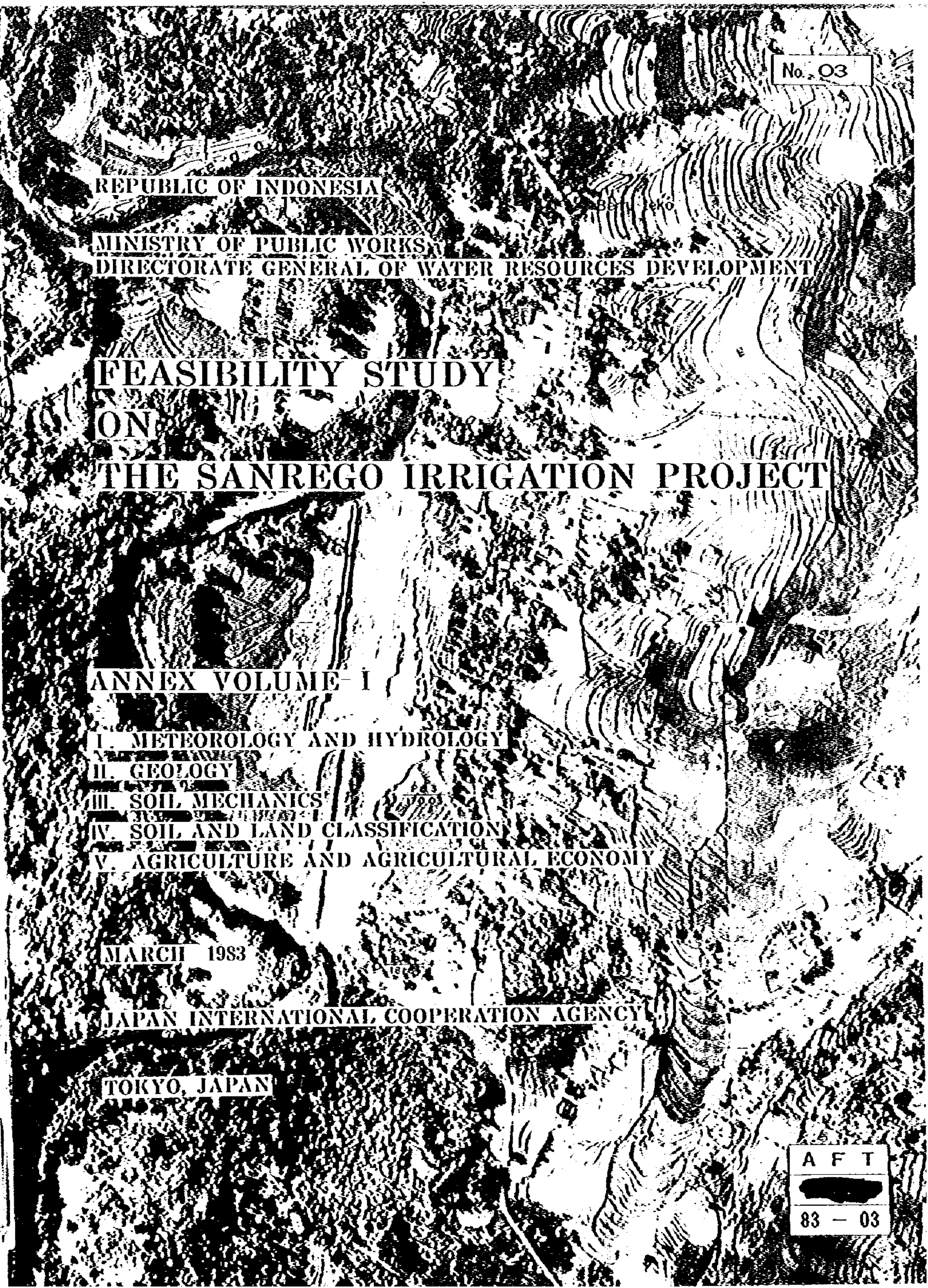

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REPUBLIC OF INDONESIA

MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

FEASIBILITY STUDY ON THE SANREGO IRRIGATION PROJECT

ANNEX VOLUME-I

I. METEOROLOGY AND HYDROLOGY
II. GEOLOGY
III. SOIL MECHANICS
IV. SOIL AND LAND CLASSIFICATION
V. AGRICULTURE AND AGRICULTURAL ECONOMY

MARCH 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

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ANNEX - I

METEOROLOGY AND HYDROLOGY

ANNEX - I METEOROLOGY AND HYDROLOGY

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ANNEX - I METEOROLOGY AND HYDROLOGY

1. GENERAL

1.1 Flow of Study

The hydrological investigation and study are conducted to make clear the hydrological properties in and around the study area for irrigation and drainage planning with the following specific objectives:

(1) Review and examination of the available basic data collected,

(2) Additional collection of meteorological and hydrological data,

(3) Spot discharge measurement,

(4) Sampling and water quality analysis, and

(5) Studies of drought and flood discharges.

The Sanrego river is a major tributary of the Walanae river and is the main water source for the Project. In the Sanrego river, there exist two (2) water level gauging stations, Sanrego and Turungeng. The discharges of the Sanrego river can be estimated by use of such actual water level records. The estimated discharges are checked by the rainfall data. Since no rainfall gauging stations exist in the Sanrego river watershed, the isohyetal map which is prepared based on the available records at the rainfall stations in and around the study area, is used for checking of the estimated Sanrego river discharges.

As regards the flood discharge of the Sanrego river, the analysis is made using the peak water level records and also 24 hours maximum rainfall data. In the study area, there are many small tributaries other than the Sanrego river, but no hydrological data are available in these tributaries. The discharges of these tributaries are estimated based on the isohyetal map and results of field investigation.

The study flow chart is shown in Fig. I.1.1.

1.2 River Basin

The Sanrego river originates in the Mt. Bohonglangi of 1,983 m in altitude. It flows down from south to northeast in the study area as shown in Fig. I.1.2. The total length of the river is about 43 km from the originating point to the confluence of the Walanae river and the average gradient of upper portion is about 3% and lower portion 0.4%. The catchment area of the Sanrego river is 225 km^2 at the confluence of the Walanae river. In the Sanrego river, there exist two water level gauging stations, namely Sanrego station and Turungeng station. The catchment areas of these two stations are measured to be 179.0 km^2 at Sanrego station and 174.3 km^2 at Turungeng station, respectively.

In the Sanrego river basin, a large depressed area of 33.7 km^2 extends on western part of the basin and is mainly covered with limestones. Very little surface runoff is observed in this Karst topography because of underground drainage systems created by corrosion. From the viewpoint of geology, almost all of this Karst water flows into the Sanrego river. This depression has a natural flood control function, reserving large rainfall water for a long term and keeping stable base flow runoff. It is judged from this peculiar drainage system that the Sanrego river drouth discharge is relatively large and stable in dry season.

The catchment area of the Sanrego river at the proposed intake weir site is 179.2 km^2 including the depression. In case of flood discharge calculation, considering above-mentioned phenomena, the catchment area of 145.5 km^2 is used excluding the depressed area of 33.7 km^2. The Sanrego river watershed is covered mainly with forest (57%) and grassland (39%).

The Parota river, one of tributaries of the Sanrego river, is located in the northwestern part of the Sanrego watershed. The Parota river basin is mainly composed of mountainous and hilly area covering with grassland (50%) and forest (45%). The maximum altitude is 740 m. The catchment area of the Parota river is 32.0 km^2 at the confluence of the Sanrego River and 30.8 km^2 at the proposed intake weir site.

The Biru river is one of the tributaries of the Walanae river and the basin is thinly shaped and located facing to east side of the Sanrego watershed. The Biru river flows from south to north and the maximum altitude of the basin is 1,060 m. The catchment area of the Biru river is 50.5 km^2 at the confluence of the Walanae river and 20.3 km^2 at the existing intake weir site. Land use of the basin consists of cultivated field (11%), grassland (40%) and forest (49%).

The Macinaga river is a upstream portion of the Baruttung river, which is also one of the tributaries of the Walanae river. The Macinaga river originates in the west slope of eastern mountains with maximum altitude of 450 m and flows to south up to the confluence of the Baruttung river which flows to west. The catchment area of the Macinaga river is 8.7 km^2 at the proposed intake weir site and 12.1 km^2 at the confluence of the Baruttung river. The Baruttung river has a catchment area of 33.7 km^2 at the confluence of the Walanae river. Land use of the Macinaga River basin is composed of cultivated land (40%), grassland (39%) and forest (21%).

Land cover in the respective watershed is summarized as shown below:

/

(Unit: ha)

Land Use Categories	Sanrego	Parota	Biru	Macinaga
Paddy field	490 (3%)	120 (4%)	210 (10%)	340 (39%)
Upland crops field	60 (1%)	30 (1%)	20 (1%)	10 (1%)
Grassland	6,940 (38%)	1,550 (50%)	800 (40%)	340 (39%)
Sparse forest	3,850 (21%)	150 (5%)	510 (25%)	20 (2%)
Dense forest	6,580 (37%)	1,230 (40%)	490 (24%)	160 (19%)
Total	17,920 (100%)	3,080 (100%)	2,030 (100%)	870 (100%)

2. METEOROLOGICAL AND HYDROLOGICAL DATA

2.1 Meteorological Data

In the study area, one meteorological station is located at Camming as shown in Fig. I.2.1. The meteorological data at the Camming station, such as temperature, evaporation, relative humidity, sunshine duration and wind velocity are given in Table I.2.1 and illustrated on Fig. I.2.2.

The seasonal trend of temperature in the study area is characterized by its narrow variation. The maximum monthly mean temperature of 28.3°C occurred in November, 1980, whereas the minimum of 24.2°C in July, 1976. The annual mean temperature is 25.9°C.

The annual mean A-pan evaporation observed at Camming meteorological station reaches 1,570 mm. The maximum monthly mean A-pan evaporation of 225 mm or the daily mean of about 7.3 mm equivalence occurred in October, 1979, and the minimum of 77 mm or the daily mean of about 2.6 mm equivalence, in June, 1979.

The relative humidity narrowly varies between the dry and wet seasons, about 83% on an average during the wet seasons, and about 76% during the dry season. The lowest relative humidity occurred in September, 1976, while the highest relative humidity, in May, 1980 and 1981.

The annual mean percentage of sunshine is 50% or 5.9 hr/day. The monthly mean sunshine hours range from 2.1 hr/day to 10.3 hr/day.

The east monsoon prevails over the study area during the wet season. The monthly mean wind velocity varies between 0.5 m/sec and 1.9 m/sec, resulting in 1.1 m/sec in terms of annual mean.

2.2 Rainfall

Rainfall data in and around the study area are collected from eleven (11) stations, among which three (3) stations are located in the study area. No rainfall stations have been established in the Sanrego and relevant small tributaries watersheds. The location of the existing stations is shown in Fig. I.2.1 and the information on data availability is summarized in Table I.2.2 and Fig. I.2.3.

Mean monthly and annual rainfall data at 11 stations are presented in Table I.2.3. Considering the observation periods, the data at nine (9) stations are mainly used for the hydrological study for the Project. The monthly rainfall patterns of the selected nine (9) stations are illustrated on Fig. I.2.4.

2.3 Water Level and Discharge Measurement

Hourly water level records (Data A) at two (2) stations, namely, Sanrego and Turungeng stations, are available in the Sanrego river. The location of these stations is shown in Fig. I.1.2. The record periods are shown in Fig. I.2.5. Automatic water level recorders are employed at these two stations.

The daily water level records (Data B) are also available from the same origin and the periods of available records are almost same as the above-mentioned hourly data (Data A).

Discharge measurement records obtained at the Turungeng and Sanrego stations by P.M.A (Penyelidikan Masalah Air: Institute of Hydraulic Section) are shown in Table I.2.4.

Spot discharge measurements were conducted in the Sanrego river and other small tributaries by JICA Team in this study. The location of measurement spots and the results are shown in Fig. I.2.6 and Table I.2.5, respectively.

2.4 Data Quality Check

(1) Water level

Daily water level data (Data B) and calculated ones from hourly water level data (Data A) should coincide with each other, but some portion of these data are not coincidental. Judging from shape of hydrograph made from the said water level data, daily water levels calculated from hourly water level data (Data A) has higher reliability. Therefore, daily water level based on hourly water level data (Data A) is used, except the case that lack of hourly data can be supplemented by the daily data (Data B).

The daily water level data at two stations, Turungeng and Sanrego, are well correlated as shown in Fig. I.2.7. Judging from this correlation together with the shape of water level hydrograph, the water level data have a fair degree of accuracy.

As for reliability of data at these two stations, it is considered that the water level data of the Sanrego station are a little less reliable by reasons that:

(a) period of lack of data is longer than that of Turungeng station in the same period from 1978 to 1982,

(b) an abrupt discontinuity is observed at left bank in the river cross-section, and

(c) no staff gauge can be seen from outside of the shelter.

In the water level records at the Turungeng station, data of a period from June to November in 1977 are judged as unreliable, because a serious flood on June 13, 1977 destroyed the automatic water level recorder.

(2) Discharge measurement

As the result of plotting discharge measurement record on a paper, it is cleared that discharge measurement was carried out with a good accuracy. Also the result of field investigation conducted in this study is coincidental.

2.5 Supplement of Water Level

Since some data are lacking in the water level records, supplement is made by the following method:

(a) In case that hourly record (Data A) is lacking and daily record (Data B) is existing, the daily records is used after checking its reliability.

(b) In case that hourly water levels are presented not fully (on in 24 hours) but a part of 24 hours, daily water level is estimated from partial hourly data.

(c) In case of short term lacking, estimation is made on the basis of preceding data and following data.

(d) A correlation between water level data of the Turungeng and Sanrego stations is established with a fair degree of accuracy as shown in Fig. I.2.7. Lack of water level data at one of these stations is supplemented from existing water level data at another station by using the correlation equation.

Mean monthly water level is summarized in Table I.2.6 and Fig. I.2.8.

3. WATER RESOURCES

3.1 Rainfall Characteristics

(1) General

The Province of South Sulawesi is a long peninsula with a width of about 85 km. There exists Mt. Lompobatang of 2,871 m in altitude locating 20 km north from southern end of the peninsula. The main mountains of about 2,000 m in altitude are running from north to south direction along somewhat western side of the peninsula and are forming main boundary of watershed.

The general rainfall pattern over the year in Indonesia and that in the east coast of South Sulawesi including the Sanrego Project area are somewhat different.

Between the continents Australia and Asia, large monsoon systems affect the trade winds which cause rainfall. In southern summer, air of heated Australia ascends and cooling air over Asia decends and flows off as monsoon winds. The wet NE trade wind from the Pacific Ocean changes its direction from NE to N and NW and causes rainy season in Indonesia generally. In South Sulawesi, this NW to N wind flows up the western mountains and at the same time causes rainfall in the west coast. After flow over the mountains, this wind becomes somewhat drier and so rainfall in east coast is not so much. This season approximately from December to March is the transitional season in the Sanrego Project area. In southern winter, air flows from cooling Australia to heated Asia as the SE monsoon or intensified SE trade wind. This continental air causes a very distinct dry season on the near Australia islands. This season approximately from August to November is the dry season in the Sanrego Project area. In the east of Indonesia early SE monsoon bypasses Australia and brings moisture from the South Pacific. Thus another rainy season is caused. This season approximately from April to July is wet season in the Sanrego Project area. In South Sulawesi, the SE wind causes rainfall mainly in the east coast and on the eastern mountain which are relatively low in altitude. After reducing its moisture as rainfall, the SE wind flows down the western mountain and causes rainfall but not so much in volume. As mentioned above, in South Sulawesi, the rainfall distribution over the year is different between the east coast side including the Sanrego Project area and the west coast side of which rainfall pattern is nearer to that in general Indonesia.

The Project area receives the average annual rainfall of about 2,100 mm. About 80% of the annual rainfall concentrates between December thru July, while only 20% is distributed within the dry season. As for rainfall in dry season, the quantity of rainfall fluctuates year by year. Some years experience very serious dry season like savannah climate with a consecutive drought of more than 2 or 3 months, while some years receive relatively stable rainfall. The maximum consecutive drought of 104 days was recorded from August to December in 1972.

(2) Isohyetal map

Based on the rainfall data in and round the study area mentioned in the previous section 2.2, an isohyetal map is prepared as shown in Fig. I.3.1. In the mountain region of high altitude, rainfall is cleared to be higher than in lower land according to the rainfall data. Considering altitude and topography, this isohyetal map is made. From this map, annual watershed rainfall of Sanrego river and three tributaries are estimated as below:

Description	Name of River			
	Sanrego	Parota	Biru	Macinaga
Annual Watershed Rainfall (mm)	2,810	2,350	2,360	2,160

(3) Long term rainfall fluctuation

Rainfall fluctuation in a long term from 1879 is studied by moving average method as shown in Fig. I.3.2 and by annual rainfall in magnitude order as shown in Fig. I.3.3. Resulting from these figures, it is judged that a period from 1974 to 1981, when sufficient hydrological data are available, is an average or somewhat dryer period.

3.2 Sanrego River Discharge

3.2.1 Rating curve

Based on the discharge measurement mentioned in the previous section 2.3, rating curves are estimated by using the least square method.

(1) Turungeng station

The rating curve is prepared dividing into two periods by the big flood on June 13, 1977, because it is considered that this flood changed the river bed shape. The rating curve is further divided by water level range based on the results of discharge measurements. The estimated rating curve is shown in Fig. I.3.4.

(2) Sanrego station

During a short observation period at the Sanrego station, cross-sectional shape of the river bed is considered to be changed a little by a flood in May 1981. The rating curve is, therefore, prepared in two terms as shown in Fig. I.3.5.

3.2.2 Estimate of discharge

On the basis of above-mentioned rating curves and daily water level records, daily discharge is calculated. After this calculation, the lacking part of discharge is supplemented by afore-mentioned method considering the purpose of the daily discharge estimation. Caldulated daily discharge will be recognized as the available water for irrigation and be used in water balance study for irrigation planning. Therefore, the daily discharge is estimated as the minimum one.

Estimated daily discharge is shown in Tables I.3.2-I.3.3 and Figs. I.3.9-I.3.10. Mean monthly discharge is shown in Table I.3.1 and Figs. I.3.6-I.3.7.

3.2.3 Analysis of discharge

(1) Relation between two stations

The proposed intake weir site has a catchment area of 179.2 km^2, which is nearly equal to those of the Turungeng and Sanrego stations. No tributaries join to the Sanrego river between those two stations. It is observed that estimated discharge at the Sanrego station and that of the Turungeng station are comparatively coincidental as shown in Table I.3.1 and Fig. I.3.7. The discharge at Turungeng station, which has a longer observation period and somewhat higher reliability as mentioned in the previous section 2.4, is applied as the available irrigation water at the intake weir site.

(2) Watershed rainfall and loss

Although no rainfall data are available in the catchment area of the Sanrego river, average watershed rainfall of the Sanrego river is assumed to be 2,850 mm according to the isohyetal map (Fig. I.3.1). Annual runoff of the Sanrego river at the proposed intake weir site is estimated around 1,850 mm in depth. Loss (rainfall minus runoff in depth) is estimated to be around 1,000 mm. Though this value is a little smaller than general value in Indonesia, this loss of 1,000 mm is judged to be within reasonable range considering that this area has generally semi-sabannah climate and that there exist the depression mainly composed of limestone in the watershed. Fig. I.3.12 shows the relation between discharge and rainfall.

3.3 Small Tributaries Discharge

3.3.1 Annual runoff

There exist many small tributaries other than the Sanrego river in the study area. Out of them, three tributaries, namely, Parota, Biru and Macinaga, are considered to be comparatively large and to be used as the supplemental water sources for the Project.

However, since there are no hydrological data available in these tributaries, following approach is made to estimate annual runoff of the tributaries. From the isohyetal map of Fig. I.3.1, annual average rainfall in each tributary watershed is obtained. On the assumption that the loss in watershed is 1,000 mm, runoff of the tributaries is estimated by deducting the loss of 1,000 mm from watershed rainfall. Ratio of runoff in depth between the tributaries and the Sanrego river is taken as that of specific discharge. Multiplying this specific discharge ratio by catchment area ratio, the discharge ratio or runoff volume ratio of the tributaries and the Sanrego river is obtained. This process is summarized as follows:

Item		Name of River				
		Sanrego	Parota	Biru	Macinaga	Total
Watershed rainfall	(mm)	2,850	2,350	2,360	2,160	
Loss (Actual Evapo-transpiration)	(mm)	1,000	1,000	1,000	1,000	
Runoff in depth	(mm)	1,850	1,350	1,360	1,160	
Specific discharge ratio	(1)	1.00	0.73	0.74	0.63	
Catchment area	(km^2)	179.2	30.8	20.3	8.7	
Catchment area ratio	(2)	1.00	0.172	0.113	0.049	
Discharge ratio (1) x (2)		1.00	0.13	0.08	0.03	1.24

The annual runoff of these three tributaries is thus estimated at 24% of the Sanrego river runoff.

3.3.2 Available irrigation water

In the Sanrego river, base flow is rather stable due to the existence of the depressed area in the catchment area as mentioned before, while base flow of other tributaries is very small as confirmed through field investigation in this study (see Table I.2.9). During the dry season from August to November, almost no available irrigation water is expected from these tributaries.

The annual runoff of the tributaries could, therefore, be utilized only for the transitional and wet seasons. The available irrigation water of the tributaries is calculated as shown below:

(Unit: m^3/sec)

Month	Name of River Sanrego (1.00)	Parota (0.13)	Biru (0.08)	Macinaga (0.03)	Total (1.24)
Jan.	12.2	1.6	1.0	0.4	15.2
Feb.	10.0	1.3	0.8	0.3	12.4
Mar.	10.2	1.3	0.8	0.3	12.6
Apr.	12.4	1.6	1.0	0.4	15.4
May	14.6	1.9	1.2	0.4	18.1
Jun.	14.4	1.9	1.2	0.4	17.9
Jul.	11.4	1.5	0.9	0.3	14.1
Aug.	9.6	0	0	0	9.6
Sep.	6.6	0	0	0	6.6
Oct.	5.6	0	0	0	5.6
Nov.	7.8	0	0	0	7.8
Dec.	10.6	1.4	0.8	0.3	13.1
Annual mean	10.5 (1.00)	1.0 (0.10)	0.6 (0.06)	0.2 (0.02)	12.4 (1.18)

4. FLOOD DISCHARGE OF SANREGO RIVER

4.1 Flood Discharge Record

(1) Basic data

The flood water level data are available at the Turungeng and Sanrego stations. As the basic data for flood analysis, flood record at the Turungeng station is used because of its longer observation period and a little higher reliability as mentioned in section 2.4.

(2) Discharge by Manning formula

The maximum flood discharge is estimated by Manning formula. River cross-section at the Turungeng station is shown in Fig. I.4.1. The maximum flood water level of 6.44 m is estimated based on flood mark. Cross-section area of flow (A) and wetted perimeter (P) are measured on the river cross-section drawing, and hydraulic radius (R) is calculated.

Slope of water surface (I) is estimated at 1/130 on the basis of 1/25,000 topographic map. Coefficient of roughness (n) is assumed by use of the largest four records in the discharge measurement. Estimated discharge at F.W.L 6.44 m is around 740 m^3/sec. According to the information collected through interview in and around the study area, flood of this scale occurs once in 100 years. So return period of this flood is assumed to be more than 50 years.

(3) Flood discharge

From the recorded water levels for 9 years from 1973 to 1981, fourty-four (44) data over 1.5 m water level are picked up as shown in Table I.4.1. Annual maximum flood discharge is:

Year	Water Level (m)	Flood Discharge (m^3/sec)
1973	3.12	241
1974	2.47	158
1975	2.50	161
1976	2.73	189
1977	6.44	740
1978	2.12	120
1979	3.11	240
1980	2.85	205
1981	2.36	146

4.2 24 hr Maximum Rainfall

(1) Rainfall data

There are no rainfall gauging stations in the catchment area of the Sanrego river but three stations, Tombolo, Palattae and Maradda are located near the Sanrego watershed. The Tombolo rainfall gauging station is located in the adjacent river basin, 27 km southern west from the intake site. The Palattae and Maradda gauging stations are located in the study area, 9 km and 3 km east from intake weir site, respectively. The observation period and available rainfall data at above three stations are summarized below.

Station	Observation Period	Available Data
Tombolo	1920-1941	- Monthly rainfall with maximum daily rainfall
Palattae (1)	1920-1941	- Monthly rainfall data with maximum daily rainfall
Palattae (2)	1974-1981	- Daily rainfall data
Maradda	1971-1981	- Daily rainfall data

24 hr maximum rainfalls at Tombolo and Palattae are shown in Table I.4.2.

(2) Probable rainfall

The probalbe rainfall is estimated using rainfall data at Tombolo and Palattae stations. The rainfall data at Maradda is not used because of its short observation period. The probable rainfall on t-year return period (Rt) is given by the following formula.

$$Rt = \frac{Rpt \cdot Ap + RTt \cdot AT}{Ap + AT}$$

where,

Rpt: probable rainfall on t-year return period at Pallatae (mm/day)

RTt: probable rainfall on t-year return period at Tombolo (mm/day)

Ap: influenced area of Palattae Station (km^2)

AT: influenced area of Tombolo Station (km^2)

The probable rainfall on t-year return period at Pallatae and Tombolo are estimated by using Gumbel and Hazen Plot methods. For example, the results on 100-year return period are shown below:

Station	Probable Rainfall (mm/day)		Influenced
	By Gumbel	By Hazen Plot	Area (km^2)
Palattae	349.4	350	48.8
Tombolo	268.0	270	96.7

The probable rainfall resulted by Hazen Plot method is employed to apply the estimation of the design probable rainfall. The result of the estimation is:

$$R100 = \frac{350 \times 48.8 + 270 \times 96.7}{145.5} = 296.8 \text{ (297 mm/day)}$$

The probable rainfall on t-year return period is summarized as below (see Fig. I.4.2).

Return	Probable 24 hr Maximum Rainfall		
Period	Palattae	Tombolo	Sanrego Basin
(year)	(mm)	(mm)	(mm)
2	120	107	111
10	215	180	193
20	255	208	224
100	350	270	297
1000	500	370	412

(3) Time of flood concentration (tc)

The time of flood concentration (tc) is estimated based on the relation between the flood discharge scale and the time from the beginning point to the peak in hydrograph, as shown in Fig. I.4.3. According to this figure, the time of flood concentration (tc) of 6 hours is employed for the estimation of big flood discharge in this study.

(4) Runoff coefficient

Taking into consideration the characteristics of the catchment area, such as topography and land use conditions in the area, the runoff coefficient of 0.65 is adopted to the estimation of the design flood discharge.

4.3 Probable Flood Discharge

The probable flood discharge is estimated by the following three methods:

(a) Exponential distribution method

The discharge records for the period of 9 years are available at Turungeng water level gauging station as described hereinbefore. The probable density function of the flood discharge is estimated by means of using exponential distribution method with the daily discharge data at Turungeng. The formula of exponential distribution method is shown:

$$Q = a \cdot \log_{10} TE + b$$

where,

- Q: probable flood discharge (m^3/sec)
- TE: return period
- a: $(\overline{x}.\overline{y} - \overline{x.y}) / (\overline{y}^2 - \overline{y^2})$
- b: $\overline{x} - a.\overline{y}$
- $\overline{x}$: mean value of records
- y: $\log_{10} T$
- T: record period/order of data
- $\overline{y}$: $\Sigma y/N$
- N: number of data

Fourty-four (44) discharge data in the non-annual exceedance series are picked up from the recorded discharges for 9 years and used in the probability analysis. The calculation result is shown in Fig. I.4.4.

(b) Melchior method

$$Qt = L \cdot F \cdot q \cdot \frac{Rt}{200}$$

where,

Qt: flood discharge with t year return period (m^3/sec)

L: runoff coefficient

F: catchment area (km^2)

q: specific discharge (m^3/sec/km^2)

Rt: probable daily rainfall on t-year return period (mm/day)

(c) Rational formula

$$Qt = \frac{1}{3.6} \cdot f \cdot rt \cdot A$$

where,

Qt: flood discharge on t-year return period (m^3/sec)

f: runoff coefficient

rt: rainfall intensity during time of flood concentration (mm/hr)

A: catchment area (km^2)

The rainfall intensity during the time of flood concentration (rt) is estimated by using the Mononobe's formula as shown below:

$$rt = \frac{Rt}{24} \cdot \left(\frac{24}{t}\right)^{2/3}$$

where,

Rt: probable daily rainfall on t-year return period (mm/day)

t: time of flood concentration (hr)

(d) Design flood discharge

The probable flood discharge with 100-year return period is taken as the design flood discharge for the Sanrego intake weir. The design flood discharge is estimated by using the above three methods:

Method	Estimated Flood Discharge (m^3/sec)	Remarks
(1) Exponential Distribution Method	758	Discharge Records of 1973 - 1982
(2) Melchior Method	691	L = 0.65, F = 145.5 km^2 Rt = 297 mm/day
(3) Rational Formula	820	f = 0.65, A = 145.5 km^2 Rt = 297 mm/day t = 6 hrs

Among the estimated flood discharges shown above, the maximum value, 820 m^3/sec by Rational Formula, is employed as the design flood discharge for the checking of the existing design of the Sanrego intake weir.

5. WATER QUALITY AND SEDIMENT

5.1 Water Quality

To make the characteristics of the irrigation water quality more clear, additional water sampling was carried out in August and September, 1982 for the Sanrego river and other main tributaries to supplement the results made in the previous studies. The location of sampling is shown in Fig. I.2.6.

For analysis, the samples were sent to the Laboratory and Testing Institute for Industrial Products, Ujung Pandang (Departemen Perindustrian, Balai Penelitian dan Pengembangan Industri). The result of water quality analysis for each site is shown in Table I.5.1, together with those of the previous studies.

According to the analysis results, the water of the Sanrego river and other main tributaries seems to be suitable for irrigation.

5.2 Sediment

Suspended sediment data for the Sanrego river which have been collected from DPMA are shwon in Table I.5.2. The values of suspended sediment are mostly below 100 mg/lit.

6. RECOMMENDATION

The hydrological analysis in this study was made mainly for the assessment of available irrigation water in the Sanrego river and three tributaries, Parota, Biru, and Macinaga. The analysis was made by the maximum use of available data obtained in and around the study area, but reliable data on hydrology are limited at present. In order to confirm more detailed hydrological conditions in the area, the following observation networks are recommended to be urgently established:

(1) To install water level gauging stations in three tributaries, Parota, Biru and Macinaga, and also install rainfall gauging stations in their watersheds.

(2) To install rainfall gauging stations in the Sanrego river watershed,

(3) To strengthen observations at the existing two water level gauging stations in the Sanrego river, and

(4) To conduct instantaneous discharge observation around the depressed area in the Sanrego river watershed.

Table 1.2.1 Meteorological Data at Camming Station

Monthly Mean Temperature

(Unit : °C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
1974	-	-	-	-	-	24.7	24.5	24.9	25.9	26.5	26.4	26.1	25.6
1975	25.9	25.9	26.0	25.9	25.2	24.9	24.7	24.9	25.6	26.0	26.2	26.1	25.6
1976	25.9	26.3	26.1	25.3	25.4	24.8	24.2	24.6	25.5	27.3	27.0	25.0	25.7
1977	26.0	26.4	26.1	26.5	25.8	24.8	24.5	24.5	25.5	26.9	27.9	26.7	26.0
1978	26.6	26.3	26.3	26.1	26.4	25.6	24.9	25.5	25.9	26.3	26.5	26.3	26.1
1979	26.0	26.0	26.3	26.1	26.5	25.4	24.8	24.8	26.0	27.1	27.7	26.4	26.1
1980	26.6	26.0	26.3	26.3	25.7	25.3	25.2	25.4	25.6	27.6	28.3	26.0	26.2
1981	26.5	26.1	26.2	26.2	26.0	25.6	25.2	24.6	25.8	26.6	26.2	26.0	25.9
Average	26.2	26.1	26.2	26.1	25.9	25.1	24.8	24.9	25.7	26.9	27.0	26.2	25.9

Monthly Mean Evaporation

(Unit : mm/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
1975	-	-	-	-	-	-	-	-	-	-	5.31	4.82	-
1976	5.17	5.73	4.67	5.06	3.87	4.72	4.71	5.25	5.25	5.23	4.39	4.30	4.86
1977	3.79	4.33	4.66	4.25	3.79	-	3.80	4.13	3.55	5.65	4.63	3.97	3.88
1978	3.81	4.40	4.26	3.65	3.06	3.54	3.20	3.76	4.35	5.14	4.58	4.75	4.04
1979	4.14	3.18	3.05	3.18	3.05	2.57	2.80	5.13	6.08.	7.25	6.11	4.58	4.26
1980	4.45	3.97	4.53	4.14	3.06	3.19	3.54	3.53	5.66	6.55	5.68	4.02	4.36
1981	4.60	4.11	3.64	3.85	3.38	3.37	2.81	3.95	4.71	5.67	4.77	3.87	4.06
Average	4.33	4.29	4.14	4.02	3.37	3.48	3.48	4.29	4.93	5.92	5.07	4.33	4.30

Monthly Mean Relative Humidity

(Unit : %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
1974	-	-	-	-	-	83	87	80	82	80	79	79	81
1975	83	83	82	81	80	79	77	75	74	75	76	76	78
1976	72	71	76	80	77	79	78	72	60	68	75	78	74
1977	76	75	76	74	76	79	79	78	73	64	65	79	75
1978	76	77	80	79	79	79	79	76	72	80	84	-	78
1979	80	82	78	80	81	90	88	86	83	78	80	85	83
1980	83	86	82	89	91	90	82	84	76	75	76	86	83
1981	82	84	88	88	91	89	91	87	-	-	-	-	-
Average	79	80	80	82	82	84	83	80	74	74	76	81	80

Monthly Mean Sunshine Duration

(Unit : hr/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
1974	-	-	-	-	-	4.9	4.7	8.1	7.7	7.1	5.7	4.8	6.1
1975	4.0	6.0	5.1	2.7	2.1	3.9	6.6	6.7	5.9	4.9	5.4	5.0	4.9
1976	6.5	6.8	6.9	7.2	6.1	5.0	6.8	9.4	10.3	7.7	7.4	5.6	7.1
1977	5.6	6.4	6.6	7.1	6.4	4.7	6.4	6.9	9.4	9.2	8.8	4.4	6.8
1978	5.1	5.2	5.5	6.1	6.4	5.3	5.9	7.0	7.2	6.3	4.2	-	5.8
1979	4.0	4.1	4.1	5.3	4.3	4.2	8.4	8.2	7.9	8.2	6.2	3.8	5.7
1980	3.0	3.8	4.9	4.6	4.0	5.0	6.5	7.0	9.2	7.0	6.5	4.1	5.5
1981	4.2	3.8	5.8	6.2	4.2	7.4	5.3	7.9	7.2	8.8	5.0	3.5	5.8
Average	4.6	5.2	5.6	5.6	4.8	5.1	6.3	7.7	8.1	7.4	6.2	4.5	5.9

Monthly Wind Velocity

(Unit : Km/hr)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
1975	-	-	-	-	-	-	-	-	-	-	2.80	3.94	-
1976	5.63	6.20	5.31	3.78	3.15	5.09	4.08	5.78	3.53	4.89	4.05	4.77	4.69
1977	4.94	5.99	4.39	3.15	3.28	2.64	3.48	3.25	3.38	4.05	5.28	2.72	3.91
1978	3.69	3.90	2.46	2.95	2.64	3.55	2.65	3.02	3.56	4.09	3.54	3.57	3.30
1979	3.68	3.65	3.65	2.95	2.53	3.07	4.20	5.69	6.83	5.37	5.25	4.82	4.32
1980	4.68	5.18	3.26	3.46	2.77	4.09	3.88	4.38	5.38	5.51	4.49	4.71	4.32
1981	3.94	3.06	4.09	2.40	2.89	2.77	3.33	3.06	3.98	3.12	1.97	-	3.51
Average	4.79	4.50	3.86	3.12	2.88	3.54	3.60	4.20	4.44	4.50	3.91	4.09	3.95

Table 1.2.2 Rainfall Gauging Stations

No. /1	Name of Station	Location: Latitude (s)	Location: Longitude (e)	Location: Altitude (m)	Data available	Belonging /2	Average Annual Rainfall (mm)
412a	Camming	4°49'	120°04'	107	1930 - 1941	PMG (412a)	2077
		-	-	-	1974 - 1982	P3SA (9)	
416	Camba	4°58'	119°47'	300	1882 - 1941	PMG (416)	2323
		-	-	-	1976 - 1980		
416a	Kappang	5°08'	119°41'	270	1920 - 1925	PMG (416a)	3976
416b	Bengo	4°59'	119°46'	368	1925 - 1928	PMG (416b)	3216
416c	Balle	4°57'	119°49'	128	1929 - 1930	PMG (416c)	2364
417	Palattae	5°02'	120°07'	200	1915 - 1941	PMG (417)	2038
		"	"	"	1971 - 1973	" (")	
		4°59'	120°06'	-	1974 - 1982	PMA (17)	
418	Sinjai	5°08'	120°13'	5	1879 - 1941	PMG (418)	2364
		"	"	"	1952 - 1976	" (")	
419	Manipi	5°12'	-	750	1917 - 1941	PMG (419)	2531
		"	"	"	1969 - 1979	" (")	
419a	Tombolo	5°14'	119°57'	1000	1920 - 1941	PMG (419a)	2489
419b	Malino	5°15'	119°47'	1021	1931 - 1941	PMG (419b)	4032
		"	"	"	1953 - 1976	" (")	
		5°16'	119°56'	-	1977 - 1980	PMA (24)	
-	Maradda	4°58'	120°04'	170	1971 - 1982	PMA (16)	1794

Remarks : /1 ; Rainfall station number of PMG

/2 ; PMG ; Meteorology and Geophisics Center (Pusat Meteorologi dan Geofisika)
PMA ; Institute of Hydraulic Section (Penyelidikan Masalah Air)
P3SA; Sub-directorate of Planning and Programming for Water Resources (Proyek Perencanaan dan Pengembangan Sumber-Sumber Air).

