FEASIBILITY REPORT
ON
THE KAMPHAENG SAEN IRRIGATED AGRICULTURE DEVELOPMENT PROJECT
IN
THE MAE KLONG RIVER BAISN
IN
THE KINGDOM OF THAILAND

APPENDIX

OCTOBER 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

No.=

FEASIBILITY REPORT

ON

THE KAMPHAENG SAEN
IRRIGATED AGRICULTURE DEVELOPMENT PROJECT

IN

THE MAE KLONG RIVER BAISN

IN

THE KINGDOM OF THAILAND

APPENDIX

OCTOBER 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

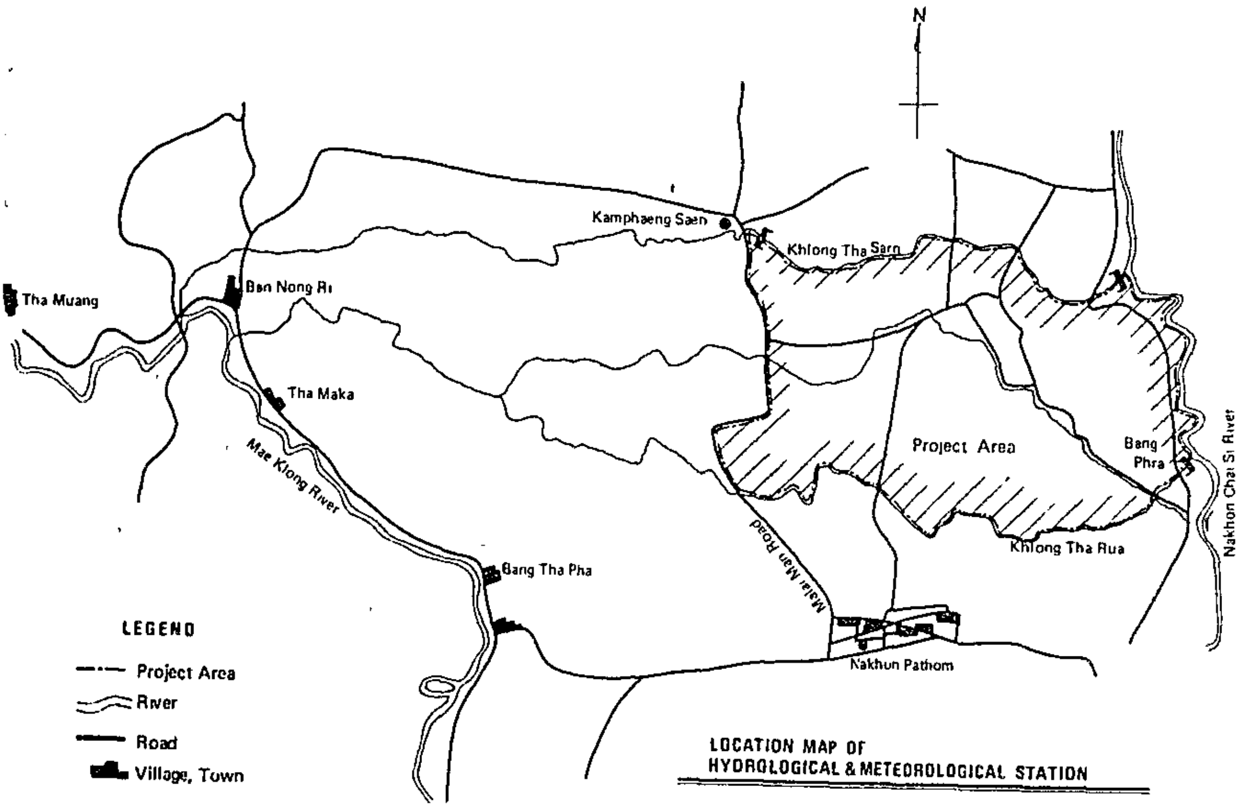
LIST OF APPENDICES

APPENDIX 1

HYDRO-METEOROLOGICAL DATA

HYDRO-METEOROLOGICAL DATA

List of Data



LOCATION MAP OF HYDROLOGICAL & METEOROLOGICAL STATION

Temperature, Relative Humidity, Wind Velocity, Sunshine Hours Duration
Evapolation (Pam - A class), 1973 – 1978, RAINFALL 1954 – 1977

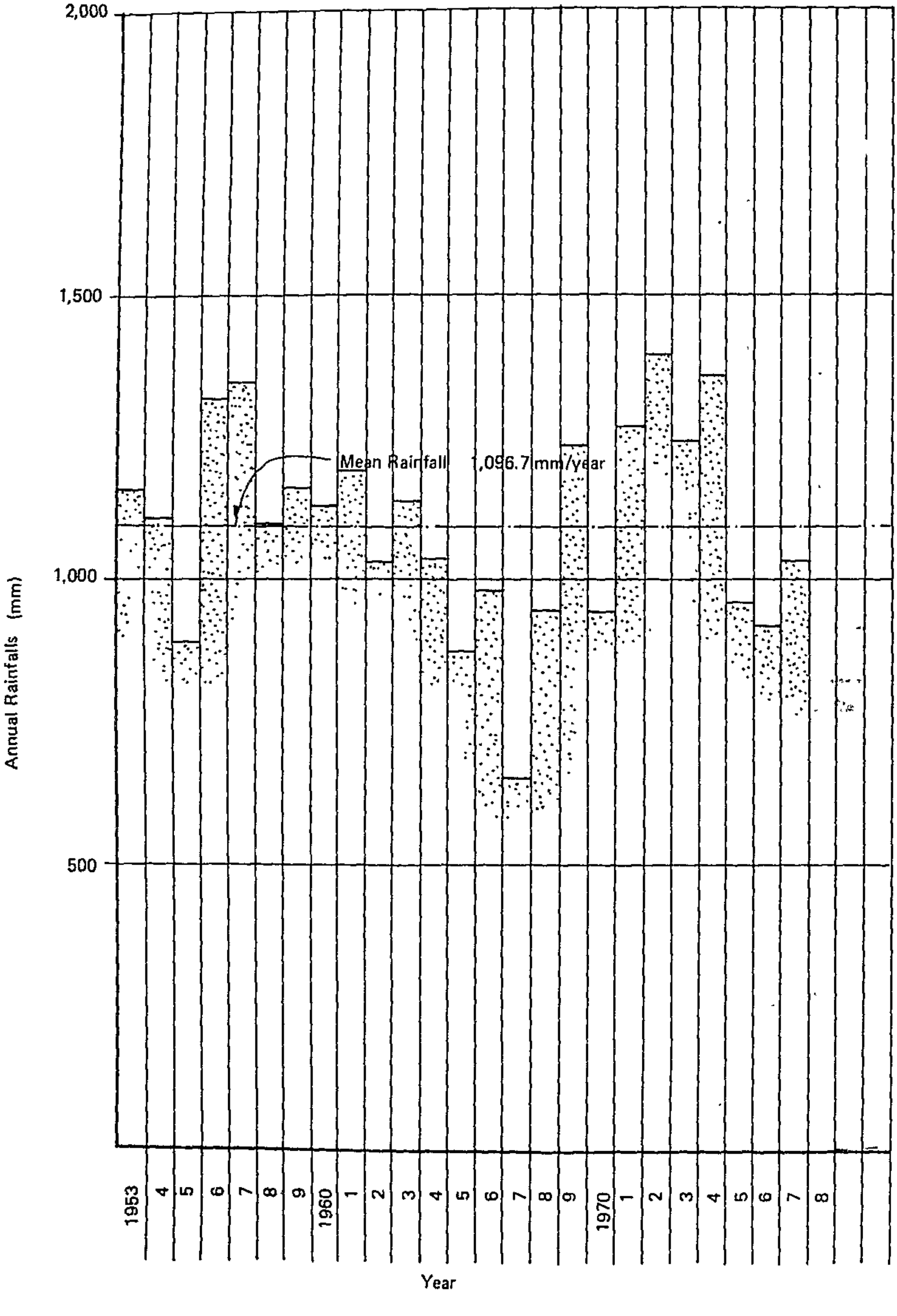
METEOROLOGICAL STATION

KAMPHAENG SAEN No 23052
Agrometeorological Division
Meteorological Department

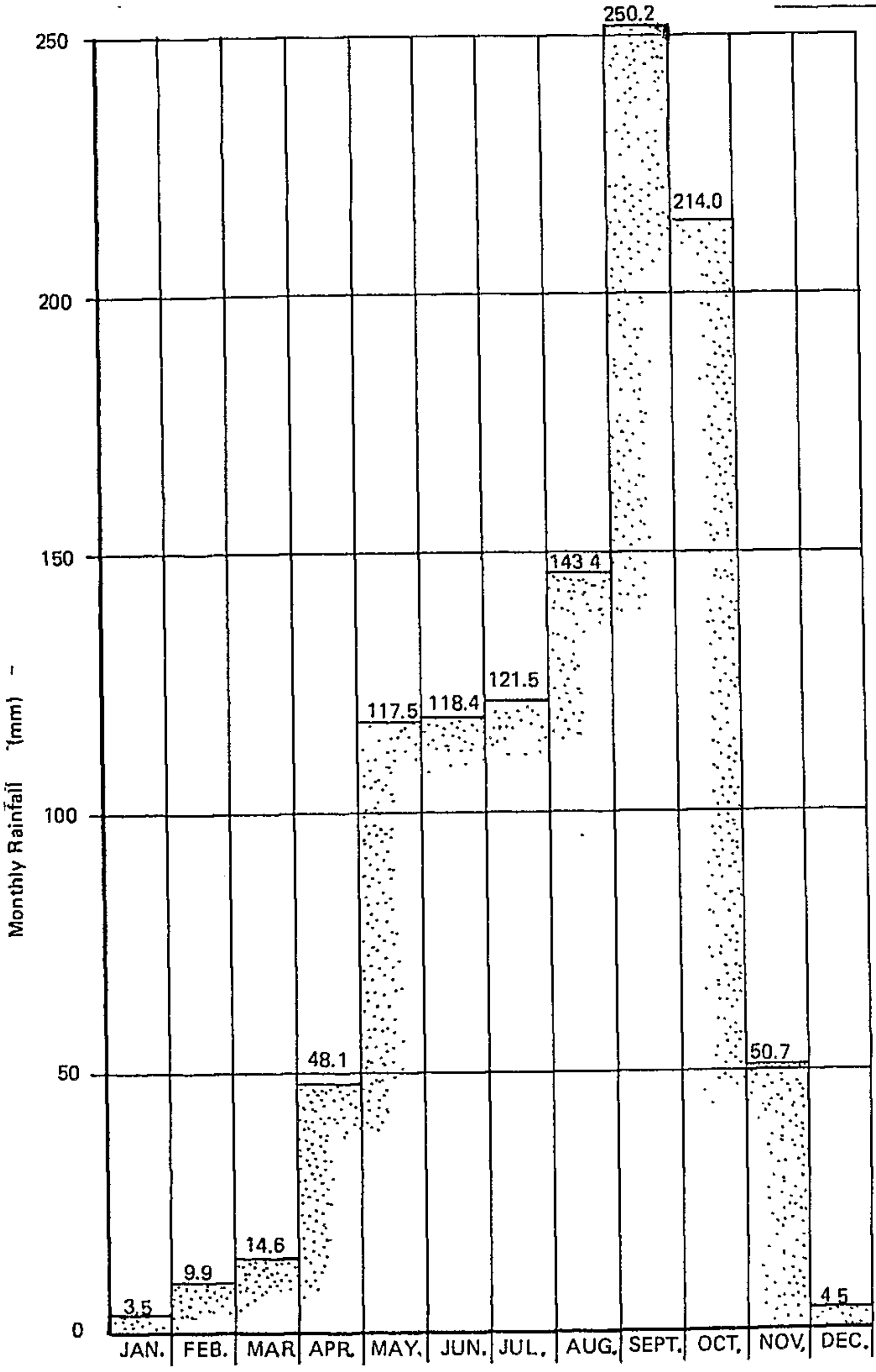
River Name	Data Available	Data Source
Mae Klong, Tha Sarn	1973 – 1975	ROYAL IRRIGATION DEPARTMENT
The Sarn	1965 – 1978	"
The Sarn, Nakhon Chai Si River	1971 – 1978	"
Tha Rua, Nakhon Chai Si River	1970 – 1978	"
Nakhon Chai Si River	1974 – 1978	"
Nakhon Chai Si River	1973 – 1978	"

WATER GAGE STATION

Tha Sarn Regulator
Kamphaeng Saen Regulator
Bang Pla
Bang Phra
Sup 45
Sup 46



Fluctuation of Annual Rainfalls (Station: 23052 Kamphaeng Saen)



Mean Monthly Rainfall Distribution

Station: 23052 Kamphaeng Saen
Period: 1952 to 1978

MAXIMUM DAILY RAINFALL

STATION: KAMPHAENG SAEN, NAKHON PATHOM (23052)

DATA PERIOD 1952 - 1978 27 YEARS

MAX.	RECORD (MM)	PERIOD	
1	132.60	6 Sep. 1972 - 6 Sep. 1972	****
2	127.30	1 Oct. 1967 - 1 Oct. 1967	****
3	125.80	1 Oct. 1963 - 1 Oct. 1963	****
4	124.20	5 Oct. 1960 - 5 Oct. 1960	****
5	112.30	27 Jun. 1958 - 27 Jun. 1958	****
6	102.00	19 Apr. 1977 - 19 Apr. 1977	****
7	100.60	1 Oct. 1957 - 1 Oct. 1957	****
8	98.90	2 Nov. 1969 - 2 Nov. 1969	****
9	98.80	7 Sep. 1962 - 7 Sep. 1962	****
10	92.00	25 Apr. 1953 - 25 Apr. 1953	****
11	91.30	9 Oct. 1955 - 9 Oct. 1955	****
12	90.10	30 Nov. 1970 - 30 Nov. 1970	****
13	85.20	16 Sep. 1971 - 16 Sep. 1971	****
14	83.00	15 Oct. 1956 - 15 Oct. 1956	****
15	79.60	1 Oct. 1959 - 1 Oct. 1959	****
16	76.50	7 Aug. 1961 - 7 Aug. 1961	****
17	74.90	21 Oct. 1952 - 21 Oct. 1952	****
18	73.60	10 Oct. 1966 - 10 Oct. 1966	****
19	72.20	18 Jun. 1975 - 18 Jun. 1975	****
20	71.90	3 Oct. 1973 - 3 Oct. 1973	****
21	69.70	15 Oct. 1974 - 15 Oct. 1974	****
22	69.50	28 Jul. 1964 - 28 Jul. 1964	****
23	68.10	6 Sep. 1976 - 6 Sep. 1976	****
24	57.90	24 Sep. 1968 - 24 Sep. 1968	****
25	55.80	1 Oct. 1954 - 1 Oct. 1954	****
26	40.30	1 Jun. 1965 - 1 Jun. 1965	****
			****
			0.0

EXCEEDING PROBABILITY

R.P.	PROBABLE VALUE
2Y	86.27
5Y	106.93
10Y	118.49
15Y	124.46
20Y	128.45
30Y	133.78
50Y	140.12

Meteorological Data

1) Major Meteorological Data of Kamphaeng Saen Station No. 23052.
(Latitude, 14°00 n, Longitude 99°59' E, 1973 to 1978)

Month	Monthly Mean Temperature (°C)	Monthly Mean Relative Humidity (%)	Monthly Mean Wind Velocity (m/s)	Monthly Mean Sunshine Hour (hrs/day)	Monthly Mean Evaporation (Pan-A mm/month)
Jan.	24.8	69	1.8	7.75	153
Feb.	26.4	67	1.8	8.03	164
Mar.	28.8	65	2.3	7.85	226
Apr.	30.3	65	2.2	8.35	246
May	29.0	72	1.8	6.37	189
Jun.	28.6	72	2.3	5.67	192
Jul.	28.2	72	2.2	5.00	177
Aug.	28.0	74	2.2	4.24	174
Sep.	27.6	77	1.4	5.32	147
Oct.	26.9	78	1.6	6.44	141
Nov.	24.6	77	2 4	7.60	143
Dec.	23.1	72	2.8	8.24	162
Annual Mean	27.2	72	2.1	6.74	176

2) Rainfall at Kamphaeng Saen Station

Annual Rainfall

Year	mm	Year	mm	Year	mm	Year	mm	Year	mm
1953	1,157	1958	1,098	1963	1,136	1968	949	1973	1,238
1954	1,108	1959	1,160	1964	1,037	1969	1,235	1974	1,358
1955	891	1960	1,130	1965	876	1970	945	1975	962
1956	1,317	1961	1,192	1966	983	1971	1,269	1976	921
1957	1,344	1962	1,029	1967	652	1972	1,396	1977	1,034

Mean Annual Rainfall: 1,097

Mean Monthly Rainfall

Month	mm	Month	mm	Month	mm	Month	mm
Jan.	3.5	Apr.	48.1	Jul.	121.5	Oct.	214.0
Feb.	9.9	May	117.5	Aug.	143.4	Nov.	50.7
Mar.	14.6	Jun.	118.4	Sep.	250.2	Dec.	4.5

Exhibit-6

METEOROLOGICAL CHART AT KAMPHAENG SAEN

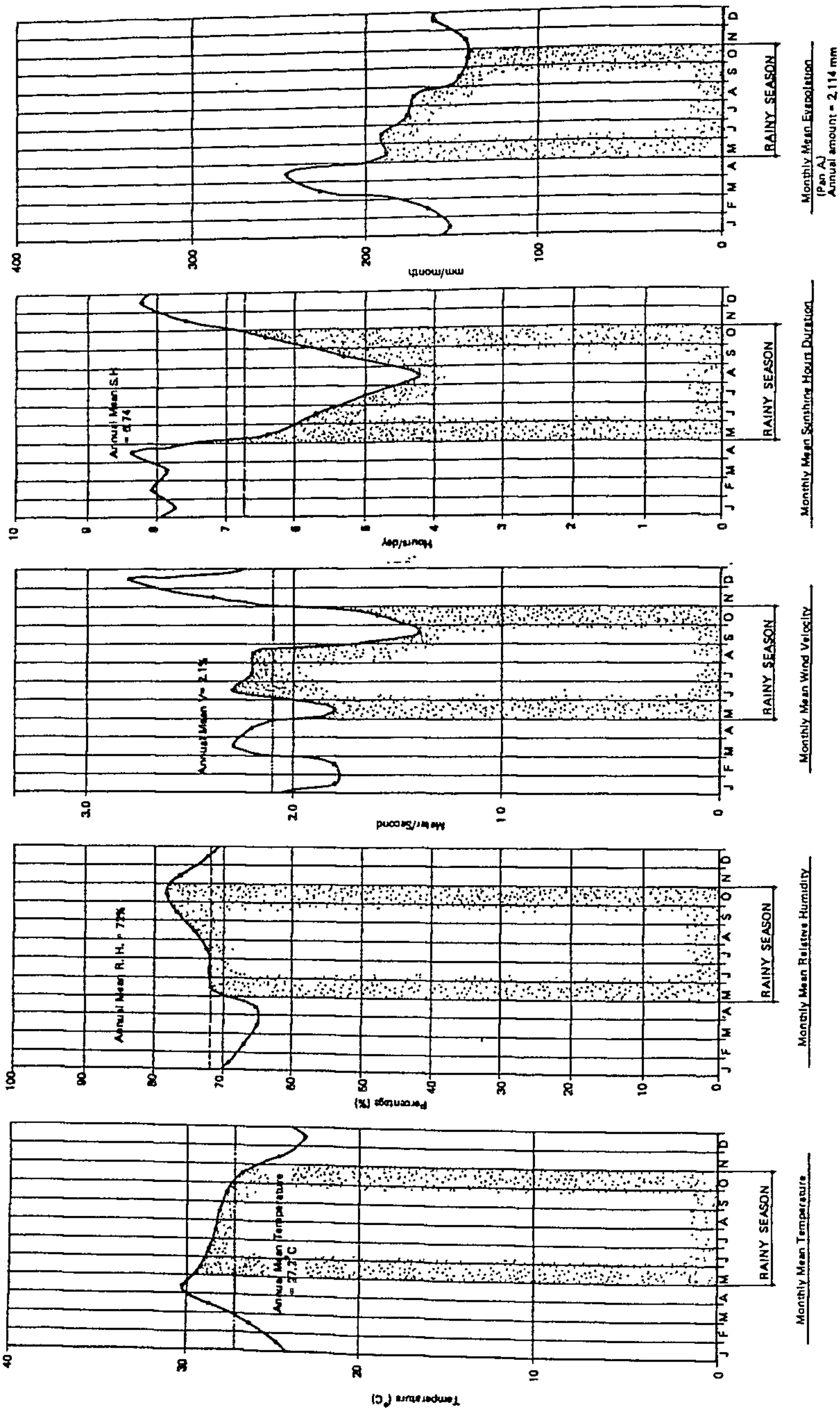


Exhibit-7

MAXIMUM SUCCESSIVE 2 DAYS RAINFALL

	Max. Record (mm)	Period
1	198.00	6 Sep. 1972 - 7 Sep. 1972
2	158.60	1 Nov. 1969 - 2 Nov. 1969
3	150.20	5 Oct. 1957 - 6 Oct. 1957
4	139.40	4 Oct. 1960 - 5 Oct. 1960
5	133.00	1 Oct. 1967 - 2 Oct. 1967
6	125.80	30 Sep. 1963 - 1 Oct. 1963
7	120.60	18 Jun. 1975 - 19 Jun. 1975
8	120.50	3 Oct. 1973 - 4 Oct. 1973
9	120.40	23 Aug. 1962 - 24 Aug. 1962
10	119.50	21 Oct. 1952 - 22 Oct. 1952
11	118.00	14 Oct. 1956 - 15 Oct. 1956
12	112.30	26 Jun. 1958 - 27 Jun. 1958
13	104.50	5 Sep. 1976 - 6 Sep. 1976
14	102.00	18 Apr. 1977 - 19 Apr. 1977
15	100.40	17 Oct. 1959 - 18 Oct. 1959
16	99.60	9 Oct. 1966 - 10 Oct. 1966
17	96.50	21 Sep. 1974 - 22 Sep. 1974
18	94.30	25 Apr. 1953 - 26 Apr. 1953
19	92.80	15 Sep. 1971 - 16 Sep. 1971
20	91.40	20 Sep. 1955 - 21 Sep. 1955
21	90.40	18 Apr. 1961 - 19 Apr. 1961
22	90.10	29 Nov. 1970 - 30 Nov. 1970
23	89.70	1 Oct. 1954 - 2 Oct. 1954
24	69.60	23 Sep. 1965 - 24 Sep. 1965
25	69.50	27 Jul. 1964 - 28 Jul. 1964
26	63.10	30 Aug. 1968 - 31 Aug. 1968

MAXIMUM SUCCESSIVE 5 DAYS RAINFALL

	Max. Record (mm)	Period
1	244.60	5 Oct. 1957 - 9 Oct. 1957
2	240.40	3 Sep. 1972 - 7 Sep. 1972
3	233.50	16 Sep. 1969 - 20 Sep. 1969
4	221.50	1 Oct. 1960 - 5 Oct. 1960
5	197.30	17 Jun. 1975 - 21 Jun. 1975
6	196.70	1 Oct. 1963 - 5 Oct. 1963
7	187.70	27 Jun. 1958 - 1 Jul. 1958
8	167.00	17 Sep. 1955 - 21 Sep. 1955
9	156.50	5 May 1966 - 9 May 1966
10	156.00	21 Sep. 1974 - 25 Sep. 1974
11	154.50	12 Oct. 1956 - 16 Oct. 1956
12	150.10	27 Sep. 1959 - 1 Oct. 1959
13	145.10	13 Sep. 1971 - 17 Sep. 1971
14	142.00	3 Sep. 1962 - 7 Sep. 1962
15	142.00	2 Oct. 1973 - 6 Oct. 1973
16	136.80	4 Sep. 1976 - 8 Sep. 1976
17	135.40	29 Sep. 1967 - 3 Oct. 1967
18	133.10	21 Oct. 1952 - 25 Oct. 1952
19	124.50	28 Apr. 1954 - 2 May 1954
20	112.30	15 Sep. 1977 - 19 Sep. 1977
21	107.80	20 Sep. 1965 - 24 Sep. 1965
22	107.00	24 Jul. 1964 - 28 Jul. 1964
23	100.70	24 Sep. 1968 - 28 Sep. 1968
24	99.70	15 Apr. 1961 - 19 Apr. 1961
25	97.30	23 Apr. 1953 - 27 Apr. 1953
26	90.10	26 Nov. 1970 - 30 Nov. 1970

MAXIMUM SUCCESSIVE 3 DAYS RAINFALL

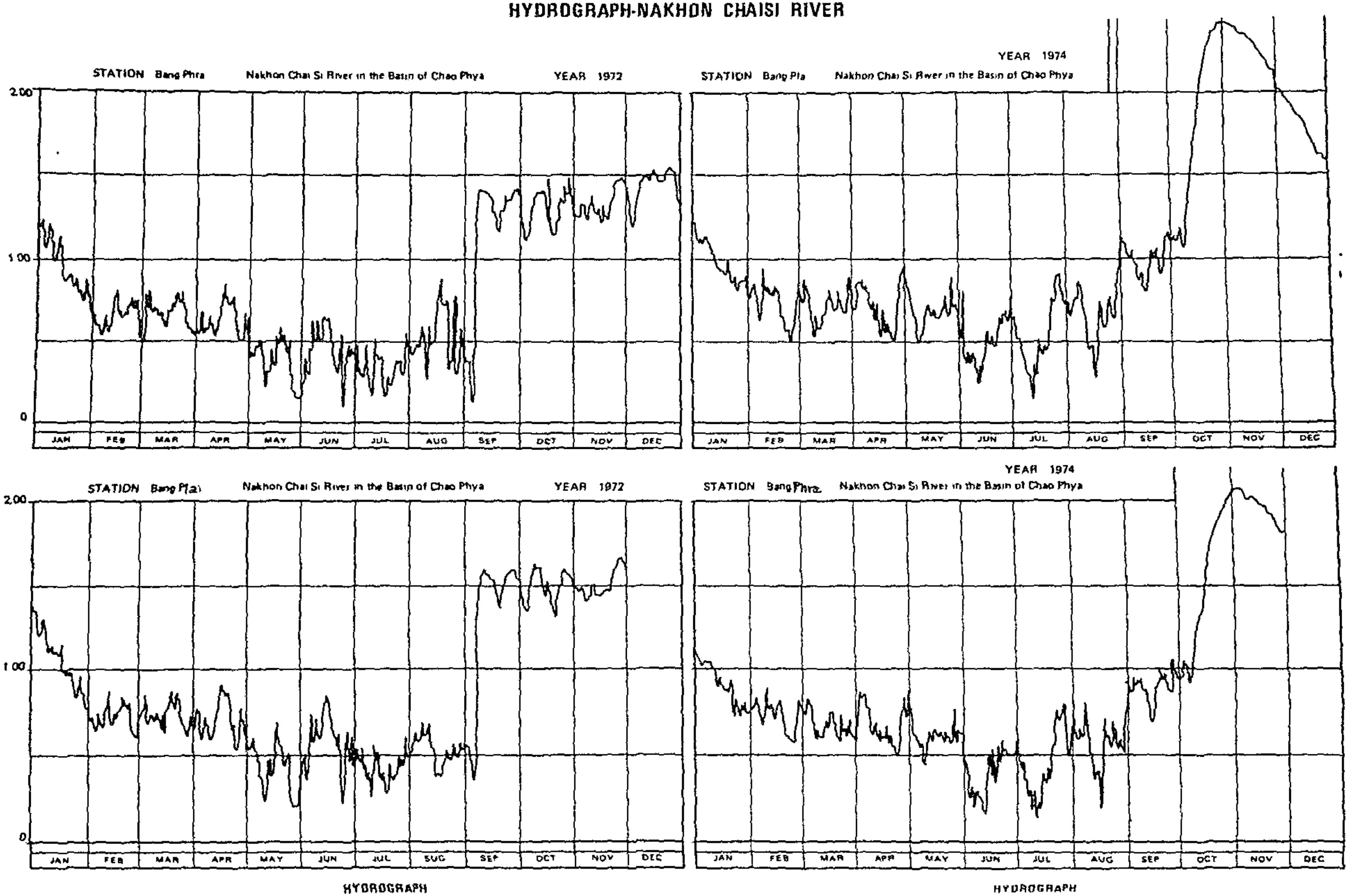
	Max. Record (mm)	Period
1	233.60	5 Sep. 1972 - 7 Sep. 1972
2	230.30	5 Oct. 1957 - 7 Oct. 1957
3	188.00	17 Sep. 1969 - 19 Sep. 1969
4	166.10	18 Jun. 1975 - 20 Jun. 1975
5	162.00	18 Sep. 1955 - 20 Sep. 1955
6	150.80	27 Jun. 1958 - 29 Jun. 1958
7	144.90	3 Oct. 1960 - 5 Oct. 1960
8	137.00	22 Sep. 1963 - 24 Sep. 1963
9	135.40	1 Oct. 1967 - 3 Oct. 1967
10	131.00	5 Sep. 1962 - 7 Sep. 1962
11	128.90	29 Sep. 1959 - 1 Oct. 1959
12	128.30	14 Oct. 1956 - 16 Oct. 1956
13	125.40	3 Oct. 1973 - 5 Oct. 1973
14	119.80	6 May 1966 - 8 May 1966
15	119.50	20 Oct. 1952 - 22 Oct. 1952
16	114.30	4 Sep. 1976 - 6 Sep. 1976
17	110.20	20 Sep. 1974 - 22 Sep. 1974
18	108.90	1 Oct. 1954 - 3 Oct. 1954
19	108.30	15 Sep. 1977 - 17 Sep. 1977
20	107.00	26 Jul. 1964 - 28 Jul. 1964
21	99.70	17 Apr. 1961 - 19 Apr. 1961
22	98.00	15 Sep. 1971 - 17 Sep. 1971
23	97.30	25 Apr. 1953 - 27 Apr. 1953
24	90.10	28 Nov. 1970 - 30 Nov. 1970
25	87.00	30 Aug. 1968 - 1 Sep. 1968
26	69.60	22 Sep. 1965 - 24 Sep. 1965

MAXIMUM SUCCESSIVE 10 DAYS RAINFALL

	Max. Record (mm)	Period
1	380.20	29 Sep. 1957 - 8 Oct. 1957
2	294.10	1 Oct. 1960 - 10 Oct. 1960
3	277.70	22 Sep. 1963 - 1 Oct. 1963
4	272.60	29 Aug. 1972 - 7 Sep. 1972
5	271.60	11 Sep. 1969 - 20 Sep. 1969
6	233.60	13 Oct. 1952 - 22 Oct. 1952
7	232.40	27 Aug. 1975 - 5 Sep. 1975
8	225.90	25 Jun. 1958 - 4 Jul. 1958
9	219.10	9 Oct. 1974 - 18 Oct. 1974
10	215.40	24 Sep. 1959 - 3 Oct. 1959
11	213.40	23 Sep. 1967 - 2 Oct. 1967
12	211.40	30 Sep. 1973 - 9 Oct. 1973
13	193.70	4 Sep. 1962 - 13 Sep. 1962
14	188.00	28 Aug. 1976 - 6 Sep. 1976
15	187.70	8 Sep. 1971 - 17 Sep. 1971
16	185.30	7 Oct. 1956 - 16 Oct. 1956
17	183.90	12 Sep. 1955 - 21 Sep. 1955
18	178.70	15 Sep. 1965 - 24 Sep. 1965
19	168.30	9 Oct. 1953 - 18 Oct. 1953
20	165.60	19 Jul. 1964 - 28 Jul. 1964
21	165.20	13 Sep. 1977 - 22 Sep. 1977
22	161.50	13 Aug. 1966 - 22 Aug. 1966
23	151.30	27 Aug. 1954 - 5 Sep. 1954
24	142.00	17 Apr. 1961 - 26 Apr. 1961
25	130.00	3 May 1968 - 12 May 1968
26	91.90	20 Sep. 1970 - 29 Sep. 1970

Successive Rainfall Data Station: Kamphaeng Saen, Nakhon Pathom (23052) Data Period: 1952-1978 27 Years.

