REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

FEASIBILITY REPORT
ON
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SEPTEMBER 197[illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

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FEASIBILITY REPORT
ON
THE RIAM KANAN IRRIGATION PROJECT

VOLUME 2 ANNEXES

SEPTEMBER 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

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ANNEX I

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ANNEX I TOPOGRAPHIC SURVEYS AND MAPS

I.1 PREVIOUS TOPOGRAPHIC SURVEYS

In 1972, the topographic survey was carried out for preparation of the topographic maps on a scale of 1 to 50,000 with contour interval of 25 m under the technical cooperation of the Japanese Government. These maps cover the Barito river basin in which the area of the Riam Kanan Irrigation Project (the Project) is included.

In 1977, the preliminary survey team was dispatched from Japan International Cooperation Agency (JICA), and the Preliminary Survey Report on the Project was prepared. In this report, the project area is divided into six sub-areas, namely the sub-areas A, B, C, D, E and F. Following the preliminary survey, more detailed topographic maps on a scale of 1 to 5,000 with contour intervals of 1 m in flat plain and 2 m in hilly area were prepared for the feasibility study on the Project also under the technical cooperation of the Japanese Government. The maps cover the sub-areas, A, B, C and a part of the sub-area D and are fully used for the feasibility study on the Project.

For preparation of these maps, detailed observation of tide was made at Takisung, about 60 km south from Banjarmasin, the capital of the South Kalimantan Province, in 1972. Based on the result of analysis of tide records thus obtained, new benchmark network, namely Takisung pile system (T.P.system), was established in the Barito river basin. The above topographic maps are all prepared by using this T.P. system. The benchmarks of this network located in and around the project area are listed in Table I-1 (see Fig. I-1).

On the other hand, there is another benchmark network established in 1953, Banjarmasin pile system (B.P. system), in the South Kalimantan. The existing structures, including the Riam Kanan dam, were constructed using this B.P. system.

The difference in elevation between these two systems was checked in connection with the field works for preparation of the 1/5,000 topo-maps in 1977. As a result, it is cleared that zero point elevation of the T.P. system is 0.676 m lower than that of the B.P. system in average value.

I.2 ADDITIONAL TOPOGRAPHIC SURVEYS

For the sub-areas E and F which are not covered by the 1/5,000 topo-maps, the topographic survey by leveling was carried out to prepare the preliminary topographic maps on a scale of 1 to 20,000 based on the available photo mosaic (uncontrolled) and the T.P. system. The maps are used for the preliminary study on these two sub-areas.

In connection with this feasibility study, the elevations related to the Riam Kanan dam such as water level in the reservoir, tail race level, etc. were checked by the Team using the T.P. system. As a result, the original elevations shown in the as-built drawings of the dam and related structures and new elevations checked at this time are as shown below.

Location	Original elevation (m)	New elevation from T.P. system (m)
1. Crest of dam	66.000	66.707
2. Water level in reservoir		
F.W.L.	63.000	63.707
H.W.L.	60.000	60.707
L.W.L.	52.000	52.707
3. Water level of tail race		
F.W.L.	18.900	19.607
Max. W.L.	14.100	14.807

The topographic survey consisting of traverse surveying, leveling and plan table surveying was carried out to prepare the topographic map of the proposed weir site B (Mandikapau site) on a scale of 1 to 1,000 with a contour interval of 1 m. In addition, additional traverse surveying and leveling were made to revise the available topographic map of the weir site A which was prepared by the Indonesian Government. Based on the results of these surveys and available 1/5,000 topo-maps, a topographic map in which two alternative weir sites A and B are shown is compiled for the feasibility study on the Project.

Spot leveling was carried out to supplement the 1/5,000 topo-maps, particularly for drawing contour lines in the swamp and low-lying areas in the sub-areas A, B, C and D. In addition, check leveling along the main irrigation canal was made. Total length of these leveling amounted to about 150 km. The results of leveling are fully used for planning and preliminary design of the irrigation and drainage networks.

Table I-1 List of Benchmarks in and around the Project Area (T.P. system)

1. Benchmarks along the road running from Banjarmasin to Banjarbaru

Benchmark	Elevation (m)
BP BM 1	1.121
BM 19	0.698
BM 138	0.912
BP BM 3	0.702
BP BM 4	1.136
BM 137	0.967
BP BM 6	7.027
BM 4	6.216
BM 109	23.020
BM 110	15.387

2. Benchmark along the road running from Banjarbaru to the Riam Kanan dam

Benchmark	Elevation (m)
TBM 3	28.758
TBM 4	16.196
TBM 5	11.328
TBM 6	10.026
BM RK VI	40.661
TBM 8	19.682
TBM 10	10.351
TBM 11	20.292
TBM 12	10.408
B S	24.228
TBM 18	34.914
TBM 20	29.177
BM 2 △1	68.474
BM 3 △1	68.998
BM 4 △1	68.428

△1 : Located on the top of the Riam Kanan dam.

3. Benchmark along the Martapura river

Benchmark	Elevation (m)
BM RK III	0.963
TBM 12	1.936
TBM 14	1.514
TBM 15	1.622
TBM 16	1.281
BM 15	1.387
BM RK IV	1.908
TBM 19	1.972
TBM 20	2.692
BM RK V	2.145
TBM 25	2.606
TBM 6	6.375
BM 5	6.028
BM 111	4.582
BM 23	4.720
BM 112	5.351

4. Benchmark along the road to Bati Bati

Benchmark	Elevation (m)
BP BM 29	2.524
BM 108	1.695
BP BM 30	1.923
BM 107	6.141
TBM 5	18.860

5. Benchmark along the road to the Maluka river

Benchmark	Elevation (m)
BM RK I	1.328
BM RK II	1.411
TBM 1	1.704

- to be continued -

6. Benchmark along the Riam Kanan river

Benchmark	Elevation (m)
TBM 9	5.586
TBM 10	6.674

7. Benchmark near Aluh Aluh Besar

Benchmark	Elevation (m)
TBM 9	0.457
TBM 11	0.621
TBM 12	0.566

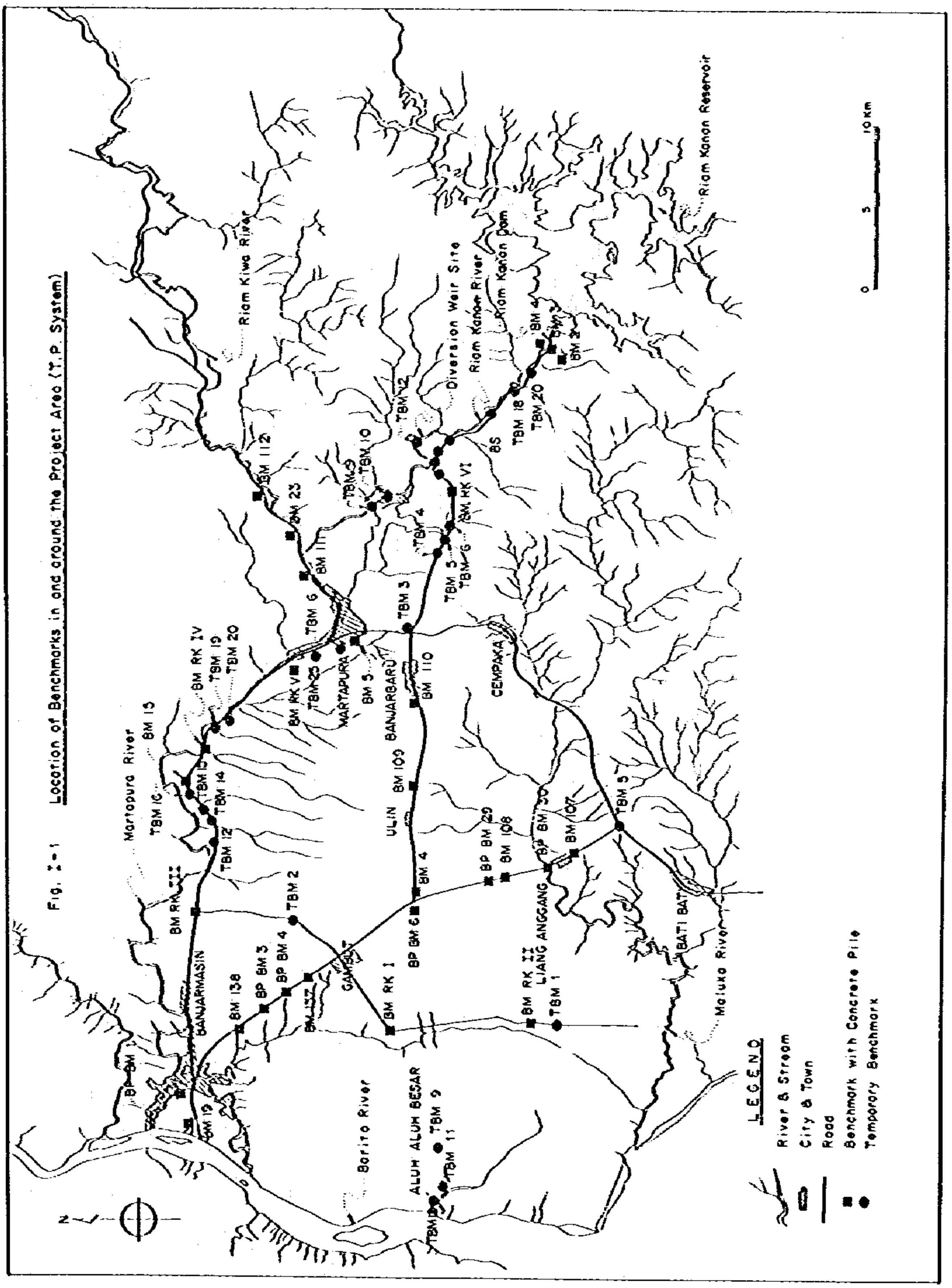

Fig. I-1 Location of Benchmarks in and around the Project Area (T.P. System)

ANNEX II

CLIMATE AND METEOROLOGY

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ANNEX II CLIMATE AND METEOROLOGY

II.1 GENERAL

The climate in the project area is characterized by the tropical monsoons. The west monsoon caused by Asian continental high pressures passes over the humid Indian Ocean and brings about wet season. The winter high pressures which occur in the Australian continent bring on the east monsoon causing the dry season. The rainfalls occur in the form of intense local storm during the wet season which lasts from November to April. In the dry season, particularly during the period of three months from July to September, there are often long spells of drought.

The meteorological data, rainfall, sunshine hour, temperature, relative humidity, wind velocity and evaporation, which are collected in the project area by the survey team are presented in the Data Book attached to this report.

II.2 RAINFALL

The daily rainfall records spanning over a fairly long period are available at three stations, Banjarbaru, Syamsudin Noor and Banjarmasin. The averages of the data from these three stations are shown in Tables II-1, II-2 and II-3.

From the figures given in these tables, it can be seen that there is a clear trend in rainfall pattern despite the fact that there is a marked difference in the yearly rainfalls. The average yearly rainfall is about 2,600 mm in the project area. But it varies widely from year to year ranging between 1,200 mm and 4,300 mm.

II.3 SUNSHINE HOUR

The sunshine hours at Banjarbaru are shown in Table II-4. From the figures given in the table, it can be seen that the sunshine hours vary from 2.8 hr/day in the wet season to 6.5 hr/day in the dry season.

II.4 TEMPERATURE

Table II-5 gives temperature records for Banjarbaru over a period of four years from 1974 to 1977. Table II-6 gives temperature records for Syamsudin Noor over a period of 17 years from 1960 to 1976 with some incomplete years.

Both tables show that the monthly mean temperature is about 26°C with very little variations. However, the daily fluctuations show fairly wide range between 8°C and 12°C.

II.5 RELATIVE HUMIDITY

The relative humidity records spanning over a fairly long period are available with some incomplete years. Table II-7 shows the monthly average relative humidity at Syamsudin Noor. The monthly average relative humidity reaches its maximum in January and is approximately 84 %, whilst its minimum occurs in September, and 74 %.

II.6 WIND VELOCITY

Since the project area is located in the equatorial light wind zone, the wind velocity is low, and no storm damage is expected. Table II-8 shows the monthly mean wind velocity in Banjarbaru. The maximum wind velocity occurs in June, whilst the minimum in October.

II.7 EVAPORATION

Table II-9 shows the monthly mean evaporation at Banjarbaru. The annual evaporation is about 1,370 mm. The daily evaporation averages 3.4 mm in the wet season and 4.1 mm in the dry season.

Table II-1 Monthly Rainfall

Station: Banjarbaru (S.P.M.A.) Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1960	351	438	296	155	346	99	189	64	135	80.5	362	186	2,701.5
1961	437	201	278	154	202	195	37	23	29	23	314	216	2,109.0
1962	530	412	273	259	229	155	113	90	98	208	529	215	3,111.0
1963	447	284	322	90	178	18	26	49	-	59	195	251	1,919.0
1964	410	249	193	155	187	128	334	69	213	182	406	122	2,648.0
1965	293	377	327	82	159	154	40	8	23	105	71	565	2,204.0
1966	549	454	349	294	96	127	57	80	54	272	264	544	3,140.0
1967	314	522	351	248	231	122	115	70	130	108	55	234	2,500.0
1968	712	209	408	321	158	244	230	136	197	186	411	286	3,498.0
1969	321	377	529	263	280	110	58	23	58	65	273	541	2,898.0
1970	505	483	880	441	452	399	111	88	140	27	145	601	4,272.0
1971	392	222	265	165	123	90	74	69	151	107	228	209	2,095.0
1972	184	128	120	258	125	37	18	4	-	8	135	361	1,378.0
1973	314	238	519	443	184	123	92	68	191	103	320	411	3,006.0
1974	155	308	20	22.1	86.9	151.7	184.6	143.3	166.5	300	273	157.5	1,968.6
1975	217.5	155.5	421	290	145	155	204	89	279	189	407	540	3,092.0
1976	591	343	277	94	103	110	-	51	3	307	542	388	2,809.0
Mean	395.4	317.7	342.8	219.7	193.2	142.2	117.7	66.1	124.5	137.0	290	342.8	2,689.1

Table II-2 Monthly Rainfall

Station: Syamsudin Noor

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1960	335.8	524.9	312.1	198.9	345.7	234.8	320.6	80.5	132.8	82.1	173.5	269.8	3,011.5
1961	485.4	317.0	243.5	294.5	235.7	127.6	52.5	6.1	40.9	47.3	272.5	182.9	2,305.9
1962	538.0	461.3	269.3	308.0	189.4	165.1	141.6	98.2	74.0	187.8	281.2	273.5	2,987.4
1963	508.0	339.0	448.0	57.0	117.0	7.0	47.0	60.0	28.0	34.0	174.0	227.0	2,046.0
1964	408.5	232.1	180.1	227.9	137.1	137.3	199.6	140.1	220.0	280.1	443.1	248.8	2,854.7
1965	227.9	355.4	278.9	79.4	174.4	125.8	6.0	11.0	10.5	81.8	107.6	373.6	1,822.3
1966	453.9	417.0	342.9	201.1	168.5	90.6	78.7	130.5	40.6	128.1	243.3	444.7	2,739.9
1967	558.1	535.4	268.9	283.0	105.3	83.1	43.9	10.9	71.0	116.9	114.2	247.4	2,438.1
1968	532.0	204.0	236.6	218.2	93.4	216.5	205.1	117.0	150.0	181.0	192.0	319.3	2,665.1
1969	186.0	128.0	315.0	152.0	170.0	66.0	19.0	36.0	9.0	85.0	190.0	455.0	1,811.0
1970	492.0	-	460.0	137.0	292.0	135.3	204.0	110.0	170.0	81.0	195.0	573.0	2,849.3
1971	431.0	213.0	253.0	115.0	96.0	36.0	152.0	165.6	344.8	155.0	321.0	338.0	2,620.4
1972	322.0	259.0	255.7	270.0	98.0	36.0	22.0	18.0	-	34.0	180.0	227.2	1,721.9
1973	324.9	331.8	494.9	231.6	293.0	110.0	100.3	115.6	190.0	249.2	211.3	309.4	2,962.0
1974	125.8	504.4	337.0	216.5	163.0	104.0	228.1	68.9	178.4	241.4	278.3	340.4	2,786.2
1975	383.0	161.2	469.1	227.3	59.3	131.0	170.0	167.2	158.0	287.0	463.0	400.0	3,076.1
1976	421.0	396.1	218.8	131.6	97.5	155.7	107.7	82.8	32.0	262.3	401.0	422.5	2,729.0
1977	400.3	416.7	376.6	462.2	158.2	240.3	35.9	125.9	27.9	60.4	256.7	412.3	2,973.4
Mean	396.3	341.0	320.0	211.7	166.3	122.3	118.6	85.8	110.5	144.1	249.9	336.9	2,603.4

Table II-3 Monthly Rainfall

Station: Banjarmasin

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1960	488	497	289	419	273	139	210	15	241	18	338	421	3,348
1961	488	431	284	297	163	115	130	10	63	33	179	215	2,408
1962	529	535	397	332	144	151	161	69	145	263	437	344	3,507
1963	533	780	747	84	110	51	65	101	1	-	325	335	3,132
1964	331	377	358	383	176	85	80	93	139	285	228	197	2,732
1965	319	248	327	174	137	69	-	2	39	38	105	383	1,841
1966	400	373	270	233	128	60	62	96	68	152	234	430	2,506
1967	273	400	192	80	141	34	45	47	52	97	58	151	1,570
1968	222	203	286	444	81	90	65	15	52	78	133	239	1,908
1969	94	147	354	120	75	9	11	12	-	49	76	282	1,229
1970	321	320	253	212	178	65	167	122	130	136	167	526	2,597
1971	116	x	244	166	107	35	44	152	225	171	357	222	
1972	367	264	223	67	85	32	4	24	-	60	208	238	1,572
1973	520	309	595	192	164	88	114	180	260	78	266	496	3,262
1974	179	461	281	145	161	70	53	83	212	154	197	175	2,171
1975	347	255	220	104	99	43	108	269	262	250	292	335	2,584
1976	312	365	283	210	20	132	39	2	31	387	311	441	2,533
1977	312	216	376	163	18	137	17	46	15	26	208	382	1,916
Mean	341.7	363.6	332.2	212.5	125.6	78.1	80.9	74.3	120.9	133.8	228.8	322.9	2,415.3

Table II-4 Monthly Sunshine Hour

Station: Banjarbaru (L.M.G.)

Unit: hr/day

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1974	-	-	-	5.3	5.1	4.2	3.8	6.2	4.4	5.0	4.1	3.0
1975	3.1	3.2	3.8	4.2	4.1	3.3	3.7	4.0	3.6	3.5	3.0	3.2
1976	3.6	3.0	3.2	3.6	5.1	5.0	5.1	6.5	5.6	3.9	3.5	2.9
1977	3.5	2.8	3.4	4.4	4.6	4.3	4.5	5.4	6.0	6.2	-	3.9
Mean	3.4	3.0	3.5	4.4	4.7	4.2	4.3	5.5	4.9	4.7	3.5	3.3

Table II-5 Monthly Mean Temperature

Station: Banjarbaru (L.M.G.)

Unit: °C

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1974	x	25.3	26.1	26.2	26.7	26.0	25.4	26.0	26.0	26.3	26.0	25.9
1975	25.5	25.7	25.5	26.3	26.2	25.5	25.0	25.3	25.2	25.8	25.5	25.3
1976	25.4	25.4	25.7	25.7	26.0	25.1	25.1	26.7	26.3	26.3	25.1	25.8
1977	25.7	25.3	25.8	26.5	26.4	25.7	25.5	25.4	26.4	27.7	27.1	26.0
Mean	25.5	25.4	25.8	26.2	26.3	25.6	25.3	25.9	26.0	26.5	25.9	25.8

Table II-6 Monthly Mean Temperature

Station: Syamsudin Noor

Unit: °C

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1960	26.2	25.9	26.0	27.0	26.7	26.4	26.0	26.5	26.7	27.9	26.2	26.7
1961	25.9	26.1	25.0	27.1	27.5	26.2	26.2	27.6	27.2	27.1	27.0	26.7
1962	25.9	25.7	26.5	26.8	27.4	26.5	26.4	26.0	26.9	26.6	26.8	26.4
1963	26.1	25.7	27.2	27.0	28.0	27.4	26.6	26.4	27.6	28.7	27.8	26.8
1964	26.5	26.5	26.8	27.1	27.4	27.1	25.8	26.4	27.8	26.0	26.4	28.2
1965	28.2	25.8	25.9	26.1	26.5	26.6	25.8	26.6	27.0	27.7	27.5	26.5
1966	26.2	26.2	26.2	26.6	27.1	26.7	26.3	26.8	27.4	27.5	26.6	25.9
1967	26.1	26.2	26.8	26.5	26.9	26.7	26.2	26.2	27.3	27.9	27.6	26.6
1968	25.9	26.1	26.1	27.1	27.0	27.0	26.3	26.3	27.1	26.6	26.7	26.0
1969	26.5	26.4	26.8	27.4	27.0	26.6	26.2	26.1	27.3	27.5	26.9	26.0
1970	26.1	26.5	26.7	26.9	26.9	26.5	26.0	26.0	26.1	27.0	26.5	25.7
1971	25.7	25.2	25.9	26.4	26.8	25.9	25.6	25.6	25.9	26.3	25.4	25.8
1972	25.8	26.0	26.2	26.3	26.8	26.5	26.2	26.7	26.9	27.7	27.0	26.3
1973	26.9	27.0	26.7	26.9	27.6	26.3	26.7	26.2	25.9	26.7	25.8	26.2
1974	26.1	24.9	26.4	26.9	26.4	25.8	25.1	25.8	25.7	26.2	25.9	25.6
1975	25.9	26.0	25.7	26.7	26.0	26.2	25.4	25.1	25.9	26.1	26.1	26.1
1976	25.9	25.9	26.2	26.3	26.9	25.7	26.0	26.0	26.8	26.5	26.3	26.1
1977	26.1	26.1	26.4	27.0	27.0	26.2	25.7	25.8	26.7	27.4	27.2	26.2
Mean	26.2	26.0	26.3	26.8	27.0	26.5	26.0	26.2	26.8	27.1	26.7	26.3

Table II-7 Monthly Mean Relative Humidity

Station: Syamsudin Noor

Unit: %

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1960	84	87	87	84	85	80	84	80	78	72	86	84
1961	86	88	93	83	82	82	73	67	67	72	78	70
1962	88	83	85	85	83	83	80	74	76	72	83	85
1963	83	86	83	78	78	75	75	73	67	64	74	82
1964	85	84	83	83	81	79	81	74	81	85	84	82
1965	85	85	87	84	83	79	73	67	63	69	76	82
1966	84	84	85	86	81	81	75	76	70	77	82	80
1967	85	84	82	84	82	79	78	81	68	73	77	85
1968	87	85	86	84	84	83	85	82	75	80	82	86
1969	84	84	86	82	83	80	76	69	69	73	80	86
1970	87	84	84	82	85	84	78	78	82	80	79	86
1971	87	85	84	81	78	80	82	84	85	77	87	83
1972	83	83	85	83	80	78	73	65	60	70	78	81
1973	83	82	85	85	83	84	82	82	84	79	84	84
1974	82	88	83	82	79	82	83	79	84	85	88	89
1975	84	86	86	84	85	82	85	79	83	82	82	84
1976	84	84	83	82	78	81	78	73	72	80	85	85
1977	85	87	84	83	81	82	75	75	71	71	77	85
Mean	85	85	85	83	82	81	79	75	74	76	81	83

Table II-8 Monthly Mean Wind Velocity

Station: Banjarbaru (L.M.G.)

Unit: Km/hr

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1974	-	3.9	-	3.7	4.0	3.4	3.8	4.7	4.1	3.8	4.6	3.7
1975	3.1	3.7	3.6	3.0	2.9	2.8	2.3	2.6	1.7	1.4	1.0	2.4
1976	-	1.7	1.9	1.9	1.4	1.4	2.4	2.7	2.4	0.8	1.6	2.4
1977	2.5	2.2	2.0	1.8	2.1	2.3	3.7	3.0	4.2	-	-	-
Mean	2.8	2.9	2.5	2.6	2.6	2.5	3.1	3.1	3.1	2.0	2.2	2.8

Table II-9 Monthly Evaporation

Station: Banjarbaru (L.M.G.)

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1975	96.4	61.1	111.6	62.9	71.5	109.3	93.8	124.8	108.1	110.9	109.2	106.0	1,165.6
	(3.1)	(2.2)	(3.6)	(2.1)	(2.3)	(3.6)	(3.0)	(4.0)	(3.6)	(4.0)	(3.6)	(3.4)	
1976	114.7	102.0	114.8	107.2	113.9	107.7	117.6	153.5	150.8	112.7	104.6	108.1	1,407.6
	(3.7)	(3.5)	(3.7)	(3.7)	(3.7)	(3.6)	(3.8)	(5.1)	(5.0)	(3.9)	(3.5)	(3.5)	
1977	113.5	77.7	131.1	124.2	121.4	113.2	138.8	121.8	165.8	107.7	121.8	97.5	1,534.5
	(3.3)	(2.8)	(4.2)	(4.1)	(3.9)	(3.8)	(4.5)	(3.9)	(5.5)	(6.7)	(4.1)	(3.1)	
Mean	108.2	80.3	119.2	98.1	102.3	110.1	116.7	133.2	141.6	143.8	111.9	103.7	1,369.1
	(3.5)	(2.9)	(3.8)	(3.3)	(3.3)	(3.7)	(3.8)	(4.3)	(4.7)	(4.6)	(3.7)	(3.3)	(3.8)

( ) shows mean daily evaporation.

ANNEX III

WATER RESOURCES

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ANNEX III WATER RESOURCES

III.1 RAINFALL

About twenty rainfall gauging stations were set and are in operation by the meteorological offices and agricultural offices. Fig. III-1 shows the location of meteorological and hydrological stations. Table III-1 shows the duration of records for the rainfall at the meteorological stations.

Among them, three stations, Banjarmasin (Agricultural office), Ulin (Syamsudin Noor) and Banjarbaru (SPMA), are selected for the study on the irrigation and drainage requirements mainly because of longer observation periods and higher reliability of records as compared with other stations. The available rainfall data at three stations are as follows:

Station	Daily record	Monthly record
Banjarmasin	Jan. 1962 - Dec. 1967 Jan. 1969 - Jul. 1978	Jan. 1960 - Jul. 1978
Ulin	Jan. 1960 - Jun. 1978	Jan. 1960 - Jun. 1978
Banjarbaru	Jan. 1960 - Dec. 1976	Jan. 1960 - Dec. 1976

The monthly rainfall records at Banjarbaru, Ulin and Banjarmasin are tabulated in Tables II-1, II-2 and II-3 in Annex II, respectively.

Consecutive three-day probable rainfalls at the three stations are estimated by Gumbel method for the study on the drainage improvement, as shown below.

Return period	Banjarbaru (mm)	Ulin (mm)	Banjarmasin (mm)
5 years	209.4	217.9	187.0
10 years	240.7	259.2	217.6

III.2 STREAM FLOWS

The river Riam Kanan has a catchment area of 1,285 km^2. It originates from the Meratus mountain in southeastern part of South Kalimantan and flows westwards. The river Riam Kiwa has a catchment area of 1,645 km^2 and flows southwestwards from the Meratus mountain. These two rivers join at Astambul and drain into the river Martapura. The river Maluka also originates from the Meratus mountain and flows westwards to the Java Sea. The catchment area is estimated at 830 km^2.

Nine water level gauging stations are in operation in and around the project area. Among them, four stations, Awang Bangkal, Sei Langsat, Sei Tabuk and Liang Anggang, are equipped with automatic water level recorder. Three stations, Martapura, Astambul and Banyuhirang, are recording the water levels using staff gauges. One automatic water level recorder is set in the old harbour on the Martapura. In addition, a new automatic water level recorder is installed by the Team at Aluh Aluh Besar near the river Barito. The observation period of each station is as follows:

River	Station	Period	Instrument
Riam Kanan	Awang Bangkal	Jul. 1975 - Present	Automatic rec.
Riam Kiwa	Sei Langsat	May 1976 - Present	- do. -
Martapura	Astambul	Sept.1976 - Present	Staff gauge
	Martapura	- do. -	- do. -
	Sei Tabuk	Aug. 1978 - Present	Automatic rec.
	Pelabuhan Lama	Jan. 1959 - Present	- do. -
Aluh Aluh Besar	Aluh Aluh Besar	Aug. 1978 - Present	- do. -
Maluka	Liang Anggang	Jul. 1978 - Present	- do. -
	Banyuhirang	Apr. 1977 - Present	Staff gauge

Water level records at the above stations except for Awang Bangkal and Sei Tabuk are presented in the Data Book attached to this report.