Table 1.2.3 Mean Monthly Rainfall (1/6)

(Summary)

(Unit : mm)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Camming	127	144	164	219	373	306	192	87	54	88	110	213	2077
Camba	437	319	293	212	176	158	95	42	30	63	163	335	2323
Kappang	733	613	726	284	145	123	50	50	36	142	348	726	3976
Palattac	140	143	149	222	343	312	208	109	72	76	94	170	2038
Sinjai	121	124	146	286	498	433	286	120	72	81	85	112	2364
Manipi	216	191	210	254	427	402	230	94	69	71	151	216	2531
Tombolo	443	311	220	227	315	262	165	72	39	37	147	251	2489
Malino	856	721	537	389	248	153	89	42	38	75	277	607	4032
Marrada	105	87	110	214	252	286	215	85	98	106	75	161	1794

Table 1.2.3 Mean Monthly Rainfall (2/6)

Camming

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1930	154	164	265	342	267	255	55	10	0	67	103	99	1781
1931	86	149	168	190	600	487	351	66	19	60	49	1594	3819
1932	65	126	148	333	351	383	242	120	0	163	-	-	--
1933	-	-	-	-	-	-	-	-	81	49	196	50	--
1934	253	134	65	234	290	389	308	62	79	85	248	40	2187
1935	307	169	257	303	551	555	122	43	0	173	152	126	2758
1936	200	64	213	377	347	386	148	47	65	0	68	44	2059
1937	22	214	222	258	240	337	217	139	69	0	15	272	2005
1938	200	33	130	93	381	137	88	282	60	60	87	216	1767
1939	101	314	19	78	261	240	106	170	58	75	64	128	1614
1940	57	92	126	168	609	445	40	43	0	0	41	-	--
1941	52	141	209	271	658	198	109	0	0	73	68	166	1945
1974	-	-	-	-	-	-	-	-	-	130	61	74	--
1975	247	186	56	270	395	315	365	218	184	321	229	103	2889
1976	50	46	131	255	445	285	264	13	0	74	226	155	1944
1977	80	71	208	67	174	400	33	56	0	0	9	161	1259
1978	55	102	84	85	185	82	152	72	109	145	87	188	1346
1979	138	213	210	127	167	262	212	53	89	0	106	107	1684
1980	121	284	93	256	445	208	33	88	0	3	127	198	1856
1981	66	73	371	123	506	183	610	86	212	270	153	121	2774
1982	160	161	146	322	221	267	-	-	-	-	-	-	--
Average	127	144	164	219	373	306	192	87	54	88	110	213	2077
Max.	307	314	371	377	658	555	610	282	212	321	248	1594	3819
Min.	22	33	19	78	167	82	33	0	0	0	9	40	1259

Palattae

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1915	154	203	214	255	466	352	197	154	112	100	143	76	2426
1916	171	111	171	222	301	304	626	381	138	-	119	236	--
1917	77	311	274	197	420	408	373	302	296	242	154	32	3138
1918	313	56	90	227	208	161	136	4	0	0	128	229	1522
1919	82	262	167	126	419	319	246	0	88	0	21	113	1915
1920	88	62	79	188	440	175	354	127	80	76	250	121	2040
1921	97	356	324	59	459	546	207	239	41	270	194	232	3024
1922	50	80	105	169	120	127	434	100	0	45	41	155	1426
1923	196	76	50	133	287	25	302	26	21	0	10	248	1374
1924	177	101	135	131	815	495	370	60	79	60	75	135	2633
1925	111	143	110	296	202	358	131	27	7	0	48	206	1639
1926	142	155	-	127	309	102	69	41	41	9	66	107	--
1927	140	96	191	300	174	304	142	69	59	58	123	249	1905
1928	333	200	124	301	566	158	102	153	65	16	79	279	2376
1929	260	57	144	269	292	193	253	13	13	55	97	373	2079
1930	49	81	219	388	365	170	81	48	0	69	60	143	1673
1931	52	169	159	161	735	692	290	74	3	29	65	209	2638
1932	134	106	175	229	241	203	244	96	9	64	133	199	1833
1933	133	189	59	170	524	257	175	189	57	56	109	14	1932
1934	86	76	62	265	121	430	211	36	141	85	208	138	1859
1935	77	79	255	151	347	367	28	41	0	50	42	163	1600
1936	286	107	114	498	184	400	244	61	32	7	103	135	2171
1937	109	253	179	388	381	299	223	120	84	12	14	320	2382
1938	341	34	153	104	565	188	136	306	116	31	72	224	2270
1939	243	290	104	239	311	336	211	140	96	11	122	55	2158
1940	52	107	95	73	638	450	75	44	3	0	63	239	1839
1941	52	269	173	212	541	424	57	15	0	413	83	230	2469
1971	-	-	-	61	178	342	143	138	103	131	193	154	--
1972	243	103	48	295	0	135	21	25	0	0	0	180	1050
1973	141	325	133	211	194	411	377	194	-	-	-	-	--
1974	-	-	-	-	-	-	82	48	311	182	69	107	--
1975	166	140	101	309	436	357	371	212	157	196	57	83	2585
1976	57	91	88	247	342	381	228	14	0	104	73	91	1676
1977	79	41	139	197	456	385	64	126	0	0	165	262	1914
1978	66	127	170	139	369	318	255	206	78	131	108	254	2224
1979	110	121	135	120	269	414	273	87	121	2	24	77	1753
1980	57	176	156	445	510	398	67	115	0	3	2	133	2062
1981	115	51	351	123	532	144	96	96	305	219	163	79	2274
1982	145	117	111	426	-	-	-	-	-	-	-	-	--
Average	140	143	149	222	343	312	208	109	72	76	94	170	2038
Max.	341	356	351	498	815	692	626	381	305	413	250	373	3138
Min.	49	34	48	59	0	25	21	0	0	0	0	14	1050

Table 1.2.3 Mean Monthly Rainfall (3/6)

Sinjol (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1879	-	-	73	154	497	632	531	544	82	263	71	93	--
1880	75	68	92	179	628	666	416	196	180	121	24	122	2767
1881	178	64	145	331	543	707	316	18	101	11	42	52	2528
1882	239	252	67	333	191	554	370	147	116	69	72	82	2492
1883	43	146	157	168	492	139	178	141	15	169	203	164	2015
1884	180	110	91	175	962	473	727	23	9	80	21	139	2990
1885	130	117	212	614	545	182	68	0	19	44	110	98	2139
1886	-	-	-	-	-	-	-	-	-	-	-	-	--
1887	80	131	44	132	278	288	424	64	129	162	97	68	1897
1888	237	231	164	436	348	213	150	8	0	7	13	88	1895
1889	175	183	132	357	435	299	1063	174	102	233	88	-	--
1890	71	85	163	269	516	453	599	195	113	62	72	59	2657
1891	50	88	208	124	526	321	244	26	0	12	29	102	1730
1892	121	66	125	802	571	644	244	157	-	54	168	225	--
1893	34	51	59	149	94	513	286	196	33	4	115	189	1723
1994	103	136	268	188	344	126	335	68	35	85	70	85	1843
1895	246	134	78	489	277	449	225	47	11	49	9	120	2134
1896	216	117	139	378	706	631	55	162	5	50	16	89	2564
1897	121	105	280	131	451	275	200	82	151	130	62	64	2052
1898	94	86	139	136	416	715	443	63	70	143	152	114	2571
1899	55	119	86	129	343	387	209	148	56	102	25	119	1778
1900	306	150	124	408	207	267	291	53	98	5	217	154	2280
1901	87	104	227	685	490	676	345	229	24	73	-	153	--
1902	83	128	71	222	478	174	172	27	0	0	2	132	1489
1903	142	211	146	159	609	751	176	44	48	141	97	69	2593
1904	51	128	178	46	514	268	405	63	2	125	247	113	2140
1905	141	201	396	-	438	544	186	16	94	-	-	50	--
1906	206	168	163	518	-	-	-	-	-	-	-	125	--
1907	63	147	213	368	534	599	173	122	7	157	121	206	2710
1908	113	87	237	49	908	521	139	232	4	549	145	253	3237
1909	96	82	116	149	203	434	151	177	81	136	47	41	1713
1910	154	70	70	135	294	311	458	231	210	209	81	248	2471
1911	71	131	116	183	432	527	119	28	18	0	83	159	1867
1912	141	25	121	440	590	535	354	76	48	2	39	123	2494
1913	104	161	154	505	684	565	-	57	23	2	16	48	--
1914	271	128	106	139	390	483	74	25	3	0	46	72	1737
1915	207	203	154	583	640	199	215	30	62	128	151	56	2628
1916	167	224	102	305	627	307	589	305	87	-	83	183	--
1917	45	195	108	249	564	588	460	285	232	212	138	89	3160
1918	110	59	156	123	298	305	78	43	0	0	158	144	1474
1919	84	228	191	184	310	487	108	13	69	0	-	120	--
1920	104	122	116	343	394	447	248	151	156	63	156	100	2400
1921	104	199	232	200	529	502	364	275	67	259	103	153	2987
1922	47	56	127	303	294	220	629	70	148	21	3	143	2069
1923	107	114	153	231	542	71	443	63	0	56	19	67	1865
1924	206	156	233	604	893	486	279	26	108	79	117	49	3236
1925	63	172	69	479	192	752	192	30	0	0	60	124	2133

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1926	123	134	101	219	453	106	97	44	81	23	23	72	1476
1927	94	31	107	262	190	320	296	112	78	56	59	126	1791
1928	15	289	30	335	803	337	92	30	50	0	31	57	2069
1929	167	87	152	400	451	376	323	24	10	11	67	96	2164
1930	68	67	136	466	639	154	119	20	0	83	183	-	--
1931	162	74	97	290	739	434	221	98	9	18	47	45	2234
1932	155	183	22	305	455	408	246	14	10	20	85	83	1986
1933	27	110	138	228	602	583	342	218	36	154	32	28	2498
1934	171	66	97	128	213	605	350	11	200	40	60	166	2107
1935	105	75	111	354	832	461	21	34	25	65	49	0	2132
1936	80	75	191	396	371	600	224	37	10	0	47	198	2229
1937	189	105	304	364	598	438	155	147	96	0	107	109	2612
1938	229	97	234	203	571	536	225	220	39	44	107	118	2623
1939	183	96	138	163	731	558	793	156	69	75	107	69	3138
1940	59	73	300	184	1061	854	178	14	4	1	21	207	2956
1941	73	93	95	271	-	647	222	21	7	40	296	91	--
1952	106	139	-	123	411	250	288	58	33	72	137	174	—
1953	27	-	-	54	380	54	185	114	52	-	142	29	--
1954	37	64	151	149	623	944	85	105	79	135	44	173	2589
1955	103	-	111	98	410	-	686	367	205	72	97	40	--
1956	161	-	-	137	320	307	247	343	-	-	-	-	--
1957	181	-	-	23	792	140	203	120	-	-	12	-	—
1958	82	150	185	268	417	713	123	235	140	-	82	91	—
1959	155	334	-	252	749	705	162	27	70	19	192	175	—
1960	131	193	120	72	331	436	403	207	32	42	141	212	2320
1961	198	102	155	-	748	756	89	0	78	0	131	142	—
1962	-	-	-	-	-	-	222	177	19	158	94	92	--
1963	85	33	93	110	700	259	69	78	-	-	-	-	--
1964	81	150	73	642	253	175	337	281	219	133	123	47	2514
1965	105	48	60	504	369	343	98	118	0	17	18	107	1787
1966	119	159	298	949	971	301	99	196	14	84	146	130	3466
1967	139	61	110	477	447	424	452	6	68	5	7	98	2294
1968	184	50	310	254	69	482	584	517	116	58	27	93	2744
1969	50	95	87	390	579	264	357	51	8	12	67	77	2037
1970	95	112	240	285	777	560	270	73	141	128	55	39	2775
1971	96	180	31	85	281	345	223	144	133	263	152	194	2077
1972	186	88	86	257	304	104	16	63	5	0	91	186	1386
1973	192	183	204	178	408	472	589	275	529	96	83	117	3326
1974	119	81	91	429	342	377	366	41	187	175	24	156	2388
1975	71	85	139	118	603	367	430	331	190	130	47	81	2597
1976	54	83	157	354	616	433	73	95	6	133	39	58	2101
Average	121	124	146	286	498	433	286	120	72	81	85	112	2364
Max.	246	334	396	802	1061	944	1063	544	529	549	296	253	3466
Min.	15	31	22	23	94	54	16	0	0	0	2	0	1386

Table 1.2.3 Mean Monthly Rainfall (4/6)

Combo (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1882	1247	143	266	192	123	203	229	88	70	168	50	452	3231
1883	183	454	211	158	108	80	5	23	2	55	271	596	2146
1884	317	332	192	276	219	207	313	14	21	69	244	310	2514
1885	338	159	349	120	203	125	6	0	0	19	49	631	1999
1886	-	-	-	-	-	-	-	-	-	-	-	-	--
1887	222	530	403	145	163	232	132	64	6	44	372	243	2556
1888	1364	490	290	148	242	74	30	20	0	0	88	190	2936
1889	224	296	162	359	186	134	264	52	117	18	370	511	2693
1890	435	333	139	290	160	181	95	183	85	171	127	424	2623
1891	299	171	215	50	288	100	34	2	22	0	198	101	1480
1892	334	192	222	347	129	416	53	10	21	181	230	191	2326
1893	270	286	249	156	117	220	221	166	25	32	144	452	2338
1894	549	583	356	211	118	64	89	38	6	81	445	206	2746
1895	1090	443	364	141	260	123	231	24	0	49	107	259	3091
1896	740	208	207	217	108	-	0	0	0	0	62	422	--
1897	536	233	598	108	272	176	193	8	92	82	161	309	2768
1898	359	86	590	186	96	307	107	8	26	244	225	366	2600
1899	509	286	438	130	46	283	3	-	-	-	106	358	--
1900	190	228	99	266	95	117	178	18	112	0	220	202	1725
1901	361	485	353	189	138	204	167	7	0	41	88	128	2161
1902	378	645	139	61	58	31	74	15	0	0	52	257	1711
1903	217	253	186	246	274	200	132	72	97	54	210	515	2456
1904	418	740	228	393	235	38	34	7	42	43	133	484	2795
1905	302	160	127	342	75	86	64	51	0	37	69	122	1435
1906	330	295	556	236	59	64	97	91	110	72	128	314	2352
1907	744	266	619	233	261	65	152	9	3	41	80	535	3008
1908	193	368	550	242	367	210	84	63	22	49	257	723	3128
1909	297	156	422	210	167	188	113	156	36	277	138	241	2401
1910	240	250	213	173	211	175	103	128	64	225	442	481	2705
1911	90	321	147	214	134	118	86	18	6	0	25	368	1527
1912	263	259	280	174	396	221	123	14	0	27	169	106	2030
1913	362	276	341	205	190	317	-	0	3	6	29	559	--
1914	396	226	293	124	162	196	0	0	0	0	5	233	1635
1915	262	241	214	123	224	147	0	22	116	73	151	256	1829
1916	847	260	380	113	16	136	230	170	47	121	329	817	3466
1917	300	390	350	256	293	152	130	63	89	133	241	148	2646
1918	440	657	190	248	148	126	13	0	0	40	138	425	2425
1919	169	483	271	263	219	67	79	0	17	114	211	252	2145
1920	725	370	431	384	149	246	285	115	37	162	389	504	3797
1921	434	383	348	280	169	71	105	53	18	72	233	311	2477
1922	302	317	352	202	104	193	61	1	24	29	219	579	2383
1923	594	346	302	105	291	48	60	6	6	5	25	365	2153
1924	210	183	286	123	238	113	113	8	37	94	312	262	1979
1925	311	334	104	88	78	94	29	0	20	0	15	173	1246
1926	463	279	124	133	154	40	44	22	24	11	125	166	1585
1927	560	216	273	355	85	114	47	10	7	38	174	794	2673
1928	753	295	182	176	148	72	41	69	21	34	136	242	2169

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1929	914	246	180	319	122	41	96	0	-	-	-	-	--
1930	-	-	-	-	-	-	-	-	-	22	79	463	--
1931	326	200	184	217	231	184	154	86	8	31	208	179	2008
1932	506	330	262	365	235	184	51	33	0	79	106	457	2608
1933	159	570	404	171	345	157	40	173	45	122	212	226	2624
1934	321	217	124	196	228	236	132	11	105	165	123	138	1996
1935	476	182	608	390	211	256	21	9	19	57	97	96	2422
1936	214	166	432	309	138	193	126	78	57	5	262	210	2190
1937	442	-	-	542	216	237	61	4	38	70	85	271	--
1938	977	183	191	41	255	52	90	151	52	0	288	360	2580
1939	668	994	226	267	180	222	169	86	12	71	47	234	3176
1940	518	509	218	138	250	138	4	0	0	12	40	-	--
1941	154	67	-	70	210	143	2	0	0	0	72	73	--
1976	331	264	423	460	120	94	88	2	19	87	-	-	--
1977	-	-	-	-	53	290	14	18	0	0	72	82	--
1978	211	141	144	120	114	119	140	37	44	92	167	304	1633
1979	402	134	308	46	67	403	28	0	8	9	130	165	1700
1980	284	358	287	114	111	72	10	21	0	44	135	511	1945
Average /2	437	319	293	212	176	158	95	42	30	63	163	335	2323
Max.	1364	994	619	542	396	416	285	183	117	244	442	817	3797
Min.	90	67	99	41	53	38	0	0	0	0	5	73	1246

/1 : Source : P.M.A.

/2 : This average is composed of following two parts.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1882 - 41	446	326	294	222	183	155	98	44	32	64	166	340	2370
1976 - 80	307	224	291	185	93	196	56	16	14	46	126	266	1820

Table 1.2.3 Mean Monthly Rainfall (5/6)

Kappang

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1920	1137	659	631	324	74	95	180	235	160	271	618	660	5044
1921	544	403	674	261	23	178	19	0	10	185	279	460	3036
1922	950	600	819	303	288	783	19	0	8	22	233	1153	4578
1923	1160	815	621	22	115	36	32	16	0	8	157	1179	4161
1924	544	589	885	508	226	125	0	0	0	223	452	178	3730
1925	62	-	-	-	-	-	-	-	-	-	-	-	--
Average	733	613	726	284	145	123	50	50	36	142	348	726	3976
Max.	1160	815	885	508	288	183	180	235	160	223	618	1179	5044
Min.	62	403	621	22	23	36	0	0	0	8	157	178	3036

Benko

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1925	-	972	258	245	134	72	0	0	30	3	145	477	--
1926	1112	641	422	143	153	0	0	0	0	39	205	609	3324
1927	1332	250	424	307	275	197	9	0	0	52	132	716	3694
1928	291	-	-	-	-	-	-	-	-	-	-	-	--
Average	912	621	368	232	187	90	3	0	10	31	161	601	3216

Rollo

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1929	810	256	210	394	142	62	127	0	9	70	145	395	2620
1930	192	198	323	334	328	78	34	-	-	-	-	-	--
Average	501	227	267	364	235	70	81	0	9	70	145	395	2364

Manipi

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1917	102	249	184	424	474	353	279	345	185	199	145	83	3022
1918	309	84	189	184	125	223	72	0	0	35	86	448	1755
1919	51	187	235	174	335	210	148	7	99	0	34	246	1726
1920	174	73	231	231	-	-	-	-	-	-	-	-	--
1921	-	-	134	155	272	796	233	174	34	102	278	209	--
1922	191	91	188	194	426	513	310	29	0	32	110	232	2316
1923	411	276	120	321	330	46	326	6	0	7	0	441	2284
1924	151	96	183	392	998	252	412	32	64	149	465	242	3436
1925	472	808	96	373	136	528	255	70	23	0	94	151	3006
1926	201	291	178	141	289	186	122	39	102	2	76	206	1833
1927	-	-	-	-	-	-	-	-	-	-	-	-	--
1928	250	148	175	450	748	465	244	44	21	33	-	-	--
1929	-	-	-	-	-	-	-	-	-	-	-	-	--
1930	71	0	359	267	273	296	73	3	3	77	60	30	1512
1931	141	84	118	176	165	414	306	92	30	15	106	162	1809
1932	296	101	-	408	826	736	499	176	12	76	156	163	--
1933	209	175	134	132	536	492	82	310	87	106	176	103	2542
1934	272	93	271	219	216	519	291	37	170	129	223	187	2627
1935	144	271	263	235	590	375	92	60	6	177	92	160	2465
1936	150	82	257	566	395	393	322	58	83	16	180	311	2813
1937	152	214	314	391	527	360	230	60	182	79	24	244	2777
1938	243	146	216	101	613	378	346	455	126	44	145	288	3101
1939	325	402	70	180	344	250	397	189	30	15	83	147	2432
1940	212	188	133	58	742	261	105	31	2	4	34	268	2038
1941	112	227	93	344	791	689	128	12	6	-	180	275	--
1969	209	154	169	240	485	429	358	137	44	38	67	74	2404
1970	-	-	-	161	344	566	280	66	66	192	165	111	--
1971	117	-	350	-	-	446	209	52	367	62	496	55	--
1972	459	211	114	115	224	335	22	10	0	-	-	-	--
1975	222	207	221	279	342	237	204	199	256	276	430	137	3010
1976	269	191	651	343	292	366	104	39	4	64	164	825	3312
1979	126	100	237	107	128	537	219	6	13	0	4	99	1576
Average	216	191	210	254	427	402	230	94	69	71	151	216	2531
Max.	472	808	359	566	998	796	499	455	367	276	496	825	3436
Min.	51	0	70	58	125	186	22	0	0	0	0	30	1512

Table 1.2.3 Mean Monthly Rainfall (6/6)

Molino

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1931	915	419	489	476	150	111	140	16	4	87	286	559	3652
1932	707	636	561	508	452	144	8	55	14	12	222	947	4266
1933	550	1156	641	383	310	321	58	100	37	152	506	592	4606
1934	1011	377	365	332	266	217	197	18	67	119	413	491	3873
1935	966	530	798	753	309	165	28	1	3	30	241	337	4161
1936	815	380	673	616	190	250	107	77	39	38	313	533	4031
1937	878	791	418	538	183	180	15	10	37	23	29	693	3725
1938	1503	606	463	220	351	241	206	71	43	11	414	767	4896
1939	974	1573	594	462	380	270	249	78	0	73	179	533	5365
1940	1369	828	531	268	313	22	33	0	0	3	113	540	4022
1941	567	632	464	413	227	136	1	0	4	16	184	850	3502
1953	412	1129	713	509	88	22	-	47	29	8	188	-	--
1956	1260	597	576	313	-	-	-	-	130	136	440	674	--
1957	-	-	-	-	-	-	-	-	-	-	-	-	--
1958	464	611	706	380	270	158	111	83	-	-	-	-	--
1959	951	415	712	339	475	153	171	0	31	8	113	564	3932
1960	839	929	243	426	458	102	97	81	32	-	340	522	--
1961	1133	831	386	467	135	155	28	8	0	118	295	452	4008
1962	898	581	479	319	139	163	67	38	61	145	320	792	3995
1963	861	570	-	242	186	11	34	22	7	-	85	424	--
1964	745	567	508	431	191	75	128	92	110	-	-	1164	--
1965	1164	947	676	85	93	58	2	7	0	0	84	424	3540
1966	178	842	429	241	48	52	24	8	0	44	265	365	3036
1967	899	716	336	293	105	35	23	45	35	1	231	523	3242
1968	1523	698	334	412	396	278	236	189	11	15	194	740	5026
1969	651	674	627	401	193	142	77	12	55	135	72	505	3544
1970	568	593	606	338	355	158	97	15	30	178	72	687	3697
1971	676	889	886	284	274	383	182	7	110	281	841	478	5291
1972	1624	566	273	221	63	0	0	0	0	0	352	340	3439
1973	532	315	491	440	292	88	243	112	241	16	730	-	--
1974	-	-	-	-	-	-	-	-	-	-	-	-	--
1975	621	621	558	570	275	205	63	64	23	194	472	615	4281
1976	833	794	862	238	204	-	5	5	0	269	187	495	--
1977	786	1033	605	394	193	294	13	41	0	0	253	677	4289
1978	650	696	364	360	240	224	264	120	132	135	320	952	4457
1979	751	577	514	282	273	142	27	0	6	74	122	586	3354
1980	678	1178	926	669	348	99	16	9	0	243	-	-	--
Average	856	721	537	389	248	153	89	42	38	75	277	607	4037
Max.	1624	1573	926	753	475	383	264	189	132	269	841	1164	5365
Min.	464	315	273	220	63	11	1	0	0	0	29	337	3036

Tombolo

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1920	-	-	-	-	253	212	167	32	24	0	365	186	--
1921	202	190	134	109	161	166	178	103	11	91	132	176	1652
1922	188	178	334	96	72	274	135	7	9	13	155	331	1792
1923	650	441	308	184	282	79	162	8	0	5	0	414	2533
1924	532	104	347	362	777	187	306	18	53	107	442	227	3462
1925	437	771	106	467	140	397	188	67	15	0	82	146	2816
1926	719	294	134	88	223	114	83	23	71	0	51	96	1896
1927	592	126	248	231	271	521	65	45	13	51	180	304	2647
1928	198	244	84	-	476	-	256	40	26	36	54	171	--
1929	1093	258	201	373	132	133	182	59	0	25	0	108	2564
1930	180	365	163	179	174	163	100	0	0	40	-	386	--
1931	325	103	128	158	340	347	122	18	55	12	136	153	1897
1932	536	269	176	203	150	237	217	160	-	-	-	-	--
1933	244	342	346	180	456	336	130	266	70	51	265	165	2851
1934	397	155	171	155	145	422	220	47	162	112	222	228	2436
1935	441	251	381	368	461	392	70	48	1	113	126	122	2774
1936	193	102	330	357	319	249	300	66	89	7	238	230	2480
1937	343	237	287	473	286	303	181	30	136	14	16	243	2549
1938	785	238	181	71	400	161	198	334	71	41	261	399	3140
1939	596	1129	203	143	347	144	185	121	17	20	51	233	3189
1940	412	551	180	105	570	187	110	23	2	0	58	373	2571
1941	230	190	169	233	489	479	73	-	0	31	100	583	--
Average	443	311	220	227	315	262	165	72	39	37	147	251	2489
Max.	1093	1129	347	473	777	521	306	334	162	113	442	583	3462
Min.	180	102	84	71	72	79	65	0	0	0	0	108	1653

Maradda

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	-	1	5	61	178	342	143	138	103	131	193	154	--
1972	230	103	48	288	0	135	21	25	0	0	0	180	1030
1973	141	322	133	211	196	411	377	194	212	116	61	82	2456
1974	22	134	129	158	177	282	257	33	214	253	54	29	1742
1975	118	30	71	157	480	373	406	268	185	229	62	92	2471
1976	95	40	141	400	309	366	130	0	0	22	102	239	1844
1977	82	35	117	199	135	640	52	0	0	0	6	309	1575
1978	93	47	115	112	189	144	293	128	89	115	58	198	1581
1979	63	77	121	120	140	294	189	12	88	19	65	217	1405
1980	87	104	13	421	322	228	53	76	0	68	45	182	1599
1981	87	34	277	162	570	131	439	58	190	153	173	93	2367
1982	134	117	149	273	332	87	-	-	-	-	-	-	--
Average	105	87	110	214	252	286	215	85	98	106	75	161	1794
Max.	230	322	277	421	570	640	439	268	214	253	193	309	2471
Min.	22	1	5	61	0	87	21	0	0	0	0	29	1030

Table 1.2.4 Discharge Measurement (1/2)

Turungenz station

No.	Date	Water Level (m)	Discharge (m3/s)	Note
1	1973 Sep. 15	0.42	6.1	
2	1973 Nov. 21	0.58	9.0	
3	1974 Jul. 22	0.60	9.8	
4	1975 Jan. 11	0.58	8.8	
5	1975 Sep. 2	0.80 x	7.0	
6	1975 Sep. 28	0.58	7.4	
7	1975 Oct. 21	0.56	9.0	
8	1975 Dec. 7	0.59	8.8	
9	1975 Dec. 29	0.56	8.9	
10	1976 Jan. 30	0.57	7.0	
11	1977 May 26	0.45	5.7	
12	1979 Apr. 21	0.44	6.6	
13	1979 May 11	0.49	8.0	
14	1979 Jun. 10	2.16	122.5	F
15	1979 Jul. 23	0.48	7.9	
16	1979 Aug. 30	0.33	4.9	
17	1979 Sep. 12	0.33	3.8	
18	1979 Oct. 27	0.28	2.8	
19	1979 Nov. 23	0.24	1.9	
20	1979 Dec. 11	0.41	3.5	
21	1980 Jan. 12	0.57	11.3	
22	1980 Feb. 19	0.58	12.8	
23	1980 Mar. 10	0.57	6.0	
24	1980 Mar. 25	0.60	14.7	
25	1980 Apr. 30	0.80	24.3	F
26	1980 Jun. 1	0.62	15.5	
27	1980 Jun. 25	0.59	12.4	
28	1980 Jul. 31	0.40	5.2	
29	1980 Sep. 10	0.24	4.0	
30	1980 Sep. 28	0.30	3.4	
31	1980 Oct. 29	0.33	3.4	
32	1980 Nov. 29	0.34	4.1	
33	1990 Dec. 30	0.48 x	5.0	
34	1981 Jan. 23	0.60	15.1	
35	1981 Feb. 28	0.50	8.3	
36	1981 Mar. 29	0.56	10.8	
37	1981 Apr. 26	0.54	9.4	
38	1981 May 29	0.58	10.2	
39	1981 Jun. 28	0.54	9.7	
40	1981 Jul. 26	0.67	16.2	
41	1981 Aug. 26	0.46	7.7	
42	1981 Sep. 23	0.40	5.0	
43	1981 Oct. 31	0.34	3.7	
44	1981 Nov. 24	0.58	11.6	
45	1981 Dec. 30	0.59	13.3	
46	1982 Feb. 9	0.62	14.3	F
47	1982 Mar. 3	0.50	7.4	
48	1982 Apr. 3	0.64	13.8	
49	1982 Apr. 23	0.50	7.3	
50	1982 Jun. 1	0.75	18.0	F

Note : F = Float

No Mark = Current Meter

x = Estimated Water Level (Original one is unreliable)

Table 1.2.4 Discharge Measurement (2/2)

Sanrego station

No.	Date	Water Level (m)	Discharge (m3/s)	Note
1	1978 Jul. 17	1.01	7.4	
2	1978 Dec. 23	1.12	11.9	
3	1979 Jan. 30	0.95	9.8	
4	1979 Feb. 24	0.93	6.1	
5	1979 Mar. 23	1.00	6.9	
6	1979 Apr. 21	0.96	6.2	
7	1979 May 11	1.03	7.8	
8	1979 Jun. 10	2.54	103.1	F
9	1979 Jul. 23	1.00	7.1	
10	1979 Aug. 30	0.81	3.9	
11	1979 Sep. 12	0.79	3.3	
12	1979 Oct. 27	0.74	3.2	
13	1979 Nov. 23	0.73	2.4	
14	1979 Dec. 11	0.94	5.8	
15	1980 Jan. 12	1.12	9.9	
16	1980 Feb. 19	1.16	10.6	
17	1980 Mar. 25	1.15	11.7	
18	1980 Apr. 30	1.71	57.3	F
19	1980 Jun. 1	1.19	13.0	
20	1980 Jun. 25	1.15	10.2	
21	1980 Jul. 31	0.89	4.7	
22	1980 Sep. 10	0.79	3.6	
23	1980 Sep. 28	0.76	2.9	
24	1980 Oct. 29	0.79	3.5	
25	1980 Nov. 29	0.81	3.8	
26	1980 Dec. 30	0.94	6.6	
27	1981 Jan. 23	1.16	12.7	
28	1981 Feb. 28	1.00	7.1	
29	1981 Mar. 29	1.06	9.7	
30	1981 Apr. 26	1.05	7.6	
31	1981 May 29	1.14	10.5	
32	1981 Jun. 28	1.11	8.2	
33	1981 Jul. 26	1.30	27.1	F
34	1981 Aug. 26	0.91	6.4	
35	1981 Sep. 23	0.95	4.3	
36	1981 Oct. 31	0.90	3.4	
37	1981 Nov. 24	1.17	8.4	
38	1981 Dec. 30	1.18	11.4	F
39	1982 Feb. 9	1.22	10.3	
40	1982 Mar. 3	0.98	6.7	
41	1982 Apr. 3	1.25	13.1	
42	1982 Apr. 23	1.09	6.8	
43	1982 Jun. 1	1.41	28.4	F

Note : F = Float

No Mark = Current Meter

Table 1.2.5 Spot Discharge Measurement

(Unit : m3/sec
(m3/sec/100 Km2))

No.	River System	River	Catchment Area (Km2)	Date: August 4/1	August 5	August 10	August 11	September 22	September 23	September 24
1.	Sanrego	Sanrego (road crossing)	220.8	-	-	-	4.0 (1.8)	3.5 (1.6)	-	-
2.	Sanrego	Sanrego (weir site)	179.2	5.5 (3.1)	-	-	4.2 (2.3)	3.6 (2.0)	-	-
3.	Sanrego	Parota	32.8	-	0.05 (0.15)	-	0.03 (0.09)	0.01 (0.03)	-	-
4.	Sanrego	Sopo (Langi)	122.1	-	-	-	-	-	-	1.6 (1.31)
5.	Sanrego	Walennal	60.1	-	-	-	-	-	-	L
6.	Walanae	Walanae	395.0	-	-	-	-	-	4.9 (1.24)	-
7.	Walanae	Akkajeng	10.8	-	0.01 (0.09)	-	L	-	-	-
8.	Walanae	Toli-Toli	14.6	-	0.16 (1.10)	-	0.10 (0.68)	-	-	-
9.	Walanae	Biru	20.3	-	-	-	0.09 (0.44)	0.03 (0.15)	-	-
10.	Walanae	Cenrana	3.9	-	0.01 (0.26)	L	-	-	-	-
11.	Walanae	Palattae	17.0	0.13 (0.76)	-	L	-	-	-	-
12.	Walanae	Sagni	11.5	0.32 (2.8)	-	L	-	-	-	-
13.	Walanae	Baturapa	6.8	0.57 (8.4)	-	0.04 (0.59)	-	-	-	-
14.	Walanae	Baruttung	33.5	1.9 (5.7)	-	0.22 (0.66)	-	-	0.01 (0.03)	-
15.	Walanae	Papparapa	12.4	0.07 (0.56)	-	L	-	-	-	-

Remarks : /1 : After rainfall on Aug.3
L : Less than 0.01 m3/sec.

