DETAILED DESIGN REPORT ON THE PILOT INFRASTRUCTURE IMPROVEMENT WORKS FOR THE IMPROVEMENT OF RICE CULTIVATION TECHNOLOGY PROJECT IN FIJI

DETAILED DESIGN REPORT
ON
THE PILOT INFRASTRUCTURE IMPROVEMENT WORKS
FOR
THE IMPROVEMENT OF RICE CULTIVATION
TECHNOLOGY PROJECT
IN
FIJI

APRIL 1988

APRIL 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

DETAILED DESIGN REPORT
ON
THE PILOT INFRASTRUCTURE IMPROVEMENT WORKS
FOR
THE IMPROVEMENT OF RICE CULTIVATION TECHNOLOGY PROJECT
IN
FIJI

APRIL 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

Recently, in Fiji, the demand for rice has increased, and a half of domestic consumption (50,000 tons) is imported. In compliance with the request from the Government of FIJI, in April 1985, the Improvement of Rice Cultivation Technology Project on development, extension and training on rice cultivation technology started with cooperation of JICA. In August 1986, the Model Farm 15ha was completed in Koronivia Research Station (KRS). Now, four experts are doing research and extension training on rice caltivation technology at KRS.

In April 1987, the Matsuyama Mission visited Fiji and discussed the rice-farming development programme. As one of cooperative activities, establishment of pilot infrastructure was decided for the purpose of domonstration and extension training of rice cultivation technology obtained from the research at KRS.

According to the decision, JICA dispatched, on 20 January 1988, the Detailed Design Survey Team on Pilot Infrastructure Works headed by Mr. Kobayashi, Ministry of Agriculture, Forestry and Fisheries.

This report was prepared to be utilized for implementation of the Pilot Infrastructure Works.

I would like to express my sincere thanks to the officials

concerned for all the assistance and cooperation.

April 1988

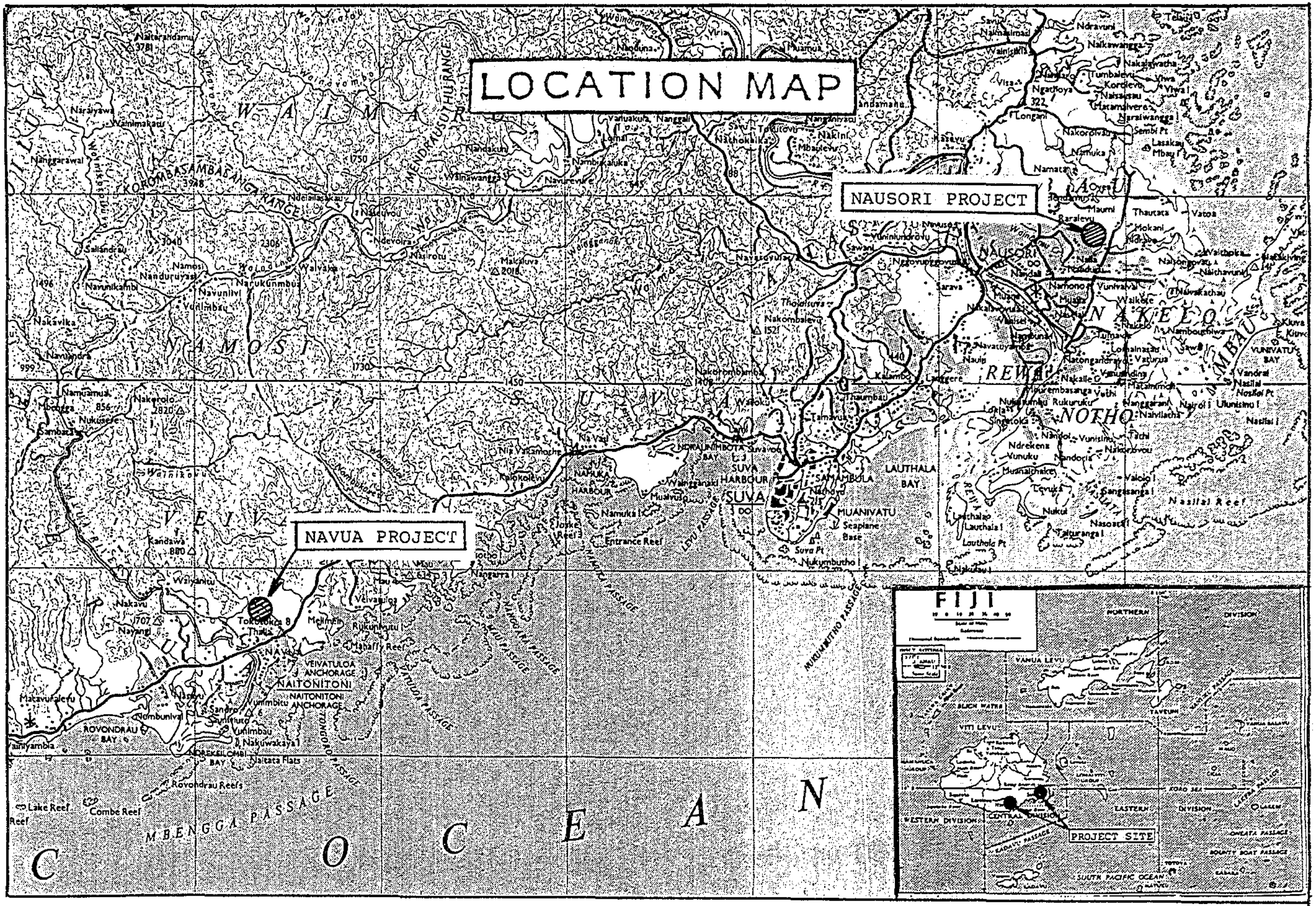
k.Miyamoto

Director

Agricultural Development

Cooperation Department

JICA

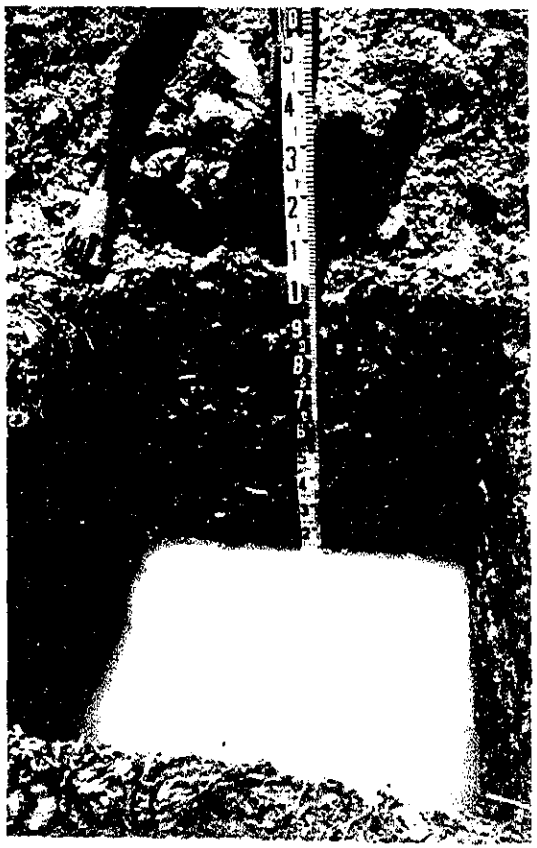

LOCATION MAP
NAUSORI PROJECT
NAVUA PROJECT
FIJI
PROJECT SITE
VANUA LEVU
VITI LEVU
NORTHERN DIVISION
WESTERN DIVISION
EASTERN DIVISION
SUVA
SUVA HARBOUR
LAUTHALA BAY
NAUSORI
NAKELO
NOTHO
REWA
NAMOSI
SUVA
NAVUA
NAITONITONI
MBENGGA PASSAGE
OCEAN

NAVUA AREA (View of North)

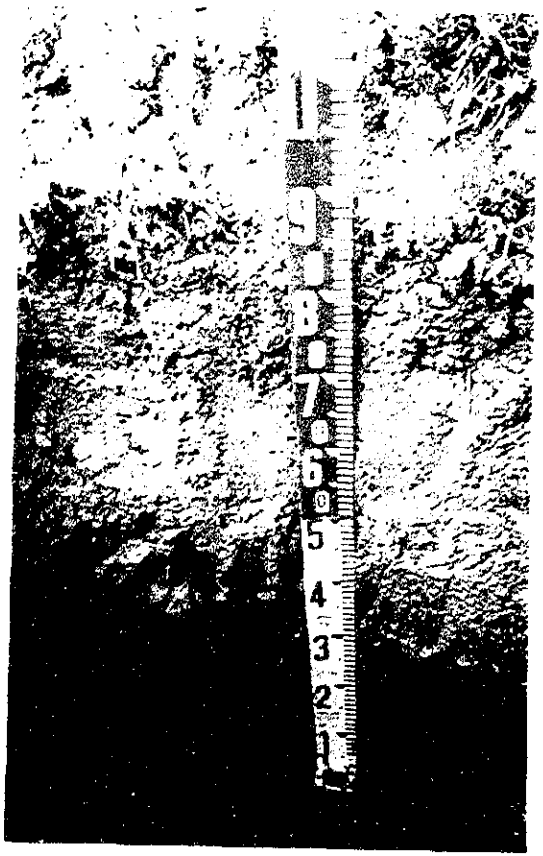
NAVUA AREA (View of North-East)

NAUSORI AREA (View of South)

NAUSORI AREA (View of North-West)



NAVUA AREA (Soil Profile)



NAUSORI AREA (Soil Profile)

ABBREVIATIONS

MPI	Ministry of Primary Industries
D&I	Drainage and Irrigation Division
KRS	Koronivia Research Station
FCA	Fiji College of Agriculture
DB	Drainage Board
FAO	Food and Agriculture Organization
UNDP	United Nations Development Programme
IRRI	International Rice Reserach Institute
JICA	Japan International Cooperation Agency
MAFF	Ministry of Agriculture, Forestry and Fisheries
ac	Acre 1ac=4,047㎡(1ha=2.47acre)
Q	Quantity (㎥/sec)
V	Velocity (m/sec)
ϕ	Diameter (mm)
Hz	Heltz
Kw	Kilo Watt
m	Meter
mm	Mili Meter
F$	Fiji Dollar=F$1= ¥93 (Jan.1988)
R/D	Record of Discussion
F/S	Feasibility Study
D/D	Detailed Design
GDP	Gross Domestic Product
DP9	Fiji's Ninth Development Plan

SUMMARY

SUMMARY

1. Background

(1) In April 1985, the Inprovement of Rice Cultivation Technology Project in Fiji started with the Cooperation of JICA. In August 1986, the Model Farm 15ha was completed in the yard of KRS, where research and extension training on rice cultivation technology are under way. In April 1987, the Matsuyama Mission visited Fiji and recommended, as one of further cooperation activities, establishment of pilot infrastructure for demonstration and extension training of rice cultivation technology.

(2) The detailed design survey team composed of four members from MAFF, JICA and consultants was dispatched to conduct a fieled survey from 20 January 1988 to 4 March 1988. During the period, the Team also discussed technical matters with officials of MPI as well as JICA experts. The delailed design has been completed through a home work based on the field survey and collected data.

2. Detailed Design of Irrigated Farm (Navua area)

(1) The area of 16.4 ha within the Navua East Project located 40 km to the west of Suva has been selected for the irrigated farm. The area owned by 9 farmers is used for paddy field cultivated by draught animals. The size of plot is 0.1~0.2 ha.

(2) Since it is impossible to change the boundaries of land ownership, the road and the canal have been designed along the boundaries. The standard size of farm plot is 0.4 ha.

(3) The road is arranged along a side of each farm plot and connects with the existing road. The total width is 4.0 m and the effective width is 3.0 m paved with gravel 15 cm thick.

(4) The irrigation requirement (1.0ℓ/sec/ha) and the drainage discharge(12.0ℓ/sec/ha) of the Navua East Project were adopted to the design. The irrigation water is taken into the area from three canals of Navua East Project, and distributed to each farm plot through inlet work. The existing drainage which lies obliquely in the area shall be realigned as the main drainage canal in the center of the area. The bottom of drainage canal shall be 1.0m below the field level.

(5) A storage house shall be constructed on the hill in the south of the area. The structure is a shed 3m×5m made of concrete block works.

3. Detailed Design of Rainfed Wetland Farm (Nausori area)

(1) The area of 14.3 ha in Vusuya village located 20 km to the north-east of Suva has been selected for the rainfed wetland farm. Waidamu Creek flows down along the sourth side of the area. The land is used mainly for grassland and cassava cultivation except 2～3 ha of paddy field.

(2) Since it is native land owned by 2 Mataqalis, the farm design was so made that the area of 2 Matuqlis may be even, The standard size of farm plot is 0.44 ha.

(3) The road is planned along the boundary of Mataqalis and the circumference of the area, so as to connect with each farm plot. The total width is 4.0 m and the

effictive width is 3.0 m paved with gravel 15 cm thick.

(4) Two drainage canals toward Waidamu Creek are planned in the area, and a weir gate is designed in each canal at the down-stream in order to store water for irrigation use. Flood water from outside of the area shall be bypassed with a realigned drainage canal along the east side of the area.

(5) A storage house shall be constructed in plot No.2-1. The shed 3m×5m is made of concrete block works.

4. Construction Plan

Construction works of Navua and Nausori shall be executed at the same time during a period of 6 months. In both area, the land consolidation work will be done in the first half of the period, and road, canal and relative facilities shall be constructed in the latter half. The construction schedule is shown in next table.

