JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

No. 2

MINISTRY OF AGRICULTURE AND LIVESTOCK
REPUBLIC OF ELSALVADOR

THE MASTER PLAN
ON
THE JIBOA RIVER BASIN INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT
IN
THE REPUBLIC OF EL SALVADOR

FINAL REPORT
(ANNEX)

MARCH 1997

KOKUSAI KOGYO CO.,LTD.

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SUPPORTING REPORT [A]

METEOROLOGY AND HYDROLOGY

ANNEX A: METEOROLOGY AND HYDROLOGY

CONTENTS

A. METEOROLOGY AND HYDROLOGY

1. METEOROLOGY

1.1 GENERAL

Daily periodic process and the local circulation of mesoscale dominates the regional climate in the tropics area as El Salvador. Daily force due to diferential temperature influenced by topography and mesoscale circulation determinates the special distribution of cloudiness and precipitation.

Rainfall in El Salvador, shows big variation in space and wide oscillations through the time, although the annual totals of precipitation are less dispersed than monthly precipitation. The rainy season is observed from May to October, and dry season from November to April and between these, the respective transitions; the rainy activities begins in the west and north part of the country and concludes in the East. In some zones of the northern area of the country up of 2000m elevation, precipitation could occur during all year. The mean yearly rainfall in El Salvador is shown in Fig. A.1.1

The Study Area is located around 13°20'-13°45' north latitude and 88°50'-89°10' west longitude. It is in the tropical climate zone with medium rainfall.

There were 8 rainfall stations and 7 meteorological stations in and near the Study Area, of which 3 rainfall stations were in poor operating and maintenance condition and 5 meteorological stations actually exist. The location of the existing rainfall and meteorological stations are presented in Fig. A.1.2.

1.2 METEOROGICAL CONDITIONS

The Jiboa basin catchment area is 605.59 K m^2. The meteorologiacal conditions in the Study Area are described below.

1.2.1 Rainfall

The annual mean rainfall in the Jiboa basin is 1,753mm . The maximum annual rainfall of 2,440 mm occured in 1961 and the minimum annual rainfall of 1,144mm occured in 1994. In the Fig. A.1.3 is presented the isohyetal map of annual rainfall in the Study Area.

1.2.2 TEMPERATURE

The monthly mean air temperature varies from 22°C to 24°C and the maximum and minimum are 36.0°C and 10.2°C respectively. The monthy mean temperature at Ilopango station is presented in the Table A.1.1.

1.2.4 RELATIVE HUMIDITY

The montly mean relative humidity ranges from 64% to 85% of Ilopango station. The monthly mean relative humidity is presented in Table A.1.2.

1.2.5 WIND VELOCITY

The monthly wind velocity in Ilopango station is 5.8 to 10.7 Km/h.

1.3 RAINFALL ANALYSIS

1.3.1 MEAN RAINFALL

Mean annual rainfall were calculated for Ilopango, Cojutepeque and San Salvador Airport stations. The results of the calculation are presented in Table. A.1.3 to Table. A.1.5

1.3.2 MAXIMUM RAINFALL

Daily and 8 hours maximum rainfall values are presented in Table 1.6 to 1.8 The tables show that the maximum daily rainfall was 168.4mm on Sept 19,1982 and the maximum 8 hours rainfall was 129.2 mm on Aug 1, 1988 for Ilopango station.

1.3.3 FREQUENCY ANALYSES

Frequency analyses for annualy, daily and 8 hours rainfall were made for Ilopango, Cojutepeque and San Salvador Airport stations. The used methods were Hazen, Iwai, Weibull-Thomas and Gumbel. The results of the analyses are presented in the Table A1.9 and Figures A.1.4 to A.1.11.

1.3.4 RAINFALL INTENSITY

The rainfall intensity was calculated for Ilopango station for 30 year return period and the used formulas were as follows:

Type I

$I = a/(t^n+b)$ Kimishima Formula (Talbot when n=1)

Type II

$I = a/t^n$ Sherman Formula

Type III

$I=a/(\sqrt{t}+b)$ Kuno-Ishiguro Formula

Where, I: rainfall intensity (mm)
t: duration
a,b,n: constants

The results of the calculation is as follows:

Formula Type	Constants			Sum of deviation
	n	a	b	
I	1	7415	32	30.9
II	0.7	-	1173	97.2
III	-	334	-2	190.9

From the table the type I formula has the minimum deviation, therefore the formula for rainfall intensity and duration for 1/30 is as follows:

$I=7415/(t+32)$

The calculated data is shown in Table A.1.10 and A.1.11.

1.3.5 STORM RAINFALL PATTERN

The rainfall pattern assumed that there are basically 3 types : maximum rainfall intensity occurs at the beginning of the rain, maximum rainfall intensity occurs at the middle of the rain, and maximum rainfall intensity occurs at the end of the rain. The 3 types of rainfall for a return period of 1 in 33 years is shown in Fig. A.1.12.

2. HYDROLOGY

2.1 GENERAL

The Jiboa River originates in San Rafael Cedros Municipio and runs in a south direction until terminating at the Pacific Ocean. The total river length of the main stream is about 61Km.and the total catchment area of the river basin is about 605 Km^2, including Ilopango Lake basin.

The water levels in the basin were recorded at two locations shown below and in Fig. 2.1.

Station	Period Recorded	Catchment Area (Km^2)
Montecristo - Los Amates	Jun. 1959 - Apr. 1985 Jun. 1993 - 1996	429.41 Km^2
Desague	Nov. 1959 - Mar. 1982 May. 1993 - 1996	205.05 Km^2

2.1.1 RATING CURVE

After evaluation of the water level records and river discharge observations, rating curve for Montecristo station was recalculated as follows:

$$Q=27.333(H-0.285)^{1.88}$$

Observation data used and the calculated rating curve are shown in Table A.2.1 and Fig. A.2.2 respectively.

2.1.2 FLOOD

The probability of exceedence of observed annual peak flood discharges of the Ilopango Lake basin (catchmente area = 205.05 Km2) at Desague station and Jiboa river (catchment area = 429.41 Km2) at Montecristo station were calculated by Hazen, Iwai and Gumbel methods and their results as follows:

Montecristo Station				Desague Station		
Return Period	Hazen Method	Iwai Method	Gumbel Method	Hazen Method	Iwai Method	Gumbel Method
2	155	162	164	3.8	3.8	3.9
5	240	238	237	5.4	5.5	5.4
10	300	291	286	6.4	6.7	6.5
20	350	343	332	7.4	7.8	7.5
30	380	374	359	8.0	8.5	8.1
50	430	423	392	9.0	9.3	8.8
100	490	467	436	10.0	10.5	9.7
200	560	522	481	10.1	11.8	10.7

Unit m^3/s

2.2 RUNOFF ANALYSIS

2.1 SPECIFIC DISCHARGE AND AVAILABLE DISCHARGE VOLUME

From the frequency analysis of annual mean rainfall at Ilopango station, the specific discharge and monthly discharge volumet were calculated for a normal year, rainy year and dry year. In this case, the rainy year is defined as the annual rainfall that is approximate to the 5 year exceedence probability and the dry year is defined as total annual rainfall that is approximate to the 5 year non-exceedence probability.

In Table A.2.2 and Table A.2.4 the specific discharge and the available discharge volume in the Jiboa basin are shown.

2.2 FLOOD RUN-OFF ANALYSIS

Tha following methods were used to estimate flood discharge:

i) Rational Formula

ii) Unit Hydrograph Method

iii) Tank model Method

2.2.1 FLOOD RUN-OFF BY RATIONAL FORMULA

The maximum flood discharge is given by the following rational formula:

$$Q_{max} = \frac{fRA}{3.6}$$

where,

Q_{max}	: the peak flood discharge (m^3/s)
f	: dimensionless runoff coefficient
R	: intensity of rainfall within the time of flood concentration (mm/h)
A	: catchment area (km^2)

1) Runoff coefficient

The runoff coeffient proposed by Monoobe for rivers in Japan is as follows:

Steep mountainous region	0.75 - 0.90
Mountains of Tertiary strata	0.70 - 0.80
Rugged land and forests	0.50 - 0.75
Flat arable land	0.45 - 0.60
Irrigated paddy fields	0.70 - 0.80
Rivers in mountainous regions	0.75 - 0.85
Small rivers in level land	0.45 - 0.75
Large rivers with over half of the catchment in flat land	0.50 - 0.75

2) Time of Flood Concentration for Rational Formula Method

For estimating the time of flood concentration Kraven's empirical formulae was used:

I	over 1/100	1/100 - 1/200	below 1/200
W	3.5 m/s	3.0 m/s	2.1 m/s

T= L/W

where, I : Slope of watercourse;

W : Flood run-off velocity;

L : Lengh of watercourse

T : Time of flood concentration.

Results of the calcutation are shown in the following table:

Basin	Catchment Area (km^2)	H (m)	L (m)	I=H/L	W (m/s)	T=L/W (h)
B	74.57	350.00	17,666.00	0.019812	3.50	1.40
A-1	205.05	-	-	-	-	-
A-2	18.68	180.00	7,403.00	0.024314	3.50	0.59
C-1	42.12	1,050.00	15,264.00	0.068789	3.50	1.21
C-2	42.62	310.00	5,260.00	0.058935	3.50	0.42
C-3	46.37	460.00	4,880.00	0.094262	3.50	0.39
E-1	53.85	700.00	21,635.00	0.032355	3.50	1.72
E-2	65.47	765.00	17,412.00	0.043935	3.50	1.38
D-1	14.63	49.00	9,170.00	0.005344	2.10	1.21
D-2	42.23	36.50	17,413.00	0.002096	2.10	2.30

3) Rainfall Intensity in Rational Formula

Following formula was used for calculation of intensity.

$$r_t = r_{24}(t/24)^k$$

where, r_t : intensity of rainfall for duration t;

r_{24} : daily rainfall

k : constant between 1/3 to 2/3, for the Study, k=1/2 was used (Takahashi).

4) Results of the calculation are shown in Fig. A2.3 to Fig. A2.9.

2.2.2 FLOOD RUN-OFF BY UNIT HYDROGRAPH METHOD

1) The characteristic values of the unit hydrograph by Nakayasu are as follows:

$$Q_{max} = 1/3.6\, A\, R_o/(0.3T_1 + T_{0.3})$$

For rising unit hydrograph curves with $0 < t < T_1$:

$$\frac{Qa}{Q_{max}} = \left(\frac{t}{T_1}\right)^{2.4}$$

For falling unit hydrograph curves

with $1 > \frac{Qd}{Q_{max}} > 0.3$:

$$\frac{Qd}{Q_{max}} = 0.3^{(t-T_1)/T_{0.3}}$$

with $0.3 > \frac{Qd}{Q_{max}} > 0.3^2$:

$$\frac{Qd}{Q_{max}} = 0.3^{(t-T_1+0.5T_{0.3})/1.5T_{0.3}}$$

with $0.3^2 > \frac{Qd}{Q_{max}}$:

$$\frac{Qd}{Q_{max}} = 0.3^{(t-T_1+1.5T_{0.3})/2.0T_{0.3}}$$

where; Qmax : Maximum discharge of unit hydrograph (m^3/s)

Qa, Qd : Discharge at the time of rising and falling limb of unit hydrograph (m^3/s)

A : Catchment area (km^2)

Ro : Unit rainfall (mm)

T_1 : Time from the start of run-off to maximum discharge

T_{03} : Time required until the discharge recesses to 0.3 times the maximum discharge

2) Nakayasu defined the unit hydrograph as stated above and concluded that T_1 and T_{03} can be expressed as follows as a function of the catchment characteristics. If the time lag is tg and the maximum length of the watercourse is L,

For L > 15 km:

$$tg = 0.4 + 0.077\,Lm = 0.4 + 0.058\,L$$

where, Lm: Length of watercourse (km) from the furthest point in the zone with the maximum width of the catchment.

Between the catchment shape and T_{03} there are the following relationships:

$$T_{03} = 0.47\,(A\,L)^{0.25}$$

Time of occurrence of peak discharge:

$$T1 = tg + 0.8\,tr$$

where, tr: Duration of unit rainfall to be used.

3) According to Nakayasu, there are the following relationships between the storm loss Rl and the accumulated rainfall R :

When R<100 mm : Rl=R(1-3.6 x 10^-4 R^1.5) in mm

When R>=100 mm: Rl=64 mm

4) Storm rainfall pattern is assumed that there are 3 types as indicated in section 1.3.5 of this supplementary report. Results of the calculation for a return period of 1 in 33 years are shown in Table A.2.5 to Table A.2.12.

2.2.3 FLOOD RUN-OFF BY TANK MODEL METHOD

The discharge of the Jiboa river at Montecristo Station is composed of discharge from Jiboa basin (without Ilopango Lake basin discharge) and Ilopango Lake basin discharge and for that reason the simulations were made with 2 tank models.

1) Tank Model for Jiboa River

The condition for the simulation was:

(1) Period of simulation : From May 1993 to April 1994

(2) Rainfall : Rainfall record of Ilopango Station

(3) Evapotranspiration : Calculated probable monthly evapotranspiration at Ilopango station

(4) Model Adjustment : Repetitive calculation and adjustment of parameters (discharge orifice coefficient, orifice height) until the calculated value matches with the observed discharge record at Montecristo Station.

(5) Catchment Area : 224.36 km^2

(6) Structure of the model : As shown in Fig. A2.10 and Fig. A2.11, lateral orifice discharge means discharge to river, and bottom orifice discharge means ground infiltration.

2) Tank Model for Ilopango Lake.

(1) Period of simulation : From May 1971 to April 1973

(2) Rainfall : Rainfall record of Ilopango Station

(3) Evapotranspiration : Calculated probable monthly evapotranspiration at Ilopango station

(4) Model Adjustment : Repetitive calculation and adjustment of parameters (discharge orifice coefficient, orifice height) until the calculated value matcheswith the observed discharge record at Desague Station and water level record of Ilopango Lake at Apulo station.

(5) Catchment Area : Lake Ilopango, 70.48 km^2
Ilopango basin, 134.57 km^2

(6) Structure of the model : As shown in Fig. A2.11. There are 2 tank models in parallel. Model A for Ilopango Lake basin and model B for Ilopango Lake. Lateral orifice discharge from Model A goes to model B (Ilopango Lake) and the bottom orifice discharge means ground infiltration. Lateral orifice discharge from model B means discharge of Ilopango Lake to Desague river and bottom orifice discharge means ground infiltration.

3) Annual Water Balance

MODEL 1 FOR JIBOA RIVER

Annual Water Balance: From May 1993 to April 1994

Catchment Area	224.36	km^2
Rainfall	1875.8	mm
Evapotranspiration	753.9	mm
River Discharge	445.9	mm
Groundwater Infiltration	677.9	mm
Change in storage volume	-1.9	mm

The observed river discharge at Montecristo Station was 416.2 mm

MODEL 2 FOR ILOPANGO LAKE BASIN

Annual Water Balance: 1971

A			B		
Catchment Area	134.6	km^2	Catchment Area	70.5	km^2
Rainfall	1721.5	mm	Rainfall	1721.5	mm
			Discharge from A	864.0	mm
Evapotranspiration	773.4	mm	Evapotranspiration	1684.0	mm
River Discharge	452.5	mm	River Discharge	552.0	mm
Groundwater Infiltration	510.2	mm	Groundwater Infiltration	458.5	mm
Change in storage volume	-15.0	mm	Change in storage volume	-106.4	mm

Observed river discharge at Desague Station was 465.9 mm

2.3 WAVES AND TIDE

2.3.1 DESIGN WAVES

There weren't any waves data in the Study Area, but by the tetrapod structures used in Acajutla's port we estimated the design wave for coastal structures along El Salvador coast.

Hudson Formula for tetrapod structure:

$$W = \frac{\gamma_r H_d^3}{K_d(\gamma_r/w_0 - 1)^3 \cot \alpha}$$

where,
- W : weigh of structure block, 8 ton tetrapod is used in Acajutla
- γ_r : density of the structure, 2.3 ton/m^3
- H_d : Wave Height when the damage is lower than 1%
- K_d : constant, for tetrapod is 8.3
- α : angle of structure slope with water level, for tetrapod is 19.5°

when, H_d = 5.64 m

2.3.2 TIDE 2.13 2.14

In El Salvador there is only one tide record at Cutuco port La Union; the tide data are shown in Table A.1.13 and A.1.14. For conversion of tide height from Cutuco port to La Libertad port(near the Study Area) the Cutuco value will be multiplied by 0.67.

HHWL = 2.35 m
HWL = 1.85 m
MWL = 1.01 m
LWL = 0.17 m
LLWL = -0.33 m

2.3.3 Design Height of Coastal Structures in the Study Area

Recomended design height is: H = H(wave)/2 + HWL(Tide)

H = 3.66 m above MWL

TABLES

TABLE A.1.1 MONTHLY MEAN TEMPERATURE AT ILOPANGO

Unit: ℃

YEAR	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1966	22.6	23.3	23.8	24.8	23.9	23.0	23.2	23.1	22.8	22.6	21.0	21.2
1967	22.3	22.5	23.4	23.7	24.7	22.9	23.4	23.3	22.6	22.3	22.2	22.2
1968	22.2	21.4	23.3	24.0	23.6	22.9	23.4	23.0	22.9	22.4	22.0	21.9
1969	22.4	23.1	24.7	24.9	24.8	23.5	24.0	22.8	22.6	22.7	22.7	22.0
1970	22.2	22.4	24.1	25.7	24.2	23.6	23.1	22.8	22.4	22.9	21.4	22.2
1971	22.0	22.5	23.5	23.4	24.1	22.9	23.2	22.6	22.3	22.7	21.9	22.2
1972	22.6	22.1	23.3	24.6	24.2	23.6	24.8	23.5	23.3	23.4	23.4	22.4
1973	22.3	23.1	24.5	25.2	24.4	23.6	23.0	23.0	23.1	22.6	22.5	20.4
1974	22.6	22.0	23.1	24.4	23.9	23.0	23.1	23.4	22.5	22.5	22.4	22.3
1975	22.4	22.2	23.6	24.6	24.0	23.9	22.9	22.9	22.3	22.3	22.0	20.6
1976	21.1	21.6	23.1	23.8	24.5	22.8	23.1	23.2	22.9	22.8	22.1	22.4
1977	21.6	23.2	24.1	24.2	23.4	23.0	23.6	23.2	23.5	23.1	22.6	22.6
1978	21.5	22.7	22.4	23.7	24.3	24.4	22.8	23.4	22.7	22.7	23.4	22.7
1979	21.9	23.1	24.3	24.7	24.3	23.6	23.7	23.4	22.6	23.2	22.6	22.7
1980	22.7	22.8	24.6	24.8	25.0	24.2	23.3	23.0	23.0	23.4	22.5	21.3
1981	22.3	24.4	24.5	25.1	24.4	23.2	23.4	23.4	23.3	23.2	22.8	22.1
1982	23.0	23.7	24.1	24.5	23.9	23.4	23.6	24.2	22.8	22.8	22.7	22.4
1983	22.4	23.7	24.4	25.4	26.0	24.2	23.9	24.0	23.1	23.1	23.1	22.6
1984	23.5	23.0	23.6	-	23.7	23.6	23.0	23.4	22.5	23.5	21.6	22.5
1985	21.8	23.2	24.3	24.3	24.1	23.7	23.3	23.2	23.2	23.1	22.7	22.6
1986	21.9	22.6	22.6	24.4	24.1	23.8	23.8	23.8	23.4	23.2	23.5	22.8
1987	21.6	23.1	24.2	-	-	-	-	-	-	23.5	23.7	23.8
1988	23.0	24.1	24.4	25.1	25.1	23.7	23.6	23.1	22.8	23.0	22.9	21.7
1989	23.1	22.8	-	24.8	24.1	23.3	23.5	23.6	23.0	22.7	-	-
1990	23.8	23.1	24.4	24.8	24.1	23.6	23.4	23.6	23.3	23.3	22.9	24.3
1991	23.3	23.5	23.8	25.2	24.2	-	26.4	25.5	23.8	23.1	22.5	22.6
1992	22.9	23.2	23.9	25.6	25.5	24.2	23.2	23.4	22.9	23.6	23.3	22.9
1993	22.6	23.3	24.1	25.2	23.7	24.2	24.1	23.6	23.0	-	23.4	21.2
1994	23.0	23.6	23.7	24.9	24.8	24.3	24.4	23.6	23.6	23.4	23.4	23.3
1995	24.1	23.3	23.8	24.2	24.9	-	23.9	23.4	23.1	23.3	23.6	23.3
Mean	22.5	23.0	23.8	24.6	24.3	23.6	23.6	23.4	22.9	23.0	22.6	22.3

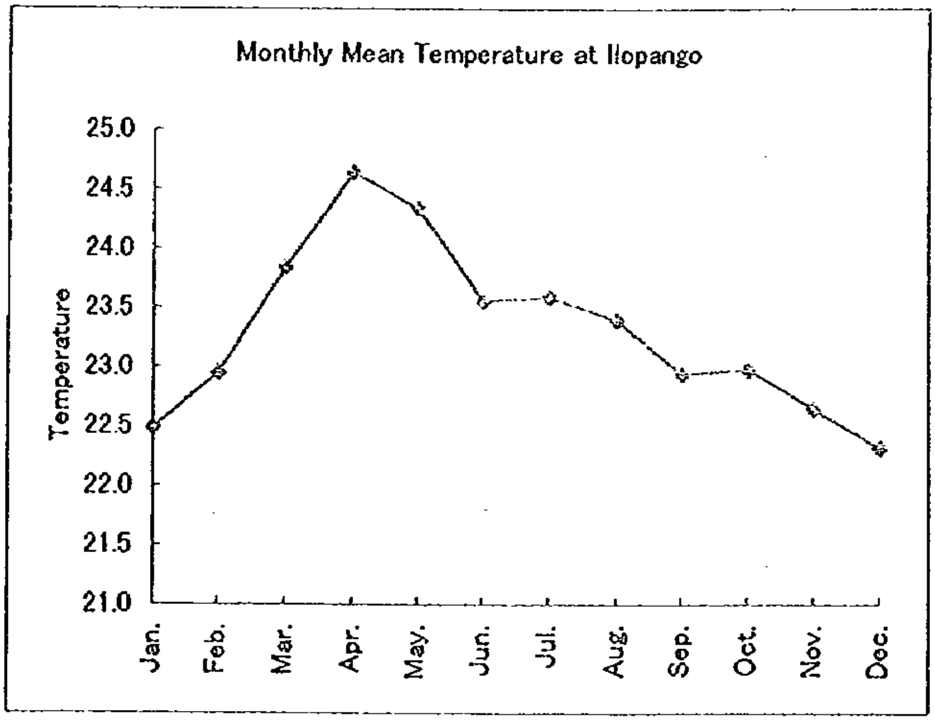


TABLE A.1.2 MONTHLY MEAN RELATIVE HUMIDITY AT ILOPANGO

Unit: %

YEAR	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1966	66.2	64.3	65.0	75.4	83.5	87.2	86.6	83.6	87.3	84.8	72.3	68.2
1967	64.4	64.4	63.2	72.6	75.0	85.8	80.3	81.7	87.6	86.1	77.9	74.6
1968	65.1	63.3	61.1	78.3	83.4	88.7	78.8	82.5	85.7	83.5	80.0	72.8
1969	66.0	69.0	66.6	75.5	79.2	86.7	80.5	88.1	86.6	87.1	74.6	70.0
1970	69.2	62.0	66.9	65.7	73.7	82.4	85.4	87.1	88.5	86.4	75.4	69.1
1971	68.9	68.0	67.1	63.7	79.3	83.8	83.2	88.3	87.7	88.5	83.5	79.7
1972	75.9	70.3	71.8	76.9	86.4	86.9	83.5	79.9	81.1	81.5	80.8	72.4
1973	64.1	63.4	68.7	72.3	77.4	82.5	82.8	85.5	87.0	87.9	78.7	69.5
1974	67.9	62.6	73.0	63.8	77.8	83.3	79.7	80.2	87.2	76.0	72.3	67.0
1975	67.7	68.8	69.2	64.4	79.5	79.8	79.6	81.2	85.4	84.9	78.9	72.8
1976	67.5	63.2	66.9	69.1	73.5	87.1	81.3	80.2	84.8	82.3	73.5	67.8
1977	64.0	64.7	66.7	67.4	83.0	84.0	79.1	83.7	86.1	81.2	79.0	77.2
1978	69.1	65.8	68.4	75.0	78.1	83.0	84.6	83.7	86.6	82.1	75.1	70.5
1979	69.5	65.7	70.0	80.7	84.5	87.5	85.6	84.0	87.6	86.5	71.5	67.6
1980	70.1	63.6	62.9	67.1	78.7	80.3	82.2	84.1	86.0	83.4	74.7	65.1
1981	61.1	58.0	68.7	65.1	80.3	85.9	82.4	83.2	84.2	82.9	70.2	68.9
1982	68.0	65.4	66.1	73.1	83.0	86.5	80.8	78.5	81.4	78.8	72.9	70.3
1983	65.7	67.4	67.7	71.2	74.9	84.0	83.2	81.6	84.4	82.6	79.9	74.7
1984	65.7	68.2	65.2	77.1	79.5	81.6	82.3	82.0	85.9	79.5	72.2	65.9
1985	62.5	61.2	64.9	72.9	80.7	80.5	79.1	81.4	82.8	83.6	77.2	69.5
1986	62.4	68.8	61.3	66.2	80.7	80.4	77.5	79.0	82.2	82.2	80.2	73.9
1987	61.3	63.9	67.6	62.0	–	–	–	–	82.3	67.3	67.0	66.3
1988	63.8	60.4	61.5	74.8	75.2	83.9	81.7	86.1	85.5	80.1	78.8	72.3
1989	66.4	59.5	–	68.0	80.1	84.3	81.4	81.8	85.8	79.6	78.8	–
1990	64.5	65.0	64.4	76.0	87.1	83.8	81.8	84.3	85.6	85.6	77.1	69.1
1991	72.2	64.7	70.1	75.0	83.0	82.0	71.5	75.5	80.7	81.0	74.7	73.3
1992	66.9	67.4	63.0	67.3	68.2	78.8	81.9	80.9	84.2	81.5	79.5	71.3
1993	68.6	63.6	64.9	71.5	79.0	81.4	78.2	80.9	83.0	82.6	74.0	66.4
1994	62.8	58.7	61.5	68.8	79.0	79.1	75.5	80.9	82.5	82.2	77.1	70.0
1995	65.7	61.0	67.1	76.3	80.5	85.1	81.3	86.4	86.1	84.0	74.8	78.6
Mean	66.4	64.4	66.3	71.1	79.5	83.7	81.1	82.6	85.1	82.5	76.1	70.8

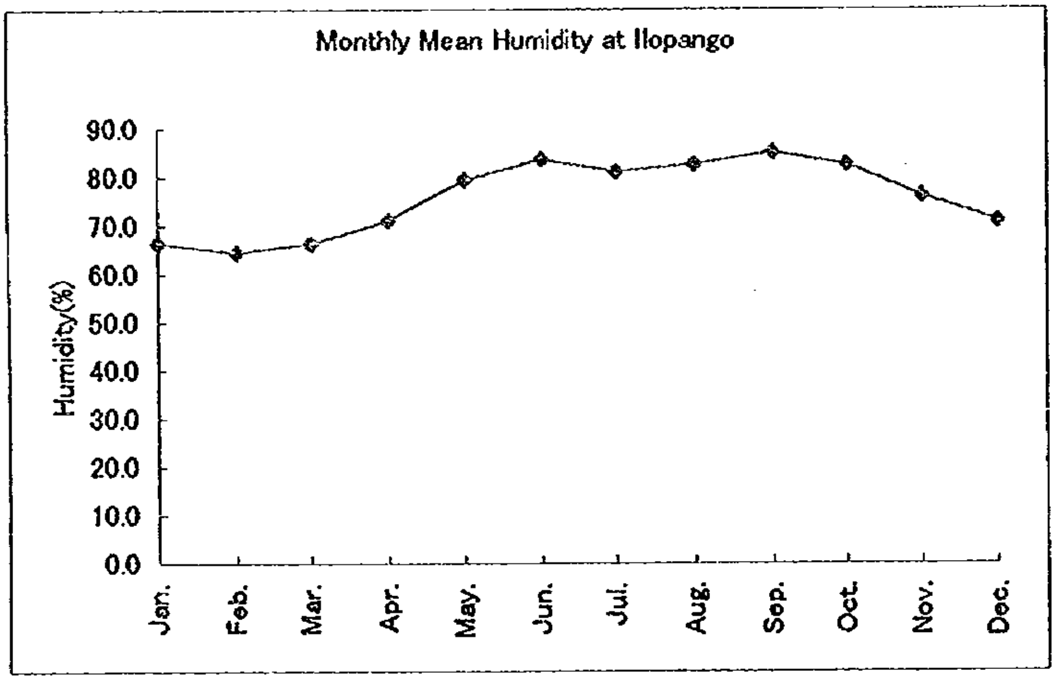


TABLE A.1.3 MEAN MONTHLY RAINFALL AT ILOPANGO

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1,967	14.0	2.0	16.3	88.2	38.7	266.7	241.9	215.7	227.3	371.4	9.6	32.0	1,523.8
1,968	0.0	0.0	0.0	52.6	191.0	229.9	183.3	421.5	428.6	224.5	69.5	0.3	1,801.2
1,969	0.0	0.5	2.9	42.9	121.1	212.6	246.3	279.4	342.8	233.1	25.7	0.0	1,507.3
1,970	3.0	0.0	0.0	4.0	227.5	195.1	342.9	306.8	416.2	299.4	26.6	28.9	1,850.4
1,971	32.8	0.0	5.1	9.9	99.4	233.8	315.0	306.5	291.4	371.8	39.3	16.5	1,721.5
1,972	7.3	1.8	4.6	55.7	215.1	197.0	225.3	240.8	367.4	146.2	62.3	19.9	1,543.4
1,973	0.0	0.0	0.0	50.9	99.0	271.2	287.3	259.6	155.7	183.6	57.1	6.1	1,370.5
1,974	3.4	0.0	50.9	18.7	78.1	442.0	304.7	311.6	454.4	122.4	2.0	0.0	1,788.2
1,975	9.2	0.0	2.6	1.4	72.6	177.9	190.0	354.1	299.1	423.9	73.3	0.0	1,604.1
1,976	0.0	0.0	0.9	26.7	112.6	445.5	271.3	291.4	470.3	111.4	13.6	2.0	1,745.7
1,977	0.0	0.0	0.0	45.1	151.2	446.7	227.0	341.1	198.8	113.4	92.3	9.6	1,625.2
1,978	0.0	0.0	27.2	25.6	132.3	230.8	402.3	470.6	354.5	159.5	9.8	2.9	1,815.5
1,979	0.0	0.0	3.4	75.3	73.2	346.9	254.3	319.5	317.9	248.0	14.5	3.9	1,656.9
1,980	47.6	0.0	0.0	1.0	308.0	364.4	342.5	451.5	361.1	257.9	5.7	0.0	2,139.7
1,981	0.0	0.0	64.9	50.7	96.7	261.0	339.3	148.2	202.8	285.4	7.3	1.1	1,457.4
1,982	13.1	6.1	0.3	2.8	227.9	445.1	237.6	214.5	499.6	103.2	22.9	40.3	1,813.4
1,983	0.6	0.9	7.1	7.7	109.2	246.7	382.5	334.9	163.6	244.3	48.1	35.7	1,581.3
1,984	0.0	17.2	1.8	22.9	65.6	273.4	512.6	248.7	423.3	195.1	20.9	0.5	1,782.0
1,985	0.0	0.0	0.0	148.7	120.2	167.5	306.9	243.3	297.6	152.8	58.1	0.1	1,495.2
1,986	0.0	0.0	0.0	81.9	146.2	276.2	310.5	378.8	388.6	165.8	30.6	0.2	1,778.8
1,987	0.0	4.0	9.4	8.2	169.6	-	463.6	263.7	248.8	38.7	4.5	1.1	-
1,988	0.0	2.6	14.2	0.7	151.0	267.7	305.4	497.0	318.3	156.9	16.6	26.7	1,757.1
1,989	0.1	0.0	0.0	10.1	175.3	252.3	306.7	200.4	600.8	302.1	64.4	0.0	1,912.2
1,990	2.4	0.7	10.0	45.5	271.6	457.8	357.3	393.4	348.0	245.8	35.5	27.8	2,195.8
1,991	3.9	0.0	0.0	24.1	163.3	344.8	179.5	240.2	333.0	254.0	37.9	24.9	1,605.6
1,992	0.0	0.0	0.0	22.6	26.8	325.6	391.5	308.7	321.0	166.1	76.5	20.8	1,659.6
1,993	0.1	2.7	9.7	27.8	175.5	330.2	236.0	454.7	397.6	257.9	6.4	0.0	1,898.6
1,994	0.8	3.1	0.8	12.8	137.3	152.8	190.2	500.2	368.0	118.1	79.5	1.9	1,565.5
1,995	0.0	0.0	2.3	30.2	94.4	305.7	336.6	278.5	338.6	156.4	28.3	16.6	1,587.6
Mean	4.8	1.4	8.1	34.3	139.7	291.7	299.7	319.8	342.6	216.8	35.8	11.0	1,705.7

