SOUTH CANTERBURY CATCHMENT BOARD

AND

REGIONAL WATER BOARD

PUBLICATION No. 24

THE WATER RESOURCES OF THE ORARI RIVER

by

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TIMARU, NEW ZEALAND
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ABBREVIATIONS

Throughout the report the following abbreviations have been adopted:

Organisations
SCCB — South Canterbury Catchment and Regional Water Board
MWD — Ministry of Works and Development
DSIR — Department of Scientific and Industrial Research
NZMS — New Zealand Meteorological Service, Ministry of Transport

Units
m — metre
km — kilometre
km^2 — square kilometre
m^3/s — cubic metres per second
l/s — litres per second
$l/s/km^2$ — litres per second per square kilometre
m/m — metres per metre

1. INTRODUCTION

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The South Canterbury Catchment Board and Regional Water Board (SCCB) has called for this report as part of its overall policy to document the water resources and usage of the major water resources within South Canterbury. The report summarises the current store of knowledge on the quality, quantity and usage of water within the Orari River and is intended to act as a base on which to prepare any future water management plan.

2. CATCHMENT DESCRIPTION

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2.1 Location

The Orari River catchment, bordered to the north by the Rangitata River and to the south by the Opuha, Waihi and Te Moana Rivers, drains approximately 750km^2 (Fig. 1). From its headwaters in the Ben McLeod Range, the river is approximately 87km long and has an approximate mean flow of 9.0m^3/s at the mouth.

The catchment has two distinct topographical zones — the mountainous upland catchment and the coastal plains.

The upper catchment is situated within the Canterbury Foothills hydrological region and has a catchment area of 520km^2. It is from this region that almost all the surface water originates. The major tributaries of the Orari River are situated within this region and consist of the Mowbray, Phantom and Hewson Rivers. Smaller tributaries with the region include the Bernard, Mt. Peel and Andrews Creeks.

The coastal catchment area of 230km^2 lies within the Canterbury Plains hydrological region and is bounded to the north by Coopers Creek and to the south by the Waihi River and Ohapi Creek.

2.2 Topography

The headwaters of the Orari River drain the south and east faces of the Ben McLeod Range (average ridge height 1900m), the High Claytons (average ridge height 1370m), the north and north-west faces of the Four Peaks Range (average ridge height 1370m) and the west faces of Mt. Peel (elevation 1717m).

Within the upper catchment, the terrain is dominated by steep ($>30°$) rugged slopes, especially in the Phantom and Hewson Rivers where cirque basins are to be found. Generally, the tributary rivers are confined to narrow steep-sided valleys with small areas of adjacent valley flats.

The terrain in the south and east of the upper catchment is generally less steep and more rounded in appearance than the northern and western areas.

Within the upper Orari basin, small areas (approximately 10 percent) of swamplands occur.

Average channel slope of the Orari River from its source to the Silverton recorder is 0.015m/m.

The plains area of the catchment extends from the foothills for some 40km to the sea and is topographically featureless.

2.3 Geology

A simplified geological map of the Orari basin is shown in Fig. 2 and more detailed descriptions of the geology of the area are described elsewhere (1,2). The following is a brief summary of the information contained in these references.

The bulk of the catchment consists of interbedded greywacke and argillite of medium induration (chlorite sub-zone 1) belonging to the Torlesse group. Extrusions of andesite and rhyolite of the Mt. Somers volcanics are found in the north-east corner of the catchment.

Uplift of these basement rocks occurred during the Rangitata Orogeny with subsequent erosion continuing into the end of the Cretaceous period.

Successive deposits of marine sandstones and siltstones formed during the Tertiary period have subsequently been eroded during the Kaikoura Orogeny (late Tertiary — early Quaternary). Only two notable outcrops of these marine deposits are present within the upper catchment, both of which occur in fault angle depressions. Outcrops of Tertiary marine deposits also occur in faulted depressions at the outlet of the Orari gorge.

The valley floors are underlain with greywacke and have a regolith mantle of recent gravels, alluvium, till and outwash. Three main faultlines occur within the basin and these are shown in Fig. 2.

The geology of the coastal plains region is consistent with that of the Canterbury Plains as a whole. From a combination of tectonic activity from the Kaikoura Orogeny and successive glaciations during the Quarternary era, the coastal plains were formed from the coalescing of alluvial fans from the major rivers. It is doubtful whether the Orari River fan contributed as much alluvium as the Opihi River and it is most likely that the present day Orari fan is building on deposits from the Rangitata fan to the north and Opihi fan to the south.

Apart from small outcrops of weathered gravels (Waimaunga and Waimea glaciations) and outwash gravels (Otira glaciation) at the gorge outlet, the rest of the coastal plains consist of till and gravels of the Burnham glaciation with recent alluvium deposits alongside the river channel.

2.4 Soils

The following brief description of soil types within the Orari catchment is concentrated on the

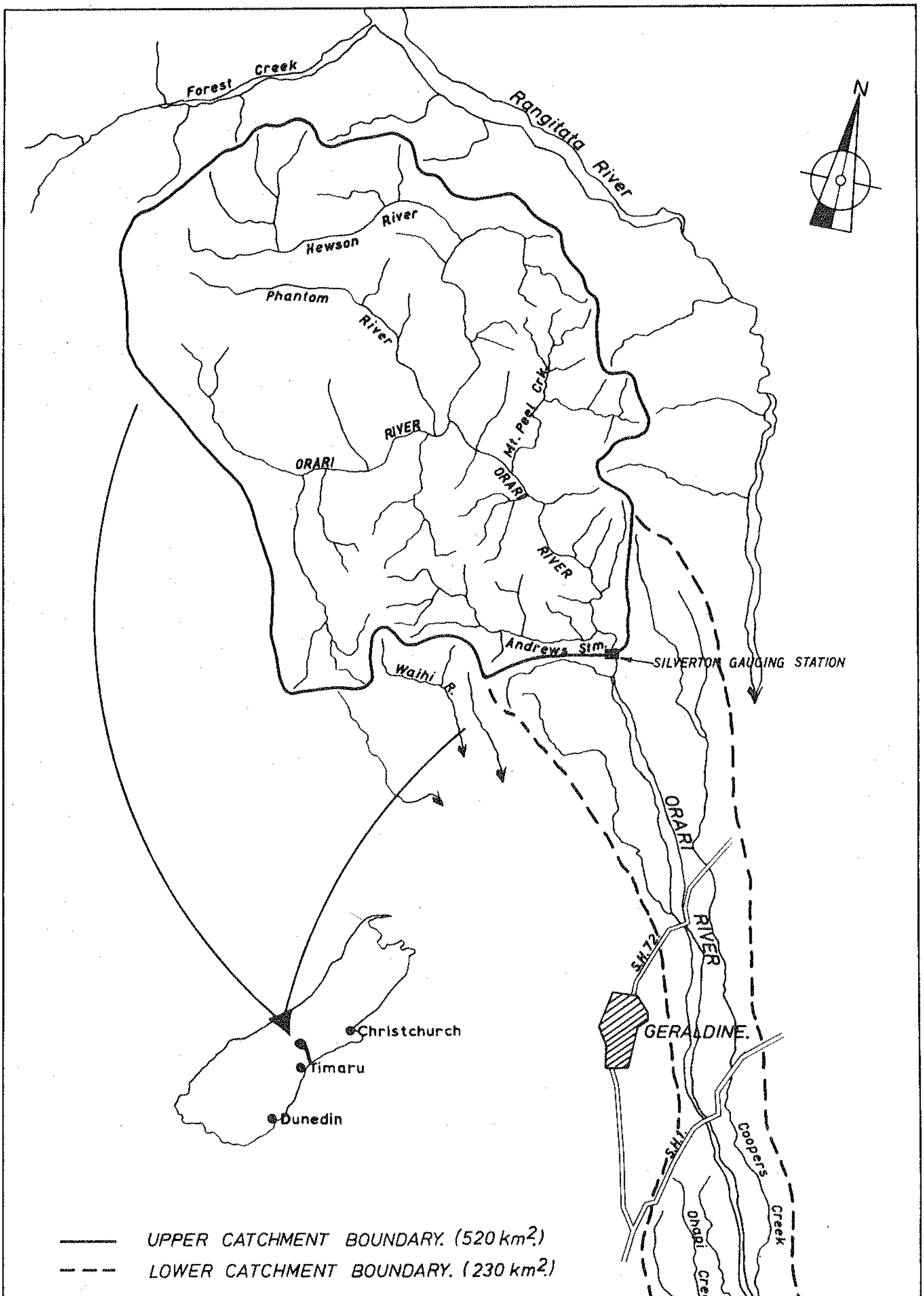


FIG. 1. LOCATION OF ORARI RIVER.

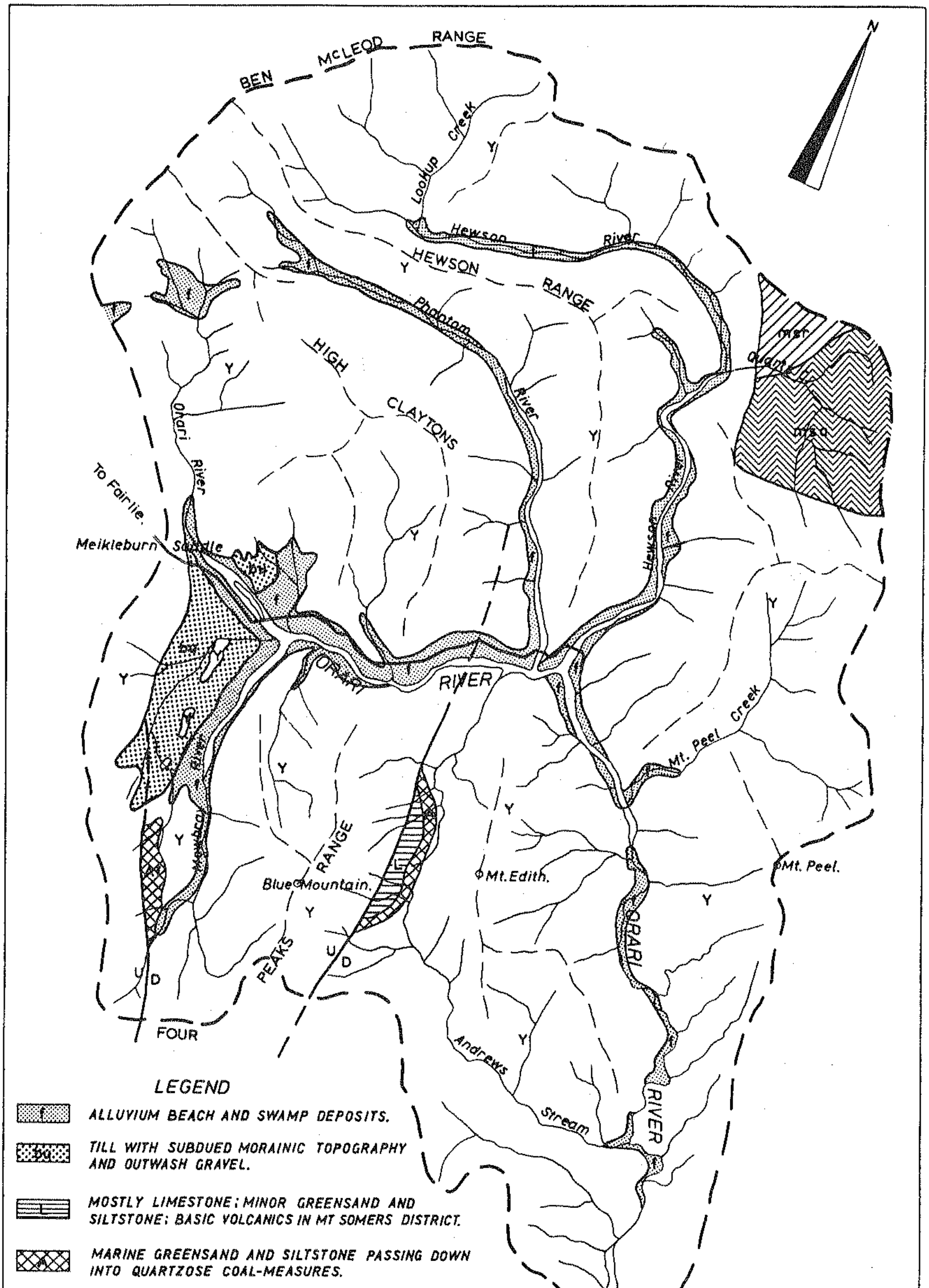


FIG. 2. GEOLOGY OF THE UPPER ORARI RIVER CATCHMENT.

1:140,000.

Scale Kilometres

N.F.D. 5/80.

coastal plains region using the Soil Bureau's classification (3). A more detailed description of the soils and their distribution over the whole Orari catchment is given by Ives (1970-1977), Webb (1975) and the N.Z. Soil Bureau (1968).

Soils within the Orari basin are typical steepland soils; bare rock, scree and talus in the higher altitudes grading to fans and terrace soils on the valley floors.

The soils of the coastal plains consist mainly of the Recent Soils — 95, 95a, 95b, 96a, 96c, (56 percent)*, Yellow —grey to Yellow — brown earths — 25a, 27e, (10.8 percent), Yellow — grey earths — 18f (8.4 percent) and Gley recent soils — 90 (8.4 percent), and it is on these soil types that the farming activities of the area are centred.

Like the bulk of the soils of the Canterbury Plains, the areal distribution of these soils is somewhat complex, tending to produce lenses and pockets of one soil type within another.

With adequate drainage for the heavier soils, and with sufficient irrigation water during droughts, the soils of the Orari coastal region are ideally suited to grazing and, to a lesser extent, to cropping.

* Percentages expressed are the percentage area of coastal catchment only.

2.5 Population

Population within the Orari catchment is relatively sparse. Within the upper catchment, population is limited to the residents and work force of the four stations — Meikleburn, Dry Creek, Blue Mountain and Lochaber. At the 1976 Census, 40 people were resident in the upper catchment (4).

Within the lower catchment, the only population centres of note are Orari Township (293 people) and Clandeboye (225 people). Including the population of Tripp Settlement, Orari Bridge, Peel Forest, Milford and the rural population, the total population of the Orari Catchment is approximately 1230.

3. CLIMATE AND RAINFALL

3. CLIMATE AND RAINFALL

3.1 Climate

The weather pattern for the Orari catchment is typical of much of the South Island's east coast. Migrating anticyclones from Australia and Antarctica separated by troughs of low pressure are responsible for the day to day weather conditions.

Along the coastal plains, winds predominate from the north-east and south-west — the former being more frequent in summer and the latter in winter. Inland, the predominant wind is from the westerly to northerly quarter resulting in moderate nor-west winds which occassionally bring heavy rainfalls to the upper catchment.

Generally, heavy rainfalls within the catchment are associated with migrating cold fronts and depressions from the south, and from slow moving or stationary depressions centred within the Canterbury Bight.

Temperatures show an annual variation with January and February being the hottest months and June and July being the coldest. Sunshine within the upper catchment is approximately 2400 hours per year (52% of the maximum possible for the latitude) and in the coastal region 1880 hours (44%). Ground frosts vary from 90 days on the plains to 154 days in the upper catchment.

No climatological stations are situated within the region — the closest stations representative of the area being Fairlie and Lake Tekapo for the upper catchment and Timaru for the lower catchment. Mean monthly climatic statistics for Lake Tekapo and Timaru are shown in tables 1 and 2.

TABLE 1: CLIMATE STATISTICS FOR LAKE TEKAPO

(after NZMS Misc. Publ. 143)

H40041 LAKE TEKAPO — LAT. 44 0S LONG. 170 28E HT. 683 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL, MILLIMETRES														
Highest monthly/annual total	1925-1970*	160	200	142	147	145	157	216	133	226	129	276	149	859
Normal	1941-1970	51	43	48	53	53	48	53	48	56	51	51	51	606
Lowest monthly/annual total	1925-1970*	2	1	0	1	8	2	6	2	0	0	3	3	324
Average number of days with rain 1.0 millimetres or more	1925-1970*	6	5	6	6	6	5	6	6	6	6	6	6	70
Maximum 1-day rainfall mm.	1925-1970*	52	91	61	73	83	59	75	51	57	121	97	70	121
ESTIMATED WATER BALANCE														
Average runoff (mm)	1925-1970*	.	3	.	5	13	23	38	33	20	13	8	3	159
Average deficit (mm)	1925-1970*	38	38	33	13	3	.	.	.	.	.	8	28	161
TEMPERATURE, DEGREES CELSIUS														
Highest maximum	1925-1970*	33.3	32.2	30.0	26.6	21.2	17.8	17.1	18.3	23.4	26.1	28.3	30.6	33.3
Mean monthly/annual maximum	1925-1970*	28.3	27.7	25.9	21.8	17.2	13.2	12.2	14.0	18.0	21.6	23.5	26.6	29.7
Mean daily maximum	1927-1970*	21.2	21.3	19.1	15.2	10.5	7.3	5.9	8.4	12.1	15.1	17.1	19.8	14.4
Normal	1931-1960	15.3	15.3	13.2	9.8	5.6	2.9	1.3	3.4	6.8	9.6	12.1	14.0	9.1
Mean daily minimum	1927-1970*	8.2	8.0	6.4	3.8	0.6	-1.7	-3.0	-1.4	1.1	3.6	5.2	7.3	3.2
Mean monthly/annual minimum	1925-1970*	1.4	1.3	0.1	-1.8	-5.2	-7.3	-8.7	-7.2	-4.7	-2.7	-1.3	0.8	-9.7
Lowest minimum	1925-1970*	-3.2	-2.2	-5.1	-6.5	-11.1	-15.6	-13.4	-13.8	-10.1	-6.1	-6.6	-5.1	-15.6
Mean daily range	1927-1970*	13.0	13.3	12.7	11.4	9.9	9.0	8.9	9.8	11.0	11.5	11.9	12.5	11.2
Mean daily grass minimum	1930-1970*	3.9	3.7	2.0	-0.8	-3.5	-5.7	-6.7	-5.2	-2.6	-0.4	1.3	3.3	-0.9
DAYS WITH FROST														
Ground frost — average	1951-1970	1.6	1.4	4.7	11.9	18.7	23.8	26.4	23.8	17.8	10.7	11.0	2.5	154.3
Frost in screen — average	1951-1970	0.2	0.1	0.4	2.4	11.2	19.6	24.0	19.6	9.1	3.9	1.1	0.2	91.8
RELATIVE HUMIDITY (%)														
Average at 9 a.m.	1950-1970	57	61	71	75	79	80	83	78	69	60	55	58	69
VAPOUR PRESSURE (MBS)														
Average at 9 a.m.	1950-1970	9.8	10.0	9.9	8.0	6.4	5.3	5.0	5.5	6.5	7.1	7.8	9.2	7.5
SUNSHINE, HOURS														
Highest	1935-1970*	299	268	256	229	190	151	167	197	248	279	290	320	2445
Average	1935-1970*	257	218	206	169	133	106	115	155	179	217	224	244	2223
% of possible	1935-1970*	56	56	54	53	46	40	41	50	52	53	52	52	52
Lowest	1935-1970*	187	150	147	111	90	69	79	120	112	161	163	172	1991
SPECIAL PHENOMENA														
Average No. of days with snow	1950-1970	.	0.1	.	0.7	1.0	1.5	3.4	1.8	1.1	1.0	0.4	0.1	11.1
Average No. of days with hail	1950-1970	.	.	.	.	0.1	.	0.1	.	.	.	.	.	0.2
Average No. of days with thunder	1950-1970	0.1	0.1	0.1	0.2	0.2	0.1	.	0.1	0.1	0.4	0.3	.	1.7

* Includes observations at various sites

TABLE 2: CLIMATE STATISTICS FOR TIMARU

(after NZMS Misc. Publ. 143)

H41421 TIMARU — LAT. 44 25S LONG. 171 15E HT. 17 M.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL, MILLIMETRES														
Highest monthly/annual total	1897-1970*	183	247	250	157	118	160	183	133	153	165	224	172	1019
Normal	1941-1970	58	58	58	48	48	36	41	38	41	48	58	69	601
Lowest monthly/annual total	1897-1970*	13	3	10	7	5	1	2	5	3	4	13	7	312
Average number of days with rain 1.0 millimetres or more	1881-1970*	8	7	7	7	6	6	6	6	6	7	7	8	81
Maximum 1-day rainfall mm.	1881-1970*	55	147	70	75	64	67	111	66	79	57	78	72	147
ESTIMATED WATER BALANCE														
Average runoff (mm)	1950-1970***	3	.	5	10	3	8	18	13	3	5	13	3	84
Average deficit (mm)	1950-1970***	41	30	20	10	3	.	.	.	3	5	13	15	140
TEMPERATURE. DEGREES CELSIUS														
Highest maximum	1910-1970	37.2	35.4	33.1	29.1	25.6	20.9	22.4	23.2	26.1	32.8	32.8	33.9	37.2
Mean monthly/annual maximum	1910-1970	30.3	29.4	27.0	23.8	19.5	16.2	15.9	18.1	21.8	25.5	26.9	28.9	32.2
Mean daily maximum	1910-1970	21.4	21.1	19.3	16.8	13.1	10.4	9.7	11.5	14.1	17.0	18.9	20.3	16.1
Normal	1931-1960	16.1	15.9	14.2	11.8	8.2	5.7	4.9	6.6	8.8	11.5	13.5	15.1	11.1
Mean daily minimum	1910-1970	10.9	10.7	9.4	6.8	3.5	1.3	0.6	1.9	3.9	6.2	7.8	9.8	6.1
Mean monthly/annual minimum	1910-1970	5.2	4.9	3.4	1.2	-1.5	-3.0	-3.7	-2.8	-0.9	0.8	2.3	4.1	-4.1
Lowest minimum	1910-1970	1.4	1.4	-0.9	-1.1	-4.2	-6.8	-6.4	-5.9	-4.6	-1.3	-1.1	0.4	-6.8
Mean daily range	1910-1970	10.5	10.4	9.9	10.0	9.6	9.1	9.1	9.6	10.2	10.8	11.1	10.5	10.0
Mean daily grass minimum	1911-1970	8.7	8.5	7.0	4.1	0.7	-1.6	-2.2	-1.0	0.8	3.4	5.3	7.7	3.4
DAYS WITH FROST														
Ground frost — average	1911-1970	.	0.1	0.4	3.0	11.5	19.5	21.2	17.4	10.3	3.4	1.1	0.1	88.0
Frost in screen — average	1906-1970	.	.	.	0.3	3.5	10.3	13.5	8.3	2.2	0.3	0.1	.	38.5
EARTH TEMPERATURES (DEGREES C)														
Average at 0.10 metres	1961-1970	17.4	16.3	14.1	10.1	6.5	2.8	2.1	3.7	7.2	10.7	13.9	16.8	10.1
RELATIVE HUMIDITY (%)														
Average at 9 a.m.	1928-1970	72	74	78	83	83	82	82	79	74	69	67	71	76
VAPOUR PRESSURE (MBS)														
Average at 9 a.m.	1928-1970	13.9	13.9	12.9	11.2	8.6	7.0	6.6	7.5	8.8	10.3	11.4	13.2	10.4
SUNSHINE, HOURS														
Highest	1935-1970	251	219	244	188	187	165	160	186	205	236	258	255	2144
Average	1935-1970	195	168	153	136	127	122	126	144	156	185	188	187	1887
% of possible	1935-1970	42	43	40	42	44	47	45	46	45	46	43	39	44
Lowest	1935-1970	129	111	94	68	94	76	85	95	96	127	111	90	1672
WIND														
Daily wind run (kilometres)	1950-1970***	270	257	246	241	227	225	212	220	240	274	282	277	248
Average No. of days with gusts 34 knots or more	1956-1970**	2.5	1.8	2.6	2.4	1.9	1.0	0.8	1.5	2.7	3.7	3.2	2.7	26.8
gusts 52 knots or more	1956-1970**	0.1	0.1	0.1	0.3	0.3	.	.	0.1	.	0.2	0.1	.	1.3
SPECIAL PHENOMENA														
Average No. of days with snow	1926-1970	.	.	.	.	.	0.2	0.4	0.2	0.2	0.1	.	.	1.1
Average No. of days with hail	1921-1970	0.3	0.2	0.2	0.1	0.1	0.2	0.2	0.1	0.3	0.5	0.4	0.4	3.0
Average No. of days with thunder	1921-1970	0.6	0.4	0.3	0.1	0.1	.	.	.	0.2	0.4	0.6	0.6	3.3

* includes observations from rainfall stations
** refers to observations at Timaru Aerodrome
*** refers to observations at Adair

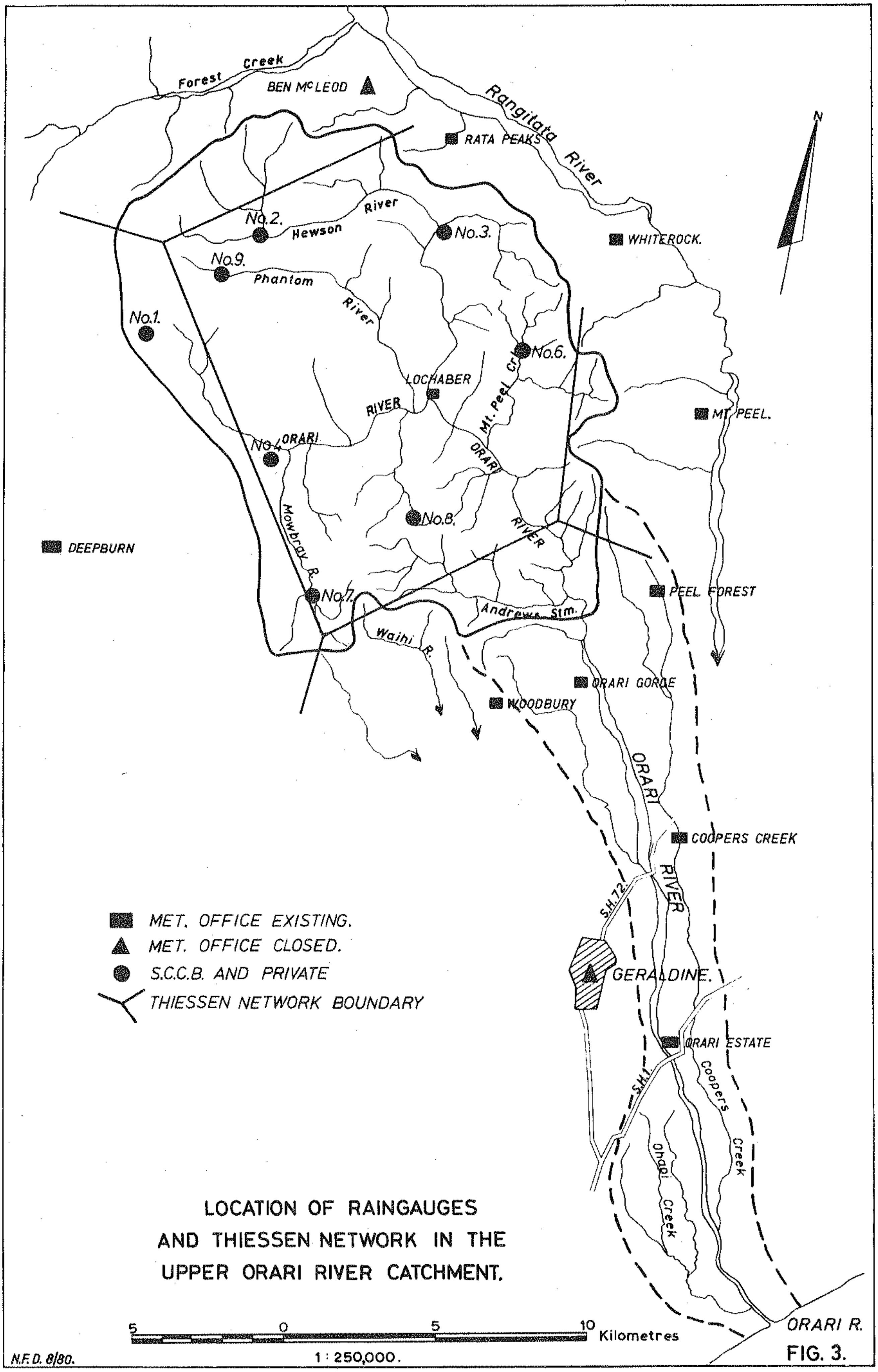
3.2 Rainfall

3.2.1 Introduction

In 1963 the SCCB installed a raingauge network within the Orari basin (Fig. 3) consisting of 2 automatic gauges and 6 Octapent storage gauges. Table 3 gives the relevant particulars of these gauges. In addition to these gauges, daily manual gauges were read by the station owners of Lochaber and Meikleburn stations. Because of difficulty of access to Lookup Creek, the Casella raingauge was moved to the Phantom River site and replaced with an Octapent storage gauge in February, 1971.

