REPUBLIC OF INDONESIA
Ministry of Public Works
Directorate General of Water Resources Development

FEASIBILITY STUDY ON THE KOMERING-I IRRIGATION DEVELOPMENT PROJECT IN THE UPPER KOMERING RIVER BASIN

VOLUME II-1

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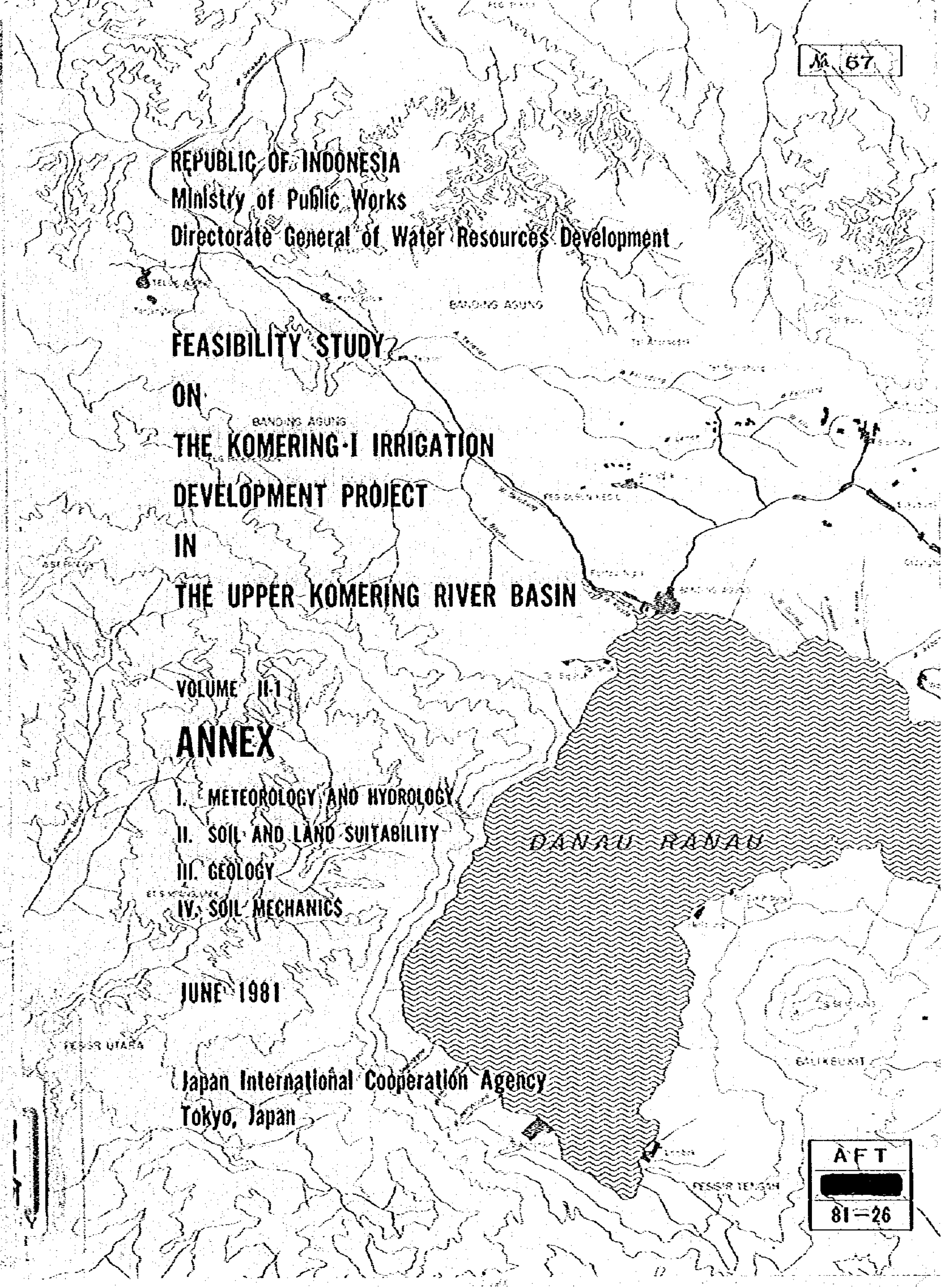
I. METEOROLOGY AND HYDROLOGY
II. SOIL AND LAND SUITABILITY
III. GEOLOGY
IV. SOIL MECHANICS

JUNE 1981

Japan International Cooperation Agency
Tokyo, Japan



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ABBREVIATION AND LOCAL TERMS

Abbreviations and local terms used in this report are listed below:

A. ABBREVIATIONS

1. Length

mm	millimeter
cm	centimeter
m	meter
km	Kilometer

2. Area

cm2	square centimeter
m2	square meter
km2	square kilometer
ha	hectare

3. Volume

lit(( )	liter (= 1,000 cm3)
m3	cubic meter

4. Weight

mg	milligram
g	gram
kg	kilogram
t (ton)	1,000 kg

5. Time

sec	second
min	minute
hr	hour

6. Other measures

%	percent
PS	horse power

pH	scale for acidity
C°	centigrade
m3/sec	cubic meter per second
lit/sec/ha	liter per second per hectare
cm/sec	centimeter per second
m.e/ℓ	milligram equivalent per liter
mgcal/cm2	milligram calorie per square centimeter
t/ha	ton per hectare
ppm	part per million
EC	electric conductivity
CEC	cation exchange capacity
No.(Nos.)	number(s)

7. Technical terms

EL	elevation above mean sea level
H	height
WL	water level
HWL	heigh water level
LWL	low water level
FWL	flood water level
Q	discharge

8. Money

US$	US Dollar
Rp.	Indonesian Rupiah

(US$ 1.0 = Rp.625.-)

9. Other abbreviations

FAO	Food and Agriculture Organization of United Nations
UNDP	United Nations Development Program
DPU	Department Pekerjaan Umum (Department of Public Works)
P3SA	Proyek Percencanaan Pengembangan Sumber-Sumber Air
IRRI	International Rice Research Institute

JICA	Japan International Cooperation Agency
WHO	World Health Organization
BRI	Bank Rakyat Indonesia (Indonesian People's Bank)
GDP	Gross Domestic Products
GRP	Gross Regional Products

B. <u>LOCAL TERMS</u>

Kab.	Kabupaten (District)
Prov.	Provinsi (Province)
OKU	Kabupaten Ogan Komering Upper River Basin
OKI	Kabupaten Ogan Komering Lower River Basin
BIMAS	Mass Guidance for Self-sufficiency in Food
INMAS	Mass Intensification for Self-sufficiency in Food
CRIA	Central Research Institute for Agriculture, Bogor
PPS	Extension Specialist
PPM	Extension Supervisor
PPL	Field Extension Worker
BPP	Rural Extension Center
KUD	Village Unit Cooperative Body
DOLOG	Depot Logistic
BULOG	Board of Logistic
KIOSK	Small Shop
ADC	Agricultural Development Center
UPP	Land Development Unit
KIK	Small Investment Credit
Desa	Village
Kecamatan	Sub-district
Kontak-Tani	Key farmer or leading farmer
Ani-Ani	Small Rice Harvesting Knife
Lebak	Swamp behind river levee
Ulu Ulu	Water master

Pelita (Repelita)	Five-year Development Plan
Sawah	Paddy field
Dalam Angka	Statistical data
Polowijo	Second crop, planted after harvest of rainy season paddy
Tegal	Upland field
Ladang	Shifting culture land
Alang-alang	Grass land

ANNEX I

METEOROLOGY AND HYDROLOGY

ANNEX - I

METEOROLOGY AND HYDROLOGY

1. METEOROLOGY

1.1 General

The project area is located around 5^{o} of south latitude and belongs to the equator climatic zone. On account of this location, the area is affected by the westerly wind and the trade wind (the SE seasonal wind). The westerly seasonal wind occurs from October to May, and it causes much rainfall in the area.

The meteorological data; rainfall, sunshine duration, temperature, relative humidity, solar radiation, wind velocity and evaporation were mainly collected at Sub. P3.S.A. Sumatera Selatan, Sub. P3.S.A. Lampung, Pertanian Office in Baturaja, and Palembang. However, the observation was either completely stopped or conducted intermittently. Location of observatories and observation periods of these data are shown in Fig. I-1 to Fig. I-4.

1.2 Rainfall

The rainfall records are available at 31 gauge stations in and around the project area, but those observation periods vary from station to station and are often interrupted. The monthly rainfall records at some representative stations are shown in Table I-1 to Table I-6.

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. It varies widely from year to year ranging between approximately 1,700 mm to 4,600 mm.

1.3 Sunshine Duration

The sunshine duration records are available at Belitang station and shown in Table I-7. From the figures given in the table, it can be seen that the monthly average sunshine hours vary from 6.3 hrs/day at maximum in May to 4.1 hrs/day at minimum in January.

1.4 Solar Radiation

The monthly solar radiation records at Belitang and Menggala are shown in Table I-8 and Table I-9. Those tables show that mean annual radiation values are 459 mgcal/cm^2 at Menggala and 401 mgcal/cm^2 at Belitang.

1.5 Temperature

Table I-10 gives the monthly mean air temperature records for Belitang over a period of 12 years from 1969 to 1980 with some incomplete years. Table I-11 and Table I-12 give the monthly mean air temperature records for Banding Agung and Menggala respectively. The observation periods are six years for Banding Agung and three years for Menggala.

Those tables show that the monthly average air temperature in Belitang and Menggala vary from 26°C to 28°C with a little seasonal variation.

1.6 Relative Humidity

The relative humidity records are shown in Table I-13, I-14 and I-15. Those tables show the monthly relative humidity at Belitang, Banding Agung and Menggala, respectively. The monthly average relative humidity at Belitang reaches its maximum about 83%, and its minimum about 77%.

1.7 Wind Velocity

The wind velocity records are shown in Table I-16, I-17 and I-18. Those tables give the monthly mean wind velocity at Belitang, Banding Agung and Menggala respectively. The monthly mean wind velocity is generally low in the flat land. The monthly averages of wind velocity are in the range from 2.4 km/hr to 3.8 km/hr in the project area.

1.8 Evaporation

Table I-19 through Table I-21 give the monthly evaporation records at Belitang, Banding Agung and Menggala respectively with some incomplete years. The annual pan evaporation observed at Belitang is about 1,640 mm (4.5 mm/day). The monthly average evaporation reaches its maximum in March approximately 5.1 mm/day and its minimum in June approximately 4.2 mm/day respectively.

2. HYDROLOGY

2.1 Komering River

In the study area, there flow four major rivers, i.e. the Komering, Macak, Belitang and the Pisang. Among them, the Komering river gives an ample perennial flow and its water stage can cover the elevations up to 80 meters, below which most of the fertile flat lands exist. Accordingly only the Komering river is taken as an irrigation water resources in this study.

The Komering river originates from the Lake Ranau, about 127 km^2 of surface area, and flows to the northwest direction down to the confluence with the Baru river. At the confluence, it changes its course toward northeast and flows down through the steep and narrow gorge. At Muaradua, it joins with the Saka river, one of its large tributaries, and flows to Martapura through hilly area. The Komering river then runs taking meandering course in the flat plain and reaches Kurungan Nyawa where the intake structure for the Belitang Proper Area is located. Near Cempaka, most of the streamflow flows into the Ogan river through five rivers; the Randu, the Arisan, the Jambu, the Sigonang, and the Anyar. The catchment area of the Komering river at Martapura is about 4,260 km^2 including the catchment area of about 508 km^2.

This river has functioned since old time as the main water source for the living of riparian people and farm lands and as a navigation route. But the patterns of the river flow coincide with that of the rainfall: the river has ample discharge in the rainy season but loses its strength in the dry season. In order to utilize its potential to maximum extent, the regulation of the river flow by means of reservoir is needed according to the seasonal demands.

The Komering river transports a considerable quantity of eroded materials and raises its river bed and the irrigation canals.

2.2 Observation

Hydrological measurement and analysis for the Komering river were carried out during the previous comprehensive study period. In order to supplement these data, the discharge measurement and water sampling are being carried out on the Komering river at the Martapura and Kurungan Nyawa gauging stations by P3SA at the interval of around 10 days. These data collected so far are under analysis at present by P3SA. These results of analyses will fully be incorporated in future studies.

The followings are extractions of the ANNEX-I "CLIMATE, HYDROLOGY AND WATER BALANCE" for the Comprehensive Study on the Upper Komering River Basin Development, JICA, 1980, particularly for the hydrology on the Komering river.

2.3 Streamflow of the Komering River

(i) Rating curve

According to the comprehensive study report, the rating curves at Banding Agung and Martapura were revised by using the least-square method as shown in the Fig. I-5 and I-6. The equations of the revised rating curves are as follows:

Banding Agung $Q = 24.9848\ (G.H. + 0.0645)^2$

Martapura $Q = 67.1531\ (G.H. - 0.8503)^2$

where,

Q : Discharge (m^3/sec)

G.H. : Gauge height (m)

The above equation at Martapura may be modified based on the results of discharge measurement being carried out by P3SA.

(ii) Monthly discharge at Martapura

Using the revised rating curve, the monthly discharges at Martapura from 1972 to 1976 were estimated. For the period from 1963 to 1970, however, monthly discharges were estimated by using the Tank Model method because of interruption of water level records at this station.

In general, a direct correlation is not observed between rainfall and runoff, because the runoff consists of surface runoff, subsurface runoff, and groundwater runoff. The nonlinearity of the rainfall-runoff process can be explained by using reservoirs (Tanks) in series and/or in parallel. The Tank Model method consisting essentially of linear reservoirs had been developed as analogous physical models to analyze river runoff. If the Tank Model is established based on the actual discharges for adequate period, the production (estimated runoff) becomes substantially reliable.

The Tank Model consisting of two linear reservoirs in series was established by using actual discharge data at Martapura from 1971 to 1973 (See Fig. I-7). In establishing the Tank Model, the rainfall at Muaradua were used and, in case no rainfall data is available at Muaradua, the rainfall was estimated from the monthly rainfall at Baturaja taking into account the correlation of rainfalls between Muaradua and Baturaja. The rainfall data used in the discharge calculation are shown in Table I-22.

Since no actual evapotranspiration data were available at Muaradua, evapotranspiration to be used for establishment of the Tank Model was estimated from a potential evapotranspiration calculated using the Penman method. In the calculation of potential evapotranspiration, the following Albedo values were used.

<u>Value of Albedo</u>

Open water	5%
Forest	15%

In the calculation of evapotranspiration, the vegetation factor of 80% was applied referring to the report on the feasibility study of the Way Seputih and Way Sekampung basins. The calculated evapotranspiration is shown in Table I-23.

The estimated monthly discharge at Martapura from 1963 to 1970 and from 1977 to 1978 is as shown in Table I-24.

Average annual run-off of the Komering river at Martapura is about 207 m^3/sec. or 6,528 x 10^6 m^3 in annual runoff. The monthly discharge reaches its maximum in April; approximately 305 m^3/sec. and its minimum in August; approximately 133 m^3/sec. The river discharge varies from year to year being dominated by the amount of rainfall. The maximum flood discharge estimated at Martapura was 1,372 m^3/sec. in 1977, and minimum discharge was 40 m^3/sec. in October 1972.

(iii) Runoff from Lake Ranau

The measured monthly runoff is available at Banding Agung during a period from 1972 to 1978. Its monthly runoff from 1963 to 1971 was estimated taking the correlation between the monthly streamflow of the Komering at Martapura and that from the residual basin extending between Banding Agung and Martapura as shown in Fig. I-8. The monthly runoff at Banding Agung is then simply estimated by deducting the monthly runoff of the residual basin from that at Martapura as shown in Table I-25.

2.4 Flood Runoff Analysis

The flood of the Komering reaches its maximum usually between February and May. The flood discharges at Martapura were estimated by using the records of the maximum mean daily discharge there.

The probabilities of the flood discharge were taken as 1/5, 1/10, 1/20, 1/50, 1/100, 1/200 and 1/1000 year, and are presented in the following table.

Calculated Flood Run-off at Martapura

Return period (year)	Probability(x) (%)	Flood Run-off (m^3/sec)
5	20	1,004
10	10	1,102
20	5	1,194
50	2	1,311
100	1	1,398
200	0.5	1,484
1000	0.1	1,684

2.5 Study of Water Level at Kurungan Nyawa

The study of the effect on the water level at the Kurungan Nyawa intake due to the intake of water at Pracak particularly during the dry season was made based on the correlation of water levels of Kurungan Nyawa and Martapura since there are no other data available. The correlation analysis was made by using the water level data during dry season (from 1975 to 1978).

The following regression line was obtained.

$$Y = 0.970 x - 16.763$$

where, y: water level at Kurungan Nyawa
(Staff gauge 0m = El. 66.17 m)

x: water level at Martapura
(Staff gauge 0m = El. 85.67 m)

From the above correlation equation, water level at Kurungan Nyawa for the irrigation water to the downstream area from the Pracak Headworks is shown in Fig. 1-9.

2.6 Water Quality

In order to check the water quality of the Komering, water samplings were carried out at 2 locations shown below in the period from September 30 through December 9, 1979, and the chemical tests were made on these samples.

1. Kayu Agung (Komering River)
2. Kangkung (Komering River)

The results of the chemical analysis are presented in Table I-26. The suitability of water for irrigation and drinking was assessed based on WHO standard for drinking water and Scofield's standard for irrigation as shown in the following table.

Standard for Drinking Water and Irrigation Water

Item		For City Water WHO Standard	For Irrigation
PH		7.0 - 8.5	6.0 - 7.5 (1)
Electric Conductivity	$K \times 10^5$		25
Ca	ppm	75	
Mg	ppm	50	
Cl	ppm	200	4 m.e/ℓ
SO_4	ppm	200	4 m.e/ℓ
$\frac{Na \times 100}{Na + Ca + Mg + K}$	(m.e/ℓ)		20 %
$KMnO_4$	ppm	10	
B	ppm		0.33 - 1

(1): Standard of Ministry of Agriculture, Forestry and Fisheries of Japan

A study of chemical properties of water shows that the water can be used for irrigation. For drinking, the water is proposed to be filtered to remove evaporated residue, and boiled thoroughly to destroy all micro-organism which may exist in the water, judging from the amount of $KMnO_4$ demand.

Table I-1 MONTHLY RAINFALL AT BK IX

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1956	310.0	282.0	305.0	200.0	156.0	95.0	216.0	262.0	223.0	421.0	556.0	274.0	3,300.0
57	681.0	231.0	405.0	368.0	164.0	358.0	181.0	153.0	108.0	87.0	463.0	437.0	3,638.0
58	347.0	299.0	578.0	260.0	76.0	53.0	110.0	150.0	10.0	241.0	565.0	286.0	2,975.0
59	383.0	-	308.0	400.0	454.0	104.0	34.0	3.0	67.0	-	-	-	-
1960	400.0	286.0	264.0	155.0	117.0	40.0	63.0	49.0	34.0	78.0	183.0	351.0	2,020.0
61	336.0	202.0	337.0	340.0	124.0	132.0	10.0	1.0	7.0	0	156.0	378.0	2,023.0
62	258.0	284.0	454.0	181.0	341.0	55.0	83.0	173.0	125.0	249.0	189.0	386.0	2,778.0
63	562.0	342.0	275.0	256.0	110.0	14.0	52.0	7.0	-	72.0	190.0	170.0	-
64	-	-	-	-	-	-	-	63.0	84.0	-	-	-	-
65	160.0	158.0	320.0	141.0	33.0	156.0	41.0	-	-	252.0	184.0	243.0	-
66	358.0	274.0	341.0	209.0	186.0	57.0	30.0	12.0	-	-	-	430.0	-
67	371.0	335.0	156.0	186.0	176.0	30.0	85.0	0	12.0	145.0	265.0	236.0	1,997.0
68	247.0	146.0	424.0	350.0	158.0	208.0	165.0	198.0	70.0	205.0	729.0	421.0	3,321.0
69	546.0	265.0	283.0	254.0	301.0	109.0	48.0	35.0	255.0	72.0	318.0	419.0	2,905.0
70	274.0	157.0	260.0	562.0	201.0	15.0	47.0	45.0	17.0	-	50.0	243.0	-
71	361.0	293.0	195.0	256.0	80.0	23.0	48.0	41.0	23.0	148.0	188.0	195.0	1,851.0
72	353.0	106.0	308.0	249.0	164.0	68.0	0	4.0	26.0	26.0	153.0	236.0	1,685.0
73	74.0	187.0	196.0	258.0	383.0	113.0	82.0	381.0	264.0	335.0	256.0	-	-
74	-	179.0	349.0	205.0	183.0	40.0	190.0	104.0	178.0	217.0	254.0	470.0	-
75	-	-	-	-	-	-	-	-	-	-	-	-	-
76	-	-	-	-	-	-	-	-	-	-	-	-	-
77	-	-	-	-	-	-	-	-	-	-	-	-	-
78	380.0	496.0	637.0	384.0	245.0	156.0	77.0	94.0	361.0	259.0	309.0	478.0	3,876.0
79	303.0	222.0	384.0	246.0	280.0	114.0	69.0	61.0	-	270.0	150.0	438.0	-
1980	214.0	106.0	284.0	338.0	75.0	145.0	-	-	-	-	-	-	-
Total	6,918.0	4,850.0	7,063.0	5,790.0	4,007.0	2,085.0	1,630.0	1,836.0	1,864.0	3,077.0	5,158.0	6,091.0	-
Mean	345.9	242.5	336.3	276	191	99	82	92	110	181	303	358	2,697

Table I-2 MONTHLY RAINFALL AT KURUNGAN NYAWA (BK.O)