Table I.2.6 Mean Monthly Water Level

Turungeng Station

(Unit: m)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	An-nual
1973	-	-	-	-	-	-	-	-	-	0.44	0.70	0.75	-
1974	0.77	0.68	-	-	0.53	-	-	0.52	0.58	0.52	0.47	0.45	-
1975	0.55	-	0.54	0.62	0.93	-	0.69	0.94	0.67	0.63	0.71	0.57	-
1976	0.61	-	-	0.58	0.58	0.63	0.50	0.37	0.31	0.33	0.32	0.47	-
1977	0.69	0.61	0.70	0.59	0.47	-	-	-	-	-	-	0.62	-
1978	0.59	0.47	0.54	0.47	0.56	0.55	0.52	0.51	0.40	0.42	0.42	0.62	0.51
1979	0.56	0.47	0.53	0.52	0.52	0.73	0.50	0.37	0.32	0.28	0.26	0.40	0.46
1980	0.49	0.61	0.59	0.71	0.71	0.60	0.46	0.39	0.33	0.28	0.30	0.56	0.50
1981	0.55	0.55	0.57	0.63	0.79	0.53	0.73	0.50	0.44	0.37	0.46	0.55	0.56
1982	0.60	0.60	0.50	0.60	0.57	-	-	-	-	-	-	-	-
Aver-age	0.60	0.57	0.57	0.59	0.63	0.61	0.57	0.51	0.45	0.41	0.47	0.55	0.54

Sanrego Station

(Unit: m)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	An-nual
1978	-	-	-	-	-	-	-	1.04	0.89	0.88	0.86	0.10	-
1979	1.13	1.04	1.05	1.01	1.07	1.32	1.03	0.85	0.80	0.75	0.74	0.92	0.98
1980	1.01	1.16	1.14	1.29	1.28	1.15	0.96	0.86	0.78	0.76	0.77	1.00	1.01
1981	1.08	1.10	1.13	1.20	1.40	1.09	1.36	1.00	0.95	0.93	1.04	1.12	1.12
1982	1.20	1.20	1.00	1.25	1.23	-	-	-	-	-	-	-	-
Aver-age	1.11	1.13	1.08	1.19	1.25	1.19	1.12	0.94	0.86	0.83	0.85	1.04	1.05

Table 1.3.1 Mean Monthly Discharge

Turungeng Station (Catchment area : 174.3 Km2)

(Unit : m3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1973	-	-	-	-	-	-	-	-	-	6.4	15.9	17.2	--
1974	18.8	13.3	8.5	17.0	7.9	8.3	15.4	8.3	13.0	8.7	6.7	6.5	11.0
1975	8.6	6.0	8.2	11.3	29.9	17.8	15.1	30.3	12.5	10.6	15.9	8.8	14.6
1976	11.1	7.0	6.0	9.2	10.3	12.7	8.1	4.9	3.5	4.0	3.7	7.2	7.3
1977	14.3	10.4	15.2	10.0	6.8	22.1	6.6	5.3	4.0	4.0	8.9	13.6	10.1
1978	13.0	7.6	10.7	7.7	11.7	10.9	9.6	9.2	5.4	6.2	6.1	14.2	9.4
1979	11.6	8.1	10.0	9.8	9.7	20.5	8.8	4.7	3.7	2.9	2.6	5.8	8.2
1980	8.4	14.2	12.4	19.3	19.1	12.8	7.3	5.2	3.9	2.9	3.4	11.6	10.0
1981	11.0	10.8	12.0	14.2	13.5	9.7	20.1	8.7	6.5	4.9	7.4	10.5	11.6
1982	13.0	13.0	8.6	13.2	12.5	-	-	-	-	-	-	-	--
Average	12.2	10.0	10.2	12.4	14.6	14.4	11.4	9.6	6.6	5.6	7.8	10.6	10.5
Average in 1978 - 1982	11.4	10.7	10.7	12.8	15.3	13.5	11.5	7.0	4.9	4.2	4.9	10.5	9.8

Sanrego Station (Catchment area : 179.0 Km2)

(Unit : m3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1978	-	-	-	-	-	-	-	9.6	5.5	5.4	5.0	11.3	--
1979	12.9	9.2	9.6	8.5	10.6	21.9	9.1	4.7	3.7	2.9	2.9	6.2	8.5
1980	8.5	14.8	12.3	20.0	19.7	12.9	7.0	4.9	3.5	3.2	3.4	8.1	9.9
1981	10.8	11.1	12.4	15.1	26.1	8.2	21.8	6.2	5.3	4.8	7.1	9.1	11.5
1982	11.7	12.2	6.3	14.4	14.8	-	-	-	-	-	-	-	--
Average	11.0	11.8	10.2	14.5	17.8	14.3	12.6	6.1	4.5	4.1	4.6	8.7	10.0

Table 1.3.2 Daily Discharge at Turungeng Station (1/5)

Year : 1973

(Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.				-	11.9	-	-	-	-	8.4	6.1	10.0
2.				-	11.9	-	-	-	-	8.2	6.0	12.4
3.				-	9.2	-	-	-	-	8.0	5.5	19.0
4.				-	8.4	-	-	-	-	7.7	23.9	12.9
5.				-	8.2	-	-	-	-	7.5	44.3	19.2
6.				-	8.6	-	-	-	-	7.3	26.1	15.6
7.				-	9.0	-	-	-	-	6.5	21.2	23.2
8.				10.5	16.2	-	-	-	-	6.3	16.8	24.6
9.				8.0	10.9	-	-	-	-	6.3	13.4	36.8
10.				7.1	10.5	-	-	-	-	6.3	12.4	30.7
Mean				-	10.5	-	-	-	-	7.3	17.6	20.3
11.				7.0	10.9	-	-	-	-	6.1	10.5	29.9
12.				7.1	9.2	-	-	-	-	6.0	9.2	30.7
13.				8.8	8.8	-	-	-	-	5.2	9.0	24.6
14.				13.4	8.8	-	-	-	-	4.3	8.8	22.5
15.				11.9	10.0	-	-	-	6.0	4.3	8.4	25.3
16.				11.9	11.9	-	-	-	8.8	4.3	8.4	18.6
17.				9.6	11.9	-	-	-	16.2	4.3	8.2	14.5
18.				14.5	9.6	-	-	-	19.2	4.3	7.8	13.4
19.				18.6	8.6	-	-	-	12.9	4.3	7.7	13.4
20.				19.2	8.4	-	-	-	9.2	19.2	8.0	13.4
Mean				12.2	9.8	-	-	-	-	6.2	8.6	20.6
21.				10.5	8.8	-	-	-	8.2	7.7	11.9	14.0
22.				18.6	9.4	-	-	-	7.8	6.5	46.2	12.4
23.				28.3	10.0	-	-	-	7.7	6.1	40.2	11.4
24.				21.8	14.5	-	-	-	11.9	5.5	22.5	10.5
25.				23.9	10.0	-	-	-	9.5	5.5	21.8	10.5
26.				18.6	-	-	-	-	8.6	5.7	22.5	11.4
27.				14.0	-	-	-	-	10.9	5.2	16.2	11.9
28.				15.1	-	-	-	-	10.5	5.2	12.9	10.5
29.				14.5	-	-	-	-	9.2	5.7	11.4	10.5
30.				12.9	-	-	-	-	8.8	5.7	10.5	10.0
31.					-		-	-		5.7		10.9
Mean				17.8	-	-	-	-	9.3	5.9	21.6	11.3
Monthly Average				-	-	-	-	-	-	6.4	15.9	17.2

Year : 1974

(Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	12.9	12.4	32.3	(7.5)	9.2	7.8	(8.0)	26.1	6.6	6.0	7.3	7.5
2.	12.4	8.6	(8.0)	"	9.2	8.0	"	15.1	6.5	6.0	7.1	6.6
3.	15.6	10.9	"	"	9.0	8.4	"	10.9	6.3	6.0	7.5	6.3
4.	15.1	16.2	"	"	8.6	8.4	"	9.2	6.1	5.5	7.3	6.1
5.	18.0	11.9	"	"	8.6	8.6	"	8.8	6.1	5.7	7.0	6.0
6.	46.2	9.0	"	18.6	8.4	8.6	"	8.6	6.3	5.7	6.8	5.5
7.	35.7	8.6	"	27.6	8.4	8.6	"	8.4	6.3	6.0	6.8	5.7
8.	33.9	8.8	"	18.6	8.2	8.8	"	8.8	6.1	6.1	6.6	6.1
9.	40.2	9.2	"	30.7	8.0	8.8	"	8.4	6.3	6.5	7.3	6.0
10.	43.1	10.0	"	23.9	7.8	8.8	"	8.2	6.3	6.5	8.0	6.0
Mean	27.3	10.6	(10.4)	(15.7)	8.5	8.5	(8.0)	11.3	6.3	6.0	7.2	6.2
11.	38.5	18.0	(8.0)	33.1	7.5	8.8	(8.0)	8.0	6.3	6.0	7.1	6.0
12.	27.6	23.9	"	23.9	7.5	8.8	"	7.8	90.0	6.0	7.0	6.0
13.	21.2	23.9	"	17.4	7.1	8.8	"	7.7	59.4	6.8	6.8	6.0
14.	16.2	21.2	"	30.7	7.1	8.8	"	7.7	49.3	7.7	6.6	6.3
15.	15.1	18.0	"	21.2	7.3	(8.0)	"	7.7	15.6	7.1	6.6	6.6
16.	13.4	15.6	(7.5)	26.1	7.5	"	"	7.5	10.0	8.0	6.6	6.8
17.	11.9	13.4	"	33.9	8.0	"	"	7.5	8.6	7.0	6.3	6.5
18.	11.9	11.9	"	27.6	7.8	"	"	7.3	8.0	23.9	6.1	6.8
19.	10.9	10.9	"	19.2	7.8	"	"	7.0	7.5	10.9	6.3	7.0
20.	10.5	10.5	"	16.2	8.0	"	"	6.8	7.1	8.2	6.1	7.0
Mean	17.7	16.7	(7.8)	24.9	7.6	(8.3)	(8.0)	7.5	26.2	9.2	6.6	6.5
21.	10.5	10.9	(7.5)	14.0	8.2	(8.0)	(8.0)	6.6	7.0	13.4	6.1	6.5
22.	9.6	10.0	"	12.4	8.0	"	"	6.3	6.8	15.6	6.0	6.5
23.	9.2	9.6	"	11.9	7.7	"	21.2	6.1	6.6	18.0	6.1	6.5
24.	10.5	9.2	"	10.9	7.3	"	107.6	6.1	6.5	14.0	6.1	6.3
25.	13.4	9.0	"	10.0	7.5	"	64.4	6.0	6.3	9.2	6.3	6.1
26.	14.0	9.0	"	9.2	7.7	"	55.3	6.1	6.3	8.6	6.8	6.5
27.	13.4	23.2	"	9.2	7.7	"	12.4	6.3	6.3	8.2	6.5	6.5
28.	12.9	19.9	"	9.0	7.7	"	9.2	6.1	6.3	7.7	6.3	6.3
29.	12.9		"	8.8	7.7	"	8.2	6.3	7.1	7.3	7.1	7.0
30.	13.4		"	8.8	7.7	"	8.2	6.3	6.5	7.3	7.5	7.7
31.	14.0		"		7.7		19.9	6.3		7.3		7.8
Mean	12.2	12.6	(7.5)	10.4	7.7	(8.0)	(28.8)	6.2	6.6	10.6	6.5	6.7
Monthly Average	18.8	13.3	(8.5)	(17.0)	7.9	(8.3)	(15.4)	8.3	13.0	8.7	6.7	6.5

Note : Figures with ( ) are estimated.

Table 1.3.2 Daily Discharge at Turungeng Station (2/5)

Year : 1976 (Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	8.4	(7.0)	(6.0)	8.8	12.4	7.1	7.5	5.5	4.3	3.9	4.3	8.6
2.	8.0	"	"	13.4	26.1	6.6	7.3	5.2	4.3	3.9	3.9	10.5
3.	7.8	"	"	12.9	13.4	7.8	7.1	5.0	4.5	4.1	3.7	8.2
4.	7.8	"	"	10.9	44.9	9.4	18.6	5.0	4.8	4.1	3.5	6.3
5.	7.7	"	"	10.5	7.3	8.0	35.2	5.0	4.8	4.1	3.5	5.7
6.	7.7	"	"	9.0	7.5	10.9	13.4	4.8	4.3	4.1	3.5	5.5
7.	7.7	"	"	8.8	7.8	55.9	9.6	4.8	4.1	3.9	3.3	5.5
8.	7.8	"	"	8.4	9.0	26.8	8.8	4.8	4.1	3.7	3.3	4.8
9.	7.5	"	"	8.2	11.4	31.5	8.4	4.8	3.9	3.7	3.3	4.5
10.	7.5	"	"	8.0	12.9	29.9	8.0	4.8	3.7	3.5	3.3	4.8
Mean	7.8	(7.0)	(6.0)	9.9	15.3	19.4	12.4	5.0	4.3	3.9	3.6	6.4
11.	7.3	(7.0)	(6.0)	8.0	11.4	22.5	7.8	4.5	3.5	3.5	3.3	5.2
12.	9.0	"	"	7.8	9.2	15.1	7.7	4.5	3.3	3.5	3.3	6.0
13.	9.0	"	"	8.0	8.6	9.6	7.7	4.5	3.3	3.5	3.3	5.7
14.	12.4	"	"	8.2	8.4	8.8	7.3	4.5	3.3	3.5	3.3	6.1
15.	21.8	"	"	9.2	8.2	8.4	7.3	4.5	3.3	3.5	3.3	6.6
16.	32.3	"	"	8.8	8.4	8.0	7.3	5.0	3.1	3.5	3.3	6.1
17.	35.2	"	"	8.2	8.2	7.8	7.0	5.0	2.8	3.3	3.5	5.7
18.	18.0	"	"	8.2	8.0	7.7	5.3	5.2	2.9	3.3	3.5	6.3
19.	12.4	"	"	8.0	7.8	10.9	6.3	5.2	2.6	3.3	3.3	6.3
20.	10.9	"	"	9.8	7.7	10.0	6.0	5.2	2.3	3.3	3.3	6.2
Mean	16.8	(7.0)	(6.0)	8.3	8.6	10.9	7.1	4.8	3.0	3.4	3.3	6.0
21.	10.0	(7.0)	(6.0)	8.2	7.7	8.8	5.7	5.2	2.1	3.3	3.5	6.3
22.	9.6	"	"	7.8	7.5	8.4	5.5	5.0	2.3	3.5	3.9	6.5
23.	9.0	"	"	15.1	7.3	8.0	5.5	5.0	2.3	4.8	4.3	6.3
24.	8.8	"	"	12.9	7.3	7.8	5.2	5.0	3.1	4.3	3.9	6.5
25.	8.6	"	"	9.6	7.1	7.7	5.2	5.0	3.7	5.2	3.7	6.6
26.	8.4	"	"	8.4	6.6	7.5	5.5	5.0	3.5	6.5	4.1	6.5
27.	8.4	"	"	8.0	7.1	7.1	5.2	4.8	3.5	5.7	4.3	7.8
28.	8.6	"	"	7.8	7.7	7.3	5.0	4.8	3.5	4.5	4.3	16.8
29.	8.4	"	"	7.7	8.0	7.7	5.0	4.8	3.9	4.1	4.5	11.9
30.	8.4		"	8.4	7.1	7.3	5.0	4.5	4.1	3.7	6.3	10.0
31.	6.4		"		7.0		5.0	4.3		3.9		11.9
Mean	8.8	(7.0)	(6.0)	9.4	7.3	7.8	5.3	4.9	3.2	4.5	4.3	8.8
Monthly Average	11.1	(7.0)	(6.0)	9.2	10.3	12.7	8.1	4.9	3.5	4.0	3.7	7.2

Year : 1975 (Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	8.8	(6.0)	7.3	6.0	20.5	(13.0)	10.9	15.6	19.2	14.0	14.5	7.7
2.	9.2	"	7.5	5.7	24.6	"	10.9	14.0	19.3	11.4	17.4	7.5
3.	9.0	"	13.4	6.8	21.8	"	11.4	12.9	18.0	11.4	23.9	7.3
4.	9.6	"	8.6	9.6	18.6	"	10.0	11.9	16.8	11.4	33.9	7.1
5.	9.0	"	8.6	14.0	19.9	"	8.2	11.4	16.8	10.5	30.7	8.8
6.	8.8	"	9.6	8.4	45.6	13.4	8.8	10.9	14.0	10.9	29.9	10.9
7.	7.8	"	7.8	7.7	105.3	15.6	9.0	11.4	14.0	10.9	19.2	8.2
8.	7.3	"	7.7	9.0	101.6	12.9	9.0	10.5	14.0	10.9	14.0	7.8
9.	7.3	"	8.2	10.5	103.4	12.4	9.2	11.9	13.4	11.4	12.9	7.7
10.	7.3	"	7.7	9.6	45.6	11.4	9.0	15.6	14.0	10.9	16.8	7.5
Mean	8.4	(6.0)	8.6	8.7	50.7	13.1	9.6	12.6	16.0	11.4	21.3	8.1
11.	8.2	(6.0)	7.7	8.6	14.5	11.4	9.0	113.8	14.0	10.0	16.8	7.7
12.	8.0	"	8.0	8.4	14.5	11.4	9.0	93.5	13.4	11.4	43.1	9.6
13.	8.2	"	10.5	8.6	15.1	10.0	9.0	49.3	12.4	12.9	31.5	10.5
14.	8.0	"	8.4	7.8	15.1	10.0	10.0	43.7	14.0	9.6	18.0	10.0
15.	8.2	"	8.4	7.9	15.6	12.9	8.4	39.0	13.4	9.2	14.0	10.0
16.	12.4	"	8.2	8.8	15.6	51.9	7.8	36.2	11.4	8.6	11.4	10.9
17.	9.2	"	8.0	18.0	14.5	72.0	8.0	34.8	10.9	8.4	10.5	10.0
18.	9.6	"	7.8	22.5	14.5	63.0	9.0	33.1	10.0	8.4	9.6	10.9
19.	9.6	"	9.6	16.2	36.2	27.6	9.6	32.3	10.0	8.2	9.6	10.5
20.	10.5	"	10.9	14.0	43.7	18.6	9.2	31.5	9.6	9.2	9.6	9.6
Mean	9.2	(6.0)	8.8	12.1	19.9	28.9	8.9	51.2	11.9	9.6	17.4	10.0
21.	12.4	(6.0)	9.0	11.9	27.6	15.1	9.0	30.7	9.2	8.8	10.9	9.0
22.	8.8	"	8.0	10.5	21.2	13.4	33.9	29.9	9.2	8.4	9.6	8.8
23.	8.6	"	7.7	9.0	16.8	12.9	33.9	29.1	9.0	9.2	9.2	8.6
24.	8.6	"	7.5	8.6	14.0	11.9	28.3	28.3	8.8	9.2	9.0	8.4
25.	6.6	"	7.5	9.2	12.4	10.9	26.1	27.6	14.0	8.6	8.8	8.4
26.	6.6	"	7.3	8.0	12.9	10.5	22.5	27.6	10.5	18.6	8.8	8.4
27.	11.9	"	7.0	9.2	11.4	10.0	19.2	26.8	9.2	11.9	8.6	8.6
28.	7.3	"	6.8	23.2	32.3	10.0	33.9	26.8	8.8	9.2	8.2	8.4
29.	6.6		6.8	26.1	36.2	9.6	36.2	29.9	9.0	8.6	8.2	8.4
30.	6.8		6.5	16.8	19.9	10.0	21.8	22.5	9.0	10.5	8.0	8.6
31.	7.1		6.1		15.1		17.4	20.5		17.4		8.4
Mean	8.3	(6.0)	7.3	13.2	20.0	11.4	25.7	27.2	9.7	10.9	8.9	8.5
Monthly Average	8.6	(6.0)	8.2	11.3	29.9	(17.8)	15.1	30.3	12.5	10.6	15.9	8.8

Table 1.3.2 Daily Discharge at Turungeng Station (3/5)

Year : 1977 (Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	9.6	8.8	14.0	9.0	7.3	6.5	(7.0)	(6.0)	(4.0)	(4.0)	(8.0)	13.2
2.	8.0	8.6	11.4	8.6	7.1	6.5	"	"	"	"	"	11.3
3.	7.3	8.4	10.9	8.6	7.0	6.5	"	"	"	"	"	10.4
4.	8.8	8.4	14.5	8.4	7.0	6.8	"	"	"	"	"	11.8
5.	17.4	8.2	18.6	8.0	6.8	10.9	"	"	"	"	"	13.7
6.	23.9	8.0	20.5	7.8	6.6	16.2	"	"	"	"	"	10.4
7.	18.6	8.0	69.7	7.7	6.6	18.0	"	"	"	"	"	10.4
8.	19.9	8.0	50.6	7.7	6.6	18.6	"	"	"	"	"	12.3
9.	20.5	8.0	26.8	11.9	6.8	18.6	"	"	"	"	"	12.7
10.	22.5	8.0	18.0	12.4	6.6	19.9	"	"	"	"	"	15.8
Mean	15.7	8.2	25.5	9.0	6.8	12.9	(7.0)	(6.0)	(4.0)	(4.0)	(8.0)	12.2
11.	31.5	9.6	14.5	36.2	6.5	12.9	(7.0)	(5.0)	(4.0)	(4.0)	(8.0)	16.3
12.	29.9	8.4	12.4	15.6	6.5	51.3	"	"	"	"	"	12.7
13.	25.3	9.6	11.9	12.4	6.6	(220.0)	"	"	"	"	"	12.3
14.	23.9	8.8	9.6	10.5	6.6	(50.0)	"	"	"	"	"	12.7
15.	16.2	8.2	8.8	9.6	6.6	(25.0)	"	"	"	"	"	12.3
16.	10.9	8.6	8.6	9.0	6.6	(20.0)	"	"	"	"	"	11.8
17.	10.5	8.4	8.6	8.8	6.5	(15.0)	"	"	"	"	"	12.3
18.	9.6	8.2	8.6	8.8	7.3	(30.0)	"	"	"	"	"	11.9
19.	10.9	8.6	8.4	9.0	9.0	(15.0)	"	"	"	"	"	16.9
20.	10.5	15.1	8.4	8.8	8.0	(10.0)	"	"	"	"	"	15.8
Mean	17.9	9.2	10.0	12.9	7.0	(44.9)	(7.0)	(5.0)	(4.0)	(4.0)	(8.0)	13.5
21.	9.6	16.8	8.4	9.0	7.3	(10.0)	(6.0)	(5.0)	(4.0)	(4.0)	10.4	13.7
22.	10.9	16.8	8.0	8.6	7.1	(10.0)	"	"	"	"	10.0	12.3
23.	12.4	15.6	8.0	8.8	6.8	(10.0)	"	"	"	"	10.0	16.3
24.	11.4	14.0	9.0	8.6	6.5	(10.0)	"	"	"	"	10.0	15.8
25.	10.5	12.9	10.0	8.4	5.5	(10.0)	"	"	"	"	10.0	14.7
26.	9.2	12.9	8.8	8.0	6.6	(10.0)	"	"	"	"	10.0	17.4
27.	8.6	12.4	9.6	7.7	6.5	(7.0)	"	"	"	"	10.4	14.7
28.	9.2	16.8	12.9	7.5	6.5	"	"	"	"	"	11.3	14.2
29.	9.2		18.6	7.3	6.5	"	"	"	"	"	12.3	14.2
30.	9.0		14.5	7.5	6.5	"	"	"	"	"	13.7	14.2
31.	9.0		10.0		6.5	"	"	"	"	"		16.3
Mean	9.9	14.8	10.7	8.1	6.7	(8.4)	(6.0)	(5.0)	(4.0)	(4.0)	10.8	14.9
Monthly Average	14.3	10.4	15.2	10.0	6.8	(22.1)	(6.6)	(5.2)	(4.0)	(4.0)	(8.9)	13.6

Year : 1978 (Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	18.6	5.5	8.8	13.7	14.2	8.4	7.3	14.2	6.0	5.7	5.2	9.6
2.	20.3	5.5	7.6	17.4	10.0	8.8	10.0	14.7	5.5	5.7	5.0	9.2
3.	21.6	7.6	8.0	13.2	41.4	10.4	14.7	11.3	5.5	5.7	4.8	10.0
4.	21.0	8.4	8.0	10.0	15.8	10.9	15.8	9.6	5.5	6.5	4.8	10.9
5.	23.5	7.6	7.6	8.4	10.9	10.9	12.7	9.2	5.2	7.3	4.8	10.4
6.	19.1	12.3	7.0	7.6	8.8	12.7	13.2	8.4	5.2	7.3	4.8	9.6
7.	16.3	10.0	7.0	7.3	7.3	21.6	12.7	8.0	5.0	9.2	5.0	9.2
8.	14.7	8.8	6.8	7.3	6.8	25.5	10.0	7.6	5.0	6.5	5.0	8.8
9.	12.3	8.0	7.3	7.0	6.2	19.1	8.8	7.3	5.0	6.0	5.2	8.4
10.	10.9	8.0	7.3	7.6	6.2	12.7	8.4	7.0	5.0	5.7	5.0	10.9
Mean	17.8	8.2	7.5	10.0	12.8	14.1	11.4	9.7	5.3	6.6	5.0	9.7
11.	23.5	8.0	8.8	9.6	5.7	11.3	8.0	6.8	4.8	5.5	5.5	9.2
12.	18.0	7.6	8.0	10.0	7.6	14.2	8.0	7.0	4.5	5.5	7.0	9.6
13.	13.7	7.3	8.8	8.0	32.0	12.7	9.2	7.0	4.5	5.2	6.5	24.9
14.	13.7	7.0	7.3	7.3	19.7	10.9	8.4	9.6	4.5	5.5	5.5	26.6
15.	14.2	6.8	8.4	6.8	21.0	10.9	10.4	9.2	4.3	6.0	5.0	24.1
16.	10.0	6.5	15.2	6.8	23.5	10.0	10.0	7.3	4.3	6.0	5.0	19.1
17.	18.6	6.8	13.6	6.5	13.7	9.2	8.0	28.0	4.5	6.0	4.8	15.2
18.	14.2	8.0	19.7	6.2	10.9	8.8	7.6	13.0	5.5	5.5	4.5	13.2
19.	11.8	7.3	10.4	6.2	9.6	8.8	7.0	12.3	7.0	5.5	4.8	11.8
20.	9.6	6.8	8.0	6.0	8.4	9.2	6.8	10.0	7.0	5.5	4.8	11.3
Mean	15.2	7.2	11.3	7.3	15.2	10.6	8.3	11.5	5.1	5.6	5.3	16.5
21.	8.4	6.5	7.3	5.7	8.8	8.0	7.0	8.4	6.2	5.2	5.0	11.3
22.	7.3	6.5	10.4	5.7	9.2	7.6	6.8	7.6	6.0	5.2	6.2	12.7
23.	7.0	6.5	24.8	5.7	8.4	7.3	6.5	7.0	6.0	9.2	6.8	12.0
24.	6.8	6.0	26.1	5.5	7.6	7.3	6.5	6.8	6.2	9.5	8.0	13.7
25.	6.5	6.0	22.2	5.5	7.3	7.3	6.5	6.5	6.0	7.3	7.6	12.7
26.	6.5	6.5	12.7	5.2	7.0	7.0	6.2	6.2	6.0	6.5	8.4	12.7
27.	6.5	8.4	10.0	5.0	6.8	7.0	6.0	6.2	5.7	6.0	8.8	13.2
28.	6.2	11.3	8.4	5.2	6.2	12.3	6.0	6.0	5.7	5.7	8.8	26.1
29.	6.2	-	7.3	8.0	7.0	9.2	5.7	5.5	5.7	5.7	9.6	20.2
30.	6.0	-	7.0	6.8	8.4	7.6	23.5	5.7	5.7	5.5	10.0	17.4
31.	5.7	-	7.6	-	7.3	-	18.6	5.5	-	5.5	-	19.1
Mean	6.6	7.2	13.1	5.8	7.6	8.1	9.0	6.5	5.9	6.5	7.9	16.1
Monthly Average	13.0	7.6	10.7	7.7	11.7	10.9	9.6	9.2	5.4	6.2	6.1	14.2

Table 1.3.2 Daily Discharge at Turungeng Station (4/5)

Year : 1979 (Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	16.3	5.5	10.9	12.3	10.9	13.6	8.8	6.0	3.9	3.1	2.9	4.1
2.	10.0	5.7	8.0	10.0	8.8	11.8	8.8	5.7	4.1	3.1	2.9	4.5
3.	9.6	5.7	7.0	8.8	7.3	12.3	8.4	5.5	4.1	2.9	2.9	7.3
4.	8.0	5.5	7.3	9.2	12.7	12.3	8.0	5.5	4.8	2.9	2.6	5.5
5.	7.3	6.8	7.0	8.0	12.7	11.8	7.6	5.5	4.5	3.1	2.6	3.9
6.	8.4	6.0	6.5	7.6	14.7	10.4	7.3	5.5	4.3	3.1	2.6	3.3
7.	14.2	5.7	10.9	10.0	12.7	9.2	7.3	5.2	4.3	3.1	2.6	3.1
8.	21.6	6.0	11.8	26.1	9.2	19.1	11.8	5.2	4.1	2.9	2.6	3.3
9.	21.0	6.0	13.2	23.5	9.2	41.4	9.2	5.0	4.3	2.9	2.8	4.3
10.	27.0	5.5	10.4	16.3	8.0	100.7	8.8	5.0	4.3	2.9	2.8	4.8
Mean	14.3	5.8	9.3	13.2	10.6	24.8	8.6	5.4	4.3	3.0	2.7	4.4
11.	33.5	5.5	10.4	12.7	8.8	38.5	8.8	4.8	4.1	2.9	2.6	5.5
12.	25.5	6.0	11.8	10.0	9.2	28.0	10.0	4.8	3.9	2.9	2.6	5.0
13.	18.0	9.6	10.0	8.8	10.9	22.2	8.4	4.8	3.9	3.1	2.8	5.0
14.	14.2	11.8	8.8	8.0	9.6	18.0	7.6	4.8	3.7	3.1	2.8	4.5
15.	11.3	12.3	8.0	7.6	8.0	30.0	7.3	4.8	3.7	3.1	2.6	3.9
16.	10.4	14.2	7.3	7.3	7.0	21.0	7.3	4.5	3.5	3.1	2.6	3.7
17.	9.2	13.7	7.0	10.4	6.8	16.3	7.0	4.8	3.3	3.1	2.6	4.8
18.	8.4	9.6	7.6	10.9	6.5	14.2	27.0	4.5	3.3	2.9	2.4	6.8
19.	7.6	7.6	11.3	7.6	6.2	12.7	15.8	4.5	3.3	2.9	2.4	8.0
20.	7.3	6.8	10.0	7.0	6.9	36.9	10.4	4.5	3.3	2.9	2.4	6.8
Mean	14.5	9.7	9.2	9.0	8.0	23.8	11.0	4.7	3.6	3.0	2.6	5.4
21.	7.0	6.5	11.3	6.5	6.8	25.5	9.2	4.5	3.3	2.9	2.4	5.0
22.	7.0	6.2	10.4	6.2	9.6	17.4	8.4	4.5	3.3	2.8	2.4	6.5
23.	7.0	6.0	9.6	6.2	10.4	14.2	7.6	4.5	3.3	2.8	2.3	5.7
24.	6.8	6.0	7.6	6.0	6.5	12.3	7.3	4.3	3.3	2.8	2.3	5.0
25.	6.5	6.0	8.4	5.5	5.7	11.3	6.8	4.3	3.1	2.8	2.4	5.2
26.	6.2	5.7	10.4	7.0	6.0	10.4	6.8	4.1	3.1	2.8	2.3	9.2
27.	6.2	12.3	8.8	8.4	5.0	9.6	6.5	4.1	3.1	2.9	2.3	12.3
28.	6.5	21.6	8.0	7.0	5.7	9.6	6.8	4.1	3.1	2.9	2.6	8.8
29.	6.5		7.6	6.5	6.5	9.2	6.2	4.1	3.1	2.9	2.8	8.4
30.	6.0		22.8	13.7	15.8	8.8	6.0	3.9	3.1	2.9	4.3	7.3
31.	5.7		18.6		35.7		6.0	3.9		2.9		6.3
Mean	6.5	8.8	11.2	7.3	10.4	12.3	7.1	4.2	3.2	2.9	2.6	7.4
Monthly Average	11.6	8.1	10.0	9.8	9.7	20.5	8.8	4.7	3.7	2.9	2.6	5.8

Year : 1980 (Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	6.5	5.7	11.3	8.0	21.6	13.7	10.4	5.5	4.3	3.1	2.9	6.5
2.	6.5	5.5	10.4	7.3	16.9	12.7	10.0	6.0	4.3	3.1	2.9	6.8
3.	6.0	5.2	10.4	7.6	30.0	12.7	9.6	6.0	4.5	3.1	2.9	6.8
4.	5.7	5.5	13.7	10.4	86.6	22.8	8.8	6.0	4.5	2.9	3.1	7.6
5.	6.0	5.5	13.2	12.3	44.3	11.8	8.8	5.7	4.5	3.1	3.1	8.0
6.	6.2	8.8	9.6	9.2	34.6	11.8	8.4	5.7	4.5	3.1	3.1	10.9
7.	7.6	9.2	10.0	8.0	32.5	10.0	8.4	5.7	4.1	3.1	3.1	7.0
8.	10.0	10.9	11.8	8.4	26.6	10.0	8.0	5.7	4.3	3.1	3.1	16.9
9.	15.8	9.2	11.3	16.9	21.6	9.6	8.0	5.7	4.3	3.1	3.1	18.0
10.	14.7	8.4	11.8	41.9	18.6	9.6	8.0	5.5	4.1	3.1	3.1	21.6
Mean	8.5	7.4	11.4	13.0	33.3	12.5	8.8	5.8	4.3	3.1	3.0	11.0
11.	14.7	8.4	10.0	23.5	15.8	9.6	7.6	5.7	4.1	2.9	3.1	22.8
12.	10.9	13.2	8.4	19.0	14.2	9.6	8.0	5.7	4.1	2.9	3.1	21.0
13.	9.2	29.0	8.4	22.2	13.2	9.6	7.3	5.5	4.1	2.9	3.1	18.6
14.	7.6	30.0	9.6	21.6	12.7	10.4	7.0	5.2	3.7	2.9	3.1	16.3
15.	7.3	34.1	11.8	25.5	12.3	10.9	7.0	5.2	3.7	2.9	3.1	12.3
16.	6.8	26.1	10.0	25.5	11.8	18.0	7.0	5.2	3.7	2.9	3.3	10.4
17.	6.5	20.3	9.6	18.6	12.3	12.3	7.0	5.0	3.7	2.9	3.3	13.7
18.	6.5	14.7	20.3	14.7	11.3	11.8	7.0	5.0	3.7	2.9	3.3	8.8
19.	8.0	11.8	16.9	13.7	10.0	16.9	7.0	5.0	3.7	2.9	3.1	7.3
20.	10.4	10.0	22.2	13.2	10.0	15.8	6.8	5.0	3.7	2.9	2.9	8.4
Mean	8.8	19.8	12.7	20.8	12.4	12.5	7.2	5.3	3.8	2.9	3.1	14.0
21.	10.4	15.2	21.0	13.2	9.6	13.7	6.5	5.0	3.5	2.9	3.1	7.3
22.	10.0	12.7	17.4	26.1	9.2	11.8	6.5	4.8	3.5	2.9	3.1	6.8
23.	9.2	13.7	14.2	28.5	9.2	11.8	6.5	4.8	3.5	2.9	3.1	8.0
24.	8.4	15.8	13.2	27.5	11.3	11.8	6.2	4.5	3.5	3.1	3.1	20.3
25.	8.8	12.3	13.2	22.8	13.7	12.7	6.2	4.5	3.5	3.3	3.3	13.7
26.	8.4	19.7	12.3	21.6	13.7	16.3	6.0	4.5	3.3	3.1	3.9	10.4
27.	7.0	24.8	10.4	24.8	13.7	17.4	5.7	4.5	3.3	2.6	5.5	10.0
28.	6.5	14.2	10.9	22.8	13.7	15.2	5.7	4.5	3.3	2.3	6.0	9.2
29.	6.2	12.3	11.3	24.8	13.7	12.3	5.7	4.5	3.3	2.6	3.9	8.4
30.	6.0		11.3	30.5	13.7	10.9	5.5	4.5	3.3	2.8	5.0	7.6
31.	6.0		9.6		13.7		5.5	4.3		2.8		7.3
Mean	7.9	15.6	13.2	24.3	12.3	13.4	6.0	4.6	3.4	2.8	4.0	9.9
Monthly Average	8.4	14.2	12.4	19.3	19.1	12.8	7.3	5.2	3.9	2.9	3.4	11.6

Table 1.3.2 Daily Discharge at Turungeng Station (5/5)

Year : 1981 (Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	7.0	10.0	7.3	20.3	9.2	10.9	8.4	12.3	6.5	5.5	4.7	8.0
2.	7.0	8.8	14.7	16.3	10.0	10.9	8.0	11.8	6.2	5.5	4.1	7.6
3.	7.0	8.4	11.3	13.2	9.6	10.4	8.0	11.3	6.2	5.5	3.9	7.3
4.	7.0	10.0	11.8	14.2	10.4	10.0	8.0	10.9	6.8	6.0	3.9	6.8
5.	7.0	10.4	14.7	12.3	14.7	9.6	8.0	10.9	6.8	5.5	4.5	7.3
6.	7.0	8.8	12.7	10.9	16.3	9.6	8.4	10.4	7.0	5.5	6.2	13.7
7.	7.0	10.0	9.6	10.4	13.7	9.2	11.8	10.4	7.0	5.2	10.0	13.2
8.	7.3	17.4	8.4	14.2	12.3	9.2	10.4	10.4	6.8	5.2	9.2	10.4
9.	7.3	14.2	8.0	18.6	17.4	8.8	11.8	10.0	10.4	5.5	8.8	10.0
10.	7.3	11.3	7.3	23.5	24.1	8.4	11.8	9.6	7.3	5.2	6.2	12.7
Mean	7.1	10.9	10.6	15.4	13.8	9.7	9.5	10.8	7.1	5.5	6.1	9.7
11.	22.8	14.7	11.3	19.7	51.9	8.4	9.6	9.2	6.8	5.2	5.5	18.0
12.	17.4	21.6	11.8	14.2	23.5	8.4	25.5	9.2	7.0	5.0	6.8	14.2
13.	11.8	18.0	20.3	17.4	48.7	8.4	21.0	9.2	6.8	4.8	7.6	11.3
14.	9.6	14.2	15.8	17.4	40.2	8.0	30.0	8.8	6.5	4.8	6.5	11.8
15.	9.2	12.3	11.3	13.7	55.3	7.6	55.9	8.4	6.2	4.8	5.7	10.9
16.	8.0	12.3	13.2	14.7	71.2	7.3	63.0	8.0	6.2	4.8	5.5	10.4
17.	10.0	12.3	11.3	16.3	37.3	7.3	39.6	8.0	6.0	4.8	6.5	9.6
18.	11.8	10.9	9.6	14.7	30.5	7.0	28.0	8.0	6.0	4.5	10.9	9.6
19.	11.3	9.6	8.8	15.2	28.5	8.3	22.2	7.6	6.0	4.5	8.4	9.6
20.	9.6	8.8	8.8	13.2	27.0	11.8	19.7	7.6	5.7	4.5	7.3	7.6
Mean	12.2	13.5	12.2	15.7	41.9	8.3	31.5	8.4	6.3	4.8	7.1	11.3
21.	9.2	8.0	8.0	11.3	23.5	15.2	36.2	7.6	5.5	4.5	8.8	7.6
22.	9.2	7.6	7.3	13.7	22.2	10.9	31.5	7.3	5.5	4.5	7.6	7.6
23.	12.3	7.3	7.3	14.7	19.1	10.0	24.1	7.3	5.5	4.5	12.3	8.0
24.	11.3	7.0	7.0	12.3	16.9	10.0	19.7	7.3	6.2	4.8	11.8	7.6
25.	10.4	7.0	7.3	11.3	15.2	12.3	18.0	7.0	7.0	4.5	9.2	7.6
26.	14.2	7.0	9.2	10.0	14.7	13.2	16.3	7.0	6.5	4.5	9.6	8.0
27.	24.8	7.0	11.8	10.9	13.7	10.9	15.2	7.0	6.5	4.5	8.4	10.9
28.	16.9	8.0	10.0	11.3	12.7	10.0	14.2	7.0	6.0	4.5	8.4	16.3
29.	15.2		13.7	10.0	11.8	9.2	13.7	7.0	5.7	4.3	8.0	17.4
30.	12.7		34.1	9.2	11.3	8.4	13.2	6.5	5.5	4.3	8.0	13.2
31.	10.9		28.0		11.3		12.7	6.5		4.1		11.3
Mean	13.4	7.4	13.1	11.5	15.7	11.0	19.5	7.0	6.0	4.5	9.2	10.5
Monthly Average	11.0	10.8	12.0	14.2	23.5	9.7	20.1	8.7	6.5	4.9	7.5	10.5