Unit:mm

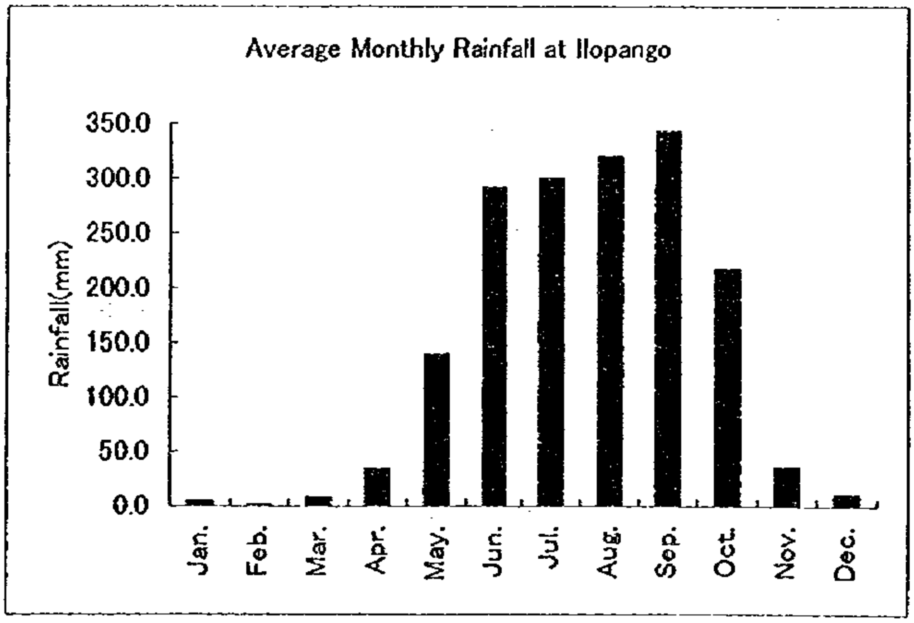


TABLE A.1.4 MEAN MONTHLY RAINFALL AT COJUTEPEQUE

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1,961	0.0	5.0	7.6	7.6	178.2	273.5	453.4	221.1	682.9	422.2	118.3	70.0	2,439.8
1,962	0.0	0.0	0.0	10.2	188.7	330.4	416.3	467.6	289.1	285.7	11.9	0.0	1,999.9
1,963	0.0	29.5	5.6	18.3	232.4	365.1	380.4	380.9	286.6	151.5	225.2	0.0	2,075.5
1,964	0.0	0.0	0.0	24.4	85.8	366.4	458.9	307.9	268.9	145.5	31.0	1.3	1,690.1
1,965	0.0	2.5	0.0	3.3	282.3	413.9	318.2	238.8	348.9	178.2	68.0	0.0	1,854.1
1,966	4.6	23.0	3.5	63.9	188.3	452.6	418.8	226.0	379.6	154.9	5.1	0.0	1,920.3
1,967	5.1	51.0	22.6	155.1	45.1	402.6	320.4	268.1	209.3	301.7	3.0	21.6	1,805.6
1,968	0.0	0.0	0.0	36.8	298.4	249.2	174.3	466.2	422.9	496.5	55.0	14.0	2,213.3
1,969	0.0	0.0	8.4	76.5	175.3	213.7	220.6	305.1	625.5	305.2	17.7	0.0	1,948.0
1,970	5.6	0.0	8.6	16.6	116.7	237.9	264.3	266.2	285.8	229.0	40.1	23.8	1,494.6
1,971	6.3	0.9	1.0	5.5	153.1	318.8	317.6	364.1	244.4	292.3	31.7	0.2	1,735.9
1,972	0.0	0.0	10.0	49.5	328.7	181.7	186.9	311.6	483.0	149.6	153.3	12.1	1,866.4
1,973	0.0	10.5	0.0	101.4	112.1	290.0	330.9	292.9	222.7	210.5	61.2	12.5	1,644.7
1,974	46.5	0.0	55.7	60.4	195.6	347.1	180.2	312.5	347.6	98.0	13.6	0.0	1,657.2
1,975	16.6	0.0	0.3	0.5	97.9	240.8	127.2	366.2	252.7	347.2	125.1	0.0	1,574.5
1,976	0.0	0.0	0.2	41.2	100.6	467.2	179.3	235.7	455.0	162.3	36.7	0.0	1,678.2
1,977	0.0	0.0	0.0	64.8	171.7	333.9	295.4	301.8	248.1	162.5	58.8	4.3	1,641.3
1,978	0.0	1.6	10.2	17.3	64.9	225.5	343.8	322.8	254.8	104.5	110.4	19.1	1,474.9
1,979	0.3	0.0	33.1	64.0	96.2	269.1	285.8	224.4	343.0	283.7	22.0	4.7	1,626.3
1,980	55.4	0.0	0.0	36.6	332.3	324.0	269.8	313.0	332.8	218.0	42.9	0.2	1,925.0
1,981	0.0	9.6	27.8	30.8	97.9	225.3	311.9	138.8	273.1	293.3	36.9	5.0	1,450.4
1,982	42.2	5.6	0.1	54.3	406.2	391.7	287.4	148.4	454.5	85.1	56.1	27.1	1,958.7
1,983	0.4	1.3	14.2	11.1	224.8	356.0	254.2	295.2	277.8	280.2	69.7	0.0	1,784.9
1,984	0.0	14.8	0.0	0.0	150.3	225.8	374.0	351.3	274.7	219.5	72.8	0.0	1,683.2
1,985	0.0	0.0	0.0	150.5	117.0	181.8	195.4	307.2	390.1	171.6	114.7	0.8	1,629.1
1,986	0.0	15.7	0.0	15.3	148.6	339.2	214.6	310.7	371.5	173.0	65.5	0.2	1,654.3
1,987	0.0	0.0	9.4	6.4	0.0	400.7	512.2	203.3	301.5	-	0.0	3.9	-
1,988	0.1	0.0	7.2	40.0	140.0	254.2	198.8	344.3	226.8	150.7	22.2	4.5	1,388.8
1,989	2.1	0.0	1.1	55.7	143.0	245.8	304.4	304.2	442.4	196.8	92.8	0.1	1,788.4
1,990	1.3	0.0	15.4	104.2	314.8	500.9	363.6	398.5	391.9	153.8	25.7	40.7	2,310.8
1,991	1.2	0.0	1.0	9.9	128.4	252.5	160.3	242.2	314.6	279.4	77.0	40.3	1,506.8
1,992	0.0	0.0	0.1	49.1	109.6	289.6	318.1	409.3	308.7	242.1	39.5	16.0	1,782.1
1,993	0.1	0.0	2.3	56.1	269.0	247.9	198.7	409.3	343.2	212.2	7.2	0.0	1,746.0
1,994	0.3	8.8	6.5	56.7	308.4	121.6	201.7	430.0	270.6	90.6	89.6	5.7	1,590.5
1,995	0.0	0.0	8.7	87.5	107.9	243.5	318.5	290.4	403.4	205.8	32.3	17.0	1,715.0
Mean	5.4	5.1	7.4	45.2	174.6	302.3	290.2	307.9	343.7	219.2	58.1	9.9	1,768.9

Unit:mm

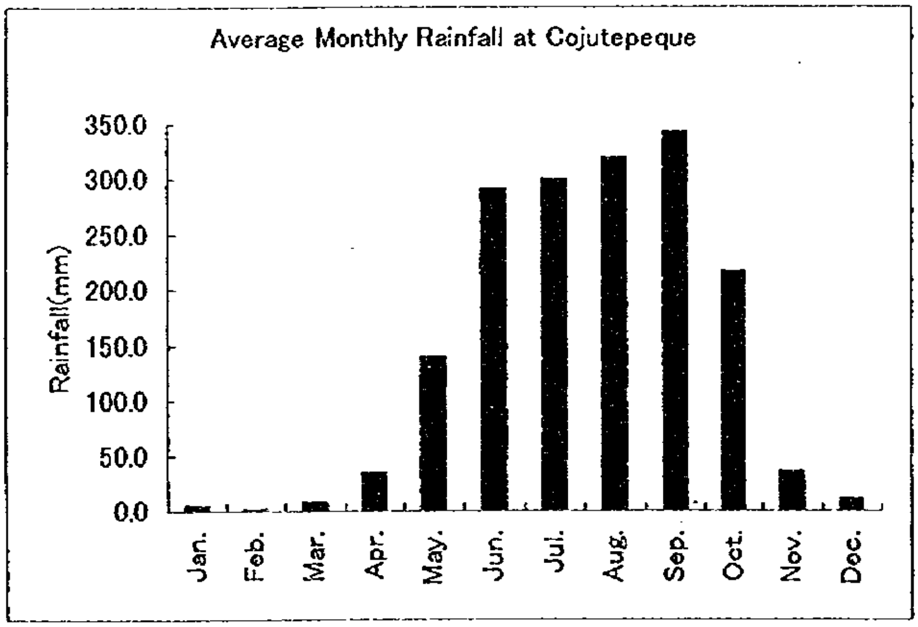


TABLE A.1.5 MEAN MONTHLY RAINFALL AT SAN SALVADOR

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1,983	0.8	0.3	20.0	38.2	60.1	117.4	219.4	227.5	218.0	249.7	20.1	0.3	1,171.8
1,984	0.0	0.8	3.4	0.0	153.2	212.9	475.5	146.1	267.0	173.8	45.5	0.0	1,478.2
1,985	0.0	0.0	39.6	67.8	41.1	76.5	244.2	239.1	217.3	244.5	139.9	0.0	1,310.0
1,986	0.0	0.0	0.0	20.4	320.4	255.0	179.9	304.8	282.0	115.7	0.0	0.0	1,478.2
1,987	0.0	0.0	51.6	28.6	110.3	-	400.2	247.8	248.7	8.8	0.0	5.7	-
1,988	0.2	0.0	11.8	46.9	158.2	318.6	239.1	763.2	363.4	161.9	0.0	9.2	2,072.5
1,989	0.0	0.0	0.8	29.7	277.2	359.6	321.1	338.0	623.9	187.2	0.0	3.1	2,140.6
1,990	0.3	0.0	51.4	91.7	222.9	247.3	243.8	432.7	216.8	379.6	68.1	54.0	2,008.6
1,991	4.0	0.0	6.3	15.8	73.0	302.0	81.2	198.6	257.8	212.6	9.6	27.9	1,188.8
1,992	0.0	0.3	5.2	25.6	53.4	177.8	401.3	235.4	410.0	147.5	24.4	4.7	1,485.6
1,993	19.9	0.0	0.0	-	-	-	-	-	-	-	-	-	-
1,994	0.0	0.0	0.0	27.9	106.7	117.1	90.7	252.3	346.7	111.8	90.7	0.5	1,144.4
1,995	0.0	0.0	8.7	87.5	104.2	223.6	-	-	-	-	-	-	-
Mean	1.9	0.1	15.3	40.0	140.1	218.9	263.3	307.8	313.8	198.4	36.2	9.6	1,545.4

Unit:mm

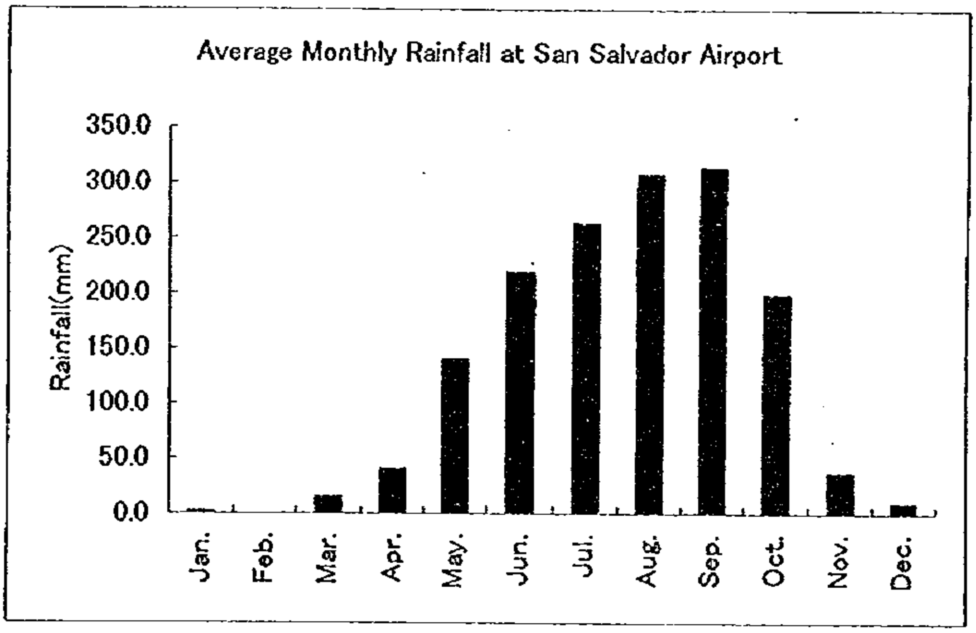


TABLE A.1.6 MAXIMUM DAILY PRECIPITATION AT COJUTEPEQUE

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.
1961	0.0	2.5	7.6	5.1	46.0	50.0	61.0	36.0	152.0	64.0	43.0	43.0	152.0
1962	0.0	0.0	0.0	5.1	48.0	51.0	65.0	64.0	38.0	44.0	9.4	0.0	65.0
1963	0.0	14.0	5.6	17.0	34.0	89.0	40.0	78.0	56.0	49.0	102.0	0.0	102.0
1964	0.0	0.0	0.0	16.0	33.0	58.0	68.0	49.0	51.0	41.0	31.0	1.3	68.0
1965	0.0	2.5	0.0	2.5	56.0	94.0	69.0	31.0	42.0	51.0	53.3	0.0	94.0
1966	4.6	23.0	2.5	30.0	87.0	69.0	56.0	28.0	81.0	66.0	5.1	0.0	87.0
1967	5.1	51.0	15.0	81.0	40.0	72.0	81.0	41.0	44.0	48.0	3.0	14.0	81.0
1968	0.0	0.0	0.0	31.0	76.0	43.0	33.0	58.0	63.0	248.0	21.0	14.0	248.0
1969	0.0	0.0	8.4	38.0	39.0	43.0	43.0	55.0	108.0	87.0	7.6	0.0	108.0
1970	5.4	0.0	8.4	15.0	40.0	58.0	49.0	40.0	54.0	64.0	38.0	21.0	64.0
1971	4.3	0.6	1.0	3.0	47.0	59.0	64.0	47.0	33.0	47.0	8.3	0.1	64.0
1972	0.0	0.0	9.8	21.0	59.0	43.0	37.0	40.0	70.0	31.0	54.0	12.0	70.0
1973	0.0	10.0	0.0	50.0	28.0	74.0	84.0	55.0	43.0	36.0	23.0	8.5	84.0
1974	28.0	0.0	20.0	60.0	71.0	49.0	49.0	48.0	146.0	43.0	9.4	0.0	146.0
1975	9.6	0.0	0.2	0.5	26.0	39.0	27.0	34.0	28.0	98.0	21.0	0.0	98.0
1976	0.0	0.0	0.1	29.0	30.0	96.0	32.0	40.0	76.0	74.0	19.0	0.0	96.0
1977	0.0	0.0	0.0	17.0	59.0	52.0	77.0	45.0	64.0	26.0	43.0	1.7	77.0
1978	0.0	1.6	3.3	6.6	22.0	39.0	39.0	47.0	49.0	35.0	78.0	18.0	78.0
1979	0.3	0.0	19.0	20.0	48.0	50.0	57.0	29.0	74.0	62.0	18.0	4.2	74.0
1980	26.0	0.0	0.0	36.0	85.0	53.0	74.0	39.0	62.0	39.0	20.0	0.2	85.0
1981	0.0	9.0	21.0	11.8	34.0	61.0	47.0	24.0	42.0	65.0	18.0	3.0	65.0
1982	16.0	3.5	0.1	33.0	101.0	44.0	44.0	38.0	147.0	31.0	23.0	14.0	147.0
1983	0.4	0.8	9.5	8.3	56.0	70.0	68.0	79.0	61.0	80.0	31.0	0.0	80.0
1984	0.0	5.6	0.0	0.0	39.0	42.0	73.0	83.0	80.0	36.0	28.0	0.0	83.0
1985	0.0	0.0	0.0	35.1	27.1	31.8	17.8	45.4	88.2	35.4	48.0	0.8	88.2
1986	0.0	10.1	0.0	6.9	26.6	49.4	41.5	47.6	75.5	49.5	21.1	0.1	75.5
1987	0.0	0.0	4.7	2.0	0.0	61.7	69.0	59.3	53.5	0.8	0.0	3.9	69.0
1988	0.1	0.0	3.8	33.5	40.6	83.3	31.6	64.5	37.9	46.2	19.2	4.5	83.3
1989	2.0	0.0	0.9	24.0	35.4	69.1	63.4	36.4	69.8	57.7	34.6	0.1	69.8
1990	1.1	0.0	12.3	43.3	44.0	53.8	68.1	73.2	85.4	38.3	15.5	31.7	85.4
1991	1.0	0.0	1.0	6.6	48.2	38.2	32.0	42.3	107.4	64.7	39.0	22.6	107.4
1992	0.0	0.0	0.1	31.5	54.9	44.2	40.0	58.7	37.5	75.8	31.8	12.5	75.8
1993	0.1	0.0	1.5	11.9	50.1	72.5	31.4	52.5	56.7	55.6	7.2	0.0	72.5
1994	0.3	3.2	6.5	48.2	50.3	23.9	49.9	69.0	42.2	16.0	72.3	3.1	72.3
1995	0.0	0.0	4.7	66.4	41.2	58.8	48.8	38.5	43.0	51.5	13.4	15.2	66.4

TABLE A.1.7 MAXIMUM DAILY PRECIPITATION AT ILOPANGO

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.
1967	14.0	2.0	9.4	30.2	13.0	73.8	41.1	41.7	41.2	90.0	9.6	24.1	90.0
1968	0.0	0.0	0.0	29.0	44.5	41.7	25.5	58.8	110.2	36.6	63.7	0.3	110.2
1969	0.0	0.5	1.5	26.7	38.0	31.7	56.0	46.6	75.2	84.5	24.4	0.0	84.5
1970	3.0	0.0	0.0	3.4	67.2	23.4	32.3	52.7	117.4	58.2	24.5	28.0	117.4
1971	32.0	0.0	4.3	6.1	33.9	31.8	60.8	31.6	49.7	82.0	22.3	15.4	82.0
1972	7.3	1.8	4.6	25.3	39.0	42.4	41.8	40.0	54.0	26.3	18.2	15.2	54.0
1973	0.0	0.0	0.0	48.9	21.2	72.5	46.0	37.9	39.8	41.4	21.0	6.1	72.5
1974	1.6	0.0	14.5	9.8	35.3	72.9	41.8	90.2	151.1	45.5	1.6	0.0	151.1
1975	9.2	0.0	2.4	1.4	26.6	43.0	46.6	53.2	39.6	95.0	17.7	0.0	95.0
1976	0.0	0.0	0.7	10.3	43.3	109.7	54.4	47.0	91.4	37.6	6.0	2.0	109.7
1977	0.0	0.0	0.0	24.9	26.1	61.3	66.1	46.7	59.7	33.4	69.3	4.5	69.3
1978	0.0	0.0	14.1	14.1	50.8	61.2	38.5	78.3	74.7	33.8	5.8	2.3	78.3
1979	0.0	0.0	1.8	35.5	24.0	92.0	39.7	37.8	90.2	77.7	9.2	3.9	92.0
1980	22.5	0.0	0.0	0.5	69.3	42.8	59.8	56.5	49.8	47.0	3.6	0.0	69.3
1981	0.0	0.0	34.9	13.2	26.8	52.1	60.6	25.6	51.7	60.9	3.3	1.1	60.9
1982	8.0	3.6	0.2	2.6	55.2	68.1	41.0	65.0	168.4	32.9	10.1	39.8	168.4
1983	0.6	0.9	5.6	7.4	45.0	40.1	83.5	48.8	39.5	66.6	18.1	14.8	83.5
1984	0.0	7.5	1.3	12.4	26.6	28.5	52.0	33.4	80.7	34.1	19.0	0.5	80.7
1985	0.0	0.0	0.0	55.1	36.8	42.0	46.8	47.3	52.6	52.5	37.1	0.1	55.1
1986	0.0	0.0	0.0	46.5	21.6	103.9	40.1	57.9	80.7	32.8	14.2	0.2	103.9
1987	0.0	4.0	5.5	4.6	78.0	-	46.5	40.8	55.1	38.7	4.0	1.1	78.0
1988	0.0	2.6	14.1	0.7	39.8	40.0	48.0	129.2	69.2	81.0	9.0	25.8	129.2
1989	0.1	0.0	0.0	6.7	33.6	52.2	82.5	40.4	75.8	62.5	28.0	0.0	82.5
1990	2.4	0.6	6.5	17.1	41.0	64.8	53.7	51.5	36.4	49.4	16.4	26.7	64.8
1991	3.9	0.0	0.0	12.2	36.0	58.4	40.6	51.6	56.0	45.2	17.1	21.0	58.4
1992	0.0	0.0	0.0	15.1	13.6	53.3	68.9	55.1	38.5	46.2	25.6	20.3	68.9
1993	0.1	2.7	6.0	14.9	39.0	72.8	34.5	51.2	60.6	43.4	5.2	0.0	72.8
1994	0.7	2.9	0.6	9.6	21.8	53.2	31.1	73.4	51.1	39.2	67.9	1.5	73.4
1995	0.0	0.0	2.1	9.4	39.8	58.3	43.4	67.0	38.4	41.5	19.8	10.0	67.0

TABLE A1.8 MAXIMUM 8 HOURS PRECIPITATION AT ILOPANGO

Unit: mm

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Max.
1967	-	-	9.4	18.5	10.0	73.8	34.3	32.0	27.1	84.0	9.6	24.1	84.0
1968	0.0	0.0	0.0	28.8	44.0	41.7	25.3	58.5	110.2	24.5	45.0	0.3	110.2
1969	0.0	0.5	1.5	26.4	33.0	31.7	56.0	22.5	37.6	72.3	1.3	0.0	72.3
1970	3.0	0.0	0.0	3.4	67.2	23.4	27.4	52.7	114.8	54.3	13.6	28.0	114.8
1971	29.5	0.0	4.3	6.1	26.4	29.4	60.8	31.6	44.3	82.0	21.6	15.4	82.0
1972	7.3	1.8	4.6	25.3	38.2	37.2	41.4	35.8	52.5	26.3	18.2	15.2	52.5
1973	0.0	0.0	0.0	48.5	21.2	70.5	28.1	36.8	31.0	37.4	21.0	4.9	70.5
1974	1.3	0.0	14.5	8.5	28.5	50.0	41.8	70.4	88.0	32.7	1.6	0.0	88.0
1975	9.2	0.0	2.4	0.9	23.0	35.7	43.8	52.0	39.6	95.0	16.8	0.0	95.0
1976	0.0	0.0	0.7	10.3	4.2	39.6	45.4	39.0	50.3	25.4	6.0	2.0	50.3
1977	0.0	0.0	0.0	24.9	23.6	35.1	57.7	46.6	46.0	17.9	35.8	4.5	57.7
1978	0.0	0.0	14.1	11.9	50.8	61.2	35.9	78.3	51.2	31.4	5.8	2.3	78.3
1979	0.0	0.0	1.8	18.0	22.2	67.0	33.0	25.5	79.5	72.6	9.2	3.9	79.5
1980	18.0	0.0	0.0	0.5	68.5	42.8	49.7	49.4	48.9	38.4	3.6	0.0	68.5
1981	0.0	0.0	33.8	11.9	25.2	37.8	51.1	25.6	29.1	60.9	3.3	1.1	60.9
1982	5.1	3.6	0.2	2.6	55.2	36.9	41.0	65.0	111.0	28.9	10.0	39.8	111.0
1983	0.6	0.5	2.4	4.5	45.0	40.0	54.9	47.0	38.5	66.6	18.1	14.8	66.6
1984	0.0	7.5	1.3	12.4	21.6	28.0	52.0	28.0	46.6	29.7	19.0	0.5	52.0
1985	0.0	0.0	0.0	55.1	36.8	30.3	46.8	46.8	52.6	47.3	37.1	0.1	55.1
1986	0.0	0.0	0.0	46.5	19.6	86.0	39.3	43.5	62.4	32.8	14.2	0.2	86.0
1987	0.0	4.0	5.5	4.6	67.0	-	46.5	36.0	52.4	25.6	4.0	1.1	67.0
1988	0.0	2.6	14.1	0.7	39.8	40.0	19.0	129.2	62.2	45.5	9.0	25.8	129.2
1989	0.1	0.0	0.0	6.7	33.6	52.2	68.5	40.4	60.8	62.5	28.0	0.0	68.5
1990	2.0	0.6	6.5	16.9	40.5	62.0	52.6	50.0	36.4	44.4	13.8	26.7	62.0
1991	3.9	0.0	0.0	12.2	25.7	58.4	40.4	51.6	56.0	45.2	17.1	12.2	58.4
1992	0.0	0.0	0.0	15.1	13.6	35.8	48.7	49.4	38.5	46.2	25.6	20.3	49.4
1993	0.1	2.7	6.0	14.9	35.3	72.2	34.5	51.2	39.5	34.8	5.2	0.0	72.2
1994	0.7	2.9	0.6	6.4	20.0	47.7	30.2	52.8	27.5	36.2	67.9	1.5	67.9
1995	0.0	0.0	1.1	9.4	39.8	50.0	42.1	44.5	26.3	26.4	19.8	10.0	50.0

TABLE A.1.9 RAINFALL FREQUENCY ANALYSIS RESULTS

STATION NAME: Ilopango 1 Day Rainfall

Return Period	Hazen Method	Iwai Method	Weibull Method	Gumbel Method
2	83	81.1	84	74.7
5	104	103.8	106	110.5
10	118	119.8	120	134.2
20	130	135.7	130	156.9
30	138	145.2	138	170.3
50	144	157.2	146	186.3
100	156	174.1	158	208.2
200	168	191.5	168	230.1

Unit: mm

STATION NAME: Cojutepeque 1 Day Rainfall

Return Period	Hazen Method	Iwai Method	Weibull Method	Gumbel Method
2	83	80.9	83	81.7
5	100	99.4	100	102.2
10	112	112.4	112	115.8
20	120	125.4	122	128.8
30	125	133.1	128	136.4
50	140	142.9	136	145.6
100	168	156.5	144	158.1
200	174	170.6	152	170.7

Unit: mm

STATION NAME: San Salvador Airport 1 Day Rainfall

Return Period	Hazen Method	Iwai Method	Weibull Method	Gumbel Method
2	83	82.3	82	81.8
5	98	96.9	97	96.0
10	108	106.1	104	105.5
20	115	114.7	112	114.5
30	120	119.6	116	119.8
50	124	125.6	120	126.1
100	130	133.7	126	134.8
200	138	141.7	132	143.5

Unit: mm

TABLE A.1.10 Calculation of Intensity of Rainfall Type I

I= a /(t^n + b) Calculation of Constants a, b, n

When n= 0.9

N	t(min)	I(mm/hr)	t^n	I*t^n	I^2	I^2*t^n	I(calculated)	s	s^2
1	10	176.4	7.9	1401.2	31117.0	247170.8	187.0	10.6	111.8
2	20	148.8	14.8	2205.6	22141.4	328195.7	141.7	-7.1	50.7
3	30	120.6	21.4	2574.9	14544.4	310530.1	115.2	-5.4	29.2
4	60	73.2	39.8	2916.4	5358.2	213480.5	75.3	2.1	4.5
5	120	44.4	74.3	3301.0	1971.4	146564.6	45.8	1.4	1.8
6	180	36.0	107.1	3855.2	1296.0	138787.5	33.3	-2.7	7.1
7	240	21.6	138.7	2996.7	466.6	64728.8	26.4	4.8	23.2
8	360	19.2	199.8	3836.8	368.6	73667.3	18.9	-0.3	0.1
9	480	15.3	258.9	3954.6	233.3	60405.9	14.8	-0.5	0.3
10	1440	6.1	695.9	4210.0	36.6	25470.5	5.7	-0.4	0.1
Total	[ ]	661.5	1558.7	31252.4	77533.5	1609001.7			228.8

a = ([I][I^2*t^n]-[I^2][I*t^n])/([I]^2-N[I^2]) = 4023.198

b = (N[I^2*t^n]-[I][I*t^n])/([I]^2-N[I^2]) = 13.57406 T = SQRT([s^2] /N) 4.78

When n= 1.0

N	t(min)	I(mm/hr)	t^n	I*t^n	I^2	I^2*t^n	I(calculated)	s	s^2
1	10	176.4	10.0	1764.0	31117.0	311169.6	174.8	-1.6	2.6
2	20	148.8	20.0	2976.0	22141.4	442828.8	141.4	-7.4	54.2
3	30	120.6	30.0	3618.0	14544.4	436330.8	118.8	-1.8	3.3
4	60	73.2	60.0	4392.0	5358.2	321494.4	80.2	7.0	49.4
5	120	44.4	120.0	5328.0	1971.4	236563.2	48.6	4.2	18.0
6	180	36.0	180.0	6480.0	1296.0	233280.0	34.9	-1.1	1.2
7	240	21.6	240.0	5184.0	466.6	111974.4	27.2	5.6	31.6
8	360	19.2	360.0	6912.0	368.6	132710.4	18.9	-0.3	0.1
9	480	15.3	480.0	7332.0	233.3	111996.3	14.5	-0.8	0.6
10	1440	6.1	1440.0	8712.0	36.6	52707.6	5.0	-1.0	1.0
Total	[ ]	661.5	2940.0	52698.0	77533.5	2391055.5			162.1

a = ([I][I^2*t^n]-[I^2][I*t^n])/([I]^2-N[I^2]) = 7414.782

b = (N[I^2*t^n]-[I][I*t^n])/([I]^2-N[I^2]) = 32.4248 T = SQRT([s^2] /N) 4.03

When n= 1.1

N	t(min)	I(mm/hr)	t^n	I*t^n	I^2	I^2*t^n	I(calculated)	s	s^2
1	10	176.4	12.6	2220.7	31117.0	391739.3	165.2	-11.2	124.8
2	20	148.8	27.0	4015.5	22141.4	597501.3	140.8	-8.0	64.3
3	30	120.6	42.2	5083.7	14544.4	613095.3	121.8	1.2	1.4
4	60	73.2	90.4	6614.2	5358.2	484159.6	85.3	12.1	145.3
5	120	44.4	193.7	8599.7	1971.4	381825.8	51.9	7.5	56.1
6	180	36.0	302.6	10891.9	1296.0	392107.1	36.7	0.7	0.5
7	240	21.6	415.2	8967.8	466.6	193704.6	28.2	6.6	43.8
8	360	19.2	648.5	12451.9	368.6	239075.6	19.1	-0.1	0.0
9	480	15.3	889.9	13594.0	233.3	207648.0	14.3	-1.0	1.0
10	1440	6.1	2979.9	18028.3	36.6	109071.0	4.5	-1.6	2.4
Total	[ ]	661.5	5601.9	90467.6	77533.5	3609927.7			439.7

a = ([I][I^2*t^n]-[I^2][I*t^n])/([I]^2-N[I^2]) = 13698.38

b = (N[I^2*t^n]-[I][I*t^n])/([I]^2-N[I^2]) = 70.31658 T = SQRT([s^2] /N) 6.63

Therefore the minimum deviation is for n ≒ 1, a = 7415, b = 32

TABLE A.1.11 CALCULATION OF RAINFALL INTENSITY TYPE II AND TYPE III

N	t(min)	I(mm/hr)	I^2	log t	log I	log t*lo	(log t)^2	t^0.5	I*t^0.5	I^2*t^0.5
1	10	176.4	31116.96	1.0000	2.2465	2.2465	1.0000	3.1623	557.83	98400.5
2	20	148.8	22141.44	1.3010	2.1726	2.8266	1.6927	4.4721	665.45	99019.5
3	30	120.6	14544.36	1.4771	2.0813	3.0744	2.1819	5.4772	660.55	79662.7
4	60	73.2	5358.24	1.7782	1.8645	3.3154	3.1618	7.7460	567.00	41504.7
5	120	44.4	1971.36	2.0792	1.6474	3.4252	4.3230	10.9545	486.38	21595.2
6	180	36.0	1296.00	2.2553	1.5563	3.5099	5.0863	13.4164	482.99	17387.7
7	240	21.6	466.56	2.3802	1.3345	3.1763	5.6654	15.4919	334.63	7227.9
8	360	19.2	368.64	2.5563	1.2833	3.2805	6.5347	18.9737	364.29	6994.5
9	480	15.3	233.33	2.6812	1.1840	3.1745	7.1891	21.9089	334.66	5111.9
10	1440	6.1	36.60	3.1584	0.7818	2.4691	9.9753	37.9473	229.58	1389.0
Total	[ ]	661.5	77533.5	20.6669	16.1521	30.4984	46.8100	139.5503	4683.4	378293.6

Type II

log a= ([log I][(log t)^2]-[log t *log I][log t])/(N[(log t)^2]-[log t][log t]) 3.069146

a = 1173

n= ([log I][log t]-N[log t *log I])/(N[(log t)^2]-[log t][log t]) 0.70

Type III

a= ([I*t^0.5][I^2]-[I^2*t^0.5][I])/(N[I^2]-[I][I]) 334

b=([I][I*t^0.5]-N[I^2*t^0.5])/(N[I^2]-[I][I]) -2

N	t(min)	I-1	d 1^2	I-2	d 2^2	I-3	d 3
1	10	170.6	34.2	232.1	3100.2	294.5	13958.3
2	20	151.7	8.2	142.5	39.5	136.7	146.0
3	30	136.6	254.4	107.1	181.0	96.9	562.5
4	60	105.1	1018.6	65.8	54.8	58.4	217.7
5	120	72.0	760.5	40.4	16.0	37.4	48.5
6	180	54.7	350.6	30.4	31.6	29.3	44.3
7	240	44.1	508.2	24.8	10.3	24.8	10.4
8	360	31.8	159.6	18.7	0.3	19.7	0.3
9	480	24.9	92.5	15.2	0.0	16.8	2.4
10	1440	9.1	9.1	7.0	1.0	9.3	10.6
Sum d^2			3196.0		3434.7		15000.9
T=SQRT(d^2)			17.9		19.5		46.2