HYDROGRAPH-NAKHON CHAISI RIVER



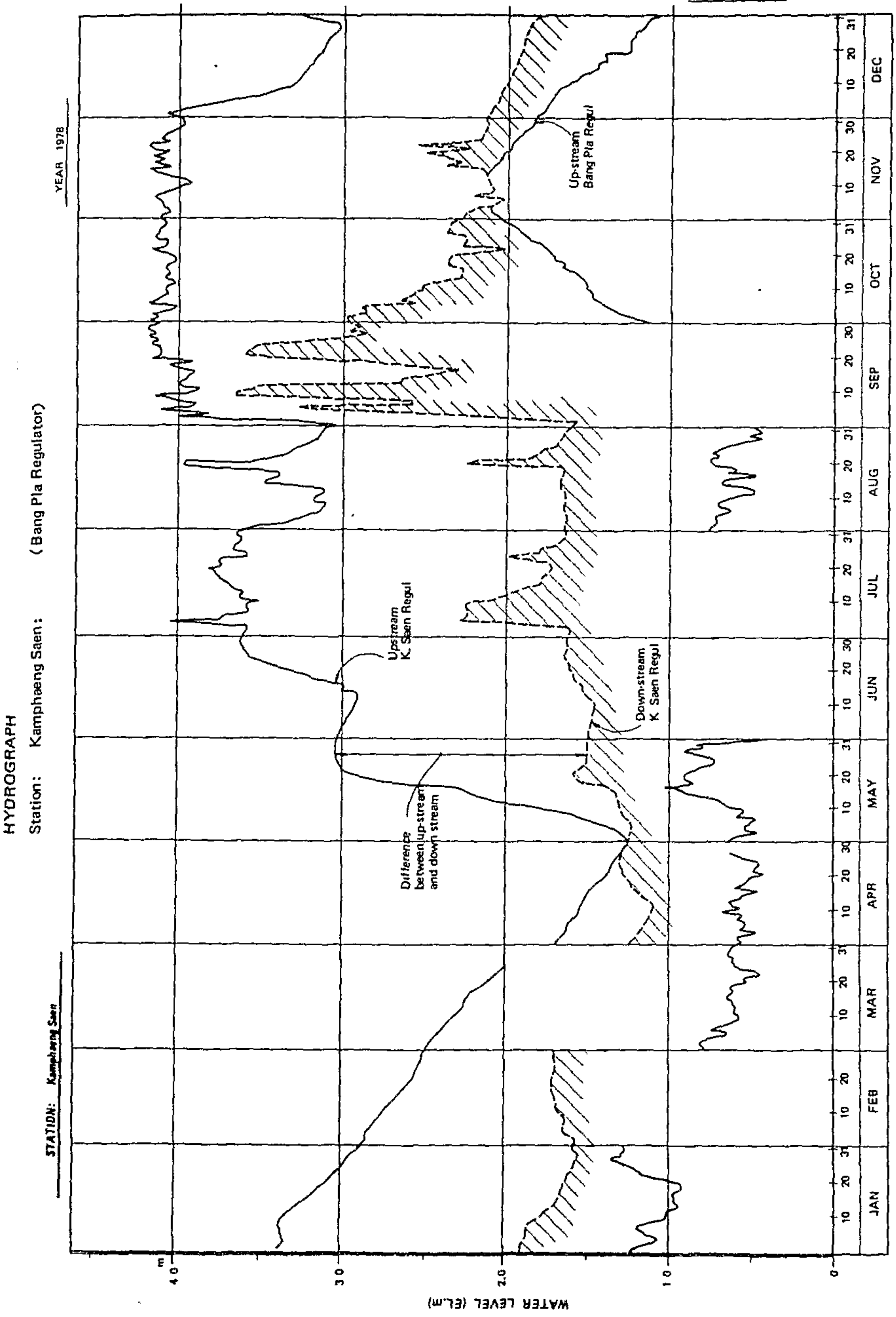

HYDROGRAPH
Station: Kamphaeng Saen: (Bang Pla Regulator)
YEAR 1978
STATION: Kamphaeng Saen
WATER LEVEL (EL.m)
m
4.0
3.0
2.0
1.0
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Upstream K. Saen Regul
Down-stream K. Saen Regul
Up-stream Bang Pla Regul
Difference between up-stream and down stream

Exhibit-10
continued

Hydrograph-Mae Klong River

WATER YEAR 1967
MAE KLONG RIVER BASIN

Mae Klong River at Wang Khanai, Kanchanaburi (K.11)

Location: Lat 13° - 56' - 55" N, Long 99° - 38' - 42" E, on left bank about 3 kilometers downstream from the district office of Amphoe Tha Muang, Kanchanaburi.

Drainage Area: 26,449 Sq.km.

Type of Gage: Staff gage.

Zero Gage at Bottom at: +11.93 m. (M.S.L.)

Bench Mark: B.M. - K.S.

Location: On left bank along the gage line.
Elevation: B.M.1 +22.097 m. (M.S.L.) and B.M.2 +22.224 m. (M.S.L.)

Gage Reading Frequency: 5 - time daily readings at 06.00, 09.00, 12.00, 15.00 and 18.00 hours.

Basis of Mean Daily Gage Height: Arithmetic mean of 5 readings.

Period of Available Gage Records: 1965 to date.

Rating Operation.

Period of Rating: 1955 - 70, 1973 to date
Rated by Float: -
Rated by Current Meter: 1955 - 70, 1973 to date

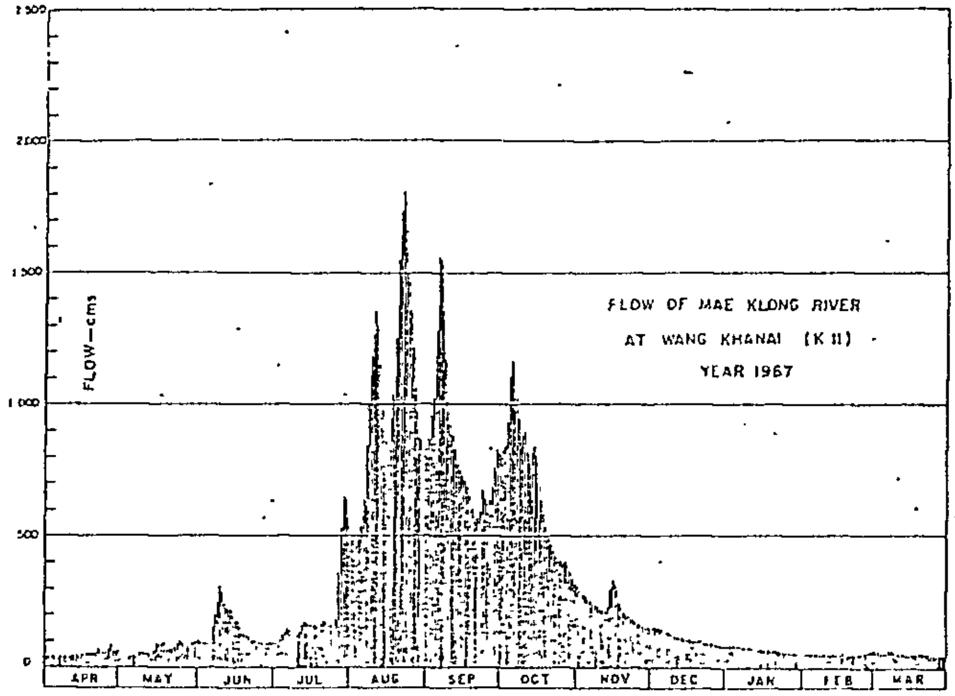
Stability of Channel Regimes: Unstable, no shifting adjustment for flow computation.

Overbank Flow Conditions: No overbank flow.

General Description: Records good. Stage - discharge relationship used is defined by discharge measurements made during 1967. Upstream state diversion for irrigation of about 2,950 hectares at Tha Lo Project about 12 kilometers above gage site.

GAGE HEIGHT IN METER (M.S.L.), WATER YEAR APRIL 1,1967 TO MARCH 31, 1968

Day	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1	12.39	12.51	12.97	12.87	15.53	16.41	16.42	14.47	13.52	13.03	12.74	12.77
2	.39	.49	.91	.93	.33	.68	.49	.35	.50	.02	.74	.70
3	.39	.45	.87	13.02	.15	.95	.53	.29	.48	.00	.73	[illegible]
4	.38	.42	.85	.14	.78	17.77	17.04	.24	.48	12.99	.72	.65
5	.38	.41	.91	.25	.57	18.45	.39	.18	.47	.98	.71	.62
6	12.38	12.45	13.37	13.31	15.98	15.43	17.14	14.12	13.44	12.97	12.70	12.7[illegible]
7	.37	.35	.74	.25	16.46	17.88	[illegible]	[illegible]	.41	.95	.69	[illegible]
8	.37	.47	14.03	.13	17.18	.77	15.72	[illegible]	.36	.95	.65	[illegible]
9	.37	.55	.30	.10	.58	16.81	.56	.01	.36	.94	.67	.66
10	.37	.57	.15	.15	.79	.64	.65	13.99	.34	.94	.66	.65
11	12.37	12.48	13.94	13.27	17.99	16.47	16.47	13.95	13.32	12.92	12.65	12.61
12	.37	.49	.87	.45	.69	.32	.25	.90	.30	.97	.66	.50
13	.40	.53	.84	.51	.00	.22	.34	.93	.28	.91	.65	.59
14	.41	.63	.75	.50	16.45	.17	.42	14.41	.26	.89	.65	[illegible]
15	.43	.68	.56	.43	.34	.12	.33	.56	.25	.88	.65	[illegible]
16	12.46	12.91	13.41	13.44	16.47	16.05	16.00	14.46	13.24	12.88	12.69	12.52
17	.50	.81	.39	.43	.81	15.93	15.78	.37	.21	.87	.67	.61
18	.52	.90	.33	.43	17.12	.82	.67	.09	.20	.86	.65	[illegible]
19	.49	.74	.19	.44	.70	.64	.45	13.98	.19	.86	.63	.59
20	.47	.69	.12	.46	18.59	.52	.33	.89	.18	.85	.67	.55
21	12.45	12.70	13.05	13.55	19.03	15.55	15.22	13.84	13.16	12.84	12.61	12.53
22	.67	.77	12.98	.50	.20	.63	.12	.78	.14	.87	.60	.55
23	.57	.90	.96	.46	18.84	.91	14.97	.73	.13	.87	.63	.54
24	.51	13.01	.93	.47	.30	.81	.89	.70	.12	.81	.64	.51
25	.54	12.93	.89	.50	17.92	.72	.95	.67	.12	.80	.67	.51
26	12.51	12.83	12.86	13.67	17.44	15.78	14.87	13.63	13.10	12.79	12.68	12.52
27	.82	.79	.86	14.44	16.97	.96	.91	.60	.05	.78	.75	.49
28	.61	.8[illegible]	.91	15.43	.58	16.20	.87	.58	.07	.77	.77	.45
29	.60	[illegible]	.87	.80	.37	.87	.76	.56	.05	.76	.79	.47
30	.57	.72	.86	.77	.37	.42	.62	.54	.03	.75		.46
31		.76		.66	.37		.51		.03	.74		.45
Mean	12.61	12.67	13.44	13.87	17.08	16.49	15.93	13.98	13.20	12.85	12.68	12.63
Max.	12.87	13.01	14.30	15.80	19.20	18.45	17.39	14.56	13.52	13.03	12.79	12.77
Min.	12.37	12.39	12.86	12.87	15.18	15.52	14.51	13.54	13.03	12.74	12.60	12.45



DISCHARGE, IN CUBIC METERS PER SECOND, WATER YEAR APRIL 1, 1967 TO MARCH 31, 1968

Day	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1	44	55	103	92	533	866	815	302	151	92	60	75
2	44	54	96	99	485	957	837	289	155	91	60	68
3	44	50	91	110	451	1,012	850	277	150	89	59	64
4	43	47	90	126	473	1,282	1,046	272	150	88	58	61
5	43	46	96	140	543	1,551	1,168	261	149	86	57	60
6	43	46	156	149	656	1,544	1,080	250	143	85	56	68
7	47	45	211	140	805	1,339	1,039	243	139	84	55	70
8	42	52	259	122	1,042	1,105	932	236	135	83	55	68
9	42	59	310	188	1,206	965	870	231	133	82	54	64
10	42	61	281	125	1,282	929	899	228	127	82	58	61
11	42	52	243	140	1,354	873	840	222	125	80	58	59
12	42	53	231	165	1,274	824	770	214	122	80	58	58
13	45	56	227	174	1,032	754	799	219	120	79	57	54
14	46	65	212	172	873	738	834	304	117	75	57	53
15	48	93	183	163	837	723	825	334	[illegible]	74	57	55
16	51	97	161	164	880	701	689	314	114	74	61	56
17	55	84	158	163	965	680	674	296	110	73	59	55
18	56	94	147	163	1,070	639	579	245	109	72	57	54
19	54	77	129	164	1,274	567	524	223	108	72	55	54
20	52	71	120	167	1,566	555	495	209	107	71	55	53
21	50	72	110	180	1,739	579	469	201	104	70	54	52
22	71	80	105	177	1,805	601	445	192	102	68	53	50
23	61	94	103	170	1,665	683	413	184	100	68	55	49
24	55	108	99	163	1,460	642	396	180	99	67	56	46
25	58	98	94	163	1,364	616	409	175	99	66	59	46
26	55	86	91	187	1,192	633	391	170	97	65	60	46
27	88	82	91	322	1,029	686	400	163	94	64	67	45
28	65	83	97	543	899	745	391	160	93	63	69	44
29	64	92	92	645	853	831	367	157	91	62	71	43
30	61	97	91	636	853	815	338	154	89	61	-	42
31	-	102	-	566	853	-	320	-	89	60	-	41
Total	1,546	2,257	4,477	6,603	32,313	25,455	20,835	6,905	3,635	2,326	1,690	1,714
Mean	51.6	72.6	149	213	1,042	848	672	230	117	75.0	58.3	55.3
Max.	88	108	310	645	1,805	1,551	1,168	334	153	92	71	75
Min.	42	45	90	92	451	555	320	154	89	60	53	41
Runoff - mcm.	133.747	194.573	385.813	570.499	2,791.843	2,199.312	1,800.144	596.592	314.064	200.966	146.016	148.090

WATER YEAR 1967 : Max. 1,805 Min. 41 Mean 301 Annual Runoff 9,482.659 mcm.

Momentary Peak Discharge

Date	Time	Gage-Height	Discharge	Date	Time	Gage-Height	Discharge
Aug.22	06.00	19.22	1,852				

APPENDIX 2

SOILS AND LAND CLASSIFICATION

SOILS AND LAND CLASSIFICATION

Table of Contents

SOILS AND LAND CLASSIFICATION

LIST OF TABLES

LIST OF FIGURES

SOILS AND LAND CLASSIFICATION

Introduction

The data available for soil survey in the Project Area are those obtained from the land classifications in the Great Mae Klong Development Project Stage I Feasibility Study (1962, RID) and the Detailed Reconnaissance Soil Survey of Southern Central Plain Area (SSR - 89, 1972) carried out from 1968 through 1971. The following studies were made as well as test pit surveys and boring test surveys on the representative sites in the Project Area, which had been carried out from 22 January through 17 March, 1979.

(1) Collecting and studying data on the Project Area and arranging the basic data and information available,

(2) Collecting, studying and arranging the data and information required for the Feasibility Study, and

(3) Preparing and compiling the maps and drawings necessary for study.

2-1. Background of the Survey

(1) Base maps and drawing

i) Topo-maps

The field survey was made by using the existing topo-maps (1 : 50,000) and newly prepared topo-maps (1 : 4,000, contours at 0.25 m intervals) as base maps. The aerial photos with scale of 1 : 4,000 were also used.

ii) Soil Map

In the Detailed Reconnaissance Soil Map of the Southern Central Plain (SSR-89), some parts along the National Highway 321 (Malaiman Road) in the Project Area were blanked. In order to supplement these blanks, the necessary data were obtained from the Soil Survey Division, Land Development Department in order to prepare the base soil map (1 : 50,000) for Feasibility Study.

iii) Land Classification Map

The land classification map (1 : 50,000) was prepared for the survey by compiling the map provided in the survey of the Greater Mae Klong Project Stage I.

(2) Test Pit Survey

Test pit survey was carried out in 14 points selected in the Project Area taking into account the distribution of soil unit and situation of land use. The survey was made on profile observation and measurement on soil hardness and field pH of soils. Also soil sampling was made at 13 points for soil analysis, which was entrusted to the Laboratory of Soil Chemistry and Fertility, Department of Agriculture, MOAC.

(3) Boring test survey

The boring test survey was carried out on representative Sample Area M-1 and M-2, among the six (6) selected sample areas. Boring sites were selected with 55 points in Sample Area M-1 and 30 points in Sample Area M-2 in applying 250 m - interval grids on the topo-maps of 1 : 4,000 (one point per 6.25 ha).

The survey was conducted by the Soil and Geology Division, RID according to the specific guidelines covering the topography, present land use, paddy yields in the sites, and soil color in each horizon, soil texture, mottles, concretions, gypsum, catclay, groundwater table at 150 cm boring depth and pH (both in field and laboratory) and electric conductivity (EC).

Measurements of pH and EC in laboratory were conducted by the Division of Research and Laboratory, RID.

2-2. Land Form

The Project Area is located at the eastern part of the tip of fan, formed by the Mae Klong river, extending in a gentle slope from low terraces at some six (6) meters in elevation along the National

Highway 321 running north to the plain area at one (1) meter in elevation along the Nakhon Chaisi river. Between the Klong Tha Sarn, the north boundary of the Project Area, and the Klong Tha Rua, the south boundary there run many old river courses formed by shifting of the Mae Klong river, functioning as natural drainage canals. Slightly undulating natural levees at about EL 4 to 5 m and strips of hollow lands extend along these old river courses. The topography becomes plain gradually apart from the natural levees to provide some lowest hollow lands below EL 1.5 m including sporadic marsh lands.

The land form of the Project Area can be roughly classified into four types as follows:

(1) Former tidal flat with recent marine and brackish water deposits

(2) Former tidal flat with old marine and brackish water deposits

(3) Flood plains of recent river alluvium

(4) Low terraces of semi-recent alluvium

Low terraces of semi-recent alluvium occupies about 55 percent of the Project Area, the largest occupancy of the above four types.

These terraces extend south-easterly from the National Highway 321, the western border of the Project Area, to the Nakhon Chaisi river along the Klong Tha Rua. The upstream portion of these terraces area are center of the upland crop farming with sugarcane growing as a major crop. The composition of the soil is Kamphaeng Saen/Nakhon Pathom Association (7,140 ha, 25.5%), Saraburi Series (4,000 ha, 14.3%), Kamphaeng Saen Series (3,330 ha, 11.9%) and Saraburi acid substratum variant (980 ha, 3.5%). On the other hand, the former tidal plain extends in the Project Area in bias from north to southeast. Bangken Series (4,960 ha, 17.7%) and Bang Len, overwash phase (200 ha, 0.7%) are distributed along the Nakhon Chaisi river. Ayutthaya Series (3,780 ha, 13.5%) and Sene Series (450 ha, 1.6%), both of which are specified as acid sulfate soils, are distributed in the inland part of the Project Area.

Most part of the former tidal plains have been used for paddy cropping; however, recently some ridged areas be digging along the Nakhon Chaisi river have been developed for vegetable and fruits gardens.

The areas with Bangken Series distributed are used only for the dry season paddy cropping due to being inundated in the wet season.

The floodplains of recent river alluvium, developed between the above two soils, occupies about 11.3 percent of the total acreage, and extends in those areas at comparatively low elevation because of its process of formation, being used mainly for paddy fields.

These soils are composed of Singburi Series (1,000 ha 3.8 %) and Singburi, acid substratum variant (2,100 ha, 7.5%). (See Table 2-1 and Figure 2-1).

2-3. Soils

In the Project Area, ten (10) mapping units, which are shown in Figure 2-2, were found and classified into two Great Soil Groups as Hydromorphic Alluvial Soil and Non-Calcic Brown Soil according to the soil classification employed in Thailand.

About 63 percent of the Project Area belongs to Hydromorphic Alluvial Soils including those of Bang Len, Bangken, Ayutthaya, Sena, Singburi and Saraburi and so forth.

About 54 percent of Hydromorphic Alluvial Soils is composed of Marine Alluvial Soil.

Non-calcic Brown Soil, developing on the natural levees and including those series of Kamphaeng Saen, Nakhon Pathom etc., occupies about 37 percent of the total.

In general view of the Project Area, the soils other than the

Kamphaeng Saen Series are considered to be suited for paddy cropping, although involving such bottlenecks for development as some acid sulfate soils, choronic inundation areas in the wet season, poor drainage soils in the low-lying marshy areas, etc.

(1) Specific properties of major soil series

Bangkhen Series

This soil series, which is formed from marine and brackish water deposits on the former tidal plains. The soils are clay. The fields of which are inundated in the wet season due to poor drainage, while there are a big crack in the dry season. Generally, the surface soils have moderate angular blocky structure, whereas weak prismatic structure are found in the subsoils.

The soil reaction is strong to slightly acid in the surface soils and slightly acid to neutral in the subsoils. They have moderately high natural fertility and fine gypsum crystals are found in the subsoils.

The areas with this series are not suitable for upland field due to inundation in the wet season, but suitable for paddy cropping. Most soils of this series are used for dry season paddy cropping and recently some of them have been ridged for vegetables and fruits gardens.

Ayutthaya and Sena Series

These series are the acid sulfate soil, which are distributed in the former tidal plains with marine and brackish water deposits. The soils, poorly drained clay, provide slightly weak structure with heavy cracks developing in the dry season. Fine gypsum crystals are found in the subsoils.

The yellow or pale yellow jarosite, which is one of the specific features of acid sulfate soil, is found in the different depths for the respective series, about 50 cm below the surface in Sena Series and 1.0 m or deeper in Ayutthaya Series. Both of the series have natural fertility to some extent, but are phosphorus-deficient soils due to strong acidity. The fields with these series are suitable for paddy cropping, while having a little suitability for upland cropping.

Singburi Series

They are clayey soils and occur on floodplain of recent alluvium developed in swampy area behind the river. They are clayey soils with moderate angular blocky structure and developed cracks in the dry season and flood in the wet season. These soils have slow permeability and moderately high natural fertility. The soil reaction is alkaline and these soils are suited for rice production but generally not suited for upland crops.

Soil unit of Singburi, acid substratum variant are developed under similar process of formation but they have fine gypsum crystals in the subsoil. The soil reaction is neutral to slightly acid in the surface soil and strong acid in the subsoil. They have similar natural fertility as Singburi soils and are suited for paddy field.

Kamphaeng Saen Series

Kamphaeng Saen series are formed from semi-recent alluvium and developed on natural levees. They are well-drained clay loam or loam with weak angular blocky structure and having calcium carbonate or fine mica flakes. They have moderately rapid permeability and moderately natural fertility, through being liable to causing moisture deficiency as upland field. The soil reaction is slightly acid in the surface soils and mildly alkaline in the subsoils. Since this series occurs on relatively elevated portion, these soils are mainly used for residential area and also have a high potentiality to be used for upland field.

Kamphaeng Saen/Nakhon Pathom Association

These soils are composed of Kamphaeng Saen and Nakhon Pathom series which occur in geographical association. Nakhon Pathom soils are formed from semi-recent alluvium and occur on low slopes of natural levees. They are somewhat poorly-drained loam or clay loam with moderate angular blocky structure and have calcium carbonate nodule in some location. They are moderately natural fertility.

The soil reaction is medium to slightly acid in the surface soils and neutral to mildly alkaline in the subsoils. This association is mostly used for paddy field and occupied about 25.5 percent of whole project area. The present land use of this soil depends largely upon the water availability because there are complex of two different soils that are suitable for paddy field (Nakhon Pathom series) and for upland field (Kamphaeng Saen series).

Saraburi Series

These soils are formed from semi-recent alluvium and occur in swampy area behind semi-recent terraces. They are somewhat poorly drained clay with weak to moderately angular blocky structure and they have calcium carbonate nodule in some portion. The soil reaction is medium to slightly acid in the surface soils and neutral to mildly alkaline in the subsoils. They have moderately high natural fertility and are suited for paddy field but not suitable for upland field.

Saraburi, acid substratum variant occurs on transitional parts between semi-recent terraces and former tidal flat and they are somewhat poorly and poorly drained clayey soils. The soils become so dried up as to develop cracks in the dry season, while being submerged in the wet season. They have weak to moderately angular blocky structure with fine gypsum crystals in deeper subsoil.

The soil reaction is medium to slightly acid in the surface soils and strong to very strong acid in the subsoils. They have moderately high natural fertility and are suited for paddy field.

(2) Test Pit Survey

The test pit survey was carried out at representative 14 points

(10 in paddy fields and 4 in upland fields) in the Project Area and the general descriptions of the survey were illustrated in Table 2-2.

The observation of morphological characteristics as the paddy soils could not make because the survey was conducted during the middle of dry season (in February) and that paddy fields had been dried up to develop deeper cracks up to 30 to 40 cm below the field surface. Therefore, the best period for soil survey would be a period between the middle of July and middle of September.

The details of test pit profiles are illustrated both in Table 2-3 and Figure 2-3, and the following outline the survey.

The patterns and distribution of mottles suggest that there have been a downward movement of irrigation waters in every test pit.

The surface soils in general, have many strong brown or yellowish red mottles, while the subsoils have grayish mottles indicating reductive spots such as brownish gray, dark gray, gray or greenish gray. This would result from the fact that the soils provide high water holding capacity but less permeability.

In test pits No.1, 2, 4, 8 and 10 relatively coarse prominent red mottles were found together with many fine gypsum crystals in the subsoils 40 - 50 cm below the ground surface. This fact reveals that these test pits are located in the former tidal plains.

In the test pit No.8, yellow or pale yellow mottles characterizing the acid sulfate soil were found together with the above-mentioned red mottles in the depth between 45 and 55 cm below the ground surface, and also in the test pits No.1, 2 and 4, the same yellowish mottles were found in the depth between 120 and 180 cm below the ground surface.

These results suggest that the soils of test pits No.1, 2 and 4 belong to Ayutthaya Series and those of test pit No.8 belong to Sena Series, respectively.

The jarosite is formed by oxidation of pyrite in the soils; such oxidation is said to take place in the dry season when the groundwater table falls to the uppermost of the reduced horizon. Judging from these facts, it is estimated that the groundwater table in the test pit No.8 is considerably high even in the dry season, while those in the test pit No.1, 2 and 4 fall to some 150 cm in the dry season.

Concretions of iron and manganese have a relation to downward movement of irrigation water, and the occurrence of these concretions in the profiles of deeper horizon can also prove that there has been a downward movement of the irrigation water.

In the test pits No.6, 9, 17 and 18, some calcium carbonate nodules were found, and these would be originated from the water supplied by Mae Klong river.

Judging from soil profiles and locations of the pits on the soil map, the pits No.6, 9 and 17 will belong to Saraburi Series and the pits No.12 and 18 will belong to Kamphaeng Saen Series.

The soil textures of the respective pit soils are shown in Tables 2-3 and 2-4 and Figure 2-3, which clarify that clay is a major component of the soils, and clay loam are found in the surface soils of the pits No.11 and 13, and only some sandy clay loam are found between 38 and 70 cm depth from the ground surface of the pits No.2 and 4.

Figure 2-4 shows proportion of particle size of the soils sampled at five (5) points in the paddy fields. The figure reveals that the soils in the pit No.9 contains about 73.7 percent of clay at the third layer, and those developing on the natural levees (Nos. 13 and 18) are liable to contain less clay contents than other soils. Furthermore, a tendency was observed that the deeper horizons contain much clay particle than the upper horizons. This phenomenon would result from the downward movement of clay particles by percolating water.

The results of chemical analysis on the respective soil samples are shown in Table 2-5. A general tendency shows that the soils belonging to non-calcic brown soil have a higher pH values than those soils formed from marine and brackish water deposits or river alluvial deposits. The soils distributed in the lower horizons have higher pH values than those soils in the upper horizons, except the acid sulfate soil; in other words, the surface soils of the paddy fields show medium to strong acidic reaction (pH 5.0 - 6.0), while the subsoils show slightly acidic to moderately alkaline reaction (pH 6.1 - 8.3). Contrarily, the soils of the sugarcane fields show adverse tendency to the above, that is, higher pH value in the surface soils than in the subsoils.

