240

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WAIDOI ESTATE

REPORT

ON A

FEASIBILITY STUDY

FOR

AGRICULTURAL DEVELOPMENT

FEBRUARY 1970

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CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

TABLES

FIGURES

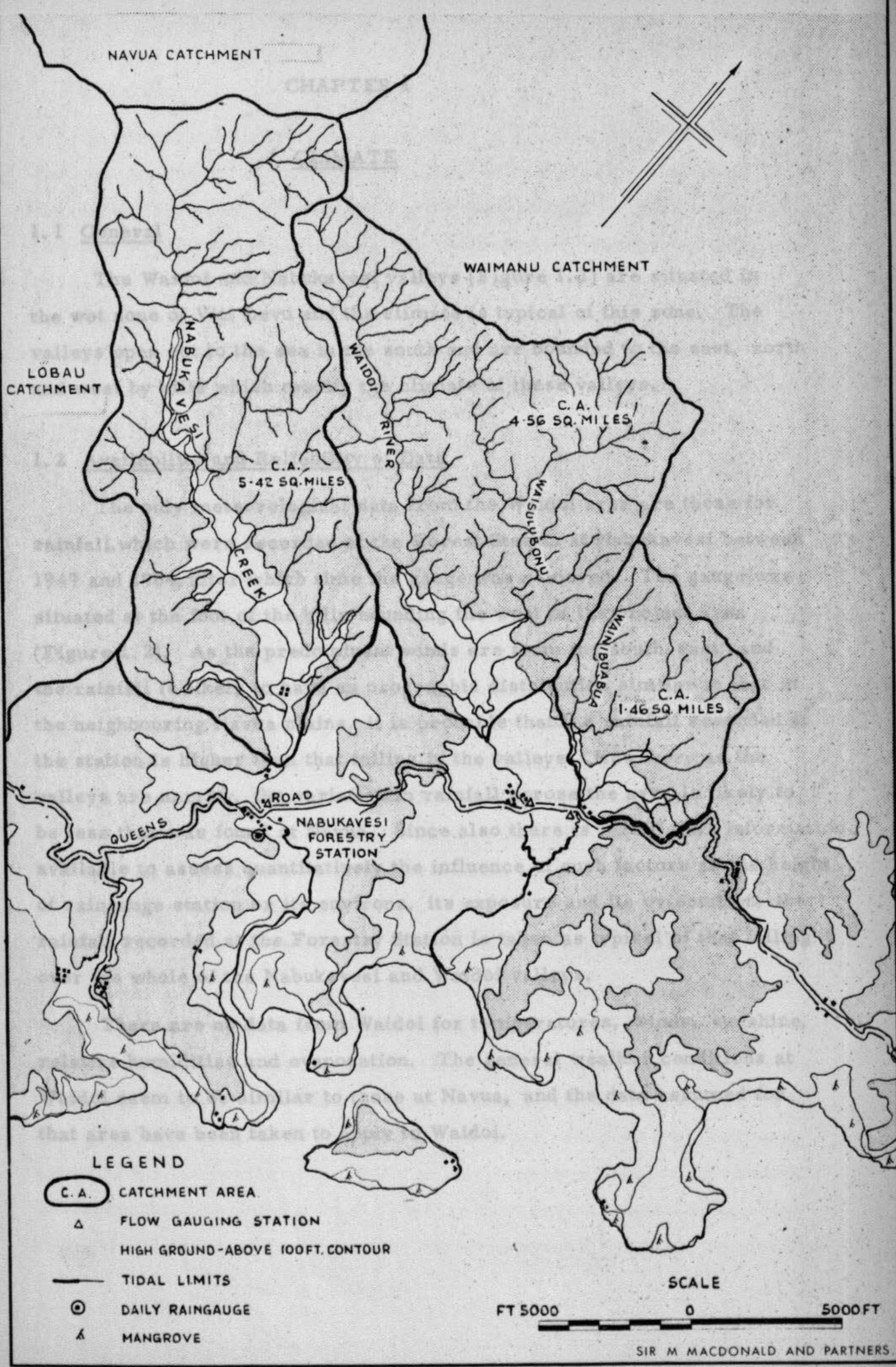
CONTENTS (Continued)

DRAWINGS (At Rear of Volume)

APPENDICES

Figure 1·1

NABUKAVESI AND WAIDOI AREA



CHAPTER 1

CLIMATE

1.1 General

The Waidoi and Nabukavesi valleys (Figure 1.1) are situated in the wet zone of Viti Levu and the climate is typical of this zone. The valleys open out to the sea in the south and are bounded to the east, north and west by hills which modify the climate of these valleys.

1.2 Availability and Reliability of Data

The only meteorological data from the Waidoi area are those for rainfall, which were recorded at the Forest Station at Nabukavesi between 1949 and 1964, after which time the gauge was removed. The gauge was situated at the foot of the hills bounding the west of the project area (Figure 1.2). As the predominant winds are from the south-east, and the rainfall is likely to have an orographic distribution similar to that in the neighbouring Navua plains, it is probable that the rainfall recorded at the station is higher than that falling in the valleys. However, as the valleys are narrow, the variation in rainfall across the area is likely to be less than was found at Navua. Since also there is insufficient information available to assess quantitatively the influence of such factors as the height of raingauge station or its environs, its exposure and its orientation, the rainfall recorded at the Forestry Station is taken as typical of that falling over the whole of the Nabukavesi and Waidoi valleys.

There are no data from Waidoi for temperatures, winds, sunshine, relative humidities and evaporation. The general weather conditions at Waidoi seem to be similar to those at Navua, and the data assumed for that area have been taken to apply to Waidoi.

1.3 Rainfall

A statistical analysis has been made of the data from Nabukavesi. For each calendar month the probabilities of occurrences of rainfall have been calculated and, by plotting first on normal probability paper and then on log probability paper, the frequency distribution best fitting the data has been found. Using this distribution, zones within which two thirds of future rainfalls are expected to lie have been estimated. Means of monthly data recorded for 1949 to 1964 have also been calculated. The above data are shown on Figure 1.2 together with the limits of monthly rainfall.

The wide variation in rainfall recorded for any particular calendar month can be seen. The winter months of June, July and August are the driest. These have mean rainfalls for 1949 to 1964 of 11.72, 12.12 and 11.54 inches respectively. The variations in rainfalls recorded in these months are from 3.39 to 21.93 inches for June, from 3.31 to 21.07 inches for July and from 1.70 to 28.13 inches for August. High mean rainfalls occur in November, January, March and April, which have values of 19.73, 20.72, 19.02 and 20.07 inches respectively. In these wetter months also variations in rainfall are high. April rainfall varies from 8.15 to 60.00 inches and in November from 2.39 to 39.77 inches. High monthly rainfalls are generally associated with high intensity storms rather than with prolonged rainfall throughout the month. Comparisons of the daily rainfalls recorded at different gauges (1) within the Navua plains and (2) at Nabukavesi and Navua indicate that intense storms may be localised.

Table 1.1 gives the rainfall recorded at Nabukavesi each calendar month, for the period 1949 to 1964, placed in order of magnitude. For each monthly rainfall the percentage of months with rainfalls less than or equal to that value and greater than or equal to that value, are calculated. For example, in February, 25 per cent of the values recorded for February rainfalls for the period 1949-1964 are less than or equal to 11.57 inches. Assuming future rainfalls show a similar distribution to past data, then, in the next 100 years, 25 years can be expected to have February rainfalls of

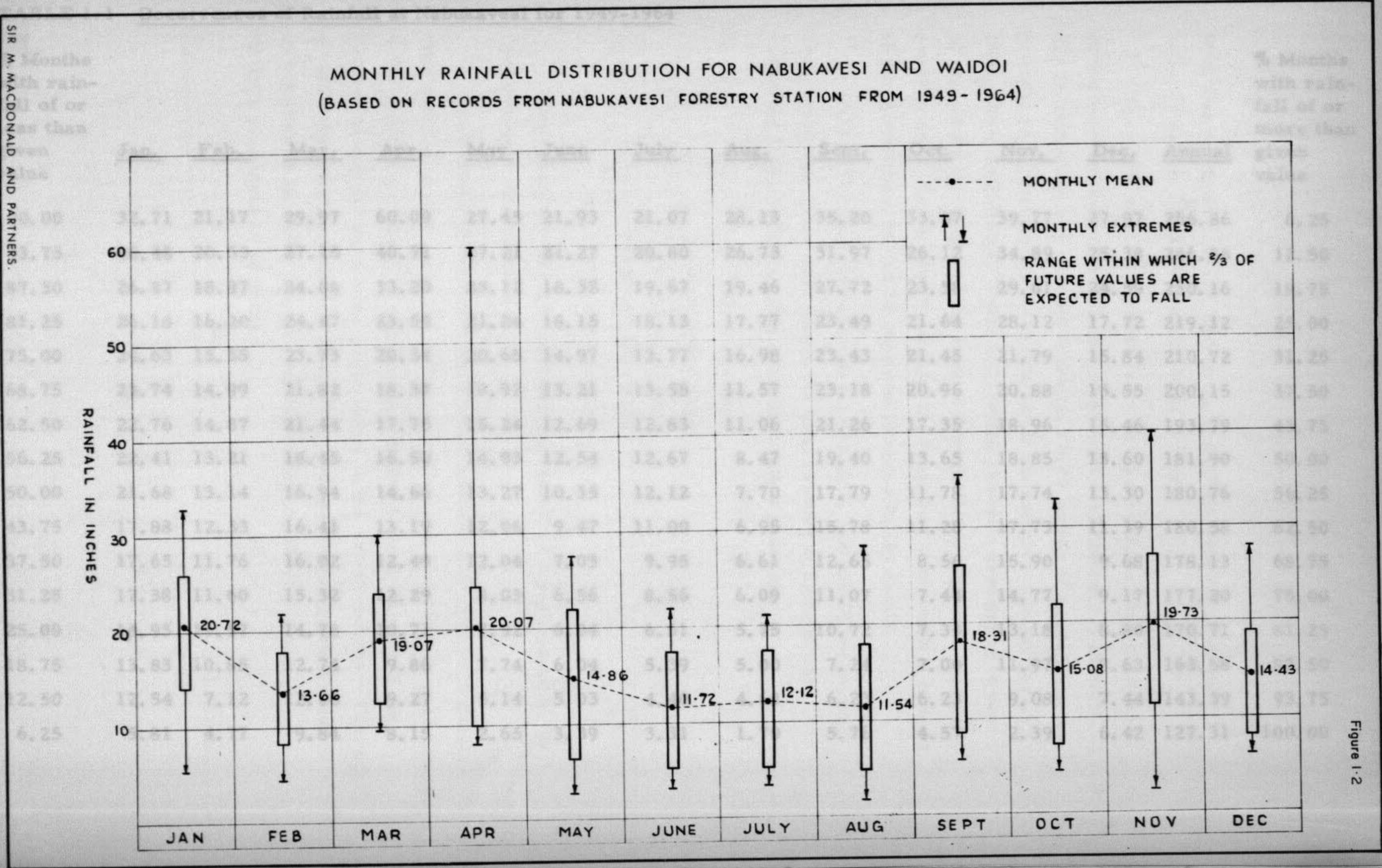

MONTHLY RAINFALL DISTRIBUTION FOR NABUKAVESI AND WAIDOI
(BASED ON RECORDS FROM NABUKAVESI FORESTRY STATION FROM 1949 - 1964)
MONTHLY MEAN
MONTHLY EXTREMES
RANGE WITHIN WHICH ⅔ OF FUTURE VALUES ARE EXPECTED TO FALL
RAINFALL IN INCHES
60
50
40
30
20
10
20·72
13·66
19·07
20·07
14·86
11·72
12·12
11·54
18·31
15·08
19·73
14·43
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
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Figure 1·2

TABLE 1.1 Occurrences of Rainfall at Nabukavesi for 1949-1964

% Months with rainfall of or less than given value	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	% Months with rainfall of or more than given value
100.00	32.71	21.17	29.97	60.00	27.45	21.93	21.07	28.13	35.20	33.07	39.77	27.97	256.86	6.25
93.75	30.48	20.53	27.10	40.71	27.21	21.27	20.80	26.73	31.97	26.12	34.89	25.38	246.86	12.50
87.50	26.87	18.97	24.88	33.20	23.12	18.32	19.67	19.46	27.72	23.58	29.61	24.59	230.16	18.75
81.25	26.18	16.20	24.47	23.59	21.24	18.15	18.13	17.77	23.49	21.64	28.12	17.72	219.12	25.00
75.00	24.63	15.55	23.73	20.34	20.65	14.97	13.77	16.98	23.43	21.45	21.79	15.84	210.72	31.25
68.75	23.74	14.99	21.82	18.37	18.92	13.21	13.55	11.57	23.18	20.96	20.88	15.55	200.15	37.50
62.50	22.76	14.87	21.44	17.75	15.24	12.69	12.83	11.06	21.26	17.35	18.96	15.46	193.79	43.75
56.25	22.41	13.21	18.45	16.50	14.93	12.54	12.67	8.47	19.40	13.65	18.85	13.60	181.90	50.00
50.00	21.68	13.14	16.94	14.66	13.27	10.35	12.12	7.70	17.79	11.78	17.74	13.30	180.76	56.25
43.75	17.88	12.33	16.41	13.19	12.06	9.47	11.00	6.95	15.78	11.28	17.73	11.39	180.58	62.50
37.50	17.65	11.76	16.02	12.49	12.04	7.03	9.95	6.61	12.65	8.56	15.90	9.68	178.13	68.75
31.25	17.38	11.60	15.32	12.29	8.03	6.56	8.56	6.09	11.07	7.44	14.77	9.17	177.20	75.00
25.00	14.95	11.57	14.78	10.71	7.92	6.04	6.61	5.75	10.72	7.33	13.18	8.80	170.71	81.25
18.75	13.83	10.85	12.74	9.86	7.74	6.04	5.39	5.00	7.24	7.00	11.97	8.63	163.68	87.50
12.50	12.54	7.12	12.08	9.27	5.14	5.03	4.40	4.68	6.23	6.23	9.08	7.44	143.39	93.75
6.25	5.81	4.77	9.84	8.15	2.65	3.39	3.31	1.70	5.76	4.57	2.39	6.42	127.31	100.00

less than or equal to 11.57 inches, i.e. a rainfall less than or equal to 11.57 inches has a return period of 4 years.

The daily rainfall records from Nabukavesi have been examined in two ways to obtain an estimate of drought occurrence. A drought day is defined as one with not more than 0.20 inches of rainfall and a drought as a period of not less than three consecutive drought days. Using these definitions, Table 1.2, which shows in descending order of magnitude the length of the longest drought occurring each year in every month, can be used to predict the frequency with which a drought of any given duration can be expected to occur in any month.

Table 1.3 takes into account all droughts, not maximum monthly droughts alone. The table shows the total number of drought days occurring in the following five drought duration groups:-

3- 5 or more days
6-10 or more days
11-15 or more days
16-20 or more days
21-25 or more days

The values for drought days are expressed as a percentage of the total numbers of days available.

The rainfall distribution and drought pattern at Waidoi is in general very similar to that recorded at Tamanua over the same fifteen year period. Total rainfall at Waidoi is considerably higher than at Navua and the number of drought days less, particularly in the winter months. There is an indication that, relative to Tamanua, June at Waidoi is much less susceptible to drought, but the records cover too short a period for a definite statement to be made.

TABLE 1.2 Maximum Monthly Durations of Drought Recorded at Nabukavesi between 1949 and 1964, Place in Order of Magnitude

% of months with drought duration of or more than given value	Drought Duration (days)											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
6.25	12	10	13	11	23	12	16	20	14	19	18	17
12.50	9	9	10	10	22	12	15	16	11	16	14	7
18.75	9	9	7	8	14	11	15	13	10	11	11	7
25.00	8	7	7	7	12	10	12	12	10	11	10	7
31.25	7	7	6	7	11	10	12	12	9	9	9	7
37.50	6	7	6	6	10	10	11	12	8	9	9	7
43.75	6	6	6	6	10	9	11	11	6	8	9	6
50.00	6	6	6	6	9	9	10	9	6	8	7	5
56.25	6	5	5	6	9	9	9	9	5	7	7	5
62.50	5	5	4	6	9	8	9	7	5	7	6	5
68.75	5	5	4	5	8	8	9	7	5	6	6	5
75.00	4	4	4	5	7	6	7	7	4	5	5	5
81.25	3	4	3	4	7	6	7	7	4	5	4	4
87.50	3	4	3	4	6	6	6	6	4	4	4	4
93.75	0	0	0	4	5	5	6	4	3	4	3	3
100.00	0	0	0	3	4	5	5	4	0	4	0	3

TABLE 1.3 Droughts of Various Durations at Waidoi

Month	3-5 days or more		6-10 days or more		11-15 days or more		16-20 days or more		21-25 days or more	
	No of drought days	% of total days	No. of drought days	% of total days	No. of drought days	% of total days	No. of drought days	% of total days	No. of drought days	% of total days
January	153	31	69	14	12	2	0	0	0	0
February	154	34	81	18	0	0	0	0	0	0
March	142	29	68	14	13	3	0	0	0	0
April	186	39	79	16	11	2	0	0	0	0
May	274	55	188	38	82	17	45	9	45	9
June	274	57	151	31	35	7	0	0	0	0
July	282	57	192	39	92	19	16	3	0	0
August	281	57	190	38	96	19	36	7	0	0
September	177	37	83	17	25	5	0	0	0	0
October	253	51	145	29	57	11	35	7	0	0
November	167	35	100	21	43	9	18	4	0	0
December	195	39	74	15	17	3	17	3	0	0

1.4 Temperatures

The available data come from Laucala Bay and Koronivia Meteorological Stations. Data from the former cover the period from 1942 to 1968; from the latter data are available from 1965-1968. For the period common to both stations the records agree well, Koronivia temperatures being slightly lower than those at Laucala Bay. The Laucala Bay means for 1942-1968 and for 1965-1968 are also in close agreement. The long term records for Laucala Bay are reproduced in Table 1.4 below. Waidoi temperatures will probably be fractionally, but not significantly lower.