Type I has minimum deviation from observed data

Therefore the intensity formula for 1/33 is

I= 7415 /(t +32)

TABLE A.2.1 CALCULATION OF RATING CURVE

n	year	Q	H	x=H-0.285	log Q	log x	(logx)^2	logQ*logx
1	1,993	3.070	0.600	0.315	0.4871	-0.5017	0.2517	-0.2444
2		2.500	0.560	0.275	0.3979	-0.5607	0.3143	-0.2231
3		2.080	0.530	0.245	0.3181	-0.6108	0.3731	-0.1943
4		0.999	0.535	0.250	-0.0004	-0.6021	0.3625	0.0003
5		1.036	0.540	0.255	0.0154	-0.5935	0.3522	-0.0091
6		1.020	0.540	0.255	0.0086	-0.5935	0.3522	-0.0051
7		1.910	0.615	0.330	0.2810	-0.4815	0.2318	-0.1353
8		2.960	0.590	0.305	0.4713	-0.5157	0.2659	-0.2430
9		9.600	0.820	0.535	0.9823	-0.2716	0.0738	-0.2668
10		4.410	0.660	0.375	0.6444	-0.4260	0.1814	-0.2745
11		16.380	0.940	0.655	1.2143	-0.1838	0.0338	-0.2231
12		7.200	0.750	0.465	0.8573	-0.3325	0.1106	-0.2851
13		4.940	0.630	0.345	0.6937	-0.4622	0.2136	-0.3206
14	1,994	1.150	0.450	0.165	0.0607	-0.7825	0.6123	-0.0475
15		1.420	0.480	0.195	0.1523	-0.7100	0.5041	-0.1081
16		1.280	0.475	0.190	0.1072	-0.7212	0.5202	-0.0773
17		1.030	0.460	0.175	0.0128	-0.7570	0.5730	-0.0097
18		1.380	0.490	0.205	0.1399	-0.6882	0.4737	-0.0963
19		2.200	0.550	0.265	0.3424	-0.5768	0.3326	-0.1975
20		12.340	0.925	0.640	1.0913	-0.1938	0.0376	-0.2115
21		4.640	0.680	0.395	0.6665	-0.4034	0.1627	-0.2689
22		3.080	0.620	0.335	0.4886	-0.4750	0.2256	-0.2320
23		1.360	0.470	0.185	0.1335	-0.7328	0.5370	-0.0979
24		1.090	0.450	0.165	0.0374	-0.7825	0.6123	-0.0293
25		1.070	0.445	0.160	0.0294	-0.7959	0.6334	-0.0234
26		1.040	0.450	0.165	0.0170	-0.7825	0.6123	-0.0133
27		1.040	0.450	0.165	0.0170	-0.7825	0.6123	-0.0133
28		1.020	0.440	0.155	0.0086	-0.8097	0.6556	-0.0070
29		0.920	0.425	0.140	-0.0362	-0.8539	0.7291	0.0309
30	1,995	1.470	0.490	0.205	0.1673	-0.6882	0.4737	-0.1152
31		4.870	0.660	0.375	0.6875	-0.4260	0.1814	-0.2929
32		12.590	0.900	0.615	1.1000	-0.2111	0.0446	-0.2322
33		11.490	0.880	0.595	1.0603	-0.2255	0.0508	-0.2391
34		6.750	0.740	0.455	0.8293	-0.3420	0.1170	-0.2836
35		6.090	0.700	0.415	0.7846	-0.3820	0.1459	-0.2997
36		1.030	0.465	0.180	0.0128	-0.7447	0.5546	-0.0096
37		0.990	0.465	0.180	-0.0044	-0.7447	0.5546	0.0033
38		0.940	0.455	0.170	-0.0269	-0.7696	0.5922	0.0207
39		0.880	0.450	0.165	-0.0555	-0.7825	0.6123	0.0434
40		0.940	0.450	0.165	-0.0269	-0.7825	0.6123	0.0210
41		0.830	0.450	0.165	-0.0809	-0.7825	0.6123	0.0633
42		0.990	0.440	0.155	-0.0044	-0.8097	0.6556	0.0035
43		0.970	0.480	0.195	-0.0132	-0.7100	0.5041	0.0094
44		1.010	0.440	0.155	0.0043	-0.8097	0.6556	-0.0035
45		3.550	0.620	0.335	0.5502	-0.4750	0.2256	-0.2613
46		0.990	0.465	0.180	-0.0044	-0.7447	0.5546	0.0033
Sum					14.6196	-27.4134	18.0981	-5.3955

$$k = \frac{n[\log x \log Q] - [\log x][\log Q]}{n[(\log x)^2] - [\log x][\log x]}$$

k = 1.883

$$\log C = \frac{[(\log x)^2][\log Q] - [\log x][\log x \log Q]}{n[(\log x)^2] - [\log x][\log x]}$$

log C = 1.440

C = 27.551

b = - 0.285

Q = 27.551 (H - 0.285) ^ 1.883

TABLE A.2.2 . SPECIFIC DISCHARGE

	Volume (MMC)			Coefficient m3/s/Km2		
Month	AT	ALL	APLL	AT	ALL	APLL
Jan.	4.76	5.81	5.72	0.00414	0.00505	0.00498
Feb.	3.44	3.98	3.98	0.00331	0.00383	0.00383
Mar.	3.15	3.63	3.45	0.00274	0.00315	0.00300
Apr.	3.25	3.78	3.79	0.00292	0.00339	0.00340
May	5.46	7.28	9.21	0.00474	0.00633	0.00801
June	12.22	25.27	11.98	0.01098	0.02271	0.01076
July	13.63	11.15	10.64	0.01185	0.00970	0.00925
Aug.	20.48	17.48	11.70	0.01780	0.01520	0.01017
Sep.	31.58	36.74	25.00	0.02838	0.03301	0.02246
Oct.	27.78	22.17	24.50	0.02415	0.01927	0.02130
Nov.	12.35	11.50	10.27	0.01110	0.01033	0.00922
Dec.	6.76	7.98	5.96	0.00588	0.00694	0.00518
Total	144.87	156.76	126.18	0.01067	0.01158	0.00930

AT: Normal Year ALL: Rainy Year(1982) APLL: Dry Year(1972)

TABLE A.2.3 AVALAIBLE DISCHARGE VOLUME IN JIBOA BASIN

	Jiboa Upstream 74.57Km2 (B Zone)			Chorreron River 42.12Km2(C1Zone)			Amojapa River 13.25Km2(C2-1Zone)		
Month	AT(m3/s)	ALL(m3/s)	APLL(m3/s)	AT(m3/s)	ALL(m3/s)	APLL(m3/s)	AT(m3/s)	ALL(m3/s)	APLL(m3/s)
Jan.	0.31	0.38	0.37	0.17	0.21	0.21	0.05	0.07	0.07
Feb.	0.25	0.29	0.29	0.14	0.16	0.16	0.04	0.05	0.05
Mar.	0.20	0.24	0.22	0.12	0.13	0.13	0.04	0.04	0.04
Apr.	0.22	0.25	0.25	0.12	0.14	0.14	0.04	0.04	0.05
May	0.35	0.47	0.60	0.20	0.27	0.34	0.06	0.08	0.11
June	0.82	1.69	0.80	0.46	0.96	0.45	0.15	0.30	0.14
July	0.88	0.72	0.69	0.50	0.41	0.39	0.16	0.13	0.12
Aug.	1.33	1.13	0.76	0.75	0.64	0.43	0.24	0.20	0.13
Sep.	2.12	2.46	1.67	1.20	1.39	0.95	0.38	0.44	0.30
Oct.	1.80	1.44	1.59	1.02	0.81	0.90	0.32	0.26	0.28
Nov.	0.83	0.77	0.69	0.47	0.44	0.39	0.15	0.14	0.12
Dec.	0.44	0.52	0.39	0.25	0.29	0.22	0.06	0.09	0.07
Mean(m3/s)	0.80	0.86	0.69	0.45	0.49	0.39	0.14	0.15	0.12

	Timiaya River 10.49Km2(C2-2 Zone)			Chicomulingo River 10.01Km2(C3-1 Zone)			Tilapa River 44.15(E1Zone)			Sepaquiapa River 65.47(E2 Zone)		
Month	AT(m3/s)	ALL(m3/s)	APLL(m3/s)	AT(m3/s)	ALL(m3/s)	APLL(m3/s)	AT(m3/s)	ALL(m3/s)	APLL(m3/s)	AT(m3/s)	ALL(m3/s)	APLL(m3/s)
Jan.	0.04	0.05	0.05	0.19	0.23	0.23	0.18	0.22	0.22	0.27	0.33	0.33
Feb.	0.03	0.04	0.04	0.15	0.18	0.18	0.15	0.17	0.17	0.22	0.25	0.25
Mar.	0.03	0.03	0.03	0.13	0.15	0.14	0.12	0.14	0.13	0.18	0.21	0.20
Apr.	0.03	0.04	0.04	0.14	0.16	0.16	0.13	0.15	0.15	0.19	0.22	0.22
May	0.05	0.07	0.08	0.22	0.29	0.37	0.21	0.28	0.35	0.31	0.41	0.52
June	0.12	0.24	0.11	0.51	1.05	0.50	0.48	1.00	0.48	0.72	1.49	0.70
July	0.12	0.10	0.10	0.55	0.45	0.43	0.52	0.43	0.41	0.78	0.63	0.61
Aug.	0.19	0.16	0.11	0.83	0.70	0.47	0.79	0.67	0.45	1.17	1.00	0.67
Sep.	0.30	0.35	0.24	1.32	1.53	1.04	1.25	1.46	0.99	1.86	2.16	1.47
Oct.	0.25	0.20	0.22	1.12	0.89	0.99	1.07	0.85	0.94	1.58	1.26	1.39
Nov.	0.12	0.11	0.10	0.51	0.48	0.43	0.49	0.46	0.41	0.73	0.68	0.60
Dec.	0.06	0.07	0.05	0.27	0.32	0.24	0.26	0.31	0.23	0.39	0.45	0.34
Mean(m3/s)	0.11	0.12	0.10	0.49	0.54	0.43	0.47	0.51	0.41	0.70	0.76	0.61

AT: Normal Year ALL: Rainy Year(1982) APLL: Dry Year(1972)

TABLE A.2.4 AVAILABLE DISCHARGE VOLUME IN JIBOA BASIN

	Jiboa Upstream 74.57Km2 (B Zone)			Chorreron River 42.12Km2(C1Zone)			Amojapa River 13.25Km2(C2-1Zone)		
Season	AT(m3/s)	ALL(m3/s)	APLL(m3/s)	AT(m3/s)	ALL(m3/s)	APLL(m3/s)	AT(m3/s)	ALL(m3/s)	APLL(m3/s)
Dry	0.37	0.41	0.37	0.21	0.23	0.21	0.07	0.07	0.07
Rainy	1.22	1.32	1.02	0.69	0.75	0.58	0.22	0.23	0.18

	Timiaya River 10.49Km2(C2-2 Zone)			Chicomulingo River 10.01Km2(C3-1 Zone)			Tilapa River 44.15(E1Zone)			Sepaquiapa River 65.47(E2 Zone)		
Season	AT(m3/s)	ALL(m3/s)	APLL(m3/s)	AT(m3/s)	ALL(m3/s)	APLL(m3/s)	AT(m3/s)	ALL(m3/s)	APLL(m3/s	AT(m3/s)	ALL(m3/s)	APLL(m3/s)
Dry	0.05	0.06	0.05	0.23	0.25	0.23	0.22	0.24	0.22	0.33	0.36	0.32
Rainy	0.17	0.19	0.14	0.76	0.82	0.63	0.72	0.78	0.60	1.07	1.16	0.89

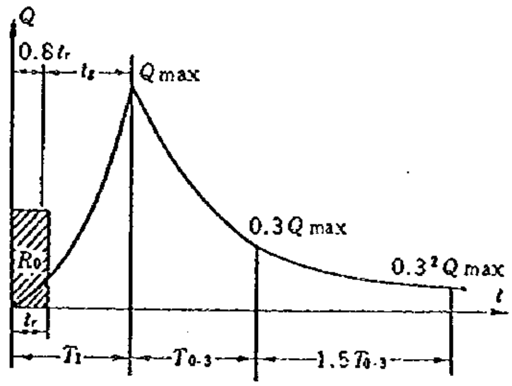
	Total Basin		
Season	AT(m3/s)	ALL(m3/s)	APLL(m3/s)
Dry	1.49	1.62	1.46
Rainy	4.84	5.25	4.05
Mean	3.16	3.43	2.76

AT: Normal Year ALL: Rainy Year(1982; APLL: Dry Year(1972)

Dry Season : January, February, March, April, November, December
Rainy Season : May to October

TABLE A.2.5 CALCULATION FORMULA FOR JIBOA RIVER AT MONTECRISTO STATION

	Formula	Value
A(km2)	-	224.36
L(km)	-	34.9
tg	0.4 + 0.058 L	2.4
tr(h)	unit rainfall	1
T1	tg+0.8*tr	3.2
T o.3	0.47(A*L)^0.25	4.4
Ro		1
Qmax	(1/3.6)ARo/(0.3T1+To.3)	11.57
Q(0-3.2)	Qmax*(t/T1)^2.4	
Q(3.2-7.6)	Qmax*(0.3)^(t-T1)/To.3)	
Q(7.6-14.2)	Qmax*(0.3)^(t-T1+0.5To.3)/1.5To.3)	
Q(14.2-)	Qmax*(0.3)^(t-T1+1.5To.3)/2.0To.3)	



Nakayasu's Synthetic Unit Hydrograph

T (hr)	R(mm/hr)	Effective Rainfall(Ri mm)		
		Pattern A	Pattern B	Pattern C
1	80.2	59.5	5.2	5.0
2	48.6	42.7	5.7	5.2
3	34.9	32.3	6.3	5.5
4	27.2	25.8	7.0	5.7
5	22.3	21.5	7.9	6.0
6	18.9	18.3	9.0	6.3
7	16.4	16.0	10.6	6.7
8	14.5	14.2	12.8	7.0
9	13.0	12.8	16.0	7.4
10	11.7	11.5	21.5	7.9
11	10.7	10.6	32.3	8.4
12	9.9	9.8	59.5	9.0
13	9.1	9.0	42.7	9.8
14	8.5	8.4	25.8	10.6
15	8.0	7.9	18.3	11.5
16	7.5	7.4	14.2	12.8
17	7.0	7.0	11.5	14.2
18	6.7	6.7	9.8	16.0
19	6.3	6.3	8.4	18.3
20	6.0	6.0	7.4	21.5
21	5.7	5.7	6.7	25.8
22	5.5	5.5	6	32.3
23	5.2	5.2	5.5	42.7
24	5.0	5.0	5.0	59.5

Effective Rainfall

R<100mm : Ri=R(1-3.6 x R^1.5/10^4)
R>=100mm : Ri=64mm

TABLE A.2.6 Discharge calculation for Jiboa River at Montecristo Station (Pattern A)

Hour	Rainfall	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Disch.
	mm/h	0.70	3.68	11.57	9.36	7.13	5.43	4.14	3.25	2.71	2.26	1.89	1.57	1.31	1.09	0.94	0.82	0.72	0.63	0.55	0.48	0.42	0.36	0.32	0.28	m3/s
1	59.5	41.4																								41.4
2	42.7	29.7	218.6																							248.3
3	32.3	22.5	156.9	687.7																						867.1
4	25.8	18.0	118.8	493.5	556.8																					1187.1
5	21.5	14.9	94.9	373.7	399.6	424.0																				1307.1
6	18.3	12.8	78.9	298.5	302.5	304.3	323.0																			1320.0
7	16.0	11.2	67.4	248.1	241.7	230.4	231.8	246.0																		1276.5
8	14.2	9.9	58.9	212.1	200.9	184.1	175.5	176.5	193.5																	1211.3
9	12.8	8.9	52.2	185.1	171.7	153.0	140.2	133.6	138.8	161.3																1145.0
10	11.5	8.0	47.0	164.4	149.9	130.8	116.5	106.8	105.1	115.8	134.6															1078.8
11	10.6	7.4	42.4	147.8	133.1	114.2	99.6	88.7	84.0	87.7	96.6	112.2														1013.6
12	9.8	6.8	38.8	133.4	119.7	101.3	86.9	75.9	69.8	70.0	73.1	80.5	93.6													949.9
13	9.0	6.3	36.0	122.2	108.0	91.1	77.2	68.2	59.7	58.2	58.4	61.0	67.2	78.0												889.4
14	8.4	5.9	33.1	113.2	98.9	82.2	69.4	58.8	52.1	49.8	48.5	48.7	50.9	56.0	65.1											832.6
15	7.9	5.5	31.0	104.2	91.7	75.3	62.6	52.9	46.2	43.4	41.5	40.5	40.6	42.4	46.7	56.1										635.5
16	7.4	5.2	29.2	97.4	84.4	69.8	57.4	47.7	41.6	38.6	36.2	34.6	33.8	33.9	35.4	40.3	49.0									575.8
17	7.0	4.8	27.4	91.8	78.9	64.3	53.2	43.7	37.5	34.7	32.2	30.2	28.9	28.2	28.3	30.5	35.1	42.7								527.4
18	6.7	4.6	25.6	86.1	74.3	60.1	48.9	40.5	34.4	31.3	28.9	26.8	25.2	24.1	23.5	24.3	26.6	30.7	37.3							486.7
19	6.3	4.4	24.5	80.4	69.7	56.6	45.8	37.3	31.8	28.7	26.1	24.1	22.4	21.0	20.1	20.2	21.2	23.2	26.8	32.5						451.7
20	6.0	4.2	23.0	77.0	65.1	53.1	43.1	34.8	29.3	26.6	23.9	21.8	20.1	18.7	17.5	17.3	17.7	18.5	20.3	23.4	28.4					422.0
21	5.7	4.0	21.9	72.5	62.3	49.6	40.4	32.8	27.4	24.4	22.2	19.9	18.1	16.8	15.6	15.1	15.1	15.4	16.2	17.7	20.4	24.8				395.6
22	5.5	3.8	20.9	69.0	58.7	47.5	37.8	30.8	25.8	22.9	20.4	18.5	16.6	15.1	14.0	13.4	13.2	13.2	13.5	14.1	15.4	17.8	21.6			372.5
23	5.2	3.6	20.1	65.6	55.9	44.7	36.2	28.8	24.2	21.5	19.1	17.0	15.4	13.9	12.6	12.1	11.7	11.5	11.5	11.7	12.3	13.5	15.5	18.9		352.0
24	5.0	3.5	19.0	63.3	53.1	42.6	34.0	27.5	22.6	20.2	18.0	15.9	14.2	12.8	11.6	10.9	10.5	10.2	10.0	10.0	10.2	10.8	11.8	13.5	16.5	333.9

TABLE A.2.7 Discharge calculation for Jiboa River at Montecristo Station (Pattern B)

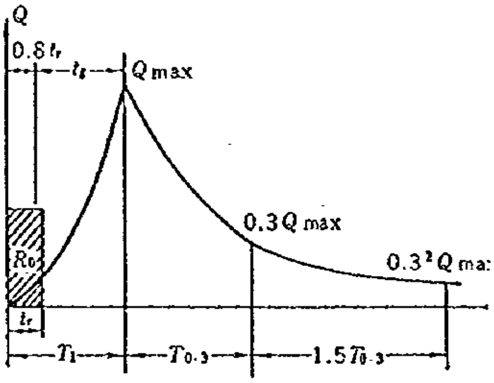
Hour	Rainfall	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Disch.
	mm/h	0.70	3.68	0.00	9.36	7.13	5.43	4.14	3.25	2.71	2.26	1.89	1.57	1.31	1.09	0.94	0.82	0.72	0.63	0.55	0.48	0.42	0.36	0.32	0.28	m3/s
1	5.2	3.6																								3.6
2	5.7	4.0	19.0																							23.0
3	6.3	4.4	20.9	59.9																						85.1
4	7.0	4.8	23.0	65.6	48.5																					142.0
5	7.9	5.5	25.6	72.5	53.1	36.9																				193.6
6	9.0	6.3	29.2	80.4	58.7	40.4	28.1																			243.1
7	10.6	7.4	33.1	91.8	65.1	44.7	30.8	21.4																		294.3
8	12.8	8.9	38.8	104.2	74.3	49.6	34.0	23.5	16.8																	350.2
9	16.0	11.2	47.0	122.2	84.4	56.6	37.8	25.9	18.5	14.0																417.5
10	21.5	14.9	58.9	147.8	98.9	64.3	43.1	28.8	20.4	15.4	11.7															504.1
11	32.3	22.5	78.9	185.1	119.7	75.3	48.9	32.8	22.6	17.0	12.8	9.8														625.5
12	59.5	41.4	118.8	248.1	149.9	91.1	57.4	37.3	25.8	18.9	14.2	10.7	8.1													821.7
13	42.7	29.7	218.6	373.7	200.9	114.2	69.4	43.7	29.3	21.5	15.7	11.8	8.9	6.8												1144.3
14	25.8	18.0	156.9	687.7	302.5	153.0	86.9	52.9	34.4	24.4	18.0	13.1	9.9	7.4	5.7											1570.8
15	18.3	12.8	94.9	493.5	556.8	230.4	116.5	66.2	41.6	28.7	20.4	15.0	10.9	8.2	6.2	4.9										1687.7
16	14.2	9.9	67.4	298.5	399.6	424.0	175.5	88.7	52.1	34.7	23.9	17.0	12.5	9.1	6.9	5.4	4.3									1603.8
17	11.5	8.0	52.2	212.1	241.7	304.3	323.0	133.6	69.8	43.4	28.9	19.9	14.2	10.4	7.6	5.9	4.7	3.7								1451.3
18	9.8	6.8	42.4	164.4	171.7	184.1	231.8	246.0	105.1	58.2	36.2	24.1	16.6	11.8	8.7	6.6	5.2	4.1	3.2							1287.4
19	8.4	5.9	36.0	133.4	133.1	130.8	140.2	176.5	193.5	87.7	48.5	30.2	20.1	13.9	9.9	7.5	5.7	4.5	3.6	2.8						1135.8
20	7.4	5.2	31.0	113.2	108.0	101.3	99.6	106.8	138.8	161.3	73.1	40.5	25.2	16.8	11.6	8.5	6.5	5.0	3.9	3.1	2.5					1004.0
21	6.7	4.6	27.4	97.4	91.7	82.2	77.2	75.9	84.0	115.8	134.6	61.0	33.8	21.0	14.0	10.0	7.4	5.7	4.4	3.4	2.7	2.2				885.4
22	6.0	4.2	24.5	86.1	78.9	69.8	62.6	58.8	59.7	70.0	96.6	112.2	50.9	28.2	17.5	12.1	8.7	6.5	5.0	3.8	3.0	2.4	1.9			774.2
23	5.5	3.8	21.9	77.0	69.7	60.1	53.2	47.7	46.2	49.8	58.4	80.5	93.6	42.4	23.5	15.1	10.5	7.6	5.6	4.3	3.3	2.6	2.1	1.6		661.9
24	5.0	3.5	20.1	69.0	62.3	53.1	45.8	40.5	37.5	38.6	41.5	48.7	67.2	78.0	35.4	20.2	13.2	9.2	6.6	4.9	3.8	2.9	2.3	1.8	1.4	527.7

TABLE A.2.8 Discharge calculation for Jiboa River at Montecristo Station (Pattern C)

Hour	Rainfall	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Disch.
	mm/h	0.70	3.68	0.00	9.36	7.13	5.43	4.14	3.25	2.71	2.26	1.89	1.57	1.31	1.09	0.94	0.82	0.72	0.63	0.55	0.48	0.42	0.36	0.32	0.28	m3/s
1	5.0	3.5																								3.5
2	5.2	3.6	18.3																							21.9
3	5.5	3.8	19.0	57.6																						80.4
4	5.7	4.0	20.1	59.9	46.6																					130.6
5	6.0	4.2	20.9	63.3	48.5	35.5																				172.3
6	6.3	4.4	21.9	65.6	51.3	36.9	27.0																			207.1
7	6.7	4.6	23.0	69.0	53.1	39.0	28.1	20.6																		237.6
8	7.0	4.8	24.5	72.5	55.9	40.4	29.7	21.4	16.2																	265.5
9	7.4	5.2	25.6	77.0	58.7	42.6	30.8	22.6	16.8	13.5																292.8
10	7.9	5.5	27.4	80.4	62.3	44.7	32.4	23.5	17.8	14.0	11.3															319.3
11	8.4	5.9	29.2	86.1	65.1	47.5	34.0	24.7	18.5	14.9	11.7	9.4														346.9
12	9.0	6.3	31.0	91.8	69.7	49.6	36.2	25.9	19.4	15.4	12.4	9.8	7.8													375.2
13	9.8	6.8	33.1	97.4	74.3	53.1	37.8	27.5	20.4	16.2	12.8	10.3	8.1	6.5												404.5
14	10.6	7.4	36.0	104.2	78.9	56.6	40.4	28.8	21.7	17.0	13.5	10.7	8.6	6.8	5.5											435.9
15	11.5	8.0	38.8	113.2	84.4	60.1	43.1	30.8	22.6	18.1	14.2	11.3	8.9	7.2	5.7	4.7										453.5
16	12.8	8.9	42.4	122.2	91.7	64.3	45.8	32.8	24.2	18.9	15.1	11.8	9.4	7.4	6.0	4.9	4.1									487.3
17	14.2	9.9	47.0	133.4	98.9	69.8	48.9	34.8	25.8	20.2	15.7	12.6	9.9	7.8	6.2	5.2	4.3	3.6								526.9
18	16.0	11.2	52.2	147.8	108.0	75.3	53.2	37.3	27.4	21.5	16.8	13.1	10.5	8.2	6.5	5.4	4.5	3.7	3.1							574.4
19	18.3	12.8	58.9	164.4	119.7	82.2	57.4	40.5	29.3	22.9	18.0	14.0	10.9	8.7	6.9	5.6	4.7	3.9	3.2	2.7						630.9
20	21.5	14.9	67.4	185.1	133.1	91.1	62.6	43.7	31.8	24.4	19.1	15.0	11.7	9.1	7.3	5.9	4.9	4.1	3.4	2.8	2.4					700.1
21	25.8	18.0	78.9	212.1	149.9	101.3	69.4	47.7	34.4	26.6	20.4	15.9	12.5	9.8	7.6	6.3	5.2	4.3	3.6	3.0	2.5	2.1				787.0
22	32.3	22.5	94.9	248.1	171.7	114.2	77.2	52.9	37.5	28.7	22.2	17.0	13.3	10.4	8.1	6.6	5.5	4.5	3.7	3.1	2.6	2.2	1.8			900.1
23	42.7	29.7	113.8	298.5	200.9	130.8	86.9	58.8	41.6	31.3	23.9	18.5	14.2	11.1	8.7	7.0	5.7	4.8	3.9	3.3	2.7	2.3	1.9	1.6		1053.9
24	59.5	41.4	156.9	373.7	241.7	153.0	99.6	66.2	46.2	34.7	26.1	19.9	15.4	11.8	9.2	7.5	6.1	5.0	4.2	3.4	2.9	2.4	2.0	1.6	1.4	1274.8

TABLE A.2.9 Calculation Formula for Jiboa River at River Mouth

	Formula	Value
A(km2)	-	400.5
L(km)	-	61.48
tg	0.4+0.058L	4.0
tr(h)	unit rainfall	1
T1	tg+0.8*tr	4.8
T o.3	0.47(A*L)^0.25	5.9
Ro		1
Qmax	(1/3.6)ARo/(0.3T1+To.3)	15.20
Q(0-4.8)	Qmax*(t/T1)^2.4	
Q(4.8-10.7)	Qmax*(0.3)^((t-T1)/To.3)	
Q(10.7-19.4)	Qmax*(0.3)^((t-T1+0.5To.3)/1.5To.3)	
Q(19.4-)	Qmax*(0.3)^((t-T1+1.5To.3)/2.0To.3)	



Nakayasu's Syntetic
Unit Hydrograph

		Effective Rainfall(Rl mm)		
T (hr)	R(mm/hr)	Pattern A	Pattern B	Pattern C
1	80.2	59.5	5.2	5.0
2	48.6	42.7	5.7	5.2
3	34.9	32.3	6.3	5.5
4	27.2	25.8	7.0	5.7
5	22.3	21.5	7.9	6.0
6	18.9	18.3	9.0	6.3
7	16.4	16.0	10.6	6.7
8	14.5	14.2	12.8	7.0
9	13.0	12.8	16.0	7.4
10	11.7	11.5	21.5	7.9
11	10.7	10.6	32.3	8.4
12	9.9	9.8	59.5	9.0
13	9.1	9.0	42.7	9.8
14	8.5	8.4	25.8	10.6
15	8.0	7.9	18.3	11.5
16	7.5	7.4	14.2	12.8
17	7.0	7.0	11.53	14.2
18	6.7	6.7	9.8	16.0
19	6.3	6.3	8.4	18.3
20	6.0	6.0	7.4	21.5
21	5.7	5.7	6.7	25.8
22	5.5	5.5	6	32.3
23	5.2	5.2	5.5	42.7
24	5.0	5.0	5.0	59.5

Effective Rainfall (Ri)

R<100mm : Rl=R(1-3.6 x R^1.5/10^4)
R>100mm : Rl=64mm

TABLE A.2.10 Discharge Calculation for Jiboa River at River Mouth (Pattern A)

Hour	Rainfall	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Disch.
	mm/h	0.36	1.89	5.01	9.99	15.20	11.81	9.63	7.85	6.40	5.21	4.25	3.80	3.31	2.89	2.52	2.20	1.92	1.68	1.46	1.30	1.17	1.06	0.96	0.86	m3/s
1	59.5	21.3																								21.3
2	42.7	15.3	112.5																							127.8
3	32.3	11.6	80.7	297.7																						390.0
4	25.8	9.3	61.1	213.6	593.8																					877.8
5	21.5	7.7	48.8	161.7	426.1	904.1																				1548.4
6	18.3	6.6	40.6	129.2	322.6	648.8	702.4																			1850.2
7	16.0	5.7	34.7	107.4	257.7	491.2	504.1	572.5																		1973.4
8	14.2	5.1	30.3	91.8	214.2	392.4	381.7	410.8	466.6																	1993.0
9	12.8	4.6	26.9	80.1	183.1	326.2	304.9	311.1	334.9	380.3																1952.1
10	11.5	4.1	24.2	71.1	159.8	278.9	253.4	248.5	253.5	272.9	310.0															1876.6
11	10.6	3.8	21.8	64.0	141.9	243.4	216.7	206.6	202.5	206.7	222.5	252.7														1782.4
12	9.8	3.5	20.0	57.7	127.6	216.1	189.1	176.6	168.4	185.1	168.4	181.3	225.7													1699.5
13	9.0	3.2	18.5	52.9	115.1	194.3	167.9	154.1	143.9	137.2	134.6	137.3	162.0	197.0												1618.0
14	8.4	3.0	17.0	49.0	105.5	175.3	151.0	136.8	125.6	117.3	111.8	109.7	122.7	141.3	171.9											1538.0
15	7.9	2.8	15.9	45.1	97.7	160.6	136.2	123.1	111.5	102.4	95.6	91.2	98.0	107.0	123.3	150.0										1080.2
16	7.4	2.7	15.0	42.2	90.0	148.8	124.8	111.0	100.3	90.9	83.5	77.9	81.4	85.5	93.4	107.6	130.8									968.5
17	7.0	2.5	14.1	39.7	84.1	137.0	115.6	101.7	90.5	81.7	74.1	68.0	69.6	71.1	74.6	81.5	93.9	114.2								878.7
18	6.7	2.4	13.2	37.3	79.2	128.1	106.4	94.2	82.9	73.8	66.6	60.4	60.8	60.8	62.0	65.1	71.1	81.9	99.6							805.2
19	6.3	2.2	12.6	34.8	74.3	120.6	99.5	86.7	76.8	67.6	60.1	54.3	53.9	53.0	53.0	54.1	56.8	62.0	71.5	86.9						743.6
20	6.0	2.1	11.9	33.3	69.4	113.2	93.7	81.1	70.7	62.6	55.1	49.0	48.5	47.1	46.3	46.3	47.2	49.6	54.1	62.4	77.2					690.7
21	5.7	2.0	11.3	31.4	66.5	105.7	87.9	76.4	66.1	57.6	51.0	44.9	43.8	42.3	41.1	40.4	40.4	41.2	43.2	47.2	55.4	69.7				644.7
22	5.5	2.0	10.7	29.9	62.5	101.2	82.1	71.7	62.3	53.9	47.0	41.6	40.1	38.2	36.9	35.8	35.2	35.2	35.9	37.7	41.9	50.0	62.9			605.0
23	5.2	1.9	10.4	28.4	59.6	95.2	78.6	66.9	58.4	50.8	43.9	38.3	37.2	35.0	33.3	32.2	31.3	30.7	30.7	31.4	33.5	37.9	45.1	56.8		569.6
24	5.0	1.8	9.8	27.4	56.6	90.7	74.0	64.1	54.6	47.6	41.4	35.8	34.2	32.4	30.5	29.1	28.1	27.3	26.8	26.8	27.9	30.2	34.2	40.8	51.3	538.0
																									Max	1993.0

TABLE A.2.11' Discharge Calculation for Jiboa River at River Mouth (Pattern B)

