Pasig-Marikina-Laguna de Bay Basins

Map of Rivers and Sub-basins

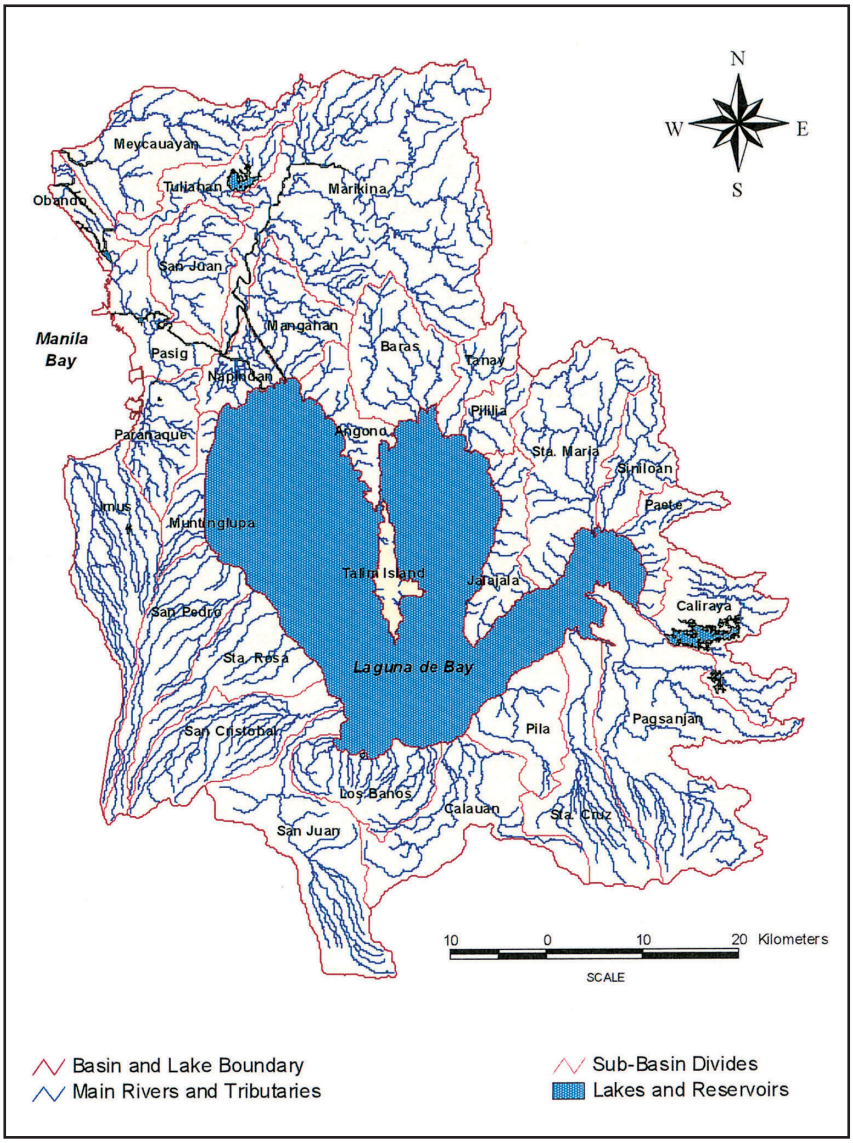


Table of Basic Data

Name: Pasig-Marikina-Laguna de Bay Basins	**Serial No. :** Philippines-4	
Total drainage area: 4,522.7 km^2	**Location:** Luzon Island, Philippines	
Lake area: 871.2 km^2	E 120° 50' - 121° 45'	N 13° 55' - 14° 50'
Length of the longest main stream: 66.8 km @ Marikina River		
Highest point: Mt. Banahao @ Laguna (2,188 m)		
Lowest point: River mouth @ Laguna lake & Manila bay (0 m)		
Main geological features: Laguna Formation (Pliocene to Pleistocene) (1,439.1 km^2), Alluvium (Halocene) (776.0 km^2), Guadalupe Formation (Pleistocene) (455.4 km^2), and Taal Tuff (Pleistocene) (445.1 km^2)		
Main land-use features: Arable land mainly sugar and cereals (22.15%), Lakes & reservoirs (19.70%), Cultivated area mixed with grassland (17.04%), Coconut plantations (13.03%), and Built-up area (11.60%)		
Main tributaries/sub-basins: Marikina river (534.8 km^2), and Pagsanjan river (311.8 km^2)		
Mean annual precipitation of major sub-basins: Marikina river (2,486.2 mm), and Pagsanjan river (2,170 mm)		
Mean annual runoff of major sub-basins: Marikina river (106.4 m^3/s), Pagsanjan river (53.1 m^3/s)		
Main reservoirs: Caliraya Reservoir (11.5 km^2), La Mesa reservoir (3.6 km^2)		
Main lakes: Laguna Lake (871.2 km^2)	**No. of sub-basins:** 29	
Population: 14,342,000 (Year 2000)	**Main Cities:** Manila, Quezon City	

1. General Description

Pasig-Marikina-Laguna de Bay Basin, which is composed of 3651.5 km^2 watershed and 871.2 km^2 lake, covers the Metropolitan Manila area (National Capital Region) in the west, portions of the Region III province of Bulacan in the northwest, and the Region IV provinces of Rizal in the northeast, Laguna and portions of Cavite and Batangas in the south.

The Laguna Lake is centrally located inside the basin and has an average depth of 2.8 m. The lake has traditionally been used as habitat for fisheries and duck-raising, waterway for minor passenger and cargo traffic, source of irrigation water in Laguna province, effluent sink by industries and municipalities, flood-control detention storage, and serves as the lower pool of the Kalayaan Pumped-Storage Hydro-Electric Plant.

One of the main sub-basins or tributaries of Pasig-Marikina-Laguna de Bay Basin is the Marikina River, which has an average annual rainfall of 2,750 mm in a drainage area of 534.8 km^2. It runs through the Marikina Valley and a portion of the flow is controlled and diverted by the Manggahan Floodway towards the Laguna Lake. The remaining water is drained to the Manila Bay through Pasig River. Napindan Hydraulic Control Structure regulates the flow between Manila Bay and Laguna Lake by blocking the high-tide inflow of saline and polluted water of Manila Bay-Pasig River and sometimes allowing reverse seaward flow to allow the entrance of saline water for fisheries. Pagsanjan River, which is the other main tributary of the basin and located at the eastern side, has a mean annual rainfall of 2,318 mm and drainage area of 311.8 km^2. Pagsanjan River also drains to the Laguna lake and its flow is partially regulated by the Caliraya Reservoir.

Aside from the two main sub-basins, there are another 27 smaller tributaries in the Pasig-Marikina-Laguna de Bay Basin. Eight of these originate from upland agricultural, rural and urbanized catchments of Rizal, twelve from lowland-agricultural, rural and urbanized catchments of Laguna, and seven other adjacent rivers in Metro Manila, which are separated from the Laguna Lake Basin by relatively low ridges. The 29 river sub-basin delineations as well as the rivers and river systems of the basin are shown in the figure above entitled *"Map of Rivers and Sub-basins"*.

2. Geographical Information

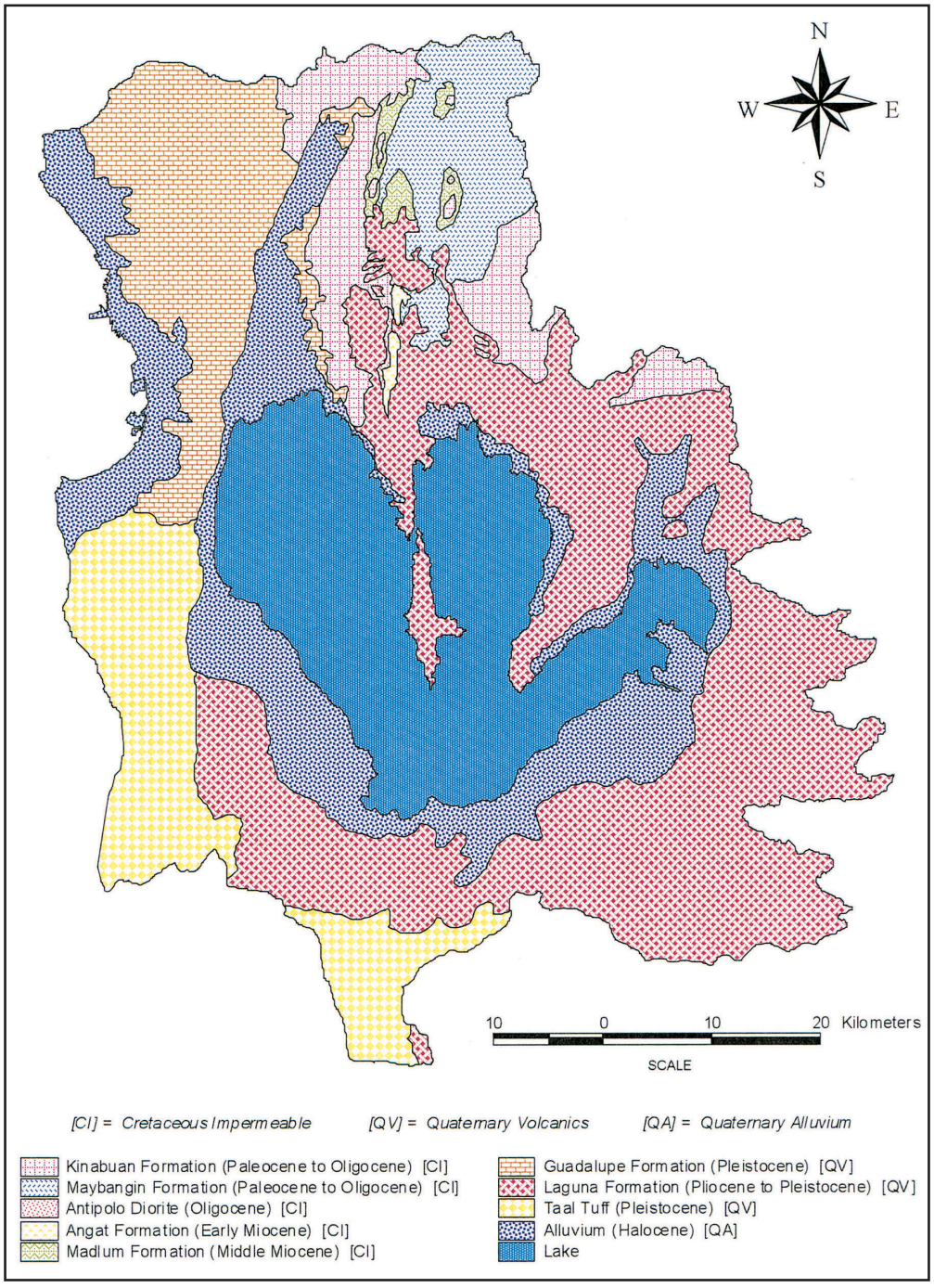
2.1 Basin Geology

The Pasig-Marikina-Laguna de Bay Basin is underlain by rocks of various origin and characteristics consisting primarily of agglomerates, pyroclastics, sandy tuff and cinder beds. These occur in association with other properties in alluvial deposits, reworked tuff and volcanic ash often displaying desirable hydrogeologic properties.

