CHAPTER 4

HYDROLOGICAL ANALYSIS

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4.1 Introduction

The hydrological analysis was conducted in this study in order to clarify the hydrological condition caused floods after the Master Plan Study in 1996. The results were used in the flood analysis for the calculation of the inundation depth and areas and the design of rivers.

4.2 Meteorological Condition

Data on the meteorological condition were obtained from the observation stations in and around the Study Area. The seasons consist of dry season, wet season and transitional periods. The dry season is normally from April to October, while the wet season is from October to March and the transitional periods between the two seasons from September – October and March – April. The average maximum, mean and minimum temperature are 28.9 °C, 23.9 °C and 19.0 °C respectively. The average humidity is 72.8 %.

4.3 River System

4.3.1 Drainage Basin

The Study Area covers the eastern part so called the Chane – Pailon area and the western part so called the San Juan – Antofagasta area. The Chane – Pailon area is composed of 2 main drainage basins: the Rio Chane – Pailon basin and the Okinawa Drainage basin. The Study Area is approximately 600 km^2 but the drainage area is approximately 2,271 km^2. The San Juan – Antofagasta area is composed of 4 main river basins and some main drainage. The 4 main river basins are the Arroyo Yapacanicito basin, the Arroyo Tejeria basin, the Arroyo Jochi basin and the Arroyo Tacuaral basin. The Study Area is approximately 607 km^2 but the drainage area is approximately 689 km^2.

A summary of the drainage area is shown as follows:

River	Area (km^2)
Downstream	262.0
Rio Pailon	1,319.0
- downstream	225.0
- midstream	228.0
- other QDA	866.0
QDA Chane	466.0
- mainstream	232.0
- QDA El Toro	234.0
Other	224.0
Total	2,271.0
Okinawa Drainage	381.5

The San Juan - Antofagasta Area

River/Arroyo	Area (km^2)
Arroyo Jochi	148.0
Arroyo Tacuaral	127.0
Arroyo Yapacanicito	370.7
Arroyo Tejeria	43.6
Total	689.3

Note: The Arroyo Antofagasta is included in the Arroyo Tacuaral basin and the San Juan drainage is included in the Arroyo Yapacanicito basin

4.3.2 River System in the Rio Chane – Pailon Area

In the Chane – Pailon area, the Rio Chane and Rio Pailon, the main river, flows from the upstream end of the study area, passes through the National Road No. 9. In the mid-stream reach, the main river thereafter is named the Rio Chane after the confluence of the Rio Pailon and the Quebrada Chane. The Rio Chane flows northwards and meets the Quebrada Chacras at the downstream reach and passes through a local road bridge, which is the end of the study area, then discharges to the Rio Piray outside the study area.

The slopes of the river in the upstream vary from 1/600 to 1/1,600, while those in the mid-stream and downstream vary from 1/1,900 to 1/2,800. The widths vary from about 10 to 15 m in the upstream to 30 – 75 m in the downstream.

4.3.3 River System in the San Juan – Antofagasta Area

In the San Juan – Antofagasta area, there are 4 main rivers, the Arroyo Yapacanicito, Tejeria, Jochi and Tacuaral. These rivers flow northwards from the southern part with small tributaries. The Arroyo Yapacanicito and Tejeria originate from combination of the tributaries and the drainage canals in the upstream reach of the Study Area and joins the Rio Yapacani at the downstream reach outside the Study Area and at the upstream of the urban area of San Juan respectively. The Arroyo Jochi and Tacuaral also originate from the tributaries and drainage canals in the upstream reach in the southern part. Both rivers flow through a natural retarding basin located in the mid-stream reach and then join the Rio Palacios in the northern part outside the study area.

The river slopes vary from 1/600 to 1/1,250, while the widths vary from about 15 to 70 m. for all the rivers.

4.4 Available Hydrological Data

Available hydrological data on rainfall, discharge and water level were obtained from seventeen (17) rainfall stations and eleven (11) river gauging stations distributing in and around the Study Area. The SEARPI, SENAMHI, CETABOL, AASANA and MACUCY operate these stations as follows:

Area/River	Number of Gauging Stations		Sources of acquired data
	Rainfall	Discharge/ Water Level	
The Chane - Pailon Area	15		SEARPI, SENAMHI, CETABOL, AASANA
The San Juan - Antofagasta Area	2		CETABOL, MACUCY
Rio Piray		7	SEARPI
Rio Grande		2	SEARPI
Rio Yapacani		1	MACUCY
Rio Palometillas		1	MACUCY
Total	17	11	

List of the available data is shown in Table 4.4.1.

The average annual rainfalls from the main stations are as follows:

Average annual rainfall

Station	Annual Rainfall (mm)
5806 Santa Cruz - Trompillo	1,301.2
56NP La Belgica - Ingenio	1,417.0
61NP Saavedra	1,356.1
62NP Mineros (Unagro)	1,556.0
Okinawa II	1,274.2
55NP Portachuelo	1,639.0
52NP San Isidro	2,066.0
Col. San Juan de Yapacani	1,897.5

In the Chane -- Pailon Area, data from 5 main stations: Saavedra, CETABOL-JICA, Warnes, Puerto Pailas and Santa Cruz-Trompillo stations were used in the hydrological analysis. However, the Santa Cruz-Trompillo and the Saavedra stations were considered as the principal stations in the Santa Cruz area and the Chane - Pailon area respectively.

In the San Juan – Antofagasta Area, only the rainfall gauging station at the San Juan de Yapacani was used in the analysis due to its location and long range records.

Locations of these stations are shown in Figure 4.4.1.

Although the Rio Grande Basin was not included in the Study Area, flood stage data at Abapo in this basin were considered as one of the main stations for the flood warning system in the Study Area. Location of the basin and Abapo is shown in Figure 4.4.2.

4.5 Rainfall Analysis

4.5.1 Rainfall Analysis in the Rio Chane – Pailon Area

Monthly and annual rainfall data until 1994 were illustrated in the Master Plan Study -- Supporting Report A, 1996. The later data collected in the Study are shown in Data Book B. The rainfalls that caused current floods in the Study Area are summarized as follows:

(1) Rainfall amounts during December 1995 to January 1996

The rainfall amounts in this period were considered pretty extensive. The data from major stations are as follows:

Saavedra	:	203.4 mm	(December)
CETABOL	:	134.6 mm	(December)
Santa Cruz – Trompillo	:	141.9 mm	(January)

(2) Rainfall amounts during December 1996 to February 1997

The rainfall amount during this period was considered not to be extensive compared to the average in Saavedra and CETABOL. However, a heavy rainfall amount was found in Santa Cruz – Trompillo. The measured rainfalls are as follows:

Saavedra	:	131.1 mm	(January)
CETABOL	:	96.6 mm	(December)

Santa Cruz – Trompillo : 186.4mm (January)

(3) Rainfall amounts at the end of 1997

The rainfall amounts during this period were the most extensive rainfalls after 1995. These rainfalls are as follows:

Saavedra : 286.3 mm (December)
CETABOL : 219.6 mm (December)
Santa Cruz – Trompillo : 182.4 mm (December)

4.5.2 Rainfall Analysis in the San Juan – Antofagasta Area

Monthly and annual rainfall data until 1994 were also illustrated in the Master Plan Study – Supporting Report A, 1996. The later data were also collected in the Study as shown in the Data Book B. The rainfalls that caused current floods in this area are summarized as follows:

(1) Rainfall amount in 1996

The rainfall amount in this year was considered pretty extensive. The peak monthly rainfall is as follows:

Col. San Juan de Yapacani : 245.0 mm (February)

(2) Rainfall amount in 1997

The rainfall amount in this year was considered the most extensive after 1995, same as in the Chane – Pailon Area. The peak monthly rainfall is as follows:

Col. San Juan de Yapacani : 443.0 mm (February)

(3) Rainfall amount in 1998

The rainfall amount in this year was considered not to be extensive. The peak monthly rainfall is:

Col. San Juan de Yapacani : 145.0 mm (February)

4.6 Frequency Analysis

Frequency analysis for the annual maximum rainfall based on the Gumbel Method in the Master Plan Study in 1996 was used in this study. The analysis was conducted in the main rainfall stations including Saavedra, CETABOL, Santa Cruz – Trompillo and

Col. San Juan de Yapacani to calculate the return period of the maximum consecutive rainfall in one (1) day until seven (7) days. The return periods of the major rainfalls caused floods in the Chane – Pailon Area and the San Juan – Antofagasta Area are shown in Table 4.6.1 and are summarized as follows:

Estimated return periods of the major rainfalls caused current floods

Date/Period of Floods	Return period (year)			
	The Chane - Pailon Area			The San Juan - Antofagasta Area
	Saavedra	CETABOL	Santa Cruz - Trompillo	San Juan de Yapacani
March 1983	< 2 years	< 2 years	< 2 years	< 2 years
January 1992	> 100 years	50 - 100 years	2 - 5 years	5 - 10 years
Dec/1995 - Feb/1996	2 - 5 years	2 years	2 years	-
January 1996	-	-	-	2 - 5 years
Dec/1996 - Feb/1997	2 years	2 years	2 - 5 years	-
January 1997	-	-	-	10 - 20 years
November 1997	10 - 20 years	5 - 10 years	3 - 5 years	-
January 1998	-	-	-	< 2 years

4.7 Design Rainfall

The design rainfall for the Study was set up in the Master Plan Study in 1996 by considering the rainfalls of the four principal stations of Saavedra, Santa Cruz, Okinawa II (CETABOL) and Colonia San Juan de Yapacani.

The design rainfall is three day continuous rainfall with post peak. Rainfall intensity curves of Saavedra and Santa Cruz were used for making their own design rainfalls. The rainfall pattern of Saavedra was also applied for making the design hydrograph of Okinawa II and Colonia San Juan de Yapacani. This is because the correlation of the annual maximum one day rainfall of these two stations with Saavedra are higher than those of these two stations with Santa Cruz.

The design rainfalls in these stations are shown in Table 4.7.1 and Figure 4.7.1.

4.8 Rainfall Runoff Analysis

The rainfall runoff analysis was conducted by using the Unit Hydrograph Method developed by the U.S. Soil Conservation Service (SCS). The analysis was done during the rainfall periods of those caused major floods in the Study Area recently as follows:

The Chane-Pailon area	:	November 30th - December 5th,	1997
		March 24th - 29th,	1998
The San Juan - Antofagasta area	:	January 30th - February 6th,	1997

The Study Area was divided in the sub-basins shown in Figs. 4.8.1 and 4.8.2, for the rainfall runoff model. The necessary parameters in the model were decided based on the calibration as shown in Supporting Report - B, and the results are shown in Figs. 4.8.3, 4.8.4 and 4.8.5. The runoff characteristics at each time period were different due to the rainfall pattern.

Rainfall runoff analysis for return periods of 2, 5, 10, 20 and 50 years was then conducted for both areas, the results for return periods of 5 and 10 years are shown in Figure 4.8.6. These were used in the hydrodynamic simulation and in designing of the structural measures for the Study.

4.9 Current Flood Condition

From the rainfall runoff analysis and flood damage survey, it can be summarized that the floods in the Study Area were caused by:

The Chane – Pailon Area:

- Extensive rainfall in Saavedra, Okinawa II (CETABOL) and Santa Cruz,
- Overflow from the Rio Grande.

The San Juan – Antofagasta Area:

- Extensive rainfall in San Juan de Yapacani.

4.9.1 Current Flood Condition in the Chane – Pailon Area

The characteristics of floods after 1995 clarified by the flood damage survey conducted through the Study in 1998 and the rainfall runoff analysis are summarized as follows:

Characteristics of floods after 1995

Flood period	Inundation Area		Probable Rainfall Period	Measured Rainfall					
	(km^2)	%		Saavedra		CETABOL		Trompillo	
				(mm)	R.P. (yrs)	(mm)	R.P. (yrs)	(mm)	R.P. (yrs)
Dec/95 - Feb/96	112.7	18.8	4 - 20 Jan/96	203.4	2 - 5	134.6	2	141.9	2
Dec/96 - Feb/97	170.9	28.5	30 Jan - 6 Feb/97	131.1	2	96.6	2	186.4	2 - 5
Nov - Dec/97	370.3	61.8	30 Nov - 5 Dec/97	286.3	10 - 20	219.6	5 - 10	182.4	2 - 5
Feb - Mar/97	98.2	16.4	No data						
Feb - Mar/98	83.5	13.9	No data						

Note : 1). % is the ratio of inundation area to the Study Area
2). R.P. = Return Period

4.9.2 Current Flood Condition in the San Juan – Antofagasta Area

The characteristics of floods after 1995 clarified from the same sources are as follows:

Characteristics of floods after 1995

Flood period	Inundation Area		Probable Rainfall Period	Measured Rainfall	
				San Juan de Yapacani	
	(km^2)	%		(mm)	R.P. (yrs)
Jan - Feb 1995	323.7	53.3	No data		
Jan - Feb 1996	405.1	66.7	2 - 8 Feb 96	245.3	2 - 5
Jan - Feb 1997	560.1	92.2	30 Jan - 6 Feb 97	443.0	10 - 20
Jan - Feb 1998	450.5	74.2	28 Jan - 2 Feb 98	156.0	< 2

Note : 1). % is the ratio of inundation area to the Study Area
2). R.P. = Return Period

4.9.3 Overflow from the Rio Grande

The floods in the Chane – Pailon Area during February – March in both 1997 and 1998 were caused apparently by the overflow from the Rio Grande according to the flood damage survey.

Due to the insufficient data in the Rio Grande basin, the rainfall runoff analysis could not be conducted. The information of the flow conditions in the Rio Grande was obtained from the water levels/discharges observed at Abapo Bridge and Puerto Pailas Bridge.

The relationship between the water levels at the Bridge of Abapo and the floods in the Okinawa Drainage area could not be verified clearly. However, during the flood in the Okinawa Drainage area from January to March 1998 as reported by the flood damage survey, the rainfall was not found to be extensive but the inundation area in the Okinawa Drainage area was remarkably wide. Therefore, it was concluded that the flood was caused by the overflow from the Rio Grande.

4.10 Flood Warning System

4.10.1 Measurement Stations

The flood warning alert levels are proposed hereinafter from the hydrological point of views. The rainfall and water level/discharge gauging stations to be used for flood warning are proposed as follows:

Existing Rainfall Gauging Station : Saavedra
CETABOL

		Santa Cruz - Trompillo
		San Juan de Yapacani
Water Level Gauging Station	:	Abapo Bridge

The rainfall gauging stations should be leveled up to be able to observe the hourly rainfal data. The water level/discharge gauging station at the Bridge of Abapo should be equipped with an automatic water level gauge for warning floods from the Rio Grande.

4.10.2 Warning Criteria

From the current floods and inundation conditions, the flood warning alert levels would be proposed to be three (3) levels based on the rainfall return period as follows:

Alert Level - 1	:	Rainfall of return period 2-year,
Alert Level - 2	:	Rainfall of return period 5-year,
Alert Level - 3	:	Rainfall of return period 10-year.

In the Master Plan Study, it was found that 3-day rainfall was the most probable to cause the floods and used as the design rainfalls. Therefore, the flood warning alert levels herein is proposed to use 1-day, 3-day and 5-day rainfalls of the selected rainfall stations for flood warning system. The magnitude of rainfalls should be as follows:

Rainfall	Return Period (year)	Chane - Pailon Saavedra	Chane - Pailon CETABOL	Chane - Pailon Trompillo	San Juan - Antofagasta S.J. Yapacani
1 Day	Calculated rainfall				
	2	104.8	102.8	100.3	139.6
	5	141.9	140.4	144.4	187.8
	10	166.4	165.3	173.7	219.7
	Proposed magnitude to be used for warning system				
	2	90.0	90.0	90.0	125.0
	5	120.0	125.0	125.0	165.0
	10	145.0	145.0	155.0	195.0
3 Day	Calculated rainfall				
	2	134.1	131.9	126.3	182.1
	5	188.7	178.1	175.4	241.6
	10	224.9	208.6	207.9	231.1
	Proposed magnitude for flood warning system				
	2	120.0	115.0	110.0	160.0
	5	165.0	160.0	155.0	215.0
	10	200.0	200.0	185.0	250.0
5 Day	Calculated rainfall				
	2	152	150.5	145.7	212.3
	5	212.2	205.9	197.7	270.9
	10	252.1	242.5	232.1	309.7
	Proposed magnitude to be used for warning system				
	2	135.0	135.0	130.0	190.0
	5	190.0	185.0	175.0	240.0
	10	225.0	215.0	205.0	275.0

4.11 Flood Analysis

In the Master Plan Study, flood analyses were conducted in both the Chane – Pailon Area and the San Juan – Antofagasta Area to simulate the flood areas with and without the flood mitigation and drainage improvement measures. The 1992 flood was used to calibrate the hydrodynamic model. The hydrodynamic model was then used to simulate the probable floods with the design rainfalls with 2, 5, 10, 20 and 50 year return periods.

In this study, the hydrodynamic model used in the Master Plan Study was updated by using the new cross sections of the newly constructed bridges along the national road No.9 and the river cross sections surveyed during the Study.

The purposes for these are:

- To verify the application of the formulated hydrodynamic model for the current floods,
- To clarify mainly:
  - the extent of the back water effect from downstream of the Rio Chane,
  - the effect of the overflow from the Rio Grande,
  - the effect of the natural retarding basins in both areas for flood mitigation,
  - the effect of the newly constructed bridges to the flow in the Study Area and
  - the effect of the confluence at the Arroyo Jochi and Tacuaral.
- To simulate the design floods at each return period years,
- To clarify the improvement of flood condition with the project in comparison with the condition without the project.

4.12 Hydrodynamic Model Structures

4.12.1 Model Formulation

The hydrodynamic model was formulated with the same basis as in the Master Plan Study. The model was set up for the river basins in the study area those were classified as the target areas for structural measures as follows:

The Chane – Pailon Area	:	The Rio Chane-Pailon and Okinawa Drainage basins,
The San Juan – Antofagasta Area	:	The Arroyo Yapacanicito, Jochi and Tacuaral basins.

(1) Model Formulation in the Chane – Pailon Area

The river system in the Chane-Pailon Area basin was composed of the main rivers, the Rio Chane, the Rio Pailon and tributaries, i.e., the Quebrada Chacras, the Quebrada Chane, the Quebrada Toro, the Quebrada Maras and the Quebrada Meco, and the Okinawa Drainage. The basin was divided into 27 sub-basins as follows:

River	Sub-basins	Total	Area (km^2)
Rio Chane	A-1, A-2, A-3, A-4, A-5 A-7, A-8, A-9, A-10, A-11	10	1,368.80
Rio Pailon	A-6	1	211.87
QDA Chacras	B-1, B-2, B-3	3	224.25
QDA Chane	C-1, C-2, C-3, C-9	4	235.61
QDA Toro	C-4, C-5, C-6	3	171.29
QDA Maras	C-7, C-8	2	62.36
QDA Meco	D-1	1	244.82
Okinawa Drainage	E-1, E-2, E-3	3	381.50

(2) Model Formulation in the San Juan – Antofagasta Area

The river system of the San Juan – Antofagasta Area is composed of the main rivers, the Arroyo Yapacanicito, the Arroyo Jochi and the Arroyo Tacuaral and some water flowing routes found during flood periods. These routes were set up as tributaries in the model namely the Jochi-Tacu, the R/W Embank and the TMP-R/W. The river system was divided into 14 sub-basins as follows:

River/Arroyo	Sub-basins	Total	Area (km^2)
Arroyo Jochi	J-1, J-2, J-3, J-4	4	148.0
Arroyo Tacuaral	T-1, T-2, T-3, T-4	4	252.8
Arroyo Yapacanicito	Y1-1, Y1-2, Y1-3, Y1-4, Y2-1, Y2-2	6	370.7

The model is shown in Figs. 4.12.1 and 4.12.2. Details of the model are shown in the Supporting Report – F.

4.12.2 Boundary Condition

The time series of flow rate in each sub-basin from the rainfall-runoff analysis were used as the inflows to the river system in the models.

Manning roughness coefficients of the rivers without the river improvement were set as follows:

Without the river improvement :

The Chane – Pailon Area = 0.035

The San Juan – Antofagasta Area = 0.045

With the river improvement :

Both areas = 0.030

The other necessary parameters in the simulation were set the same as in the Master Plan Study.

Water levels at the downstream end of the rivers during the current floods in 1997 and 1998 were obtained from the questionnaire surveys conducted during the Study in both river basins.

4.12.3 Hydrodynamic Simulation Program

A hydrodynamic simulation program, MIKE11 used in the Master Plan Study, was also adopted in this study to analyze the current floods with the unsteady flow condition. The calibration results and necessary parameters in the model set up in the Master Plan Study were also used in this simulation.

4.13 Hydrodynamic Simulation for the Current Floods

The flood analysis was conducted using the current floods in 1997 – 1998, which were reported to have caused flood damages in the study area, in order to clarify the following points:

- The application of the flood model for the current floods,
- The effect of the back water from the Rio Piray to the Rio Chane,
- The effect of the overflow from the Rio Grande,
- The effect of the retarding basin at the upstream of the Rio Pailon and QDA Chane,
- The effect of the construction of seven bridges along the National Road No. 9,
- The effect of the inundation from the Rio Yapacani,
- The effect of the retarding basin at the confluence of the Arroyo Jochi and Arroyo Tacuaral,
- The effect of the inflow from the Arroyo Jochi to the San Juan area and
- The effect of the contraction in the Arroyo Yapacanicito, Jochi, Tacuaral and others.

The simulation was done for the floods in 1997 and 1998 in order to compare with the actual inundation depths and areas obtained from the flood damage survey conducted in this study.

(1) Simulation Set-up in the Chane – Pailon Area

The simulation periods were as follows:

The Rio Chane- Pailon basin :	November – December 1997
The Okinawa drainage basin :	November – December 1997 and February – March 1998

The changes of river condition and flow due to the construction of 7 bridges after 1995, the overflow from the Rio Grande basin and the back water from the Rio Piray were to be clarified in the simulation. These points were taken into consideration in the model as explained in the Supporting Report – F.

(2) Simulation Set-up in the San Juan – Antofagasta Area

The simulation period was as follows:
The Arroyo Yapacanicito, Jochi and Tacuaral Basin : January – February 1997

The changes of river condition and flow during the flood period were to be clarified. The main causes of these changes were the overflow from the Rio Yapacani, the contraction in the Arroyo Yapacanicito, Jochi, Tacuaral and others, the effect of retarding basin at the confluence of the Arroyo Jochi and Tacuaral and the inflow from the Arroyo Jochi to the San Juan area. These points were taken into consideration in the model as explained in the Supporting Report F.

4.14 Simulation Results

(1) In the Chane – Pailon Area

The simulation was done for the floods during November – December 1997 for the Rio Chane – Pailon basin and during November – December 1997 and February – March 1998 for the Okinawa drainage basin.

The Rio Chane – Pailon basin

The effect of the back water from the Rio Piray and the contraction of the rivers were examined by varying the water level at the downstream end of the Rio Chane for 2 cases, those are:

Case I : Water level set up from the questionnaire survey
Case II : Very high water level set up for the comparison

The simulation results revealed that:

1) In Case I, the model was found applicable for these floods.

2) In Case II, it was apparent that the effect of back water was terminated at the chainage 63.60 km, which was the location of a bridge across the river near the junction of the Rio Chane and Pailon (or the cross section No. R310 in the Master Plan Study).
The hydraulic characteristics showed that the flow condition changed from the sub-critical flow in the upstream to almost the critical flow at this section and to the sub-critical flow again in the downstream. Therefore, the water level at this section was comparatively stable although there was some water level fluctuation at the downstream.

3) The retarding basin at the upstream of the Rio Pailon was located between the chainage 2.00 km and 6.00 km and that of the QDA Chane was located between the river survey distance 13.60 km and 16.30 km.
The result showed that the peak discharge at the upstream of the Rio Pailon was reduced remarkably for about 35 % after passing through the retarding basin. But the delayed time of the peak and the decrease of water level between the upstream and downstream of the retarding basin could not be found clearly.
The peak discharge at the upstream of the QDA Chane was also reduced remarkably for about 73 % after passing through the retarding basin. But the delayed time of the peak and the decrease of the water level between the upstream and downstream of the retarding basin could not be found clearly either.

4) The cross sections at the newly constructed bridges along the National Road No. 9 were used in the simulation. The results showed no any sudden change in the water level at these cross sections, therefore, it was summarized that there was no significant adverse effect by the construction of these bridges to the flow.

The Okinawa Drainage

The effect of the overflow from the Rio Grande was verified. The simulation was done during the period with and without the overflow as reported in the flood damage survey as follows:

Case I	:	The flood during November – December 1997, (Without overflow from Rio Grande)
Case II	:	The flood during February – March 1998, (With overflow from Rio Grande)

The simulation results revealed that

1) In Case I, the model was found applicable for this flood.
2) In Case II, the simulation result clarified that there was almost no inundation during that period because the rainfalls in the basin at that time were not extensive. The water level was about same as the bank elevation. However the questionnaire survey revealed that at that period the whole area was inundated by the floodwater from the Rio Grande. Therefore, it was summarized that the causes of inundation in the Okinawa Drainage were from the heavy rainfalls in the basin and the overflow from the Rio Grande.

(2) In the San Juan – Antofagasta Area

The simulation was done for the floods during January – February 1997. However, from the flood damage survey, it was found that during that period:

- There was no inundation from the Rio Yapacani,
- There was no inflow from the Arroyo Jochi to the San Juan area,

Therefore, these effects could not be verified from these floods.

The simulation results revealed that

1) The model was found applicable for this flood.
2) The retarding basin at the confluence of the Arroyo Jochi and Tacuaral apparently delayed the peak of the water level in the Arroyo Jochi's downstream of the retarding basin.
   The retarding basin was located between the river survey distance 25.60 km and 35.80 km. The delayed time was in a range between 12 – 24 hours. The peak discharge in the Arroyo Jochi also decreased remarkably about 47% after the retarding basin.
   However, the Arroyo Tacuaral also passed through this retarding basin but the delayed time at the downstream of the retarding basin could not be found. This was due to the topography of these rivers that the Arroyo Tacuaral has a lower elevation than the Arroyo Jochi. The flow direction in the retarding basin was mainly from the Arroyo Jochi towards the Arroyo Tacuaral. Therefore, the discharge at the downstream of the Arroyo Tacuaral after the retarding basin remarkably increased.
3) The water level fluctuation in the longitudinal profile was not so high and no any sudden water level change was found along all the rivers. Therefore,

the effect of the contraction and meandering was considered negligibly small.

