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REPUBLIC OF THE PHILIPPINES

METROPOLITAN WATERWORKS AND SEWERAGE SYSTEM

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

VOLUME 1

SUMMARY REPORT

JUNE 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF THE PHILIPPINES

METROPOLITAN WATERWORKS AND SEWERAGE SYSTEM

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PREFACE

In response to a request from the Government of Republic of the Philippines the Government of Japan decided to conduct Study for the Groundwater Development in Metro Manila and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Philippines a study team headed by Mr. Toru Hayashi, Nippon Jogesuido Sekkei Co., Ltd. composed of members from the above company and Kokusai Kogyo Co., Ltd. from August, 1990 to March, 1992.

The team held discussions with the officials concerned of the Government of Philippines, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Republic of the Philippines for their close cooperation extended to the team.

JUNE, 1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

June, 1992

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Yanagiya

Letter of Transmittal

We are pleased to submit to you the final report of Study for the Groundwater Development in Metro Manila of Republic of the Philippines.

The field survey and analytical study were conducted during the period between August 1990 and March 1992.

The final report consists of four volumes: One - Summary report which succinctly describes the study and recommendations; Two - Main report which describes the results of the study and analysis; Three - Supporting report which contains the details of study and analysis; Four - Data report which contains the results of the field survey, well inventory, water quality analysis and computer output.

We hope that implementation of the proposed groundwater development scheme would greatly contribute to improve the water supply conditions in Metro Manila of the Philippines.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs. We also wish to express our deep gratitude to the Metropolitan Waterworks and Sewerage System of Republic of the Philippines for the close cooperation and assistance extended to us during our investigations and study.

Very truly yours,

Toru Hayashi

Toru Hayashi
Team Leader
Study for the Groundwater Development
in Metro Manila

CONTENTS

CHAPTER 1 INTRODUCTION

1.1 STUDY BACKGROUND

The National Capital Region or NCR, better known as Metro Manila, lies on an alluvial plain and terrace along Manila Bay, south of the island of Luzon. Containing a land area which is less than one percent (0.21 percent) of the country's total area and having thirteen percent (7.9 million) of the country's total population, the area is characterized by rapid urbanization posing serious problems in water supply, sewerage, transportation, housing, garbage disposal and other related issues.

The problem of water supply shortage in particular is of such seriousness as to spur the Metropolitan Waterworks and Sewerage System (MWSS), which has jurisdiction over Metro Manila's water supply services, to embark on implementing several projects to meet the increasing demand and to have under wraps plans for some more. Notwithstanding the amount of effort the MWSS is exerting to solve the problem, the water shortage in the metropolis remains as grave, even appearing as if it has been further compounded, considering the superannuation and leakage in the distribution pipes of the MWSS.

Metro Manila's water supply, historically, has depended on groundwater as an important source. The deep and shallow wells that were drilled provide water for industry and commerce and for the domestic supply of areas outside the coverage of the central distribution system (CDS) of the MWSS as well. Another source is the surface water of the Angat River in the Province of Bulacan which is a major one for the MWSS.

The uncontrolled development and excessive pumping of groundwater, however, had caused the widespread decline of water levels in artesian aquifers, this decline dating back as far as the Sixties. What had thus resulted was the intrusion of salt water in the aquifers of coastal areas. Many wells had to be abandoned, new ones have to be drilled, with this seeking of fresh water in deeper aquifers becoming a vicious cycle and in the process expanding more the area affected by the intrusion of salt water.

The above phenomenon has not spared the MWSS. A considerable number of the deep wells in its service area had been affected by the regional salinization and were therefore abandoned. Some of these wells form part of the well network that supplies groundwater through pipelines connected to the CDS.

To compensate for the losses from these salt-intruded wells and increase the water supply in areas covered by its central distribution system, the MWSS currently is implementing the Angat Water Supply Optimization Project (AWSOP). For areas where no future water supply plans using surface water as source exist, two projects using groundwater as source are currently under implementation. These are the Fringe Areas Water Supply Project (FAWSP) and the Rizal Province Water Supply Improvement Project (RPWSIP).

It is still projected, however, that even with the increment in supply brought forth by the above efforts, supply would not meet the increasing water demand as rapid urbanization has already taken place. The rational development and conservation of groundwater and the establishment of a system for its proper management must therefore be given greater and sustained attention.

The Philippine Government's concern, in the context of the above, prompted it to request the Government of Japan for technical assistance, which request the Japanese Government acceded to by sending a preliminary mission for the period 12-22 January 1990 to clarify the background and specifics of the request. An agreement was reached between the MWSS and the Japan International Cooperation Agency (JICA) on the Implementing Arrangement (IA) for a study. The agreement was signed on 18 January 1990 by representatives of both parties. Based on the IA, a Study Team was dispatched to carry out the study.

The Study Team stayed in the Philippines for the periods 26 August to 20 December 1990 (Stage I of the Study), 08 January to 26 March 1991 (Stage II of the Study) and 27 May to 20 December 1991 (from First to Third period of Stage III of the Study). In cooperation with MWSS personnel, the team conducted surveys on the groundwater resources of the MWSS service area (MSA).

1.2 STUDY OBJECTIVES AND AREA

1.2.1 Study Objectives

The Study aims to:

(1) Formulate a plan for the rehabilitation, operation, maintenance and development of MWSS-supervised wells in MSA.

(2) Evaluate the groundwater resources potential and formulate a groundwater development plan for the Antipolo Area.

(3) Come up with solutions or remedial measures and preventive schemes for areas with heavy saline water intrusion.

(4) Formulate a plan for the establishment of a groundwater monitoring system in Metro Manila.

1.2.2 Study Area

As shown in Figure 1.1, the Study Area covers the MSA. The MSA comprises five (5) cities and thirty two (32) municipalities (an area of 1,780 km^2), namely:

<u>Metro Manila</u>: 4 cities and 13 municipalities

The Cities of Manila, Pasay, Quezon and Caloocan; the Municipalities of Las Piñas, Makati, Malabon, Mandaluyong, Marikina, Muntinlupa, Navotas, Parañaque, Pasig, Pateros, San Juan, Taguig and Valenzuela.

<u>Cavite Province</u>: 1 city and 5 municipalities

The City of Cavite and the Municipalities of Bacoor, Imus, Kawit, Noveleta and Rosario.

Rizal Province: 14 municipalities

Antipolo, San Mateo, Taytay, Cainta and Montalban (BP 799: Angono, Baras, Binangonan, Cardona, Jala-Jala, Morong, Pililla, Tanay and Teresa).

1.3 ORGANIZATION OF THE STUDY

In carrying out the study, the Metropolitan Waterworks and Sewerage System (MWSS) of the Republic of the Philippines acted as the counterpart agency and the Japan International Cooperation Agency (JICA), the official agency in behalf of the Government of Japan.

The study period is from August 1990 to March 1992.

The Study was carried out by a joint study team composed of a JICA team and a MWSS team:

JICA Study Team

Toru HAYASHI	Team Leader/Water Supply Engineer
Akira KAMATA	Co-Team Leader/Hydrogeologist
Masaharu KINA	Urban Planner
Shoichi OOMORI	Geologist
Naoaki SHIBASAKI	Hydrogeologist
Kenji TAKAYANAGI	Hydrogeologist
Masuomi HIROYAMA	Water Quality Engineer
Reynaldo R. MEDINA	Hydrologist
Mitsuo TSUTSUMI	Drilling Supervisor
Yu AYUSAWA	Drilling Supervisor
Kakuji SUEMATSU	Well Engineer
Takafumi KIGUCHI	Water Supply Planner

MWSS Team

Rolando E. ROCA	Manager, Planning & Programming Dept.
Victor J. BALAGTAS	Project Manager C, MMGWDP

Ernesto V. ALCANTARA	Asst. Project Manager C, MMGWDP
Renee A. PINGOL	Sr. Statistician
Norma M. SANTIAGO	Sr. Hydrogeologist A
Godofredo C. CARPIO	Hydrogeologist A
Richard G. BURCE	Supervising Engineer
Romeo S. MANLAPIG	Sr. Engineer A
Rogelio G. OTIVAR	Sr. Engineer A
Enrico A. RUIDERA	Sr. Draftsman
Rodulfo M. NOVEDA	Engineering Assistant A
Rodolfo B. VICENTE	Engineering Assistant A
Oliver B. PADRON	Sr. Engineer A
Noel B. ZACARIAS	Engineering Assistant A
Daisy C. ARANAN	Data Encoder/Controller
Juliana F. VELADO	Data Encoder/Controller
Ramon N. MENDOZA	Engineering Assistant A
Lorenzo A. DUMANDAN	Engineering Assistant A
Judith S. CADAPAN	Draftsman A
Gemmalyn S. SANTOS	Administrative Service Assistant A
Olivia M. SANTIAGO	Clerk/Processor B

1.4 OUTLINE OF THE STUDY

The Study commenced in August 1990 and was completed in March 1992. The Study period of 20 months was divided into three stages: Stage I (Basic Survey), Stage II (Detailed Survey) and Stage III (Analysis and Planning).

The study procedure is flowcharted as shown in Figure 1.2.

(1) Stage I: Basic Survey

This stage involves the review and analysis of existing studies and data, field geological reconnaissance, arrangement of existing well inventory, questionnaire survey on groundwater use, preparation of the database system and appraisal survey on the ability and availability of local drilling contractors.

(2) **Stage II: Detailed Survey**

The Study at this stage includes investigation of MWSS wells, the electric resistivity survey of the Antipolo Area, drilling and pumping tests, installation of monitoring equipment, pumping tests of existing wells, simultaneous observation of water levels, survey on groundwater use (collection and analysis of questionnaires) and preparation of the database system.

(3) **Stage III: Analysis and Planning**

The Study at Stage III concerns the planning of the rehabilitation program for MWSS wells, the groundwater development and management program, the analysis of saltwater intrusion and the planning for the groundwater monitoring system in MSA.

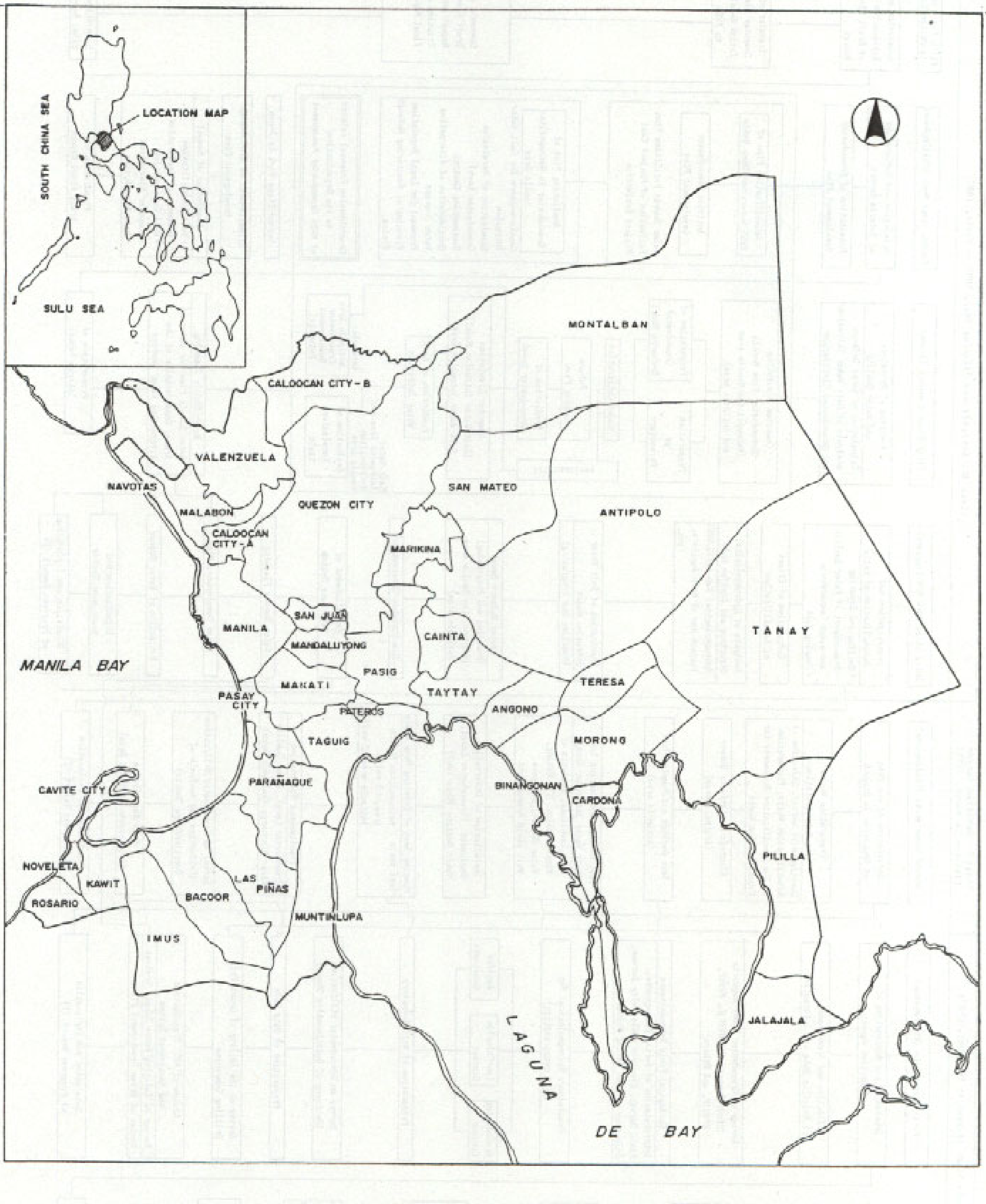
1.5 CONSTITUTION OF THE FINAL REPORT

The Final Report consists of five volumes: Summary Report, Main Report, Supporting Report and Data Report.

The Summary Report contains the summary of the study, conclusions and recommendations. The Main Report describes the results of the study on aquifer distribution, groundwater use, groundwater levels, water quality and rehabilitation of MWSS deep wells. In the Main Report is also contained the evaluation of the groundwater resource of Metro Manila based on the hydrogeologic analyses and computer groundwater simulations. It also contains the proposed groundwater development and management program. Conclusions and recommendations are summarized in the final chapter.

The Supporting Report contains the results of groundwater investigation, test borings,computer simulation, details of urban development planning, water supply systems and future water demand.

The results of electric resistivity survey, pumping tests, well rehabilitation, well inventory, water quality analysis and computer output are presented in the Data Report.



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 1.1 THE STUDY AREA

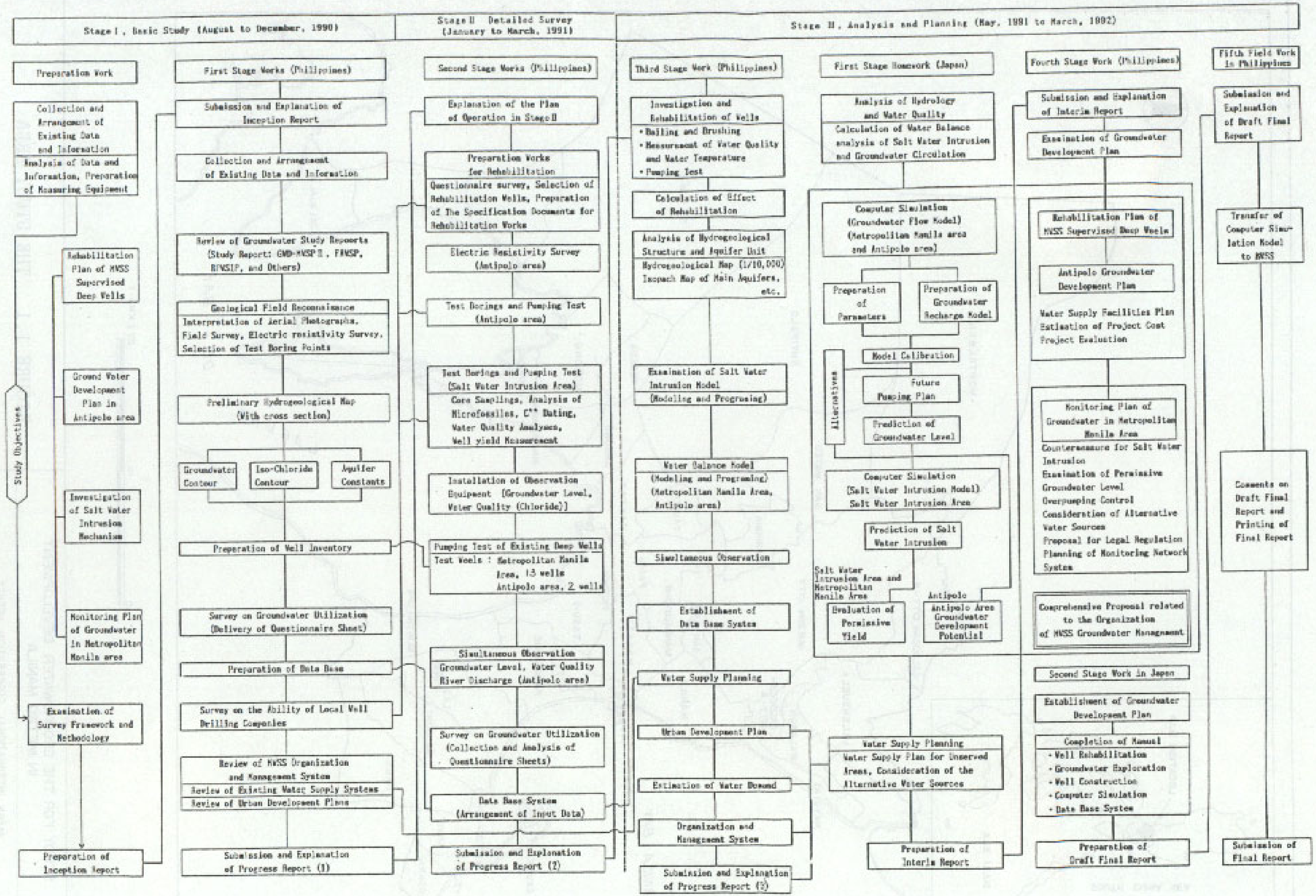


FIGURE 1.2 FLOWCHART OF THE STUDY

CHAPTER 2 SOCIO-ECONOMY AND WATER SUPPLY

2.1 SOCIO-ECONOMIC BACKGROUND

(1) Location

The Philippines consists of more than 7,000 islands located on the Western Pacific Ocean at latitudes 4°23'N to 21°25'N and longitudes 116°E to 126°30'E. Its eleven major islands occupy 90% of the country's total land area of about 300,000 km². Metro Manila, the capital region, lies at the center of Luzon Island at latitude 14°35'N and longitude 121°E.

(2) Area and Population

There are thirteen administrative regions in the Philippines including the National Capital Region (NCR). The Study Area includes the NCR and two provinces (Rizal and part of Cavite) of Region IV, a total of five cities and thirty-two municipalities. Its total land area is about 2,125km², of which NCR accounts for 636km², or 30% of the Study Area (Figures 2.1.1 and 2.1.2).

The 1990 Philippine Population Census placed the population of the country at 60,685,000. The total population of the Study Area was about 9.17 million (NCR: 7.83, Cavite: 0.46, and Rizal: 0.88) representing 15% of total population of the country (Table 2.1.1). Eighty-five percent (85%) of the Study Area's population is in the NCR. Population density in the NCR is around 123 persons per hectare.

(3) Social Background

The NCR and Region IV are the most urbanized and economically developed areas among the regions and have the major advantage in terms of social services, physical facilities, and those amenities associated with urban life. However, a large portion of its population still bears the brunt of poverty and its attendant ills. For Metro Manila, its labor force of the younger generation is abundant while the employment rate is relatively low and was recorded at 82.8% in 1988.

(4) Economic Background

The NCR is the country's center of trade, finance and commerce and education. It is also the seat of the National Government. The NCR accounts for 30% of the country's total Gross Domestic Product (GDP). GDP of the NCR reached 31,323 million pesos in 1988.

The average annual family income in the NCR is about 57,200 pesos, comparing favorably with the Philippine average of 31,000 pesos. Seventy-five percent (75%) of this income comes from non-agricultural sources.

(5) Land Use

Forty-seven percent (47%) of NCR's total land area is built-up area. Rizal's built-up area is only 11.7%. Cavite has its built-up area gradually increasing due to urbanization.

The recent years witnessed industries being located and/or relocated at cheaper sites to the north (Bulacan), east (Rizal) and south (Cavite) of the metropolis, along major transport routes. Agricultural and fishpond areas are converted to residential and/or commercial areas sporadically due to population growth.

2.2 WATER SUPPLY

(1) Present Water Supply Services

As of end-1987, around 63% of the country's total population have access to public water supply systems. The served population then was 86% for Metro Manila and its contiguous areas. Out of the 86% covered in Metro Manila, only 57% were directly served with MWSS water, 16% were served indirectly by MWSS through ambulant vendors, and the rest got their water through private wells and other undetermined sources (Table 2.2.1). The rest of the country's population, approximately 37%, depended on water from open dug wells, rainwater cisterns, lakes and streams.

In Metro Manila, water supply service consists of individual house connections, private wells, some public standpipes in blighted areas, and ambulant vendors. In large urban centers outside Metro Manila, majority of the people are served by Level III systems. In the rural areas, however, the most common water supply facilities are protected wells and Level I developed springs.

(2) Institutional Aspect

Water supply facilities are under the responsibility of the Department of Public Works and Highways (DPWH) and two of its attached agencies, namely, MWSS and the Local Water Utilities Administration (LWUA). The MWSS operates the water supply and sewerage systems in Metro Manila and its contiguous areas, while the LWUA handles the development and improvement of water and sewerage systems in areas not covered by MWSS.

The DPWH is concerned mainly with the development of Level I systems and is the lead agency in establishing national water supply plans and programs. Other agencies involved in the sector include the National Water Resources Board (NWRB) which is involved mainly in policies and regulations concerning the proper utilization and rights thereof of water resources all over the Philippines.

(3) Master Plan of the Philippines

The Water Supply, Sewerage, and Sanitation Master Plan for the period 1988-2000 was formulated in 1987. The Master Plan calls for a two-stage implementation of projects: the first stage covering the period 1988 to 1992; the second stage, the period 1993-2000.

The following activities are envisaged for the first stage. In Metro Manila and its contiguous areas, various projects are to be undertaken to expand and improve the service coverage of the MWSS to 87% of the Metro Manila's population. In other urban areas, population coverage shall be increased to 77% through the construction and rehabilitation of 450 and 250 piped systems (Levels II and III) respectively.

In the rural areas, about 933 piped systems and around 87,146 point sources (Level I) will be constructed. In addition, 21,620 facilities will be repaired or rehabilitated. Taken together, these rural projects should raise the service coverage to about 92% of the rural population.

The second stage of the Master Plan considers the complete water supply coverage of both urban and rural areas, with emphasis on proper operation and maintenance of facilities and the construction of sewerage systems.

In Metro Manila, the Manila Water Supply Project III is planned to boost the service coverage to 97%.

(4) Present Water Supply in MSA

The MWSS has jurisdiction (based on Republic Act No. 5234) over five cities and thirty-two municipalities.

Only specific areas of Metro Manila, plus some parts of Bacoor and Kawit of Cavite Province, are covered by the CDS of MWSS. Excluded from the CDS coverage in Metro Manila are those peripheral areas in the north, east and south of the metropolis. These excluded areas and the other areas in the Rizal and Cavite Provinces predominantly rely on isolated groundwater supply systems which are operated by MWSS and other public entities such as Water Districts, municipalities and barangays (Figure 2.2.1).

Currently under implementation, AWSOP targets an additional 15m^3/sec of surface water supply. It also aims to expand the area covered by the CDS.

(5) Served Population and Water Amount

The total population served by MWSS in 1990 was 8.2 million, or 90% of the total population within MSA. Of this figure, 2.6 million or 29% of total MSA population was estimated as illegal users of the system (Table 2.2.2).

Surface water and groundwater production by MWSS in 1990 amounted to 876 MCM and 33.3 MCM, respectively.

Private groundwater use for industries, offices, schools, hotels and condominiums, etc. in 1990 was estimated at 307 MCM (see Section 3.3).

(6) Existing Water Supply Facilities

MWSS water sources consist of surface water and groundwater. Water is distributed through CDS. The drawn surface water is first stored in Angat Dam, afterwhich it flows through Angat river down to Ipo Dam. From Ipo dam, the water is conveyed via two tunnels to the Bicti Headworks. It is then diverted to four aqueducts connected to the La Mesa Dam, afterwhich it is conveyed to the Balara and La Mesa Treatment Plants. (See Figure 2.2.2.)

Most of the treated water from the Balara Treatment Plant is sent to the San Juan and Pasig Reservoirs and Balara Pumping Station. That from the La Mesa Treatment Plant is sent to the Bagbag Reservoir. Present capacity of these treatment systems is approximately 2.5 MCM per day. (Refer to Table 2.2.3.)

The groundwater drawn from MWSS deepwells is injected directly into the distribution systems after chlorination. Of the 258 MWSS deepwells, 52 wells are abandoned and 75 wells inactive as of March 1991. Capacity of groundwater source is approximately 90,000 CMD.

The total number of private deepwells is estimated to be more than 3,000.

(7) Ongoing and Proposed Projects

The MWSS is implementing several rehabilitation and expansion projects to reduce non-revenue water (NRW) and increase the service concessionaires. Among these are AWSOP, Manila Water Supply Rehabilitation Project I and II (MWSRP I and MWSRP II), and Metropolitan Manila Water Distribution Project (MMWDP). Several additional projects (e.g. RPWSIP and FAWSP) were also planned with the principal objectives of expanding the service area and augmenting the water production capacity.

(8) **Future Water Source and Production Capacity**

Based on the implementation plans of ongoing projects, only the AWSOP can be expected to augment the yield of water source by an annual average of 1.3 MCM/day. This increase in production capacity shall be achieved through construction of La Mesa Treatment Plant No. 2 with a capacity of 0.9 MCM/day.

MWSS is implementing several rehabilitation projects in order to recover non-revenue water (NRW). Targeted to be recovered by the MWSRP I and II are 0.765 MCM/day of NRW. As more than half of this amount is estimated to be accounted for by leakage from the distribution lines, around 0.4 MCM/day shall be left for consumption.

Several projects are lined up by the MWSS to augment the yield of its water sources. However, these projects are still on the feasibility study or detailed design stage, and financial sources for them have yet to be assured. As such, their implementation schedules are only tentative. The outlook therefore is for groundwater to supply the fringe areas of Metro Manila and Rizal over a long period of time.