Complex tectonic and volcanic events, mainly during the Late Tertiary and Quaternary periods, together with large relative sea level changes have produced the basic structure observable today in the study area. The table below summarizes the surface geology and significant geological features (strata) of the Pasig-Marikina-Laguna de Bay Basin followed by its geological map.

Code	Geologic Description	Land-Use Area (km^2)	Percentage (%)
Kb	Kinabuan Formation (Cretaceous to Paleocene)	268.69	5.94
Tmb	Maybangin Formations (Paleocene to Oligocene)	220.14	4.87
Tad	Antipolo Diorite (Oligocene)	2.99	0.07
Ta	Angat Formation (Early Miocene)	9.70	0.21
Tma	Madlum Formation (Middle Miocene)	34.40	0.76
Qg	Guadalupe Formation (Pleistocene)	455.41	10.07
Ql	Laguna Formation (Pliocene to Pleistocene)	1,439.12	31.82
Qt	Taal Tuff (Pleistocene)	445.07	9.84
Qal	Alluvium (Halocene)	775.96	17.16
Lk	Lake	871.25	19.26
	Total	**4,522.72**	**100.00**

Geological Map

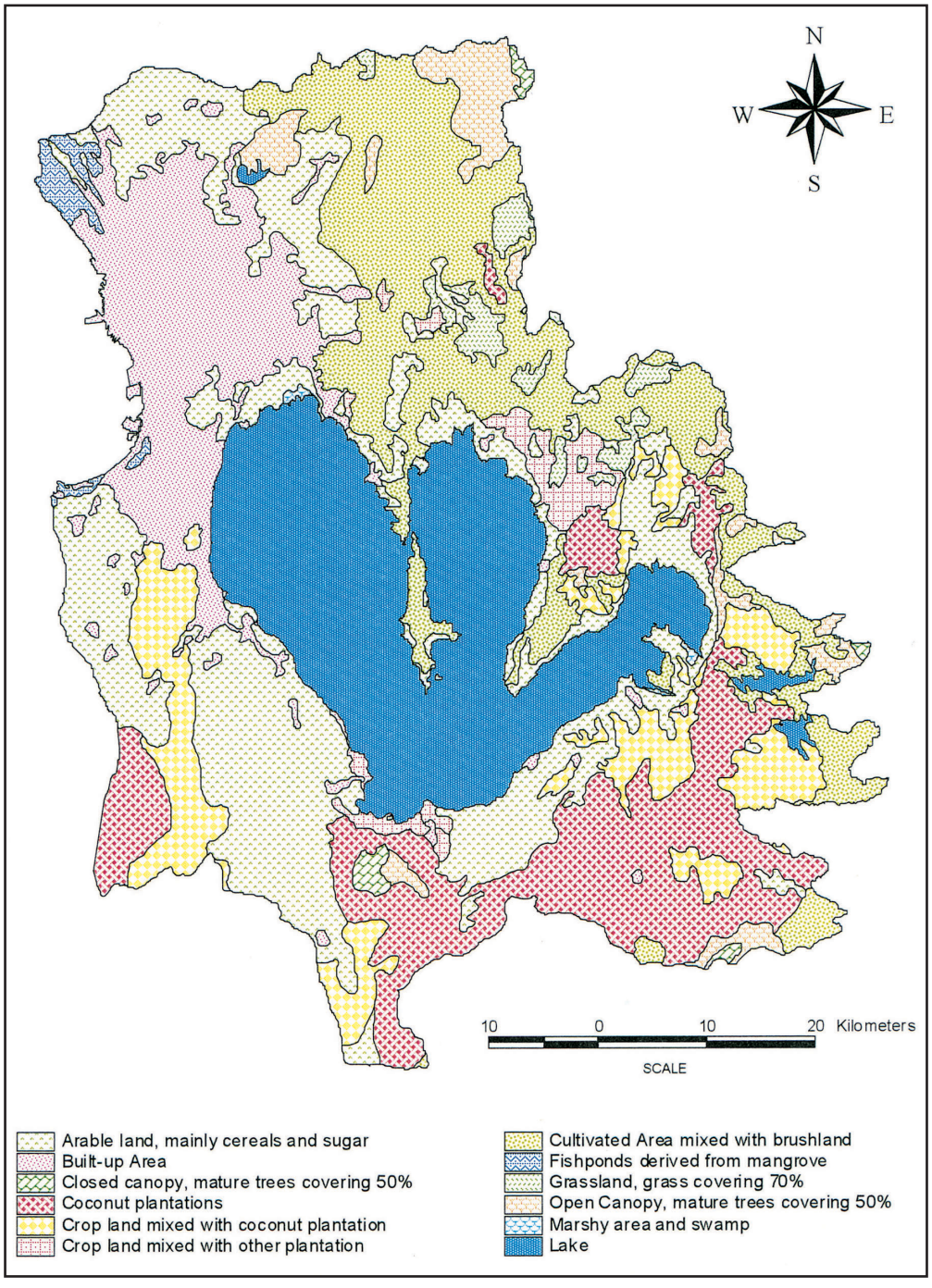


2.2 Basin Land-use

The table below shows the different types of land-use in the basin and summarizes the area of each land-use as well as its percentage over the total area of the basin.

Code	Land-Use Description	Land-Use Area (km^2)	Percentage (%)
Ic	Arable land, mainly cereals and sugar	1,001.93	22.15
B	Built-up area	524.63	11.60
Fdc	Closed canopy, mature trees covering > 50 percent	21.62	0.48
Ipc	Coconut plantations	589.31	13.03
Imc	Crop land mixed with coconut plantation	363.44	8.04
Imo	Crop land mixed with other plantation	84.90	1.88
Ec	Cultivated area mixed brushland and grassland	770.63	17.04
Ifm	Fishponds derived from mangrove	37.04	0.82
Eg	Grassland, grass covering > 70 percent	78.33	1.73
L	Lakes and Reservoir	890.83	19.70
M	Marshy area and swamp	4.37	0.10
Fdo	Open canopy, mature trees covering < 50 percent	155.27	3.43
Un	Unclassified	0.43	0.01
	Total	**4,522.72**	**100.00**

Land-Use Map

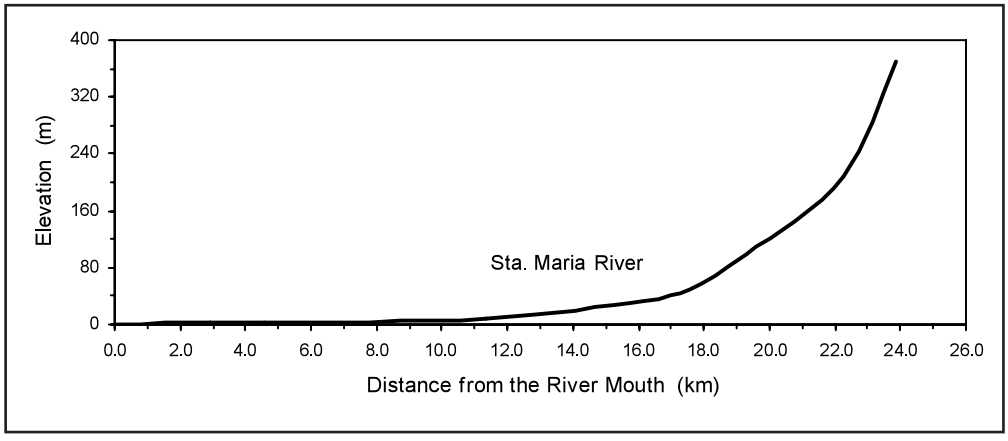

N
W
E
S
10
0
10
20 Kilometers
SCALE
Arable land, mainly cereals and sugar
Built-up Area
Closed canopy, mature trees covering 50%
Coconut plantations
Crop land mixed with coconut plantation
Crop land mixed with other plantation
Cultivated Area mixed with brushland
Fishponds derived from mangrove
Grassland, grass covering 70%
Open Canopy, mature trees covering 50%
Marshy area and swamp
Lake

2.3 Characteristics of the Sub-basins and Tributaries

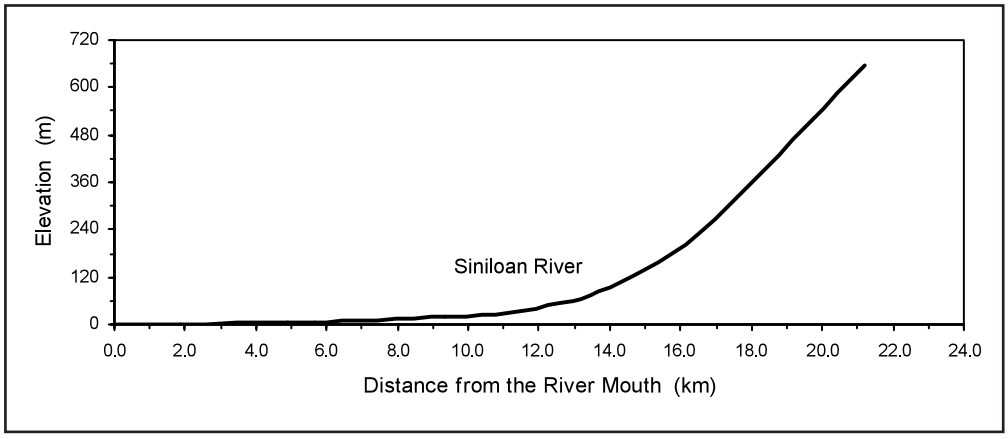
The Pasig-Marikina-Laguna de Bay Basin is composed of 29 sub-basins, which drain to the Laguna Lake and Manila Bay. A summary of some basin and river characteristics that includes drainage area, length of the main river, and land-use composition of 12 selected sub-basins is shown in the following table. The selection is based on the length of the river and the size of the drainage area. The following figures in Section 2.4 exhibit the longitudinal profiles of these rivers.