Runoff discharges were measured at Awang Bangkal, Sei Langsat and Banyuhirang by the survey team. The results of the measurement are given in Table III-2.

Based on these runoff measurements, rating curves are prepared for the Awang Bangkal and Sei Langsat stations as shown in Figs. III-2 and III-3. The monthly mean runoff for two years, from June 1976 to May 1978, at Sei Langsat on the river Riam Kiwa is estimated using the rating curve as shown below.

Riam Kiwa

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Runoff (m^3/sec)	83	96	140	95	78	32	11	6	3	5	22	64

The runoff discharge in the river Riam Kanan is regulated by the Riam Kanan dam. The monthly mean discharge in 1976 is estimated at the Riam Kanan dam site from the operation data of the Riam Kanan power station as shown below.

Riam Kanan

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Runoff (m^3/sec)	100	69	43	34	23	17	33	17	18	18	18	35

The operation records of the Riam Kanan dam from 1973 to 1977 and 10-days mean runoff at the Riam Kanan dam site from 1965 to 1977 are presented in the Data Book attached to this report.

As for the Maluka, there are only few data on rainfalls, water levels and discharge measurements. Although the further observation will be required to work out the features of the Maluka, the available irrigation water from the Maluka is provisionally estimated in the subsequent section.

III.3 INVESTIGATION OF SALINE WATER INTRUSION

The water released from the Riam Kanan power station would be used for domestic water supply as well as irrigation. There are two pumping stations which are supplying municipal water to Banjarmasin from the river Martapura. One is located near Banjarmasin (the Sei Bilu station), and this station is affected by saline water intrusion particularly in the dry season. Then, investigation is required to study the saline water intrusion which might be increased when the discharge from the Riam Kanan is decreased.

The investigation was made under the flood tide condition. The first investigation was carried out on September 15 and 16, 1978 along the Martapura. The electric conductivity of the river water at Banjarmasin, about 9.5 km upstream from the estuary of the Martapura, was 0.16 to 0.22 mmho/cm as shown in Fig. III-4. The electric conductivity along the Martapura between the estuary and Banjarmasin also showed very small values ranging from 0.1 to 0.3 mmho/cm as illustrated in Fig. III-5.

The second investigation conducted on October 10 and 11, 1978 also showed a small electric conductivity on the estuary of the Martapura. Fig. III-6 shows the highest value of 0.77 mmho/cm on the estuary and 0.71 mmho/cm in the Barito at the confluence with the Martapura.

These results indicate that there were no saline water intrusions into the Martapura in this year, which was attributed to the large runoff in both the Barito and the Martapura. Then, the influence of saline water intrusion at the pumping stations for city water supply could not be studied using these results.

The past records on the salinity of the river water are shown in Figs. III-7 and III-8. These would be used for the estimation of the amount of water for the river maintenance and city water supply. Details are referred to in the subsequent section.

The river Maluka is proposed to be the source of another irrigation water. The Maluka is the tidal river, and the influence of tide reaches beyond Liang Anggang. The investigation of saline water intrusion was made to work out the amount of water which does not contain any salt. The locations of the measurements are shown in Fig. III-9.

The first investigation was carried out at Kurau on October 19, 1978. Fig. III-10 shows the result of the measurement. After the water surface started to rise by tidal influence, the river changed its flow direction from the downstream to the upstream. Then, electric conductivity of the river water increased up to 38 mmho/cm at the bottom of the river. The water level fluctuation showed the range of 1.5 m.

The second investigation was made at the proposed pumping station site on October 23 and 24, 1978. Fig. III-11 shows the water level fluctuation at 4 stations, which are Aluh Aluh Besar, Kurau, Liang Anggang and Banyuhirang. The water level fluctuation at Aluh Aluh Besar, which is located on one of the tributaries of the Barito, is regarded as the same with that of the Java Sea, because the Aluh Aluh Besar station is located only 10 km upstream from the estuary of the Barito, and the phase of fluctuation coincides with that of the estuary of the Barito. At Kurau, the form of fluctuation is approximately the same with that of Aluh Aluh Besar, and the amplitude of water level fluctuation is about 1.6 m. The effect of tide is recognized even at Liang Anggang located about 37 km upstream from the estuary of the Maluka.

At the proposed pumping site, the saline water intrusion was observed. The river discharge was 6.6 m^3/sec at Banyuhirang. The result of the measurement is shown in Fig. III-12. The electric conductivity of the river water increased up to 30 mmho/cm.

III.4 AMOUNT OF WATER AVAILABLE FOR THE PROJECT

The source of irrigation water for the Project is the rivers Riam Kanan and Maluka. The river water from the Riam Kanan will be used for the sub-areas A, B, C, D and E. A part of the sub-area E would be served by the water from the Maluka in view of the situation and topography.

III.4.1 Amount of Water Available from the Riam Kanan

The amount of water available from the Riam Kanan depends entirely on the discharge released from the power plants in the dry season, and the discharge varies with the power demand. This section deals with the estimation of water available for the Project based on the available hydrological data and the forecast of power demand in the future.

According to the information obtained from PLN, the Riam Kanan power station would be operated with 24 to 27 MW of power demand at peak, keeping some reserve for the emergency peak power demand, even after the completion of the Riam Kanan second stage project. Load factor at that time (ratio of average output to peak output) is forecasted to increase to about 65% from the present load factor ranging from 60 to 62 %. The peak demand of 24 MW in and after 1984 is adopted to estimate the amount of water available for the Project from the power station for the conservative estimation. With these forecasted power demand and load factor, the average output is estimated at 24 MW x 0.65 = 15.6 MW. This is the basis for estimating the discharge to be released through the power plants.

An output of hydropower depends entirely on the static head, a difference in height between the water level in the reservoir and the tail race of the dam. Various amounts of discharges enough to generate 15.6 MW of electric power are considered with the variation of the static head. According to the study on the irrigation water requirement made in Annex VII, the peak water requirement would occur in mid-August. The proposed reservoir operation program for the Riam Kanan dam/1 shows that the water level in the reservoir in August will range between 60.707 m and 58.70 m. The design high water level in the reservoir, say 60.707 m in elevation, is used for conservative estimation of the amount of water available for the Project, because the higher the reservoir water level, the less the amount of released water would be.

The relationship among the discharge, static head and generating output may be expressed by the following equations:

$P = 9.8 \times \eta \times He \times Q$ .... Equation (1)

$He = 0.94 \times (WLR - WLTR)$ .... Equation (2)

where,
- P : Generating output, 15.6 MW
- η : Efficiency of turbin generator, 0.86
- He : Effective head in m
- Q : Discharge in m^3/sec.
- WLR : Water level in the reservoir, 60.707 m
- WLTR : Water level in the tail race in meter

/1 : Regulation for Operation of the Riam Kanan Dam, the Riam Kanan Project prepared in June, 1972.

The relationship between Q and WLTR may be expressed as follows:

$$WLTR = 60.707 - \frac{1,969}{Q} \quad \text{............ Equation (3)}$$

The rating curve showing the relationship between the water levels in the tail race and the discharges is shown in Fig. III-13. The required values of the discharges and gross static head under the above conditions are indicated at the intersecting point of the two curves, the rating curve at the tail race and the curve derived from the above equation (3). As a result, 42 m^3/sec of water would be expected as the amount of water available for the Project including the maintenance water of the river Martapura.

Fig. III-14 shows the mass curve of runoff at the Riam Kanan dam site for the full period of 12 years from June 1965 to May 1977. The high reliability of releasing 42 m^3/sec of water from the power plants is confirmed by this mass curve, except for 40 m^3/sec in 1972 which was very drought year.

As will be described in the subsequent section, mean drought runoff, 8 m^3/sec, as the minimum discharge for the maintenance of the Martapura would have to be released from the weir. Therefore, the amount of water available for the Project is estimated at 34 m^3/sec.

III.4.2 Amount of Water Available from the Maluka

Monthly mean discharge in August at the Riam Kanan dam site is applied to estimate the available water on the river Maluka, since there are no available data on the Maluka to estimate the amount of water.

Fig. III-15 shows the probable discharge at the Riam Kanan dam site based on the monthly mean discharge in August for 12 years. The probable discharge with 80% dependability is 6.5 m^3/sec at the dam site. The proposed pumping site is located at 11 km upstream from the estuary of the Maluka, and the catchment area is 780 km^2. On the other hand, the probable discharge at the dam site is estimated at 6.5 m^3/sec with the catchment area of 1,040 km^2. The probable discharge at the pumping site in August on the Maluka is estimated at 6.5 m^3/sec x (780/1,040) = 4.8 m^3/sec with 80% dependability.

III.5 MUNICIPAL WATER SUPPLY AND RIVER MAINTENANCE DISCHARGE

The river water released from the Riam Kanan power station would be diverted to the project area for irrigation use by constructing a diversion weir on the Riam Kanan. It would not be allowed, however, that all amount of such river water available from the station be used for the project use only. This means that some amount of water would have to be secured as the river maintenance discharge for the downstream reaches of the Martapura, particularly for protecting the municipal water supply from the saline water intrusion and water pollution.

III.5.1 Municipal Water Supply

The municipal water supply facility is available only in Banjarmasin. The present supply capacity is 275 lit/sec, and the City Waterworks Bureau has a plan to increase the supply capacity to 550 ℓ/sec. The city water is supplied from the Martapura by two pumping stations. One is located at Sei Bilu near the estuary of the Martapura, and the other is at Sei Tabuk, about 20 km upstream from the Sei Bilu pumping station. The Sei Bilu station is mainly used for the water supply services. The concentration of Chlorine Cl^- is measured every hour at the Sei Bilu station in the dry season. When the measured value of Chlorine exceeds 200 ppm, the Sei Tabuk station is operated instead of the Sei Bilu station.

The river Martapura is affected by tide. According to the data on Chlorine concentration measured at the Sei Bilu station, the saline water intrusion is observed depending on the season. However, the saline water intrusion was not observed at the Sei Tabuk station even before the completion of the Riam Kanan dam, with the exception of the year of 1972 which was very drought year and in which the Riam Kanan dam started to store the water.

The first pumping station for the city water supply was constructed in Banjarmasin in 1945 and operated throughout the year, except for the period during which the saline water intrusion was observed. When the river water was affected by the saline water, the city water was taken at the Sei Tabuk site. In 1970, the Sei Tabuk pumping station was constructed to supply clean water to Banjarmasin. Mainly because of high operation cost for the Sei Tabuk station, however, the Sei Bilu station was constructed in 1973. Since then, this station is in operation as mentioned above.

According to the data on Chlorine concentration of the water measured at the Sei Bilu station, the river water of the Martapura is affected by the saline water coming through the river Barito for 3 to 6 months depending on the years. The maximum value of Chlorine concentration of about 7,000 ppm was observed in October, 1977, whereas 5,400 ppm and 4,300 ppm in August and September, respectively in 1976 as shown in Fig. III-7. Some data on Chlorine concentration measured at the Sei Tabuk station in 1972 are also available as shown in Fig. III-8. According to the figure, the river water at the Sei Tabuk station is not affected by the saline water since 1945, except for the year of 1972 in which high value of 3,940 ppm was recorded.

For further study on this matter, the investigation of the saline water intrusion was carried out through measurement of the electric conductivity of the river water of the Martapura at flood tide. As mentioned before, the vertical and longitudinal variation of the electric conductivity of the river water ranged between 0.2 and 0.4 mmho/cm in the reach from the Sei Bilu station to the Sei Tabuk station. Even at the estuary of the Martapura, the electric conductivity was less than 0.8 mmho/cm. This means that there is no saline water intrusion into the Martapura in this year. It seems that these facts are due to large runoff in both the Barito and the Martapura.

III.5.2 River Maintenance Discharge

Generally, some amount of water has to be released from dams and diversion weirs in the upstream to the downstream reaches of a river in order to keep the environmental and social functions of the river in the downstream area. The river maintenance discharge would be determined, taking into account the conservation of proper quality of the river water, protection of saline water intrusion, navigation and other water use.

According to the guideline prepared by the Ministry of Construction, Japan, the river maintenance discharge to the downstream reaches of a given river may be tentatively estimated using one of the following two methods, taking up either

a) Unit discharge of 1 m^3/sec/100 km^2 or

b) mean drought runoff in 10 years.

The catchment area at the proposed diversion weir site is 1,123 km^2 (1,043 km^2 + 80 km^2). Applying the above method a), the minimum release of 12 m^3/sec of water to the downstream reaches would have to be secured at the diversion weir site.

The discharge duration curve at the Riam Kanan dam site is prepared as shown in Fig. III-16. From this figure, the drought runoff which is the mean value of 12 years' drought runoff is estimated at 8 m^3/sec.

Below are some considerations on the effects, which would arise in the downstream reaches of the Martapura, caused by the difference in discharge between 12 m^3/sec and 8 m^3/sec.

1) For conservation of proper quality of the river water, the larger the maintenance discharge, the better the effect on the conservation of water quality would be. In this view, the larger maintenance discharge would have to be released,

though careful study would be required to clarify the effect on this matter caused by the change in discharge condition of the river.

2) As mentioned before, the saline water intrusion was not observed at the Sei Tabuk pumping station even before the completion of the Riam Kanan reservoir, with the exception of the year of 1972 which was very drought year and in which the Riam Kanan reservoir began to store water. With this view, it is thought that the discharge of 8 m^3/sec of water to the downstream reaches would be enough for protection of the river from saline water intrusion.

3) The average water depth in the reach between the estuary and the Martapura bridge is approximately 4 meters. When the discharge from the Riam Kanan is reduced to 8 m^3/sec, the average water depth would be reduced from the present 4 meters to 3.3 meters, and in case of 12 m^3/sec discharge it would be 3.6 meters. On the other hand, the present navigation by small boats with a shallow draft is predominant in the Martapura, and the navigation by big vessels would not be expected yet in the near future. Under these conditions, discharge of 8 m^3/sec of water would not give any big trouble to the navigation in the Martapura.

4) One of the main items in the use of the river water in the near future will be irrigation to paddy field extending on the right bank of the Martapura. When such a paddy field is needed to be irrigated by gravity, the irrigation using the water from the river Riam Kiwa would be more practical rather than the use of the river water from the Martapura.

In addition, it is thought that the unit discharge mentioned above, 1 m^3/sec/100 km^2, is estimated empirically, taking into account the topographic conditions of the river and its catchment area, runoff regime, sand flushing in the river, etc. in Japan. Furthermore, the release of 1 m^3/sec/100 km^2 of maintenance water is for avoiding any trouble to the use of groundwater particularly from shallow aquifer in the downstream areas. The use of such a groundwater in the downstream areas of the Martapura is very rare at present.

Comparing the natural conditions and the present groundwater use in and around the project area with those in Japan, much care should be paid for application of such a unit discharge to this project, and it is thought that the maintenance discharge estimated using this unit discharge is not necessarily released to the downstream areas in case of this project. Moreover, consideration is paid to use the river water available from the Riam Kanan power station as much as possible for agricultural development in South Kalimantan.

Taking into account the above considerations, the discharge of 8 m^3/sec of water is tentatively recommended as the minimum river maintenance discharge to the downstream reaches of the Martapura. However, since this is very important item for suitable design of the Project, more detailed study on this matter would have to be made at the detailed design stage in connection with preparation of operation and maintenance manual for the Project.

III.6 WATER QUALITY

Silt content of river water of the rivers Riam Kanan and Maluka was measured by DPMA Bandung. The results of the measurements in 1977 and 1978 show that the silt content ranges between 5 and 73 mg/lit at Awang Bangkal on the Riam Kanan, 5 mg/lit at Liang Anggang and 27 mg/lit at Banyuhirang on the Maluka. The present silt content of the river water measured at Awang Bangkal is lower than that measured in 1961 and 1962 in which the Riam Kanan dam was not constructed.

The chemical analysis of water samples taken from the rivers Riam Kanan, the Martapura, the Barito, the Aluh-Aluh Besar, and the Maluka is made to confirm their quality for irrigation and domestic use. The results of the analysis are as follows:

Sample	PH Field	PH H_2O_2	Na (me/l)	K (me/l)	Ca+Mg (me/l)	SO_4^{2-} (me/l)	Cl^- (ppm)	EC (mhr/cm)	Sodium Percentage (%)
a. Sei Riam Kanan (Weir site)	7.4		0.2	0.025	2.13	0.16	74	143	13
b. Sei Martapura	6.6	6.3	0.4	0.1	2.8	trace	trace	174	16
c. Sei Barito	6.2	5.9	13	1.3	17.5	4.0	80	1,076	47
d. Sei Aluh-Aluh Besar	6.1	5.9	13	1.4	20.0	3.2	80	1,213	44
e. Sei Maluka (P.S. Site)	7.0		0.65	0.025	1.47	0.48	60	182	38

According to the standards for irrigation waters by Wilcox/1, the quality of water of the Riam Kanan is classified into excellent to good, and the quality of water of the Maluka is also classified into excellent to good in case of no saline water intrusion.

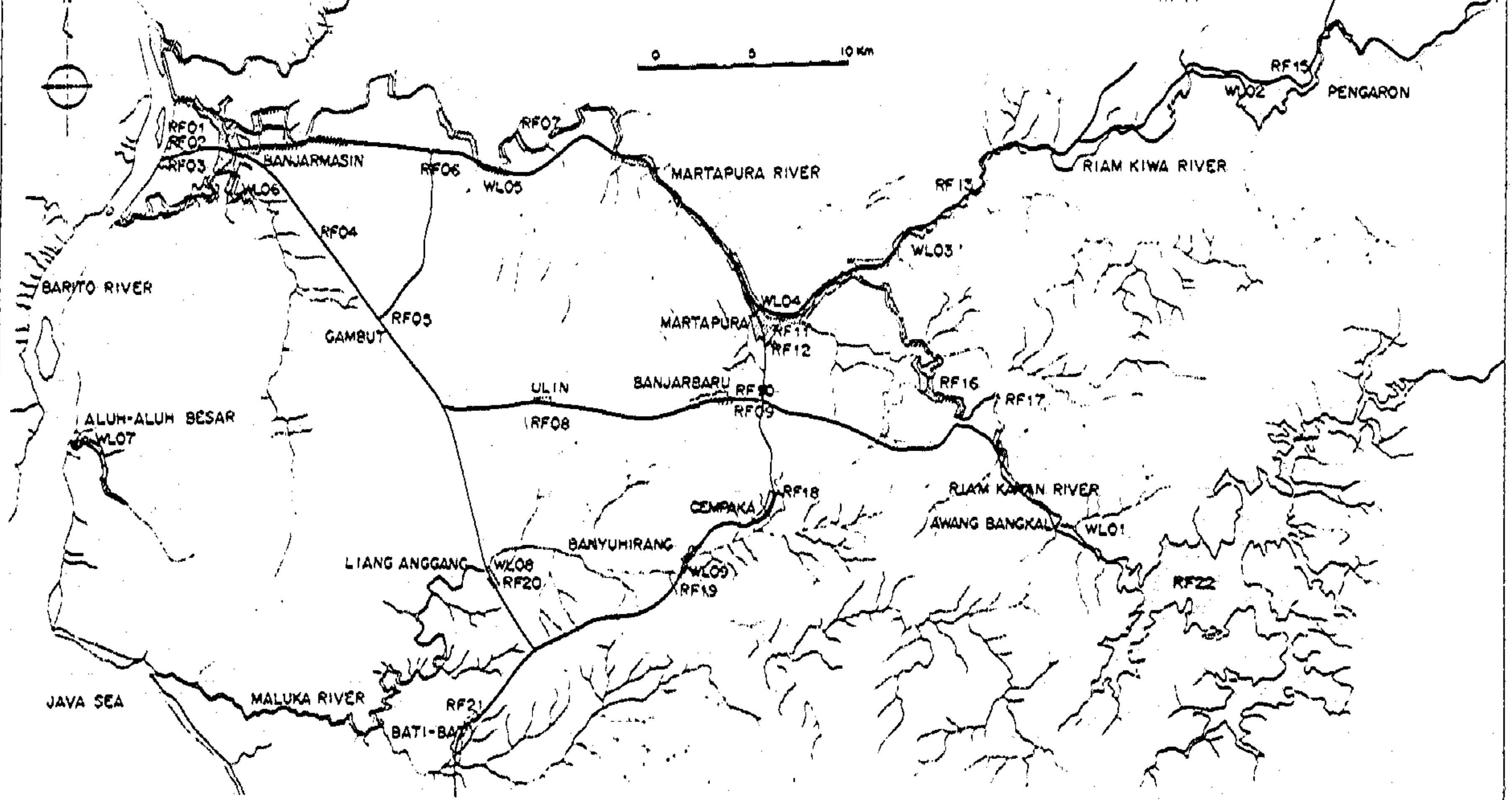
/1 : Irrigation Handbook, W. R. Ames Company in 1962, Fig. No. I-27, page FRI-38.

The City Waterworks Bureau in Banjarmasin also made chemical analysis of the river water of the Martapura, and the results of the analysis are as follows:

Sample	PH	Ca (ppm)	Mg (ppm)	Fe (ppm)	SO_4^{2-} (ppm)	Cl^- (ppm)	EC (mho/cm)	Organic Matter (ppm)
Sei Bilu	6.6	10.1	5.98	1.0	6.9	9.16	110	15.5
Sei Tabuk	6.9	10.8	8.69	0.4	5.7	5.46	115	8.22

The results of the analysis show that the river water sampled at Sei Bilu on the Martapura is contaminated by organic matter from the viewpoint of its domestic use, which will require suitable treatment of the water.

Fig. III-1 Location of Meteorological and Hydrological Stations



Rainfall Gauging Station

RF01	Banjarmasin, Diperta
RF02	Banjarmasin, P4S (Automatic)
RF03	Banjarmasin, PU
RF04	Kertak Hanyar
RF05	Gambut
RF06	Sei Tabuk, PU (Automatic)
RF07	Sei Tabuk, Diperta
RF08	Ulin, Syamsudin Noor (Automatic)
RF09	Banjarbaru, LMG (Automatic)
RF10	Banjarbaru, SPMA
RF11	Martapura, PU
RF12	Martapura, Diperta
RF13	Danau Salak
RF14	Simpang Empat
RF15	Pengaron (Automatic)
RF16	Karang Intan
RF17	Sei Asam
RF18	Cempaka
RF19	Banyuhirang
RF20	Liang Anggang
RF21	Bati-Bati
RF22	Kalaan Riam Kanan (Automatic)

Water Level Gauging Station

WL01	Awang Bangkal (Automatic)
WL02	Sei Langsar (Automatic)
WL03	Astambul
WL04	Martapura
WL05	Sei Tabuk (Automatic)
WL06	Pelabuhan Lama (Automatic)
WL07	Aluh-Aluh Besar (Automatic)
WL08	Liang Anggang (Automatic)
WL09	Banyuhirang

Table III-1 List of Rainfall Gauging Station

Station			Daily Data	
Banjarmasin,	Diperta		Jan.'62 ~ Dec.'67,	Jan.'69 ~ Jul.'78
			(monthly data:	Jan.'60 ~ Jul.'78)
Banjarmasin,	P4S	(Auto)	Jan.'74 ~ Jun.'78	
Banjarmasin,	PU		Mar.'75 ~ May '77,	Jul.'77 ~ Jun.'78
Kertak Hanyar			Jan.'76 ~ Jul.'76,	Jan.'78 ~ Jun.'78
Gambut			Jan.'54 ~ Jul.'68,	May '69 ~ Feb.'77
			Oct.'77 ~ May '78	
Sei Tabuk,	PU	(Auto)	Feb.'78 ~ Jun.'78	
Sei Tabuk,	Diperta		Jan.'78 ~ May '78	
			(monthly data:	Jan.'73 ~ Jul.'75)
Ulin, Syamsudin Noor		(Auto)	Jan.'60 ~ Jun.'78	
Banjarbaru,	LMG	(Auto)	Feb.'74 ~ Jun.'78	
Banjarbaru,	SPMA		Jan.'60 ~ Dec.'76	
Martapura,	PU		Mar.'75 ~ Jun.'78	
Martapura,	Diperta		May '14 ~ Jun.'78	
Danau Salak			Jan.'60 ~ Jun.'78	
Simpang Empat			Jan.'74 ~ Apr.'78	
			(monthly data:	Jan.'72 ~ Apr.'78)
Pengaron		(Auto)	Feb.'76 ~ Dec.'76	
Karang Intan			Feb.'76 ~ Jun.'78	
Sei Asam			Feb.'78 ~ Jun.'78	
Cempaka			Jan.'78 ~ Jun.'78	
Banyuhirang			Apr.'77 ~ Jun.'78	
Liang Anggang			Apr.'77 ~ Jun.'78	
Bati-Bati			Jun.'62 ~ Jul.'78	
Kalaan Riam Kanan		(Auto)	Aug.'76 ~ Oct.'76,	Jan.'78 ~ May '78
Riam Kanan Dam			Jan.'65 ~ Apr.'78	
Pleihari			Jan.'60 ~ Mar.'69,	Nov.'70 ~ May '78

Table III-2 Discharge Measurement on Riam Kanan, Riam Kiwa and Maluka Rivers

River	Station	Date	Gauge Reading	Discharge
			(m)	(m^3/sec)
Riam Kanan	Awang Bangkal	2 Oct. 1977	1.38	16.7
		14 Nov. 1977	1.44	23.6
		25 Mar. 1978	1.95	70.6
		8 Aug. 1978	1.91	37.0
		11 Sep. 1978	1.59	25.6
Riam Kiwa	Sei Langsat	15 Feb. 1976	1.43	47.8
		15 Feb. 1976	1.41	45.7
		19 Oct. 1976	0.31	4.1
		3 Mar. 1977	3.31	116.3
		13 Aug. 1977	0.61	11.3
		10 Sep. 1977	0.32	4.5
		28 Sep. 1977	0.45	7.4
		14 Nov. 1977	0.13	2.2
		28 Feb. 1978	1.66	45.0
		17 Jun. 1978	1.16	28.2
		8 Aug. 1978	0.95	20.6
		10 Sep. 1978	0.73	14.6
		12 Sep. 1978	0.63	12.2
Maluka	Banyuhirang	14 Sep. 1978	0.49	10.5
		22 Oct. 1978	0.30	7.8
		22 Oct. 1978	0.29	7.2