Table 2.1.1 Population and Growth Rate by Region for Census Years

	POPULATION (THOUSANDS)												GROWTH RATE (%)				
	1960		1970		1975		1980		1985 (Estimate)		1990		1960/1970	1970/1975	1975/1980	1980/1985	1985/1990
Philippines	27,088	100.0	36,684	100.0	42,071	100.0	48,098	100.0	54,688	100.0	60,685	100.0	3.1	2.8	2.7	2.6	2.4
NCR (National Capital Region)	2,462	9.1	3,697	10.8	4,970	11.8	5,296	12.3	6,942	12.7	7,929	13.1	4.9	4.6	3.6	3.2	3.1
Region																	
1. Ilocos	2,428	9.0	2,991	8.1	3,269	7.8	3,541	7.4	3,903	7.1	3,551	5.9	2.1	1.8	1.6	2.0	1.6
2. Cagayan Valley	1,202	4.4	1,691	4.6	1,933	4.6	2,215	4.6	2,521	4.6	2,341	3.9	3.5	2.7	2.8	2.6	2.0
3. Central Luzon	2,525	9.3	3,615	9.9	4,210	10.0	4,803	10.0	5,456	10.0	6,199	10.2	3.7	3.1	2.7	2.6	2.5
4. Southern Tagalog	3,081	11.4	4,457	12.1	5,214	12.4	6,119	12.7	7,089	13.0	8,266	13.6	3.8	3.2	3.3	3.0	3.0
5. Bicol	2,363	8.7	2,967	8.1	3,194	7.6	3,477	7.2	3,922	7.2	3,910	6.4	2.3	1.5	1.7	2.4	1.3
6. Western Visayas	3,078	11.4	3,618	9.9	4,146	9.8	4,526	9.4	5,092	9.3	5,393	8.9	1.6	2.8	1.8	2.4	1.8
7. Central Visayas	2,523	9.3	3,033	8.3	3,387	7.9	3,787	7.9	4,195	7.7	4,593	7.6	1.9	2.2	2.3	2.1	1.9
8. Eastern Visayas	2,041	7.5	2,381	6.5	2,600	6.2	2,799	5.8	2,073	5.6	3,055	5.0	1.6	1.8	1.5	1.9	0.9
9. Western Visayas	1,351	5.0	1,869	5.1	2,048	4.9	2,528	5.3	2,863	5.2	3,159	5.2	3.3	1.8	4.3	2.1	2.3
10. Northern Mindanao	1,297	4.8	1,953	5.3	2,314	5.5	2,759	5.7	3,718	5.8	3,510	5.8	4.2	3.5	3.6	2.9	2.3
11. Southern Mindanao	1,353	5.0	2,201	6.0	2,715	6.5	3,347	7.0	3,836	7.0	4,457	7.3	5.0	4.3	4.3	2.8	2.9
12. Central Mindanao	1,383	5.1	1,941	5.3	2,070	4.9	2,271	4.7	2,598	4.8	3,171	5.2	3.4	1.3	1.9	2.7	3.5

Source: 1960-1980 Philippine Statistical Yearbook 1989 (NEDA)
1985 Philippine Yearbook 1989 (NSO)
1990 1990 Census of Population and Housing (NSO)

TABLE 2.1.2 GROSS REGIONAL DOMESTIC PRODUCT, FOR 1987-1988
(AT CONSTANT 1972 PRICES)

REGION	Actual (in PM)		Growth Rate	Per Capita GRDP (in P)	Growth Rate (in %)
	1987	1988*	1987-1988	1988	1987-1988
PHIL.	95,948	101,758	6.63	1,733	3.56
NCR	28,502	31,323	9.90	4,143	6.89
I	4,323	4,507	4.25	1,090	2.28
II	2,301	2,432	5.70	897	3.16
III	7,664	8,286	8.12	1,413	5.59
IV	14,221	14,929	4.97	1,941	2.19
V	3,120	3,257	4.41	776	2.09
VI	6,545	6,902	5.44	1,269	3.19
VII	6,905	7,421	7.48	1,669	5.45
VIII	2,323	2,383	2.60	735	0.76
IX	3,350	3,492	4.24	1,141	1.96
X	5,248	5,570	6.13	1,620	3.41
XI	7,082	7,186	1.47	1,739	-0.98
XII	3,844	4,064	5.74	1,451	3.14

(*) As of January 1989

Sources: Economic and Social Statistics Office
National Statistical Coordination Board

TABLE 2.2.1 EXISTING WATER SUPPLY COVERAGE

(million)

Area	Total Population	(%)	Population Served: Total	(%)	Wells/Developed Spring	(%)	Piped System	(%)	Underserved/ Unserved Population	(%)
Philippines	57.36	100	36.17	63	17.92	31	18.25	32	21.19	37
Urban	23.53	100	15.39	65	12.52	53	2.87	12	8.14	35
Metro Manila and and its contiguous area*	8.16	100	7.01	86	6.84	84	0.17	2	1.15	14
Others	15.37	100	8.38	55	5.68	37	2.70	18	6.99	45
Rural	33.83	100	20.78	62	5.40	16	15.38	46	13.05	38

* Excluding the 303,433 population of the towns of Rizal province under BP 799.

Source: Department of Public Works and Highways, Water Supply, Sewerage, and Sanitation Master Plan of the Philippines: 1988-2000.

TABLE 2.2.2 MWSS WATER SUPPLY STATISTICS

Year	1984	1985	1986	1987	1988	1989	1990
1) Pop'n under MWSS (million)	7.480	7.712	7.938	8.167	8.405	8.651	9.133
2) Water Production							
a) Surface Water (million m3)	642.24	757.37	874.07	834.75	849.34	859.10	875.80
b) Groundwater (million m3)	25.56	29.45	30.43	27.87	29.48	28.96	33.33
Total	667.80	786.83	904.51	862.62	878.82	888.06	909.13
Increase	-	119.03	117.68	(41.89)	16.20	9.24	21.07
3) Water Comsumption							
a) Volume Sold (million m3)	289.90	302.85	310.78	336.51	359.45	375.77	384.67
%	43.4%	38.5%	34.4%	39.0%	40.9%	42.3%	42.3%
b) NRW (million m3)	377.90	483.98	593.73	526.11	519.37	512.29	524.46
%	56.6%	61.5%	65.6%	61.0%	59.1%	57.7%	57.7%
Total	667.80	786.83	904.51	862.62	878.82	888.06	909.13
c) House Connection (mil. m3)	168.55	183.55	195.47	218.48	225.85	235.74	244.97
d) P.F. & Other Conn. (mil. m3)	121.35	119.30	115.31	118.03	133.60	140.03	139.70
e) Illegal Use (mil. m3)	151.16	193.59	237.49	210.44	207.75	204.92	209.78
Sub Total	441.06	496.44	548.27	546.95	567.20	580.69	594.45
%	66.0%	63.1%	60.6%	63.4%	64.5%	65.4%	65.4%
f) Leak, Meter Error (mil. m3)	226.74	290.39	356.24	315.67	311.62	307.37	314.68
%	34.0%	36.9%	39.4%	36.6%	35.5%	34.6%	34.6%
Total	667.80	786.83	904.51	862.62	878.82	888.06	909.13
4) Number of Connections							
a) House Connection	321,512	377,538	442,323	490,223	508,545	543,128	599,754
b) Public Faucet	1,020	1,080	1,160	1,230	1,300	1,420	1,490
c) Others	27,039	27,368	26,919	26,703	44,688	43,910	47,343
Total	349,571	405,986	470,402	518,156	554,533	588,458	648,587
Increase	-	56,415	64,416	47,754	36,377	33,925	60,129
5) Estimated Population Served							
a) House Connection (million)	2.604	3.058	3.583	3.971	4.119	4.399	4.858
b) Public Faucet (million)	0.496	0.525	0.564	0.598	0.632	0.690	0.724
Sub Total	3.100	3.583	4.147	4.569	4.751	5.089	5.582
Increase	-	0.483	0.564	0.422	0.182	0.338	0.493
c) Illegal Use (million)	1.358	1.955	2.738	2.483	2.381	2.399	2.649
Total	4.458	5.538	6.884	7.052	7.132	7.489	8.232
Increase	-	1.080	1.347	0.167	0.080	0.357	0.743
6) Per Capita Water Consumption (lpcd)							
a) for distributed water	410	389	360	335	338	325	303
b) for effective water	271	246	218	212	218	212	198
c) for domestic water	177	164	149	151	150	147	138

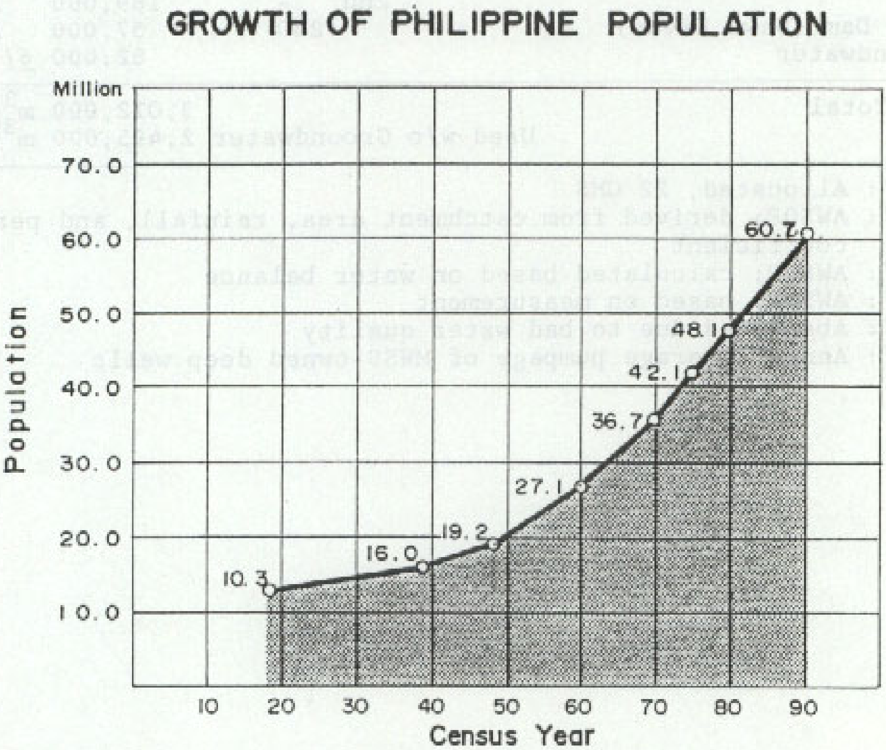
Note: 5a = 4a x 8.1, 5b = 4b x 486, 5c = (3b x 0.4 x (3c/3a)) / (3c/4a) x 8.1
6a = (3a+3b) / (5a+5b+5c), 6b = (3c+3d+3e) / (5a+5b+5c), 6c = 3c / 5a

Source: Corporate Planning Group

Table 2.2.3 Capacity of Water Sources

Source		Area of Watershed (km^2)	Water Right or Capacity (m^3/day)	Status
Angat Dam (Angat River)		568	1,901,000 1/	Used
Ipo Dam (Angat River, Ipo River)	Old	-	(Submerged by New Dam)	
	New	70	474,000 2/	Used
La Mesa Dam (Novaliches Watershed)		27	100,000 3/	Used
Alat Diversion Dam (Alat River)		14	20,000 4/	Used
Marikina River Pumping Stations 5/	1st	-	189,000	Abandoned
	2nd	-	189,000	Abandoned
Wawa Dam (Wawa River)		280	57,000	Abandoned
Groundwater			82,000 6/	Used
Total			3,012,000 m^3/day	
		Used w/o Groundwater	2,495,000 m^3/day	

1/: Allocated, 22 CMS
2/: AWSOP; derived from catchment area, rainfall, and permeability coefficient
3/: AWSOP; calculated based on water balance
4/: AWSOP; based on measurement
5/: Abandoned due to bad water quality
6/: Annual average pumpage of MWSS-owned deep wells



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 2.1.1
JAPAN INTERNATIONAL COOPERATION AGENCY	GROWTH OF THE PHILIPPINE POPULATION

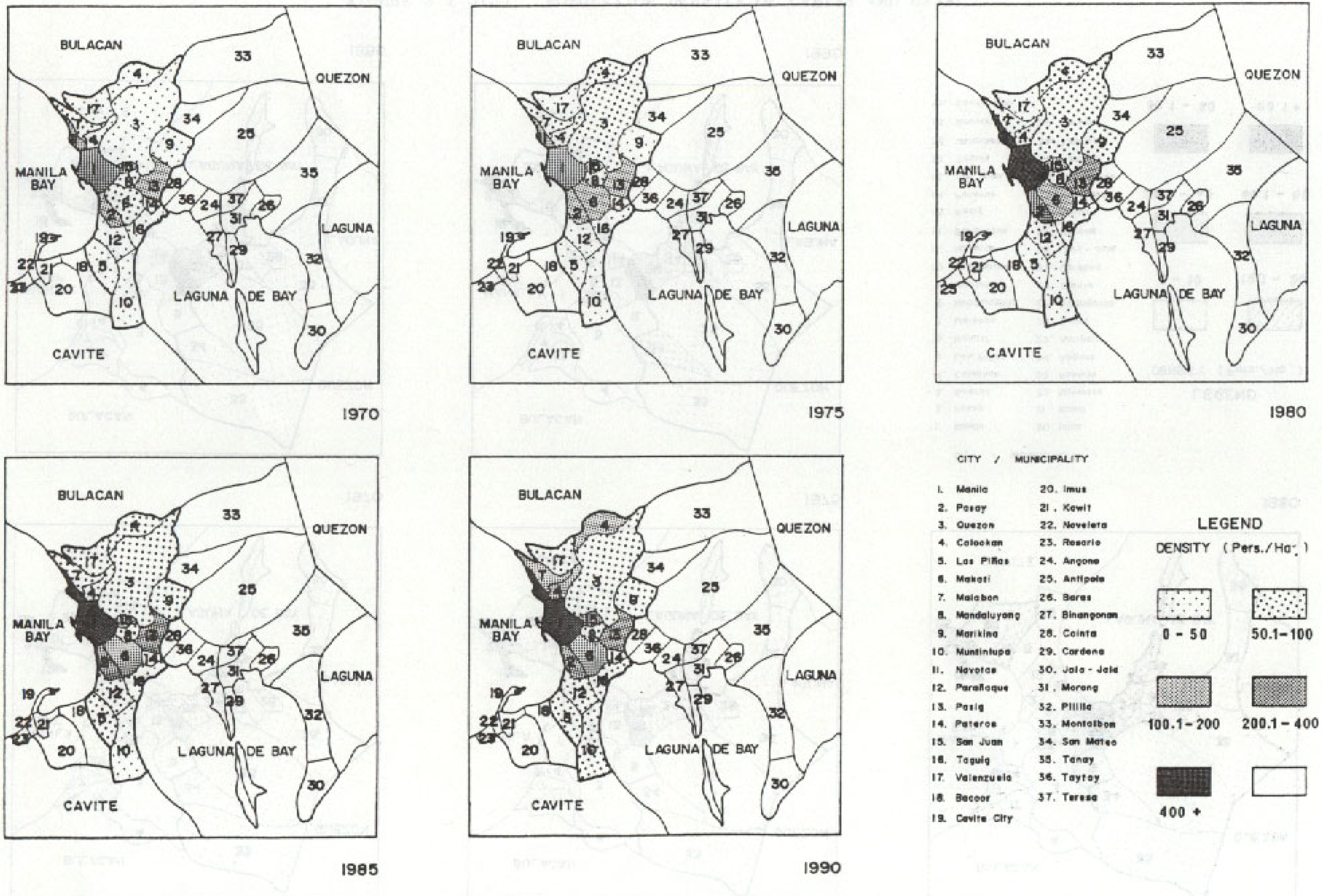


FIGURE 2.1.2(1) POPULATION DENSITY OF NCR

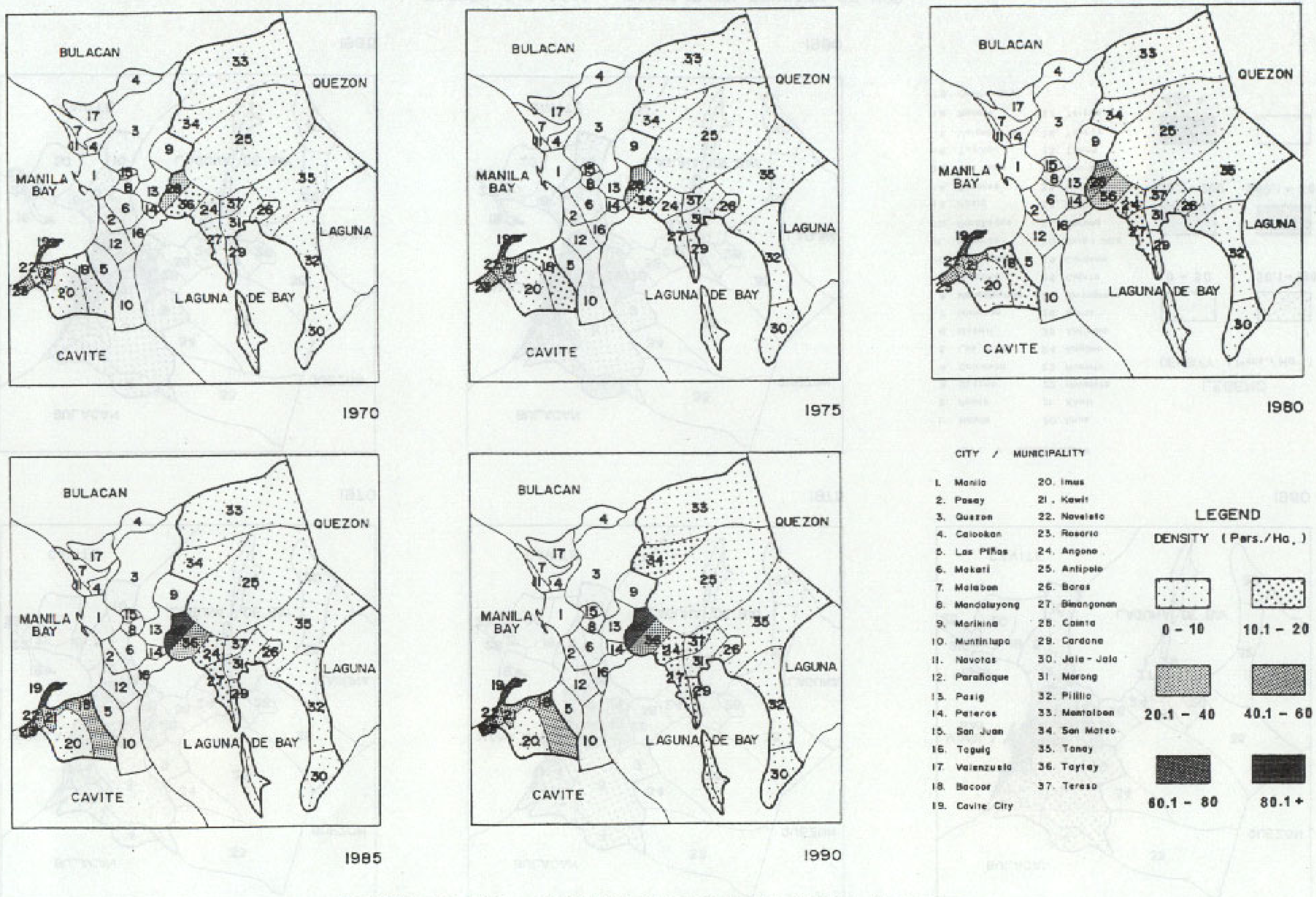
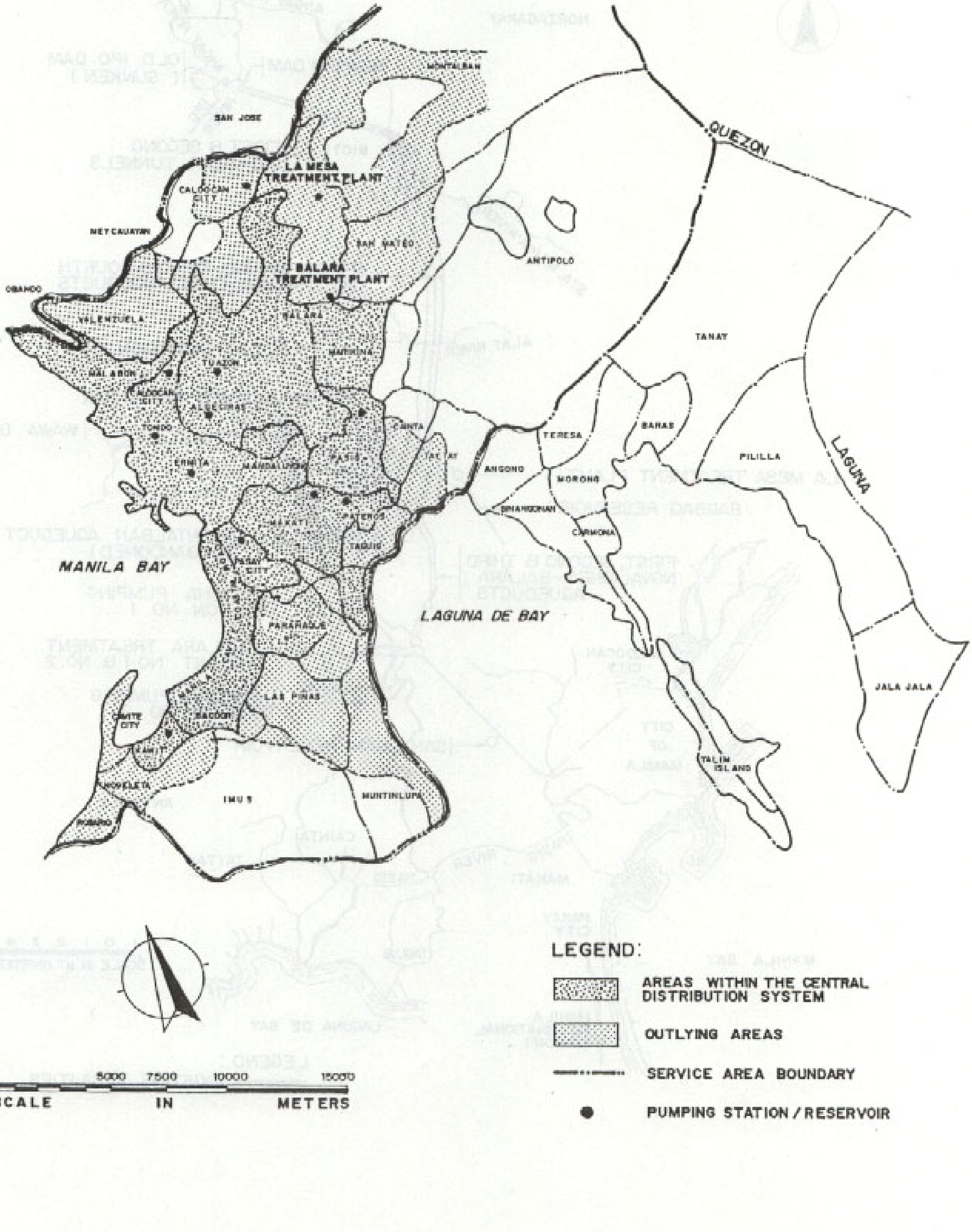
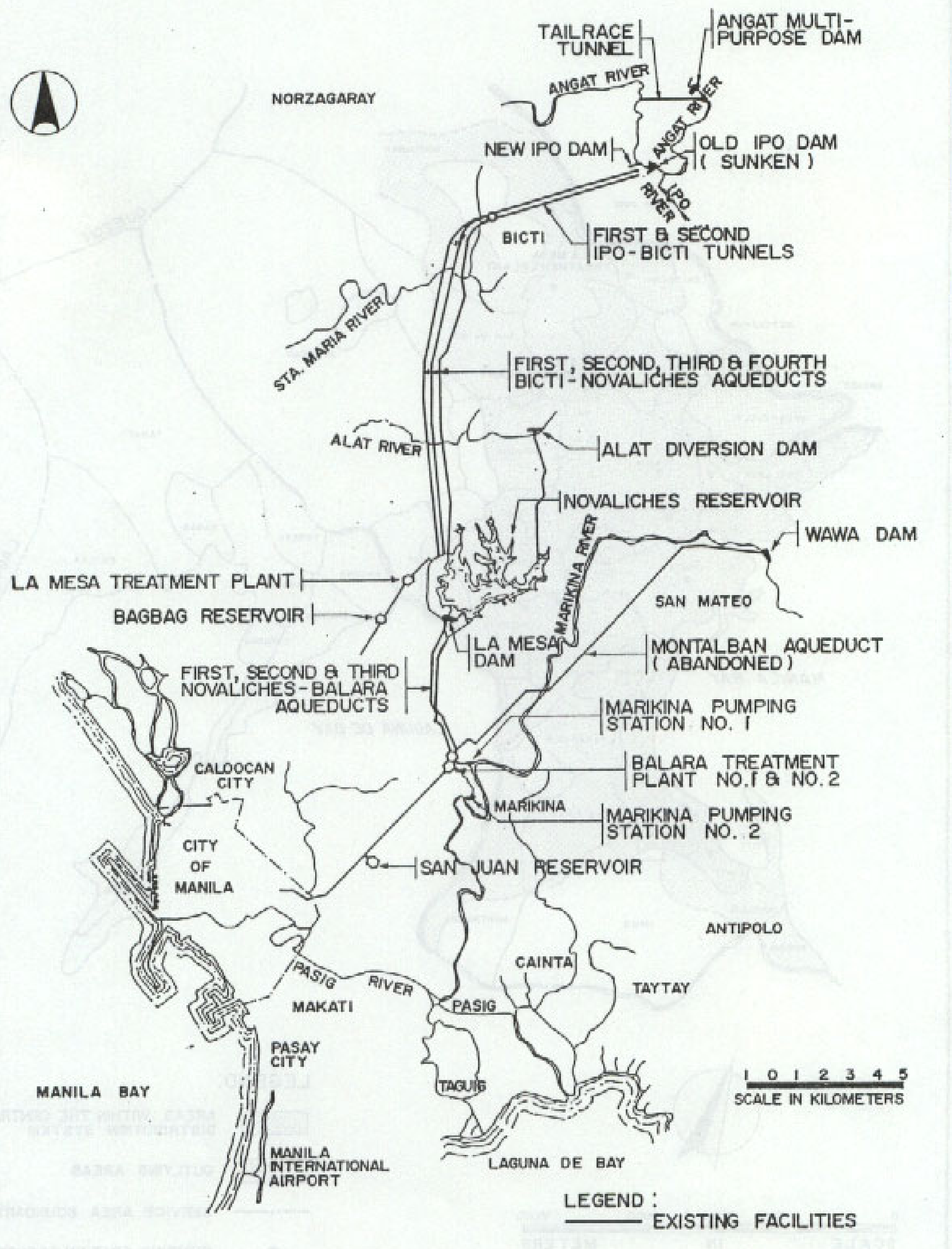


FIGURE 2.1.2(2) POPULATION DENSITY OF CAVITE AND RIZAL



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 2.2.1 PRESENT WATER SUPPLY SERVICE AREA BY MWSS



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 2.2.2
JAPAN INTERNATIONAL COOPERATION AGENCY	EXISTING AND MAJOR SUPPLY FACILITIES

CHAPTER 3 GROUNDWATER

3.1 HYDROLOGICAL ENVIRONMENT

3.1.1 Climate

The climate in the Study Area is divided into two seasons: the rainy season from May to October and the dry season from November to April. About 90 percent of annual rainfall occurs during the rainy season.

