6.3 Sedimentation

The basic plan for this project makes it difficult for sand to accumulate in the dam, both from the structural and operational aspects, since the total capacity of the reservoir is rather small (approximately 1.5 million m^3). Therefore, the crest peak of the spillway gate is lower than the available water level, thus allowing excess sand to be discharged together with floodwater through the gate.

In addition, the water level of the main regulatory pool varies greatly during the course of a day, which often results in creating something like river conditions within the reservoir. Therefore, a flushing effect can be always expected.

However, with the alternative plan, it will be easy for sand to accumulate in the dam, since the total capacity of the reservoir is rather large (approximately 17 million m^3), and the water level does not fluctuate very much.

In this study, the amount of sedimentation in the reservoir will be estimated according to the results of observation and analysis conducted by ICE.

Since it has been proven that there is no permanent sedimentation when using the basic plan (as discussed later in the chapter on trap efficiency), further discussion of the basic plan was eliminated.

6.3.1 Data to be Used in Calculation of the Amount of Sedimentation

Sand which drifts down a river is divided into suspended loads and bed loads, according to its condition when drifting. Obtaining samples is the established observation method for suspended loads. ICE has conducted observations in Costa Rica employing this method. However, studies on bed loads are currently done based on presumptions, since it is difficult to obtain samples of bed loads in an actual river.

Generally, in order to calculate a projected amount of sedimentation in a reservoir, both the observation data for a suspended load obtained near the project site and the actual sedimentation data for the existing reservoir are utilized. In a case where no observation data within the basin is available, observation data for a nearby river which shares similar characteristics is used.

Observation data from Londres Runoff gauging station is available for the Naranjo River area.

Figures 6-9 and 6-10 shows sedimentation-related data.

(1) **Amount of Suspended Load**

ICE has been conducting observations on river inflow and sedimentation at Londres Runoff Gauging Station. Figure 6-9 and 6-10 shows the relationship between the amount of suspended load (suspended load concentration) and the river inflow.

Annual amount of suspended load	:	151,000 tons/year
Suspended load amount rate	:	720 tons/year/km^2

The figures indicate that there is a correlation between the amount of suspended load and river inflow.

(2) **Amount of Bed Load**

Since there is no established method for measuring bed load, calculation was done at ICE according to the equation for amount of bed load. Two equations for amount of bed load were used for Londres Runoff gauging station, and the average amounts resulting from the equations were calculated.

The following are the results of the calculations:

Londres Runoff Gauging Station (210.2 km^2)

Meyer-Peter equation	:	49,000 tons/year
Einstein-Brown equation	:	35,000 tons/year
Average	:	42,000 tons/year
Boad amount rate	:	200 tons/year/km^2

6.3.2 Calculation of the Amount (Weight) of Sedimentation in the Reservoir

Amounts of suspended load and bed load at the planned dam site were calculated according to the basin area of Londres Runoff Gauging Station, as mentioned earlier.

The following are the results of the calculations with regard to the amount of sand flowing in the reservoir:

Site of the dam		($147.0\ km^2$)
Amount of suspended load		106,000 tons/year
		(720 tons/year/km^2)
Amount of bed load		30,000 tons/year
		(200 tons/year/km^2)
Total	136,000 tons/year	(920 tons/year/km^2)

(1) **Trap Efficiency of the Reservoir**

Brune's chart indicates the relationship between trap efficiency and total capacity of reservoir water/annual total inflow.

The following are the values of (total capacity of reservoir water/annual total inflow) according to the calculations:

i) **Basic Plan (with total capacity of reservoir water at $1.5 - 2 \times 10^6\ m^3$):**

$$(1.5 \sim 2) \times 10^6 m^3 \div 472 \times 10^6 m^3 \fallingdotseq 0.003$$

Wherein
Total capacity of reservoir water: $1.57 \sim 2 \times 10^6 m^3$
Annual total inflow: $472 \times 10^6 m^3$
(Average area of the basin, 1971～1993: $147.0\ km^2$)

When applying the above figures to Brune's chart, the trap efficiency of sand inflow indicates almost 0 (zero). So sand flowing in the reservoir will be flowing out without accumulation, although there will be a small time lag.

ii) **Alternative Plan (total capacity of reservoir water: $17 \times 10^6 m^3$)**

$$17 \times 10^6 m^3 \div 472 \times 10^6 m^3 = 0.035$$

Wherein
Total capacity of reservoir water: $17 \times 10^6 m^3$

Annual total inflow: 472 × 10^6 m^3
(Average area of the basin, 1971～1993: 147.0 km^2)

When applying the above figures to Brune's chart, the trap efficiency of sand inflow will be indicated as 75%.

(2) Density of Sedimentation

The volume of sand accumulated in the reservoir should be calculated considering the density after accumulation. The following is the equation by Lone and Koelzer to calculate average accumulation density (Wt. [tons/m^3]) after a lapse of time (t):

$$W1 = W1 + 0.434K \times \{t \div (t-1) \times (\log_e t-1)\}$$

Wherein
W1: Initial density (tons/m^3)
K: Coefficient of increase in density (tons/m^3)

Initial density (W1) and the coefficient of increase in density (K) vary depending on the components of sedimentation and operational conditions of the reservoir. In this study, W1 = 74 lb/cu ft and K = 2.7 were used according to the results of observation of the suspended load and the operational conditions of the reservoir.

The calculation period (t) for the projected amount of sedimentation was determined as 50 years.

As a result, the average density of sedimentation in the reservoir after 50 years was calculated as 1.241 tons/m^3.

6.3.3 Calculation of the Sedimentation Capacity of the Reservoir

The alternate plan is discussed in this section. The following is the equation to calculate the projected amount of sedimentation (Vs) downstream from the dam by applying the figures obtained above:

Vs = (annual total sand inflow) x (trap efficiency) x (period)/(density of sedimentation)

$= 136{,}000 \text{ tons/year} \times 75\% \times 50 \text{ years} \div 1.241$

$= 4.2 \times 10^6 \text{ m}^3$

(1) Setting a Sedimentation Surface in the Reservoir

Upon setting a sedimentation surface for the alternate plan, it was presumed that sand would accumulate horizontally. The estimated sedimentation level at downstream from of the dam was determined as elevation 496 m according to the reservoir-water-capacity curve.

As to low water level, it was determined to maintain a depth of approximately twice the diameter of the tunnel in order to prevent air from mixing in the tunnel, and to maintain a depth of approximately 2 m from the sedimentation surface to the raceway foundation, in order to prevent sand from flowing in.

6.4 Flood Analysis

6.4.1 Outline

The following data are required for flood analysis:

1) Dam design flood discharge of the Naranjo River
2) Flood discharge at the outlet of the Power House of the Paquita River
3) Flood discharge for care of river during construction
4) Flood discharge used for evaluation of environmental effects at Cerritos site of the Paquita River

Each above datum has an individual purpose and importance.

The dam design flood discharge is the most important of all, and probable maximum flood (hereinafter referred as PMF) is utilized.

As to the rest, probable flood discharge according to degree of importance is employed upon calculating probability using inflow data.

6.4.2 Data to be Used in Calculation of the Amount of Flood

(1) Meteorological Data

Meteorological data is used when calculating PMF to analyze probable flood.

i) Data Required for PMP Analysis

Meteorological data required for calculation of PMP includes data on precipitation, dew point, temperature, relative humidity, vapor pressure, and so forth. Playon Observation Station (located approximately 40 km west of the project dam site), Copey de Dota Observation Station (located at the north end of the area), and Naranjillo Observation Station (located within the immediate area) can provide satisfactory data which fulfill the above conditions. However, the data from Copey de Dota and Naranjillo was recorded over an extremely short period (4 years and 3 years, respectively) except for precipitation data, of which the accuracy will be compromised when obtaining the past maximum dew point.

Therefore, meteorological data recorded at Playon for 18 years was converted to conduct analysis at Naranjillo and Providencia.

ii) Data Required for Run-off Analysis

In order to conduct an run-off analysis, precipitation and run-off data recorded in the same period are required.

With regard to flood waves, it is best to use actual measurements observed at the site. Fortunately, several flood waves were observed at Los Llanos Run-off gauging station, which is located at the project dam site.

The following are the precipitation data protocols to be used in the analysis:

1) Data should represent the catchment area
2) Data should have a time unit frequent enough to follow the ever-changing inflow volume
3) Data should be collected in the corresponding period used for calculation of PMF

In order to verify the above conditions, effective time precipitation data collected at 5 stations (Naranjillo, Providencia, Copey de Dota, P.H. Savegre, and Rio Naranjo), including stations located near the planned dam site, were compared against several past flood waves.

Figure 6-11 shows a hyetograph and hydrograph.

As a result, it was found that precipitation was always recorded when a flood occurred at Naranjillo and Providencia Observation Stations. On October 26, 1993, when the most massive flood occurred in the area, the acute shapes of the hydrographs and hyetographs showed an especially close resemblance. Data collected at these two observation stations were employed for run-off analysis, because the value-analysis method involving a unit-hydrograph gives more priority to results than to a midway inflow mechanism.

(2) **Flood Data**

Data used in flood analysis are actual measurements of flood waves required for run-off analysis used to calculate PMF, as well as peak inflow of annual maximum discharge required for probability analysis. As to the former data, flood waves recorded at Los Llanos gauging station were used.
As to the latter, flood waves recorded at Londres gauging station, which had a longer period of observation, were used. A conversion formula was developed from the degree of correlation between data during high water at Londres and Los Llanos, and was used with the data at the dam site.(See Fig. 6-12)

The precipitation distribution during hurricanes (See Fig. 6-13), and the catchment area rate according to data collected at Londres, were used in making the calculations for the other areas.

Table 6-16 shows the actual measurements of the annual maximum flood.

6.4.3 Probable Flood Discharge at the Project Sites

(1) Londres Gauging Station

The fundamental data--annual maximum peak discharge data were collected from 1971 through 1993 at this station.

In order to conduct a probability analysis, it is necessary to first obtain coefficients based on actual measurement data then select the corresponding distribution functions.

As a result of examination, Log Pearson Type III* was employed for the analysis.

The following are the probable flood volumes: (See Fig. 6-14)

Return Period (year)	Probable Flood (m^3/s)
10	630
20	770
100	1,120
1,000	1,760
10,000	2,610

* Analyzed by ICE

(2) The Project Dam Site (Los Llanos Gauging Station)

In order to convert Londres data to data for the project dam site, a conversion formula was developed by analyzing the degree of correlation between actual measurements of high-water inflow at Los Llanos and Londres.

Unlike the low-water level analysis discussed in the previous section, data used for correlation were converted to a flow-duration curve. The former was based on correlation to date and time of occurrence, whereas the latter was based on frequency of occurrence.

Figure 6-12 shows the relationship between the top 35 daily average inflows observed at both flow-gauging stations. A correlation calculation was done for the top 20 figures and the top 35 figures.

For the top 20 figures: $Qd = 0.61 \times QL - 9$ (m^3/s)
For the top 35 figures: $Qd = 0.56 \times QL - 5$ (m^3/s)

As a result, the high-water level at the project dam site was estimated as approximately 60% of the inflow at Londres.

This percentage equals that of the total precipitation observed during Hurricane Joan in October 1988.

$$\Sigma Pd / \Sigma PL = 348 \text{ mm} \times 143.7 \text{ km}^2 \div 394 \text{ mm} \times 210.2 \text{ km}^2 = 60\%$$

Σ Pd Total precipitation at Dam site during the hurricane in October 1988
Σ PL Total precipitation at Londes during the hurricane in October 1988

Table 6-18 shows flood volume 1971-1993, calculated with the equation used for the top 20 figures discussed in the above.

Log Pearson Type III was used to calculate probability in the same way with the Londres calculation.(See, Fig. 6-15)

Return Period (year)	Probable Flood (m^3/s)
10	380
20	460
100	670
1,000	1,050
10,000	1,540

(3) Power House Site

In order to convert Londres data to data for the power house site, the ratio between precipitation distribution during the hurricane in October 1988 and the catchment area was used for calculation.

$$Qfp = QfL \times Pph \div PLh \times C.App \div C.AL \text{ (m}^3\text{/s)}$$

Qfp : Flood discharge at the power station

Pph : Total precipitation at the power station during the hurricane in October 1988 (443 mm)

C.App : Catchment area at the power station (24.5 km^2)

QfL : Flood discharge at Londres

Plh : Total precipitation at Londres during the hurricane in October 1988 (394 mm)

C.AL : Catchment area at Londres (210.2 km^2)

Return Period (year)	Probable Flood (m^3/s)
10	90
20	100
50	130
100	150

(4) Cerritos Site

In order to convert Londres data to data for Cerritos, the ratio between precipitation distribution during the hurricane in October 1988 and the catchment area was used for calculation.

$$Qfc = QfL \times Ppc \div PLh \times C.Apc \div C.AL\ (m^3/s)$$

Qfc : Flood discharge at the power station

Ppc : Total precipitation at the power station during hurricane in October 1988 (491 mm)

C.Apc : Catchment area of the power station (70 km^2)

QfL : Flood discharge at Londres

PLh : Total precipitation at Londres during the hurricane in October 1988 (394 mm)

C.AL : Catchment area at Londres (210.2 km^2)

Return Period (year)	Probable Flood (m^3/s)
10	260
20	320
50	400
100	470

6.4.4 Probable Maximum Flood (PMF)

In order to obtain PMF, it is necessary to first calculate probable maximum precipitation (hereinafter referred as PMP).

Then, run-off analysis should be conducted according to the relationship between actual measurements of inflow and precipitation. PMP should be applied to the result, in order to calculate PMF.

In this study, PMP at Playon, which obtained data over an extended period (18 years), was obtained first. The calculation process used to obtain PMP at Playon was applied to data at Naranjillo and Providencia for run-off analysis. Actual measurements of precipitation at both Sites (after being adjusted according to elevation), were used to calculate PMP in the project basin. In addition, a probability analysis was conducted on data obtained at the precipitation observation station in order to verify the results.

(1) Calculation of PMP (Probable Maximum Precipitation)

Generally, precipitation caused by a hurricane is considered nonorographic precipitation. Torrential rain peculiar to the area of the project site is related to hurricanes. Therefore, for calculation of PMP, precipitation should be treated as nonorographic precipitation.

i) Dew Point

Generally, PMP is obtained by multiplying the past actual measurement of torrential precipitation by the maximum probability calculated according to the dew point. The maximum probability equals the ratio between actual measurement of humidity in the air during torrential rain and probable maximum humidity during the same period. Probable maximum humidity is obtained according to a 12-hour continuous reading of the dew point.

Data on temperature, relative humidity and vapor pressure were recorded 3 times a day at Playon Observation Station. These data were generally found to be low in morning, highest at midday, and again low in evening. They tended to follow a sine curve over the course of a day. Therefore, the daily average dew point was employed as a 12-hour continuous value to be used in analysis.

Figure 6-16 shows the maximum 12-hour continuous readings of dew point at Playon observed from 1976 through 1993.

According to the figure, the past maximum values in September and October (hurricane season) were 26.1 °C and 26.3 °C respectively. The annual maximum value, which was 27.8 °C, was observed in March, the end of the dry season.

However, it is unlikely that a hurricane would occur during the end of dry season, upon considering the above results when determining the maximum dew point. At the same time, the recording period for weather data (18 years) is still relatively short.

Therefore, a separate probability was calculated for each month during a typical rainy season (May through November).

Item		Dew Point
Actually measured past maximum	(March)	27.8 °C
Probable figure for 50 years	(May-November)	27.2 °C
	(Sept.- Nov.)	26.3 °C
Probable figure for 100 years	(May-November)	27.5 °C
	(Sept.- Nov.)	26.5 °C
Probable figure for 200 years	(May-Nov.)	27.8 °C
	(Sept.- Nov.)	26.7 °C

As shown the above, the actual measurement of the past maximum dew point equals the probable figure for 200 years. In this study, 27.8 °C was adopted for calculation.

ii) **Selecting a Representative Storm**

Maximization was conducted for a relatively large sample of 40 storms recorded after 1976 at Playon.

However, the calculation was simplified, since it was a preliminary examination the purpose of which was to select a single representative storm. Daily precipitation was used as precipitation data. One thousand hPa was chosen as the figure for precipitable water without correcting according to elevation. The margin of error should be minimal, since the elevation of Playon is only 65 m.

However, the maximum probability is rather small, thus resulting in smaller temporary PMP.

The results of the calculations are shown in Table 6-18 and Figure 6-17.

As a result, Hurricane Joan of October 1988 scored the maximum value. Therefore, this hurricane was selected as the representative storm.
Figure 6-13 shows the precipitation distribution during the hurricane at the project basin. The figures indicate that the precipitation in the area decreased from south to north.

iii) Calculating PMP

PMP was calculated according to the dew-point data discussed above and storm data recorded in October 1988.

The calculation process is shown in Table 6-20.

The results are shown as follows (probability in 10,000 years is also shown as a reference):

Site	Actual measurement of precipitation, 12-hr continuous maximum value (mm/12 hr.)	Rate of maximization	PMP (mm/12hr)	PMP (mm/day)	Probability 1,000 years (mm/day)
Playon	195	1.59	310	406	386
Naranjillo	240	1.64	393	447	399
Providencia	214	1.67	358	408	356

iv) Creating a Hyetograph

The time unit used for run-off analysis should be as short as possible, within reason, since the area of the project site is in the mountains and the catchment area is relatively small (147 km^2). In this study, it was determined as 1 hour, considering the availability of observation data.

The following formula was used according to the ratio based on the Thiessen polygon Method in order to calculate area average precipitation per hour at the project Site:

$$Pi = 0.76\ Pna + 0.24\ Ppr\ (mm/hr)$$

Pi : Area average precipitation at the project Site at given time i (mm/hr)
Pna : Precipitation at Naranjillo at given time i (mm/hr)
Ppr : Precipitation at Providencia at given time i (mm/hr)

Figures 6-18 and 6-19 show the relationship between duration time and maximum precipitation during a hurricane in October 1988 observed in Naranjillo and Providencia.

The figures indicate that it was a torrential downpour with a duration of only 10 hours.

In order to obtain the maximum flood volume when calculating PMF based on the relationship discussed above (the depth-duration curve), maximum precipitation was selected randomly regardless of order of occurrence. Then inflow was recalculated to rearrange the data by strength of precipitation.

Figure 6-20 and Table 6-21 show the time distribution of PMP.

(2) Creating a Unit Hydrograph

Torrential rain causing large-scale flood in the Naranjo River area occurs during a hurricane.

Several flood waves were observed at Los Llanos Runoff gauging station, located at the project dam site.

The maximum acute inflow was recorded on October 26, 1993 as high water level. The peak inflow was 144 m^3/s, which is the 5th from the top among the record of annual maximum inflow at the project dam site (see Table 6-22) for the past 24 years obtained by converting data at Londres, as discussed previously.

Figure 6-11 shows the hydrograph and hyetograph.

Among the various methods of run-off analysis, correlative value analysis based on unit-hydrograph theory was selected for this project, thus effectively utilizing the above-mentioned observation data.

The unit-hydrograph calculation had an irregularity of including some negative figures. Therefore correction was made to even out the data. Figure 6-21 shows the unit hydrograph for the project dam site.

(3) **Effective precipitation**

Effective precipitation required for run-off analysis is obtained by subtracting precipitation loss from total precipitation. In this study, the following method*1 was used for calculation of precipitation loss:

$R < 100$ mm	$RL = R(1 - 3.36 \times 10^{-4} R^{1.5})$ mm
$R >= 100$ mm	$RL = 64$ mm

R : Cumulative precipitation
RL : Cumulative precipitation loss

(See Figure 6-23 and Table 6-21)

(4) **PMF (Probable Maximum Flood)**

The PMF hydrograph was obtained by adding the base inflow of 50 m^3/s to the effective precipitation obtained from the unit hydrograph discussed above. Base inflow was determined as 50 m^3/s, since the maximum monthly average inflow during the rainy season was 42 m^3/s.

As a result, PMF at the project dam site was calculated as 1,590 m^3/s. This figure equals approximately the probable flood volume in 10,000 years (1,540 m^3/s), as described earlier. The results are shown in Table 6-25 and Figure 6-24.