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1955	406.0	209.0	631.0	425.0	40.0	113.0	280.0	40.0	120.0	336.0	185.0	337.0	3,162.0
56	419.0	215.0	333.0	295.0	269.0	140.0	215.0	141.0	141.0	295.0	322.0	308.0	3,093.0
57	485.0	253.0	317.0	391.0	252.0	106.0	255.0	172.0	23.0	199.0	232.0	648.0	3,333.0
58	357.0	447.0	451.0	242.0	272.0	182.0	89.0	268.0	27.0	176.0	419.0	423.0	3,353.0
59	328.0	-	-	225.0	351.0	51.0	55.0	8.0	23.0	-	-	-	-
1960	570.0	223.0	389.0	533.0	132.0	56.0	133.0	126.0	154.0	101.0	302.0	715.0	3,434.0
61	273.0	309.0	336.0	452.0	453.0	236.0	5.0	41.0	31.0	23.0	230.0	493.0	2,882.0
62	494.0	253.0	514.0	287.0	311.0	151.0	290.0	131.0	277.0	286.0	184.0	-	-
63	289.0	346.0	308.0	114.0	131.0	67.0	6.0	19.0	0	261.0	93.0	335.0	1,969.0
64	-	-	-	-	-	-	-	68.0	81.0	-	-	-	-
65	219.0	291.0	397.0	378.0	181.0	-	-	-	-	122.0	163.0	222.0	-
66	-	326.0	360.0	176.0	208.0	-	106.0	-	-	392.0	393.0	-	-
67	271.0	387.0	298.0	259.0	257.0	42.0	59.0	0	8.0	163.0	178.0	372.0	2,294.0
68	225.0	134.0	369.0	277.0	205.0	233.0	65.0	197.0	141.0	214.0	412.0	412.0	2,884.0
69	372.0	309.0	518.0	193.0	217.0	92.0	124.0	40.0	281.0	148.0	571.0	372.0	3,237.0
1970	321.0	139.0	447.0	538.0	351.0	137.0	83.0	59.0	92.0	140.0	212.0	580.0	3,099.0
71	232.0	250.0	408.0	305.0	164.0	110.0	91.0	84.0	27.0	393.0	233.0	334.0	2,631.0
72	386.0	228.0	505.0	313.0	140.0	76.0	0	72.0	21.0	38.0	164.0	366.0	2,309.0
73	239.0	373.0	285.0	228.0	563.0	165.0	9.0	213.0	307.0	127.0	222.0	273.0	3,004.0
74	202.0	285.0	275.0	281.0	405.0	70.0	103.0	149.0	173.0	195.0	252.0	361.0	2,751.0
78	388.0	351.0	388.0	209.0	229.0	264.0	98.0	147.0	198.0	432.0	293.0	333.0	3,330.0
79	329.0	234.0	435.0	246.0	150.0	120.0	102.0	64.0	-	389.0	141.0	365.0	-
1980	-	-	425.0	227.0	154.0	338.0	-	-	-	-	-	-	-
Total	6,805.0	5,562.0	8,389.0	6,594.0	5,435.0	2,749.0	2,168.0	2,039.0	2,125.0	4,430.0	5,201.0	7,289.0	-
Mean	340	278	399	300	247	137.0	108	102	112	222	260.0	384	2,923

Table I-3 MONTHLY RAINFALL AT MARTAPURA

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1951	592.0	362.0	242.0	328.0	166.0	171.0	126.0	70.0	112.0	128.0	94.0	570.0	2,961.0
1952	568.0	408.0	735.0	399.0	393.0	189.0	235.0	259.0	271.0	108.0	435.0	682.0	4,682.0
1953	786.0	628.0	636.0	408.0	364.0	96.0	139.0	17.0	21.0	189.0	622.0	297.0	4,203.0
1954	367.0	419.0	318.0	168.0	214.0	97.0	79.0	121.0	35.0	97.0	71.0	229.0	2,215.0
1955	196.0	188.0	370.0	233.0	90.0	114.0	87.0	154.0	292.0	231.0	159.0	504.0	2,618.0
1956	392.0	233.0	369.0	363.0	163.0	140.0	334.0	108.0	202.0	255.0	351.0	173.0	3,083.0
1957	-	-	-	-	-	-	-	-	-	-	-	-	-
1958	468.0	328.0	491.0	644.0	98.0	189.0	-	220.0	12.0	162.0	336.0	443.0	-
1960	420.0	301.0	308.0	-	-	44.0	-	194.0	42.0	76.0	361.0	527.0	-
1966	270.0	160.0	132.0	218.0	321.0	285.0	40.0	280.0	30.0	340.0	180.0	500.0	2,756.0
1971	286.0	281.0	457.0	271.0	257.0	188.0	7.0	52.0	38.0	242.0	201.0	151.0	2,431.0
1972	318.0	259.0	560.0	410.0	192.0	55.0	3.0	76.0	54.0	9.0	145.0	346.0	2,427.0
1973	275.0	217.0	134.0	241.0	428.0	259.0	30.0	453.0	321.0	199.0	93.0	234.0	2,884.0
1974	29.0	417.0	160.0	209.0	235.0	52.0	-	-	-	-	-	-	-
1975	305.0	319.0	225.0	181.0	174.0	50.0	150.0	63.0	192.0	277.0	391.0	182.0	2,209.0
1976	215.0	-	270.0	214.0	30.0	54.0	99.0	210.0	65.0	305.0	417.0	556.0	-
1977	289.0	199.0	121.0	642.0	129.0	77.0	96.0	119.0	132.0	126.0	189.0	416.0	2,535.0
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	112.0	152.0	55.0	99.0	0	93.0	353.0	261.0	222.0	-
1980	180.0	122.0	206.0	147.0	227.0	129.0	3.0	-	-	-	-	-	-
Total	5,956.0	4,841.0	5,734.0	5,188.0	3,623.0	2,244.0	1,527.0	2,396.0	1,912.0	3,097.0	4,306.0	6,032.0	-
Mean	350	303	337	305	214	125	102	150	120	194	269	377	2,846

Table I-4 MONTHLY RAINFALL AT MUARADUA

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1952	383.0	319.0	394.0	282.0	-	40.0	41.0	111.0	167.0	-	270.0	482.0	-
1953	416.0	303.0	204.0	228.0	326.0	49.0	82.0	34.0	13.0	287.0	264.0	220.0	2,426.0
1966	270.0	100.0	400.0	102.0	340.0	219.0	111.0	124.0	60.0	167.0	270.0	380.0	2,543.0
1967	185.0	265.0	460.0	155.0	330.0	100.0	125.0	-	-	75.0	380.0	245.0	-
1968	145.0	65.0	370.0	275.0	315.0	250.0	222.0	210.0	125.0	250.0	365.0	340.0	2,832.0
1969	398.0	210.0	174.0	524.0	277.0	200.0	290.0	140.0	152.0	200.0	314.0	465.0	3,344.0
1970	307.0	190.0	340.0	243.0	495.0	50.0	141.0	304.0	192.0	103.0	299.0	175.0	2,839.0
1971	140.0	189.0	285.0	345.0	162.0	115.0	260.0	160.0	80.0	241.0	215.0	340.0	2,532.0
1972	298.0	219.0	443.0	358.0	304.0	-	-	-	-	-	-	-	-
1973	86.0	255.0	159.0	230.0	242.0	95.0	39.0	153.0	138.0	132.0	-	-	-
1974	129.0	182.0	111.0	380.0	219.0	68.0	299.0	38.0	327.0	227.0	115.0	173.0	2,268.0
1975	267.0	210.0	159.0	196.0	82.0	60.0	30.0	163.0	153.0	202.0	206.0	76.0	1,804.0
1976	136.0	148.0	261.0	197.0	89.0	9.0	76.0	67.0	24.0	309.0	352.0	331.0	1,999.0
1977	253.0	319.0	134.0	402.0	153.0	214.0	55.0	15.0	109.0	17.0	182.0	387.0	2,240.0
1978	191.0	287.0	259.0	156.0	304.0	190.0	217.0	70.0	190.0	341.0	166.0	287.0	2,558.0
1979	193.0	287.0	269.0	244.0	139.0	127.0	177.0	65.0	85.0	121.0	-	-	-
1980	-	-	-	180.0	17.0	33.0	210.0	-	-	-	-	-	-
Total	3,797.0	3,448.0	4,622.0	4,497.0	3,694.0	1,819.0	2,375.0	1,654.0	1,815.0	2,672.0	3,398.0	3,901.0	-
Mean	237	216	289	265	231	114	148	118	130	191	261	300	2,500

Table I-5 MONTHLY RAINFALL AT BANDING AGUNG

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1973	-	343.0	251.0	285.0	113.0	131.0	96.0	147.0	267.0	186.0	113.0	251.0	-
1974	128.0	190.0	157.0	233.0	283.0	123.0	96.0	121.0	228.0	100.0	244.0	141.0	2,044.0
1975	278.0	285.0	144.0	321.0	166.0	26.0	179.0	151.0	113.0	217.0	206.0	176.0	2,262.0
1976	413.0	148.0	152.0	49.0	-	0	272.0	51.0	-	274.0	318.0	136.0	-
1977	189.0	263.0	-	-	144.0	214.0	21.0	91.0	58.0	56.0	153.0	239.0	-
1978	133.0	102.0	439.0	150.0	271.0	55.0	-	-	-	224.0	290.0	464.0	-
1979	92.0	115.0	158.0	204.0	175.0	151.0	162.0	71.0	185.0	198.0	245.0	216.0	1,972.0
1980	415.0	243.0	182.0	387.0	-	-	-	-	-	-	-	-	-
Total	1,648.0	1,689.0	1,483.0	1,629.0	1,152.0	700.0	826.0	632.0	851.0	1,255.0	1,569.0	-	-
Average	235	211	212	233	192	100	138	105	170	179	224	232	2,093

Table I-6 MONTHLY RAINFALL AT MENGGALA

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1972	320.0	434.0	535.0	121.0	188.0	6.0	10.0	1.0	0	0	188.0	395.0	2,198.0
1973	280.0	451.0	364.0	125.0	395.0	212.0	17.0	-	-	-	-	-	-
1974	211.0	314.0	438.0	228.0	28.0	92.0	133.0	116.0	209.0	289.0	301.0	387.0	2,746.0
1975	444.0	290.0	229.0	261.0	153.0	47.0	196.0	152.0	170.0	385.0	193.0	149.0	2,669.0
1976	198.0	176.0	499.0	222.0	85.0	50.0	37.0	81.0	22.0	79.0	152.0	202.0	1,803.0
1977	266.0	213.0	329.0	125.0	115.0	141.0	131.0	4.0	78.0	14.0	226.0	591.0	2,233.0
1978	286.0	423.0	421.0	75.0	125.0	228.0	226.0	30.0	233.0	255.0	264.0	260.0	2,826.0
Total	2,005.0	2,301.0	2,815.0	1,157.0	1,089.0	776.0	750.0	384.0	712.0	1,022.0	1,324.0	1,984.0	-
Average	286.4	328.7	402.1	165.3	155.6	110.9	107.1	64.0	118.7	170.3	220.7	330.7	2,461.0

Table I-7 MONTHLY SUNSHINE DURATION AT BELITANG

(Unit: Hr)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1969	4.94	-	-	5.85	-	-	-	-	-	-	5.78	4.35	-
1970	-	-	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	4.48	4.69	-	-	-	-	-	-	-	-	-
1972	4.00	-	5.10	6.60	6.30	7.20	-	6.80	5.30	4.50	4.80	4.30	-
1973	5.60	5.60	4.30	5.10	5.50	5.40	-	6.40	4.80	6.30	5.70	3.40	-
1974	2.50	4.00	5.70	7.40	6.10	6.00	5.80	5.50	5.30	4.80	4.70	4.00	5.15
1975	4.10	4.00	-	5.00	-	5.00	5.10	5.80	5.70	5.60	5.40	3.20	-
1976	2.90	5.60	4.70	-	7.40	6.60	5.70	6.30	5.90	4.50	4.40	5.00	-
1977	3.50	3.60	4.20	6.70	7.20	6.60	6.70	6.60	6.50	5.60	4.90	5.10	5.60
1978	5.40	-	-	5.30	5.90	4.90	4.10	5.90	4.30	3.40	4.20	3.40	-
1979	4.20	3.40	4.98	4.80	6.10	5.10	4.50	4.50	4.00	5.76	5.02	4.85	4.77
1980	3.89	4.63	5.63	3.65	5.99	-	-	-	-	-	-	-	-
Average	4.10	4.40	4.89	5.51	6.31	5.85	5.32	5.98	5.23	5.06	4.99	4.18	5.17

Table I-8 MONTHLY SOLAR RADIATION AT BELITANG

(Unit: mmH_2O)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1971	-	-	-	-	-	-	-	-	-	-	-	14.0	-
1972	13.4	-	-	-	-	12.6	13.7	12.4	12.2	12.1	13.3	13.6	-
1973	13.5	14.0	11.9	13.9	12.7	12.0	13.4	13.9	11.4	13.7	13.7	11.2	12.9
1974	10.3	11.6	12.9	14.5	12.5	-	11.4	12.3	12.7	14.1	13.9	13.5	-
1975	12.2	11.8	-	13.1	12.3	11.0	10.7	12.3	12.9	13.8	13.6	11.2	-
1976	9.2	12.9	13.1	14.0	13.4	12.4	12.2	13.5	14.3	14.5	13.8	13.3	13.1
1977	11.2	11.8	12.8	14.2	13.2	12.1	12.3	13.5	14.1	13.9	13.1	12.2	12.9
1978	-	12.6	-	14.8	13.8	12.0	8.9	14.1	-	12.1	8.4	16.0	-
1979	12.0	13.1	15.4	14.5	12.5	12.8	10.0	13.0	14.3	14.1	14.0	11.7	13.1
1980	10.7	11.9	16.6	12.8	13.7	-	-	-	-	-	-	-	-
Average (mmH_2O)	11.6	12.5	13.8	14.0	13.0	12.1	11.6	13.1	13.1	13.5	13.0	13.0	13.0
Average (Cal/cm^2)	365.5	387.9	425.3	428.0	401.4	377.1	365.5	404.1	404.1	414.9	401.4	401.4	401.4

Table I-9 MONTHLY SOLAR RADIATION AT MENGGALA

(Unit: gm Cal/cm^2)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	480.3	473.0	462.0	458.0	454.7	416.7	381.3	412.7	467.7	474.0	493.7	439.3	451.1
1976	-	465.0	492.0	483.7	479.0	454.0	421.7	466.7	464.3	427.0	442.3	481.3	-
1977	417.3	435.3	466.7	494.7	472.0	444.3	438.7	470.3	456.0	486.7	480.3	492.0	462.9
Average	448.8	457.8	473.6	478.8	468.6	438.3	413.9	449.9	462.7	462.6	472.1	470.9	458.5

Table I-10 MONTHLY AIR TEMPERATURE AT BELITANG

(Unit: C°)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1969	27.4	27.0	28.0	27.8	28.3	27.4	27.5	27.1	27.9	28.0	28.0	-	-
1970	-	-	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	26.1	28.1	26.7	27.8	27.8	27.2	27.5	27.8	-	26.5	-
1972	25.8	26.7	26.7	26.9	27.4	28.0	27.9	28.1	28.4	28.8	28.3	27.6	27.6
1973	27.6	27.4	27.6	28.1	27.5	27.5	28.2	27.3	26.7	27.3	27.8	26.4	27.5
1974	26.1	26.0	26.9	28.0	27.7	27.3	26.8	27.3	26.7	27.7	27.0	26.5	27.0
1975	26.6	26.5	-	27.8	28.1	27.7	26.8	27.4	27.1	27.3	27.0	26.8	-
1976	21.3	26.7	27.0	27.5	-	27.8	27.4	27.8	28.2	27.6	27.4	27.4	-
1977	26.7	26.5	27.0	27.8	28.1	27.5	27.6	28.1	28.4	29.2	28.3	27.4	27.7
1978	27.1	27.6	27.7	27.9	27.1	27.7	27.2	28.0	-	27.5	27.4	26.8	-
1979	27.0	27.1	27.9	28.1	28.3	28.1	28.3	27.6	27.7	22.2	22.7	26.9	26.7
1980	27.1	27.1	27.4	27.7	28.2	-	-	-	-	-	-	-	-
Average	26.3	26.9	27.2	27.8	27.7	27.7	27.5	27.6	27.6	27.3	27.1	26.9	27.3

Table I-11 MONTHLY AIR TEMPERATURE AT BANDING AGUNG

(Unit: C°)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	23.3	23.9	24.0	24.2	24.5	23.2	24.3	22.8	23.4	23.8	24.3	23.7	23.8
1976	22.4	22.7	23.9	23.9	24.2	24.0	23.7	24.0	23.2	23.6	23.5	23.3	23.5
1977	22.9	23.2	23.7	25.0	24.0	23.9	23.2	23.2	24.2	24.5	24.0	24.3	23.8
1978	23.6	24.3	24.6	24.4	24.3	24.9	24.4	22.9	24.0	24.1	24.0	23.6	24.1
1979	23.0	24.9	23.0	23.7	23.9	22.4	23.7	24.1	23.8	24.8	24.5	20.9	23.6
1980	23.7	22.3	24.2	23.7	-	-	-	-	-	-	-	-	-
Average	23.2	23.6	23.9	24.2	24.2	23.7	23.9	23.4	23.7	24.2	24.1	23.2	23.8

Table I-12 MONTHLY AIR TEMPERATURE AT MENGGALA

(Unit: C°)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	27.0	27.2	26.6	27.8	27.6	26.1	24.9	25.5	25.7	26.0	26.3	25.3	26.3
1976	-	27.5	27.6	27.7	27.7	26.9	26.9	27.9	28.0	27.7	27.7	28.0	27.6
1977	27.5	27.1	27.7	28.0	28.9	27.8	27.2	27.8	28.0	28.4	28.3	29.0	28.0
Average	27.3	27.3	27.3	27.8	28.1	26.9	26.3	27.1	27.2	27.4	27.4	27.4	27.3

Table I-13 MONTHLY RELATIVE HUMIDITY AT BELITANG

(Unit: %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1969	82	84	82	82	82	83	77	75	77	75	78	81	80
1970	82	80	82	83	82	82	80	76	77	81	82	82	81
1971	85	84	85	81	80	80	74	72	77	78	-	85	-
1972	86	83	85	85	84	81	73	75	70	68	75	81	79
1973	81	83	83	82	84	82	74	79	83	81	79	83	81
1974	82	82	82	81	80	80	80	80	82	79	82	78	81
1975	82	81	83	82	80	79	79	80	80	80	81	81	81
1976	83	80	82	82	-	76	76	76	70	80	81	81	-
1977	84	83	83	84	84	81	77	73	72	67	75	83	79
1978	82	84	83	84	83	81	82	79	81	80	81	83	82
1979	84	84	81	84	80	80	81	77	79	79	81	83	81
1980	82	81	77	84	82	-	-	-	-	-	-	-	-
Average	83	82	82	83	82	80	78	77	77	77	80	82	80

Table I-14 MONTHLY RELATIVE HUMIDITY AT BANDING AGUNG

(Unit: %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	82	78	82	79	75	81	72	85	81	83	80	87	80
1976	82	86	88	81	85	84	86	81	83	81	82	83	84
1977	82	87	80	82	-	88	89	88	82	85	80	77	-
1978	88	78	78	77	84	82	82	83	91	80	81	83	82
1979	88	81	85	80	81	85	85	76	82	79	82	78	82
1980	86	86	87	88	-	-	-	-	-	-	-	-	-
Average	85	83	83	82	81	81	83	83	84	82	81	82	83

Table I-15 MONTHLY RELATIVE HUMIDITY AT MENGGALA

(Unit: %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	89	88	88	88	88	93	93	92	91	91	90	90	90
1976	-	-	63	71	-	-	-	65	63	70	71	71	-
1977	62	59	59	76	84	64	58	53	53	51	51	57	57
Average	76	74	70	78	86	79	76	70	69	71	71	73	73

Table I-16 MONTHLY MEAN WIND VELOCITY AT BELITANG

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1971	-	-	-	-	-	-	-	-	-	-	-	3.2	-
1972	4.6	3.6	3.6	2.6	2.8	3.1	3.9	4.8	4.7	4.3	3.4	3.5	3.7
1973	4.5	4.3	3.7	2.6	2.4	2.3	2.7	3.0	3.2	3.0	2.9	3.8	3.2
1974	-	4.4	3.6	2.8	2.8	2.6	2.9	3.2	3.2	2.6	3.1	3.3	-
1975	3.4	3.7	-	2.6	2.5	2.9	3.3	3.4	2.7	2.7	2.9	3.0	-
1976	3.9	3.1	3.0	2.5	2.4	2.3	3.1	3.1	3.1	2.5	2.2	2.6	3.0
1977	3.1	3.3	2.9	2.2	2.1	2.3	3.1	3.5	3.2	3.6	2.4	3.0	2.9
1978	-	3.0	-	2.6	2.7	1.8	3.2	2.4	-	2.4	2.5	3.3	-
1979	3.4	3.1	3.0	2.5	2.2	2.2	2.3	2.8	2.7	2.5	2.3	3.2	2.7
1980	3.7	3.6	2.8	2.3	1.9	-	-	-	-	-	-	-	-
Average	3.8	3.6	3.2	2.5	2.4	2.4	3.1	3.3	3.3	3.0	2.7	3.2	3.1

Table I-17 MONTHLY MEAN WIND VELOCITY AT BANDING AGUNG

(Unit: Km/hr)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	3.8	-	4.4	4.6	4.5	4.2	5.6	4.5	4.8	5.1	5.5	4.2	-
1976	2.4	2.6	-	-	-	-	-	-	-	-	-	-	-
Average	3.1	2.6	4.4	4.6	4.5	4.2	5.6	4.5	4.8	5.1	5.5	4.2	4.4

Table I-18 MONTHLY MEAN WIND VELOCITY AT MENGGALA

(Unit: Km/hr)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	2.2	2.4	2.0	2.0	2.2	2.4	2.6	2.7	2.5	2.6	2.5	2.7	2.4
1976	-	2.4	2.7	2.6	3.0	2.9	3.4	3.1	3.6	2.3	2.3	2.4	-
1977	2.6	3.0	2.7	2.1	2.4	2.5	3.2	3.3	4.1	3.0	2.5	2.8	2.9
Average	2.4	2.6	2.5	2.2	2.5	2.6	3.1	3.0	3.4	2.6	2.4	2.6	2.7

Table I-19 MONTHLY EVAPORATION AT BELITANG

(by Class - A Pan)

(Unit: mm/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1971	-	-	6.3*	6.4*	6.2*	4.3*	-	-	-	-	-	-	-
1972	-	-	-	-	4.7	4.7	5.5	5.9	5.9	-	5.3	5.1	-
1973	5.1	-	-	-	4.7	4.2	4.9	-	4.2	-	4.9	4.5	-
1974	4.3	4.3	-	5.5	-	-	-	5.1	-	-	-	4.6	-
1975	4.0	4.3	-	4.9	-	4.1	-	4.7	4.8	4.9	5.0	4.2	-
1976	3.8	4.3	4.6	4.9	4.4	4.4	4.3	4.9	4.9	4.4	4.4	4.4	4.5
1977	3.8	3.8	4.1	4.4	4.3	4.0	4.1	4.5	5.0	5.3	3.6	4.8	4.3
1978	-	4.3	-	4.5	4.3	3.9	3.7	4.4	5.1	-	4.5	4.3	-
1979	5.2	5.0	5.2	4.5	4.5	4.0	3.6	4.7	4.5	5.1	4.7	4.2	4.6
1980	5.0	4.4	5.3	4.1	4.4	-	-	-	-	-	-	-	-
Average (mm/day)	4.5	4.3	5.1	4.9	4.7	4.2	4.4	4.9	4.9	4.9	4.6	4.5	4.5

Note * : The value measured by Piche evaporation.

