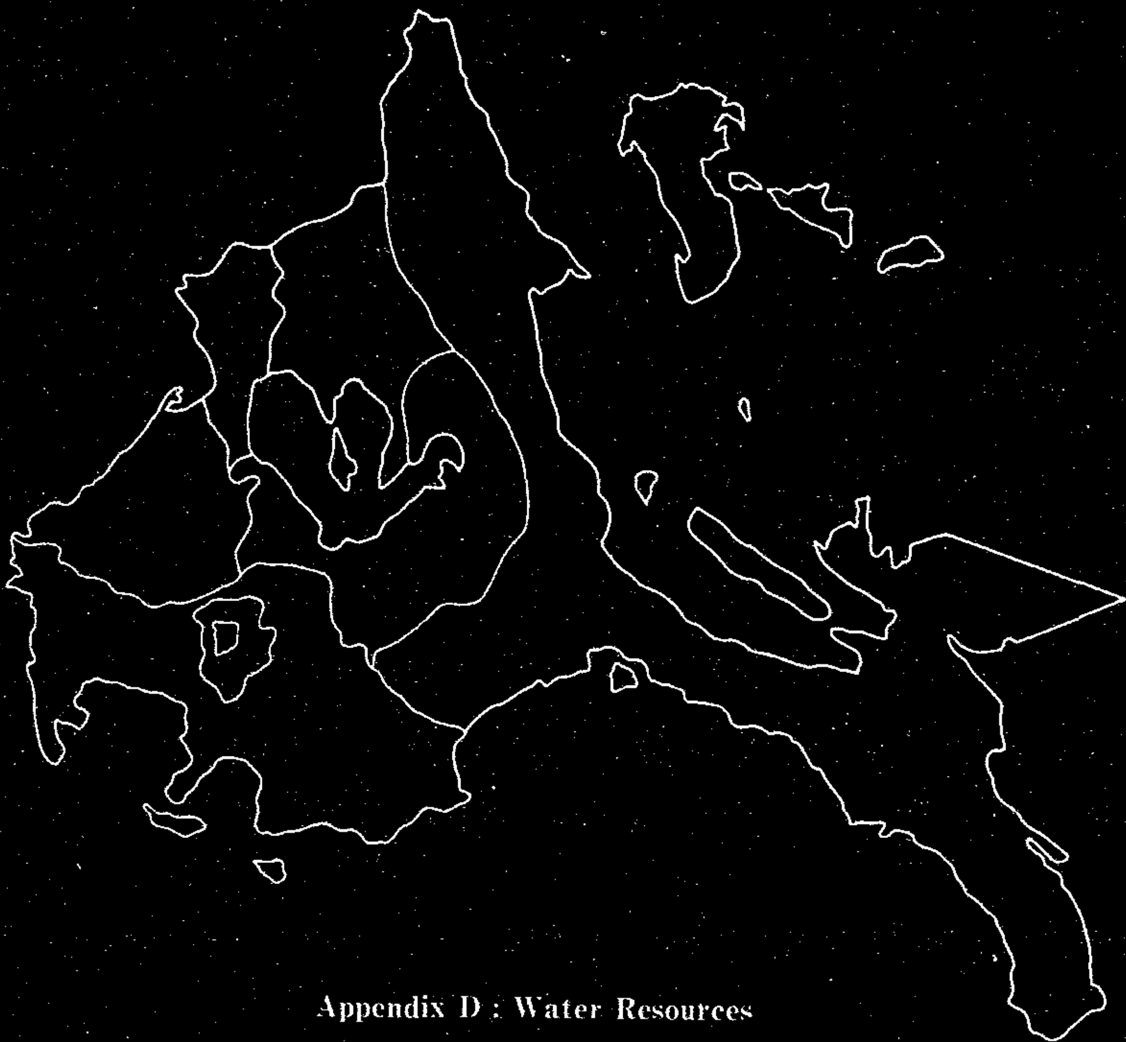
REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF TRADE AND INDUSTRY

THE MASTER PLAN STUDY ON THE PROJECT CALABARZON

FINAL REPORT



Appendix D : Water Resources

October, 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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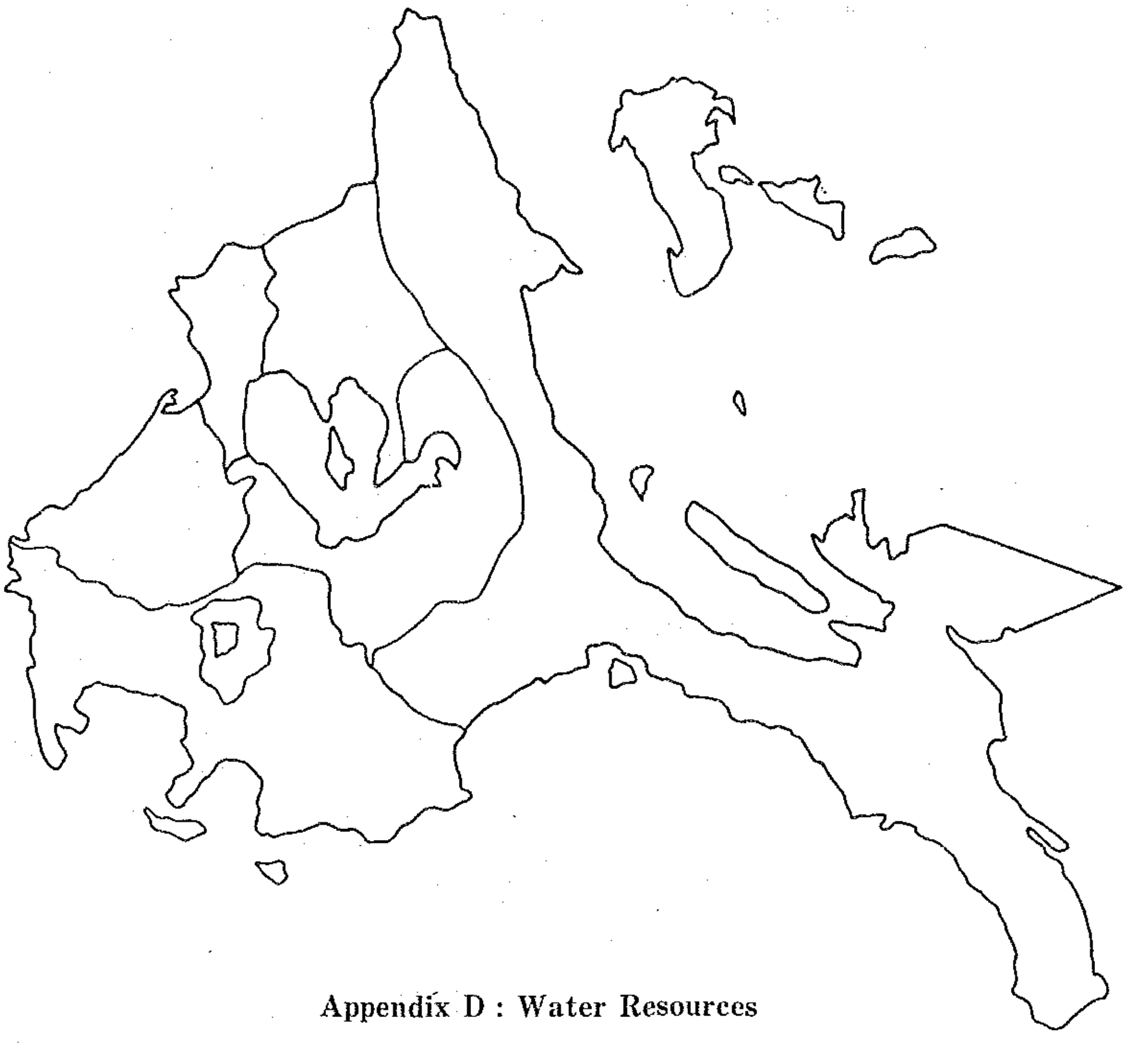

Appendix D : Water Resources

October, 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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Appendix D: WATER RESOURCES

D.1 Water Related Institutions

Several government agencies are involved in policy formulation, project planning, implementation and management related to water resources in the Philippines. Those more directly involved in water supply are described here. Others are related to hydropower development, water quality and environment, irrigation and others.

D.1.1 Central agencies

DPWH

The Department of Public Works and Highways (DPWH) is responsible for the development of integrated water supply plans, mainly but not exclusively for source development of Level I water supply systems, in line with national plans and policies. It performs engineering and construction functions such as drilling of wells and development of springs. DPWH is also responsible for providing technical assistance and exercising government budget allocation for construction and major repair and rehabilitation of water works.

NWRB

The National Water Resource Board (NWRB), attached to DPWH, is a high level body responsible for coordinating and integrating all the activities related to water resources development and management. It formulates policies, evaluates and coordinates water resources programs, regulates and controls the utilization, exploitation, development and conservation of the Country's water resources and the regulation of water utilities' operation.

DOH

The Department of Health (DOH) is responsible for the formulation and implementation of sanitation programs nation-wide and the administration of health education programs. It also promotes safe water supply and exercises surveillance of water quality.

DLG

The Department of Local Government (DLG) undertakes the USAID-assisted barangay water program, which aims at developing a strategy for rural water supply projects, using indigenous capability for operation and maintenance, and developing the capability of provinces and cities to undertake waterworks projects using this strategy. Targets are rural communities with population not exceeding 10,000, which are willing to operate and maintain their own projects. For communities with piped systems, DLG provides institution-building services. Local government units plan and implement waterworks projects, and the recipient communities finance the operation and maintenance of the facilities through user charges.

D.1.2 Local agencies

<u>MWSS</u>

The Metropolitan Waterworks and Sewerage System (MWSS) provides for potable water supply and sewerage requirements of four cities and 13 municipalities in Metro Manila and contiguous areas. It is responsible for the planning, design, construction, operation and maintenance of water supply and sewage disposal systems within its jurisdiction.

<u>LWUA</u>

The Local Water Utilities Administration (LWUA) is responsible for water supply development in all the areas not covered by MWSS. It provides water services through Level III (piped waterworks system) and Level II (communal faucet system). In addition, it undertakes institution building activities, planning and engineering for the implementation of sewerage projects in several urban areas.

Specifically, LWUA provides loans to water districts (WD's) for the development of water systems at concessionary terms based on their development potentials and continued viability. It extends engineering services to WD's as well. Its functions include also the promotion of organization for works of the rural waterworks and sanitation associations (RWSA's), and the provision of institutional, technical and financial assistance to RWSA's in the construction, operation and maintenance of rural water supply systems.

<u>WD's and RWSA's</u>

Water districts and rural waterworks and sanitation associations are institutions to be established for the purpose of ensuring proper operation and maintenance of completed water supply, sewerage and sanitation facilities. As mandated by law, these institutions are organized and registered with LWUA.

A water district is a non-profit, quasi-public and local entity created primarily for the purpose of acquiring, installing, improving, maintaining and operating water supply and distribution system within the boundaries of the district. WD's are formed at the option of the local government concerned. RWSA's are non-stock, non-profit organizations envisioned to operate and manage Level I and II water supply facilities constructed by DPWH, LWUA, DLG and DOH.

D.2 Existing Conditions of Water Resources and Use

D.2.1 Basin system in CALABARZON

The whole country is divided into twelve Water Resources Regions as units for comprehensive water resources development and management. The CALABARZON region is a part of Water Resources Region IV(Southern Tagalog), located in the southern portion of Luzon island.

The Water Resource Region IV is further divided into five water resource planning units, that is, Laguna Lake basins, Taal Lake basins, Quezon basins, Mindoro island basins and Palawan island basins. Laguna Lake basins, Taal Lake basins and Quezon basins cover the CALABARZON region. Laguna Lake basins have a total area of about 5,080 km^2 and cover the entire provinces of Laguna and Rizal and a part of Batangas and Cavite. Taal Lake basins have a total area of 3,940 km^2 covering almost the entire provinces of Cavite and Batangas. Quezon basins have a total area of 10,160 km^2 , corresponding largely to the province of Quezon but including also parts of Batangas and Laguna.

(1) Laguna Lake basins

The Laguna Lake basins are bounded in the north by the province of Bulacan, in the east and south by the province of Quezon and in the west by the provinces of Cavite and Batangas. Mountain areas are found mainly in the northern part of the basins. Flat lands prevail along the lakeshore and in the northwestern and southwestern portions of the basins.

The basins are composed of the Pasig-Laguna de Bay river basin with 4,680 km^2 and small watersheds with 400 km^2 (Figure D.1). The Pasig-Laguna de Bay river basin drains three distinct and different sub-basins: Marikina river basin (510 km^2), Laguna de Bay basin (4,120 km^2) and the urban watershed (50 km^2) which includes part of the Metro Manila urban area. The main drainage of the basin is through the Pasig river toward Manila Bay, while the other rivers drain towards the centrally located Laguna Lake.

(2) Taal Lake basins

The Taal Lake basins are bounded in the northeast by the Laguna Lake basins, in the south by Batangas Bay, in the west by the Luzon sea, and the northwest by Manila Bay. The basins are relatively flat and broken by dispersed mountains of which average elevation is about 300 m. The prominently raised elevations are the chain of mountains that cut through the basin composed of Tagaytay Ridge in the adjoining Taal Lake and Naligang, Mt. Cayluya, and Mt. Palay toward the west coast.

The Taal Lake basins consist of one major river basin (Taal Lake or Pansipit), ten minor basins and several small watersheds (Figure D.1). The Taal Lake basin drains an area of 660 km^2 including the lake itself, about 240 km^2 with the Taal volcano in the center. The Pansipit river which flows into Balayan Bay is the only outflow from the lake.

(3) Quezon basins

The Quezon basins correspond largely to the province of Quezon, but include part of Padre Garcia in Batangas, San Pablo City and other municipalities in Laguna. The basins are bounded in the north by the province of Aurora, in the south by Sibuyan Sea, in the west 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 basins comprise 21 small river basins having a total land area of 10,106 km^2 (Figure D.1). The basins have generally ragged terrains with the Sierra Madre mountain range and Mt. Banahaw. Lowlands are confined to narrow strips along the coasts and narrow river valleys and small fluvial plains.

D.2.2 Natural conditions by basin

(1) Laguna Lake basins

<u>Meteorology</u>

The Laguna Lake basins exhibit two types of climate (Figure D.2). In the eastern-most part of the basin, rainfall is more or less evenly distributed throughout the year (Type IV). The rest has two pronounced seasons: dry season from November to April and wet season during the rest of the year (Type I).

There are twenty rainfall stations, shown in Figure D.1, within the basins all managed by the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA). Observed rainfall data of the representative stations are given below and illustrated in Figure D.3.

<u>Mean Monthly Rainfall (mm)</u>

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Sta. Cruz (1957 - 1980)													
	40	10	29	42	150	241	254	273	265	265	250	151	1,978
Port area/Manila (1957- 1981)													
	15	4	13	18	161	285	437	467	335	212	129	42	2,118

Sta.Cruz is located in the southeastern part of the basins and about 85% of the annual rainfall is observed during the wet season from May to November. Port area/Manila is located in the northeastern part, and about 95% of the annual rainfall is observed during the wet season and further a remarkable peak is recorded during July and August.

Estimated annual rainfall over the basins varies from 1,900 mm in the western part to 2,450 mm towards the eastern part of the basin (Figure D.4). The mean annual rainfall of the basins is 2,148 mm.

PAGASA has three synoptic stations recording atmospheric temperature and relative humidity observations. The stations recording these atmospheric data are all situated within Metro Manila. Monthly mean temperature and relative humidity at Port area/Manila are summarized below and illustrated in Figure D.5.

<u>Mean Monthly Temperature and Relative Humidity</u>

Jan	Feb	Mar	Mar	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
Temperature(°C, 1947-1976)												
26	26	28	29	29	29	28	27	27	28	27	26	27.5
Relative humidity(%, 1947-1976)												
72	69	63	65	69	76	79	82	81	77	76	75	73.7

The lowest value of temperature is observed from December to February and the highest value observed during April and May. The highest relative humidity is observed in August and September while the lowest in March and May. The mean annual temperature and relative humidity in the Laguna Lake basins are 27°C and 76% respectively.

There are four evaporation stations within the basins. However only the stations in Los Baños and Science Garden in Quezon City have available evaporation data. Monthly pan evaporation at the two stations is shown in Figure D.6 and below.

Monthly Pan Evaporation (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Los Baños (1959-1974)	136	159	210	247	226	167	145	142	134	136	124	116	1,942
Science Garden (1976-1982)	104	126	165	155	169	120	123	114	106	96	90	101	1,469

Annual Pan evaporation is 1,949 mm in Los Baños and 1,469 mm at Science Garden in Quezon City.

Surface runoffs

The Pasig river flowing from east to west through central Manila is 17 km long from the confluence with the Marikina and Napindan channel to Manila Bay. A principal tributary is the San Juan river. The flow of the river depends upon the elevation of the water surface at the Pasig-Napindan junction, lake water level of Laguna de Bay, sea water level in Manila Bay and the discharge from the San Juan river. During periods of high tide in the bay and low water level in the lake in the dry season, the Pasig river reverses its flow direction. During high tide conditions and high flow of the San Juan river, a backwater effect slows down the flow of Pasig river and causes overbanking. The Marikina river flows are carried predominantly to Manila Bay, and during periods of high river discharge, a significant portion of the discharge flows into the Laguna lake via Mangahan floodway.

Laguna de Bay is a shallow lake with average depth of about 3 m immediately inland from the Metro Manila area. About forty short streams enter the lake. The major tributaries to the lake, Santa Cruz, Pagsanjan and Romero rivers, drain the southern and eastern slopes of the watershed. Laguna de Bay functions as a natural retarding basin for discharges from the surrounding tributaries. The only outlet is the Pasig river via Napindan channel.

Twenty-two stream gauging stations are established in the Laguna Lake basins, of which only nine have discharge data, while the rest have records of only gauge height. Principal features of the rivers in the basins are provided below (more details in Table D.1).

Information on Main Rivers in Laguna Lake Basins

River Name	Station Code	Catchment Area (km^2)	Specific Discharge ($m^3/s/km^2$)	Runoff Ratio
1. Marikina R. (Sto. Niño)	407	499	0.06	0.89
2. Marikina R. (San Rafael)	409	282	0.06	0.86
3. Arangilan R.	413	87	0.01	0.13
4. Mabacan R.	415	46	0.03	0.38
5. Paputok R.	416	8.5	0.11	-
6. Sta. Cruz R.	417	103	0.05	0.63
7. Balanac R. (upper)	418	116	0.08	0.82
8 Balanac R. (lower)	419	u.d.	-	-
9. Mayor R.	421	45	0.04	0.52

u.d.: undefined

Using the mean annual runoff volume observed at the above gauging stations, a map of mean annual runoff in terms of runoff depth is provided by the National Water Resources Board (Figure D.7). According to the mapped values, the mean annual runoff depth of the basin is placed at 1,435 mm (approximately 7,300 million cm^3). Runoff ratio to the total rainfall volume in the basin is calculated to be about 67 %.

Flood area

The major flood prone area in Laguna lake basins includes the low portions of Marikina Valley, Metro Manila and the Laguna Lake shoreland. Flood problems are generally caused by excessive runoff in the watershed and limited lake outflows, inadequate drainage facilities, overbank flow of the Marikina and the Pasig rivers, and high lake water stage affecting the lake shoreland and extending for months due to excessive runoffs into the lake and limited lake outflow.

The extent of potential flooding along the Laguna lakeshore, defined as the area between 10.5 m and 14.6 m above the LLDA datum level, was calculated in 1975 to be 26,600 ha. The land use in this area consisted in the same year of 1,992 ha residential, 14,478 ha agricultural, 323 ha industrial and 102 ha commercial constituting 63% of the total, with the rest being marshes and swamps. Rapid urbanization in the flood plains has increased the potential for flood damage. More than 14,000 ha are subject to flooding every year.

Hydrogeology

The province of Rizal is underlain by volcanic rocks chiefly dacite and andesite flows with pyroclastic and/or volcanic debris. These formations are not good aquifers and thus the chance of successful shallow wells (with depth of not more than 20 m) is very slim. Recent formations composed of consolidated and unconsolidated sand, gravel and clay constitute only 135 km^2 or 10% of the total land area and this is where shallow well areas are mostly found. These areas are situated in the western part of Rizal particularly in the towns of San Mateo, Taytay, Cainta and some parts of Angono. Deep well (with depth of more than 20m) areas are scattered all over the province, majority of which are concentrated in the eastern portion of Rizal encompassing portions of the towns of Montalban, Antipolo and Tanay. About 60 km^2 or 4% of the total land area are considered the deep well area. The remaining 86% falls under the category of difficult areas. These areas are mostly underlain by volcanic rocks. The difficult areas cover most of the towns in the southern part of Rizal specifically the mountainous areas of Binangonan, Talim Island, Jala-Jala, Pililla, Tanay, Baras and Morong.

The groundwater of Laguna will most likely occur within the recent alluvial deposits particularly in well sorted sediments. Borehole data indicate that a number of wells have cut through these aquifers with depth ranging from 22 m to 25 m. Shallow wells areas are confined in this formation. This includes layers of sand, occasional lens of gravel and considerable silt and clay derived from the weathering of volcanic and pyroclastic rock upland. About 260 km^2 or 15% of the total land area falls in the category of shallow wells. This formation is found along the southern shores of Laguna Lake covering the northern portions of the coastal towns of Laguna, particularly Famy, Siniloan, Pangil, Pakil, Paete, Kalayaan, Lumbang, Sta. Cruz, Pila, Victoria, Bay, Calamba, Cabuyao, Sta. Rosa and Biñan. Northern portions of these towns fall under difficult areas for groundwater development.