Sub-basin Code	River/Sub-basin Name	Length/Drainage area		Primary Land-use					
		[km]	[km^2]	Code	[km^2]	Code	[km^2]	Code	[km^2]
SB1	Sta. Maria River	23.86	204.91	Ec	67.1	Ic	40.7	Imc	28.2
SB2	Siniloan River	21.23	74.31	Ec	28.4	Ic	17.2	Ipc	15.6
SB5	Pagsanjan River	54.10	311.77	Ipc	146.8	Imc	87.5	Ec	33.5
SB6	Sta. Cruz River	33.00	148.35	Ipc	103.6	Imc	21.7	Ic	10.9
SB10	San Juan River	39.97	191.77	Ic	98.1	Ipc	44.9	Imc	40.1
SB11	San Cristobal River	29.35	140.66	Ic	82.4	Imc	47.7	Ipc	10.6
SB13	Binan River	34.65	132.13	Ic	48.3	Imc	39.0	Ipc	26.0
SB16	Marikina River	66.81	534.80	Ec	298.7	Ic	78.9	Fdo	76.1
SB19	Morong River	26.71	122.09	Ec	80.7	Ic	30.0	Eg	7.6
SB23	Marilao River	48.92	169.45	Ic	103.2	B	33.7	Ec	21.5
SB24	Tuliahan River	24.93	75.12	B	40.4	Fdo	19.6	Ic	11.2
SB29	Imus River Basin	41.01	171.39	Ic	112.5	Imc	23.3	B	17.7