Table I-20 MONTHLY EVAPORATION AT BANDING AGUNG

(by Class - A Pan)

(Unit: mm/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	5.8	4.9	5.5	5.0	4.7	5.1	6.7	5.4	5.8	-	-	5.0	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	4.9	5.3	3.3	3.5	5.1	5.4	4.9	5.4	5.1	5.6	5.2	4.6	4.9
1979	5.0	4.7	3.7	2.6	2.7	3.1	3.7	3.4	3.5	3.6	2.9	2.4	3.4
1980	3.6	3.3	4.3	3.7	-	-	-	-	-	-	-	-	-
Average	4.8	4.6	4.2	3.7	4.2	4.5	5.1	4.7	4.8	4.6	4.1	4.8	4.2

Table I-21 MONTHLY EVAPORATION AT MENGGALA

(by Class - A Pan)

(Unit: mm/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	6.1	3.7	5.5	4.7	4.2	3.0	4.3	5.0	-	8.6	5.7	4.6	-
1976	-	6.2	8.7	6.1	5.3	3.5	3.6	4.1	4.1	4.4	5.0	5.1	-
1977	5.4	7.0	7.6	5.2	3.7	5.6	3.8	3.8	4.6	4.2	5.0	7.2	5.3
Average	5.8	5.6	7.3	5.3	4.4	3.0	3.9	4.3	4.4	5.7	5.2	5.6	5.1

Table I-22 MONTHLY RAINFALL AT MUARDUA

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1963	(163)	(172)	(112)	(244)	(141)	(87)	(60)	(132)	(7)	(41)	(99)	(264)
1964	(162)	(219)	(141)	(374)	(258)*	(139)*	(160)*	(172)*	(155)	(115)	(222)	(283)*
1965	(99)	(34)	(91)	(166)	(280)	(200)	(160)	(197)	(405)	55	(259)	(397)
1966	270	100	400	102	340	219	111	124	60	167	270	380
1967	185	265	460	155	330	100	125	(172)*	(149)*	75	380	245
1968	145	65	370	275	215	250	222	210	125	250	365	340
1969	398	210	174	524	277	200	290	140	152	200	314	465
1970	307	190	340	243	495	50	141	304	192	103	299	175
1971	140	189	285	345	162	115	260	160	80	241	215	340
1972	298	219	443	358	304	(59)	(8)	(37)	(50)	(50)	(261)*	(283)*
1973	86	255	159	230	242	95	39	153	138	132	(122)	(251)
1974	129	182	111	380	219	68	299	38	327	227	115	173
1975	267	210	159	196	82	60	30	163	153	202	206	76
1976	136	148	261	197	89	9	76	67	24	309	352	331
1977	253	319	134	402	153	214	55	15	109	17	182	387
1978	191	187	259	156	304	190	217	70	190	341	166	287
1979	193	281	259	426	268	129	157	165	85	121		

Note ( ) : Estimated from correlation between Muaradua and Baturaja.

( )* : Average of the monthly rainfall.

Table I-23 ACTUAL EVAPOTRANSPIRATION IN THE BASIN

Month	Eo mm/day	Mean Albedo %	E_T mm/day	Vegetation factor %	E_{Ta} mm/day
Jan.	4.56	14.7	3.9	80	3.1
Feb.	4.71	"	4.1	"	3.3
Mar.	4.91	"	4.2	"	3.4
Apr.	4.98	"	4.3	"	3.4
May	4.76	"	4.1	"	3.3
Jun.	4.43	"	3.8	"	3.0
Jul.	4.42	"	3.8	"	3.0
Aug.	4.66	"	4.0	"	3.2
Sep.	4.93	"	4.3	"	3.4
Oct.	5.20	"	4.5	"	3.6
Nov.	4.88	"	4.2	"	3.4
Dec.	4.66	"	4.0	"	3.2

Note:

Eo ; Evaporation from open water surface calculated by Penman method.

E_T ; Potential evapotranspiration.

E_{Ta} ; Evapotranspiration.

Table I-24 MONTHLY DISCHARGE AT MARTAPURA

(Unit: m^3/sec) C.A. = 4,260 Km^2

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1963	193.8	274.2	252.4	201.6	252.1	186.3	115.0	88.0	78.3	76.1	69.4	64.8	149.7
1964	141.6	166.2	204.4	266.2	138.1	118.4	118.3	100.2	99.6	116.3	115.0	203.8	149.0
1965	243.6	347.1	255.5	391.8	306.7	299.6	132.9	146.7	108.8	86.6	125.6	120.2	213.7
1966	155.2	133.6	141.7	132.3	233.0	217.5	129.8	119.4	101.8	99.3	122.7	237.9	160.3
1967	182.6	241.9	360.3	214.9	269.8	146.6	127.2	76.9	77.1	71.4	106.2	118.1	167.7
1968	113.9	103.7	150.6	204.2	177.7	212.4	194.0	173.9	126.2	143.6	275.1	307.9	181.9
1969	369.3	292.4	175.5	407.9	316.9	246.2	264.4	160.5	140.2	137.0	228.3	383.0	260.1
1970	341.9	267.9	290.5	255.3	412.3	181.0	143.4	217.7	179.7	132.9	189.7	157.7	230.8
1971	293.2	163.4	200.9	399.7	227.3	141.1	99.9	96.7	98.3	178.4	260.5	287.7	203.9
1972	336.9	321.9	309.5	416.3	471.5	200.9	91.9	71.2	59.3	45.1	71.2	189.5	215.4
1973	244.4	292.4	241.6	316.7	292.7	219.2	111.2	128.9	272.3	224.1	221.9	222.4	232.3
1974	113.6	230.9	119.6	261.6	278.0	113.3	96.5	98.6	206.7	218.6	190.6	236.0	180.3
1975	260.0	380.3	188.3	306.9	136.8	172.5	189.0	230.9	231.7	228.0	307.4	206.5	236.5
1976	306.0	294.9	372.0	447.9	130.6	190.1	152.6	167.8	150.6	370.8	321.7	385.7	274.2
1977	371.3	465.7	257.8	427.0	256.7	238.9	131.0	105.6	102.9	78.5	98.8	249.5	231.9
1978	258.8	273.7	297.9	224.7	288.6	234.7	215.8	129.4	136.6	190.2	187.3	308.0	228.8
MEAN	245.4	262.5	244.9	304.7	261.8	194.9	144.6	133.3	135.6	149.5	180.7	229.9	207.3

Table I-25 MONTHLY DISCHARGE AT BANDING AGUNG

(Unit: m^3/sec) C.A.= 508 Km^2

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1963	16.5	17.7	18.6	16.8	18.6	16.2	16.9	13.9	12.1	10.7	10.4	9.5	14.8
1964	17.2	15.3	16.9	18.9	17.2	17.0	17.0	16.4	16.4	17.0	16.9	16.9	16.9
1965	18.3	20.6	18.6	21.1	19.9	19.7	17.2	17.2	16.8	13.7	17.1	17.1	18.1
1966	17.1	17.2	18.2	17.2	18.0	17.4	17.2	17.0	16.5	16.4	17.1	18.1	17.3
1967	16.0	18.2	20.7	17.3	19.0	17.2	17.2	16.3	11.8	10.8	16.7	17.0	16.5
1968	16.9	16.6	17.1	16.9	15.8	17.2	16.5	15.6	17.1	17.2	19.2	19.9	17.2
1969	20.8	19.6	15.7	21.2	20.1	18.4	18.9	17.0	17.2	17.2	17.8	21.0	18.7
1970	20.5	19.0	19.5	18.6	21.2	16.0	17.2	17.4	15.9	17.2	16.3	17.0	18.0
1971	19.7	17.0	16.6	21.1	17.6	17.2	14.1	13.8	16.0	16.3	18.9	19.5	17.3
1972	20.4	29.4	28.8	27.8	28.8	20.9	14.6	11.4	8.8	6.4	7.7	10.1	17.9
1973	13.8	17.0	19.1	20.9	18.2	17.8	15.8	15.4	18.2	20.4	20.4	18.2	17.9
1974	16.2	16.2	17.0	17.4	15.4	13.8	18.0	14.6	22.3	21.4	17.1	16.3	17.1
1975	20.4	21.8	18.2	20.4	20.4	17.8	12.8	13.1	13.5	12.8	14.2	13.1	16.5
1976	18.8	22.7	22.4	22.9	22.5	16.8	13.7	15.4	11.8	13.5	18.0	17.2	18.0
1977	20.0	24.9	21.3	27.9	25.7	24.4	22.3	17.9	16.0	14.9	14.3	18.5	20.9
1978	17.8	18.4	20.9	19.8	20.4	17.5	17.4	18.2	16.2	16.5	23.0	19.9	18.8
MEAN	18.2	19.5	19.4	20.4	19.9	17.8	16.7	15.7	15.4	15.2	16.6	16.8	17.6

Table I-26 WATER QUALITY ANALYSIS

RIVER		KOMERING		KOMERING	
LOCATION		KAYU AGUNG		KANGKUNG	
SAMPLE NO.		1 - 1	1 - 2	2 - 1	2 - 2
DATE OF COLLECTION		Sep. 30. 1979	Oct. 30. 1979	Oct. 9. 1979	Oct. 30. 1979
PH		6.90	6.60	6.80	7.10
Electric Conductivity	v/cm	7.565 x 10	3.490 x 10	7.240 x 10	6.785 x 10
Na	meq/ℓ	0.02	0.01	0.02	0.02
	mg/ℓ	0.52	0.27	0.47	0.41
K	meq/ℓ	0.03	0.02	0.03	0.03
	mg/ℓ	1.07	0.93	1.07	1.07
Ca	meq/ℓ	0.25	0.08	0.30	0.27
	mg/ℓ	5.07	1.54	5.95	5.51
Mg	meq/ℓ	0.13	0.04	0.13	0.13
	mg/ℓ	1.58	0.51	1.64	1.54
Alkalinity	meq/ℓ	0.48	0.08	0.50	0.46
Cl	meq/ℓ	0.12	0.16	0.18	0.11
	mg/ℓ	4.15	5.70	6.22	3.97
SO_4	meq/ℓ	0.12	0.08	0.10	0.09
	mg/ℓ	5.53	3.62	4.91	4.51
SiO_2	mg/ℓ	38.52	20.69	35.36	35.46
Σ^2 Cation	meq/ℓ	0.43	0.15	0.48	0.45
Σ Anion	meq/ℓ	0.71	0.32	0.78	0.67
Σ Ion	meq/ℓ	1.15	0.47	1.26	1.11
Evaporated Residue	ppm	85.8	85.7	153.9	144.6
Surface Substance	ppm	15.0	41.9	70.4	81.2
NO_3 - N	ppm	0.10	0.25	0.10	0.09
$KMnO_4$ demand	ppm	21.5	39.5	20.1	21.8
B	ppm	0.03	0.02	0.03	0.03

Fig. I-1 LOCATION MAP OF HYDRO-METEOROLOGICAL STATION

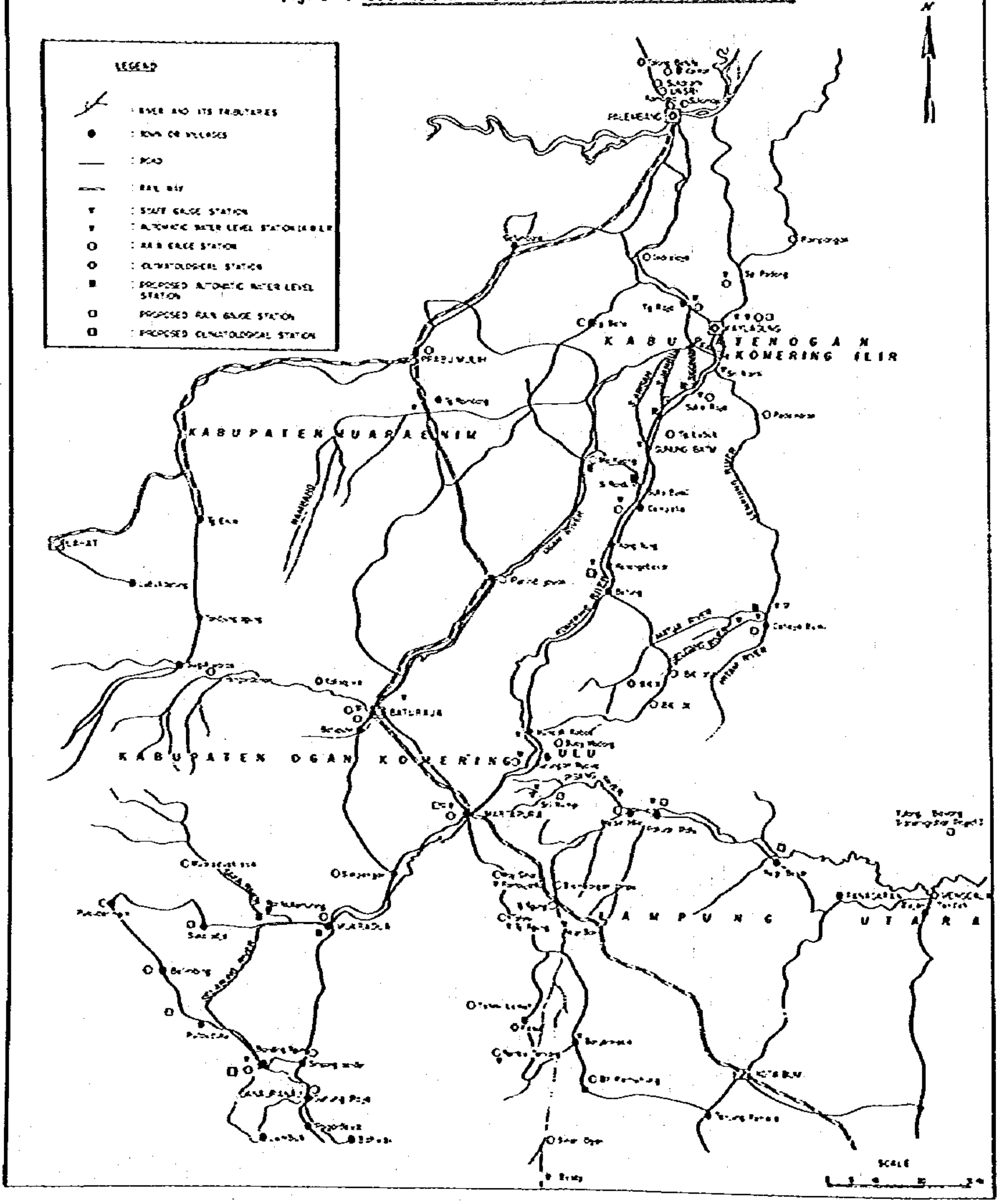


Fig. I-2 AVAILABLE DAILY RAINFALL DATA (1/2)

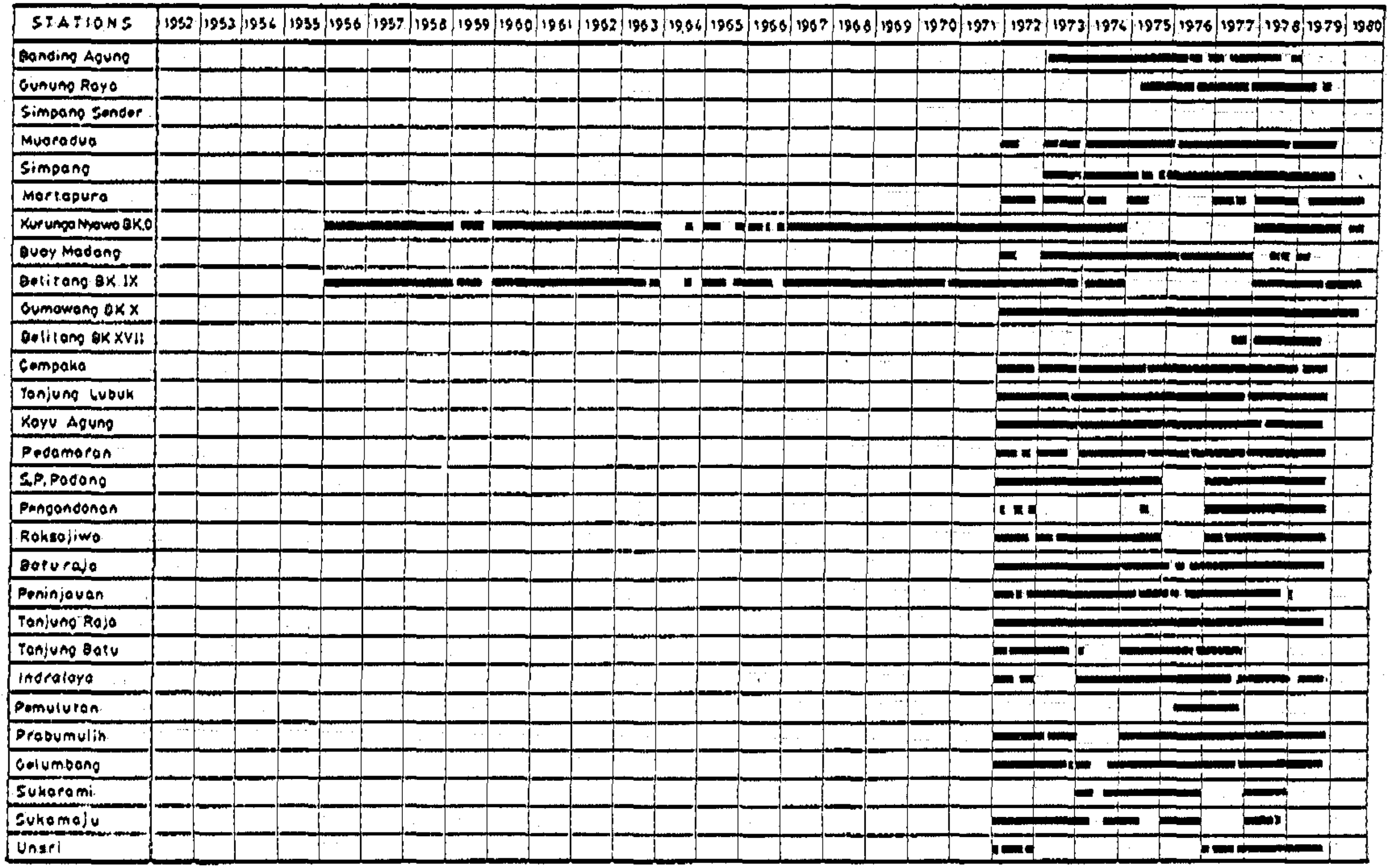


Fig. I-2 AVAILABLE DAILY RAINFALL DATA (2/2)