4.15 Improvement of the Hydrodynamic Simulation

Although the flood analysis for the current floods showed satisfactory results, the model was improved for the hydraulic design by using a new topographic survey conducted by the Study in 1998. The range of new cross-sections of the rivers and drainage set up in the model were as follows:

River	Chainage of new cross-section (km)	
	From	To
The Chane-Pailon Area		
Chane	24.00	59.60
Pailon	60.00	88.10
Okinawa	0.00	26.80
The San Juan - Antofagasta Area		
Yapacanicito	14.30	31.70
Jochi	13.80	25.60
Tacuaral	16.80	22.60
San Juan km 11	0.00	2.41
San Juan km 13	0.00	3.82
San Juan km 15	0.00	8.93
San Juan km 17	0.00	4.27
San Juan km 24	0.00	5.58
San Juan km 28	0.00	10.55
Antofagasta	0.00	8.80
Road-cum-emb.	0.00	9.00

The model structure was in principle exactly the same as in the Master Plan Study and the progress stage of this study, except the number and shapes of the new cross sections.

The flood simulation was also done again with the new cross sections in order to compare with the result from the flood simulation in the Master Plan Study and the progress stage of this study. It is found that the results using the new cross section were almost the same as before with no significant difference. The new cross sections are shown in the Data Book.

4.15.1 Condition Set-up in the Simulation

In order to obtain sufficient information for the river design, preparation of flood hazard maps and economic analysis, a total of 10 cases each in the Chane - Pailon Area and the

San Juan – Antofagasta Area was set up in the simulation. These cases, as shown below, were considered as sufficient to reveal all the necessary hydrodynamic information including water levels, flow rates, etc. for the further analysis. The simulation cases are as follows:

Design Flow (return period year)	Calculation cases				Remarks
	Rio Chane-Pailon		A. Yapacanicito and others		
	Cross section		Cross section		
	Existing	Design	Existing	Design	
2	1	1	1	1	Flow rate in the calulation was design flow with different return period year
5	1	1	1	1	
10	1	1	1	1	
20	1	1	1	1	
50	1	1	1	1	
Total cases	5	5	5	5	

All design discharge hydrograph had the same shape but different magnitude as explained in the following section.

4.15.2 Simulation Results for Design Discharge

Simulation for the design discharge was done in the study area for 2 cases, they are:

Case I : Existing cross section with design discharge (without project)
Case II : Design cross section with design discharge (with project)

(1) In the Chane – Pailon Area

The simulation was done for the design discharge with the return periods of 2, 5, 10, 20 and 50 years with the same shape but different magnitude. Peak runoff at each return period of the sub-basins is shown in the Supporting Report - F.

For Case I (without the project), the cross sections were updated in the Study Area by the new topographic survey as shown in the Data Book.

For Case II (with the project), the cross sections were the design sections as proposed in the Study which were considered as sufficiently large and suitable to accommodate the flood at the design return period. The dimension of the design sections are summarized as follows:

River	Chainage (km)		Proposed cross section				River	Design
	From	to	Top Width (m)	Depth (m)	Side Slope (1/**)	Bed Width (m)	Slope (1/***)	Discharge (m^3/s)
Chane	60.00	81.90	75.0	6.0	2.0	51.0	1,212	1,212
	81.90	88.00	100.0	6.0	2.0	76.0	1,500	1,500
Pailon	36.50	51.40	65.0	5.0	2.0	45.0	995	995
	51.40	59.60	70.0	5.0	2.0	50.0	908	908

Results of the simulation for the Rio Chane and Pailon basin are shown in Tables 4.15.1 and 4.15.2 and Figure 4.15.1, and those for the Okinawa Drainage are shown in Tables 4.15.3 and 4.15.4. A summary of the water level differences is shown in the following tables.

It is found that in most of the sections, the water level decreased significantly in the design sections (with the project) from the existing sections (without the project). However, in some parts, the water level of the design cross sections (with the project) were higher than the existing sections (without the project) because the design sections were set up in order to avoid the irregular flow. However, the effectiveness of the improvement with the project compared to the case without the project was considered from the decrease of the inundation depth as explained in the latter section.

Rio	Chainage (km)	Water level difference (m) (WL without - WL with)				
		2 year	5 year	10 year	20 year	50 year
Chane	88.000	-0.44	-0.78	-0.85	-1.02	-0.74
	86.400	-0.16	-0.48	-0.49	-0.20	-0.40
	84.800	0.09	-0.18	-0.20	-0.20	-0.20
	83.800	0.34	0.01	-0.09	0.16	-0.09
	82.800	0.40	-0.02	-0.15	0.22	-0.08
	81.900	0.38	-0.06	-0.20	-0.01	-0.13
	81.000	0.52	0.14	0.05	0.14	0.29
	80.000	1.29	0.53	0.43	0.47	0.42
	78.800	1.36	0.64	0.51	0.81	0.51
	77.700	0.87	0.17	0.03	0.22	0.08
	76.500	0.68	-0.01	-0.15	0.03	-0.08
	75.200	0.42	-0.08	-0.13	0.17	-0.04
	74.300	0.29	-0.25	-0.38	0.53	-0.28
	73.400	0.22	-0.44	-0.55	0.09	-0.42
	72.500	0.18	-0.40	-0.52	-0.16	-0.39
	71.500	0.12	-0.34	-0.42	-0.27	-0.32
	70.500	0.07	-0.41	-0.39	0.34	-0.26
	69.500	-0.05	-0.50	-0.45	-0.43	-0.33
	68.500	0.10	-0.38	-0.39	-0.24	-0.29
	67.500	0.04	-0.41	-0.46	0.21	-0.35
	66.500	0.00	-0.48	-0.52	-0.06	-0.42
	65.500	-0.05	-0.47	-0.56	0.12	-0.46
	64.500	-0.15	-0.54	-0.53	0.20	-0.28
	63.600	-0.27	-0.63	-0.65	-0.21	-0.41
	62.600	-0.28	-0.60	-0.61	-0.43	-0.38
	61.600	0.13	-0.26	-0.47	0.18	-0.34
	60.800	0.27	-0.06	-0.26	0.17	-0.35
	60.000	2.68	1.89	1.89	1.92	1.96
Average		0.32	-0.16	-0.23	0.10	-0.13

Rio	Chainage (km)	Water level difference (m) (WL without - WL with)				
		2 year	5 year	10 year	20 year	50 year
Pailon	59.600	2.61	1.80	1.77	1.92	1.82
	58.900	3.26	2.64	2.65	3.28	2.88
	58.200	2.83	2.53	2.45	3.11	2.62
	57.500	2.97	2.78	2.64	2.96	2.73
	56.800	4.52	4.28	4.16	4.63	4.19
	55.650	4.25	4.11	3.93	4.25	3.96
	54.500	3.66	3.58	3.36	3.67	3.38
	53.900	3.33	3.28	3.02	3.39	2.99
	53.200	3.10	2.95	2.82	3.08	2.92
	52.500	3.15	2.96	2.83	3.30	2.85
	51.400	2.94	2.77	2.67	2.95	2.67
	50.300	2.90	2.71	2.63	2.85	2.59
	49.200	2.94	2.77	2.70	2.76	2.68
	47.800	2.00	1.85	1.72	2.19	1.69
	46.500	2.04	1.80	1.72	2.06	1.73
	45.300	2.01	1.82	1.69	2.03	1.68
	44.200	1.64	1.44	1.39	1.63	1.49
	42.800	1.27	1.20	1.20	1.53	1.39
	41.500	1.39	1.34	1.34	1.60	1.45
	40.500	1.52	1.46	1.46	2.09	1.63
	39.500	1.38	1.36	1.45	2.04	1.74
	38.500	0.92	1.04	1.20	1.31	1.23
	37.800	1.24	1.35	1.47	1.63	0.82
	37.100	1.61	1.69	1.80	2.19	1.44
	36.500	1.67	1.65	1.67	1.98	1.43
	36.500	1.60	1.58	1.57	1.62	1.35
	35.500	1.19	1.12	1.09	1.76	0.95
	34.600	0.90	0.79	0.80	1.17	0.77
	33.700	0.81	0.78	0.84	0.90	0.73
	32.300	0.87	0.85	0.88	1.23	0.90
	31.300	0.71	0.72	0.79	1.34	0,92
	30.600	0.72	0.75	0.83	1.09	0.98
	29.900	1.07	1.05	1.08	1.30	1.13
	24.000	0.95	0.88	0.95	-17.37	1.10
Average		2.06	1.93	1.90	1.69	1.91

River/ Drainage	Chainage (km)	Water level difference (m) (WL without - WL with)				
		2 year	5 year	10 year	20 year	50 year
Okinawa	26.800	0.00	0.00	0.00	0.00	0.00
	25.600	0.09	0.05	0.06	0.04	0.02
	24.100	0.24	0.14	0.16	0.10	0.04
	23.600	0.26	0.17	0.21	0.15	0.07
	22.400	0.85	0.88	0.89	0.90	0.88
	20.600	0.56	0.57	0.61	0.64	0.67
	19.100	0.90	0.83	0.83	0.85	0.88
	18.300	1.12	1.02	1.02	1.03	1.05
	16.600	1.11	1.00	1.00	1.00	1.00
	15.900	1.01	0.89	0.88	0.89	0.91
	14.000	0.82	0.73	0.73	0.75	0.79
	13.200	0.87	0.69	0.68	0.69	0.70
	12.000	0.93	0.64	0.68	0.65	0.66
	10.100	1.15	0.83	0.88	0.84	0.82
	9.300	1.14	0.82	0.87	0.82	0.81
	8.400	1.03	0.72	0.79	0.75	0.73
	7.000	0.62	0.40	0.50	0.50	0.51
	6.300	0.46	0.38	0.40	0.38	0.37
	5.200	0.49	0.39	0.40	0.37	0.35
	0.000	0.54	0.59	0.44	0.41	0.38
Average		0.70	0.58	0.60	0.59	0.58

(2) In the San Juan -- Antofagasta Area

The Arroyo Yapacanicito, Jochi, Tacuaral, Tejeria and Antofagasta

The simulation was done for the design discharge with the return periods of 2, 5, 10, 20 and 50 years with the same shape but different magnitude as explained in the hydrological part. Peak runoff at each return period of the sub-basins is shown in the Supporting Report F.

For Case I (without the project), the cross sections used were the existing cross section from the topographic survey conducted in this study as shown in the Data Book.

For Case II (with the project), the cross sections were the design sections as proposed in the Study which were considered as sufficiently large and suitable to accommodate the flood at the design return period. The dimension of the design sections are summarized as follows:

River	Chainage (km)		Proposed cross section				River Slope (1/***)
	From	to	Top Width (m)	Depth (m)	Side Slope (1/**)	Bed Width (m)	
Yapacanicito	14.30	28.10	30.0	3.0	2.0	18.0	1,280
	28.10	31.70	35.0	3.0	2.0	23.0	1,280
Jochi	13.80	16.00	22.0	3.5	2.0	8.0	900
	16.00	25.60	30.0	3.5	2.0	16.0	900
Tacuaral	16.80	22.60	26.0	4.0	2.0	10.0	900

Results of the simulation are shown in Tables 4.15.5 and 4.15.6 and Figure 4.15.2.

It is found that the water level decreased significantly from the condition of "without the project" to "with the project" as shown below:

Arroyo	Chainage (km)	Water level difference (m) (WL without - WL with)				
		2 year	5 year	10 year	20 year	50 year
Yapacanicito	14.300	0.30	0.33	0.34	0.35	0.36
	14.320	0.33	0.33	0.28	0.27	0.27
	15.400	1.19	1.18	1.16	1.15	1.14
	16.400	0.81	0.76	0.75	0.79	0.89
	17.100	0.16	0.14	0.09	0.07	0.04
	19.000	-0.05	-0.07	-0.21	-0.40	-0.45
	20.000	-0.04	-0.07	-0.19	-0.33	-0.41
	20.400	-0.17	-0.23	-0.25	-0.26	-0.27
	22.200	0.67	0.60	0.51	0.50	0.36
	23.100	0.19	0.13	0.13	0.12	0.06
	24.100	0.14	0.13	0.09	0.10	0.08
	25.300	0.19	0.14	0.11	0.10	0.09
	26.200	0.18	0.15	0.12	0.12	0.10
	27.000	0.19	0.16	0.14	0.13	0.12
	28.100	0.18	0.15	0.13	0.12	0.11
	29.100	0.18	0.14	0.12	0.11	0.10
	30.100	0.19	0.15	0.12	0.12	0.11
	31.100	0.19	0.15	0.13	0.12	0.11
	31.700	0.19	0.15	0.13	0.12	0.11
	Average	0.26	0.23	0.19	0.17	0.15

It should be noted herein that some cross sections in the middle part of the Rio Yapacanicito had water level in the design sections higher than the existing sections because those existing sections were pretty low and therefore were designed to have higher elevation to avoid irregular flow. As a result, the water level in design section was higher than the existing section.

Arroyo	Chainage (km)	Water level difference (m) (WL without - WL with)				
		2 year	5 year	10 year	20 year	50 year
Jochi	13.800	1.28	1.24	1.22	1.19	1.15
	15.000	0.40	0.35	0.33	0.29	1.39
	15.010	0.39	0.60	0.52	0.46	0.27
	15.020	0.42	0.37	0.34	0.31	0.68
	16.000	1.16	1.17	1.16	1.15	1.11
	17.200	1.56	1.61	1.61	1.61	1.59
	18.300	1.53	1.57	1.59	1.60	1.57
	19.000	1.51	1.55	1.57	1.57	1.55
	20.000	1.28	1.33	1.36	1.37	1.34
	20.900	1.32	1.38	1.41	1.42	1.40
	21.900	1.34	1.37	1.39	1.40	1.37
	22.700	1.55	1.57	1.58	1.58	1.56
	22.710	1.48	1.60	1.67	1.91	1.86
	22.720	1.51	1.54	1.55	1.56	1.54
	23.700	1.67	1.72	1.75	1.77	1.77
	24.900	1.90	1.54	1.43	1.41	1.40
	25.600	0.29	0.43	0.31	0.27	0.16
	Average	1.21	1.23	1.22	1.23	1.28

Arroyo	Chainage (km)	Water level difference (m) (WL without - WL with)				
		2 year	5 year	10 year	20 year	50 year
Tacuaral	16.800	0.65	0.38	0.33	0.34	0.18
	16.810	0.65	0.37	0.33	0.34	0.18
	16.820	0.65	0.38	0.33	0.34	0.18
	17.600	0.65	0.37	0.33	0.34	0.18
	18.500	0.65	0.38	0.33	0.34	0.18
	19.100	0.65	0.36	0.32	0.34	0.18
	19.110	0.66	0.40	0.35	0.34	0.18
	19.120	0.65	0.33	0.29	0.34	0.18
	20.000	0.67	0.46	0.41	0.34	0.18
	21.200	0.62	0.20	0.17	0.34	0.19
	22.100	0.71	0.73	0.65	0.35	0.17
	22.600	0.54	0.61	0.59	0.33	0.20
	Average	0.65	0.41	0.37	0.34	0.18

The inundation depth was explained in the latter section. These results were also used afterwards for the flood mitigation measures.

TABLES

TABLE 4.4.1(1) AVAILABLE DATA

Rainfall

No	St No	Station Name	Latitud	Longitud	Elevation (m)	Year 43 45 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95 97
Okinawa / Chane-Pailon (SEARPI, SENAMHI, CETABOL and AASANA)						
1	22NP	Montero	17°20'	63°23'	317	
2	25NP	Sta Cruz-Oficina	17°47'	63°10'	416	
3	28NP	Peroto	17°29'	63°10'42"	350	
4	50NP	Viru-Viru Aeropuerto	17°38'51"	63°07'55"	360	
5	51NP	Warnes	17°30'	63°08'	330	
6	61NP	Saavedra	17°14'	63°10'	320	
7	62NP	Mineros	17°06'	63°14'	245	
8	5806	Sta Cruz-Trompillo	17°47'	63°10'	437	
9	5807	Sta Cruz-Universidad	17°46'38"	63°11'	725	
10		Est. Exp. Vallecito	17°46'	63°09'	398	
11		Okinawa 1	17°13'	62°53'	252	
12		Puerto Pailas	17°39'	62°47'	280	
13		CETABOL-JICA	17°23'	62°54'	280	
14		Vallegrande				
15		Camiri				
San Juan de Yapacani / Antofaganta (CETABOL and MACUCY)						
1		San Juan de Yapacani	17°15'	63°50'	350	
2	13PY	Buena Vista	17°27'	63°40'	379	

TABLE 4.4.1(2) AVAILABLE DATA

Discharge / Water Level

No	St No	Station Name	Latitud	Longitud	Elevation (m)
Rio Pirai (SEARPI)					
1	506	Angostura	18°09'59"	63°34'05"	620
2	510	La Belgica	17°32'	63°13'	348
3	505	Bermejo	18°06'	63°38'	1000
4	504	Colorado	18°08'	63°08'	1020
5	512	P. Eisenhower	17°19'	63°19'	279
6	520	Espejos	17°58'30"	63°34'17"	497
7	530	San Pedro Terevinto	17°43'05"	63°26'	450
Rio Grande (SEARPI)					
1	401	P. Abapo			440
2	402	Puerto Pailas	17°40'	62°47'	280
Rio Yapacani (MACUCY)					
1	004H	Puente Yapacani	17°24'	63°43'	283
Rio Palometillas (MACUCY)					
1	003H	Puente Palometillas	17°23'	63°32'	290

Year: 43 45 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95 97

TABLE 4.6.1 PROBABLE MAXIMUM RAINFALL WITHIN 24 HOURS BY GUMBEL METHOD

STATION: SAAVEDRA

(Unit:mm)

Duration	Return Period(Year)							
(hr)	2	5	10	20	30	40	50	100
0.5	26.0	37.9	45.9	53.5	57.9	61.0	63.3	70.7
1.0	44.2	58.6	68.1	77.3	82.5	86.2	89.1	98
2.0	59.1	79.8	93.5	106.7	114.3	119.6	123.8	136.6
3.0	69.1	93.0	108.9	124.1	132.9	139.0	143.8	158.6
4.0	74.9	100.9	118.1	134.6	144.1	150.8	156.0	172
5.0	81.3	111.0	130.7	149.6	160.4	168.1	174.0	192.3
6.0	85.8	118.0	139.2	159.6	171.3	179.6	186.0	205.8
9.0	94.2	130.0	153.7	176.4	189.5	198.7	205.8	227.8
12.0	99.2	137.5	155.2	177.9	191.0	200.2	207.3	229.3
24.0	102.4	137.9	161.4	184.0	197.0	206.1	213.2	235.1

STATION: SANTA CRUZ-OFICINA

(Unit:mm)

Duration	Return Period(Year)							
(hr)	2	5	10	20	30	40	50	100
0.5	26.5	36.5	43.1	49.4	53	55.6	57.6	63.7
1.0	49.8	62.3	70.7	78.6	83.2	86.5	89	96.7
2.0	71.7	94.0	108.8	122.9	131.1	136.8	141.3	155
3.0	85.0	113.9	133.0	151.3	161.9	169.3	175	192.8
4.0	97.3	133.0	156.7	179.4	192.5	201.7	208.8	230.9
5.0	97.5	140.7	165.7	189.7	203.5	213.2	220.8	244
6.0	97.7	140.9	166.1	201.9	216.8	227.3	235.4	260.4
9.0	98.2	141.6	167.5	202.0	217.1	227.7	235.9	261.3
12.0	98.7	142.3	168.8	202.0	217.3	228.1	236.4	262.1
24.0	100.9	145.0	174.2	202.2	218.3	229.7	238.5	265.6

TABLE 4.7.1(1) RAINFALL VALUES FOR EACH RETURN PERIOD

Saavedra (unit: mm)

Time		Return Period (Year) 2	5	10	20	30	50
1st Day	1	0.0	0.1	0.1	0.1	0.1	0.1
	2	0.0	0.1	0.1	0.1	0.1	0.1
	3	0.1	0.1	0.1	0.1	0.2	0.2
	4	0.1	0.1	0.1	0.2	0.2	0.2
	5	0.1	0.1	0.2	0.2	0.2	0.3
	6	0.1	0.2	0.2	0.3	0.3	0.4
	7	0.1	0.3	0.3	0.4	0.4	0.5
	8	0.2	0.4	0.5	0.6	0.6	0.7
	9	0.3	0.5	0.7	0.9	0.9	1.0
	10	0.5	0.9	1.2	1.5	1.6	1.8
	11	1.1	1.9	2.5	3.0	3.3	3.7
	12	4.7	8.2	10.6	12.8	14.1	15.7
	13	2.0	3.5	4.5	5.4	6.0	6.7
	14	0.7	1.2	1.6	1.9	2.1	2.4
	15	0.4	0.7	0.9	1.1	1.2	1.3
	16	0.2	0.4	0.6	0.7	0.7	0.8
	17	0.2	0.3	0.4	0.5	0.5	0.6
	18	0.1	0.2	0.3	0.3	0.4	0.4
	19	0.1	0.2	0.2	0.3	0.3	0.3
	20	0.1	0.1	0.2	0.2	0.2	0.2
	21	0.1	0.1	0.1	0.2	0.2	0.2
	22	0.0	0.1	0.1	0.1	0.1	0.2
	23	0.0	0.1	0.1	0.1	0.1	0.1
	24	0.0	0.1	0.1	0.1	0.1	0.1
Sub-total		11.3	19.9	25.6	31.0	34.1	38.1
2nd Day	1	0.1	0.1	0.1	0.1	0.2	0.2
	2	0.1	0.1	0.1	0.2	0.2	0.2
	3	0.1	0.1	0.2	0.2	0.2	0.2
	4	0.1	0.2	0.2	0.2	0.3	0.3
	5	0.1	0.2	0.3	0.3	0.3	0.4
	6	0.2	0.3	0.3	0.4	0.4	0.5
	7	0.2	0.4	0.4	0.5	0.6	0.6
	8	0.3	0.5	0.6	0.8	0.8	0.9
	9	0.5	0.8	1.0	1.2	1.3	1.4
	10	0.8	1.3	1.7	2.0	2.2	2.4
	11	1.7	2.8	3.4	4.1	4.5	5.0
	12	7.3	11.7	14.6	17.4	19.0	21.0
	13	3.1	5.0	6.2	7.4	8.1	9.0
	14	1.1	1.7	2.2	2.6	2.8	3.2
	15	0.6	1.0	1.2	1.5	1.6	1.8
	16	0.4	0.6	0.8	0.9	1.0	1.1
	17	0.3	0.4	0.5	0.6	0.7	0.8
	18	0.2	0.3	0.4	0.5	0.5	0.6
	19	0.1	0.2	0.3	0.3	0.4	0.4
	20	0.1	0.2	0.2	0.3	0.3	0.3
	21	0.1	0.1	0.2	0.2	0.2	0.3
	22	0.1	0.1	0.2	0.2	0.2	0.2
	23	0.1	0.1	0.1	0.2	0.2	0.2
	24	0.1	0.1	0.1	0.1	0.1	0.2
Sub-total		17.6	28.3	35.4	42.2	46.1	51.0
3rd Day	1	0.3	0.6	0.7	0.8	0.9	1.0
	2	0.4	0.6	0.8	1.0	1.1	1.2
	3	0.5	0.8	1.0	1.2	1.3	1.4
	4	0.6	0.9	1.2	1.4	1.5	1.7
	5	0.7	1.2	1.5	1.7	1.9	2.1
	6	1.0	1.5	1.9	2.2	2.4	2.7
	7	1.3	2.0	2.4	2.9	3.1	3.5
	8	1.8	2.7	3.3	3.9	4.3	4.7
	9	2.8	4.0	4.9	5.7	6.1	6.7
	10	4.8	6.5	7.8	8.9	9.5	10.3
	11	10.0	11.6	12.7	13.8	14.4	15.2
	12	42.2	58.7	69.4	79.8	85.8	93.2
	13	18.0	22.1	24.8	27.3	28.8	30.6
	14	6.3	7.2	7.7	8.3	8.7	9.1
	15	3.6	5.1	6.1	7.0	7.5	8.2
	16	2.2	3.3	4.0	4.7	5.1	5.5
	17	1.5	2.3	2.8	3.3	3.6	4.0
	18	1.1	1.7	2.1	2.5	2.7	3.0
	19	0.8	1.3	1.6	1.9	2.1	2.4
	20	0.7	1.1	1.3	1.6	1.7	1.9
	21	0.5	0.9	1.1	1.3	1.4	1.6
	22	0.4	0.7	0.9	1.1	1.2	1.3
	23	0.4	0.6	0.7	0.9	1.0	1.1
	24	0.3	0.5	0.6	0.8	0.8	0.9
Sub-total		102.4	137.9	161.4	184.0	197.0	213.2
TOTAL		131.3	186.1	222.4	257.2	277.2	302.3

Trompillo (unit: mm)

