2. Rainfall

2.1 Climate

The climate of the Upper Citarum Basin is typically tropical, characterized by two (2) distinct seasons: rainy and dry. Average annual rainfall ranges from 1,800 mm to 2,800 mm. Isohyetal map of the annual rainfall is shown in Fig. G.2.

Heavy rainfall in the Upper Citarum Basin is caused by the east monsoon as shown in Fig. G.3. Rainy season extends from November to April during which approximately 70% of the annual rainfall occurs. Monthly distribution of annual rainfall in the representative stations of the Study Area is shown in Table G.5.

2.2 Storm Rainfall

2.2.1 Rainfall Intensity

Rainfall intensity-duration curves with 2-year and 50-year frequencies were made by the Study of Bandung Urban Development Project for four (4) gauging stations located in the Bandung Metropolitan Area. (See Fig. G.4.)

Rainfall intensities for duration of 60 minutes are:

2-year rainfall	:	40 ~ 51 mm/hr.
50-year rainfall	:	67 ~ 80 mm/hr.

2.2.2 Probable Basin Rainfall Depth

Probabilities of average basin rainfall of 1-day, and 2, 3, 4 and 5-consecutive days were computed for the following nine (9) drainage basins: Citarik (776.1 km^2), Cisangkuy (330.2 km^2), Cibodas (81.5 km^2), Cikapundung (144.3 km^2), Ciwidey (268.7 km^2), Cibeureum (117.2 km^2), Cimahi (54.0 km^2), Dayeuh Kolot (1,332.1 km^2) and Nanjung (1,718.0 km^2).

The above nine (9) drainage basins are shown in Fig. G.5. The estimated probable basin rainfall depths are shown in Table G.6 and Fig. G.5.

Rainfall stations of which data were used for calculation of the probable average basin rainfall are shown in Fig. G.6.

Average basin rainfalls were obtained by constructing different Tiesen Polygons every year for the available rainfall stations.

2.2.3 Basin Rainfall Depth of the Past Floods

The large floods occurred in the recent years are the floods of March 1931, April 1982, February 1983, January 1984, January 1985 and March 1986.

The basin rainfall depths of 1-day and 5-consecutive days during the flood peaks in the above mentioned past floods were calculated for the upstream basins of Dayeuh Kolot and Nanjung. The estimated basin rainfall depths are shown in Table G.7. Their estimated return periods are also presented in the same table.

2.2.4 Regional Distribution of Basin Rainfall

Isohyetal maps of 5-consecutive days rainfalls during the flood peaks of the recent floods are shown in Fig. G.7 and Fig. G.8. The analysed recent floods are the floods of April 1982, April 1983, April 1984 and March 1986.

Regional distributions of the above mentioned 5-consecutive days rainfalls are shown in Fig. G.9. The southern part of the Basin is prone to heavy storm rainfall. The March 1986 Storm uniformly distributed the rainfall over the Basin.

3. Existing Hydraulic Condition

3.1 Water Stage and Discharge Relation

Water stage-discharge curves at Dayeuh Kolot (1,332.1 km^2) and Nanjung (1,718.0 km^2) gauging stations are shown in Fig. G.10. From the stage-discharge curves, the peak discharge of the March 1986 flood is estimated to be 265 m^3/s at Dayeuh Kolot and 311 m^3/s at Nanjung.

Yearly maximum discharges at Dayeuh Kolot and Nanjung in the past years are estimated as shown in Table G.8.

3.2 Water Stage, Flood Area and Flood Storage Volume Relation

The Citarum River floods in the upstream reaches of Dayeuh Kolot gauging station. The 1986 March flood marked the peak water stage of EL. 659.8 m at Dayeuh Kolot gauging station and caused 7,249 ha of inundation with approximately 66.0 million m^3 of flood water storage in the upstream reaches. Fig. G.11 shows the flood depth contour map of the 1986 flood.

From the above mentioned map, the relations between river water stage at Dayeuh Kolot, and flood area and flood storage volume were obtained as shown in Fig. G.12.

4. Flood Run-off Simulation

4.1 Mathematical Model

(1) Calculation of Effective Rainfall

Effective rainfall (Re) is calculated as follows.

$Re(t) = f_1 \cdot R(t)$: before the accumulated basin rainfall ($\Sigma R(t)$) reaches the saturation basin rainfall (R_{sa}).

$Re(t) = f_{sa} \cdot R(t)$: after the accumulated basin rainfall ($\Sigma R(t)$) exceeds the saturation basin rainfall (R_{sa}).

Where f_1 and f_{sa} are flood run-off coefficients and R_{sa} is the rainfall depth required to saturate the soils of the basin. Those factors are all characteristic to each basin.

(2) Flood Run-off Calculation of Watershed Area

The Storage Function Method is applied for the calculation of flood run-offs of the watershed areas. Flood run-offs are obtained by solving the following equations.

$S = K \cdot q^p$

$\gamma e - q = ds/dt$

Where: S = Storm water storage depth (mm)
q = Run-off depth (mm)
γe = Effective rainfall intensity (mm/hr)
K = Constant characteristic to drainage basin
p = Constant = 0.6

(3) Flood Routing in the Flood Plain

Flood routing in the upstream flood plain of Dayeuh Kolot is done by using the following continuity equation of flood flow.

$$I(t) - Q(t) = dv/dt$$

Where, $I(t)$ = Inflow discharge of the flood plain

$Q(t)$ = Outflow discharge at Dayeuh Kolot

dv/dt = Variation of flood water storage in the flood plain.

4.2 Flood Run-off Simulation Model

The Study Area is divided into 28 sub-basins to calculate flood run-offs of the watershed areas as shown in Fig. G.13.

The constructed flood run-off simulation model of the Study Area River Basin consists of 28 sub-basins and one (1) flood plain. It is also shown in Fig. G.13.

4.3 Flood Run-off Coefficients and Base Flow

Monthly average flood run-off coefficients in the watershed were calculated, based on the rainfall and discharge records observed during the period from October 1985 to April 1986. The calculated results are shown in Table G.9 and Fig. G.14.

The flood run-off coefficients increase gradually over the period of rainy season, reaching the maximum at the end of the rainy season.

It is mainly due to change in the infiltration capacity of rainfall in the watershed.

The following run-off coefficients are applied for flood run-off simulation of the Study Area, collating the above calculated run-off coefficients with the standard ones in Japan.

Land-use / Factor	Water	Forest	Paddy Field	Dry Field Plantation	Built-up Area
f_1	1.0	0.3	0.4	0.4	0.7
R_{sa} (mm)	200	200	200	200	200
f_{sa}	1.0	0.3	0.4	0.4	0.7

River discharge in late June is assumed to be the base flow of the Upper Citarum Basin because:

(1) Rainy season is over before June and river discharge during the period after June does not include run-off of storm water.

(2) River discharge is affected by withdrawal of irrigation water during the period after July.

Average river discharges observed in late June at Nanjung and Dayeuh Kolot are shown in Table G.10.

Base flow of the Upper Citarum Basin is assumed to be 0.01 $m^3/s/km^2$.

4.4 Characteristics of Drainage Basin

The characteristics of the divided 28 sub-basins are shown in Table G.11. The characteristics include: catchment area, existing land-use, ground elevation, basin length, basin slope, roughness coefficient of basin, constants of the Storage Function and time lag of flood run-off.

4.5 Calibration of Flood Run-off Simulation Model

Flood run-off simulation was conducted for the 1984 and 1986 floods under the following calculation conditions.

Case 1 (daily basis calculation)

Input data : Daily rainfall distribution
Output data : Daily discharge distribution
Land-use : Existing
Inundation : Actual record

Case 2 (hourly basis calculation)

Input data : Hourly rainfall distribution
Output data : Hourly rainfall distribution
Land-use : Existing
Inundation : Actual record

Daily basis calculation was made for both 1984 and 1986 floods. However, hourly basis calculation was done for only the 1986 flood because of lack of hourly data concerning the 1984 flood.

The calculated water stage and discharge hydrographs at Dayeuh Kolot and Nanjung gauging stations are illustrated in comparison with the recorded ones in Fig. G.15, Fig. G.16 and Fig. G.17. The corresponding basin rainfall distributions are also illustrated in the same figures.

The proposed flood run-off simulation model is considered adequate.

4.6 Comparison of Daily and Hourly Basis Calculations

Flood peak discharge calculated on hourly basis is larger than that calculated on daily basis. Flood peak discharges of the Citarum River and tributaries calculated under the following condition are shown in Table G.12.

(Daily basis calculation)

- Input data : Daily rainfall distribution of the 1986 Storm
- Output data : Daily discharge distribution
- Land use : Existing
- Inundation : Without inundation or with inundation of 1,000 ha in the flood plain of the Citarum River.

(Hourly basis calculation)

- Input data : Hourly rainfall distribution of the 1986 Storm
- Output data : Hourly discharge distribution
- Land use : Existing
- Inundation : Without inundation or with inundation of 1,000 ha in the flood plain of the Citarum River.

Ratio of the daily and hourly peak discharges calculated under the conditions without inundation is considerably large as shown in Table G.12. However, no significant difference is recognized between the daily and hourly peak discharges at Dayeuh Kolot and Nanjung if inundation of 1,000 ha is allowed in the flood plain of the Citarum River.

Complete removal of flood water from the low-lying areas along the Citarum River may be impracticable and inundation will be allowed to a certain extent in planning the improvement of the Citarum River (Refer to Supporting Report H).

From the above considerations, daily basis calculation will be applied in planning the improvement of the Citarum River, by that lack of available hourly rainfall data can be overcome. While, hourly basis calculation will be applied for the tributaries.

5. Basic Design Flood Discharge

Basic design flood discharge is defined as a discharge with a certain return period estimated under the basin conditions of future land-use, without dam and without inundation.

5.1 Characteristics of Drainage Basin

Future land-use of the Basin in the year 2005 is estimated as shown in Table G.13. The other characteristics of the Basin: ground elevation, basin length, basin slope, roughness coefficient of basin, constants of the Storage Function and time lag of flood run-off are also shown in Table G.13.

5.2 Design Basin Rainfall

A design basin rainfall is made up of the three (3) elements:

- Average basin rainfall depth
- Time distribution
- Regional distribution

The time and regional distribution patterns of the 1986 Storm are employed as the design ones for the following reasons.

- Sufficient daily rainfall data are available.
- The time and regional distribution patterns are typical and frequent ones.

Design average basin rainfall depth is determined to meet a required safety level of flood control project.

5-consecutive days rainfall is selected as a probability variable for calculation of design basin rainfall, because flood peak of the Citarum River is governed by the rainfall depth accumulated during several days before the peak occurs. It is due to the retarding effects of flood run-off in the Basin. In the 1986 flood, the period of flood rising stage was approximately 5 days.

Design basin rainfall depth of 5-consecutive days with various frequencies are calculated for the drainage basin of Dayeuh Kolot as shown in Table G.14. Ratio of the estimated design rainfall depth and recorded rainfall depth of the 1986 Storm is also shown in the same table.

A design basin rainfall of each basin of the Citarum River with a given return period is obtained by multiplying the recorded 1986 basin rainfall by the magnification ratio shown in Table G.14.

5.3 Estimated Basic Design Discharge

Basic design discharges with various probabilities at Dayeuh Kolot and Nanjung are estimated under the basin conditions of future land use, without dam and without inundation as shown in Table G.15.

Basic design discharges with 5-year, 20-year and 50-year frequencies estimated for the other major sites of the Citarum River are shown in Table G.16.

Basic design discharge hydrographs with 5-year and 20-year frequencies estimated for Dayeuh Kolot is shown in Fig. G.18.

6. Hydraulic Effects of River Dredging

The Citarum River inundates the low-lying areas located in the upstream reaches of Dayeuh Kolot. Dredging of the downstream of Dayeuh Kolot will lower the flood water level in the upstream flood plain. In this Chapter, hydraulic effects of the river dredging are discussed.

6.1 River Dredging

The following six (6) cases of river dredging are proposed for the study of the hydraulic effects.

Case 1 : Existing river condition, discharge capacity at Dayeuh Kolot of 160 m^3/s

Case 2 : River improvement corresponding to the discharge capacity at Dayeuh Kolot of 310 m^3/s

Case 3 : River improvement corresponding to the discharge capacity at Dayeuh Kolot of 390 m^3/s

Case 4 : River improvement corresponding to the discharge capacity at Dayeuh Kolot of 450 m^3/s

Case 5 : River improvement corresponding to the discharge capacity at Dayeuh Kolot of 505 m^3/s

Case 6 : River improvement corresponding to the discharge capacity at Dayeuh Kolot of 540 m^3/s

The cross sections at Dayeuh Kolot are proposed as shown in Fig. G.19, assuming that roughness coefficient is n=0.03 and river bed slope is 1/5,500.

Water stage-discharge curves at Dayeuh Kolot calculated for the six (6) cases of river dredging are shown in Fig. G.20.

6.2 Flood Run-off Simulation

Flood run-off simulation was conducted by the simulation model proposed in Chapter 4. The simulation was done under the following river and basin conditions.

Land-use	:	Land-use in the year 2005
Inundation of flood plain	:	Relation between water stage at Dayeuh Kolot and flood water storage volume in the flood plain is shown in Fig. G.12.
River discharge capacity	:	Water stage-discharge curve at Dayeuh Kolot for each dredging case is shown in Fig. G.20.

Hydraulic effects of the proposed six (6) cases of river dredging are estimated in terms of the maximum flood water level at Dayeuh Kolot, flood duration and inundation area in the flood plain, for various flood frequencies as shown in Table G.17.

Relation between flood water level and discharge capacity at Dayeuh Kolot with a parameter of flood frequency is shown in Fig. G.19.

7. Design Discharge Distribution of Citarum River

The design flood water level of the Citarum River at Dayeuh Kolot is proposed to be EL. 658.1 m, allowing approximately 1,000 ha of inundation and 2,700 houses unrelieved from floods in the low-lying parts of the flood plain (Refer to Supporting Report H).

Design discharge distribution of the Citarum River with various probabilities are estimated under the following river and basin conditions.

Land-use	:	Land-use in the year 2005
Inundation of flood plain	:	1,000 ha of inundation is allowable.
Design flood water level	:	EL. 658.1 m at Dayeuh Kolot

Estimated design discharge distributions of the Citarum River with 5-year, 20-year and 50-year frequencies are shown in Table G.18, being compared with basic design discharge distribution.

Design discharge hydrographs with 5-year and 20-year frequencies at Dayeuh Kolot are shown in Fig. G.21, with a comparison to basic design hydrograph. The corresponding basin rainfall time distribution and water stage hydrograph are also shown in the same figure.

8. Hydraulic Effects of Cisangkuy Diversion

The proposed project diverts flood run-offs of the upstream basin of the Cisangkuy River to the downstream of the Citarum River as shown in Fig. G.22.

The main features of the diversion are:

Inlet site	:	8.5 km distance of the Cisangkuy River
Outlet site	:	11.7 km distance of the Citarum River (Margahayu)
Catchment area	:	206.9 km^2, 16% of the drainage area of Dayeuh Kolot (1,332.1 km^2)
Route length	:	3.1 km

Flood run-off simulation was conducted for the following four (4) cases.

	Flood Frequency	Citarum River Improvement	Diversion Project
Case 1-1	5-year	5-year design discharge	Without
Case 1-2	5-year	5-year design discharge	With
Case 2-1	20-year	20-year design discharge	Without
Case 2-2	20-year	20-year design discharge	With

Estimated maximum flood discharge and water level at Dayeuh Kolot are shown in Table G.19.

Lowering of flood water level at Dayeuh Kolot by the Cisangkuy Diversion is approximately 0.2 m.

Flood hydrographs with and without diversion at Dayeuh Kolot are compared in Fig. G.23.

9. Design Discharge of Tributaries

In this Chapter, design discharge of the Citarum (upstream), Citarik, Cikeruh and Cisangkuy Rivers is discussed. Flood run-off of the tributaries are calculated on hourly data basis. (Refer to Chapter 4).

9.1 Storm Rainfall Patterns Selected for Flood Run-off Simulation

Storm rainfall with a 24-hour rainfall more than 20 mm are selected for flood run-off simulation from among all the storm rainfalls occurred in 1986, because the available hourly rainfall data are limited to the records in 1986.

15 storm rainfalls are selected for the Citarum (upstream) River, 11 storm rainfalls for the Citarik River, 12 storm rainfalls for the Cikeruh River and 9 storm rainfalls for the Cisangkuy River.

Hourly distribution of the above selected storm rainfalls are shown in Fig. G.24 to Fig. G.27.

9.2 Estimated Probable Discharge

Probable storm rainfalls of the selected patterns with 5-year, 20-year and 50-year frequencies are obtained by magnifying the recorded 24-hour rainfall depths to 5-year, 20-year and 50-year daily rainfall depths respectively.

Flood peak discharges with 5-year, 20-year and 50-year frequencies are calculated from the corresponding probable storm rainfalls of the selected patterns.

The calculation results are shown in Table G.20 to G.23.

9.3 Design Discharge

Design discharges with 5, 20, 50-year frequencies are obtained by averaging the probable discharges simulated from the selected storm rainfalls with the corresponding rainfall frequencies.

The design discharges of the tributaries are shown in Table G.24.

The design discharge distribution of the tributaries are shown in Fig. G.28 and G.29.

10. Impact of Land-use Change on Flood Run-off

Land development of the river basin generally increases flood peaks in the downstream reaches. The existing urban area of 126.4 km^2 in the Upper Citarum Basin (1,771.0 km^2) will expand to 284.0 km^2 in the year 2005. The urbanization will mostly take place in the Bandung Metropolitan Area. (See Table G.11 and Table G.13)

Flood run-offs were calculated under existing and future land-use conditions with 5, 20-year frequencies by the following methods.

- Citarum River	:	Storage Function method, 1986 storm rainfall pattern, Daily basis calculation
- Major Tributaries	:	Storage Function method, 1986 storm rainfall, Hourly basis calculation
- Triburtaries flowing through Bandung Urban Area	:	Rational formula, Rainfall intensity-duration curves of Bandung Station, Hourly basis calculation (Refer to Supporting Report F)

Discharges estimated under the existing and future (2005) land-use by 5, 20-year frequency floods are compared in Table G.25.

The future land development will have no significant effect on the flood run-off of the Citarum, Cisangkuy and Citarik River. It will, however, give a impact on the run-off of some tributaries flowing through Bandung Urban Area, Citepus, Cicadas and Ciwastra Rivers, with an increase in peak discharge of 30 - 60%.

Measures for discharge increase of the tributaries flowing through Bandung Urban Area is described in Chapter 3 of Supporting Report F.

11. Effect of Citarum River Improvement on Saguling Dam

The spillway of Saguling Dam was designed to be safe for 1,000-year flood hydrograph. The Citarum River improvement is proposed for 20-year flood discharge. So, in case a 1,000-year flood will occur, the Citarum River will be flooded widely in the flood prone area along the upstream streches from Dayeuh Kolot. The flood discharge change will, however, be insignificant even if the Citarum River is improved, because of the flood effect. Hence, the spillway of Saguling Dam will not be affected by the river improvement.

Design hydrograph for the Spillway is of short duration with high discharge, while the flood hydrograph for the Citarum River improvement is of long duration with low discharge. In this section, safety of the spillway was confirmed using the following data.

- Saguling Dam gate operation mode
- The relation between water stage and water volume of the reservoir
- 1000-year flood discharge hydrograph for the Citarum River improvement

The results are described below and that the safety of the spillway is confirmed.

Item	River Improvement Hydrograph	Saguling Design
Nanjung Discharge	1023 m^3/s	-
Inflow to Reservoir	1481 m^3/s	5195 m^3/s
Outflow from Spillway	1407 m^3/s	2384 m^3/s
Reservoir Water Level	644.5 m	645.0 m

The method of calculations are described in Data Book III.

Table G.1 AVAILABLE RAINFALL DATA (DAILY)

No.	No.Sta.	Name of Station	Authority	1920 ▼	1	2	3	4	5	6	7	8	9	1930 ▼	1	2	3	4	5	6	7	8	9	1940 ▼	1	2	3	4	5	6	7	8	9
1.	150	Padalarang	B.M.G																														
2.	151a	Sindangkerta	I.H.E																														
3.	151c	Batujajar	B.M.G																														
4.	152	Cimahi I.H.E	I.H.E																														
5.	153a	Gambung	B.M.G																														
6.	153b	Ciwidey	•																														
7.	154b	Margahayu	•																														○
8.	157	Cikapundung	•	○	○	○	○	○	○	○	△	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○							
9.	160	Pakar	I.H.E																														
10.	162a	Cihampelas	•							○	○	○	○	○	○	○	○	○	○	○	○	○	△	○	○	○							
11.	163a	Banjaran	B.M.G																														
12.	163c	Cisondari	I.H.E																														
13.	163d	Cirateun	B.M.G								○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○							
14.	163f	Cibadak	•											○	○	○	○	○	○	△	△	△	○	○	○	○							
15.	163g	Husein	•																														○
16.	164	Jatinangor(perk)	•																														
17.	164a	Buahbatu	•																		○	○	△	○	○	○							○
18.	164b	Pasirjati	•																														
19.	167	Majalaya	I.H.E																														
20.	168	Arjasari(perk)	B.M.G	○	○	○	○	○	○	○	△	○	○	○	○	○	○	○	○	○	△	○	○	○	○	○							○
21.	170	Paseh (Cipaku)	I.H.E																														
22.	172	Ciniruan	•							○	○	○	○	○	○	○	○	○	○	△	○	○	○	○	○	○							
23.	173a	Cinchona	B.M.G																														○
24.	173b	Pangalengan	•																														
25.	174	Cibeureum	•																														
26.	178	Argasari	•	○	○	○	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○							
27.	178a	Gn. Halimun	•	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	○	○	○	○	○							
28.	179	Cibitung	•	○	○	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	○	○	○	○							
29.	179a	Pacet	•		△	○	○	○	○	△	○	○	○	△	○	○	○	△	○	○	○	○	○	○	○	○							
30.	180	Malabar	I.H.E																														
31.	181b	Cileunca	B.M.G					○	○	○	△	○	△	△																			○
32.	194b	Tanjungsari 1	•																														
33.	195d	Tanjungsari 2	•																△	○	○	○	△	○							○
34.	196	Cimanggerang	•																														○
35.	200	Sitiarja	•	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○							

No.	Name of Station	1950 ▼	1	2	3	4	5	6	7	8	9	1960 ▼	1	2	3	4	5	6	7	8	9	1970 ▼	1	2	3	4	5	6	7	8	9	1960 ▼	1	2	3	4	5	6	7	8	9
1.	Padalarang									△	○	△	△	○	○	△	△	△	△				○	○	△	△	△	△	△	○	○		△								
2.	Sindangkerta	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○				
3.	Batujajar	△	△	△	△	△	△	△	○	△	○	△	△	△			△	△	△	△	△	△	△	○	○	○	△	○													
4.	Cimahi I.H.E	○	○	○	○	○	○	○	○	○	○	○	○	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○				
5.	Gambung			△	○	○	○	△	○	△	○	△	△	○	○	△	△	△			△	○	○	△	△																
6.	Ciwidey									○	○	△	○	○	○	○	○	△	△	○	○	△	○	○	△	△	△	○	○	○	○	○	○	○	△	△	○				
7.	Margahayu	○	△	○	○	○	○	△	△	○	△	△	○	△	○	○	○	△	○	○	○	△	△	○	△	△	△	△				△	△								
8.	Cikapundung													△	○	○	○	△	○	○	○																				
9.	Pakar	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○				
10.	Cihampelas	○	○	○	○	○	○	○	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○				
11.	Banjaran																							○	○	○									○	○					
12.	Cisondari	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	○	○	○				
13.	Cirateun																																								
14.	Cibadak																													○	○										
15.	Husein	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	○	△	○	△	△	△	△	△	○	△	△	△	△	△	△	△	△				
16.	Jatinangor(perk)																						△	△	○	△	○	○	△	△											
17.	Buahbatu	○	○	△	○	△	△	○	△	△	○	△	△	△	△	△	△	△	△	○	△	○	○	○	○	△															
18.	Pasirjati																						○	○	○	○		△	○	△		△	○	○	○	○	△				
19.	Majalaya	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○				
20.	Arjasari(perk)	△																					○	△	○	△	○	○	○	○	○	○	○	○	○	△	△				
21.	Paseh (Cipaku)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○				
22.	Ciniruan	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	○	○				
23.	Cinchona	○	○	○	○	○	○	○	○	○	△	○	○	△	△			△	○					△	○	△	○														
24.	Pangalengan																						○	○	○	△	○	△	○	○	○	△	△	△	△	△	△				
25.	Cibeureum																							△	○	△		△	○	○	○	○	△	○	○	△	△				
26.	Argasari																																								
27.	Gn. Halimun																																								
28.	Cibitung																																								
29.	Pacet																																								
30.	Malabar		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○				
31.	Cileunca	△	○	○																△	○	△	○	○	○	△	○	△	○	○	△	○	△	△	△	○	○				
32.	Tanjungsari 1			△	○	○	○	○	○	△	△	○	○	△	△	△							△			△	△	△	○	○	○	○	△								
33.	Tanjungsari 2	△	○	△	○	○	△	○	○	○	○	○				△	○	○	△	△	○	○		○	○	○	○	○	○	○	○	○	○	△	○	△					
34.	Cimanggerang	○	○	○	○	○	○	○	○	○	○																										○				
35.	Sitiarja																															○	○	○	○	○	○				

Note : ○ = Existing △ = Partially lacking

Type A : Automatic
Type T : Telemeter
Type _ : Manual

Table G.2 AVAILABLE RAINFALL DATA (HOURLY)

No.	Station Name	Year	Type	1983												1984												1985											
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1.	Cibintinu	1983	A						△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○						
2.	Pasir Jampana	"	A						△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
3.	Cibuntu	"	A								△	○		○	○	○	△	△	○	△	○	△	○	○	○	○	○	○	○	○	△	△	△	○	△	○	△	○	○
4.	Bbk.Siliwangi	"	A								△	○	○	○	○	△	△	△	○	△	○	○	○	○	○	○	○	△	○	○	○	○	○	○	○	○	△	○	○
5.	Banjaran	1984	A														△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
6.	Cisondari	"	A														△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
7.	Pangalengan	"	A															△	△	△	△	○	○	△	○	○	○	○	○	△	○	○	○	○	○	○	○	△	△
8.	Perwati	1985	A																																		△	○	○
9.	Bojongmonyet	"	A																																		△	○	○
10.	Tanjakan	"	A																																				
11.	Ciharalang	"	A																																		△	○	△
12.	Selacan	"	A																																		△	○	○
13.	Lemburawa	"	A																																				
14.	Mande	"	A																																				
15.	Cisaranten Kidul	"	A																																		△	△	○
16.	Cicalengka	"	T																																				
17.	Paseh	"	T																																				
18.	Cinchona	"	T																																				
19.	Ciparay	"	T																																				
20.	Ujungberung	"	T																																				
21.	Bandung	"	T																																				
22.	Sukawarna	"	T																																				
23.	Cisondari	"	T																																				
24.	Cililin	"	T																																				