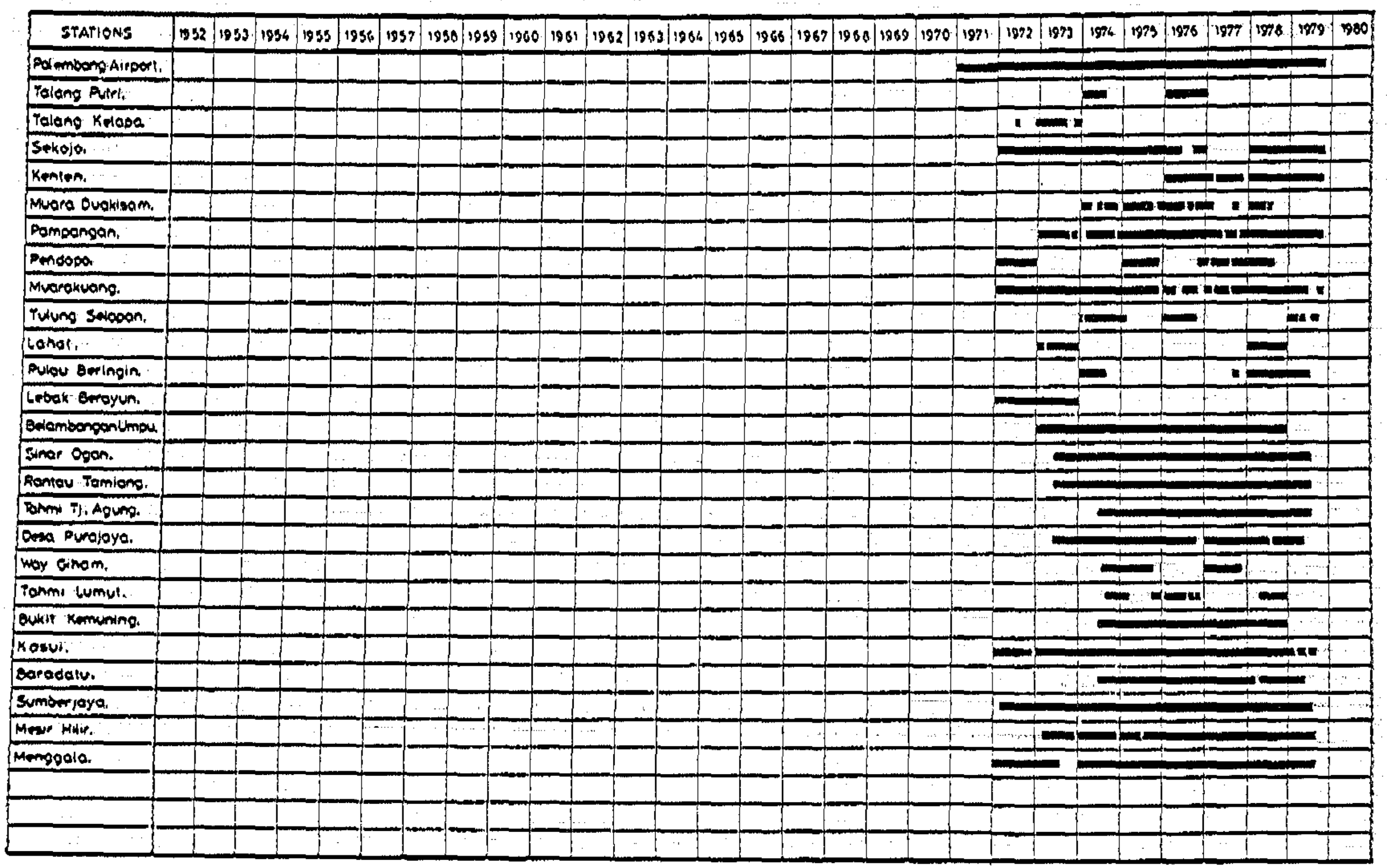


Fig. I - 3 AVAILABLE MONTHLY RAINFALL DATA

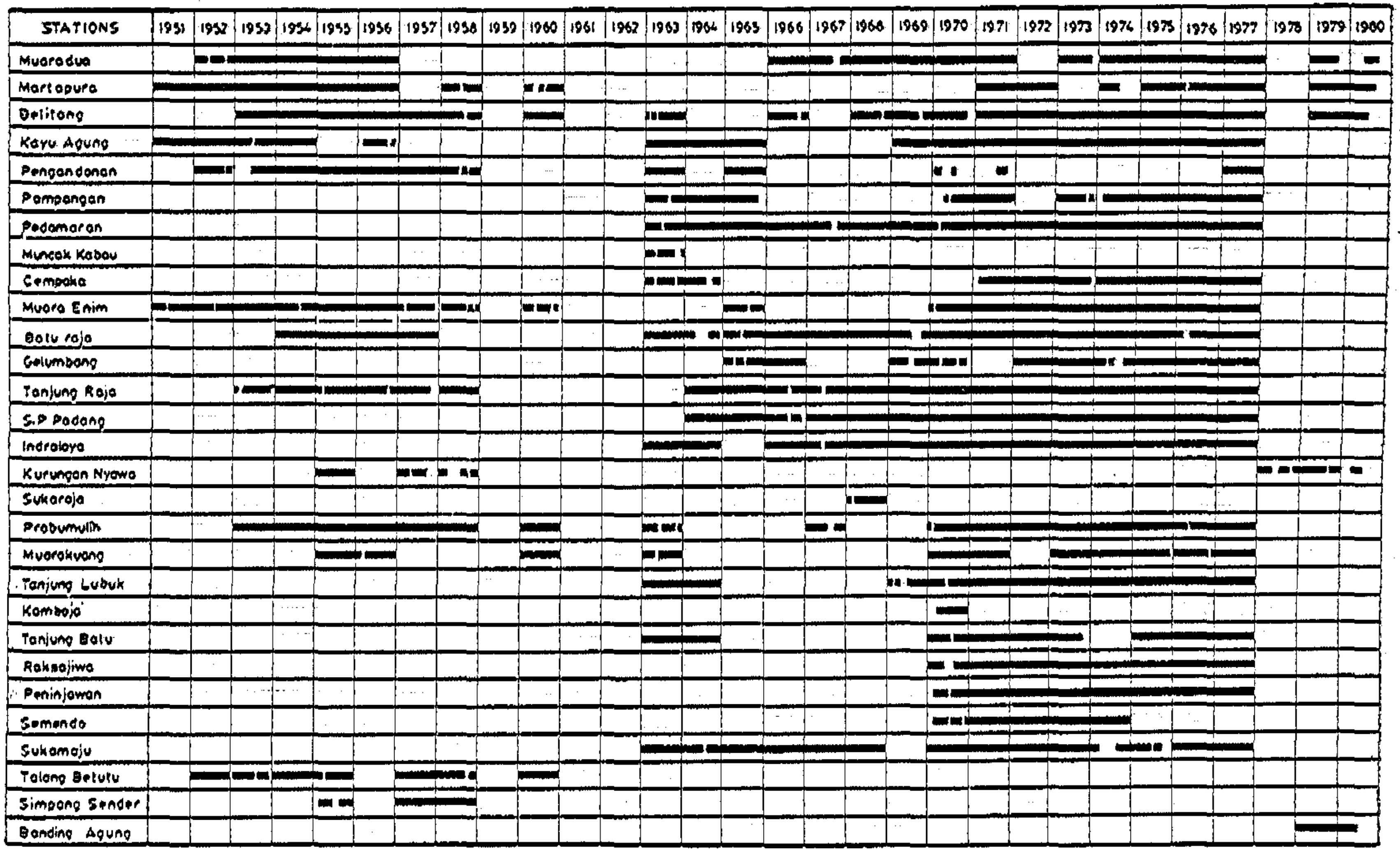


Fig. I－4　AVAILABLE CLIMATOLOGICAL DATA

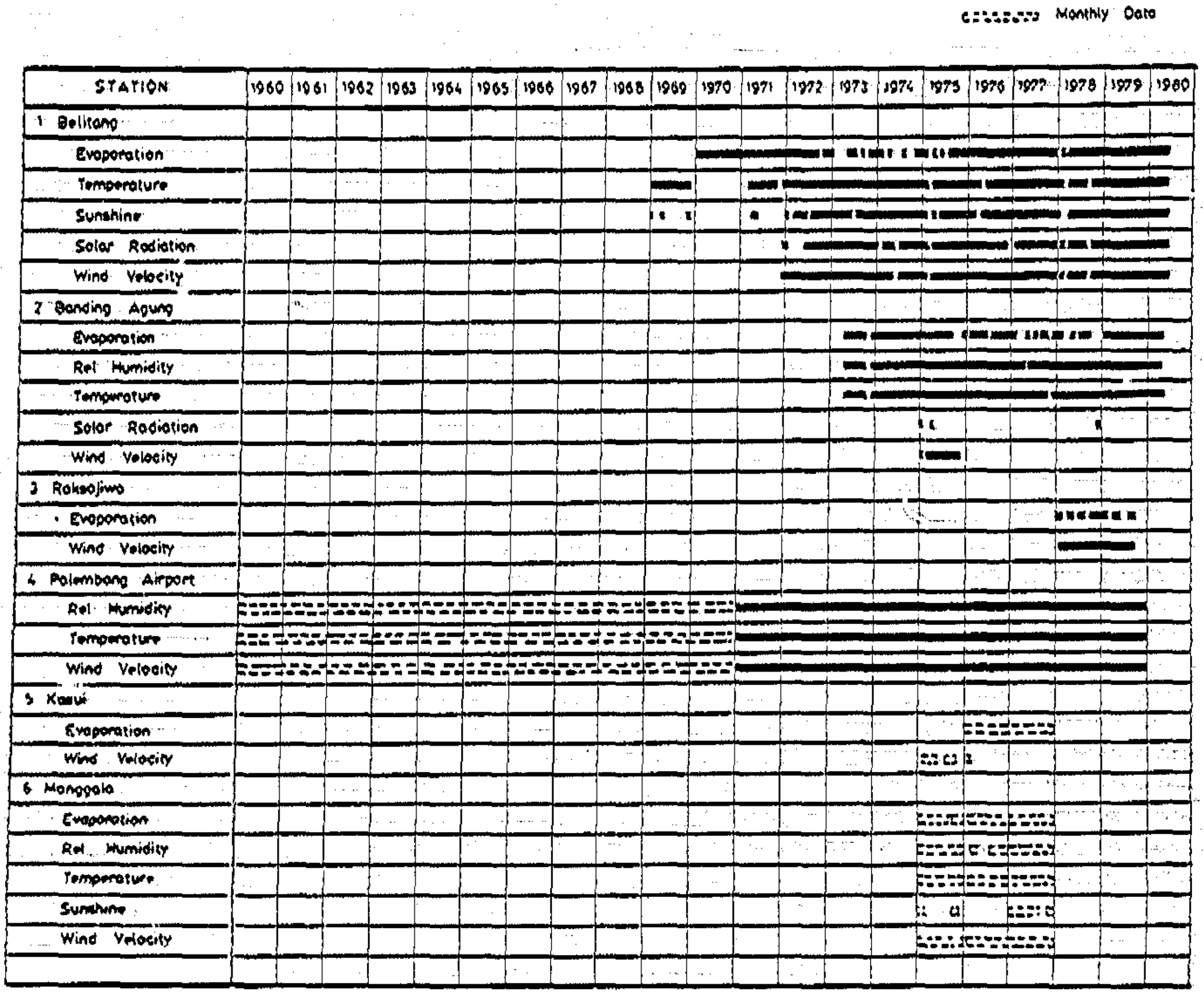


Fig. I — 5 RATING CURVE AT BANDING AGUNG (SELABUNG RIVER)

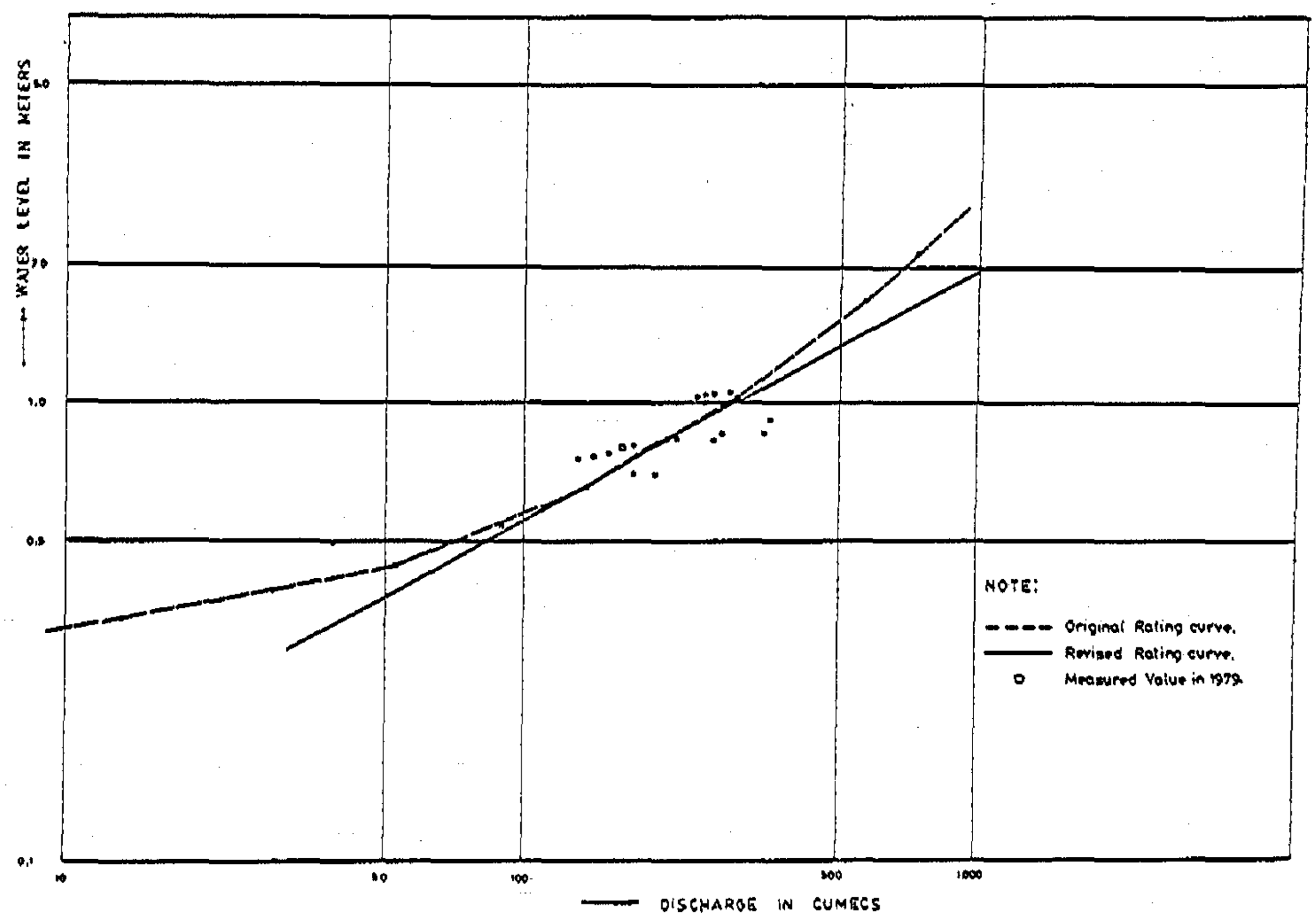


Fig. I−6 RATING CURVE AT MARTAPURA (KOMERING RIVER)

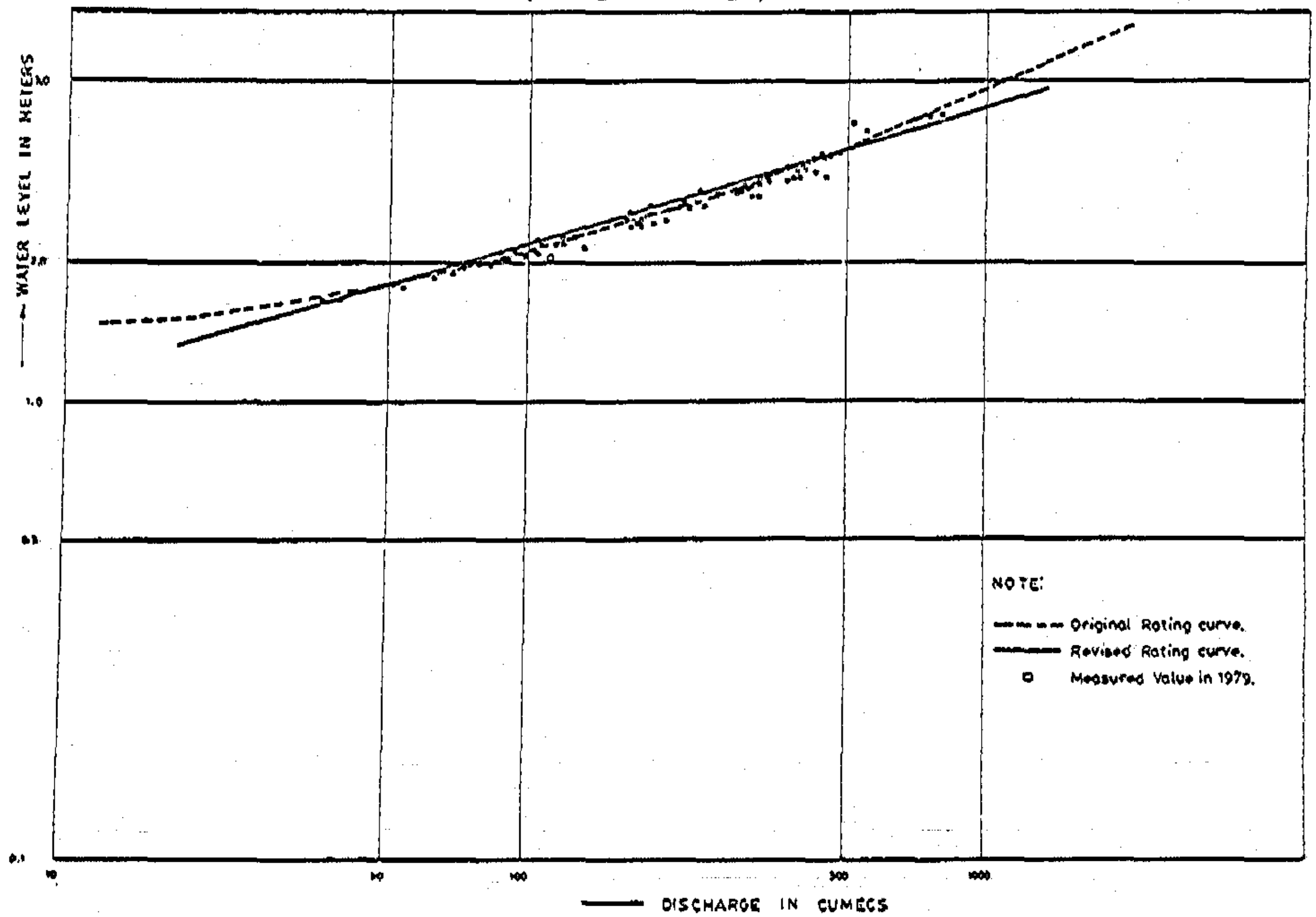


Fig.I-7 ASSUMED TANK

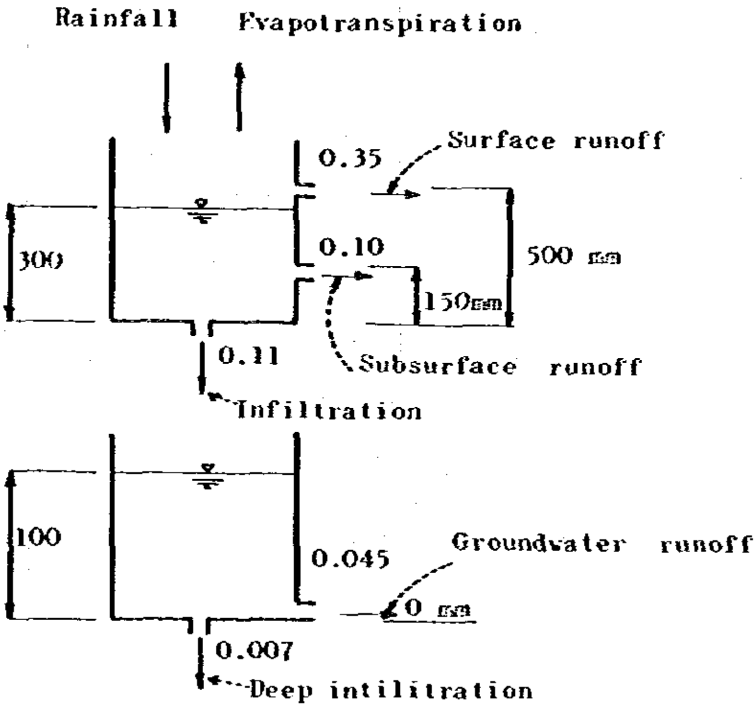


Fig I - 8 CORRELATION OF STREAMFLOWS BETWEEN WHOLE BASIN AND RESIDUAL BASIN

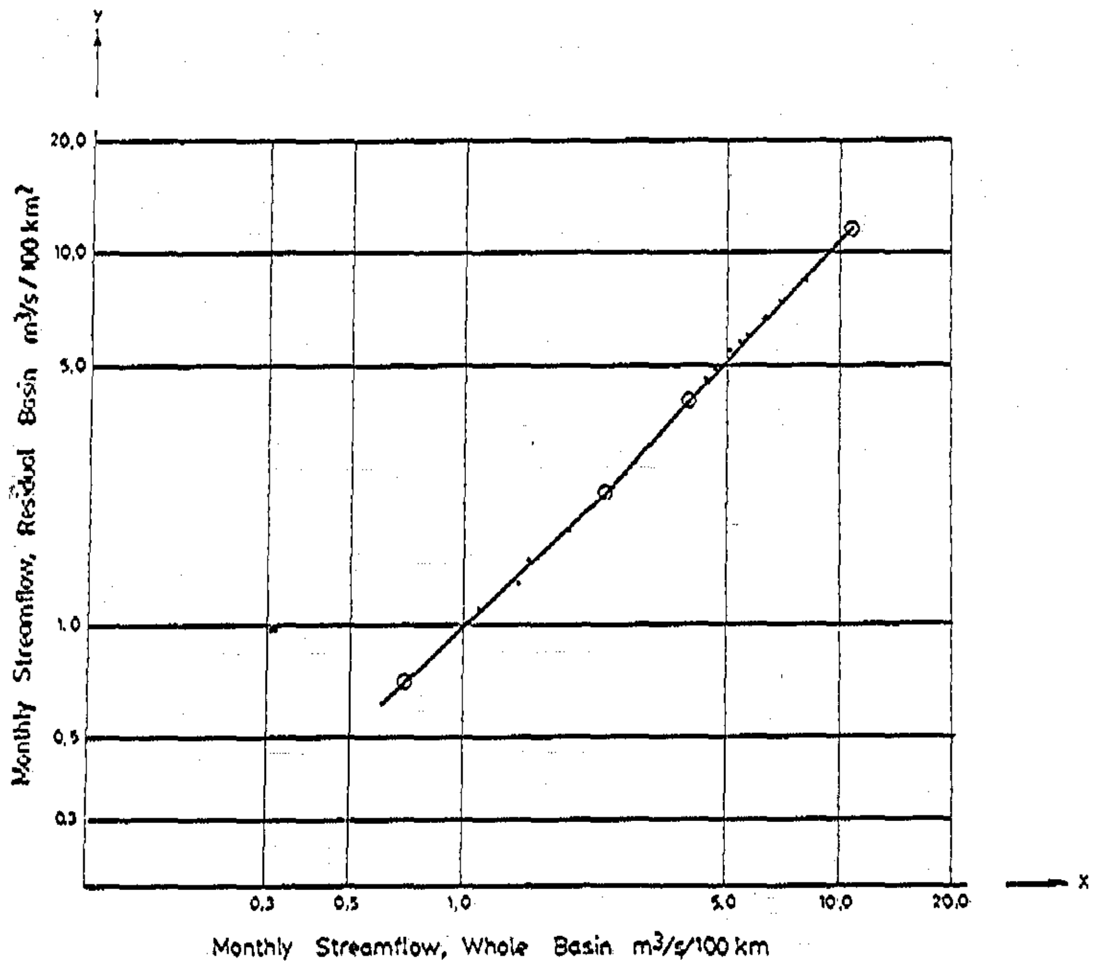
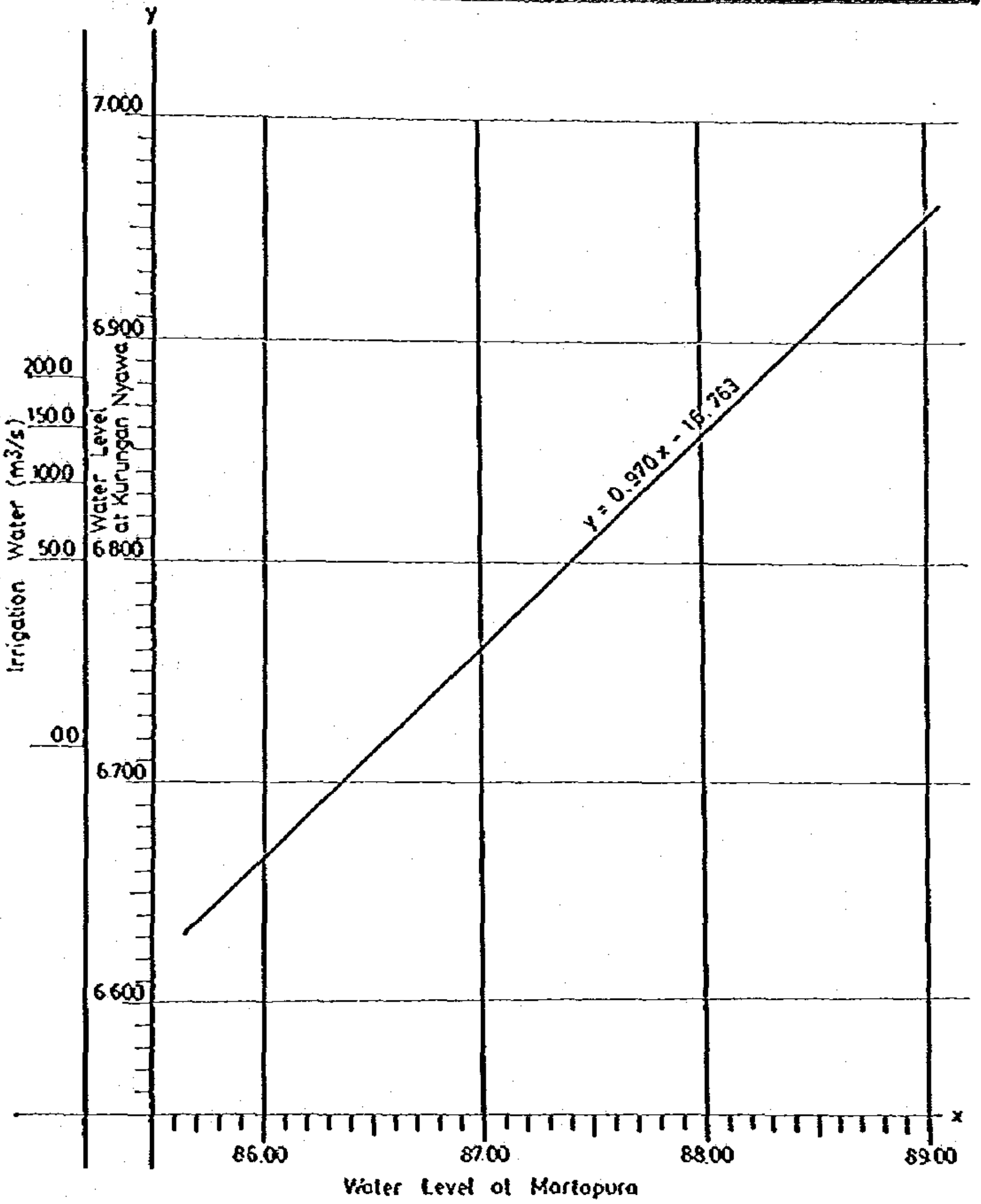


Fig I-9 CORRELATION OF WATER LEVEL BETWEEN MARTAPURA AND KURUNGAN NYAWA



ANNEX II

SOIL AND LAND SUITABILITY

ANNEX - II

SOIL AND LAND SUITABILITY

1. SOIL

1.1 History of Soil Study

In the past, the soil investigations and studies in the Belitang and its surrounding areas have been carried out by several experts as summarized below.