Time		Return Period (Year) 2	5	10	20	30	50
1st Day	1	0.0	0.0	0.0	0.0	0.0	0.0
	2	0.0	0.0	0.0	0.0	0.0	0.0
	3	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	0.0
	5	0.0	0.0	0.0	0.0	0.0	0.0
	6	0.0	0.0	0.0	0.0	0.0	0.0
	7	0.0	0.0	0.0	0.0	0.0	0.0
	8	0.0	0.0	0.0	0.0	0.0	0.0
	9	0.0	0.0	0.0	0.0	0.0	0.0
	10	0.0	0.0	0.0	0.1	0.1	0.1
	11	1.3	1.5	1.6	1.8	1.8	1.9
	12	3.7	4.4	4.8	5.1	5.3	5.6
	13	2.0	2.4	2.6	2.8	2.9	3.1
	14	0.9	1.0	1.1	1.2	1.2	1.3
	15	0.0	0.0	0.0	0.0	0.0	0.0
	16	0.0	0.0	0.0	0.0	0.0	0.0
	17	0.0	0.0	0.0	0.0	0.0	0.0
	18	0.0	0.0	0.0	0.0	0.0	0.0
	19	0.0	0.0	0.0	0.0	0.0	0.0
	20	0.0	0.0	0.0	0.0	0.0	0.0
	21	0.0	0.0	0.0	0.0	0.0	0.0
	22	0.0	0.0	0.0	0.0	0.0	0.0
	23	0.0	0.0	0.0	0.0	0.0	0.0
	24	0.0	0.0	0.0	0.0	0.0	0.0
Sub-total		8.1	9.4	10.3	11.1	11.5	12.2
2nd Day	1	0.0	0.0	0.0	0.0	0.0	0.0
	2	0.0	0.0	0.0	0.0	0.0	0.0
	3	0.0	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	0.0
	5	0.0	0.0	0.0	0.0	0.0	0.0
	6	0.0	0.0	0.0	0.0	0.0	0.0
	7	0.0	0.0	0.0	0.0	0.0	0.0
	8	0.0	0.0	0.0	0.0	0.0	0.0
	9	0.0	0.0	0.1	0.1	0.1	0.1
	10	0.1	0.1	0.1	0.1	0.1	0.1
	11	2.9	3.5	3.9	4.3	4.6	4.8
	12	8.5	10.3	11.5	12.7	13.4	14.2
	13	4.6	5.6	6.3	6.9	7.3	7.7
	14	2.0	2.4	2.7	3.0	3.1	3.3
	15	0.1	0.1	0.1	0.1	0.1	0.1
	16	0.0	0.0	0.0	0.0	0.0	0.1
	17	0.0	0.0	0.0	0.0	0.0	0.0
	18	0.0	0.0	0.0	0.0	0.0	0.0
	19	0.0	0.0	0.0	0.0	0.0	0.0
	20	0.0	0.0	0.0	0.0	0.0	0.0
	21	0.0	0.0	0.0	0.0	0.0	0.0
	22	0.0	0.0	0.0	0.0	0.0	0.0
	23	0.0	0.0	0.0	0.0	0.0	0.0
	24	0.0	0.0	0.0	0.0	0.0	0.0
Sub-total		18.4	22.3	24.9	27.4	28.9	30.6
3rd Day	1	0.0	0.2	0.3	0.4	0.5	0.6
	2	0.0	0.2	0.3	0.5	0.6	0.7
	3	0.0	0.3	0.4	0.6	0.7	0.8
	4	0.0	0.3	0.5	0.7	0.9	1.0
	5	0.0	0.4	0.6	0.9	1.1	1.3
	6	0.1	0.5	0.8	1.2	1.4	1.6
	7	0.1	0.7	1.2	1.6	1.9	2.2
	8	0.1	1.1	1.7	2.3	2.7	3.1
	9	0.2	1.7	2.7	3.6	4.1	4.7
	10	0.5	3.2	4.9	6.2	7.0	8.1
	11	15.9	20.6	23.7	26.6	28.3	30.4
	12	46.7	61.9	72.1	81.7	87.3	94.2
	13	25.4	33.1	38.2	43.0	45.9	49.4
	14	10.9	14.0	16.1	18.0	19.2	20.6
	15	0.3	2.3	3.6	4.6	5.2	6.1
	16	0.2	1.3	2.1	2.8	3.3	3.8
	17	0.1	0.9	1.4	1.9	2.2	2.6
	18	0.1	0.6	1.0	1.4	1.6	1.9
	19	0.1	0.5	0.7	1.1	1.2	1.4
	20	0.0	0.3	0.6	0.8	1.0	1.1
	21	0.0	0.3	0.5	0.7	0.8	0.9
	22	0.0	0.2	0.4	0.5	0.6	0.8
	23	0.0	0.2	0.3	0.5	0.5	0.6
	24	0.0	0.2	0.3	0.4	0.5	0.5
Sub-total		100.9	145.0	174.2	202.2	218.3	238.5
TOTAL		127.4	176.7	209.4	240.7	258.7	281.3

TABLE 4.7.1(2) RAINFALL VALUES FOR EACH RETURN PERIOD

CETABOL (unit: mm)

Time		Return Period (Year) 2	5	10	20	30	50
1st Day	1	0.0	0.1	0.1	0.1	0.1	0.1
	2	0.1	0.1	0.1	0.1	0.1	0.1
	3	0.1	0.1	0.1	0.1	0.1	0.1
	4	0.1	0.1	0.1	0.1	0.2	0.2
	5	0.1	0.1	0.2	0.2	0.2	0.2
	6	0.1	0.2	0.2	0.2	0.3	0.3
	7	0.2	0.2	0.3	0.3	0.3	0.4
	8	0.2	0.3	0.4	0.5	0.5	0.5
	9	0.4	0.5	0.6	0.7	0.7	0.8
	10	0.6	0.9	1.0	1.2	1.3	1.4
	11	1.3	1.8	2.1	2.5	2.7	2.9
	12	5.3	7.6	9.0	10.4	11.3	12.3
	13	2.3	3.2	3.8	4.4	4.8	5.2
	14	0.8	1.1	1.4	1.6	1.7	1.8
	15	0.5	0.6	0.8	0.9	1.0	1.1
	16	0.3	0.4	0.5	0.6	0.6	0.7
	17	0.2	0.3	0.3	0.4	0.4	0.4
	18	0.1	0.2	0.2	0.3	0.3	0.3
	19	0.1	0.2	0.2	0.2	0.2	0.2
	20	0.1	0.1	0.1	0.2	0.2	0.2
	21	0.1	0.1	0.1	0.1	0.1	0.2
	22	0.1	0.1	0.1	0.1	0.1	0.1
	23	0.0	0.1	0.1	0.1	0.1	0.1
	24	0.0	0.1	0.1	0.1	0.1	0.1
Sub-total		12.9	18.4	21.9	25.3	27.3	29.8
2nd Day	1	0.1	0.1	0.1	0.1	0.1	0.1
	2	0.1	0.1	0.1	0.1	0.1	0.1
	3	0.1	0.1	0.1	0.1	0.1	0.1
	4	0.1	0.1	0.1	0.1	0.1	0.1
	5	0.1	0.1	0.2	0.2	0.2	0.2
	6	0.2	0.2	0.2	0.2	0.2	0.2
	7	0.2	0.2	0.3	0.3	0.3	0.3
	8	0.3	0.3	0.4	0.4	0.4	0.5
	9	0.4	0.5	0.6	0.6	0.7	0.7
	10	0.8	0.9	1.0	1.1	1.2	1.2
	11	1.6	1.9	2.1	2.3	2.4	2.5
	12	6.7	8.0	8.8	9.7	10.1	10.7
	13	2.8	3.4	3.8	4.1	4.3	4.6
	14	1.0	1.2	1.3	1.4	1.5	1.6
	15	0.6	0.7	0.8	0.8	0.9	0.9
	16	0.4	0.4	0.5	0.5	0.5	0.6
	17	0.2	0.3	0.3	0.3	0.4	0.4
	18	0.2	0.2	0.2	0.3	0.3	0.3
	19	0.1	0.2	0.2	0.2	0.2	0.2
	20	0.1	0.1	0.1	0.2	0.2	0.2
	21	0.1	0.1	0.1	0.1	0.1	0.1
	22	0.1	0.1	0.1	0.1	0.1	0.1
	23	0.1	0.1	0.1	0.1	0.1	0.1
	24	0.0	0.1	0.1	0.1	0.1	0.1
Sub-total		16.2	19.3	21.4	23.4	24.6	26.0
3rd Day	1	0.3	0.6	0.7	0.9	0.9	1.0
	2	0.4	0.7	0.8	1.0	1.1	1.2
	3	0.5	0.8	1.0	1.2	1.3	1.5
	4	0.6	1.0	1.2	1.4	1.6	1.8
	5	0.7	1.2	1.5	1.8	2.0	2.2
	6	1.0	1.5	1.9	2.3	2.5	2.7
	7	1.3	2.0	2.5	3.0	3.2	3.6
	8	1.8	2.8	3.4	4.0	4.4	4.8
	9	2.8	4.1	5.0	5.8	6.3	6.9
	10	4.9	6.7	8.0	9.2	9.8	10.6
	11	10.0	11.8	13.0	14.2	14.9	15.7
	12	42.4	59.7	71.1	82.1	88.4	96.2
	13	18.1	22.5	25.4	28.1	29.6	31.6
	14	6.4	7.3	7.9	8.6	8.9	9.4
	15	3.6	5.2	6.2	7.2	7.8	8.5
	16	2.3	3.4	4.1	4.8	5.2	5.7
	17	1.5	2.4	2.9	3.4	3.7	4.1
	18	1.1	1.7	2.2	2.6	2.8	3.1
	19	0.8	1.3	1.7	2.0	2.2	2.4
	20	0.7	1.1	1.3	1.6	1.8	2.0
	21	0.5	0.9	1.1	1.3	1.4	1.6
	22	0.4	0.7	0.9	1.1	1.2	1.3
	23	0.4	0.6	0.8	0.9	1.0	1.1
	24	0.3	0.5	0.7	0.8	0.9	1.0
Sub-total		102.8	140.4	165.3	189.2	202.9	220.1
TOTAL		131.9	178.1	208.6	237.9	254.8	275.9

San Juan de Yapacani (unit: mm)

Time		Return Period (Year) 2	5	10	20	30	50
1st Day	1	0.1	0.1	0.1	0.1	0.1	0.1
	2	0.1	0.1	0.1	0.1	0.1	0.1
	3	0.1	0.1	0.1	0.1	0.1	0.1
	4	0.1	0.1	0.1	0.1	0.1	0.1
	5	0.1	0.1	0.1	0.1	0.2	0.2
	6	0.2	0.2	0.2	0.2	0.2	0.2
	7	0.2	0.2	0.2	0.3	0.3	0.3
	8	0.3	0.3	0.3	0.4	0.4	0.4
	9	0.5	0.5	0.5	0.6	0.6	0.6
	10	0.8	0.9	0.9	1.0	1.0	1.0
	11	1.7	1.8	1.9	2.0	2.0	2.1
	12	7.0	7.6	8.0	8.3	8.6	8.8
	13	3.0	3.2	3.4	3.5	3.7	3.8
	14	1.1	1.1	1.2	1.2	1.3	1.3
	15	0.6	0.6	0.7	0.7	0.7	0.8
	16	0.4	0.4	0.4	0.4	0.5	0.5
	17	0.3	0.3	0.3	0.3	0.3	0.3
	18	0.2	0.2	0.2	0.2	0.2	0.2
	19	0.1	0.2	0.2	0.2	0.2	0.2
	20	0.1	0.1	0.1	0.1	0.1	0.1
	21	0.1	0.1	0.1	0.1	0.1	0.1
	22	0.1	0.1	0.1	0.1	0.1	0.1
	23	0.1	0.1	0.1	0.1	0.1	0.1
	24	0.1	0.1	0.1	0.1	0.1	0.1
Sub-total		17.0	18.4	19.3	20.2	20.8	21.4
2nd Day	1	0.1	0.1	0.1	0.1	0.2	0.2
	2	0.1	0.1	0.2	0.2	0.2	0.2
	3	0.1	0.2	0.2	0.2	0.2	0.3
	4	0.1	0.2	0.2	0.3	0.3	0.3
	5	0.2	0.2	0.3	0.3	0.4	0.4
	6	0.2	0.3	0.4	0.4	0.5	0.5
	7	0.3	0.4	0.5	0.6	0.6	0.7
	8	0.4	0.6	0.7	0.8	0.9	1.0
	9	0.7	0.9	1.1	1.3	1.3	1.5
	10	1.1	1.6	1.9	2.2	2.3	2.5
	11	2.4	3.3	3.9	4.5	4.8	5.2
	12	10.0	13.9	16.4	18.9	20.3	22.1
	13	4.2	5.9	7.0	8.0	8.6	9.4
	14	1.5	2.1	2.5	2.8	3.0	3.3
	15	0.9	1.2	1.4	1.6	1.7	1.9
	16	0.5	0.7	0.9	1.0	1.1	1.2
	17	0.4	0.5	0.6	0.7	0.7	0.8
	18	0.3	0.4	0.4	0.5	0.5	0.6
	19	0.2	0.3	0.3	0.4	0.4	0.4
	20	0.2	0.2	0.3	0.3	0.3	0.3
	21	0.1	0.2	0.2	0.2	0.3	0.3
	22	0.1	0.1	0.2	0.2	0.2	0.2
	23	0.1	0.1	0.1	0.2	0.2	0.2
	24	0.1	0.1	0.1	0.1	0.1	0.2
Sub-total		24.2	33.6	39.8	45.8	49.2	53.5
3rd Day	1	0.5	0.8	0.9	1.1	1.3	1.4
	2	0.5	0.9	1.1	1.3	1.5	1.6
	3	0.7	1.1	1.3	1.6	1.7	1.9
	4	0.8	1.3	1.6	1.9	2.1	2.3
	5	1.0	1.6	2.0	2.4	2.6	2.9
	6	1.3	2.1	2.5	3.0	3.3	3.6
	7	1.8	2.7	3.3	3.9	4.3	4.7
	8	2.5	3.7	4.6	5.4	5.8	6.4
	9	3.8	5.5	6.7	7.8	8.4	9.1
	10	6.6	8.9	10.7	12.2	13.0	14.1
	11	13.6	15.8	17.4	18.9	19.8	20.9
	12	57.4	80.1	95.0	109.3	117.5	127.7
	13	24.5	30.2	33.9	37.4	39.4	42.0
	14	8.6	9.8	10.6	11.4	11.9	12.5
	15	4.9	6.9	8.3	9.6	10.3	11.2
	16	3.1	4.5	5.5	6.4	6.9	7.6
	17	2.1	3.2	3.9	4.6	5.0	5.5
	18	1.5	2.3	2.9	3.4	3.7	4.1
	19	1.1	1.8	2.2	2.7	2.9	3.2
	20	0.9	1.4	1.8	2.1	2.3	2.6
	21	0.7	1.2	1.5	1.7	1.9	2.1
	22	0.6	1.0	1.2	1.5	1.6	1.8
	23	0.5	0.8	1.0	1.2	1.4	1.5
	24	0.4	0.7	0.9	1.1	1.2	1.3
Sub-total		139.3	188.3	220.8	251.9	269.8	292.2
TOTAL		180.5	240.3	279.9	317.9	339.8	367.1

TABLE 4.15.1(1) WATER LEVEL FROM HD CALCULATION IN THE RIO CHANE-PAILON BASIN

River	Section	Chainage in HD Model (km)	Acc. Distance in Topo Survey (m)	Existing			Prop. Riverbed EL (m)	Maximum water level from probable flood (m)					Maximum water level from probable flood (m)				
								Existing cross section					Design cross section				
				Left Bank	Riverbed	Right Bank		2 year	5 year	10 year	20 year	50 year	2 year	5 year	10 year	20 year	50 year
Chane	No. 28	60.000	26,354	244.286	238.242	244.437	234.629	242.71	242.99	243.14	243.29	243.47	240.03	241.10	241.25	241.37	241.51
	No. 27	60.800	25,441	240.088	233.709	240.125	234.121	239.69	240.49	240.57	240.65	240.82	239.42	240.55	240.83	240.48	241.17
	No. 26	61.600	24,646	239.532	232.972	238.979	233.680	238.95	239.52	239.79	240.00	240.32	238.82	239.78	240.26	239.82	240.66
	No. 25	62.600	23,229	239.578	231.949	238.830	232.893	237.88	238.62	238.99	239.29	239.63	238.16	239.22	239.60	239.72	240.01
	No. 24	63.600	22,748	238.378	231.799	237.782	232.625	237.79	238.49	238.86	239.16	239.50	238.06	239.12	239.51	239.37	239.91
	No. 23	64.500	21,817	239.143	230.725	239.548	232.108	237.56	238.25	238.64	238.93	239.27	237.71	238.79	239.17	238.73	239.55
	No. 22	65.500	20,812	237.726	231.065	238.267	231.550	237.02	237.68	237.96	238.16	238.46	237.07	238.15	238.52	238.04	238.92
	No. 21	66.500	19,745	237.127	229.245	236.859	230.957	236.40	236.95	237.29	237.52	237.84	236.40	237.43	237.81	237.58	238.26
	No. 20	67.500	18,876	235.705	228.568	235.248	230.474	235.97	236.54	236.38	237.14	237.45	235.93	236.95	237.34	236.93	237.80
	No. 19	68.500	17,966	235.251	228.911	236.790	229.969	235.24	235.85	236.28	236.55	236.90	235.14	236.23	236.67	236.79	237.19
	No. 18	69.500	16,951	233.925	228.623	234.151	229.405	234.93	235.59	236.07	236.33	236.67	234.98	236.09	236.52	236.76	237.00
	No. 17	70.500	15,936	235.677	227.598	235.409	228.841	234.58	235.24	235.78	236.07	236.43	234.51	235.65	236.17	235.73	236.69
	No. 16	71.500	14,821	235.601	226.602	236.064	228.222	234.12	234.62	234.98	235.27	235.71	234.00	234.96	235.40	235.54	236.03
	No. 15	72.500	13,844	231.806	227.436	234.238	227.679	233.84	234.34	234.72	235.04	235.41	233.66	234.74	235.24	235.20	235.80
	No. 14	73.400	12,773	232.479	226.925	234.664	227.084	233.38	233.94	234.34	234.69	235.08	233.16	234.38	234.89	234.60	235.50
	No. 13	74.300	12,030	234.073	226.330	234.948	226.671	232.94	233.50	233.88	234.23	234.65	232.65	233.75	234.26	233.70	234.93
	No. 12	75.200	11,349	233.970	225.706	233.855	226.293	232.56	233.05	233.34	233.58	233.90	232.14	233.13	233.47	233.41	233.94
	No. 11	76.500	10,192	233.608	226.328	230.865	225.650	232.05	232.47	232.75	233.02	233.36	231.37	232.48	232.90	232.99	233.44
	No. 10	77.700	9,292	232.315	224.950	227.820	225.150	231.93	232.35	232.62	232.88	233.21	231.06	232.18	232.59	232.66	233.13
	No. 9	78.800	8,275	231.822	224.770	232.776	224.585	231.73	232.13	232.40	232.66	232.99	230.37	231.49	231.89	231.85	232.48
	No. 8	80.000	7,351	234.050	225.922	230.278	224.072	230.82	231.26	231.61	231.84	232.15	229.53	230.73	231.18	231.37	231.73
	No. 7	81.000	6,044	230.591	223.990	231.812	223.345	229.28	229.80	230.06	230.36	230.77	228.76	229.66	230.01	230.22	230.48
	No. 6	81.900	5,103	226.672	223.542	231.683	222.822	229.07	229.56	229.78	230.01	230.32	228.69	229.62	229.98	230.02	230.45
	No. 5	82.800	4,124	226.451	222.832	230.171	222.473	228.94	229.44	229.65	229.86	230.15	228.54	229.46	229.80	229.64	230.23
	No. 4	83.800	3,002	228.598	222.236	229.708	222.072	228.62	229.15	229.35	229.52	229.77	228.28	229.14	229.44	229.36	229.86
	No. 3	84.800	2,089	227.788	221.616	228.670	221.746	228.15	228.71	228.97	229.16	229.36	228.06	228.89	229.17	229.36	229.56
	No. 2	86.400	1,149	227.185	221.955	228.151	221.410	227.57	228.04	228.30	228.52	228.76	227.73	228.52	228.79	228.72	229.16
	No. 1	88.000	0	227.463	221.794	226.155	221.000	226.38	226.69	226.91	227.14	227.44	226.82	227.47	227.76	228.16	228.18

TABLE 4.15.1(2) WATER LEVEL FROM HD CALCULATION IN THE RIO CHANE-PAILON BASIN

River	Section	Chainage in HD Model (km)	Acc. Distance in Topo Survey (m)	Existing			Prop. Riverbed EL (m)	Maximum water level from probable flood (m)					Maximum water level from probable flood (m)				
								Existing cross section					Design cross section				
				Left Bank	Riverbed	Right Bank		2 year	5 year	10 year	20 year	50 year	2 year	5 year	10 year	20 year	50 year
Pailon	No. 33	24.000	58,032	256.647	253.692	258.817	252.724	259.34	259.67	259.91	260.12	260.39	258.39	258.79	258.96	277.49	259.29
	No. 32	29.900	57,429	258.332	252.300	258.387	252.624	258.91	259.22	259.45	259.65	259.91	257.84	258.17	258.37	258.35	258.78
	No. 31	30.600	56,630	257.532	252.805	257.603	252.491	258.42	258.79	259.04	259.25	259.52	257.70	258.04	258.21	258.16	258.54
	No. 30	31.300	55,181	256.591	251.823	256.982	252.249	258.18	258.56	258.81	259.01	259.27	257.47	257.84	258.02	257.67	258.35
	No. 29	32.300	54,048	256.273	251.902	256.255	252.060	257.79	258.16	258.39	258.58	258.81	256.92	257.31	257.51	257.35	257.91
	No. 28	33.700	53,048	256.163	251.573	256.621	251.894	257.35	257.69	257.89	258.06	258.27	256.54	256.91	257.05	257.16	257.54
	No. 27	34.600	52,167	255.418	252.195	255.575	251.747	257.17	257.46	257.62	257.75	257.92	256.27	256.67	256.82	256.58	257.15
	No. 26	35.500	51,006	257.104	251.887	256.231	251.553	257.03	257.34	257.51	257.64	257.81	255.84	256.22	256.42	255.88	256.86
	No. 25	36.500	49,986	255.548	252.421	255.221	251.383	256.50	256.80	256.97	257.10	257.28	254.90	255.22	255.40	255.48	255.93
	No. 25	36.500	49,986	255.548	252.421	255.221	251.383	256.50	256.80	256.97	257.10	257.28	254.83	255.15	255.30	255.12	255.85
	No. 24	37.100	48,688	255.343	251.433	254.903	250.518	256.10	256.49	256.74	256.94	257.18	254.49	254.80	254.94	254.75	255.74
	No. 23	37.800	47,686	254.669	251.413	254.645	249.850	255.39	255.78	256.06	256.28	256.56	254.15	254.43	254.59	254.65	255.74
	No. 22	38.500	46,768	253.463	250.632	253.448	249.238	254.98	255.42	255.72	255.96	256.25	254.06	254.38	254.52	254.65	255.02
	No. 21	39.500	45,942	253.351	249.798	253.450	248.687	254.77	255.18	255.46	255.68	255.96	253.39	253.82	254.01	253.64	254.22
	No. 20	40.500	44,756	252.351	248.077	252.105	247.897	254.30	254.67	254.91	255.10	255.35	252.78	253.21	253.45	253.01	253.72
	No. 19	41.500	43,217	251.905	248.613	252.968	246.871	253.63	253.94	254.14	254.33	254.57	252.24	252.60	252.80	252.73	253.12
	No. 18	42.800	42,781	252.445	247.857	251.474	246.580	252.90	253.23	253.46	253.65	253.91	251.63	252.03	252.26	252.12	252.52
	No. 17	44.200	41,632	251.052	248.427	251.142	245.814	252.43	252.76	252.98	253.17	253.41	250.79	251.32	251.59	251.54	251.92
	No. 16	45.300	40,697	251.226	248.296	250.996	245.191	252.17	252.46	252.65	252.82	253.05	250.16	250.64	250.96	250.79	251.37
	No. 15	46.500	39,675	251.131	246.781	251.346	244.509	251.56	251.78	251.94	252.08	252.28	249.52	249.98	250.22	250.02	250.55
	No. 14	47.800	38,936	249.271	245.241	249.481	244.016	250.69	250.99	251.18	251.36	251.58	248.69	249.14	249.46	249.17	249.89
	No. 13	49.200	37,958	249.836	247.392	250.002	243.365	250.47	250.74	250.93	251.09	251.30	247.53	247.97	248.23	248.33	248.62
	No. 12	50.300	36,414	248.898	247.532	248.887	242.335	249.76	250.03	250.21	250.36	250.58	246.86	247.32	247.58	247.51	247.99
	No. 11	51.400	35,150	247.719	246.367	247.785	241.493	249.02	249.31	249.50	249.67	249.89	246.08	246.54	246.83	246.72	247.22
	No. 10	52.500	33,888	247.204	244.481	246.672	240.651	248.49	248.76	248.95	249.11	249.33	245.34	245.80	246.12	245.81	246.48
	No. 9	53.200	33,505	247.235	243.985	247.355	240.396	247.91	248.22	248.43	248.61	248.85	244.81	245.27	245.61	245.53	245.93
	No. 8	53.900	32,447	244.603	243.073	245.333	239.691	247.59	247.99	248.23	248.42	248.68	244.26	244.71	245.21	245.03	245.69
	No. 7	54.500	31,742	246.207	242.102	245.707	239.221	247.52	247.90	248.13	248.32	248.56	243.86	244.32	244.77	244.65	245.18
	No. 6	55.650	30,668	245.989	241.226	245.764	238.505	247.32	247.71	247.94	248.12	248.35	243.07	243.60	244.01	243.87	244.39
	No. 5	56.800	29,673	245.932	240.767	247.553	237.842	246.79	247.18	247.42	247.57	247.78	242.27	242.90	243.26	242.94	243.59
	No. 4	57.500	28,754	244.455	239.598	244.571	237.229	244.73	245.25	245.42	245.58	245.79	241.76	242.47	242.78	242.62	243.06
	No. 3	58.200	28,011	241.190	239.042	244.246	236.733	244.02	244.57	244.87	245.13	245.40	241.17	242.04	242.42	242.02	242.78
	No. 2	58.900	27,331	244.681	238.311	244.702	236.280	243.73	244.22	244.49	244.78	245.06	240.47	241.58	241.84	241.50	242.18
	No. 1	59.600	26,354	244.286	238.242	244.437	235.629	242.71	242.99	243.14	243.29	243.47	240.10	241.19	241.37	241.37	241.65