Work Item	First Month	Second Month	Third Month	Forth Month	Fifth Month	Sixth Month
1.NAVUA						
1)Temporary work						
2)Land Consolidation work						
3)Irrigation Facilities						
4)Drainage Facilities						
5)Road work						
6)Relative Facilities						
2.NAUSORI						
1)Temporary work						
2)Land Consolidation work						
3)Drainage Facilities						
4)Road work						
5)Relative Facilities						

5. Construction Cost

The construction cost of Navua and Nausori is summarized as follows.

Work Item	NAVUA	NAUSORI	
	F$	F$	¥
Land Consolidation work	97,067	38,088	
Irrigation Facilities	35,399	—	
Drainage Fecilities	33,172	41,575	
Road Work	27,928	25,800	
Relative Facilities	13,244	14,640	
Sub Total	206,810	120,106	30,402,000
Overhead Cost	62,043	36,031	9,120,000
Total	268,853	156,137	39,522,000
Contingencies	—	—	6,125,000
Grand Total	—	—	45,647,000

CONTENTS

CHAPTER 1 BACKGROUND OF THE SURVEY

Chapter 1 BACKGROUND OF THE SURVEY

1-1 Background and Objectives

Recently, in Fiji, the increasing demand for rice has exceeded 50,000 tons every year since 1982. While, the self sufficiency being around 50% has forced to spend yearly 6 ~7million F$ for import of rice.

The Government of Fiji being faced with the problem requested the Grovernment of Japan for technical cooperation on development of rice farming. In April 1985, the Improvement of Rice cultivation Technology Project started with the cooperation of JICA. Now, four Japanese, experts of the Project Team based at Koronivia Research Station (KRS) are doing research and extension training of rice cultivation technology. In August 1986, the Model Farm was completed in the yard of KRS.

In April 1987, the Project Finding Mission headed by Mr.Ryozo Matsuyama visited Fiji to conduct surveys for further cooperation in the field of rice cultivation. The Mission discussed the rice-farming development programme in DP9 with the Government of Fiji and the Project Team. As one of the necessary cooperative activities, establishment of pilot infrastructure was recommended for the purpose demonstration and extension training of rice cultivation technology obtained from the research at KRS.

The pilot farms are to be set up in two different regions to adapt the technology to each local condition, sele-

cting about 15 ha of land each in Navua area located 40 km to the west of Suva and Nausori area located 20 km to the North-East of Suva.

The objectives of this survey are selection of suitable sites in Navua and Nausori area, site survey, data collection and detailed design of the Pilot Infrastructure together with preparation of contract documments for implementation of the construction works.

1-2 Progress of The Survey

20(Wed)-22(Fri) January 1988	Tokyo-Suva
22(Fri) January 1988	Arrival at Suva Courtesy call to JICA office and Embassy of Japan, Meeting with Project Team at KRS.
23(Sat)January 1988	Reconnaissance survey to Navua and Nausori area
25(Mon)January 1988	Courtesy call to Ministry of Primary Industries (MPI) Meeting at Drainage and Irrigation Division (D&I)
26(Tue)～28(Thu)January 1988	Site survey
25(Fri)January 1988	Meeting at MPI Submitting of letter of Team Leader (as per attached copy)
30(Sat)January 1988	Mr.K.Kobayashi and Mr.H.Goto left Fiji.

30(Sat)January 1988	Consultant members carried out
~ 2(Wed)March 1988	field survey, data collection and rough design with officials concerned of Government as well as Project Team.
3(Thu)-4(Fri)March 1988	Suva-Tokyo

1-3 Major Persons Involved

Government of Fiji

Mr.Uiliame Goneleru	Minister, Ministry of Primary Industries
Mr.Yarrow	Permanent Secretary, Ministry of Primary Industries.
Mr.Navin Patel	Director, Department of Agriculture, MPI
Mr.Param Sivan	Assistant Director, Chief of Reserach Division
Mr.Narayan Reddy	Principal Research officer, Research Division
Mr.Vijay Nath	Assistant Director, Chief of D&I
Mr.Uma Datt	Acting Principal Engineer, D&I
Mr.Sami Nair	Senior Agricultural Officer, ADP
Mr.Alex	Expert from Grovernment of Netherland, D&I

Embassy of Japan	
Mr.s.Nishimura	Councilor
Mr.T.Ueshima	Secretary
JICA office in Suva	
Mr.Y.Yoshida	
Project Team	
Dr.Y.Watanabe	Team Leader
Dr.S.Miura	Soil and Fertilizer
M.M.Hikiji	Extension
M.K.Masumi	Coordination and Training

CHAPTER 2 DESIGN PRINCIPLES OF PILOT INFRASTRUCTURE

Chapter 2 Design Principles of Pilot Infrastructures

2-1 Irrigated Farm (Navua area)

1. Site Selection

Calia of Navua area located 40 km to the west of Suva-city has been selected for the irrigated farm.

2. Design Principles

Design principles of irrigated paddy farm are as follows.

1) The boundaries of each farm are not changed because of free hold land.
2) The size of each plot is about 0.4 ha.
3) Irrigation and drainage canals are separately designed along the short side of each plot.
4) Roads will be constructed for transportation of materials and equipments.
5) Tractor passages to each farm will be designed.
6) A storage house is planned.

2-2 Rainfed Wetland Farm (Nausori area)

1. Site Selection

Among the three sites-namely, Vusuya, Naila and Nakaikogo proposed by the Government, Vusuya has been selected for the rainfed wetland farm taking into account topography, soils and type of land ownership.

2. Design Principles

Design principles of rainfed wetland farm are as follows.

1) Because the site comprises tow Mataqali lands, the location of pilot farm is so decided that the area

of two Mataqalis will be even.

2) The size of each plot is about 0.44 ha.

3) Roads will be constructed for transportation of materials and equipments.

4) Flood water from the ontside of the farm will be bypassed.

5) Tractor passages to each farm will be constructed.

6) Irrigation facilities covering whole area is not planned.

However, some storage facilities with weir gate will be designed in drainage canal.

7) A storage house is planned.

CHAPTER 3 DETAILED DESIGN OF IRRIGATED FARM (NAVUA)

Chapter 3 Detailed Design of Irrigated Farm (Navua)

3-1 Physical Condition

1. Topography

The area is in the center of the Navua East Porject. The total area is 16.4 ha excluding a 1.5 ha of small hill about 4-9 m high in the south of the area. The land is already reclaimed for paddy field and owned by 9 farmers. The size of each plot is 0.1-0.2 ha at present, and the elevation varies EL 2-4 m.

2. climate

The average annual rainfall of 50 years' period is 3,082 mm. The average monthly rainfall is heavy in main season, November to April, the maximum of 370 mm in March and the minimum of 159 mm in June. However, as shown in Table 3-1, the rainfall varies year by year and greatly affects the rice cultivation.

Number of rainy days is around 17 in main season and 11 in off season.

The average daily maximum temperature and minimum temperature are as follows.

	Main season (Nov.-Apr.)	off season (May.-Oct.)
Average daily max.	30℃	27℃
Average daily min.	22℃	19℃

3. Soils

According to the soil map issued by the Government and the result of field survey, the whole area is covered

with clay or silty clay except a small part near the existing drainage canal running through from North to Sourth in the centre of the area where some peat is found at the depth of 80 cm. The soil of P.H.5.5-6.0 will be suitable for rice cultivation. (Ref. Table 3-2) The peat layer of P.H. 4.8-5.3 existing 80 cm underground will not affect crop cultivation.

4. Irrigation

Irrigation canals CCa I - II and CCa I - III of Navua East Project have been constructed on the south-west side of the area, and on the north-east side the canal CCo I - IV is now under construction and scheduled to complete in the off-season 1988.

Nauva East Project plants to construct a dam having a total storage of 4.26 million m^3 at Wainikavika Creek for irrigation of 770 ha including Navua West Project area. At present, the Stage I having a storage of 1.6 million m^3 has been completed and irrigation has started for some part.

The pilot farm included in the Project will be supplied irrigation water from the dam even in off season.

5. Drainage

At the time heavy rain, some of flooded water from the north adjacent area flows into the existing drainage canal running through the centre of the area. Also, from the westside, flood water across the Calia road comes into the area.

The drainage condition is not good in the section of

410 m from the south end of the area to the new drainage canal CA9 and CA10 constructed by D & I.

3-2 Farm Design

1. Land Use Plan

The total area of 16.4 ha is Free hold land owned by 9 farmers namely No.28-No.36, ranging from 1.5 ha to 2.3 ha per farmer.The area is utilized for paddy field 0.8 ha of grassland. Each free hold land is long in the direction of east to west and the width is 40 m or 80 m. Since it is imposible to change the boundaries, the road, and irrigation and drainage canals will be arranged along the boundaries. It will be taken into consideration that area allotted to roads and canals may be even among the land owners.

The area excluded from paddy field plan at the request of land owners are house area of 600~800 ㎡ in No.32, No.35 and No.36, and pasture area of 3,800 ㎡ in No.33. The land for the storage house is to be secured on the hill.

Land use plan is as follows.

Paddy Field	13.4 ha
House Area	0.2 ha
Pasture Area	0.4 ha
Road, Canal Area	2.4 ha
Total	16.4 ha

2. Farm Plot Plan

The pilot farm has the shape of a rectangle about 600 m south to north and about 300 m east to west. Irrigation canals of Navua East Project run along the east and west side of the area.

The boundaries of land ownership are located in the direction of east to west at every about 80 m, and average area of land ownership varies 1.5 ha to 2.3 ha. So far, in Fiji, a large sized plot of about 2 ha has been constructed for mechanized farming under the direct water control by the Government. However, the size has been reconsidered with the present state of farm management and the standard of rice cultivation by draught animals. The standard size is about 0.4 ha in a irrigation project under implementation.

In this pilot farm, considering the area of each farmer and the rice cultivation technology, the design size of farm plot will be 0.4 ha.

2~3 plots (0.8~1.2ha) will be levelled at the same elevation where the topography allows with view to adopt appropiate machanization if necessary.

The farm plot plan is shown in Fig 3-1.

3. Land Consolidation Plan

(1) Consolidation Work

In principle, the land is levelled within each plot, the elevation of which shall be of suppliable with W.L. of irrigation canal, CCa I - Ⅱ, CCa I - Ⅲ and CCo I - Ⅳ.

(2) Design Elevation

The design elevations of each plot are shown in Fig.3-1.

Since W.L. of canal CCa I - Ⅲ is EL. 3.50 m, the design elevation of Plots No.28-1, No.29-1, No.30-1, No.31-1, shall be lower than EL. 3.20 m taking into account the conveyance loss and the field water depth, while the present elevation of those plots is EL. 3.40 m. The excess volume of earth will be conveyed to plots No.32-1 and No.32-2 where the present elevation is EL. 2.0~2.20 m and to be improved by soil dressing being weak foundation caused by some peat layer in the ground.

(3) Handling of Surface Soil

The result of soil survey by means of test pit and boring stick shows that the surface soil of some plots is rich in humus with a thickness of about 10 cm, as shown in Fig.3-1.

These fertile surface soil shall be utilized again with the sequence of - surface soil removing, land grading, subsoil compaction and backfilling.

(4) House Area

The house are will be on plots of No.32-3, No.35-5 and No.36-5. The design elevation shall be 30 cm higher than adjacent paddy field.

(5) Storage House Lot

The storage house will be constructed on the small hill located in the south of the Pilot farm. The design elevation is EL. 8.50 m.

(6) Hauling of Soil

Though the land levelling within each plot is a general rule, hauling of soil between some plots will be necessary. The hauling plan shall be well combined so as to minimize hauling distance.

(7) Others

Structures of farm fidge and tractor passage are shown in Fig.3-2.

3-3 Road Plan

1. Road Network

Along the west side of the pilot farm, the Calia road runs leading to Queen's Highway.

The road network within the area will be laid out along the boundaries of land ownership i.e. along the short side of each plot as shown in Fig.3-3.

2. Structure of Road

(1) Width

The road used for transportation of cultivating machines and crops shall have a width available for traffic of middle size tractor and/or 2 ton-truck, as follows.

Effective width	3.0 m
Road Edge	0.5 m
Total width	4.0 m

(2) Structure

The elevation of road surface shall be 40 cm above the field surface.

The subsoil after removing surface soil will be used for banking material.

The banking slope shall be 1:1.5, and the effective width will be paved with graval 15 cm in thickness.

The maximum gradient of road in the division connecting to the hill shall be 10 %.

The structure of road is shown in Fig.3-4.

3-4 Irrigation Plan

1. Irrigation Requirement

(1) Unit Water Requirement

The pilot farm area is included in Navua East Irrigation Project. The unit water requirement of the project shall be adopted to the area, that is,

Unit Water Requirement:1.0 ℓ/s/ha

(2) Irrigation Network

The required capacity of each canal is calculated proportion to each command area. The capacity and irrigation net work are shown in Table 3-3 and Fig. 3-5.

2. Canal Design

(1) Type of Canal

The canal coustructed by Nauva East Irrigation Project is earth canal. So, the canal in the area shall be in the same way. The slope shall be 1:1.5 and the longitudinal grandient will be 1:4,000 (0.00025).

(2) Canal Section

As shown in Table 3-3, the required capacity of each canal is 1.62～2.48 ℓ/S.

The standard cross section will be designed as shown in Fig.3-6.

(3) Collateral Work

Collateral work comprises division work from main canal, inlet work to each plot and road crossing work, as follows.

1) Division work from main canal

A division gate is a major component of the structure to control division of water.

2) Inlet work to each plot

A box type inlet with a sluice will be easy to distribute water to each plot.