PMF at the project dam site: 1,600 m^3/s

*1Yonezo Nakayasu, 7th Technology Study Meeting under the Supervision of the Ministry of Construction of Japan, 1953

Fig. 6-1 Location Map of Runoff and Meteorological Gauging Stations

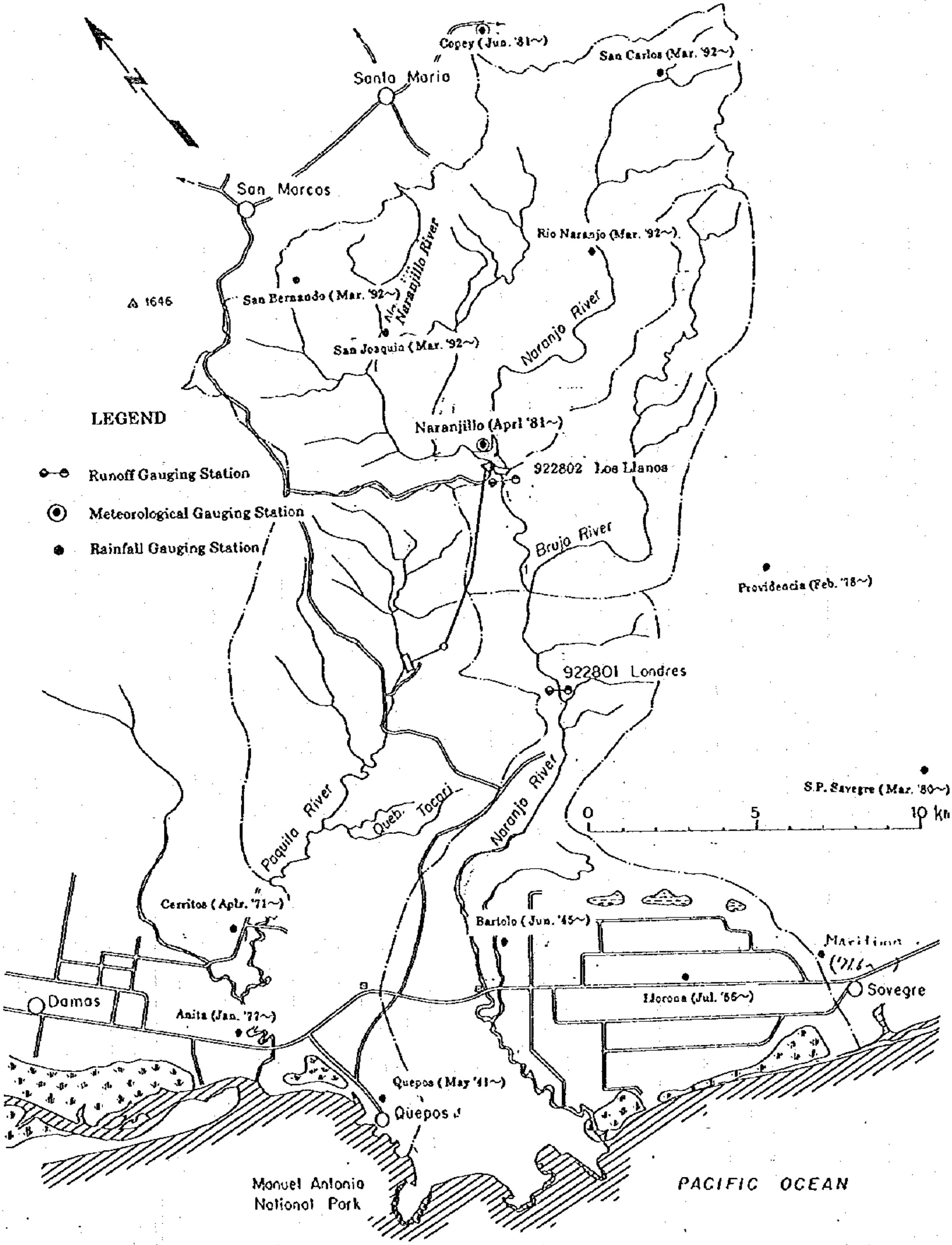


Fig. 6-2 Annual Isohyetal Map of Project Region

(p e r i o d : 1970 to 1989)

S = 1 ／200 000

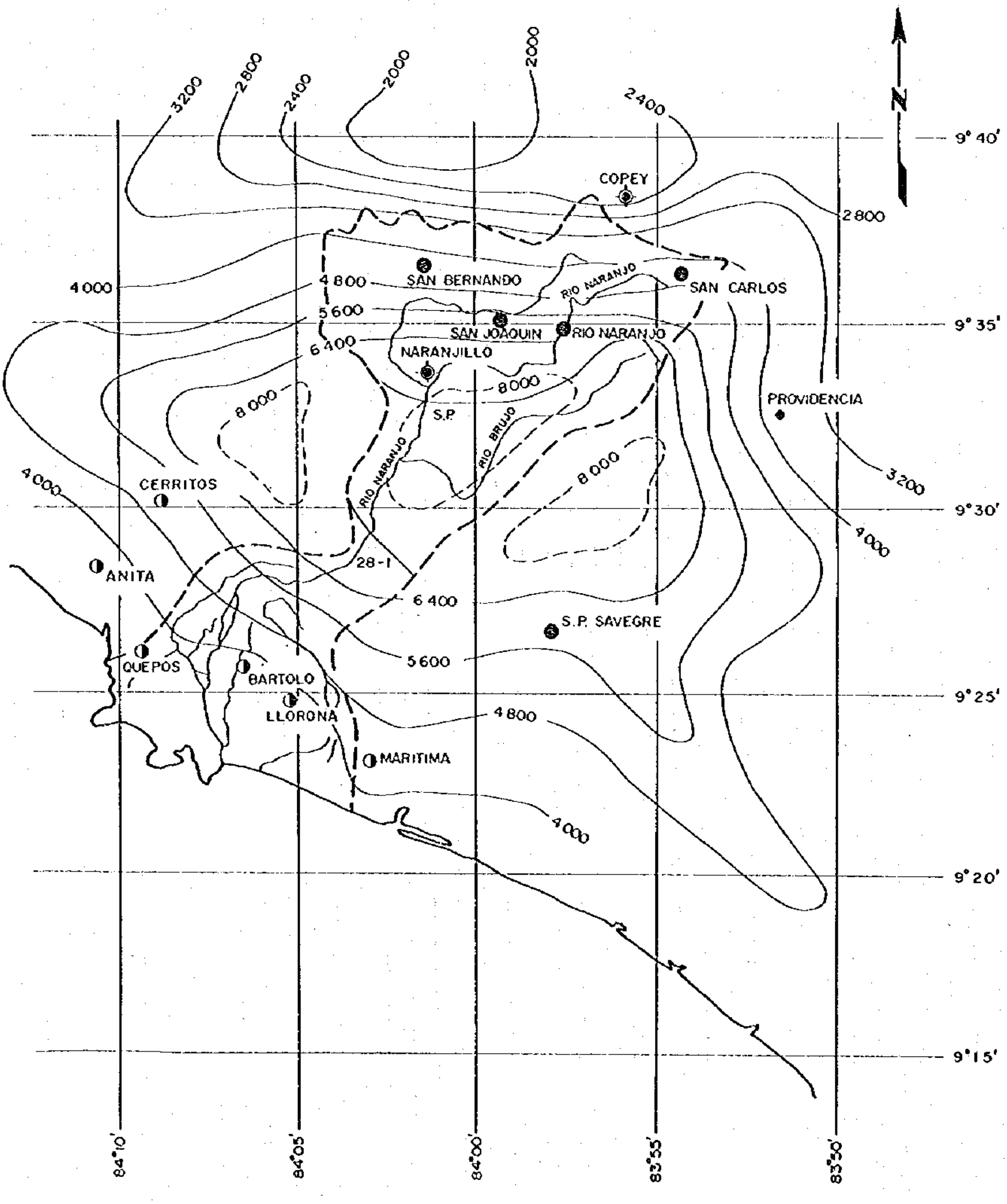


Fig. 6-3 Monthly Precipitation at Naranjillo

(1981~1993)

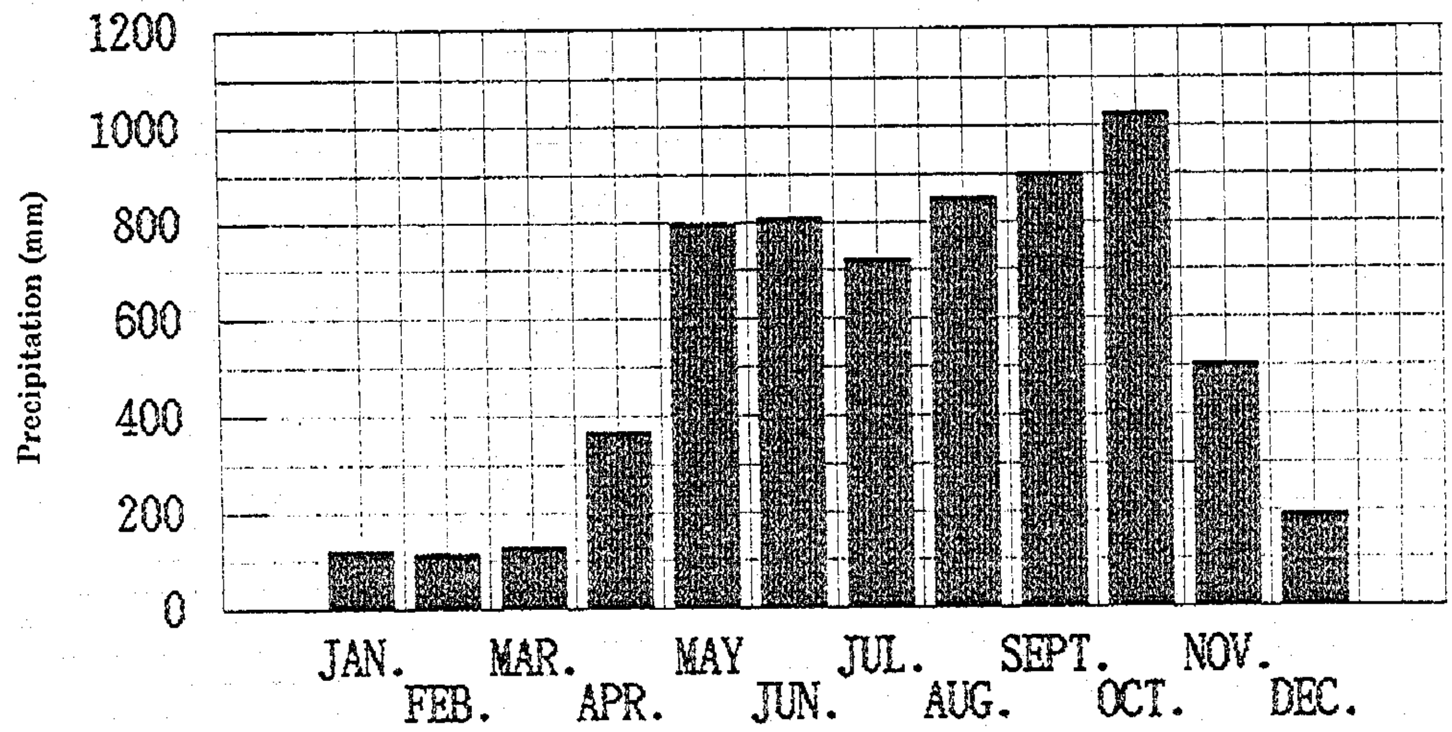
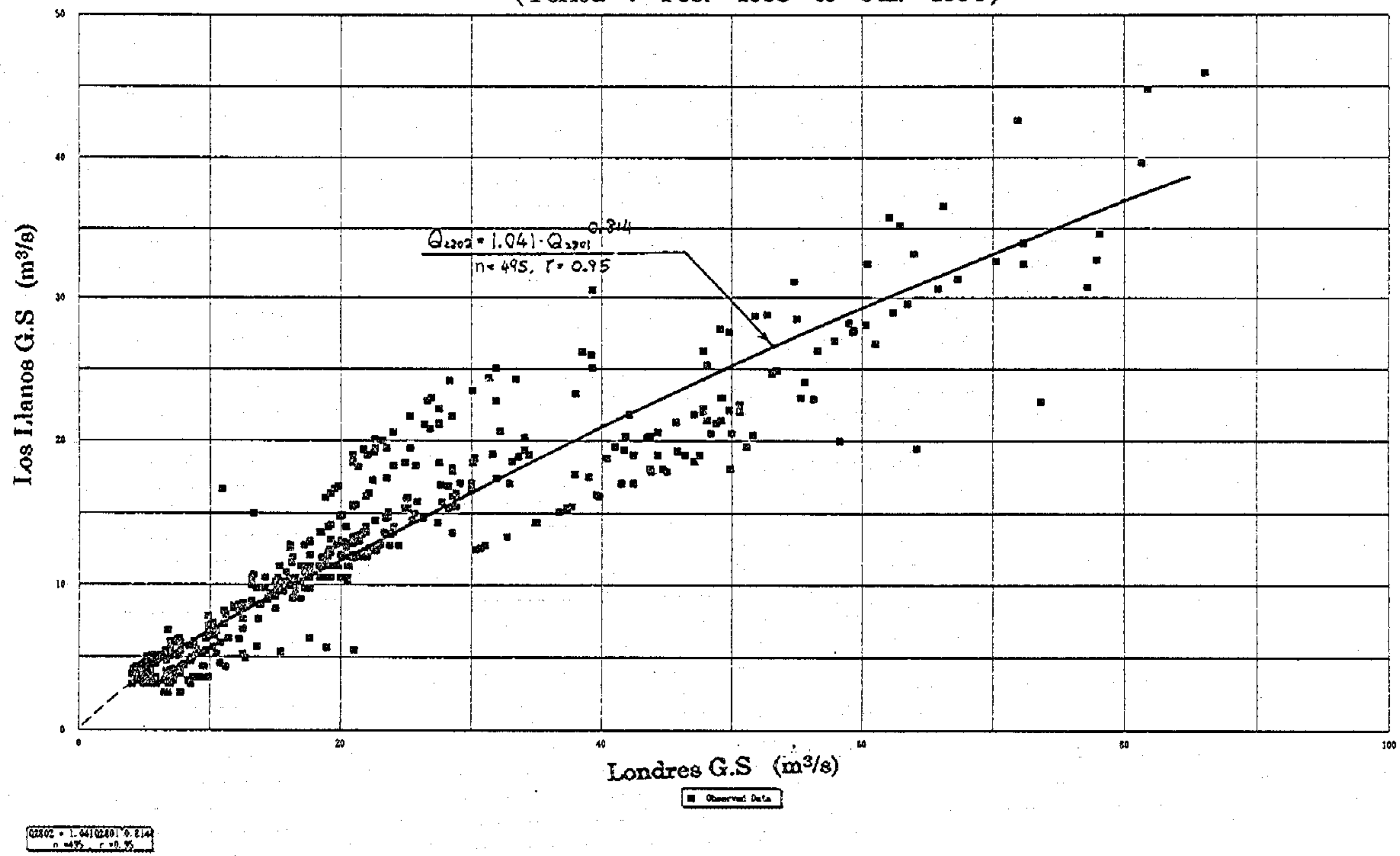


Fig. 6-4 Correlation between the Daily Discharge of Londres and Los Llanos Gauging Stations

(Period : Feb. 1993 to Jul. 1994)



6-4

Fig. 6-5 Estimated Discharge at the Los Llanos Site

Qe=1.0413*Qo^0.8148 r=0.95 (MAY '93 - JUL. '94)

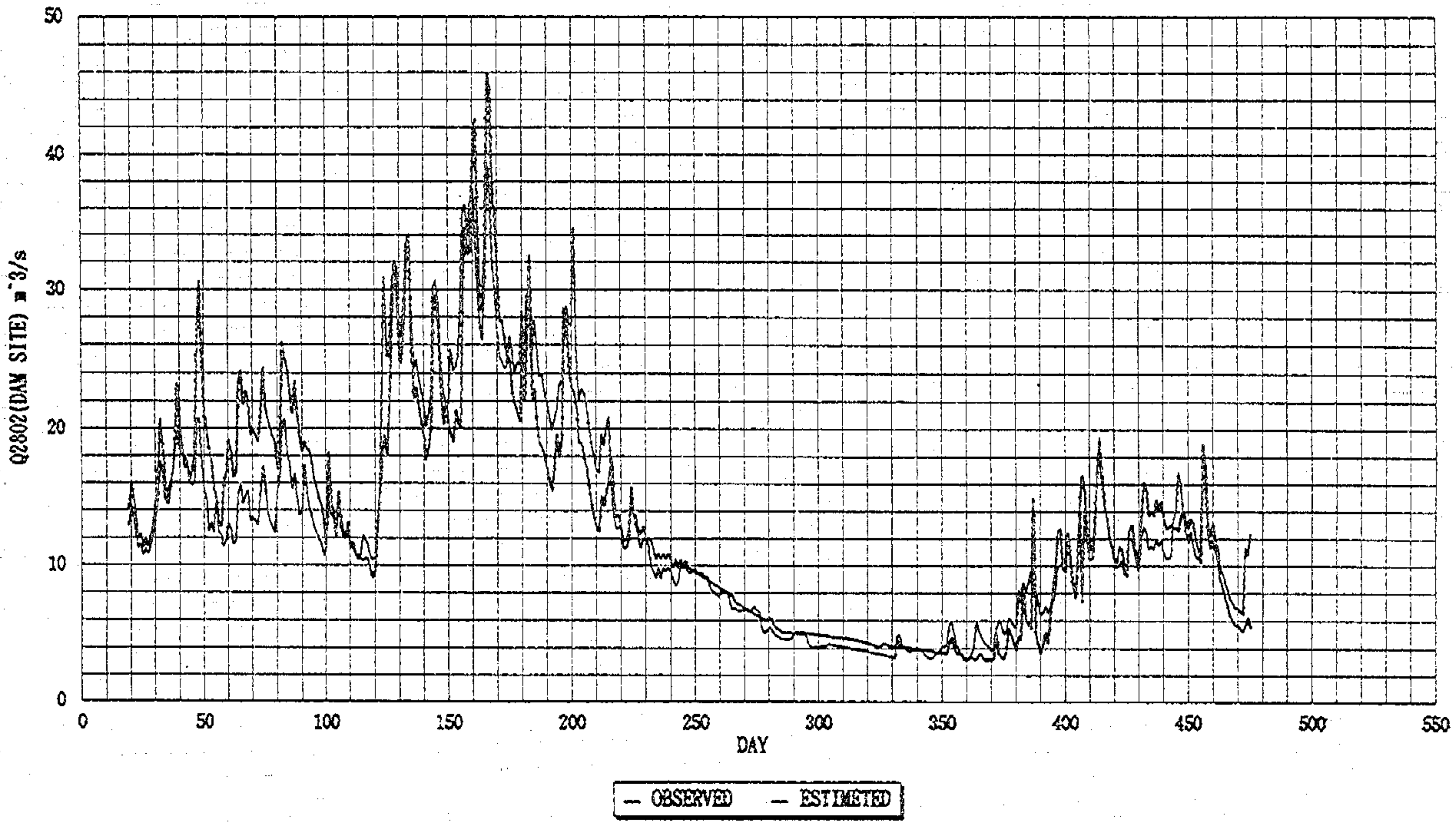


Fig. 6-6 Duration Curve at the Londres Gauging Station

Period : 1971 to 1993

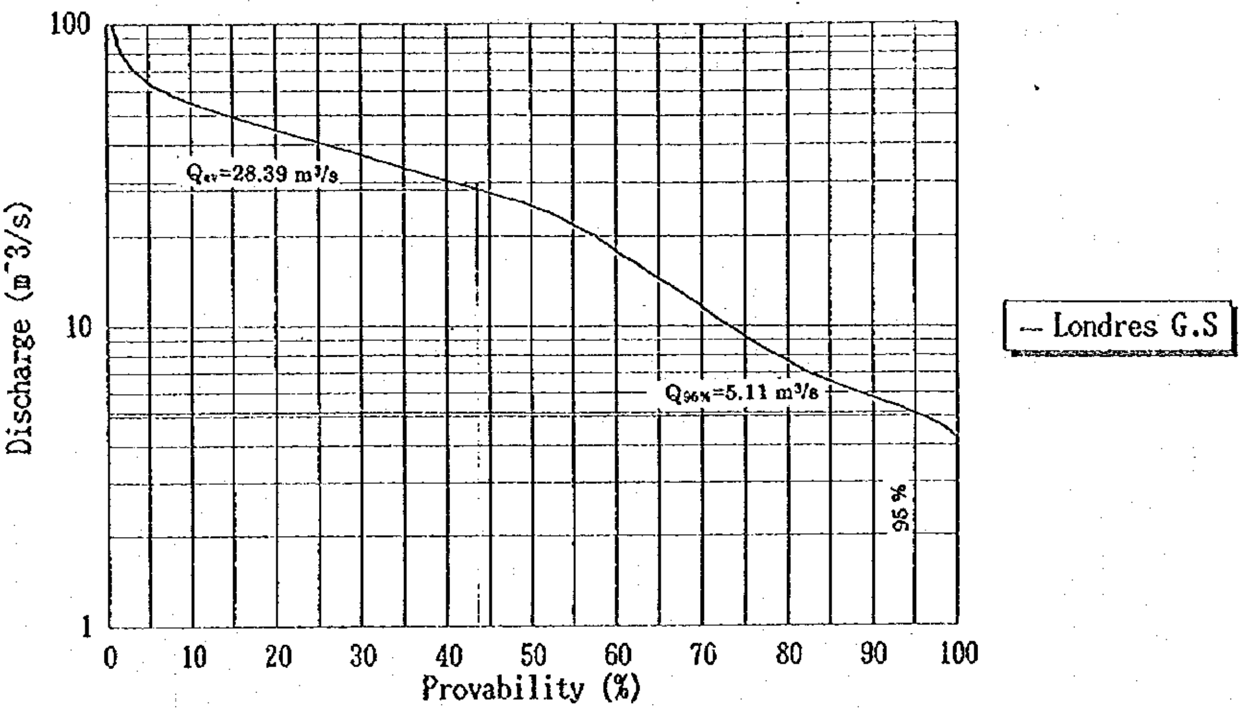
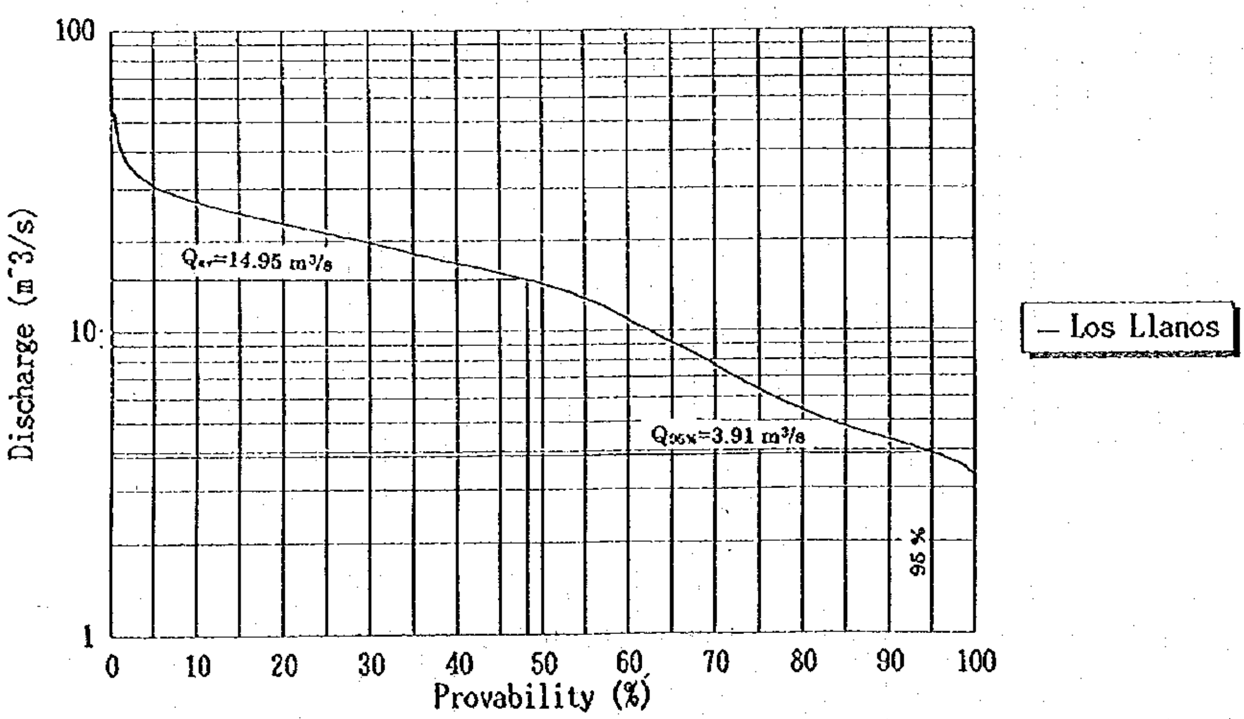