Fig. III-2 Rating Curve at Awang Bangkal on Riam Kanan River

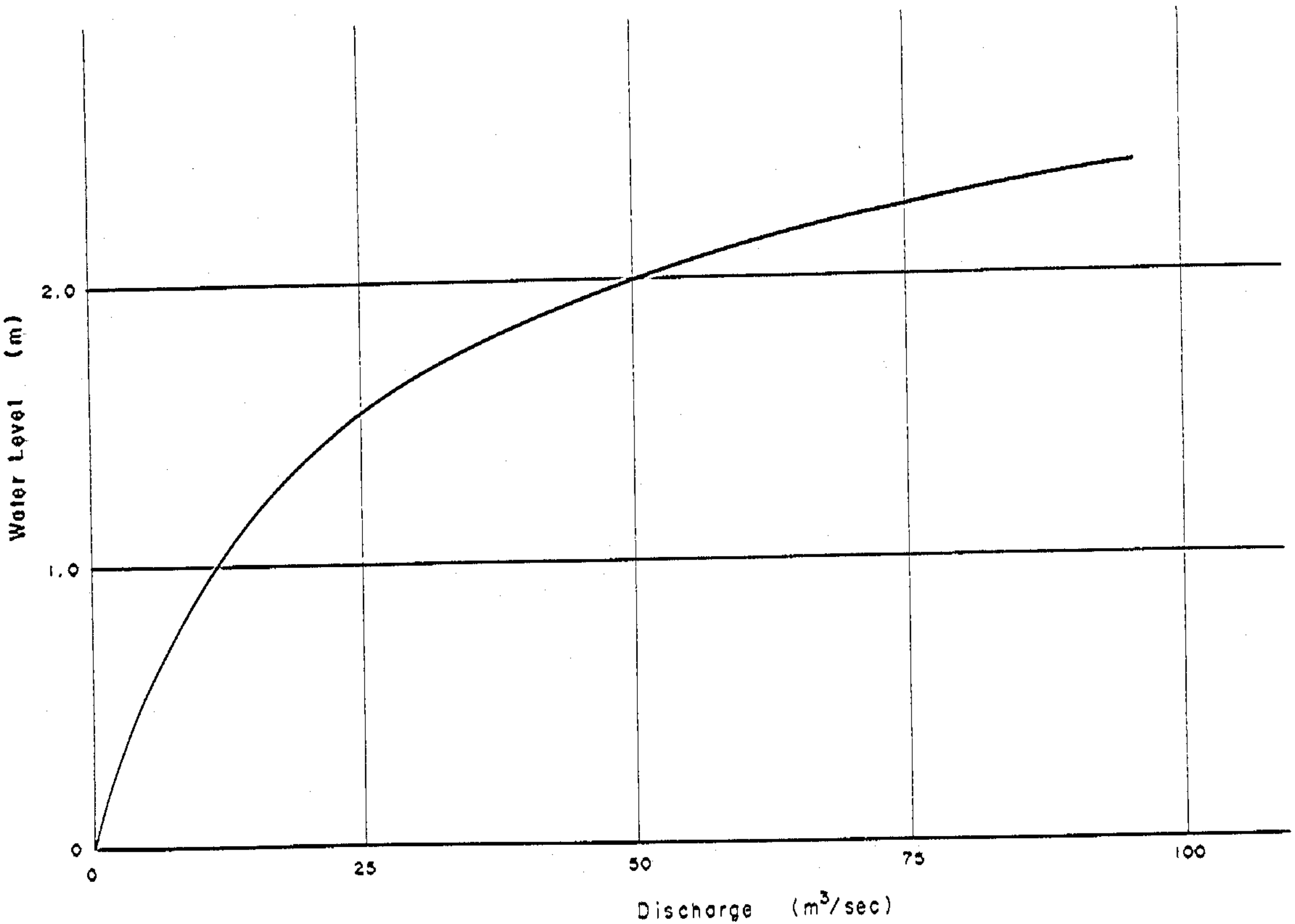


Fig.III-3 Rating Curve at Sei Langsat on Riam Kiwa River

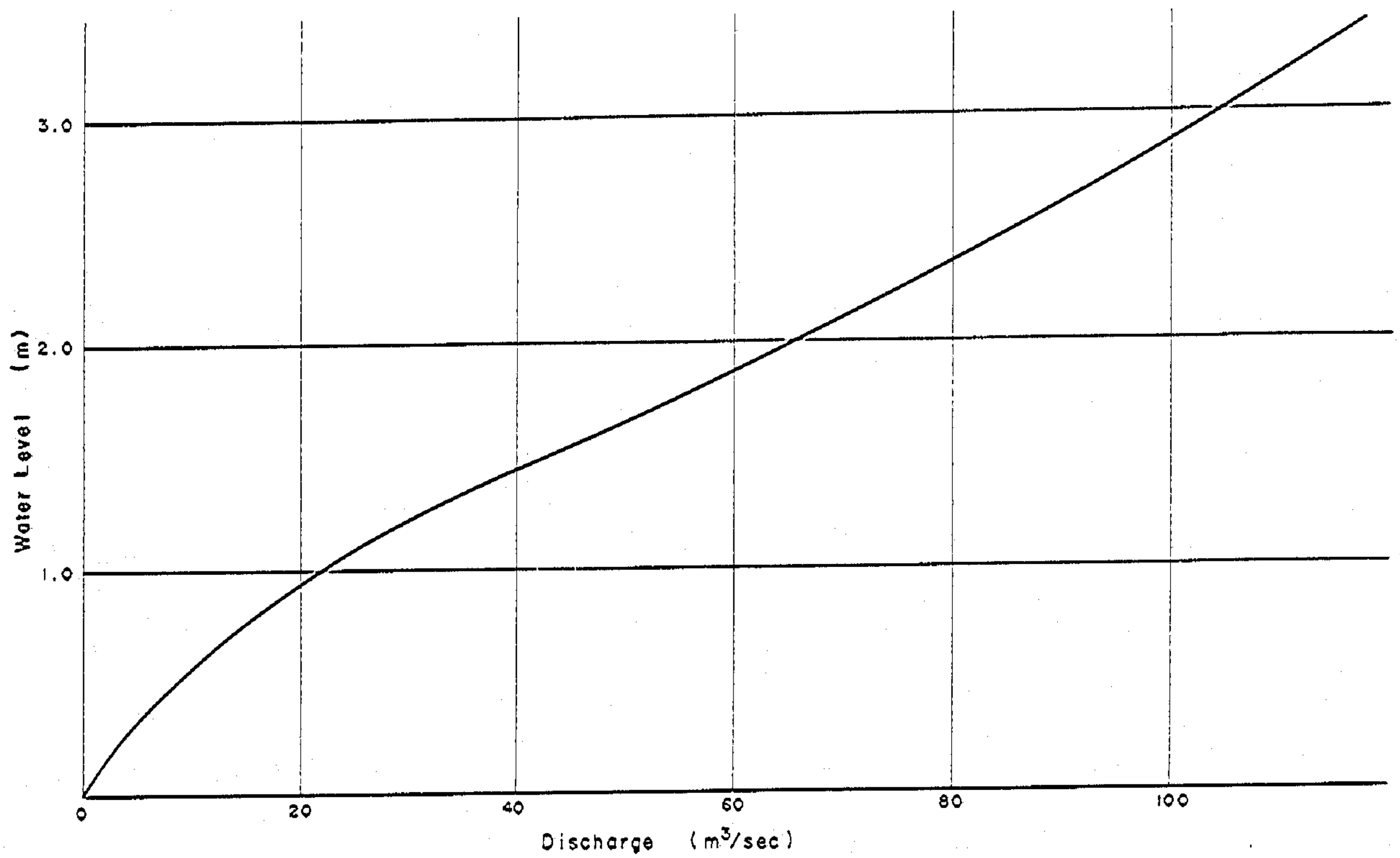
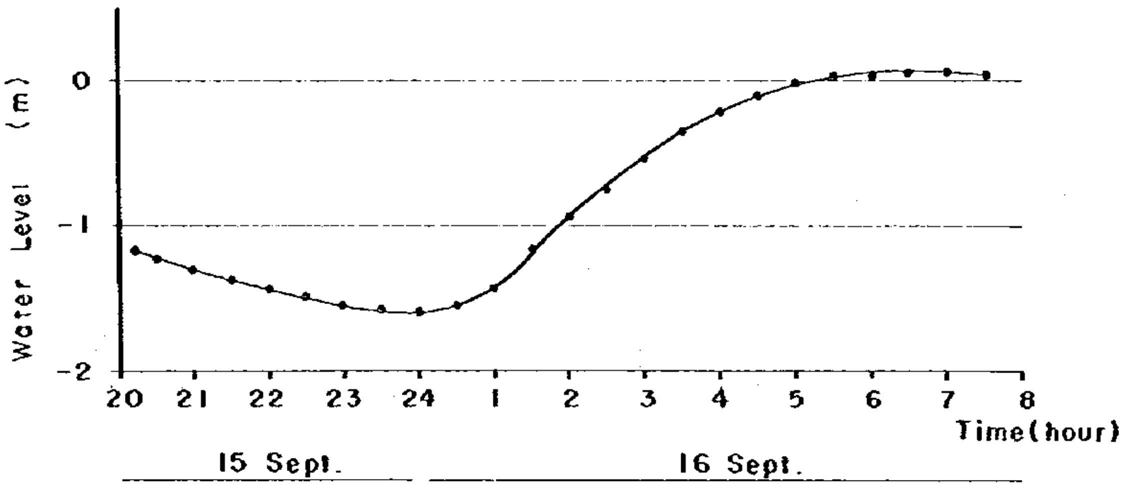
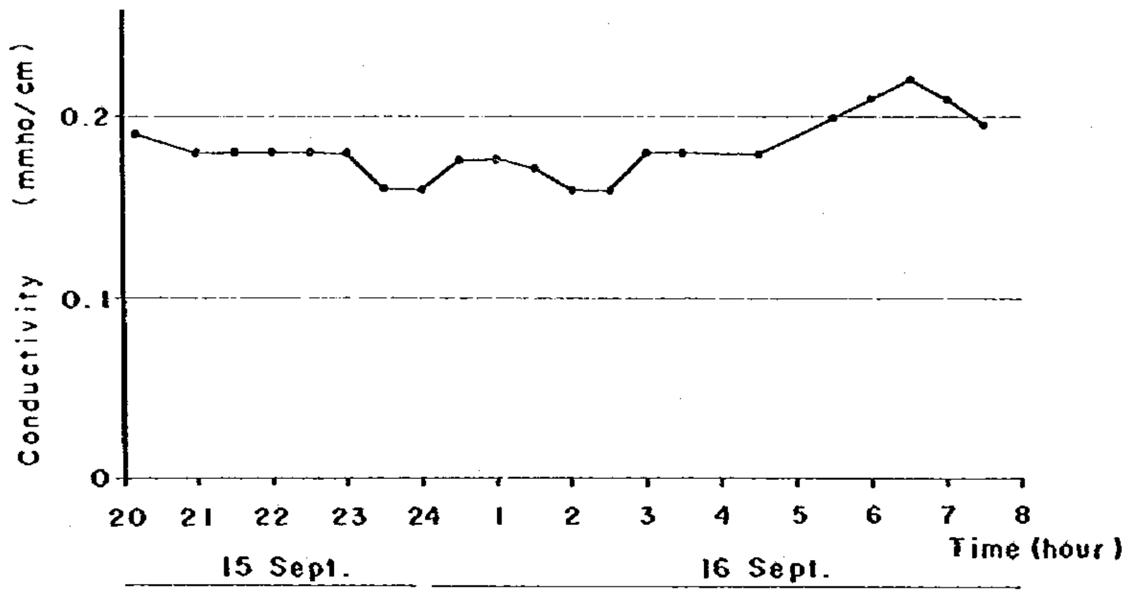


Fig. III-4 Investigation of Saline Water Intrusion at Banjarmasin on Martapura River (15,16, Sept. 1978)



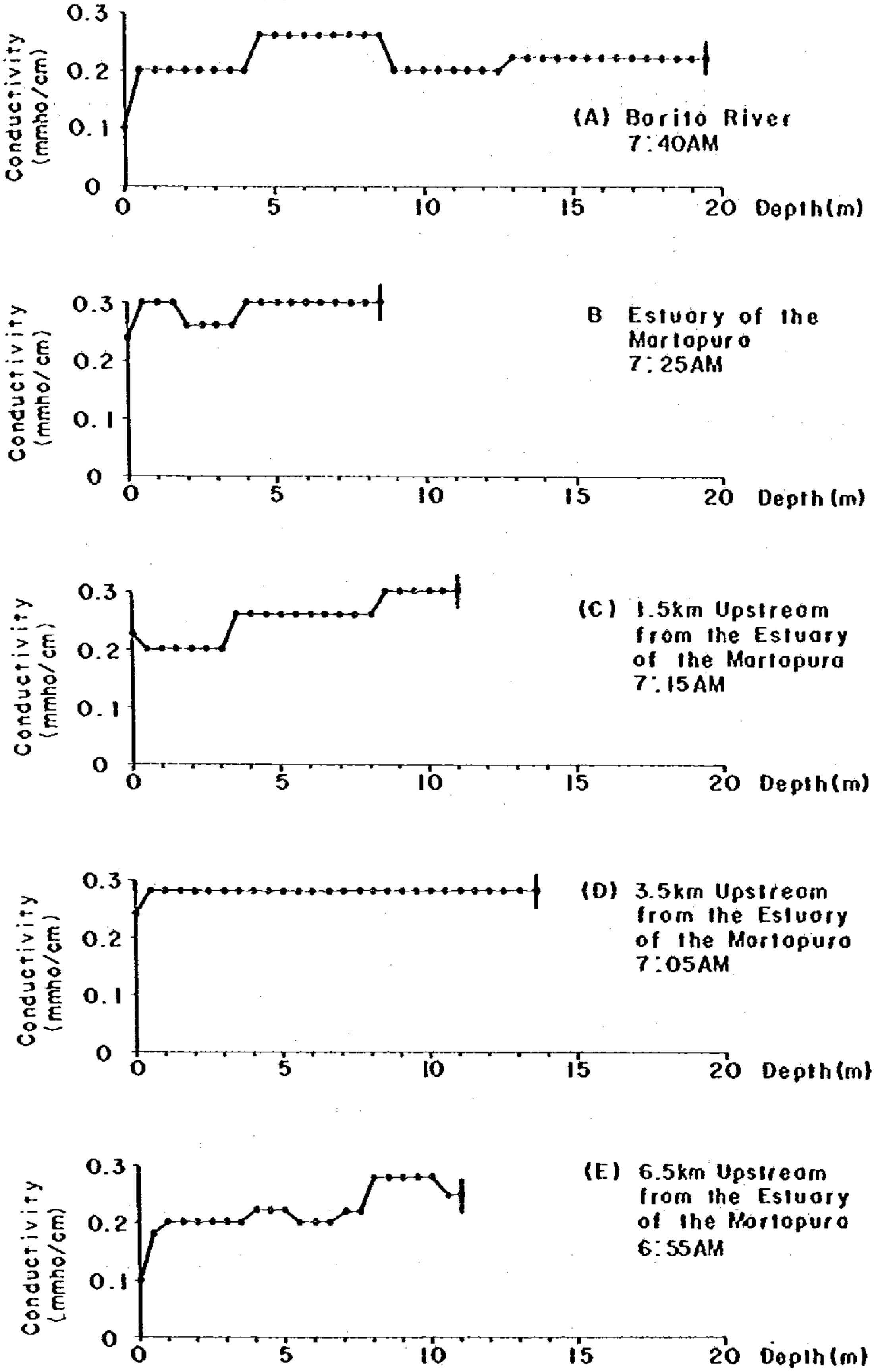


Note:

1) Temperature of river water ranges from 27.4 to 27.9°C

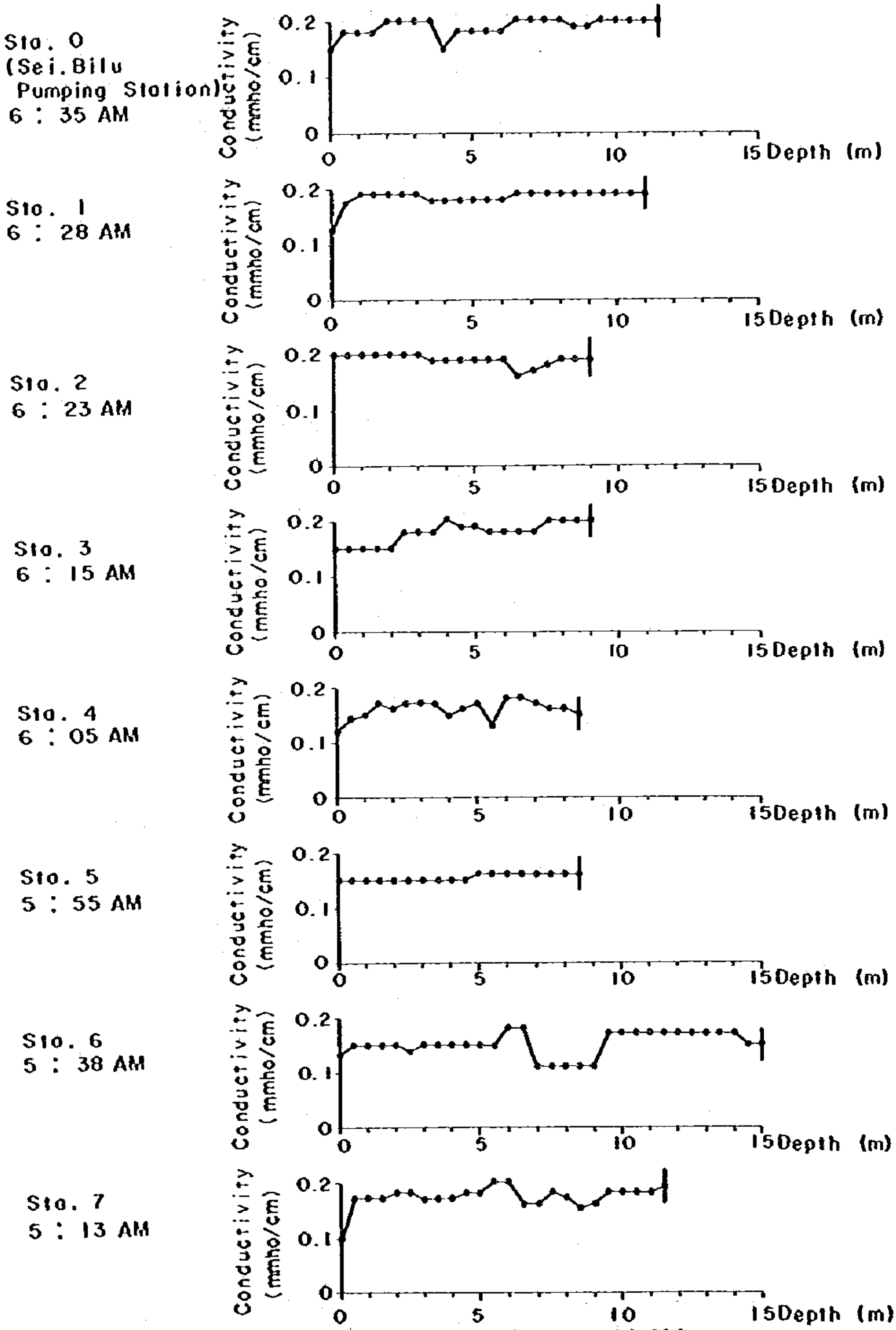
2) Location : 9.5 km upstream from the Estuary of Martapura river.

Fig. III-5 Investigation of Saline Water Intrusion on Martapura River (16. Sept. 1978)



Note : Temperature of river water ranges from 27.4 to 28.1°C

- to be continued -



Note : Temperature ranges between 27.2°C and 28.0°C.

Fig. III-6 Investigation of Saline Water Intrusion on the Martapura and the Barito (10,11,Oct.'78)

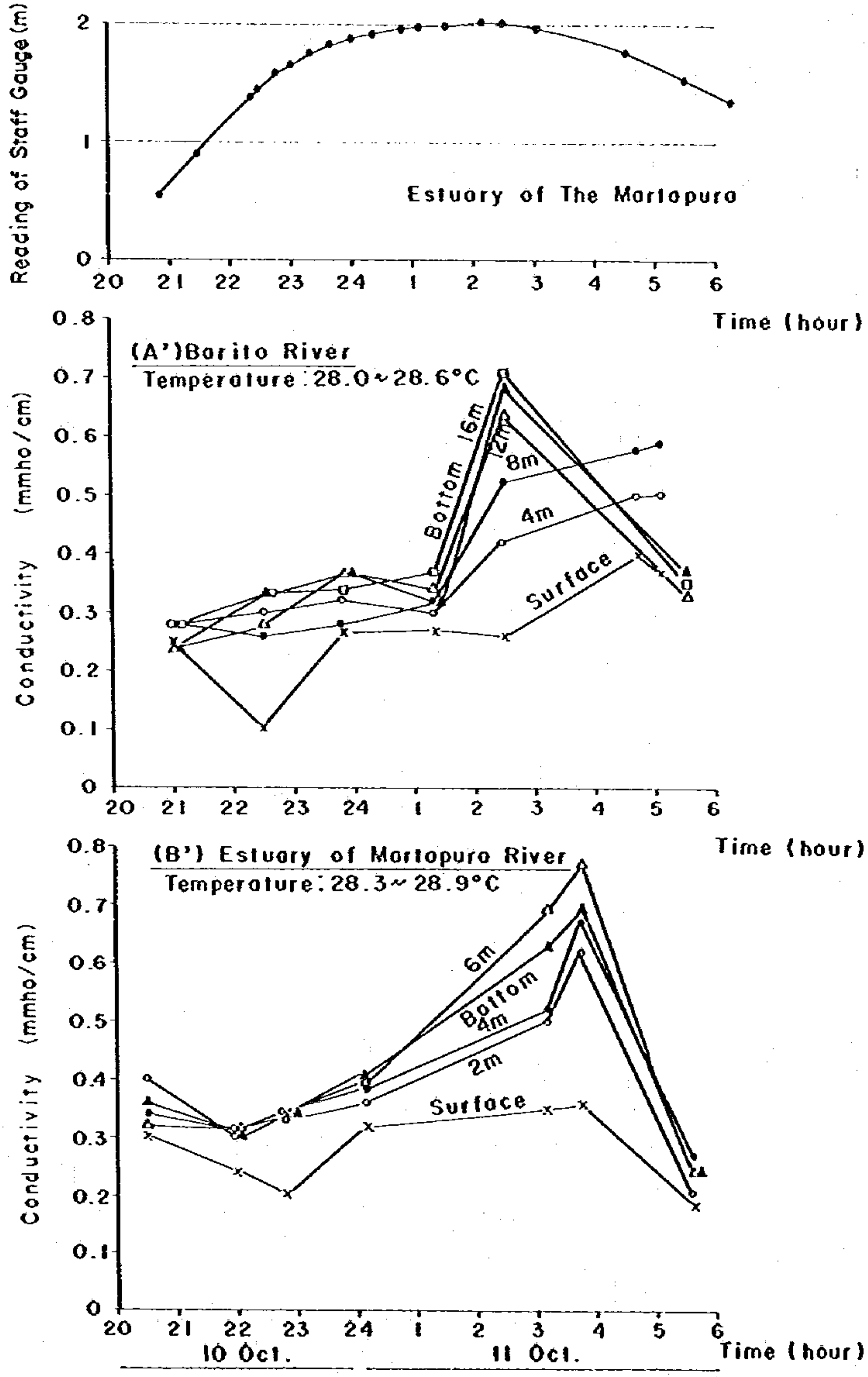


Fig. III-7 Daily Max. Chlorine Concentration at Sei Bilu Station

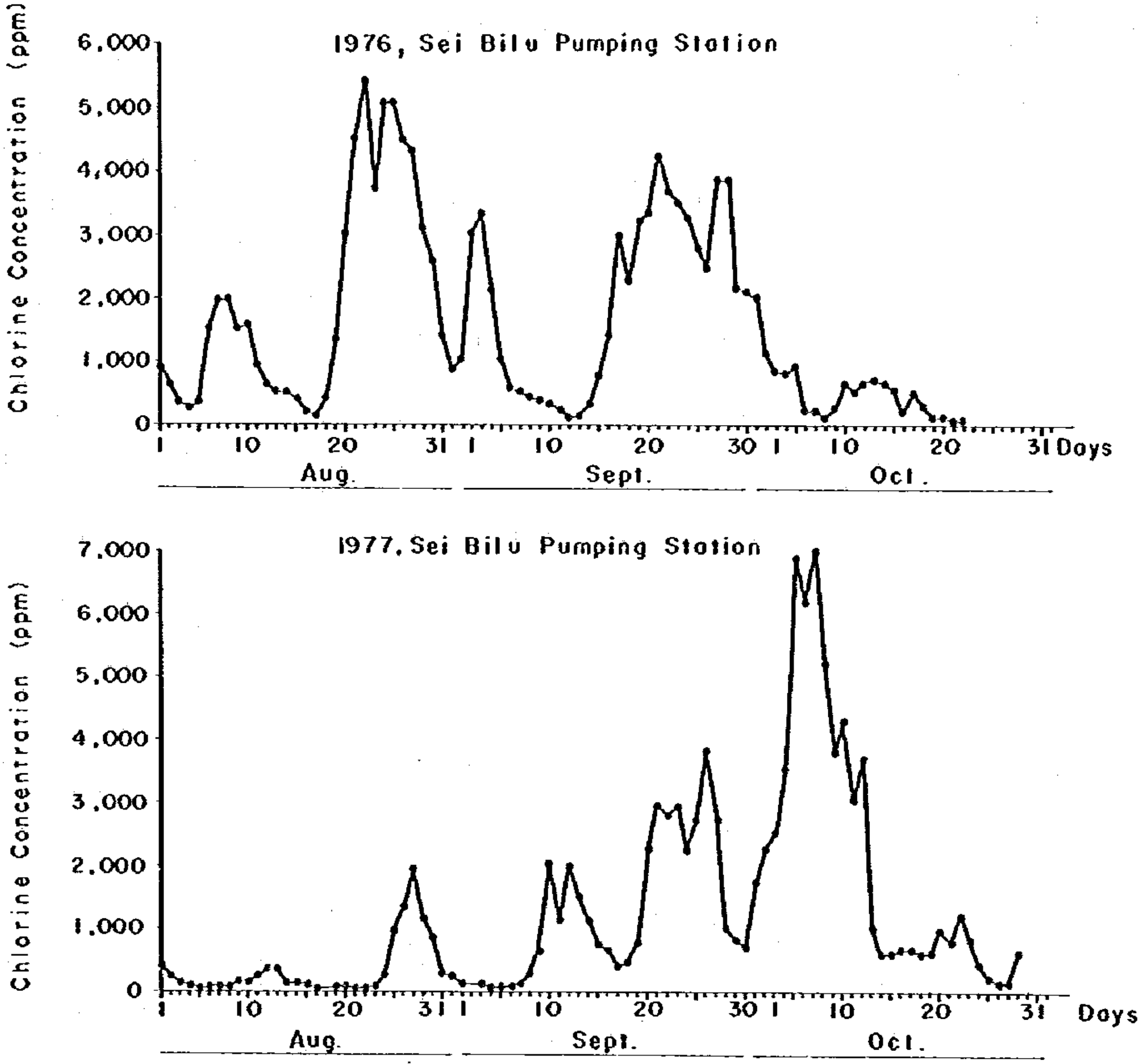


Fig. III-8 Daily Max. Chlorine Concentration at Sei Tabuk Station

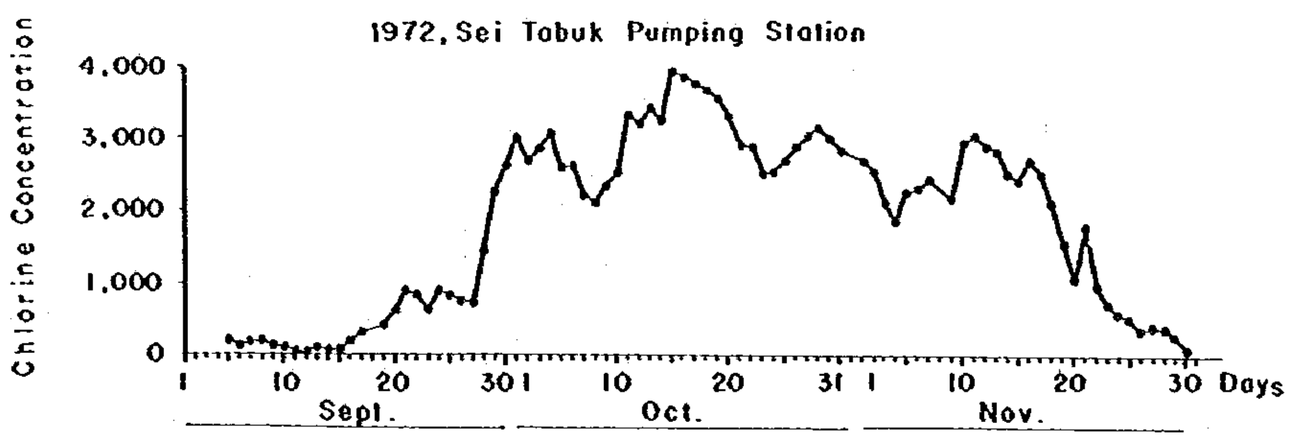


Fig. III-9 Location of Saline Water Observation and Water Sampling

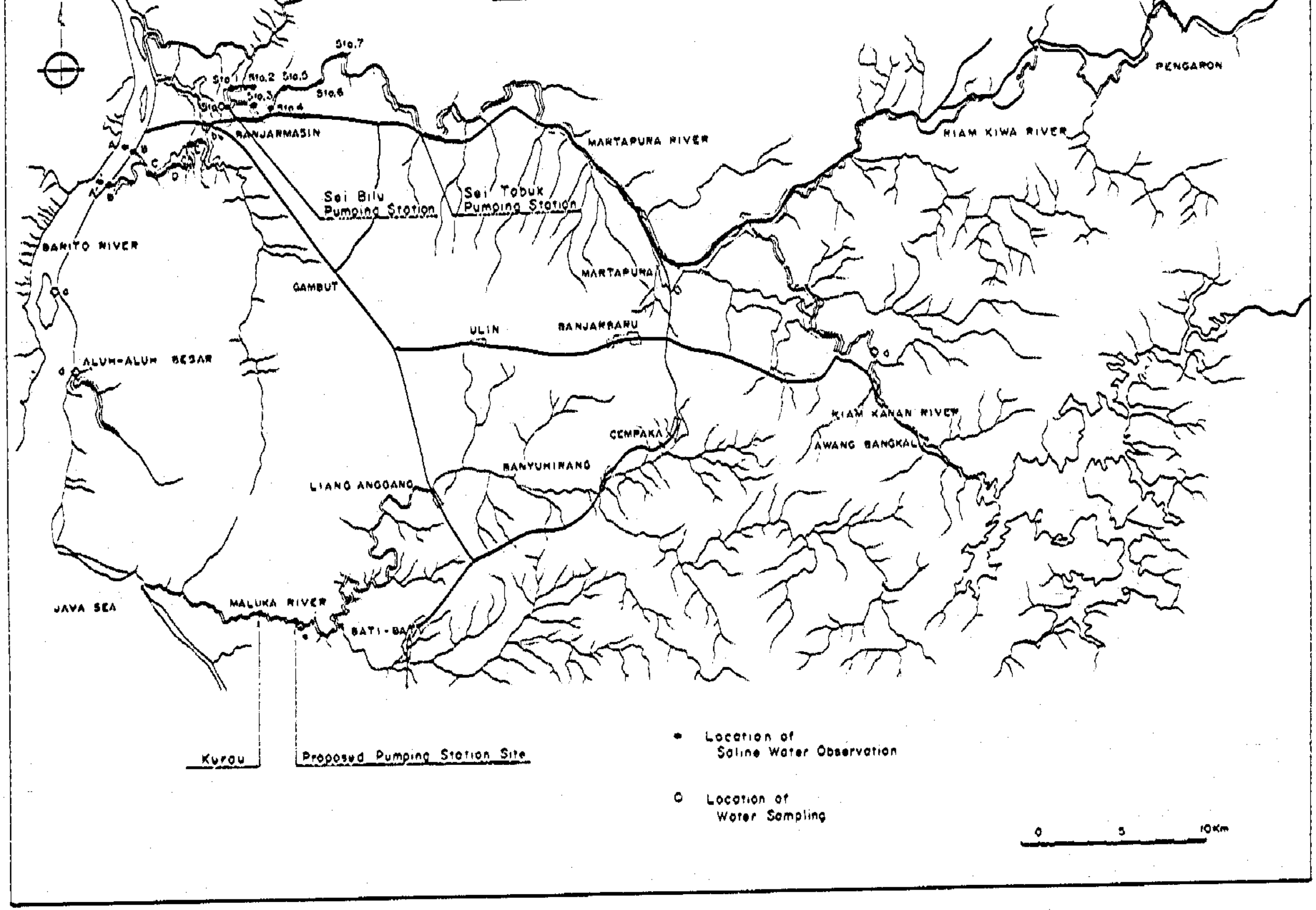


Fig. III-10 Investigation of Saline Water Intrusion at Kurau (19,Oct.'78)