(1) First study was done by Dr. Van der Voort/1 on morphology and distribution of soils in the Belitang Proper Area in 1936 and detailed soil map on a scale of 1: 10,000 was prepared for about 12,000 ha of farmlands in the alluvial plain lying among the hills.

(2) Dr. M. Soepraptohardjo conducted the reconnaissance soil survey for about 200,000 ha in the southern part of South Sumatra Province in 1957.

(3) In 1971, the exploratory Soil Map of Southern Sumatra/2 on a scale of 1: 1,000,000 as an attachment of Indonesia Text, was published by the Soil Research Institute in Bogor.

(4) FAO/UNDP started the reconnaissance survey in Southeastern Sumatra from 1970 and completed the survey in 1976. Based on the survey results with the interpretation of aerial photographs, FAO prepared the reconnaissance soil map and land capability map covering about 43,000 Km^2/3.

/1 Van der Voort, M.(1936): Versalang Van De Bodenkundige Kaerteering Van Het Belitang Gebied.

/2 Soil Research Institute, Bogor (1971): An explanatory text to the exploratory soil map of South Sumatra.

/3 FAO/UNDP (1976): Land and Water Resources Development in Southeast Sumatra, INDONESIA, FAO/UNDP, AG; DP/INS/69/518.

(5) Besides, for the detailed planning of agricultural development in both the Belitang Proper and Extension Areas, FAO/UNDP carried out the soil survey in 160,000 ha of the said areas in 1972, and prepared the soil map on a scale of 1: 50,000/1.

(6) Thence, for the comprehensive study on the Upper Komering River Basin Development Project, JICA carried out the reconnaissance soil survey over the total area of about 500,000 ha and prepared the soil map and land capability map on a scale of 1: 100,000 in 1980/2.

1.2 Survey Area

The present soil survey is carried out over the total area of around 90,000 ha. The survey area is broadly divided into two sub-areas by the Pisang river; the Belitang Extension Central Area (83,000 ha) and the Pisang Area (7,000 ha). The topography of the Belitang Extension Central Area is characterized by flat alluvial plain and flat or almost flat to gently sloping peneplain/3. The Pisang Area is located on the extension of this peneplain.

It is considered that the alluvial plain was formerly formed by the old Komering river or its branch. But the present alluvial plain in the Project Area belongs to the inland river basin of two main rivers, the Belitang and the Macak, which run in the northeast direction along the foot of southeastern and northwestern peneplains. These two rivers are serving to drain the alluvial plain. As a result, the alluvial plain does not suffer from severe flooding.

/1 FAO/UNDP (1973) : Belitang Extension Area Agricultural Development Project, FAO/UNDP, AGL; SP/INS/18-1. Annex E.

/2 JICA (1980) : Comprehensive Study on the Upper Komering River Basin Development.

/3 Peneplain is physiographically defined as the land which had been eroded up to the base level of erosion and has generally flat or almost flat topography.

The peneplain is geomorphologically separated into two planation surfaces, upper and lower. These two surfaces are covered with residium derived from sandstone, claystone or volcanic materials. An additional planation surface, i.e. river terrace, exists locally on the foot of the peneplain. The land is composed of recent alluvium derived from adjacent hills and mountains. The fairly notable discontinuity of topography bordered by escarpment with slopes of more than 5% is found between the surfaces.

The soils of the Project Area can broadly be divided into five according to their physiographical conditions, i.e., 1) Soils on the peneplain, 2) Soils on the river terrace, 3) Soils on the alluvial plain, 4) Soils on the natural levee and 5) Soils on the swale or depression.

In reference to the past soil studies, the extents of Great Soil Group/1 nearly coincide with their topographical features as follows:

(1) Peneplain------------------ Podzolic Soils,

(2) River terrace-------------- Alluvial Soils, Hydromorphic Soils and Gley Soils,

(3) Alluvial plain------------- Alluvial Soils, Hydromorphic Soils and Gley Soils,

(4) Natural levee-------------- Alluvial Soils and Hydromorphic Soils,

(5) Swale or depression-------- Gley Soils and Organic Soils.

The distribution and properties of these soils at the level of semi-detailed survey are discussed in the followings.

/1 The name of Great Soi Group was given by Dudal/Soepraptohardjo System in 1961.

1.3 Survey Method

1.3.1 Procedure of Field Survey and Sampling

The past surveys show that the soil in the survey area is classified into five Great Soil Groups, i.e., Podzolic Soils, Hydromorphic Soils, Alluvial Soils, Gley Soils and Organic Soils in conformity with the national soil classification system of Indonesia. The past surveys also show that these soils extend over macro and micro reliefs; peneplain, terrace, natural levee, alluvial plain, swale and depression. This information is fully taken into consideration when pre-study is carried out.

Prior to the present field survey, the division of the survey area into several physiographical units is done using the topographic map on a scale of 1: 50,000 as the base map and aerial photograph on a scale of 1: 20,000.

For the selection of test pitting and soil sampling sites, the following matters are taken into consideration:

(1) Extent of area with similar soil groups based upon the past soil survey results,

(2) Accessibility to sites,

(3) Extent of area with similar topographical features based upon the interpretation of aerial photograph.

At each sampling site, a test pit of one meter deep is dug, and profile observations are made in accordance with the Guidelines for Soil Profile Description, FAO in 1977 as follows:

(1) Thickness of horizon and horizon boundary,

(2) Color of matrix,

(3) Mottling (color, abundance, size and contrast),

(4) Texture,

(5) Structure (grade, type and size),

(6) Consistence,

(7) Compactness,

(8) Others (Cutan, Porosity, Clay coating, Rooting, etc.).

In addition, boring exploration with hand auger or stick are done to ascertain soil group boundary.

For physio-chemical analyses in laboratory, 287 soil samples are collected at the representative horizons of 92 profiles. Besides, 50 core samples are taken from typical 13 test pits. These core samples are tested for their moisture retention curves (p^F curves). In addition, the rate of infiltration (intake rate) is measured at 11 representative sites.

1.3.2 Laboratory Test

Chemical and physical properties of soils are examined at the Soil Research Institute in Bogor. The items of tests are as follows:

(1) Particle size analysis,

(2) Total carbon,

(3) Total nitrogen,

(4) $p^H(H_2O)$, pH(KCl), with soil-water or chloride ratio 1:2.5,

(5) Electric conductivity (EC),

(6) Cation exchange capacity (CEC),

(7) Exchangeable cation for Ca, Mg, Na and K,

(8) Exchange acidity,

(9) Phosphate absorption coefficient,

(10) 0.2 N HCl soluble Fe_2O_3, SiO_2 and Al_2O_3,

(11) Three phase distribution and p^F-moisture curves.

The detailed test results are shown in DATA BOOK.

1.4 Sample Numbering and Sampling Site

The pit number, location, land use, physiography and the name of Great Soil Group of each sample are given in Table II-1. Each Great Soil Group is identified according to the Dudal/Soepraptohardjo System in 1961. The locations of sampling, test pit and auger boring are plotted in the soil map (PLATE NO. 2 of Volume-III).

1.5 Soil Grouping

1.5.1 Soil Classification

The surveyed soils are classified into six Great Groups according to the national soil classification system in Indonesia/1. The Great Groups are correlated with those of modified D/S System in 1978 and FAO/UNESCO Soil Classification System in 1974 as shown in Table II-2.

These Great Groups are, furthemore, classified into 18 Sub-groups based on the color of subsoil, and then, sub-classified into 25 phases which are the special category of soil grouping to separate the soil according to the physiography significant to its practical use and management such as the difference in elevation, slope and depth due to erosion, etc. as shown in Table II-3. The developments of Great Groups, Sub-groups and Phases are summarized as in the followings. The physical and chemical status are rated by criteria shown in Table II-4, which are preliminarily estimated based on the specific degree generally accepted.

(1) Podzolic Great Group

The soils of this Great Group are the residuals of sandstone, claystone and tuff and extend widely on the peneplain in the northern and southern parts of Belitang inland river basin. Their elevations range from 2? to 90 meters. The relief is gently undulating with steep slope or escarpment at its edge. They are put

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/1 Sistem Klasifikasi tanah di Balai Penyelidikan Tanah, M. Soepraptohardjo, Bogor, 1961. (commonly called "D/S System") under erosion rather remarkably, especially on the fallow lands after extensive reclamation such as shifting culture. Their erodabilities are depending upon their land gradients. All the soils of this Great Group have horizon sequence of A-B-C in common, while the thickness of the top soil tends to become thinner with time due to the erosion. The soils are deep to moderately deep, well to moderately well drained having slow to medium drainage and moderate permeability. Groundwater table is generally deep and the land is free from flooding. There are plinthite formations in the upper or lower parts of B horizon, and coarse sands of quartz are included in A and B horizons.

This Great Group is subdivided into five Sub-groups, i.e. Yellowish Brown Podzolic, Strong Brown Podzolic, Brown Podzolic, Yellowish Red Podzolic and Red Podzolic. They are, furthermore, classified into eight Phases as shown in followings.

<u>Phase 1, Higher Elevated Yellowish Brown Podzolic Soils</u>

Podzolic Soils in Great Group, Yellowish Brown Podzolic Soils in Sub-group/1,

Plinthic and Orthic Ferralsols in Soil Unit/2.

The soils of this Phase cover the nearly flat or very gently sloping land on the upper peneplain with elevation ranging between 25 and 90 meters. Their topsoils are yellowish brown in color, medium in texture, weak subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet. Their subsoils are predominantly yellowish brown in color, fine in texture, structureless massive in structure, slightly sticky and slightly plastic in consistence when wet.

/1 According to the definition of D/S system in 1961.

/2 According to the soil classification system of FAO/UNESCO in 1974.

They have strong acid reaction throughout the profile. Their topsoils are moderately high in organic matter content, while their subsoils are low. Cation Exchange Capacity is low in both topsoil and subsoil, while Base Saturation Degree is moderately high in both soils.

The soils are mostly grown with wild grasses such as alang-alang which are dominant flora after rough reclamation. Cassava is a main crop on these soils. Other diversified crops such as maize, peanut, sweet potato, tomato and tobacco are planted in very limited scale. The upland paddy in the wet season is also cultivated within excessively limited extent. In newly reclaimed area, various perennial crops such as clove, coconut and banana are planted. The narrow valley bottoms in this peneplain are used for lowland paddy in the wet season. During the dry season, however, they are left fallow due to lack of water.

<u>Phase 2, Higher Elevated Strong Brown Podzolic Soils</u>

Podzolic Soils in Great Group, Strong Brown Podzolic Soils in Sub-group.

Plinthic and Xanthic Ferralsols in Soil Unit.

The soils of this Phase extend over the gently undulating land on the upper peneplain. Their topsoils are very dark grayish brown in color, medium in texture, weak subangular blocky in structure, slightly sticky and plastic in consistence when wet. Their subsoils are predominantly strong brown in color, fine in texture, medium subangular blocky in structure, sticky and plastic in consistence when wet.

They have strong acid reaction throughout the profile. The content of organic matter is high in topsoil, while low in subsoil. Cation Exchange Capacity and Base Saturation Degree are moderately high in topsoil, while low in subsoil.

They are almost grown with wild grasses such as alang-alang with sparse secondary forest, and only very small area is used for the cultivation of cassava and some upland crops.

Phase 5, Middle Elevated Strong Brown Podzolic Soils

Podzolic Soils in Great Group, Strong Brown Podzolic Soils in Sub-group,

Xanthic Ferralsols in Soil Unit.

The soils of this Phase develop on the gently sloping land of the lower peneplain. Their topsoils are brown in color, fine in texture, weak subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet. Their subsoils are predominantly strong brown in color, fine in texture, structureless massive in structure, slightly sticky and slightly plastic in consistence when wet.

Soil reaction is strong acid in both topsoil and subsoil. The organic matter content is high in topsoil, while low in subsoil. Their Cation Exchange Capacities and Base Saturation Degrees are low in both topsoil and subsoil.

Most lands of these soils are grown with wild grasses such as alang-alang though some small areas are used for the cultivation of cassava, peanut, tomato and other upland crops.

Phase 3, Higher Elevated Brown Podzolic Soils

Podzolic Soils in Great Group, Brown Podzolic Soils in Sub-group,

Plinthic Ferralsols in Soil Unit.

The soils of this Phase cover the gently undulating land on the upper peneplain. Their topsoils are mostly darkbrown in color, medium to fine in texture, weak subangular blocky in structure and have slightly sticky and slightly plastic to plastic consistence when wet. Their subsoils are predominantly brown in color, fine to coarse in texture, structureless massive in structure, slightly sticky and slightly plastic in consistence when wet.

They have strong acid reaction throughout the profile. The content of organic matter is moderately high in topsoil and low in subsoil. Cation Exchange Capacities are rather low in both topsoil and sub-soil, while their Base Saturation Degrees are moderately high in both soils. At present, these soils are grown with wild grasses and brush.

Phase 6, Middle Elevated Brown Podzolic Soils

Podzolic Soils in Great Group, Brown Podzolic Soils in Sub-group,

Xanthic Ferralsols in Soil Unit.

The soils of this Phase develop on the gently undulating land of the lower peneplain. Their topsoils are dark grayish brown in color, fine in texture, weak angular in structure and have non-sticky and slightly plastic consistence when wet. Their subsoils are brown in color, fine in texture, non-sticky and plastic in consistence when wet.

They have strong acid reaction throughout the profile. The content of organic matter is moderately high in topsoil, and low in subsoil. Their Cation Exchange Capacities are rather low in both topsoil and subsoil, and their Base Saturation Degrees are moderately high in both soils.

At present, they are grown with wild grasses such as alang-alang, and very small parts are used for the culture of cassava, peanut, tomato, pepper and other upland crops.

Phase 4, Higher Elevated Yellowish Red Podzolic Soils

Podzolic Soils in Great Group, Yellowish Red Podzolic Soils in Sub-group,

Xanthic Ferralsols in Soil Unit.

The soils of this Phase occupy the undulating upper peneplain in association with other Phases. Their topsoils are dark yellowish brown in color, fine in texture, weak subangular blocky in structure and have slightly sticky and slightly plastic consistence when wet. Their subsoils are yellowish red in color, fine in texture, structureless massive in structure and have slightly sticky and plastic consistence when wet.

They are strong acid throughout the profile. The content of organic matter is high in topsoil, while low in subsoil. Their Cation Exchange Capacities are very low in both topsoil and subsoil. Base Saturation Degree is moderately high in topsoil and low in subsoil. At present, they are grown with wild grasses and brush.

Phase 7, Middle Elevated Yellowish Red Podzolic Soils

Podzolic Soils in Great Group, Yellowish Red Podzolic Soils in Sub-group,

Plinthic, Rhodic and Xanthic Ferralsols in Soil Unit.

The soils of this Phase cover the gently undulating land of lower peneplain. Their topsoils are brown in color, medium in texture, weak subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet. Their subsoils are predominantly yellowish red in color, medium in texture, structureless weak massive in structure, slightly sticky and slightly plastic in consistence when wet.

They have strong acid reaction in both topsoil and subsoil. The content of organic matter is moderately high in topsoil, while low in subsoil. Cation Exchange Capacities are low in both topsoil and subsoil, while Base Saturation Degrees are moderately high in both soils.

Most parts of these soils are grown with wild grasses except very small areas cultivated for cassava, upland rice, etc.

Phase 8, Middle Elevated Red Podzolic Soils

Podzolic Soils in Great Group, Red Podzolic Soils in Sub-group,

Rhodic Ferralsols in Soil Unit.

The soils of this Phase develop on the gently sloping land of the lower peneplain. Their topsoils are yellowish red in color, fine in texture, weak subangular blocky in structure, slightly sticky and plastic in consistence when wet. Their subsoils are red in color, fine in texture, massive in structure, sticky and plastic in consistence when wet.

They have very strong acid reaction in both topsoil and subsoil. The content of organic matter is moderately high in topsoil, while low in subsoil. The values of Cation Exchange Capacity and Base Saturation Degree are low in both soils.

At present, most parts are grown with wild grasses such as alang-alang except some remarkable area grown with cassava and very limited fields of peanut, tomato and pepper.

(2) Alluvial Great Group

The soils of this Great Group are derived from alluvial deposits and extend on the various land units such as river terrace, natural levee, valley bottom and alluvial plain. Their elevations range from 40 to 70 meters. They have A - C horizon sequence with gray to brown color and fine texture. They are shallow to moderately deep, well to poorly drained. The relief of these soils is nearly level with slope less than 2%. This Great Group consists of five Sub-groups, i.e. Grayish Brown Alluvial, Dark Yellowish Brown Alluvial, Yellowish Brown Hydromorphic Alluvial, Brown Alluvial, and Gray Hydromorphic Alluvial. They are, furthermore, classified into six Phases as shown in followings.

Phase 10, Lower Elevated Grayish Brown Alluvial Soils

Alluvial Soils in Great Group, Grayish Brown Alluvial Soils in Sub-group,

Dystric Fluvisols in Soil Unit.

The soils of this Phase develop locally on slightly elevated river terrace along the Hitam and Umpu rivers. They are derived from alluvial deposits including volcanic material having a weak profile development of A-(B)-C horizon. Their topsoils are dark brown in color, fine in texture, weak subangular blocky in structure, slightly sticky and plastic in consistence when wet. Their subsoils are grayish brown in color, fine in texture, structureless massive in structure, slightly sticky and slightly plastic in consistence when wet.

They have very strong acid reaction in both topsoil and subsoil. The content of organic matter is very high in topsoil but low in subsoil. Cation Exchange Capacity is high in topsoil and moderately high in subsoil. Base Saturation Degrees are very low in both soils.

At present, they are covered with wild grasses with sparse brush or forest.

Phase 11, Lower Elevated Dark Yellowish Brown Alluvial Soils

Alluvial Soils in Great Group, Dark Yellowish Brown Alluvial Soils in Sub-group,

Dystric Fluvisols in Soil Unit.

The soils of this Phase develop on river terrace extending between peneplain and alluvial plain. They occupy convex relief on river terrace dissected by run-off flow having faint horizon sequence of A-C in general and stratified distinctly. Their topsoils are dark grayish brown in color, fine in texture, structureless, slightly sticky and slightly plastic in consistence when wet. Their subsoils are dark yellowish brown in color, fine in texture, weak subangular blocky in structure, sticky and plastic in consistence when wet.

Their physical and chemical features are akin to those of Phase 14 such as strong acidity, low fertility as shown by their low Cation Exchange Capacity and low Base Saturation Degree.

At present, these soils are mainly used for the cultivation of cassava and other upland crops.

Phase 12, Lower Elevated Yellowish Brown Hydromorphic Alluvial Soils

Alluvial Soils in Great Group, Yellowish Brown Hydromorphic Alluvial Soils in Sub-group,

Dystric Gleysols and Dystric Fluvisols in Soil Unit.

The soils of this Phase develop on river terrace extending between peneplain and alluvial plain. Their topsoils are dark grayish brown in color, fine in texture, structureless massive in structure, slightly sticky and slightly plastic in consistence when wet. Their subsoils are yellowish brown in color, fine in texture, structureless, slightly sticky and plastic in consistence when wet.

They have moderately strong acid reaction in topsoil and strong acid reaction in subsoil. The content of organic matter is moderately high in topsoil, while low in subsoil. Though the values of Cation Exchange Capacity are low in both soils, the values of Base Saturation Degree are high in both soils.

At present, these soils are used for the cultivation of rainfed paddy in the wet season. In the dry season, however, they are left fallow due to lack of water.

