No. 52

THE REPUBLIC OF THE PHILIPPINES
NATIONAL IRRIGATION
ADMINISTRATION (NIA)

JAPAN INTERNATIONAL
COOPERATION AGENCY
(JICA)

FEASIBILITY STUDY ON THE UPLAND IRRIGATION AND RURAL DEVELOPMENT PROJECT IN SOUTHERN LUZON

VOLUME II
APPENDIXES

March, 1995

NIPPON GIKEN INC.
TOKYO, JAPAN

NIPPON KOEI, CO., LTD.
TOKYO, JAPAN

THE REPUBLIC OF THE PHILIPPINES
NATIONAL IRRIGATION
ADMINISTRATION (NIA)

JAPAN INTERNATIONAL
COOPERATION AGENCY
(JICA)

FEASIBILITY STUDY ON THE UPLAND IRRIGATION AND RURAL DEVELOPMENT PROJECT IN SOUTHERN LUZON

VOLUME II

APPENDIXES

March, 1995

NIPPON GIKEN INC.
TOKYO, JAPAN

NIPPON KOEI, CO., LTD.
TOKYO, JAPAN

FEASIBILITY STUDY
ON
THE UPLAND IRRIGATION AND RURAL DEVELOPMENT PROJECT
IN SOUTHERN LUZON

VOLUME II

APPENDIXES

Contents

FEASIBILITY STUDY ON
THE UPLAND IRRIGATION AND
RURAL DEVELOPMENT PROJECT
IN SOUTHERN LUZON

APPENDIX-I

METEOROLOGY AND HYDROLOGY

FEASIBILITY STUDY
ON
THE UPLAND IRRIGATION AND RURAL DEVELOPMENT PROJECT
IN SOUTHERN LUZON

APPENDIX-I

METEOROLOGY AND HYDROLOGY

Contents

List of Table

List of Figures

APPENDIX-I METEOROLOGY AND HYDROLOGY

1 Basin System and Climate

1.1 Basin System

The whole country is divided into twelve (12) Water Resources Regions as units for comprehensive water resources development and management. The Study area is located at the Water Resource Region IV (Southern Tagalog). The Water Resources Region IV is further divided into five (5) water resources planning units, viz., Laguna Lake basins, Taal Lake basins, Quezon basins, Mindoro island basins and Palawan island basins. The Study area is located in southern-most part of the Laguna Lake basins, which has a total area of 5,078 sq.km.

The Laguna Lake basin is bounded on the north by the Province of Balacan, on the east and south by the Province of Quezon and on the west by the Provinces of Cavite and Batangas. It is composed of the Pasig-Laguna Bay river basin with 4,678 sq.km and 400 sq.km of watersheds. Fig. I.1.1 presents the boundaries of the Laguna Lake basins and the Province of Laguna. Most part of the Province of Laguna is located in the Laguna Lake basins, however, south-east part of the Province is in the Quezon basins which are bounded in the north by the Provinces of Bulacan, Rizal, Laguna and Batangas, in the east by the Pacific Ocean, in the southeast by the Provinces of Carmarines Norte and Carmarines Sur, and in the southwest by Tayabas Bay. The Quezon basins have generally ragged terrains with the Sierra Madre mountain range and Mt. Banahaw.

2 Meteorology

2.1 Coronas Climate Classification

The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) utilizes the Coronas climate classification system based on the rainfall distribution, in which a climate condition in a particular area in the Philippines is classified into four (4) types as follows: (see Fig. I.2.1)

Type I — Type I has two (2) pronounced seasons, the dry season from November to April, and the wet season during the rest of the year.
(western Luzon, western Mindoro, western Panay, western Palawan, and western Negros islands)

Type II — Type II has no dry season with a very pronounced, much rainfall from November to January.
(south-eastern Luzon, eastern Samar, eastern Lyte, Eastern Mindoro, and eastern Mindanao islands)

Type III — Type III has a feature that the seasons are not pronounced, relatively the dry season from November to April and the wet season during the rest of the year.
(eastern Palawan, eastern Panay, eastern Negros,, and southern Cebu islands)

Type IV — Type IV has a rainfall more or less evenly distributed throughout the year and no clear boundary between the dry and wet seasons.
(north-western Luzon, western Lyte, Bohol, and western Mindanao islands)

The Study area is located at the northern hilly area of Mts. Banahaw and San Cristobal in the southern - most part of the Laguna Lake basins. The Laguna Lake basins exhibit two (2) types of climate as shown in Fig. I.2.2. In the eastern-most part of the basin, which is classified climate Type IV by PAGASA based on the rainfall distribution, rainfall is more or less evenly distributed throughout the year. The rest has two pronounced seasons of the dry season from November to April and the wet season during the rest of the year, classified in Type I. The Study area ranges from El. 300 m to 1,300 m of the northern slopes of Mts. Banahaw and San Cristobal. The climate of the Study area is categorized in the Type I. However, the rainfall pattern shows the intermediate types of Type I and IV at eastern part of the Study area for the reasons that the Study area is located close to the boundary of Type I and IV, which is topographically divided by the Sierra Madre mountain range and also its elevated location of the northern slope of Mts. Banahaw and San Cristobal as indicated in Fig. I.2.2. Rainfall distribution in accordance with the different period of the dry and wet seasons is indicated in Fig. I.2.3.

2.2 Meteorological Data Collection

(1) Observation Stations

Meteorological observation stations in the vicinity area of the Study area are shown in Fig. I.2.4. The rainfall data and other meteorological data, such as temperature, relative humidity, and pan evaporation data in the Study area have been observed at three (3) stations in Nagcarlan and Liliw. It is, however, not available for a statistical data analysis due to its considerably short observation period. The reliable meteorological data in the vicinity area have observed at the stations of Sta. Cruz and Los Baños (University of the Philippines :UPLB, the International Rice Research Institute:IRRI) and Cavinti. The observation periods of these meteorological observation data in the vicinity of the Study area are referred to in Fig. I.2.5.

(2) Rainfall

Distribution of the rainfall in the drainage area of the Laguna Lake basins is shown in Fig. I.2.6. The Laguna Lake basins shows pronounced differences in the annual rainfall amount. The distribution ranges from 1,950 mm in the western area to 2,450 mm in the eastern area. Annual average rainfall amount of 4,200 mm was observed at Cavinti, Laguna which is located at the eastern-most boundary of the Laguna Lake basins and also located in Climate Type IV.

Annual average rainfall amount in the Study area is around 2,350 to 2,400 mm on the basis of the observation data for three (3) years from 1979 to 1981 at the Municipality of Liliw. Around 80 % of the annual rainfall is observed in seven months, from May to November. Monthly rainfall of more than 400 mm has scarcely observed in the Study area due to infrequent influence of typhoons. Monthly rainfall amount of 200 mm to 370 mm is more or less evenly distributed during the wet season.

The observation data of the rainfall in the vicinity of the Study area are summarized below:

Mean Monthly Rainfall (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Los Baños	46.2	20.9	29.9	35.1	160.7	237.6	267.7	254.8	242.1	274.8	251.0	159.3	1,980.2
Sta. Cruz	42.9	18.4	27.3	39.3	128.5	212.5	247.6	258.8	243.5	265.1	225.1	123.9	1,832.9
Cavinti	274.9	180.5	111.6	172.8	119.8	371.7	440.2	391.7	301.6	670.5	597.1	434.4	4,195.8
Tayabas	156.2	90.0	93.0	101.0	215.0	266.2	272.7	188.3	275.3	476.5	520.0	364.7	3,018.9
Liliw	67.2	31.0	33.2	121.8	219.6	327.3	276.1	134.4	279.2	368.8	321.2	204.5	2,384.3
Caliraya	107.0	51.1	86.8	104.1	241.4	306.6	284.5	262.4	280.7	390.2	547.5	455.1	3,117.6

Source: PAGASA (rainfall data of Kaliraya were observed by Kaliraya Hydraulic Electric Plant Office)
Observation period of Liliw was 3 years (1979 to 1981)
Observation period of other stations are illustrated in Fig. I.1.6

Monthly rainfall amount of the above stations are tabulated in Table I.2.1 to Table I.2.5. Monthly rainfall data observed in the Study area during the Study period are also shown in Table I.2.6 and Table I.2.7.

(3) Temperature

Temperature have observed at Los Baños, Cavinti and Barangay Poblacion and Bukal in the Study area. Mean monthly temperature ranges from a minimum of 14°C to a maximum of 29°C at the elevation of 700 m at Barangay Bukal, Nagcarlan in the Study area. The coldest months are from December to March while the warmest months are April to June.

The following are mean monthly temperature data observed at Los Baños, Cavinti, Barangays Poblacion and Bukal in the Municipality of Nagcarlan.

Mean Monthly Temperature (°C)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Los Baños	25.1	25.6	26.8	28.4	29.0	28.3	27.7	27.5	27.4	27.1	26.5	25.5	27.1
Cavinti	22.4	22.7	23.9	25.6	26.4	25.9	25.3	25.2	25.0	24.6	23.8	22.4	24.4
Nagcarlan (Poblacion)	24.2	24.6	25.4	27.0	28.5	27.8	27.3	27.2	27.0	25.4	25.3	24.0	26.1
Nagcarlan (Bukal)	20.6	20.6	21.2	22.2	23.6	23.0	22.0	22.8	22.5	22.2	22.0	21.0	22.0

Source: UPLB, IRRI (Los Baños)
Compilation of Weather Data: IRRI (Cavinti)
JICA Study Team (Nagcarlan)
Observation period is illustrated in Fig. I.1.6
Station elevation: Los Baños(El. 21 m), Cavinti(El. 305 m), Poblacion(El. 300 m), Bukal(El. 700 m)

Temperature decrease is estimated at around 0.7 °C per 100 m. Tables I.2.8, 9, 10, 11 show mean (max, min) temperature data of Los Baños, Cavinti, Poblacion and Bukal, Nagcarlan.

(4) Relative humidity

Relative humidity have observed at Los Baños, Cavinti and Barangays Poblacion and Bukal in the Study area. Mean monthly relative humidity ranges from a minimum of 68 % to a maximum of 98 % at the elevation of 700 m at Barangay Bukal, Nagcarlan in the Study area.

The following are mean monthly relative humidity data observed at Los Baños, Cavinti, Poblacion and Bukal in Nagcarlan. Monthly relative humidity, on the average, ranges from a maximum of 91 % to a minimum of 73 % at Barangay Bukal, Nagcarlan. Monthly relative humidity observed at Los Baños is shown in Table I.2.12.

Mean Monthly Relative Humidity (%)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Los Baños	82	79	75	74	76	80	82	83	83	84	83	83	80
Cavinti	93	93	92	90	90	91	92	93	93	93	93	93	92
Nagcarlan (Poblacion)	84	78	77	73	76	82	79	73	79	81	84	90	80
Nagcarlan (Bukal)	89	82	82	81	87	88	85	85	85	85	n.a.	91	85

Source: UPLB, IRRI (Los Baños)
Compilation of Weather Data:IRRI (Cavinti)
JICA Study Team (Nagcarlan)
Observation period is illustrated in Fig. I.1.6
n.a.: not available

(5) Evaporation

Evaporation data (Class A-pan) are observed at Los Baños (refer to Table I.2.13), Cavinti and Barangay Bukal, Nagcarlan. The following are the monthly pan evaporation data:

Mean Monthly Pan Evaporation (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Los Baños	119.6	143.8	195.4	218.0	195.5	146.7	130.2	127.7	116.6	117.9	101.3	100.2	1,712.9
Cavinti	105.4	115.6	161.0	173.4	178.0	145.0	136.9	130.2	118.0	110.8	98.3	92.8	1,565.4
Nagcarlan (Bukal)	n.a.	93.2	79.1	100.8	88.4	86.1	70.4	82.2	n.a.	83.1	114.6	n.a.	n.a.

Source: UPLB, IRRI (Los Baños)
Compilation of Weather Data:IRRI (Cavinti)
JICA Study Team (Nagcarlan)
Observation period is illustrated in Fig. I.1.6
n.a.: not available

(6) Wind velocity and direction

Wind velocity and direction data were observed at the stations of Los Baños and Cavinti. Average wind velocity observed at Los Baños and Cavinti range from a minimum of 0.8 m/sec, 1.4 m/sec to a maximum of 1.3 m/sec, 2.7 m/sec, respectively.

Mean Monthly Wind Velocity (m/sec)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Los Baños	1.1	1.2	1.3	1.3	1.1	0.9	0.9	0.9	0.8	0.8	1.0	1.1	1.0
Cavinti	2.6	2.4	2.3	2.0	1.7	1.5	1.4	1.7	1.4	1.5	2.2	2.7	2.0

Source: UPLB, IRRI (Los Baños)
Compilation of Weather Data:IRRI (Cavinti)
Observation period is illustrated in Fig. I.1.6

Prevailing Wind Direction

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Los Baños	NE	E	NE	NE	NE	E	SW-E	SW	E	E	E	NE

Source: UPLB, IRRI (Los Baños)
Observation period is illustrated in Fig. I.1.6

Monthly wind velocity and prevailing wind direction observed at Los Baños are tabulated in Tables I.2.14.

(7) Sunshine duration

Monthly percent possible sunshine were observed at Los Baños. The average high possible sunshine was 72 % in April and low possible sunshine was 38 % in August. Mean monthly percent possible sunshine and sunshine duration data observed at Los Baños are listed in Tables I.2.15,16.

Mean Monthly Percent Possible Sunshine (%)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Los Baños	47	58	66	72	61	45	41	38	39	43	43	49	49

Source: UPLB, IRRI (Los Baños)
Observation period is illustrated in Fig. I.1.6

Mean Monthly Sunshine Duration (hr/day)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Los Baños	5.3	6.8	7.9	8.8	7.8	5.8	5.2	4.8	4.8	5.1	5.0	4.5	6.0

Source: UPLB, IRRI (Los Baños)
Observation period is illustrated in Fig. I.1.6

(8) Tropical cyclones

Frequency of tropical cyclones and annual distribution of tropical cyclones by intensity are referred to Tables I.1.17, 18,19.

2.3 Statistical Data Analysis

The rainfall data and other meteorological data, such as temperature, relative humidity, and pan evaporation data in the Study area have been observed at three (3) stations in the Municipalities of Nagcarlan and Liliw. It is, however, not available for a statistical data analysis due to its considerably short observation period. The reliable meteorological data in the vicinity area have observed at the stations of Sta. Cruz, Laguna, Los Baños, Laguna (University of the Philippines: UPLB, International Rice Research Institute:IRRI), Cavinti, Laguna, and Tayabas, Quezon Province.

In the statistical data analysis, (1) probable rainfall, (2) probable rainfall intensity curve, (3) parameter for Penman method, (4) number of the rainy days. (5) correlation of rainfall amongst several observation stations were estimated applying the meteorological observation data in the Study area and in the vicinity area as described above in due consideration of its data reliability.

(1) Probable rainfall

Probable annual rainfalls were estimated using the Iwai method at the stations of Los Baños, Sta. Cruz, Tayabas, Ambulong and Caliraya.

Probable Annual Rainfall (mm)

Return period (years)	Observation station					
	Los Baños	Sta. Cruz	Tayabas	Ambulong	Caliraya	Remarks
2	1,949.9	1,835.5	2,991.5	1,899.0	3,078.6	
3	1,777.9	1,656.2	2,778.1	1,732.1	2,855.4	
5	1,622.0	1,496.1	2,588.8	1,575.4	2,657.5	
7	1,539.6	1,412.5	2,490.3	1,490.4	2,554.8	
10	1,463.5	1,336.0	2,400.3	1,410.4	2,460.9	
15	1,387.6	1,260.2	2,311.5	1,329.0	2,368.3	
20	1,339.0	1,212.0	2,255.1	1,276.1	2,309.6	
25	1,303.6	1,177.1	2,214.4	1,237.3	2,267.2	
30	1,276.3	1,150.3	2,183.0	1,207.0	2,234.5	
40	1,235.2	1,110.0	2,136.2	1,161.1	2,185.7	
50	1,205.3	1,080.8	2,102.2	1,127.3	2,150.4	
100	1,119.6	997.8	2,005.9	1,029.1	2,050.2	
150	1,074.3	954.2	1,955.4	976.2	1,997.8	
200	1,043.8	925.1	1,921.7	940.2	1,962.7	
Max. annual rainfall (year)	3,016.9 (1986)	2,851.4 (1960)	4,143.2 (1976)	2,602.3 (1976)	3,674.1 (1975)	
Min. annual rainfall (year)	1,216.0 (1965)	1,145.1 (1983)	1,983.5 (1982)	1,179.2 (1965)	1,990.3 (1969)	
Observation period	1950 - 1993	1956 - 1993	1971 - 1992	1961 - 1984	1965 - 1983	
Number of observation years	44	35	20	24	10	

Source: JICA Study Team
Probable rainfall more than 15 year return period at Caliraya is not reliable due to its short observation data.

(2) Probable rainfall intensity curve

Probable rainfall intensity curves were calculated using the data of Tayabas in Quezon Province, and Ambulong in Batangas Province. These two (2) stations are close to the Study area amongst 38 selected stations in the Philippines(Rainfall Intensity-Duration Frequency Data). For an estimate of flood discharge in connection to the proposed facilities planning, such as intake, road drainage, rainfall intensity data observed at Ambulong in Batangas Province should be applied for the reason that the rainfall intensity at Ambulong gives larger amount comparing with that at Tayabas taking safety factor for the planning into account.

Rainfall Intensity Curve (Tayabas)

Observation station: Tayabas, Quezon Province
Observation period: 30 years

Return Period (years)	Return Period 15 (min)	30 (min)	60 (min)	2 (hrs)	6 (hrs)	12 (hrs)	24 (hrs)	Intensity Curve (mm/hr)
2	91.6	66.8	49.2	33.7	16.5	10.5	5.7	$R=\frac{68.14}{t^{0.77}+0.40}$
5	104.0	80.2	60.1	43.3	22.7	16.3	10.1	$R=\frac{83.73}{t^{0.65}+0.40}$
10	112.0	89.0	67.3	49.6	26.7	20.2	13.0	$R=\frac{95.89}{t^{0.61}+0.43}$
15	116.8	94.0	71.3	53.2	29.0	22.4	14.7	$R=\frac{102.24}{t^{0.59}+0.43}$
20	120.0	97.6	74.2	55.7	30.7	23.9	15.8	$R=\frac{110.63}{t^{0.59}+0.48}$
25	122.4	100.2	76.4	57.6	31.9	25.1	16.7	$R=\frac{113.51}{t^{0.58}+0.48}$
50	130.0	108.6	83.1	63.6	35.7	28.7	19.5	$R=\frac{125.44}{t^{0.56}+0.50}$
100	137.6	116.8	89.8	69.5	39.5	32.4	22.2	$R=\frac{139.66}{t^{0.55}+0.55}$

Source: First Edition, Rainfall Intensity-Duration Frequency Data, January 1981
The Hydrology and Flood Forecast Center, PAGASA

Rainfall Intensity Curve (Ambulong)

Observation station: Ambulong, Tanauan, Batangas Province
Observation period: 14 years

Return Period (years)	Return Period 15 (min)	30 (min)	60 (min)	2 (hrs)	6 (hrs)	12 (hrs)	24 (hrs)	Intensity Curve (mm/hr)
2	100.4	76.8	49.0	32.4	15.5	9.7	5.6	$R=\frac{68.73}{t^{0.78}+0.35}$
5	134.4	101.2	66.0	42.5	23.8	18.2	11.3	$R=\frac{75.01}{t^{0.59}+0.12}$
10	156.8	117.4	77.3	49.3	29.2	23.7	15.0	$R=\frac{81.43}{t^{0.53}+0.04}$
15	169.2	126.6	83.7	53.0	32.3	26.9	17.2	$R=\frac{84.22}{t^{0.50}-0.00}$
20	178.0	133.0	88.2	55.7	34.5	29.1	18.7	$R=\frac{88.57}{t^{0.49}-0.01}$
25	184.8	137.8	91.6	57.8	36.1	30.8	19.8	$R=\frac{90.55}{t^{0.48}-0.02}$
50	206.0	153.0	102.2	64.0	41.3	36.1	23.3	$R=\frac{95.72}{t^{0.45}-0.07}$
100	226.8	168.2	112.7	70.3	46.3	41.3	26.8	$R=\frac{102.45}{t^{0.43}-0.10}$

Source: First Edition, Rainfall Intensity-Duration Frequency Data, January 1981
The Hydrology and Flood Forecast Center, PAGASA

(3) Parameter for Penman method

Potential evapotranspiration is estimated by Penman method using the data of temperature, relative humidity, wind velocity, sunshine duration. In this paragraph, these meteorological parameter for the estimate of the potential evapotranspiration are estimated.

a) Temperature

Mean monthly temperature is not fluctuated throughout several years. The difference of mean monthly temperature data between at Loa Baños and Nagcarlan ranged from 4 to 5 °C in each month. In this fact, temperature observed at Barangay Bukal, Nagcarlan in the Study area is available despite of its one (1) year observation period.

Mean Monthly Temperature (°C)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nagcarlan (Bukal)	20.6	20.6	21.2	22.2	23.6	23.0	22.0	22.8	22.5	22.2	22.0	21.0	22.0

Source: JICA Study Team

b) Relative humidity

In general, relative humidity indicates high percentage during rainy days. In this connection, one (1) year observation data in the Study area was affected by the number of rainy days. Relative humidity data observed at Los Baños are applied for potential evapotranspiration calculation due to its long observation period.