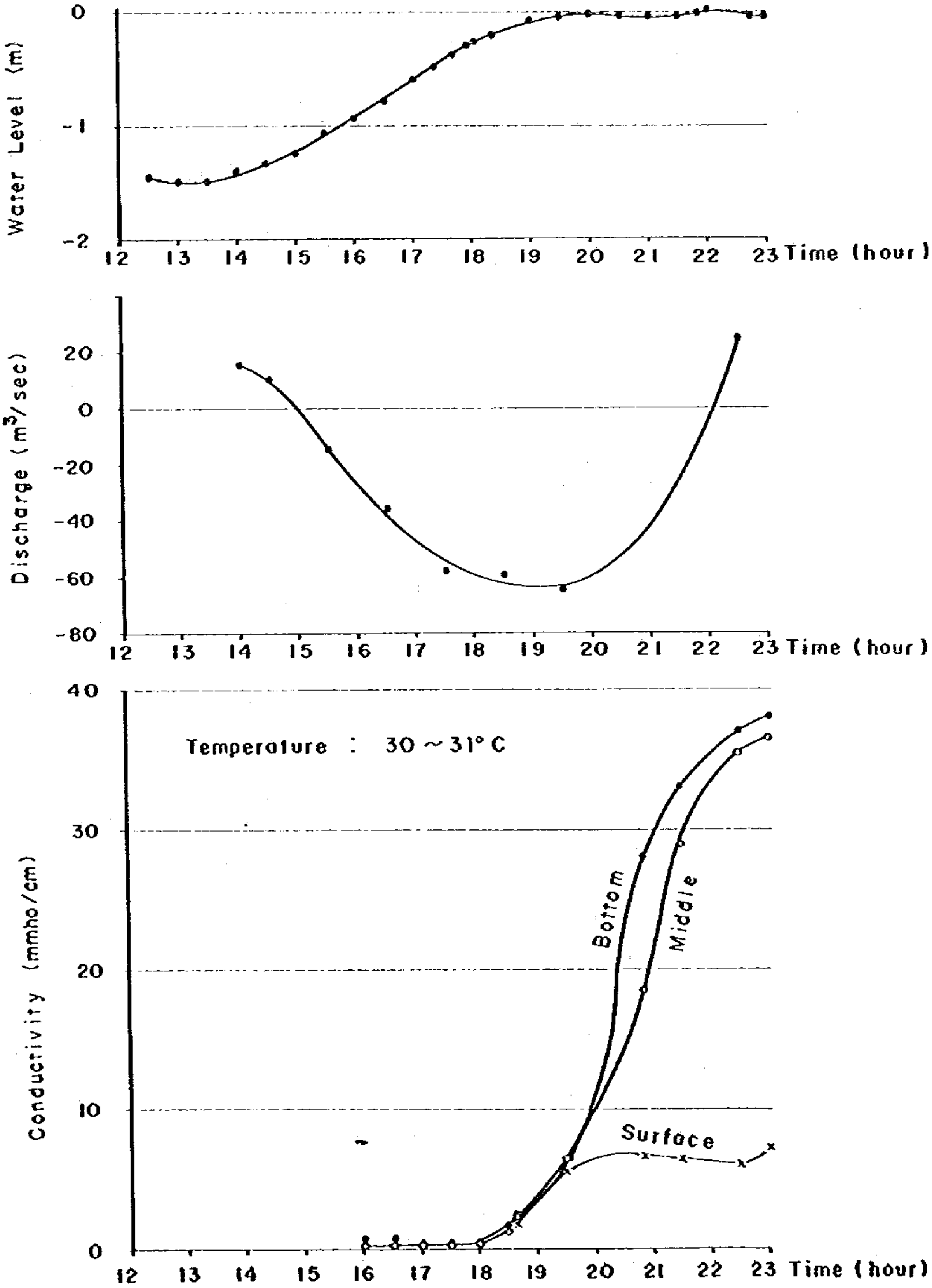


Fig. III-11 Water Level Record on Maluka River (23,24 Oct.'78)

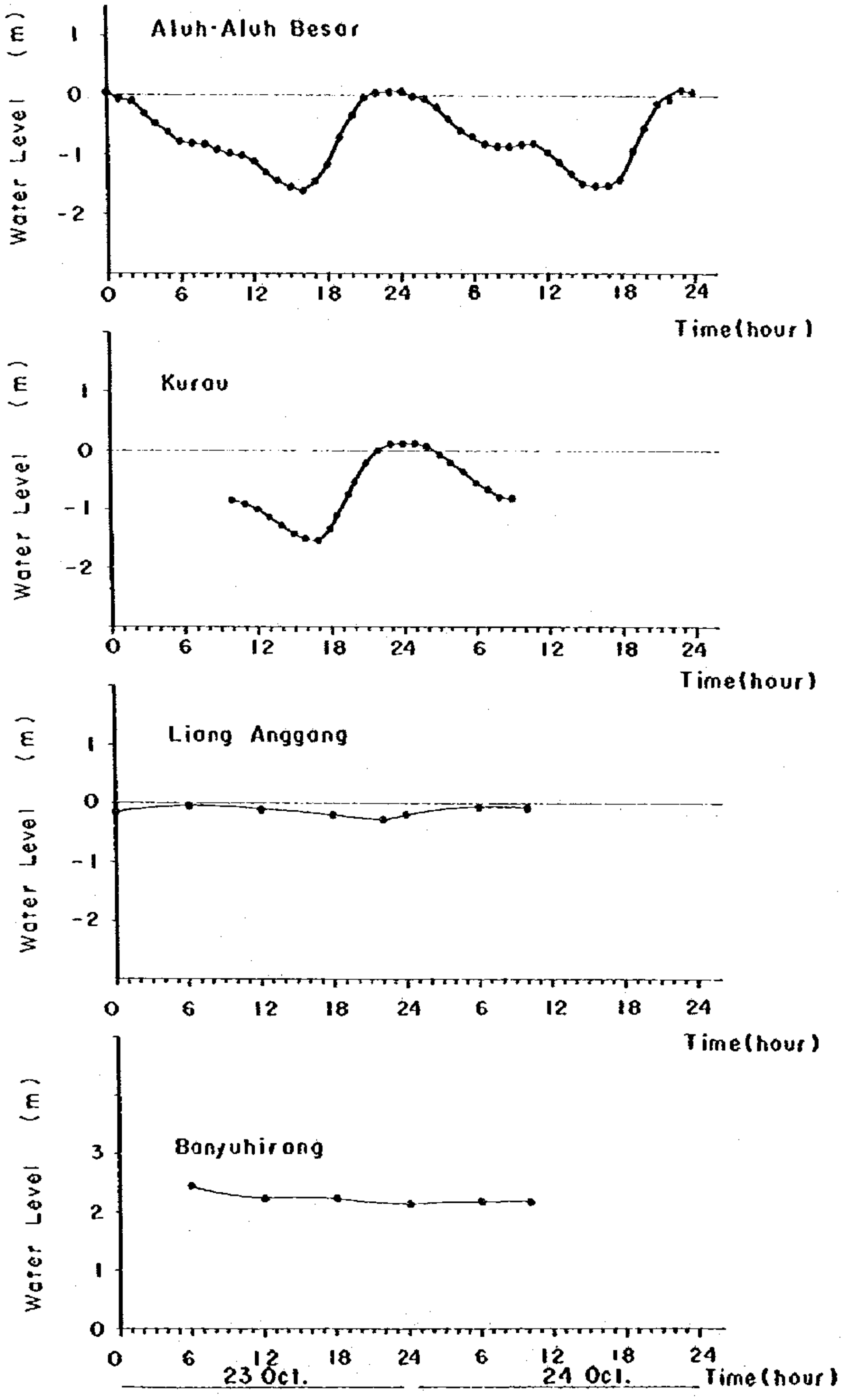


Fig. III - 12 Investigation of Saline Water Intrusion at Proposed Pumping Station Site (23,24,Oct. 1978)

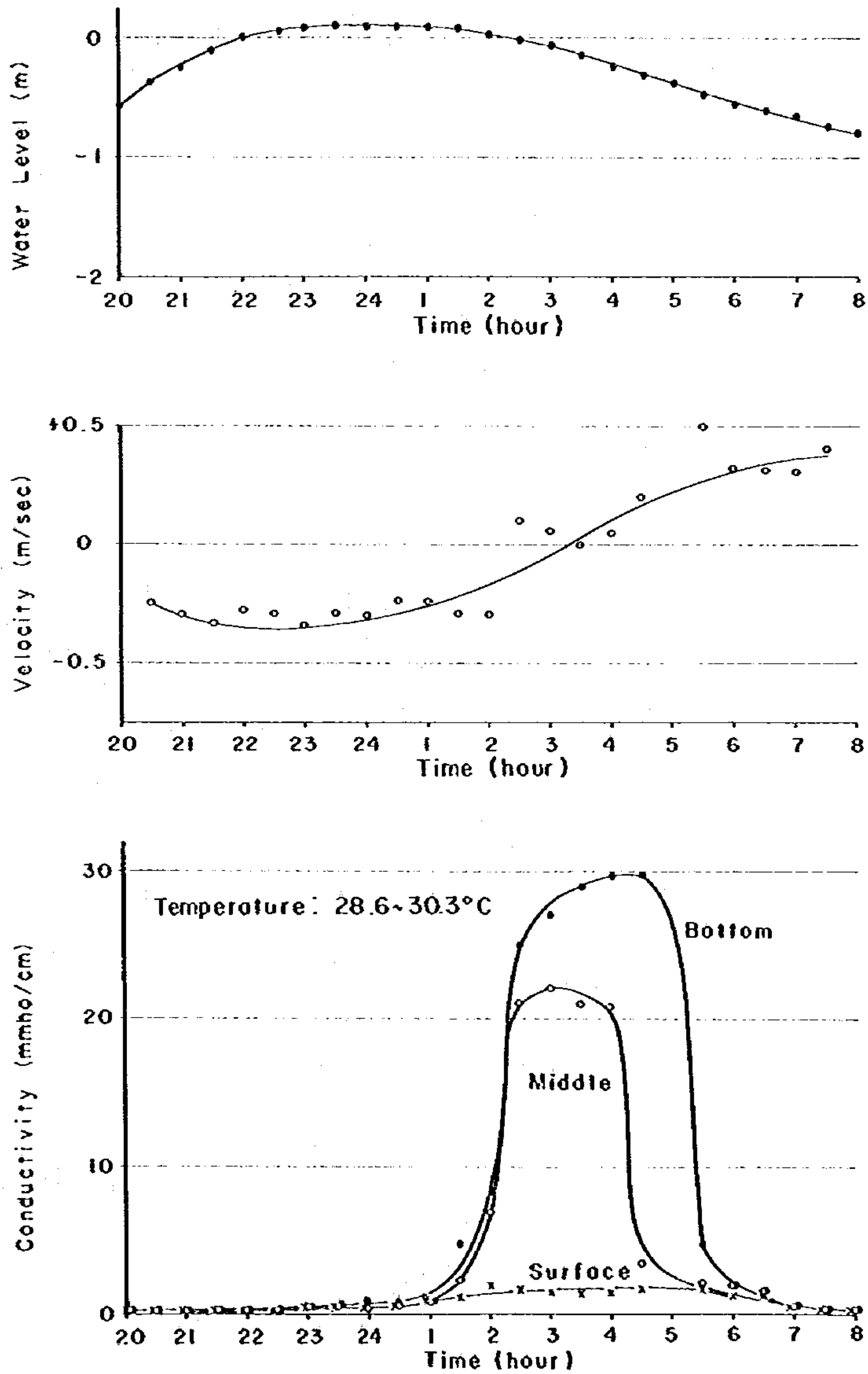


Fig. III-13 Relationship Between Expected Discharge and Gross Head

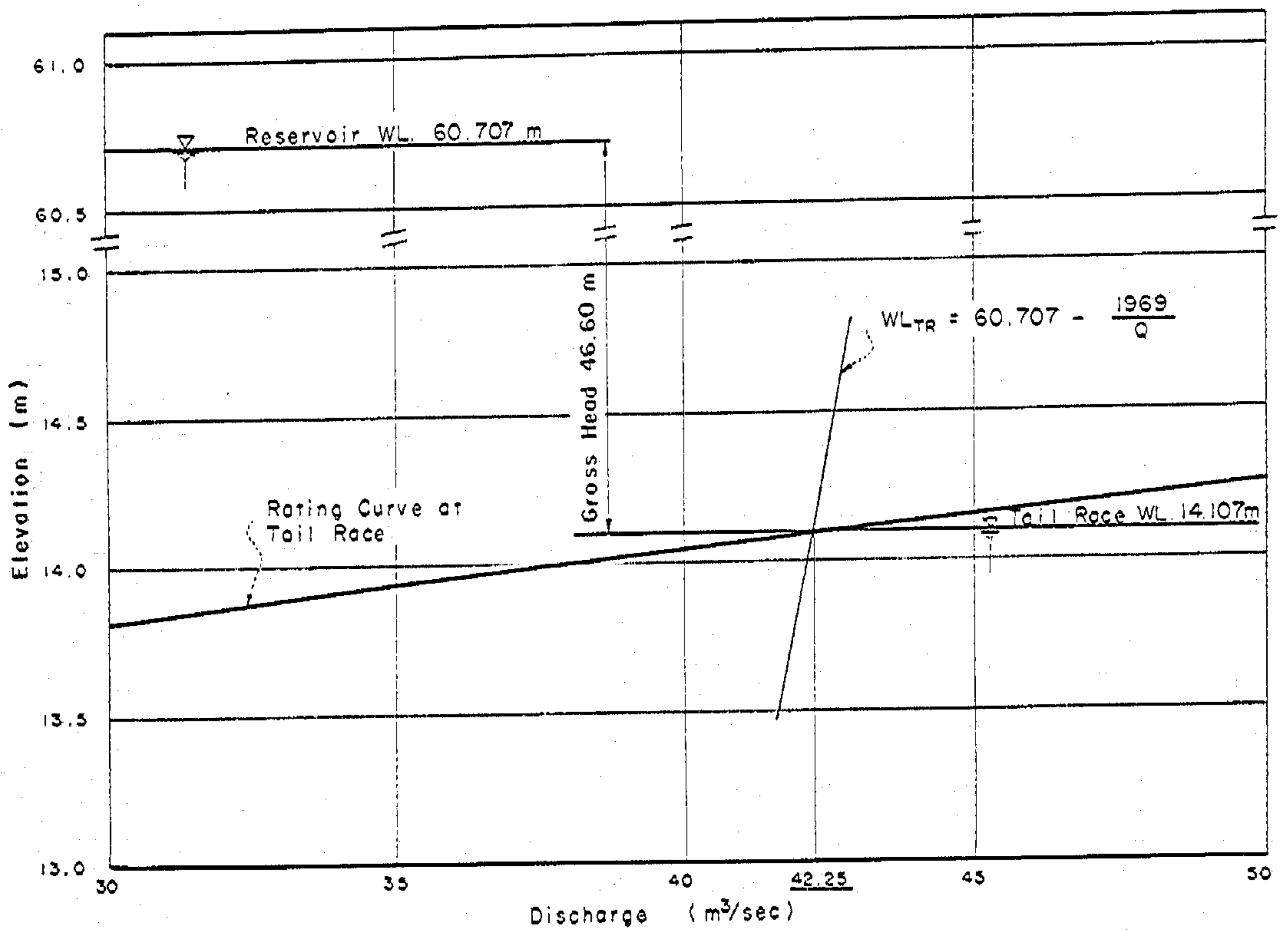


Fig. III-14 Mass Curve by 10 – days Mean Run-off at Riam Kanan Dam

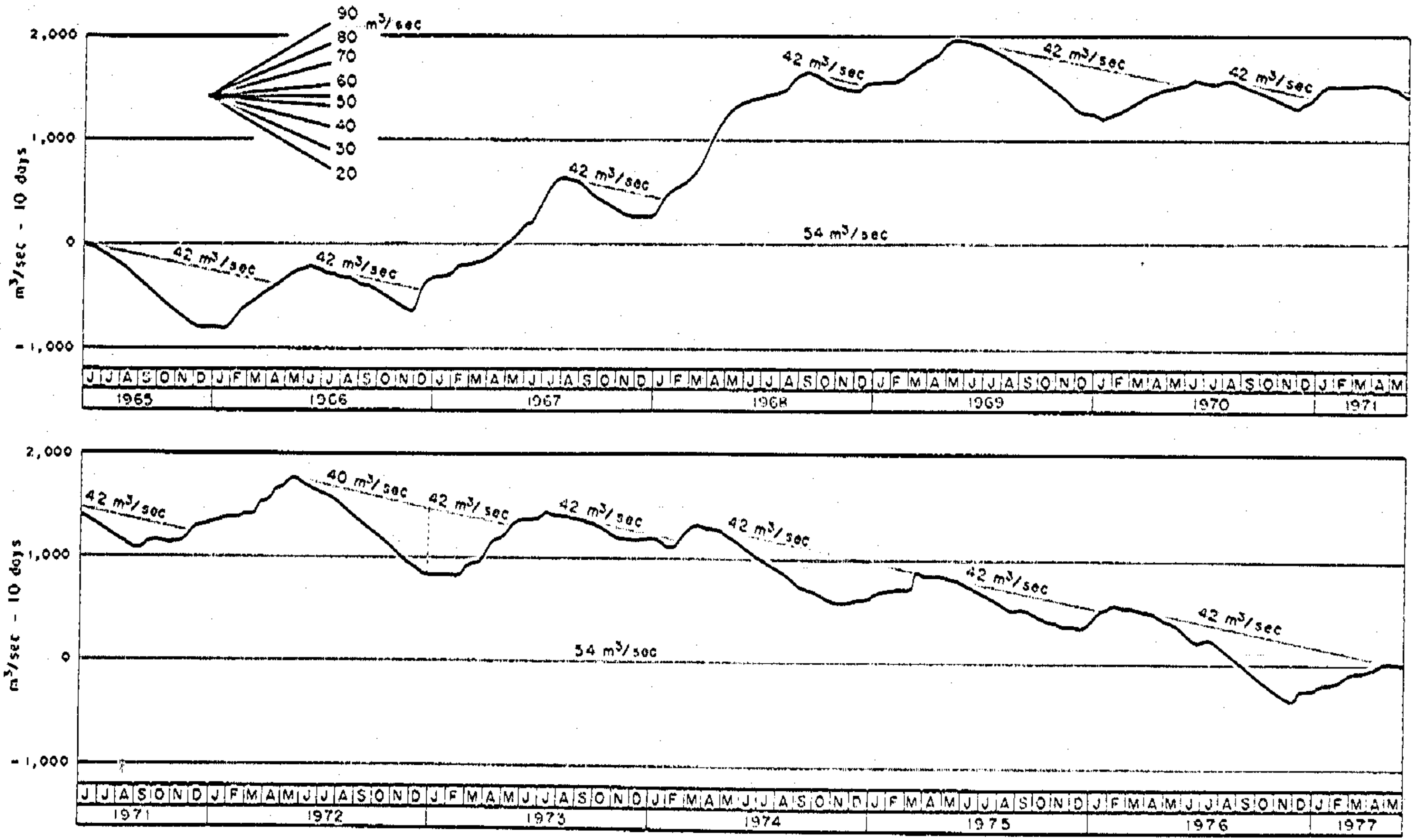


Fig. III-15 Monthly Mean Discharge in August at Riam Kanan Dam Site

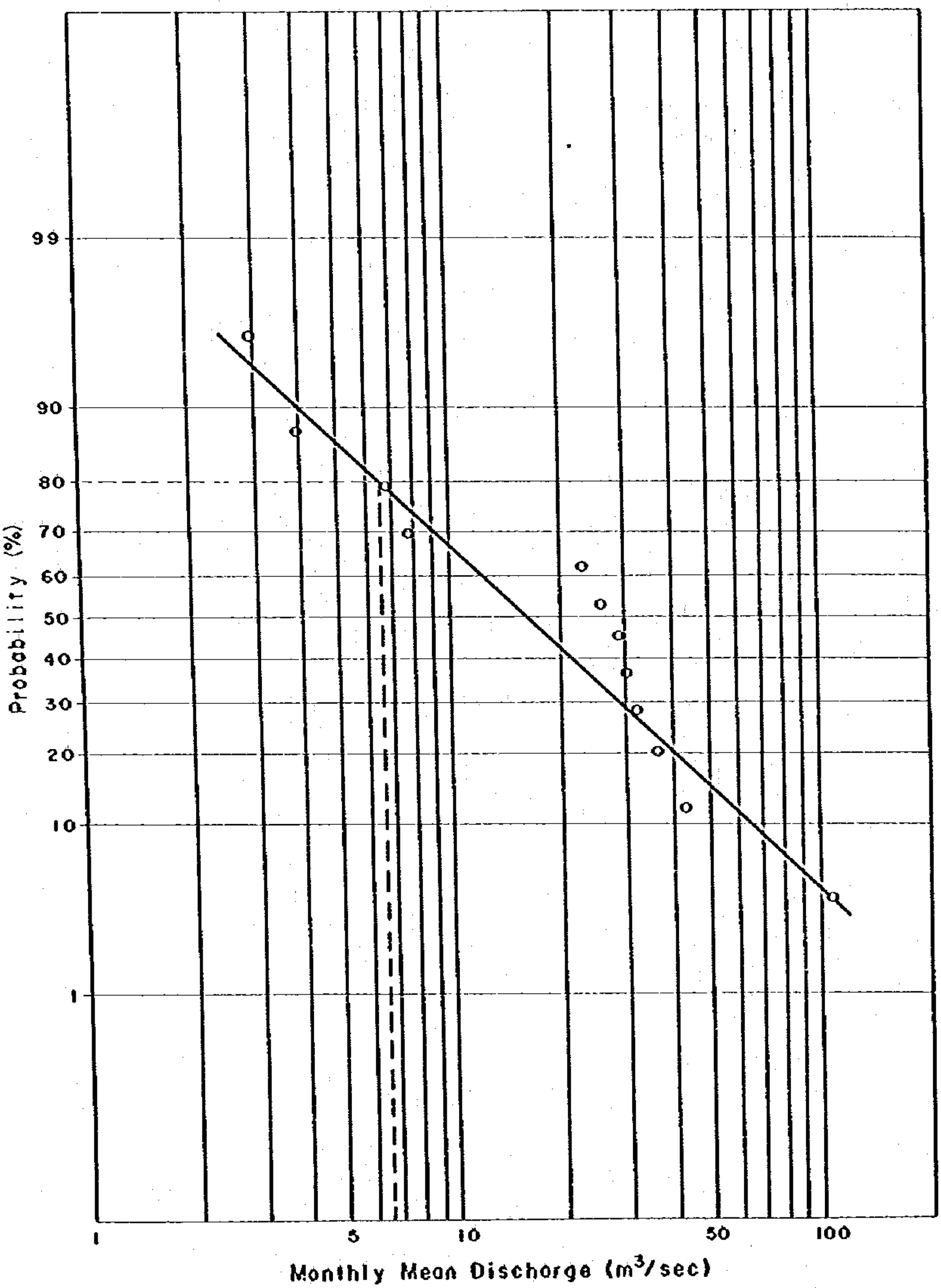
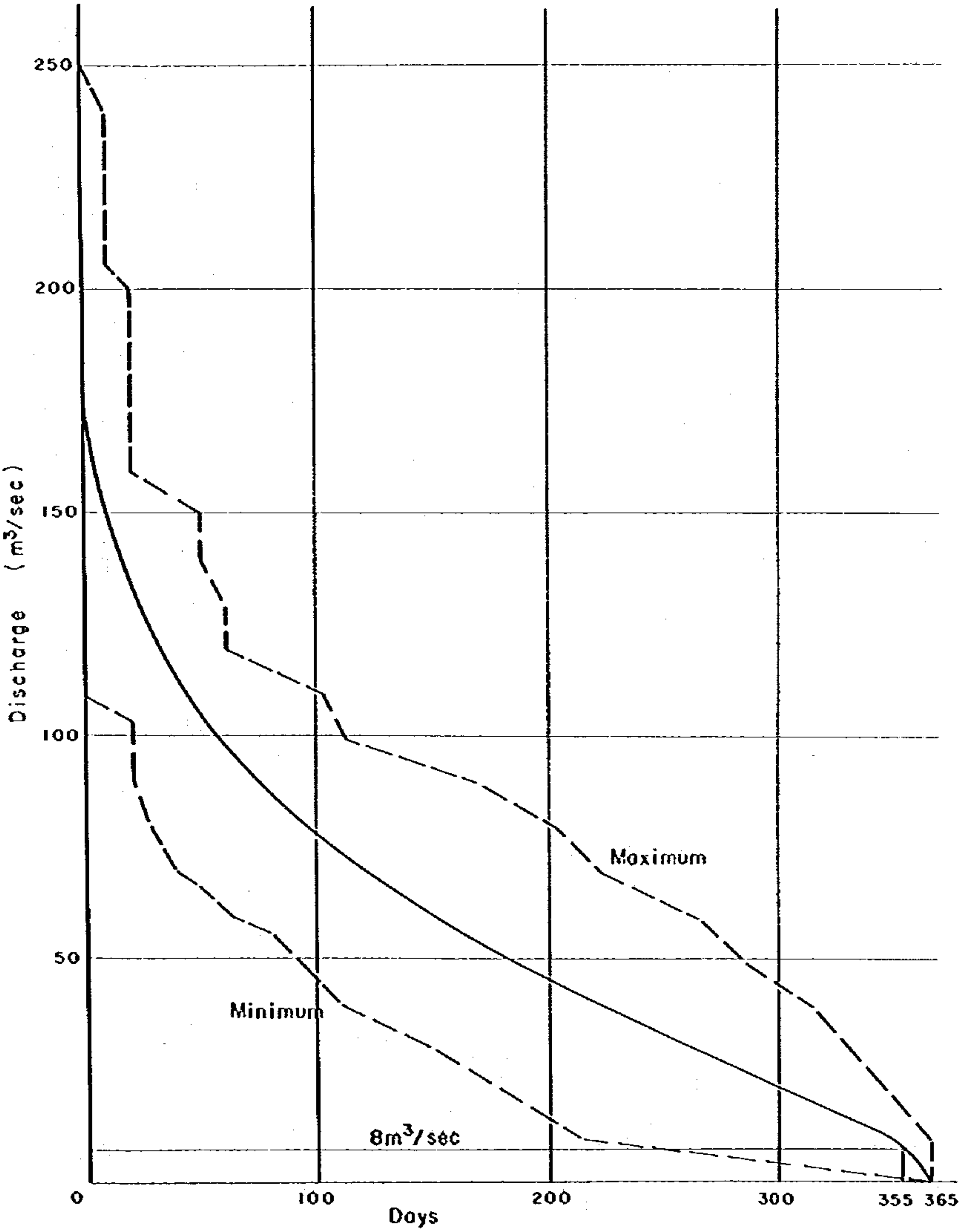


Fig. III-16 Discharge Duration Curve at Riam Kanan Dam Site



ANNEX Ⅳ

GEOLOGY

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ANNEX IV GEOLOGY

IV.1 INTRODUCTION

The main objective of geological investigation carried out for the feasibility study is to study the engineering geology of two alternative sites for the construction of diversion weir on the Riam Kanan river through the detailed field survey and test drilling and of the foundation for the main irrigation canal by digging test pits along the canal. The investigation also includes mechanical tests of soil samples obtained from the test pits and the preliminary survey of materials necessary for the construction of the weir.