Average annual rainfall in the Study Area ranges from 1900mm to 2200mm. It is high in the eastern mountainous area, where it ranges from 2,200mm to 2,400mm, and gradually decreases from 2000mm to 1900mm westward. (See Figure 3.1.1.)

Mean monthly temperature varies from 25°C to 30°C. The coldest months are from December to February; the warmest months, April and May.

3.1.2 Topography and Hydrology

The Study Area faces Manila Bay in the west and the northern coast of Laguna de Bay in the south. The Antipolo Plateau is located in the east at an elevation of 250m. It extends in the north-south direction along Marikina Valley. The mountainous area of Montalban is located in the northeast.

Surface elevation ranges from 0m at the coast to 1400-1500m at the northeastern mountainous area. Most of the Study Area consists of coastal plains and hilly areas extending in the north-south direction along Manila Bay. Surface elevation ranges from 0-10m on the coastal plains and 20-70m on the hills.

Hydrologically, the Study Area is located within the Pasig-Laguna de Bay River Basin. This basin drains three (3) distinct and different sub-basins, namely, the Marikina River Basin, the Laguna de Bay Basin, and the urban watershed which includes the Greater Manila urban area.

Flowing east to west through central Manila is the Pasig River which is about 17 kilometers in length from the confluence of the Marikina River and Napindan Channel to Manila Bay.

Laguna de Bay is a shallow lake serving as a natural detention reservoir of discharges from the surrounding tributary streams. The lake's only outlet is via the Napindan Channel and Pasig River. The Napindan River normally flows from Laguna de Bay to Pasig, but it can and does flow in either direction, depending upon river and lake levels (Figure 3.1.2).

3.2 HYDROGEOLOGY

3.2.1 Metro Manila and Its Environs

(1) Outline of Geology

Geographically, the Study Area is situated in the southeastern part of the Luzon Central Plain and mainly constitutes the East Side Hill. The Luzon Central Plain extends in the north-south direction and faces Manila Bay in the south and the Lingayen Gulf in the north. (Refer to Figure 3.2.1.)

The plain is underlain by Alluvium, Guadalupe formation of the Pleistocene to the Pliocene age, and Neogene Tertiary system, in descending order. This sedimentary basin is named as the Luzon Central Valley Basin.

The East Side Hill ranges in the north-south direction in the east of the Luzon Central Plain at an elevation of 40-200m. It also extends from Palayan to Laguna de Bay. The hill almost coincides with the area where the Guadalupe formation is exposed. Most of Metro Manila is located on the hill.

The Southwest Luzon Upland is situated south of the Study Area. The elevation decreases towards the north. The southern piedmont area of Taal volcano is contiguous to Manila Bay and Laguna de Bay and is widely covered by thick volcanic materials and mud flows. The area constitutes a recharge zone of the lake water of Laguna de Bay and of the groundwater south of the Study Area.

South Sierra Madre presents a landform at the maturity stage with an elevation range of 300-1,500m. The area is underlain by pyroclastics, clastic rocks and limestone of Mesozoic to Neogene age and constitutes a part of the hydrogeological basement of the Study Area.

West of the Central Plain and extending north to east is the Zambales Range. This range is a mountainous region composed of volcanoes with heights of more than 1,200m. The basement of mountains consists of ultra-basic rocks. The volcanoes of the region range from north to south and form a row extending to the Bataan Peninsula, the Corregidor island, the Luzon upland and Mt. Batulao.

The volcanic row bounds the western Luzon Central Valley Basin and is considered to be a principal source of materials during the diluvial age of the sedimentary basin of the Guadalupe formation in the western part (Figure 3.2.2).

(2) Stratigraphy and Distribution

The Study Area is underlain by Kinabuan and Maybangain Formations of Cretaceous to Paleogene age, Angat and Madlum Formations of Neogene age, and Guadalupe Formation and Alluvium of Quaternary age (Figure 3.2.3).

Marikina Valley is situated at the center of the Study Area and it extends in the north-south direction. West of this valley, the Guadalupe formations and Alluvium underlie the area. In the east, the area is underlain by all the formations mentioned above.

(3) Geologic Formations as Aquifers

Consolidated clastic and volcanic rocks are deemed to be relatively impermeable. Weathered parts and fissure zone of rocks form an aquifer. However, most of these rocks yield very poor water or form aquifuges.

Clastic facies, such as tuffaceous sandstone, conglomerate and coarse tuff of Guadalupe formation form good aquifers in the Study Area. The Guadalupe formation distributes separately into three sedimentary basins. Each basin is surrounded by impermeable base rocks and forms isolated groundwater basin.

The Guadalupe Sedimentary Basin forms a part of the Luzon Central Valley Basin. Most of Metropolitan Manila is located in this latter basin. It is covered by Alluvium in the coastal areas of Manila Bay and the Marikina Valley. Generally, the strata gently dip westward in the east of the basin. The thickness of Guadalupe formation is also estimated to be more than 2,000m (3.2.4).

Antipolo Plateau is a small sedimentary basin surrounded by impermeable base rocks. Its center is in the town of Antipolo. The plateau forms a groundwater basin having an area of about $30km^2$ and contains exploitable water, quantity- and quality-wise. The thickness of the formation is about 230m.

North of the plateau, the Guadalupe formation forms a small sedimentary basin overlying the basaltic rocks of the Kinabuan formation.

The Alluvium is mainly composed of soft clay and thin loose sand and is distributed in the coastal areas of Manila Bay and Laguna de Bay, the Marikina Valley and the intramountain basins in the eastern mountain-area. The Alluvium forms a phreatic aquifer; however, water is salinized in the coastal area.

3.2.2 Antipolo Plateau

The Guadalupe formation may be divided into four members. The lowermost member, member I, consists of conglomerate and coarse sandstone and underlies the north of the plateau. Member II has two parts. The lower part is composed of consolidated medium sandstone and conglomerate while alternating beds of tuffaceous mudstone and sandstone compose the upper part. This member crops out at the steep cliff in the east of the plateau. Member III consists of alternating beds of mudstone and tuff. It covers the central area of the plateau. Member IV consists of deeply weathered tuff breccia and volcanic conglomerate. It overlies the north of the plateau (Figure 3.2.5).

The basement of Antipolo Plateau is composed of hard rocks of Pre-Neogene age. The basin is shaped like a ship-bottom with a depth-range of 180 to 230m at the center. The basement rocks are exposed in the east, west, and north of the plateau, in fault contact or unconformity with the Guadalupe formation. A number of springs are found along the marginal zone of the plateau, with water being discharged from the plateau.

Basing on JICA test wells and electric resistivity survey, hydrogeologic units can be defined as upper Gs and lower Gmd in terms of rock facies, formation resistivities and transmissivity values of the formations. Gs is mainly composed of coarse sandstone and tuff of member III and forms a fairly good confined aquifer. Its thickness is 100-120m. Gmd is mainly composed of tuffaceous mudstone of member II and forms an aquitard or aquifuge.

The Guadalupe formation is weathered at depths of 30-50m from the surface. The weathered unit contains unconfined water or perched water. From the flow condition of the spring, the Antipolo Plateau is considered to constitute an isolated groundwater basin (Figure 3.2.6).

Elevation of the water table at the center of Antipolo Plateau ranges from 160m to 170m, with groundwater level at about 30m to 40m below ground surface. A groundwater mound can be seen in the southern and eastern parts of the plateau. However, the water table becomes rather low at the center of the poblacion where it gradually descends westward.

The hydraulic gradient of the water table is steep in areas where escarpments are formed. These areas are located in the northeastern, eastern and southwestern edges of the plateau, at a relative height of about 200m. The hydraulic gradient of the water table in these places is steep such that the groundwater is discharged from the basin.

3.2.3 Las Piñas

The Las Piñas area is a flat land with an elevation range of 0-10m. It is located at the mouth of the Zapote and Las Piñas Rivers. Old rivers and marine ponds are found in this area. An alluvial plain extends inland at about 1.5-2.0km from the coast. A gently undulating hill is situated behind this plain at an elevation of 20-40m.

The lowland is covered by the Alluvium which is composed of sand and clay. The Guadalupe formation is exposed in the previously said undulating hill and is composed of alternating beds of sandstone, conglomerate, mudstone and tuff. The strata have strikes parallel to the coastal line and incline towards Manila Bay at 3-5 degrees. The thickness of the Guadalupe Formation possibly reaches to more than 2,000m.

In order to clarify the hydrogeology and saline water intrusion in Las Piñas, core borings and test well drillings were carried out. The thickness of Alluvium is less than 10m. The rest of the strata belongs to the Guadalupe Formation which is composed of tuffaceous silt, fine sand and medium to coarse sand. Significant thickness of clayey sediments that form the confining layer (CL) was traced at depths of about 60m to 90m. Four characteristic pumice-bearing layers (PM) occur at depths below 100m. These layers can be traced horizontally in the Las Piñas area (Figures 3.2.7 and 3.2.8).

The Guadalupe formation which is about 300m in thickness can be roughly divided into two aquifer units. The first aquifer has a thickness of about 60m and is confined. Since groundwater is highly salinized, no existing deep well taps this aquifer. The second aquifer has a thickness of more than 200m and is also confined. Existing deep wells have their screen sections at this aquifer. The CL--the first aquitard--particularly has an important role in saline water intrusion because of the high salinity of the first aquifer.

Groundwater level varies from aquifer to aquifer. Water levels of Las Piñas 100m-test wells are 4.6m and 3.7m for No.1 and No.2, respectively. In contrast, water levels of two 200m-test wells are 37.3m for No. 1 and 43.4m for No. 2. Water levels of 300m-test wells are 44.5m (No. 1) and 50.0m (No. 2), a little lower than those of 200m-test wells, indicating that groundwater is mainly pumped from the second aquifer.

The marked drop of the piezometric surface at the second aquifer to 60m below sea level near Pamplona points to the heavy pumping in this area as cause for the decline in piezometric head. Regional groundwater flows towards the depression in Pamplona, from the first aquifer towards the second aquifer through downward leakage.

3.3 GROUNDWATER USE

The total number of inventoried private deepwells in MSA is 3,434; of which, 2,216 were estimated as operational and 1,218 as abandoned wells. Private wells are concentrated in Parañaque, Las Piñas, Muntinlupa, Pasig, Quezon City, Caloocan City and Valenzuela.

Of the 258 MWSS-supervised wells, only 131 wells were active as of March 1991.

A groundwater use survey was conducted in the Study Area so that the average annual pumpage of private deep wells may be estimated. These wells were classified in terms of usage, area, and specific capacity. Of the 1063 sample-wells visited, only 542 were found valid for the estimation.

Pumpage of MWSS-supervised wells was determined using year-1990 pumping records.

The combined total withdrawal in 1990 was estimated at 339.6 MCM (private: 306.8 MCM; MWSS: 32.8 MCM). In terms of usage, the distribution was 26.34 MCM for commercial; 129.54 MCM for industrial and 150.97 MCM for public and institutional (Figure 3.3.1).

3.4 GROUNDWATER LEVELS

Three sets of simultaneous observations of groundwater levels of 231 deepwells were carried out in November 1990, April-May 1991 and August 1991. Groundwater contour maps were then prepared from the measurements (Figures 3.4.1 (1) and (2)).

The piezometric surface is higher in northern Caloocan City (from 20m to 60m above Mean Sea Level (MSL)) and in southern Bacoor and Imus (from 10m to 50m above MSL). However, a greater portion of Metro Manila has the piezometric surface below MSL: -70m to -80m in Las Piñas and Parañaque; -50m to -60m in Pasig and Quezon City; and -110m in Valenzuela.

The piezometric surface reveals that groundwater in the northern part of Metro Manila is flowing southward and westward, and in the southern part, northward. Both parts have groundwater flowing to areas of heavy pumpage, i.e., where the piezometric surface is below MSL. It also shows that Manila Bay and Laguna de Bay are recharging the depressions on their coastal areas.

Comparing the piezometric condition in 1981 and 1991, it may be noted that water levels have recovered at a maximum of more than 80m in the central part of Metro Manila, i.e., Manila, Makati and Mandaluyong (Figure 3.4.1 (3)). This recovery is considered as an outcome of the reduced pumpage arising from the completion of Manila Water Supply Project II (MWSP II).

The year-1991 fluctuation in Metro Manila of water levels between the dry and wet seasons indicates a rise of about one to six meters in the north sector and two to four meters in the south sector. In most of Metro Manila, however, water level was continuously declining due to pumping.

3.5 RECHARGE ANALYSIS

Direct recharge from rainfall over the Antipolo Groundwater Basin and the entire Study Area was estimated based on the following equation:

$$P = R + E + I$$

where, P: mean annual rainfall; R: runoff; E: evapotranspiration; and I: effective infiltration, all in mm.

The estimate of the direct recharge in the Antipolo basin is as follows.

Annual rainfall	:	2,720.8
Runoff	:	1,142.7
Evapotranspiration	:	958.8
Recharge	:	619.3 (23% of annual rainfall)

The estimate of the direct recharge over the Study Area had the present land use condition considered. It is as follows.

Annual rainfall	:	2,329.7
Runoff	:	1,397.8
Evapotranspiration	:	816.6
Recharge	:	115.3 (4.9% of annual rainfall)

The direct recharge over the Study Area is about 153.6mm (6.1% of 2498.8mm annual rainfall) and 114.7mm (5.0% of 2308.2mm annual rainfall) at its northern and southern parts.

3.6 AQUIFER PARAMETERS

The transmissivity and specific capacity maps (Figure 3.6.1) were prepared based on existing pumping test data plus those obtained from pumping tests conducted at MWSS deepwells. The average value of the transmissivity in the Metro Manila area is 58.3 m^2/d, with a range of 50 m^2/d to 100 m^2/d. High transmissivity zones are found in the coastal areas of Manila Bay, Laguna de Bay and Marikina Valley.

3.7 GROUNDWATER QUALITY

A total of 90 water samples were collected from operational deepwells. Seven major ions (Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3, SO_4) were analyzed and plotted on the key diagram. (Refer to Figures 3.7.1 and 3.7.2.)

Most of the samples from the coastal area were plotted on domains III (carbonate alkali) and IV (noncarbonate alkali) of the diagram. Samples in domain IV are salinized and contain more than 200 mg/l of chloride. In two JICA 100m-test wells in Las Piñas, chloride concentration was extremely high and reached more than 17,000 mg/l. Samples in domain III are not salinized. Their chemical composition is thought to change from II to III along flow paths.

Samples from Guadalupe Hill were plotted on domains II (carbonate hardness) and III. They may have evolved geochemically from domain II. Chloride and sulfate concentrations of these samples are low and amount to less than 50 mg/l, suggesting groundwater of the Guadalupe aquifer in the hill to be not contaminated yet by saline water.

Samples from Marikina Valley were plotted on all the domains from I to IV. Two samples plotted on domains I and IV are remarkable. Chloride concentration of these samples show more than 140 mg/l. They are possibly contaminated by connate saline water contained in the deep aquifers.

All samples from the Antipolo Plateau were plotted on domain II. Surface water samples taken from Wawa Dam also belong to domain II. The chemical component of groundwater in the plateau is similar to that of surface water. Cation and anion characteristics of groundwater suggest that it has not been long since rain infiltrated through the soil into the aquifer system.

The groundwater quality of the Guadalupe aquifer is considered as originally belonging to domain II, but due to the saline water intrusion particularly in the coastal area, this quality was altered to the non-carbonate alkali type.

In Marikina Valley, connate water migrates into the shallow aquifer due to upconing.

3.8 SALINE WATER INTRUSION

Saline water intrusion of coastal areas in Metro Manila has been already observed in the late 1960s. Areas where saline water intruded were observed in Parañaque, in parts of Las Piñas and Cavite along Manila Bay, in Muntinlupa, in Pateros areas along Laguna de Bay and in parts of Cainta located downstream of the Marikina River.

Comparing the distribution of electric conductivity (EC) for years 1981 and 1991, a reduction of the saltwater intruded areas in Manila and Malabon may be noted. This reduction could be a result of the recovery of the groundwater level, which in turn was caused by the conversion of water source from groundwater to surface water. However, in an inland area within a few kilometers from the coast of Las Piñas and Bacoor, saline water has intruded (Figures 3.8.1 (1) and (2)).

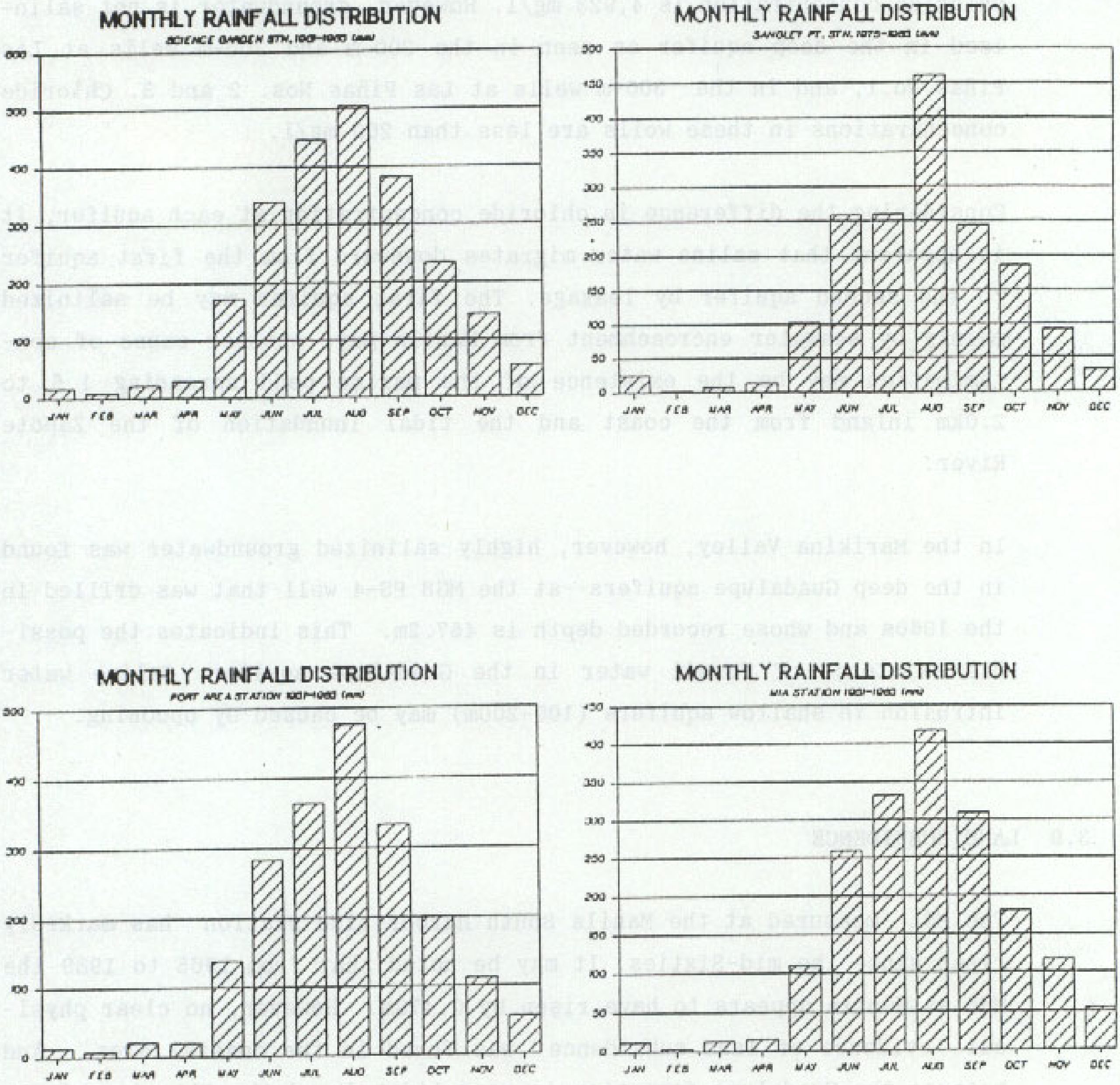
Electric conductivity and chloride concentration of the groundwater at the Las Piñas test wells show different values from aquifer to aquifer. At 100-m wells, Nos.1 and 2, high chloride concentrations of 17,144 mg/l and 21,100 mg/l were found. At the 200-m well at Las Piñas No.2, chloride concentration is 4,923 mg/l. However, groundwater is not salinized in the deep aquifer as seen in the 200-m and 300-m wells at Las Piñas No.1, and in the 300-m wells at Las Piñas Nos. 2 and 3. Chloride concentrations in these wells are less than 200 mg/l.

Considering the difference in chloride concentration at each aquifer, it is apparent that saline water migrates downward from the first aquifer to the second aquifer by leakage. The first aquifer may be salinized mainly by seawater encroachment from Manila Bay. Another cause of contamination may be the existence of the marine pond spreading 1.5 to 2.0km inland from the coast and the tidal inundation of the Zapote River.

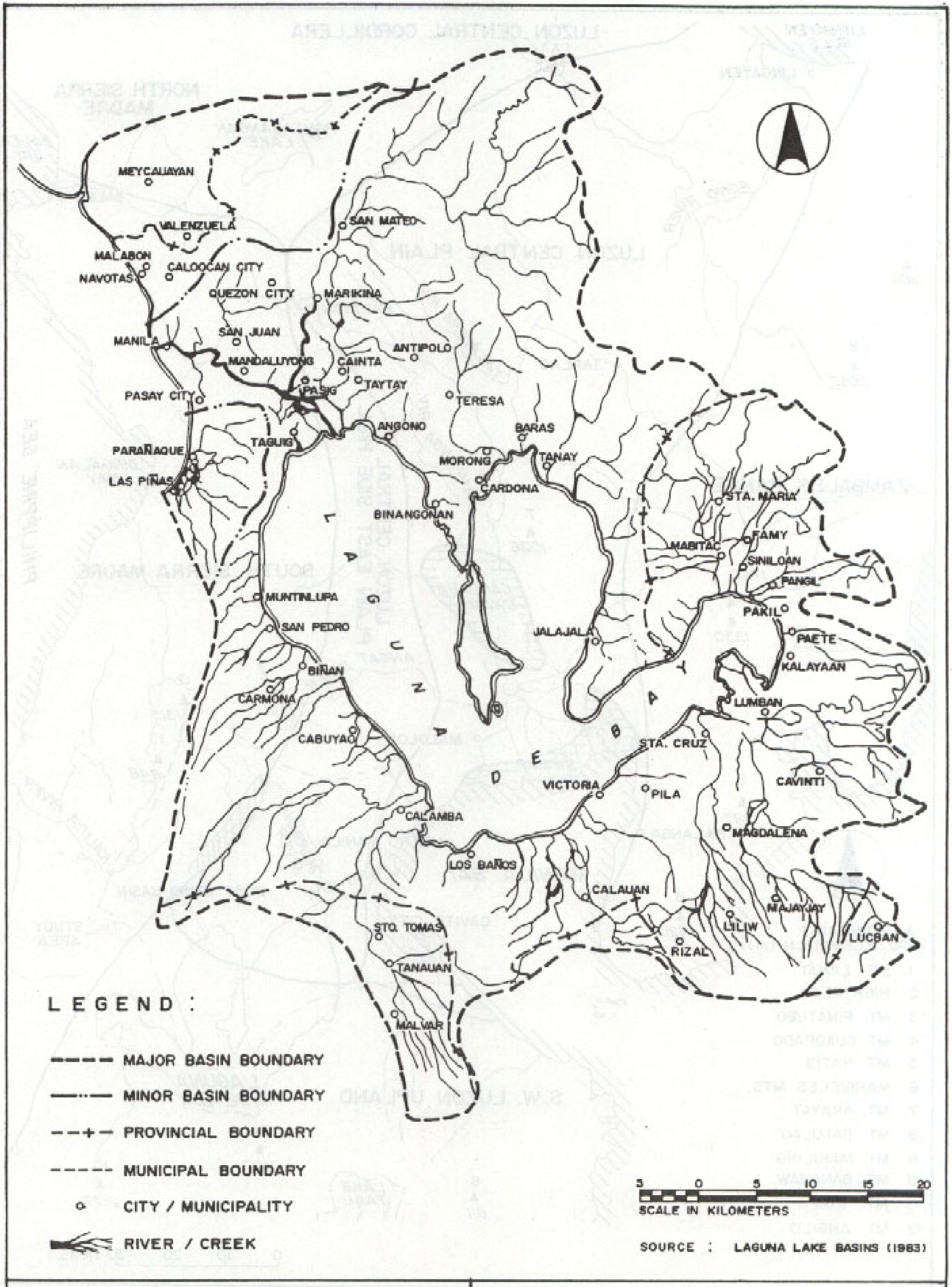
In the Marikina Valley, however, highly salinized groundwater was found in the deep Guadalupe aquifers--at the MGB PS-4 well that was drilled in the 1960s and whose recorded depth is 457.2m. This indicates the possible existence of fossil water in the Guadalupe aquifer. Saline water intrusion in shallow aquifers (100-200m) may be caused by upconing.