Phase 15, Slightly Elevated Brown Alluvial Soils

Alluvial Soils in Great Group, Brown Alluvial Soils in Sub-group,

Dystric Fluvisols in Soil Unit.

The soils of this Phase occupy the natural levee of the old Komering river or its branch. Their topsoils are dark brown in color, fine in texture, medium subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet. Their subsoils are predominantly brown in color, fine in texture, medium subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet.

They have moderately strong acid reaction in topsoil and strong acid reaction in subsoil. The content of organic matter is moderately high in topsoil, while low in subsoil. Cation Exchange Capacities are moderately high in both soils. Base Saturation Degree is high in topsoil and moderately high in subsoil.

At present, most lands of these soils are used for farmyard or the culture of perennial crops such as coconut, banana and clove etc. along with various annual crops such as cassava, tomato, sweet potato and eggplant etc.

Phase 19, Valley Bottom Gray Hydromorphic Alluvial Soils

Alluvial Soils in Great Group, Gray Hydromorphic Alluvial Soils in Sub-group,

Dystric Fluvisols in Soil Unit.

This soils of this Phase occupy the flat valley bottom among peneplain. They are derived from run-off deposits from adjacent hills. Their topsoils are dark brown in color, fine in texture, structureless massive in structure, very sticky and very plastic in consistence when wet. Their subsoils are gray in color, fine in texture, structureless massive in structure, non-sticky and slightly plastic in consistence when wet. They have weak horizon sequence of A-Cg-C in common. They are shallow in effective soil depth and have poor internal and external drainage. Groundwater table comes up to almost the ground surface and stays for more than 6 months in most years. The areas are submerged in the wet season.

They have strong acid reaction in topsoil and moderately strong acid reaction in subsoil. The content of organic matter is moderately high in topsoil, while low in subsoil. Cation Exchange Capacities are moderately high in both soils. Base Saturation Degrees are low in both soils.

At present, these soils are used for lowland paddy cultivation in the wet season. In the dry season, however, they are left fallow due to deficit of water.

Phase 22, Flat Gray Hydromorphic Alluvial Soils

Alluvial Soils in Great Group, Gray Hydromorphic Alluvial Soils in Sub-group,

Dystric Fluvisols in Soil Unit.

The soils of this Phase extend over recent alluvial plain of Belitang inland river basin. They are characterized by slight profile development of A-(B)-C having hydromorphic properties within 50 cm below the surface. Their topsoils are dark grayish brown in color, fine in texture, weak subangular blocky in structure, slightly sticky and plastic in consistence when wet. Their subsoils are gray in color, medium in texture, structureless massive in structure, non-sticky and non-plastic in consistence when wet.

They have strong acid reaction in topsoil and moderately strong acid reaction in subsoil. The content of organic matter is moderately high in topsoil, while low in subsoil. The value of Cation Exchange Capacity is low in topsoil and moderately high in subsoil. Base Saturation Degrees are moderately high in both soils.

These soils are mostly used for paddy cultivation in the wet season, but they are left fallow due to insufficient water supply.

(3) Hydromorphic Great Group

These soils of this Great Group are derived from alluvial deposits on the river terrace and natural levee. The land is nearly flat with slope of less than 2%. They have specific horizon sequence of A-(B)-C characterized by hydromorphic properties within 50 cm below the ground surface, and have higher chroma than the soils of Gley Great Group. These soils are rather deep and poorly to moderately drained with low external drainability and permeability. The land is free from flooding in general.

This Great Group consists of four sub-groups, i.e. Yellowish Brown Hydromorphic, Gray Hydromorphic, Brown Hydromorphic and Pale Brown Hydromorphic. They are, furthermore, classified into five Phases as shown in followings.

Phase 13, Lower Elevated Yellowish Brown Hydromorphic Soils

Hydromorphic Soils in Great Group, Yellowish Brown Hydromorphic Soils in Sub-group,

Dystric Gleysols in Soil Unit.

The soils of this Phase develop on elevated river terrace extending between peneplain and alluvial plain. Their topsoils are dark yellowish brown in color, fine in texture, weak fine subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet. Their subsoils are yellowish brown in color, fine in texture, structureless massive in structure, slightly sticky and plastic in consistence when wet.

These soils occupy the convex microrelief on river terrace. At present, they are mainly used for the culture of cassava.

Phase 17, Slightly Elevated Yellowish Brown Hydromorphic Soils

Hydromorphic Soils in Great Group, Yellowish Brown Hydromorphic Soils in Sub-group,

Dystric Fluvisols in Soil Unit.

The soils of this Phase occupy the natural levee of the old Komering river or its branch in association with other Phases. Their topsoils are brown in color, fine in texture, weak subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet. Their subsoils are yellowish brown in color, weak subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet. The soils have faint hydromorphic diagnosis with few fine strong brown mottles, clay skins on ped at about 50 cm below the surface.

They have strong acid reaction in topsoil and moderately strong acid reaction in subsoil. The content of organic matter is very low throughout the profile. The values of Cation Exchange Capacity are low and Base Saturation Degrees are moderately high in both topsoil and subsoil.

At present, these soils are used for farmyard and the culture of perennial and various annual upland crops.

Phase 14, Lower Elevated Gray Hydromorphic Soils

Hydromorphic Soils in Great Group, Gray Hydromorphic Soils in Sub-group,

Dystric Gleysols in Soil Unit.

The soils of this Phase develop on river terrace extending between peneplain and alluvial plain. Their topsoils are dark brown in color, fine in texture, weak subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet. Their subsoils are predominantly gray in color, fine in texture, structureless massive in structure, slightly sticky and slightly plastic in consistence when wet. These soils have horizon sequence of A-Bg-C and slightly hydromorphic diagnosis within 50 cm below the surface.

They have very strong acid reaction in both topsoil and subsoil. The content of organic matter is moderately high in topsoil and low in subsoil. Cation Exchange Capacities are moderately high in both soils. Base Saturation Degrees are low in both soils.

At present, these soils are mostly covered with wild grasses such as alang-alang with sparse brush except rather small area grown with cassava and other upland crops.

Phase 16, Slightly Elevated Brown Hydromorphic Soils

Hydromorphic Soils in Great Group, Brown Hydromorphic Soils in Sub-group,

Dystric Fluvisols in Soil Unit.

The soils of this Phase occupy the natural levee of the old Komering river or its branch in association with other Phases. Their topsoils are grayish brown in color, fine in texture, medium subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet. Their subsoils are predominantly brown in color, fine in texture, weak subangular blocky in structure, slightly sticky and plastic in consistence when wet. They have hydromorphic diagnosis within 50 cm below the surface.

They have very strong acid reaction in topsoil and strong acid reaction in subsoil. The content of organic matter is moderately high in topsoil and low in subsoil. Cation Exchange Capacities are moderately high in both topsoil and subsoil. Base Saturation Degree is moderately high in topsoil, while low in subsoil.

At present, the lands of these soils are used for farmyard and the culture of perennial and upland crops such as coconut, banana, clove, cassava, tomato, sweet potato and eggplant etc.

Phase 18, Slightly Elevated Pale Brown Hydromorphic Soils

Hydromorphic Soils in Great Group, Pale Brown Hydromorphic Soils in Sub-group,

Dystric Fluvisols in Soil Unit.

The soils of this Phase occupy the natural levee of the old Komering river or its branch in association with other Phases. Their topsoils are brown in color, fine in texture, medium subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet. Their subsoils are predominantly pale brown in color, fine in texture, weak massive and moderately blocky in structure, non-sticky and non-plastic in consistence when wet.

They have moderately strong acid reaction in topsoil and slightly acid reaction in subsoil. The organic matter content is moderately high in topsoil, while very low in subsoil. The values of Cation Exchange Capacity are low in both topsoil and subsoil, while Base Saturation Degree is high in topsoil and moderately high in subsoil.

At present, most lands of these soils are used for farmyard and the culture of perennial and annual upland crops.

(4) Gley Great Group

The soils of this Great Group are derived from recent alluvial depsits. They have horizon sequence of A-Ag-C having hydromorphic features within 50 cm below the ground surface. Most soils have gray-colored surface horizon with low chroma less than 2. External and internal drainage are very poor. Groundwater table is shallow throughout the year. These soils extend on the alluvial plain, the narrow flat valley bottom land among peneplain and the concave micro-relief on river terrace.

This Great Group is subdivided into two Sub-groups, i.e. Low Humic Gley and Humic Gley. They are, furthermore, classified into four Phases as shown in followings.

Phase 9, Lower Elevated Low Humic Gley Soils

Gley Soils in Great Group, Low Humic Gley Soils in Sub-group, Dystric Gleysols in Soil Unit.

The soils of this Phase occupy the depression on river terrace. They have nearly flat topography and horizon sequence A-Bg-Cg-C. Their topsoils are dark grayish brown in color, fine in texture, structureless massive in structure, sticky and plastic in consistence when wet. Their subsoils are predominantly gray in color, fine in texture, structureless massive in structure, slightly sticky and plastic in consistence when wet.

They have strong acid reaction throughout the profile. The content of organic matter is moderately high in topsoil and low in subsoil. The values of Cation Exchange Capacity and Base Saturation Degree are moderately high in both soils. They are under excessively moist conditions throughout the year.

At present, they are used for rainfed paddy in the wet season. In the dry season, they are left fallow due to deficit of water supply.

Phase 20, Valley Bottom Low Humic Gley Soils

Gley Soils in Great Group, Low Humic Gley Soils in Sub-group, Dystric and Eutric Gleysols in Soil Unit.

The soils of this Phase occupy the valley bottom among peneplain. They are derived from run-off deposits from neighbouring elevated areas. Their topsoils and subsoils are predominantly gray in color, fine in texture, structureless massive in structure, very sticky and very plastic in consistence when wet. These soils are characterized by low chroma less than 2 in soil color which indicates that the soils are under reductive condition.

They have strong acid reaction throughout the profile. The content of organic matter is moderately high in topsoil and low in subsoil. The values of Cation Exchange Capacity and Base Saturation Degree are moderately high in both topsoil and subsoil.

At present, they are used for paddy culture in the wet season, but are left fallow in the dry season due to deficit of water supply.

Phase 23, Flat Low Humic Gley Soils

Gley Soils in Great Group, Low Humic Gley Soils in Sub-group, Dystric and Eutric Gleysols in Soil Unit.

The soils of this Phase widely extend over recent alluvial plain in association with those of Phase 22. They are nearly flat and horizon sequence of A-Ag-C with hydromorphic diagnosis at lower A horizon. Their topsoils and subsoils are predominantly gray in color, very fine in texture, structureless massive in structure, very sticky and very plastic in consistence when wet. These soils are characterized by low chroma less than 2 in subsoil and have mottles within 30 cm below the surface.

They have strong acid reaction throughout the profile. The content of organic matter is moderately high in topsoil and low in subsoil. Cation Exchange Capacities are low in both topsoil and subsoil, while Base Saturation Degrees are moderately high in both soils.

At present, these soils are used for paddy cultivation in the wet season, but in the dry season they are left fallow due to the deficit of water supply. Of these soils, heavy textured clay is used as brick materials.

Phase 24, Depressed Humic Gley Soils

Gley Soils in Great Group, Humic Gley Soils in Sub-group, Dystric Gleysols in Soil Unit.

The soils of this Phase occupy depressions extending on recent alluvial plain. They have horizon sequence of A-Ag-Cg-C. Their topsoils are dark olive gray in color, fine in texture, structureless massive in structure, non-sticky and slightly plastic in consistence when wet. Their subsoils are dark olive gray in color, coarse in texture, structureless, sticky and non-plastic in consistence when wet.

They have strong acid reaction throughout the profile. Cation Exchange Capacity and Base Saturation Degree are low in common.

At present, some small parts of these soils are used for paddy cultivation in the wet season, but most areas are covered with brush and aquatic plants.

(5) Organic Great Group

The soils of this Great Group develop on depression in flat alluvial plain with low elevation. They have special horizon sequence of O-C in general. The O horizon is accumulation of plant remains decomposed to some extent. The land is saturated with water throughout the year and lies waste due to extremely low drainability and low fertility.

Organic Great Group consists of one Sub-group, i.e. Organic Sub-group, one Phase, i.e. Depressed Organic Soils.

Phase 25, Depressed Organic Soils

Organic Soils in Great Group,

Dystric Histosols in Soil Unit

The soils of this Phase occupy deep depression and swale in alluvial plain. The uppermost part is composed of accumulated remains of plants. They have horizon sequence of O-Og-C. Their topsoils are very dark brown in color, fine in texture, structureless, non-sticky and non-plastic in consistence when wet. Their subsoils are brownish brown in color, fine in texture, structureless, non-sticky and non-plastic in consistence when wet.

They have extremely strong acid reaction in both topsoil and subsoil. The contents of organic matter are very high in both soils. Cation Exchange Capacities are very high in both soils, while Base Saturation Degrees are very low in both soils.

These soils have thick O horizon of 50 cm or more. The lands are mostly covered with aquatic plants.

(6) Andosol Great Group

The soils of this Great Group develop locally on the foot of peneplain and have horizon sequence of A-C in general. They are derived from volcanic ash. The land has gentle slope of less than 5%. Groundwater table is deep. Drainage condition is good both externally and internally.

This Great Group consists of one Sub-group, i.e. Andosol Sub-group, one Phase, i.e. Valley Bottom Andosols.

Phase 21, Valley Bottom Andosols

Andosols in Great Group,

Humic Andosols in Soil Unit.

Their topsoils are dark brown in color, fine in texture, structureless massive in structure, sticky and very plastic when wet, and loose when dry in consistence. Their subsoils are dark brown in color, fine in texture, weak subangular blocky in structure, very sticky and very plastic when wet, and hard when dry in consistence.

They have strong acid reaction in topsoil and very strong acid reaction in subsoil. The content of organic matter is high in topsoil, while low in subsoil. Cation Exchange Capacities are moderately high and Base Saturation Degrees are low in both topsoil and subsoil.

At present, these soils are mostly used for rainfed paddy cultivation only in the wet season, while other areas are grown with wild grasses and brush.

1.5.2 Soil Mapping Unit

According to the results of soil research, it is necessary to apply the specific soil mapping unit of soil association in order to illustrate the location of major soil groups for making the basic agricultural development program. This is due to the reason that most major soil groups distribute too fractionally and intricately to illustrate them separately on the map on a small scale of 1: 50,000. In the present study, then, eight Mapping Units are differentiated as the association of 25 Phases. The Mapping Units and Phases are tabulated in Table II-5. The acreage and proportional extent of each Mapping Unit in the survey area are shown in Table II-6.

The physiographical condition and constraints for agricultural development of each Mapping Unit are outlined as in the followings.

(1) Mapping Unit 1: Association of Phases 1, 2, 3 and 4.

The soils of this Mapping Unit extend widely on the upper peneplain in the northern and southern parts of Belitang inland river basin and cover 46,130 ha or 51% of the survey area.

This Mapping Unit is Association of four Phases which consist of Podzolic Soils. The land suitabilities for gravity irrigation farming of paddy rice are evaluated by the soil fertility, permeability and topography. Podzolic Soils are quite deficient in the essential plant nutrients. Soil nutrient status, however, could be improved by the supply of irrigation water to acceptable extent for paddy rice cultivation like in the lowland under the cultivation of paddy rice. Puddling would decrease the percolation through the subsoil. Undulating or rolling relief conditions on peneplain are the biggest constraint to the proper agricultural development. The land having steep slope is classified as the permanently unsuitable class because of its uneconomical land reclamation for paddy field.

The limiting factors for diversified crops in upper peneplain are natural infertility, strong acidity, inadequate water holding capacity, erosion hazards and undulating topography. The biggest constraint among these limiting factors is the erosion hazards due to the excessive run-off resulting from the heavy tropical showers. At present, the lands are truncated by erosion in consequence of deforestation. The conservation treatments such as contour farming, bench terracing, mulching, etc. are required for controlling or preventing sheet erosion under the cultivation of upland crops.

(2) Mapping Unit 2: Association of Phases 5, 6, 7 and 8.

The soils of this Mapping Unit develop on the lower peneplain in the northern and southern parts of Belitang inland river basin. Most parts of Pisang area are categorized in this Mapping Unit. This Unit occupies 10,820 ha or 12% of the survey area.

This Mapping Unit is Association of four Phases which consist of Podzolic Soils. The limitations or constraints to their use for farming are almost same as those of Mapping Unit 1 except the elevation.

(3) Mapping Unit 3: Association of Phases 9, 11, 12, 13 and 14.

The soils of this Mapping Unit develop on river terrace extending between peneplain and alluvial plain. This Mapping Unit covers 8,660 ha or 10% of the survey area.

This Mapping Unit is Association of five Phases which consist of Gley Soils, Alluvial Soils and Hydromorphic Soils. They are highly suitable for irrigation farming, because their topography allows the excess water to be drained easily without any water logging problems. River terrace has two microreliefs made by dissective flow, i.e. convex and concave. This topography requires relatively high capital investiment for land levelling. Besides, the heavy textured soils which occur locally on terrace restrict the workability and the tillability. The content of essential plant nutrients in the soil is poor in common.

(4) Mapping Unit 4: Uniformity of Phase 10.

The soils of this Mapping Unit develop locally on slightly elevated river terrace along the Hitam and the Umpu rivers. This Unit extends over 1,270 ha or 1% of the survey area.

This Mapping Unit consists of one Phase of Alluvial Soils. They have no severe limitations to their use for gravity irrigation farming except low fertility.

(5) Mapping Unit 5: Association of Phases 15, 16, 17 and 18.

The soils of this Mapping Unit develop on the natural levee of the old Komering river or its branch. The lands are scattered in the alluvial plain of the Belitang inland river basin. This unit covers 1,390 ha or 2% of the survey area.

This Mapping Unit is Association of four Phases which consist of

Alluvial Soils and Hydromorphic Soils. The land of these soils is nearly flat and is higher than alluvial plain for around 50 cm. The groundwater table is about 50 cm below the surface, and the land is free from flooding. There is no place to be developed newly for agriculture on the natural levee, because most parts of this area are used for the farmyard or the cultivation of perennial crops such as banana, coconut, clove, etc. Furthermore the size of land is too small to be developed economically.

(6) Mapping Unit 6: Association of Phases 19, 20 and 21.

The soils of this Mapping Unit develop on the flat bottom of valley extending among peneplains or between peneplain and alluvial plain. They consist of the run-off deposits derived from the adjacent hills and have horizon sequence of A-Cg-C. The moisture conditions of these soils tend to become more moist with time, because valleys are commonly constricted by natural levee of the old Komering river or its branch. The land of this unit is flat or nearly flat with slope of less than 2%. This unit covers 8,120 ha or 9% of the survey area.

Small flat valleys are formed by the tributaries of two rivers; the Belitang and the Macak, in the Belitang inland river basin. The lands are used only for paddy field in the wet season at present. Soil conditions of the lands are similar to those on the alluvial plain formed by the old Komering river, while their parent materials are different. They are suitable for paddy caltivation. For introduction of upland crops, however, high capital investment will be required for the improvement of drainage condition.

(7) Mapping Unit 7: Association of Phases 22 and 23.

The soils of this Mapping Unit develop broadly on the alluvial plain in the Belitang inland river basin. The land of this Unit is nearly flat with slope of less than 2%. Groundwater table stays near ground surface for more than 6 months in most years. This Unit covers 8,720 ha or 10% of the survey area.

This Mapping Unit is Association of two Phases which consist of Alluvial Soils and Gley Soils. The Gley Soils extend wider than Alluvial Soils. This fact indicates that this alluvial plain is under moist condition. Waterlogging caused by overirrigation should therefore be eliminated by proper drainage system. The content of the essential plant nutrients in the soil is poor in common. For introduction of upland crops, high capital investment will be required for the improvement of drainage condition.

(8) Mapping Unit 8: Association of Phases 24 and 25.

The soils of this Mapping Unit occupy depression and swale in the alluvial plain of the Belitang inland river basin. This area is nearly flat with slope of less than 2%. Groundwater table is at or near the surface throughout the year. This Unit covers 4,590 ha or 5% of the survey area.

This Mapping Unit consists of Phases 24 and 25 which are intricated with each other. The soil of Phase 24 has thin O horizon of less than 50 cm, while Phase 25 has thick O horizon of more than 50 cm.

The depression and swale have very serious limitations to the use for farming due to the deep water stagnation, very strong acid reaction, lack of mineral stratification or fraction, deficiency of essential plant nutrients, etc. The organic soils occur in limited scale, and when dried, they subside tremendously due to the decomposition and compression of organic matter. In the light of the above-mentioned conditions, these lands are marginally suitable for paddy rice cultivation, while not suitable for upland crop farming.

2. LAND SUITABILITY

2.1 Category of Land Suitability Classification

The land suitability in the Project Area is classified at three categories, i.e. order, class and sub-class by the application of the Framework for Land Evaluation, FAO in 1976. The categories are defined as in the followings.

2.1.1 Order

The highest category is Order and the land in the project area is divided into 3 Orders as follows.

(1) Suitable --- S

Land on which the sustained use of paddy rice and upland crops are expected to yield benefits to justify the required recurrent inputs without unacceptable risk to land resources on the site or in adjacent area.

(2) Non-suitable --- N

Land on which the sustained use of paddy rice and upland crops can not be expected to result sufficient benefits to justify the required recurrent inputs.

(3) Conditionally suitable --- Sc

Land on which the sustained use of paddy rice and upland crops can not be expected to yield benefits to justify the required recurrent inputs. But, the land could be used for profitable farming if the specific management practices would be implemented to overcome the limitations on farm production.

2.1.2 Class

Out of three Orders, suitable and conditionally suitable Orders are subdivided into three classes respectively, and non-suitable Order is subdivided into two classes.

(1) Highly suitable --- S1

Land having no significant or only minor limitations to the sustained cultivation of paddy rice and upland crops that will significantly reduce production levels.

(2) Moderately suitable --- S2

Land having limitations which in the aggregate are moderately severe for the sustained cultivation of paddy rice and upland crops, and will reduce production levels.

(3) Marginally suitable --- S3

Land having limitations which in the aggregate are severe for the sustained cultivation of paddy rice and upland crops and will so reduce production levels that such expenditure will only be marginally justified.

(4) Conditionally highly suitable --- Sc1

Land having characteristics which, in general, preclude sustained economic cultivation of paddy rice and upland crops. The land, however, could be used if the special management practices defined at Sub-class level were implemented, and would be equivalent in suitability to the land of Class S1.