One weir site is located near Sungai Asam village, about 12 km downstream from the Riam Kanan dam (site-A), and the other is situated at about 1 km upstream from the site-A, near Mandikapau village (site-B).

The main irrigation canal runs approximately westwards from the diversion weir to Gambut in the hilly area extending in the southern part of the project area. The length of the canal would be about 48 km.

IV.2 GENERAL GEOLOGY IN AND AROUND THE PROJECT AREA

The general geology in and around the project area is studied using the following available geological maps :

		Year	Map scale
(1)	Koolhoven, W,C,B : Het primaire Vookmen van den Zuid-Borneo diamont. Verh, Geol, Mijab Gen V, Ned & Kol, Geol, Serie 11.	1935	1:100,000
(2)	Geophoto Service Inc. : Geological map and morphostructural Analysis. Barito Basin Area.	1968	1: 50,000
(3)	Geological Survey of Indonesia : Geological map of Southeast Kalimantan.	1969	1:500,000
(4)	Ministry of Public Works and Electric Power : Investigation of Technical Geology at Riam Kanan, South Kalimantan	1972	1: 25,000 1: 2,000

The geological map is prepared as shown in Fig. IV-1. The general geological sequence in and around the project area is shown below :

Geological sequence	Formation	Age
1	Alluvium (contain terrace deposits)	Quaternary
	~~ unconformity ~~~~~~~~~~~~~~~~	
2	Sandstone, tuff, clay, marl	Tertiary (Miocene)
	~~ unconformity ~~~~~~~~~~~~~~~~	
3	Quartz sandstone, shale, limestone	Tertiary (Paleogene)
	~~ unconformity or fault ~~~~~~~~~~~~	
4	Tuffaceous sandstone - Manunggul form	Upper Cretaceous
	~~ unconformity ~~~~~~~~~~~~~~~~	
5	Plutonic acidic rocks	Lower Cretaceous
	x x x x x intrusion x x x x x x x x x x x x x x	
6	Basic igneous rocks (peridotite, pyroxenite)	Lower Cretaceous
	x x x x x intrusion x x x x x x x x x x x x x x	
7	Tuffaceous sandstone - Alino Form	Jurassic
	~~ unconformity ~~~~~~~~~~~~~~~~	
8	Crystalline schist	Pre-Mesozoic

Among them, sedimentary formations have a general strike of N 50° - 60°E and distribute north to south with a sequence of 2 - 3 - 4 - 7 - 8. The formations dip generally towards the north. As seen in the general geological map, Miocene sediments (2) distribute, elongating towards E-W, but the strike seems to be N-E direction. The intrusive direction of igneous rocks concordants mostly with the strike of sedimentary rocks. Generally, geological structures in this area is very simple with no large geological movements and remarkable fault zones.

IV.3 GENERAL GEOLOGY OF DIVERSION WEIR SITES, AFTER-BAY AREA AND ALONG THE MAIN IRRIGATION CANAL

IV.3.1 Diversion Weir Sites (see Dwg. No. 3)

In the area around the weir sites, Alluvium, Tertiary (paleogene) sandstone, Cretaceous tuffaceous sandstone and Jurassic tuffaceous sandstone with the intrusion of pyroxenite distribute.

Alluvium consists of recent deposits and terrace deposits, and the latter is generally covered with the former. The recent deposits are composed of silt, clay and sand, and have lateritic part and arkose part according to the geology around the areas where the deposits distribute. The thickness of the deposits range between 1 and 3 m in general, except for thick deposits with a thickness of 7 to 8 m mostly distributed on the right bank of the river. The terrace deposits consist mainly of gravels of quartz stone, intrusive igneous rocks, sandstone, laterite, etc. cementing sand and silt. The thickness is between 2 and 8 m, and 4 m on an average.

Tertiary (Paleogene) quartz sandstone distributes in the right bank area extending between Sungai Asam village and Sungai Alang village, and the Riam Kanan river forms the geological boundary of this formation. This boundary may be formed by fault, because ferruginous breccia is seen in a part of the boundary. Rock facies is coarse grain rock mainly composed of quartz grain. This formation is relatively compact and resistive against weathering. This formation is characterized by interbedding of coal and seam of coaly shale. The strike of the formation is N60° - 70°E, and the dip is 25° - 40°N.

Cretaceous tuffaceous sandstone distributes in the south of Mandikapau village. It lies on Jurassic sediments of lower sediment, because Jurassic sediments distribute on both sides of this Cretaceous tuffaceous sandstone. Such a distribution pattern of the formations is only an exception of the geology in this area. The distribution width of this sediment is about 1.5 km. Rock facies is siliceous and fine grain tuffaceous sandstone and has whitish color. In the eastmost part of the area covered with this sediment, andesitic tuff is found, and phenocryst of feldospar (1 to 2 mm in size) is clearly observed. The strike and dip of this sediment are N 50°E and 50°N, respectively.

Jurassic tuffaceous sandstone distributes widely in the center part of this area, sandwitched with Tertiary sediments and Cretaceous sediments, and distributes again in the south of Cretaceous sediments. Rock facies is sandstone containing medium grain quartz and mafic minerals, and has dark green color. Weathered soil of this sediment has reddish brown to lateritic color. Bedding is hardly found in this sediment, and the sediment is massive. Tuff breccia distributes on the hill located in the eastmost part of the area covered with this sediment.

Pyroxenite distributes in the center part of this area, forming two small bodies of pyroxenite on the ground surface intruding into Jurassic sediments. However, the geological report prepared by Indonesian Government in 1972 shows that pyroxenite elongates to the north of this area underneath Alluvium. In addition, test drilling at the weir site-B shows that there exists pyroxenite on both banks of the river, at about 17 m deep on each bank. From these survey results, it is thought that there may exist a considerable mass of pyroxenite, making the above two bodies in one in deep part. Rock facies has porphyritic texture with phenocryst of feldspar, pyroxenite, etc. and dark green to black color, and is hard. The weathered soil of this rock has lateritic to reddish color.

IV.3.2 After-bay Area

An after-bay would be created by the construction of diversion weir on the Riam Kanan. With the creation of the after-bay, the lower area extending between Mandikapau and Awangbangkal villages, about 2 km in length along the Riam Kanan, would be submerged. The general geology in this after-bay area is surveyed.

In this area, Cretaceous and esitic tuff, Jurassic tuff breccia and peridotite distribute from the north to south with the strike of N 40° - 50°E. The area with an elevation lower than 10 m in which the river water would be stored is covered with Alluvium in general.

IV.3.3 Main Irrigation Canal

The elongated area along the main irrigation canal is composed of Quaternary sediments, except for some part of the area consisting of Tertiary (Miocene) sediments. The general geology of this area is summarized from the results of soil mechanical survey carried out along the canal as shown below.

Sequence	Formation	Age
1	Humic soil (black)	Quaternary
2	White sand	
3	Brown soil	
4	Gravel (and sand)	
5	White sand and clay with laterite	
	~~Unconformity~~~~~~	
6	Tuff, silt, sandstone and marl	Tertiary (Miocene)

Humic soil covers most of the area with a thickness of 10 to 40 cm.

White sand is of pure quartz and distributes forming an elongated zone extending from C1 test pit (see Fig. IV-4) to both north and southwards. It has loose texture with coarse quartz grain (1 to 2 mm in maximum size). It is thought that this is recent beach sand.

Brown soil and gravel are generally of river sediments and distribute with a thickness of 1 to 2 m.

White sand and clay with laterite distribute in the layer deeper than 2 m from the ground surface. They contain clay and laterite and are relatively compact.

Tertiary sediments distribute east to west in highland extending from the diversion weir site to Banjarbaru city. According to the result of test drilling carried out around Banjarbaru by the Indonesian Government, sandstone is found at about 15 m deep from the ground surface. It is thought, therefore, that Tertiary sediments distribute nearly as far as Banjarbaru city.

IV.3.4 Structural Geology

Generally, the area around the weir sites, after-bay area and the area along the main canal have a very simple geological structure with no large geological movement due to orogenic activity, volcanic activity, etc. Therefore, there are mostly no remarkable folding and fault in these areas.

The geological map prepared by Geophoto Service Inc. in 1968 shows the existence of three faults with the directions of NW, NS and NE. It is assumed from the geological reconnaissance at this time, however, that there will be two faults : one with NW-direction in Tertiary (Paleogene) sandstone formation and the other with NE-direction in the Riam Kanan river near Sungai Asam village.

As mentioned before, sedimentary formations in these areas have a geological structure with NE-strike and N-dip, and such a geological structure is clearly reflected on the topography of the area. The area composed of Quaternary sediments has generally flat topography, and a remarkable geological structure is not observed.

IV.4 ENGINEERING GEOLOGY AND SOIL MECHANICS

IV.4.1 Foundation of Weir

Weir Site A

Geological investigation of the site-A by test drilling was made by the Indonesian Government in 1972, and the geological report on this site was prepared. The investigation also included the survey by digging test pits, electric sounding and field permeability test by pumping. The geology of this site is summarized below.

	Thickness		Permeability (K)
Alluvium	1-2 m	Total 10 m	Order of 10^{-5} - 10^{-7} cm/sec
Terrace deposits	4-5 m		
Weathered pyroxenite	3-4 m		
Fresh pyroxenite			

Fresh pyroxenite is found at about 10 m deep from the ground surface. This pyroxenite is compact and hard enough for constructing concrete weir with a height of about 6 m. The field permeability tests showed that the leakage was negligible in fresh rock. As a result, this site has favourable geological condition for the foundation of the proposed concrete weir.

Weir Site B

This site is selected, through field reconnaissance based on the 1/5,000 topo-maps, in view of favourable topography for weir construction which forms relatively narrow gorge with two hills on both sides of the river, and outcrop of fresh rock is seen on the bank of the river.

Geological investigation by test drilling was carried out at 5 holes selected along the weir axis, 3 holes on the right bank, 1 hole in the river and 1 hole on the left bank (see Fig. IV-2). Total drilling depth was 84.2 m. In addition, the standard penetration test and field permeability test by packer test were carried out at each drilling hole.

Geology of this site is summarized in the next page, and the geological section of this site is shown in Fig. IV-2. The drilling records of each hole are given in Fig. IV-3.

		Left bank			River	Right bank		
		T	P	S	T	T	P	S
Surface soil		1.7				3-8		3, 27, 26
Sand		2.8	10^{-4}	45		0-2		
Gravel and sand					1.6	1-5	10^{-3}-10^{-4}	
Weathered sand-stone	(soft)	4.5	10^{-3}	32	1.2	4-7	10^{-3}-10^{-4}	18, 70, 92
- do. -	(hard)					0-3		
Fresh sandstone	(soft)	7.0				0-4		16, 28
- do. -	(hard)				1.2+	3+		
Pyroxenite		2.0+				4+		

T : Thickness in m
P : Packer test (K value in cm/sec)
S : Standard penetration test (N value)
4+ : Means more than 4 m

The test drilling shows that pyroxenite intrudes on both sides of the river. The fresh rocks at this site are of hard tuffaceous sandstone. As seen in Fig. IV-2, the depth to fresh hard rock averages 9 m on the left bank, 3 m in the river and 16 m on the right bank. Under these geological conditions, deep excavation which will call for high construction cost would be required for removing thick overburden in the right bank area to construct the weir on the hard fresh rock. In order to minimize the construction cost of the weir, the combined fixed and floating types of weir may be considered. In this case, the floating type of weir would be constructed on the weathered rocks which have rather high permeability of 10^{-3} - 10^{-4} cm/sec. Deep cut-off wall may be required for these weathered rocks to minimize water leakage through these rocks. The rocks other than these weathered rocks are compact and massive enough for the foundation of the proposed concrete weir with a height of about 13 m. There is few difference in geological conditions between the two sites. Only a difference is that the thickness of overburden at the site-B is a little bit shallow as compared with that at the site-A.

Drawing No. 3 is the detailed geological map of the area in which two weir sites A and B are located.

IV.4.2 After-bay Area

Most of the area to be submerged by the creation of after-bay is covered with Alluvium and terrace deposits. It is assumed from field permeability test that the K value of this deposits is around the order of 10^{-3} - 10^{-4} cm/sec. Because the water depth in the after-bay would be 2 to 3 m, big problem in water leakage would not occur. Since the area has a gentle topography in general and remarkable faults are not observed, in addition, landslide in the after-bay area would not be anticipated.

IV.4.3 Main Irrigation Canal

Soil mechanical survey of the foundation and embankment materials for constructing the main irrigation canal was carried out by digging 10 test pits along the proposed canal route. The location of test pits is shown in Fig. IV-4. The geological sections of each test pit and test items made at each pit are shown in Fig. IV-5.

Disturbed soil samples were taken from each strata of 5 pits, No. 3, No. 5, No. 6, No. 7, and No. 8. These disturbed soil samples were tested in the laboratory of Bina Marga Department, South Kalimantan Public Works in Banjarmasin. The test results are shown in Table IV-1.

The standard penetration test was also carried out to measure N-value. As seen in Fig. IV-5, N-value is generally small ranging from N = 2 to N = 7. Carefully study on the foundation for large-scale canal structure such as highway bridge would be required for proper design of these structures.

High ground water tables, about 0.5 m below the ground surface, were observed in the downstream reaches of the canal (from test pit C.2 down to the end of the canal near Gambut). The soils of these parts ar of sandy soils in general. Under these conditions, the study on suitable canal lining for these parts may be required.

Hard rocks are not observed in shallow layers throughout the canal area. Hard rocks (sandstone) are found at about 15 m deep in the hilly areas around Banjarbaru.

IV.5 CONSTRUCTION MATERIALS

IV.5.1 Rock Materials

There is a quarry site located at about 5 km south from the weir site-B, which is being used for producing rock materials for the road construction by the Public Works. The rocks available at this quarry site are peridotite of igneous intrusive rocks. This peridotite could be used as rock rip-rap materials for the construction of diversion weir, after eliminating the serpentinized part of peridotite.

The quarry site is about 200 m in length, 100 m in width and 50 m in height. The quantity of rock materials available from this quarry site is roughly estimated at 500,000 m^3 in gross. The net available quantity, excluding overburden, weathered soils, serpentinized zone, etc., is estimated at 200,000 m^3 to 300,000 m^3. This is quite enough for the requirement of rock materials.

IV.5.2 Gravel and Sand

In the area around the weir sites, Alluvium and terrace deposits distribute along the river Riam Kanan with a width of several hundred meters. They consist of gravel, sand, clay and silt. The average thickness of these deposits is assumed to be 4 m from the previous geological reports and field reconnaissance.

For the material survey, this area is divided into six blocks (A to F) as shown in Fig. IV-6, and soil samples were taken from representative pits in each block which were used for diamond mining by the local people. The grain size analysis of these soil samples was made in the laboratory in Bina Marga, South Kalimantan Public Works in Banjarmasin.

The results of the analysis are given in Table IV-2. Grain size accumulation curves of samples tested are shown in Fig. IV-7. As seen in this table, the gravel content ranges between 49% and 77%, and sand content between 20% and 47%. Based on these data, the preliminary estimates of gravel and sand available from this area is made and shown in Table IV-3. The estimated total quantity of the materials would be as follows :

Gravel	1,770,000 m^3 in net
Sand	800,000 m^3 in net

These would meet the requirements.

IV.5.3 Embankment Materials

For the study on embankment materials available in the area around the site-B, soil samples were taken from six representative sites and were tested in the laboratory of Bina Marga. The test results are shown in Table IV-4 and indicate that the materials available around the site-B could be used for embankment.

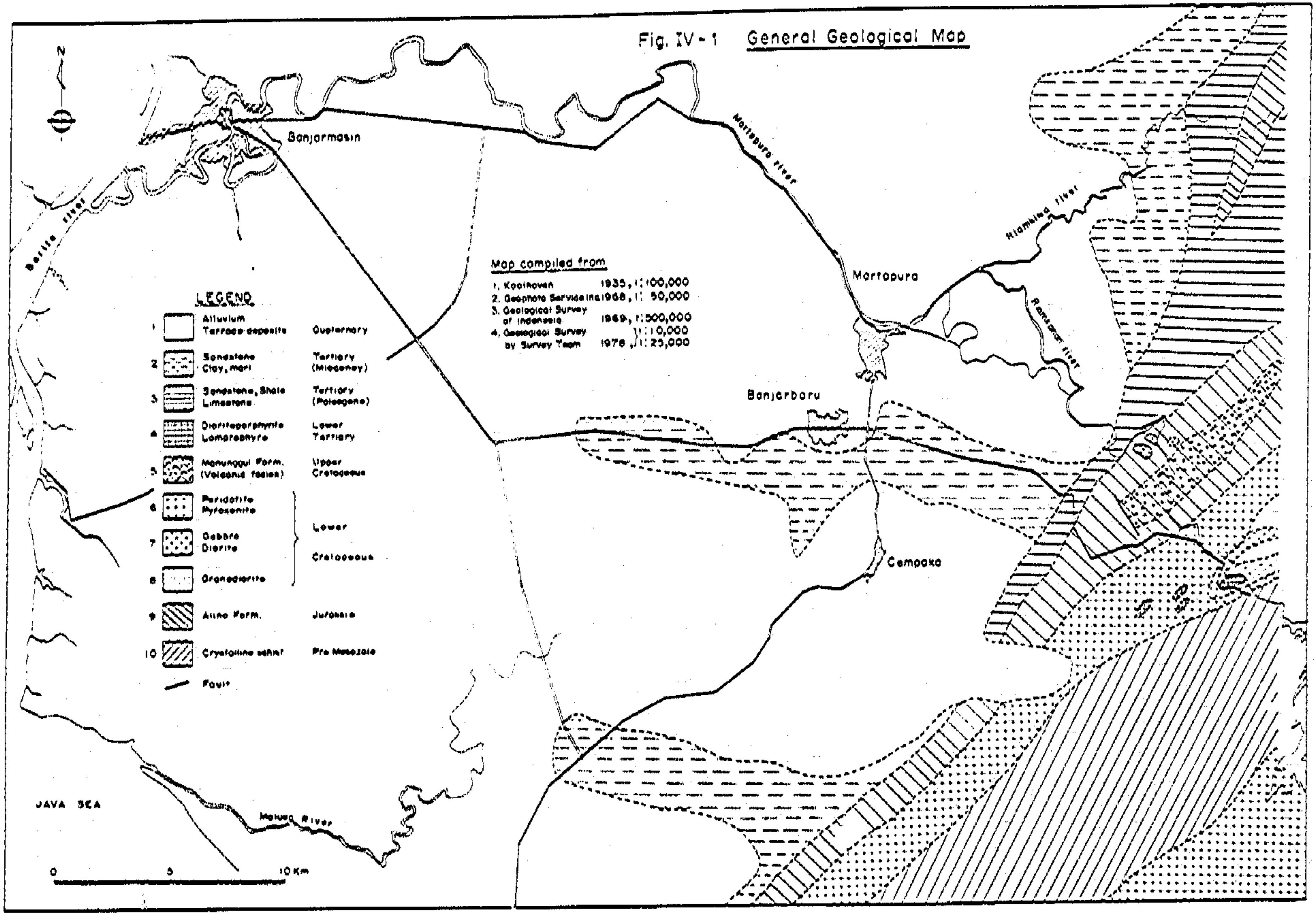


Fig. IV-1 General Geological Map

Fig.IV-2 Geological Section of Weir Site B and Location of Test Holes

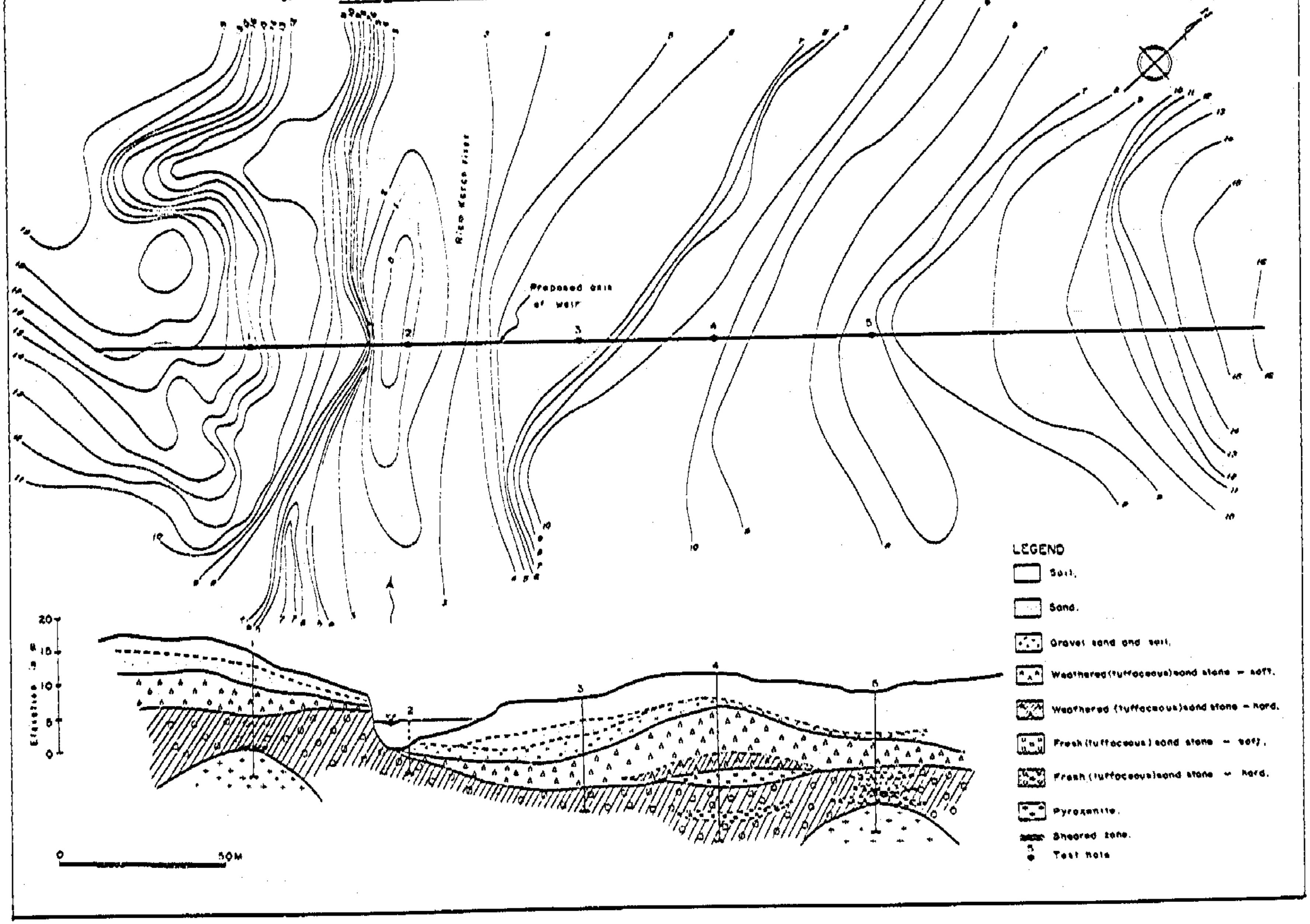


Fig. IV-3-(1) Drilling Records

Hole No. 1	Drilling period : 14/10 – 18/10,1978				Depth: 18.0 m	Location : Left side of river		
m	Depth	Bit	Core Recovery (%)	Geological Section	Geological Description	Packer Test(K)	S.P.T. (N)	Ground water level
0–1			80		Lateritic soil			Dry
1–2	1.70		94		Lateritic soil with gravel			
2–3			100		White sand and clay	Q = 6.2 ℓ/min K = 2.58 x 10^{-4} cm/sec		
3–4			100		- ditto -		45	
4–5	4.50		100		- ditto - Weathered tuff and breccia			
5–6			80		- ditto -			
6–7	6.70		75		- ditto - Weathered sandstone			
7–8			85		Weathered sand stone and Lateritic	Q = 30.5 ℓ/min K = 1.62 x 10^{-3} cm/sec		
8–9	9.00		100		- ditto -		32	
9–10	9.50 10.00		100		Fresh sand stone, hard Weathered sand stone			
10–11			90		Fresh sand stone, hard			-8.00m
11–12			85		- ditto -			
12–13			90		- ditto -			
13–14			85		- ditto -			
14–15	14.40		85		- ditto - Tuffaceous sand stone,			
15–16	16.00		100		Green color, hard			-9.75m
16–17	16.30		85		Sheared zone Pyroxenite, fresh, hard		32	
17–18			80		- ditto -			
18–19					End			
19–20								
20–21								
21–22								
22–23								
23–24								

-·-·-·- Metal bit ——— Diamond bit

Fig. IV-3-(2) Drilling Records

Hole No. 2	Drilling period: 10/10 – 12/10, 1978			Depth: 4.0 m		Location: Centre of river		
m	Depth	Bit	Core Recovery (%)	Geological Section	Geological Description	Packer Test(K)	S.P.T. (N)	Ground water level
			75		Gravel and sand			
1					– ditto –			
	1.60		90					
2					Weathered sand stone			
	2.80		90		Weathered sand stone sometimes hard			
3								
			100		Fresh rock, tuffaceous sand stone, hard			
4					End			
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								