TABLE 4.15.2(1) FLOW RATE FROM HD CALCULATION IN THE RIO CHANE-PAILON BASIN

River	Chainage in HD Model (km)	Maximum flow rate from probable flood (m^3/s) Existing cross section					Maximum flow rate from probable flood (m^3/s) Design cross section				
		2 year	5 year	10 year	20 year	50 year	2 year	5 year	10 year	20 year	50 year
Chane	0.500	521.45	787.41	964.32	1,129.48	1,347.67	436.25	654.43	807.81	954.97	1,153.70
	1.500	519.13	784.32	960.89	1,125.79	1,343.61	435.21	652.93	805.98	952.89	1,151.01
	2.500	518.19	783.26	959.74	1,124.61	1,342.36	434.88	652.48	805.44	952.30	1,150.25
	3.500	518.25	783.39	959.94	1,124.86	1,342.64	435.04	652.71	805.71	952.65	1,150.58
	4.500	518.57	783.90	960.59	1,125.68	1,343.52	435.33	653.10	806.27	953.27	1,151.23
	5.500	518.87	784.35	961.17	1,126.40	1,344.37	435.61	653.53	806.78	953.92	1,151.99
	6.500	519.15	784.79	961.75	1,127.11	1,345.14	435.89	653.97	807.27	954.60	1,152.70
	7.500	519.45	785.30	962.38	1,127.87	1,346.00	436.16	654.38	807.83	955.21	1,153.32
	8.417	519.74	785.69	962.83	1,128.38	1,346.53	436.41	654.72	808.28	955.75	1,153.94
	9.250	519.98	786.02	963.30	1,129.00	1,347.23	436.65	655.08	808.65	956.27	1,154.42
	10.083	520.20	786.44	963.80	1,129.58	1,347.86	436.88	655.43	809.11	956.74	1,155.00
	10.969	520.46	786.87	964.31	1,130.20	1,348.55	437.14	655.78	809.56	957.28	1,155.63
	11.906	520.76	787.30	964.83	1,130.93	1,349.43	437.33	656.13	810.01	957.88	1,156.25
	12.844	521.05	787.70	965.45	1,131.67	1,350.25	437.55	656.47	810.45	958.45	1,156.83
	13.781	521.34	788.17	966.04	1,132.37	1,351.00	437.85	656.85	810.88	959.01	1,157.43
	14.719	521.63	788.64	966.60	1,133.02	1,351.76	438.03	657.25	811.38	959.58	1,158.13
	15.656	521.90	789.09	967.12	1,133.72	1,352.61	438.45	657.67	811.92	960.19	1,158.83
	16.594	522.13	789.52	967.69	1,134.46	1,353.40	438.89	658.08	812.43	960.86	1,159.48
	17.531	522.43	789.92	968.29	1,135.16	1,354.12	438.67	658.47	812.92	961.49	1,160.17
	18.500	522.76	790.40	968.88	1,135.82	1,354.93	438.81	658.87	813.40	962.09	1,160.89
	19.500	523.06	790.90	969.43	1,136.56	1,355.80	439.89	659.29	813.94	962.67	1,161.56
	20.500	523.35	791.36	970.01	1,137.33	1,356.58	440.26	659.72	814.46	963.34	1,162.19
	21.500	523.63	791.80	970.65	1,138.05	1,357.33	439.72	660.10	814.94	963.95	1,162.88
	22.500	523.93	792.25	971.23	1,138.68	1,358.19	439.94	660.54	815.46	964.59	1,163.61
	23.500	524.07	792.63	971.76	1,139.37	1,358.89	439.94	660.51	815.48	964.73	1,163.76
	24.500	525.27	793.15	971.80	1,139.20	1,357.88	442.59	665.18	819.32	968.49	1,167.76
	25.438	347.76	476.37	569.35	662.79	793.09	408.11	559.28	676.15	768.75	878.71
	26.313	348.80	477.68	570.32	663.89	794.51	408.59	558.30	674.97	770.63	883.43
	27.188	348.74	479.02	573.44	667.44	798.51	408.58	557.22	673.39	768.94	890.01
	28.063	346.97	474.87	571.62	665.28	796.40	410.57	557.70	673.28	769.76	893.33
	28.850	425.77	594.57	728.65	860.64	1,045.63	508.19	606.29	677.46	749.61	823.99
	29.550	472.63	665.71	818.19	966.18	1,170.71	562.55	681.35	743.59	806.38	889.74
	30.250	518.92	736.10	907.01	1,070.91	1,294.99	620.63	757.68	829.49	901.79	994.50
	30.950	561.01	803.82	993.67	1,173.55	1,417.35	673.90	833.51	917.90	1,000.92	1,107.15
	31.800	576.13	832.27	1,031.76	1,219.15	1,472.19	690.75	863.14	954.85	1,044.11	1,159.55
	32.650	571.46	826.18	1,026.75	1,214.13	1,467.08	691.56	858.81	951.38	1,040.18	1,153.35
	33.350	563.73	818.38	1,021.35	1,209.29	1,461.88	688.29	855.68	946.32	1,035.32	1,146.65
	34.150	549.34	801.99	1,007.01	1,195.19	1,445.12	465.49	565.43	627.90	687.08	1,124.57
	35.050	435.06	614.38	735.59	853.36	1,008.77	458.89	539.46	590.32	650.36	756.02
	35.950	434.49	613.43	737.58	855.33	1,016.35	459.98	535.18	586.95	646.55	752.61
	36.450	435.79	617.76	741.98	864.81	1,028.77	460.57	535.54	587.25	646.82	752.83
	36.550	436.08	617.83	742.06	865.29	1,029.72	460.69	535.62	587.32	646.89	752.89
	36.850	437.56	630.47	779.31	922.05	1,101.40	461.03	535.83	587.50	647.06	753.01
	37.450	507.57	826.90	1,091.65	1,296.39	1,548.29	461.36	536.12	587.32	646.14	1,020.78

Chainage in HD Model (km)	Maximum flow rate from probable flood (m^3/s) Existing cross section					Maximum flow rate from probable flood (m^3/s) Design cross section				
	2 year	5 year	10 year	20 year	50 year	2 year	5 year	10 year	20 year	50 year
38.150	493.16	783.37	1,008.77	1,216.72	1,472.84	461.44	536.34	585.66	644.08	1,018.75
39.000	485.56	747.45	961.67	1,152.34	1,409.72	674.00	799.16	888.28	981.30	1,017.48
40.000	480.25	732.55	935.32	1,116.53	1,364.99	674.00	792.78	882.63	975.53	1,015.60
41.000	478.68	727.86	927.60	1,102.77	1,344.80	668.60	790.71	877.46	969.96	1,011.68
41.825	414.24	602.00	745.22	881.43	1,076.54	668.78	790.79	876.37	948.32	985.98
42.475	413.75	601.30	744.12	880.09	1,074.98	668.80	788.18	872.32	944.98	984.37
43.150	413.03	600.45	743.08	878.54	1,073.08	665.80	786.57	870.15	942.07	982.94
43.850	412.25	599.59	742.04	877.14	1,071.09	664.52	784.74	866.56	938.79	981.06
44.475	411.71	598.93	741.20	876.13	1,069.47	664.71	783.19	861.21	935.70	978.96
45.025	411.46	598.59	740.73	875.51	1,068.43	664.86	782.23	858.85	933.53	977.29
45.600	411.21	598.19	740.18	874.76	1,067.40	665.05	782.36	857.21	932.56	976.60
46.200	411.12	597.91	739.71	874.04	1,066.31	665.23	782.51	857.30	932.68	976.13
46.825	410.83	596.20	736.36	868.30	1,056.69	665.42	782.67	857.40	932.82	976.27
47.475	410.35	595.60	735.64	867.41	1,055.66	665.62	782.82	857.44	932.87	975.72
48.150	409.71	594.89	734.84	866.44	1,054.58	665.81	781.91	854.67	929.45	974.16
48.850	409.32	594.44	734.32	865.78	1,053.81	665.45	781.73	854.06	929.08	973.66
49.475	409.15	594.21	734.03	865.39	1,053.30	665.56	781.87	854.14	929.19	973.78
50.025	409.05	594.04	733.79	865.04	1,052.83	664.11	781.25	852.91	928.46	973.43
50.575	408.94	593.83	733.48	864.58	1,052.17	664.27	781.40	853.03	928.58	973.55
51.125	408.72	593.44	732.92	863.80	1,051.09	664.00	781.35	852.73	928.39	973.52
51.675	408.28	592.74	731.97	862.55	1,049.41	664.19	781.52	852.85	928.51	973.64
52.225	407.70	591.84	730.74	860.92	1,047.22	664.39	781.68	852.96	928.61	973.75
52.850	395.10	571.43	704.62	828.46	1,008.01	664.61	781.88	853.09	928.71	973.88
53.550	394.06	569.79	702.16	825.57	1,004.62	664.83	782.10	856.91	936.42	978.19
54.200	391.16	567.04	698.59	821.83	1,000.55	665.06	782.29	860.37	941.27	985.41
54.787	370.45	549.85	675.69	800.28	976.02	665.25	782.46	868.01	948.78	993.39
55.362	369.09	549.51	675.12	799.91	975.52	665.36	782.59	875.23	956.12	1,001.40
55.938	368.20	549.38	674.81	799.74	975.24	665.57	782.77	882.72	963.56	1,009.43
56.513	367.92	549.45	674.77	799.76	975.17	665.78	782.96	890.21	971.07	1,017.66
57.150	368.06	549.61	674.93	799.92	975.29	666.01	783.18	898.50	979.51	1,026.97
57.850	368.21	549.57	674.84	799.60	975.07	666.27	783.42	907.66	988.88	1,037.40
58.550	368.24	549.57	674.87	799.18	974.88	666.55	785.25	915.87	997.50	1,047.31
59.250	368.40	549.73	675.02	799.01	974.93	666.84	793.59	924.92	1,006.77	1,057.65
59.800	368.48	549.81	675.11	799.20	975.27	667.09	800.14	932.09	1,014.15	1,065.93
60.400	430.40	622.91	753.85	892.09	1,096.04	910.92	1,367.78	1,581.75	1,725.89	1,895.93
61.200	430.59	622.91	754.17	892.20	1,096.12	914.58	1,367.35	1,580.99	1,730.12	1,902.30
62.100	430.77	622.83	754.01	891.65	1,095.25	918.21	1,357.42	1,576.10	1,733.16	1,908.36
63.050	430.25	621.89	753.36	890.93	1,093.98	907.19	1,353.95	1,577.15	1,735.71	1,912.09
64.100	429.63	620.32	752.32	889.69	1,092.72	891.76	1,342.39	1,576.25	1,740.54	1,918.33
65.000	431.94	620.34	752.31	889.63	1,092.63	897.77	1,343.91	1,582.24	1,748.49	1,926.59
66.000	436.59	619.90	752.48	889.58	1,091.87	903.49	1,344.20	1,583.85	1,752.18	1,932.94
67.000	441.27	619.69	752.02	889.05	1,090.90	909.33	1,337.70	1,580.60	1,752.13	1,936.20
68.000	443.63	618.86	750.51	887.93	1,089.69	905.72	1,330.93	1,576.05	1,752.18	1,937.37
68.950	447.72	618.15	749.30	887.26	1,089.07	911.32	1,330.10	1,577.83	1,757.12	1,935.38

TABLE 4.15.2(2) FLOW RATE FROM HD CALCULATION IN THE RIO CHANE-PAILON BASIN

River	Chainage in HD Model (km)	Maximum flow rate from probable flood (m^3/s)					Maximum flow rate from probable flood (m^3/s)				
		Existing cross section					Design cross section				
		2 year	5 year	10 year	20 year	50 year	2 year	5 year	10 year	20 year	50 year
Chane	69.450	448.29	617.70	748.28	886.73	1,088.54	908.13	1,329.54	1,578.06	1,758.77	1,938.44
	69.550	448.42	617.61	748.05	886.62	1,088.41	907.75	1,329.42	1,578.24	1,759.16	1,939.05
	70.050	449.61	617.38	747.18	886.21	1,088.01	906.88	1,329.01	1,579.57	1,761.19	1,942.46
	71.000	453.30	617.59	745.99	885.17	1,087.03	913.20	1,324.49	1,576.95	1,758.65	1,943.54
	72.000	457.21	617.80	746.20	885.39	1,086.52	919.79	1,334.66	1,586.21	1,761.46	1,942.79
	72.950	458.69	617.39	745.50	884.12	1,085.67	917.35	1,335.39	1,580.42	1,758.51	1,942.32
	73.850	460.28	617.12	745.31	883.81	1,085.42	919.67	1,337.97	1,583.82	1,758.57	1,943.92
	74.750	463.30	617.30	745.50	883.58	1,085.23	925.85	1,347.03	1,587.74	1,764.98	1,952.20
	75.525	465.90	618.52	745.66	883.74	1,085.29	931.05	1,354.72	1,596.39	1,774.39	1,962.70
	76.175	468.03	620.53	745.39	883.42	1,085.01	933.39	1,358.48	1,600.06	1,778.77	1,967.94
	76.800	468.09	622.23	745.17	883.07	1,084.72	930.08	1,359.08	1,601.80	1,782.00	1,972.45
	77.400	468.30	623.89	744.98	882.78	1,084.44	928.73	1,359.47	1,602.40	1,783.65	1,974.00
	77.975	468.81	625.53	744.82	882.52	1,084.21	928.41	1,361.62	1,603.82	1,784.14	1,975.05
	78.525	469.32	626.99	744.63	882.22	1,083.94	927.90	1,362.91	1,605.41	1,786.44	1,976.57
	79.075	470.29	628.63	744.49	881.92	1,083.69	931.80	1,367.12	1,608.32	1,790.53	1,978.08
	79.625	471.50	630.30	744.50	881.89	1,083.68	935.20	1,370.48	1,612.47	1,795.33	1,983.42
	79.950	472.18	644.63	891.25	881.88	1,083.67	937.49	1,270.81	1,614.32	1,797.95	1,986.44
	80.050	472.45	631.66	744.53	881.88	1,083.67	938.19	1,370.97	1,614.94	1,798.75	1,987.37
	80.550	473.49	633.28	744.53	881.86	1,083.67	941.68	1,372.85	1,618.12	1,802.97	1,992.11
	81.450	475.86	636.41	744.73	881.86	1,083.43	947.60	1,381.16	1,627.33	1,812.72	2,001.42
	82.350	477.43	640.44	744.58	881.04	1,082.91	939.58	1,380.83	1,631.12	1,818.19	2,008.26

Chainage in HD Model (km)	Maximum flow rate from probable flood (m^3/s)					Maximum flow rate from probable flood (m^3/s)				
	Existing cross section					Design cross section				
	2 year	5 year	10 year	20 year	50 year	2 year	5 year	10 year	20 year	50 year
83.300	478.53	643.62	746.50	880.86	1,082.85	928.38	1,378.77	1,634.14	1,823.24	2,013.87
84.300	479.38	646.31	747.59	880.66	1,082.51	928.35	1,374.92	1,634.52	1,825.79	2,016.92
85.200	573.62	797.49	950.97	1,101.94	1,269.91	1,172.91	1,690.38	1,972.46	2,178.29	2,405.27
86.000	571.77	793.57	944.59	1,092.00	1,264.53	1,161.16	1,682.78	1,967.13	2,173.23	2,398.86
86.775	570.60	791.05	941.24	1,086.32	1,261.63	1,152.04	1,678.71	1,963.96	2,168.83	2,392.52
87.525	570.72	790.83	940.27	1,084.65	1,260.60	1,151.12	1,678.00	1,963.17	2,166.21	2,387.90
87.950	570.90	791.02	940.55	1,085.05	1,261.13	1,151.34	1,678.28	1,963.39	2,153.14	2,351.85
88.050	570.95	791.07	940.63	1,085.16	1,261.28	1,151.43	1,678.38	1,963.49	2,153.23	2,351.94
88.500	571.13	791.25	940.90	1,085.56	1,261.86	1,151.67	1,678.73	1,963.66	2,153.43	2,352.08
89.300	571.12	791.03	940.59	1,085.20	1,261.92	1,151.51	1,676.22	1,961.33	2,152.15	2,351.02
90.100	570.87	790.40	939.74	1,084.09	1,261.20	1,148.94	1,670.46	1,956.60	2,149.52	2,348.97
90.917	570.43	789.48	938.68	1,082.72	1,260.09	1,144.52	1,664.20	1,951.93	2,147.06	2,347.14
91.750	570.12	788.89	938.14	1,082.10	1,259.56	1,141.24	1,659.58	1,948.50	2,145.32	2,345.86
92.583	570.14	788.69	938.03	1,081.95	1,259.59	1,139.30	1,656.77	1,946.38	2,144.33	2,345.15
93.500	570.34	788.77	938.21	1,082.21	1,260.00	1,138.47	1,655.43	1,945.48	2,143.95	2,344.92
94.500	570.66	789.09	938.61	1,082.74	1,260.73	1,138.60	1,655.39	1,945.53	2,144.21	2,345.21

TABLE 4.15.2(3) FLOW RATE FROM HD CALCULATION IN THE RIO CHANE-PAILON BASIN

River	Chainage in HD Model (km)	Maximum flow rate from probable flood (m^3/s) Existing cross section					Maximum flow rate from probable flood (m^3/s) Design cross section				
		2 year	5 year	10 year	20 year	50 year	2 year	5 year	10 year	20 year	50 year
Pailon	0.500	93.39	135.51	168.01	202.61	250.91	93.39	135.51	168.01	202.61	250.91
	1.500	93.06	136.06	169.15	204.41	253.72	93.06	136.06	169.15	204.41	253.72
	2.500	92.92	136.73	170.40	206.37	256.59	92.92	136.73	170.40	206.37	256.59
	3.500	92.89	137.39	171.60	208.26	259.26	92.89	137.39	171.60	208.26	259.26
	4.500	92.72	137.74	172.45	209.75	261.34	92.72	137.74	172.45	209.75	261.34
	5.500	91.87	137.18	172.29	210.05	261.85	91.87	137.17	172.29	210.05	261.85
	6.500	63.73	90.51	111.40	133.77	167.06	63.73	90.50	111.40	133.77	167.06
	7.500	63.39	90.36	111.13	133.28	166.85	63.39	90.36	111.13	133.28	166.84
	8.500	63.27	90.32	110.95	133.10	166.84	63.27	90.32	110.95	133.10	166.84
	9.500	63.31	90.36	110.82	133.20	166.99	63.31	90.36	110.82	133.20	166.99
	10.433	63.33	90.30	110.48	133.45	167.22	63.33	90.29	110.48	133.45	167.22
	11.300	63.23	90.13	110.20	133.48	167.20	63.23	90.12	110.20	133.48	167.20
	12.167	63.36	90.24	110.30	133.54	167.32	63.36	90.24	110.30	133.54	167.32
	12.650	63.48	90.36	110.42	133.66	167.46	63.48	90.36	110.42	133.66	167.46
	12.750	63.50	90.38	110.44	133.68	167.49	63.50	90.38	110.44	133.68	167.49
	13.225	63.62	90.50	110.55	133.81	167.63	63.62	90.50	110.55	133.81	167.63
	14.075	71.69	97.60	114.07	134.02	167.87	71.69	97.60	114.07	134.02	167.87
	14.975	82.33	112.27	132.16	153.60	186.51	82.33	112.27	132.16	153.60	186.51
	15.925	93.39	127.19	150.61	174.56	210.06	93.37	127.18	150.65	174.56	210.15
	16.450	99.50	135.55	161.01	186.46	223.44	99.47	135.54	161.06	186.46	223.57
	16.550	100.67	137.16	163.01	188.73	226.00	100.65	137.15	163.06	188.73	226.13
	17.067	106.83	145.67	173.48	200.66	239.47	106.80	145.65	173.53	200.66	239.63
	18.000	117.88	160.77	191.65	221.38	263.01	117.86	160.80	191.25	221.59	263.47
	18.933	127.58	175.61	209.76	242.29	286.95	127.59	175.72	208.94	242.58	287.70
	19.850	137.99	190.38	228.05	263.25	311.04	138.02	190.57	226.89	263.79	312.07
	20.750	148.34	205.19	246.31	284.31	335.44	148.39	205.44	244.79	285.12	336.64
	21.250	154.16	213.51	256.54	296.20	349.21	154.20	213.80	254.88	297.15	350.60
	21.350	155.32	215.19	258.60	298.60	351.99	155.37	215.48	256.89	299.58	353.42
	21.833	160.89	222.92	267.58	309.15	364.40	161.04	223.57	266.46	311.01	366.74
	22.700	170.01	235.24	282.31	326.59	384.93	171.01	238.11	283.66	331.85	390.89
	23.567	175.70	243.74	291.35	334.79	395.37	180.58	252.40	300.56	351.73	412.26
QDA. Chane	0.450	239.16	334.32	397.60	457.91	536.23	239.16	334.32	397.60	457.91	536.23
	1.350	244.88	341.84	406.27	467.87	547.71	244.88	341.84	406.27	467.87	547.71
	2.250	249.36	348.79	414.83	478.14	560.10	249.36	348.79	414.83	478.14	560.10
	3.150	252.76	354.89	422.57	487.34	571.37	252.76	354.89	422.57	487.34	571.37
	4.050	255.39	360.05	429.62	496.22	582.60	255.39	360.05	429.62	496.22	582.60
	4.963	259.65	367.58	438.99	507.58	596.60	259.65	367.58	438.99	507.58	596.60
	5.887	262.29	376.10	450.37	521.57	613.73	262.29	376.10	450.37	521.57	613.73
	6.813	264.95	382.71	459.46	533.38	629.43	264.94	382.71	459.47	533.39	629.43
	7.738	264.45	386.83	466.37	542.49	641.31	264.43	386.80	466.35	542.47	641.29
	8.667	214.38	277.04	315.43	350.96	396.49	214.29	276.50	315.05	350.70	396.47
	9.600	217.64	281.48	320.99	357.67	404.84	218.65	280.95	320.57	357.41	404.67
	10.533	219.95	285.33	326.03	363.94	412.70	219.90	284.84	325.72	363.62	412.63
	11.500	222.88	289.43	331.25	370.33	420.76	220.22	287.93	335.78	378.67	421.57
	12.400	223.99	292.87	335.76	376.00	427.98	223.92	294.60	335.94	377.14	429.28
	13.200	225.55	296.00	339.73	380.90	434.11	225.52	299.41	341.18	383.86	435.19
	14.017	226.29	298.70	343.34	385.48	440.04	227.93	301.69	344.21	388.05	441.33
	14.850	226.79	300.97	346.50	389.60	445.50	229.69	305.63	348.55	389.53	445.28
	15.683	227.23	303.68	350.50	394.88	452.11	231.98	309.38	352.16	393.07	448.59
	16.150	225.70	343.20	727.65	818.38	766.56	233.13	444.03	354.71	396.02	452.24
	16.250	97.93	160.67	190.98	241.26	313.19	163.34	245.42	278.32	289.56	351.54
	16.717	95.88	141.11	172.23	207.84	261.27	159.30	208.10	237.38	265.99	307.31
	17.550	93.81	139.86	168.87	203.62	256.19	158.16	206.57	233.88	262.05	299.62
	18.383	91.09	139.05	168.48	203.35	255.20	158.29	203.95	231.76	258.91	295.93
	19.150	90.57	138.55	167.98	202.84	253.36	158.29	203.96	231.93	259.07	296.23
	19.850	90.62	138.66	168.07	202.93	253.49	158.39	203.88	232.05	259.15	296.38
	20.550	90.69	138.65	168.05	202.88	253.27	158.48	203.82	232.22	259.26	296.48
	21.300	89.18	138.20	167.80	202.61	252.83	158.50	204.47	231.89	257.97	295.36
	22.100	90.75	137.77	167.43	202.14	252.19	158.51	204.13	231.98	257.55	294.81
	22.900	88.85	137.31	166.94	201.62	251.58	158.48	204.04	231.95	256.97	294.62
	23.717	87.53	136.89	166.31	197.94	244.09	158.44	204.08	231.94	256.92	294.62
QDA. Chane	24.550	85.63	136.85	166.26	197.88	243.97	158.42	203.53	231.40	256.02	294.61
	25.383	85.05	136.70	166.05	197.65	243.66	158.08	202.88	230.92	255.45	294.49
	26.200	83.89	136.47	165.84	197.52	243.56	158.05	202.83	230.85	255.36	293.00
	27.000	81.44	136.10	165.26	197.35	243.37	156.30	201.01	229.58	253.52	292.22
	27.800	79.09	135.25	164.89	196.78	243.15	155.86	200.46	229.18	253.05	292.01
	28.633	79.07	134.80	164.23	195.06	241.69	155.85	200.46	229.16	253.00	291.99
	29.500	79.08	134.82	164.28	195.13	241.35	155.83	200.43	229.13	253.00	292.00
	30.367	79.11	134.91	164.46	195.22	241.96	155.84	200.44	229.68	252.99	292.03
	31.200	256.68	330.72	378.87	436.47	511.32	427.87	562.18	652.91	714.23	827.46
	32.000	254.65	329.40	377.81	435.81	510.67	427.92	562.12	652.85	714.19	825.72
	32.800	252.96	328.23	376.39	434.30	509.49	428.05	562.07	652.78	714.12	825.37
	33.600	250.52	327.32	374.94	432.57	508.12	428.33	561.99	652.66	714.00	824.23
QDA. Meco	0.500	82.15	115.75	137.75	159.07	185.66	82.15	115.75	137.75	159.07	185.66
	1.500	235.26	335.87	401.57	465.09	544.20	235.26	335.87	401.57	465.09	544.20
	2.100	4.27	5.12	5.60	6.03	6.53	4.27	5.12	5.60	6.03	6.53
Chuco II	0.375	109.72	185.47	271.30	343.05	442.56	220.84	276.83	305.22	335.65	330.00
	1.125	108.80	184.31	270.24	341.95	444.64	220.81	276.51	304.08	334.91	327.93
	1.900	114.72	223.88	304.91	376.22	469.97	220.76	276.65	303.26	334.77	324.55
	2.350	124.74	672.77	634.87	1,055.46	1,365.65	220.06	274.79	302.43	335.68	319.93
	2.425	194.34	889.90	1,043.41	1,529.71	1,528.97	220.06	270.71	314.91	341.74	331.40
	2.725	163.21	565.31	763.70	894.63	1,088.35	220.01	271.03	314.94	341.76	331.71
QDA. Toro	0.200	199.57	279.41	332.39	382.86	446.54	200.87	279.43	332.44	383.03	574.56
	0.450	214.66	279.47	332.41	382.64	445.75	258.98	279.47	998.32	382.83	476.08
	0.550	199.57	279.60	332.56	382.79	445.89	216.85	279.60	3,019.77	382.98	664.55
	1.067	199.79	279.81	332.64	368.78	427.65	199.82	279.83	563.31	370.09	429.67
	2.000	201.52	281.89	334.00	364.38	429.06	201.54	281.91	446.20	362.62	428.66
	2.933	201.08	282.73	334.59	361.34	429.28	201.20	282.88	423.53	359.48	426.92
	3.700	201.96	283.34	335.79	361.53	430.39	202.07	283.33	418.28	359.68	426.97
	4.300	203.61	284.99	338.21	363.48	432.42	203.67	285.13	416.81	361.29	428.12
	5.000	308.12	413.60	484.97	528.43	601.40	308.89	413.05	486.42	534.12	616.61
	5.800	312.16	418.16	489.08	535.49	606.53	311.88	416.34	490.86	539.93	623.17
	6.700	316.18	422.47	491.06	540.49	600.09	316.33	421.24	497.48	548.89	633.04
	7.700	320.25	425.78	494.07	543.62	592.91	320.71	425.65	506.57	561.76	643.42
	8.700	318.41	424.03	493.28	543.47	592.85	327.25	429.61	508.95	561.10	643.79
	9.700	312.21	419.44	489.46	539.99	590.47	330.62	426.17	498.59	549.79	641.91
	10.700	308.08	416.27	486.66	537.83	588.74	331.41	428.27	501.14	553.71	645.73
	11.680	225.42	285.96	323.75	358.98	405.31	335.21	432.09	505.88	560.60	648.57
	12.640	226.38	286.14	324.35	359.16	405.27	338.90	435.82	510.48	567.31	651.23
	13.600	223.07	286.39	324.66	359.21	405.11	342.53	439.51	515.03	573.97	654.12
	14.560	221.11	283.91	324.98	359.28	404.90	346.07	443.12	519.46	580.04	657.35
	15.520	221.38	279.58	325.31	358.80	403.75	349.43	446.59	523.67	584.61	658.39
QDA. Manas	0.200	81.44	112.03	132.34	151.82	176.91	81.44	112.03	132.34	151.77	176.87
	0.450	81.41	110.04	129.32	148.23	173.16	81.41	110.81	129.37	148.35	173.31
	0.600	81.24	101.74	114.85	129.54	148.84	81.09	102.03	115.26	129.94	149.79
	1.087	83.06	103.63	117.01	131.94	151.13	82.90	103.99	117.42	132.44	152.64
	1.862	86.22	106.90	120.81	136.06	155.54	86.02	107.49	121.26	136.71	157.52
	2.638	89.67	110.36	124.71	140.39	160.40	89.44	111.08	125.44	141.19	162.72
	3.412	92.77	116.18	130.77	144.70	165.37	92.47	115.52	130.82	146.27	167.92
	4.700	98.85	133.21	143.83	164.86	188.21	96.25	124.98	139.43	160.10	178.96
	5.500	102.89	175.05	159.93	180.38	205.73	100.54	135.29	151.37	174.75	200.65
	6.325	111.27	151.86	172.77	196.12	249.73	105.77	145.43	163.47	187.38	217.96
	6.975	116.21	151.34	173.37	206.54	248.38	112.25	151.18	175.91	199.88	235.43

