014	0.054

Age at death: y year, m month, SB stillborn.

Bone: F femur, H humerus, L long bones, V vertebrae, R rib, S skull.

\* Occupationally exposed to luminizing materials.

\*\* Resident in New Zealand a very short time - most of life spent in Australia.

## ACKNOWLEDGEMENT

### Work Done on Collection of Samples

The assistance of the Director of the New Zealand Meteorological Service (Dr J. F. Gabites) and of his staff of observers has made it possible to:

1. Obtain gamma radiation dose rate measurements several times each day at 6 Pacific Islands from the monitoring instruments installed by this Laboratory;
2. Obtain daily air filter samples at 4 Pacific Islands and at Wellington from the air samplers installed by this Laboratory;
3. Obtain weekly rainwater samples at 11 collecting stations;
4. Obtain monthly rainwater samples at 2 Pacific Islands and at 9 collecting stations in New Zealand.

The co-operation of the Directors of Health at Apia, and of Medical Services at Suva, and their staff has made it possible to extract radioiodine locally from fresh milk by resin column procedures and despatch these samples to Christchurch for measurement.

Officers of the New Zealand Department of Health assisted in obtaining thrice weekly milk samples from 7 towns, and the Auckland daily air filter sample.

Weekly samples of cattle thyroids are obtained through the assistance of the Department of Agriculture's meat inspection service at 8 collecting stations.

Other types of samples are obtained through the assistance of the Soil Bureau, Geological Survey, and Fruit Research Orchard of the Department of Scientific and Industrial Research, from pathologists, and from a number of privately operated milk processing plants.

### Work Done Within the Laboratory

Mr J. F. McCahon, Senior Principal Radiation Officer, was responsible for establishing the relationship between gamma radiation dose rate and potential health hazard, on which the operation of the gamma radiation monitors in the Pacific Islands is based. The monitors were calibrated by Mr N.G. Wilson.

All measurements of gross radioactivity and specific radionuclides were made in the low level environmental section of this Laboratory:

- (a) All arrangements for sample collection, all radiochemical procedures, and all measurements of alpha and beta radioactivity are under the control of Mr L.P. Gregory, Principal Radiation Officer, who is also responsible for all editorial work in the preparation of this series of reports. Professional assistance is given by Mr T. Baltakmens, and technical assistance by Mr R.H. Chapman and Miss J. Sandle.
- (b) Gamma ray spectroscopy is under the control of Mr H.J. Yeabsley, Deputy Director. The measurements are made by Mr J.E. Dobbs, Technical Officer.

Maps and graphs for this report have been drawn by Miss S. Loader, and Mr T. Baltakmens.

  
G.E. ROTH  
DIRECTOR