(Continued) AVAILABLE RAINFALL DATA (HOURLY)

Type A : Automatic
Type T : Telemeter
Type _ : Manual

No.	Station Name	Year	Type	1986												1987																							
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1.	Cibintinu	1983	A			△	○	○	○	○	○	○	○	○	○	○																							
2.	Pasir Jampana	"	A	○	○	○	○	○	○	○	○	○	○	○	○																								
3.	Cibuntu	"	A	△	○		○																																
4.	Bbk.Siliwangi	"	A	○	○	○																																	
5.	Banjaran	1984	A	○	○	○	○	○	○	○	○	○	○																										
6.	Cisondari	"	A	○	○	○	△					△	○	○	△	○	△																						
7.	Pangalengan	"	A	○	○	○	○	○	○	△	△	○	○	○	○																								
8.	Perwati	1985	A	○	○	○	○	○	○	○	○	○	○	○	○																								
9.	Bojongmonyet	"	A	○	○	○	○	○	○	○	○	○																											
10.	Tanjakan	"	A																																				
11.	Ciharalang	"	A	○	○	○	○	○	○	○																													
12.	Selacan	"	A	○	○	○	○	○	○	○	○	○	○	○	○																								
13.	Lemburawa	"	A	△	△	△	△	△	△	○	△	△	△	△	○																								
14.	Mande	"	A	○	○	○	○	○	○	△	○	○	○	△	△																								
15.	Cisaranten Kidul	"	A	△	△	△	○	△				△	△	○	○	○	○																						
16.	Cicalengka	"	T	○	○	○	○	○	○	○	○	○	○	○																									
17.	Paseh	"	T	○	○	○	○	○	○	○	○	○	○	○																									
18.	Cinchona	"	T	○	○	○	○	○	○	○	○	○	○	○																									
19.	Ciparay	"	T	○	○	○	○	○	○	○	○	○	○	○																									
20.	Ujungberung	"	T	○	○	○	○	○	○	○	○	○	○	○																									
21.	Bandung	"	T	○	○	○	○	○	○	○	○	○	○	○																									
22.	Sukawarna	"	T	○	○	○	○	○	○	○	○	○	○	○																									
23.	Cisondari	"	T	○	○	○	○	○	○	○	○	○	○	○																									
24.	Cililin	"	T	○	○	○	○	○	○	○	○	○	○	○																									

Table G.3 AVAILABLE WATER LEVEL AND DISCHARGE DATA (DAILY)

No.	Station	River	Catchment Area (Km^2)	Type	Year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1.	Nanjung	Citarum	1718.0	A	1973	△	○	○	○	△	△	△	△	△	
2.	Dayeuhkolot	Citarum	1138.5	A	1980								△	○	○
3.	Rancakemit	Citaric	447.1		1984-2										
4.	Majalaya	Citarum	268.2		1984-2										
5.	Bbk. Bandung	Cikeruh	48.3	A	1984-10										
6.	Cikkuda	Cikeruh	53.9		1984-2										
7.	Sukapada	Cidurian	17.6	A	1985-10										
8.	Kepuh	Cipanjalu	15.3	A	1985-10										
9.	Jatisari	Cibodas	18.8		1984-2										
10.	Cengkrong	Cirasea	64.0	A	1984-10										
11.	Sukajadi	Cibeureum	38.5	A	1985-9										
12.	Gandok	Cikapundung	88.7	A	1957	○	○	○	△	○	○	○	○	△	
13.	Maribaya	Cikapundung	54.1	A	1952	○	○	○	○	△	○	○	△		
14.	Maribaya	Cigulung	16.6	A	1952	○	△	△	○	△	△	○	△	○	
15.	Cibangoa	Citarum	85.6	A	1985-10										
16.	Cipendeuy	Cisangkuy		A	1984-9										
17.	Peundeuy	Cijalupang	20.8	A	1984-9										
18.	Andir	Cirasea	67.5		1984-2										

Note : ○ = Existing   △ = Partially lacking

Type A : Automatic
Type T : Telemeter
Type _ : Manual

(Continued)

AVAILABLE WATER LEVEL AND DISCHARGE DATA (DAILY)

No.	Station	River	Catchment Area (Km^2)	Type	Year	1983	1984	1985	1986					
1.	Nanjung	Citarum	1718.0	A	1973									
2.	Dayeuhkolot	Citarum	1138.5	A	1980									
3.	Rancakemit	Citaric	447.1		1984-2				△					
4.	Majalaya	Citarum	268.2		1984-2		△		○					
5.	Bbk. Bandung	Cikeruh	48.3	A	1984-10									
6.	Cikkuda	Cikeruh	53.9		1984-2		△		△					
7.	Sukapada	Cidurian	17.6	A	1985-10				△					
8.	Kepuh	Cipanjalu	15.3	A	1985-10				△					
9.	Jatisari	Cibodas	18.8		1984-2		△							
10.	Cengkrong	Cirasea	64.0	A	1984-10				△					
11.	Sukajadi	Cibeureum	38.5	A	1985-9				△					
12.	Gandok	Cikapundung	88.7	A	1957		△							
13.	Maribaya	Cikapundung	54.1	A	1952									
14.	Maribaya	Cigulung	16.6	A	1952									
15.	Cibangoa	Citarum	85.6	A	1985-10									
16.	Cipendeuy	Cisangkuy		A	1984-9									
17.	Peundeuy	Cijalupang	20.8	A	1984-9		△		△					
18.	Andir	Cirasea	67.5		1984-2				○					

Note : ○ = Existing △ = Partially lacking

Type A : Automatic
Type T : Telemeter
Type _ : Manual

Table G.4 AVAILABLE WATER LEVEL AND DISCHARGE DATA (HOURLY)

No.	Station	River	Catchment Area (Km^2)	Type	Year	1 1986 (Mar) 1/3 ~ 30/4		2 1984 (Jan) 1/1 ~ 31/1		3 1984 (Feb) 1/2 ~ 28/2		4 1984 (Apr) 1/4 ~ 30/4		5 1982 (Dec	
						W.L	D	W.L	D	W.L	D	W.L	D	W.L	D
1.	Nanjung	Citarum	1718.0	A	1973	○	○	○		○		○		○	
2.	Dayeuh kolot	Citarum	1138.5	A	1980	○	○	○		○		○		○	
3.	Rancakemit	Citaric	447.1		1984-2										
4.	Majalaya	Citarum	268.2		1884-2										
5.	BBK. Bandung	Cikeruh	48.3	A	1984-10	○	○								
6.	Cikuda	Cikeruh	53.9		1984-2										
7.	Cikapada	Cidurian	17.6	A	1985-10	○	○								
8.	Kepuh	Cipanjalu	15.3	A	1985-10	○	○								
9.	Jatisari	Cibodas	18.8		1984-2										
10.	Cengkrong	Cirasea	64.0	A	1984-10	○	○								
11.	Sukajadi	Cibeureum	38.5	A	1985-9	○	○								
12.	Gandok	Cikapundung	88.7	A	1957			○		○		○		○	
13.	Maribaya	Cikapundung	54.1	A	1952									○	○
14.	Maribaya	Cigulung	16.6	A	1952	○	○	○	○	○	○	○	○	○	○
15.	Cibangoa	Citarum	85.6	A	1985-10	○									
16.	Cipeundeuy	Cisangkuy		A	1984-9	○	○								
17.	Peundeuy	Cijalupang	20.8	A	1984-9	○	○								
18.	Andir	Cirasea	67.5		1984-2										

Note : 1) W.L : Water Level data
D : Discharge data

Type A : Automatic
Type T : Telemeter
Type _ : Manual

(Continued) AVAILABLE WATER LEVEL AND DISCHARGE DATA (HOURLY)

No.	Station	River	Catchment Area (Km^2)	Type	Year	6		7		8		9	
						1985 (Jan) 1/1~31/1		1985 (Feb) 1/2~28/2		1985 (Oct) 18/10~24/10		1985 (Nov) 20/12~26/12	
						W.L	D	W.L	D	W.L	D	W.L	D
1.	Nanjung	Citarum	1718.0	A	1973							○	○
2.	Dayeuh kolot	Citarum	1138.5	A	1980	○		○					
3.	Rancakemit	Citaric	447.1		1984-2								
4.	Majalaya	Citarum	268.2		1984-2					○			
5.	BBK. Bandung	Cikeruh	48.3	A	1984-10								
6.	Cikuda	Cikeruh	53.9		1984-2					○		△	
7.	Cikapada	Cidurian	17.6	A	1985-10								
8.	Kepuh	Cipanjalu	15.3	A	1985-10							○	○
9.	Jatisari	Cibodas	18.8		1984-2								
10.	Cengkrong	Cirasea	64.0	A	1984-10								
11.	Sukajadi	Cibeureum	38.5	A	1985-9							○	○
12.	Gandok	Cikapundung	88.7	A	1957	○		○					
13.	Maribaya	Cikapundung	54.1	A	1952								
14.	Maribaya	Cigulung	16.6	A	1952	○	○	○	○	○	○	○	○
15.	Cibangoa	Citarum	85.6	A	1985-10							○	
16.	Cipeundeuy	Cisangkuy		A	1984-9								
17.	Peundeuy	Cijalupang	20.8	A	1984-9					○	○	○	○
18.	Andir	Cirasea	67.5		1984-2								

Note : 1) W.L : Water Level data
D : Discharge data

Type A : Automatic
Type T : Telemeter
Type _ : Manual

Table G.5 AVERAGE MONTHLY RAINFALL (1950-1985)

Station	Month												Total
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Cimahi	240	186	247	183	102	45	73	54	84	144	218	228	1804
Pakar	238	223	233	213	148	65	55	59	85	176	256	260	2011
Cisondari	254	211	258	247	255	91	95	68	117	171	309	314	2390
Majalaya	269	211	319	215	137	79	59	44	68	121	242	287	2051
Cinyiruan	407	317	323	316	189	107	79	79	109	199	304	361	2790

Source: Pre Feasibility Study 21 Lokasi: Paket III Dalam Bidang, Water Resources Studies and Hydrologic Analysis, (Appendix III-2) Rainfall Data, August 1986

Table G.6 BASIN RAINFALL BY SUB-BASIN BY PROBABILITY

Day	Drainage Basin	Return Period (Year)							
		2	5	10	20	30	50	100	200
1	1. Citarik	50.0	63.6	72.0	80.1	84.5	90.0	97.3	104.4
	2. Cisangkuy	53.8	66.8	74.8	82.2	86.3	91.3	97.9	104.4
	3. Cibodas	55.0	68.9	77.4	85.3	89.8	95.2	102.4	109.5
	4. Cikapundung	54.3	73.6	86.3	98.3	105.3	114.0	125.7	137.6
	5. Ciwidey	62.1	87.7	105.1	122.0	131.8	144.2	161.3	178.7
	6. Cibeureum	51.8	70.3	82.4	93.9	100.6	108.9	120.2	131.5
	7. Cimahi	62.1	87.7	105.1	122.0	131.8	144.2	161.3	178.7
	Dayeuh Kolot	45.3	57.3	64.8	71.7	75.5	80.3	86.6	92.8
	Nanjung	44.7	56.1	63.3	69.8	73.5	78.1	84.1	90.0
2	1. Citarik	76.8	98.1	111.5	124.0	131.0	139.6	151.0	162.5
	2. Cisangkuy	82.4	101.4	113.0	123.6	129.5	136.8	146.3	155.6
	3. Cibodas	78.7	98.6	110.9	122.2	128.6	136.3	146.6	156.7
	4. Cikapundung	81.9	108.6	125.8	142.1	151.9	163.0	178.6	194.2
	5. Ciwidey	90.6	125.1	148.1	170.3	183.2	199.2	221.2	243.5
	6. Cibeureum	74.4	99.6	116.0	131.6	140.5	151.6	166.7	181.7
	7. Cimahi	70.1	86.4	96.3	105.4	110.4	116.6	124.7	132.7
	Dayeuh Kolot	72.3	89.1	99.4	108.8	114.0	120.4	128.9	137.1
	Nanjung	70.1	86.3	96.3	105.4	110.4	116.6	124.8	132.7
3	1. Citarik	98.2	124.0	140.0	154.8	163.2	173.4	187.0	200.3
	2. Cisangkuy	102.5	124.9	138.6	150.9	157.8	166.1	177.2	187.9
	3. Cibodas	96.5	121.4	136.9	151.2	159.2	169.0	182.1	194.9
	4. Cikapundung	102.8	136.4	158.2	178.8	190.5	205.1	224.8	244.5
	5. Ciwidey	108.6	148.3	174.5	199.6	214.1	232.3	256.9	281.8
	6. Cibeureum	92.2	121.1	139.6	157.1	167.0	179.3	195.9	212.4
	7. Cimahi	97.1	133.5	157.6	180.8	194.2	211.0	233.9	257.0
	Dayeuh Kolot	91.4	112.3	125.0	136.7	143.2	151.0	161.5	171.6
	Nanjung	88.6	108.1	120.0	130.8	136.8	144.1	153.7	163.0
4	1. Citarik	113.9	145.3	166.0	186.0	197.5	211.8	231.1	250.4
	2. Cisangkuy	120.1	147.1	163.5	178.4	186.7	196.8	210.1	223.1
	3. Cibodas	112.6	140.9	158.4	174.5	183.5	194.6	209.2	223.6
	4. Cikapundung	121.1	160.7	186.3	210.5	224.3	241.5	264.7	287.8
	5. Ciwidey	125.9	172.3	203.0	232.4	249.5	270.7	299.7	328.9
	6. Cibeureum	108.4	141.9	163.4	184.5	195.0	209.2	228.3	247.2
	7. Cimahi	114.1	155.9	183.5	210.0	225.3	244.4	270.4	296.6
	Dayeuh Kolot	108.7	133.3	148.2	161.8	169.4	178.7	190.8	202.7
	Nanjung	106.1	129.4	143.6	156.4	163.6	172.3	183.7	194.8
5	1. Citarik	131.9	164.8	185.1	203.8	214.2	227.0	244.0	260.6
	2. Cisangkuy	131.5	169.7	193.9	216.5	229.3	245.0	266.2	287.1
	3. Cibodas	127.2	160.4	181.0	200.0	210.7	223.8	241.2	258.4
	4. Cikapundung	136.2	181.7	211.1	239.1	255.1	274.9	301.8	328.7
	5. Ciwidey	140.6	195.8	232.9	268.8	289.6	315.7	351.5	387.9
	6. Cibeureum	123.1	160.7	184.8	207.3	220.1	236.0	257.3	278.4
	7. Cimahi	129.7	176.6	207.6	237.3	254.4	275.7	304.8	334.0
	Dayeuh Kolot	124.8	152.2	168.9	184.0	192.4	202.6	216.1	229.2
	Nanjung	122.0	148.9	165.3	180.2	188.5	198.6	211.9	224.8

Table G.7 BASIN RAINFALL OF PAST FLOOD

Day	Date	Dayeuh Kolot		Nanjung	
		Depth (mm)	Return Period (Year)	Depth (mm)	Return Period (Year)
1-day	3/ 1 ,1931	47	1.8	45	1.9
	3/16 ,1982	35	1.3	31	1.1
	3/17 ,1983	38	1.4	37	1.3
	3/24 ,1984	42	1.6	36	1.3
	3/27 ,1985	37	1.4	35	1.2
	3/11 ,1986	36	1.3	34	1.2
5-day	2/28 - 3/ 4 ,1931	177	14.0	164	10.0
	4/11 - 4/15 ,1982	107	1.4	105	1.4
	2/15 - 2/19 ,1983	109	1.4	116	1.7
	1/11 - 1/15 ,1984	141	3.0	134	3.0
	1/ 4 - 1/ 8 ,1985	100	1.2	94	1.1
	3/ 7 - 3/11 ,1986	116	1.5	119	1.8

Table G.8 YEARLY MAXIMUM DISCHARGE OF THE CITARUM RIVER

Year	Discharge (m3/s)	
	Nanjung	Dayeuh Kolot
1918	244	146
1919	244	146
1920	217	179
1921	261	210
1922	275	200
1923	252	179
1924	252	-
1925	204	-
1926	208	-
1927	194	-
1928	256	-
1929	207	-
1930	355	-
1931	455	-
1932	350	-
1933	335	-
1934	328	-
1973	269	-
1974	323	-
1975	364	-
1976	247	-
1977	290	-
1978	302	-
1979	301	-
1980	220	82
1981	197	108
1982	261	149
1983	303	132
1984	335	230

Table G.9 MONTHLY RUN-OFF CO-EFFICIENT (1986 FLOOD)

Station : Majalaya (A=176.5 km^2)

Case	Date	Rainfall Depth (mm)	Run-off Depth (mm)	Rate of Run-off
	Oct. 1985	287.5	219.5	0.76
	Nov.	117.0	182.4	1.56
	Dec	354.5	266.5	0.75
1	Jan. 1986	331.0	302.9	0,92
	Feb.	267.0	283.7	1.06
	Mar.	463.0	513.2	1.11
	Arp.	191.0	410.0	2.15
	Total	2011.0	2178.2	1.08
	Oct. 1985	287.5	140.8	0.49
	Nov.	117.0	106.3	0.91
	Dec.	354.5	187.8	0.53
2	Jan. 1986	331.0	224.2	0.68
	Feb.	267.0	212.6	0.80
	Mar.	463.0	434.5	0.74
	Apr.	191.0	333.9	1.75
	Total	2011.0	1640.1	0.82

Station : Andir (A=67.5 km^2)

Case	Date	Rainfall Depth (mm)	Run-off Depth (mm)	Rate of Run-off
	Oct. 1985	171.5	63.9	0.37
	Nov.	141.5	49.5	0.35
	Dec.	168.5	150.1	0,89
1	Jan. 1986	284.0	189.6	0.67
	Feb.	187.0	161.5	0.86
	Mar.	411.0	298.6	0.73
	Apr.	288.1	223.6	0.78
	Total	1651.6	1136.8	0.69
	Oct. 1985	171.5	50.8	0.30
	Nov.	141.5	36.8	0.26
	Dec	168.5	137.0	0.81
2	Jan. 1986	284.0	176.5	0.62
	Feb.	187.0	149.7	0.80
	Mar.	411.0	285.5	0.69
	Apr.	288.1	210.9	0.73
	Total	1651.6	1047.2	0.63

Station : Peundeuy (A=20.8 km^2)

Case	Date	Rainfall Depth (mm)	Run-off Depth (mm)	Rate of Run-off
	Oct, 1985	778.0	69,0	0.09
	Nov.	254.0	53.7	0.21
	Dec.	541.0	92.0	0.17
1	Jan. 1986	261.0	154.1	0.59
	Feb.	214.0	90.5	0.42
	Mar.	468.0	238.4	0.51
	Apr.	176.0	205.9	1.17
	Total	2692.0	903.6	0.34
	Oct. 1985	778.0	42.2	0.05
	Nov.	254.0	27.8	0.11
	Dec.	541.0	65.2	0.12
2	Jan. 1986	261.0	127.3	0.49
	Feb.	214.0	66.3	0.31
	Mar.	468.0	21.6	0.45
	Apr.	176.0	180.1	1.02
	Total	2692.0	720.5	0.27

Station : Cikuda (A=53.9 km^2)

Case	Date	Rainfall Depth (mm)	Run-off Depth (mm)	Rate of Run-off
	Oct. 1985	247.0	13.0	0.05
	Nov.	220.0	25.0	0.11
	Dec.	302.0	38.0	0.13
1	Jan. 1986	262.0	96.6	0.37
	Feb.	268.0	59.2	0.22
	Mar.	281.0	146.3	0.52
	Apr.	177.0	138.5	0.78
	Total	1757.0	516.6	0.29
	Oct. 1985	247.0	10.4	0.04
	Nov.	220.0	22.5	0.10
	Dec.	302.0	35.4	0.12
2	Jan. 1986	262.0	94.0	0.36
	Feb	268.0	56.8	0.21
	Mar.	281.0	143.8	0.51
	Apr.	177.0	135.9	0.77
	Total	1757.0	418.8	0.28

Station : Jatisari (A=18.8 km^2)

Case	Date	Rainfall Depth (mm)	Run-off Depth (mm)	Rate of Run-off
	Oct. 1985	247.0	267.8	1.08
	Nov.	220.0	186.1	0.85
	Dec.	302.0	304.1	1.01
1	Jan. 1986	148.8	101.6	0.68
	Feb.	106.6	153.6	1.44
	Mar.	245.0	324.6	1.32
	Apr.	236.3	324.6	1.11
	Total	1505.7	1600.0	1.06
	Oct. 1985	247.0	215.3	0.87
	Nov.	220.0	135.3	0.62
	Dec.	302.0	251.6	0.83
2	Jan. 1986	148.8	49.1	0.33
	Feb.	186.6	106.2	1.00
	Mar.	245.0	273.8	1.12
	Apr.	236.3	209.7	0.89
	Total	1505.7	1241.0	0.82

Station : Sukajadi (A=38.5 km^2)

Case	Date	Rainfall Depth (mm)	Run-off Depth (mm)	Rate of Run-off
	Oct. 1985			
	Nov.	294.0	46.5	0.16
	Dec	80.0	65.1	0.81
1	Jan. 1986	218.0	51.2	0.23
	Feb.	188.0	62.5	0.33
	Mar.	367.0	102.0	0.28
	Apr.	219.0	87.9	0.40
	Total	1366.0	415.2	0.30
	Oct. 1985			
	Nov.	294.0	33.8	0.11
	Dec.	80.0	65.0	0.81
2	Jan. 1986	218.0	38.1	0.17
	Feb.	188.0	50.7	0.27
	Mar.	367.0	89.3	0.24
	Apr.	219.0	74.8	0.34
	Total	1366.0	338.7	0.25

Note : (1) Case 2 : Base flow is excluded.

Table G.10 BASE FLOW DISCHARGE

Date	Nanjung		Dayeuh Kolot	
	Discharge (m3/s)	Specific Discharge (m3/s/km2)	Discharge (m3/s)	Specific Discharge (m3/s/km2)
1974	14.5	0.008	-	-
1975	24.6	0.014	-	-
1976	5.8	0.003	-	-
1977	24.6	0.014	-	-
1978	-	-	-	-
1979	17.8	0.01	-	-
1980	7.0	0.004	10.8	0.008
1981	21.4	0.012	12.8	0.01
1982	13.3	0.008	7.6	0.006
Average	16.1	0.009	10.4	0.008

Table G.11 CHARACTERISTICS OF DRAINAGE BASIN (EXISTING)

Block No	Catchment Area (km2)	Area (Km2)					Elevation			Length (km)	Slope I	Co-efficient of Roughness N	K	P	Te (hr)	Remarks
		Water	Forest	Paddy Field	Dry Field Plantation, etc.	Built-up Area	Max. Elevation H1 (m)	Min. Elevation H2 (m)	Elevation Diff. H (m)							
1. 1A	97.2	0.5	33.4	38.1	22.3	2.9	980	666	314	17.5	0.0179	1.243	25.4	0.6	0.26	
2. 1B	99.8	0.0	55.3	10.9	33.4	0.2	1600	980	620	12.0	0.0517	0.940	12.7	0.6	0	Cibangoak
3. 2A	29.1	0.0	0.0	23.0	2.6	3.5	700	666	34	5.0	0.0068	1.622	19.2	0.6	0	
4. 2B	64.0	0.0	20.1	19.6	24.3	0.0	1100	700	400	9.0	0.0444	1.116	12.4	0.6	0	Cengkrong
5. 3A	260.6	0.8	33.1	129.6	88.3	8.8	1200	660	540	31.0	0.0174	1.292	27.7	0.6	0.90	
6. 3B	20.8	0.0	1.9	7.9	10.7	0.3	960	700	260	6.0	0.0433	1.109	9.7	0.6	0	Peundeuy
7. 4A	119.6	0.0	9.8	66.3	37.2	6.3	800	661	139	15.5	0.0090	1.347	22.8	0.6	0.17	
8. 4B	15.3	0.0	6.5	4.4	4.2	0.2	1300	680	620	8.5	0.0729	1.138	10.4	0.6	0	
9. 4C	48.3	0.0	25.5	8.4	14.4	0.0	1100	800	300	13.0	0.0231	1.025	17.8	0.6	0.05	Bbk.Bandung
10. 5	53.7	0.0	0.8	33.6	18.2	1.1	700	661	39	6.5	0.0060	1.436	21.6	0.6	0	
11. 6A	10.9	0.0	0.0	7.9	1.4	1.6	680	660	20	9.0	0.0022	1.518	27.0	0.6	0	
12. 6B	18.8	0.0	0.0	8.4	9.1	1.3	1200	680	520	8.5	0.0612	1.138	11.0	0.6	0	Jatisari
13. 6C	21.4	0.0	1.8	11.8	6.7	1.1	800	661	139	15.5	0.0090	1.345	31.0	0.6	0.17	
14. 7A	34.2	0.0	0.0	23.1	1.3	9.8	720	660	60	13.5	0.0044	1.378	26.4	0.6	0.07	
15. 7B	17.6	0.0	1.5	10.5	4.1	1.5	850	720	130	6.0	0.0217	1.397	13.8	0.6	0	Sukapada
16. 8A	53.9	0.0	0.0	7.4	6.8	39.7	800	659	141	13.5	0.0104	0.360	12.4	0.6	0.07	
17. 8B	34.5	0.0	15.2	2.2	15.9	1.2	1500	800	700	16.0	0.0438	0.800	14.4	0.6	0.19	Gandok
18. 8C	36.8	0.0	14.0	2.6	17.6	2.6	1600	1160	440	8.5	0.0518	0.763	9.0	0.6	0	Maribaya (Cigulung)
19. 8D	19.1	0.0	9.5	1.6	7.7	0.3	1200	1000	200	6.0	0.0333	0.867	9.1	0.6	0	Maribaya (Cikapundung)
20. 9A	69.6	0.0	16.4	30.6	19.4	3.2	680	659	21	9.7	0.0022	1.256	25.2	0.6	0	
21. 9B	206.9	4.9	76.2	46.6	78.9	0.3	1500	680	820	23.0	0.0357	1.010	16.1	0.6	0.52	Cipeundeuy
22. 10	60.1	0.0	0.0	44.4	14.5	1.2	840	658	182	9.5	0.0192	1.599	20.4	0.6	0	
23. 11	200.6	0.0	73.9	78.4	48.0	0.3	1600	658	942	27.0	0.0349	1.270	20.5	0.6	0.71	
24. 12A	78.7	1.6	0.0	40.9	4.0	32.2	760	656	104	10.0	0.0104	0.897	20.0	0.6	0	
25. 12B	38.5	0.0	7.9	10.7	15.1	4.8	1700	760	940	15.0	0.0627	0.961	13.9	0.6	0.15	Sukajadi
26. 13	8.0	0.0	0.0	5.1	2.7	0.2	680	656	24	1.0	0.0240	1.640	4.7	0.6	0	
27. 14	48.0	0.3	16.8	18.8	10.7	1.4	1500	656	844	24.0	0.0352	1.389	25.5	0.6	0.57	
28. 15	6.0	0.0	0.0	2.1	3.5	0.4	680	656	24	4.5	0.0053	1.007	14.4	0.6	0	

