Table 4.4, the basin mean 4-day rainfall is estimated at 629 mm, 575 mm, 413 mm, 168 mm and 385 mm at San Roque, Carmen, Wawa, Tibag and rivermouth of the Agno River respectively.

(3) Outlow/inflow at Binga and Ambuklao dams

Reservoir operation record during typhoon Maring is available at both dams of the Binga and the Ambuklao. Hourly inflow and outflow of both reservoirs are estimated based on their operation record as shown in Fig. 4.13.

The Binga and Ambuklao dams are not equipped with a reservoir space for flood control because of their single purpose for power generation. As given in Fig. 4.12, therefore, outflow from reservoir shows almost same pattern of flood inflow to reservoir at both dams.

(4) Inundation map

Flood mark survey was carried out by the Study Team to confirm the extent of inundation area as well as water depth of the flood caused by typhoon Maring. Thus, the inundation map is available for use in calibration of proposed model.

4.3.3 Basic conditions for simulation

(1) Runoff coefficient

Runoff coefficient is derived from the relationship between the volume of direct flood runoff and the total rainfall amount during flood.

Along this line, six flood inflow hydrographs at the Ambuklao dam are examined to estimate runoff coefficient as illustrated in Fig. 4.14.

Shown in Fig. 4.15 is the examined relation for selected flood assuming that the base flow is equivalent to the initial runoff immediately before the rising limb of flood hydrographs.

The plotted data shows that the runoff coefficient of 0.5 is adequate until the rainfall amount reaches up to 300 mm, while it shifts to 1.0 beyond

the rainfall amount of 300 mm.

(2) Base flow

The relationship between average base flow and drainage area is established as given in Fig. 4.16. From this relationship, the specific base flow is estimated to be 0.055 $m^3/sec/km^2$.

(3) By-pass floodway channel to the Poponto swamp

Discharge rating curves at the inlet of the by-pass floodway channel to the Poponto Swamp are constructed based on the non-uniform flow calculation as prepared in Fig. 4.17. In this simulation, the diverted flood discharge to the by-pass channel is estimated by use of these rating curves.

In this connection, the flood from the Tarlac River basin directly flows into the Poponto Swamp.

(4) Breached/overtopped flow to the Allied Rivers

As mentioned before, there still remains several breaches/gaps dowstream of San Roque along the existing dike on the right bank of the main Agno River.

Thus, it is reported that flood runoff of the Agno River was partly overflowed into the Allied Rivers.

The bankful flow capacity at the said breaches/gaps is estimated at about 1,200 m^3/sec based on the non-uniform flow calculation along subjective river stretches. In this simulation, the flood discharge over 1,200 m^3/sec is assumed to be overflowed into the Allied Rivers.

4.3.4 Calibration results

Calibration of model parameters is performed through try and error by assuming that parameter K of storage function for each sub-basin is adjustable for best combination and other remaining parameters of sub-basins and river channels are fixed as values initially set up.

After final calibration, parameters K for sub-basins are taken up by multiplying 1.6 times to initial K values set up by impirical formula mentioned before.

The simulated flood runofff is compared with the observed ones at 4 water level stations and the Binga and the Ambuklao dams as shown in Fig. 4.18. As seen in this figure, the applied model well simulated the recorded flood appropriately. Fig. 4.19 shows simulated water level and discharge hydrograph at the Poponto swamp during typhoon Maring. The retarded volume in the swamp is estimated at about 251 x $10^6 m^3$. The results of final calibration are summarized in Table 4.5 and 4.6 for sub-basin and river channel respectively.

4.4 Design Rainfall

The available rainfall data is analyzed for design of the rainfall duration, the probable basin mean rainfall at base point and its hourly distribution. The results of this analysis are used to estimate the probable flood runoff.

(1) Design rainfall duration

The design rainfall duration is determined from the duration of recorded major storms. Fig. 4.20 shows accumulated rainfall curves at San Roque, Wawa, Tibag and Sta. Barbara stations of AFFWS. Major storms recorded at the said stations show that rainfall duration is usually 4 days. The rainfall duration for runoff calculation is therefore, decided to be 4 days.

(2) Probable basin mean rainfall

Annual basin mean rainfall with duration of 1, 2, 3 and 4 days are estimated at each base point by means of Thiessen polygon method and adjustment for basin mean elevation as mentioned before. The daily rainfall data at 16 stations is used for this estimation. Taking into account the data availability of selected stations, three types of Thiessen polygon are laid out as shown in Fig. 4.21. Applied Thiessen's weight and adjustment factor are tabulated in Tables 4.7 and 4.8 respectively. The annual maximum basin mean 4-day rainfall at rivermouth of the Agno River (BP-1), the Cayanga-Patalan River (BP-8) and the Pantol-Sinocalan River (BP-9) are thus estimated for the

period from 1970-1986 as summarized in Tables 4.9 to 4.11 respectively.

In case that rainfall data is not available as it is missing, the rainfall data is extraporated based on the highest correlated relation among selected stations.

The probable basin mean rainfall is computed from estimated annual maximum basin mean rainfall by means of Pearson Type III method. The estimated probable rainfall at 9 base points for duration of 1, 2, 3 and 4 days are summarized in Table 4.12. Frequency curves of annual maximum basin mean rainfall at each base point is given in Fig. 4.22.

(3) Hourly rainfall distribution

3-hour rainfall records of 29 major storms at 5 stations of San Roque, Carmen, Wawa, Tibag and Sta. Barbara are adopted to design the hourly rainfall distribution.

The average 1-day accumulated curve is developed using the 1-day maximum rainfall which is derived from the recorded distribution with 4-day duration as shown in Fig. 4.23.

The average daily distribution of the total rainfall amount with 4-day duration is analyzed as follows:

Day	Ratio (%)
1st day	19
2nd day	25
3rd day	32
4th day	24

Considering the above average distribution, the design rainfall distribution for 4-day duration is determined as follows:

1st day : Uniform distribution of R4-R3
2nd day : Uniform distribution of R2-R1

3rd day : Distribution of R1 by average rainfall pattern

4th day : Uniform distribution of R3-R2

Where, R1 : probable 1-day basin mean rainfall

R2 : probable 2-day basin mean rainfall

R3 : probable 3-day basin mean rainfall

R4 : probable 4-day basin mean rainfall

Typical hourly distribution of design rainfall is illustrated in Fig. 4.23.

4.5 Evaluation of Probable Flood under Present River Condition

Before proceeding to the probable flood runoff estimation under the alternative flood control schemes to be discussed in succeeding Sub-section, the probable flood runoff estimated from rainfall is compared and evaluated with the one resulting from recorded flood runoff through frequency analysis.

Flood record at San Roque is selected for this evaluation. This is because San Roque is not so far affected by flooding whenever the existing dike system was breached/overtopped.

(1) Probable flood runoff from recorded flood runoff

The probable flood at San Roque is estimated by the Pearson Type III method using the recorded annual maximum peak discharge as given in Table 4.1. Fig. 4.24 shows the frequency curve at San Roque.

(2) Probable flood runoff from rainfall

The probable flood runoff at San Roque is estimated from probable basin mean rainfall at San Roque under the present river condition.

(3) Comparison and evaluation

The estimated probable flood peak runoff is summarized below.

Return Period (year)	Probable Flood Runoff (m^3/s)	
	from Flood Record	from Rainfall
100	6,440	6,260
50	5,000	5,060
25	3,900	3,960
10	2,570	2,720
5	1,810	1,710
2	990	830
1.05	370	320

Fig. 4.25 shows the comparison results schematically. The estimated probable flood discharge calculated based on rainfall data and the one computed from recorded flood agree well with each other. This fact implies that the approach for estimation of flood runoff based on rainfall is appropriate and applicable to flood control planning.

4.6 Probable Flood Runoff under River Improvement Condition

4.6.1 Condition for calculation

The flood runoff calculation is carried out under the following conditions:

(1) River channel : Confining dike system along the main Agno River and major tributaries

(2) Dam/reservoir : As for the existing dams of Binga and Ambuklao there is no flood control space in the reservoir. Therefore, the outflow is assumed to be equal to the inflow. San Roque dam in which the detail design has been completed and Balog-Balog dam under construction are to be incorporated. The reservoir operation proposed in their report is applied.

(3) Retarding area : Poponto swamp is not taken into account.

Tables 4.13 and 4.14 show parameters of storage function of river channel

under confining dike condition. Estimated storage function of sub-basin of the Allied Rivers is tabulated in Table 4.15.

4.6.2 Probable flood peak distribution

Based on the above conditions, the flood runoff calculation is made with different return period of 1.05, 2, 5, 10, 25, 50 and 100 years. The estimated flood peak distributions for the Agno River and the Allied Rivers basins are summarized in Figs. 4.2.6 and 4.2.7 respectively. The probable flood hydrographs at 9 base points having reccurrence interval of 10, 25, 50 and 100 years are shown in Fig. 4.28. The relationship between the basin area and the specific runoff estimated for 100-year peak flood is illustrated in Fig. 4.29. The specific runoff at locations having watershed of steep mountainous area such as the upstream basin of the Agno River and the Ambayoan River shows bigger values compared with the one in other mountainous area. This tendency becomes more remarkable in the Allied Rivers.

Shown in Fig. 4.30 is comparison of the probable flood peak discharge distribution under confining dike condition with and without San Roque dam.

4.7 Flood Water Level and Duration in Inundation Area

(1) Inundation map during typhoon Maring

Flood mark survey was carried out by the Study Team to confirm the extent of inundation area as well as water depth of the flood caused by the typhoon Maring. Thus, the inundation map is available for use in calibration of proposed model.

(2) Simulation by flood inundation model

The inundation analysis for typhoon Maring in 1984 are carried out by use of the flood inundation model.

The simulation results is compared with the actual inundation area and maximum depth based on flood mark survey as shown in Fig. 4.31. The inundated area and maximum inundation depth by the typhoon Maring is simulated fairly well.

(3) Probable inundation area

The inundation area and maximum inundated area in the lowland of the Allied Rivers basin under the occurrence of the probable 100-year flood is estimated by the simulation model. Calculation result is illustrated in Fig. 4.3.2.

For the above simulation, the flood inflow to be overflowed from the dike of the Agno River is estimated based on the following hydrological condition:

- The river dike is to be breached when the flood water level rises to the level corresponding to the 50% of free board.
- The flood runoff corresponding to the above water level is assumed to be the breach-starting discharge.
- The flood runoff over the breach-starting discharge is assumed to be flowed into the Allied Rivers basin.
- The breach-starting discharge is determined for each river stretch based on the river cross section data as given below:

River stretch of the Agno River	Breach-starting discharge (m^3/s)
San Roque - Confluence of the Ambayoan R.	1,200
Conf. of the Ambayoan R. - Conf. of the Banila R.	5,470
Conf. of the Banila R. - Poponto floodway	3,130
Poponto floodway - Conf. of the Tarlac R.	1,230
Conf. of the Tarlac R. - Conf. of the Olo R.	10,200
Conf. of the Olo R. - Rivermouth	6,890

5. LOW FLOW STUDY

5.1 General

The objective of the low flow study is to obtain runoff data at selected locations for the Sediment Study in the Agno River basin on a daily basis for a continuous period of more than 20 years. These daily runoff data is to be used in the sediment balance study to assess the sediment transport capacity in the Agno River.

Taking into account the availability of discharge and rainfall records, the runoff characteristic at San Roque is initially examined by applying the tank model method using the daily discharge and rainfall records for the period of 1960-1971. Then the missing part and unreliable period of the daily discharge record at San Roque is supplemented with the generated runoff resulting from the applied simulation model for the period of 1960-1986 taking into account the data reliability.

Finally the daily runoff for the period of 1960-1986 at selected locations is estimated based on the ratio of the basin area and the annual basin mean rainfall thereof.

5.2 Available Data

Along the main Agno River and the Tarlac River, nine water level gauging stations exist as given below:

Station	Recorded Period
Agno River	
(1) San Roque	1960 - 1971
(2) Carmen	1960 - 1971
(3) Poblacion	1960 - 1971
(4) Wawa	1964 - 1972
(5) Banaga	1965 - 1972
(6) Baay West	1965 - 1972

Tarlac River

(7)	Villa Aglipay	1962,1964 - 1972
(8)	Palublub	1965 - 1972
(9)	Sta. Lucia	1966,1968 - 1972

Among the above stations, San Roque is selected for the evaluation of runoff record taking into account the following hydrological conditions:

(1) Runoff record of stations located in the main Agno River shows that the runoff at San Roque is not affected by flood overflow into the Allied River basins through the existing breached portion of the right bank dike system, while the one at stations located in the downstream of San Roque is influenced thereby.

(2) In the evaluation of runoff record, the rainfall data and the runoff data during the corresponding period is necessary to examine the relation between basin mean rainfall amount and runoff depth. The rainfall data at four stations which cover in the upstream basin of San Roque are available for comparison with the record at the stations in the Tarlac River basin which are intermittent.

(3) Runoff record at San Roque is more or less affected by the operation of the Binga and Ambuklao dams located in the upstream basin of the Agno River. Low flow is expected to be supplementarily increased by the outflow from the Binga dam. However, the influence is minimal from the viewpoint of Sediment Study, hence it is not taken into account in evaluation. The high flow is the main focus in this evaluation as it is not affected by the operation of both dams where no space for flood control is provided.

5.3 Procedure of Simulation

The basic procedure of simulation is explained below:

(1) The tank model is firstly constructed at San Roque for the upstream basin of the Agno River for 1960-1971 of available runoff record. The concept of the model is described in the succeeding Section 5.4.

(2) The calibration of the model parameters is mainly carried out in terms of the following aspects:

- monthly mean runoff
- duration curve of daily runoff, and
- runoff coefficient

The best combination of model parameters is determined through try and error method.

(3) The daily runoff at San Roque is generated on daily basis by using the calibrated model for continuous 27 years from 1960 to 1986.

(4) In the preparation of natural daily runoff at San Roque, the simulated daily runoff is used instead of recorded runoff when they are judged to be unreliable or not available due to data collection interruption. Thus, the natural daily runoff at San Roque is supplemented by generated runoff for the period of 1960-1986. The estimated natural runoff is examined further by the double mass curve method to check its reliability and consistency.

(5) Finally, the daily runoff for the period of 1960-1986 at an arbitrary location is estimated based on the ratio of the basin area and the annual basin mean rainfall thereof.

5.4 Simulation Model

(1) Basic concept of tank model

Suppose a tank having two holes, one at the bottom and the other at the side as shown in Fig. 5.1. When the tank is filled with water, the water will be released from through two holes. In the low flow analysis, the water released through the side hole corresponds to the direct runoff to a stream and the water from the bottom hole goes into the ground water zone.

The depth of water released from a hole is given by the following relation:

$I = C \cdot H$

where, I : Depth of water released (mm/day)

C : Hole coefficient

H : Water depth above hole (mm)

(2) Applied tank model

For the low flow simulation, four tanks vertically combined are usually applied as shown in Fig. 5.1. Each tank represents each runoff mechanism in the watershed. The top tank corresponds to the surface runoff, the second one to the subsurface runoff and the third and fourth to base flow from the ground water zone.

In a process of simulation, the simulating process, daily rainfall depth is placed into the top tank and the depth of water released from a hole is calculated by the above equation. The water from the bottom hole is put into the second tank and the same process is repeated to the fourth tank.

The depth of stream runoff is given as the sum of the water released from the side holes of four tanks. Loss due to evapotranspiration is expressed by subtracting the depth of daily evapotranspiration from the storage of the top tank.

5.5 Calibration of Model

5.5.1 Input data

(1) Basin mean rainfall

The daily basin mean rainfall in the upstream basin of San Roque is estimated by means of weighted average of the four rainfall stations in its watershed considering the basin mean elevation as described in previous Section 4.3. The Thiessen weight and adjustment factor of the selected four stations are as follows:

Station	Thiessen weight	Adjustment factor for basin mean elevation
Bugias	0.25	1.41
Ambuklao	0.28	1.36
Baguio	0.20	0.86
Bobok	0.27	1.18

The estimated monthly basin mean rainfall at San Roque is summarized in Table 5.1.

(2) Evaporation ratio

The monthly evaporation data by class A-pan is available at Ambuklao and its average monthly mean evaporation for the period of 1954-1966 is given below.

(Unit: mm/day)

Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
4.8	5.1	5.2	4.5	3.9	3.6	3.1	2.5	2.6	4.0	4.3	4.2

(3) Observed runoff at San Roque

Recorded monthly runoff at San Roque for the period from 1960 to 1971 is summarized in Table 5.2.

5.5.2 Calibration results

The simulation model developed at San Roque is calibrated by examining the following three aspects of the calculated runoff:

- duration curve
- monthly mean runoff
- runoff coefficient

Calibration of runoff on daily basis is not valid because area distribution of a rainfall is usually not uniform in the basin and the basin mean rainfall does not coincide the peak in the observed runoff.

(1) Monthly mean runoff

Monthly mean runoff simulated by the model is compared with the observed monthly mean runoff as shown in Fig. 4.2. The simulated runoff is satisfactorily similar to the recorded runoff for the period of 1960-1966, while the occurrence of flood do not coincide with observed one after 1967 except in 1968.

(2) Duration curve

Tank parameters of the simulation model is firstly adjusted so as to fit the daily flow duration curve of the simulated runoff to that of the runoff observed in each year. Along this line, fitting of the curve is mainly made in high flow discharge to satisfy the requirement of the Sediment Study. Flow duration curves of simulated runoff is prepared in comparison with that of observed runoff for each year for the period from 1960 to 1971 as given in Fig. 5.3.

In calibration of duration curves, curves in 1967, 1970 and 1971 do not show similar patterns to the observed ones. This is mainly because the observed runoff data involves unreasonably high discharge in dry season. The calibration disregards these years.

(3) Runoff coefficient

Table 5.3 shows runoff coefficients of observed and simulated runoff together with errors of simulation. The average runoff coefficients for the period of 1960-1971 are estimated to be 0.71 and 0.72 for observed and simulated respectively. The coefficient for each year varies from 0.60 to 0.88 which is within an acceptable range.

In addition, the errors range from 0% to 17%, which is considered to be acceptable for this calibration.

(4) Tank parameters

Based on the above calibration, parameters of the applied tank model are determined as shown in Fig. 5.1

5.6 Long-term Runoff at San Roque

Fig. 5.4 shows simulated daily runoff at San Roque after the final calibration. Thus, daily discharge record at San Roque is supplemented with the generated runoff for the continuous 27 years from 1960 to 1986.

In this extrapolation by simulated runoff, the daily runoff for 1967-1986 is estimated by means of simulation model. The observed runoff for 1967-1971 is judged to be unreliable due to unreasonably high discharge period in the dry season. The estimated long-term runoff at San Roque is examined by introduction of the double mass curve to check its reliability and consistency based on the relation between runoff depth and basin mean rainfall. As shown in Fig. 5.5, the double mass curve shows reliable relation between runoff depth and basin mean rainfall with a satisfactory consistency.

Accordingly, annual runoff at San Roque is estimated to be 95.3 m^3/sec. on an average in 1960-1986. Monthly mean runoff is summarized in Table 5.4.

5.7 Estimate of Runoff in Sub-basin

In order to estimate the daily runoff at an arbitrary location from estimated runoff at San Roque, the following equation is applied:

$$Q = C . Qs$$
$$C = A/As . R/Rs$$

where, C : Conversion ratio
Q : Daily runoff at the objective sub-basin
Qs : Daily runoff at San Roque
A : Catchment area of the objective sub-basin
As : Catchment area at San Roque
R : Annual basin mean rainfall of the objective sub-basin
Rs : Annual basin mean rainfall at San Roque

Flow duration curves of natural runoff for the period of 1960-1986 are constructed at Wawa and rivermouth of the Agno River based on the daily natural runoff at San Roque as shown in Fig. 5.6.

The dependable discharge for different percentage of time are derived from the above flow duration curves. The estimated dependable discharge is tabulated below:

(Unit: m^3/sec.)

Location	Percent of time (%)				
	90	80	50	20	10
San Roque	15	18	41	161	233
Wawa	42	51	115	452	654
Rivermouth	56	67	152	597	864

6. METEOHYDROLOGICAL OBSERVATIONS

6.1 Establishment of Observation Stations

Four automatic raingauges and nine automatic water level gauges were installed by DPWH as shown in Fig. 6.1. Their detailed locations are given in Appendix.

These station were selected from the hydrological viewpoint taking into account the existing meteohydrological observation network in the Agno River and the Allied River basins. The observed meteohydrological data thereby together with the existing stations are to be used for the hydrological study in the Feasibility Study stage.

The selected stations are given below.

Raingauges (4 sets)

(1) Camp 4 : Near the Aropong-Camp 4 in the upper basin of the Bued River

(2) Saytan : At the compound of Saytan Elem. School in the lower basin of the Bued River

(3) Sto. Domingo : Near the Tacnien town in upper basin of the Tuboy River

(4) Iba : Near the Iba town in the lower basin of the Bulsa River

Water level gauges (9 sets)

Agno River (3 sets)

(1) Poponto Left Dike : Just upstream of the overflow spillway in the left side earth dike at the Poponto floodway, Agno River

(2) Poponto Right Dike: End of the right side earth dike at the Poponto floodway, Agno River

(3) Cojuangco Bridge : Road bridge connecting the towns of Camiling and Moncado, Tarlac River

Rivers (6 sets)

(4) Camp 1 : Road bridge crossing Bued River between Baguio City and Brgy. Saytan, Tuba.

(5) Aloragat : Road bridge at Aloragat River and connecting towns of Manaoag and Barangay Nalsian

(6) Angalacan : Road bridge at Angalacan River connecting Barangays Aloragat and Cabanbaran.

(7) Tagamusing : Road bridge at Tagamusing River connecting the tocons of Binalonan and San Manuel

(8) Sinocalan : Road bridge at Sinocalan River connecting the town of Mapandan and Brgy. Pinmaludpud, Urdaneta

(9) Ingalera : Road bridge crossing Ingalera River at Brgy. Nansangaan, Malasiqui.

Installation of automatic gauges at the above stations was completed as given below:

Station	Date of Completion	Elevation/Zero of Gauge (EL.m)
Rainfall		
(1) Camp 4	Aug. 21, 1989	about 700
(2) Saytan	Aug. 21	about 190
(3) Sto. Domingo	Sept. 3	about 90
(4) Iba	Sept. 3	about 100
Water level		
(1) Poponto Left Dike	Sept. 28, 1989	18.325
(2) Poponto Right Dike	Oct. 5	12.669
(3) Cojuangco Bridge	Nov. 23	14.500
(4) Camp 1	Dec. 4	178.600
(5) Aloragat	Oct. 23	11.400
(6) Angalacan	Oct. 17	10.300
(7) Tagamusing	Oct. 25	31.800
(8) Sinocalan	Oct. 20	9.200
(9) Ingalera	Dec. 15	2.700

6.2 Observations

The following observation works were carried out by DPWH under the supervision of the hydrological monitoring expert.

(1) Rainfall

Hourly observation by the automatic rain gauge.

(2) Water level

Hourly reading of the staff gauge installed at gauging station during flood before completion of the installation of automatic water level gauges.

(3) Discharge measurement

Discharge measurement to construct discharge rating curves at respective stations. Measurement by float is applied during flood, while current meter during low flow.

(4) Sediment load

Sediment sampling at 10 sites and their laboratory test

(5) Water quality

Electric conductivity test is scheduled to be conducted in coming dry season in 1990 to assess the sea water intrusion into the Agno, the Cayanga-Patalan and Pantol-Sinocalan Rivers.

6.3 Observation Record

(1) Normal observation

Hourly observation by automatic rainfall and water level gauges was called out after completion of their installation.

(2) Observation during typhoon Openg

In the period of September 10 to 14, 1989, the typhoon Openg attacked the Agno River basin. Hydrological observation records observed during the typhoon are summarized below:

Rainfall

- Hourly rainfall were observed at four new stations.
- 3-hourly rainfall were observed at five stations of the Agno river FFWS.

Water Level

- Hourly water level were observed by staff gauge reading at four new stations, at Cojuangco Bridge, Ingalera, Sinocalan and Tagamusing.

The observation records of hourly rainfall and water level are compiled in Fig. 6.2 and Fig. 6.3 respectively. The water level hydrograph observation was started almost at the time of flood peak because the typhoon hit the area during the weekend and, therefore, dispatch of observation crew was somehow delayed.

The basin mean 4-day rainfall is estimated at 431 mm. The rainfall isohyetal map shown in Fig. 6.4 indicates that a very heavy rainfall was experienced at Bued river basins. The basin mean rainfall in Allied River basin is estimated at 506 mm which corresponds to the 5-year probable rainfall. On the other hand, the basin mean rainfall in the Agno River basin is calculated at 253 mm, which is less than the probable rainfall with a 2-year return period.

(3) Flood inundation due to typhoon Openg

Field investigation on flood conditions was carried out in two days, September 10 to 11 1989. In addition, aerial survey by helicopter was also conducted on September 13, 1989. The flood inundation area widely spread to the downstream of Sinocalan river, especially at Dagupan City, Calasiao and Santa Barbara. Two bridges were broken at Manaoag along Aloragat river due to the flood.

TABLES

Table 3.1 SUMMARY OF CLIMATIC CONDITIONS

	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean Temperature (°c)													
Dagupan City (1951-1985)	25.9	26.6	28.1	29.5	29.4	28.6	28.1	27.5	27.9	28.0	27.2	26.4	27.8
Baguio (1951-1985)	17.8	18.4	19.6	20.4	20.5	20.0	19.6	18.9	19.3	19.5	19.0	18.4	19.3
San Miguel (1968-1979)	25.1	25.0	27.0	28.6	28.8	28.1	27.4	26.8	27.3	26.8	26.3	25.4	26.9
Mean Maximum Temperature (°c)													
Dagupan City (1951-1985)	30.9	31.8	33.5	34.9	34.3	32.9	32.0	31.1	31.7	32.2	31.7	31.2	32.4
Baguio (1951-1985)	22.6	23.6	24.7	25.1	24.6	23.6	23.0	22.0	22.9	23.5	23.2	22.8	23.5
San Miguel (1968-1979)	31.0	31.7	33.9	35.3	34.7	33.3	32.1	30.9	31.6	31.7	30.2	30.7	33.3
Mean Maximum Temperature (°c)													
Dagupan City (1951-1985)	20.9	21.4	22.7	24.2	24.6	24.4	24.2	24.0	24.1	23.8	22.8	21.7	23.2
Baguio (1951-1985)	12.9	13.1	14.3	15.5	16.2	16.2	16.0	15.9	15.7	15.4	14.8	14.0	15.0
San Miguel (1968-1979)	18.8	19.0	20.3	21.9	23.1	23.2	22.8	23.1	22.6	22.3	21.6	20.2	21.6
Mean Relative Humidity (%)													
Dagupan City (1951-1985)	74	72	70	70	73	81	82	85	84	80	77	75	77
Baguio (1951-1985)	80	78	78	80	86	88	90	92	90	87	83	80	84
San Miguel (1968-1979)	83	75	78	72	79	86	88	91	89	87	83	82	83
Number of Rainy Days													
Dagupan City (1951-1985)	2	2	3	5	13	17	22	24	20	12	5	2	127
Baguio (1951-1985)	4	2	4	9	19	22	26	27	25	17	9	5	169
Evaporation (mm)													
San Miguel (1968-1979)	146	152	194	204	170	138	128	113	127	131	131	135	1,768
Ambuklao Dam (1954-1966)	149	144	160	134	122	108	96	77	80	124	129	131	1,296

Table 4.1 RECORDED ANNUAL MAXIMUM DISCHARGE

Station : SAN ROQUE

Year	Occurrence Date		Gauge Height (m)	Discharge (m3/sec)
1950	Aug. 8	6:00 AM	5.06	1,040
1951	Jul. 31	6:00 AM	4.25	717
1952	Oct. 28	6:00 AM	3.95	473
1953	Aug. 21	0:00 PM	5.10	1,036
1954	Nov. 8	0:00 PM	5.80	1,404
1955	Sep. 24	6:00 AM	3.49	583
1956	Sep. 25	6:00 AM	3.87	314
1960	Aug. 26	6:00 PM	5.60	1,093
1961	Jul. 14	6:00 PM	4.99	758
1962	Jul. 22	-	-	900
1963	Sep. 12	6:00 AM	6.44	1,214
1964	Aug. 7	0:00 PM	6.96	2,046
1965	Jul. 15	7:00 AM	6.20	870
1966	May 20	5:00 PM	7.99	3,694
1967	Oct. 18	-	-	1,182
1968	Sep. 29	0:00 PM	8.40	4,350
1969	Jul. 29	6:00 AM	7.03	2,158
1970	Oct. 15	7:00 AM	5.90	550
1971	Aug. 14	-	6.99	862

Station : CARMEN

Year	Occurrence Date		Gauge Height (m)	Discharge (m3/sec)
1950	Aug. 8	6:00 AM	25.53	1,720
1951	Jul. 31	0:00 PM	25.60	1,180
1952	Aug. 17	0:00 PM	24.30	725
1953	Jun. 5	0:00 PM	25.20	3,400
1954	Nov. 9	0:00 PM	25.48	3,075
1955	Sep. 24	6:00 AM	25.61	3,270
1956	Sep. 2	5:00 PM	24.32	1,283
1960	Aug. 23	8:00 PM	26.38	2,476
1961	Jul. 14	10:00 PM	24.88	1,326
1962	Jul. 23	6:00 AM	25.75	1,950
1963	Sep. 12	1:30 AM	25.92	2,114
1964	Aug. 8	3:00 PM	26.43	2,527
1965	Jul. 14	7:00 AM	26.66	2,743
1966	May 20	10:00 PM	26.60	2,404
1967	Oct. 17	11:00 SM	27.60	3,855
1968	Sep. 29	5:00 PM	26.68	2,764
1969	Jul 28	7:00 PM	25.83	1,658
1970	Sep. 12	6:00 PM	25.18	1,545
1971	Oct. 11	-	26.17	2,307

Source : Philippine Water Data - Surface Water Records, NWRC

Table 4.2 MAJOR FLOOD RECORDS OBSERVED BY AFFWS

(1) Rainfall (duration: 4-day)

(Unit: mm)

Typoon	Rainfall gauging station				
	San Roque	Carmen	Wawa	Tibag	Sta. Barbara
Maring	475	277	250	105	334
Kuring	-	336	331	207	397
Daring	279	181	338	330	367
Gading	-	401	345	241	548
Miding	457	202	187	165	360

(2) Maximum discharge

(Unit: cu.m/sec)

Typoon	Rainfall gauging station				
	San Roque	Carmen	Wawa	Tibag	Sta. Barbara
Maring	2,816	2,220	3,061	610	265
Kuring	-	-	1,365	730	265
Daring	-	-	2,423	1,181	260
Gading	-	-	2,363	-	-
Miding	-	-	2,705	-	262

Table 4.3 DISCHARGE RECORD OF TYPHOON MARING IN 1984

(Unit: cu.m/sec)

Date	Time	San Roque	Carmen	Wawa	Tibag	Sta. Barbara
Aug. 28, 1984	2:00	493	252	605	137	166
	5:00	349	243	590	137	162
	8:00	203	292	582	137	162
	11:00	261	261	586	137	159
	14:00	294	282	597	137	157
	17:00	373	282	616	137	166
	20:00	863	292	632	137	192
	23:00	1365	410	651	137	226
Aug. 29	2:00	1925	513	691	147	257
	5:00	2392	513	1523	308	264
	8:00	2581	513	1697	440	265
	11:00	2737	2220	2037	519	265
	14:00	2776	2181	2186	440	265
	17:00	2816	2142	2288	398	265
	20:00	2710	2142	2378	137	265
	23:00	2355	1932	2593	443	265
Aug. 30	2:00	1870	1932	2665	471	265
	5:00	1870	1932	2753	474	265
	8:00	1992	1266	2810	542	265
	11:00	2071	1214	2851	610	265
	14:00	1969	1227	2893	566	265
	17:00	2129	1227	2926	555	264
	20:00	1992	1227	2934	555	264
	23:00	1816	1227	3019	509	264
Aug. 31	2:00	1567	1227	3053	496	264
	5:00	1474	1227	3040	463	263
	8:00	1383	1227	3027	431	263
	11:00	1026	1227	3061	363	262
	14:00	923	1227	2976	346	262
	17:00	871	1227	2737	319	260
	20:00	1050	1273	2689	301	260
	23:00	1002	1112	2641	280	260
Sep. 1	2:00	947	1227	2617	255	259
	5:00	931	1227	2586	240	257
	8:00	923	1227	2523	226	255
	11:00	636	1227	2469	215	252
	14:00	580	1227	2423	197	247
	17:00	611	1227	2363	184	241
	20:00	592	1227	2303	180	234
	23:00	476	1227	2230	163	226
Sep. 2	2:00	533	1227	2179	159	217
	5:00	465	1227	2129	157	209
	8:00	449	1227	2065	147	201
	11:00	449	1227	2009	137	195
	14:00	438	513	1954	137	189
	17:00	418	513	1900	137	182
	20:00	382	513	1866	137	177
	23:00	574	513	1813	137	172
Sep. 3	2:00	498	513	1768	137	168
	5:00	433	513	1723	137	165
	8:00	407	513	1697	137	160
	11:00	339	513	1659	137	154
	14:00	312	513	1560	137	148
	17:00	308	513	1523	137	143
	20:00	290	513	1434	137	138
	23:00	325	513	1365	137	133
Sep. 4	2:00	358	513	1303	137	128
	5:00	282	513	1259	137	124
	8:00	449	513	1221	137	120
	11:00	387	513	1194	137	116
	14:00	444	513	1183	137	113
	17:00	460	513	1189	137	109
	20:00	290	513	1173	137	105
	23:00	237	513	1141	137	102
Sep. 5	2:00	196	513	1090	137	99
	5:00	156	513	1009	137	97
	8:00	156	513	932	137	96
	11:00	156	513	854	137	95
	14:00	363	513	805	137	94
	17:00	498	513	775	137	93
	20:00	286	513	753	[illegible]	91
	23:00	261	513	818	137	89

Table 4.4 BASIN MEAN RAINFALL AT TYPHOON MARING

Rainfall Station (4-day Rainfall)	Adjust-ment Factor	Thiesen Weight at Base Point				
		San Roque	Carmen	Wawa	Tibag	Rivermouth
1. Baguio (826mm)	0.73	0.18	0.09	0.05	-	0.04
2. Ambuklao (538 mm)	1.15	0.70	0.42	0.24	-	0.18
3. San Roque (475 mm)	1.52	0.12	0.12	0.07	-	0.05
4. San Nicolas (381 mm)	1.49	-	0.23	0.13	-	0.09
5. Binalonan (254 mm)	1.00	-	0.01	0.01	-	0.01
6. Balungao (293 mm)	1.08	-	0.12	0.12	-	0.09
7. Carmen (279 mm)	1.00	-	0.01	0.03	-	0.02
8. Wawa (254 mm)	1.00	-	-	0.06	-	0.06
9. Tibag (105 mm)	1.19	-	-	0.20	0.59	0.15
10. Mayantoc (179 mm)	1.28	-	-	0.09	0.41	0.17
11. Mangatarem (273 mm)	1.37	-	-	-	-	0.10
12. Matalava (334 mm)	1.16	-	-	-	-	0.04
Basin Mean 4-day Rainfall (mm)		629	575	413	168	385