TABLE 1.4 Daily Temperatures at Laucala Bay 1942-1968 (^{o}F)

	Mean Maximum	Mean Minimum	Mean
January	85.7	74.4	80.1
February	86.1	74.4	80.3
March	85.8	74.0	79.9
April	84.3	73.3	78.8
May	82.0	71.3	76.7
June	80.5	70.3	75.4
July	78.9	68.5	73.7
August	79.0	68.6	73.8
September	79.6	69.8	74.7
October	80.8	70.8	75.8
November	82.5	72.1	77.3
December	84.6	73.6	79.1

1.5 Winds

The south-east trade winds prevail for most of the year. Wind speed records are available for Laucala Bay and for Koronivia, but the height of the wind mast at the latter station is not known. At Laucala Bay, where the anemometer mast is 50 feet above ground level, mean wind speeds for the period 1954-1967 were as follows (miles run per day):-

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
209	191	164	182	198	220	223	247	246	244	258	218

The following table for correcting wind speed for height of observation has been worked out by the Israel Meterological Service.

TABLE 1.5 Correction of Wind Speed for Height of Observation

	Height (metres)					
	3	4	5	10	15	20
Ratio of wind speed at 2 metres to that at given height	0.94	0.92	0.89	0.70	0.72	0.68

1.6 Sunshine

Sunshine hours at Navua were estimated by adjusting the long term average at Laucala Bay by a factor obtained from the relationship between sunshine records at Koronivia and Laucala Bay. The estimated long term average sunshine at Navua is shown in Table 1.6. Figures for Waidoi are likely to be similar.

TABLE 1.6 Estimated Sunshine at Navua

	hrs./day	hrs./month
January	4.8	148.8
February	5.1	142.8
March	4.5	139.5
April	4.6	138.0
May	4.8	148.8
June	3.8	114.0
July	4.1	123.0
August	4.5	139.5
September	3.8	114.0
October	3.8	107.8
November	5.2	156.0
December	5.1	158.1

The best estimate of monthly solar radiation is as follows (cal/cm^2):-

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1600	14500	14100	12300	11400	9500	10200	11800	12200	13700	15800	16400

1.7 Relative Humidities

The mean relative humidities at Laucala Bay for the period 1943-1967 were as follows (%):-

	From daily readings taken at 9 a.m.	From hourly readings
January	81	85
February	82	85
March	83	86
April	82	85
May	80	83
June	81	83
July	79	81
August	78	81
September	79	82
October	77	81
November	78	82
December	79	83

1.8 Evaporation

Data are available from Koronivia for the period 1965-1968. The measurements were made with a class A pan.

	Mean daily evaporation inches	Mean monthly evaporation inches
January	0.18	5.45
February	0.20	5.59
March	0.17	5.29
April	0.14	4.13
May	0.13	3.95
June	0.12	3.69
July	0.13	4.08
August	0.12	3.61
September	0.15	4.50
October	0.19	5.89
November	0.22	6.51
December	0.22	6.67

CHAPTER 2

WATER RESOURCES

2.1 General

The Nabukavesi and Waidoi rivers rise in the southern coast range. Their catchment areas are 5.42 and 4.56 sq.mls. respectively and are covered with dense rain forest. The catchments lie broadly in a north-south direction and are bounded to the north by the Navua and Waimanu watersheds, to the west by the Lobau watershed, and to the east by the Wainaboro watershed.

2.2 Nabukavesi and Waidoi Rivers

The catchment areas of the Nabikavesi, Waidoi and Wainibuabua, (a tributary of the Waidoi), are given in Figure 1.1. The estimated limits of tidal influence in these rivers are also marked.

No previous information has been collected for these rivers and it is difficult to assess variation in flows. It seems likely that seasonal variation in flow will resemble closely the seasonal variation in rainfall recorded at Nabukavesi forestry station. During the study a series of gaugings were made on these rivers (Table 2.1).

TABLE 2.1 Gaugings Made during the Study

River	Date	Flow in cusecs
Waidoi	22-4-69	27.5
"	17-6-69	12.9
Wainibuabua	17-6-69	2.4
Nabukavesi	22-4-69	20.7
"	17-6-69	10.8

All gaugings were made during periods of low flow. In the Navua plains the period of drought before 17-6-69 was estimated as having an occurrence of 1 in 8 years. Therefore flows less than those measured on 17-6-69 will occur only seldom.

No high flows have been gauged in these rivers. Estimates of flood discharges can be made from studies made for the Navua project. As data available at present are limited the flood flows given in Table 2.2 should be regarded at best as "of the order" estimates.

TABLE 2.2 Estimates of Flood Flows (cusecs)

River	Flood flows occurring on average 1 in 5 yrs.	1 in 10 yrs.	1 in 20 yrs.
Nabukavesi	520	700	1100
Waidoi	430	560	900
Wainibuabua	140	200	300

It is noticeable that for an area of such heavy rainfall the silt content of the rivers is low. The dense rain forest affords considerable protection against soil erosion. In areas where development, for example,road works, forestry, has taken place soil erosion is high. Any development must be planned with care to avoid soil erosion.

A survey was carried out of both the Nabukavesi and Waidoi rivers. The data obtained are given in Figures 2.1 - 2.2. Both rivers have gravel and cobblestone beds in the upper reaches where the bed slope is steep. The river beds are wide, particularly that of the Waidoi river, which has been used as a source of river gravel. Thus the depth of water at low flows is small, which could lead to difficulties in the siting of pump stations.

No records have been kept of flooding in the area. From the surveys carried out, and flood flows estimated, the effects of flooding may be speculated. In the Nabukavesi upstream of the Queens Road the river falls steeply and local informants say that the peak annual flows will pass. Downstream of the Queens Road the bed slopes less steeply and the flow the river will pass depends on the state of the tide. Mere flooding is likely to be frequent.

Figure 2·1

NABUKAVESI RIVER

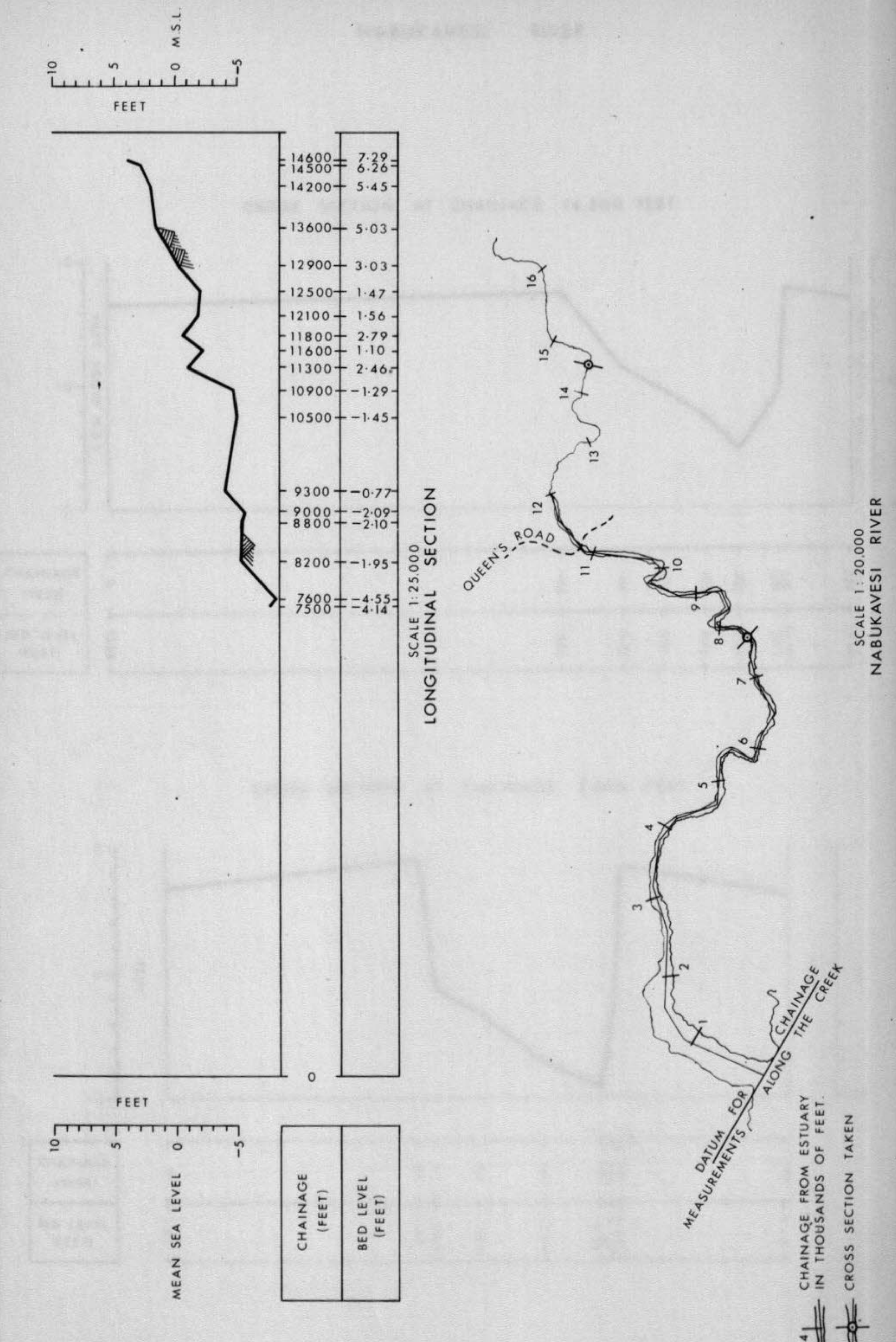

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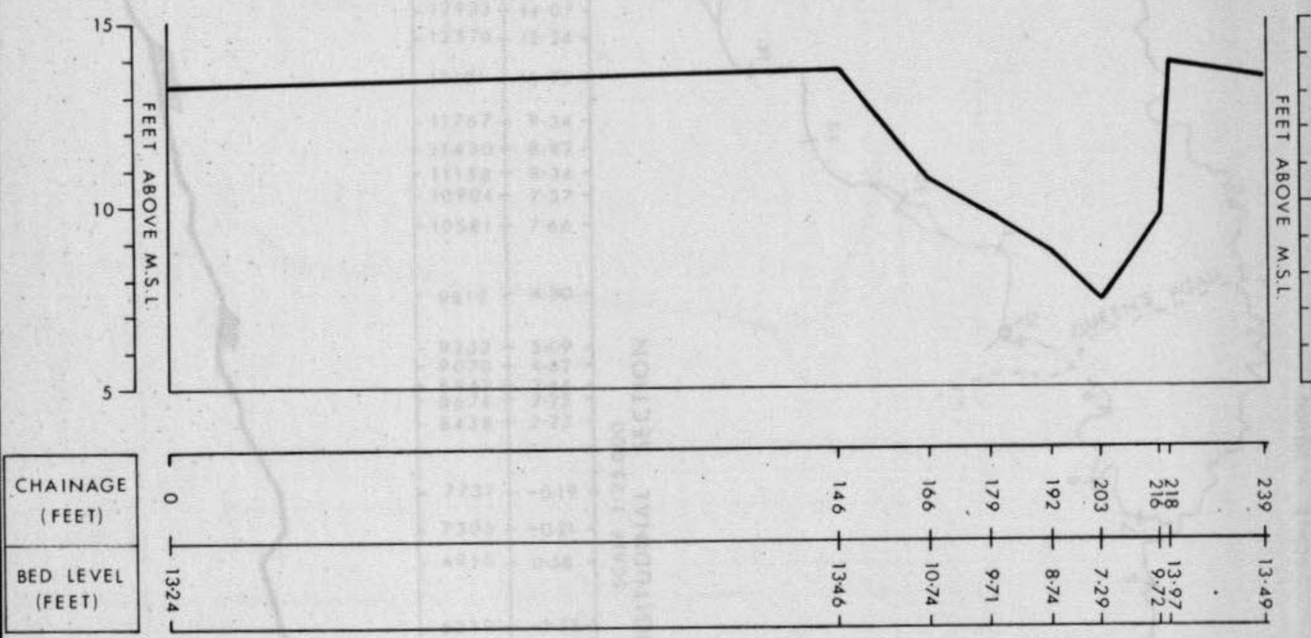
Figure 2·2