------ Metal bit —— Diamond bit

Fig. IV-3-(3) Drilling Records

Hole No.3	Drilling period: 22/9 – 26/9, 1978	Depth: 16.5 m	Location: Right side of river

m	Depth	Bit	Core Recovery (%)	Geological Section	Geological Description	Packer Test (K)	S.P.T. (N)	Ground water level
0–1		Metal bit	70		Lateritic soil			
1–2		Metal bit	75		-ditto-			
2–3	2.20	Metal bit	75		Lateritic soil and clay		3	Dry
3–4	3.20	Metal bit	80		Fine Sand			
4–5		Metal bit	70		Fine Sand			
5–6	5.50	Metal bit	50					
6–7		Metal bit	70		Gravel and sand	Q = 4.24 l/min; K = 4.9 x 10^{-4} cm/sec		
7–8	7.00 7.40	Metal bit	40		Sandy clay Gravel			1.75m
8–9	9.00	Metal bit	65		Gravel and sand			
9–10		Metal bit	85		Weathered of tuffaceous sand stone, clayish, soft			
10–11		Metal bit	70		- ditto -			
11–12		Metal bit	75		- ditto -		18	
12–13		Metal bit	55		- ditto -			2.00m
13–14	13.60	Metal bit	65		- ditto -			
14–15		Metal bit	60		Fresh rock of tuffaceous sand stone, hard			
15–16	15.50 16.00	Metal bit	50		-ditto- Sand stone, hard			
16–17	16.50	Metal bit	65		Silicified tuffaceous sand stone End			

------ Metal bit —— Diamond bit

Fig. IV-3-(4) Drilling Records

Hole No. 4	Drilling period: 27/9 – 3/10, 1978			Depth: 25.0 m		Location: Right side of river		
m	Depth	Bit	Core Recovery (%)	Geological Section	Geological Description	Packer Test (K)	S.P.T. (N)	Ground water level
0–1			80		Lateritic soil			
1–2			80		– ditto –			
2–3			90		– ditto –			
3–4			90		– ditto –		27	
4–5	4.00 4.80 5.00		75		Gravel and soil Lateritic soil	Q=8 ℓ/min K=1.13x10^{-3} cm/sec		Dry
5–6			50		Weathered tuffaceous sand stone			
6–7			60		Sand with brown color			
7–8			75		Weathered coarse sand stone – ditto –			
8–9	8.30		95		Weathered brecciated s.s.		70	
9–10	9.00		95		Tuffaceous sand stone, brown color			
10–11			35		– ditto –			-6.00m
11–12			50		– ditto –			
12–13			80		Weathered tuffaceous sand stone, sometimes hard	Q=3 ℓ/min K=5.78x10^{-4} cm/sec		
13–14			60		– ditto – – ditto –			
14–15	14.40		92			Q=8.8 ℓ/min K=3.14x10^{-4} cm/sec		
15–16			75		Fresh tuffaceous sand stone green color, not so hard – ditto –			
16–17	16.30		93		Fresh tuffaceous sand stone, rather hard		16	
17–18	17.30		60		Brecciated tuffaceous sand stone, green color, rather hard			-6.25m
18–19	18.50		95					
19–20			90		Brecciated tuffaceous sand stone, brown color, sometimes hard			
20–21	20.00		82		Green tuffaceous sand stone, sometimes hard			
21–22	21.50		75		– ditto –			
22–23			100		Green tuffaceous sand stone, soft		28	
23–24	23.50		85					-6.50m
24–25	24.00 25.00		90		Green and brown, tuffaceous sand stone, hard, rather weathered			

–·–·–·– Metal bit —— Diamond bit

Fig. IV-3-(5) Drilling Records

Hole No. 5	Drilling period: 4/10 – 7/10, 1978				Depth: 20.7 m	Location: Right side of river		
m	Depth	Bit	Core Recovery (%)	Geological Section	Geological Description	Packer Test(K)	S.P.T. (N)	Ground water level
1			80		Lateritic soil			
2	2.00		95		-ditto-			
3			93		Brown soil			
4			80		Brown soil, sometimes sandy			
5	5.00		100		Brown soil		26	-1.85m
6			75		Gray soil, sometimes with organic fragment			
7			92		-ditto-			
8	8.00		95		-ditto-			
9	8.60		95		Soil and gravel, dense			
10			85		Brown lateritic, weathered tuffaceous sand stone			
11			75		-ditto, sometimes fresh-			
12	11.70		90		-ditto-		92	
13	12.60 13.00		90		Fresh tuffaceous sand stone, hard Brown weathered sand stone			-1.60m
14	13.60 14.00 14.20		90		Fresh tuffaceous sand stone, hard Weathered sand stone, brown [illegible]			
15			80		Weathered lateritic sand stone, not so hard, compact			
16			60		-ditto-	Q = 82 ℓ/min K = 1.58 × 10^{-3} cm/sec		
17	17.00		77		- ditto but more hard with lateritic soil -			-1.62 m
18			90		Pyroxenite, hard rock			
19			70		-ditto-			
20			70		-ditto-			
21	20.70		100		-ditto- End			
22								
23								
24								

------- Metal bit ——— Diamond bit

Fig.IV-4 Geological Section along the Main Irrigation Canal and Location of Test Pits

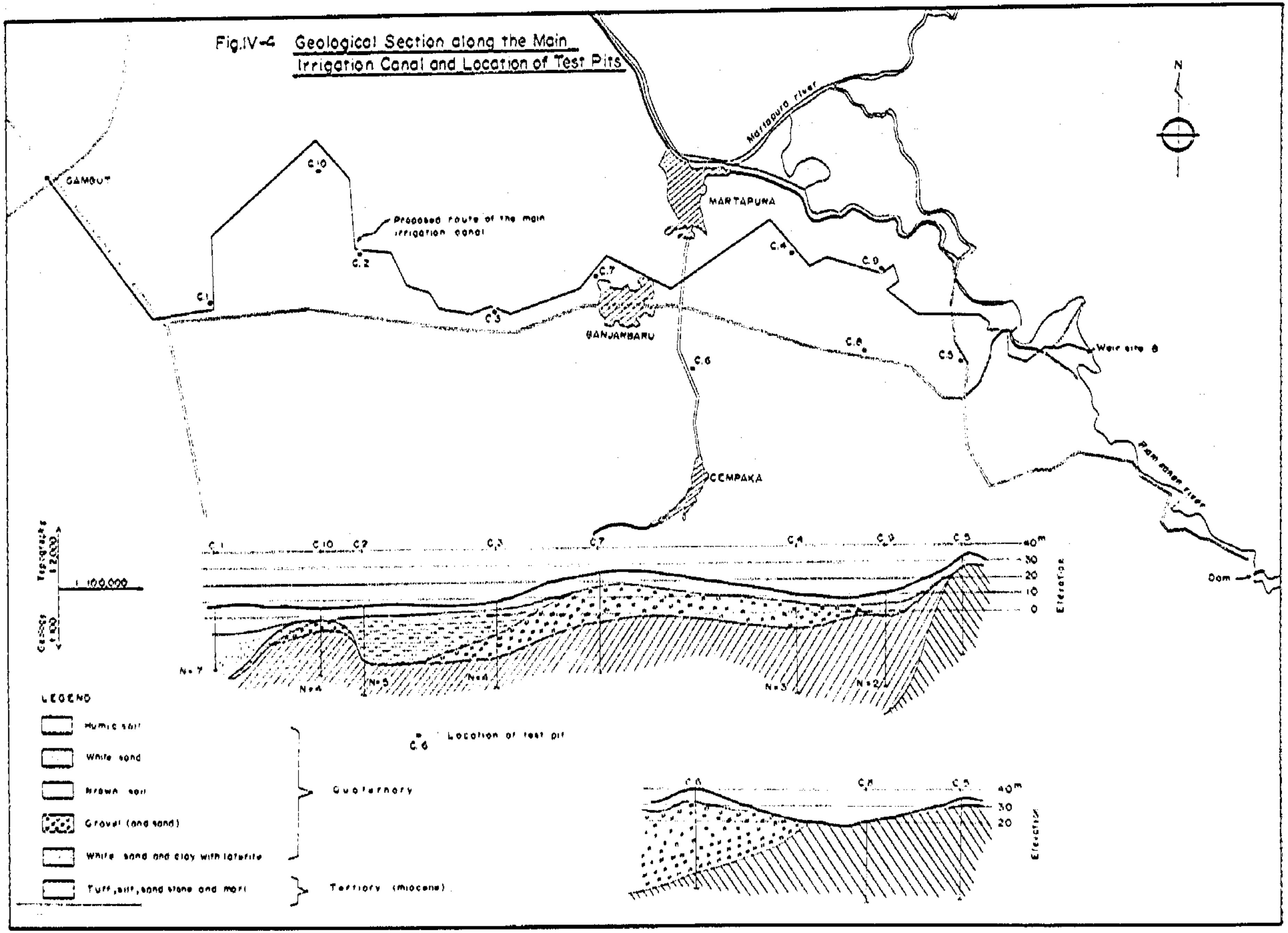


Fig.IV-5 Geological Section of Test Pits

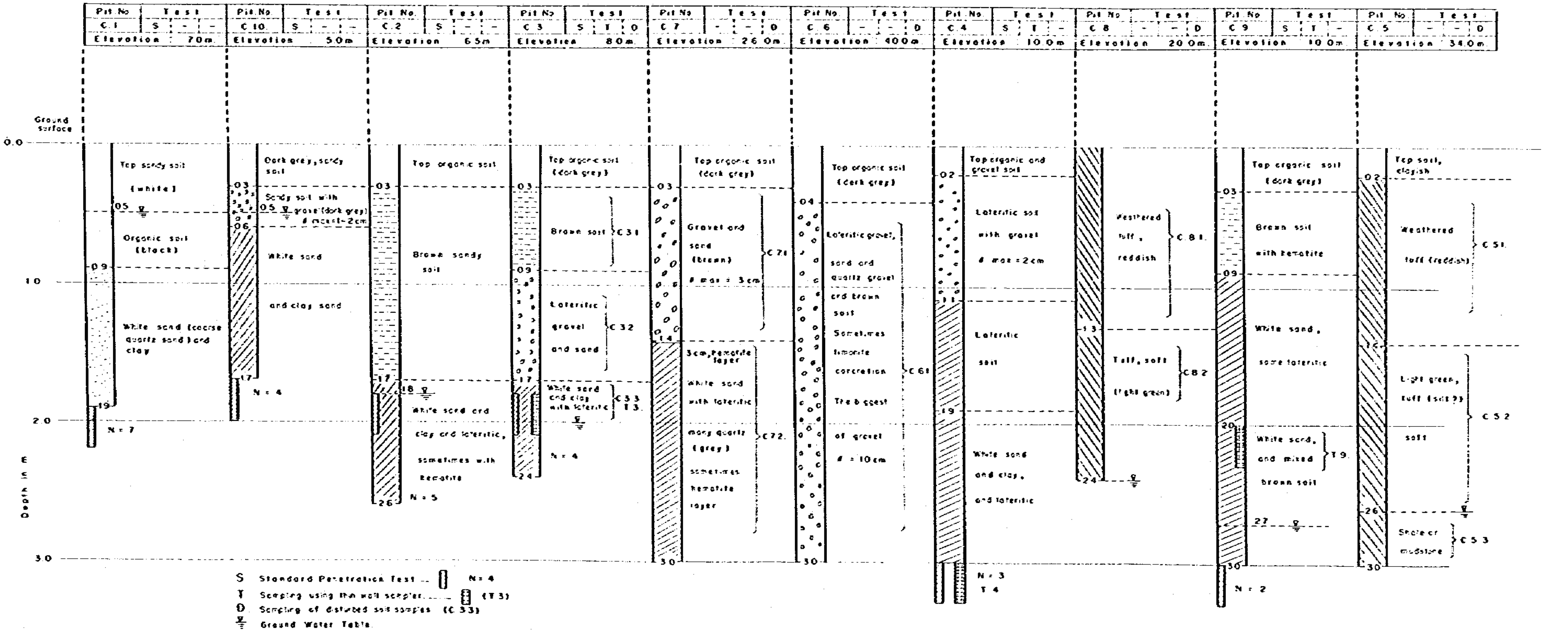


Table IV-1 Results of Soil Tests of Samples taken from Main Irrigation Canal Area

Item	Soil sample									
	C.3.1	C.3.2	C.3.3	C.7.1	C.7.2	C.6.1	C.8.1	C.8.2	C.5.1	C.5.2
1. Specific gravity	2.5	2.5	2.4	2.6	2.6	2.7	3.5	2.7	2.9	2.8
2. Moisture content (%)	9.98	8.77	8.77	12.05	9.70	12.39	10.39	11.77	10.99	11.35
3. Grain size analysis										
2,000 (10 mesh) - T	98.29	97.96	97.99	98.05	98.74	95.82	99.02	98.98	97.62	99.72
420 (40 mesh) - T	94.50	88.40	94.76	89.68	94.70	88.74	96.05	96.14	94.23	98.58
74 (200 mesh) - T	74.42	68.24	78.69	71.52	74.56	70.59	85.21	80.59	76.98	82.27
4. Liquid limit	67.09	65.25	69.12	70.40	71.70	71.00	71.50	67.47	61.65	62.25
5. Plastic limit	25.37	19.25	21.33	31.39	32.49	35.35	30.39	29.32	23.32	19.82
6. Plasticity index	42.02	46.00	47.79	38.01	39.21	35.65	41.11	38.15	38.33	42.43
7. Compaction test										
d max. g/cm3	1.45	1.45	1.36	1.55	1.52	1.53	1.86	1.59	1.61	1.63
Wopt (%)	22	22	21	22	22	24	25	25	23	24
8. Unified soil classification	CH	CH	CH	CH	CH	CH	CH	CH	CH	CH

T : Total throughing in %
d max. : Maximum dry density
Wopt : Optimum water content

Fig. IV-6 Gravel and Sand Materials around Weir Sites

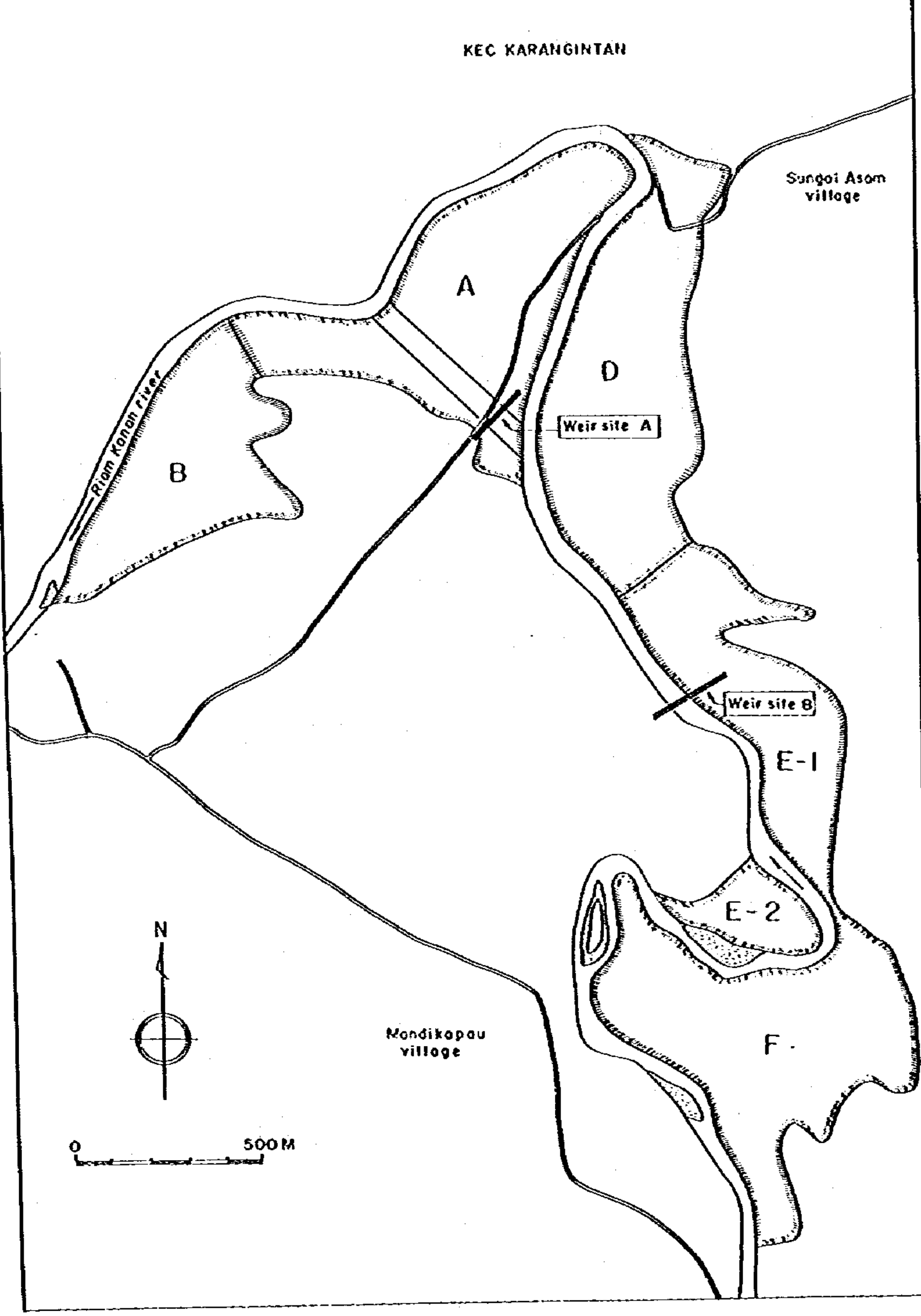


Table IV-2 Grain Size Analysis (Gravel and Sand) /1

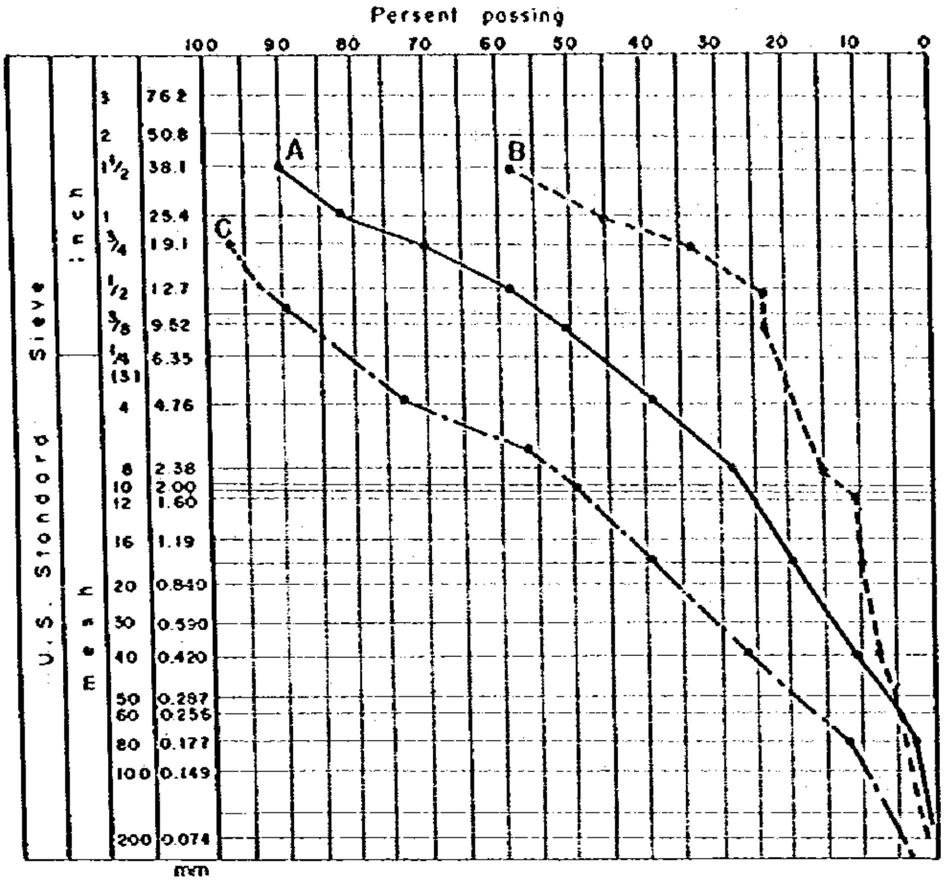
Sample / Sieve size	A T	A C	B T	B C	C T	C C	D T	D C	E T	E C	F T	F C
1 1/2 inch	90	10	54	46			85	15	87	13	84	16
1 inch	82	8	46	8			67	18	70	17	70	14
3/4 inch	70	12	33	13	98	2	54	13	64	6	54	11
1/2 inch	59	11	23	10	95	3	43	11	48	16	45	9
3/8 inch	51	8	23	0	87	8	36	7	42	6	41	4
No. 4 mesh					74	13	25	11	36	6		
No. 8 mesh	28	23	15	8	53	21	16	9	31	5	24	17
No. 10 mesh	26	3	11	4	50	3	14	2	30	1	22	2
No. 40 mesh	12	13	7	4	26	4	9	5	22	8	8	14
No. 50 mesh	6	6	5	2	20	6	6	3	19	3	3	5
No. 80 mesh	4	2	3	2	12	8	3	3	15	4	1	2
No. 200 mesh	1	3	1	2	6	6	1	2	13	2	1	0
Pan	0	1	0	1	0	6	0	1	0	13	0	1
Gravel in %	49		77				64		58		59	
Sand in %	47		20				33		27		40	

T : Total throughing in %

C : Containing in %

/1 : This was made in the laboratory of the Bina Marga Department, Public Works in South Kalimantan Province.

Fig. IV - 7 Grain Size Accumulation Curve



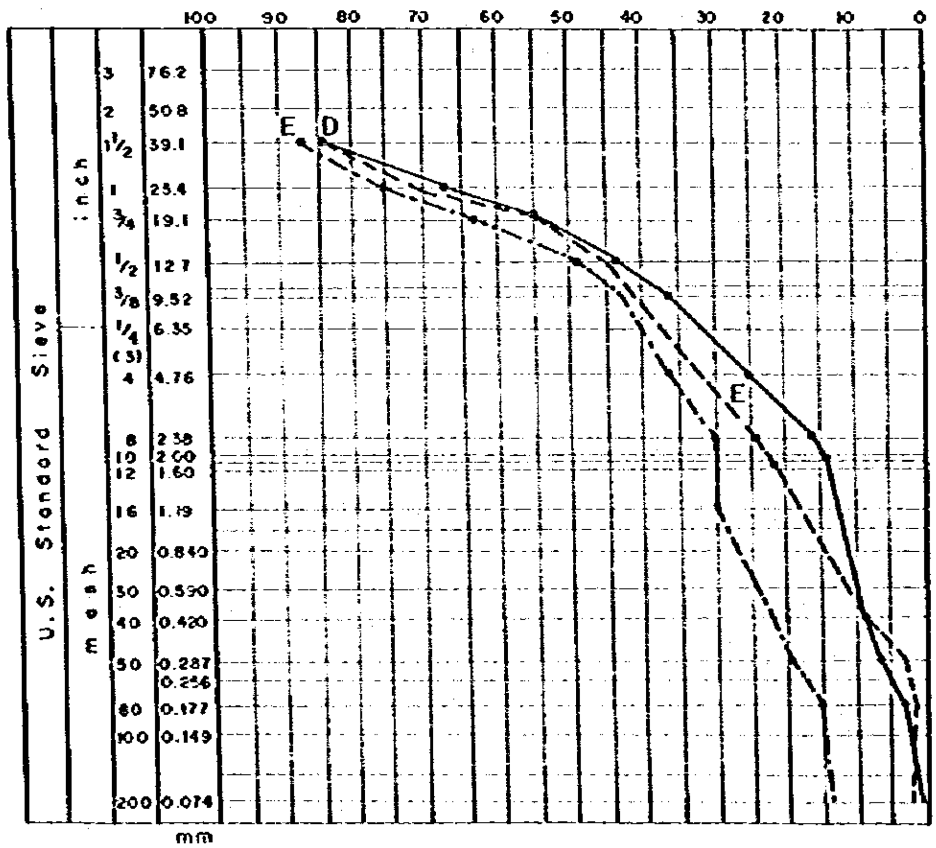


Table IV-3 Available Quantity of Sand and Gravel

Survey area /1	Area (m^2)	Thickness (m)	Total earth volume (m^3)	Minable earth volume (50 %) (m^3)	Content (%)		Volume of materials (m^3)	Recovery gravel 90% sand 70%
A	366,000	4	1,464,000	732,000	gravel	49	358,680	322,810
					sand	47	344,040	240,830
B	226,000	4	904,000	452,000	gravel	77	348,040	313,240
					sand	20	90,400	63,280
D	360,000	4	1,440,000	720,000	gravel	64	460,800	414,720
					sand	33	237,600	166,320
E-1	239,000	4	956,000	478,000	gravel	58	277,240	249,520
					sand	27	129,060	90,340
E-2	62,000	4	248,000	124,000	gravel	58	71,920	64,730
					sand	27	33,480	23,440
F	377,000	4	1,508,000	754,000	gravel	59	444,860	400,370
					sand	40	301,600	211,120

Average content

Gravel: 61.4%

Sand : 33.4%

Total volume

Gravel: 1,765,390

Sand : 795,330

Gravel : over 10 mm (3/8 inch)

Sand : 10 - 0.22 mm (3/8 inch - 80 mesh)

/1 : Refer to Fig. IV-6

Table IV-4 Results of Soil Test of Embankment Materials (Diversion Weir)

Item	Soil sample					
	W1	W2	W3	W4	W5	W6
1. Specific gravity	2.5	2.65	2.6	2.5	1.9	2.6
2. Moisture content (%)	12.76	12.48	10.78	13.36	14.89	13.90
3. Grain size analysis						
2000 (10 mesh) - T	99.94	99.13	99.42	95.81	99.35	94.57
420 (40 mesh) - T	98.96	95.54	97.51	92.63	97.25	91.78
74 (200 mesh) - T	81.40	87.70	90.79	90.12	95.51	91.00
4. Liquid limit	52.50	52.90	52.45	52.00	53.37	52.75
5. Plastic limit	27.22	25.35	23.32	20.38	21.32	21.72
6. Plasticity index	25.28	27.55	29.13	29.62	32.05	31.03
7. Compaction test						
d max. g/cm^3	1.51	1.50	1.63	1.45	1.16	1.38
Wopt (%)	23	26	20	26	31	28
8. Unified soil classification	CH	CH	CH	CH	CH	CH

T : Total throughing in %
d max. : Maximum dry density
Wopt : Optimum water content

ANNEX V

SOILS AND LAND CLASSIFICATION

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ANNEX V SOILS AND LAND CLASSIFICATION

V.1 GENERAL

The primary soil investigation and studies, covering approximately 35,750 ha of the sub-areas D and E, were conducted in 1974 by the Department of Soil Sciences, Faculty of Agriculture, Bogor Agricultural University, in conformity with the U.S. Soil Taxonomy system. Besides, the soil investigation and studies in the sub-areas A, B and F, covering about 50,000 ha in gross, were also carried out by the Pedologic Section in the Bogor Soil Research Institute in 1976, making reference to the FAO/UNESCO system. These previous soil studies are accepted as the basic data and information for the feasibility study on the Riam Kanan Irrigation Project, though unification on the soil classification and mapping is necessary.

For the project studies, therefore, the present soil investigation and studies are primarily concentrated on the confirmation of the soils particularly classified into the potential acid sulphate soils, the tropical peat soils, lateritic and/or podzolic sandy skeletals.

As for the sub-area C which is excluded in the previous soil studies, regular profile survey and sampling specified in the Terms of Reference are carried out so as to complete the soil maps for the whole project area. Besides, in order to make accurate demarcation of the potential irrigable area and to assist particularly proper study on the drainage improvement, approximately 22,000 ha of land lying along the river Barito is also included in this soil and land classification.

Since the groundwater table lies near the ground surface, the soil profile survey and sampling are made mainly by hand-augering with 15 cm in diameter. The profiles are examined to the depth of 2 to 2.5 m and at an average density of one profile per 300 ha. In connection with the profile survey, land productivity or crop yielding condition, seasonal flooding and its standing depth, etc. are also confirmed by the field interview with the farmers.

In the profile examinations, about 160 soil samples are taken from the major horizons or layers in various soil associations and tested on their acidity as well as degree of potential acidity and salinity as the basic characteristics of the soils. Subsequently, detailed chemical analysis of soils, including the test items of water soluble salts, exchangeable bases, organic carbon, total nitrogen, phosphate, etc., are made in the laboratory of the Lambung Mangkurat University in Banjarbaru.