Table 4.5 STORAGE FUNCTION OF SUB-BASIN OF AGNO RIVER

Sub-basin No.	Catchment Area (Km2)	River Length (Km)	River Gradient	Coeff. of Storage Function K	Coeff. of Storage Function P	Lag-time (hr)
A01	514	58.5	1 / 40	62.9	0.666	5.0
A02	103	22.5	1 / 10	95.3	0.481	2.0
A03	243	27.5	1 / 20	77.4	0.566	2.0
A04	191	16.5	1 / 20	77.4	0.566	1.0
A05	199	14.0	1 / 10	95.3	0.481	1.0
A06	85	16.5	1 / 20	77.4	0.566	1.0
A07	10	1.1	1 / 1480	21.3	0.990	0.0
A08	151	25.5	1 / 20	77.6	0.565	2.0
A09	119	11.0	1 / 10	95.3	0.481	1.0
A10	40	7.0	1 / 10	95.3	0.481	1.0
A11	53	14.0	1 / 10	95.1	0.482	1.0
A12	7	1.6	1 / 1510	21.2	0.990	0.0
A13	50	17.0	1 / 20	77.4	0.566	1.0
A14	47	12.5	1 / 240	36.7	0.990	2.0
A15	11	8.0	1 / 190	39.4	0.961	1.0
A16	39	14.0	1 / 10	96.4	0.477	1.0
A17	26	8.0	1 / 10	95.3	0.481	1.0
A18	70	18.0	1 / 10	95.3	0.481	1.0
A19	4	0.5	1 / 1630	20.7	0.990	0.0
A20	54	2.2	1 / 1380	21.7	0.990	0.0
A21	119	23.0	1 / 240	36.7	0.990	3.0
A22	73	23.0	1 / 20	77.8	0.564	2.0
A23	4	0.8	1 / 1470	21.3	0.990	0.0
A24	93	27.5	1 / 20	77.4	0.566	2.0
A25	94	17.0	1 / 180	40.0	0.949	2.0
A26	31	17.0	1 / 850	25.1	0.990	2.0
A27	14	3.5	1 / 90	49.3	0.806	0.0
A28	20	1.1	1 / 1450	21.4	0.990	0.0
A29	24	2.2	1 / 1660	20.6	0.990	0.0
A30	119	23.5	1 / 20	77.4	0.566	2.0
A31	39	17.0	1 / 20	77.4	0.566	1.0
A32	120	13.5	1 / 30	68.5	0.623	1.0
A33	25	4.0	1 / 100	47.8	0.826	0.0
A34	283	37.5	1 / 190	39.4	0.961	3.0
A35	254	23.5	1 / 60	55.7	0.733	2.0
A36	21	3.5	1 / 90	49.3	0.806	0.0
A37	155	22.0	1 / 150	42.3	0.909	2.0
A38	102	13.5	1 / 270	35.5	0.990	2.0
A39	778	32.7	1 / 1220	22.6	0.990	4.0
A40	221	27.0	1 / 20	77.2	0.567	2.0
A41	20	5.5	1 / 10	95.3	0.481	0.0
A42	42	11.5	1 / 70	53.2	0.760	1.0
A43	26	8.5	1 / 430	30.8	0.990	1.0
A44	190	31.5	1 / 60	55.7	0.733	3.0
A45	105	29.0	1 / 30	68.5	0.623	2.0
A46	44	8.5	1 / 850	25.1	0.990	1.0
A47	51	2.2	1 / 1340	21.9	0.990	0.0
A48	157	25.5	1 / 20	77.4	0.566	2.0
A49	130	25.5	1 / 20	77.9	0.564	2.0
A50	10	1.5	1 / 1410	21.6	0.990	0.0
A51	78	15.0	1 / 30	68.5	0.623	1.0
A52	64	15.0	1 / 20	77.4	0.566	1.0
A53	8	1.1	1 / 1590	20.8	0.990	0.0
A54	54	11.0	1 / 20	77.4	0.566	1.0
A55	42	3.5	1 / 1660	20.6	0.990	0.0
A56	122	20.5	1 / 30	68.5	0.623	2.0
A57	79	8.5	1 / 10	95.3	0.481	1.0
A58	80	6.0	1 / 1330	22.0	0.990	1.0

Table 4.6 STORAGE FUNCTION OF RIVER CHANNEL UNDER PRESENT RIVER CONDITION OF AGNO RIVER

Channel No.	River Length (km)	River Slope	Storage Function K	Storage Function P	Lag Time (hr)
1	15.0	1/ 70	19264	0.659	1.0
2	23.0	1/ 150	59433	0.608	2.0
3	22.5	1/ 110	84650	0.624	2.0
4	12.0	1/ 190	62208	0.611	1.0
5	0.5	1/ 400	25920	0.611	1.0
6	19.0	1/ 70	13006	0.829 Q < 1800	2.0
			49844	0.645 Q > 1800	
7	5.5	1/ 90	6770	0.761 Q < 5500	0.0
			19798	0.645 Q > 5500	
8	4.2	1/ 140	8243	0.753 Q < 3500	0.0
			19107	0.641 Q > 3500	
9	8.0	1/ 200	16384	0.796 Q < 1000	1.0
			43896	0.653 Q > 1000	1.0
10	7.2	1/ 190	14236	0.748 Q < 800	1.0
			39063	0.602 Q > 800	
11	7.0	1/ 350	11525	0.854 Q < 140	1.0
			29519	0.669 Q > 140	
12	20.5	1/ 840	6839	1.048	3.0
13	9.0	1/ 600	24927	0.661 Q < 150	1.0
			6591	0.931 Q > 150	
14	5.5	1/ 800	18434	0.637 Q < 300	1.0
			2277	1.030 Q > 300	
15	10.5	1/ 800	36868	0.637 Q < 300	1.0
16	15.0	1/1650	13374	0.954 Q < 2300	2.0
			106718	0.685 Q > 2300	
17	18.5	1/1650	23662	0.954 Q < 2300	2.0
			188810	0.685 Q > 2300	
18	15.3	1/ 190	29519	0.669 Q < 550	1.0
			6291	0.923 Q > 550	
19	11.5	1/ 350	29519	0.669 Q < 350	2.0
			3197	1.040 Q > 350	
20	17.8	1/ 180	38147	0.662 Q < 750	2.0
			4000	1.000 Q > 750	
21	9.5	1/ 290	24927	0.661 Q < 400	1.0
			2766	1.026 Q > 400	
22	18.0	1/ 890	308909	0.596	2.0
23	16.5	1/1350	312500	0.602	2.0
24	5.0	1/ 80	10994	0.646 Q < 550	0.0
			1200	1.000 Q > 550	
25	11.0	1/ 130	27977	0.667 Q < 400	1.0
			3258	1.022 Q > 400	
26	21.5	1/1390	95132	0.650 Q < 200	3.0
			17486	0.968 Q > 200	
27	20.0	1/1650	162258	0.597 Q < 3500	3.0
			246	1.388 3500 < Q < 8400	
			50516	0.801 Q > 840	
28	10.2	1/ 600	22606	0.681 Q < 200	1.0
			3582	1.036 Q > 200	
29	6.2	1/ 700	14400	0.699	1.0
30	14.0	1/2320	242532	0.581 Q < 3400	2.0
			33	1.678 3400 < Q < 8200	
			141615	0.752 Q > 8200	
31	19.2	1/7000	334925	0.581 Q < 3400	3.0
			45	1.678 3400 < Q < 8200	
			195563	0.752 Q > 8200	

Table 4.7 TIESEN WEIGHT BY BASE POINT FOR AGNO RIVER BASIN

(1) Type A (Period: 1970-1976, 1978)

Base Point	Rainfall Gauging Station										
	Buguias	Adaoay	Sayangan	Bobok	Baguio	San Nicolas	Binalonan	Balungao	San Miguel	Surgui	Matalava
BP-1	0.04	0.04	0.02	0.05	0.04	0.12	0.01	0.14	0.12	0.34	0.08
BP-2	0.05	0.07	0.02	0.08	0.05	0.20	0.01	0.18	0.16	0.18	-
BP-3	0.08	0.12	0.05	0.18	0.09	0.32	0.03	0.12	-	0.01	-
BP-4	0.17	0.22	0.08	0.23	0.16	0.12	0.01	-	-	-	-
BP-5	-	-	-	-	-	-	-	-	-	1.00	-
BP-6	-	-	-	-	-	-	-	0.23	0.38	0.39	-
BP-7	-	-	-	0.48	-	0.52	-	-	-	-	-

(2) Type B (Period: 1977, 1979 - 1980)

Base Point	Rainfall Gauging Station										
	Bobok	Baguio	Tabeyo	San Nicolas	Binalonan	Balungao	Alcala	San Miguel	Mayantoc	Mangatarem	Matalava
BP-1	0.10	0.03	0.10	0.12	0.01	0.09	0.08	0.10	0.21	0.12	0.04
BP-2	0.13	0.04	0.13	0.21	0.01	0.11	0.11	0.13	0.13	-	-
BP-3	0.28	0.06	0.21	0.31	0.01	0.11	0.02	-	-	-	-
BP-4	0.38	0.10	0.39	0.12	0.01	-	-	-	-	-	-
BP-5	-	-	-	-	-	-	-	-	0.99	0.01	-
BP-6	-	-	-	-	-	0.13	0.22	0.32	0.33	-	-
BP-7	0.48	-	-	0.52	-	-	-	-	-	-	-

(3) Type C (Period: 1981 - 1986)

Base Point	Rainfall Gauging Station									
	Bobok	Baguio	Binalonan	San Nicolas	Balungao	Alcala	Tibag	Mayantoc	Mangatarem	Matalava
BP-1	0.16	0.05	0.01	0.12	0.09	0.07	0.15	0.20	0.11	0.04
BP-2	0.21	0.05	0.01	0.21	0.13	0.09	0.20	0.10	-	-
BP-3	0.47	0.10	0.01	0.30	0.10	0.02	-	-	-	-
BP-4	0.67	0.19	0.01	0.13	-	-	-	-	-	-
BP-5	-	-	-	-	-	-	-	0.99	0.01	-
BP-6	-	-	-	-	0.13	0.19	0.46	0.22	-	-
BP-7	0.66	-	-	0.34	-	-	-	-	-	-

Table 4.8 ADJUSTMENT FACTOR FOR BASIN MEAN ELEVATION

(1) Type A (Period: 1970-1976, 1978)

Base Point	Rainfall Gauging Station										
	Buguias	Adaoay	Sayangan	Bobok	Baguio	San Nicolas	Binalonan	Balungao	San Miguel	Surgui	Matalava
BP-1	1.19	1.39	0.60	1.15	0.55	1.55	1.00	1.13	1.29	1.16	1.25
BP-2	1.19	1.39	0.60	1.15	0.55	1.55	1.00	1.13	1.28	1.27	-
BP-3	1.19	1.39	0.60	1.15	0.55	1.55	1.00	1.16	-	1.00	-
BP-4	1.19	1.39	0.60	1.15	0.55	1.50	1.00	-	-	-	-
BP-5	-	-	-	-	-	-	-	-	-	1.25	-
BP-6	-	-	-	-	-	-	-	1.13	1.28	1.27	-
BP-7	-	-	-	0.96	-	1.50	-	-	-	-	-

(2) Type B (Period: 1977, 1979 - 1980)

Base Point	Rainfall Gauging Station										
	Bobok	Baguio	Tabeyo	San Nicolas	Binalonan	Balungao	Alcala	San Miguel	Mayantoc	Mangatarem	Matalava
BP-1	1.08	0.68	0.98	1.54	1.00	1.14	1.00	1.26	1.17	1.20	1.25
BP-2	1.08	0.68	0.98	1.54	1.00	1.14	1.00	1.26	1.20	-	-
BP-3	1.08	0.68	0.98	1.54	1.00	1.18	1.00	-	-	-	-
BP-4	1.08	0.68	0.98	1.47	1.00	-	-	-	-	-	-
BP-5	-	-	-	-	-	-	-	-	1.21	1.10	-
BP-6	-	-	-	-	-	1.15	1.00	1.26	1.20	-	-
BP-7	1.06	-	-	1.50	-	-	-	-	-	-	-

(3) Type C (Period: 1981 - 1986)

Base Point	Rainfall Gauging Station									
	Bobok	Baguio	Binalonan	San Nicolas	Balungao	Alcala	Tibag	Mayantoc	Mangatarem	Matalava
BP-1	0.95	0.73	1.00	1.54	1.15	1.00	1.23	1.12	1.10	1.25
BP-2	0.95	0.73	1.00	1.54	1.15	1.00	1.23	1.24	-	-
BP-3	0.95	0.73	1.00	1.54	1.24	1.00	-	-	-	-
BP-4	0.96	0.73	1.00	1.54	-	-	-	-	-	-
BP-5	-	-	-	-	-	-	-	1.19	1.00	-
BP-6	-	-	-	-	1.12	1.00	1.23	1.24	-	-
BP-7	0.95	-	-	1.50	-	-	-	-	-	-

Table 4.9 (1/2) ANNUAL MAXIMUM BASIN MEAN 4-DAY RAINFALL AT RIVERMOUTH OF AGNO RIVER (BP-1)

(Unit : mm)

Year	Occurrence Date	Rinafall Gauging Station																Basin Mean
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1970	Jun. 11	7.6	54.6	6.0	13.7	-	11.7	19.7	23.3	26.0	-	10.9	-	13.7	-	-	4.0	20.2
	Jun. 12	25.4	26.2	20.1	31.2	-	46.0	44.9	53.0	59.3	-	27.2	-	34.3	-	-	0.0	41.7
	Jun. 13	25.3	71.7	20.0	107.2	-	70.3	94.1	80.7	84.2	-	56.9	-	68.8	-	-	0.0	80.8
	Jun. 14	27.8	38.6	22.0	28.7	-	52.5	41.3	48.8	54.6	-	18.1	-	22.8	-	-	0.0	35.1
																		(177.8)
1971	Oct. 9	30.7	47.0	64.8	62.0	-	45.9	106.8	89.6	92.5	-	46.2	-	31.0	-	-	0.0	64.0
	Oct. 10	55.1	108.4	24.1	137.2	-	72.7	44.8	58.0	48.7	-	52.0	-	48.7	-	-	0.0	62.9
	Oct. 11	53.3	40.4	15.7	4.6	-	1.3	111.1	91.8	95.5	-	17.3	-	24.4	-	-	0.0	54.0
	Oct. 12	61.0	3.0	36.9	51.6	-	55.0	118.1	95.2	100.4	-	78.7	-	55.1	-	-	0.0	80.1
																		(251.1)
1972	Jul. 17	69.4	100.2	53.8	243.6	-	479.6	190.3	177.5	150.9	-	115.3	-	140.5	-	-	83.3	176.0
	Jul. 18	60.7	92.4	255.3	148.9	-	292.6	141.9	143.5	117.1	-	171.7	-	187.2	-	-	172.5	189.4
	Jul. 19	45.7	75.9	187.0	47.0	-	139.0	104.2	134.9	90.7	-	118.8	-	108.8	-	-	132.1	123.6
	Jul. 20	0.0	0.0	78.3	50.5	-	144.6	102.0	70.6	89.2	-	70.3	-	119.6	-	-	142.6	112.2
																		(601.1)
1973	Oct. 13	9.9	6.1	0.8	42.4	-	7.1	33.9	13.2	36.8	-	12.7	-	15.2	-	-	19.1	25.5
	Oct. 14	2.8	111.8	27.9	1.3	-	3.6	0.0	0.2	0.0	-	0.0	-	0.0	-	-	9.1	8.2
	Oct. 15	37.1	21.1	40.9	110.8	-	53.3	76.5	65.0	71.3	-	207.0	-	102.4	-	-	46.7	114.8
	Oct. 16	21.1	22.4	15.0	41.4	-	74.5	36.7	7.6	39.9	-	20.9	-	33.8	-	-	14.0	37.5
																		(186.0)
1974	Aug. 14	20.3	73.9	30.4	44.9	-	38.4	29.2	20.3	31.7	-	40.9	-	40.2	-	-	29.2	44.9
	Aug. 15	70.8	124.7	30.0	109.8	-	136.7	188.1	105.1	149.4	-	142.5	-	157.0	-	-	186.7	182.2
	Aug. 16	61.7	40.1	29.2	100.6	-	188.5	233.5	189.5	181.1	-	240.8	-	276.6	-	-	294.4	264.3
	Aug. 17	10.2	22.1	22.0	70.9	-	101.8	42.8	53.4	46.5	-	52.8	-	79.5	-	-	287.8	92.3
																		(583.6)
1975	Aug. 10	67.0	16.5	76.2	111.5	-	163.6	79.3	50.3	1.0	-	26.0	-	78.7	-	-	68.6	71.7
	Aug. 11	76.5	10.4	79.8	23.4	-	39.4	2.8	2.0	63.2	-	0.3	-	5.9	-	-	5.3	21.0
	Aug. 12	70.9	7.1	25.4	8.4	-	15.2	3.1	1.8	0.0	-	3.3	-	1.0	-	-	1.8	6.7
	Aug. 13	89.7	40.6	125.7	16.5	-	42.0	21.3	52.6	0.8	-	12.7	-	41.9	-	-	24.9	35.4
																		(134.7)
1976	May 22	63.7	46.5	59.7	45.7	-	19.6	106.7	0.0	250.2	-	97.0	-	179.9	-	-	23.1	156.8
	May 23	83.6	225.0	102.9	84.6	-	67.8	124.7	0.0	106.7	-	161.1	-	100.0	-	-	103.9	139.8
	May 24	91.5	317.0	265.7	179.1	-	201.9	101.6	0.0	312.5	-	126.0	-	191.8	-	-	214.1	225.7
	May 25	199.1	178.3	675.1	343.0	-	605.3	0.0	0.0	182.9	-	90.4	-	117.4	-	-	150.1	164.6
																		(686.9)
1977	Jul. 21	-	-	-	38.1	53.6	9.2	2.0	0.8	38.3	5.6	32.5	-	-	7.9	9.1	0.0	21.5
	Jul. 22	-	-	-	22.9	5.9	14.0	10.7	30.5	6.3	9.4	6.9	-	-	6.6	7.6	48.3	13.1
	Jul. 23	-	-	-	82.6	82.1	216.0	103.7	62.2	74.4	3.6	8.9	-	-	19.8	22.8	47.5	61.2
	Jul. 24	-	-	-	38.4	62.8	42.8	26.9	60.0	3.8	0.0	9.7	-	-	29.5	33.9	48.5	33.2
																		(129.0)
1978	Aug. 22	38.4	63.7	30.3	4.0	-	29.4	53.3	1.3	8.4	-	22.3	-	49.8	-	-	3.8	41.2
	Aug. 23	68.9	99.8	95.8	214.4	-	534.2	197.6	148.0	130.8	-	88.1	-	46.8	-	-	124.5	136.7
	Aug. 24	129.8	154.6	277.5	200.7	-	285.6	80.2	119.2	83.3	-	106.4	-	44.0	-	-	129.3	112.4
	Aug. 25	124.4	149.7	261.3	29.2	-	38.0	13.0	1.0	8.6	-	13.5	-	4.6	-	-	22.9	30.3
																		(320.6)

Remarks ; 1: Buguias 2: Adaoay 3: Sayangan 4: Bobok
5: Tabeyo 6: Baguio 7: San Nicolas 8: Binalonan
9: Balungao 10: Alcala 11: San Miguel 12: Tibag
13: Surgui 14: Mayantoc 15: Mangatarem 16: Matalava

Table 4.9 (2/2) ANNUAL MAXIMUM BASIN MEAN 4-DAY RAINFALL AT RIVERMOUTH OF AGNO RIVER (BP-1)

(Unit : mm)

Year	Occurrence Date	Rinafall Gauging Station																Basin Mean
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1979	Aug. 13	-	-	-	15.0	23.1	96.1	44.2	39.4	5.1	6.1	26.6	-	-	16.8	18.5	3.1	25.8
	Aug. 14	-	-	-	16.6	62.5	285.4	134.1	50.3	49.0	26.4	28.8	-	-	116.1	110.5	62.9	97.9
	Aug. 15	-	-	-	68.6	44.3	75.8	65.3	86.9	79.8	102.1	173.2	-	-	218.8	198.6	160.3	154.2
	Aug. 16	-	-	-	8.9	13.7	81.3	18.8	42.5	21.6	29.0	26.0	-	-	161.1	149.1	102.1	81.8
																		(359.7)
1980	Nov. 3	-	-	-	22.9	0.0	2.0	0.0	0.0	14.7	0.0	0.0	-	-	0.0	0.0	0.0	4.0
	Nov. 4	-	-	-	133.4	133.7	64.8	50.8	41.7	83.9	45.5	68.4	-	-	23.6	25.9	0.0	69.7
	Nov. 5	-	-	-	496.6	280.2	698.7	280.6	102.6	141.2	22.6	141.2	-	-	95.7	93.0	86.3	225.1
	Nov. 6	-	-	-	44.4	4.6	99.5	0.0	0.0	12.2	1.5	0.6	-	-	0.0	0.0	31.5	19.3
																		(309.1)
1981	Jun. 10	-	-	-	48.2	-	47.4	16.0	15.0	18.0	21.6	-	60.8	-	36.5	40.1	45.0	38.6
	Jun. 11	-	-	-	25.4	-	52.7	16.6	50.1	17.8	0.0	-	61.2	-	43.7	48.0	45.3	38.5
	Jun. 12	-	-	-	59.7	-	126.0	55.6	60.5	48.3	34.3	-	96.3	-	93.8	91.4	84.6	91.0
	Jun. 13	-	-	-	58.4	-	73.8	52.6	65.6	64.0	50.6	-	63.0	-	83.6	82.6	46.7	73.7
																		(241.8)
1982	Jun. 30	-	-	-	0.0	-	64.4	0.0	4.1	67.6	9.9	-	55.5	-	21.3	23.4	41.1	24.3
	Jul. 1	-	-	-	16.5	-	101.8	36.0	50.6	0.0	30.0	-	110.4	-	42.3	46.5	101.6	40.9
	Jul. 2	-	-	-	60.9	-	164.4	35.6	11.4	2.5	44.5	-	181.0	-	90.3	88.4	186.7	73.1
	Jul. 3	-	-	-	28.9	-	116.0	13.2	16.7	0.0	0.0	-	134.2	-	85.9	84.6	130.3	59.0
																		(197.2)
1983	Aug. 12	-	-	-	93.2	-	145.4	40.2	52.6	18.1	19.6	-	42.3	-	43.7	48.0	31.4	60.8
	Aug. 13	-	-	-	79.5	-	103.9	29.8	24.4	22.8	27.7	-	59.8	-	35.6	39.1	44.3	50.6
	Aug. 14	-	-	-	114.2	-	208.8	32.8	99.8	103.6	78.5	-	114.0	-	130.9	123.2	105.9	104.8
	Aug. 15	-	-	-	72.7	-	83.6	42.4	60.8	44.9	59.7	-	103.4	-	73.4	73.9	93.1	76.0
																		(292.2)
1984	Aug. 27	-	-	-	43.4	-	35.3	30.2	11.4	102.1	3.6	-	81.3	-	54.2	57.4	66.6	47.8
	Aug. 28	-	-	-	171.4	-	381.8	212.6	158.8	114.6	79.0	-	123.9	-	125.3	118.4	117.9	189.4
	Aug. 29	-	-	-	136.7	-	276.7	67.0	76.7	61.7	17.0	-	104.5	-	43.0	47.2	94.5	95.2
	Aug. 30	-	-	-	88.7	-	131.9	71.2	7.1	14.2	14.5	-	71.6	-	45.0	49.5	54.9	67.5
																		(399.9)
1985	Jun. 20	-	-	-	52.2	-	42.4	24.7	0.3	26.9	88.4	-	36.0	-	34.5	39.6	26.7	41.4
	Jun. 21	-	-	-	134.4	-	269.9	119.8	226.8	101.6	99.6	-	59.0	-	85.7	83.1	43.7	116.2
	Jun. 22	-	-	-	145.9	-	304.6	119.1	105.2	101.1	88.9	-	56.7	-	108.2	99.3	42.0	128.6
	Jun. 23	-	-	-	95.4	-	152.2	103.5	60.2	90.2	4.6	-	65.9	-	105.0	97.0	48.8	103.2
																		(389.4)
1986	Jul. 8	-	-	-	172.2	-	384.0	162.7	104.4	131.6	121.3	-	166.9	-	113.0	102.7	169.7	208.3
	Jul. 9	-	-	-	218.8	-	525.0	137.9	59.7	114.3	107.2	-	127.2	-	80.7	79.5	121.9	164.3
	Jul. 10	-	-	-	80.5	-	107.0	116.2	20.9	99.1	94.8	-	96.7	-	89.6	85.9	85.1	100.7
	Jul. 11	-	-	-	3.7	-	3.0	19.7	0.0	21.4	23.5	-	0.0	-	8.7	10.0	0.0	11.3
																		(484.5)

Remarks ; 1: Buguias 2: Adaoay 3: Sayangan 4: Bobok
5: Tabeyo 6: Baguio 7: San Nicolas 8: Binaloman
9: Balungao 10: Alcala 11: San Miguel 12: Tibag
13: Surgui 14: Mayantoc 15: Mangatarem 16: Matalava

Table 4.10 (1/2) ANNUAL MAXIMUM BASIN MEAN 4-DAY RAINFALL AT RIVERMOUTH OF CAYANGA-PATALAR RIVER (BP-8)

(Unit : mm)

Year	Occurrence Date	Rinafall Gauging Station Basin								Mean
		1	2	3	4	5	6	7	8	
1970	Jun. 11	11.7	56.6	23.3	-	35.4	24.9	-	-	25.6
	Jun. 12	46.0	121.0	53.0	-	88.5	54.9	-	-	63.4
	Jun. 13	70.3	163.3	80.7	-	146.2	92.6	-	-	95.9
	Jun. 14	52.5	118.5	48.8	-	58.9	45.3	-	-	58.7
										(243.7)
1971	Jul. 17	48.0	69.1	28.4	-	109.9	4.1	-	-	47.3
	Jul. 18	37.9	134.2	61.6	-	14.9	31.5	-	-	56.9
	Jul. 19	379.5	102.1	42.0	-	150.4	70.1	-	-	149.3
	Jul. 20	303.7	30.9	12.7	-	161.1	51.0	-	-	108.7
										(362.3)
1972	Jul. 17	479.6	310.6	177.5	-	320.0	147.8	-	-	286.3
	Jul. 18	292.6	258.8	143.5	-	314.5	170.8	-	-	216.7
	Jul. 19	139.0	245.7	134.9	-	231.8	156.8	-	-	161.2
	Jul. 20	144.6	147.8	70.6	-	253.2	183.4	-	-	124.7
										(788.9)
1973	Oct. 6	22.8	54.4	22.4	-	35.2	26.2	-	-	27.8
	Oct. 7	379.7	29.6	12.2	-	136.3	99.9	-	-	126.3
	Oct. 8	126.4	108.6	44.7	-	110.8	37.5	-	-	80.7
	Oct. 9	32.5	4.1	1.7	-	17.4	11.2	-	-	12.1
										(246.9)
1974	Aug. 14	38.4	49.3	20.3	-	112.7	25.5	-	-	39.8
	Aug. 15	136.7	200.4	105.1	-	236.7	194.5	-	-	143.3
	Aug. 16	188.5	328.9	189.5	-	371.5	260.0	-	-	230.0
	Aug. 17	101.8	121.6	53.4	-	155.1	108.4	-	-	87.9
										(501.0)
1975	Aug. 10	163.6	116.9	50.3	-	131.3	68.1	-	-	97.4
	Aug. 11	39.4	4.9	2.0	-	26.7	20.1	-	-	15.5
	Aug. 12	15.2	4.4	1.8	-	9.3	6.4	-	-	6.6
	Aug. 13	42.0	120.4	52.6	-	28.3	32.3	-	-	53.8
										(173.3)
1976	Jun. 28	109.7	116.2	47.8	-	11.8	38.1	-	-	66.5
	Jun. 29	333.7	180.4	92.0	-	64.8	79.9	-	-	159.8
	Jun. 30	386.4	342.0	198.1	-	182.9	140.4	-	-	258.3
	Jul. 1	76.9	57.3	23.6	-	55.5	14.5	-	-	44.7
										(529.3)
1977	Sep. 15	359.1	158.6	77.7	-	0.0	92.7	-	-	149.5
	Sep. 16	116.2	180.7	92.2	-	0.0	60.7	-	-	95.8
	Sep. 17	67.3	29.2	12.0	-	0.0	57.9	-	-	28.1
	Sep. 18	115.0	40.6	16.7	-	83.9	33.9	-	-	53.4
										(326.8)
1978	Aug. 21	42.2	103.3	42.5	-	28.9	42.6	-	-	47.6
	Aug. 22	29.4	3.2	1.3	-	31.3	2.8	-	-	12.5
	Aug. 23	534.2	265.7	148.0	-	142.5	169.7	-	-	259.8
	Aug. 24	286.6	221.8	119.2	-	189.6	153.5	-	-	183.1
										(503.0)

Remarks : 1: Baguio 2: San Roque 3: Binaloan 4: Alcala
5: Sta.Barbara 6: Dagupan 7: Matalava 8: Mangatarem

Table 4.10 (2/2) ANNUAL MAXIMUM BASIN MEAN 4-DAY RAINFALL AT RIVERMOUTH OF CAYANGA-PATALAR RIVER (BP-8)

(Unit : mm)

Year	Occurrence Date	Rinafall Gauging Station Basin								Mean
		1	2	3	4	5	6	7	8	
1979	Aug. 13	96.1	95.7	39.4	-	37.4	7.7	-	-	58.9
	Aug. 14	285.4	116.9	50.3	-	206.9	47.0	-	-	137.1
	Aug. 15	75.8	172.6	86.9	-	361.2	162.5	-	-	130.4
	Aug. 16	81.3	103.3	42.5	-	274.5	141.4	-	-	91.4
										(417.8)
1980	Nov. 3	2.0	0.0	0.0	-	0.0	0.0	-	-	0.5
	Nov. 4	64.8	101.3	41.7	-	52.3	24.2	-	-	55.0
	Nov. 5	698.7	196.5	102.6	-	176.3	103.0	-	-	274.4
	Nov. 6	99.5	0.0	0.0	-	0.0	0.0	-	-	25.4
										(355.4)
1981	Jun. 10	47.4	36.5	15.0	-	81.0	43.6	-	-	34.8
	Jun. 11	52.7	116.6	50.1	-	97.0	52.8	-	-	64.2
	Jun. 12	126.0	132.4	60.5	-	173.5	126.6	-	-	101.6
	Jun. 13	73.8	140.2	65.6	-	158.1	59.9	-	-	87.4
										(288.0)
1982	Jun. 30	64.4	10.0	4.1	-	47.3	23.9	-	-	26.2
	Jul. 1	101.8	117.3	50.6	-	93.9	91.0	-	-	77.9
	Jul. 2	164.4	27.7	11.4	-	168.2	88.8	-	-	74.4
	Jul. 3	116.0	40.6	16.7	-	161.6	96.8	-	-	65.4
										(243.9)
1983	Aug. 12	145.4	120.4	52.6	-	97.0	70.6	-	-	90.0
	Aug. 13	103.9	59.3	24.4	-	79.0	53.6	-	-	56.4
	Aug. 14	208.8	192.3	99.8	-	229.2	41.0	-	-	152.1
	Aug. 15	83.6	132.9	60.8	-	142.9	82.0	-	-	85.7
										(384.2)
1984	Aug. 26	33.4	134.7	62.0	-	12.9	49.6	-	-	56.4
	Aug. 27	35.3	27.7	11.4	-	114.0	8.0	-	-	32.0
	Aug. 28	381.8	282.1	158.8	-	220.8	232.2	-	-	239.8
	Aug. 29	276.7	157.1	76.7	-	96.3	127.4	-	-	140.8
										(469.0)
1985	Jun. 20	42.4	0.7	0.3	-	80.1	76.5	-	-	23.6
	Jun. 21	269.9	385.7	226.8	-	158.9	135.2	-	-	244.2
	Jun. 22	304.6	202.0	106.2	-	187.3	85.3	-	-	177.0
	Jun. 23	152.2	132.0	60.2	-	183.3	52.0	-	-	106.8
										(551.5)
1986	Jul. 8	384.0	199.3	104.4	-	193.3	376.8	-	-	206.7
	Jul. 9	525.0	131.2	59.7	-	152.7	173.8	-	-	201.9
	Jul. 10	107.0	50.8	20.9	-	163.9	62.4	-	-	65.4
	Jul. 11	3.0	0.0	0.0	-	20.3	0.0	-	-	3.3
										(477.2)

Remarks ; 1: Baguio 2: San Roque 3: Binalonan 4: Alcala
5: Sta.Barbara 6: Dagupan 7: Matalava 8: Mangatarem

Table 4.11 (1/2) ANNUAL MAXIMUM BASIN MEAN 4-DAY RAINFALL AT RIVERMOUTH OF PANTOL-SINOCALAN RIVER

(Unit : mm)

Year	Occurrence Date	Rinafall Gauging Station Basin								Mean
		1	2	3	4	5	6	7	8	
1970	Jun. 11	-	56.6	23.3	54.6	35.4	24.9	4.0	17.5	30.8
	Jun. 12	-	121.0	53.0	26.2	88.5	54.9	0.0	43.8	47.7
	Jun. 13	-	163.3	80.7	71.7	146.2	92.6	0.0	75.8	69.0
	Jun. 14	-	118.5	48.8	38.6	58.9	45.3	0.0	29.1	40.6
										(229.5)
1971	Oct. 8	-	162.6	80.3	72.4	60.9	0.0	0.0	30.1	61.8
	Oct. 9	-	176.8	89.6	47.0	110.8	50.6	0.0	55.6	68.1
	Oct. 10	-	128.5	58.0	108.4	146.7	46.5	0.0	76.1	64.7
	Oct. 11	-	180.0	91.8	40.4	88.4	2.5	0.0	43.8	64.2
										(298.9)
1972	Jul. 16	-	109.1	44.9	93.6	154.3	31.2	49.0	80.5	72.4
	Jul. 17	-	310.6	177.5	100.2	320.0	147.8	83.3	175.1	148.9
	Jul. 18	-	259.8	143.5	92.4	314.5	170.8	172.5	171.9	138.5
	Jul. 19	-	245.7	134.9	75.9	231.8	156.8	132.1	124.7	123.8
										(578.7)
1973	Oct. 5	-	0.0	0.0	33.1	18.5	0.0	0.0	9.1	8.6
	Oct. 6	-	54.4	22.4	67.1	35.2	26.2	15.0	17.4	36.1
	Oct. 7	-	29.6	12.2	67.6	136.3	99.9	48.2	70.2	41.4
	Oct. 8	-	108.6	44.7	40.7	110.8	37.5	37.9	55.6	44.7
										(178.6)
1974	Aug. 14	-	49.3	20.3	73.9	112.7	25.5	29.2	56.7	46.1
	Aug. 15	-	200.4	105.1	124.7	236.7	194.5	186.7	127.5	134.0
	Aug. 16	-	328.9	189.5	40.1	371.5	260.0	294.4	204.5	164.7
	Aug. 17	-	121.6	53.4	22.1	155.1	108.4	287.8	80.9	76.5
										(526.9)
1975	Aug. 12	-	4.4	1.8	7.1	9.3	6.4	1.8	4.6	4.6
	Aug. 13	-	120.4	52.6	40.6	28.3	32.3	24.9	14.0	46.0
	Aug. 14	-	48.6	20.0	31.6	92.3	51.9	80.0	45.7	35.0
	Aug. 15	-	11.9	4.9	17.9	61.6	20.4	50.8	30.5	15.0
										(131.3)
1976	May 22	-	0.0	0.0	46.5	150.5	59.6	23.1	78.3	31.9
	May 23	-	0.0	0.0	225.0	219.9	29.9	103.9	117.9	76.7
	May 24	-	0.0	0.0	317.0	252.9	286.5	214.1	136.7	126.6
	May 25	-	0.0	0.0	178.3	351.6	368.0	150.1	193.1	89.7
										(436.1)
1977	Sep. 15	-	158.6	77.7	50.1	0.0	92.7	62.0	0.0	60.5
	Sep. 16	-	180.7	92.2	29.1	0.0	60.7	66.8	0.0	61.4
	Sep. 17	-	29.2	12.0	37.0	0.0	57.9	65.6	0.0	27.3
	Sep. 18	-	40.6	16.7	30.2	83.9	33.9	28.2	41.5	23.6
										(187.3)
1978	Aug. 21	-	103.3	42.5	33.7	28.9	42.6	44.2	14.3	40.0
	Aug. 22	-	3.2	1.3	63.7	31.3	2.8	3.8	15.5	21.1
	Aug. 23	-	266.7	148.0	99.8	142.5	169.7	124.5	73.7	126.2
	Aug. 24	-	221.8	119.2	154.6	189.6	153.5	129.3	100.6	117.9
										(367.4)