1) : Te : time lag of flood run-off

Table G.12 COMPARISON OF DAILY AND HOURLY BASIS CALCULATIONS

River	Catchment Area (km2)	Land Use	Inundation	Peak Discharge Daily (m3/s)	Peak Discharge Hourly (m3/s)	Hourly/Daily
Citarum River		Existing	Without			
Dayeuh Kolot	1,332.1			320	480	1.50
Nanjung	1,718.0			420	580	1.38
Citarum River		Existing	With 1,000ha			
Dayeuh Kolot	1,332.1			271	287	1.06
Nanjung	1,718.0			363	378	1.04
Cikapundung River	114.3	Existing	Without	31	74	2.30
Cisangkuy River	276.5	Existing	Without	62	93	1.50

Table G.13 CHARACTERISTICS OF DRAINAGE BASIN (YEAR 2005)

Block No	Catch-ment Area (km2)	Area (Km2)					Elevation			Length (km)	Slope I	Co-efficient of Roughness N	K	P	Te (hr)	Remarks
		Water	Forest	Paddy Field	Dry Field Plantation, etc.	Built-up Area	Max. Elevation H1 (m)	Min. Elevation H2 (m)	Elevation Diff. H (m)							
1. 1A	97.2	0.5	33.4	36.2	22.3	4.8	980	666	314	17.5	0.0179	1.243	25.4	0.6	0.26	
2. 1B	99.8	0.0	55.3	10.9	33.4	0.2	1600	980	620	12.0	0.0517	0.940	12.7	0.6	0	Cibangoak
3. 2A	29.1	0.0	0.0	17.5	0.8	10.8	700	666	34	5.0	0.0068	1.622	16.2	0.6	0	
4. 2B	64.0	0.0	20.1	17.2	24.3	2.4	1100	700	400	9.0	0.0444	1.116	11.9	0.6	0	Cengkrong
5. 3A	260.6	0.8	33.1	126.3	85.8	14.6	1200	660	540	31.0	0.0174	1.292	27.3	0.6	0.90	
6. 3B	20.8	0.0	1.9	7.9	10.7	0.3	960	700	260	6.0	0.0433	1.109	9.7	0.6	0	Peundeuy
7. 4A	119.6	0.0	9.8	56.4	26.5	26.9	800	661	139	15.5	0.0090	1.347	20.7	0.6	0.17	
8. 4B	15.3	0.0	6.5	3.0	3.0	2.8	1300	680	620	8.5	0.0729	1.138	9.2	0.6	0	
9. 4C	48.3	0.0	25.5	8.4	14.4	0.0	1100	800	300	13.0	0.0231	1.025	17.8	0.6	0.05	Bbk.Bandung
10. 5	53.7	0.0	0.8	33.6	18.2	1.1	700	661	39	6.5	0.0060	1.436	21.6	0.6	0	
11. 6A	10.9	0.0	0.0	7.3	1.4	2.2	680	660	20	9.0	0.0022	1.518	25.8	0.6	0	
12. 6B	18.8	0.0	0.0	7.0	8.2	3.6	1200	680	520	8.5	0.0612	1.138	10.0	0.6	0	Jatisari
13. 6C	21.4	0.0	1.8	10.1	4.8	4.7	800	661	139	15.5	0.0090	1.345	28.1	0.6	0.17	
14. 7A	34.2	0.0	0.0	15.9	0.4	17.9	720	660	60	13.5	0.0044	1.378	21.1	0.6	0.07	
15. 7B	17.6	0.0	1.5	10.5	4.1	1.5	850	720	130	6.0	0.0217	1.397	13.8	0.6	0	Sukapada
16. 8A	53.9	0.0	0.0	0.0	5.6	48.3	800	659	141	13.5	0.0104	0.360	5.0	0.6	0.07	
17. 8B	34.5	0.0	15.2	0.0	15.5	3.8	1500	800	700	16.0	0.0438	0.800	12.9	0.6	0.19	Gandok
18. 8C	36.8	0.0	14.0	2.6	16.8	3.4	1600	1160	440	8.5	0.0518	0.763	9.0	0.6	0	Maribaya (Cigulung)
19. 8D	19.1	0.0	9.5	1.6	7.7	0.3	1200	1000	200	6.0	0.0333	0.867	9.1	0.6	0	Maribaya (Cikapundung)
20. 9A	69.6	0.0	16.0	21.6	17.9	14.1	680	659	21	9.7	0.0022	1.256	21.8	0.6	0	
21. 9B	206.9	4.9	76.2	46.6	78.9	0.3	1500	680	820	23.0	0.0357	1.010	16.1	0.6	0.52	Cipeundeuy
22. 10	60.1	0.0	0.0	34.6	13.1	12.4	840	658	182	9.5	0.0192	1.599	17.7	0.6	0	
23. 11	200.6	0.0	73.9	73.9	45.3	7.5	1600	658	942	27.0	0.0349	1.270	20.0	0.6	0.71	
24. 12A	78.7	0.0	0.0	7.6	0.9	70.2	760	656	104	10.0	0.0104	0.897	7.8	0.6	0	
25. 12B	38.5	0.0	7.9	3.9	11.1	15.6	1700	760	940	15.0	0.0627	0.961	10.1	0.6	0.15	Sukajadi
26. 13	8.0	0.0	0.0	5.1	2.7	0.2	680	656	24	1.0	0.0240	1.640	4.7	0.6	0	
27. 14	48.0	0.3	16.8	10.5	6.7	13.7	1500	656	844	24.0	0.0352	1.389	20.5	0.6	0.57	
28. 15	6.0	0.0	0.0	2.1	3.5	0.4	680	656	24	4.5	0.0053	1.007	14.4	0.6	0	

1) : Te : time lag of flood run-off

Table G.14 DESIGN BASIN RAINFALL FOR DAYEUH KOLOT BASIN

Return Period (Year)	1986 Storm (5-days, mm)	Design Rainfall (5-days, mm)	Ratio
2	115.9	124.8	1.08
5	115.9	152.2	1.31
10	115.9	168.9	1.46
20	115.9	184.0	1.59
50	115.9	202.6	1.75
100	115.9	216.1	1.86

Table G.15 ESTIMATED BASIC DESIGN DISCHARGE (DAYEUH KOLOT, NANJUNG)

Return Period	Basic Design Discharge (m3/s)	
(Year)	Dayeuh Kolot (1,332.1 km2)	Nanjung (1,718.0 km2)
2	331	438
5	414	547
10	467	617
20	514	678
50	572	754
100	614	809

Table G.16 ESTIMATED BASIC DESIGN DISCHARGE (MAJOR SITES OF CITARUM RIVER)

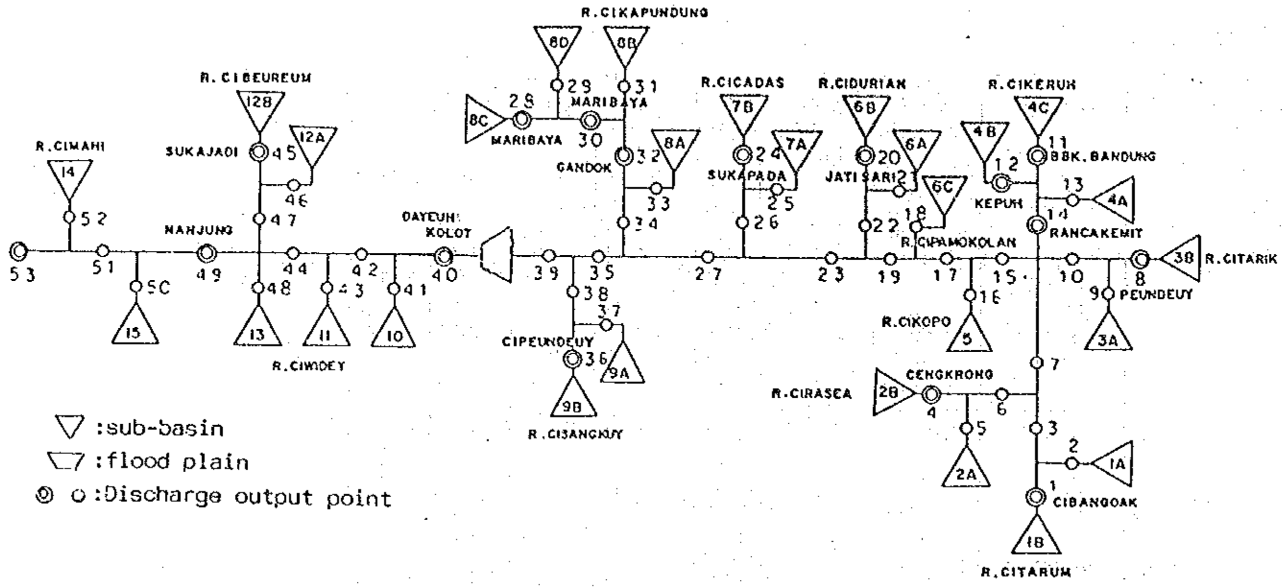
Site No.	Basic Design Discharge (m3/s)		
	5-year	20-year	50-year
15 (Sapan)	256	316	351
23	277	342	380
35	309	382	424
39	414	514	572
40 (Dayeuh Kolot)	414	514	572
44	501	622	691
49 (Nanjung)	547	678	754
53 (Curug Jompong)	563	698	775

Table G.17 HYDRAULIC EFFECTS OF RIVER DREDGING

Level of River Improvement	Rainfall Probability (Year)	Max. Flood Elevation at Dayeuh Kolot (m)	Flood Depth at D.K. (m)	*1 (m)	*2 (m)	*3 (day)
1 Existing River	1986 March	659.60	1.50	0.00	0.00	more than 2 months
	1/2	659.84	1.74	-0.24	0.00	
	1/5	660.28	2.18	-0.68	0.00	
	1/10	660.59	2.44	-0.99	0.00	
	1/20	660.87	2.77	-1.27	0.00	
160 m³/s	1/50	661.21	3.11	-1.61	0.00	
	1/100	661.45	3.35	-1.85	0.00	
2	1986 March	657.83	-0.27	1.77	1.77	19
	1/2	657.99	-0.11	1.61	1.85	37
	1/5	658.58	0.46	1.02	1.70	51
	1/10	658.95	0.85	0.65	1.64	54
	1/20	659.27	1.17	0.33	1.60	57
310 m³/s	1/50	659.66	1.56	0.06	1.67	58
	1/100	659.87	1.77	-0.27	1.58	58
3	1986 March	657.23	-0.87	2.37	2.37	9
	1/2	657.45	-0.65	2.15	2.39	13
	1/5	657.99	-0.11	1.61	2.29	22
	1/10	658.31	0.21	1.24	2.23	39
	1/20	658.55	0.45	1.05	2.32	46
390 m³/s	1/50	658.88	0.78	0.72	2.33	51
	1/100	659.12	1.02	0.48	2.33	53
4	1986 March	656.84	-1.26	2.76	2.76	7
	1/2	657.13	-0.97	4.47	2.71	9
	1/5	657.69	-0.41	1.41	2.09	15
	1/10	657.97	-0.13	1.63	2.62	18
	1/20	658.22	0.12	1.38	2.65	24
450 m³/s	1/50	658.50	0.40	1.10	2.71	38
	1/100	658.71	0.61	0.89	2.74	47
5	1986 March	656.56	-1.54	3.04	3.04	4
	1/2	656.78	-1.32	2.82	3.06	8
	1/5	657.37	-0.73	2.23	2.91	13
	1/10	657.68	-0.42	1.93	2.91	14
	1/20	657.93	-0.17	1.67	2.94	21
505 m³/s	1/50	658.20	0.10	1.40	3.01	29
	1/100	658.34	0.29	1.21	3.04	38
6	1986 March	656.37	-1.73	3.23	3.23	2
	1/2	656.57	-1.53	3.03	3.27	3
	1/5	657.26	-0.84	2.34	3.02	8
	1/10	657.54	-0.56	2.06	3.05	12
	1/20	657.81	-0.29	1.79	3.06	16
540 m³/s	1/50	658.07	-0.03	1.53	3.14	18
	1/100	658.30	0.20	1.30	3.15	27

*1 Flood depth reduction from 1986 flood
*2 Flood depth reduction from existing river condition
*3 Maximum flood duration at the lowest point of flood area

Table G.18 DESIGN DISCHARGE DISTRIBUTION OF CITARUM RIVER



Site No.	Design Discharge (m3/s)			Basic Design Discharge (m3/s)		
	5-year	20-year	50-year	5-year	20-year	50-year
15 (Sapan)	256	316	351	256	316	351
23	277	342	380	277	342	380
35	309	382	424	309	382	424
39	414	514	572	414	514	572
40 (Dayeuh Kolot)	374	466	534	414	514	572
44	465	578	658	501	622	691
49 (Nanjung)	505	627	712	547	678	754
53 (Curug Jompong)	521	647	733	563	698	775

Table G.19 HYDRAULIC EFFECTS OF CISANGKUY DIVERSION

	Max. Discharge (m3/s)	Discharge Reduction (m3/s)	Max. Water Stage (EL.m)	Water Stage Reduction (m)	Remarks
Case 1-1	373	-	658.04	-	5-year flood, without diversion
Case 1-2	324	49	657.83	0.21	5-year flood, with diversion
Case 2-1	465	-	658.09	-	20-year flood, without diversion
Case 2-2	401	64	657.85	0.24	20-year flood, with diversion

Table G.20 PROBABLE DISCHARGE OF CITARUM (UPSTREAM) RIVER

UNIT: m3/s

No.	Selected Storm	5-year	20-year	50-year
1	1986, 1. 2	80	102	120
2	1. 4	141	190	226
3	1. 8	71	88	105
4	2. 8	90	117	138
5	2. 10	71	90	108
6	2. 23	87	110	128
7	2. 27	101	132	155
8	3. 5	171	225	263
9	3. 8	178	242	287
10	3. 9	73	93	109
11	3. 11	77	101	119
12	3. 13	122	165	197
13	3. 20	73	93	109
14	3. 23	112	107	126
15	4. 11	73	94	111
Average		101	130	153

Table G.21 PROBABLE DISCHARGE OF CITARIK RIVER

Unit: m3/s

No.	Selected Storm	5-year	20-year	50-year
1	1986, 1. 2	71	94	110
2	1. 4	61	79	91
3	1. 6	62	80	92
4	2. 2	73	97	112
5	2. 27	82	112	131
6	3. 1	67	94	109
7	3. 5	72	95	110
8	3. 9	70	92	106
9	3. 11	82	109	126
10	3. 23	68	89	103
11	4. 7	102	138	162
Average		74	98	114

Table G.22 PROBABLE DISCHARGE OF CIKERUH RIVER

Unit: m3/s

No.	Selected Storm	5-year	20-year	50-year
1	1986, 1. 2	67	90	105
2	1. 5	87	121	149
3	1. 7	85	117	139
4	1. 8	61	82	97
5	2. 5	88	121	144
6	2. 8	57	75	86
7	2. 27	61	79	91
8	2. 28	77	105	123
9	3. 7	65	88	102
10	3. 31	82	111	129
11	4. 12	70	95	111
12	4. 18	64	87	101
Average		72	98	115

Table G.23 PROBABLE DISCHARGE OF CISANGKUY RIVER

Unit: m3/s

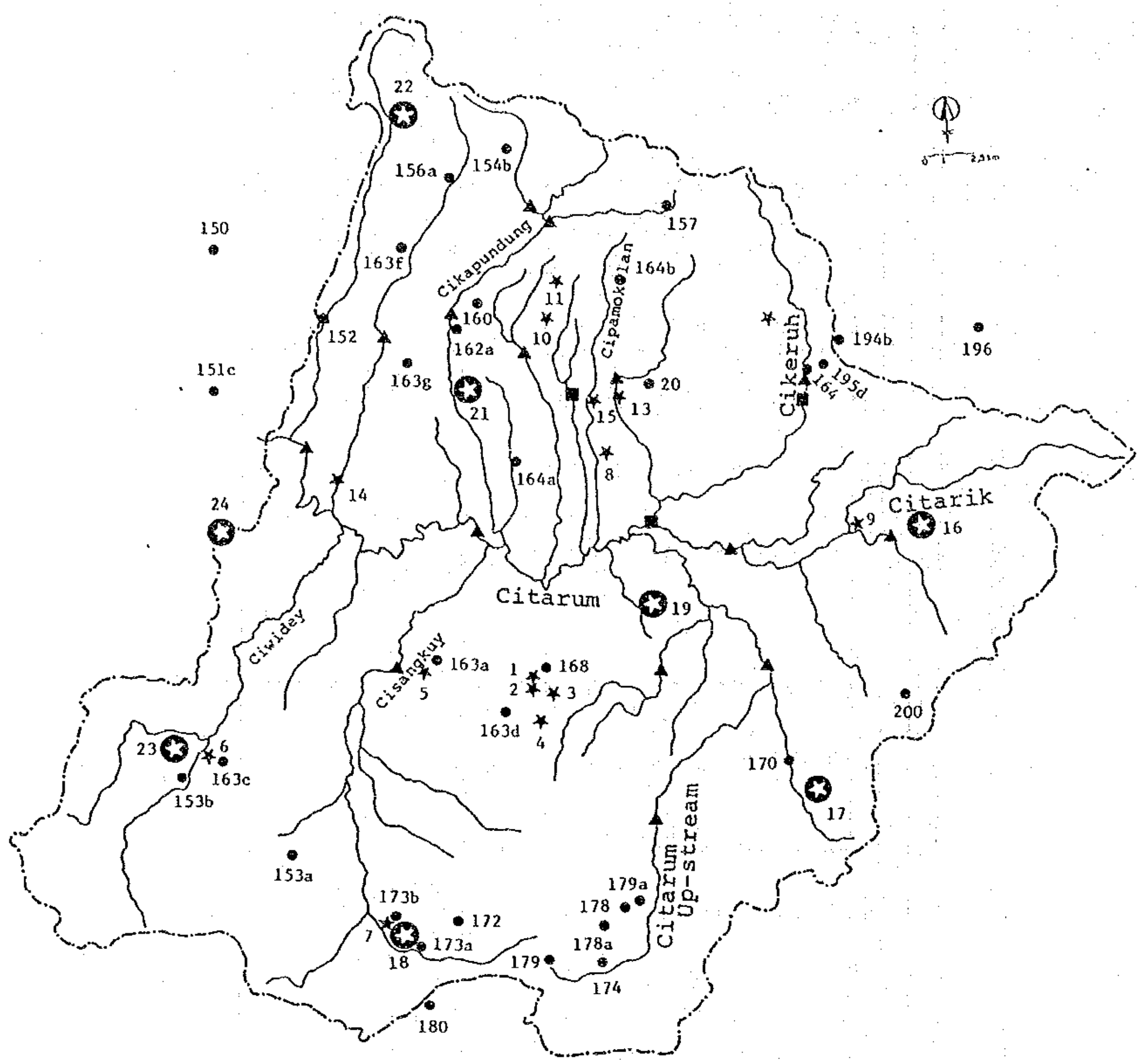
No.	Selected Storm	5-year	20-year	50-year
1	1986, 2. 10	123	159	183
2	2. 23	135	173	196
3	2. 27	145	187	214
4	3. 5	124	158	179
5	3. 10	147	191	218
6	3. 11	122	155	175
7	3. 14	139	180	205
8	3. 23	125	159	179
9	4. 2	127	163	186
Average		132	169	193

Table G.24 DESIGN DISCHARGE OF TRIBUTRIES

	Catchment Area (km2)	Design Discharge (m3/s)		
		5-year	20-year	50-year
Citarum (upstream) River	290.1	110	130	160
Citarik River	281.4	80	100	120
Cikeruh River	183.2	80	100	120
Cisangkuy River	276.5	135	170	195

Table G.25 FLOOD RUN-OFF CHANGE DUE TO LAND DEVELOPMENT

River	Catchment Area (km2)	5 - year			20 - year		
		Land Use		Ratio	Land Use		Ratio
		Existing	Future		Existing	Future	
Citarum River							
Dayeh Kolot	1,332.1	406	414	1.02	505	514	1.02
Nanjung	1,718.0	528	547	1.04	656	678	1.03
Tributaries							
Citarum (Upstream)	290.1	91	101	1.11	119	130	1.09
Citarik	281.4	71	74	1.04	95	98	1.03
Cikeruh	183.2	59	72	1.22	80	98	1.23
Cisangkuy	276.5	126	132	1.05	161	169	1.05
Tributaries of Bandung Urban Area							
Citapus	18.4	56	92	1.64	66	105	1.57
Cikapundung	110.2	144	165	1.15	168	170	1.13
Cikapundung Kolot	22.5	100	115	1.15	112	125	1.12
Cicadas	24.1	54	68	1.26	64	80	1.25
Ciwastra	8.9	26	35	1.35	30	40	1.33
Cidurian	27.1	54	60	1.11	63	70	1.11
Cipamokolan	44.8	104	111	1.07	124	130	1.05



1 Cibintinu
2 Pasir Jampana
3 Cibuntu
4 Bbk.Siliwangi
5 Banjaran
6 Cisondari
7 Pangalengan
8 Perwati
9 Bojongmonyet
10 Tanjakan
11 Ciharalang
13 Lemburawa
14 Mande
15 Cisaranten Kidul
16 Cicalengka
17 Paseh
18 Cinchona
19 Ciparay
20 Ujungberung
21 Bandung
22 Sukawarna
23 Cisondari
24 Cililin

150 Padalarang
151c Batujajar
152 Cimahi I.H.E
153a Gambung
153b Ciwidey
154b Margahayu
157 Cikapundung
160 Pakar
162a Cihampelas
163a Banjaran
163c Cisondari
163d Cirateun
163f Cibadak
163g Husein
164 Jatinangor(perk)
164a Buahbatu
164b Pasirjati
168 Arjasari(perk)
170 Paseh(Cipaku)
172 Ciniruan
173a Cinchona
173b Pangalengan

174 Cibeureum
178 Argasari
178a Gn.Halimun
179 Cibitung
179a Pacet
180 Marabar
194b Tanjungsari 1
195d Tanjungsari 2
196 Cimanggerang
200 Sitiarja

● Rainfall Station (Ordinary)
★ Rainfall Station (Automatic)
✪ Rainfall Station (Telemeter)
■ Water Level Station (Staff)
▲ Water Level Station (Automatic)

FIG. G.1 LOCATION OF HYDROLOGICAL OBSERVATION IN AND AROUND STUDY AREA

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

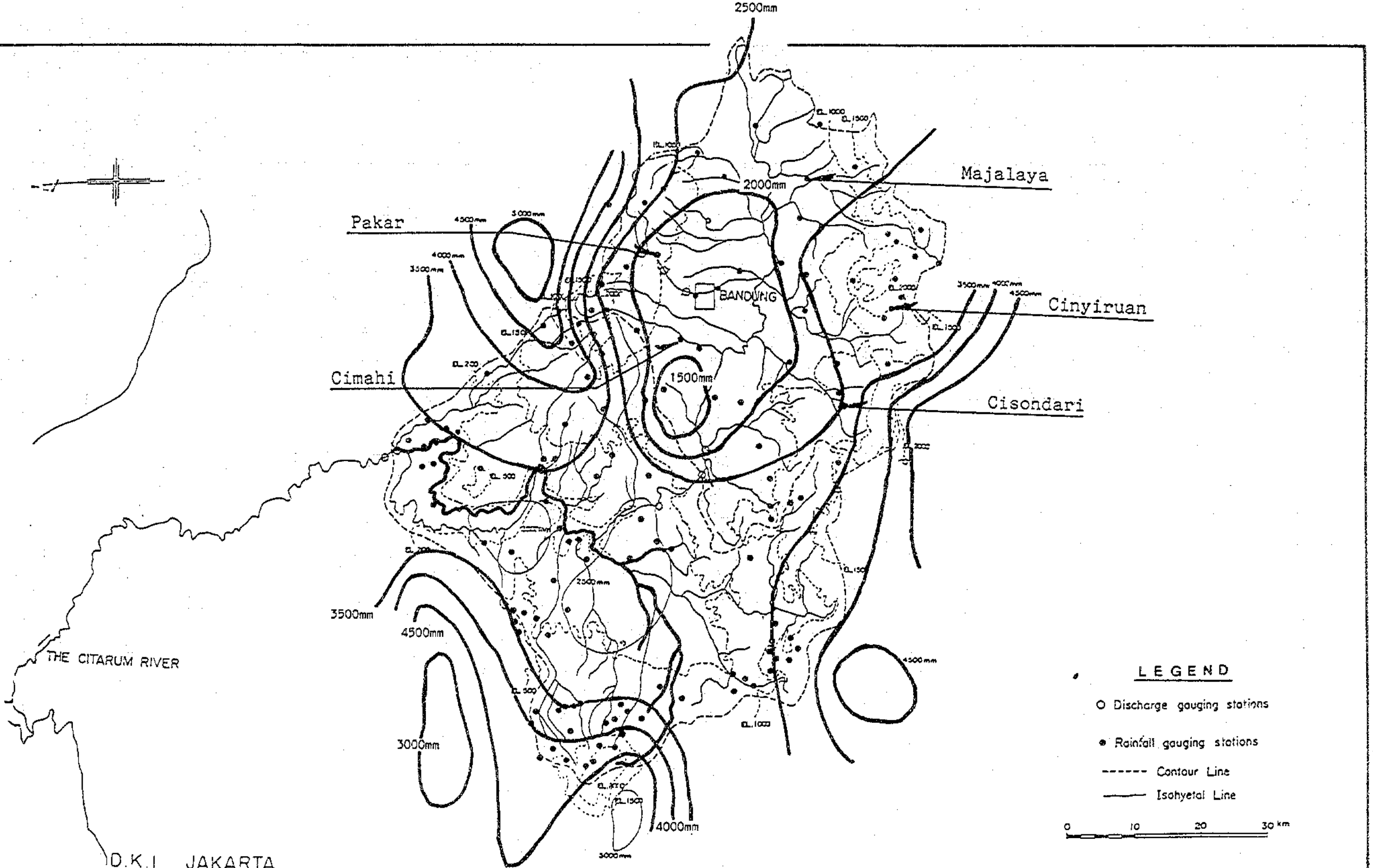
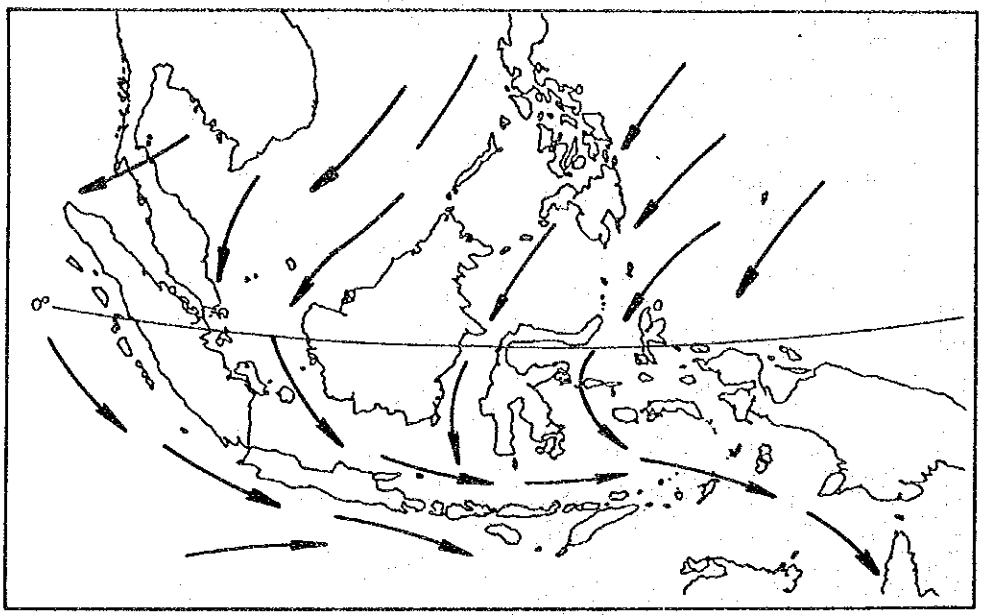