Hydrogeologically, the volcanic formations comprising basaltic to andesitic flows with intercalated pyroclastic and minor sedimentary rocks serve as impermeable layers. These formations characterize difficult areas. Majority of the total land area of Laguna falls under these formations. The presence of fractured zones in these formations serve as aquifers. About 1,500 km^2 or 85% of the total land area falls within this difficult area category. They are dispersed dominantly in the central and northern portions of the province. Aquifer distribution in the basin is shown in Figure D.8.

(2) Taal Lake basins

Meteorology

The entire Taal Lake basins are characterized by two types of climate (Figure D.2). The southeastern tip falls under a category with seasons not very pronounced and is relatively dry from November to April and wet during the rest of the year (Type III). The remaining parts belong to another category with two pronounced seasons, dry from November to April and wet during the rest of the year (Type I).

There are presently eight rainfall stations within the Taal Lake basins all managed by PAGASA (Figure D.1). Observed rainfall data of the representative stations are given below and illustrated in Figure D.9.

Mean Monthly Rainfall (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nasugbo (1972 - 1980)	4	1	11	10	251	205	457	644	348	260	45	45	2,363
Lobo (1969 - 1979)	19	5	9	29	136	191	180	184	187	248	130	104	1,422
Ambulong (1952 - 1971)	27	23	17	31	159	220	261	338	253	220	165	127	1,841

Nasugbu is located in the most western part with two pronounced seasons. More than 90% of the annual rainfall is observed during the wet season from May to October. The difference between dry and wet season is very large and a remarkable peak is recorded in August. Lobo is located in the southeastern part of the basins and about 80% of the annual rainfall is observed during the wet season. No large fluctuation of monthly rainfall during the wet season is observed. In addition, rainfall data at Ambulong is given for the comparison with the other atmospheric data described below. This station is located in the northern part of Taal lake with two pronounced seasons. Though the annual rainfall is about 500 mm less than that of Nasugbu, the rainfall pattern throughout a year is almost the same as that of Nasugbu.

Estimated annual rainfall over the basins varies from 1,900 mm to 2,150 mm with the western coastal area experiencing more precipitation. The mean annual rainfall of the basins is 2,026 mm.

The mean annual temperature and relative humidity at Ambulong in Tanauan, the only synoptic station of PAGASA for the Taal Lake basins, are 27.4°C and 78%, respectively (Figure D.10).

Mean Monthly Temperature and Relative Humidity

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
Temperature(deg.C, 1951-1970)													
	26	27	28	29	29	28	28	27	27	27	27	26	27.4
Relative humidity(%, 1951-1970)													
	78	73	70	69	73	80	83	83	84	82	81	80	78.0

Monthly temperature fluctuates from a mean maximum of 35°C to a mean minimum of 22°C. Monthly mean temperature varies from 26°C to 29°C and annual mean is 27°C. April and May are the warmest months while December and January the coldest. Monthly relative humidity fluctuates from a mean maximum of 92% to a mean minimum of 60 %. Monthly mean relative humidity ranges from 69% to 84% and September registers the highest value, while April has the lowest.

There are two evaporation stations within the basin situated at Ambulong in Tanauan, Batangas and at Indang in Cavite. However, only the station in Ambulong has available evaporation data. Observed data at the above station is shown in Figure D.6 and below.

Monthly Pan Evaporation (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ambulong (1959-1974)													
	106	113	137	153	145	119	110	109	105	106	101	97	1,401

Monthly mean pan evaporation ranges from 97 mm to 153 mm over a 16-year period and the annual mean is set at 1,401 mm. According to the above data, it is said that fluctuation of evaporation throughout a year is influenced by the two seasons. Comparatively large value is recorded in March, April and May during the dry season and not so much fluctuation is observed during the wet season.

Surface runoffs

There are eight stream gauging stations within the Taal Lake basins (Figure D.1). All stations, except the Molino river in Batangas , have about twenty years of available data. However, only data up to 1979 are discharge data. The data from 1980 to the present are recorded in terms of gauge height and not converted to discharge value. Principal features of rivers are shown below (more details in Table D.1).

Information on Main Rivers in Taal Lake Basins

River Name	Station Code	Catchment Area (km^2)	Specific Discharge ($m^3/s/km^2$)	Runoff Ratio
1. Ilang-ilang R.	422	60	0.01	0.22
2. Panaysayan R.	423	29	0.03	0.54
3. Balsahan R.	424	22	0.06	-
4. Maragondon R.	425	260	0.08	-
5. Palico R.	426	158	0.05	0.67
6. Molino R.	427	51	0.04	0.61
7. Dacanlao R.	428	40	0.06	0.84
8 Pansipit R.	429	644	0.02	0.34

Using the mean annual runoff volume observed at the above gauging stations, a map of mean annual runoff in terms of runoff depth is provided by National Water Resources Board. According to the mapped values, the mean annual runoff depth of the basin is placed at 1,246 mm (approximately 4,900 million cm^3). Runoff ratio to the total rainfall volume in the basin is calculated to be about 61 %.

According to the map, relatively high runoff depth between 1,300 mm and 1,500 mm is shown at the southern part of Cavite and the most eastern part of Batangas in the basin. While low runoff depth less than 1,100 mm is shown at the southwestern part of Taal Lake.

Flood Area

No major flood prone area exists in the Taal Lake basins. Flood problems are generally minor and localized. Nevertheless, small scale flood control measures are adopted to the Sta. Isabel , Balilihan and Wawa rivers in Cavite and the Lawaye, Pansit, Lobo, Lucsuhin and San Juan rivers in Batangas.

Hydrogeology

Hydrogeological units of the Cavite province indicate that the possibility of finding shallow well areas is most likely within the recent alluvial deposits made primarily of old silt and clay. About 210 km^2 or 16% of the total land area of Cavite is categorized as shallow well areas, found predominantly in the northern part of the province specifically in the coastal towns of Ternate, Naic, Tanza, Rosario, Noveleta, Kawit, Cavite City and Bacoor. Shallow well areas occur also in a small portion in the northeastern part of the province particularly in the towns of Carmona, Imus and the eastern portion of Dasmariñas. Shallow wells in these towns have an average discharge ranging from 0.32 lps to 1.26 lps. However, water in these deposits, except in Imus, Carmona and Dasmariñas, is likely to be saline because of its proximity to the sea.

Deep well areas cover most of the town of Maragondon and the upland towns of the province. These areas consists principally of lithified/unlithified and reworked pyroclastic deposits such as agglomerates, fine lapilli tuff, unconsolidated volcanic ash and other fragmentals. About 160 km² or 13% of the total land area are found to be deep well areas. The static water level ranges from 3 m to 17 m below ground surface (mbgs) and average well discharge ranges from 0.32 lps to 15.8 lps.

Pliocene to pleistocene volcanic and clastic rocks make up about 910 km² or 71% of the total land area where difficult areas are found. Formations consist principally of lithified and unlithified pyroclastics such as breccias, agglomerates, tuff with lava flows, dikes and tuffaceous and sandstone, mudstone and siltstone. The towns in the southeast up to the central and southeastern parts of Cavite fall under this category. Formations are generally tight with low groundwater yields.

Deep well areas prevail on the western side of the province of Batangas particularly in the towns of Calatagan, Balayan, Lian and the northern portion of Nasugbu. Some small deep well areas are found in the southern part of the province in the towns of Tingloy and Bauan and along the boundary of Batangas City and Lobo. In the eastern part they are dispersed between the towns of Taysan, Rosario and San Juan. As a whole, deep well areas make up about 470 km² or 15% of the provincial area. About 250 km² or 8% of the total land area are designated as shallow well area. These areas are distributed in small portions of Lian and Nasugbu in the west, and along the coastal areas of Balayan, Calaca, Lemery, Taal, San Luis, Bauan, San Pascual, western part of Batangas City and Lobo. Small occurrence is also found in the northern and eastern portions of San Juan.

Difficult areas comprise the largest area in the province with a total of about 2,400 km² or 77% of the total land area.

(3) Quezon basins

Meteorology

Four types of climatic conditions are observed in the Quezon basins (Figure D.11). The southern-most (Bondoc Peninsula), northwestern and central portions are characterized by an even distribution of rainfall throughout the year (Type IV). The eastern section including the group of islands has no dry season with a pronounced maximum rainfall from November to January (Type II). The northern side has two pronounced seasons-dry from November to April and wet from May to October (Type I), while the southern side has no pronounced seasons - relatively dry from November to April and relatively wet from May to October (Type III). Types I and III predominate the westernmost tip of the province.

Only four operating rainfall stations exist in the Quezon basins, all managed by PAGASA. Observed rainfall data of these stations are summarized below.

Mean Monthly Rainfall (mm)

Station (Observation Period)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Alabat (1961-85)	251	134	99	82	110	200	226	175	253	510	531	571	3,222
Infanta (1951-85)	354	220	187	180	225	249	259	196	325	608	597	597	3,998
Lucena (1951-70)	89	60	43	55	90	160	185	199	226	336	305	235	1,983
Tayabas(1970-85)	155	72	72	103	228	258	261	173	316	513	520	414	3,084

Based on the isohyet map prepared by NWRB (Figure D.4), the mean annual basin rainfall has been estimated at 2,260 mm. The mean annual temperature and relative humidity in the basins are 27°C and 83%, respectively.

Surface runoffs

Only ten stream gauging stations are presently operated in the basins, located mostly in the central portion of the Quezon province (Figure D.1). Data for these stations are summarized below.

Information on Some Rivers in the Quezon Basins

River Name/Location	Drainage Area (km^2)	Specific Discharge ($m^3/s/km^2$)	Annual Runoff Depth (mm)
Agos R/Banugao, Infanta	879	0.13	4,258
Maapon R/Sampaloc, Sampaloc	88	0.07	2,072
Ibia R/Ayaas, Tayabas	15	0.12	3,791
Dumaca-A R/Alsam, Ayaas, Tayabas	54	0.12	3,719
Dumaca-A R/Lakawan, Tayabas	74	0.14	2,858
Morong R/Morong, Sariaya	12	0.06	1,764
Sariaya R/Tumbaga, Sariaya	6	0.06	1,486
Hibanga R/Mamala, Sariaya	5	0.04	1,115
Lagnas R/Lagalag,Tiaong	54	0.02	470
Bulakin R/Bulakin, Tiaong	11	0.11	3,454

Based on the mean annual runoff map (Figure D.7), the mean annual runoff depth of the basins is estimated to be 1,445 mm, making the average runoff ratio 64%.

Flood area

There are no major flood prone areas in the Quezon basins. Flood problems are generally minor and localizes.

Hydrogeology

Hydrogeologic units of the basins indicate that recent formations composed of alluvial deposits of unconsolidated sand, gravel and clay are where shallow well areas are most likely to occur. Borehole data show that wells have cut through these aquifers with depths ranging from 6.8 m to 20 m. About 697 km^2 or 8% of the land area have been categorized as shallow well areas. These areas occupy most of the towns in the central parts of Southern Quezon, particularly the coastal areas of Pagbilao, Padre Burgos, Agdangan, Unisan, Pitogo, Gumaca, Plaridel and Atimonan and in the eastern portion of Southern Quezon in Lopez and Calauag and Burdeos on the Polilio island. Wells in these formations have an average discharge ranging from 0.33 lps to 1.04 lps.

Majority of the towns in Southern Quezon fall under deep well areas. Lithologic units are made up of pyroclastic rocks dominantly bedded with tuffaceous sandstones, coralline limestone, marls and other unmapped rocks. About 4,353 km^2 or 53% of the land area are designated as deep well areas. These are found in the eastern part of Southern Quezon particularly in the towns of Catanauan, Mulanay, San Francisco, San Andres, San Narciso, Buenavista, Guinayangan, Tagkawayan, Perez and Alabat, and the central part including portions of the western part of Southern Quezon, viz. Plaridel, Atimonan, portions of Pagbilao, Tayabas and Mauban. In Northern Quezon, deep well areas are found sporadically in the western part of the towns of Real and General Nakar and in small portions on the Alabat island.

Difficult areas are predominant in Northern Quezon. Majority of the land in these areas is underlain by ultramafic and mafic plutonic rocks, diorite, metamorphosed shale with intermediate flows and pyroclastic. Generally these formations are not aquifers. In the province of Quezon, the difficult areas are concentrated in the western portion particularly in the towns of Lucban, Dolores, Tiaong, San Antonio, Candelaria, part of Atimonan, Tagkawayan and the town of Quezon. The difficult areas make up 42% or 3,656 km^2 of the total land area. The groundwater map of Quezon is shown in Figure D.8.

D.2.3 Existing water use

(1) *Domestic water*

Domestic water use is estimated on the basis of data in 1987 for number of facilities, population served and production volume from sources. For Level I and Level II supply facilities, the water use is obtained using service population and average per capita daily use. The average per capit daily use is set at 30, 60 and 105 liters for Levels I, II and III, respectively. Levels I and II supply facilities deliver water to an average of 100 persons and 100 households in rural areas, respectively. The average number of family members is six persons per household.

The result of estimation for four provinces except Quezon is summarized below (details in Table D.2).

Domestic Water Use in Four Provinces and Metro Manila

(1,000 m^3/year)

Supply system/Water source	Province				
	Rizal	Laguna	Cavite	Batangas	Metro Manila
Level I (well/spring)	2,580	3,498	5,451	6,296	(1,862)
Level II (well/spring)	587	446	1,716	3,634	(13,052)
Level III (well/spring)	7,382	14,597	7,943	8,030	(0)
(surface water)	0	947	0	0	(336,510)
Other sources (rain, lake & stream)	2,766	4,605	2,658	4,579	(35,084)
Total	13,315	24,093	17,768	22,539	(386,500)

Domestic water use in Quezon is estimated separately based on the per capita requirement of 0.115 m^3 per day and 0.025m^3 per day respectively in urban and rural areas, and urban and rural population in 1990. The total domestic water use in Quezon is estimated at 26,060,000 m^3/year, consisting of 17,290,000 m^3/year in urban area and 8,770,000 m^3/year in rural area.

The domestic water in CALABARZON depends mostly on groundwater. Loss of water due to leakage and illegal connection is still significant .

(2) Industrial water

NWRB estimated the industrial water use in 1975 and 1980 based on the estimate of industrial output. The results are given below by basin.

Industrial Water Use in CALABARZON

	1975	1980
Laguna lake basins (mcm/year)		
Manufacturing	13.7	21.3
Mining	0.02	0.03
Construction	0.50	0.79
Electricity	0.30	0.48
Total	14.5	22.6
Taal lake basins (1,000 cm^3/year)		
Manufacturing	583	1,370
Mining	1	-
Construction	12	-
Electricity	3	-
Total	599	-
Quezon basins (1,000 m^3/year)		
Manufacturing	211	421
Mining	2	3
Construction	8	3
Electricity	3	5
Total	225	440

Of the total industrial water use in 1980 in Laguna lake basins, the manufacturing sector is the biggest user with 94% followed by construction with 3% and electricity and mining sharing 2% and less than 1% respectively. Also in Taal lake basins, the manufacturing sector is the biggest user with 97% of the total industrial water(value in 1975). The combined share of mining, construction and electricity is only 3 %.

The water use by manufacturing is further classified into three groups: primary, intermediate and capital goods industry. In Laguna lake basins, the shares of primary, intermediate and capital goods industry are 33%, 36% and 31%, respectively. In Taal lake basins, the share of intermediate industry is 92%.

(3) Irrigation water

Existing water use for irrigation is estimated on the basis of data on the irrigated land area obtained from NIA and the pattern of water requirement. The latter is 1.5 l/sec/ha for 90 days in January-March, 1.0 l/sec/ha for 132 days in June-October, and 41 days in November - December.

Average annual water use for the period 1985 through 1989 is summarized below by province (details in Table D.3).

Irrigation Water Use

Province	Irrigation water (Mm^3/year)		
	NIS	CIS	Total
Cavite	175	7	182
Laguna	199	116	315
Batangas	19	40	59
Rizal	-	50	50
Quezon	49	106	155
Total	442	319	761

NIS: National irrigation system
CIS: Communal irrigation system

Almost all irrigation water is supplied from river water with a small diversion dam or intake gate. There exist some communal irrigation systems to which insufficient water or no water is supplied during the dry season because of small storage capacity of dam or no water regulation facility.

D.2.4 Existing facilities

(1) Dams and reservoirs

According to the inventory of water impounding projects conducted by NWRB, five dams exist in the provinces of Batangas and Cavite as listed below. Locations of existing dams are shown in Figure D.12.

List of Water Impounding Reservoirs

Site	River Purpose	Province	Catchment Area (km^2)	Dam Height (m)	
Novaliches	La Mesa	Rizal	26	30	M & I
Wawa	Marikina	Rizal	280	11	M & I
Caliraya	Caliraya	Laguna	92	106	P, etc.
Nagcarlan	Balugbog	Laguna	-	-	P
Majayjay	Botocan	Laguna	5		P

M & I : Municipal and industrial water supply
P : Power

(2) Water supply facilities

The Government through various agencies involved in water supply defines three levels of water service as follows. Level I consists of a point source usually a protected spring or well without distribution system, often provided in areas where houses are few and scattered thinly. It essentially covers 100 persons. Level II is a communal faucet system intended for rural areas where houses are clustered enough to justify a simple distribution system with a public standpipe. It delivers water to an average of 100 households per system. Level III water supply service refers to a piped system with individual house connections, generally suited for dense urban areas.

According to the 1987 data of DPWH, LWUA, and MWSS, the approximate number of existing water supply facilities in the CALABARZON region is as shown below.

Inventory of Water Supply Facilities

Province	Level		
	I	II	III
Cavite	5,140	90	35
Laguna	3,430	30	57
Batangas	2,720	227	33
Rizal	1,680	38	36
Quezon*	5,506	-	10
Metro Manila	1,700	-	1
Total	20,176	385	172

* As of December 1990

(3) Flood control structure

Flood protection measures have been implemented to alleviate the flood problems of the basins. These measures involve the construction of revetments, spur dike, drainage, mains and river walls, and dredging. Existing condition of flood protection measures by province is shown below.

Inventory of Flood Protection Measures

Province	Dike/Levees (km)	Revetment (km)	Dredging (km)	Spur Dikes (m)	River Walls (km)	Drainage Main (m)
Cavite	0.1	0.65	0.0	0.0	0.0	0.0
Laguna	0.0	2.54	0.0	79.0	0.0	196
Batangas	2.2	0.34	0.9	10.0	0.0	0.0
Rizal	0.0	3.63	11.7	0.0	0.22	0.0
Quezon	0.6	0.53	-	-	0.23	-
Total	2.3	7.69	12.6	89.0	0.45	196

Source: Southern Tagalog, Frame Work Plan 1983 by NWRC

Major flood control structures for the Metro Manila area are the Mangahan floodway and the Napindan hydraulic control structure. The general features are as follows.

Mangahan flood way

The Mangahan flood way is a diversion channel which limits the flood discharge of the Pasig river to the bank. It will carry the remaining portion of the flood discharge from the Marikina river to Laguna Lake for temporary storage to prevent overbank flow into the Manila area. It consists of a 9 km long, 80 to 220 m wide structure. Other features are a 150 m long overflow weir at an intake of the floodway, 2 to 5 m wide gated sluice way at the upper end of the weir and a gated control structure across the Marikina river immediately downstream of the floodway intake to assure regulated downstreams release not exceeding the Pasig river safe capacity.

Napindan hydraulic structure

The Napindan hydraulic control structure is a gated spillway dam situated across the Napindan river. This was constructed to prevent back flow of the Pasig river to the lake and at the same time provide a means of storing water for water supply and irrigation purposes.

D.2.5 Planned and on-going projects

(1) Water impounding reservoir projects

Six reservoirs in the Laguna Lake basins, two reservoirs in the Taal Lake basins and nine reservoirs in the Quezon basins are either proposed or identified (Figure D.12).

Proposed/Potential Water Impounding Reservoirs

Site	River	Province	Catchment area (km^2)	Dam height (m)	Purpose
Wawa	Marikina	Rizal	280.0	135	P, FC, M&I, etc.
Pililla	Unnamed Cr.	Rizal	1.0	-	I, FC, etc.
Morong	Unnamed Cr.	Rizal	1.8	-	I, FC, etc.
Mt. Banbang	Lanatin	Rizal	70.0	-	P, FC, M&I, etc.
Montalban 1	Mango	Rizal	18.4	60	P, FC, M&I, etc.
Montalban 2	Puray	Rizal	33.0	50	P, FC, M&I, etc.
Rosario	Malakin-ilog	Batangas	235.0	40	P, FC, M&I, etc.
San Juan	-	Batangas	0.3	-	I, FC, etc.
Lower Agos	Agos	Quezon	873.0	130	P
Pagbilan	Caliwa	Quezon	-	9	P
Daraitan	Unnamed Cr.	Quezon	340.0	106	P, M&I, etc.
Kanan	Kanan	Quezon	357.0	-	P, M&I, etc.
Picsan	Guinhalinan	Quezon	54.8	50	I, P, M&I
Camohaguin	Camohaguin	Quezon	10.0	-	I, FC, etc.
Mauban	Balay-balay	Quezon	65.0	-	P, FC, etc.
Gen. Luna	Hingoso	Quezon	30.0	40	P, FC, M&I
Santa Rosa	Adoa	Quezon	42.4	30	I, FC, etc.

M & I: Municipal & industrial water supply
P: Power I: Irrigation FC: Flood control

The Wawa dam project (Marikina multi-purpose project) is a major project involving the construction of a dam, spillway, diversion tunnels, water treatment plant and a hydroelectric plant. It is specifically intended for alleviating the recurring potable water and power deficiencies for Metro Manila during dry periods and controlling the flood flows along the Marikina river during the rainy season in conjunction with the Mangahan floodway.