TABLE 3: SCCB RAINGAUGE NETWORK

No.	Site	Map Reference	Height (m)	Type	Remarks
1	Orari Saddle	S90/445195	811	686mm Octapent	
2	Lookup Ck.	S90/502262	884	1270mm Octapent	Casella removed 2/71 to Phantom
3	Quartz Ck.	S91/604286	625	1270mm Octapent	
5	Lochaber	S91/622190	488	Lambrecht automatic	
6	Mt. Peel	S91/664227	580	686mm Octapent	
7	Mowbray	S91/574067	716	686mm Octapent	
8	Mt. Edith	S91/618127	695	686mm Octapent	
9	Phantom	S90/482232	783	Casella 95 day automatic	Casella installed 2/71 from Lookup Ck.



LOCATION OF RAINGAUGES AND THIESSEN NETWORK IN THE UPPER ORARI RIVER CATCHMENT.

FIG. 3.

Mean catchment rainfall figures derived from a Thiessen network using the SCCB raingauges are listed in Appendix 1. The record is only short term due to problems or poor access and lack of reliable records from the Caselia automatic gauge. For the purposes of the report, a Thiessen network was set up (Fig. 3) using the following long term N.Z. Meteorological Service (NZMS) Stations.

TABLE 4: THIESSEN NETWORK OF NZMS RAINGAUGES

Station No.	Station Name	Map Reference	Height (m)	Length of Record	Weight Factor
H130691	Mesopotamia	S80/465432	522	1948 to present	0.068
H131801	Lochaber	S91/622189	488	1946 to present	0.701
H131822	Mt. Peel	S91/775194	351	1964 to present	0.027
H131926	Orari Gorge	S91/733030	259	1899 to present	0.080
H130981	Deepburn	S90/426085	518	1948 to present	0.124

Catchment rainfall records using the NZMS Thiessen network were obtained from 1948 to the present using the weight factors from the above table. Prior to Mt. Peel records starting in 1964, the weight factors of Lochaber and Orari gorge were increased to 0.723 and 0.085 respectively.

Catchment monthly rainfall from 1948 to 1979 inclusive is reproduced in Appendix 2. To test the realiability of these figures, a correlation of monthly figures from 1964 to 1968 inclusive from both the SCCB and Met. office networks was obtained (Fig. 4). The resultant relationship was so close to a 45° relationship that the NZMS figures were accepted as being of sufficient accuracy for use in this report.

Raingauge stations within the catchment and in the vicinity are shown in Fig. 3 and an inventory of NZMS sites together with their rainfall normals is given in Appendix 3.

In the following sections on rainfall, the data has been separated into data above Silverton and data below Silverton. This has been done because all the runoff-producing rain to the river occurs above Silverton while rainfall on the coastal plains infiltrates to groundwater and thus determines the amount and frequency of irrigation requirements.

3.2.2 Average Annual Rainfall

3.2.2.1 Above Silverton

Average annual catchment rainfall for the Orari above Silverton is 901mm using Met. office figures from 1948-1979. Fig. 5 shows the distribution of mean annual rainfall over the Orari basin. It can be seen that rainfall varies from a high of 1200mm per annum in the southern Ben McLeod Range to a low of 750mm in the Mowbray-Four Peaks area.

3.2.2.2 Below Silverton

Average annual rainfall below Silverton ranges from 1100mm at the gorge outlet to 600mm at the coast. Average annual rainfall for this part of the catchment is approximately 800mm.

3.2.3 Monthly Rainfall Distribution

3.2.3.1 Above Silverton

Average monthly rainfall distribution for the Orari catchment above Silverton is shown in Fig. 6. Also shown are the 10 and 90 percentiles for the record period. A 10 percentile means that only 10 percent of the rainfall recorded for that period was less than that value; i.e. 80 percent of the rainfall recorded was within the 10 and 90 percentiles.

Rainfall tends to show a seasonal trend with a low in the winter months of May through to September, with higher rainfall from October to January.

3.2.3.2 Below Silverton

Average monthly rainfall distribution for selected rainfall stations is shown in Fig. 6. Again, the 10 and 90 percentiles for each station are shown.

Although the Coldstream site (H41153) is outside the Orari Catchment, it has a similar annual mean rainfall (639mm) as that recorded at the Orari river mouth and can be assumed to be representative of the coastal Orari catchment.

Coopers creek (H41024) is situated within the catchment and can be considered representative of the catchment between the gorge and State Highway 1 (SH1).

Again, the rainfall distribution in the lower catchment displays a distinct trend of lower winter rainfalls and higher spring and summer falls.

3.2.4 Irrigation Season Rainfall

Isohyetal maps showing irrigation season (Oct-Mar incl.) average rainfall, 10 percent probability and 20 percent probability are shown in Figures 7, 8, 9 respectively. The 10 percent probability of return shows the rainfall that is expected to occur once in 10 years, while the 20 percent probabil-

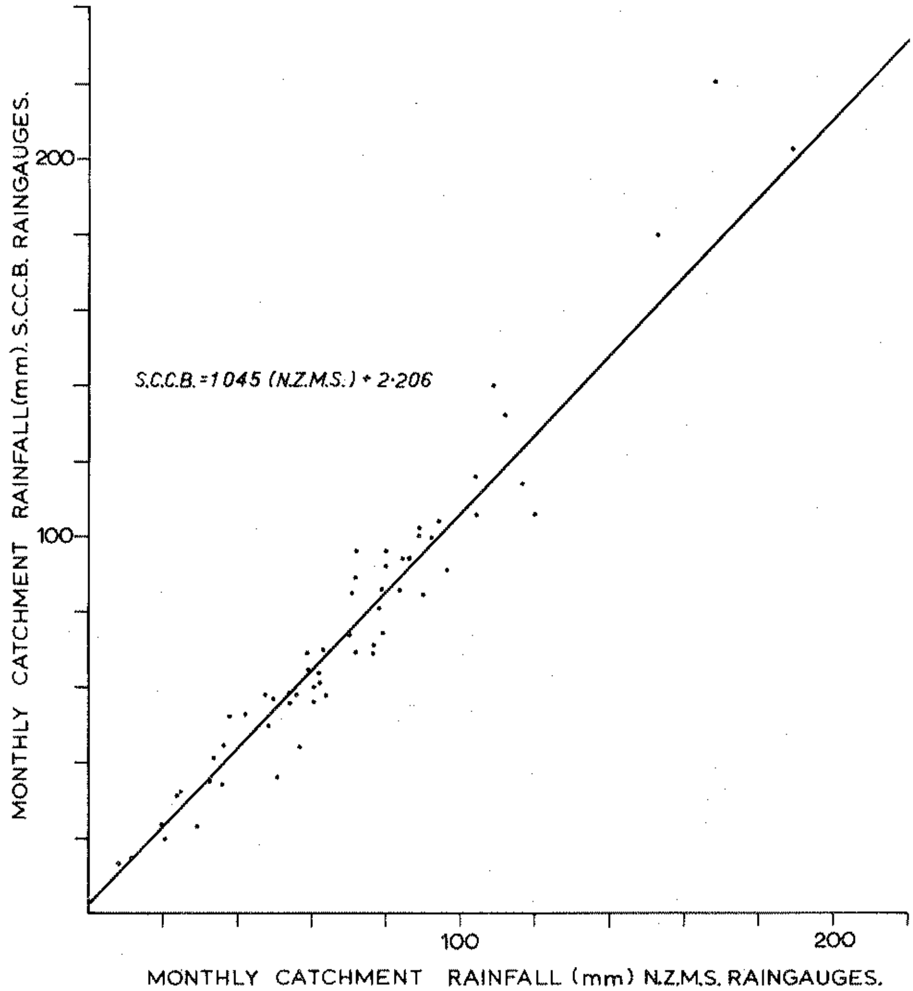


FIG. 4 CORRELATION BETWEEN S.C.C.B. AND N.Z.M.S. RAINGAUGES. (1964 - 1968)

ity is the rainfall that could be expected twice in 10 years (i.e. every five years).

At present practically all irrigation carried out using Orari catchment water is centred on the plains from the gorge to the sea. In this region, mean irigation season rainfall varies from 320mm on the coast to 700mm at Silverton. Corresponding 10 percent (1:10 years) and 20 percent (1:5 years) probability rainfalls for these districts are 220mm to 500mm for 10 percent and 250mm to 530mm for the 20 percent probability respectively.

In the Orari basin, mean irrigation season rainfall varies from a low of 400mm in the central portion to a high of 700mm around the Mt. Peel-Orari gorge area and also in the south-west of the basin. Corresponding rainfall for the 10 and 20 percent rainfalls for the above regions are 250mm to 500mm for the 10 percent and 300mm to 500mm for the 20 percent respectively.

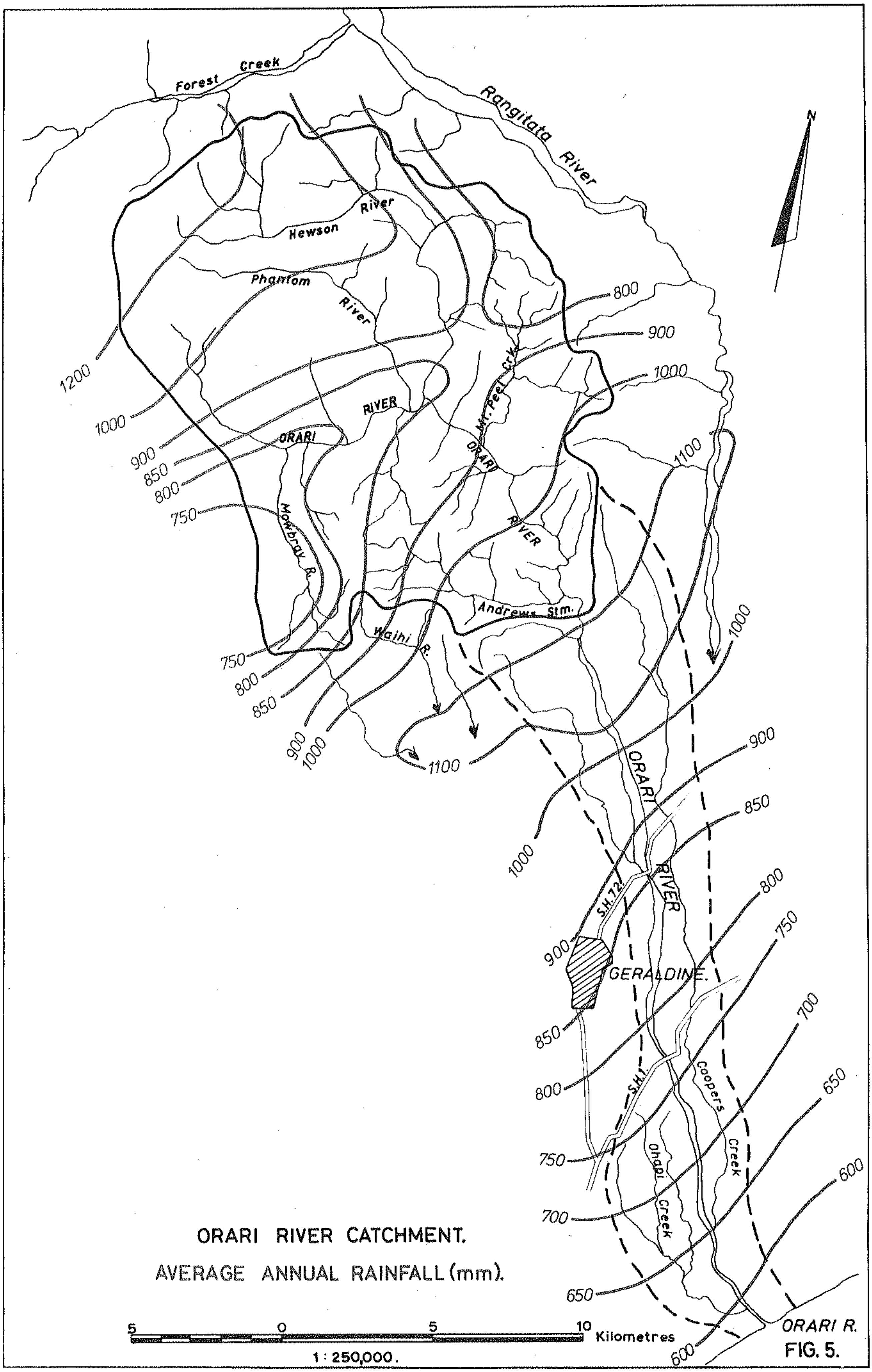
3.2.5 Droughts

Agricultural drought is defined to occur when the soil moisture within the rooting depth of the soil profile depletes to below permanent wilting point for pasture. Wilting point varies with soil type and, in the coastal Orari area, varies from 9 percent (6) soil moisture limit in the Waimakariri soils through 11 percent for Lismore and up to 25 percent for the Temuka (Gley) soils of the Milford area.

According to records from Lake Tekapo, soils in the Mackenzie Basin have a soil moisture content below wilting point from February to mid April each year and are below field capacity from mid October to the end of July each year.

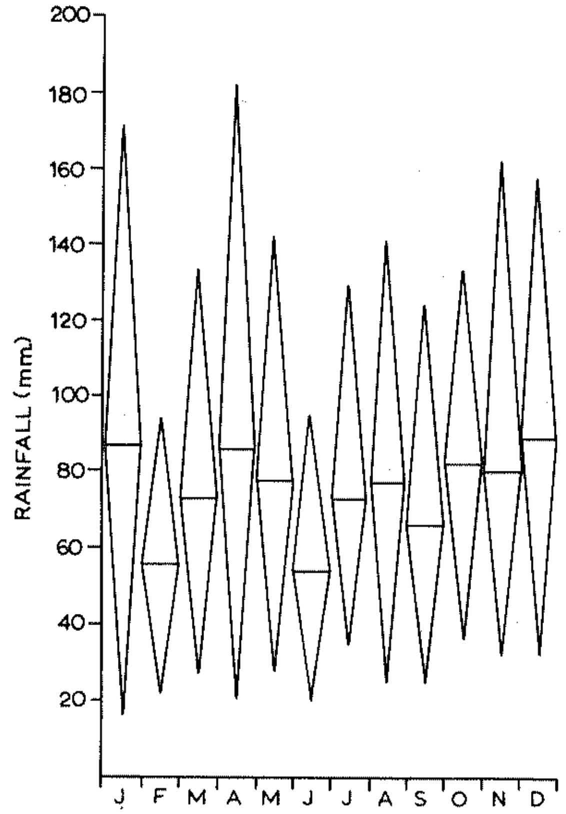
Agricultural drought is likely to occur on the coastal plains in almost every irrigation season, although the duration of such droughts is as yet unknown.

Figure 10 shows the irrigation season drought frequency rainfall for the upper Orari catchment, Coopers creek (H41024) and Coldstream No. 3 (H41153) rainfall stations. From these curves, it can be seen that a 1 in 20 year drought will produce a maximum of 200mm rainfall on the coast at Coldstream, and 278mm rainfall over the upper catchment.

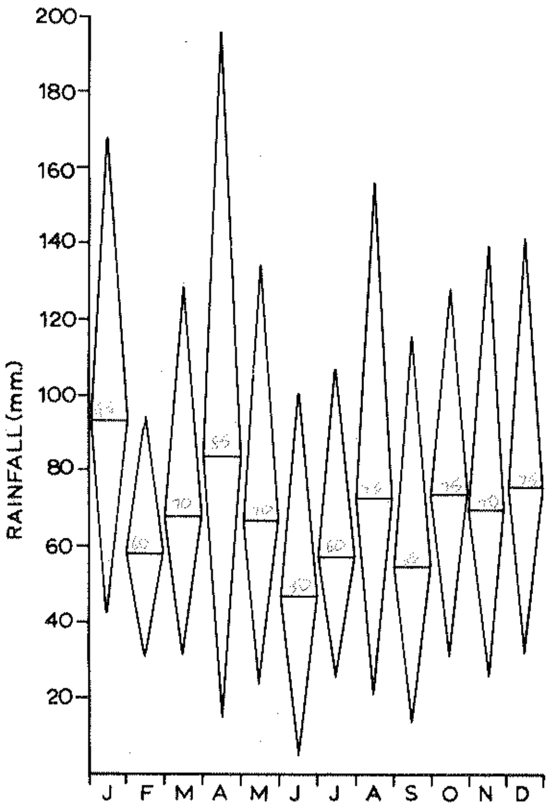


ORARI RIVER CATCHMENT.
AVERAGE ANNUAL RAINFALL (mm).

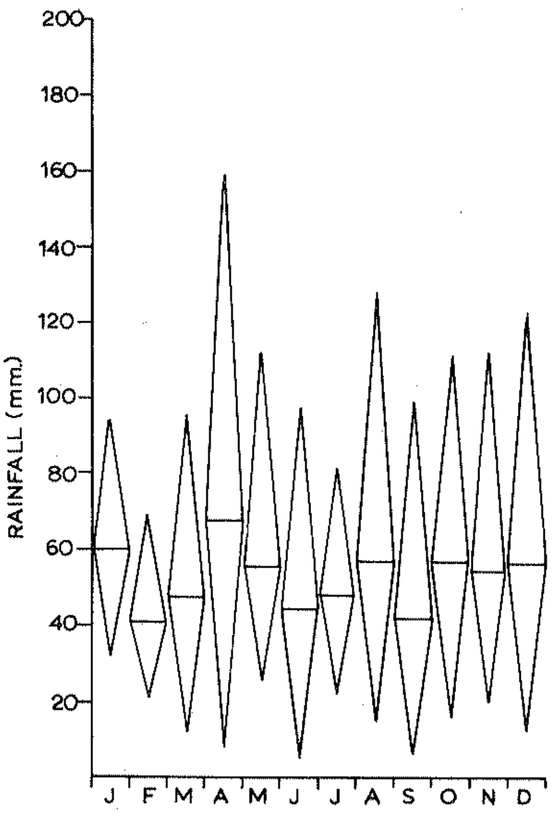
FIG. 5.



ORARI BASIN CATCHMENT MEAN RAINFALL.
(1948 – 1979.)

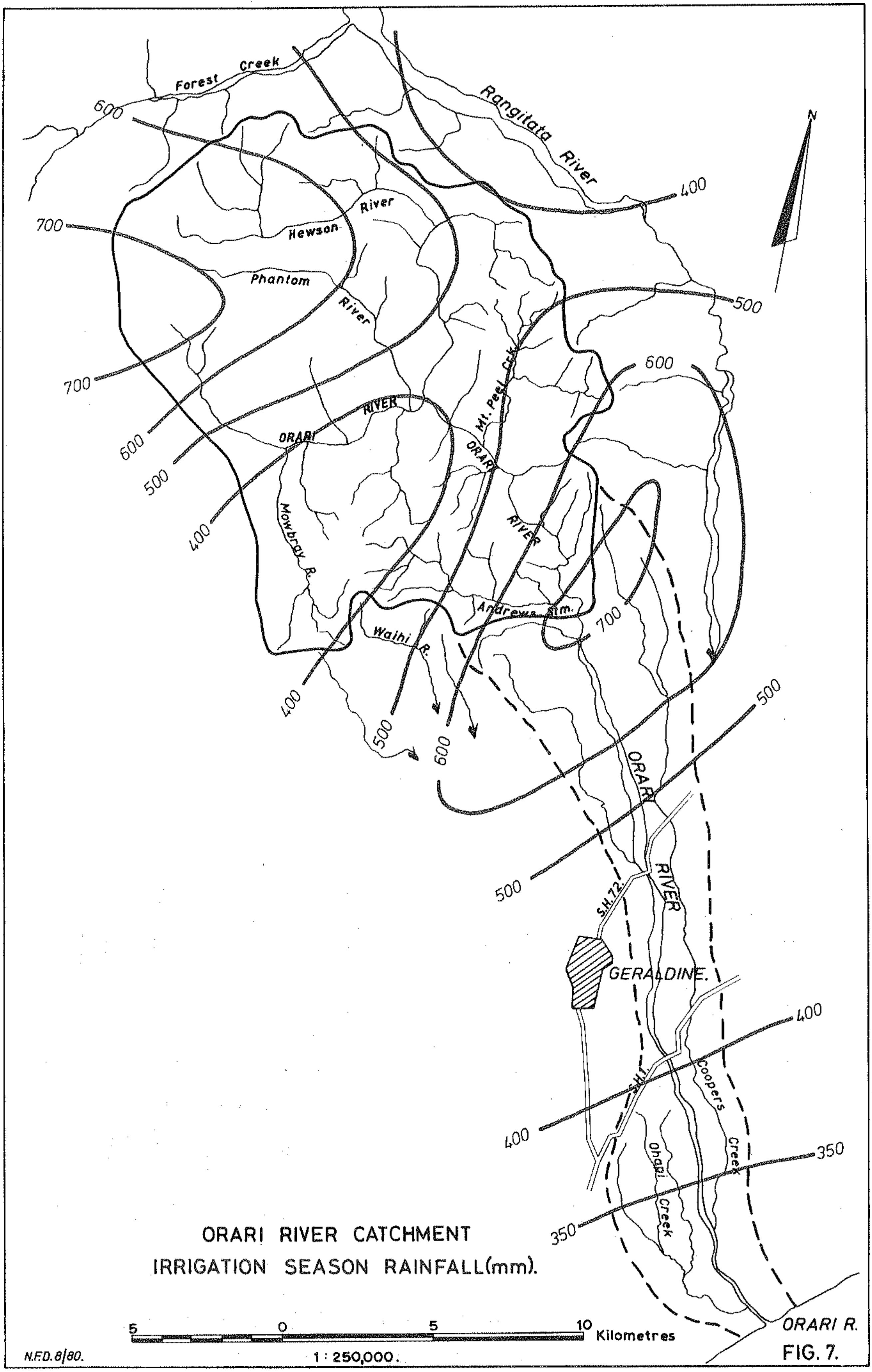


H.41024. COOPERS CREEK.
(1964 – 1979.)



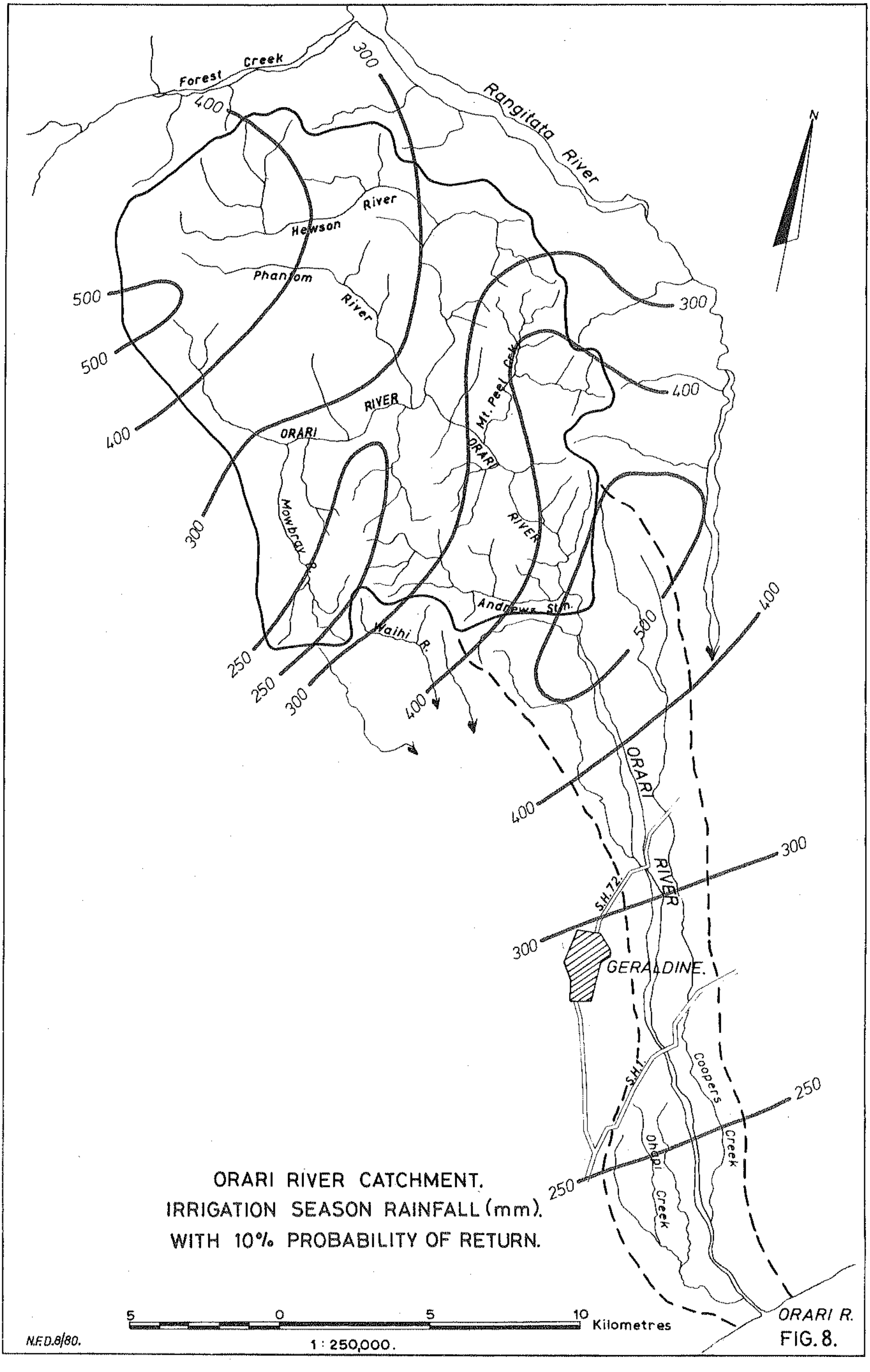
H 41153 COLDSTREAM No.3.
(1964 – 1979.)