Fig. 6-7 Duration Curve at the Los Llanos Gauging Station

Period : 1971 to 1993



6-9

4-7

Fig. 6-8 Mass Curve at the Tocori Site (C.A = 5 km²)

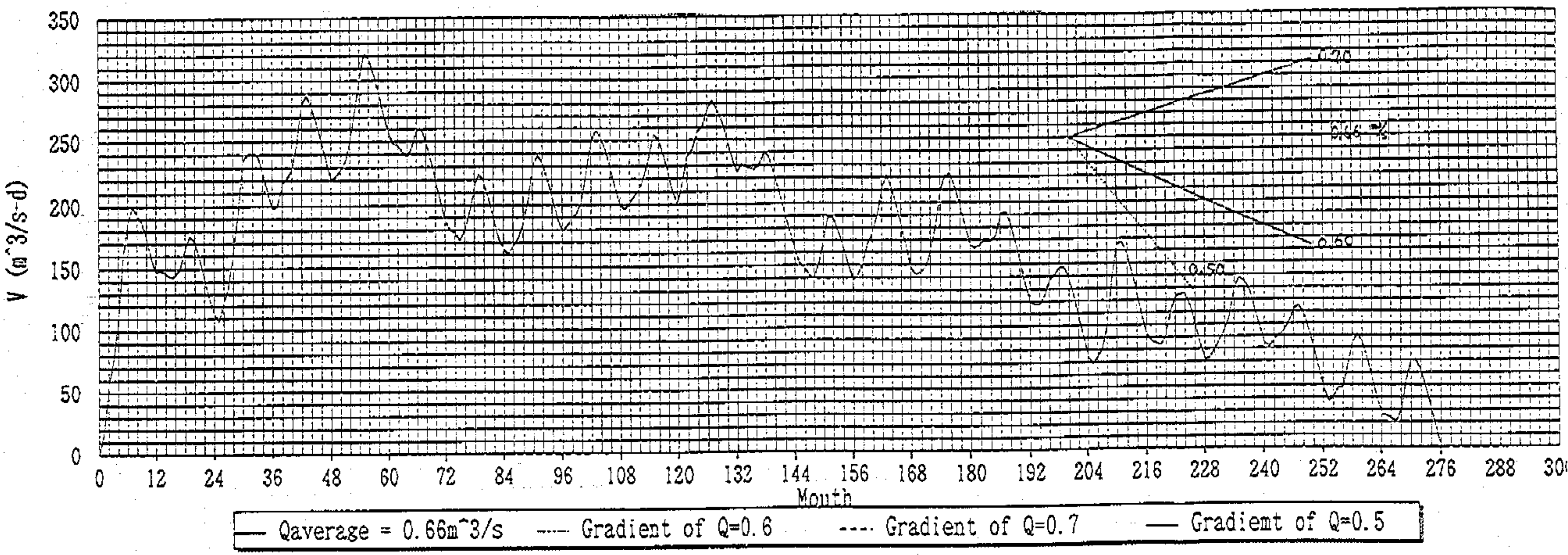


Fig. 6-9 Correlation between the Concentration of Suspended Load and the Discharge at the Londres Gauging Station

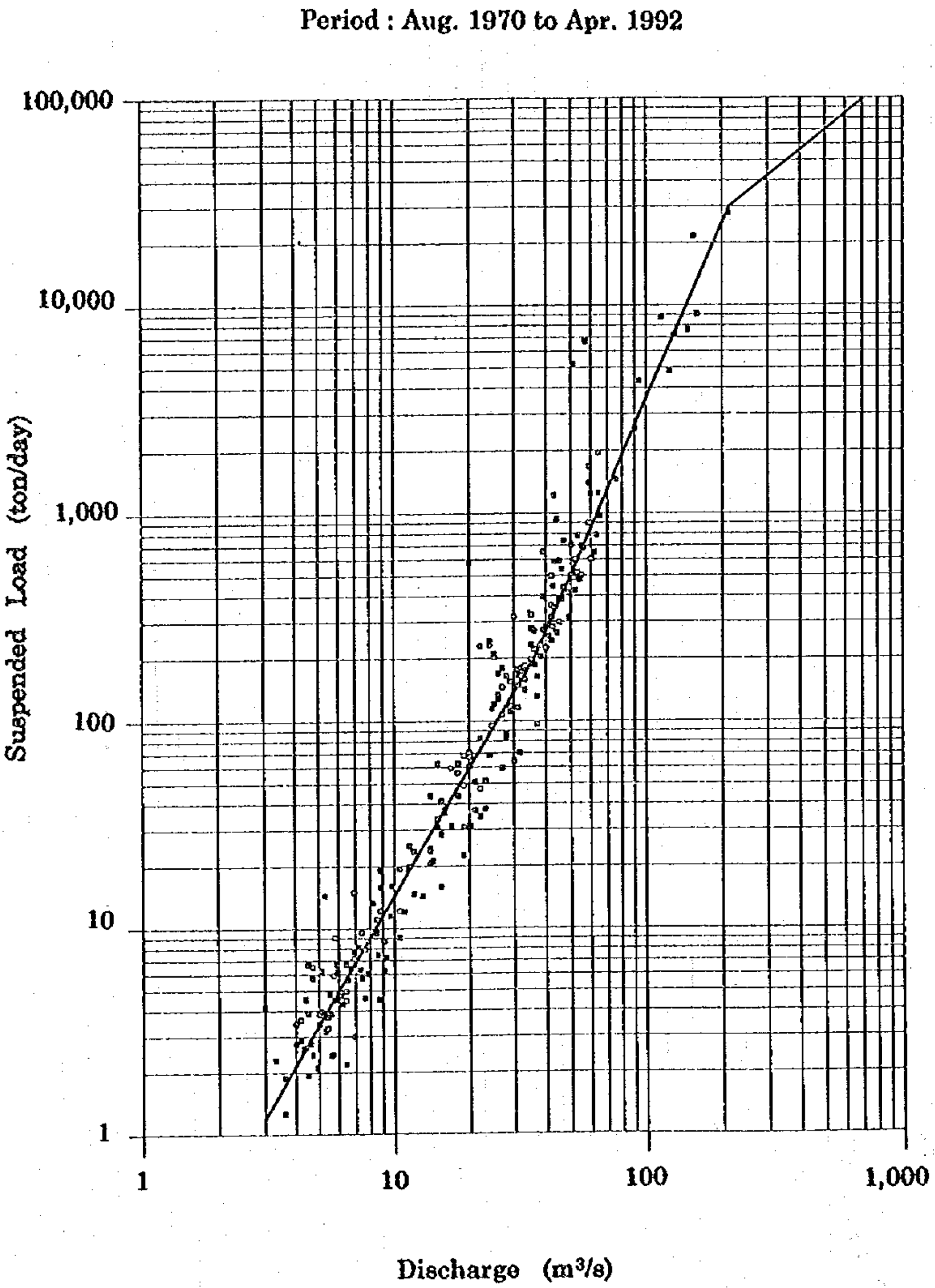


Fig. 6-10 Correlation between the Suspended Load and the Discharge at the Londres Gauging Station

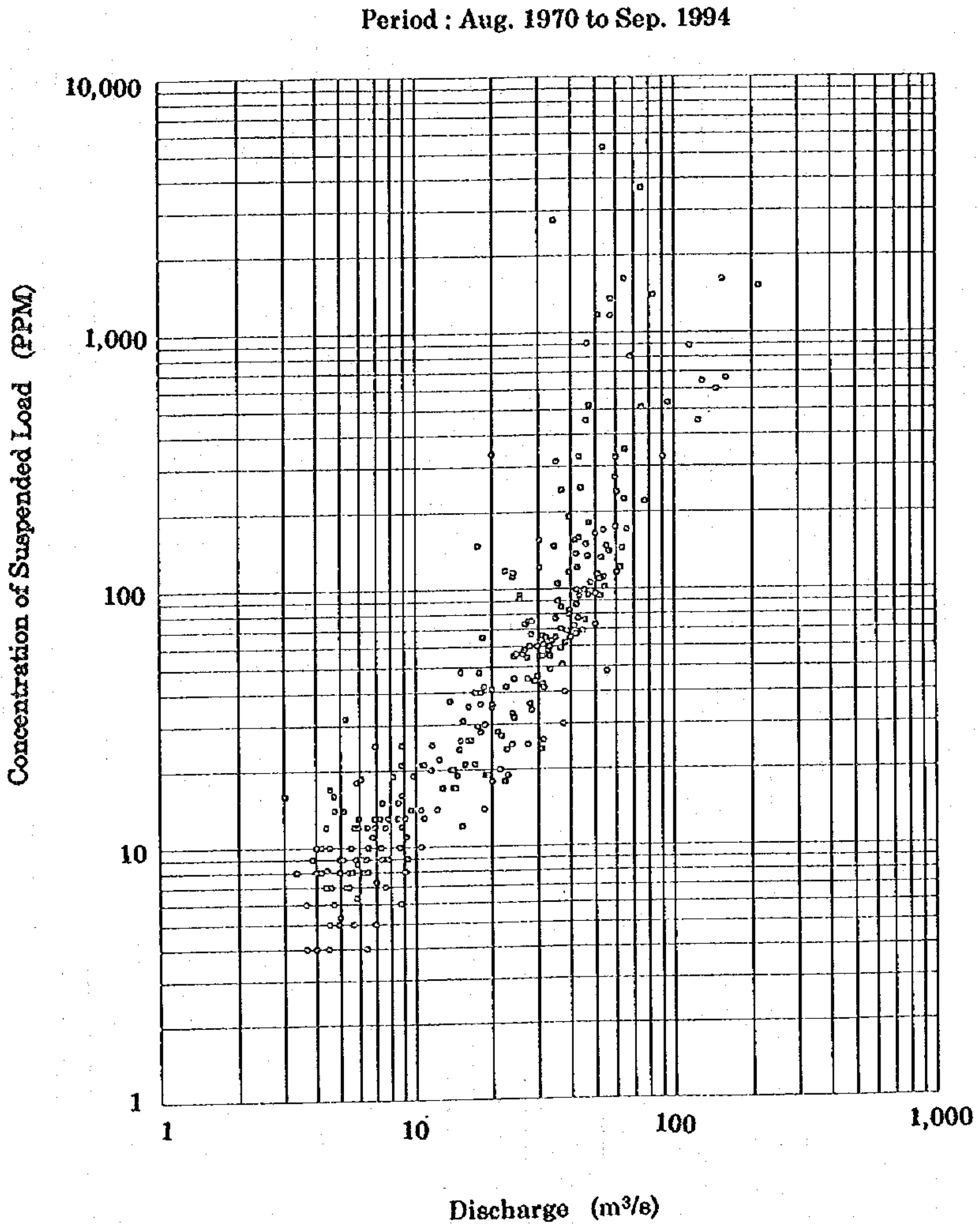
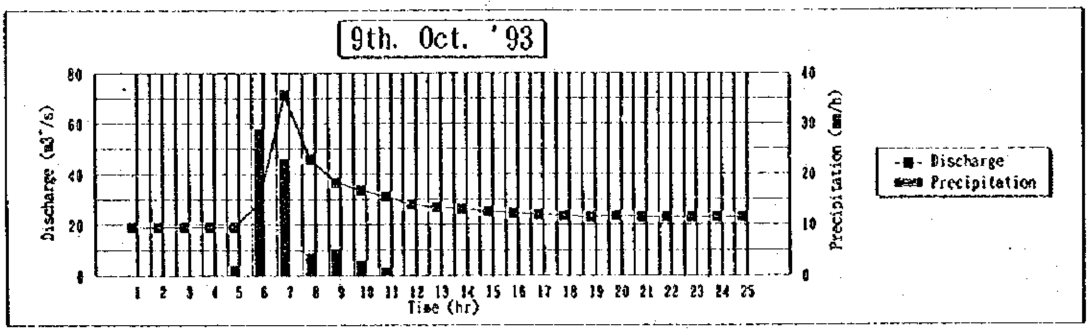
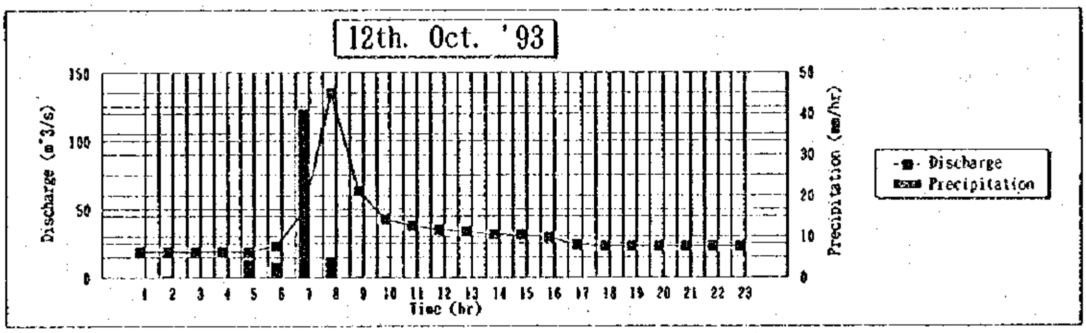
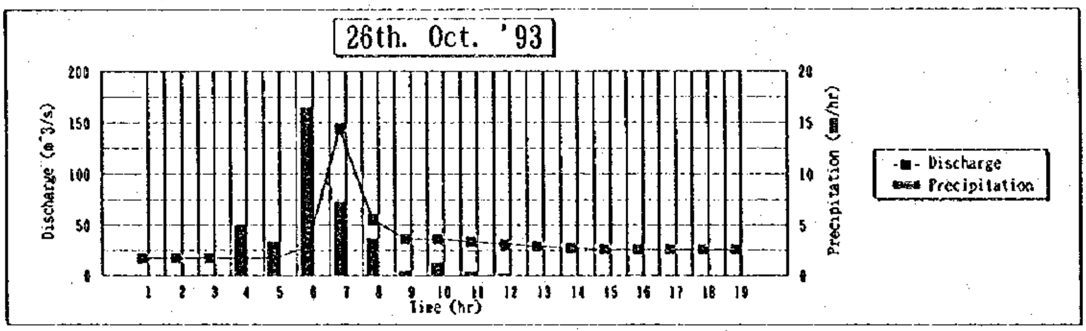


Fig. 6-11 Hydrographs and Hyetographs during several floods at the Los Llanos Site







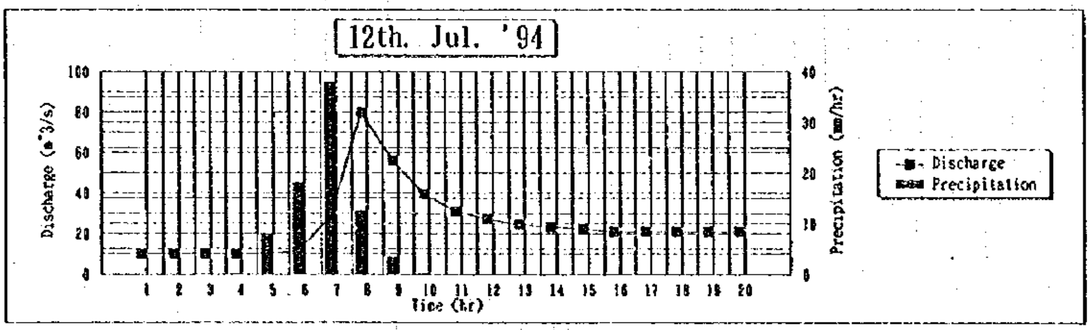


Fig. 6-12 Correlation between Duration of the Londres and the Los Llanos Gauging Stations