In addition, a transbasin water project from the Kaliwa river basin is planned. The Kaliwa river originates from the boundary area between Rizal and Quezon. The project involves the construction of a dam and transbasin tunnel to connect the Kaliwa reservoir (Laiban dam) to the Marikina reservoir for the purpose of augmentation the safe yield in the

Marikina reservoir for water supply. The estimated reservoir yield of the Laiban dam is 22.1 m^3/s.

(2) Water supply projects

Major water supply projects are planned or implemented by the Metropolitan Waterworks and Sewerage System (MWSS). They are listed in Table D.4. List of local water supply projects undertaken by the Local Water Utility Administration (LWUA) is given in Table D.5. There are 860 Level I/II water supply projects proposed by the DPWH Region IV-A office for the province of Quezon as listed in Table D.6.

(3) Flood control and drainage project

Parañaque spillway

This is a proposed artificial channel about 9 km long. This will cut the narrow neck of land between Laguna Lake and Manila Bay as an additional outlet for excess water in Laguna Lake.

Pasig river walls

This project will confine excess flood flows within the channel of the rivers. There is actually a proposal to raise the existing walls to transport higher flood flows in the Pasig river.

In addition, many flood control projects have been identified by DPWH regional offices of the CALABARZON provinces.

D.3 Water Resources Potential and Prospects

D.3.1 Surface water potential

Preliminary evaluation of surface water potential has been carried out on the basis of the mean annual rainfall and runoff maps and observed annual rainfall and stream discharge (Figures D.4 and D.7). Runoff ratios at existing stream gauging stations are calculated using annual basin rainfall and observed discharge data. The runoff ratio by each river is presented in Table D.1. Annual runoff depth in some sub-basins, where stream gauging station is not installed, is estimated using the above runoff ratio and annual basin rainfall, and the estimated runoff depth is compared with the annual runoff map. Results indicate that the map reflects the annual rainfall and the runoff ratio and approximately represents the runoff condition of the basins.

Estimated annual runoff depth and runoff volume are provided in Table D.7.

(1) Laguna Lake basins

The Marikina river basin is the largest sub-basin of the Laguna Lake basins. The runoff ratio is among the highest and the specific discharge is relatively high. Thus the annual runoff is estimated to be over 1,000 million m^3, equivalent to the runoff depth of over 1,700 mm.

The Balanac and Sta. Cruz river basins are located in the highest rainfall intensity area in the Laguna lake basins and the runoff ratio is relatively high. The annual runoff depth is about 1,500 mm. The San Antonio river basin has relatively high runoff coefficient and annual runoff volume. The runoff depth is between 1,400 and 1,500 mm.

Other basins have either small catchment area or low runoff ratios, and thus are considered of low potential. The annual runoff depth varies from less than 1,300 mm in the southern part of Laguna de Bay up to 1,600 mm in the high rainfall area in the northern and the eastern part of the lake.

(2) Taal Lake basins

The Taal lake basins have generally smaller runoff depth than the Laguna Lake basins ranging between 1,000 and 1,400 mm. The Maragondon river basin has relatively high runoff ratio and runoff depth in the range of 1,300-1,400 mm. The Kumpang river basin has the largest area and total annual runoff volume of some 800 million m^3, although its runoff depth is relatively small at 1,200 mm.

Other river basins having relatively high potential are the Rosario, Bolbok and Bayan river basins in the eastern part of Batangas and the Lian and Molino river basins in the western part of Batangas. The Pansipit river draining the Taal Lake basin has low runoff ratio estimated at 0.35 and small runoff depth below 1,000 mm, but its discharge is stable throughout a year due to regulating effects of Taal Lake. The northern part of Cavite is drained by many small rivers having low runoff ratios. Surface water potential in this area is generally low with small runoff depth.

(3) Quezon basins

The Quezon basins have generally larger runoff depth than the Laguna Lake basins, ranging between 1,300 and over 1,800 mm. The Agos river basin in the northern most part has the largest catchment area and large runoff depth over 1,500 mm. Rivers draining the central part also have large runoff depth but their catchment areas are small. Rivers in other parts of the Quezon basins are mostly short, have small catchment area, and their runoff depth is generally in the range of 1,400 - 1,500 mm.

D.3.2 Groundwater potential

(1) Classification of aquifers

For planning purposes, the Region is divided into the following groundwater categories from the aspect of aquifer depth. Shallow well area is where wells with depth not greater than 20m are recommended and the static water levels are generally within 6m below ground water surface (mbgs). Deep well area is where wells with depth greater than 20m are recommended and the static water levels usually exceed 6 mbgs. Difficult area is where groundwater depth varies considerably and about 25% of such area may yield non-productive boreholes.

Shallow well areas generally consist of recent formation with slope raging from 0 to 3%. Most of these areas are located at elevation within 50m above mean sea level, like alluvial and coastal plains and river valleys. Shallow wells are less susceptible to saltwater intrusion compared to deep wells with the same discharge and location. Although shallow wells can easily be made safe from bacteriological pollution, they may not be resistant to the effect of fertilizer and pesticides, particularly those close to rice fields.

Deep well areas are generally of sedimentary formations, 90% of which are water carriers. These are usually located in areas of slope reaching up to 10%, usually at elevation of more than 50 m above the mean sea level. The possibilities of finding successful shallow wells are slim since the aquifer or water-bearing formation is found at the layer greater than 20 mbgs. The water from deep wells is, in general, of good quality except the water from aquifer in limestone formations where calcium carbonates are the major constituents.

Difficult areas have varying slope, elevation and water depth. The water supply source to the aquifer is mainly replenished by way of sheared rock, that is, through fissures, cracks and crevices. The basic grain of the geologic formations in this category is so arranged and sized that only a negligible amount of water can move. This accounts for the high probability of non-productive boreholes. Springs are generally found in these difficult areas. The yield from springs may well be the only viable source in such areas, primarily in the mountainous part of the basins.

(2) Procedure of groundwater potential assessment

A "Rapid Assessment of Water Supply Source" for each province was conducted by the National Water Resources Board(NWRB). In this report, safe yield concept is adopted to assess groundwater potential, that is, groundwater is a part of the hydrologic cycle and a water resource replenished by rainfall.

The estimation of the potential maximum number of wells that can be developed in each town was based on safe yield and the average capacity of well for the different groundwater categories. Safe yield is estimated with the assumption that groundwater recharge is 10% of the annual rainfall in the area. Well capacities were determined from the average specific capacities of existing wells assuming a maximum drawdown of static water level to be 5 m.

(3) Laguna Lake basins

Distribution condition of three categories of groundwater area in the basin is shown in Figure D.8 and the general feature is as described in Section D.2. On the basis of the available data on existing wells in the basin, a summary water potential is provided in Table D.8 and statistics by province is summarized below.

Groundwater Data for Laguna Basins

	Rizal	Laguna
Total land area (km^2)	1,350	1,760
Number of wells (nos.)	187	398
shallow wells	57	48
deep wells	130	350
Well depth (m)	8 - 153	18 - 156
SWL (mbgs)	2.9 - 1.37	0.3 - 120.4
Specific capacity (lps/m)	0.21 - 1.37	0.40 - 5.29
Ave. actual capacity (lps)	0.59 - 4.25	0.53 - 1.95
Safe yield level (mcm/year)	230	440

Source: Rapid Assessment of Water Supply Source in 1982

High yielding areas are principally found in the flat land such as the area along the shore of Laguna de Bay and western part of Mt. Cristobal in the province of Laguna. In the province of Rizal, the area is very limited and low yielding area prevails on the most part of the province (Figure D.8).

(4) Taal Lake basins

A summary of ground water potential is provided in Table D.8 and statistics by province are summarized below.

Groundwater Data for Taal Basins

	Cavite	Batangas
Total land area (km^2)	1,290	2,390
Number of wells (nos.)	410	1,140
shallow wells	10	101
deep wells	400	1,039
Well depth (m)	13 - 234	4 - 260
SWL (mbgs)	1.3 - 42.4	7.1 - 65.9
Specific capacity (lps/m)	0.19 - 1.98	0.21 - 1.35
Ave. actual capacity (lps)	-	0.32 - 3.47
Safe yield level (mcm/year)	265	470

Source: Rapid Assessment of Water Supply Source in 1982

As shown, major high yielding areas are found in the flat land extending from Trece Martires to the coastal area along Manila Bay, from Batangas City to the southern shoreland of Taal Lake, the coastal area along Balayan Bay and from Rosario to San Juan in the eastern end of the province of Batangas (Figure D.8).

Groundwater potential in the Quezon basins is given in Table D.8 and summarized below.

Groundwater Data for Quezon Basins

Total land area (km^2)	10,106
Number of wells (nos.)	584
shallow wells	-
deep wells	-
Well depth (m)	7 - 50
SWL (mbgs)	0.6 - 17.2
Specific capacity (lps/m)	0.11 - 2.07
Ave. actual capacity (lps)	-
Safe yield level (mcm/year)	-

High yielding areas are found in the central part of the Quezon basins. The average specific capacity is high in the western central part such as in Candelaria, Mauban, Sariaya and Tiaong, but wells in these areas tend to be deep. The average specific capacity is high also in lowlands of Infanta, Real, Agdangan and istands of Alabat and Patnanungan.

D.4 Water Resources Development Plan

D.4.1 Objectives for water resources development

(1) National goals

According to the Water Resources Policies of the Philippines prepared by NWRB, all development activities of the Government in respect to water and related land resources are pursued in accordance with the Philippine Development Plan and the pertinent provision of the Water Code.

The current Philippine Development Plan (1988-1992) outlines the national targets and strategies in attaining an improved quality of life for every Filipino. It indicates a continuing effort to provide for the basic needs of the majority of the population and to promote their economic and social well-beings.

Among the various development goals of the Country, the followings are related to the water resources sector.

a. improvement of the living standards of the poor
b. attainment of self-sufficieny in food
c. greater self-reliance in energy
d. proper management of the environment
e. accelerated development of lagging regions

As described above, the water sector is closely linked with the basic human needs and further renders a basic service to the growth of the Country. Therefore the goals of development in CALABARZON region should also follow the national goals.

(2) Sector objective

According to the Water Supply, Sewerage and Sanitation Master Plan of the Philippines(1988-2000), the objective of the sector is to provide reliable and safe water supply that is easily accessible to the majority of the households within the shortest time practicable in a cost effective manner.

The population coverage of the present water supply system in CALABARZON is considerably low especially in rural areas except for some municipalities. In terms of the percentage of population coverage, major part of present demand is covered by another such sources as private well, water vendors and dubious sources both in the water quality and quantity.

Therefore, to provide reliable and safe water through public service can be adopted as the development objective also for the CALABARZON region. Attainment of this objective contributes to the the creation of a better human environment, that is, to the enhancement of living conditions of people and the protection of public health through pollution abatement and control of water-borne diseases. It would be expected that the attainment contributes to the raising of living standard, particularly in rural areas.

D.4.2 Strategy for water resources development in CALABARZON

(1) Characteristics of water resources in CALABARZON

Water resources potential evaluated for both surface water and groundwater is summarized in Figure D.13. The CALABARZON region is relatively rich in water resources in terms of total endowments. However, their seasonal variations are large, and geographic distribution is biased. There are extensive areas where extended dry periods are observed every year. Most river basins in CALABARZON are small with limited impoundment areas and capacity.

Groundwater availability is relatively high, but most promising groundwater reserves are confined largely to fluvial lowlands along the lakeshore of Laguna de Bay and limited areas along the coasts.

Another notable characteristic is the existence of much utilized Laguna de Bay and largely unutilized Taal Lake. Particularly, Laguna de Bay and its catchment area represent vulnerable water and related land environment. Lands in CALABARZON are extensively covered by volcanic ashes to make them vulnerable to erosion. The Marikina river basin is also susceptible to erosion due to its topography, soil conditions and lack of sufficient vegetation covers.

(2) *Strategy for water resources development*

As outlined above, water resources in CALABARZON are relatively rich but their distribution varies highly both seasonally and spatially. CALABARZON is characterized also by vulnerable water and related land environment. Therefore, water resources development and management are critically important for the CALABARZON regional development.

Water supply

Water supply for various uses is vitally important for the livelihood of people and economic development. Sources of water for different uses will not basically change in the future. For domestic drinking water, local sources such as springs and streams should be utilized as much as possible except in the suburbanization area of Metro Manila. For irrigation water, various sources should be combined to meet the requirements in particular localities, such as local rivers, groundwater, small water impoundments, springs, groundwater and lake water. Industrial water will continue to depend primarily on groundwater except in the MWSS area.

The following strategy for municipal water supply, due to NWRB, seems reasonable in CALABARZON.

1) The level of water supply (Level I, II, or III) shall be determined based on technical and financial considerations, needs of WD and RWSA, and their willingness and ability to share costs and responsibilities of construction and maintenance of waterworks.
2) New water supply projects shall be selected by the criteria of (1) community commitment, (2) inadequacy of existing water supply, (3) prevalence of water-related diseases, (4) development status and potential of the community, and (5) capital costs per capita.
3) Technology suitable for local needs, conditions and resources shall be selected.
4) The planning for new water supply systems in suburban areas shall be coordinated with the existing system of the urban areas.
5) A large scale new water supply system with individual house connections shall not be planned in principle, but instead upgrading or expansion of existing systems shall be planned.

Watershed management

In view of generally vulnerable water and related land environment, concepts of watershed management should be applied widely to water resources development and management in CALABARZON. Objectives of watershed management are (1) to minimize the erosion of productive top soil, (2) to minimize the discharge of organic and non-organic wastes into the ambient environment, and (3) to enhance the water retaining and productive capacities of the land.

General measures for watershed management include not only structural measures to store flood water for subsequent use or to arrest sand for erosion control but also the following.

1) Improvement of farming practices such as deep ploughing, terracing on slopes, buffer strip cropping and mulching as well as controlled application of irrigation water, fertilizer and pesticides,
2) Allocation of sufficient cultivation area to perennial crops and other crops of better land surface coverage and soil enriching characteristics,
3) On-farm tree planting,
4) Pasture management,
5) Promotion of controlled grazing, and
6) Afforestation.

Applicability of these measures differs depending on particular areas such as the Marikina watershed, the Laguna basin, upland areas in Cavite and Batangas, and mountainous areas in Quezon. Important factors affecting the applicability are rainfall patterns (both spatial and temporal), land use, vegetation cover, soil characteristics and topography (slope gradient and slope length). Appropriate measures should be selected for each area, taking account of these factors.

Water resources development

Opportunities to develop water resources in substantial scale are quite limited in CALABARZON. Development of surface water generally involves large capital costs and long lead time.

In order to utilize limited opportunities to the maximum, multi-purpose development should be pursued as long as relevant. Watershed management should be an important consideration in such development, but effective development of water resources in limited areas would contribute to this objective as well.

Industrialization in CALABARZON will depend more on groundwater development. As more industries locate in larger areas, availability of groundwater will become a critical factor for successful industrialization. Over-extraction of groundwater will cause serious problems such as exhaustion of the source, deterioration of water quality and land subsidence. As reliable and comprehensive data are lacking on groundwater resources in CALABARZON, a comprehensive groundwater survey should be undertaken in the nearest future.

D.4.3 Water supply plan

For the planning of water supply projects most suitable for specific local conditions, further data collection and study will be necessary; that is, not only the future water demand but also the present water supply condition of the project areas, local socio-economic and financial conditions, and availability of local water source should be examined. On the basis of the results of such a study, supply target in terms of the supply coverage, unit water consumption and facility type should be planned.

Supply target as a general guideline for the entire CALABARZON region, conceivable supply measures, criterai for project identification and priority project area are presented below.

(1) Supply target

According to the Water Supply, Sewerage and Sanitation Plan of the Philippines (1988-2000), the Government intends to raise water supply coverage in the rural area to about 92% and in the urban area to about 77% by the end of 1992. In more specific terms, the following target for the development of water supply shall be pursued by the concerned agencies during a two-stage implementation period.

Physical Target and Service Coverage

	Year			
	1988 - 1992		1993 - 2000	
	Urban	Rural	Urban	Rural
Supply Coverage (%)	77	92	95	93
Facility				
Level I (nos.)	–	88,320 (12,620)	-	13,340 (31,000)
Level II/III (nos.)	476 (250)	526	654 (350)	794

* Number in parenthesis show the number of facilities of which the repair/rehabilitation is planned.

The service coverage in the entire CALABARZON region as of 1987 is estimated at 64%. In order to achieve the target by 1992 set above, a large number of wells and/or distribution systems have to be constructed and operated in a short period, and prior to the implementation, a study at feasibility level including an investigation for local groundwater potential would be needed to evaluate the existence of reliable water sources.

Considering also the financial condition of the Government, the target for service coverage presented below is applied to the water supply plan in the CALABARZON region.

Target for CALABARZON Region

Category	Existing		Target Year	
	1987	1995	2000	2010
Urban area	55%	77%	95%	100%
Rural area	62%	92%	93%	100%

(2) Supply measures and water source

Water supply coverage at different levels will be as follows.

Level I(point source)

A protected well with hand pump or developed springs with an outlet but without a distribution system is generally adaptable for rural areas where the houses are sparsely scattered.

A level I facility normally serves around 15 to 25 households and it must not be more that 250 m a way from the farthest user. The yield or discharge is generally 40 to 150 liters per minute.

Level II(communal faucet system or stand posts)

A system is composed of a source, a storage facility(water tank), electric or diesel pump, a simple distribution network and communal faucets, located at not more than 25 m from the farthest house. The system is designed to deliver about 40 to 80 liters of water per capita per day to an average of 100 households, with one faucet per 4 to 6 households. It is suitable generally for rural and urban fringe areas where houses are clustered densely to justify a simple piped system.

Level III(waterworks system on individual house connections)

A system consists of a source, a reservoir, a piped distribution network and household taps. It is generally suited for densely populated urban areas. Features of the above three levels of water supply measures are summarized in Table D.9.

In the formulation of the development plan, the following measures or the combination would be conceived and the most appropriate measure for the local condition would be selected.

Type of Water Supply Measure

I.	Construction of Level I	
II.	System upgrading	
	a.	Level I to Level II
	b.	Level I to Level III
	c.	Level II to Level III
III.	System expansion	
	a.	Level II
	b.	Level III

Water sources

For almost all the existing piped systems, groundwater is utilized as the water source. It may be necessary to examine the possibility of surface water source considering the groundwater potential or the scale of supply system to be newly developed. In case of the development of surface water for drinking purpose, the cost for purification facility as well as water transmission and distribution should be examined in order to provide reliable quality water.

Considering that a large capital cost is required for the surface water development and the construction of supply system, water supply plans utilizing surface water sources should cover a larger area including several municipalities or cities.

(3) Criteria for project identification

Adequacy of water supply level

The development of water supply should follow urgency based on the health and sanitation needs. Appropriate level of water service to be adopted should be determined considering such factors as shown below.

(a) population and population density
(b) type and availability of water source
(c) socio-economic factors such as living condition in the area and financial capacity

Priority of project site

The factors to be considered in determining priority in project selection are presented below.

(a) Community needs

Priority is given to communities with inadequate water supply services from the aspects of water quality, quantity, reliability and accessibility. Communities with serious problem of water borne or related diseases and/or depressed areas usually require urgent upgrading of water supply facilities.

(b) Community involvement

The most important problems associated with water supply are operation and maintenance. Community involvement may be measured in terms of readiness by members to form a Rural Waterworks and Sanitation Association. This is also indicated by the willingness to provide local equity in the form of contribution to the capital for system construction, operation and maintenance.

(c) Present development status of the community

Priority will be given to less developed areas to upgrade their living conditions, and also to areas where residents are more capable and willing to pay for the appropriate water service.

(d) Economic potential of the community

Communities with high economic potential should be provided with basic amenities to induce productive activities for sustained economic growth and development. Water supply project areas with relatively strong economic potential should be given the priority.

(e) Capital cost

The upgrading of the water supply system in the entire Country requires large investments. Priority, therefore, should be given to projects which entail a low capital cost per capita for a given level of service.

D.4.4 Multi-purpose water resource development and management projects

Under the strategy described above and in line with the CALABARZON Master Plan,the following projects are vital for the overall development of the Region.

(1) *Taal Lake multi-purpose water resource development project*

This project is to develop alternative water supply sources for the eastern and the southern parts of Taal Lake which are expected to be rapidly transformed into urban/industrial/commercial areas.

Intended water use is primarily for municipal and industrial water supply, but the possibility of irrigation water use will also be examined. Alternative water sources include not only Taal Lake itself but also the Kalumpang river having the largest catchment area in the Taal Lake basins. A careful study should be undertaken first, including risk analysis of the volcanic activity of Taal.

(2) Marikina watershed development and management

This project will be a comprehensive package of measures to be taken to protect and enhance the Marikina watershed. It may also cover the Pililla - Tanay and the Talim island areas of the Laguna Lake watershed. It will start with reforestation of selected areas, but more positive measures will be formulated at the same time for subsequent implementation. Opportunities for productive activities will be provided to prevent illicit logging and shift cultivation activities in such a way that will not cause soil erosion and other environmental problems. Agro-forestry and production of high value-added crops with on-farm tree planting and other proper farming practices will be promoted. The on-going integrated social forestry program will be effectively utilized to complement this project.

(3) CALABARZON groundwater potential study

This study will provide a comprehensive survey of groundwater reserves in CALABARZON and quantitative evaluation of their yields. Future industrialization of CALABARZON will depend critically on groundwater availability. This study will generate data essential for rational industrial location, avoiding over-exploitation of groundwater and associated problems.