Organic matter are contained by 1.45 to 2.48 percent in the surface soil, which is classified into the medium content of organic matter; whereas the organic matter contents in the subsoils below 30cm is lower from one (1) percent or less.

The annual alternation of drying and flooding of soils under the high temperature should affect on the mineralization of organic nitrogen. As a result, the decomposition of organic matter would be promoted to decrease the contents of organic matter and soil nitrogen.

In terms of soils of the paddy fields, the organic matter contents of the pits No.2, 4, 8 and 10 are slightly higher than those of other soils. It is considered that the low soil reaction in these soils has prevented decomposition of organic matter. In other respect, there is a tendency that the paddy fields with two paddy a year contain less organic matter than those with single paddy a year.

Most of the soils show a tendency to have low available phosphorus almost below 5 ppm, although the surface soils contains much available phosphorus as compared with the subsoils. Particularly, the soils of narine and brackish water deposits are low in the available phosphorus.

The contents of available phosphorus in the sugarcane fields are more than that in the paddy fields. This fact is probably in parts due to residual of phosophorus fertilizer applied.

The cation exchange capacity (CEC), indicating nutrients absorption capacity of soils, is considered as an index of soil fertility. The CEC of the surface soils is as low as 10 meq/loog, except those of the pits No.9 and 10, and the CEC of the subsoils ranges from medium to moderately high in the pits No.6, 8, 12 and 18.

The soils in every pit show considerably high base saturation percent, and generally, the soils with high base saturation percent have superior physio-chemical properties and give favorable effect to activities of microbes in the soils; particularly, calcium salt give favorable influence to physical properties of the soils.

Figure 2-5 illustrates the composition of exchangeable cation in the paddy fields. The said figure reveals that exchangeable cation in most of soils except those in the third horizon of pit No.2 (43 - 70 cm, sandy clay loam), and exchangeable potasium accounts for only 1 to 2 percent of all exchangeable cations.

Exchangeable sodium widely varies from 3 to 35 percent with increasing tendency in the marine and brackish water deposits. Every exchangeable cation contained much in the deeper horizons and more exchangeable calcium was found in the horizons having gypsum and calcium carbonate nodule than in other horizons.

Results of electric conductivity (EC) indicated that most of the soil samples had comparatively low EC values, except the sample taken at 54 - 100 cm deep in pit No.8 and at 65 - 100 cm deep in pit No.4 which gave 3.3 m mhos/cm and 3.6 m mhos/cm, respectively.

The surface soils generally have higher EC values than the subsoils. Every EC values measured, however, show lower value compared crop growth. Therefore, there are no problems on crop growth in terms of the salinity in the test pit areas. As mentioned in the following paragraph, however, there may be a large possibility existing in the local high accumulation of salts.

Tables 2-5 and 2-6 show the results of estimation on natural soil fertility of the surface and subsoils at every test pit on the basis of chemical analysis.

The above table suggest that the soils at every test pit will have medium to moderately low natural fertility.

Profile surveys of the soils found that there were some different soils distributed from those indicated in the soil map; for instance, the soils of pits No.1 and 4 can be classified into Ayutthaya Series because gypsum and catclay were recognized around 100 cm deep from the ground surface, whereas the same were indicated by Saraburi, acid substratum variant (Map Symbol 53) and Saraburi Series (Map Symbol 52) in the soil map.

Another examples show that the soils of pits No.17 and 9 are indicated as Saraburi, acid substratum variant and Singburi, acid substratum variant in the soil map, whereas the soil reactions and occurrence of calcium carbonate suggest different characteristics of the profile in subsoils from those of acid substratum variant.

The discrepancy mentioned above might be due to the use of Detailed Reconnaissance Soil Map as base map. It is recommended, therefore, that further detailed soil survey should be carried out for successful farm management in the development program as well as providing the basic data and information.

(3) Boring test survey in the Sample Areas

Two sample areas, Sample Areas M-1 and M-2, where selected among six (6) proposed sample areas for land consolidation scheme in referring to base maps for field survey (1 : 4,000) and existing aerial photos available. In the above two Sample Areas, the boring test survey was carried out to take samples from the points at every 250 m intervals. The soil samples were measured on pH and EC, respectively.

i) General descriptions of Sample Areas
(See Figure 2-6 and 2-7)

Sample Area M-1

This area is located in Tambon Sam Ngan north of Don Tum having an acreage of about 290 ha bordered by Klong Tha Sarn at north, 7L-1R-Il-5L at east, 1R-1L-5L at south and road leading to Tako Sung via Ban Laem Makula at west.

The drainage canal 2R, excavated from almost the center of Area to northwest to reach Klong Tha Sarn, drains the lands. In general view, the Sample Area M-1 is well-drained or fairly-drained, although boring test confirmed the groundwater table in a range from 50 to 100 cm deep from the ground surface.

The area is roughly divided into two parts, the one located in the south and west edges at EL 2.5 - 4.0 m with slightly uneven upland fields and residential area, and the other located west of 7L-1R-5L with low-lying paddy field areas. Borrow pits along the canals are used for farm ponds and irrigation is executed by five (5) terminal ditches branched off from 7L-1R-iL-5L.

In the eastern part of the Area, there appear the soils of marine and brackish water deposits containing fine gypsum crystals and cat-clay, while in the natural levees at western borders there appear the soils of semi-recent alluvium containing calcium carbonate nodule and mica flats and in a part of the south there are well-developed soils in the alluvial floodplains. Briefly, the Sample Area M-1 is complex in soil composition with different kinds of parents materials.

The effective depth of soil was deeper than 150 cm, except that the presence of limestone layer was found at 70 cm depth from the ground surface in the boring test No.44 site. Most part of surface soils in the lowlying area are clay and the medium textured soils (SL, L SiL, CL, SCL, SiCL) were found in the slightly uneven natural levees.

The soil texture of the subsoils have similar nature to those of the surface soils, but there are many cases that the clay appear in the depth of 100 to 150 cm from the ground surface. (See Figure 2-8)

Figure 2-9 shows the outline of the present land use. Most of the upland fields are cropped with lead trees, bananas, mangos, coconuts, sugarcanes, etc., and the paddy fields are used mainly for the dry season transplanting paddy.

The paddy yield survey was carried out at 21 points to obtain the results as follows:

Below 1.25 ton/ha	2 points
1.25 - 1.88 "	9 "
1.88 - 2.50 "	8 "
2.50 - 3.12 "	2 "

The farm-economy survey made by RID for the Kamphaeng Saen Project Area resulted in the average paddy yield of 1.56 t/ha (for 15 farmers) in Tambon Sam Ngan including the Sample Area M-2. And comparison of the current survey results with the RID's result sugests that the yield in the Sample Area M-1 is a little higher than the average yield of the whole Project Area.

Furthermore, the current survey revealed that the paddy yield at the field with groundwater table within 150 cm from the ground surface ranged from 1.88 to 2.50 t/ha, which is slightly higher than that in other fields of the Area.

Sample Area M-2

The Sample Area M-2 is located in the south of Don Tum, administratively belonging to Tambon Sam Ngan, similar to Sample Area M-1.

The Area has an acreage of about 210 ha, bordered three sides by two canals of 2R-1R-1L-5L and 1L-2R-1R-1L-5L with their diversion site as a starting point.

In the almost central part (a little baised to the east), a drainage canal runs through, reaching the drainage canal 5R-1L (Tharua-Bangpan-Old river course), and in the northeast corner of the Area there is a marsh area extending with inundation 50 - 100 cm deep in the wet season. In general, the Area is well-drained or fairly-drained, and the groundwater table seems to fall to 100 - 150 cm or so in the end of the dry season. The current survey, however, found the groundwater table within 150 cm from the groundsurface in the western part of the Area (No.27, 28, 30) and the southern part No.7, 10).

The borrow pits along the canals are used for farm ponds and six (6) terminal irrigation ditches were excavated.

The Sample Area M-2 is roughly divided into two parts by the lands at EL 2.5 - 3.0 m (residential areas and upland fields) extending in bias from southwest to eastern borders. The low-lying lands below EL 2.5 m are used mainly as paddy fields, where there are soils originated from marine and brackish water deposits having fine gypsum crystals and catclay.

On the other hand, river alluvium occur on slightly high elevated lands. The surface soils are fine or medium-textured soil, although the medium textured soils prevail in slightly uneven parts an shown in Figure 2-10. Most of the subsoils are fine textured soil (SC, SiC, C), and the effective depth of soil in more than 1.5 m. Little land levelling works will be required for this Area.

Figure 2-11 shows the general description of the present land use. The upland fields are cropped with sugarcanes, lead tree, bananas, mangos, coconuts, etc., while the paddy fields are cropped with dry season transplanting paddy.

The paddy yield in the Sample Area M-2 are high as compared with that in the Sample Area M-1. The yield survey found the results as follows;

1.25 - 1.87 t/ha	5 points
1.87 - 2.5 "	5 "
2.5 - 3.12 "	2 "

ii) Soil Reaction

Varied soil reactions were observed in both Sample Areas. As shown in Figure 2-12, many soils with acidic reaction were found in Area M-2, while in Area M-1, many soils have neutral or alkaline reaction. These reactions are considered due mainly from influence of acid sulfate soil in Area M-2 and from considerably strong influence of fluvial deposits of the Mae Klong river in Area M-1.

The soil reactions in both Sample Areas can be grouped into six (6) as follows.

Pattern of pH status in the sample area

Surface soil	Subsoil	Area M-1	Area M-2
1) pH 5.0 - 7.3	pH 5.6 - 7.3	29	13
2) pH 5.5	pH 7.4	1	0
3) pH 7.4	pH 7.4	1	1
4) pH 5.5	pH 5.5	1	9
5) pH 5.5	pH 5.5	5	2
	pH 7.4	10	1
Subsurface soil	Surface soil		
6) pH 5.6 - 7.3	pH 5.5	6	1
	pH 7.4	2	1
	Total	55	30

The soil reaction with pH 5.6 - 7.3, which are to be tolerable to crop growth, were found 27 points in the Area M-1 and 13 points in the Area M-2. Contrarily, the soils with strong acidic reaction or alkaline reaction both in the surface and sub-surface were found at 3 points in the Area M-1 and 12 points in the Area M-2.

The soils with strong acidity or alkalinity in either surface or subsurface, which are considered critical to crop growing, were found at 23 points in the Area M-1 and five (5) points in the Area M-2.

On the surface, the soils below slightly-acidic-reaction were found at 38 points (pH 6.5 - 4.7) and those with alkalinity (pH 7.4 - 7.7) were found at four (4) points in the Area M-1, while 20 points (lowest pH 4.5) and four (4) points (highest pH 7.9) were found respectively in the Area M-2.

On the other hand, on the subsurface, the soils having felow slightly acidic reaction (lowest pH 5.9) were found at 27 points as those with alkalinity (highest pH 8.0) were found at 13 points in the Area M-1, while 20 points (lowest pH 4.2) and at four (4) points (highest pH 8.0) were found respectively in the Area M-2.

The above data suggest that the subsurface soils in the Area M-1 widely distribute those with neutral or alkaline reaction.

Although, in general, the soils of the paddy field areas in the Area M-1 have a tendency of soil reaction as, subsoils surface soils, the similar tendency was observed in the upland field soils in the Area M-2.

Commonly, when the soil reactions are below pH 5.0 fixation of phosphoric acid, leaching of potasium and hazards by excessive aluminum and manganese tend to take place; contrarily when over pH 7.4 (alkaline reaction), the deficiency tends to take place with boron, iron, manganese, etc.

The soils in the Sample Areas will substantially involve the latent problems as mentioned above, although no factual information could be obtained during the current survey.

In due consideration of the situation, further systematic studies will be needed for fact-finding of the matter in terms of farm management.

iii) Salinity

Salinity distribution in the Sample Area is shown in Figure 2-13, which reveals that salinity is generally higher in Area M-2 than in M-1 in comparison with number of measurements in the respective Area.

Generally, there is almost no effect on crop growth when the EC value is below 4 m mhos/cm.

In taking this value of 4 m mhos/cm as the tolerable salinity to crop growth, the salinity distribution in both Areas M-1 and M-2 can be grouped into the following four patterns;

Pattern of EC status in the sample area

Surface soil	Subsoil	Area M-1	Area M-2
1) m mohs 4	m mhos 4	39	15
2) m mhos 4	m mhos 4.1 - 8	6	5
3) m mhos 4.1 - 8	m mhos 4	7	6
4) m mhos 4.1 - 8	m mhos 4.1 - 8	3	4
	Total	55	30

The soils which are expected to suffer from less salt injuries are found at 39 points in Area M-1 and 15 points in Area M-2, respectively. Among these soils, those with lower EC values about 1 - 2 m mhos/cm were found at upland fields or residential areas on slightly higher in elevation than the paddy fields.

The soils with higher salinity than the tolerable EC value in higher surface soils or subsoils were found at 13 points in Area M-1 and 11 points in Area M-2, and those with higher values than the above tolerable level in both of the surface soils and subosils were at three (3) points in Area M-1 and four (4) points in Area M-2.

The general tendency shows that salinity of upland fields is slightly higher than that of paddy fields. The surface soils of the paddy fields shows high salinity than the subsoils, this seems mainly due to the salt accumulation at the surface soils by copillary phenomenon during the dry season.

Juding from the values of SAR (Sodium Adsorption Ratio), salinity of the soils in the Sample Areas are affected more largely by Calcium and magnesium than by sodium, and sodium is considered not so hazardous as expected.

The desalination, although only in parts, would have to be carried out, since the survey found locally high salinity as well as probable salt accumulation in both Areas.

The best suited way of desalination in the Areas, is to leach out excessive salt by irrigation. The effective desalination by irrigation will essentially require well-controlled on-farm level water management together with preparation of drainage facilities; particularly the water management for irrigation should play an important role in desalination of the upland fields.

iv) Problems and countermeasures

a) Topographically, the natural levees (EL 3 - 4 m) and the transitional areas adjacent to them in the southern borders of the Area M-1 are slightly undulating and will partly require the levelling works in land consolidation, while topographically less troublesome in Area M-2 than in Area M-1.

No replacement of top soil in the levelling works will be needed in terms of civil works because of sufficiently providing the effective depth of soil in the both Areas.

In most cases of land levelling, however, the surface soils are taken away and the subsoils less fertile than the surface soils are newly provided for cropping. Therefore, the present production level can hardly be maintained in these areas with new top soils, unless much more organic materials as well as fertilizers are applied to increase soil fertility for two or three years.

b) Both Sample Areas M-1 and M-2 are medium or fine textured soils with considerably deep effective depth of soil.

Generally, the soil of paddy field areas, low-lying portions, are clay, and natural levees are composed of medium textured soils. Most of the paddy fields are used for the dry season transplanting paddy cultivation. Due to such prevailing cropping pattern, the soils of the field become extremely dry to develop large cracks owing to drying up during a period of several months from the end of the wet season (around the end of October) to the plowing time (February) for the dry season paddy. Such development of cracks on the field in closely related to the development of soil structure and seems to contribute to the promotion of soil permeability as a result. It appears that such natural mechanism of soil enables to maintain the drainage in the fields well or moderately well. In some parts of the both Areas, however, the groundwater tables were found in a range from 40 to 150 cm below the ground surface.

In view of the present land use of paddy fields by single dry season paddy cultivation, annual alternated swell and shrinkage of the soils with long drying-up period will give a favorable effect for keeping well drainage of the fields. Essentially, however, the soils of these Areas are composed mainly of clay with extremely high water holding capacity. Consequently, introduction of two paddy a year, which is the main objective of the Project, will unavoidably induce degrading the drainability of soils due to excessive moisture kept long in the soil.

In order to cope with such a situation, a proper countermeasure by reasonable water management should be established for eliminating the excessive surface water as well as the drainage facilities should be provided adequately.

c) It is natural that the soils give a variety of reactions at the respective boring test points. As a whole, many soils in Area M-1 show neutral or alkaline reaction affected by the major parents materials of river deposits, while many soils in Area M-2 show acidic reaction affected by marine and brackish water deposits.

The soils with tolerable soil reaction to the crop growth (pH 5.6 - 7.3) were found at 29 points in M-1 and 13 points in M-2.

Either of surface soils or subsoils at other points than the above (26 points in Area M-1 and 17 points in Area M-2) showed unfavorable soil reaction for crop growth due to their strong acidity (below pH 5.5), and the soils with critical alkalinity (above pH 7.4) were found at 14 points in Area M-1 and 5 points in Area M-2, respectively.

The strong acid soils will cause phosphorous deficiency, leaching of Calcium and potassium, etc., while the strong alkaline soils will cause deficiency of boron, iron, manganese, etc. The further survey and study will be required for detailed fact findings on the matters.

In general, paddy soils are kept in the reduced state under the flooding during the period of paddy growing and then soil reaction will be stabilized in a range form pH 6.5 to 7.5. On the other hand, since paddy plants are adoptable to the soil with considerable wide range of pH values, the paddy cropping seems to have little direct influence by soil reaction itself.

Upland cropping, however, will essentially require correction of soil reaction because the upland crop being different from paddy plants, will be directly affected by soil reaction. The acid soils can be corrected by application of liming materials and the acid sulfate soils in the paddy fields can be leached out by irrigation to meet the purpose. The alkaline soils in the present extent can be leached by irrigation water to reduce the reaction.

d) In general, there is almost no effect on crop growth when the EC value is below 4 m mhos/cm, and the soils within a range of the above EC values both in surface and subsoils were found at 55 points in M-1 and 30 points in M-2. Judging from the data, the Sample Area M-2, as a whole, seems to have higher salinity. The soils with salinity above the tolerable value in either soils of surface or subsurface were found at 13 points in M-1 and 11 points in M-2. Furthermore, the soils exceeding the tolerable value in both soils of surface and subsurface were found at three (3) points in Area M-1 and four (4) points, in Area M-2, respectively.

As a general tendency, salinity in the upland field is higher than that in the paddy field soils. And in the paddy field, the surface soils show higher salinity than the subsoils. This is considered to result from salt accumulation in the upper horizon during the dry season.

Salinity seems to be caused mainly by calcium and magnesium salts but little affected by sodium salts.

The best way to eliminate excessive salts is leaching by irrigation water. Consequently, successful desilination by this method requires establishing the reasonable on-farm level water management system as well as providing functional drainage facilities.

(4) Acid Sulfate soil

In the southern area of the Central Plain in Thailand, there are acid sulfate soil widely distributed, and strong acidity of the soils is a hazard to paddy cropping.

In the central part of the Project Area, the acid sulfate soil of Ayutthaya and Sena Series are distributed, occupying about 15 percent (4,220 ha). The development of acidity in the acid sulfate soil is said to result from sulfuric acid produced in the process of oxidation of iron sulfide (mainly pyrite) contained in the soils (marine sediments).

The characteristic features of acid sulfate soil is occurrence of yellow or pale yellow jarosite mottles, the so-called catclay. Ayutthaya series have a catclay horizon starting below 100 cm from the ground surface, while Sena series have catclay below 40 cm, but within 100 cm from the ground surface.

Pyrite is oxidized in the dry season when the groundwater table drops to the uppermost of the reduced horizons, and sulfuric acid formed and aluminium sulfate by-formed therefrom will be harmful substances to the crop growth. Another feature of the soil is fine gypsum crystals found in the lower part of A horizon and the upper part of B horizon and prominent red mottles found in the upper part of B horizon in the soil profile.

Ayutthaya and Sena series are classified as the second class soils for paddy field owing to their strong acidity according to the existing data available[1/] and these series, among acid sulfate soil widely distributed in the Central Plain, are considered suitable soils for paddy cultivation.

These soils, however, will be less suitable for upland crops without application of liming materials to correct soil acidity because the soils will be increasingly oxidized to show stronger acidic reaction under the stage of upland fields.

1/ Detailed Reconnaissance Soil Survey of Southern Plain Area (SSR-89, 1972)

When the soil reaction shows the strong acidity, the said soils will prevent supply of nutrients directly affecting the plants for their growth; particularly the supply of phosphorus will be largely affected.

In general, the soils in the paddy fields show the neutral reaction with pH values from 7.5 to 7.5 when the fields are submerged for paddy cropping.

According to the result of the experiment on liming effect to the acid sulfate soil for paddy cropping, the liming is found to serve the increase in available calcium and also the liming promote the mineralization of soil nitrogen during the early growing stage of rice plants.

In the strong acid soils, however, the effect of liming is not considered to give good response owing to severe phosphorus deficiency unless the phosphorus fertilizers are applied. In other words, the increasing application of phosphorus fertilizers may produce more yield of paddy than only liming for correcting soil acidity.

A considerable amount of lime is required to be applied for neutralization of soil acidity if the lime only is used for the purpose. Liming in such a way will aggravate the burden in farm economy and furthermore, much of the applied lime may be leached out when used inadequately.

Consequently, preparation of drainage facilities to promote the leaching of oxidizable sulfate will ensure the reasonable liming with minimum amount of lime.

In order to meet the purpose, the paddy fields after harvesting should be plowed to accelerate oxidation of the soils and then irrigate to leach out acid and acidic substances. The conservative measure for preventing the soils from acidification is that the groundwater table should be maintained at the level of catclay horizon, where oxidation takes place every year, so as to keep them in reductive conditions under saturation with groundwater.

In this way, however, the paddy fields will indispensably remain excessively moistened. Under the situation, not only the routine farming will be difficult in practices but introduction of upland crops as the second crops and large-sized farming machineries also will be difficult.

In other respect, the decomposable organic matter will be accumulated in the soil to produce, with increase in temperature during paddy growing stage, hydrogen sulfide and other harmful substances which adversely affect the roots of rice plants. Furthermore, excessive nitrogen uptake by the rice plants, which causes from rapid release of soil nitrogen, will result in lodging and blast disease and other hazards taking place commonly in the poorly drained paddy fields.

2-4. Land Classification

The land classification survey on the Project Area had been made by RID in the survey for the Greater Mae Klong Development Project Stage I. The RID land classification was made not by an orthodox method which uses the soil map as base map, but by a method meeting the requirements of irrigated agriculture development by assessing soil suitability. This RID's method was evaluated in some reports, which covers a recommendation to improve the said method.

In due consideration of the fact, the current survey had been planned to be made in referring to soil map, topo-map, land use map etc. for preparation of the land classification map. The actual survey, however, was obliged to be based largely on the existing limited data and information due to insufficiency in basic data and restriction of time factor.

The land classification method which the RID employs at present is based on the specification shown in Table 2-8. In the RID's method, the following descriptions are adopted to cover both items of paddy fields and upland fields taking into account the differences is soil conditions.

$$\frac{U2s}{R1} \qquad \frac{\text{2nd class upland field with some soio limitations}}{\text{1st class paddy field}}$$

The classification includes seven (7) classes; three (3) for upland fields, three (3) for paddy fields and the last one for the lands suitable both for uplands and paddy fields. Aside the above classification, three (3) limitations (soils, topography, drainage) are provided for sub-classficiation. Furthermore, one class (class 6) is set up for non-arable land. Therefore, the Project·Area was classified into seven (7), six (6) for arable lands and one (1) for non-arable lands.

Group U1	Land best suitable for irrigated upland crops
Group U2	Land less suitable for irrigated upland crops with one or more limitations in the soil, topography or drainage characteristics
Group U3	Land of distinctly restricted suitability for irrigated upland crops, because of extreme limitations in the soil, topography or drainage characteristics
Group R1	Land best suited for rice production
Group R2	Land adapted for rice production but with one or more limitations
Group U2/R2	Land suitable for either upland crops or rice production but with one or more limitations for both upland crops and rice

Class 6 Land unsuitable for the production of crops

The whole Project Area of 28,000 ha was classified by the above criteria to show the results in Table 2-9, which was illustrated in Figure 2-14.

As shown in the table, 17,880 ha (78.0%) of the arable lands of 22,920 ha were classified suitable for paddy fields, and 2,960 ha (12.9%) for upland fields. The remaining 9.1 percent (2,080 ha) was classified as suitable for both paddy fields and upland fields. These figures suggest that the Project Area has a very high suitability for paddy fields. Groupwise descriptions are as follows;

°U1 group (2,730 ha, 11.9%)

The group includes the sub-classes of U1/R2s and U/R3s, and the majority belongs to U1/R3s (2,630 ha). The group is located on the low terraces, cropped with sugarcane, lead trees, coconuts as well as used for residential areas. Some of the irrigable areas are used for paddy fields.

°U2, U3 groups (230 ha, 1.0%)

Located on the low terraces, like the group U1, most of the lands in the groups are used for upland fields and residential areas.

°R1 group (13,760 ha, 60.0%)

The group consist of those four sub-classes of U3sd/R1, U3s/R1, U2s/R1 and U2st/R1, U3sd/R1 of which occupies about 81.1 percent of the total. Most of the paddy field areas in the southeastern part of the Project Area are composed of this group, developing on the former tidal plains and floodplains of river alluvium. The lands developed on low terraces where located on somewhat low elevation, are also classified into this group. Although the lands extending in the southeastern part of the Project Area, in term of their formation process, have drainage limitations for upland fields, can be classified as the first class paddy field.

The R1 group lands sporadically located in the western half of the area almost extend on the low terraces, and will have little drainage problem for upland fields.

Recently, in certain areas along the Nakhon Chaisi river have been ridged for the cultivation of vegetables and fruits. Some arable lands are found to be used for the purposes other than the paddy fields due to lack of irrigation water, although classified into the first class paddy fields.

°R2 Group (4,120 ha, 18.0%)

The poorly drained areas distributed on the former tidal plains and the floodplains of river alluvium extending from Klong Tha Sarn, the north border of the Project Area, to the southern part of Don Tum, are classified as the second class paddy field. These lands are suitable for paddy culture but they are more or less deeply flooded by river water for a prolonged period due to insufficient natural drainage.

The lands, providing the first class condition in soils and topography, will be graded up to the first class paddy fields, if the surface water drainage and lowering of groundwater table can be successfully performed.

The lands of this group, extending in the northwest of Don Tum, are used for single cropping of the wet season paddy, while those extending from the northeast of Bang Len to the south are used for the dry season paddy or double cropping of paddy.

°U2/R2 group (2,080 ha, 9.1%)

This group comprises land suitable for either upland fields or paddy fields but it is not the best land for either crop because of soil limitations and for paddy also because of topographic restrictions.

The lands are located on low terraces extending between the northeastern border of the Project Area and central part of the southeast side. The lands are used mainly for sugarcane forming with some of paddy field.

Class 6 (910 ha, 3.2%)

This group includes fish ponds, bogs, low-lying marsh lands, etc., most of which scatte in the floodplains of recent river alluvium in the northern border and the eastern part of the Area.

The boundaries of bogs and mashes vary from the dry season to the wet season, and parts of these lands are used for arable lands in the end of the dry season.

The most parts of these lands will be fully utilized as paddy fields, if the development is made with drainage facilities provided to cover these areas. However, it will not be economical.

The data available for present land use show that the existing paddy fields are 14,640 ha, accounting for 63.9 percent of total arable lands (22,920 ha) and sugarcane fields are 4,620 ha, accounting for 20.1 percent.

The paddy cropping acreage of 14,640 ha accounts for about 81.9 percent of the total acreage of the lands suited for paddy cropping (17,880 ha) and the sugarcane cropping acreage is about 1.6 time as large as the lands suited for upland cropping.

In terms of the above figures- most of the lands of 2,080 ha in U2/R2 group and the non-irrigable lands among the lands suited for paddy fields, would have been converted to the sugarcane fields or some paddy fields might be converted to upland fields or be fallowed.

For project formuration, arable land in the project area would be shown as an area of 22,830 ha, less an area of 90 ha for right-of-way of newly constructed drainage canals under the project from 22,920 ha.

Conclusion and Recommendations

Approximately 63 percent of the Project Area is covered with hydromorphic alluvial soils and the remaining 37 percent is covered with non-calcic brown soils. Approximately 54 percent of the hydromorphic alluvial soils belongs to the marine alluvial soils.

Most of the soils are clayey soil except non-calcic brown soils distributed on the natural levees, and the soils with relatively high clay contents are widely distributed in the Project Area.

The soils with acidity ranging from weak to strong are found at many points, while the soils with neutra to alkaline reaction are also widely spread in the Area.

These facts indicate that the Project Area is composed of the soils in complex of marine and brackish water deposits and fluvial deposit having relatively high calcium contents which originated from the Mae Klong river.

The effective depth of soil are so deep as to require no replacement of top soil in land levelling in term of civil works. When, however, the existing surface soils are completely taken away, the present production level can hardly be maintained in these land with new top soils for two or three years, unless much more organic materials (manure, compost) as well as fertilizers are applied to increase soil fertility.

The existing data available show that the soils in the Project Area have moderately high natural fertility with higher cation exchange capacity and base saturation percent. The test pit surveys on the representative soils, however, revealed that the soils were generally medium to slightly low in cation exchange capacity, although high in base saturation percent, and the natural fertility was evaluated by moderate to low.

One of the important problems for execution of the development plan is improvement of poor drainage caused by topography and soil properties, and land improvement for the poorly drained paddy fields. The low-lying lands along the Nakhon Chaisi river and other major rivers in the Area are inundated chronically in the wet season, being used only for the single cropping of dry season pady. There are also the areas poorly drained or slightly poorly drained, extending from Klong Tha Sarn, the northern border, to the south of Don Tum. Furthermore, many marshes are found sporadically in the whole Project Area, and the areas along borrow pits are kept as swamps.

These poorly drained areas have difficulty in natural drainage due to unfavorable topographical conditions, and the soils are left under excessive moisture for a long time in a year.

The single cropping of dry season paddy is a major cropping pattern for the paddy fields. Consequently, heavy cracks develop on the field at the plowing time because the paddy fields are left under the dry condition during several months after the wet season. Such annual swell and shrinkage of the soils will affect favourably developed soil structure and increasing in soil permeability

The Project Area is composed mainly of clay with high water holding capacity. Consequently, introduction of double cropping paddy a year, the main objective of the Project, will unavoidably include the state of excessive soil moisture which would remain for long time and also would inevitably result in deterioration of drainable.

The countermeasure to be taken will be to provide a peper water management for eliminating excessive surface water to establish the functional drainage system to meet the above purpose.