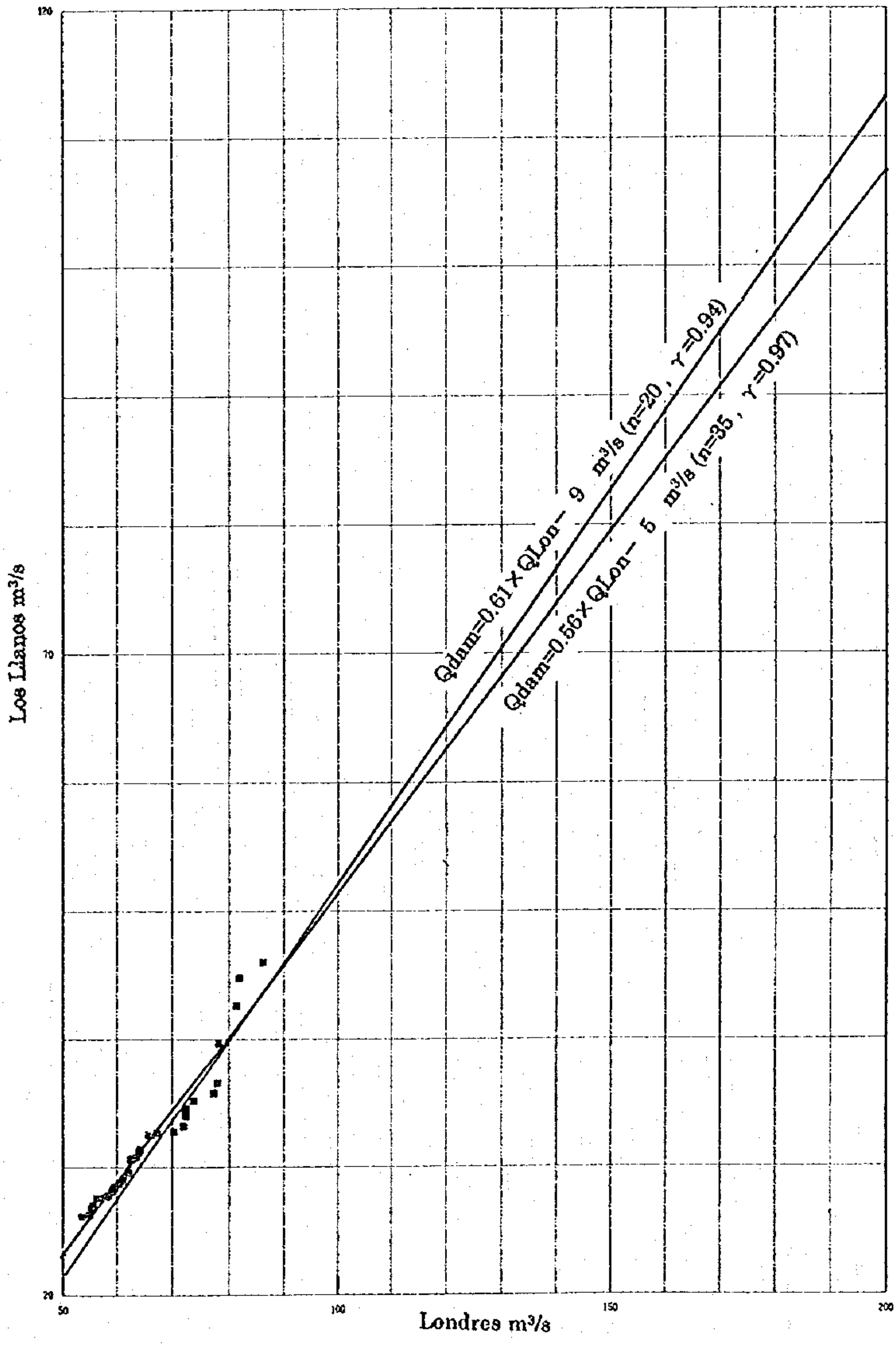


Fig. 6-13 Isohyetal Map of Project Region During Joan Hurricane in 1988

S = 1 / 200 000

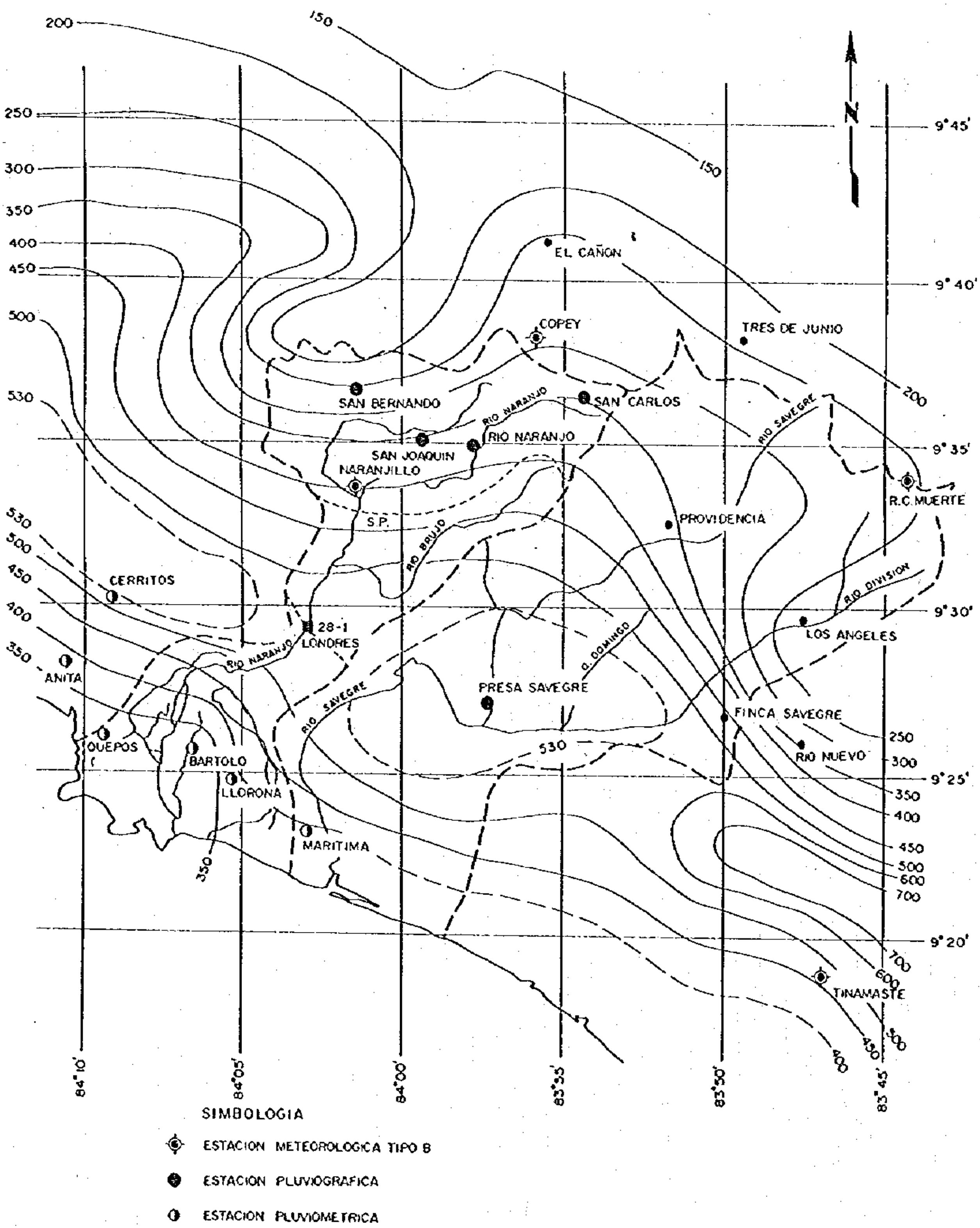


Fig. 6-14 Probable Flood Discharge at the Londres Gauging Station

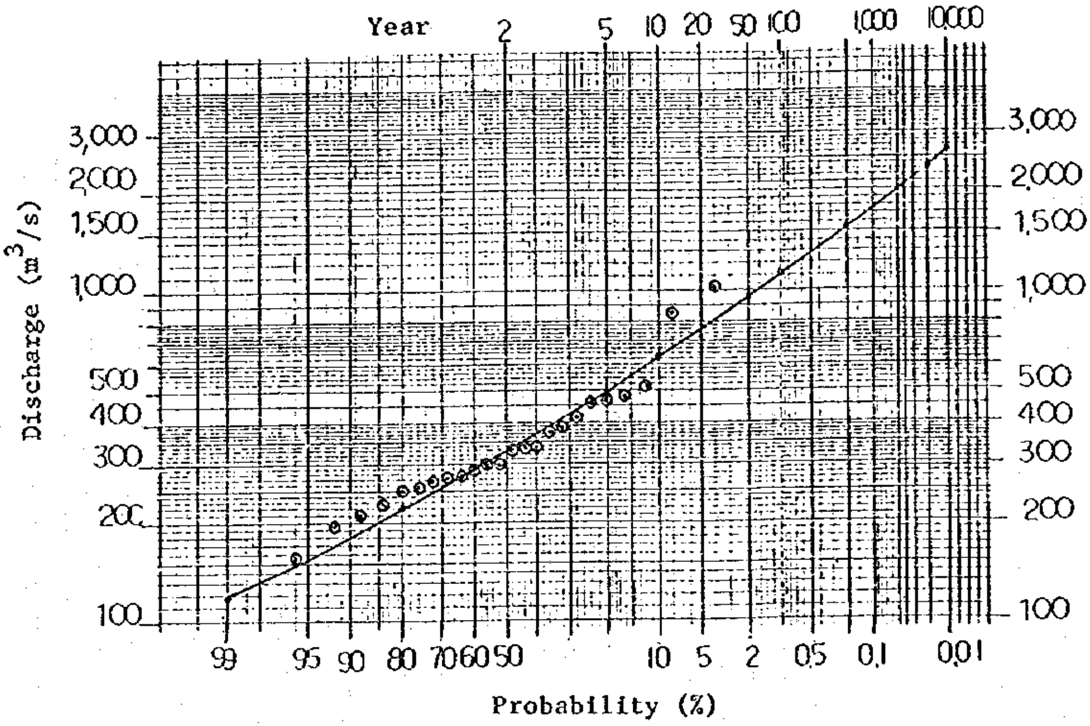


Fig. 6-15 Probable Flood Discharge at Los Llanos Site

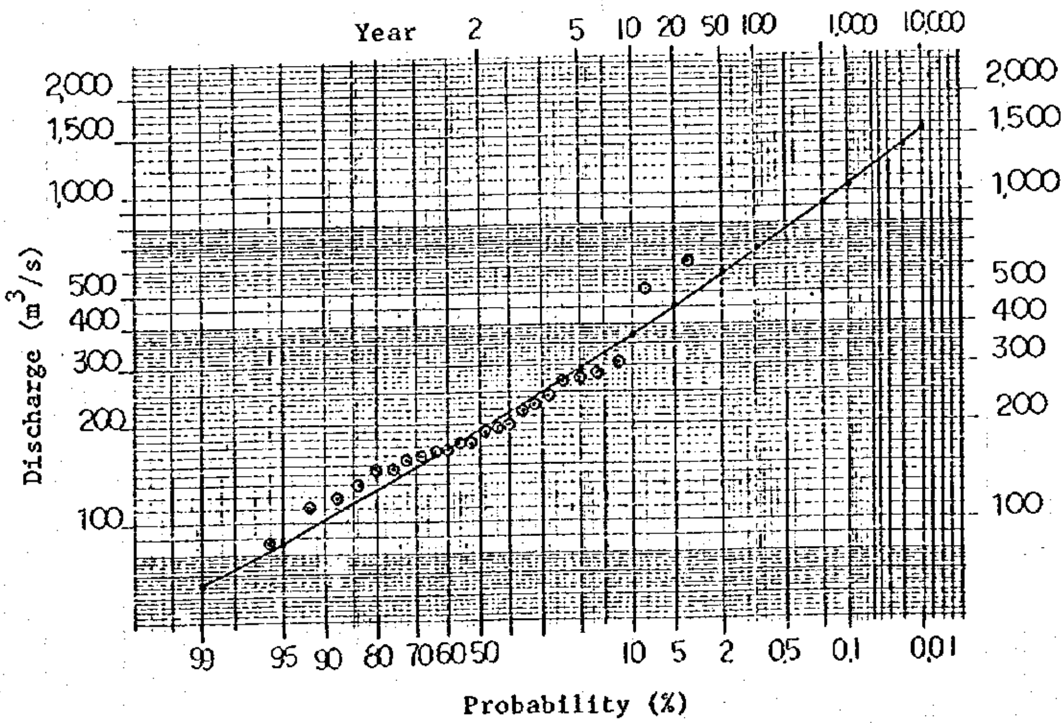


Fig. 6-16 Maximum Persisting 12-hour 1,000 hPa Dew Point at the Playon Site

(1976 - 1993)