(4) Other water resources development projects

Other water resources development projects for further investigation include the Kaliwa/Kanan rivers diversion and the Umiray - Angat transbasin project. Also, the management of the Laguna Lake is of vital importance for the CALABARZON regional development (Appendix J : Environment).

D.4.5 Institutional measures

(1) Coordination of water-related activities

Wide application of concepts of watershed management and multi-purpose development, as advocated above, will call for improvement or reinforcement of the coordination system for water resources development and management. In addition to the agencies described in subsection 5.1.1, other agencies will be more actively involved such as DENR, DA, DAR, LLDA and DTI.

NWRB is the body responsible for coordinating and integrating all activities related to water resources development and management. Its prime objective is to achieve a scientific and orderly development and management of all water resources. To realize this objective, the status and membership of NWRB may be reviewed. Policy initiative can be achieved by NWRB through the direction of main thrusts of its operational program given to water-related implementing agencies for program formulation, project evaluation and coordination. To thresh out specific problems, NWRB should effectively utilize task forces or technical committees to consult with related agencies. This "botton-up" mechanism will be more important to address to specific problems in specific localities.

(2) Basic data collection

NWRB has initiated the establishment of a national water resources data system for the purpose of systematically improving collection, storage and dissemination of water resources data. The data cover meteoro-hydrology, groundwater, existing conditions of water resources development, inventory of water-related facilities and their use and production record. These data are useful not only for planning water resources development but also for monitoring the effects of such development. Clarification of specific uses will help in developing a more efficient system. The envisioned Laguna basins environmental monitoring system should link to this system effectively to allow easy access.

(3) Manpower development

MWSS, LWUA and DPWH have their own training programs, and courses and seminars on systems management, administration, technical aspects and other subjects are provided to project personnel and beneficiaries. RWSA gives orientation about RWSA's roles, importance of rural sanitation and responsibilities of people in related communities. These programs should be extended further to make people more conscious about their responsibilities as well as to provide basic technical information.

(4) Water use regulation

Water use regulation is effected by NWRB through administrative concession or water permit system. These functions of NWRB involve generally:

1) approval, modification or denial of water permit applications for diverting and using surface water or groundwater,
2) resolution of conflicts in water use, and
3) prescription of rules and regulations governing water use, conservation and protection.

These water right functions are the most established activity of NWRB. For groundwater development, a monitoring system for production volume and regulations to control total extraction should be established to avoid problems due to over-exploitation.

Tables

Table D.1 Information of Main Rivers in the Study Area

River	Station Code	Catchment Area (sq.km)	Annual Ave. Discharge (cub.m/s)	Specific Discharge (cub.m/s/sq.km)	Annual Runoff (mcm/yr.)	Runoff Depth (mm)	Runoff Ratio
I. Laguna Lake basins							
1. Marikina river (Sto.nino)	407	499	30.31	0.06	958.2	1,920	0.89
2. Marikina river (San Rafael)	409	282	16.60	0.06	525.6	1,864	0.86
3. Arangilan river (San Cristobal R.)	413	87	0.64	0.01	20.1	232	0.13
4. Mabacan river (Bay R.)	415	46	1.21	0.03	38.3	833	0.38
5. Paputok river (Prinza R.)	416	8.5	0.95	0.11	29.9	3,522	-
6. Sta. Cruz river	417	103	4.74	0.05	149.6	1,453	0.63
7. Balanac river (upper)	418	116	8.72	0.08	275.2	2,373	0.82
8. Mayor river (Romero R.)	421	45	1.64	0.04	51.9	1,153	0.52
II. Taal Lake basins							
1. Ilang-ilang river	422	60	0.83	0.01	26.2	437	0.22
2. Panaysayan river (Rio Grande)	423	29	1.00	0.03	31.8	1,095	0.54
3. Balsahan river	424	22	1.35	0.06	42.9	1,949	-
4. Maragondon river	425	260	21.73	0.08	689.0	2,650	-
5. Palico river (Lian R.)	426	158	7.35	0.05	232.9	1,474	0.67
6. Molino river (Obispo R.)	427	51	2.07	0.04	65.5	1,284	0.61
7. Dacanlao river	428	40	2.22	0.06	70.1	1,753	0.84
8. Pansipit river	429	644	13.99	0.02	441.7	686	0.34
III. Quezon basins							
1. Agos river (Banugao, Infanta)	430	879	117.14	0.13	3,742.3	4,257.5	-
2. Maapon river (Sampaloc, Sampaloc)	431	88	5.78	0.07	182.3	2,071.5	0.91
3. Ibia river (Ayaas, Tayabas.)	432	15	1.80	0.12	56.9	3,790.8	-
4. Dumaca-A river (Alsam, Ayaas, Tayabas)	433	54	6.36	0.12	200.8	3,719.3	-
5. Dumaca-A river (Lakawan, Tayabas)	434	74	10.52	0.14	211.5	2,857.6	-
6. Morong river (Morong, Sariaya)	435	12	0.67	0.06	21.2	1,764.3	0.78
7. Sariaya river (Tumbaga, Sariaya)	436	6	0.28	0.06	8.9	1,485.9	0.66
8. Hibanga river (Mamala, Sariaya)	437	5	0.18	0.04	5.6	1,114.9	0.49
9. Lagnas river (Lagalag, Tiaong)	438	54	0.84	0.02	25.4	470.1	0.20
10. Bulakin river (Bulakin, Tiaong)	439	10.5	1.15	0.11	36.3	3,454.0	-

Table D.2 Present Domestic Water Demand (1/4)

(Province of Cavite)

No. Municipality	Population	Level I				Level II				Level III				Other Sources			Total	Total
		Well/ spring (nos.)	Popu. served	Service ratio (%)	Water demand (cm/yr.)	well/ spring (nos.)	Popu. served	Service ratio (%)	Water demand (cm/yr.)	well/ spring (nos.)	Popu. served	Service ratio (%)	Water demand (cm/yr.)	Popu. served	Service ratio (%)	Water demand (cm/yr.)	Water Demand (cm/yr.)	Service Ratio (%)
1. Alfonso	26,771	33	7,212	26.9	78,971	19	12,371	46.2	270,925	1	5,939	22.2	227,612	1,249	4.7	13,677	591,185	100.0
2. Amadeo	19,300	11	3,482	18.0	38,128	19	11,400	59.1	249,660	1	3,914	20.3	150,004	504	2.6	5,519	443,311	100.0
3. Bacoor	125,181	86	85,729	68.5	938,733					1	2,935	2.3	112,484	36,517	29.2	399,861	1,451,078	100.0
4. Carmona	87,291	0	18,106	20.7	198,261									69,185	79.3	757,576	955,836	100.0
5. Cavite City	97,529	44 **	12,529	12.8	137,193					9	85,000	87.2	3,257,625	0	0.0	0	3,394,818	100.0
6. Dasmarinas	70,869	50	26,599	37.5	291,259					5	21,000	29.6	804,825	23,270	32.8	254,807	1,350,891	100.0
7. Gen.E.Aguinaldo	10,791	15	4,518	41.9	49,472	1	425	3.9	9,308					5,848	54.2	64,036	122,815	100.0
8. Gen.M.Alvares		1 *	100		1,095					9	50,676		1,942,158				1,943,253	
9. Gen.Trias	50,669	868	46,356	91.5	507,598	1	3,711	7.3	81,271					602	1.2	6,592	595,461	100.0
10. Imus	74,659	172	74,659	100.0	817,516									0	0.0	0	817,516	100.0
11. Indang	37,747	27	3,761	10.0	41,183	19	13,838	36.7	303,052	1 *	5,072	13.4	194,384	15,076	39.9	165,082	703,702	100.0
12. Kawit	49,246	2,385	49,246	100.0	539,244									0	0.0	0	539,244	100.0
13. Magallanes	11,080	8	10,067	90.9	110,234									1,013	9.1	11,092	121,326	100.0
14. Maragondon	22,802	94	19,783	86.8	216,624									3,019	13.2	33,058	249,682	100.0
15. Mendez	17,438	10	3,915	22.5	42,869	2	7,251	41.6	158,797	2	2,283	13.1	87,496	3,989	22.9	43,680	332,842	100.0
16. Naic	46,909	114	25,915	55.2	283,769									20,994	44.8	229,884	513,654	100.0
17. Noveleta	17,751	509	17,751	100.0	194,373									0	0.0	0	194,373	100.0
18. Rosario	42,481	123	37,209	87.6	407,439									5,272	12.4	57,728	465,167	100.0
19. Silang	66,421	28	10,095	15.2	110,540	19	23,868	35.9	522,709	3 *	15,750	23.7	603,619	16,708	25.2	182,953	1,419,821	100.0
20. Tagaytay City	20,761	1 **	400	1.9	4,380	1 *	600	2.9	13,140	2	11,076	53.4	424,488	8,685	41.8	95,101	537,108	100.0
21. Tanza	55,057	536	35,776	65.0	391,747									19,281	35.0	211,127	602,874	100.0
22. Ternate	14,046	20 *	2,050	14.6	22,448	1 *	653	4.6	14,301					11,343	80.8	124,206	160,954	100.0
23. Trece Martires	10,579	7 **	2,550	24.1	27,923	8	4,257	40.2	93,228	1	3,600	34.0	137,970	172	1.6	1,883	261,004	100.0
Total	975,378	5,142	497,808	49.6	5,450,998	90	78,374	27.8	1,716,391	35	207,245	29.9	7,942,665	242,727	24.1	2,657,861	17,767,913	

Note :
water demand/capita/day : 0.03 litre for Level I and other sources
0.06 litre for Level II
0.105 litre for Level III
Level II : It delivers water to an average of 100 households in rural area per system.
Average family member is 6 persons.
Estimation of water use is executed on the basis of data in 1987.

* : data as of 1989 year
** : data as of 1980 year

Table D.2 Present Domestic Water Demand (2/4)

(Province of Laguna)

No.	Municipality	Population	Level I Well/ spring (nos.)	Level I Popu. served	Level I Service ratio (%)	Level I Water demand (cm/yr.)	Level II Well/ spring (nos.)	Level II Popu. served	Level II Service ratio (%)	Level II Water demand (cm/yr.)	Level III Well/ spring (nos.)	Level III Popu. served	Level III Service ratio (%)	Level III Water demand (cm/yr.)	Level III Surface water (nos.)	Level III Popu. served	Level III Service ratio (%)	Level III Water demand (cm/yr.)	Other Sources Popu. served	Other Sources Service ratio (%)	Other Sources Water demand (cm/yr.)	Total Water Demand (cm/yr.)	Total Service Ratio (%)
1	Alaminos	23,685	65	6,500	27	71,175	6	5,134	22	112,435	1	8,816	37	337,873					3,235	14	35,423	556,906	100
2	Bay	27,511	14	1,400	5	15,330					1	14,800	54	567,210					11,311	41	123,855	706,395	100
3	Binan	101,402	240 *	24,000	24	262,800					2	16,930	17	648,842					60,472	60	662,168	1,573,811	100
4	Cabuyao	57,265	495	49,500	86	542,025						5,820	10	223,052					1,945	3	21,298	786,374	100
5	Calamba	150,330	445 *	44,500	30	487,275	4	3,576	2	78,314	1	36,500	24	1,398,863					65,754	44	720,006	2,684,458	100
6	Calauan	28,116	229	22,900	81	250,755	2	1,290	5	28,251	1 *	1,694	6	64,923					2,232	8	24,440	368,369	100
7	Cavinte	14,905	3	300	2	3,285	1	360	2	7,884	2	4,800	32	183,960					9,445	63	103,423	298,552	100
8	Famy	6,103	100 *	6,103	100	66,828													0	0	0	66,828	100
9	Calayaan	12,262	2	200	2	2,190					3	3,024	25	115,895					9,038	74	98,966	217,051	100
10	Liliw	19,441	21	2,100	11	22,995	1	690	4	15,111	3	12,480	64	478,296					4,171	21	45,672	562,074	100
11	Los Banos	59,804	171	13,400	22	146,730					5 *	46,404	78	1,778,433					0	0	0	1,925,163	100
12	Luisiana	13,516	0	0	0	0					2	4,504	33	172,616					9,012	67	98,681	271,297	100
13	Lumban	20,075	205 *	12,195	61	133,535	2	1,200	6	26,280	9	6,680	33	256,011					0	0	0	415,826	100
14	Mabitac	9,922	20 *	2,000	20	21,900													7,922	80	86,746	108,646	100
15	Magdalena	12,103	3	300	2	3,285					2	5,056	42	193,771					6,747	56	73,880	270,936	100
16	Majayjay	14,968	1	100	1	1,095	1	654	4	14,323	1	7,888	53	302,308					6,326	42	69,270	386,995	100
17	Nagcarlan	34,979	64	6,400	18	70,080	1	1,530	4	33,507	1	12,160	35	466,032					14,889	43	163,035	732,654	100
18	Paete	18,584	53 *	5,300	29	58,035					7	10,600	57	406,245					2,684	14	29,390	493,670	100
19	Pagsanjan	23,217	6	600	3	6,570					1	11,496	50	440,584					11,121	48	121,775	568,929	100
20	Pakil	10,068	46 *	4,600	46	50,370	1	900	9	19,710	1	4,326	43	165,794					242	2	2,650	238,524	100
21	Pangil	12,514	59	5,900	47	64,605					5	4,000	32	153,300					2,614	21	28,623	246,528	100
22	Pila	24,165	5 *	500	2	5,475	1	600	2	13,140									23,065	95	252,562	271,177	100
23	Rizal	7,543	20	1,215	16	13,304					1	6,328	84	242,521					0	0	0	255,825	100
24	San Pablo C.	150,118	15 **	1,500	1	16,425	2	1,300	1	28,470	1 *	116,410	78	4,461,413					30,908	21	338,443	4,844,751	100
25	San Pedro	106,904	5	500	0	5,475					1 *	7,637	7	292,688					98,767	92	1,081,499	1,379,662	100
26	Sta.Cruz	71,184	101 **	10,100	14	110,595					1 *	10,524	15	403,332	1	24,700	35	946,628	25,860	36	283,167	1,743,722	100
27	Sta.Maria	17,668	73	7,300	41	79,935	6	1,830	10	40,077	2	5,600	32	214,620					2,938	17	32,171	366,803	100
28	Sta.Rosa	77,542	628	62,800	81	687,660	1	600	1	13,140		10,810	14	414,293					3,332	4	36,485	1,151,579	100
29	Siniloan	20,512	77	7,700	38	84,315	1	684	3	14,980	1	5,600	27	214,620					6,528	32	71,482	385,396	100
30	Victoria	19,519	263	19,519	100	213,733					1								0	0	0	213,733	100
	Total	1,165,925	3,429	319,432	30	3,497,780	30	20,348	5	445,621	56	380,887	38	14,597,494	1	24,700		946,628	420,558	33	4,605,110	24,092,633	

Note :

water demand/capita/day : 0.03 litre for Level I and other sources
0.06 litre for Level II
0.105 litre for Level III

Level II : It delivers water to an average of 100 households in rural area per system.
Average family member is 6 persons.

Estimation of water use is executed on the basis of data in 1987.

* : data as of 1989 year
** : data as of 1980 year

Table D.2 Present Domestic Water Demand (3/4)
(Province of Batangas)

No. Municipality	Population	Level I Well/ spring (nos.)	Level I Popu. served	Level I Service ratio (%)	Level I Supply vol. (cm/yr.)	Level II well/ spring (nos.)	Level II Popu. served	Level II Service ratio (%)	Level II Supply vol. (cm/yr.)	Level III well/ spring (nos.)	Level III Popu. served	Level III Service ratio (%)	Level III Supply vol. (cm/yr.)	Other Sources Popu. served	Other Sources Service ratio (%)	Other Sources Supply vol. (cm/yr.)	Total Water Demand (cm/yr.)	Total Service Ratio (%)
1. Agoncillo	19,025	104	13,533	71.1	148,186	4	4,270	22.4	93,513	2	1222	6.4	46,833	0	0.0	0	288,533	100.0
2. Alitagtag	17,364	18	3,809	21.9	41,709	30	13,555	78.1	296,855					0	0.0	0	338,563	100.0
3. Balayan	50,727	29	12,641	24.9	138,419									38,086	75.1	417,042	555,461	100.0
4. Balete	9,661	99	7,858	81.3	86,045	1	1,803	18.7	39,486					0	0.0	0	125,531	100.0
5. Batangas City	168,891	806	42,537	25.2	465,780	30	19,338	11.4	423,502	1	40,000	23.7	1,533,000	67,016	39.7	733,825	3,156,108	100.0
6. Bauan	50,878	70	39,878	78.4	436,664					1	11,000	21.6	421,575	0	0.0	0	858,239	100.0
7. Calaca	43,256	46	17,021	39.3	186,380	3	600	1.4	13,140					25,635	59.3	280,703	480,223	100.0
8. Calatagan	32,849	29	28,746	87.5	314,769	2	3,583	10.9	78,468					520	1.6	5,694	398,930	100.0
9. Cuenca	19,593	17	12,612	64.4	138,101	1	4,712	24.0	103,193	3	2,269	11.6	86,959	0	0.0	0	328,254	100.0
10. Ibaan	29,908	32	10,068	33.7	110,245	24	5,933	19.8	129,933	1	2,781	9.3	106,582	11,126	37.2	121,830	468,589	100.0
11. Laurel	21,820	8 *	800	3.7	8,760	3	3,118	14.3	68,284	1	1,766	8.1	67,682	16,136	74.0	176,689	321,415	100.0
12. Lemery	50,019	66	21,004	42.0	229,994	7	5,054	10.1	110,683	1	4,120	8.2	157,899	19,841	39.7	217,259	715,834	100.0
13. Lian	30,135	14	23,335	77.4	255,518					1	6,800	22.6	260,610	0	0.0	0	516,128	100.0
14. Lipa City	142,016	492	50,002	35.2	547,522	47	18,688	13.2	409,267	2 *	73,326	51.6	2,810,219	0	0.0	0	3,767,008	100.0
15. Lobo	27,777	78	7,847	28.2	85,925									19,930	71.8	218,234	304,158	100.0
16. Mabini	27,474	224	3,959	14.4	43,351	1	647	2.4	14,169	5	4,373	15.9	167,595	18,495	67.3	202,520	427,636	100.0
17. Malvar	21,257	21	9,009	42.4	98,649	9	6,733	31.7	147,453	2	5,515	25.9	211,362	0	0.0	0	457,464	100.0
18. Mataas na Kahoy	13,919	18	8,364	60.1	91,586	1	1,200	8.6	26,280	2	2,184	15.7	83,702	2,171	15.6	23,772	225,340	100.0
19. Nasugbu	70,526	28	35,532	50.4	389,075	1	1,183	1.7	25,908	2	12,715	18.0	487,302	21,096	29.9	231,001	1,133,287	100.0
20. Padre Garcia	22,570	26	7,188	31.8	78,709	4	2,490	11.0	54,531	1	1,518	6.7	58,177	11,374	50.4	124,545	315,962	100.0
21. Rosario	63,612	61	41,992	66.0	459,812	1	1,451	2.3	31,777	1	2,136	3.4	81,862	18,033	28.3	197,461	770,913	100.0
22. San Jose	32,699	57	19,675	60.2	215,441	4	5,045	15.4	110,486					7,979	24.4	87,370	413,297	100.0
23. San Juan	68,540	28	26,305	38.4	288,040					1	7,800	11.4	298,935	34,435	50.2	377,063	964,038	100.0
24. San Luis	20,091	24	7,644	38.0	83,702	7	4,318	21.5	94,564	1	700	3.5	26,828	7,429	37.0	81,348	286,441	100.0
25. San Nicolas	12,585	7 *	700	5.6	7,665	1	960	7.6	21,024	1	108	0.9	4,139	10,817	86.0	118,446	151,274	100.0
26. San Pascual	30,905	8 *	800	2.6	8,760	9	9,146	29.6	200,297	1	1,154	3.7	44,227	19,805	64.1	216,865	470,149	100.0
27. Sta.Teresita	12,474	14	7,670	61.5	83,987	3	2,053	16.5	44,961					2,751	22.1	30,123	159,071	100.0
28. Sto.Tomas	50,780	65	22,020	43.4	241,119	9	16,871	33.2	369,475	1	11,889	23.4	455,646	0	0.0	0	1,066,240	100.0
29. Taal	33,607	38	17,848	53.1	195,436	3	14,404	42.9	315,448					1,355	4.0	14,837	525,720	100.0
30. Talisay	22,883	8 *	800	3.5	8,760	1	110	0.5	2,409					21,973	96.0	240,604	251,773	100.0
31. Tanauan	83,520	139	61,655	73.8	675,122	10	5,786	6.9	126,713	1	10,650	12.8	408,161	5,429	6.5	59,448	1,269,444	100.0
32. Taysan	22,547	30	10,423	46.2	114,132	10	12,124	53.8	265,516					0	0.0	0	379,647	100.0
33. Tingloy	15,431	5 *	500	3.2	5,475									14,931	96.8	163,494	168,969	100.0
34. Tuy	29,318	12 *	1,200	4.1	13,140	1	770	2.6	16,863	1	5,500	18.8	210,788	21,848	74.5	239,236	480,026	100.0
Total	1,368,657	2,721	574,975	41.6	6,295,976	227	165,945	18.3	3,634,196	33	209,526		8,030,084	418,211		4,579,410	22,539,666	

* data as of 1989 year

Note :
water demand/capita/day : 0.03 litre for Level I and other sources
0.06 litre for Level II
0.105 litre for Level III
Level II : It delivers water to an average of 100 households in rural area per system.
Average family member is 6 persons.
Estimation of water use is executed on the basis of data in 1987.