3.9 LAND SUBSIDENCE

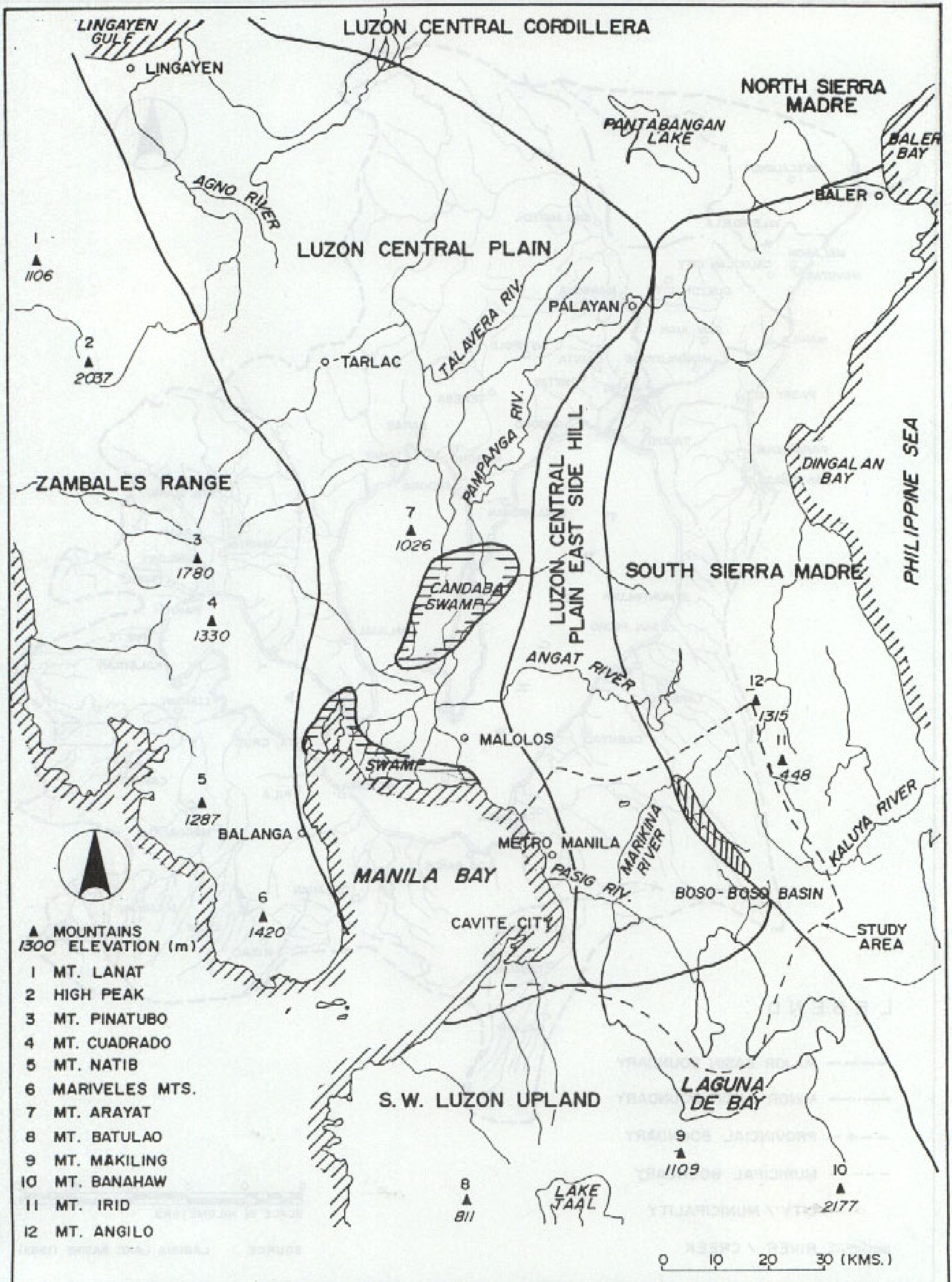
The MSL measured at the Manila South Harbor tide station has markedly risen since the mid-Sixties. It may be noted that from 1965 to 1989 the MSL at Manila appears to have risen by 0.478m. However, no clear physical evidence of land subsidence was found in the coastal area. And because the Guadalupe formation is consolidated and the Alluvium clayey bed is thin, the probability of land subsidence occurring in this area is nil. Obtaining clear evidence of land subsidence therefore requires periodical regional leveling in Metro Manila.



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 3.1.1
JAPAN INTERNATIONAL COOPERATION AGENCY	MONTHLY RAINFALL DISTRIBUTION



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 3.1.2
JAPAN INTERNATIONAL COOPERATION AGENCY	DRAINAGE MAP

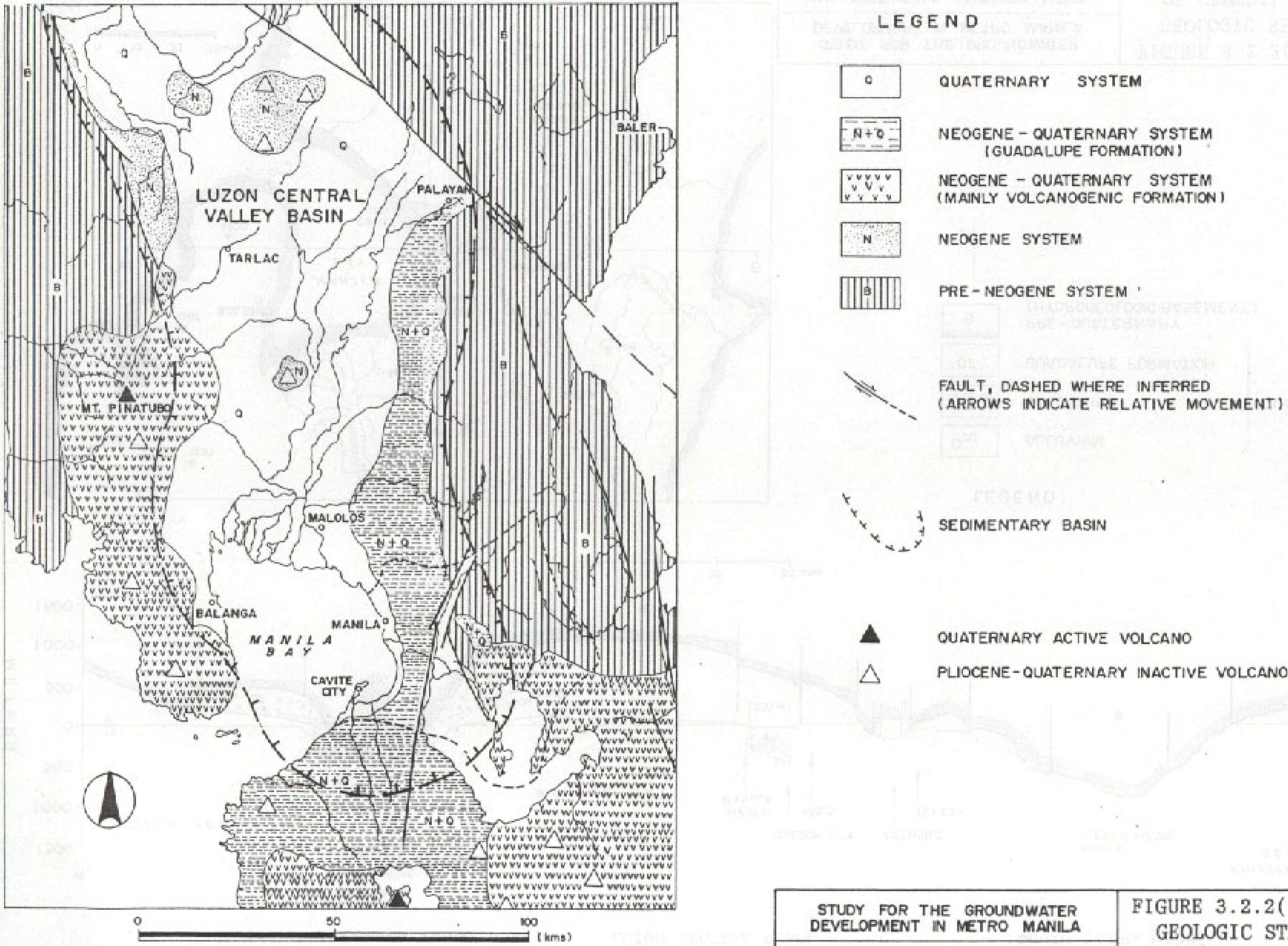


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

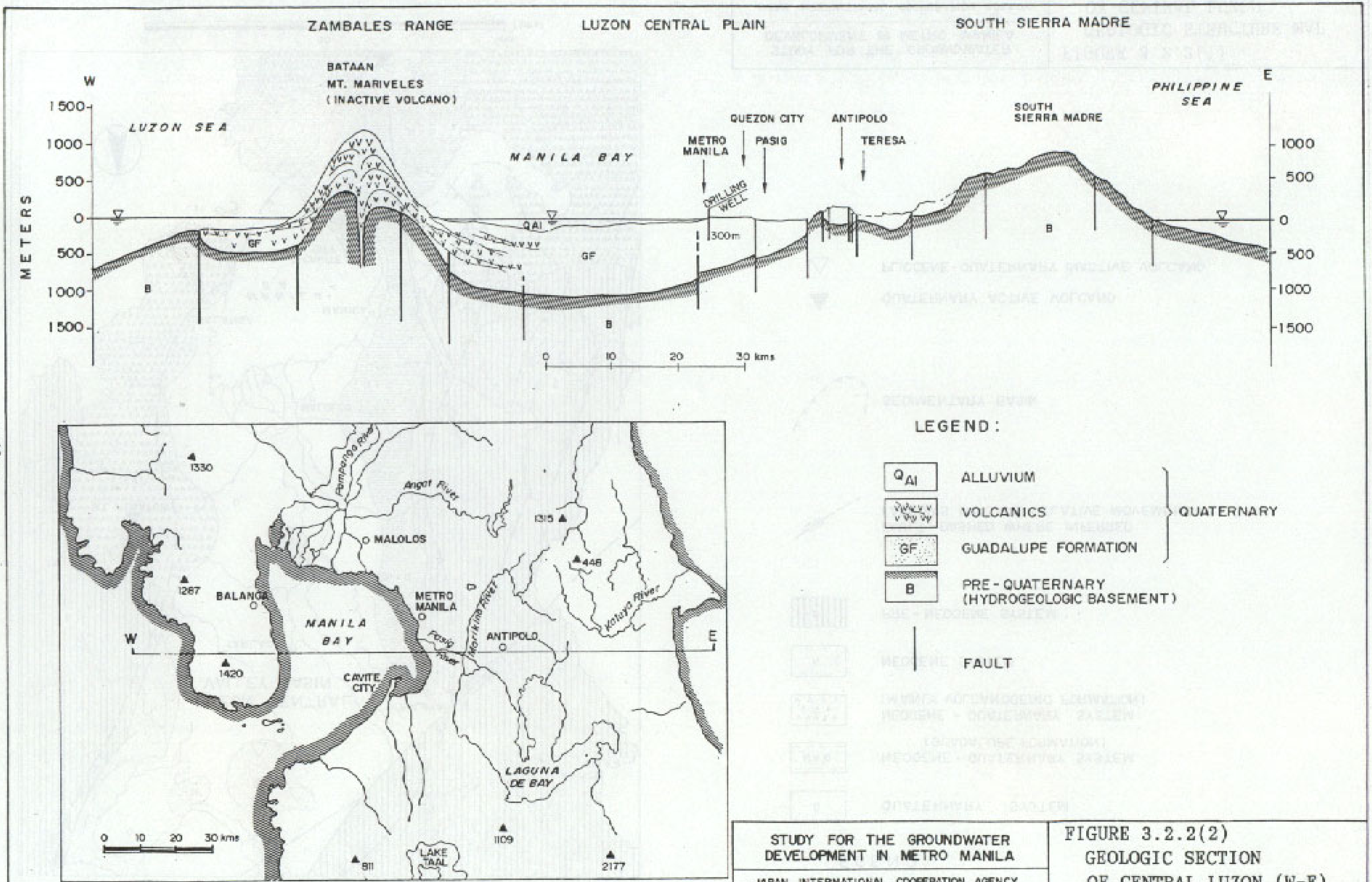
JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 3.2.1

PHYSIOGRAPHIC PROVINCES OF CENTRAL LUZON



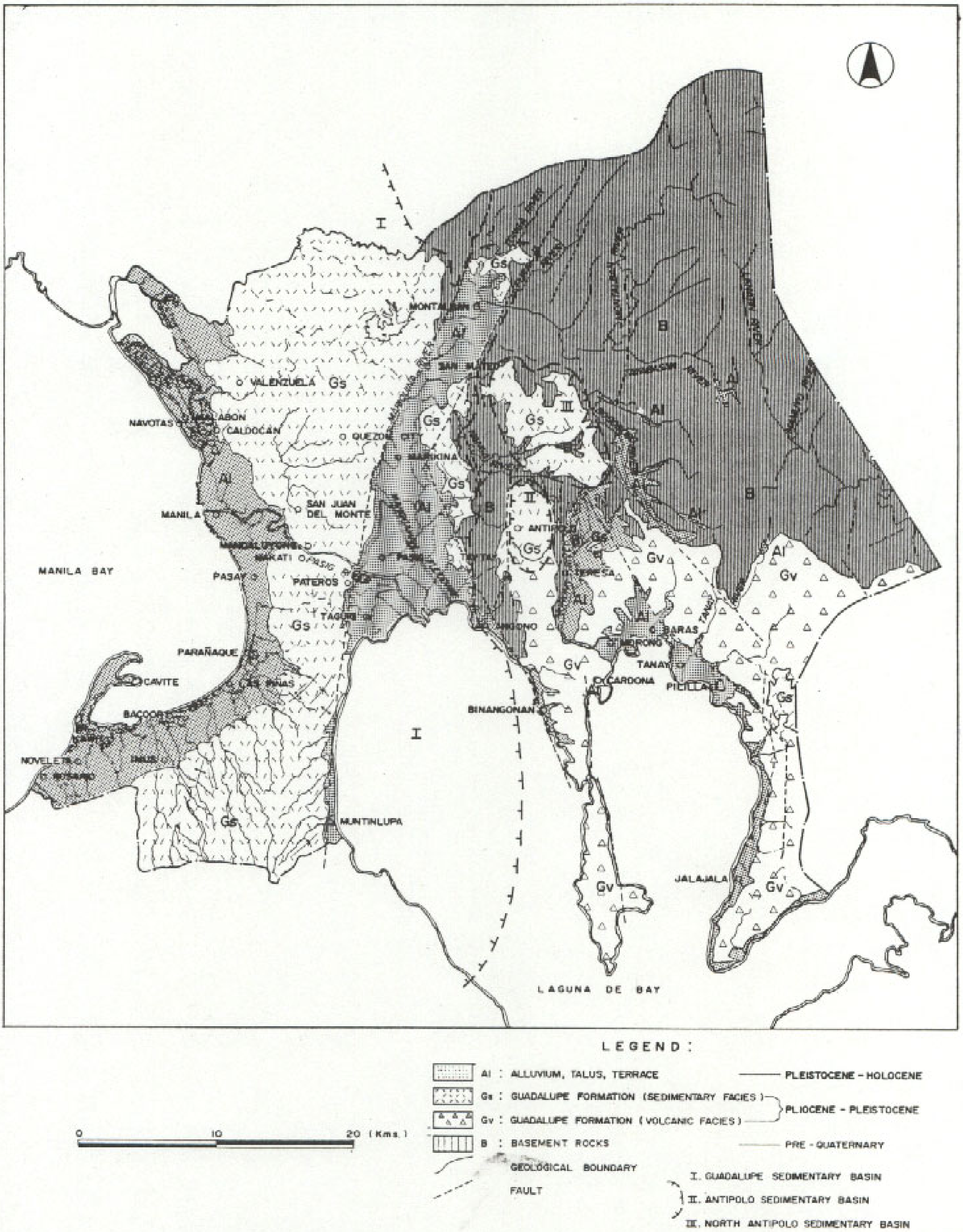
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 3.2.2(1) GEOLOGIC STRUCTURE MAP OF CENTRAL LUZON
JAPAN INTERNATIONAL COOPERATION AGENCY	



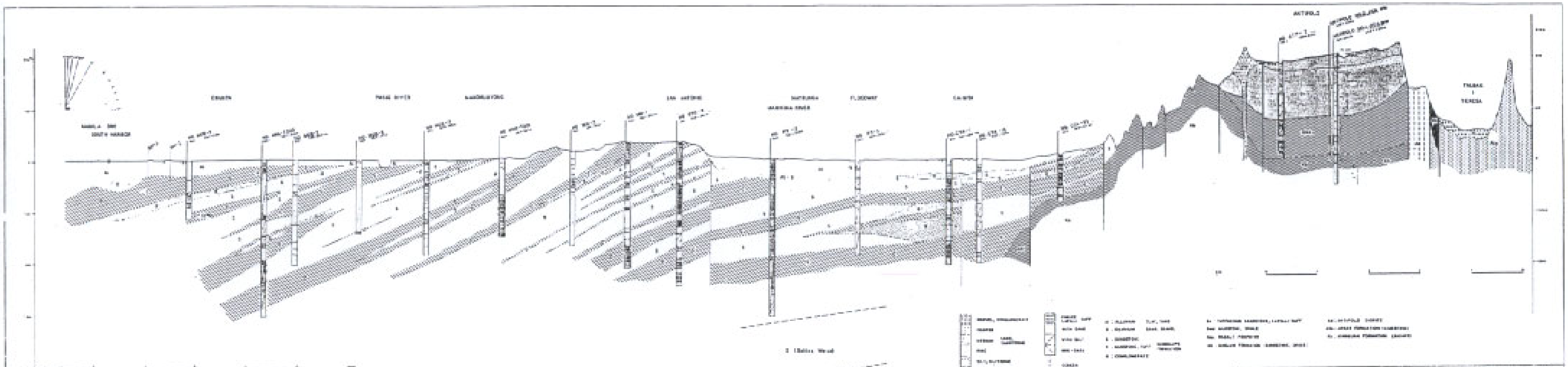
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 3.2.2(2)
GEOLOGIC SECTION OF CENTRAL LUZON (W-E)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 3.2.3
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMPLIFIED GEOLOGIC MAP -STUDY AREA-



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 3.2.4 GEOLOGIC PROFILE (MANILA W -ANTIPOLO E)

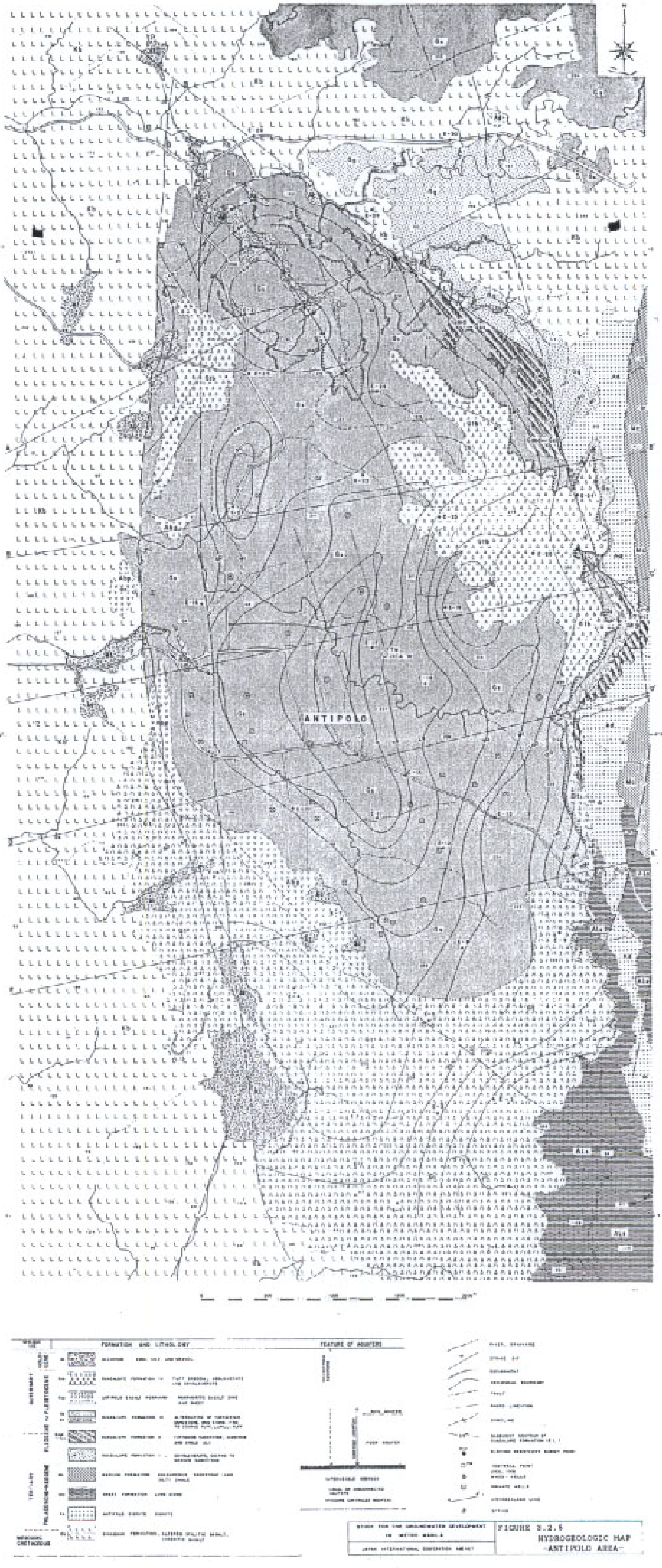
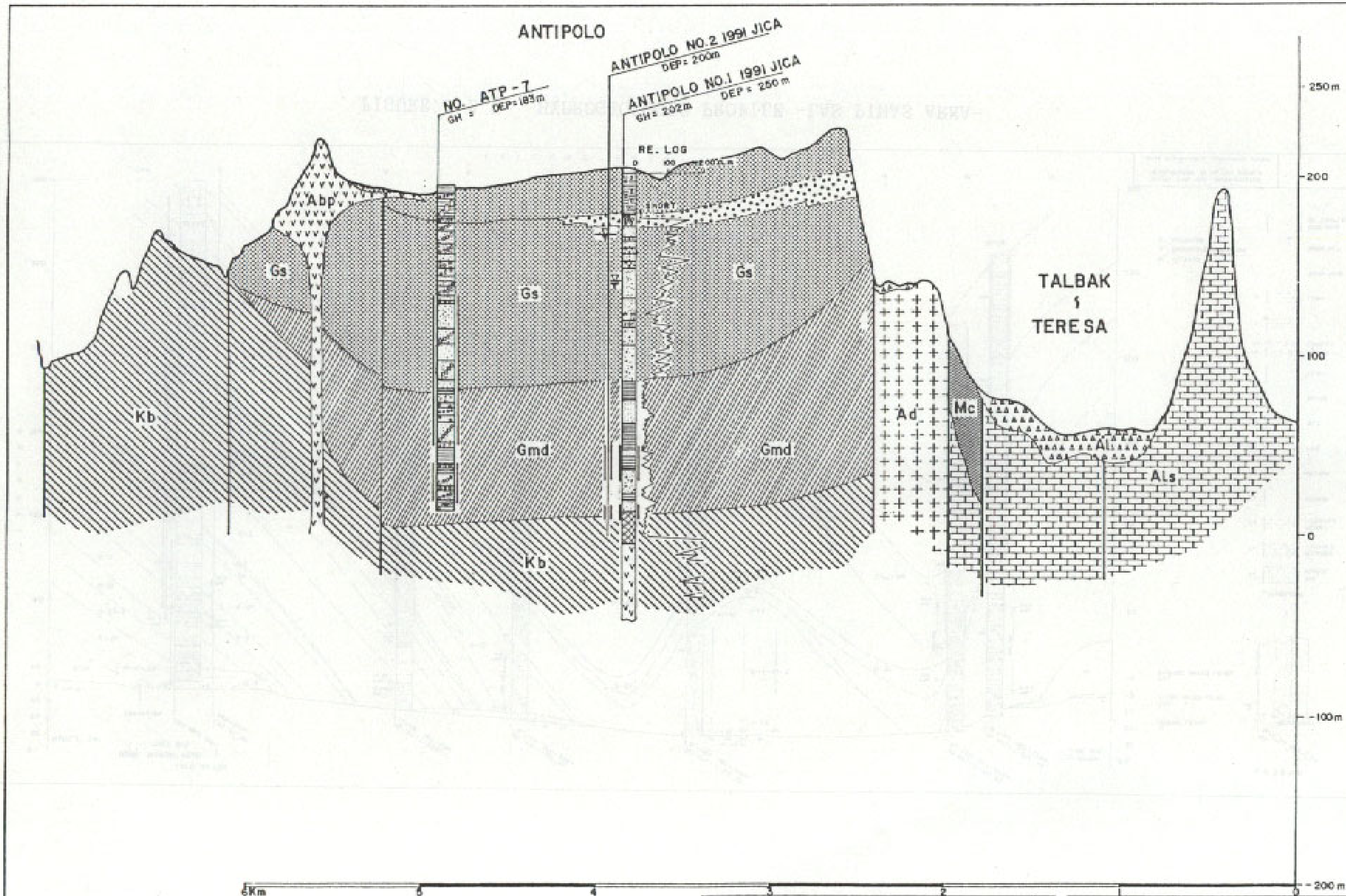


FIGURE 3.2.5
HYDROGEOLOGIC MAP
-ANTIPOLO AREA-



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 3.2.6 HYDROGEOLOGIC PROFILE -ANTIPOLO AREA-
JAPAN INTERNATIONAL COOPERATION AGENCY	