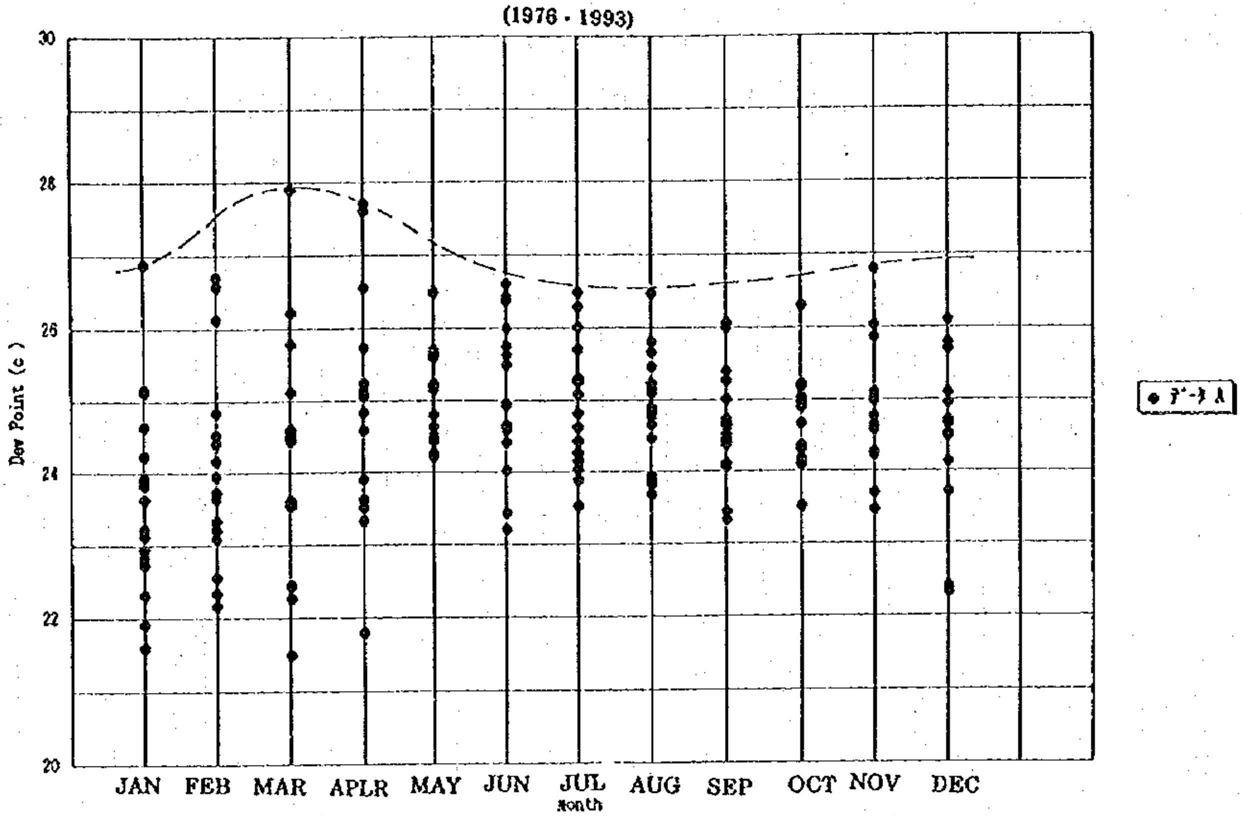


Fig. 6-17 Tentative Maximizing Factor of the Playon Site

Precipitable Water value are not revised to elevation

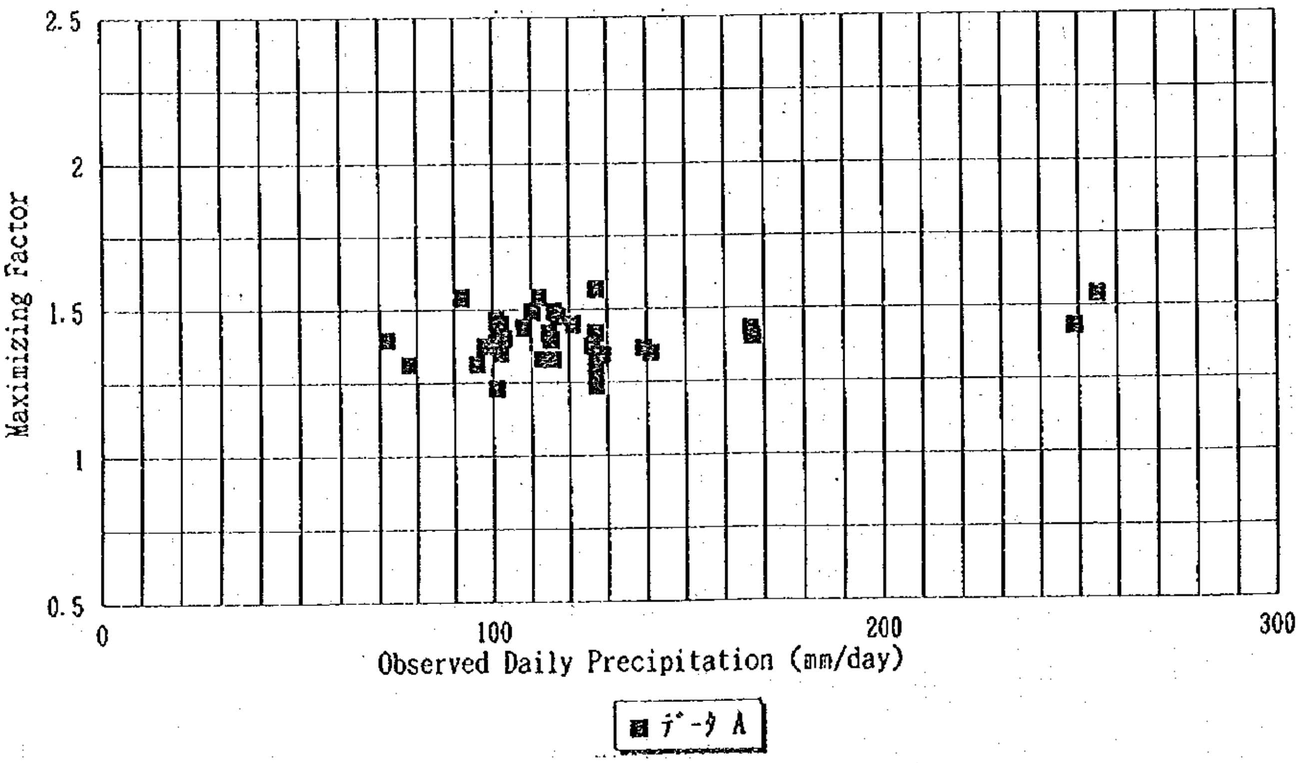


Fig. 6-18 Depth - Duration Curve at the Naranjillo Site in 22 to 24 Oct. 1988

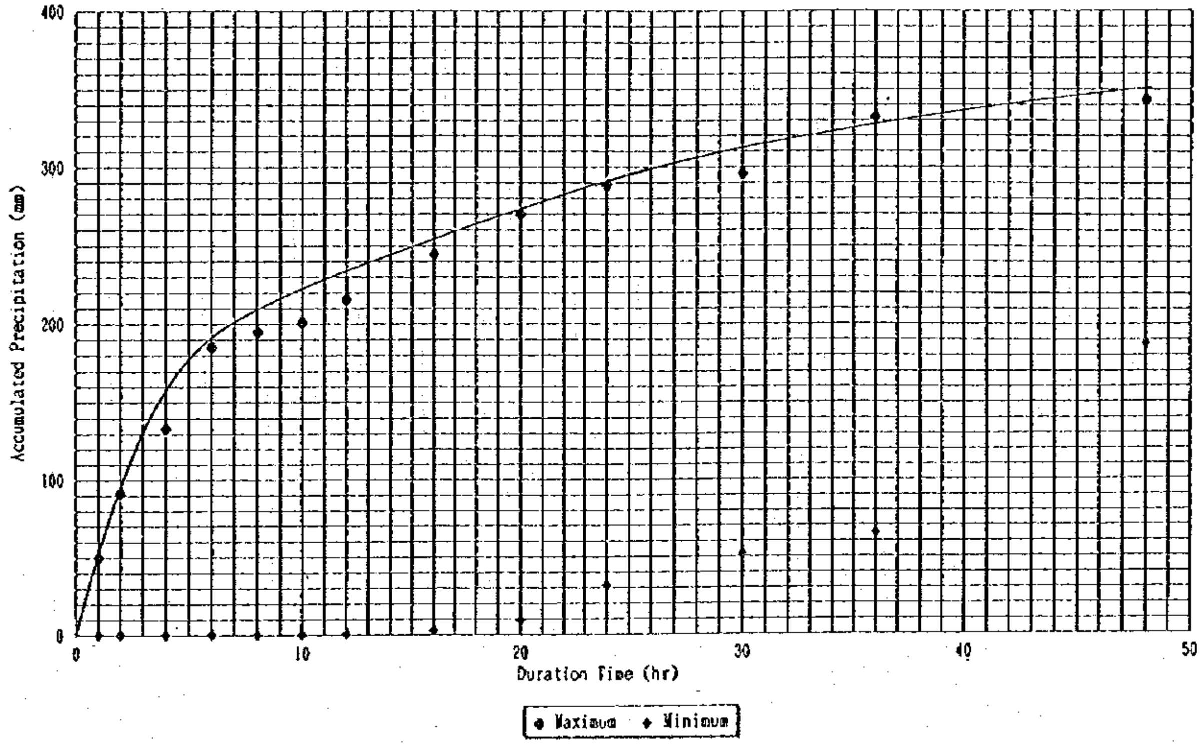


Fig. 6-19 Depth - Duration Curve at the Providencia Site in 22 to 24 Oct. 1988

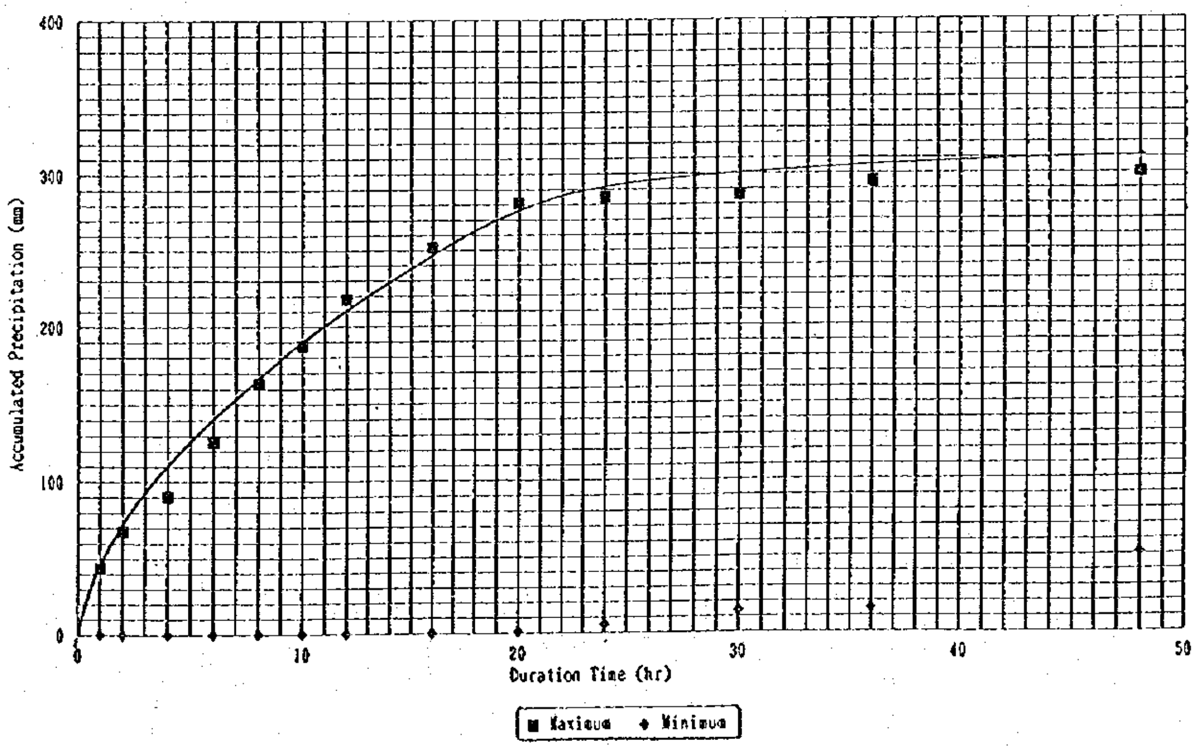


Fig. 6-20 Rainfall Distribution in the Project Basin on 26 Oct. 1993

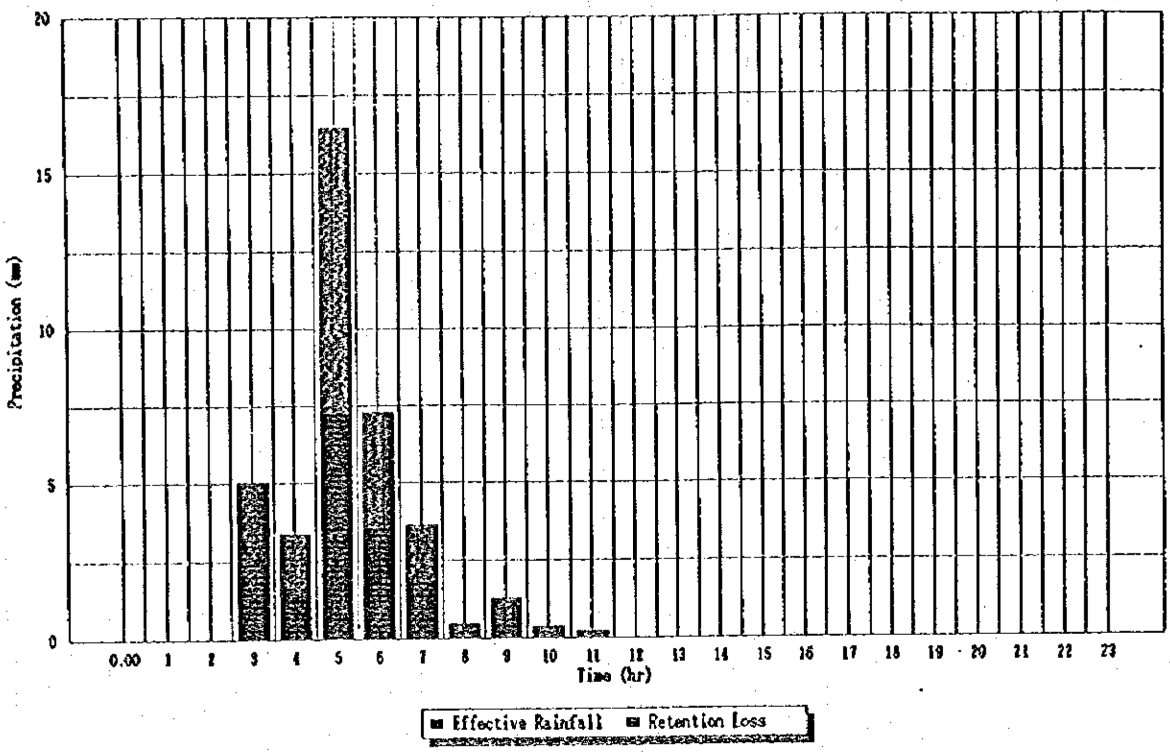
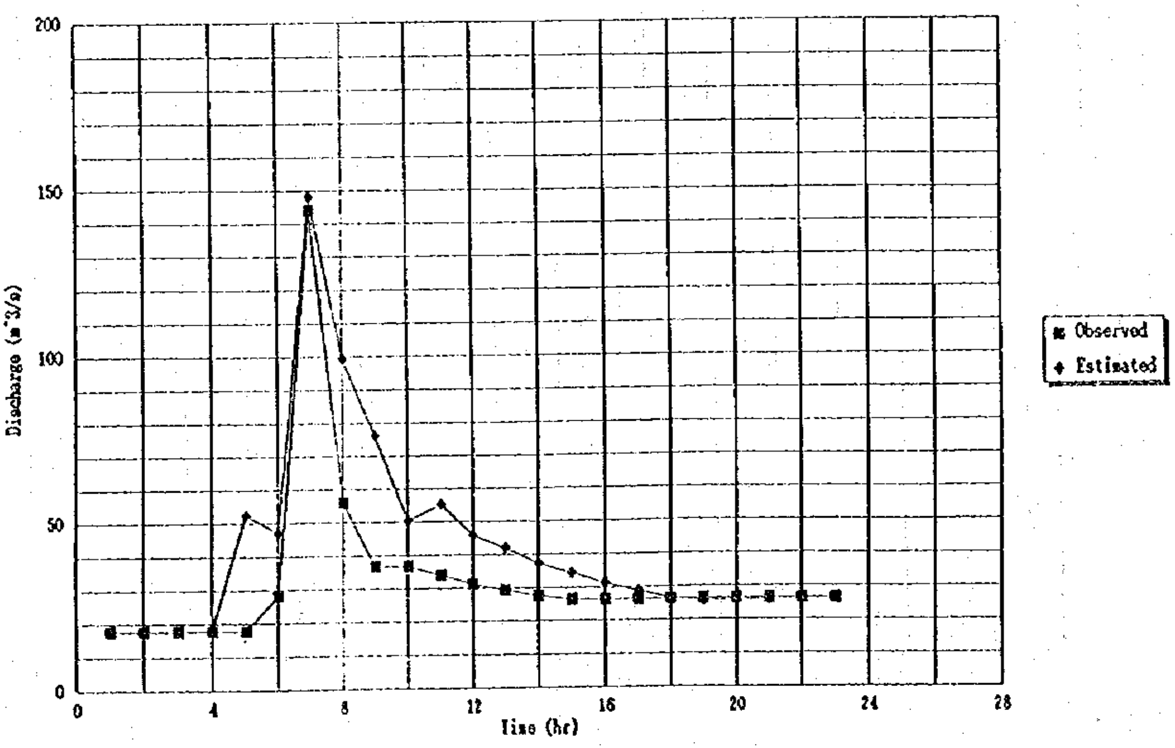


Fig. 6-21 Flood Hydrograph at the Los Llanos Site on 26 October 1993



41-9

Fig. 6-22 Unit Hydrograph at the Los Llanos Site (26 Oct. 1993)

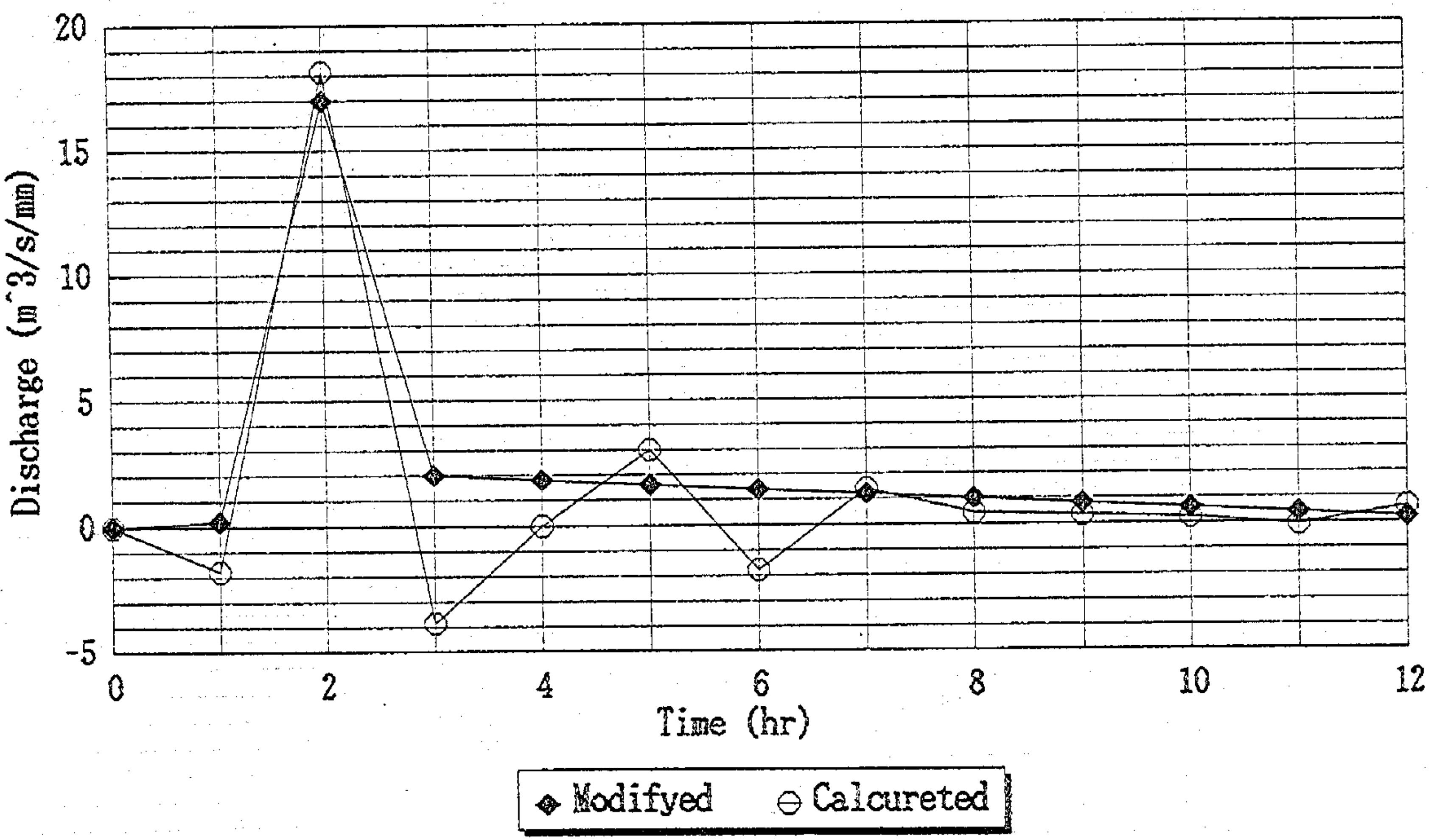


Fig. 6-23 Time Distribution of PMP in the Project Basin

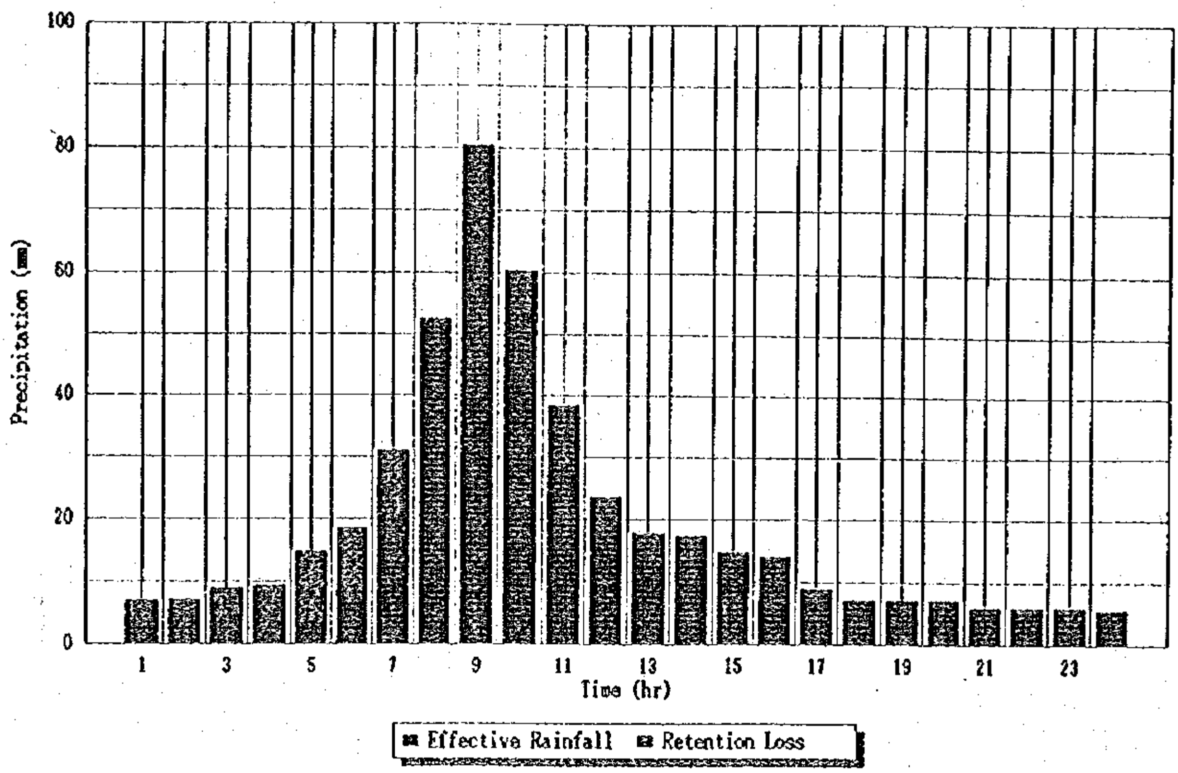


Fig. 6-24 Hydrograph of PMF at the Los Llanos Site

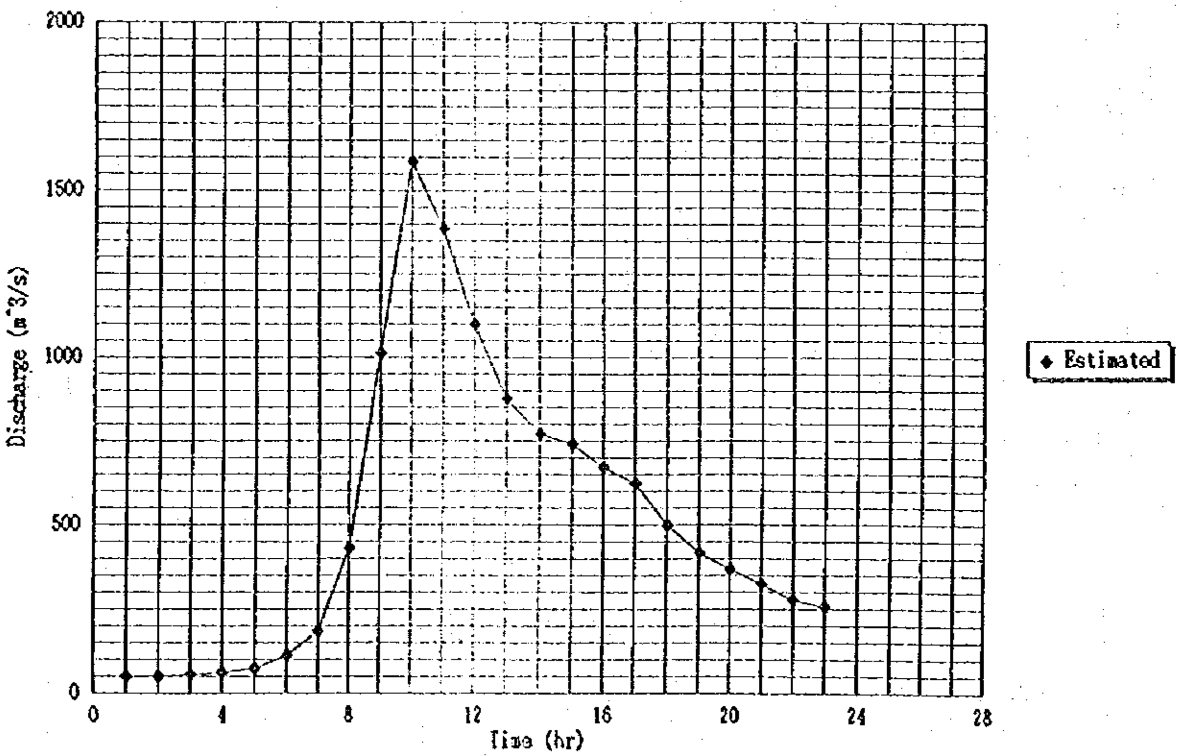
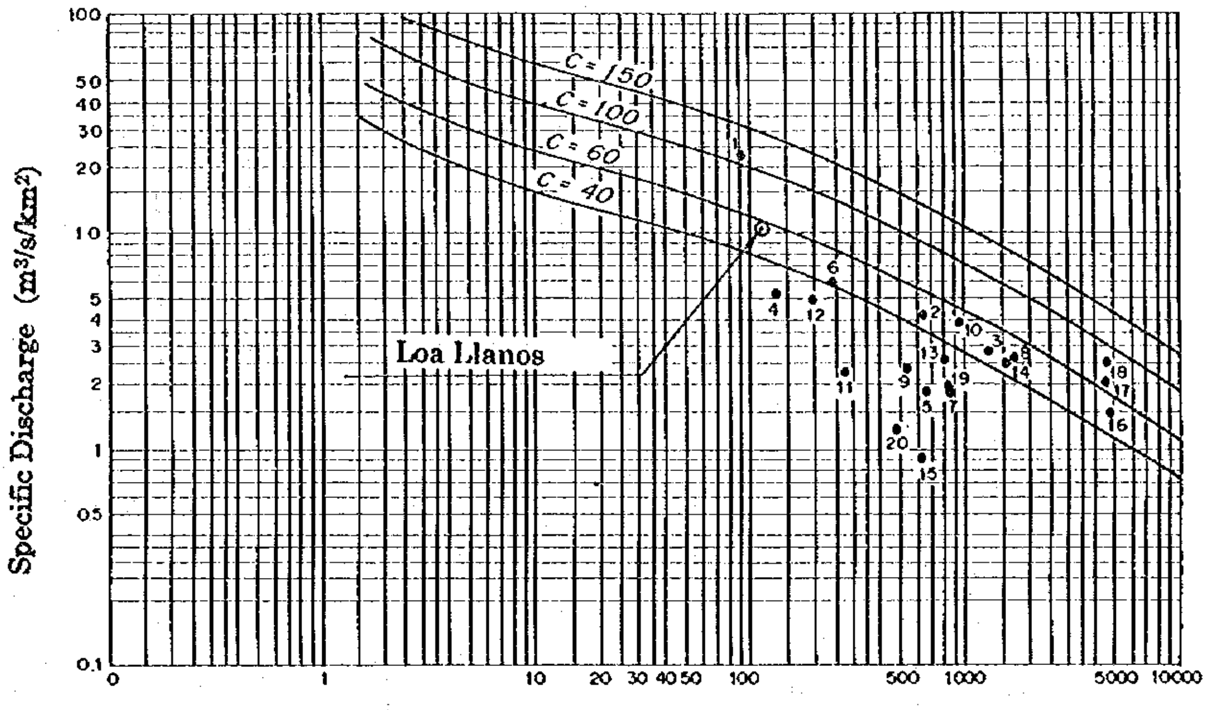


Fig. 6-25 Specific Flood Discharge for Existing and Los Llanos Dam Site



Maximum Experienced Flood in Costa Rica

No.	River	Site	Date	Discharge (m³/s)	C
1	Banano	Asuncion	1-8-76	2,170	114
2	Pacuare	Siquirres	9-4-70	2,920	51
3	Reventazon	Angostura	9-4-70	3,600	47
4	Pejibaye	El Humo	9-4-70	720	31
5	Reventazon	Cachi	9-4-70	1,300	22
6	Pejibaye	Oriente	9-4-70	1,380	42
7	Reventazon	El Congo	22-9-68	1,610	24
8	Reventazon	Pascua	9-4-70	4,260	47
9	Rio San Carlos	Jabillos	20-10-74	1,260	24
10	Tempisque	Guardia	27-10-60	2,060	54
11	Corobici	Corobici	23-9-74	742	18
12	Barranca	Nagatac	25-8-71	983	33
13	Virilla	San Miguel	25-11-68	2,210	34
14	Grande de Tarcoles	Balsa	24-11-69	1,976	22
15	Grande	Press La Sarita	6-9-61	577	10
16	Grande de Terraba	Palmar	29-8-73	7,300	62
17	Grande de Terraba	Palmar	20-10-54	10,600	73
18	Grande de Terraba	Palmar	13-10-55	12,000	85
19	General	La Cuesta	29-8-73	1,630	25
20	Arenal	Sangregado	20-10-74	655	13

$$Q = 1.3C\left[\frac{A}{2.59}\right]^{0.936A^{-0.048}}$$

Los Llanos Project

River : Naranjo River

Catchment Area : 147.0 km²

Design Flood Discharge : 1,600 m³/s (PMF)

Specific Discharge : 10.8 m³/s/km²

C : 50

Table 6-1 Exiting Meteorological Gauging Stations

No.	Station	Type	East Longitude	North Latitude	Elevation (m)	Start of Observation
88015	Playon	B	09° 36′	84° 18′	65	May 1971
92004	Nranjillo	B	09° 34′	84° 02′	780	Aprl. 1981
94005	Providencia	PG	09° 31′	83° 52′	1,490	Feb. 1978
88023	Copey de Dota	B	09° 39′	83° 55′	1,880	Jun. 1981
90003	Quepos	PV	09° 26′	84° 09′	5	May 1941
90005	Finca Cerritos	PV	09° 30′	84° 09′	15	Aprl. 1971
90008	Anita	PV	09° 28′	84° 10′	15	Jan. 1977
90001	Bartolo	PV	09° 26′	84° 06′	10	Jun. 1945
92002	Finca Llorona	PV	09° 24′	84° 05′	10	Jul. 1956
92006	San Bernardo	PG	09° 37′	84° 18′	1,260	Mar. 1992
92008	Rio Naranjo	PG	09° 35′	83° 57′	1,500	Mar. 1992
92010	S.Carlos Dota	PG	09° 36′	83° 54′	2,500	Mar. 1992
92012	San Joaquin	PG	09° 35′	83° 59′	1,300	Mar. 1992
92002	Maritima	PG	09° 23′	84° 03′	8	Jun. 1971
94010	Poyecto Savegre	PG	09° 27′	83° 57′	200	Mar. 1980

Table 6-2 Exiting Runoff Gauging Stations

No.	Station	Catchment Area (km^2)	East Longitude	North Latitude	Elevation (m)	Start of Observation
28-01	Londres	210.2	09° 28.9′	84° 02.9′	170	01 Aug. 1970
28-02	Los Llanos	147.0	09° 27′	83° 57′	480	28 Mar. 1992