FIG. 6. MEAN MONTHLY RAINFALL AND 10 AND 90 PERCENTILES FOR SELECTED RAINFALL STATIONS.



ORARI RIVER CATCHMENT
IRRIGATION SEASON RAINFALL(mm).

FIG. 7.

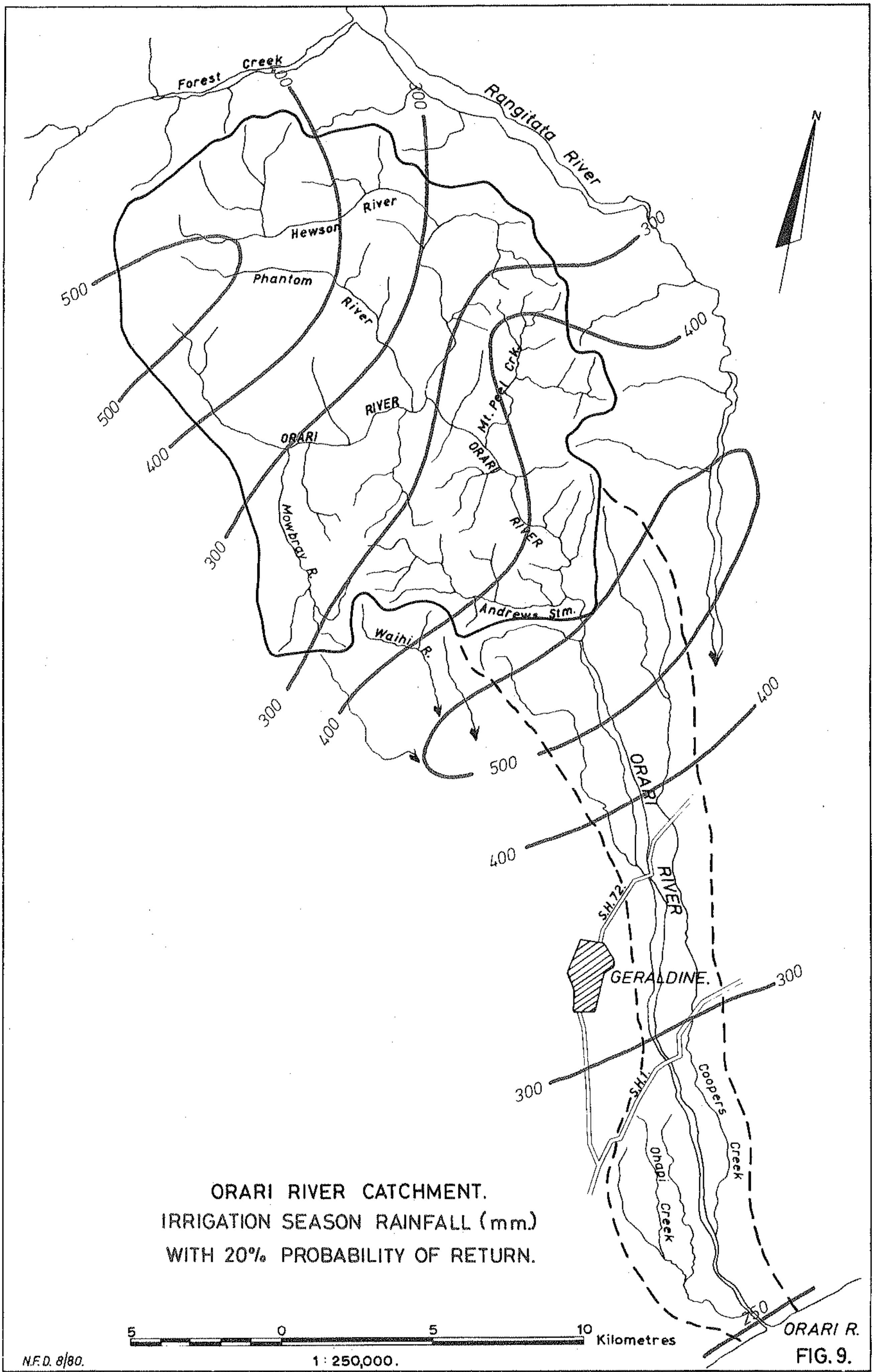


ORARI RIVER CATCHMENT.
IRRIGATION SEASON RAINFALL (mm).
WITH 10% PROBABILITY OF RETURN.

5 0 5 10 Kilometres

1 : 250,000.

FIG. 8.



ORARI RIVER CATCHMENT.
IRRIGATION SEASON RAINFALL (mm.)
WITH 20% PROBABILITY OF RETURN.

FIG. 9.

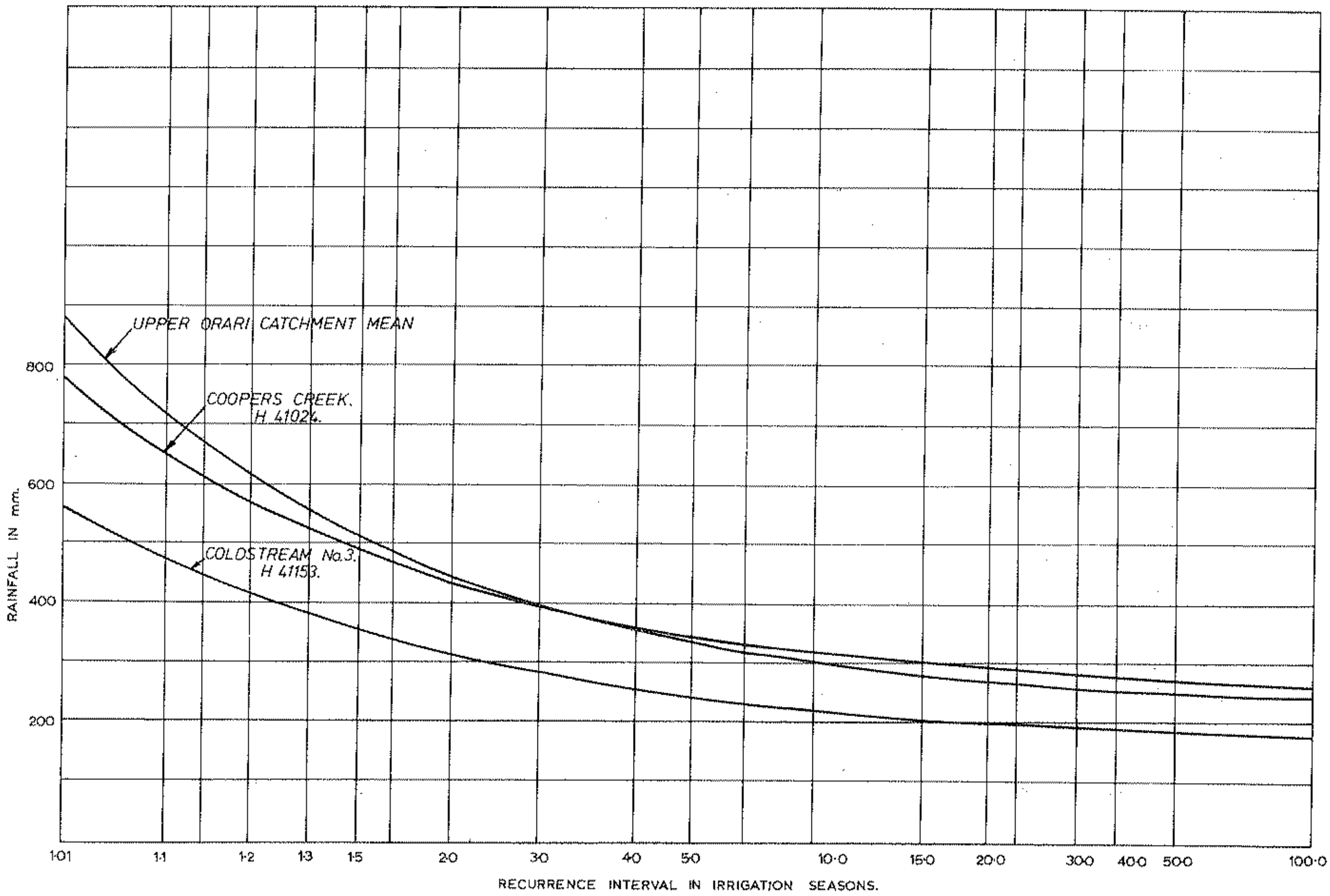


FIG. 10. IRRIGATION SEASON DROUGHT FREQUENCY CURVES FOR SELECTED STATIONS.

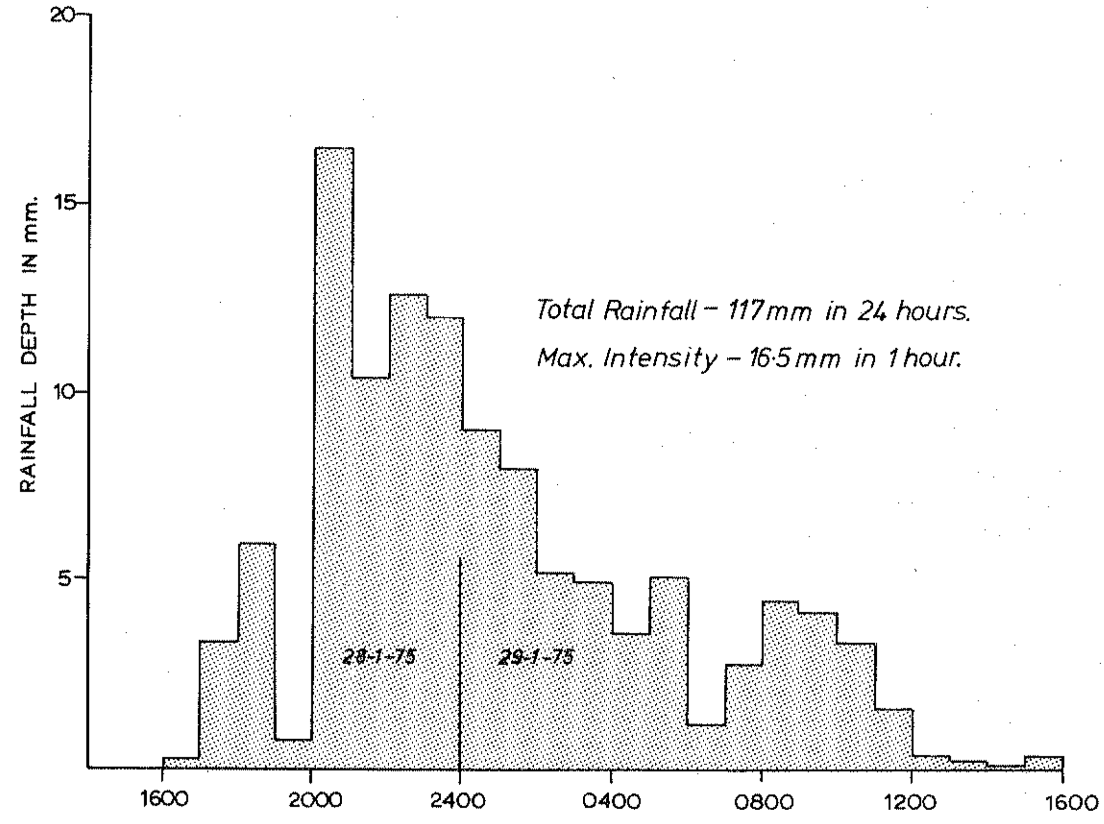


FIG.11. RAINFALL INTENSITY AT LOCHABER 28 – 29 JAN. 1975.

3.2.6 Rainfall Intensity

High intensity rainfalls generally occur within the Orari catchment from slow moving or stationary depressions centred in the Canterbury Bight together with high pressures to the south of the South Island. The associated frontal activity can bring prolonged heavy rainfalls which are concentrated on the physical barriers of the frontal foothills such as Mt. Peel and the Four Peaks Range.

Situations such as these occurred in February 1945 (Orari Estate rainfall was 200mm in 24 hrs and 300mm in 48 hrs) and in the "Blandswood Disaster" of January 1975 (Mt. Peel 168mm in 12 hrs).

Figure 11 shows the rainfall intensities at Lochaber for the January 1975 storm. Total rainfall was 117mm in the 24 hr period 1600 hrs to 1600 hrs with a maximum intensity of 16.5mm in 1 hour. Successive hourly intensities in millimetres at the peak of rainfall were: 16.5, 10.4, 12.6, 12.0, 9.0, 8.0, 5.3 and 5.1.

These figures relate to intensities recorded at Lochaber — however, the storm was centred over Mt. Peel where it is probable that even higher intensities would have occurred.

Heavy rainfall can also occur within the upper Orari basin through spillover of heavy north-west rainfalls along the Southern Alps. Rainfall intensities for such storms within the upper catchment are unknown although figures from Erewhon (H30581) would suggest that 75mm in 24hrs would occur at least once every 2 years.

To investigate the frequency of the high intensity rainfall events, depth — duration — frequency analyses were carried out for Lochaber (H31801) and Orari Estate (H41131). Results are shown in Table 5. Both these stations are equipped with daily manual gauges and so data for durations of less than 24 hrs are unavailable. Figures from Deepburn (H30981) were obtained from the N.Z. Met. Service Miscellaneous Publication 162 (1980).

TABLE 5: RAINFALL DEPTH—DURATION—FREQUENCY FOR SELECTED ORARI STATIONS

Return Period 1:x years	Lochaber (H31801) 24hr	Lochaber (H31801) 48hr	Orari Estate (H41131) 24hr	Orari Estate (H41131) 48hr	Deepburn (H30981) 24hr	Deepburn (H30981) 48hr
Average Annual	62	84	54	77	68	86
1:10	97	133	77	121	120	152
1:50	133	181	100	164	166	210
1:100	148	201	110	182	185	234

From Table 5 the magnitude of the rainfall recorded at Orari Estate in February 1945 can be appreciated. Rainfall totals of 200mm in 24 hrs and 300mm in 48 hrs represent an excess of 1:100 year events.

Rainfalls of at least 50mm in 24 hours and 75mm in 48 hours can be expected on the middle plains area of the Orari catchment every year.

3.3 Potential Evapotranspiration (PET)

To estimate monthly PET using the Penman method (7) requires the following monthly mean climatic information; radiation, temperature, humidity and wind speed. Radiation data is seldom available and may be estimated from sunshine hours using the equation.

$$r = R\,(0.23 + 0.53\frac{n}{N})$$

Where r is the radiation (langleys/day), n is the observed sunshine hours and N and R physical constants describing maximum possible sunshine hours and radiation for the latitude and month of year.

No climatological stations exist within the Orari basin, thus information on PET within the region is very limited. Table 6 summarises the results obtained using the Penman method and climatological data recorded at Lake Tekapo (H40041) and Fairlie. Wind data is not available for Lake Tekapo and so the Fairlie wind data was used. The results obtained from both Lake Tekapo (683 m.a.s.l.) and Fairlie (306 m.a.s.l.) are believed to be representative of much of the upper Orari catchment.

TABLE 6: MONTHLY OPEN WATER, GRASSLAND AND SNOW TUSSOCK PET (mm) FOR ORARI

LAKE TEKAPO — H40041 (El. 683 m.s.a.l.)

MONTH	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	TOTAL
OPEN WATER	150	115	85	43	20	11	11	26	55	96	125	147	884
GRASSLAND	119	90	65	31	14	6	7	18	42	75	99	117	683
SNOW TUSSOCK	110	83	60	28	12	5	5	15	38	70	92	109	627

FAIRLIE — H40182 (El. 306 m.a.s.l.)

MONTH	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	TOTAL
OPEN WATER	134	101	76	41	21	10	12	28	55	92	116	131	817
GRASSLAND	107	80	58	30	14	5	7	20	43	73	93	105	635
SNOW TUSSOCK	100	74	53	27	12	4	6	18	39	68	87	98	586

A study of the Mowbray catchment (8) indicates that within the low rainfall area around Meikleburn the average PET for the years 1963-1969 was approximately 703mm.

An estimate of the PET over the coastal plains area of the catchment can be obtained from Ashburton PET figures. (9) Mean annual PET for pasture at Ashburton is approximately 826mm. With the absence of the strong nor-westers that the Ashburton area receives, an estimated mean annual PET for the coastal Orari region would be in the order of 750mm.

3.4 Water Deficit

The difference between PET and rainfall totals for the growing season (Oct-April incl.) approximates to the annual water deficit. During this time, rainfall generally replenishes a depleted soil moisture storage with little surface runoff.

Using mean figures for Lake Tekapo and Fairlie an annual mean water deficit of 80mm (Table 7) is obtained.

TABLE 7: AVERAGE ANNUAL WATER DEFICIT FOR ORARI (mm)

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	TOTAL
AVERAGE WATER DEFICIT	Nil	13	18	23	26	Nil	Nil	80

4. WATER USE

4. WATER USE

4.1 Introduction

With the introduction of the Water and Soil Conservation Act 1967 it became mandatory, under section 21, to obtain a water right for any actions to take, use, divert or discharge water with respect to any natural waters. Existing users covered by a diversity of prior legislation, principally the Public Works Act 1928, were then required to register their usage prior to 1st April, 1970.

Specifically excluded from having to apply for water rights are users taking water for stock, domestic and fire fighting purposes. This does not include bulk rural and urban water supply schemes which, because of the magnitudes of water extraction, must be registered as a water right.

An inventory of current water rights is maintained by the SCCB and figure 12 shows the distribution of users within the Orari catchment. Tables 8, 9, 10 give a breakdown of current usage of water within the area.

TABLE 8: SUMMARY OF PRESENT REGISTERED WATER USAGE IN THE ORARI CATCHMENT

TOTAL WATER USED

		Average daily abstraction (m^3)	Max Rate (l/s)
SURFACE	Orari R.	86300	1294.60
	Ohapi Ck.	38100	1140.00
	Coopers Ck.	5300	119.00
		129700	2553.60
UNDERGROUND:	Orari R.	18200	392.36
	Ohapi Ck.	11600	295.25
	Coopers Ck.	7000	168.20
		36800	855.80
	Total	166500	3409.40

TABLE 9: TOTAL AVERAGE DAILY ABSTRACTION* OF WATER WITHIN THE ORARI CATCHMENT

* Units in m^3

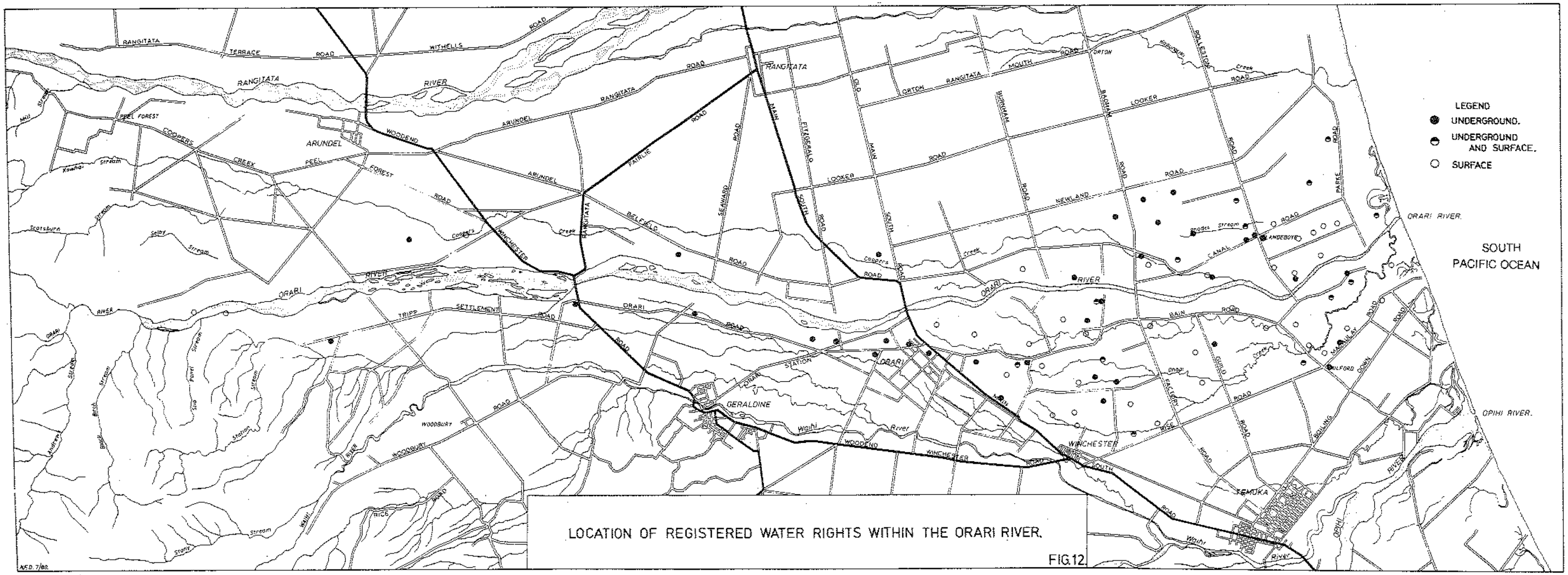
(a) SURFACE WATER

Source	Water Supply	Irrigation	Dairy Etc.	Other	Total
Orari R.	63600	22700	7.0	—	86300
Ohapi Ck.	—	38100	—	—	38100
Coopers Ck.	—	5300	—	—	5300
Total	63600	66100	7.0	—	129700

(b) UNDERGROUND WATER

Source	Water Supply	Irrigation	Dairy Etc.	Other	Total
Orari R.	2900	13200	1600	500	18200
Ohapi Ck.	2700	8050	50	800	11600
Coopers Ck.	—	7000	10	—	7000
Total	5600	28250	1660	1300	36800

Grand Totals	69200	94350	1660	1300	166500



LOCATION OF REGISTERED WATER RIGHTS WITHIN THE ORARI RIVER.

FIG.12.

TABLE 10: TOTAL MAXIMUM RATE OF ABSTRACTION* OF WATER WITHIN THE ORARI CATCHMENT

* Units in l/s

(a) SURFACE WATER

Source	Water Supply	Irrigation	Dairy Etc.	Other	Total
Orari R.	736.40	558.20	—	—	1294.60
Ohapi Ck.	—	1140.00	—	—	1140.00
Coopers Ck.	—	119.00	—	—	119.00
Total	736.40	1817.20	—	—	2553.60

(b) UNDERGROUND WATER

Source	Water Supply	Irrigation	Dairy Etc.	Other	Total
Orari R.	52.50	297.72	21.92	20.22	392.36
Ohapi Ck.	31.16	226.10	7.54	30.45	295.25
Coopers Ck.	0.31	165.00	2.89	—	168.20
Total	83.97	688.82	32.35	50.67	855.81

Grand Totals	820.37	2506.02	32.35	50.67	3409.41

4.2 Irrigation

Water for irrigation within the Orari catchment is obtained from the surface waters of the Orari River, Ohapi Creek, Coopers Creek, drains and creeks within the Clandeboye area, and from underground supplies. A study of current water rights shows that irrigation represents 57% of the total daily average usage of water within the area.

The majority of users of irrigation water are situated alongside the lower river flood plain from Orari Township to the sea. The dominant use for water in this area is in the irrigation of pastures for dairy farming. Potato farming, market gardening and some mixed cropping account for most of the rest of the irrigation demand.

4.2.1 Ohapi Creek

Of the 66100m³ allocated daily for surface irrigation over the whole Orari catchment, 38100m³ (57.7 percent) is drawn from the Ohapi creek and its tributaries. From a study of the water rights held, the maximum extraction rate possible for surface waters of the Ohapi creek and tributaries is 1140 l/s. This figure, representing the maximum possible extraction if all irrigators were to use their rights to the fullest extent at the same time, is 57 percent of the estimated mean discharge of the Ohapi creek at Milford road.

To protect the fishery of Ohapi creek, the SCCB has imposed special conditions on water rights issued for the abstraction of irrigation water from this creek. These special conditions restrict the taking of water for irrigation purposes when the flow rate of the Ohapi Creek at Milford road is at or below 570 l/s.

Maximum irrigation demand from groundwater in the Ohapi creek area is 226 l/s and is unlikely to have any marked effect on the surface flows within Ohapi creek.

4.2.2 Coopers Creek

Surface water irrigation from Coopers creek is carried out by 3 water users at an average daily abstraction of 5300m³. The maximum abstraction rate for these water rights totals 119 l/s. Average daily usage (including both surface and underground sources) at present is approximately 12300m³ with a maximum abstraction rate totalling 284 l/s. No irrigation restrictions are placed on the Coopers creek resource.

4.2.3 Orari River

Within the Orari River, only 4 water rights have been issued to take surface water from the river, all other surface irrigation being from drains and creeks which join the Orari River near its mouth. Total daily average usage from both underground and surface sources is approximately 35900m³ at a maximum abstraction rate of 856 l/s.

It is clearly evident that demand for abstraction of surface water from the Orari River is minimal and has little effect on the water resource available within the lower river system. Because of this, no irrigation restrictions are placed on users within the Orari River.

4.3 Stock and Domestic Supplies

4.3.1 Stock Supplies

Within the Orari River, there are only two major stock water races, both of which originate from sites some 4 to 5km below the gorge outlet. The maximum abstraction rates from these two races is 736 l/s. Stockwater use is seasonably variable and so actual flow rates from these races would tend to fluctuate about the quoted maximum.

Many farmers within the region obtain stockwater individually from miscellaneous sources including drains, streams and groundwater.

4.3.2 Domestic Water Supplies

Only three domestic supplies drawing water from the Orari catchment exist and these are summarised in Table 11.

Geraldine Borough pumps water from 3 wells near the corner of Bennetts Road and Orari Back Road; Orari township receives its water from a well near the Orari racecourse; and the Temuka Borough augments their supply by pumping from a well from the Ohapi Creek.

TABLE 11: SUMMARY OF DOMESTIC WATER SUPPLY USAGE IN ORARI RIVER DISTRICT

SUPPLY	ORIGIN	MAX RATE (l/s)
Temuka Borough	1 well — Ohapi Ck.	31.16
Orari Township	1 well	7.5
Geraldine Borough	3 wells	45.0
	TOTAL	83.66

Much of the farming community obtains domestic water from privately owned wells for which no water right is required.