FIG. G.2 ISOHYETAL MAP OF ANNUAL RAINFALL FOR STUDY AREA

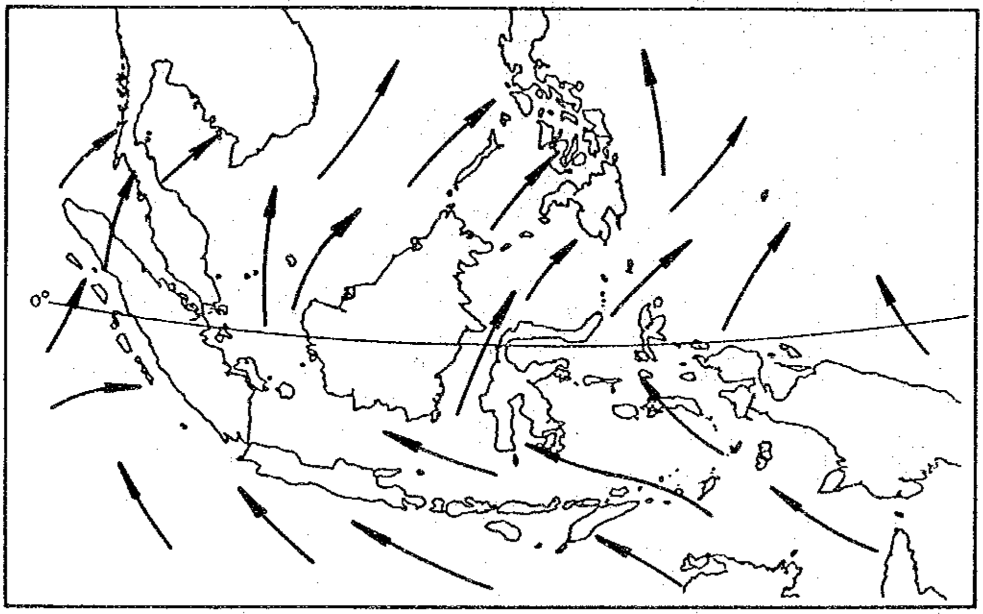
STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA

EAST MONSOON (DEC, JAN)



WEST MONSOON (JUL, AUG)

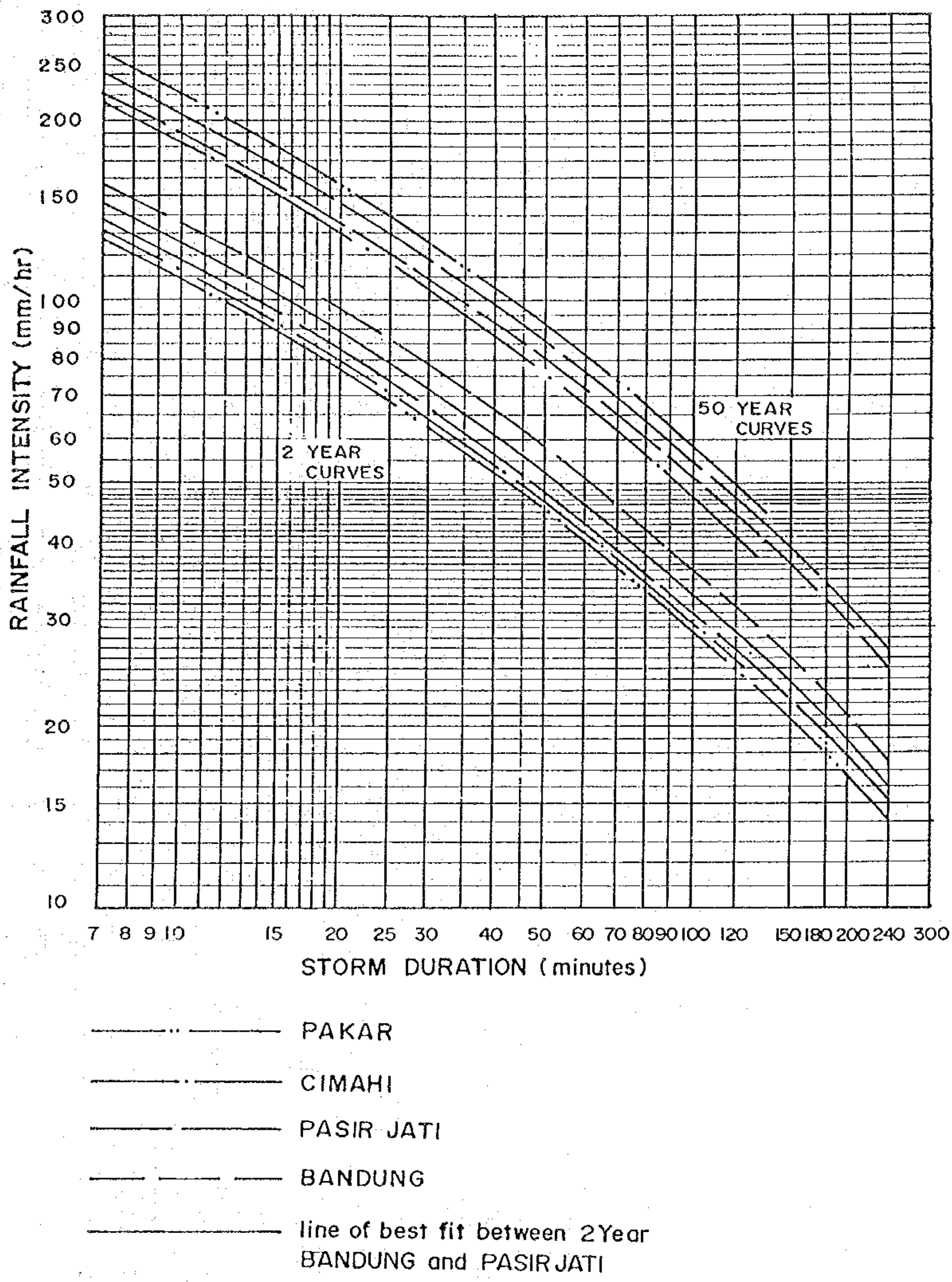


SOURCE : B M G

FIG. G.3 MONSOON OF INDONESIA

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

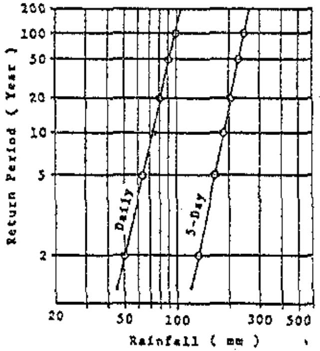
JICA



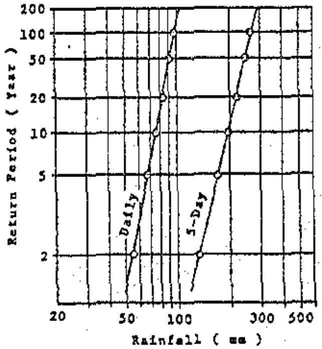
Source : Bandung Urban Development Project

FIG. G.4	RAINFALL INTENSITY DURATION CURVE

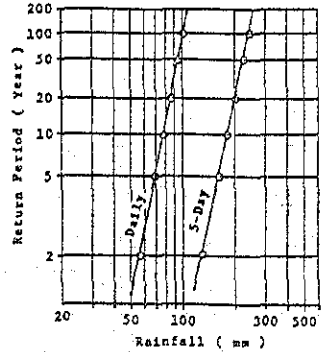
STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN



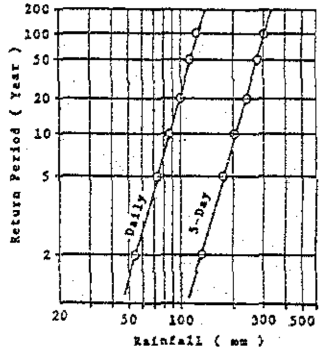
1 Citarik



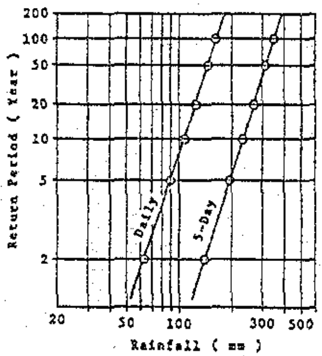
2 Cisangkuy



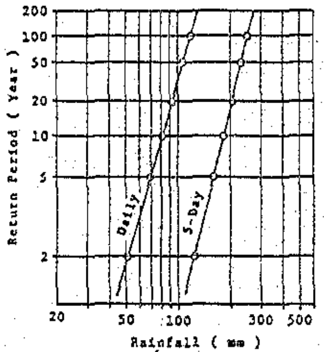
3 Cibodas



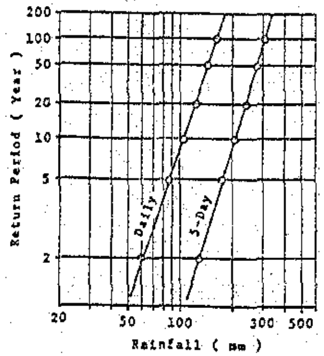
4 Cikapundung



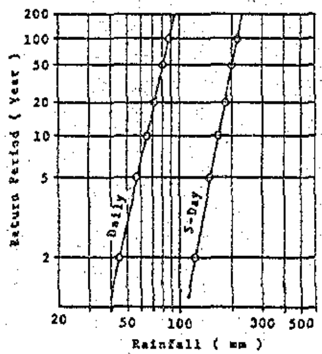
5 Ciwidey



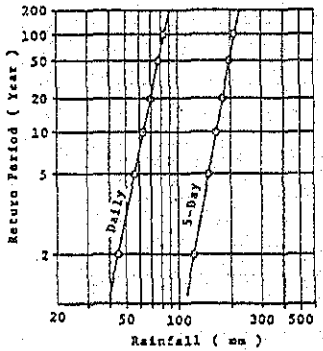
6 Cibeureum



7 Cimahi



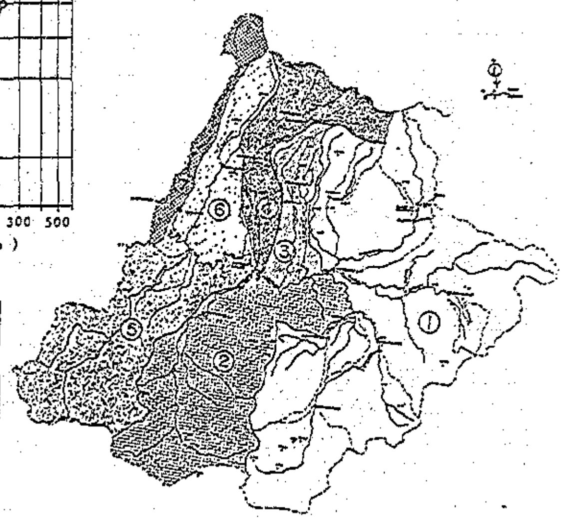
Dayeuh Kolot



Nanjung

Drainage Basin	Area (Km2)
1. Citarik	776.1
2. Cisangkuy	330.2
3. Cibodas	81.5
4. Cikapundung	146.3
Dayeuh Kolot	1,332.1
5. Ciwidey	268.7
6. Cibeureum	117.2
Nanjung	1,718.0
7. Cimahi	54.0
Curug Jompong	1,771.0

Drainage Basin Area



Drainage Basin Map

FIG. G.5 PROBABILITY OF DAILY AND 5-DAY RINFALL

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA

No.	No.Sta.	Name of Station	Authority
1.	150	Padalarang	B.M.G
2.	151a	Sindangkerta	I.H.E
3.	151c	Batujajar	B.M.G
4.	152	Cimahi I.H.E	I.H.E
5.	153a	Gambung	B.M.G
6.	153b	Ciwidey	"
7.	154b	Margahayu	"
8.	157	Cikapundung	"
9.	160	Pakar	I.H.E
10.	162a	Cihampelas	"
11.	163a	Banjaran	B.M.G
12.	163c	Cisondari	I.H.E
13.	163d	Ciraseun	B.M.G
14.	163f	Cibadak	"
15.	163g	Husein	"
16.	164	Jatinangor(perk)	"
17.	164a	Buahbatu	"
18.	164b	Pasirjati	"
19.	167	Majalaya	I.H.E
20.	168	Arjasari(perk)	B.M.G
21.	170	Paseh (Cipaku)	I.H.E
22.	172	Ciniruan	"
23.	173a	Cinchona	B.M.G
24.	173b	Pangalengan	"
25.	174	Cibeureum	"
26.	178	Argasari	"
27.	178a	Gn. Halimun	"
28.	179	Cibitung	"
29.	179a	Pacet	"
30.	180	Malaber	I.H.E
31.	181b	Cileunca	B.M.G
32.	194b	Tanjungsari 1	"
33.	195d	Tanjungsari 2	"
34.	196	Cimanggerang	"
35.	200	Sitiarja	"

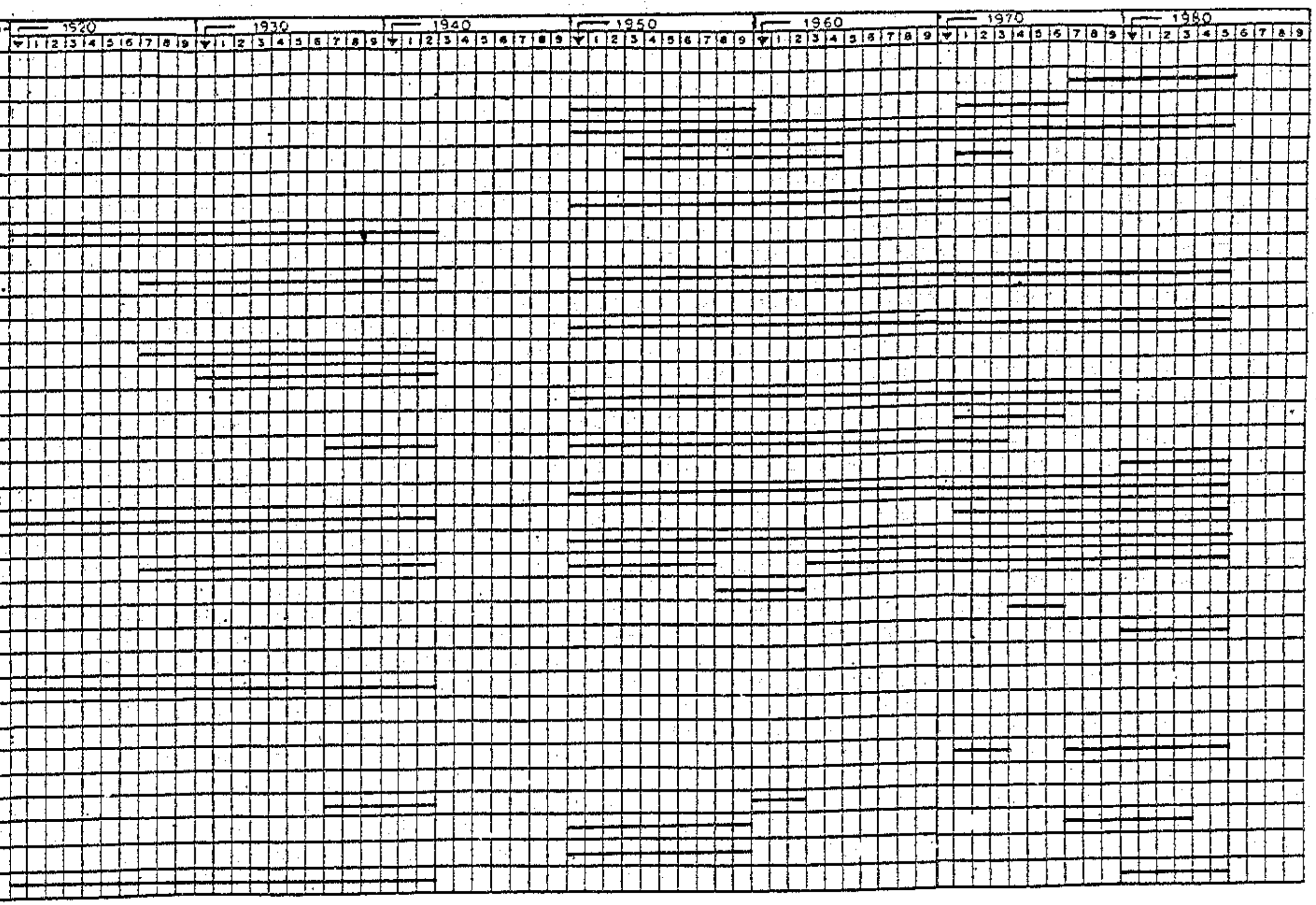


FIG. G.6 RAINFALL STATION USED FOR STATISTICAL ANALYSIS

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA

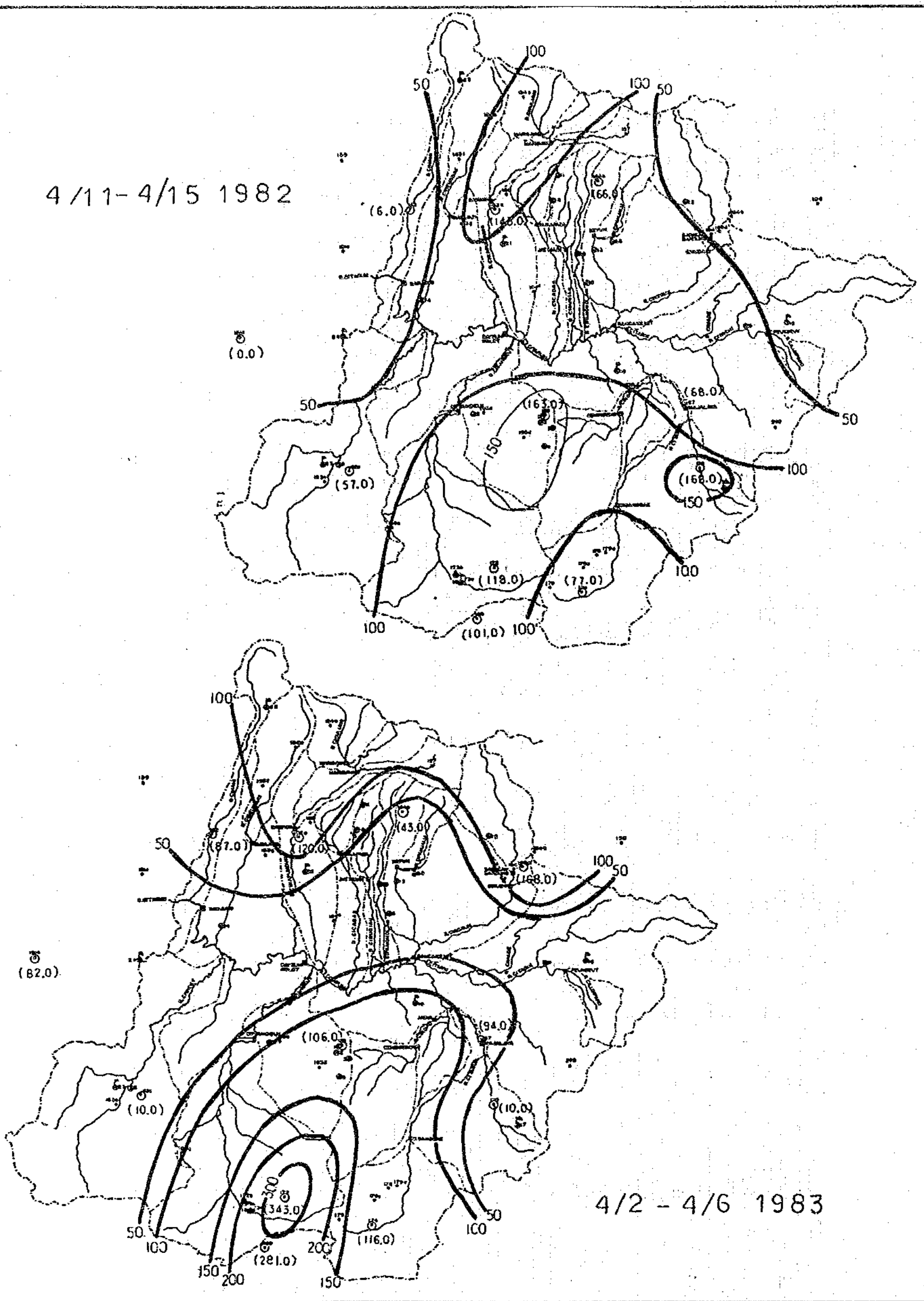


FIG. G.7 ISOHYETAL MAP OF 5-DAY RAINFALL OF RECENT FLOOD (1)

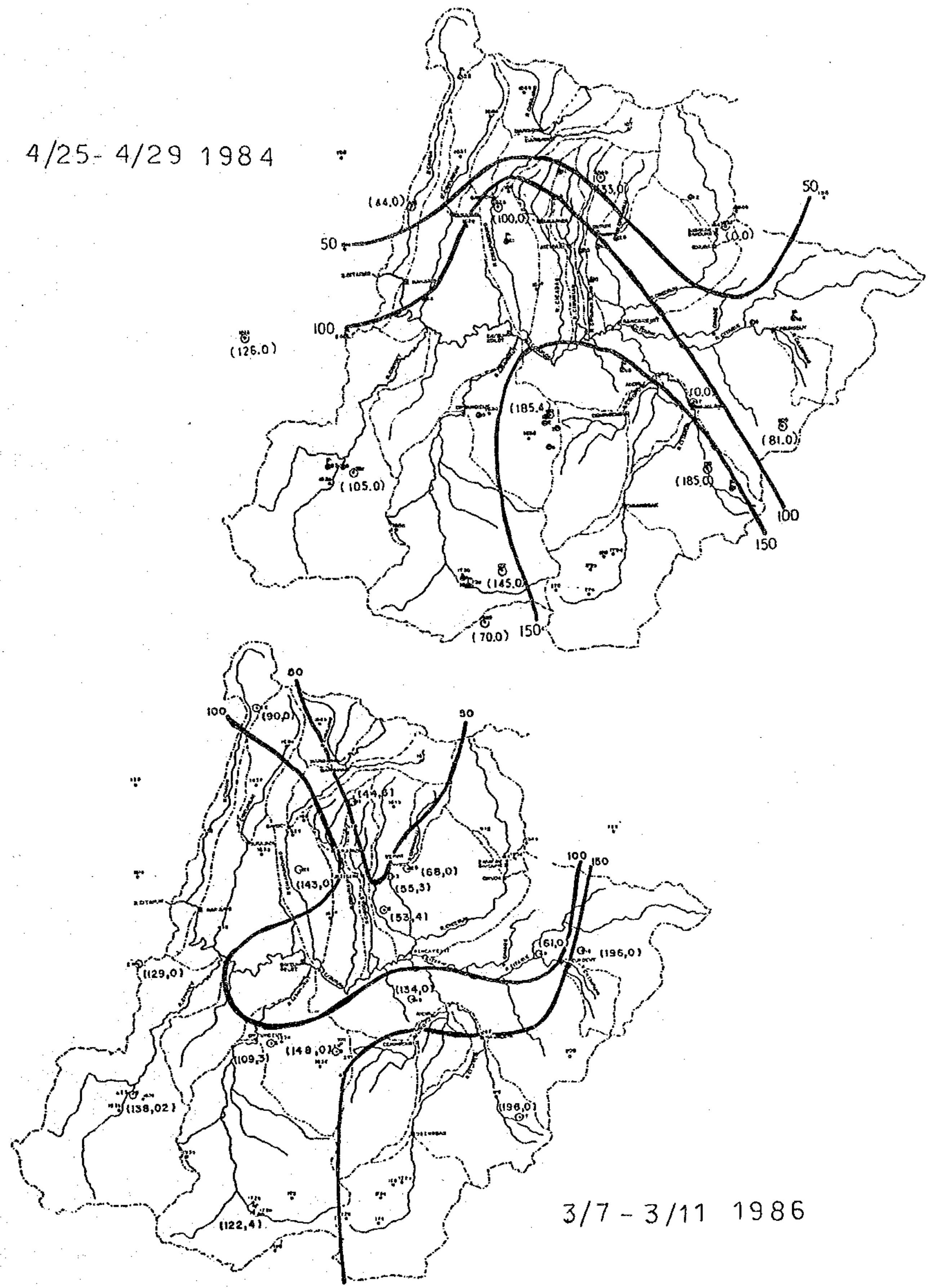


FIG. G.8 ISOHYETAL MAP OF 5-DAY RAINFALL OF RECENT FLOOD (2)