CROSS SECTIONS OF THE NABUKAVESI RIVER

CROSS SECTION AT CHAINAGE 14,500 FEET



CROSS SECTION AT CHAINAGE 7,600 FEET

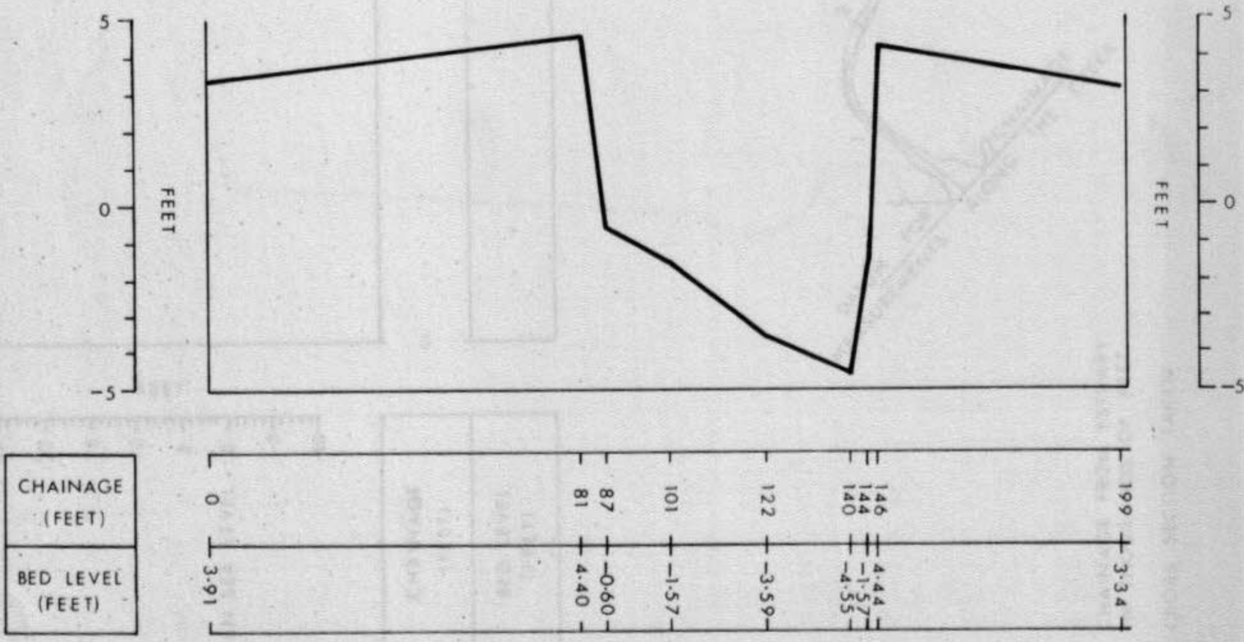


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Figure 2·3

WAIDOI RIVER

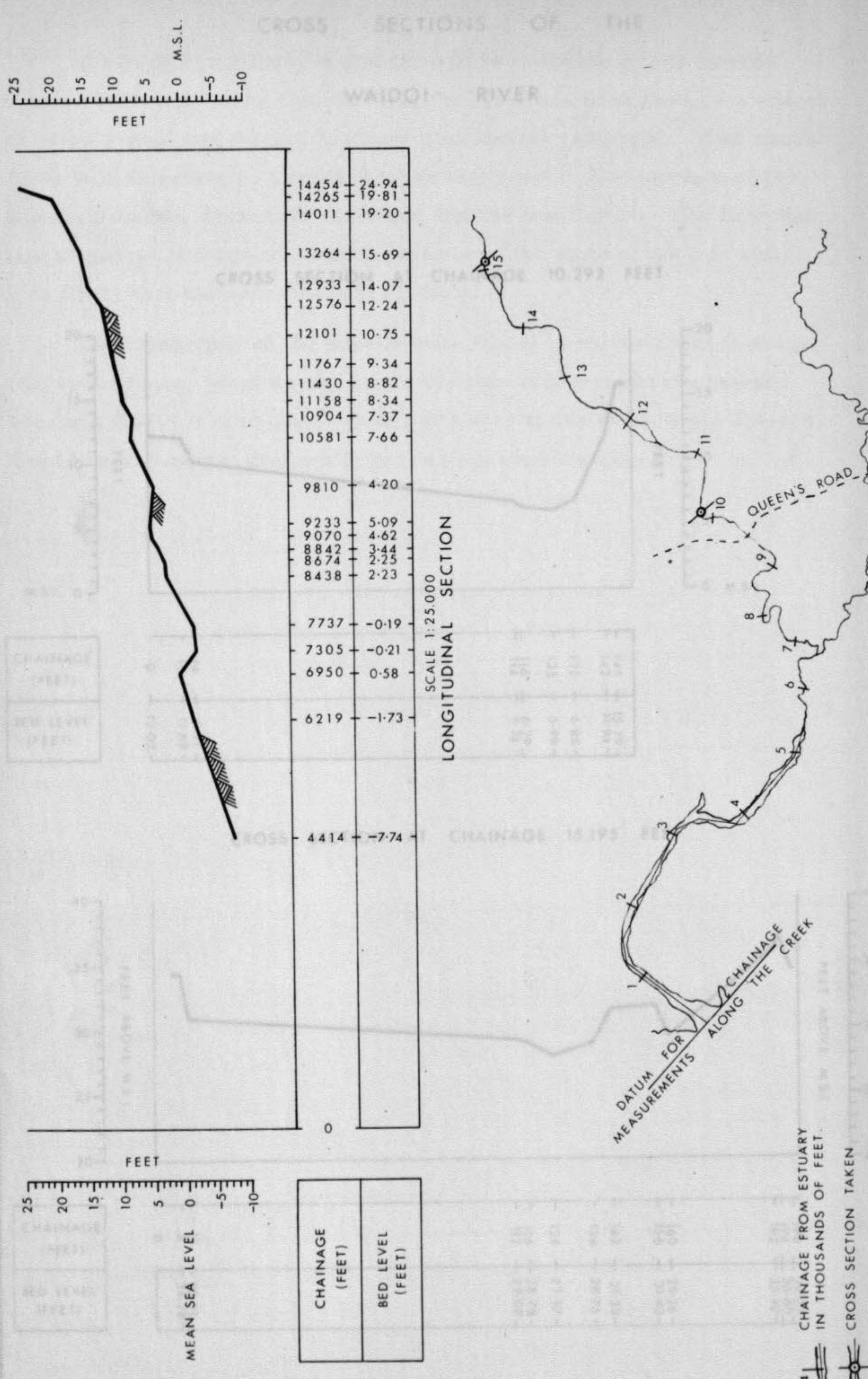

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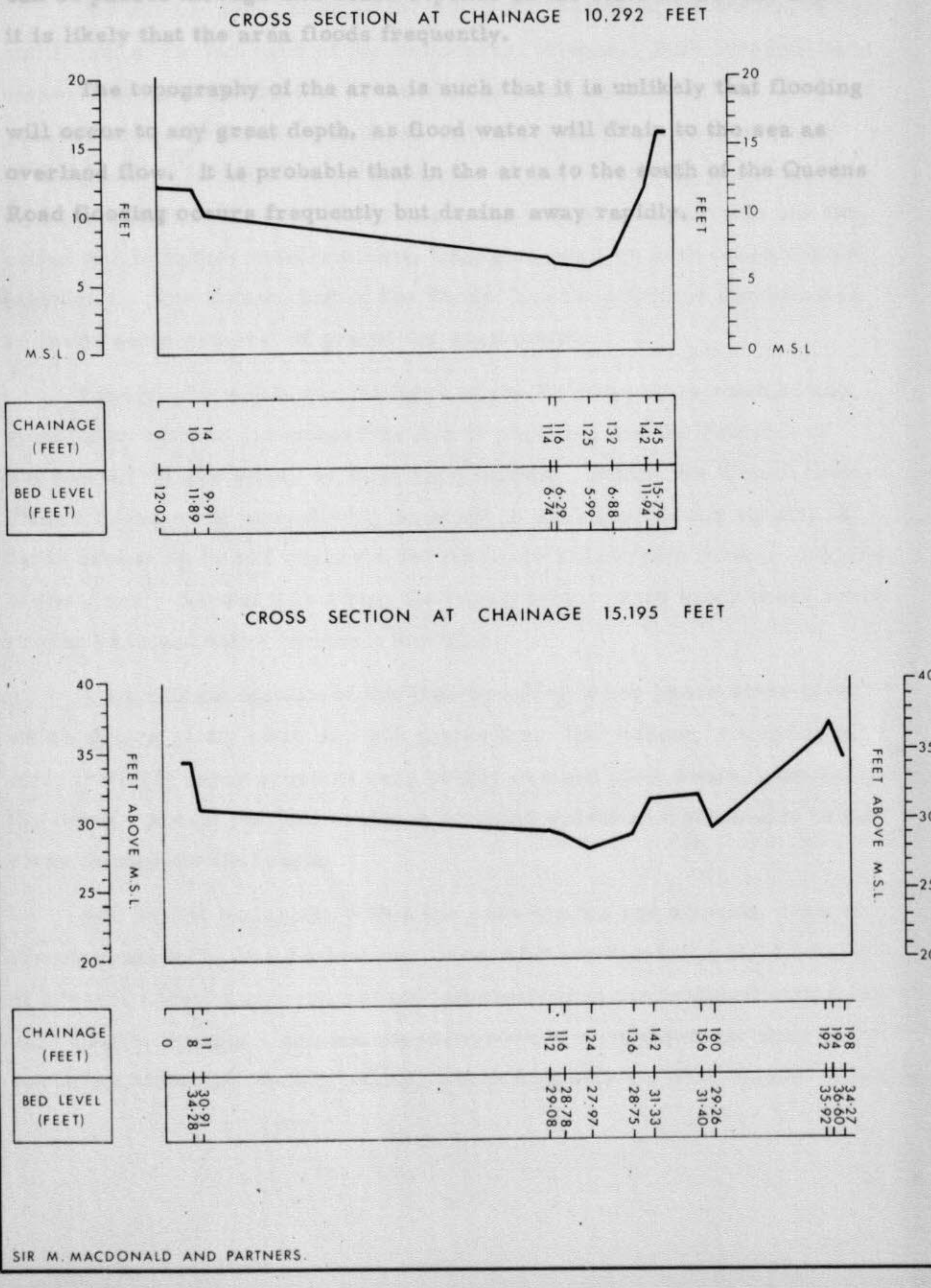
Figure 2·4

CROSS SECTIONS OF THE WAIDOI RIVER



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Similarly the Waidoi is divided into two reaches by the Queens Road. Upstream of the Queens Road the river has been used as a source of river gravel and the bed has been considerably enlarged. High annual flows will therefore be passed through this reach. Downstream of the Queens Road the channel is narrower and the bed flatter. The flow that can be passed through this reach depends on the state of the tide and it is likely that the area floods frequently.

The topography of the area is such that it is unlikely that flooding will occur to any great depth, as flood water will drain to the sea as overland flow. It is probable that in the area to the south of the Queens Road flooding occurs frequently but drains away rapidly.

CHAPTER 3

THE LAND

3.1 Physical Features

The survey area includes the alluvial deposits of the Waidoi valley and those on the left bank of the Nabukavesi stream. Both streams have rather steep gradients, that of the Waidoi being about 1 in 300. The gradient of the Nabukavesi is of the order of 1 in 350. The steepness of the gradient is reflected in the nature of the floodplain, particularly in the case of the Waidoi. The stream channel is very unstable and the actual bed is rather indeterminate, changing position with considerable frequency. The stream bed of the Waidoi has been further complicated by large scale removal of gravel for road metal.

Topography within the left bank of the Nabukavesi is subdued and, apart from surface irregularities due to poaching and the remains of old moated village sites, is relatively smooth. Within the Waidoi floodplain a broad strip immediately adjacent to each bank of the stream is badly broken up by old channels and meander scars from former courses of the river. Beyond this strip, the topography is very much more even, broken here and there by small low hills.

A significant feature of the Waidoi valley is the broad river levee which slopes gently away at right angles from the stream, resulting in comparatively large areas of very poorly drained back swamp land behind the levee. A well marked drainage gradient exists at right angles to the river throughout its length.

Soil parent materials within the survey area are alluvial, both of riverine and estuarine derivation. Most of the estuarine materials are at present under mangrove and are generally medium textured with fairly high quartz contents. Beyond the mangrove is a very narrow zone of estuarine material, weakly saline, which supports a rather mixed vegetation.

The riverine deposits of the Nabukavesi have high silt contents except on the levee tops where textures are coarser. The greater part of the catchment of the Nabukavesi lies within the Tawavuta Tuff formation, a basic, fine grained lithic tuff. The catchment of the Waidoi river lies within two main rock formations. The headwaters drain an area of intrusive gabbro, and the middle section lies within the Tawavuta Tuff formation. The riverine alluvium of both rivers is thus of rather basic derivation.

Between the deposits of riverine and estuarine derivation, is a narrow zone where riverine alluvium has been laid down over material of estuarine derivation.

South of the Queens Road, on the right bank of the Waidoi valley, a small area of peat occurs along the edge of the bordering hill land.

3.2 The Soils (Drawing 1)

Parent material and drainage are the main factors used in defining the different soils found in this area. Four drainage categories are recognised, well, imperfectly, poorly and very poorly drained. These occur as a drainage succession from levee to back swamp, giving a naturally occurring soil succession. Table 3.1 lists the acreages of the eight soils found in the survey. Detailed descriptions of four soils pits are given in Appendix I and chemical analyses in Appendix II.

All the series found at Waidoi occur also at Navua, and in general the corresponding series are similar. However, the available phosphorus levels at Waidoi are even lower than in the corresponding counterpart profiles at Navua.

TABLE 3.1 Waidoi Soils

Riverine alluvium	Acres	
Rewa - well drained	269	
Tamanua - imperfectly drained	232	
Navua - poorly drained	140	
Tokotoko - very poorly drained	200	841
Estuarine alluvium		
Soso	7	
Dogo	163	170
Mixed alluvium		
Naitonitoni - poorly drained	59	59
Peat		
Melimeli	22	22
Total acreage		1092

3.2.1 Riverine alluvium

Within the Waidoi valley Rewa soils occur in a broad strip along each bank of the river, and much smaller areas are associated with the other minor tributaries. Soils of this series are well-drained, with little or no mottling in the profile. The top soils are medium textured and well structured, resting usually on coarse, gravelly subsoils. The infiltration and permeability rates of Rewa soils are high and water moves freely through the profile. Smaller areas of Rewa soils are found in which there is either no gravel subsoil, or gravel only in the deep subsoil. These soils usually have at least 40 inches of medium textures. In the Nabukavesi valley soils of the Rewa series are confined to a narrow strip along the top of the levee. They are mainly medium textured except for small areas between the main levee and the river where gravelly subsoils occur.

Soils of the Tamanua series are imperfectly drained and are distinctly mottled red and grey through the profile. Matrix colours are usually paler than for Rewa soils. These soils are moderately well structured, but more compact than Rewa soils, and infiltration rates are rather low, especially in the Nabukavesi valley where silty textures predominate. The low infiltration has resulted in considerable poaching of the surface by grazing cattle. As a result of this poaching, many of the Tamanua soils show distinct gleying in the upper few inches of the profile. Another feature of most Tamanua soils is the high amount of manganese found in the profiles, mainly in nodular form.

Poorly drained gley soils, in which a redox horizon occurs within 20 inches of the surface, are contained in the Navua series. These soils are generally silty or fine textured, compact and moderately well structured. Like soils of the Tamanua series their infiltration rates are low and severe poaching of the surface has often occurred under grazing. Where poaching is severe strong gleying of the surface few inches has occurred. The less poached soils show a reasonably well drained top soil with some mottling on a very strongly mottled or variegated horizon, which in turn overlies a grey or olive grey subsoil with some mottling, especially along root channels. This mottling decreases with depth.

Tokotoko gley soils are the most heavily gleyed of the riverine succession, reduction conditions predominating throughout the profile. The upper part of the profile normally shows distinct red mottling, mainly along old root channels. The structure of Tokotoko soils is weakly developed and many subsoils show poor cohesion. Infiltration and permeability rates are very low.

3.2.2 Estuarine Alluvium

All soils derived from estuarine alluvium are saline. They have been divided into two series. Soso saline gley soils are less saline than Dogo soils, which support pure mangrove vegetation. The area of the former is very small. Both soils are medium to coarse textured with high coarse sand and quartz contents. They are generally weakly structured with very low cohesion, especially in the subsoils. Contents of raw organic matter, much of it the woody remnants of mangrove debris are high. Many of these soils give off a fairly strong smell of Hydrogen sulphide indicating that sulphur contents may be high. The formation of acid sulphate horizons on reclamation and drainage is a strong possibility.

In a narrow band around these saline soils occur soils which are composed of two different parent materials, a surface layer of riverine deposits and a lower layer of estuarine derivation. These soils have been called the Naitonitoni series. The depth of riverine deposits must be more than 6 inches and less than 40 inches within this series. If 16 inches or less the soil is regarded as truly estuarine, and if 40 inches or more the soil is regarded as riverine.

3.3 Suitability for Padi Cultivation

The area has been classed in three grades on the basis of its suitability for swamp padi cultivation. The most suitable land comprises the gently sloping soils of the Tamanua, Navua and Tokotoko series, where soil conditions are adequate and topography presents little problem to development.

Land of intermediate suitability are mainly those areas of similar soils at present carrying a dense cover of trees and scrub, the clearance of which would involve considerable extra cost in development.

Lands not recommended for rice include the uneven, coarse textured Rewa soils, the deep peats, the saline estuarine soils, and those soils of the Naitonitoni series in which acid sulphate horizons occur close to the surface.

Drawing 2 shows the locations of the three classes of land. Acreages of each class are as follows:

Class I	390 acres
Class II	222 acres
Class III	480 acres
	1092 acres

There are therefore just under 600 acres of land which are considered to be suitable for cultivation of wet land padi.

CHAPTER 4

THE PRESENT SITUATION

4.1 The Population

There are two centres of population, one at Nabukavesi, the other at Waidoi. The former is entirely Fijian; in the latter 75 per cent of the families are Indian, the remainder Fijian. According to the population census of 1966 the Fijian population amounted to 190 persons in 31 households, and the Indian population to 127 in 18 households. Assuming the country's overall rates of annual increase to apply to the area, present population will be 141 Indians and 208 Fijians. The average household sizes are as follows:-

Fijian	6.1
Indian	7.05

Sex and age structure appear to be as follows:-

	Indian household			Fijian household		
Age Group	Males	Females	Total	Males	Females	Total
0-14	1.71	1.78	3.49	1.31	1.40	2.71
15-19	0.38	0.41	0.79	0.30	0.32	0.62
20-59	1.28	1.29	2.57	1.17	1.32	2.49
60 and over	0.12	0.08	0.20	0.13	0.15	0.28
	3.49	3.56	7.05	2.91	3.19	6.10

The above household compositions and sizes are very similar to those found at Navua. It would seem reasonable to apply to them the same assumptions regarding the number of families per household and the availability of the different components as farm labour. If this is done family labour availability in hours per 5 day period can be assumed to be as follows:-

	Indian		Fijian	
	Normal	Peak	Normal	Peak
Male	38	64	32	54
Female	20	33	18	30
Total	58	97	50	84

4.2 Land Use

Most of the surveyed area is composed of swamp sedges, Navua sedge and grasses of varying usefulness, but mostly poor. Much of the area is covered with tree and scrub, particularly on the Nabukavesi left Bank and Waidoi Right Bank. A few farmers grow a little padi and some vegetables, and cattle graze the area at will. The standard of husbandry is low at present. Most of the farmers only work in their spare time as they have full time work in other occupations, commonly logging or in saw-mills. Others are engaged in fishing. The situation is very similar to that found in the Navua plains.

4.3 Land Tenure

The Fijians at Nabukavesi farm on the right bank of the river there on mataqali land, which is outside the area under study. The Indian farmers interviewed at Waidoi hold their land on annual tenancies. Most of them had less than 5 acres, and most expressed a wish for more.

4.4 Present Productivity

The present productivity is low. The natural environment, sociological organisation and farming methods are broadly similar to those at Navua, and the estimates of yield made for Navua can be taken to apply at Waidoi. Thus small farmers at Waidoi can be assumed to be obtaining a main crop yield of some 13 cwt. per acre; with double cropping on perhaps 1/6 of the land, the annual yield can be put at 15 cwt. per acre.

CHAPTER 5

DEVELOPMENT ALTERNATIVES

5.1 Economic Background

In recent years the value of rice imports into Fiji has steadily increased. Prices have been high, and this has stimulated efforts to effect some import substitution. Prices for locally produced padi have been around $ 100 per ton.

The most recent evidence strongly suggests that this situation has changed. The world shortage of rice is less than it was in 1967, and it seems unlikely that a shortage of the 1967 magnitude will recur. Production is increasing through the adoption of new high yielding varieties on a steadily increasing scale. Increased fertiliser usage, improved control of pests, diseases and weeds, and investments in irrigation and drainage works have also played a part in the achievement of these increases. Some large producer countries, formerly importers, are or will shortly be seeking export markets. Other countries have been stimulated by the recent high prices to increase local production and aim at self-sufficiency. The price per ton of rice f. o. b. Bangkok has fallen from $185 in 1968 to $151 in the first eight months of 1969 and it is thought that future short term movement will be still further downward.

Assuming that Fiji does not produce an exportable surplus, it is thought that the competitive price of padi will not fall below $ 56 per ton at the farm gate, but over production could lower the price still further, to perhaps $ 44, and it must be emphasised that existing local production and demand estimates are open to question, making it difficult to assess with any precision how much more padi is required to achieve self-sufficiency. It is clear, therefore, that there is a considerable element of risk for a private investor expecting a reasonable rate of return to invest in an expensive padi development project at the present time.