4.4. Dairy Use

The major user of water within the area for dairy farming is the Temuka Co-operative Dairy Company, which has a right to pump 18.9 l/s for use in its dairy factory at Clandeboye. The remaining total water rights for 13.45 l/s are used for cleaning milking sheds and cooling milk.

4.5 Miscellaneous Uses

A total average daily use of 1300m^3 at a maximum rate of 50.67 l/s is made up from a variety of users such as schools, golf club, racecourse, N.Z. Railways, gravel washing and ready-mix concrete.

4.6 Recreation and Wildlife

4.6.1 Recreation

Fishing is the most popular recreational activity carried out within the Orari River catchment with the major interest being in quinnat salmon, brown and rainbow trout, and whitebaiting. The Orari River is one of the smallest rivers to support a quinnat salmon run and most success for anglers is centred around the lagoon and seawaters around the mouth, where up to 40 salmon per day may be caught.

The catchable stock of trout for the Orari River has been estimated at 310 fish per kilometre (5) with the average crop taken (1962-1967) being 10 fish per kilometre. Average trout weight has remained constant over a 20 year study period at 0.54kg (5).

Because the Orari River frequently dries up in its middle reaches, angling is mainly confined to the lower reaches. High numbers of trout frequent the drains and creeks (especially Ohapi creek) within this lower area. Fish salvaging operations are carried out by the S.C. Acclimatisation Society within the middle reaches of the river during most drought years.

The Orari River is one of the few rivers within South Canterbury that does not support any recreat-ional settlements.

The shallow water depths and lack of water in its middle reaches precludes the use of jet boats on the river. Canoeing is becoming more popular in recent years and during the warmer summer months, swimming and picnicing are popular throughout the length of the river.

4.6.2 Wildlife

Within the Orari basin, paradise ducks, grey ducks and mallard ducks predominate. The grey heron is also common in the upper catchment.

Wetland birds such as the pukeko and, to a lesser extent, the bittern inhabit the swampy areas of the Ohapi Creek and Clandeboye drains area.

Within the lower reaches in the lagoon area, estuarine birds such as the pied oyster catcher, black-billed gull, red-billed gull and pied stilt abound.

5. SURFACE WATER RESOURCES

5. SURFACE WATER RESOURCES

5.1 Orari at Silverton

5.1.1 Introduction

The present recorder site at Silverton (S91:730080) is situated at the lower end of the Orari Gorge some 40 kilometres from the mouth and drains 520km² of catchment (Fig. 13). Reliable flow records from a digital automatic water-level recorder commenced in June 1964. No flow control is present at the site, thus constant measurements have to be made to ensure reliability of the record. Measurements up to 20m³/s can be obtained by wading the river while flood flows are measured from a permanent gauging cableway some 1200m downstream of the recorder at map reference S91:734073.

Approximately 100m upstream of the cableway is a disused concrete water-level recording station. This station was built in the late 1950s and chart records are available from January 1960 to July 1967. Due however to lack of sufficient gauging and constant changes in bed cross-section, records prior to June 1964 are of lesser accuracy than those derived from the present site.

5.1.2 Flow Distribution

A table of monthly mean discharges from the site is presented in Table 12. Annual mean discharge at the Silverton site is 10.7m³/s. Flow duration curves showing percentage of time a discharge was equalled or exceeded are presented for the total period (1962-79), irrigation season (Oct-Mar), October-December and January-March periods in figures 14,15,16 and 17. Also shown is the minimum flow duration curve recorded for each period considered.

With a winter snow-line of approximately 1300 metres, 13% of the catchment above Silverton provides snow storage for the spring thaw.

TABLE 12: ORARI AT SILVERTON — SUMMARY OF MONTHLY AND ANNUAL MEAN DISCHARGES (1961-1979)

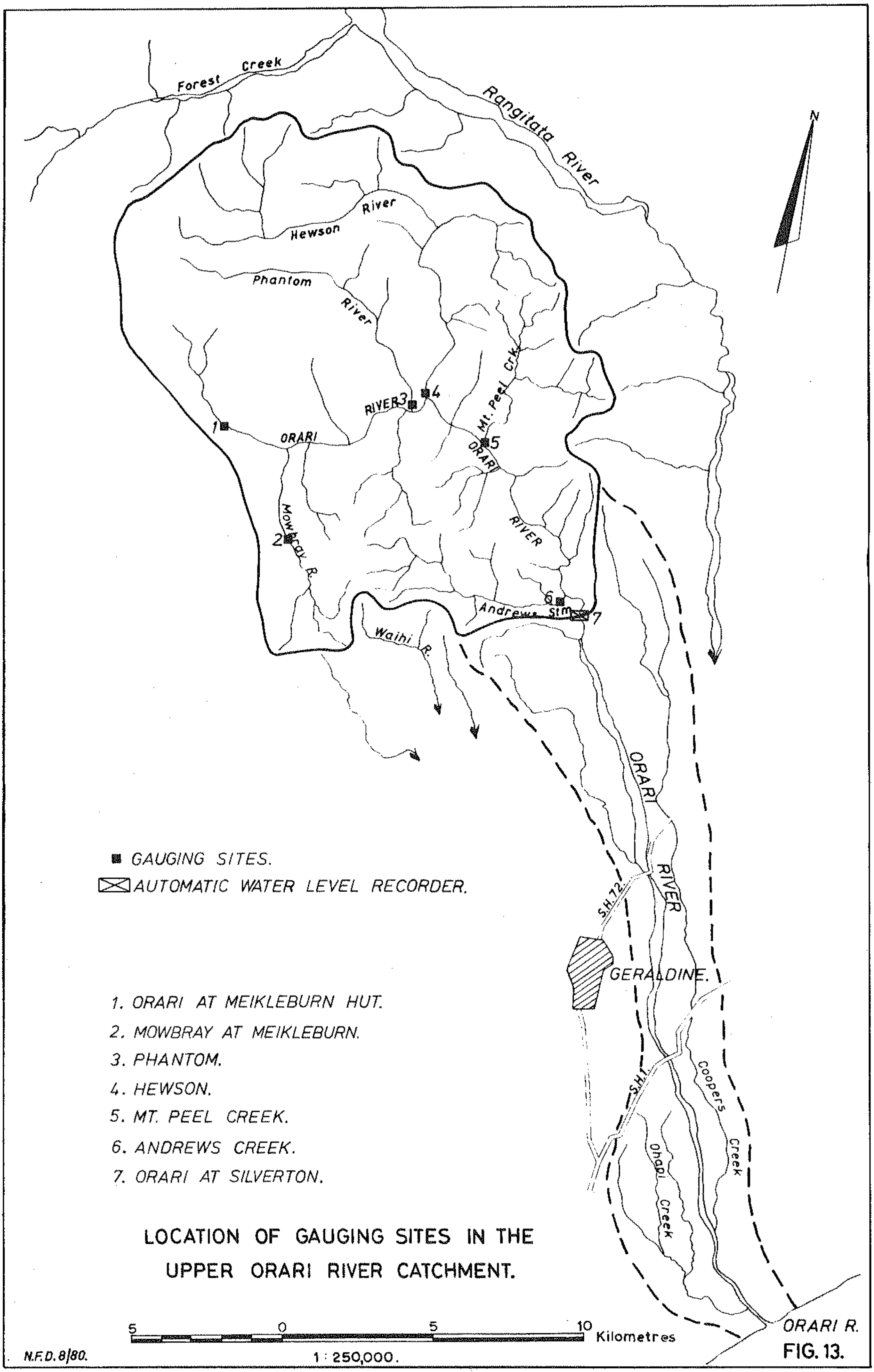
Values in m³/s

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1961								12.14	13.77	12.66	6.35	4.46	
1962	4.26	2.99	4.97	5.87	11.82	15.70	14.14	15.59	14.06	10.69	21.69	6.95	10.73
1963	4.02	4.62	4.26	27.11	13.15	12.28	43.34	16.23	26.65	8.25	4.86	4.99	14.15
1964	3.03	2.75	4.09	2.62	8.62	7.16	8.79	6.79	4.73	7.79	9.23	6.50	6.01
1965	17.13	21.13	10.94	10.62	5.43	5.80	8.56	12.03	9.77	10.71	15.30	5.78	11.10
1966	7.96	4.65	6.67	3.68	6.47	4.03	5.04	13.13	13.69	9.57	11.63	8.79	7.94
1967	16.28	7.09	5.19	6.23	5.48	3.93	9.09	8.07	6.25	8.16	38.06	15.92	10.81
1968	7.39	9.79	7.88	33.62	12.94	17.39	18.24	14.67	12.88	16.16	11.72	10.33	14.42
1969	4.94	6.62	2.87	2.86	4.24	3.31	3.09	3.93	6.97	4.86	3.15	11.26	4.84
1970	12.00	7.98	7.32	3.89	3.48	6.45	7.12	20.25	64.89	10.18	6.94	4.06	12.88
1971	4.84	3.05	3.46	6.23	4.88	13.34	10.94	9.91	11.08	19.31	11.50	5.72	8.69
1972	3.61	2.83	2.28	4.85	16.41	8.34	11.35	8.15	8.75	16.47	5.89	6.99	7.99
1973	3.63	2.21	1.93	2.31	4.24	5.25	2.53	19.54	18.68	8.07	8.95	4.65	6.83
1974	3.45	6.42	12.06	24.22	7.46	11.83	10.24	9.04	18.26	21.71	8.90	3.93	11.46
1975	26.89	13.98	18.36	12.44	9.43	10.04	12.21	26.10	20.11	12.51	10.90	4.94	14.83
1976	3.50	5.75	3.15	2.86	3.89	6.55	10.63	14.62	21.02	16.40	10.35	22.30	10.08
1977	22.30	7.32	4.69	3.69	8.05	8.97	13.11	6.90	18.50	14.57	6.58	9.38	10.34
1978	6.52	3.58	2.69	29.74	16.42	9.93	25.00	25.39	32.68	20.39	10.72	14.77	16.48
1979	5.09	3.26	10.38	11.85	24.42	7.74	5.16	26.50	12.70	20.79	19.87	9.04	13.07
MEAN	8.71	6.44	6.32	10.82	9.27	8.78	12.14	14.26	17.87	13.14	12.02	8.68	10.70
MAX	26.89	21.13	18.36	33.62	24.42	17.39	43.34	26.50	64.89	21.71	38.06	22.30	16.48
MIN	3.03	2.21	1.93	2.31	3.48	3.31	2.53	3.93	4.73	4.86	3.15	3.93	4.84

The magnitude of the effect of snow on the spring flows is dependent on the amount of snow pack present and climatic conditions. Snow thaw is usually completed by early to mid November.

Monthly discharges show a distinct seasonal trend with maximum discharges occurring in the July-October period and minimum flows occurring in February to March.

Maximum discharge occurring since the SCCB was formed in 1945 was an estimated 1000m³/s (11) occurring in February 1945, while the minimum measured flow since 1961 was 1.88m³/s on 20th March, 1973.



LOCATION OF GAUGING SITES IN THE UPPER ORARI RIVER CATCHMENT.

FIG. 13.

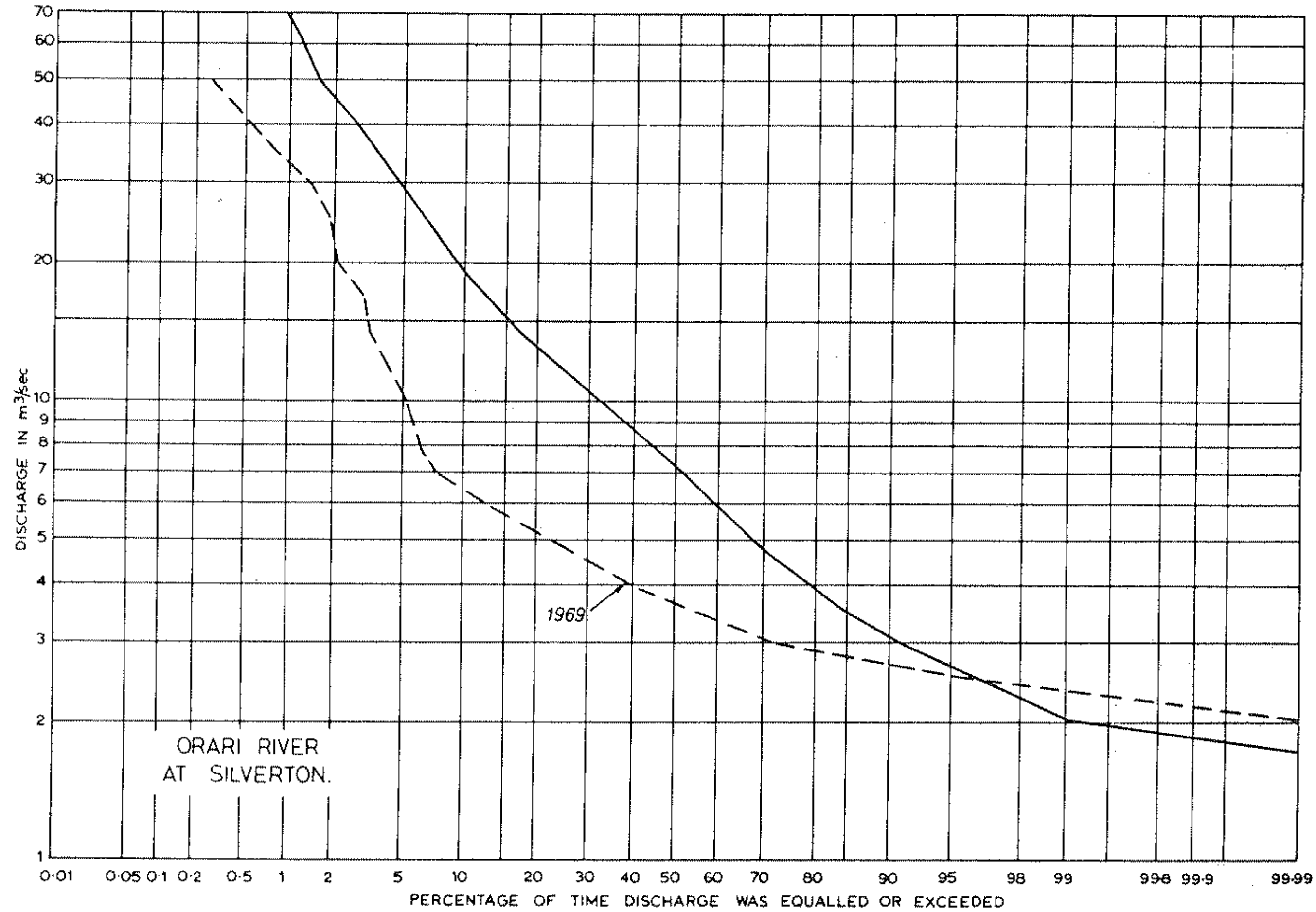


FIG. 14. FLOW DURATION CURVE OF DAILY MEAN DISCHARGES 1962 – 79.

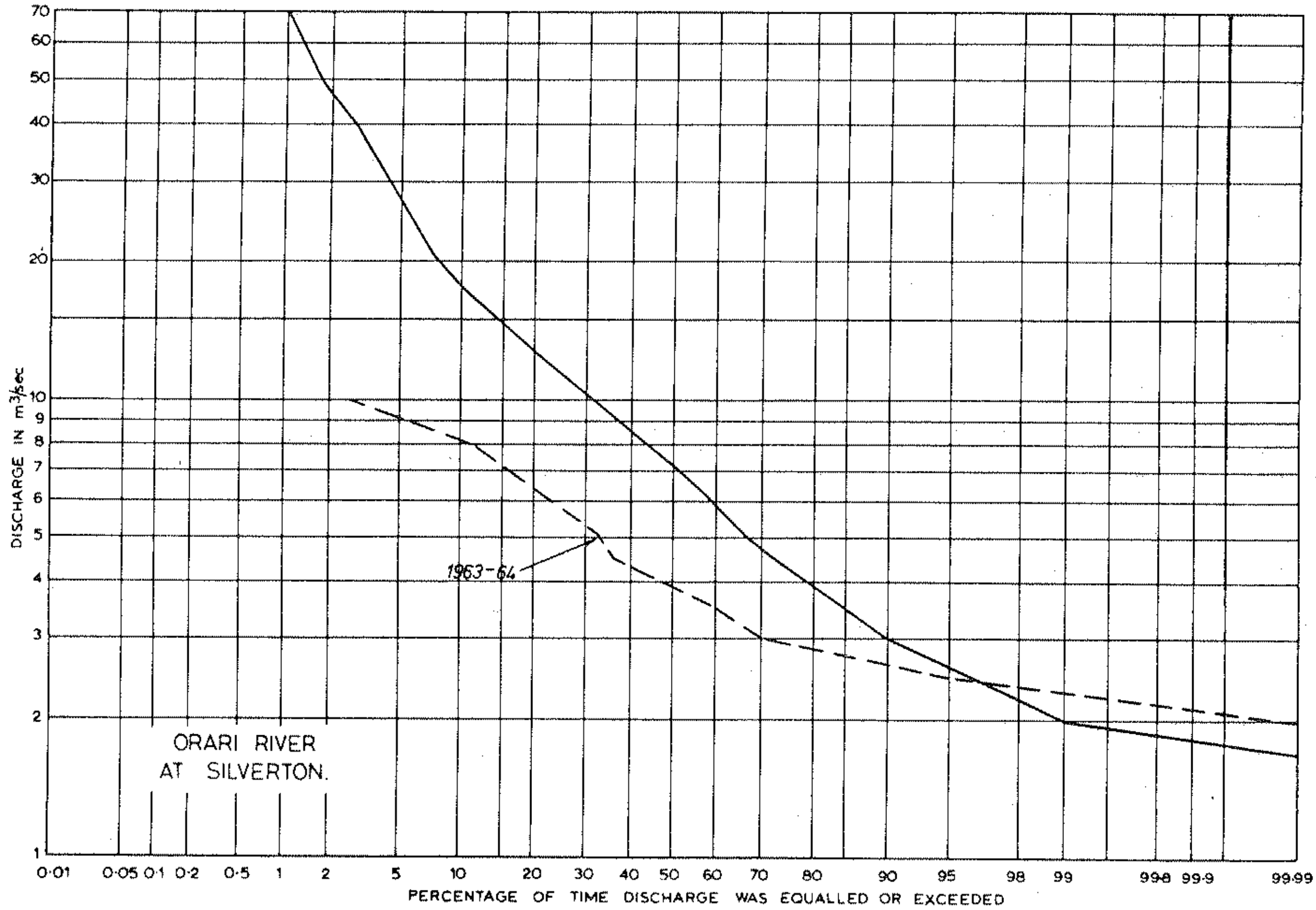


FIG. 15. FLOW DURATION CURVE OF DAILY MEAN DISCHARGES. IRRIGATION SEASON OCT – MAR 1961 – 79 incl.

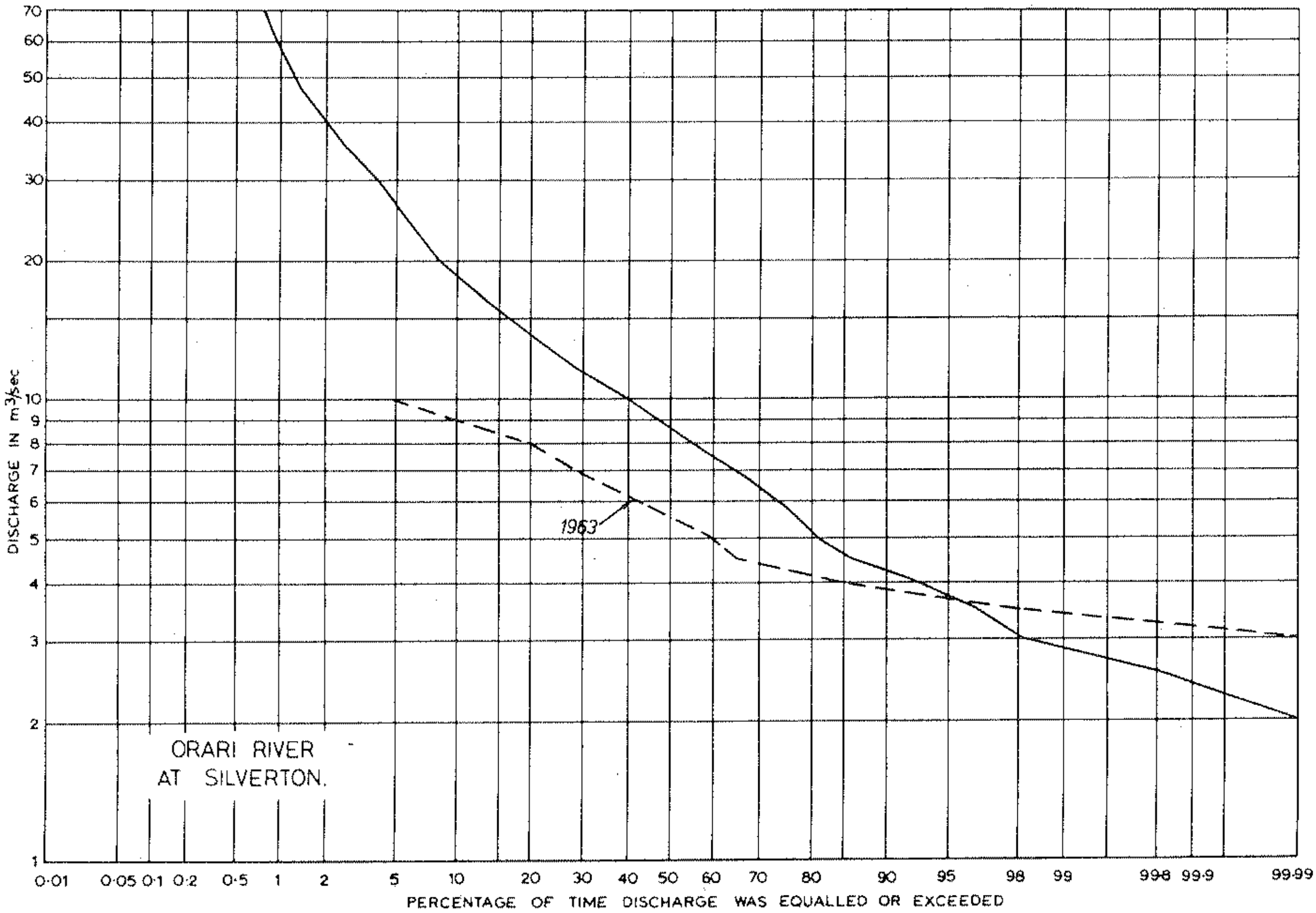


FIG. 16. FLOW DURATION CURVE OF DAILY MEAN DISCHARGES OCT - DEC 1961-79 incl.

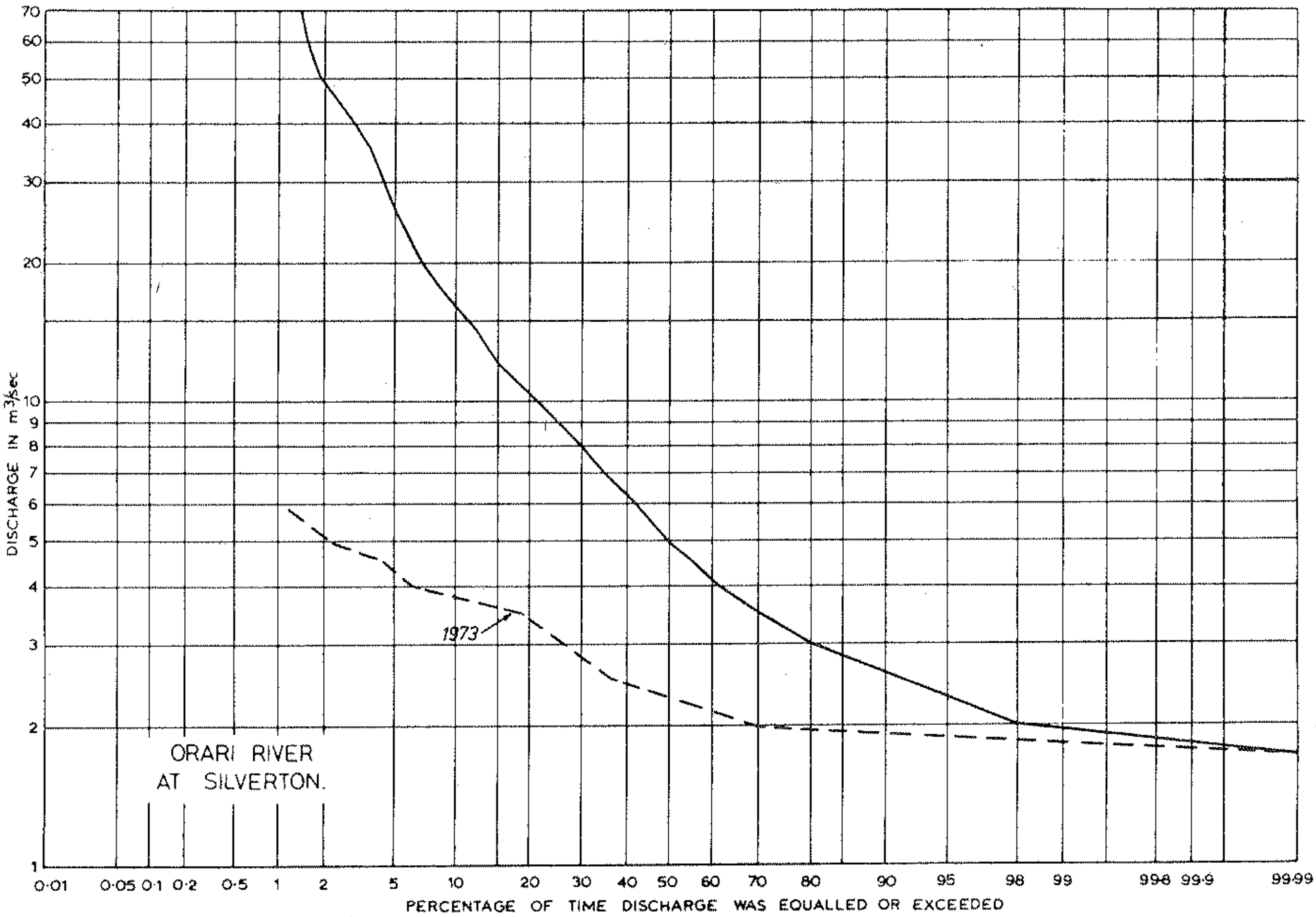
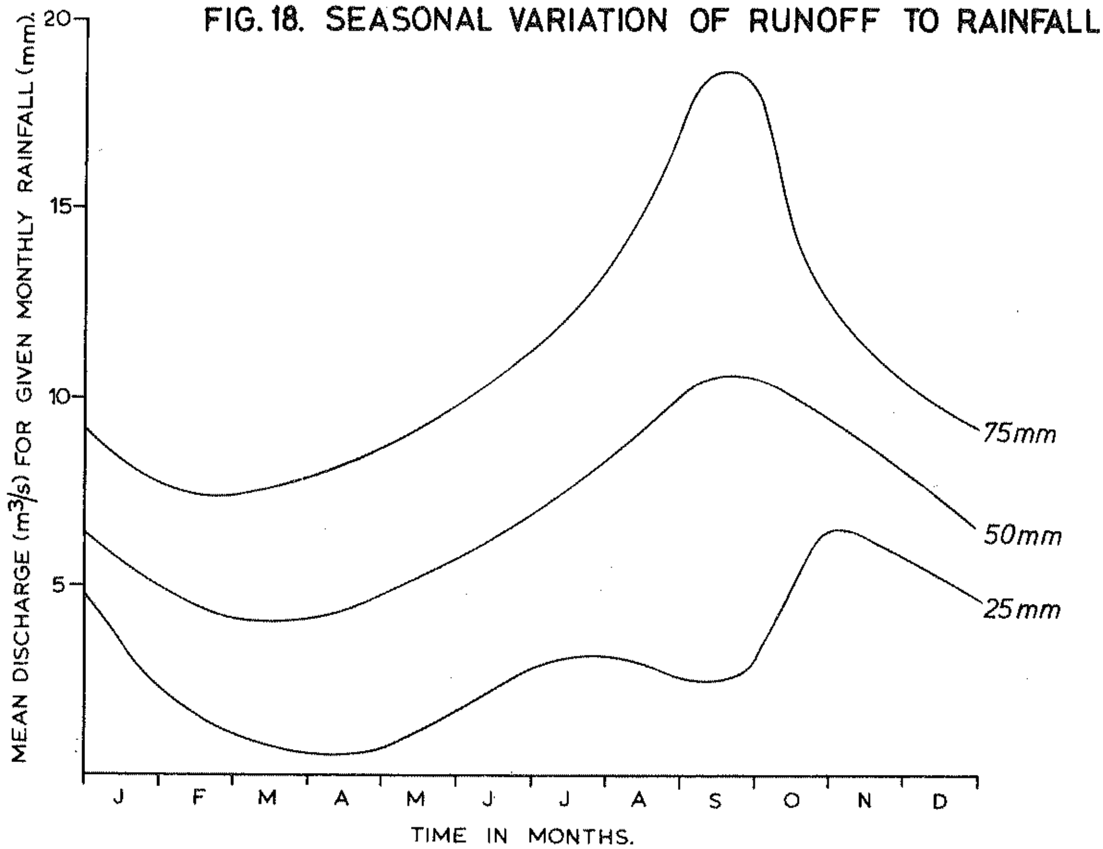


FIG. 17. FLOW DURATION CURVE OF DAILY MEAN DISCHARGES JAN-MAR 1962-80 incl.