(5) Conditionally moderately suitable --- Sc2

Land having characteristics which, in general, preclude sustained economic cultivation of paddy rice and upland crops. The land, however, could be used if the special management practices defined at Sub-class level were implemented, but would only be equivalent in suitability to the land of Class S2 as moderately severe limitations indicated by Sub-class symbol would remain.

(6) Conditionally marginally suitable --- Sc3

Land having characteristics which, in general, preclude sustained economic cultivation of paddy rice and upland crops. The land, however, could be used if the special management practices defined at Sub-class level were implemented, but would only be equivalent in suitability to the land of Class S3 as severe limitations indicated by Sub-class symbol would remain.

(7) Currently non-suitable --- N1

Land having limitations which appear so severe as to preclude any possibility of successful sustained paddy rice and upland crop cultivation, or having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at presently acceptable cost.

(8) Permanently non-suitable --- N2

Land having limitations which appear so severe as to preclude any possibility of successful sustained paddy rice and upland crop cultivation.

2.1.3 Sub-Class

Each class is divided into sub-classes according to the kind of limiting factors. The following conditions are considered as the limiting factors or constraints for the cultivation of paddy rice and upland crops in this survey area.

Topography (t): limitation due to unfavorable relief, e.g. macro or micro relief, and/or relative elevation limiting to its use (unsuitable elevation for economical gravity irrigation, and relief conditions unsuitable for economical drainage improvement and economical field arrangement).

Erosion (e) : limitation caused by erosion hazards or past erosion damages.

Wetness (w) : limitation caused by waterlogging due to high groundwater-table, long consecutive seasonal floodings, low permeability or slow surface drainage and/or the combination of these regimes.

Inundation (i): limitation due to frequent floodings.

Acidity (O) : limitation due to strong acid soil reaction (pH), and/or high degree of 1N-KCl extractable aluminum (so-called active or free aluminon) and/or low degree of base saturation to cation exchange capacity (CEC).

Fertility (f) : limitation due to low contents of chemical nutrients in the soils particularly of nitrogen, phosphate, potash, effective bases. Generally, organic carbon is not essential factor for this evaluation.

Texture (x) : Texture quality very close to the moisture regime or hydro-dinamic features of soils, e.g. permeabiliey, basic intake rate, and/or also close to the land tillability or arability.

Physical soil deficiency (p): limitation due to unfavorable physical soil properties, e.g. very hard consistence, firmly consolidated soils, massive structure, very plastic and sticky consistence when wet, etc.

Depth (d) : limitation due to shallowness of soils, restricting root development and/or effective irrigation and drainage operation.

Each of above limitations is expressed by abbreviated symbol letter as shown in Table II-7, and is used as the suffix of Sub-class nomination of land suitability.

2.2 Grading of Essential Land Features by Land Suitability

The gradings of essential land features by land suitability are summarized as shown in Table II-8 to II-14.

2.3 Evaluation of Land Suitability by Soil Group

Based upon the gradient of limiting factor to land suitability, the grade of land suitability is evaluated by Soil Phase and Great Soil Group as listed in Table II-15. The acreage and propertional extent of each land suitability unit are tabulated in Table II-16.

Table II-1 PIT NUMBERS AND SOME DESCRIPTIONS OF THE SAMPLES

Pit No.	Location	Land Use	Physiography	Great Group (D/S system, 1961)
1	Sidomulyo	Paddy	River terrace	Gley soils
2	Sidomulyo	Grass growth	River terrace	Hydromorphic soils
3	Sidomulyo	Grass growth	Peneplain (lower)	Padzolic soils
4	Sidomulyo	Paddy	Flat valley	Gley soils
5	Sumber suko	Paddy	Alluvial plain	Alluvial soils
6	Sumber suko	Paddy	Alluvial plain	Gley soils
7	Suko jadi	Paddy	Flat valley	Alluvial soils
8	Suko jadi	Grass & Brush	Peneplain(upper)	Podzolic soils
9	Jayamakmur	Grass & Brush	Natural levee	Hydromorphic soils
10	Jayamakmur	Paddy	Ox bow	Gley soils
11	Kurungan nyawa	Paddy	Alluvial plain	Gley soils
12	Tanjung bulan	Paddy	Former course of river	Alluvial soils
13	Way Halom	Paddy	Alluvial plain	Gley soils
14	Way Halom	Grass & Upland field	Peneplain(lower)	Podzolic soils
15	Gunung ruya	Upland field	Natural levee	Alluvial soils
16	Bandar jaya	Upland field	Natural levee	Alluvial soils
17	Kurungan nyawa	Upland field	Natural levee	Hydromorphic soils
18	Eling-eling	Paddy	Flat valley	Gley soils
19	Way Halom	Upland field	Natural levee	Hydromarphic soils
20	Way Halom	Paddy	Alluvial plain	Gley soils
21	Muncak kabru	Paddy	Alluvial plain	Gley soils
22	Lebak harjo	Swale	Depression	Organic soils
23	Jaya mulya	Paddy	Flat valley	Gley soils
24	Jatimulya	Grass growth	Peneplain(upper)	Podzolic soils
25	Sukaraja	Paddy	Alluvial plain	Gley soils
26	Sukaraja	Grass growth	Peneplain(lower)	Podzolic soils
27	Kurungan nyawa	Paddy	Alluvial plain	Alluvial soils
28	Kurungan nyawa	Paddy	Alluvial plain	Gley soils
29	Tanjung rejo	Paddy	Alluvial plain	Gley soils
30	Trimoharjo	Paddy	Alluvial plain	Gley soils
31	Gunung sugih	Grass & Brush	Natural levee	Hydromorphic soils
32	Margo dadi	Forest	Peneplain(upper)	Podzolic soils

(to be continued)

Pit No.	Location	Land Use	Physiography	Great Group (D/S system, 1961)
33	Margo rejo	Grass growth	Peneplain(upper)	Podzolic soils
34	Margo mulyo	Grass growth	Peneplain(upper)	Podzolic soils
35	Totorejo	Grass growth	Peneplain(upper)	Podzolic soils
36	Tegal lesal	Grass growth	River terrace	Hydromorphic soils
37	Raman jaya	Grass growth	Flat valley	Alluvial soils
38	Raman jaya	Just after burning	Peneplain(upper)	Podzolic soils
39	Raman jaya	Forest	Peneplain(upper)	Podzolic soils
40	Sumber harapan	Grass growth	Peneplain(upper)	Podzolic soils
41	Sumber sari	Grass growth	Peneplain(upper)	Podzolic soils
42	Harjo mulyo	Grass growth	Peneplain(upper)	Podzolic soils
43	Mesis Ilir	Grass growth	Peneplain(upper)	Podzolic soils
44	Sapto renggo	Paddy	Flat valley	Hydromorphic soils
45	Karangan	Grass growth	Peneplain(upper)	Podzolic soils
46	Karangan	Grass growth	Flat valley	Hydromorphic soils
47	Karangan	Brush	Peneplain(upper)	Podzolic soils
48	Bumi harjo	Grass growth	Peneplain(upper)	Podzolic soils
49	Bumi harjo	Grass growth	Peneplain(upper)	Podzolic soils
50	Suka agung	Grass growth	Peneplain(upper)	Podzolic soils
51	Suka agung	Paddy	Flat valley	Alluvial soils
52	Suka rejo	Grass growth	Peneplain(upper)	Podzolic soils
53	Pahang Asri	Grass growth	Peneplain(lower)	Podzolic soils
54	Pahang Asri	Grass growth	Peneplain(upper)	Podzolic soils
55	Pemetung Busuki	Paddy	Flat valley	Gley soils
56	Suka agung	Paddy	River terrace	Alluvial soils
57	Suka agung	Paddy	River terrace	Gley soils
58	Suka bumi	Grass growth	Peneplain(lower)	Podzolic soils
59	Suka bumi	Paddy	Alluvial plain	Gley soils
60	Suka bumi	Paddy	Alluvial plain	Gley soils
61	Sri katon	Grass growth	Peneplain(lower)	Podzolic soils
62	Sumber asri	Upland field	Natural levee	Hydrmorphic soils
63	Sumber asri	Grass & Brush	River terrace	Hydromorphic soils
64	Sumber asri	Grass growth	Peneplain(lower)	Podzolic soils
65	Sumber asri	Grass growth	Peneplain(upper)	Podzolic soils
66	Bangsa negara	Grass growth	River terrace	Hydromorphic soils
67	Bangsa negara	Grass growth	Peneplain(upper)	Podzolic soils
68	Bangsa negara	Paddy	Flat valley	Andosols

(to be continued)

Pit No.	Location	Land Use	Physiography	Great Group (D/S system, 1961)
69	Tugu mulyo	Grass growth	Peneplain(upper)	Podzolic soils
70	Tugu mulyo	Upland field	Peneplain(lower)	Podzolic soils
71	Tugu mulyo	Paddy	Flat valley	Gley soils
72	Banjar rejo	Grass growth	Peneplain(lower)	Podzolic soils
73	Banjar rejo	Grass growth	Peneplain(lower)	Podzolic soils
74	Banjar rejo	Paddy	River terrace	Alluvial soils
75	Banjar rejo	Grass growth	Peneplain(lower)	Podzolic soil
76	Banjar rejo	Grass growth	Peneplain(upper)	Podzolic soils
77	Way Halom	Grass growth	Peneplain(lower)	Podzolic soils
78	Way Halom	Paddy	Flat valley	Gley soils
79	Way Halom	Grass growth	Peneplain(upper)	Podzolic soils
80	Sido mulyo	Grass growth	Peneplain(upper)	Podzolic soils
81	Sido mulyo	Grass growth	Peneplain(lower)	Podzolic soils
82	Sido mulyo	Grass growth	Peneplain(lower)	Podzolic soils
83	Totorejo	Grass growth	River terrace	Alluvial soils
84	Margo dad	Paddy	Flat valley	Alluvial soils
85	Bum, harjo	Paddy	River terrace	Alluvial soils
86	Nusa raya	Upland field	River terrace	Alluvial soils
87	Pahang asri	Paddy	Alluvial plain	Alluvial soils
88	Way Handa	Paddy	Alluvial plain	Gley soils
89	Kurungan nyawa	Paddy	Alluvial plain	Gley soils
90	Way Halom	Paddy	Alluvial plain	Gley soils
91	Margo mulyo	Upland field	Peneplain(upper)	Podzolic soils
92	B.M.10	Upland field	Peneplain(upper)	Podzolic soils

Table II-2 GREAT GROUP OF D/S SYSTEM CORRELATED WITH FAO/UNESCO SYSTEM

	Dudal/Soepraptohardjo system (1957, 1961)	D/S system (modified in 1978)	FAO/UNESCO (1974)
1	Alluvial soils	Alluvial soils	Fluvisols
2	Andosols	Andosols	Andosols
3	Brown Forest soils	Brunizem	Cambisols
4	Grumusols	Grumusols	Vertisols
5	Latosols	Cambisols	Cambisols
		Latosols	Nitosols
		Oxisols/Lateritics	Ferralsols
6	Litosols	Litosols	Litosols
7	Mediterranean	Mediterranean	Luvisols
8	Organic soils	Organosols	Histosols
9	Podzols	Podzols	Podzols
10	Reddish Yellow Podzolic soils	Podzolic soils	Acrisols
11	Regosols	Regosols	Regosols
12	Renzinas	Renzinas	Rendzinas
13	Gley soils	Gleysols	Gleysols
	Humic Gley soils		
	Low Humic Gley soils		
	Gray Hydromorphic soils		
	Hydromorphic Alluvial soils		

Table II-3 SOIL CLASSIFICATION

Great Soil Group	Soil Sub-group	Soil Phase /1
1. Podzolic	1. Yellowish Brown Podzolic	1. Higher Elevated Yellowish Brown Podzolic Soils
	2. Strong Brown Podzolic	2. Higher Elevated Storng Brown Podzolic Soils
		5. Middle Elevated Strong Brown Podzolic Soils
	3. Brown Podzolic	3. Higher Elevated Brown Podzolic Soils
		6. Middle Elevated Brown Podzolic Soils
	4. Yellowish Red Podzolic	4. Higher Elevated Yellowish Red Podzolic Soils
		7. Middle Elevated Yellowish Red Podzolic Soils
	5. Red Podzolic	8. Middle Elevated Red Podzolic Soils
2. Alluvial	6. Grayish Brown Alluvial	10. Lower Elevated Grayish Brown Alluvial Soils
	7. Dark Yellowish Brown Alluvial	11 Lower Elevated Dark Yellowish Brown Alluvial Soils
	8. Yellowish Brown Hydromorphic Alluvial	12. Lower Elevated Yellowish Brown Hydromorphic Alluvial Soils
	9. Brown Alluvial	15. Slightly Elevated Brown Alluvial Soils
	10. Gray Hydromorphic Alluvial	19. Valley Bottom Gray Hydromorphic Alluvial Soils
		22. Plat Gray Hydromorphic Alluvial Soils
3. Hydromorphic	11. Yellowish Brown Hydromorphic	13. Lower Elevated Yellowish Brown Hydromorphic Soils
		17. Slightly Elevated Yellowish Brown Hydromorphic Soils
	12. Gray Hydromorphic	14. Lower Elevated Gray Hydromorphic Soils
	13. Brown Hydromorphic	16. Slightly Elevated Brown Hydromorphic Soils
	14. Pale Brown Hydromorphic	18. Slightly Elevated Pale Brown Hydromorphic Soils
4. Gley	15. Low Humic Gley	9. Lower Elevated Low Humic Gley Soils

Great Soil Group	Soil Sub-group	Soil Phase
		20. Valley Bottom Low Humic Gley Soils
		23. Flat Low Humic Gley Soils
	16. Humic Gley	24. Depressed Humic Gley Soils
5. Organic	17. Organic	25. Depressed Organic Soils
6. Andosol	18. Andosol	21. Valley Bottom Andosols

/1 Phase numbers coincide with those in interim report of this feasibility study, 1980.

Table II-1 RATING OF SOIL CONDITION

1. **Textural classes**

Coarse textured :	sands, loamy sands and sandy loams with less than 15 percent clay, and more than 65 percent sand.
Medium textured :	loams, silty loams, sandy clay loams, clay loams and silty clay loams with less than 25 percent clay.
Fine textured :	sandy clays, light clays, silty clays and heavy clays with more than 25 percent clay.

2. **Soil acidity** (pH: H_2O, 1 : 2.5 soil-water suspension)

Slightly acid to neutral	6.1 to 7.5
Moderately strong acid	5.6 to 6.0
Strong acid	5.1 to 5.5
Very strong acid	4.6 to 5.0
Extremely strong acid	less than 4.5

3. **Soil fertilities**

	High	Moderately high	Low
Organic carbon (%)	more than 2.0	1.0 to 2.0	less than 1.0
Total nitrogen (%)	more than 0.05	0.01 to 0.05	less than 0.01
CEC (m.eq./100g)	more than 20	10 to 20	less than 10
Potassium (m.eq./100g)	more than 0.2	0.1 to 0.2	less than 0.1
Base saturation (%)	more than 50	20 to 50	less than 20

Table II-5 SOIL MAPPING UNIT LEGEND OF THE SEMI-DETAILED SOIL MAP

Mapping unit	Description	Land form	Parent Material
1	Association of Phases 1, 2, 3 and 4 Phase 1 : Higher Elevated Yellowish Brown Podzolic Soils (Plinthic Ferralsols, Orthic Ferralsols) Phase 2 : Higher Elevated Strong Brown Podzolic Soils (Plinthic Ferralsols, Xanthic Ferralsols) Phase 3 : Higher Elevated Brown Podzolic Soils (Plinthic Ferralsols) Phase 4 : Higher Elevated Yellowish Red Podzolic Soils (Xanthic Ferralsols)	Upper peneplain	Acid sandstone or claystone
2	Association of Phases 5, 6, 7 and 8 Phase 5 : Middle Elevated Strong Brown Podzolic Soils (Xanthic Ferralsols) Phase 6 : Middle Elevated Brown Podzolic Soils (Xanthic Ferralsols) Phase 7 : Middle Elevated Yellowish Red Podzolic Soils (Plinthic Ferralsols, Rodic Ferralsols, Xanthic Ferralsols) Phase 8 : Middle Elevated Red Podzolic Soils (Rhodic Ferralsols)	Lower peneplain	Acid sondstone or claystone
3	Association of Phases 9, 11, 12, 13 and 14 Phase 9 : Lower Elevated Low Humic Gley Soils (Dystric Gleysols) Phase 11: Lower Elevated Dark Yellowish Brown Alluvial Soils (Dystric Fluvisols) Phase 12: Lower Elevated Yellowish Brown Hydromorphic Alluvial Soils (Dystric Gleysols, Dystric Fluvisols) Phase 13: Lower Elevated Yellowish Brown Hydromorphic Soils (Dystric Gleysols)	River terrace	Ancient alluvial deposits

(to be continued)

Mapping unit	Description	Land form	Parent Material
	Phase 14: Lower Elevated Gray Hydromorphic Soils (Dystric Gleysols)		
4	Uniformity of phase 10	River terrace	Ancient alluvial deposits rich in volcanic materials
	Phase 10: Lower Elevated Grayish Brown Alluvial Soils (Dystric Fluvisols)		
5	Association of Phases 15, 16, 17 and 18	Natural levee	Recent alluvial deposits
	Phase 15: Slightly Elevated Brown Alluvial Soils (Dystric Fluvisols)		
	Phase 16: Slightly Elevated Brown Hydromorphic Soils (Dystric Fluvisols)		
	Phase 17: Slightly Elevated Yellowish Brown Hydromorphic Soils (Dystric Fluvisols)		
	Phase 18: Slightly Elevated Pale Brown Hydromorphic Soils (Dystric Fluvisols)		
6	Association of Phases 19, 20 and 21	Flat valley	Recent alluvial deposits
	Phase 19: Valley Bottom Gray Hydromorphic Alluvial Soils (Dystric Fluvisols)		
	Phase 20: Valley Bottom Low Humic Gley Soils (Dystric Gleysols, Eutric Gleysols)		
	Phase 21: Valley Bottom Andosols (Humic Andosols)		
7	Association of Phases 22 and 23	Alluvial plain	Recent alluvial deposits developed along the old komering river or its branch
	Phase 22: Flat Gray Hydromorphic Alluvial Soils (Dystric Fluvisols)		
	Phase 23: Flat Low Humic Gley Soils (Dystric Gleysols, Eutric Gleysols)		

(to be continued)

Mapping unit	Description	Land form	Parent Material
8	Association of Phases 24 and 25 Phase 24: Depressed Humic Gley Soils (Dystric Gleysols) Phase 25: Depressed Organic Soils (Dystric Histosols)	Swales	Deposits of plant remains overlying alluvium sediments

NOTE: Names in parentheses show the unit by FAO/UNESCO system

Table II-6 ACREAGE AND PROPORTIONAL EXTENT OF EACH MAPPING UNIT IN THE TOTAL PROJECT AREA

Mapping unit	Soil phase	Great Soil Group	Land form	Soil surveyed area		Gross irrigable area	
				ha	%	ha	%
1	1, 2, 3, 4	Podzolic Soils	Upper peneplain	46,130	51	17,510	34
2	5, 6, 7, 8	Podzolic Soils	Lower peneplain	10,820	12	5,630	11
3	9, 11, 12, 13, 14	Gley Soils, Alluvial Soils Hydromorphic Soils	River terrace	8,660	10	8,490	17
4	10	Alluvial Soils	River terrace	1,270	1	1,100	2
5	15, 16, 17 18	Alluvial Soils Hydromorphic Soils	Natural levee	1,390	2	1,330	3
6	19, 20, 21	Alluvial Soils Gley Soils Andosols	Flat valley	8,120	9	6,670	13
7	22,23	Alluvial Soils Gley Soils	Alluvial plain	8,720	10	8,120	16
8	24, 25	Gley Soils Organic Soils	Swales	4,590	5	1,780	4
Total				89,700	100	50,630	100

Table II-7 LAND USE LIMITATION BY AVAILABILITY

Land Availability	Essential Land Features	Symbol of Limitation /1
Natural fertility	Contents of N.P.K. effective bases, CEC, base saturation degree, pH	f
Drainability	Groundwater table, infiltration rate, permeability in sub-strata, effective depth to impermeable layers	p, t, w, x
Flooding hazard	Depth, duration and frequency of flooding or seasonal inundation	i, t
Workability	Consistence (stickness and plasticity), structure, stoniness, presence of hard pan	p, t
Acidity	Acid reaction, sodium percent, sodium absorption rate	o
Erosion hazard	Slope, infiltration rate, texture, structure, bulk density, soil depth, aggregate stability	d, e, p, t, x
Topographical adequacy	Slope, micro-relief, macro-relief (slope complexity), elevation	t

/1 See the subsection 2.1.3 hereof.

Table II-8 NATURAL FERTILITY GRADING

Suitability	Highly suitable	Moderately suitable	Marginally suitable
Degree	1	2	3
Organic C (%)	more than 2.0	2.0 to 1.0	less than 1.0
Total N (%)	more than 0.05	0.05 to 0.01	less than 0.01
Exchangeable potash (m.eq.)	more than 0.2	0.2 to 0.1	less than 0.1
CEC (m.eq.)	more than 20	20 to 10	less than 10
Base saturation degree (%)	more than 50	50 to 20	less than 20

Table II-9 DRAINABILITY GRADING

Suitability	Highly suitable	Moderately suitable	Marginally suitable	Non-suitable
Degree	1	2	3	4
Drainability	well drainable	Moderately drainable	Poorly drainable	Very poorly drainable
Minimum depth to groundwater (cm)	more than 200	120 to 200	75 to 120	less than 75
Soil depth to impermeable layer (cm)				
for paddy rice	more than 90	50 to 90	20 to 50	less than 20
for upland crops	more than 150	120 to 150	100 to 120	less than 100

Table II-10 FLOODING HAZARD GRADING

Suitability	Highly suitable	Moderately suitable	Marginally suitable	Non-suitable
	1	2	3	4
Seasonal flooding	Non seasonal flooding (non inundation)	Seasonal flooding shallowly (Sometime inundated)	Seasonal flooding deeply (frequently inundated)	Flooding throughout the year (inundated all the time)

Table II-11 WORKABILITY GRADING

Suitability		Highly suitable	Moderately suitable	Marginally suitable	Non-suitable
Degree		1	2	3	4
Soil consistence					
	wet	Nonsticky to slightly sticky and nonplastic to slightly plastic	Sticky to very plastic to very	sticky and plastic	-
	dry	Loose to rather hard	Hard to very hard	Extremely hard	Extremely hard

Note: For this classification, man-power and/or animal-power is taken into account for the land preparation or other field works. Contents of coarse gravels, stones and boulders are not relevant to this survey area.