Hour	Rainfall	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Disch.
	mm/h	0.36	1.89	5.01	9.99	0.00	11.81	9.63	7.85	6.40	5.21	4.25	3.80	3.31	2.89	2.52	2.20	1.92	1.68	1.46	1.30	1.17	1.06	0.96	0.86	m3/s
1	5.2	1.9																								1.9
2	5.7	2.0	9.8																							11.8
3	6.3	2.2	10.7	25.9																						38.9
4	7.0	2.5	11.9	28.4	51.7																					94.4
5	7.9	2.8	13.2	31.4	56.6	78.7																				182.7
6	9.0	3.2	15.0	34.8	62.5	86.2	61.2																			263.0
7	10.6	3.8	17.0	39.7	69.4	95.2	67.0	49.9																		342.1
8	12.8	4.6	20.0	45.1	79.2	105.7	74.0	54.6	40.6																	423.9
9	16.0	5.7	24.2	52.9	90.0	120.6	82.1	60.3	44.5	33.1																513.5
10	21.5	7.7	30.3	64.0	105.5	137.0	93.7	66.9	49.2	36.3	27.0															617.5
11	32.3	11.6	40.6	80.1	127.6	160.6	106.4	76.4	54.6	40.1	29.6	22.0														749.6
12	59.5	21.3	61.1	107.4	159.8	194.3	124.8	86.7	62.3	44.5	32.7	24.1	19.7													938.7
13	42.7	15.3	112.5	161.7	214.2	243.4	151.0	101.7	70.7	50.8	36.2	26.6	21.5	17.2												1222.8
14	25.8	9.3	80.7	297.7	322.6	326.2	189.1	123.1	82.9	57.6	41.4	29.5	23.8	18.8	15.0											1617.6
15	18.3	6.6	48.8	213.6	593.8	491.2	253.4	154.1	100.3	67.6	47.0	33.7	26.4	20.7	16.4	13.1										2036.5
16	14.2	5.1	34.7	129.2	426.1	904.1	381.7	206.6	125.6	81.7	55.1	38.3	30.1	23.0	18.1	14.3	11.4									2418.2
17	11.5	4.1	26.9	91.8	257.7	648.8	702.4	311.1	168.4	102.4	66.6	44.9	34.2	26.3	20.1	15.8	12.5	9.9								2459.3
18	9.8	3.5	21.8	71.1	183.1	392.4	504.1	572.5	253.5	137.2	83.5	54.3	40.1	29.8	22.9	17.5	13.8	10.9	8.7							2317.2
19	8.4	3.0	18.5	57.7	141.9	278.9	304.9	410.8	466.6	206.7	111.8	68.0	48.5	35.0	26.0	20.0	15.3	12.0	9.5	7.6						2117.4
20	7.4	2.7	15.9	49.0	115.1	216.1	216.7	248.5	334.9	380.3	168.4	91.2	60.8	42.3	30.5	22.7	17.5	13.4	10.5	8.3	6.7					1899.5
21	6.7	2.4	14.1	42.2	97.7	175.3	167.9	176.6	202.5	272.9	310.0	137.3	81.4	53.0	36.9	26.6	19.8	15.2	11.6	9.2	7.4	6.1				1680.4
22	6.0	2.1	12.6	37.3	84.1	148.8	136.2	136.8	143.9	165.1	222.5	252.7	122.7	71.1	46.3	32.2	23.2	17.3	13.3	10.2	8.1	6.6	5.5			1464.8
23	5.5	2.0	11.3	33.3	74.3	128.1	115.6	111.0	111.5	117.3	134.6	181.3	225.7	107.0	62.0	40.4	28.1	20.3	15.1	11.6	9.0	7.3	6.0	4.9		1246.1
24	5.0	1.8	10.4	29.9	66.5	113.2	99.5	94.2	90.5	90.9	95.6	109.7	162.0	197.0	93.4	54.1	35.2	24.5	17.7	13.2	10.3	8.1	6.6	5.4	4.5	964.1
																									Max	2459.3

TABLE A.2.12 Discharge Calculation for Jiboa River at River Mouth (Pattern C)

Hour	Rainfall	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Disch.
	mm/h	0.36	1.89	5.01	9.99	0.00	11.81	9.63	7.85	6.40	5.21	4.25	3.80	3.31	2.89	2.52	2.20	1.92	1.68	1.46	1.30	1.17	1.06	0.96	0.86	m3/s
1	5.0	1.8																								1.8
2	5.2	1.9	9.4																							11.3
3	5.5	2.0	9.8	24.9																						36.7
4	5.7	2.0	10.4	25.9	49.7																					88.0
5	6.0	2.1	10.7	27.4	51.7	75.7																				167.7
6	6.3	2.2	11.3	28.4	54.7	78.7	58.8																			234.1
7	6.7	2.4	11.9	29.9	56.6	83.2	61.2	47.9																		293.1
8	7.0	2.5	12.6	31.4	59.6	86.2	64.7	49.9	39.1																	345.9
9	7.4	2.7	13.2	33.3	62.5	90.7	67.0	52.7	40.6	31.9																394.6
10	7.9	2.8	14.1	34.8	66.5	95.2	70.5	54.6	43.0	33.1	26.0															440.6
11	8.4	3.0	15.0	37.3	69.4	101.2	74.0	57.5	44.5	35.0	27.0	21.2														485.1
12	9.0	3.2	15.9	39.7	74.3	105.7	78.6	60.3	46.8	36.3	28.5	22.0	18.9													530.5
13	9.8	3.5	17.0	42.2	79.2	113.2	82.1	64.1	49.2	38.2	29.6	23.3	19.7	16.5												577.7
14	10.6	3.8	18.5	45.1	84.1	120.6	87.9	66.9	52.2	40.1	31.1	24.1	20.8	17.2	14.4											626.9
15	11.5	4.1	20.0	49.0	90.0	128.1	93.7	71.7	54.6	42.6	32.7	25.4	21.5	18.1	15.0	12.6										633.3
16	12.8	4.6	21.8	52.9	97.7	137.0	99.5	76.4	58.4	44.5	34.7	26.6	22.7	18.8	15.8	13.1	11.0									676.8
17	14.2	5.1	24.2	57.7	105.5	148.8	106.4	81.1	62.3	47.6	36.2	28.3	23.8	19.8	16.4	13.8	11.4	9.6								727.1
18	16.0	5.7	26.9	64.0	115.1	160.6	115.6	86.7	66.1	50.8	38.8	29.5	25.3	20.7	17.2	14.3	12.0	9.9	8.3							785.3
19	18.3	6.6	30.3	71.1	127.6	175.3	124.8	94.2	70.7	53.9	41.4	31.6	26.4	22.1	18.1	15.1	12.5	10.5	8.7	7.3						854.0
20	21.5	7.7	34.7	80.1	141.9	194.3	136.2	101.7	76.8	57.6	43.9	33.7	28.3	23.0	19.2	15.8	13.1	10.9	9.2	7.6	6.5					937.0
21	25.8	9.3	40.6	91.8	159.8	216.1	151.0	111.0	82.9	62.6	47.0	35.8	30.1	24.7	20.1	16.8	13.8	11.5	9.5	8.0	6.7	5.8				1038.0
22	32.3	11.6	48.8	107.4	183.1	243.4	167.9	123.1	90.5	67.6	51.0	38.3	32.0	26.3	21.5	17.5	14.7	12.0	10.0	8.3	7.1	6.1	5.3			1164.6
23	42.7	15.3	61.1	129.2	214.2	278.9	189.1	136.8	100.3	73.8	55.1	41.6	34.2	27.9	22.9	18.8	15.3	12.8	10.5	8.7	7.4	6.4	5.5	4.8		1329.6
24	59.5	21.3	80.7	181.7	257.7	326.2	216.7	154.1	111.5	81.7	60.1	44.9	37.2	29.8	24.3	20.0	16.4	13.4	11.2	9.2	7.7	6.6	5.8	4.9	4.3	1553.9

Max 1553.9

TABLE A.2.13(1) High Water Level at Cutuco/La Union 1993

Month	Mean	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
Jan	2.81	2.38	2.59	2.29	2.56	2.23	2.56	2.19	2.62	2.29	-	2.71	2.41	2.83	2.59	2.99	2.80	3.11	2.99	3.20	3.14	3.23	3.26	3.20	3.29	3.08	3.23	2.93	3.14	2.74	3.02
Feb	2.85	2.23	2.56	2.19	2.59	2.26	2.65	2.41	-	2.77	2.62	2.93	2.90	3.11	3.11	3.20	3.29	3.26	3.41	3.23	3.41	3.11	3.35	2.96	3.20	2.74	2.99	2.53	2.77	2.35	2.62
Mar	2.85	2.35	2.62	2.29	2.56	2.26	2.56	2.32	2.59	2.47	-	2.71	2.71	2.87	2.99	3.05	3.23	3.17	3.38	3.20	3.47	3.20	3.44	3.08	3.35	2.93	3.14	2.71	2.93	2.50	2.68
Apr	2.83	2.38	2.56	2.47	2.59	2.62	-	2.68	2.83	2.80	3.08	2.93	3.26	3.05	3.41	3.11	3.44	3.08	3.41	3.02	3.26	2.87	3.08	2.71	2.87	2.53	2.65	2.41	2.47	2.32	2.32
May	2.82	2.68	2.59	2.80	2.65	2.96	-	2.71	3.11	2.83	3.26	2.93	3.35	2.96	3.35	2.96	3.29	2.93	3.17	2.83	3.02	2.74	2.83	2.62	2.65	2.50	2.50	2.44	2.35	2.41	2.29
Jun	2.77	2.99	-	2.62	3.08	2.68	3.17	2.77	3.20	2.83	3.23	2.87	3.17	2.87	3.11	2.83	2.99	2.77	2.83	2.71	2.71	2.65	2.56	2.59	2.44	2.53	2.35	2.53	2.29	2.56	2.26
Jul	2.72	2.53	2.99	2.56	3.02	2.65	3.05	2.74	3.08	2.80	3.08	2.87	3.02	2.87	2.96	2.83	2.87	2.80	2.74	2.74	2.62	2.68	2.50	2.65	2.41	2.59	2.32	2.59	2.26	2.62	2.29
Aug	2.70	2.59	2.90	2.68	2.93	2.77	2.96	2.87	2.96	2.90	2.93	2.90	2.87	2.87	2.77	2.83	2.65	2.77	2.53	2.68	2.41	2.62	2.32	2.59	2.29	2.59	2.29	2.65	-	2.41	2.77
Sep	2.71	2.77	2.83	2.83	2.87	2.90	2.87	2.93	2.83	2.90	2.74	2.87	2.65	2.77	2.56	2.71	2.44	2.62	2.35	2.56	2.32	2.53	2.35	2.59	2.50	2.71	-	2.71	2.87	2.96	3.05
Oct	2.75	2.83	2.77	2.90	2.77	2.93	2.77	2.93	2.71	2.87	2.65	2.80	2.56	2.71	2.50	2.62	2.44	2.56	2.44	2.53	2.50	2.56	2.62	2.65	-	2.83	2.80	3.05	2.96	3.26	3.11
Nov	2.83	2.93	2.71	2.93	2.68	2.90	2.68	2.83	2.65	2.77	2.62	2.68	2.59	2.59	2.62	2.56	2.68	2.56	2.77	2.59	2.93	2.71	-	3.08	2.83	3.23	2.96	3.35	3.05	3.38	3.11
Dec	2.86	2.96	2.74	2.96	2.77	2.93	2.80	2.87	2.80	2.77	2.83	2.68	2.63	2.62	2.83	2.56	2.90	2.53	2.96	2.59	-	3.02	2.65	3.11	2.77	3.20	2.90	3.23	2.99	3.20	3.02

TABLE A.2.13(2) High Water Level at Cutuco/La Union 1993

Month	16		17		18		19		20		21		22		23		24		25		26		27		28		29		30		31	
Jan	2.56	2.87	2.41	2.74	2.32	2.68	2.35	-	2.68	2.41	2.71	2.53	2.74	2.62	2.80	2.74	2.83	2.80	2.83	2.83	2.80	2.83	2.74	2.83	2.65	2.77	2.53	2.71	2.41	2.65	2.32	2.59
Feb	2.26	2.50	2.26	-	2.47	2.35	1.53	2.47	2.59	2.59	2.65	2.71	2.71	2.80	2.74	2.87	2.74	2.90	2.71	2.90	2.65	2.83	2.53	2.77	2.44	2.71						
Mar	2.35	2.50	2.23	2.38	2.23	-	2.35	2.32	2.38	2.44	2.44	2.56	2.53	2.71	2.62	2.80	2.65	2.90	2.68	2.93	2.68	2.93	2.62	2.90	2.56	2.83	2.47	2.74	2.41	2.65	2.38	2.59
Apr	2.29	2.29	2.35	-	2.29	2.44	2.35	2.59	2.44	2.71	2.50	2.83	2.59	2.90	2.62	2.96	2.65	2.99	2.62	2.96	2.62	2.90	2.59	2.83	2.56	2.74	2.56	2.65	2.59	2.59		
May	2.44	2.26	2.50	-	2.29	2.62	2.35	2.71	2.44	2.83	2.53	2.93	2.59	3.02	2.65	3.05	2.71	3.05	2.74	2.99	2.77	2.93	2.77	2.87	2.80	2.77	2.83	2.68	2.87	2.62	2.93	2.59
Jun	2.62	-	2.32	2.71	2.38	2.83	2.50	2.96	2.62	3.05	2.74	3.11	2.87	3.14	2.96	3.14	3.02	3.08	3.05	2.99	3.05	2.87	3.02	2.74	2.99	2.62	2.96	2.56	2.96	-		
Jul	2.71	-	2.38	2.80	2.50	2.96	2.68	3.08	2.90	3.20	3.05	3.26	3.17	3.26	3.26	3.20	3.26	3.08	3.20	2.93	3.11	2.74	3.02	2.41	2.90	2.50	2.83	2.44	2.80	-	2.50	2.83
Aug	2.59	2.93	2.80	3.08	3.05	3.23	3.23	3.29	3.38	3.32	3.41	3.26	3.38	3.11	3.29	2.96	3.11	2.74	2.93	2.56	2.77	2.44	2.65	2.41	2.62	-	2.47	2.65	2.56	2.71	2.68	2.77
Sep	3.20	3.20	3.38	3.29	3.47	3.29	3.51	3.23	3.41	3.11	3.26	2.93	3.05	2.71	2.83	2.56	2.65	2.44	2.53	2.41	2.47	-	2.44	2.50	2.53	2.56	2.65	2.65	2.74	2.71		
Oct	3.41	3.20	3.47	3.23	3.47	3.17	3.35	3.05	3.20	2.90	2.99	2.74	2.74	2.59	2.56	2.47	2.41	2.44	2.35	2.44	2.35	-	2.53	2.41	2.62	2.50	2.71	2.56	2.80	2.65	2.90	2.68
Nov	3.35	3.08	3.26	3.02	3.11	2.93	2.93	2.80	2.71	2.65	2.53	2.56	2.38	2.50	2.29	2.47	2.26	2.50	2.26	-	2.56	2.32	2.65	2.41	2.77	2.50	2.83	2.59	2.93	2.68		
Dec	3.14	2.99	3.05	2.96	2.90	2.87	2.71	2.74	2.56	2.65	2.41	2.56	2.29	2.50	2.19	2.50	2.16	2.53	2.19	-	2.59	2.29	2.68	2.41	2.77	2.56	2.90	2.68	2.96	2.83	3.02	2.93

HWL 2.79 m　　HHWL = 3.47 m　　in Cutuco/La Union

HWL 1.87 m　　HHWL = 2.32 m　　in La Libertad (WL Cutuco * 0.67)

TABLE A.2.14(1) Low Water Level at Cutuco/La Union 1993

Month	Mean	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
Jan	0.19	0.58	0.55	0.64	0.64	0.67	0.70	0.64	0.70	0.52	0.64	0.37	0.49	0.18	0.30	-0.03	0.12	-0.18	-0.06	-0.30	-0.18	-0.37	-0.21	-0.37	-	-0.21	-0.27	-0.09	-0.12	0.03	0.09
Feb	0.09	0.55	0.64	0.58	0.67	0.52	0.61	0.40	0.46	0.18	0.24	-0.03	0.00	-0.24	-0.21	-0.40	-0.37	-0.49	-0.40	-0.46	-0.37	-0.37	-	-0.24	-0.15	-0.06	0.06	0.15	0.30	0.37	0.55
Mar	0.04	0.34	0.46	0.43	0.55	0.46	0.58	0.46	0.55	0.34	0.40	0.15	0.15	-0.06	-0.09	-0.27	-0.30	-0.43	-0.46	-0.49	-0.49	-0.46	-0.46	-0.34	-	-0.30	-0.12	-0.09	0.12	0.15	0.37
Apr	0.06	0.37	0.52	0.37	0.46	0.34	0.30	0.15	0.09	-0.03	-0.12	-0.21	-0.30	-0.34	-0.43	-0.37	-0.46	-0.34	-0.40	-0.21	-0.24	-0.30	-	-0.06	0.21	0.15	0.43	0.37	0.61	0.55	0.73
May	0.15	0.27	0.40	0.24	0.27	0.18	0.12	0.06	-0.06	-0.06	-0.21	-0.15	-0.30	-0.18	-0.30	-0.12	-0.27	-0.03	-0.15	0.12	-	0.00	0.30	0.18	0.46	0.37	0.64	0.52	0.73	0.64	0.79
Jun	0.30	0.24	0.21	0.21	0.09	0.15	0.00	0.09	-0.09	0.06	-0.12	0.06	-0.09	0.12	-0.03	0.21	0.09	0.34	-	0.21	0.46	0.34	0.61	0.49	0.70	0.61	0.76	0.70	0.79	0.73	0.73
Jul	0.40	0.40	0.30	0.37	0.21	0.30	0.15	0.24	0.09	0.24	0.06	0.21	0.09	0.27	0.12	0.34	-	0.21	0.43	0.30	0.52	0.43	0.61	0.55	0.70	0.67	0.76	0.73	0.76	0.76	0.70
Aug	0.44	0.43	0.30	0.37	0.21	0.27	0.15	0.24	0.15	0.24	0.15	0.27	0.21	0.34	-	0.30	0.40	0.40	0.52	0.52	0.61	0.61	0.70	0.70	0.73	0.76	0.73	0.73	0.61	0.58	0.43
Sep	0.37	0.27	0.24	0.21	0.21	0.18	0.21	0.18	0.21	0.21	0.27	0.30	-	0.37	0.40	0.46	0.49	0.58	0.58	0.64	0.64	0.70	0.64	0.67	0.58	0.52	0.40	0.27	0.18	0.03	-0.03
Oct	0.28	0.21	0.27	0.15	0.24	0.12	0.27	0.15	0.30	0.18	0.37	0.27	-	0.43	0.37	0.52	0.46	0.58	0.52	0.61	0.55	0.55	0.49	0.43	0.34	0.21	0.15	-0.03	-0.03	-0.24	-0.18
Nov	0.17	0.09	0.30	0.09	0.30	0.12	0.34	0.15	0.37	0.21	-	0.43	0.27	0.46	0.37	0.49	0.40	0.46	0.40	0.34	0.30	0.18	0.18	0.00	0.06	-0.18	-0.06	-0.30	-0.15	-0.37	-0.18
Dec	0.13	0.06	0.27	0.03	0.24	0.03	0.24	0.06	-	0.24	0.12	0.27	0.18	0.30	0.24	0.34	0.30	0.30	0.34	0.21	0.27	0.09	0.21	-0.03	0.09	-0.15	0.03	-0.21	-0.03	-0.24	0.00

TABLE A.2.14(2) Low Water Level at Cutuco/La Union 1993

Month	16		17		18		19		20		21		22		23		24		25		26		27		28		29		30		31	
Jan	0.21	0.30	0.34	0.46	0.43	0.58	0.43	0.58	0.37	0.52	0.30	0.43	0.21	0.34	0.12	0.27	0.09	0.21	0.06	0.21	0.09	0.21	0.15	-	0.27	0.24	0.34	0.34	0.43	0.42	0.49	0.53
Feb	0.49	0.67	0.55	0.67	0.52	0.61	0.43	0.49	0.30	0.37	0.21	0.27	0.15	0.18	0.09	0.12	0.09	0.12	0.12	0.15	0.18	-	0.18	0.27	0.27	0.37						
Mar	0.37	0.58	0.55	0.73	0.61	0.73	0.61	0.67	0.52	1.52	0.43	0.40	0.30	0.27	0.21	0.15	0.18	0.09	0.15	0.06	0.15	0.06	0.18	0.09	0.24	-	0.15	0.30	0.21	0.40	0.30	0.49
Apr	0.64	0.76	0.67	0.70	0.61	0.58	0.52	0.46	0.43	0.30	0.34	0.18	0.27	0.12	0.24	0.06	0.21	0.03	0.21	0.03	0.24	-	0.06	0.46	0.12	0.34	0.18	0.40	0.24	0.43		
May	0.70	0.76	0.70	0.67	0.64	0.55	0.58	0.40	0.49	0.27	0.40	0.15	0.30	0.06	0.24	0.03	0.21	0.00	0.21	0.00	0.21	-	0.03	0.24	0.09	0.30	0.15	0.34	0.21	0.37	0.24	0.30
Jun	0.73	0.64	0.67	0.52	0.58	0.37	0.46	0.21	0.34	0.09	0.21	-0.03	0.12	-0.09	0.09	-0.12	0.06	-	-0.09	0.12	-0.03	0.18	0.09	0.27	0.18	0.34	0.30	0.37	0.37	0.37		
Jul	0.73	0.61	0.61	0.43	0.46	0.24	0.27	0.06	0.12	-0.09	-0.03	-0.18	-0.09	-0.24	-0.12	-0.21	-0.06	-	-0.12	0.06	0.03	0.21	0.21	0.37	0.37	0.46	0.49	0.52	0.55	0.46	0.52	0.40
Aug	0.40	0.21	0.15	0.00	-0.06	-0.18	-0.21	-0.30	-0.30	-0.34	-0.30	-0.27	-0.21	-	-0.15	-0.06	0.03	0.15	0.24	0.37	0.46	0.52	0.61	0.61	0.64	0.58	0.58	0.52	0.49	0.43	0.40	0.34
Sep	-0.18	-0.21	-0.37	-0.34	-0.43	-0.37	-0.43	-0.30	-0.30	-	-0.15	-0.09	0.06	0.12	0.30	0.37	0.52	0.55	0.67	0.67	0.70	0.67	0.64	0.61	0.52	0.52	0.40	0.43	0.27	0.34		
Oct	-0.40	-0.30	-0.46	-0.30	-0.43	-0.21	-0.30	-0.09	-0.12	-	0.12	0.12	0.34	0.34	0.55	0.55	0.67	0.67	0.70	0.73	0.67	0.70	0.58	0.61	0.46	0.55	0.34	0.46	0.21	0.40	0.15	0.34
Nov	-0.37	-0.12	-0.24	0.00	-0.09	-	0.15	0.09	0.34	0.30	0.52	0.49	0.64	0.64	0.73	0.73	0.70	0.76	0.64	0.73	0.55	0.67	0.43	0.58	0.30	0.49	0.18	0.40	0.12	0.34		
Dec	-0.18	0.06	-0.09	0.15	0.06	-	0.30	0.21	0.43	0.40	0.58	0.24	0.67	0.70	0.73	0.79	0.70	0.82	0.64	0.79	0.52	0.70	0.40	0.58	0.24	0.43	0.12	0.27	0.00	0.15	-0.09	0.09

LWL 0.22 m	LLWL= -0.49 m	in Cutuco/La Union
LWL 0.15 m	LLWL= -0.33 m	in La Libertad (WL Cutuco * 0.67)

FIGURES

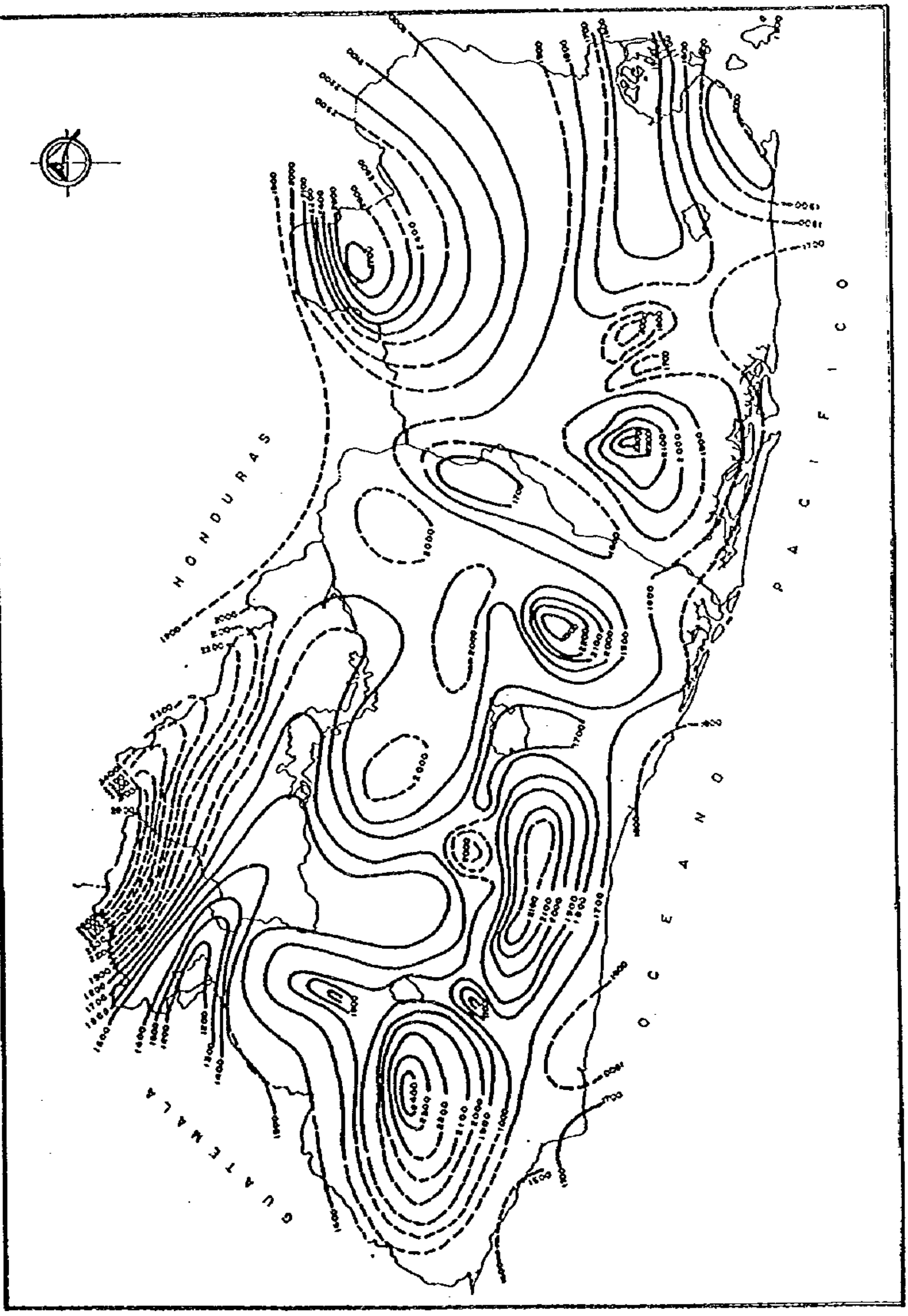


Fig. A.1.1 Isohyetal Map of Annual Rainfall in El Salvador

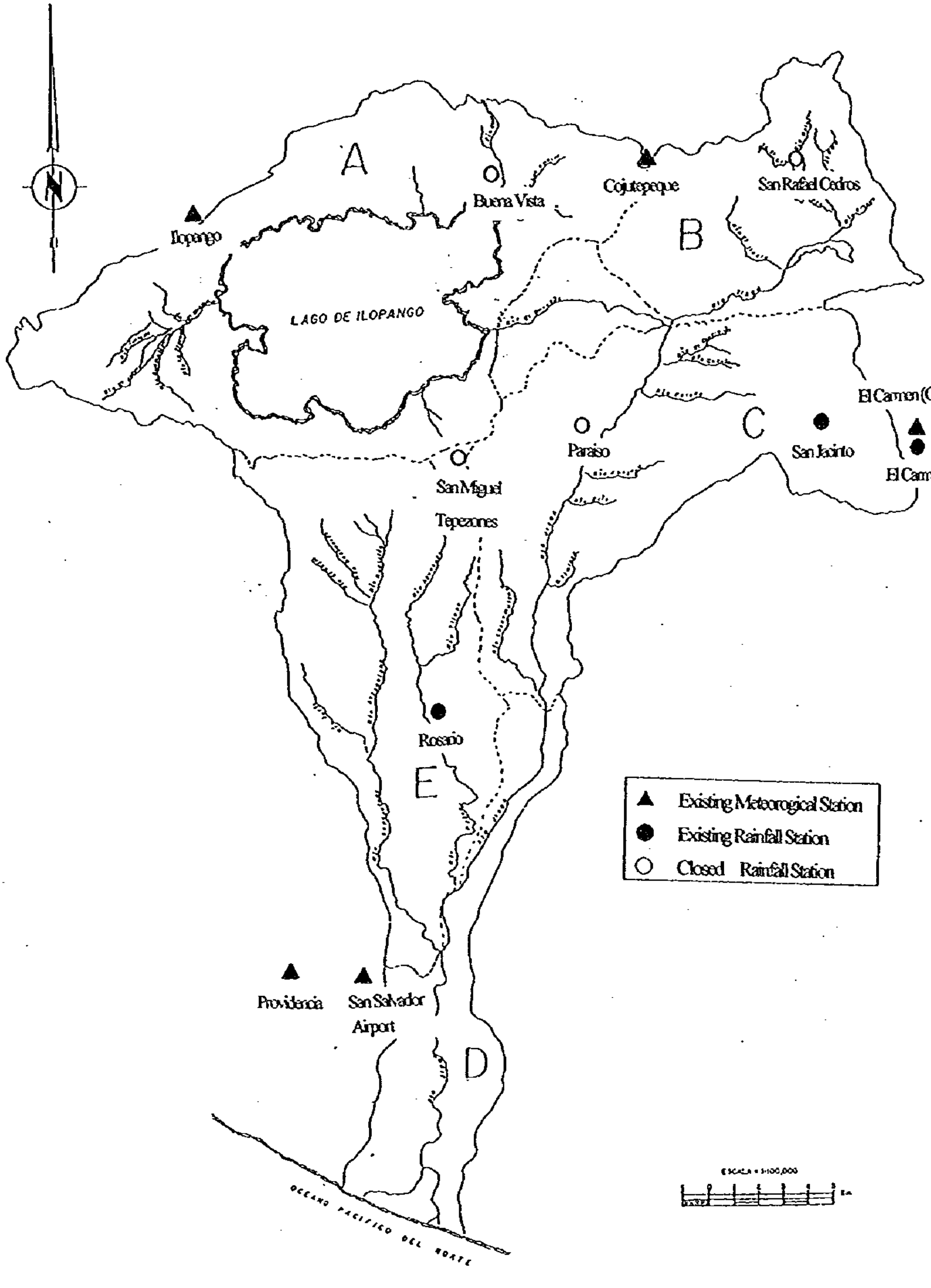


Fig. A.1.2 Location of Rainfall and Meteorological Stations

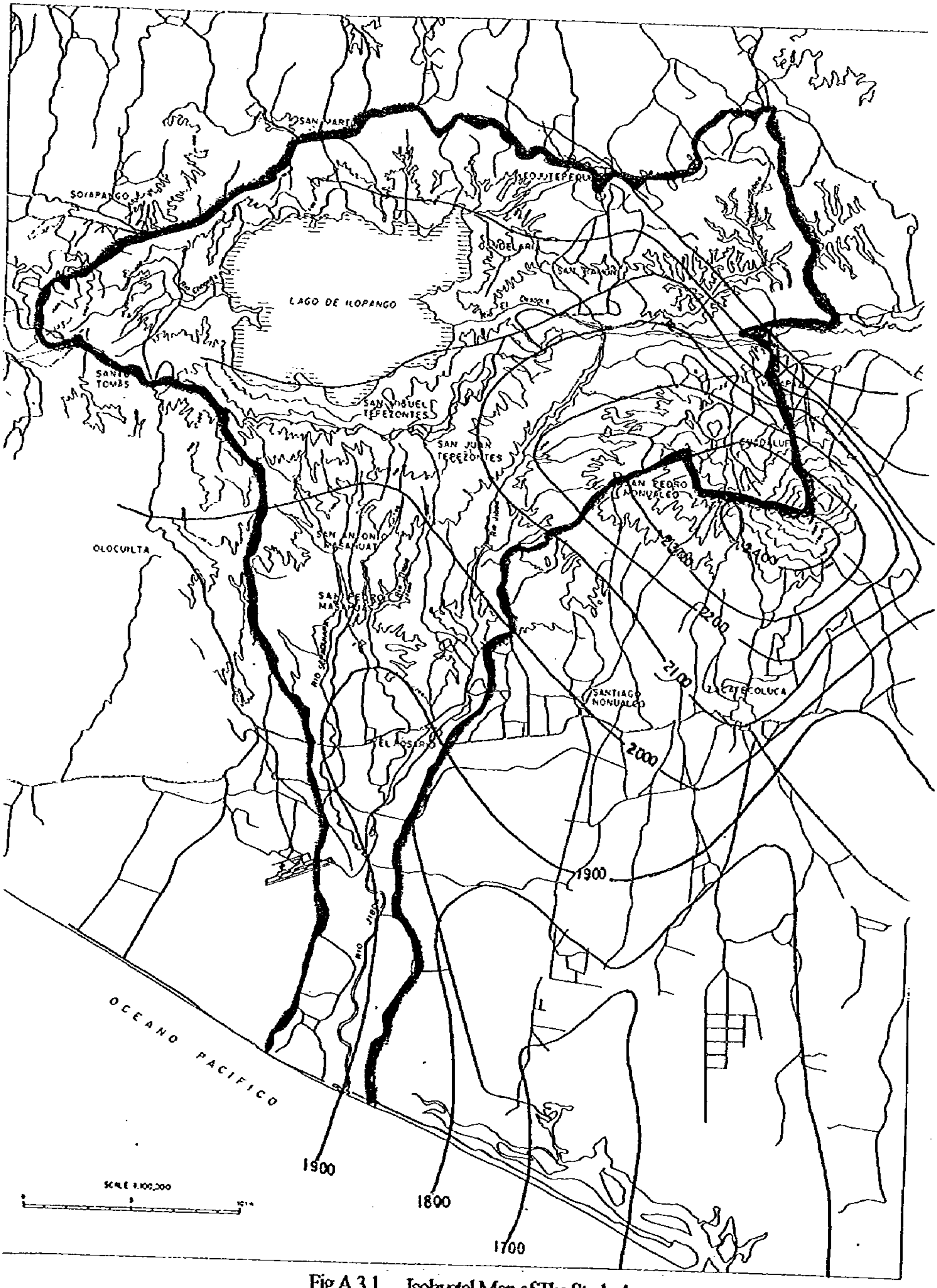
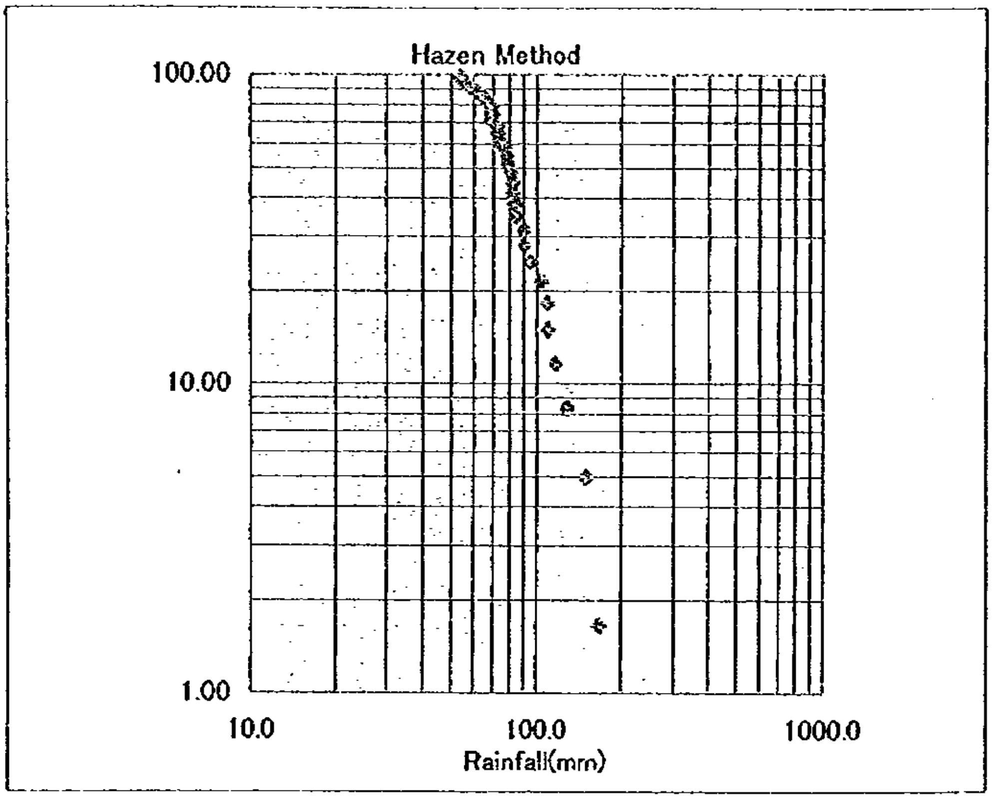