Mean Monthly Relative Humidity (%)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Los Baños	82	79	75	74	76	80	82	83	83	84	83	83	80

Source: UPLB, IRRI

c) Wind velocity

Wind velocity data were observed at Los Baños and Cavinti. Wind velocity data observed at Los Baños are applied for potential evapotranspiration calculation because of a topographical similarity of Los Baños and the Study area.

Wind Velocity (m/sec)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Los Baños	1.1	1.2	1.3	1.3	1.1	0.9	0.9	0.9	0.8	0.8	1.0	1.1	1.0

Source: UPLB, IRRI

d) Sunshine duration

Sunshine duration data were given at Los Baños. However, it is assumed that the percent possible sunshine is certainly small in the Study area comparing with that of at Los Baños because of the difference of the elevation and influence of the monsoon wind direction throughout the year. For the calculation of potential evapotranspiration, 80 % of sunshine duration observed at Los Baños is applied at the Study area based on the monthly rainy days rates between those of at Loa Baños and Nagcarlan.

Mean Monthly Sunshine Duration (hr/day)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
(Nagcarlan)	4.2	5.4	6.3	7.1	6.2	4.5	4.2	3.9	3.8	4.1	4.0	3.6	4.8

Source: JICA Study Team

(4) Number of rainy days

Number of rainy days were observed at the station of Los Baños, Cavinti, sta. Cruz and the Municipality of Liliw. The Following are mean monthly data of each stations.

Mean Monthly Rainy Days (day)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Los Baños (1950 - 1993)	12	7	6	6	12	18	20	20	20	19	18	17	176
Cavinti (1085 - 1993)	24	19	14	13	17	19	20	21	21	23	24	25	240
Sta. Cruz (1956 - 1990)	9	6	6	6	10	15	18	18	18	18	16	13	153
Liliw (1979 - 1981)	9	9	6	7	12	16	16	13	19	20	18	18	163

Source: PAGASA (Los Baños, Sta. Cruz, Liliw)
Compilation of Weather Data: IRRI (Cavinti)

(5) Correlation of rainfall data amongst several observation stations

In connection to the water requirement for irrigation planning, correlation of the daily rainfall data observed in the vicinity of the Study area was examined in due consideration of the shortage of the rainfall data at Liliw station located at the Study area for the reliable simulation of the water requirement. The following are the correlation coefficient of each observed rainfall data at the stations of Liliw, Sta. Cruz, Los Baños and Caliraya. As a result of the analysis, rainfall data observed at Caliraya has highest correlation coefficient with that of Liliw.

Correlation Coefficient of Rainfall Data

Station	Liliw	Sta. Cruz	Los Baños	Caliraya
Liliw	1			
Sta. Cruz	0.347	1		
Los Baños	0.391	0.568	1	
Caliraya	0.464	0.607	0.640	1

Source : JICA Study Team
Rainfall data: 1979 - 1981 (3 years)

3 Hydrology

3.1 River System

(1) Laguna Lake basins

The Laguna Lake basins is composed of the Pasig-Laguna Bay river basin with total drainage area of 4,678 sq.km and small watersheds with its total area of 400 sq.km. The Pasig-Laguna Bay river basin drains three (3) district and different sub-basins, viz., the Marikina river basin, the Laguna Lake basin, and the urban watershed which includes the Manila urban area. The Study area is included in the Laguna Lake basin. Laguna de Bay is a shallow lake. It serves as a natural detention reservoir for discharges from the surrounding forty (40) tributaries. Major tributaries amongst them are Pila-Santa Cruz, San Juan, San Cristobal, Pagsanjan and Romero-Sta. Maria rivers. The only outlet is the Pasig river via Napindan channel.

There are twenty two (22) stream gaging stations within the Laguna Lake basins, of which nine (9) stations have discharge data. The mean annual runoff depth of the Laguna Lake basins is placed at 1,435 mm or approximately 7,287 MCM with the Pasig-Laguna de Bay river basin (Laguna Lake Basins) accounting for more than 92 %, supplying 6,713 MCM. The following are the runoff data of main rivers in Laguna Lake basins.

Runoff Data of Main Rivers in Laguna Lake Basins

	River	Drainage area (sq.km)	Mean discharge (cu.m/sec)	Specific discharge (cu/m/sec/sq.km)	Max. Annual (cu.m/sec)	Min. Annual (cu.m/sec)	*Runoff ratio
1	Marikina river (Sto. Niño)	499	30.31	0.061	3,420.0	0.07	0.89
2	Marikina river (San Rafael)	282	16.60	0.059	1,017.0	0.01	0.86
3	Arangilan river	87	0.64	0.007	380.7	0.02	0.13
4	Mabacan river	46	1.21	0.026	215.3	0.01	0.38
5	Paputok river	8.5	0.95	0.111	91.1	0.12	-
6	Sta. Cruz river	103	4.74	0.460	298.0	0.02	0.63
7	Balanac river (upper)	116	8.72	0.752	531.2	0.89	0.82
8	Balanac river (lower)	n.d.	1.75	-	175.5	0.03	-
9	Mayor river	45	1.64	0.037	139.5	0.01	0.52

n.d.: not defined
Source : Laguna Lake Basins, National Water Resources Council, 1983
Source*: The Master Plan Study on the project CALABARZON
Observation period:

1	Marikina river (Sto. Niño)	(1958 - 69)
2	Marikina river (San Rafael)	(1956 - 69)
3	Arangilan river	(1956 - 70)
4	Mabacan river	(1955 - 70)
5	Paputok river	(1955 - 70)
6	Sta. Cruz river	(1944 - 70)
7	Balanac river (upper)	(1958 - 70)
8	Balanac river (lower)	(1956 - 70)
9	Mayor river	(1949 - 70)

Fig. I.3.1 presents the flow duration curve of above main rivers in the Laguna Lake basins. As a results, annual fluctuation of the runoff of the rivers of Sta. Cruz and Balanac, which are originated from the Mts. Banahaw and San Cristobal, is considerably small comparing with those of the other rivers because of predominant recharge capacity of groundwater due to permeable volcanic deposits in their watersheds.

(2) The Study area

The Study area is located at the upstream of the drainage areas of the Sta. Cruz and Balanac rivers. Drainage areas of the several tributaries of the Sta. Cruz and Balanac rivers are shown in Fig. I.3.2. Drainage area of each river is as follows:

Drainage Areas of Rivers in the Study Area

Rivers	Drainage area (sq.km)
(Sta. Cruz river)	103.00
1 San Diego river	7.65
2 Nagcarlan river	17.95
3 Oples river	3.28
4 Liliw river	10.27
5 Buncol river	6.19
6 Bancal river	5.63
7 Maimpis river	15.40
(Balanac river)	116.00
7 Olla river	6.76
8 Atila river	5.65

Drainage area of each river is estimated at conjection with Sta. Cruz and Balanac rivers.
Drainage areas of the Sta. Cruz and Balanac rivers are at runoff observation stations.
Source: Sta. Cruz/Balanac rivers: Laguna Lake Basins, National Water Resources Council
Other rivers: JICA Study Team

As shown in Fig. I.3.2, the San Diego, Nagcarlan, Oples, Liliw, Bancal and Maimpis rivers are tributaries of the Sta. Cruz river. Meanwhile, the Olla river is tributary of the Balanac river. The following are monthly flow of these rivers. Runoff ratios of the Sta. Cruz and Balanac rivers are 0.63, 0.82, respectively.

Mean Monthly Flow

Rivers	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Sta. Cruz (1944 - 70)	5.82	4.59	3.73	3.05	2.94	3.59	3.86	4.64	5.44	6.04	6.59	6.62	4.74
Balanac (1958 - 70)	8.76	7.27	6.60	6.01	5.56	6.08	7.43	8.25	10.59	11.98	13.96	12.16	8.72

Source: Laguna Lake Basins, National Water Resources Council

3.2 Surface Run-off

3.2.1 General

Around 80 % of the annual rainfall is observed in seven months, from May to November. Monthly rainfall amount of 200 mm to 350 mm is more or less evenly distributed during the wet season. From the geological point of view, permeable volcanic deposits that thickly mantle the mountainsides of Mts. Banahaw and San Cristobal accelerate recharge of groundwater by runoff percolation. In relation to the fact, stable spring yield and surface water originated from springs are perennially observed in the Study area.

Major rivers in the Study area are illustrated in Fig. I.3.3. There are seven (7) rivers, namely, the San Diego and the Nagcarlan rivers in Nagcarlan Municipality, the Oples, the Liliw and Bancal rivers in Liliw Municipality, and the Maimpis and the Olla rivers in Majayjay Municipality. Out of these rivers, three (3) the San Diego, the Oples and the Bancal rivers dry up in the dry season, where as the Nagcarlan, the Liliw, the Maimpis, the Olla rivers are perennial.

In this survey period, four (4) springs with considerable yield were confirmed. Bukal spring in Nagcarlan, lower Luquin and upper Luquin springs, and Maimpis river spring in Majayjay. Several springs were also observed at the lower elevated area (El. 450 m or less). These spring have adequate yields and have been utilized for the domestic water use outside of the Study area.

3.2.2 River runoff

During the dry season, discharge of 0.17 to 0.22 cu.m/sec in the Liliw river, and 0.28 to 0.34 cu.m/sec in the Maimpis river were observed at the observation stations shown in Fig. I.3.4. Runoff observation of the rivers were carried out at the rivers of Liliw and Maimpis. Monthly runoff data are as follows:

Mean Monthly Flow (cu.m/sec)

Rivers	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Liliw river													
1993				0.165	0.218	0.351	0.239	0.249	0.230	0.250	0.281	0.315	
1994	n.a.	0.218	0.223										0.249
Maimpis river													
1993				0.440	0.493	0.514	0.459	0.474	0.461	0.373	0.446	0.461	
1994	0.342	0.291	0.284										0.420

n.a.: not available
Source: JICA Study Team

Drainage areas of the rivers at the observation points, annual flow, minimum flow during the Study period and runoff ratios are as follows (refer to Fig. I.3.4):

Runoff observation Data of Rivers in the Study Area

Rivers	Drainage area (sq.km)	Annual flow (cu.m/sec)	Specific discharge (cu.m/sec/sq.km)	Minimum flow (cu.m/sec)	Specific discharge (cu.m/sec/sq.km)
Liliw river	6.68	0.249	0.037	0.120	0.018
Maimpis river	8.75	0.420	0.048	0.279	0.032

Source: JICA Study Team
Location is indicated in Fig. I.3.4

3.2.3 Spring yield

In the Study area, four (4) springs with considerable yield were confirmed at the elevation of more than 500 m. Bukal spring in Nagcarlan yields 0.040 to 0.045 cu.m/sec at El. 890 m. Two springs, lower Luquin and upper Luquin springs yield 0.200 cu.m/sec and 0.070 cu.m/sec at El. 560 m and El. 610 m, respectively.

Maimpis river spring in Majayjay yields as large as 0.200 cu.m/sec at El. 600 m. The yield frequency of Bukal spring are listed below for one year observation period from May 1993 to April 1994.

Spring Yield of Bukal Spring

(unit: cu.m/sec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1993					0.041	0.054	0.046	0.042	n.a.	0.042	0.041	0.048
1994	0.075	n.a.	0.043	0.055								

n.a.: not available
Source: JICA Study Team
Location is indicated in Fig. I.3.4

Spring yields in December 1993 and January 1994 were remarkably abundant due to the rainfall as the end of the wet season. Despite the short observation period of the spring yields, it is estimated that the spring yield is not less than 0.040 cu.m/sec at Bukal spring. Few observation data at the springs of the Luquin and Majayjay were not useful to estimate their spring yield. However, as described above, the observation yield during the dry season give minimum spring yields assuming a spring yield in the dry season to be constant.

Spring Yield of Luquin Spring

(unit : cu.m/sec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994		0.07	0.06	n.a.	n.a.	n.a.	0.08	n.a.	n.a.			

n.a.: not available
Source: JICA Study Team
Location is indicated in Fig. I.3.4

4 Water Quality

4.1 Water Quality Test

Water quality of the surface water and spring is an important factor for the water resources development. Water quality test is key determinant to identify sound water resources availability.

Twenty (20) sampling sites were specified in the Study area as shown in Fig. I.4.1.

(1) Items of water quality test

Six (6) items of water quality test (temperature, pH, conductivity, dissolved oxygen (DO), total suspended solids (TSS) and chemical oxygen demand (COD)), were conducted taking matters mentioned below into consideration.

a) to complete test quickly (avoiding change in water quality)

b) to examine the availability of surface or spring water for irrigation and domestic use.

(2) Results of the test

Results of the water quality test is listed as follows:

Results of Water Quality Test

Area	Sample No.	Temperature (°C)	pH	Conductivity (µmho/cm)	DO (mg/l)	TSS (mg/l)	COD (mg/l)	Sources
Nagcarlan	1	25.7	6.30	32	8.43	<1.0	<4.0	Spring(river)
	2	25.1	6.85	42	8.43	<1.0	<4.0	Spring
	3	24.5	6.35	52	8.17	<1.0	<4.0	Spring
	4	25.1	6.62	82	8.69	<1.0	<4.0	Spring
	5	24.5	6.60	68	8.01	9.0	<4.0	Spring(river)
	6	24.5	6.01	51	8.11	4.5	<4.0	Spring(river)
	7	24.2	5.70	38	8.13	3.0	<4.0	Spring
	8	25.2	6.55	67	6.78	<1.0	<4.0	Spring
	9	24.6	6.65	48	7.05	<1.0	<4.0	Spring(river)
	10	24.4	5.78	167	8.53	<1.0	<4.0	Spring(river)
	11	24.2	5.88	110	7.57	<1.0	<4.0	Spring(river)
	12	25.8	5.78	120	7.46	<1.0	<4.0	Spring(river)
	13	24.7	6.60	60	8.96	<1.0	<4.0	Spring
	14	24.8	6.48	92	8.52	<1.0	<4.0	Spring(river)
	15	25.1	6.62	93	5.14	26.5	<4.0	Spring
	16	24.3	6.70	66	8.11	<1.0	<4.0	River
Liliw	17	24.6	6.55	55	7.65	2.0	<4.0	River
Majayjay	18	24.3	6.65	50	8.66	<1.0	<4.0	River
Nagcarlan	19	25.9	5.80	157	1.61	8.0	<4.0	Fish pond
	20	24.6	6.30	82	5.24	2.0	<4.0	Pond

Test date: February 1994

(3) Considerations

According to an authorized water quality guideline listed below, irrigation water had levels above 6 ppm of BOD, COD, and 1 m.mho of electrical conductivity and less than 5 ppm of dissolved oxygen, thus constituting a growth impediment for crop plants. As a reference, guidelines of water quality for irrigation in the Philippines is shown as follows:

Limited Content of Water Pollution or Crop Growth

Items	Unit	Unaffected Content	Notes
pH	pH	6.0 - 7.0	Acidity - Alkalinity
Cl	ppm	500 - 700	Chloride
EC	m.mho/cm	Less than 1	Electrical Conductivity
T-N	ppm	Less than 5	Total - Nitrogen
NH4-N	ppm	Less than 3	Ammonia - Nitrogen
ABS	ppm	Less than 3	Alkyl Benzene Sulfonate
COD	ppm	Less than 6	Chemical Oxygen Demand
BOD	ppm	Less than 5 - 8	Biochemical Oxygen Demand
DO	ppm	More than 5	Dissolved Oxygen
As	ppm	Less than 1	Arsenic
SS	ppm	Less than 100	Suspended Solid

Source : Agricultural pollution handbook in Japan

Water Quality Standards for Potable Water

Items	Unit	AA	A	B
pH	pH	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5
BOD	ppm	Less than 1	Less than 2	Less than 3
COD	ppm	Less than 1	Less than 3	Less than 3
DO	ppm	More than 7.5	More than 7.5	More than 5.0
SS	ppm	Less than 25	Less than 25	Less than 25

Source : Design Criteria for Waterworks Facilities (Japan Water Works Association)

AA : Filtration, disinfection are required.

A : Filtration, sedimentation and disinfection are required.

B : Special treatment are required.

Water temperature data in the Study area show almost the same ranging from 24°C to 26°C. Acidity - alkalinity values range from pH 5.70 to 6.85, and electrical conductivity values show less than 200 μmho/cm, thus these are quite harmless for irrigation use. As for acidity - alkalinity, the value shows slightly acidic. This tendency is generally observed from the water in the pyrogenous area.

Dissolved oxygen (DO) values show more than five (5) mg/l except the water in fish pond (Sample No. 19). It is assumed that the low values of DO of the spring water (Sample No. 15) and pond water (Sample No. 20) are caused by contamination by bacilli due to its stagnation. Total suspended solid values are less than 25 and chemical oxygen demand values also show less than 4 mg/l.

As described above, almost surface and spring water is harmless for irrigation use. Meanwhile, it is recommended that the intake facilities for domestic water supply should be provided at highly elevated springs to avoid an contamination as indicated in the DO values.

4.2 Water Quality of the Laguna de Bay

The Laguna de Bay is a shallow with its average depth of around three (3) m. At present, the lake is mainly used for fishery, navigation and limited irrigation. The Laguna Lake Development Authority (LLDA) is undertaking water quality monitoring program at four (4) monitoring stations on the Laguna de Bay. The water quality data for recent six years are shown in Table I.4.2. The current water of the Laguna de Bay is rather clean conditions with high concentration of DO (7 - 8 ppm) and low of BOD (2 - 3 ppm), and it complies with the designated criteria of Class "C" (refer to Table I.4.3).

Table I.2.1 Monthly Rainfall Data of Los Baños (UPLB)

Observation Station: University of the Philippines
Los Banos, Laguna

(unit:mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	93.2	44.7	71.4	31.0	231.9	149.9	117.9	182.6	202.9	200.4	180.8	126.2	1632.9
1951	29.2	11.4	1.3	46.7	174.5	149.6	187.7	222.2	218.2	160.0	537.5	142.5	1880.8
1952	50.0	42.7	21.3	9.6	116.6	217.2	457.4	T	199.9	413.3	80.5	392.2	T
1953	20.6	67.1	34.8	4.1	136.1	256.0	115.3	295.4	102.9	78.5	266.7	190.7	1568.2
1954	28.2	43.7	68.3	26.7	100.1	157.0	264.4	233.2	183.1	162.6	144.8	184.7	1596.8
1955	106.2	3.6	9.6	48.3	149.9	116.3	126.7	137.9	154.4	230.4	397.6	23.4	1504.3
1956	40.9	1.8	22.6	74.4	209.8	180.6	244.1	317.0	349.2	113.0	180.8	357.4	2091.6
1957	127.2	3.3	27.9	27.2	26.7	169.4	224.8	213.1	109.2	399.5	61.0	18.8	1408.1
1958	42.4	31.5	28.4	17.0	95.5	330.7	243.8	195.1	190.2	321.8	91.9	8.1	1596.4
1959	31.6	5.0	75.1	8.2	147.4	131.1	418.9	210.6	77.0	82.9	334.9	208.6	1731.3
1960	161.6	132.7	38.7	78.7	455.0	442.5	152.7	354.2	334.3	458.2	136.0	33.1	2777.7
1961	20.0	11.7	13.1	22.9	159.5	351.6	175.1	317.0	305.8	215.4	394.4	63.6	2050.1
1962	11.3	10.2	15.2	24.5	138.9	152.4	440.7	190.0	715.0	62.8	316.8	30.2	2108.0
1963	10.6	4.0	1.0	13.0	48.0	270.8	268.8	326.6	483.5	131.6	77.7	136.1	1771.7
1964	20.5	66.7	17.3	35.6	190.6	487.3	266.7	262.3	245.6	289.9	455.5	100.7	2438.7
1965	33.5	10.3	20.1	79.7	133.5	91.0	238.3	106.6	123.2	84.4	173.9	121.5	1216.0
1966	36.1	23.6	22.0	4.1	441.6	194.0	167.9	198.7	201.7	140.0	410.4	423.0	2263.1
1967	174.2	11.9	11.2	17.1	20.9	232.9	126.2	297.5	267.5	177.6	428.5	36.7	1802.2
1968	21.6	3.6	10.7	15.9	113.4	245.7	221.0	207.0	192.1	158.0	72.1	20.3	1281.4
1969	12.7	0.3	24.3	2.1	60.5	134.8	331.8	146.0	167.2	106.1	122.2	253.1	1361.1
1970	41.0	16.8	20.2	20.3	19.9	177.9	149.7	182.6	294.6	560.5	412.8	152.7	2049.0
1971	13.3	13.3	107.3	14.1	213.8	320.6	338.8	65.3	133.7	313.5	260.1	487.3	2281.1
1972	52.1	4.6	31.7	17.3	170.3	334.4	815.2	322.0	225.2	150.5	218.9	141.3	2483.5
1973	35.3	12.1	23.5	34.9	92.5	171.0	227.6	220.1	162.5	314.5	513.1	288.5	2095.6
1974	3.4	14.9	23.4	2.9	132.0	307.0	165.6	439.6	133.3	372.8	501.0	398.4	2494.3
1975	68.5	5.2	31.5	136.3	69.0	135.8	216.1	265.2	214.1	165.9	187.7	338.8	1834.1
1976	34.1	8.1	35.8	21.0	857.7	351.4	85.4	296.1	230.7	109.6	134.0	202.9	2366.8
1977	84.8	40.8	18.8	18.0	103.7	134.9	234.4	198.7	390.4	102.3	239.2	19.3	1585.3
1978	10.8	4.7	4.1	38.7	228.1	87.6	273.9	526.1	461.3	729.8	217.2	90.9	2673.2
1979	11.5	6.0	5.8	163.7	231.3	287.3	142.2	395.4	373.1	124.2	146.5	69.4	1956.4
1980	15.0	16.7	119.1	7.7	127.5	370.1	331.2	293.2	156.7	422.5	298.3	96.8	2254.8
1981	27.4	9.2	1.6	5.0	87.5	332.0	278.7	79.6	265.2	285.9	289.5	119.4	1781.0
1982	14.0	12.2	12.6	43.9	54.0	81.2	320.5	191.6	454.4	54.8	74.4	122.7	1436.3
1983	72.1	1.6	5.4	0.2	48.3	192.2	619.4	179.2	141.2	369.6	30.4	17.9	1677.5
1984	43.8	7.9	32.4	81.8	275.5	287.4	79.8	300.5	119.0	757.9	128.4	25.6	2140.0
1985	11.7	4.6	29.5	94.9	57.0	665.3	391.3	59.1	247.7	346.6	145.8	97.2	2150.7
1986	11.1	53.0	8.8	10.9	147.2	184.1	503.0	418.0	319.9	812.4	422.7	125.8	3016.9
1987	39.6	3.2	3.5	18.5	73.8	255.3	126.9	152.0	287.9	75.9	252.4	281.4	1570.4
1988	225.3	28.2	10.9	117.2	92.0	247.9	196.0	192.8	92.7	846.5	433.5	23.2	2506.2
1989	71.7	80.1	118.6	11.2	400.1	206.2	295.1	229.1	271.1	301.9	40.3	29.8	2055.2
1990	12.7	3.9	31.1	6.6	239.7	369.2	254.5	426.1	203.1	310.5	323.6	150.5	2331.5
1991	33.3	23.6	72.5	29.2	50.3	281.4	295.4	504.6	186.2	66.7	287.9	161.7	1992.8
1992	8.4	15.7	32.1	37.5	114.4	74.0	406.3	329.4	240.9	168.7	382.4	102.0	1911.8
1993	22.1	2.8	2.6	24.1	35.8	141.5	241.7	277.7	224.7	339.7	240.1	596.4	2149.2
Average	46.2	20.9	29.9	35.1	160.7	237.6	267.7	254.8	242.1	274.8	251.0	159.3	1980.2