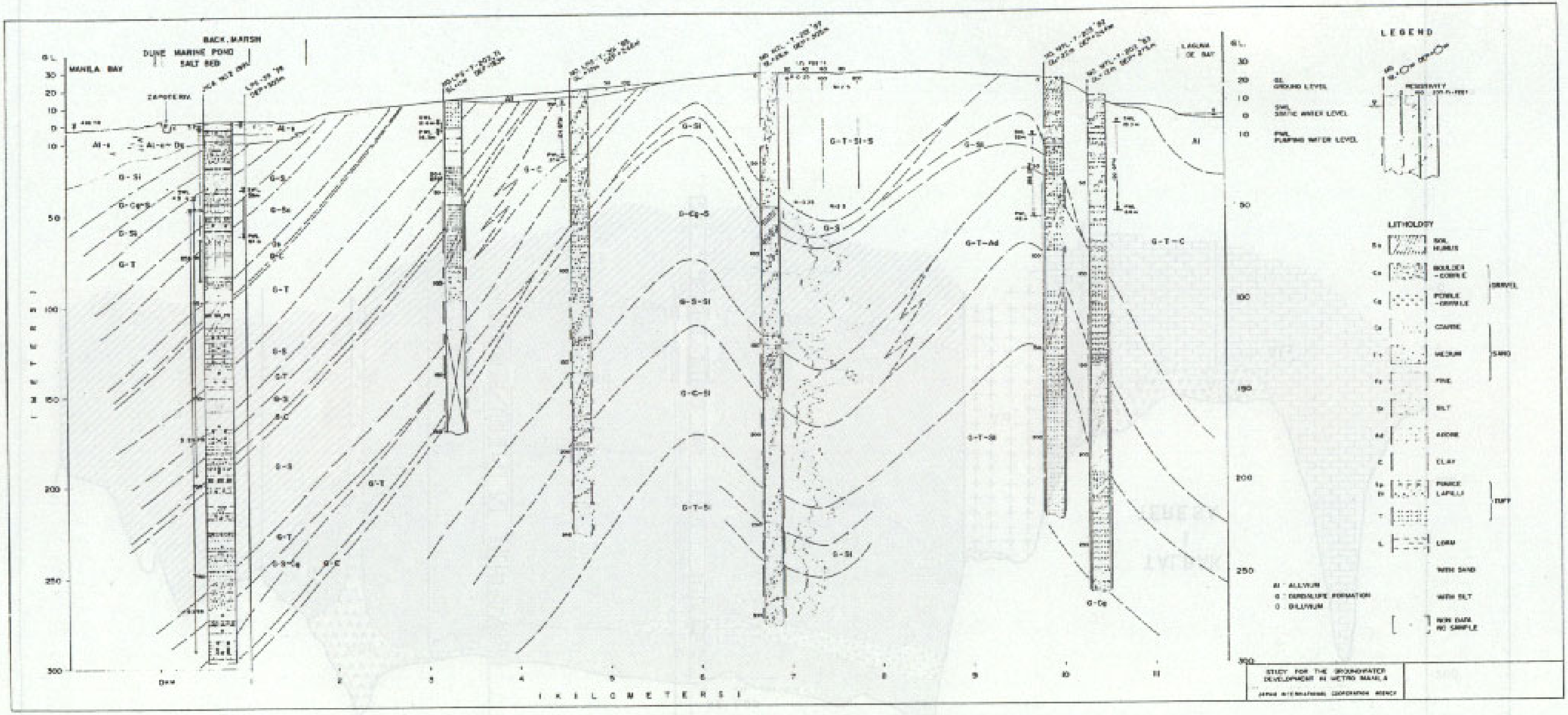
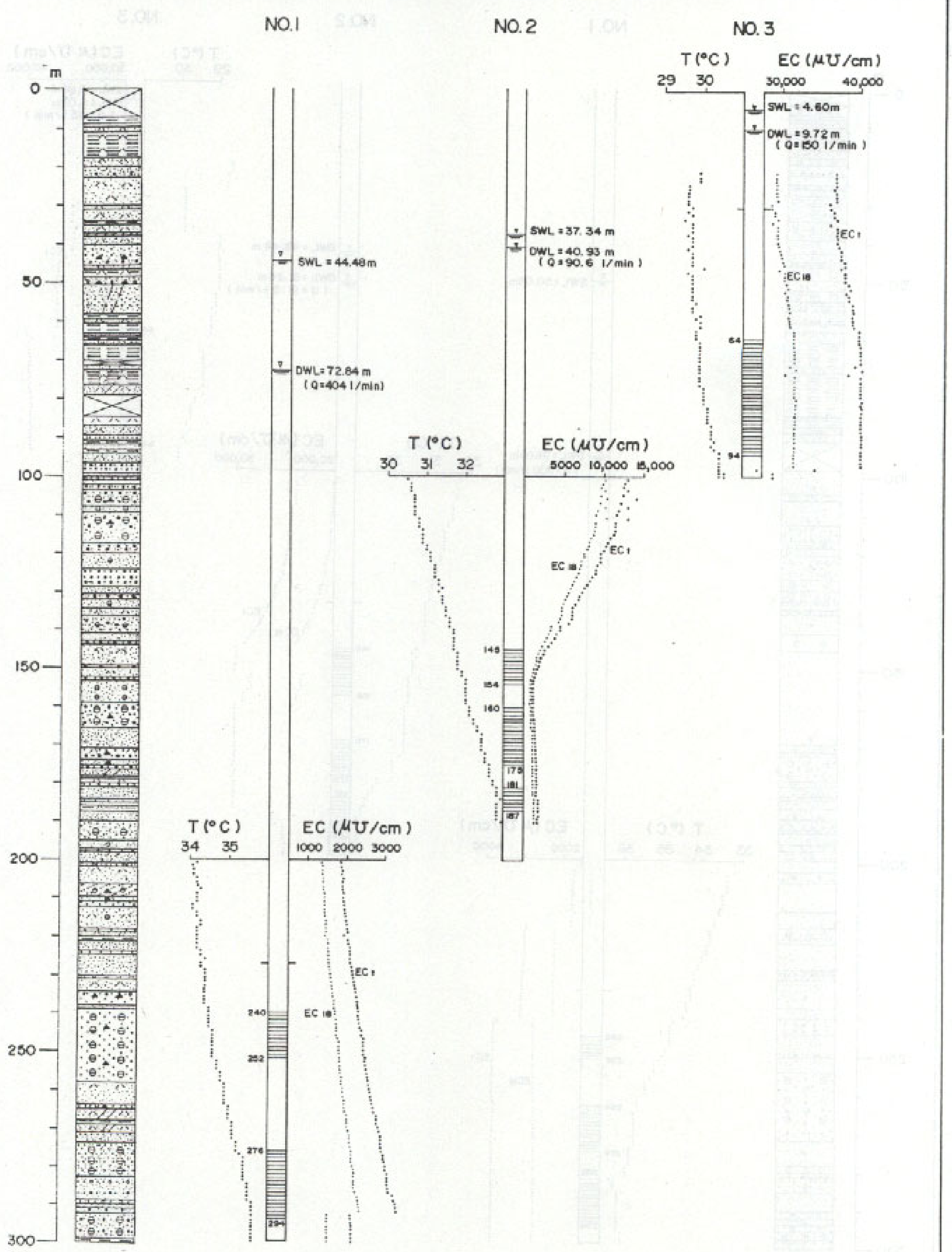


FIGURE 3.2.7 HYDROGEOLOGIC PROFILE -LAS PINAS AREA-



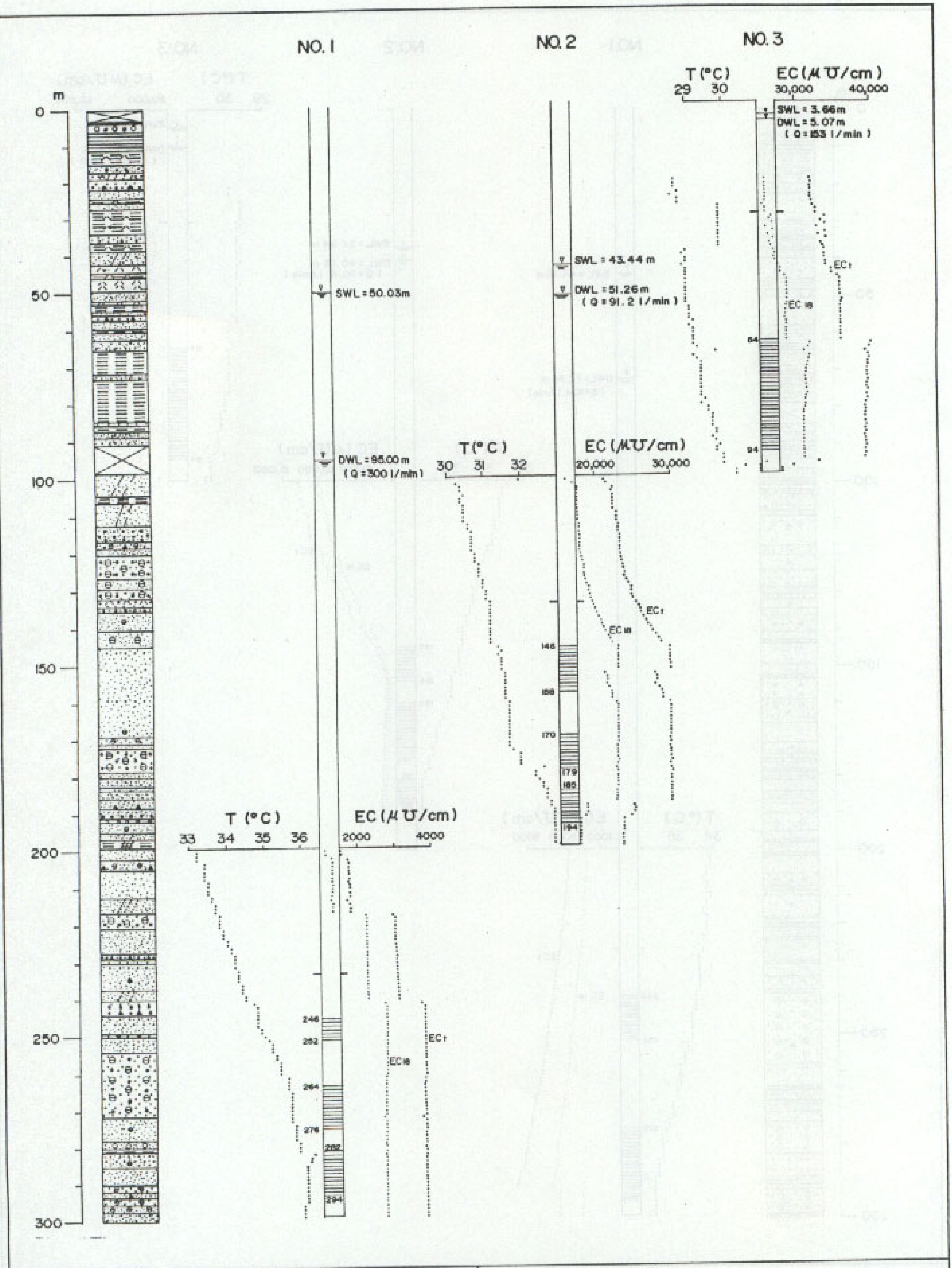
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 3.2.8(1)

TEMPERATURE AND EC LOGS AT SITES NO.1

-LAS PINAS AREA-

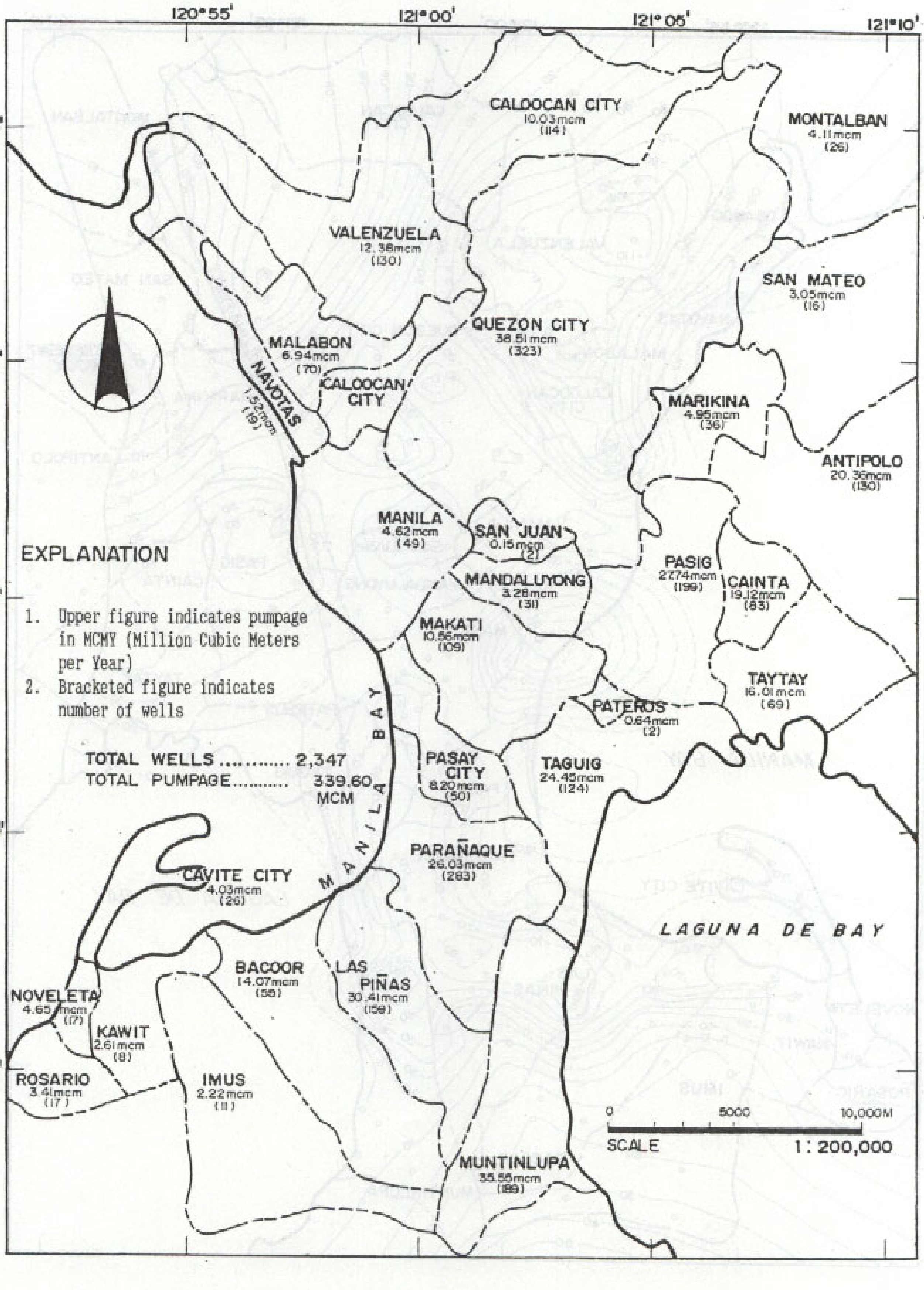


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 3.2.8(2)

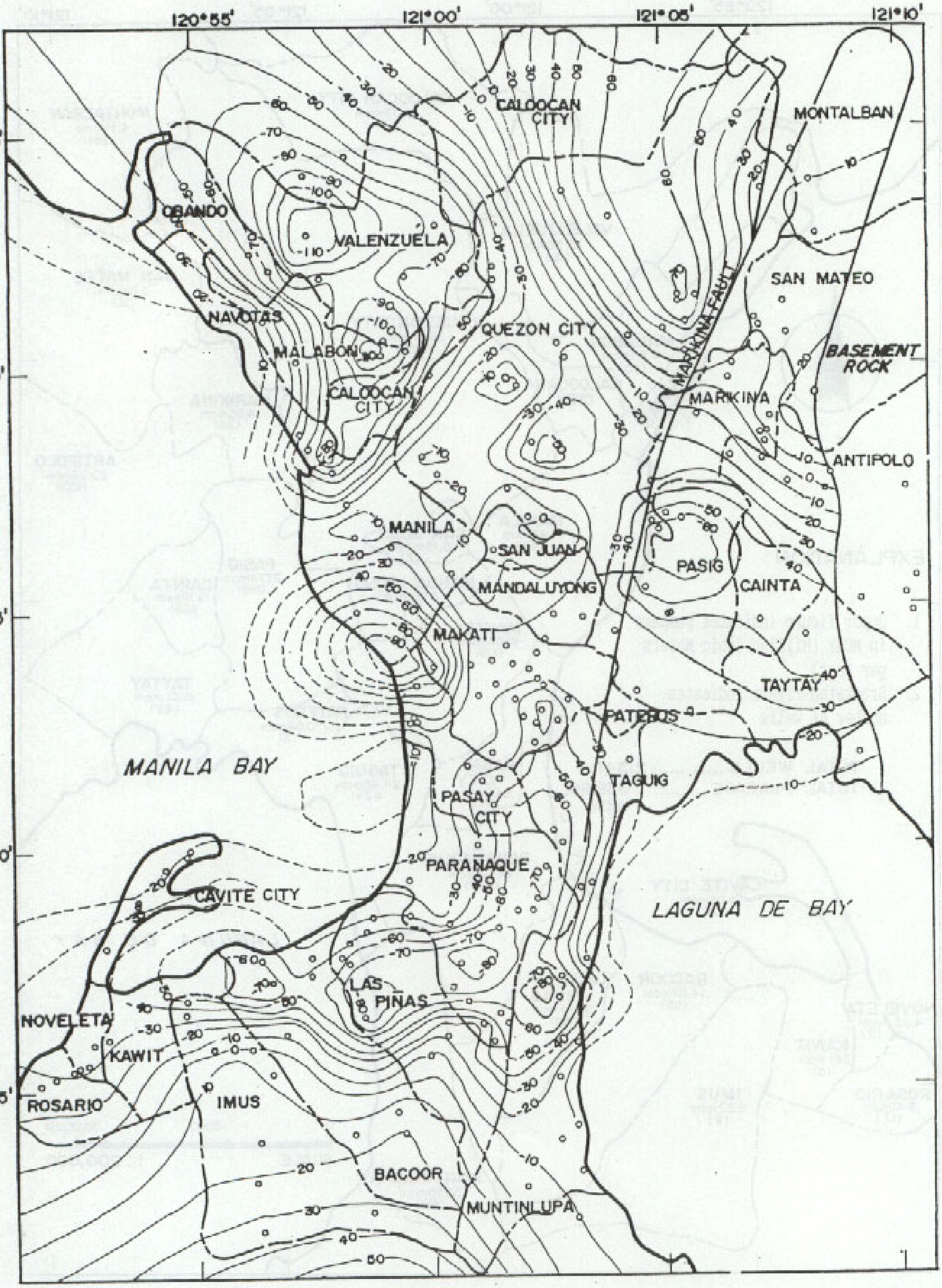
TEMPERATURE AND EC LOGS AT SITES NO. 2 -LAS PINAS AREA-



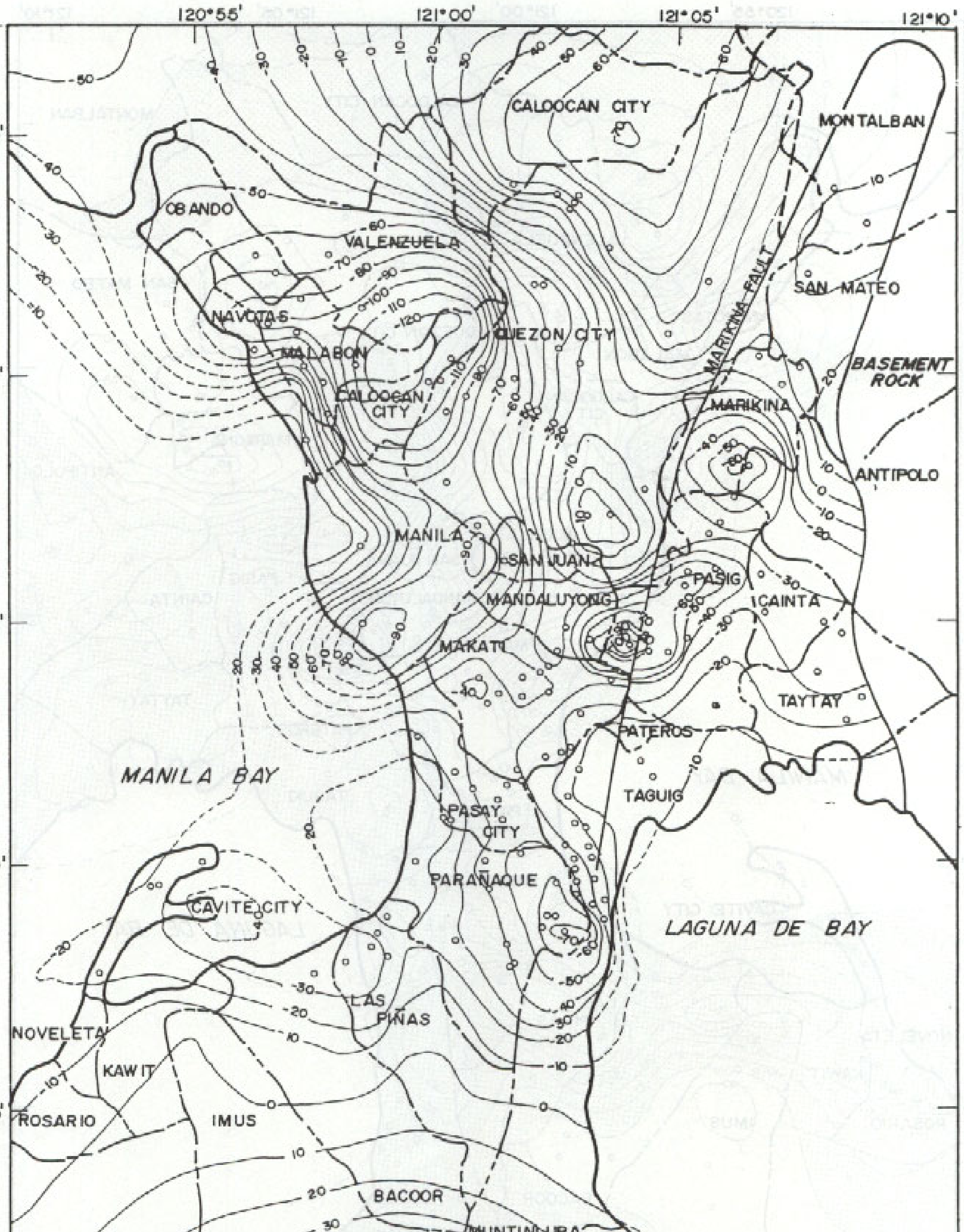
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

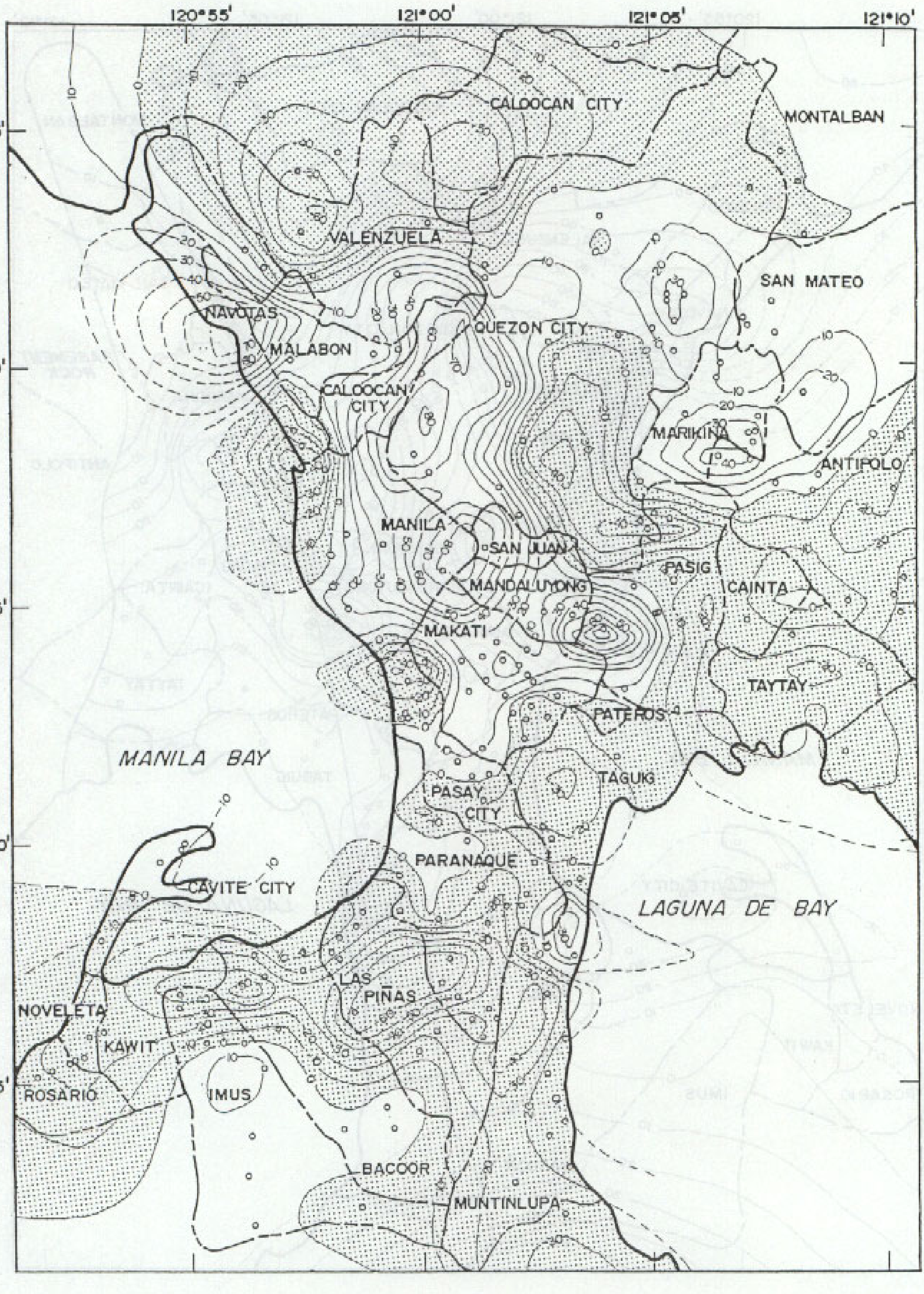
FIGURE 3.3.1
GROUNDWATER PUMPAGE
IN THE STUDY AREA, 1990



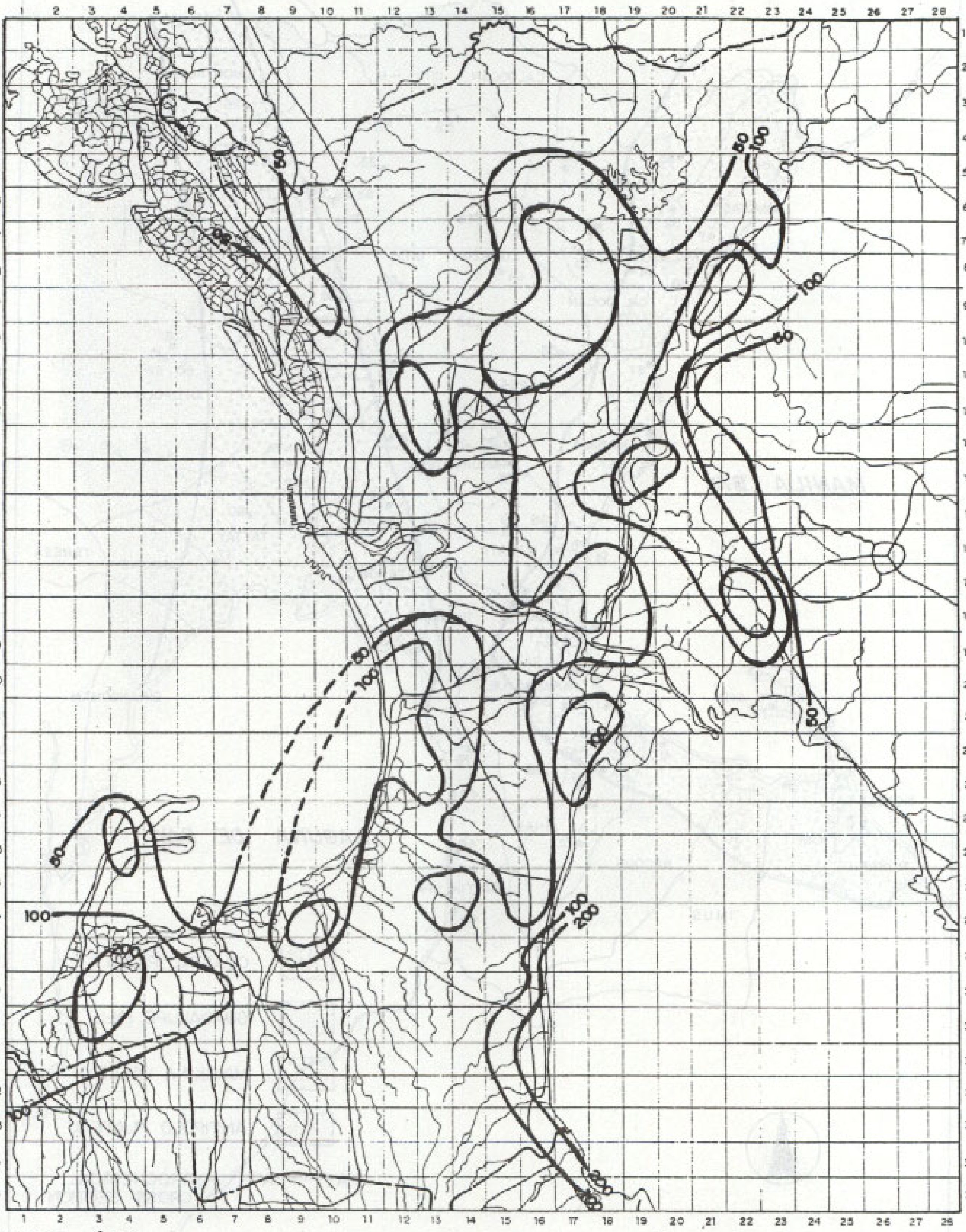
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 3.4.1(1) PIEZOMETRIC CONTOUR MAP OF THE STUDY AREA, 1990
JAPAN INTERNATIONAL COOPERATION AGENCY	