Fig.A.3.1 Isohyetal Map of The Study Area



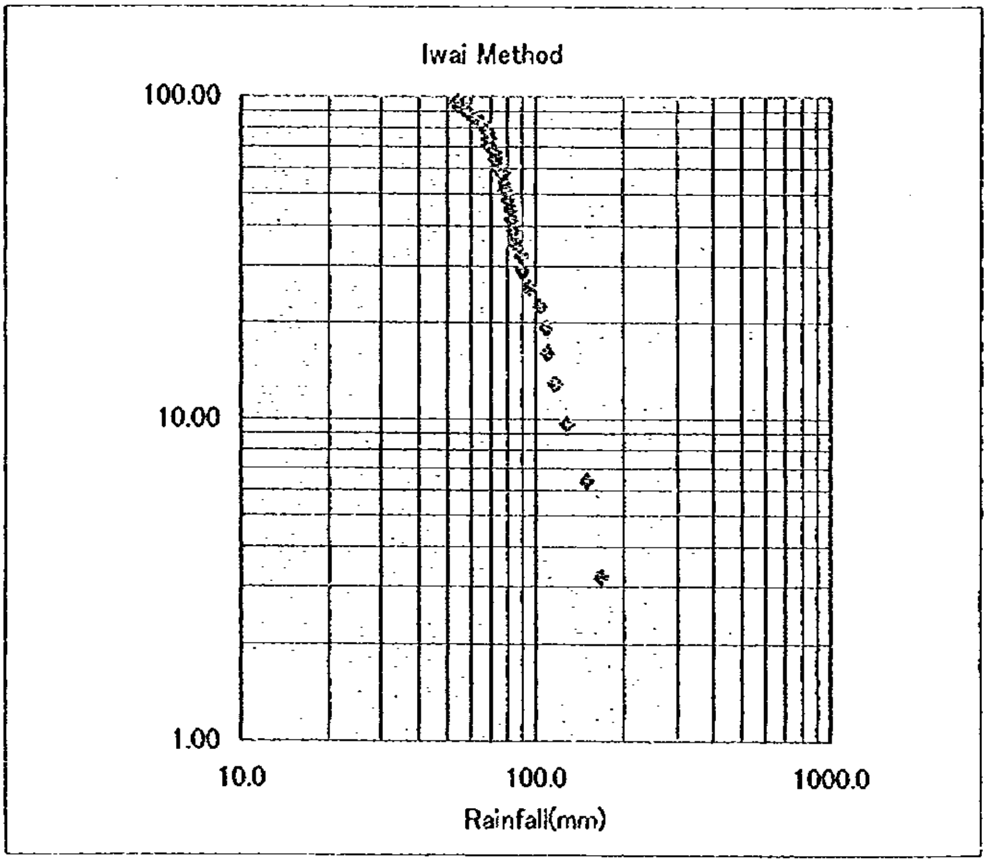
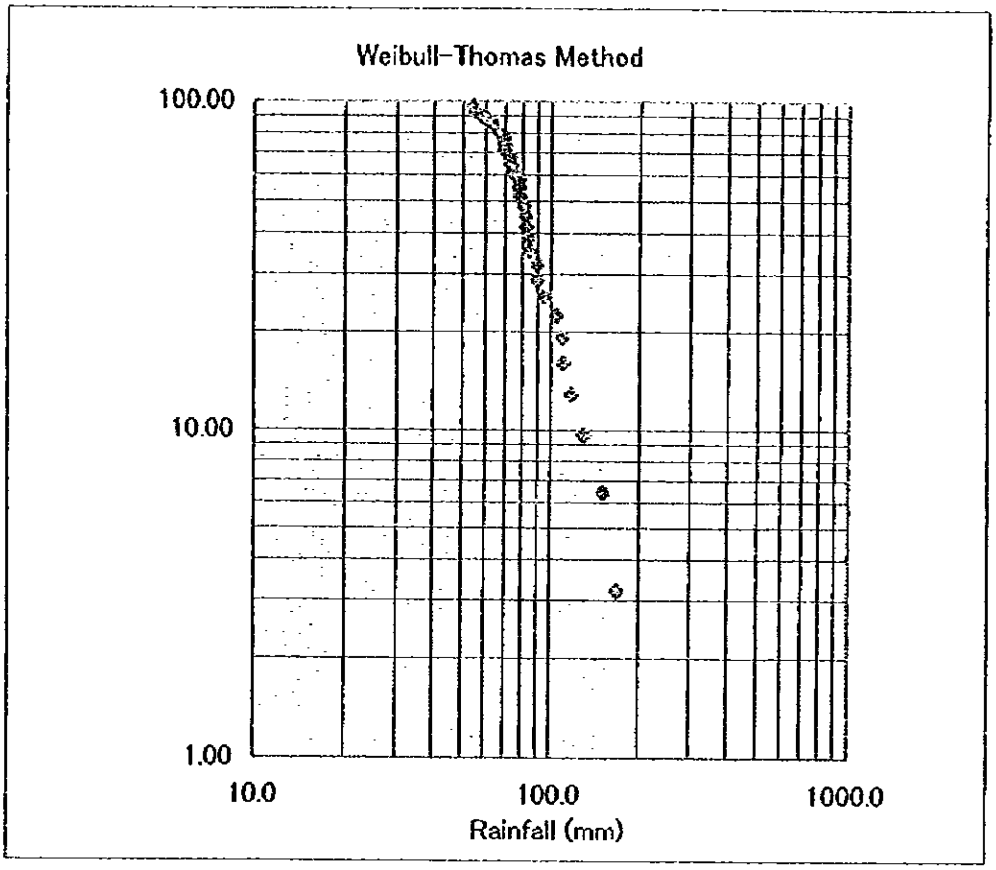


Fig. A.1.4 Frequency Analysis for Daily Rainfall at Ilopango



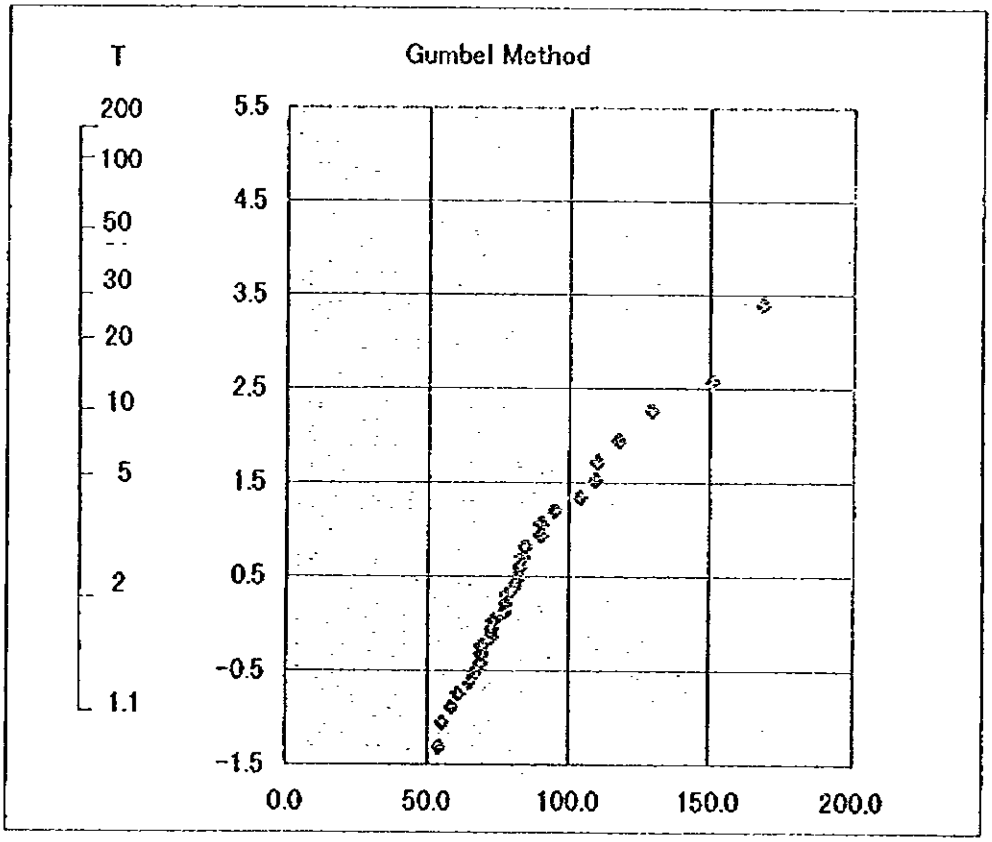
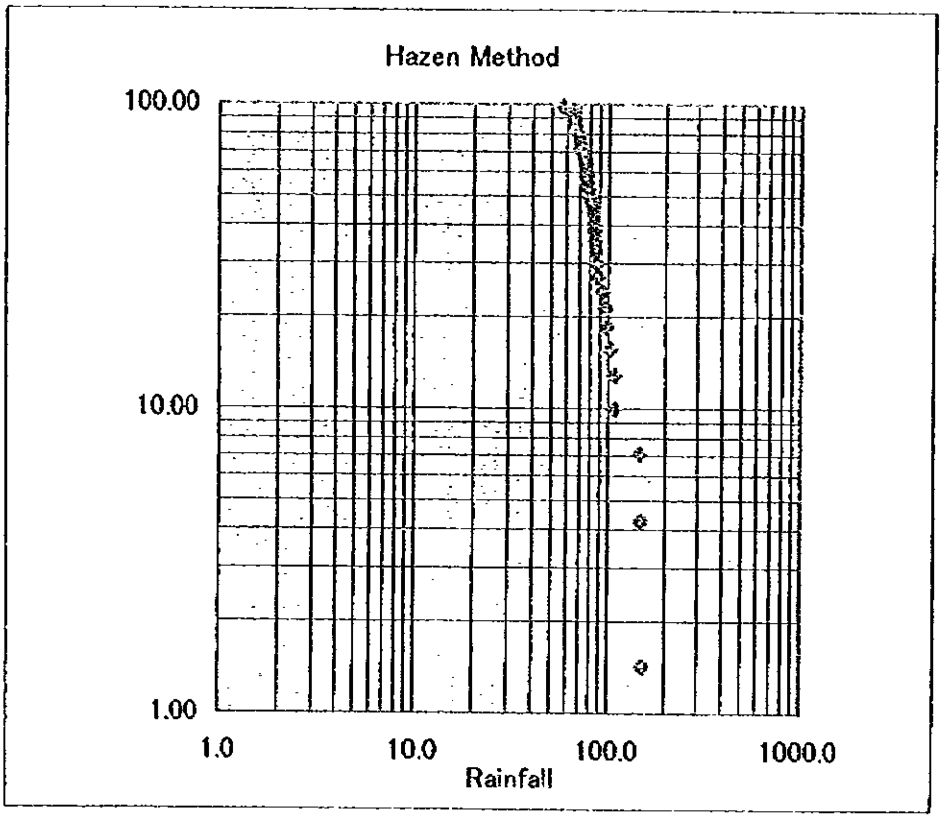


Fig. A.1.5 Frequency Analysis for Daily Rainfall at Ilopango



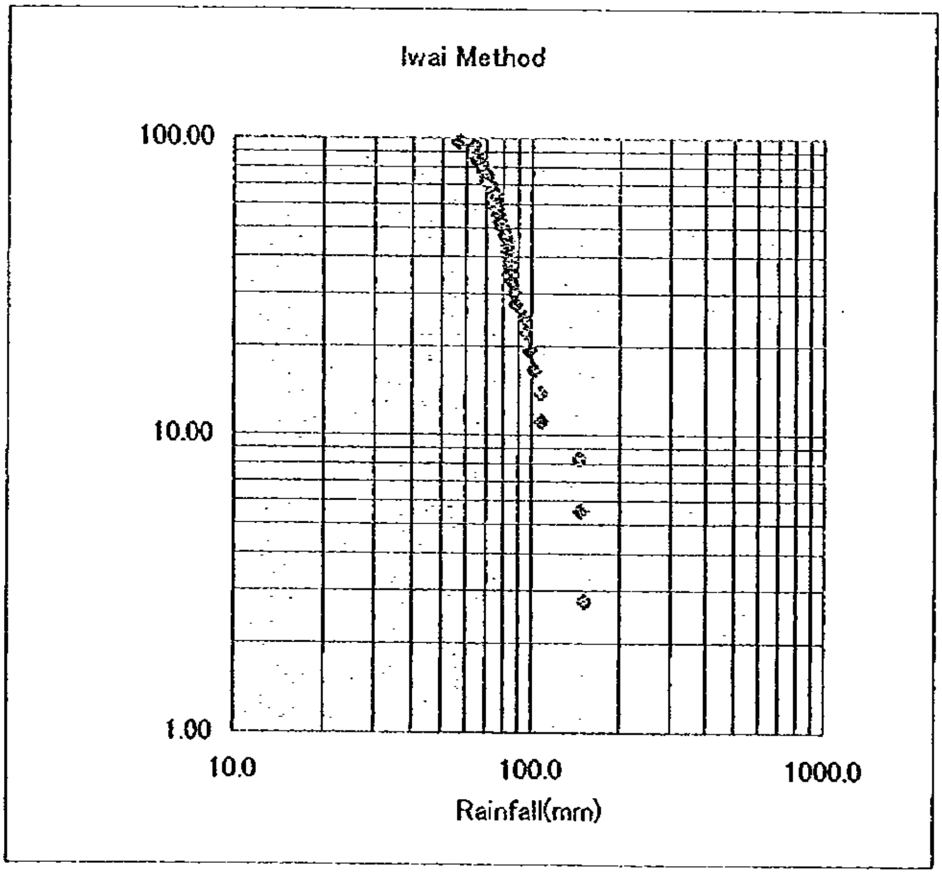
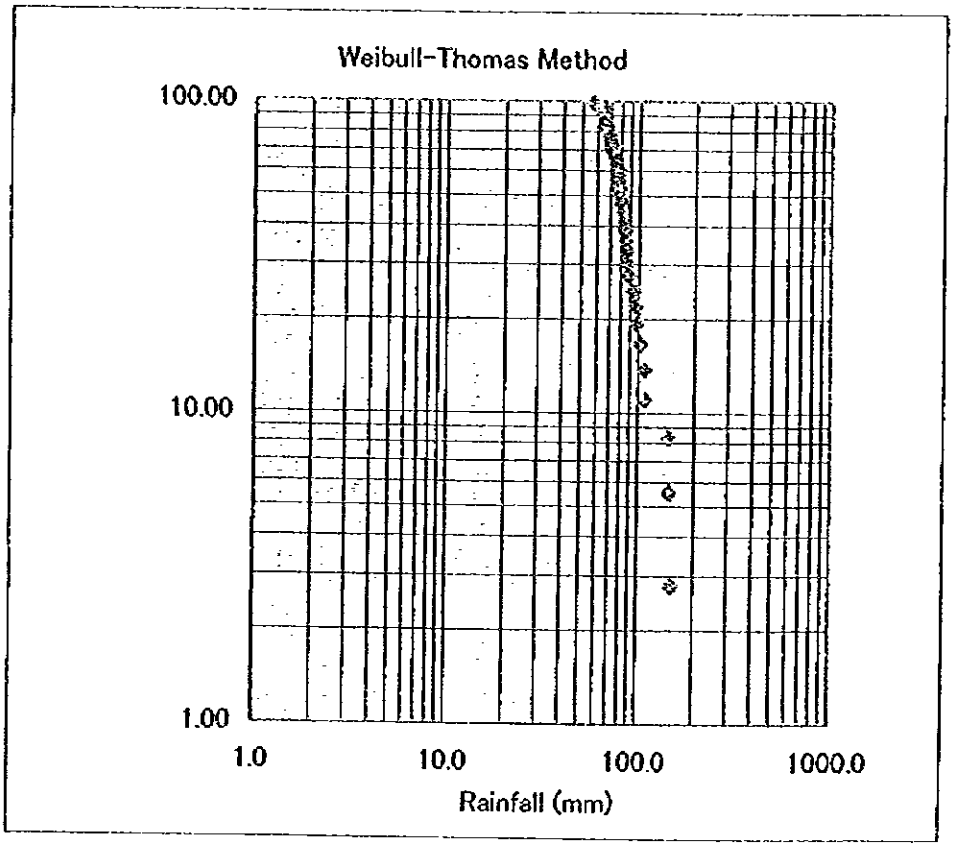


Fig. A.1.6 Frequency Analysis for Daily Rainfall at Cojutepeque



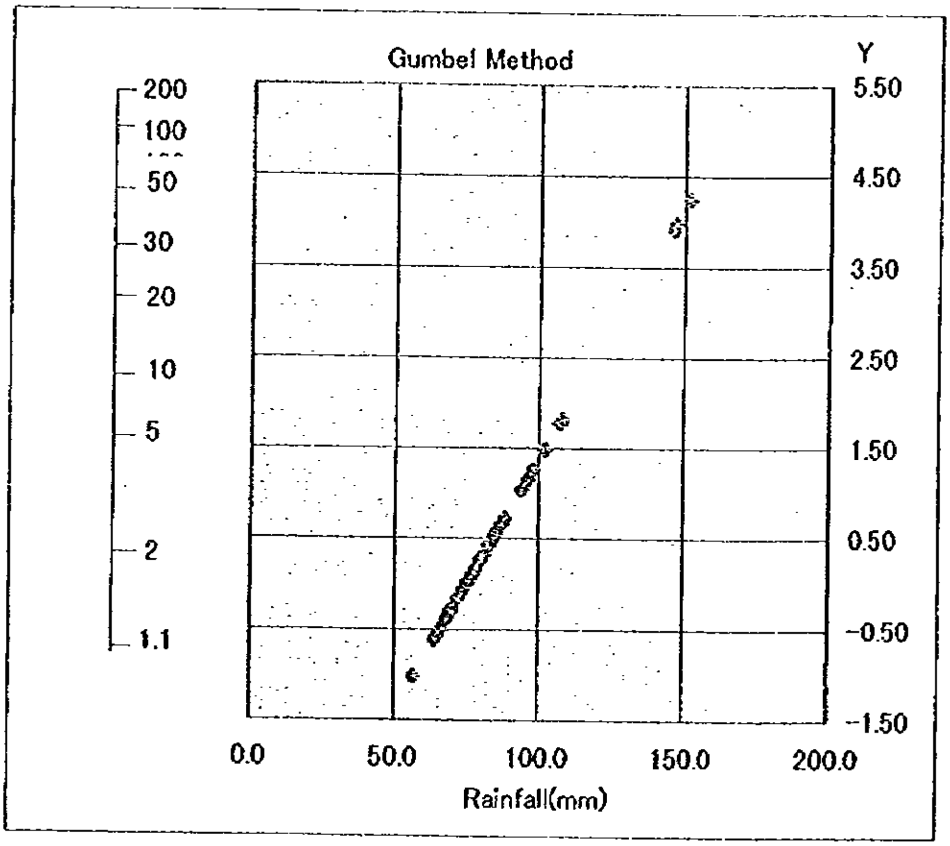
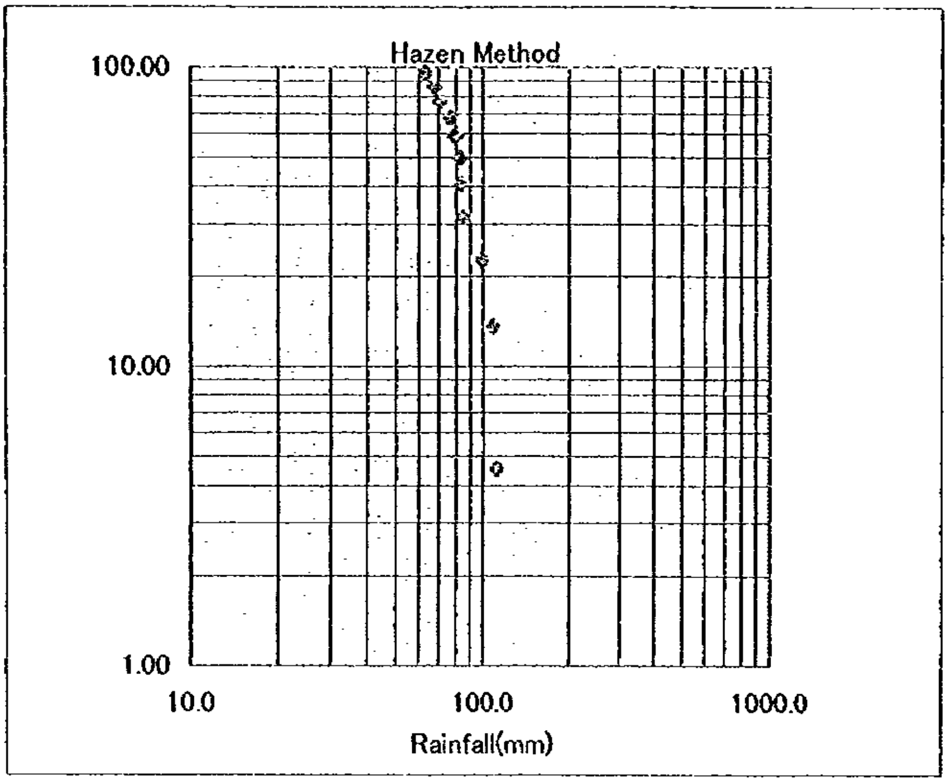


Fig. A.1.7 Frequency Analysis for Daily Rainfall at Cojutepeque



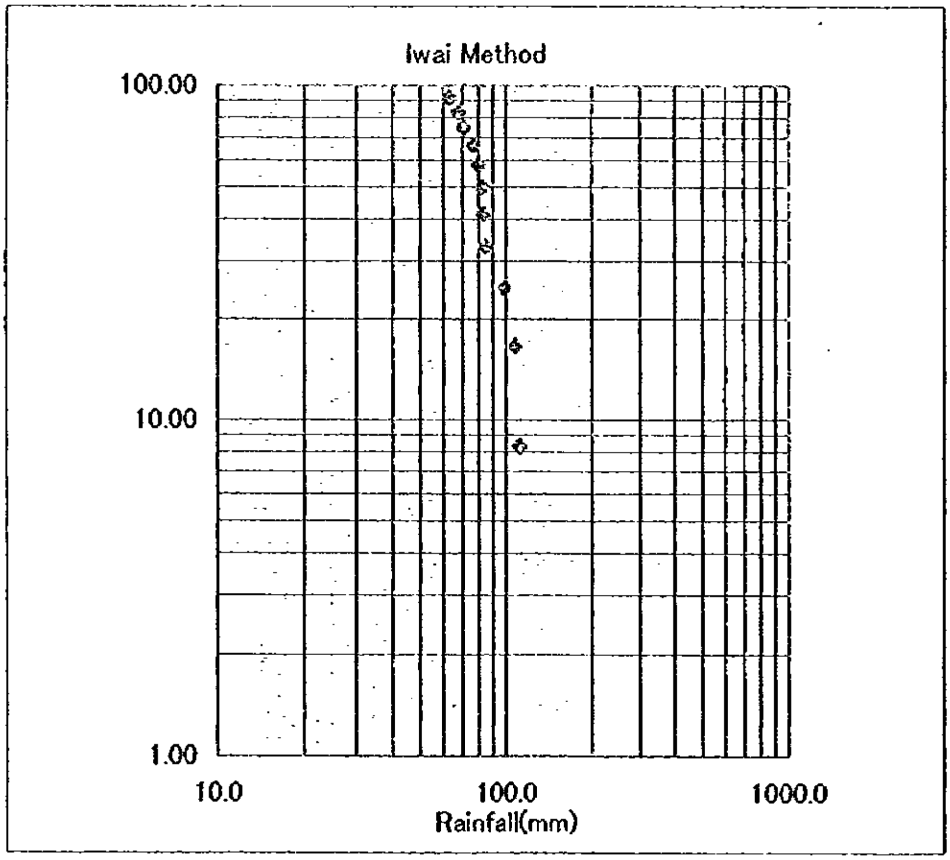
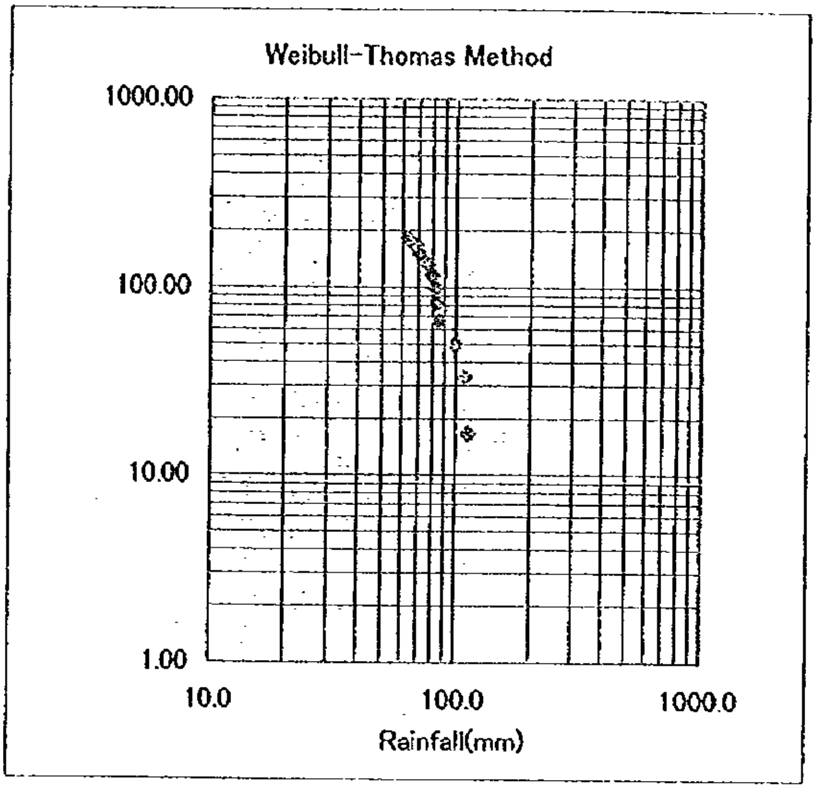


Fig. A.1.8 Frequency Analysis for Daily Rainfall at San Salvador Airport



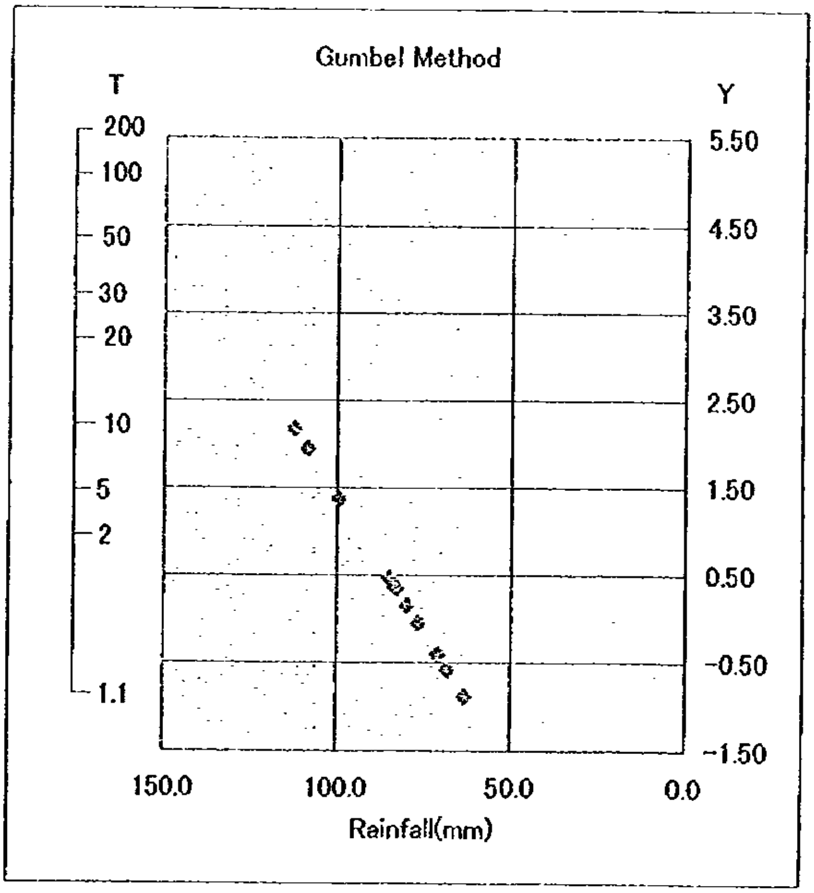
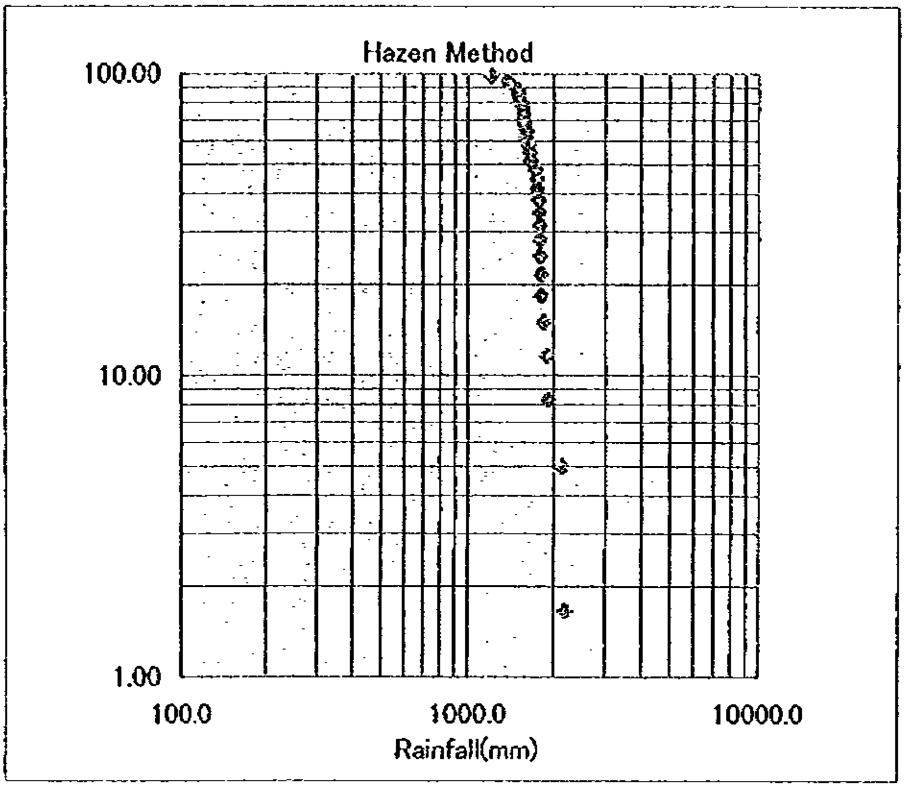