Appendix 4 shows the regression lines of correlations of mean runoff and mean rainfall for summer (Dec-Feb), autumn (March-May), winter (June-Aug), spring (Oct-Nov) and September. Fig 18 shows the variation of runoff with rainfall for the periods stated for mean rainfalls of 25mm, 50mm and 75mm derived from the correlations.

Interpretation of these results are only speculative at this stage as runoff is not solely dependent on rainfall but also on other parameters such as temperature, ground cover, snow pack, and evapotranspiration.

Fig. 18 shows that for September the runoff per unit rainfall is much greater than in any other month with the exception of the 25mm rainfall. It is assumed that the higher runoff in September is caused by the effect of rainfall melting the snowpack to give higher flows. The lower runoff in September for 25mm rainfall is most probably due to the winter freeze in that 25mm of rainfall during this time would not be sufficient to cause as much snowmelt as in the October-November period.

5.1.3 Low Flow Frequency Analysis — Orari at Silverton

Low flow in the Orari River normally coincides with the irrigation season. Depending on the amount of the snow pack on the hills low flows usually start in mid December and can continue into March or April.

Using flow figures from 1962 to 1979 the low flow characteristics of the Orari River at Silverton were analysed using a frequency analysis of annual minimum flows recorded for durations of 1, 7, 15 and 30 consecutive days. The low flow series is presented in Appendix 5 and results are shown in Table 13 and Figure 19.

TABLE 13: LOW FLOW FREQUENCY (m^3/s) ORARI RIVER AT SILVERTON

Return Period	Number of Consecutive Days			
1:x Years	1	7	15	30
Av. Annual (1:2.33)	2.66	2.77	3.03	3.34
1:10	1.83	1.93	2.04	2.14
1:100	1.63	1.74	1.82	1.88

From Table 13 it can be seen that once in ten years the average low flow in the Orari River at Silverton over seven consecutive days may be expected to be less than $1.93m^3/s$ ($3.7\ l/s/km^2$) and once in 50 years the flow would be less than $1.74m^3/s$ ($3.3\ l/s/km^2$).

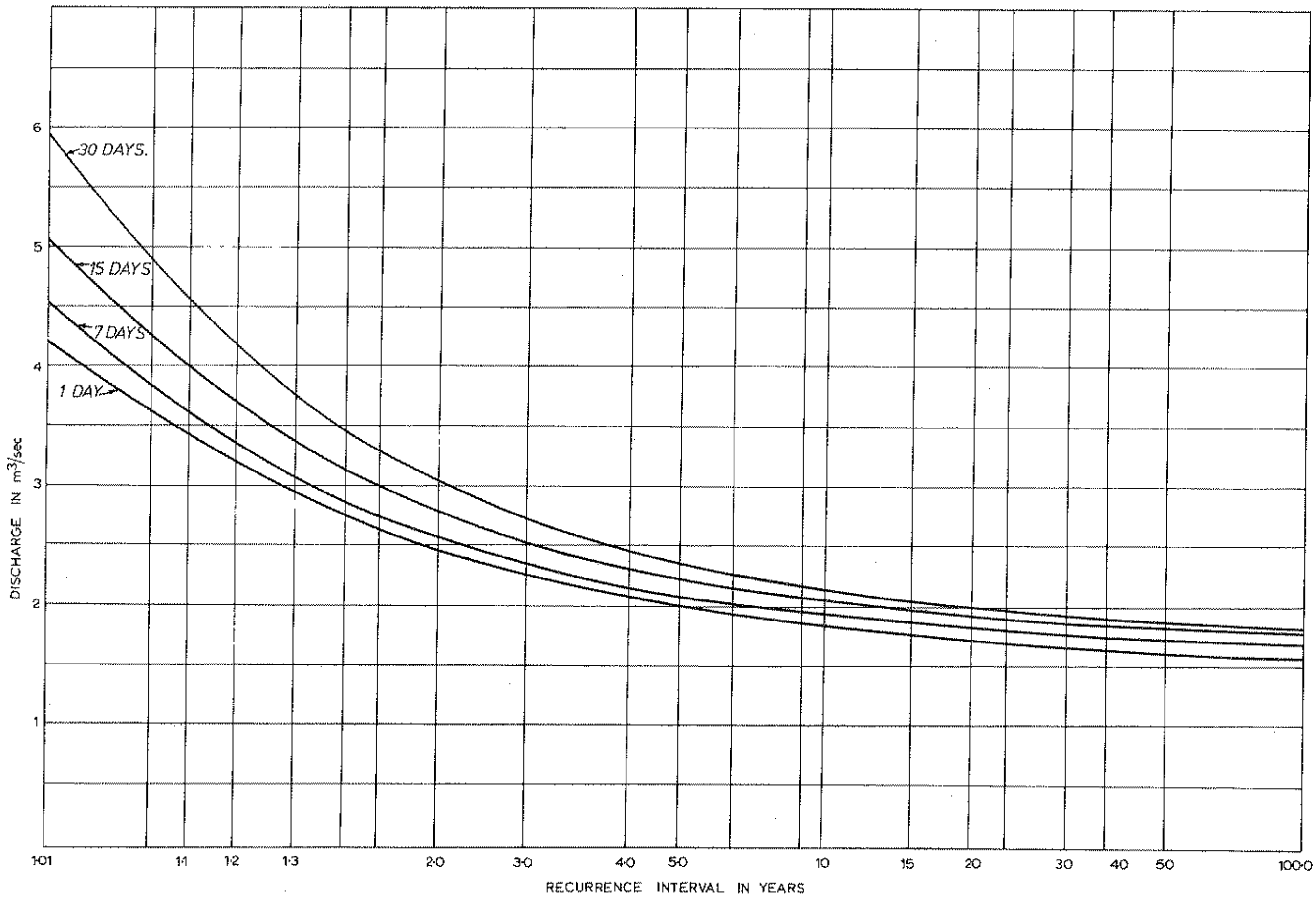
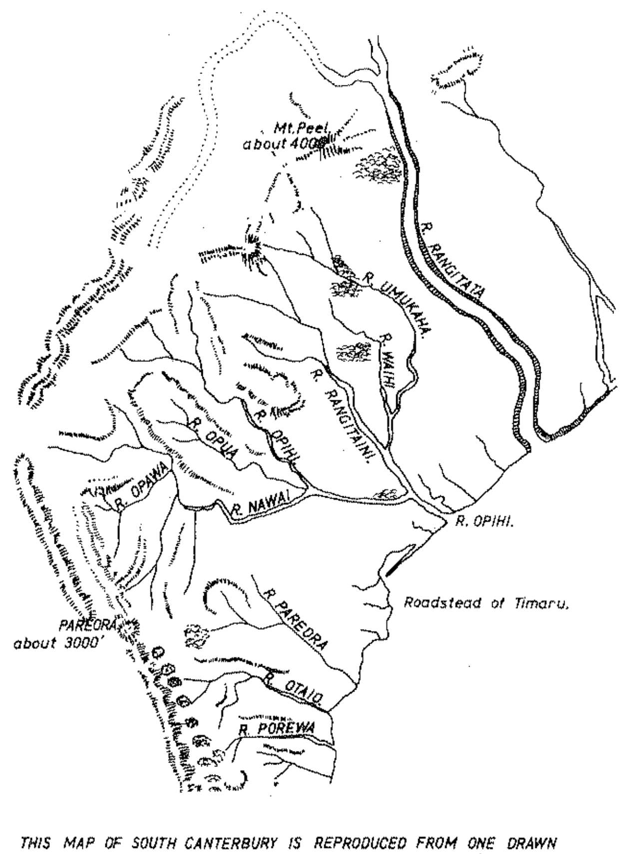
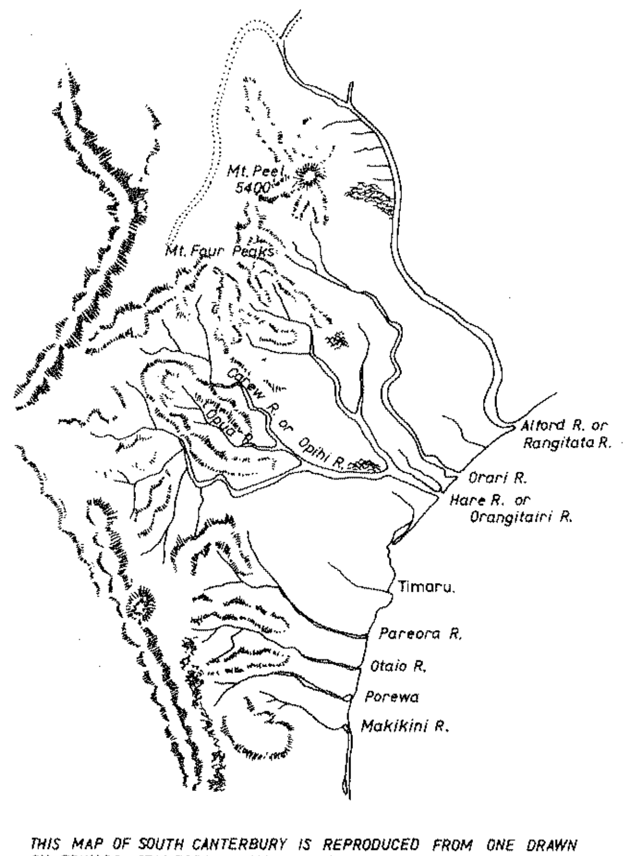


FIG. 19. LOW FLOW FREQUENCY CURVES FOR 1, 7, 15, & 30 DAY DROUGHTS.



THIS MAP OF SOUTH CANTERBURY IS REPRODUCED FROM ONE DRAWN BY C.O. TORLESSE, AFTER HIS SOUTHERN EXPLORING TRIP 1849. THE ORARI RIVER (UMUKAHA) AT THIS TIME FLOWED INTO THE WAIHI NEAR WINCHESTER.



THIS MAP OF SOUTH CANTERBURY IS REPRODUCED FROM ONE DRAWN BY EDWARD STANFORD IN 1856. BY THIS TIME THE ORARI RIVER HAD FORMED ITS OWN CHANNEL TO THE SEA.

MAPS REPRODUCED FROM "SOUTH CANTERBURY - A RECORD OF SETTLEMENT" BY O. A. GILLESPIE.

FIG. 20. ORARI RIVER COURSES 1849 AND 1856.

5.1.4 Flood Flows

5.1.4.1 Historic Floods

Until the SCCB was formed in 1945, historic floods within the Orari River were not well documented as far as peak discharges were concerned. The history of the present day Orari River can be traced to the flood of 1852. Prior to, and during 1849 the Orari River (then named the Umukaha) flowed directly south from the present day gorge to join the Waihi River at Winchester (approximately) thus flowing into the Temuka and Opihi system. This fact is clearly illustrated in a sketch map produced in 1849 (Fig. 20) of South Canterbury by Torlesse (10). A subsequent sketch map produced in 1856 (10) (Fig. 20) shows the Orari River in its present day course. Because of its youth as a river system, the Orari River channel below the Silverton site was very unstable and flood flows frequently broke out of the channel and flowed into the Waihi system (1868, 1902, 1945).

Until SCCB training works and stopbanking was completed in the early 1960s, most floods inundated the flat coastal areas from Clandeboye to the sea resulting in widespread land and stock damages and disruption to communications. Because of the training works undertaken, it is now virtually impossible to compare floods prior to 1950s with comparable flows of today.

The flood of 1852 (estimated peak 1130m³/s) was responsible for the Orari River cutting its own course to the sea, and is the earliest documented flood in the river.

Possibly the largest flood to occur was in February 1868 when an estimated peak flow of 1250m³/s (11) occurred when Mt. Peel received 205mm rainfall in 24 hours. It is most probable that the Orari overflowed its banks below the gorge as there were reports of sheep from Raukapuka being deposited in the streets of Temuka.

Other notable floods have occurred in the Orari River in 1871, Feb 1892, Dec 1902, Dec 1911, 1941, Feb 1945, April 1951, Nov 1952, May 1957, May 1961, July 1961, April 1963, July 1963, Jan 1965, June 1968, May 1972, Jan 1975 and April 1978.

The floods of 1945 and 1975 were both caused by heavy rainfalls concentrated around Mt. Peel and the lower gorge areas.

5.1.4.2 Flood Frequency Analysis — Orari at Silverton

A summary of annual maximum instantaneous flows recorded at the Orari gorge from 1962 to 1979 is given in Appendix 6.

Using the Gumbel distribution for flood frequency analysis, the distribution was fitted to the flood series by the method of least squares. Instantaneous flood flows for specific return periods are summarised in Table 14.

TABLE 14: FLOOD FREQUENCY ANALYSIS (m³/s) ORARI AT SILVERTON

Return Period (1:x years)	2.33*	5	10	50	100
Peak flow m³/s	307	511	677	1040	1200

* 1:2.33 return period is equivalent to average annual flood

From the table, it can be seen that the 1868 flood was in excess of a 100 year flood, while the 1852 flood was a 75 year flood.

5.2 Orari River Above Silverton Recorder

5.2.1 Introduction

The Orari River has its source in the headwaters of the Orari basin from the tributaries of the Orari, Mowbray, Phantom and Hewson Rivers (Fig. 13). All four tributaries join before the gorge inlet at Lochaber. Below Lochaber the only tributaries of any importance are Mt. Peel creek (39km²) and Andrews creek (39km²).

5.2.2 Orari River Above Meikleburn Hut

The Orari River has its origins in the Upper Orari basin (Fig. 13) which receives runoff from the eastern faces of the Ben McLeod range. The majority of precipitation is in the form of rainfall, although snow does lie on the higher slopes for up to 5 or 6 weeks depending on weather conditions.

Approximately 10% of the Upper Orari basin consists of swamplands which act as a water storage reservoir to release flows during drought periods.

Concurrent gaugings above the Meikleburn hut (S90/502151) and the Orari at Silverton are summarised in Appendix 7 and the derived correlation is shown in Fig. 21. From this correlation

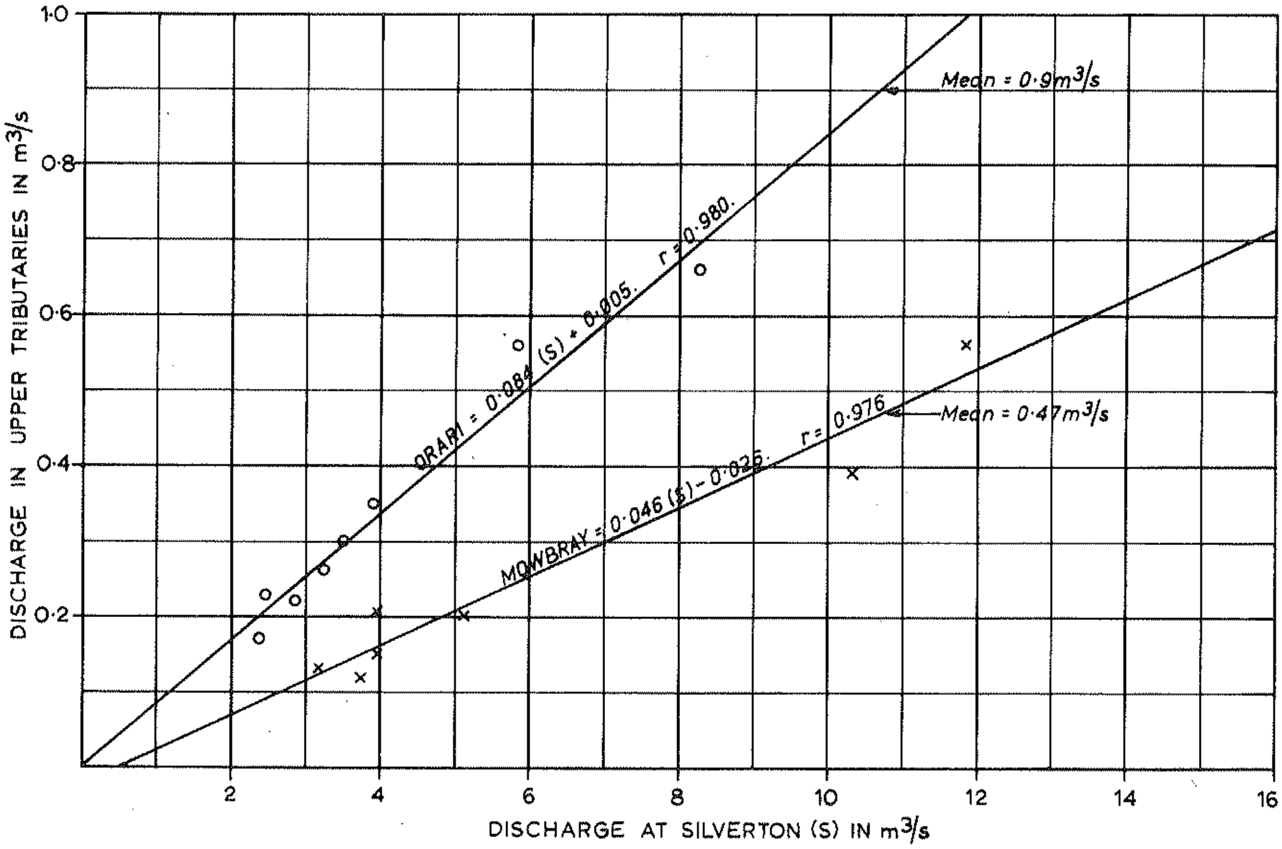


FIG. 21. FLOW CORRELATION OF UPPER ORARI TRIBUTARIES AND SILVERTON.

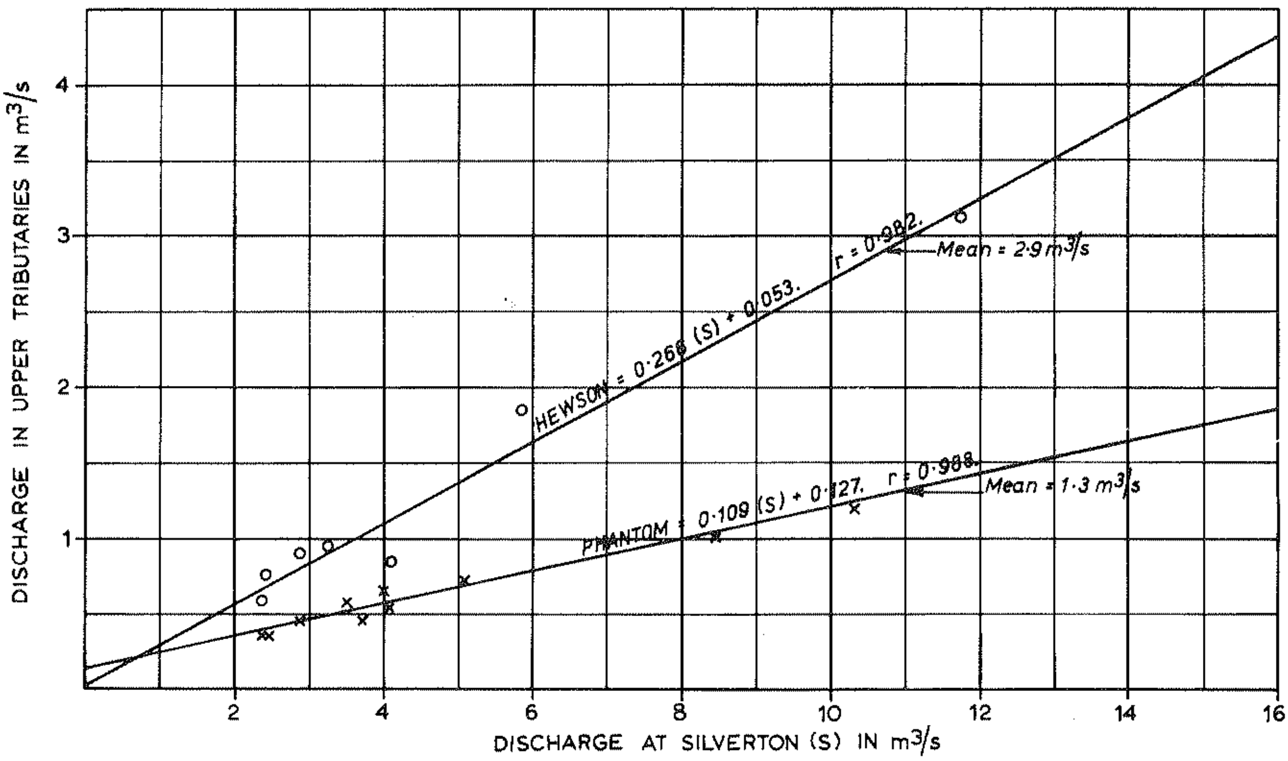


FIG. 22. FLOW CORRELATION OF UPPER ORARI TRIBUTARIES AND SILVERTON.

the approximate mean discharge of the Orari River at this site is 0.91m³/s from a catchment area of 44km². This represents an average runoff of 20.7 l/s/km².

Below the Meikleburn hut, surface flow usually ceases as the water flows into the gravels of the alluvial fan.

5.2.3 Mowbray Above Meikleburn Station

The Mowbray River joins the Orari River below Meikleburn Station at map reference S90/545142 (Fig. 13) and receives its runoff from the north-west and west faces of the Four Peaks range. As with the Orari above Meikleburn hut, the Mowbray losses water to the gravels of its bed when the river fans out from its gorge.

The gauging site for this river is situated approximately 2km from the gorge entrance at map reference S90/548100, and a summary of concurrent gaugings with the Orari at Silverton is shown in Appendix 7. From the derived correlation of these gaugings (Fig. 21) estimated mean flow from the Mowbray at the gauging site is $0.47 m^3/s$ from a catchment area of $38 km^2$. This represents an average runoff of 12.4 l/s/km.

5.2.4 Phantom River Above Lochaber Road Bridge

The Phantom River has its source in the south-east faces of the Ben McLeod range (max. elevation 2000 metres). Snowfalls during winter months give a limited supply of snow storage to the river during the spring thaw. The river is generally confined to a single thread channel throughout the length of its narrow river valley.

The gauging site is situated above the Lochaber Road bridge at map reference S91/610183 (Fig. 13) and, at this point, the catchment area is $63 km^2$. Concurrent gaugings with the Orari River at Silverton are tabulated in Appendix 7 and the resulting correlation is shown in Fig. 22. Estimated average annual discharge is $1.3 m^3/s$, representing an annual average runoff of 20.6 $l/s/km^2$.

5.2.5 Hewson River Above Lochaber Road Bridge

The Hewson River also has its source in the south and east faces of the Ben McLeod range and also drains the steep north faces of the Hewson range. Snowmelt during the spring thaw is more dominant in this tributary than in any of the previously mentioned tributaries.

The gauging site is situated above the Lochaber Road bridge at map reference S91/616190 (Fig. 13) and, at this point the catchment area is $134 km^2$. Concurrent gaugings with the Orari at Silverton are tabulated in Appendix 7 and the resulting correlation is shown in Fig. 22. Estimated average annual discharge is $2.97 m^3/s$ representing an annual average runoff of 22.2 $l/s/km^2$.

5.2.6 Mt. Peel Creek at Orari Confluence

Mt. Peel Creek drains the west faces of Mt. Peel (1717m). During the winter months snow lies from an altitude of approximately 1300 metres, although this rapidly disappears with the spring thaw.

The gauging site is situated above the confluence with the Orari River at map reference S91/657166 (Fig. 13) and, at this point, the catchment area is $39 km^2$.

Concurrent gaugings with the Orari River at Silverton are tabulated in Appendix 7 and the resulting correlation is shown in Fig. 23. Estimated average annual discharge is $0.785 m^3/s$ which represents an average annual runoff of 20.1 $l/s/km^2$.