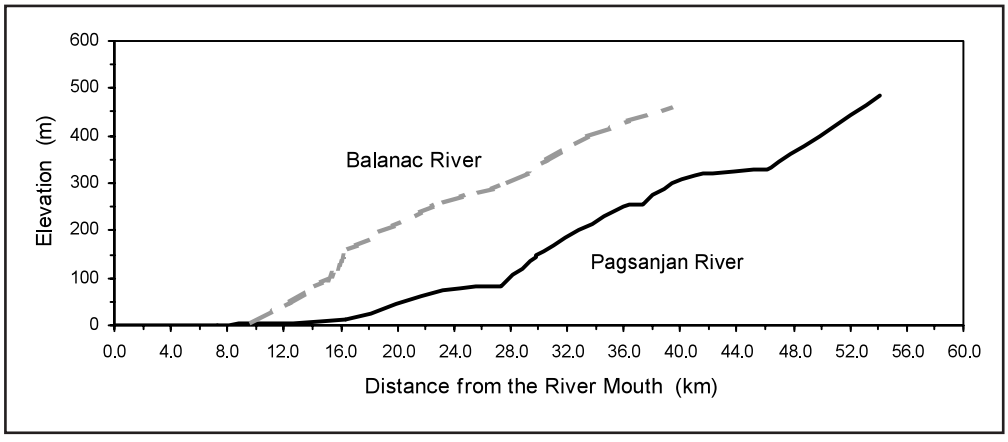
2.4 Longitudinal Profiles



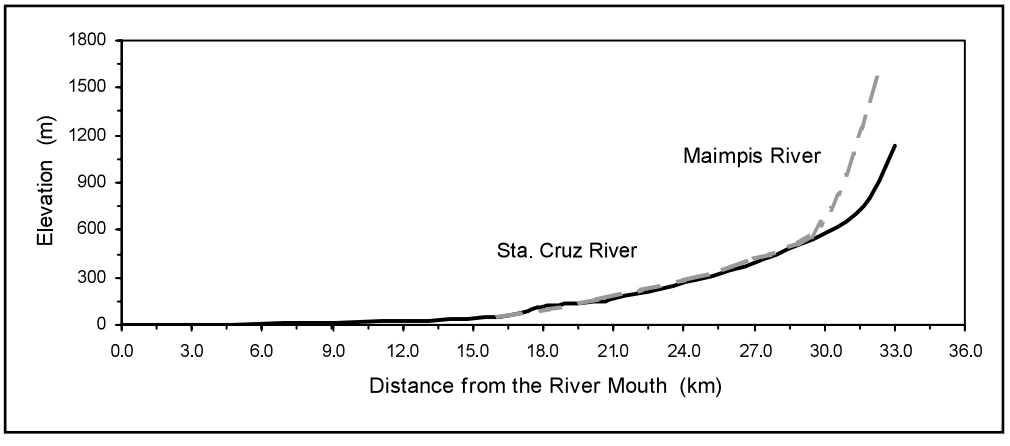
Sta. Maria River



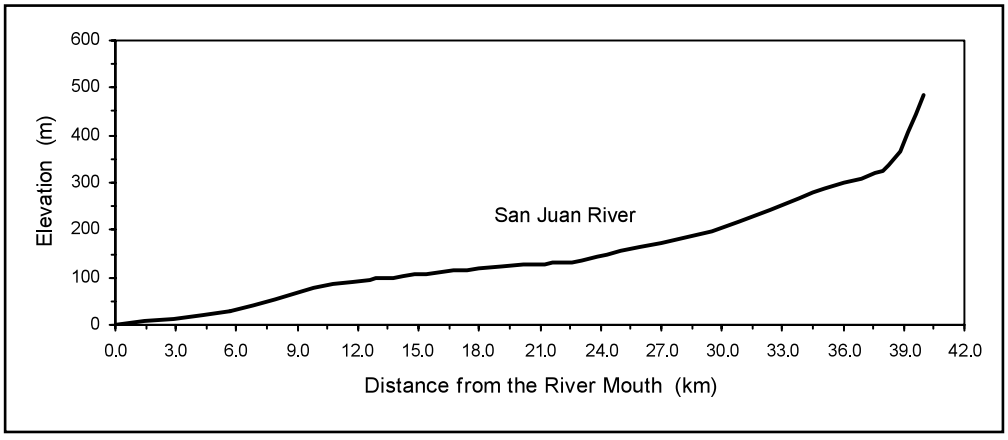
Siniloan River



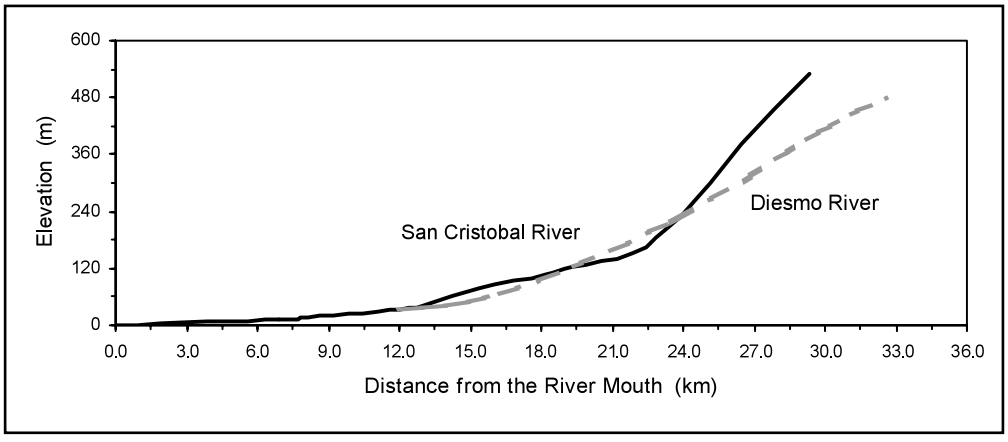
Pagsanjan River



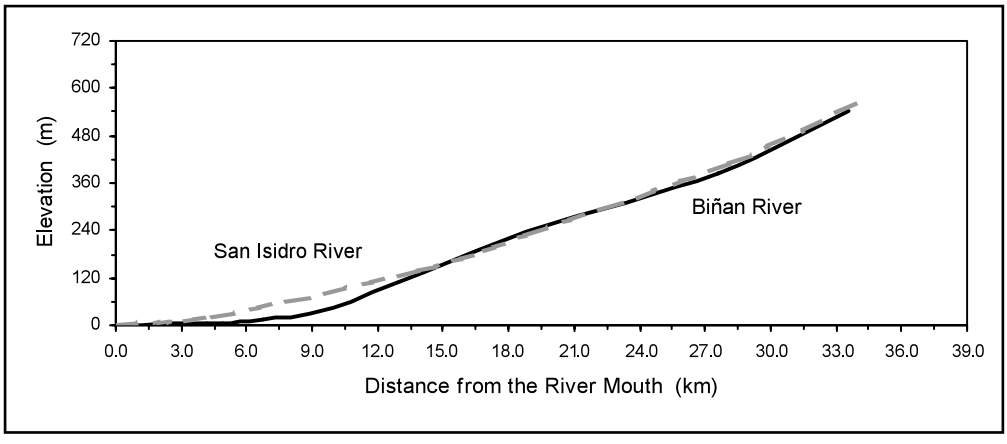
Sta. Cruz River



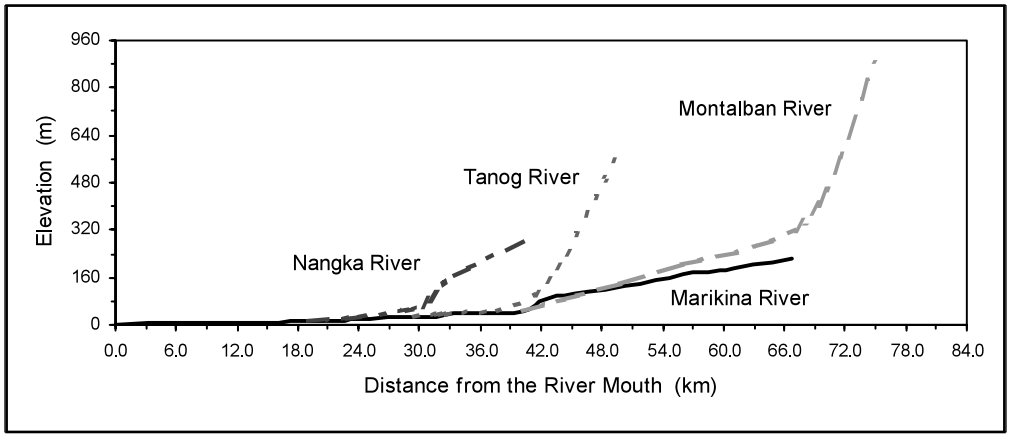
San Juan River



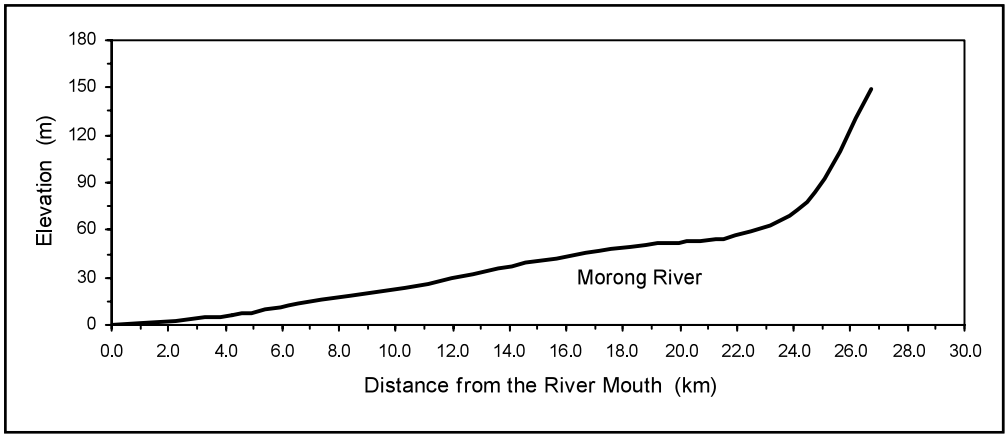
San Cristobal River



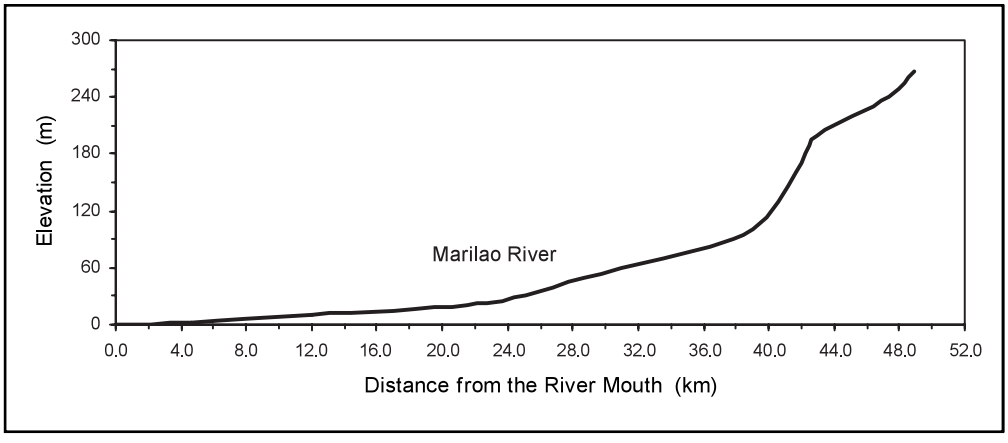
Biñan River



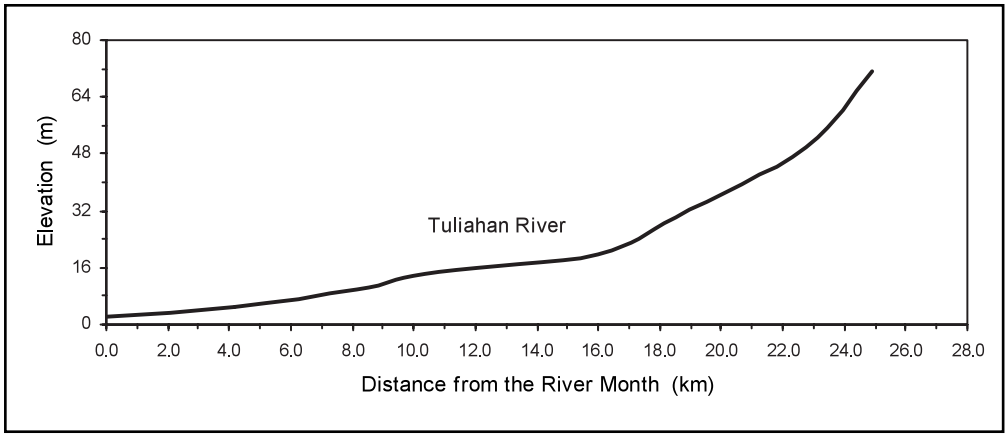
Marikina River



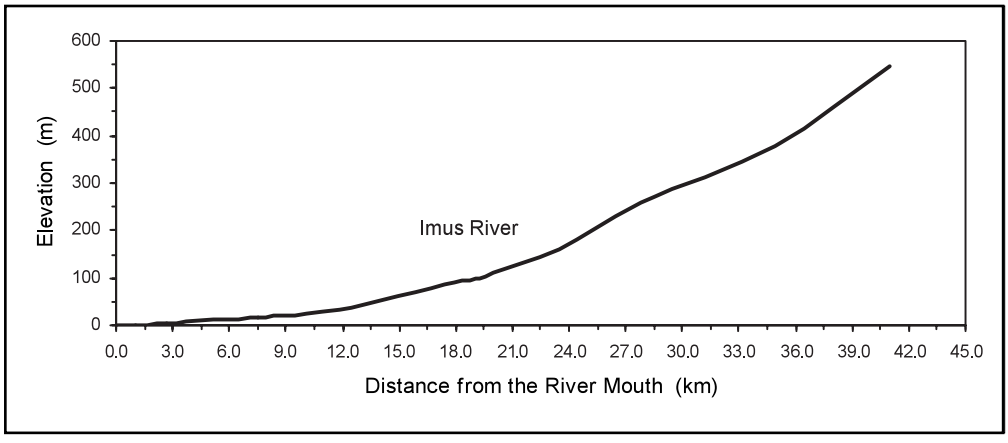
Morong River



Marilao River



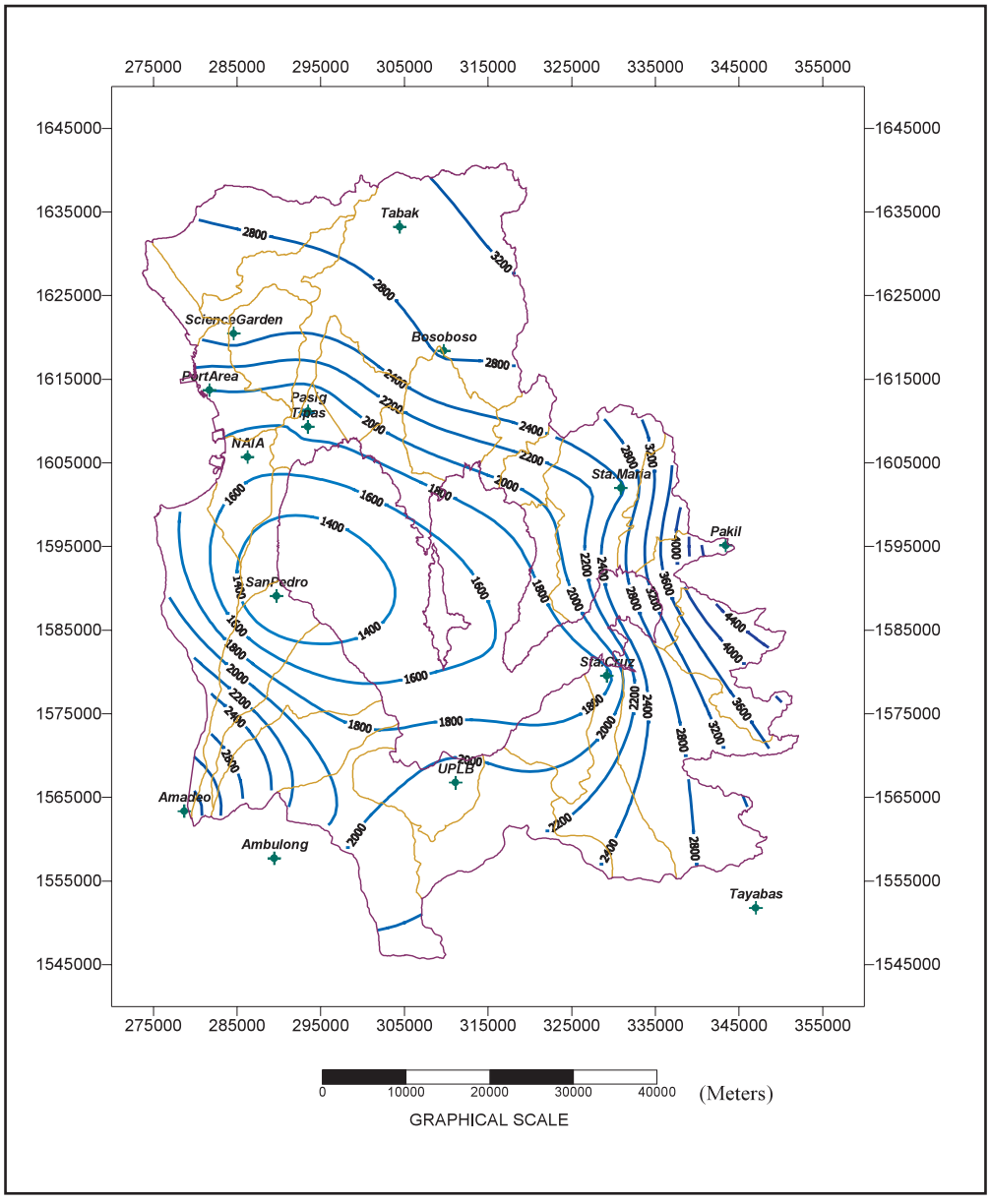
Tuliahan River



Imus River

3. Climatological Information

3.1 Annual Isohyetal Map and Observation Stations



3.2 List of Meteorological Observation Stations

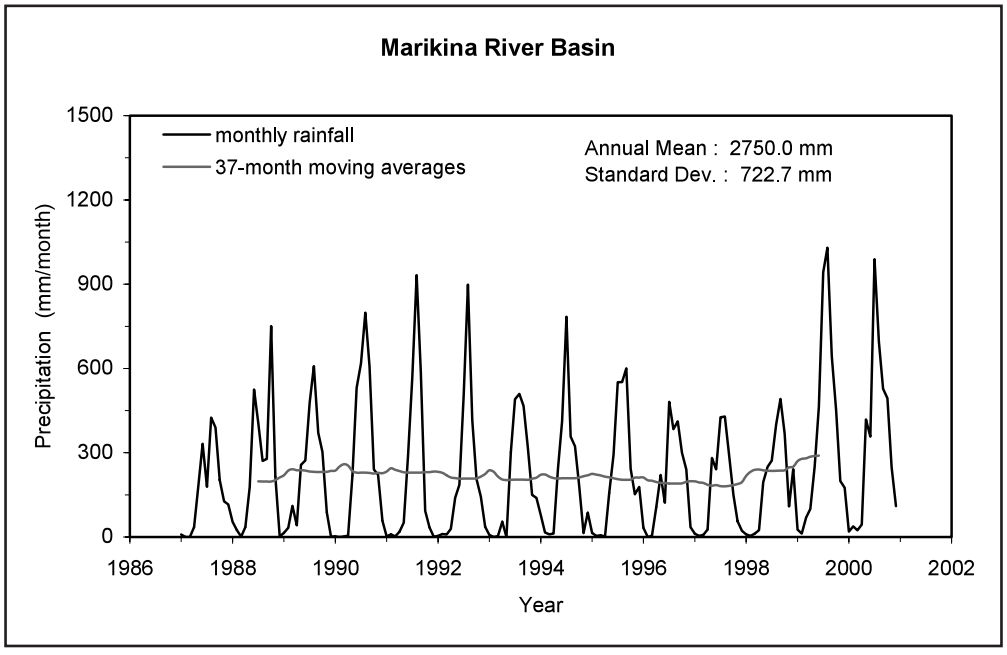
There are fifteen available rainfall stations in the Pasig-Marikina-Laguna de Bay Basin that are being maintained by the PAGASA. Eleven of these stations are climatic, three are synoptic, and the remaining one is an agromet. The table below provides a summary of the types, location in UTM coordinates, mean annual rainfall, and length of records of the stations. Moreover, the figure at Section 3.1 displays the rainfall observation stations as well as the annual isohyetal map generated from the available annual rainfall data from the 15 stations.