3) Road crossing work

A ϕ 300 mm concrete pipe is used for canal to cross the road.

3-5 Drainage Plan

1. Drainage Discharge

(1) Unit Dischage

The unit discharge of Navua East Irrigation Project shall be adopted to the area, that is,

q : 12 ℓ/sec/ha

(2) Drainage Network

The design discharge of each drainage canal corresponding to catchment area and the drainage network are shown in Table 3-4 and Fig.3-6.

2. Design of Drainage Canal

(1) Type of Canal

The type shall be earth canal with 1:1.5 slope. The existing drainage canal that lies obliquely in the area shall be relocated and realigned as the main drainage canal (No.1) in the center of the area.

According to Navna East Project, the water of the north adjacent area is drained to CA 1 drainage canal located to the east of the area. However, at the time of heavy rain, some of excessive water flows into the existing drainage canal in the area through a existing pipe culvert laid under the north side road. Therefore, a new pipe culvert will be designed at the upper end of the drainage canal No.1 with the some size of ϕ 600 mm as the existing one.

The longitudinal gradient of drainage canal No.1 shall be 1/536, since elevations of upstream and downstream are fixed.

The longitudinal grandient of other drainage canals (No.2~7) will be 1/2,000.

(2) Section of Drainage Canal

The depth of canal will be more than 1 m so as to dry up paddy field. The standard cross section is shown in Fig.3-8. The design descharge is 0.02 ~ 0.41 m^3/sec, as shown in Table 3-4.

(3) Collateral Work

1) Box Culvert

3 road crossing works are needed for drainage canal No.1. The structure is 1.0 m × 1.0 m of box culvert.

2) Pipe Culvert

As stated before, a pipe culvert is planned at the upper end of the drainage canal No.1.

For the drainage canal No.2, 2 pipe culverts o ϕ 600 mm shall be designed to cross passage ways of house lot.

3-6 Relative Facilities

A storage house shall be constructed as follows.

1. Location

   On the hill located in the south of the area.

2. Size

   3 m × 5 m, able to store equipments for cultivation, harvesting, etc.

3. Structure

   A shed made of concrete block works.

4. Device

   Water supply system for washing of equipments.

(Table 3 – 1) CLIMATOLOGICAL SUMMARY

1.Monthly Rainfall Station: NAITONITONI

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1917	351	201	411	357	285	349	267	350	402	291	407	292	3962
1918	106	303	181	280	611	338	282	217	69	241	113	424	3165
1919	236	160	261	413	114	193	162	133	185	282	361	252	2752
1920	220	243	225	575	335	173	157	112	254	97	110	319	2820
1921	516	373	372	699	239	106	110	377	197	280	751	862	4880
1922	418	374	539	256	161	74	68	275	231	170	541	273	3380
1923	299	362	339	103	202	124	210	95	131	133	392	188	2578
1924	154	134	393	146	632	644	87	697	384	641	429	155	4499
1925	235	145	121	454	164	49	129	114	144	204	84	109	1953
1926	80	304	288	242	95	279	134	5	428	107	135	102	2197
1927	678	463	205	154	436	353	101	118	304	436	320	626	4193
1928	127	159	574	628	438	42	61	263	127	179	152	238	2989
1929	204	371	267	206	162	538	88	213	200	106	294	584	3234
1930	367	550	350	161	180	134	49	40	125	31	93	222	2303
1931	220	501	322	138	233	130	119	91	208	250	260	342	2812
1932	256	407	391	390	256	58	323	155	74	239	359	159	3066
1933	235	304	513	1105	210	176	68	65	172	261	609	843	4560
1934	535	376	504	435	448	132	332	123	252	238	183	161	3720
1935	420	128	232	263	194	220	191	417	165	410	501	310	3450
1936	337	171	324	186	695	118	86	160	157	437	93	381	3147
1937	241	201	507	254	317	98	300	241	437	276	193	108	3173
1938	299	135	239	93	334	148	331	317	341	259	464	585	3543
1939	278	234	545	754	655	51	119	225	88	286	319	149	4203
1940	331	64	510	471	160	163	117	168	188	276	197	577	3222
1941	257	353	114	895	159	261	103	213	196	52	68	228	2898
1942	44	261	127	518	287	331	126	167	116	154	32	255	2419
1943	256	275	161	435	188	29	63	78	81	276	257	113	2212
1944	216	172	803	230	250	99	39	182	285	107	77	390	2851
1945	199	321	227	113	203	369	118	294	100	391	173	324	2832
1946	424	834	592	160	193	180	104	132	109	196	175	141	3240
1947	368	239	485	232	464	271	233	90	208	80	155	156	2981
1948	518	593	366	341	181	52	215	60	62	142	243	212	2984
1949	258	295	285	221	379	90	186	236	395	251	146	197	2940
1950	403	236	429	297	314	55	261	168	253	447	406	246	3515
1951	256	224	277	280	216	202	103	76	211	172	22	233	2272
1952	509	399	476	137	219	258	287	55	146	53	261	511	3310
1953	555	365	431	346	172	109	8888	8888	8888	8888	8888	8888	88888
1954	8888	8888	8888	8888	8888	8888	8888	8888	8888	8888	354	245	88888
1955	328	284	455	250	357	204	164	360	546	156	557	479	4139
1956	303	364	572	404	146	95	216	122	96	327	454	59	3157
1957	401	273	391	466	202	173	64	59	180	114	279	74	2676
1958	85	268	18	653	246	0	38	58	22	86	302	160	1937
1959	365	148	228	262	159	207	20	348	312	164	176	26	2414
1960	283	284	473	230	123	164	214	86	75	150	571	216	2869
1961	467	274	248	356	272	200	133	202	240	150	474	410	3426
1962	387	566	405	204	99	355	126	22	200	104	299	171	2939
1963	384	124	301	575	445	127	89	595	165	145	236	351	3538
1964	196	274	584	428	400	17	246	390	171	123	246	350	3425
1965	308	590	589	386	407	39	175	105	173	122	121	49	3064
1966	268	149	309	456	167	157	144	104	25	27	22	246	2074
1967	337	169	194	458	105	28	40	105	250	347	6	144	2184
1968	142	293	283	100	89	113	74	93	257	90	35	112	1680
1969	212	263	679	306	80	7	421	103	57	205	260	394	2989
1970	429	515	232	222	39	200	178	68	175	194	682	103	3037
1971	208	140	404	204	164	294	201	151	147	501	241	358	3093
1972	473	194	178	320	219	84	133	174	243	103	234	599	2954
1973	167	274	768	685	106	141	346	103	170	155	270	292	3477
1974	286	218	369	377	8888	8888	8888	8888	8888	8888	8888	8888	88888
Averag	315	296	370	358	261	171	159	181	199	213	271	288	3082

Re: 8888: missing

2. Air Temperatures -- ℃ 1971-1977

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Av.daily max.	30.3	30.3	30.1	29.3	28.4	27.8	26.8	26.9	27.4	28.4	28.8	29.7	28.7
daily min.	22.2	22.2	21.5	21.5	20.2	19.8	18.7	19.0	20.1	20.3	21.2	21.7	20.7
Average daily	26.3	26.3	25.8	25.4	24.3	23.8	22.8	23.0	23.8	24.4	25.0	25.7	24.7
Highest max.	36.7	33.9	32.8	32.2	31.7	31.1	30.0	32.2	31.1	32.2	32.2	31.7	
Av.monthly max	32.7	32.0	32.2	31.6	31.0	30.5	29.2	31.1	30.5	30.6	31.4	31.3	
Lowest max.	27.2	26.7	25.0	22.0	24.4	23.9	21.1	21.1	22.8	24.4	25.0	25.6	
Highest min.	26.7	25.6	23.9	23.9	24.4	24.4	22.8	25.0	24.4	23.9	24.4	25.6	
Av.monthly min	20.4	20.4	19.4	18.6	17.3	16.7	15.2	16.2	17.0	17.3	18.5	18.5	
Lowest min.	20.0	18.9	16.1	17.0	15.6	15.0	12.8	14.4	16.0	14.4	16.0	16.0	

3. Dry Bulb Temperature at 8 a.m. 1971-1977

Average	26.0	25.6	25.2	24.4	23.5	22.6	21.7	22.2	23.4	24.3	25.4	25.7	24.2

4. Relative Humidity at 8 a.m. - percent 1971-1977

Average	82	83	83	83	83	84	83	82	82	78	80	81	82

5. Vapour Pressure at 8 a.m. - millibars 1971-1977

Average	27.6	27.3	26.6	25.4	24.1	23.1	21.6	22.0	23.6	23.7	26.0	26.8	24.8

6. Duration of Bright Sunshine - hours 1971-1977

Average	181	160	123	152	131	119	117	163	128	165	164	148	1,751

(Table 3－2) Soil pH and Soil Hardness at NAVUA Project

Sample No.	Depth cm	p H	Soil hardness kg/cm²	Remarks
No. 1	0 ～ 20	5.62	5～7	EC=0.05m /cm
	20 ～ 40	6.11	7～8	
	40 ～ 60	6.12	8～10	T=30℃
	60 ～ 80	6.09	8～10	
	80 ～100	6.10	8～10	
No. 2	0 ～ 10	5.52	1～2	EC=0.03m /cm
	10 ～ 20	5.64	2～5	
	20 ～ 40	5.95	5～8	T=28℃
	40 ～ 60	6.06	8～10	
	60 ～ 80	6.06	5～8	
No. 3	0 ～ 20	4.82	2～4	EC=0.12m /cm
	20 ～ 40	5.02	1.5～3	
	40 ～ 60	5.30	2～4	T=35℃
	60 ～ 80	4.96	0.5～1	
No. 4	0 ～ 20	6.04	3～5	EC=0.14m /cm
	20 ～ 40	5.78	2～5	
	40 ～ 60	5.80	2～3	T=27℃
	60 ～ 80	5.72	2～4	
	80 ～100	5.48	2～4	
No. 5	0 ～ 10	5.71	0.5～1.5	EC=0.04m /cm
	10 ～ 20	5.78	4～5	
	20 ～ 40	6.02	5～7	T=26℃
	40 ～ 60	6.09	3～5	
	60 ～ 80	6.00	4～5	
No. 6	0 ～ 10	5.98	0.5～1	EC=0.18m /cm
	10 ～ 20	5.42	1～2	
	20 ～ 40	5.68	3～4	T=27℃
	40 ～ 60	5.20	3～4	
	60 ～ 80	5.59	3～4	

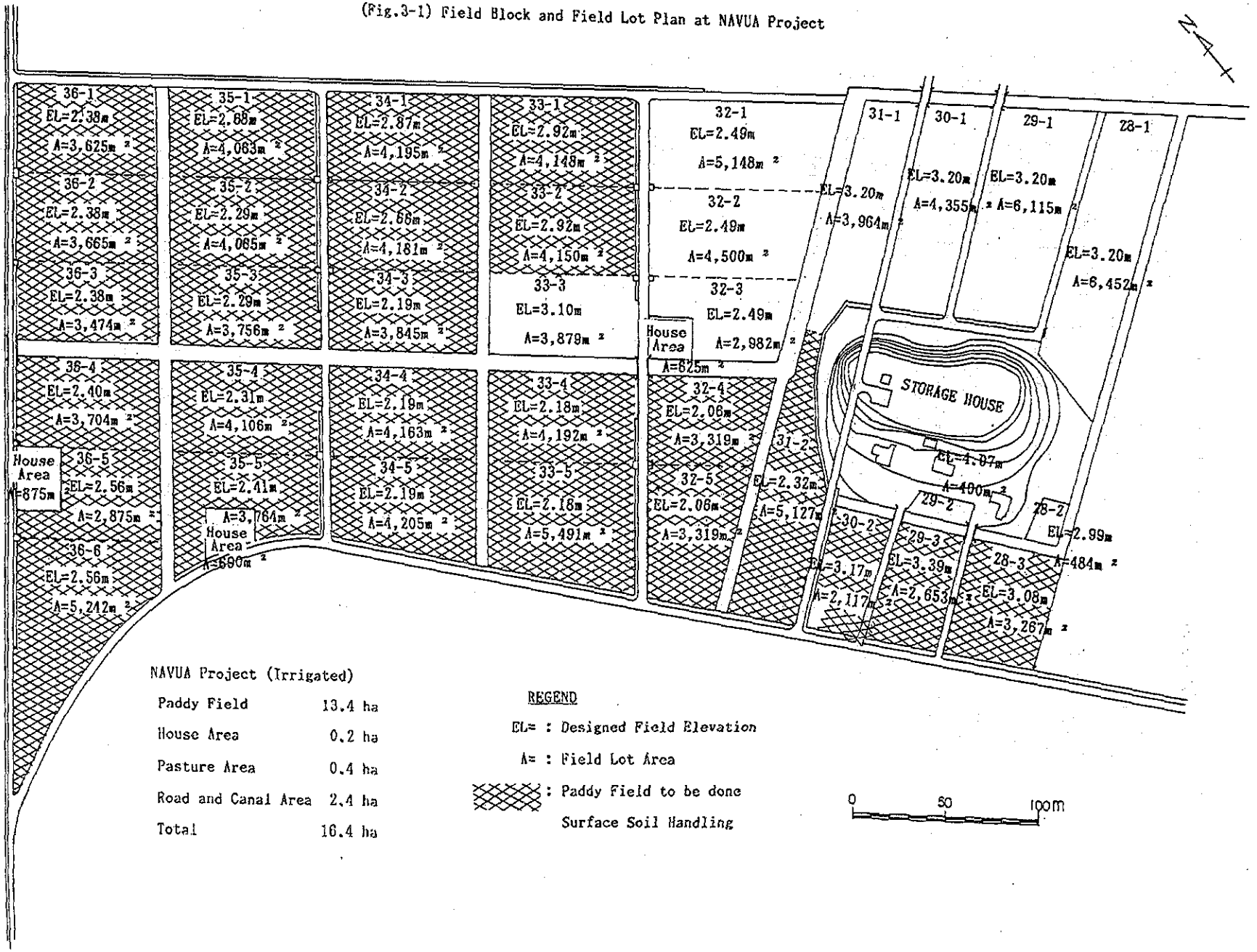
(Table 3－3) Water Requirement for Irrigation Canal at NAVUA Project