TABLE 4.15.3 WATER LEVEL FROM HD CALCULATION IN THE OKINAWA DRAINAGE

Drainage	Section	Chainage in HD Model	Acc. Distance in Topo Survey (m)	Existing			Maximum water level from probable flood (m) Existing cross section					Maximum water level from probable flood (m) Design cross section				
				Left Bank	Riverbed	Right Bank	2 year	5 year	10 year	20 year	50 year	2 year	5 year	10 year	20 year	50 year
Okinawa	No. 24	0.000		252.000		252.000	252.470	252.810	252.840	252.990	253.190	251.930	252.220	252.400	252.580	252.810
	No. 23	5.200	21,652	251.590	247.540	251.555	252.110	252.240	252.390	252.480	252.610	251.620	251.850	251.990	252.110	252.260
	No. 22	6.300	20,550	250.970	249.410	251.212	251.890	252.000	252.130	252.210	252.320	251.430	251.620	251.730	251.830	251.950
	No. 21	7.000	19,839	250.972	249.472	251.072	251.730	251.700	251.880	251.940	252.020	251.110	251.300	251.380	251.440	251.510
	No. 20	8.400	18,429	250.316	249.161	250.381	251.570	251.530	251.720	251.770	251.850	250.540	250.810	250.930	251.020	251.120
	No. 19	9.300	17,570	250.744	249.214	250.744	251.470	251.430	251.610	251.660	251.740	250.330	250.610	250.740	250.840	250.930
	No. 18	10.100	16,711	250.348	249.762	250.468	251.300	251.270	251.450	251.510	251.580	250.150	250.440	250.570	250.670	250.760
	No. 17	11.100	15,740	250.595	248.775	251.155	251.010	250.990	251.160	251.220	251.290	249.920	250.210	250.330	250.430	250.530
	No. 16	12.000	14,807	250.425	248.483	251.281	250.650	250.640	250.800	250.860	250.970	249.720	250.000	250.120	250.210	250.310
	No. 15	13.200	13,639	249.579	248.524	250.679	250.300	250.400	250.520	250.620	250.740	249.430	249.710	249.840	249.930	250.040
	No. 14	14.000	12,846	249.609	248.219	250.149	250.050	250.220	250.350	250.460	250.600	249.230	249.490	249.620	249.710	249.810
	No. 13	15.300	11,538	248.720	247.015	248.810	249.810	250.020	250.170	250.290	250.430	248.920	249.230	249.360	249.460	249.570
	No. 12	15.900	10,968	248.711	247.081	248.916	249.760	249.970	250.110	250.230	250.370	248.750	249.080	249.230	249.340	249.460
	No. 11	16.600	10,229	248.858	246.661	249.228	249.660	249.860	250.010	250.130	250.260	248.550	248.860	249.010	249.130	249.260
	No. 10	18.300	8,540	248.719	245.914	248.789	249.170	249.350	249.470	249.580	249.700	248.050	248.330	248.450	248.550	248.650
	No. 9	19.100	7,714	248.008	245.758	248.198	248.690	248.870	248.990	249.100	249.230	247.790	248.040	248.160	248.250	248.350
	No. 8	20.600	6,267	247.001	245.201	247.289	247.830	248.070	248.220	248.340	248.480	247.270	247.500	247.610	247.700	247.810
	No. 7	21.400	5,415	246.597	244.667	246.797	247.580	247.810	247.950	248.070	248.200	246.960	247.180	247.300	247.400	247.510
	No. 6	22.400	4,433	246.567	245.247	246.807	247.260	247.460	247.570	247.670	247.770	246.410	246.580	246.680	246.770	246.890
	No. 5	23.600	3,222	245.379	244.069	245.559	246.130	246.140	246.270	246.340	246.440	245.870	245.970	246.060	246.190	246.370
	No. 4	24.100	2,728	245.250	243.930	245.430	246.000	246.010	246.130	246.210	246.330	245.760	245.870	245.970	246.110	246.290
	No. 3	25.600	1,280	245.097	244.917	245.077	245.500	245.629	245.799	245.954	246.124	245.410	245.576	245.739	245.916	246.109
	No. 2	26.500	302	244.929	243.077	244.869	245.290	245.450	245.640	245.830	246.020	245.230	245.430	245.620	245.820	246.020
	No. 1	26.800	0	244.414	242.944	244.704	245.200	245.400	245.600	245.800	246.000	245.200	245.400	245.600	245.800	246.000

TABLE 4.15.4 FLOW RATE FROM HD CALCULATION IN THE OKINAWA DRAINAGE BASIN

Drainage	Chainage in HD Model (km)	Maximum flow rate from probable flood (m^3/s)					Maximum flow rate from probable flood (m^3/s)				
		Existing cross section					Design cross section				
		2 year	5 year	10 year	20 year	50 year	2 year	5 year	10 year	20 year	50 year
Okinawa	1.000	32.830	41.586	75.128	79.205	84.509	14.995	22.601	28.128	33.782	41.554
	5.750	86.411	120.018	142.273	157.012	179.223	73.016	96.998	116.933	137.309	164.512
	6.650	97.692	137.304	163.922	181.646	208.703	86.237	114.875	138.528	162.822	195.120
	7.700	42.335	50.796	63.899	68.999	75.929	89.761	100.427	109.233	116.103	124.601
	8.850	43.161	51.970	63.918	69.009	76.087	95.472	108.325	116.174	123.302	132.527
	9.700	44.148	54.228	64.144	71.842	82.341	99.467	112.459	121.547	128.775	138.969
	10.600	36.800	44.675	59.544	64.654	71.774	103.936	118.544	128.237	135.747	144.214
	11.550	36.958	44.834	59.700	64.808	71.924	108.893	124.447	133.513	140.569	148.647
	12.600	37.133	45.010	59.875	64.984	72.099	114.543	131.765	140.726	147.466	154.936
	13.600	37.537	48.660	60.039	66.126	75.288	119.881	138.356	148.318	155.873	164.113
	14.650	41.743	54.236	65.248	74.385	85.388	125.657	146.045	156.713	165.131	174.722
	15.600	44.421	59.236	71.406	81.886	94.636	129.874	150.781	162.721	172.239	183.400
	16.250	46.556	62.787	75.821	87.208	101.114	133.280	154.790	167.108	177.244	189.385
	17.450	50.850	69.691	84.406	97.494	113.551	139.487	162.579	175.887	187.026	200.701
	18.700	55.385	77.095	93.567	108.465	126.844	146.126	170.895	185.500	198.066	213.809
	19.850	59.368	83.413	101.219	117.578	137.889	152.343	178.826	194.153	207.274	224.517
	21.000	61.410	88.152	107.600	125.503	147.823	156.995	184.956	201.431	215.803	235.035
	21.900	63.135	91.950	112.657	131.765	155.645	160.433	190.053	207.197	222.462	243.256
	23.000	65.611	96.839	119.013	139.568	165.301	165.787	197.116	214.868	230.805	253.169
	23.850	36.891	44.635	56.643	62.231	69.931	107.945	117.026	119.561	125.492	141.090
	25.300	36.889	44.634	56.639	62.229	69.930	107.646	117.031	119.613	125.581	141.187
	26.650	36.888	44.634	56.639	62.229	69.930	107.645	117.031	119.614	125.582	141.188

TABLE 4.15.5(1) WATER LEVEL FROM HD CALCULATION IN THE ARROYO YAPACANICITO,JOCHI AND TACUARAL

Arroyo	Section	Chainage in F/S (km)	Existing Elevation (m)			Maximum water level from probable floods (m) for existing and design cross sections									
						2 Year		5 Year		10 Year		20 Year		50 Year	
			Left	Bed	Right	Existing	Design	Existing	Design	Existing	Design	Existing	Design	Existing	Design
Yapacanicito		0.000	283.02	278.61	282.56	282.95	282.95	283.37	283.37	283.60	283.60	283.79	283.79	284.02	284.02
		1.500	281.52	277.11	281.06	281.28	281.28	281.72	281.72	281.96	281.96	282.16	282.16	282.40	282.40
		3.600	279.42	275.01	278.96	278.97	278.97	279.39	279.39	279.63	279.63	279.85	279.85	280.09	280.09
		6.100	276.92	272.51	276.46	276.18	276.18	276.57	276.57	276.82	276.82	277.05	277.05	277.33	277.33
		8.600	274.42	270.01	273.96	274.37	274.37	274.48	274.48	274.54	274.54	274.61	274.61	274.69	274.69
		12.200	270.82	266.41	270.36	270.05	270.05	270.26	270.26	270.37	270.37	270.48	270.48	270.62	270.62
Improvement	No. 1	14.300	268.22	262.21	268.26	267.56	267.26	267.75	267.42	267.84	267.50	267.93	267.58	268.04	267.68
	No. 2	14.320	268.22	262.21	268.26	267.44	267.11	267.61	267.28	267.70	267.42	267.78	267.51	267.87	267.60
	No. 3	15.400	265.11	261.94	266.74	266.35	265.16	266.47	265.30	266.53	265.37	266.58	265.43	266.65	265.51
	No. 4	16.400	265.08	261.69	266.60	264.86	264.05	265.00	264.24	265.09	264.34	265.19	264.40	265.38	264.48
	No. 5	17.100	262.85	260.39	264.41	262.67	262.51	262.71	262.57	262.74	262.65	262.80	262.73	262.84	262.80
	No. 6	19.000	259.72	256.00	259.85	259.56	259.61	259.60	259.67	259.63	259.84	259.67	260.07	259.70	260.15
	No. 7	20.000	257.77	255.32	259.68	257.60	257.64	257.65	257.72	257.68	257.87	257.72	258.05	257.75	258.16
	No. 8	20.400	254.71	252.78	256.60	255.79	255.96	255.89	256.11	255.94	256.19	255.99	256.25	256.05	256.32
	No. 9	22.200	257.80	254.88	256.35	256.30	255.63	256.38	255.78	256.45	255.94	256.51	256.01	256.53	256.17
	No. 10	23.100	255.55	254.24	257.95	255.52	255.33	255.58	255.45	255.74	255.61	255.81	255.69	255.83	255.77
	No. 11	24.100	257.34	253.56	255.07	255.59	255.44	255.69	255.56	255.75	255.66	255.81	255.71	255.88	255.80
	No. 12	25.300	254.49	253.39	256.75	255.50	255.31	255.60	255.46	255.65	255.54	255.81	255.71	256.02	255.93
	No. 13	26.200	253.98	252.91	256.31	254.40	254.22	254.73	254.58	254.95	254.83	255.16	255.04	255.40	255.30
	No. 14	27.000	253.70	252.04	255.56	254.40	254.20	254.80	254.64	255.04	254.90	255.26	255.13	255.52	255.40
	No. 15	28.100	255.88	252.31	253.64	253.51	253.32	253.93	253.77	254.17	254.04	254.40	254.27	254.66	254.54
	No. 16	29.100	255.18	251.65	253.17	253.29	253.12	253.72	253.57	253.97	253.85	254.19	254.08	254.45	254.35
	No. 17	30.100	254.60	251.36	252.38	252.56	252.37	252.97	252.82	253.22	253.09	253.44	253.32	253.69	253.58
	No. 18	31.100	253.05	250.49	254.33	252.73	252.54	253.04	252.89	253.22	253.09	253.38	253.26	253.57	253.46
	No. 19	31.700	251.56	250.64	253.98	252.14	251.95	252.29	252.14	252.39	252.26	252.47	252.35	252.58	252.47
		36.700	248.30	245.51	249.60	246.04	247.61	246.25	248.07	246.35	248.34	246.43	248.59	246.55	248.88
		41.700	245.06	242.27	246.36	243.67	245.20	243.89	245.64	244.00	245.90	244.09	246.14	244.21	246.41
		46.700	241.82	239.03	243.12	239.62	240.94	239.82	241.35	239.92	241.59	240.02	241.82	240.13	242.10
		51.700	238.58	235.79	239.88	239.98	240.13	240.41	240.59	240.67	240.88	240.92	241.14	241.21	241.47
		53.100	237.67	234.88	238.97	238.90	239.08	239.34	239.53	239.60	239.81	239.84	240.05	240.12	240.37
		58.100	234.43	231.64	235.73	239.35	239.67	239.82	240.16	240.09	240.42	240.32	240.62	240.56	240.81
		62.300	230.30	227.75	231.42	232.30	232.30	232.30	232.30	232.30	232.30	232.30	232.30	232.30	232.30

TABLE 4.15.5(2) WATER LEVEL FROM HD CALCULATION IN THE ARROYO YAPACANICITO,JOCHI AND TACUARAL

Arroyo	Section	Chainage in F/S (km)	Existing Elevation (m)			Maximum water level from probable floods (m) for existing and design cross sections									
						2 Year		5 Year		10 Year		20 Year		50 Year	
			Left	Bed	Right	Existing	Design	Existing	Design	Existing	Design	Existing	Design	Existing	Design
Jochi		0.000	288.23	283.88	288.13	288.82	288.82	289.10	289.10	289.27	289.27	289.43	289.43	289.62	289.62
		3.000	284.23	279.88	284.39	284.69	284.69	285.16	285.16	285.43	285.43	285.65	285.65	285.90	285.90
		6.000	280.23	275.88	280.39	281.05	281.05	281.24	281.24	281.36	281.36	281.47	281.47	281.62	281.62
		9.520	275.49	271.88	275.11	276.47	276.47	276.68	276.68	276.81	276.81	276.92	276.92	277.06	277.06
		12.800	268.75	265.91	268.88	269.01	268.86	269.05	268.92	269.07	268.96	269.08	269.00	269.10	269.03
Improvement	No. 1	13.800	266.62	264.83	266.32	267.63	266.35	267.69	266.45	267.72	266.51	267.75	266.56	267.78	266.63
	No. 2	15.000	265.08	262.11	265.08	265.11	264.71	265.20	264.85	265.26	264.93	265.28	264.99	266.47	265.07
		15.010	265.08	261.03	265.08	265.27	264.88	265.43	264.83	265.42	264.90	265.42	264.96	266.09	265.82
		15.020	265.08	262.11	265.08	265.08	264.66	265.17	264.80	265.22	264.88	265.25	264.94	265.71	265.03
	No. 3	16.000	264.07	261.03	264.83	264.89	263.74	264.99	263.83	265.03	263.87	265.07	263.92	265.09	263.98
	No. 4	17.200	262.92	260.08	263.44	263.35	261.79	263.48	261.87	263.53	261.92	263.57	261.95	263.60	262.01
	No. 5	18.300	262.62	258.66	262.34	261.86	260.33	261.98	260.42	262.05	260.46	262.10	260.50	262.13	260.56
	No. 6	19.000	261.55	257.75	261.04	260.95	259.44	261.08	259.53	261.14	259.58	261.19	259.62	261.23	259.68
	No. 7	20.000	260.78	256.80	260.60	260.70	259.42	260.84	259.51	260.92	259.56	260.97	259.60	261.00	259.67
	No. 8	20.900	260.06	255.13	260.80	259.96	258.63	260.11	258.73	260.19	258.78	260.24	258.82	260.28	258.88
	No. 9	21.900	258.95	253.66	259.34	259.07	257.73	259.19	257.82	259.25	257.86	259.30	257.90	259.33	257.96
	No. 10	22.700	258.43	253.73	259.09	258.31	256.76	258.41	256.84	258.47	256.89	258.51	256.92	258.54	256.98
		22.710	258.91	253.73	259.09	258.44	256.96	258.76	257.16	259.08	257.42	259.15	257.24	259.42	257.56
		22.720	258.91	253.73	259.09	258.20	256.68	258.31	256.77	258.36	256.81	258.41	256.85	258.44	256.90
	No. 11	23.700	256.00	252.22	255.93	256.80	255.14	256.93	255.21	257.00	255.25	257.05	255.28	257.10	255.33
	No. 12	24.900	254.19	250.38	254.33	254.59	252.69	254.66	253.13	254.71	253.28	254.75	253.34	254.80	253.40
	No. 13	25.600	253.61	248.89	253.62	252.81	252.51	252.92	252.50	252.97	252.66	253.00	252.73	252.96	252.80
		29.700	251.36	244.03	251.06	246.75	245.98	246.07	246.22	246.27	246.40	246.47	246.57	246.69	246.77
		29.800	246.46	243.46	246.46	245.71	245.92	246.02	246.17	246.20	246.35	246.38	246.50	246.60	246.74
		35.800	245.50	242.34	243.55	243.72	243.74	243.82	243.85	243.88	243.92	243.93	244.00	243.96	244.16
		43.400	242.93	241.05	242.68	243.00	243.00	243.00	243.00	243.00	243.00	243.00	243.00	243.00	243.00
Tacuaral		0.000	279.21	275.44	279.05	279.48	279.48	279.60	279.60	279.66	279.66	279.72	279.72	279.79	279.79
		3.000	275.73	271.96	275.57	276.14	276.14	276.31	276.31	276.41	276.41	276.49	276.49	276.59	276.59
		6.000	272.26	268.49	272.10	272.47	272.47	272.56	272.55	272.60	272.60	272.64	272.64	272.68	272.68
		9.000	268.78	265.01	268.62	269.06	269.06	269.16	269.18	269.21	269.25	269.25	269.28	269.32	269.35
		12.000	265.31	261.54	265.15	265.47	265.45	265.55	265.51	265.60	265.55	265.63	265.59	265.66	265.63
Improvement	No. 1	16.800	260.35	255.88	260.49	260.58	259.92	260.72	260.34	260.74	260.41	260.76	260.42	260.77	260.59
		16.810	260.35	255.88	260.49	260.63	259.98	264.18	263.80	260.79	260.46	265.84	265.50	267.63	267.45
		16.820	260.35	255.88	260.49	260.69	260.04	260.84	260.47	260.83	260.50	260.88	260.54	260.87	260.69
	No. 2	17.600	259.88	256.32	260.04	260.00	259.35	260.14	259.77	260.16	259.83	260.18	259.83	260.19	260.01
	No. 3	18.500	259.00	255.13	259.06	258.87	258.21	259.03	258.65	259.06	258.72	259.10	258.76	259.12	258.94
	No. 4	19.100	258.31	253.62	258.12	258.27	257.62	258.46	258.10	258.51	258.19	258.55	258.21	258.59	258.41
		19.110	257.62	253.62	258.12	258.51	257.85	258.45	258.05	258.77	258.42	258.95	258.61	259.32	259.14
		19.120	257.62	253.62	258.12	258.24	257.59	258.43	258.10	258.48	258.19	258.52	258.18	258.56	258.38
	No. 5	20.000	257.28	254.28	257.33	257.50	256.84	257.69	257.23	257.74	257.33	257.77	257.43	257.80	257.63
	No. 6	21.200	256.12	252.98	255.86	256.14	255.52	256.31	256.11	256.35	256.18	256.38	256.04	256.41	256.22
	No. 7	22.100	254.58	252.43	254.50	254.49	253.78	254.60	253.87	254.63	253.98	254.65	254.30	254.67	254.51
	No. 8	22.600	254.36	249.03	254.37	252.36	251.82	252.50	251.89	252.54	251.94	252.56	252.24	252.58	252.37
		27.500	245.41	240.19	245.22	245.77	246.00	246.08	246.25	246.26	246.43	246.43	246.58	246.61	246.80
		27.600	245.41	240.19	245.22	245.74	245.98	246.06	246.22	246.26	246.40	246.47	246.56	246.69	246.77
		32.100	243.30	239.30	243.50	244.40	244.44	244.64	244.69	244.76	244.84	244.87	244.95	244.84	245.07
		37.900	241.90	238.90	242.00	243.00	243.00	243.00	243.00	243.00	243.00	243.00	243.00	243.00	243.00

TABLE 4.15.6(1) FLOW RATE FROM HD CALCULATION IN THE ARROYO YAPACANICITO,JOCHI AND TACUARAL

Arroyo	Chainage in F/S (km)	Maximumflow rate from probable floods (m^3/s) for existing and design cross sections									
		2 Year		5 Year		10 Year		20 Year		50 Year	
		Existing	Design	Existing	Design	Existing	Design	Existing	Design	Existing	Design
Yapacanicito	0.750	138.59	138.59	191.55	191.55	225.63	225.63	258.77	258.77	299.75	299.75
	2.550	118.15	118.15	165.30	165.30	198.72	198.72	231.63	231.63	273.67	273.67
	4.850	101.18	101.18	138.92	138.92	167.74	167.74	197.73	197.73	236.37	236.37
	7.350	93.27	93.27	122.53	122.53	144.40	144.40	167.52	167.52	200.75	200.75
	8.610	52.63	52.63	60.02	60.02	65.10	65.10	72.95	72.95	83.13	83.13
	12.210	48.00	48.00	53.67	53.67	56.81	56.81	59.88	59.88	63.74	63.74
Improvement	14.310	48.00	47.99	53.67	53.66	56.80	56.80	59.88	59.88	63.73	63.73
	14.860	48.00	47.99	53.67	53.66	56.80	56.80	59.88	59.88	63.73	63.73
	15.900	48.00	47.98	53.67	53.66	56.80	56.80	59.88	59.87	63.72	63.73
	16.750	47.99	47.97	53.67	53.66	56.80	56.79	59.87	59.86	63.69	63.70
	18.010	47.99	47.96	53.67	53.65	56.80	56.75	59.87	59.61	63.64	63.42
	18.550	47.99	47.96	53.66	53.65	56.79	56.75	59.87	59.61	63.64	63.42
	19.500	47.98	47.96	53.66	53.65	56.79	56.75	59.87	59.61	63.64	63.42
	20.200	47.92	47.96	53.60	53.66	56.74	56.74	59.82	59.61	63.59	63.42
	21.300	47.26	47.97	53.05	53.67	56.23	56.73	59.33	59.59	63.15	63.39
	22.650	39.58	48.02	44.34	53.70	47.08	56.74	49.83	59.59	53.30	63.39
	23.600	39.48	48.25	44.27	53.74	47.02	56.77	49.78	59.60	53.26	63.39
	24.700	39.37	48.93	44.20	54.01	46.97	56.85	49.73	59.62	53.19	63.39
	25.750	39.28	50.54	44.15	54.83	46.92	57.16	49.69	59.66	53.10	63.40
	26.600	39.23	54.04	44.10	57.20	46.89	59.04	49.66	61.31	53.02	64.32
	27.550	39.23	57.40	44.06	61.63	46.85	63.54	49.63	65.06	52.91	70.01
	28.600	39.33	61.22	45.89	66.40	49.57	68.78	52.83	70.33	59.51	77.04
	29.600	42.00	63.68	51.27	69.31	57.29	72.06	63.10	76.43	71.59	84.50
	30.600	182.44	201.74	255.36	281.89	304.06	333.05	351.56	380.13	410.40	441.30
	31.400	181.97	201.74	254.75	281.38	303.36	332.19	350.80	379.37	409.55	440.31
	34.200	50.87	201.57	61.53	281.01	68.20	332.05	74.96	379.57	84.44	439.57
	39.200	50.77	194.46	61.44	268.31	68.02	318.02	74.95	365.47	84.72	424.63
	44.200	50.79	186.72	61.53	254.17	68.65	302.05	75.54	348.36	85.26	406.31
	49.200	50.70	176.43	61.41	239.59	68.16	285.09	74.88	330.48	83.98	388.85
	52.400	264.65	296.83	364.26	405.33	428.81	476.94	490.98	545.35	570.69	640.59
	55.600	246.55	290.70	343.32	400.22	408.58	474.17	471.85	545.07	552.60	639.14
	60.200	212.90	265.73	295.70	371.82	355.66	448.45	416.67	524.25	499.40	625.98