Remarks ; 1: Baguio 2: San Roque 3: Binaloran 4: Alcala
5: Sta.Barbara 6: Dagupan 7: Matalava 8: Mangatarem

Table 4.11 (2/2) ANNUAL MAXIMUM BASIN MEAN 4-DAY RAINFALL AT RIVERMOUTH OF PANTOL-SINOCALAN RIVER

(Unit : mm)

Year	Occurrence Date	Rinafall Gauging Station Basin								Mean
		1	2	3	4	5	6	7	8	
1979	Aug. 13	-	95.7	39.4	35.8	37.4	7.7	3.1	18.5	41.3
	Aug. 14	-	116.9	50.3	83.9	206.9	47.0	62.9	110.5	79.8
	Aug. 15	-	172.6	86.9	68.7	361.2	162.5	160.3	198.6	112.6
	Aug. 16	-	103.3	42.5	21.2	274.5	141.4	102.1	149.1	60.4
										(418.0)
1980	Jul. 18	-	14.3	5.9	26.0	23.0	5.4	20.3	11.4	12.2
	Jul. 19	-	164.3	81.4	0.0	16.4	3.5	7.9	8.1	44.8
	Jul. 20	-	187.1	96.4	86.1	43.6	65.0	46.5	21.6	76.6
	Jul. 21	-	120.0	52.3	98.4	62.0	117.7	116.1	30.7	68.2
										(221.9)
1981	Jun. 10	-	36.5	15.0	83.2	81.0	43.6	45.0	40.1	38.9
	Jun. 11	-	116.6	50.1	50.0	97.0	52.8	45.3	48.0	57.0
	Jun. 12	-	132.4	60.5	86.4	173.5	126.6	84.6	91.4	79.6
	Jun. 13	-	140.2	65.6	86.2	158.1	59.9	46.7	82.6	68.1
										(306.0)
1982	Jun. 30	-	10.0	4.1	0.0	47.3	23.9	41.1	23.4	14.0
	Jul. 1	-	117.3	50.6	32.5	93.9	91.0	101.6	46.5	61.3
	Jul. 2	-	27.7	11.4	86.7	168.2	88.8	186.7	88.4	61.7
	Jul. 3	-	40.6	16.7	56.9	161.6	96.8	130.3	84.6	48.2
										(247.2)
1983	Aug. 12	-	120.4	52.6	93.5	97.0	70.6	31.4	48.0	61.2
	Aug. 13	-	59.3	24.4	90.6	79.0	53.6	44.3	39.1	52.8
	Aug. 14	-	192.3	99.8	98.0	229.2	41.0	105.9	123.2	97.7
	Aug. 15	-	132.9	60.8	89.2	142.9	82.0	93.1	73.9	73.2
										(355.3)
1984	Aug. 26	-	134.7	62.0	78.7	12.9	49.6	19.1	6.4	58.0
	Aug. 27	-	27.7	11.4	80.2	114.0	8.0	66.6	57.4	44.1
	Aug. 28	-	282.1	158.8	110.1	220.8	232.2	117.9	118.4	135.0
	Aug. 29	-	157.1	76.7	102.7	95.3	127.4	94.5	47.2	83.8
										(380.8)
1985	Jun. 20	-	0.7	0.3	84.8	80.1	76.5	26.7	39.6	34.1
	Jun. 21	-	385.7	226.8	102.3	158.9	135.2	43.7	83.1	151.2
	Jun. 22	-	202.0	106.2	104.7	187.3	85.3	42.0	99.3	98.0
	Jun. 23	-	132.0	60.2	94.0	183.3	52.0	48.8	97.0	67.1
										(421.1)
1986	Jul. 7	-	0.0	0.0	10.9	0.0	25.0	0.0	0.0	12.6
	Jul. 8	-	199.3	104.4	110.3	193.3	376.8	169.7	102.7	126.8
	Jul. 9	-	131.2	59.7	120.1	152.7	173.8	121.9	79.5	91.2
	Jul. 10	-	50.8	20.9	90.8	163.9	62.4	85.1	85.9	49.5
										(340.2)

Remarks ; 1: Baguio 2: San Roque 3: Binalonan 4: Alcala
5: Sta.Barbara 6: Dagupan 7: Matalava 8: Mangatarem

Table 4.12 PROBABLE BASIN MEAN RAINFALL BY BASE POINT

(Unit: mm)

Base Point	Return Period (Year)							
	1.05	2	5	10	25	50	100	200
1-Day								
BP-1	71	142	202	242	295	334	375	416
BP-2	71	148	214	260	319	364	411	458
BP-3	74	159	236	291	364	421	479	540
BP-4	68	158	251	323	425	510	603	704
BP-5	99	147	203	249	316	378	445	521
BP-6	64	140	208	256	320	369	420	473
BP-7	88	178	268	338	437	519	609	706
BP-8	90	176	246	294	355	401	447	494
BP-9	81	138	182	210	244	269	294	319
2-Day								
BP-1	96	216	326	405	509	590	674	761
BP-2	98	227	346	431	546	635	728	826
BP-3	112	251	376	465	583	675	770	868
BP-4	106	252	389	488	622	727	837	952
BP-5	130	221	325	410	537	648	774	917
BP-6	98	207	316	399	517	613	718	833
BP-7	124	277	415	513	643	745	849	958
BP-8	142	282	400	480	582	660	739	819
BP-9	116	227	319	381	460	519	579	640
3-Day								
BP-1	110	263	408	514	657	769	887	1,010
BP-2	118	277	426	533	678	792	910	1,034
BP-3	130	302	462	577	732	854	980	1,112
BP-4	133	308	471	588	746	869	997	1,131
BP-5	130	268	421	546	733	896	1,080	1,288
BP-6	116	252	397	512	681	825	984	1,162
BP-7	145	330	500	621	783	910	1,041	1,178
BP-8	168	337	478	574	697	791	886	983
BP-9	144	277	385	457	550	619	689	759
4-Day								
BP-1	126	301	466	586	747	875	1,008	1,147
BP-2	138	319	486	606	766	891	1,022	1,158
BP-3	157	344	511	629	784	904	1,028	1,156
BP-4	154	342	512	632	791	914	1,042	1,174
BP-5	147	305	482	629	849	1,041	1,259	1,506
BP-6	130	287	454	586	780	944	1,125	1,327
BP-7	177	374	545	664	818	927	1,059	1,183
BP-8	199	378	521	617	738	829	920	1,012
BP-9	157	308	433	517	625	707	789	873

Table 4.13 STORAGE FUNCTION OF RIVER CHANNEL UNDER CONFINING DIKE CONDITION OF AGNO RIVER

Channel No.	Storage Function K	Storage Function P		Lag Time (hr)
1	19,264	0.659		1.0
2	59,433	0.608		2.0
3	84,850	0.624		2.0
4	43,896	0.653	Q<1700	1.0
	81	1.523	1700<Q<3000	
	20,250	0.824	Q>3000	
5	26,053	0.628	Q<1200	1.0
	38	1.566	1200<Q<2100	
	13,107	0.769	Q>2100	
6	13,006	0.829	Q<1800	2.0
	49,844	0.645	Q>1800	
7	6,770	0.761	Q<5500	0.0
	19,798	0.645	Q>5500	
8	8,243	0.753	Q<3500	0.0
	19,107	0.641	Q>3500	
9	16,384	0.796	Q<1000	1.0
	43,896	0.653	Q>1000	
10	13,223	0.664	Q<250	1.0
	1,447	1.079	250<Q<450	
	20,503	0.648	Q>450	
11	24,350	0.615	Q<310	1.0
	293	1.359	310<Q<700	
	49,875	0.602	Q>700	
12	165,888	0.620	Q<1200	3.0
	29	1.845	1200<Q<2000	
	161,945	0.717	Q>2000	
13	46,875	0.602		1.0
14	25,453	0.624		1.0
15	31,069	0.671		1.0
16	156,250	0.602	Q<1200	2.0
	420	1.444	1200<Q<2300	
	219,479	0.653	Q>2300	
17	147,595	0.669		
18	29,519	0.669	Q<550	1.0
	6,291	0.923	Q>550	
19	29,519	0.669	Q<350	2.0
	3,197	1.040	Q>350	
20	38,147	0.662	Q<750	2.0
	4,000	1.000	Q>750	
21	24,927	0.661	Q<400	1.0
	2,766	1.026	Q>400	
22	145,094	0.613	Q<1200	2.0
	82	1.673	1200<Q<1700	
	55,783	0.789	Q<1700	
23	228,766	0.561	Q<900	
	23,840	0.888	Q>900	
24	148,698	0.561	Q<900	1.0
	15,496	0.888	Q>900	
25	10,994	0.646	Q<550	0.0
	1,200	1.000	Q>550	
26	27,977	0.667	Q<400	1.0
	3,258	1.022	Q>400	
27	117,188	0.602	Q<200	3.0
	52,488	0.745	Q>200	
28	234,375	0.602	Q<2300	3.0
	29,282	0.959	2300<Q<6000	
	177,799	0.716	Q>6000	
29	35,570	0.632		1.0
30	25,453	0.624		1.0
31	203,125	0.602	Q<2600	2.0
	9	1.879	2600<Q<6000	
	69,409	0.834	Q<6000	
32	266,778	0.632	Q<2400	
	49	1.727	2400<Q<5000	3.0
	113,225	0.817	Q>5000	

Table 4.14 STORAGE FUNCTION OF RIVER CHANNEL UNDER CONFINING DIKE CONDITION OF ALLIED RIVERS

Channel No.	River Length (Km)	River Slope	K	P		Lag Time (hr)
Panto River						
1.	4.9	1 / 80	8,059	0.646		0.0
2.	6.0	1 / 130	14,655	0.660		1.0
3.	6.5	1 / 350	27,984	0.638		1.0
4.	6.0	1 / 900	18,662	0.677		1.0
5.	17.5	1 / 580	18,662	0.677		2.0
6.	6.8	1 / 900	31,668	0.607	Q < 500	1.0
			10,198	0.784	Q > 500	
7.	12.5	1 / 860	52,107	0.628	Q < 600	2.0
			21,041	0.760	Q > 600	
8.	3.5	1 / 860	19,753	0.653		0.0
9.	5.4	1 / 1910	35,333	0.626		1.0
10.	18.0	1 / 1050	59,038	0.669		2.0
11.	24.5	1 / 1870	96,318	0.672		3.0
12.	9.5	1 / 1910	62,248	0.632		1.0
13.	8.0	1 / 1500	24,138	0.712		1.0
14.	7.8	1 / 1500	27,364	0.685		1.0
15.	7.1	1 / 1500	34,333	0.626		1.0
16.	2.5	1 / 1910	12,463	0.661		0.0
Cayanga River						
1.	11.3	1 / 420	35,138	0.658	Q < 400	1.0
			23,427	0.733	Q > 400	
2.	12.5	1 / 1090	68,667	0.626		2.0
3.	14.0	1 / 700	57,078	0.656		2.0
4.	10.0	1 / 1270	45,756	0.636	Q < 250	1.0
			38,896	0.678	Q > 250	
5.	18.0	1 / 220	106,209	0.616		2.0
6.	6.0	1 / 1270	36,868	0.637		1.0

Table 4.15 STORAGE FUNCTION OF SUB-BASIN OF ALLIED RIVERS

Sub-basin No.	Catchment Area (Km2)	River Gradient	Coeff. of Storage Function K	Coeff. of Storage Function P	Lag-time (hr)
P01	75	1 / 20	48.38	0.354	1.0
P02	15	1 / 40	39.30	0.416	1.0
P03	21	1 / 20	48.38	0.354	0.0
P04	16	1 / 40	39.30	0.416	1.0
P05	40	1 / 150	26.43	0.568	1.0
P06	15	1 / 1470	13.33	0.971	0.0
P07	33	1 / 40	39.30	0.416	1.0
P08	30	1 / 600	17.44	0.787	2.0
P09	34	1 / 900	15.44	0.866	2.0
P10	24	1 / 740	16.38	0.827	2.0
P11	44	1 / 2750	11.04	0.990	1.0
P12	10	1 / 1320	13.77	0.947	0.0
P13	54	1 / 400	19.69	0.715	3.0
P14	29	1 / 520	18.20	0.761	2.0
P15	12	1 / 1630	12.92	0.995	0.0
P16	39	1 / 700	16.65	0.816	2.0
P17	98	1 / 100	29.85	0.516	0.0
P18	60	1 / 1370	13.61	0.955	0.0
P19	8	1 / 1420	13.47	0.963	0.0
P20	83	1 / 2800	10.99	0.990	2.0
P21	113	1 / 610	17.35	0.790	3.0
P22	19	1 / 1390	13.55	0.959	0.0
P23	53	1 / 3600	10.19	0.990	2.0
P24	57	1 / 1520	13.20	0.979	0.0
P25	20	1 / 1610	12.97	0.992	0.0
P26	4	1 / 1450	13.38	0.968	0.0
P27	76	1 / 1500	13.25	0.976	0.0
P28	31	1 / 1610	12.97	0.992	0.0
C01	66	1 / 20	48.38	0.354	1.0
C02	30	1 / 330	20.86	0.684	2.0
C03	48	1 / 470	18.76	0.743	1.0
C04	55	1 / 90	30.81	0.504	1.0
C05	17	1 / 20	43.38	0.354	0.0
C06	44	1 / 380	20.00	0.707	1.0
C07	38	1 / 210	23.89	0.615	2.0
C08	180	1 / 30	42.84	0.389	3.0
C09	67	1 / 30	42.84	0.389	1.0
C10	39	1 / 140	26.99	0.559	0.0
C11	34	1 / 600	17.44	0.787	1.0

Table 5.1 MONTHLY BASIN MEAN RAINFALL AT SAN ROQUE

(Unit: mm)

YEAR	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1960	50	113	64	204	232	408	335	1531	441	186	37	5	3606
1961	0	0	125	76	210	471	774	566	389	152	83	1	2847
1962	0	5	26	83	144	223	990	574	557	91	77	1	2772
1963	8	2	35	28	120	781	302	362	788	29	27	64	2546
1964	1	1	27	71	227	452	292	1220	579	376	276	431	3952
1965	5	9	85	144	336	346	634	224	431	191	49	0	2455
1966	16	18	45	66	872	248	316	503	609	87	279	70	3127
1967	18	5	9	209	190	1108	707	1095	621	1140	244	2	5347
1968	12	0	56	139	301	349	1028	1697	1254	64	33	0	4932
1969	20	2	11	82	375	375	1277	747	647	300	60	22	3919
1970	46	16	73	115	380	572	575	665	648	446	158	63	3757
1971	6	26	69	120	290	699	1231	670	440	569	157	127	4405
1972	24	4	52	187	301	846	2415	773	371	60	86	25	5143
1973	12	10	63	60	427	336	270	628	287	495	108	42	2737
1974	63	8	76	169	238	482	314	985	233	1089	280	55	3992
1975	27	6	43	50	282	207	195	629	389	268	40	46	2182
1976	18	11	49	63	1067	1207	403	357	571	161	32	6	3946
1977	3	0	3	4	164	242	503	535	541	61	163	0	2218
1978	1	0	24	121	212	484	470	1106	551	449	28	47	3492
1979	0	0	2	42	290	177	487	478	263	153	22	29	1944
1980	2	0	39	36	400	90	715	244	431	256	579	3	2796
1981	6	0	0	71	155	535	919	599	380	150	200	3	3017
1982	0	27	22	99	101	300	557	596	201	182	58	15	2158
1983	7	4	3	2	128	212	692	768	413	116	50	0	2393
1984	28	0	27	117	385	250	286	1079	213	279	10	0	2674
1985	0	14	23	167	174	1075	255	845	338	274	76	10	3252
1986	10	0	0	7	471	218	840	670	475	135	50	17	2893
Mean	14	10	39	94	314	470	659	746	484	287	121	40	3278

Table 5.2 RECORDED MONTHLY RUNOFF AT SAN ROQUE

(Unit: m/3sec)

YEAR	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1960	30.1	21.1	15.5	19.9	30.3	74.8	84.8	441.9	112.9	80.9	27.4	14.8	79.5
1961	25.0	25.2	23.2	22.2	29.3	43.2	164.6	135.4	157.1	106.3	46.1	40.7	68.2
1962	27.1	20.4	29.1	31.5	43.5	36.3	181.2	170.0	243.8	105.0	44.8	44.9	81.5
1963	48.3	38.2	35.3	28.1	22.3	153.7	112.3	132.9	347.6	92.0	36.7	18.6	88.8
1964	17.2	19.2	10.0	24.1	17.1	21.4	64.7	508.5	255.3	282.2	102.9	57.0	115.0
1965	14.1	9.2	13.6	10.4	6.3	33.4	193.6	167.2	129.7	116.4	29.9	16.0	61.7
1966	7.9	8.0	8.1	8.6	229.4	172.2	156.8	178.6	244.5	60.0	54.4	58.5	98.9
1967	0.0	9.6	52.6	369.8	100.8	132.8	117.0	257.6	211.9	191.9	208.4	83.2	144.8
1968	27.1	14.5	10.3	14.9	18.5	15.7	108.0	561.1	645.2	275.0	60.1	24.9	148.3
1969	24.4	20.4	21.2	10.0	43.0	63.9	213.7	244.8	350.5	188.3	58.2	18.2	105.3
1970	9.1	6.3	6.6	15.3	14.0	108.5	161.8	184.3	201.5	244.2	158.4	121.9	103.3
1971	72.2	70.5	54.9	41.3	47.8	84.3	200.5	270.9	240.6	350.0	71.2	23.1	127.9
Mean	25.2	21.9	23.4	49.7	50.2	78.4	146.6	271.1	261.7	174.4	74.9	43.5	101.9

TABLE 5.3 RUNOFF COEFFICEINTS OF OBSERVED AND SIMULATED RUN OFF

YEAR	Basin Rainfall (mm)	Observed		Simulated		Error (%)
		Runoff (mm)	Coeff.	Runoff (mm)	Coeff.	
1960	3,606	2,006	0.56	2,238	0.62	11
1961	2,847	1,721	0.60	1,993	0.70	16
1962	2,772	2,056	0.74	1,991	0.72	-3
1963	2,546	2,240	0.88	1,857	0.73	-17
1964	3,952	2,901	0.73	2,740	0.69	-6
1965	2,455	1,557	0.63	1,698	0.69	9
1966	3.127	2,495	0.80	2,124	0.68	15
1967	5,347	3,653	0.68	4,047	0.76	11
1968	4,932	3,742	0.76	3,787	0.77	1
1969	3,919	2,657	0.68	2,987	0.76	12
1970	3,757	2,606	0.69	2,730	0.73	5
1971	4,405	3,227	0.73	3,217	0.73	0
Average	3,639	2,572	0.71	2,617	0.72	5

Table 5.4 ESTIMATED MONTHLY RUNOFF AT SAN ROQUE

(Unit:m3/sec.)

YEAR	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1960	30.1	21.1	15.5	19.9	30.3	74.8	84.8	441.9	112.9	80.9	27.4	14.8	79.5
1961	25.0	25.2	23.2	22.2	29.3	43.2	164.6	135.4	157.1	106.3	46.1	40.7	68.2
1962	27.1	20.4	29.1	31.5	43.5	36.3	181.2	170.0	243.8	105.0	44.8	44.9	81.5
1963	48.3	38.2	35.3	28.1	22.3	153.7	112.3	132.9	347.6	92.0	36.7	18.6	88.8
1964	17.2	19.2	10.0	24.1	17.1	21.4	64.7	508.5	255.3	282.2	102.9	57.0	115.0
1965	14.1	9.2	13.6	10.4	6.3	33.4	193.6	167.2	129.7	116.4	29.9	16.0	61.7
1966	7.9	8.0	8.1	8.6	229.4	172.2	156.8	178.6	244.5	60.0	54.4	58.5	98.9
1967	15.5	14.7	15.0	56.2	40.1	321.9	236.1	363.5	277.9	386.7	173.4	24.2	160.4
1968	18.4	18.1	18.5	25.2	66.1	94.5	259.6	476.4	550.4	217.4	36.1	20.9	150.1
1969	20.3	20.0	19.7	24.6	78.3	123.8	279.0	398.8	264.5	139.1	31.5	21.1	118.4
1970	22.6	20.4	23.0	25.2	86.3	191.6	163.7	216.8	274.8	175.0	70.9	27.8	108.2
1971	20.8	19.8	22.6	29.7	60.7	192.8	360.7	323.3	178.6	229.4	53.1	38.4	127.5
1972	27.4	21.1	20.8	39.7	63.7	227.4	673.7	492.6	203.4	72.2	29.6	23.5	157.9
1973	23.1	22.8	24.0	22.9	96.9	106.3	95.8	172.3	146.3	173.2	47.5	24.0	79.6
1974	23.0	21.4	24.3	36.3	40.1	166.8	101.9	274.8	159.9	292.2	189.0	44.5	114.5
1975	22.0	20.7	21.1	21.3	53.9	61.7	61.5	175.7	150.6	105.5	32.7	20.7	62.3
1976	19.9	19.6	19.3	20.8	216.2	333.9	313.9	166.0	191.8	100.2	25.4	20.7	120.6
1977	20.4	20.1	19.8	19.5	34.5	61.1	132.2	181.0	204.1	68.8	48.6	19.2	69.1
1978	18.9	18.6	18.4	21.4	34.8	143.7	136.9	323.1	273.2	162.2	58.8	22.3	102.7
1979	19.1	18.2	18.6	18.3	57.5	71.1	113.3	175.1	93.1	80.5	18.3	18.5	58.5
1980	17.6	17.3	17.4	19.7	83.3	50.3	166.4	122.9	140.8	86.9	212.4	25.3	80.0
1981	16.9	16.7	16.4	17.8	23.1	134.3	217.8	280.0	168.4	79.4	51.7	22.9	87.1
1982	16.8	16.6	16.3	22.1	22.6	55.5	154.3	195.1	117.7	62.9	19.2	16.0	59.6
1983	15.8	15.0	15.3	15.1	32.9	45.6	188.0	265.2	153.7	71.7	22.7	15.6	71.4
1984	17.2	15.1	15.9	20.1	88.8	73.1	82.8	247.1	198.3	87.8	33.2	15.4	74.6
1985	15.2	14.9	14.8	26.7	36.6	223.3	205.4	248.7	173.6	86.5	34.2	15.8	91.3
1986	15.6	15.3	15.1	14.9	90.5	99.6	253.5	182.6	238.7	73.1	20.2	16.1	86.3
Mean	20.6	18.8	18.9	23.8	62.4	122.7	190.9	259.8	209.3	133.1	57.4	26.1	95.3

FIGURES

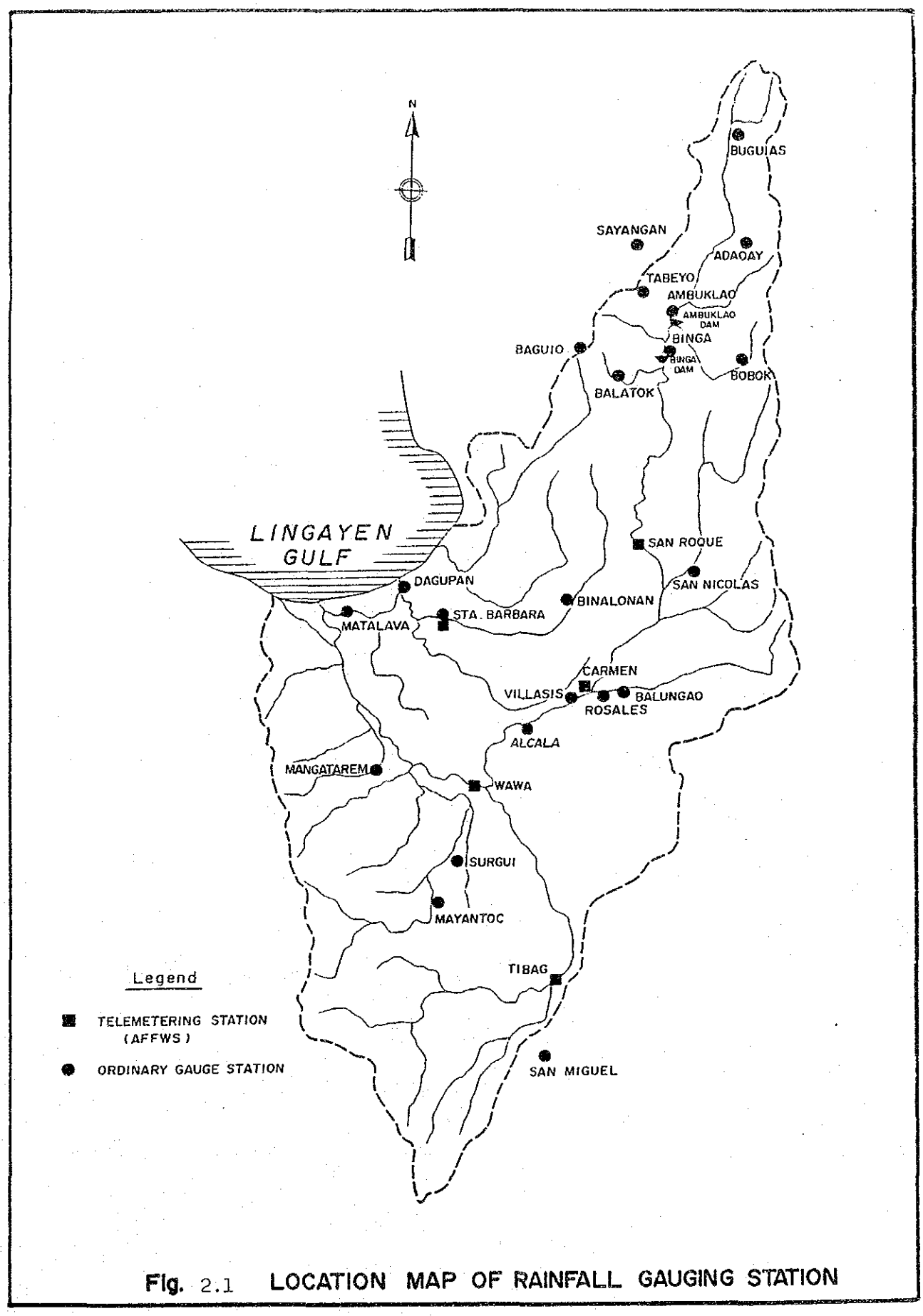


Fig. 2.1 LOCATION MAP OF RAINFALL GAUGING STATION

No.	Station Name	Location		Elevation (MSL)	Record	Data Availability	Recorded Period
		Lat.	Long.			1960 61 62 63 64 65 66 67 68 69 1970 71 72 73 74 75 76 77 78 79 1980 81 82 83 84 85 86 87 88	
1.	BUGUIAS	16°43'00"	120°50'00"	1,316	Daily		19
2.	ADAOAY	16°38'00"	120°45'00"	816	Daily		11
3.	SAYANGAN	16°32'00"	120°40'00"	2,286	Daily		8
4.	AMBUKLAO	16°29'00"	120°45'00"	735	Daily		19
5.	TABEYO	15°49'00"	121°00'00"	1,723	Daily		11
6.	BAGUIO	16°24'00"	120°36'00"	1,483	Daily		29
7.	BINGA	16°23'21"	120°43'46"	588	Daily		10
8.	BOBOK	16°27'00"	120°50'00"	1,367	Daily		27
9.	BALATOK	16°22'00"	120°39'00"	950	Daily		11
10.	SAN NICOLAS	16°01'00"	120°45'00"	-	Daily		10
11.	BINALONAN	16°03'00"	120°35'00"	-	Daily		17
12.	DAGUPAN	16°03'00"	120°20'00"	5	Daily		24
13.	MATALAVA	16°02'00"	120°14'00"	-	Daily		19
14.	STA. BARBARA	15°59'47"	120°42'04"	-	Daily Hourly		14 7
15.	BALUNGAO	15°54'00"	120°42'14"	-	Daily		18
16.	ROSALES	15°53'36"	120°37'42"	-	Daily		20
17.	ALCALA	15°50'40"	120°21'00"	-	Daily		15
18.	MANGATAREM	15°47'30"	120°17'30"	-	Daily		9
19.	SURGUI	15°51'00"	120°25'00"	-	Daily		18
20.	MAYANTOC	15°36'20"	120°27'50"	-	Daily		10
21.	SAN MIGUEL	15°27'00"	120°38'00"	-	Daily		14
22.	SAN ROQUE	16°07'37"	120°41'07"	-	Hourly		7
23.	CARMEN	15°53'24"	120°35'34"	-	Hourly		7
24.	WAWA	15°46'18"	120°26'50"	-	Hourly		7
25.	TIBAG	15°29'14"	120°34'09"	-	Hourly		7

Fig. 2.2 DATA AVAILABILITY OF RAINFALL RECORD

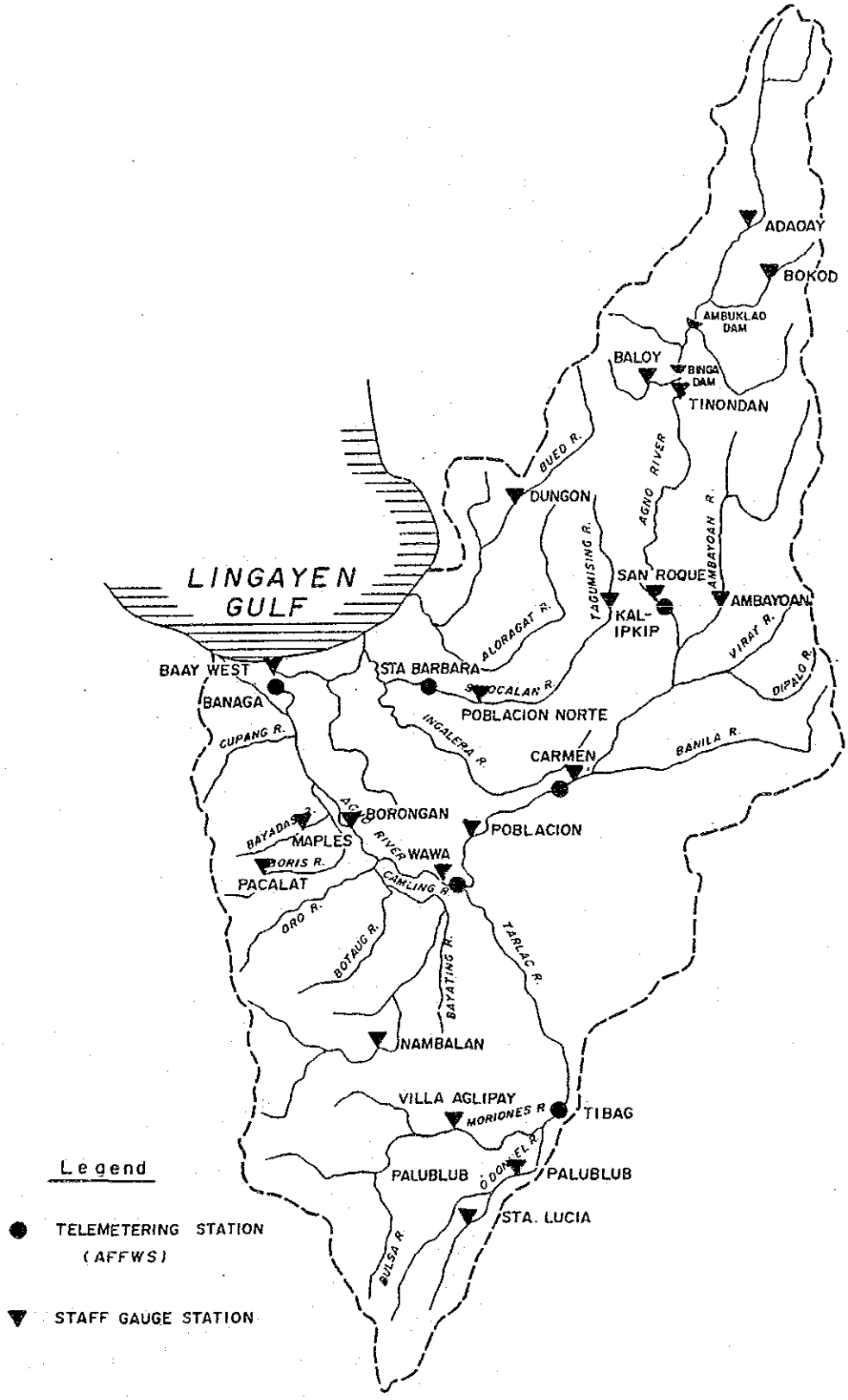


Fig. 2.3 LOCATION MAP OF WATER LEVEL GAUGING STATIONS

Fig. 2.4 DATA AVAILABILITY OF DISCHARGE RECORD

No.	Station Name	Location		River	Drainage Area (km²)	Data Availability																														Recorded Period
		Lat.	Long.			1960	61	62	63	64	65	66	67	68	69	1970	71	72	73	74	75	76	77	78	79	1980	81	82	83	84	85	86	87	88	
1.	ADAOAY	26°35'00"	120°49'00"	Agno	246																															11
2.	BOKOD	16°29'00"	120°50'00"	Bokod	48																															13
3.	BALOY	16°23'08"	120°32'22"	Twin	87																															6
4.	TINONGDAN	16°23'06"	120°43'17"	Agno	958																															9
5.	SAN ROQUE	16°08'07"	120°41'45"	Agno	1,225																															12
6.	AMBAYOAN	16°07'10"	120°46'50"	Ambayoan	281																															12
7.	CARMEN	15°53'30"	120°35'30"	Agno	2,209																															11
8.	POBLACION	15°49'07"	120°27'22"	Agno	2,284																															12
9.	VILLA AGLIPAY	15°28'06"	120°26'56"	Tarlac	405																															10
10.	PALUBLUB	15°23'47"	120°30'05"	Tarlac	240																															8
11.	STA. LUCIA	15°22'10"	120°29'11"	Tarlac	90																															6
12.	DUNGON	16°14'50"	120°30'50"	Bued	141																															10
13.	POBLACION NORTE	16°00'00"	120°28'20"	Sinocalan	180																															11
14.	KALIPKIP	16°07'36"	120°38'18"	Sinocalan	74																															9
15.	BAAY WEST	16°00'39"	120°12'30"	Agno	5,646																															8
16.	BANAGA	15°59'42"	120°13'19"	Agno	5,564																															8
17.	MAPLES	15°49'24"	120°15'00"	Bayaoas	64																															12
18.	BORONGAN	15°49'23"	120°19'32"	Agno	5,134																															12
19.	PACALAT	15°44'03"	120°15'29"	Camiling	117																															9
20.	WAWA	15°45'50"	120°26'28"	Agno	4,196																															9
21.	NAMBALAN	15°32'42"	120°19'48"	Camiling	142																															9
22.	TIBAG	15°29'55"	120°34'00"	Tarlac	872																															9
23.	STA. BARBARA	15°59'47"	120°42'04"	Sinocalan	—																															—

Remarks; ———: Daily Water Level ·····: 3-hourly Water Level (AFFWS)