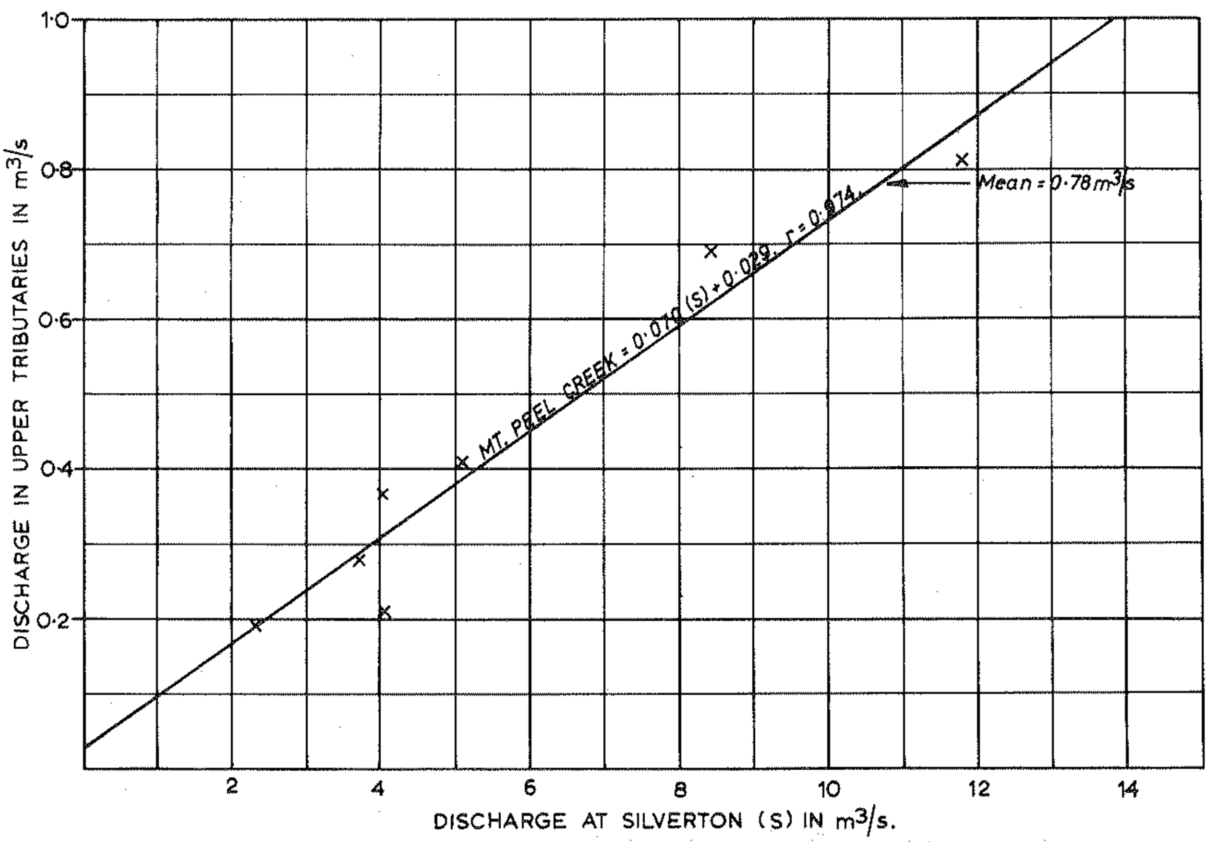
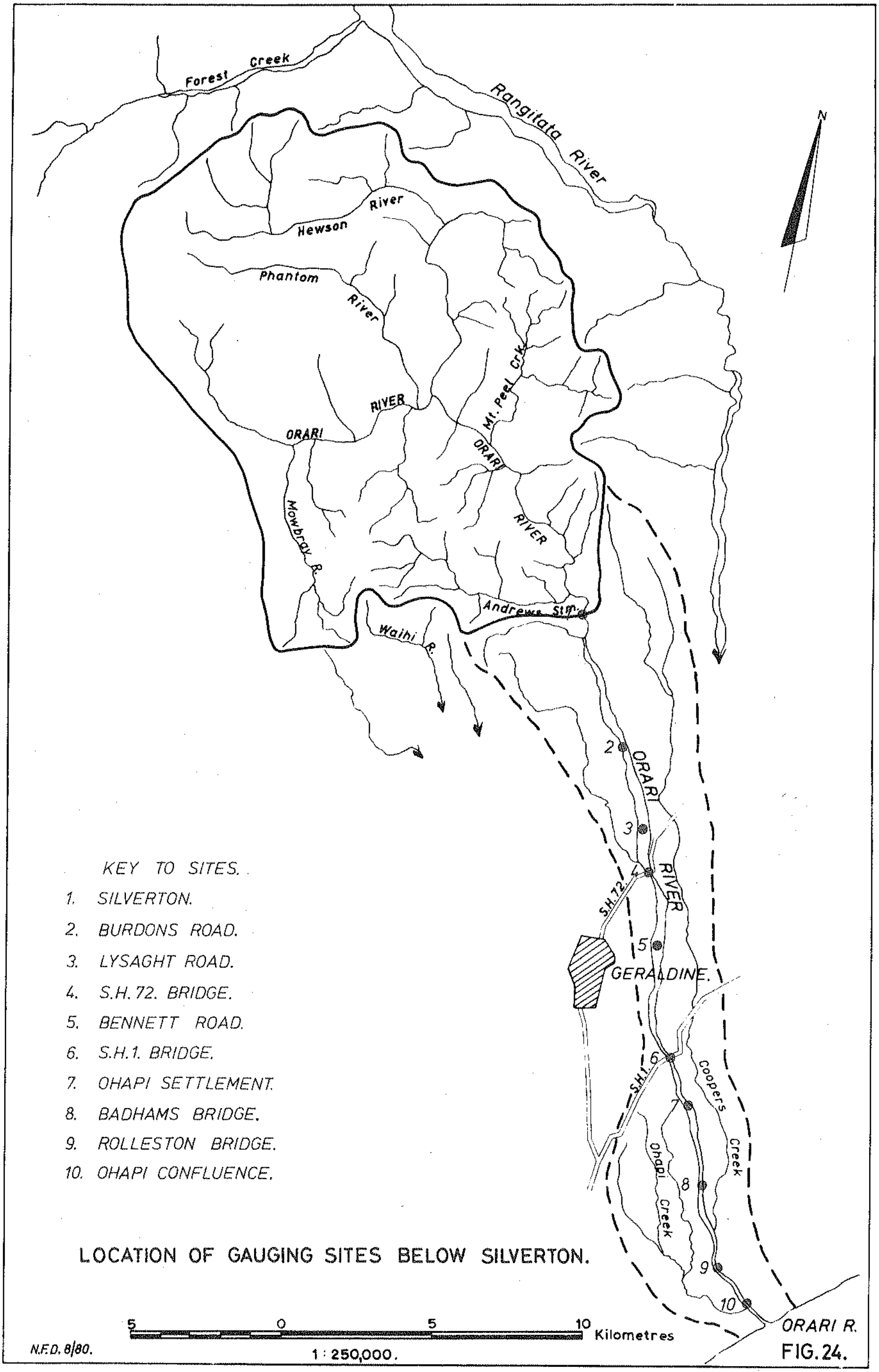


FIG. 23. FLOW CORRELATION OF UPPER ORARI TRIBUTARIES AND SILVERTON.



LOCATION OF GAUGING SITES BELOW SILVERTON.

FIG. 24.

5.2.7 Andrews Creek at Orari Gorge Confluence

Andrews Creek joins the Orari River 1.9km above the Silverton gauging site at map reference S91/720092 (Fig. 13) and drains the east faces of the Four Peaks Range. Only one gauging has been carried out at this site (28.2.73) at a discharge of 0.101m^3/s. At Silverton, the concurrent discharge was 2.05m^3/s which is 19 percent of the mean flow. Using a 19 percent equivalent flow for Andrews Creek, a tentative estimate of the average annual discharge is 0.53m^3/s which represents an annual runoff of 13.6 l/s/km^2 off a catchment area of 39km^2.

This runoff figure is similar in magnitude to that derived from the Mowbray River (12.4 l/s/km^2). As both tributaries drain the lower rainfall areas of the Four Peaks Range, it is considered that the Andrews Creek estimate should not have too great an error.

5.3 Orari River Below Silverton Recorder

5.3.1 General Flow Profile and Channel Losses

Figure 24 shows the location of gauging sites below Silverton, and Fig. 25 illustrates the variation in flow rates that occur within the lower Orari River. Five separate conditions representing mean flow rate, 45 percent flow rate, median (50 percent) flow rate and low flow rates are shown.

From Fig. 25 it can be seen that all of the flow-producing catchment is situated above the recorder site in the gorge. Apart from the flow contributions from Te Ao, Coopers and Ohapi creeks, the only other contribution to the river flow is from small drains in the lower catchment.

Generally, there is a loss to groundwater from the gorge site to below Victoria Bridge (SH1) and then a recovery from groundwater from there to the sea. Losses to groundwater become greater in the low flow range as the water table drops. In extreme low flow conditions, the Orari River is dry from 3km above Burdons Road crossing (S91/770010) to Ohapi Settlement Road (S102/855800). The Orari River is usually dry from the Upper Orari Bridge (SH72) to Victoria Bridge in the Jan-Feb period of most low rainfall years.

From Ohapi Settlement Road to the mouth, river flows increase through the contributions from groundwater. This increase however is not as rapid as the rate of loss in the upper region, thus flow rates at the mouth are less than those at the recorder site during low to mean flows.

During low flows the maximum channel losses occur between SH72 bridge and Bennetts Road crossing (S102/813903). It is from this region of the river that the old channel used to make its way from the present course to join the Waihi River. It is most probable that the water picked up from Dobies, Worners and Raukapuka streams originates from Orari water which is still following the old river channel and contributing to the groundwater to the south of the river bed. The intercepted groundwaters of Dobies, Worners and Raukapuka streams flows into the Temuka River which in turn flows into the lower Opihi River. In times of drought it is this water which makes up the entire flow of the Lower Opihi River.

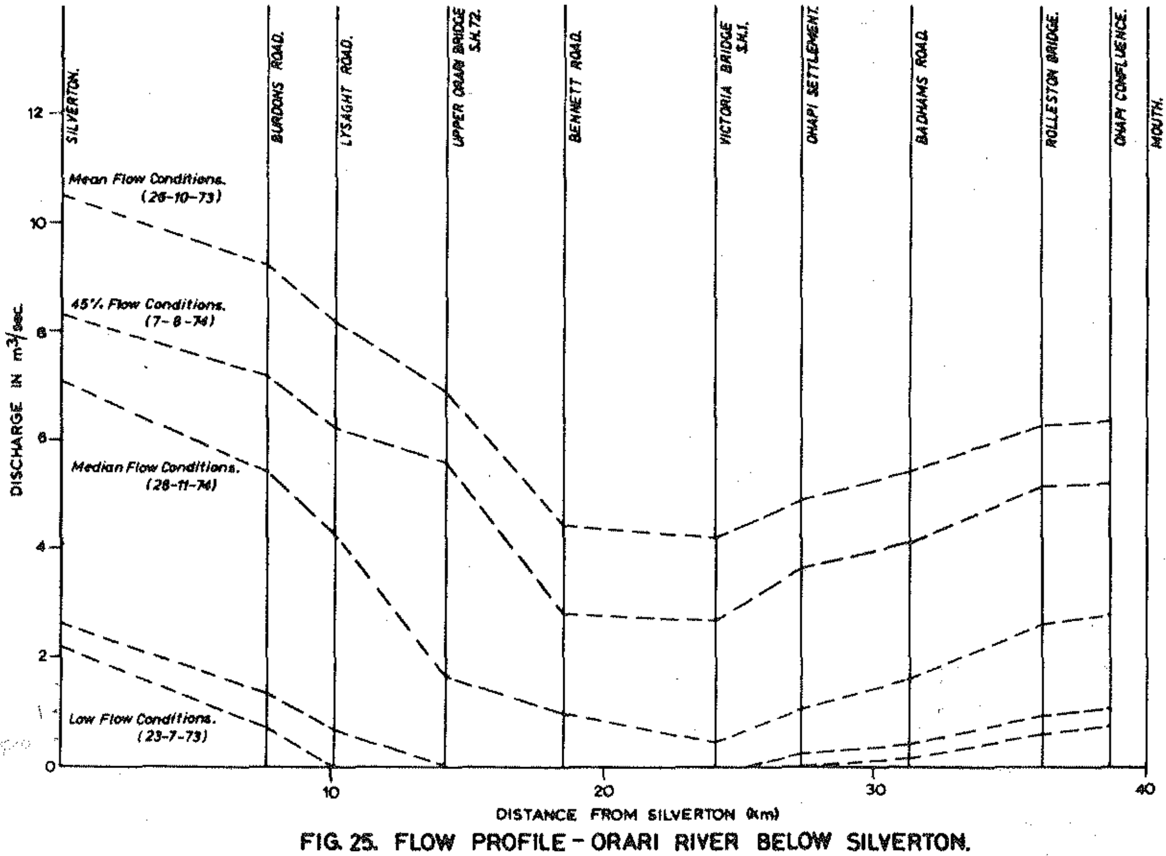


FIG. 25. FLOW PROFILE - ORARI RIVER BELOW SILVERTON.

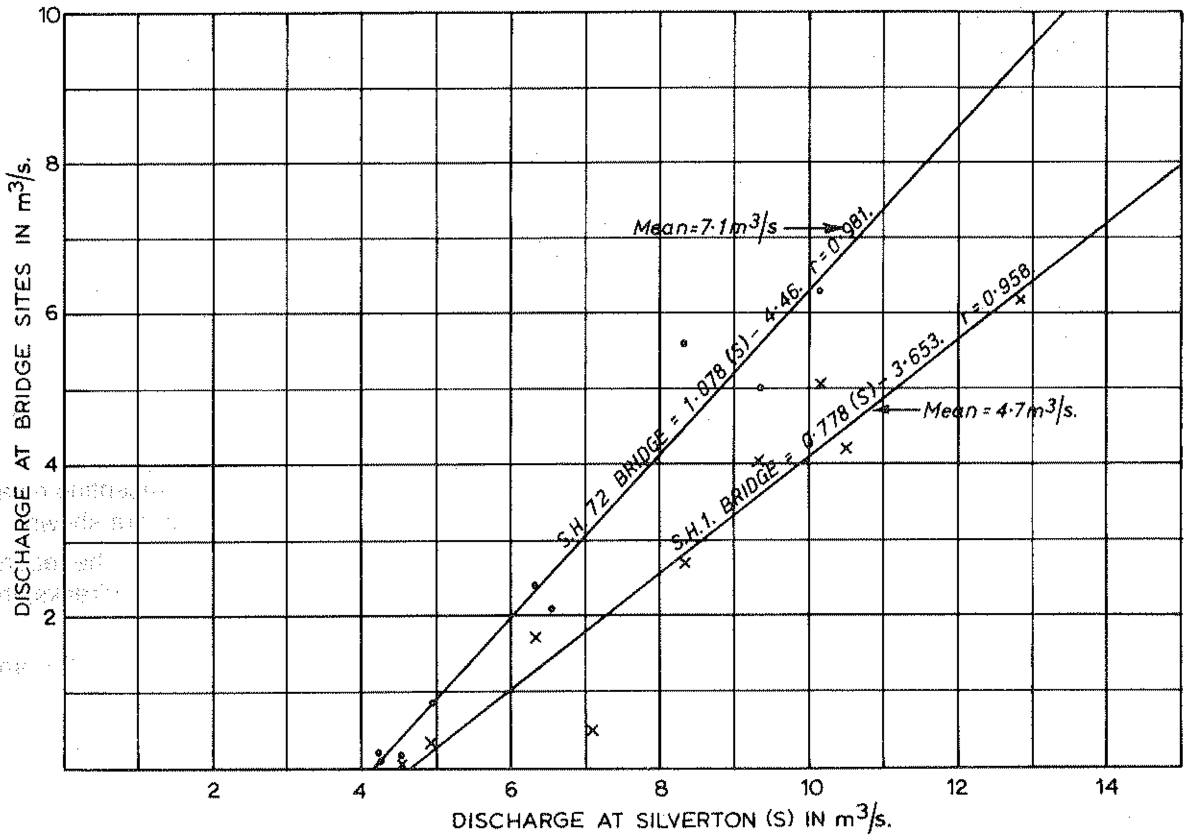


FIG. 26. FLOW CORRELATION AT SILVERTON WITH S.H.72. AND S.H.1. BRIDGES

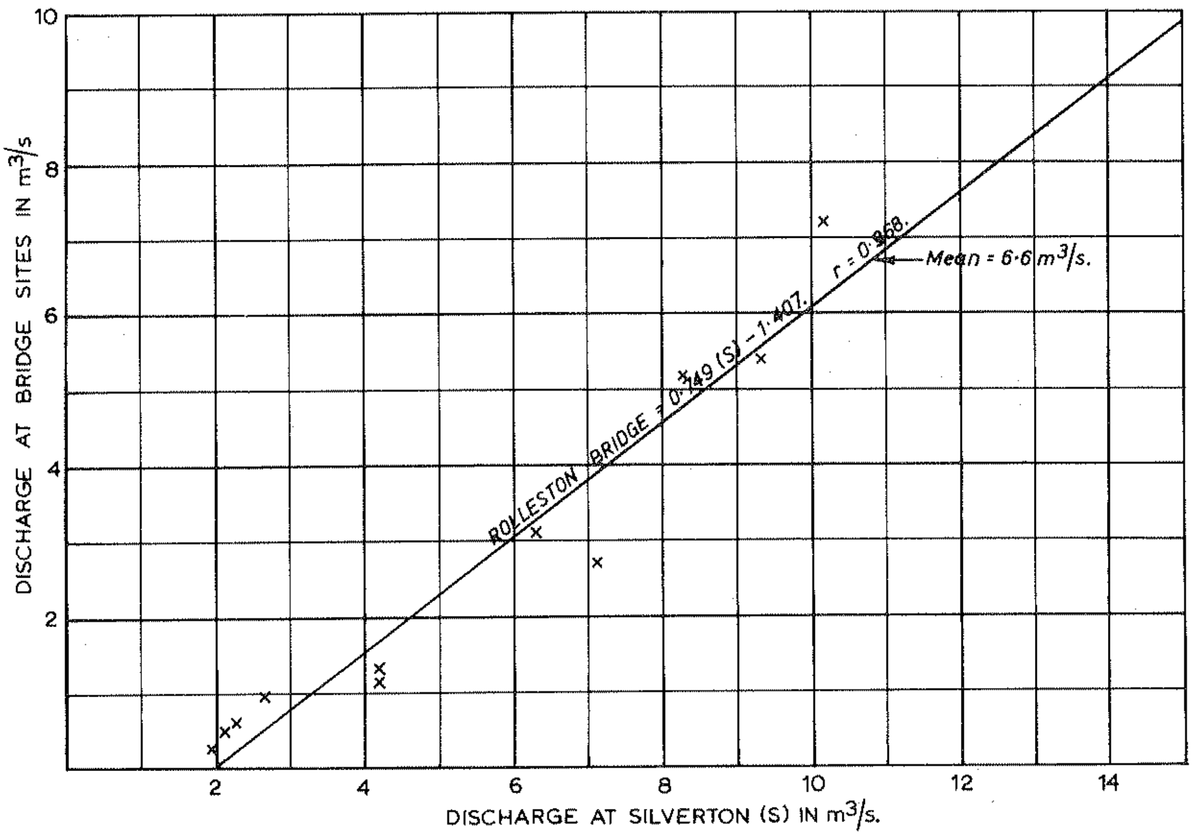


FIG. 27. FLOW CORRELATION AT SILVERTON WITH ROLLESTON BRIDGE.

5.3.2 Silverton to Upper Orari (SH72) Bridge

Channel losses from the gorge to the Upper Orari Bridge (14km in length) appear to be relatively constant at an average loss of 220 l/s/km during mean flows. The only abstraction from the river in this section is from two county stock water races situated 4.1km below the gorge at map references S91/745046 and S91/741056. These races abstract between 0.6 and 0.75m³/s of available surface water.

Concurrent gaugings with the Orari River at Silverton and Upper Orari Bridge are tabulated in Appendix 8 and the resulting correlation is shown in Fig. 26. Estimated average annual discharge at the Upper Orari Bridge is 7.70m³/s (7.10m³/s if water race abstraction is considered).

During times of extreme low flow, the river is dry from approximately 3km above Burdons Road crossing (10km above the Upper Orari Bridge) while under normal low flow conditions the river is dry from some 3 to 4km above the bridge.

5.3.3 Upper Orari (SH72) Bridge to Victoria (SH1) Bridge

Channel losses from the Upper Orari Bridge to Victoria Bridge (10km downstream) vary during periods of low to mean flow from 121 to 292 l/s/km depending on depth of water table. The largest loss within the section occurs between the Upper Orari Bridge and Bennetts Road (4km downstream) which coincides approximately to where the previous river channel continued southwards to join the Waihi at Winchester.

It would appear that the channel losses in this area are governed mainly by the prevailing ground water table level. With higher water table levels, channel losses are in order of 30 to 40 percent, while in times of low water table levels and low flows, losses of up to 80-100 percent occur.

No appreciable amounts of water enter the river in this reach and there are no irrigation rights issued for the abstraction of water from the river.

Concurrent gaugings with the Orari River at Silverton and Victoria Bridge are tabulated in Appendix 8 and the resulting correlation is shown in Fig. 26. Estimated average annual discharge at Victoria bridge is 4.7m³/s.

The reach between SH72 and SH1 remains dry for periods of up to 5 weeks during drought years while under average annual low flow conditions the river will be dry from Bennetts Road to the NZR bridge 400m above Victoria bridge.

5.3.4 Victoria Bridge to the Mouth

Channel losses continue in this reach for another 2.4km below the Victoria Bridge to Ohapi Settlement Road after which the flow increases from groundwater discharge into the river channel.

Increases in river flow appear to remain constant from mean flow conditions to low flow conditions at a rate of 145 l/s/km. The steady rate of increase appears to be independent of flow rates, most likely due to the fact that the groundwater table levels in the lower reaches of the river remain at a much more constant level than those in the upper reaches.

Within this 15km reach of the river the Orari receives water from Te Ao, Coopers and Ohapi creeks. Increases in flow from Te Ao Creek has little effect on the general river flow during high and mean flows, while in drought conditions, any contribution to the river is quickly lost. Te Ao Creek arises from springs on the North Bank of the Orari River above Victoria bridge and has been gauged at 0.61m³/s. Coopers Creek has an estimated mean flow of some 0.3m³/s at its confluence with the Orari, but is frequently dry in its middle reaches.

Ohapi Creek joins the Orari some 1.4km above the mouth and thus has only a local impact on the water resource of the Orari River.

Estimated annual average flow for the Ohapi Creek is in the order of 1.8-2.2m³/s.

Concurrent gaugings with the Orari River at Silverton and the Orari River at Rolleston Bridge are tabulated in Appendix 8 and the resulting correlation is shown in Fig. 27. Estimated average annual discharge at Rolleston Bridge is 6.68m³/s.

5.4 Water Storage

Although existing water usage and likely future water demand did not justify extensive surveys of possible water storage, it was felt that some brief comment on the possibility or otherwise be made. All investigations on storage volumes available were made from topographical maps and no geological or cost/benefit investigations have been made.

Storage requirements were calculated using mass runoff techniques with a minimum flow of 6.0m³/s to be maintained at the dam site. This figure was arbitrarily selected and would maintain a minimum flow of approximately 1.5m³/s at the SH1 Bridge.

Maximum storage volume required to maintain the flow during the 1962-79 period would have been 69 × 10⁶m³ (1973 drought). A site exists at NZMS 1 Map Reference S91/703126 which would have minimal impact on productive or grazing land, the lake tail level reaching the Mt. Peel Creek confluence. Dam height would be 69.2 metres above the existing river bed and, with no provision for flushing, would have a diminishing effectiveness for an estimated 200 years. This latter statement is based on an annual trapping of 300,00m³ of material. Obviously to provide for an effective life of 50 years or more, the storage volume would necessarily have to be increased to cope with the sedimentation.

6. GROUNDWATER

6. GROUNDWATER

6.1 Introduction

In the late 1940s the MWD (then the Public Works Department) sunk a number of observation pipes throughout the lower Orari area. These wells were read by both MWD and DSIR staff. The probable reason for these pipes was to monitor groundwater levels for investigations into drainage of the higher water table areas. Records from these observation pipes are incomplete with many wells becoming blocked within a few years and abandoned. Some monthly records do however exist from mid 1950, with some records continuing through to the mid 1960s and early 1970s.

In June 1980 the SCCB selected some 110 existing irrigation and house supply wells within the area bounded by the Rangitata River in the north and the Waihi-Temuka Rivers in the south (Fig. 28). It is intended to have these wells read at regular intervals to gain an accurate long term record of groundwater behaviour within the area.

6.2 Groundwater Behaviour

Hydrographs from selected wells from the MWD network are shown in Figures 29 and 30 and locations of these wells are shown in Fig. 28. Owing to the short term record of most of these wells it is difficult to identify any significant trends in water levels.

Average water level appears to have remained relatively constant for the wells south of the Orari River (MWD 29 and 140) whereas the Orton well (DSIR S102/3) shows a distinct lowering of the average water level from 1964 to 1970.

Generally, those wells closest to the Orari River, and those wells between SH72 and SH1 bridges tend to show the greatest fluctuations in water levels — the Orari Bridge well (DSIR 102/20) shows a maximum fluctuation of 5.5 metres plus, whereas the Winchester well (MWD 140) has a maximum fluctuation of 1.0 metre.

From Fig. 29 it can be seen that in general, the Winchester well (5.1km from the Orari River) responds directly to rainfall whereas the well in Macauley Road (2km from the Orari River) appears to respond to both rainfall and river levels.