TABLE 4.15.6(2) FLOW RATE FROM HD CALCULATION IN THE ARROYO YAPACANICITO,JOCHI AND TACUARAL BASIN

Arroyo	Chainage in F/S (km)	Maximumflow rate from probable floods (m^3/s) for existing and design cross sections									
		2 Year		5 Year		10 Year		20 Year		50 Year	
		Existing	Design	Existing	Design	Existing	Design	Existing	Design	Existing	Design
Jochi	1.500	146.35	146.35	202.33	202.33	237.14	237.14	269.22	269.22	309.12	309.12
	4.500	143.41	143.41	199.10	199.10	233.90	233.90	266.17	266.17	306.41	306.41
	6.920	50.22	50.22	53.43	53.43	55.35	55.35	57.21	57.21	59.77	59.77
	9.620	46.51	46.51	50.24	50.24	52.39	52.39	54.25	54.25	56.71	56.71
	13.300	46.05	46.23	50.14	49.90	52.28	52.00	53.89	53.78	55.69	56.44
Improvement	14.400	51.50	46.23	55.15	49.90	57.61	52.00	58.46	53.78	59.92	56.44
	15.005	70.12	77.18	115.69	145.38	107.04	212.98	107.91	280.99	133.79	291.51
	15.015	66.67	55.58	109.11	105.99	107.62	161.01	109.33	226.98	118.78	275.14
	15.460	57.79	46.23	60.66	49.90	61.48	52.00	62.42	53.78	61.96	56.43
	16.600	46.33	46.23	50.45	49.90	52.70	52.00	54.25	53.78	55.44	56.43
	17.750	46.02	46.23	49.89	49.90	52.13	52.00	53.67	53.78	54.89	56.43
	18.650	45.93	46.23	49.88	49.90	52.08	52.00	53.63	53.78	54.84	56.43
	19.500	45.92	46.23	49.87	49.90	52.07	52.00	53.62	53.78	54.82	56.43
	20.450	45.90	46.23	49.87	49.90	52.05	52.00	53.61	53.78	54.79	56.43
	21.400	45.88	46.23	49.86	49.90	52.04	52.00	53.61	53.78	54.77	56.43
	22.300	45.88	46.23	49.86	49.90	52.03	52.00	53.61	53.78	54.74	56.43
	22.705	85.66	90.88	150.39	129.50	155.04	158.29	144.54	181.97	158.11	163.24
	22.715	75.39	98.13	145.67	141.85	158.84	159.65	159.64	176.33	174.75	163.85
	23.210	45.87	46.23	49.86	49.90	52.03	52.00	53.60	53.78	54.72	56.43
	24.300	45.86	46.23	49.85	49.89	52.02	51.99	53.60	53.78	54.68	56.44
	25.250	45.86	46.25	49.85	49.93	52.02	52.01	53.61	53.79	54.68	56.43
	27.650	48.64	104.59	58.04	141.30	62.31	153.26	64.93	175.46	62.62	200.33
	29.750	23.49	24.44	23.92	26.74	23.58	26.84	23.67	26.89	24.34	37.61
	32.800	19.70	20.48	25.91	26.79	30.11	31.13	34.60	39.75	72.77	87.11
	37.700	12.07	12.70	15.45	16.54	17.79	19.44	20.04	22.92	21.34	31.20
	41.500	11.37	12.07	14.59	15.95	16.77	18.75	18.85	22.15	19.40	30.75
Tacuaral	1.500	159.76	159.78	181.24	181.25	193.69	193.69	204.95	204.95	218.39	218.37
	4.500	158.70	158.75	180.28	180.27	192.66	192.63	203.73	203.71	216.89	216.87
	7.500	144.78	144.47	157.99	158.84	165.27	166.34	171.46	172.25	179.03	179.94
	10.500	144.54	143.78	158.05	158.86	165.49	166.73	171.84	172.46	179.53	180.53
	14.400	137.71	139.97	153.21	148.80	159.96	154.32	163.38	160.48	168.24	165.47
Improvement	16.805	168.07	153.32	183.51	198.74	198.46	217.94	207.07	231.29	229.20	242.69
	16.815	168.35	177.72	173.51	184.84	194.40	201.16	203.05	221.48	217.50	238.29
	17.210	146.01	140.12	172.06	189.08	184.51	190.67	180.84	212.87	178.89	222.32
	18.050	129.16	140.12	151.62	148.82	154.06	167.50	157.85	198.13	159.45	213.26
	18.800	127.26	140.10	149.20	148.81	152.59	157.10	156.77	193.98	158.30	205.97
	19.105	155.37	140.16	161.65	162.64	166.41	172.59	197.48	201.37	203.37	225.36
	19.115	169.62	158.74	169.88	179.77	183.09	189.56	191.54	201.45	205.28	209.32
	19.560	112.02	140.16	135.07	148.83	141.09	177.77	145.83	257.72	150.21	233.29
	20.600	111.86	140.10	134.94	148.80	141.03	154.32	145.81	172.04	150.06	201.52
	21.650	111.54	140.10	134.74	148.80	140.92	154.32	145.78	171.82	149.71	190.31
	22.350	111.77	140.11	134.81	148.80	140.95	154.32	145.80	171.58	149.53	189.99
	25.050	110.64	140.11	134.12	148.80	140.58	154.31	145.66	170.86	148.66	189.47
	27.550	103.63	128.86	127.83	151.16	138.11	165.15	148.32	177.01	159.88	198.78
	29.850	141.45	167.37	172.72	199.00	195.53	221.21	222.32	240.32	253.91	270.96
	35.000	102.89	105.96	125.26	130.84	137.83	146.33	149.73	158.90	146.75	172.46