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA

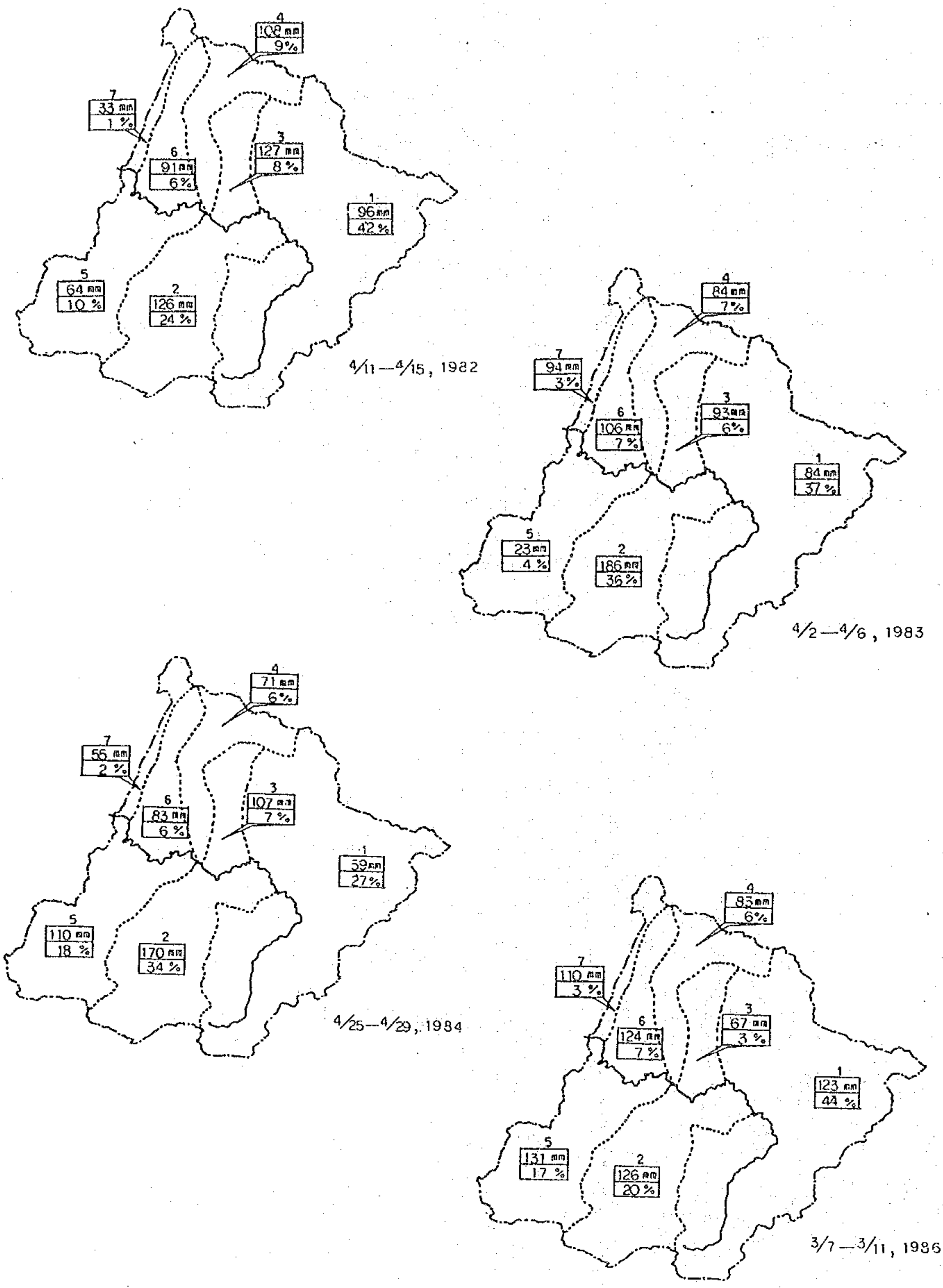
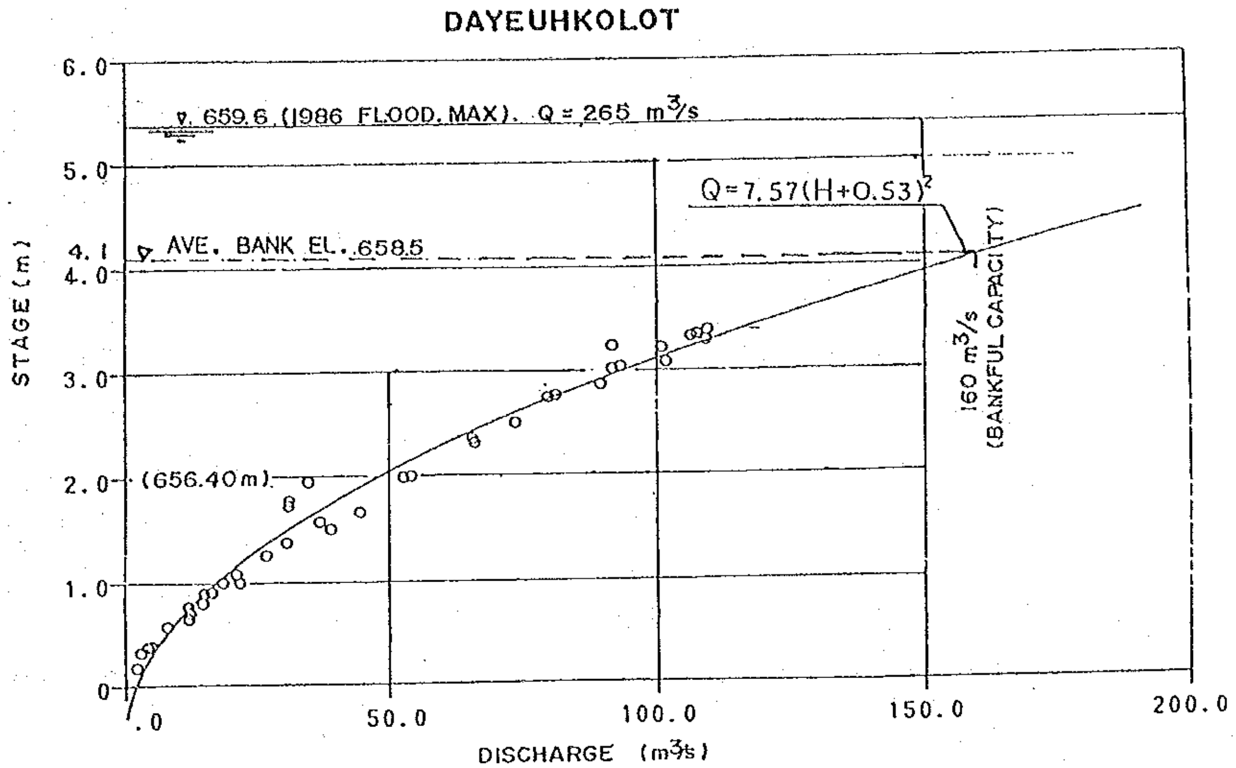
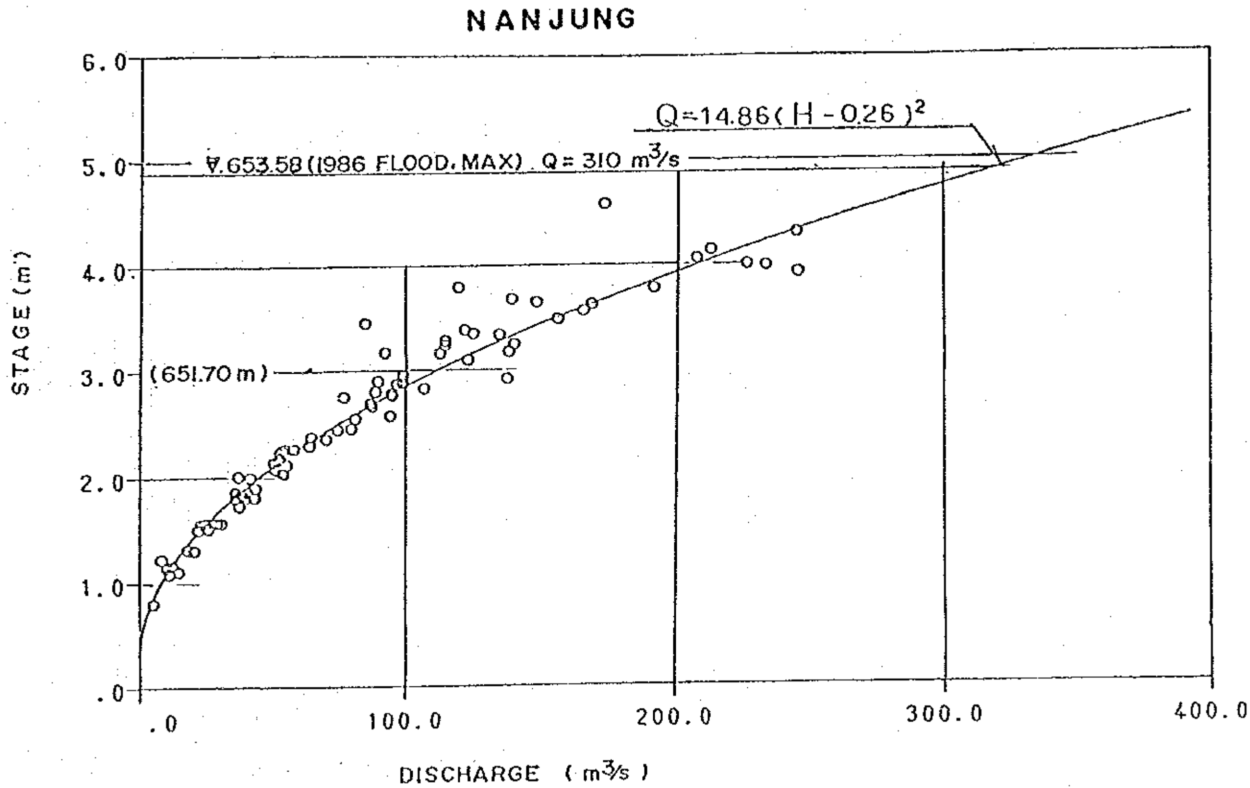


FIG. G.9	REGIONAL DISTRIBUTION OF 5-DAY RAINFALL OF RECENT FLOOD

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

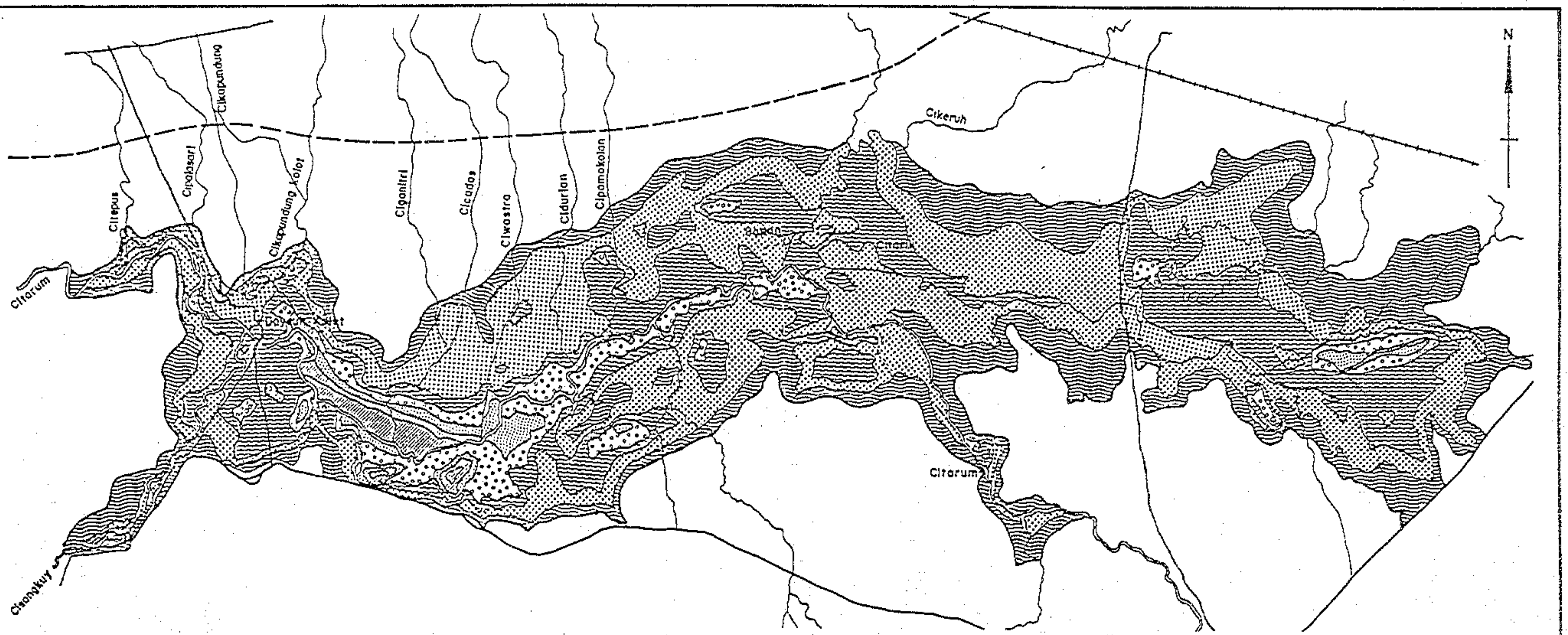




SOURCE : IHE DATA, STUDY TEAM

FIG. G.10 WATER STAGE - DISCHARGE CURVES AT DAYEUH KOLOT AND NANJUNG GAUGING STATIONS

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN



LEGEND

- 3,7 m — 2,5 m
- 2,5 — 2,0
- 2,0 — 1,5
- 1,5 — 1,0
- 1,0 — 0,5
- 0,5 — 0,0

Flood Depth	Area (Unit ; ha)
3,7 - 2,5 m	98,1
2,5 - 2,0 m	145,6
2,0 - 1,5 m	773,5
1,5 - 1,0 m	1853,7
1,0 - 0,5 m	2484,4
0,5 - 0,0 m	1893,7

SCALE

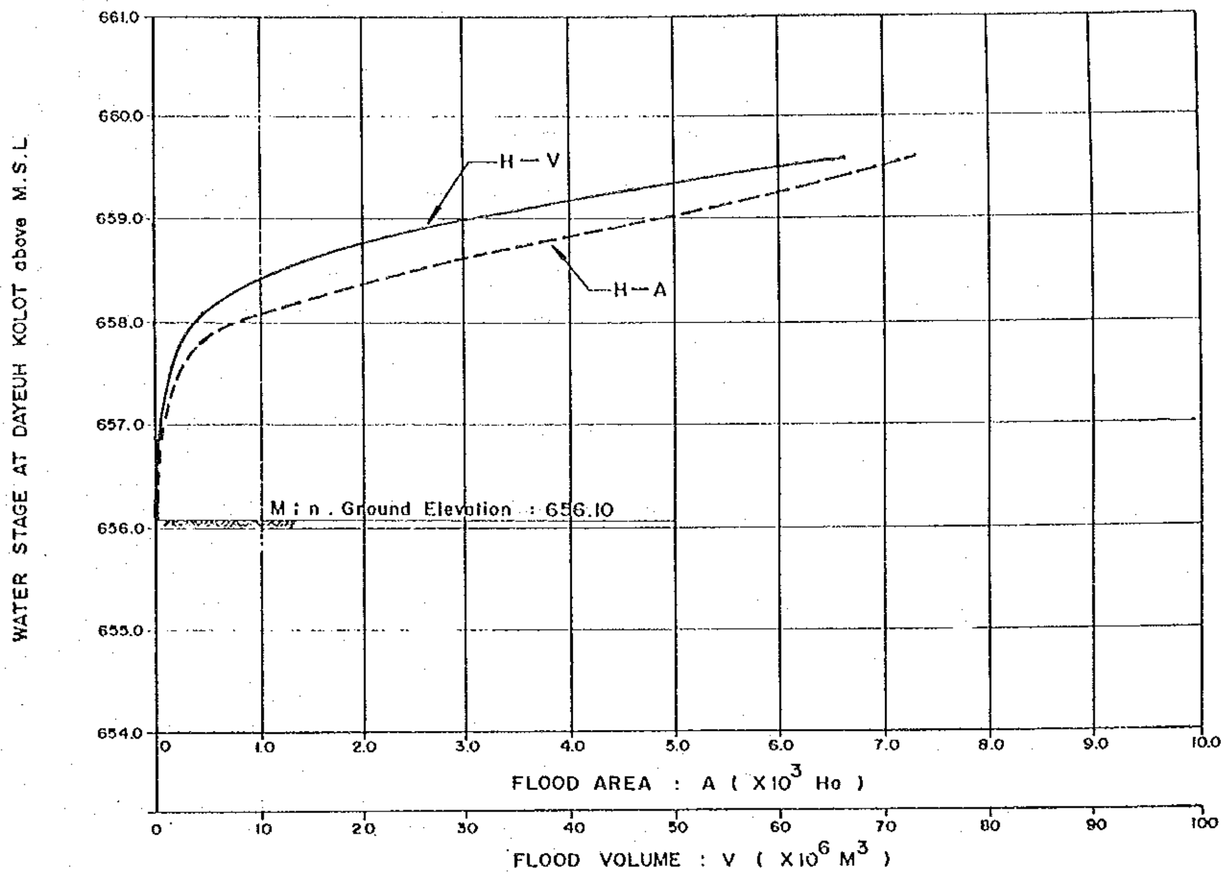
0 1 2 3 4 5 KM

NOTE : FLOOD DEPTHS ARE VALUES ON PADDY FIELD

FIG. G.11 FLOOD DEPTH CONTOUR MAP OF 1986 FLOOD

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

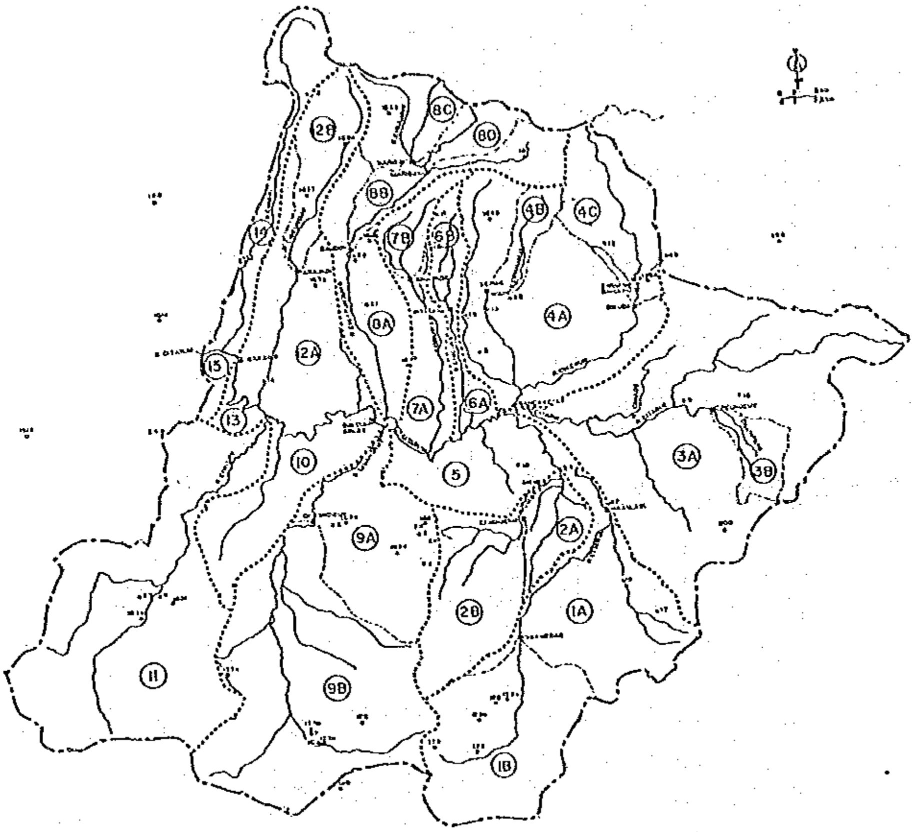
JICA



WATER STAGE (m)	FLOOD AREA A (x 10^3 ha)	FLOOD VOLUME (x 10^6 ha)
656.1	0	0
657.1	0.098	0.49
657.6	0.244	1.34
658.1	1.017	4.50
658.6	2.871	14.22
659.1	5.355	34.78
659.8	7.249	66.29

FIG. G.12 FLOOD WATER STAGE AT DAYEUH KOLOT - FLOOD AREA AND FLOOD WATER STORAGE VOLUME CURVE

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN



Name of Drainage basion	Area (km2)
1. Citarum	197.0
2. Cirasea	93.1
3. Citarik	281.4
4. Cikeruh	204.6
5. Kopo	53.7
6. Cibodas	29.7
7. Cidurian	51.8
8. Cikapundung	144.3
9. Cisangkuy	276.5
Dayeuh Kolot	1332.1
10. Cijalupang	60.1
11. Ciwidey	200.6
12. Cibeureum	117.2
13. The basin of the rest	6.0
Nanjung	1718.0
14. Cimahi	48.0
15. The basin of the rest	6.0
Curug Jompong	1771.0

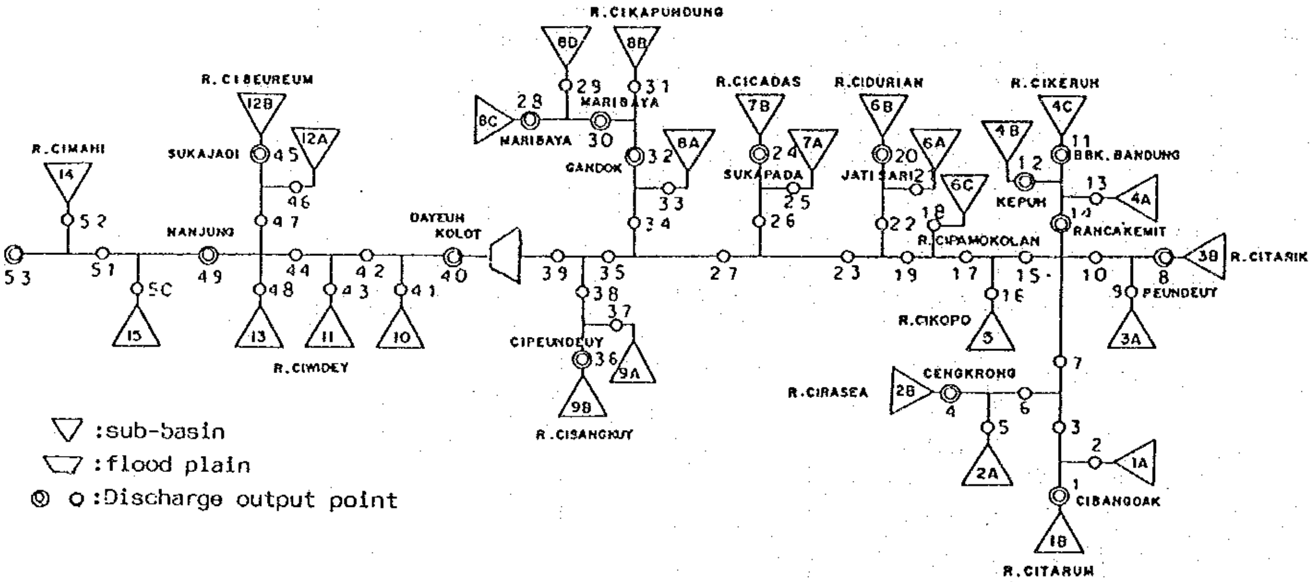


FIG. G.13 FLOOD RUN-OFF SIMULATION MODEL

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

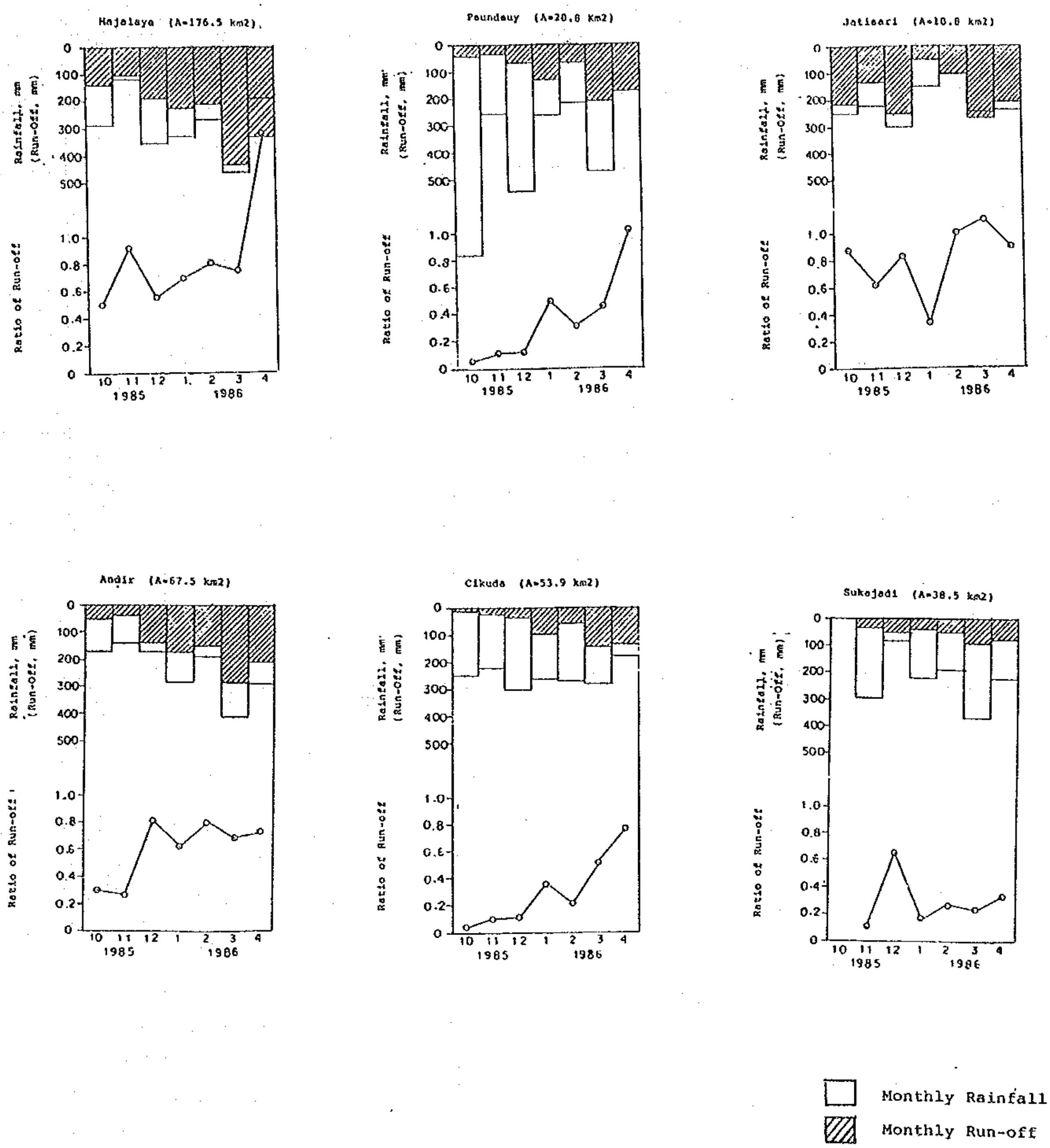


FIG. G.14 MONTHLY RUN-OFF CO-EFFICIENTS (1986 FLOOD, TRIBUTARIES)