Table I.2.2 Monthly Rainfall Data of Sta. Cruz

Observation Station: Sta. Cruz (MRAIN034)
Sta. Cruz, Laguna

(unit:mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1956	43.1	5.3	63.5	136.2	210.6	239.8	307.2	458.1	494.7	195.6	158.6	309.4	2622.1
1957	139.6	4.6	28.5	78.3	5.4	130.7	202.9	283.0	204.5	326.7	59.0	27.2	1490.4
1958	38.6	11.3	4.6	38.4	57.7	209.1	257.4	214.8	291.9	294.4	135.8	23.2	1577.2
1959	45.8	12.0	56.0	4.9	65.3	97.9	322.6	366.0	104.9	157.4	381.1	172.3	1786.2
1960	146.4	129.8	32.8	81.7	326.3	501.1	136.7	487.9	433.6	444.9	109.7	28.2	2859.1
1961	19.6	8.4	32.2	8.9	187.3	249.6	320.8	372.4	467.3	239.1	382.8	65.6	2354.0
1962	6.7	7.6	5.4	43.9	196.8	302.6	421.9	280.2	548.9	61.0	128.4	91.3	2094.7
1963	5.9	35.1	0.8	7.3	7.3	326.4	197.6	461.0	511.6	157.7	112.1	86.4	1909.2
1964	43.1	35.1	31.5	39.2	109.8	249.1	307.6	185.3	351.2	282.7	375.9	135.4	2145.9
1965	33.5	10.3	20.3	35.1	133.9	125.5	238.3	103.0	123.2	82.6	173.1	108.6	1187.4
1966	50.5	35.5	50.5	6.9	377.9	111.4	244.4	127.5	223.9	195.5	401.6	280.7	2106.3
1967	175.8	12.0	7.0	17.1	30.5	233.2	122.6	282.3	173.9	167.2	427.7	36.4	1685.7
1968	37.4	3.8	14.8	4.5	77.5	157.1	176.3	215.1	233.4	225.8	59.6	20.3	1225.6
1969	16.3	0.5	11.8	9.5	69.1	111.8	362.9	141.8	141.1	124.2	130.6	232.2	1351.8
1970	30.4	17.7	21.3	38.0	111.0	206.0	256.0	134.8	359.2	516.6	577.0	178.8	2446.8
1971	12.5	25.6	82.7	18.3	229.8	392.8	317.9	165.8	208.5	418.5	340.9	449.6	2662.9
1972	65.2	3.0	65.4	38.1	145.5	330.5	753.1	274.9	126.8	227.4	179.2	110.1	2319.2
1973	34.9	6.3	7.5	9.6	86.0	209.4	185.5	135.6	257.8	321.0	356.7	288.0	1898.3
1974	3.8	22.4	11.6	8.9	123.2	194.5	145.9	429.7	151.5	326.1	386.2	270.0	2073.8
1975	113.5	8.5	90.6	202.3	62.5	149.8	86.0	246.3	236.4	269.4	184.5	355.1	2004.9
1976	25.7	8.6	13.3	39.2	539.2	227.4	202.6	256.2	228.4	127.1	197.8	213.3	2078.8
1977	143.8	21.7	27.5	11.3	85.6	272.0	179.5	230.7	256.3	133.7	190.5	21.0	1573.6
1978	21.6	7.4	0.5	28.5	105.5	97.3	126.9	503.6	299.6	749.0	148.8	107.1	2195.8
1979	9.9	10.7	3.3	188.5	228.4	279.2	135.8	271.6	231.7	230.7	206.3	24.6	1820.7
1980	4.9	T	91.5	13.9	96.1	232.9	245.0	215.5	135.7	T	362.4	190.2	T
1981	18.1	3.7	4.9	23.9	108.5	216.3	353.2	174.2	261.0	305.1	316.8	78.1	1863.8
1982	1.4	14.8	26.9	22.7	65.4	131.4	464.0	151.0	312.2	111.9	160.2	59.9	1521.8
1983	54.7	3.2	14.7	0.5	18.5	101.2	222.8	189.8	126.3	300.2	107.0	5.2	1144.1
1984	9.1	1.6	10.8	57.1	178.6	203.7	70.2	323.4	162.9	618.4	122.4	27.3	1785.5
1985	9.1	12.4	21.9	54.9	114.6	465.4	211.2	93.5	159.0	361.2	115.9	81.4	1700.5
1986	10.6	8.8	1.0	4.2	109.6	30.0	226.8	341.5	192.7	340.5	299.9	80.5	1646.1
1987	14.8	1.4	1.0	1.0	33.4	119.7	T	170.0	245.1	86.1	218.8	106.6	T
1988	98.6	47.1	1.5	124.7	83.5	296.9	147.1	185.9	146.7	582.4	372.9	7.6	2094.9
1989	80.9	100.6	109.7	0.0	185.3	164.4	312.3	328.4	270.1	167.3	27.0	14.9	1760.9
1990	30.0	8.2	32.2	4.8	204.4	299.2	200.6	330.2	193.8	301.6	183.6	109.0	1897.6
1991	22.4	31.5	15.8	43.6	40.9	162.8	206.4	320.5	178.4	103.8	65.5	136.6	1328.2
1992	9.6	0.0	16.0	42.2	71.0	90.0	244.4	229.8	148.6	92.5	244.4	52.5	1241.0
1993	4.0	5.4	5.6	3.8	0.0	158.2	248.7	151.6	60.0	163.0	152.2	T	T
Ave.	42.9	18.4	27.3	39.3	128.5	212.5	247.6	258.8	243.5	265.1	225.1	123.9	1832.9

Table I.2.3 Monthly Rainfall Data of Tayabas

Observation Station: Tayabas, Quezon

(unit:mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1971	109.9	85.9	144.7	65.1	494.8	427.4	423.7	79.0	157.0	472.5	522.3	654.1	3636.4
1972	204.6	61.1	76.8	90.7	284.3	283.6	467.5	245.4	282.1	382.0	597.5	297.2	3272.8
1973	194.4	68.5	47.4	101.6	81.1	185.0	254.6	168.1	248.1	455.4	501.0	790.8	3096.0
1974	41.4	134.3	65.3	50.8	245.6	205.2	144.3	148.4	183.1	373.4	851.3	597.5	3040.6
1975	229.5	79.2	152.1	345.5	82.7	274.5	147.5	138.4	489.2	205.3	385.9	892.7	3422.5
1976	213.9	27.3	43.4	38.2	1060.8	214.8	169.7	307.3	278.3	517.6	653.5	618.4	4143.2
1977	159.4	186.7	96.7	36.3	149.5	182.6	325.3	235.2	237.9	415.5	583.9	194.3	2803.3
1978	137.7	64.5	19.7	120.9	154.5	161.0	155.9	223.0	505.1	T	419.9	319.1	T
1979	102.3	50.8	6.5	224.1	171.0	308.0	91.9	131.1	350.4	239.1	371.7	118.7	2165.6
1980	67.9	86.3	227.3	25.1	130.8	543.8	279.2	236.2	139.4	T	510.8	260.0	T
1981	120.6	29.0	16.1	91.9	201.8	254.7	281.3	75.6	298.7	587.9	945.5	332.4	3235.5
1982	126.8	90.6	35.6	51.9	65.8	49.1	213.6	218.6	466.9	133.0	290.4	241.2	1983.5
1983	253.3	9.0	26.2	41.9	19.3	105.9	785.0	105.3	217.3	942.9	203.1	128.4	2837.6
1984	194.3	75.4	42.8	117.5	131.5	186.2	80.3	241.1	312.3	621.8	223.5	102.0	2328.7
1985	95.3	29.9	254.8	169.6	275.3	437.6	165.9	4.6	470.3	447.7	460.0	272.8	3083.8
1986	197.7	44.2	27.8	67.9	74.0	289.0	448.5	255.0	179.3	1067.6	600.7	188.8	3440.5
1987	239.8	43.0	73.6	76.1	41.4	423.8	128.8	357.7	156.7	179.5	398.3	673.0	2791.7
1988	354.2	207.5	50.2	243.5	230.5	236.4	134.9	87.3	365.6	1030.4	756.8	85.6	3782.9
1989	174.8	223.5	288.7	88.4	330.3	297.6	270.1	121.8	215.1	553	124.2	79.4	2766.9
1990	10.9	67.5	110.1	6.5	154.5	262.0	254.1	411.7	189.6	384.7	618.6	472.5	2942.7
1991	T	221.7	164.3	T	133.0	377.6	342.0	207.7	111.3	247.2	562.2	438.9	T
1992	51.6	94.5	75.3	68.5	217.5	149.7	435.6	143.9	203.4	272.6	859.1	266.6	2838.3
1993													
Average	156.2	90.0	93.0	101.0	215.0	266.2	272.7	188.3	275.3	476.5	520.0	364.7	3018.9

Source: PAGASA

Table I.2.4 Monthly Rainfall Data of Liliw

Observation Station: Liliw, Laguna

(unit:mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1978	T	T	T	T	T	278.7	T	T	T	T	T	T	T
1979	29.7	30.7	4.7	252.4	264.9	175.8	313.8	279.0	529.0	260.4	253.9	135.1	2529.4
1980	21.0	31.6	T	35.6	102.6	503.1	180.4	36.3	69.8	264.9	388.4	273.9	T
1981	150.9	30.8	61.7	77.5	291.3	303.0	334.1	87.8	238.8	581.1	T	T	T
1982	T	104.4	T	80.5	76.0	T	T	T	T	T	T	123.1	T
1983	103.9	16.5	0.0	23.5	27.3	102.1	279.4	31.6	259.8	T	T	T	T
Average	67.2	31.0	33.2	121.8	219.6	327.3	276.1	134.4	279.2	368.8	321.2	204.5	2384.3

Source: PAGASA

Average rainfall was calculated for 3 years, 1979 - 1981

Table I.2.5 Monthly Rainfall Data of Caliraya

Observation Station: Caliraya Hydro Electric Plant

(unit:mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1965	142.2	61.3	110.6	82.8	156.7	154.2	385.5	217.2	331.9	325.9	490.4	559.5	3018.2
1966	80.5	36.3	25.4	2.0	183.2	T	T	T	331.5	273.4	676.8	807.7	T
1967	503.3	29.6	43.3	81.5	7.6	327.0	179.8	455.3	174.9	201.5	T	T	T
1968	T	T	102.2	16.5	73.9	279.2	261.3	254.1	241.5	187.8	150.4	97.7	T
1969	150.6	17.8	36.2	46.6	9.9	34.4	381.0	252.3	204.9	210.7	179.1	466.8	1990.3
1970	73.4	23.2	18.1	42.8	29.8	247.3	172.4	59.5	466.7	670.7	956.6	380.8	3141.3
1971	52.3	65.7	80.7	15.0	225.4	394.0	313.3	57.9	94.8	631.1	582.3	670.8	3183.3
1972	73.6	9.4	28.8	28.5	50.6	264.6	791.3	T	100.1	278.2	322.9	260.0	T
1973	97.7	T	30.3	25.2	79.2	162.0	248.9	164.5	263.2	553.0	486.8	274.8	T
1974	9.4	47.6	53.6	28.5	206.3	298.6	253.2	457.8	238.4	445.5	858.0	658.7	3555.6
1975	254.2	48.4	179.4	420.0	135.2	200.9	144.5	282.0	296.2	377.8	429.2	906.3	3674.1
1976	150.0	26.8	47.6	57.4	827.5	424.6	155.7	345.6	280.3	301.7	390.4	412.5	3420.1
1977	144.2	145.9	90.9	45.7	111.6	191.6	478.9	401.4	302.0	209.5	524.1	132.7	2778.5
1978	110.0	30.0	10.2	140.9	142.1	198.7	185.5	601.6	T	1253.1	302.0	275.7	T
1979	30.3	6.9	10.6	253.9	474.9	461.4	171.5	345.9	316.7	363.9	466.2	130.4	3032.6
1980	63.5	67.8	240.3	48.2	237.0	659.0	388.9	204.8	275.3	365.4	598.8	232.5	3381.5
1981	80.7	49.0	63.6	T	T	299.5	402.7	273.8	T	533.1	697.9	60.3	T
1982	T	T	85.0	T	189.5	T	T	T	478.2	187.5	387.7	248.4	T
1983	235.5	13.6	19.0	39.6	26.5	150.5	565.0	211.1	T	656.8	T	T	T
Average	107.0	51.1	86.8	104.1	241.4	306.6	284.5	262.4	280.7	390.2	547.5	455.1	3117.6

Table I.2.6 Monthly Rainfall Data of Study Area (Poblacion, Nagcarlan)(1/2)

Station: Municipal Office of Nagcarlan

Period: March to December, 1993

(unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1			0.0	0.0	0.0	15.0	18.6	51.0	2.4	2.9	8.8	19.3
2			0.0	0.0	0.0	0.0	0.2	5.6	0.0	2.8	93.4	70.0
3			0.0	0.0	0.0	0.0	7.8	1.0	0.0	0.0	0.0	10.0
4			0.0	0.0	0.0	4.4	29.8	6.8	24.8	16.8	0.0	6.3
5			0.0	0.0	0.0	0.8	7.4	0.0	0.0	59.4	5.7	17.6
6			0.0	0.0	0.0	3.4	9.2	0.0	5.2	30.0	6.1	325.4
7			0.0	0.0	0.0	18.6	0.0	0.0	0.0	7.5	12.6	38.0
8			0.0	0.0	0.0	0.0	9.4	25.0	0.0	0.8	7.8	85.0
9			0.0	0.0	0.0	13.8	59.0	27.0	10.8	0.0	6.2	1.0
10			0.0	0.0	0.0	10.0	1.6	71.6	13.4	0.0	2.0	9.0
11			0.0	0.0	0.0	0.0	16.2	1.2	0.0	0.0	0.4	62.4
12			0.0	0.0	1.0	10.2	0.8	0.0	0.0	0.0	4.2	17.8
13			0.0	7.6	1.4	0.6	3.4	23.8	30.6	18.0	0.4	8.4
14			0.0	5.0	0.0	0.0	12.0	0.0	6.6	21.7	0.0	7.8
15			0.0	1.0	0.0	0.0	4.0	0.0	0.0	46.6	0.0	11.8
16			0.0	0.0	0.0	2.6	27.2	0.0	12.0	8.9	1.8	56.6
17			0.0	0.0	0.0	0.6	0.0	0.0	2.2	6.8	8.4	9.0
18			0.0	0.0	0.0	0.8	0.0	7.0	2.0	17.8	0.4	6.8
19			0.0	0.0	1.0	0.0	0.0	8.8	34.4	11.2	7.8	0.5
20			0.0	0.0	0.0	82.6	21.6	2.6	25.8	8.5	1.0	0.0
21			0.0	0.0	0.0	7.2	0.0	0.0	0.0	0.0	65.0	18.8
22			14.8	0.0	0.0	0.0	16.0	3.0	14.4	5.5	63.8	35.4
23			0.4	0.0	0.0	0.8	3.0	19.8	0.0	10.6	1.8	3.1
24			0.0	0.0	0.0	0.0	0.0	13.8	0.2	27.8	6.6	0.0
25			0.0	0.0	0.0	1.6	0.0	0.0	2.2	119.6	19.0	3.6
26			0.0	0.0	0.0	60.2	0.0	0.0	0.0	8.9	5.1	5.8
27			0.0	0.0	0.0	6.4	0.0	5.8	2.8	1.6	15.8	88.4
28			0.0	0.0	3.8	0.0	8.0	38.0	9.2	2.2	3.8	91.4
29			0.0	0.0	0.0	15.0	9.4	42.2	3.0	4.0	1.8	14.6
30			0.0	6.8	0.0	11.8	42.0	2.2	4.4	6.5	9.0	0.0
31			0.0		0.0		8.4	0.0		0.6		0.0
Total			15.2	20.4	7.2	266.4	315.0	356.2	206.4	447.0	358.7	1,023.8

Table I.2.6 Monthly Rainfall Data of Study Area (Poblacion, Nagcarlan)(2/2)

Station: Municipal Office of Nagcarlan

Period: January to August, 1994

(unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	15.8	0.0	0.0	0.0	0.0	12.0	3.2	1.4				
2	15.2	0.0	0.0	0.0	28.0	0.0	6.4	21.0				
3	0.0	0.0	2.2	0.0	0.0	18.0	0.0	0.0				
4	0.0	3.8	0.0	0.0	6.4	65.2	61.8	0.0				
5	0.4	0.0	84.4	0.0	0.0	26.8	1.4	0.0				
6	20.0	0.0	5.0	0.0	0.0	3.0	16.6	18.4				
7	14.4	0.0	0.0	0.0	55.0	1.2	10.6	0.0				
8	3.0	0.0	0.0	0.0	2.8	2.2	10.0	0.0				
9	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0				
10	0.0	3.2	0.0	0.0	22.6	0.0	33.4	0.0				
11	1.6	9.8	0.0	10.8	5.8	0.0	14.8	0.0				
12	24.2	12.4	0.0	5.0	0.0	32.0	0.2	0.0				
13	0.4	3.0	0.0	0.0	0.0	100.0	0.4	0.0				
14	0.0	8.4	1.3	0.0	0.0	48.0	2.8	0.0				
15	0.8	0.0	0.5	0.0	0.0	1.2	6.4	0.0				
16	2.0	0.0	0.1	5.2	0.0	1.4	0.8	0.0				
17	13.8	0.0	0.3	0.2	15.6	0.0	60.0	0.0				
18	0.0	0.0	0.0	0.0	18.3	0.0	0.0	0.0				
19	2.2	0.0	0.0	0.0	0.0	42.8	21.0	0.0				
20	0.0	0.0	0.0	0.0	0.0	7.0	16.6	0.0				
21	0.0	0.0	0.0	0.8	0.0	1.0	0.0	0.0				
22	0.0	0.0	10.8	0.0	0.0	12.0	16.4	0.0				
23	1.2	0.0	0.0	0.0	0.0	163.8	0.0	20.0				
24	9.2	0.0	0.0	0.0	30.0	77.0	1.8	9.2				
25	2.0	0.0	0.0	5.6	34.0	6.6	24.8	0.0				
26	41.6	10.4	0.0	3.0	54.0	0.0	8.8	6.2				
27	9.0	0.0	0.0	4.0	0.0	2.8	4.8	0.0				
28	5.0	0.0	0.0	3.0	0.0	0.2	12.4	59.8				
29	0.0		39.2	0.0	0.6	2.8	30.2	17.2				
30	6.3		2.0	1.8	0.4	13.2	13.2	8.7				
31	17.1				30.0		0.0	0.7				
Total	205.2	51.0	145.8	39.4	310.5	640.2	378.8	162.6	0.0	0.0	0.0	0.0