Fig. A.1.9 Frequency Analysis for Daily Rainfall at San Salvador Airport



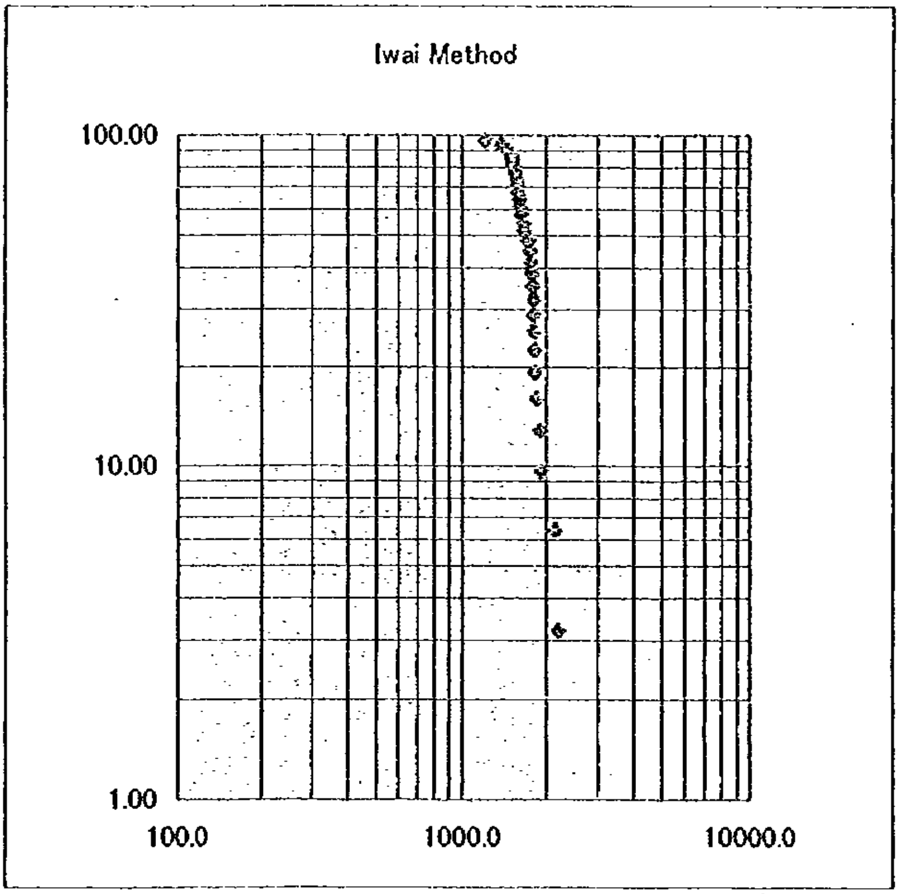
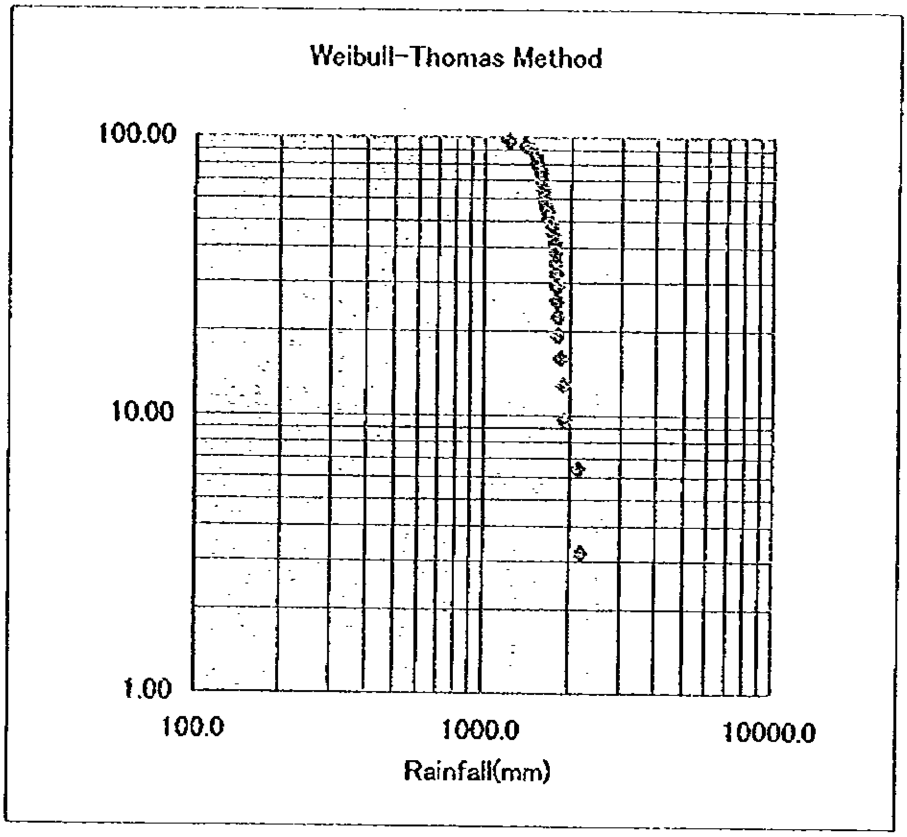


Fig. A.1.10 Frequency Analysis for Annually Rainfall at Ilopango



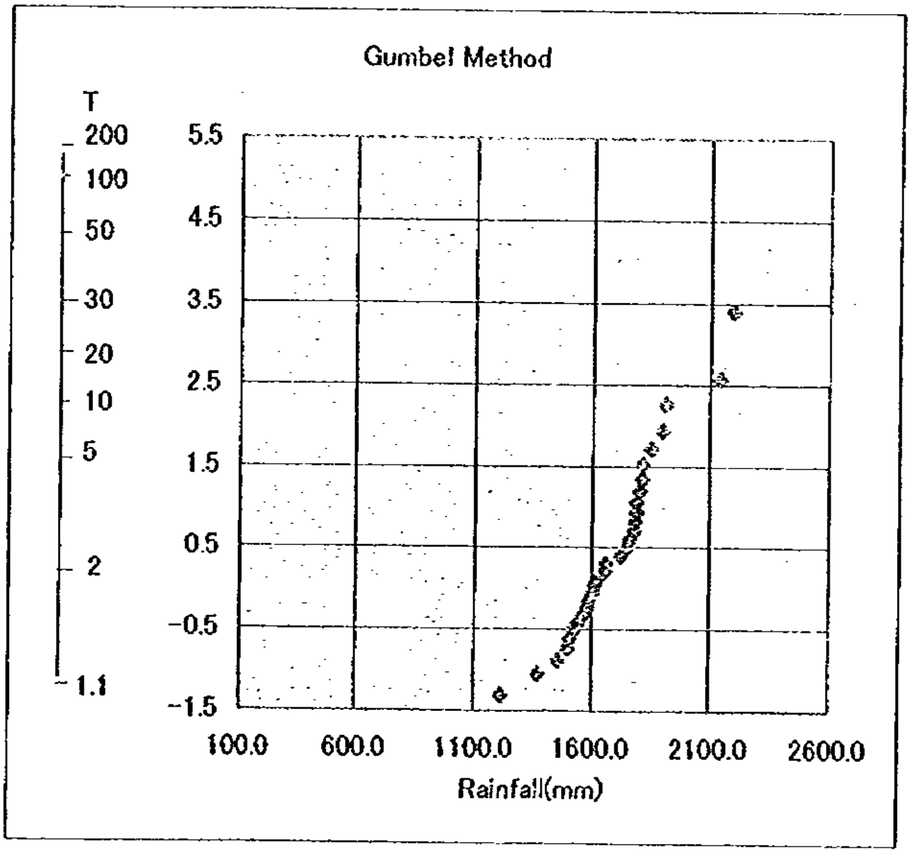


Fig. A.1.11 Frequency Analysis for Annually Rainfall at Ilopango

Rainfall at Ilopango 1 in 33 years

T(hr)	Rainfall Intensity (mm/hr)		
	Pattern A	Pattern B	Pattern C
1	80.2	5.2	5.0
2	48.6	5.7	5.2
3	34.9	6.3	5.5
4	27.2	7.0	5.7
5	22.3	8.0	6.0
6	18.9	9.1	6.3
7	16.4	10.7	6.7
8	14.5	13.0	7.0
9	13.0	16.4	7.5
10	11.7	22.3	8.0
11	10.7	34.9	8.5
12	9.9	80.2	9.1
13	9.1	48.6	9.9
14	8.5	27.2	10.7
15	8.0	18.9	11.7
16	7.5	14.5	13.0
17	7.0	11.7	14.5
18	6.7	9.9	16.4
19	6.3	8.5	18.9
20	6.0	7.5	22.3
21	5.7	6.7	27.2
22	5.5	6.0	34.9
23	5.2	5.5	48.6
24	5.0	5.0	80.2