Canal Name	Number of Field Lot	Area ㎡	Unit Water Requirement ℓ／s／ha	Water Requirement ℓ／s	Remarks
Direct Division from existing canal	No.28－2	484	1.0		
	－3	3,267	〃		
	No.29－2	400	〃		
	－3	2,653	〃		
	No.30－2	2,117	〃		
	sub-total	8,921	〃	0.89	
Irrigation Canal No.1	No.28－1	6,452	1.0		
	No.29－1	6,115	〃		
	No.30－1	4,355	〃		
	No.31－1	3,964	〃		
	－2	5,127	〃		
	sub-total	26,013	〃	2.60	
Irrigation Canal No.2	No.32－4	3,319	1.0		
	－5	3,319	〃		
	No.33－4	4,192	〃		
	－5	5,491	〃		
	sub-total	16,321	〃	1.63	
Irrigation Canal No.3	No.32－1	5,148	1.0		
	－2	4,500	〃		
	－3	2,982	〃		
	No.33－1	4,148	〃		
	－2	4,150	〃		
	－3	3,879	〃		
	sub-total	24,807	〃	2.48	
Irrigation Canal No.4	No.34－4	4,163	1.0		
	－5	4,205	〃		
	No.35－4	4,106	〃		
	－5	3,764	〃		
	sub-total	16,238	〃	1.62	
Irrigation Canal No.5	No.34－1	4,195	1.0		
	－2	4,187	〃		
	－3	3,845	〃		
	No.35－1	4,063	〃		
	－2	4,065	〃		
	－3	3,756	〃		
	sub-total	24,111	〃	2.41	
Irrigation Canal No.6	No.36－1	3,625	1.0		
	－2	3,665	〃		
	－3	3,474	〃		
	－4	3,704	〃		
	－5	2,875	〃		
	－6	5,242	〃		
	sub-total	22,585	〃	2.26	
	Total	138,996			

(Table 3－4) Drainage Discharge for Drainage Canal at NAVSORI Project

Drainage Canal Name	Catchment Area ha	Drainage Discharge m^3/s	Uniform Flow Depth m	Remarks
Drainage Canal No.1	5.1	0.06	0.20	I =1/536 n =0.03
〃	26.3	0.32	0.46	〃
〃	27.6	0.33	0.47	〃
〃	30.7	0.37	0.50	〃
〃	34.2	0.41	0.52	〃
Drainage Canal No.2	3.5	0.04	0.23	I =1/2,000 n =0.03
Drainage Canal No.3	1.3	0.02	0.16	I =1/2,000 n =0.03
Drainage Canal No.4	18.4	0.22	0.53	I =1/2,000 n =0.03
Drainage Canal No.5	2.8	0.03	0.20	I =1/2,000 n =0.03
Drainage Canal No.6	2.5	0.03	0.20	I =1/2,000 n =0.03
Drainage Canal No.7	2.6	0.03	0.20	I =1/2,000 n =0.03

(Fig.3-1) Field Block and Field Lot Plan at NAVUA Project



NAVUA Project (Irrigated)

Paddy Field	13.4 ha
House Area	0.2 ha
Pasture Area	0.4 ha
Road and Canal Area	2.4 ha
Total	16.4 ha

REGEND

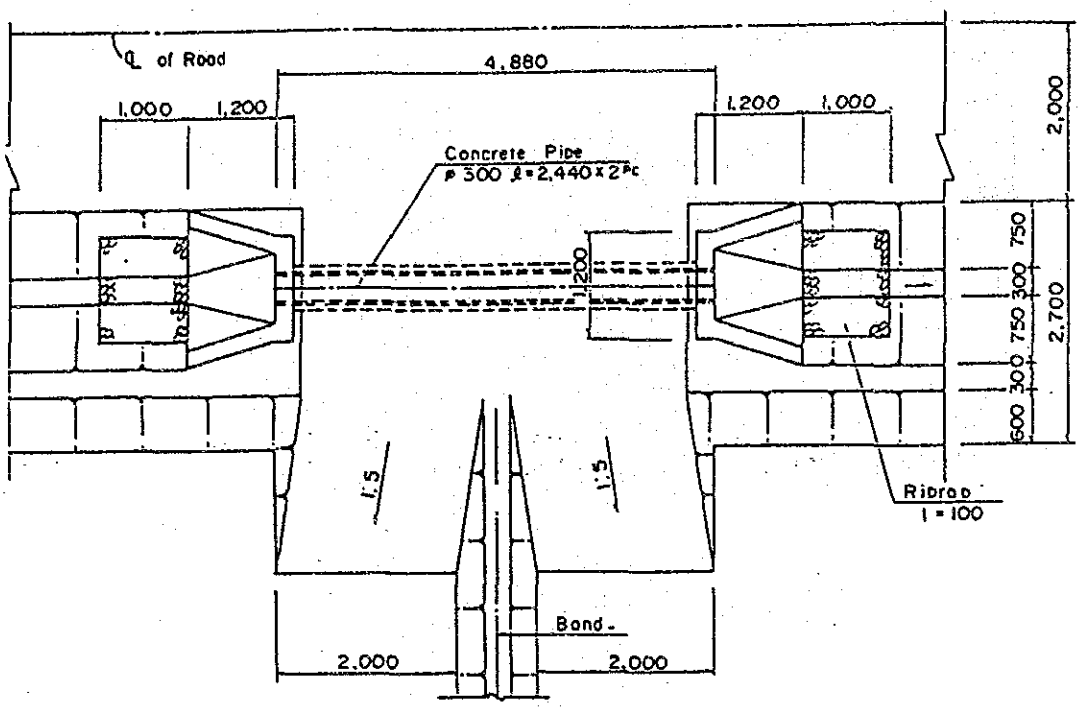
EL= : Designed Field Elevation

A= : Field Lot Area

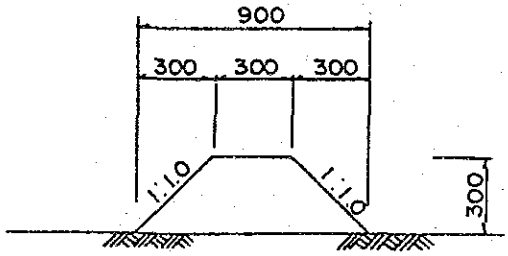
: Paddy Field to be done Surface Soil Handling

(Fig.3-2) Standard Section of Tractor Passage and Band

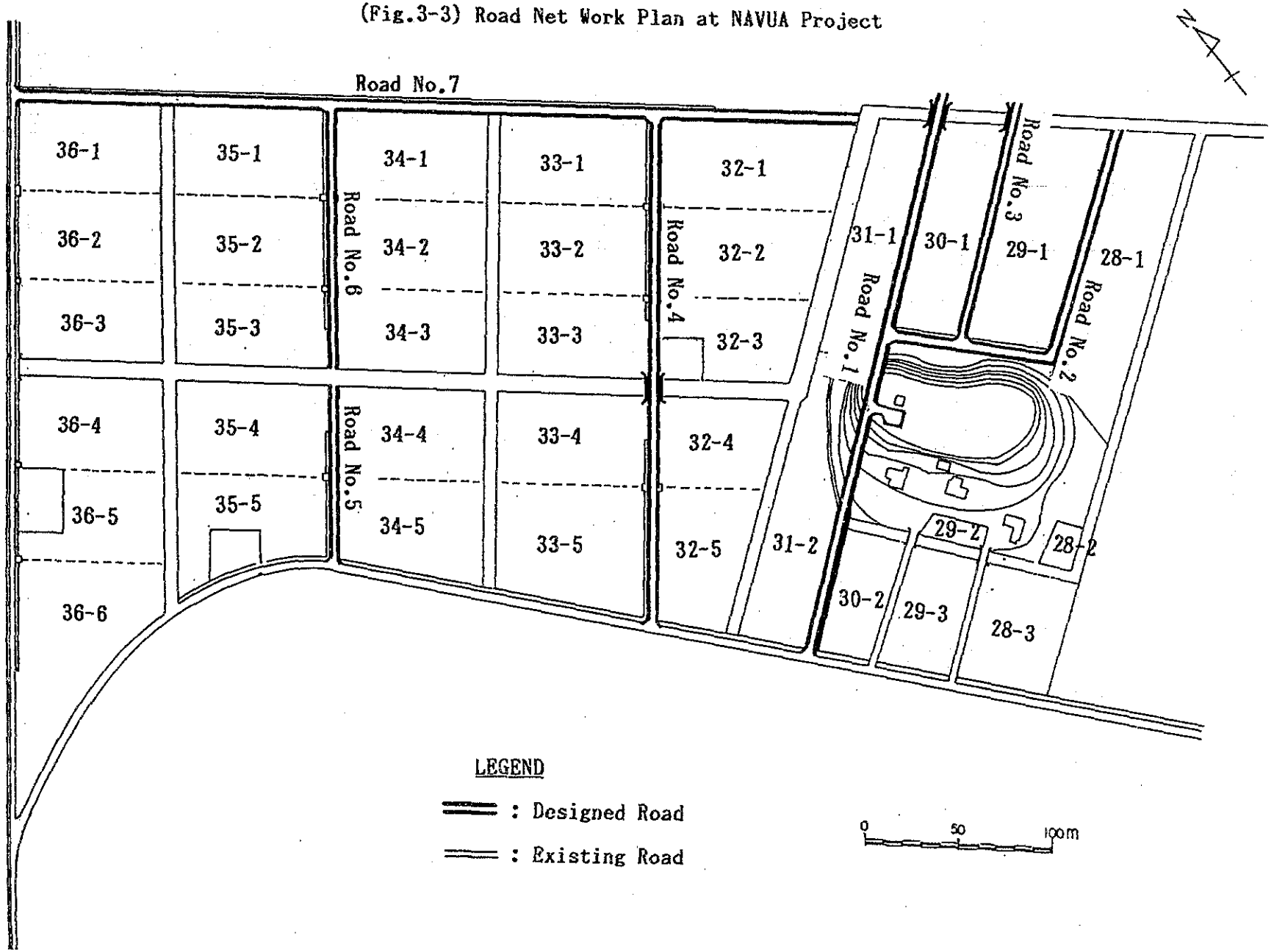
Standard Section of Tractor Passage



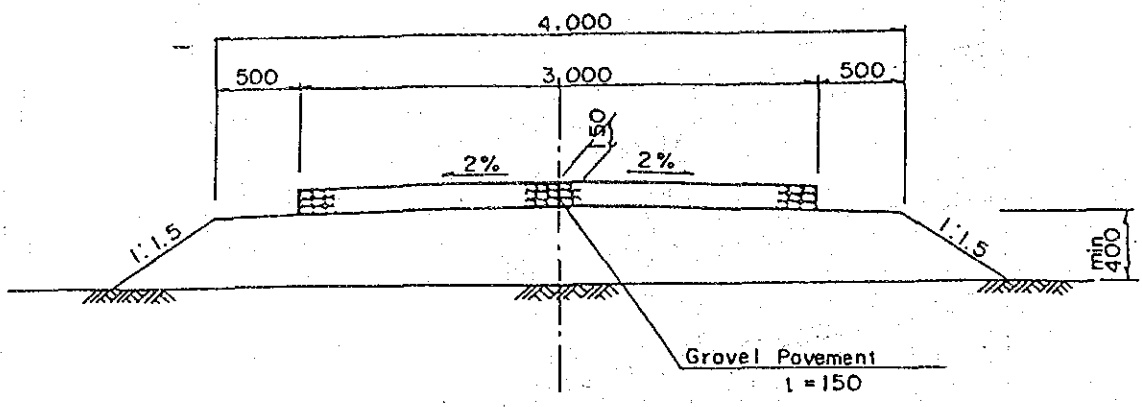
Standard Section of Band



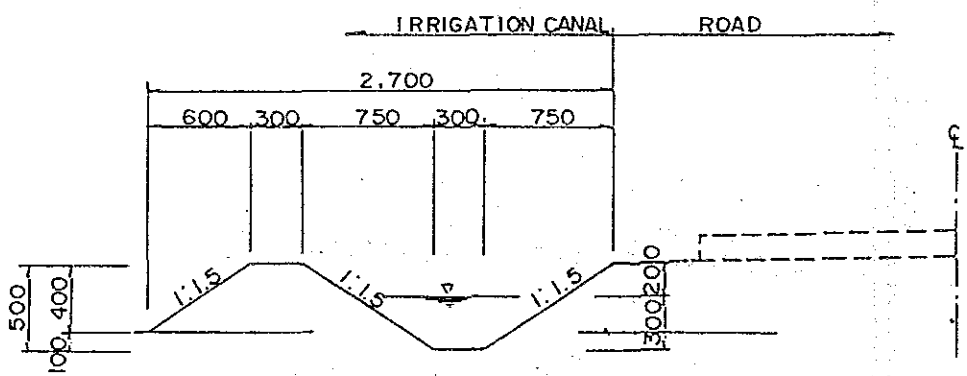
(Fig.3-3) Road Net Work Plan at NAVUA Project