Table D.2 Present Domestic Water Demand (4/4)

(Province of Rizal)

No. Municipality /City	Population	Level I				Level II				Level III				Other Sources			Total	Total
		Well/ spring (nos.)	Popu. served	Service ratio (%)	Water demand (cm/yr.)	well/ spring (nos.)	Popu. served	Service ratio (%)	Water demand (cm/yr.)	well/ spring (nos.)	Popu. served	Service ratio (%)	Water demand (cm/yr.)	Popu. served	Service ratio (%)	Water demand (cm/yr.)	Water Demand (cm/yr.)	Service Ratio (%)
1. Angono	36.288	125	10.924	30.1	119.618	2	1.200	3.3	26.280					24.164	66.6	264.596	410.494	100.0
2. Antipolo	102,211	415	40.164	39.3	439,796					7	31.890	31.2	1,222,184	30,157	29.5	330.219	1,992,199	100.0
3. Baras	12.567	58	6.655	53.0	72.872					1	351	2.8	13.452	5.561	44.3	60.893	147.217	100.0
4. Binangonan	97.020	230	45.611	47.0	499.440	7 *	4.200	4.3	91.980	11	42.567	43.9	1,631,380	4.642	4.8	50.830	2.273.631	100.0
5. Cainta	91.940	56	33,537	36.5	367,230					2	10,354	11.3	396,817	48,049	52.3	526,137	1,290,184	100.0
6. Cardona	27.819	99	17.684	63.6	193,640	3	1,685	6.1	36.902	1	3.230	11.6	123,790	5,220	18.8	57,159	411,490	100.0
7. Jala-Jala	14.059	348	10.553	75.1	115.555	1	1,753	12.5	38.391	2	1.753	12.5	67,184	0	0.0	0	221.130	100.0
8. Montalban	52.070	6 *	250	0.5	2,738					1	21.871	42.0	838,206	29.949	57.5	327.942	1.168,885	100.0
9. Morong	28.368	39	10,615	37.4	116.234	5	5.071	17.9	111.055	2	11.300	39.8	433,073	1,382	4.9	15,133	675.495	100.0
10. Pililla	27,781	59	19,092	68.7	209,057	12	8,689	31.3	190.289					0	0.0	0	399.347	100.0
11. San Mateo	63.932	4 *	750	1.2	8.213					1	17.651	27.6	676,475	45.531	71.2	498,564	1,183,252	100.0
12. Tanay	46.961	108	18.284	38.9	200,210	6 *	3,600	7.7	78.840	6	14,605	31.1	559,737	10,472	22.3	114,668	953,455	100.0
13. Taytay	89,109	28	6,983	7.8	76,464					2	37,052	41.6	1,420,018	45,074	50.6	493.560	1,990,042	100.0
14. Teresa	17,567	105	14,526	82.7	159,060	2	594	3.4	13,009					2,447	13.9	26.795	198,863	100.0
Total	707.692	1680	235,628	41.6	2,580.127	38	26,792	10.8	586.745	36	192.624	26.8	7,382,315	252.648	31.2	2.766.496	13,315,682	
Metro Manila	8,167,000	1700	170.000	2.1	1,861,500		596,000	7.3	13,052,400	1	4,197,000	51.4	336,510,000	3,204,000	39.2	35,083,800	386,507,700	100.0

Note :

water demand/capita/day : 0.03 litre for Level I and other sources
0.06 litre for Level II
0.105 litre for Level III

Level II : : It delivers water to an average of 100 households in rural area per system.
Average family member is 6 persons.

Estimation of water use is executed on the basis of data in 1987.

* : data as of 1989 year

Table D.3 Irrigation Water Use (1/4)

Province: CAVITE

Municipality	1986 Irr. Water (Total) mcm/year	1987 Irr. Water (Total) mcm/year	1988 Irr. Water (Total) mcm/year	1989 Irr. Water (Total) mcm/year
CIS				
1. Ternate				
2. Lantic I	2.34	2.34	2.34	1.68
3. Lantic II	2.61	2.61	2.50	2.34
4. Carmona	1.33	1.33	1.33	2.50
5. San Juan Alvarez	0.40	0.40		1.33
6. Pinagsanjan	0.98	0.98		
Sub-Total	**7.66**	**7.66**	**6.17**	**7.85**
NIS				
1. Cavite FLIS	181.43	173.45	162.81	175.69
Grand Total	**189.09**	**181.11**	**168.98**	**183.54**

CIS : Communal Irrigation System
NIS : National Irrigation System

Table D.3 Irrigation Water Use (2/4)

Province: LAGUNA

Municipality	1985 Irr. Water (Total) mcm/year	1986 Irr. Water (Total) mcm/year	1987 Irr. Water (Total) mcm/year	1988 Irr. Water (Total) mcm/year	1989 Irr. Water (Total) mcm/year
CIS					
1. Calauan	28.82	24.60	12.75	16.73	24.60
2. Majayjay	11.27	11.80	0.47	10.59	10.95
3. Nagcarlan	2.18	2.53	0.71	2.64	1.97
4. Cavinti	1.91	1.86	0.36	1.54	1.82
5. Pangil	8.16	4.75	1.28	6.54	8.07
6. Famy	0.27	0.27	0.27	0.54	0.75
7. Bay	22.68	24.65	2.30	22.05	25.50
8. San Pablo	6.55	6.55	0.55	6.14	6.55
9. Liliw	4.12	3.45	0.40	2.89	3.56
10. Victoria	4.78	4.78	2.10	8.04	9.62
11. Rizal	1.01	1.06		1.29	1.41
12. Magdalena	2.56	2.56		3.30	3.30
13. Kalayaan	2.47	2.47		2.81	2.81
14. Mabitac	0.29	0.29		0.29	0.29
15. Paete	2.02	2.02		1.91	1.91
16. Pakil	4.56	4.54		4.20	4.20
17. Los Banos	1.70	1.70	1.70		
18. San Pedro	0.64	0.64		0.64	0.64
19. San Crispin	1.38	1.38		1.38	1.38
20. Lumban	1.38	0.16		2.85	2.85
21. Siniloan	10.61	10.99		10.64	11.52
22. Pagsanjan	0.54	0.90			
Sub-Total	**119.90**	**113.95**	**22.89**	**107.01**	**123.70**
NIS					
1. Cabuyao East Pump-Diezmo	70.26	69.98	71.80	71.34	74.57
2. Sta. Maria-Mayor	28.55	32.55	21.10	23.71	28.36
3. Sta. Cruz-Mabacan-Malaunod-Balanac-Lumban	107.30	93.94	94.90	89.66	115.64
Sub-total	**206.11**	**196.47**	**187.80**	**184.71**	**218.57**
Grand Total	**326.01**	**310.42**	**210.69**	**291.72**	**342.27**

CIS : Communal Irrigation System
NIS : National Irrigation System

Table D.3 Irrigation Water Use (3/4)

Province: BATANGAS

Municipality	1985 Irr. Water (Total) mcm/year	1986 Irr. Water (Total) mcm/year	1987 Irr. Water (Total) mcm/year	1988 Irr. Water (Total) mcm/year	1989 Irr. Water (Total) mcm/year
CIS					
1. Lobo	3.11	3.64	2.34	3.44	3.44
2. Rosario	4.76	7.91	4.67	6.65	6.72
3. Balayan	3.27	3.53	2.82	3.00	3.00
4. Laurel	4.33	5.41	5.82	3.03	3.22
5. San Juan		1.56	1.56	1.86	1.86
6. Lian	5.80	6.79	2.10	3.51	3.79
7. Calatagan	1.71	2.77	0.11	2.60	2.60
8. Ibaan	4.41	4.42	2.50	4.59	4.56
9. San Jose	0.35	0.35	0.27	0.27	0.27
10. Tanauan	0.37	0.37	0.37	0.37	0.37
11. San Pascual	0.13	0.13		0.19	0.19
12. Batangas City					
13. Bauan	2.34	2.11		4.07	4.07
14. Lipa	0.53	0.53		0.46	0.53
15. San Luis	0.53	0.53		0.17	0.17
16. Padre Garcia	4.56	4.26		4.56	4.56
Total	**36.2**	**44.31**	**22.56**	**38.77**	**39.35**
NIS					
1. Palico	21.86	4.26	0	4.56	4.56
Grand Total	**58.06**	**48.57**	**22.56**	**43.33**	**43.91**

CIS : Communal Irrigation System
NIS : National Irrigation System

Table D.3 Irrigation Water Use (4/4)

Province: RIZAL

Municipality	1985 Irr. Water (Total) mcm/year	1986 Irr. Water (Total) mcm/year	1987 Irr. Water (Total) mcm/year	1988 Irr. Water (Total) mcm/year	1989 Irr. Water (Total) mcm/year
CIS					
1. Teresa	5.37	5.34	1.52	5.22	5.22
2. Antipolo	7.37	6.71	3.39	4.58	6.08
3. Binangonan	1.25	1.30	0.44	1.25	1.25
4. Jala-Jala	7.21	6.33	2.58	6.34	6.34
5. Morong	6.32	5.13	1.07	8.38	8.38
6. Rodriguez	5.09	3.37	0.46	2.15	4.09
7. Pililla	4.66	4.43	1.61	3.03	3.03
8. Taytay	0.83	0.30	0.08	0.64	
9. Caniogan	0.80				
10. Baras	4.24	4.24		4.24	4.24
11. Tanay	9.70	12.60		11.22	11.22
12. San Mateo	0.46	0.34		0.34	0.34
Total	**53.3**	**50.09**	**11.15**	**47.39**	**50.19**

CIS : Communal Irrigation System

Table D.4 Summary of MWSS Water Supply Project

Project	Total Project Cost (M.P)	Vol. of Supply (ML/D)	Water Source
1. Rizal Province Water Supply Improvement Project (1990-2005)			
Stage I	486	43	G/W, L/L
Stage II	469	41	G/W
Stage III	259	57	G/W, L/L
2. Fringe Area Water Supply Project (1989-1993)	189	-	G/W
3. Manila South Water Supply Project			
Phase I (1990-1992)	1,056	-	L/L
Phase II (1992-1994)	850	-	L/L
4. Manila Water Supply Project III (2000-2006)	15,410		Kaliwa River
5. Water Supply for Montalban and San Mateo (1990-1994)	460	72	Wawa Dam
6. Taal Lake Water Works Development	2,340		Taal Lake

NOTE: G/W: Ground water
L/L : Laguna lake water

Table D.5 List of Local Water Supply Project (undertaken by LWUA)

Water District	Phase	FS	Design	Construction	Remarks
1. Tagaytay City	IA	1976	1978	1982	
2. Silang, Cavite	IA	1980	1982	1983	
3. Dasmarinas, Cavite	IA	1981	1982	1984	
	IIA		1987	1989	
4. Indang, Cavite	IA	1982	1983	1987	
5. Tanza, Cavite	POW	1989			Well drilling to start 1990 (2nd quarter
6. Bucal, Maragondon, Cavite	POW	1989			Well drilling to start January 1990
7. Anoling, Mendez, Cavite	POW	1989			
8. San Pablo, Laguna	IA	1973	1975	1978	
	IIA	1984	1988	0.18	Construction on-going
9. Calamba, Laguna	IA	1977	1979	1981	
	IIA	1990			FS on-going
10. Alaminos, Laguna	IA	1981	1982	1983	
11. Sta. Cruz, Laguna	IA	1982	1983	1988	
12. Pagsanjan, Laguna	IA	1983	1983		
13. Los Banos, Laguna	IA	1978	1979	1982	
	IIA	1990			FS on-going
14. Bay, Laguna	I	1986	1987	1988	UNDP Pilot on Low-Cost system
15. San Pedro, Laguna	IA	1985	1988		
16. Calauan, Laguna	IA	1986	suspended		For re-evaluation
17. Cabuyao-Binan, Laguna					
18. Sta. Rosa, Laguna	IA	1987			
19. Lipa City	IA	1976	1978	1982	
20. Batangas City	IA	1974	1976	1978	
21. San Juan, Batangas	IA	1981	1981		
22. Mabini, Batangas	IA	1981	suspended		Mini-loan implemented
23. Balayan, Batangas	IA	1981	1982	1987	
24. Rosario, Batangas	IA	1982	1983		
25. Lemery, Batangas	IA	1985	1985	0.85	
26. Nasugbu, Batangas	IA	1986	1989		
27. Tanay, Rizal	IA	1978	1981	1983	
28. Morong, Rizal	IA	1980	1982	1983	
Proposed Projects					
1. Silang, Cavite	FS				Phase II
2. Amadeo, Cavite	POW				
3. Gen. Mariano Alvarez	POW				
4. Siniloan, Laguna	POW				
5. Calauan, Laguna	FS				
6. Tuy, Batangas	POW				
7. Rosario, Batangas	FS/DESIGN				
8. Tanauan, Batangas	FS/DESIGN				
9. Sto. Tomas, Batangas	FS/DESIGN				
10. Lobo, Batangas	POW				
11. Alitagtag, Batangas	POW				
12. Agoncillo, Batangas	POW				

Table D.6 List of Proposed Water Supply Projects (Level I & II) in Quezon

Towns	Number of Proposed Water Supply Projects				
	Deep Well	Rain Collector	Spring Development	Shallow Well	Total
1 Agdangan	13	1	-	5	19
2 Alabat	15	1	2	-	18
3 Atimonan	13	2	2	-	17
4 Buenavista	11	1	1	10	23
5 Burdeos	2	3	5	6	16
6 Calauag	14	1	2	17	34
7 Candelaria	6	-	3	3	12
8 Catanauan	22	-	1	10	33
9 Dolores	-	-	2	-	2
10 Gen. Luna	20	-	1	9	30
11 Gen. Nakar	-	-	9	7	16
12 Guinayangan	10	1	2	14	27
13 Gumaca	17	1	2	21	41
14 Infanta	-	-	7	5	12
15 Jumalig	-	-	-	12	12
16 Lopez	8	2	2	20	32
17 Lucban	-	-	3	-	3
18 Lucena City	-	-	-	-	0
19 Macalelon	17	-	-	10	27
20 Mauban	-	-	5	12	17
21 Mulanay	16	-	3	16	35
22 Pagbilao	4	-	3	-	7
23 Padre Burgos	17	-	2	12	31
24 Panukulan	-	-	5	9	14
25 Patnanungan	-	-	1	6	7
26 Perez	16	1	1	11	29
27 Pitogo	15	1	2	10	28
28 Plaridel	11	1	1	10	23
29 Polillo	4	-	2	15	21
30 Quezon	16	1	1	12	30
31 Real	-	-	1	7	8
32 Sampaloc	-	-	7	3	10
33 San Andres	9	1	4	13	27
34 San Antonio	3	-	1	13	17
35 San Francisco (Aurora)	20	-	5	15	40
36 San Narciso	11	-	5	3	19
37 Sariaya	6	-	5	18	29
38 Tagkawayan	17	1	2	16	36
39 Tayabas	2	-	3	-	5
40 Tiaong	3	-	4	19	26
41 Unisan	16	-	-	11	27
Total	354	19	107	380	860

Table D.7 Estimated Run-off Depth in Sub-basins

Basin Name	Total Area (sq.km)	Ave.runoff Depth (mm)	Total Runoff Vol. (mcm)	Basin Name	Total Area (sq.km)	Ave.runoff Depth (mm)	Total Runoff Vol. (mcm)
1 Marikina R.	572.6	1,670	956	17 Small basin 3	36.9	1,350	50
2 Taytay	126.3	1,460	184	18 Looc R.	69.9	1,310	92
3 Morong R.	112.0	1,560	175	19 Lian R.	254.4	1,260	321
4 Tanay R.	68.2	1,540	105	20 Ermita R.	166.3	1,250	208
5 Pililla	83.2	1,450	121	21 Molino R.	161.3	1,250	202
6 San Antonio R.	297.9	1,440	429	22 Dacanlao R.	199.1	1,180	235
7 Small basin 1	50.6	1,450	73	23 Pansipit R.	656.0	690	450
8 Pangil R.	105.0	1,450	152	24 Small basin 4	59.5	990	59
9 Sta.Cruz	623.2	1,550	966	25 Small basin 5	23.8	1,150	27
10 Los Banos	248.9	1,370	341	26 Kalumpong R.	675.4	1,230	831
11 San Juan R.	212.7	1,190	253	27 Rosario R.	343.8	1,320	454
12 San Cristobal	413.7	1,140	472	28 San Pablo	246.3	1,390	342
13 Small basin 2	111.1	1,330	148	29 Bolbok R. (Malaguin R.)	496.8	1,340	666
14 San Juan (Metro Manila)	115.7	1,450	168	30 Laguna lake	900.0	-	3,200 *
15 Cavite north	649.4	1,230	799	31 Taal lake	240.0	-	>8,000 *
16 Maragondon R.	366.6	1,370	502				

* estimated lake water volume

Table D.8 Ground Water Potential (1/5)
(Province of Cavite)

No.	Town/ City	No. of Wells (nos.)	Average Specific Capacity (lps/m)	Well Depth (m)	Average SWL (mbgs)	Inflow (1000lpd)		Potential Max. of well	
						SW area	DW area	SW (nos.)	DW (nos.)
1.	Alfonso	31	0.72	63	34.58	*	6,372	*	20
2.	Amadeo	15	0.21	83	48.43	*	4,724	*	70
3.	Bacoor	25	0.70	159	4.94	8,219	**	150	**
4.	Bailen	2	0.00	49	30.18	*	5,040	*	40
5.	Carmona	32	0.27	117	52.42	6,609	1,983	160	15
6.	Cavite City	44	1.23	235	17.95	3,879	**	30	**
7.	Dasmarinas	23	0.56	80	24.95	*	8,117	*	15
8.	General Trias	13	0.19	43	9.24	1,430	7,723	20	40
9.	Kawit	24	1.05	121	4.02	4,406	**	100	**
10.	Imus	20	1.34	64	2.45	29,261	**	470	**
11.	Indang	47	0.73	64	29.77	*	8,068	*	25
12.	Naic	14	0.75	106	8.74	1,292	6,977	30	20
13.	Noveleta	6	0.35	53	2.51	1,841	**	40	**
14.	Magallanes	10	0.23	42	23.20	*	7,752	*	50
15.	Maragondon	17	0.88	51	16.57	*	42,746	*	65
16.	Mendez	18	1.66	114	73.07	*	1,647	*	10
17.	Trece Martires City	7	0.32	46	18.94	*	3,857	*	20
18.	Rosario	2	1.98	81	1.98	1,184	**	30	**
19.	Silang	32	0.38	96	42.48	*	13,976	*	40
20.	Tagaytay City	1	0.00	157	1.25	*	7,999	*	40
21.	Tanza	16	0.54	75	10.72	10,711	3,808	180	10
22.	Ternate	8	0.30	66	2.80	715	13,587	10	60
23.	Caballo Island	2	0.28	13	2.59	-	-	-	-
	Total	409						1,220	540

* No shallow well area
mbgs : meter below ground surface
SWL : static water level

** No deep well area
lps : litter per second

Table D.8 Ground Water Potential (2/5)
(Province of Laguna)

No.	Town/ City	No. of Wells (nos.)	Average Specific Capacity (lps/m)	Well Depth (m)	Average SWL (mbgs)	Inflow (1000lpd)		Potential Max. of well	
						SW area	DW area	SW (nos.)	DW (nos.)
1.	Alaminos	15	0.41	68	33.54	*	8,992	*	30
2.	Bay	14	1.33	60	18.84	11,565	4,112	230	10
3.	Binan	21	0.81	58	1.97	16,685	2,145	340	10
4.	Cabuyao	19	0.95	57	4.41	13,907	9,734	410	15
5.	Calamba	29	0.47	72	44.57	11,902	19,836	230	35
6.	Calauan	11	0.55	37	16.83	7,277	8,732	140	20
7.	Calayaan	1	-	37	2.74	*	11,573	*	30
8.	Los Banos	11	-	86	12.97	1,595	2,658	40	10
9.	Canlubang	2	-	156	5.80	2,553	6,894	60	20
10.	Cavinte	1	-	29	13.11	*	6,428	*	20
11.	Famy	11	-	31	8.34	3,096	8,359	60	20
12.	Longos	1	-	36	6.71	*	10,389	*	20
13.	Luisiana	1	-	64	7.62	10,608	12,730	240	30
14.	Liliw	6	-	30	8.34	10,041	8,836	230	20
15.	Lumban	3	-	29	3.25	*	5,655	*	10
16.	Mabitac	10	-	28	2.07	*	11,441	*	30
17.	Magdalena	6	-	23	11.38	*	12,839	*	30
18.	Nagcarlan	13	0.51	18	7.08	888	4,971	20	10
19.	Pagsanjan	11	0.86	37	4.35	723	4,050	20	10
20.	Pakil	13	0.82	22	2.92	498	1,923	10	10
21.	Pangil	6	1.37	22	0.66	1,890	3,151	40	10
22.	Pila	7	0.40	34	1.29	5,984	1,881	140	10
23.	Rizal	1	-	62	36.59	*	4,586	*	10
24.	Sta.Maria	9	0.61	36	1.81	*	35,178	*	80
25.	Sta.Cruz	101	0.81	37	3.47	4,844	2,180	100	10
26.	San Pablo City	15	2.28	35	18.29	5,630	4,955	100	10
27.	San Pedro	22	0.64	90	31.50	9,518	3,384	220	10
28.	Sta.Rosa	14	1.31	57	2.76	7,036	18,996	160	40
29.	Victoria	11	0.96	57	2.61	17,140	1,286	450	10
30.	Siniloan	22	5.29	59	1.31	9,373	2,215	230	10
	Total	407						3,470	590

* No shallow well area
mbgs : meter below ground surface
SWL : static water level

** No deep well area
lps : litter per second

Table D.8 Ground Water Potential (3/5)
(Province of Batangas)