Table 6-3 Monthly Average In-flow at the Londres Gauging Station

Catchment Area : 210.2 km^2 Annual Precipitation 6577 mm

Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	52.03	81.67	54.12	78.14	93.66	68.19	45.26	19.67	18.03	9.03	6.22	12.77	44.95
1972	29.57	24.29	23.50	29.56	35.06	50.45	40.98	20.96	9.35	6.37	5.71	9.31	23.86
1973	18.86	48.85	44.02	66.24	72.33	84.06	36.84	27.63	25.39	10.27	6.75	8.81	37.68
1974	29.44	52.49	33.26	38.29	52.86	74.67	39.01	14.70	8.79	6.26	6.18	7.36	30.31
1975	31.18	34.58	36.85	49.12	64.47	63.20	55.53	21.89	11.38	6.02	4.59	5.40	32.16
1976	14.89	25.84	19.99	21.80	38.24	47.18	28.73	13.55	7.51	5.75	5.17	6.31	19.64
1977	15.18	25.92	18.15	40.62	46.52	55.82	42.85	18.75	8.57	6.00	5.63	15.32	24.95
1978	21.15	36.61	37.02	44.36	53.83	63.39	40.44	19.42	10.19	6.94	6.08	11.61	29.37
1979	33.13	36.60	33.46	40.57	58.43	63.63	39.92	20.00	13.44	8.02	5.55	9.23	30.31
1980	22.85	34.75	35.52	35.34	40.81	48.28	53.11	21.58	11.95	7.93	6.96	13.86	27.74
1981	49.45	56.93	35.41	46.78	34.60	46.50	39.64	16.21	13.26	7.84	7.96	10.64	30.56
1982	37.02	25.59	25.89	25.87	33.55	40.85	21.44	9.46	6.04	5.68	6.83	7.69	20.60
1983	11.17	24.28	18.62	24.80	43.63	54.65	54.27	25.81	12.71	10.33	8.45	8.80	24.79
1984	32.61	42.00	48.60	38.97	48.55	56.26	44.47	14.86	6.90	5.00	3.91	4.70	29.03
1985	18.86	31.10	32.48	46.97	52.97	67.82	44.53	31.11	12.02	6.44	4.79	6.63	29.79
1986	24.30	32.65	31.08	26.52	33.48	51.99	31.67	13.55	7.39	5.21	4.13	7.16	22.46
1987	23.68	28.00	36.74	45.21	33.26	36.45	27.42	14.98	8.08	5.21	4.42	5.30	22.54
1988	18.62	35.86	37.28	56.83	77.21	67.31	28.70	13.88	8.14	4.48	3.38	4.74	29.83
1989	20.32	24.89	25.28	38.83	55.92	43.08	30.66	28.18	12.68	7.35	6.33	9.43	25.27
1990	29.32	36.89	38.27	38.70	42.23	60.35	40.56	23.75	17.73	7.95	5.75	9.20	29.37
1991	22.55	35.38	33.16	33.42	36.92	42.84	30.78	19.12	9.20	7.71	4.88	5.75	23.59
1992	10.43	33.18	37.96	28.14	53.85	51.66	36.38	19.70	8.31	6.11	5.83	8.57	25.01
1993	27.18	23.56	25.20	40.86	59.83	50.03	28.62	14.34	8.20	5.33	4.95	7.03	24.70
Total	593.79	831.91	761.86	935.94	1162.21	1288.66	881.81	443.10	255.26	157.23	130.45	195.62	638.50
Average	25.82	36.17	33.12	40.69	50.53	56.03	38.34	19.27	11.10	6.84	5.67	8.51	27.76
Min.	10.43	23.56	18.15	21.80	33.26	36.45	21.44	9.46	6.04	4.48	3.38	4.70	19.64
Max.	52.03	81.67	54.12	78.14	93.66	84.06	55.53	31.11	25.39	10.33	8.45	15.32	44.95

Table 6-4 Monthly Average In-flow at the Los Llanos Site

Catchment Area : 143.7 km^2
Q2802= 1.04128 * Q2801 ^ 0.81483 r = 0.95 Q95%(347th.day) = 3.91 m^3/s
Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	25.32	36.54	26.57	36.09	41.78	32.31	23.17	11.72	10.91	6.24	4.61	8.19	21.98
1972	16.27	13.97	13.59	16.35	18.83	25.27	21.37	12.35	6.42	4.70	4.30	6.16	13.35
1973	11.20	24.67	22.53	30.33	33.95	38.43	19.52	15.51	14.40	6.90	4.93	6.10	19.12
1974	16.24	26.10	17.97	20.05	26.29	34.88	20.47	9.24	6.11	4.63	4.58	5.25	15.99
1975	16.79	18.55	19.61	24.69	30.63	30.51	27.14	12.85	7.50	4.49	3.59	4.08	16.78
1976	9.07	14.71	11.92	12.78	20.09	23.82	15.99	8.66	5.38	4.32	3.94	4.64	11.31
1977	9.34	14.56	11.02	21.06	23.54	27.46	22.17	11.27	5.98	4.47	4.23	8.99	13.67
1978	12.42	19.47	19.73	22.81	26.74	30.42	21.08	11.62	6.89	5.05	4.52	7.46	15.74
1979	17.92	19.44	18.13	21.06	28.31	30.33	20.79	11.91	8.53	5.67	4.20	6.23	16.12
1980	13.20	18.52	18.76	18.92	21.26	24.46	26.42	12.68	7.83	5.62	5.05	8.65	15.11
1981	24.89	27.85	18.99	23.74	18.59	23.72	20.60	10.05	8.52	5.57	5.63	7.11	16.34
1982	19.45	14.59	14.67	14.71	18.03	21.30	12.62	6.49	4.50	4.27	4.95	5.47	11.81
1983	7.33	13.93	11.26	14.17	22.53	27.05	26.73	14.58	8.24	6.95	5.92	6.05	13.73
1984	17.48	21.79	24.60	20.57	24.57	27.75	22.79	9.32	5.02	3.86	3.16	3.62	15.44
1985	11.25	17.10	17.64	23.74	26.41	32.10	22.71	16.98	7.86	4.74	3.73	4.83	15.83
1986	13.31	17.77	17.10	15.02	18.16	25.98	17.37	8.66	5.30	3.99	3.30	5.12	12.61
1987	13.67	15.66	19.59	23.22	18.08	19.43	15.37	9.41	5.71	4.00	3.48	4.02	12.71
1988	11.15	18.94	19.80	27.91	35.41	31.86	15.89	8.84	5.73	3.53	2.80	3.64	15.52
1989	12.09	14.23	14.45	20.48	27.57	22.30	16.91	15.68	8.22	5.28	4.68	6.39	14.03
1990	16.25	19.67	20.17	20.38	21.96	29.29	21.14	13.70	10.81	5.62	4.33	6.29	15.87
1991	13.12	18.96	18.02	17.99	19.65	22.15	16.88	11.40	6.35	5.49	3.79	4.32	13.24
1992	6.94	17.92	20.11	15.77	26.67	25.86	19.43	11.70	5.84	4.59	4.12	5.35	13.69
1993	16.89	19.13	17.16	19.18	29.06	22.28	14.14	9.65	6.09	4.76	4.03	3.93	13.90
Total	331.59	444.07	413.39	481.02	578.11	628.96	460.70	264.27	168.14	114.74	97.87	131.89	343.87
Average	14.42	19.31	17.97	20.91	25.14	27.35	20.03	11.49	7.31	4.99	4.26	5.73	14.95
Min.	6.94	13.93	11.02	12.78	18.03	19.43	12.62	6.49	4.50	3.53	2.80	3.62	11.31
Max.	25.32	36.54	26.57	36.09	41.78	38.43	27.14	16.98	14.40	6.95	5.92	8.99	21.98

Table 6-5 Monthly Average In-flow at the Intake Channel Site (without Project)

Catchment Area : 230 km^2 Annual Precipitation 6,167 mm

Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	53.38	83.79	55.53	80.17	96.09	69.96	46.44	20.18	18.50	9.26	6.38	13.10	46.07
1972	30.34	24.92	24.11	30.33	35.97	51.76	42.04	21.50	9.59	6.54	5.86	9.55	24.38
1973	19.35	50.12	45.16	67.96	74.21	86.24	37.80	28.35	26.05	10.54	6.93	9.04	38.48
1974	30.21	53.85	34.12	39.28	54.23	76.61	40.02	15.08	9.02	6.42	6.34	7.55	31.06
1975	31.99	35.48	37.81	50.40	66.15	64.84	56.97	22.46	11.68	6.18	4.71	5.54	32.85
1976	15.28	26.51	20.51	22.37	39.23	48.41	29.48	13.90	7.71	5.90	5.30	6.47	20.09
1977	15.57	26.59	18.62	41.68	47.73	57.27	43.96	19.24	8.79	6.16	5.78	15.72	25.59
1978	21.70	37.56	37.98	45.51	55.23	65.04	41.49	19.92	10.45	7.12	6.24	11.91	30.01
1979	33.99	37.55	34.33	41.62	59.95	65.28	40.96	20.52	13.79	8.23	5.69	9.47	30.95
1980	23.44	35.65	36.44	36.26	41.87	49.53	54.49	22.14	12.26	8.14	7.14	14.22	28.47
1981	50.73	58.41	36.33	48.00	35.50	47.71	40.67	16.63	13.60	8.04	8.17	10.92	31.23
1982	37.98	26.25	26.56	26.54	34.42	41.91	22.00	9.71	6.20	5.83	7.01	7.89	21.03
1983	11.46	24.91	19.10	25.44	44.76	56.07	55.68	26.48	13.04	10.60	8.67	9.03	25.44
1984	33.46	43.09	49.86	39.98	49.81	57.72	45.63	15.25	7.08	5.13	4.01	4.82	29.65
1985	19.35	31.91	33.32	48.19	54.35	69.58	45.69	31.92	12.33	6.61	4.91	6.80	30.41
1986	24.93	33.50	31.89	27.21	34.35	53.34	32.49	13.90	7.58	5.35	4.24	7.35	23.01
1987	24.30	28.73	37.69	46.38	34.12	37.40	28.13	15.37	8.29	5.35	4.53	5.44	22.98
1988	19.10	36.79	38.25	58.31	79.22	69.06	29.45	14.24	8.35	4.60	3.47	4.86	30.47
1989	20.85	25.54	25.94	39.84	57.37	44.20	31.46	28.91	13.01	7.54	6.49	9.68	25.90
1990	30.08	37.85	39.26	39.71	43.33	61.92	41.61	24.37	18.19	8.16	5.90	9.44	29.98
1991	23.14	36.30	34.02	34.29	37.88	43.95	31.58	19.62	9.44	7.91	5.01	5.90	24.09
1992	10.70	34.04	38.95	28.87	55.25	53.00	37.33	20.21	8.53	6.27	5.98	8.79	25.66
1993	27.89	24.17	25.85	41.92	61.38	51.33	29.36	14.71	8.41	5.47	5.08	7.21	25.23
Total	609.22	853.53	781.66	960.26	1192.41	1322.15	904.72	454.61	261.89	161.32	133.84	200.70	653.03
Average	26.49	37.11	33.99	41.75	51.84	57.48	39.34	19.77	11.39	7.01	5.82	8.73	28.39
Min.	10.70	24.17	18.62	22.37	34.12	37.40	22.00	9.71	6.20	4.60	3.47	4.82	20.09
Max.	53.38	83.79	55.53	80.17	96.09	86.24	56.97	31.92	26.05	10.60	8.67	15.72	46.07

Table 6-6 Monthly Average In-flow at the Intake Channel Site (with Project)

$Q_{max.} = 27\ m^3/s$

Catchment Area : 230 km^2

Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	28.06	56.79	28.96	53.17	69.09	42.96	23.27	8.46	7.59	3.02	1.77	4.91	27.34
1972	14.07	10.95	10.52	13.98	17.14	26.49	20.67	9.15	3.17	1.84	1.56	3.39	11.08
1973	8.15	25.45	22.63	40.96	47.21	59.24	18.28	12.84	11.65	3.64	2.00	2.94	21.25
1974	13.97	27.75	16.15	19.23	27.94	49.61	19.55	5.84	2.91	1.79	1.76	2.30	15.74
1975	15.20	16.93	18.20	25.71	39.15	37.84	29.97	9.61	4.18	1.69	1.12	1.46	16.75
1976	6.21	11.80	8.59	9.59	19.14	24.59	13.49	5.24	2.33	1.58	1.36	1.83	8.81
1977	6.23	12.03	7.60	20.62	24.19	30.27	21.79	7.97	2.81	1.69	1.55	6.73	11.96
1978	9.28	18.09	18.25	22.70	28.49	38.04	20.41	8.30	3.56	2.07	1.72	4.45	14.61
1979	16.07	18.11	16.20	20.56	32.95	38.28	20.17	8.61	5.26	2.56	1.49	3.24	15.29
1980	10.24	17.13	17.68	17.34	20.61	25.07	28.07	9.46	4.43	2.52	2.09	5.57	13.35
1981	25.84	31.41	17.34	24.26	16.91	23.99	20.07	6.58	5.08	2.47	2.54	3.81	15.03
1982	18.53	11.66	11.89	11.83	16.39	20.61	9.38	3.22	1.70	1.56	2.06	2.42	9.27
1983	4.13	10.98	7.84	11.27	22.23	29.07	28.95	11.90	4.80	3.65	2.75	2.98	11.71
1984	15.98	21.30	25.26	19.41	25.24	30.72	22.84	5.93	2.06	1.27	0.85	1.20	14.34
1985	8.10	14.81	15.68	24.45	27.94	42.58	22.98	14.94	4.47	1.87	1.18	1.97	15.08
1986	11.62	15.73	14.79	12.19	16.19	27.36	15.12	5.24	2.28	1.36	0.94	2.23	10.42
1987	10.63	13.07	18.10	23.16	16.04	17.97	12.76	5.96	2.58	1.35	1.05	1.42	10.34
1988	7.95	17.85	18.45	31.31	52.22	42.06	13.56	5.40	2.62	1.07	0.67	1.22	16.20
1989	8.76	11.31	11.49	19.36	30.37	21.90	14.55	13.23	4.79	2.26	1.81	3.29	11.93
1990	13.83	18.18	19.09	19.33	21.37	34.92	20.47	10.67	7.38	2.54	1.57	3.15	14.37
1991	10.02	17.34	16.00	16.30	18.23	21.80	14.70	8.22	3.09	2.42	1.22	1.58	10.91
1992	3.76	16.12	18.84	13.10	28.58	27.14	17.90	8.51	2.69	1.68	1.86	3.44	11.97
1993	11.00	5.04	8.69	22.74	34.38	29.05	15.22	5.06	2.32	0.71	1.05	3.28	11.55
Total	277.63	419.85	368.27	492.57	652.01	741.58	444.16	190.34	93.75	46.58	35.97	68.81	319.29
Average	12.07	18.25	16.01	21.42	28.35	32.24	19.31	8.28	4.08	2.03	1.56	2.99	13.88
Min.	3.76	5.04	7.60	9.59	16.04	17.97	9.38	3.22	1.70	0.71	0.67	1.20	8.81
Max.	28.06	56.79	28.96	53.17	69.09	59.24	29.97	14.94	11.65	3.65	2.75	6.73	27.34

Table 6-7 Monthly Average In-flow at the River Mouth of Naranjo (without Project)

Catchment Area : 332 km^2 Annual Precipitation 5.543 mm

Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	69.26	108.71	72.04	104.01	124.67	90.77	60.25	26.18	24.00	12.02	8.28	17.00	59.77
1972	39.36	32.33	31.28	39.35	46.67	67.16	54.55	27.90	12.45	8.48	7.60	12.39	31.63
1973	25.11	65.03	58.60	88.17	96.28	111.90	49.04	36.78	33.80	13.67	8.99	11.73	49.92
1974	39.19	69.87	44.27	50.97	70.36	99.40	51.93	19.57	11.70	8.33	8.23	9.80	40.30
1975	41.50	46.03	49.05	65.39	85.82	84.13	73.92	29.14	15.15	8.01	6.11	7.19	42.62
1976	19.82	34.40	26.61	29.02	50.90	62.80	38.24	18.04	10.00	7.65	6.88	8.40	26.06
1977	20.21	34.50	24.16	54.07	61.92	74.30	57.04	24.96	11.41	7.99	7.49	20.39	33.20
1978	28.15	48.73	49.28	59.05	71.66	84.38	53.83	25.85	13.56	9.24	8.09	15.45	38.94
1979	44.10	48.72	44.54	54.00	77.78	84.70	53.14	26.62	17.89	10.68	7.39	12.29	40.15
1980	30.42	46.26	47.28	47.04	54.32	64.27	70.70	28.73	15.91	10.56	9.26	18.45	36.93
1981	65.82	75.78	47.14	62.27	46.06	61.90	52.77	21.58	17.65	10.44	10.60	14.16	40.51
1982	49.28	34.06	34.46	34.44	44.66	54.38	28.54	12.59	8.04	7.56	9.09	10.24	27.28
1983	14.87	32.32	24.79	33.01	58.08	72.75	72.24	34.36	16.92	13.75	11.25	11.71	33.00
1984	43.41	55.91	64.69	51.87	64.63	74.89	59.20	19.78	9.18	6.66	5.20	6.26	38.47
1985	25.11	41.40	43.24	62.52	70.51	90.28	59.28	41.41	16.00	8.57	6.38	8.83	39.46
1986	32.35	43.46	41.37	35.30	44.57	69.21	42.16	18.04	9.84	6.94	5.50	9.53	29.85
1987	31.52	37.27	48.91	60.18	44.27	48.52	36.50	19.94	10.76	6.94	5.88	7.06	29.81
1988	24.79	47.73	49.62	75.65	102.78	89.60	38.20	18.48	10.84	5.96	4.50	6.31	39.54
1989	27.05	33.13	33.65	51.69	74.44	57.35	40.81	37.51	16.88	9.78	8.43	12.55	33.61
1990	39.03	49.11	50.94	51.51	56.21	80.33	53.99	31.61	23.60	10.58	7.65	12.25	38.90
1991	30.02	47.10	44.14	44.49	49.15	57.03	40.97	25.45	12.25	10.26	6.50	7.65	31.25
1992	13.88	44.17	50.53	37.46	71.68	68.77	48.43	26.22	11.06	8.13	7.76	11.41	33.29
1993	36.18	31.36	33.54	54.39	79.64	66.60	38.10	19.09	10.92	7.09	6.59	9.36	32.74
Total	790.42	1107.39	1014.14	1245.86	1547.06	1715.38	1173.81	589.83	339.79	209.29	173.65	260.40	847.25
Average	34.37	48.15	44.09	54.17	67.26	74.58	51.04	25.64	14.77	9.10	7.55	11.32	36.84
Min.	13.88	31.36	24.16	29.02	44.27	48.52	28.54	12.59	8.04	5.96	4.50	6.26	26.06
Max.	69.26	108.71	72.04	104.01	124.67	111.90	73.92	41.41	33.80	13.75	11.25	20.39	59.77

Table 6-3 Monthly Average In-flow at the River Mouth of Naranjo (with Project)

$Q_{max.} = 27\ m^3/s$

Catchment Area : 332 km^2

Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	43.94	81.71	45.47	77.01	97.67	63.77	37.08	14.46	13.09	5.78	3.67	8.81	41.04
1972	23.09	18.36	17.69	23.00	27.84	41.89	33.18	15.55	6.03	3.78	3.30	6.23	18.33
1973	13.91	40.36	36.07	61.17	69.28	84.90	29.52	21.27	19.40	6.77	4.06	5.63	32.69
1974	22.95	43.77	26.30	30.92	44.07	72.40	31.46	10.33	5.59	3.70	3.65	4.55	24.97
1975	24.71	27.48	29.44	40.70	58.82	57.13	46.92	16.29	7.65	3.52	2.52	3.11	26.52
1976	10.75	19.69	14.69	16.24	30.81	38.98	22.25	9.38	4.62	3.33	2.94	3.76	14.79
1977	10.87	19.94	13.14	33.01	38.38	47.30	34.87	13.69	5.43	3.52	3.26	11.40	19.57
1978	15.73	29.26	29.55	36.24	44.92	57.38	32.75	14.23	6.67	4.19	3.57	7.99	23.54
1979	26.18	29.28	26.41	32.94	50.78	57.70	32.35	14.71	9.36	5.01	3.19	6.06	24.50
1980	17.22	27.74	28.52	28.12	33.06	39.81	44.28	16.05	8.08	4.94	4.21	9.80	21.82
1981	40.93	48.78	28.15	38.53	27.47	38.18	32.17	11.53	9.13	4.87	4.97	7.05	24.31
1982	29.83	19.47	19.79	19.73	26.63	33.08	15.92	6.10	3.54	3.29	4.14	4.77	15.52
1983	7.54	18.39	13.53	18.84	35.55	45.75	45.51	19.78	8.68	6.80	5.33	5.66	19.28
1984	25.93	34.12	40.09	31.30	40.06	47.89	36.41	10.46	4.16	2.80	2.04	2.64	23.16
1985	13.86	24.30	25.60	38.78	44.10	63.28	36.57	24.43	8.14	3.83	2.65	4.00	24.13
1986	19.04	25.69	24.27	20.28	26.41	43.23	24.79	9.38	4.54	2.95	2.20	4.41	17.26
1987	17.85	21.61	29.32	36.96	26.19	29.09	21.13	10.53	5.05	2.94	2.40	3.04	17.18
1988	13.64	28.79	29.82	48.65	75.78	62.60	22.31	9.64	5.11	2.43	1.70	2.67	25.26
1989	14.96	18.90	19.20	31.21	47.44	35.05	23.90	21.83	8.66	4.50	3.75	6.16	19.63
1990	22.78	29.44	30.77	31.13	34.25	53.33	32.85	17.91	12.79	4.96	3.32	5.96	23.29
1991	16.90	28.14	26.12	26.50	29.50	34.88	24.09	14.05	5.90	4.77	2.71	3.33	18.07
1992	6.94	26.25	30.42	21.69	45.01	42.91	29.00	14.52	5.22	3.54	3.64	6.06	19.60
1993	19.29	12.23	16.38	35.21	52.64	44.32	23.96	9.44	4.83	2.33	2.56	5.43	19.05
Total	458.83	673.71	600.75	778.17	1006.66	1134.81	713.25	325.56	171.65	94.55	75.78	128.51	513.52
Average	19.95	29.29	26.12	33.83	43.77	49.34	31.01	14.15	7.46	4.11	3.29	5.59	22.33
Min.	6.94	12.23	13.14	16.24	26.19	29.09	15.92	6.10	3.54	2.33	1.70	2.64	14.79
Max.	43.94	81.71	45.47	77.01	97.67	84.90	46.92	24.43	19.40	6.80	5.33	11.40	41.04

Table 6-9 Monthly Average In-flow at the Power House Site (without Project)