The soils, distributed in the year-round inundation areas along the road from Don Tum to Ban Suan Thura, swamps along the borrow pits and studded marshes in the whole Project Area are strongly gley soils rich in semi-decomposed organic matters, which are formed under the strongly reductive state of soils in the inundation.

In the poorly drained paddy field with gley soils, hydrogen sulfide and other toxic substances which adversely affect the rice plants growth are formed during the paddy growing period. Furthermore, excessive nitrogen uptake by rice plants, which causes from rapid release of soil nitrogen will result in lodging and blast disease and other hazards taking place commonly in the poorly drained paddy fields to hinder the sound production of paddy.

The land improvement for these poorly drained fields will require to provide adequate drainage facilities for lowering the groundwater table and gradual drying the soils/

Sample Area M-1 for land consolidation scheme have many soils with neutral to alkaline reactions, while Sample Area M-2 have many soils with acidic reactions. These soil reactions are considered to result from influence of the respective parents materials of the fluvial deposits and acid sulfate soil.

The soils with tolerable reactions in a range form pH 6.5 to 7.4, which is commonly said to be less hazardous to crop growth were found at 29 points in Area M-1 and at 13 points in M-2, respectively.

The soils with problems in strong acidity (below pH 5.5) were found at 13 points in Area M-1 and 12 points in Area M-2, whereas the soils with problems in strong alkalinity (over pH 7.4) were found at 14 points in Area M-1 and five (5) points in Area M-2.

The development of acidity, generally, results in phosphorus deficiency, leaching of calcium and potassium or vigorous activation of iron, aluminum and manganess that these might be toxic to the normal growth of rice plants, while the development of alkalinity results in deficiency in boron, iron and manganess, etc. In these connections, a further study will be needed for fact-findings.

In general, the soils of paddy fields are under the submerged situation, where the soil reaction will stabilized from 6.5 to 7.5. On the other hand, since rice plants are adaptable to the soils with considerable wide range pH values, the paddy cropping seems to have little direct influence by soil reaction itself. Upland crops, however, will essentially require correction of soil reaction by the application of liming materials.

The soils with salinity below 4 m mhos/cm, which is considered tolerable to crop growth, were found at 39 points in Area M-1 and 15 points in Area M-2. The measurements of salinity at points other than the above shown the values ranging from 4 to 8 m mhos/cm in either of surface soils or subsoils, or in both of them. In generall, paddy plants can grow even in the soils with salinity of 4 - 8 m mhos/cm, but an attention should be paid to their seedling stage since they have a little resistance to salinity.

The surface soils have higher salinity than the subsoils and this is considered as a result of salts accumulation at surface soils in the dry season.

Excessive salts can be leached out by irrigation water, and an adequate irrigation should be carried out for upland crops in particular so as to eliminate salts accumulation in root zones.

In the area M-1, the natural levees (EL 3 - 4 m) in the southern border and the transitional area to paddy field area adjacent thereto are slightly undulating. In the Area M-2, there extends lands (EL 2.5 - 3 m) from southwest to east-north east in bias to divide the Area.

The both sample areas are composed of fine textured or moderately fine textured soils with considerably deeper effective depth of soil, and no presence of sand or gravel layers are found therein. Consequently, replacement of top soil will not be required in the land levelling works.

In the Project Area, about 4,000 ha of acid sulfate soil are distributed, and the liming will be essentially needed for correction for soil acidity. However, these soils also suffer from phosphorus deficiency. The field experiments have proven that an increasing application of phosporus fertilizers can successfully accomplish the paddy production increase. Consequently, the phosphorus fertilizers application will be essential to the paddy field, while correction of soil acidity by liming is necessary for upland fields.

Land classification for the arable lands of 22,920 ha, including an area of 90 ha for new drainage canals' right-of-way, in the Project Area according to the RID's criteria resulted in 2,730 ha of the first class upland fields, 120 ha of the second class and 110 ha of the third class, totaling 2,960 ha. The lands classified as suitable for both uplands and paddy fields is 2,080 ha. finally, the arable lands in the Project Area include 77.9 percent of the lands for paddy field (17,790 ha), 13.0 percent of the lands for uplands fields (2,960 ha) and 9 percent of the lands for uplands or paddy fields (2,080 ha).

According to the existing data available for present land use, the paddy fields are 14,640 ha, occupying 64.1 percent of the total projected arable lands (22,830 ha) and the sugarcane fields are 4,680 ha, occupying 20.5 percent.

The present paddy fields of 14,640 ha account for 81.9 percent of the lands suitable for paddy lands of 17,880 ha, while the existing sugarcane fields are 1.6 time as large as the lands suitable for uplands fields of 2,960 ha.

Consequently, the above figures suggest that most of the U2/R2 group lands and some unirrigable lands of the suitable lands for paddy fields might be converted to the sugarcane fields, and furthermore, some of the suitable lands for paddy fields might be converted to the sugarcane fields or remain fallowed.

The soils differ form soil unit which are shown in the existing soil map, were found during the test pit survey. This discrepancy may come from the accuracy of the detailed reconnaissance level of soil map which was used as base map of the survey.

Under the circumstances, further detailed soil survey will be required for preparing the detailed soil map as basic data for various development scheme and guidacne of farm management according to the project implementation schedule.

The soil fertility should be studied to prepare the basic data as well as the land classification should be made by applying the method adopted in the Soil Interpretation Handbook for Thailand, FAO, 1973.

Table 2-1 Acreage of Mapping Unit in The Project Area

(Unit: ha)

1. Former tidal flat with recent marine and brackish water deposits:		
Bang Len, overwash phase		200 (0.7%)
2. Former tidal flat with old marine and brackish water deposits:		9,190 (32.8%)
Ayutthaya	3,780 (13.5%)	
Sena	450 (1.6%)	
Bang Khen	4,960 (17.7%)	
3. Flood plain of recent river alluvium		3,160 (11.3%)
Singburi	1,060 (3.8%)	
Singburi, acid substratum variant	2,100 (7.5%)	
4. Low terrace of semi-recent alluvium		15,450 (55.2%)
Kamphaeng Saen/Nakhon Pathom Association	7,140 (25.5%)	
Kamphaeng Saen	3,330 (11.9%)	
Saraburi	4,000 (14.3%)	
Saraburi, Acid substratum variant	980 (3.5%)	
	Total	28,000 ha.

Data Source: Detailed Reconnaissance Soil Survey of Southern Central Plain Area. Report SSR-89. Soil Survey Division, Land Development Department, Ministry of National Development.

Fig. 2-1 MAP SHOWING LAND FORMS

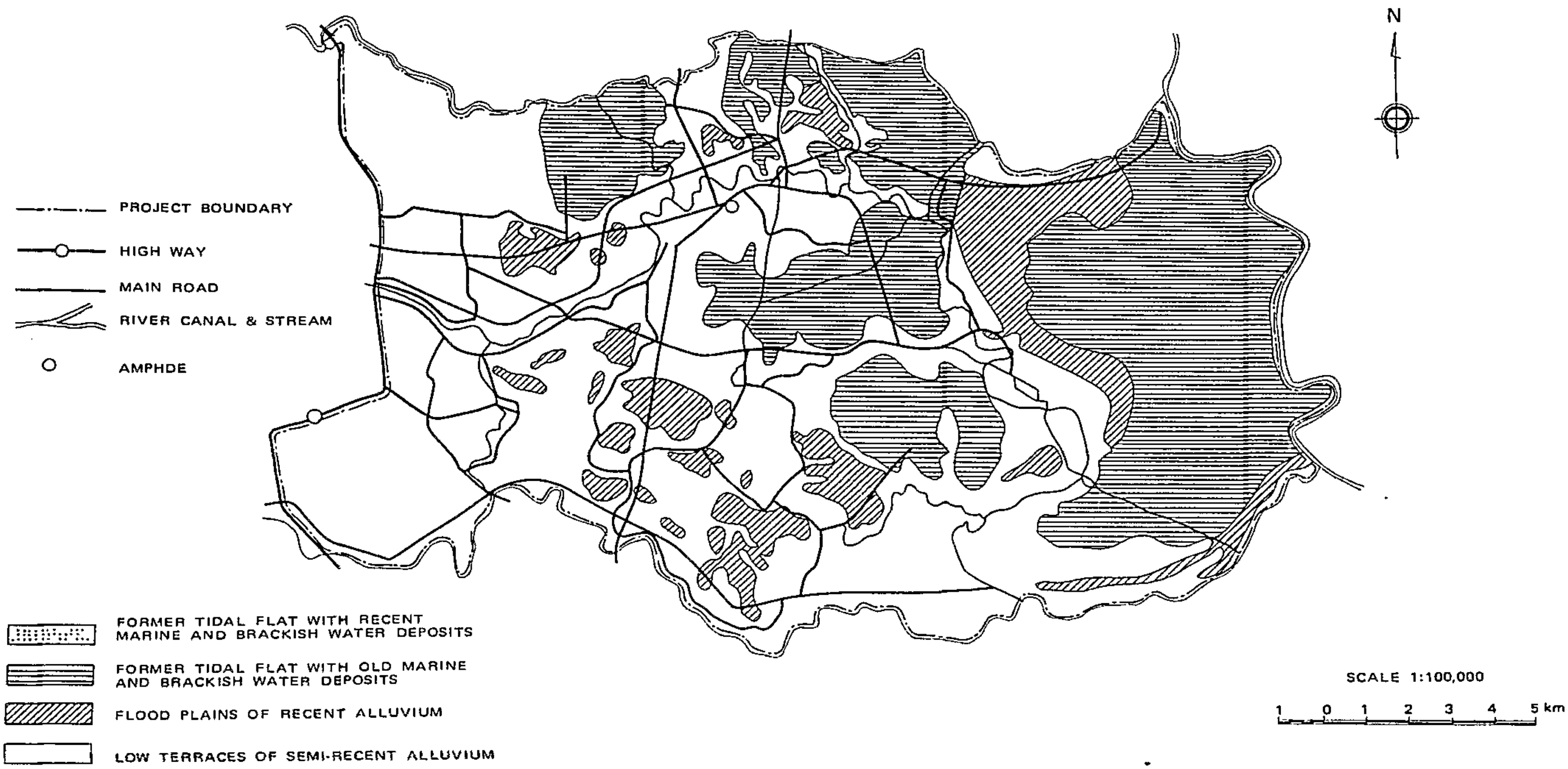
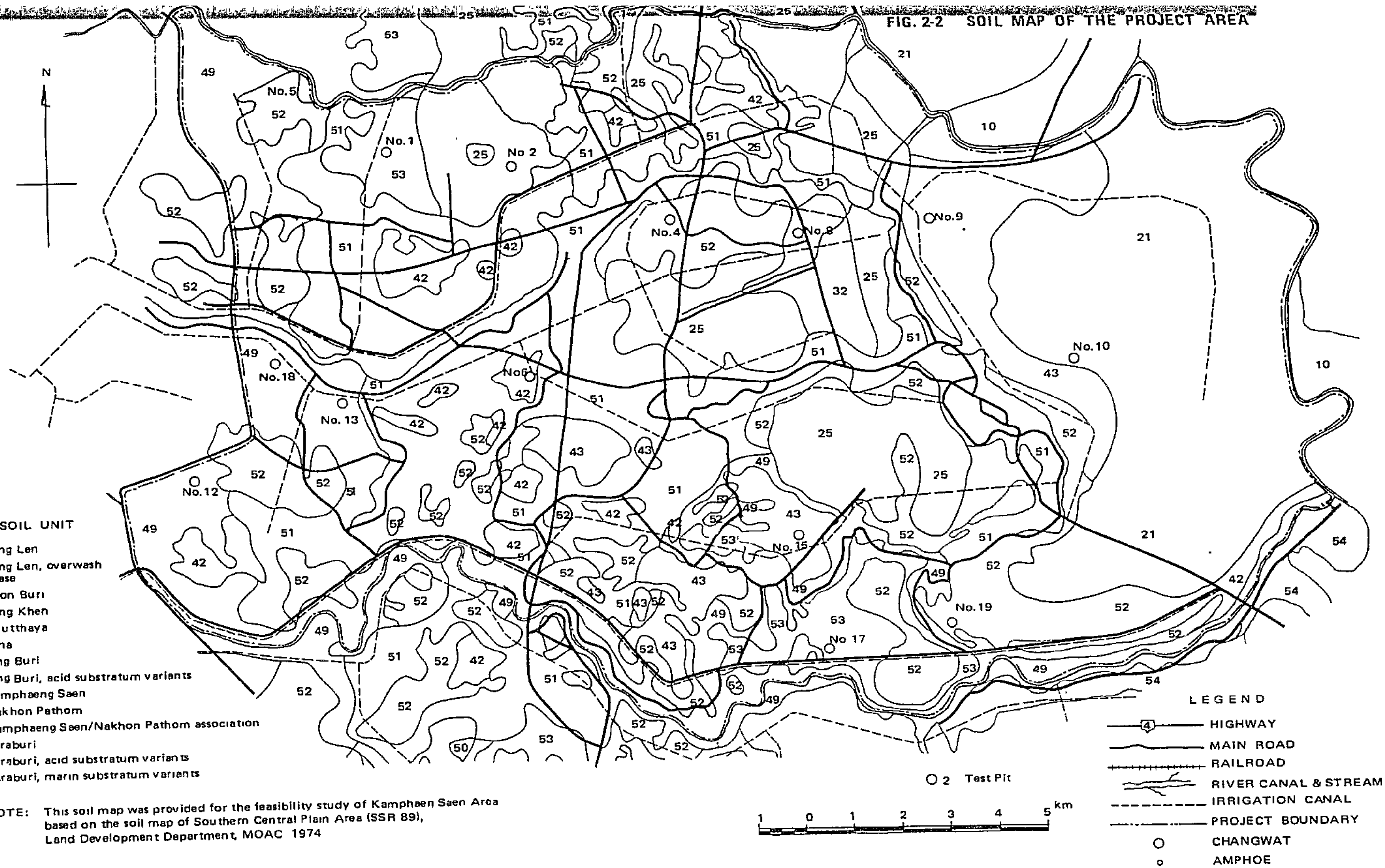


FIG. 2-2 SOIL MAP OF THE PROJECT AREA



SOIL UNIT

9 Bang Len
10 Bang Len, overwash phase
14 Thon Buri
21 Bang Khen
25 Ayutthaya
32 Sena
42 Sing Buri
43 Sing Buri, acid substratum variants
49 Kamphaeng Saen
50 Nakhon Pathom
51 Kamphaeng Saen/Nakhon Pathom association
55 Saraburi
53 Saraburi, acid substratum variants
54 Saraburi, marin substratum variants

NOTE: This soil map was provided for the feasibility study of Kamphaen Saen Area based on the soil map of Southern Central Plain Area (SSR 89), Land Development Department, MOAC 1974

Table 2-2 Outline of Test Pit Site

Pit. No.	Land use	Wet season paddy Variety	Wet season paddy Yield	Dry season paddy Variety	Dry season paddy Yield	Sugar cane yield(t/ha)	Land Class	Name of Soil
1	Paddy	Laungrahaeng	2.50 (t/ha)	RD 18	3.75 (t/ha)	'	R1	Ayutthaya
2	"	"	1.88	RD 7	3.13	'	R2	"
4	"	RD 16	3.44	'	'	'	R2	"
5	Cane	'	'	'	'	62.5	U2/R2	Saraburi
6	"	'	'	'	'	'	U1	Singburi
8	Paddy	'	'	'	'	'	R2	Sena
9	"	'	'	RD 18	3.75	'	R1	Singburi acid substratum
10	"	'	'	RD1, RD7	3.75	'	R1	Bangkhen
11	Cane	'	'	'	'	'	R1	Kamphaeng Saen/Nakhon Pathom
12	"	'	'	'	'	50.0	U1	Kamphaeng Saen
13	Paddy	Laungrahaeng	4.06	RD 1	4.38	'	R1	Kamphaeng Saen/Nakhon Pathom
17	"	'	1.88	'	2.50	'	R1	Saraburi, acid substratum
18	"	'	'	'	'	'	U2/R2	Kamphaeng Saen
19	"	'	'	Kae Mali	3.75	'	R1	Saraburi

Table 2-3 Profile Description of Test Pit

Pit No.	Mapping Unit	Land use	Depth cm	PH	Compactness	Color	Texture	Mottles	Concretions	Remarks
13	Kamphaeng Saen/ Nakhon Pathom	Paddy	0/30	5.7	29	dark reddish brown (5YR 3/6)	clay loam	many fine distinct strong brown & yellowish red		weak coarse subangular blocky many fine roots, clear smooth boundary
			30/55	6.1	29	dark yellowish brown (10YR 4/4)	clay	common fine distinct strong brown & yellowish red, faint brownish gray		weak fine angular blocky, common fine roots, gradual wavy boundary
			55/100	6.2	19	yellowish brown (5YR 5/6)	clay	common fine faint brownish gray	few soft Mn	massive weak fine angular blocky
11	"	Sugar Cane	0/30	5.5	32	very dark grayish brown (10YR 3/2)	clay loam			many fine roots gradual wavy boundary
			30/100	5.3	30/26	dark yellowish brown (10YR 4/4)	clay	common fine distinct	common Mn/Fe	weak fine prismatic
18	Kamphaeng Saen	Paddy	0/10	5.9	33	very dark gray (10YR 3/1)	clay	many very fine distinct strong brown & yellowish red		weak fine angular blocky many fine roots clear smooth boundary
			10/20	7.1	32	very dark grayish brown (10YR 3/2)	clay	common fine distinct strong brown & yellowish red		weak fine angular blocky, common fine roots, gradual wavy boundary
			20/55	7.4	26	dark yellowish brown (10YR 3/4), very dary gray (10YR 3/1)	clay	few fine distinct brownish gray		weak fine angular blocky, common fine roots, gradual slightly irregular boundary
			55/100	7.8	23/19	dark yellowish brown (10YR 4/4)	clay	few fine distinct brownish gray	few Mn/Fe ca nodule	weak fine angular blocky, few fine roots
8	Sena	Paddy	0/12	5.2	35	very dark borwn (10YR 2/2)	clay	common fine distinct strong brown & yellowish red		weak medium angular blocky many fine root clear smooth boundary
			12/40	4.3	30	very dark brown (10YR 3/1)	clay	common medium distinct yellowish red		weak medium angular blocky common fine roots gradual smooth boundary
			40/55	4.2	22	grayish brown (10YR 5/2) & dark gray (10YR 4/1)	clay	many medium prominent red, common medium prominent yellow/ brownish yellow (cat clay)		massive many gypsum crystal few fine roots gradual wavy broundary

Table 2-3 cont.

Pit No.	Mapping Unit	Land use	Depth cm	PH	Compactness	Color	Texture	Mottles	Concretions	Remarks
			12/38	4.4	28	dark yellowish brown (10YR 4/5)	clay	common fine distinct cark gray		weak fine angular blocky, common fine roots, clear smooth boundary
			38/65	4.3	19	dark brown (7.5YR 4/2)	sandy clay loam	many coarse prominent red		massive few mica flakes common fine root clear smooth boundary
			65/100	4.1	22	dark gray (10YR 4/1)	clay loam	many coarse prominent red		massive many gypsum crystal
9			45/80	6.2	25	dark gray (10YR 4/1)	clay	common fine distinct dark yellowish brown		weak fine angular blocky, few medium slickenside common fine roots
			80/100	7.5	18	olive brown (2.5Y 4/4)	clay	few fine distinct greenish gray	many Mn few Ca. nodule	massive
6	Singburi	Sugar cane	0/42	4.9	31	very drak gray (10YR 3/1)	clay	common fine distinct yellowish red & gray		weak fine angular blocky, few mica flake, shell many fine roots, clear smooth boundary
			42/100	5.4	30	dark yellowish brown (10YR 3/4), brown (10YR 4/6)	clay	common fine distinct gray	few Mn, soft Fe, Ca. nodule	Massive
1	Ayutthaya	Paddy	0/20	6.8*	26	dark brown (10YR 3/3)	clay	common fine strong brown		moderate medium angular blocky, many fine roots clear smooth boundary
			20/57	7.8*	22	yellowish brown (10YR 5/6)	clay	few fine faint grayish brown	few Mn	weak medium angular blocky, few medium slickenside, few sypsum crystal, many very fine roots, gradual wavy boundary
			57/87	5.5*	20	dark yellowish brown (10YR 4/4) & dark gray (10YR 4/1)	clay	aboundant medium prominent red	few Mn	weak medium angular blocky, many gypsum crystal, many very fine roots, gradual wavy boundary
			87/100	5.0*	22	dark gray (10YR 4/1)	clay	aboundant medium prominent red		massive many gypsum crystal, few very fine roots

Note: * field PH.

Table 2-3 cont.

Pit No.	Mapping Unit	Land use	Depth cm	PH	Compact-ness	Color	Texture	Mottles	Concretions	Remarks
			72/100	7.2	25	yellowish brown (10YR 5/4)	clay	few fine faint very dary grayish brown	few soft Mn	weak coarse angular blocky, few very fine roots weak coarse subangular blocky
19	Saraburi	Paddy	0/11	5.7	25	dark yellowish brown (10YP 3/4)	clay	many fine distinct strong brown, yellowish red, faint dark grayish grown		many fine roots gradual wavy boundary
			11/30	6.7	25	dark gray (5Y 4/1)	clay	common fine distinct brown, strong brown & yellowish red	few Mn/Fe	massive common fine roots gradual wavy boundary
			30/53	7.7	21	gray (10Y 4/1)	clay	common fine distinct strong brown, fine faint dark reddish brown & brown	few Mn	weak fine angular blocky, few small slickenside, few very fine roots, gradual wavy boundary
			53/100	8.3	21	strong brown (7.5YP 5/6)	clay	common fine distinct dark gray, few fine distinct red	few Mn	massive few fine roots

Table 2-3 cont.

Pit No.	Mapping Unit	Land use	Depth cm	PH	Compact-ness	Color	Texture	Mottles	Concretions	Remarks
5	"	Sugar Cane	0/25	6.3	30	brownish black (10YR 2/2)	clay			weak line angular blocky many fine roots clear smooth boundary
			25/85	6.1	31/25	dark yellowish brown (10YR 4/4), yellowish red (5YR 4/8)	clay	common fine distinct strong brown, gray	few Fe	weak fine subangular blocky, common fine/median roots, gradual wavy boundary
			85/100	6.4	20	very dark gray (10YR 3/1)	clay	few fine distinct dark brown, faint gray		weak fine subangular blocky
17	Saraburi acid substratum	Paddy	0/12	5.2	32	very dark grayish brown (10YR 3/2)	clay	many fine distinct reddish yellow		weak medium angular blocky many fine roots, clear smooth boundary
			12/40	6.9	30	very dark gray (10YR 3/1)	clay	many fine distinct reddish yellow, common fine faint gray	common Mn Fe nodule	weak fine angular blocky, Few fine roots gradual smooth boundary
			40/64	7.4	21	brown (10YR 4/3) very dark grayish brown (10YR 3/2)	clay	few fine distinct black		massive few fine roots gradual wavy boundary
			64/100	8.0	16	dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/8)	clay	few fine faint gray, few fine faint dark gray	few Mn few ca nodule	massive effervessence++
9	Singburi, acid substratum	Paddy	0/20	5.4	35	very dark grayish brown (10YF 3/2)	clay	many fine distinct strong brown & yellowish brown		weak coarse angular blocky many fine roots gradual smooth boundary
			20/45	5.2	35	brownish gray (7.5YR 4/1) dark brown (7.5YR 3/2)	clay	common fine distinct strong brown		moderate medium prismatic, few small shall, common fine roots gradual wavy boundary
12	"	Sugar Cane	0/30	7.8	31	very dark grayish brown (10YR 3/2)	clay		common, Ca nodule	weak coarse angular blocky, very few mica flake many fine roots clear smooth boundary
			30/72	7.4	31	very dark gray (10YR 3/1)	clay			weak medium prismatic common fine root gradual smooth boundary

Table 2-3 cont.

Pit No.	Mapping Unit	Land use	Depth cm	PH	Compact-ness	Color	Texture	Mottles	Concretions	Remarks
			55/100	4.0	19	grayish brown (10YR 5/2) & dark gray (10YR 4/1)	clay loam	many medium prominent red		massive many gypsum crystal
10	Bang Khen	Paddy	0/12	5.3	36	dark gray (10YR 4/1)	clay	many very fine distinct strong brown & yellowish red		weak fine angular blocky, many fine roots, clear smooth boundary
			12/26	5.6	25	very dark gray (10YR 3/1)	clay	common fine distinct yellowish red, fine faint blackish brown, few red spot		massive common fine roots, clear smooth boundary
			26/45	5.?	17	reddish gray (2.5YF 5/1)	clay	common fine distinct yellowish brown, red	few Mn	massive few large slicken-sides few gypsum crystal few few fine root, gradual slightly irregular boundary
			45/100	6.4	17	yellowish gray (2.5YR 6/1)	clay	common fine faint yellowish brown, few fine distinct red, dark gray		massive few gypsum crystal few black rotten roots
2	"	Paddy	0/15	5.1	32	very dark gray (10YR 3/1)	clay	common fine distinct strong brown		moderate medium angular blocky many fine roots clear smooth boundary
			15/43	6.1	28	brown (10YR 4/3)	clay	common fine frint yellowish brown, few fine distinct grayish brown	common Mn	weak fine angular blocky, common fine roots, gradual slightly wavy boundary
			43/70	4.6	18	light bray (10YR 6/1)	sandy clay loam	many coarse prominent red & dark yellowish brown		massive few mica flakes common fine roots gradual smooth boundary
			70/100	4.3	20	gray (10YR 5/1)	clay	many coarse prominent red & bright brown		massive few mica flakes
			180/210			Jarasite				many gypsum crystal few fine roots weak medium angular blocky
4	"	Paddy	0/12	4.8	32	dark brown (10YR 3/3)	clay	common fine distinct strong brown		many fine roots gradual smooth boundary

Fig. 2-3 DIAGRAMATIC REPRESENTATIONS OF SOIL PROFILES

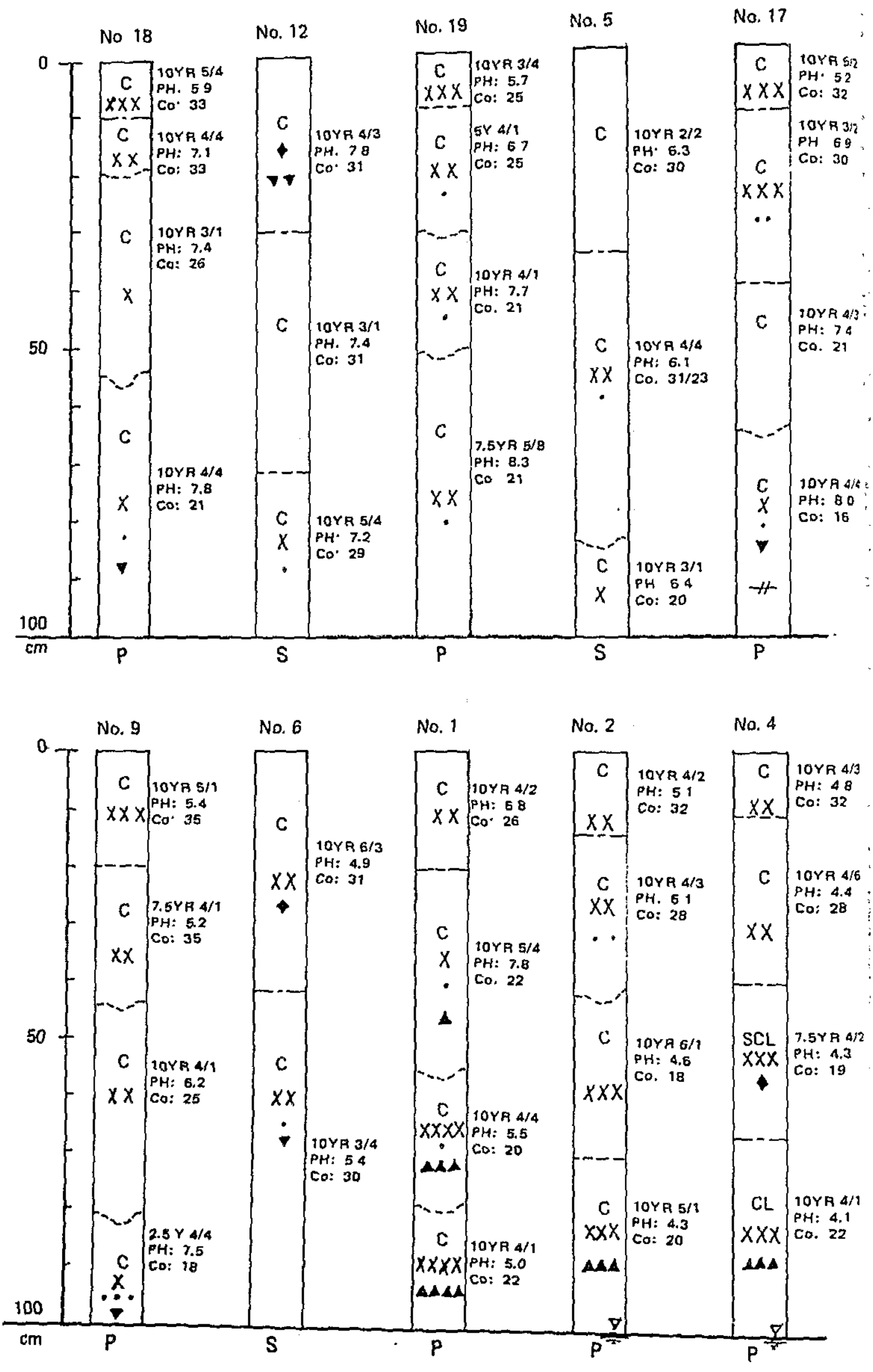
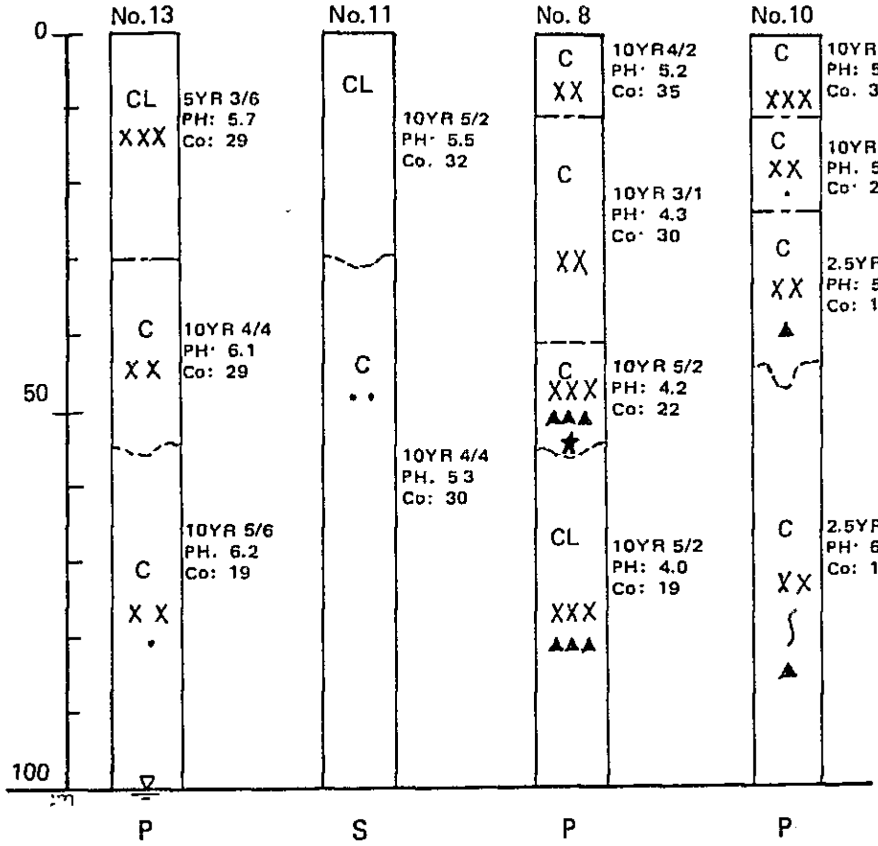