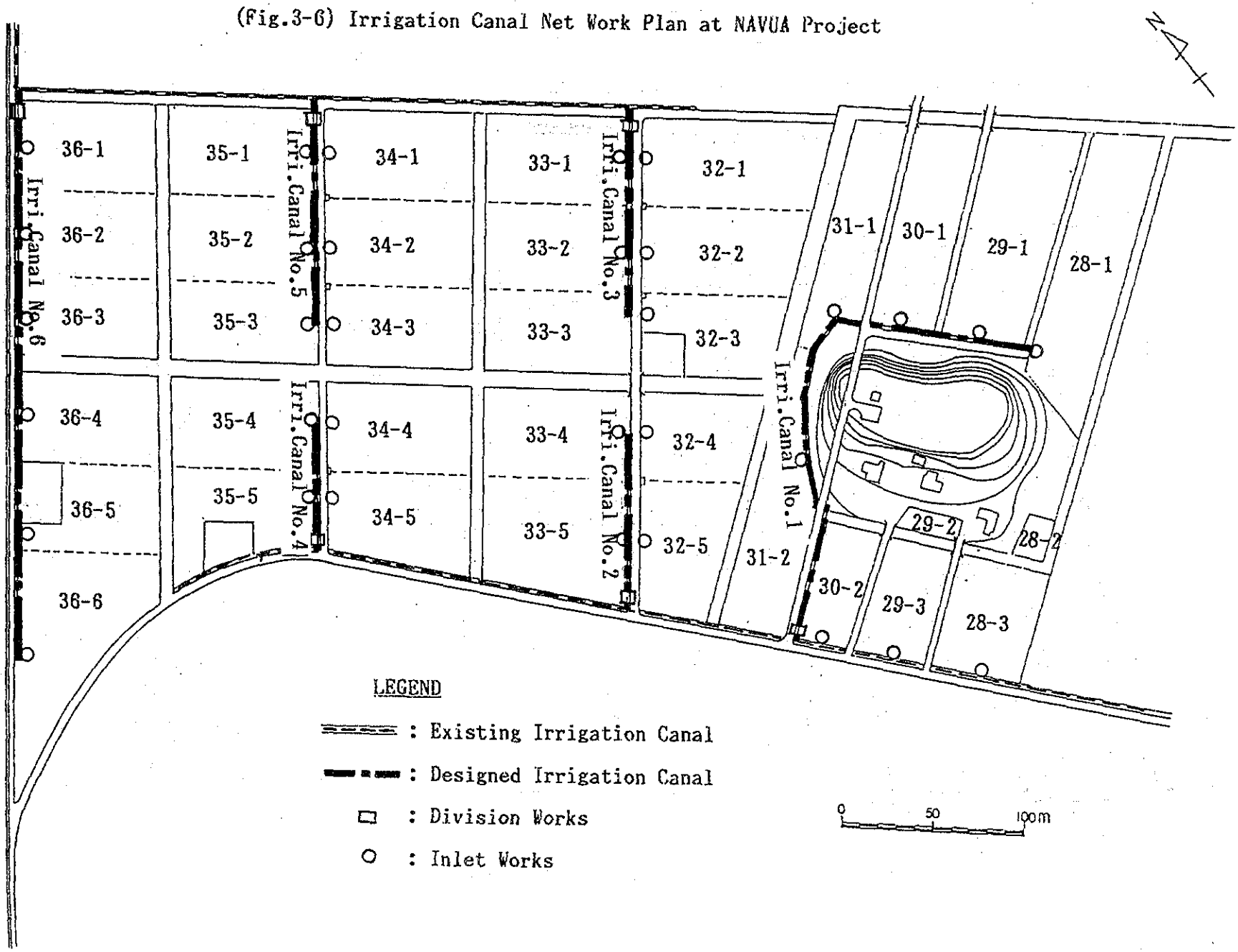
(Fig.3-4) Standard Section of Road



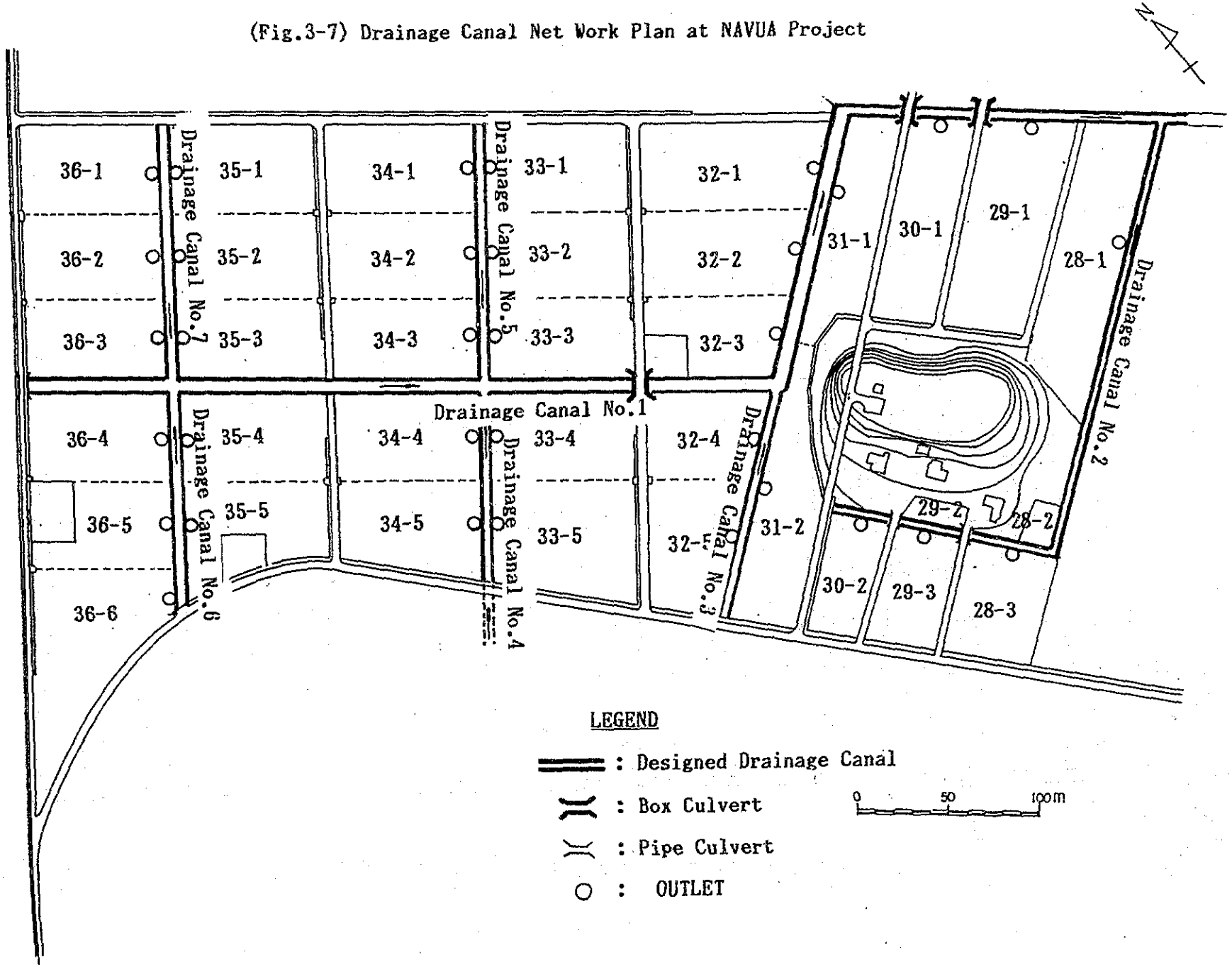
(Fig 3-5) Standard Section of Irrigation Canal



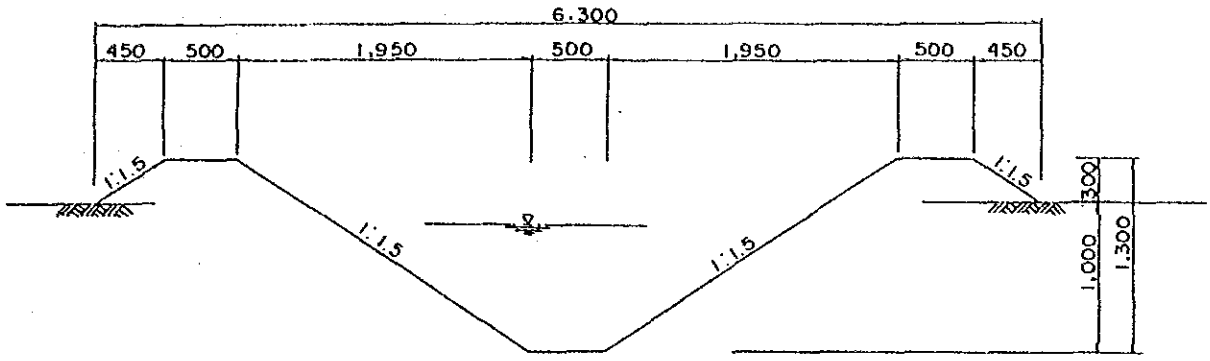
(Fig.3-6) Irrigation Canal Net Work Plan at NAVUA Project



(Fig.3-7) Drainage Canal Net Work Plan at NAVUA Project



(Fig.3-8) Standard Section of Drainage Canal



CHAPTER 4 DETAILED DESIGN OF RAINFED WETLAND FARM (NAUSORI)

Chapter 4 Detailed Design of Rainfed Wetland Farm (Nausori)

4-1 Physical Condition

1. Topography

The area located at the north side of Waidamu Creek is owned by 2 Mataqalis. The total area is 14.3 ha.

At present, the land is used mainly for grassland and cassava cultivation except 2~3 ha of paddy field.

The land being generally flat at the elevation of EL. 0.5~1.8 m, is low in the center part and makes a slight ascent toward the Vusuya road of the north side and Waidamu creek of the south side.

2. Climate

According to the records of 24 years' period observed at Nausori Airport, located about 3.5 km to the south west of the area, the average daily maximum temperature is around 29 ℃ ~ 31℃ in main season, and 26 ℃ ~ 27℃ in off season. The average daily minimum is about 23 ℃ in main season and 19℃ ~ 20℃ in off season.

The average annual rainfall is 3,045 mm.

The average monthly rainfall is 402 mm in March and 142 mm in August.

Number of rainy days per month is 17-22 in main season and 14-17 in off season.

3. Soils

According to the "Land Capability Classification Map" issued by the Government in April 1982, this area is

"Fair arable land, poorly drained, moderate to poor gley soil".

The result of field soil survey shows that the whole area is covered loam except a partly found clay layer at the depth of 60 ~ 80 cm. The P.H. is 5.5 ~ 6.0. The soil will be suitable for rice cultivation.

4. Drainage

Two drainage canals have been constructed by D & I: one is along the existing Vusuya road, and another from the village to Waidamn Creek.

However, there is no more drainage facilities other than the above, causing puddles everywhere.

The drainage condition needs to be improved.

5. Irrigation

There is no irrigation facilities in the area.

4-2 Farm Design

1. Land Use Plan

The boundary of two Mataqalis lies from north to south in the middle of the area. A road will be designed along the boundary. Two drainage canals toward Waidamu Creek will be planned in the area. Flood water from outside of the area shall be bypassed with a new drainage canal along the east side of the area.

The total area of 14.3 ha has been selected taking into account soils, topography and vegetation.

Land use plan is as follows.

Paddy Field	12.5 ha
House Area	0.1 ha
Road, Canal Area	1.7 ha
Total	14.3 ha

2. Farm Plot Plan

As a standard, the design size of from plot will be 0.44 ha with long side 110 m and short side 40 m, taking into account the shape of owned land.

The farm plot plan is shown in Fig.4-1.

3. Land Consolidation Plan

(1) Consolidation Work

In principle, the land is levelled within each plot.

(2) Design Elevation

The design elevation of each plot is shown in Fig 4-1.

(3) Handling of Surface Soil

According to the field soil survey, there is no surface soil different from subsoils.

Any particular handling of surface soil will not be necessary in this area.

(4) House Area

The house area will be planned in plot No.1-5.

The design elevation shall be 30 cm above adjacent paddy field.

(5) Storage House Lot

The storage house lot will be set in plot No.2-1. The design elevation shall be 30 cm higher than adjacent paddy field.

(6) Others

Structure of farm ridge and tractor passage are shown in Fig. 4-2.

4-3 Road Plan

1. Road Network

At the north side of the area, Vusuya road runs and lends to Nausori town through Raralevu.

The road network of the area will be planned along the boundary of two Mataqalis and the circumference of the area.

2. Structure of Road

(1) Width

The road to be used for transportation of equipments and crops shall have a width available for traffic of middle size tractor and 2 ton-truck, as follows.

Effective width	3.0 m
Total width	4.0 m

(2) Structure

The elevation of road surface shall be 40 cm above the field surface. The banking slope shall be 1:1.5, and the effective width will be paved with gravel 15 cm in thickness.

4-4 Drainage Plan

1. Drainage Discharge

(1) Unit Discharge

The unit discharge adopted to the area is 12 ℓ/sec/ha.

(2) Drainage Network

The design discharge of drainage canal corresponding to each catchment area and the drainage network are shown in Table 4-3 and Fig.4-3.

2. Design of Drainage Canal

(1) Type of Canal

The type shall be earth canal with 1:1.5 slope.

The longitudinal gradient will be 1/2,000.