Catchment Area : 24.5 km^2 Annual Precipitation 7.577 mm

Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	6.99	10.97	7.27	10.49	12.58	9.16	6.08	2.64	2.42	1.21	0.84	1.71	6.03
1972	3.97	3.26	3.16	3.97	4.71	6.77	5.50	2.81	1.26	0.86	0.77	1.25	3.19
1973	2.53	6.56	5.91	8.89	9.71	11.29	4.95	3.71	3.41	1.38	0.91	1.18	5.04
1974	3.95	7.05	4.47	5.14	7.10	10.03	5.24	1.97	1.18	0.84	0.83	0.99	4.07
1975	4.19	4.64	4.95	6.60	8.66	8.49	7.46	2.94	1.53	0.81	0.62	0.73	4.30
1976	2.00	3.47	2.68	2.93	5.13	6.34	3.86	1.82	1.01	0.77	0.69	0.85	2.63
1977	2.04	3.48	2.44	5.45	6.25	7.50	5.75	2.52	1.15	0.81	0.76	2.06	3.35
1978	2.84	4.92	4.97	5.96	7.23	8.51	5.43	2.61	1.37	0.93	0.82	1.56	3.93
1979	4.45	4.91	4.49	5.45	7.85	8.54	5.36	2.69	1.80	1.08	0.75	1.24	4.05
1980	3.07	4.67	4.77	4.75	5.48	6.48	7.13	2.90	1.60	1.06	0.93	1.86	3.73
1981	6.64	7.64	4.75	6.28	4.65	6.24	5.32	2.18	1.78	1.05	1.07	1.43	4.09
1982	4.97	3.44	3.48	3.47	4.51	5.49	2.88	1.27	0.81	0.76	0.92	1.03	2.75
1983	1.50	3.26	2.50	3.33	5.86	7.34	7.29	3.47	1.71	1.39	1.13	1.18	3.33
1984	4.38	5.64	6.53	5.23	6.52	7.55	5.97	2.00	0.93	0.67	0.53	0.63	3.88
1985	2.53	4.18	4.36	6.31	7.11	9.11	5.98	4.18	1.61	0.86	0.64	0.89	3.98
1986	3.26	4.38	4.17	3.56	4.50	6.98	4.25	1.82	0.99	0.70	0.55	0.96	3.01
1987	3.18	3.76	4.93	6.07	4.47	4.89	3.68	2.01	1.08	0.70	0.59	0.71	3.01
1988	2.50	4.82	5.01	7.63	10.37	9.04	3.85	1.86	1.09	0.60	0.45	0.64	3.99
1989	2.73	3.34	3.39	5.21	7.51	5.78	4.12	3.78	1.70	0.99	0.85	1.27	3.39
1990	3.94	4.95	5.14	5.20	5.67	8.10	5.45	3.19	2.38	1.07	0.77	1.24	3.92
1991	3.03	4.75	4.45	4.49	4.96	5.75	4.13	2.57	1.24	1.04	0.66	0.77	3.15
1992	1.40	4.46	5.10	3.78	7.23	6.94	4.89	2.65	1.12	0.82	0.78	1.15	3.36
1993	3.65	3.16	3.38	5.49	8.03	6.72	3.84	1.93	1.10	0.72	0.66	0.94	3.30
Total	79.73	111.71	102.30	125.68	156.06	173.04	118.41	59.50	34.28	21.11	17.52	26.27	85.47
Average	3.47	4.86	4.45	5.46	6.79	7.52	5.15	2.59	1.49	0.92	0.76	1.14	3.72
Min.	1.40	3.16	2.44	2.93	4.47	4.89	2.88	1.27	0.81	0.60	0.45	0.63	2.63
Max.	6.99	10.97	7.27	10.49	12.58	11.29	7.46	4.18	3.41	1.39	1.13	2.06	6.03

Table 6-10 Monthly Average In-flow at the Power House Site (with Project)

$Q_{max.} = 27\ m^3/s$

Catchment Area : 24.5 km^2

Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	32.31	37.97	33.84	37.49	39.58	36.16	29.25	14.36	13.33	7.45	5.45	9.90	24.76
1972	20.24	17.23	16.75	20.32	23.54	32.04	26.87	15.16	7.68	5.56	5.07	7.41	16.49
1973	13.73	31.23	28.44	35.89	36.71	38.29	24.47	19.22	17.81	8.28	5.84	7.28	22.27
1974	20.19	33.15	22.44	25.19	33.39	37.03	25.71	11.21	7.29	5.47	5.41	6.24	19.39
1975	20.98	23.19	24.56	31.29	35.66	35.49	34.46	15.79	9.03	5.30	4.21	4.81	20.40
1976	11.07	18.18	14.60	15.71	25.22	30.16	19.85	10.48	6.39	5.09	4.63	5.49	13.91
1977	11.38	18.04	13.46	26.51	29.79	34.50	27.92	13.79	7.13	5.28	4.99	11.05	16.99
1978	15.26	24.39	24.70	28.77	33.97	35.51	26.51	14.23	8.26	5.98	5.34	9.02	19.33
1979	22.37	24.35	22.62	26.51	34.85	35.54	26.15	14.60	10.33	6.75	4.95	7.47	19.71
1980	16.27	23.19	23.53	23.67	26.74	30.94	33.55	15.58	9.43	6.68	5.98	10.51	18.84
1981	31.53	34.64	23.74	30.02	23.24	29.96	25.92	12.23	10.30	6.62	6.70	8.54	20.29
1982	24.42	18.03	18.15	18.18	22.54	26.79	15.50	7.76	5.31	5.03	5.87	6.50	14.51
1983	8.83	17.19	13.76	17.50	28.39	34.34	34.02	18.05	9.95	8.34	7.05	7.23	17.05
1984	21.86	27.43	31.13	25.80	31.09	34.55	28.76	11.32	5.95	4.53	3.69	4.25	19.20
1985	13.78	21.28	22.00	30.05	33.52	36.11	28.69	21.16	9.47	5.60	4.37	5.72	19.31
1986	16.57	22.15	21.27	18.58	22.66	32.96	21.62	10.48	6.29	4.69	3.85	6.08	15.60
1987	16.85	19.42	24.52	29.29	22.55	24.32	19.05	11.42	6.79	4.70	4.07	4.73	15.64
1988	13.65	23.76	24.81	34.63	37.37	36.04	19.74	10.70	6.82	4.13	3.25	4.28	18.27
1989	14.82	17.57	17.84	25.69	34.51	28.08	21.03	19.46	9.92	6.27	5.53	7.66	17.37
1990	20.19	24.62	25.31	25.58	27.63	35.10	26.59	16.89	13.19	6.69	5.10	7.53	19.53
1991	16.15	23.71	22.47	22.48	24.61	27.90	21.01	13.97	7.59	6.53	4.45	5.09	16.33
1992	8.34	22.38	25.21	19.55	33.90	32.80	24.32	14.35	6.96	5.41	4.90	6.50	17.05
1993	20.54	22.29	20.54	24.67	35.03	29.00	17.98	11.58	7.19	5.48	4.69	4.87	16.99
Total	411.32	545.39	515.69	593.37	696.46	753.61	578.97	323.77	202.42	135.85	115.39	158.16	419.20
Average	17.88	23.71	22.42	25.80	30.28	32.77	25.17	14.08	8.80	5.91	5.02	6.88	18.23
Min.	8.34	17.19	13.46	15.71	22.54	24.32	15.50	7.76	5.31	4.13	3.25	4.25	13.91
Max.	32.31	37.97	33.84	37.49	39.58	38.29	34.46	21.16	17.81	8.34	7.05	11.05	24.76

Table 6-11 Monthly Average In-flow at the Cerritos Site (without Project)

Catchment Area : 68 km^2 Annual Precipitation 7,241 mm

Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	18.53	29.09	19.28	27.83	33.36	24.29	16.12	7.01	6.42	3.22	2.22	4.55	15.99
1972	10.53	8.65	8.37	10.53	12.49	17.97	14.60	7.47	3.33	2.27	2.03	3.32	8.46
1973	6.72	17.40	15.68	23.59	25.76	29.94	13.12	9.84	9.04	3.66	2.40	3.14	13.36
1974	10.49	18.69	11.85	13.64	18.83	26.59	13.89	5.24	3.13	2.23	2.20	2.62	10.78
1975	11.11	12.32	13.12	17.49	22.96	22.51	19.78	7.80	4.05	2.14	1.63	1.92	11.40
1976	5.30	9.20	7.12	7.76	13.62	16.80	10.23	4.83	2.67	2.05	1.84	2.25	6.97
1977	5.41	9.23	6.46	14.47	16.57	19.88	15.26	6.68	3.05	2.14	2.01	5.46	8.88
1978	7.53	13.04	13.19	15.80	19.17	22.58	14.40	6.92	3.63	2.47	2.17	4.14	10.42
1979	11.80	13.04	11.92	14.45	20.81	22.66	14.22	7.12	4.79	2.86	1.98	3.29	10.74
1980	8.14	12.38	12.65	12.59	14.53	17.20	18.92	7.69	4.26	2.82	2.48	4.94	9.88
1981	17.61	20.28	12.61	16.66	12.32	16.56	14.12	5.77	4.72	2.79	2.84	3.79	10.84
1982	13.19	9.11	9.22	9.21	11.95	14.55	7.64	3.37	2.15	2.02	2.43	2.74	7.30
1983	3.98	8.65	6.63	8.83	15.54	19.46	19.33	9.19	4.53	3.68	3.01	3.13	8.83
1984	11.61	14.96	17.31	13.88	17.29	20.04	15.84	5.29	2.46	1.78	1.39	1.67	10.29
1985	6.72	11.08	11.57	16.73	18.87	24.15	15.86	11.08	4.28	2.29	1.71	2.36	10.56
1986	8.65	11.63	11.07	9.45	11.92	18.52	11.28	4.83	2.63	1.86	1.47	2.55	7.99
1987	8.43	9.97	13.09	16.10	11.85	12.98	9.77	5.34	2.88	1.86	1.57	1.89	7.98
1988	6.63	12.77	13.28	20.24	27.50	23.97	10.22	4.94	2.90	1.60	1.20	1.69	10.58
1989	7.24	8.86	9.00	13.83	19.92	15.34	10.92	10.04	4.52	2.62	2.25	3.36	8.99
1990	10.44	13.14	13.63	13.78	15.04	21.49	14.45	8.46	6.31	2.83	2.05	3.28	10.41
1991	8.03	12.60	11.81	11.90	13.15	15.26	10.96	6.81	3.28	2.75	1.74	2.05	8.36
1992	3.71	11.82	13.52	10.02	19.18	18.40	12.96	7.02	2.96	2.18	2.08	3.05	8.91
1993	9.68	8.39	8.98	14.55	21.31	17.82	10.19	5.11	2.92	1.90	1.76	2.50	8.76
Total	211.49	296.29	271.35	333.35	413.93	458.97	314.07	157.82	90.91	56.00	46.46	69.67	226.69
Average	9.20	12.88	11.80	14.49	18.00	19.96	13.66	6.86	3.95	2.43	2.02	3.03	9.86
Min.	3.71	8.39	6.46	7.76	11.85	12.98	7.64	3.37	2.15	1.60	1.20	1.67	6.97
Max.	18.53	29.09	19.28	27.83	33.36	29.94	19.78	11.08	9.04	3.68	3.01	5.46	15.99

Table 6-12 Monthly Average In-flow at the Cerritos Site (with Project)

$Q_{max.} = 27\ m^3/s$

Catchment Area : 230 km^2 Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	43.85	56.09	45.85	54.83	60.36	51.29	39.29	18.73	17.33	9.46	6.83	12.74	34.72
1972	26.80	22.62	21.96	26.88	31.32	43.24	35.97	19.82	9.75	6.97	6.33	9.48	21.76
1973	17.92	42.07	38.21	50.59	52.76	56.94	32.64	25.35	23.44	10.56	7.33	9.24	30.59
1974	26.73	44.79	29.82	33.69	45.12	53.59	34.36	14.48	9.24	6.86	6.78	7.87	26.11
1975	27.90	30.87	32.73	42.18	49.96	49.51	46.78	20.65	11.55	6.63	5.22	6.00	27.50
1976	14.37	23.91	19.04	20.54	33.71	40.62	26.22	13.49	8.05	6.37	5.78	6.89	18.25
1977	14.75	23.79	17.48	35.53	40.11	46.88	37.43	17.95	9.03	6.61	6.24	14.45	22.52
1978	19.95	32.51	32.92	38.61	45.91	49.58	35.48	18.54	10.52	7.52	6.69	11.60	25.82
1979	29.72	32.48	30.05	35.51	47.81	49.66	35.01	19.03	13.32	8.53	6.18	9.52	26.40
1980	21.34	30.90	31.41	31.51	35.79	41.66	45.34	20.37	12.09	8.44	7.53	13.59	25.00
1981	42.50	47.28	31.60	40.40	30.91	40.28	34.72	15.82	13.24	8.36	8.47	10.90	27.04
1982	32.64	23.70	23.89	23.92	29.98	35.85	20.26	9.86	6.65	6.29	7.38	8.21	19.05
1983	11.31	22.58	17.89	23.00	38.07	46.46	46.06	23.77	12.77	10.63	8.93	9.18	22.55
1984	29.09	36.75	41.91	34.45	41.86	47.04	38.63	14.61	7.48	5.64	4.55	5.29	25.61
1985	17.97	28.18	29.21	40.47	45.28	51.15	38.57	28.06	12.14	7.03	5.44	7.19	25.89
1986	21.96	29.40	28.17	24.47	30.08	44.50	28.65	13.49	7.93	5.85	4.77	7.67	20.58
1987	22.10	25.63	32.68	39.32	29.93	32.41	25.14	14.75	8.59	5.86	5.05	5.91	20.61
1988	17.78	31.71	33.08	47.24	54.50	50.97	26.11	13.78	8.63	5.13	4.00	5.33	24.86
1989	19.33	23.09	23.45	34.31	46.92	37.64	27.83	25.72	12.74	7.90	6.93	9.75	22.97
1990	26.69	32.81	33.80	34.16	37.00	48.49	35.59	22.16	17.12	8.45	6.38	9.57	26.02
1991	21.15	31.56	29.83	29.89	32.80	37.41	27.84	18.21	9.63	8.24	5.53	6.37	21.54
1992	10.65	29.74	33.63	25.79	45.85	44.26	32.39	18.72	8.80	6.77	6.20	8.40	22.60
1993	26.57	27.52	26.14	33.73	48.31	40.10	24.33	14.76	9.01	6.66	5.79	6.43	22.45
Total	543.08	729.97	684.74	801.04	954.33	1039.54	774.63	422.09	259.05	170.74	144.33	201.56	560.42
Average	23.61	31.74	29.77	34.83	41.49	45.20	33.68	18.35	11.26	7.42	6.28	8.76	24.37
Min.	10.65	22.58	17.48	20.54	29.93	32.41	20.26	9.86	6.65	5.13	4.00	5.29	18.25
Max.	43.85	56.09	45.85	54.83	60.36	56.94	46.78	28.06	23.44	10.63	8.93	14.45	34.72

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Table 6-13 Monthly Average In-flow at the Tocori Site

Catchment Area : 5 km^2

Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	1.24	1.94	1.29	1.86	2.23	1.62	1.08	0.47	0.43	0.21	0.15	0.30	1.07
1972	0.70	0.58	0.56	0.70	0.83	1.20	0.97	0.50	0.22	0.15	0.14	0.22	0.57
1973	0.45	1.16	1.05	1.58	1.72	2.00	0.88	0.66	0.60	0.24	0.16	0.21	0.89
1974	0.70	1.25	0.79	0.91	1.26	1.78	0.93	0.35	0.21	0.15	0.15	0.18	0.72
1975	0.74	0.82	0.88	1.17	1.53	1.50	1.32	0.52	0.27	0.14	0.11	0.13	0.76
1976	0.35	0.61	0.48	0.52	0.91	1.12	0.68	0.32	0.18	0.14	0.12	0.15	0.47
1977	0.36	0.62	0.43	0.97	1.11	1.33	1.02	0.45	0.20	0.14	0.13	0.36	0.59
1978	0.50	0.87	0.88	1.06	1.28	1.51	0.96	0.46	0.24	0.17	0.14	0.28	0.70
1979	0.79	0.87	0.80	0.97	1.39	1.51	0.95	0.48	0.32	0.19	0.13	0.22	0.72
1980	0.54	0.83	0.84	0.84	0.97	1.15	1.26	0.51	0.28	0.19	0.17	0.33	0.66
1981	1.18	1.35	0.84	1.11	0.82	1.11	0.94	0.39	0.32	0.19	0.19	0.25	0.72
1982	0.88	0.61	0.62	0.62	0.80	0.97	0.51	0.23	0.14	0.14	0.16	0.18	0.49
1983	0.27	0.58	0.44	0.59	1.04	1.30	1.29	0.61	0.30	0.25	0.20	0.21	0.59
1984	0.78	1.00	1.16	0.93	1.15	1.34	1.06	0.35	0.16	0.12	0.09	0.11	0.69
1985	0.45	0.74	0.77	1.12	1.26	1.61	1.06	0.74	0.29	0.15	0.11	0.16	0.71
1986	0.58	0.78	0.74	0.63	0.80	1.24	0.75	0.32	0.18	0.12	0.10	0.17	0.53
1987	0.56	0.67	0.87	1.08	0.79	0.87	0.65	0.36	0.19	0.12	0.11	0.13	0.53
1988	0.44	0.85	0.89	1.35	1.84	1.60	0.68	0.33	0.19	0.11	0.08	0.11	0.71
1989	0.48	0.59	0.60	0.92	1.33	1.02	0.73	0.67	0.30	0.17	0.15	0.22	0.60
1990	0.70	0.88	0.91	0.92	1.00	1.44	0.96	0.56	0.42	0.19	0.14	0.22	0.70
1991	0.54	0.84	0.79	0.79	0.88	1.02	0.73	0.45	0.22	0.18	0.12	0.14	0.56
1992	0.25	0.79	0.90	0.67	1.28	1.23	0.87	0.47	0.20	0.15	0.14	0.20	0.59
1993	0.65	0.56	0.60	0.97	1.42	1.19	0.68	0.34	0.20	0.13	0.12	0.17	0.59
Total	14.12	19.79	18.12	22.26	27.65	30.65	20.98	10.54	6.07	3.74	3.10	4.65	15.14
Average	0.61	0.86	0.79	0.97	1.20	1.33	0.91	0.46	0.26	0.16	0.13	0.20	0.66
Min.	0.25	0.56	0.43	0.52	0.79	0.87	0.51	0.23	0.14	0.11	0.08	0.11	0.47
Max.	1.24	1.94	1.29	1.86	2.23	2.00	1.32	0.74	0.60	0.25	0.20	0.36	1.07

Table 6-14 Monthly Average In-flow at the River Mouth of Paquita (without Project)

Catchment Area : 178.5 km^2 Annual Precipitation 6.207 mm

Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	41.70	65.45	43.37	62.62	75.06	54.65	36.27	15.76	14.45	7.24	4.98	10.23	35.98
1972	23.70	19.47	18.83	23.69	28.10	40.43	32.84	16.80	7.49	5.11	4.58	7.46	19.04
1973	15.11	39.15	35.28	53.09	57.97	67.37	29.52	22.14	20.35	8.23	5.41	7.06	30.06
1974	23.59	42.07	26.66	30.69	42.36	59.84	31.26	11.78	7.04	5.02	4.95	5.90	24.26
1975	24.99	27.71	29.53	39.37	51.67	50.65	44.50	17.54	9.12	4.82	3.68	4.33	25.66
1976	11.93	20.71	16.02	17.47	30.65	37.81	23.02	10.86	6.02	4.61	4.14	5.06	15.69
1977	12.17	20.77	14.55	32.55	37.28	44.74	34.34	15.03	6.87	4.81	4.51	12.28	19.99
1978	16.95	29.34	29.67	35.55	43.14	50.80	32.41	15.56	8.17	5.56	4.87	9.30	23.44
1979	26.55	29.33	26.82	32.51	46.83	50.99	31.99	16.03	10.77	6.43	4.45	7.40	24.17
1980	18.31	27.85	28.47	28.32	32.71	38.69	42.56	17.29	9.58	6.36	5.58	11.11	22.24
1981	39.63	45.62	28.38	37.49	27.73	37.27	31.77	12.99	10.63	6.28	6.38	8.53	24.39
1982	29.67	20.51	20.75	20.73	26.89	32.74	17.18	7.58	4.84	4.55	5.47	6.16	16.42
1983	8.95	19.46	14.92	19.88	34.97	43.80	43.49	20.68	10.19	8.28	6.77	7.05	19.87
1984	26.13	33.66	38.95	31.23	38.91	45.09	35.64	11.91	5.53	4.01	3.13	3.77	23.16
1985	15.11	24.92	26.03	37.64	42.45	54.35	35.69	24.93	9.63	5.16	3.84	5.31	23.76
1986	19.47	26.17	24.91	21.25	26.83	41.67	25.38	10.86	5.92	4.18	3.31	5.74	17.97
1987	18.98	22.44	29.44	36.23	26.66	29.21	21.97	12.01	6.48	4.18	3.54	4.25	17.95
1988	14.92	28.74	29.88	45.54	61.88	53.94	23.00	11.12	6.52	3.59	2.71	3.80	23.80
1989	16.28	19.95	20.26	31.12	44.82	34.53	24.57	22.58	10.16	5.89	5.07	7.56	20.23
1990	23.50	29.56	30.67	31.01	33.84	48.37	32.51	19.03	14.21	6.37	4.61	7.37	23.42
1991	18.07	28.35	26.58	26.78	29.59	34.33	24.67	15.32	7.37	6.18	3.91	4.61	18.81
1992	8.36	26.59	30.42	22.55	43.16	41.40	29.16	15.79	6.66	4.90	4.67	6.87	20.04
1993	21.78	18.88	20.20	32.75	47.95	40.09	22.94	11.49	6.57	4.27	3.97	5.63	19.71
Total	475.87	666.71	610.57	750.08	931.42	1032.76	706.70	355.11	204.57	126.01	104.55	156.77	510.09
Average	20.69	28.99	26.55	32.61	40.50	44.90	30.73	15.44	8.89	5.48	4.55	6.82	22.18
Min.	8.36	18.88	14.55	17.47	26.66	29.21	17.18	7.58	4.84	3.59	2.71	3.77	15.69
Max.	41.70	65.45	43.37	62.62	75.06	67.37	44.50	24.93	20.35	8.28	6.77	12.28	35.98