Year : 1982 (Unit : m^3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	10.0	8.4	8.4	30.0	10.9	18.0						
2.	10.9	8.4	8.8	24.1	26.1	15.8						
3.	12.3	8.4	8.4	14.2	15.8	16.9						
4.	13.7	8.4	8.4	12.3	13.2	16.3						
5.	14.2	9.6	8.0	10.9	12.7	15.8						
6.	15.8	17.4	8.0	10.4	12.3							
7.	24.1	23.5	8.0	10.4	10.0							
8.	23.5	18.0	8.4	10.4	10.0							
9.	15.8	14.7	8.4	10.0	9.6							
10.	14.2	12.3	8.0	11.3	9.6							
Mean	15.5	12.9	8.3	14.4	13.0							
11.	15.2	11.3	8.0	22.8	9.2							
12.	17.4	15.8	7.6	17.4	9.2							
13.	15.8	16.3	7.3	15.9	7.6							
14.	14.2	31.5	7.3	16.3	7.6							
15.	16.9	22.2	7.3	13.2	7.3							
16.	19.1	17.4	7.6	12.3	6.8							
17.	14.7	14.2	7.3	10.9	6.8							
18.	12.3	12.3	7.3	10.4	6.2							
19.	11.3	10.9	7.0	10.0	6.0							
20.	10.0	11.3	7.3	9.2	6.0							
Mean	14.7	16.3	7.4	13.9	7.3							
21.	9.2	11.3	10.0	9.2	5.7							
22.	10.0	10.0	8.8	8.8	5.2							
23.	10.4	9.2	8.0	8.4	5.2							
24.	9.6	8.8	7.6	8.4	11.3							
25.	9.6	8.4	7.6	9.6	30.0							
26.	9.2	8.4	7.3	9.2	19.1							
27.	8.8	8.4	7.3	12.3	29.0							
28.	8.8	8.4	10.4	16.9	15.2							
29.	8.8		13.2	16.9	14.2							
30.	8.8		12.3	12.3	27.0							
31.	8.4		18.6		22.2							
Mean	9.2	9.1	10.1	11.2	16.7							
Monthly Average	13.0	13.0	8.6	13.2	12.5							

Table 1.3.3 Daily Discharge at Sanrego Station (1/3)

Year : 1978 (Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.								14.9	5.6	5.2	3.9	7.9
2.								15.7	5.4	5.2	3.8	7.9
3.								12.3	5.2	5.4	3.8	7.9
4.								10.6	5.2	6.5	3.8	8.9
5.								10.0	5.6	7.1	3.6	8.6
6.								9.1	5.2	7.1	3.6	7.9
7.								8.6	5.2	9.7	3.8	7.6
8.								8.1	5.2	6.9	3.8	7.4
9.								7.9	5.0	6.3	3.8	7.1
10.								7.6	4.8	6.0	3.8	9.4
Mean								10.5	5.2	6.5	3.8	8.1
11.								7.6	5.2	6.5	3.8	8.1
12.								7.9	5.6	5.6	5.2	9.1
13.								8.1	5.6	5.4	4.8	20.5
14.								10.6	5.6	5.4	4.1	26.6
15.								10.3	5.4	4.8	3.8	24.1
16.								8.9	5.2	4.5	3.6	18.2
17.							8.1	27.3	5.2	4.5	3.6	13.1
18.							7.9	19.9	4.5	4.3	3.4	10.3
19.							7.4	14.2	8.1	4.1	4.5	8.9
20.							7.1	9.7	7.9	4.1	5.2	7.9
Mean							-	12.5	5.8	4.8	4.2	14.7
21.							7.1	8.1	6.5	3.9	5.2	7.4
22.							7.1	7.4	5.8	3.8	6.7	9.4
23.							6.9	5.7	5.6	7.4	6.7	11.0
24.							6.7	6.5	5.4	7.4	7.1	8.6
25.							6.7	6.3	5.4	5.4	6.9	8.3
26.							6.7	6.3	5.2	4.7	7.1	8.3
27.							6.5	5.8	5.2	4.3	7.1	8.6
28.							6.5	5.6	5.2	4.1	7.4	10.9
29.							6.5	5.5	5.2	4.1	7.9	15.7
30.							36.6	5.4	5.2	4.1	8.1	12.3
31.							18.9	5.2	-	2.9	-	14.2
Mean							10.6	6.2	5.5	5.3	7.0	11.1
Monthly Average							-	9.6	5.5	5.4	5.0	11.3

Year : 1979 (Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	14.9	6.5	11.0	10.0	11.7	26.6	8.6	6.3	4.1	3.1	2.8	4.1
2.	11.3	6.5	8.6	7.9	7.6	16.6	8.3	5.8	4.1	3.1	2.8	4.3
3.	10.3	6.7	7.6	7.1	6.3	17.2	7.9	5.6	4.1	3.1	2.8	7.1
4.	9.1	6.5	7.9	7.4	14.2	17.7	7.9	5.4	4.7	3.1	2.8	5.2
5.	8.6	7.6	7.4	6.5	13.8	17.2	7.4	5.0	4.3	3.1	2.8	3.9
6.	9.7	6.9	6.9	6.0	15.7	15.3	6.9	4.8	4.3	3.1	2.8	3.4
7.	15.7	6.7	11.3	7.6	14.2	13.4	6.7	4.8	4.1	3.1	2.7	3.6
8.	23.5	6.9	12.3	14.9	10.6	24.7	11.7	4.8	3.9	3.1	2.7	3.4
9.	23.5	6.9	13.8	19.3	10.3	47.4	9.1	4.8	3.9	3.0	2.7	4.1
10.	30.0	6.5	11.3	13.4	9.4	91.5	8.9	4.8	3.9	2.8	2.8	4.5
Mean	15.7	6.8	9.8	10.0	11.4	28.8	8.3	5.2	4.1	3.1	2.8	4.4
11.	38.2	6.5	10.3	10.6	9.7	40.6	9.4	4.8	3.9	3.0	2.8	6.0
12.	28.0	6.7	12.0	8.3	9.7	26.6	10.3	4.8	3.8	3.0	2.8	5.4
13.	21.0	11.0	10.0	7.1	12.0	20.5	8.6	4.8	3.8	3.0	3.0	5.2
14.	15.3	13.1	8.6	6.5	10.0	17.2	7.6	4.8	3.6	3.0	3.0	4.7
15.	12.3	13.9	8.3	6.0	8.6	32.2	7.6	4.8	3.6	3.0	2.8	4.1
16.	11.0	15.7	7.6	6.3	7.9	21.6	7.6	4.8	3.4	3.0	2.8	4.1
17.	10.0	15.7	7.4	8.1	7.4	16.1	7.4	4.7	3.4	3.0	2.8	5.2
18.	9.1	9.1	7.6	9.1	6.9	13.8	26.0	4.7	3.4	3.0	2.8	8.3
19.	8.6	8.9	11.0	6.7	6.7	12.7	17.7	4.7	3.4	3.0	2.8	8.9
20.	8.2	9.4	10.0	6.0	7.6	38.2	12.0	4.7	3.4	3.0	2.8	7.4
Mean	16.2	11.0	9.3	7.5	8.7	24.0	11.4	4.8	3.6	3.0	2.8	5.9
21.	7.9	10.0	10.0	6.5	7.9	26.6	10.6	4.5	3.4	2.8	2.8	6.5
22.	7.9	10.3	10.3	6.7	10.3	17.7	9.4	4.5	3.3	2.8	2.8	6.9
23.	7.9	10.6	8.3	6.9	12.0	14.2	8.1	4.5	3.4	2.8	2.8	6.0
24.	7.9	7.6	6.3	6.5	7.6	12.3	7.6	4.3	3.4	2.8	2.8	5.4
25.	7.6	6.3	6.5	6.3	6.9	11.3	7.6	4.3	3.4	2.8	2.8	5.8
26.	7.4	6.0	8.3	8.1	7.1	10.6	7.1	4.3	3.4	2.8	2.8	10.3
27.	7.4	10.3	6.9	9.7	7.4	10.0	7.1	4.3	3.4	2.8	2.8	13.8
28.	7.1	19.9	6.5	7.9	7.1	9.4	7.1	4.3	3.4	2.8	3.0	10.0
29.	7.1		6.3	7.4	7.6	9.1	6.7	4.1	3.4	2.8	3.1	9.1
30.	6.9		12.0	14.9	14.2	8.9	6.5	4.1	3.1	2.8	4.1	9.3
31.	6.5		15.2		39.8		6.3	4.1		2.8		8.1
Mean	7.4	10.1	9.7	8.1	11.6	13.0	7.6	4.3	3.4	2.8	3.0	8.2
Monthly Average	12.9	9.2	9.6	8.5	10.6	21.9	9.1	4.7	3.7	2.9	2.9	6.2

Talbe 1.3.3 Daily Discharge at Sanrego Station (2/3)

Year : 1980 (Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	7.6	5.4	11.7	6.1	22.8	13.8	10.6	5.6	3.8	3.1	3.0	5.0
2.	6.9	5.2	10.6	7.6	17.2	13.1	9.7	6.0	3.8	3.1	3.0	4.5
3.	6.5	5.2	9.7	8.1	32.9	13.1	9.4	6.0	3.8	3.3	3.0	4.3
4.	6.5	5.2	14.6	10.0	74.3	17.7	9.1	6.0	3.8	3.3	3.0	4.7
5.	6.9	5.2	13.4	13.1	50.9	10.6	8.9	6.0	3.8	3.4	3.1	6.0
6.	7.4	6.7	9.7	9.4	39.0	10.6	8.1	6.0	3.8	3.4	3.0	7.9
7.	8.9	9.1	9.4	8.1	35.1	10.0	7.9	5.6	3.8	3.4	3.0	6.3
8.	11.3	11.0	11.3	8.1	28.0	10.0	7.6	5.6	3.8	3.4	3.8	11.0
9.	17.2	8.9	11.0	15.7	23.5	10.0	7.4	5.4	3.8	3.6	3.0	14.2
10.	15.7	8.3	11.3	39.8	19.9	10.0	7.1	5.2	3.6	2.6	3.0	8.9
Mean	9.5	7.0	11.3	12.8	34.4	11.9	8.6	5.7	3.8	3.4	3.0	7.3
11.	15.7	8.1	8.9	26.0	16.6	10.0	6.9	5.2	3.6	3.4	3.0	7.9
12.	11.3	13.8	7.9	35.1	15.3	10.0	6.9	5.0	3.6	3.3	3.0	7.4
13.	9.1	32.9	7.4	24.1	14.6	10.0	6.9	4.8	3.6	3.3	3.0	7.6
14.	7.9	34.4	8.6	22.8	13.4	10.3	6.9	4.8	3.4	3.3	3.1	16.6
15.	7.1	40.6	11.0	27.3	13.1	10.3	6.7	4.8	3.4	3.1	3.1	12.3
16.	6.9	28.6	9.4	28.0	12.7	31.4	6.7	4.7	3.4	3.1	3.1	7.9
17.	6.5	22.8	9.1	19.9	13.8	10.6	6.5	4.5	3.4	3.0	3.1	6.9
18.	6.3	16.1	20.5	14.9	11.3	10.6	6.5	4.5	3.4	3.0	3.1	7.1
19.	7.6	12.7	17.2	13.8	9.7	18.8	6.5	4.5	3.4	2.8	3.3	7.6
20.	9.7	10.6	22.2	13.1	9.7	14.2	6.5	4.5	3.4	2.8	3.4	7.1
Mean	8.8	22.1	12.2	22.5	13.0	13.6	6.7	4.7	3.5	3.1	3.1	8.8
21.	9.4	13.4	22.8	13.4	9.1	12.0	6.5	4.5	3.4	3.0	3.3	6.9
22.	8.9	13.8	18.8	21.6	8.9	11.0	6.3	4.5	3.4	3.0	3.3	6.7
23.	8.1	14.2	14.6	30.0	8.9	11.0	6.3	4.3	3.3	3.0	3.3	12.7
24.	7.9	16.6	12.0	29.3	11.3	11.0	6.0	4.3	3.3	3.0	3.4	11.3
25.	7.9	12.0	13.1	23.5	14.6	13.1	6.0	4.3	3.3	3.0	3.4	7.1
26.	7.6	13.1	12.0	22.2	13.8	16.1	6.0	4.3	3.3	3.1	3.4	7.6
27.	6.9	28.6	10.3	25.3	13.8	17.7	5.6	4.3	3.3	3.1	5.0	8.3
28.	6.5	14.9	10.0	24.1	13.8	15.7	5.6	4.3	3.1	3.3	6.3	7.9
29.	6.0	12.7	11.7	25.3	13.8	12.7	5.6	4.1	3.1	3.0	3.9	7.1
30.	5.8		11.3	33.6	13.8	11.7	5.6	4.1	3.1	3.0	4.5	5.5
31.	5.6		9.4		13.8		5.4	3.9		3.0		6.9
Mean	7.3	15.5	13.3	24.8	12.2	13.2	5.3	4.3	3.3	3.0	4.0	8.1
Monthly Average	8.5	14.8	12.3	20.0	19.7	12.9	7.0	4.9	3.5	3.2	3.4	8.1

Year : 1981 (Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	6.7	9.4	7.4	22.8	8.1	8.7	7.4	10.2	4.4	5.4	4.5	7.4
2.	6.3	8.6	15.3	17.2	8.6	8.5	7.2	9.9	4.2	5.2	4.5	7.2
3.	6.0	7.9	12.3	13.8	8.3	8.3	7.2	9.7	4.2	5.2	4.4	6.8
4.	5.8	9.4	12.7	13.4	8.3	8.0	7.6	9.4	4.4	6.0	4.4	6.3
5.	5.8	10.3	15.7	12.0	11.3	7.8	7.8	9.4	4.5	5.2	5.0	6.8
6.	5.8	8.9	13.8	10.6	16.6	7.6	8.0	9.4	5.2	5.0	6.8	11.5
7.	5.8	13.8	10.3	9.4	13.1	7.6	11.2	8.0	5.0	5.0	9.7	11.2
8.	6.3	18.8	8.9	11.7	11.7	7.6	9.9	8.0	5.0	5.0	9.0	9.4
9.	6.3	14.6	8.3	22.8	15.7	7.4	10.9	7.6	7.4	5.2	8.7	9.0
10.	6.5	12.0	7.6	30.0	24.1	7.2	11.2	6.2	5.2	5.0	6.3	11.2
Mean	6.1	11.4	11.2	16.4	12.6	7.9	8.8	8.8	5.0	5.2	6.3	8.7
11.	24.1	14.9	13.4	30.7	62.7	7.2	8.7	5.8	4.7	4.9	5.4	17.2
12.	19.3	22.2	13.8	20.5	42.4	7.2	24.8	5.6	4.7	4.7	6.8	12.0
13.	13.1	22.8	18.2	19.9	61.4	7.0	23.3	5.4	4.7	4.7	7.4	9.9
14.	10.6	15.3	18.2	21.6	56.3	7.0	34.7	5.4	4.9	4.7	6.2	9.2
15.	9.1	12.7	12.0	15.3	70.7	6.8	64.6	5.4	4.9	4.7	5.8	8.3
16.	8.6	13.1	14.2	14.9	79.3	6.8	73.5	5.0	5.2	4.7	5.4	7.8
17.	11.7	12.3	12.3	15.7	52.7	6.5	53.3	5.2	5.4	4.7	6.3	7.4
18.	12.0	10.6	10.3	14.6	42.2	6.3	34.7	5.2	5.6	4.5	9.9	7.2
19.	11.3	9.7	9.4	14.9	34.7	7.6	26.4	5.0	5.4	4.5	7.6	7.2
20.	9.1	8.3	8.3	13.4	30.4	9.2	21.9	5.0	5.4	4.5	6.8	7.2
Mean	12.9	14.2	13.0	18.2	53.3	7.2	36.6	5.3	5.1	4.7	6.8	9.3
21.	8.9	7.6	7.9	11.7	24.8	13.7	46.2	5.0	5.4	4.5	7.8	7.0
22.	8.9	7.4	7.4	12.3	21.9	9.4	39.3	4.9	5.4	4.5	7.0	7.2
23.	12.7	7.1	6.9	14.6	17.2	8.5	26.4	5.0	5.6	4.5	10.2	7.4
24.	10.0	6.7	6.5	12.0	14.8	8.5	20.5	4.9	6.2	4.7	9.9	7.2
25.	10.3	6.7	6.3	10.6	12.0	10.2	17.2	4.9	6.8	4.7	8.3	7.0
26.	21.0	6.7	7.4	9.4	11.2	11.7	14.3	4.7	6.3	4.5	8.7	7.4
27.	21.0	6.7	11.7	9.1	10.4	9.7	13.1	4.5	6.3	4.5	7.6	9.2
28.	16.1	7.6	9.7	10.3	10.2	8.5	11.7	4.5	5.9	4.5	7.6	15.4
29.	14.6		11.3	8.9	9.4	8.3	11.2	4.5	5.6	4.4	8.0	14.8
30.	11.7		33.6	8.3	9.0	7.6	10.7	4.4	5.4	4.4	7.4	10.9
31.	9.7		34.4		8.7		10.4	4.4		4.4		9.9
Mean	13.2	7.1	13.0	10.7	13.6	9.6	20.1	4.7	5.9	4.5	8.3	9.4
Monthly Average	10.8	11.1	12.4	15.1	26.1	8.2	21.8	6.2	5.3	4.8	7.1	9.1

Table 1.3.3 Daily Discharge at Sanrego Station (3/3)

Year : 1982 (Unit :m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.	9.2	8.0	6.5	31.2	10.9	19.8						
2.	9.7	7.8	6.2	23.3	30.4	14.3						
3.	10.4	7.8	5.8	11.7	16.0	16.0						
4.	12.6	7.8	5.8	10.2	12.0	15.4						
5.	11.7	9.0	5.6	9.9	10.7	13.7						
6.	13.7	11.7	5.8	9.7	10.2							
7.	27.1	34.7	5.8	10.2	9.7							
8.	22.6	19.2	5.8	10.7	9.7							
9.	13.7	12.0	6.0	12.6	9.4							
10.	11.5	10.2	5.8	15.4	9.2							
Mean	14.2	12.8	5.9	14.5	12.8							
11.	12.6	9.2	5.8	21.2	9.0							
12.	16.0	11.5	5.6	42.2	8.7							
13.	13.1	13.7	5.4	37.4	8.5							
14.	11.7	34.7	5.4	16.6	8.3							
15.	14.3	21.9	5.4	11.7	7.8							
16.	18.5	16.0	5.4	10.7	8.0							
17.	12.6	11.7	5.2	9.9	7.8							
18.	10.7	10.7	5.2	9.9	7.8							
19.	9.7	9.4	5.2	9.0	7.4							
20.	9.0	9.4	5.2	8.7	7.4							
Mean	12.8	14.8	5.4	17.7	8.1							
21.	8.3	10.2	7.0	8.3	7.2							
22.	9.0	9.0	6.2	8.0	7.0							
23.	9.0	8.5	5.8	8.0	7.0							
24.	8.7	8.0	5.6	8.3	12.6							
25.	8.5	7.8	5.6	9.2	40.2							
26.	8.3	7.4	5.4	9.2	24.1							
27.	7.8	7.4	5.6	11.5	38.3							
28.	8.0	7.0	7.0	17.2	17.2							
29.	8.5		9.4	17.2	16.6							
30.	8.3		9.9	11.5	49.1							
31.	8.3		15.4		32.1							
Mean	8.4	6.2	7.5	10.8	22.9							
Monthly Average	11.7	12.2	6.3	14.4	14.8							

Table 1.4.1 **Flood Discharge Record**

Order	Water level (m)	Discharge (m3/sec)
1.	6.44	740
2.	3.12	241
3.	3.11	240
4.	2.85	205
5.	2.73	189
6.	2.50	161
7.	2.50	161
8.	2.47	158
9.	2.47	158
10.	2.36	146
11.	2.34	143
12.	2.24	133
13.	2.12	120
14.	2.12	120
15.	2.07	115
16.	1.94	103
17.	1.92	101
18.	1.92	101
19.	1.92	101
20.	1.90	99
21.	1.89	98
22.	1.85	95
23.	1.84	94
24.	1.82	92
25.	1.81	91
26.	1.79	89
27.	1.78	89
28.	1.78	89
29.	1.76	87
30.	1.72	84
31.	1.70	82
32.	1.70	82
33.	1.69	81

Order	Water level (m)	Discharge (m3/sec)
34.	1.60	74
35.	1.60	74
36.	1.58	72
37.	1.56	71
38.	1.56	71
39.	1.56	71
40.	1.56	71
41.	1.55	70
42.	1.54	69
43.	1.53	68
44.	1.52	68

Station : Turungong
Period : 1973 - 1981
Discharge: Not less than 68 m^3/sec

Table 1.4.2 24 Hours Maximum Rainfall

(Unit : mm/day)

Year	Station			
	Palattae	Order	Tombolo	Order
1920	152	8	70	19
1921	290	1	34	22
1922	165	6	54	21
1923	120	13	160	3
1924	120	14	68	20
1925	58	27	152	4
1926	65	25	124	10
1927	59	26	102	11
1928	140	10	99	12
1929	150	9	169	2
1930	83	21	78	17
1931	206	4	82	16
1932	100	15	78	18
1933	281	2	87	14
1934	92	19	98	13
1935	100	16	129	9
1936	213	3	145	6
1937	75	23	86	15
1938	164	7	134	8
1939	92	20	195	1
1940	166	5	138	7
1941	99	18	151	5
1974	67	24	-	
1975	82	22	-	
1976	100	17	-	
1977	135	11	-	
1978	124	12	-	

Table 1.5.1 Water Quality Analysis (1/2)

Parameter		Unit	Sanrego River 1975 Jun.5 /1	1978 Oct.24 /2	1979 Mar.7 /2
Temperature		°C	24.5	-	-
Colour		Unit PtCo	12.5	2.5	7.5
Turbidity		mg/l.SiO2	78.0	-	-
Dissolved Solid		mg/l	202.0	264	115
Suspended Solid		mg/l	24.16	412	39
Total Solid		mg/l	226.16	676	154
Electrical Conductance		u mho/cm	308.0	363	185
pH		-	7.20	8.2	7.6
Organic Solid		mg/l.KMnO4	4.74	6.4	5.6
Hardness		°d	9.34	8.5	3.8
S.A.R.		-	0.19	0.15	0.20
% Na		%	6.59	5.4	10
Nitrogen Total		mg/l	-	1.3	0.59
+ Ion (K)					
Potassium	(K)	mg/l	2.4	2.3	1.4
Sodium	(Na)	mg/l	5.5	4.2	3.9
Calcium	(Ca)	mg/l	58.34	48	21
Magnesium	(Mg)	mg/l	5.11	7.8	4.4
Iron	(Fe)	mg/l	2.20	*	*
Manganese	(Mn)	mg/l	*	*	*
Ammonium	(NH_4)	mg/l	*	*	0.10
- Ion (A)					
Chloride	(Cl)	mg/l	7.48	7.1	6.0
Sulphate	(SO_4)	mg/l	3.4	6.8	4.6
Carbonate	(CO_3)	mg/l	-	-	-
Bicarbonate	(HCO_3)	mg/l	169.8	177	78
Nitrate	(NO_3)	mg/l	0.070	4.4	0.28
Nitrite	(NO_2)	mg/l	0.015	0.02	*
Phosphate	(PO_4)	mg/l	*	0.16	0.24
Carbondioxide	(CO_2)	mg/l	5.28	3.9	8.8
Silicate	(SiO_2)	mg/l	2.5	39	32
Cadmium	(Cd)	mg/l	-	*	*
Chromium	(Cr)	mg/l	-	*	*
Lead	(Pb)	mg/l	-	*	-
Zinc	(Zn)	mg/l	-	0.11	*
Copper	(Cu)	mg/l	-	*	*
Fluorine	(F)	mg/l	-	*	0.10
Boron	(B)	mg/l	*	-	0.10
D.O.		mg/l	12.16	-	-
B.O.D.		mg/l	4.99	-	-
C.O.D.		mg/l	8.62	-	-

Remarks : - ; no analysis   * ; neglibible small

/1; Source : Hasil Analisa Kwalitas Air, No. Lab.: H.K. 75/128.

/2; Source : Laporan Hasil Analisa Kwalitas Air Sungai di Sulawesi Selatan, 1979 May, DPMA.

Table 1.5.1 Water Quality Analysis (2/2)

(Sampled in 1982 by JICA team)

Year : 1982

Parameter	Unit	Sanrego River Weir Site Aug.4	Sanrego River Weir Site Aug.11	Sanrego River Weir Site Sep.2	Parota River Aug.5	Parota River Aug.11	Parota River Sep.2	Biru River Toli-Toli River/1 Aug.5	Biru River Toli-Toli River/1 Aug.11	Biru River Intake/2 Sep.2	Baruttung River/3 Aug.4	Baruttung River/3 Aug.10	Baruttung River/3 Sep.1	Palattae River (Walenae River) Aug.4	Palattae River (Walenae River) Aug.10	Palattae River (Walenae River) Sep.1
Suspended Sediment	mg/l	10.80	8.40	12.0	9.80	21.60	41.4	12.80	13.8	10.8	303.20	42.6	19.8	120.20	38.40	20.4
pH	-	7.5	7.4	7.5	7.5	7.4	7.4	7.3	7.4	7.42	7.3	7.1	7.42	7.5	7.1	7.4
Organic Solid ($KMnO_4$)	mg/l	0.53	0.64	27.49	1.05	29.83	27.41	1.17	30.13	27.23	0.70	31.36	27.66	0.94	31.88	28.02
Hardness	°d	8.1	8.0	11.0	7.60	8.3	8.75	5.8	6.1	6.8	1.9	3.7	8.5	5.5	3.9	7.1
S.A.R.	-	0.05	0.07	0.04	0.09	0.16	0.23	0.11	0.16	0.18	0.08	0.12	0.21	0.12	0.13	0.16
% Natrium		1.3	2.0	1.4	2.5	4.7	7.8	3.7	5.6	7.1	4.9	6.2	7.1	4.2	4.8	5.8
Nitrogen Total (N)	mg/l	8.94	2.98	6.70	6.95	1.99	3.97	4.67	1.99	9.44	3.97	4.67	6.21	12.91	4.67	7.95
- Ion (K)																
Potassium (K)	mg/l	1.02	0.81	0.30	1.41	1.44	3.0	1.62	1.77	0.60	1.17	1.23	1.20	2.58	1.95	0.60
Sodium (Na)	mg/l	1.76	2.76	1.4	3.48	5.80	6.8	3.36	4.8	4.80	1.36	2.56	6.8	3.44	3.84	4.60
Calcium (Ca)	mg/l	60.80	60.80	72.8	58.80	61.20	44.0	41.38	43.17	37.5	13.60	27.40	36.4	31.28	27.20	35.02
Magnesium (Mg)	mg/l	32.51	34.22	8.0	34.47	24.30	14.8	20.80	16.09	10.1	5.40	3.40	24.4	22.15	28.83	18.0
Iron (Fe)	mg/l	Negative	Negative	Negative	Negative	Negative	0.01	Negative	Negative	0.01	0.75	Negative	Negative	Negative	0.06	0.01
- Ion (A)																
Chloride (C.)	mg/l	10.0	5.0	5.0	2.5	4.5	5.0	5.0	5.0	5.0	9.0	5.5	10.0	7.50	8.0	5.0
Sulphate (SO_4)	mg/l	1.81	3.77	6.09	2.31	1.81	4.12	1.90	31.27	3.46	1.85	4.12	9.38	6.91	4.61	7.41
Carbonate (CO_3)	mg/l	30.01	29.82	10.67	30.84	41.12	25.90	21.58	24.68	17.06	19.53	30.84	27.93	30.06	41.12	11.81
Bicarbonate (HCO_3)	mg/l	10.30	1.02	118.52	0	0	124.70	4.12	5.65	117.04	0	0	132.60	0	0	150.33
Phosphate (PO_4)	mg/l	0.09	0.05	0.98	0.13	0.09	1.30	0.09	0.05	1.95	0.26	0.13	1.63	0.18	0.13	3.26
Silicate (SiO_2)	mg/l	5.1	4.2	6.4	6.40	5.30	6.4	4.2	3.80	6.4	2.6	3.40	6.4	10.60	5.3	6.4
Cadmium (Cd)	mg/l	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
Boron (B)	mg/l	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative

Remark : /1 : downstream of Biru River

/2 : existing weir of Maradda Irrigation System

/3 : downstream of Macinaga River

Table 1.5.2 Suspended Sediment of Sanrego River

Location	Date	Water Volume (1) (ml)	Suspended Sediment (2) (mg)	(2)/(1) (mg/l)
Sina	1979 Feb.24	369	7.5	20
Sanrego	1979 Mar. 9	362	12.7	35
Sina	1979 Mar.23	369	26.8	73
Hulu	1979 May 11	393	4.2	11
Siwa	1979 May 11	380	6.2	16
Turungeng	1979 Jun.10	492	702.8	1428
Sina	1979 Jun.10	462	328.3	711
Turungeng	1979 Jul.23	369	8.9	24
Sina	1979 Jul.23	272	36.3	134
Sina	1979 Aug.30	374	10.8	29
Turungeng	1979 Aug.30	377	10.7	28
Turungeng	1979 Sep.12	382	2.6	7
Sina	1979 Sep.12	377	1.8	5
Turungeng	1979 Oct.27	380	9.4	25
Sina	1979 Oct.27	410	8.8	21
Sina	1980 Feb.19	367	14.8	40
Turungeng	1980 Feb.19	338	15.2	45
Turungeng	1980 Mar.25	474	7.0	14
Sina	1980 Mar.25	459	7.2	16
Turungeng	1980 Apr.30	363	20.0	55
Sina	1980 Apr.30	370	120.5	326
Turungeng	1980 Jun. 1	343	16.5	48
Sina	1980 Jun. 1	323	14	43
Turungeng	1980 Jun.25	336	12.1	36
Sina	1980 Jun.25	354	8.8	25
Turungeng	1980 Sep.10	363	6.6	18
Sina	1980 Sep.10	367	7.5	20

Source : Hydrochemical Laboratory, Institute of Hydraulic Engineering, Bandung.