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

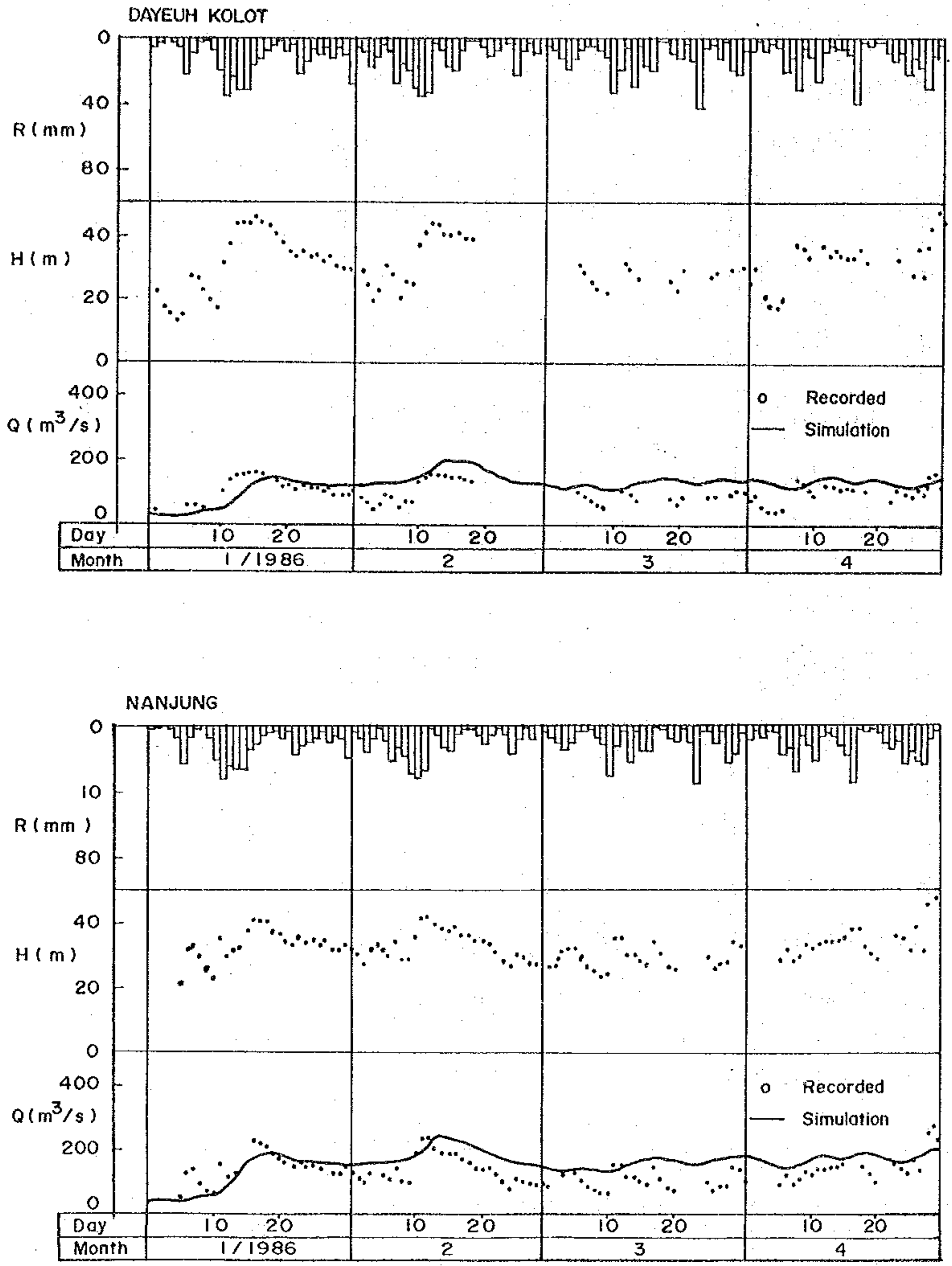
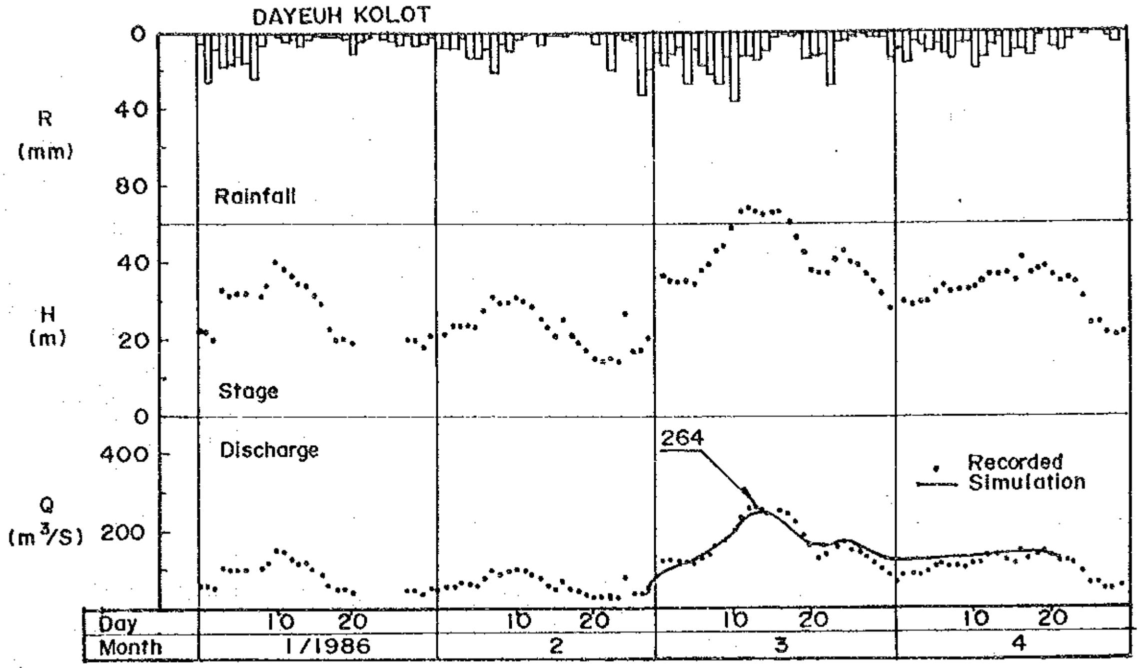


FIG. G.15	RUN-OFF SIMULATION OF 1984 FLOOD (DAILY COMPUTATION)

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN



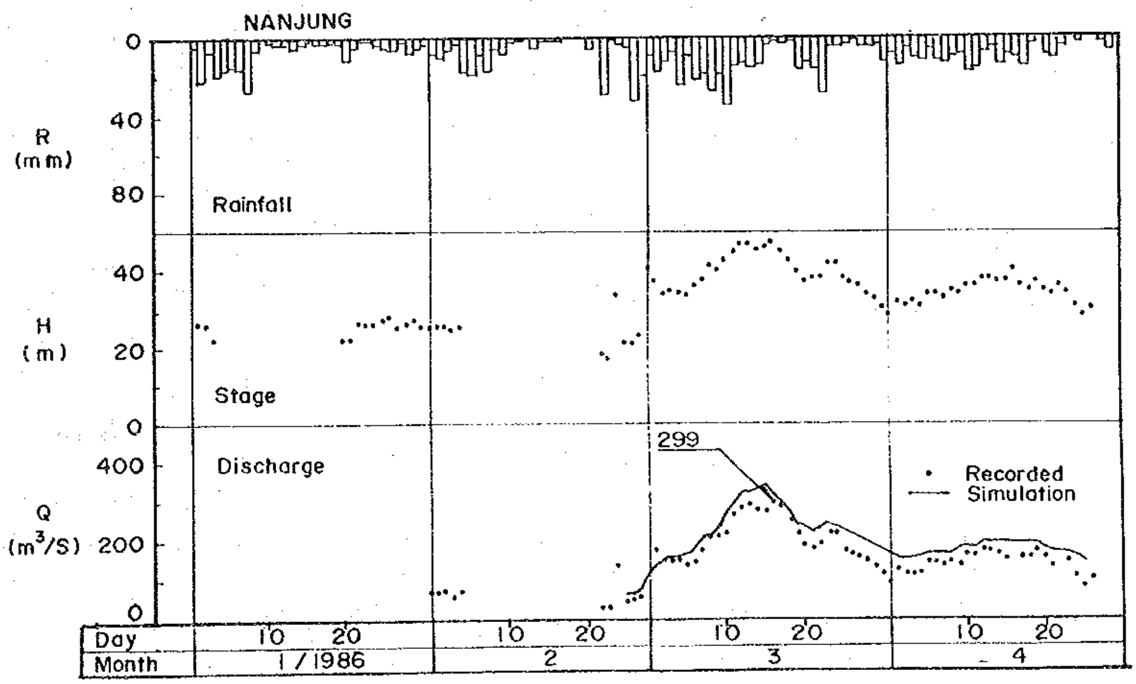
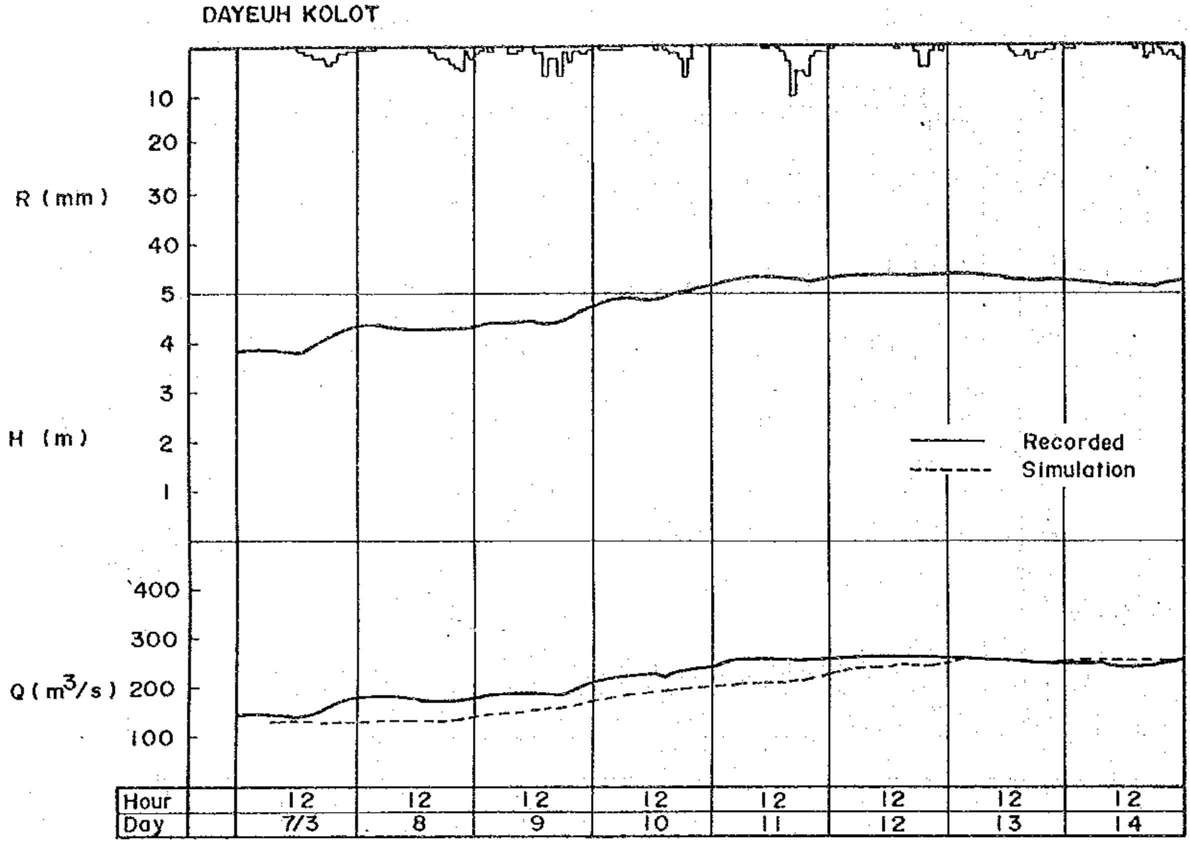


FIG. G.16 RUN/OFF SIMULATION OF MARCH 1986 FLOOD (DAILY COMPUTATION)

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN



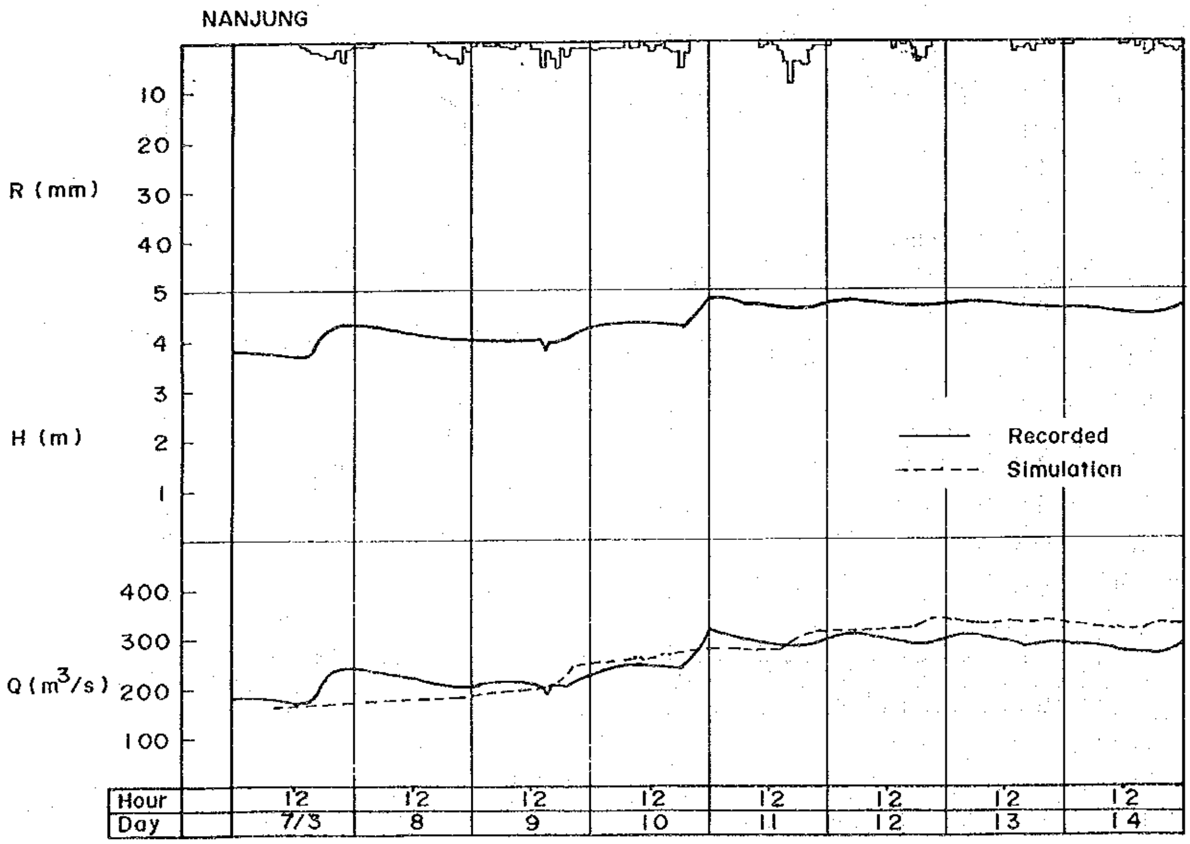


FIG. G.17 RUN-OFF SIMULATION OF 1986 FLOOD (HOURLY COMPUTATION)

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

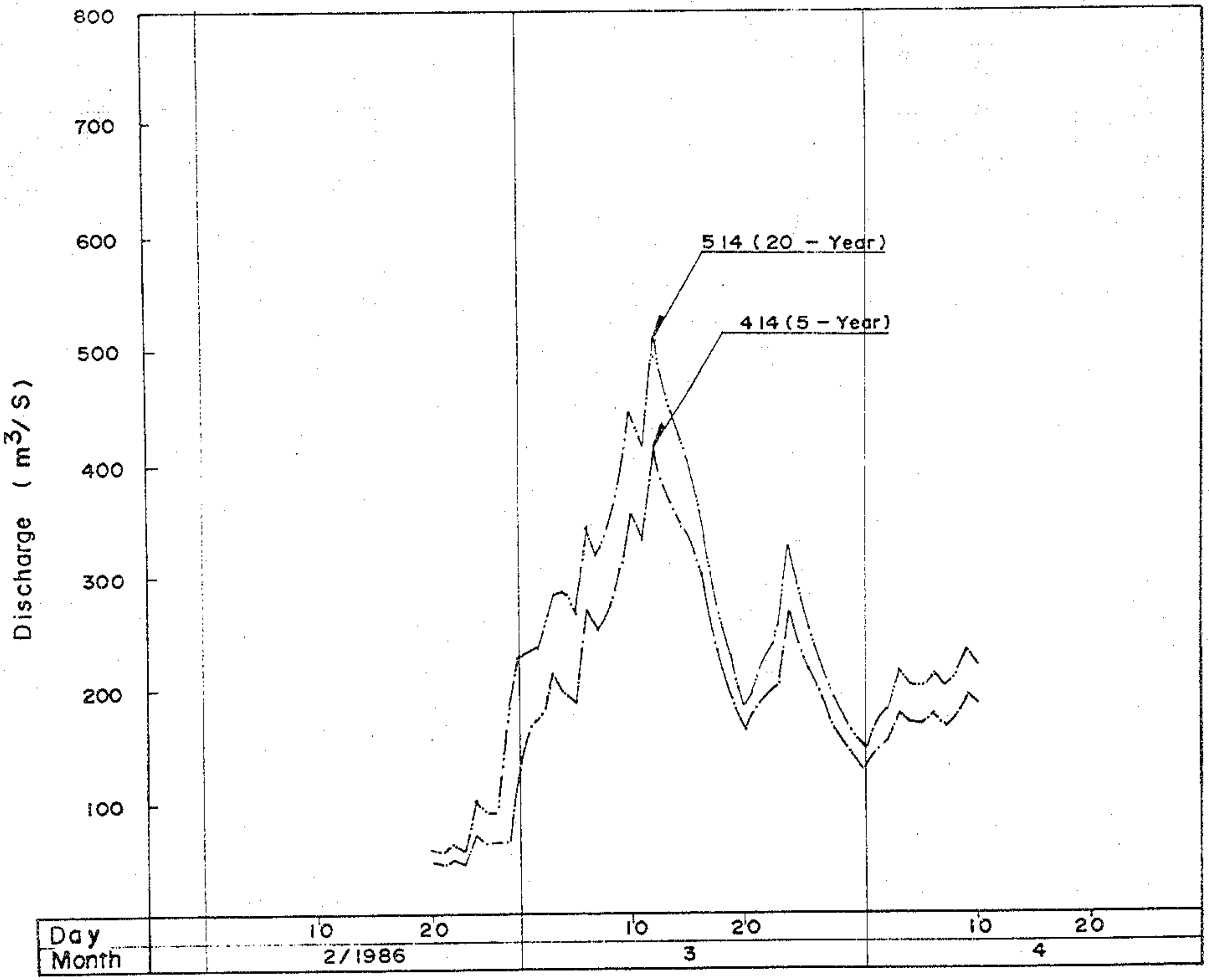
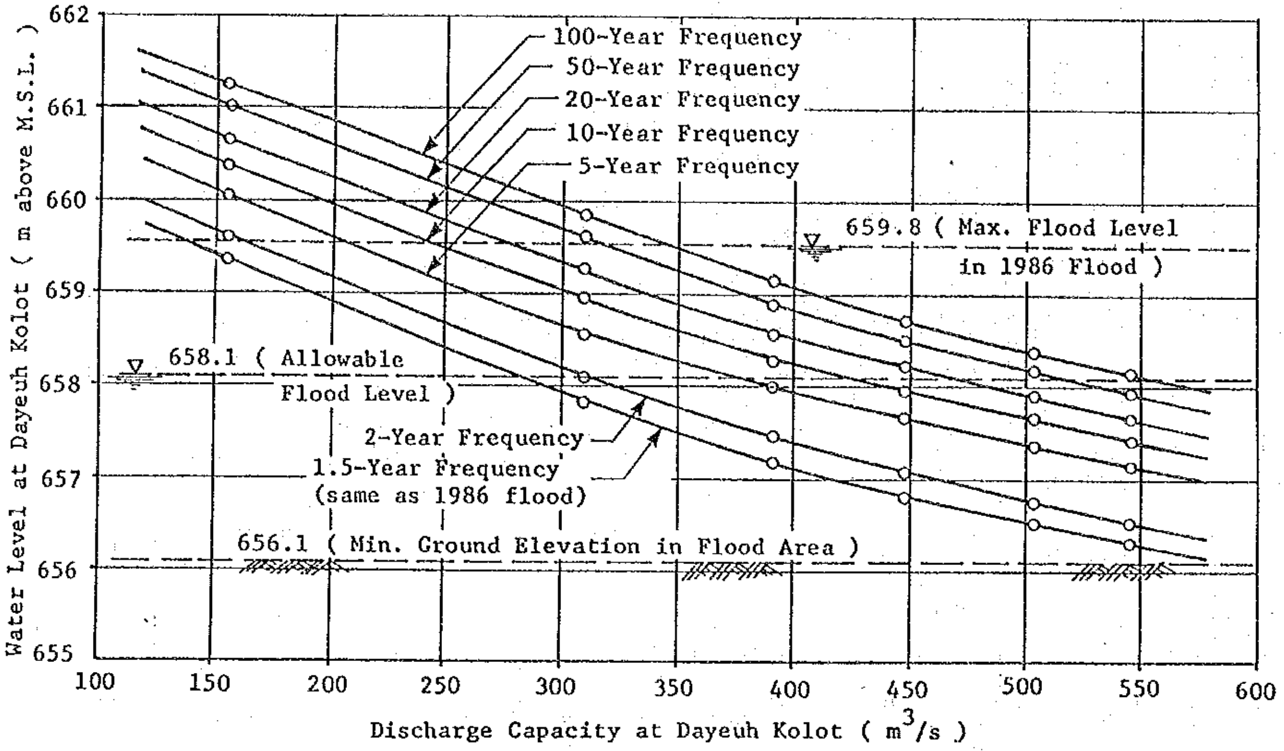
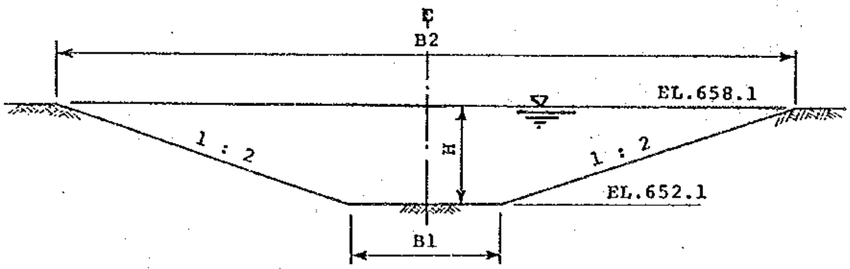


FIG. G.18 BASIC DESIGN DISCHARGE HYDROGRAPH (DAYEUH KOLOT)

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN



RELATION BETWEEN FLOOD WATER LEVEL AND DISCHARGE CAPACITY AT DAYEUH KOLOT



Hydraulic Cross Section at Dayeuh Kolot

Improvement Plan	B1 (m)	B2 (m)	H (m)	Expected Discharge Cap. (m^3/s)	Corresponding Frequency
Case 1	Existing Cross Section			160	Frequent
Case 2	30.5	54.5	6.0	310	2-Year
Case 3	40.0	64.0	6.0	390	5-Year
Case 4	47.0	71.0	6.0	450	10-Year
Case 5	53.0	77.0	6.0	505	20-Year
Case 6	56.5	80.5	6.0	540	50-Year