Table I.2.7 Monthly Rainfall Data of Studt Area (Bukal Nagcarlan)(1/2)

Station: Barangay Bukal (Demo-Farm)

Period: October to December, 1993

(unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1										2.0	7.0	21.0
2										1.0	25.0	52.2
3										0.0	0.0	13.1
4										19.0	0.0	2.0
5										81.0	2.0	20.4
6										34.0	17.0	100.0
7										15.0	14.0	34.6
8										5.0	17.0	62.2
9										0.0	12.0	2.0
10										0.0	11.0	56.0
11										0.0	7.0	72.0
12										0.0	1.0	14.0
13										6.0	0.0	11.2
14										24.0	0.0	26.1
15										10.0	0.0	32.0
16										27.0	0.0	84.2
17										7.0	18.0	11.4
18										25.0	0.0	7.3
19										11.0	14.0	0.0
20										6.0	1.0	7.2
21										2.0	60.0	35.6
22										5.0	52.0	59.6
23										10.0	8.0	7.0
24										21.0	46.0	0.0
25										68.0	6.0	0.0
26										4.0	9.0	22.2
27										0.0	5.0	102.0
28										0.0	14.0	104.0
29										3.0	13.0	21.0
30										6.0	19.0	0.0
31										10.0		10.0
Total			0.0	0.0	0.0	0.0	0.0	0.0	0.0	402.0	378.0	990.3

Table I.2.7 Monthly Rainfall Data of Studt Area (Bukal, Nagcarlan)(2/2)

Station: Barangay Bukal (Demo-Farm)

Period: January to September, 1994

(unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	10.0	0.0	0.0	0.0	0.0	0.0	11.0	37.5	1.5	28.0		
2	2.0	0.0	0.0	1.5	6.5	0.0	0.0	9.0	29.0	0.0		
3	0.0	6.0	0.0	25.5	26.5	19.0	1.5	0.0	7.0	0.0		
4	0.0	53.0	0.0	104.5	14.5	-	67.5	0.0	6.5	4.0		
5	0.0	0.0	0.0	0.0	0.0	-	11.5	0.0	0.0	24.5		
6	4.0	0.0	0.0	0.0	2.0	-	9.0	26.0	0.0	4.0		
7	24.0	0.0	0.0	0.0	84.0	-	21.5	0.0	20.5	0.0		
8	0.0	0.0	0.0	0.0	24.0	-	10.0	0.0	3.5	0.0		
9	0.0	0.0	0.0	0.0	0.0	-	33.0	0.0	0.0	6.0		
10	0.0	16.0	0.0	0.0	21.0	-	26.0	0.0	0.0	0.0		
11	0.0	37.0	52.0	0.0	16.0	-	0.5	0.0	0.0	0.0		
12	14.0	0.0	47.0	1.0	0.0	-	0.0	0.0	11.0	0.0		
13	8.0	0.0	0.0	3.0	0.0	-	16.5	0.0	7.0	0.0		
14	0.0	0.0	0.0	0.0	4.0	-	9.5	0.0	25.0	3.5		
15	0.0	0.0	11.0	2.0	1.0	0.0	9.5	0.0	0.0	1.0		
16	0.0	0.0	0.5	14.5	70.0	0.0	6.5	0.0	19.0	0.0		
17	9.2	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.0			
18	1.0	0.0	0.0	0.0	7.0	0.0	19.0	0.0	0.5			
19	10.0	0.0	5.5	0.0	1.5	33.5	8.5	30.0	19.0			
20	0.0	0.0	2.0	0.0	0.5	34.5	15.5	0.0	2.0			
21	0.0	0.0	0.0	3.0	0.0	10.5	0.0	0.0	3.0			
22	0.0	0.0	0.0	-	0.5	201.0	13.0	6.0	0.5			
23	3.3	0.0	1.0	-	0.5	18.0	0.5	4.5	0.5			
24	33.3	0.0	2.5	-	33.0	29.5	4.5	15.0	2.5			
25	0.0	0.0	20.0	-	12.0	23.0	34.0	5.0	41.5			
26	42.2	4.0	21.0	-	1.5	3.5	15.0	9.0	13.0			
27	6.2	0.0	0.0	-	0.0	0.0	22.5	32.5	1.5			
28	1.0	2.0	0.0	-	0.5	2.0	14.5	48.0	1.0			
29	0.0		0.0	38.0	19.5	0.0	34.5	8.5	0.0			
30	2.0		0.0	0.0	6.0	37.5	10.5	0.0	15.5			
31	29.4		0.0		0.0		1.0	0.5				
Total	199.6	118.0	162.5	193.0	353.0	412.0	426.5	231.5	232.5	71.0		

- : data missing

Rainfall were observed by automatic recording rainfall gauge since March 15, 1994

Table I.2.8 Monthly Temperature of Los Baños

Observation Station: University of the Philippines (Los Banos)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max.	29.4	30.7	32.4	34.0	34.2	32.8	31.7	31.3	31.5	30.9	30.2	29.0	31.5
Min.	21.6	21.5	22.1	23.5	24.2	24.2	23.6	23.7	23.6	23.4	23.2	22.2	23.1
Mean	25.5	26.1	27.3	28.7	29.2	28.5	27.6	27.5	27.5	27.2	26.7	25.6	27.3

Source: Compilation of Weather Data, IRRI

Observation period: 1979 - 1993

Table I.2.9 Monthly Temperature of Cavinti

Observation Station: Cavinti, Laguna

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max.	25.3	26.0	27.7	30.0	31.0	30.2	29.4	28.9	28.9	28.1	26.9	25.3	28.1
Min.	19.4	19.3	20.0	21.1	21.8	21.9	21.4	21.6	21.3	21.2	20.9	19.7	20.8
Mean	22.4	22.7	23.9	25.6	26.4	26.1	25.4	25.2	25.1	24.7	23.9	22.5	24.5

Source: Compilation of Weather Data, IRRI

Observation period: 1985 - 1993

Table I.2.10 Monthly Temperature of Poblacion, Nagcarlan

Observation Station: Poblacion, Nagcarlan

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max.	27.2	27.8	28.5	30.9	32.6	31.7	30.7	30.5	30.7	28.0	27.4	25.6	29.3
Min.	21.2	21.4	22.3	22.3	24.3	23.9	23.8	23.3	23.2	22.8	23.2	22.1	20.8
Mean	24.2	24.6	25.4	27.0	28.5	27.8	27.3	27.2	27.0	25.4	25.3	24.0	26.1

Source: JICA Study Team

Observation period: 1993 - 1994

Table I.2.11 Monthly Temperature of Bukal, Nagcarlan

Observation Station: Bukal, Nagcarlan

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max.	23.5	23.8	24.4	25.9	27.1	26.2	24.0	25.4	25.1	24.4	n.a.	22.1	24.7
Min.	17.8	17.4	17.8	18.5	20.0	19.7	19.9	19.8	19.9	20.0	n.a.	19.8	19.1
Mean	20.6	20.6	21.2	22.2	23.6	23.0	22.0	22.8	22.5	22.2	n.a.	21.0	22.0

Source: JICA Study Team

Observation period: 1993 - 1994

Table I.2.12 Monthly Relative Humidity of Los Baños

UPLB-NAS

Observation Station: University of the Philippines (Los Banos)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1954	77	75	77	65	66	74	77	82	80	81	82	87	77
1955	87	69	62	65	65	76	75	78	78	77	80	74	74
1956	76	69	67	69	75	76	79	82	79	77	76	82	76
1957	78	68	65	62	58	72	79	78	76	78	74	77	72
1958	74	71	64	60	65	77	75	78	77	81	80	75	73
1959	84	80	82	75	81	83	88	87	88	88	89	90	85
1960	88	86	79	82	87	84	85	85	91	87	89	86	86
1961	84	81	80	78	84	88	87	88	89	90	88	87	85
1962	87	84	83	84	83	87	90	84	92	85	85	86	86
1963	84	78	75	75	73	82	83	82	84	79	76	82	79
1964	83	87	81	79	82	86	88	85	90	89	90	84	85
1965	82	79	76	81	84	84	89	88	87	87	90	89	85
1966	84	81	78	74	87	84	87	85	87	88	88	89	84
1967	89	84	82	77	76	83	84	87	87	86	87	86	84
1968	82	79	81	76	77	84	85	85	85	84	84	86	82
1969	82	78	77	74	74	81	84	82	85	84	84	88	81
1970	85	78	75	76	75	80	84	87	86	88	87	85	82
1971	81	80	78	77	86	87	86	84	88	89	89	91	85
1972	84	80	79	77	81	85	83	86	87	86	87	84	83
1973	81	78	74	74	76	82	83	86	85	86	86	88	82
1974	82	82	75	74	82	81	85	83	84	87	86	85	82
1975	82	77	77	82	79	84	86	84	88	86	84	87	83
1976	83	78	77	72	78	80	82	87	88	88	89	89	83
1977	89	92	81	77	82	87	90	83	90	85	87	85	86
1978	79	77	67	68	61	62	66	82	82	82	80	83	74
1979	82	80	75	76	79	78	81	80	81	80	82	79	79
1980	80	78	78	76	76	82	80	81	80	80	79	81	79
1981	80	77	74	73	75	80	79	77	79	82	82	81	78
1982	78	78	73	75	74	74	79	78	80	76	79	77	77
1983	77	69	69	66	72	74	80	78	77	81	78	79	75
1984	80	76	75	72	75	79	76	79	75	78	76	77	77
1985	82	78	79	77	75	78	81	75	80	85	85	81	80
1986	82	82	75	73	75	81	84	82	84	87	85	81	81
1987	81	80	73	70	69	75	78	80	82	78	85	86	78
1988	84	78	71	76	73	78	79	76	76	86	82	78	78
1989	81	83	79	75	77	79	80	84	81	83	80	82	80
1990	81	77	77	70	76	81	81	80	80	82	82	84	79
1991	82	81	77	75	73	78	83	86	81	80	82	82	80
1992	83	81	76	75	74	78	84	86	82	82	82	81	80
1993	81	77	76	73	72	82	86	86	85	85	82	85	81
Average	82	79	75	74	76	80	82	83	83	84	83	83	80

Table I.2.13 Monthly Pan Evaporation of Loa Baños

UPLB-NAS Observation Station: University of the Philippines (Los Banos)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1959	136.1	193.1	203.9	274.9	232.6	201.5	139.0	144.8	144.5	137.5	115.1	116.0	2039.0
1960	137.3	136.1	247.4	221.6	178.0	169.4	171.9	174.4	131.0	153.5	121.2	135.3	1977.1
1961	148.8	176.6	227.5	276.3	200.9	123.7	140.0	110.5	130.9	128.4	110.0	117.8	1891.4
1962	117.3	152.1	209.5	214.0	227.4	167.5	82.9	134.7	65.1	150.5	115.6	107.5	1744.1
1963	103.0	157.1	226.6	244.2	284.3	131.4	127.6	108.7	78.7	144.6	126.0	100.3	1832.5
1964	131.0	126.5	200.1	247.1	206.2	156.3	143.6	127.7	100.3	94.4	53.8	93.2	1680.2
1965	123.2	149.5	197.4	219.3	166.8	143.1	112.1	133.3	131.3	128.1	97.2	95.8	1697.1
1966	137.5	136.5	185.0	249.6	97.3	132.1	133.6	137.5	122.4	118.9	107.4	94.7	1652.5
1967	108.5	144.8	179.4	234.3	245.4	159.3	144.8	112.8	117.2	99.8	100.3	104.7	1751.3
1968	123.8	160.7	195.4	236.7	220.5	153.2	134.5	124.0	132.3	143.4	121.9	119.6	1866.0
1969	153.7	180.8	217.7	265.2	255.2	167.2	120.8	134.2	126.5	141.2	129.3	83.9	1975.7
1970	122.8	156.0	203.2	228.1	262.9	147.9	138.9	121.6	119.8	104.5	81.0	120.0	1806.7
1971	138.1	138.3	185.4	226.0	160.0	118.1	136.9	180.1	129.2	107.4	95.0	87.4	1701.9
1972	130.0	173.5	185.5	233.0	220.0	150.5	128.8	132.5	134.6	157.4	119.6	131.1	1896.5
1973	150.5	156.3	226.9	254.0	262.4	194.5	169.1	136.0	135.3	126.5	116.4	73.1	2001.0
1974	139.3	146.3	210.3	257.0	203.6	167.1	118.7	130.4	160.5	107.1	98.4	119.9	1858.6
1975	128.2	160.3	217.0	190.6	220.9	166.8	168.0	137.9	133.5	137.1	83.6	61.2	1805.1
1976	117.7	165.9	216.2	252.5	180.4	178.4	185.0	121.6	134.5	149.0	110.6	102.8	1914.6
1977	125.6	116.6	218.6	261.6	230.1	181.0	153.8	165.2	116.2	161.0	103.1	121.7	1954.5
1978	126.0	140.0	210.6	191.8	165.3	130.2	110.1	98.9	89.3	87.5	94.8	89.9	1534.4
1979	109.6	134.1	186.9	172.6	124.9	113.9	125.7	118.7	107.3	107.6	90.2	106.4	1497.9
1980	98.4	130.1	162.3	168.2	157.5	115.0	107.1	113.4	92.9	106.0	105.2	90.3	1446.4
1981	101.9	134.5	218.0	225.3	169.8	130.1	131.9	154.2	124.3	112.7	98.4	93.9	1695.0
1982	119.3	123.5	185.8	163.6	164.9	149.3	114.6	127.0	103.2	121.9	110.0	99.4	1582.5
1983	108.2	168.3	170.7	219.2	226.7	178.9	115.0	117.1	103.9	92.9	98.8	90.8	1690.5
1984	95.3	122.9	164.9	183.8	140.6	107.3	132.0	117.8	136.9	89.1	97.8	102.3	1490.7
1985	117.5	148.7	180.1	189.3	197.9	140.1	137.7	159.7	121.8	112.0	98.8	100.4	1704.0
1986	98.5	125.2	193.6	196.5	156.1	147.7	136.7	112.5	115.2	88.0	90.2	118.1	1578.3
1987	110.6	134.7	192.4	218.2	211.6	140.1	114.8	140.2	105.8	137.7	96.2	79.3	1681.6
1988	94.2	130.7	180.8	169.6	192.1	125.4	121.2	130.1	125.3	56.2	87.0	96.3	1508.9
1989	106.9	92.4	128.0	160.8	131.8	116.8	120.5	120.2	102.1	108.9	114.9	108.2	1411.5
1990	120.3	134.3	173.5	210.8	163.5	102.5	109.0	117.2	112.5	102.8	96.1	94.0	1536.5
1991	107.9	110.2	170.6	181.0	194.7	143.9	111.2	76.6	107.2	122.7	87.8	95.8	1509.6
1992	102.4	132.2	187.8	192.8	180.1	143.0	102.0	104.0	99.5	118.0	92.6	86.2	1540.6
1993	94.9	144.5	179.6	200.6	211.6	142.7	116.9	93.7	90.0	71.3	82.6	69.2	1497.6
Average	119.6	143.8	195.4	218.0	195.5	146.7	130.2	127.7	116.6	117.9	101.3	100.2	1712.9

Table I.2.14 Monthly Wind Velocity of Los Baños

Observation Station: University of the Philippines (Loa Banos)

UPLB-NAS

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1959	0.9	1.4	1.5	2.3	1.3	0.9	0.9	0.9	0.8	0.9	1.1	1.0	1.2
1960	1.1	1.0	1.2	1.2	0.9	1.1	0.9	1.6	0.8	1.2	1.0	1.0	1.1
1961	1.3	1.3	1.3	1.6	1.3	1.1	1.2	1.1	1.1	0.8	1.2	1.2	1.2
1962	1.1	1.5	1.5	1.4	1.4	0.8	1.0	1.0	0.8	0.8	1.2	1.1	1.1
1963	1.1	1.6	1.7	1.6	1.6	1.4	0.9	0.8	1.1	0.9	1.1	1.0	1.2
1964	1.1	1.4	1.4	1.7	1.2	1.1	0.8	1.3	0.8	0.8	0.9	1.3	1.1
1965	1.3	1.4	1.3	1.3	1.1	0.9	1.0	0.8	0.8	0.9	0.9	1.2	1.1
1966	1.2	1.3	1.3	1.5	1.1	0.9	0.9	0.9	1.2	1.0	1.2	1.1	1.1
1967	1.6	1.6	1.4	1.4	1.3	1.4	1.0	0.9	0.6	0.9	1.4	1.2	1.2
1968	1.2	1.3	1.4	1.4	1.1	0.8	1.3	1.1	1.3	1.0	1.3	1.1	1.2
1969	1.1	1.2	1.3	1.5	1.2	0.9	1.1	0.9	1.0	0.8	0.9	0.9	1.1
1970	0.8	0.9	1.0	1.0	1.0	0.6	0.5	0.5	0.6	0.8	0.8	0.9	0.8
1971	1.1	1.2	1.2	1.1	0.8	0.6	1.1	0.8	0.6	1.0	0.7	0.9	0.9
1972	1.1	1.0	1.1	1.2	0.9	0.7	1.9	0.8	0.5	0.8	0.9	0.9	1.0
1973	0.8	1.0	1.3	1.3	1.1	0.7	0.7	0.5	0.5	1.0	0.9	0.9	0.9
1974	1.0	1.1	1.2	1.1	0.9	0.8	0.6	1.1	0.6	0.8	1.0	1.0	0.9
1975	1.0	1.0	1.0	1.0	0.7	0.6	0.4	0.9	0.5	0.5	0.8	0.9	0.8
1976	1.0	1.0	1.2	1.2	1.8	1.2	0.7	0.6	0.7	0.5	0.7	0.7	0.9
1977	0.7	1.1	1.1	1.3	1.1	0.7	0.8	0.8	1.0	0.9	1.2	1.3	1.0
1978	1.3	1.3	1.3	1.4	0.9	0.6	0.4	0.8	0.7	0.9	0.8	1.0	1.0
1979	1.0	1.0	1.3	1.2	0.9	0.8	1.0	1.0	0.7	0.8	0.8	1.1	1.0
1980	1.0	1.1	1.2	1.2	1.1	0.8	1.0	0.6	0.6	0.6	1.0	0.8	0.9
1981	1.2	1.2	1.4	1.3	0.9	0.9	0.7	1.1	0.8	0.5	0.8	1.0	1.0
1982	1.1	1.1	1.3	0.9	0.9	0.9	0.9	0.7	0.6	0.6	0.6	0.7	0.9
1983	0.6	0.8	0.9	1.3	1.4	1.2	1.1	0.8	0.6	0.7	1.0	1.4	1.0
1984	1.2	1.3	1.2	1.1	0.8	0.9	0.6	1.5	0.8	0.8	1.0	1.2	1.0
1985	1.2	1.3	1.3	1.2	1.2	1.8	0.8	1.1	0.8	0.7	0.8	0.9	1.1
1986	1.3	1.0	1.3	1.4	0.8	0.5	0.7	0.8	0.7	0.6	0.7	0.9	0.9
1987	1.0	1.1	1.2	1.1	0.9	0.6	0.5	0.7	0.6	0.8	0.9	1.0	0.9
1988	0.9	0.9	1.1	1.0	1.1	0.9	0.7	0.5	0.6	1.0	1.3	1.6	1.0
1989	1.7	1.3	1.2	1.3	1.3	0.9	1.3	1.1	1.1	1.2	1.5	1.4	1.3
1990	1.3	1.6	1.5	1.5	1.2	0.9	0.8	2.0	1.0	0.7	1.1	1.2	1.2
1991	1.1	1.1	1.3	1.3	1.3	1.3	1.0	0.6	1.0	1.1	1.1	1.3	1.1
1992	0.9	1.1	1.3	1.2	1.1	1.0	0.8	1.4	1.0	1.0	1.0	1.2	1.1
1993	1.2	1.3	1.5	1.4	1.4	1.0	0.8	0.6	0.4	1.0	1.1	1.3	1.1
Average	1.1	1.2	1.3	1.3	1.1	0.9	0.9	0.9	0.8	0.8	1.0	1.1	1.0