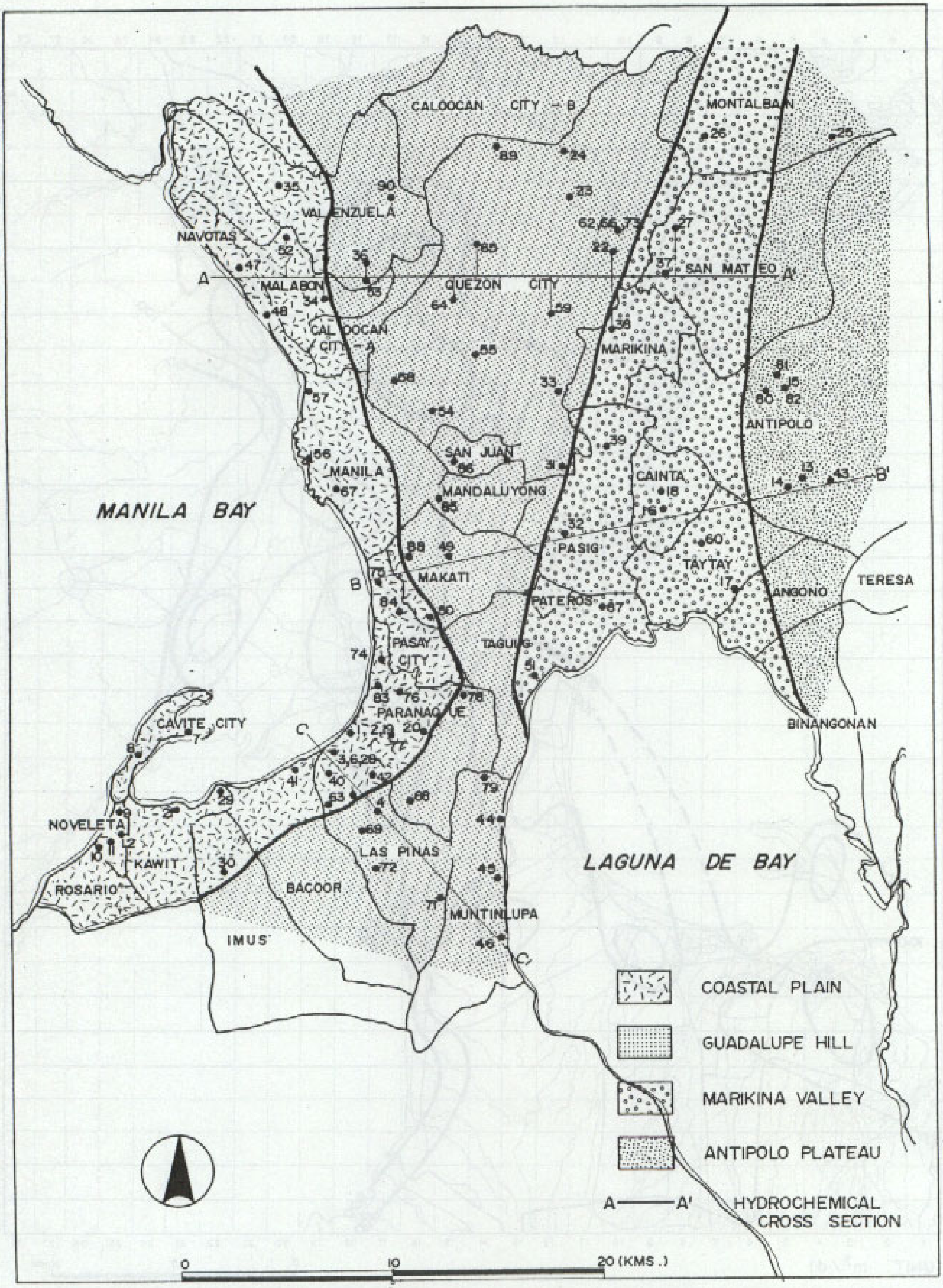
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 3.4.1(2)
JAPAN INTERNATIONAL COOPERATION AGENCY	PIEZOMETRIC CONTOUR MAP OF THE STUDY AREA, 1991



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 3.4.1(3) CHANGE IN PIEZOMETRIC CONTOURS IN THE STUDY AREA FROM 1981 TO 1990
JAPAN INTERNATIONAL COOPERATION AGENCY	



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 3.6.1 ESTIMATED TRANSMISSIVITY MAP FROM SPECIFIC CAPACITY
JAPAN INTERNATIONAL COOPERATION AGENCY	



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 3.7.1
JAPAN INTERNATIONAL COOPERATION AGENCY	LOCATION OF WATER SAMPLING POINTS

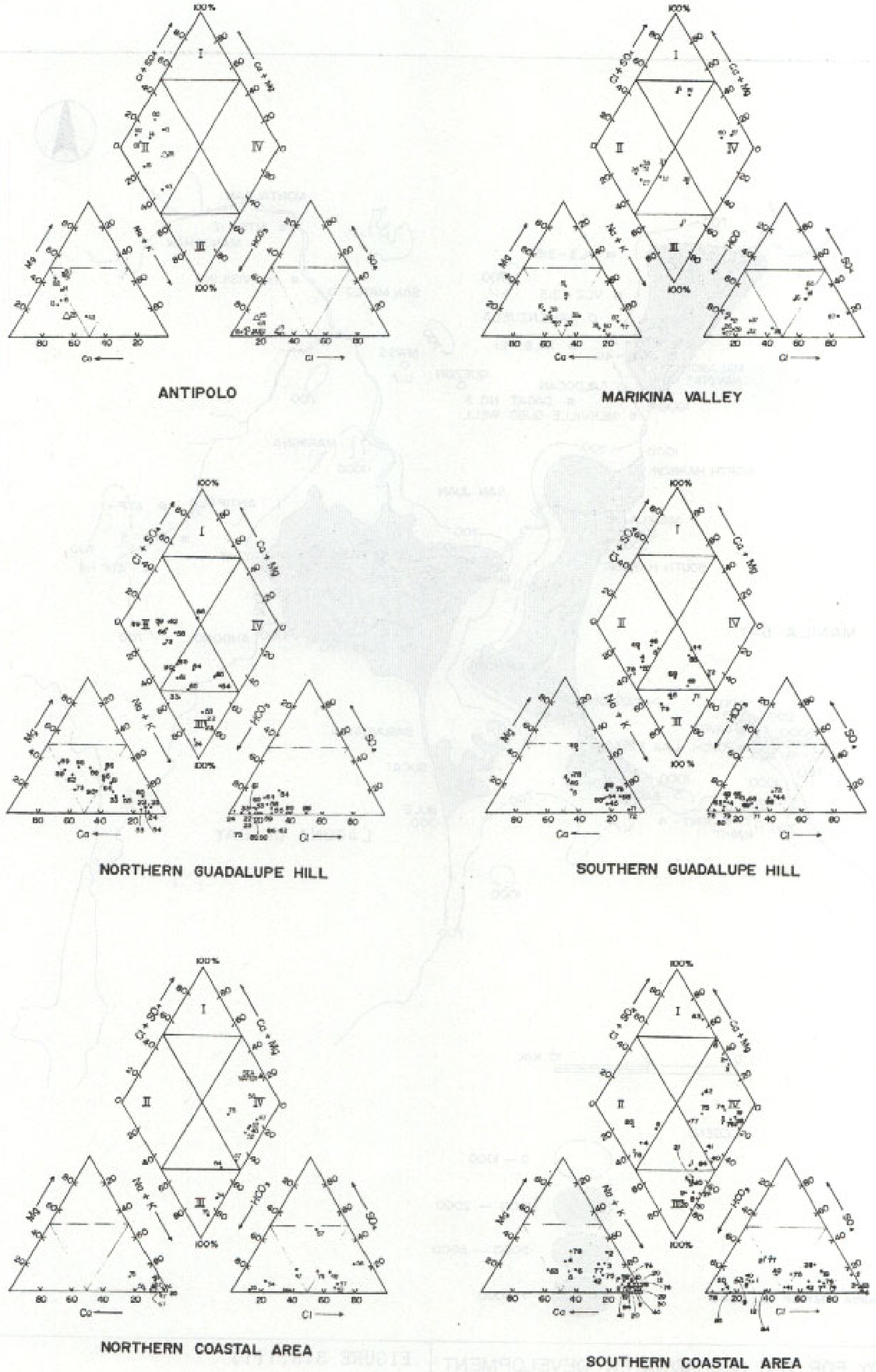
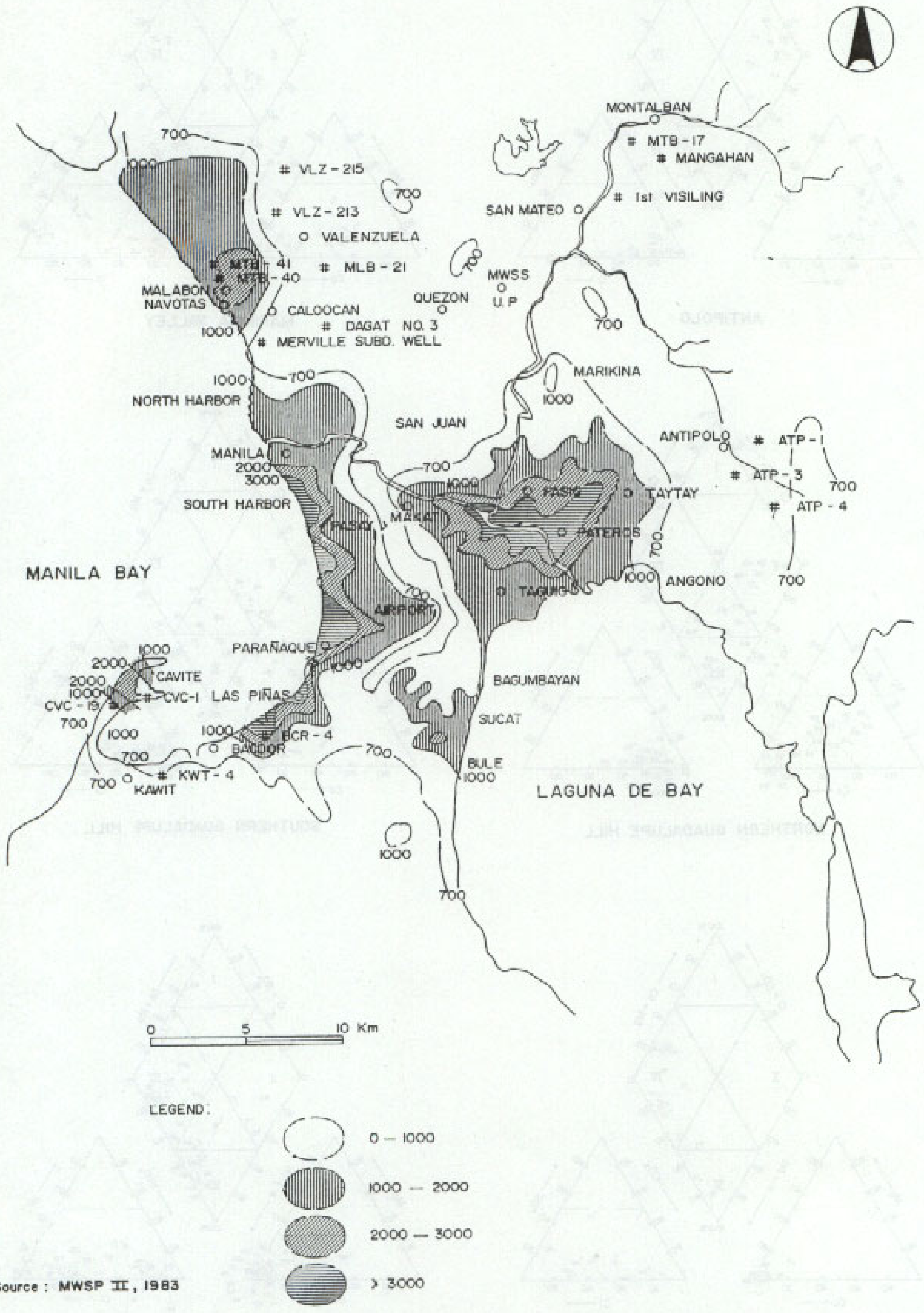
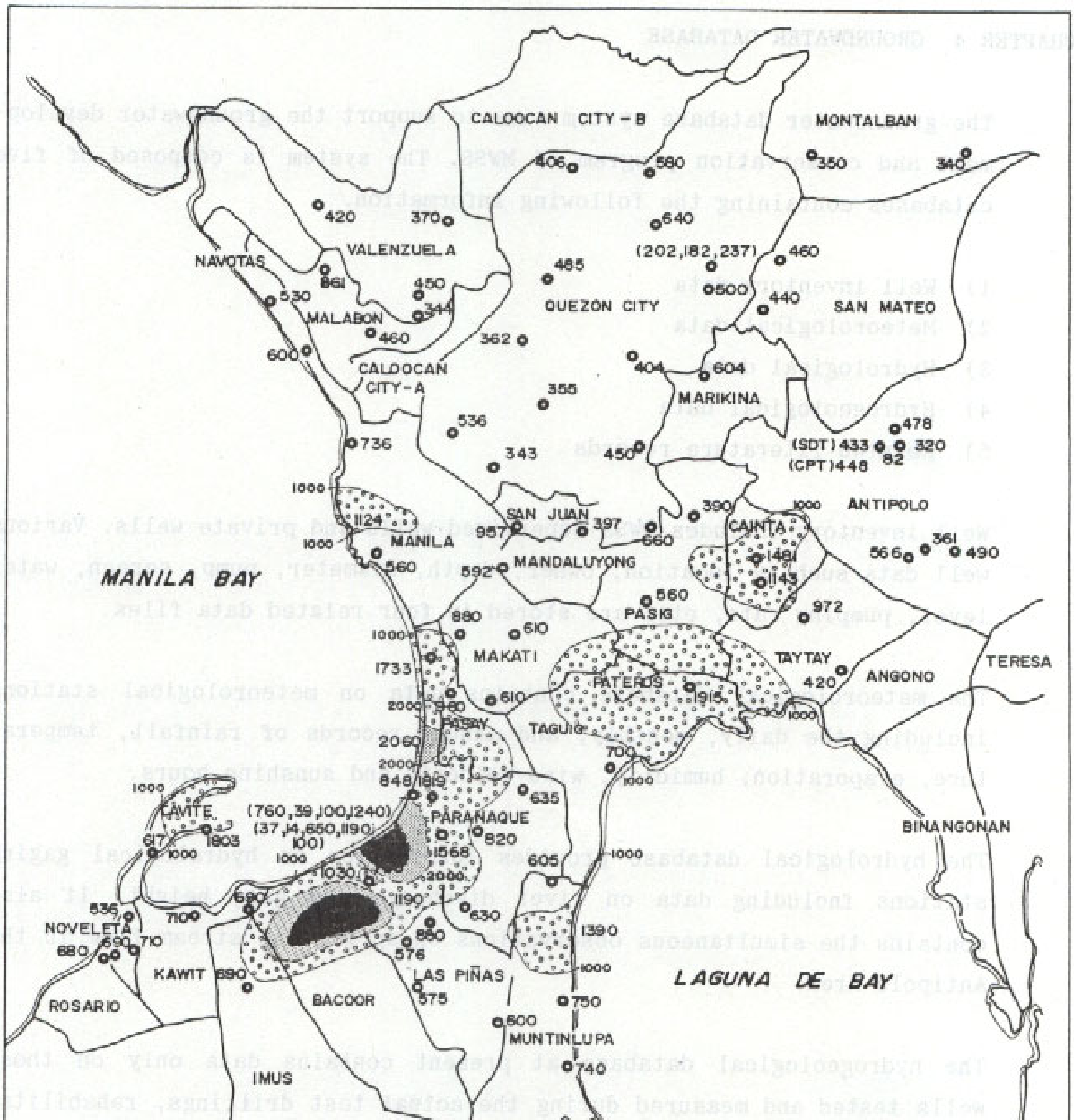


FIGURE 3.7.2 TRILINEAR DIAGRAM REPRESENTATION OF GROUNDWATER SAMPLES IN METRO MANILA



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 3.8.1(1) ELECTRIC CONDUCTIVITY OF GROUNDWATER IN METRO MANILA
JAPAN INTERNATIONAL COOPERATION AGENCY	



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 3.8.1(2)

DISTRIBUTION OF ELECTRIC CONDUCTIVITY

CHAPTER 4 GROUNDWATER DATABASE

The groundwater database system aims to support the groundwater development and conservation program of MWSS. The system is composed of five databases containing the following information.

1) Well inventory data
2) Meteorological data
3) Hydrological data
4) Hydrogeological data
5) Related literature records

Well inventory includes MWSS-supervised wells and private wells. Various well data such as location, owner, depth, diameter, pump, screen, water level, pumping rate, etc. are stored in four related data files.

The meteorological database contains data on meteorological stations including the daily, monthly, and annual records of rainfall, temperature, evaporation, humidity, wind velocity and sunshine hours.

The hydrological database provides information on hydrological gaging stations including data on river discharge and gage height. It also contains the simultaneous observations on spring and stream flow in the Antipolo Area.

The hydrogeological database at present contains data only on those wells tested and measured during the actual test drillings, rehabilitation studies, pumping test and groundwater quality investigations.

The literature database provides literature records relevant to the groundwater development study.

CHAPTER 5 WELL REHABILITATION SURVEY

5.1 PRESENT CONDITION OF MWSS WELLS

Of the 258 MWSS wells in MSA in 1991, 52 are abandoned, 131 active and 75 inactive.

Based on site visits and interviews with the operators, the well conditions were classified into four: "Good", "Damaged", "Stand by" and "Others" (Table 5.1.1).

"Good" : wells being operated are in good condition

"Damaged" : wells are damaged as indicated by any of the following: salty water, dirty water, caved-in, dried-up, defective pump unit

"Standby" : wells are on standby, under rehabilitation or an adequate surface water supply is present

"Others" : reason is not clear; inactive or abandoned

Thirty two (32) out of 131 wells which were reported to be active are substantially inactive for they have the characteristics falling under the classification "Damaged" and "Others". Only 99 wells are operating normally.

5.2 DETAILED SURVEY

A detailed survey which included doing pumping tests was conducted at well sites. Out of 28 damaged wells, sixteen (16) were surveyed in order to identify the conditions and requisites for a proper rehabilitation procedure. Seven (7) wells were subsequently selected as candidate wells for experimental well rehabilitation.

The survey revealed that an increase in the discharge rate of 6 wells out of 9 can be affected by the improvement of pumping unit. The condition of the remaining 3 wells are unclear, except for one which is contaminated by saline water.

5.3 EXPERIMENTAL REHABILITATION WORK

In order that causes of damage may be clarified and technical specifications of the rehabilitation work may be properly established, an experimental work on five (5) wells selected through detailed survey was carried out (Figure 5.3.1). These five wells are: Sumulong in Taytay; Cogeo No.1, Antipolo; Cogeo No.6, Antipolo; IBP No.3, Quezon City; and Naga No.2, Las Piñas.

The standard experimental rehabilitation work involves the following activities.

1) Preparation and mobilization
2) Pulling out of existing pumping unit
3) Measuring of well depth and water level
4) Inspection of existing pumping unit
5) Installation of test pumping unit
6) First pumping test
7) Surging, bailing and airlifting
8) Second pumping test
9) Installation of existing pumping unit
10) Demobilization

Rehabilitation was effective at Sumulong and Cogeo No.1 in terms of specific capacity and well loss constant. In Naga No.2 and Cogeo No.6, these parameters did not improved, indicating the ineffectiveness of rehabilitation (Table 5.3.2). The IBP No.3 well was recommended to be abandoned because of its damaged casing and its low water discharge.

TABLE 5.1.1 WELL CONDITIONS OF MWSS DEEP WELLS

(NUMBER OF WELLS)

WELL CONDITIONS	STATUS			
	ACTIVE	INACTIVE	ABANDONED	TOTAL
IN GOOD CONDITION	99	0	0	99
DAMAGED WELLS				
Defective unit	13	9	3	25
Yields salty water	2	0	17	19
Well caved-in	1	0	14	15
Yields dirty water	3	0	5	8
Well is almost dry	0	0	3	3
TOTAL	19	9	42	70
STAND BY				
Stand by	0	16	0	16
Under Rehabilitation Program	0	25	0	25
Adequate surface water supply	0	23	6	29
TOTAL	0	64	6	70
OTHERS	13	2	4	19
GRAND TOTAL	131	75	52	258

TABLE 5.3.1 WELLS FOR EXPERIMENTAL REHABILITATION WORK

Well Name	Municipality	Status	Total Depth	Casing Pipe Position Size	Well Screen Position	Exist. Pump		Test Pump		Pump After Rehab.	
						Set.	Cap.	Set.	Spec.	Set.	Spec.
Cogeo Antipolo No.1	Antipolo	Inactive	91.44m	0m-9.75m 8" 9.75-91.44 6"	64m-87.78m	66m	7.5 Hp	78m	SP8-21 7.5HP OD 133	3" 78m	Existing Pump Installed
Sumulong	Taytay	Inactive	202.69	0-80.77 8" 80.77-202.7 6"	Unknown	75	30	78m 120m	30 HP 10 HP OD 133mm	NO	No Pump Installed
Naga Road No.2	Las Pinas	Active	243.84	0-243.84 10"	103.63-121.91 128.01-158.49 164.59-170.68 182.88-213.36 219.45-237.74	78	30	120m 102m	SP45-12 30HP OD 150	3" 102m	Existing Pump Installed
IBP (Congress) No.3	Quezon City	Inactive	202.69	0-80 10" 80-202.69 8"	87-99 103-122 129-144 151-166 173-197	120	20	108	20 HP 9 stage OD 140	NO	No Pump Installed
Cogeo Antipolo No.6	Antipolo	Inactive	117.35	0-91.44 8"	91.44-177.35 bore hole	99	20	90	20 HP 9 stage OD 140	NO	No Pump installed

TABLE 5.3.2 RESULTS OF EXPERIMENTAL REHABILITATION WORK

	Sumulong Taytay	I B P No. 3	Cogeo ATP No.1	Cogeo ATP No.6	Naga Road No.2
Well Depth (m)	202.68	202.69	91.44	117.35	243.84
Accumulation (m)	5.68	32.69	4.44	11.35	0
Static Water Level (m)	58.00	39.30	7.25	11.50	55.40
EC-T Logging					
ECt (uS/cm)	684–961	92–144	335–390	316–342	517–9585
T (°C)	30.2–30.7	27.7–28.1	25.8–27.10	26.4–27.50	30.0–34.20
Micro Current	*	*	*	*	
1st Pumping Test					
Discharge Rate (m^3/d)	285	(25.9)	285	294	544
Drawdown (m)	30.00	(70.7)	48.80	68.40	17.70
Specific Capacity (m^2/d)	9.50	(0.37)	5.84	4.30	30.70
Transmissivity (m^2/d)					
Continuous - Theis	14.6	–	2.83	1.33	36.9
Continuous - Jacob	15.2	–	5.27	7.19	31.1
Recovery - Jacob	11.4	–	32.6	19.8	29.2
Storage Coeff.	$7.65x10^{-5}$	–	1.19	2.26	$3.18x10^{-4}$
Aquifer Loss Coeff. (day/m^2)	$5.40x10^{-2}$	–	$8.00x10^{-3}$	0.0	$3.2x10^{-2}$
Well Loss Coeff (day^2/m^5)	$1.65x10^{-4}$	–	$2.55x10^{-4}$	$8.0x10^{-4}$	$6.2x10^{-6}$
2nd Pumping Test					
Discharge Rate (m^3/d)	328	(54.4)	285	294	518
Drawdown (m)	25.10	(70.70)	19.50	64.20	17.07
Specific Capacity (m^2/d)	13.07	(0.77)	14.60	4.58	31.9
Transmissivity (m^2/d)					
Continuous - Theis	14.6	–	4.37	1.34	36.6
Continuous - Jacob	4.10	–	11.1	4.88	31.1
Recovery - Jacob	44.8	–	17.4	15.2	31.9
Storage Coeff.	$1.03x10^{-4}$	–	2.05	3.32	$3.90x10^{-4}$
Aquifer Loss Coeff. (day/m^2)	$2.6x10^{-2}$	–	$2.0x10^{-3}$	0.0	$2.95x10^{-2}$
Well Loss Coeff (day^2/m^5)	$1.43x10^{-4}$	–	$2.10x10^{-4}$	$7.35x10^{-4}$	$6.2x10^{-6}$

CHAPTER 6 URBAN DEVELOPMENT AND FUTURE WATER DEMAND

6.1 URBAN DEVELOPMENT PLANNING

It is anticipated that by the year 2000 Metro Manila shall have expanded its urban area by an additional 25km radius which would include Cavite, Antipolo, and the coastal area of Laguna de Bay. This expansion which may primarily be led by private sectors could inevitably change the land use pattern and its intensity, and would be marked by an increased number and density of blighted areas, the development of middle and upper class residential subdivisions on the urban periphery, a great increase of townhouses and/or condominiums in the main urban area, and the conversion of agricultural and fishpond areas to residential and/or commercial uses.

Population growth and urbanization in the year 2010 were predicted using the 1990 data of the National Statistics Office (NSO). Total population of the MSA in year 2010 would be approximately 14.1 million, a 4.7 million increase over the year 1990 figure (Table 6.1.1).

Based on 1985 statistics, approximately 2.3 million people in the MSA were living in blighted areas. It increased to around 2.8 million in 1990, about 30% of the population of NCR (7.93 million). The blighted population is projected to reach 4.09 million in 2010.

A basic structure plan of urban development was set up with due regard to the above. The plan lays out Metro Manila as an inner urban core surrounded by a transition zone located between the inner urban core and outlying areas. Industrial concentration areas and intensive residential development areas are laid in the south and north of the outlying areas of the transition zone. Other industrial and residential areas are to be located north of Laguna de Bay (Figure 6.1.1).