The unification of the soil maps previously made by two soil Authorities in Bogor and completion of soil classification and mapping are herein made in accordance with the soil Taxonomy system defined by the Soil Conservation Services, the U.S. Department of Agriculture (1973). The land classification for the specific purpose of establishing the extent and degree of suitability of land for sustaining irrigation farming is made in conformity with the land classification system defined by the Bureau of Reclamation, U.S. Department of Interior in 1953 and modified in 1967 for evaluating lowlying lands.

V.2 GENERAL CONDITIONS OF LAND AND SOILS

The Riam Kanan Irrigation Project area was demarcated approximately 60,000 ha in gross in the Preliminary Survey Report, 1977. For the comprehensive planning of proper irrigation and drainage system integrally, the soil survey is carried out on the area of about 92,800 ha including some additional area to the preliminary survey area.

The investigated area is mostly the coastal land extending over the left bank on the lowest reaches of the river Barito. The area is bounded by the river Martapura on the north, the river Maluka on the south, the river Barito on the west and the national road Martapura - Pleihari through Cempaka on the east.

From the geomorphological viewpoint, the land in the survey area is broadly divided into the following four topographies:

(1) Alluvial plain, which occupies about two-thirds of the survey area, has very flat topography including natural levee, slight depression and tidal marshes. The land lies an elevation ranging between - 0.5 m and 1.0 m above mean sea level. The land consists of fine textured sediments deeply deposited by the rivers Barito, Martapura, Maluka, etc. in the recent and the quaternary land formation stages. Almost all of the lands have been developed as the paddy field and have been cultivated with local varieties of paddy rice long since. Seasonal flooding stands rather deeply for more than 120 consecutive days during the months from early December to late March in the slightly depressed land, and for 160 consecutive days from early December to early May in the tidal marshes.

(2) Deep depression, which might be primarily the alluvial depression (backswamp) in the quaternary land formation. The area, corresponding to about 10 % of the total survey area, extends mainly in the sub-area B. The land is deeply covered by the tropical peat being fed with the swampy forest. Deep water stands throughout the year.

(3) Old sand dune and terrace formation, having nearly flat to very gentle topography, extend narrowly along the boundaries of the sub-areas B and C, and the sub-areas D and E, and also on the foot of hills. The land consists of medium to fine particle of quartz sand with small gravels and roughly covered with bushes and gelam shrub.

(4) Undulating or rolling hills, which might be the tertiary land formation. The land, which lies at an elevation higher than 10 m above mean sea level, extends over the eastern-most of the survey area. The land consists of loamy to sandy skeletal soils. Agricultural setting in this area is being gradually exploited by the local people, but most is still wasted from the agricultural production because of relatively steep topography and unfavourable soil conditions.

The soils in the survey area are primarily derived from the clayey to fine loamy alluvium in the recent to quaternary ages and loamy to sandy skeletals in the quaternary to tertiary ages. The clayey to fine loamy alluvium, which generally consist of 35 to 70 % of clay, 30 to 60 % of silt fractions and very rare sandy particles, are deeply deposited in the most part of the alluvial plain (1) developed widely along the rivers Barito, Martapura and Maluka. Under the seasonal water stagnation, these alluvium have been put under the soil formation process of the hydromorphic weathering (gleyzation and mottlings) caused by the waterlogging and the seasonal fluctuation of groundwater to a certain extent. Generally, these alluvium deeply overlay the marine sediments (so-called mud-clay) with the depth at about 1.5 m of the soil profile. With the exception of land where it is depressed and formes tidal marshes, those mud-clay (called potential acid sulphate soils) underlie within 50 cm below the land surface.

Quartz sands derived from the beach deposits rather deeply lie the old sand dune and terrace extending on the foot of hills (3) and loamy to sandy skeletals originated from the quaternary deposits or directly from the tertiary formation (sandstones) are found in the undulating or rolling hills (4) on the east of the survey area. These soil materials have been mostly put under the soil formation process with the oxidization weathering under the tropical humid climate.

Other than the above soil formations, the organic soils (so-called tropical peat) are also developed in the lowlying area (2) where the land is deeply depressed mainly on the foot of undulating hill. Generally, these organic soils are 1 to 2 m deep on profile, and thereafter, mud-clay underlies deeply.

The lithological features of major soils and their relation to the schematic topography stated in the above are summarized in Fig. V-1.

To speak in general, almost all of the soils in the survey area are leached out their inherent bases through hydromorphic and oxidation weathering under the tropical humid climate, and then, strong to very strong acidity of soils with pH values ranging between 4.0 and 5.0 is verified throughout the profiles. This chemical deficiency of bases in the soils, however, could be improved by proper farm management and fertilization practices in the future. Salt accumulation in the soils is not observed in the whole survey area, though the sea water intrudes into the paddy field in a certain period according to the information from local inhabitants. It is considered that rain water would wash out the salts in the rainy season, year and year, even though the soils are affected by salinity to some extent nearly in the dry season.

V.3 SOIL CLASSIFICATION

V.3.1 Basic Consideration of Soil Classification

The soil classification is made in conformity with the Soil Taxonomy system compiled by the Soil Conservation Services, The U.S. Department of Agriculture, 1973.

In reference to the Soil Taxonomy the following terms of soil features are taken into consideration for the soil classification and mapping in the survey area.

(1) Parent material or lithological materials:

- recent to quaternary alluvial deposits, having 35 to 70 % of clay, 30 to 60 % of silty fractions and very rare sandy particles.
- organic materials, having three different types according to degree of decomposition of organic matters, i.e, Fibric, Hemic and Sapric, and these organic materials have no mineral stratification.
- quartz sands, which are medium to fine particles and have very rare weatherable mineral compounds.
- diluvium and/or sandstones of tertiary formation, having coarse textural qualities characterized into loamy to sandy skeletals.

(2) Lithological sequence in the specific depth (150 cm) of the profile:

- organic layer underlies in shallow profile
- marine sediments layer or so-called mud-clay (potential acid sulphate soils) underlies in shallow profile
- organic material deeply deposited under submerged conditions

- quartz sands or colluvium rather shallowly overlie the diluvial layer or the tertiary formation of sandstones.

(3) Basic soil formation:

- hydromorphic weathering such as leaching process of inherent bases, and gleization and mottling caused by waterlogging and/or seasonal groundwater fluctuation.
- oxidation weathering such as laterization and podzolization under the tropical humid climate.

(4) Diagnostic profile features and soil chemical and physical properties:

- surface horizon in which soils have different soil colour (mainly defined as the ochric and umbic epipedons), humus contents (somewhat defined as the histic epipedon) and gravelly or stony regime (skeletal in factor).
- sub-surface horizon or layer lying within 150 cm below the ground surface in which the soils have shallow groundwater table, or gleyic horizon affected by groundwater or surface water stagnation, or spodic horizon developed through leaching process, or histic horizon being buried shallowly under the recent alluvium, or the soils characterized into the potential acid soils (sulfic horizon or layer and/or dysic regime) in shallow profile.

In order to make the unification of the previous soil classification made by the two Soil Authorities in Bogor, the terms of the above soil features are carefully studied by cross-checking survey on both field and laboratory tests, also making reference to the previous field data and the results of soil test.

V.3.2 Soil Classification

Upon the bases of the diagnostic soil characteristics and the profile features, the soils in the survey area are primarily classified into Entisols, Inceptisols, Ultisols and Histosols in order in the highest soil category of soil classification. Of them, Entisols develop on the quarternary alluvium, Inseptisols and ultisols develop on the diluvium and the tertiary formation, and Histosols on the deep alluvial depressions.

The soils of Entisols are classified into four sub-orders; Psamments, Orthents, Aquents and Fluvents. These four soils are, furthermore, classified into five great groups; Quartzipsamments, Troporthents, Fluvaquents, Hydraquents and Tropofluvents, and then, sub-classified into seven sub-groups;

Aquic Quartzipsamments, Haplaquodic Quartzipsamments, Typic Troporthents, Typic Fluvaquents, Thapto-Histic Fluvaquents, Sulfic Hydraquents and Typic Tropofluvents in the higher categories of the soil classification. Each soil in the sub-groups is also divided into one to two soil families in the lower category of the soil classification, as shown in Tables V-1 and V-2.

Inceptisols in the survey area classified into two sub-orders; Tropepts and Aquepts. Tropepts consist of such a great group as Dystropepts which is composed of one sub-group or Typic Dystropepts and then one family of Loamy Skeletal, Acid Typic Dystropepts.

The sub-order Aquepts are composed of two great groups, such as Tropaquepts and Haplaquepts, and then Tropaquepts are divided into three sub-groups, such as Aeric Tropaquepts, Typic Tropaquepts and Histic Tropaquepts, while Haplaquepts are divided into two sub-groups such as Aeric Haplaquepts and Typic Haplaquepts. Each of these sub-groups except Histic Tropaquepts is consisting of one family as shown in Table V-2. Histic Haplaquepts are divided into two families, such as Loamy, Acid, Histic Tropaquepts and Sandy, Dysic, Histic Tropaquepts.

Ultisols consist of one sub-order, i.e. Ustalts, one great group, i.e. Haplustults, one sub-group, i.e. Typic Haplustults, and one family, i.e. Sandy skeletal, Acid, Typic Haplustults.

The soils in the order of Histosols are divided into three sub-orders, such as Fibrists, Hemists and Saprists according to the degree of decomposition of their organic components. Each of these soil groups in these sub-orders consists of one great group, one sub-group and one family under the various categories of soil classification, respectively. Namely, the sub-order of Fibrists consists of the great group of Tropofibrists, the sub-group of Terric Tropofibrists, the family of Dysic, Terric Tropofibrists. The sub-order of Hemists consists of the great group of Tropohemists, the sub-group of Terric Tropohemists and the family of Dysic, Terric Tropohemists. While, the sub-order of Saprists consists of the great group of Troposaprists, the sub-group of Terric Troposaprists and the family of Dysic, Terric Troposaprists.

The lower categories of soil classification system, such as the series, type and phase were not yet defined in detail in the U.S. Soil Taxonomy. On these matters, there are such simple explanations as "the series should be nominated by the use of abstruct place names which could be taken from a place near the location where the series could have been first recognized, and the types and phases should be differentiated according to the pragmatic features for practical utilization of soil groups".

Under the present circumstances of soil survey works in Indonesia, there is no results to be applied for the denomination of the series and other soil groups in the lower categories. Such being the case, the family is taken up as the unit of soil grouping and mapping for conveniences' sake of this feasibility study. A sense of the soil classification by the lower categories, such as textural qualities, effective soil depth, degree of acidity and drainability, etc., and land form and topographic conditions is as much as possible put into the criteria for the land classification which will be described latter. It may be needless to say that the differentiation of the soil series, types and phases should be done at the detailed design stage of the project study works, if necessary.

The correlation with the soil classes defined herein and with those classified by the previous studies are summarized in Table V-3. The typical soil profile features and chemical properties in each soil group and association, further environmental conditions such as topography, vegetation and/or land use, flooding, etc. are tabulated in Table V-4. The development of the soils classified hereinabove is illustrated on the semi-detailed soil map attached to this report.

V.4 PRINCIPAL NATURE AND PROPERTIES OF SOIL

As stated in the preceding section V.3, it is clarified that the soils in the survey area can be primarily classified into four orders, 10 sub-orders, 12 great groups, 17 sub-groups and 18 families. In due consideration of the soil usabilities for agricultural production, the principal natures and properties of each soil group are explained in detail as follows:

V.4.1 Entisols

The soils of Entisols in order develop mainly on the low-lying alluvial plain and terrace at the foot of hills. The land of this soil extends over about 30,890 ha, corresponding to about 30 % of the total survey area.

Out of the total area of Entisols, about 10,240 ha in gross are now being used for paddy rice cultivation under rainfed condition. The remaining area of 20,650 ha still lie in waste and mostly covered by gelam shrub, mangroves, and swampy grasses, etc.

Acid, Aquic Quartzipsamments

Soil unit (1): Entisols in order, Psamments in sub-order, Quartzipsamments in great group, Aquic Quartzipsamments in sub-group.

The soils of Aquic Quartzipsamments are primarily the sandy soils derived from pure quartz sand in the quaternary period. The soils of this soil group develop on the old sand dune which narrowly stretches and across the central part of the survey area in the north-south direction. Almost all the land is covered with sparse bushes and grasses. In small area, some fruit trees and pine-apples, etc. are recently planted, but most of them lie in waste without harvesting due to very poor productivity at present.

The soils of Aquic Quartzipsamments are identified with Regosols in the U.S.D.A. classification modified in 1949, and also identified with Oxic Regosols in the previous soil study made by the Soil Research Institute, Bogor, 1976.

The main factor to identify the soils to Aquic Quartzipsamments is that they have groundwater within 1 m of the profile throughout the year and no diagnostic profile features except very few yellowish mottlings.

Generally, the soils of Aquic Quartzipsamments have A1/ C1/ C12g in horizon sequence. A1 horizon having grayish brown (10YR 5/2) in the matrix colour is thin at less than 10 cm and sometimes absent on the profile because of out-washing by heavy rain due to poor vegetation. C1 horizon to a depth of 50 cm or around is light gray (10YR 7/1) and rather compacted. C12g or C2g horizon is generally under the groundwater. Very rare yellowish mottlings are found in these horizons. The basic colour of the matrix is white to pinkish white ranging between 10YR 8/1 and 7.5YR 8/2. Medium to fine sandy particles are distributed throughout the profile. They are loose and structureless in common.

Regarding the chemical properties, the soils are strong acid ranging between 4.5 and 5.5 in pH value (H_2O 1:1) throughout the profile. EC values are mostly less than 0.1 m.mho/cm/25°C, indicating that they have no salinity problems. Total organic carbon in A1 horizon is estimated at 1 to 2 %, while 0.3 % or less in sub-soils. Cation exchange capacity (C.E.C.) is about 2 to 7 m.eq. Base saturation degree is less than 10 % of the total C.E.C. The plant nutrients such as nitrogen, phosphate, potassium, etc. are quite deficient in most soils.

As for their hydrodynamic features, the soils have a very small water holding capacity, very high percolation rate and intake rate.

In the light of their profile features, chemical and physical properties, the soils of Aquic Quartzipsamments are scarcely suitable for the agricultural utilization.

Sandy skeletal, Acid, Haplaquodic Quartzipsamments

Soil unit (2) : Entisols in order, Psamments in sub-order Quartzipsamments in great group, Haplaquodic Quartzipsamments in sub-group.

The soils of Haplaquodic Quartzipsamments are mainly found in the low-lying terrace area developed at the foot of the hills. The land is mostly undisturved up to the present and covered with the wild vegetation of gelam shrub, bushes, alang-alang grasses, etc.

These soils consist of quartz sand which might be deposited in the quaternary period. Groundwater rises within 1 m of the surface profile and saturates the surface soil for 6 cumulative months or more in most years. These soils can be, distinguished from the Aquic Quartzipsamments by their profile features having an albic (eluvial) and spodic (illuvial) horizons (within their shallow depth.

The soils of Haplaquodic Quartzipsamments are identified to Regosols in the U.S.D.A. classification system in 1949, and classified into Humic Spodosols by the previous study on soils in this area.

The diagnostic horizon sequence of these soils is A1/ A2/ B1/ B2/ C1/ IIC2 in which A2 (albic) and B1 (spodic) horizons are the main factors for the identification of these soils. A1 horizon is a sandy epipedon having dark brown (7.5YR 3/2) to very dark gray (5YR 3/1) in matrix colour, indicating rather rich in humus. Generally, the thickness of epipedon is very thin at 5 to 10 cm. The albic A2 horizon consists of rather coarse particle of quartz sand and is about 5 to 10 cm in thickness. The soils in this horizon are strongly affected by eluvial soil formation through hydromorphic weathering. Matrix of the soils shows white (10YR to 7.5YR 8/1 - 8/2) as the native colour of quartz. B2 horizon is a spodic sandy soils which have an accumulation of amorphous materials including organic carbon. The spodic soils are generally dark brown to brown (7.5YR 4/2 - 10YR 5/3). Upper boundary of this horizon is abrupt and smooth, while the bottom is diffuse and irregular. The thickness of this horizon is about 10 to 15 cm in general. C1 horizon to a depth of about 50 to 100 cm consists of medium size of quartz sands. These sands are generally white in colour, loose and very friable in consistence. Sandy clayey to loamy clayey soils underlie deeply as the C2 horizon. The soils are compacted, while rather friable when wet.

As for their chemical features, the soils are extremely to very strong acid ranging from 4.0 to 5.0 in pH value (H_2O 1:1) throughout the profile. Total organic carbon is estimated at less than 3 % in the surface soil, about 0.1 % in the sub-soils. Cation exchange capacity (C.E.C) is less than 5 m.eq. in the surface, while 5 to 10 m.eq. in the soil of B2 horizon. Base saturation degree is very low in common, and the essential plant nutrients are also quite deficient. Physical natures are unfavourable for the profitable farming.

Sandy Skeletal, Acid, Typic Troporthents

Soil unit (3): Entisols in order, Orthents in sub-order, Troporthents in great group, Typic Troporthents in sub-group.

The soils of Typic Troporthents are Orthents which are primarily the colluvial soils derived from eroded face of land. These soils will be correlated with Lithosols and Regosols in the classification system by the U.S. Department of Agriculture in 1949. In the previous soil study in this area, these soils were classified into Oxic Regosols.

The soils of this family develop on the bottom land of the undulating or rolling hills which extend over the eastern part of the survey area. Recently, some extent of this land has been reclaimed by the spontaneous migrants and grown with clove, fruits (jack fruit is predominant) and leguminious crops, cassava, etc. Almost all of the land is, however, still lie in waste and densely covered with alang-alang grasses and bushes.

Generally, the soils have no diagnostic characteristics except their sandy skeletal to coarse loamy textural features and their relatively shallow profiles underlaid with diluvial or tertiary formation (sandstones) in general. The horizon sequence is A1/ C1/ C2 in common. A1 horizon is a epipedon having ochric in matrix colour regime ranging between dark brown (7.5YR 3/2) and brown (7.5YR 4/2). This epipedon is usually 10 to 15 cm in thickness. The soils in this horizon are coarse loamy to sandy texture and have small gravels of more than 35 %. Some sub-angular blocky structures are weakly developed, while rather firmly consolidated. The soils in C1 horizon are primarily derived from the colluvial deposits having sandy to coarse loamy skeletal texture. The soils are relatively compact, but friable when wet. They are white in colour and sandy textured diluvium or tertiary sandstones are directly underlying as C2 horizon or bedrock (B). They have a weak and/or slight paralithic contact regime.

Generally speaking, these soils have a rather small moisture holding capacity, very high percolation rate ranging between 1.5×10^{-3} and 5.4×10^{-3} cm/sec. Regarding their chemical features, the soils are strong acid ranging from 4.5 to 5.0 in pH value (H_2O 1:1) throughout the profile. Total organic carbon is 1 % or so in the surface soil, while abruptly decrease to 0.2 % in the sub-soils. C.E.C. ranges from 2 to 4 m.eq., and degree of base saturation is about 15 % on an average. The content of inherent plant nutrient is quite deficient.

In the light of their soil profile features and chemical and physical properties, the land of this soil can be used for agricultural development. In order to realize the profitable farming, however, rather high capital investment and recurrent cost are required for the land reclamation and crop production. Field plot will be limited to a small size due to irregular configulation of lands.

Fine, Acid, Typic Fluvaquents

Soil unit (4): Entisols in order, Aquents in sub-order, Fluvaquents in great group, Typic Fluvaquents in sub-group.

The soils of Typic Fluvaquents are primarily Aquents or typical wet Entisols. These are exclusively very young fluvial deposits. The soils generally have fine stratifications at a shallow depth and/or have very few evidence of alteration to cambic horizon. Mottling in them extends downward from the point very close to the surface. The groundwater table is close to the surface on profile.

The soils of this group are mainly found on the river levee extending narrowly along the river Barito. The soils are used for village accommodation, coconut plantation and paddy rice production in a small extent.

These soils are correlated with Alluvial soils and/or Low-Humic Gley soils in the U.S.D.A. classification system modified in 1949. No reference is available on these soils in the previous soil study in the survey area.

The typical profile of these soils is A11/ A12/ C_{1g}/C_{2g}. A11 horizon is an ochric epipedon having 10 cm in thickness; dark brown to brown in colour and silty clay to clay in texture; massive structure; hard consistence when dry and friable consistance when wet; few yellowish brown mottles; abrupt and smooth boundary with underlying horizon. A12 horizon is mottled soils having a depth of 30 cm or so; dark gray (N1/) to dark grayish brown (10YR 4/2) in colour; fine clayey texture; massive structure; friable when wet but hard consistence when dry; fine and strong brown stains around old roots; very clear and smooth boundary with the next soils. C_{1g} horizon with depth of about 65 cm is the gley soils having the features such as gray (5Y 5/1) in colour; silty clay to clay in texture; massive structure; strong brown (7,5YR 5/6) stains around old roots; intercarating very thin silt strata; clear and smooth boundary. C2g horizon to a depth of about 150 cm or little more is gley soils which are gray (N5/) in colour; silty clay to silty loam in texture; massive structure; no mottlings.

Regarding their chemical properties, the soils are very strong acid with pH values ranging from 4.5 to 5.0 (H_2O 1:1) under the field conditions and 4.0 to 4.5 in the air-dried conditions. EC values are less than 1 m.mho/cm/25°C throughout the profile, indicating that the soils are free from salinity problem, at present. Total organic carbon is about 2 to 3 % in surface soil, while 0.1 to 0.3 % in sub-soils. C.E.C. value ranges between 30 to 45 m.eq. which are saturated by bases at 35 to 40 % in which calcium and magnecium are dominant bases. The contents of available plant nutrients such as nitrogen, phosphate, potassium, etc. are quite deficient.

As for their hydrodynamic characteristics, the soils have very high water holding capacity, while very low permeability coefficient ranged at about 1.6×10^{-4} to 3.5×10^{-5} cm/sec.

In the light of their profile features and chemical and physical properties, the soils in this group are suitable for paddy cultivation. As for the cultivation of diversified crops, neverthless, it is required to improve the soil conditions particularly the soil acidity and moisture level by means of liming practice and provision of controlable drainage system. The lime requirement is estimated at 10 tons/ha of limestone powders for softening the acidity to favourable condition at about 6.5 in pH.

Fine, Dysic, Thapto-Histic Fluvaquents

Soil unit (5): Entisols in order, Aquents in sub-order, Fluvaquents in great group, Thapto-Histic Fluvaquents in subgroup.

The soils of Thapto-Histic Fluvaquents are wet Entisols similar to Typic Fluvaquents mentioned in the above. These soils are, however, distinguished from the above soils according to their following diagnostic profile features. They have a buried histic horizon (peat soils) whose upper boundary is within 1 m below the soil surface. It is considered that these soils are formed as a result of deposition of recent alluvium on histosols adjacent to Typic Fluvaquents on the river levee along the Barito. They are not extensive in the survey area.

The soils of Thapto-Histic Fluvaquents can be correlated with Alluvial soils and/or Humic Gley soils in the U.S.D.A. classification system modified in 1949. These soils are not included in the previous study on soils made by the Soil Authority in Bogor in 1974 and 1976.

The land of these soils are more or less submarged with the stagnant flood water in most of the year. Using the flood water, the most lands are at present, used for the rainy season culture of paddy rice (local varieties). The unit yield of paddy rice is normally 1.75 tons of dry unhusked paddy/ha.

Generally, the soils in this group have a horizon sequence of A11/ A12/ Ob and samewhat A11/ A12/ Ob/ IICg with abrupt but wavy or irregular boundaries. The surface soils (A11) are brownish black to gray (10YR 3/2 to 5Y 4/2) in colour; fine clay in texture; massive structure; friable and very soft consistence when wet, while hard and firm consistence when dry. They change to A12 horizon in which the soils are light clay to silty in texture; very few stains around the old roots; friable and soft consistence when wet. The colour of soil matrix when wet is mostly similar to or slightly lighter than that of A11 horizon, in common. Ob horizon which specified as the histic horizon lies at the depth of 50 to 75 cm below the surface and its thickness is more than 100 cm. The soils are brownish gray (10YR 5/1) to dark grayish brown (2.5 YR 4/2) in colour; fibric (not so well decomposed); and very loose in compactness. Following Ob horizon, Cg horizon underlies deeply. The soils of Cg horizon are considered to be derived from marine sediments and are so-called mud-clay or potential acid sulphate soils incommon. They are silty clay to fine sand in texture and have many buried celles.

The soils of this family are very strong acid in the present field condition ranged from 4.5 to 5.0 in pH (H_2O 1:1) throughout the profile, even the soils of Cg horizon. When air-dried the soils change their acid reaction to extremely strong conditions which are indicated by pH value from 3.5 to 4.5. No salinity regime is observed for these soils except the soils of Cg horizon which have a strong salinity attained to more than 10 m.mhos/cm/25°C. Organic carbon is about 2 to 3 % in surface soil and 50 to 65 % in histic horizon. C.E.C. values range from 25 to 45 m.eq. and the capacity is saturated at 30 to 45 % by bases in which calcium and magnesium are predominant. The plant nutrients are quite poor in all the soils. They have rather high water holding capacity, and low in permeability coefficient.

According to their specific soil natures and properties as stated above, the soils of this group would be arable for paddy rice cultivation, although proper improvement of drainage is required so as to expect the further production increase. Regarding the suitability of land for diversified crops, the grade is estimated at rather low from economical and technical point of view. There may be some difficulties to provide proper drainage facilities to maintain soil moisture at proper level. As for the neutrization of the soil acidity, it is estimated that the lime will be required at 12 to 15 tons/ha for modifying the present soil acidity to favourable range of soil reaction at 6.0 to 6.5 in pH values.

Loamy, Dysic, Sulfic Hydraquents

Soil unit (6): Entisols in order, Aquents in sub-order, Hydraquents in great group, Sulfic Hydraquents in sub-group.

The soils of Sulfic Hydraquents are one of wet Entisols. The soils are correlated with Low-Humic Gley soils in the U.S.D.A. classification system defined in 1938. The soils have been commonly called as the Potential Acid Sulphate soils due to their specific chemical properties long since. In the previous soil study in this area, the soils were correlated with Thionic Alluvial soils referred to the FAO/UNESCO standard.

The soils of the Sulfic Hydraquents are mud-soils derived from watery deposits in the tidal marshes.

At present, out of 12,700 ha, approximately 6.500 ha or 50 % has been cultivated for rainy season culture of paddy rice. Remaining area which mainly extends over the sub-area E is still densely covered with wild vegetation such as mangroves, gelam forest and swampy grasses, etc..

Because of deep water stagnancy throughout the year, the soils are put under strong reduction and gleization. Their horizon sequence is A11g/ A12g/ Cg with gradual and/or diffuse boundaries. A11g horizon is less than 15 cm in thickness. The soils in this horizon are liberate from the water stagnation in very short time at the neap tide in the dry season. They are fine clay to silty clay; very soft and friable when wet; dark gray (5Y 4/2) to grayish olive (7.5Y 5/2) in matrix colour. A12g horizon to a depth of about 35 to 50 cm of soil surface is also the alluvium of gray (2.5Y 5/1 to 5Y 5/1) in colour; clay to silty clay in texture; plastic and sticky consistence when wet. No mottling is found in this horizon. Cg horizon is typical mud-clay. The soils are silty clay to fine loam in texture; grayish yellow (2.5Y 4/2) to grayish olive (7.5Y 5/3); massive structure with very low bearing capacity of less than 0.7 Kg/cm^2 in N-value.

The soils are very strong acid (4.5 to 5.0 in pH values at 1:1 soil-water suspension) throughout the profile in the field condition. When air-dried, their reactions change to extremely strong acid ranging from 3.0 to 4.0 in pH values. Particularly, the soils in Cg horizon show less than 3.0 in pH under their air-dried conditions. Potential acidity of oxidized soil by H_2O_2 is at 3.5 for the surface soil and at 2.5 for the sub-surface soils. Organic carbon in the surface soil is about 5 % on an average, but the contents abruptly decrease to 2 % or so in the sub-soils. C.E.C. ranges between 50 to 60 m.eq. and are saturated 10 to 20 % of bases throughout the profile.