Table I.2.15 Monthly Percent Possible Sunshine of Los Baños

Observation Station: Univrtsity of the Philippines (Los Banos)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1959	40	57	39	51	51	45	39	46	47	40	31	41	44
1960	39	22	51	39	22	28	41	48	43	47	35	34	37
1961	40	44	55	64	55	40	50	42	56	58	61	63	52
1962	57	70	78	84	80	67	47	60	53	57	41	41	61
1963	38	60	73	84	77	33	39	41	30	54	56	38	52
1964	61	48	60	75	66	48	43	33	30	34	26	31	46
1965	38	60	55	71	51	40	26	43	38	46	40	37	45
1966	52	61	65	76	34	58	41	55	37	40	52	42	51
1967	42	53	62	77	77	42	43	27	41	46	41	47	50
1968	48	64	65	80	67	56	42	36	42	58	49	50	55
1969	68	81	68	79	68	50	38	42	33	51	47	27	54
1970	48	65	62	70	73	35	40	31	43	35	36	47	49
1971	53	45	57	73	49	36	32	55	40	37	37	37	46
1972	42	71	53	72	63	52	24	32	44	56	53	59	52
1973	59	62	69	79	77	58	46	35	34	38	50	18	52
1974	50	50	71	78	58	58	46	25	54	25	39	47	50
1975	45	62	73	62	73	44	50	36	44	44	53	28	51
1976	39	64	67	78	47	53	51	35	40	54	37	38	50
1977	47	32	70	79	67	57	43	52	33	56	43	53	53
1978	52	59	76	71	58	37	40	23	29	33	46	40	47
1979	60	72	80	71	50	40	42	41	46	39	39	49	52
1980	47	58	65	74	59	41	41	41	25	43	53	35	49
1981	33	61	83	77	56	31	40	42	43	35	31	40	48
1982	49	52	71	62	56	50	28	29	29	50	50	41	47
1983	45	81	75	79	71	58	42	39	37	32	38	22	52
1984	34	55	63	70	50	33	51	22	48	28	48	40	45
1985	45	71	70	60	65	39	48	48	39	43	43	42	51
1986	26	53	65	68	56	44	41	29	36	36	46	50	46
1987	51	57	78	78	73	45	32	42	34	54	42	30	51
1988	45	66	74	64	66	43	39	49	45	16	31	34	48
1989	38	34	46	70	54	46	37	34	39	56	49	43	45
1990	56	77	68	78	51	36	40	30	44	38	43	43	50
1991	48	48	66	71	69	44	39	16	33	48	40	36	46
1992	52	60	74	78	61	44	35	26	37	43	44	43	50
1993	43	69	67	74	76	48	43	35	28	28	44	23	48
Average	47	58	66	72	61	45	41	38	39	43	43	40	49

Table I.2.16 Monthly Sunshine Duration of Los Baños

Observation Station: Univrtsity of the Philippines (Los Banos)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1959	8496	11180	8647	11296	11987	10579	9355	10797	10314	8839	6346	8355	9683
1960	8295	4476	10666	8759	6283	6538	9780	11317	9473	10350	7345	7247	8377
1961	8741	8952	12247	14454	13113	9477	11958	9706	12181	12757	12528	13365	11623
1962	12150	13839	17719	18772	18981	15589	11187	14144	11889	12441	8551	8529	13649
1963	8011	11854	13697	11373	18670	7671	9367	9605	6663	11798	11594	8338	10720
1964	11341	10121	13537	16834	15751	11054	10588	7809	6545	7438	5383	6612	10251
1965	7980	11875	12378	16008	12132	8881	6455	10139	8253	10096	8307	7824	10027
1966	10926	11964	14490	16944	8500	13589	9843	12782	8036	8877	10845	9080	11323
1967	8926	10334	14358	17237	18196	9745	10435	6262	8992	10085	8447	9849	11072
1968	10225	13005	14017	17878	15942	13016	10132	8349	9241	12772	10149	10203	12077
1969	14442	15862	15379	17615	16071	11690	8544	9832	7197	11186	9719	6518	12005
1970	10112	12214	13986	15782	16806	7783	9624	7232	9519	7798	7516	9920	10691
1971	11017	8821	12861	16288	11605	8227	7774	12936	8920	8194	7671	7453	10147
1972	8806	14038	11955	16249	14398	12126	5778	7519	9644	12615	10912	12312	11363
1973	12522	12221	15406	17684	18287	13464	10770	8196	7218	8433	10298	3751	11521
1974	10634	9833	15955	17428	13894	13595	11263	5932	11957	5583	8018	9959	11171
1975	9601	12180	16394	13918	17375	10306	11911	8424	9819	9686	10880	5948	11370
1976	8323	12388	15128	17139	11125	12459	12255	8187	9147	11653	7628	8059	11124
1977	9832	6350	15707	17776	15919	13236	10297	12262	7266	12364	8739	11268	11751
1978	11403	11636	17086	15953	13823	8626	9594	5260	6722	7310	9459	8333	10434
1979	12771	14163	18005	15498	11834	9204	10089	9538	10156	8477	8138	10387	11522
1980	9938	11846	14446	16493	13928	9663	9774	9603	5427	9520	10889	7462	10749
1981	6994	11965	18513	17137	13263	7234	9672	9804	9485	7657	6502	8469	10558
1982	10394	10158	15891	13974	13412	11775	6657	6770	6300	10985	10328	8673	10443
1983	9520	15804	16835	17790	16943	13399	10075	9211	8228	7129	7931	4701	11464
1984	7255	11276	14132	15564	11967	7660	12203	5114	10674	6129	10019	8443	10036
1985	9457	13871	15794	13498	15479	9138	11441	11135	8561	9466	8953	8885	11307
1986	5665	10418	14503	15195	13331	10356	9776	6779	7981	7841	9612	10491	10162
1987	10994	11202	17542	17387	17292	10463	7584	9777	7488	11872	8759	6255	11385
1988	9480	13376	16522	14604	15219	9963	9383	11347	9852	3792	6283	7151	10581
1989	7997	6607	9713	15771	12374	10652	8908	8032	8549	12219	10090	8958	9989
1990	11830	15007	15187	17522	12661	8042	9563	7127	9657	8575	8791	9010	11081
1991	10070	9323	14837	15967	16393	10340	9320	3710	7228	10540	8283	7529	10295
1992	10925	12278	16658	17537	14445	10173	8309	6158	8251	9495	9095	8688	11001
1993	9085	13450	14929	16498	18067	11252	10209	8469	6226	6180	9027	4862	10688
Average	9833	11540	14718	15881	14442	10485	9711	8836	8659	9433	8944	8368	10904

Table I.2.17 Frequency of Tropical Cyclones in the Philippine Area

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1948 - 1986	19	13	11	16	32	60	126	134	118	101	88	57	775
1987	1	0	0	0	0	1	4	3	2	2	2	1	16
1988	1	0	0	0	1	3	3	0	3	6	2	1	20
1989	1	0	0	0	1	2	6	1	2	3	2	1	19
1990	0	0	0	0	3	3	2	3	4	1	3	1	20
Total	22	13	11	16	37	69	141	141	129	113	97	61	850
Mean	0.5	0.3	0.3	0.4	0.9	1.6	3.3	3.3	3.0	2.6	2.3	1.4	19.8

Table I.2.18 Frequency of Tropical Cyclones Crossing the Philippines

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1948 - 1986	6	2	6	9	15	25	51	42	50	59	53	35	353
1987	0	0	0	0	0	0	0	2	1	1	2	1	7
1988	1	0	0	0	0	2	1	0	1	2	2	0	9
1989	0	0	0	0	1	1	3	0	0	3	1	0	9
1990	0	0	0	0	0	3	0	1	1	0	1	0	6
Total	7	2	6	9	16	31	55	45	53	65	59	36	384
% of Total	1.8	0.5	1.6	2.3	4.2	8.1	14.3	11.7	13.8	16.9	15.4	9.4	

Table I.2.19 Annual Distribution of Tropical Cyclones by Intensity

Year	Tropical Depression	Tropical Storm	Typhoon	Total
1948 - 1986	154	202	419	775
1987	1	2	13	16
1988	3	7	10	20
1989	3	8	8	19
1990	3	6	11	20
Total	164	225	461	850
Mean	3.8	5.2	10.7	19.8

* Source Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)

Table I.4.1 Guidelines for Interpretation of Water Quality for Irrigation in the Philippines

Irrigation Problem	No Problem	Degree of Problem: Increasing Problem	Severe Problem
Salinity *2 (affected crop water availability)			
ECw (mmhos/cm)	0.75	0.75 - 3.0	3.0
Permeability (affect infiltration rate into soil)			
ECw (mmhos/cm)	0.5	0.5 - 0.2	0.2
Montmorillonite (2:1 crystal lattice)	6	6 - 9 *3	9
Illite - Vermiculite (2:1 crystal lattice)	8	8 - 16*3	16
Kaolinite - Sesquioxides (1:1 crystal lattice)	16	16 - 24*3	24
Specific on Toxicity (affects sensitive crops)			
Sodium *4 *5 (Adj. SAR) *1	3	3 - 9	9
Chloride *4 *5 (meq/l)	4	4 - 10	10
Boron (mg/l)	0.75	0.75 - 2.0	2.0
Miscellaneous (affect susceptible crops)			
NO3 - N (mg/l) NH4 - N (mg/l)	5	5 - 30	30
HCO3 (meq/l) (ever land sprinkling)	1.5	1.8 - 8.5	8.5
pH	(normal range 6.5 - 8.4)		

*1 Adj. SAR mean adjusted Sodium Adsorption Ratio.

*2 Values presented area for the dominant type of clay material on the soil since structual stability varies between the various clay type (Raling, 1966 and Rhoaden, 1975). Ploblems are less likely to develop if water salinity is high; more likely if water salinity is low.

*3 Use the lower range if ECw 0.4 mmhos/cm. Use the intermediate range if Ecw 0.4 - 1.6 mmhos/cm. Use upper limit of Fcw 1.6 mmhos/cm.

*4 Most tree crop and woody or namentals are sensitive to sodium and chloride (use value shown).Most annual crops are not sensitive.

*5 With sprinkler irrigation or sensitive crops, sodium or chloride is excess of 33 meq under certain condition has resulted to excessive leaf adsorption and crop damage.

Table I.4.2 Water Quality Conditions of the Laguna Lake

Year	W.Temp. (C)	pH	TURB. (NTU)	DSS (mg/lit)	DO (mg/lit)	BOD (mg/lit)	COD (mg/lit)
LL-1. West Bay							
1982	30.0	8.4	18	1,378	8.4	–	–
1983	28.8	8.1	22	780	8.6	–	26.8
1984	29.0	8.1	24	508	7.7	–	31.2
1985	28.0	8.0	46	308	7.2	–	36.7
1986	27.4	8.2	34	609	8.1	3.5	42.0
1987	29.0	8.2	29	337	8.0	2.4	31.1
Mean	28.7	8.2	29	718	8.0	3.0	33.6
LL-2. East Bay							
1982	30.1	8.1	15	875	7.8	–	–
1983	30.3	8.2	21	797	8.8	–	27.3
1984	28.0	7.8	18	390	6.8	–	28.3
1985	28.0	7.9	32	246	7.5	–	25.9
1986	27.4	8.0	40	342	7.7	2.8	13.1
1987	28.5	7.8	28	316	7.4	2.2	24.6
Mean	28.7	8.0	25	530	7.7	2.5	23.8
LL-3. Central Bay							
1982	30.7	8.3	15	1,272	8.8	–	–
1983	30.8	8.1	22	812	8.8	–	–
1984	28.0	8.0	18	511	7.9	–	–
1985	28.0	8.0	37	311	7.4	–	–
1986	27.6	8.1	28	646	8.4	3.3	20.3
1987	28.2	8.0	26	349	7.8	2.8	24.1
Mean	28.9	8.1	24	710	8.2	3.1	22.2
LL-4. South Bay							
1982	–	–	–	–	–	–	–
1983	–	–	–	–	–	–	–
1984	–	–	–	–	–	–	–
1985	–	–	–	–	–	–	–
1986	27.6	8.0	35	402	8.0	2.4	17.2
1987	29.2	8.2	29	326	8.1	2.3	25.5
Mean	28.4	8.1	32	364	8.1	2.4	21.4

Note – : Not analysed.
Source: Flood Control and Drainage Project in Metro Manila, JICA

Table I.4.3 Parameters of the Water Quality Criteria

Quality Parameter	Fresh Surface Water					
Class	AA	A	B	C	D	E
Color, Units		75	50	50		
Temperature Âé		30	30	3(e)	3(e)	
Transparency			(c)	(c)	(c)	
Dissolved Oxygen		5	5	5	3	2
5-day BOD at 20 Âé		10	15	20		
Total Dissolved Solids				1,000	1,000	
Total Solids	(a)	(a)		2,000	2,000	
pH	(a)	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5	6.0 - 8.5	5.0 - 9.0
Coliform, MPN/100 mlit	50	5,000	1,000	5,000		
Phenolic substances	(a)	(a)	0.002	0.02		

Remarks:

1. (a) National standards for Drinking Water in the Philippines.
   (b) Shall not be present in concentration to cause deleterious or abnormal biotic growth.
   (c) Secchi Disk shall be visible at a minimum depth of one (1) meter.
   (d) Recommended maximum concentration for irrigating citrus is 0.075 mg/lit.
   (e) Rise in temperature.

2. All values are maximum permissible except for Dissolved Oxygen which is minimum permissible.

3. All units in mg/lit except those indicated.

4. Water usage and classification of fresh surface water:

Classifications	Best usage
– Class AA	For source of public water supply. This class is intended primarily for water having watersheds which are uninhabited and otherwise protected and which require only approved disinfection in order to meet the National Standards for Drinking Water (NSDW) of the Philippines.
– Class A	For source of water supply that will require complete treatment (coagulation, sedimentation, filtration and disinfection) in order to meet the NSDW.
– Class B	For primary contact recreation.
– Class C	For the propagation and growth of fish and other aquatic resources.
– Class D	For agriculture, irrigation, livestock watering and industrial cooling and processing.
– Class E	For navigational use.

Source: Rules & Regulations of the National Pollution Control Commission (1978), Section 69, Table 1 - NPCC Water Quality Criteria (1978)