The proposed future land use plan of the MSA is divided into two major zones consisting of an Urban Consolidation Zone and Complementary Urban Satellites. Layout of land use was roughly designed according to the trend of urbanization in Metro Manila: as residential and open areas, industrial and tourism areas, agro-industrial and regional open spaces, flooding area, and reservation area.

There is at present a progressive development of residential areas and urban facilities in the Antipolo area because of its contiguity to Metro Manila. The area is still relatively abundant in forest/grass land and agricultural land. Based on population projections for the Antipolo area, the population would reach 435,000 in 2010 from the 208,000 in 1990 (Table 6.1.2). The future land use plan thus incorporated the development of the tourism and agro-forest industries in the Antipolo area (Figure 6.1.2).

6.2 WATER DEMAND PROJECTIONS

Domestic, commercial and industry water demand was projected considering the population projection described in Section 6.1.

From the records of the MWSS Computer Center, daily domestic consumption in the MSA in 1990 was 785,000 CMD, of which 781,000 CMD were for house service connections and 4,000 CMD for public faucets. The served population, estimated by water meters, was 5,037,000 for house service connections and 236,000 for public faucets. Thus the average per capita domestic consumption in the MSA for house service connections and public faucets were 170 lpcd and 19 lpcd, respectively. Water consumption for commercial use was 344,000 CMD and 84,000 CMD for industrial use. Those not served by MWSS use groundwater; their consumptions were estimated at 379,000 CMD for domestic use, 107,000 CMD for commercial purpose and 355,000 CMD for industrial supply (Tables 6.2.1 to 6.2.3).

In projecting water demand, the per capita consumption was set at 180 lpcd in 1995 and 200 lpcd in 2010, in consideration of actual per capita consumption in the area. For some municipalities with high per capita consumption at present, another value was adopted. In the respective areas covered by RPWSP and FAWSP, the per capita consumption employed in each project was also adopted. Based on the population projection, the total domestic water demand in MSA would become 1,596,000 CMD in 2010 and 2,136,000 CMD in 2010. The domestic water demand in the area outside the service of MWSS is estimated at 306,000 CMD in 2000 and 246,000 CMD in 2010 (Table 6.2.4).

The calculation of commercial water demand was done using two factors, i.e., the economic growth rate and the tariff change planned by CORPLAN of MWSS. Areal allocation was made based on the actual commercial water consumption. In the area covered by RPWSP, the same method was adopted. The total commercial water demand shall become 570,000 CMD in 2000 and shall increase to about 801,000 CMD in 2010. Outside the MSA, the total commercial demand shall become 132,000 CMD in 2000 and 157,000 CMD in 2010 (Table 6.2.5).

Future industrial water demand was calculated basically in the same manner as that for commercial water demand and areal allocation. The total industrial water demand will become 153,000 CMD in 2000 and 224,000 CMD in 2010. It will also become 482,000 CMD in 2000 and 595,000 in 2010 in the area outside the MSA (Table 6.2.6).

Water losses during distribution were added to the estimate of the total water demand in the MSA. Leakage ratios of 30% and 20% for years 2000 and 2010, respectively, were used in projecting total water demand. In the MSA, the respective total water demand for years 2000 and 2010 are 3,306,000 CMD and 4,203,000 CMD. Outside the MSA, these respective demands are 920,000 CMD and 998,000 CMD. (See Tables 6.2.7 to 6.2.10 and Figures 6.2.1 to 6.2.3.)

On the assumption that the planned and ongoing projects, i.e. AWSOP, UATP, etc., shall proceed on schedule, it is predicted that the surface water supply capacity in the area covered by CDS shall exceed the total water demand until the year-2010 (Figure 6.2.4). However, the area outside the CDS must rely on groundwater.

As shown in Tables 6.2.11 and 6.2.12, four scenarios were established for the estimation of future groundwater pumpage in the MSA. This projection of future pumpage aims to predict future groundwater levels and to come up with a tentative permissive yield for the Metro Manila Groundwater Basin.

In Antipolo, the water demand in the years 2000 and 2010 was projected at 27,300 CMD and 45,500 CMD, respectively. Groundwater supply can meet the demand up to 1998 in daily average base by augmentation through rehabilitation and new construction of MWSS-supervised wells. However, the shortage in water supply would become 1,830 CMD in 2000 and 18,150

CMD in 2010. Therefore, the extension of the CDS to cover Antipolo is necessary in the future. (Refer to Table 6.2.13 and Figure 6.2.5.)

TABLE 6.1.1 POPULATION PROJECTIONS FOR SELECTED YEARS, STUDY AREA

CITY/MUNICIPALITY	1980 (CENSUS)	1990 (CENSUS)	1995	2000	2005	2010
I. NCR	5,970,307	7,928,867	8,971,800	9,948,977	10,847,652	11,649,608
1. Manila	1,642,708	1,598,918	1,666,014	1,705,567	1,723,126	1,723,147
2. Pasay City	289,927	366,623	402,932	433,048	457,147	475,225
3. Quezon City	1,174,605	1,666,766	1,870,519	2,049,017	2,200,635	2,323,154
4. Caloocan City	471,323	761,011	872,801	979,527	1,076,883	1,164,630
5. Las Pinas	137,537	296,851	413,469	551,808	708,704	878,109
6. Makati	375,424	452,734	489,333	517,961	539,315	553,794
7. Malabon	192,433	278,380	305,870	328,653	346,868	360,515
8. Mandaluyong	206,906	244,538	265,870	282,944	296,044	305,315
9. Marikina	213,199	310,010	359,368	405,480	447,289	483,621
10. Muntinlupa	137,704	276,972	346,829	419,918	493,739	565,215
11. Navotas	127,092	186,799	207,567	225,328	240,031	251,550
12. Paranaque	210,115	307,717	369,370	430,253	488,493	541,964
13. Pasig	270,583	397,309	466,552	532,663	593,888	648,283
14. Pateros	40,590	51,401	58,438	64,776	70,318	74,945
15. San Juan	131,063	126,708	133,478	137,583	140,304	141,007
16. Taguig	135,143	266,080	311,031	353,627	392,792	427,323
17. Valenzuela	213,955	340,050	432,359	530,824	632,076	731,811
II. CAVITE	324,273	457,020	534,043	611,062	686,825	756,085
1. Bacoor	90,364	159,685	196,636	235,538	275,150	313,838
2. Cavite City	87,666	91,641	98,576	104,379	109,908	112,628
3. Imus	59,103	92,125	107,162	121,860	135,818	148,542
4. Kawit	39,368	47,755	55,217	62,446	69,254	75,407
5. Noveleta	14,460	20,409	23,325	26,102	28,673	30,955
6. Rosario	33,312	45,405	53,127	60,737	68,022	74,715
III. RIZAL	567,346	980,194	1,150,043	1,325,537	1,503,547	1,667,350
1. Angono	27,136	46,014	55,062	64,219	72,979	80,788
2. Antipolo	70,377	207,842	261,738	319,849	379,154	435,886
3. Baras	11,434	16,880	19,051	21,063	22,808	24,182
4. Binangonan	82,702	127,561	140,791	152,533	162,155	169,117
5. Cainta	60,280	126,839	164,650	206,860	251,447	295,646
6. Cardona	25,024	32,962	35,194	36,995	38,270	38,952
7. Jala-Jala	12,199	16,318	17,814	19,109	20,131	20,826
8. Montalban	42,749	67,074	75,766	83,837	90,845	96,318
9. Morong	25,387	32,165	34,528	36,957	40,222	43,304
10. Pililla	23,716	32,771	36,137	39,119	41,556	43,312
11. San Mateo	53,014	82,310	92,401	101,679	109,620	115,769
12. Tanay	41,303	58,410	65,923	72,889	78,925	83,678
13. Taytay	76,930	112,403	129,481	148,322	173,025	197,131
14. Teresa	15,095	20,645	21,507	22,106	22,410	22,441
TOTAL	6,861,926	9,366,081	10,655,886	11,885,576	13,038,024	14,073,043

Source: Estimation made by the Study Team based on NSO data

TABLE 6.1.2 POPULATION PROJECTIONS FOR SELECTED YEARS, MUNICIPALITY OF ANTIPOLO

MUNICIPALITY/ BARANGAY	1990	1995	2000	2005	2010
ANTIPOLO	207,842	261,738	319,849	379,154	435,886
1. Bagong Nayon	18,002	22,644	27,647	32,752	37,637
2. Beverly Hills	1,034	1,385	1,767	2,161	2,532
3. Calawis	1,662	2,172	2,725	3,293	3,831
4. Cupang	25,696	32,283	39,380	46,620	53,551
5. Dalig	20,344	25,566	31,204	36,956	42,461
6. De La Paz (Pob.)	21,033	26,441	32,269	38,215	43,906
7. Inarawan	4,965	6,312	7,767	9,254	10,673
8. Mambugan	15,636	19,680	24,039	28,487	32,743
9. Mayamot	15,887	19,995	24,423	28,941	33,264
10. San Isidro	19,260	24,220	29,566	35,020	40,240
11. San Jose	26,121	32,815	40,028	47,385	54,428
12. San Juan	1,394	1,838	2,319	2,813	3,280
13. San Luis	6,241	7,910	9,712	11,553	13,311
14. San Roque	17,227	21,673	26,465	31,355	36,034
15. Sta. Cruz	13,340	16,804	20,538	24,349	27,995

Source: Estimation made by the Study Team based on NSO data. Due to the absence of population data at barangay level prior to 1990, population projections at barangay level were based on the growth rate of the whole Antipolo municipality.

TABLE 6.2.1 STATUS OF DOMESTIC WATER SUPPLY BY MWSS AND PRIVATE SYSTEM

CITY/MUNICIPALITY	1990 CENSUS POPULATION (1)	MWSS HOUSE SERVICE CONNECTION: AVG. DAILY CONSUMPTION AMOUNT (M3/D) (2)	% TO TOTAL (3)	CONNECTIONS: NUMBER (4)	EQUIVALENT NO. OF POPULATION (5)	% TO TOTAL POP. (6)	AVERAGE PER CAPITA CONS. (LPCD) (7)	CORR'D PER CAPITA CONS. (LPCD) (8)	MWSS PUBLIC FAUCETS: AVERAGE DAILY CONSUMP. (M3/D) (9)	PUBLIC FAUCETS: NUMBER (10)	EQUIV. NO. OF POP. (11)	% TO TOTAL POP. (12)	AVERAGE PER CAPITA CONS. (LPCD) (13)	CORR'D PER CAPITA CONS. (LPCD) (14)	EQUIVALENT NO. OF POPULATION SERVED BY MWSS: TOTAL (HSC+PF) (15)	% TO TOTAL POP. (16)	PRIVATE WELL: DOMESTIC SUPPLY AMOUNT (M3/D) (17)	ESTIMATED SERVED POPULATION (18)	SHARE IN SUPPLY AMOUNT (%) (19)	EQUIVALENT NO. OF POPULATION SERVED BY MWSS & PRIVATE SYSTEM: TOTAL (20)	% TO TOTAL (21)
I. NCR	7,328,861	755,590	96.8	587,778	4,761,002	65.0	158.7	174	3,319	452	224,532	2.8	17.5	19	4,985,534	62.9	266,335	1,355,526	24.3	6,341,059	80.0
1. Manila	1,598,918	207,941	26.6	155,052	1,255,921	78.5	165.6	181	972	86	41,796	2.6	23.3	25	1,297,717	81.2	2,214	12,204	1.0	1,309,921	81.9
2. Pasay City	366,623	27,941	3.6	25,087	203,205	55.4	137.5	151	170	33	16,038	4.4	10.6	12	219,243	59.8	5,827	32,372 *	15.9	251,615	68.6
3. Quezon City	1,666,766	200,035	25.6	147,326	1,193,341	71.6	167.6	184	1,366	167	81,162	4.9	16.8	18	1,274,503	76.5	31,316	170,503	12.4	1,445,006	86.7
4. Caloocan City	761,011	44,116	5.6	44,673	361,851	47.5	121.9	134	324	41	19,926	2.6	16.3	18	381,777	50.2	19,137	106,317 *	28.2	488,094	64.1
5. Las Pinas	296,851	2,966	0.4	7,939	64,306	21.7	46.1	51	37	8	3,888	1.3	9.6	10	68,194	23.0	57,141	311,450 *	94.6	385,644	129.9
6. Makati	452,734	61,236	7.8	40,210	325,701	71.9	188.0	206	21	5	2,430	0.5	8.5	9	328,131	72.5	10,075	48,906	13.1	377,037	83.3
7. Malabon	278,380	17,096	2.2	18,012	145,897	52.4	117.2	128	155	19	9,234	3.3	16.8	18	155,131	55.7	1,892	10,511 *	9.1	165,642	59.5
8. Mandaluyong	244,538	25,901	3.3	21,345	172,895	70.7	149.8	164	140	19	9,234	3.8	15.1	17	182,129	74.5	1,495	9,108	5.0	191,236	78.2
9. Marikina	310,010	37,855	4.8	28,315	229,352	74.0	165.1	181	260	23	11,178	3.6	23.3	26	240,530	77.6	5,340	29,525	11.3	270,054	87.1
10. Muntinlupa	276,972	3,604	0.5	5,505	44,591	16.1	80.8	89	-	-	0	-	-	-	44,591	16.1	43,108	272,822 *	92.3	317,413	114.6
11. Navotas	186,799	8,807	1.1	13,795	111,740	59.8	78.8	86	54	6	2,916	1.6	18.5	20	114,656	61.4	1,691	9,394 *	14.8	124,050	66.4
12. Paranaque	307,717	32,413	4.2	13,552	109,771	35.7	295.3	324	117	17	8,262	2.7	14.2	16	118,033	38.4	41,553	146,979	57.2	265,012	86.1
13. Pasig	397,309	43,316	5.5	32,630	264,303	66.5	163.9	180	124	21	10,206	2.6	12.1	13	274,509	69.1	5,223	51,361	16.2	325,870	82.0
14. Pateros	51,401	1,722	0.2	2,349	19,027	37.0	90.5	99	-	-	0	-	-	-	19,027	37.0	0	0 *	0.0	19,027	37.0
15. San Juan	126,708	23,653	3.0	12,851	104,093	82.2	227.2	249	125	8	3,888	3.1	32.1	35	107,981	85.2	252	1,012	1.0	108,993	86.0
16. Taguig	266,080	3,258	0.4	4,060	32,886	12.4	99.1	109	21	3	1,458	0.5	14.3	16	34,344	12.9	21,514	119,522 *	85.7	153,866	57.8
17. Valenzuela	340,050	13,827	1.8	15,077	122,124	35.9	113.2	124	28	6	2,916	0.9	9.5	10	125,040	36.8	3,157	17,539 *	17.2	142,579	41.9
II. CAVITE	457,020	11,793	1.5	16,879	136,133	29.8	86.6	95	119	17	8,262	1.8	14.4	16	144,395	31.6	46,884	260,354	78.2	404,749	88.6
1. Bacoor	159,685	2,580	0.3	3,881	31,436	19.7	82.1	90	54	5	2,430	1.5	22.3	24	33,866	21.2	31,507	175,039 *	91.6	208,905	130.8
2. Cavite City	91,641	5,433	0.7	7,807	63,237	69.0	85.9	94	47	8	3,888	4.2	12.0	13	67,125	73.2	849	4,717 *	12.4	71,842	78.4
3. Imus	92,125	779	0.1	978	7,335	8.0	106.2	116	-	0	0	0.0	-	-	7,335	8.0	3,268	18,156 *	78.3	25,491	27.7
4. Kawit	47,755	2,262	0.3	3,055	24,746	51.8	91.4	100	18	4	1,944	4.1	9.0	10	26,690	55.9	2,830	15,722 *	53.1	42,412	88.8
5. Noveleta	20,409	323	0.0	507	4,107	20.1	78.6	86	-	0	0	0.0	-	-	4,107	20.1	5,659	31,439 *	94.1	35,546	174.2
6. Rosario	45,405	417	0.1	651	5,273	11.6	79.0	87	-	0	0	0.0	-	-	5,273	11.6	2,751	15,282 *	85.8	20,555	45.3
III. RIZAL	980,194	13,404	1.7	17,136	133,499	14.2	96.1	105	76	9	3,215	0.3	23.5	26	142,115	14.5	65,171	362,061	81.5	504,776	51.5
1. Angono	46,014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Antipolo	207,842	3,606	0.5	4,445	36,005	17.3	100.1	110	4	1	54	0.0	71.1	79	36,059	17.3	25,367	163,150 *	88.1	199,209	95.8
3. Baras	16,980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Binangonan	127,561	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Cainta	126,839	2,728	0.3	3,003	24,324	19.2	112.2	123	11	2	972	0.8	11.7	13	25,296	19.9	5,273	51,517 *	75.5	76,813	60.6
6. Cardona	32,552	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Jala-Jala	16,318	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8. Montalban	67,034	1,498	0.2	2,039	15,904	23.7	94.2	103	0	0	0	0.0	-	-	15,904	23.7	4,244	23,578 *	72.1	39,482	58.9
9. Morong	32,165	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10. Pililla	32,771	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11. San Mateo	82,310	2,305	0.3	3,678	31,263	38.0	73.7	81	33	4	1,218	1.5	27.5	30	32,481	39.5	2,647	14,706 *	50.8	47,187	57.3
12. Tanay	58,438	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13. Taytay	112,403	3,268	0.4	3,951	32,003	28.5	102.1	112	27	2	972	0.9	27.6	30	32,975	29.3	19,640	109,111 *	84.5	142,086	126.4
14. Teresa	20,645	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	8,766,081	780,888	100.0	621,773	5,036,634	57.4	155.0	170	4,113	488	236,010	2.5	17.4	19	5,272,644	60.1	378,970	1,977,941	30.6	7,250,585	77.4

(5)=(4)x8.1 (7)=(2)/(5)x1000 (8)=(7)x1.0957 (11)=(10)x486 (13)=(9)/(11)x1000 (14)=(13)x1.0957 (15)=(5)+(11) (18)=(17)/(8)x1000 (19)=(17)/[((2)+(9))*1.0957+(17)]*100 (20)=(15)+(18)

* Assumed per capita consumption of 180 lpcd was used instead of estimated per capita consumption considering suppressed water supply condition.

TABLE 6.2.2 STATUS OF COMMERCIAL CONSUMPTION IN 1990

CITY/MUNICIPALITY	AVG. DAILY BILLED MWSS COMMERCIAL CONSUM.			NUMBER OF MWSS METER CONNECTION	CONSUMPTION PER METER CONNECTION		PRIVATE WELL COMM'L PUMPAGE (M3/DAY)	ESTIMATED TOTAL COMM'L CONSUM. (M3/DAY)	% TO TOTAL (%)	SHARE OF PRIVATE WELL (%)
	AMOUNT (M3/DAY)	CORRECTED (M3/DAY)	% TO TOTAL		BILLED (M3/DAY)	CORRECTED (M3/DAY)				
I. NCR	301,200	341,350	99.2	41,010	7.345	8.324	93,315	434,665	96.4	21.5
1. Manila	116,049	131,518	38.2	14,452	8.030	9.100	4,665	136,183	30.2	3.4
2. Pasay City	14,597	16,543	4.8	1,907	7.655	8.675	8,795	25,338	5.6	34.7
3. Quezon City	76,185	86,340	25.1	10,695	7.123	8.073	27,641	113,981	25.3	24.3
4. Calookan City	10,071	11,414	3.3	2,535	3.973	4.502	3,674	15,088	3.3	24.4
5. Las Pinas	547	620	0.2	315	1.738	1.970	3,678	4,299	1.0	85.6
6. Makati	41,955	47,548	13.8	3,189	13.156	14.910	11,721	59,269	13.1	19.8
7. Malabon	2,831	3,208	0.9	989	2.862	3.244	2,016	5,224	1.2	38.6
8. Mandaluyong	9,891	11,210	3.3	1,123	8.808	9.982	2,128	13,338	3.0	16.0
9. Marikina	3,424	3,881	1.1	1,288	2.659	3.013	1,400	5,280	1.2	26.5
10. Muntinlupa	69	78	0.0	106	0.648	0.734	8,230	8,308	1.8	99.1
11. Navotas	1,795	2,035	0.6	471	3.812	4.320	621	2,655	0.6	23.4
12. Paranaque	5,920	6,709	1.9	1,045	5.665	6.420	4,914	11,624	2.6	42.3
13. Pasig	8,247	9,346	2.7	1,105	7.463	8.458	6,658	16,004	3.5	41.6
14. Pateros	49	56	0.0	34	1.446	1.639	0	56	0.0	0.0
15. San Juan	7,237	8,201	2.4	920	7.866	8.915	97	8,299	1.8	1.2
16. Taguig	319	361	0.1	61	5.222	5.918	3,655	4,016	0.9	91.0
17. Valenzuela	2,014	2,282	0.7	775	2.598	2.944	3,423	5,705	1.3	60.0
II. CAVITE	1,080	1,224	0.4	731	1.477	1.674	5,175	6,399	1.4	80.9
1. Bacoor	237	268	0.1	132	1.793	2.032	703	971	0.2	72.4
2. Cavite City	642	727	0.2	398	1.612	1.827	3,480	4,207	0.9	82.7
3. Imus	57	65	0.0	54	1.058	1.199	644	709	0.2	90.9
4. Kawit	108	122	0.0	119	0.905	1.025	0	122	0.0	0.0
5. Noveleta	4	5	0.0	5	0.872	0.989	0	5	0.0	0.0
6. Rosario	32	36	0.0	23	1.399	1.585	348	385	0.1	90.5
III. RIZAL	1,452	1,646	0.5	654	2.220	2.516	8,338	9,983	2.2	83.5
1. Angono	-	-	-	-	-	-	-	-	-	-
2. Antipolo	533	604	0.2	223	2.390	2.709	2,763	3,367	0.7	82.1
3. Baras	-	-	-	-	-	-	-	-	-	-
4. Binangonan	-	-	-	-	-	-	-	-	-	-
5. Cainta	396	449	0.1	134	2.958	3.353	3,173	3,622	0.8	87.6
6. Cardona	-	-	-	-	-	-	-	-	-	-
7. Jala-Jala	-	-	-	-	-	-	-	-	-	-
8. Montalban	37	42	0.0	36	1.019	1.155	844	886	0.2	95.3
9. Morong	-	-	-	-	-	-	-	-	-	-
10. Pililla	-	-	-	-	-	-	-	-	-	-
11. San Mateo	164	186	0.1	107	1.530	1.734	390	576	0.1	67.8
12. Tanay	-	-	-	-	-	-	-	-	-	-
13. Taytay	322	365	0.1	154	2.092	2.371	1,167	1,532	0.3	76.2
14. Teresa	-	-	-	-	-	-	-	-	-	-
TOTAL	303,732	344,219	100.0	42,395	7.164	8.119	106,828	451,047	100.0	23.7

TABLE 6.2.3 STATUS OF INDUSTRIAL CONSUMPTION IN 1990

CITY/MUNICIPALITY	AVG. DAILY BILLED MWSS INDUSTRIAL CONSUM.			NUMBER OF MWSS METER CONNECTION	CONSUMPTION PER METER CONNECTION		PRIVATE WELL IND'L PUMPAGE (M3/DAY)	ESTIMATED TOTAL IND'L CONS. (M3/DAY)	% TO TOTAL	SHARE OF PRIVATE WELL (%)
	BILLED (M3/DAY)	CORRECTED (M3/DAY)	% TO TOTAL		BILLED (M3/DAY)	CORRECTED (M3/DAY)				
I. NCR	71,792	81,361	96.3	6,291	11.412	12.933	280,687	362,048	82.4	77.5
1. Manila	15,545	17,617	20.9	795	19.554	22.160	5,786	23,403	5.3	24.7
2. Pasay City	810	918	1.1	169	4.793	5.432	3,375	4,293	1.0	78.6
3. Quezon City	17,066	19,341	22.9	1,988	8.585	9.729	32,368	51,708	11.8	62.6
4. Calookan City	8,170	9,259	11.0	723	11.300	12.806	4,665	13,923	3.2	33.5
5. Las Pinas	138	156	0.2	51	2.702	3.062	20,959	21,115	4.8	99.3
6. Makati	4,110	4,658	5.5	302	13.609	15.423	3,383	8,041	1.8	42.1
7. Malabon	5,270	5,972	7.1	369	14.281	16.184	14,565	20,537	4.7	70.9
8. Mandaluyong	6,881	7,799	9.2	261	26.365	29.879	5,353	13,151	3.0	40.7
9. Marikina	1,241	1,406	1.7	506	2.452	2.779	6,833	8,239	1.9	82.9
10. Muntinlupa	71	80	0.1	106	0.667	0.756	34,280	34,360	7.8	99.8
11. Navotas	1,785	2,023	2.4	129	13.836	15.681	1,739	3,762	0.9	46.2
12. Paranaque	1,482	1,679	2.0	171	8.666	9.821	17,691	19,370	4.4	91.3
13. Pasig	7,128	8,079	9.6	277	25.734	29.165	60,077	68,156	15.5	88.1
14. Pateros	3	4	0.0	3	1.037	1.175	1,756	1,760	0.4	99.8
15. San Juan	1,059	1,200	1.4	147	7.201	8.161	59	1,259	0.3	4.7
16. Taguig	8	9	0.0	9	0.926	1.049	41,198	41,208	9.4	100.0
17. Valenzuela	1,026	1,162	1.4	285	3.599	4.079	26,600	27,763	6.3	95.8
II. CAVITE	1,014	1,149	1.4	1,346	0.753	0.853	5,889	7,037	1.6	83.7
1. Bacoor	62	70	0.1	61	1.014	1.149	0	70	0.0	0.0
2. Cavite City	210	238	0.3	250	0.840	0.952	0	238	0.1	0.0
3. Imus	6	7	0.0	7	0.906	1.027	530	538	0.1	98.7
4. Kawit	507	574	0.7	672	0.754	0.854	0	574	0.1	0.0
5. Noveleta	78	88	0.1	105	0.741	0.840	0	88	0.0	0.0
6. Rosario	151	171	0.2	251	0.602	0.682	5,358	5,530	1.3	96.9
III. RIZAL	1,747	1,980	2.3	195	8.959	10.153	68,328	70,308	16.0	97.2
1. Angono	-	-	-	-	-	-	-	-	-	-
2. Antipolo	1,565	1,773	2.1	44	35.561	40.301	12,025	13,798	3.1	87.1
3. Baras	-	-	-	-	-	-	-	-	-	-
4. Binangonan	-	-	-	-	-	-	-	-	-	-
5. Cainta	42	48	0.1	34	1.247	1.414	36,173	36,221	8.2	99.9
6. Cardona	-	-	-	-	-	-	-	-	-	-
7. Jala-Jala	-	-	-	-	-	-	-	-	-	-
8. Montalban	15	17	0.0	13	1.151	1.305	2,941	2,958	0.7	99.4
9. Morong	-	-	-	-	-	-	-	-	-	-
10. Pililla	-	-	-	-	-	-	-	-	-	-
11. San Mateo	48	55	0.1	47	1.029	1.166	604	658	0.1	91.7
12. Tanay	-	-	-	-	-	-	-	-	-	-
13. Taytay	77	87	0.1	57	1.343	1.522	16,586	16,672	3.8	99.5
14. Teresa	-	-	-	-	-	-	-	-	-	-
TOTAL	74,552	84,490	100.0	7,832	9.519	10.788	354,904	439,394	100.0	80.8