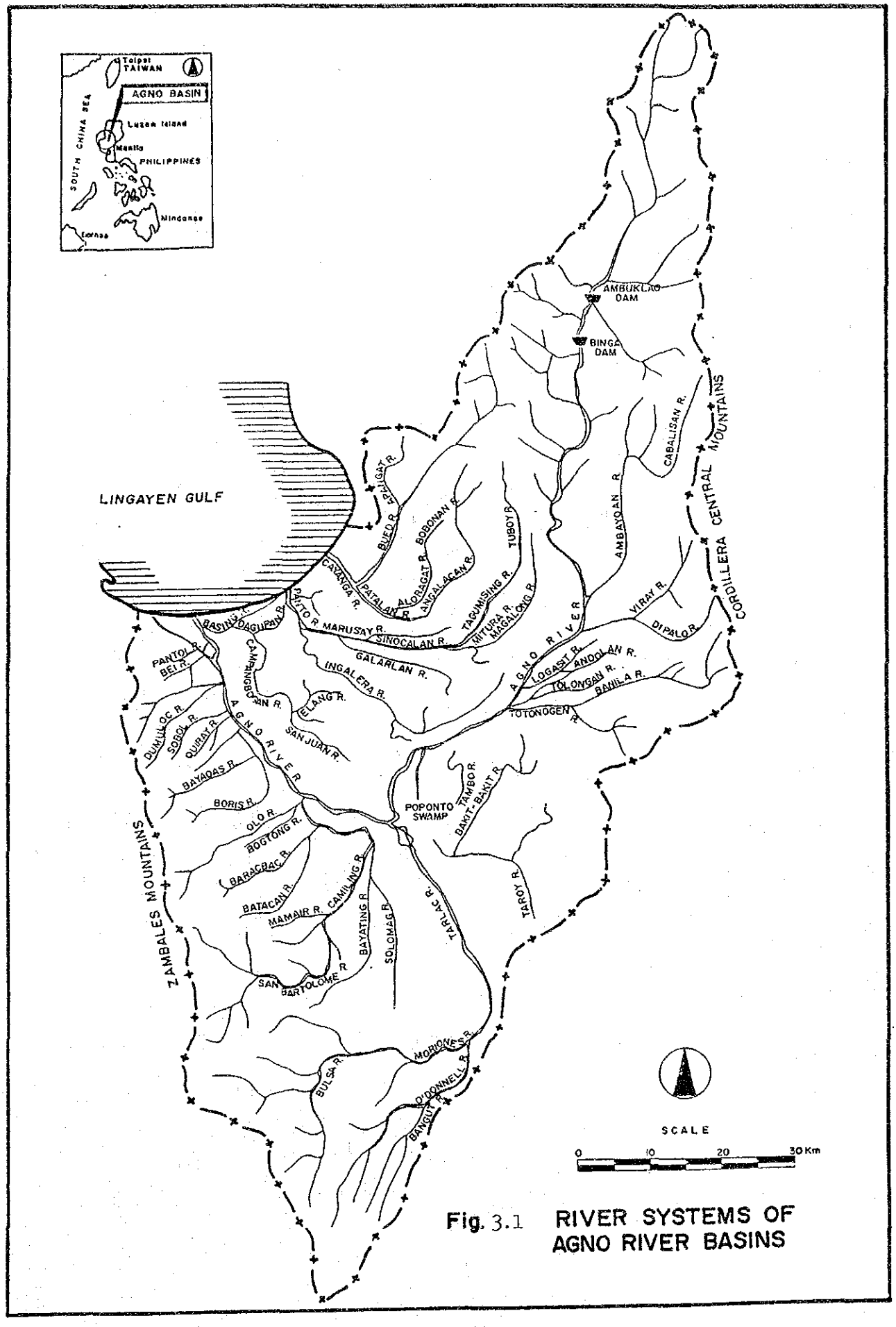
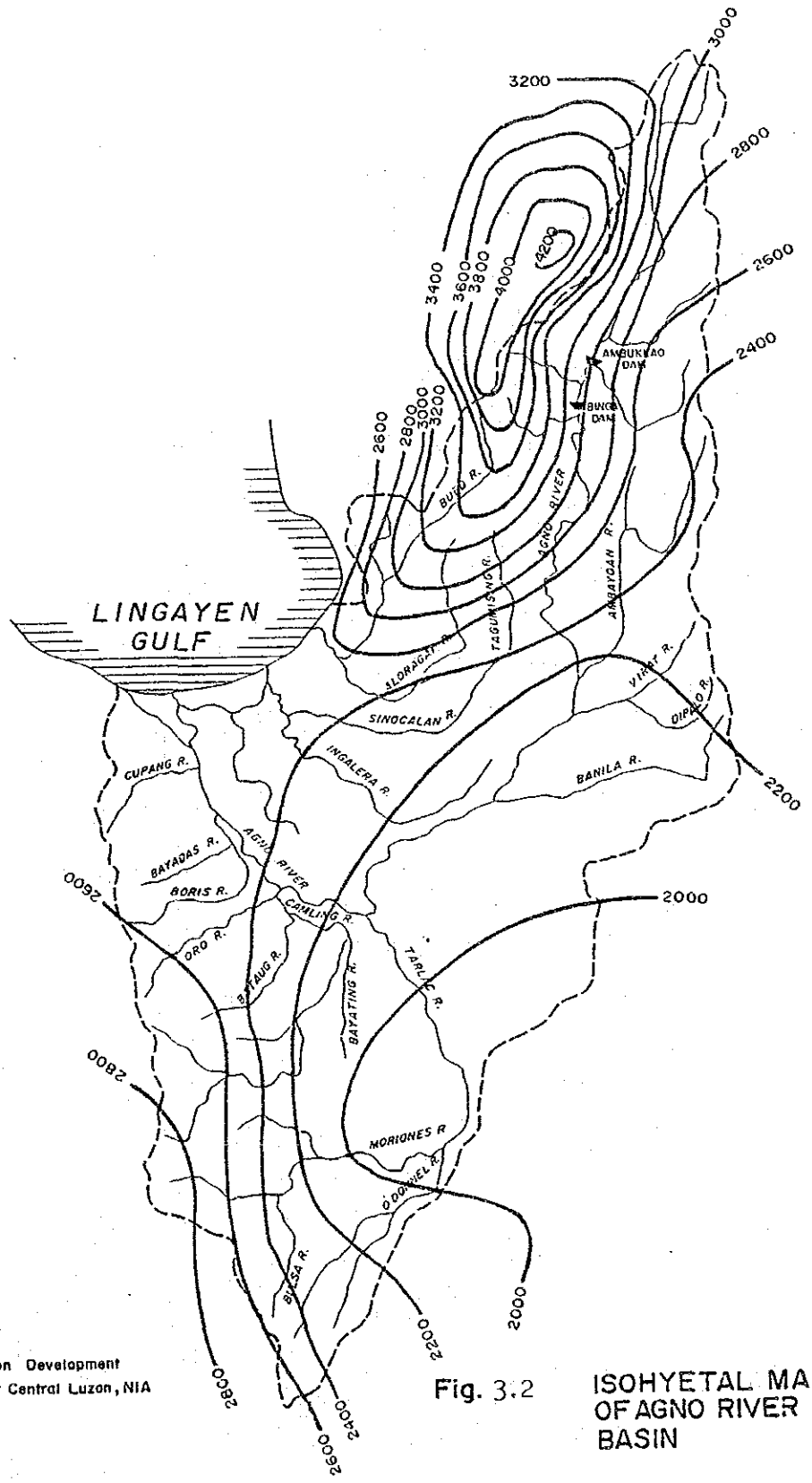
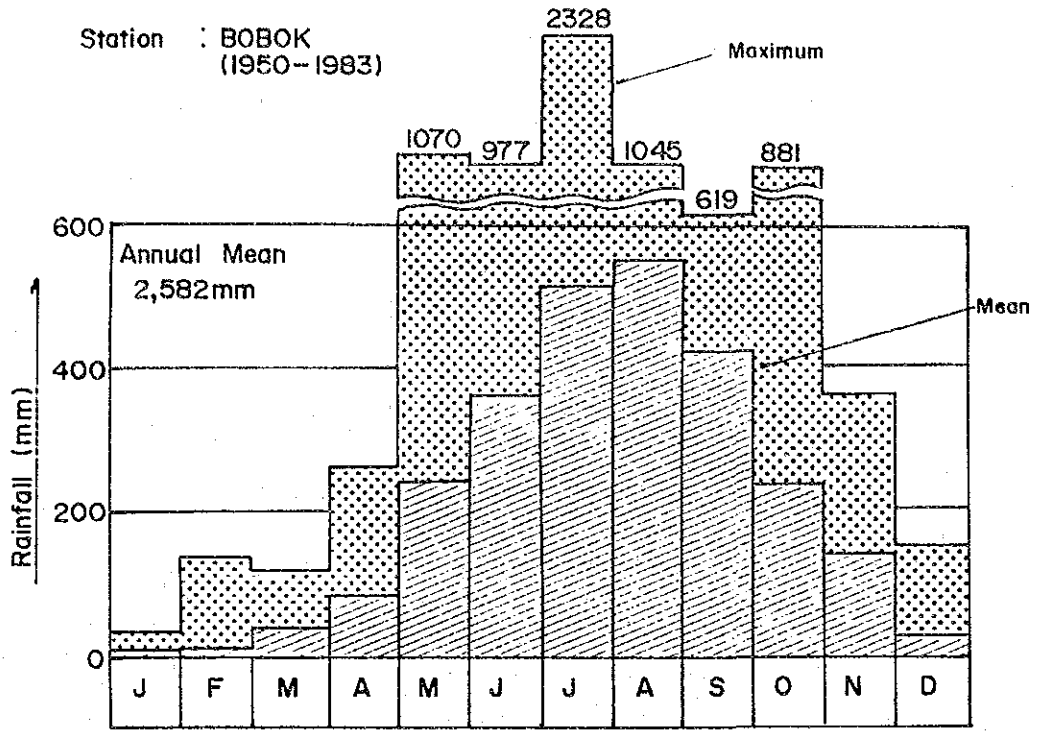


Fig. 3.1 RIVER SYSTEMS OF AGNO RIVER BASINS



Source: Irrigation Development Plan for Central Luzon, NIA

Fig. 3.2 ISOHYETAL MAP OF AGNO RIVER BASIN



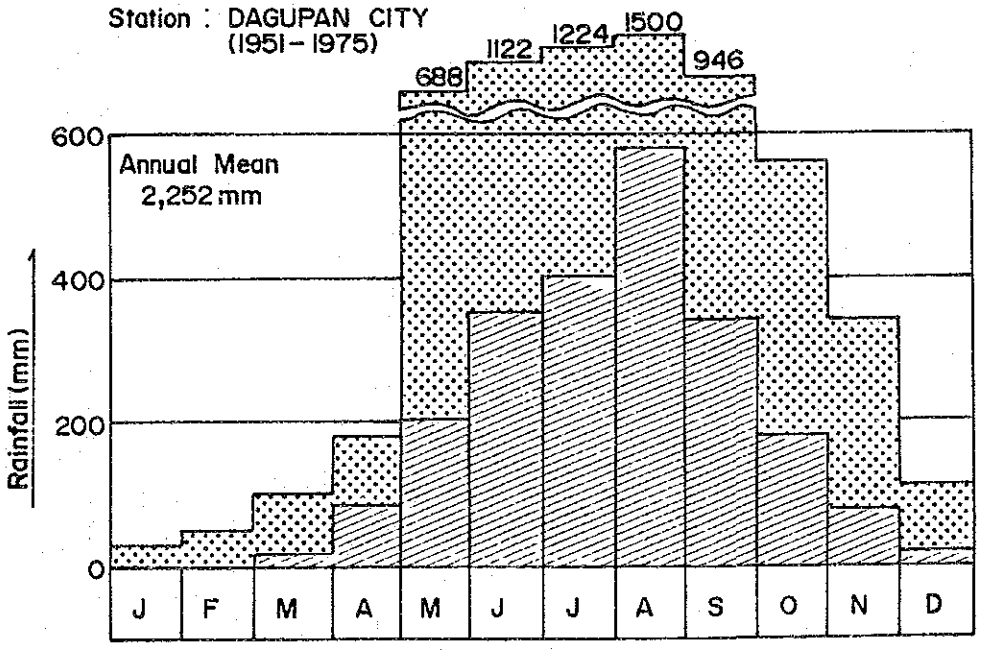


Fig 3.3 MONTHLY RAINFALL DISTRIBUTION

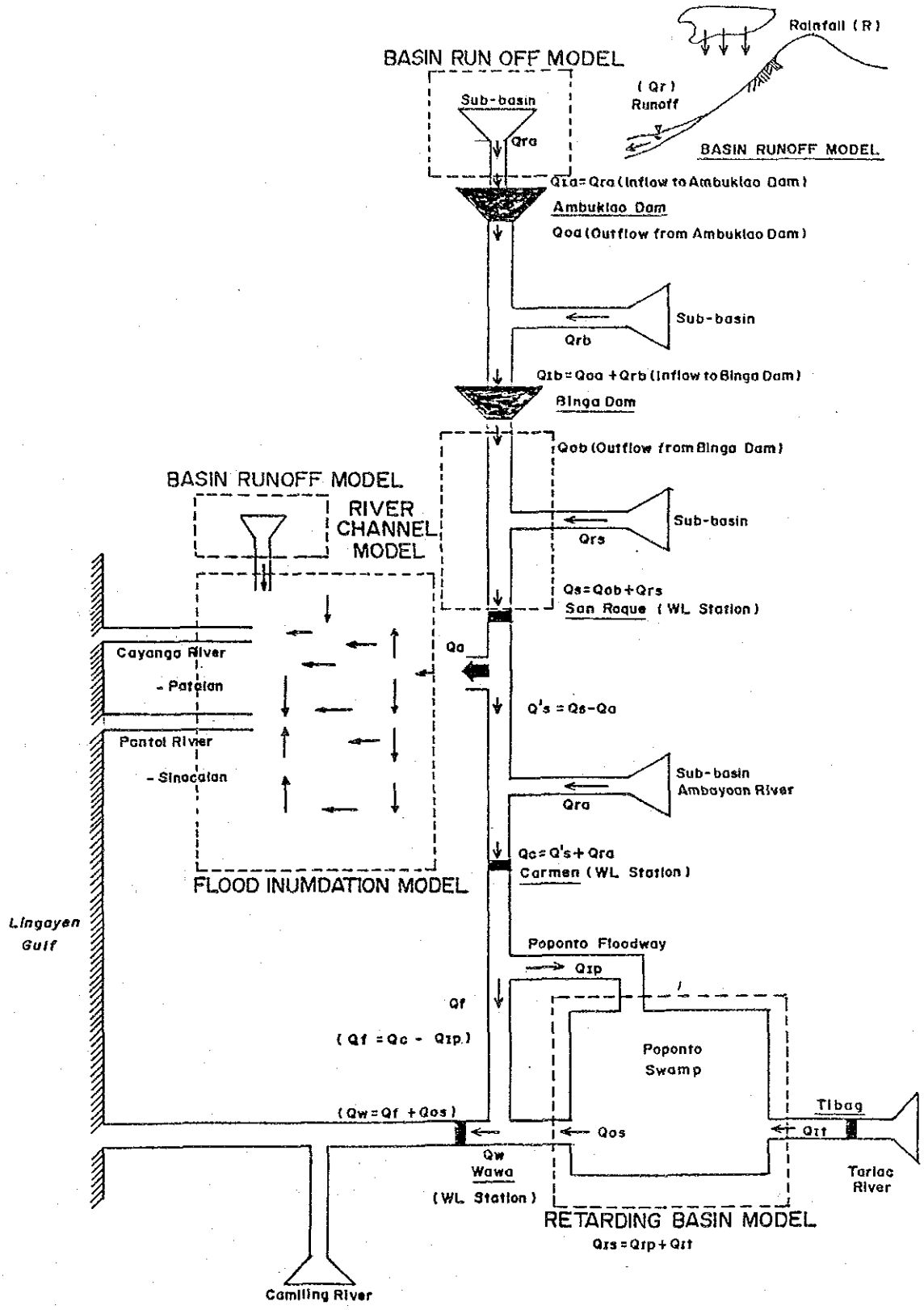


Fig. 4.1 ILLUSTRATION OF RIVER BASIN MODEL

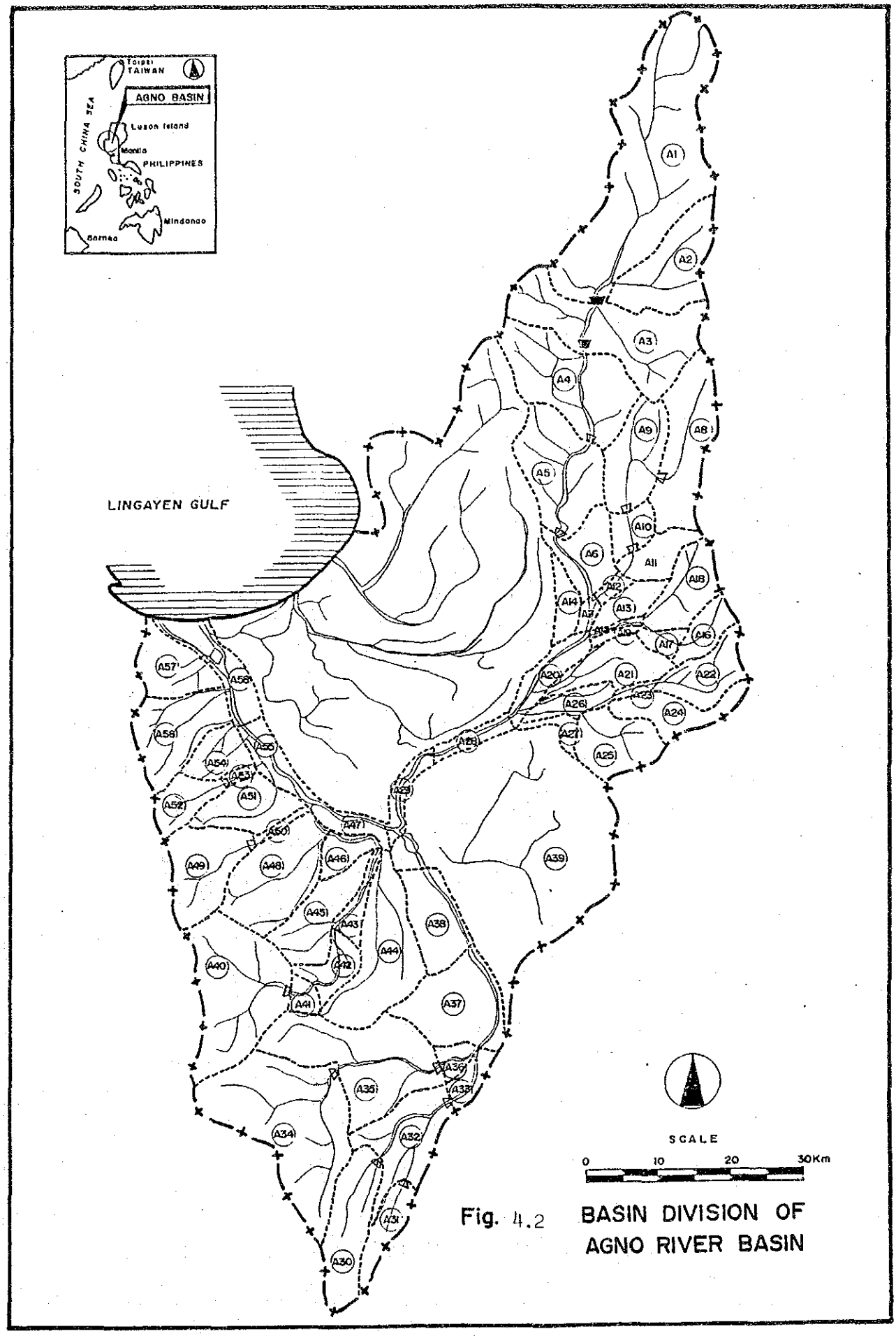


Fig. 4.2 BASIN DIVISION OF AGNO RIVER BASIN

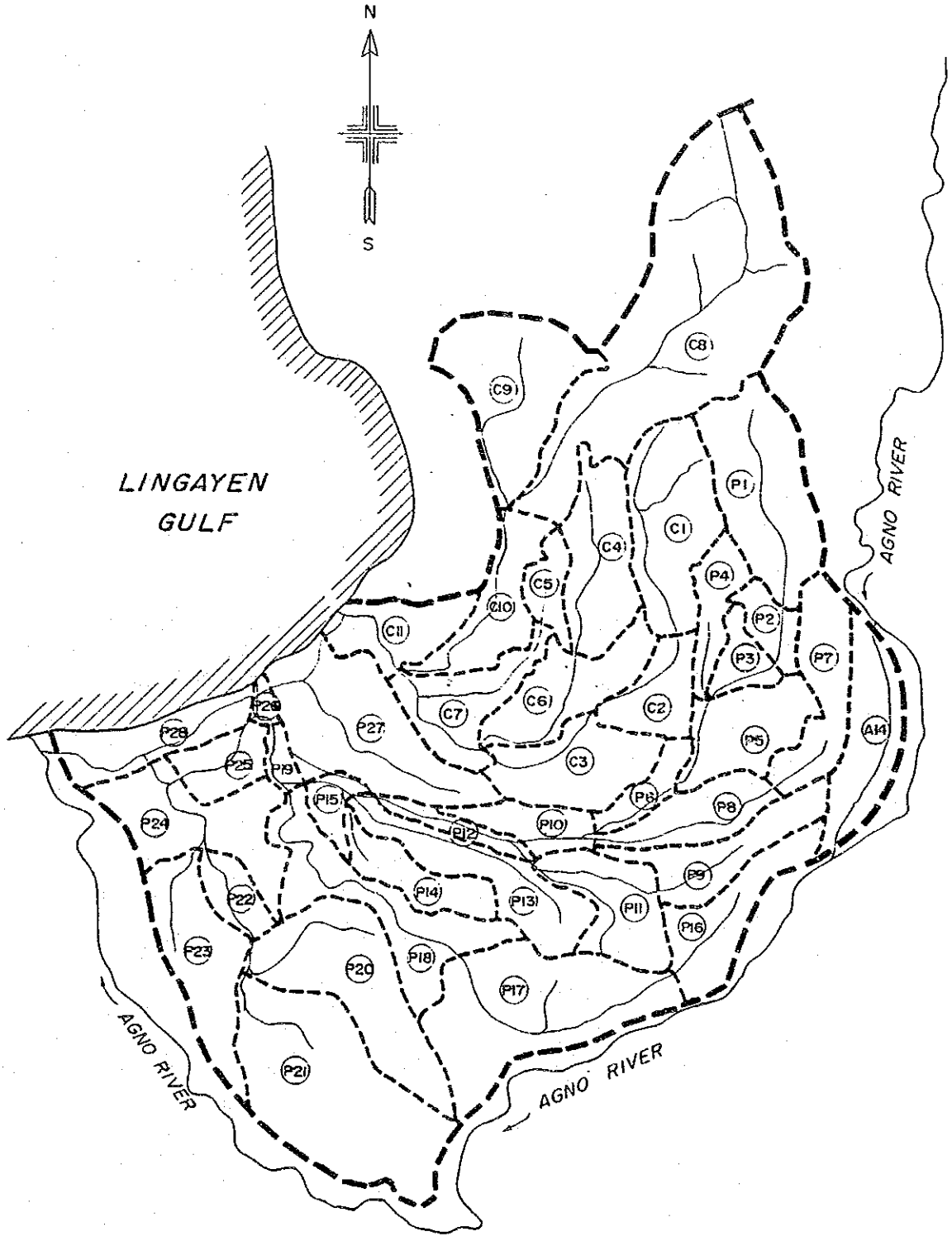


Fig. 4.3 BASIN DIVISION OF ALLIED RIVER BASIN

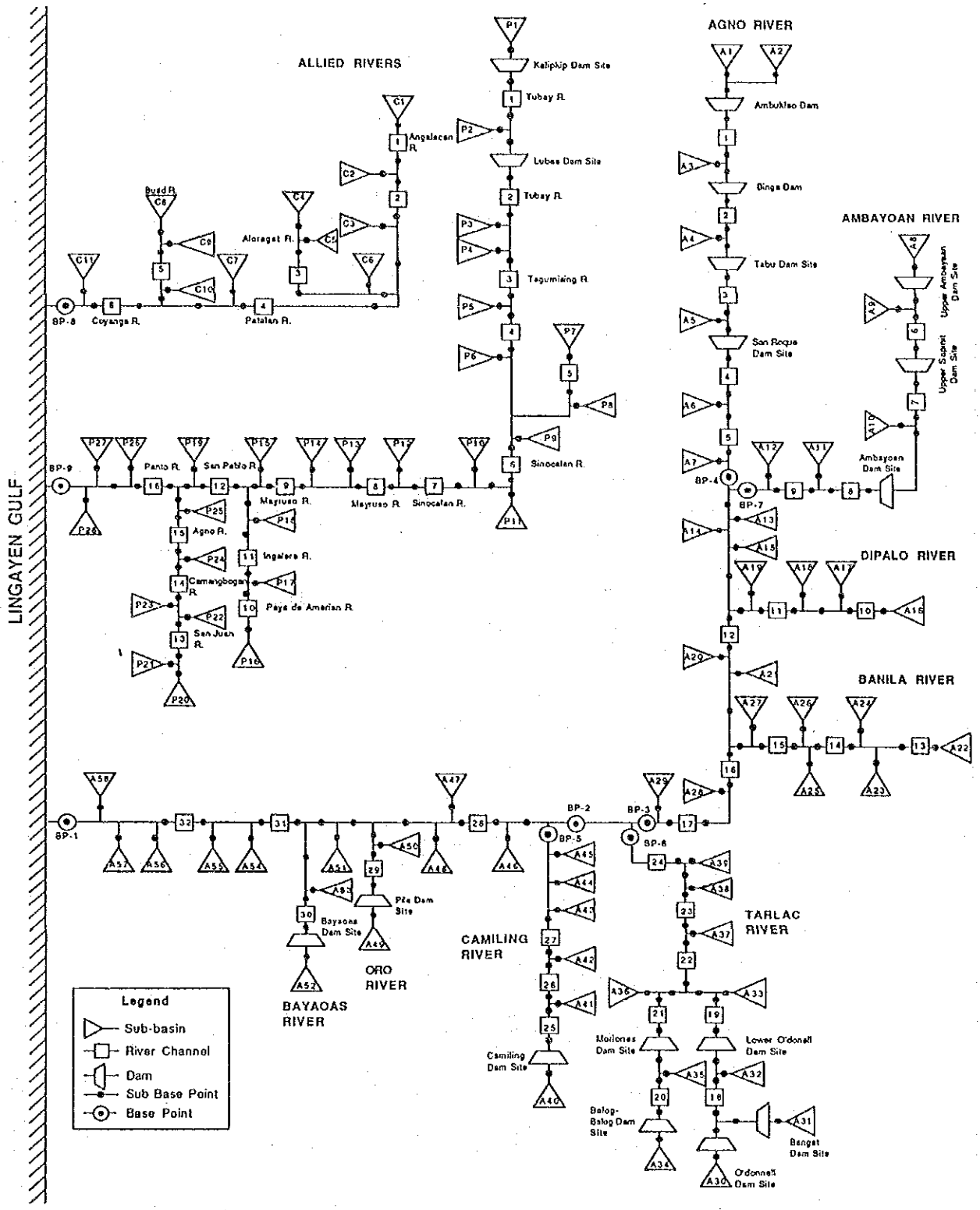
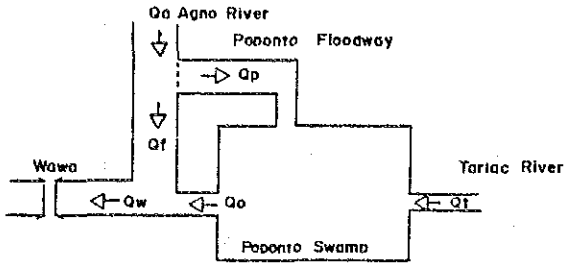


Fig. 4.4 RIVER SYSTEM MODEL OF AGNO AND ALLIED RIVERS FOR FLOOD RUNOFF ANALYSIS

(1) Model Diagram



$$\begin{cases} Qa = Qp + Qf \\ Qw = Qf + Qo \\ Qi = Qp + Qt \quad \text{(Inflow to Swamp)} \end{cases}$$

(2) Hydraulic Equations in Swamp

Equation of Continuity : $Qi - Qo = \frac{dS}{dt}$

(S : Storaged volume in swamp)

Equation of Movement : $Qo = C\sqrt{2g} \cdot A \cdot |Hp - Hw|^{1/2}$

(C : Runoff Coeffient
A : Flow Area
Hp : Water level at Swamp
Hw : Water level at Wawa)