Table II-12 ACIDITY GRADING

Suitability	Highly suitable	Moderately suitable	Marginally suitable	Non-suitable
Degree	1	2	3	4
pH	6.1 to 8.0	8.1 to 9.0 or 5.1 to 6.0	4.6 to 5.0	less than 4.5

Table II-13 <u>EROSION HAZARD GRADING</u>

Suitablility	Highly suitable	Moderately suitable	Marginally suitable	Non-suitable
Degree	1	2	3	4
Evidence of the sheet erosion	None to slight	moderate	severe	-
Susceptibility to the soil erosion	insignificant	slight	moderate	severe

Note: Evidence of sheet erosion could be found on the soil surface observing the fact whether top soil has been eroded out or not. None to slight evidence would be defined by existence of rather thick humic horizon, very thin humic horizon for moderate range and no humic horizon for severe erosion in evidences. Susceptibility to the soil erosion is estimated by many land characteristic, i.e. texture quality of the surface soil, contents of organic matter, structure, soil permeability coefficient, slope, vegetation, land use, etc.

Table II-14 TOPOGRAPHICAL ADEQUACY

Suitability	Highly suitable	Moderately suitable	Marginally suitable	Non-suitable
Degree	1	2	3	4
Slope (%)				
Upper limit	1 (0.5)	3 (2)	8 (5)	-
Micro relief (m)	0 to 15	15 to 30	30 to 60	more than 60
Surface soil	more than 50	30 to 50	15 to 30	less than 15

Note: Figures in parentheses in terms of upper limit of slope are the specific basis for paddy field.

Table II-15 LAND SUITABILITY GRADING BY SOIL PHASE AND GREAT SOIL GROUP

Soil phase	1		2		3		4		5		6		7	
Great soil group	Podzolic Soils								Podzolic Soils					
Physiography	Upper peneplain								Lower peneplain					
Present land use	Forest, Brush,		Glassland		(alang-alang)		Upland field		Forest, Brush,		Grassland		(alang-alang)	
Land use proposed under gravity irrigation /1	p	uf	p	uf	p	uf	p	uf	p	uf	p	uf	p	uf
Land feature /2	3	3	2	2	3	3	3	3	3	3	3	3	3	3
Natural fertility														
Drainability	1	1-2	1	1-2	1	1-2	1	1-2	1	1-2	1	1-2	1	1-2
Flooding hazard	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Workability	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Acidity	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Erosion hazard	1	1-3	1	1-3	1	1-3	1	1-3	1	1-3	1	1-3	1	1-3
Topographical adequacy	1-4	1-4	1-4	1-4	1-4	1-4	1-4	1-4	1-4	1-4	1-4	1-4	1-4	1-4
Suitability														
Class	S3,S3 N2	S2,S3 N2	S2,S3 N2	S2,S3 N2	S3 N2	S3 N2	S3 N2	S3 N2	S2,S3 N1	S2,S3 N1	S3 N1	S3 N1	S3 N1	S3 N1
Limiting factors in Sub-class /3	f,t	f,t O	f,t	e,f O	ft	e,f O	f,t	e,f O	f,t	e,f O	f,t	e,f O	f,t	e,f O

Soil phase	8		9		10		11		12		13		14	
Great soil group	Podzolic Soils		Gley Soils		Alluvial Soils						Hydromorphic Soils			
Physiography	Lower peneplain				River terrace									
Present land use	Upland field		Paddy		Forest, Brush Grassland (alang-alang)		Upland field		Paddy		Upland field		Upland field Grassland	
Land use proposed under gravity irrigation /1	p	uf	p	uf	p	uf	p	uf	p	uf	p	uf	p	uf
Land feature /2	3	3	2	2	3	3	-	-	3	3	-	-	3	3
Natural fertility														
Drainability	1	1-2	2	3	1	1	1	1	2	3	1	1	1	1
Flooding hazard	1	1	1	2	1	1	1	1	2	2	1	1	1	1
Workability	1	1	2	2	2	2	1	1	2	2	1	1	2	2
Acidity	3	3	2	2	3	3	-	-	2	2	-	-	3	3
Erosion hazard	1	1-3	1	1	1	1	1	1	1	1	1	1	1	1
Topographical adequacy	1-4	1-4	1	1	2	2	2	2	1	1	2	2	2	2
Suitability														
Class	S3,Se3 N1	S3 N1	S2	S3	S3	S3	S2	S2	S2	S3	S2	S2	S3	S3
Limiting factors in Sub-class /3	f,t	e,f O	f,w	f,w	f,o	f,o	f,t	f	f	f,w	f,t	f	f,t O	f,o

L1 Column P and uf indicate the land use for paddy and upland field respectively.

L2 Figures show the availability grade of land feature in reference to Table II-8 to II-14 hereof.

L3 See the subsection 2.1.3 hereof.

(to be continued)

Soil phase	15		16		17		18		19		20		21		22		23		24		25	
Great soil group	Alluviali Soils		Hydromorphic Soils						Alluvial Soils		Gley Soils		Andosols		Alluvial Soils		Gley Soils				Organic Soils	
Physiography	Natural levee								Flat valley						Alluvial plain				Swales			
Present land use Land use proposed under gravity irrigation			Farmyard, Upland field						Paddy				Paddy Grassland		Paddy				Paddy, Brush Aquatic plant		Aquatic plant Swale	
	p	uf	p	uf	p	uf	p	uf	p	uf	p	uf	p	uf	p	uf	p	uf	p	uf	p	uf
Land feature																						
Natural fertility	2	2	2	2	3	3	3	3	3	3	3	3	3	3	2	2	3	3	-	-	3	3
Drainability	2	2	2	2	2	2	2	2	2	3	2	3	1	1	2	3	3	4	3	4	4	4
Flooding hazard	1	1	1	1	1	1	1	1	2	2	2	2	1	1	2	2	2	2	3	3	4	4
Workability	1	1	1	1	1	1	1	1	3	3	3	3	2	2	2	2	2	2	2	2	2	2
Acidity	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	-	-	4	4
Erosion hazard	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Topographical adequacy	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Suitability																						
Class	Se2	S2	Se2	S2	Se3	S3	Se3	S3	S3	S3	S3	S3	S3	S3	S2	S3	S3	N1	S3	N1	N1	N1
Limiting factors in Subclass	f,t	f	f,t	f	f,t	f	f,t	f	f,p	f,p,w	f,p	f,p,w	f	f	f	f,w	f,w	f,w	i,w	i,w	f,i,o w	f,i,o w

Table II-16 ACREAGE AND PROPORTIONAL EXTENT OF EACH LAND SUITABILITY UNIT

Grade	Suitability Class	Suitability Sub-class	Survey Area		Gross Irrigable Area	
			Area(ha)	Proportion(%)	Area(ha)	Proportion(%)
I	Highly suitable	S1	11,120	12	10,070	20
II	Moderately suitable	S2f, S2ft	11,710	13	9,900	20
III	Marginally suitable	S3fw, S3fi, S3ft	49,740	55	24,410	48
			72,570	80	44,380	88
IV	Conditionally highly suitable	Sc1t	1,500	2	1,270	3
V	Conditionally moderately suitable	Sc2ft	480	1	460	1
VI	Currently non-suitable	N1ft	11,470	13	3,820	7
VII	Permanently non-suitable	N2t	3,680	4	700	1
			17,130	20	6,250	12
		Total	89,700	100	50,630	100

ANNEX III

GEOLOGY

ANNEX - III

GEOLOGY

1. INTRODUCTION

1.1 Purpose

Geological explorations at the alternative headworks sites; Perjaya and Pracak, and Ranau regulating dam site are required to supplement surface observation to establish the adequacy of the sites and provide sufficient information for preparation of reliable designs and cost estimates. Results of water pressure tests will give important information for the design of structural foundation particularly for leakage protection through the foundation.

1.2 Method of Investigation

(1) Equipment

The equipment described below are used for the drilling and the tests.

- Drill rig ; Rotary drilling machine with a capacity of 50 m in depth with NX bit (76 mm diameter)
- Drilling pump ; Reciprocating piston type with discharge capacity of 60 lit/min and capable pressure of 15 kg/cm^2
- Packer ; Pneumatically expanding type
- Penetration test equipment ; 63.5 kg drive hammer and free fall from 75 cm of height

(2) Core drilling

Diameter of the drill hole is 76 mm. All core samples taken at every depth of drill hole are kept arranged in order in wooden cases which are marked with the depth of core recovery at every one meter interval and hole numbers. Small wooden plate partition is placed at the position of depth where core barrel is recovered.

During the drilling, the following matters are recorded;

- Hole No., date of operation and diameter of hole,
- Groundwater table in the hole,
- Depth of drilling, progress of drilling and length of recovered core samples for each recovery of core barrel, and time for each progress of drilling,
- Change in quantity of return water from the hole, and
- Description of judgement on subsurface conditions, especially about boundary of each stratum.

(3) Field penetration test

The field penetration tests are carried out in accordance with the specifications mentioned in Earth Manual (Designation E-21).

(4) Field permeability tests

i) Water pressure test

Water pressure test is performed in the drill holes for the bed rock by applying the descending stage method, namely, the first 5-m section is drilled and water-tested and then next lower 5-m section is drilled and tested, and so on. A single packer is installed at each of test section. Clean water is pumped into the test section under a constant pressure. After the injection rate becomes stable, the injected water quantity is measured for 10 minutes for each constant pressure.

For each test section, the test pressure is varied as follows;

1 kg/cm^2 (for 10 minutes) - 3 kg/cm^2 (10 minutes) - 5 kg/cm^2 (10 minutes) - 3 kg/cm^2 (10 minutes) - 1 kg/cm^2 (10 minutes)

ii) Constant-waterhead test

Since field permeability tests under high water pressure are often failed at unconsolidated layer of borehole, constant-waterhead test is performed in the drill holes for the unconsolidated layer of borehole.

The test is carried out by descending stage method in such a way that the first 3-m section is drilled and then next lower 3-m section is drilled and tested, and so on. A pipe casing is sunk to the desired depth and cleaned to the bottom of the test section. After the hole is cleaned to the proper depth, the test is started by adding clean water through a metering system. During the tests, the measurement of constant head, constant rate of flow into the hole, size of borehole and length of the test section are recorded.

iii) Calculation of permeability coefficient

Permeability Coefficient K is calculated using the following formula:

$$K = \frac{Q}{2\pi LH} \cdot \log \frac{L}{r} \text{ (cm/sec)}$$

where,

Q : Constant rate of flow into the hole,

L : length of the portion of the hole tested,

H : Total water head, and

r : radius of hole tested

In case the bore hole diameter is 76 mm, 1 Lugeon is approximately correspondent to 1.2×10^{-5} cm/sec. The test results are shown in Table III-1 through III-3.

2. GENERAL GEOLOGY

General geology in and around the project area is described in the text book "The Geology of Indonesia" written by R.W. van Bemmelen in 1949.

The present broad tectonic features of Sumatra are rather simple. The Barisan Mountains forms the backbone, occupying the western portion of the island which is the divide between the west and east coasts. The slopes towards the Indian Ocean is generally steep and the eastern side of the island is occupied by board, hilly region of Tertiary formations and alluvial lowland. (See Fig. III-1)

The southern end of the Barisan Mountains widens in the Lampung Province, and comprises also the crystalline basement complex of the eastern Lampung. This wide section of the Barisan Mountains has been block-faulted into three main units, called; the Benkulen Block, the Semangko Block and Sekampong Block. The Benkulen Block is a long, narrow crusty slice, which has been tilted along an axis parallel with the coast. It is bounded to the NE by the Semangko Graben. Lake Ranau, situated in the Semangko Graben, is a rectangular volcano-tectonic. The Sekampong Block can be considered the northeastern flank of the Barisan zone in South Sumatra, forming in this respect the counterpart of the Benkulen Block.

A geological map of 1:200,000 (1932), Baturaja were also prepared by van Bemmelen (See Fig. III-2). Based on this map, the stratigraphy of the investigation site and its vicinity area are understood as follows.

<u>The Telisa formation</u> (Miocene)

This formation consists of globigerina marls and shales with intercalations of andesitic tuffs and breccias, formation of glauconitic sandstone, platy or concretionary limestone, and occasional layers with plant remains. In central Palembang the Telisa formation contains important oil horizons.

The Lower Palembang formation (Late-Miocene)

This formation is composed of bluish gray frequently glauconitic marls and mudstones interbedded with tuffaceous sandstone and glauconitic, concretionary, marly limestones.

The Middle Palembang formation (Late-Miocene to Lower-Miocene)

This formation is composed of mudstone, tuffaceous sandstone, interbedded with marly or glaucoitic concretions, glauconite sands and several groups of brown-coal beds.

The Upper Palembang formation (pliocene to pleistocene)

This formation mainly consist of acid pumice tuffs, tuff-sands and kaolinlike clay (bentonites), practically without marine horizons and with few coal strings. The formation does not contain oil.

The Alluvial deposits with acid tuff (Quaternary)

This formation consists of tuffaceous sand, clay and chalcedonic gravel beds intercalated with thin layers of acid pumice tuff, which contains andesite fragments and carbonized wood. Gradually it moves into the Upper and Middle Palembang formations, which are also horizontal, and which are composed of acid tuffs and tuffaceous sandstone with indistinct boundaries.

The Igneous rocks of Bukit Mapas (Quaternary)

The Mapas comples is an andesitic lava domes of hornblende andesitic composition, rising for 100 - 300 m from the surrounding plain. The complex has a diameter of about 8 km. Its center is of also a crater, with a diameter of 1.2 km. From this center also some basaltic lava flows descended in various directions. The basement of these volcanic formations consists of folded Neogene formation.

3. GEOLOGICAL SURVEY AT PRACAK HEADWORKS SITE

3.1 General Feature

An alternative headworks site was selected at Pracak, about 5 km upstream of Martapura highway bridge, where the Komering river changes its course from east-northeast to northeast (see Fig. III-1). Solidified claystone of Pliocene-Pleistocene is exposed in a limited area at the water-edge on both banks of the river.

3.2 Drilling Investigation

Drilling investigation at the Section-A which was originally selected was made by the Government of Indonesia in April 1980 and its geological report was prepared in June 1980. The investigation also included the test pit survey and soil mechanical tests in laboratory. The results of soil mechanical analyses are shown in Table III-4.

Another site (Section-B) is selected at 100-meter upstream from the Section-A through the present field reconnaissance and based on the 1:5,000 topographic maps, in view of its favorable topography for the headworks construction. (See Fig. III-3)

Geological investigation by test drilling at Section-B was recommended at four holes selected along the weir axis; two holes on the left bank, one hole on the right bank and one hole in the river bed, of which the former three have been completed so far. Total proposed drilling depth would be 100 m. In addition, standard penetration test and field permeability test were carried out in each drilling hole.

3.3 Results of Laboratory Tests

Ten soil samples were taken from each bore hole at the Section-A and were tested by the Government in the laboratory of soil mechanics in Bandung for the following test items. The test results are shown in Table III-4.

Test items

Moisture Content
Volume Weight

Specific Gravity

Direct Shear

Triaxial

Unconfined Compression

Consolidation

Atterberg Limit

Grain Size Analysis

3.4 Geological Conditions at Headworks Site

According to the geological survey by means of test drilling at the Section-A and Section-B, the foundation of the Pracak headworks site consists of Pliocene-Pleiostocene formations; an alternating layers of sandstone and claystone. (See Fig. III-4, 5, 6)

3.4.1 Section-A

C1 layer

C1 layer extends over the top of the right bank, being composed of clay and gravelly sand. The thickness of this layer is 8-meter. Gravelly sand is generally of a brownish red color, and the upper part has a dark brown color. Clay is generally yellowish-white, and plastic and cohesive. The results of field tests indicate that permeability coefficient (K) and standard penetration test valves of this layer are between 1.5 - 8.5 x 10^{-5} cm/sec and 15 - 38 blows respectively.

S1 layer

S1 layer crops out facing the Komering river at the Section-B. This layer is generally, white and very dense fine grained, and the forming fragment are composed of feldspar, plagioclase and quarts well sorted. The matrix consists of glass, cemented with clay. This layer is estimated to be 3.5-meter thick having permeability of between 1.0 - 4.0 x 10^{-5} cm/sec and N-value of between 17 - 50.

C2 layer

C2 layer crops out on the shore of the Komering river. This layer is gray and bluish gray color, very hard, with the forming mineral generally consisting of clay, chlorite, quartz, plagioclase. Its cementation consists of iron oxide and clay, poorly cemented. This layer shows low permeability having small coefficient around $K = 3 \times 10^{-5}$ cm/sec in the constant head tests and standard penetration value of 50.

S2 layer

S2 layer can be observed on the recovered core of the drilling hole Bl pr.2, 3 and 4. The layer is composed of medium to fine grained sandstone and its cementation consists of clay. The matrix consists of glass, relatively well cemented. This layer is impermeable having very small coefficient $K = 3 \times 10^{-6}$ cm/sec in the water pressure test and standard penetration value of 50.

C3 layer

C3 layer can be observed on the reserved core of the all drilling holes. The layer consists of very hard gray to bluish gray claystone. Its fresh facies are moderately consolidated having standard penetration value of 40 - 50 and permeability of between 10^{-4} - 10^{-6} cm/sec.

S3 layer

S3 layer is composed of sandy clay, sand and gravel, clay, and quartz sand. The sand and gravel bed is interpreted as the sedimentation results of river. The core boring result indicates that the permeability coefficient and standard penetration test values of this layer are between 10^{-3} - 10^{-5} cm/sec and 11 - 42 blows respectively.

S4 layer

S4 layer consists of sand and gravel, and tuff breccia. Tuff breccia is observed on the recovered core at the drilling hole Bl pr.2 from 21 to 24 meters in depth. This layer is blackish gray color and very dense. The forming fragment consists of andesite components and sub-angular relatively well sorted with a mixture of pumice component of 0.5 - 32 cm angular. The matrix consists of clay, feldspar and glass. The cementation consists of clay relatively well cemented. The sand and gravel layer shows partly the high permeability of 2.67×10^{-2} - 8.28×10^{-3} cm/sec, and shows over 50 in N-value.

C3' layer

C3' layer can be observed on the reserved core of the drilling hole BI pr-1. This layer is sandwitched in between S3 and C3 layer and consists of gray, stiff and plastic sandy clay. This layer shows very small permeability coefficient of 3.7×10^{-6} cm/sec and small standard penetration value of 11.

3.4.2 Section-B

C1 layer

C1 layer extends over the top of the right bank, being composed by tuffaceous clay with gravel, stiff to very stiff having 7.5-meter thickness. The results of field tests indicate that permeability coefficient and standard penetration test values of this layer are between 5.55×10^{-4} - 6.30×10^{-5} cm/sec and 9 - 23 blows respectively.

S1 layer

S1 layer crops out facing on the Komering river at the right bank of this Section. This layer is generally of yellow-white, dense, hard, fine to coarse grain sand angular well sorted. The fragment consists of pumice tuff and quartz, and the matrix consists of glass, cemented with clay. This layer is estimated to be 3.5-meter thick having permeability of 5.55×10^{-4} cm/sec and N-value of between 34 - 50.

C2 layer

C2 layer crops out on the shore of the Komering river. This layer is bluish gray, very stiff and hard. This layer is estimated to be 3.0-meter thick having N-value of between 26 - 38.

S2 layer

S2 layer can be observed on the reserved core from the drilling hole BH 1-2 and 1-4. The layer is composed of fine to medium grain sand and angular, and well sorted. The fragment consists of pumice, quartz and sediment stone, rather well cemented by clay. This layer is impermeable having very small coefficient $K = 7.2 \times 10^{-5} - 6.57 \times 10^{-6}$ cm/sec, and having standard penetration value of 50.

C3 layer

C3 layer can be observed on the reserved core of the all drilling holes. The layer consists of very hard bluish gray claystone and hard clay. The core boring result indicates that the permeability coefficient and standard penetration test values of this layer are between 3.4×10^{-5} - 2.39×10^{-6} cm/sec and 38 - 50 blows respectively.

C3' layer

C3' layer can be observed on the reserved core of the drilling hole BH 1-1. This layer is sandwitched in between S3 and C3 layer. This layer is bluish gray and soft to medium hard clay. This layer is estimated to be 4.0-meter thick having permeability of between 8.64×10^{-5} -4.6×10^{-6} cm/sec and N value of between 15 - 36.

S3 layer

S3 layer is composed of sandy clay, sand and gravel, clay and quartz sand. The sand and gravel bed is interpreted as the sedimentation results of river. S3 layer can be observed on the reserved core of the drilling hole BH 1-1 and BH 1-2 and this layer extends upper part of the left bank. The total thickness is about 10 meters. The sandy clay and sand layer shows partly the N-value of 14 and permeability coefficient of between 1.11×10^{-4} - 7.87×10^{-6} cm/sec.

S4 layer

S4 layer consists of sand and gravel, sandstone and partly tuff breccia. Sandstone is observed on the recovered core at the drilling hole BH 1-1 from 18 to 21 meters in depth. It is bluish gray and blue black color and very hard. The forming fragment consists of volcanic components with a mixture of pumice component. This layer is impermeable having small coefficient of 3.66×10^{-5} - 6.62×10^{-6} cm/sec and standard penetration value of 50.

3.5 Foundation of Weir

The fresh hard rocks at this site are of an alternating layers of sandstone and claystone.

Fig. III-6 shows a section-B along the proposed weir line. As seen in Fig. III-6, the depth to fresh hard rock averages 14 m on the left bank, and 16 m on the right bank. Bore hole BH 1-1 and BH 1-2 show about 6 m depth of the gravelly sand layer on the left bank.

The results of the field permeability test and standard penetration test carried out each borehole along the proposed weir line are summarized in Table III-1-1 and Fig. III-4-5, III-4-6 and III-4-7. General permeability in the fresh hard rock showed between 2 x 10^{-5} and 2 x 10^{-6} cm/sec having standard penetration value of 50.

From the above results, it is preliminarily concluded that the fresh hard rocks are compact and massive enough for the foundation of the proposed headworks. For the further detailed study, however, more boreholes be required to be drilled particularly in the river bed along the proposed weir line.