Fig. 2 - 3 (Continued)



Pit No.	Location of Test Pit
1.	Community #3, Tombon Lam Haei, Amphoe Don Tum
2.	Community #10, Tambon Lam Haei, Amphoe Don Tum
4.	#1. Tambon Sam Ngam, Amphoe Don Tum
5.	#3. Tambon Thung Kraphangham, Amphoe Kamphaeng Saen
6.	Ban Thung Pichai, Tambon Huai Phra, Amphoe Don Tum
8.	Ban Ko Klong (2) Amphoe Don Tum
9.	Ban Ko Raet, Amphoe Don Tum
10.	Ban Nong Plong, Amphoe Don Tum
11.	Tambon Huai Khwang, Amphoe Kamphaeng Saen
12.	#1. Tambon Thapluang, Amphoe Muang
13.	#1. Tambon Huai Kwang, Amphoe Kamphaeng Saen
17.	Ban Lumtapho, Tambon Thung Noi, Amphoe Mung
18.	Ban Rang I Muie, Tambon Huai Kwang, Amphoe Kamphaeng Saen
19.	Ban Huai Krat, Tambon Laem Bua, Amphoe Nakhon Chaisi

Fig. 2-3 (Continued)

LEGEND

C: Clay CL: Clay loam SCL: Sandy clay loam

Color:

5YR 3/6	dark reddish brown	10YR 4/4	darm yellowish brown
7.5YR 5/8	strong brown	3/1	very dark gray
4/2	darm brown	3/2	very dark grayish brown
4/1	brownish gray	3/3	darm brown
10YR 6/1	light gray	3/4	dark yellowish brown
5/1	gray	2/2	very darm brown
5/2	grayish brown	2.5Y 6/1	yellowish gray
5/4	yellowish brown	5/1	" "
5/6	" "	4/4	olive brown
4/1	dark gray	5Y 4/1	dark gray
4/3	brown		

Mottle & concretion

XXXX aboundant (>30%)

XXX many (10-30%)

XX common (2-10%)

X few (<2%)

X thredy, thred-root like filmy, cloudy

S vein-like

• concretion

▲ gypsum crystal

▼ ca nodule

Co. Compactness

◆ mica flak

ca-reaction strong

Boundary

— - — clear (3-5 cm)

- - - - gradual (5 cm)

Shape of boundary

—— smooth

∼ wavy

∽ irregular

▽ ground water level

★ jarosite

	moist soil	dry soil
Some what compact	15–19	20–24
Compact	20–24	25–29
Very compact	725	730

Table 2-4 Soil Analysis Result

Lab. No.	Field No.	Depth cm	PH H_2O	PH KCl	Organic C %	Total N %	Total P ppm	Avai. P Bray II ppm	C.E.C. me/100 gm	Exchangeable bases me/100 g Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Electrical conductivity M.mhos/cm
9335	2	0-15	5.1	5.0	1.29	0.136	321	2.7	6.52	5.8	7.33	2.09	0.35	800
9336		15043	6.1	5.6	0.36	0.057	258	1.4	9.13	7.0	11.00	5.22	0.32	1,460
9337		43-71	4.6	4.2	0.09	0.019	178	2.2	1.09	1.6	4.80	3.74	0.49	920
9338		71-100	4.3	3.8	0.27	0.054	196	3.0	15.76	40.0	12.00	8.00	0.37	1,040
9339	4	0-12	4.8	4.4	1.41	0.128	380	12.8	4.35	4.8	8.27	4.00	0.21	950
9340		13-38	4.4	3.9	0.39	0.052	326	2.0	4.02	1.6	4.53	4.61	0.09	1,300
9341		38-65	4.3	3.9	0.15	0.028	240	3.3	0.87	0.8	8.27	3.57	0.33	1,220
9342		65-100	4.1	3.7	0.36	0.054	2.8	3.4	8.04	32.0	4.80	6.60	0.17	3,600
9232	5	0-25	6.3	5.9	1.44	0.102	702	56.5	3.80	15.4	5.47	3.91	0.13	1,780
9344		25-85	6.1	5.3	0.45	0.064	433	6.0	4.89	11.3	5.47	2.78	0.09	840
9345		85-100	6.4	5.5	0.60	0.052	335	7.5	6.74	11.1	6.53	3.04	0.26	546
9346	6	0-42	4.9	4.5	1.26	0.126	376	8.0	2.06	7.8	7.33	3.22	0.22	1,050
9347		42-100	5.4	4.8	0.48	0.068	303	1.8	18.48	5.8	8.67	3.30	0.39	1,240
9348	8	0-12	5.2	4.8	1.38	0.144	296	5.1	7.39	7.0	8.27	4.78	0.22	1,650
9349		12-40	4.3	3.8	0.63	0.070	232	2.0	14.67	5.5	7.73	3.48	0.14	1,400
9350		40-55	4.2	3.8	0.24	0.052	338	1.5	25.54	11.1	8.73	3.30	0.28	1,230
9351		55-100	4.0	3.6	0.18	0.031	241	3.4	14.67	35.6	9.20	4.43	0.39	3,300
9352	9	0-20	5.4	4.6	1.26	0.134	231	4.8	29.90	11.8	7.73	1.04	0.26	255
9353		20-45	5.2	4.3	0.78	0.100	344	3.8	30.40	8.2	12.00	2.26	0.32	365
9354		45-80	6.2	5.4	0.45	0.068	238	4.4	22.82	11.1	13.33	3.74	0.18	465
9355		80-100	7.5	6.5	0.21	0.036	246	4.0	25.54	13.0	13.33	4.43	0.45	790
9356	10	0-12	5.3	4.6	1.29	0.151	210	2.6	32.83	11.0	12.00	1.04	0.34	335
9357		12-26	5.6	4.9	0.48	0.075	180	1.7	30.98	11.0	12.00	2.08	0.33	700

Note: Soil analysis was conducted by Lab. Soil Chemistry and Fertility, Department of Agriculture.

Table 2-4 cont.

Lab. No.	Field No.	Depth cm	PH H_2O	PH KCl	Organic C %	Total N %	Total P ppm	Avai. P Bray II ppm	C.E.C. me/100 gm	Exchangeable bases me/100 g Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Electrical conductivity M.mhos/cm
9358		26-45	5.9	5.3	0.24	0.054	160	1.3	28.26	11.6	13.33	2.26	0.23	1,900
9359		45-100	6.4	5.7	0.06	0.026	170	1.1	21.74	19.2	12.00	2.96	0.28	2,360
9360	11	0-30	5.5	4.7	1.20	0.095	661	5.8	6.30	7.2	2.87	0.52	0.14	79
9361		30-100	5.3	4.2	0.30	0.044	368	4.0	5.76	6.5	3.47	0.61	0.64	86
9362	12	0-30	7.8	7.0	1.29	0.116	550	5.1	6.52	16.4	4.00	2.17	0.77	590
9363		30-72	7.4	6.4	0.60	0.082	347	6.5	16.52	9.8	4.53	2.73	0.51	465
9364		72-100	7.2	6.4	0.51	0.068	313	3.6	27.72	9.8	6.13	4.17	0.43	690
9365	13	0-30	5.7	5.0	0.84	0.072	529	3.7	4.13	6.2	3.07	1.13	0.14	192
9366		30-55	6.1	5.2	0.33	0.054	366	4.8	8.04	7.0	3.47	0.38	0.19	130
9367		55-100	6.2	5.2	0.21	0.036	284	3.0	4.13	7.6	4.27	0.43	0.16	136
9368	17	0-12	5.2	4.6	1.26	0.118	392	7.4	5.65	8.2	2.87	0.63	0.12	250
9369		12-40	6.9	6.0	0.45	0.062	336	3.8	20.65	10.0	5.80	1.22	0.12	210
9370		40-64	7.4	6.4	0.39	0.049	297	5.1	23.91	7.6	13.60	1.82	0.10	245
9371		64-100	8.0	7.1	0.18	0.036	275	12.0	8.80	14.8	13.60	2.96	0.08	540
9372	18	0-10	5.9	5.1	1.29	0.128	811	67.0	7.50	9.0	2.87	0.57	0.26	165
9373		10-20	7.1	6.0	0.78	0.093	1,066	84.0	15.20	9.2	3.33	0.43	0.30	110
9374		20-55	7.4	6.3	0.42	0.070	1,145	350.0	15.76	10.0	2.67	0.86	0.72	131
9375		55-100	7.8	6.8	0.27	0.052	632	60.0	16.30	17.2	2.33	0.57	0.77	150
9376	19	0-11	5.7	4.5	1.35	0.131	329	7.7	9.89	8.8	5.80	0.96	0.22	93
9377		11-30	6.7	5.3	0.66	0.077	334	4.5	22.80	8.8	7.73	1.91	0.21	81
9378		30-53	7.7	6.3	0.15	0.068	274	2.6	20.04	8.8	8.67	4.17	0.19	148
9379		53-100	8.3	7.0	0.24	0.039	483	2.9	18.45	7.8	7.33	5.91	0.09	270

Pit No.	Depth cm	Mechanical Analysis Sand %	Silt %	Clay %	Texture
2	0-15	23.7	32.7	43.6	C
	15-43	15.5	24.6	59.9	C
	43-71	55.6	22.7	21.7	SCL
	71-100	21.7	8.6	69.7	C
4	0-12	27.9	32.4	39.7	C
	12-38	17.8	26.5	55.7	C
	38-65	60.5	12.5	27.0	SCL
	65-100	36.9	24.6	38.5	CL
5	0-25	20.8	36.7	42.5	C
	25-85	15.9	26.4	57.7	C
	85-100	20.3	28.1	51.6	C
6	0-42	27.5	24.4	48.1	C
	42-100	17.7	22.5	59.8	C
8	0-12	25.5	26.4	48.1	C
	12-39	25.4	16.6	58.0	C
	39-54	33.0	22.6	44.4	C
	54-100	37.3	30.8	31.9	CL
9	0-20	14.1	30.2	55.7	C
	20-45	14.8	19.2	60.0	C
	45-80	12.1	14.2	73.7	C
	80-100	14.0	17.6	68.4	C
10	0-11	14.6	23.8	61.6	C
	11-26	16.2	17.6	66.2	C
	26-45	16.8	17.8	65.4	C
	45-100	16.6	27.7	55.7	C
11	0-30	32.1	33.8	34.1	CL
	30-100	34.5	25.7	39.8	C
12	0-30	23.3	28.4	48.3	C
	30-72	21.7	23.9	54.4	C
	72-100	15.3	28.1	56.6	C
13	0-30	31.5	34.3	34.2	CL
	30-55	27.3	28.4	44.3	C
	55-100	31.4	26.3	42.3	C
17	0-12	21.1	38.4	40.5	C
	12-40	17.3	32.3	50.4	C
	40-64	15.2	34.3	50.5	C
	64-100	25.0	34.5	40.5	C

Pit No.	Depth cm	Mechanical Analysis Sant %	Silt %	Clay %	Texture
18	0-10	28.9	30.3	40.8	C
	10-20	27.2	28.2	44.6	C
	20-55	19.4	32.3	48.3	C
	55-100	19.0	24.6	56.4	C
19	0-11	19.0	20.1	60.9	C
	11-30	17.2	18.1	64.7	C
	30-53	17.1	18.1	64.8	C
	53-100	17.1	30.1	52.8	C

Fig. 2-4　　PROPORTION OF PARTICLE SIZE OF SELECTED SOIL SAMPLES

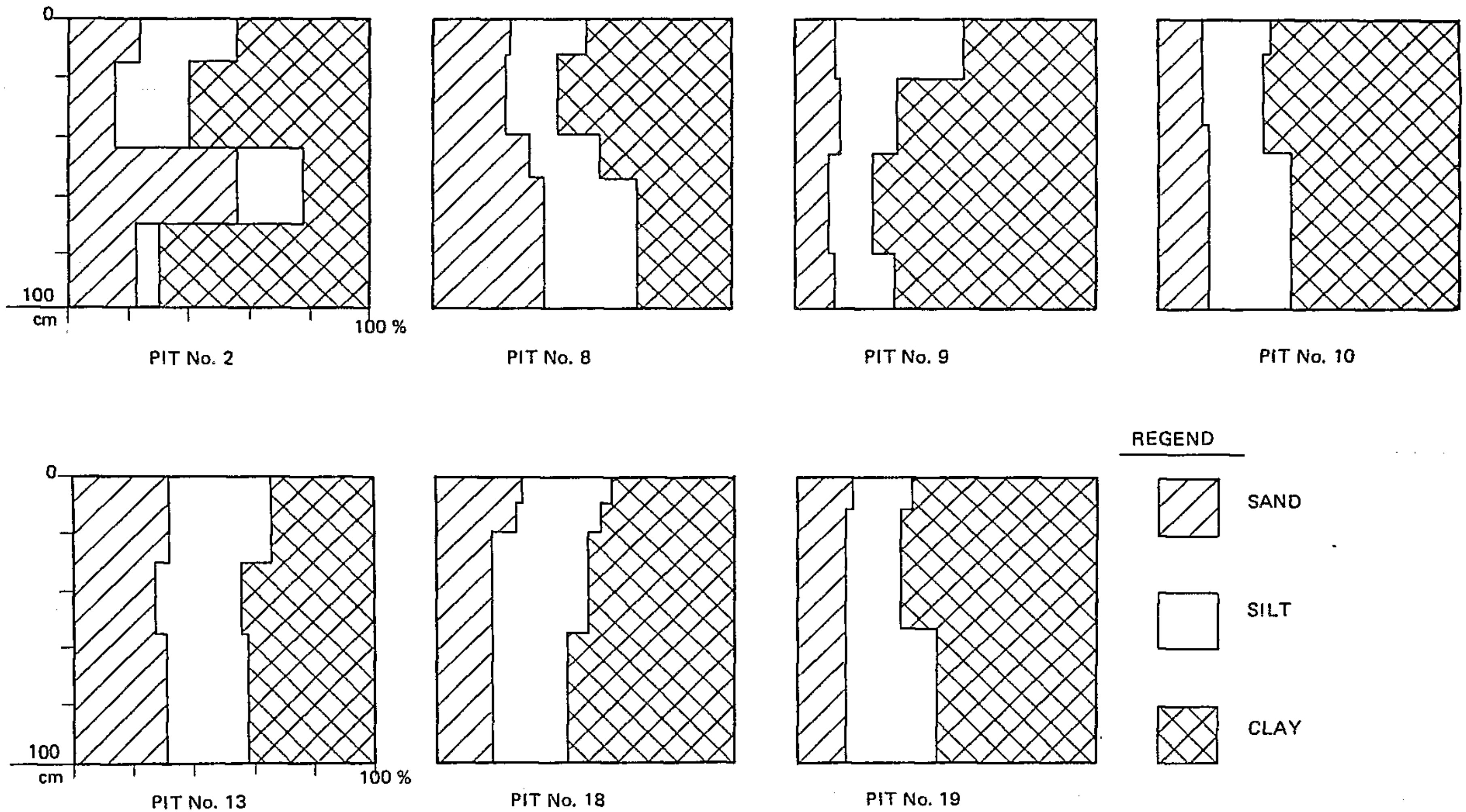


Table 2-5 Estimated Natural Fertility of Surface Soil

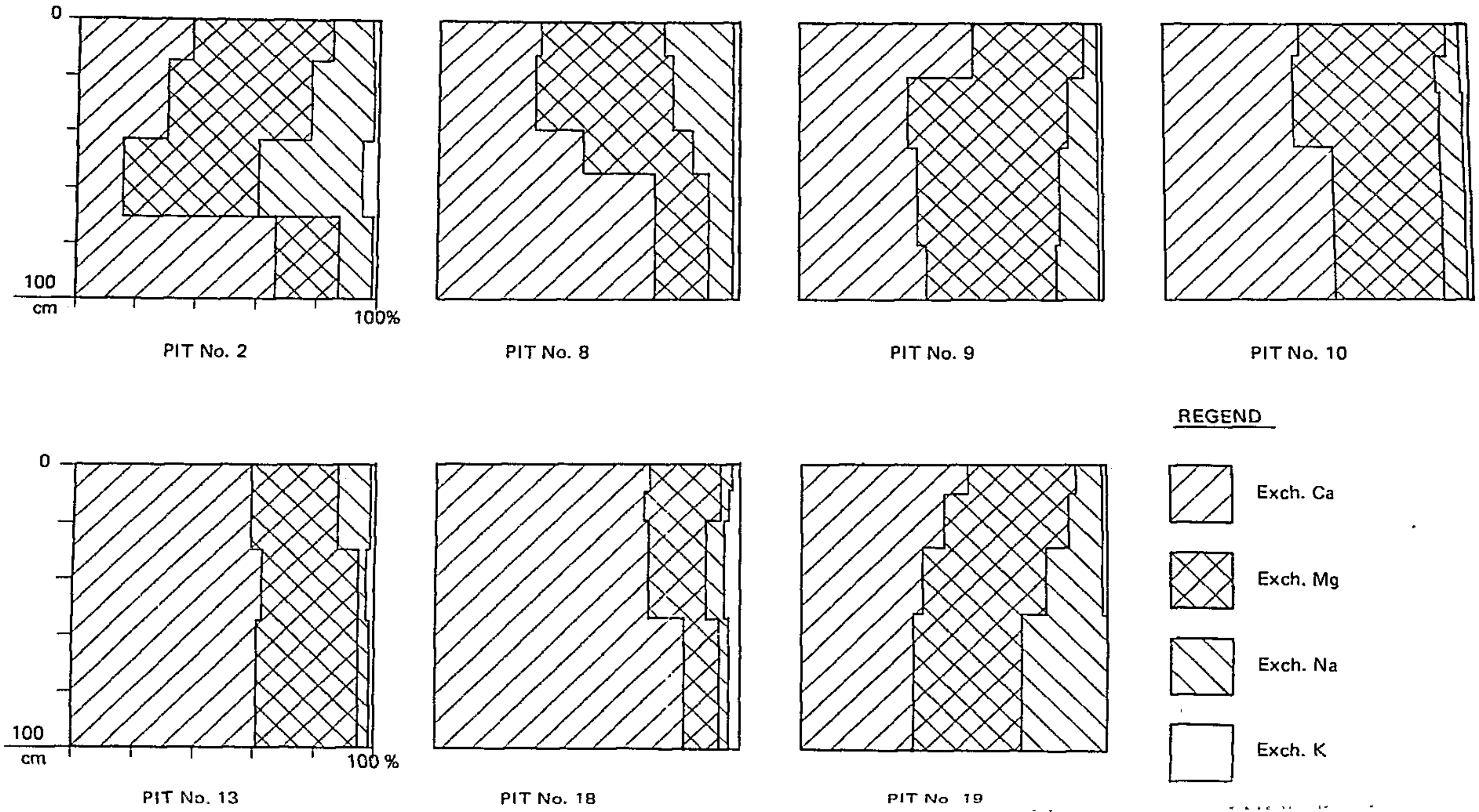
PIT No.		CEC	Base saturation %	Organic matter %	Available phosphate ppm	Estimated Natural Fertility Paddy rice	Estimated Natural Fertility Upland crops
13	V	4.13	255	1.45	3.7	ML	ML
	R	L	H	ML	L		
11	V	6.30	170	2.07	5.8	M	ML
	R	ML	H	M	L		
18	V	7.50	169	2.22	7.5	M	ML
	R	ML	H	M	ML		
12	V	6.25	357	2.22	5.1	M	ML
	R	ML	H	M	L		
19	V	9.89	159	2.33	7.7	M	M
	R	ML	H	M	ML		
5	V	3.80	635	2.48	56.5	ML	ML
	R	L	H	M	vH		
17	V	5.65	209	2.17	7.4	M	M/ML
	R	ML	H	M	ML		
9	V	29.9	69	2.17	4.8	M	M/ML
	R	H	M	M	L		
6	V	2.06	901	2.17	8.0	ML	ML/L
	R	L	H	M	ML		
10	V	32.8	74	2.22	2.6	ML	M/ML
	R	H	M	M	vL		
2	V	6.52	238	2.22	2.7	M	L
	R	ML	H	M	vL		
4	V	4.35	397	2.43	12.8	ML	ML
	R	L	H	M	M		
8	V	7.39	274	2.38	5.1	M	ML
	R	ML	H	M	L		

Note: based on Key for estimating natural fertility, Soil Interpretation Handbook for Thailand 1973.

Table 2-6 Estimated Natural Fertility of Subsurface Soil

PIT No.		CEC	Base saturation %	Organic matter %	Available phosphate ppm	Estimated Natural Fertility Paddy rice	Upland crops
13	V	8.04	137	0.57	4.8	ML	ML/L
	R	ML	H	L	L		
11	V	5.76	194	1.52	4.0	ML	ML/L
	R	ML	H	L	L		
18	V	15.2	97	1.34	(840)	*	*
	R	MH	H	ML	*		
12	V	16.5	106	1.03	6.5	MH	M
	R	MH	H	ML	ML		
19	V	4.56	408	1.34	4.5	ML	ML
	R	L	H	ML	L		
5	V	4.81	403	0.87	6.0	L	ML
	R	L	H	L	ML		
17	V	20.6	83	0.78	3.8	ML	M
	R	H	H	L	L		
9	V	30.4	74	1.34	3.8	M	M
	R	H	M	ML	L		
6	V	18.4	98	0.83	1.8	ML	ML
	R	MH	H	L	vL		
10	V	30.9	82	0.83	1.7	ML/L	ML
	R	H	H	L	vL		
2	V	9.13	257	0.63	1.4	ML/L	ML
	R	ML	H	L	vL		
4	V	4.02	269	0.67	2.0	ML/L	L
	R	L	H	L	vL		
8	V	14.6	114	1.09	2.0	M	M
	R	M	H	ML	vL		

Fig. 2-5 PROPORTION OF EXCHANGEABLE CATION OF SELECTED SOIL SAMPLES



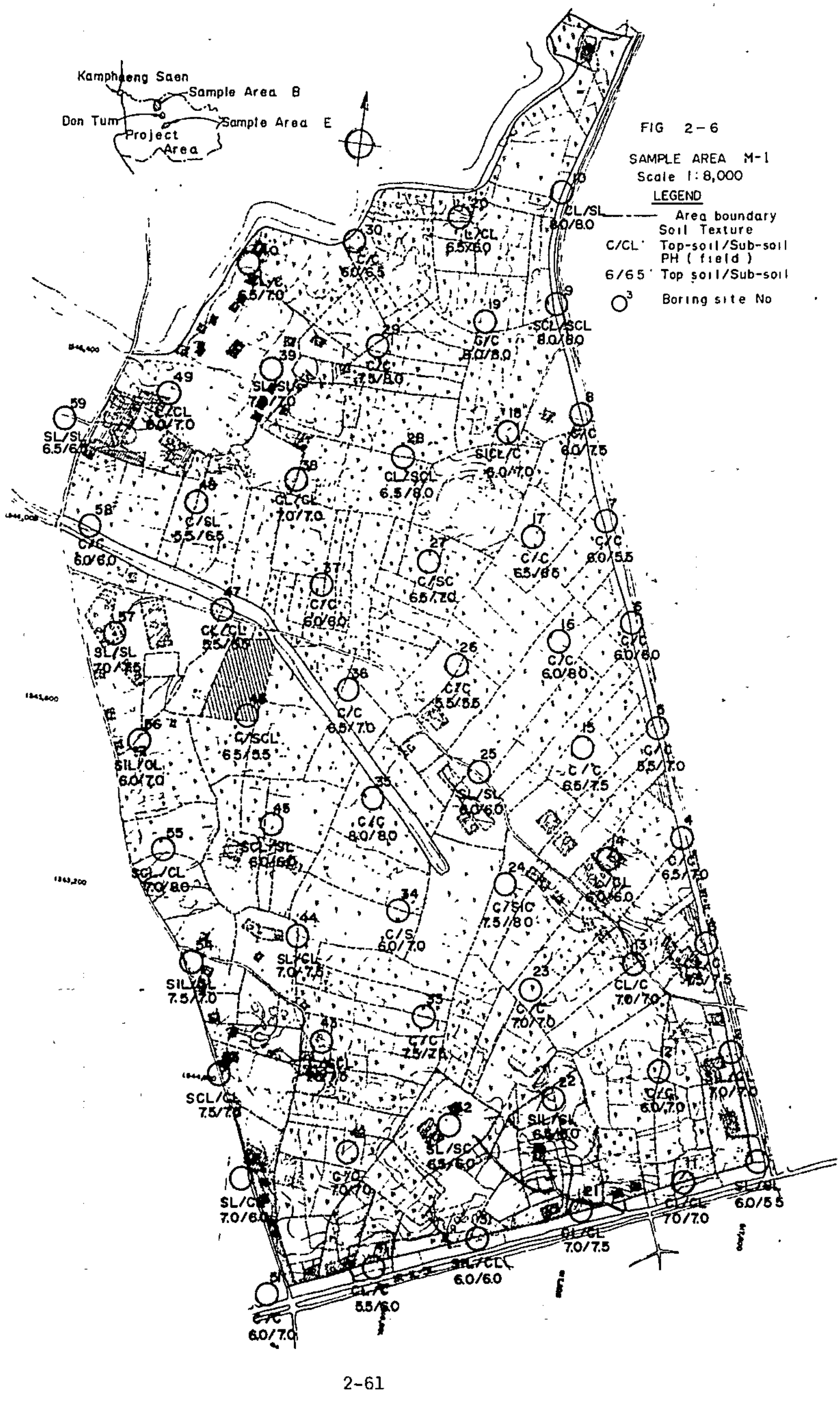


FIG 2-6
SAMPLE AREA M-1
Scale 1:8,000
LEGEND
Area boundary
Soil Texture
C/CL Top-soil/Sub-soil
PH (field)
6/6.5 Top soil/Sub-soil
Boring site No
Kamphaeng Saen
Sample Area B
Don Tum
Sample Area E
Project Area

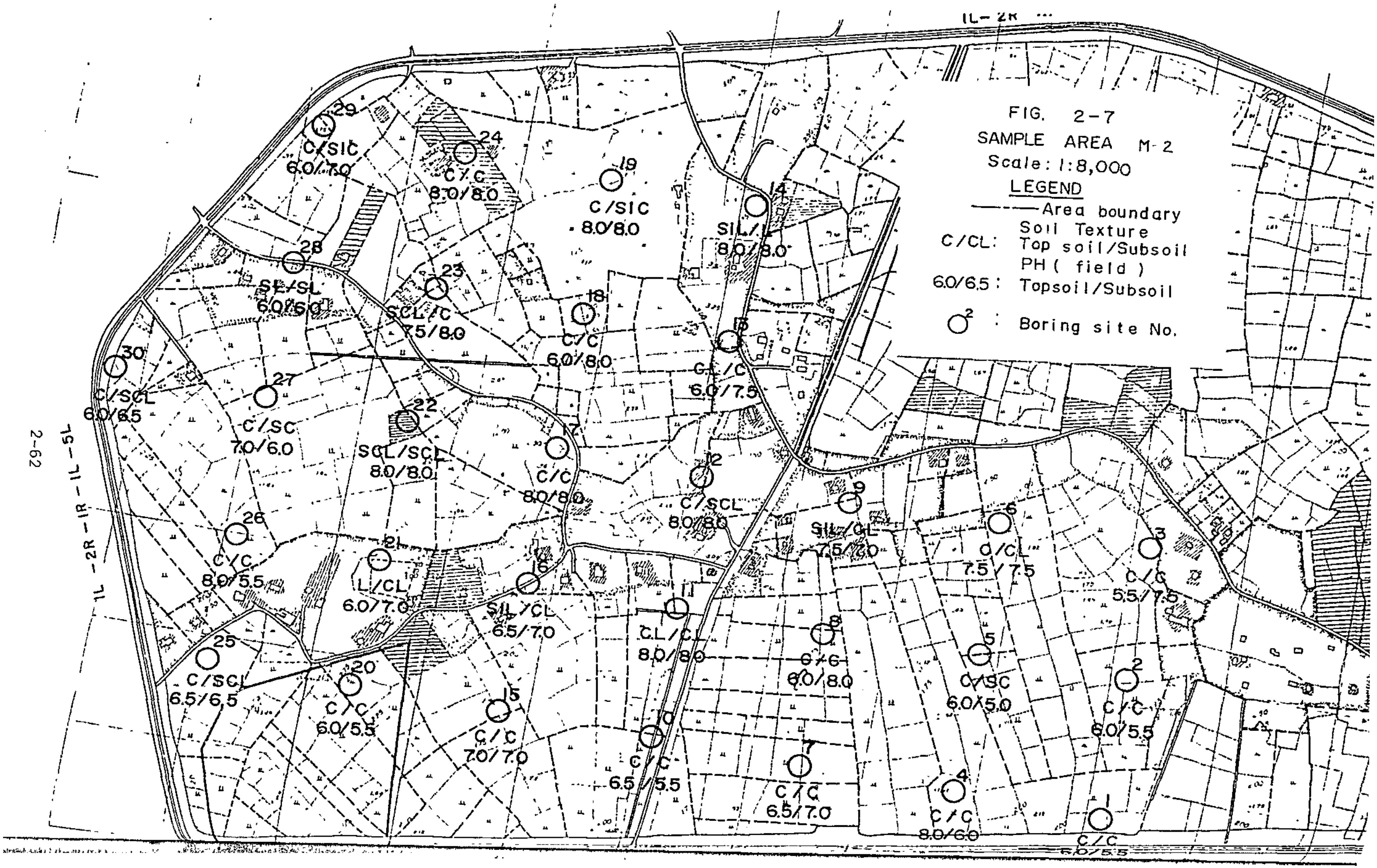


FIG. 2-7
SAMPLE AREA M-2
Scale: 1:8,000
LEGEND
Area boundary
Soil Texture
C/CL: Top soil/Subsoil
PH (field)
6.0/6.5: Topsoil/Subsoil
: Boring site No.
1L-2R
1L -2R - 1R - 1L -5L
1 C/C 6.0/5.5
2 C/C 6.0/5.5
3 C/C 5.5/7.5
4 C/C 8.0/6.0
5 C/SC 6.0/5.0
6 C/CL 7.5/7.5
7 C/C 6.5/7.0
8 C/C 6.0/8.0
9 SIL/CL 7.5/8.0
10 C/C 6.5/5.5
11 CL/CL 8.0/8.0
12 C/SCL 8.0/8.0
13 CL/C 6.0/7.5
14 SIL/L 8.0/8.0
15 C/C 7.0/7.0
16 SIL/CL 6.5/7.0
17 C/C 8.0/8.0
18 C/C 6.0/8.0
19 C/SIC 8.0/8.0
20 C/C 6.0/5.5
21 L/CL 6.0/7.0
22 SCL/SCL 8.0/8.0
23 SCL/C 7.5/8.0
24 C/C 8.0/8.0
25 C/SCL 6.5/6.5
26 C/C 8.0/5.5
27 C/SC 7.0/6.0
28 SL/SL 6.0/6.0
29 C/SIC 6.0/7.0
30 C/SCL 6.0/6.5