5.2 Alternative Methods of Development

The existing low labour and material inputs reflect the poverty of the present farmers, the element of uncertainty in the existing environment and the attitude of the farmers towards this uncertainty. Improvements in productivity may be effected by three main lines of development, all of them calling for the injection of substantial amounts of money.

(1) By the adoption of a full range of improved techniques and inputs.

(2) By (1) with the addition of drainage.

(3) By (1) and (2) and also irrigation.

It should be noted that the three alternatives are cumulative; irrigation must not be used without drainage and neither drainage nor irrigation should be undertaken without a proper investment in agricultural inputs.

The survey carried out at Navua revealed deficiencies in farming practices. Land preparation, particularly levelling, is often neglected; weed infestation is common; insect attacks, usually by roller moths and/or plant hoppers, are seldom controlled. A large number of inferior varieties are sown. By planting FK 135, the currently recommended non photo-sensitive variety, and by proper attention to land preparation, weed and pest control, it is considered that the existing average annual padi yield could be raised from 15 cwt. to 24 cwt. per acre. When experiments have proved the effects of fertilizer it could well be that the yields will be higher still.

In the 1969 main crop season at Navua several farmers obtained padi yields of around 30 cwt. per acre, where water control was reasonable and where the crops were kept free of weeds and pests. It is considered that if full drainage and irrigation facilities are provided at Waidoi a similar yield can be obtained in both seasons and that the whole area can be double-cropped, raising the annual yield to 3 tons per acre of padi.

Annual production per acre is the product of the yield per crop; the extent of double-cropping and the 3 ton per acre target is only likely to be obtained if conditions in each season are suitable for the preparation, growing and harvesting of a full crop over the whole area.

The variety of padi at present recommended for Waidoi is FK 135. This occupies the ground for from 105-120 days in the main crop season and from 120-135 days in the off-season. Thus, unless and until a suitable variety of shorter duration is introduced, the time available for preparing the land twice in a year will be limited. If high farming intensities are to be achieved it will be imperative to make maximum use of this limited period. Unimpeded work will be necessary and even then considerable organising ability will be required to secure the harvest of the standing crop swiftly and then to prepare the land for the next crop. In order to facilitate harvesting operations it is desirable to drain standing water from the fields some three weeks before reaping and also to remove quickly any rain falling during these three weeks. Should this period be followed by a dry spell the typical gley soils would be likely to dry out excessively, thus preventing the ploughing of the land with draught animals. Then without irrigation it would not be possible to achieve full double-cropping.

The considerations that govern the most suitable operations calendar for irrigated padi are discussed in detail in the next chapter. The recommended calendar is shown in Figure 5.1 from which it can be seen that the two periods of land preparation are from Christmas time to the third week of February and from the last week of June to the end of July.

The possibility of droughts occurring during these periods of land preparation can be assessed by examining the data presented in Chapter 1, (Tables 1.2 and 1.3). A drought day is defined as one with not more than 0.2 inches of rain. It can be seen from Table 1.2 that there is an even chance of getting 10 or more consecutive drought days in July. In this month 19 per cent of the days are drought days of 11-15 days duration or longer. The chances of a drought in January are small.

FIGURE 5·1

FARMING CALENDAR

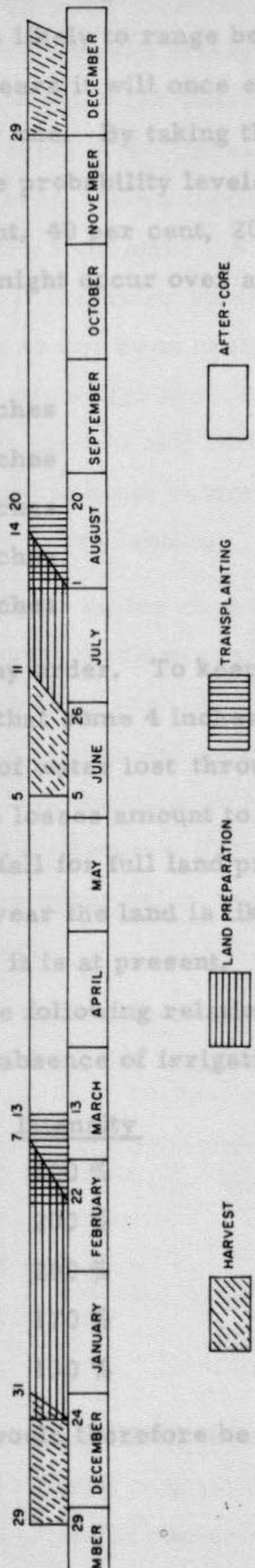


Figure 1.2 and Table 1.1 show how unpredictable the rainfall is in July. In four years out of six it is likely to range between 5.0 inches and 17.50 inches. In the other two years it will once exceed the upper value and once be less than the lower one. By taking the July rainfall values shown in Table 1.1 against the probability levels nearest to 100 per cent, 80 per cent, 60 per cent, 40 per cent, 20 per cent, it can be seen that the sort of pattern that might occur over a five year period in July would be as follows:-

(1) 18.9 - 21.1 inches
(2) 12.8 - 18.9 inches
(3) 11.0 - 12.8 inches
(4) 6.0 - 11.0 inches
(5) 3.1 - 6.0 inches

The occurrences could be in any order. To keep the land in a cultivable condition it is considered that some 4 inches of rain would be required over and above the amount of water lost through evaporation and from the groundwater. In July these losses amount to 6.5 inches. In three out of five years adequate rainfall for full land preparation in the off-season can be expected. In one year the land is likely to be so dry that off-season could be nearly as low as it is at present. In the fifth instance the conditions are intermediate. The following relationship is assumed between rainfall and intensity in the absence of irrigation:-

Rainfall	Intensity
(1)	200 %
(2)	200 %
(3)	200 %
(4)	170 %
(5)	130 %

The average annual intensity would therefore be 180 per cent in the absence of irrigation.

Reference to Figure 5.1 shows that main crop padi will be transplanted in the last week of February and first fortnight in March and the off-season crop in the first three weeks of August. Transplanting is best done into a puddled field, after which the water level should be gradually raised and maintained at a level of 4-6 inches until draining off starts two or three weeks before harvest. Some flexibility is permissible with regard to the depth of water on the field after the crop is established, and the crop would not come to harm if the water depth fell to 1 inch. The main object of the greater depth is to assist weed control. What is essential for full yields is that the crop should not suffer from water shortage, which would occur if the moisture content of the soil fell below 50 per cent of available moisture capacity. The plant is most vulnerable to the effects of drought in the first two weeks after transplanting.

Examination of the drought analysis tables shows that the main crop will seldom suffer seriously if irrigation is not available. The position in August is, however, different. There is an even chance of getting nine or more consecutive drought days in this month, and 19 per cent of the days in August are drought days of 11-15 days duration or longer. The rainfall is as unpredictable as in July, ranging between 4.5 inches and 18 inches in four years out of six, exceeding the upper value one year in six and falling below the lower value in the sixth year.

The probable 5-year range of August rainfall (Table 1.3) is as follows:-

(1) 1.7 - 5.4
(2) 5.4 - 7.0
(3) 7.0 - 11.1
(4) 11.1 - 18.6
(5) 18.6 - 28.0

occurring in any order.

Evaporation and groundwater losses in August are estimated to be 6.2 inches. On occasions (5) and (4) rainfall is plentiful or at least adequate. On occasion (1) it is deficient, on occasion (2) somewhat less so, and on occasion (3) it is marginal. The following assumptions are made on the relationship between rainfall occurrence in August and off-season crop yield in the absence of irrigation.

Rainfall	Yield cwt./acre
(1)	10
(2)	15
(3)	25
(4)	30
(5)	30

The average off-season yield without irrigation will therefore be 22 cwt. per acre. No benefit is assumed for irrigation in the main season. It would seldom be required and its installation for the main crop would not be justified. Nevertheless, once it is installed, it may on occasions be used for main crop if exceptionally dry weather occurs at a critical time.

The following comparisons may now be made between the projected condition with farm inputs and full water control, that with farm inputs and drainage but without irrigation, and that with farm inputs alone.

	Farm Inputs only	Farm Inputs & Drainage	Farm Inputs & Drainage & Irrigation
Main crop area	100 %	100 %	100 %
Off-season crop area	20 %	80 %	100 %
Main crop Yield	20 cwt./acre	30 cwt./acre	30 cwt./acre
Off-season crop yield	20 cwt./acre	22 cwt./acre	30 cwt./acre
Annual yield	24 cwt./acre	48 cwt./acre	60 cwt./acre

Thus, starting from an existing 15 cwt. per acre per annum it can be seen that investment in farm inputs may be expected to increase the annual yield per acre by 9 cwt.; the drainage facility could add a further 24 cwt. per acre and the irrigation yet another 12 cwt. per acre.

The benefits from irrigation are due entirely to the increased area and yield obtained from the off-season crop. The drainage benefits spring from a substantial main crop yield increase and a larger off-season crop area.

The combined effects of irrigation and drainage are the same as at Navua, but the contribution attributable to drainage is much higher at Waidoi. This is to be expected as the rainfall recorded is much greater at Waidoi than at Navua and it is distributed in much the same pattern and with similar intense storms frequently occurring.

The financial implications of the two partial investments and of the whole are discussed in Chapter 6.

CHAPTER 6

PRODUCTION BY SMALLHOLDERS

6.1 Introduction

Production may be organised on an estate basis using direct labour or through a system of tenant farmers. At Navua one of the main objectives is the relief of population pressure on land, and another is the raising of rural living standards. Both of these objectives are sociological and not necessarily economic. Their attainment makes it necessary to plan a smallholder tenant project, aiming at maximum production per acre to enable the greatest number of families to participate in the benefit.

Although the same objectives do not necessarily apply to any private investment at Waidoi, nevertheless the method of development is technically feasible, and is one of the choices open for consideration. The technical criteria will be very similar to those found applicable to Navua and these are described in the following sections.

6.2 Description of Area

A cultivable commandable area of 538 acres has been selected as being suitable for irrigated padi production. This area (Drawing 3) comprises the following three units, each of which has its own pump station, canal and drainage system:-

Nabukavesi Left Bank	183 acres
Waidoi Left Bank	149 acres
Waidoi Right Bank	206 acres
	538 acres

6.3 Soils

The soils of the area belong mainly to the poorly and very poorly drained Navua and Tokotoko series and to the imperfectly drained Tamanua series. The Nabukavesi is predominantly composed of the latter series, while in the Waidoi Left Bank unit the Tokotoko series is the most important. In Waidoi Right Bank the Navua and Tokotoko soils predominate.

The land capability plan (Drawing 2) showed that there are 612 acres of land suitable for padi. However, 74 acres lie in two small blocks that are too small to warrant the expense of installing pump stations for their irrigation. One of these areas, amounting to 23 acres, lies on the left bank of the Wainibuabua river just north of the Queen's Road; the other 51 acres, lies on the left bank of the Waidoi river below the confluence of the Wainibuabua and Waidoi rivers. These areas, which have been omitted from the present irrigation scheme because of their small size, lie on Navua and Tokotoko soils, are considered to be in Class I for padi, and would benefit from drainage to the same extent as areas within the scheme.

6.4 Cropping Pattern

It is considered that the basic cropping pattern should be two crops of padi per year. However, sufficient land on each farm is provided to allow for a garden and homestead plot and for growing fodder to compensate for the loss of the fallow grazing that is obtained under the present extensive methods of cultivation.

6.5 Farming Calendar

Double-cropping on all padi land will require a rigid calendar of operations. If the time, and therefore labour requirements, for land preparation are to be kept at a similar level in each season, the two crops must be given more or less equal spacing in time, that is to say the harvests will be separated by about six months.

With the provision of drainage and irrigation to overcome the constraints imposed at present on land preparation, the harvesting period becomes the fixed point round which to plan the calendar.

Optimum conditions for harvesting are an unbroken spell of dry weather and for the best yields some 200 sunshine hours (or 14000 Cal/cm^2 solar radiation) are needed in the preceding 30 days.

The best available estimate of solar radiation for Waidoi was shown in Chapter 1 to be as follows:-

Estimated Monthly Solar Radiation at Waidoi (Cal/cm^2)

January	16000
February	14500
March	14100
April	12300
May	11400
June	9500
July	10200
August	11800
September	12200
October	13700
November	15800
December	16400

Thus there is sufficient solar radiation from November to March only. The months in this period with the best chance of not being excessively wet are November and December. As far as the main crop harvest is concerned, there is less than optimum solar radiation, but the earlier the crop is harvested the better. The driest three months are June, July and August. The best compromise appears to be to harvest the main crop in June and early July and the off-season crop in December.

It is undesirable to use a large number of different varieties of padi to spread the harvest period because of the difficulties of avoiding the mixing of varieties, especially during processing. However, by sowing seed-beds at intervals over a period of 2-3 weeks, transplanting can be spread over three weeks and the harvest over $4\frac{1}{2}$ - $5\frac{1}{2}$ weeks.

The assumed calendar is shown in Figure 5.1. It will be needed that the period of land preparation for the off-season crop is much shorter than for the main crop. The period could be extended by earlier stubble ploughing, but this would reduce the harvest labour available. It would be a great help if a suitable shorter term variety than FK 135 could be found for off-season cropping. This could be transplanted later in August, so extending the time for land preparation.

6.6 Labour Availability

Using the same criteria and parameters as have been adopted for Navua, family labour availability can be taken to be as follows (in hours per 5 days):-

	Indian		Fijian	
	Normal periods	Peak periods	Normal periods	Peak periods
Male	38.4	64.0	32.1	53.5
Female	19.8	33.0	18.2	30.3
Total	58.2	97.0	50.3	83.8

Reference to Figure 5.1 shows that the labour availability over the critical periods of the different operations will be as follows:-

	Indian	Fijian
Off-season land preparation	582-970 hrs	503-838 hrs
Transplanting	233-388 hrs	201-335 hrs
Main crop after-care	990-1650 hrs	856-1404 hrs
Off-season harvest	378-630 hrs	327-545 hrs

The above labour availability will be used as one of the parameters for deciding on the most suitable basic farm size. However, the concept of a "typical" family must not be taken too rigidly. The settlement will be composed of families with labour to spare and families with too little labour. It is assumed that the larger families, who will require more than the average income, will hire out their surplus labour to smaller families, who will be in a position to afford hired labour. This pool of labour will include children during the school holidays and also persons over 60 years of age, who do assist at critical periods of labour demand.

The contribution of these two components of population has not been quantified on account of its irregularity.

6.7 Farm Power Availability

The main source of farm power is working oxen. In the survey of 125 households carried out during the Navua investigation, it was revealed that there was an average of one pair of working oxen per household. Eighty per cent of the households owned at least one pair. At Waidoi the farmers questioned all owned a pair of oxen. Tractors as yet are hardly used; the job most commonly mechanised is threshing. While the Department of Agriculture and a number of private farmers possess threshers, which are hired out at $1 per acre, the traditional method of threshing by trampling with bullocks is still widespread.

A bullock's normal working day can be assumed to be 6 hours effective, in peak periods 9 hours. Thus in the most critical period for ox work (off-season land preparation) one pair of oxen will be able to provide between 210 and 315 hours.

6.8 Labour Requirements

Data are scanty and most estimates are subjective and show considerable variation. Using oxen, and traditional cultivation methods, but with improved animal drawn and manual implements, and threshing with locally available machines the present labour requirements are assumed to be as follows for one acre of padi:-

Nursery preparation and maintenance	12 hours
Hand preparation (ox work)	44 hours
Hand preparation (manual work)	32 hours
Transplanting	60 hours
Pest and weed control	42 hours
Water control	40 hours
Harvesting	50 hours
Threshing	18 hours
Winnowing	18 hours
Marketing	4 hours
Miscellaneous	20 hours
	340 hours

These requirements could be reduced by mechanisation. An examination of the relative merits of tractors and oxen was made in the context of the Navua project; some of the arguments apply also to Waidoi. The following points merit consideration:-

1. Although the quality of land preparation work performed by a tractor is superior to that done by oxen, there is insufficient evidence to confirm that the superiority is reflected in a higher productivity per acre.
2. The introduction of water control will make working conditions easier for oxen, and allied with an improved range of animal implements should enable output per animal to be raised.
3. The costs of land preparation by oxen and tractors were calculated to be as follows:-

By Oxen	44 hrs @ \$0.12 = \$5.28 per acre
By 2-wheel tractor	16 hrs @ \$0.40 = \$6.40 per acre
By conventional farm tractor	4 hrs @ \$2.00 = \$8.00 per acre

4. Tractors require an outlay of foreign exchange, which is at present not easily available.

5. The majority of farmers own at least one pair of oxen.

6. The peak periods of work occur at transplanting which for the present has to remain a manual operation, and at the time the main crop harvest and the land preparation for the off-season crop. The value of the combine harvester in the unpredictable weather conditions has still to be proved. The machine is also expensive and requires foreign exchange. Further it is not necessary to reduce the hours to the extent that a combine harvester would achieve. There are simple hand pushed reapers made in Japan, and winnowers and threshers, both hand and power driven are available cheaply from external sources; if proved suitable some at least could be manufactured locally.

It is considered that smallholders should be encouraged to maintain oxen as the prime source of farm power. At Navua it was found necessary to supplement oxen by tractors to the extent of one-sixth of the cropped area, and it is recommended that a similar precaution be taken at Waidoi. Only one tractor would be required and this should be hired. Provision has been made in the estimates for one-sixth of the area to be prepared by tractor each season at a cost of Rs. 9.00 per acre.