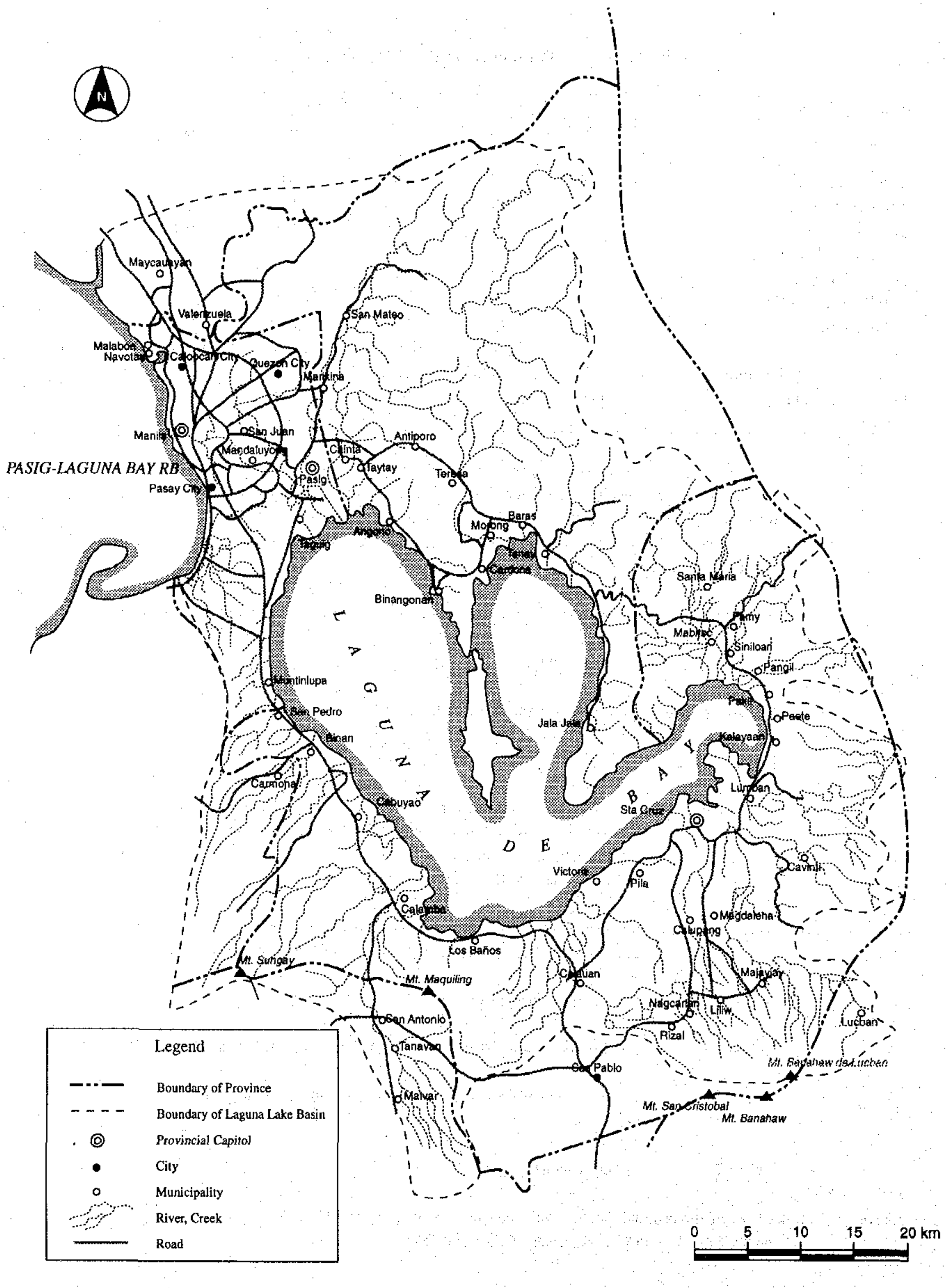


Fig. I.1.1 Boundaries of the Laguna Lake Basins

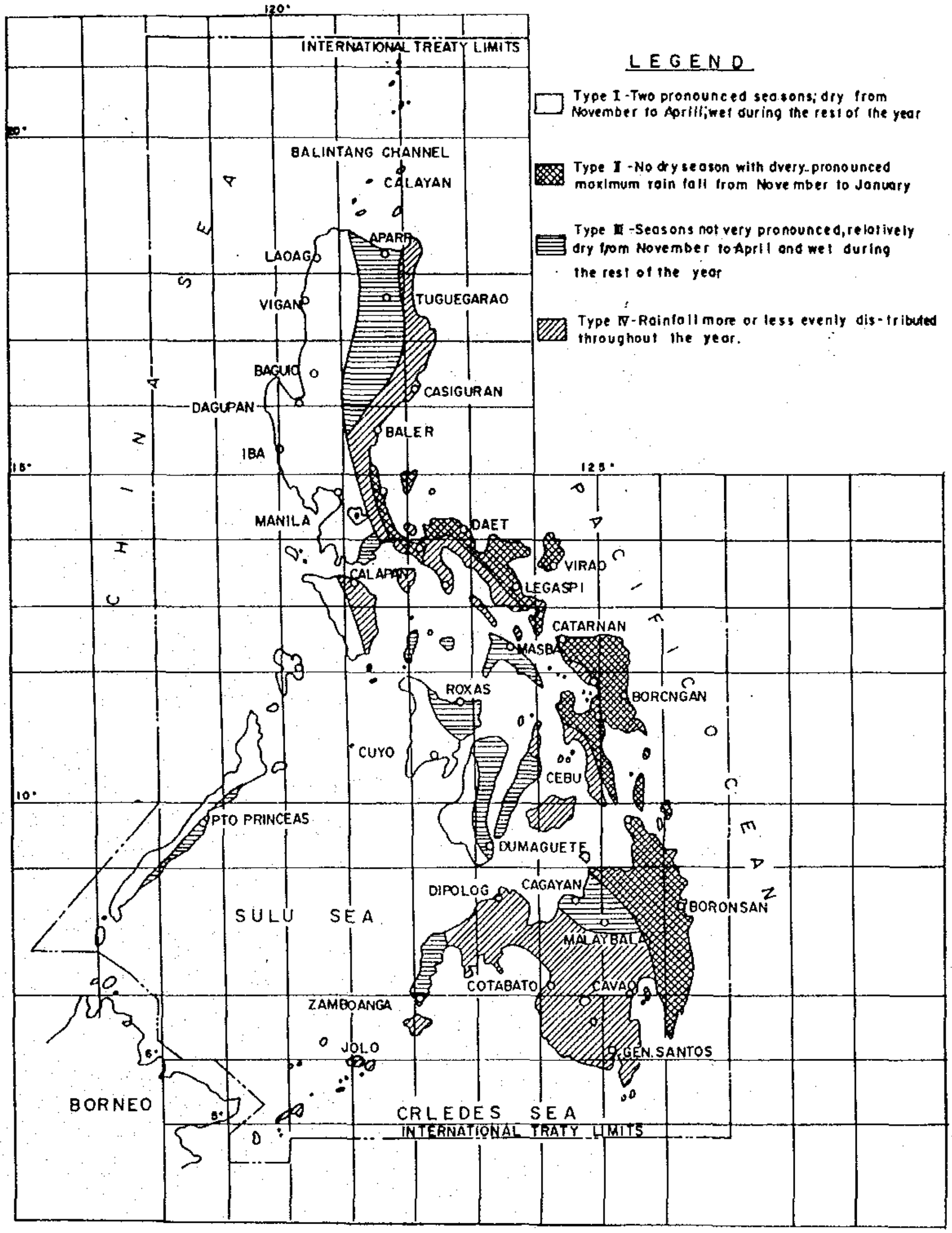


Fig. I.2.1 Coronas Climate Classification in the Philippines

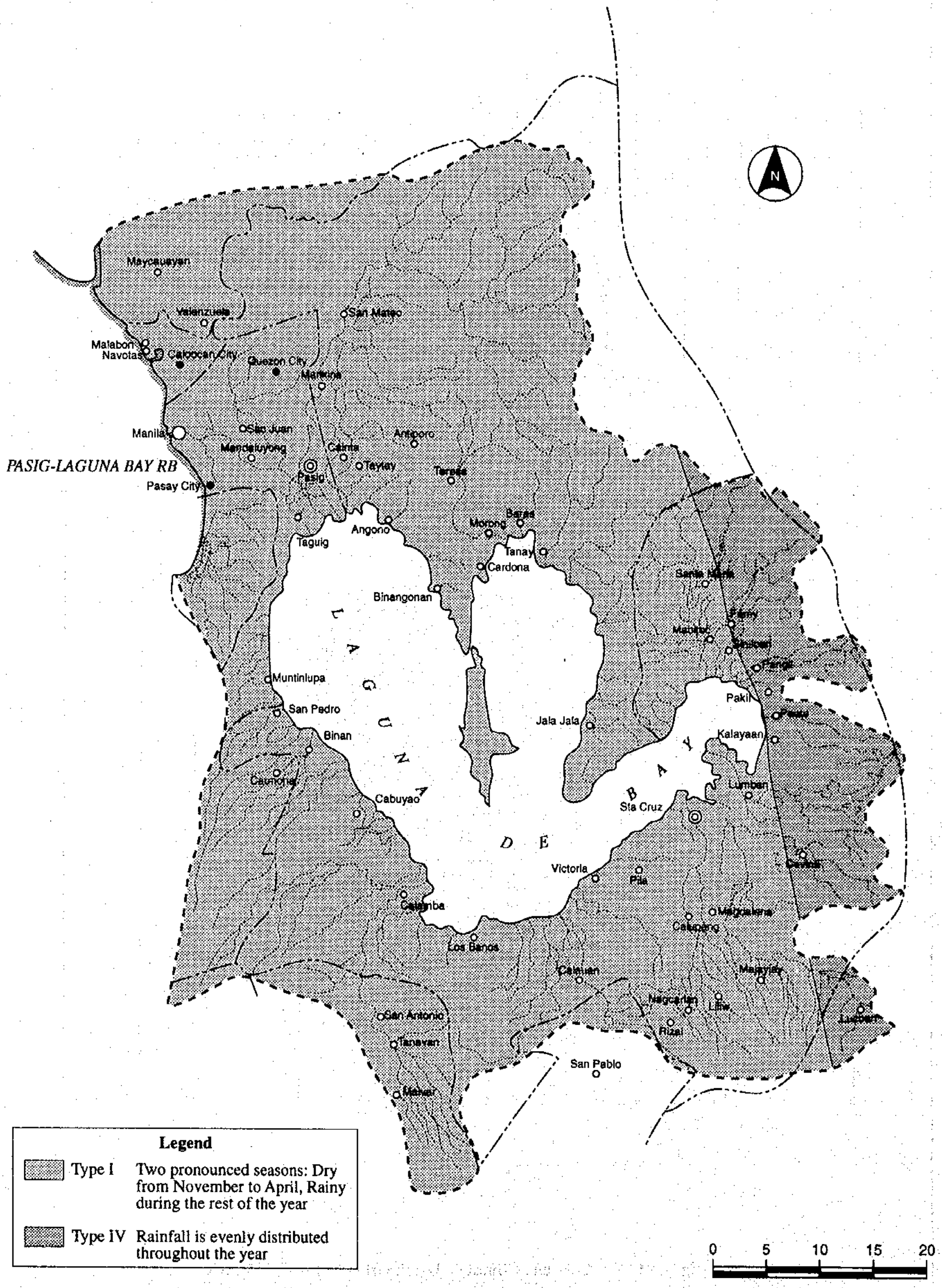


Fig. I.2.2 Climate Type of the Laguna Lake Basins

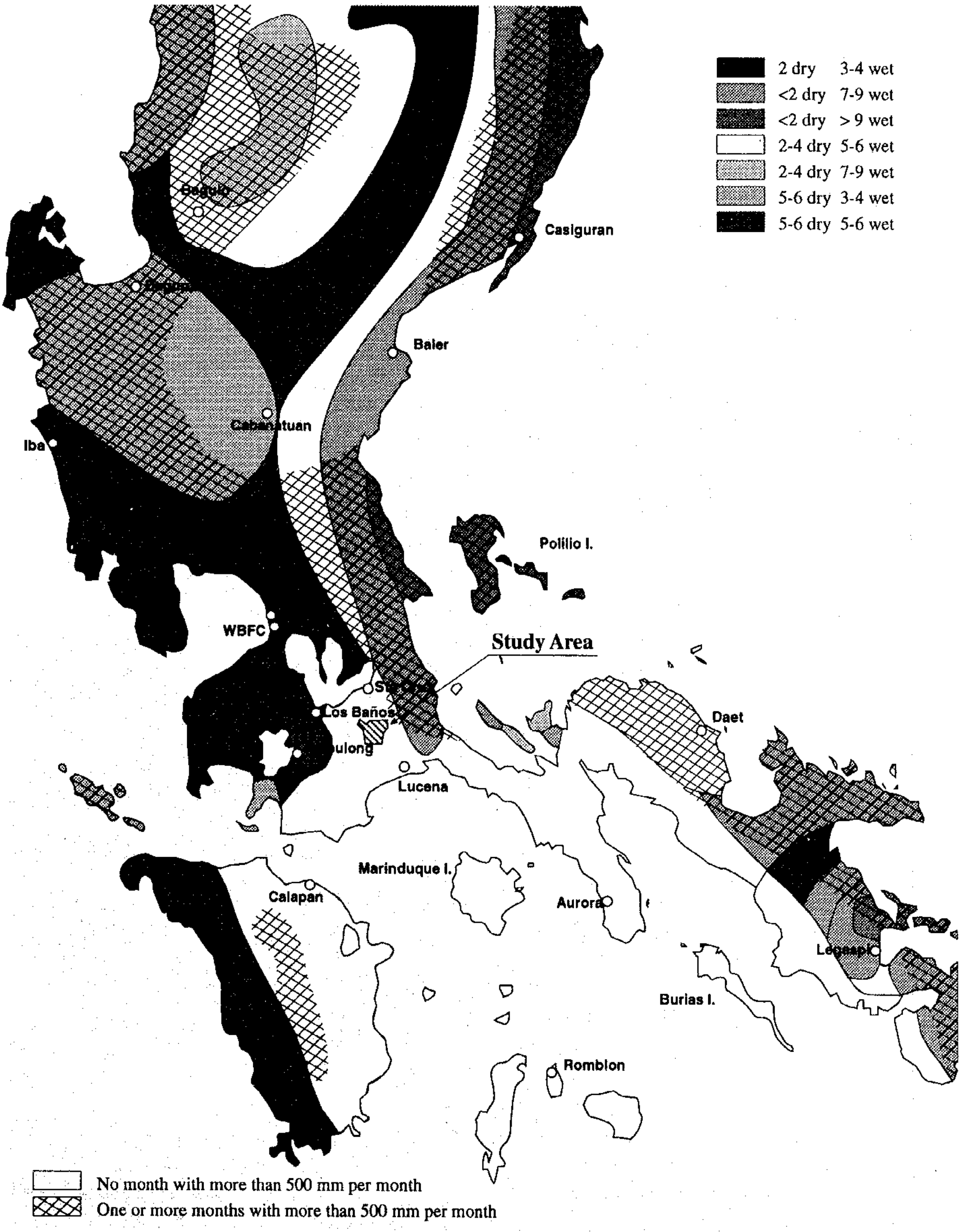


Fig. I.2.3 Rainfall Distribution

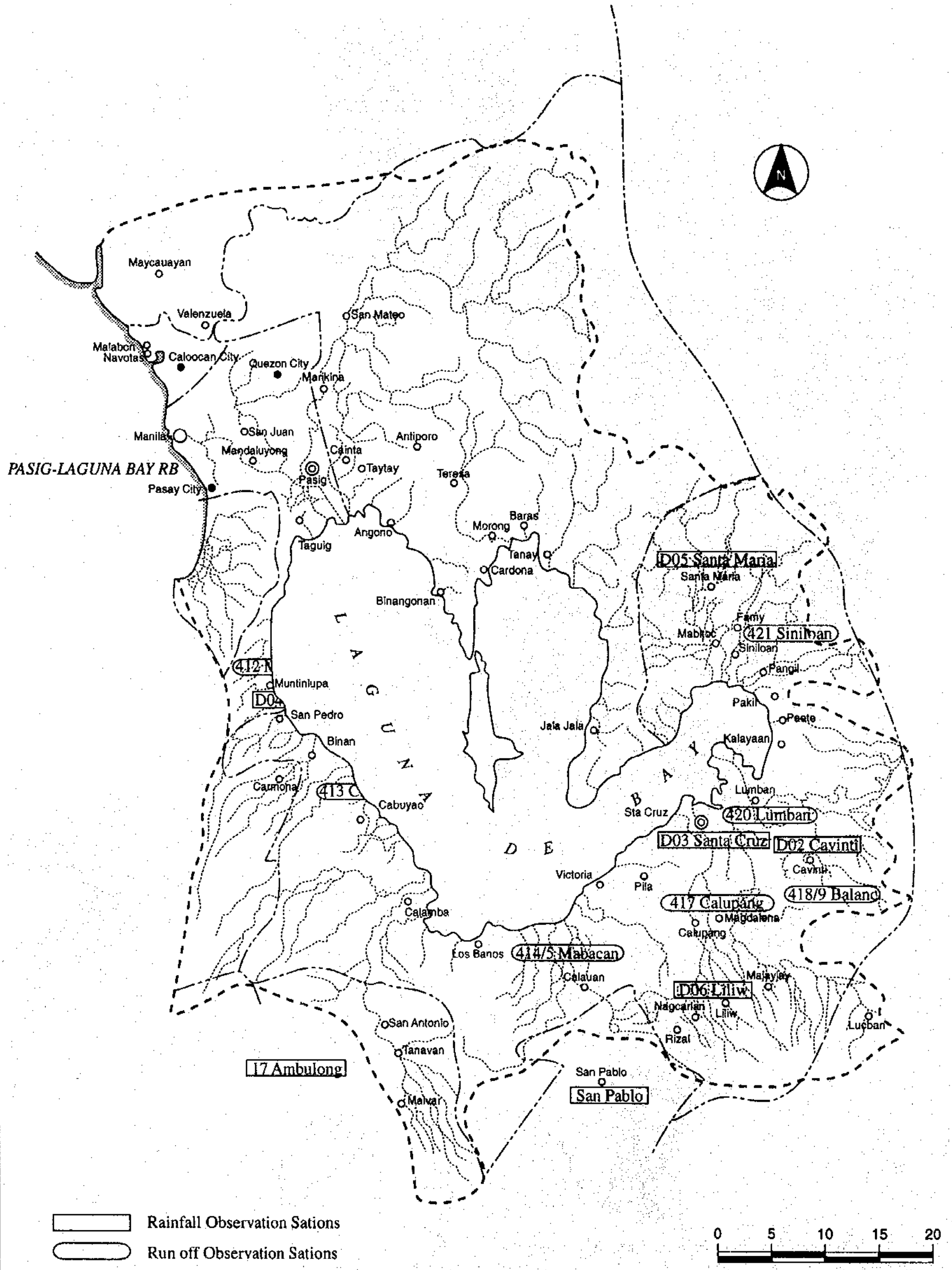


Fig. I.2.4 Location Map of the Meteorogical/Hydrological Observation Stations

Items	Location	Coordinates	
		Latitude	Longitude
Rainfall	Los Banos, Laguna	14° 11'	121° 15'
	Lumot, Cavinti, Laguna	14° 15'	121° 30'
	Sta. Cruz, Laguna	14° 17'	121° 25'
	Liliw, Laguna	14° 08'	121° 26'
	Nagcarlan, Laguna	14° 05'	121° 26'
	Lucena, Quezon	13° 56'	121° 37'
	Infanta, Quezon	14° 45'	121° 39'
	Tayabas, Quezon	14° 02'	121° 35'
	Caliraya, HEP, Laguna	14° 17'	121° 30'
	Caliraya, Lumot, Laguna	14° 16'	121° 32'
	Kalayaan, Laguna	14° 19'	121° 28'
Temperature	Los Banos, Laguna	14° 11'	121° 15'
	Cavinti, Laguna	14° 17'	121° 30'
	Nagcarlan	14° 05'	121° 26'
Relative Humidity	Los Banos, Laguna	14° 11'	121° 15'
	Cavinti, Laguna	14° 17'	121° 30'
	Nagcarlan	14° 05'	121° 26'
Pan Evaporation	Los Banos, Laguna	14° 11'	121° 15'
	Nagcarlan	14° 05'	121° 26'
Wind Velocity /Direction	Los Banos, Laguna	14° 11'	121° 15'
	Cavinti, Laguna	14° 17'	121° 30'