FIG. G.19 HYDRAULIC EFFECTS OF RIVER IMPROVEMENT

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

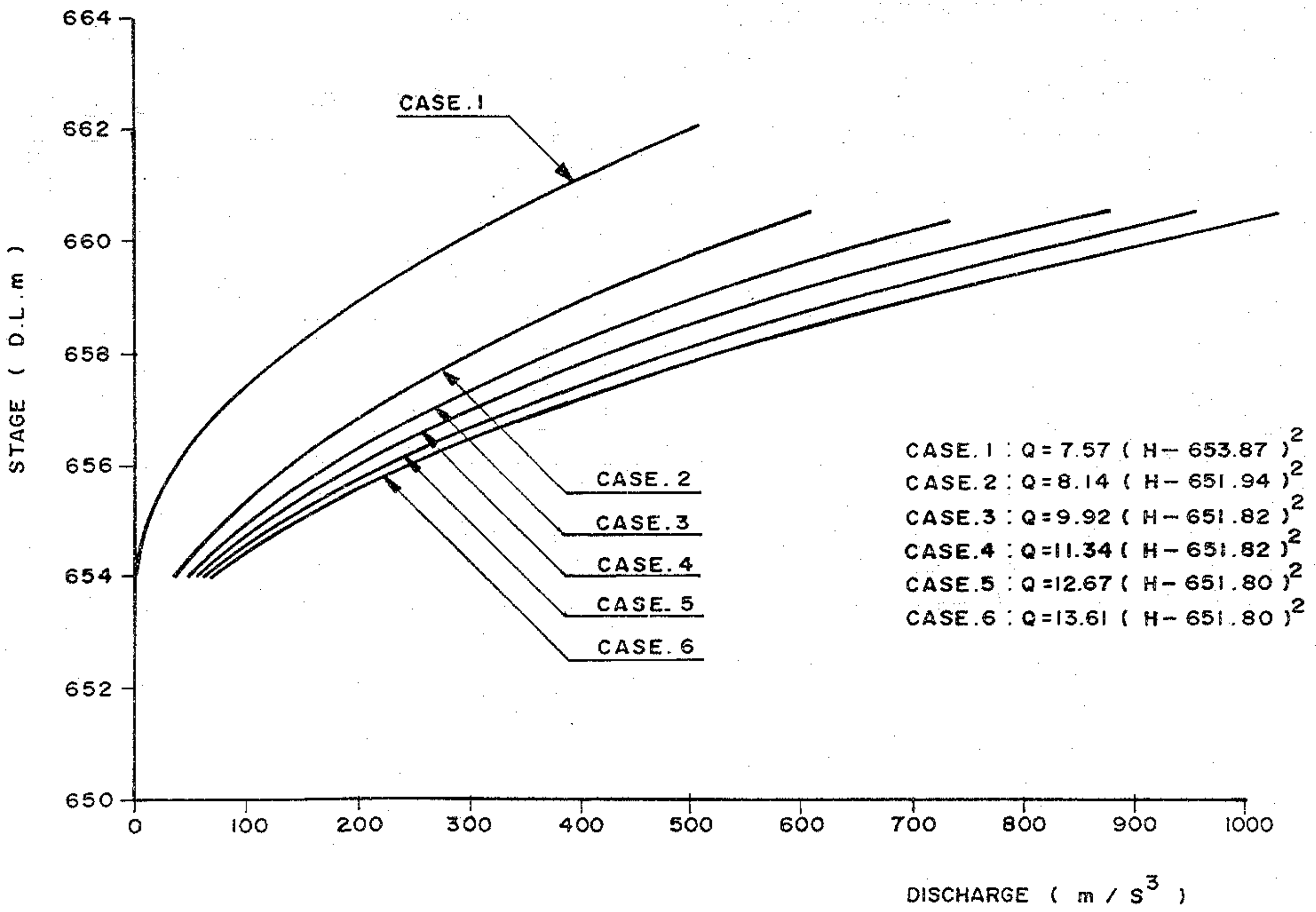
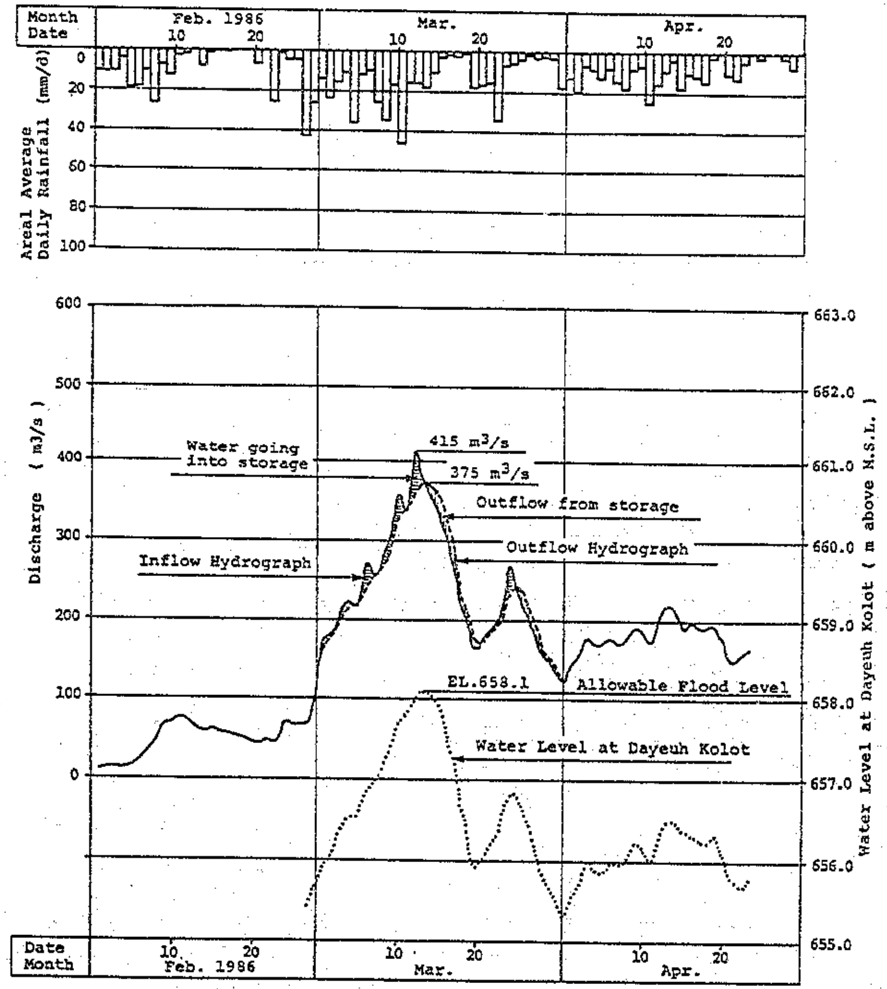


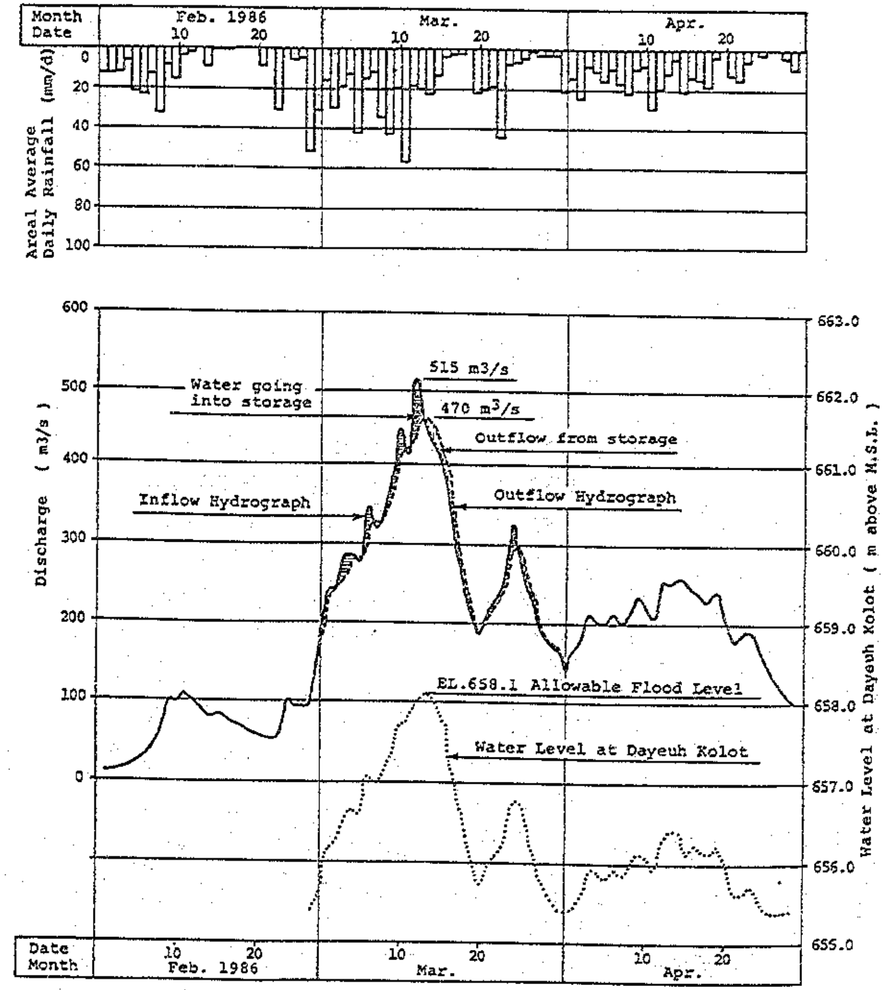
FIG. G.20 STAGE - DISCHARGE CURVE AT DAYEUH KOLOT

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

JICA



5-Year Frequency



20-Year Frequency

FIG. G.21	DESIGN DISCHARGE HYDROGRAPH (DAYEUH KOLOT)

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

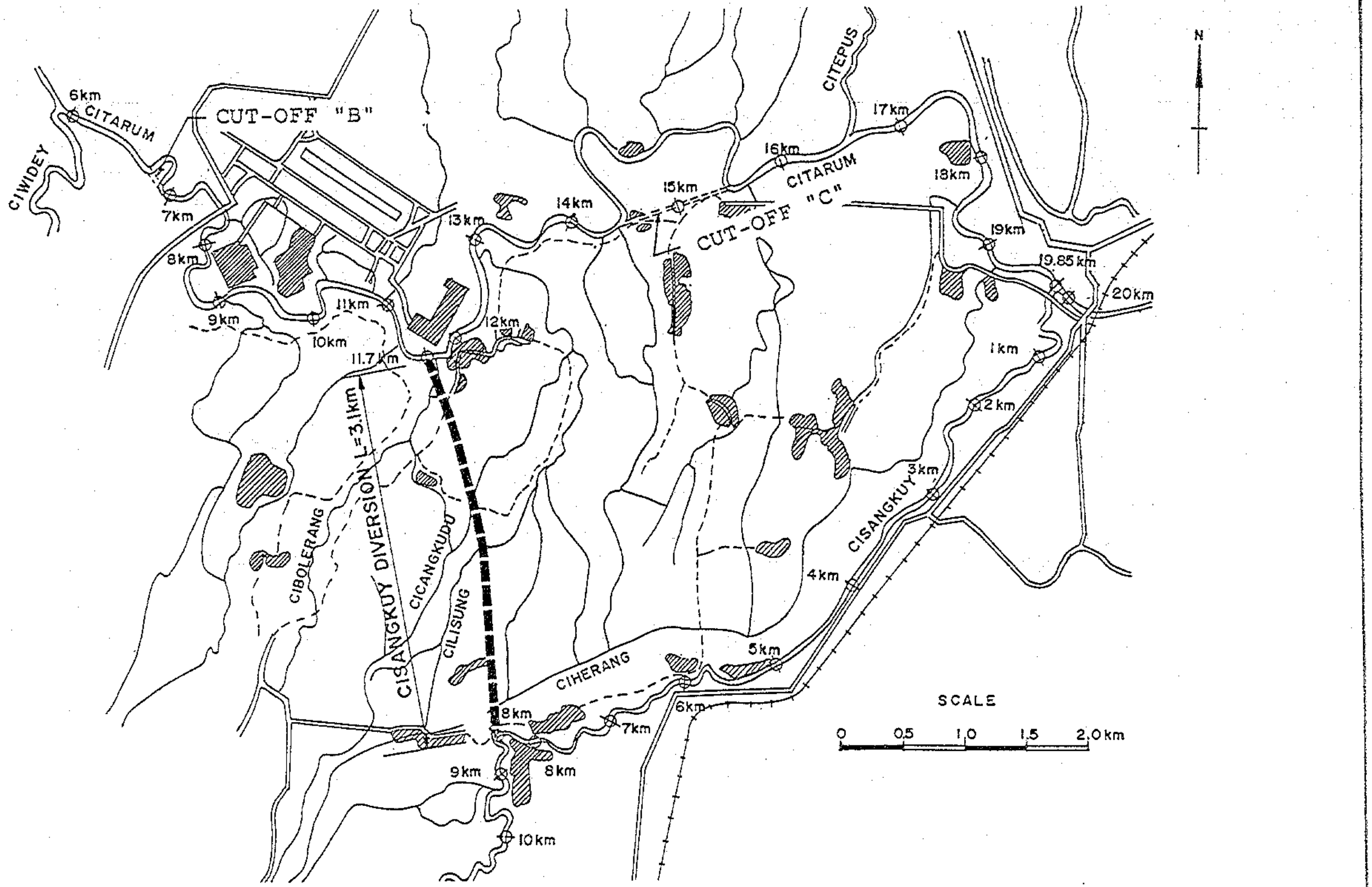


FIG. G.22	LOCATION OF PROPOSED CISANGKUY DIVERSION

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

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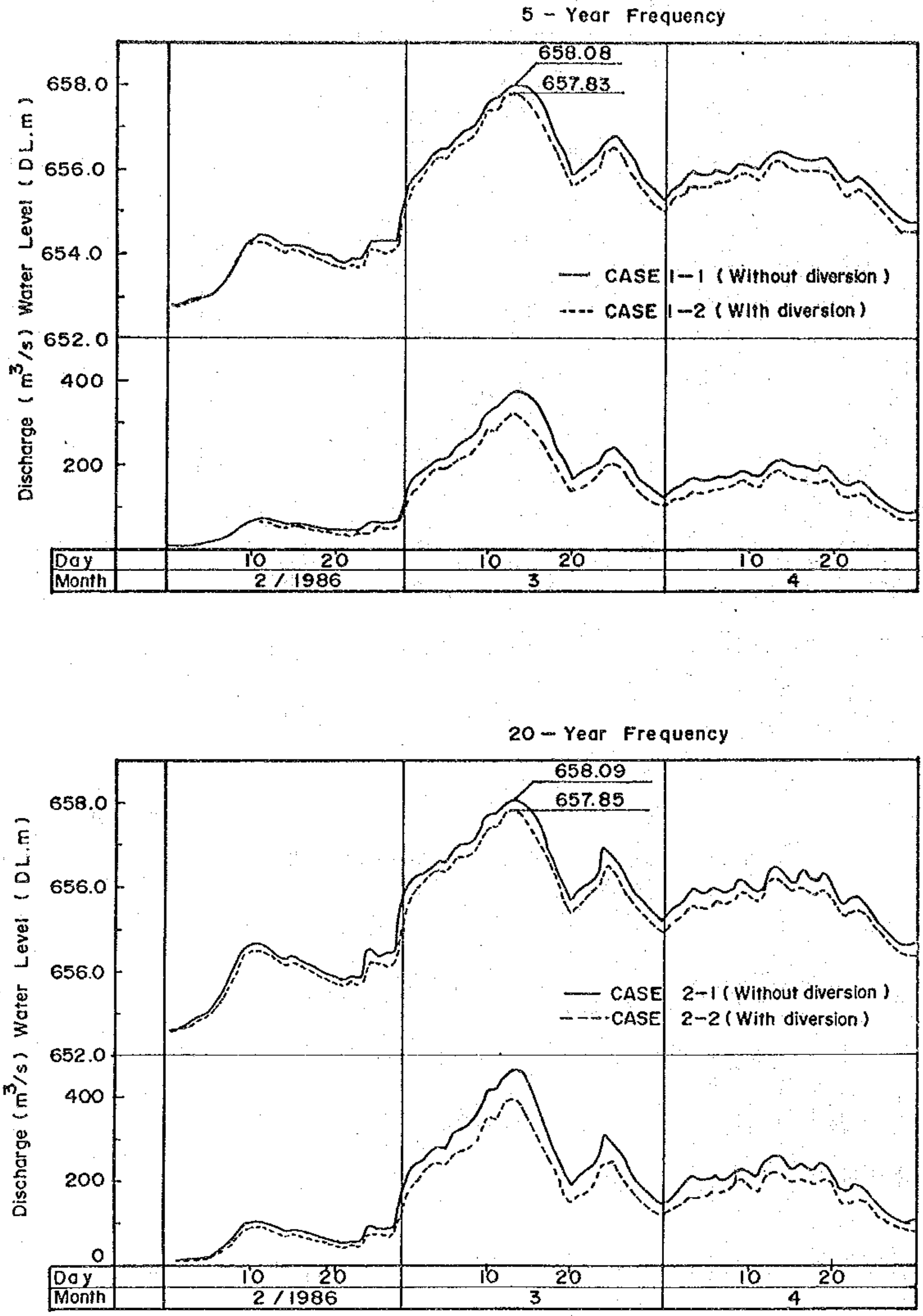

FIG. G.23	HYDROGRAPH AT DAYEUH KOLOT WITH AND WITHOUT CISANGKUY DIVERSION

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

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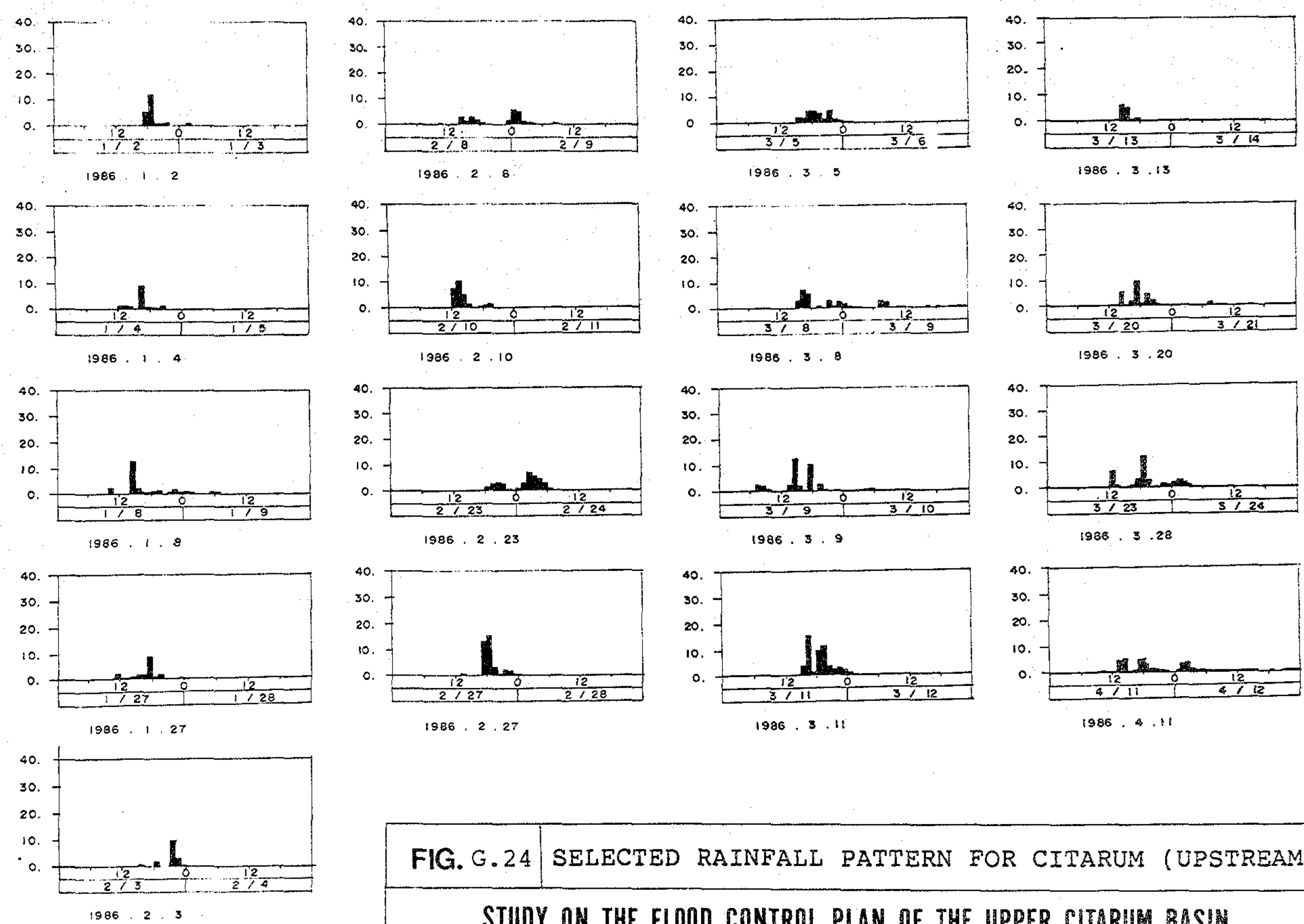

FIG. G.24 SELECTED RAINFALL PATTERN FOR CITARUM (UPSTREAM)

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

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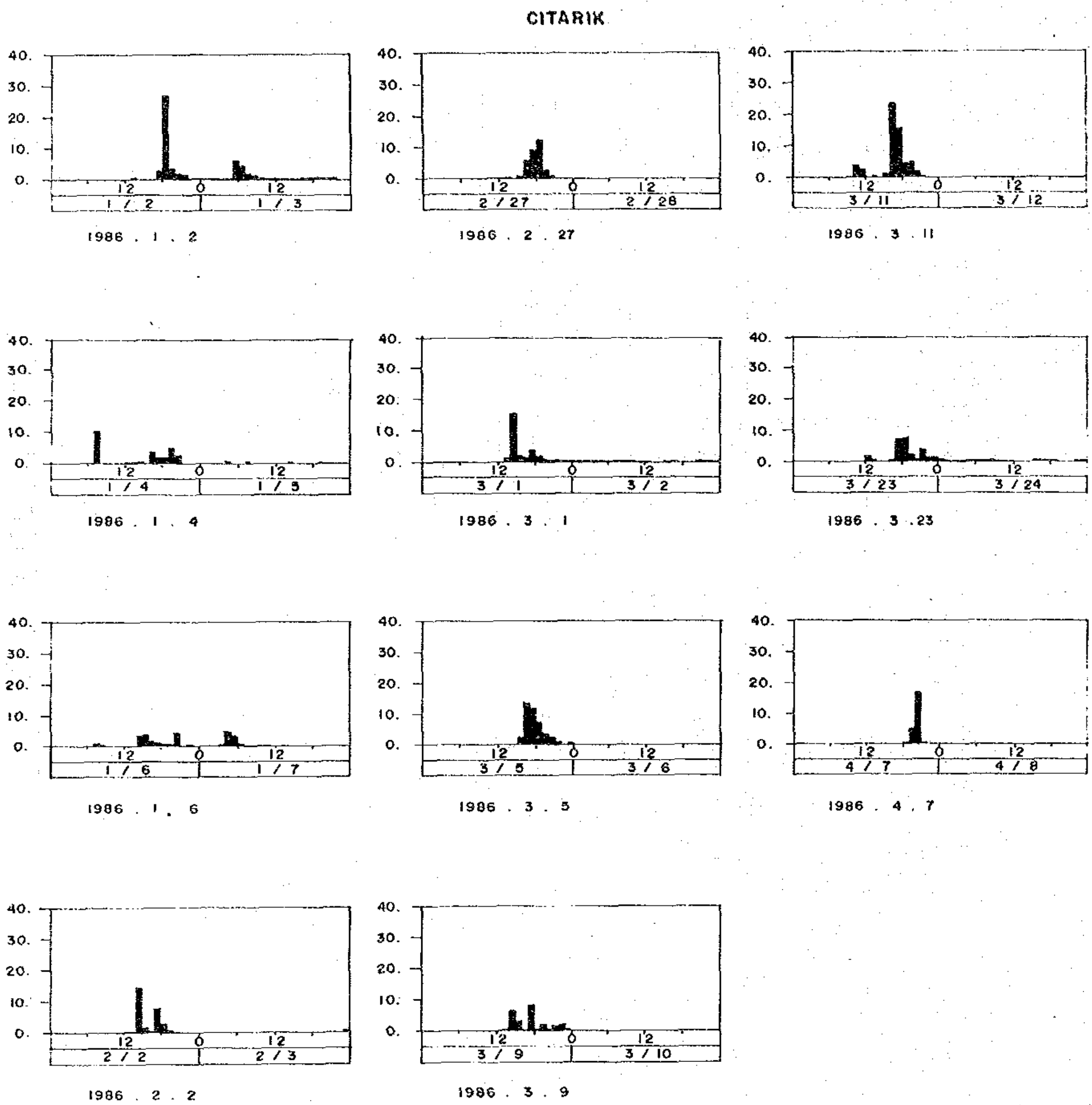