With oxen, using improved tillage implements, and adopting simple aids to speed up the harvesting operations, it is considered that the labour requirements per acre can be reduced to the following:-

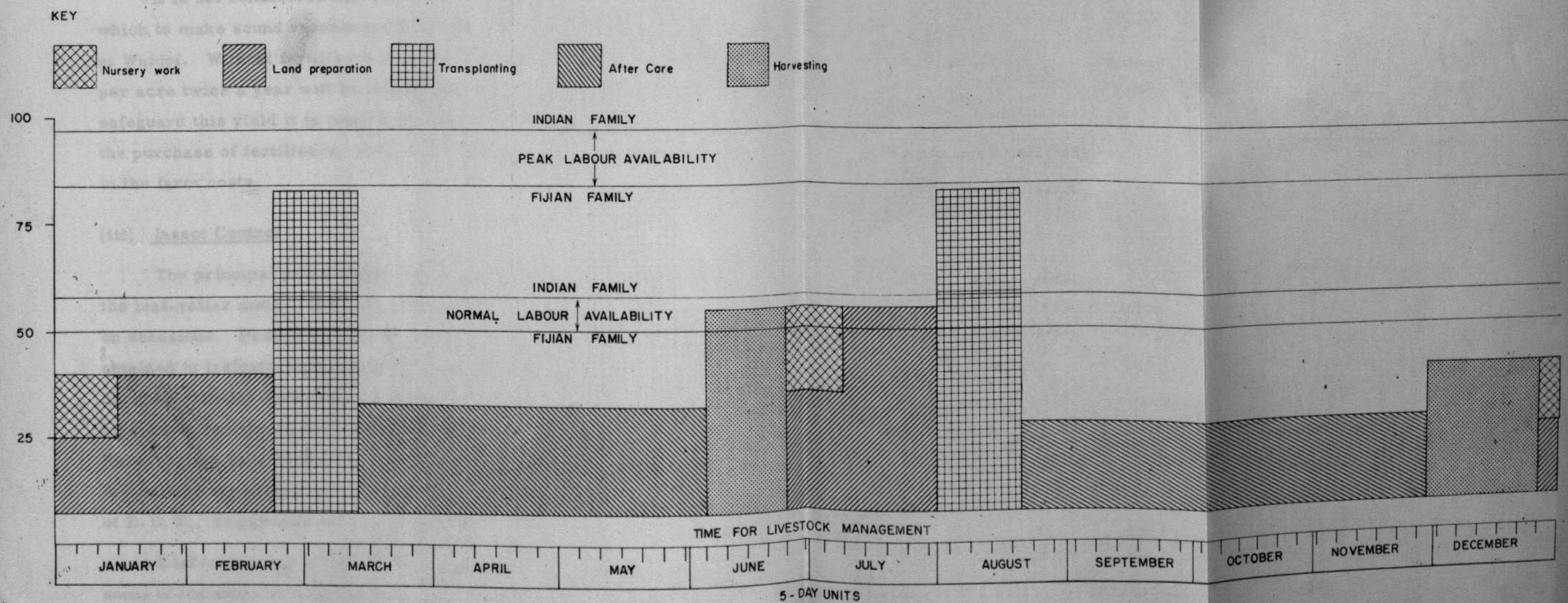
Nursery preparation and maintenance	12 hours
Land preparation (ox work)	33 hours
Land preparation (hand work)	32 hours
Transplanting	60 hours
Pest and weed control	42 hours
Water control	40 hours
Harvesting	15 hours
Threshing	15 hours
Winnowing	3 hours
Marketing	4 hours
Miscellaneous	20 hours
	276 hours

If oxen are to remain the prime source of farm power, some time must be set aside every day for their care. If they are kept under control near the homestead this should not be more than half an hour per pair per day. The oxen must also be properly fed if they are to perform the work required of them successfully. A cheap, balanced ration can be provided from padi straw and para grass, with rice bran as a supplement during periods of peak activity. This system of keeping the stock under control and hand feeding fodder is much to be preferred to the present wasteful fallowing of the padi areas to support unproductive animals, and it is recommended that every holding should have one acre of land set aside for its homestead lot, vegetable garden and fodder plot.

If the reduced labour requirements for the various padi production operations are examined in relation to the farming calendar and labour availability, it will be found that the average Indian family, working within normal labour capacity except at transplanting time, can handle 5 acres of double-cropped padi. Figure 6.1 shows the distribution of the family labour requirements for this acreage of padi. It is clear that there is ample time for the family to handle their garden and fodder plot in addition to their padi. It is also very clear that transplanting is the major constraint on increasing the size of the holding. Without hiring labour for this operation the Fijian family cannot handle more than 5 acres of padi. The Indian family could manage 6 acres.

FIGURE 6·1

LABOUR DISTRIBUTION FROM MATURITY ON BASIC HOLDING



6.9 Agricultural Inputs

(i) Varieties and Seed

The recommended variety at present is FK 135. Other recently introduced varieties are showing promise, notably IR5 and IR8. The introduction of a non-photo sensitive variety, maturing in 15-20 days less time than FK 135 in the off-season, would be welcome. A seed rate of 28 lb per acre is required. There is an official scheme through which farmers can obtain pure seed of good quality, and it is assumed that all farmers will use only good standard seed of the approved variety. Further, when a new variety is proven, it should be introduced throughout the area and the superseded variety banned.

(ii) Fertilisers

It is not considered that sufficient knowledge is yet available on which to make sound recommendations for irrigated padi in the conditions at Waidoi. Without fertilisers it is unlikely that a yield of 30 cwt or more per acre twice a year will be sustainable over a long period. In order to safeguard this yield it is considered prudent to make some provision for the purchase of fertilisers, and a sum of $10 per acre has been included in the farm costs.

(iii) Insect Control

The principal pests of padi in the area are the plant hoppers and the leaf-roller moth. The rice army worm also causes severe damage on occasions. Promising control of plant hoppers has recently been obtained in irrigated padi fields by using 20 lb per acre of 5 per cent diazinon granules. However, these granules are expensive and are unlikely to replace D. D. T. except in lodged and near maturing padi. Recent trials have shown that satisfactory control can be obtained by low volume spraying directed at the base of the rice plants. 1.6 pints of D. D. T., 25 per cent M. L. in 8 gallons of water per acre are required.

Leaf-roller has become increasingly serious in recent years; some of the short strawed varieties seem particularly susceptible.

Evidence from trials indicates that yield losses of 20 per cent may be sustained even when the visual damage at flowering time is negligible. Where damage is severe loss of crop may be nearly 50 per cent. The recommended treatment is 8 oz of Bidrin (103 per cent w/v concentrate) in 100 gallons of water per acre.

Rice army worm attacks are sporadic. When severe they can be effectively controlled by spraying 0.5 lb active material per acre of D.D.T. 50 per cent WP, that is 1 lb of the formulation in 50 gallons of water per acre. The cost per round of the recommended treatments is taken as follows:-

Plant hoppers control	$1
Leaf roller control	$1
Army worm control	$0.50

For full control of plant hoppers and leaf rollers 3-4 rounds of spraying may be necessary against each pest. It is difficult to predict what the average cost of control will be; not every farm will be attacked every year. However it is necessary for full protection to be enforced where necessary of the projected yields are to be reached. It has been assumed that the average cost of insecticide for full insect control will amount to $5 per acre, and that by the fifth year and onwards full control measures will be adopted. It has been further assumed that adoption will be gradual as follows:-

Year 1	Year 2	Year 3	Year 4	Year 5 on
20 %	40 %	60 %	80 %	100 %

(iv) Sacks

The standard bag used holds 1 cwt of padi. It is assumed that the whole crop will be handled in these bags. The projected yields per acre are given in Section 6.12. Experience in Fiji indicates that the cost of a sack can be assumed to be $0.10, based on its depreciation over six seasons.

The number and cost of sacks per acre will be as follows in the years following settlement:-

	Soils	
Up to and including	No.	$
base year	14	1.40
Year 1	18	1.80
Year 2	22	2.20
Year 3	24	2.40
Year 4	27	2.70
Year 5	29	2.90
Year 6	30	3.00
Year 7 on	32	3.20

6.10 Farm Housing and Stores

The majority of Indian farmers live on their farms, while Fijians live in their villages. It is most satisfactory if the farmer lives on his farm. Much time is wasted daily by the farmer who lives away and has to travel each day to work. With an irrigation system that will demand night work and with the need to feed animals with fodder from the farm, supervision of watering and prevention of stock theft will only be efficient if the farmer is resident. It is recommended that all settlers, except those already possessing their own houses, should be encouraged to live on their holding.

The Fiji Development Bank lends money to the agricultural sector at $5\frac{1}{2}$ per cent interest. A Standard house can be built for $500. It is assumed that this loan will continue to be available to farmers from the Bank. No cost for housing has been included in the project costs.

Houses in the area are usually built 2-3 feet off the ground to protect then from flooding. In some parts of the wet tropics houses are built on stilts high enough from the ground to allow comfortable movement beneath the house. This allows the area under the house to be used for storing of implements and farm stores. The additional cost of bulding at say 6 feet from the ground instead of 3 feet would be small, certainly less than building separate stores, and there is also a useful saving of land. It is appreciated that the risk of hurricane damage may be increased by building higher and this may be the reason why buildings are at present low. However, the advantages of having the extra usable space below the house may be considerable - for example during a wet harvest when the grain could be spread and protected from falling rain; it is suggested therefore that consideration be given to designing a basic house with 6 feet clearance from the ground. Meantime, for costing purposes, $100 per holding has been provided in the project costs for provision of farm stores.

6.11 Engineering Requirements

6.11.1 Irrigation Requirements

The depths of water assumed on the padi field during the different stages of cultivation are shown below:-

Land preparation period	4 inches depth maintained
Before transplanting	depth allowed to fall to 2 inches
After transplanting	depth is increased to 4 inches over a period of about 2 weeks
Growing period	4 inches maintained
Before and after harvesting	fields completely drained two to three weeks before harvesting and maintained in a dry condition until land preparation for next crop

The maximum irrigation requirement is calculated by considering the water balance within a holding taking consideration of each internal plot and the method and timing of irrigations. The water balance takes into account evaporation losses, evaporation from the water table, groundwater losses, rainfall and run-off. This analysis is shown in detail in Tables 6.1 and 6.2. The maximum irrigation requirement occurs in July and is based on the 1 in 5 year low rainfall. The maximum application of water required per week per holding is approximately 7.A acre inches when A = area of each plot in acres.

TABLE 6.1 Rainfall and Run-off during Drying-out Period Preceding Off-Season Land Preparation

	May 1954			June 1963			July 1963		
	Rain-fall	Depth from previous day	Run-off	Rain-fall	Depth from previous day	Run-off	Rain-fall	Depth from previous day	Run-off
1				-	0.79	-	-	0.59	-
2				-	0.59	-	-	0.38	-
3				-	0.39	-	-	0.17	-
4				-	0.19	-	-	-	-
5				-	-	-	0.05	-	-
6				-	-	-	-	-	-
7				0.34	-	-	-	-	-
8				-	0.14	-	-	-	-
9				-	-	-	-	-	-
10				0.17	-	-	-	-	-
11				-	-	-	0.32	-	-
12				0.38	-	-	0.50	0.11	-
13				2.56	0.18	1.74	0.40	0.40	-
14				1.26	0.80	1.06	0.83	0.59	0.42
15				2.21	0.80	2.01	-	0.79	-
16				0.47	0.80	0.27	-	0.58	-
17				0.75	0.80	0.55	-	0.36	-
18				-	0.80	-	-	0.15	-
19				-	0.60	-	0.94	-	-
20				0.32	0.40	-			
21				-	0.52	-			
22	-	-	-	-	0.32				
23	-	-	-	-	0.12	-			
24	-	-	-	0.36	-	-			
25	-	-	-	-	0.16	-			
26	0.05	-	-	-	-	-			
27	-	-	-	-	-	-			
28	-	-	-	1.07	-	0.07			
29	0.51	-	-	-	0.80	-			
30	0.67	0.70	-	0.40	0.60	-			
31	0.45	0.76	0.21	-	0.80	-			

<u>Assumptions:</u>

1) Evaporation and groundwater losses for May, June and July are 0.21, 0.20, 0.21 inches per day respectively.

2) Run-off is possible only when the depth on the field exceeds one inch.

TABLE 6.2 Water Balance May to July

	Rice Plots 1	2	3	4	Total irrigation (acre inches)
Start of dry period	22 May	2 June	12 June	21 June	
End of dry period	28 June	5 July	12 July	19 July	
Rainfall (inches)	11.57	10.34	10.15	4.87	
Run-off	5.91	5.70	5.70	0.49	
Evaporation and groundwater losses	7.70	6.85	6.32	5.99	
Net deficit at end of dry period	2.04	2.21	1.87	1.61	
Irrigation 29/6	7.00				7.00 A1
Deficit from dry period	2.04				
Depth	4.96				
Rainfall 29/6 - 5/7	0.45				
Evap. and G. W. losses 29/6 - 5/7	1.45				
Depth on 5/7	3.96				
Irrigation 6/7		7.00			7.00 A2
Deficit from dry period		2.21			
Depth	3.96	4.79			
Rainfall 6/7 - 12/7	0.82	0.82			
Losses 6/7 - 12/7	1.47	1.47			
Depth on 12/7	3.31	4.14			
Irrigation 13/7			6.00		6.00 A3
Deficit from dry period			1.87		
Depth	3.31	4.14	4.13		
Rainfall 13/7 - 19/7	2.17	2.17	2.17		
Losses 13/7 - 19/7	1.47	1.47	1.47		
Depth on 19/7	4.01	4.84	4.83		
Irrigation 20/7				6.00	6.00 A4
Deficit from dry period				1.61	
Depth	4.01	4.84	4.39	4.39	

The largest irrigation unit is the Waidoi right bank area (206 acres CCA). It has already been demonstrated that a family can manage a holding of six to seven acres and so the area would be split up into holdings of approximately 7 acres, of which one acre would be used for fodder, vegetables, homestead, farm channels etc. and the rest would be made up of four 1.50 acre padi plots. Taking account also of distribution channels and roads there would be approximately 28 seven acre holdings in the Waidoi right bank area. Each holding, receives water once a week and the irrigation turn is for 6 hours.

Therefore, 7.A acre ins. must be supplied in 6 hours. (A = 1.50 acres). The holding discharge required, allowing 10 per cent losses between the turn-out and the inlet to the padi field is 2.0 cusecs.

The head discharge of each unit is assumed to be 2.2 cusecs which includes 10 per cent transit losses.

6.11.2 <u>Drainage Requirements</u>

The essential requirements for drainage are that the system should provide for:-

a) The removal of all excess rain water which could damage crops by flooding or by erosion.

b) The removal of all standing water from the padi fields prior to harvesting and the reduction in water level in the fields before transplanting together with the removal of rainfall in the period before land preparation in order to maintain the fields in as dry a condition as possible.

c) The disposal of run-off from adjoining hills which drain into the rice area.

The drainage rates used for design of the drainage system are based on those used for the Navua Project. The rainfall in the Waidoi Nabukavesi area is approximately 50 per cent more than that in the Navua area so the drainage rates have been increased accordingly. The table below summarises the drainage requirements.

TABLE 6.3 Summary of Drainage Requirements

Area	Drainage Requirement	
	inches per day	acres per cusec
Padi Area	2.73	8.8
Hills	11.03	2.0

6.11.3 Irrigation Works

The irrigation system is designed to distribute the water supplies as and when required for land preparation and during the growing period.

Each unit has its own pump station which will deliver a maximum of 2.2 cusecs from the Waidoi or Nabukavesi river. The pump stations discharge into the canal systems, in which all the channels are designed for 2.2 cusecs maximum discharge.

"Ornel-type" irrigation pumps would probably be used because they are readily available from Australia and are already working satisfactorily elsewhere in Fiji. A special arrangement for the pump intake may be required because of the shallow nature of the rivers and also because the river bed is in a mobile condition.

The area will be split up into holdings of approximately 6 acres. Each holding takes the full discharge of the pump station in turn. Checks are provided on the canals to enable the full discharge to be diverted through a turnout onto the holding. The checks are located where possible adjacent to the turnouts and the maximum distance from a turnout to the next down-stream check is 715 feet. Falls will be incorporated in the checks where necessary. An escape is placed adjacent to the last turnout on all canals to take away any excess irrigation water.

Irrigation structures are illustrated in Drawing 4.

6.11.4 Drainage works

The drainage system is provided to carry away all excess water from the area.

The drains within the rice area will remove all excess irrigation water and rainfall. Drains are provided on the upstream side of canals adjacent to high land to dispose of run-off from the uphill catchments which at present drain into the rice area. Underpasses are required in the Nabukavesi and Waidoi Right Bank areas to carry this run-off under the canal and dispose of it into the rivers. All drains outfall into existing rivers or creeks. Falls constructed of Gabions will be necessary in some drains where the land slope is excessive and also at drain functions where there is a difference in water levels.

In areas adjacent to the river the excess water from the holdings will drain directly into the river. Each holding will have a field drain into which excess water will be disposed. The field drain will be controlled by a small stop gate.

Drainage structures are illustrated in Drawing 4.

6.11.5 Associated Works

Extensive tree and scrub clearance is required in the Nabukavesi Left Bank and Waidoi Right Bank areas.