(3) Calculation Procedure

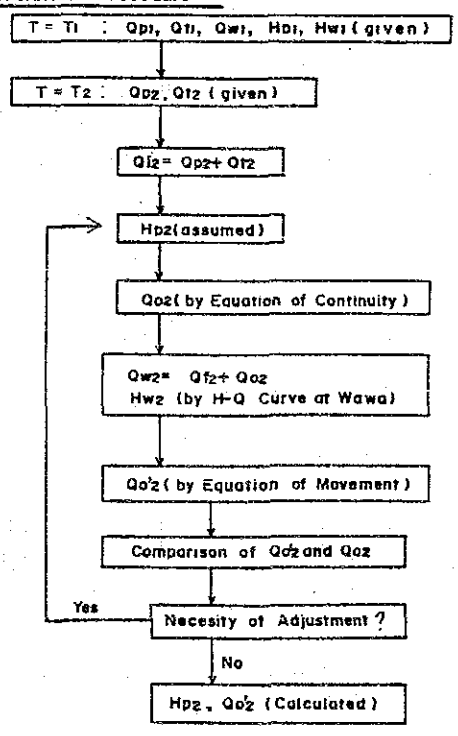


Fig. 4.5 ILLUSTRATION OF HYDRAULIC MODEL FOR POPONTO SWAMP

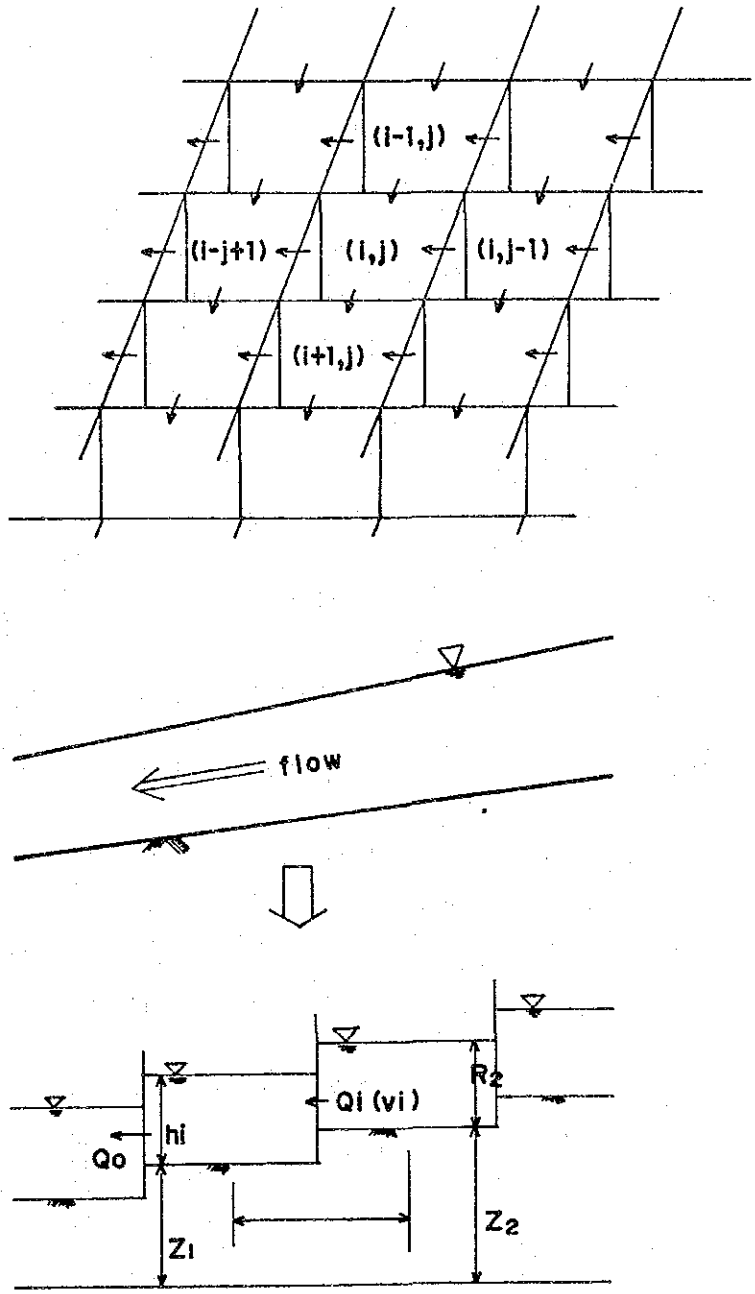


Fig. 4.6 ILLUSTRATION OF SEQUENTIAL MODEL POND

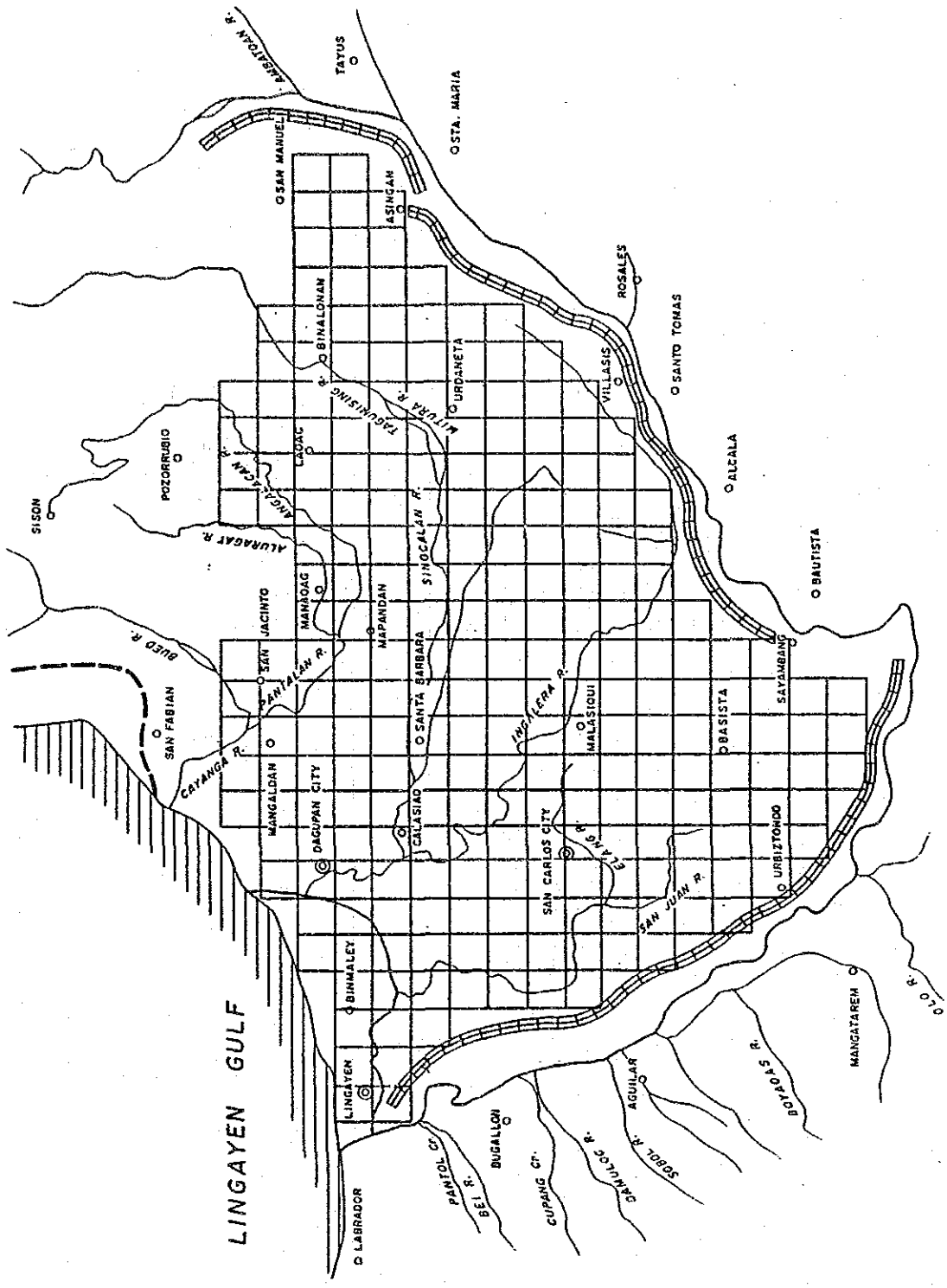


Fig. 4.7 DIVIDED MESH BLOCK OF ALLIED RIVER BASIN FOR FLOOD INUNDATION ANALYSIS

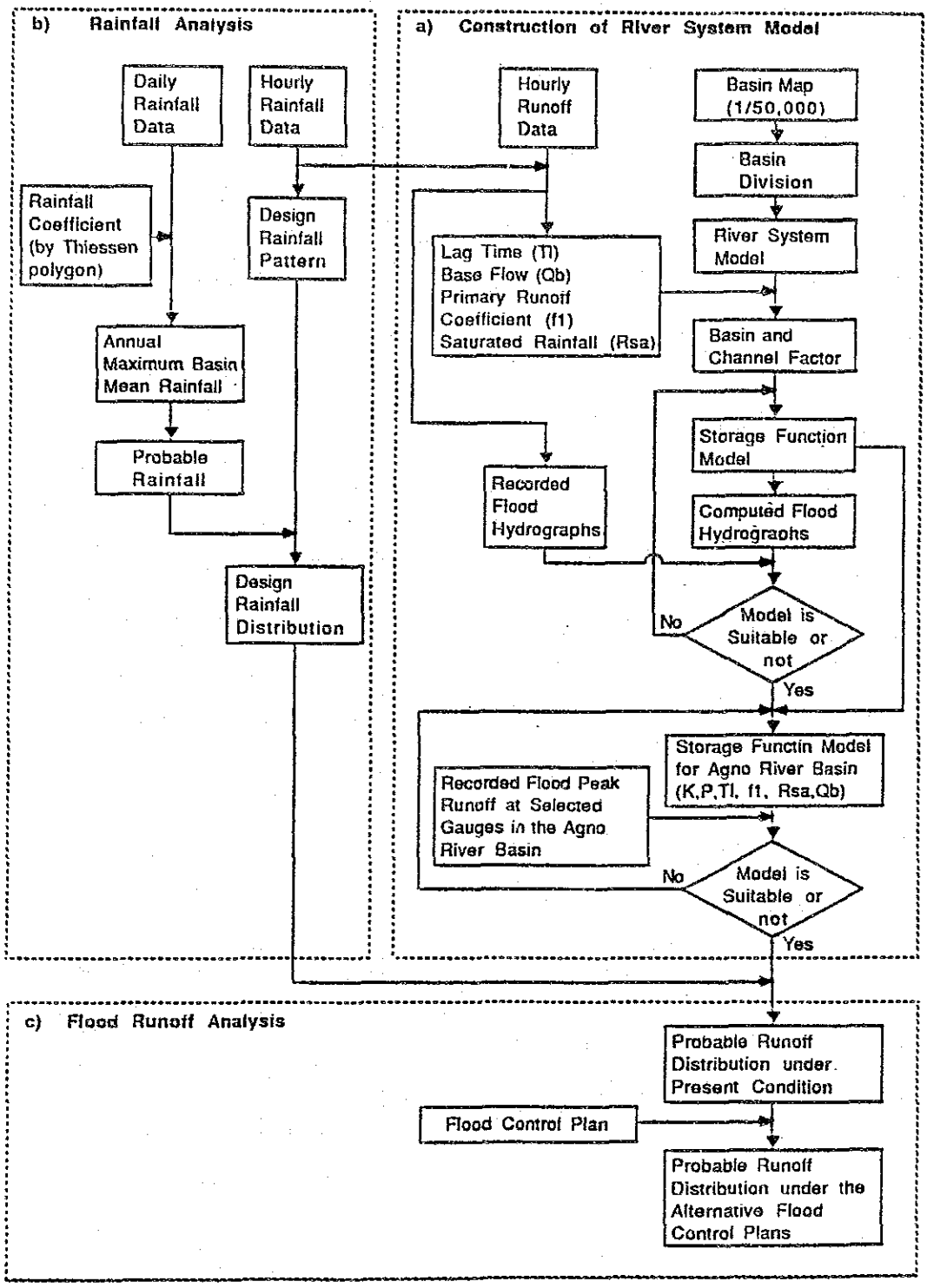


Fig. 4.8 WORK FLOW CHART FOR FLOOD STUDIES

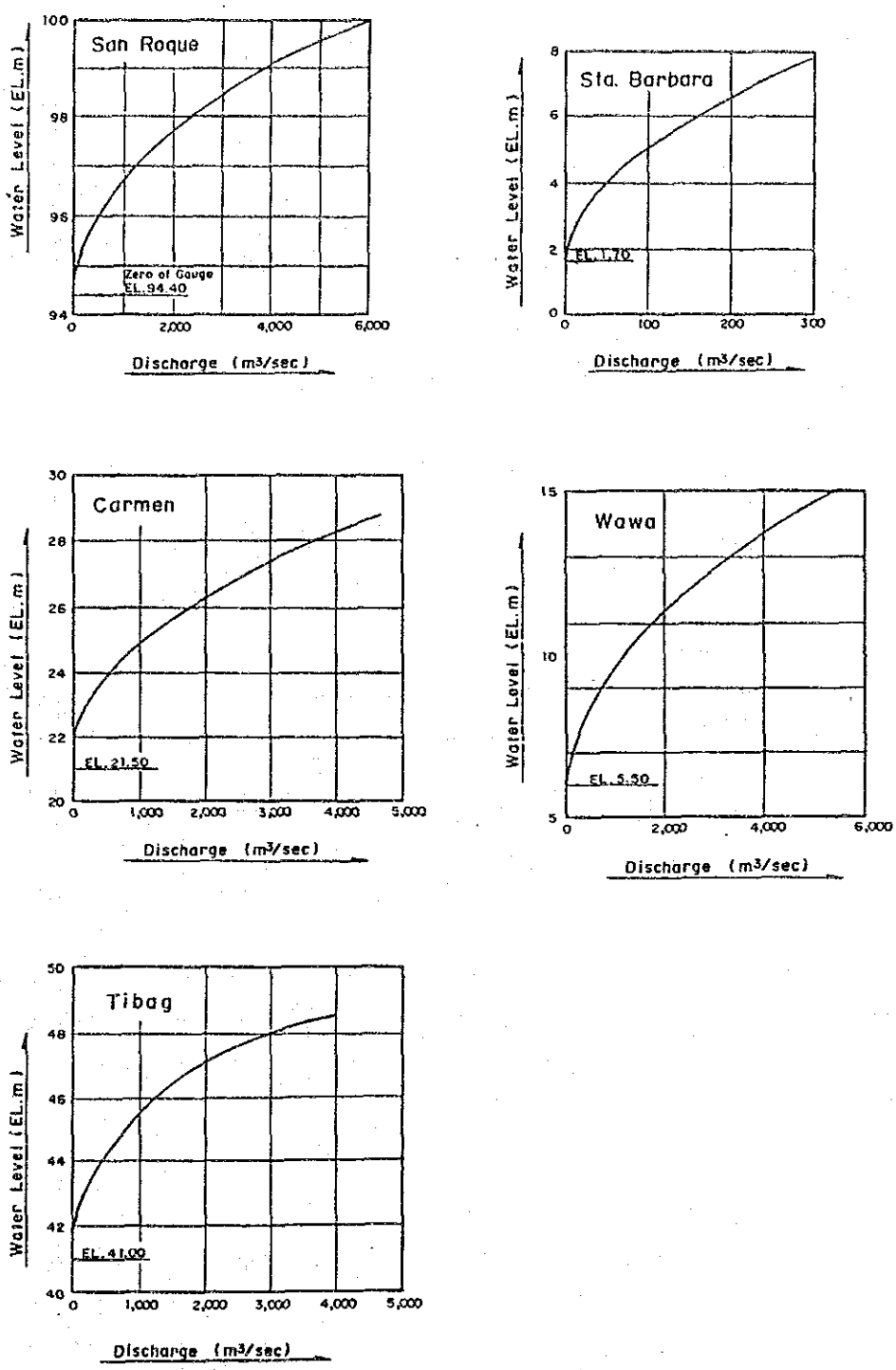


Fig. 4.9 DISCHARGE RATING CURVES AT TELEMETERING STATION

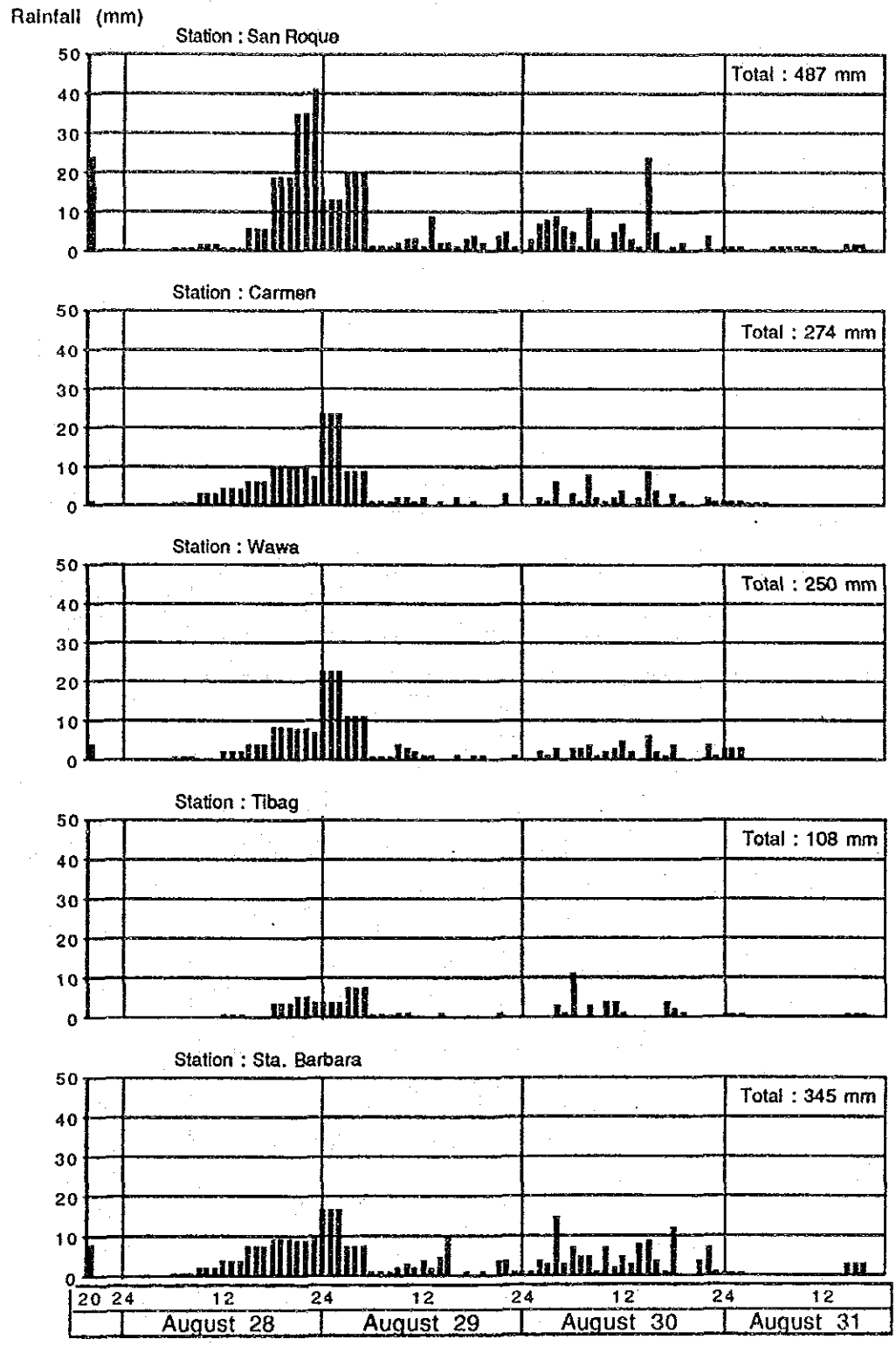


Fig. 4.10 RECORDED RAINFALL HYETOGRAPHS DURING THYPOON MARING IN 1984

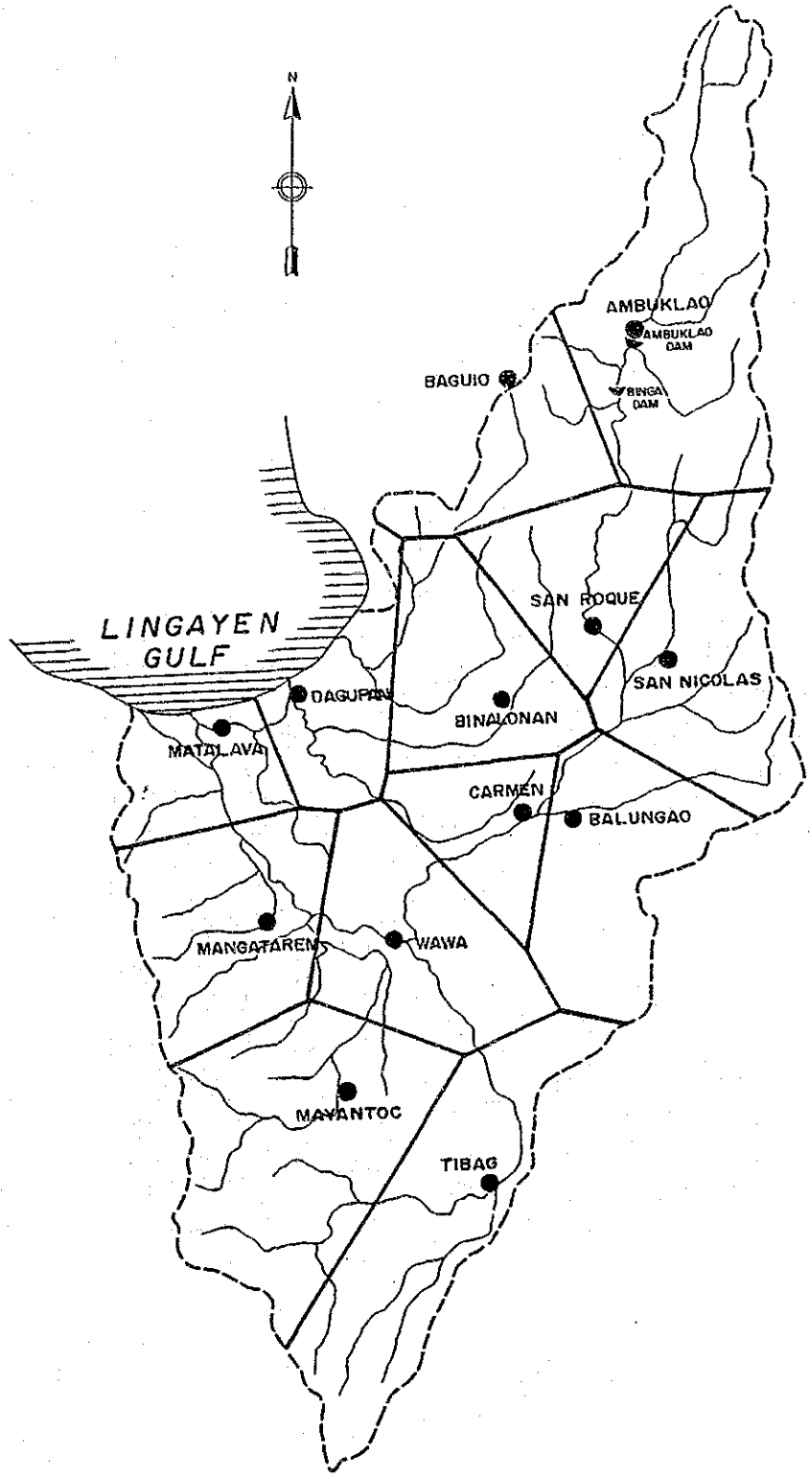
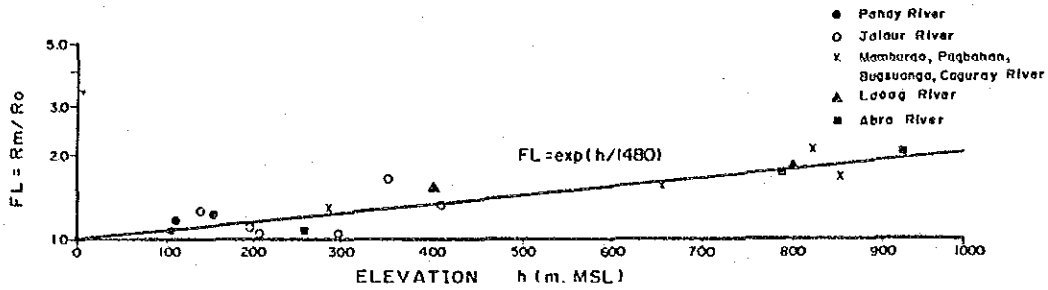


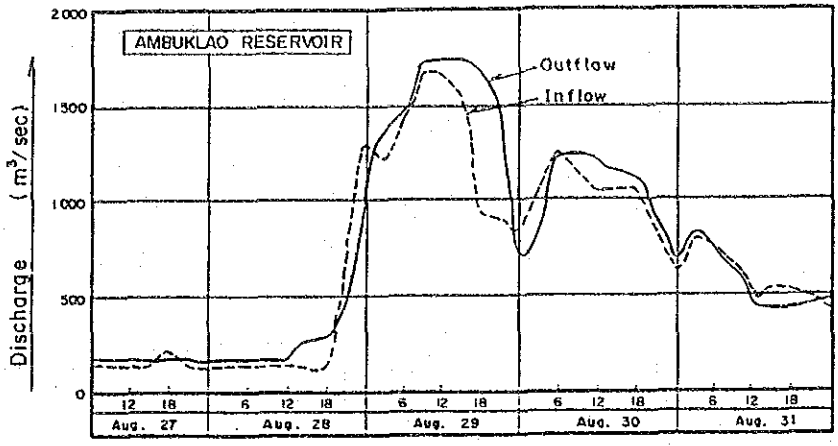
Fig. 4.11 THIESSEN POLYGON AT TYPHOON MARING IN 1984



RIVER NAME	STREAM GAGING STATION	DRAINAGE AREA (A: Km²)	Q ann / A (mm/yr)	RUNOFF RATE (mm/yr)	Rm (Q ann/ft A) (mm/yr)	FL (Rm/Ro)	AVERAGE BASIN ELEVATION (m, MSL)	Ro (mm/yr)
PANAY RIVER	STA. RITA CUARTERO	880	1780	0.7	2540	1.20	158	2120
	PALAGUIAN MAAYON	265	1480	0.6	2470	1.16	120	2120
	TUMALALUD MAMBUSAO	307	1350	0.6	2250	1.06	111	2120
JALAUR RIVER	ALIBUNAN CALINOG	120	1990	0.8	2490	1.28	418	1940
	SIMSIMAN CALINOG	169	2490	0.8	3110	1.60	359	1940
	POBLACION, PASSI	534	1450	0.6	2420	1.25	180	1940
	PADER, DUENAS	247	1390	0.7	1990	1.02	295	1940
	SAN MATIAS DINGLE	1065	1240	0.6	2070	1.07	193	1940
	MINA, POTOTAN	186	1170	0.6	1950	1.01	213	1940
	CALYAN POTOTAN	1499	1420	0.6	2370	1.22	156	1940
MAMBURAO R.	CABACO ABRA DE ILOG	189	3251	0.8	4064	1.59	833	2555
PAGBAHAN R.	TALABIAN, MAMBURAO	263	3560	0.8	4450	2.00	844	2229
BUGSUANGA	BATASAN SAN JOSE	434	2723	0.7	3890	1.50	662	2590
CAGURAY R.	OTOYAN SAN JOSE	136	2688	0.8	3360	1.25	270	2698
LAOAG RIVER	POBLACION LAOAG	1355	2214	0.7	3163	1.49	401	2117
	MANALAC SOLSONA	73	2723	0.8	3404	1.77	804	1928
ABRA RIVER	BANAOANG BANTAY	4813	2512	0.6	4187	1.67	779	2513
	PANG-OT LAGAYON	664	3619	0.7	5170	1.97	952	2620
	LINGSAD PENERUBIA	120	2295	0.8	2869	1.03	267	2780

Source: Nationwide Flood Control Plan

Fig. 4.12 ADJUSTMENT FACTOR FOR BASIN MEAN ELEVATION



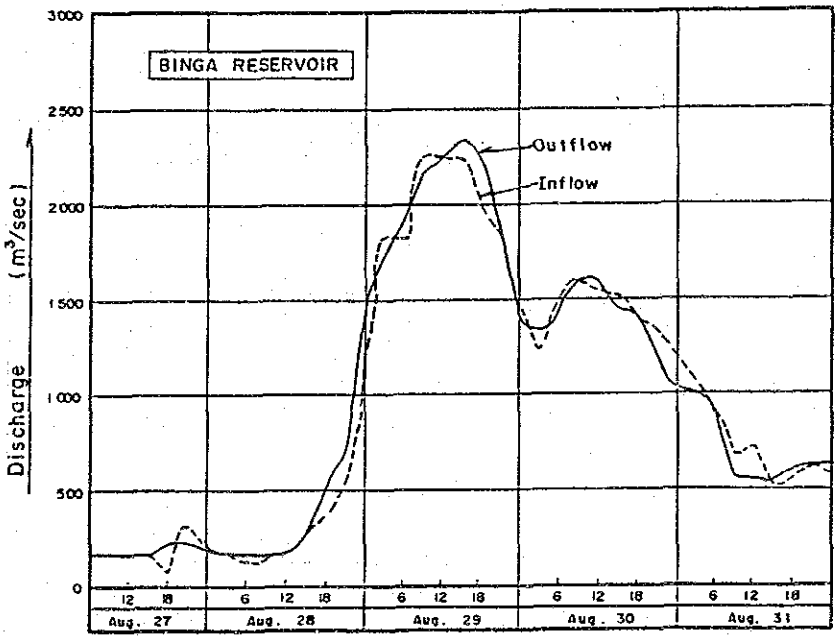


Fig. 4.13 RESERVOIR OPERATION AT BINGA AND AMBUKLAO DAMS DURING TYPHOON MARING IN 1984

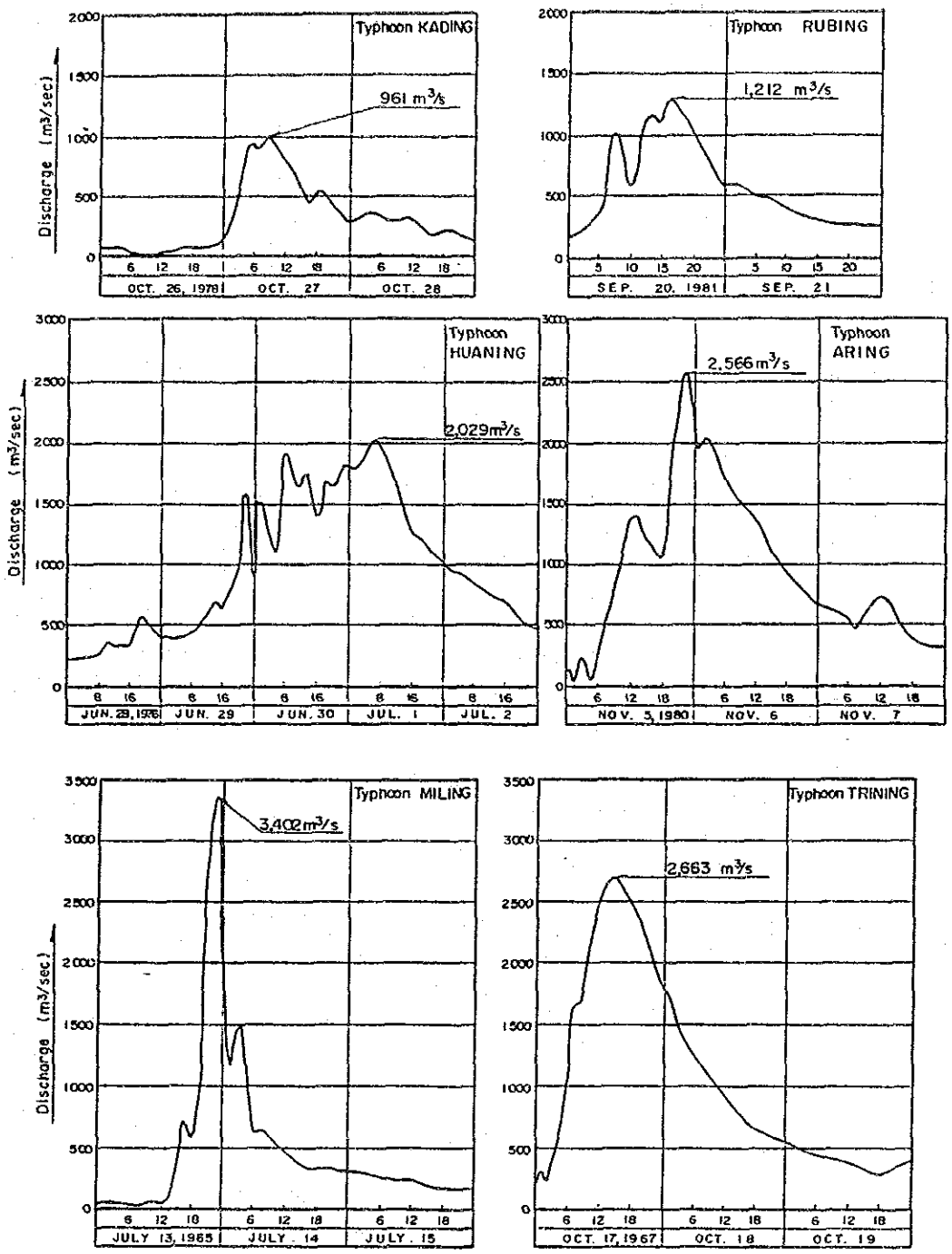


Fig. 4.14 FLOOD INFLOW HYDROGRAPHS AT AMBUKLAO DAM

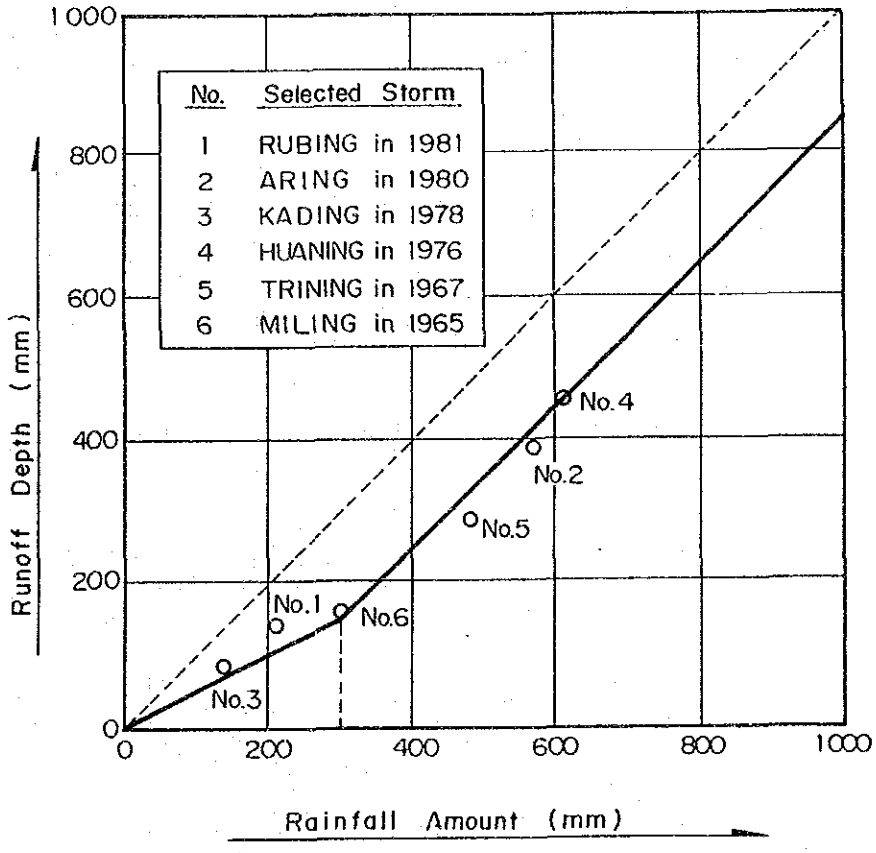
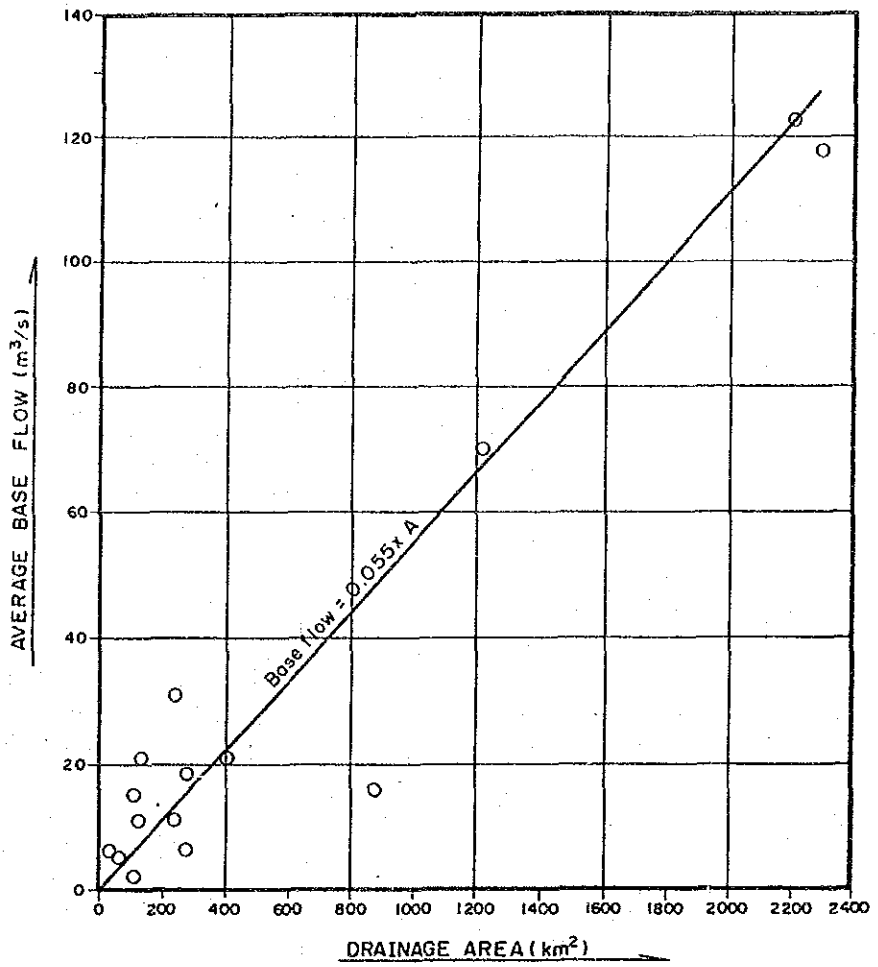
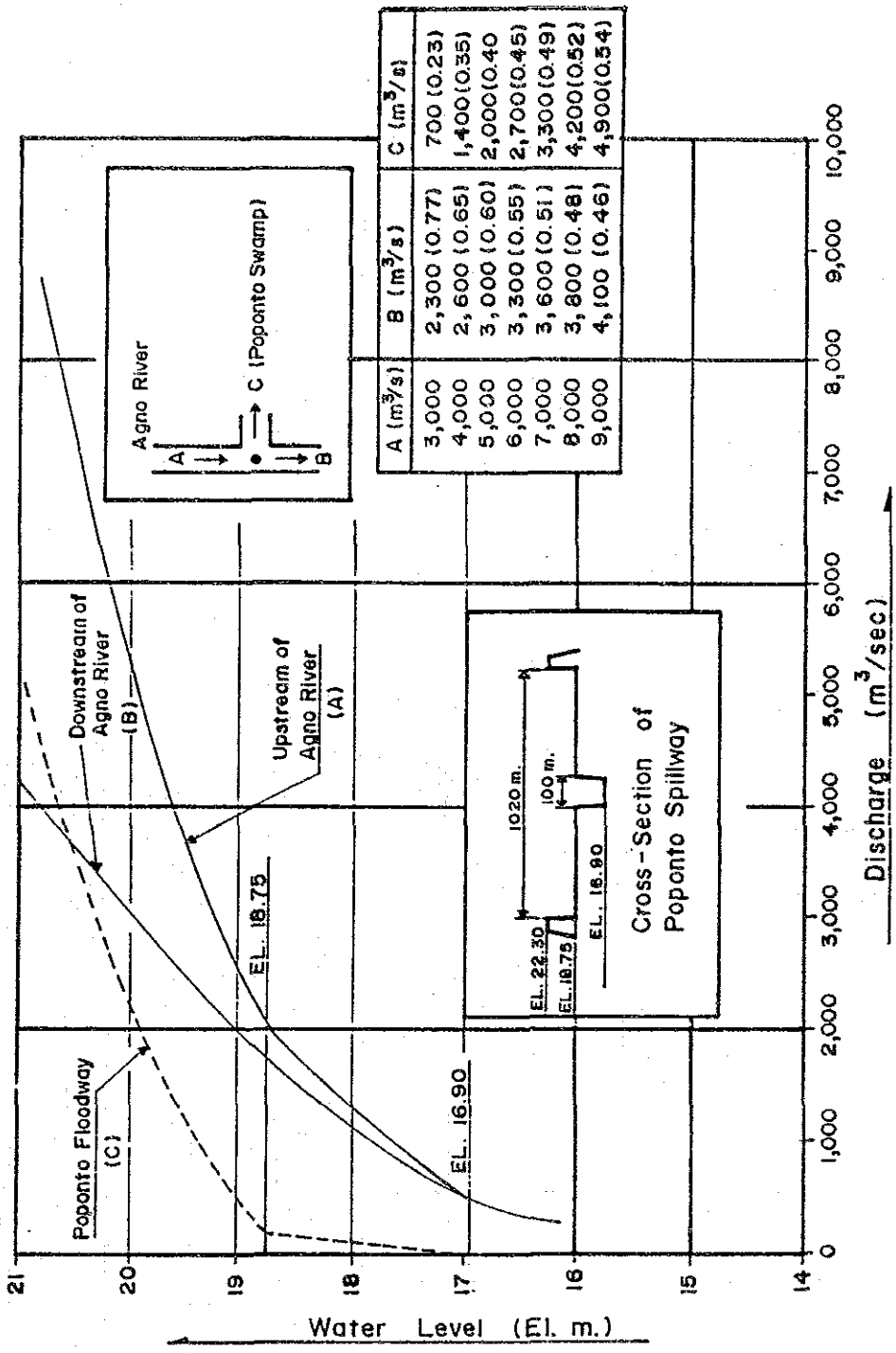


Fig. 4.15 RELATION BETWEEN RAINFALL AMOUNT AND RUNOFF DEPTH AT AMBUKLAO DAM



STATION NAME	DRAINAGE AREA(km²)	AVERAGE BASE FLOW (m³/s)
San Roque, San Manuel	1,225	70.5
Carmen, Rosales	2,209	122.8
Sta.Maria, San Nicolas	281	18.5
Pacalat, Mangatarem	126	11.1
Poblacion, Bayambang	2,284	118.9
Maples, Aguilar	64	5.1
Adaoag, Kabayan	246	31.0
Bokod, Benguet	48	6.8
Balongao-Compatling	112	2.6
Villa Agilpay	405	21.1
Tibag, Tarlac	872	15.9
Poblacion, Moyantoc	280	6.8
Nambalan, Moyantoc	142	21.4
Palublub, Capas	240	11.5
Pacalat, Mangatarem	117	15.5

Fig. 4.16 BASE FLOW CURVE



A (m³/s)	B (m³/s)	C (m³/s)
3,000	2,300 (0.77)	700 (0.23)
4,000	2,600 (0.65)	1,400 (0.35)
5,000	3,000 (0.60)	2,000 (0.40)
6,000	3,300 (0.55)	2,700 (0.45)
7,000	3,600 (0.51)	3,300 (0.49)
8,000	3,800 (0.48)	4,200 (0.52)
9,000	4,100 (0.46)	4,900 (0.54)