FIG. G.25 SELECTED RAINFALL PATTERN FOR CITARIK

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

CIKERUH

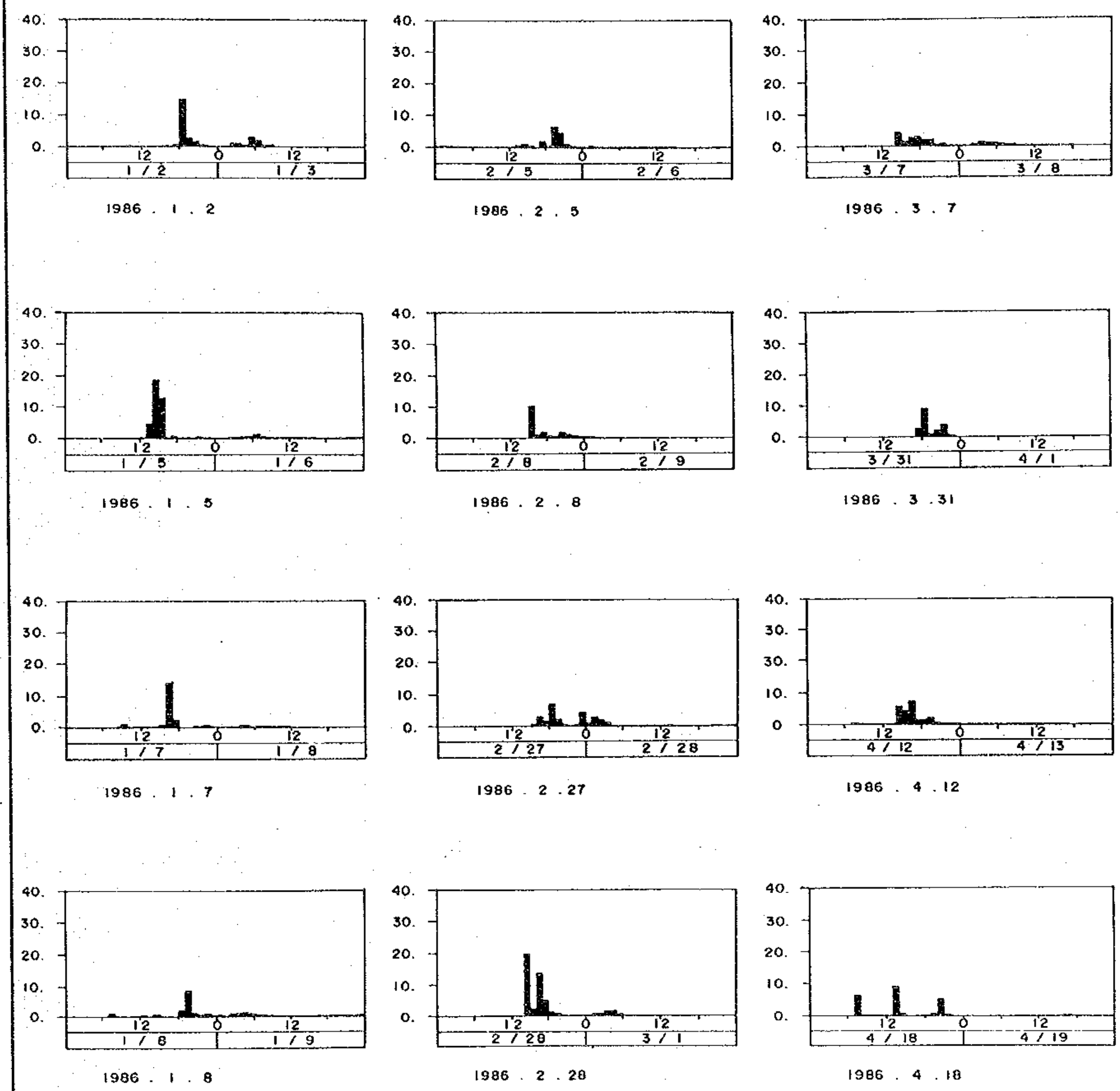

FIG. G.26 SELECTED RAINFALL PATTERN FOR CIKERUH

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

CISANGKUY

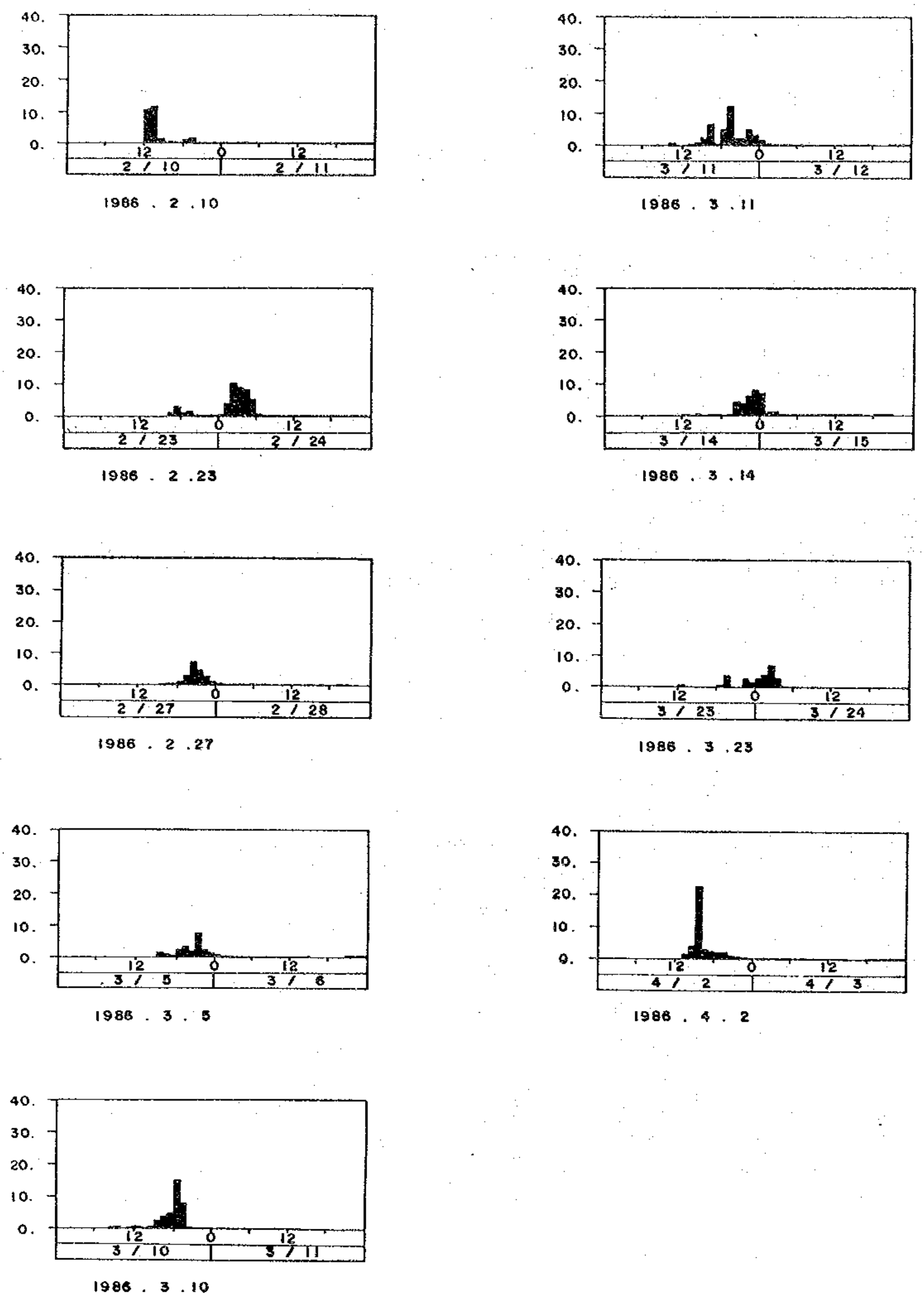

FIG. G.27 SELECTED RAINFALL PATTERN FOR CISANGKUY

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

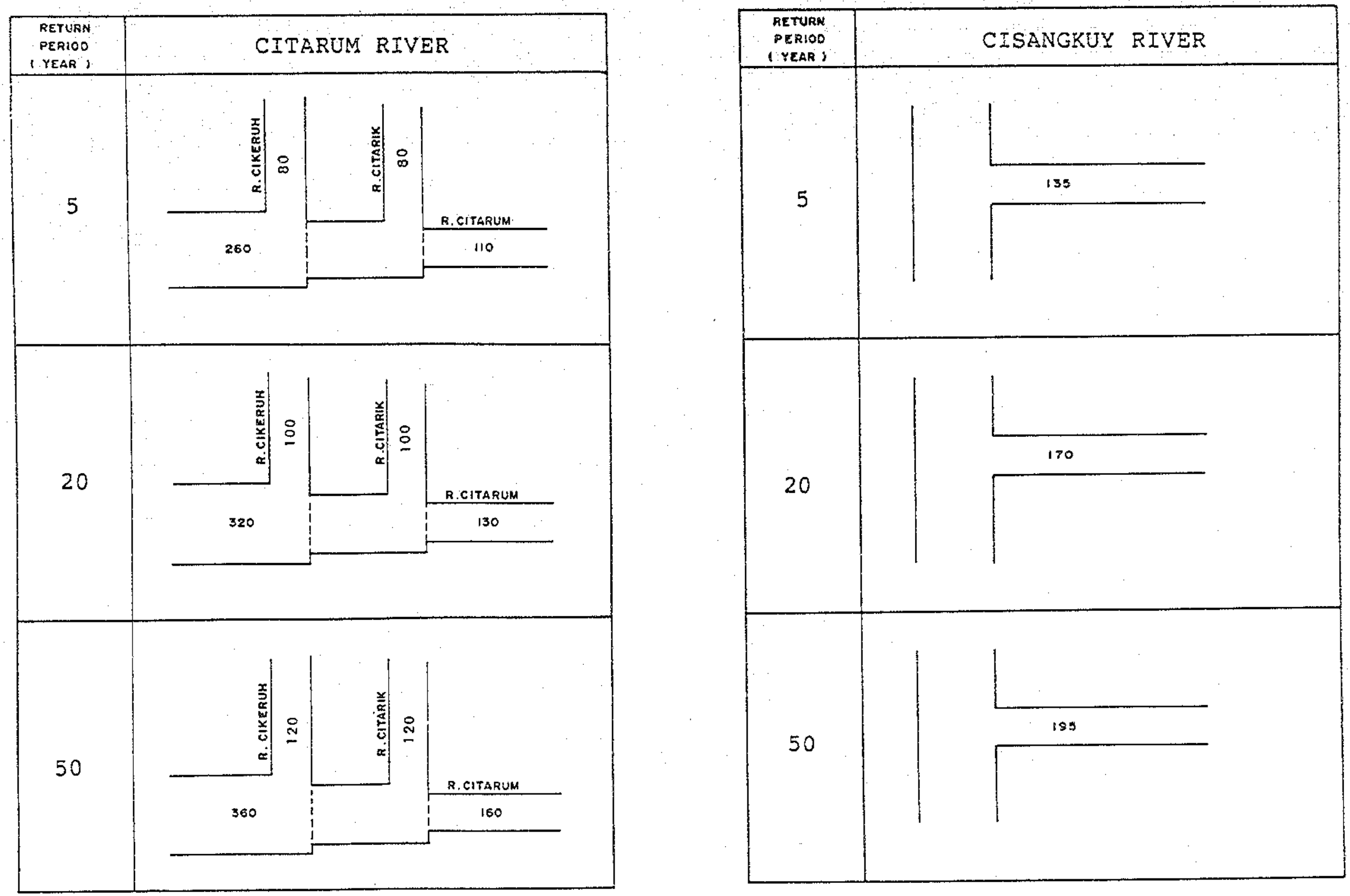

FIG. G.28 DESIGN DISCHARGE DISTRIBUTION OF TRIBUTARIES (1)

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

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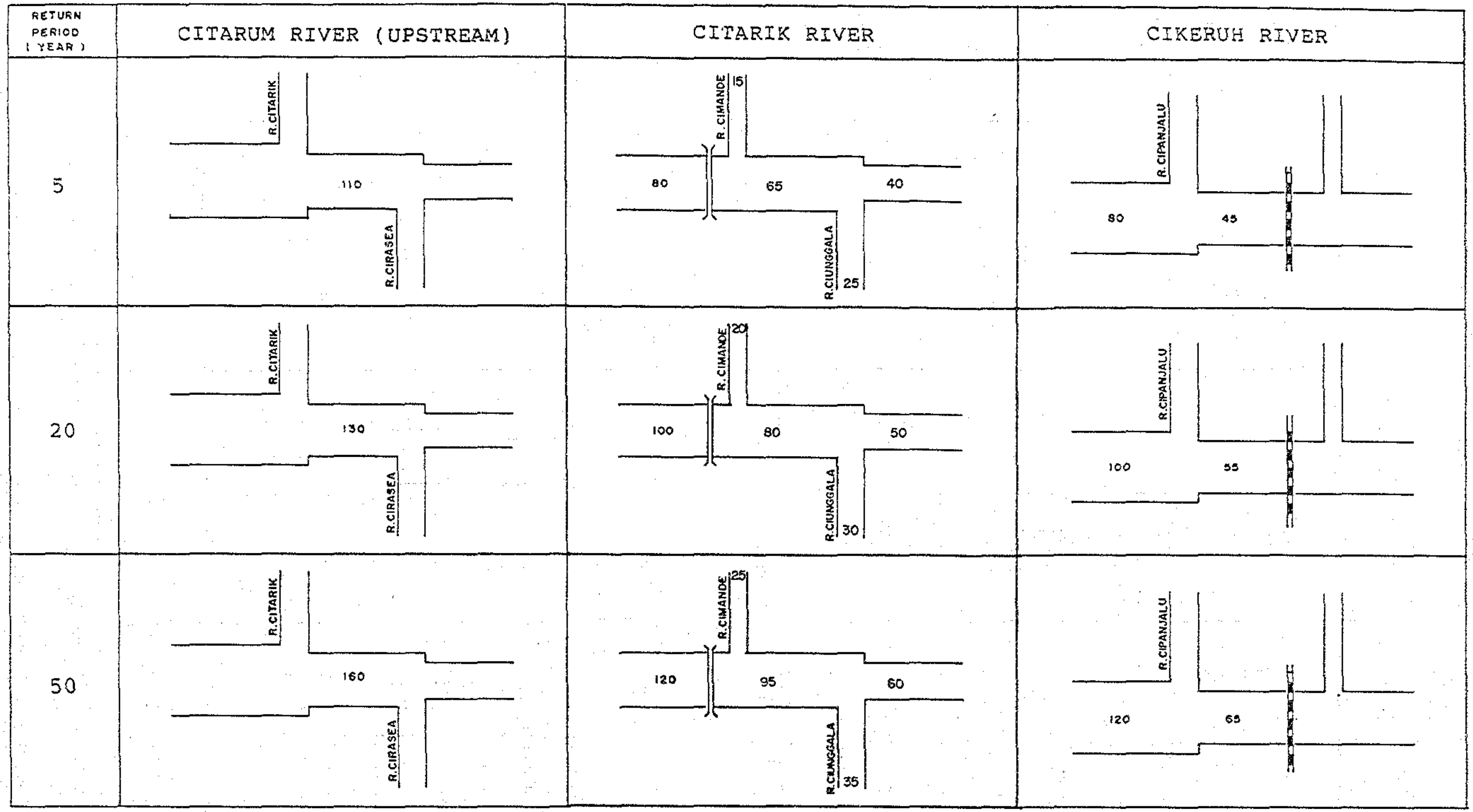

FIG. G.29 DESIGN DISCHARGE DISTRIBUTION OF TRIBUTARIES (2)

STUDY ON THE FLOOD CONTROL PLAN OF THE UPPER CITARUM BASIN

SUPPORTING REPORT H

OVERALL FLOOD CONTROL PLAN

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LIST OF FIGURES

SUPPORTING REPORT H
OVERALL FLOOD CONTROL PLAN

1. Target Flood Area

Flood control measures in the Study Area will be provided to mitigate the flood problems existing in the following flood prone areas as shown in Fig. H.1.

- Citarum River flood area:
  This is the flood areas of the Citarum River and its related tributaries, Citarik, Cikeruh and Cisangkuy, with a potential flood area of 7,249 ha.

- Flood area in Bandung Urban Area:
  This is the flood areas of the tributaries flowing through Bandung Urban Area with a potential flood area of 971 ha.

For the flood area in Bandung Urban Area, the flood control project consisting of the improvements of the related tributaries is on-going by the Government of Indonesia. The tributaries included in the project are the Cipamokolan, Cidurian, Ciwastra, Cicadas, Cikapundung Kolot, Cipalasari and Citepus Rivers. The improvements of most of the above tributaries are planned to carry the design floods with a 20-year frequency for the projected land-use conditions in 2005. Even the discharge capacity of the remaining tributaries can be increased to carry 20-year design floods only by dredging within the proposed river widths (Refer to Supporting Report F). The proposed project is considered to meet the long-term requirement of flood control for Bandung Urban Area.

In this Study, the overall flood control plan is prepared to meet the projected socio-economic conditions in the year 2005, however, only for the Citarum River flood area, based on the above considerations.

2. Flood Control Measures

An integrated approach of structural and non-structural flood control measures is required to attain a satisfactory solution of the flood problems in the flood areas of the Citarum River and related tributaries. Since the non-structural flood control measures is effective only with a proper land-use regulation and guidance, both flood control and land-use plans of the Basin shall be well coordinated.
Conceivable structural and non-structural measures are as follows.

- Flood control dam
- Retarding basin
- River improvement
- Watershed management
- Flood plain management

(1) Flood Control Dam

Possible dam sites are limited to the upstream of the tributaries, and are also with a low storage volume and a small catchment area. Potential dams have been studied by Bina Program (1986), Bandung Water Supply Project (1987) and the West Java Province Public Work Service (1985).

In these studies, it is concluded that there are some potential dams for water use but not for flood control, because their low storage capacity is too small compared to the magnitude of flood.

Locations and main features of the potential dams are shown in Fig. H.2.

Flood control by dam is not proposed in this Study.

(2) Retarding Basin

To attain an effective flood control of the Citarum River, retarding basin with a large area is required. No suitable retarding basin sites are available since the flood prone areas are all highly developed with paddy cultivation and residential uses.

Flood control by retarding basin is not proposed in this Study.

(3) Watershed Management

Erosion control in the watersheds is essentially required to maintain the downstream river course as planned. Erosion control works of the critical areas are being carried out in accordance with the plans proposed by the Ministry of Forestry. The proposed erosion control works include:

1) Terrace formation of dry fields
2) Small dams for sediment storage
3) Drainage channel
4) Storm water infiltration works.

(Refer to Supporting Report F)

From the above considerations of (1) ~ (3), the flood control measures consisting of river improvements and flood plain management are only considered as the viable alternatives for the overall flood control plan of the Citarum River.

The project components constituting the overall flood control plan of the Upper Citarum Basin are shown in Fig. H.3.

3. Alternative Study of Long-Term River Improvement Plan

3.1 Alternative Scheme of River Improvement Method

Two (2) basic methods are conceivable for the improvement of the Citarum River, namely dredging method and dyke method.

The dredging works will be conducted for the Citarum Main River and major tributaries to lower the flood water level down to the allowable level. The planned stretches of dredging are:

- Citarum Main River : 40.2 km (Curug Jompong-Sapan)

- Major Tributaries : 31.5 km (Citarum upstream, Citarik, Cikeruh and Cisangkuy Rivers)

Location of the river dredging reaches is shown in Fig. H.4.

The dyke construction will be carried out not only for the Citarum Main River and major tributaries but also for the small tributaries joining the Citarum Main River to confine flood waters within the dykes. The dyke method will require additional pump drainage of the inner water of the areas surrounded by the constructed dykes.

The planned stretches of dyke construction and areas of pump drainage are:

- Citarum Main River : 16.8 km (Dayeuh Kolot-Sapan)

- Major Tributaries : 45 km (Citarum upstream, Citarik, Cikeruh and Cisangkuy Rivers)

- Small Tributaries : 63.9 km

- Pump Drainage Area : 137 km^2

Location of the dyke construction reaches and pump drainage areas is shown in Fig. H.4.

Estimated costs of both alternative methods, shown in Table H.1, are summarized below. In this estimates, the design flood frequency for the river improvements is assumed to be 20 years.

Dredging method = Rp. 118.7 billion
Dyke method = Rp. 210.0 billion

Dredging method is more economical and recommended.

3.2 Alternative Scheme of Design Flood Frequency

The design flood frequency of long-term flood control plan in Indonesia is 20 to 50 years in general as shown in Table H.2. In this Section, the following two (2) alternative river improvement plans are discussed.

Alternative Scheme of Design Flood Frequency

Name of River	Improvement Stretch (km)	Alternative I (20-year plan)	Alternative II (50-year plan)
Citarum (main)	40.2	20-year	50-year
Citarum (upstream)	6.0	20-year	20-year
Citarik	15.0	20-year	20-year
Cikeruh	2.0	20-year	20-year
Cisangkuy	8.5	20-year	20-year

(2) Design Discharge Distribution

The design discharge distributions for the two (2) alternative plans are shown in Fig. H.5.

(3) Design River Profile and Cross Section

The design river profiles of both alternative plans are as follows:

Citarum River (main stream)	:	1/5,500 (0.00018)
Citarum River (upstream)	:	1/3,600 (0.00028)
Citarik River	:	1/4,500-1/1,100 (0.00022 - 0.00091)
Cikeruh River	:	1/4,500 (0.00022)
Cisangkuy River	:	1/2,800 (0.00036)

The design river cross sections of the two (2) alternative plans are shown in Fig. H.6.

(4) Construction Works and Costs

The required construction works and costs of the two (2) alternative plans are shown in Table H.3 and Table H.4.

(5) Flood Damage Reduction and Economic Internal Rate of Return (EIRR)

Reduction of average annual flood damage and EIRR by the two (2) alternative plans are estimated as follows:

Item	Annual Flood Damage (Million ERp.)	Reduction (Million Rp.)	Reduction Rate (%)	EIRR (%)
Without Project	16,136	-	-	-
Alternative I	130	16,006	99.2	11.6
Alternative II	88	16,047	99.5	10.2

Note : 1. ERp shows economic price in Rupiah.
2. Breakdown of economic evaluation is shown in Table H.5.

(6) Conclusion

A design flood frequency of 20-year is applied for the long-term river improvement plan based on the following facts and considerations.

1) The design flood frequency of 40 to 50-year is applied for the long-term flood control plan of the important rivers in Indonesia in general. Those rivers are all planned by dyking system. While, a design flood of lower safety level can be applied for the flood control plan by dredging system than that by dyking system in consideration of the difference of flood damages caused by overflow floods of the rivers with dykes and without dykes.

2) The river improvement of 20-year frequency flood can drain a 50-year frequency flood with a small flood depth of 0.3 m above ground level at Dayeuh Kolot (See Fig. G.19 of Supporting Report G).

3) The 50-year plan increases the construction cost to a large extent than the 20-year plan. While, it produces a small additional benefit.

3.3 Alternative Scheme of Cisangkuy Diversion

3.3.1 General

The Ministry of Public Works has carried out the preliminary study on the Cisangkuy Diversion Plan, as a link in the chain of the mid-term plan for the Citarum River flood control program. The study consists of a hydrological and hydraulic study, alternative study of its diversion routes and their topographic survey.

The feasibility of the Cisangkuy diversion plan is, however, not yet concluded. The Study Team has carried out the feasibility study on the Cisangkuy diversion plan by the request of the Indonesian government.

3.3.2 Outline of the Plan

(1) Objectives of the Plan

The Cisangkuy diversion plan is prepared for the following three objectives:

1) To reduce flood damages occurring in the Citarum upstream area of Dayeuh Kolot. It is roughly estimated that 20 percent of the flood damages is caused by the Cisangkuy flood water, considering that the drainage area of the Cisangkuy River occupies approximately 20% of the total drainage area at Dayeuh Kolot.

2) To divert flood waters of the Cisangkuy upstream area to the Margahayu site of the Citarum River, in order to supplement the existing poor discharge capacity between Margahayu and Dayeuh Kolot of the Citarum River.

3) To mitigate the flood damage occurring frequently along the Cisangkuy downstream reaches.

(2) Diversion Route

The proposed diversion route is illustrated in Fig. H.7.

- Intake site : 8.5 km upstream of the Cisangkuy River
- Outlet site : 11.7 km upstream from the Curug Jompong of the Citarum River
- Diversion length : Approximately 3.1 km

(3) Effect of Diversion

The diversion would make it unnecessary the improvement of the existing Cisangkuy River course and would reduce the requirement of river enlargement for the reaches between Margahayu and Dayeuh Kolot of the Citarum River.

3.3.3 Comparison of With and Without Project Alternaties

The following two (2) alternative plans are compared.

Alternative I (Without Diversion)	:	Existing Cisangkuy River improvement and large scale improvement of the Citarum River
Alternative II (With Diversion)	:	Diversion construction and small scale improvement of Citarum River

(1) Design Discharge

Based on the flood run-off calculations presented in Supporting Report G, the design discharge distributions with a 20-year frequency of the two (2) alternative plans are proposed as shown in Table H.6 and Fig. H.8.

(2) River Profile and Cross Section

The proposed river profiles and cross sections of two (2) alternative plans are shown in Table H.7 and Fig. H.8 and Fig. H.9. Main features of the improvement plans are determined based on the hydraulic characteristics of the existing rivers, topographic conditions of the diversion route and the scale of the proposed design discharges.

The location of the proposed major structures to be constructed in the Cisangkuy River and Cisangkuy Diversion are illustrated in Fig. H.10.

(3) Required Construction Works and Costs

The required construction works and costs of the two (2) alternative plans are shown in Table H.8.

(4) Conclusion

The Cisangkuy Diversion is not recommended for the following reasons.

1) Alternative II requires a higher construction cost than Alternative I.

2) The diversion channel splits the communities and would affect the traffic and agricultural activities of residents.

3) The diversion project can produce no beneficial effects until its completion. On the contrary, the improvement of the existing river course can yield beneficial effects in accordance with its progress.

3.4 Alternative Scheme of Design Flood Water Level

The lowest ground elevation of the flood area is EL. 656.1 m. Dayeuh Kolot is located at an level of EL. 658.1 m.

The inundation area and flood prone houses existing between EL. 656.1 m and EL. 658.1 m are estimated to be approximately 1,000 ha and 2,700 houses (10% of the potential flood prone houses of 27,310). They increase at a high rate when the flood water level rises above EL.

658.1 m. On the other hand, they decrease rapidly when the flood water level lowers down to an EL. 657.6 m as shown in Fig. H.11.

From the above facts, the design flood water level of the Citarum River at Dayeuh Kolot is decided to be at an elevation between EL. 658.1 m and EL. 657.6 m.

Lowering of the design flood water level increases the required river dredging cost although it will reduce flood damages. The following two (2) alternatives are compared to obtain the optimum design flood water level.

Item	Alt. I	Alt. II	Difference
Design Flood Frequency	1/20	1/20	-
Design Flood Water Level (EL. m)	658.1	657.6	0.5
Required Const. Cost (Million Rp.)	118,996	138,824	19,826
Annual Flood Damage Reduction (Million ERp.)	16,006	16,048	42

Alternative I is recommended.

The design flood water level of the Citarum River at Dayeuh Kolot is proposed to be EL. 658.1 m, allowing approximately 1,000 ha of inundation and 2,700 houses unrelieved from floods in the low-lying parts of the flood plain.

4. Proposed Long-Term River Improvement Plan (Structural Measure)

4.1 Planning Policy and Design Criteria

The long-term river improvement is planned and designed in accordance with the following policy and criteria.

(1) Target year is set for the year 2005. Plans are to be prepared to meet the population and land use condition projected in the year 2005.

(2) The plans are to be prepared to mitigate flood damage in the existing potential flood prone areas surveyed in this Study.

(3) As for design flood and rainfall pattern, respectively, a 20-year frequency flood and the March 1986 Storm are adopted.

(4) Allowable inundation area considered is approximately 1,000 ha.

(5) Target flood water levels determined at Dayeuh Kolot, Sapan and Rancakemit (Majalay-Rancaekek Rd.) are respectively of EL. 658.1 m, EL. 660.1 m and EL. 661.6 m, considering the ground elevation in the flood prone area and extent of allowable inundation area.

(6) The proposed river channel will be improved by dredging and no major dykes will be provided.

(7) Manning's coefficient of roughness adopted are 0.030 and 0.035, respectively, for low-water and high-water channels based on the channel conditions.

(8) A standard bank slope for the river channel will be adopted as follows:

Citarum River	:	downstream reaches from Dayeuh Kolot 1:1.5
Citarum River	:	upstream reaches from Dayeuh Kolot 1:2
Cisangkuy River	:	1:1.5
Other River	:	1:2

The river channel is designed based on the following surveys.

(1) A series of the topographic maps of 1/10,000 scale and aerial photograph of 1/10,000 scale are used for design of river channel alignments.