FIGURES

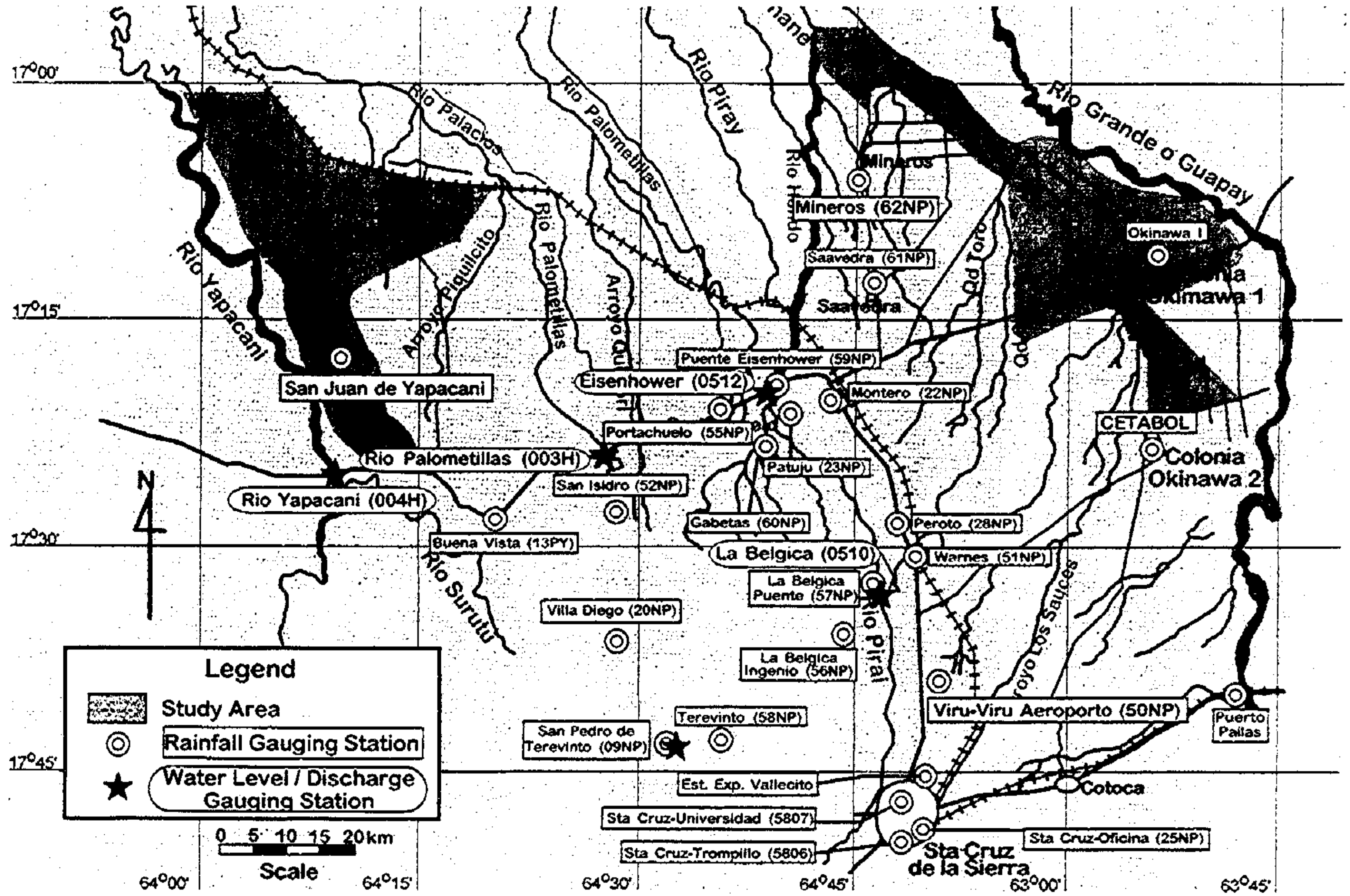


FIG.4.4.1 EXISTING MEASUREMENT STATIONS

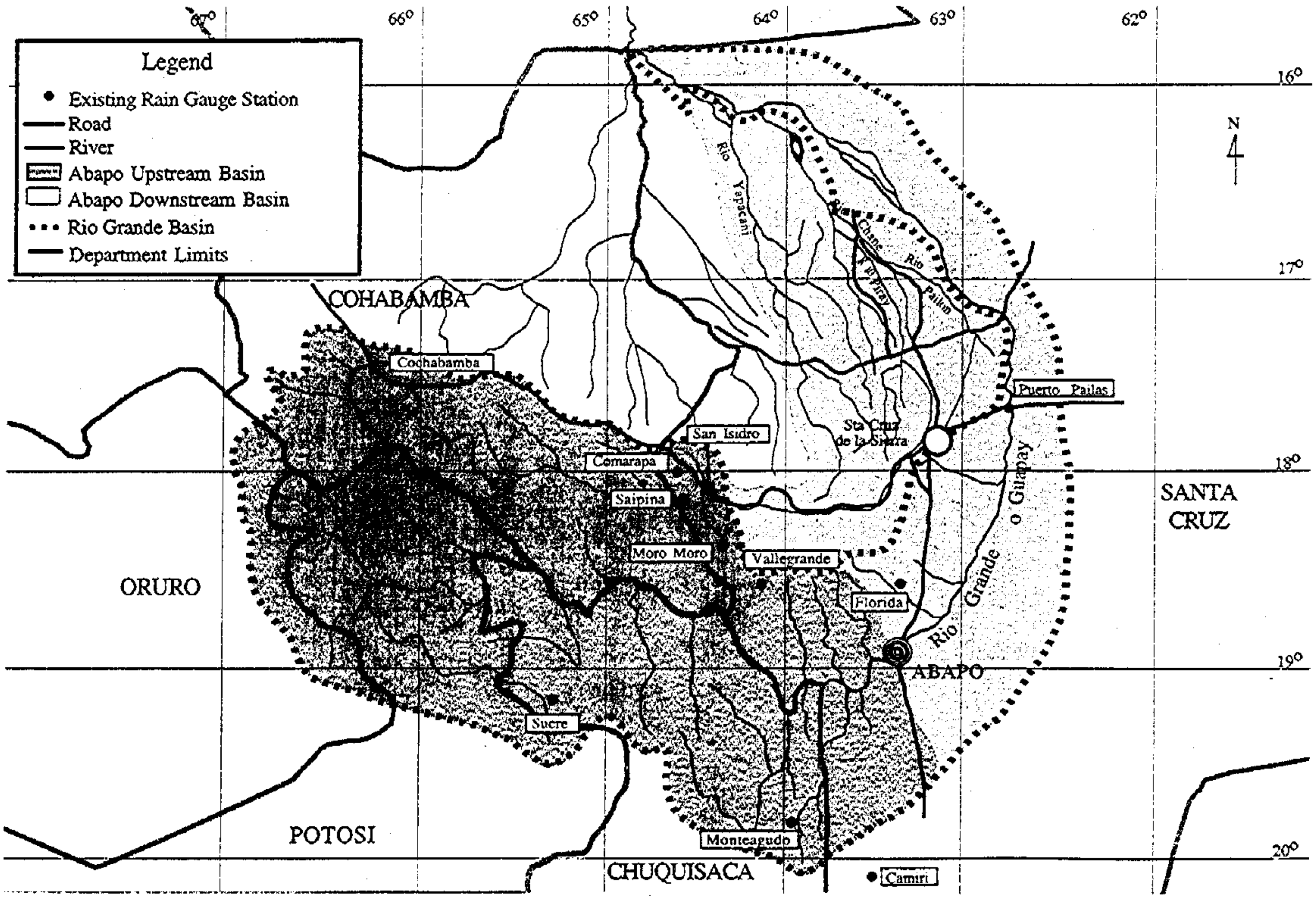


FIG.4.4.2 THE RIO GRANDE BASIN

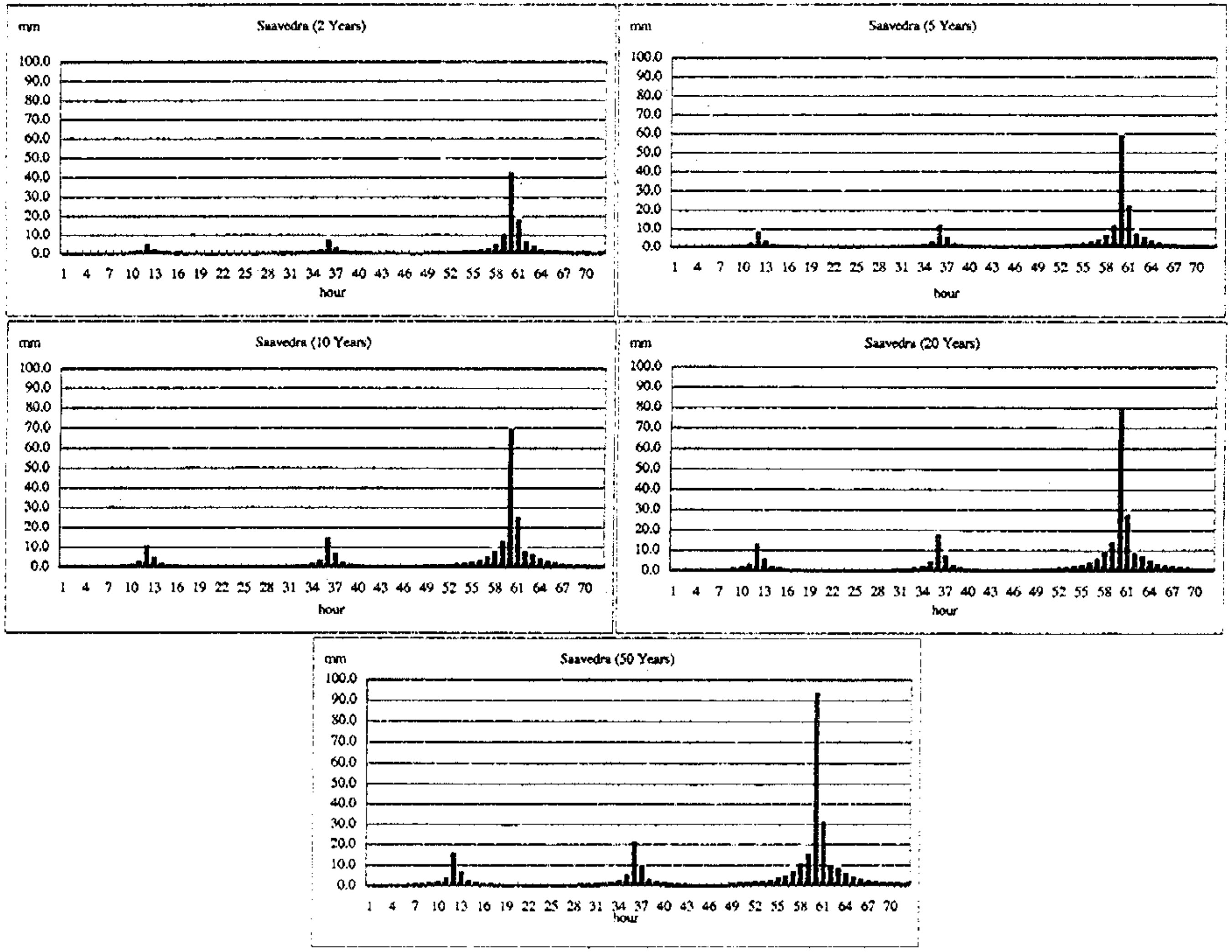


FIG.4.7.1(1) DESIGNED RAINFALL FOR SAAVEDRA

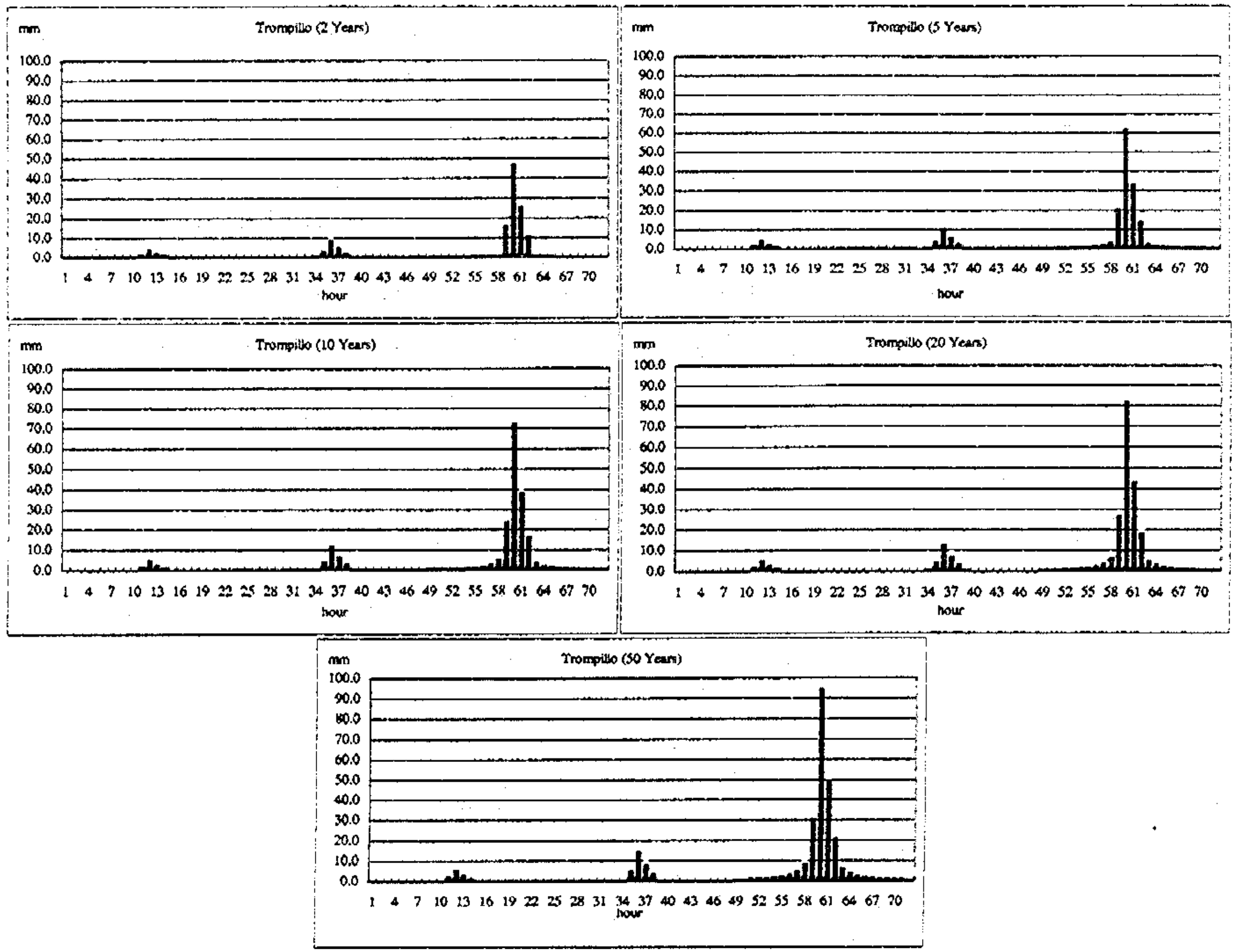


FIG.4.7.1(2) DESIGNED RAINFALL FOR TROMPILLO

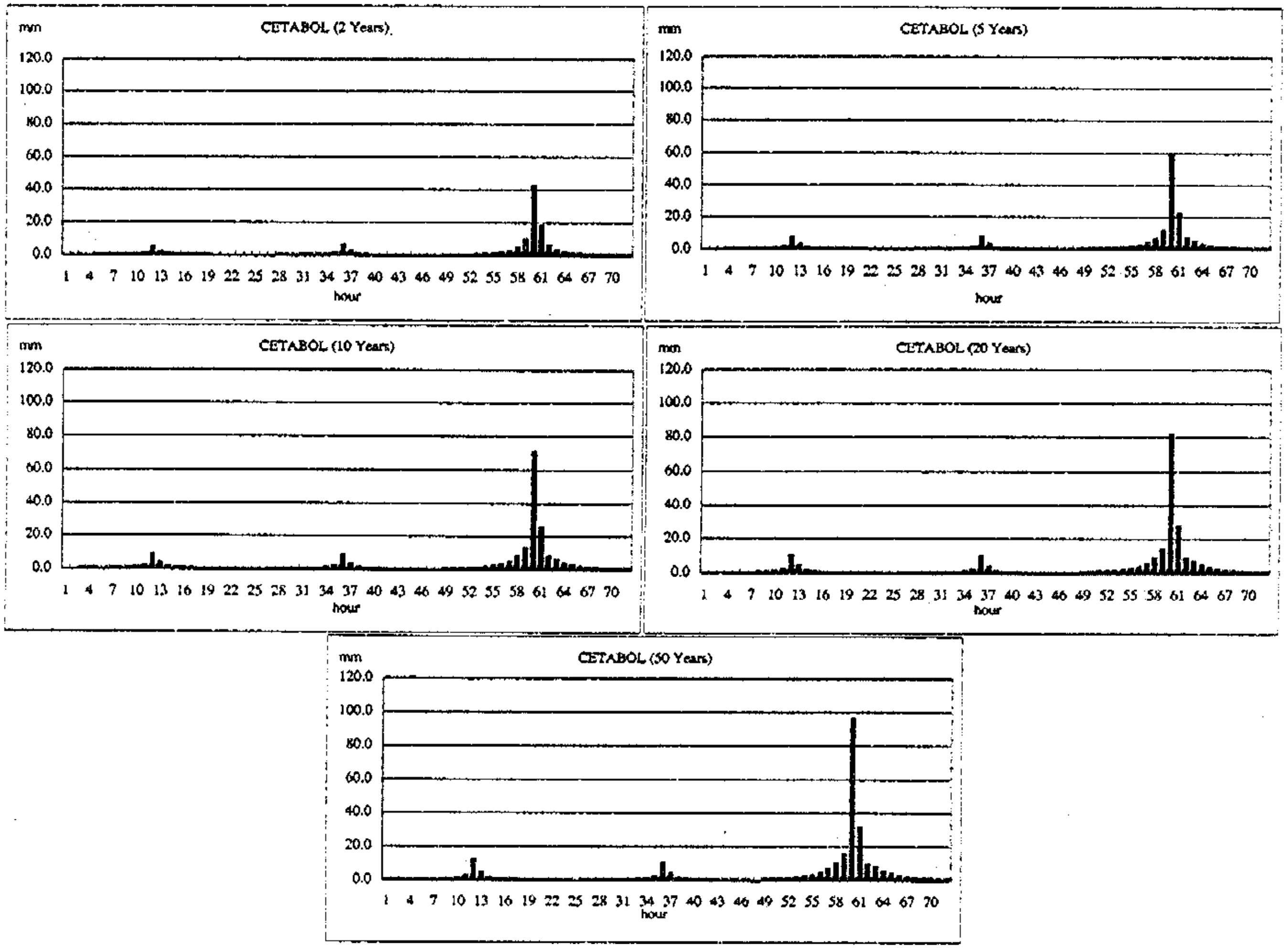


FIG.4.7.1(3) DESIGNED RAINFALL FOR CETABOL

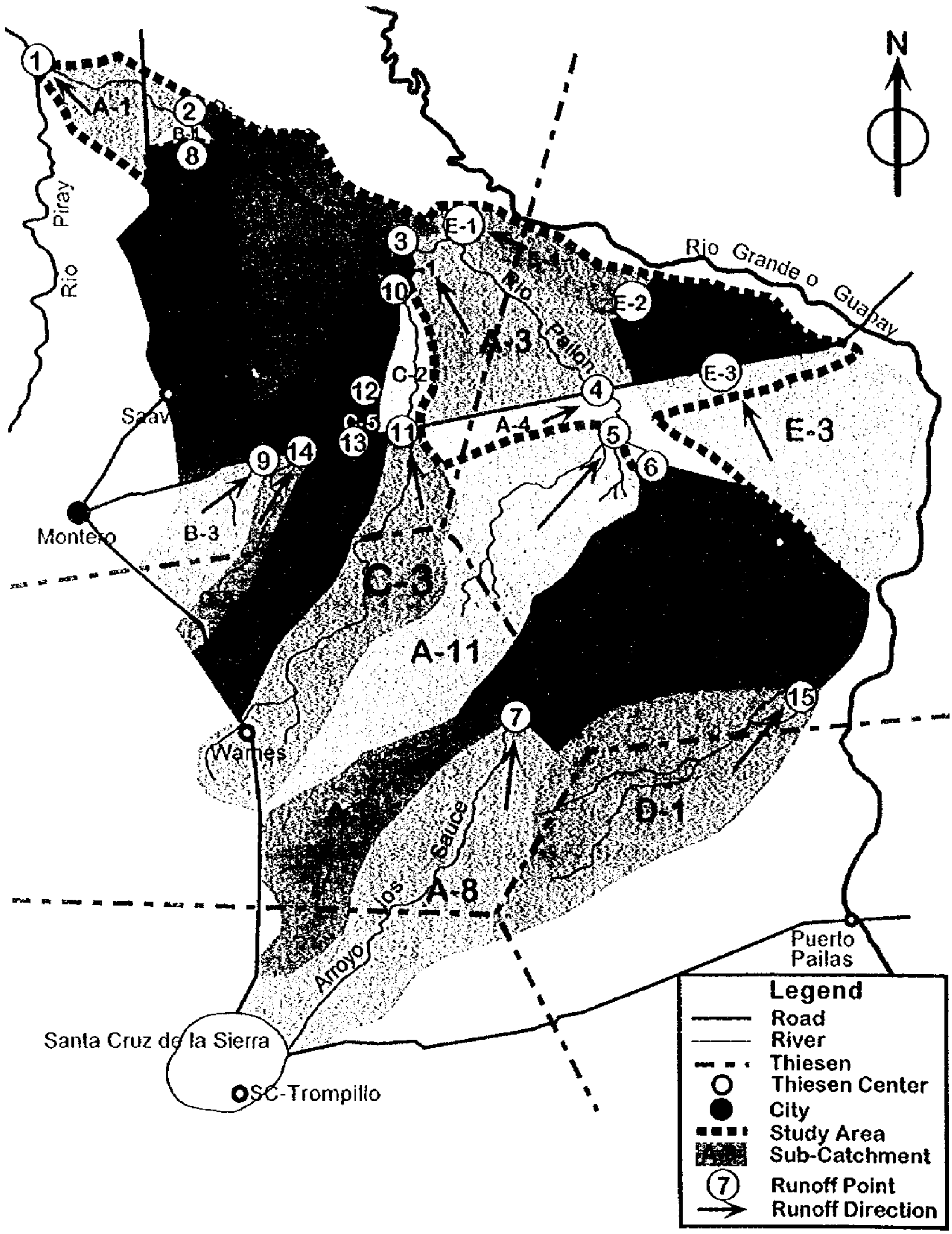


FIG.4.8.1 CATCHMENT AREAS FOR THE RUNOFF ANALYSIS FOR THE CHANE-PAILON AREA

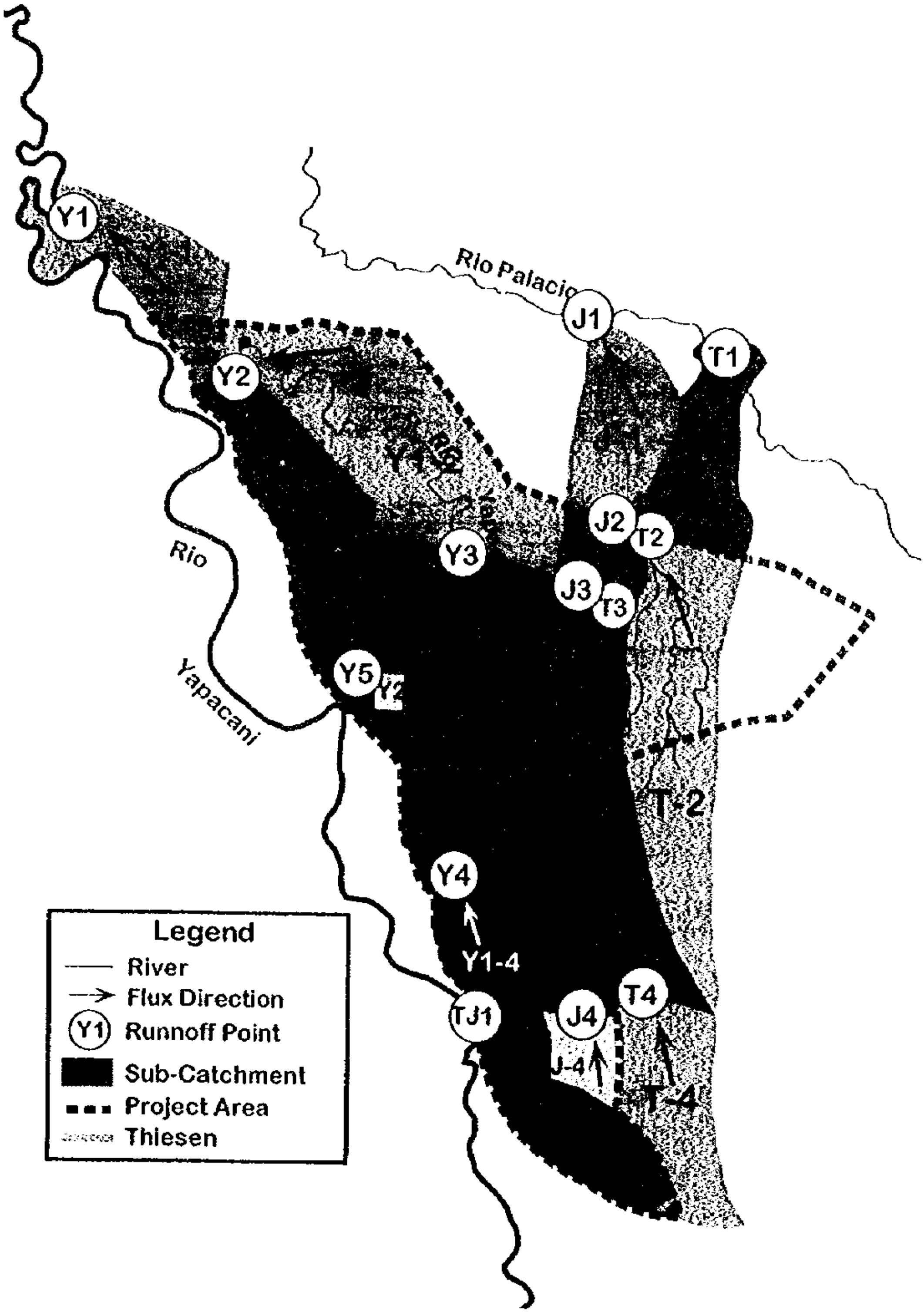


FIG.4.8.2 CATCHMENT AREAS FOR THE RUNOFF ANALYSIS FOR THE SAN JUAN-ANTOFAGASTA AREA

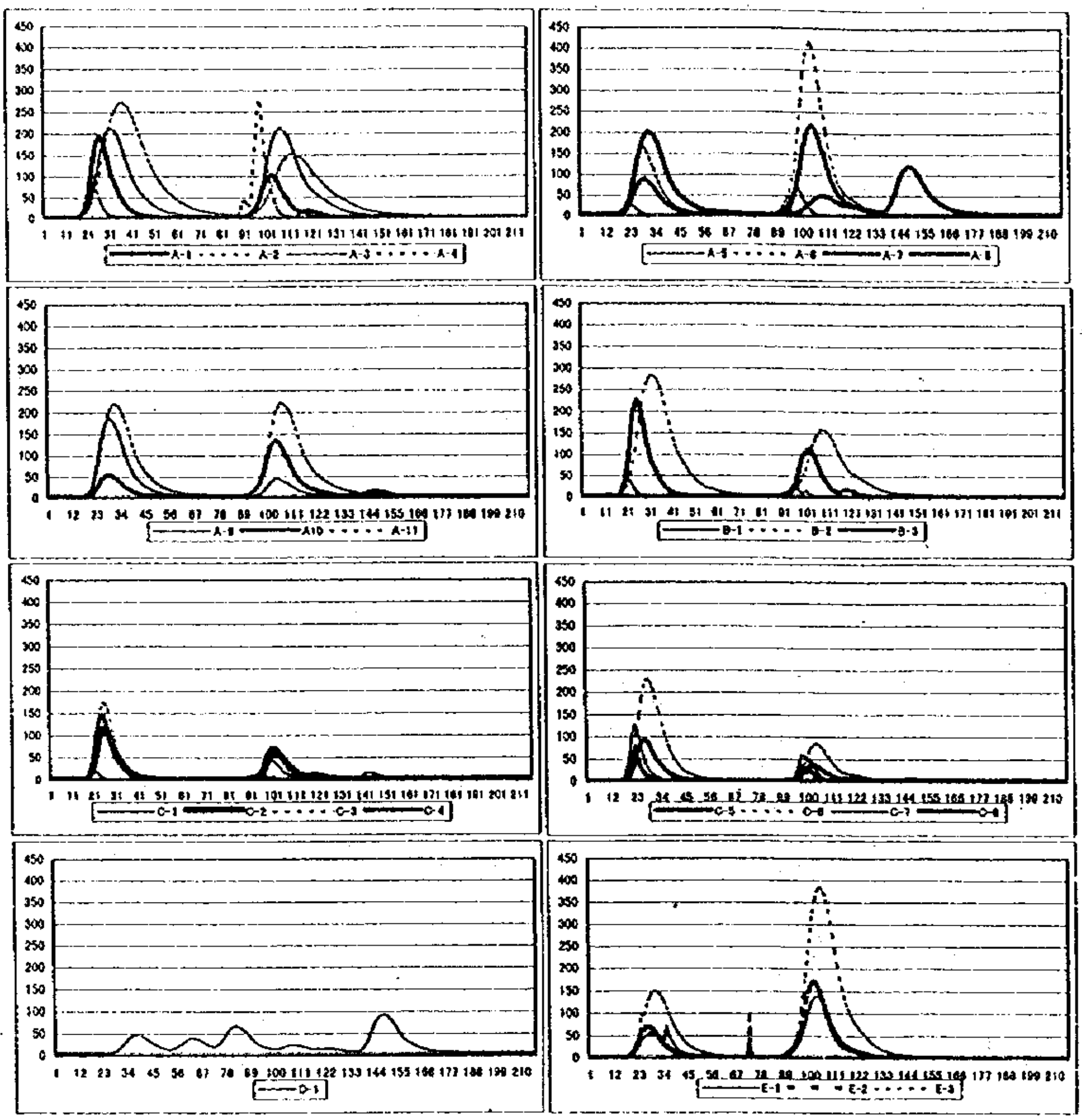


FIG.4.8.3(1) RELATIONSHIP BETWEEN RUNOFF(M^3/S)AND TIME (HOUR) FOR THE CHANE-PAILON AREA DURING NOV.30 TO DEC.5 IN 1997

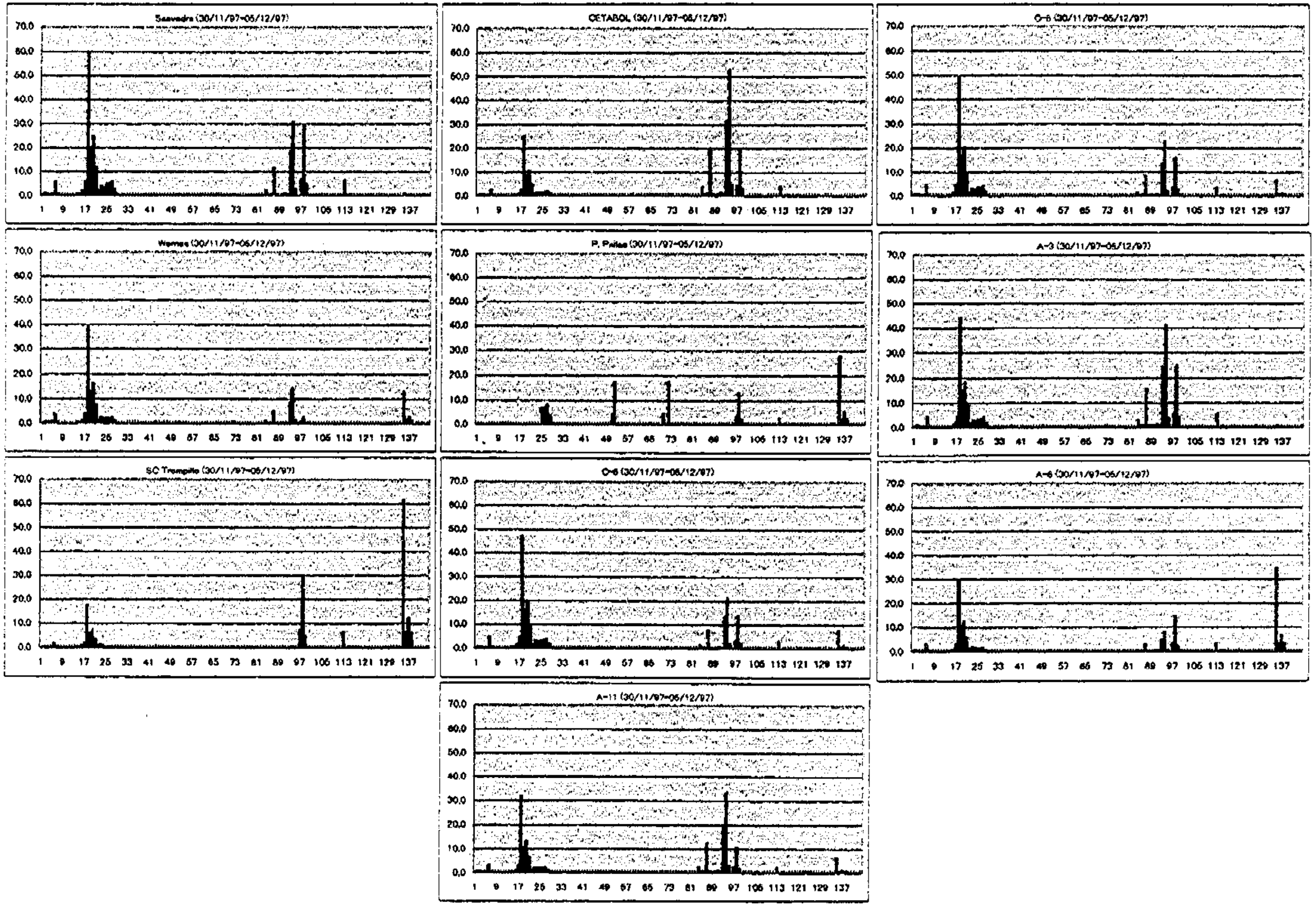


FIG.4.8.3(2) RAINFALL FOR THE RUNOFF SIMULATION FOR THE CHANE-PAILON AREA [RAINFALL(MM)-TIME(HOUR) CURVE]

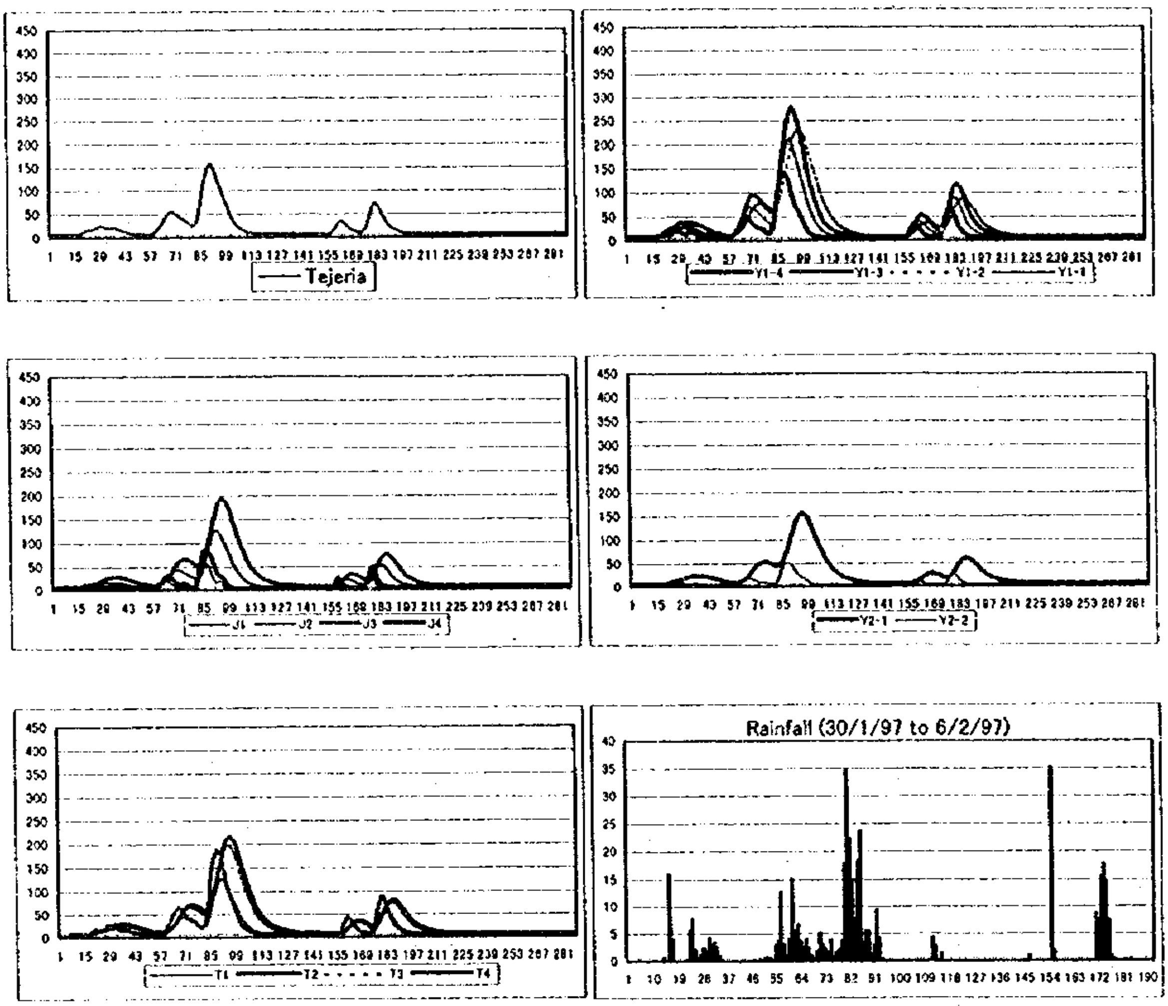
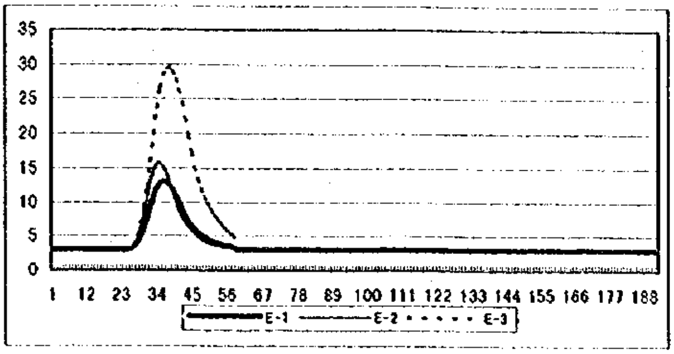


FIG.4.8.4 RELATIONSHIP BETWEEN RUNOFF(M^3/S)AND TIME (HOUR) FOR THE SAN JUAN-ANTOFAGASTA AREA DURING JAN.30 TO JUN.2 IN 1997



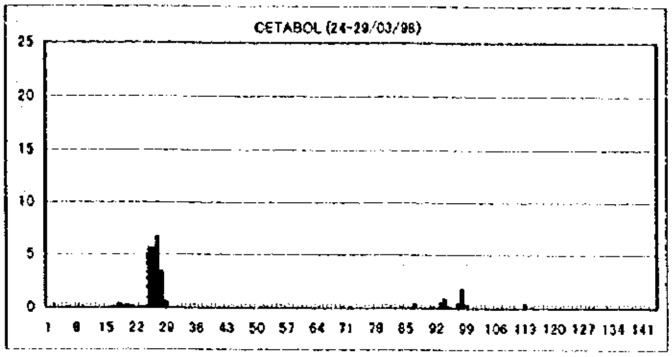


FIG.4.8.5 RUNOFF RESULTS FOR THE RIO GRANDE CONTRIBUTIOR CHANE-PAILON AREA

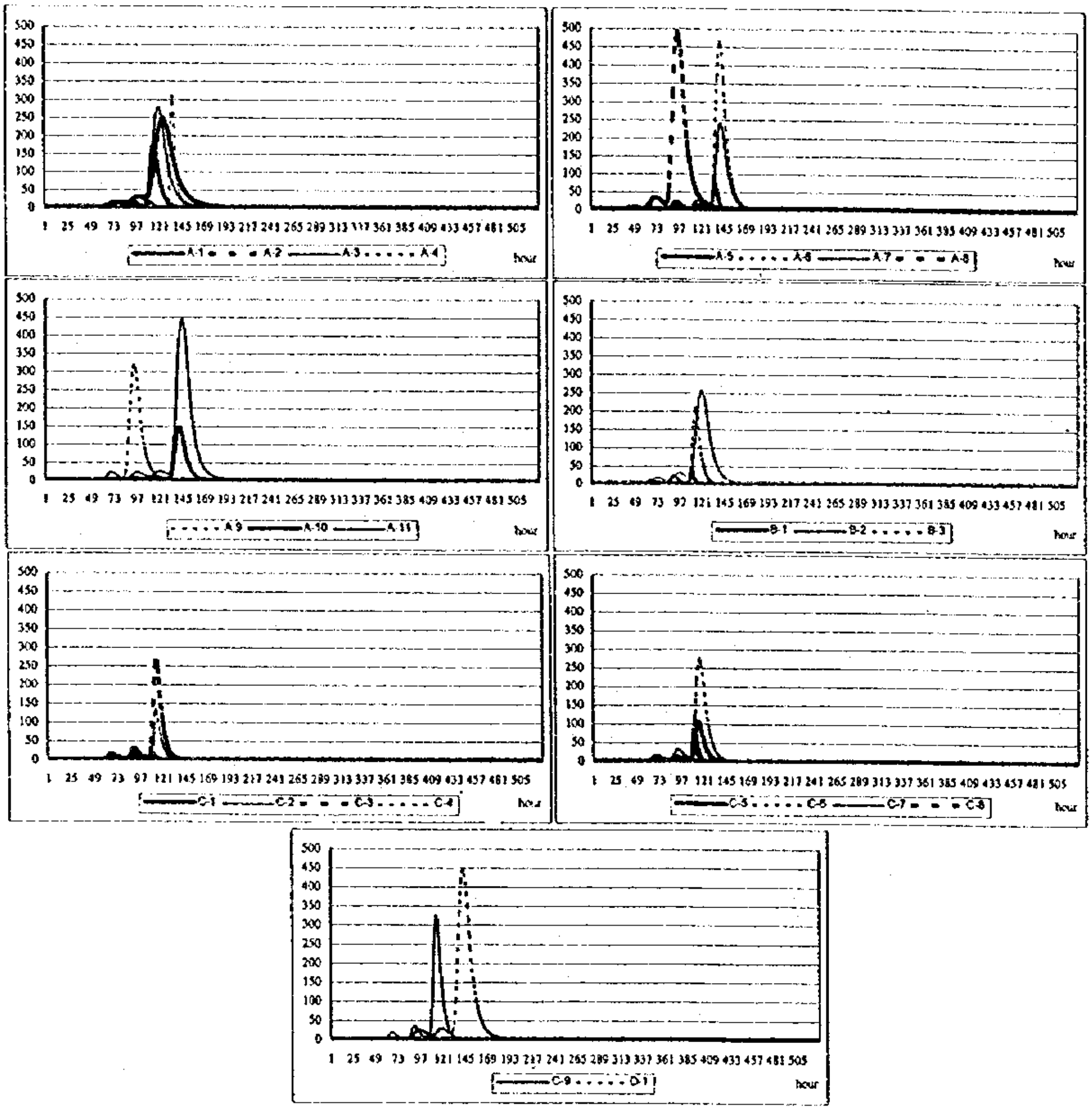


FIG.4.8.6(1) RUNOFF FOR RETURN PERIOD OF 5 YEARS FOR THE CHANE-PAILON AREA

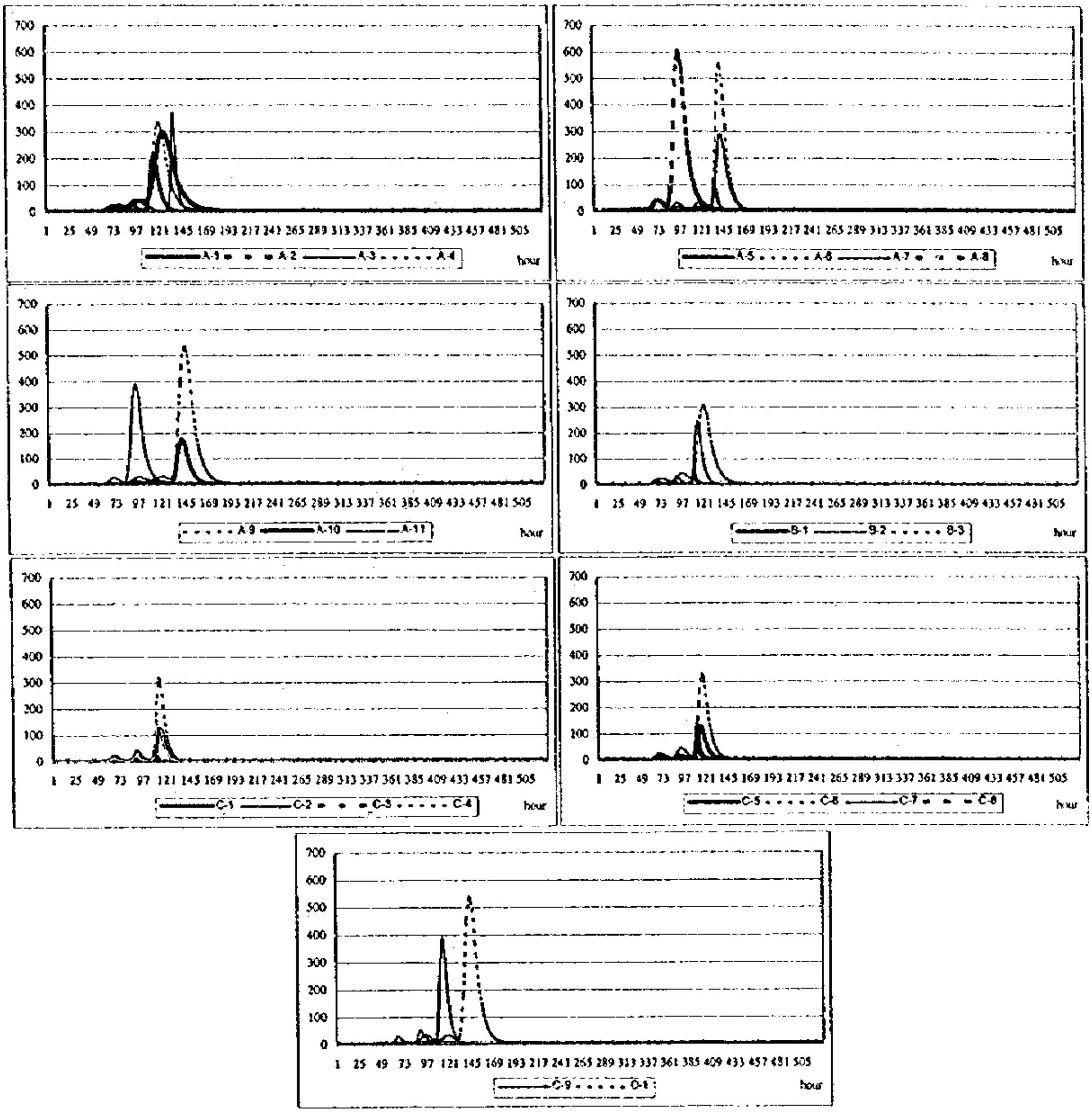


FIG.4.8.6(2) RUNOFF FOR RETURN PERIOD OF 10 YEARS FOR THE CHANE-PAILON AREA(1/2)