Fig. 4.17 DISCHARGE RATING CURVES AT POPONTO FLOODWAY

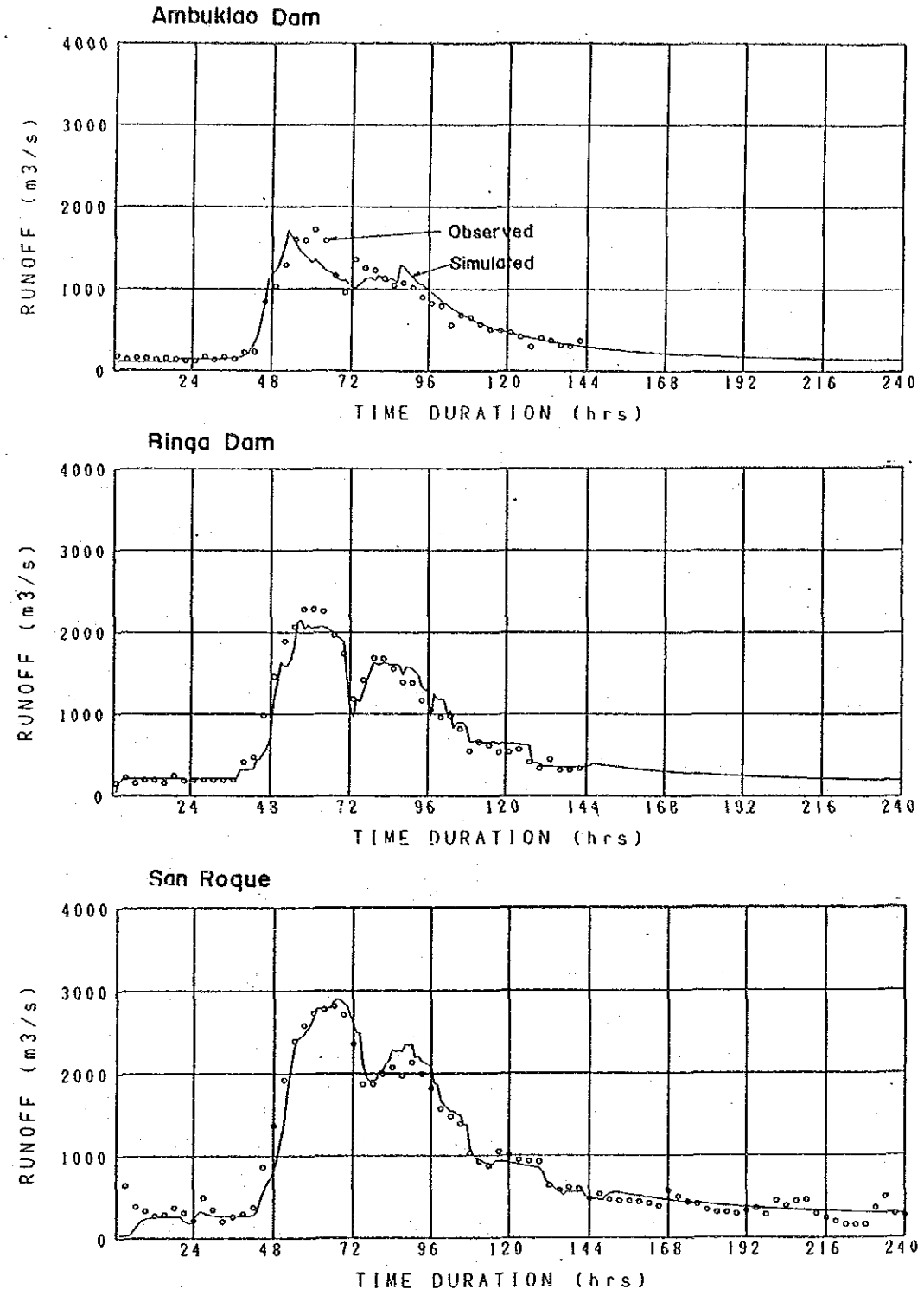


Fig. 4.18 OBSERVED AND SIMULATED FLOOD HYDROGRAPHS DURING TYPHOON MARING IN 1984 (1/2)

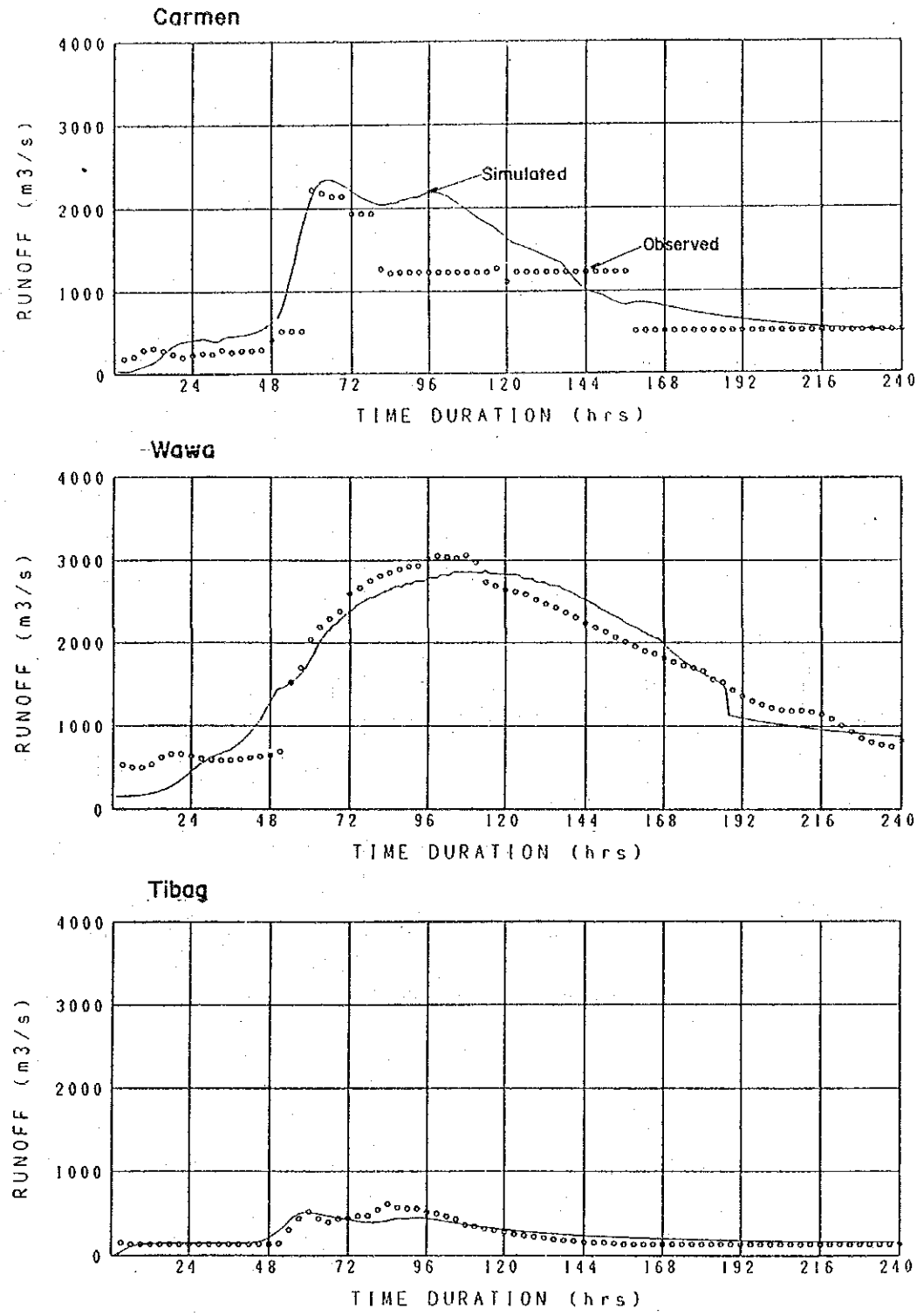


Fig. 4.18 OBSERVED AND SIMULATED FLOOD HYDROGRAPHS DURING TYPHOON MARING IN 1984(2/2)

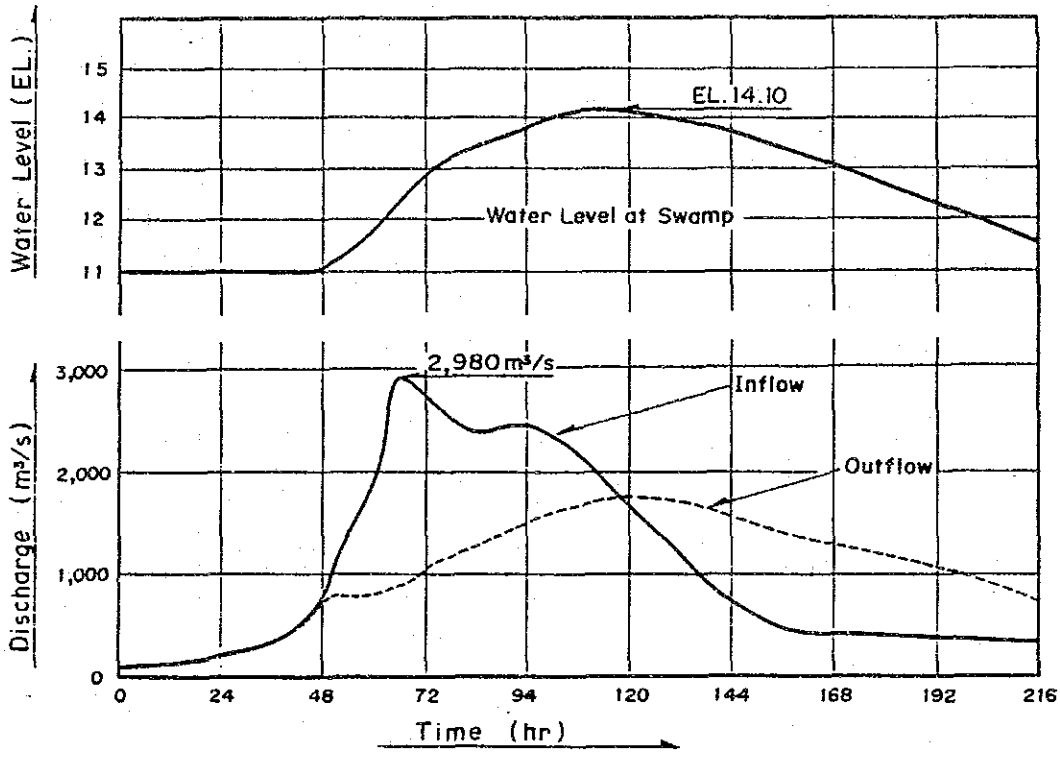


Fig. 4.19 SIMULATED WATER LEVEL AND DISCHARGE HYDROGRAPHS AT POPONT SWAMP DURING TYPHOON MARING IN 1984

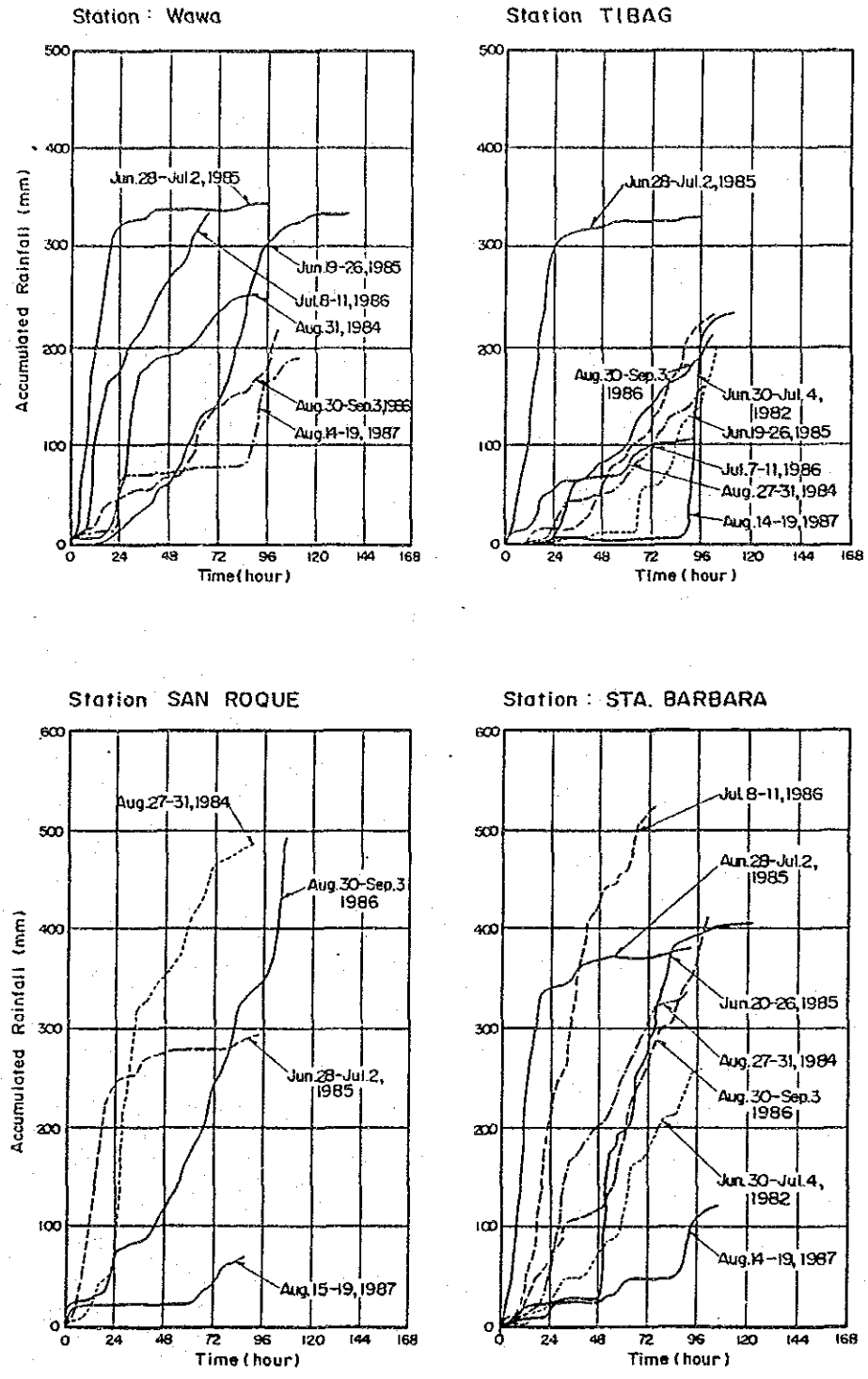


Fig. 4.20 ACCUMULATED RAINFALL CURVES AT TELEMETERING STATION

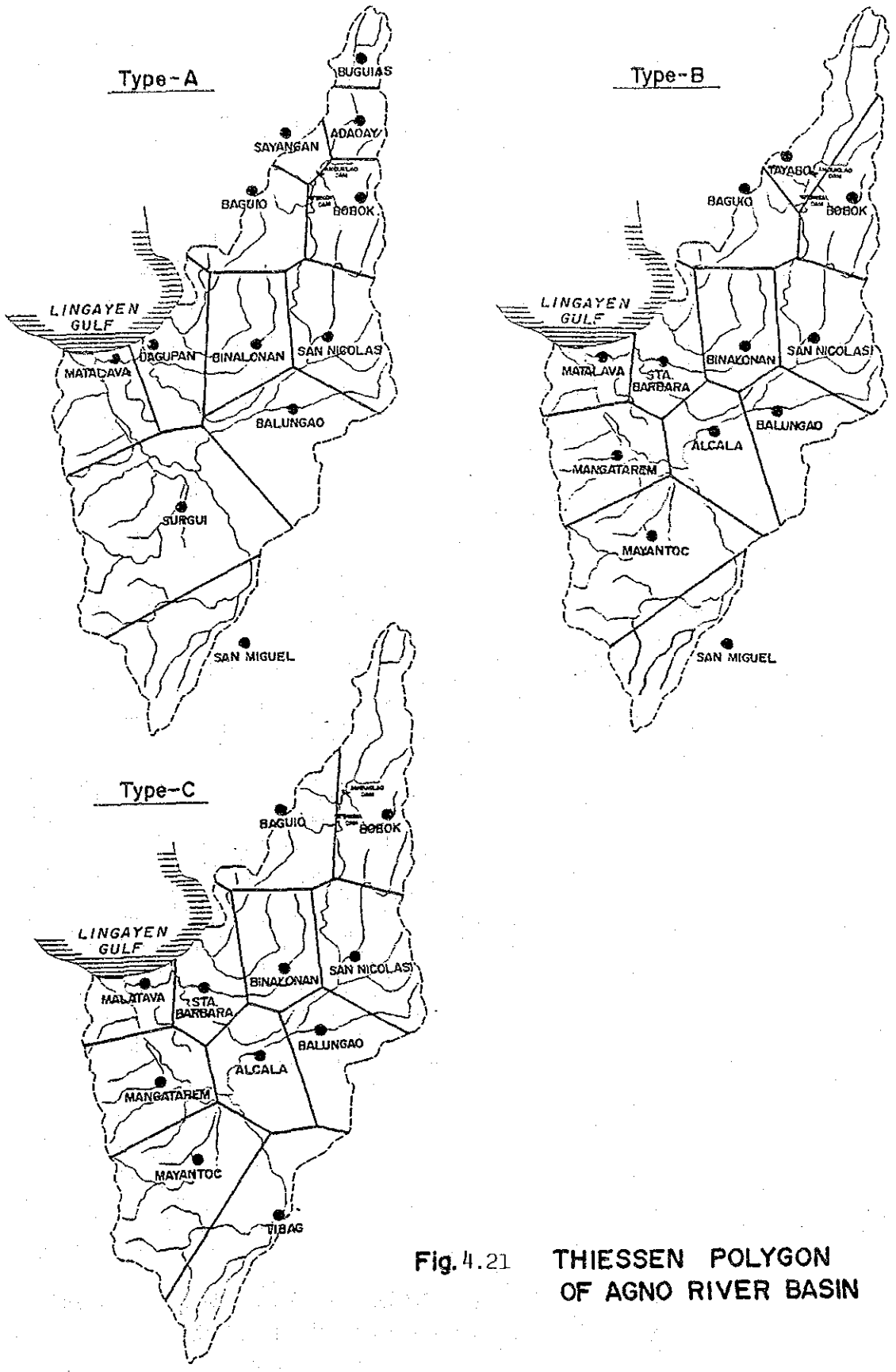


Fig. 4.21 THIESSEN POLYGON OF AGNO RIVER BASIN

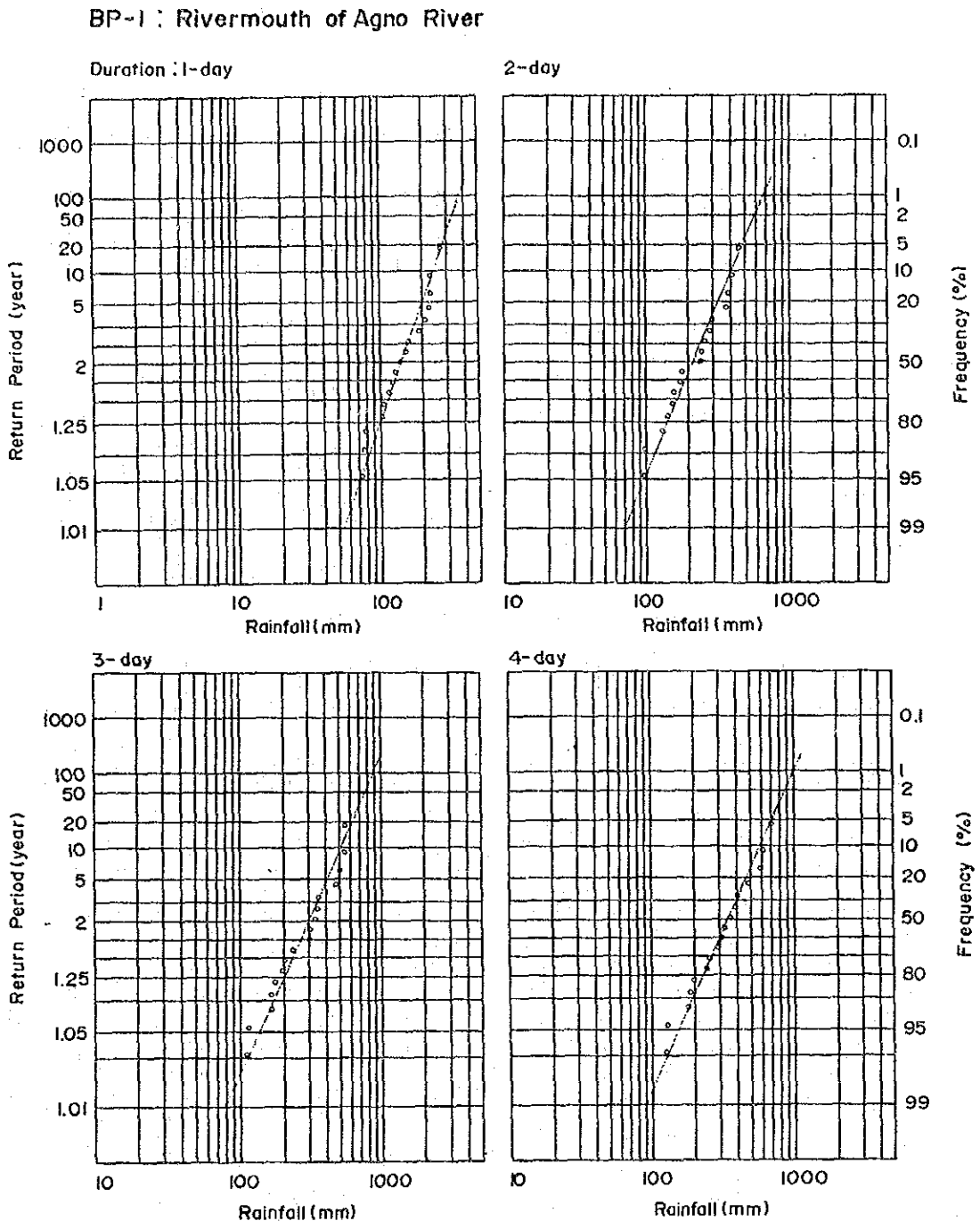


Fig. 4.22 FREQUENCY CURVE OF ANNUAL MAXIMUM BASIN MEAN RAINFALL AT BASE POINT (1/9)

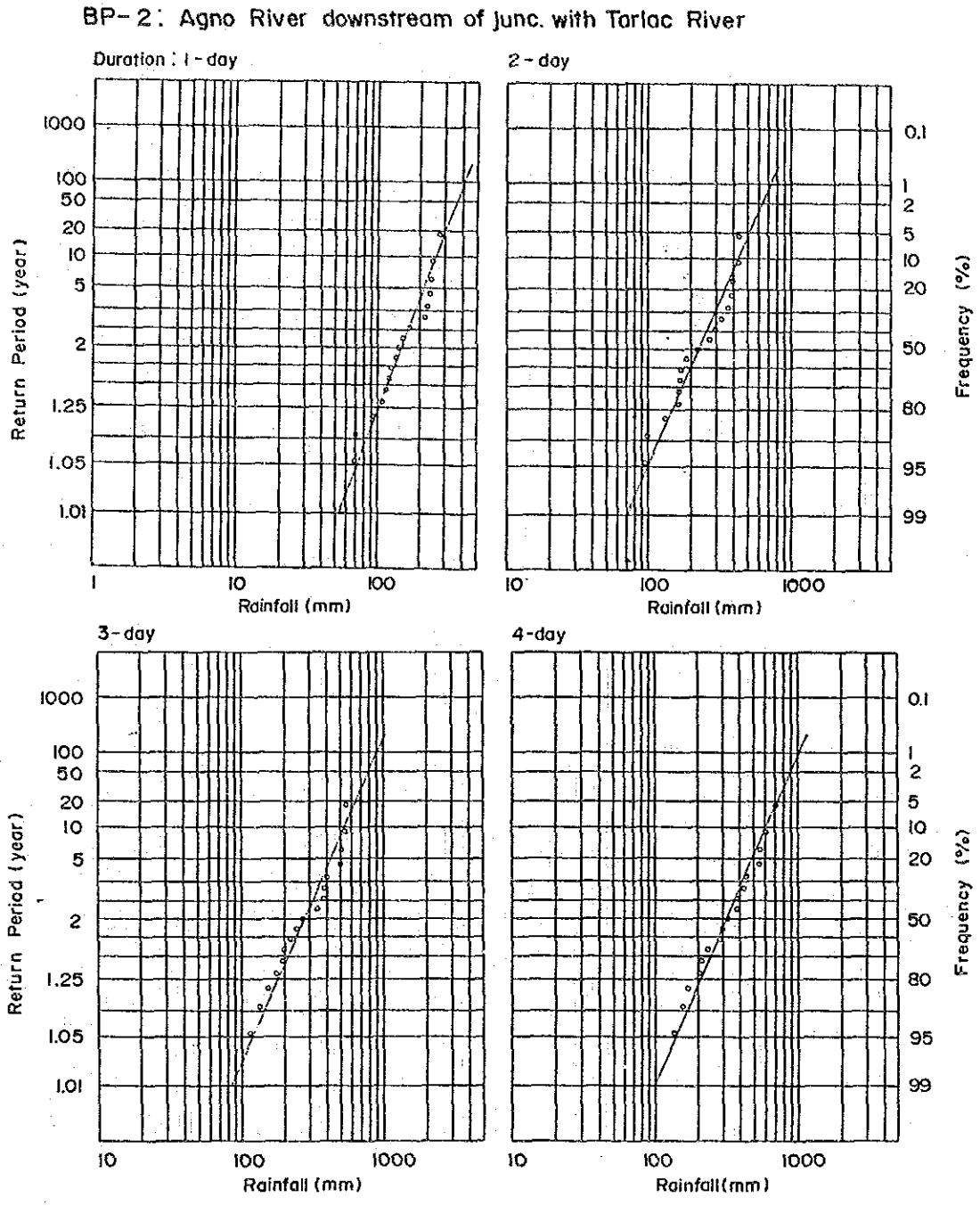


Fig. 4.22 FREQUENCY CURVE OF ANUAL MAXIMUN BASIN MEAN RAINFALL AT BASE POINT (2/9)

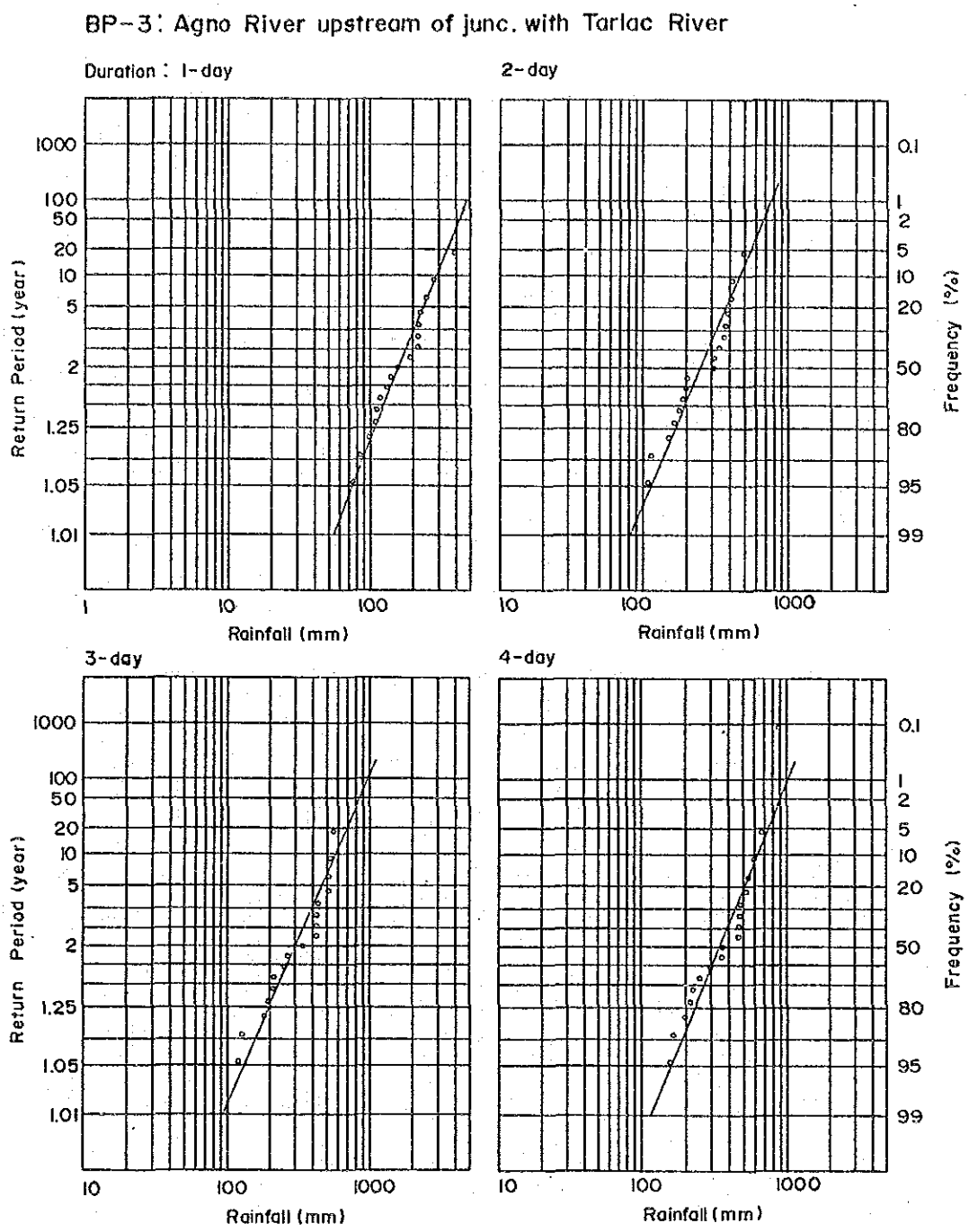


Fig. 4.22 FREQUENCY CURVE OF ANNUAL MAXIMUM BASIN MEAN RAINFALL AT BASE POINT (3/9)

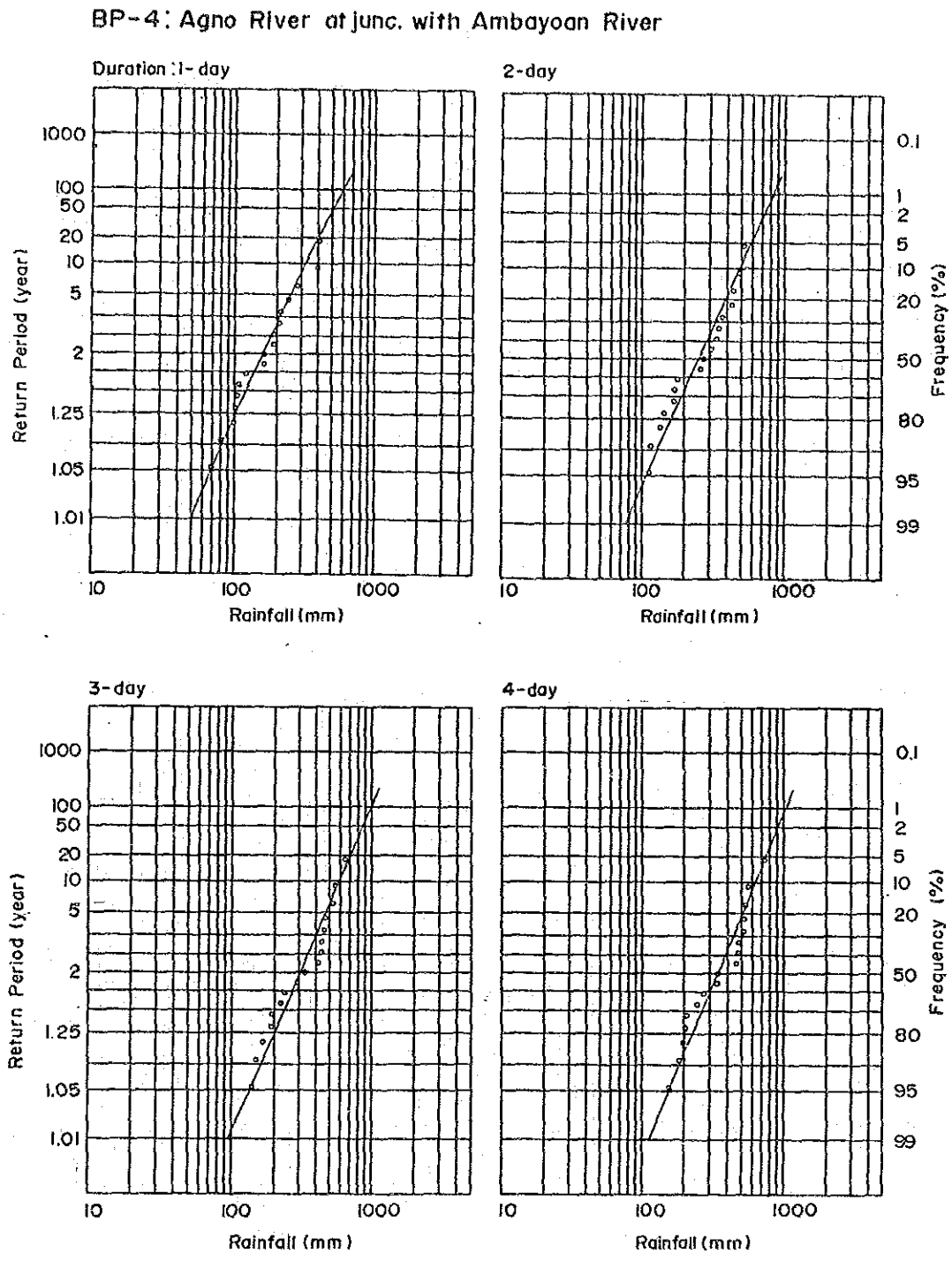


Fig. 4.22 FREQUENCY CURVE OF ANNUAL MAXIMUM BASIN MEAN RAINFALL AT BASE POINT (4/9)

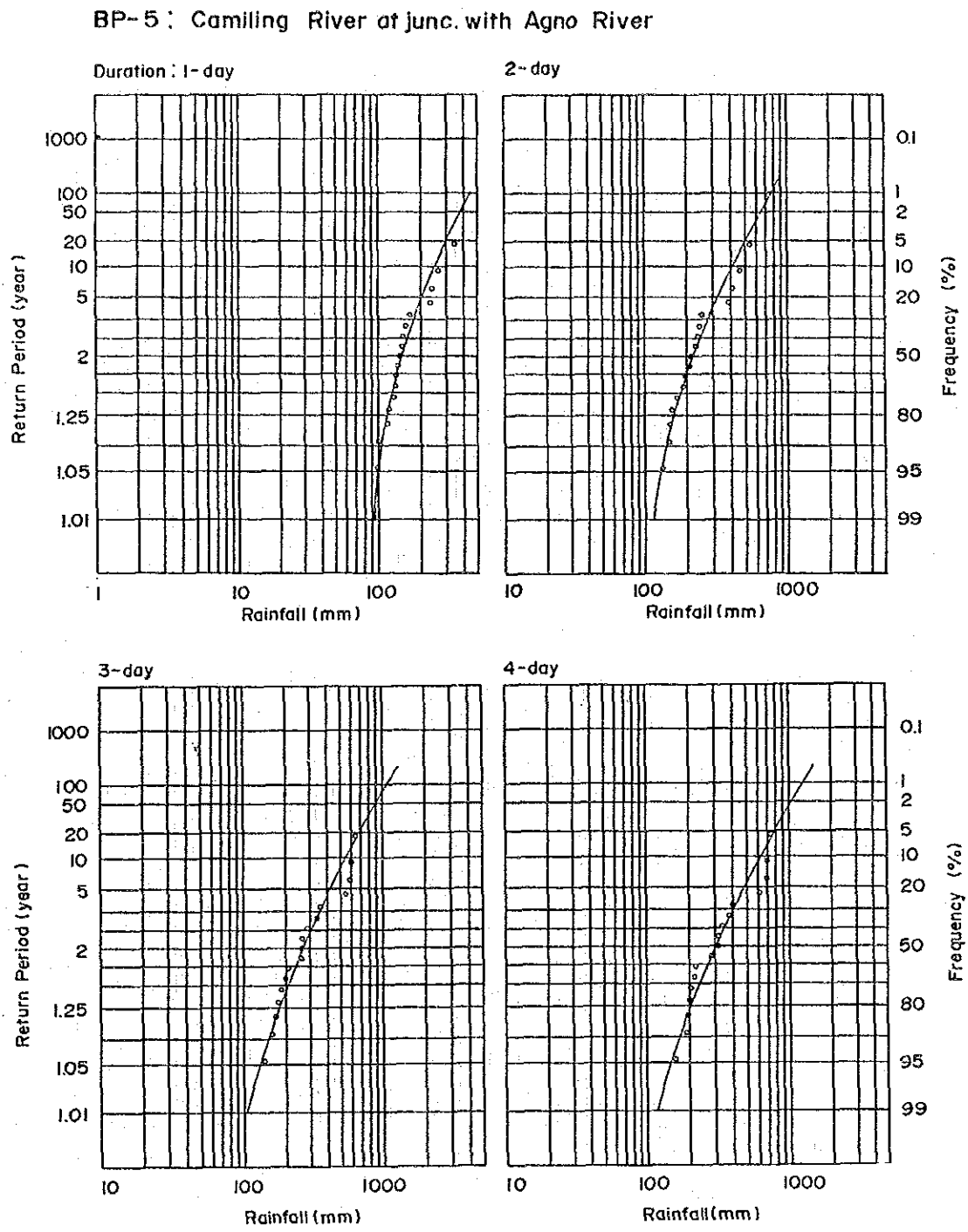


Fig. 4.22 FREQUENCY CURVE OF ANNUAL MAXIMUM BASIN MEAN RAINFALL AT BASE POINT (5/9)