The extremely unfavorable drainability and the abrupt hightening of acidity soon after the dehydration of the land of these soil are the most decisive limiting factors of their agricultural use for paddy rice and other tropical common crops. It is, therefore, recommended to provide a trial farm in order to fined out the most rational and profitable procedures for the agricultural utilization of these lands in advance of their reclamation.

<u>Clayey, Acid, Typic Tropofluvents</u>

Soil unit (7): Entisols in order, Fluvents in sub-order, Tropofluvents in great group, Typic Tropofluvents in sub-group.

The soils of Typic Tropofluvents are correlated with Alluvial soils in the U.S.D.A. classification in 1938. In the previous soil study in this area, these soils are correlated with Dystric Alluvial soils. Besides, these soils are partially correlated with Aquic Tropofluvents defined by the Bogor Agricultural University, in 1976.

Typic Tropafluvents are the brownish soils developed on the aqueous sediments through hydromorphic weathering. The groundwater table is commonly deeper than 50 cm in the soil profile, though some seasonal fluctuation are observed.

At present, almost all the land of this soil is densely covered with the natural vegetation of gelam shrub. In undisturbed conditions, the soils have the horizon sequence of A1/ C1/ C2g with gradually to diffuse boundary in common. A1 horizon is primarily the humic epipedon having dark brown to grayish brown (10YR 5/1 to 5/2); silty clay to clay; weak sub-angular blocky structure; soft and friable consistence when wet; clear and smooth boundary. The thickness is about 15 cm on an average. C1 horizon, which is a brown soil with few mottling of low chroma (2 or less). The soils to a depth of about 50 to 60 cm below the ground surface is clay to silty clay; massive structure; plastic and sticky when wet; rather compact; hard consistence and firmly consolidated when dry. C2g horizon is generally put under strong reductive condition and show greenish gray (5GY 5/1) to light olive gray (5Y 6/2) in matrix colour. There are many cloudy type of ferruginous mottles in the upper part of this horizon and they are gradually decrease with the depth. The soils are silty clay; rather compact; massive structure; very plastic and sticky when wet and hard consistence when dry.

Regarding the chemical features, the surface soil (A1) is rather rich in organic matters ranged between 5 to 8 %, and abruptly decrease to about 1 % in sub-surface soils. Throughout the profile, the soils are very strong to extremely strong acid ranging from 4.0 to 5.0 in pH when wet in the field condition and 3.5 to 4.0 when air-dried. C.E.C. is about 30 to 50 m.eq. and base saturation degree is estimated at 30 to 50 % over the whole soils in this group. Essential plant nutrients are quite deficient. The lime requirement for softening the acidity to be suitable for paddy rice cultivation is estimated about 10 to 20 tons/ha.

According to the test results on the hydrodinamic characteristics of the soils made by the Soil Authorities in Bogor, permeability coefficient ranges from 2.5×10^{-4} to 6.3×10^{-5} cm/sec.

In the light of above-mentioned conditions, the land of this soil group will be suitable for paddy rice cultivation. While, the land will have some limitations to the culture of diversified dry field crops. Poor internal drainage due to fine texture of soils and extremely acid soil reaction are the essential hinderance to their vigorous growths.

V.4.2 Inceptisols

The soils of Inceptisols develop widely over the alluvial plain where the land has been cultivated with paddy rice long since, and narrowly on undulating hilly land. The area of this soil is approximately 46,950 ha, corresponding to about 50 % of the total survey area. The soils have diagnostic profile features as the results of hydromorphic or oxidation weatherings. They have histic, umbic and ochric epipedon and gleyic, mottled, cambic, spodic, sub-soils.

Loamy Skeletal, Acid, Typic Dystropepts

Soil unit (8): Inceptisols in order, Tropepts in sub-order, Dystropepts in great group, Typic Dystropepts in sub-group.

The soils are reddish and acid Tropepts. The soils are derived from the loamy skeletal diluvium or from sandstones of the tertiary formation. The soils have been put under laterization process in humid tropical climates. Base saturation degree is very low and KCL-extractable aluminum (so-called active acidity) is rather rich in general. The soils have a cambic B horizon weakly developed under the ochric epipedon. In certain extent, the soils have a paralithic contact or underlying white sandy clay diluvial layer as saprolites (residuals) in the profile shallower than 100 cm below the surface.

These soils were considered as Reddish-yellow Latosols in the U.S.D.A. classification system modified in 1950. In the previous soil study in this area, the soils were classified into Latosols and the Lateric soils.

The land of this soil group is gently undulating with slope less than 5 % and is mostly covered with bushes, alang-alang grasses, etc. In small extent of this soil, the land developed as the house-yard for the spontaneous transmigrants and/or as the upland field mainly for producing such consumables as cassava, legumes, corn, etc. Besides, in rare case, milch cow grazing is practiced by few farmers. Those agricultural productions are, however, very poor due to infertility and unfavourable texture of soils such as loamy skeletals etc.

Generally, the soils have an ochric epipedon as A1 horizon. Thickness of this epipedon is about 15 cm on an average. The soils are dark brown (10YR 5/2) and reddish brown (10YR 5/3) in colour and are gravelly loam to sandy clay loam in texture; sub-angular blocky structure; friable consistence when wet; rather firmly consolidated when dry. The top soil is washed out by heavy rain because of poor vegetation, exposed small gravels on the ground surface. The second horizon to a depth of about 45 to 50 cm is a cambic B1 horizon. The soils in this horizon are yellowish red (5YR 5/6) to reddish brown (10YR 4/4) in colour; coarse loamy to sandy loam skeletal in which many small gravels, fragments of laterites and ferruginous concretions are included; sub-angular blocky structure; rather friable consistence when wet; firmly consolidated under the natural condition. The soils gradually change to underlying B2 horizon with smooth boundary. B2 horizon is commonly yellowish red (5YR 4/8) in matrix colour; gravelly sandy clay loam to fine loam some loamy skeletal in texture; massive to very coarse blocky structure; compact and rather firmly consolidated. Generally, C horizon underlies at the depth of about 90 to 100 cm below the ground surface. The soils of this horizon are loamy to loamy sand in texture with effusive quartz gravels; yellowish brown (2.5YR 5/4 to 5YR 5/6) in colour; massive and compact. They have paralithic contacts or saprolites of sandstones in certain extent where the land extends at the elevation more than 20 m. On the other hand, where the land lies at the elevation less than 20 m, C horizon consists of white sand clayey or clay loamy diluvium. These soils are still put under the unweathered condition. They are very compact when dry, while very friable when wet.

As for their chemical features, the soils are strong acid with pH ranged from 4.5 to 5.5 in 1:1 soil-water suspension. They are poor in plant nutrients, poor in organic matters. C.E.C. is about 8 to 10 m.eq., and the capacity is saturated by the bases at less than 15 % on an average.

In regard to their physical natures, the soils consist of 25 to 35 % of clay and 15 to 30 % of silt and 40 to 50 % of sandy particles, and more than 35 % of small gravels. Generally, the soils have a small moisture holding capacity, but high permeability coefficient ranged from 3.5×10^{-3} to 5.6×10^{-3} cm/sec and rather high basic intake rate ranging between 30 and 50 mm/hr.

In the light of their above-mentioned features, it is considered that the soils of Loamy skeletal, Acid Typic Dystropepts are economically unsuitable for the irrigated farming. In order to expect the profitable agricultural use of these soils, it is necessary to develop special production patterns such as afforestation, orchard plantation and animal grazing etc. without intensive irrigation system.

Loamy, Acid, Aeric Tropaquepts

Soil unit (9): Inceptisols in order, Aquepts in sub-order, Tropaquepts in great group, Aeric Tropaquepts in sub-group.

The soils of the Aeric Tropaquepts are mostly gray in colour at the surface and mottled in sub-soils in common. The groundwater table fluctuates but stands relatively shallow throughout the year.

These soils are considered Low-Humic Gley soils in the U.S. D.A. classification in 1938 and Dysic Alluvial soils in the previous soil study in this area.

The soils extend widely over the alluvial plain and occupy about 25,830 ha, corresponding to about 28 % of the total survey area. Almost all the land of these soils have been well developed as paddy field long since. Generally, seasonal flooding stands during the months from early December to March and its stagnant depth at the peak season (end of January) attains to about 30 cm. The groundwater table fluctuates seasonally at the depth below the ground surface between 0 cm in the rainy season and 50 cm in the peak dry season.

The soils are derived from the quaternary deposits and have clayey to silty clay in texture. They have deep profile to a depth of about 150 cm below the ground surface and are underlaid with the marine sediments (so-called mud-clay). The horizon sequence of these soils is Al(g)/ Clg/ C2g/ C3g (or IIC3g). Their horizon boundaries are mostly gradual and/or diffuse but smooth, in common.

Al(g) horizon is an ochric epipedon which has a thickness of about 15 cm. The soils are dark gray to very dark gray (10 YR 4/2 to 3/2) in colour; fine clay in texture; some strong brown stains around old roots; slightly sticky and plastic when wet; massive structure; friable consistence when wet, while hard and firm when dry. Clg horizon to a depth of about 50 cm below the ground surface is the sub-surface soils which are mottled through the influence of groundwater fluctuation. The soils are silty clay to fine clay in texture; light gray to light brownish gray (10YR 6/1 to 7/1) in matrix colour; many to effusive and distinct mottles with strong brown (7.5 YR 5/6) in colour; massive structure; plastic and sticky when wet; rather friable when moistened and hard consistence when dry. C2g horizon to a depth of about 75 to 90 cm below the surface is also mottled silty clay soils. They have darker colours than Clg horizon, while their mottlings are rather coarse and sparse in size and density. The soils are gray to grayish brown (7.5Y 5/1 to 6/1) in colour; massive structure; very hard consistence when dry and plastic and sticky when wet. C3g horizon is a permanent glay soils. They are dark gray to gray (2.5Y 4/0 to 5/0) mixed with light greenish in matrix colour; silty clay to fine clay; very plastic and sticky when wet and very hard consistence when dry. Below the C3g horizon, mud-clay layer underlies deeply with clear and smooth boundary. The mud-clay is generally very dark gray (2.5 YR 3/0 to 3/1) in colour; silty clay to fine loam in texture and have many small buried cells on the profile.

The soils are very strong to strong acid ranged between 4.5 and 5.5 in pH (H_2O 1:1) throughout the profile. Organic carbon is about 3 to 5 % in the surface soil but abruptly decrease to less than 1 % in the sub-soils. C.E.C. is rather variable from 20 to 50 m.eq. in both surface and sub-soils. Degree of base saturation is estimated at less than 50 % in common. Both surface and sub-surface soils are free from the salinity problems according to the EC values measured at less than 1.0 m.mho/cm/25°C. While, the mud-clay has a brackish constraint expressed in EC value ranged more than 10 m.mhos/cm/ 25°C.

According to the test results on the potential acidity of soils, both surface and sub-surface soils are mostly free from the dysic regime. However, the mud-clay has an extremely high potential acidity ranged around 2.5 in pH.

Regarding the physical natures, the soils have high moisture holding capacity, and very low permeability coefficient ranged from 4.3×10^{-4} to 7.5×10^{-5} cm/sec. Bearing capacity which is expressed in the N-value is as low as 4 Kg/cm^2 in surface soil, while it abruptly decreases to 0.7 to 1 Kg/cm^2 in sub-soils at the present field conditions (dry season in August).

In the light of the soil features stated in the above, the soils of this group are suitable for paddy rice cultivation. However, for introduction of palawija, high capital investment will be required for the improvement of drainage and chemical features.

Loamy, Acid, Typic Tropaquepts

Soil unit (10): Inceptisols in order, Aquepts in suborder, Tropaquepts in great group, Typic Tropaquepts in subgroup.

The soils of Typic Tropaquepts are the glay and mottled soils like the soil unit (9). These soils are, however, distinguished mainly due to the profile features characterized by rich in humus and thick in epipedon and strong glay in subsoils, and groundwater table shallower than that of the Aeric Tropaquepts (9). In the survey area, these soils are mainly found in slightly depressed land lying relatively wide in the alluvial plain. The land of this soil is inundated for about 160 cumulative days from early December to May, and the maximum depth of the flood is about 50 cm at the peak season (early February). Using the flood water, all of the land has been well cultivated for paddy rice, long since.

These soils are correlated with Low-Humic Gley soils in the U.S.D.A. standard modified in 1949. In the previous soil study in this area made by the Bogor Soil Research Institute, 1976, these soils were classified into Eutric Alluvial soils.

Under the long continuous waterlogging, the soils are put under strong reductive conditions and gleization and mottling formation are observed even on the shallow profile. Thus, the soils have diagnostic horizon sequence of Ag/ C1g/ C2g/ C3g with gradual and/or diffuse boundaries. Ag horizon is the epipedon which has a humic regime and about 20 cm in thickness on an average. The soils in this horizon are grayish black to very dark gray (2.5Y 2/0 to 3/0); humic clay to humic silty clay in texture; very soft and very friable consistence when wet but rather hard and firm consistence when dry; massive structure; strong brownish stains around old roots. C1g horizon to an average depth of 45 cm below the ground-surface is the mottled. It has light brownish gray to light gray (10YR 6/2 to 7.5Y/6/2) in matrix colour; rather coarse and distinct ferruginous mottles with brown to yellowish brown (10 YR 5/6 to 5/8) in colour, clay to silty clay in texture; very plastic and sticky; soft and friable consistence when wet, while firmly consolidated when dry; massive structure. C2g horizon to a depth of about 75 cm is a strong glay soils. The soils are fine clay in texture; gray (7.5Y 4/2 to 5/1) in colour; few, coarse and cloudy type of ferruginous mottles with yellowish brown in colour; very plastic and sticky; soft consistence when wet; massive structure; hard and firmly consolidated when dry. C3g horizon to a depth of about 130 cm is a permanent glay soils. The soils are silty clay; dark gray (5Y 3/1 to 4/0) in matrix colour; no mottling; massive structure; very plastic and sticky; soft consistence when wet but very hard when dry. Below C3g horizon, mud clays underlie as the basic layer. They are fine loam to fine sandy loam in texture including many buried cells. The ground water in this layer is brackish expressed in EC values ranged more than 10 m.mhos/cm/25°C.

Regarding chemical properties, the soils are strong to very strong acid ranged between 4.5 to 5.0 in pH (H_2O 1:1) throughout the profile. The total organic carbon is estimated about 10 % or somewhat less in the surface, while less than 1 % in the sub-sois. C.E.C. ranges relatively wide from 30 to 60 m.eq. Total exchangeable bases are corresponded to 40 to 60 % of the C.E.C. in which calcium is predominant. Essential plant nutrient such as nitrogen, phosphate, etc. are quite deficient throughout the profile. The exchange acidity expressed in the 1 N-KCL extractable aluminum is relatively high throughout the profile, and the potential acidity is so strong as 4.0 to 4.5 in pH. As for the mud-clay, the potential acidity is so extremely strong as estimated at 2.5 or so in pH which is determained under maximum oxidation made by the use of H_2O_2.

As for their physical features, the soils have a relativgly weak bearing capacity expressed by N-values less than 3 Kg/cm^2 throughout the soils. Maximum moisture holding capacity of these soils is about 60 % of dry solid. Permeability coefficient of the sub-surface profile ranges between 2.6×10^{-4} and 6.5×10^{-5} cm/sec.

In due consideration of the above soil features and properties, the soils of Typic Tropaquepts are usable for paddy rice cultivation, though some constraints such as strong acid, poor plant nutrient, deep seasonal flooding, etc. will limit the productivity to some extent. However, usability of these soils for palawija culture is rather low from the economical point of view. In order to expect the high production of palawija, relatively high capital investment and recurrent cost will be required for land melioration.

<u>Loamy, Acid, Histic Tropaquepts</u>

Soil unit (11): Inceptisols in order, Aquepts in sub-order, Tropaquepts in great group, Histic Tropaquepts in sub-group.

The soils of this group are classified into Tropaquepts associated with the former soils (9) and (10). These soils are, distinguished from others according to their profile features characterized by the histic or sapric epipedon with thickness of about 35 cm on an average.

Seasonal flooding also occurs in the area of these soils. The flooding stands about 120 cumulative days from early December to March and its maximum depth is about 30 cm at the peak season (end of January). The groundwater lies relatively shallow and seasonal fluctuation of the table ranges between 10 to 50 cm.

The soils of Histic Tropaquepts are correlated with Humic Gley soils in the U.S.D.A. classification system modified in 1949 and they are classified into Dystric Alluvial soils in the previous soil study in the survey area by the Bogor Soil Research Institute, 1976.

At present, all the lands of this soil group are still wild land covered by gelam shrub. Under the natural condition, the soils generally have the horizon sequence of Ao or A1/ C1g/ C2g/ C3g with diffuse or gradual boundaries. Ao or A1 horizon is the histic soils which can be specified into sapric epipedon. The soils consist of well decomposed organic matters homogeneously mixed with silty clayey mineral components. The matrix colour ranges from dark reddish brown to very dark grayish brown (5YR 3/0 to 7.5Y 3/0). They are soft and very friable consistence when wet but very hard and firm consistence when dry. C1g horizon to a depth of about 50 cm below the surface is mottled caused by the seasonal fluctuation of groundwater. The soils are dark grayish brown to gray (5Y 3/1 to 4/2) in matrix colour; fine clay to silty clay in texture; many distinct ferruginous mottles (10YR 5/4 to 5/6); massive structure; plastic and sticky; soft and friable consistence when wet, while hard and firm consistence when dry. C2g horizon to a depth of about 75 cm is also mottled. These soils are light brownish gray to light gray (5Y to 7.5Y 4/3 to 5/2) in colour; few to common, cloudy type of ferruginous mottling with yellowish brown (7.5YR 5/3) in colour; massive structure; soft and friable consistence when wet but firm consistence when dry. C3g horizon to a depth of about 150 cm is permanent glay soils. They are fine clay in texture; dark gray (5Y 4/1 to 4/2) mixed with grayish olive (2.5Y 5/4) in matrix colour; massive structure; plastic and sticky when wet. Below the C3g horizon, mud-clay are underlying deeply. The mud-clay soils are very dark gray (5Y 3/0 to 4/1) in colour; fine loam in texture and massive structure.

Regarding their chemical properties, the surface soil has 20 % or so of total organic carbon; 50 to 60 m.eq. of C.E.C.; less than 10 % of base saturation degree and extremely strong acid ranged at 4.0 to 4.5 in pH. The sub-surface soils have a few percent of organic carbon; 30 to 40 m.eq. of C.E.C.; 15 to 20 %

of base saturation degree and strong acid at 4.5 to 5.9 in pH. Essential plant nutrients are quite poor throughout the profile.

The mud-clay soils show a strong acid at 4.5 to 5.0 in pH on the field when moistened. However, once air-dried, their reactions change to extremely strong acid ranged at less than 3.5 in pH. The potential acidity of the soils measured by H_2O_2 oxidization method is expressed in 2.5 or so in pH. The mud-clay soils have salinity or brackish problems. EC values of these soils range from 10 to 15 m.mhos/cm/25°C in 1:1 soil-water extraction.

As regards their physical natures, the soils have very weak bearing capacities. The surface soil is generally less than 1 kg/cm^2 in N-value. Clg horizon is rather compact expressed in about 3 Kg/cm^2, while its lower layer becomes soft at less than 2 Kg/cm^2. The moisture holding capacity of these soils is as high as 50 % of the bulk dry solid, while the percolation rate in the sub-soil layer is very low ranged at 3.5 x 10^{-4} to 8.5 x 10^{-5} cm/sec.

Taking into consideration the soil features in the above, these soils are suitable for paddy rice cultivation, although rather high recurrent cost will be required for land improvement. To realize the optimum production of upland crops, both surface and internal drainage controls are indispensable. Besides, a proper soil amendment particularly for the moderation of soil reaction is required not only at the initial stage of the development but also throughout the period of sustainable farming.

Sandy, Dysic, Histic Tropaquepts

Soil unit (12): Inceptisols in order, Aquepts in sub-order, Tropaquepts in great group, Histic Tropaquepts in sub-group.

The soils of this group are classified into Histic Tropaquepts along with the soil unit (11). According to sandy textural features throughout the profile, these soils can be distinguished from other Tropaquepts. These soils were classified as Dystric Alluvial soils in the previous soil study in this survey area, 1976.

The soils develop on the lowlying terrace and consist of quartziferous sands. At present, almost all the land is covered with gelam shrub mixed with small bushes and ferns. Partial area of small extent where the land is free from the seasonal flooding, some vegetables, cassava and fruit trees are planted by the farmers.

The horizon sequence is same as the soils of soil unit (11). Remarkable differences from the soils (11) are that all the soils have sandy to sandy loam texture throughout the profile and the profile is rather shallow and is underlaid with diluvial layer.

A1 horizon with about 30 cm in thickness consists of sapric epipedons. The soils are humic sandy loam; very dark brown

(10YR 3/2 to 4/1); soft and rather loose consistence when wet; structureless even under their cultivated conditions. C1g horizon to a depth of about 45 cm is the sandy loam which consist of medium to fine quartz particles with grayish brown clayey matrix. They are rather compact but friable when wet. There are many, fine and distinct ferruginous mottlings. C2g horizon to a depth of about 100 cm is the gleyic soils. They are dark gray to brownish gray (7.5Y 5/1 to 5/2); sandy loam in texture; very friable consistence when wet; permanently saturated with the groundwater. C3 horizon is the basic soil layer to be derived from the diluvium. The soils are white to grayish white in colour; sandy clay to sandy clay loam in texture; very compact but very friable when wet. The soils include some percent of plinthites and small quartz gravels.

Regarding their chemical properties, the surface soil is extremely strong acid at about 3.5 to 4.0 in pH, while the sub-soils are generally strong acid ranging at 4.5 to 5.0. Total organic carbon is estimated at about 20 % or so in the surface soil but few in sub-soils. C.E.C. of the surface soil is 100 to 130 m.eq. owing to rich colloidal humus, while 10 to 20 m.eq. in sub-soils. Base saturation degree is as low as only a few percent throughout the profile. Essential plant nutrients are quite deficient. Based upon the C.E.C. values and base saturation degree, it is estimated that the lime requirement for modification of the soil reaction would be 50 tons/ha for surface soil, while 10 tons/ha or so for the subsoils.

As for the hydrodynamic characteristics of soils, it is very high moisture holding capacity of more than 70 % of the gross dry solid in the surface soil and 20 to 30 % in the sub-soils. Permeability coefficient of sub-surface strata is as high as 4.5×10^{-3} to 1.0×10^{-3} cm/sec, but that in the diluvial layer is relatively low as 5.0 to 8.5×10^{-4} cm/sec.

In the light of soil natures and properties, the capability of soils for both paddy rice and palawija is rather low. Under the current situation of farm economics, it is rather difficult to expect the profitable crop production in the area of these soils. A high capital investment and recurrent cost will be required for soil melioration.

Clayey, Acid, Aeric Haplaquepts

Soil unit (13): Inceptisols in order, Aquepts in sub-order, Haplaquepts in great group, Aeric Haplaquepts in sub-group.

The soils of this group are the levee soils derived from the fine textured alluvium of the quaternary period. They are mostly free from the seasonal flooding and have relatively shallow groundwater table. They can be specified as the mottled soils and/or the groundwater glay soils which have generally an ochric pedon throughout the profile.

The soils are correlated with Low-Humic Glay soils in the soil classification system modified in 1949 by the U.S. Department of Agriculture, and were classified into Dystric Alluvial soils in the previous soil study in this area, 1976.

At present, the land of this soil area, which mainly extends narrowly over along the river Martapura, is used for the village accommodation including garden, and is also used for coconut plantation and rubber plantation to some extent.

The horizon sequence of the soils is, in common, A11/ A12/ C1g/ C2g with gradual or diffuse but smooth boundaries. The average thickness or depth below the surface of each specific horizon is estimated at about 10 cm, 15 cm (or 25 cm deep), 30 cm (55 cm), 70 cm (125 cm) and deeper than 150cm respectively. Throughout the profile, the soils are fine clay in texture; rather compact; soft and friable consistence when wet, but hard and firm consistence when dry; massive structure; very plastic and sticky when wet. When the soils dry at less than the field capacity in moisture regime, rather wide and deep cracking is developed coarsely.

A11 horizon is an ochric epipedon having grayish brown (5Y 4/2) to brownish gray (7.5YR 5/2) in matrix colour. Strong brown (10YR 5/6) of stains are densily accumulated around old roots. A12 horizon is the sub-surface soils that have light brownish gray (7.5YR 5/4 to 5/6); many and fine size of distinct ferruginous mottles (10YR 5/5) and reddish brown stains around old roots. C1g horizon is the mottled soils that are light grayish brown (7.5Y 5/4 to 5/6) in colour; distinct mottlings of effusive and coarse size and fine tublar stains along old roots. C12g horizon is also the mottled soils but their matrix colour are slightly darker than that of C1g horizon, and the mottling in the horizon is common, coarse in size but cloudy in type. A density of these mottlings is gradually decrease with depth. C2g horizon is permanent gley soils that are over-saturated with the groundwater all the times. They are gray (2.5Y to 5Y 5/2) mixed with grayish olive (2.5Y 6/4 to 6/5) in colour.

The soils are moderately strong to strong acid with pH value ranged from 4.5 to 6.0 throughout the profile. Total organic carbon in the surface soil is a few percent in common. C.E.C. value ranges between 25 to 35 m.eq. and these capacities are saturated at 30 to 50 % by exchangeable bases. The essential plant nutrients such as nitrogen, phosphate potash, etc. are quite deficient. The soils have rather high extractable aluminum (so-called an exchange acidity), while no potential acidity even in the deep sub-soils.

As for their physical features, the soils have rather high bearing capacity expressed at about 4 Kg/cm^2 or so in N-value on the surface profile of 50 cm deep, while the capacity abruptly decreases to 1 to 2 Kg/cm^2 on the sub-surface profile. Maximum water holding capacity of the soils ranges from 45 to 50 % of gross dry solid. Permeability coefficient of the sub-soil strata is as low as 10^{-4} to 10^{-5} cm/sec.

In the light of the soil features and chemical properties, the soils can be used for paddy rice cultivation, though proper soil fertilization is necessary. It can be expected that the paddy rice production on these soils would be high enough to justify the capital investment and recurrent cost for soil melioration and land preparation.

Clayey, Acid, Typic Haplaquepts

Soil unit (14): Inceptisols in order, Aquepts in sub-order, Haplaquepts in great group, Typic Haplaquepts in sub-group.

The soils of Typic Haplaquepts are Aquepts in sub-order developed on the levee and are similar to the soil unit (13). These soils have groundwater table deeper than 50 cm below ground surface. There is no seasonal flooding in the area of these soils. These soils are correlated with Low-Humic Gley soils or Humic Gley soils in the U.S.D.A soil classification system modified in 1949. In the previous soil study in this area, these soils are classified into Eutric Alluvial soils making reference to the FAO/UNESCO system.

All the land of these soils have been developed and used for rubber plantation and village-yard long since. At present, however, most rubber plants are too old to be used for latex production.

Under undisturbed condition, the soils have horizon sequence of A1/ A12 (B)/ C1g/ C12g with diffuse boundaries. A1 horizon is an ochric epipedon with dark brown (10YR 4/2 to 5/1) to dark grayish brown (7.5Y 3/1 to 4/2) in matrix colour; silty clay in texture; weak sub-angular blocky structure; slightly sticky and plastic when wet; friable consistence but rather hard consistence when dry. A12 horizon (or weakly developed B horizon) has cambic feature. The soils in this horizon are dark reddish brown (5 YR 3/2) to dark brown (7.5YR 4/2) in colour; fine clay in texture; blocky structure; friable consistence when wet, while firmly consolidated when dry; plastic and sticky; rather compact. The soils of C1g horizon are mottled and have light grayish brown (5Y 5/5 to 6/4) in matrix colour; clay in texture; strong brown ferruginous mottlings (10YR 5/6); massive structure. C2g horizon consists of gleyic soils with brown mottles in the gray and silty clay matrix. These soils are rather compact and firmly consolidated when dry, C3g horizon is the permanent gleyic soils lying under the groundwater table all the times.

As regards their chemical properties, the soils are moderate to strong acid ranged from 4.5 to 5.5 in pH throughout the profile. The content of total organic carbon is a few percent in the surface soil and less than 0.5 % in the sub-soils. C.E.C. is estimated at about 30 to 50 m.eq. The total exchangeable bases is about 10 to