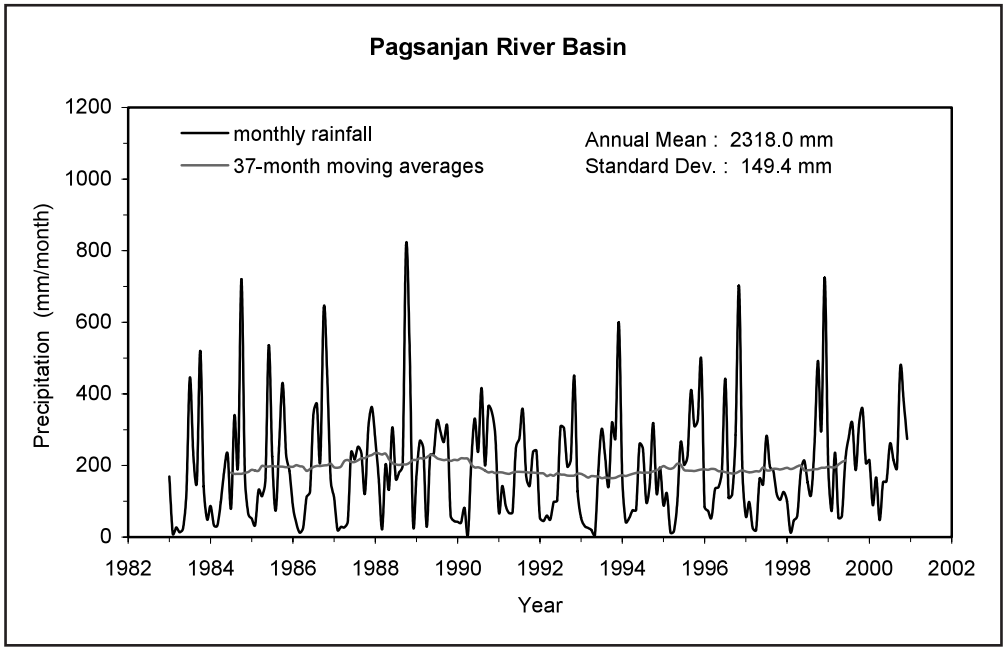
Station Name	Location (UTM)		Type of Station	Mean Annual (mm)	Data Available	
	X-Coord	Y-Coord			From	To
Amadeo	278702.0	1563343.0	Climatic	3,996.81	1985	2000
Ambulong	289455.6	1557718.6	Climatic	1,908.10	1961	2000
Bosoboso	309721.0	1618413.5	Climatic	2,816.70	1976	2000
NAIA	286264.6	1605697.0	Synoptic	1,685.31	1961	2000
Pakil	343419.2	1595126.4	Climatic	5,562.35	1991	2000
Pasig	293498.6	1611168.0	Climatic	1,761.23	1975	2000
Port Area	281711.5	1613711.6	Synoptic	1,996.24	1961	2000
San Pedro	289717.9	1589068.6	Climatic	1,043.10	1971	1998
Science Garden	284598.9	1620466.5	Synoptic	2,517.72	1961	2000
Sta. Cruz	329204.4	1579546.9	Climatic	1,807.60	1956	2000
Sta. Maria	330889.3	1602003.4	Climatic	2,313.68	1994	2000
Tabak	304453.4	1633208.5	Climatic	2,998.33	1976	1996
Tayabas	347019.6	1551775.8	Climatic	3,030.23	1971	2000
Tipas	293483.1	1609324.0	Climatic	1,874.95	1975	1996
UPLB	311124.6	1566768.4	Agromet	2,152.15	1977	2000

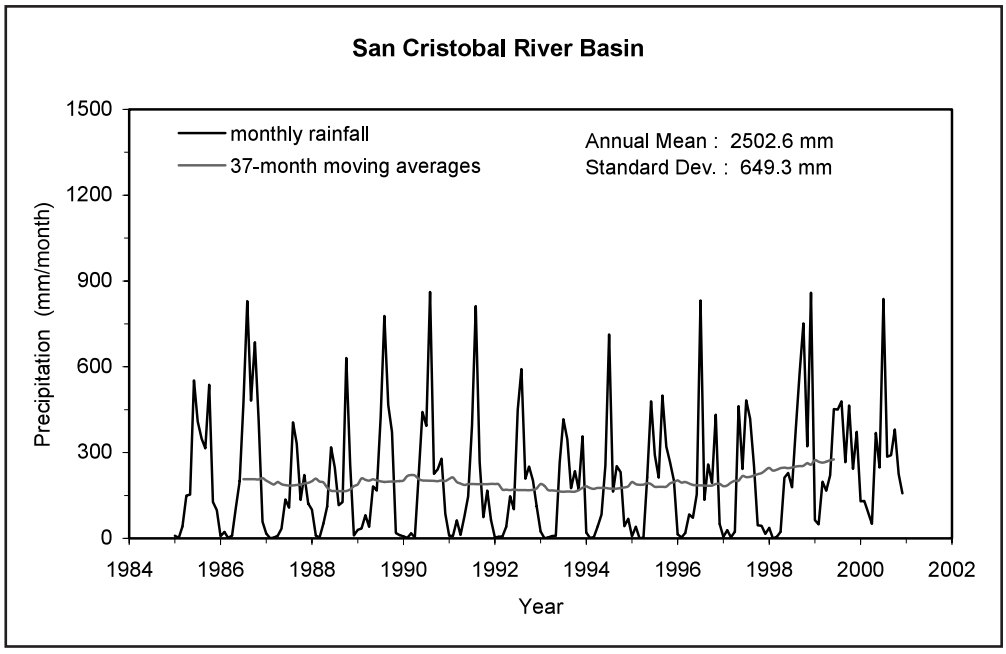
3.3 Monthly Climate Data (Observation Station: UPLB)

Observation Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period
Precipitation (mm)	45.6	23.7	41.7	43.7	125.7	233.4	301.5	262.8	260.3	353.3	224.9	165.8	2,152.2	1977 - 2000
Evaporation (mm)	106.3	122.7	175.9	190.1	166.0	127.2	116.3	114.7	97.5	104.8	96.5	92.6	1,510.7	1977 - 2001
Wind Speed (m/s)	2.2	1.5	2.7	2.1	2.4	2.0	1.9	2.7	1.7	1.9	2.1	2.5	2.1	1977 - 2001