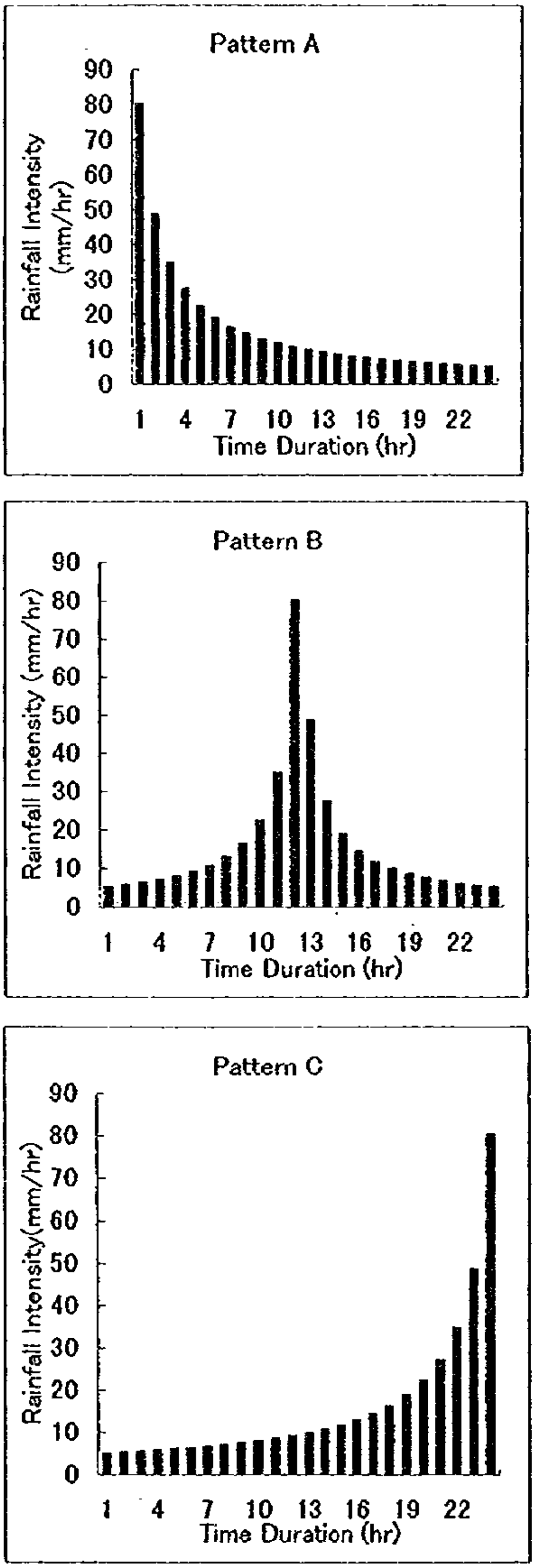


Fig. A.1.12 Rainfall Pattern for Runoff Analysis

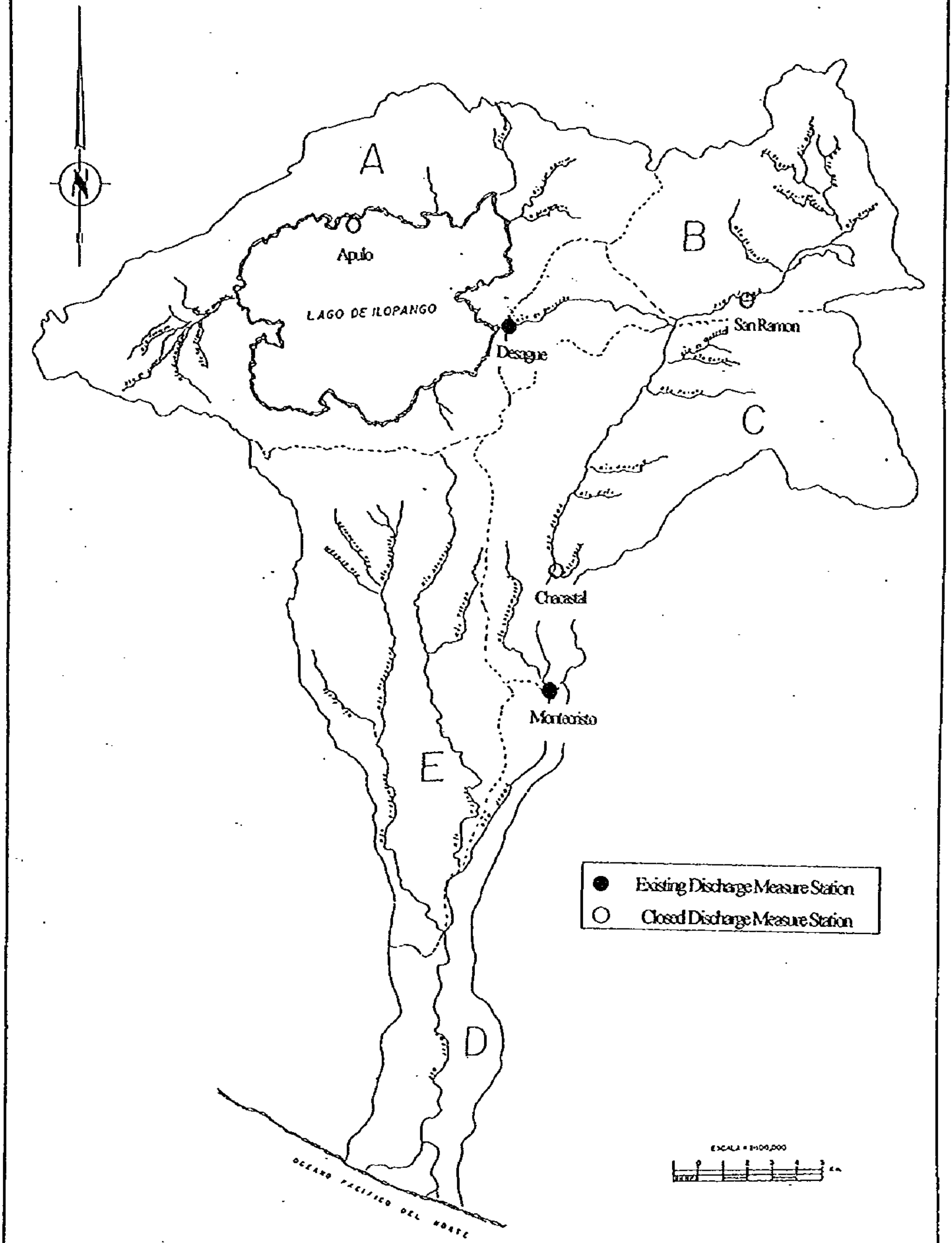


Fig. A.2.1 Location of Discharge Measurement Stations

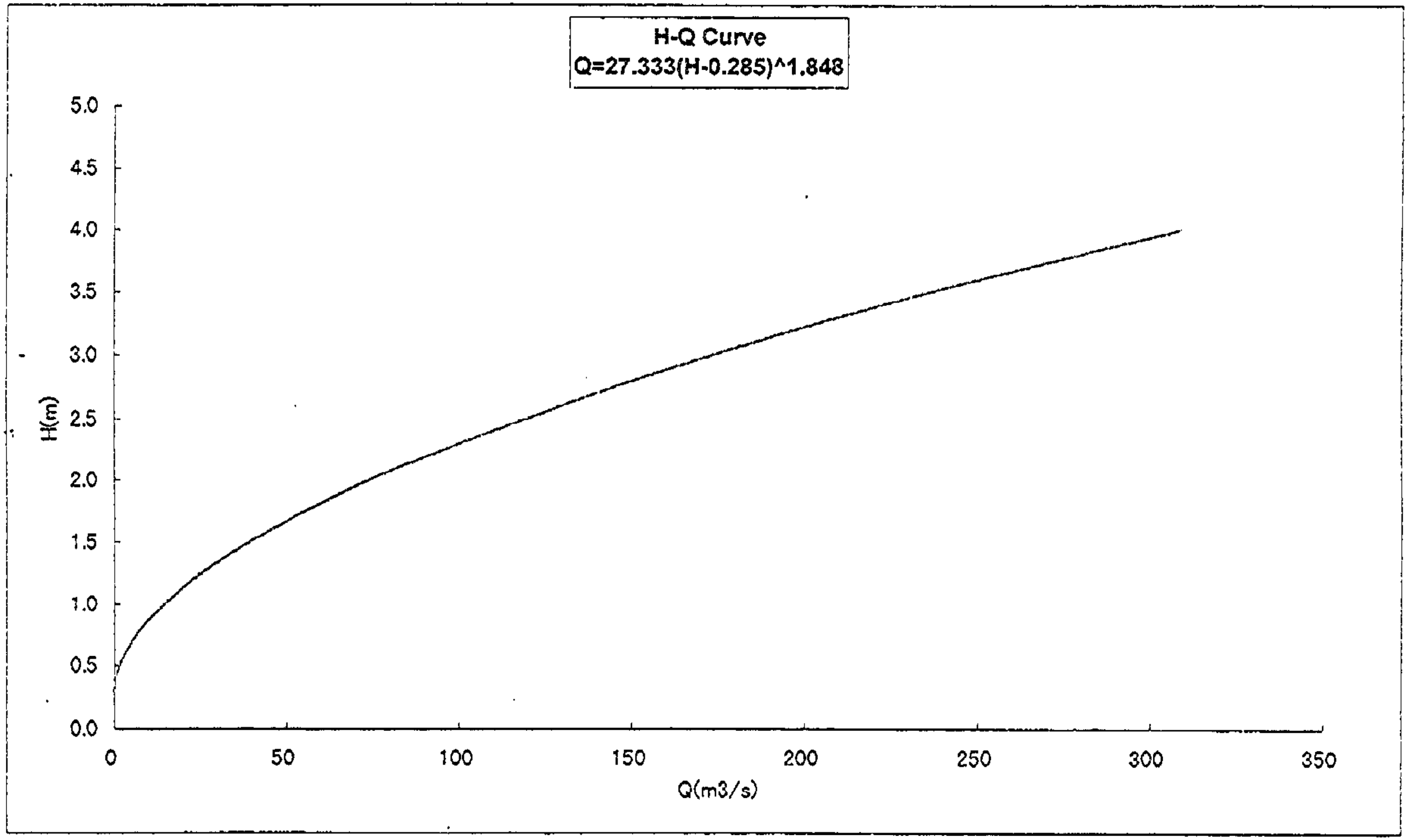


Fig. A.2.2 H-Q Curve for Montecristo Station

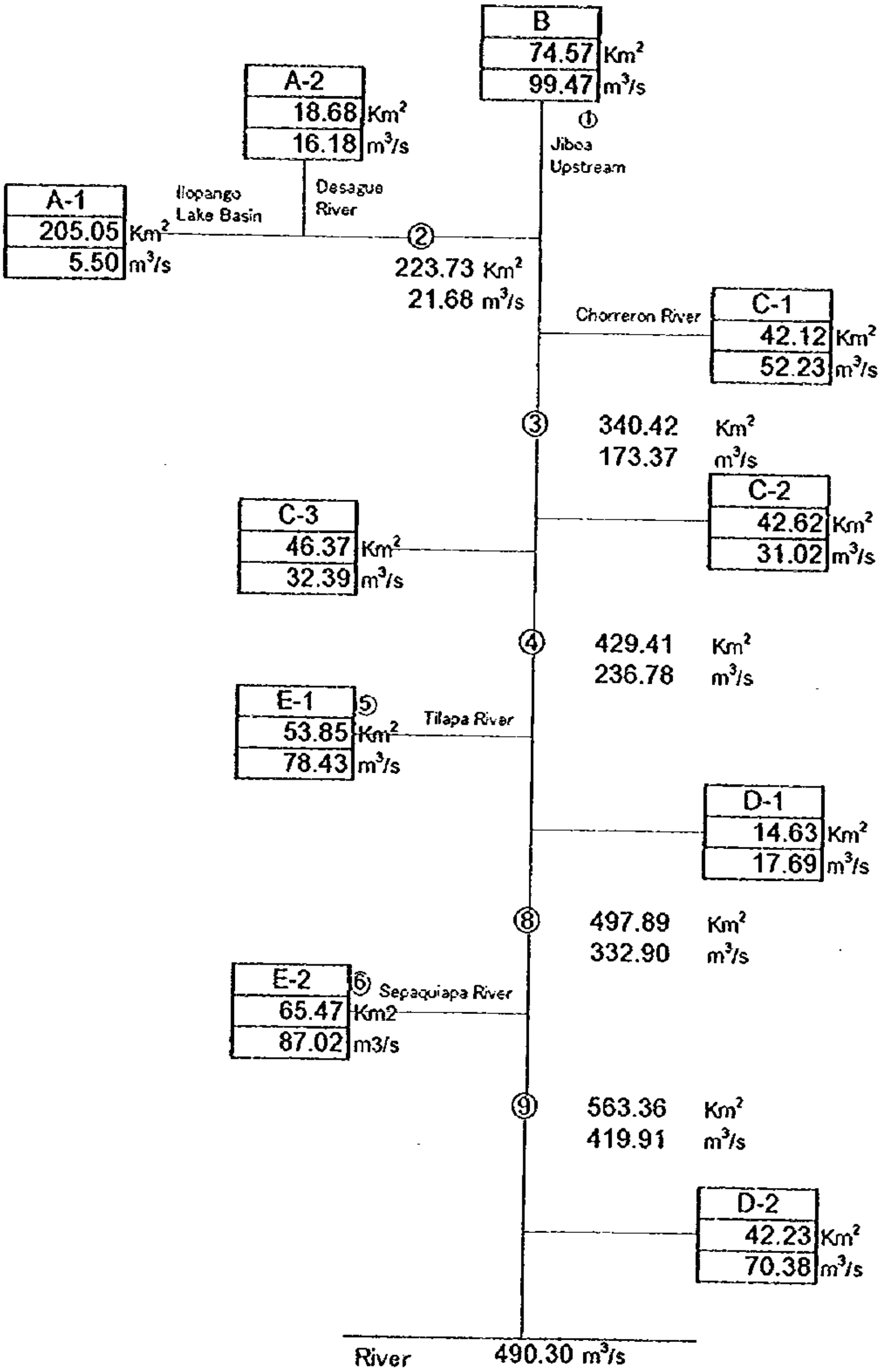


Fig. A.2.3 Peak Flood for Return Period 1 in 5 Years

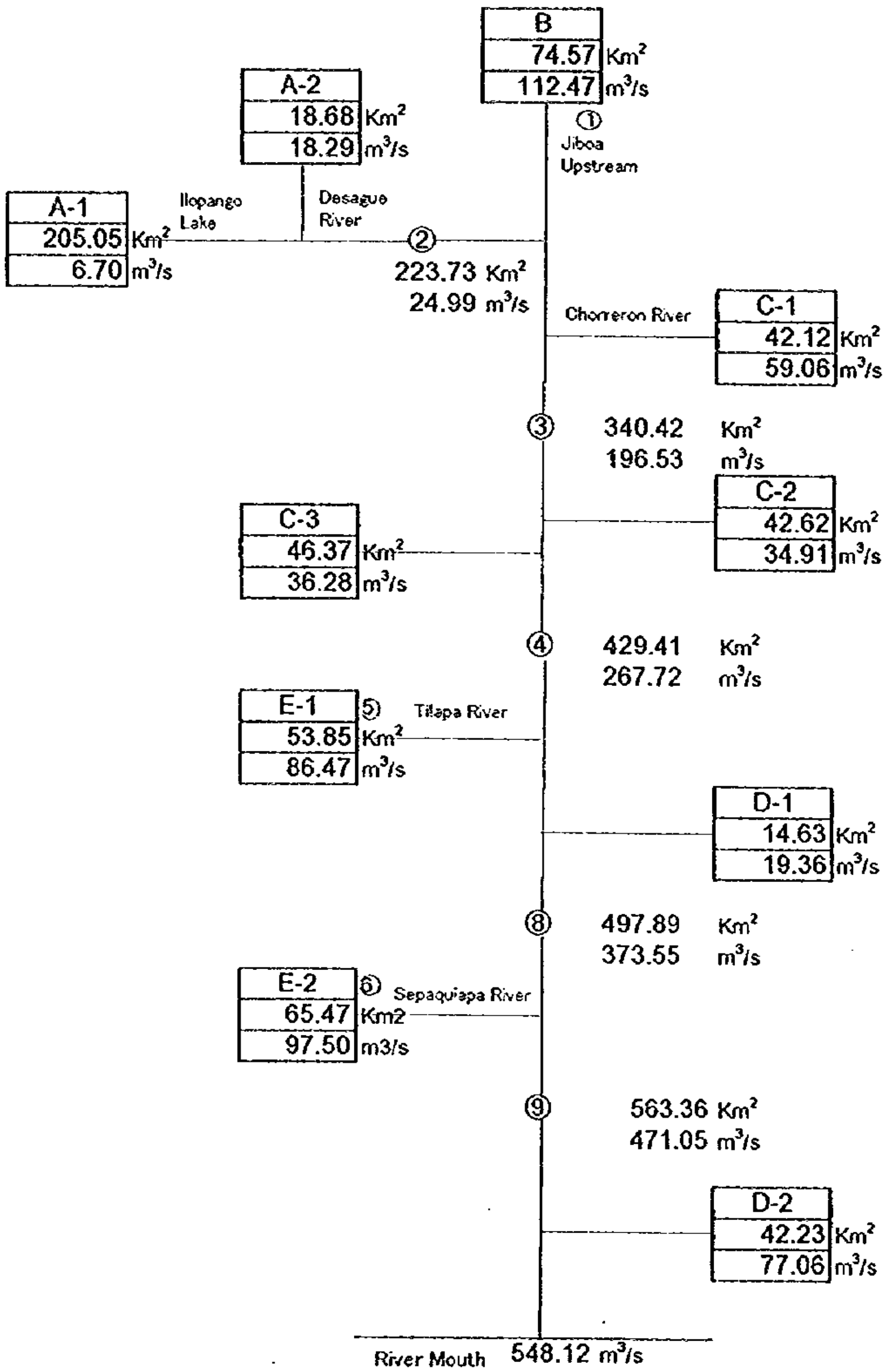


Fig. A.2.4 Peak Flood for Return Period 1 in 10 Years

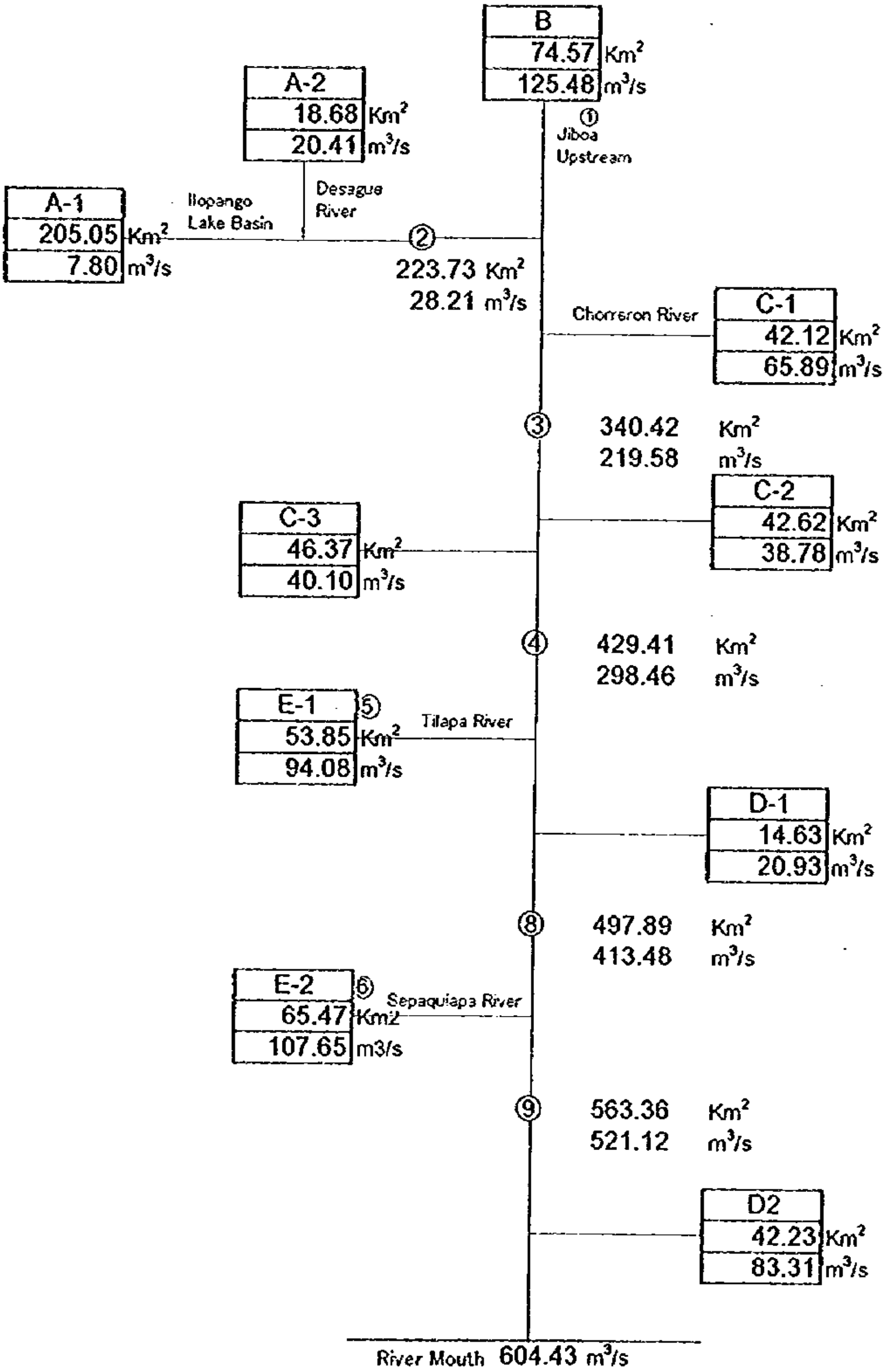


Fig. A2.5 Peak Flood for Return Period 1 in 20 Years

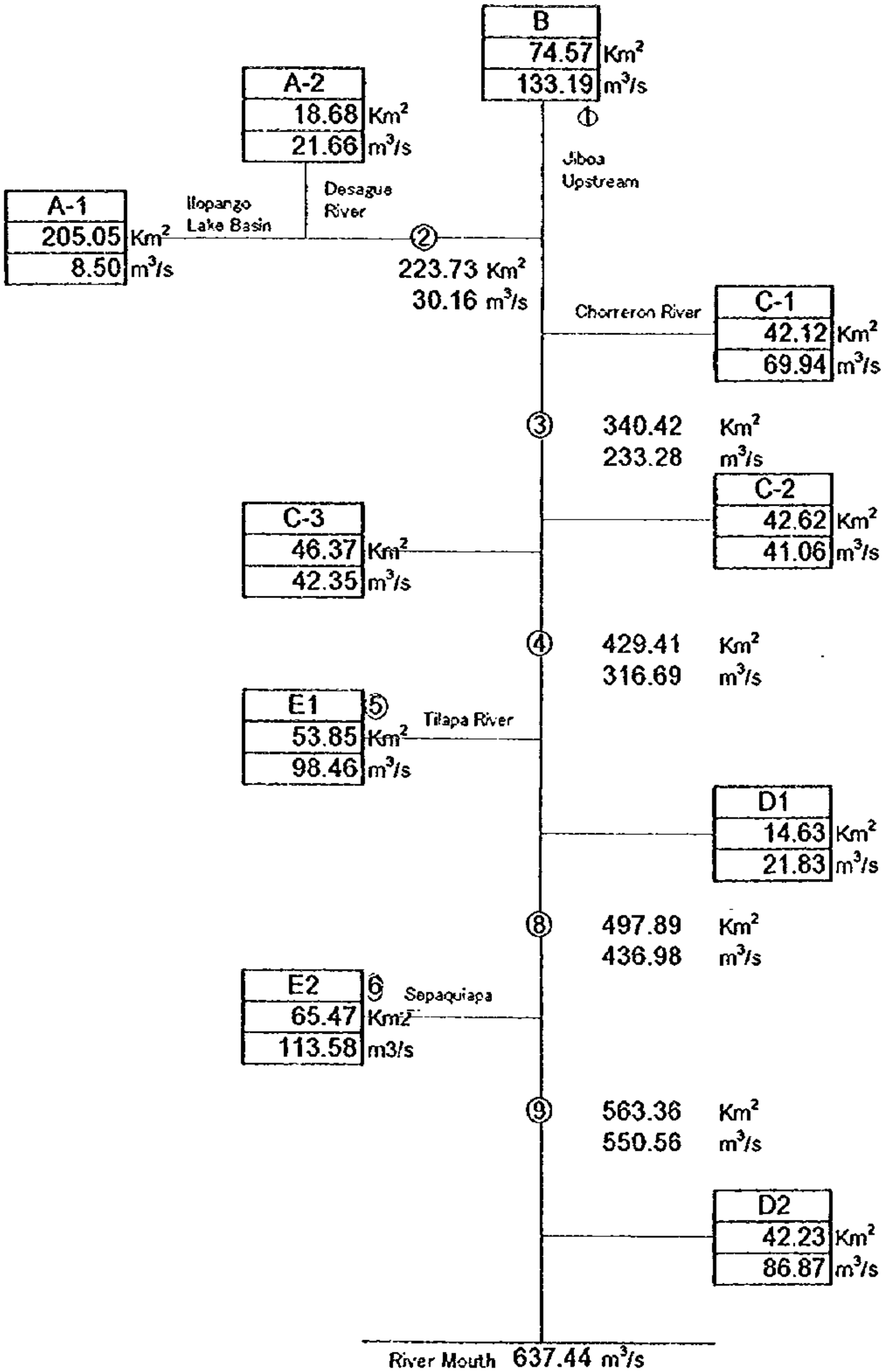


Fig. A2.6 Peak Flood for Return Period 1 in 30 Years

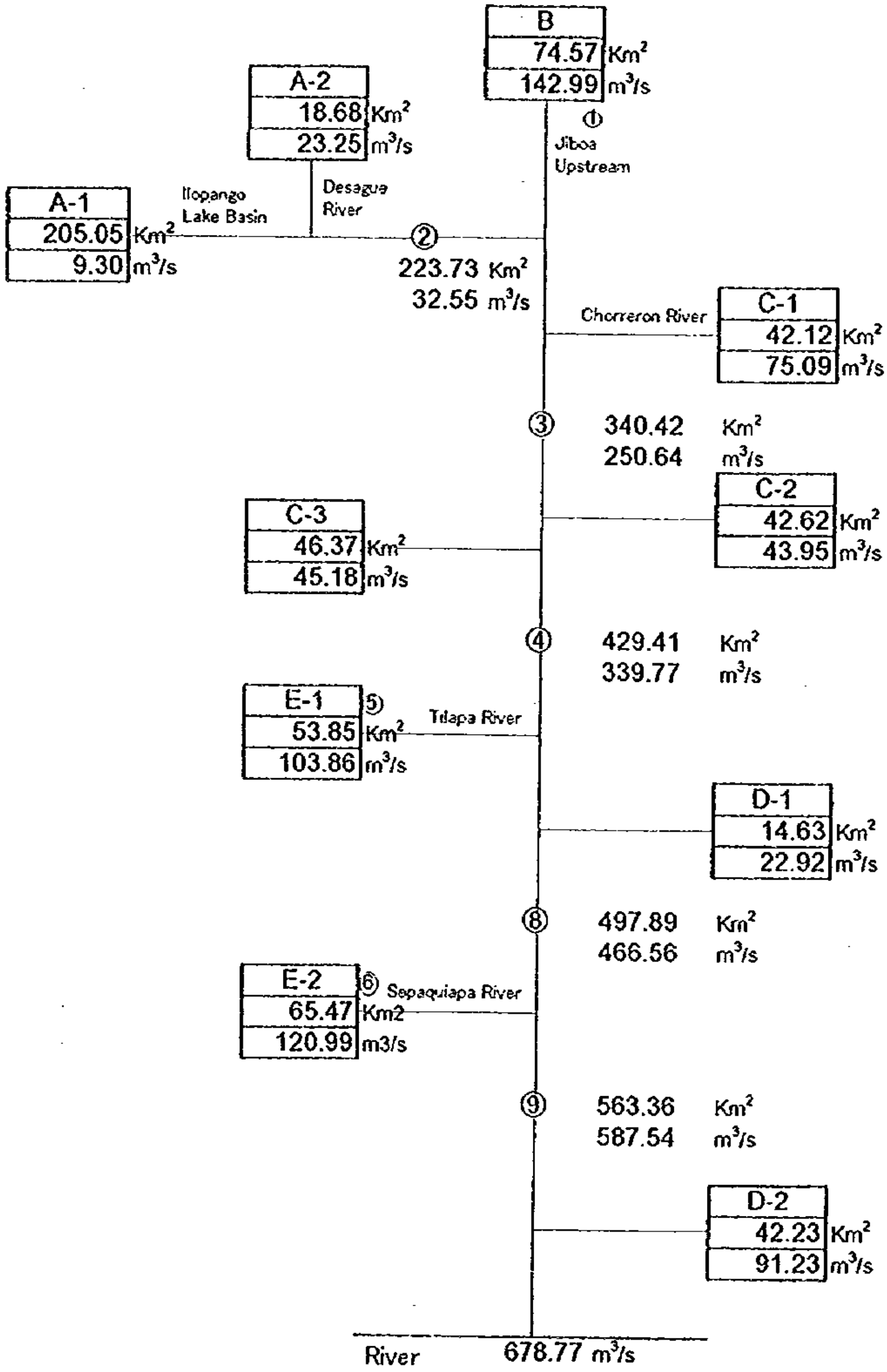


Fig. A.2.7 Peak Flood for Return Period 1 in 50 Years

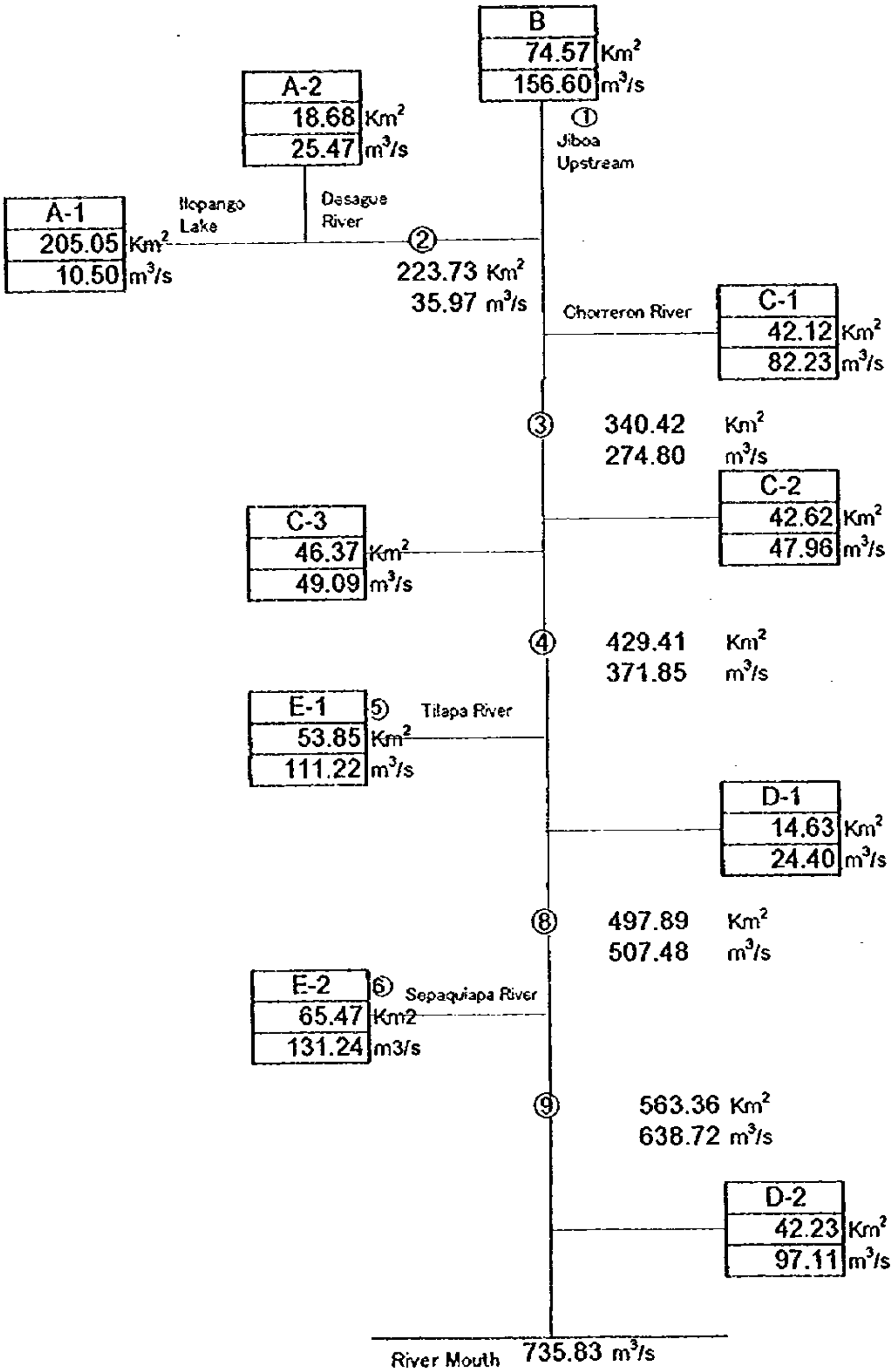


Fig. A.2.8 Peak Flood for Return Period 1 in 100 Years

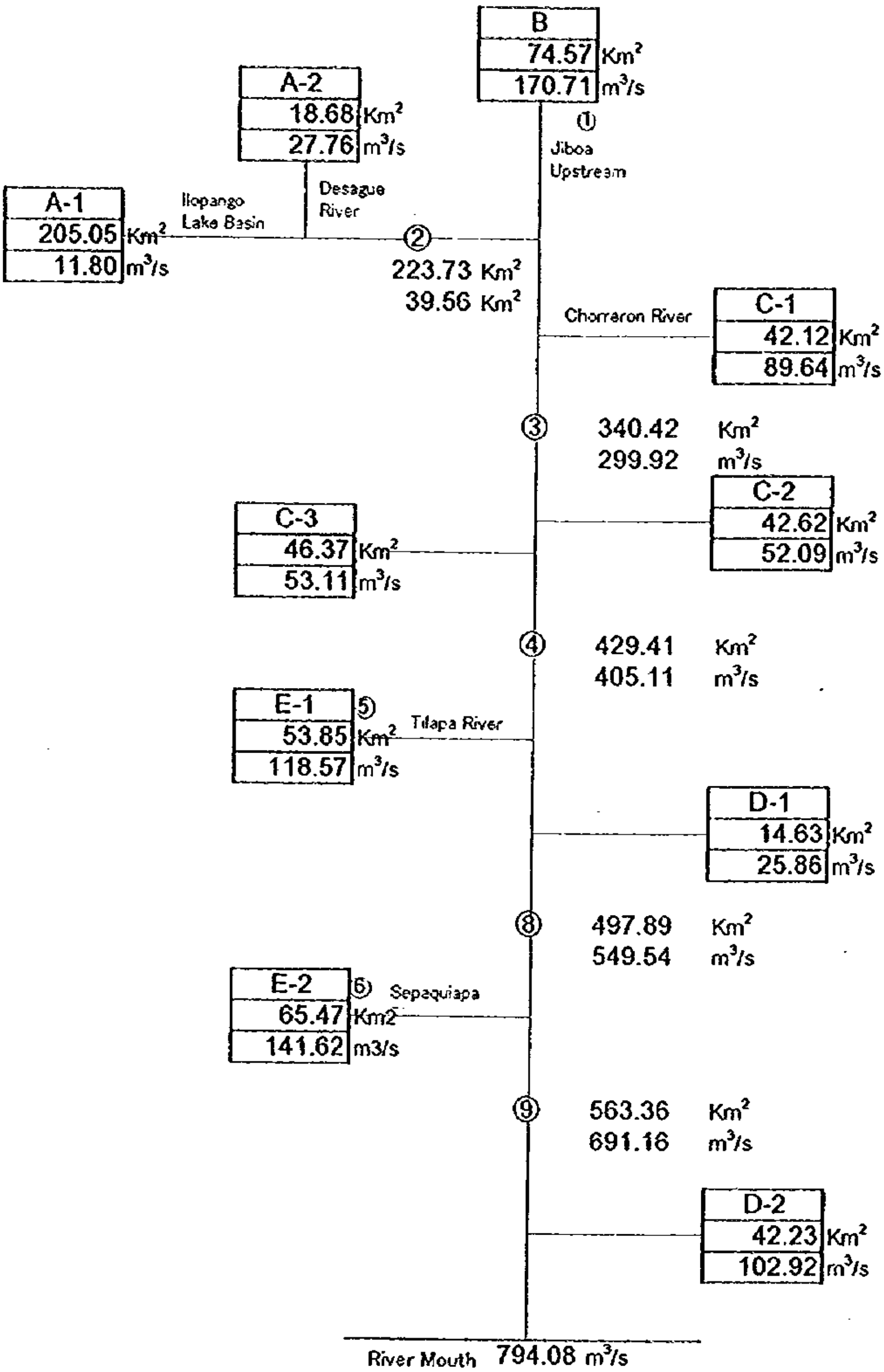


Fig. A.2.9 Peak Flood for Return Period 1 in 200 Years

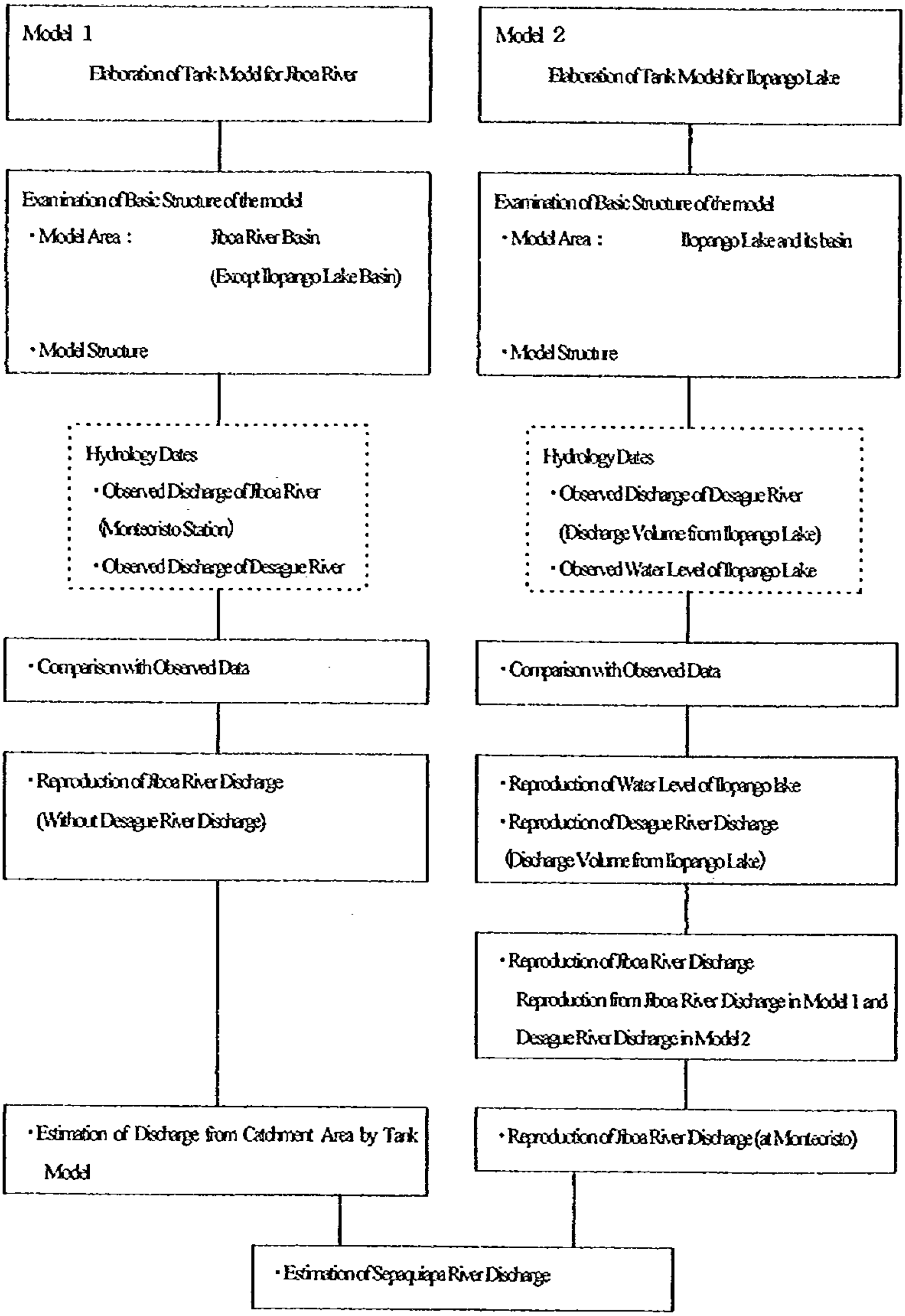


Fig. A.2.10 Flow Chart for Elaboration of Tank Model

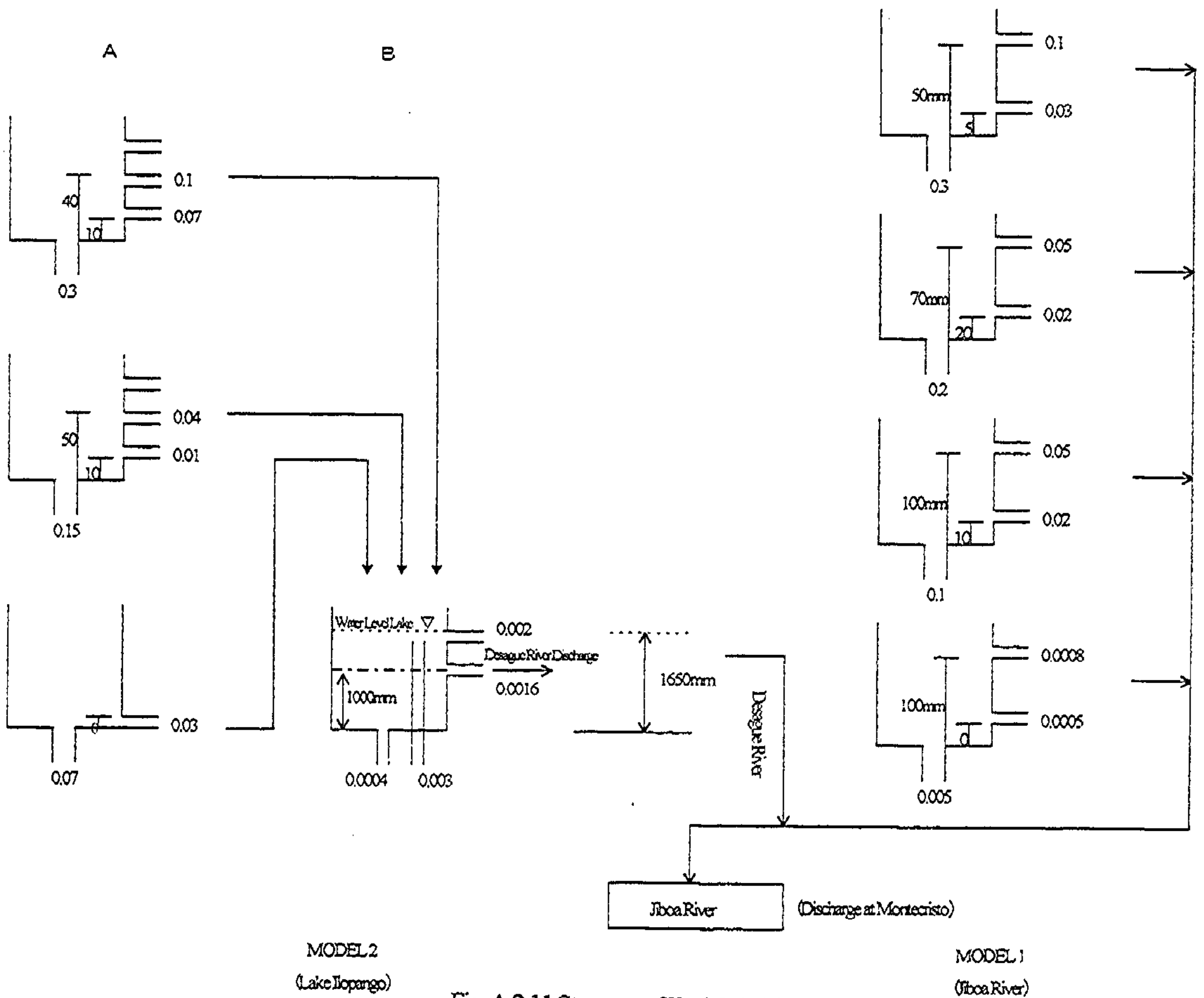


Fig. A.2.11 Structure of Tank Model

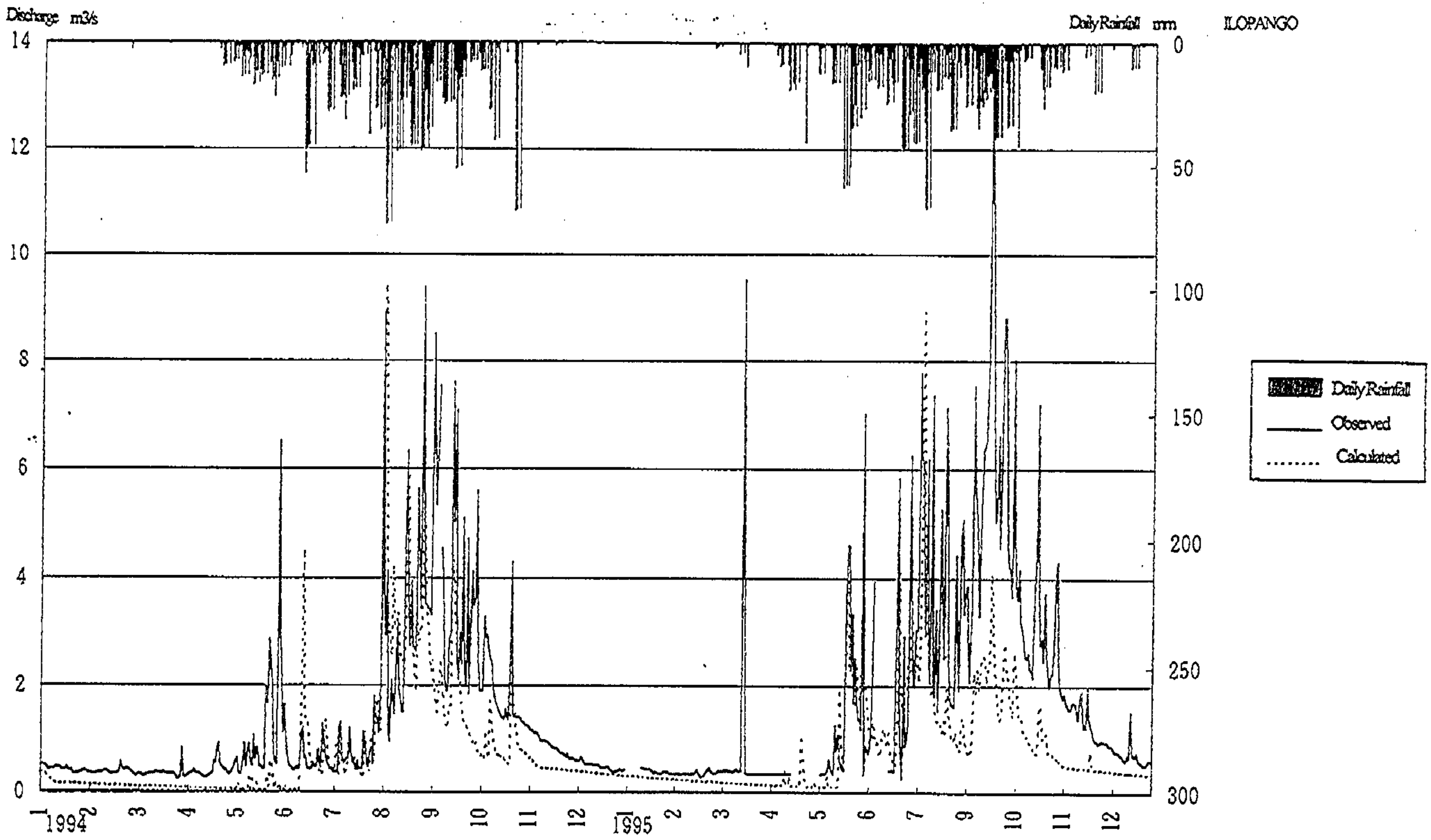


Fig. A.2.12 Simulation of Discharge in 1994-1995 (Without Desague Discharge)

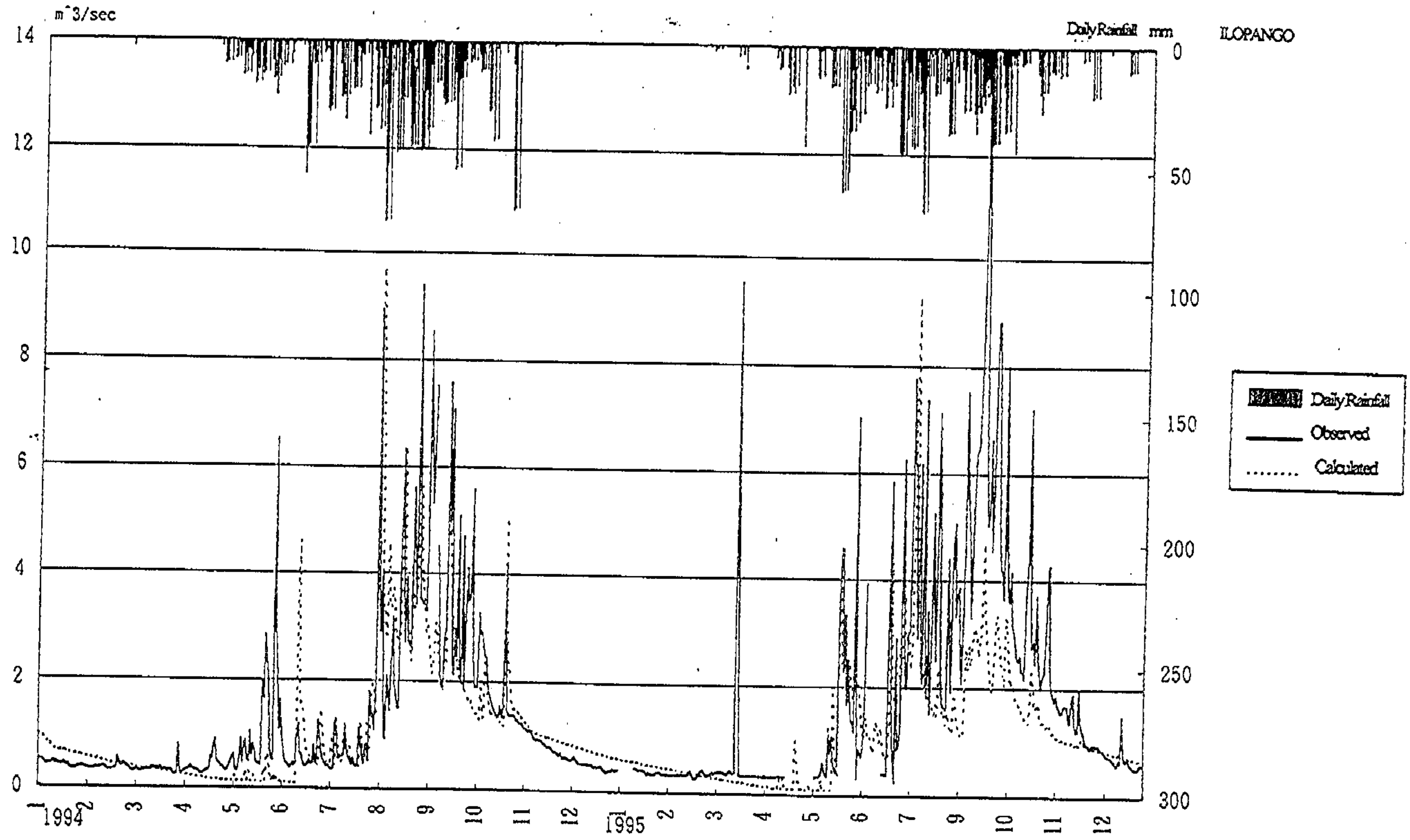


Fig. A.2.13 Simulation of Discharge in 1994-1995 (With Desague Discharge)

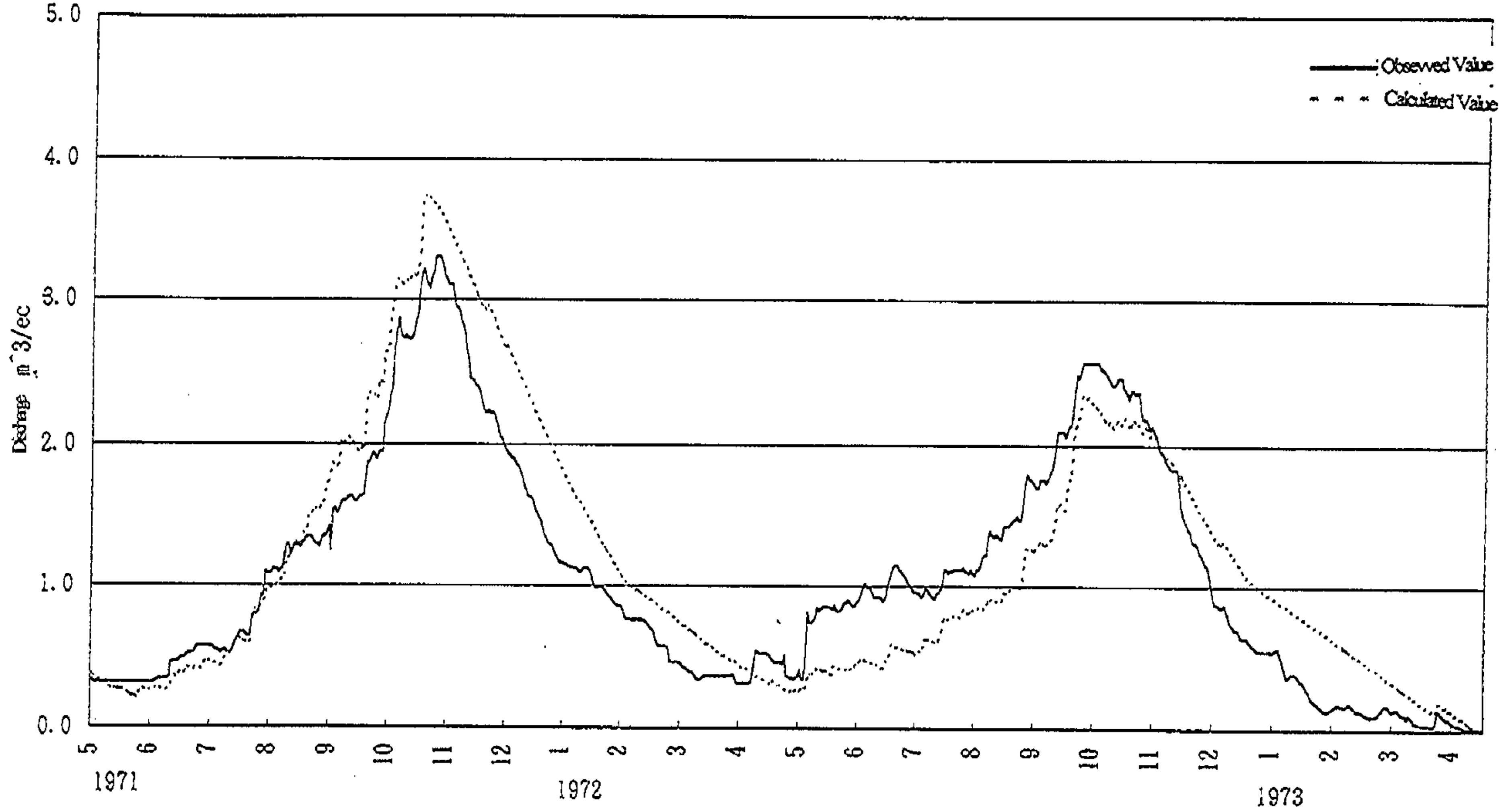


Fig. A.2.14 Discharge Volume of Desague River

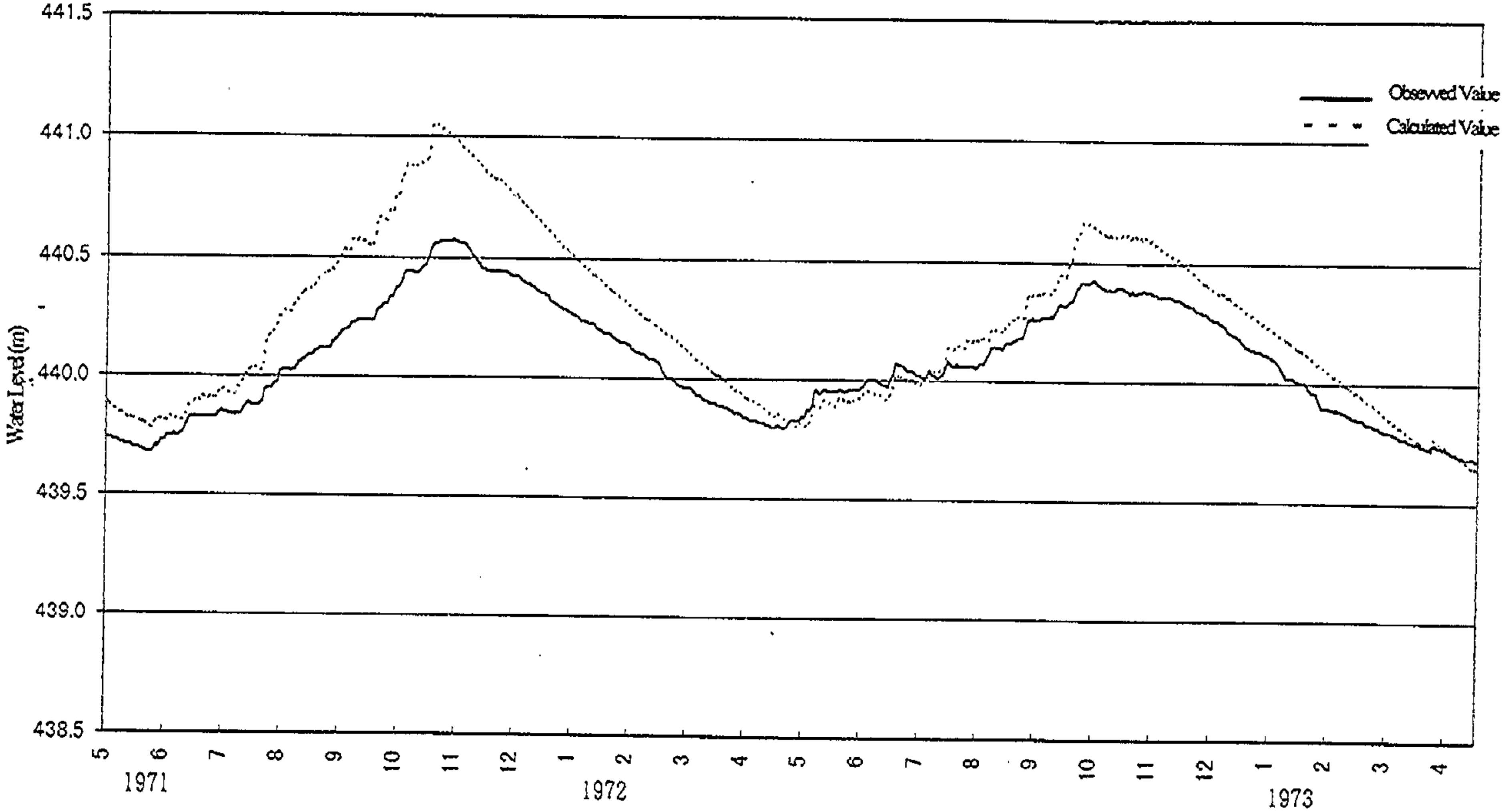


Fig. A.2.15 Ilopango Lake Water Level Variation

SUPPORTING REPORT [B]

PROTECTION WORKS

ANNEX B: PROTECTION WORKS

CONTENTS

B. Protection Works (Flood Control Plan)

B.1 Basic Policy

B.1.1 Design Target Year

The design target year is set at 2010 in view of the importance of the project to the government's national development plan.