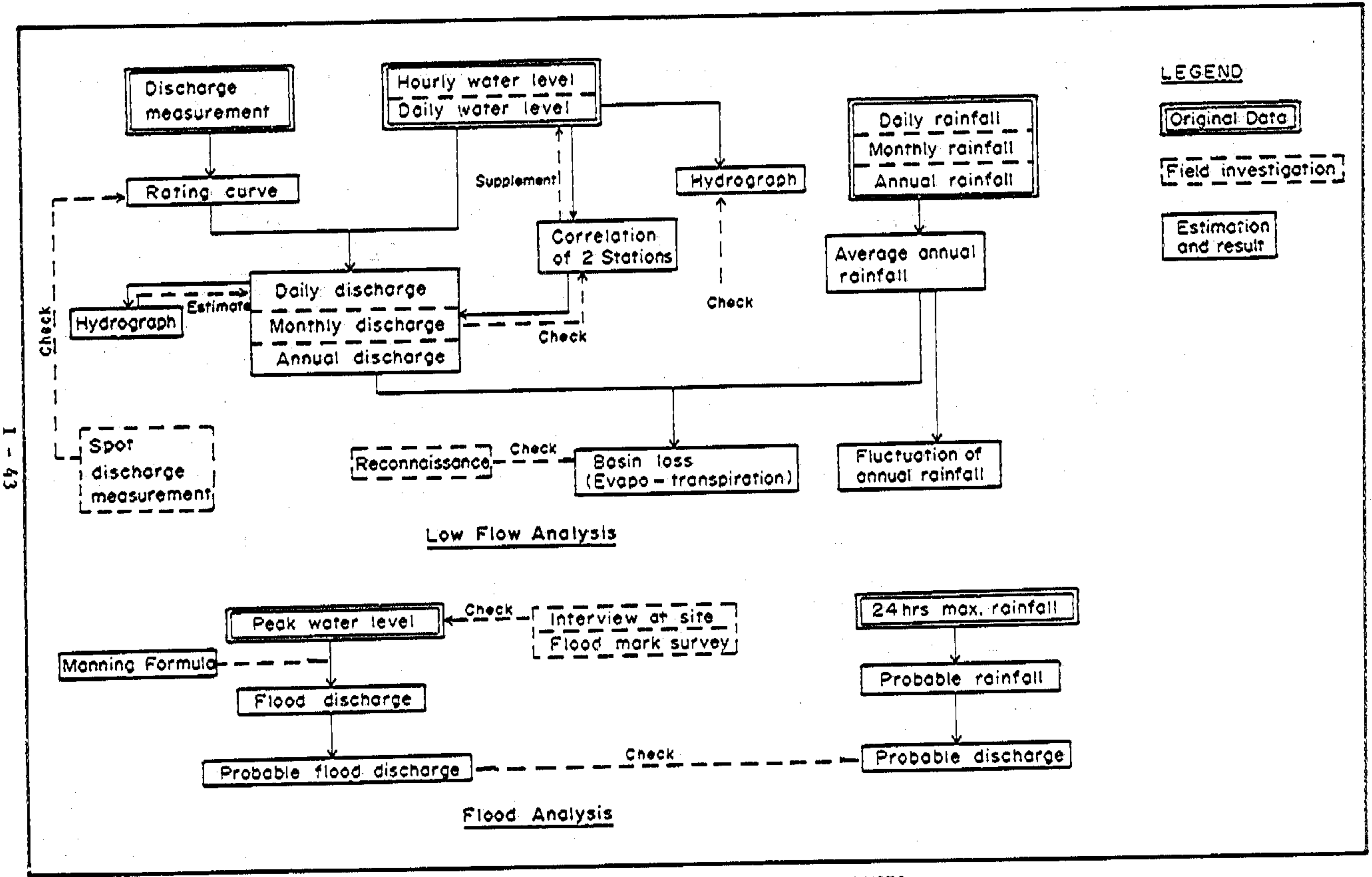


Fig. I.1.1 FLOW CHART OF RUNOFF ANALYSIS

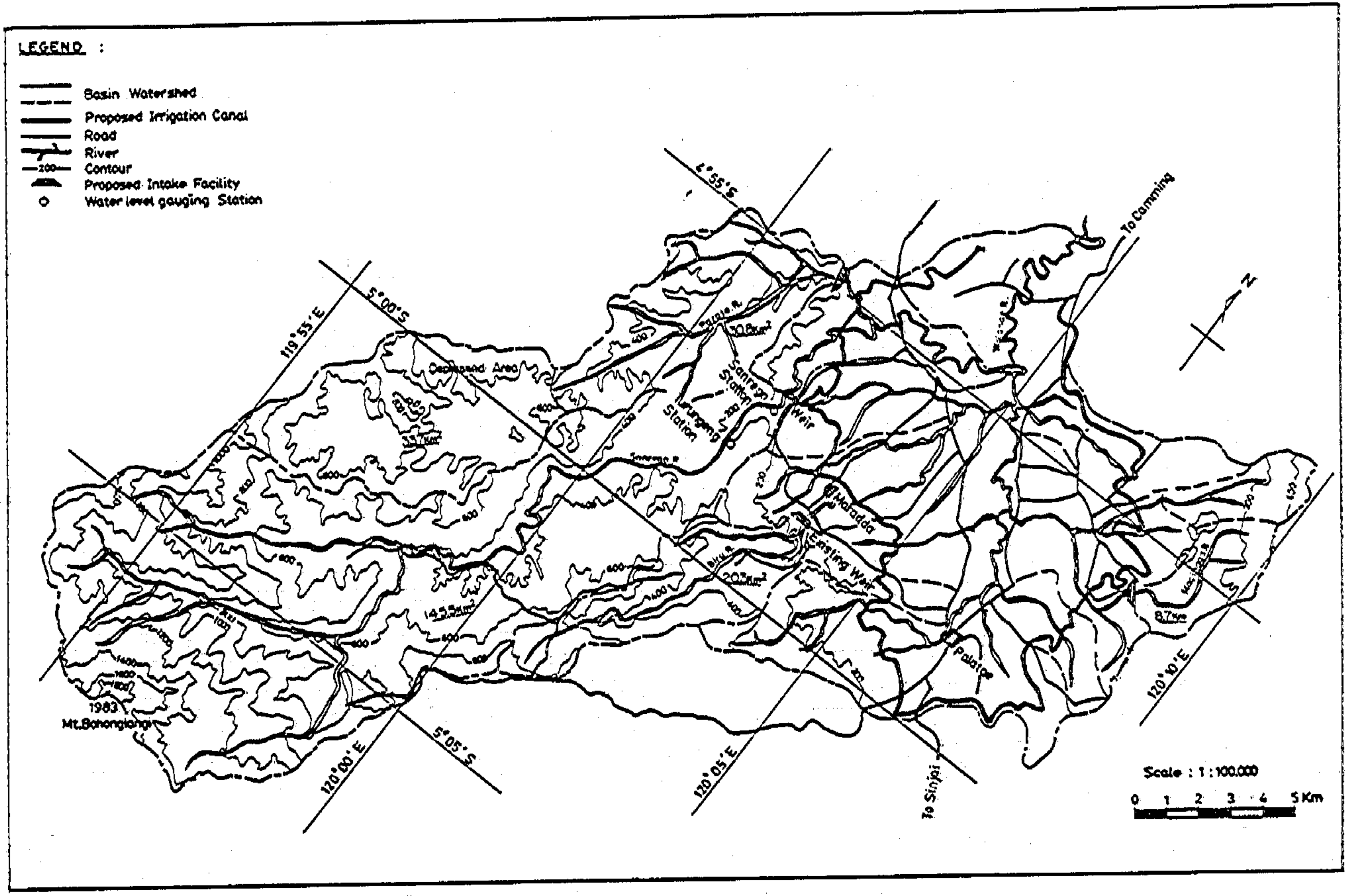


Fig. I.1.2 WATERSHED OF SANREGO RIVER AND TRIBUTARIES

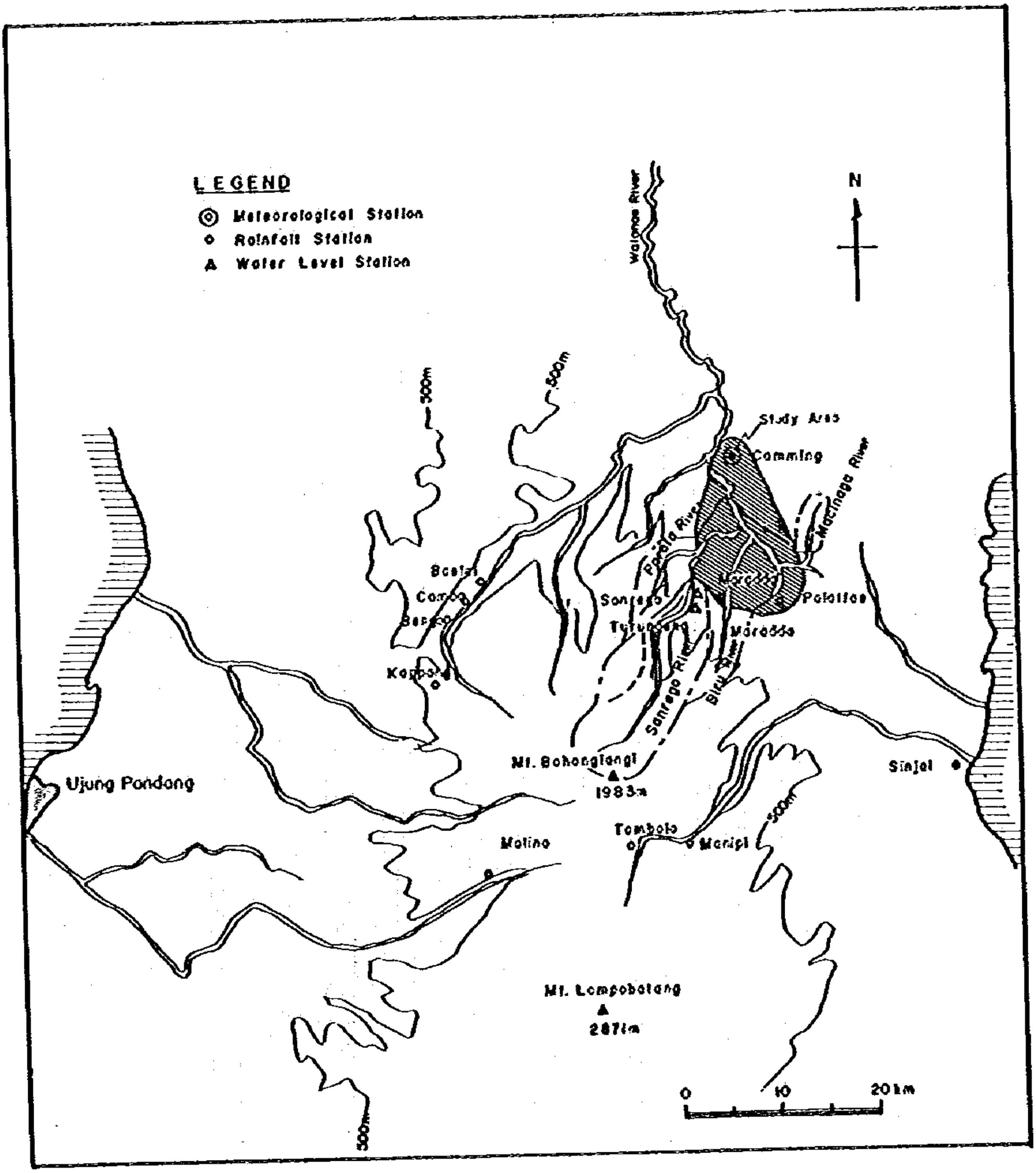
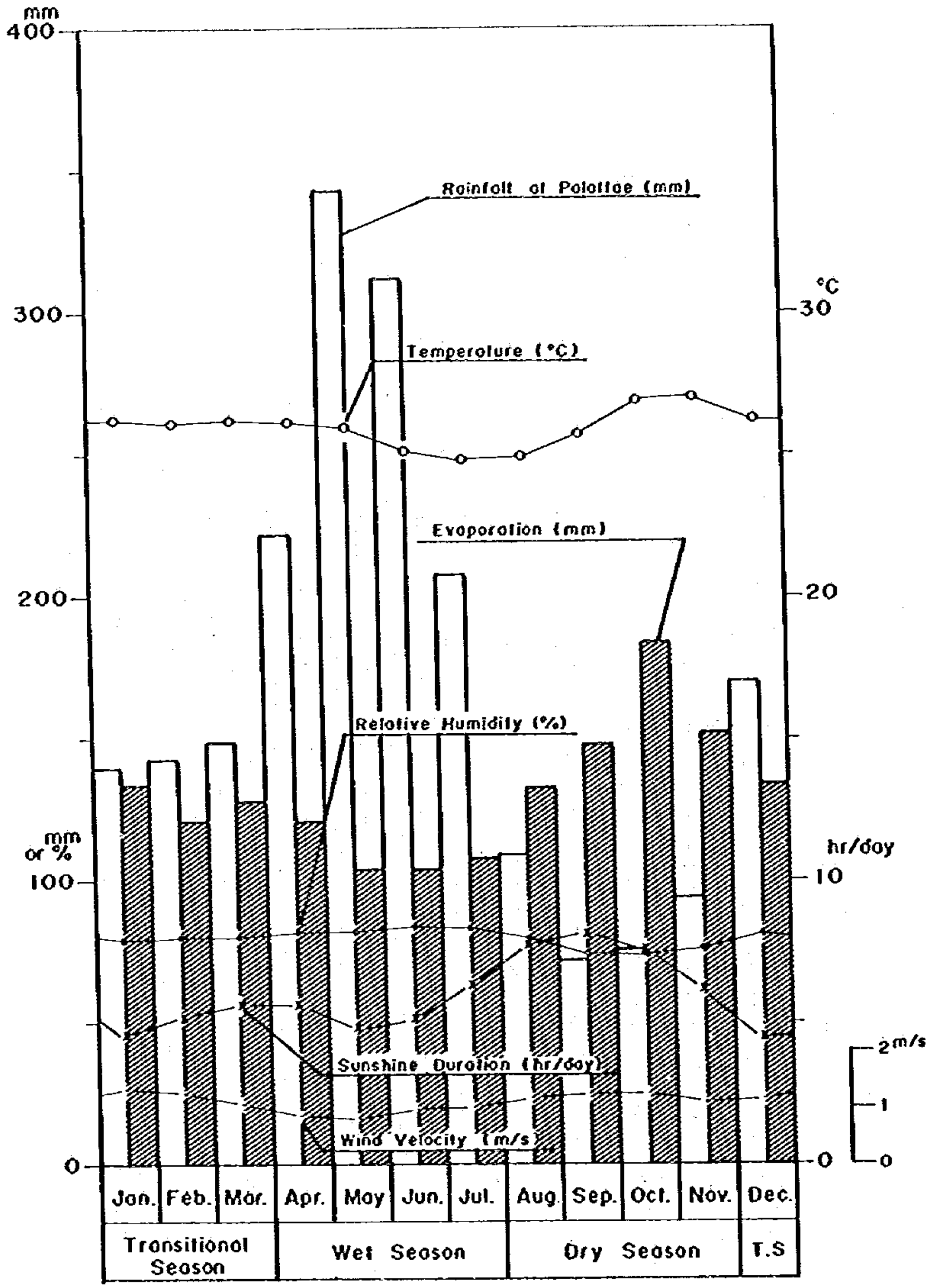
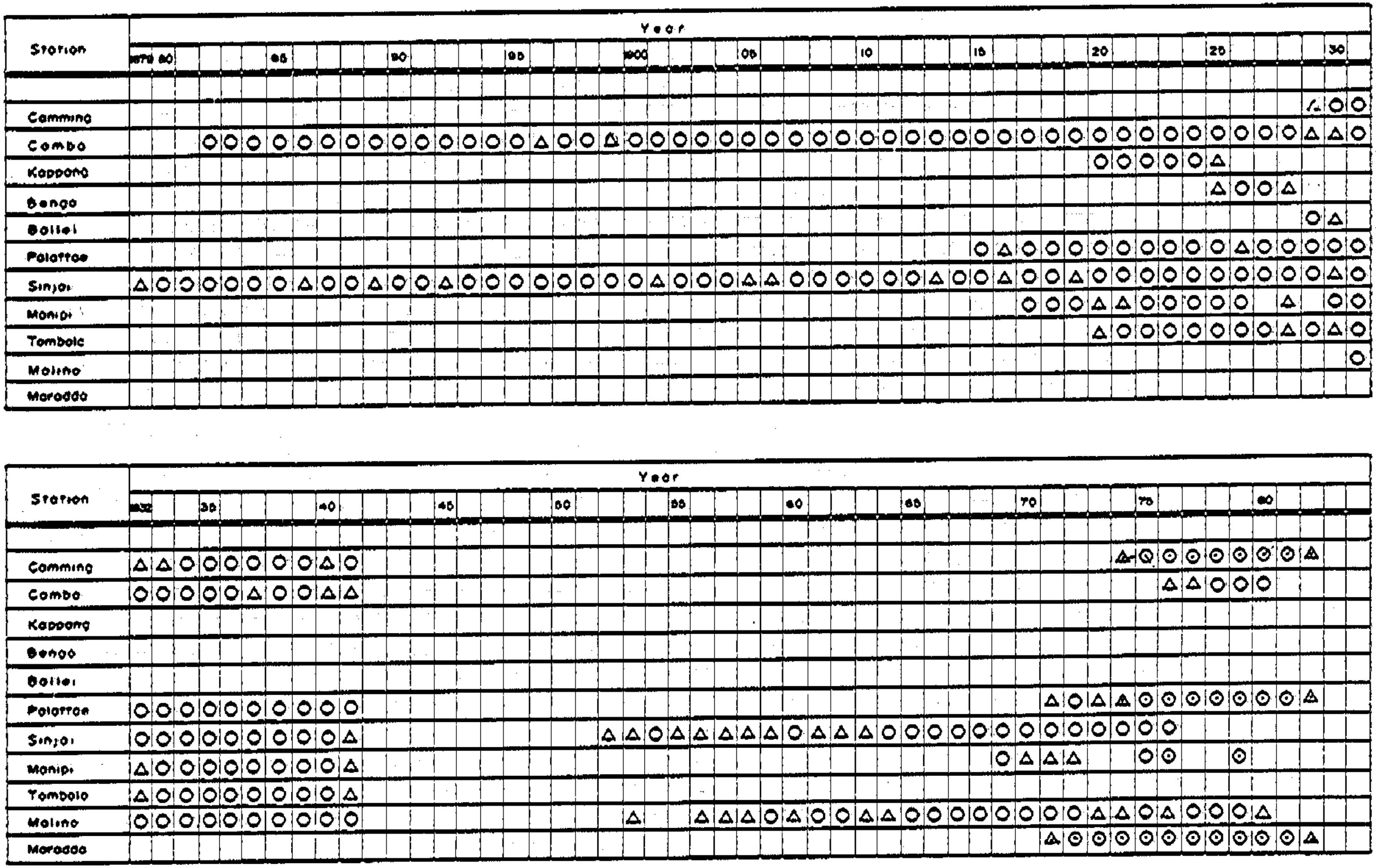


Fig. 1.2.1 LOCATION OF STATION



Station : Camming (only rainfall : Polotloe)

Fig. I.2.2 METEOROLOGICAL CHARACTERISTICS



LEGEND : ○ Monthly data , available
△ Monthly data , partially available
⊙ Daily data , available
▲ Daily data , partially available

Fig. I.2.3 COLLECTED RAINFALL DATA

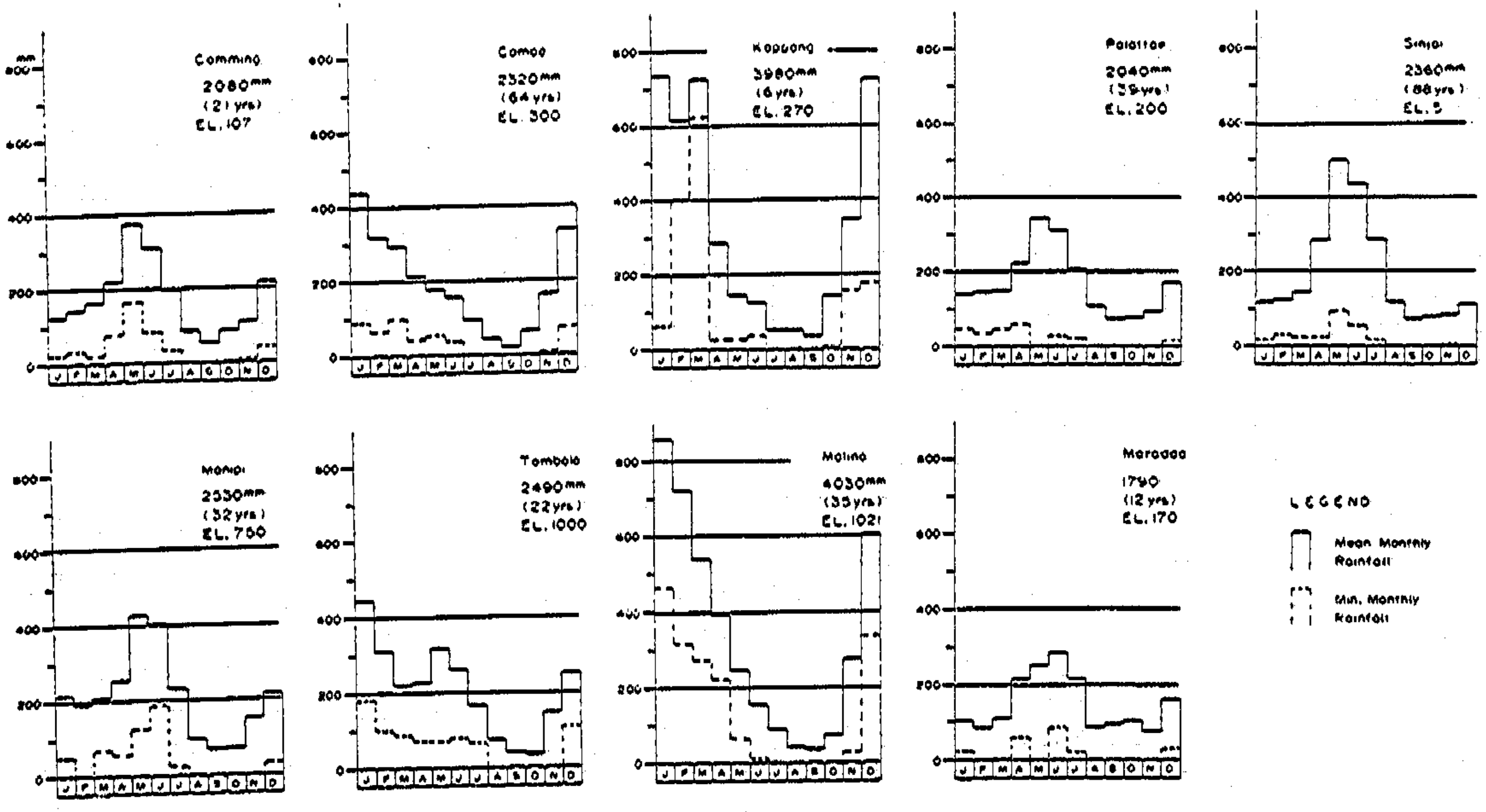


Fig. I.2.4 ANNUAL PATTERN OF MONTHLY RAINFALL

Name	River	Catchment Area (Km^2)	Location		Period of Data
			Latitude (S)	Longitude (E)	
Sanrego	Sanrego	179.0	4° 59'	120° 02'	1978 — 1982
Turungeng	Sanrego	174.3	4° 56'	120° 02'	1973 — 1982

LEGEND

- Data available (solid)
- Data partialy available (hatched)

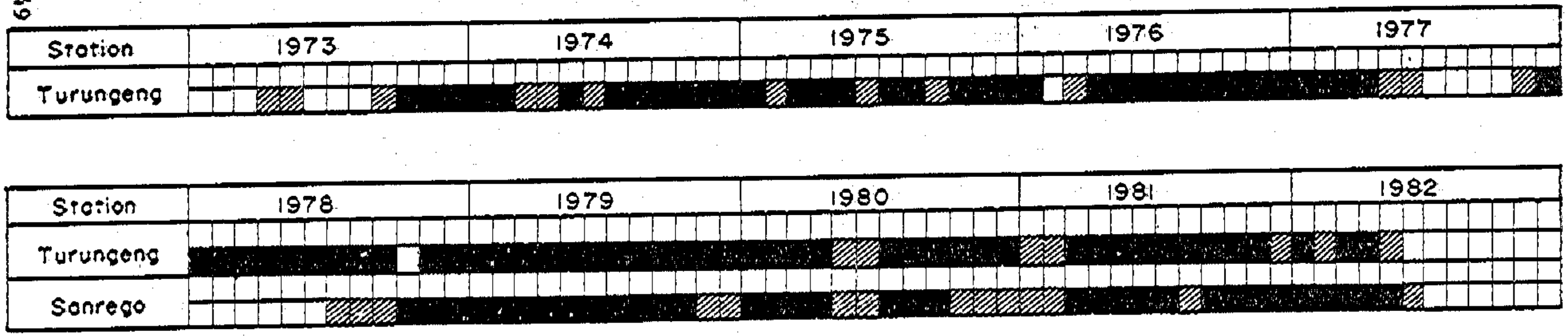


Fig. I.2.5 WATER LEVEL GAUGING STATION AND DATA CONDITION

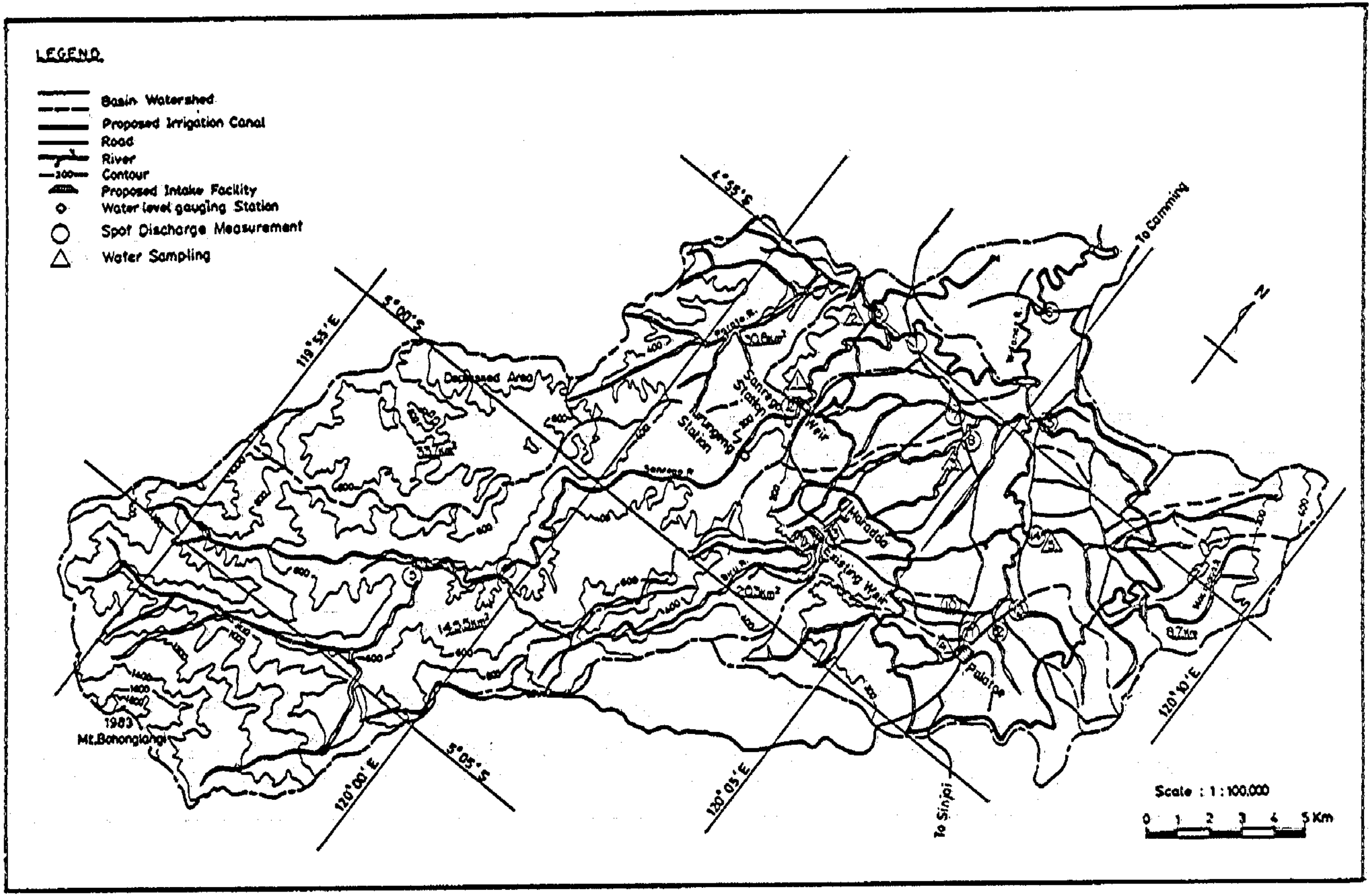


Fig. I.2.6 LOCATION OF SPOT DISCHARGE MEASUREMENT AND WATER SAMPLING

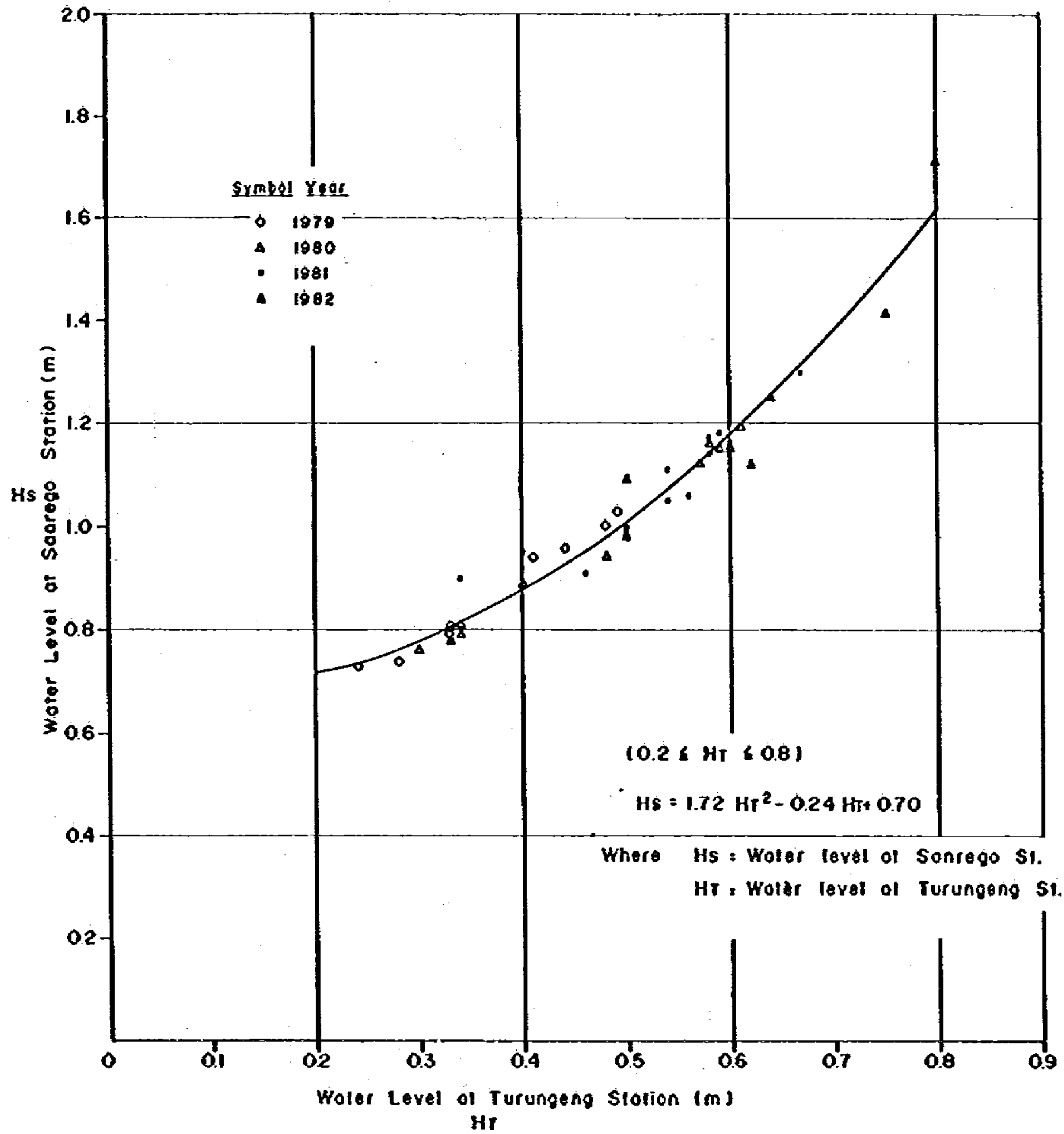


Fig. I.2.7 CORRELATION OF WATER LEVEL BETWEEN TURUNGENG AND SANREGO STATIONS

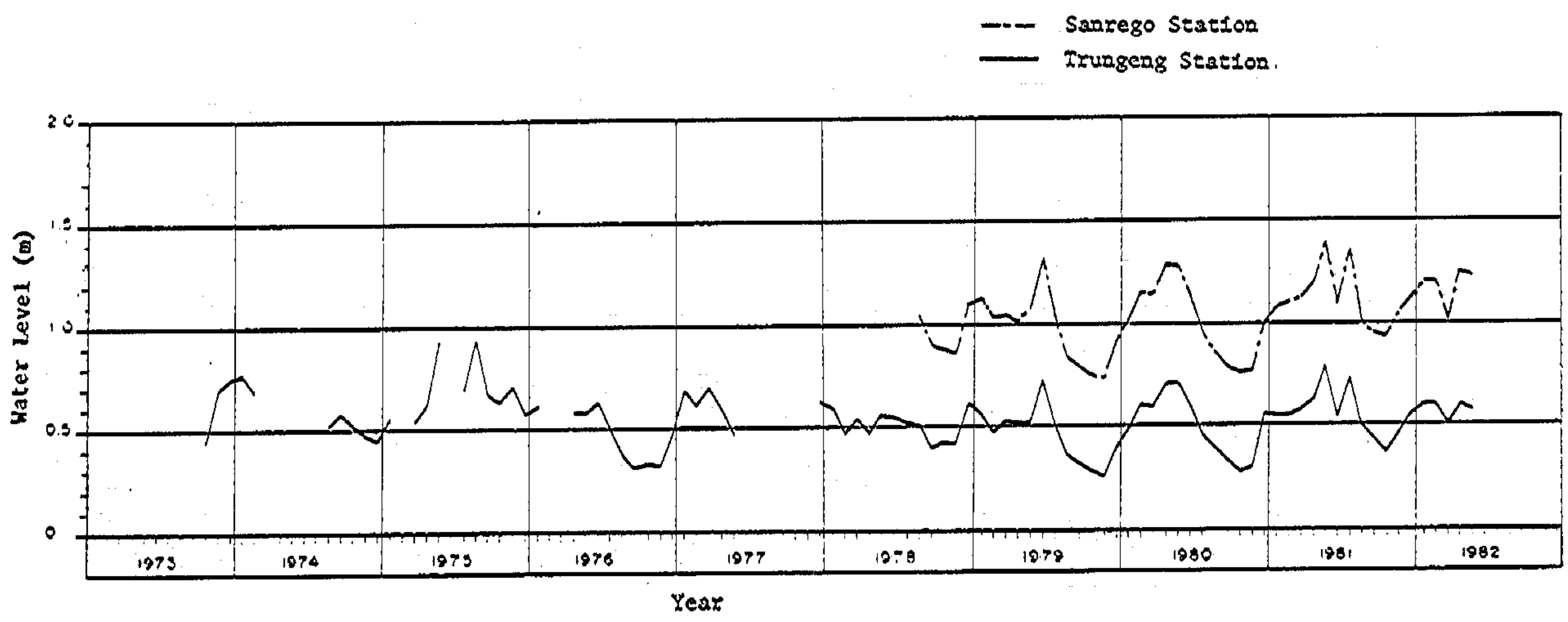


Fig. I.2.8 MONTHLY WATER LEVEL OF SANREGO STATION

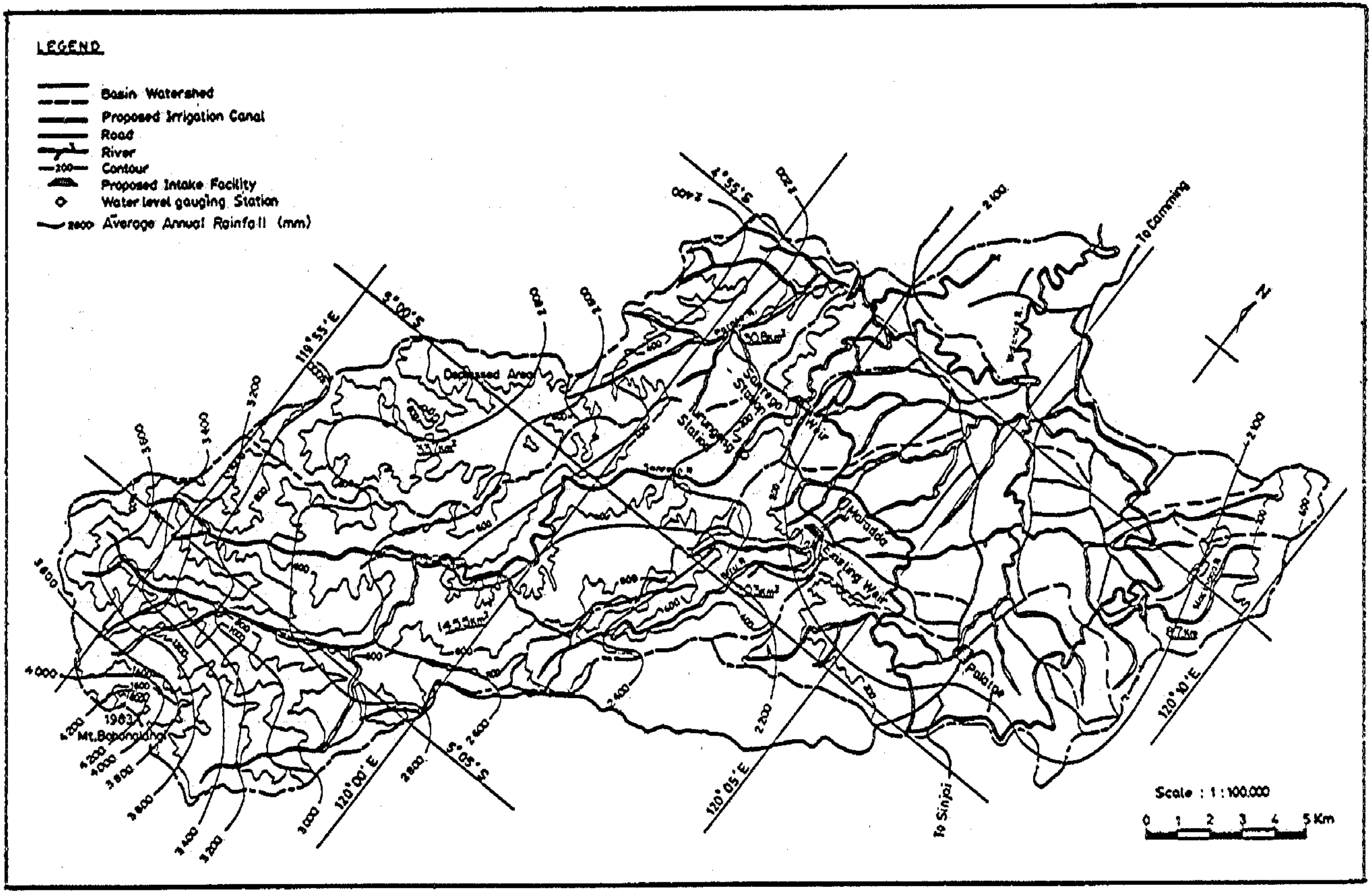


Fig. I.3.1 ISOHYETAL MAP

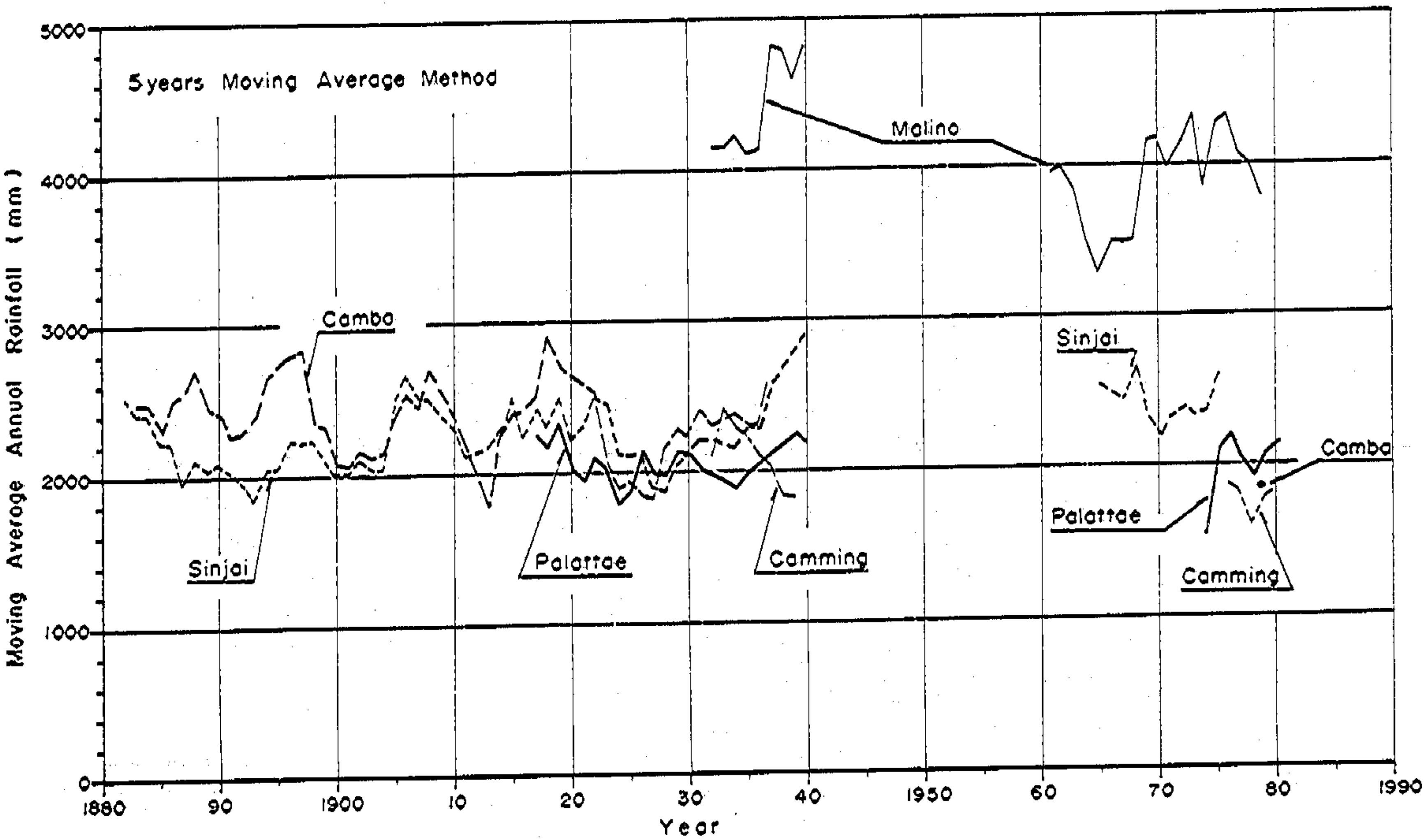


Fig. I.3.2 FLUCTUATION OF ANNUAL RAINFALL

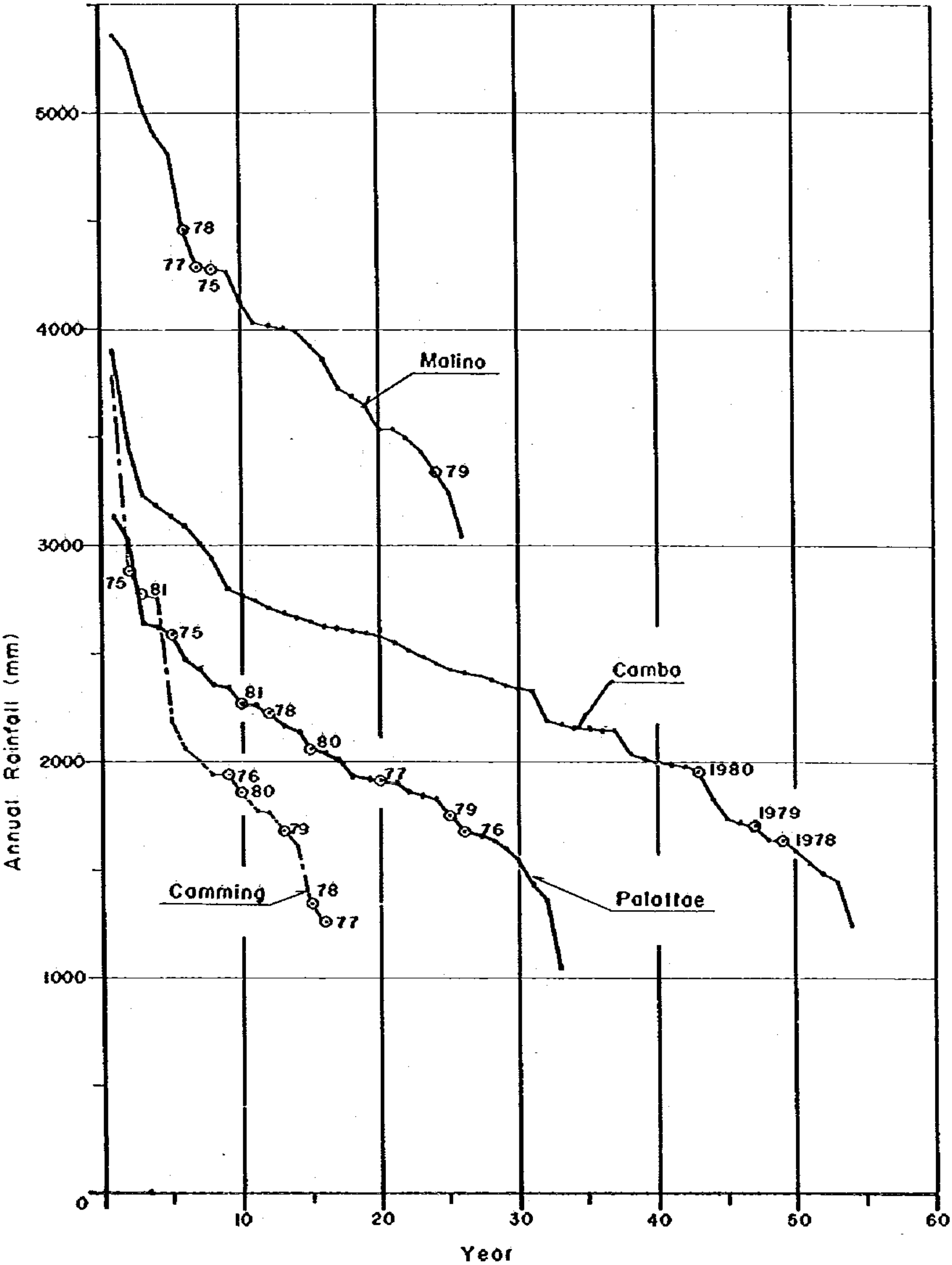
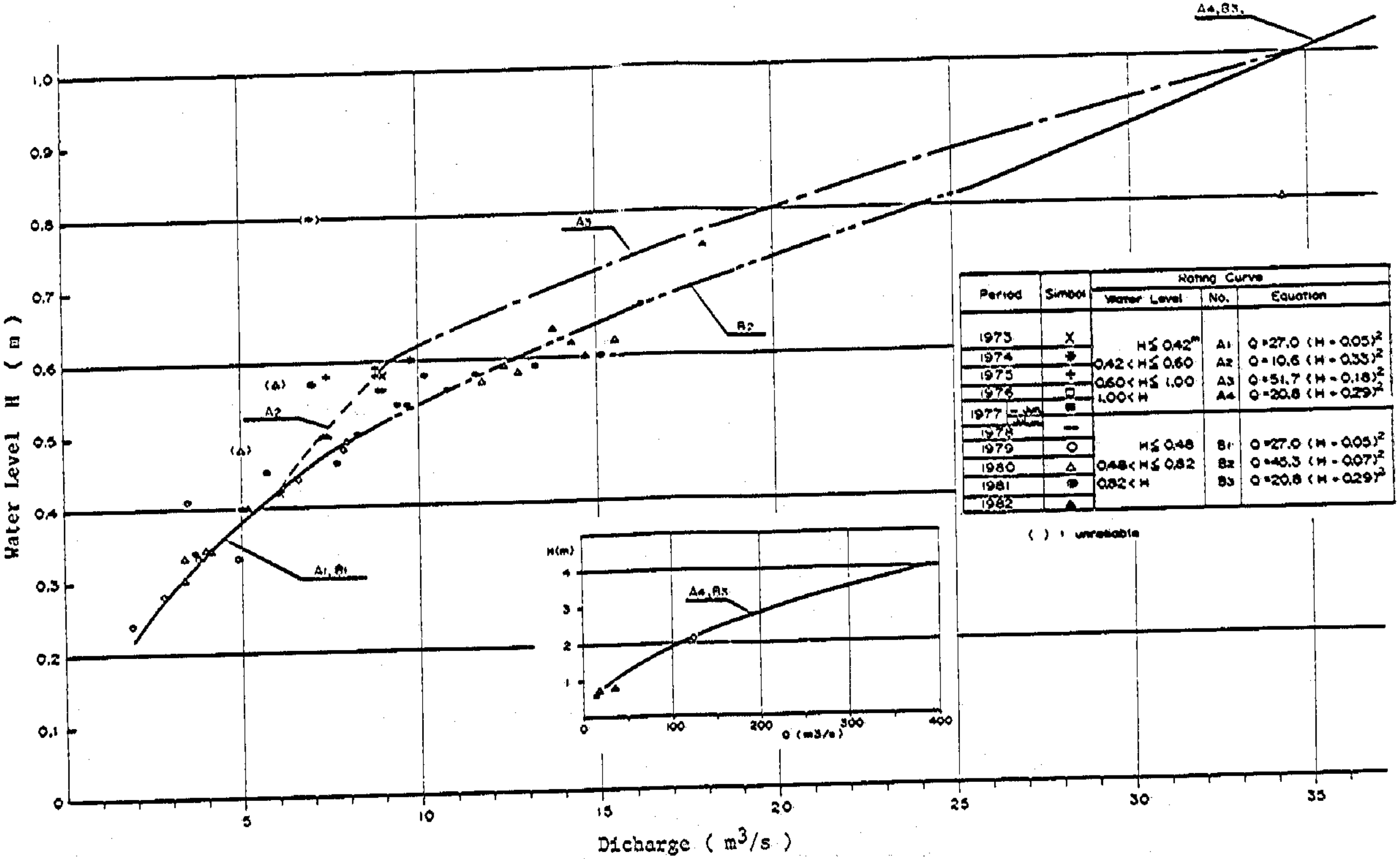