FIG. 29 LAND USE MAP OF SAMPLE AREA M 1

Scale 1 8,000

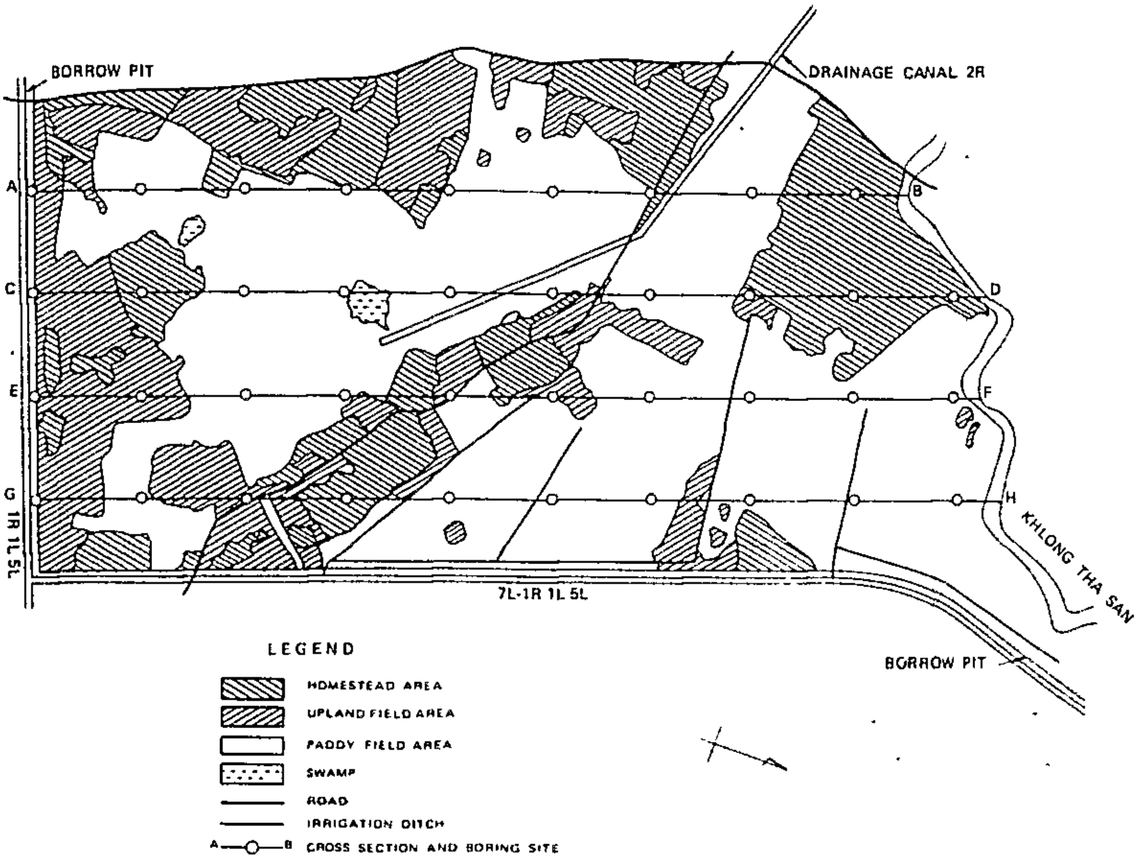


FIG. 28 CROSS SECTION OF SAMPLE AREA M-1

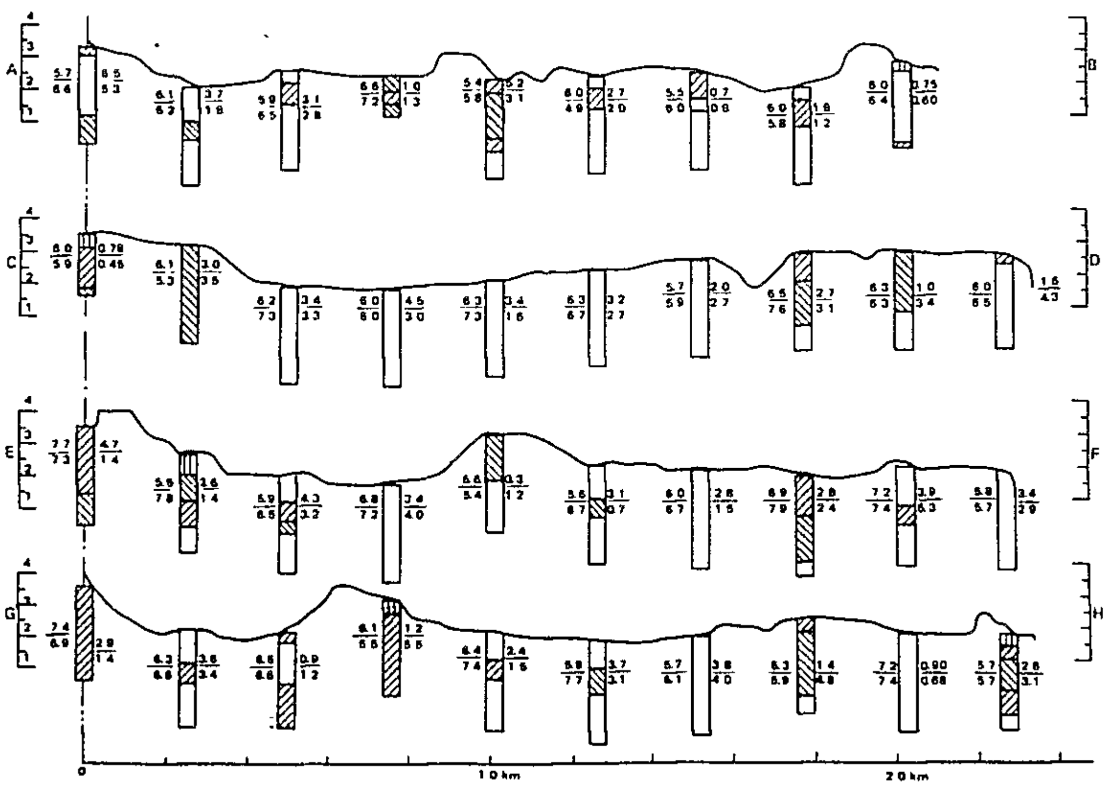


FIG. 2-11 LAND USE MAP OF SAMPLE AREA M-2

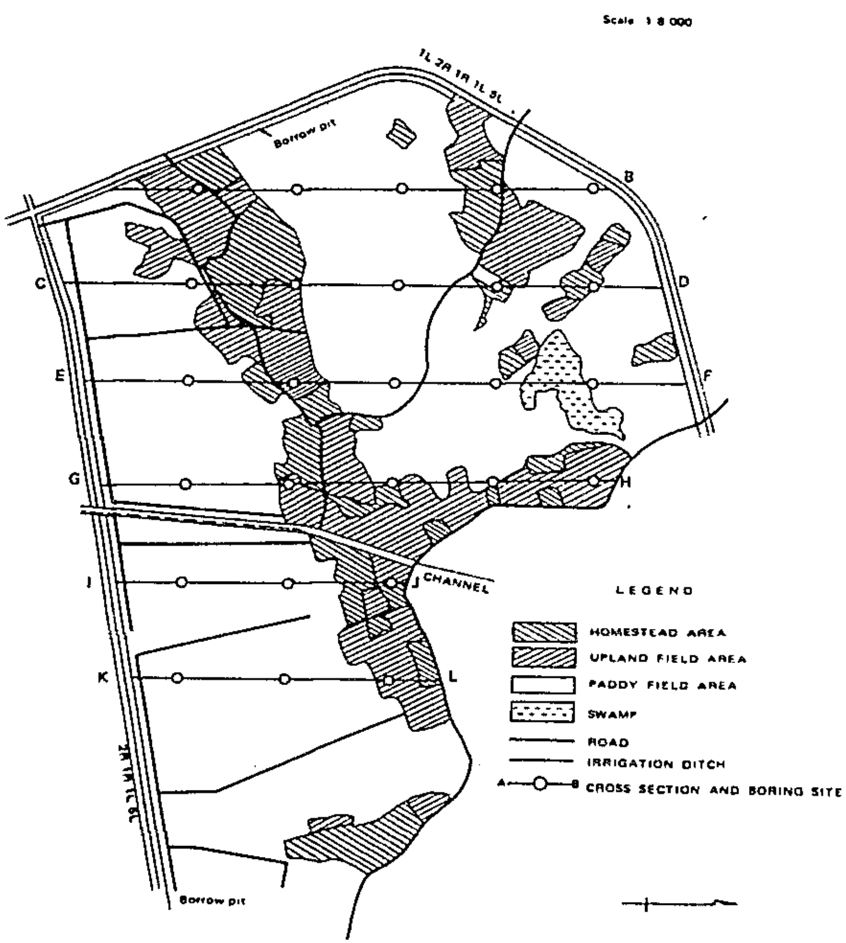


FIG. 2.10 CROSS SECTION OF SAMPLE AREA M-2

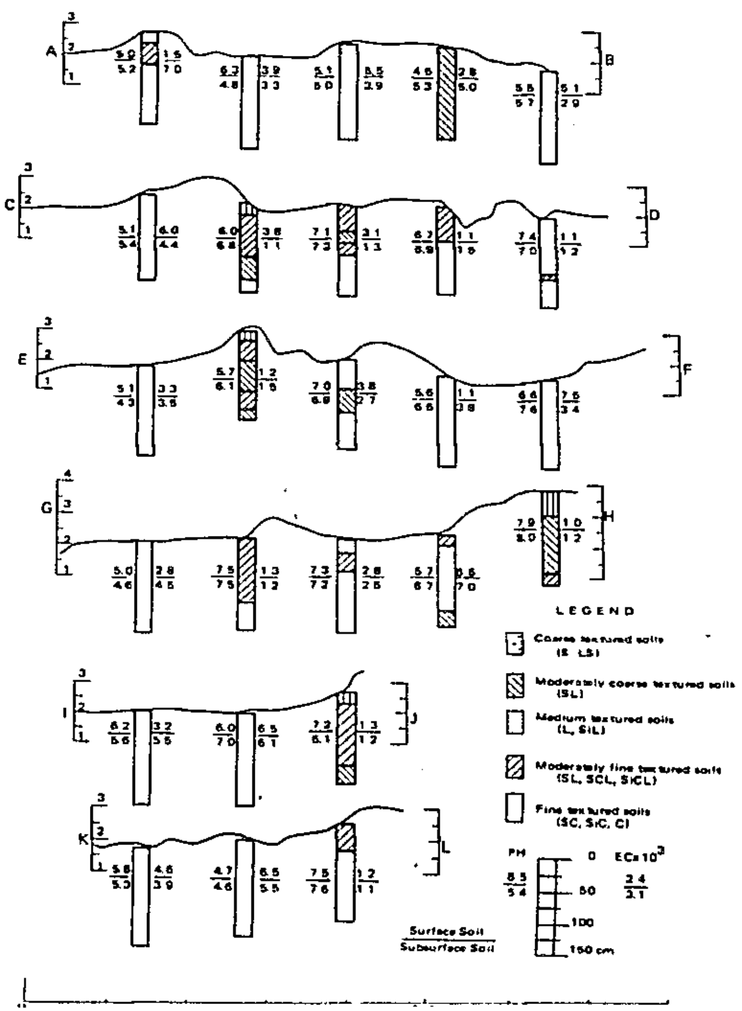


Table 2-7 Result of Soil Analysis, Sample Area M-1 & M-2

SAMPLE AREA M-1

No.	Depth cm	PH (H_2O) 1:1	Sat. Extract $ECx10^3$	Sat.% SP	Na mg/ℓ	Ca+Mg mg/ℓ	SAR
1	0-20	6.3	0.55	23.9			
	20-60	6.0	0.60	26.4			
2	0-20	7.0	1.1	33.7			
	20-50	6.3	1.6	58.0			
3	0-15	7.3	6.5	48.6	33	53	6.4
	15-40	6.9	1.8*	55.0	129	116	1.7
4	0-20	5.9	1.2	62.8			
	20-50	7.8	0.95	64.2			
5	0-15	5.7	5.0	49.2	29	35	6.9
	15-50	6.1	6.5	66.8	46	61	8.3
6	0-15	5.7	4.9	57.7	34	40	7.6
	15-40	5.8	1.1*	66.6	44	92	6.5
7	0-15	4.9	3.7	65.5	15	44	3.2
	15-40	5.0	1.6	58.4			
8	0-15	4.7	7.0	69.5	44	66	7.7
	15-60	6.3	4.8	82.9	23	50	4.6
9	0-20	6.4	5.9	46.9	34	57	6.4
	20-50	7.4	2.3	44.5	13	16	4.6
10	0-15	6.9	2.1	49.4	7.3	22	2.2
	15-50	7.4	0.98	33.4			
11	0-20	7.4	2.9	37.7	26	82	1.3
	20-50	6.9	1.4	48.3			
12	0-20	6.3	3.5	65.1	15	38	3.4
	20-50	6.6	3.4	56.8	13	38	2.9
13	0-15	6.5	0.9	41.0			
	15-40	6.6	1.2	49.0			
14	0-20	6.1	1.2	36.0			
	20-45	5.5	5.5	49.6	31	41	6.8

Soil analysis was conducted by Division of Research and Laboratory. RID.

Note: * marks mean $EXx10^3$ of extract dilution 1:9.

Table 2-7 cont.

No.	Depth cm	PH (H_2O) 1:1	Sat. Extract $ECx10^3$	Sat. % SP	Na mg/ℓ	Ca+Mg mg/ℓ	SAR
15	0-15	6.4	2.4	63.0	11	21	3.4
	15-40	7.4	1.5	67.0			
16	0-20	5.9	3.7	51.5	19	19	6.2
	20-40	7.7	3.1	62.8	17	30	4.4
17	0-15	5.7	3.8	71.4	18	40	4.0
	15-20	5.1	4.0	74.9	17	44	3.6
18	0-20	5.3	1.4*	42.7	86	87	1.3
	20-60	5.9	4.8	41.1	35	48	7.1
19	0-15	7.2	0.90	75.0			
	15-40	7.4	0.68	76.0			
20	0-15	5.7	2.6	42.0	9.0	29	2.4
	15-20	5.7	3.1	47.7	12	35	2.9
21	0-15	7.7	4.7	46.0	16	40	3.6
	15-60	7.8	1.4*	46.0	82	66	1.4
22	0-30	5.5	2.6*	39.1	184	124	2.3
	30-70	7.8	1.4*	57.7	87	108	1.2
23	0-15	5.9	4.3	57.2	17	51	3.4
	15-40	6.5	3.2	73.4	11	38	2.5
24	0-20	6.8	3.4	82.6	15	36	3.5
	20-50	7.1	4.0	61.6	15	45	3.2
25	0-20	5.6	0.30	23.7			
	20-40	5.4	1.2	31.6			
26	0-15	5.5	3.1	63.3	16	27	4.3
	15-50	6.7	0.70	71.6			
27	0-15	6.0	2.8	71.6	11	28	2.9
	15-40	6.7	1.5	54.8			
28	0-20	6.9	2.8	44.6	10	32	2.5
	20-60	7.9	2.4	42.1	5.4	32	1.3
29	0-15	7.2	3.9	67.3	22	35	5.2
	15-60	7.4	5.3	69.3	31	55	5.9
30	0-15	5.8	3.4	69.4	17	34	4.1
	15-40	5.7	2.9	62.7	19	23	5.6

Table 2-7 cont.

No.	Depth cm	PH (H_2O) 1:1	Sat. Extract ECx10³	Sat. % SP	Na mg/ℓ	Ca+Mg mg/ℓ	SAR
31	0-20	6.0	0.78	32.6			
	20-50	5.9	0.45	34.1			
32	0-20	6.1	3.0	23.6	7.8	29	2.0
	20-60	5.3	3.5	28.5	15	27	4.1
33	0-20	6.2	3.4	74.8	9.6	48	1.9
	20-60	7.3	3.3	65.0	7.6	43	1.6
34	0-20	6.0	4.5	63.9	19	52	3.7
	20-70	6.0	3.0	49.6	10	32	2.5
35	0-20	6.8	3.4	79.1	10	41	2.2
	20-50	7.3	1.6	76.0			
36	0-25	6.3	3.2	63.1	16	29	4.2
	25-30	6.7	2.7	74.5	15	19	4.9
37	0-20	5.7	2.0	58.1	16	14	6.0
	20-40	5.9	2.7	64.3	20	18	6.7
38	0-20	6.6	2.7	48.9	6.4	37	1.5
	20-40	7.6	3.1	40.0	7.3	41	1.6
39	0-20	6.3	1.0	27.3			
	20-50	6.3	3.4	31.6	15	31	3.8
40	0-15	6.0	1.5	46.9			
	15-45	6.5	4.3	63.2	23	30	5.9
41	0-15	5.7	6.5	52.5	37	46	7.7
	15-50	6.6	5.3	61.9	32	26	8.9
42	0-15	6.1	3.7	73.2	10	47	2.1
	15-50	6.2	1.8	72.0			
43	0-15	5.9	3.1	61.3	8.1	43	1.7
	15-50	6.5	2.8	43.3	7.6	37	1.8
44	0-20	6.6	1.0	39.7			
	20-45	7.2	1.3	47.4			
45	0-20	5.4	5.2	35.2	27	52	5.3
	20-40	5.8	3.1	39.5	22	8	7.3
46	0-20	6.0	2.7	48.3	13	22	3.9
	20-50	4.9	2.0	49.6	11	16	3.9

Table 2-7 cont.

No.	Depth cm	PH (H_2O) 1:1	Sat. Extract ECx10^3	Sat. % SP	Na mg/ℓ	Ca+Mg mg/ℓ	SAR
47	0-15	5.5	0.7	44.1			
	15-40	6.0	0.8	49.5			
48	0-20	6.0	1.8	69.2			
	20-60	5.8	1.2	29.9			
49	0-15	6.0	0.75	35.2			
	15-40	6.4	0.60	42.5			
51	0-20	5.5	2.0	62.9	6.7	19	2.2
	20-50	5.8	1.2	75.1			
52	0-15	5.9	1.8	35.6			
	15-40	6.8	5.2	39.5	13	4.9	2.6
53	0-20	7.6	0.85	33.6			
	20-60	7.9	0.85	47.3			
54	0-20	7.7	1.0	35.7			
	20-50	6.8	0.8	43.0			
55	0-20	7.0	0.95	52.6			
	20-50	8.0	1.2	40.0			
56	0-20	6.7	1.0	29.4			
	20-50	6.6	4.6	39.9	17	36	4.0
57	0-20	7.1	0.95	33.2			
	20-50	7.0	2.1	33.1	5.6	15	2.0
58	0-20	5.4	1.1*	56.6	54	92	7.9
	20-45	6.1	6.0	65.8	39	62	7.0
59	0-20	6.5	0.75	29.5			
	20-50	6.1	0.95	27.5			

Table 2-7 cont.

SAMPLE AREA M-2

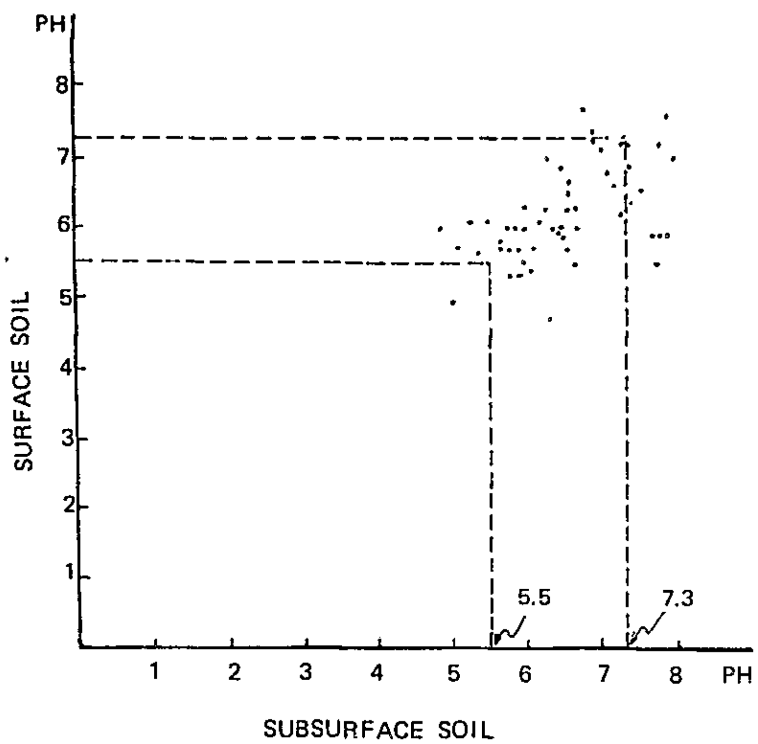
No.	Depth cm	PH (H_2O) 1:1	Sat. Extract ECx10³	Sat. % SP	Na mg/ℓ	Ca+Mg mg/ℓ	SAR
1	0-20	5.5	3.6	80.9	15	36	3.5
	20-70	4.2	49	87.0	23	62	4.1
2	0-15	4.9	7.0	61.9	40	74	6.6
	15-40	4.4	3.3	69.2	17	31	4.3
3	0-15	6.1	5.7	67.0	32	59	5.8
	15-40	5.7	1.7	71.0			
4	0-15	5.6	5.6	65.7	12	70	2.0
	15-40	5.3	3.9	64.3	15	50	3.0
5	0-20	4.7	6.5	74.1	18	67	3.1
	20-40	4.6	5.5	53.0	31	71	5.2
6	0-15	7.5	1.2	50.8			
	15-40	7.6	1.1	53.4			
7	0-20	6.2	3.2	73.1	16	32	4.0
	20-50	5.6	5.5	85.7	30	59	5.5
8	0-15	6.0	6.5	71.2	42	66	7.3
	15-50	7.0	6.1	81.4	39	60	7.1
9	0-20	7.2	1.3	41.8			
	20-70	6.1	1.2	40.1			
10	0-20	5.0	2.8	70.6	18	26	5.0
	20-50	4.6	4.5	70.5	50	32	1.3
11	0-20	7.5	1.3*	50.8	70	69	12
	20-50	7.5	1.2*	50.7	81	66	14
12	0-20	7.3	2.8	62.4	21	12	8.6
	20-50	7.2	2.5	51.1	20	11	8.5
13	0-15	5.7	6.5	55.7	48	43	10
	15-50	6.7	7.0	59.0	59	46	12
14	0-15	7.9	1.0	35.6			
	15-40	8.0	1.2	38.6			
15	0-15	5.1	3.3	75.5	13	38	2.9
	15-40	4.3	3.5	80.3	11	44	2.3

Table 2-7 cont.

No.	Depth cm	PH (H_2O) 1:1	Sat. Extract $ECx10^3$	Sat. % SP	Na Mg/ℓ	Ca+Mg mg/ℓ	SAR
16	0-15	5.7	1.2*	42.3	37	92	5.4
	15-50	6.1	1.5*	48.3	87	84	13
17	0-20	7.0	3.8	63.9	21	29	5.5
	20-50	6.9	2.7	68.0	15	17	5.1
18	0-15	5.6	1.1*	65.5	41	95	5.9
	15-40	6.6	3.8	59.6	20	28	5.3
19	0-15	6.6	7.5	71.4	52	41	11
	15-40	7.6	3.4	58.8	25	14	9.4
20	0-15	5.1	6.0	61.2	35	51	7.5
	15-45	5.4	4.4	66.8	29	25.	8.2
21	0-20	6.0	3.8	39.8	22	28	5.9
	20-60	6.8	1.1*	53.1	53	63	9.4
22	0-15	7.1	3.1*	47.7	181	171	19
	15-40	7.3	1.3*	44.9	67	103	9.3
23	0-20	6.7	1.1*	66.7	62	66	11
	20-60	6.9	1.5*	51.6	98	100	14
24	0-15	7.4	1.1*	61.3	50	92	7.4
	15-50	2.0	1.2*	62.3	54	90	8.0
25	0-15	5.0	1.5*	72.8	58	119	7.5
	15-50	5.2	7.0	42.3	35	74	5.7
26	0-20	6.3	3.9	64.1	12	50	2.4
	20-50	4.8	3.3	71.4	8.5	49	1.7
27	0-15	5.1	5.5	65.1	28	61	5.1
	15-45	5.0	3.9	48.3	22	29	5.8
28	0-15	4.5	2.8*	28.0	198	12	81
	15-40	5.3	5.0	29.4	38	20	12
29	0-15	5.5	5.1	69.7	19	53	3.7
	15-40	5.7	2.9	56.3	16	20	5.0
30	0-15	5.6	3.0	71.9	16	30	4.1
	15-50	5.6	3.4	61.8	18	26	5.0

FIG. 2-12 STATUS OF PH IN THE SAMPLE AREA

SAMPLE AREA M-1



SAMPLE AREA M-2

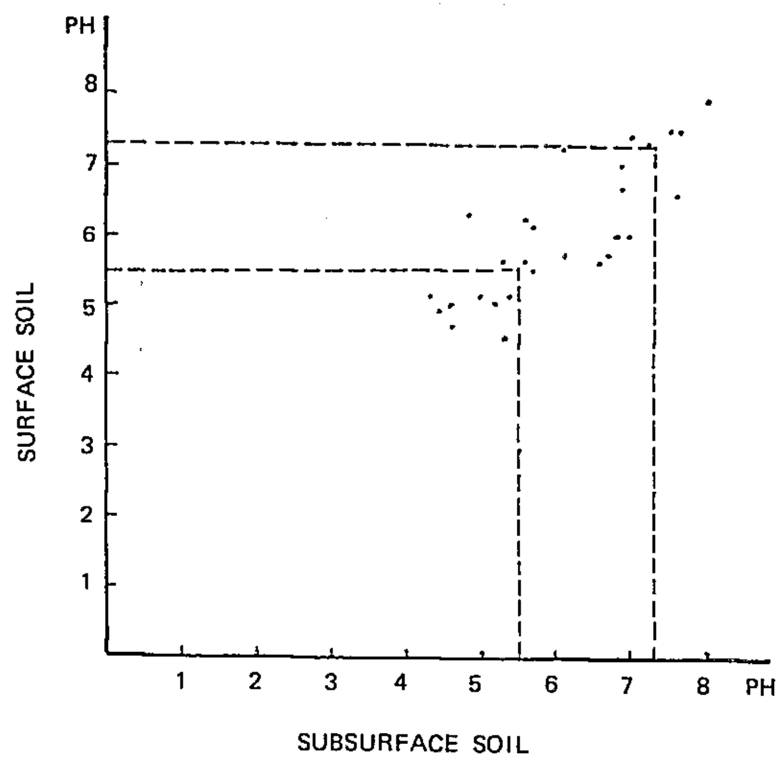


FIG. 2-13 STATUS OF ELECTRIC CONDUCTIVITY IN THE SAMPLE AREA

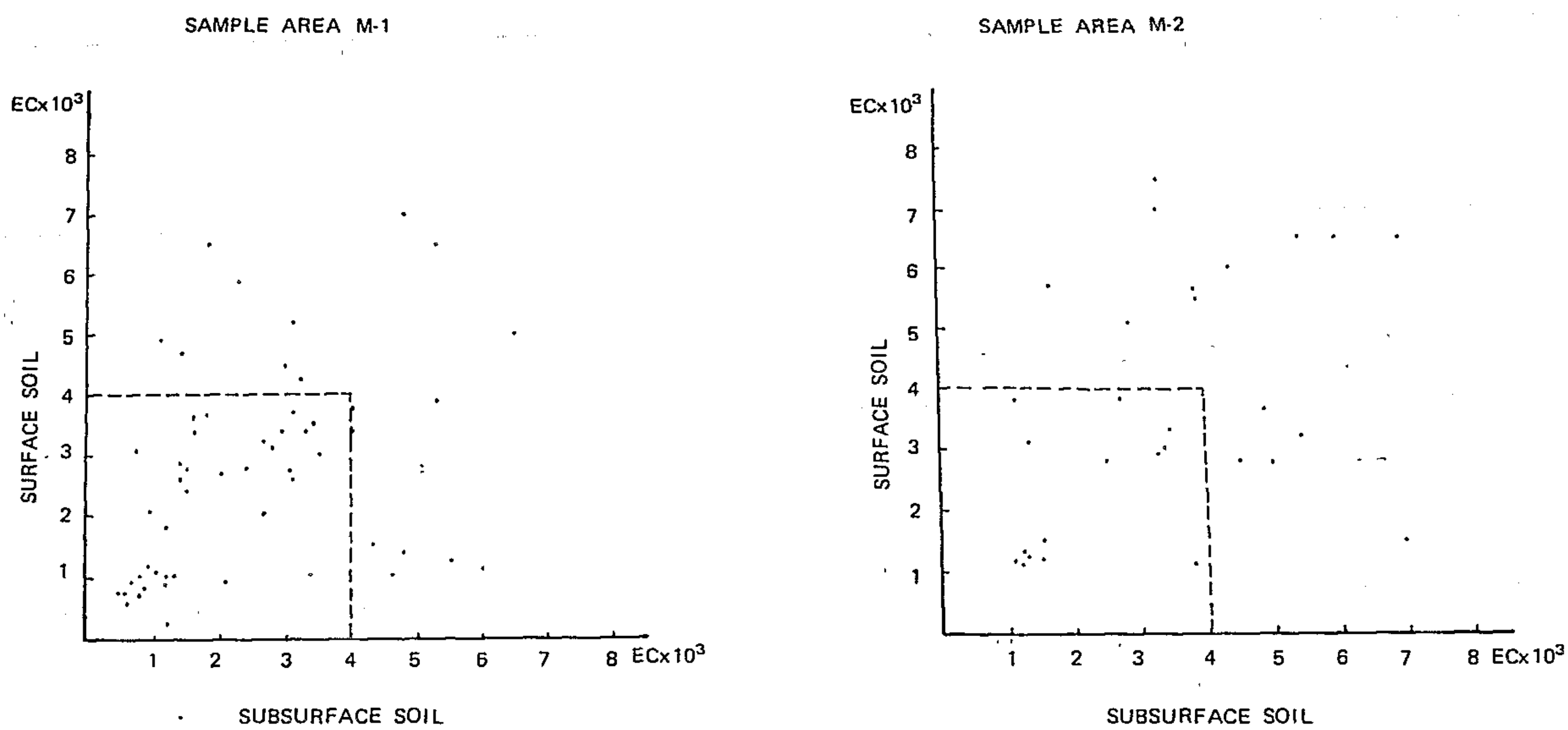


Table 2-8 Specification for Semi-detailed Land Classification
Mae Klong River Project

Classification Characteristics	Upland Field U1	U2	U3	Paddy Field R1	R2	R3
SOIL						
Soil texture	SL-fri CL	LS-sp. C LS 30cm	SL-sp. C LS 60cm	CL-vsp.C CL 30cm	SL-vsp.C SL 15cm L 30cm CL 30cm	ES-vsp.C LS 15cm
Depth of soil	150 cm	120 cm	90 cm	90 cm	60 cm	30 cm
PH(paste)	5.5-8.0	5.0-8.5	4.5-8.5	5.0-8.0	4.5-8.5	4.0-8.5
Salinity						
EX x 10^3	<4	<6	<8	<4	<6	<8
Exchangeable sodium meq/100gm	<2	<2	<3	<3	<4	<4
Water-holding Capacity in 120 cm/depth	15 cm	11 cm	8 cm	not applicable	not applicable	not applicable
TOPOGRAPHY						
Relief	smooth	uneven	rough	smooth	eneven	rough
Slop	<2%	<4%	<6%	<2%	<4%	<4%
Leveling requirement	low	medium	high	low	low	medium
Gravel or rock	few	few	some but tillable	few	few	some but tillable
Rock removal	none	none	some	none	none	some
Tree or bruch cover	slight clearing	moderate clearing	heavy clearing	slight clearing	moderate clearing	heavy clearing
DRAINAGE						
Surface	good	good-fair	fair-poor	good	good-fair	fair-poor
Sub-surface	good	good-fair	fair-poor	poor	good-fair	good
Flood	none	none	occasional	infrequent damaging floods	periodic damaging floods	annual damaging floods

Class 6 Non-arable lands - includes all lands which do not meet the minimal requirements for classes 1, 2 and 3.