3.4 Long Term Variation of Monthly Precipitation Series

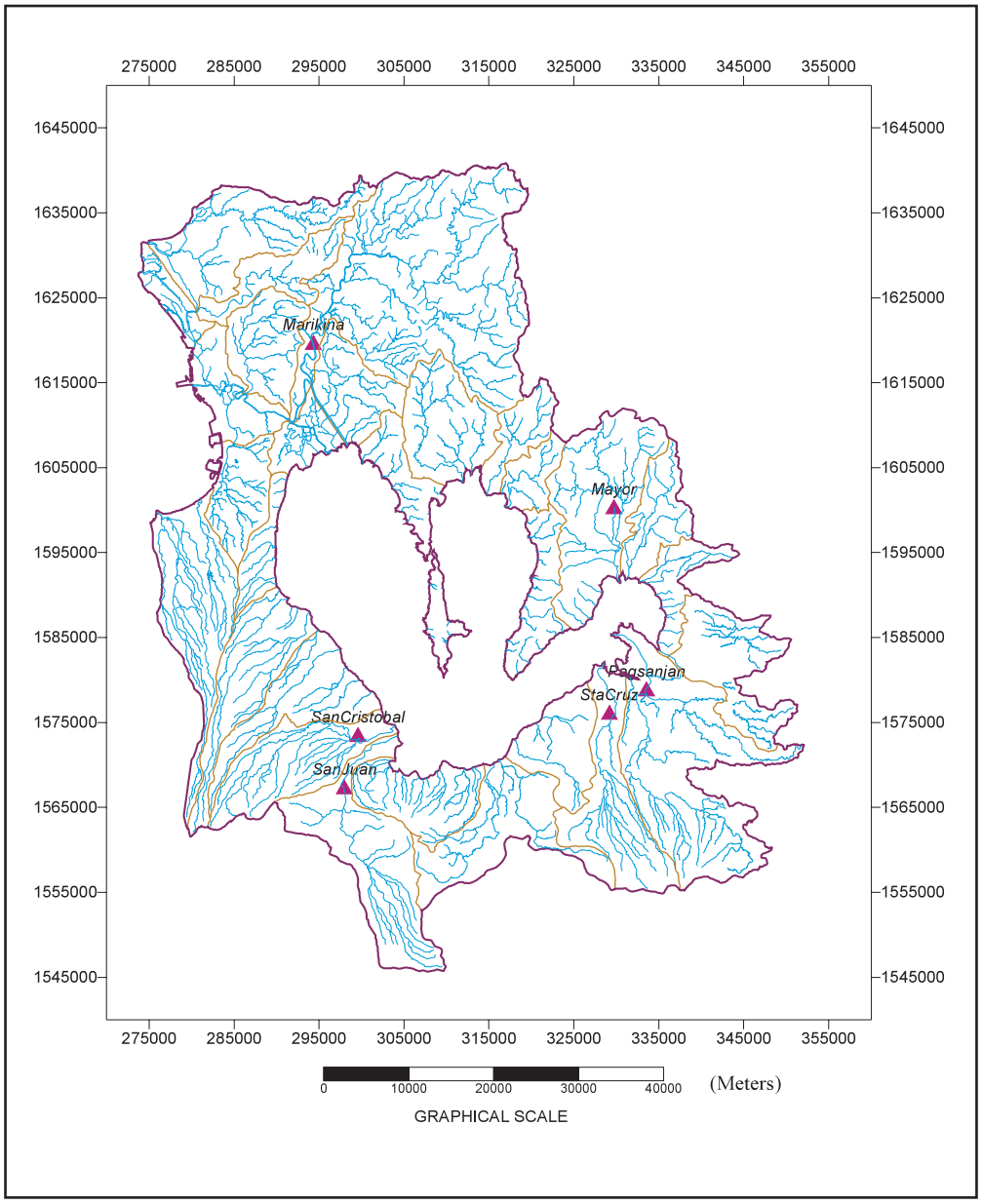





San Cristobal River Basin
monthly rainfall
37-month moving averages
Annual Mean : 2502.6 mm
Standard Dev. : 649.3 mm
Precipitation (mm/month)
1500
1200
900
600
300
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
Year

4. Hydrological Information

4.1 Map of Streamflow Observation Stations



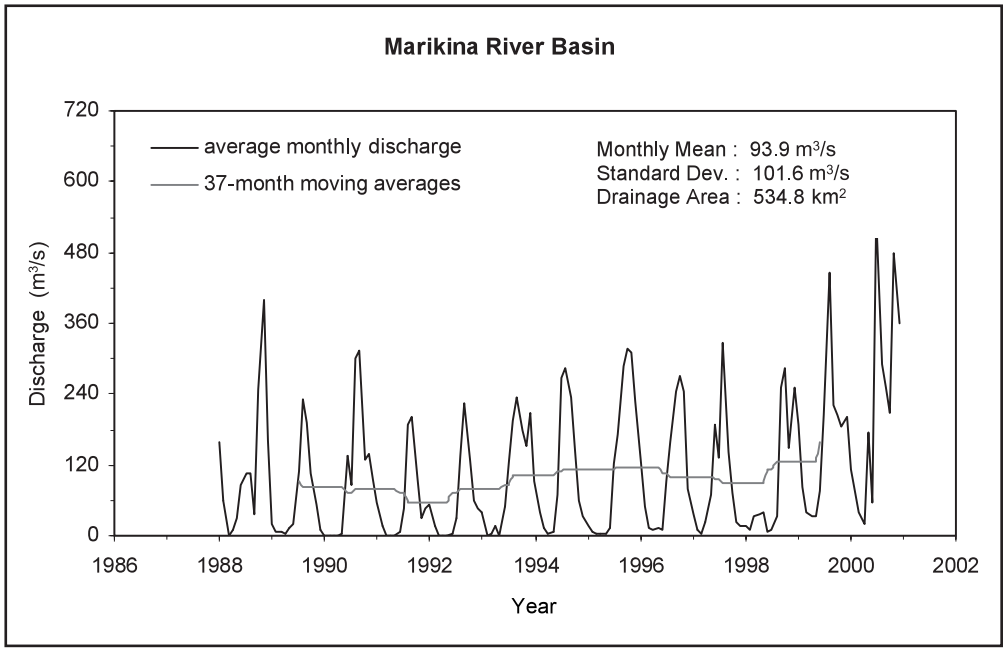
4.2 List of Hydrological Observation Stations

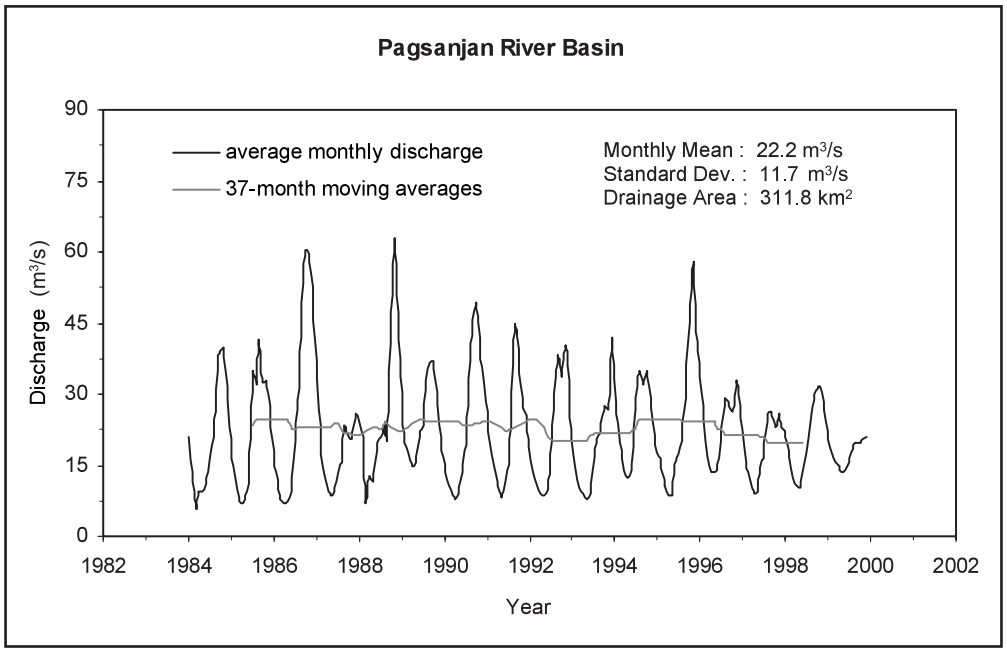
Station Name	Location (UTM)		Type of Station	Mean Annual (m^3/s)	Data Available	
	X-Coord	Y-Coord			From	To
Marikina River	294334.7	1619747.6	Stream	102.95	1988	2000
Mayor River	329737.3	1600379.5	Stream	3.34	1986	2000
Pagsanjan River	333546.9	1578933.8	Stream	22.10	1984	2000
San Cristobal River	299582.9	1573551.0	Stream	1.74	1984	2000
San Juan River	297981.3	1567412.8	Stream	3.08	1994	2000
Sta Cruz River	329193.8	1576167.0	Stream	6.49	1994	2000