Fig. 1.3.3 ANNUAL RAINFALL IN MAGNITUDE ORDER



Period	Simbol	Rating Curve: Water Level	No.	Equation
1973	X	$H \leq 0.42^m$	A1	$Q = 27.0 (H + 0.05)^2$
1974	✻	$0.42 < H \leq 0.60$	A2	$Q = 10.6 (H + 0.33)^2$
1975	+	$0.60 < H \leq 1.00$	A3	$Q = 51.7 (H - 0.18)^2$
1976	□	$1.00 < H$	A4	$Q = 20.8 (H + 0.29)^2$
1977	■			
1978	—			
1979	○	$H \leq 0.48$	B1	$Q = 27.0 (H + 0.05)^2$
1980	Δ	$0.48 < H \leq 0.82$	B2	$Q = 45.3 (H - 0.07)^2$
1981	◉	$0.82 < H$	B3	$Q = 20.8 (H + 0.29)^2$
1982	▲			

( ) : unreliable

Fig. I.3.4 RATING CURVE AT TURUNGENG STATION

Period		Symbol	Rating Curve: Water Level	No.	Equation
1978		◇	$H \leq 1.05$ m	A1	$Q = 18.6\ (H - 0.35)^2$
1979		○	$1.05 < H \leq 1.25$	A2	$Q = 25.2\ (H - 0.45)^2$
1980		△	$1.25 < H \leq 1.70$	A3	$Q = 40.6\ (H - 0.62)^2$
1981	–May.16	●	$1.70 < H$	A4	$Q = 17.0\ (H - 0.03)^2$
	May.17–	✦	$H \leq 1.25$	B1	$Q = 15.5\ (H - 0.37)^2$
1982		▲	$1.25 < H \leq 1.70$	B2	$Q = 57.0\ (H - 0.79)^2$
			$1.70 < H$	B3	$Q = 17.0\ (H - 0.03)^2$

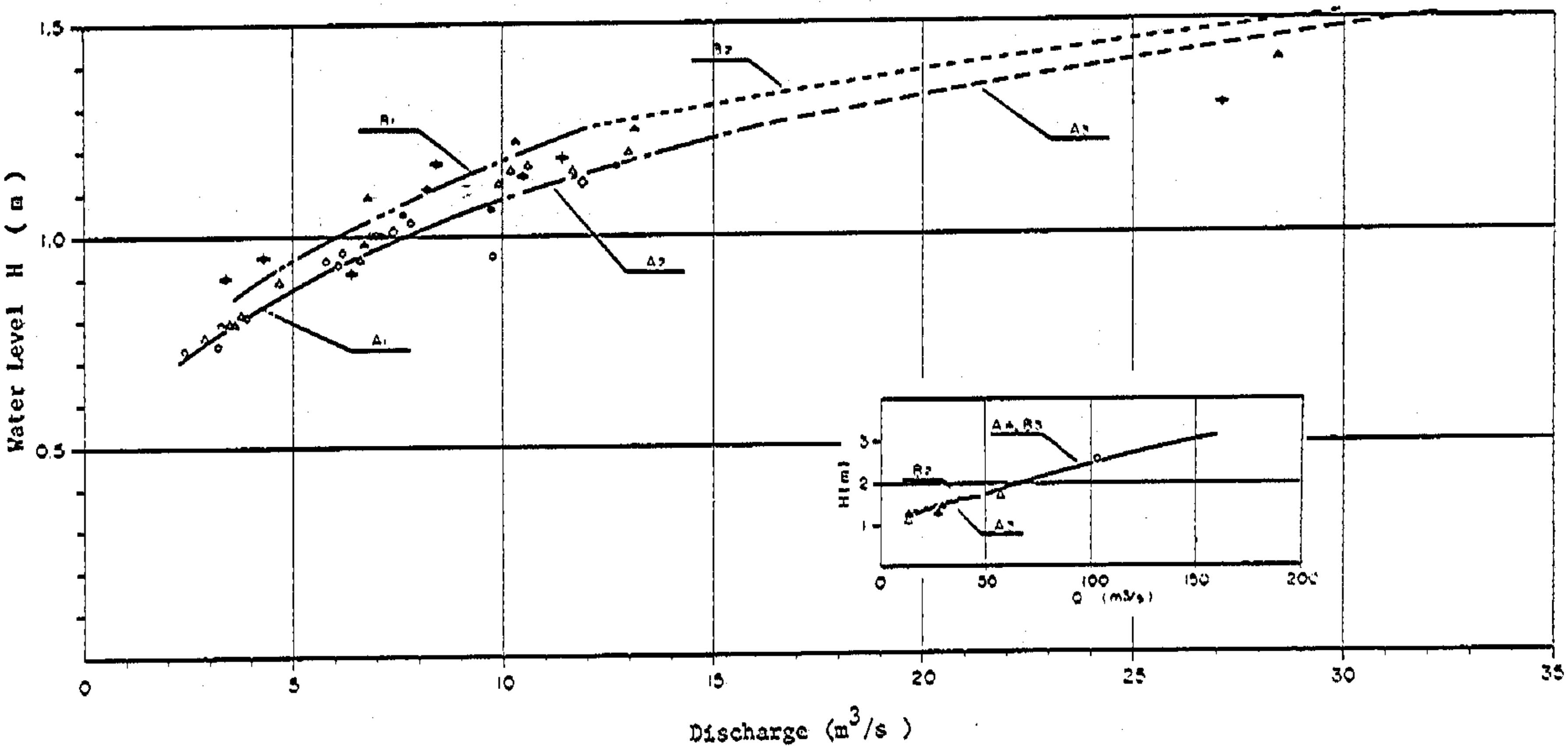


Fig. I.3.5 RATING CURVE AT SANREGO STATION

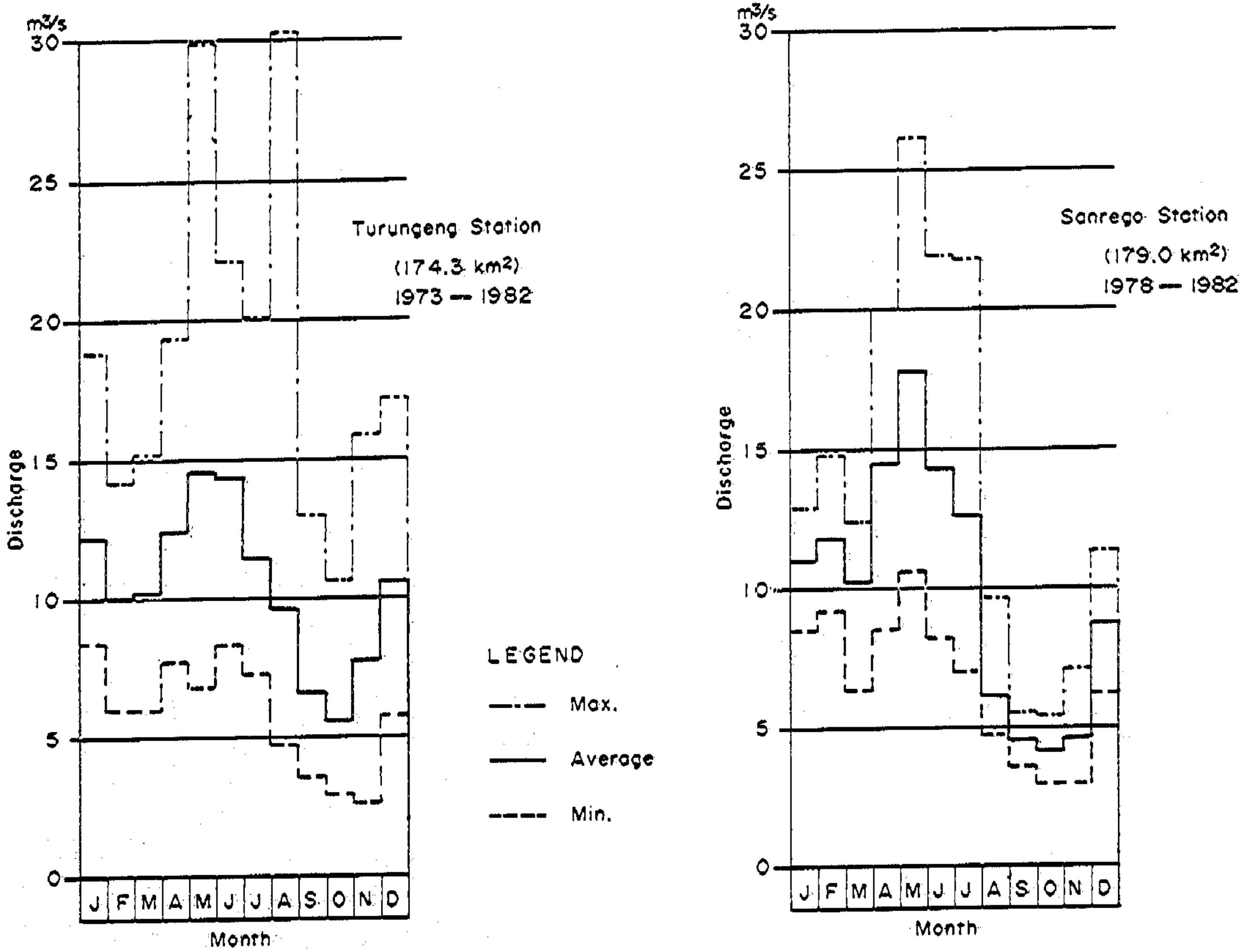


Fig. I.3.6 ANNUAL PATTERN OF MEAN MONTHLY DISCHARGE

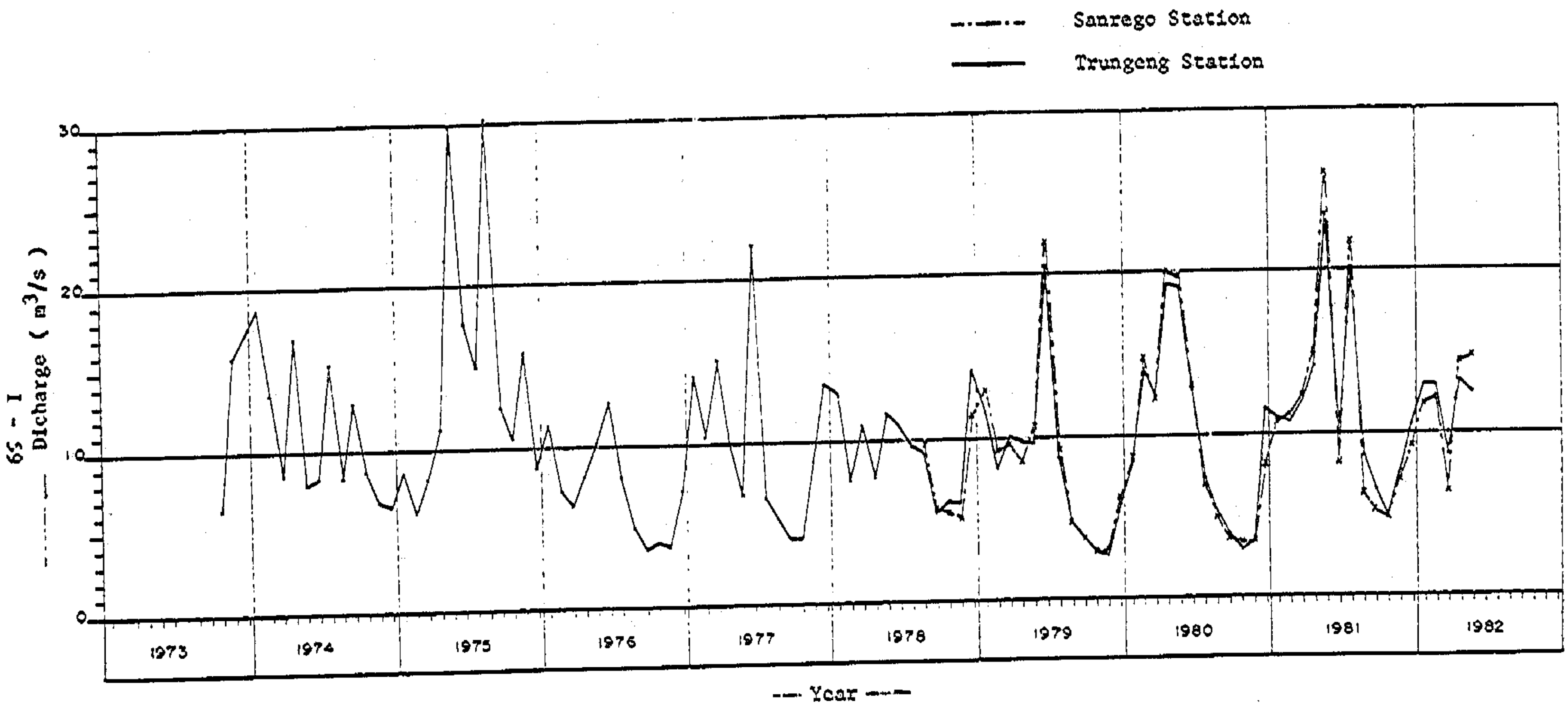


Fig. I.3.7 MONTHLY DISCHARGE OF SANREGO RIVER

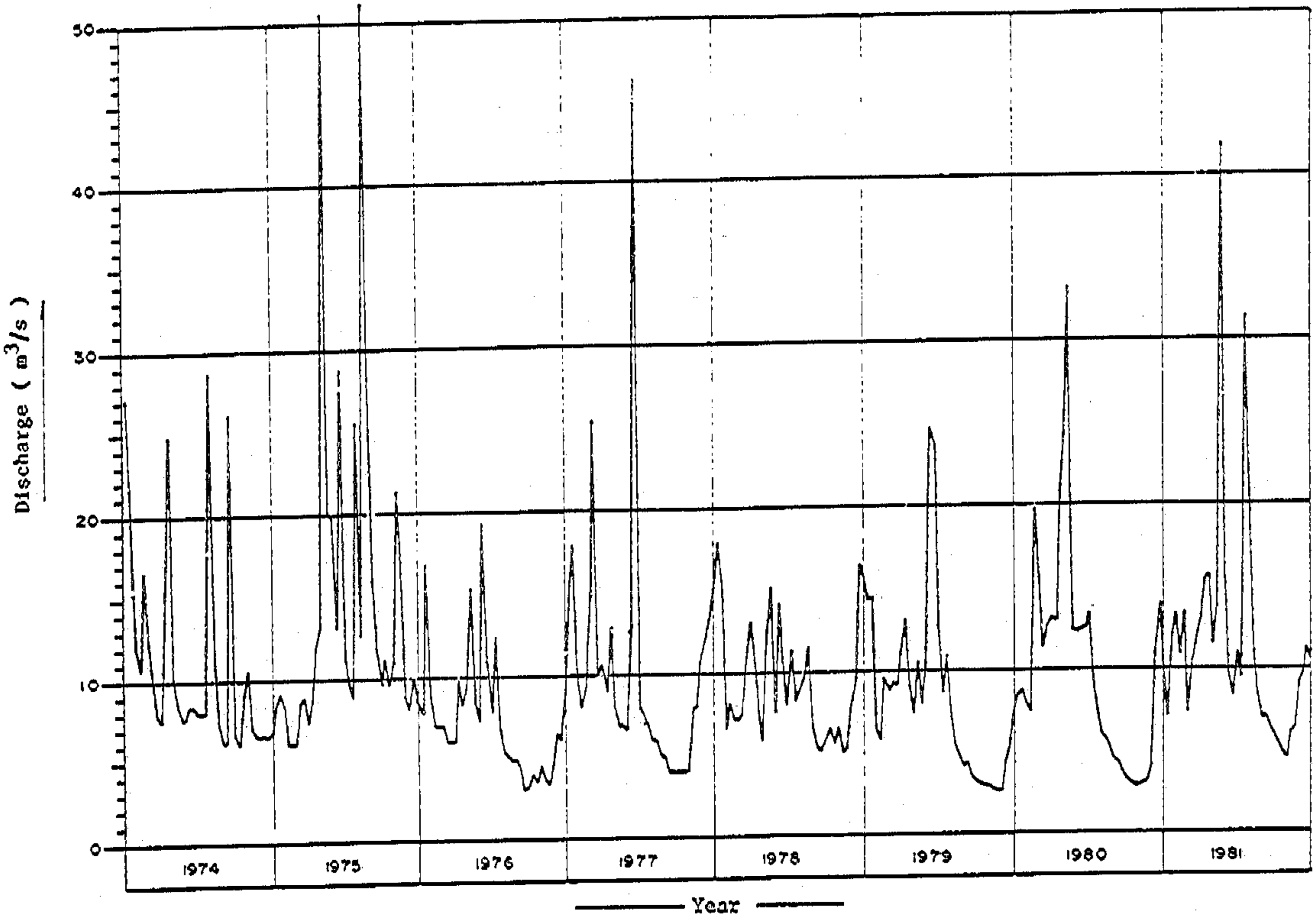
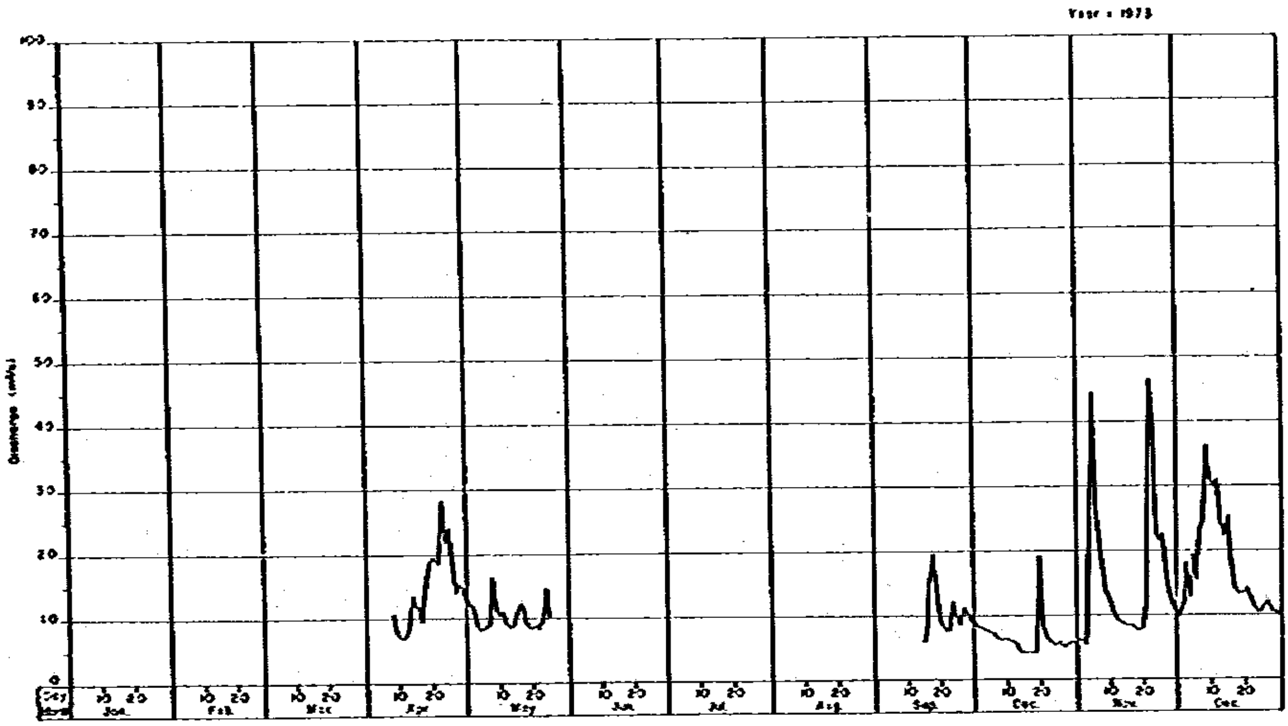


Fig. I.3.8 10-DAY AVERAGE DISCHARGE OF SANREGO RIVER



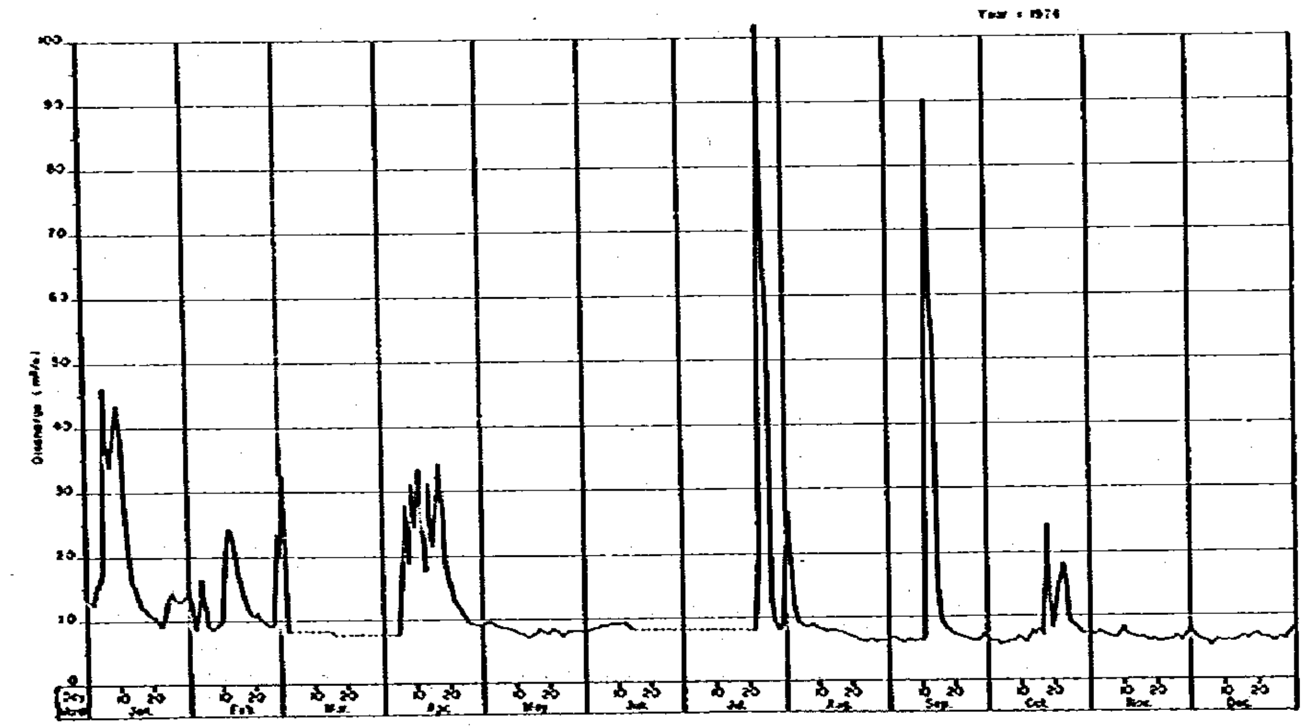
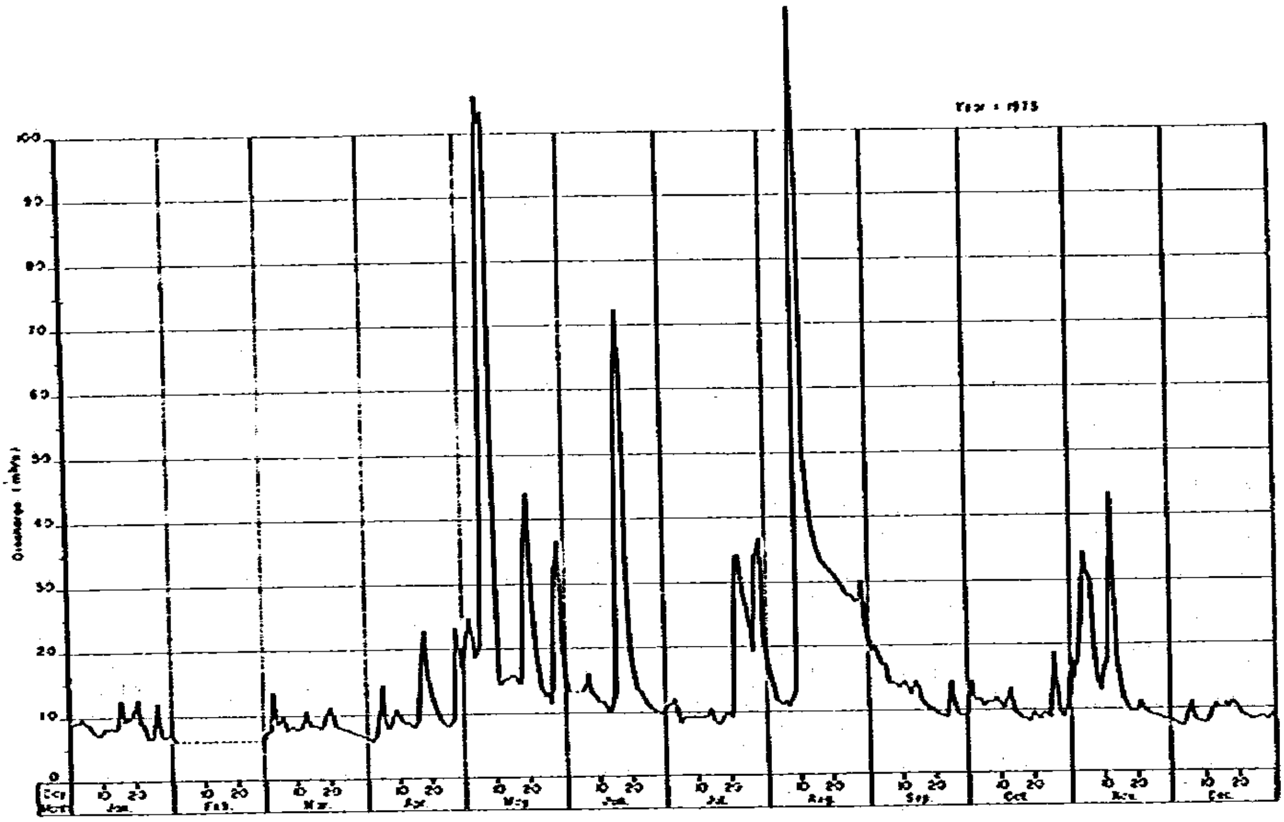


Fig. I.3.9 DAILY DISCHARGE AT TURUNGENG STATION (1/5)



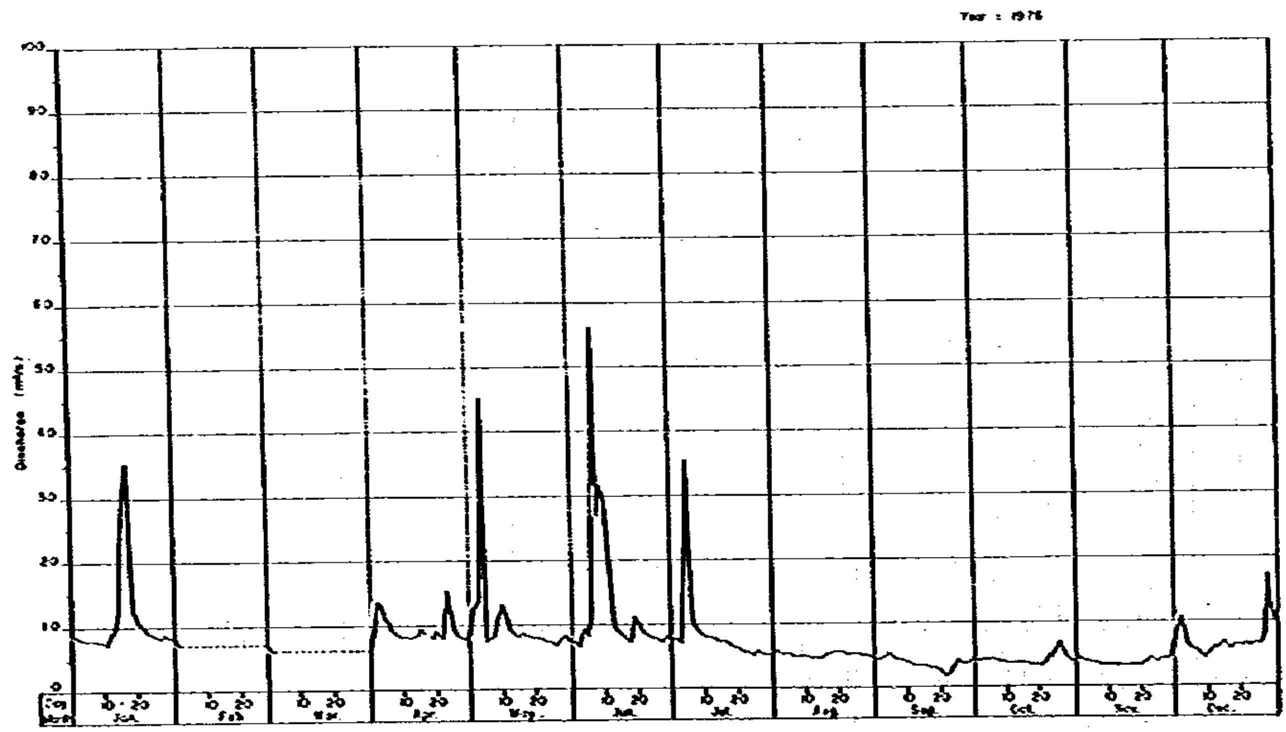
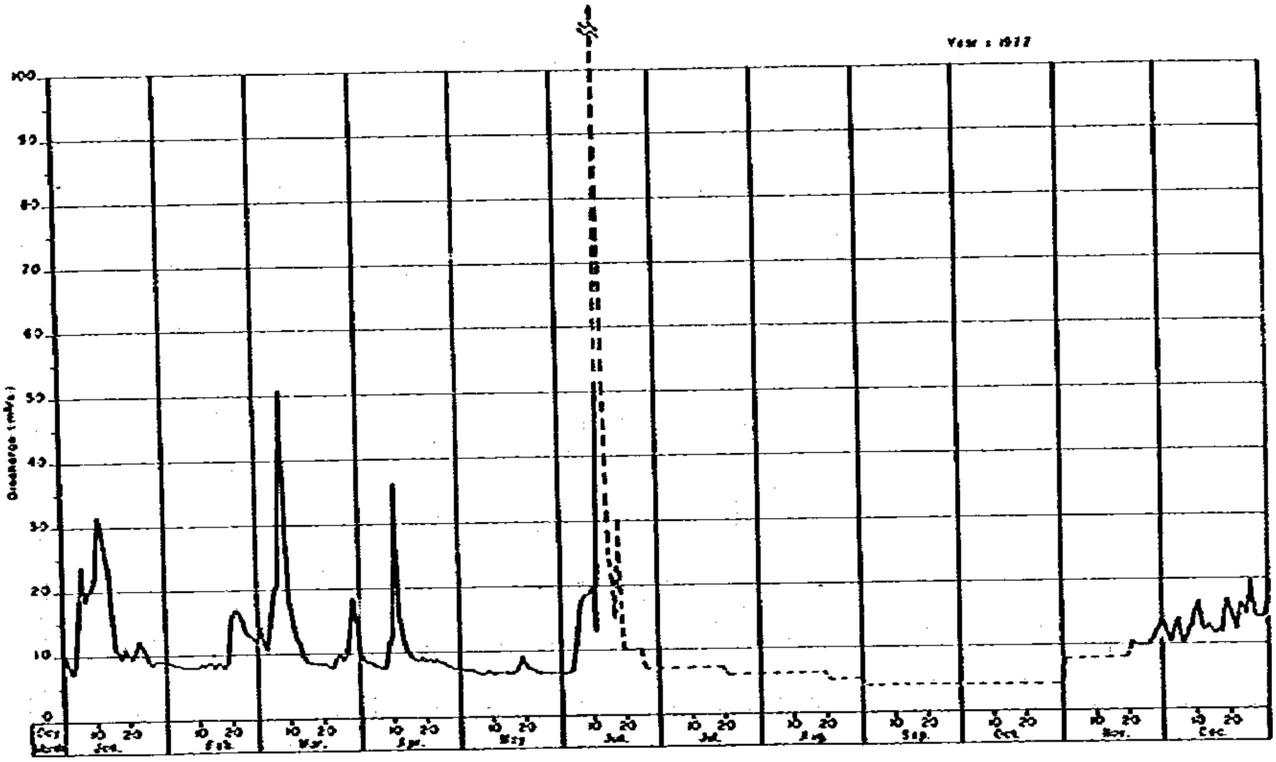