Some land levelling will be necessary. This will entail the removal of irregularities in fields that are reasonably level and terracing sloping land.

Access roads are provided to each holding. These roads will run alongside the canals and will be gravelled to provide all weather access. Crossing points are provided where necessary at the canal checks. Two culverts are required to carry the main road over canals in the Nabukavesi and Waidoi Left Bank areas.

6.12 Yield Projections

In Chapter 5 it was estimated that, given full water control and the adoption of modern husbandry, the average yield in each season could confidently be expected to reach 30 cwt. per acre. It will also be feasible to grow two crops on all the land planted to padi. Thus a yield of 3 tons per acre per annum is predicted. Yields of 60 cwt. per acre per crop have been recorded for the new high yielding padi varieties under the best environmental conditions. With the shortage of sunshine at Waidoi such high yields are unlikely. However, it is considered that yields of 45-50 cwt. per crop are feasible. This potential is well in excess of the predicted overall average, as it must be to allow for the human factor. This is the main constraint to be overcome, once the necessary facilities are provided. It is the rate at which these facilities are successfully adopted by farmers long accustomed to farming at a low level that will determine ultimate success.

The annual yield assumes two full crops each of 30 cwt. per acre. In practice it will result from a combination of various yields and intensities, both of which will increase over time.

Yield criteria were adopted for Navua, based on an examination of the distribution of yield classes over a sample of more than 100 farmers. It is considered that the criteria and assumptions are equally valid for Waidoi.

Intensity was assumed at Navua to increase rapidly at first and more slowly as farmers got closer to complete double cropping. A simple formula was used to express these assumptions, and it is also applicable to Waidoi.

The predicted intensities and yields are set out in Table 6.4.

Table 6.4 Future Annual Yields per Acre

	Earning Intensity-Seasonal Yield %	(cwt.)	Annual Yield (nearest cwt.)
Present	116	13.5	16
Year 1	144	18.4	27
Year 2	163	21.4	35
Year 3	175	24.1	42
Year 4	183	26.5	48
Year 5	189	28.6	54
Year 6	193	30.2	58
Year 7 on	195	31.9	62

6.13 Development

Out of the total CCA 95 per cent only can be cultivated, the remainder being required for canals, drains and roads. On the cultivated area six acres out of seven are devoted to padi. Following the assumption in Table 6.4, the annual area and production of padi will build up as follows to maturity.

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7 on
Acres	631	714	767	802	828	845	854
Tons padi	591	766	920	1051	1183	1270	1358

6.14 Management

We are unaware of what management arrangements may be made, for cost purposes it has been assumed that the charge per acre will be similar to that at Navua, and supervising staff, housing and office, and transport have been charged as if Waidoi were a fifth area at Navua.

6.15 Costs and Returns

6.15.1 Capital Costs

The estimated capital costs of providing full water control are as follows:-

Item		
A. Priliminary		
Land clearance	4,710	
Land levelling	14,900	
		19,610
B. Irrigation		
Pump stations	29,840	
Earthworks	23,890	
Structures	26,350	
		80,080
C. Drainage		
Outfalls	8,680	
Earthworks	8,730	
Structures	4,340	
		21,750
D. General		
Roads	10,590	
Buildings	4,580	
Transport	1,800	
		16,970
	138,410	
Contingencies @ 10 %	13,840	
		152,250
Engineering & Supervision @ 10 %		15,250
Total		167,500

= $311 per acre CCA.

6.15.2 Recurrent Costs

Crop production costs are estimated to be as follows ($):

Item	Year 1	2	3	4	5	6	7 on
Seed @ $2 per acre	1,262	1,428	1,534	1,604	1,656	1,690	1,708
Fertilisers @ $10 per acre	6,310	7,140	7,670	8,020	8,280	8,450	8,540
Tractor hire @ $1.50 per acre[(a)]	945	1,071	1,150	1,203	1,242	1,268	1,281
Insecticides	631	1,428	2,301	3,208	4,140	4,225	4,270
Bags	1,136	1,571	1,841	2,165	2,401	2,535	2,733
Total	10,284	12,638	14,496	16,200	17,719	18,168	18,532

(a) 1/6th of the cultivated area @ $9.00 per acre.

The estimated annual fixed farm costs are shown below. It has been assumed that the basic holding will be 7 acres with 6 acres under padi, which was shown to be the maximum that can be handled by a family under the proposed system of planting without hiring labour. Since labour is a cost in a private enterprise it is clearly advantageous to make the holding as large as possible, thus reducing labour and fixed farm costs. In this respect Waidoi differs from Navua where Government is attempting to settle the maximum number of families compatible with a target income of Rs 800 per family. Assuming the holdings at Waidoi to be 7 acres, with 6 acres of padi, the number of tenant families will be 70 and the fixed costs as follows ($):-

Bullocks @ $40 per farm	2,800
Farm stores @ 24.40 per farm	1,708
Farm equipment @ $8.14 per farm	5,698
Total	10,206

Estimated project operational and maintenance costs are as follows ($):-

	Year						
Item	1	2	3	4	5	6	7 on
Operation - pump station	2,008	2,008	2,008	2,008	2,008	2,008	2,008
Operation - staff	4,719	3,722	3,604	3,314	3,314	3,314	2,343
Operation maintenance - transport	1,072	536	536	536	536	536	536
Maintenance - pump station	602	602	602	602	602	602	602
Maintenance - irrigation structure	290	290	290	290	290	290	290
Maintenance - drainage structures	143	143	143	143	143	143	143
Canal & drain cleaning	1,914	1,914	1,914	1,914	1,914	1,914	1,914
Upkeep of roads	583	583	583	583	583	583	583
	11,331	9,798	9,680	9,390	9,390	9,390	8,419
Contingencies @ 10 per cent	1,133	980	968	939	939	939	842
Total	12,464	10,778	10,648	10,329	10,329	10,329	9,261

Thus total recurrent costs will be ($ rounded off):-

	Year						
Item	1	2	3	4	5	6	7 on
Crop costs	10,280	12,640	14,500	16,200	17,720	18,170	18,530
Farm fixed costs	10,210	10,210	10,210	10,210	10,210	10,210	10,210
Other costs	12,460	10,780	10,650	10,330	10,330	10,330	9,260
Total	32,950	33,630	35,360	36,740	38,260	38,710	38,000

6.15.3 Returns

At present world market prices for rice are in a highly volatile phase. Continuing increases in rice production make it seem unlikely that scarcity prices of 1967 and 1968 will return and substantial price decreases from the levels of these years run likely in the short term. However it is difficult to predict how far this trend will continue and in these circumstances it is only possible to give the likely range of the farm gate prices for padi, as shown below:-

Assumed Farm Gate Prices for Padi

Year	Price 1	Price 2
1972	78	75
1973	77	72
1974	76	70
1975	75	68
1976	74	65
1977	72	62
1978	70	60
1979	69	58
1980	68	56

At the price levels assumed in the above two scales, the revenue from sales of padi will be as follows:-

Year	Gross production tons	Retain on farm tons	Sold tons	Gross Price 1	Sales $ Price 2
1	591	70	521	40638	39075
2	766	70	696	53592	50112
3	920	70	850	64600	59500
4	1051	70	981	73575	66708
5	1183	70	1113	82362	72345
6	1270	70	1200	86400	74400
7	1358	70	1288	90160	77280
8	1358	70	1288	88872	74704
9	1358	70	1288	87584	72128

6.15.4 Rate of Return

The Table 6.5 below shows the projected cash flow at the two levels of price range assumed. On the more optimistic range the rate of return is approximately 3.5 per cent;on the lower range the rate of return is less than 1 per cent.

TABLE 6.5 Projected Cash Flow ($)

	Receipts		Disbursements		Net Cash Flow	
Year	Price 1	Price 2	Recurrent	Tenant Capital	Price 1	Price 2
1				167500	-167500	-167500
2	40638	39075	32950	22700	15012	16575
3	53592	50122	33630	25700	5738	9208
4	64600	59500	35360	27600	1640	3460
5	73575	66708	36740	28900	7935	1068
6	82362	72345	38260	29800	14302	4285
7	86400	74400	38710	30400	17290	5290
8	90160	77280	38000	31500	20660	7780
9	88872	74704	38000	31500	19372	4574
10 on	87584	72128	38000	31500	18084	2628

Based on the proposed minimum tenant income for Navua of $800 per year, which is composed of $450 cash + $350 imputed retail value of food produced and consumed on the farm. The equivalent cost to Waidoi is the cash payment ($450) plus the value of the ton of padi retained by the tenant and the value of the production lost from the homestead lot. These additional values are estimated to amount to between $180 and $200 depending on the price assumed for padi.

6.15.5 Evaluation of Project

Although the project would be of economic benefit to the country, it is not an attractive private investment. The cost of tenant labour amounts to over 40 per cent of the recurrent costs. If direct labour could be hired more cheaply, the rate of return would be improved, but the improvement would have to be substantial to justify the high risk involved in this investment due to the uncertainty of future padi prices.

6.16 Drainage Project, Without Irrigation

The scheme for full water control and tenant production cannot be regarded as an attractive investment. However, in Chapter 5 it was estimated that the yield increase due to drainage would be twice that due to irrigation. It is therefore necessary to examine a project for drainage without irrigation

6.16.1 Yield Projections

Intensity can be expected to increase as in the previous scheme, but to a maximum of 180 per cent (see Chapter 5). The average off-season yield at maturity will be 22 cwt. The pattern of annual yield increase is assumed to be as follows (cwt/acre).

Year	Main Crop	Off-season	Annual
1	1 acre @ 18.4 cwt +	.44 acres @ 13.4 cwt =	1.44 acres giving 24 cwt
2	1 acre @ 21.4 cwt +	.63 acres @ 15.6 cwt =	1.63 acres giving 31 cwt
3	1 acre @ 24.1 cwt +	.75 acres @ 17.6 cwt =	1.75 acres giving 37 cwt
4	1 acre @ 26.5 cwt +	.80 acres @ 19.3 cwt =	1.80 acres giving 41 cwt
5	1 acre @ 28.6 cwt +	.80 acres @ 20.8 cwt =	1.80 acres giving 45 cwt
6	1 acre @ 30.2 cwt +	.80 acres @ 22.0 cwt =	1.80 acres giving 48 cwt

Acreage and production will therefore build up as follows:-

Year	1	2	3	4	5	6 on
Acres	631	714	767	788	788	788
Tons padi	526	679	810	898	986	1,051

6.16.2 Capital Costs

The estimated capital costs of a drainage project without irrigation are as follows:-

A. Preliminary		$	
	Land clearance	4,710	
	Land levelling	14,900	
			19,610
B. Drainage			
	Outfalls	8,680	
	Earthworks	10,520	
	Structures	7,640	
			26,840
C. General			
	Roads	10,590	
	Buildings	3,660	
	Transport	1,440	
			15,690
			62,140
	Contingencies @ 10 %		68,350
	Engineering & supervision @ 10 %		6,835
	Total		75,185
			= $140 per acre CCA.

Some additions have been made to the drainage costs compared with the previous estimate for the with irrigation condition. The additions cover the cost of road crossing structures and flood protection banks, previously included under irrigation, and still required under this scheme.

6.16.3 Recurrent Costs

Crop production costs are estimated to be as follows ($):-

	Year					
Item	1	2	3	4	5	6 on
Seed @ $2 per acre	1262	1428	1534	1576	1576	1576
Fertiliser @ $10 per acre	6310	7140	7670	7880	7880	7880
Insecticides	631	1428	2301	3152	3940	3940
Bags	1136	1571	1841	2128	2285	2364
Total	9339	11567	13346	14736	15681	15760

The reduction in off-season cropping enables all the land to be prepared by the oxen; thus a hire charge for tractors is not required.

The farm fixed costs remain as in the estimate for the with irrigation project, but operational and maintenance rates will be reduced to the following ($):-

	Year						
Item	1	2	3	4	5	6	7 on
Operation - staff [(a)]	3775	2978	2883	2651	2651	2651	1874
Operation and maintenance - transport	858	429	429	429	429	429	429
Maintenance - drainage structures	163	163	163	163	163	163	163
Drain cleaning	1110	1110	1110	1110	1110	1110	1110
Upkeep of roads	583	583	583	583	583	583	583
Total	6489	5263	5168	4936	4936	4936	4159

[(a)] Taken at 80 per cent of the with irrigation project costs.

Total recurrent costs are therefore ($):-

	Year						
Item	1	2	3	4	5	6	7 on
Crop costs	9340	11570	13350	14740	15680	15760	15760
Farm Fixed costs	10210	10210	10210	10210	10210	10210	10210
Other costs	6490	5260	5170	4940	4940	4940	4160
Total	26040	27040	28730	29890	30830	30910	30130

6.16.4 Returns

On the two ranges of price assumptions used previously the revenue from sales of padi will be as follows:-

Year	Gross production	Retained on farm	Sold	Gross sales Price 1	Gross sales Price 2
	tons	tons	tons	$	$
1	526	70	456	35568	34200
2	679	70	609	46893	43848
3	810	70	740	56240	51800
4	898	70	828	62100	56304
5	986	70	916	67784	59540
6	1051	70	981	70632	60822
7	1051	70	981	68670	58860
8	1051	70	981	67689	56898
9	1051	70	981	66708	54936

6.16.5 Rate of Return and Evaluation

Investment in drainage only is even less attractive than investment in irrigation the rate of return being less than 1 per cent at the higher price range. This is due to the fact that, because of lower yields, net receipts drop by over $20,000 while the annual disbursements only drop by $8,000 making a drainage scheme completely unattractive as a private investment.

CASH FLOW

Year	Receipts		Disbursement		Capital	Net Cash/Flow	
	Price 1	Price 2	Annual costs	Tenant income	Cost	Price 1	Price 2
					75, 185	75, 185	75, 185
2	35, 568	34, 200	26, 040	22, 700		13, 172	14, 540
3	46, 898	43, 848	27, 040	25, 700		5, 842	8, 892
4	56, 240	51, 800	28, 730	27, 600		90	4, 530
5	62, 100	56, 304	29, 890	28, 900		3, 310	2, 486
6	67, 784	59, 540	30, 830	29, 800		7, 154	1, 090
7	70, 632	60, 822	30, 910	30, 400		9, 322	488
8	68, 670	58, 860	30, 130	31, 500		7, 040	2, 770
9	67, 689	56, 898	30, 130	31, 500		6, 059	4, 732
10-20	66, 708	54, 936	30, 130	31, 500		5, 078	6, 694

CHAPTER 7

ESTATE PRODUCTION

7.1 Introduction

It has been shown that the relatively high cost of labour makes production by tenant smallholders unattractive as a private investment. The cost assumed was $65 per acre, of which $45 per acre was in cash, the balance in kind. At this cost the tenant would receive an income of $800 per year at project maturity. This figure is the target that has been set for the public project at Navua.

Thus labour is over 40 per cent of the total annual costs of production. To make a tenant project attractive the annual costs of production would have to be reduced by some $25000 to $30,000, that is about $50-60 per acre.

The cost of land preparation by tractors would be about $8 per acre (inclusive of drivers' wages). The cost of bullock work including the drivers' wage, could be about $13. Thus a saving of $5 per acre per season or $10 per acre per year could be saved by mechanisation of land preparation.

Conditions at Waidoi, even with water control, would not be easy for drilling of seed, but assuming it could be done the cost would be about $1.60 per acre. Transplanting requires 60 hours per acre, costing $10 in labour. Allowing for the extra seed needed for drilling compared with that for transplanting from a nursery, a saving of about $8 per acre per season, or $16 per acre per year, might be achieved. There would also be the saving on the nursery work, say $2 per acre twice a year.

Thus the drilling method could save $10 per acre per crop, equivalent to between 2½ and 4 cwt of padi, depending on the price of padi. In the conditions at Waidoi the yield of a drilled crop would probably be on average, less than a transplanted crop. The saving therefore is problematical.

The labour requirements after transplanting and until harvest are small, and a large proportion of them, such as controlling the irrigation, can only be done by manual labour. Mechanisation of operations during this period would save little or nothing.

The major operation requiring manual labour at present is harvesting. Threshing may be done by machine, but with the threshers now used which are excellent for coping with wet straw, much time has to be spent on winnowing. Present harvesting and threshing costs are of the order of $17 per acre for hand labour. The use of a combine harvester would reduce this by about $10 per acre. However conditions at Waidoi for combine harvesting will be extremely difficult. Trials commend in the summer of 1968 in the Nausori area and at Koronivia with a Claessen combine harvester. Weather conditions were good and the machine's performance was promising. It cannot, however, be considered to have proved itself until it has been tested throughout at least two main and off-season crops and continued to give satisfaction.

Assuming that mechanised harvesting and crop drilling can be successfully adopted and that the land preparation is done by tractors; assuming further that yields of drilled padi do not average less than those of transplanted padi, then the total labour saving per crop could be as follows:-

Land preparation	$ 5 per crop acre
Drilling	$ 10 per crop acre
Harvesting	$ 10 per crop acre
	$ 25 per crop acre or $ 50 per acre per annum.

Therefore under the best set of assumptions the minimum saving required to make development attractive is just achieved. This leaves nothing for contingencies, and it is clear from what has been said that there are a great many practical difficulties to overcome.

It is not therefore recommended that at present any attempt should be made to develop irrigated, intensive padi production along estate lines.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

For the reasons outlined in Chapters 6 and 7 it is not considered that intensive irrigated padi production, either by tenants or on an estate basis with hired labour, is an attractive proposition for a private investor in the light of the uncertainties about the future padi prices.