6.3 Depth to Groundwater

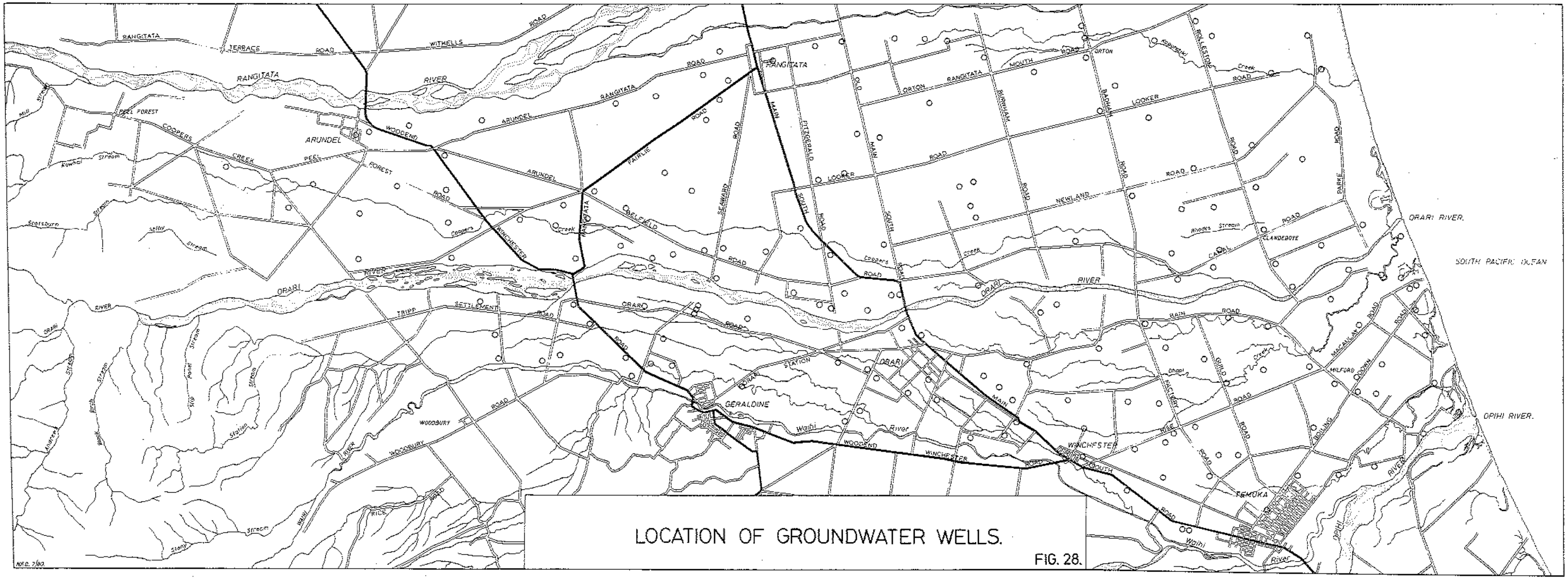
Figure 31 shows a map of depth to groundwater within the lower Orari River as at 24th-26th June, 1980. The map was produced from well readings based on the wells shown in Fig. 28. Comparison of groundwater levels in June 1980 and a previous survey carried out by MWD staff in January 1947 shows that within the area from SH1 to the sea, the configuration of equal depth contours has remained similar.

Depths to groundwater within the study area are relatively shallow when compared to groundwater depths in the Rangitata-Hinds area. In general, groundwater depths from SH1 to the mouth are within1 and 2 metres of ground level close to the Orari River, with a gradual deepening of the water table to 4 metres below ground level some 4km from the river banks.

Above SH1, the pattern is similar, although the water table shows a steeper and more variable gradient away from the river.

6.4 Discussion

At present, detailed knowledge of groundwater behaviour within the area is very limited. While some of the old MWD well records span periods of up to 30 years, most readings were only carried out at monthly to three monthly intervals. Although present demand for groundwater within the area does not warrant a full scale groundwater modelling programme, regular well readings at fortnightly intervals would be required if such a programme was initiated.



LOCATION OF GROUNDWATER WELLS.

FIG. 28.

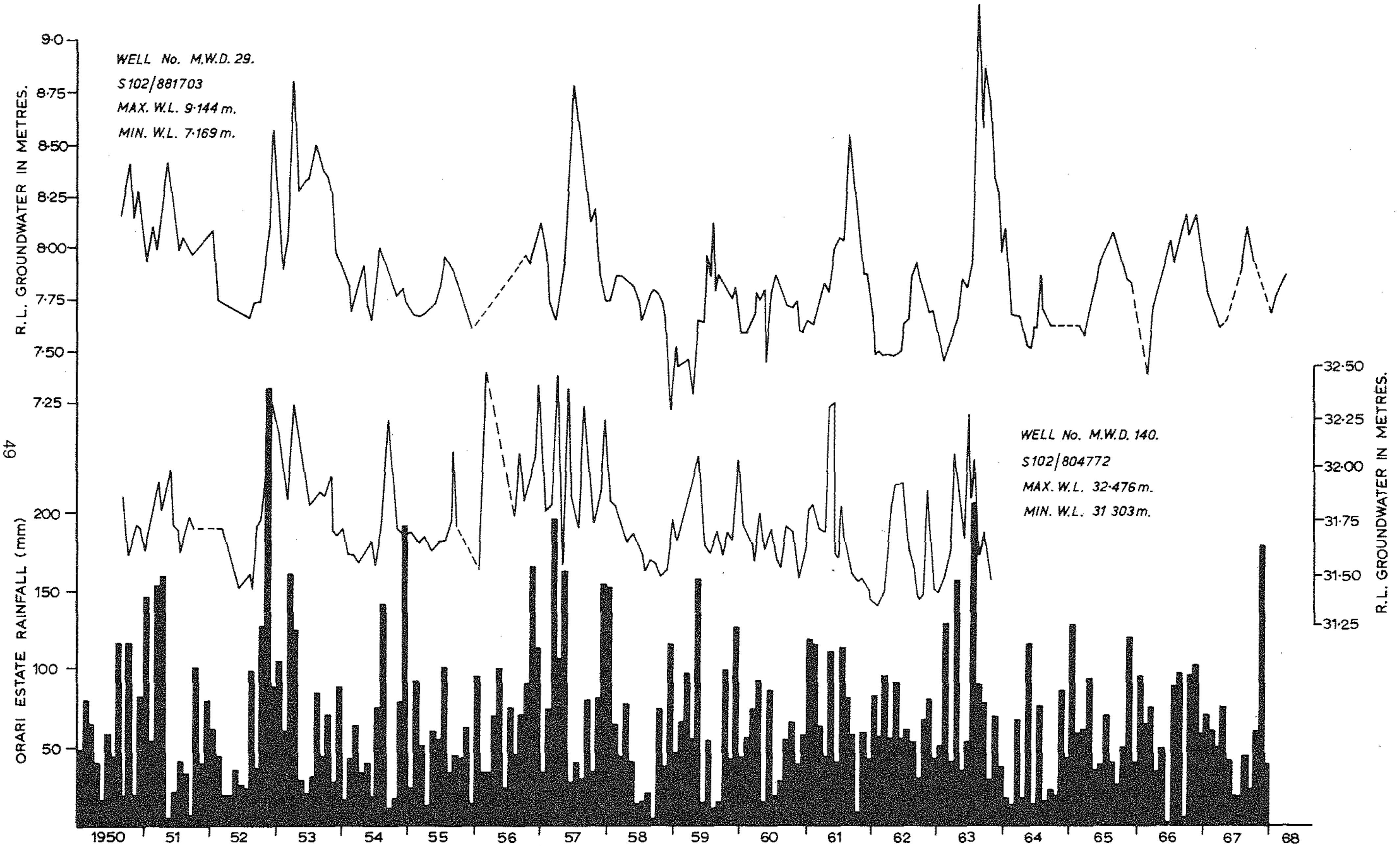


FIG 29 HYDROGRAPHS FROM SELECTED WELLS SOUTH OF ORARI RIVER.

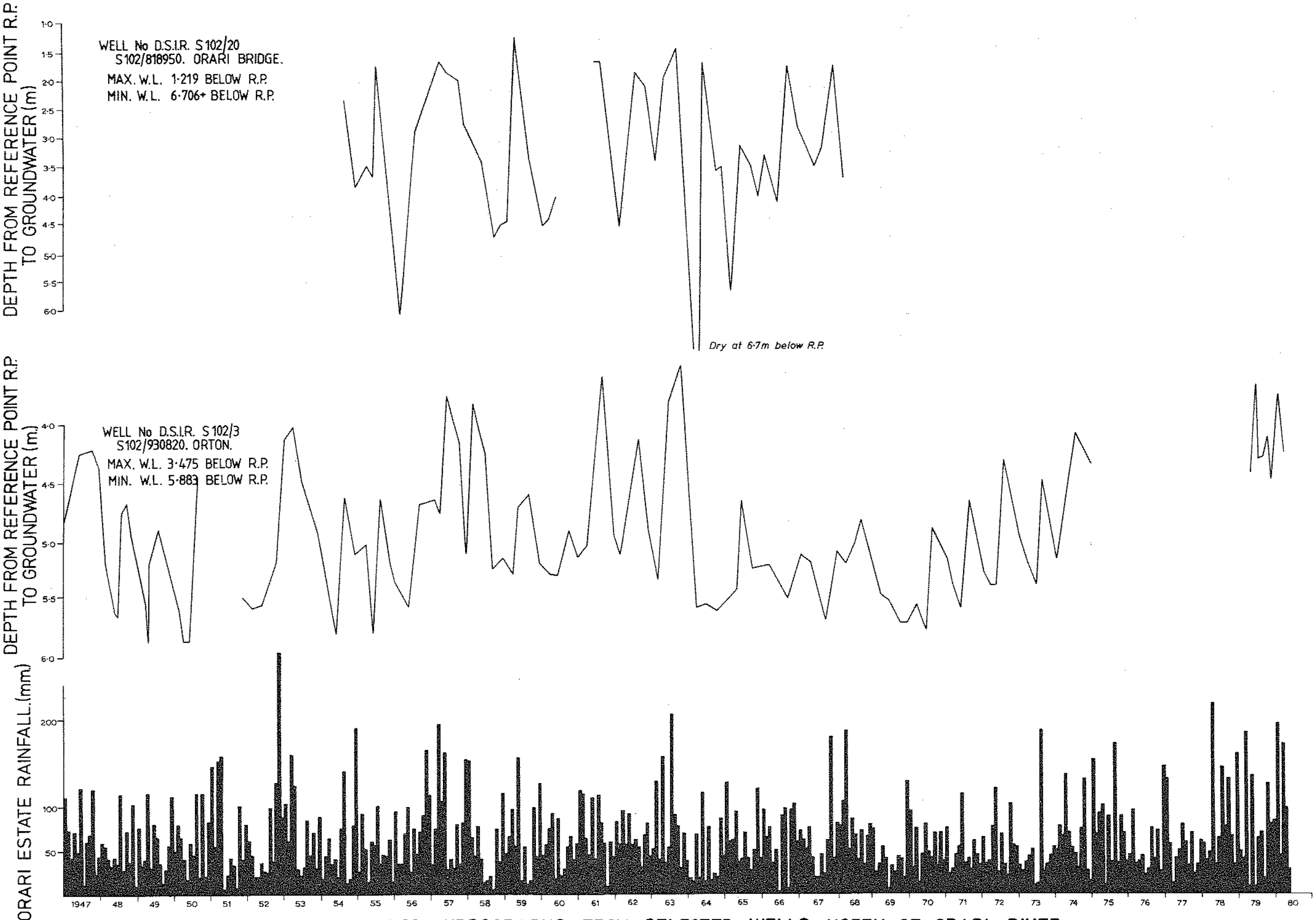
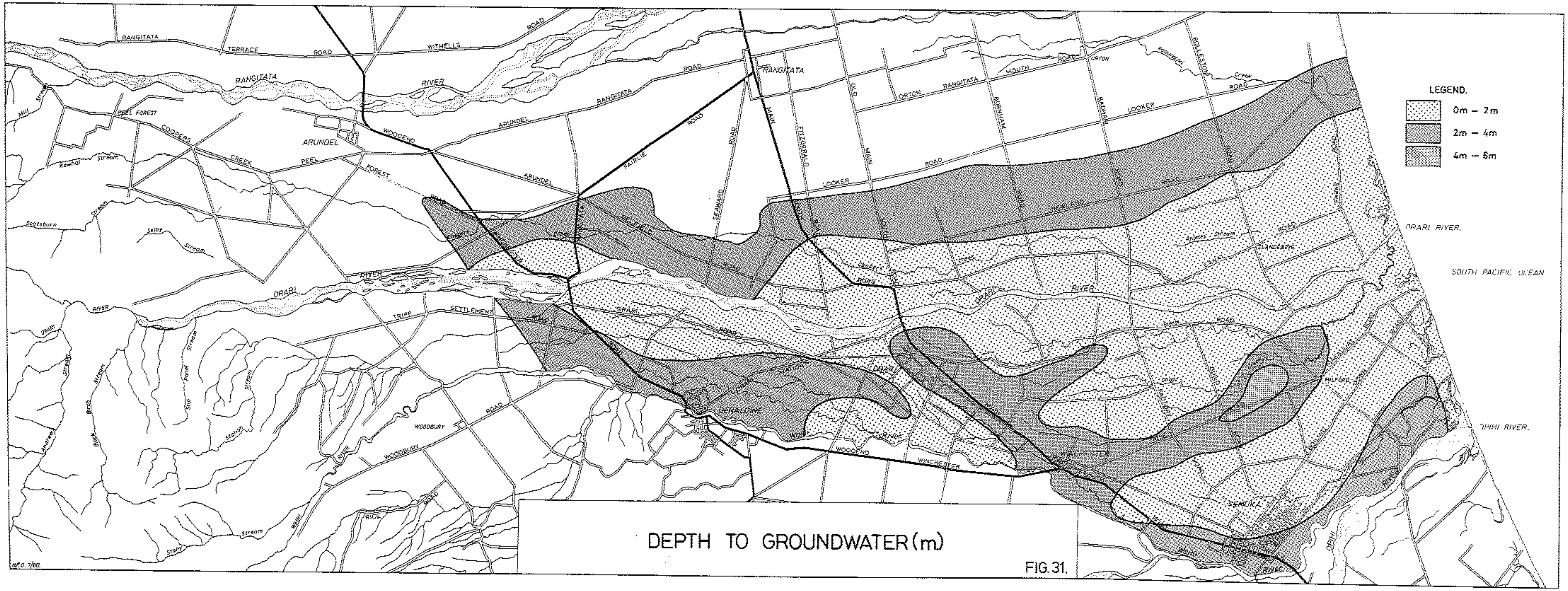


FIG. 30. HYDROGRAPHS FROM SELECTED WELLS NORTH OF ORARI RIVER.



DEPTH TO GROUNDWATER (m)

FIG. 31.

7. WATER QUALITY

7. WATER QUALITY

7.1 Introduction

Since August 1977 the SCCB has been carrying out a water quality monitoring survey of the Orari River, downstream of the gorge. Four permanent sampling sites have now been selected, and to date three separate series of sampling runs (August 1977, May 1978, June 1980) have been completed.

Physical parameters measured include temperature, pH, and dissolved oxygen, while bacteriological parameters include solely faecal coliform count.

Fig. 32 shows the location of the principle sampling sites and Table 15 summarises the available water quality data. Analytical methods are described in Appendix 9.

7.2 Water Quality Classification Standards

The criteria used to establish classified standards are included in a schedule to the Water and Soil Conservation Act 1967 in Appendix 10.

Waters are classified A to D as follows:

- Class A is kept in its natural state with no waste permitted to enter them.
- Class B is suitable for non-body contact recreation and general industrial use.
- Class C is suitable for body contact recreation.
- Class D is suitable for agriculture and industrial use.

TABLE 15: SUMMARY OF WATER QUALITY DATA

(Median Values)

Site	Parke Road			Rolleston Bridge			Badham's Bridge		
Sample Period	a	b	c	a	b	c	a	b	c
Temperature (°C)	7.3	9.4	—	—	—	7.4	7.9	10.3	—
pH	7.3	7.05	—	—	—	7.1	7.3	7.1	—
Dissolved Oxygen (mg/l)	11.4	10.1	—	—	—	11.5	11.1	10.2	—
Faecal Coliforms (No. per 100 mls)	110	114	—	—	—	41	21	78	—
Site	Victoria Bridge			Upper Orari Bridge			Orari Gorge		
Sample Period	a	b	c	a	b	c	a	b	c
Temperature (°C)	7.2	10.1	7.1	8.1	9.3	4.2	4.8	8.1	2.2
pH	7.2	7.1	7.0	7.35	7.05	7.15	7.4	7.2	7.3
Dissolved Oxygen (mg/l)	11.4	10.0	11.4	11.1	10.1	12.6	11.4	10.2	12.9
Faecal Coliforms (No. per 100 mls)	12	64	20	6	76	73	15	29	10

a. 22-8-77 to 19-9-77 (5 Samples)
b. 11-5-78 to 8-6-78 (5 Samples)
c. 19-6-80 to 24-7-80 (5 Samples)

7.3 Discussion

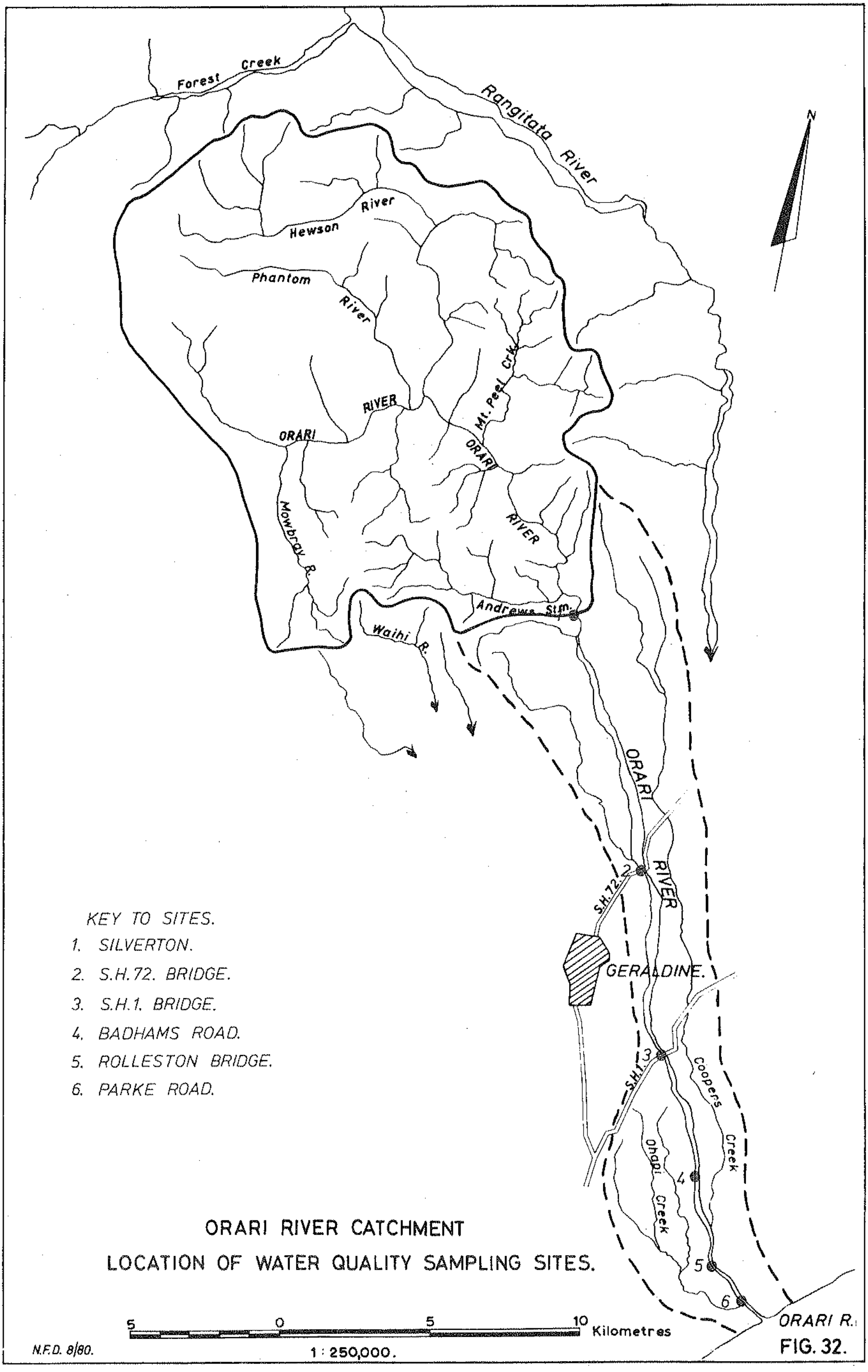
The quality of natural water is influenced by a complex inter-action of natural processes and human activities. Quality varies with time of day, season of year and flow in the river.

As only three sampling series have been carried out to date, over only a three year period, any interpretation must be considered preliminary at this stage.

All water quality sampling sites are downstream of the Orari Gorge, it being reasonably assumed that water quality upstream of this will be as high, or higher than the lower sampling sites.

7.3.1 Temperature

The maximum temperature that adult fish can tolerate varies with the species of fish, prior acclimatisation, and oxygen availability. Median tolerance levels for salmon (Oncorhynchus) species, brown trout (Salmo trutta) and rainbow trout (Salmo gairdneri) are 25, 27 and 28.5°C respectively.



ORARI RIVER CATCHMENT
LOCATION OF WATER QUALITY SAMPLING SITES.
FIG. 32.

Sudden changes in temperature are deleterious to fish life particularly to eggs and young fish (12).

Temperature data indicates that the Orari River provides a favourable environment for freshwater species.

7.3.2 Dissolved Oxygen

Dissolved oxygen content of water is related to temperature. For example, water at 11°C contains 11.1mg/l of oxygen at saturation, and at 22°C it contains only 8.8mg/l of oxygen. Thus the amount of oxygen available to fish life decreases with increasing temperature.

Dissolved oxygen levels remain at or close to saturation throughout the Orari River system, providing ample oxygen for fish species.

7.3.3 pH

The pH of natural waters falls within the range 4 to 9, with the majority of fresh waters slightly alkaline due to the presence of carbonate and bicarbonate (13).

In the Orari River levels of pH indicate slight alkalinity ranging from pH 7 (neutral) to pH 7.4. In all sampling periods the pH value was greatest (higher alkalinity) at the Gorge site. The values tend to reduce to a minimum at Victoria Bridge and then increase slightly. See Fig. 33.

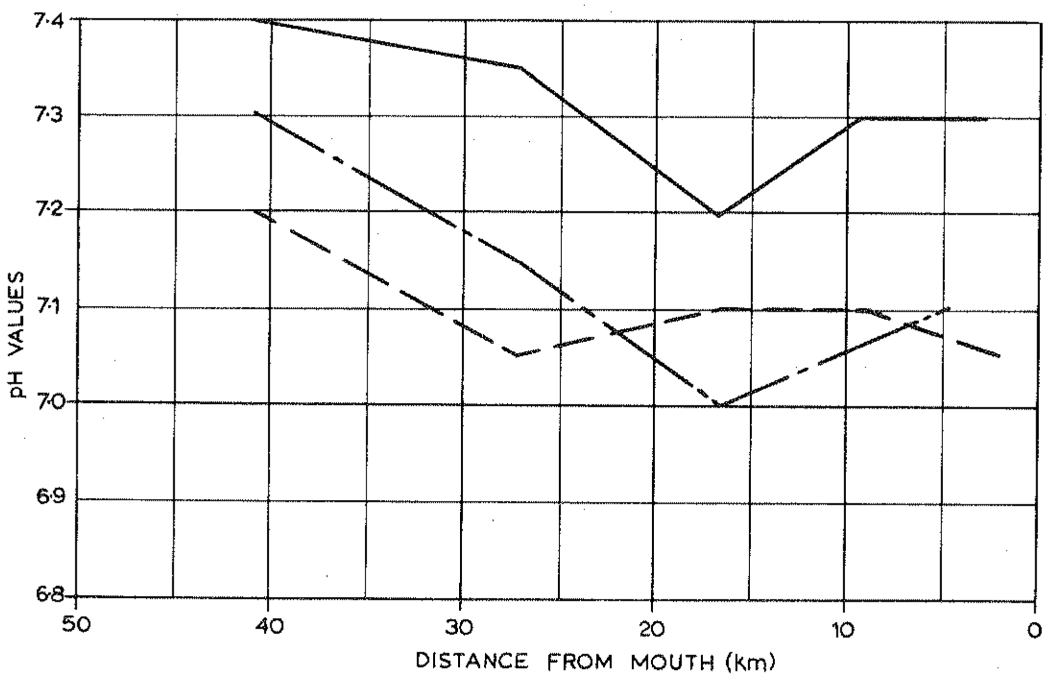


FIG. 33. MEDIAN pH VALUES ORARI RIVER.

7.3.4 Faecal Coliforms

Faecal Coliforms are coliform bacteria that grow in the intestines of warm blooded animals, including man. The presence of faecal coliforms indicates faecal pollution and the possible contamination of the water with pathogenic organisms.

The Orari River flows entirely through farmland and has no registered discharges entering it. Any faecal pollution will be wholly due to run-off from pasture catchments.

Median faecal coliform values at the sample sites are low (Fig. 34) tending to a maximum in the lower reaches of the river. This is probably due to increased farm density and inflow in the Clandeboye-Ohapi area.

7.3.5 Quality Standards

The waters of the Orari River are of a high and consistent quality, equivalent to Class A or Class C waters. Only six out of a total of seventy samples (8.6%), taken to date, have been over the Class C median coliform level of 200 per 100mls.

Future water quality will very much depend on any inflowing discharges, these most probably occuring in the lower portion of the river.

7.4 Sediment Discharge

7.4.1 Introduction

The transport of sediment by rivers has been the subject of much investigation both in New Zealand and overseas. Basically, sediment is transported by a river either in suspension (suspended sediment) or by rolling and sliding along the river bed (bed-load). In general the suspended load consists of the finer particles and the bed load the courser material.

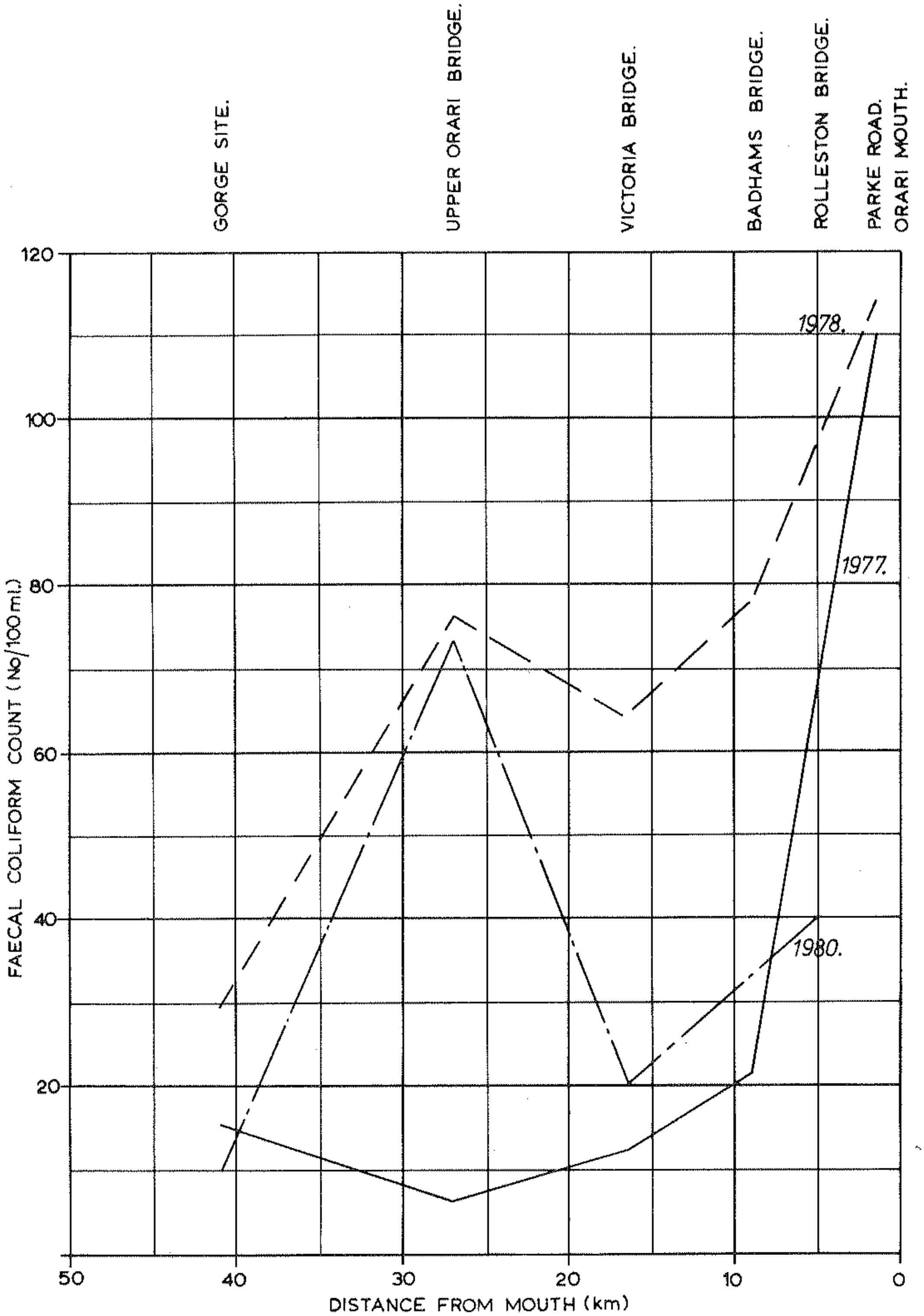


FIG. 34. FAECAL COLIFORM LEVELS IN THE ORARI RIVER

Suspended sediment can be readily measured by use of suspended sediment samplers such as the DH 48 and D 49 samplers and a fairly accurate result can be obtained. Measurement of the bed load is much more difficult. Many types of samplers have been designed, but most of these are designed to collect specific kinds of bed load.