A weir gate shall be installed in each canal at the downstream in order to store water for irrigation use.

(2) Section of Canal

The botton elevation shall be more than 1 m below field level to dry up the field.

The standard cross section is shown in Fig 4-4.

(3) Collateral Work

3 box culvert shall be planned at the places of road crossing. The size is 1.0 m × 1.0 m.

4-5 Relative Facilities

A storage house will be designed as follows.

1. Location

   In the plot No. 2-1.

2. Size

   3 m × 5 m, capable to store equipments for cultivation, harvesting, etc.

3. Structure

   A shed made of concrete block works.

4. Device

   Water supply system for washing of equipments.

(Table 4 – 1) CLIMATOLOGICAL SUMMARY : NAUSORI AIRPORT
(Lat 18° 03'S Long 178° 34'E Height 6m Grid Ref XF656041)

	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Year
Average	330	277	402	368	221	162	153	142	192	232	296	270	3045
Highest	610	612	799	944	497	427	560	393	473	914	646	585	3911
Lowest	112	136	145	182	38	27	25	35	66	44	28	70	1952
Max 1-Day	151	159	279	218	178	185	386	110	180	361	307	237	
Date	6/79	23/69	4/73	3/80	5/79	24/70	3/69	11/80	10/59	19/67	13/58	16/63	
		Number of days with rainfall 0.25mm(0.01inch) or more											1957-1970
Average	22	22	22	21	18	17	16	14	16	17	17	19	221
		Number of days with Thunderstorms											1973-1980
Average	5	5	5	4	1	0	0	0	1	4	2	4	31
		Number of days with Fog											1973-1980
Average	2	2	1	1	2	2	1	1	1	1	1	0	15
		AIR TEMPERATURES – ℃											1957-1980
Av.D.Max*	30.2	30.7	30.4	29.3	28.0	27.2	26.3	26.3	26.8	27.7	28.5	29.4	28.4
Av.D.Min*	22.9	23.0	22.8	22.1	20.7	20.2	19.0	19.4	20.0	20.7	21.2	22.0	21.2
Average	26.6	26.9	26.6	25.6	24.3	23.8	22.7	22.9	23.4	24.2	24.9	25.8	24.8
Highest	34.4	34.4	34.0	32.9	33.6	31.5	31.2	31.7	31.4	32.7	33.4	33.0	
Av.M.Max*	32.5	32.8	32.6	31.6	30.8	30.2	29.4	29.7	30.0	30.5	31.2	31.7	33.1
Lowest Max	25.4	25.8	24.3	23.7	22.6	21.7	21.9	20.4	20.6	22.8	23.8	25.2	
Highest Min	26.9	26.3	25.9	26.7	24.6	25.5	23.5	24.5	26.1	25.5	26.6	26.1	
Av.M.Min*	20.2	20.8	20.2	18.9	17.0	16.5	14.7	15.0	16.1	16.2	17.3	18.6	14.0
Lowest	15.5	18.6	17.1	16.7	15.1	13.6	12.5	12.1	13.2	13.3	14.7	15.7	
		* D = Daily M = Monthly or Annual											
		AVERAGE TEMPERATURES AT FIXED HOURS FST – ℃											1957-1980
0000*	24.7	24.7	24.3	23.6	22.6	22.1	21.1	21.3	21.7	22.6	23.1	23.7	23.0
0600	23.5	23.5	23.2	22.7	21.4	21.0	19.9	20.2	20.5	21.4	22.1	22.7	21.8
0900	27.3	27.3	26.8	25.9	24.6	23.7	22.8	23.4	24.1	25.2	25.7	26.8	25.3
1200	28.6	29.4	29.0	27.9	26.8	26.1	25.0	25.1	25.6	26.4	27.1	28.1	27.1
1800*	27.4	27.4	26.7	25.7	24.4	24.2	23.3	23.3	23.7	24.8	25.4	26.5	25.2
		* 1973-1980											
		AVERAGE RELATIVE HUMIDITY AT FIXED HOURS FST – %											1957-1980
0000*	92	93	94	93	91	91	89	88	90	90	90	91	91
0600	95	96	97	96	94	94	93	92	93	92	94	94	94
0900	83	84	85	86	85	86	84	81	80	77	77	78	82
1200	74	73	75	76	73	74	72	71	74	71	72	71	73
1800*	81	81	84	84	83	83	79	79	80	79	81	77	81
		* 1973-1980											
		Daily Relative Humidity (all hours) – %											1973-1980
Average	85	85	87	86	84	85	82	83	83	82	83	82	84
		AVERAGE SEA LEVEL PRESSURE AT FIXED HOUR – Millibars											1973-1979
0000	07.8	09.1	10.1	11.0	12.8	13.6	14.5	14.1	14.6	13.6	11.4	09.2	11.8
0600	06.8	07.9	08.9	10.0	11.8	12.8	13.6	13.3	13.6	12.8	10.5	08.2	10.9
0900**	09.0	09.2	10.3	11.8	13.6	14.9	15.3	15.6	15.0	14.2	11.9	09.8	12.6
1200	06.8	08.4	09.4	10.5	12.4	13.4	14.4	14.0	14.1	13.1	10.6	08.2	11.3
1800	06.0	07.4	08.3	09.5	11.3	12.3	13.1	12.7	12.9	12.1	09.8	07.5	10.2

Daily Sea Level Pressure (all horus) – Millibars * 1973-1979

Average	06.9	08.2	09.2	10.3	12.1	13.0	13.9	13.5	13.8	12.9	10.6	08.2	11.1

* Add 1000 to above values
** 1957-1980

VAPOUR PRESSURE AT 0900 FST – Millibars 1971-1980

Average	29.5	29.9	29.8	28.4	26.0	25.5	23.3	23.6	24.1	25.4	26.5	27.3	26.6

SURFACE WIND SPEED* – Knots 1973-1980

Average	4.9	4.1	3.9	4.0	4.4	4.0	4.6	4.8	4.8	5.4	5.1	4.7	4.6

*Anemometer head height is 10 metres

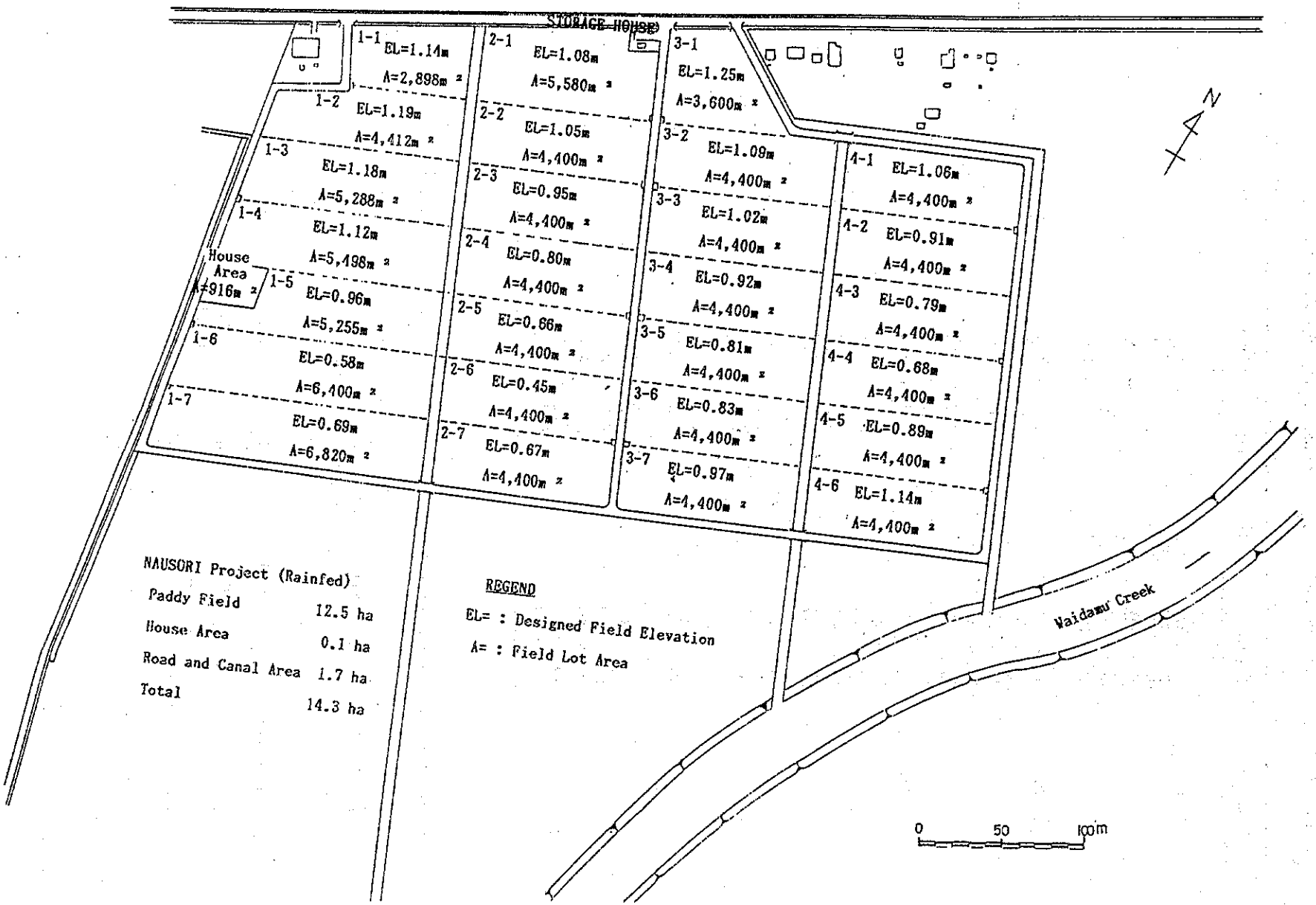
(Table 4 − 2) Soil pH and Soil Hardness at NAVSORI Project

Sample No.	Depth cm	p H	Soil hardness kg/cm²	Remarks
202	0 ~ 10	5.60	1.0 ~ 3.0	
	10 ~ 20	5.94	3.1 ~ 4.9	
	20 ~ 40	6.00	3.1 ~ 4.8	
	40 ~ 60	5.88	2.3 ~ 4.5	
	60 ~ 80	5.72	2.3 ~ 4.5	
302	0 ~ 10		5.4 ~ 7.3	
	10 ~ 20		4.8 ~ 7.3	
	20 ~ 40		2.6 ~ 4.0	
	40 ~ 60		3.5 ~ 4.8	
	60 ~ 80		2.6 ~ 3.5	
305	0 ~ 10		1.2 ~ 2.6	
	10 ~ 20		2.6 ~ 4.7	
	20 ~ 40		4.0 ~ 5.4	
	40 ~ 60		3.5 ~ 4.0	
	60 ~ 80		4.0 4.8	
210	0 ~ 10		2.2 ~ 3.5	
	10 ~ 20		5.4 ~ 7.3	
	20 ~ 40		4.8 ~ 7.3	
	40 ~ 60		4.8 ~ 6.3	
	60 ~ 80		2.6 ~ 4.0	
D 6	0 ~ 10		1.2 ~ 1.4	
	10 ~ 20		2.2 ~ 3.0	
	20 ~ 40		3.5 ~ 4.8	
	40 ~ 60		2.2 ~ 3.0	
	60 ~ 80		2.2 ~ 2.6	

(Table 4 − 3) Drainage Discharge for Drainage Canal at NAUSORI Project

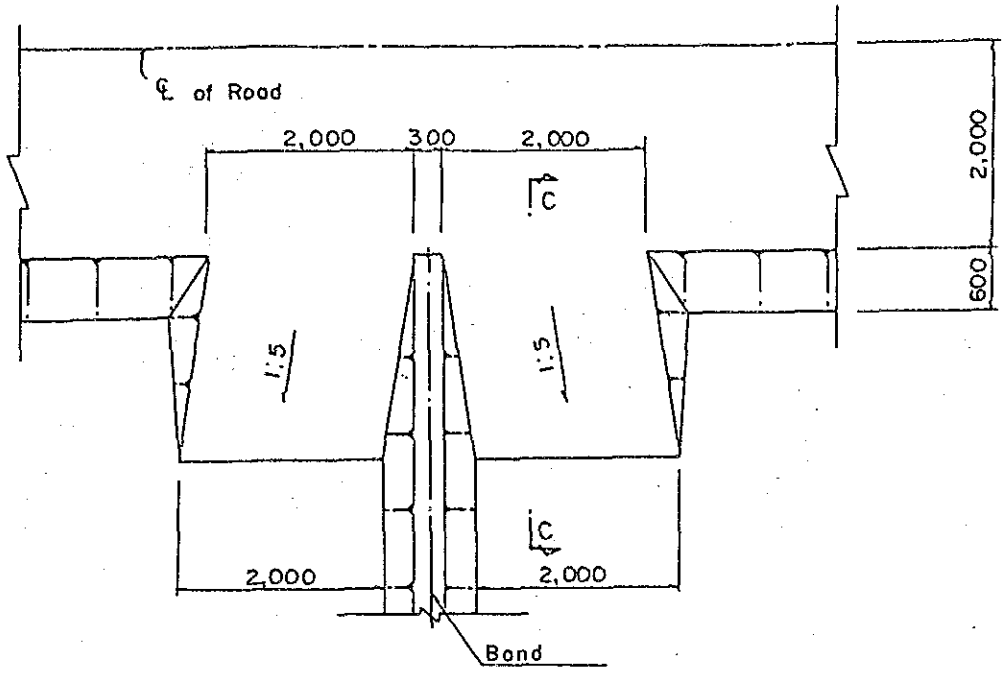
Drainage Canal Name	Catchment Area ha	Drainage Discharge m³/s	Uniform Flow Depth m	Remarks	
Drainage Canal No.1	50.0	0.60	0.83	I =1/2000	n =0.03
〃	65.3	0.66	0.87	I =1/2000	n =0.03
Drainage Canal No.2	5.6	0.07	0.30	I =1/2000	n =0.03
〃	9.0	0.11	0.38	I =1/2000	n =0.03
Drainage Canal No.3	6.9	0.08	0.33	I =1/2000	n =0.03
〃	14.0	0.17	0.47	I =1/2000	n =0.03