Table 6-15 Monthly Average In-flow at the River Mouth of Paquita (with Project)

$Q_{max.} = 27\ m^3/s$

Catchment Area : 178.5 km^2

Unit : m^3/s

Year	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
1971	67.02	92.45	69.94	89.62	102.06	81.65	59.44	27.48	25.36	13.48	9.59	18.42	54.71
1972	39.97	33.44	32.42	40.04	46.93	65.70	54.21	29.15	13.91	9.81	8.88	13.62	32.34
1973	26.31	63.82	57.81	80.09	84.97	94.37	49.04	37.65	34.75	15.13	10.34	13.16	47.29
1974	39.83	68.17	44.63	50.74	68.65	86.84	51.73	21.02	13.15	9.65	9.53	11.15	39.59
1975	41.78	46.26	49.14	64.06	78.67	77.65	71.50	30.39	16.62	9.31	7.27	8.41	41.76
1976	21.00	35.42	27.94	30.25	50.74	61.63	39.01	19.52	11.40	8.93	8.08	9.70	26.97
1977	21.51	35.33	25.57	53.61	60.82	71.74	56.51	26.30	12.85	9.28	8.74	21.27	33.63
1978	29.37	48.81	49.40	58.36	69.88	77.80	53.49	27.18	15.06	10.61	9.39	16.76	38.84
1979	44.47	48.77	44.95	53.57	73.83	77.99	52.78	27.94	19.30	12.10	8.65	13.63	39.83
1980	31.51	46.37	47.23	47.24	53.97	63.15	68.98	29.97	17.41	11.98	10.63	19.76	37.35
1981	64.52	72.62	47.37	61.23	46.32	60.99	52.37	23.04	19.15	11.85	12.01	15.64	40.59
1982	49.12	35.10	35.42	35.44	44.92	54.04	29.80	14.07	9.34	8.82	10.42	11.63	28.18
1983	16.28	33.39	26.18	34.05	57.50	70.80	70.22	35.26	18.43	15.23	12.69	13.10	33.59
1984	43.61	55.45	63.55	51.80	63.48	72.09	58.43	21.23	10.55	7.87	6.29	7.39	38.48
1985	26.36	42.02	43.67	61.38	68.86	81.35	58.40	41.91	17.49	9.90	7.57	10.14	39.09
1986	32.78	43.94	42.01	36.27	44.99	67.65	42.75	19.52	11.22	8.17	6.61	10.86	30.56
1987	32.65	38.10	49.03	59.45	44.74	48.64	37.34	21.42	12.19	8.18	7.02	8.27	30.59
1988	26.07	47.68	49.68	72.54	88.88	80.94	38.89	19.96	12.25	7.12	5.51	7.44	38.08
1989	28.37	34.18	34.71	51.60	71.82	56.83	41.48	38.26	18.38	11.17	9.75	13.95	34.21
1990	39.75	49.23	50.84	51.39	55.80	75.37	53.65	32.73	25.02	11.99	8.94	13.66	39.03
1991	31.19	47.31	44.60	44.77	49.24	56.48	41.55	26.72	13.72	11.67	7.70	8.93	31.99
1992	15.30	44.51	50.53	38.32	69.83	67.26	48.59	27.49	12.50	9.49	8.79	12.22	33.74
1993	38.67	38.01	37.36	51.93	74.95	62.37	37.08	21.14	12.66	9.03	8.00	9.56	33.40
Total	807.46	1100.39	1023.96	1217.77	1471.82	1613.33	1167.26	619.38	372.71	240.75	202.42	288.66	843.82
Average	35.11	47.84	44.52	52.95	63.99	70.14	50.75	26.93	16.20	10.47	8.80	12.55	36.69
Min.	15.30	33.39	25.57	30.25	44.74	48.64	29.80	14.07	9.34	7.12	5.51	7.39	26.97
Max.	67.02	92.45	69.94	89.62	102.06	94.37	71.50	41.91	34.75	15.23	12.69	21.27	54.71

Table 6-16 Flood Discharge at Londres and Los Llanos Sites

Unit : m^3/s

No.	Year	Date	Londres	Los Llanos
1	70-71	22 OCT	373	219
2	71-72	3 JUN	1,030	619
3	72-73	18 OCT	210	119
4	73-74	2 OCT	252	145
5	74-75	31 OCT	299	174
6	75-76	9 SEP	852	511
7	76-77	15 SEP	196	111
8	77-78	25 AUG	286	166
9	78-79	8 AUG	335	195
10	79-80	21 OCT	514	305
11	80-81	26 JUL	468	277
12	81-82	14 AUG	387	228
13	82-83	9 OCT	299	174
14	83-84	1 DEC	277	160
15	84-85	26 MAY	326	190
16	85-86	27 OCT	416	245
17	86-87	10 SEP	254	146
18	87-88	5 OCT	157	87
19	88-89	24 OCT	482	285
20	89-90	21 SEP	228	130
21	90-91	23 OCT	457	270
22	91-92	30 AUG	341	199
23	92-93	25 JUN	269	155
24	93-94	13 NOV	273	164

Table 6-17 Maximum Persisting 12-hour Dew Point at the Playon Site

Year	Jan.	Feb.	Mar.	Apr..	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1976	23.1	22.3	22.4	24.6	25.1	24.9	24.6	24.9	26.0	25.0	25.9	24.9
1977	21.9	23.1	25.1	27.6	24.3	24.9	25.3	25.1	25.4	24.4	24.3	24.7
1978	25.2	26.7	26.2	26.5	25.7	26.0	25.1	25.5	25.3	24.9	25.9	25.1
1979	26.9	26.1	27.8	27.7	26.5	26.4	26.3	26.5	26.1	26.3	26.0	26.1
1980	22.9	23.6	21.5	25.1	26.5	26.4	26.5	25.8	23.3	25.0	23.5	22.3
1981	23.2	22.2	24.5	23.6	24.5	23.4	23.5	23.8	24.4	24.9	24.6	23.7
1982	23.6	24.2	23.5	21.8	24.2	24.0	24.1	23.7	23.4	24.1	24.2	22.4
1983	21.6	23.9	25.8	23.9	24.8	23.2	26.3	25.1	24.7	25.2	26.8	25.7
1984	22.7	23.7	24.4	23.3	25.1	24.4	23.9	23.9	24.4	24.2	23.7	23.7
1985	22.3	22.5	22.4	25.1	24.6	24.6	24.0	24.7	24.1	24.3	24.6	24.1
1986	22.8	23.3	23.6	23.5	24.4	26.6	24.3	23.9	24.1	23.5	25.1	24.5
1987	25.1	24.5	23.6	25.2	25.6	25.5	25.7	25.7	25.0	25.2	25.0	25.8
1988	24.6	26.6	24.5	24.8	25.6	25.7	25.3	24.5	24.4	24.3	24.6	24.7
1989	23.9	23.2	22.3	25.7	24.5	24.6	26.0	25.2	24.6	24.7	24.8	24.5
1990	24.2	24.8	24.5	25.1	25.2	25.5	24.4	24.8	24.7	24.9	24.6	24.5
1991	23.8	24.4	24.5	25.1	25.2	25.6	24.8	24.8	24.5	25.0	25.0	24.5
1992	24.0	24.4	24.7	24.8	25.3	25.3	25.1	24.7	24.0	24.7	24.7	24.4
1993	24.1	23.3	24.4	24.6	25.4	25.6	25.4	25.7	24.1	24.1	24.7	24.3
Max.	25.9	26.7	27.8	27.7	26.5	26.6	26.5	26.5	26.1	26.3	26.8	26.1

Table 6-18 Tentative PMP of Observed Storms at 1,000 hPa

No.	Date	Temperature	Vapour Press	Dew Point	Precipi-table water	M.F'	Pob (mm/d) (mm/day)	PMP' (mm/day)
1	881022	23.2	97.0	22.7	66.5	1.54	255.0	392.7
2	851029	25.1	91.0	23.5	71.6	1.43	249.0	356.1
3	920915	24.3	95.0	23.5	71.6	1.43	166.7	238.4
4	880912	25.3	91.0	23.7	72.9	1.40	167.0	234.6
5	860526	25.3	91.0	23.7	72.9	1.40	167.0	234.6
6	770930	24.3	89.0	22.4	65.3	1.57	127.0	199.2
7	901102	25.1	94.0	24.1	74.9	1.37	139.2	190.3
8	881110	24.5	98.0	24.2	75.9	1.35	141.0	190.2
9	781021	23.9	98.0	23.6	72.1	1.42	127.0	180.4
10	891102	25.0	90.0	23.3	70.6	1.45	121.2	175.8
11	850826	25.0	94.0	24.0	74.4	1.38	126.0	173.4
12	831126	26.3	82.0	23.0	68.6	1.49	116.0	173.2
13	930813	26.2	89.0	24.3	76.2	1.34	128.7	173.0
14	820930	25.8	85.0	23.1	69.3	1.48	117.0	172.9
15	840922	24.3	91.0	22.7	66.5	1.54	112.0	172.5
16	761014	24.9	96.0	24.2	75.9	1.35	127.0	171.3
17	771116	24.6	98.0	24.3	76.2	1.34	127.0	170.7
18	780424	24.7	98.0	24.4	77.0	1.33	127.0	168.9
19	760925	25.3	95.0	24.5	78.0	1.31	127.0	166.7
20	761018	25.3	96.0	24.6	78.5	1.30	127.0	165.7
21	900601	25.9	84.0	23.0	68.6	1.49	110.2	164.5
22	920727	24.3	96.0	23.6	72.1	1.42	114.7	162.9
23	770825	26.1	93.0	24.9	80.5	1.27	127.0	161.6
24	921121	24.5	96.0	23.8	73.2	1.40	115.4	161.4
25	790426	25.7	97.0	25.2	82.8	1.24	127.0	157.1
26	870429	26.9	81.0	23.4	71.1	1.44	108.0	155.5
27	871023	25.2	95.0	24.4	77.0	1.33	116.0	154.3
28	880516	26.3	89.0	24.4	77.0	1.33	113.0	150.3
29	921124	25.6	87.0	23.3	70.6	1.45	102.1	148.1
30	851004	23.9	96.0	23.2	70.0	1.46	101.0	147.7
31	880618	24.4	96.0	23.7	72.9	1.40	103.0	144.7
32	930510	27.8	78.0	23.7	72.9	1.40	101.5	142.6
33	810813	25.0	87.0	22.7	66.5	1.54	92.0	141.7
34	931009	24.9	94.0	23.9	73.7	1.39	100.9	140.2
35	860910	25.2	94.0	24.2	75.9	1.35	102.0	137.6
36	910626	25.4	92.0	24.0	74.4	1.38	98.0	134.9
37	900527	26.4	89.0	24.5	78.0	1.31	96.0	126.0
38	880710	26.1	95.0	25.3	83.3	1.23	101.0	124.2
39	851002	25.5	94.0	24.5	78.0	1.31	77.8	102.1
40	870828	25.2	92.0	23.8	73.2	1.40	72.0	100.7

Table 6-19 Rainfall Duration for PMP

NO.	Naranjillo				NO.	Providencia			
	Hurricane Data		P.M.P			Hurricane Data		P.M.P	
	(Oct. 1988)		Max. Factor	1.64		(Oct. 1988)		Max. Factor	1.67
	Accumulated	hourly	PMP	Accumulated		Accumulated	hourly	PMP	Accumulated
1	50.0	50.0	82.0	82.0	1	45.0	45.0	75.2	75.2
2	92.0	42.0	68.9	150.9	2	70.0	25.0	41.8	116.9
3	126.0	34.0	55.8	206.6	3	90.0	20.0	33.4	150.3
4	152.0	26.0	42.6	249.3	4	105.0	15.0	25.1	175.4
5	172.0	20.0	32.8	282.1	5	120.0	15.0	25.1	200.4
6	186.0	14.0	23.0	305.0	6	135.0	15.0	25.1	225.5
7	196.0	10.0	16.4	321.4	7	150.0	15.0	25.1	250.5
8	206.0	10.0	16.4	337.8	8	165.0	15.0	25.1	275.6
9	216.0	10.0	16.4	354.2	9	178.0	13.0	21.7	297.3
10	224.0	8.0	13.1	367.4	10	190.0	12.0	20.0	317.3
11	232.0	8.0	13.1	380.5	11	202.0	12.0	20.0	337.3
12	240.0	8.0	13.1	393.6	12	214.0	12.0	20.0	357.4
13	244.3	4.3	7.0	400.6	13	224.0	10.0	16.7	374.1
14	248.5	4.3	7.0	407.5	14	234.0	10.0	16.7	390.8
15	252.8	4.3	7.0	414.5	15	243.0	9.0	15.0	405.8
16	257.0	4.3	7.0	421.5	16	252.0	9.0	15.0	420.8
17	261.3	4.3	7.0	428.5	17	256.5	4.5	7.5	428.4
18	265.5	4.3	7.0	435.4	18	261.0	4.5	7.5	435.9
19	269.8	4.3	7.0	442.4	19	265.5	4.5	7.5	443.4
20	274.0	4.3	7.0	449.4	20	270.0	4.5	7.5	450.9
21	277.6	3.5	5.7	455.1	21	274.0	4.0	6.7	457.6
22	281.0	3.5	5.7	460.8	22	278.0	4.0	6.7	464.3
23	284.5	3.5	5.7	466.6	23	282.0	4.0	6.7	470.9
24	288.0	3.5	5.7	472.3	24	285.0	3.0	5.0	476.0
25	291.3	3.3	5.5	477.8	25	286.0	1.0	1.7	477.6
26	294.7	3.3	5.5	483.3	26	287.0	1.0	1.7	479.3
27	298.0	3.3	5.5	488.7	27	288.0	1.0	1.7	481.0
28	301.3	3.3	5.5	494.2	28	289.0	1.0	1.7	482.6
29	304.7	3.3	5.5	499.7	29	290.0	1.0	1.7	484.3
30	308.0	3.3	5.5	505.1	30	291.0	1.0	1.7	486.0
31	310.7	2.7	4.4	509.5	31	292.0	1.0	1.7	487.6
32	313.3	2.7	4.4	513.9	32	293.0	1.0	1.7	489.3
33	316.0	2.7	4.4	518.2	33	294.0	1.0	1.7	491.0
34	318.7	2.7	4.4	522.6	34	295.0	1.0	1.7	492.7
35	321.3	2.7	4.4	527.0	35	296.0	1.0	1.7	494.3
36	324.0	2.7	4.4	531.4	36	297.0	1.0	1.7	496.0
37	326.7	2.7	4.4	535.7	37	298.0	1.0	1.7	497.7
38	329.3	2.7	4.4	540.1	38	299.0	1.0	1.7	499.3
39	332.0	2.7	4.4	544.5	39	300.0	1.0	1.7	501.0
40	334.7	2.7	4.4	548.9	40	301.0	1.0	1.7	502.7
41	337.3	2.7	4.4	553.2	41	302.0	1.0	1.7	504.3
42	340.0	2.7	4.4	557.6	42	303.0	1.0	1.7	506.0
43	341.7	1.7	2.7	560.3	43	304.0	1.0	1.7	507.7
44	343.3	1.7	2.7	563.1	44	305.0	1.0	1.7	509.4
45	345.0	1.7	2.7	565.8	45	306.0	1.0	1.7	511.0
46	346.7	1.7	2.7	568.5	46	307.0	1.0	1.7	512.7
47	348.3	1.7	2.7	571.3	47	308.0	1.0	1.7	514.4
48	350.0	1.7	2.7	574.0	48	309.0	1.0	1.7	516.0

Table 6-20 Process of PMP Estimation

Item	Playon	Nranjillo	Providencia
Elevation (m)	60	780	1490
1. Maximum Dew Point (c)	27.8		
2. Reductin 1. to 1,000 mb (c)	27.7	27.7	27.7
3. Precipitable Water (mm) 1000 hPa	102.4	102.4	102.4
200 hPa	5	20	35
Total	97.4	82.4	67.4
4. Representative Dew Point (c)	22.5		
5. Reduction 4. to 1,000 mb (c)	22.4	22.4	22.4
6. Precipitable Water (mm) 1000hPa	65.3	65.3	65.3
200 hPa	4	15	25
Total	61.3	50.3	40.3
7. Maximumizing factor 3./6.	1.59	1.64	1.67
8. Maximum Rainfall (mm/12hr)	195.1	240.0	214.0
9. Maximizing 7. * 8. (mm/12hr)	310.0	393.2	357.9

Table 6-21 Time Distribution of PMP in the Project Basin

No.	Naranjillo Duration	Naranjillo Arranged	Providencia Duration	Providencia Arranged	Actual Preci. 0.76Pn+0.24Pp	Retention Loss	Effective Rainfall
0		0.0		0.0	0.0	0.0	0.0
1	82.0	7.0	75.2	6.7	6.9	6.9	0.0
2	68.9	7.0	41.8	7.5	7.1	6.9	0.2
3	55.8	7.0	33.4	15.0	8.9	8.3	0.6
4	42.6	7.0	25.1	16.7	9.3	8.1	1.2
5	32.8	13.1	25.1	20.0	14.8	11.4	3.3
6	23.0	16.4	25.1	25.1	18.5	11.4	7.1
7	16.4	32.8	25.1	25.1	31.0	10.5	20.4
8	16.4	65.8	25.1	41.8	52.4	0.4	52.0
9	16.4	82.0	21.7	76.2	80.4	0.0	80.4
10	13.1	68.9	20.0	33.4	60.4	0.0	60.4
11	13.1	42.6	20.0	25.1	38.4	0.0	38.4
12	7.0	23.0	20.0	25.1	23.5	0.0	23.5
13	7.0	16.4	16.7	21.7	17.7	0.0	17.7
14	7.0	16.4	16.7	20.0	17.3	0.0	17.3
15	7.0	13.1	15.0	20.0	14.8	0.0	14.8
16	7.0	13.1	15.0	16.7	14.0	0.0	14.0
17	7.0	7.0	7.5	15.0	8.9	0.0	8.9
18	7.0	7.0	7.5	7.5	7.1	0.0	7.1
19	7.0	7.0	7.5	7.5	7.1	0.0	7.1
20	7.0	7.0	7.5	7.5	7.1	0.0	7.1
21	5.7	5.7	6.7	6.7	5.9	0.0	5.9
22	5.7	5.7	6.7	6.7	5.9	0.0	5.9
23	5.7	5.7	6.7	6.7	5.9	0.0	5.9
24	5.7	5.7	5.0	5.0	5.5	0.0	5.5

Table 6-22 Annual Maximum Daily Precipitation Records

Year	Playon	Naranjillo	Providencia
1976	142.4		
1977	148.3		
1978	210.4		78.6
1979	127.2		103.2
1980	129.7		64.4
1981	123.3	188.7	85.6
1982	117.1	205.4	87.4
1983	116.1	119.3	59.1
1984	111.8	146.7	84.2
1985	248.4	182.9	115.5
1986	166.5	159.4	168.8
1987	122.1	125.8	68.3
1988	255.1	272.7	244.5
1989	121.2	162.0	126.0
1990	139.2	147.5	74.7
1991	98.0	168.0	109.7
1992	166.7	168.4	91.9
1993	128.7	101.1	91.5
1994	110.4	131.1	94.4

Table 6-23 Probable Daily Precipitation and PMP

	Playon	Naranjillo	Providencia
Pomax.	127.2	0.0	103.2
100	264.0	282.0	218.0
500	307.0	324.0	265.0
1000	325.0	341.0	285.0
5000	368.0	381.0	334.0
10000	387.0	399.0	356.0
PMP	406.0	447.0	408.0

Table 6-24 Process of PMF Estimation

Base Flow = 50 m^3/s

Unit Hydro	0.20	17	2	1.8	1.6	1.4	1.2	1	0.8	0.6	0.4	0.2															
Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Estimated	Total Q	
Rainfall	0.0	0.2	0.6	1.2	3.3	7.1	20.4	52.0	80.4	60.4	38.4	23.5	17.7	17.3	14.3	14.0	8.9	7.1	7.1	7.1	5.8	5.9	5.9	5.5			
Time																											Time
1	0																								0	50	1
2	0	0																							263	313	2
3	1	4	0																						650	700	3
4	0	0	11	0																					12	62	4
5	0	0	1	21	1																				23	73	5
6	0	0	1	2	57	1																			62	112	6
7	0	0	1	2	7	120	4																		134	184	7
8	0	0	1	2	6	14	347	10																	381	431	8
9	0	0	1	2	5	13	41	884	16																962	1012	9
10	0	0	1	1	5	11	37	104	1365	12															1537	1587	10
11	0	0	1	1	4	10	33	94	161	1026	8														1337	1387	11
12	0	0	0	1	3	8	29	83	145	121	653	5													1048	1098	12
13		0	0	1	3	7	24	73	129	109	77	400	4												825	875	13
14			0	0	2	6	20	62	113	97	68	47	300	3											720	770	14
15				0	1	4	16	52	96	85	61	42	35	293	3										691	741	15
16					1	3	12	42	80	72	54	36	32	35	251	3									622	672	16
17						1	8	31	64	60	45	33	28	31	30	237	2								572	622	17
18							4	21	40	43	38	28	25	28	27	28	152	1							448	498	18
19								10	32	36	31	24	21	24	24	25	18	121	1						367	417	19
20									16	24	23	19	18	21	21	22	16	14	121	1					316	366	20
21										12	15	14	14	17	18	20	14	13	14	121	1				274	324	21
22											8	9	11	14	15	17	12	11	13	14	101	1			226	276	22
23												5	7	10	12	14	11	10	11	13	12	101	1		207	257	23
24													4	7	9	11	9	9	10	11	11	12	101	1	194	244	24