B.1.2 Design Scale

Considering the instability of the river bed and the fact that the river has a wide range of old river courses which are flooded during heavy rains and are potentially dangerous due to the increasing population in the zone and the large agricultural lands, the flood control plan will be formulated for a return period of 1 for every 100 years. On the other hand the drainage plan will be formulated for a return period of 1 every 5 years.

B.1.3 Basic Guidelines

The flood control plan generally consists of :

- Rehabilitation of river channels: dredging and realignment
- Construction of embankments
- Construction of drainage channels

B.2 Study of Basic Flood Discharge

The control point for flood control is set at the area downstream from the confluence of the Sepaquiapa and Jiboa rivers.

B.2.1 Design Rainfall

A daily rainfall exceedence probability of 1/100 and a daily maximum rainfall amount of 163 mm/day shall be used as the design rainfall for this study.

B.2.2 Runoff Calculation Model

The tank model is the runoff calculation model selected for the conversion of the design rainfall to runoff discharge, in view of data availability and accuracy, basin conditions, and the project's relevance to past projects.

B.2.3 Calculation of the Design Flood Discharge in the Jiboa River

The basic design flood discharge without flooding and natural retarding functions was calculated using the design rainfall. The design flood discharge was established under a heavy rainfall probability of 1 in 100 years. The results of the calculation are shown in Table B. 2.3.1.

Table B.2.3.1 Design Flood Discharge

Daily Rainfall Exceedence Probability	Daily Rainfall (Cojutepeque) mm/day	Design Flood Discharge m3/sec
1/5	100	490.3
1/10	112	548.1
1/20	120	604.4
1/30	125	637.4
1/50	140	678.8
1/100	168	735.8

B.3 Alternative Plans

The basin has been divided into blocks in consideration of geological and land use conditions, and flood countermeasures in harmony with the characteristics of each basin block were formulated. Thereafter, alternative flood control plans were prepared.

B.3.1 Regional Division by Flood Control Function

Because the natural and social conditions in the study area vary, the formulation of the flood control measures must take into account the characteristics of each block. In this study, the basin was basically divided into the following two districts:

Storm Water Retention District (ABCE blocks):

This district is predominantly made up of hilly areas and stores a lot of the water resource recharge volume. Therefore, there is a need to consider water management, mainly in terms of the acquisition of or increase in primary rainfall seepage, soil runoff prevention measures, and water retention functions. A soil conservation plan should be separately formulated for this district.

Low-lying district (D block):

Rainwater is mainly retained in this district and not discharged into the river. Because the river channels are unstable, flooding occurs. Accordingly, flood countermeasures should be implemented especially in areas susceptible to flooding due to river inflow.

B.3.2 Applicable Flood Control Measures

The flood countermeasures applicable in the study area are as follows:

Hard Countermeasures (Structural Measures)

A) River channel and drainage rehabilitation

To improve the flow capacity of the river channel, widening and dredging should be carried out, and embankments should be constructed.

B) Construction of training dike, separation levee, revetment, and groin

To stabilize the alignment of the river channels, training dikes, separation levees, revetment, and groin of natural form planted with willows should be constructed.

C) Construction of Drainage Channels for Agricultural Use

Drainage channels shall be constructed to direct the flow retained in the downstream area into the outside area.

D) Waterproof Facilities

This countermeasure comprises of waterproof wells, lavatories as well as community centers.

The construction of community centers is recommended in villages heavily susceptible to inundation, to serve as an evacuation center or a multipurpose assembly hall.

Table B.3.2.1 shows the total number of facilities proposed in this project.

Table B.3.2.1 Waterproof Facilities to be Installed in Inundation Prone Villages

Place	Waterproof Wells	Lavatories	Community Centers
Caserio San Jose Luna	5	5	1
Campamento San Jose Luna	3	3	
Caserio El Porvenir	11	11	1
Caserio San Marcos Jiboa	3	3	
Caserio San Carlos	5	5	
Coop. Santa Maria del Coyol	10	10	1
Coop. Brisas Marinas (Las Moras)	11	11	1
Caserio Las Hojas	10	10	1
Caserio San Marcelino	1	1	
Caserio El Pimental	30	30	1
TOTAL	89	89	6

Main characteristics of the proposed facilities are as follows:

Wells	:	100 cm in diameter; 1.5m in depth
Lavatories	:	1.43 m^2 with a floor level of 1.5 m
Community Centers	:	300 m^2 with a floor level of 1.5 m

Soft Countermeasures (Non-Structural Measures)

Non-structural measures are included within the flood control plan as a complement to the structural measures and also for the zones where physical works cannot be executed due to financial restraints.

Some of these measures are as follows:

- Land use regulation in areas prone to flooding
- Flood forecasting, warning and evacuation
- Public education

B.4 Examination of Flood Control Plan

The basic design conditions of the facilities for the established flood control plan were studied.

B.4.1 Calculation of the Design Flood Discharge

The runoff calculation model was adjusted for the established plan to calculate the design flood discharge at the main points and of the facilities.

The flood discharge probability at the Sepaquiapa River confluence and the mouth of the Jiboa River are shown in Table B.4.1.1.

Table B.4.1.1 Flood Discharge Probability at Different Points

Probability / Station	1/5	1/10	1/50	1/100
	m3/sec	m3/sec	m3/sec	m3/sec
Sepaquiapa River Confluence	455.77	471.03	587.55	638.70
Jiboa River Mouth	490.30	548.10	678.78	735.81

B.4.2 River Channel Stabilization Plan

Constant flooding in the downstream basin of the Jiboa River is considered to be caused by the rise in river bed due to sediment accumulation, lack of water cross sections and unregulated river flow. The river channel stabilization plan shall therefore consider the rehabilitation of the 10.0 km river channel section from the Sepaquiapa River confluence to the Jiboa River mouth. The plan shall also consider the sections between the confluence and Las Flores Village (3.0km), as well as the distance between the bridge of the new road (CA-2) and the confluence (2.5km).

a) Calculation Condition

Section Interval:	10.0 km, 3.0 km, 2.5 km
Gross Head:	23.5 m
Riverbed Gradient at Sepaquiapa River Mouth:	io= 0.00436

B.4.3 River Improvement Plan

The outline of the river improvement plan is as follows (see Figs.B.4.3.1and B.4.3.2):

a) River Section Rehabilitation

The Jiboa River Improvement Plan shall be implemented from the Jiboa -Sepaquiapa confluence to the Jiboa River mouth. The river cross sections shall be compound, with the low water channel planned for a flood probability of 1 every less than 5 years, and the upper channel for a flood probability of 1 every 100 years. Channeling and dredging works are proposed for this sections.

Considering that the rise in the river bed downstream due to the clogging of the river mouth results in flooding, dredging is proposed from the junction of the new road (CA-2) up to the river mouth (12.5 km), to correcct the river course at intermediate sections where the river bed is unstable. Dredging is also proposed at the section between the Jiboa and Sepaquiapa confluence and the Las Flores Village (3.0km), where the river course is observed to change every year.

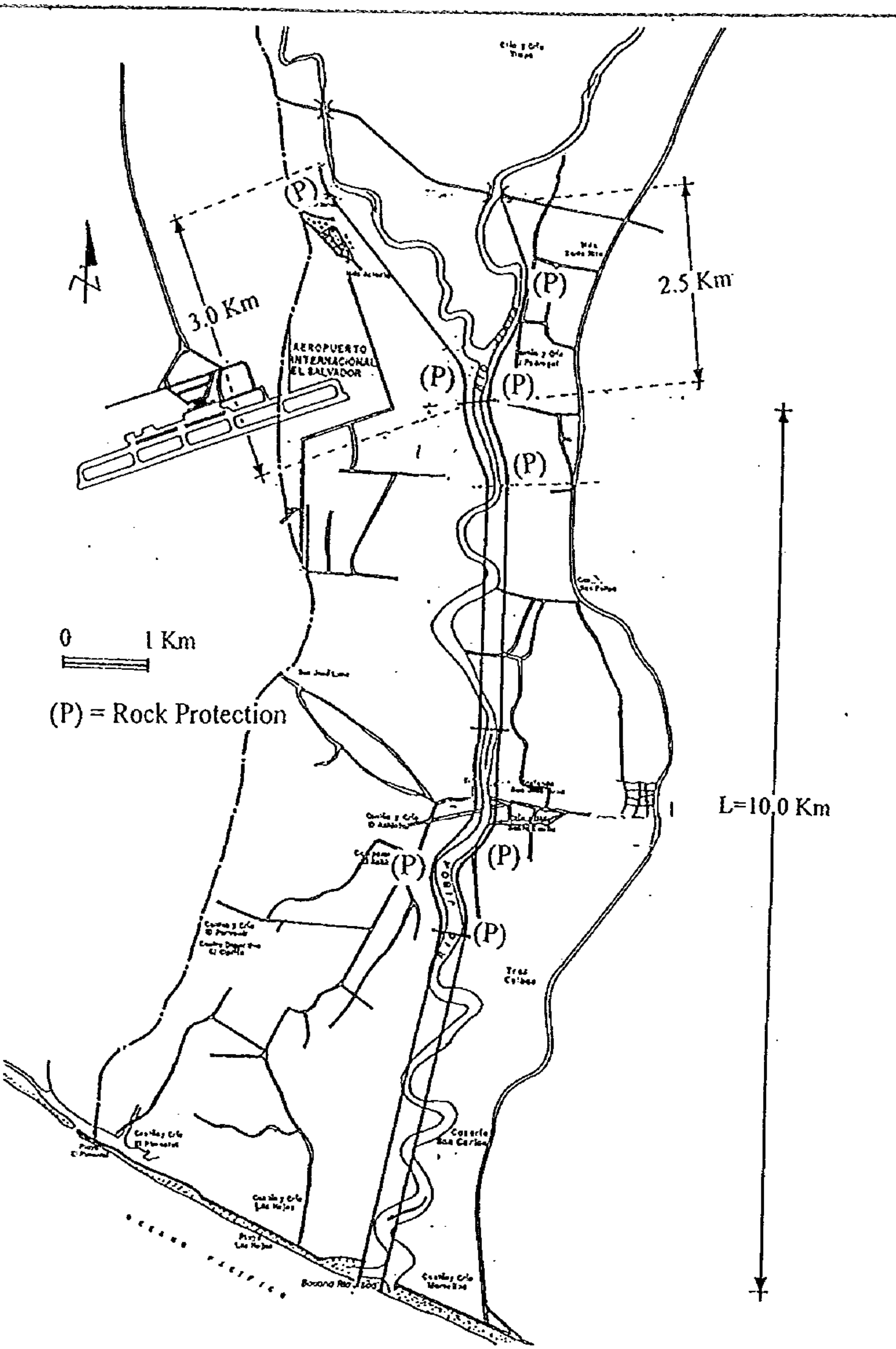
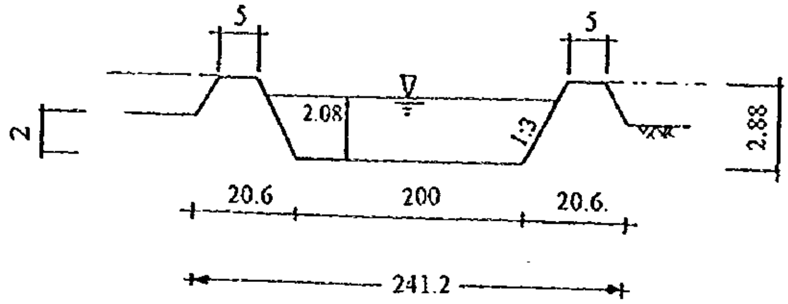


Fig. B.4.3.1 Outline of River Improvement Plan

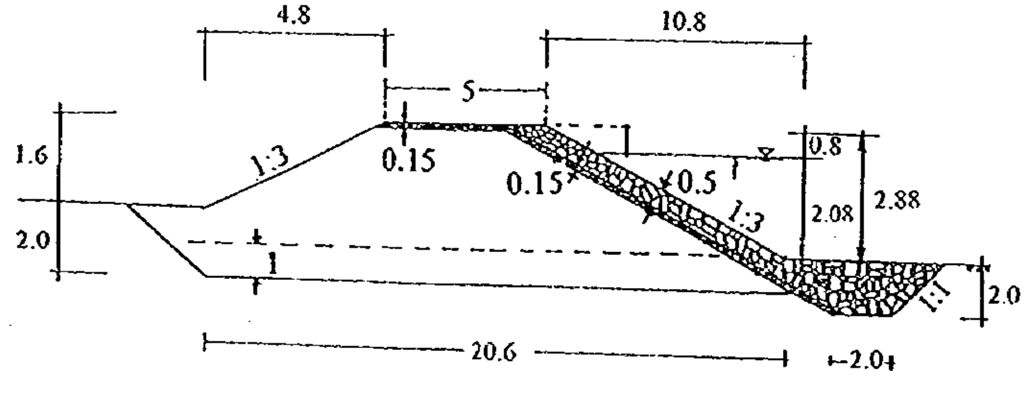
MASTER PLAN OF THE JIBOA RIVER BASIN
INTEGRATED AGRICULTURAL DEVELOPMENT
IN THE REPUBLIC OF EL SALVADOR

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Note: Dimensions in Meters



Typical Section of Channeling and Diking Works



Typical Section of Dikes with Rock Protection

Fig. B.4.3.2. Typical Cross Sections of the Channeling, Diking and Rock Protection Works

MASTER PLAN OF THE JIBOA RIVER BASIN INTEGRATED AGRICULTURAL DEVELOPMENT IN THE REPUBLIC OF EL SALVADOR

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

b) Linear Planning

The final linear measurements are usually calculated based on the stability of the channels and the topography of the area (Figs. B.4.3.1 and B.4.3.3). However, in this phase, the measurement was only based on the river channel wave length. The river improvement plan shall be in accordance with the present river course.

c) Borrow Materials

For the construction of the earth dikes, borrow materials obtained from the river bed dredging works should be used. Samples from the river bed downstream were taken at the following points: Caserio San Carlos (M-1), Caserio Achiotales (M-2), Caserio El Pedregal (M-3), Caserio Las Flores (M-4), and Jiboa bridge at CA-2 (M-5) (Fig.B.4.3.4). The sampling test results are shown in Table B.4.3.1.

As these are gravel-sandy materials, they should be mixed with clay. Clay banks exist within or in the outskirts of the basin, along the zone of Tres Ceibas, Comalapa (San Luis Talpa, Montaña la Hulera), Olocuilta and Santiago Nonualco.

TableB.4.3.1 Grain Size of River Bed Materials in the Jiboa River Downstream Area

Grain Size	% Passing M-1	% Passing M-2	% Passing M-3	% Passing M-4	% Passing M-5
3"					100
2"				100	89
1 1/2"				99	71
1"				89	54
3/4"				83	40
1/2"				75	27
3/8"				70	22
1/4"	100	100	100	64	18
No.4	90	88	86	60	17
No.8	87	86	84	48	15
No.20	82	73	80	30	13
No.40	73	52	70	14	10
No.60	57	31	53	6	7
No.100	26	13	24	2	3
No.140	14	8	12	1	2
No.200	3	1	1	0	0
S.G.					2.66

The borrow materials for the filters, the base for rock protection, and the road surface on the dike crown should be taken from the selected sites within the basin, which are made up of basaltic and andesitic rocks measuring a maximum of 4" to 6" (see Fig. 4.3.4).

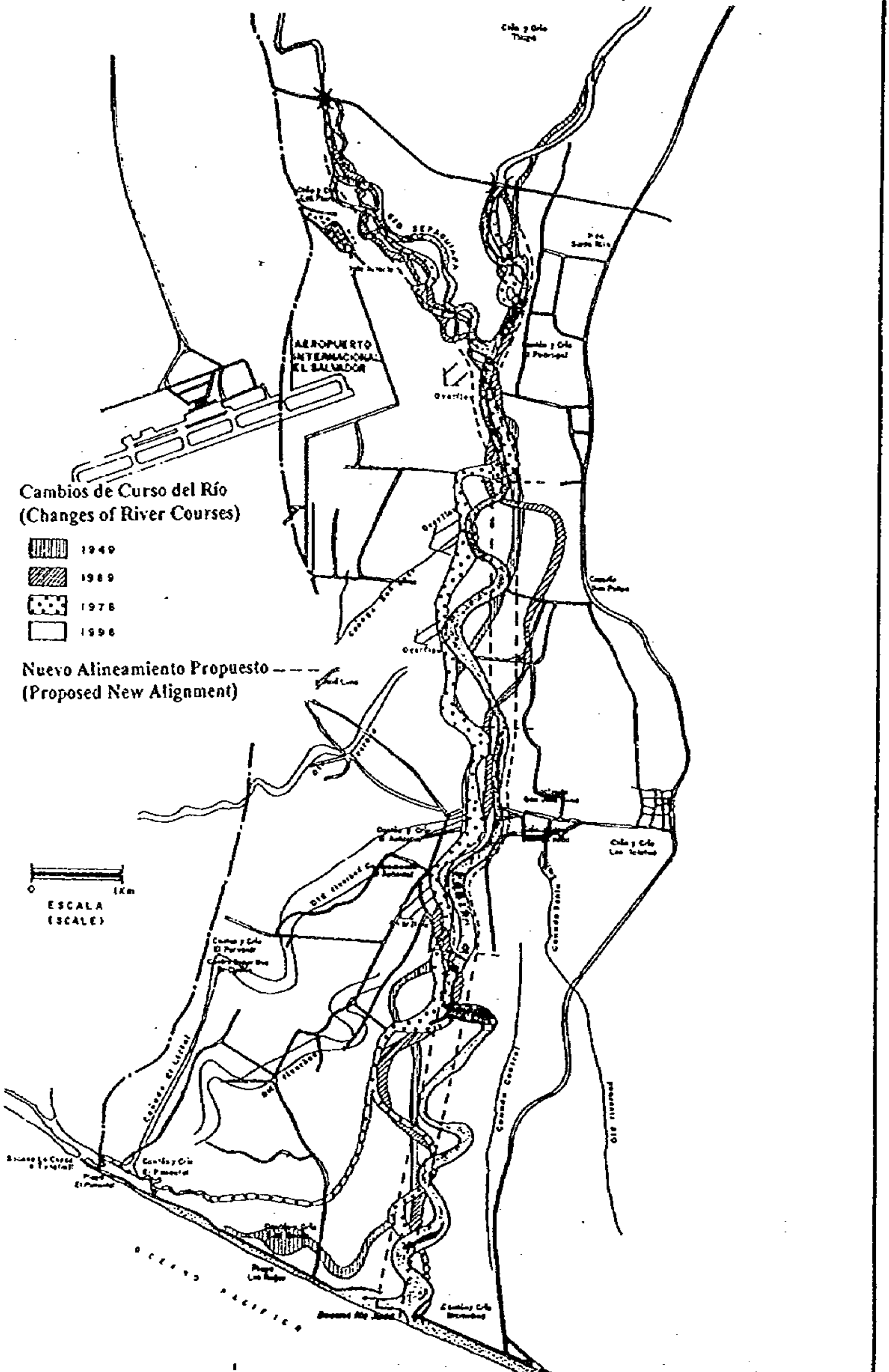


Fig B.4.3.3. Changes of Course of Jiboa River and Proposed New Alignment

MASTER PLAN OF THE JIBOA RIVER BASIN INTEGRATED AGRICULTURAL DEVELOPMENT IN THE REPUBLIC OF EL SALVADOR

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

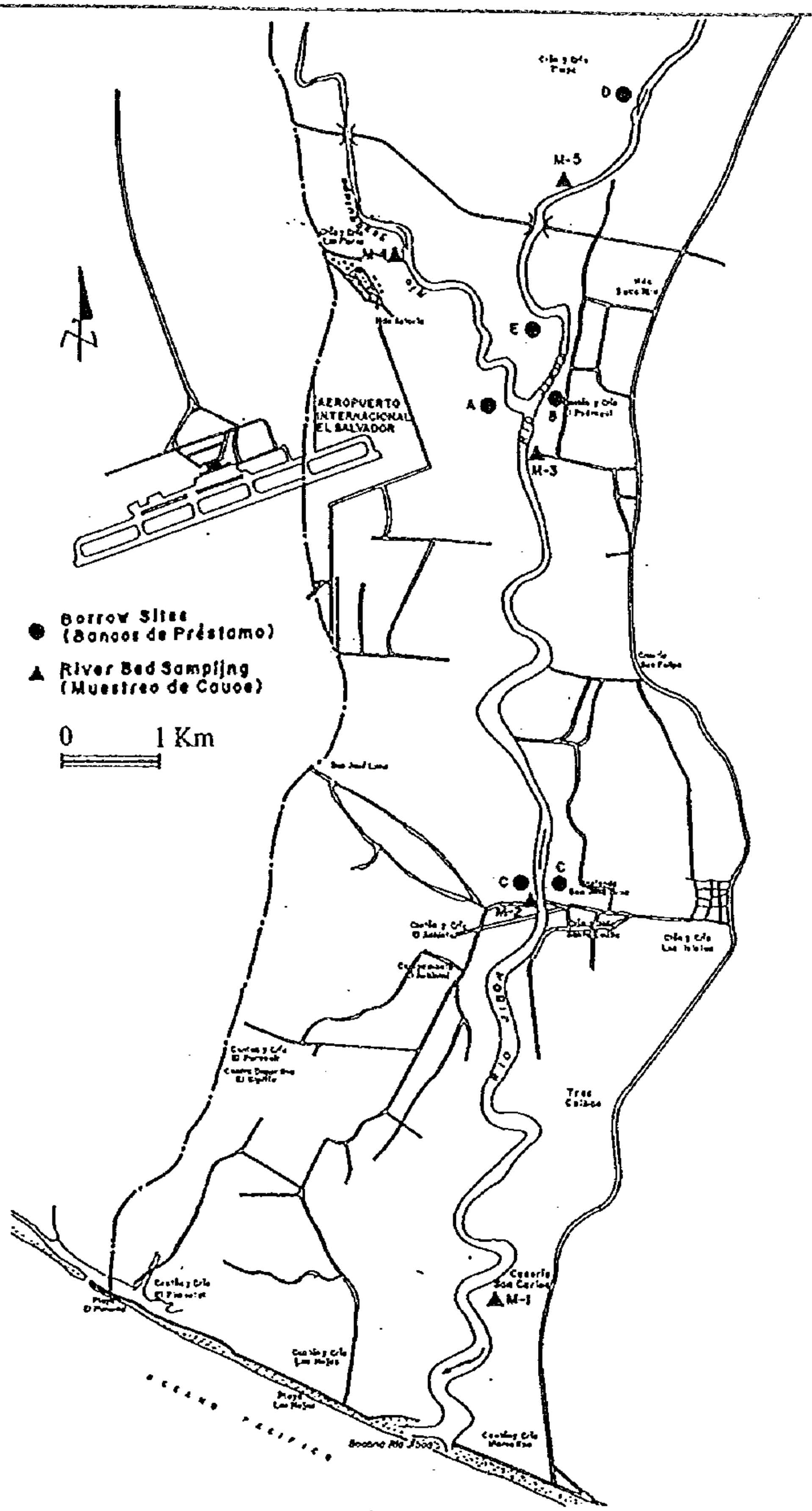


Fig. B.4.3.4 Location of Borrow Materials, and River Bed Sampling Sites

MASTER PLAN OF THE JIBOA RIVER BASIN
INTEGRATED AGRICULTURAL DEVELOPMENT
IN THE REPUBLIC OF EL SALVADOR

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The characteristics of these materials are shown in Table B.4.3.2.

TableB.4.3.2 Grain Size of Borrow Materials for Filters,
Base for Protection, and Crown Surface of Dikes

Grain Size	% Passing A	% Passing B	% Passing C	% Passing D	% Passing E
3"	100	100	100	100	
2"	79	82	86	88	100
1 1/2"	61	67	77	77	95
1"	53	56	65	69	83
3/4"	49	51	61	64	77
1/2"	44	45	55	59	72
3/8"	41	42	53	56	69
No.4	34	36	48	49	64
No.8	26	29	41	37	58
No.16	20	24	34	28	46
No.30	10	15	21	15	23
No.50	4	6	8	6	10
No.100	2	2	2	2	3
No.200	1	1	1	1	1
Max. Size	5"	4"	4"	6"	5"
Abrasion	35%	40%	50%	40%	40%

The materials to be used for dike protection, shall be extracted from the Jiboa river bed, ½ km upstream of the crossing of the old road (CA-2). The rocks vary in size, from 30 cm up to 2 m.

B.5 Selection of the Optimum Alternative Plan

The following aspects were examined for the selection of the optimum alternative plan:

- Total cost
- Coordination of the basin development plan and land use plan
- Difficulties in land acquisition and resettlement of the residents
- Difficulties in construction works
- Whether the phased implementation of the plan would facilitate the improvement of safe flood control measures

- Whether the plan is in conformity with present and future water-use conditions
- Natural and socio-economic impacts

B.6 Further Studies Needed

For a comprehensive understanding of the topographical and geotechnical conditions of the area where the river improvement plan is proposed, the following surveys are recommended:

a) Measurement of topographical cross sections of the river at least every 500 m (total: 30)
b) Standard Penetration Test (SPT) every 500 m (total: 30), at 1m depth.
c) Soil Samples every 500 m (total:30) at 1m depth, to perform the following tests:

- Triaxial
- Permeability
- Grade Size
- Plasticity

d) The same tests in c) above shall be conducted for the borrow materials. The Modified Proctor test shall be conducted for the dike contruction materials.

B.7 Review of Flood Control

B.7.1 Review of the previous works

According to reports from MAG, most of these works continued operating well up to 1983. At present remains of these works have not been observed and apparently were already washedout by the continued floods.

Later, several works have been performed, some of them financed by the AID in1982:

- Soil conservation works protecting about 300 Ha.
- Construction of 32 gavion dikes (800 m3)
  -Gavion baffles (some of them were washedout by the floods)

During 1982 the Engineering Department of ISTA elaborated an study and budget for stabilization and correction of 3 kilometers of the Jiboa river bed immediately upstreams of the mouth and it included the following works:

- Anchored tree protection (espigones) with galvanized wire

Return Period (Years)	Los Amates (Montecristo) Hydrological Station Max. Discharge (m3/sec)		
	Log-Pearson III	Log-Normal	Gumbel
5	417	377	450
10	537	538	576
25	692	741	734
50	832	965	862
100	955	1,103	968

The designed dikes were considered for protection of the agricultural lands along the Jiboa River low basin (right bank) between the confluence with the Sepaquiapa River and their mouth.
The characteristics of these dikes are as follows:

Total length	=	13.2 Km
Height	=	1.5 to 3.0 meters
Channel width	=	400 m

Some other projects were undertaken by the same period or more recently. Summing up, there have been in total at least ten projects of varied magnitudes for the flood control at the lower basin, some of them connected with soil conservation works. However most of them have not been executed because of lack of financing.

- Correction and enlargement of river bed
- Construction of dikes at contour lines

However, these works were not constructed.

In February 1983 several cooperatives of the agrarian reform requested to the Soil Conservation Service of MAG the technical assistance for solving the problems of overflowing and floods of the Jiboa River at the right bank.
Following this request a Technical Commission was settled which after making a field study made the corresponding recommendations and estimation of cost for:

- Construction of dikes along both sides of the Jiboa River
- Channeling works, to drain the area
- Afforestation of the river banks
- Gavion works

More recently in 1987-90 by a financing of IDB it was elaborated the FEASIBILITY STUDY OF THE IRRIGATION PROJECT OF COMALAPA with subsequent designs and Tender documents.

This study was elaborated by PRC-AMSA-CAS an American-Salvadoran Consortium.
By a probabilistic estimation of the instantaneous maximum discharge according to the methods of Gumbel, Log-Normal and Log-Pearson the maximum discharges for differents return periods are as follows:

B.7.2 Flood for design

By using the existing recorded data of maximum instantaneous discharges, the corresponding probabilistic analysis will be carried out to decide the discharge for design. At the hydrological station of Montecristo the records of maximum instantaneous discharges are as follows:

YEAR	DISCHARGE (m3/sec)	MONTH
1961	132.79	September
1962	80.80	July
1963	73.50	July
1964	135.50	July
1965	484.80	September
1966	616.00	August
1967	642.00	October
1968	441.00	October
1969	307.00	October
1970	261.00	September
1971	187.00	October
1972	203.00	October
1973	273.00	July
1974	389.00	September
1975	193.00	October
1976	1/	
1977	1/	
1978	254.57	October
1979	197.01	September
1980	276.94	August
1981	175.22	September
....	2/	
1993	65.50	September
1994	407.41	September
1995	748.13	June

1/ No data available because moving of hydrological station from Los Amates to Montecristo District.

2/ No data available because of security problems of the civil war.

B.8 Design Criteria for Dikes and Channels of the Jiboa River

B.8.1 Maximum Velocities along the Channel

MATERIAL	VELOCITY (m/sec)
Very loose	0.30 - 0.45
Loose	0.40 - 0.75
Regular	**0.80 - 1.00** *
Compact	0.85 - 1.20
Very Compact	1.15 - 1.50
Concrete	2.50 - 4.00

Source: ?
* Used Value in the report

B.8.2 Width of Channel

MAXIMUM DESIGN DISCHARGE (m3/sec)	WIDTH OF CHANNEL (m)
300	40 - 60
500	**60 - 80** *
800	**80 - 110** *
1,000	90 - 120
1,500	120 - 170
2,000	160 - 220
3,000	220 - 300
5,000	350 - 450

Source: Yoshihiro Takemoto, 1981, "Manual of Design and Construction Procedure Procedures of Hydraulic Works ("Manual de Diseño y Procedimientos de Construcción de Obras Hidráulicas", Tegucigalpa, Honduras.
* Used ranges in the report

B.8.3 Free Height

MAXIMUM DESIGN DISCHARGES (m3/sec)	FREE HEIGHT (m)
< 200	0.6
200 - 500	0.8
500 - 2,000	1.0 *
2,000 - 5,000	1.2
5,000 - 10,000	1.5
> 10,000	2.0

Source: Yoshihiro Takemoto, 1981, "Manual de Diseño y Procedimientos de Construcción de Obras Hidráulicas", Tegucigalpa, Honduras.
* Used values in the report

NOTE: The rules established by this table would mean that if we have a dike of 2 m height the effective height would be 2-1= 1m. So, I decided to use a 3 m height of dike in order to have an effective height of 2 m.

B.8.4 Width of Dike Crown

MAXIMUM DESIGN DISCHARGES (m3/sec)	WIDTH OF CROWN (m)
< 500	3
500 - 2,000	4
2,000 - 5,000	5
5,000 - 10,000	6
> 20,000	7

Source: Yoshihiro Takemoto, 1981, "Manual de Diseño y Procedimientos de Construcción de Obras Hidráulicas", Tegucigalpa, Honduras.