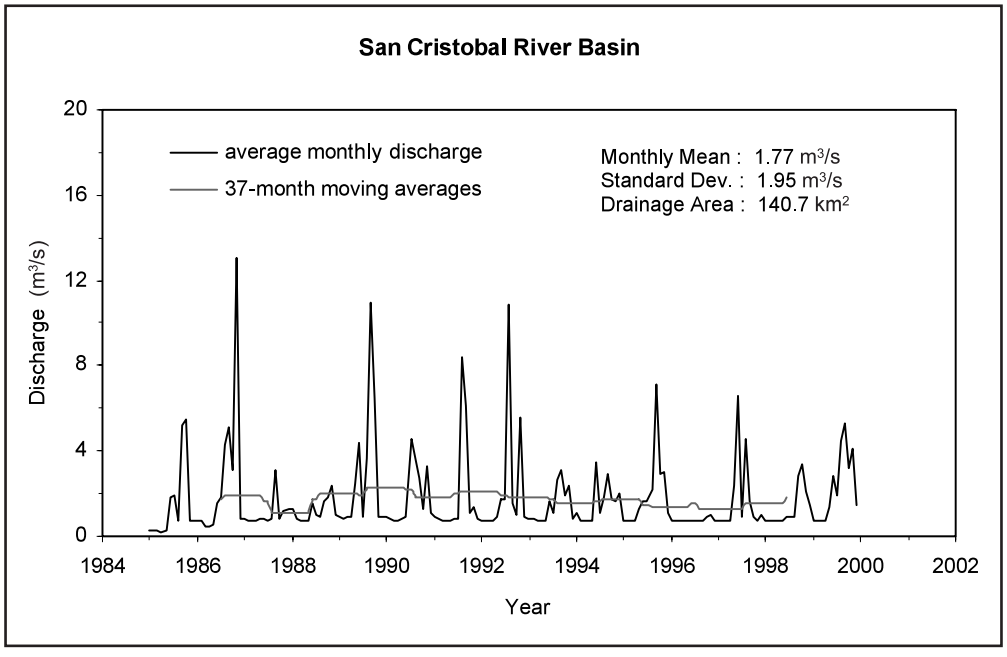
Station Name	Q_{ave} [m^3/s]	Q_{max} [m^3/s]	Q_{max_ave} [m^3/s]	Q_{min_ave} [m^3/s]	Q_{ave}/A [$m^3/s/100km^2$]	Q_{max}/A [$m^3/s/100km^2$]	period of statistics
Marikina River	102.95	2,772.87	1,487.90	6.39	19.25	518.49	1988 - 2000
Pagsanjan River	22.13	140.80	84.90	6.23	7.10	45.16	1984 - 1999

Q_{ave} = mean annual discharge
Q_{max} = maximum discharge
Q_{min_ave} = mean minimum discharge
Q_{max_ave} = mean maximum discharge

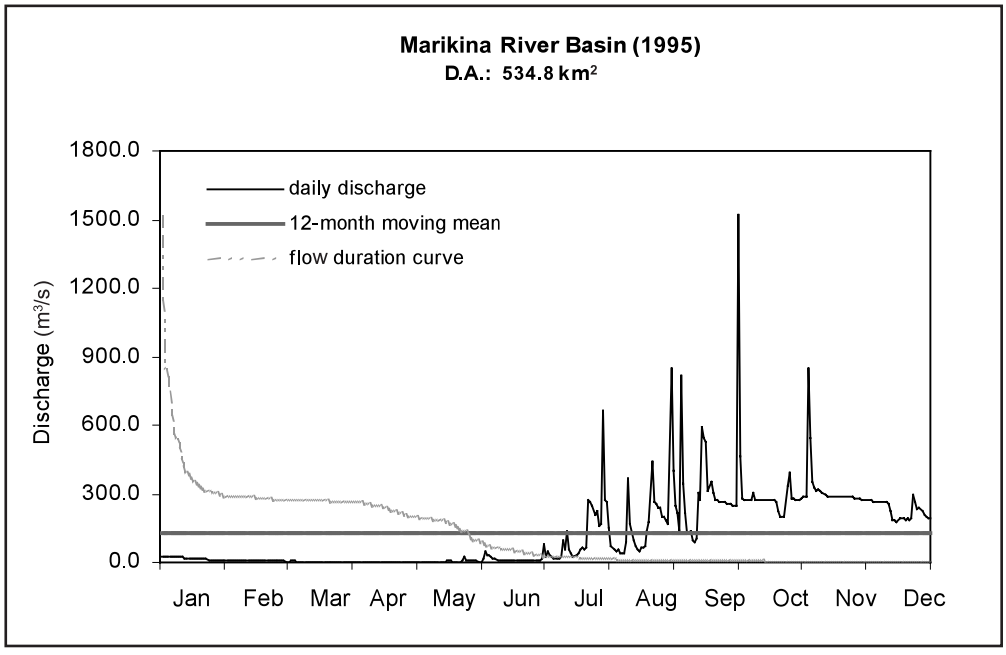
4.3 Long Term Variation of Monthly Discharge

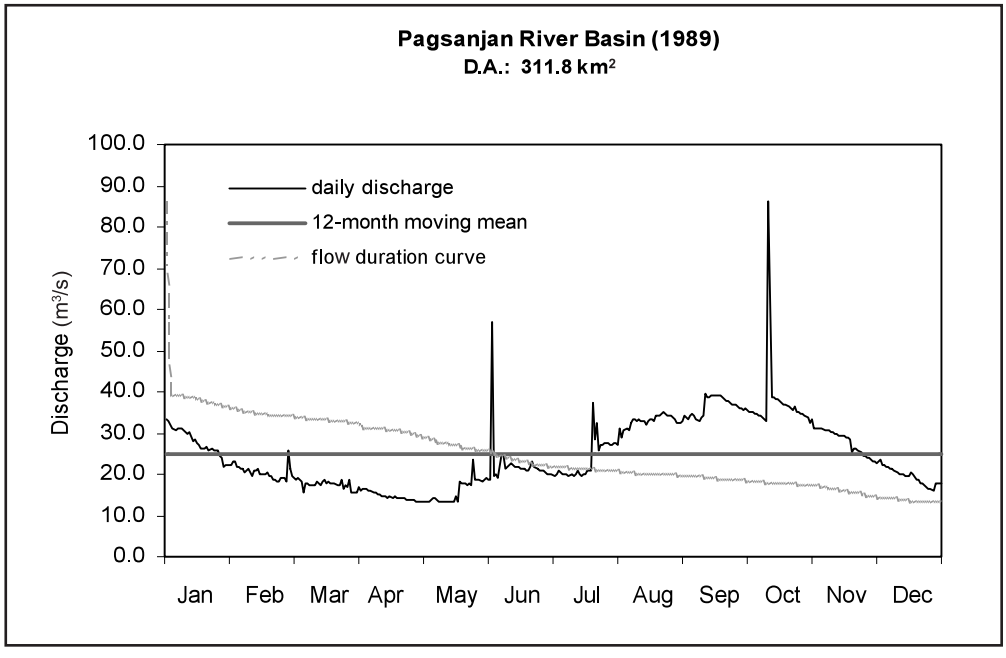



Pagsanjan River Basin
average monthly discharge
37-month moving averages
Monthly Mean : 22.2 m3/s
Standard Dev. : 11.7 m3/s
Drainage Area : 311.8 km2
Discharge (m3/s)
Year
0
15
30
45
60
75
90
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002


San Cristobal River Basin
average monthly discharge
37-month moving averages
Monthly Mean : 1.77 m3/s
Standard Dev. : 1.95 m3/s
Drainage Area : 140.7 km2
Discharge (m3/s)
Year
0
4
8
12
16
20
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002

4.4 Annual Pattern of Discharge





4.5 Annual Maximum and Minimum Discharges

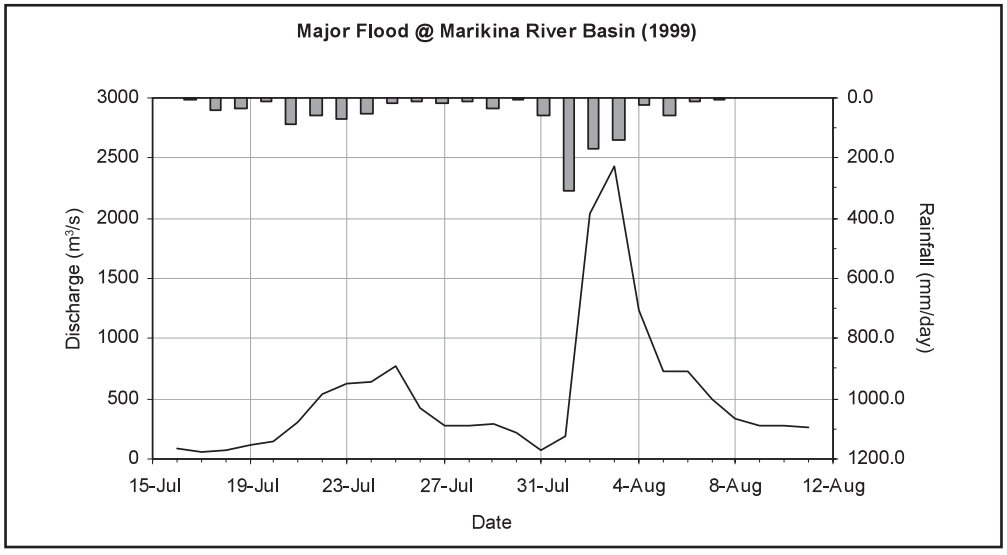
Station: Marikina River [D.A.: 534.8 km^2]