(Fig.4-1) Field Block and Field Lot Plan at NAUSORI Project

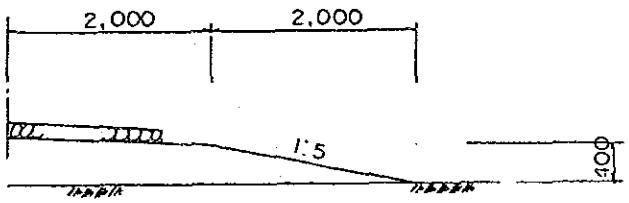


(Fig.4-2) Standard Section of Tractor Passage and Band

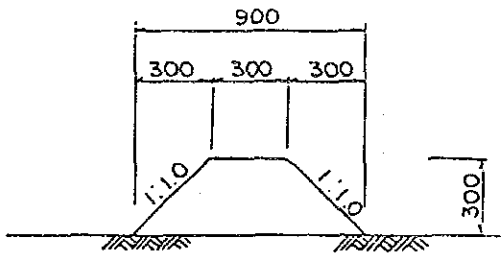
Standard Section of Tractor Passage



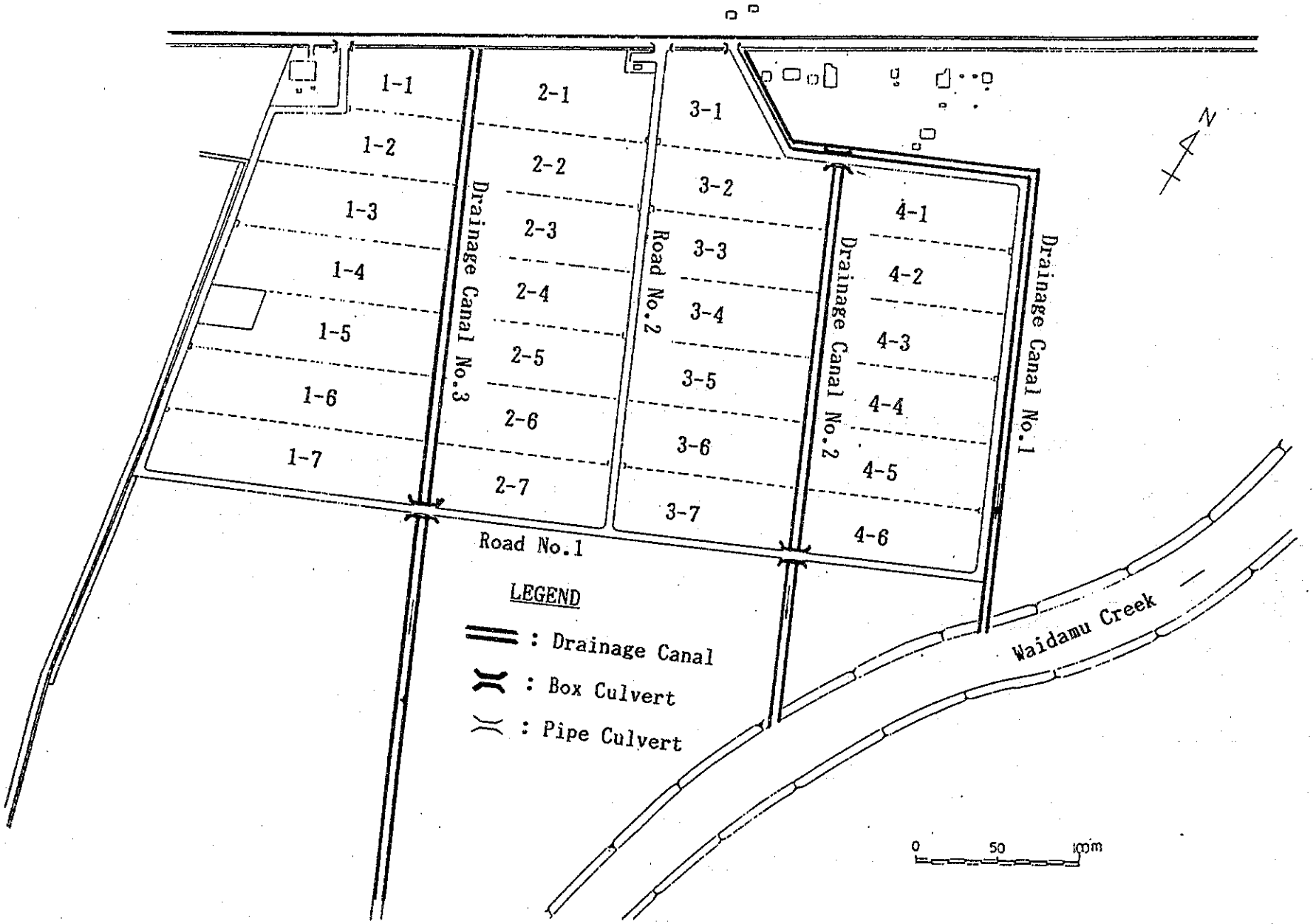
C-C SECTION
S=1/50



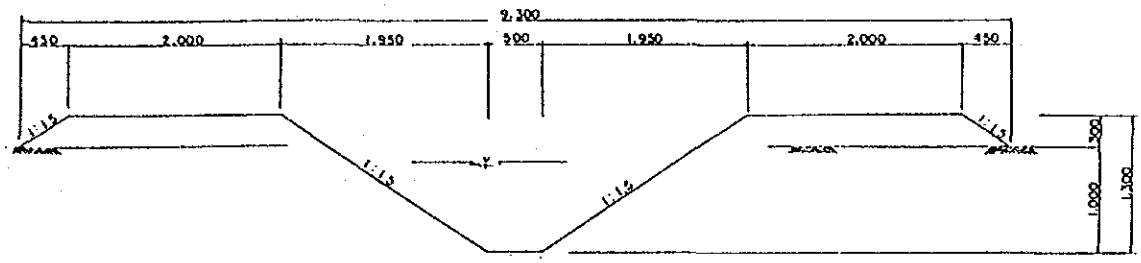
Standard Section of Band



(Fig.4-3) Drainage Canal Net Work Plan at NAUSORI Project



(Fig.4-4) Standard Section of Drainage Canal



CHAPTER 5 CONSTRUCTION PLAN

Chapter 5 Construction Plan

5-1 Construction Plan

1. Construction Schedule

Construction works of Navua and Nansori will be executed at the same time during a period of 6 months. In both area, the land consolidation work will be carried out in the first half of construction period, and road, canal and relative facilities shall be constructed in the latter half.

The construction schedule of both area are shown in teble 5-1.

2. Construction Plan

Construction plan of each work will be summarized as follows.

(1) Temporary Works

Establishment of site office, confirmation of road for construction use, center line setting of road and canal, and preparation of constrtuction material shed will be carried out.

(2) Land Consolidation Works

1) Nouva area : 16.4 ha

As for plot No.28-1, No.29-1, No.30-1, No.31-1, No.32-1 to 3, the works will be carried out with the sequence of - excavation and soil hauling- land grading and compaction, without handling of surface soil. Since these plots have to be

cut down to EL.3.20 m in view of irrigation water level, the hauling distance will be 107 m and two steps pushing work with 11 ton class bulldozer will be necessary.

In this case, as the working capacity of bulldozer is 8.3 m³/hr and volume of earth work is 6,200 m³, so T = 6,200/8.3 = 747 hr = 125 unit/day of bulldozer work will be required.

While, as for the other plots, the handling of surface soil 10 cm thick is necessary. The works shall be done with the sequence of - surface soil removing → excavation and hauling→ land grading and compaction → subsoil leveling→ backfilling.

The required bulldozer work will be 88-68-58-80-91 unit/day respectively.

Therefore, in the whole area, 507 unit/day of bulldozer work, that is, 4 bulldozers will be required.

2) Nausori area : 14.3 ha

The works will be carried out with the sequence of - excavation and hauling - land grading and compaction, with 11 ton class bulldozer.

The hauling distance will be 35 m and 65 m, and the working capacity will be 22.3 m³/hr and 13.1 m³/hr for excavation and hauling, and 19.4 m³/hr for land grading and compaction.

From the volume of earth work (V = 3,500 m³ and 2,800m³), the required bulldozer work will be 27 + 36 - 31 + 25 = 119 unit/day respectively.

For land conlidation work of the area, 2 bulldozers will be required.

(3) Irrigation Canal Works

1) Navua area

The irrigation canal in Navua area is planned along the road. Since it is a small earth canal, the banking and compaction works will be done along with the road construction work with 11 ton bulldozer. After that, the excavation will be carried out with back-hoe.

Construction length = 1,050 m

(4) Drainage Canal Works

1) Navua area

The existing drainage canal will be backfilled with bulldozer, after removing of soft soils and weeds with back-hoe.

The new drainage canal will be excavated with back-hoe, after completion of land consolidation works.

Construction length = 1,880 m

2) Nausori area

The new drainage canal within the area will be excavated with back-hoe, after completion of land consolidation works.

In the neighbourhood of Waidamu Creek, the excavation will be done after clearing and uprooting of bushes.

Construction length = 1,500 m

(5) Road Construction Works

1) Navua area

The road parallel to the irrigation canal will be constructed roughly along with the land consolidation works, of which the subsoils could be converted to road foundation. A bulldozer will be used for land grading and compaction.

Construction length = 1,810 m

2) Nausori area

The road will be constructed roughly along with the land consolidation works. The field subsoil could be converted to road foundation. A bulldozer will be used for both land grading and compaction.

Construction length = 1,670 m

5-2 Construction Cost

1. Total Cost

The construction cost of Pilot Infrastructure Works in Novua and Nausori area is estimated as ¥ 45.647,000 in total summarized as follows.

I Construction Cost

A. Direct Cost

Navua area	¥ 19,233,000
Nausori area	¥ 11,169,000
sub-total	¥ 30,402,000

B. Overhead Cost

A × 30 %	¥ 9,120,000

C. Contingenciess

(A+B)× 10 %	¥ 3,952,000
Total	¥ 43,474,000

Ⅱ Fee

Ⅰ × 5 %	¥ 2,173,000
Ⅲ Grand Total	¥ 45,647,000

2. Direct Cost of Navua area

The breakdown is as follows.

Item	Quantity	Unit cost	Cost	Remarks
(1) Land Consolidation works		F$	F$	
Surface soil handling	10,500 m³	3.67	38,535	ℓ= 40 m
Cutting & Banking, Part A	6,200 m³	3.74	23,188	ℓ=107 m
Cutting & Banking, Part B	8,000 m³	2.08	16,640	ℓ= 40.5m
Land grading	12.9 ha	1,234.57	15,926	
Farm-ridge work	1,280 m	2.17	2,778	
sub-total			97,067	

(2) Irrigation Facilities				
Irrigation canal	1,050	m	6.63	6,962
Division work, Type-A	3	nos	2,345.03	7,035
Division work, Type-B	3	nos	1,919.80	5,759
Inlet work, Type-A	9	nos	195.54	1,760
Inlet work, Type-B	24	nos	72.15	1,732
Passage work, Type-A	6	nos	930.57	5,583
Passage work, Type-B	4	nos	2.34	9
Passage work, Type-C	5	nos	651.31	3,257
Passage work, Type-D	9	nos	1.17	11
Road crossing work	4	nos	822.87	3,291
sub-total				35,399
(3) Drainage Facilities				
Drainage canal	1,880	m	12.03	22,616
Pipe culvert	4	nos	622.55	2,490
Box culvert	3	nos	1,767.66	5,303
Outlet	33	nos	83.72	2,763
sub-total				33,172
(4) Road Construction				
Road	1,810	m	15.43	27,928
sub-total				27,928
(5) Relative Facilities				
Storage house	15	m^2	750.00	11,250
Water supply	200	m	9.97	1,994
sub-total				13,244
Total				206,810

F$ 206,810 × ¥ 93/F$ = ¥ 19,233,330

= ¥ 19,233,000

3. Direct Cost of Nausori area

The breakdown is as follows

Item	Quantity		Unit cost	Cost	Remarks
(1) Land Consolidation works			F$	F$	
Cutting & Banking, Part A	2,800	m³	3.10	8,680	ℓ=65 m
Cutting & Banking, Part B	3,500	m³	2.35	8,225	ℓ=35 m
Land grading	12.5	ha	1,234.57	15,432	
Farm ridge work	2,650	m	2.17	5,751	
sub-total				38,088	
(2) Drainage facilities					
Drainage Canal	1,500	m	12.03	18,045	
Weir gate	2	nos	5,472.52	10,945	
Outlet, type-2m	26	nos	107.78	2,802	
Outlet, type-4m	1	nos	246.26	247	
Pipe culvert	3	nos	622.55	1,868	
Box culvert	3	nos	1,767.66	5,303	
clearing & uprooting	6,400	m²	0.37	2,368	
sub-total				41,578	
(3) Road Construction					
Road	1,670	m	15.43	25,768	
Passage, Type-A	12	nos	2.34	28	
Passage, Type-D	3	nos	1.17	4	
sub-total				25,800	

(4) Relative Facilities

Storage house	15	㎡	750.00	11,250
Water supply	340	m	9.97	3,390
sub-total				14,640
Total				120,106

F$ 120,106 × ¥ 93/F$ = ¥ 11,169,858

≒ ¥ 11,169,000

4. Unit Cost

Unit costs used for cost estimation are listed in Table 5-2. These are based on data collected in Fiji.