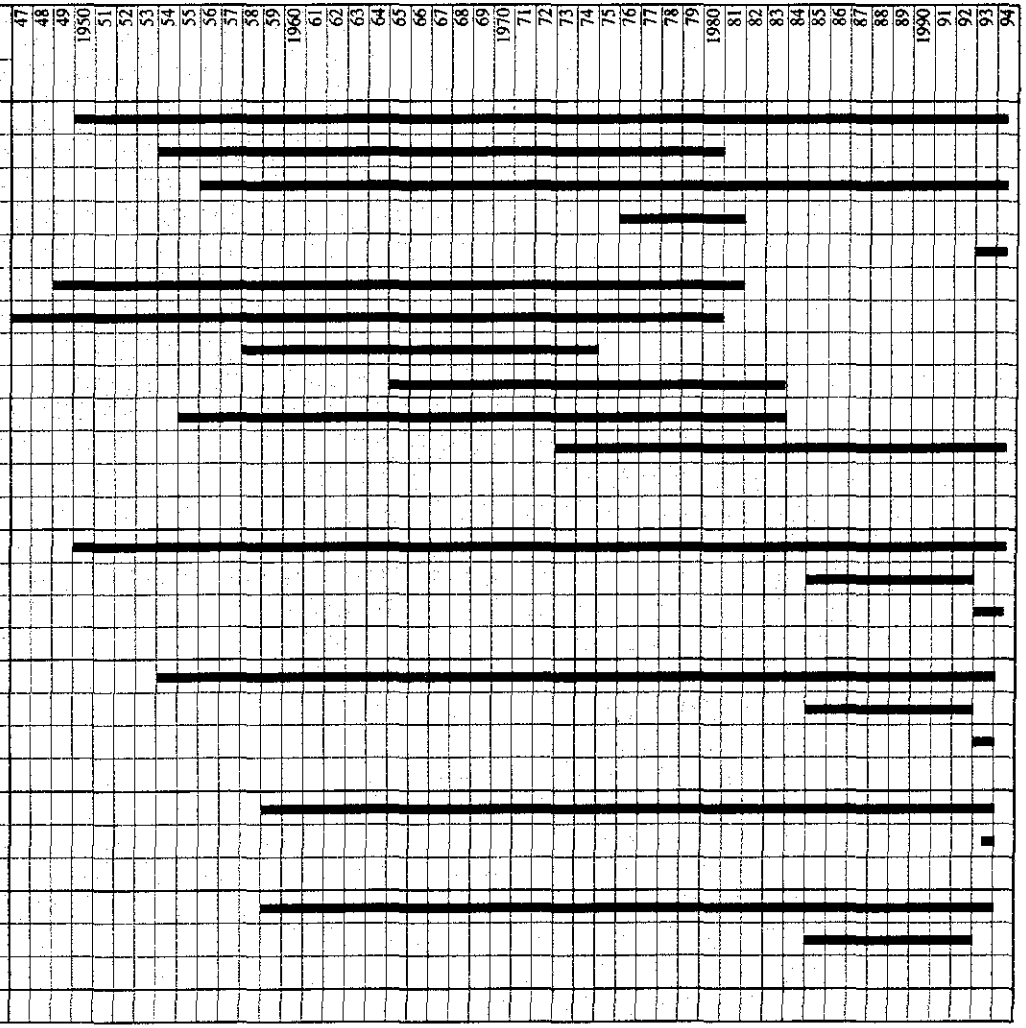


Fig. I.2.5 Historical Meteorological Observation Records

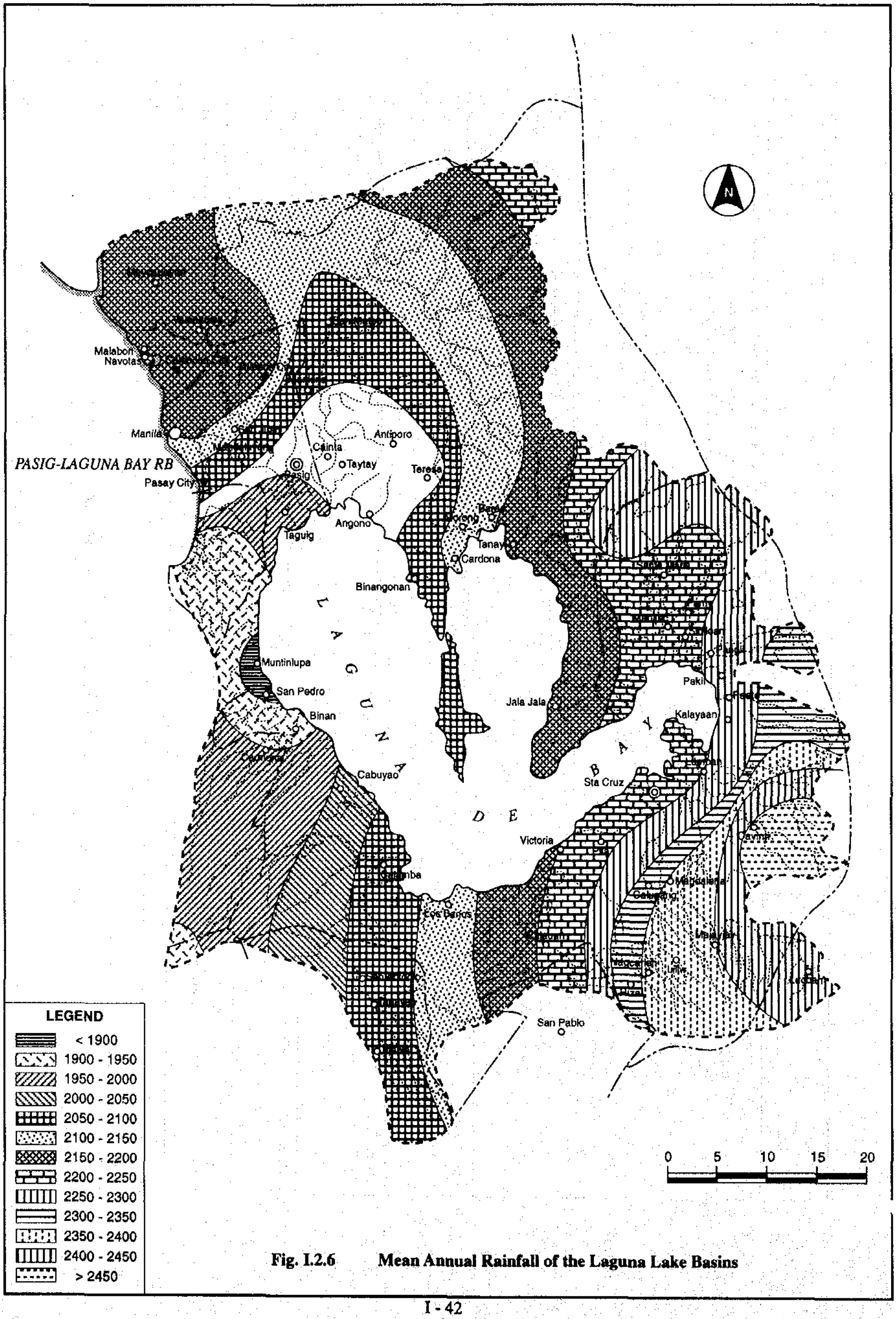


Fig. I.2.6 Mean Annual Rainfall of the Laguna Lake Basins

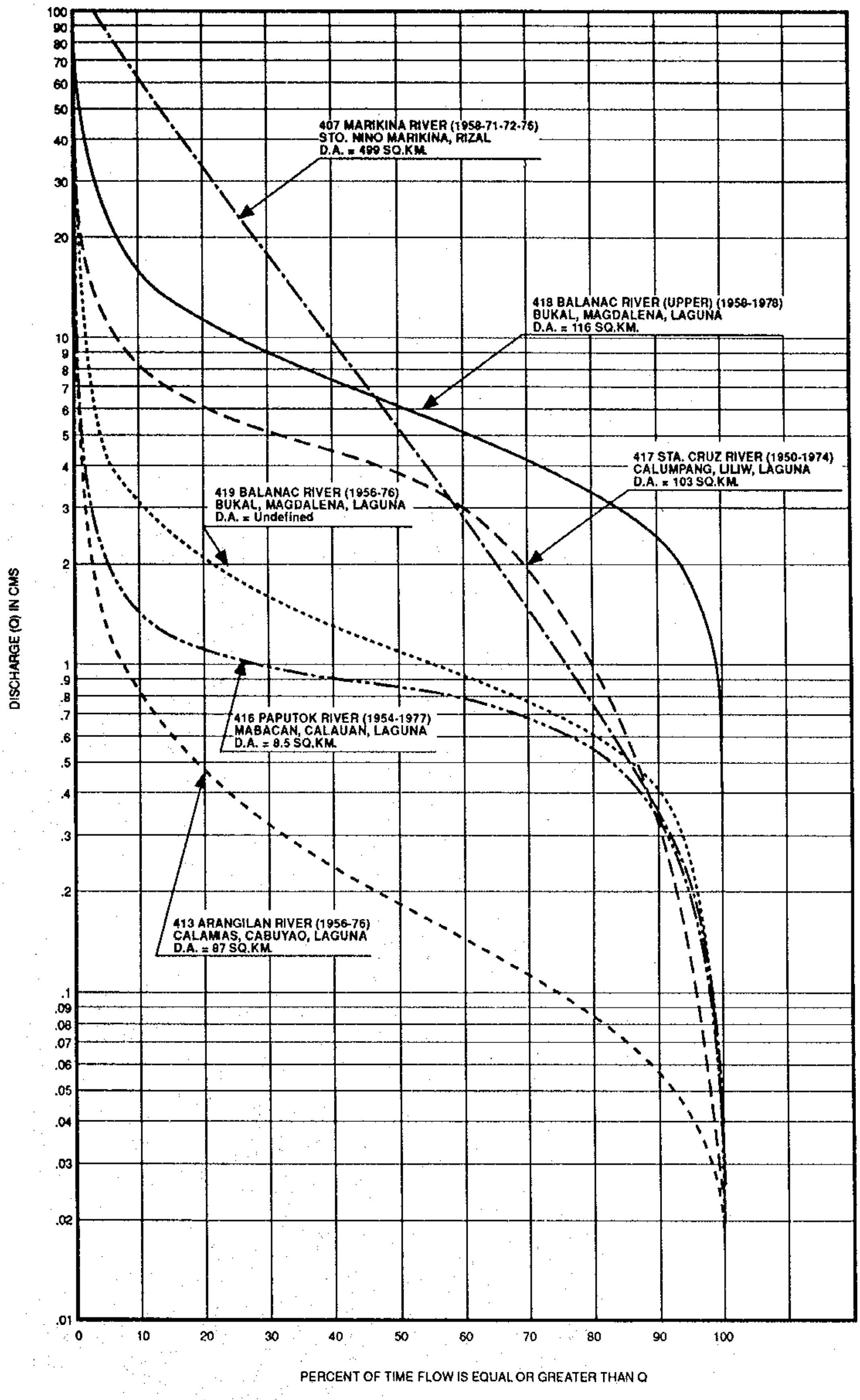


Fig. I.3.1 **Flow Duration Curves of Rivers in the Laguna Lake Basins**

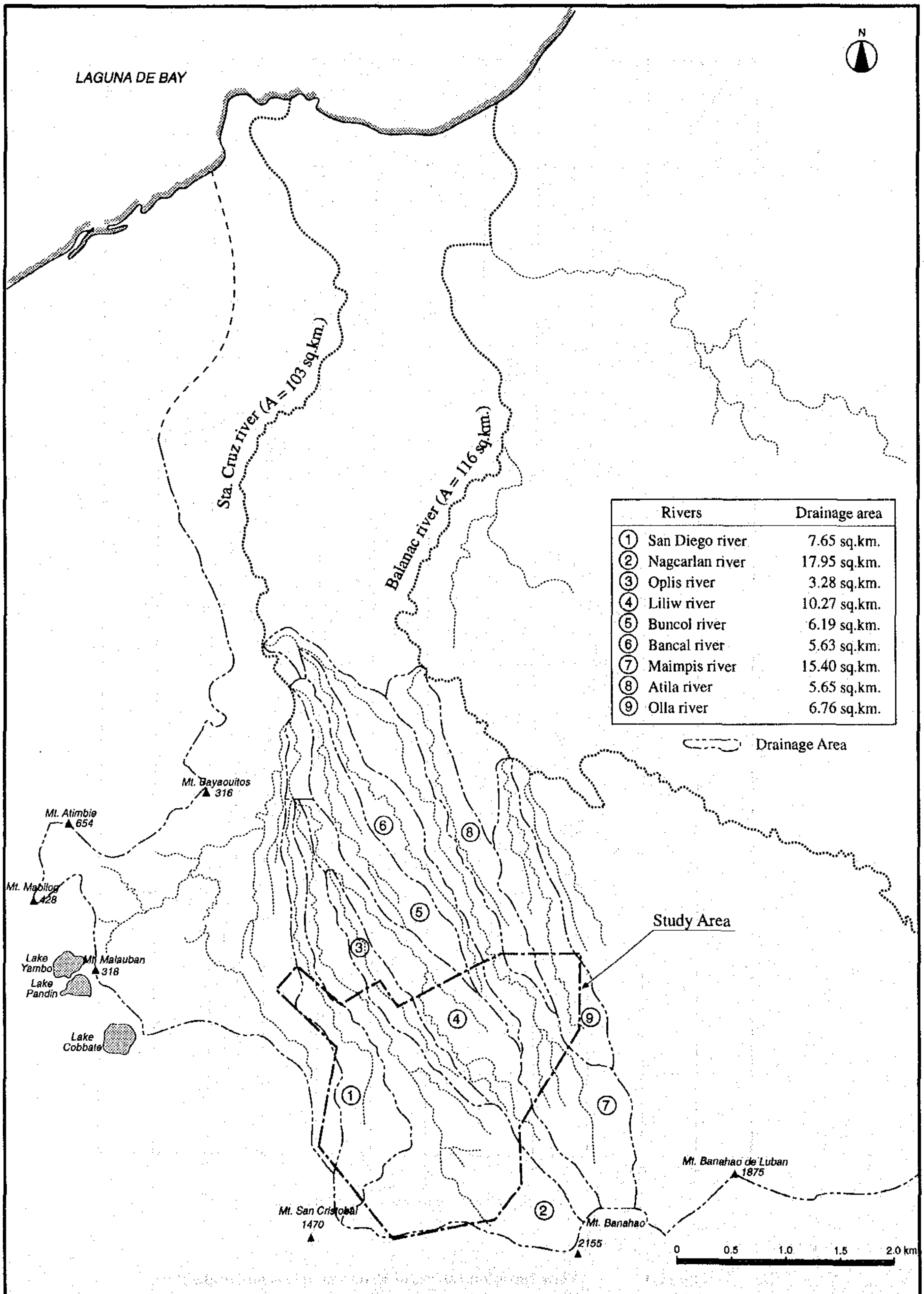
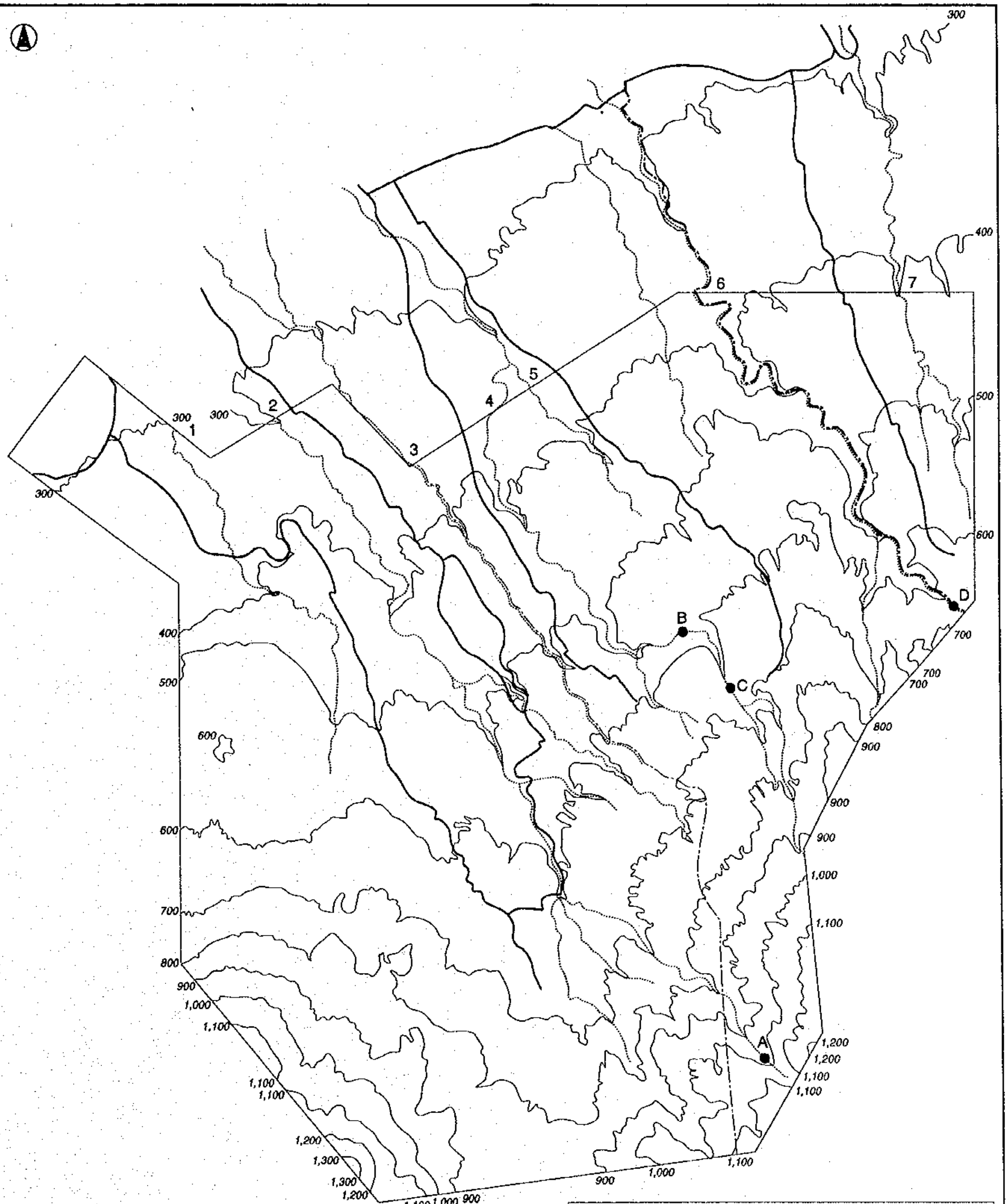


Fig. I.3.2 Drainage Area of Rivers in the Study Area



No.	Rivers	No.	Springs
1	San Diego River	A	Bukal Spring
2	Nagcarlan River	B	Lower Liliw River Spring
3	Oples River	C	Upper Liliw River Spring
4	Liliw River	D	Maimpis River Spring
5	Bancal River		
6	Maimpis River		
7	Olla River		

0 200 400 600 800 1,000 m

Fig. I.3.3 Majoir Rivers in the Study Area

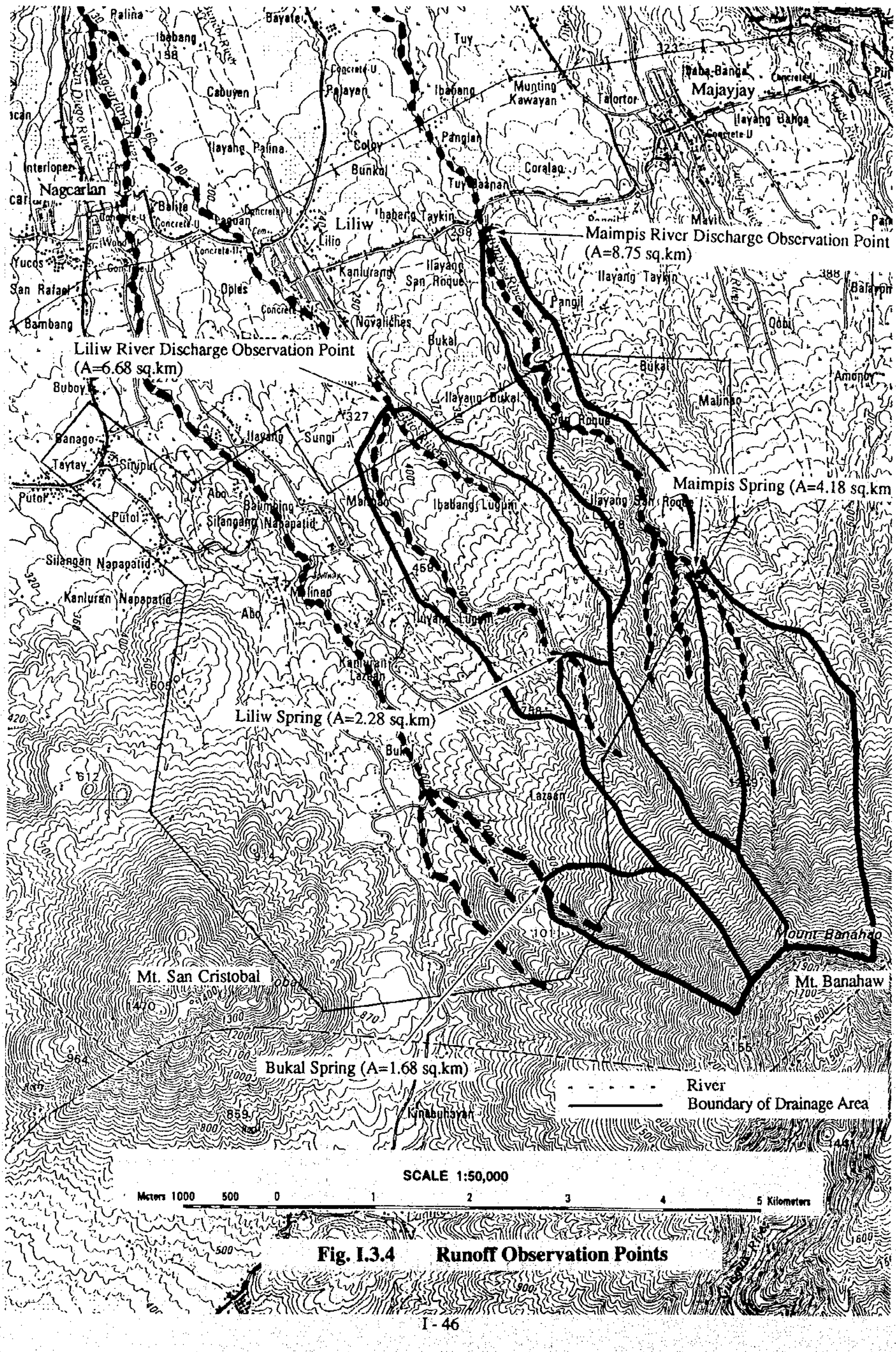
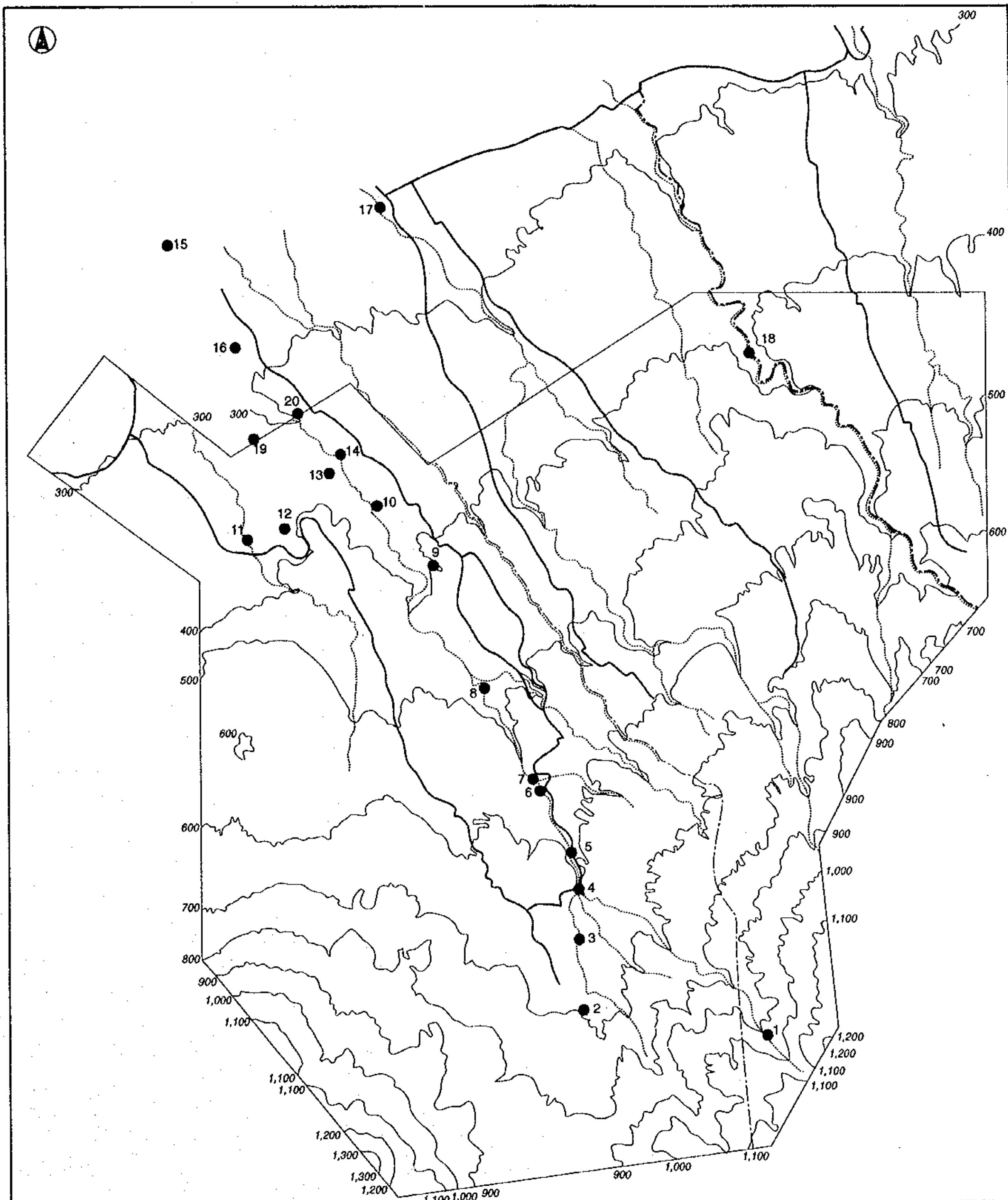


Fig. I.3.4 Runoff Observation Points



Sampling No.	Water sources	Sampling No.	Water sources
1	Spring (River)	11	Spring (River)
2	Spring	12	Spring (River)
3	Spring	13	Spring
4	Spring	14	Spring (River)
5	Spring (River)	15	River Water
6	Spring (River)	16	River Water
7	Spring	17	River Water
8	Spring	18	River Water
9	Spring (River)	19	Fish Pond
10	Spring (River)	20	Pond

Fig. I.4.1 Sampling Sites of Water Quality Test

FEASIBILITY STUDY ON
THE UPLAND IRRIGATION AND
RURAL DEVELOPMENT PROJECT
IN SOUTHERN LUZON

APPENDIX-II

GEOLOGY AND GROUNDWATER

FEASIBILITY STUDY
ON
THE UPLAND IRRIGATION AND RURAL DEVELOPMENT PROJECT
IN SOUTHERN LUZON

APPENDIX-II
GEOLOGY AND GROUNDWATER

Contents

Page

List of Figures

Attachment

APPENDIX-II GEOLOGY AND GROUNDWATER

1 Introduction

This Appendix-II was prepared based on the results of geological, hydrogeological and groundwater surveys which were carried out during the both Phase 1 and Phase 2 field works of the Feasibility Study on the Upland Irrigation and Rural Development Project in Southern Luzon.

During the Phase 1 field work, test well drillings including electric logging and geoelectric survey were conducted in order to clarify hydrogeological condition in the Study area and to make a rough evaluation of groundwater resources for providing a comprehensive guideline for the planning of an optimum irrigation system in the area. In the Phase 2 stage, core borings and associated standard penetration tests were made in order to obtain basic geotechnical data for foundation design of the structures.

Whole locations of the above mentioned geological surveys are shown in Fig. II.1.1. Main work items conducted under the geological, hydrogeological and groundwater surveys are as follows:

- To collect and review of the existing data and reports from government agencies concerned,
- To carry out field reconnaissance survey for general geological condition and present groundwater use,
- To execute the test well drillings with 50 to 125 m depth and 4" diameter at the 3 selected sites,
- To execute the geoelectric resistivity survey with sounding depth of more than 200 m at the 4 selected typical area,
- To execute the core borings including standard penetration tests with the depth of 25 m each at the 2 selected sites, and
- To study possibility of the groundwater irrigation system, and to estimate bearing capacity for structure designing.

2 Data Collection and Field Checking

In order to estimate the aquifer potential in the Study area, the following data and maps regarding to the geological and hydrogeological condition were collected and reviewed through geological reconnaissance and field checking of the existing groundwater facilities at the site:

- Geological Map of the Macolod Corridor (Taal - Banahaw) Scale 1:100,000
  Department of Science and Technology, Philippine Institute of Volcanology and Seismology, Quezon City, 1991
- Rapid Assessment of Water Supply Sources, Province of Laguna, National Water Council, 1982

3 Geography and Geology

3.1 Geographical Condition

The Study area, in the Municipality of Nagcarlan and its vicinities, Province of Laguna, southern Luzon, is about 75 km southeast of Manila as seen in General Location Map attached at the head of volume of the main report, and is also located on the area from northwestern foot of Mt. Banahaw to northeastern foot of Mt. San Cristobal geographically. It has about 3,000 ha and extend in the section between 300 to 1,300 m above sea level.