No.	Town/ City	No. of Wells (nos.)	Average Specific Capacity (lps/m)	Well Depth (m)	Average SWL (mbgs)	Inflow (1000lpd) SW area	DW area	Potential Max. of well SW (nos.)	DW (nos.)
1.	Agoncillo	35	0.38	59	41.26	*	5,395	*	15
2.	Alitagtag	12	0.43	125	67.02	*	2,308	*	10
3.	Balayan	18	0.57	47	15.64	5,311	11,380	140	30
4.	Balete	-	-	-	-	*	2,465	*	10
5.	Bauan	76	0.29	80	46.79	1,095	6,131	30	20
6.	Batangas City	144	0.48	68	42.54	13,956	29,733	400	130
7.	Calaca	20	0.75	71	50.27	2,306	8,895	70	40
8.	Calatagon	25	1.12	18	7.62	1,105	35,717	20	120
9.	Cuenca	14	0.38	77	47.11	*	3,985	*	15
10.	Ibaan	26	0.47	75	21.44	*	9,764	*	30
11.	Laurel	-	-	-	-	672	6,045	20	20
12.	Lemery	27	0.82	84	61.17	3,340	9,019	80	20
13.	Lian	4	0.33	94	18.68	4,450	14,685	160	100
14.	Lipa City	143	0.54	60	44.51	*	20,653	*	150
15.	Lobo	6	0.21	43	17.00	6,335	21,540	150	100
16.	Mabini	38	0.59	30	13.60	*	5,231	*	20
17.	Malvar	28	0.43	92	47.51	*	3,590	*	20
18.	Mataas na Kahoy	13	0.54	78	48.50	*	2,180	*	10
19.	Nasugbu	43	0.86	35	14.28	1,693	4,403	40	10
20.	Padre Garcia	18	0.75	41	16.58	*	9,242	*	30
21.	Rosario	26	0.50	41	16.48	*	29,266	*	120
22.	San Jose	64	0.39	49	29.77	*	4,882	*	30
23.	San Juan	18	0.49	48	15.78	17,977	22,472	330	70
24.	San Luis	34	0.41	92	62.79	5,182	2,332	150	10
25.	San Nicolas	15	0.58	60	47.10	*	2,624	*	10
26.	San Pascual	-	-	-	-	*	3,452	*	10
27.	Sta.Teresita	9	0.35	73	47.95	*	1,233	*	10
28.	Sto.Tomas	51	0.57	57	28.54	*	8,985	*	20
29.	Taal	29	0.52	85	42.87	1,953	2,343	40	10
30.	Talisay	14	0.73	41	34.95	*	2,781	*	10
31.	Tanauan	126	0.46	101	65.88	*	10,573	*	50
32.	Taysan	30	0.62	47	31.37	*	16,904	*	130
33.	Tingloy	9	0.89	11	7.08	*	7,882	*	60
34.	Tuy	18	1.35	52	26.10	*	12,072	*	30
	Total	1133						1,630	1,470

* No shallow well area
mbgs : meter below ground surface
SWL : static water level

** No deep well area
lps : litter per second

Table D.8 Ground Water Potential (4/5)
(Province of Rizal)

No.	Town/ City	No. of Wells (nos.)	Average Specific Capacity (lps/m)	Well Depth (m)	Average SWL (mbgs)	Inflow (1000lpd) SW area	DW area	Potential Max. of wel SW (nos.)	DW (nos.)
1.	Baras	11	0.21	26	2.89	1,638	4,423	40	10
2.	Binangonan	48	1.37	47	14.35	9,644	10,391	180	20
3.	Cainta	1	0.47	153	8.53	*	4,424	*	10
4.	Cardona	33	0.88	35	5.00	916	13,285	20	30
5.	Jala-Jala	17	0.55	23	*	5,141	2,285	90	10
6.	Morong	16	0.53	85	18.14	*	5,898	*	20
7.	San Mateo	4	1.02	59	8.60	*	9,320	*	20
8.	Pililla	16	0.66	33	3.89	9,855	65,185	160	150
9.	Tanay	14	1.20	8	12.38	*	7,108	*	20
10.	Taytay	6	0.61	67	7.71	*	13,970	*	20
11.	Teresa	1	0.41	137	18.29	20,448	6,143	320	20
12.	Montalban	3	-	100	38.65	*	93,559	*	140
13.	Antipolo	9	0.94	141	14.05	18,336	1,711	320	10
14.	Angono	14	0.49	61	5.41	*	3,516	*	10
	Total	193						1,130	490

* No shallow well area
mbgs : meter below ground surface
SWL : static water level

** No deep well area
lps : litter per second

Table D.8 Ground Water Potential (5/5)
(Province of Quezon)

No.	Town/ City	No. of Wells (nos.)	Average Specific Capacity (lps/m)	Well Depth (m)	Average SWL (mbgs)	Inflow (1000lpd) SW area	DW area	Potential Max. of well SW (nos.)	DW (nos.)
1.	Unisan	12	0.33	24	3.11	*	42,709	*	220
2.	Sampaloc	3	-	37	2.90	*	36,395	*	200
3.	Agdangan	11	0.96	18	3.05	4,767	15,732	100	40
4.	Alabat	20	0.62	18	2.00	1,253	61,418	30	160
5.	San Francisco	-	-	-	-	9,513	307,574	240	1,830
6.	Atimonan	45	0.47	13	2.44	11,425	52,554	340	120
7.	Buenavista	6	0.46	13	3.66	10,411	87,452	270	300
8.	Calauag	21	0.14	25	6.90	55,343	221,370	1,510	2,330
9.	Catanauan	21	0.19	25	10.68	12,295	110,651	320	740
10.	Gen. Luna	8	0.18	44	10.37	11,318	82,997	440	620
11.	Guinayangan	9	0.59	37	7.27	12,173	89,265	350	400
12.	Gumaca	35	0.29	24	2.84	12,164	139,891	320	750
13.	Lopez	26	0.31	15	3.50	27,062	244,555	-	30
14.	Macalelon	21	0.26	43	5.16	16,113	48,339	610	230
15.	Mulanay	3	0.27	10	1.83	10,719	203,665	270	1,310
16.	Perez	8	1.21	15	1.68	*	40,137	*	80
17.	Pitogo	24	0.13	21	4.03	24,767	37,151	780	190
18.	Quezon	19	0.59	18	3.34	*	24,411	*	60
19.	San Narciso	11	0.71	25	5.39	*	138,630	*	300
20.	Tagkawayan	23	0.26	17	6.09	8,863	323,500	240	1,350
21.	Plaridel	5	0.25	14	2.59	3,126	8,038	70	40
22.	Real	1	2.07	10	0.61	*	115,850	*	270
23.	San Andres	2	0.26	12	3.76	*	136,233	*	750
24.	Panukulan	1	0.11	9	1.52	*	87,545	*	1,840
25.	Patnanungan	1	0.72	13	2.44	6,721	54,375	170	170
26.	Padre Burgos	12	0.41	23	4.96	17,985	29,344	510	160
27.	Burdeos	3	0.25	12	2.74	16,206	41,671	470	380
28.	Gen. Nakar	3	-	7	3.05	18,401	331,225	490	490
29.	Candelaria	27	1.25	47	16.91	*	30,555	*	40
30.	Dolores	3	0.78	39	11.59	*	10,890	*	30
31.	Infanta	19	0.52	9	2.42	78,363	3,688	2,110	10
32.	Lucban	1	-	20	-	*	**	*	**
33.	Lucena City	49	0.42	40	11.32	15,014	15,483	440	40
34.	Mauban	16	0.98	39	4.01	14,247	165,261	430	290
35.	Pagbilao	13	0.15	35	5.31	46,849	63,246	1,660	460
36.	Polillo	22	0.52	29	1.84	39,452	90,740	1,120	250
37.	Sariaya	51	1.77	35	11.09	13,441	46,372	280	70
38.	Tayabas	4	0.21	27	6.10	*	141,709	*	800
39.	San Antonio	3	0.29	39	16.71	*	11,096	*	90
40.	Tiaong	22	1.20	50	17.23	*	11,856	*	40
41.	Jumalig	-	-	-	-	3,541	31,870	90	100
	Total	584						13,660	17,580

* No shallow well area
mbgs : meter below ground surface
SWL : static water level

** No deep well area
lps : litter per second

Table D.9 Features of the Three (3) Levels of Service

Level No.	Means of Delivery	Means of Drawing Water	HH Served Per Source or Connection	Design Supply Volume	Socio-Economic Status of User	Capital Cost Per HH (Jun '84)
I	Direct From Source	Hand Pump with Pail of Bucket	15-25 per Source	40-150 (l/min.)	Poor to Middle Income	P500-2000
II	Piped Water System	Public Faucet with Pail or Bucket	100 Per Public Faucet	40-80 (l/d/cap.)	Poor to Middle Income	P1500-2500
III	Piped Water System	Individual Connection	one per connection		Middle to High Income	P3000-5000

Figures

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THE PROJECT CALABARZON

Legend | **Figure D.1**

- MAJOR WATERSHED
- MINOR WATERSHED
- OTHER SMALL WATERSHED
- RIVER
- PROVINCIAL BOUNDARY
- MUNICIPALITY
- EXISTING RAINFALL STATION
- EXISTING STREAM GAUGING STATION

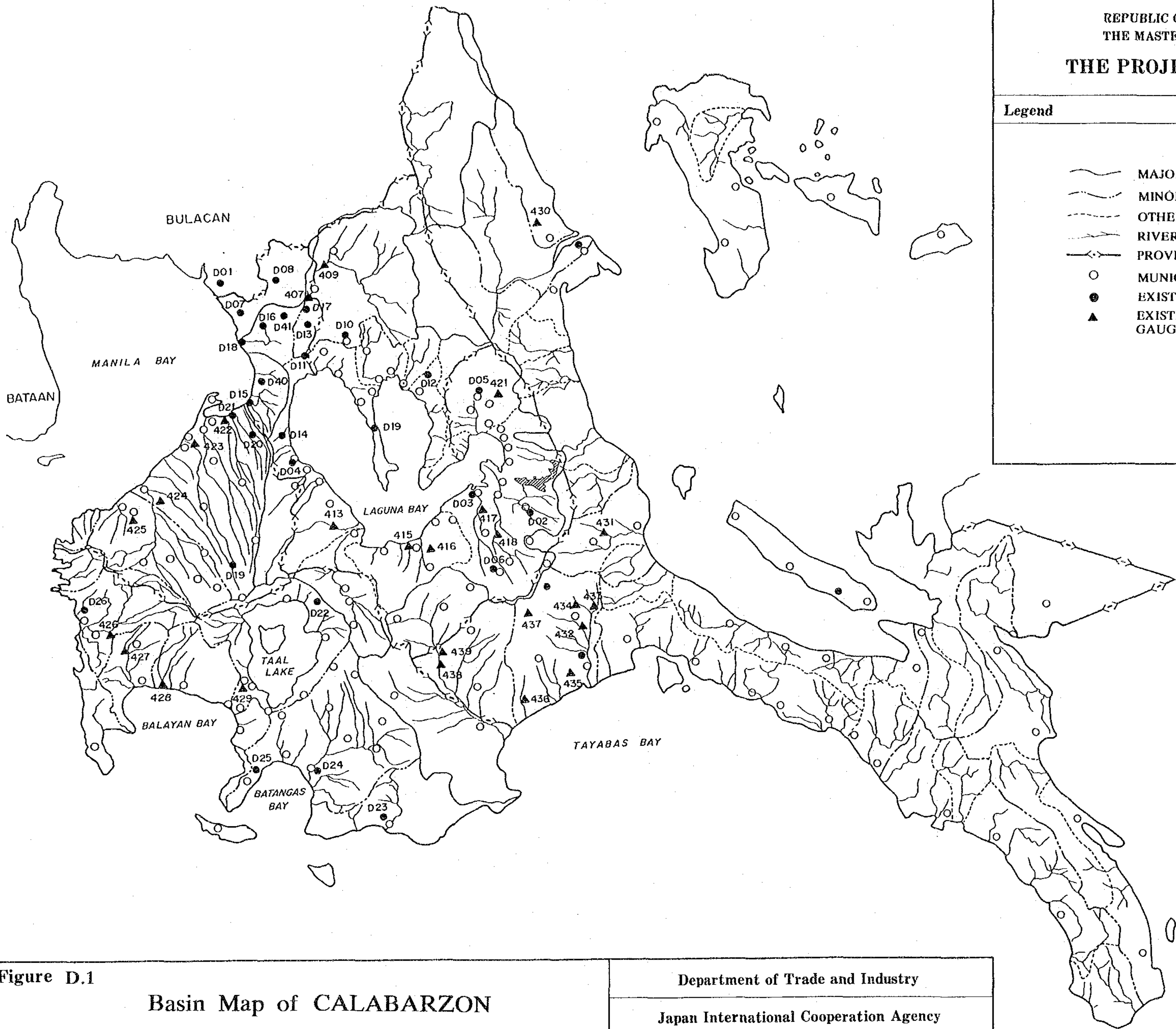

Figure D.1

Basin Map of CALABARZON

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Japan International Cooperation Agency

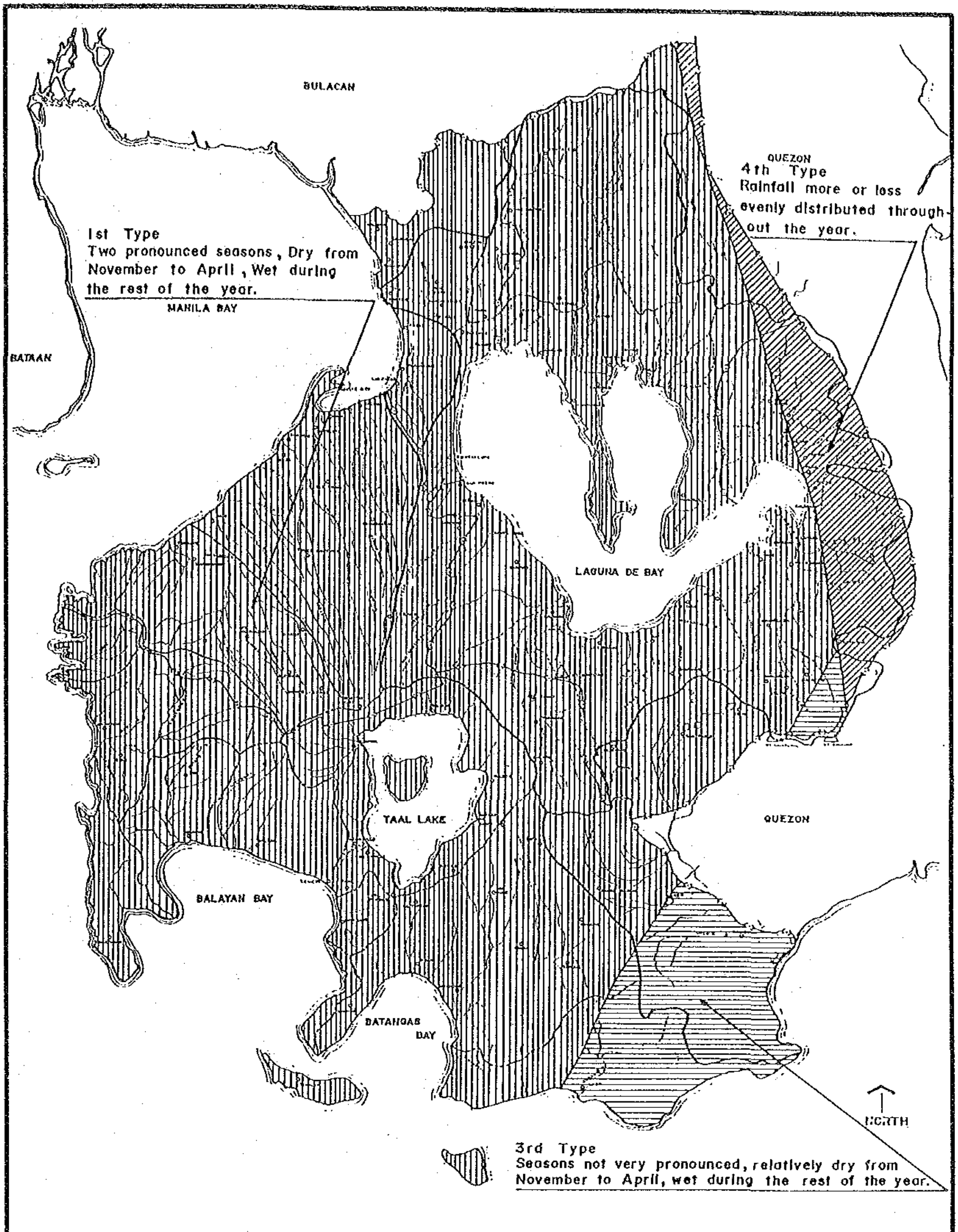

FIGURE D.2 Climatic Types in Laguna Lake and Taal Basins

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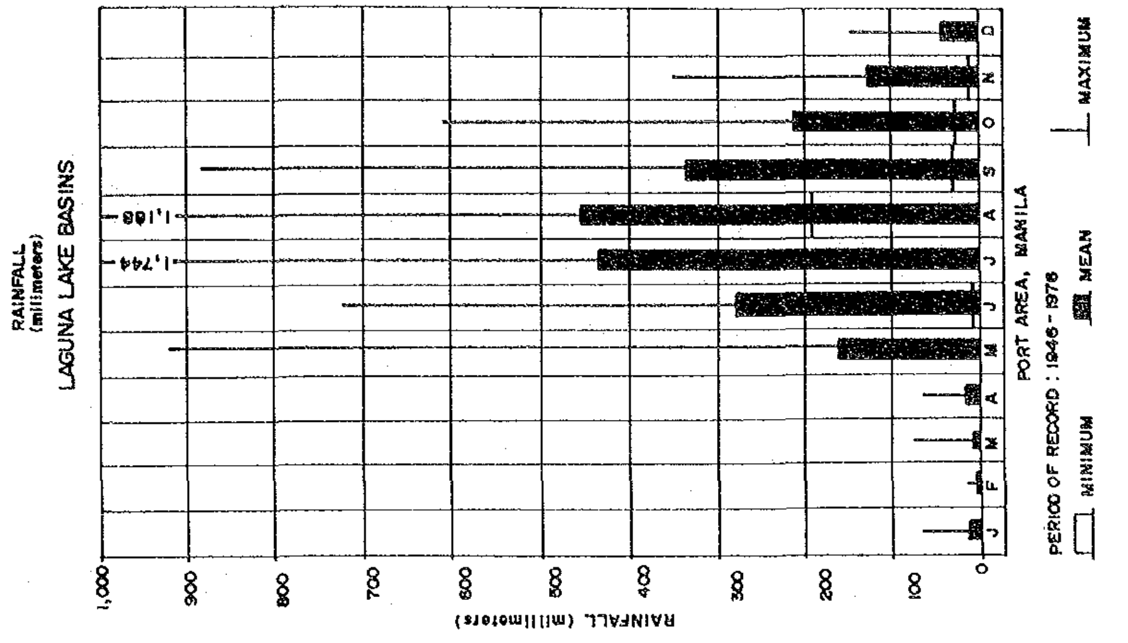
LEGEND :

- 1st Type: Two pronounced seasons, Dry from November to April, Wet during the rest of the year.
- 3rd Type: Seasons not very pronounced, relatively dry from November to April, Wet during the rest of the year.
- 4th Type: Rainfall more or less evenly distributed throughout the year.