(Table 5－1) Construction Schedule

Work Item	Quantities	First Month	Second Month	Third Month	Forth Month	Fifth Month	Sixth Month
A. NAVUA Project							
1. Temporary Work	L.S.	———					———
2. Land Consolidation Works	16.4ha						
1) Surface Soil Handling	10,500㎥		———	———	———		
2) Cutting and Banking for A-Type	6,200㎥	———	———				
3) Cutting and Banking for B-Type	8,000㎥		———	———	———		
4) Land Leveling	12.9ha		———		———		
5) Band	1,280m					———	
3. Irrigation Facilities							
1) Irrigation Canal	1,050m				———	———	
2) Relative Facilities	L.S.					———	
4. Drainage Facilities							
1) Drainage Canal	1,880m				———	———	———
2) Relative Facilities	L.S.					———	———
5. Road Works	1,810m		———	———	———		
6. Relative Facilities							
1) Storage House	15㎡				———	———	———
2) Water Line	200m						———
B. NAUSORI Project							
1. Temporary Work	L.S.	———					———
2. Land Consolidation Works	14.3ha						
1) Cutting and Banking for A-Type	2,800㎥	———	———				
2) Cutting and Banking for B-Type	3,500㎥		———	———			
3) Land Leveling	12.5ha			———			
4) Band	2,650m				———		
3. Drainage Facilities							
1) Drainage Canal	1,500m				———	———	———
2) Relative Facilities	L.S.					———	———
4. Road Works							
1) Road Works	1,670m		———	———			
2) Relative Facilities	L.S.			———	———		
5. Relative Facilities							
1) Storage House	15㎡				———	———	———
2) Water Line	340m					———	———

(Table 5 − 2) Unit Price

No.	Item	Unit	Unit Price F $	Remarks
1	Surface soil handling(ℓ = 40 m)	m³	3.67	t = 10cm
2	Cutting and Banking (ℓ = 107 m)	m³	3.74	t = 30cm
3	Cutting and Banking (ℓ = 65 m)	m³	3.10	t = 10cm
4	Cutting and Banking (ℓ = 40.5m)	m³	2.08	t = 15cm
5	Cutting and Banking (ℓ = 35 m)	m³	2.35	t = 10cm
6	Land leveling	ha	1,234.57	
7	Road work	m	15.43	
8	Irrigation calal work	m	6.63	
9	Drainage canal work	m	12.03	
10	Pipe culvert (ϕ600)	place	622.55	
11	Box culvert	place	1,767.66	
12	Inlet work for A-type	place	195.54	
13	Inlet work for B-type	place	72.15	
14	Outlet work for 4m Type	place	246.16	
15	Outlet work for 2m Type	place	107.78	
16	Outlet work for 0.5m Type	place	83.72	
17	Tractor passage for A-type	place	930.57	
18	Tractor passage for B-type	place	2.34	
19	Tractor passage for C-type	place	651.31	
20	Tractor passage for D-type	place	1.17	
21	Band work	m	2.17	
22	Irrigation calal passage	place	822.87	
23	Division work for A-type	place	2,345.03	
24	Division work for B-type	place	1,919.80	
25	Stop gate	place	5,472.52	
26	Storage house	m²	750.00	
27	Land clearing	m²	0.37	
28	Water line work	m	9.97	

5-3 Specification

1. Contract

CONTRACT

ON

THE PILOT INFRASTRUCTURE IMPROVEMENT WORKS

FOR

THE IMPROVEMENT OF RICE CULTIVATION TEVHNOLOGY PROJECT

CONTRACT

on the Pilot Infrastructure improvement Works

for

The Improvement of Rice Cultivation Technology Project

This Contract is made entered into this _____ day of_____
at the JICA Suva Office between Japan International Cooperation Agency, Suva Offic by_____ Title_____
as its authorized representative of the Suva Office, hereinafter called "the JICA" of the one part, and _____
whose office is situated at _____
Represented by_____ Nationality _____ Title_____
hereinafter called "the Contractor" of the other part.

Both parties mutually agree under the terms of this Contract as follows:-

Article - 1 (a) (Description of Work)

Contractor shall carry out the construction of irrigated and rainfed rice fields and its related facilities for the Koronivia Research Station.

Article - 1 (b)

The following documents shall be deemed to form, be read and constructed as port of this agreement viz:-

i) Bill of quantities (itemized statement)

ii) The attached construction drawings

iii) The attached specification

Article - 2 (Contract Sum of Construction)

The contract sum of construction shall be F$ _____. ( ) and be based on the bill of quantities attached here.

Article - 3 (Time Limit on Construction and its Prolongation)

The Contractor shall start work within ten (10) days of signing by both parties of this agreement, and complete work by the __th of __ , 1987.

Article - 4 (Delays)

In a case where it is clear that the Contractor is failing to fulfil his obligations within the period referred to in the preceeding Article. The Contractor shall inform the JICA of this as soon as possible and if the JICA agrees that the delay is due to such causes as natural calamity or others for which the Contractor is not liable, a reasonable extension of time shall be approved. In this case, the sum referred to in Article 15 shall not be collected.

Article - 5 (Process of carrying out of Work)

The Contractor shall carry out the work in accordance with the drawings and specification referred to in Article 1(b). And in cases where it is necessary for carrying out such work as is not mentioned therein for the purpose of promoting the present construction or for reasons of established practices, the Contractor shall caryy out the said work under the direction of the JICA. In cases where the Contractor finds any doubt in the plans of construction, the Contractor shall ask the JICA for the necessary directions before commencing work

on that part for which there exists some doubt. The JICA must provide such information and details within seven (7) days of the written request from the Contractor.

Article - 6

The Contractor shall follow the direction of the JICA or the Engineer to be appointed by the JICA. As to materials for the construction, the Contractor shall use only those inspected and approved by the JICA or the Engineer appointed by the JICA. In cases where any defective work has been done as a result of such use of materials which have not been inspected by the Engineer. The Contractor shall be liable to change the materials or repair the work at his own responsibility. The construction shall be carried out in accordance with the proper technique and durability shall be the principal aim as regards to the construction.

Article - 7

As to the workman to be hired by the Contractor for the work, the Contractor shall assume the responsibility as entrepreneur or employer, as provided for by Laws and Regulations.

Article - 8 (Transfer of Right and Obligation)

The Contractor shall not assign or sublet to a third party the whole or part of the construction except in cases where the Contractor has obtained written approval from the JICA.

Article - 9 (Damages)

In cases where any damage is caused to the JICA or a third party, materials or buildings, through carelessness on the part of the Contractor during the course of work or transportation of materials, the Contractor shall be liable to repair or compensate such damage at his own expense by the date appointed by the JICA or the third party.

Article - 10

In case where the Contractor fails to repair or compensate such damages referred to in the proceeding Article by the fixed date, the JICA may pay for such repair on behalf of the Contractor and collect compensation from the Contractor by deducting the amount from the sum of construction to be paid to the Contractor under the provisions of Article 20, and in cases where the damages exceed the sum of construction, the JICA may collect the deficit.

Article - 11(a) (Change of Construction Drawing and Submission of Necessary Documents)

In cases where the JICA feels it necessary to discontinue work owing to unavoidable circumstances or to alter the plan of construction, the JICA may request the Contractor to calculate, on the basis of the unit prices as detailed in the priced bill of quantities referred to in Article - 2, as increase or decrease in the sum of construction resulting from the suspension or alteration of the work and the Contractor shall comply with the request. When the JICA orders such a suspension or alteration, depending on the statement of the above mentioned calculation, the Contractor shall submit a written consent by the date appointed the JICA.

Article - 11(b)

Where additional work cannot be properly measured and valued on the basis of the unit price in the bill of quantities referred to in Article - 2, the Contractor shall be allowed daywork rates in accordance with a written consent by the JICA .

Article - 12 (Price Adjustment)

(a) In the case of the costs of materials rising sharply as a result of the fluctuation in the market prices due to an unexpected change in the economic conditions, a reasonable adjustment of the above mentioned sum or the contents of the work, will be made according to a mutual agreement between the JICA and the Contractor.

(b) In a case where the Contractor incurs loss or suffers loss unreasonably in some item of Bill of quantities due to the JICA's failure to provide the information and details referred to in Article - 5 of the particular item or work, then reasonable adjustment of the above mentioned losses shall be considered by the JICA on the detailed claim submitted by the Contractor.

Article - 13 (Right to Rescind Contract and Penalty)

In cases where the Contractor fails to fulfil his obligations under this contract, the JICA may rescind the whole or part of the Contract. In such a case, the JICA may collect from the Contractor a sum as a penalty of 10 percent (10%) of the amount which is equivalent to the rescinded. In cases where the damages caused on the JICA, on account of the non-fulfilment of contract by the Contractor, exceed the sum referred to in the

preceeding paragraph, the JICA may further demand the Contractor to pay the excess.

Article - 14

In cases other than provided for in the preceeding Article where the Contractor fails to fulfil his obligations, or in cases where the fulfilment of obligation by the Contractor is regarded to be difficult, the JICA may have a third party fulfil, at the cost of the Contractor, the whole or part of the obligations of the Contractor. Even if liability of the Contractor exceeds the contract sum referred to in Article - 2 in consequence of this, the Contractor may not raise any objection to it.

Article - 15

In cases other than provided for in Article 13, where the Contractor fails to complete the construction at his own responsibility, within the period referred to in Article - 3, the Contractor shall be liable, a period fixed by the JICA, to pay the JICA, per week of delay, a sum equivalent to 0.2 percent (0.2%) of the contract sum referred to in Article - 2.

Article - 16 (Damages caused by Natural Calamity etc.)

In cases where serious damages occur to the completed part of the work, or the materials, tools etc., already carried into the field of construction, the Contractor shall promptly inform the JICA of the circumstances. If such damages are caused by a natural calamity, an earthquake, a flood, a civil war, a war, an epidemic, or a general/trade strike, rioting or other unavoidable reasons, for the occurance of which no responsibility

can be attributed to either the JICA or the Contractor and it is abmitted that the Contractor has paid the care of good administration to avoid the occurance of such damages, the JICA shall be liable for the amount of the damages which shall be fixed through negotiations between the JICA and the Contractor.

Article - 17(a) (Inspection)

The work at any stage shall be subject to inspection to be conducted by the JICA or an inspector appointed by the JICA, in the presence of the Contractor and necessary labour and articles required for such an inspection shall be provided by the Contractor.

Article - 17(b)

In cases where the work fails to pass the inspection referred to in the proceeding paragraph, the Contractor shall carry out necessary repair at his own cost, under the direction of the JICA.

Article - 18 (Date of completion of construction and obligation thereafter)

The date of completion of construction shall be regarded as that on which the final work, including removal of temporary constructions and cleaning, has passed the inspection referred to in Article - 17 and on that date the object of the total construction shall be delivered to the JICA by the Contractor. For a period of three (3) months thereafter, any defect in the construction, the cause of which is judged in the opinion of the JICA to be attributable to faulty or inadequate technique or materials employed by the Contractor, shall be immediately repaired or improved at the cost of the Contractor.

Article - 19(a)(Payment & currency)

The JICA shall pay to the Contractor in local currency as follows:-

Payment for the part of the work already completed shall be allowed by the JICA three times during the course of construction at the request of the Contractor, provided that it has passed the inspection referred to in Article - 17.

However, the amount of the payment shall be limited to ninety per cent (90%) of the work already completed. The final payment will be carried out within one month after the JICA receives the bill which will be submitted by the Contractor on or after the date of completion of construction referred to in the preceeding Article.

Article - 19(b)

Ten per cent (10%) of the contract price shall be paid as abvance payment for mobilization with order to commence, upon production of a refund bond or Bank Guarantee for the same amount as the said advance payment.

Article - 19(c)

This advance payment shall be adjusted from subsequent monthly bills by such sum as the proportionate to the monthly progress stated in the said bills.

Article - 19(d)

The refund bond or bank guarantee as provided in paragraph (b) here or shall be returned to the Contractor by the JICA upon the delivery of the works.

Article - 20 (Interest for the delay of payment)

In cases of the payment referred to in the preceeding Article being delayed owing to a cause or causes attributable to the JICA, the Contractor may request the JICA to pay, per week of delay, a sum equivalent to 1.0 per cent (1.0%) of the bill sum on arreare of payment.

Article - 21(a)(Settlement of dispute)

If there arises any dispute with regard to this Agreement or the construction Drawings or Specification referred to in Article - 1(b) it will be settled by a mutual consultion between the JICA and Contractor.

Article 21(b)

Should it not be possible to reach a mutual agreement between the JICA and the Contractor on such dispute, then it shall be referred to an Arbitrator or Arbitrators acceptable to both the JICA and the Contractor and the decision of this Arbitrator or/of Arbitrators shall be binding on both the JICA and the Contractor.

The Conclusion of the Agreement:

Two copies of the Agreement shall be prepared with the signature of both parties affixed to each of the copies, one copy to be held by each party.

Date :_____

.....JICA

Mr. _____ , Resident Representative
JICA, Suva Office

.....Contractor

.....Witness

.....Witness