Mt. Banahaw (El. 2,165 m) is the tallest active volcano of the Macolod Corridor and surrounding volcanic fields. It has secondary lava cones of Mt. San Cristobal (El. 1,470 m) on the west and Mt. Banahaw de Lucban (El. 1,850 m) on the east. The summit caldera is 600 m deep and has a diameter of 2 km. The caldera opens southward in a 4 km long canyon. Mt. San Cristobal is a complex doming structure with two small crater lake at its summit. Mt. Banahaw de Lucban is the only dome on the east side. It is reported that the activity of Mt. Banahaw is from 1.6 Ma to 1743, and after last eruption in 1743, no remarkable volcanic activity has been recorded. Although debris avalanche occurred at the southern side in 1982 has been reported (Barcelona et al. 1982), the northern side including the Study area seems to be stable against future debris avalanche controlled by the topographical shape of the summit Caldera.

Terrain found within the Study area includes steep mountain slopes, moderately to gently sloping hilly area and lava dome mounds. The steep mountain slopes above around El. 700 m are covered with natural forest in which major river systems such as Nagcarlan river, Liliw river and Maimpis river are originating. The tropical forests at higher portion of Mt. Banahaw have been conserved their ecological environment as the National Park by the government agency. The hilly area underlain by pyroclastics widely extend to the northward. Most of the hilly land is used as coconuts field and small-scale upland field. The dome mounts formed by lava cone are locally found at the northern foots of Mt. San Cristobal in the western side of the Study area.

River system in the Study area is permanent and semi-permanent stream. Major permanent streams, from west to east, are the Nagcarlan river, the Liliw river and the Maimpis river which are originating northern shoulder of Mt. Banahaw and having wide catchment area. The Nagcarlan and the Liliw rivers flow northwestward through the Municipality of Nagcarlan and the Municipality of Liliw respectively. The Maimpis river flows along the boundary between the Municipality of Liliw and Majayjay. The San Diego river originating Mt. San Cristobal and its tributary of the Lameo river have revived water at the lower portion of the Study area at around El. 340 to 320 m even in the dry season. The Oples river, the boundary between Municipality of Nagcarlan and the Municipality of Liliw as well as many other tributaries flow only in the rainy season. These rivers reach to Lake Laguna (Wl. 1 m) at around 30 km north from the Study area.

Annual rainfall is about 2,400 mm at the Municipality of Liliw site where corresponding to the lower outside of the Study area, while that in the Study area seems to be more high. Monthly rainfall varies yearly, however 72 % of the total annual rainfall falls in the period between June and November.

Springs are sporadically found at the riverside cliff and river floor. These spring water has been used as domestic water by pipe line network. The major springs at the higher portion, which expected to be available water sources for the upland irrigation, are around El. 890 m in the Nagcarlan river and around El. 560 m and El. 610 in the Liliw river.

3.2 Geological Condition

Geologically, the Study area is underlain by Quaternary volcanic products of Mt. Banahaw, which consist of andestic lava flow, tephra (fallen pyroclastic materials) deposits, ash flow and lahar deposits. According to the Geological Map of the Macolod Corridor (see Fig. II.3.1), published by Philippine Institute of Volcanology and Seismology, et al. 1991, Mt. San Cristobal and Mt.Banahaw de Lucban are built up on the secondary andestic lava cones of Mt.Banahaw. The upper regions of Mt. Banahaw are covered with lava flows and extrusive lava breccias. Steep slopes between El. 800 m and 700 m, pyroclastics and lahar deposits are predominant. Below El. 700m, ash flow and lahar deposits extend northward to the Laguna de Bay. The steep slopes at upper part of Mt. San Cristobal consist of andestic lava of secondary cone. In addition, small-scale mounds formed by andestic lava dome and basaltic andesite lava are distributed on the north to northeastern part of Mt. San Cristobal in the Study area.

Greater part of the Study area is moderately to gentle sloping hilly area except the riverside cliffs, and is covered with pyroclastics of Mt. Banahaw and Mt. San Cristobal. It mainly consists of brown loam originating fallen volcanic ash, ash flow and lahar deposits. According to the core borings in the Phase 2 stage, the thickness of the uppermost loam layer is around 6 m, and its N-Values range from 7 to 10 with average value of 8 except the rock fragments contained section. The lahar deposits observed along the Abo-Bukal Barangay road contain a large quantity of big andesite boulders of more than 1 m in diameter.

3.3 Hydrogeological Condition

Hydrogeological conditions in the Study area, such as lithologic condition, depth of the groundwater level, shape of the water bearing formations, and the resistivity structure are revealed by execution of the field surveys as follows:

Thick andestic lava, tuff, and superficial silt and loam were observed by execution of three (3) test well drillings conducted at the Abo (TW-1: 125 m), Silangan Lazaan (TW-2: 50 m), and Malinao (TW-3: 125 m) sites. The andestic lava is thick but generally highly fissured. The tuff formation is intercalated within the andestic lava in the section from 80 to 98 m in the drilling hole of TW-1, and from 22 to 42 m in the TW-3. The uppermost silty and loamy layers with gravel are distributed with the thickness of 6 to 10 m from the ground surface.

During the test well drilling works, leakage of the drilling water was observed through the whole sections. Trial measurement for the permeability coefficient was also made in the Phase 2 stage. Although more than 500 lit. of water was injected into boring hole, no rise up of the water level was observed due to sudden leakage. Accordingly, the strata in the Study area should be highly porous and permeable.

Groundwater level observed in the drilling holes was generally low, namely at the depth of 57 m and 47 m from the ground surface in the holes of TW-1 and TW-3. The groundwater level in the TW-2 seems to be below the bottom of the hole, because no groundwater level was observed during the drilling operation up to the depth of 50 m.

Water bearing formations were found from the electric logging in the drilling holes. The sections of the water bearing zones are 59 to 62 m, 79 to 93 m 107 to 121 m in the TW-1, 38 to 39 m, 45 to 47 m in the TW-2, and 69 to 71 m, 88 to 100 m, 109 to 113 m in the TW-3. Since these zones are generally thin, the aquifer system is to be fissure water system in the andestic lava.

Resistivity structure in the Study area is divided into two (2) to five (5) layers, however, it is fairly difficult to follow the continuity of resistivity layer. The thin first and second layers are distributed near the surface with depth of around 10 m, and their resistivity vary from 300 to 8,000 Ω-m. The third resistivity layer has specific resistivity with 200 to 900 Ω-m in low values and 1,500 to 6,000 Ω-m in high values. The fourth resistivity layer appears at the depth below 30 to 130 m from the ground surface and its resistivity values range from 100 to over 10,000 Ω-m. The fifth layer is partially found in the Bukal and Malinao area with 200 to 4,000 Ω-m.

Based on the above mentioned hydrogeological conditions, the groundwater in the Study area is deep due to fissure water in the andestic lava and its continuity is assumed to be poor. Therefore, it suggests that the good aquifer suitable for the groundwater irrigation purpose is absent.

4 Test Well Drilling

4.1 General

The exploratory well drillings with a depth of 50 to 125 m were carried out at the 3 sites by employing a local drilling contractor, Mineral Exploration and Geo Analysis, in the Municipality of Nagcarlan where will be major development area. The drilling work was done in the Phase 1 stage under the supervision by the JICA Study team in order to get all information of hydrogeological condition of the area and to estimate possibility of the groundwater irrigation. These wells will be used for further groundwater observation.

4.2 Location and Quantities

Arrangement for test well drillings was made at the selected three (3) locations. The test drilling sites were selected in the Barangay of Abo, Silangan Lazaan and Malinao in the Municipality of Nagcarlan considering accessibility and workability as shown in Fig. II.5.2 and Fig. II.5.3. Selected locations, drilling depth, and elevation of the test wells are shown as follows:

Nos.of Well	Depth	Barangay	Elevation
TW-1	125 m	Abo	462 m
TW-2	50 m	Silangan Lazaan	475 m
TW-3	125 m	Malinao	411 m
Total	300 m		

4.3 Design of Test Well and Procedure

The test wells were designed as a observation well which is proposed to be observation borehole for groundwater level. Installation of casing pipes and screen were also designed in the 125 m deep wells of TW-1 and TW-3. The casing of piezometer is 3" diameter galvanized steel, while screen section is 3" galvanized slotted steel pipe. The standard procedure of drilling works is briefed as follows:

- Drilling 12" borehole from surface down to 3 m depth.
- Installation of 12" temporary conductor pipe down to 3 m depth.
- Drilling 4" pilot hole from bottom of conductor pipe including sampling of drill cutting in each meter.
- Electric logging.
- Installation of 3" dia. steel casing and screen pipes to designed depth.
- Placing of gravel pack grading 2 to 7 mm in annular space from the bottom.
- Well development by high velocity water jetting and over pumping.
- Construction of concrete slab and well cap.

4.4 Electric Logging

To carry out the electric logging, one set of automatic operated geologger 300 was used in the test drilling program. The well probe consists of a current electrode and three potential electrodes spaced at 25 cm, 50 cm and 100 cm from the current electrode.

The normal electrode management for resistivity measurement are used for all test wells. The measurement was derived from four electrode systems, using two electrode A and B, and two potential electrode M and N. The electrode spacing used for Short Normal is AM=50 cm and for Long Normal is AM=100 cm.

The self potential (SP) measurement is conduct using electrode spacing similar to the resistivity measurement. The SP log records the natural potential developed between the borehall fluid and the surrounding rock material.

The measured values of the Short Normal resistivity and the self potential ranged from 100 to 4,000 Ω-m and from (-) 60 to (+) 25 mili volt respectively as shown in Fig. II.4.1 to II.4.3. The logging peaks of relatively high resistivity sections indicating water bearing formation were found as follows:

TW-1	TW-2	TW-3
59 to 62 m	38 to 39 m	69 to 71 m
79 to 93 m	45 to 47 m	88 to 100 m
107 to 121 m		109 to 113 m

4.5 Test Well Construction

The works were started on February 24 by using three (3) sets of drilling rigs and is completed on the end of March 1994.

The test wells were constructed in accordance with the standard well design. The 3" diameter galvanized steel and 3" galvanized slotted steel for 20 m long screen section were installed in the TW-1 and TW-3. To develop the well, high velocity water jetting and over pumping were conducted at the test wells for total amount of more than 24 hours.

4.6 Lithology and Groundwater Level

Thick andestic lava, tuff, and superficial silt and loam were observed by execution of the test well drillings. The andestic lava is thick but generally highly fissured. The tuff formation is intercalated within the andestic lava in the section from 80 to 98 m in the drilling hole of TW-1, and from 22 to 42 m in the TW-3. The uppermost silty and loamy layers with gravel due to tephra deposits, ash flow and lahar deposits are distributed with the thickness of 6 to 10 m from the ground surface.

Groundwater level observed in the drilling holes was generally low, namely at the depth of 57 m and 47 m from the ground surface in the holes of TW-1 and TW-3. The groundwater level in the TW-2 seems to be below the bottom of the hole, because no groundwater level was observed during the drilling operation up to the depth of 50 m.

The lithological condition and groundwater level in each drilling hole are shown in Fig. II.4.1 to II.4.3 together with result of electric logging.

5 Geoelectric Survey

5.1 General

In order to clarify the hydrogeological condition and aquifer distribution, the geoelectric survey was conducted by resistivity method with survey depth of more than 200 m. Field measurement was done in the period from middle February to early March 1994.

5.2 Survey Area and Measured Points

Measurement was made at 48 points surrounding the test well drilling sites located in the Barangay of Bukal, Abo, Silangan Lazaan and Malinao. The measured sounding points and referenced test well locations are shown in Fig. II.5.1 to II.5.3 and summarized below:

Area	Nos. of Sounding Points	Referenced Test Well
Bukal	8	-
Abo	25	TW-1
Silangan Lazaan	10	TW-2
Malinao	5	TW-3
Total	48	

5.3 Selection of Survey Points

Survey points are arranged to form a suitable profile line or zone in an interval of 50 to 100 m at each area, and are decided with the following consideration:

(1) for spreading electrodes, select the site flat as possible

(2) over contact resistance on the ground

(3) avoiding such site having electric noise in the earth caused on electric transmission line, buried steel pipe, etc.

5.4 Instrument of Geoelectric Survey

Instrument, Mcohm, Model-2115, used for this survey was prepared by the JICA Study Team and its specifications are as follows:

* Transmitter	
Output voltage	400 Vpp max.
Input voltage	1, 2, 3, 10, 20, 50, 100, 200 mA (Constant Current)
Operating potential	12 V DC
* Receiver	
Input impedance	1 M-ohm
Measurement potential	± 0.6 V, ± 6 V (auto range)
Resolution	20 μV
Noise reduction ratio	90 dB (with 50/60 Hz power)
Stack count	1, 4, 16, 64 (Stacking can be stopped)
Time of one measurement cycle	3.5 sec.
* Data memory	
Max. no. of files	128
Max. no. of data	2,000
Max. no. of data files	110
* Interface	RS-232C
* Power	DC 12 battery, externally connected,or rechargeable batteries, installed in the battery holder.
* Operative temperature range	0 - 50 °C
* Dimensions	206 x 281 x 200 mm
* Weight	Approx.7.5 kg

5.5 Survey Method

The resistivity survey was carried out by the vertical electric sounding method adopted Schlumberger's electorode configuration. The potential (M and N) and current (A and B) electrodes of originate from a center point. The electrode spacing adopted for this survey were as follows:

MN (m)	AB/2 (m)						
0.3	1.0	1.5	2.5	3.5	5.0		
1.0	7.0	10.0	15.0				
3.0	22.0	32.0	47.0				
10.0	69.0	100.0	125.0	150.0	180.0	20.0	270.0

5.6 Interpretation of Data and Resistivity Structure

Based on the measured resistance (Ω), the apparent resistivities were given through the following formula:

$$\rho a = \rho \times R \times \{(AB/2)^2 - (MN/2)^2\} / MN$$

where, R : measured resistance (Ω)
ρa : apparent resistivity (Ω-m)
AB : current electrode separation (m)
MN : potential electrode separation (m)

The resistivity - spacing curves in which apparent resistivity was plotted against various spacing *(AB/2)* at one sounding point, are interpreted by curve-matching method as shown in the attachment. The result of interpretation obtained by curve-matching method is used at first approximate, then after this is modified by try and error to get good coincident between theoretical curve and the observation curve. The resistivity-electrode spacing curves for each survey point are attached in the end of volume.

The resistivity logs for each sounding point and the typical resistivity profiles obtained by interpretation of the resistivity-electrode spacing curves are shown Fig. II.5.4 to II.5.6 and Fig. II.5.7 to II.5.9, respectively.

According to the interpretation results, resistivity structure in the Study area was divided into two (2) to five (5) layers, however, it is fairly difficult to follow the continuity of resistivity layer. The thin first and second layers are distributed near the surface with depth of around 10 m, and their resistivity vary from 300 to 8,000 Ω-m. The third resistivity layer has specific resistivity with 200 to 900 Ω-m in low values and 1,500 to 6,000 Ω-m in high values. The fourth resistivity layer appears at the depth below 30 to 130 m from the ground surface and its resistivity range from 100 to over 10,000 Ω-m. The fifth layer is partially found in the Bukal and Malinao area with 200 to 4,000 Ω-m.

6 Groundwater Resources

6.1 Previous Assessment for Groundwater Availability

A study on Rapid Assessment of Water Supply Sources at the provincial and municipal levels had been carried out by the National Water Resources Council (NWRC) in May 1982. According to the report, there were 587 developed and operational water resources as of 1980 in the province of Laguna. Of this total, 7 % were springs, 8 % were shallow wells and 85 % were deep wells.

The study had also included an assessment of groundwater resources and the preparation of a provincial base groundwater map. From the view points of groundwater availability, each province had been divided into three categories as follows:

(1) Shallow Well Areas are suitable for construction of wells with depths of within 20 m below ground surface. The static water level in these areas are generally within 6 m.

(2) Deep Well Areas are characterized by aquifer of water bearing formation generally located at a depth of more than 20 m below ground surface. Therefore, deep wells with depths of more than 20 m are recommended in these areas.

(3) Difficult Areas where groundwater supply is minimal and the probability of encountering non-productive boreholes is very high. Groundwater replenishment in these areas are only through rock fissures, cracks and crevices, which predominantly exist in place where there are faults and other geologic discontinuities.

Based on the above classification, the Province of Laguna consists of 15 % shallow well areas and 85 % difficult areas. The shallow well areas in the province are only located at the alluvial flat plain along the shore of Lake Laguna. All of the hilly and Mountainous areas including the Study area have been classified as the difficult areas for groundwater development.

The numbers of wells constructed as of 1980 were 13 wells in the Municipality of Nagcarlan and 6 wells in the Municipality of Liliw. However, no water wells had been recorded in any Barangay concerning to the Study area.

6.2 Present Groundwater Use

During the Phase I field work of the Study, present groundwater use was surveyed through the site reconnaissance, review of existing data and hearing survey. There are no groundwater facilities such as dug well, shallow well and deep well in the Study area at present, because both of the water resources for domestic and irrigation water in the Study area are springs.

On the other hand, there are five mineral water factories including suspending ones, Pagoda, Ligo, Hidden Spring, Cosmic and Klear Water, near the lower boundary of the Study area along the national highway connected from Nagcarlan to San Pablo. According to information obtained from the biggest company of Hidden Spring located at just outside of the Study area, the factory has two deep tube wells with depths of 60 m and 9" in diameter. The groundwater at the factory site has been pumped up with the ratio about 1 to 1.3 lit/sec by using 2" diameter jet pump.

6.3 Possibility of Groundwater Irrigation

According to the hydrogeological investigations consist of the test well drillings including electric logging and the geoelectric survey, the Study area is mainly underlain by andestic lava and surface soil layer. The groundwater level was around 50 m from the ground surface or more. The water bearing formations due to fissure water from the andestic lava are generally thin. The resistivity structure indicates the poor continuity of the aquifer.

Based on the above mentioned hydrogeological condition in addition to the previous assessment results of difficult area about the groundwater development, planning of the groundwater irrigation system will be not recommended due to technical and economical difficulty of pumping up from the deep aquifer and its uncertain yield of groundwater. In the case of groundwater irrigation, numinous pumping test will be required additionally to evaluate the groundwater yield in the Study area. Furthermore, influence survey to the existing mineral water facilities and the springs are also required to assess decrease of water quantities. Therefore, springs or river water will be recommended for the optimum water sources for the upland irrigation.

7 Geotechnical Investigation

7.1 General

Based on the basic development concept established through the Phase 1 Study, geotechnical investigation consisting of core borings and standard penetration test (SPT) was planned in the Phase 2 stage in order to obtain basic data for foundation design of structures.

7.2 Locations of the Selected Core Boring Sites

Through the preparatory work and the field reconnaissance of the Phase 2 Study, two (2) core boring sites were selected in Barangay Bukal, Municipality of Nagcarlan and Barangay Novaliches, Municipality of Liliw as shown in Fig.II.1.1 and Fig.II.7.1 to II.7.2 where the most heavy structures of farm ponds are planned.

The core borings, CB-1 at the Bukal site and CB-2 at the Novaliches site, were planned to the depth of 25 m each with SPT at 1 m interval.

7.3 Operation of the Core Boring Works

The core boring works including SPT were carried out at the two (2) selected sites. The field operation was done during the period from middle June to late July, 1994, by the local contractor, Mineral Exploration and Geo-Analysis, under supervision of the JICA Study Team.

7.4 Geotechnical Condition

The strata underlain at the boring sites are geotechnically classified into two layers, namely unconsolidated tephra composed of loam and hard lava rocks of basalt and andesite.

The uppermost stratum of loam is brown colored and its thickness is 5.57 m at the CB-1 and 6.0 m at the CB-2 from the ground surface. It is mainly composed of clayey materials, and a small quantity of pebbles of basalt and andesite are partially contained.

The basalt lava appears in the section between 5.6 m and 8.9 m below the loam stratum at the CB-1 with fractured part in the upper section. The andesite lava, observed in the both bore holes of CB-1 and CB-2, is generally tuffaceous and hard. At the bore hole CB-1, it colors pale gray and its rock faces is generally fresh although cracks are partially developed. At the CB-2, the andesite lava appears in alternation of gray colored part and reddish gray part. It includes moderately to highly fractured zone even in the deeper section in addition to the fresh section. Since the lava formations including fractured part have sufficient bearing capacity, serious problem on foundation design may be negligibly small.

Leakage of drilling water which indicates porous and permeable of the strata was observed. Although the boring works was done in the rainy season, no groundwater level was observed in the both boreholes of CB-1 and CB-2. In order to grasp the permeability of the ground, more than 500 lit of water was injected in the boring hole. However, the permeability coefficient could not be measured due to no rise up of water level resulting from sudden leakage. According to this permeable condition, special protection against leakage such as vinyl sheeting or water-proof mat shielding will be required if reservoir type irrigation system is adopted.

The N-values obtained from SPT vary from 7 to 31 in the loam layer, with an average of N=8 as shown in Fig.II.7.3 and II.7.4, of which the layers with N-values of more than 10 contain pebbles or rock fragments. The N-values in the lava layers including fracture part are generally more than 50.