Suspended sediment yields can be calculated through the compiling of a discharge-suspended sediment rating and use of flow duration curves because all rivers carry suspended sediments in varying quantities for almost 100% of their flow range. In contrast, bed load is only transported during flood peaks and high flows. During such times bed load may account for up to 85% of total sediment yield depending on the availability of supply. Because of the sporadic nature of bedload movements it is not generally possible to accurately calculate volumes of bed load, instead the accepted practice is to assume that bed load constitutes a certain percentage of total sediment load annually.

Estimation of the percentage of bed load to total sediment varies with many factors such as stream size, stream energy, rainfall intensity and availability of supply. The interested reader is referred to more detailed texts (14, 15, 16) as to the most reliable methods for determining bed load yields. The SCCB has recently set up its own water quality laboratory, and, in future will be able to analyse results from suspended sediment gaugings.

7.4.2 Suspended Sediment

From a series of sediment gaugings carried out by MWD staff, a suspended sediment rating curve (discharge in m^3/s against suspended sediment in tonnes per day) has been derived. The relationship between suspended sediment and discharge is given as:

$$Gs = 0.03202Q^{2.8586} \quad r = 0.924$$

where Q = discharge in m^3/s

Gs = Sediment concentration in tonnes/day

Using this relationship and the flow duration curve of flows from 1962 to 1979 inclusive, a mean daily suspended sediment discharge of 775 tonnes per day was calculated. Assuming a specific gravity of $960kg/m^3$ for the suspended sediment, this gives a volume of $745m^3$ suspended sediment per day ($270,000m^3$ per year).

Average catchment suspended sediment yield is thus in the vicinity of 545 tonnes/km^2/year, which compares with an estimated yield from the nearby Selwyn River catchment (a catchment within the same hydrological region) of 490 tonnes/km^2/year.

7.4.3 Bed Load

As yet, little is known as to the proportion of bed load to total sediment discharge. Estimates appear to vary from less than 5% to over 75% of total sediment. Data from the Roxburgh and Matahina lakes (14) show bed load to be 6.5% of total sediment for Roxburgh and 14.8% for Matahina. A figure of 10% is frequently adopted for bed load, but for mountainous rivers this figure is likely to be higher.

Assuming the bed load to be 15 percent of total sediments transported, the average daily bed load is approximately 140 tonnes per day. (51100 tonnes per year). Assuming a specific gravity of 1.8 tonnes/m^3 for this material the annual volume of bed load amounts to some $28400m^3$ per year.

Thus total sediment discharge from the Orari River at Silverton is in the order of $298400m^3$ per year (334000 tonnes per year).

8. SUMMARY AND CONCLUSIONS

8. SUMMARY AND CONCLUSIONS

The Orari River at Silverton has a mean flow of 10.7m³/sec from a catchment area of 520km² and mean rainfall of 900mm. This represents an annual runoff of 647mm or 72 percent of mean annual rainfall.

Annual average runoff is 21 l/s/km² which compares with an annual average runoff from the Selwyn River at Whitecliffs of 19.5 l/s/km² and the North Ashburton River at SH72 bridge of 25.5 l/s/km². Both of these latter stations lie within the same hydrological region as the Orari River.

From the gorge outlet, surface flow is continually lost to ground water for some 25km down-stream to Ohapi Settlement Road where there is a change to an increase in flow from here to the sea. Mean flow at the mouth is approximately 9.0m³/sec which represents an overall channel loss of some 1.7m³/sec.

Much of the surface water that is lost in the middle reaches of the river appears to be picked up by Dobies Creek which follows approximately the old Orari River course to the Waihi River. It is also most likely that Worners and Raukapuka Creeks intercept groundwater from the Orari. In times of low flow, it is the flow from these three creeks which make up the total surface flow in the Waihi-Temuka-Opihi system.

The Orari River thus provides an important resource to the Temuka and lower Opihi River systems in times of low flows.

Present water usage indicates that there is no excess demand for water from the Orari River and its tributaries and that likely future demand will not cause excessive demands upon the resource.

With water storage in the catchment it would be possible to augment drought flows but present demand does not warrant further investigations as yet.

Little work has as yet been done on the study of groundwater within the study area and while there appears to be sufficient groundwater for present needs, further investigation should be carried out to quantify this resource and to assess the impact of withdrawing water from the middle reaches of the river.

9. RECOMMENDATIONS

9. RECOMMENDATIONS

Following on from the summary and conclusions in the previous section, it is felt that the following recommendations should be made.

9.1 Continuation of long term records

It is recommended that the maintenance of stage-discharge relationships and long term water level records at Silverton be continued for the following reasons.

(a) To provide further information on flood frequency and magnitudes to ensure that the Board's flood control schemes and river protection works are adequately designed and working effectively.

(b) To monitor future effects of increased water demand and possible deterioration of water quality.

(c) To provide further information for the introduction of future water allocation plans.

(d) To be able to more accurately define the high stage rating through the measurement of more flood discharges.

(e) To provide reliable information from a catchment within the Canterbury Foothills hydrological region, thus helping to complete data within the Water and Soil Divisions network of hydrological information.

9.2 Suspended Sediment Gaugings

To date, only 15 sediment gaugings have been carried out at the Silverton site and only one of these was at a discharge greater than $16m^3/s$ ($118m^3/s$ on 23-11-67). These gaugings were carried out by MWD staff in the period 21-3-67 to 13-3-68.

Now that the SCCB is fully equipped to carry out suspended sediment gaugings and analyse results, it is recommended that such gaugings are undertaken to build up a comprehensive sediment-discharge rating to allow for a more accurate determination of sediment yield from the catchment.

9.3 Groundwater Investigations

No long term records on water table levels are available for the study area. It is recommended that the SCCB set up a comprehensive network of existing wells with the aim of recording and analysing the fluctuations of the water table and the determination of the availability or otherwise of groundwater for both present and future irrigation demand.

9.4 Water Quality

Further investigations into water quality are required. It is recommended that the network of water quality sites set up so far be continually monitored to assess any possible changes in the water quality of the resources.

9.5 Effect of Orari River water on the Opihi system

Because of the importance of Orari ground water to the lower Opihi River, it is recommended that further investigations be carried out regarding channel losses from the Orari River and gains in surface water into the Waihi River, especially during times of low flow.

ACKNOWLEDGEMENTS

ACKNOWLEDGEMENTS

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APPENDICES

APPENDIX 1: CATCHMENT MONTHLY RAINFALL USING SCCB RAINGAUGE NETWORK

Values in mm

YEAR	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	TOTAL
1964	52	14	105	20	180	13	94	23	50	53	101	74	779
1965	221	60	106	58	35	70	56	57	45	96	132	36	972
1966	116	56	61	58	58	31	69	106	32	74	140	96	897
1967	114	54	58	102	34	23	69	87	41	85	281	92	1039
1968	94	69	85	203	86	91	71	65	86	100	64	81	1095

APPENDIX 2: CATCHMENT MONTHLY RAINFALL USING NZMS RAINGAUGE NETWORK

Values in mm

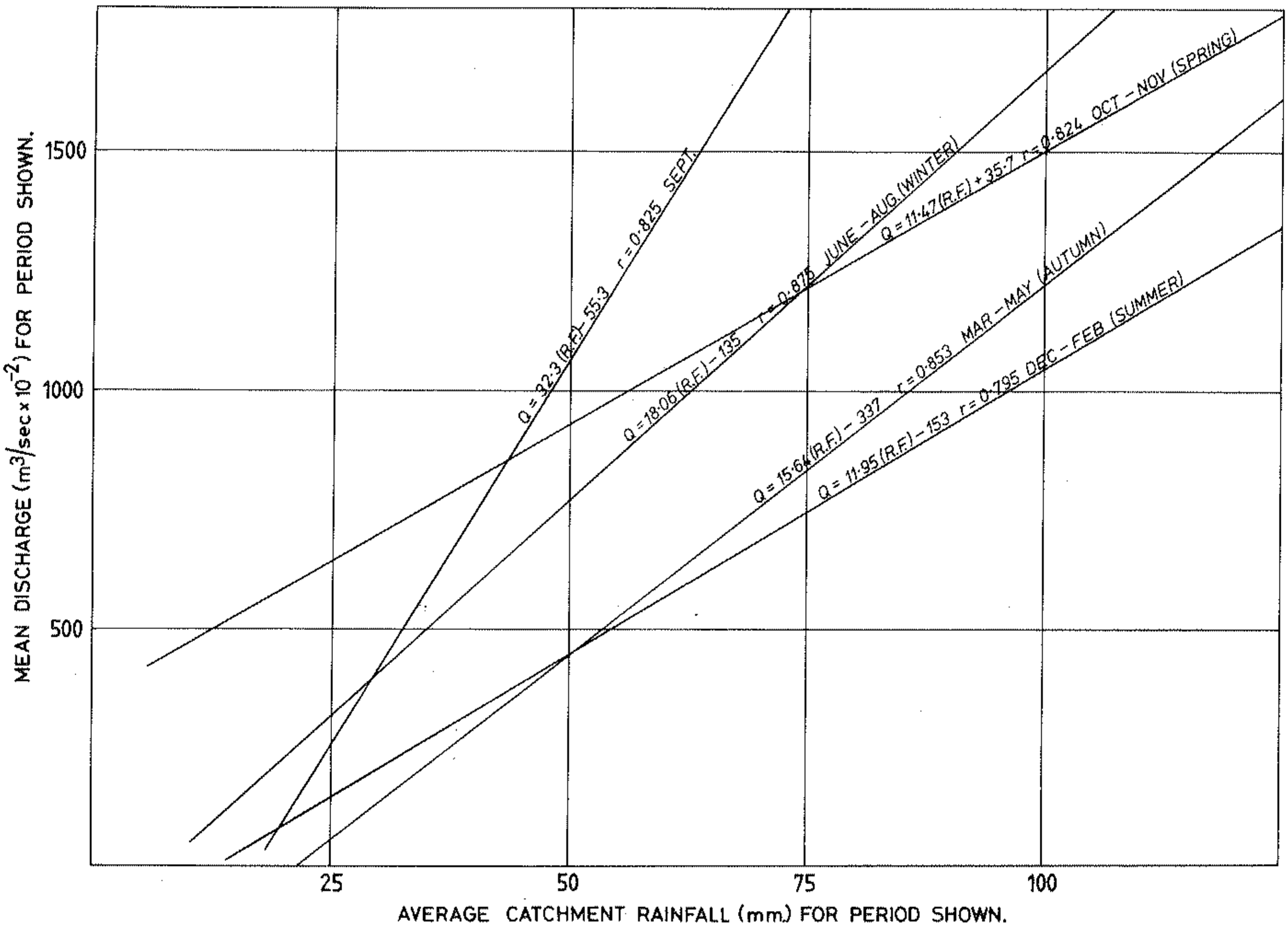
YEAR	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	TOTAL
1948	62	59	84	47	65	38	69	27	104	93	140	21	809
1949	110	81	63	113	42	77	82	54	13	68	49	93	845
1950	134	41	49	36	61	45	76	112	52	99	45	123	873
1951	120	90	143	290	26	16	112	53	30	120	85	88	1173
1952	65	42	23	32	54	39	39	114	53	135	240	171	1007
1953	136	41	135	117	40	53	40	89	39	77	44	110	921
1954	19	38	101	35	46	76	72	163	13	35	38	160	796
1955	46	75	50	8	113	57	80	61	71	43	55	16	675
1956	97	19	26	86	89	49	65	46	96	95	155	102	925
1957	29	51	169	76	166	35	52	33	75	108	119	138	1051
1958	154	83	37	75	98	27	24	26	13	78	24	87	726
1959	36	70	89	117	147	36	85	21	58	88	65	112	924
1960	46	33	106	37	25	102	38	44	94	94	56	102	777
1961	89	104	94	61	126	51	162	70	76	13	63	38	947
1962	80	62	82	71	123	87	73	74	45	73	107	53	930
1963	47	86	50	187	62	56	197	104	91	18	57	54	1009
1964	38	12	94	21	153	9	86	20	49	42	87	70	681
1965	168	61	105	64	33	63	61	50	37	80	112	51	885
1966	104	54	62	54	48	24	77	120	25	79	109	72	828
1967	117	57	56	89	36	29	59	72	34	71	294	80	994
1968	85	72	90	187	79	96	77	59	84	92	62	78	1061
1969	73	16	30	58	57	20	34	37	60	63	29	159	636
1970	129	49	74	13	44	84	66	129	189	33	61	55	926
1971	45	34	72	47	56	122	36	64	76	142	57	29	780
1972	69	30	33	92	167	46	83	48	44	110	56	60	838
1973	45	16	39	61	73	43	17	161	44	62	76	72	709
1974	44	98	62	159	52	73	58	66	101	118	28	38	897
1975	333	95	64	123	45	74	64	163	53	79	68	45	1206
1976	57	76	29	48	50	57	54	69	98	88	45	174	845
1977	108	45	15	73	62	80	65	42	115	46	42	116	809
1978	62	26	47	241	92	54	170	148	146	100	39	156	1281
1979	35	65	175	31	166	11	62	121	44	167	54	138	1069
MEAN	87	56	73	86	78	54	73	77	66	82	80	89	901
90 Percentile	171	94	134	182	142	95	129	141	124	133	162	157	
10 Percentile	16	22	27	21	28	20	35	25	24	36	31	31	

APPENDIX 3: INVENTORY OF RAINFALL STATIONS IN AND ADJACENT TO THE ORARI CATCHMENT

Number	Site	Type (1)	Latitude °	'	Longitude °	'	Altitude (m)	Rainfall Normal (2)	Normal Reliability (3)
H30691	Mesopotamia	M	43	38	170	54	552	1012	2
H30981	Deepburn	M	43	56	170	51	518	969	2
H31702	Rata Peaks	M	43	43	171	03	433	773	2
H31703	Ben McLeod *	M	43	42	171	00	457	740	3
H31711	White Rock	M	43	45	171	10	518	700	4
H3088A	Orari No. 1	S	43	50	170	52	811	1200	5
H3079A	Orari No. 2	S	43	47	170	56	884	1120	5
H3070A	Orari No. 3	S	43	46	171	03	625	975	5
H3181A	Orari No. 6	S	43	49	171	07	580	860	5
H3190A	Orari No. 7	S	43	57	171	01	716	840	5
H3180B	Orari No. 8	S	43	54	171	04	695	870	5
H3089B	Orari No. 9 *	A	43	48	170	55	783	1025	5
H31801	Lochaber	M	43	50	171	04	488	844	2
H31822	Mt. Peel	M	43	50	171	15	351	1097	2
H31921	Peel Forest	M	43	56	171	14	335	1124	2
H31926	Orari Gorge	M	43	58	171	12	259	1175	1
H41011	Woodbury	M	44	00	171	10	305	1131	2
H41024	Coopers Creek	M	44	02	171	17	158	831	2
H41121	Geraldine *	M	44	06	171	15	122	818	2
H41131	Orari Estate	M	44	08	171	19	81	772	1
H41153	Coldstream No. 3	M	44	09	171	33	12	655	2
H41223	Temuka	M	44	15	171	17	18	697	2

* Closed Station

1. Type of Raingauge Observation: A = Automatic, M = Daily Manual, S = Storage.
2. Rainfall normals — from NZMS Publ. 145: 1973 "Rainfall normals for N.Z."
3. Normal reliability —
    1. Base station with complete records from 1941-1970 inclusive.
    2. Stations with shorter but homogeneous records with small error of estimate.
    3. Stations with shorter records and lacking a nearby base station to provide a confident normal estimate.
    4. Stations with shorter records and discontinuous records and no nearby base station.
    5. Storage gauges where annual totals are only approximate.



APPENDIX 4: CORRELATION OF SEASONAL RUNOFF AND RAINFALL

APPENDIX 5: MINIMUM FLOWS (m^3/s) FOR 1, 7, 15 and 30 CONSECUTIVE DAYS FOR ORARI RIVER AT SILVERTON

	NUMBER OF CONSECUTIVE DAYS							
	1		7		15		30	
YEAR	DATE*	FLOW	DATE*	FLOW	DATE*	FLOW	DATE*	FLOW
1962	26/2	1.86	25/2	2.04	17/2	2.39	1/2	3.02
1963	13/4	1.78	8/4	1.89	4/4	2.24	20/3	2.59
1964	17/4	2.16	16/4	2.21	15/4	2.32	13/4	2.37
1965	31/12	4.02	25/12	4.30	16/5	4.72	11/5	5.04
1966	25/7	2.75	22/7	2.82	14/7	2.90	30/6	3.00
1967	1/7	3.23	14/6	3.48	17/6	3.60	2/6	3.87
1968	5/3	3.22	1/3	3.35	23/2	3.58	8/2	4.85
1969	20/7	2.38	16/4	2.41	8/4	2.45	24/3	2.57
1970	29/4	2.89	24/4	2.97	17/4	3.14	10/4	3.37
1971	19/3	2.26	14/3	2.36	6/3	2.48	23/2	2.65
1972	24/3	2.07	30/3	2.15	22/3	2.17	7/3	2.23
1973	31/3	1.70	15/3	1.73	7/4	1.80	22/2	1.91
1974	3/2	2.79	28/1	2.92	20/1	3.14	5/1	3.44
1975	7/1	2.60	1/1	2.76	1/1	4.07	2/12	4.89
1976	29/4	2.19	23/4	2.32	15/4	2.45	19/4	2.71
1977	6/4	2.94	3/4	3.05	27/3	3.28	26/3	3.33
1978	13/4	2.19	7/4	2.34	2/4	2.47	18/3	2.58
1979	10/3	2.72	5/3	2.81	2/3	3.04	13/2	3.08
AVERAGE	2.54		2.66		2.90		3.19	

* Date at start of consecutive day period.

APPENDIX 6: ANNUAL INSTANTANEOUS FLOOD FLOWS (m^3/s) — ORARI AT SILVERTON

YEAR	DATE	LEVEL (m) *	FLOW (m^3/s)
1961	19/7	5.38	731
1962	3/11	2.87	104
1963	20/4	5.43	750
1964	15/5	2.32	31
1965	31/1	5.40	741
1966	14/8	2.61	62
1967	23/11	3.78	269
1968	13/4	3.52	216
1969	26/12	2.60	61
1970	24/9	4.18	362
1971	29/6	2.70	75
1972	16/5	4.16	357
1973	13/8	2.87	104
1974	16/4	3.43	200
1975	28/1	5.24	683
1976	7/9	2.95	120
1977	13/12	2.77	87
1978	20/4	4.08	338
1979	6/5	3.92	301

* To 1979 DATUM.

APPENDIX 7: CONCURRENT GAUGINGS AT SILVERTON AND UPPER ORARI TRIBUTARIES

DISCHARGE (m^3/s) AT VARIOUS SITES

DATE	SILVERTON	ORARI	MOWBRAY	PHANTOM	HEWSON	Mt. PEEL Ck
11-5-71	4.04			0.54	0.83	0.21
12-5-71	3.94	0.35	0.14			
2-3-72	2.36	0.17		0.36	0.58	0.19
1-7-75	8.42			1.01		0.69
13-10-75	11.79		0.56	1.48		0.81
18-11-75	10.26		0.38	1.19		0.75
10-12-75	5.07		0.19	0.71		0.41
7-1-76	3.71		0.12	0.45		0.27
24-2-76	3.98		0.19	0.66		0.37
24-3-76	2.85	0.22		0.45	0.90	
20-4-77	3.17		0.12			
21-4-77	3.52	0.30		0.58		
17-3-78	2.41	0.23		0.37	0.76	
13-2-79	3.23	0.25			0.95	
27-6-79	5.82	0.56			1.85	
15-8-79	11.71				3.12	
20-3-80	8.24	0.66				

APPENDIX 8: CONCURRENT GAUGINGS AT SILVERTON AND LOWER ORARI GAUGING SITES

DISCHARGE (m^3/s) AT VARIOUS SITES

DATE	SILVERTON	BURDONS ROAD	LYSAGHT ROAD	S.H. 72 BRIDGE	BENNETT ROAD	S.H. 1 BRIDGE	OHAPI SETTLEMENT	BADHAMS BRIDGE	ROLLESTON BRIDGE	ABOVE OHAPI CONFLUENCE
25-8-55	9.32			5.04		4.05			5.41	
4-11-55	6.54			2.07						
23-11-55	4.16			0.19		0			1.23	
17-1-56	2.09			0		0			0.48	
12-3-56	1.97			0		0			0.25	
30-8-56	6.29			2.43		1.69			3.09	
14-5-57	10.14			6.34		5.04			7.19	
21-1-59	3.45			0		0				
22-7-59	4.90			0.85		0.31				
1-3-72	2.46	1.05		0						
26-9-72	8.25	5.94								
5-4-73	2.25	0.77		0		0		0.18	0.62	
23-7-73	2.63	1.37	0.68	0		0	0.24	0.42	0.94	
26-10-73	10.50	9.25				4.19				
7-12-73	4.22	2.99		0.06					1.33	
7-8-74	8.31	7.16	6.22	5.59	2.80	2.69	3.66	4.10	5.14	5.19
28-11-74	7.10	5.41	4.23		0.96	0.44	1.04	1.62	2.66	2.81
24-1-75	12.83					6.16		7.40		
16-12-75	4.48			0.15	0.06	0.03				

APPENDIX 9: WATER QUALITY ANALYTICAL METHODS

PARAMETER	METHOD
Temperature	Mercury thermometer (in field)
pH	Portomatic 175 meter (in laboratory)
Dissolved Oxygen	a) Sodium azide modification of Winkler titrations (chemicals added in field) b) YSI meter and attachments (in field)
Faecal coliforms	Membrane filtration (m FC broth at 44.5°C only)
Suspended solids	Vacuum filter (Whatman GF/C filters)
Biological oxygen demand (BOD)	a) BOD greater than 6 — HACH manometric apparatus b) BOD less than 6 — standard titration (after 5 days)

APPENDIX 10: WATER QUALITY CLASSIFICATION SCHEDULES

FIRST SCHEDULE

Standards for Class A Waters

The waters shall in all respect be maintained in their natural state, and no waste shall be permitted to enter them.

SECOND SCHEDULE

Standards for Class B Waters

The quality of Class B waters shall conform to the following requirements:

(a) The natural water temperature shall not be changed by more than 3°C.

(b) The acidity or alkalinity of the waters as measured by the pH shall be within the range of 6.0 to 8.5 except when due to natural causes.

(c) The waters shall not be tainted so as to make them unpalatable, nor contain toxic substances to the extent that they are unsafe for consumption by humans or farm animals, nor shall they emit objectionable odours.

(d) There shall be no destruction of natural aquatic life by reason of a concentration of toxic substances.

(e) The natural colour and clarity of the waters shall not be changed to a conspicuous extent.

(f) The oxygen content in solution in the waters shall not be reduced below 6mg per litre.

(g) Based on not fewer than 5 samples taken over not more than a 30 day period, the median value of the faecal coliform bacteria content of the waters shall not exceed 2,000 per 100ml and the median value of the total coliform bacteria content of waters shall not exceed 10,000 per 100ml.

(h) Repealed by S.30 (a) of the Water and Soil Conservation Amendment Act 1973.

THIRD SCHEDULE

Standards for Class C Waters

The quality of Class C waters shall conform to the following requirements:

(a) The natural water temperature shall not be changed by more than 3°C.

(b) The acidity or alkalinity of the waters as measured by the pH shall be within the range 6.5 to 8.3 except when due to natural causes.

(c) The waters shall not be tainted so as to make them unpalatable, nor contain toxic substances to the extent that they are unsafe for consumption by human or farm animals nor shall they emit objectionable odours.

(d) There shall be no destruction of natural aquatic life by reason of a concentration of toxic substances.

(e) The natural colour and clarity of the waters shall not be changed to a conspicuous extent.

(f) The oxygen content in solution in the waters shall not be reduced below 6mg per litre.

(g) Based on not fewer than 5 samples taken over not more than a 30 day period, the median value of the faecal coliform bacteria content of the waters shall not exceed 200 per 100ml.

(h) Repealed by S.30 (b) of the Water and Soil Conservation Amendment Act 1973.

FOURTH SCHEDULE

Standards for Class D Waters

The quality of Class D waters shall conform to the following requirements:

(a) The natural water temperature shall not be changed by more than 3°C.

(b) The acidity or alkalinity of the waters as measured by the pH shall be within the range of 6.0 to 9.0 except when due to natural causes.

(c) The waters shall not be tainted so as to make them unpalatable, nor contain toxic substances to the extent that they are unsafe for consumption by farm animals, nor shall they emit objectionable odours.

(d) There shall be no destruction of natural aquatic life by reason of a concentration of toxic substances.

(e) The natural colour and clarity of the waters shall not be changed to a conspicuous extent.

(f) The oxygen content in solution in the waters shall not be reduced below 5mg per litre.

(g) Repealed by S.30 (c) of the Water and Soil Conservation Amendment Act 1973.

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