Note: vsp: very slowly permeable. p: permeable. fri: friable.
LS 30cm means that no more than 30cm topsoil may be Loamy Sang

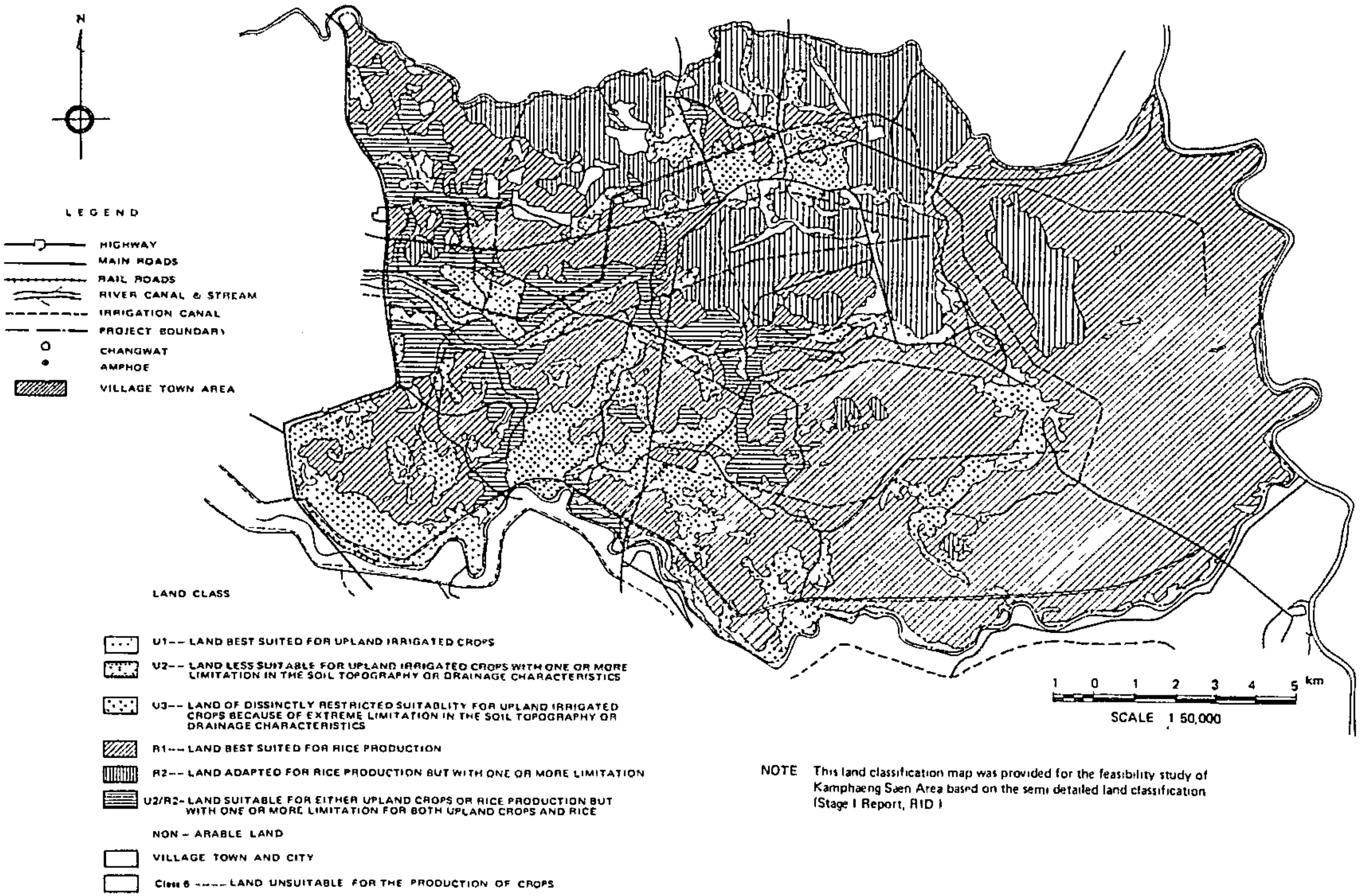
Data source: The Greater Mae Klong Multi-purpose Project II stage Development, 1968.

Table 2-9 Cultivable Area and Land Class Group

Project Gross Area	28,000 ha	100%	
Homestead area	2,110	7.5	
Public area	2,060	7.4	
Class 6 land	910	3.2	
Sub-total	5,080	18.1	
Caltivable area	22,920	81.9	100%
Upland Crop Field	2,960	10.6	12.9
Class 1:	2,730		11.9
U1/R2s	100		
U1/R3s	2,630		
Class 2:	120		0.5
U2sd/R3sd	120		
Class 3:	110		0.5
U3s/R3s	110		
Rice Field	17,880	63.9	78.0
Class 1:	13,760		60.0
U3sd/R1	11,160		
U3s/R1	1,400		
U2s/R1	1,140		
U2st/R1	60		
Class 2:	4,120		18.0
U3sd/R2d	4,120		
Upland Crop Field/Rice Field	2,080	7.4	9.1
U2s/R2s	2,080		

Fig. 2 - 14

LAND CLASSIFICATION MAP OF THE PROEJCT AREA



APPENDIX 3

IRRIGATION

IRRIGATION

Table of Contents

IRRIGATION

LIST OF TABLES

LIST OF FIGURES

IRRIGATION

3-1. Present Irrigation Systems

(1) Irrigation System and Facilities

Irrigation System

The Kamphaeng Saen area is served with irrigation water by 12 canals taking off from the left main canal constructed under the Greater Mae Klong Irrigation Project. The area has been divided into three irrigation sub-systems viz., 2L-5L, 1R-1L-5L and 2R-1R-1L-5L (see Figs. 3-1 & 3-2).

The actual irrigated area was estimated at about 4,130 ha in the wet season and about 7,140 ha in the dry season, based on the records of water supplied to the Kamphaeng Saen Area and the commandable area by Full Supply Level (FSL) in canals, the designed water surface elevation, although the RID's total designed irrigation area was 27,860 ha.

Facilities

The irrigation canals in the Project Area include two systems, the main irrigation canal system constructed under the Greater Mae Klong Irrigation Project and the farm ditch system under the "Ditches and Dikes" Program.

The farm ditches function to supply the water diverted at farm turnouts on the irrigation canals to the farm plots. The total length of 12 irrigation canals and farm ditches are approximately 119 km and 304 km, respectively. The density of farm ditches, as an index of water use efficiency at farm level, was estimated at 10.9 m/ha on an average. In the Project Area, 239 farm turnouts have been constructed, and average commandable area and length of farm ditch per farm turnout are 117 ha and 1,270 m, respectively. The sub-systemwise descriptions are shown as follows and detailed in Table 3-1.

Sub-system	Designed irrig. Area (ha)	Total Length of Canals (m)	Farm Ditch		Turnouts		
			Length (m)	Density (m/ha)	Nos.	Commandable Area/ turnout (ha)	Ditch Length/ turnout (m)
2L-5L	9,820	36,550	104,400	10.6	70	140	1,490
1R-1L-5L	12,500	46,012	128,400	10.3	104	120	1,230
2R-1%-1L-5L	5,540	35,610	71,300	12.9	65	85	1,100
Total	27,860	119,072	304,100	10.9	239	117	1,270

The total canal capacities to the designed irrigation area were calculated by 20.9 m^3/s, based on the water duty of 0.75 $\ell/s/ha$. In the Greater Mae Klong Irrigation Project, the water requirements were computed for a supplemental wet season irrigation on the cropping pattern basis of 100 percent paddy cropping.

Of the total canal length of 119,072 m, 96,730 m except 8L-1R-1L-5L and parts of 2L-5L and 1R-1L-5L, are lined with concrete, occupying 80 percent of the total length. The thickness of lining varies from 5 to 10 cm depending on the canal discharge capacity. In general, the canal lining is in good condition.

Full supply level at the head of the sub-systems are maintained at EL 6,866 m for 2L-5L, EL 6,311 m for 1R-1L-5L and EL 5,195 m for 2R-1R-1L-5L. The slope of the canal bed is designed by 1 : 10,000, excepting for one by 1 : 50,000. The check facilities including tail regulators total 40, which are installed at about 4.0 km interval on an average.

Most of road crossing structures are roadway culverts consisting of single or double barrels of reinforced concrete pipes, totalling 24 culverts. The head loss by the roadway culverts rainges from 0.1 m to 0.3 m by sizes and discharge capacities.

(2) Commandability of the Area

The irrigation systems in the Kamphaeng Saen area was constructed with the purpose of supplying irrigation water for the area of 27,860 ha, and have been operated six years since completed. There can be seen many farm plots which can not be so irrigated with the existing systems as originally designed, however. These uncommandable farm plots are located higher than the elevation of FSL minus required head losses for water distribution, or lack farm ditches/ farm inlets with which the farm plots receive water from the main irrigation system. In the latter case, the situation could be improved by construction of adequate on-farm facilities, which will be discussed in Appendix V.

Based on the detailed topographical map (1:4,000 with 0.25 m contour interval) and canal profiles prepared by RID, commandable area as served by the existing gravity system has been estimated at a gross area of about 17,970 ha. The basic data for this estimation were: (i) 0.10m of diversion water head loss at farm turnout, (ii) 0.25 m/km of conveyance loss head in farm ditches, and (iii) 0.10 m of distribution loss head at the terminal point of farm ditches (Table 3-2). The total commandable area is about 17,970 ha including about 13,440 ha of arable lands, which accounts for about fifty-nine (59) percent of the total existing arable lands.

As stated above the existing canal capacities were designed for supplementary wet season paddy irrigation. The Sri Nagarind dam which is under construction on the Khwae Yai, is expected to supply water for large-scale irrigation for dry season crops starting from 1981.

The RID has decided to take water duty as 0.25 ℓ/s/rai (or 1.56 ℓ/s/ha) for farm ditch design in the 2nd stage area, taking into account the dry season paddy cropping. The dry season paddy cropping has spread rapidly in place of traditional rainy season paddy single cropping in the low land as well as paddy double cropping has been introduced by some 27 percent area at present. The Sri Nagarind storage operation would permit the dry season paddy cropping to be increased to the considerable extent.

The existing canal capacities at the head of sub-systems are 20.9 m^3/s in total, which implies that can command 14,520 ha area of dry season paddy cropping as a whole. On the other hand, the area of paddy fields is estimated at 14,640 ha, based on the various statistic data and topographic maps with scale at 1 : 4,000. Besides the paddy fields, in the area there is an area of 1,340 ha of fallow land. The irrigable area of dry season paddy under the existing canal capacities may amount to some 91 percent of the total paddy fields as a whole, on condition that sugar cane area remains and furthermore fallow land is to be converted to paddy fields, resulting in a total area of 15,980 ha. This, however, does not always applicable to individual canals, because the canals command different acreages and various lands in categories.

The canals are designed for steady uniform flow based on peak water requirements. Water levels in the canals are kept at FSL by operating check facilities when less discharges than the designed one are required. Installation of additional check facilities will be needed at suitable locations in order to extend commandable areas both at full and partial supply.

3-2. Water Requirements

(1) Estimation

Irrigation water requirements were computed by the following procedures.

- Net Water Requirements (NWR) = Consumptive Use for Crops + Deep Percolation + Necessary Water for Land Preparation

- Field Water Requirements (FWR) = Net Water Requirements - Effective Rainfalls + Field Loss

- Diversion Water Requirement (IWR) = Field Water Requirements + Conveyance Loss + Operation Loss.

(2) Crop Factor

Consumptive use for crops is obtained by Evapotranspiration multiplying by crop factor on its growing stage.

Evapotranspiration (ET)

The Penman's formula, which is applicable to computation for the humid climate zone, was employed to obtain Evapotranspiration.

Three observation stations at Suphanburi, Kanchanaburi and Bangkok, which provide highly reliable and long-term records in the hydrological study in the Master Plan Study of the Mae Klong River Basin (JICA), were selected as representative observation stations for evapotranspiration. The data collected therefrom were treated by Thiessen Method to compute the average evapotranspiration in the Mae Klong irrigation areas.

The values of evapotranspiration (Master Plan Study) shown in the following table (average values for the whole Mae Klong Area) were adopted to estimate the evapotranspiration for the Kamphaeng Saen Area Irrigation program.

Evapotranspiration

(Unit: mm/day)

Month	Suphanburi	Kanchanaburi	Bangkok	Average
1	3.71	3.47	3.42	3.5
2	4.39	4.22	4.06	4.2
3	5.12	4.84	4.58	4.8
4	5.52	5.52	4.83	5.2
5	4.82	4.49	4.23	4.5

- cont'd -

Month	Suphanburi	Kanchanaburi	Bangkok	Average
6	4.49	4.08	3.92	4.1
7	4.09	3.78	3.57	3.8
8	3.98	3.76	3.52	3.7
9	3.61	3.50	3.33	3.5
10	3.72	3.50	3.49	3.5
11	3.75	3.46	3.46	3.5
12	3.50	3.21	3.16	3.3
Year Average	4.2	4.0	3.8	4.0
Areal ratio	18.5%	54.2%	27.3%	100.0%

Note: NB: — Reaording Period 1951 - 1975 (25 years)

Crop Factor

The crop factor was determined in reference to various data and records, such as the Report on the Greater Mae Klong Irrigation Project (LOACO, 1974) and actual results obtained in Indonesia, Philippines and Thailand (San Chook Experimental Farm). For transplanting paddy the crop factor was taken by 1.0 for a period of two months from paddling, nursery to transplanting.

Crop Factors

Grouth Stage (Month)	Transplanting Paddy Local varieties	Transplanting Paddy HYV	Sugar cane	Upland crops	Vegetables and Fruit-trees 1/
1	1.0	1.0	0.6	0.4	0.7
2	1.0	1.25	0.8	0.7	0.7
3	1.2	1.35	1.0	1.0	0.7
4	1.35	1.3	1.2	0.9	0.7
5	1.3	1.1	1.25	0.5	
6	1.2		1.2		
7	1.1		1.15		
8			1.0		
9			0.85		
10			0.65		
11			0.6		
12			0.5		

NB: 1/.. Growth period of perenial crops and overlapping growth period of some vegetable cropping in a year.

(3) Percolation and Others

Percolation

Percolation is largely affected by soil properties. The soil of the Mae Klong Area including the Kamphaeng Saen Project Area are rich in clayey properties to allow a comparatively small percolation.

According to the result obtained in the Mae Klong Area, the percolation in paddy fields in the Kamphaeng Saen Area was estimated at 1.0 mm/day throughout the dry season and the wet season.

The percolation in the upland irrigation was counted in the field loss as irrigation loss.

Necessary Water for Land Preparation

Besides the crop factors, the land preparation water and pre-irrigation water will be required for paddy cropping and upland cropping, respectively.

The cropwise necessary water amounts are illustrated in the table in the right column.

Land Preparation Water

Crops	Water (mm)
Paddy	200
Sugarcane	50
Upland crops	40

The land preparation water of 200 mm is to be supplied on the first day of the works, and the water will have to be supplimentarily supplied to meet evaporation and percolation during about 30 days since then.

(4) Effective Rainfall

The Master Plan Study (JICA) has performed a tank model simulation on the basis of water holding function for the effective rainfalls to irrigation, and the simulation adopted the records for 26 years by 21 representative rain gauge stations. Hence, the relationship between rainfalls and effective rainfalls were found, as shown in the following table. The results of computation on effective rainfall by RID for the Mae Klong Multi-purpose Project are identical with those obtained in the Master Plan Study of the Mae Klong Project.

The study on the effective rainfall was carried out by using the rainfall recorded at Kamphaeng Saen observation station, based on the results of the Master Plan Study below.

Relationship Between Rainfalls and Effective Rainfalls

(Unit: mm)

Crops	Effect. Rainfall	Maximum Month	Maximum 10-days
Paddy	0.75 R	200	70
Sugar cane	0.75 R	150	50
Upland crops	0.75 R	120	40

The monthly mean rainfalls and the probable mimimum rainfalls with 5- and 10-year return period were estimated as follows based on the 26-year observation records between 1952 and 1978 at the Kamphaeng Saen observation station.

Probable Monthly Minimum Rainfalls

Month	Return-Period 2 yrs	5 yrs	10 yrs	Month	Return-Period 2 yrs	5 yrs	10 yrs
1	0	0	0	7	113	68	48
2	0	0	0	8	140	86	60
3	0	0	0	9	234	169	143
4	7	0	0	10	199	129	100
5	109	61	40	11	27	7	4
6	107	66	51	12	0	0	0

The effective rainfalls for irrigation was calculated based on the monthly mean rainfalls for comparing with the estimated effective rainfalls in the Mae Klong Irrigation Project Stage I, and the results were shown below. In the Mae Klong Irrigation Project Stage I, the monthly mean rainfalls were estimated according to the 10-year rainfall records observed at 11 rain gauge stations covering the Mae Klong Area. From these data on monthly mean rainfalls the monthly effective rainfalls were estimated in taking the effective rainfall rate by 75 percent for the months from April to September, by 65 percent for October because of its higher rainfall intensity, by 80 percent for November and 90 percent for the months from December to March, respectively.

Monthly Mean Effective Rainfalls

(Unit: mm)

Month	I Stage	The Project	Month	I Stage	The Proejct
1	4	0	7	96	85
2	10	0	8	103	105
3	22	0	9	178	176
4	44	5	10	133	149
5	99	82	11	49	20
6	87	80	12	5	0
			Total	830	702

In this estimation, water requirements and its availability were studied in taking 10 days as a unit period, and the probable effective rainfalls were computed as follows for the Kamphaeng Saen Area.

Probable 10-Day Minimum Rainfalls

Month	10-Day	Return Period 2 Yrs.	5 Yrs.	10 Yrs.	Month	10-Day	Return Period 2 Yrs.	5 Yrs.	10 Yrs.
4	early	11.0	0	0	8	early	37.4	9.1	0.8
	mid	18.0	0	0		mid	42.3	10.4	2.6
	last	17.6	0	0		last	69.4	28.4	13.7
5	early	34.7	3.5	1.2	9	early	77.9	25.9	4.3
	mid	37.6	7.7	1.5		mid	82.1	41.8	5.3
	last	47.4	7.9	2.9		last	94.5	43.7	21.2
6	early	34.4	4.3	0	10	early	113.1	36.1	24.7
	mid	39.7	15.6	1.9		mid	53.9	22.8	2.8
	last	47.6	18.3	6.5		last	37.1	7.5	0
7	early	36.7	9.6	1.7	11	early	22.8	0	0
	mid	40.3	13.6	1.8		mid	19.3	0	0
	last	42.5	4.4	0		last	7.8	0	0

(5) Water Losses

Field Loss

A part of irrigated water to the fields is lost in the field by horizontal percolation from ridges, surface runoff, misoperation of the facilities, etc. Consequently, the water to be supplied to the fields is estimated by the following equation.

$$FWR = \frac{NWR - Re}{Ef}$$

Where, FWR = Field Water Requirements
NWR = Net Water Requirements
Re = Effective Rainfall
Ef = Field Efficiency

The field efficiency is decided depending upon on-farm facilities conditions, irrigation method, irrigation amount, etc. In this study, the following average values were applied; 0.70 for paddy cropping and 0.60 for crops other than paddy. The field losses include the losses caused in the farm ditches.

Conveyance and Operation Loss

This conveyance loss is caused in the canals and laterals while the necessary water is conveyed through the canal system to the farm ditches. The necessary water to be diverted from the Mae Klong river includes the conveyance loss. The operation of diversion facilities, which should be made to adequately meet the water reqire-ments, will unavoidably cause the losses, particularly in the wet season.

Under the situation, the data and information on rainfall should be collected and propertly communicated to the organization concerned for the most effective utilization of rainfalls. In the vast Mae Klong Area, however, it will be extremely difficult to forecast the right time, place and amount in occurrence of rainfall and also a certain time lag will inevitably take place in following the vari-able requirement of water through the long irrigation system.

In taking into account these factors, the diversion requirements of irrigation water is estimated by the following equation.

$$DR = IWR \times \frac{1}{Eo} = \frac{FWR}{Ec} \times \frac{1}{Eo}$$

Where, Ec = Conveyance efficiency

Eo = Operation efficiency

The conveyance efficiency is adopted by 0.95 for concrete lining canals and 0.70 for earth canals. The canal capacities are obtained by dividing the FWR (Field Water Requirements) at the peak of the dry season when no effective rainfall is expected by conveyance and operation efficiencies. The operation efficiency of 0.80 at the diversion site was studied in the Master Plan Study of the Mae Klong River Basin Development Project/JICA.

3.3. Water Demand and Supply

(1) Unit Water Requirement

The unit water requirement was obtained by the previous equation (crop factor was based on the proposed cropping pattern). The maximum water requirement is found at last day of paddling works in every cropping calendar. The 10-day water requirements for each cropping pattern are shown in Table 3-3.

(2) Water Demand

The water demand for Kamphaeng Saen Area may be estimated as follows according to the unit water requirement and the proposed land use in full development.

Water Demand

	Area	Max (m^3/sec) Wet	Max (m^3/sec) Dry
Paddy (Type-1)	540 ha	0.43	0.59
(Type-2)	2,020 ha	1.73	2.06
(Type-3)	12,620 ha	16.85	19.12
Sub-total	15,180 ha	19.01	21.77
Sugar cane	4,660 ha	3.71	4.94
Vegetable, Fruit trees	2,150 ha	1.35	1.75
Total		24.07	28.46

(3) Water Supply

Currently, the existing irrigation facilities can supply water at the designed capacity 20.9 m^3/sec through three lateral canals, 1R-1L-5L, 2L-5L, and 2R-1R-1L-5L, all of which cross the national highway of Malaiman Road.

Present amount of water (20.9 m^3/sec), however, accounts only 74 percent of the water requirement at the stage of full development of the Project. Under the present situation that the terminal facilities for the Mae Klong Irrigation Project Area have not been completely provided, this amount of water is expected to be secured throughout the year by starting water operation of Sri Nagarind dam in 1981.

The necessary water demand for the total development program should be studied in the second stage of this Project and also the Master Plan Study is expected to take up the study.

(4) Irrigable Areas

The irrigable areas are studied based on the conveyance capacities of the respective lateral and tertial canals. The irrigable areas by three major lateral canals crossing the Malaiman Road were obtained based on the designed capacity (conveyance capacity). The case study was made with two case for the irrigable areas; Case 1 — Irrigation priority is given to the dry season paddy cropping, and Case 2 — The priority is given to the present irrigated 1,200 ha of sugar cane fields and the remaining water is supplied to paddy fields.

Wet Season Irrigable Area

Lateral canals	Capacity (m^3/s)	Case-1 Paddy (ha)	Case-1 Sugar cane (ha)	Case-2 Paddy (ha)	Case-2 Sugar cane (ha)
1R-1L-5L	9.45	6.814	-	6,704	766
2R-1R-1L-5L	4.30	3,382	-	3,382	163
2L-5L	7.15	4,784	271	4,784	271
Total	20.90	14,980	271	14,870	1.200

Dry Season Irrigable Area

Lateral canals	Capacity (m^3/s)	Case-1 Paddy (ha)	Case-1 Sugar cane (ha)	Case-2 Paddy (ha)	Case-2 Sugar cane (ha)
1R-1L-5L	9.45	6,660	-	6,541	766
2R-1R-1L-5L	4.30	2,800	-	2,755	163
2L-5L	7.15	4,784	271	4,784	271
Total	20.90	14,599	271	14.080	1,200

The existing lateral and tertiary canals can cover about 13,440 ha by present FSL. The heightening of the existing canal embankment will be necessary for the effective use of 20.9 m^3/sec of the water available at present so as to increase the irrigable areas by raising FSL of the canal. Estimated irrigable area and water requirement for each lateral are shown in Tables 3-4 and 3-5.

3-4. Upgrading of the Existing System

(1) Plan Formulation

The three major canals of 2L-5L, 1R-1L-5L and 2R-1R-1L-5L, which are main components of these sub-systems in the Proejct Area, have supplied the water to the upstream areas of Proejct.

The total length of these canals in the upstream areas reaches about 4 km and their design was made on the same criteria as that of the canals provided in the Project Area.

Under the circumstances, the following three alternatives are proposed for raising FSL of the canals and increasing the capacity.

i) Upgrading and section enlargement of the major canals will be carried out in the upstream area outside Proejct Area as well as in the Project Area for 100 percent cropping of the dry season paddy.

ii) Under the present conditions of FSL and capacity of the canals at the end of the upstream in the Project Area, possible upgrading and capacity increase will be carried out.

iii) Upgrading and section enlargement of the canals only in the Project Area will carried out for 100 percent cropping of the dry season paddy on condition of implementation of upgrading and capacity increase for all systems in the Mae Klong Irrigation Project.

At present, however, supplemental water supply and the implementation of the works in the upstream areas can not be expected, and therefore, it may not be the right time to make a plan of increasing the dry season paddy cropping up to 100 percent.

Hence, in this Project the irrigable area increase will be made by hightening of the existing canal embankments in the Area for the bese use of the maximum water available at 20.9 m^3/sec in the three major laterals crossing the Malaiman Road.

Upgrading and capacity increase will enable the existing canals to distribute the water effectively and efficiently with control facilities to be provided as well as to convey sufficient water for complete irrigation in the future.

(2) Upgrading of the Canals

The increase in FSL is planned by providing check facilities or upgrading of the canals for possible expansion of the capacities so as to meet the requirements both in full irrigation and supplmental irrigation to effective commandable area by existing canal system.

Careful study has been made on the 12 laterals and sub-laterals whether or not these laterals would be improved in order to increase the commandable area.

The heightening of canal embankments is essentially required to reduce the unirrigable areas by gravity irrigation.

Since the three canals of 2L-5L, 6L-1R-1L-5L and 7L-1R-1L-5L have drops with water head difference of more than 0.7 m at the head of the canals, FSL of the canals will be easily increased by upgrading of the diversion/control facilities and heightening of the embankment.

The head of other eight (8) canals is only below 0.3 m and even upgrading control facilities and cross-road culverts has limitation in the extent of raising FSL. The earth canal of 8L-1R-1L-5L is desirable to be upgraded with concrete lining.