Fig. I.3.9 DAILY DISCHARGE AT TURUNGENG STATION (2/5)



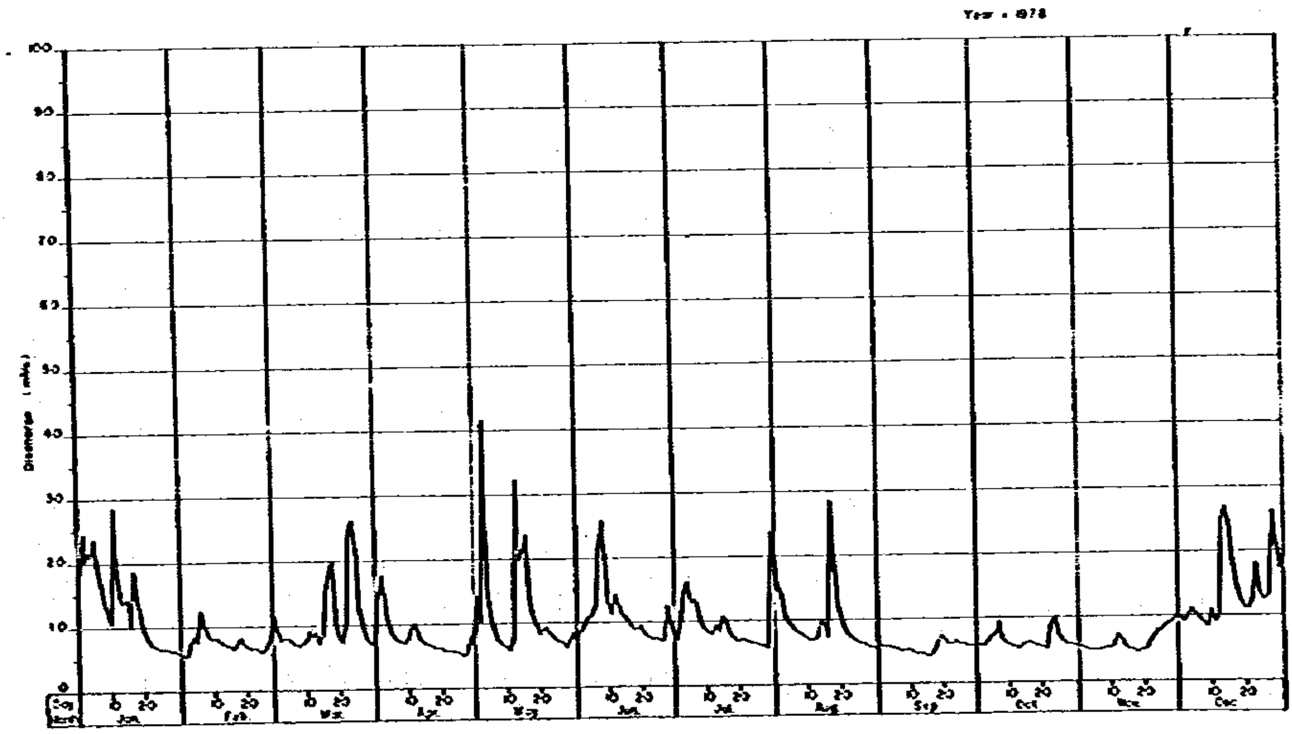
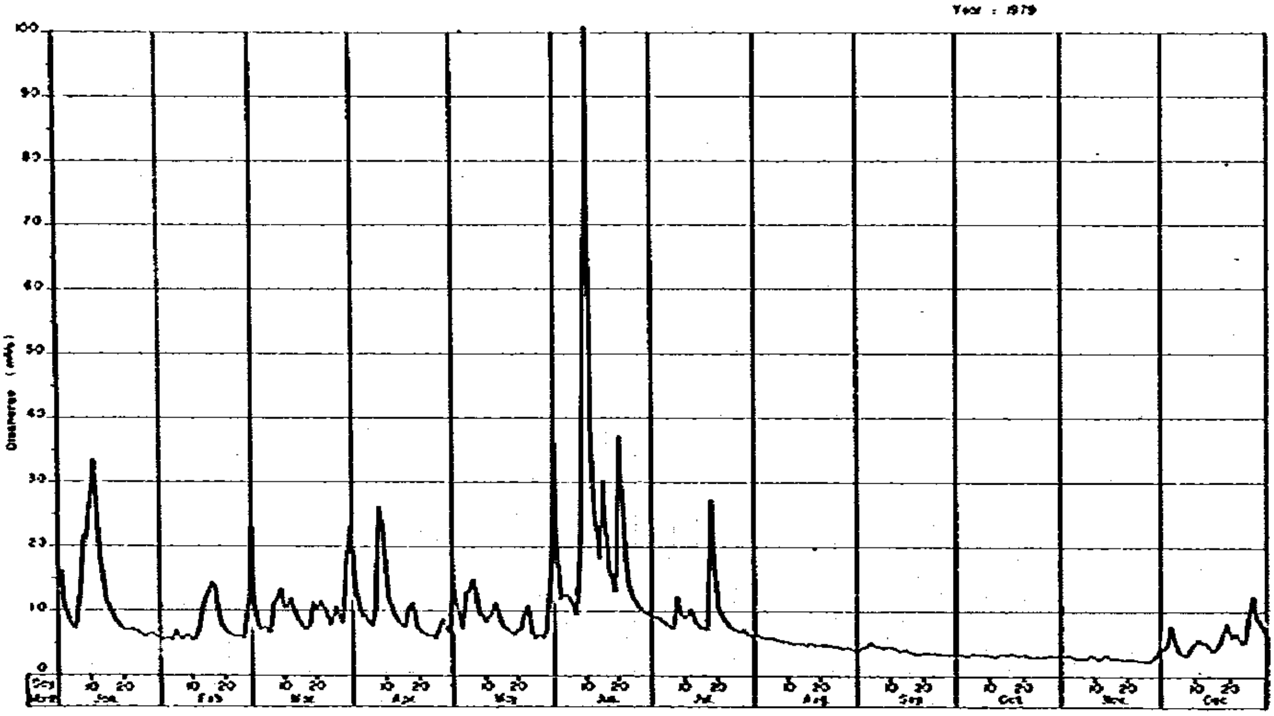


Fig. I.3.9 DAILY DISCHARGE AT TURUNGENG STATION (3/5)



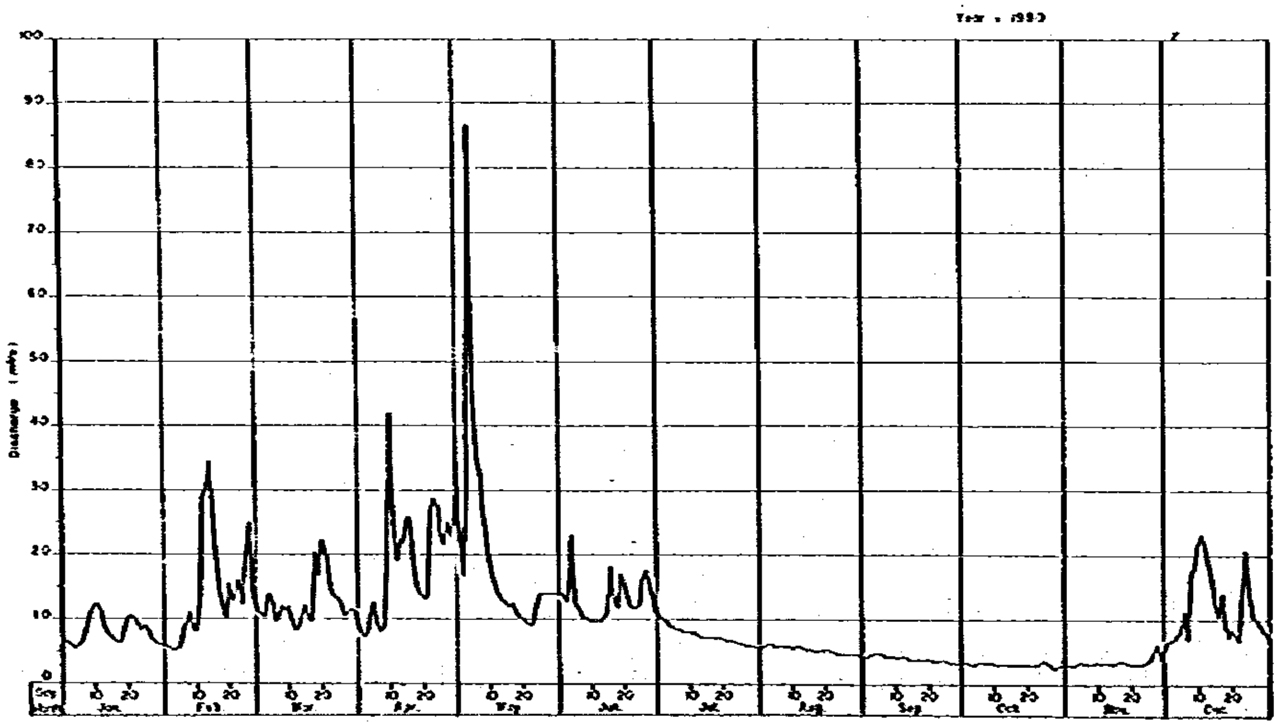
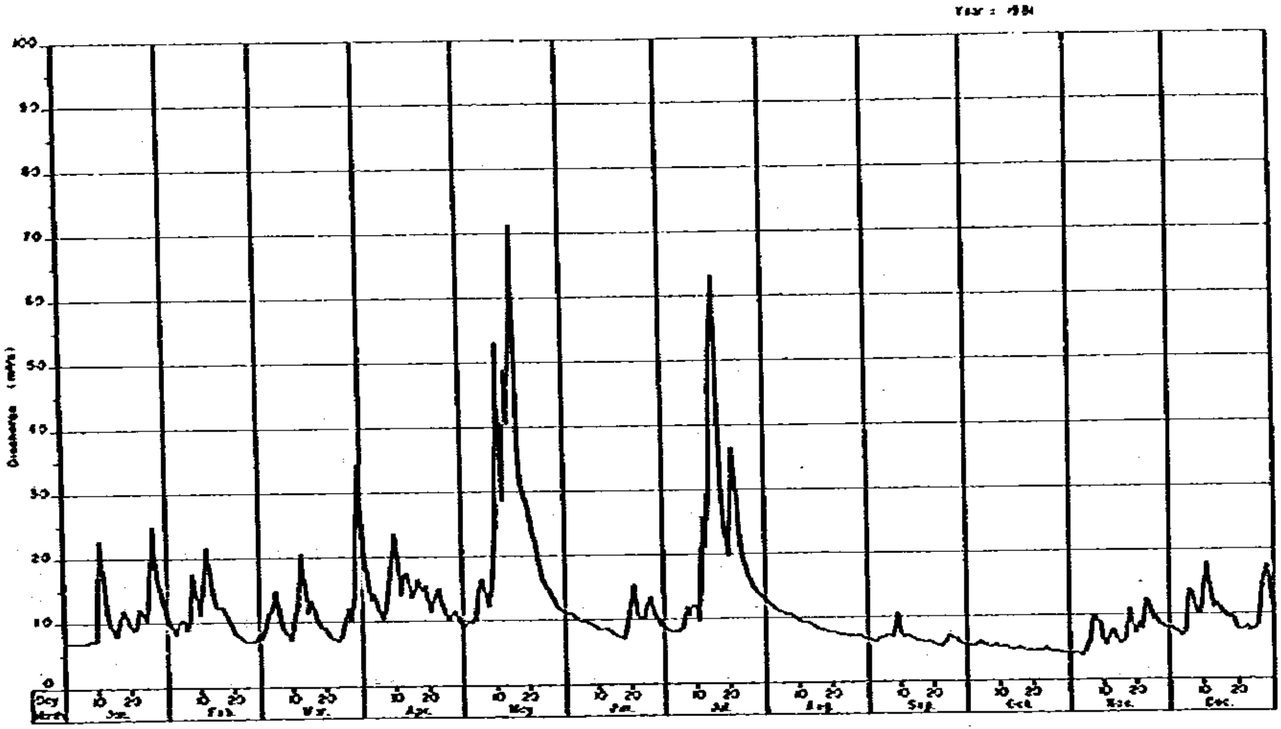


Fig. I.3.9 DAILY DISCHARGE AT TURUNGENG STATION (4/5)



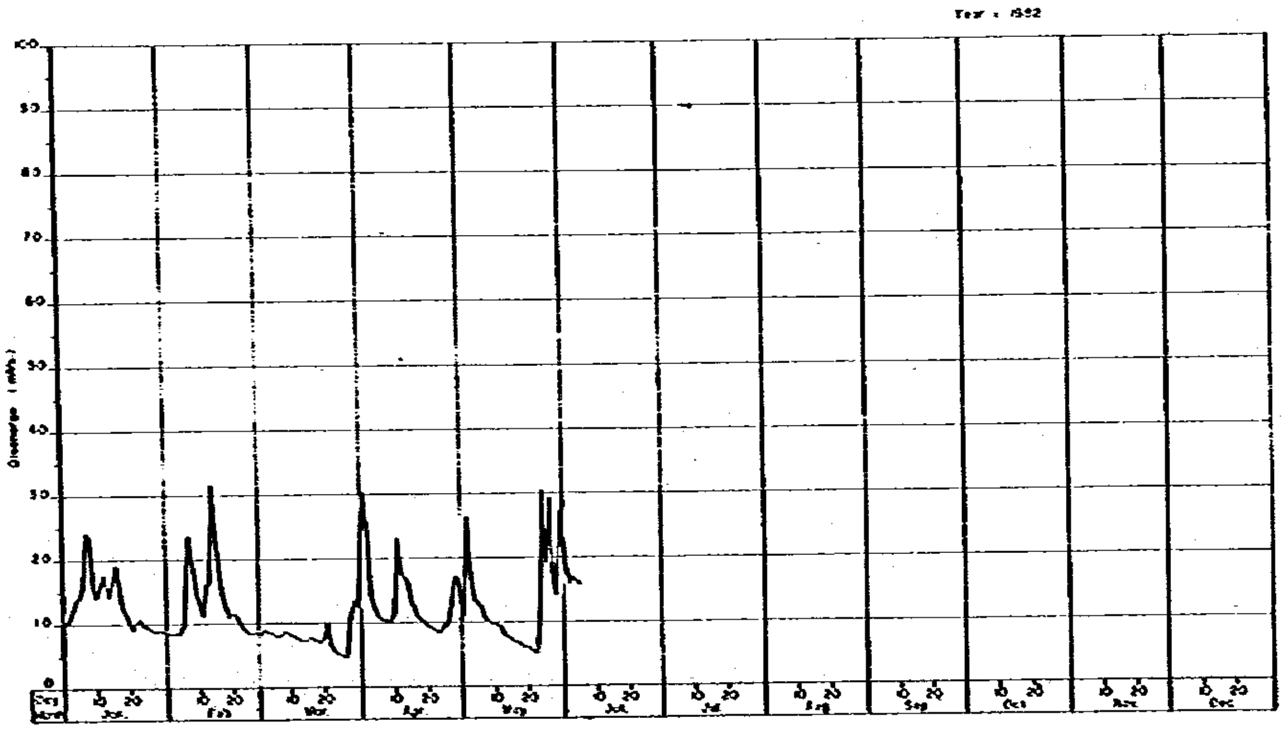
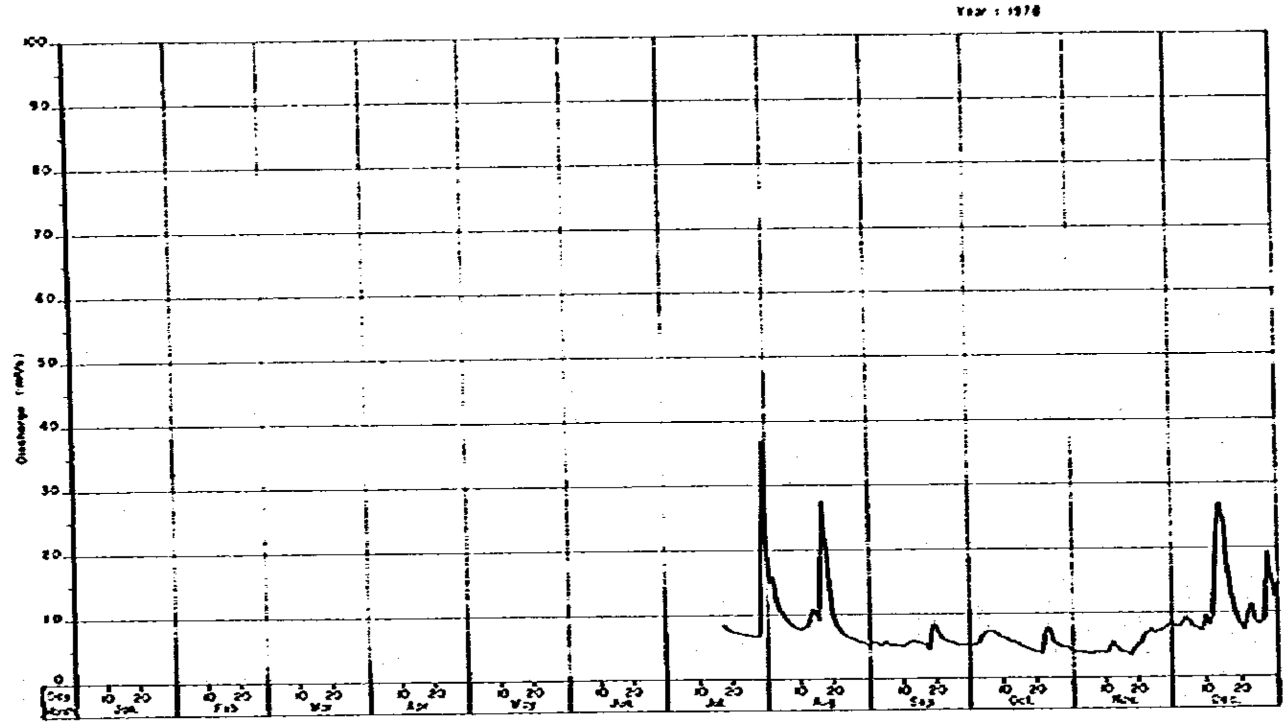


Fig. I.3.9 DAILY DISCHARGE AT TURUNGENG STATION (5/5)



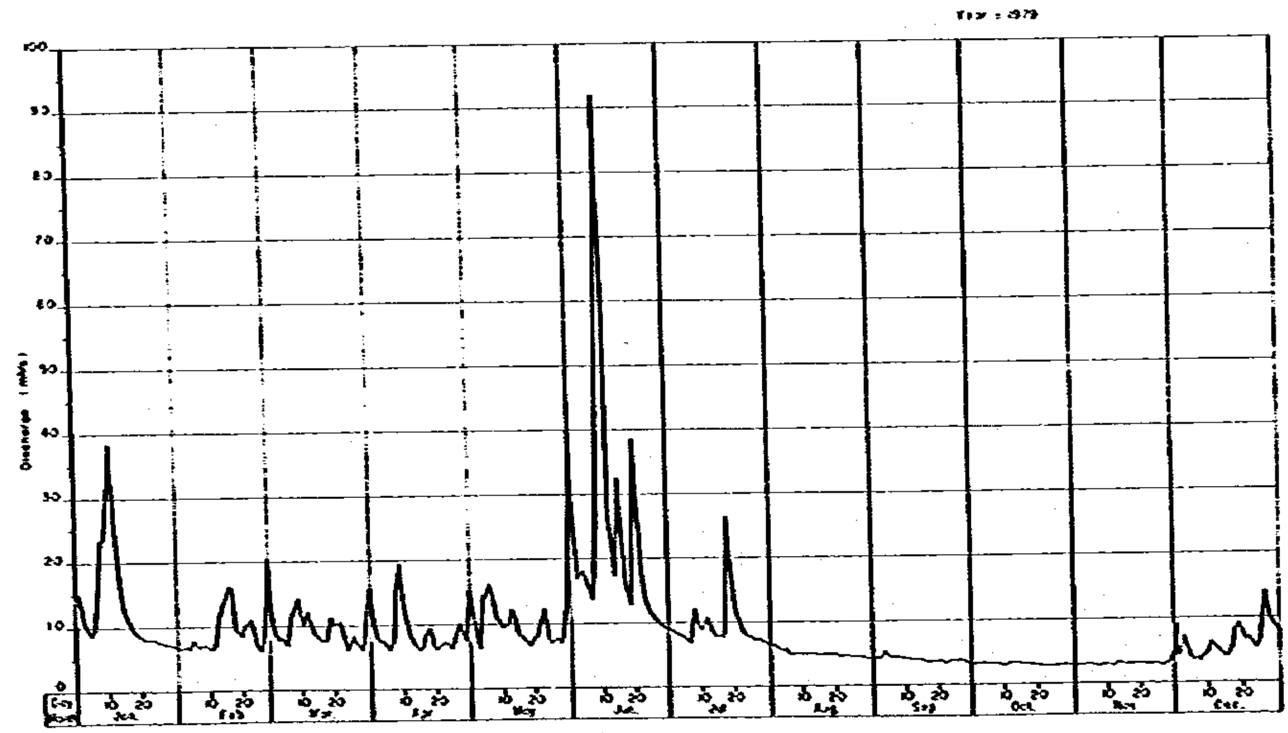
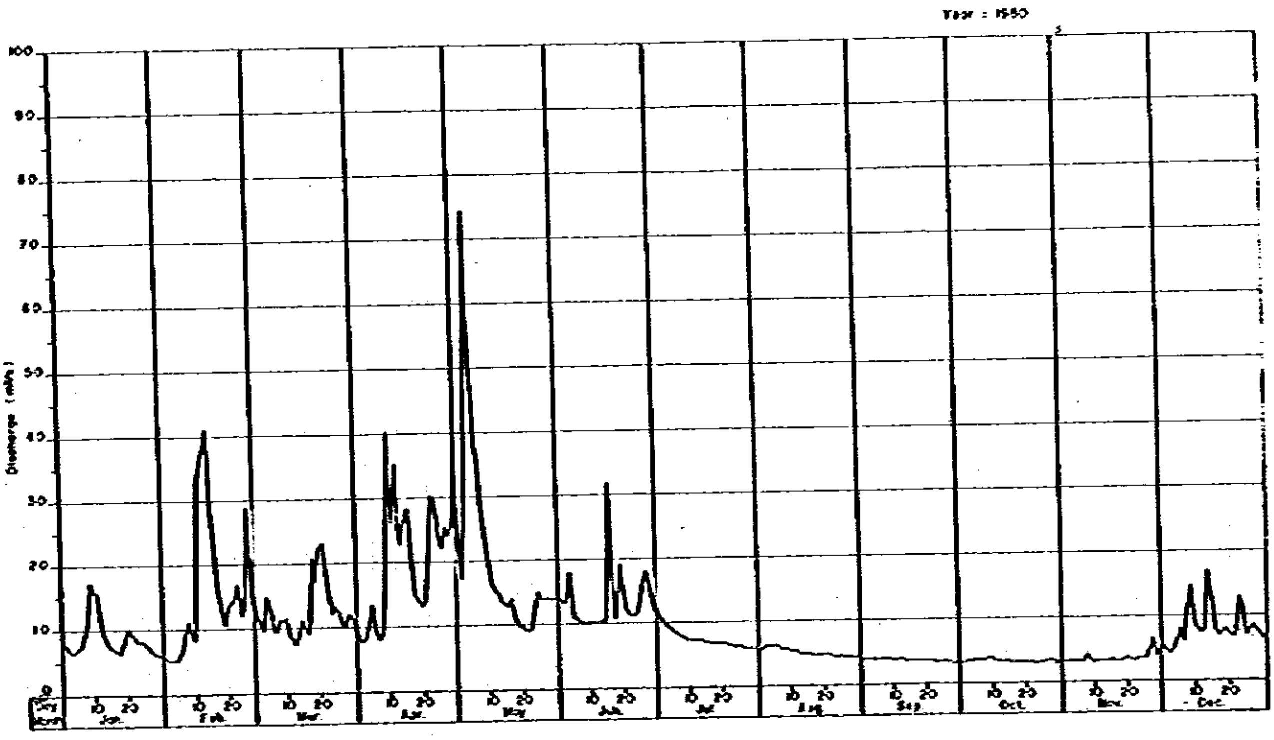


Fig. I.3.10 DAILY DISCHARGE AT SANREGO STATION (1/3)



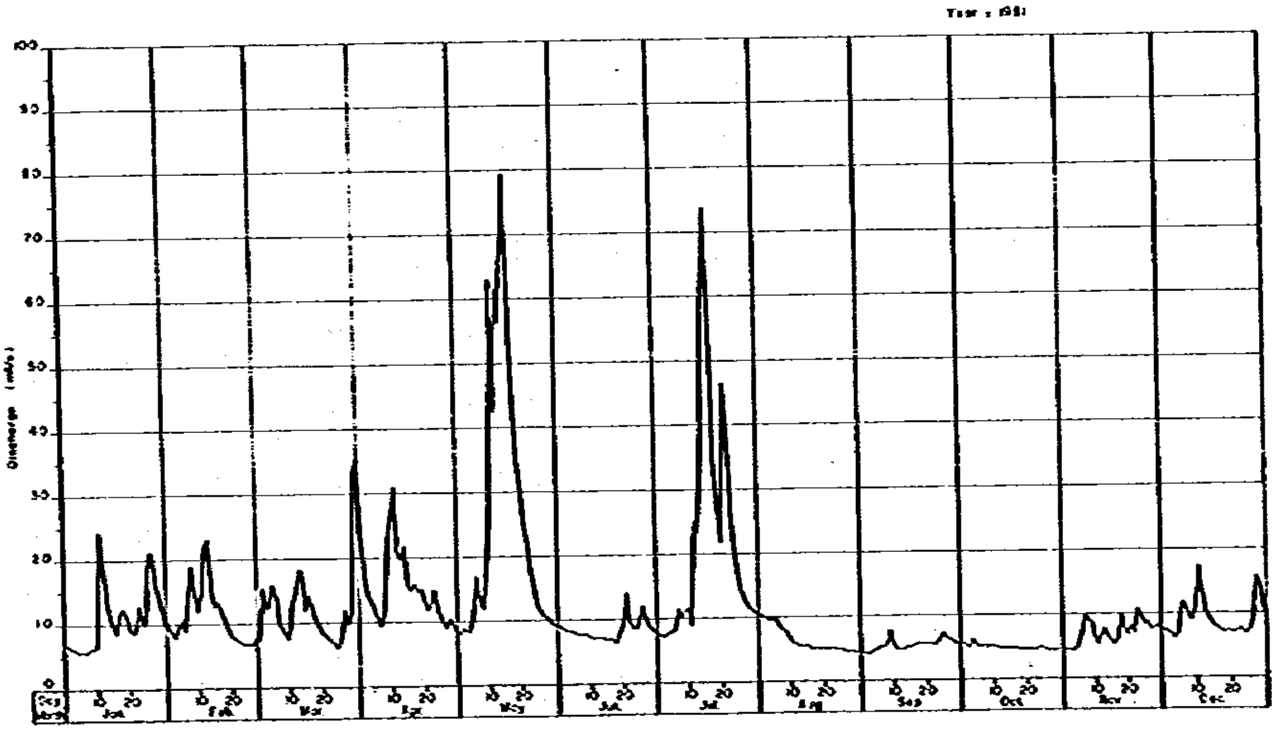


Fig. I.3.10 DAILY DISCHARGE AT SANREGO STATION (2/3)

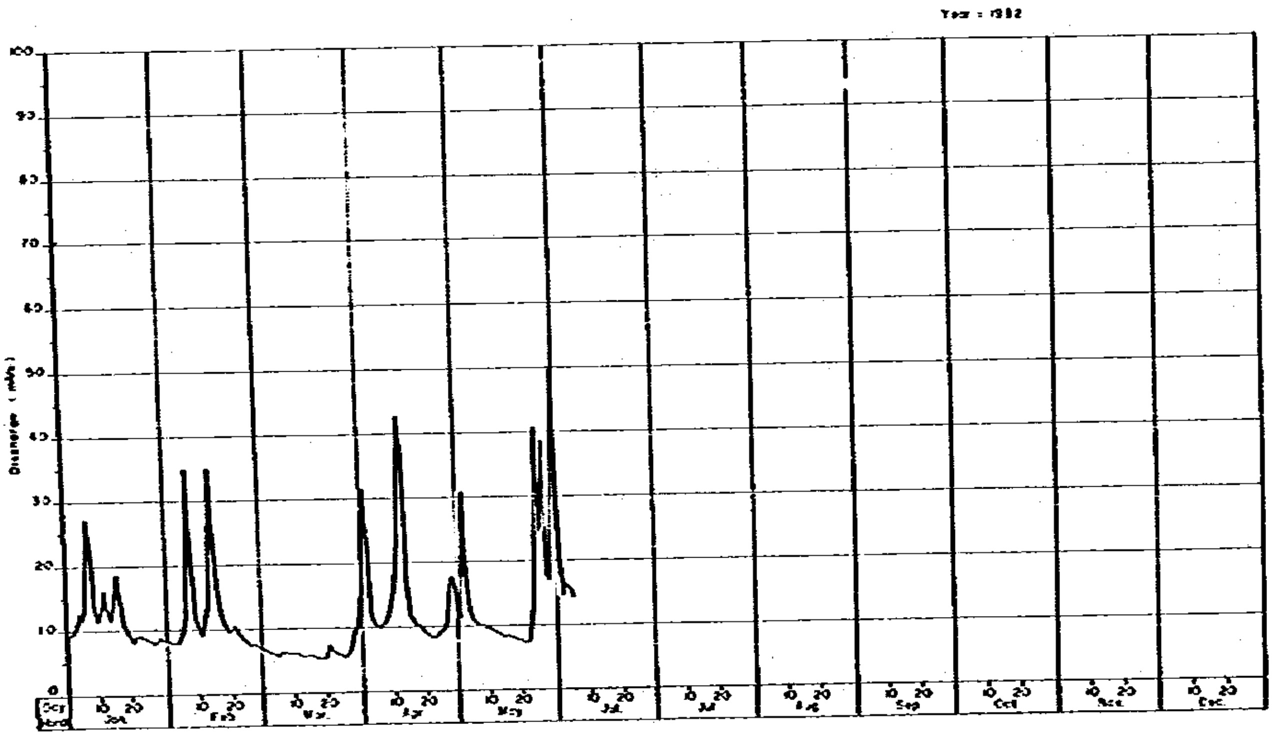


Fig. I.3.10 DAILY DISCHARGE AT SANREGO STATION (3/3)