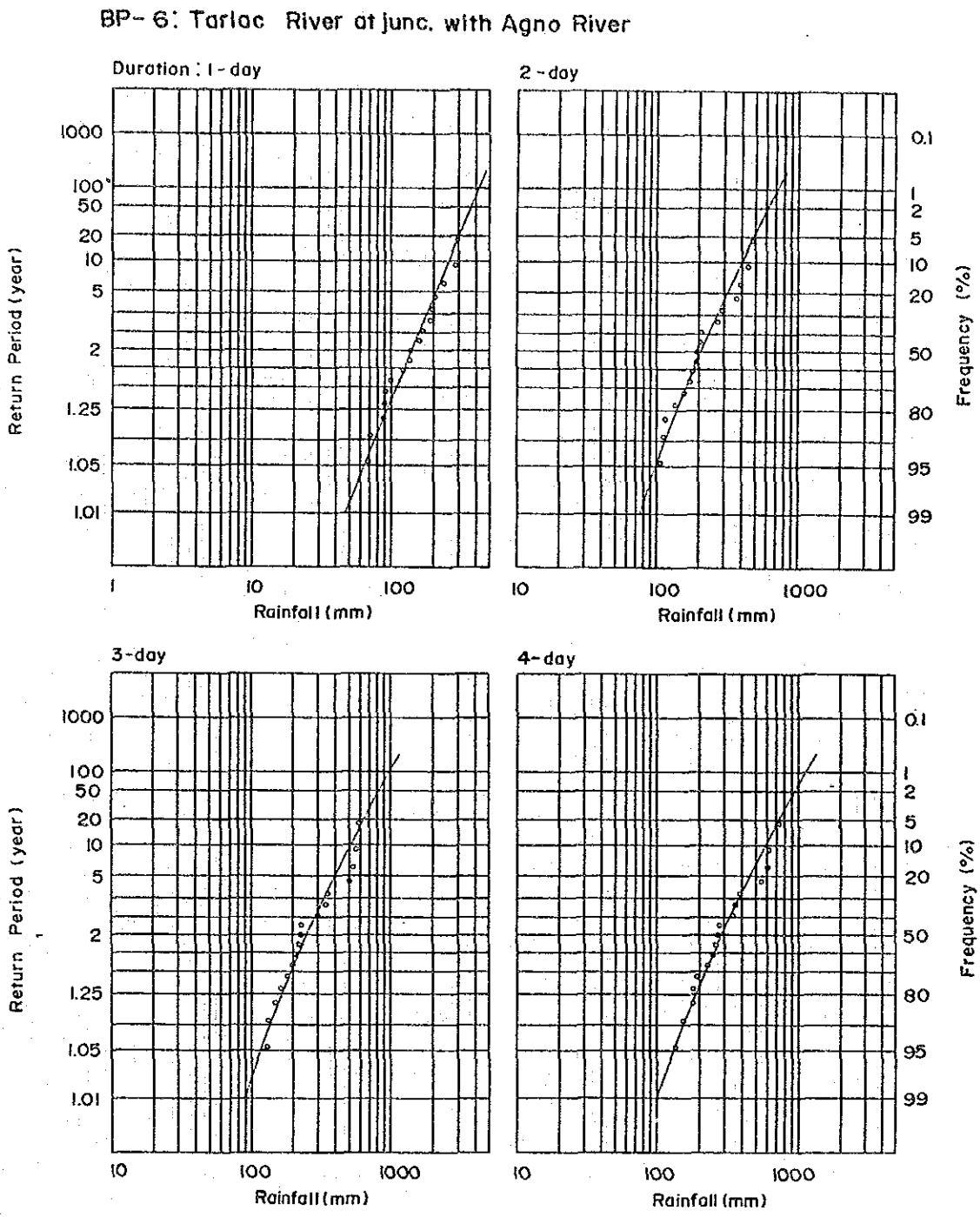


Fig. 4.22 FREQUENCY CURVE OF ANNUAL MAXIMUM BASIN MEAN RAINFALL AT BASE POINT (6/9)

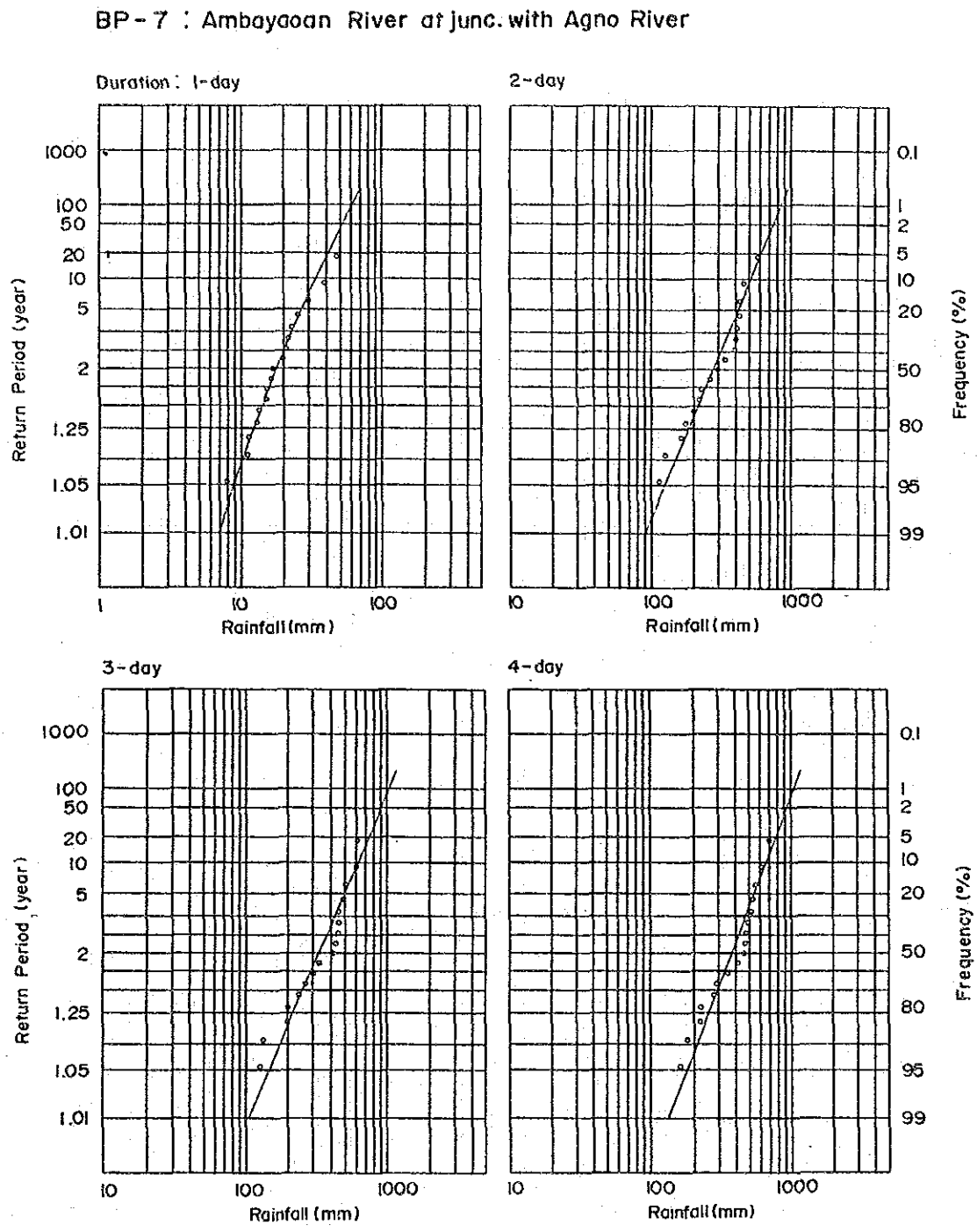


Fig. 4.22 FREQUENCY CURVE OF ANUAL MAXIMUN BASIN MEAN RAINFALL AT BASE POINT (7/9)

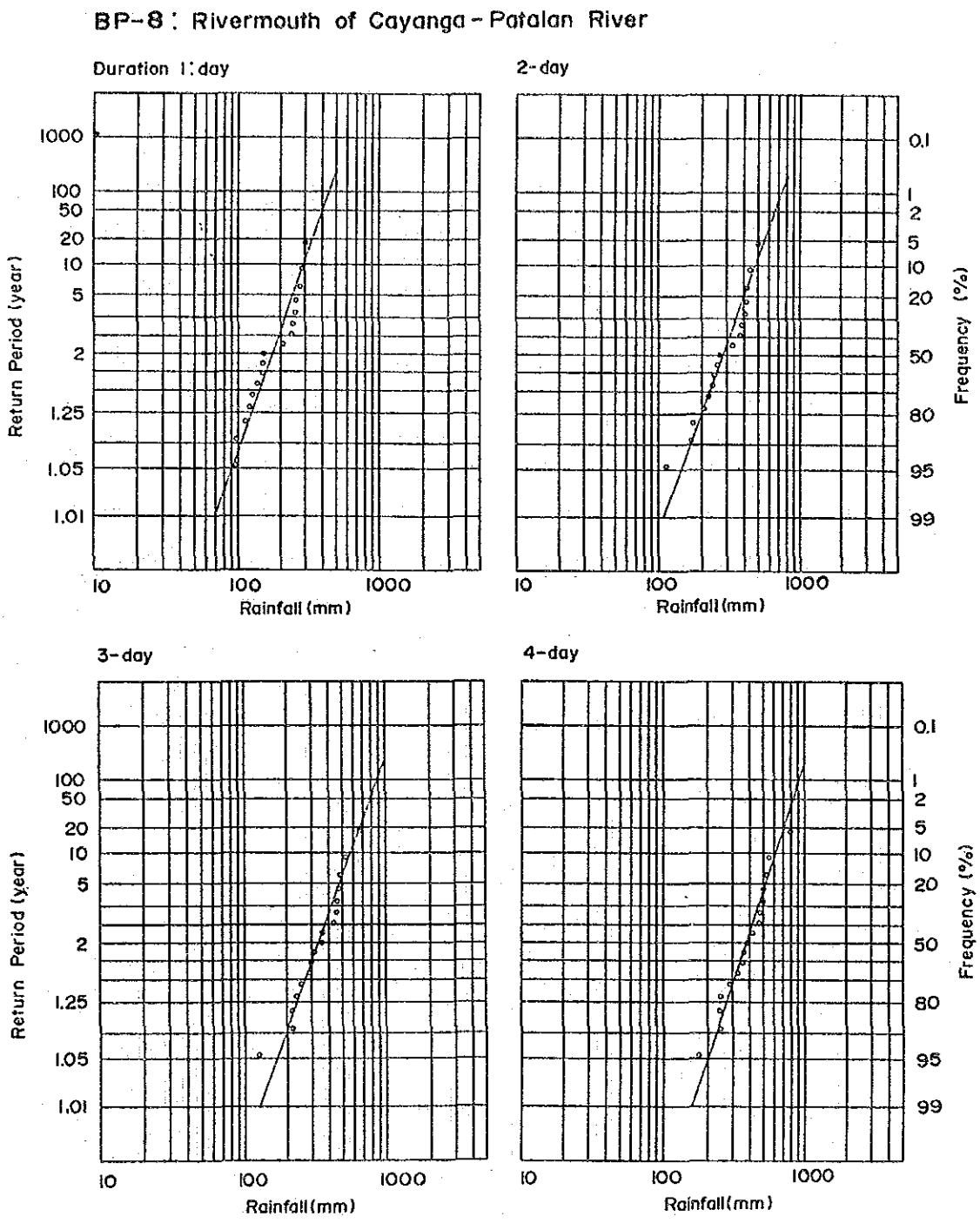


Fig. 4.22 FREQUENCY CURVE OF ANNUAL MAXIMUM BASIN MEAN RAINFALL AT BASE POINT (8/9)

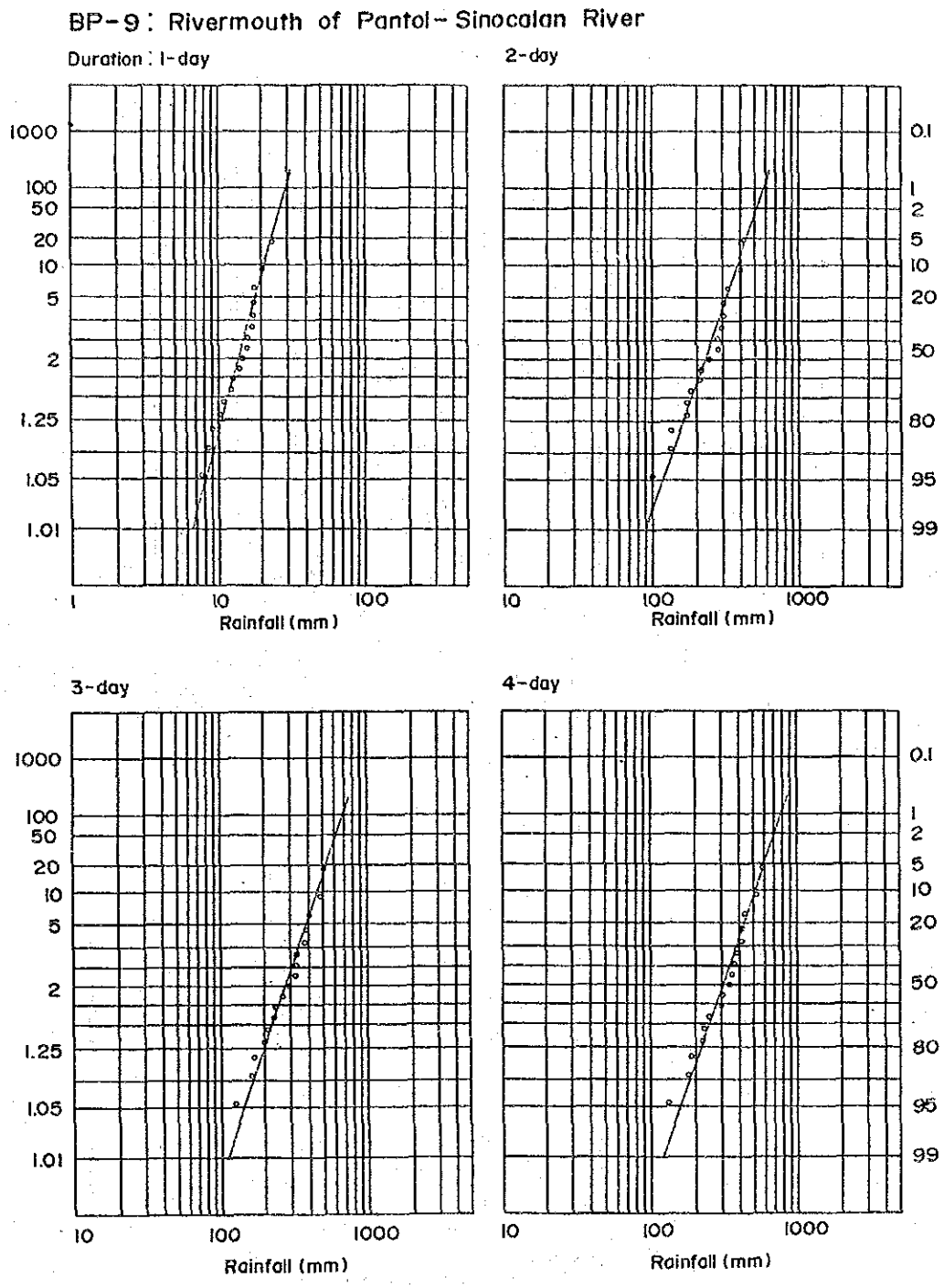
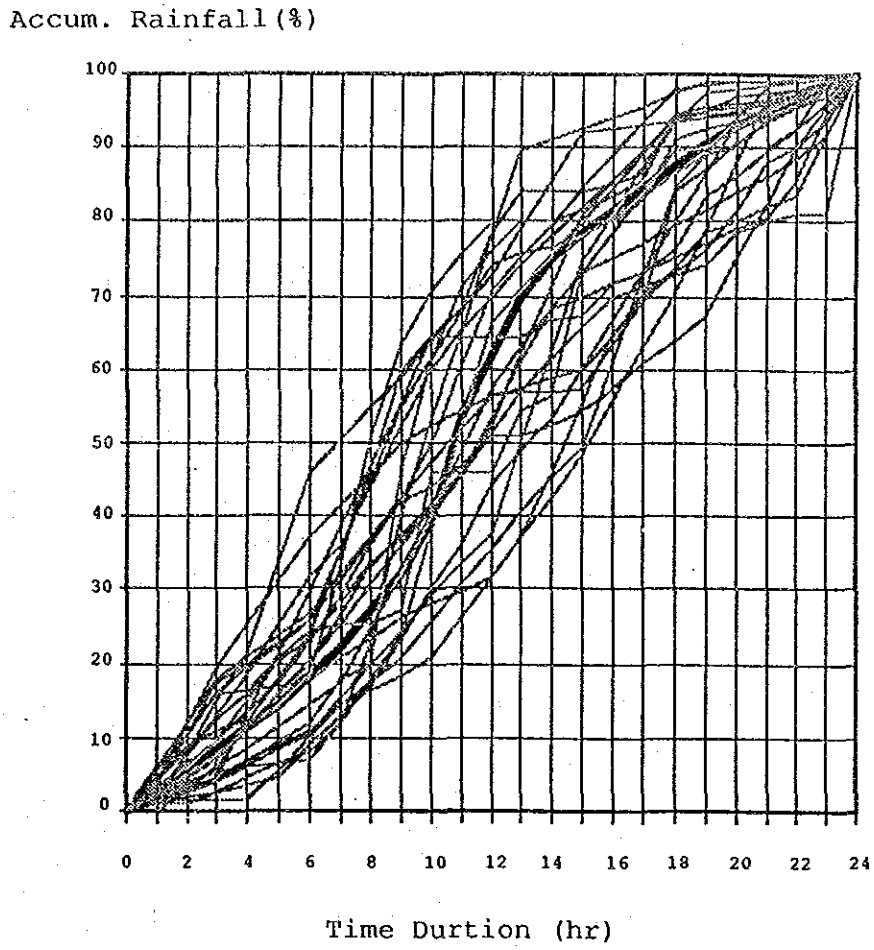


Fig. 4.22 FREQUENCY CURVE OF ANNUAL MAXIMUM BASIN MEAN RAINFALL AT BASE POINT (9/9)



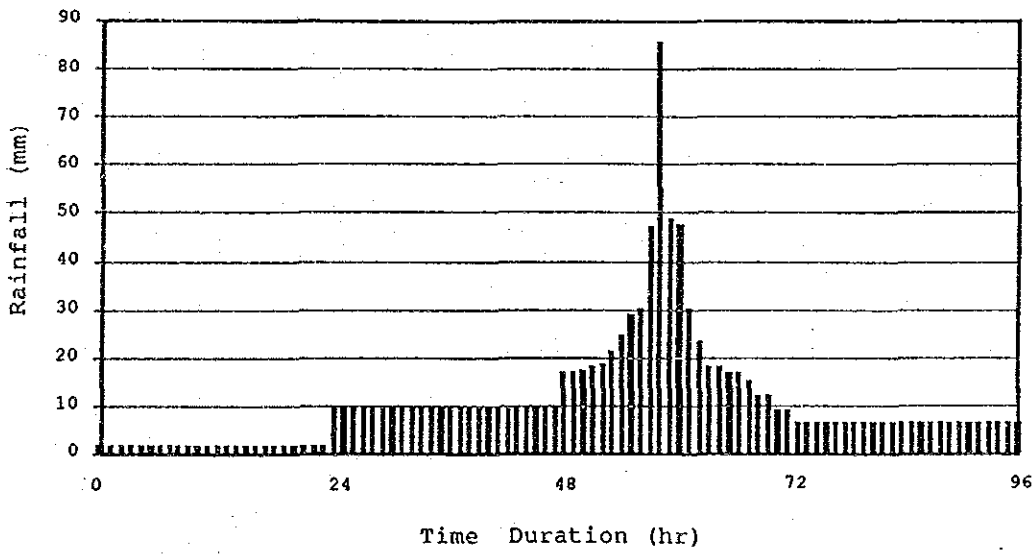


Fig. 4.23 HOURLY DESIGN RAINFALL DISTRIBUTION

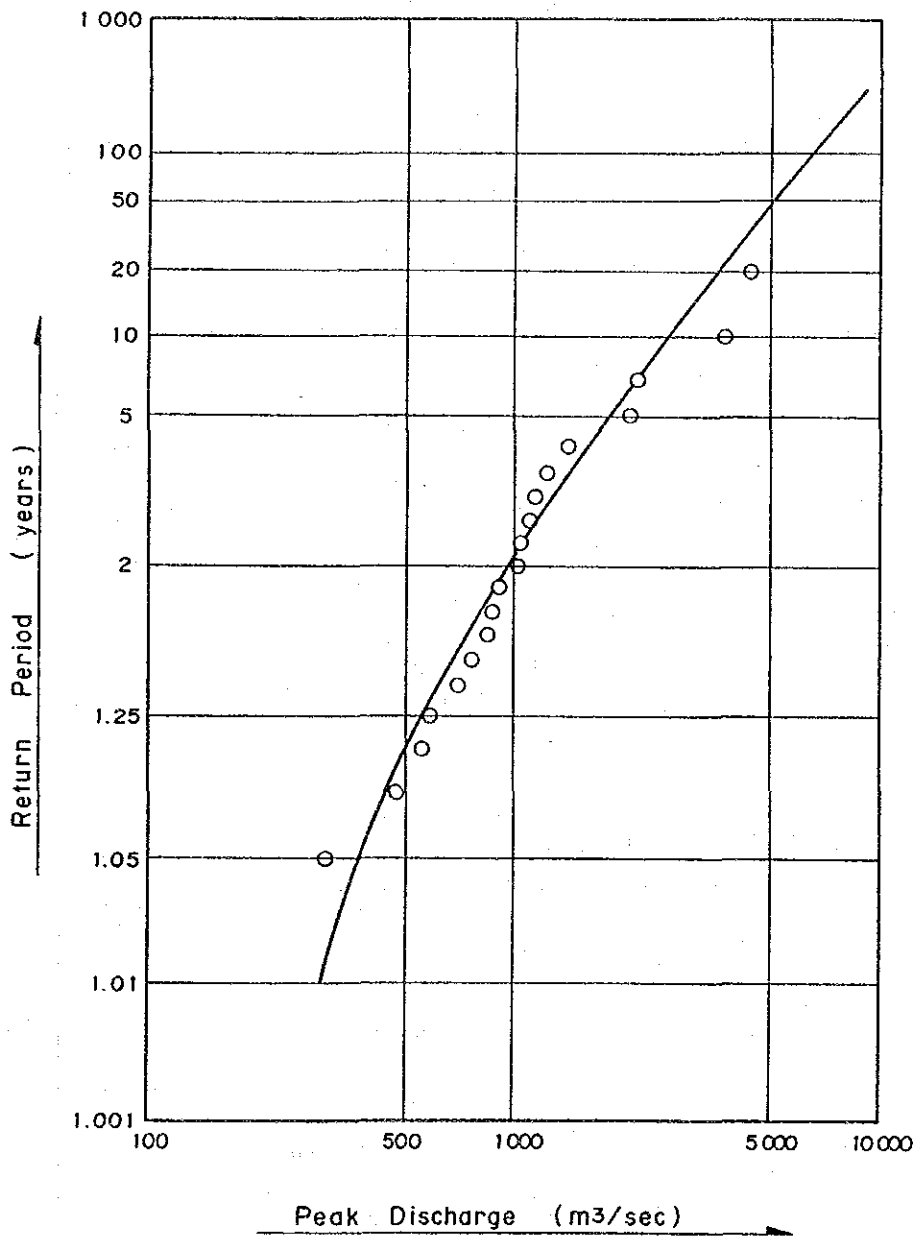
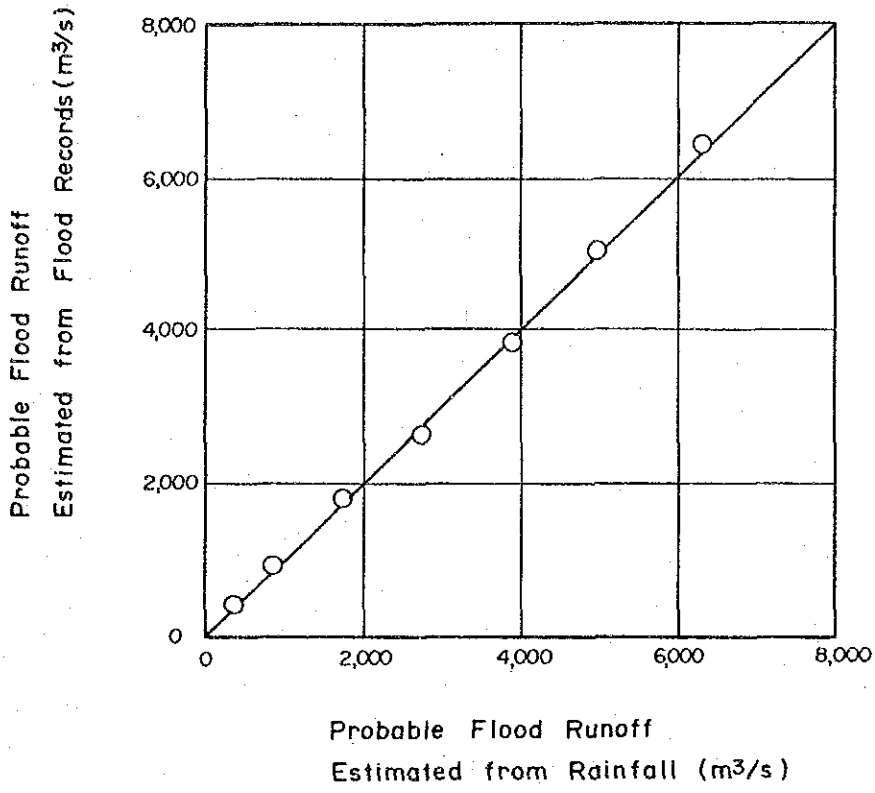
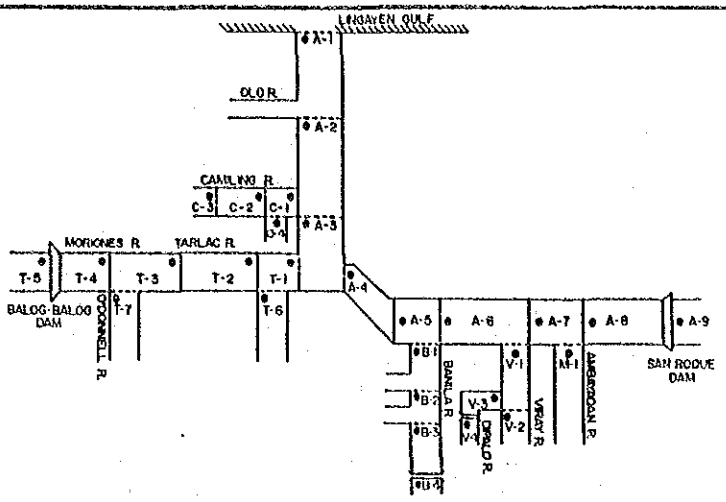


Fig. 4.24 FREQUENCY CURVE OF ANNUAL MAXIMUM PEAK DISCHARGE AT SAN ROQUE



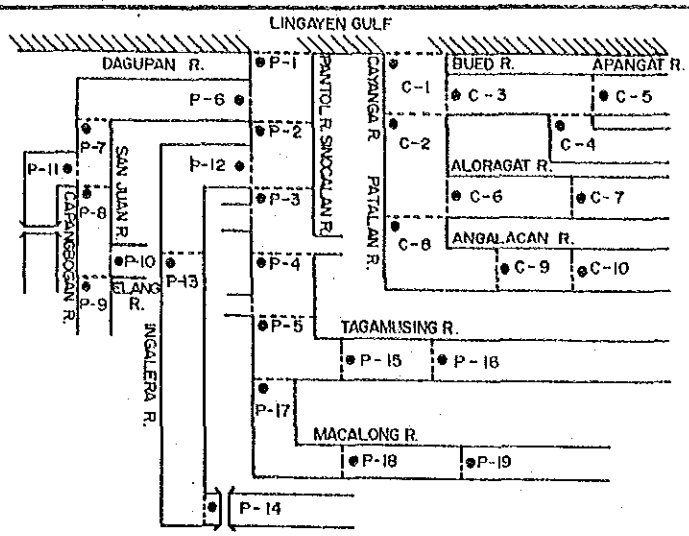
Return Period (year)	Probable Flood Runoff (m³/s)	
	from Flood Record	from Rainfall
100	6,440	6,260
50	5,000	5,060
25	3,900	3,960
10	2,570	2,720
5	1,810	1,710
2	990	830
1.05	370	320

Fig. 4.25 COMPARISON OF PROBABLE FLOOD PEAK RUNOFF AT SAN ROQUE



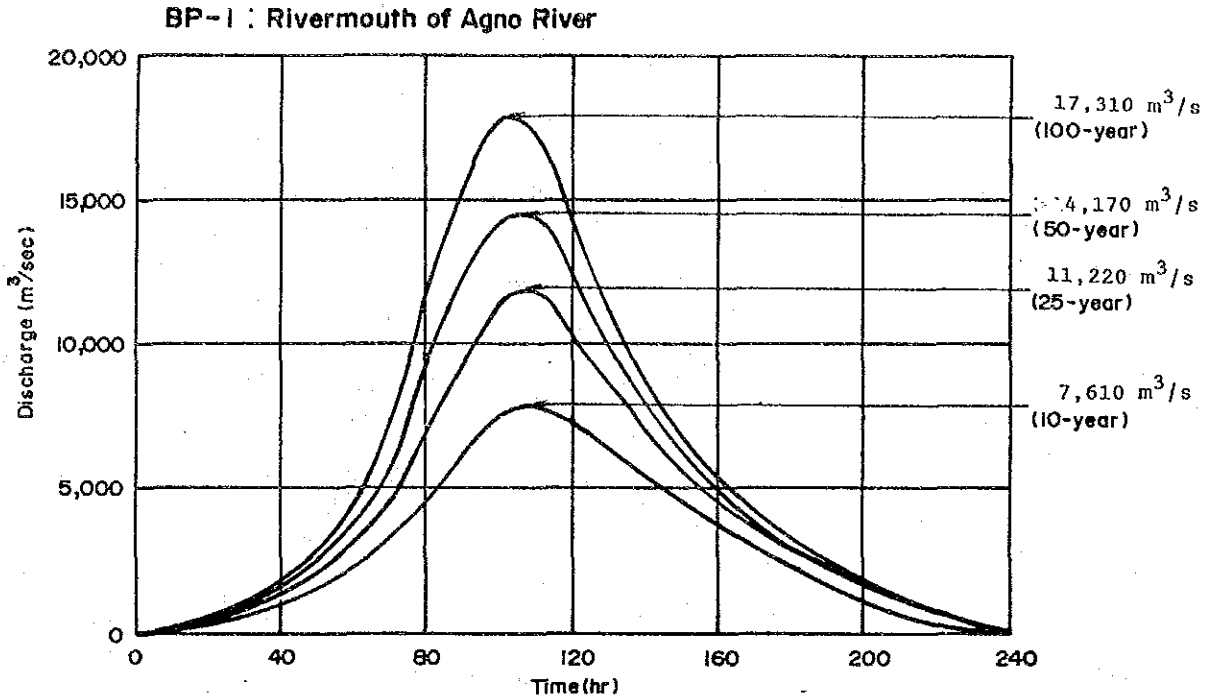
River/Stretch	Location No.	Return Period (year) 1.05	2	5	10	25	50	100
1. Main Agno River								
Rivermouth	A-1	1160	2510	5100	7610	11220	14170	17310
Before Junction with Olo R.	A-2	990	2250	4700	6910	10140	12730	15680
Before Junction with Camiling R.	A-3	880	2100	4350	6410	9330	11960	14820
Before Junction with Tarlac R.	A-4	500	1330	2690	3980	5760	7460	9210
Upstream of Poponto Floodway	A-5	490	1320	2680	3960	5730	7430	9190
Before Junction with Banila R.	A-6	410	1140	2330	3470	5020	6570	8140
Before Junction with Viray-Dipalo R.	A-7	360	970	2050	3010	4380	5930	7280
Before Junction with Ambayoan R.	A-8	260	700	1530	2340	3780	5120	6370
San Roque Dam	A-9	320	830	1710	2600	3950	5060	6260
2. Tarlac River								
Junction with Agno R.	T-1	460	960	2000	2930	4350	5510	6720
Before Junction of Baka R.	T-2	240	550	1140	1690	2540	3230	3940
Tarlac	T-3	180	430	870	1340	2020	2580	3180
Baka R. + Sub Basin	T-6	260	530	1000	1490	2150	2640	3150
Moriones R.	T-4	110	280	570	860	1270	1610	1950
O'Donnell R.	T-7	70	170	310	490	760	1000	1230
Balog-Balog	T-5	80	160	300	430	610	760	900
3. Camiling River								
Junction with Agno R.	C-1	200	360	660	1020	1630	2170	2660
Before Junction with Bayating R.	C-2	130	240	450	700	1140	1520	1850
Before Junction with Mamair R.	C-3	90	170	310	480	850	1130	1380
Bayating R.	C-4	70	120	210	320	500	660	800
4. Banila River								
Junction with Agno R.	B-1	110	250	510	740	990	1380	1610
Before Junction with Matablong R.	B-2	60	160	320	470	650	950	1100
Before Junction with Karayoga R.	B-3	30	70	150	220	300	440	510
Bridge	B-4	20	60	110	160	230	330	390
5. Viray-Dipalo River								
Junction with Agno R.	V-1	50	120	240	380	530	730	840
Viray R.	V-2	20	60	130	190	270	370	420
Dipalo R. (Down stream of San Pedro)	V-3	20	60	110	170	250	350	400
(Upstream of San Pedro)	V-4	10	30	70	100	150	210	240
6. Ambayoan River								
Junction with Agno R.	M-1	110	300	590	880	1310	1730	2090