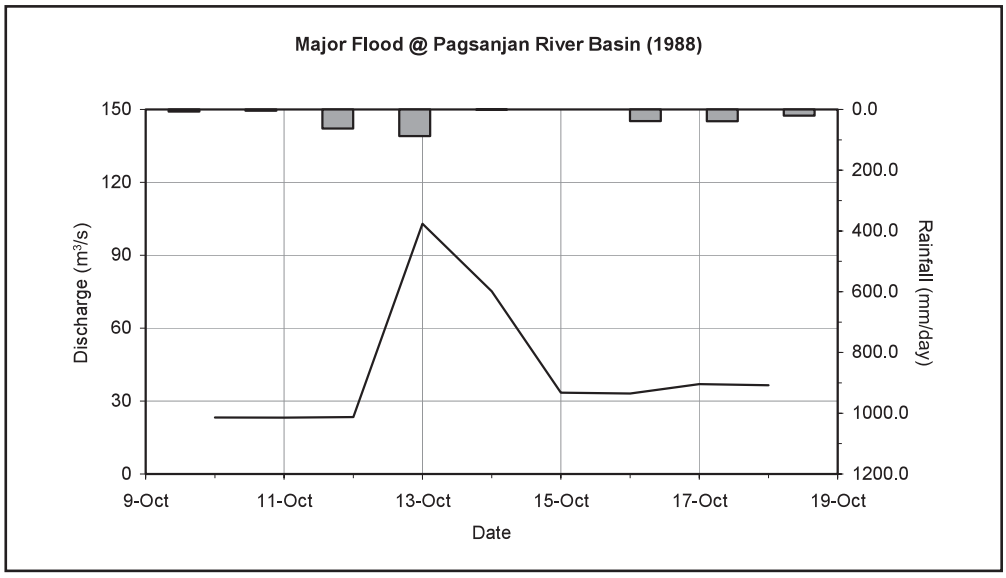
Year	Maximum		Minimum		Year	Maximum		Minimum	
	Date	m^3/s	Date	m^3/s		Date	m^3/s	Date	m^3/s
1988	10/11	2,063.4	9/2	15.82	**1994**	7/25	1,154.2	5/31	3.32
1989	9/9	2,349.8	4/28	0.28	**1995**	10/1	1,521.2	5/9	0.97
1990	9/1	2,063.4	1/5	0.13	**1996**	10/31	914.9	3/29	6.76
1991	8/26	275.0	2/27	0.01	**1997**	8/19	1,815.3	5/16	1.05
1992	9/5	263.3	6/2	0.04	**1998**	10/23	2,772.9	6/3	1.97
1993	1/5	235.0	1/15	30.76	**1999**	8/3	2,426.4	5/23	15.61

Station: Pagsanjan River [D.A.: 311.8 km^2]

Year	Maximum		Minimum		Year	Maximum		Minimum	
	Date	m^3/s	Date	m^3/s		Date	m^3/s	Date	m^3/s
1984	10/21	92.23	5/13	8.10	**1992**	11/12	91.75	4/9	7.03
1985	6/28	84.62	4/3	6.26	**1993**	12/6	103.67	5/11	7.30
1986	7/14	88.41	4/29	5.75	**1994**	11/3	140.80	6/1	9.77
1987	11/27	66.54	6/6	6.38	**1995**	11/3	140.80	4/24	7.03
1988	10/13	111.38	5/22	10.63	**1996**	11/27	47.90	4/28	12.24
1989	10/11	121.52	4/28	13.00	**1997**	2/26	32.14	5/16	7.56
1990	11/14	69.45	5/6	6.64	**1998**	12/28	65.88	5/3	6.13
1991	12/11	42.82	5/18	7.03	**1999**	11/4	58.44	5/29	16.11

4.6 Hyetographs and Hydrographs of Major Floods





5. Water Resources

5.1 General Description

The Pasig-Marikina-Laguna de Bay Basin is composed of 29 sub-basins of which 22 sub-basins collectively known as Laguna de Bay basin drains to the Laguna Lake, while runoffs from the other seven Metro Manila river sub-basins flow to the Manila Bay. River diversions for irrigation systems are made from the Laguna sub-basins before reaching the lake. The lake on the other hand is used for fisheries, duck-raising, navigation, effluent sink by industries and municipalities, flood-control detention storage, lower pool of the Kalayaan Pumped-Storage Hydro-Electric Plant, and earmarked for future source of fresh-water supply.

There are two major reservoirs in the Pasig-Marikina-Laguna de Bay Basin i.e. the Caliraya Reservoir and the La Mesa or Novaliches Reservoir. Caliraya Reservoir, which is located at Laguna, has a catchment area of 129 km^2 with an effective capacity of 78 million cubic metres (MCM). It is used for power generation, flood control as well as for municipal and industrial use of water. It is also used by the Kalayaan pumped-storage hydropower plant for its cycles of water pumping and releasing between Laguna de Bay and the Caliraya lake. La Mesa Reservoir, which supplies water both for municipal and industrial use for almost the whole of the Metro Manila area has a catchment area of only 27 km^2. However, the volume of water in the reservoir is augmented by diverting water from the Angat Reservoir to Ipo Dam down to the La Mesa Reservoir through the Ipo Tunnels and Bicti-Novaliches Aqueducts. The Alat Dam with a watershed of 14 km^2 also diverts water to the La mesa reservoir through the Alat-Sapang Kawayan Aqueducts. The gross capacity of La Mesa Reservoir is 45.4 MCM and its effective capacity is 38 MCM.

5.2 List of Major Water Resources Facilities

Major Reservoirs

Name of River	Name of Dam	Catchment Area [km^2]	Gross Capacity [1 x 10^6 m^3]	Effective Capacity [1 x 10^6 m^3]	Purpose
Caliraya	**Caliraya**	129.0	86.0	78.0	M. F, I, P
Tuliahan	**La Mesa**	27.0	45.4	38.0	M. F, I
Wawa	**Wawa**	280.0	840.0	540.0	M. F, I, P

Purpose: P = Power Generation, F = Flood Control, M = Municipal Use, I = Industrial Use.

Major Interbasin Transfer

Name of Transfer Line	Name of rivers connected		Length (km)	Maximum Capacity [m^3/s]	Purpose
	From	To			
Tunnel 1	Ipo Dam	La Mesa	21.4	8.80	M
Tunnel 2	Ipo Dam	La Mesa	21.5	21.9	M
Alat Aqueduct	Alat Dam	La Mesa	2.1	4.4	M

5.3 Major Floods and Droughts

Date		Peak Discharge [m^3/s]	Rainfall [mm]	Duration [days]	Meteorological Cause
From	To				
21-Oct-98	**24-Oct-98**	2,772.9	420.0	4 ~ 5	storm
31-Jul-99	**7-Aug-99**	2,426.4	773.6	7 ~ 8	storm
25-Oct-00	**30-Oct-00**	2,157.0	354.7	6 ~ 7	storm

6. Socio-cultural Characteristics

The inhabitants of the Pasig-Marikina-Laguna de Bay belong to the Tagalog-speaking people of the country and are predominantly Christian (majority are Roman Catholic). There are small segments of cultural minorities living in the eastern mountain ranges. Most of the rural population are farmers (lowland and upland), and lake fishermen. The urban population is engaged in commerce, light to heavy industries, and services. The smallest political units are called “barangays” which compose the municipalities (towns and cities), while the municipalities form the provinces (Metro-Manila, Cavite, Laguna, Batangas, Rizal and Quezon). The latter five provinces are grouped as the “Calabarzon” region which lies directly south of Metro Manila. The language and culture of the people have been molded by the tropical humid environment (farming and fishing), with a strong Spanish influence. The word “Tagalog” is derived from “taga ilog” which means “river dweller”. The name of the lake “Laguna de Bay” is formed by the Spanish phrase “Laguna de” (lake of) and the Tagalog word “Bai” (woman). The Tagalog word “Pasig” means sand bar, while Marikina comes from the Spanish name “Mariquina”. The Tagalog language is the basis of the national language, Filipino, and is basically Malayan, with a major influx of Spanish words. Spoken Filipino is often interspersed with English, an influence of American-dominated mass media such as TV and cinema.

While lowland farmers raise rice, sugar, and coconut as well as ducks, chicken and hogs, upland farmers/foresters grow orchards of fruits and vegetables (including honey), or else extract forest products such as bamboo and rattan. Horses, water buffaloes (carabaos), cattle, and goats are also

raised for animal power, meat or dairy products. The native cuisine of the region is thus mainly characterized by rice, fish, coconut, sugar, tubers and other tropical crops. Thus one encounters native rice cakes enriched with coconut meat or coconut milk and sweetened by unrefined brown sugar, beverages such as coconut wine ("tuba") and coconut liquor ("lambanog"), all sorts of coconut confections, and the unique salted egg with the immature duck fetus ("balut") which is a Laguna de Bay cultural icon. Small fishermen make their catch in the open lake waters and lakeshores while commercial aquaculture operators raise milkfish ("bangus") and other brackish-water species inside fish pens and fish cages. However, with the growing urbanization and westernization, the eating habits of the population, as in the rest of the Philippines, are gradually shifting to less rice and more bread, pasta and pizza. Fresh fish, however, remain to be a premium source of protein, compared to the usual pork and chicken.

The native dwelling or nipa huts (made of bamboo members and panels, and roofed with palm-leaf shingles) are elevated on stilt posts, with the upper floor raised above the highest flood of experience and are less vulnerable than the more modern bungalows. The old horse-drawn "carretela" has huge wheels which keep the passengers dry and above the water during floods. This wheeled vehicle together with the native dugout boats ("banca"), equipped with outriggers and engined-propellers, are ready substitutes for the motorcars as means of transportation during monsoon floods.

The urban workers are employed in commerce, services, manufacturing (electronics, automotive assembly, chemicals, food and beverages, appliances, handicrafts, etc.) and mining. The major service sectors are power utilities, water utilities, irrigation systems, transportation, telecommunications, and tourism. The other government services are military, health, education, social welfare, disaster and environmental management and protection, similar to other regions of the country.

Inside Metro Manila, the basic municipal services such as traffic, solid waste and flood management are administered by the Metro Manila Development Authority (MMDA), which coordinates with the local governments of the various cities. Flood-control monitoring and operations in the Pasig-Marikina rivers are also the functions of MMDA, through its Effective Flood Control Operations System (EFCOS). The environmental quality of the Pasig River, in particular, is being improved by the Pasig River Rehabilitation Project (PRRP) under the Office of the President. The natural resource management of the watersheds and lake in the Laguna de Bay Basin, are the functions of a river basin organization, the Laguna Lake Development Authority (LLDA), attached to the Department of Environment and Natural Resources (DENR), which also coordinates with various local governments. Other agencies which develop and maintain infrastructures and provide related services in the region are the Department of Public Works and Highways (DPWH), Metropolitan Waterworks and Sewerage System (MWSS), Local Water Utilities Administration (LWUA), National Irrigation Administration (NIA), National Power Corporation (NPC), Bureau of Soils and Water Management (BSWM), Department of Health (DOH), Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and Philippine Ports Authority (PPA).