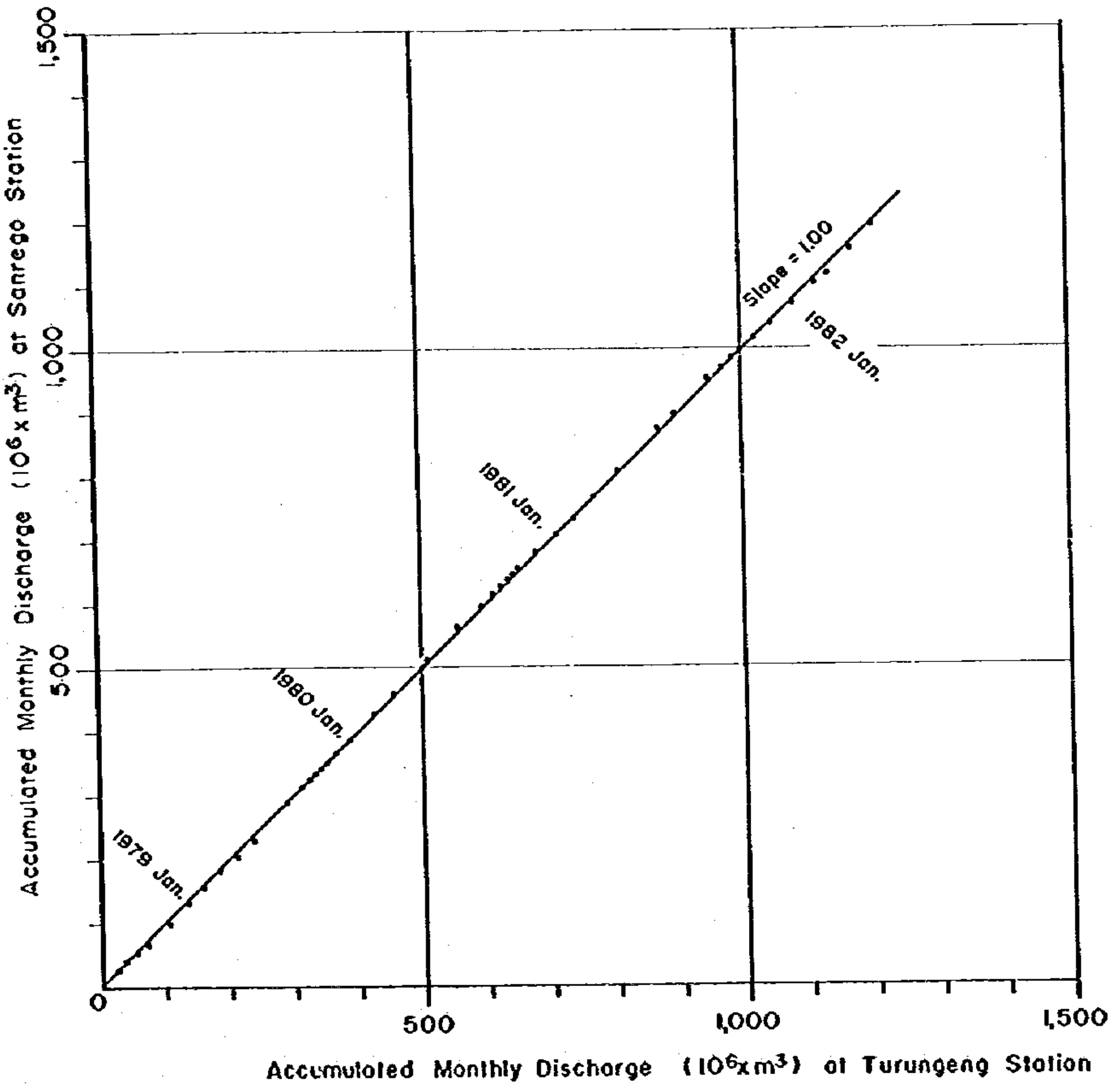


Fig. I.3.11 DOUBLE-MASS CURVE OF DUSCHARGE

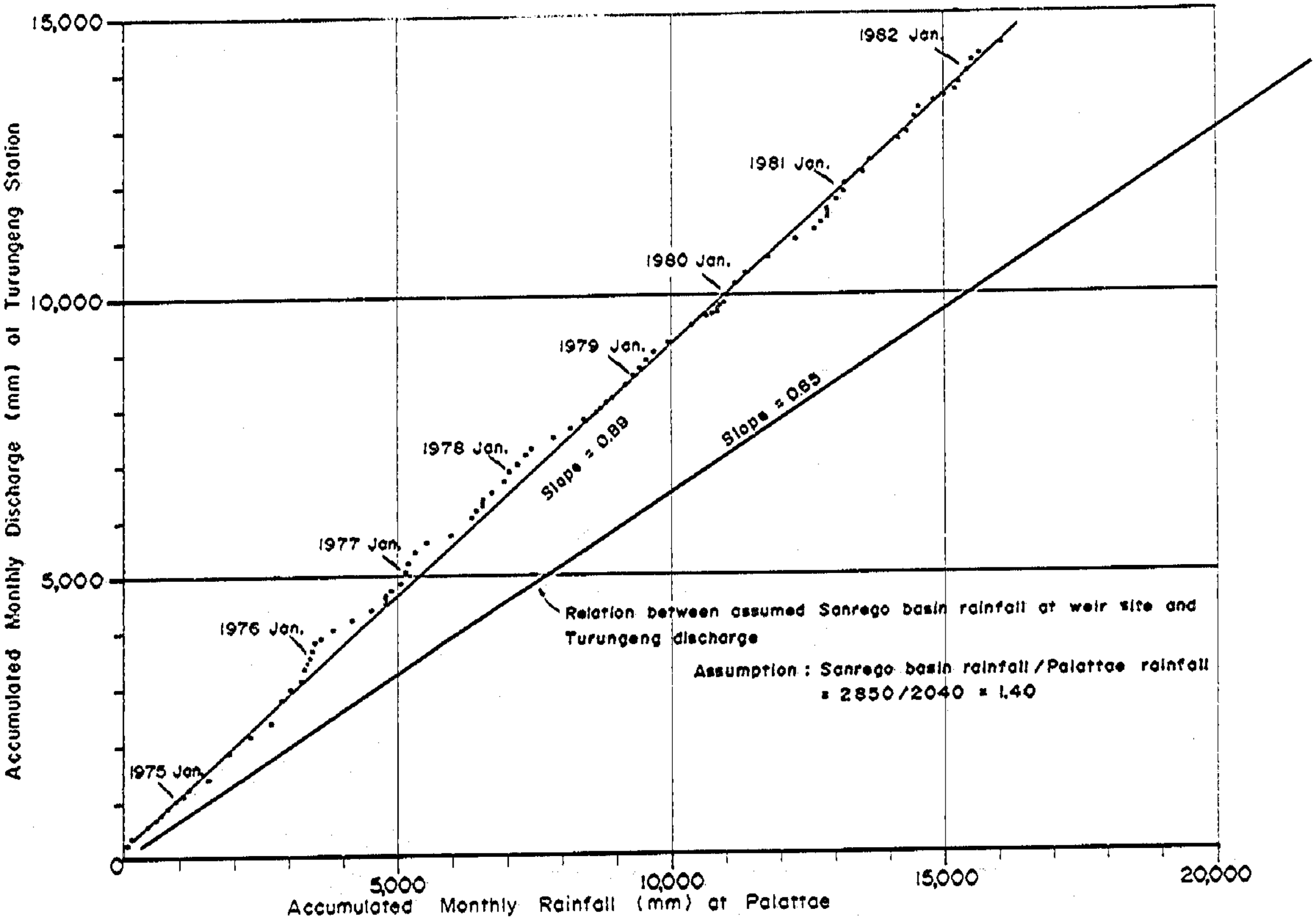


Fig. I.3.12 DOUBLE-MASS CURVE OF RAINFALL AND DISCHARGE

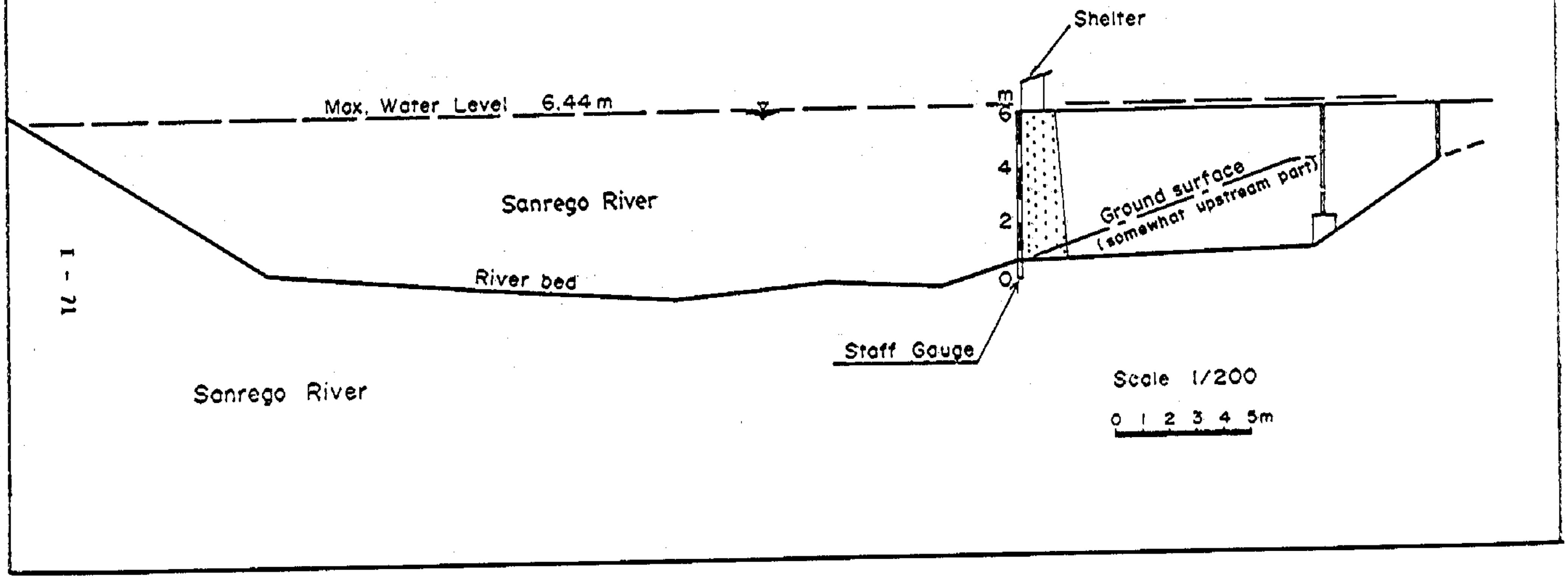


Fig. I.4.1 RIVER CROSS-SECTION AT TURUNGENG STATION

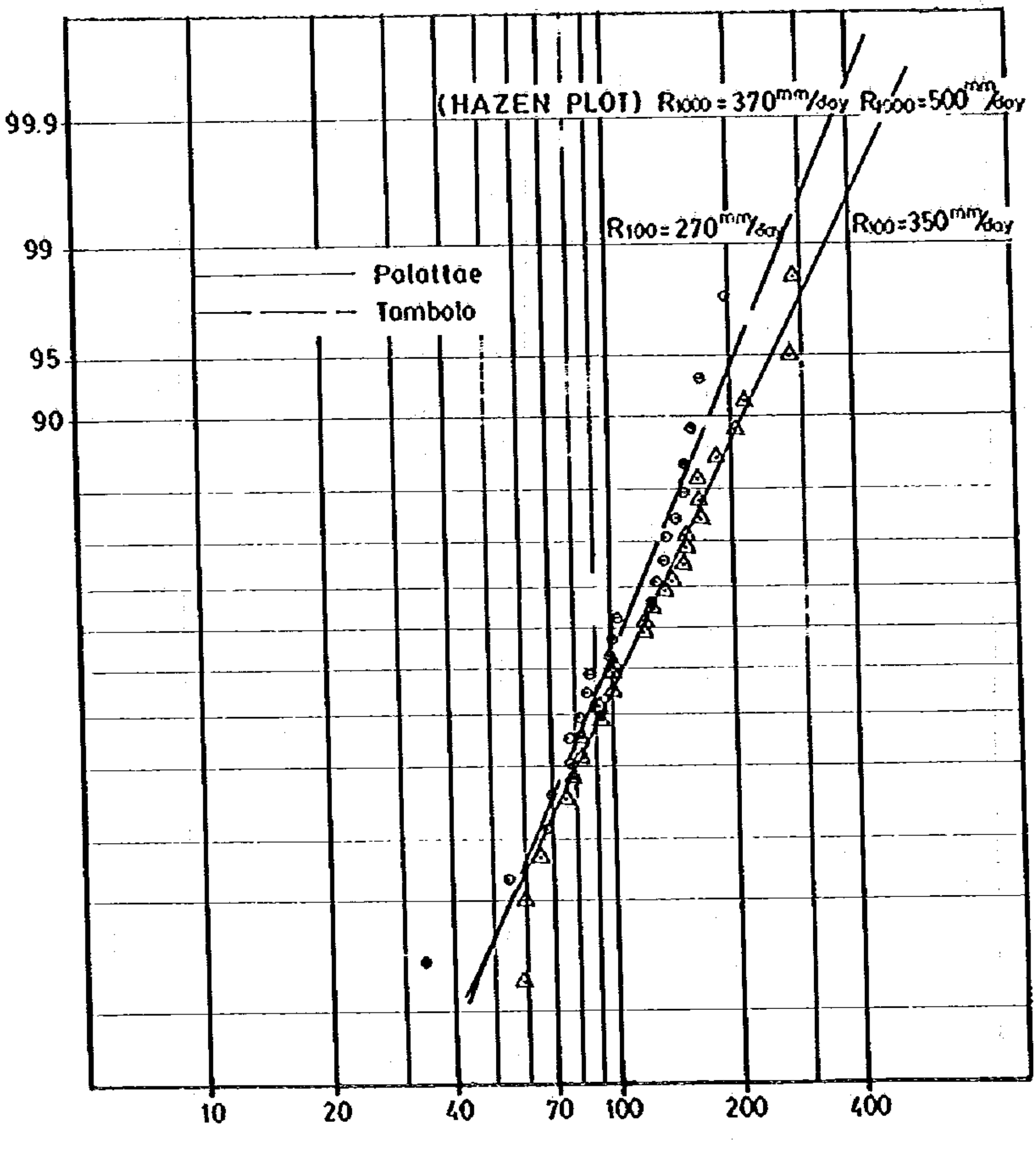


Fig. I.4.2 PROBABLE RAINFALL

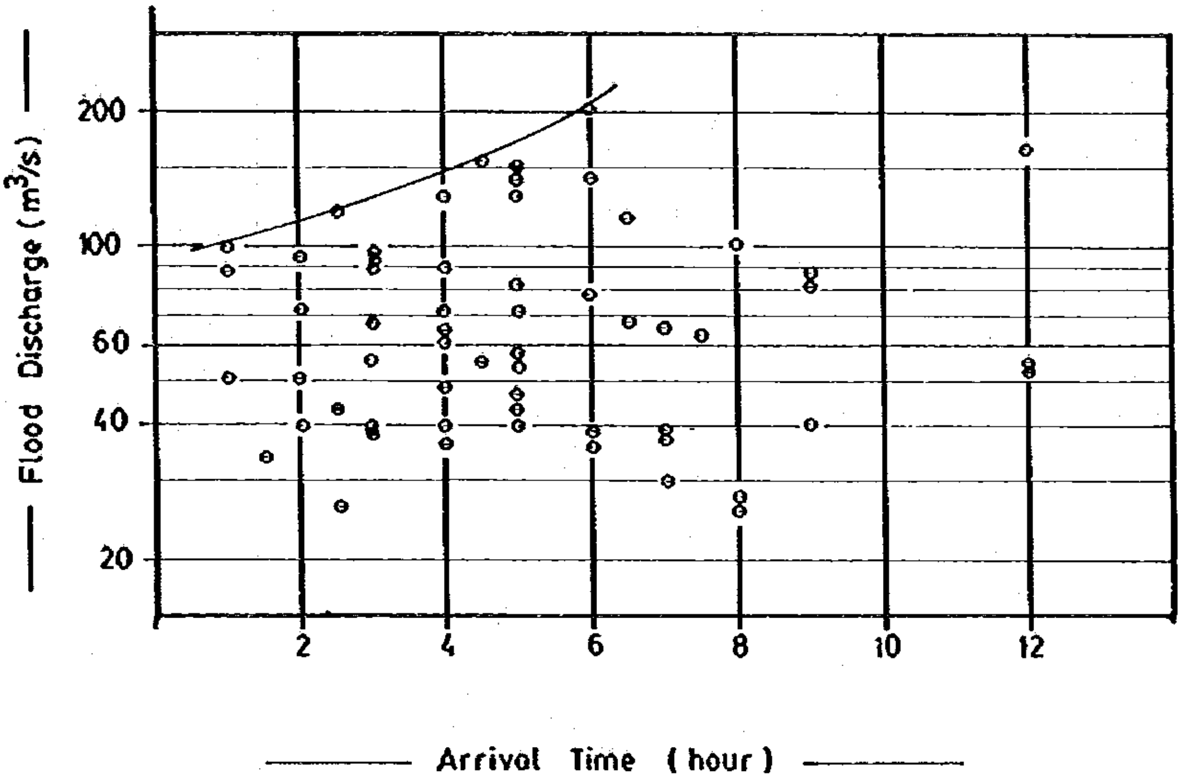


Fig. I.4.3 RELATION BETWEEN FLOOD DISCHARGE AND ARRIVAL TIME

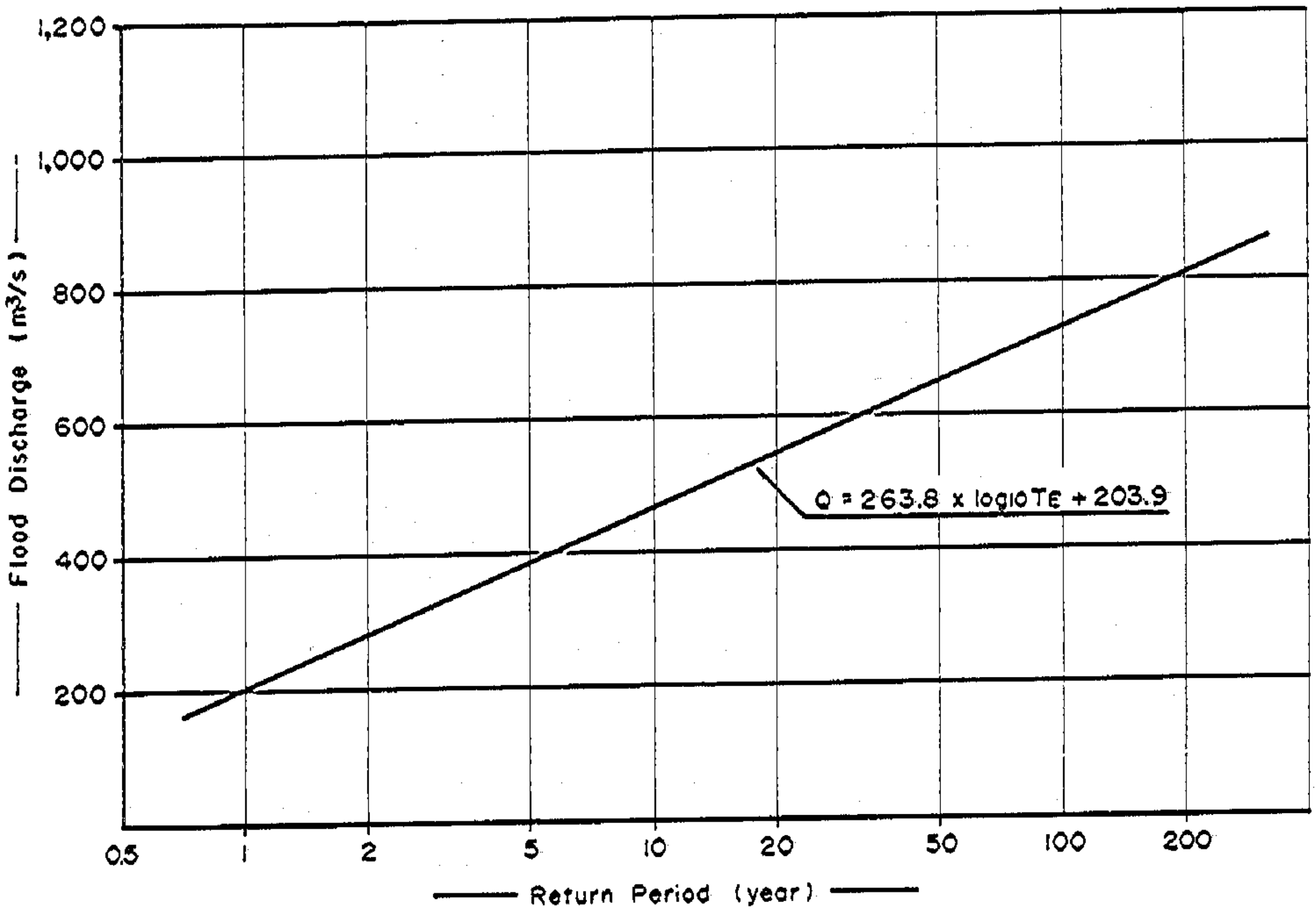


Fig. I.4.4 PROBABLE FLOOD DISCHARGE OF SANREGO RIVER BY EXPONENTAL DISTRIBUTION METHOD

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12. Tables of "Meteorological Data", Camming Sugar Cane Project South Sulawesi. ("Table 12 "Meteorologi Data" , Proyek Pabrik Gula Camming, Sulawesi Selatan).

13. "Hydrology for Design of Water Resources Construction". Ir. Iman Subarkah, Published by Idea Dharma, Bandung, 1978. ("Hydrologi untuk Perencanaan Bangunan Air" oleh Ir. Iman Subarkah, Penerbit Idea Dharma, Bandung, 1978).

ANNEX - II

GEOLOGY

ANNEX - II GEOLOGY

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ANNEX - II GEOLOGY

1. INTRODUCTION

1.1 Purpose of the Study

The Sanrego intake weir is designed as the main structure fixed on the sound foundation rock in the Sanrego river in order to take water to the paddy field through the canal. The intake weir, the heavy structure, is to be constructed on the sound foundation of a impervious and well consolidated rock for its stability.

A number of the canal structures are planned through the main and the secondary canal routes running along the foot of hill masses and crossing the tributaries of the Sanrego river and the Walanae river. Those structures require the firm foundation against the load and the scouring by a flood flow.

As the canal route runs along the foot of hill masses, a slope failure and/or erosion of soil would cause the difficulties during the construction and the maintenance. If the difficulties would be predicted from the geological viewpoint, a countermeasure is to be undertaken prior to the construction.

It has been known that the Sanrego river has a comparatively large base-flow discharge in the dry season. This characteristic is considered to be subject to the geology in the watershed of the river.

Based on the view point mentioned above, the geological investigation was carried out on the following two categories as,

(a) study on the foundation of the Sanrego intake weir and of the canal structures in order to provide the efficient information on the foundation for the reliable design, and

(b) study on erosion of soil along the canal route and base-flow discharge of the Sanrego river from the geological point of view.

1.2 Method of the Investigation

The geological investigation was initially carried out by the field geological reconnaissance to understand the general geology in and around the study area. The available data concerning the geology such as existing reports, maps and air photos were also reviewed.

Many drilling works have been accomplished by the local consultants at the Sanrego weir site and the canal structure sites. The geological study on those structure sites was made by the field inspection and the review of the result of the drilling works.

The geological study along the main canal and the major secondary canals was conducted by the field inspection and excavation of test pits to confirm the stability of the slope of the hill masses.

As for the geology of the watershed, the study was made by reading the air photos combined with the field reconnaissance, specially to reveal the distribution of limestone masses and the condition of the residual soil.

1.3 Previous Study

The drilling works for the Sanrego intake weir site and other structure sites have been carried out since 1976.

The results of drilling works and other field tests were described in the following four (4) reports:

(a) PENYELIDIKAN GEOLOGI TEKNIK DAN MEKANIKA TANAH RENCANA BENDUNG SANREGO DI PROP. SULAWESI SELATAN
(Reported in 1976 by P.T. Tricon)

(b) LAPORAN AKHIR PENYELIDIKAN GEOLOGI TEKNIK DAN MEKANIKA TANAH PENCANA TANGGUL PENUTUP BENDUNG SANREGO DI PROPINSI SULAWESI SELATAN (Reported in 1980 by P.T. Wecon)

(c) LAPORAN PENYELIDIKAN GEOLOGI TEKNIK DAN MEKANIKA TANAH PADA BANJUNAN PERLINTASAN DAN SALURAN DI DAERAH IRIGASI SANREGO PROPINSI SULAWESI SELATAN
(Reported in 1982 by WIRATMAN CABANG UJUNG PANDANG)

(d) LAPORAN PENYELIDIKAN GEOLOGI TEKNIK DAN MEKANIKA TANAH PADA BANGUNAN PERLINTASAN DAN SALURAN
(Reported in 1982 by WIRATMAN CABANG UJUNG PANDANG)

Reports (a) and (b) present the results of drilling works, field permeability tests,and electrical prospecting carried out at the Sanrego intake weir site.

Reports (c) and (d) include the results of drilling works and standard penetration tests carried out along the main and the secondary canal routes.

2. GENERAL GEOLOGY

The study area is located in the Walanae Depression. The Walanae Depression is surrounded with the Bone Mountains in the east, the Western Divide Mountains in the west, and Mt. Lompobatang in the south (see Fig. II.2.1). The Walanae river drains toward the north running in the Depression. The Walanae Depression is formed of gentle hilly areas and flat plains underlain by tuff breccia, alternation of weakly cemented mudstone and sandstone, coral limestone, and unconsolidated terrace and alluvial deposits (see Table II.2.1 and Figs. II.2.2 and II.2.3).

In the study area, the central area enclosed with the Walanae river and the Sanrego river is generally made up of widespread flat plain, ranging from 110 to 170 meters in altitude, and this is underlain by Pliocene Molasse (poorly consolidated conglomerate, siltstone, sandstone and pumiceous tuff etc.) and overlain by thick pleistocene terrace deposit.

The outskirts of the study area are mainly or partly made up of gently undulated hill masses, ranging from 170 to 220 meters in altitude, where the weathered basement rock is exposed directly underneath the thin residual soil. The basement rock is composed of strongly consolidated cretaceous hard shale and sandstone occuring in southwestern area, medially consolidated middle tertiary tuff breccia, sandstone and siltstone in western area, and weakly to medially consolidated upper tertiary tuff breccia and sandstone in eastern area.

The upper reaches of the Sanrego river is underlain by andesitic and basaltic lava associated with those pyroclastic rocks and intercalated with huge lenticular mass of reef limestone formed from Eocene to middle Miocene. This area, with the exception of limestone area, is composed of steep mountains covered by thick residual soil. In addition, the height of hill masses increases gradually from about 300 meters to about 2,000 meters of Mt. Bohonglangi in the south. Whereas, the area occupied by limestone mass shows a characteristic topography, that is, all the peaks are flat or slightly inclined ranging from 500 to 800 meters in altitude and rarely covered by residual soil, all slopes make steep cliff with rocky surface, and this limestone area makes a large basin enclosed with precipitous mountains.

The Sanrego intake weir site is selected on the Sanrego river, 15 kilometers upstream from the confluence of the Walanae river. The site is situated on the most southwestern edge of the study area, and underlain by medially consolidated siltstone and sandstone formed of the Miocene, covered with the unconsolidated diluvial and alluvial terrace deposit, and the river bed deposit. The siltstone and the sandstone are alternated. The siltstone is well laminated, therefore, crack is aboundant along the lamination. The unconsolidated deposits is about 8 meters in maximum thickness. Most of the structure sites on the main and the secondary canals show outcrop of the basement rock at the river water level, but those rock are overlain by thick diluvial terrace deposits at the flat plain, alluvial terrace deposits at the channel side, and flood plain and river bed deposits at the river course.

3. FOUNDATION ROCKS OF THE SANREGO INTAKE WEIR SITE

3.1 Review of Previous Study

3.1.1 Items of investigation

The following items and quantities of geological investigation were carried out on the foundation of the Sanrego intake weir in 1976 and 1980.

(a) Geological reconnaissance in the site with the map of 1/2,000

(b) Cone drilling and permeability test

Site	Year	Nos of Hole (holes)	Total Length (m)	Nos of Permeability Test (stages)
Intake Weir Guide Wall	1976	5 (Named as BI1 to BI5)	81.0	24
Closing Dike	1980	6 (Named as BMI to BMVI)	98.4	21
Total		11	179.4	45

(c) Electrical prospecting

The location of drilling holes at the intake weir site is shown in Fig. II.3.1 and the result of above mentioned investigation are summarized in Fig. II.3.2 and II.3.3. Moreover, the detail of the result of review is described in the following section.

3.1.2 Geological occurrence

(a) The broad flat plain spreading at the right bank of the Sanrego river is underlain by diluvium and alluvium. Relation height of diluvial terrace ranges from 5 meters to 10 meters above the river bed, and that deposits is about 4 meters in maximum thickness and composed of mainly sandy clay derived from lower to middle tertiary pyroclastics. Alluvial terrace of which thickness is 7 meters in maximum, situates about 3 meters in height from the river bed, and that deposits are composed of silt, sand, pebble and cobble. Unconsolidated deposits of alluvium appear being deepest at the drilling hole BM IV, which seems to suggest the existence of the old river course trenched in the most early Holocene. Accordingly, the thick deposits possibly trend from the upstream to the downstream, as shown Fig. II.3.1.

(b) Flood plain deposits and river bed deposits distribute in and around the river course. In addition, those deposits range from 1 to 3 meters in thickness, and are composed of sand, pebble and cobble.

(c) At the left bank of the Sanrego river, weathered rocks exposed underneath the thin residual soil.

(d) The foundation rock is composed of Miocene alternation of sandstone and siltstone, and intercalated with tuff breccia. In addition, the alternation is well bedded and laminated, therefore, abundant in numerous cracks paralleled with the stratification. Moreover, the numerous cracks and other vertical cracks are filled with calcite veinlet.

(e) Along the axis of the closing dike and at the right bank, the strongly to mediäly weathered zone lies under diluvial and alluvial terrace deposits with 1.5 to 3.5 meters in thickness. On the contrary, at the left bank, from strongly to mediary weathered zone is thick and about 6 meters in thickness.

(f) Along the axis of the coupure channel and at the upper stream side of that channel, the strongly to medialy weathered zone is comparatively thin and about 1.5 to 2 meters in thickness. On the contrary, at the lower, such as weathered zone is rather thick and 3.5 meters in thickness.

3.1.3 Permeability

(a) Alluvial terrace deposits, and flood plain and river bed deposits indicate 10^{-3} cm/sec in order.

(b) Diluvial terrace deposits indicates 10^{-4} to 10^{-5} cm/sec in order.

(c) The foundation rock indicates variable order ranging from 10^{-2}cm/sec to 10^{-6} cm/sec. However, the order of 10^{-3} cm/sec is the most dominant in number of the sections of field permeability test carried out only in the foundation rock, such as:

Order of Permeability (cm/sec)	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
Numbers of the Sections of the Foundation rock	2	20	5	7	1

(d) The permeability of the foundation rock is seemed to be influenced with that of the 1st stage. In other words, the order of permeability is almost same and not changeable from the surface to the bottom of each drilling hole, except BI3, BI4 and BI5.

(e) The phenomenon above-mentioned with the permeability of foundation rock is presumed to be caused from the unsuitable method of field permeability test. That is, the permeability test was carried out using with the casing method. The method is available for unconsolidated and clayey material but not available for consolidated rock. Therefore, it is presumable that the permeability of alluvial and diluvial deposits is exact, but that of the foundation rock has error and more higher than the exact value.

(f) Except only 2 sections indicated 10^{-2} cm/sec in order, all of sections range from 10^{-3} cm/sec to 10^{-6} cm/sec. Accordingly, it is presumed that the permeability of foundation rock is lower than 10^{-3} cm/sec in order and the foundation rock surely includes the part of 10^{-4} to 10^{-6} cm/sec in permeability.

(g) It is quite presumable that the weathered zone and the most upper section of the fresh zone have the mixed condition ranged from 10^{-2} to 10^{-5} cm/sec in permeability. Consequently, it is seemed to be suitable that the design of foundation rock must be based on 10^{-3} cm/sec in order of the permeability. Moreover, it is also presumable that the slightly weathered zone and the fresh zone have the rather lower permeability ranged from 10^{-4} to 10^{-6} cm/sec in order.

3.1.4 Electrical prospecting

Electrical prospecting was carried out using the YOKOGAWA TYPE NEW 3244. It is said that this type has the ability of analysis for about 20 meters in depth from ground surface.

According to the electrical prospecting, the foundation rock is largely classified into two groups with the lines of 30 to 50 Ω.m. Unconsolidated deposits and weathered rock indicate the value of less than 30 to 50 Ω.m. On the other hand, slightly weathered rock and fresh rock indicate 50 to 100 Ω.m. Moreover, the counter lines ranged from 30 to 50 Ω.m are closely crowded to suggest the existence of some boundary line dividing the foundation rock. On the profile along the axis of the coupure channel, the contour lines ranged from 30 to 50 Ω.m incline into the downstream, and suggest that the geologic structure of the foundation rock trend to the downstream and weathered zone is possibly thick at the downstream from the axis of the closing dike. For example, the line of 30 Ω.m is suddenly deepened at the dike axis and toward the downstream, and that line is emplaced 15 to 20 meters under from the surface. Similarly, on the profile along the axis of the closing dike, the contour lines ranged from 30 to 50 Ω.m gently undulate and have the tendency to incline slightly into the left bank. The undulated lines are seemed to suggest that the boundary line between weathered rock and fresh rock is irregular and weathered rock changes intermittently into fresh rock. Additionally, the slightly inclined lines suggest that the geologic structure of the foundation rock trend also to the left bank.

3.2 Result of Field Survey

3.2.1 Geological structure

The foundation rock at the Sanrego intake weir site has the tendency to incline northwestward with 10° in dip. Because, the intake weir site is situated at the west wing of the anticline structure, having the north-westnorth axis running at the right bank of the Sanrego river.

3.2.2 The condition of the foundation rock of the intake weir

Along the coupure channel, the excavation is on going, therefore, the foundation rock is able to be observed. The foundation rock, just under the intake weir structure and about 5 meters under from the ground surface, is composed of weathered siltstone. The siltstone is well consolidated and rather hard, however, contains numerous cracks parallel with lamination, and weathered to change the color into brown, and slightly opened to crumble the platy blocks from the cracks easily. According to the above condition, the permeability of the upper part of the foundation rock is appeared to be 10^{-3} cm/sec in order.

3.2.3 The condition of the foundation rock at the upstream

At the right bank 200 meters upstream from the axis of closing dike, well consolidated and slightly weathered sandstone crops out. The sandstone is well bedded and intercalated with thin beds of siltstone. Therefore, in spite of bluish-gray and fresh in the core, numerous open cracks exists at silty beds with regular intervals of several 10 centimeters and parallely with the bedding plane.

3.2.4 The condition of the left abutment of the closing dike

At the just left abutment of the closing dike, well bedded siltstone and massive volcanic breccia crop out. The siltstone makes thin beds at regular intervals of several to 10 centimeters, and that is intercalated with medium to fine sandstone. In addition, the siltstone is slightly broken and softened along the bedding planes. However, the bedding planes are nearly closed and oftenly filled with clayey thin film. On the other hand, the volcanic breccia is so massive and rare with crack. However, in the case of some crack exist, that crack is usually sharp and continuous, moreover that is open in the weathered outcrop.

Additionally, the one disturbed zone is observed at the outcrop 100 meters downstream from the axis of closing dike. The disturbed zone strikes N45°W and dips 90°SW, and meets at right angles with the axis of closing dike. Then, the disturbed zone has undergone alteration and decomposition to soften the rather hard tuff breccia, and that zone has about 1 meter in width at the 1 meter height from the river bed. Nevertheless, the disturbed zone has not undergone brecciation, therefore, that zone has no fault clay and fault breccia. Furthermore, the disturbed zone decreases in width from 1 meter into 20 centimeters at the river bed. According to the above-mentioned phenomenon, the disturbed zone is presumed to be derived from alternation took place the last volcanism along the crack. In addition, the disturbed zone is also presumed to decrease in width and finally to close at the underground.

3.3 Result of Analysis

3.3.1 Rock grade classification

The foundation rock must be classified into some rock grades from the view point of engineering geology. For this purpose, Table II.3.1 has been proposed in Japan. Moreover, each rock grade classified by Table II.3.1 is physically estimated with numerous experience, as shown in Table II.3.2. Therefore, it seems exact to classify the foundation rock occurred at the intake weir site by use of Table II.3.1.

According to Table II.3.1, the foundation rock is grouped into Medium hard rocks. In addition, in the fresh zone sandstone, volcanic breccia and tuff breccia are classified into C grade because those are well consolidated and lack in cracks paralleled with stratification. On the contrary, fresh siltstone must be classified into D grade because that is abundant in parallel cracks. Additionally, in the weathered zone, sandstone, volcanic breccia and tuff breccia are mainly classified into the low grade of D and partly classified into E. On the other hand, weathered siltstone must be classified into E.

The division of the weathered zone and fresh zone, and geological occurrence along the axis of closing dike are illustrated on Fig. II.3.2.

Unconsolidated deposits such as diluvium and alluvium must be classified into F.

Each physical value of the foundation rock is experimentally estimatable, as follows:

Rock Name	Sandstone, Volcanic Breccia, Tuff Breccia		Siltstone		Diluvium Alluvium
Weathering	Weathered	Slightly weathered to fresh	Weathered	Slightly weathered to fresh	Unconsolidated
Rock grade	lower D to E	C	E	D	F
Static modulus of elasticity (kg/cm^2)	10,000 to 15,000	50,000	5,000 to 10,000	20,000	2,000
Modulus of deformation (kg/cm^2)	7,000	30,000	5,000	10,000	1,000
Cohesion (kg/cm^2)	10	25	5	10	2
Internal frectional angle (°)	40	50	35	45	20

The designed closing dike is almost based on the weathered zone, and at only narrow part based on the unconsolidated deposits. The weathered zone has too enough strength to make no diformation against the load of the dike. Moreover, it is presumable that the unconsolidated has also enough strength against the load.

3.3.2 Permeability of the basement of the closing dike

The permeability of the weathered zone of the foundation rock ranges from 10^{-3} to 10^{-5} cm/sec in order. This phenomenon indicates that the weathered zone makes irregular condition on the permeability, and numerous open crack paralleled with stratification is scattered irregularly, and then, the parts of high permeability probably continue throughout the weathered zone. Consequently, for the purpose of the design of the closing dike, the permeability must be based on the 10^{-3} cm/sec in order.

4. FOUNDATION ROCKS OF OTHER MAJOR STRUCTURE SITES

4.1 Intake Weir Sites of Small Tributaries

4.1.1 The Parota river

Throughout the river course, well consolidated volcanic breccia and tuff breccia, grouped into medium hard rock and classified into C grade in Table II.3.1, crop out at the river bed and the channel bank, and partly overlain with unconsolidated river bed deposit. At the flat plain area around the river course, some parts are exposed with weathered rock and other parts are overlain with Mollase and Diluvium. Perhaps, there is no problem for the construction of the low intake weir.

4.1.2 The Biru river

The Maradda intake weir has been operated already. At the downstream of the Maradda intake weir, hardly consolidated and slightly weathered hard shale crops out on the river bed. The hard shale is grouped into medium hard rock and classified into C grade in Table II.3.1.

4.1.3 The Macinaga river

Throughout the river course, medially consolidated and massive tuff breccia crops out at the river bed and the channel bank. In addition, the tuff breccia is slightly weathered at the riverbed, and medially to strongly weathered and softened at the bank. Therefore, the tuff breccia, originally grouped into soft rock and classified into D grade, must be classified into low D at the river bed and E at the bank.
It seems that there is no problem for the construction of the low intake weir.

4.2 Major Structure Sites on Canal Routes

4.2.1 Items of investigation

The following drilling works and standard penetration tests were carried out for the design of the major structures planning at the Biru river, the Sanrego river and the Parota river, and for the engineering geological occurrence along the Aming secondary.

Name of Canal	Name of River	Nos of Hole	Total Length	Nos of Standard Penetration Test
Sanrego Main	Biru river	4	50	17
Parota	Sanrego river	7	130	21
Secondary	Parota river	4	70	8
Aming Secondary	Throughout the canal route	29	290	85

The result of above-mentioned investigation is summarized in Fig. II.4.4 to Fig. II.4.7, and the result of review and geological reconnaissance is described in the following sections. Moreover, the engineering geological occurrence and classification for the design of the major structures are illustrated on Fig. II.4.1, Fig. II.4.2 and Fig. II.4.3.

4.2.2 Sanrego main canal

An aqueduct has been under the plan at the Biru river. The geological occurrence and the division of weathered zone are illustrated on Fig. 4.1. The figure shows that cretaceous hard shale is overlain with Mollase basal conglomerate, diluvial terrace deposit and alluvial deposit, and then, hard shale and basal conglomerate are slightly weathered, moreover, each standard-penetration-test indicates that N-value is more higher than 50.

The diluvial terrace deposit and the weathered Mollase are too hard and compact to indicate that N-value is higher than 50. However, there is a possibility that the N-value is estimated more higher than the natural value of the clayey matrix of the diluvial terrace deposit and Mollase, because of the influence of numerous pebble included in those deposits. Additionally, the diluvial deposit is abundant with clayey material, and the weathered Mollase is probably decomposed into clayey sand from weakly consolidated conglomeratic sandstone. Accordingly, in the case of that the aqueduct abutment is based on the diluvial terrace deposit and the weathered Mollase, the wide footing must be prepared. Consequently, it seems most good that the abutments and the piers are fixed on the fresh Mollase and the hard shale directly.

In addition, in the case of that abutments and the piers in emplaced at the river shore, the supporting of the foot must be made because the unconsolidated and loose alluvial terrace deposit occupies the shore-side.

4.2.3 Parota secondary canal

Major structures have been planned at the Sanrego river and at the Parota river. Geological occurrence and the division from the weathering point of view are illustrated on Fig. II.4.2 and Fig. II.4.3.

At the Parota river, there is no problem to construct major structures, because well consolidated volcanic breccia and tuff breccia underlie at the shallow part. In addition, alluvial deposit and diluvial deposit overlie rarely.

At the Sanrego river, the alluvial terrace deposit is thick and wide spreaded at the right bank. Therefore, the excavation for the fixed pier must be made with large volume. The weathered zone is thick and makes a irregular distribution at the left bank. Accordingly, the shore side must be firmly protected against the flood water and the crumbling caused from denudation.

4.2.4 Aming secondary canal

At the almost structure sites, weakly to medially consolidated Mollase crops out at the river bed and banks. The Mollase is only slightly weathered at the out-crop, therefore possibly fresh at the underground from the level of each river bed. The fresh Mollase is grouped into soft rock and classified into E in Table II.3.1. With more detail, 1st and 5th member are classified into high E, and other members are classified into the mediel E.

Perhaps, each abutment and pier are able to be fixed on the fresh Mollase directly. However, in the case that the structures are based on weathered zone, careful treatment of design is seemed to be necessary. Furthermore, diluvial terrace deposit is generally less than 30 to 50 in N-value and only partly 50 to 100. Therefore, more careful design is necessary at the site occupied with thick diluvial terrace deposit.

5. GEOLOGIC CONDITION OF UPPER WATERSHED AREA

5.1 Limestone Stratum

The thick mass of limestone occupies the upper watershed area of the Sanrego river, mainly in the west of the Sanrego river. The limestone stratum ranges from 100 to 300 meters in thickness.

The limestone stratum gently warps around the syncline axis trending northeast at the left bank of the Sanrego river. Moreover, the syncline axis evidently plunges 10 to 15°NE, and the axis plane slightly inclines to northwest. Therefore, the groundwater in the limestone stratum may be gathered northeastward and flows out to the Sanrego river.

The limestone has numerous small caves, and vertical and horizontal fissures. In addition, the limestone area is abundant in steep and deep gully. Moreover the limestone area lacks thick residual soil, and forms tableland. Accordingly, the limestone area may have a high permeability to permit rainfall to percolate into subground and store groundwater for a comparatively long period.

It was also confirmed along the river course of the Sanrego river that the spring flows out from calcareous sandstone and the lower most of limestone stratum, supplying constantly groundwater into the Sanrego river even in dry season.

Consequently, it is presumed that the mass of limestone plays the role of a groundwater reservoir. That is, rain water is stored in the limestone, and groundwater flows according to the geologic structure to supply almost constant discharge at springs throughout a year.

5.2 Weathering Condition of Rocks on Upper Reach

The upper watersheds of the Sanrego river and the Biru river are covered by the thick lateritizated residual soil, because these areas may have been subjected to long-continued weathering since the late Miocene. Especially, in the area above almost 400 meters in altitude, the residual soil seems very thick, partly more than 3 meters in thickness, and has low cohesion. Therefore, slope-failures has often occurred in the residual soil zone, with 10 to 30 meters in width and 1 to 2 meters in depth.

On the contrary, in the area below almost 400 meters in altitude, generally the residual soil is thin, and weathered rock underlies immediately beneath the thin black soil. Because, this area had been affected by the movement of transgression and regression, and exposed against wave erosion.