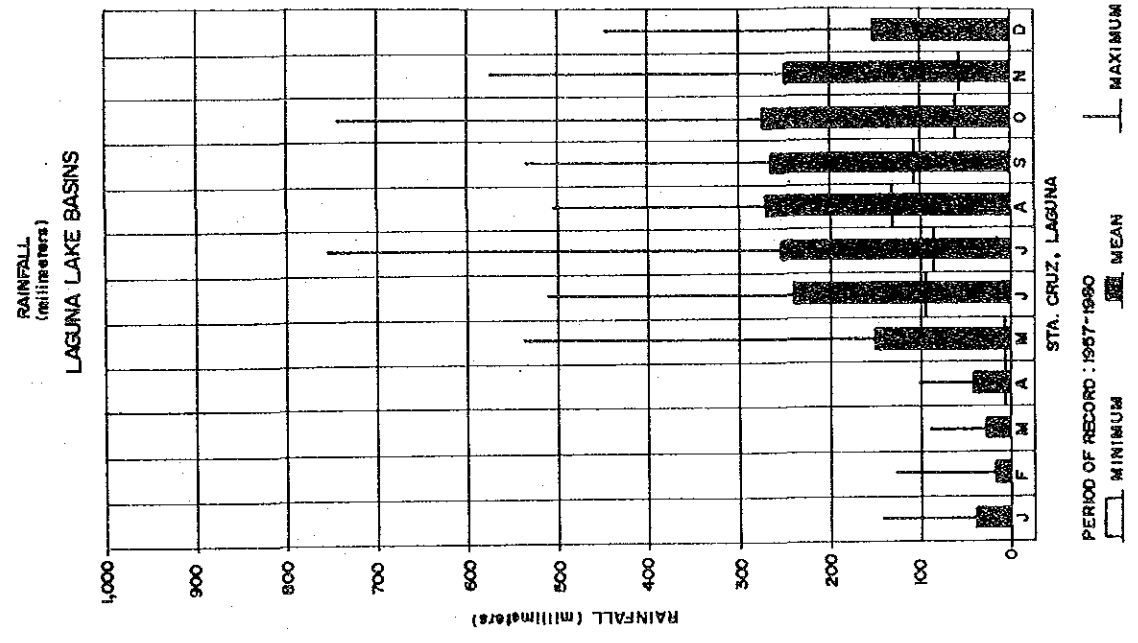


FIGURE D.3
Observed Rainfall Data at Sta.Cruz and Port Area, Manila

LEGEND :

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Legend	Figure D.4

- < 1950
- 1950 - 2000
- 2000 - 2050
- 2050 - 2100
- 2100 - 2150
- 2150 - 2200
- 2200-2250
- 2250-2300
- 2300-2350
- 2350-240
- 2400-2450
- > 2450

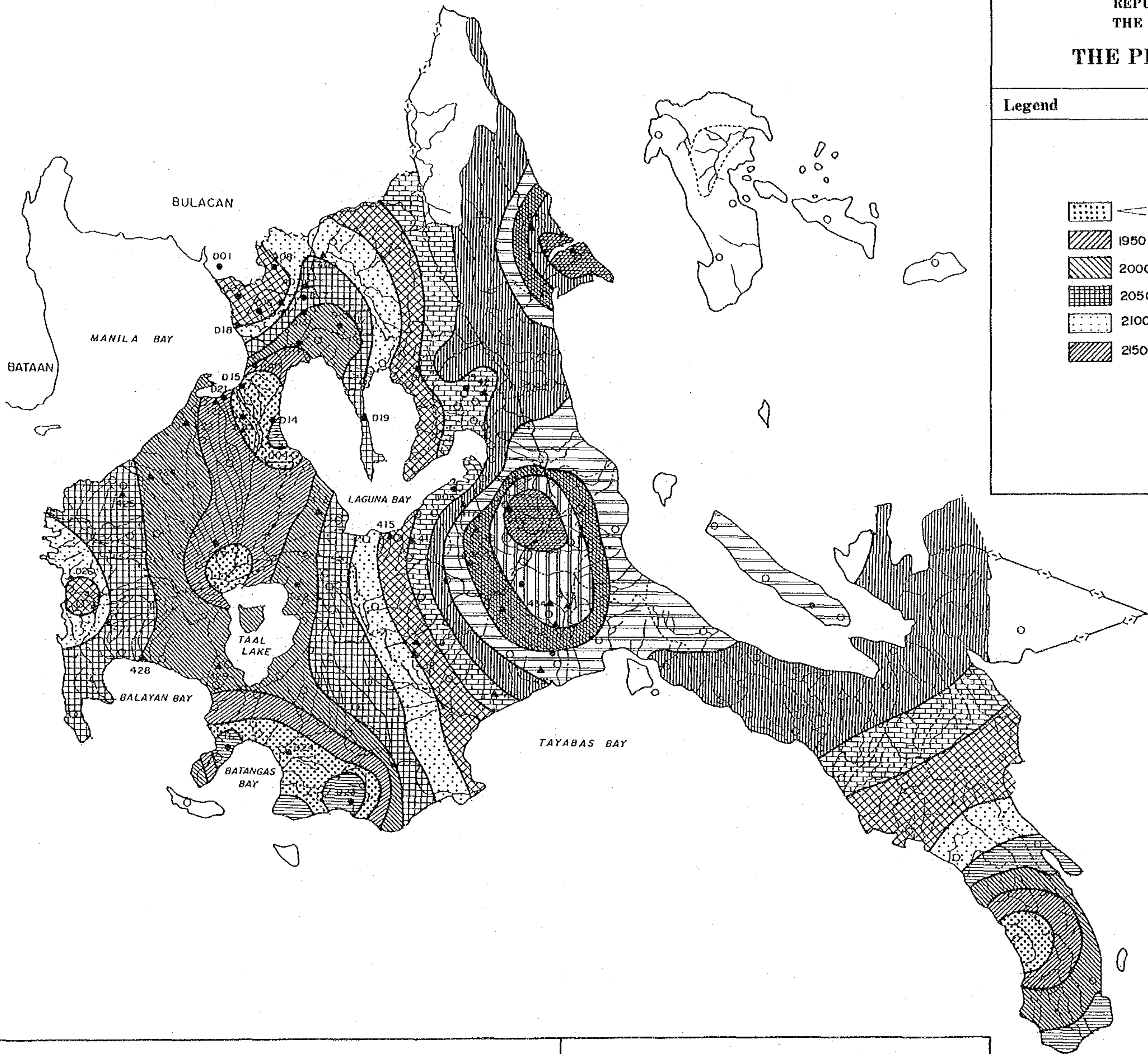

Figure D.4

Mean Annual Rainfall Map

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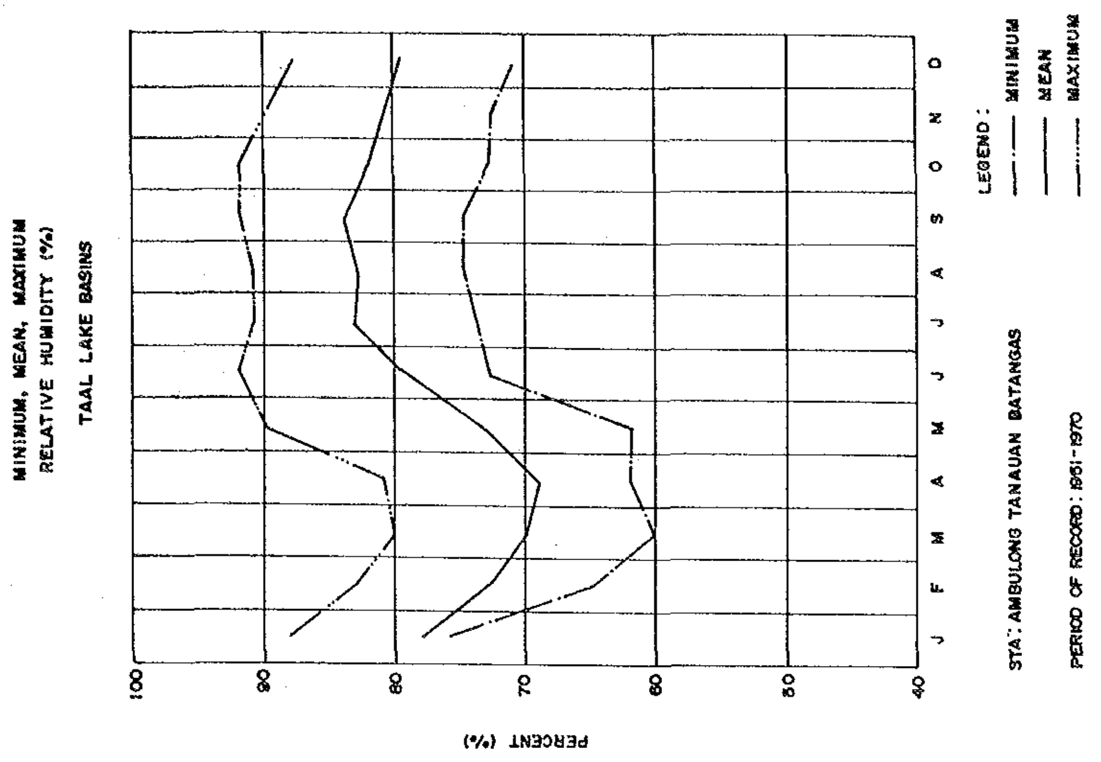
Japan International Cooperation Agency



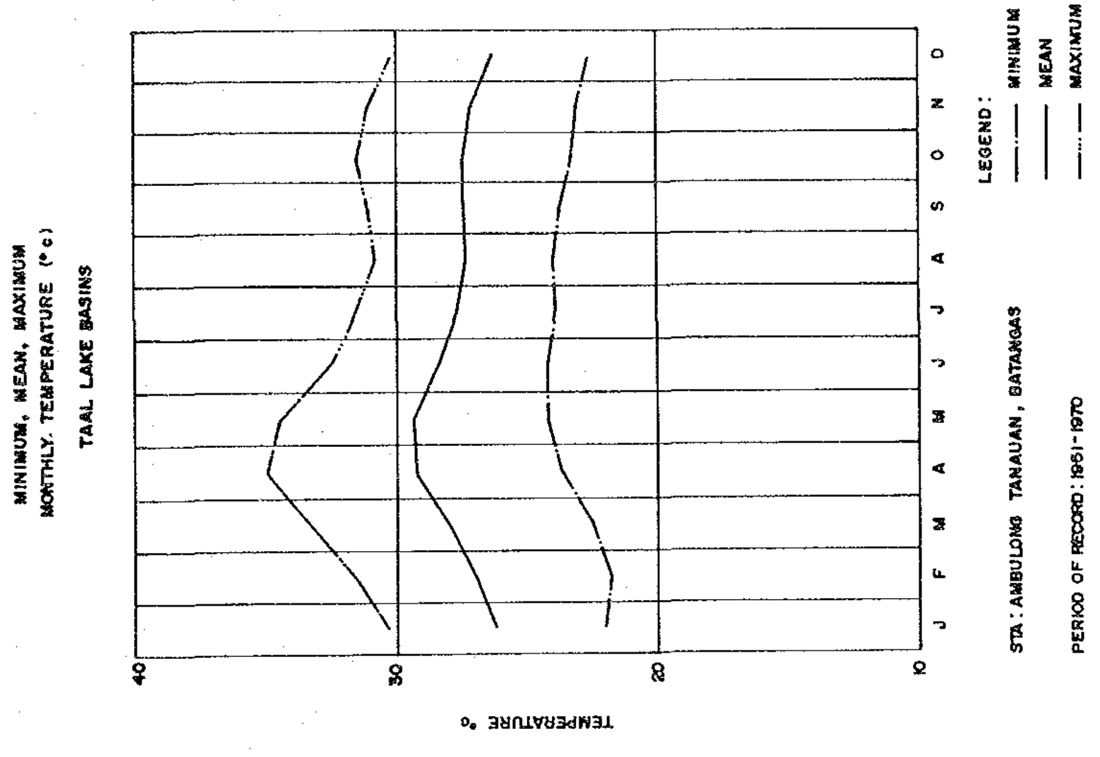


Figure D.5
Monthly Mean Temperature and Relative Humidity at Port Area, Manila

LEGEND :

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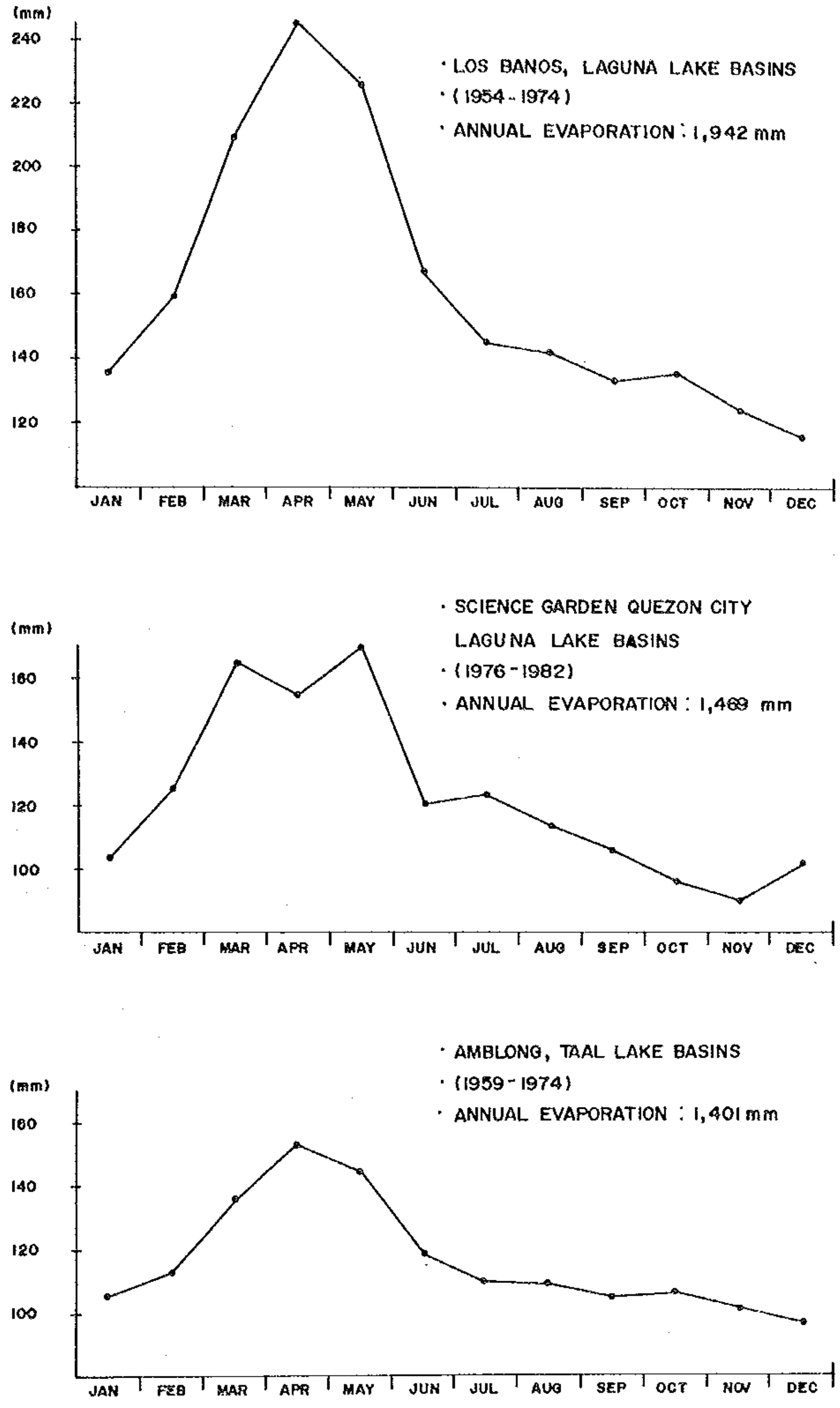

FIGURE D.6	Monthly Pan Evaporation at Los Banos, Science Garden.–. Quezon City, and Ambulong	LEGEND :

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Legend	Figure D.7

	< 1300
	1300 - 1400
	1400 - 1500
	1500 - 1600
	1600 - 1700
	1700 - 1800
	> 1800

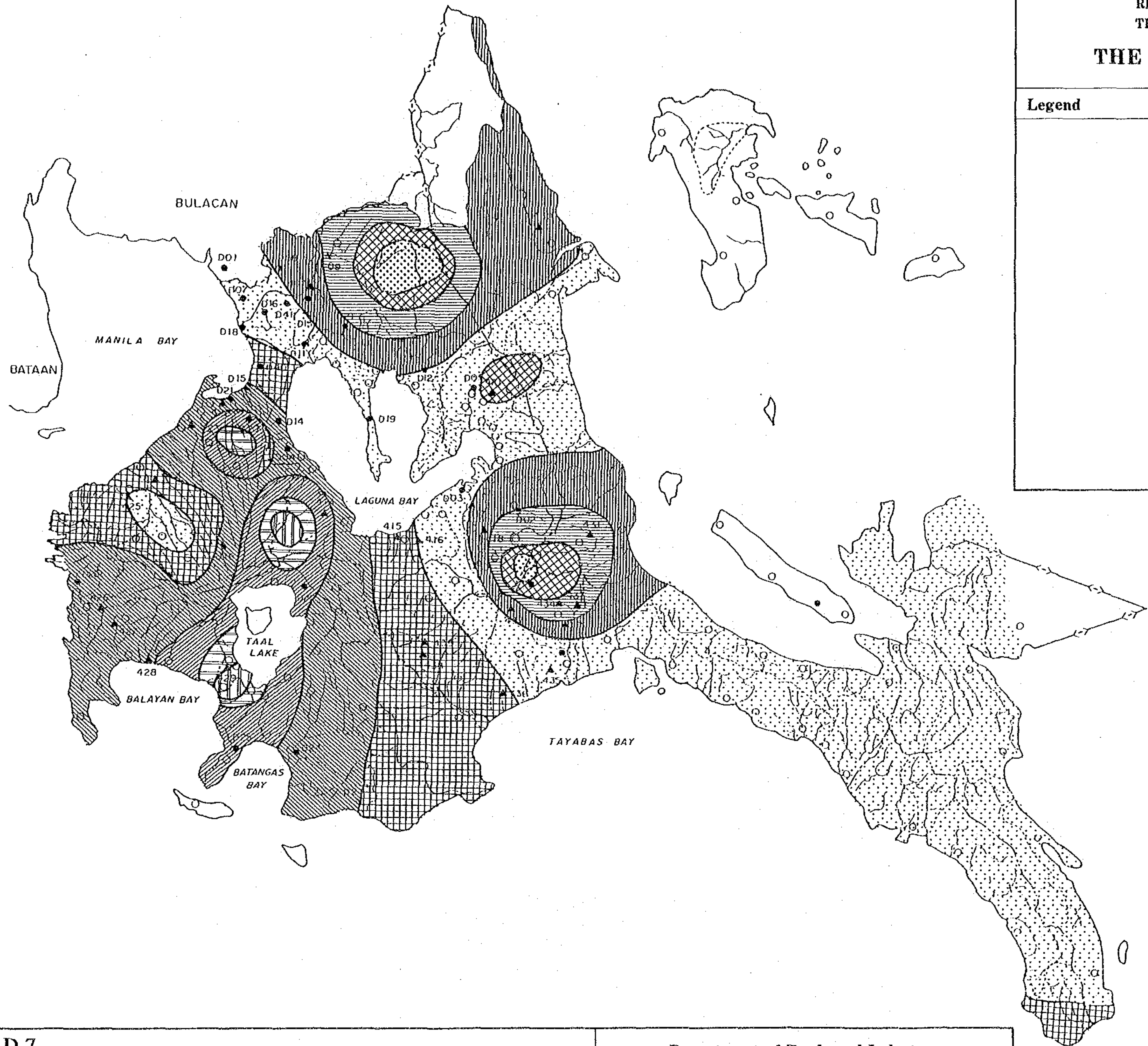

Figure D.7

Mean Annual Runoff Map

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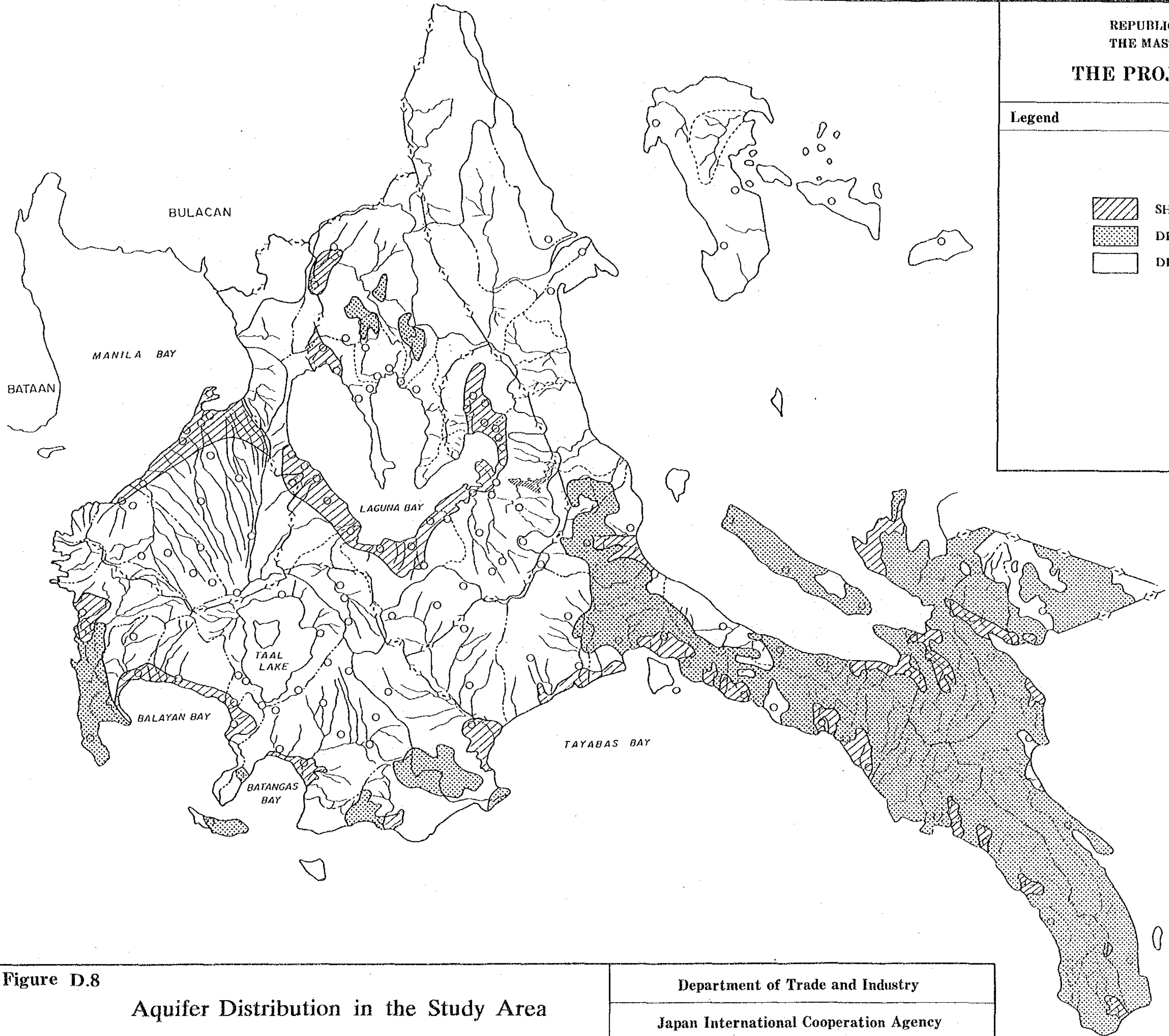