This is not to say that Waidoi is not worth development for padi. Conditions for growing the crop are similar to those prevailing at Navua. Costs and returns are also similar, and judged as a public investment as a land settlement project, where labour element is not a cost, Waidoi is as attractive as any of the Navua schemes.

At Navua the scheme is calculated to produce an adequate surplus to

1. Repay the development loan.
2. Pay the management costs.
3. Pay the family an income of $800 in cash and kind.
4. Pay the landowner the unimproved rental of his land (taken to be Rs 7 per acre),

provided that the price of padi does not fall below $66 per ton at the farm gate.

It is considered that Waidoi will do as well as this and that the best course of action is to negotiate with the Government for the lease of the land to fit for inclusion in the Navua project. In this way without taking any future investment risk it should be possible to secure a reasonable return in rent for the full padi areas at Waidoi.

APPENDIX I

PROFILE PIT DESCRIPTIONS

Pit No.	D 586
Location:	Run 299 : photo 52
Topography:	Very gently sloping on Waidoi levee.
Parent Material:	Riverine alluvium of intermediate composition.
Vegetation:	Abandoned rubber plantation; rough grazing; Navua sedge; Waidoi grass.
Drainage:	Imperfect.
Soil Class:	Tamanua.

Description

0- 7"	10YR 4/4 dark brown, silt loam; many fine distinct rusty mottles; strong medium to fine granular; wet and sticky; medium organic matter; abundant roots; earthworms; smooth diffuse boundary to:-
7-13"	10YR 5/4 yellowish brown, silt loam; many medium distinct rusty and grey mottles; moderate medium subangular blocky; breaking to strong fine granular; moist and firm; many roots; low organic matter; earthworms; smooth clear boundary to:-
13-20"	10YR 5/6 yellowish brown, fine sandy clay loam; moderate medium angular blocky; moist and firm; distinct grey mottling in root channels; black staining along some root channels; manganese; low organic matter; smooth clear boundary to:-
20-27"	10YR 5/8 yellowish brown, heavy coarse sandy loam; few fine faint rusty mottles; subangular blocky; moist and firm; few roots; low organic matter; smooth diffuse boundary to:-
27-32"	As above but light coarse sandy loam; smooth clear boundary to:-

32-36"	10YR 6/6 brownish yellow; fine gravelly sandy loam; weak fine subangular blocky; moist and firm; manganese stains; few roots; low organic matter; clear wavy boundary to:-
36-46"	10YR 6/2 light brownish grey, silty clay; many coarse distinct rusty mottles, especially in root channels; moderate to strong coarse subangular blocky breaking to moderate fine subangular; few roots; manganese stains; charcoal; clear wavy boundary to:-
46" +	5Y 5/1 grey, silty clay loam; many medium prominent rusty mottles; massive; wet and very sticky; low organic matter; no roots.
	Water table 36".

Pit No.:	D 587
Location:	Run 299 : photo 52
Topography:	Flat and level.
Parent Material:	Riverine alluvium of intermediate composition.
Vegetation:	Swamp sedges; Navua sedge; Waidoi grass; willow primrose.
Drainage:	Poor.
Soil Class:	Navua.
Description	
0- 9"	2.5Y 3/2 very dark greyish brown, silty clay loam; few fine distinct red mottles; medium fine subangular blocky; wet and very sticky; moderate organic matter; clear smooth boundary to:-
9-14"	2.5Y 4/4 olive brown and 5Y 4/4 olive variegated, fine sandy clay loam; moderate medium angular blocky; wet sticky; many roots; low organic matter; diffuse wavy boundary to:-
14-20"	2.5Y 4/4 olive brown, sandy loam; many medium distinct red mottles; weak medium angular blocky; wet and slightly sticky; low organic matter; few roots; smooth diffuse boundary to:-
20-33"	10YR 5/4 yellowish brown, heavy sandy loam; many medium distinct grey and red mottles; weak coarse angular blocky; wet and sticky; few roots; low organic matter; manganese stains; clear wavy boundary to:-
33" +	Variegated 10YR 5/6 yellowish brown and 5Y 6/1 grey, loam, grey soil massive, yellowish brown moderate medium angular blocky; wet and sticky; low organic matter; no roots.
	Water table 14".

Pit No:	D 588
Location:	Run 299 : photo 50.
Topography:	Flat and level.
Parent Material:	Riverine alluvium of intermediate composition.
Vegetation:	Navua sedge; few swamp sedges; carpet grass.
Drainage:	Poor.
Soil Class:	Navua.

Description

0- $6\frac{1}{2}$"	10YR 5/2 greyish brown, silty loam; many fine distinct rusty mottles; moderate to strong fine subangular blocky to granular; moist and firm; abundant roots; medium organic matter; clear wavy boundary to:-
$6\frac{1}{2}$-15"	10YR 5/6 yellowish brown, silty clay loam; many medium distinct rusty and grey mottles; moderate medium subangular blocky; moist and very firm; many roots; low organic matter; many manganese stains; smooth diffuse boundary to:-
15-28"	10YR 6/1 grey and 10YR 5/6 yellowish brown, variegated silty loam; moderate coarse angular blocky breaking to moderate fine subangular blocky; moist and firm; many fine manganese stains; few roots; low organic matter; smooth diffuse boundary to:-
28-46"	10YR 6/3 pale brown clay loam; abundant coarse grey mottles; moderate coarse angular blocky; moist and very firm; abundant manganese mottles and concretions; few roots; low organic matter; clear wavy boundary to:-
46" +	5Y 5/1 grey, silty clay; no mottles; massive; wet and very sticky; no roots; low organic matter.

Water table 28".

<u>Pit No.</u> : D 589

<u>Location:</u> Run 299 : photo 52

<u>Topography:</u> Towards bottom edge of very low levee; heavily poached.

<u>Parent Material:</u> Riverine alluvium of intermediate composition.

<u>Vegetation:</u> Navua sedge; carpet grass.

<u>Drainage:</u> Imperfect.

<u>Soil Class:</u> Tamanua.

<u>Description</u>

0- 6" 10YR 5/4 yellowish brown, silty loam; few fine distinct rusty and grey mottles; moderate subangular blocky; wet and sticky; abundant roots; medium organic matter; earthworms; smooth diffuse boundary to:-

6-12" Variegated 10YR 5/1 grey and 5/6 yellowish brown, heavy very fine sandy loam; strong fine subangular blocky; moist and firm; abundant roots; low organic matter; smooth clear boundary to:-

12-23" 10YR 5/6 yellowish brown, heavy very fine sand loam; many coarse grey mottles; moderate medium angular blocky; moist and firm; many roots; low organic matter; smooth diffuse boundary to:-

23-30" 10YR 5/4 - 5/6 yellowish brown, loam; abundant medium grey mottles; moderate medium angular blocky; moist and firm; few roots; low organic matter; smooth diffuse boundary to:-

30-37" 7.5 YR 4/4 dark brown; heavy fine sandy loam; many fine distinct grey mottles; moderate medium angular blocky; moist and firm; few roots; low organic matter; smooth clear boundary to:

37" + 10YR 6/4 light yellowish brown, silty clay loam; moderate medium prominent grey mottles; moderate medium subangular blocky; wet and sticky; no roots; low organic matter.

Water table 37".

APPENDIX II

SOILS CHEMICAL DATA

FIJI, WAIDOI

Site No.	Profile No.	Depth in.	Soil Separates: % American Sand	% Int. Sand	% American Silt	% Int. Silt	% Clay	Cations extracted by 2.5% Acetic Acid Me/100g.: Ca	Mg	Na	K	Exchangeable H Me/100g.	pH Soil : Water 1:2½	pH Soil 1:2½ $CaCl_2$	E. C. 1:1 Soil Water mmhos/cm	Available Phosphorus ppm.
D 566	W001											15.5	4.9	4.0	0.1	
	2											16.9	5.2	3.8	0.1	
	3											8.3	5.6	4.2	0.1	
	4											7.7	5.5	4.2	0.1	
	5											7.4	5.4	4.2	0.2*	
D 570	6											16.9	4.7	4.0	0.2	
	7											9.3	5.3	4.0	0.1	
	8											20.5	3.9	3.4	3.7	
	9											39.3	2.7	2.6	4.2*	
	10											21.8	3.2	3.2	6.4	

* 1:5 Extract
Soil : Water

Site No.	Profile No.	Depth in.	Soil Separates: % American Sand	% Int. Sand	% American Silt	% Int. Silt	% Clay	Cations extracted by 2.5% Acetic Acid Me/100g.: Ca	Mg	Na	K	Exchangeable H Me/100g.	pH Soil : Water 1:2½	pH Soil 1:2½ $CaCl_2$	E.C. 1:1 Soil Water mmhos/cm	Available Phosphorus ppm*
D 569	W011											9.8	5.4	4.2	0.1	
	12											9.2	5.7	4.2	0.1	
	13											6.3	5.9	4.7	0.1	
D 571	14											7.3	5.5	4.5	0.1	
	15											7.6	5.4	4.3	0.1	
D 576	W021											14.8	5.2	4.4	0.1	
	22											9.5	5.1	4.4	0.2	
	23											9.3	5.4	4.3	0.1	
	24											20.8	3.3	3.2	4.8	
	25											24.8	3.1	3.1	7.2	

FIJI, WAIDOI

Site No.	Profile No.	Depth in.	Soil Separates: % American Sand	% Int. Sand	% American Silt	% Int. Silt	% Clay	Cations extracted by 2.5% Acetic Acid Me/100g.: Ca	Mg	Na	K	Exchangeable H Me/100g.	pH Soil : Water $1:2\frac{1}{2}$	pH Soil $1:2\frac{1}{2}$ $CaCl_2$	E. C. 1:1 Soil Water mmhos/cm	Available phosphorus ppm
D 578	W026											16.8	5.1	4.6	0.2*	
	27											19.2	3.9	3.8	1.8	
	28											41.7	2.7	2.7	5.1*	
	29											44.5	2.8	2.5	5.9*	
	30											34.8	2.8	2.7	10.2	
D 585	31											9.6	5.2	4.3	0.4	
	32											8.7	5.3	4.4	0.1	
	33											6.5	5.6	4.6	0.1	
	34											6.6	5.6	4.6	0.1	
	35											5.9	5.6	4.6	5.3	

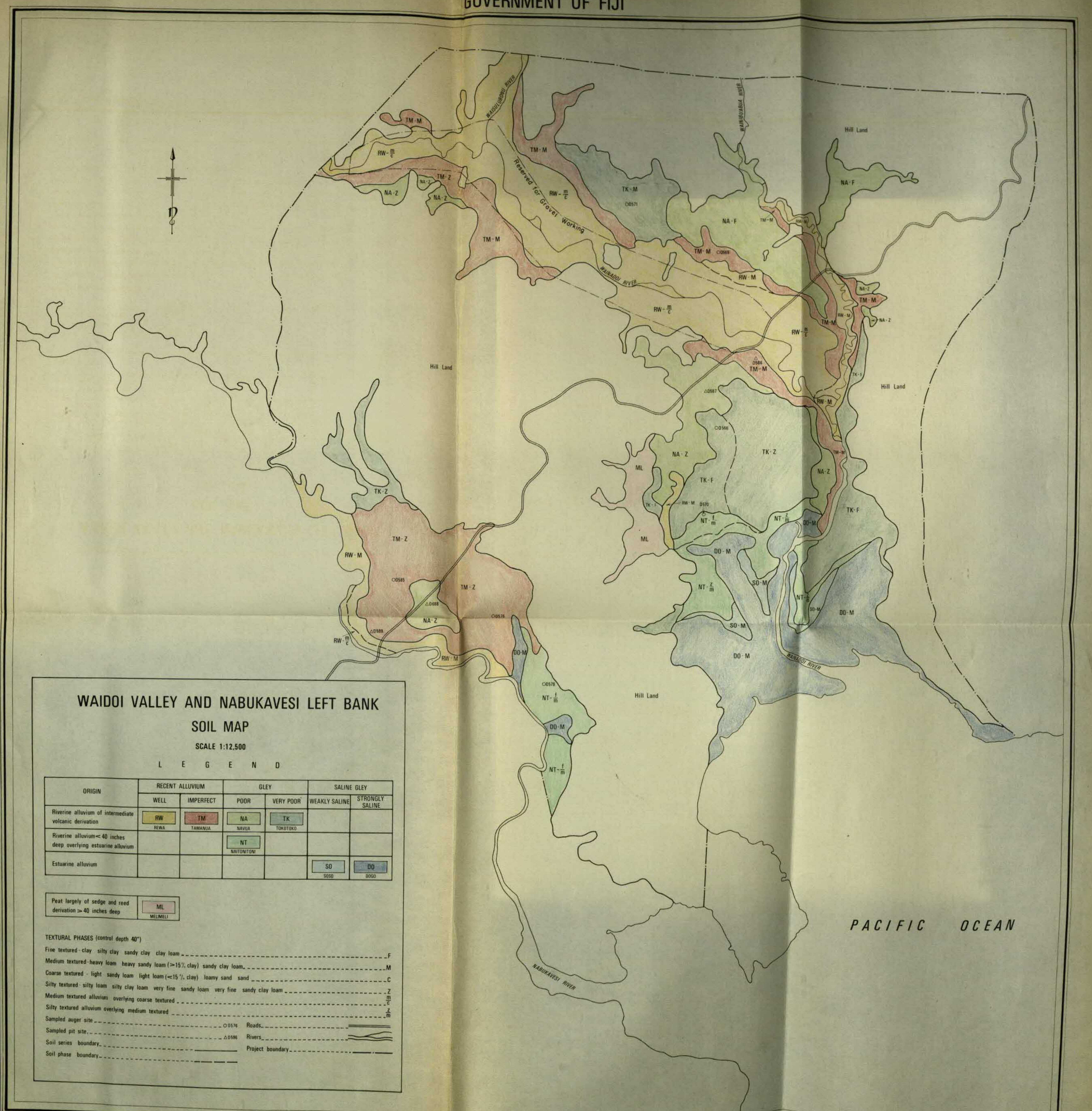
* 1:5 Soil Water

Site No.	Profile No.	Depth in.	Soil Separates: % American Sand	% Int. Sand	% American Silt	% Int. Silt	% Clay	Cations extracted by 2.5% Acetic Acid Me/100g.: Ca	Mg	Na	K	Exchangeable H Me/100g.	pH Soil : Water $1:2\frac{1}{2}$	pH Soil $1:2\frac{1}{2}$ $CaCl_2$	E. C. 1:1 Soil Water mmhos/cm	Available Phosphorus ppm.
D 586	W036		22	40	59	41	19	2.7	2.3	0.2	0.3	8.9	5.4	4.4	1.6	73
	37		22	40	54	36	24	2.9	2.3	0.2	0.1	9.2	5.6	4.5	0.3	37
	38		30	40	41	31	29	2.3	2.1	0.3	0.1	8.2	5.7	4.6	0.1	0
	39		70	75	16	11	14	2.0	1.5	0.3	0.02	7.5	5.5	4.4	0.1	47
	40		72	77	19	14	9	1.2	0.6	0.2	0.02	6.0	5.7	4.6	0.1	167
	41		70	75	21	16	9	2.5	1.4	0.3	0.04	6.1	5.8	4.7	0.1	153
	42		12	22	46	36	42	3.8	4.1	0.3	0.04	7.2	5.9	4.8	0.1	155
	43		20	32	43	31	37	2.1	3.0	0.3	0.06	7.5	5.3	4.2	4.1	168

Site No.	Profile No.	Depth in.	Soil Separates: % American Sand	% Int. Sand	% American Silt	% Int. Silt	% Clay	Cations extracted by 2.5% Acetic Acid Me/100g.: Ca	Mg	Na	K	Exchangeable H Me/100g.	pH Soil : Water 1:2½	pH Soil 1:2½ $CaCl_2$	E.C. 1:1 Soil Water mmhos/cm	Available Phosphorus ppm.
D 587	W045		30	45	53	38	17	0.9	1.1	0.2	0.1	9.9	5.1	4.3	0.3	0
	46		40	55	43	28	17	0.5	1.2	0.2	0.02	8.2	5.3	4.5	0.1	37
	47		63	73	25	15	12	1.0	2.0	0.2	0.02	7.4	5.5	4.4	0.05	37
	48		65	80	28	13	7	2.4	3.8	0.3	0.3	4.6	6.0	5.2	0.1	60
	49		70	78	21	13	9	2.1	3.2	0.3	0.3	5.8	5.4	4.3	0.1	144
D 588	50		23	38	53	38	24	2.7	3.1	0.2	0.2	9.0	5.1	4.4	0.7	99
	51		20	33	51	38	29	1.5	2.1	0.1	0.25	8.6	5.2	4.3	0.9	37
	52		20	30	46	36	34	1.5	3.9	0.1	0.3	8.3	5.2	4.4	0.1	0
	53		20	28	41	33	39	1.8	4.5	0.1	0.2	7.0	5.5	4.6	0.1	127
	54		8	15	43	36	49	1.2	3.0	0.3	0.1	9.0	4.9	4.1	0.2	315