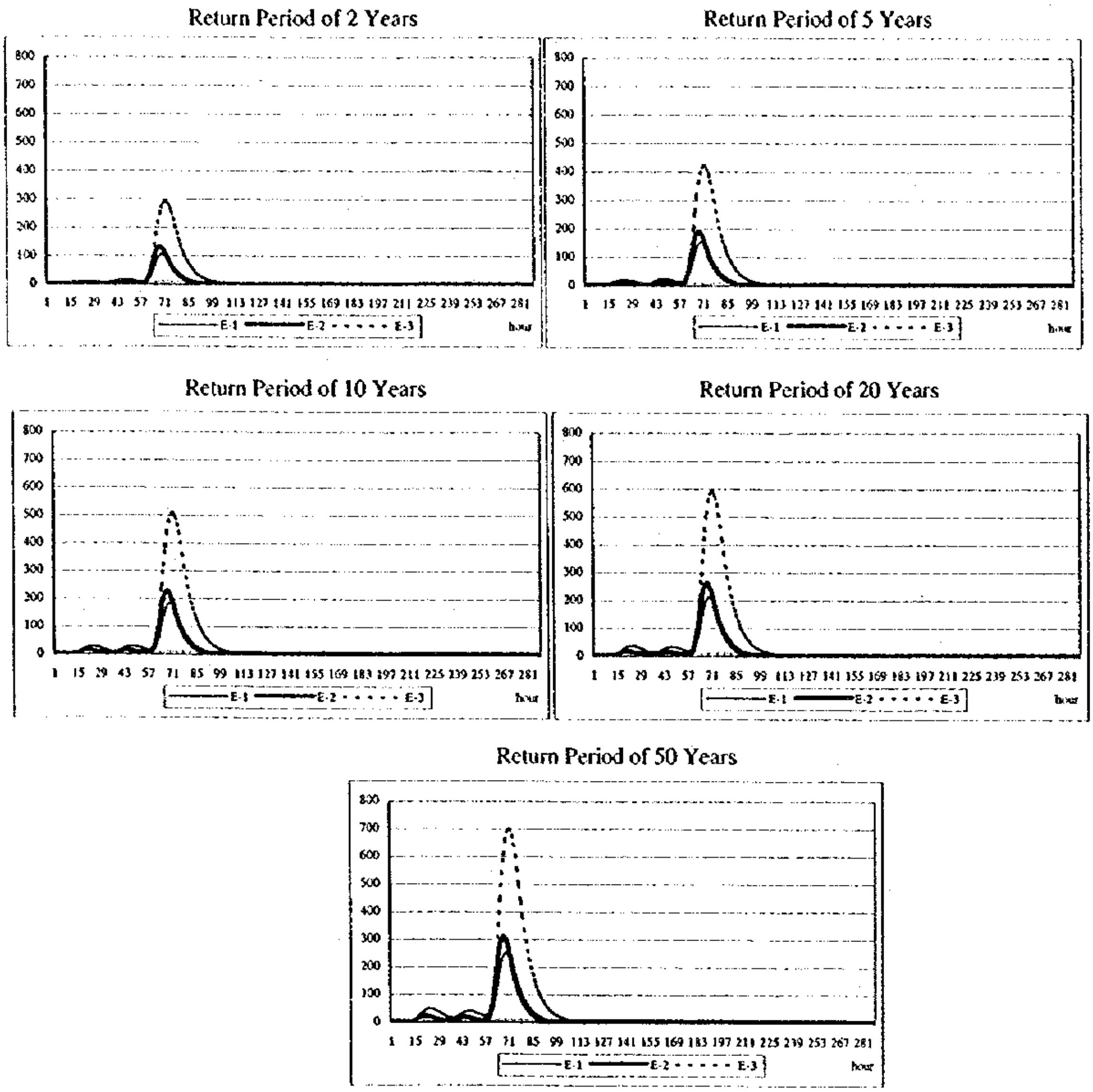


FIG.4.8.6(3) RUNOFF FOR THE CHANE-PAILON AREA(2/2)
(2,5,10,20,50 YEARS RETURN PERIOD FOR THE OKINAWA DRAINAGE BASIN)

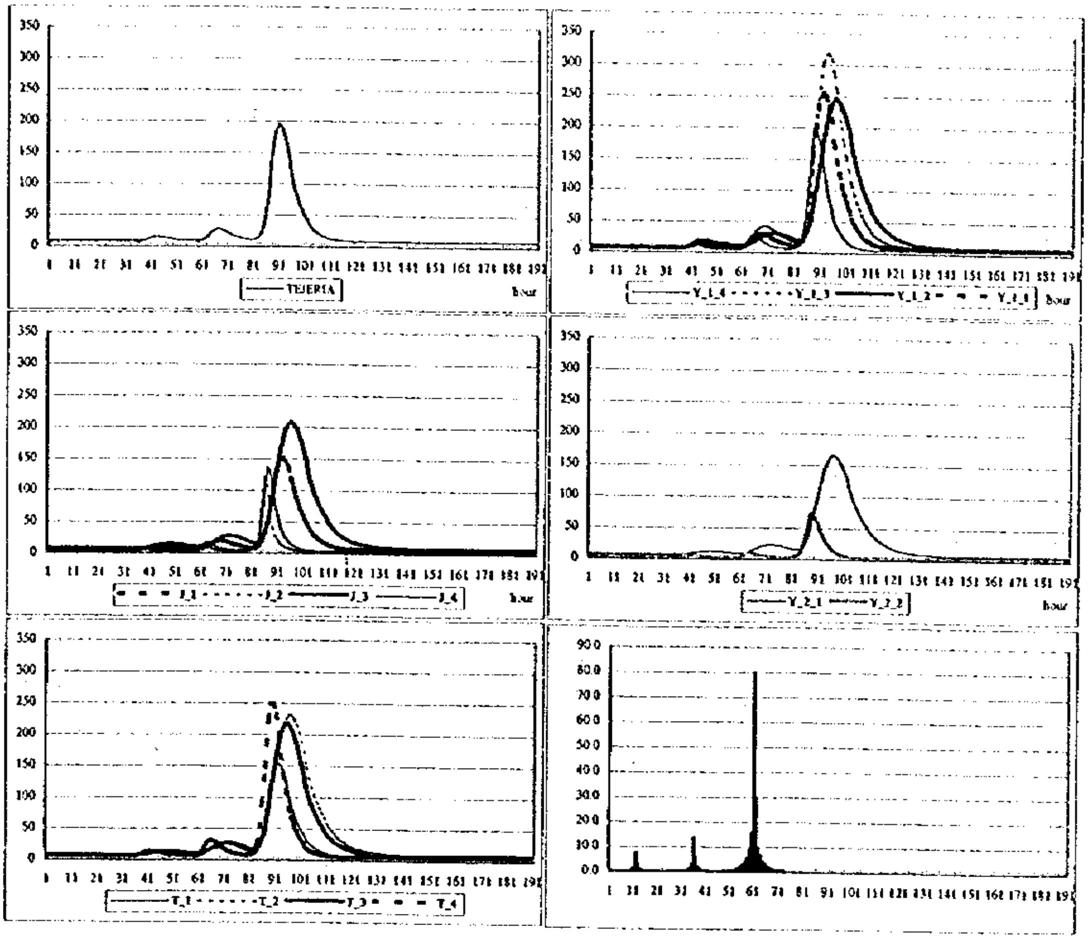


FIG.4.8.6(4) RUNOFF FOR RETURN PERIOD OF 5 YEARS FOR THE SAN JUAN-ANTOFAGASTA AREA

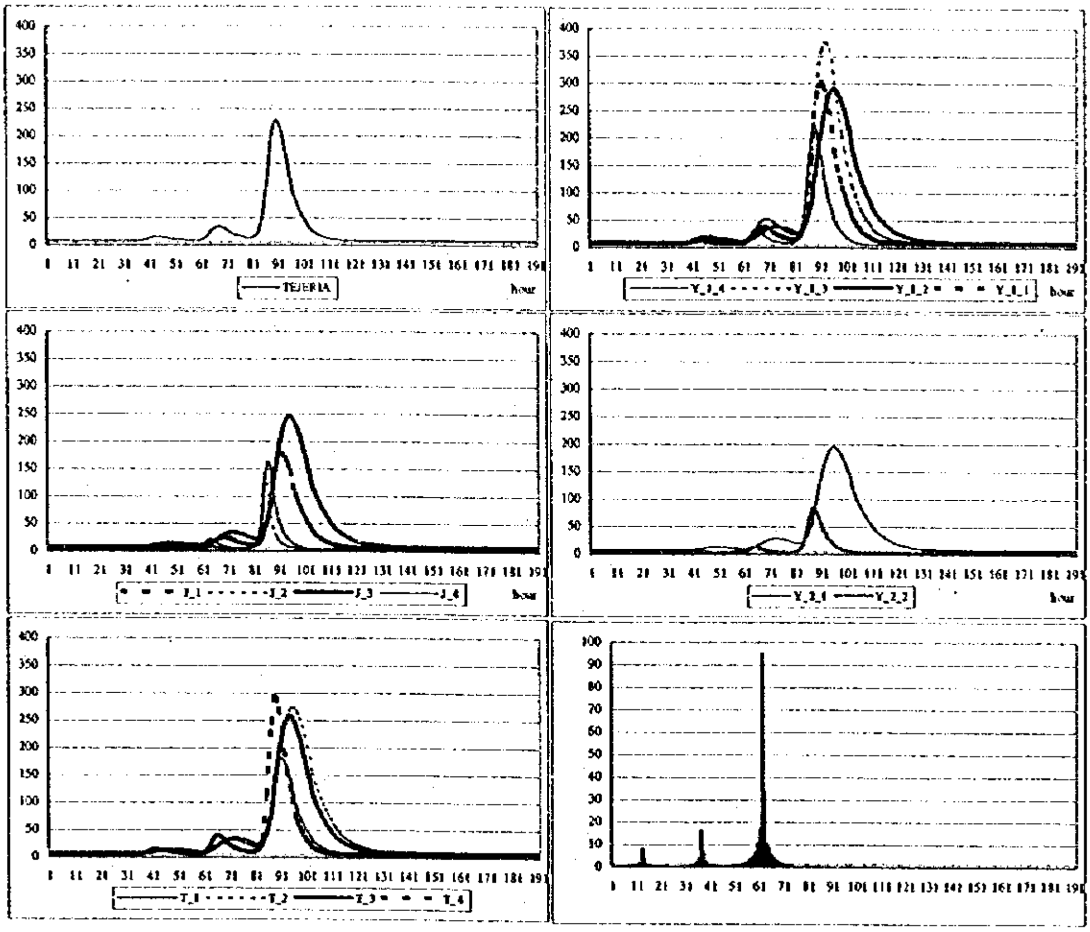


FIG.4.8.6(5) RUNOFF FOR RETURN PERIOD OF 10 YEARS FOR THE SAN JUAN-ANTOFAGASTA AREA

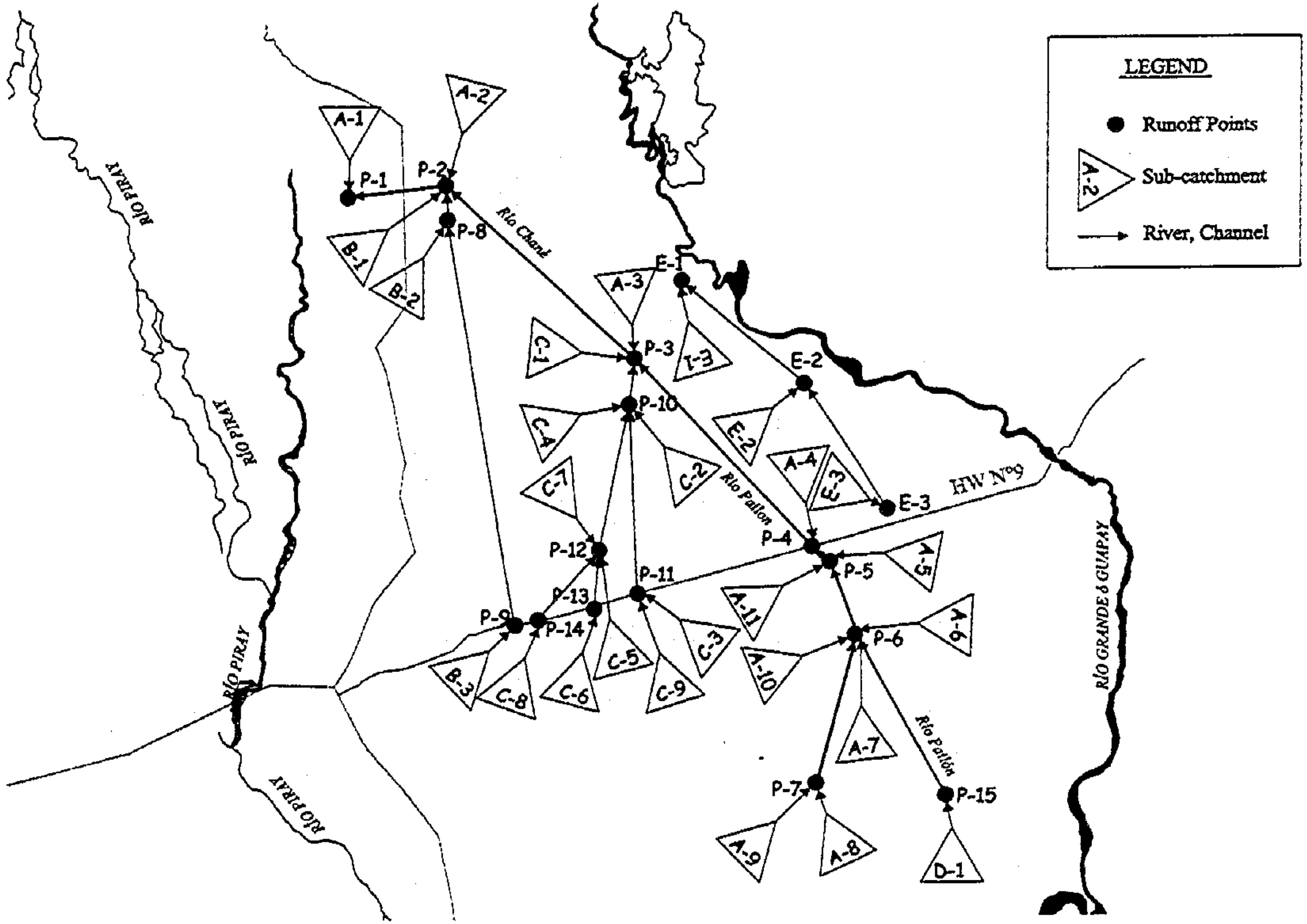


FIG.4.12.1 FLOW MODEL IN THE RIO CHANE-PAILON BASIN AND OKINAWA DRAINAGE BASIN

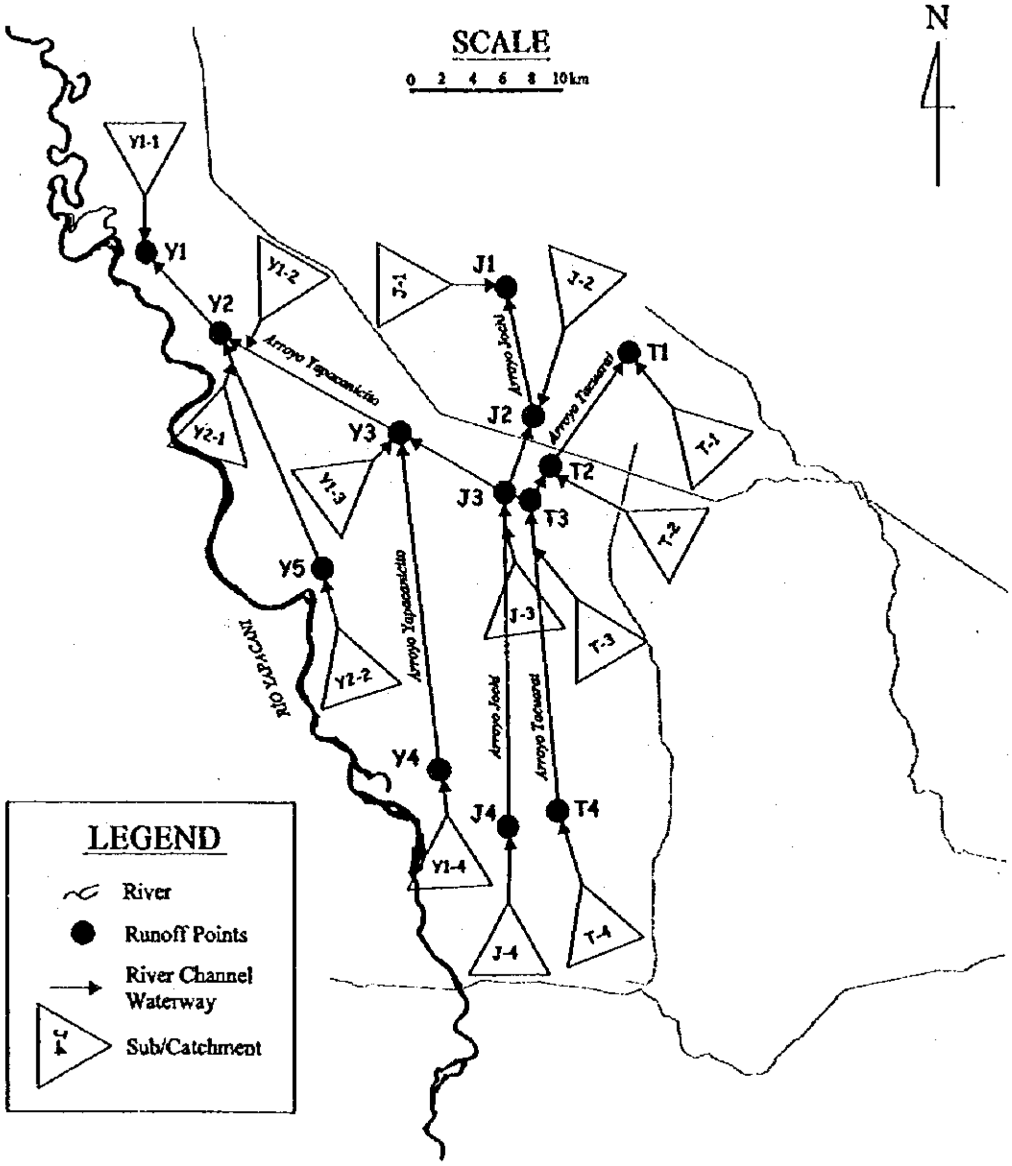


FIG.4.12.2 FLOW MODEL IN THE ARROYO YAPACANICITO, JOCHI AND TACUARAL BASIN

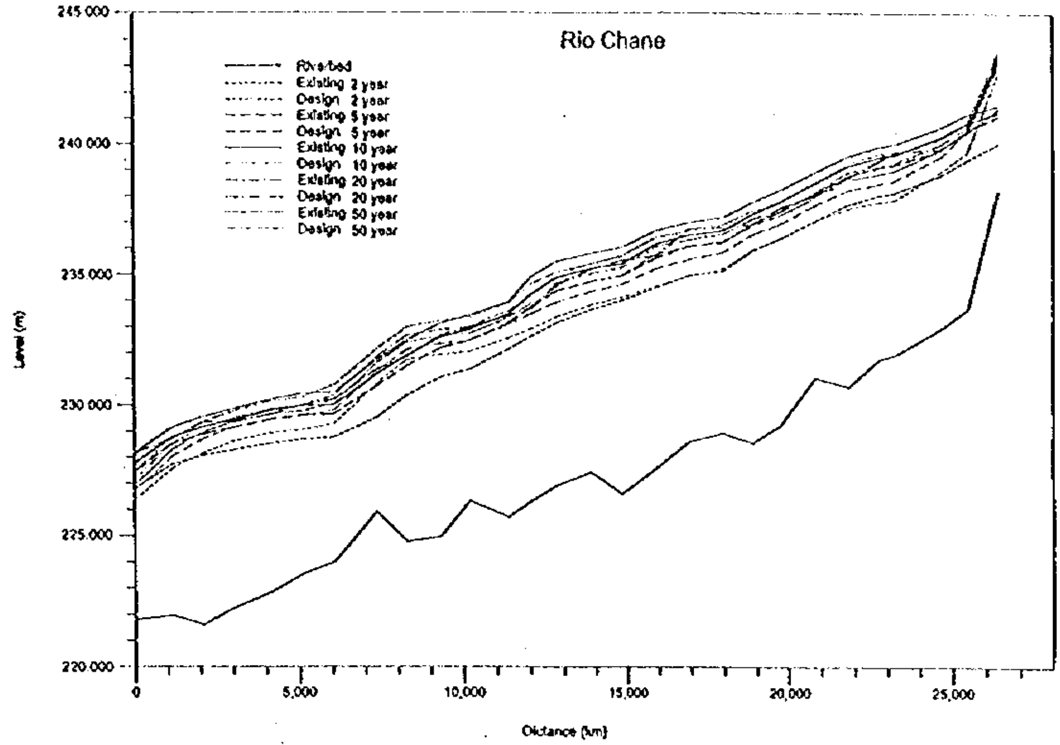


FIG.4.15.1(1) WATER LEVEL FROM HD CALCULATION IN THE CHANE-PAILON AREA

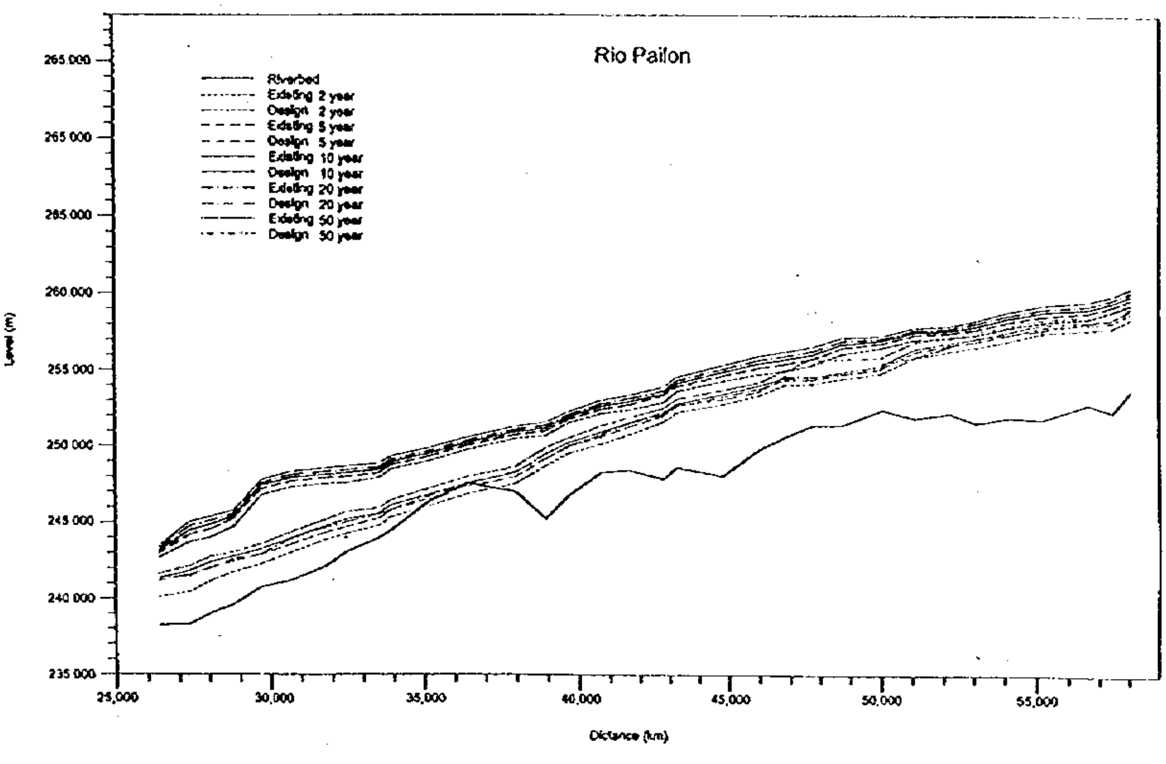


FIG.4.15.1(2) WATER LEVEL FROM HD CALCULATION IN THE CHANE-PAILON AREA

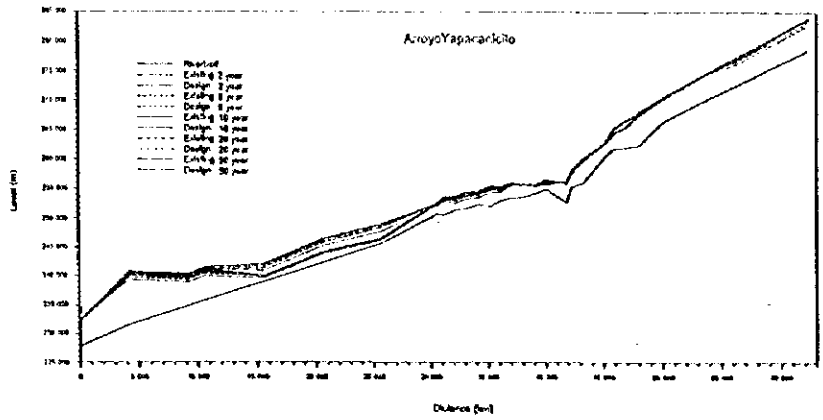


FIG.4.15.2(1) WATER LEVEL FROM HD CALCULATION IN THE SAN JUAN-ANTOFAGASTA AREA

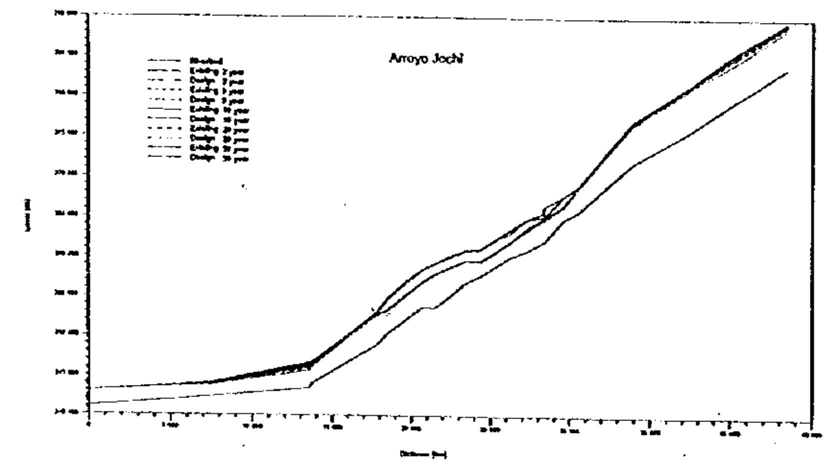


FIG.4.15.2(2) WATER LEVEL FROM HD CALCULATION IN THE SAN JUAN-ANTOFAGASTA AREA

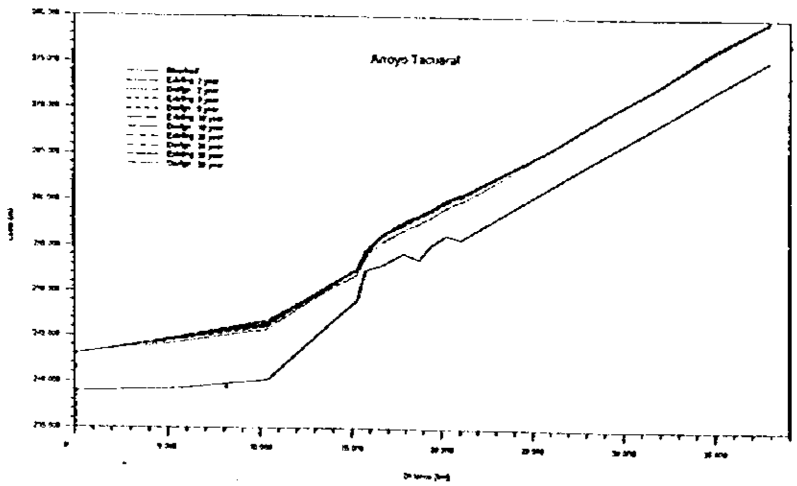


FIG.4.15.2(3) WATER LEVEL FROM HD CALCULATION IN THE SAN JUAN-ANTOFAGASTA AREA