The heightening of canal embankment will make it sure to increase the canal capacities. Embankment heightening shall be implemented concentratively for the tertiary canals, and commenced with major three laterals, if a considerable water is found in the tertiary canals.

3-5. Project Works

Main project works for upgrading to irrigation system are as follows and summarized in Table 3-7.

i) Improvement of canals, by way of increasing canal side wall height (about 25.17 km) (see Fig. 3-4) and concrete lining of earth canal (about 22.6 km), are as follows:

Improvement of Canals

Laterals	Increased hight (m)	Improved canal length	Notes
2L-5L	0.60	17,652 1/	16+488 to 32+140
1R-1L-5L	0.40	9,146 1/	36+946 to 44.092
5L-1R-1L-5L	0.60	4,500	0 to 4+500
7L-1R-1L-5L	0.60	2,700	0 to 2+700
8L-1R-1L-5L	0.55	7,766 1/	0 to 7_766
4R-2R-1R-1L-5L	0.20	6,100	3+190 to 9+200

1/ all of 8L-1R-1L-5L and part of 2L-5L and 1R-1L-5L would be improved to concrete lining canal

ii) Removal of culverts, in order to get enough water surface elevation to increase irrigated area.

iii) Construction of bridges, which consist of construction of road bridges placed removed culverts site and foot bridges.

iv) Improvement of head gates for increased water demand and repaire of form turnouts.

Figure 3-1 MAP OF PRESENT IRRIGATION SYSTEM

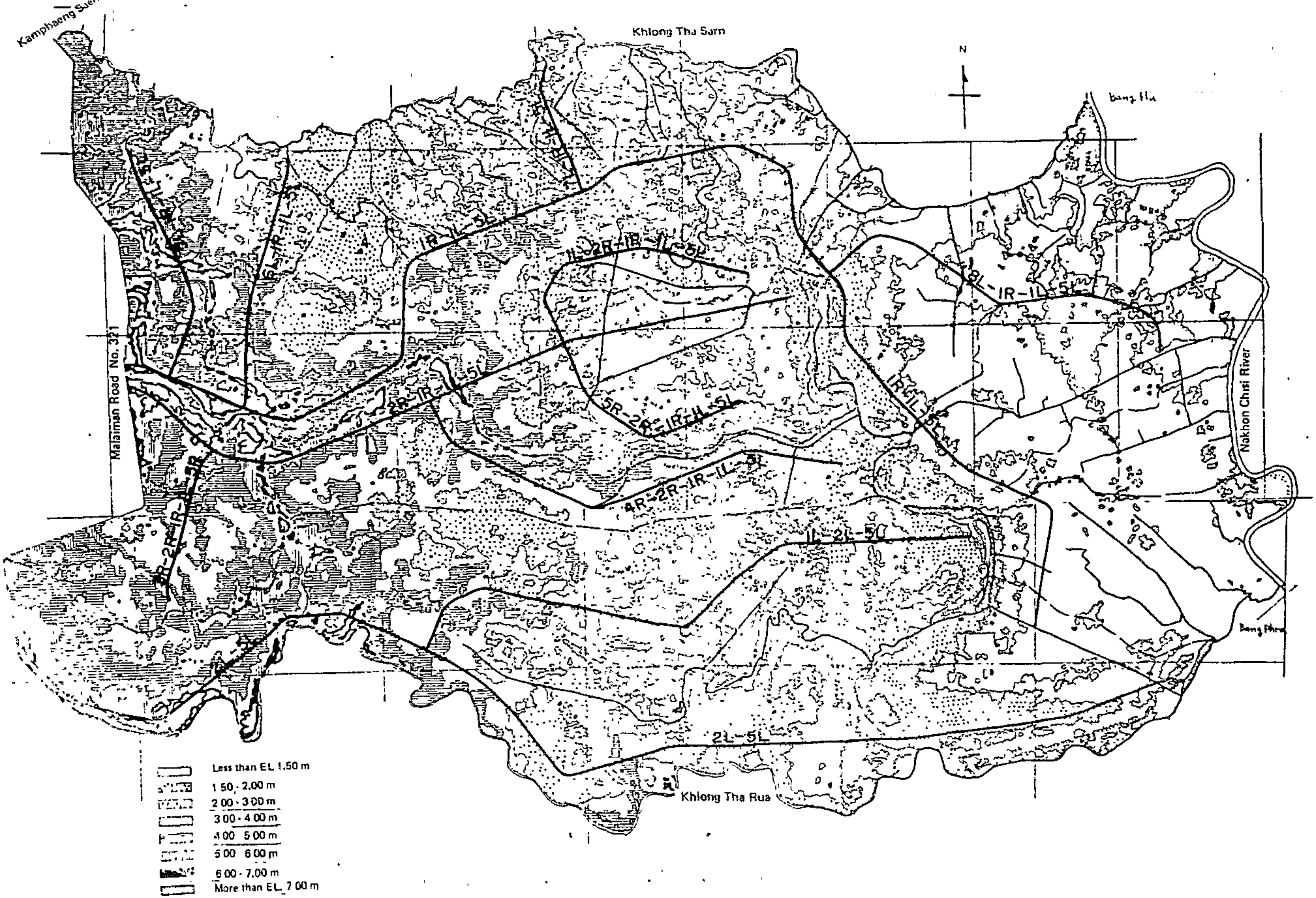


Figure 3-2. SYSTEMATIC DIAGRAM OF PRESENT IRRIGATION SYSTEM

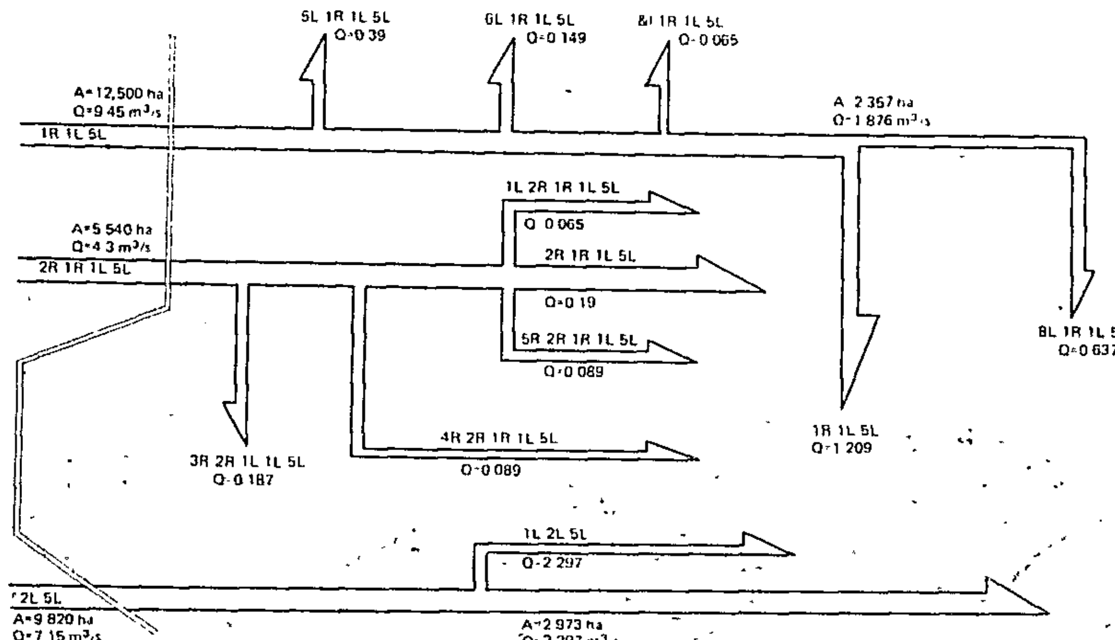


Table 3-1. MAIN FEATURE OF PRESENT IRRIGATION SYSTEM

Total designed area = 27,860 ha
Total canal capacity = 20 9 m³/s

Canal	Designed Area ha	Length m	Capacity m³/s	F S L EL m	Nos of Farm T-out	Length of Farm Ditch	Density of Canal	Farm Turnout Number	Farm Turnout Area per T out	Farm Ditch Length m Total	Farm Ditch Length m per ha	Farm Ditch Length m per Farm T out
2L 5L	9 820	25 000	7.15	6 886	46	60 400	3 7	46	148 8	60,400	8 8	1 313
1L 2L 5L	2,973	11 550	2 297	3 898	24	44 000	3 9	24	123 9	44,000	14 8	1,833
1R 1L 5L	12 500	27,196	9 45	6 311	61	89 000	3 5	61	127 8	89,000	11 4	1,459
5L 1R 1L 5L	978	4,480	0 799	6 096	12	5,800	4 6	12	81 5	5 800	5 9	483
6L 1R 1L 5L	1 005	4 805	0 741	4 798	10	15 800	4 8	10	100 5	15 800	15 7	1 580
7L 1R 1L 5L	367	2,685	0 331	2 148	5	5,900	7 3	5	73 4	5 900	16 1	1,180
8L 1R 1L 5L	2,357	7,746	1 876	2 300	16	11,900	3 3	16	147 3	11 900	5 0	744
2R 1R 1L 5L	5 540	13 670	4 30	5 915	26	26 000	5 6	26	93 3	26 000	10 7	1,060
1L 2R 1R 1L 5L	621	5,285	0 452	2 898	8	7 500	8 5	8	77 6	7,500	12 1	938
3R 2R 1R 1L 5L	684	2 890	0 534	5 498	4	4,600	4 2	4	171 0	4,600	6 7	1,150
4R 2R 1R 1L 5L	1,176	9,185	0 966	4 998	19	17,900	7 8	19	61 9	17 900	15 2	942
5R 2R 1R 1L 5L	633	4 580	0 534	2 798	8	15 300	7 2	8	79 2	15 300	24 2	1 913
Total		119 072 m			239	304 100 m	4 3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 3-2 Present Land Use and Irrigable Area by FSL for each sub-system

Sub-system	Item	Arable land (ha)					
		Paddy	Sugercane	Upland crops	Orchard	Fallow	Total
1R-1L-5L	Present land use	7,035	1,664	1,154	281	337	10,471
	Irrigable by FSL	5,693	287	0	0	157	6,137
2R-1R-1L-5L	Present land use	3,096	1,429	107	150	474	5,256
	Irrigable by FSL	2,670	163	4	0	474	3,311
2L-5L	Present land use	4,509	1,587	229	249	529	7,103
	Irrigable by FSL	3,624	18	0	0	350	3,992
Total	Present land use	14,640	4,680	1,490	680	1,340	22,830
	Irrigable by FSL	11,987	468	4	0	981	13,440

Table 3-3 Unit Water Requirement for Each Cropping Pattern

Calendar day	Crop Pattern type 1			Crop. Pattern type 2			Crop. Pattern type 3			
	Pattern	Dry S. Paddy	Wet S Paddy	Pattern	Dry S Paddy	Wet S Paddy	Pattern	Dry. S. Paddy	Wet S. Paddy	Sugarcane
Jan. 1 - 10	D	0.857	0.214	Lp	1.504			0 907		0 135
11 - 20	H	1.003	0 050	T	0 966			1.036		0 195
21 - 31	Lp	1.163			1.001			1.208		0 212
Feb 1 - 10	P	1 445			1.235		Lp	1 472		0 228
11 - 21		1 816			1 260			1.357		0 288
21 - 28	T	1 303		M	1.265		T	1 133		0 359
Mar 1 - 10		1 320			1.266			1 322		0 478
11 - 20		1.375			1.034			1 400		0 575
21 - 31	M	1.407			0 792			1 410		0 684
Apr 1 - 10		1.512		D	0.586		M	1.515		0 817
11 - 20		1.352		H	0 332	0 737		1.467		0 934
21 - 30		1.101			0 082	0 937		1 220		1 060
May 1 10		0 695				1 041		0 810		0 858
11 - 20		0 464	0.690			1 166		0 551		0 832
21 - 31	D	0 264	0 840	Lp		1.352		0 354		0 875
Jun 1 - 10	H	0.062	0.864			1 534	D	0 154		0 885
11 - 20			0.989			0.815		0 002	0 647	0 663
21 - 30	Lp		1.054			0 795			0.739	0 632
Jul. 1 - 10			1.288			0 944			0 917	0 784
11 20	T		0.683	M		0.892			1 001	0 713
21 - 31			0 874			1.069	Lp		1 306	0 940
Aug. 1 - 10			0 792			0 854			1 355	0.797
11 - 20			0.799			0 677	T		0 819	0 749
21 - 31			0 501			0 309			0 510	0 339
Sep. 1 - 10			0.536	D		0 214			0 556	0 351
11 - 20			0.254			0 045	M		0.271	0
21 - 30	M		0.234	H		0			0.244	0
Oct 1 - 10			0 388						0 391	0 080
11 - 20			0 645						0 575	0 347
21 - 31			0 929						0 603	0 661
Nov. 1 - 10			1.053						0 603	0 661
11 - 20			1.033		0.712		D		0 423	0.579
21 - 30			0.902		0 850				0 242	0 497
Dec 1 - 10			0.690		0.986		H		0 058	0 386
11 - 20			0.526	Lp	1 138			0 336		0 312
21 - 31	D	0.708	0.366		1 312			0 775		0 238

Note: Lp: Land preparation, T: Transplanting, M: Management, D: Drainage, H: Harvesting

Table 3-4 Estimated Irrigable Area and Water Requirement[a/] for Each Sub-system of Irrigation

Laterals	Season (Area & Q)	Paddy[b/] Type 1	Paddy[b/] Type 2	Paddy[b/] Type 3	Paddy[b/] Total	Sugar Cane	Total
1R-1L-5L	Wet Season Are (ha)	540	1,118	5,046	6,704	766	7,470
	Q. (m^3/s)	0.47	1.20	6.59	8.26	0.72	8.98[c/]
	Dry Season Area (ha)	540	1,428	4,573	6,541	766	7,307
	Q. (m^3/s)	0.78	1.76	6.73	9.27	0.17	9.44[d/]
2R-1R-1L-5L	Wet Season Area (ha)	-	-	3,382	3,382	163	3,545
	Q. (m^3/s)	-	-	4.00	4.00	0.12	4.12[e/]
	Dry Season Area (ha)	-	-	2,755	2,755	163	2,918
	Q. (m^3/s)	-	-	4.17	4.17	0.13	4.30[f/]
2L-5L	Wet Season Area (ha)	-	592	4,192	4,784	271	5,055
	Q. (m^3/s)	-	0.63	6.11	6.74	0.25	6.99[c/]
	Dry Season Area (ha)	-	592	4,192	4,784	271	5,055
	Q. (m^3/s)	-	0.63	6.15	6.78	0.25	703[g/]
Total	Wet Season Are (ha)	540	1,710	12,620	14,870	1,200	16,070
	Q. (m^3/s)	0.47	1.83	16.70	19.00	1.09	20.09
	Dry Season Area (ha)	540	2,020	11,520	14,080	1,200	15,280
	Q. (m^3/s)	0.78	2.39	17.05	20.22	0.55	20.77

Note: a/ Maximum 10-day diversion requirement.
b/ Type are shown as type of cropping pattern.
c/ At the last 10-day of July.
d/ At the first 10-day of February
e/ At the middle of August.
f/ At the first 10-day of April
g/ At the middle of April

Table 3-5 Estimated Diversion Requirement for Monthly and 10-day Bases

Crops	Irrigated Area	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
		(m^3/s)											
Monthly Average													
Paddy													
Type 1 (Wet season)	540	0.05	-	-	-	0.28	0.55	0.51	0.38	0.18	0.35	0.54	0.28
(Dry season)	540	0.54	0.82	0.70	0.71	0.26	0.01	-	-	-	-	-	0.13
Type 2 (Wet season)	1,710	-	-	-	0.96	2.03	1.79	1.66	1.05	0.15	-	-	-
(Dry season)	2,020	2.34	2.53	2.08	0.67	-	-	-	-	-	-	1.05	2.31
Type 3 (Wet season)	12,620	-	-	-	-	-	4.27	12.65	11.87	4.32	7.32	6.58	0.95
(Dry season)	11,520	12.10	15.22	15.86	16.14	6.50	0.60	-	-	-	-	-	4.19
Sub-total	28,950	15.03	18.57	18.68	18.48	9.16	7.22	14.82	13.30	4.65	7.67	8.17	7.86
Sugar Cane	1,200	0.22	0.35	0.69	1.12	1.03	0.87	0.97	0.75	0.14	0.41	0.69	0.37
Total	30,150	15.25	18.92	19.37	19.60	10.19	8.09	15.79	14.05	4.79	8.08	8.86	8.23
Max 10-day Average													
Paddy													
Type 1 (Wet season)	540	-	-	-	-	-	0.57	0.47	0.43	0.29	0.50	0.57	0.37
(Dry season)	540	0.63	0.78	0.74	0.73	0.38	-	-	-	-	-	-	-
Type 2 (Wet season)	1,710	-	-	-	1.26	1.78	1.36	1.83	1.46	0.37	-	-	-
(Dry season)	2,020	2.04	2.50	2.09	0.67	-	-	-	-	-	-	-	1.99
Type 3 (Wet season)	12,640	-	-	-	-	-	6.83	15.37	16.08	6.76	9.53	8.87	1.88
(Dry season)	11,520	13.92	16.96	16.13	16.90	9.33	-	-	-	-	-	-	-
Sub-total	28,950	15.59	20.24	18.96	19.56	11.49	8.76	15.67	17.97	7.42	10.03	9.44	4.24
Sugar Cane	1,200	0.25	0.27	0.69	1.12	1.03	0.76	1.13	0.96	0.42	0.74	0.79	0.46
Total	30.150	16.84	20.51	19.65	20.68	12.52	9.52	18.80	18.93	7.84	10.75	10.23	4.70

Figure 3-3. SYSTEMATIC DIAGRAM OF PROPOSED IRRIGATION SYSTEM

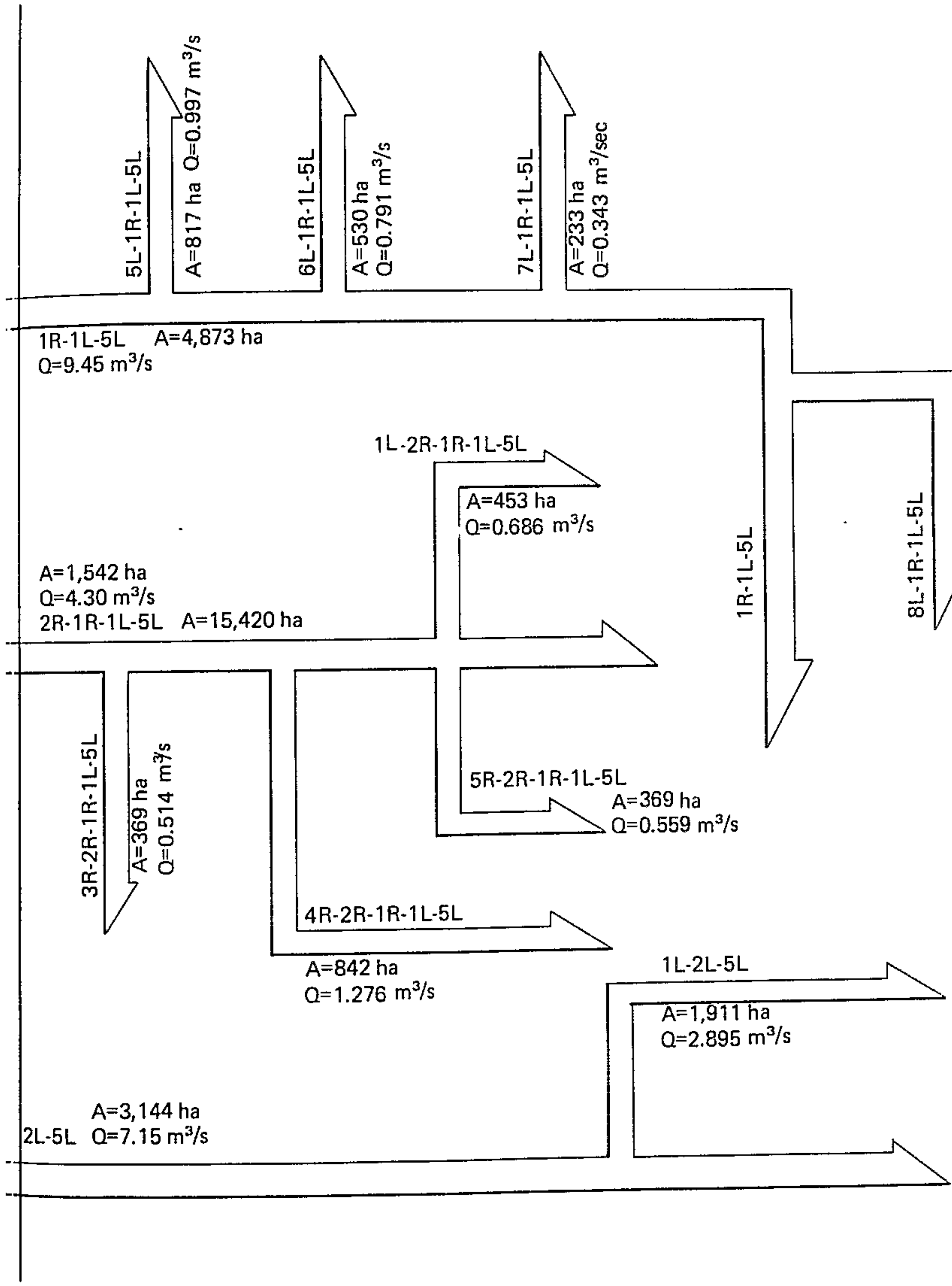


Table 3-6 Estimate of Design Canal Capacities for Each Laterals and Sub-laterals (continued)

Name of canals	Item(Unit)	Paddy *by crop. pattern type)				Sugar-cane	Sub-Total	Add. Crops.		Sub-Total	Total
		Type 1	Type 2	Type 3	Total			Sugar-cane	Others		
5L-1R-1L-5L	A(ha)	44	-	273	317	500	817	32	30	62	879
	$Q(m^3/s)$	0.048	-	0.414	0.462	0.530	0.997	0.034	0.024	0.058	1.055
6L-1R-1L-5L	A(ha)	27	-	503	530	-	530	392	5	397	922
	$Q(m^3/s)$	0.029	-	0.762	0.791	-	0.791	0.416	0.004	0.420	1.211
7L-1R-1L-5L	A(ha)	44	-	189	233	-	233	8	3	11	244
	$Q(m^3/s)$ 2/	0.059	-	0.284	0.343	-	0.343	0.008	0.002	0.010	0.353
8L-1R-1L-5L	A(ha)	425	362	540	1327	-	1327	2	446	448	1775
	$Q(m^3/s)$ 3/	0.772	0.456	0.698	1.926	-	1.926	0.002	0.362	0.364	2.290
1R-1L-5L	A(ha)	-	1066	3541	4607	266	4873	451	936	1387	6260
	$Q(m^3/s)$	-	1.086	5.365	6.451	0.282	6.733	0.478	0.760	1.238	7.971
Sub-total or max.	A(ha)	540	1428	5046	7014	766	7780	885	1420	2305	10.085
	$Q(m^3/s)$	0.595	1.455	7.645	9.695	0.812	10.507	0.938	1.153	2.091	12.598
2R-1R-1L-5L	A(ha)	-	-	1379	1379	163	1542	592	114	706	2248
	$Q(m^3/s)$	-	-	2.089	2.089	0.173	2.262	0.628	0.093	0.721	2.983
1L-2R-1R-1L-5L	A(ha)	-	-	453	453	-	453	29	56	85	538
	$Q(m^3/s)$	-	-	0.686	0.686	-	0.686	0.031	0.045	0.076	0.762
3R-2R-1R-1L-5L	A(ha)	-	-	339	339	-	339	36	24	60	399
	$Q(m^3/s)$	-	-	0.514	0.514	-	0.514	0.038	0.019	0.057	0.571
4R-2R-1R-1L-5L	A(ha)	-	-	842	842	-	842	157	43	200	1042
	$Q(m^3/s)$	-	-	1.276	1.276	-	1.276	0.166	0.035	0.201	1.477

Name of canals	Item(Unit)	Paddy(by crop. pattern type)				Sugar-cane	Sub-Total	Add. Crops.		Sub-Total	Total
		Type 1	Type 2	Type 3	Total			Sugar-cane	Others		
5R-2R-1R-1R-5L	A(ha)	-	-	369	369	-	369	450	19	469	838
	Q(m^3/s)	-	-	0.559	0.559	-	0.559	0.477	0.015	0.492	1.051
Sub-total or max.	A(ha)	-	-	3382	3382	163	3545	1264	256	1520	5065
	Q(m^3/s)	-	-	5.124	5.124	0.173	5.297	1.340	0.208	1.548	6.845
1L-2L-5L	A(ha)	-	-	1911	1911	-	1911	418	171	589	2500
	Q(m^3/s)	-	-	2.895	2.895	-	2.895	0.443	0.139	0.582	3.477
2L-5L	A(ha)	-	592	2281	2873	271	3144	893	303	1196	4340
	Q(m^3/s)	-	0.603	3.456	4.059	0.287	4.346	0.947	0.246	1.193	5.539
Sub-total or max.	A(ha)	-	592	4192	4784	271	5055	1311	474	1785	6840
	Q(m^3/s)	-	0.603	6.351	6.954	0.287	7.241	1.390	0.385	1.775	9.016
Total or max.	A(ha)	540	2020	12620	15180	1200	16380	3460	2150	9870	21990
	Q(m^3/s)	0.595	2.058	19.120	21.773	1.272	23.045	3.668	1.746	5.414	28.459

Note: 1. Unit water requirements of 1.101 ℓ/s/ha for type 1 of paddy, 1.019 ℓ/s/ha for type 2 of paddy, 1.515 ℓ/s/ha for type 3 of paddy, 1.060 ℓ/s/ha for sugarcane and 0.812 ℓ/s/ha for other crop applied for design of canals.

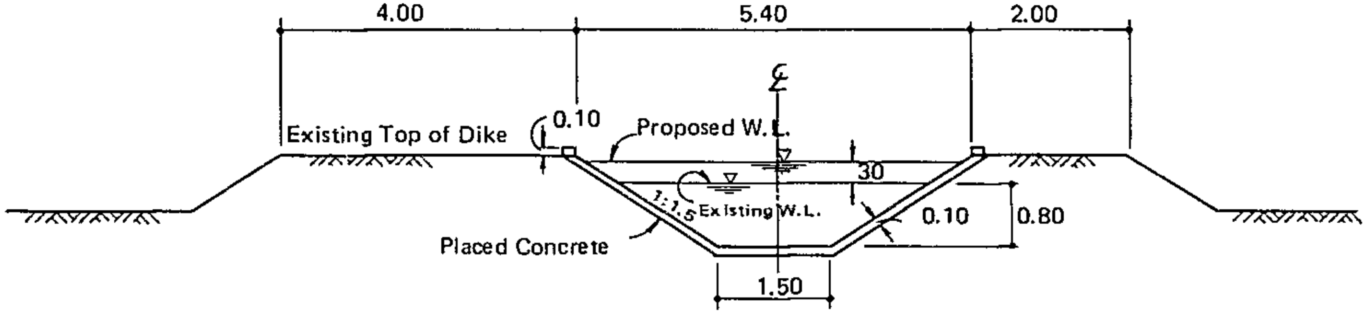
2. 1.352 ℓ/s/ha for type 1 and 1.507 ℓ/s/ha for type 3 of paddy, because of estimating at the max.

3. 1.816 ℓ/s/ha for type 1, 1.260 ℓ/s/ha for type 2 and 1.292 ℓ/s/ha for type 3 of paddy, because of estimating at the max.

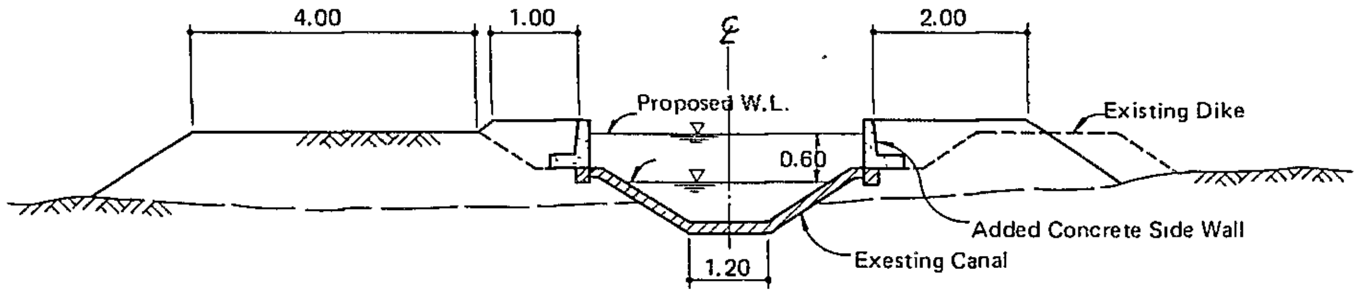
Table 3-7 List of Proposed Works for Irrigation System Upgrading

Name of Canals	Improved Canals (m)	Removed Culverts (Nos.)	Const'ed Bridges (Nos.)	Const'ed Foot Bridg. (Nos.)	Improved T'-out (Nos.)	Repaired T'-out (Nos.)
2L-5L	17,652	5	5	-	0	46
1L-2L-5L	-	-	-	13	-	24
1R-1L-5L	9,146	2	2	36	1	61
5L-1R-1L-5L	4,500	6	6	3	1	12
6L-1R-1L-5L	-	-	-	4	-	10
7L-1R-1L-5L	2,700	1	1	1	1	5
8L-1R-1L-5L	7,766	3	5	3	1	16
2R-1R-1L-5L	-	-	-	15	-	26
1R-2R-1R-1L-5L	-	-	-	5	-	8
3R-2R-1R-1L-5L	-	-	-	2	-	4
4R-2R-1R-1L-5L	6,010	3	3	7	-	19
5R-2R-1R-1L-5L	-	-	-	4	-	80
Total	47,774	20	22	93	4	311

Figure 3 - 4 Typical Cross Section of Canals To Be Improved



Canals To Be Improved By Concrete Lining



Canals To Be Improved By Added Concrete Side Wall

Note: Dimensions are shown in meter.