Fig. 4.26 PROBABLE FLOOD PEAK DISCHARGE DISTRIBUTION OF AGNO RIVER UNDER CONFINING DIKE CONDITION (WITH SAN ROQUE DAM)



River/Stretch	Location No.	1.05	2	5	10	25	50	100
1.1 Cayanga/Patalan Rivers								
Rivermouth	C-1	270	580	1070	1490	2080	2560	3030
Before Junction with Bued R.	C-2	140	300	550	770	1060	1310	1550
1.2 Bued River								
Junction with Cayanga R.	C-3	130	290	520	730	1040	1290	1550
Before Junction with Apangat R.	C-4	90	200	340	500	750	950	1170
Apangat R.	C-5	30	60	120	160	220	260	300
1.3 Aloragat River								
Junction with Patalan R.	C-6	50	110	210	280	380	470	550
Amagbagan	C-7	30	60	100	140	200	240	290
1.4 Angalacan River								
Junction with Patalan R.	C-8	70	150	200	400	670	710	840
Maraboc	C-9	50	110	190	270	400	510	620
Killo	C-10	30	80	130	190	290	370	460
2.1 Panto/Sinocalan River								
Rivermouth	P-1	430	810	1340	1900	2710	3260	4000
Before Junction with Dagupan R.	P-2	280	540	850	1220	1740	2220	2670
Before Junction with Ingalera R.	P-3	190	380	600	860	1260	1640	2000
Before Junction with Quinabolotan R.	P-4	140	280	430	620	950	1250	1530
Catablan	P-5	120	250	370	540	850	1120	1380
2.2 Dagupan City								
Junction with Panto R.	P-6	170	300	480	690	950	1110	1260
Before Junction with Basing R.	P-7	130	240	380	540	740	870	990
Lower San Juan R.	P-8	100	170	270	390	540	630	720
Upper San Juan R.	P-9	50	90	150	200	280	330	380
Elang R.	P-10	50	80	120	190	260	310	350
Campangbogan R.	P-11	30	50	80	120	170	190	220
2.3 Ingalera River								
Junction with Sinocalan R.	P-12	80	150	250	360	500	600	670
Talospatang	P-13	60	120	180	260	370	450	540
San Nicolas	P-14	20	40	50	80	120	150	180
2.4 Tagumising/Tuboy River								
Junction with Sinocalan R.	P-15	80	170	250	350	580	790	990
Yatyat	P-16	70	150	230	330	540	730	910
2.5 Macalong River								
Junction with Sinocalan R.	P-17	40	90	130	190	270	330	390
Urdaneta	P-18	30	60	80	120	190	240	280
San Manuel	P-19	20	30	50	70	100	140	160

Fig. 4.27 PROBABLE FLOOD PEAK DISCHARGE DISTRIBUTION OF ALLIED RIVERS UNDER CONFINING DIKE CONDITION



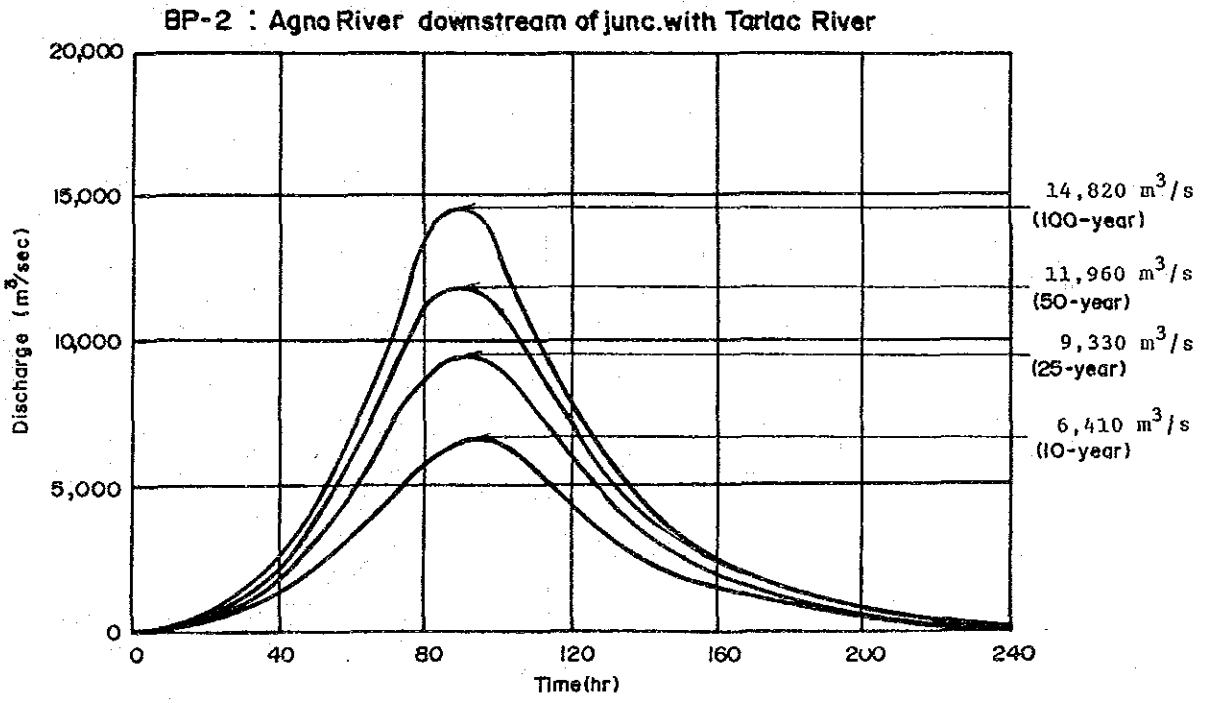
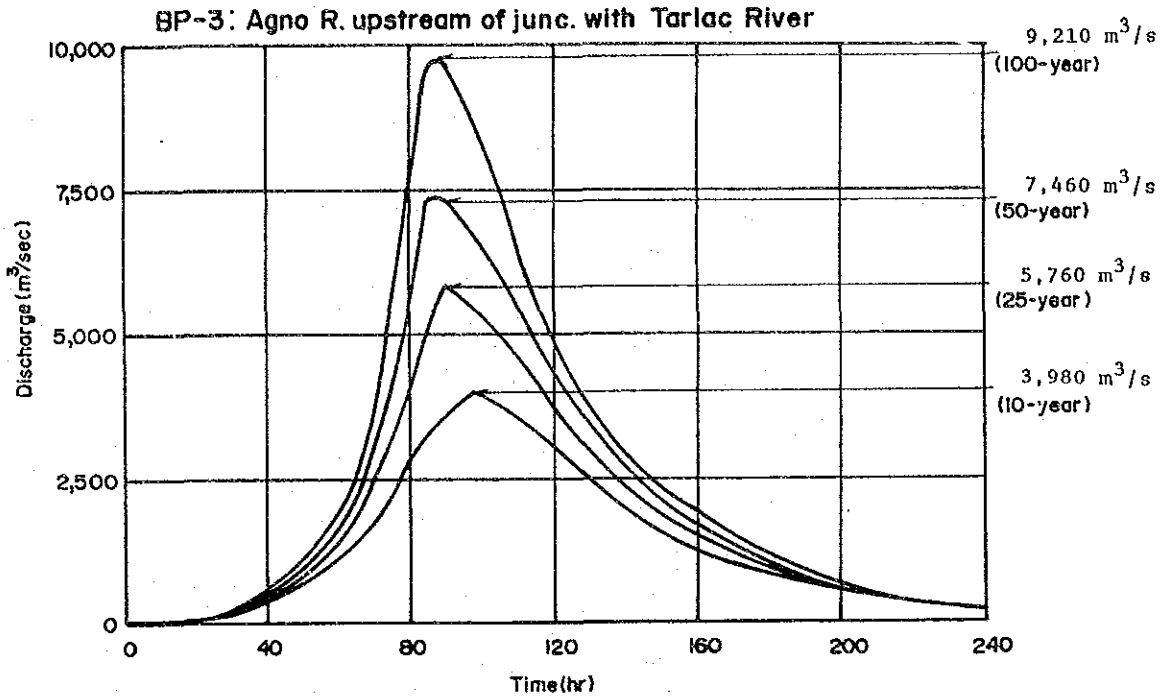


Fig. 4.28 PROBABLE FLOOD HYDROGRAPHS AT BASE POINT WITH SAN ROQUE DAM (1/5)



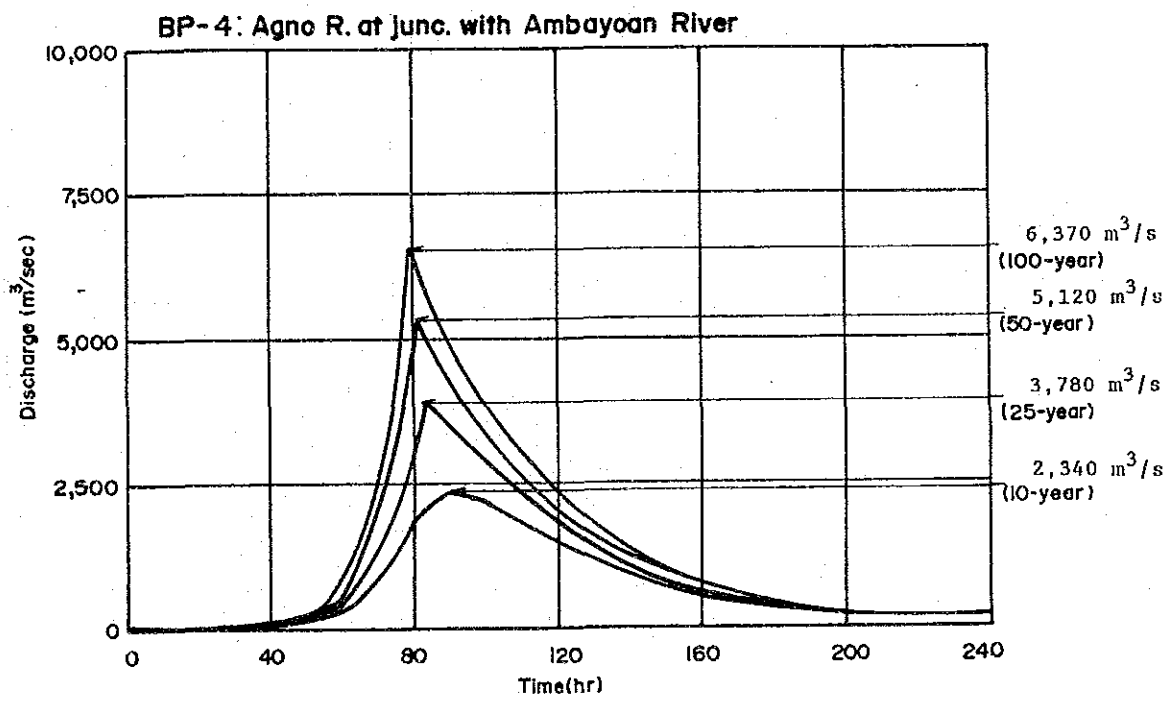
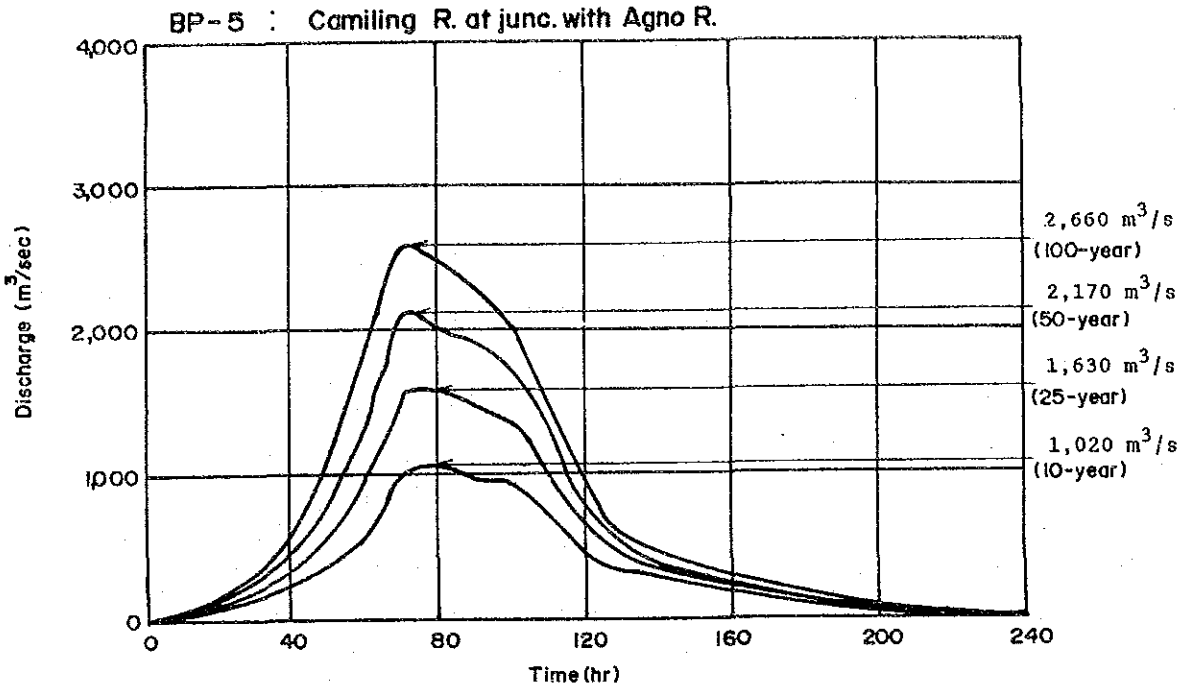


Fig. 4.28 PROBABLE FLOOD HYDROGRAPHS AT BASE POINT WITH SAN ROQUE DAM (2/5)



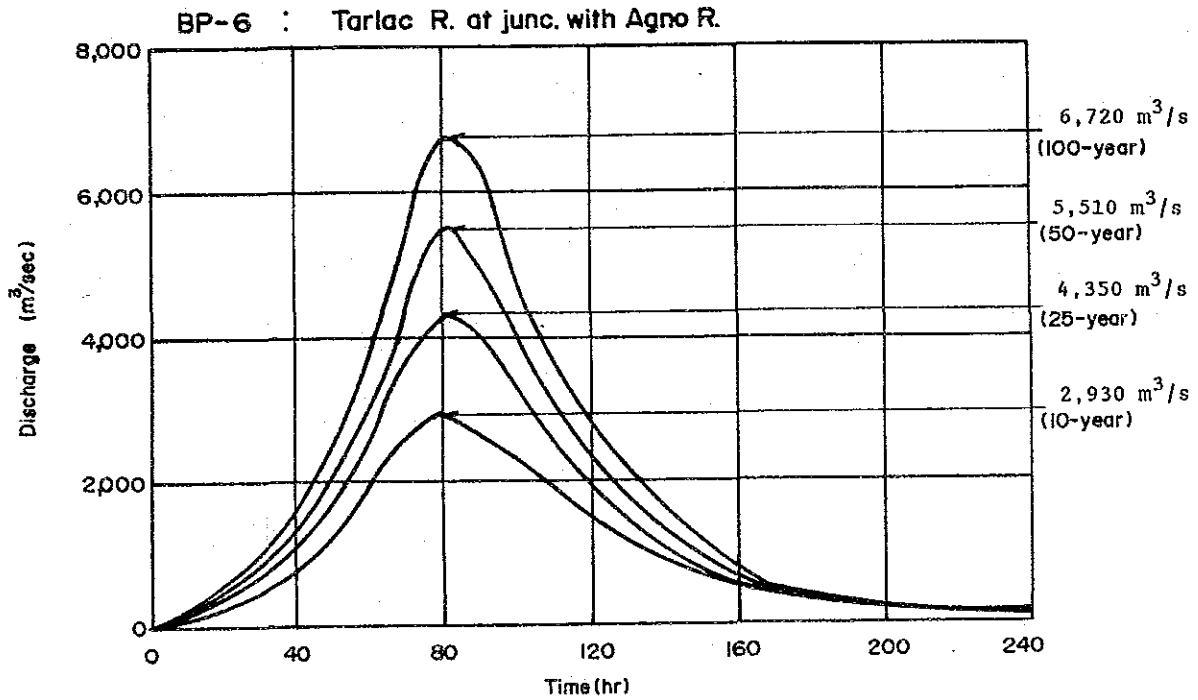


Fig. 4.28 PROBABLE FLOOD HYDROGRAPHS AT BASE POINT WITH SAN ROQUE DAM (3/5)

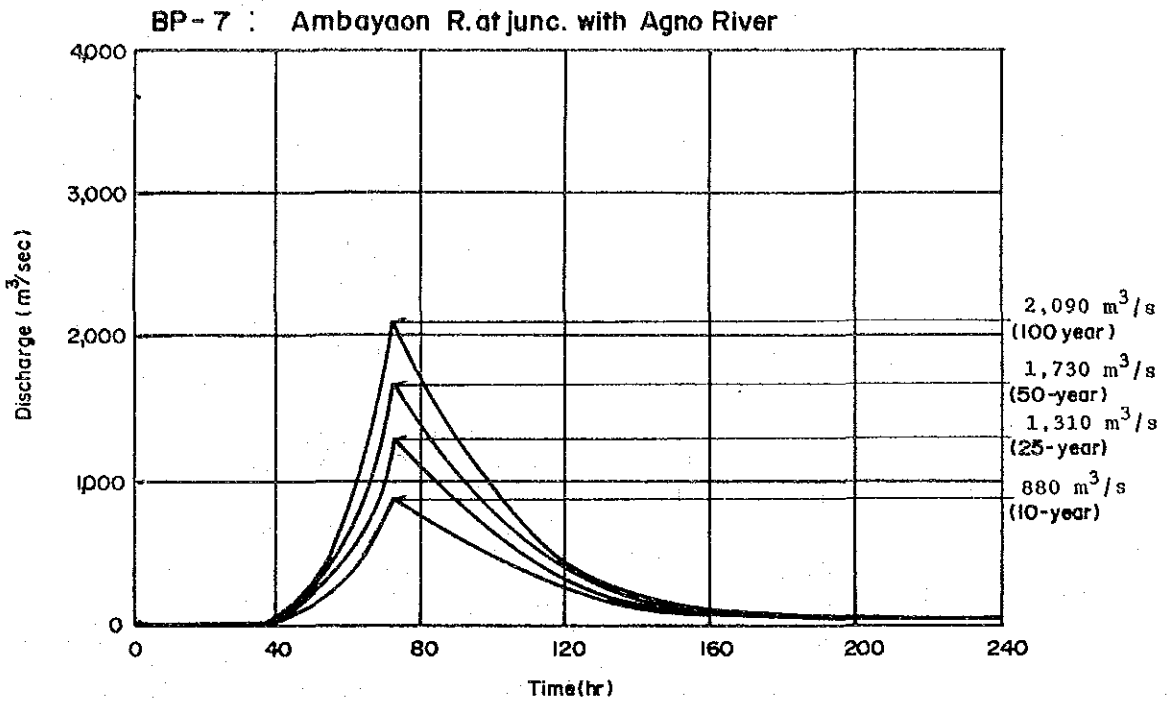
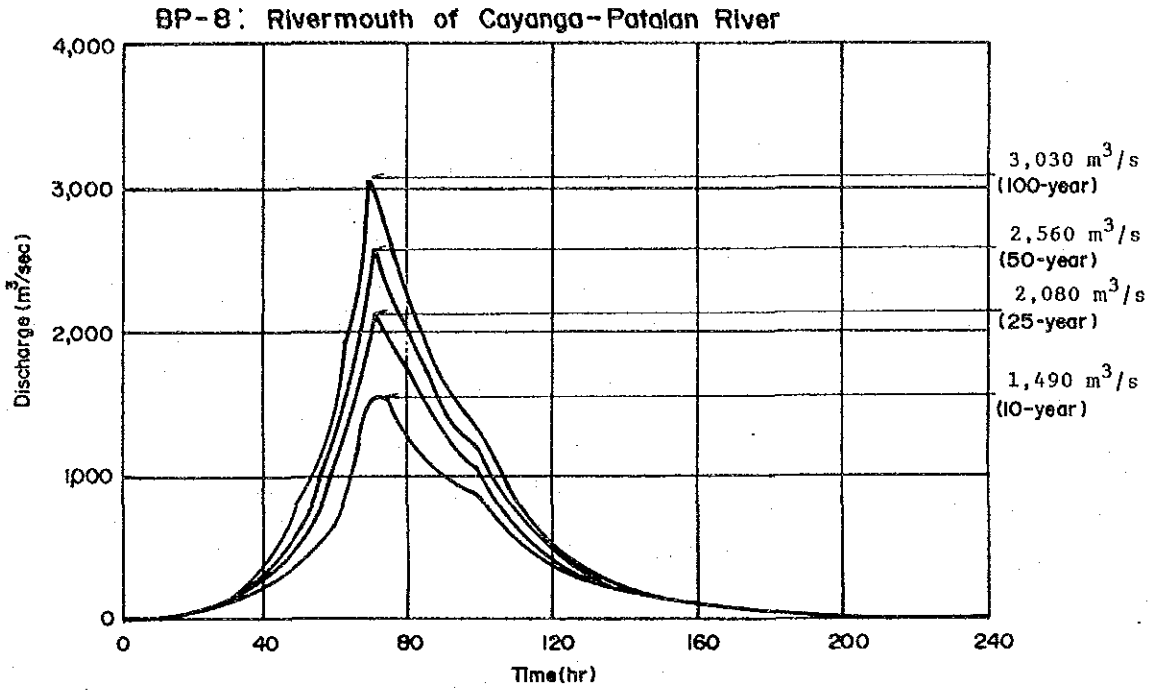


Fig. 4.28 PROBABLE FLOOD HYDROGRAPHS AT BASE POINT WITH SAN ROQUE DAM (4/5)



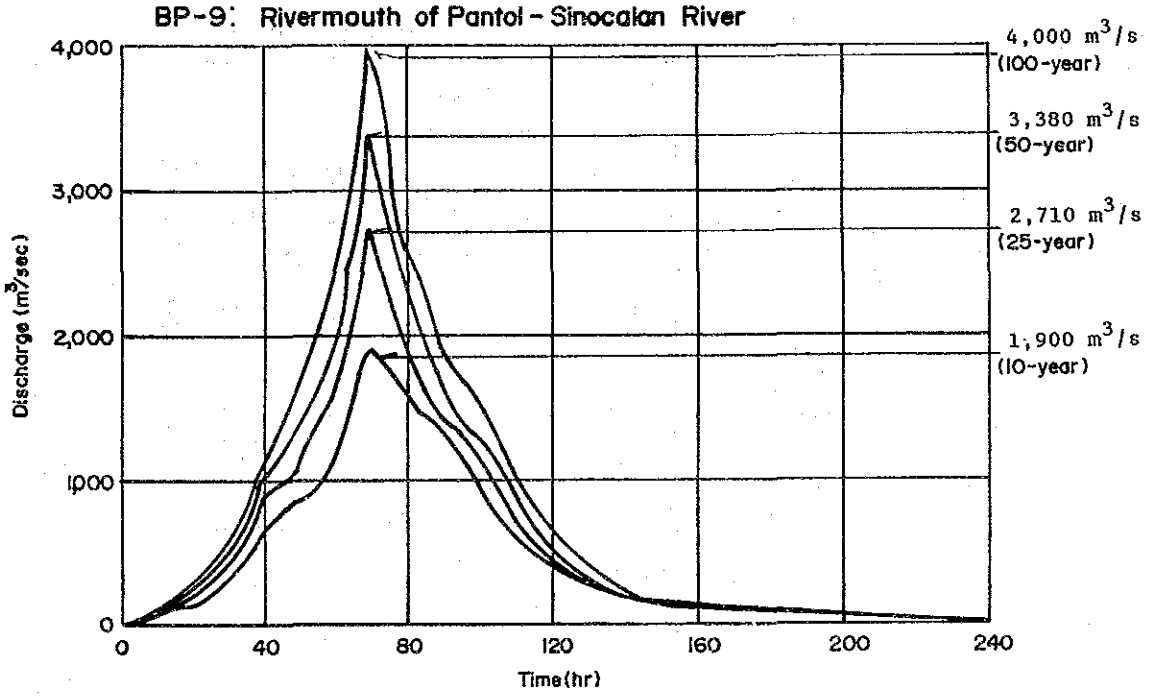
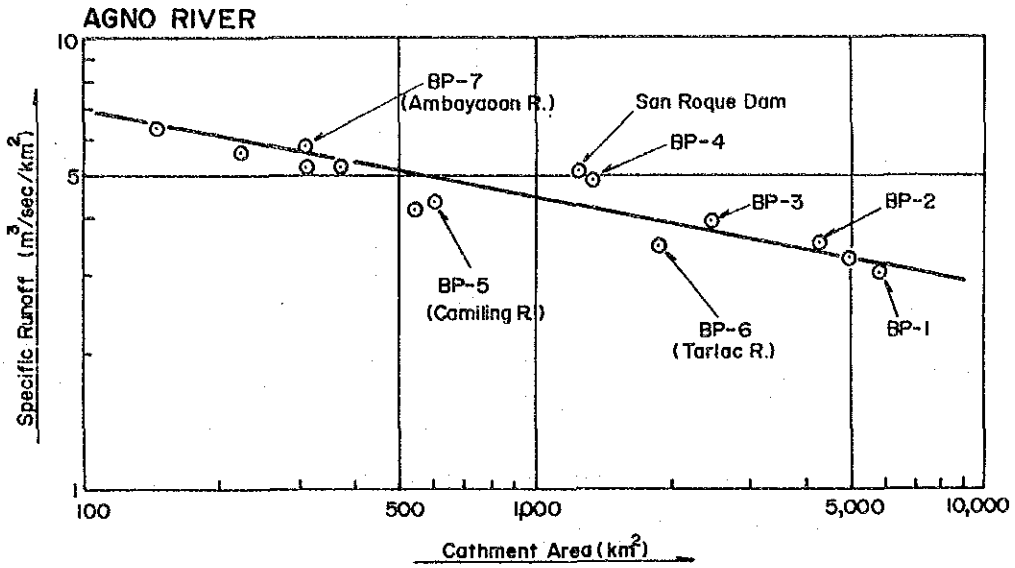


Fig. 4.28 PROBABLE FLOOD HYDROGRAPHS AT BASE POINT WITH SAN ROQUE DAM (5/5)



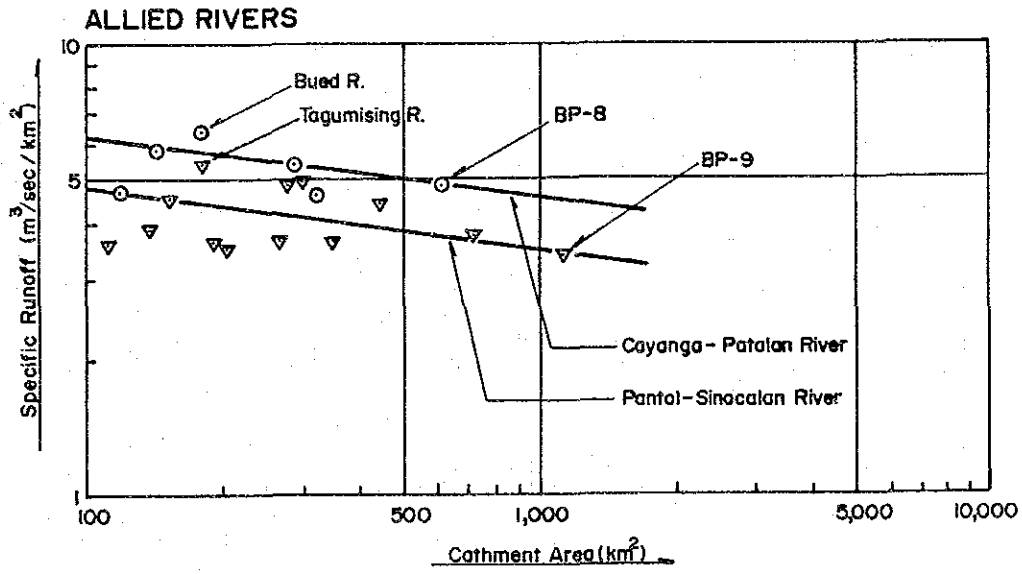
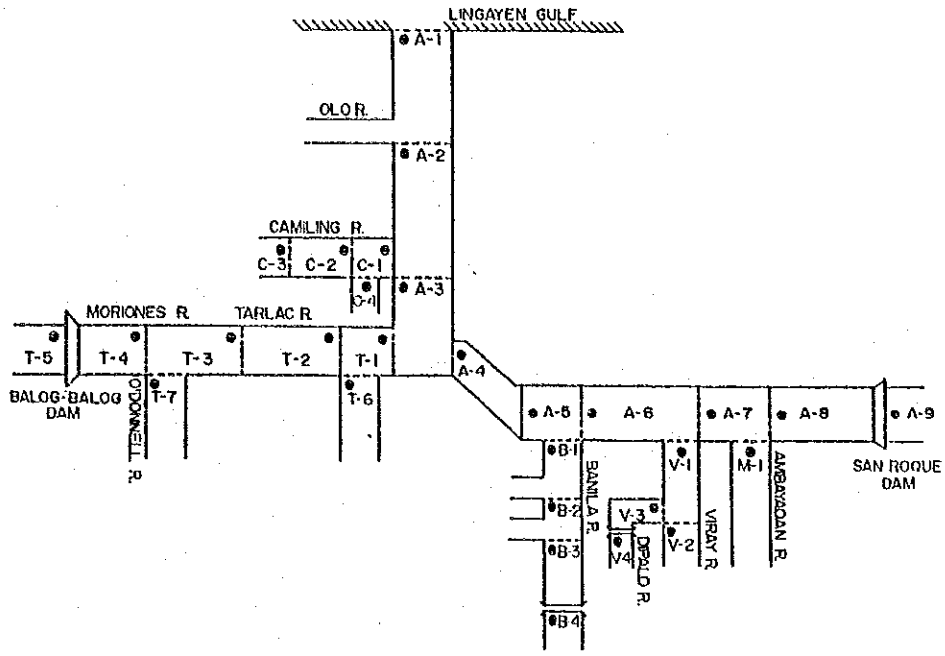


Fig. 4.29 RELATIONSHIP BETWEEN SPECIFIC RUNOFF OF 100 - YEAR FLOOD AND CATCHMENT AREA



River/Stretch	Location No.	Return Period (year) 1.05	2	5	10	25	50	100
1. With San Roque Dam								
Rivermouth	A-1	1160	2510	5100	7610	11220	14170	17310
Before Junction with Olo R.	A-2	990	2250	4700	6910	10140	12730	15680
Before Junction with Camiling R.	A-3	880	2100	4350	6410	9330	11960	14820
Before Junction with Tarlac R.	A-4	500	1330	2690	3980	5760	7460	9210
Upstream of Poponto Floodway	A-5	490	1320	2680	3960	5730	7430	9190
Before Junction with Banila R.	A-6	410	1140	2330	3470	5020	6570	8140
Before Junction with Viray-Dipalo R.	A-7	360	970	2050	3010	4380	5930	7280
Before Junction with Ambayoan R.	A-8	260	700	1530	2340	3780	5120	6370
San Roque Dam	A-9	320	830	1710	2600	3950	5060	6260
2. Without San Roque Dam								
Rivermouth	A-1	1240	2760	5520	8270	12020	15000	17960
Before Junction with Olo R.	A-2	1090	2610	5120	7510	10850	13530	16250
Before Junction with Camiling R.	A-3	1010	2430	4840	7070	10270	12790	15420
Before Junction with Tarlac R.	A-4	660	1570	3060	4470	6450	8040	9730
Upstream of Poponto Floodway	A-5	650	1560	3030	4430	6420	7990	9660
Before Junction with Banila R.	A-6	570	1370	2650	3890	5670	7060	8560
Before Junction with Viray-Dipalo R.	A-7	500	1220	2300	3420	5020	6230	7540
Before Junction with Ambayoan R.	A-8	340	890	1820	2740	4190	5370	6660
San Roque Dam	A-9	320	830	1710	2600	3950	5060	6260

Fig. 4.30 PROBABLE FLOOD PEAK DISCHARGE UNDER CONFINING DIKE CONDITION WITH AND WITHOUT SAN ROQUE DAM

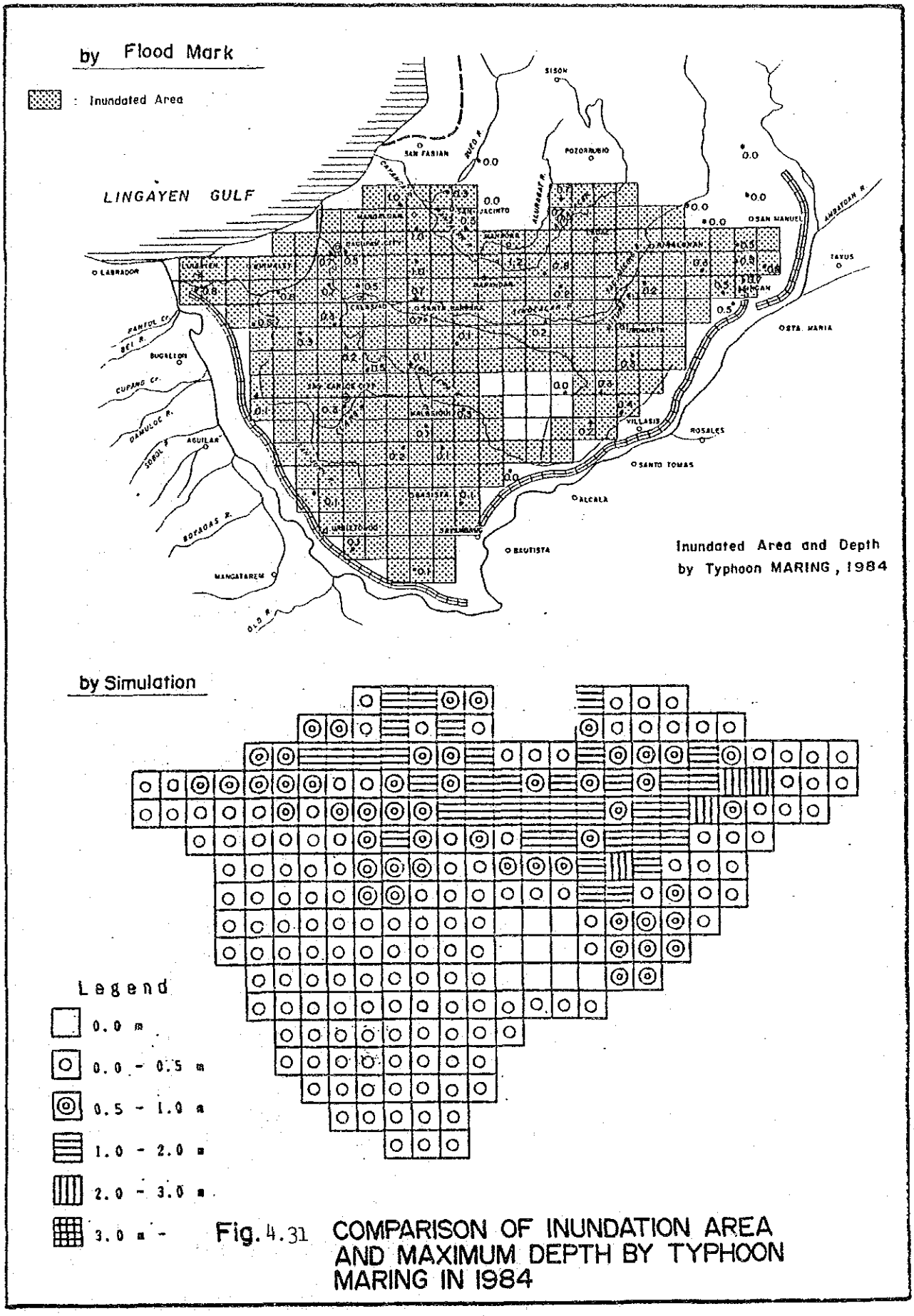


Fig. 4.31 COMPARISON OF INUNDATION AREA AND MAXIMUM DEPTH BY TYPHOON MARING IN 1984