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Legend	Figure D.8

- SHALLOW WELL AREA
- DEEP WELL AREA
- DIFFICULT AREA

Figure D.8

Aquifer Distribution in the Study Area

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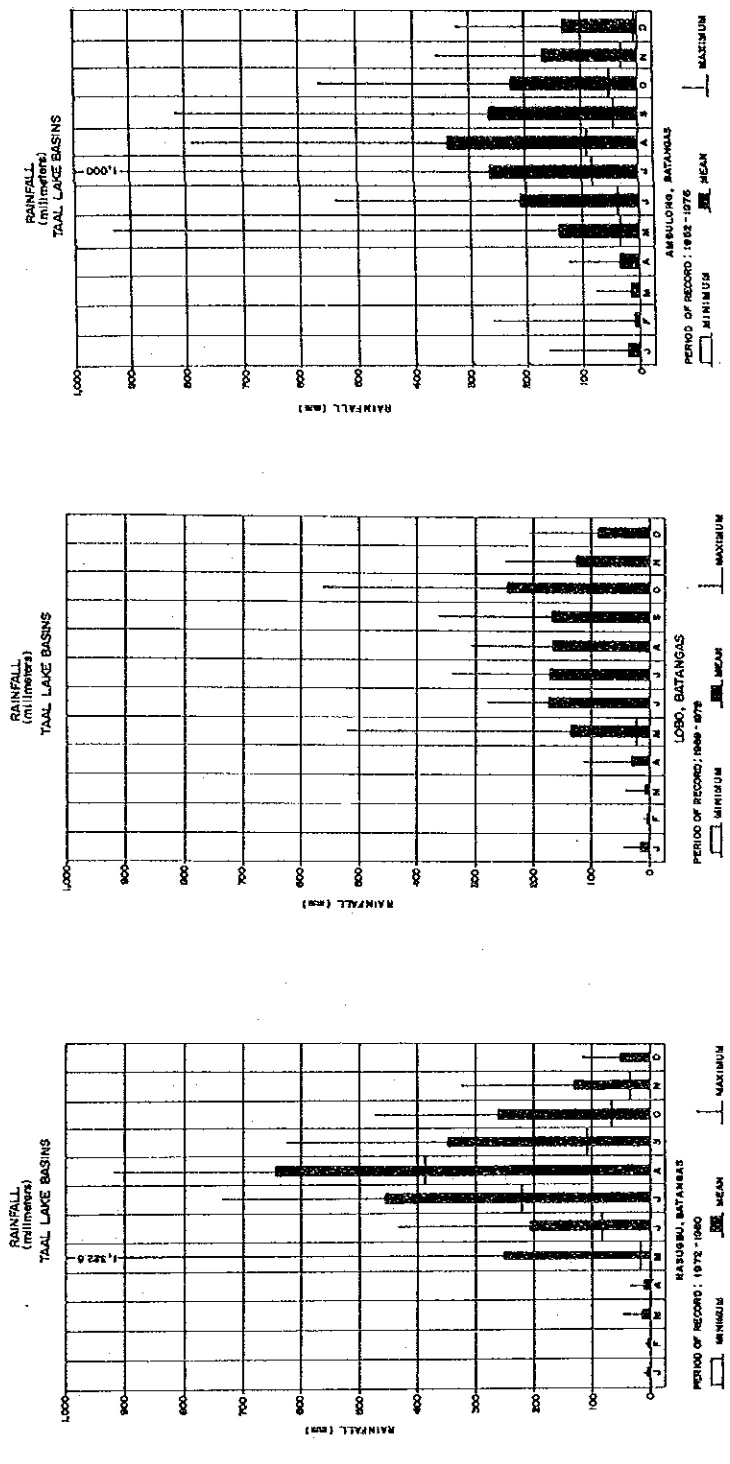

Figure D.9
Observed Rainfall Data at Nasgbu, Lobo, and Ambulong

LEGEND :

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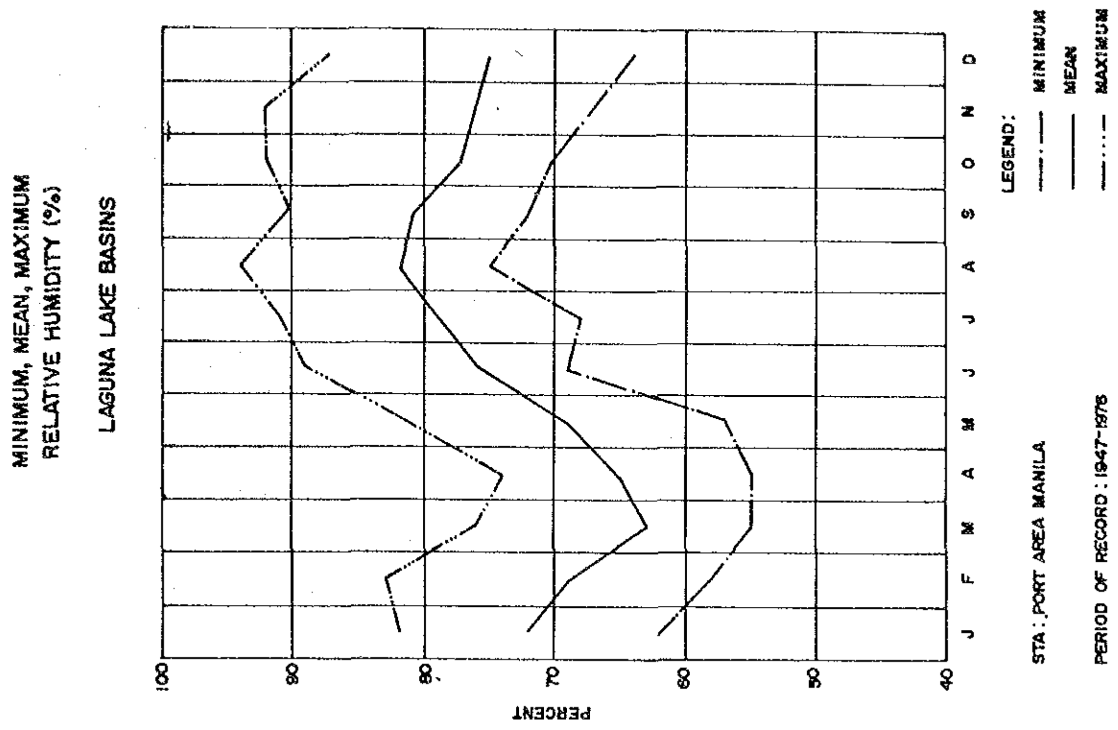

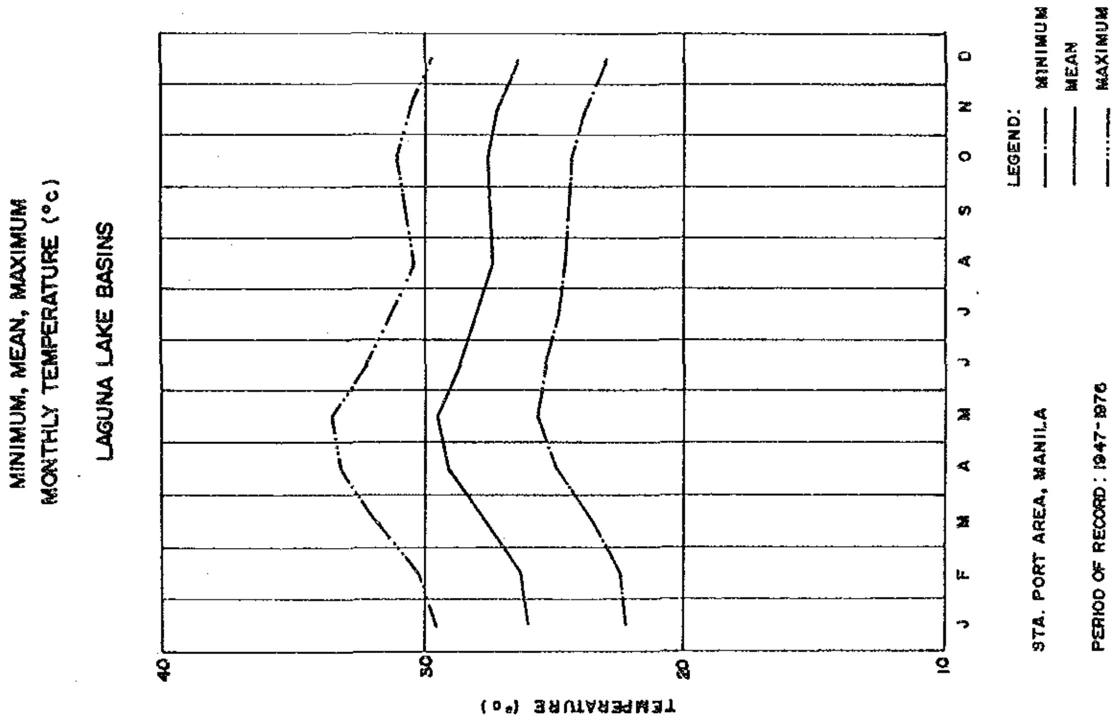

FIGURE D.10
Mean Monthly Tempesative and Relative Htumidily at Ambulong

LEGEND :

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Legend	Figure D.11

- 1ST TYPE - TWO PRONOUCED SEASONS, DRY FROM NOVEMBER TO APRIL, WET DURING THE REST OF THE YEAR
- 2ND TYPE - NO DRY SEASON WITH A VERY PRONOUNCED MAXIMUM RAINFALL NOVEMBER TO JANUARY
- 3RD TYPE - SEASONS NOT VERY PRONOUNCED RELATIVELY DRY FROM NOVEMBER TO APRIL AND WET DURING THE REST OF THE YEAR
- 4 TH TYPE - RAINFALL MORE OR LESS EVENLY DISTRIBUTED THE YEAR

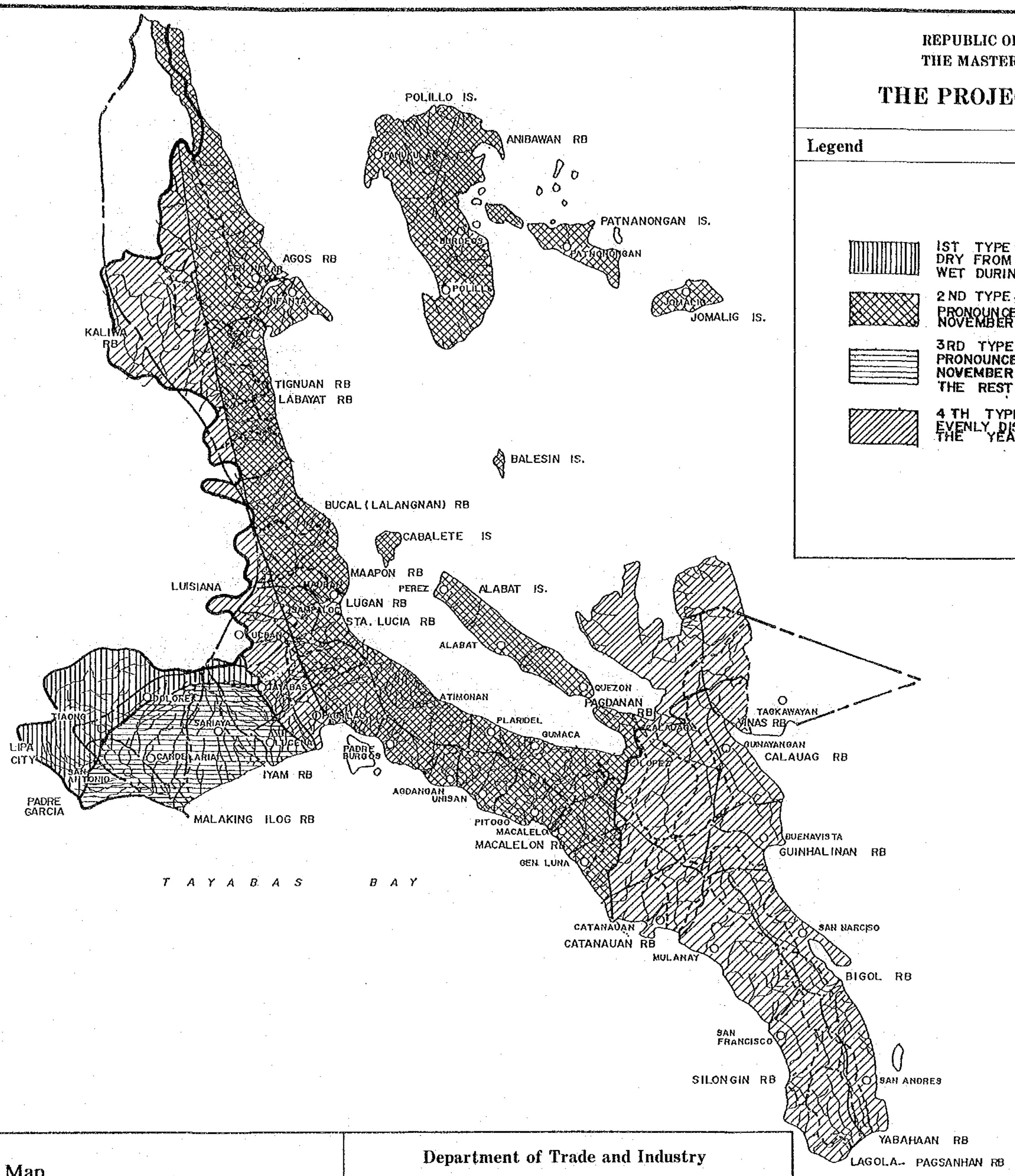

Figure D.11	Climate Map (Quezon Province)	Department of Trade and Industry Japan International Cooperation Agency

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Legend	Figure D.12

- EXISTING DAMSITE
- PROPOSED DAMSITE
- POTENTIAL DAMSITE

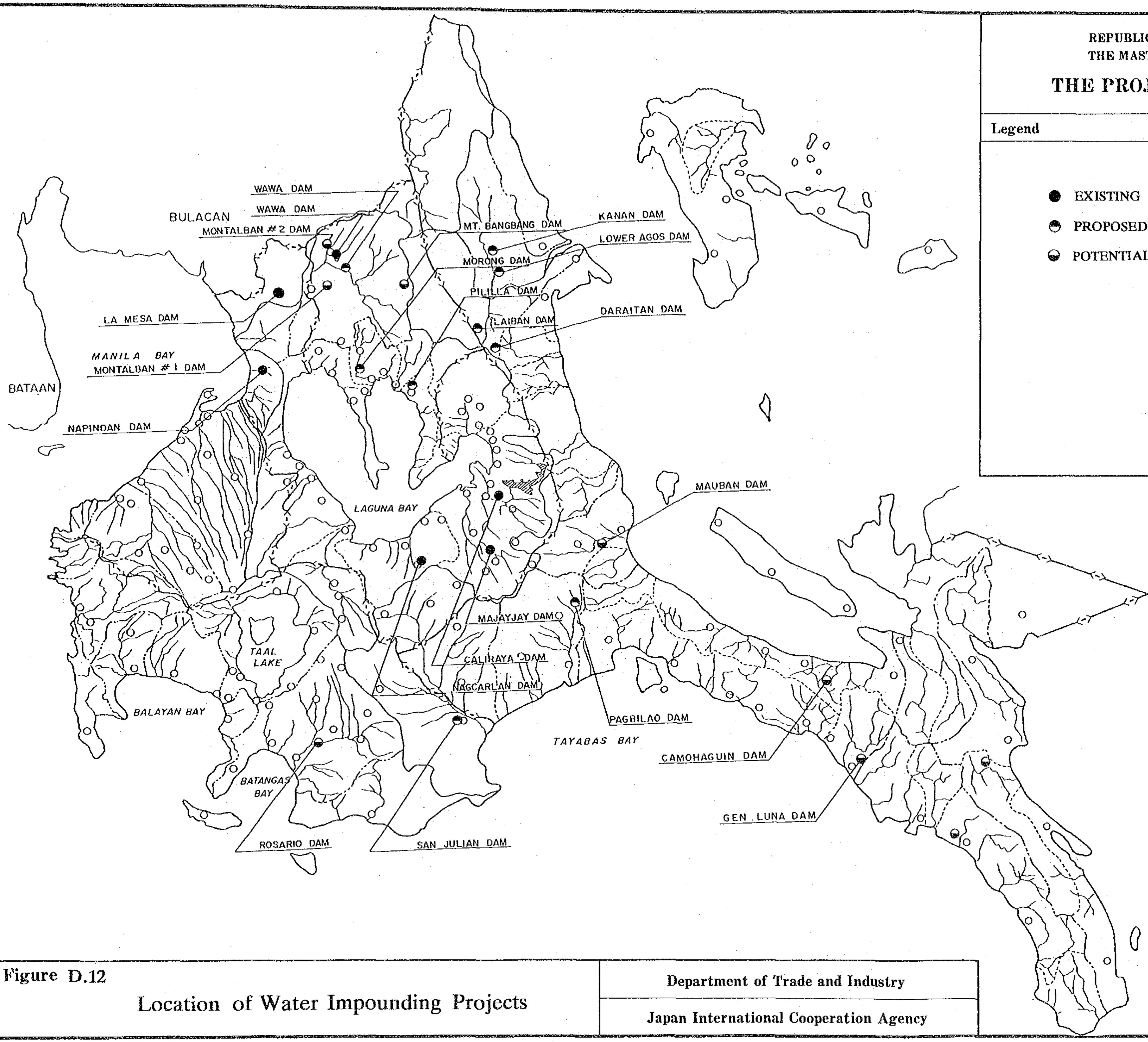

Figure D.12

Location of Water Impounding Projects

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THE PROJECT CALABARZON

Legend	Figure D.13

Surface water potential (median value)

S 1 : over 1,501mm
S 2 : 1,251–1,500
S 3 : below 1,250

Groundwater potential

G 1 : High
G 2 : Low

Composite water potential

Highest : S1+G1
High : S1+G2, S2+G1
Moderate : S2+G2, S3+G1
Low : S3+G2

APPROX, AREAL EXTENT OF SALT WATER INTRUSION

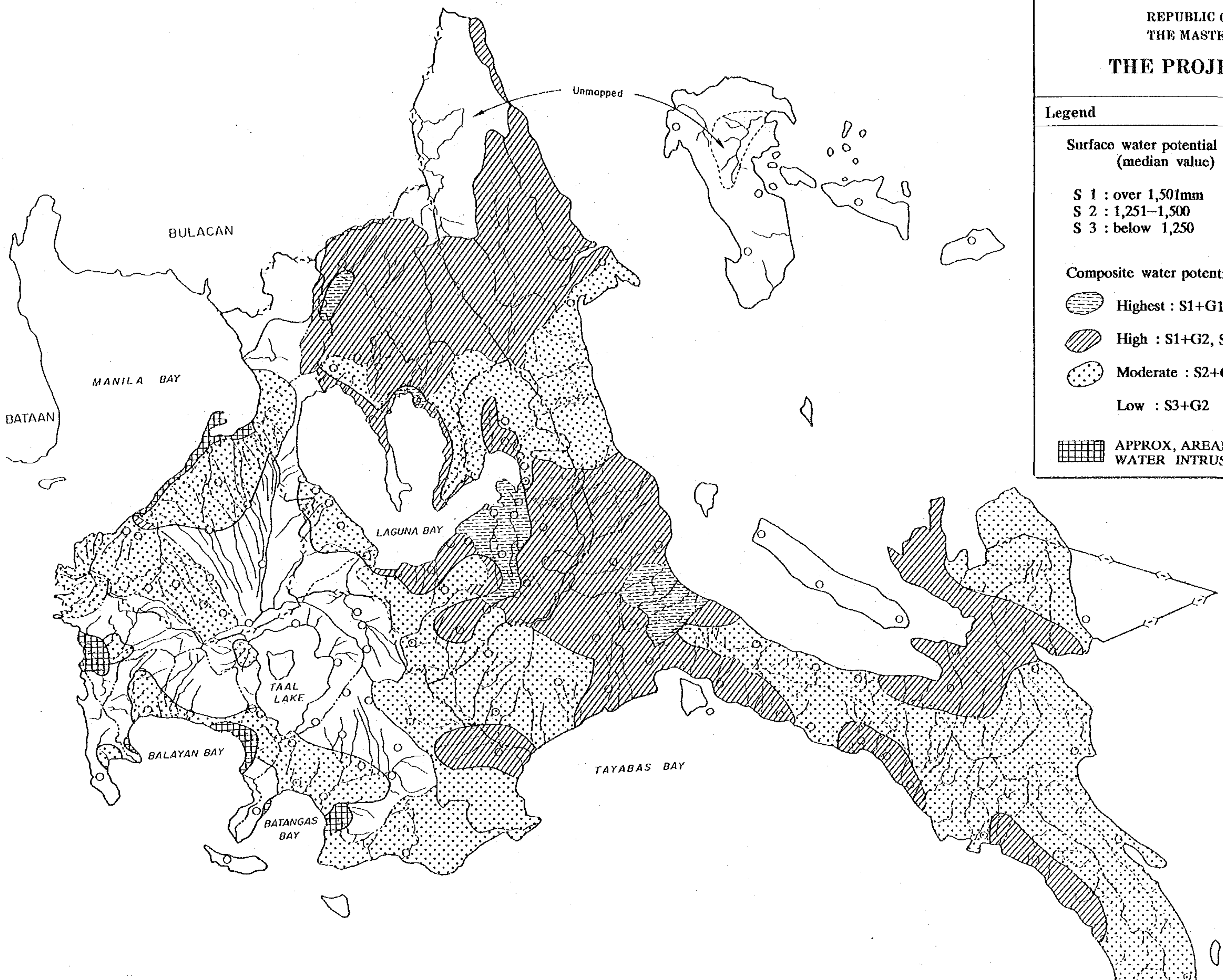

Figure D.13

Water Resources Potential Map

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