Site No.	Profile No.	Depth in.	Soil Separates: % American Sand	% Int. Sand	% American Silt	% Int. Silt	% Clay	Cations extracted by 2.5% Acetic Acid Me/100g.: Ca	Mg	Na	K	Exchangeable H Me/100g.	pH Soil : Water $1:2\frac{1}{2}$	pH Soil $1:2\frac{1}{2}$ $CaCl_2$	E. C. 1:1 Soil Water mmhos/cm	Available Phosphorus ppm.
D 589	W055		25	38	51	38	24	2.1	1.4	0.2	0.1	9.7	5.1	4.1	0.2	158
	56		33	45	45	33	22	2.3	1.8	0.2	0.06	9.6	5.1	4.1	0.1	63
	57		15	30	66	41	29	1.7	2.0	0.2	0.06	9.6	5.4	4.2	0.1	37
	58		13	23	50	40	37	1.7	2.5	0.2	0.06	9.3	5.4	4.2	0.1	0
	59		45	63	38	20	17	1.7	2.8	0.2	0.04	7.7	5.5	4.3	0.05	60
	60		20	28	43	35	37	2.1	3.9	0.2	0.06	7.0	3.6	4.5	0.06	61

GOVERNMENT OF FIJI



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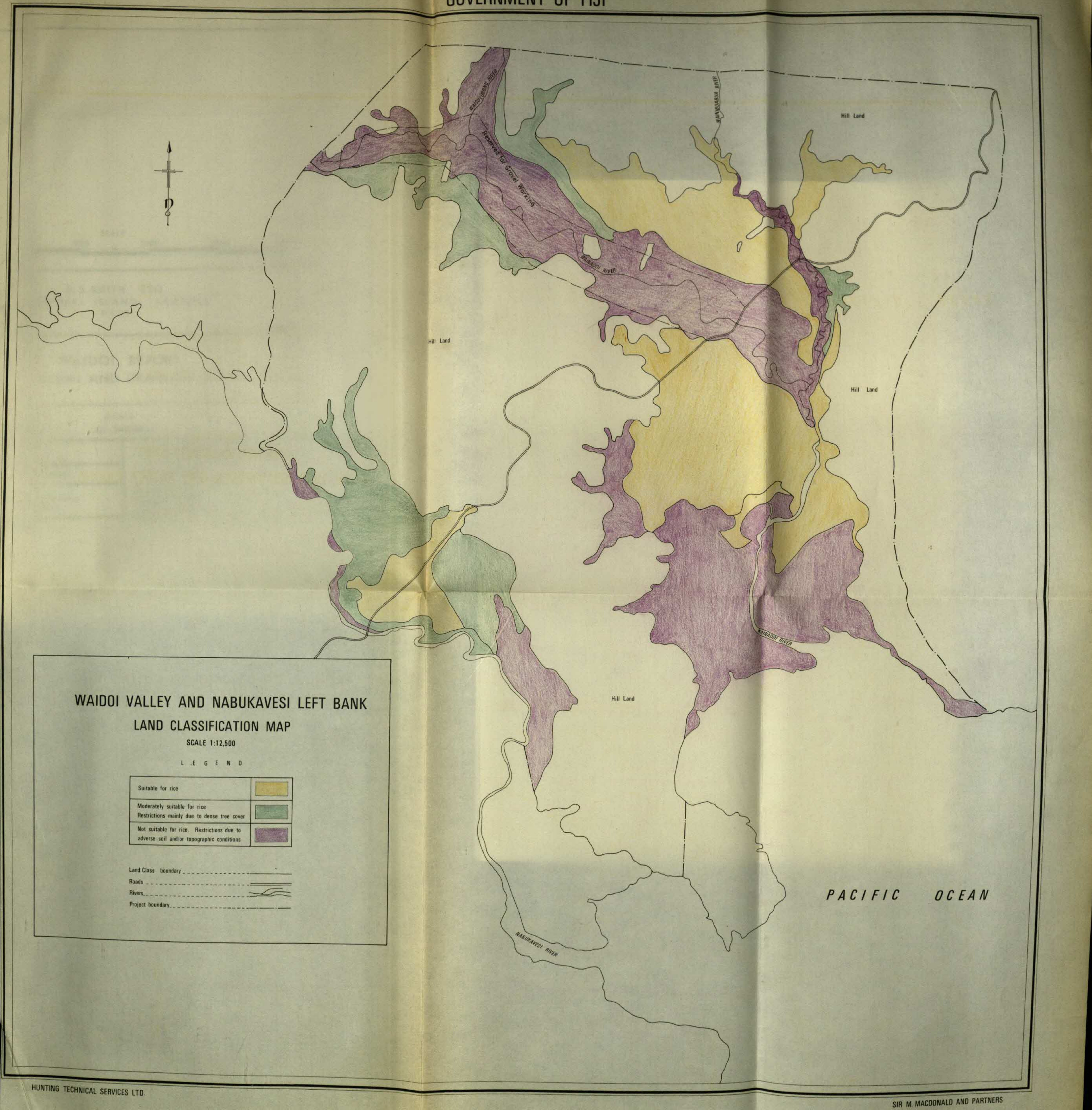
GOVERNMENT OF FIJI



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WAINIBUA RIVER
WAIDOI RIVER
NBUKAVESI RIVER

SCALE

FT. 1000 0 1000 2000 3000 4000 FT.

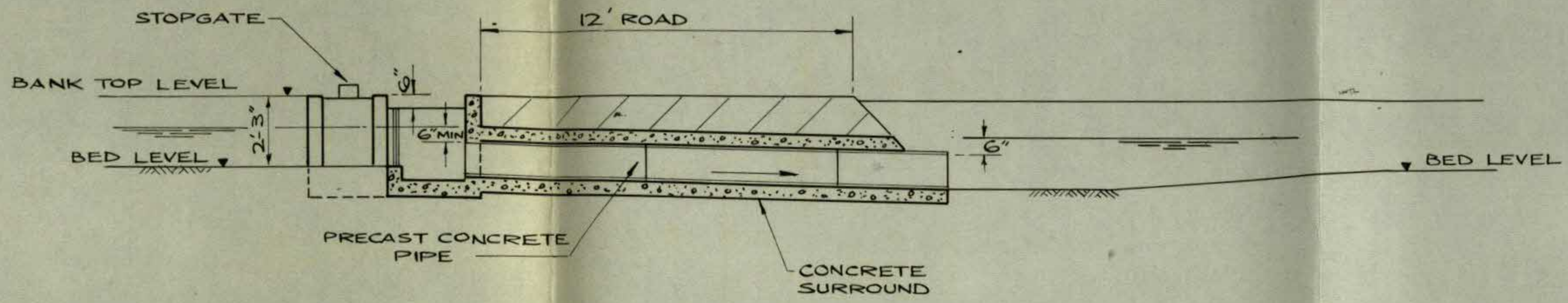
R.S. SMITH, ESQ.,
CASTAWAY ISLAND, LAUTOKA
FIJI

WAIDOI REPORT
PROPOSED IRRIGATION AND DRAINAGE SYSTEM LAYOUT

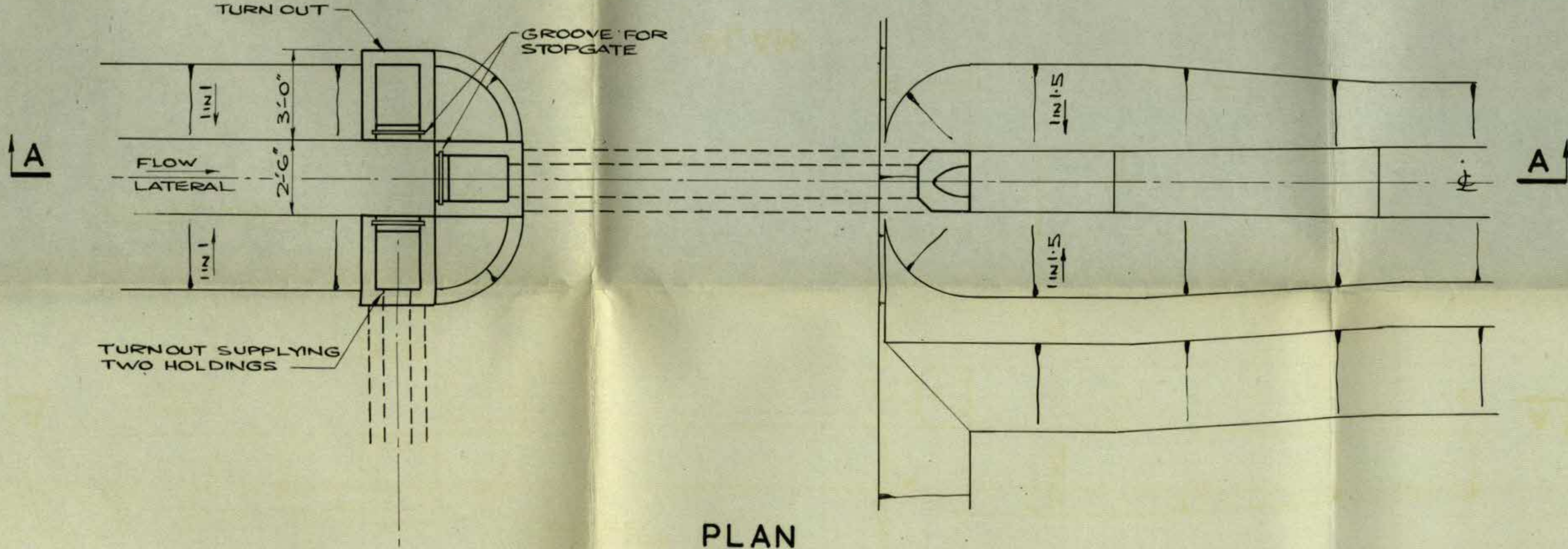
SCALE
AS SHOWN

SERIAL No.	
PRINTED	NOVEMBER 1969
COMPILED	SIR M. MACDONALD & PARTNERS

HUNTING TECHNICAL SERVICES LIMITED
LAND USE AND AGRICULTURAL CONSULTANTS
6, ELSTREE WAY, BOREHAM WOOD.
HERTS, ENGLAND
In Association with
SIR M. MACDONALD & PARTNERS
CONSULTING ENGINEERS
HANOVER HOUSE, 73 HIGH HOLBORN,
LONDON W.C.1

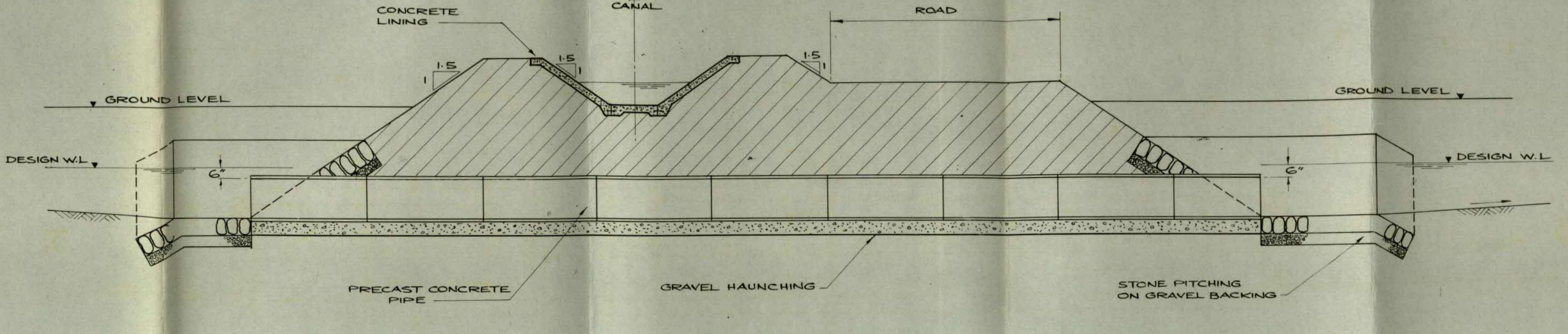


SECTION A-A



PLAN

LATERAL CHECK AND TURN OUTS


CONCRETE
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GROUND LEVEL
DESIGN W.L
DESIGN W.L
6"
6"
PRECAST CONCRETE
PIPE
GRAVEL HAUNCHING
STONE PITCHING
ON GRAVEL BACKING

SECTION C-C

R.S. SMITH, ESQ.,
CASTAWAY ISLAND, LAUTOKA
FIJI

WAIDOI REPORT
TYPICAL PROPOSED CANAL & DRAIN STRUCTURES

SCALE
AS SHOWN

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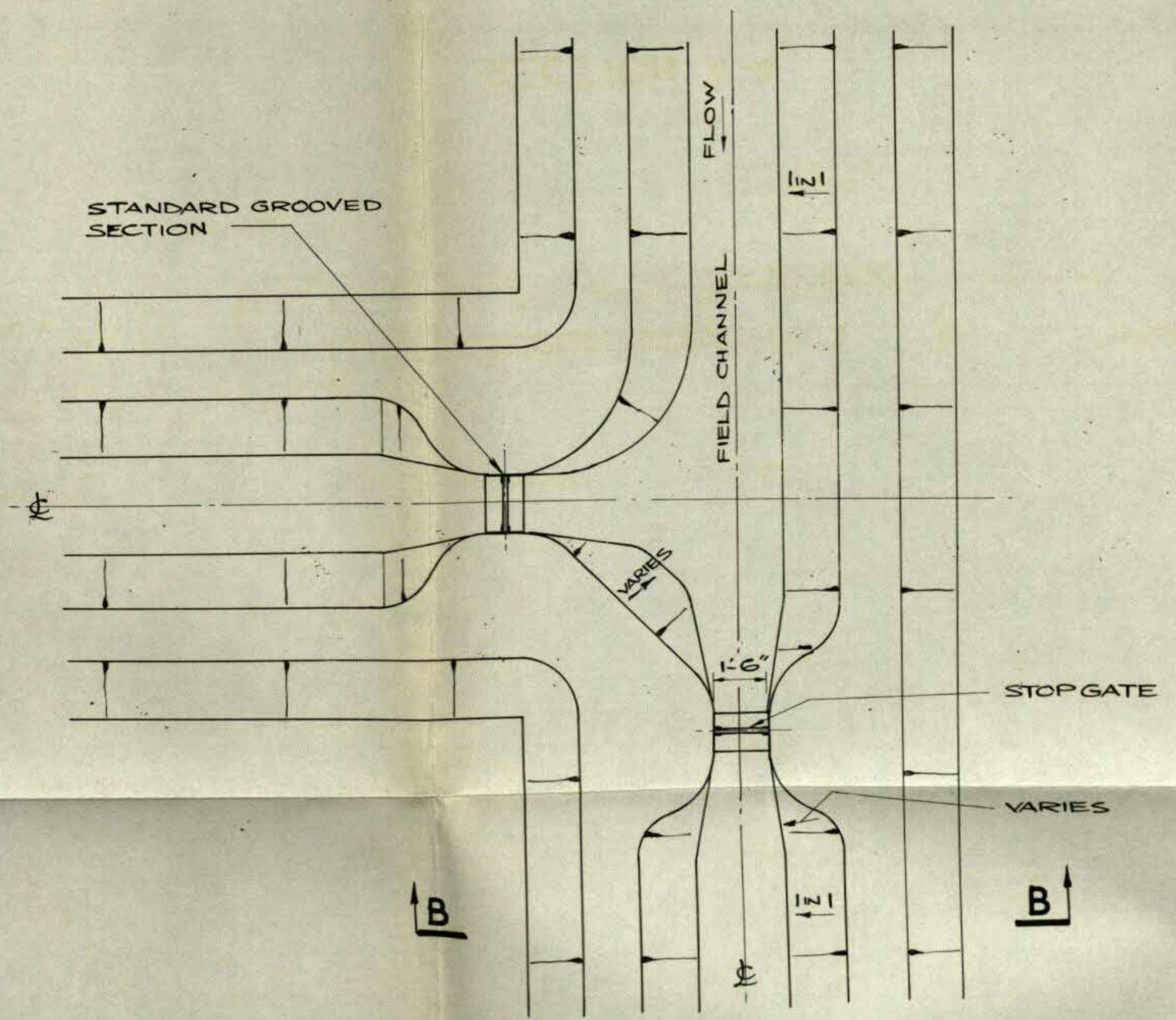
PLAN

LATERAL CHECK AND TURN OUTS



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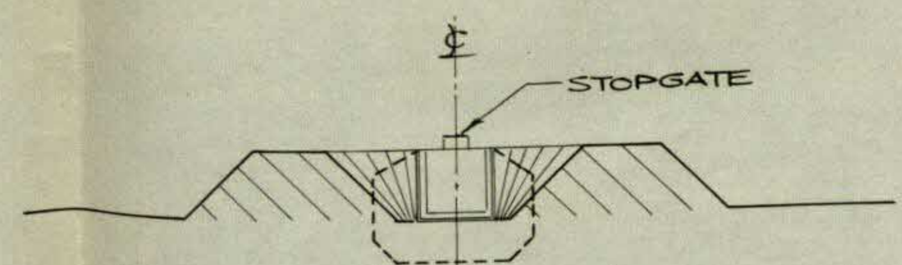

SECTION B-B

FIELD CHANNEL DIVISION

(FOR TURN OUT SUPPLYING TWO HOLDINGS)

DESIGNED	P. CHESWORTH
CHECKED	J.I.M. DEMPSTER
APPROVED	[illegible]

R. S. SMITH ESQ.

WAIDOI ESTATE

REPORT

ON A

FEASIBILITY STUDY

FOR

AGRICULTURAL DEVELOPMENT

FEBRUARY 1970

HUNTING TECHNICAL SERVICES LTD.
[illegible]

SIR M. MACDONALD & PARTNERS
Consulting Engineers