Billed Water Consumption categorized in Others are included in Industrial Consumption

TABLE 6.2.4 PROJECTED DOMESTIC WATER CONSUMPTION BY CITY/MUNICIPALITY IN 2010

CITY/MUNICIPALITY	TOTAL POPULATION (2010)			PER CAPITA CONSUMPTION		DOMESTIC CONSUMPTION (2010)			MWSS CONNECTED %			MWSS CONNECTED POPULATION			MWSS DOMESTIC CONSUMPTION			PRIVATE DOM. CONSUMPTION		
	TOTAL	GENERAL	WATER BLIGHTED	GEN'L (LPCD)	BL'D (LPCD)	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)	GEN'L POP.	WATER BL'D POP.	MWSS TOTAL POP.	GENERAL POP.	WATER BLIGHTED POP.	TOTAL POP.	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)
I. NCR	11,649,608	9,319,686	2,329,922	204	35	1,905,230	81,547	1,986,777	92	75	89	8,581,840	1,747,441	10,329,281	1,753,065	61,180	1,814,245	152,144	20,387	172,531
CITY OF MANILA	1,723,147	1,464,188	258,959	200	35	292,838	9,064	301,901	95	75	92	1,390,978	194,219	1,585,198	278,196	6,798	284,993	14,642	2,266	16,908
PASAY CITY *a	475,225	326,828	148,397	200	35	65,366	5,194	70,560	95	75	89	310,487	111,298	421,784	62,097	3,396	65,593	3,268	1,298	4,567
QUEZON CITY	2,323,154	1,860,880	462,274	200	35	372,176	16,180	388,356	95	75	91	1,767,836	346,705	2,114,542	353,567	12,135	365,702	18,609	4,045	22,654
CALOOCAN CITY *a	1,164,630	838,274	326,356	200	35	167,655	11,422	179,077	90	75	86	754,446	244,767	999,214	150,889	8,567	159,456	16,765	2,856	19,621
LAS PINAS *a	878,109	767,379	110,730	200	35	153,476	3,876	157,351	85	75	84	652,272	83,047	735,320	130,454	2,907	133,361	23,021	969	23,990
MAKATI	553,794	482,797	70,997	220	35	106,215	2,485	108,700	95	75	92	458,657	53,248	511,905	100,904	1,864	102,768	5,311	621	5,932
MALABON *a	360,515	288,282	72,233	200	35	57,656	2,528	60,185	90	75	87	259,454	54,175	313,629	51,891	1,896	53,787	5,766	632	6,398
MANDALUYONG	305,315	242,650	62,665	200	35	48,530	2,193	50,723	95	75	91	230,517	46,999	277,516	46,103	1,645	47,748	2,426	548	2,975
MARIKINA	483,621	395,470	88,151	200	35	79,094	3,085	82,179	95	75	91	375,697	66,113	441,810	75,139	2,314	77,453	3,955	771	4,726
MUNTINLUPA *a	565,215	451,573	113,642	200	35	90,315	3,977	94,292	85	75	83	383,837	85,232	469,069	76,767	2,983	79,750	13,547	994	14,542
NAVOTAS *a	251,550	180,739	70,811	200	35	36,148	2,478	38,626	95	75	89	171,702	53,109	224,810	34,340	1,859	36,199	1,807	620	2,427
PARANAQUE *a	541,964	502,098	39,866	250	35	125,525	1,395	126,920	85	75	84	426,783	29,899	456,683	106,696	1,046	107,742	18,829	349	19,178
PASIG	648,283	519,301	128,982	200	35	103,860	4,514	108,375	95	75	91	493,336	96,736	590,072	98,667	3,386	102,053	5,193	1,129	6,322
PATEROS *a	74,945	66,282	8,663	200	35	13,256	303	13,560	90	75	88	59,654	6,497	66,151	11,931	227	12,158	1,326	76	1,401
SAN JUAN	141,007	130,635	10,372	250	35	32,659	363	33,022	95	75	94	124,103	7,779	131,882	31,026	272	31,298	1,633	91	1,724
TAGUIG *a	427,323	352,472	74,851	200	35	70,494	2,620	73,114	90	75	87	317,224	56,139	373,363	63,445	1,965	65,410	7,049	655	7,704
VALENZUELA *a	731,811	449,840	281,971	200	35	89,968	9,869	99,837	90	75	84	404,856	211,479	616,334	80,971	7,402	88,373	8,997	2,467	11,464
II. CAVITE	756,085	744,387	11,698	200	35	148,877	409	149,287	87	56	86	644,697	6,494	651,190	128,939	227	129,167	19,938	182	20,120
BACOOR *f,a	313,838	309,444	4,394	200	35	61,889	154	62,043	85	75	85	263,027	3,296	266,323	52,605	115	52,721	9,283	38	9,322
CAVITE CITY *f	112,628	111,952	676	200	35	22,390	24	22,414	100	100	100	111,952	676	112,628	22,390	24	22,414	0	0	0
IMUS *f	148,542	146,579	1,963	200	35	29,316	69	29,385	85	51	84	124,258	995	125,253	24,852	35	24,886	4,464	34	4,498
KAWIT *f	75,407	75,106	301	200	35	15,021	11	15,032	100	100	100	75,105	302	75,407	15,021	11	15,032	0	0	0
NOVELETA	30,955	30,476	479	200	35	6,095	17	6,112	87	69	86	26,422	328	26,751	5,284	11	5,296	811	5	816
ROSARIO *f	74,715	70,830	3,885	200	35	14,166	136	14,302	62	23	60	43,932	897	44,829	8,786	31	8,818	5,380	105	5,484
III. RIZAL	1,667,207	1,242,272	424,935	186	36	230,791	15,185	245,976	81	14	64	1,006,835	61,112	1,067,947	190,411	2,405	192,815	40,381	12,780	53,161
ANGONO *r	80,788	56,552	24,236	205	35	11,583	848	12,431	100	0	71	56,552	0	56,552	11,583	0	11,583	0	848	848
ANTIPOLO *f	435,886	376,317	59,569	162	46	60,883	2,740	63,623	58	19	53	218,993	11,261	230,254	35,430	518	35,948	25,453	2,222	27,675
BARAS *r	24,182	3,412	20,770	205	30	699	630	1,329	100	0	14	3,412	0	3,412	699	0	699	0	630	630
BINANGONAN *r	169,117	108,067	61,050	205	34	22,135	2,063	24,198	100	0	64	108,067	0	108,067	22,135	0	22,135	0	2,063	2,063
CAINTA *a	295,646	266,082	29,565	200	35	53,216	1,035	54,251	90	75	88	239,473	22,173	261,647	47,895	776	48,671	5,322	259	5,580
CARDONA *r	38,352	5,348	33,004	205	30	1,095	1,020	2,115	100	0	14	5,348	0	5,348	1,095	0	1,095	0	1,020	1,020
JALA-JALA *r	20,826	4,821	16,005	205	31	988	490	1,478	100	0	23	4,821	0	4,821	988	0	988	0	490	490
MONTALBAN *f	96,318	85,317	11,001	128	46	10,959	506	11,475	83	44	78	70,530	4,788	75,318	9,058	220	9,288	1,901	286	2,187
MORONG *r	43,304	11,947	31,357	205	31	2,447	966	3,413	100	0	28	11,947	0	11,947	2,447	0	2,447	0	966	966
PILILLA *r	43,312	14,971	28,341	205	31	3,067	882	3,949	100	0	35	14,971	0	14,971	3,067	0	3,067	0	882	882
SAN MATEO *f	115,769	83,360	32,409	219	46	18,250	1,491	19,741	77	25	63	64,384	8,105	72,489	14,103	373	14,476	4,157	1,118	5,274
TANAY *r	83,535	40,939	42,596	205	32	8,385	1,366	9,751	100	0	49	40,939	0	40,939	8,385	0	8,385	0	1,366	1,366
TAYTAY *a	191,131	177,418	13,713	200	35	35,484	690	36,174	90	75	89	159,676	14,785	174,461	31,935	517	32,453	3,548	172	3,721
TERESA *r	22,441	7,721	14,720	205	31	1,581	458	2,039	100	0	34	7,721	0	7,721	1,581	0	1,581	0	458	458
TOTAL	14,072,900	11,306,345	2,766,555	202	35	2,284,899	97,141	2,382,040	91	66	86	10,233,371	1,815,047	12,048,418	2,072,436	63,792	2,136,228	212,463	33,349	245,812

NOTE: 1. Areas with (*a) have suppressed demand due to low water pressure, and be expected to be improved by AWSOP.
2. Areas with (*a) also have suppressed demand due to low water pressure, and be expected to be improved by MSWDP.
3. Areas with (*f) have suppressed demand due to limited water sources, and be expected to be improved by FAWSP.
4. Areas with (*r) are merged area under BPT99, and be expected to be improved by RPWSIP.

TABLE 6.2.5 MWSS COMMERCIAL CONSUMPTION PROJECTION

CITY/MUNICIPALITY	1990 ESTIMATED CONSUMPTION				1995			2000			2005			2010		
	TOTAL QT'TY (M3/DAY)	% IN TOTAL	MWSS SHARE (%)	PRIV. SHARE (%)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)
I. NCR	434,555	96.4	78.5	21.5	550,461	448,632	101,829	671,952	561,191	110,761	792,069	672,476	119,593	913,196	784,697	128,498
1. Manila *	135,163	30.2	96.6	3.4	172,462	167,797	4,665	210,526	205,861	4,665	248,160	243,494	4,665	286,109	281,444	4,665
2. Pasay City *	25,338	5.6	65.3	34.7	32,088	23,293	8,795	39,170	30,375	8,795	46,172	37,377	8,795	53,233	44,438	8,795
3. Quezon City *	113,981	25.3	75.7	24.3	144,346	116,705	27,641	176,204	148,563	27,641	207,702	180,061	27,641	239,464	211,824	27,641
4. Caloocan City *	15,088	3.3	75.6	24.4	19,107	15,433	3,674	23,324	19,650	3,674	27,494	23,820	3,674	31,698	28,024	3,674
5. Las Pinas	4,299	1.0	14.4	85.6	5,444	786	4,658	6,646	959	5,686	7,833	1,131	6,703	9,031	1,303	7,728
6. Makati *	59,269	13.1	80.2	19.8	75,058	63,337	11,721	91,624	79,903	11,721	108,003	96,282	11,721	124,519	112,798	11,721
7. Malabon *	5,224	1.2	61.4	38.6	6,616	4,600	2,016	8,076	6,060	2,016	9,519	7,504	2,016	10,975	8,959	2,016
8. Mandaluyong *	13,338	3.0	84.0	16.0	16,891	14,763	2,128	20,620	18,491	2,128	24,305	22,177	2,128	28,022	25,894	2,128
9. Marikina	5,280	1.2	73.5	26.5	6,687	4,914	1,773	8,163	5,999	2,164	9,622	7,071	2,551	11,094	8,153	2,941
10. Muntinlupa	8,308	1.8	0.9	99.1	10,521	98	10,423	12,843	120	12,723	15,139	142	14,997	17,454	163	17,291
11. Navotas *	2,655	0.6	76.6	23.4	3,363	2,742	621	4,105	3,484	621	4,839	4,218	621	5,578	4,958	621
12. Paranaque	11,624	2.6	57.7	42.3	14,720	8,497	6,223	17,969	10,372	7,597	21,181	12,226	8,955	24,420	14,096	10,324
13. Pasig	16,004	3.5	58.4	41.6	20,268	11,836	8,431	24,741	14,449	10,292	29,163	17,031	12,132	33,623	19,636	13,987
14. Pateros	56	0.0	100.0	0.0	71	71	0	86	86	0	102	102	0	117	117	0
15. San Juan *	8,299	1.8	98.8	1.2	10,510	10,412	97	12,829	12,732	97	15,122	15,025	97	17,435	17,338	97
16. Taguig	4,016	0.9	9.0	91.0	5,086	457	4,629	6,208	558	5,650	7,318	658	6,660	8,437	758	7,679
17. Valenzuela	5,705	1.3	40.0	60.0	7,224	2,890	4,335	8,819	3,528	5,291	10,395	4,158	6,237	11,935	4,794	7,141
II. CAVITE	6,399	1.4	19.1	80.9	8,103	1,550	6,554	9,892	1,892	8,000	11,660	2,230	9,430	13,443	2,571	10,873
1. Bacoor	971	0.2	27.6	72.4	1,230	340	890	1,502	415	1,087	1,770	489	1,281	2,041	564	1,477
2. Cavite City	4,207	0.9	17.3	82.7	5,327	921	4,406	6,503	1,124	5,379	7,666	1,325	6,341	8,838	1,528	7,310
3. Imus	709	0.2	9.1	90.9	898	82	816	1,096	100	996	1,292	118	1,174	1,490	136	1,354
4. Kawit	122	0.0	100.0	0.0	155	155	0	189	189	0	222	222	0	256	256	0
5. Noveleta	5	0.0	100.0	0.0	6	6	0	8	8	0	9	9	0	10	10	0
6. Rosario	385	0.1	9.5	90.5	487	46	441	595	56	538	701	66	635	809	77	732
III. RIZAL	9,983	2.2	16.5	83.5	15,668	5,109	10,559	20,285	7,396	12,889	25,513	10,320	15,193	31,370	13,854	17,517
1. Angono	-	-	-	-	623	623	0	1,028	1,028	0	1,585	1,585	0	2,317	2,317	0
2. Antipolo	3,367	0.7	17.9	82.1	4,264	765	3,499	5,205	934	4,271	6,136	1,101	5,035	7,074	1,269	5,805
3. Baras	-	-	-	-	25	25	0	38	38	0	80	80	0	140	140	0
4. Binangonan	-	-	-	-	1,402	1,402	0	2,180	2,180	0	3,183	3,183	0	4,427	4,427	0
5. Cainta	3,622	0.8	12.4	87.6	4,587	569	4,018	5,600	695	4,905	6,601	819	5,782	7,610	944	6,667
6. Cardona	-	-	-	-	98	98	0	126	126	0	168	168	0	219	219	0
7. Jala-Jala	-	-	-	-	15	15	0	54	54	0	114	114	0	198	198	0
8. Montalban	888	0.2	4.7	95.3	1,122	53	1,069	1,370	64	1,305	1,614	75	1,539	1,861	87	1,774
9. Morong	-	-	-	-	191	191	0	251	251	0	354	354	0	489	489	0
10. Pililla	-	-	-	-	141	141	0	232	232	0	432	432	0	613	613	0
11. San Mateo	576	0.1	32.2	67.8	729	235	494	890	287	603	1,049	338	711	1,209	390	819
12. Tanay	-	-	-	-	434	434	0	785	785	0	1,176	1,176	0	1,677	1,677	0
13. Taytay	1,532	0.3	23.8	76.2	1,941	462	1,478	2,369	565	1,804	2,792	665	2,127	3,219	767	2,452
14. Teresa	-	-	-	-	96	96	0	158	158	0	229	229	0	316	316	0
TOTAL	451,047	100.0	76.3	23.7	574,232	455,291	118,941	702,129	570,478	131,651	829,242	685,026	144,216	958,009	801,121	156,888

TABLE 6.2.6 MWSS INDUSTRIAL CONSUMPTION PROJECTION

CITY/MUNICIPALITY	1990 ESTIMATED CONSUMPTION				1995			2000			2005			2010		
	TOTAL QT'TY (M3/DAY)	% IN TOTAL	MWSS SHARE (%)	PRIV. SHARE (%)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)
I. NCR	352,048	82.4	22.5	77.5	437,871	113,331	324,540	515,868	146,218	369,650	588,825	176,980	411,846	659,386	206,731	452,655
1. Manila *	23,403	5.3	75.3	24.7	28,304	22,519	5,786	33,346	27,560	5,786	38,062	32,276	5,786	42,623	36,837	5,786
2. Pasay City *	4,293	1.0	21.4	78.6	5,192	1,817	3,375	6,116	2,742	3,375	6,981	3,607	3,375	7,818	4,443	3,375
3. Quezon City *	51,708	11.8	37.4	62.6	62,538	30,170	32,368	73,677	41,310	32,368	84,097	51,730	32,368	94,175	61,807	32,368
4. Caloocan City *	13,923	3.2	66.5	33.5	16,839	12,175	4,665	19,839	15,174	4,665	22,644	17,980	4,665	25,358	20,693	4,665
5. Las Pinas	21,115	4.8	0.7	99.3	25,537	189	25,348	30,086	222	29,863	34,341	254	34,087	38,456	284	38,171
6. Makati *	8,041	1.8	57.9	42.1	9,725	6,342	3,383	11,458	8,074	3,383	13,078	9,694	3,383	14,645	11,262	3,383
7. Malabon *	20,537	4.7	29.1	70.9	24,838	10,273	14,565	29,263	14,698	14,565	33,401	18,836	14,565	37,404	22,839	14,565
8. Mandaluyong *	13,151	3.0	59.3	40.7	15,906	10,553	5,353	18,739	13,386	5,353	21,389	16,036	5,353	23,952	18,599	5,353
9. Marikina	8,239	1.9	17.1	82.9	9,965	1,701	8,264	11,739	2,004	9,736	13,400	2,287	11,113	15,005	2,561	12,444
10. Muntinlupa	34,360	7.8	0.2	99.8	41,556	97	41,459	48,958	114	48,844	55,882	130	55,751	62,578	146	62,432
11. Navotas *	3,762	0.9	53.8	46.2	4,550	2,811	1,739	5,360	3,621	1,739	6,118	4,379	1,739	6,852	5,112	1,739
12. Paranaque	19,370	4.4	8.7	91.3	23,427	2,031	21,396	27,600	2,393	25,207	31,503	2,731	28,772	35,278	3,059	32,220
13. Pasig	68,156	15.5	11.9	88.1	82,430	9,770	72,659	97,113	11,511	85,602	110,847	13,139	97,708	124,130	14,713	109,417
14. Pateros	1,760	0.4	0.2	99.8	2,128	4	2,124	2,507	5	2,502	2,862	6	2,856	3,205	6	3,198
15. San Juan *	1,259	0.3	95.3	4.7	1,522	1,463	59	1,794	1,735	59	2,047	1,988	59	2,293	2,234	59
16. Taguig	41,208	9.4	0.0	100.0	49,838	11	49,826	58,715	13	58,702	67,019	15	67,004	75,050	17	75,033
17. Valenzuela	27,763	6.3	4.2	95.8	33,577	1,406	32,171	39,558	1,656	37,902	45,153	1,891	43,262	50,564	2,117	48,446
II. CAVITE	7,037	1.6	16.3	83.7	8,511	1,389	7,122	10,027	1,637	8,391	11,445	1,868	9,577	12,817	2,092	10,725
1. Bacoor	70	0.0	100.0	0.0	85	85	0	100	100	0	114	114	0	128	128	0
2. Cavite City	238	0.1	100.0	0.0	288	288	0	339	339	0	387	387	0	433	433	0
3. Imus	538	0.1	1.3	98.7	650	9	641	766	10	756	874	12	863	979	13	966
4. Kawit	574	0.1	100.0	0.0	694	694	0	818	818	0	934	934	0	1,045	1,045	0
5. Noveleta	88	0.0	100.0	0.0	107	107	0	126	126	0	143	143	0	161	161	0
6. Rosario	5,530	1.3	3.1	96.9	6,688	207	6,481	7,879	244	7,635	8,993	278	8,715	10,071	312	9,759
III. RIZAL	70,308	16.0	2.8	97.2	90,479	3,347	87,131	108,913	5,440	103,472	127,524	9,149	118,375	146,764	14,834	131,930
1. Angono	-	-	-	-	1,121	196	925	1,850	555	1,295	2,854	1,284	1,570	4,170	2,502	1,668
2. Antipolo	13,798	3.1	12.9	87.1	16,688	2,145	14,543	19,661	2,527	17,134	22,441	2,884	19,557	25,130	3,230	21,901
3. Baras	-	-	-	-	46	8	38	68	20	48	144	65	79	252	151	101
4. Binangonan	-	-	-	-	2,523	442	2,081	3,924	1,177	2,747	5,729	2,578	3,151	7,968	4,781	3,187
5. Cainta	36,221	8.2	0.1	99.9	43,807	58	43,749	51,610	68	51,541	58,909	78	58,831	65,968	88	65,880
6. Cardona	-	-	-	-	177	31	146	227	68	159	303	136	167	395	237	158
7. Jala-Jala	-	-	-	-	27	5	22	97	29	68	204	92	112	355	213	142
8. Montalban	2,958	0.7	0.6	99.4	3,578	21	3,557	4,215	24	4,191	4,811	28	4,784	5,388	31	5,357
9. Morong	-	-	-	-	344	60	284	451	135	316	636	286	350	881	529	352
10. Pililla	-	-	-	-	253	44	209	417	125	292	778	350	428	1,104	662	442
11. San Mateo	658	0.1	8.3	91.7	796	66	730	938	78	860	1,071	89	982	1,199	100	1,099
12. Tanay	-	-	-	-	782	137	645	1,413	424	989	2,118	953	1,165	3,019	1,811	1,208
13. Taytay	16,672	3.8	0.5	99.5	20,164	105	20,059	23,756	124	23,632	27,116	141	26,975	30,365	158	30,207
14. Teresa	-	-	-	-	173	30	143	286	86	200	411	185	226	570	342	228
TOTAL	439,394	100.0	19.2	80.8	536,861	118,068	418,793	634,808	153,295	481,513	727,795	187,997	539,798	818,967	223,657	595,310

* Future demand increase was assumed to be shouldered by MWSS only.

TABLE 6.2.7 SUMMARY OF PROJECTED WATER DEMAND IN 1995 (CASE 3)

CITY/ MUNICIPALITY	MWSS SERVED WATER DEMAND (M3/D)						PRIVATELY SERVED WATER DEMAND (M3/D)				TOTAL WATER DEMAND (M3/D)					MWSS SERVICE RATIO (%)			
	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	LOSS %	TOTAL	DOMESTIC	COMMERCIAL	INDUSTRIAL	TOTAL	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	TOTAL	D	C	I	T
I. NCR	1,126,290	448,632	113,331	909,059	35.0	2,597,312	315,907	101,829	324,540	742,276	1,442,197	550,461	437,871	909,059	3,339,588	78.1	81.5	25.9	77.8
1. Manila	252,399	167,797	22,519	238,385	35.0	681,100	19,345	4,665	5,786	29,796	271,745	172,462	28,304	238,385	710,897	92.9	97.3	79.6	95.8
2. Pasay City	43,524	23,293	1,817	36,957	35.0	105,590	10,561	8,795	3,375	22,731	54,085	32,088	5,192	36,957	128,321	80.5	72.6	35.0	82.3
3. Quezon City	270,472	116,705	30,170	224,725	35.0	642,072	23,246	27,641	32,368	83,254	293,717	144,346	62,538	224,725	725,326	92.1	80.9	48.2	88.5
4. Caloocan City	81,416	15,433	12,175	58,705	35.0	167,729	39,838	3,674	4,665	48,176	121,254	19,107	16,839	58,705	215,905	67.1	80.8	72.3	77.7
5. Las Pinas	29,775	786	189	16,558	35.0	47,307	37,007	4,658	25,348	67,013	66,782	5,444	25,537	16,558	114,320	44.6	14.4	0.7	41.4
6. Makati	80,974	63,337	6,342	81,121	35.0	231,774	10,477	11,721	3,383	25,581	91,451	75,058	9,725	81,121	257,355	88.5	84.4	65.2	90.1
7. Malabon	31,384	4,600	10,273	24,908	35.0	71,165	14,689	2,016	14,565	31,270	46,074	6,616	24,838	24,908	102,435	68.1	69.5	41.4	69.5
8. Mandaluyong	36,610	14,763	10,553	33,345	35.0	95,271	3,248	2,128	5,353	10,729	39,858	16,891	15,906	33,345	106,000	91.9	87.4	66.3	89.9
9. Marikina	52,397	4,914	1,701	31,775	35.0	90,788	4,343	1,773	8,264	14,380	56,741	6,687	9,965	31,776	105,169	92.3	73.5	17.1	86.3
10. Muntinlupa	20,636	99	97	11,217	35.0	32,049	31,571	10,423	41,459	83,453	52,208	10,521	41,556	11,217	115,501	39.5	0.9	0.2	27.7
11. Navotas	24,677	2,742	2,811	16,278	35.0	46,507	4,120	621	1,739	6,480	28,797	3,363	4,550	16,278	52,987	85.7	81.5	61.8	87.8
12. Paranaque	62,984	8,497	2,031	39,583	35.0	113,095	42,310	6,223	21,396	69,929	105,294	14,720	23,427	39,583	183,025	59.8	57.7	8.7	61.8
13. Pasig	62,935	11,836	9,770	45,522	35.0	130,063	9,182	8,431	72,659	90,273	72,117	20,268	82,430	45,522	220,336	87.3	58.4	11.9	59.0
14. Pateros	4,252	71	4	2,330	35.0	6,657	5,277	0	2,124	7,401	9,529	71	2,128	2,330	14,057	44.6	100.0	0.2	47.4
15. San Juan	29,410	10,413	1,463	22,231	35.0	63,517	1,731	97	59	1,887	31,141	10,510	1,522	22,231	65,404	94.4	99.1	96.1	97.1
16. Taguig	9,793	457	11	5,525	35.0	15,787	38,207	4,629	49,826	92,662	48,000	5,086	49,838	5,525	108,449	20.4	9.0	0.0	14.6
17. Valenzuela	32,651	2,890	1,406	19,894	35.0	56,841	20,755	4,335	32,171	57,261	53,406	7,224	33,577	19,894	114,101	61.1	40.0	4.2	49.8
II. CAVITE	44,332	1,550	1,389	20,259	30.0	67,529	49,094	6,554	7,122	62,769	93,425	8,103	8,511	20,259	130,299	47.5	19.1	16.3	51.8
1. Bacoor	15,408	340	85	6,785	30.0	22,617	18,918	890	0	19,808	34,325	1,230	85	6,785	42,425	44.9	27.6	100.0	53.3
2. Cavite City	10,954	921	288	5,213	30.0	17,375	6,511	4,406	0	10,917	17,465	5,327	288	5,213	28,293	62.7	17.3	100.0	61.4
3. Imus	7,781	82	9	3,374	30.0	11,245	11,023	816	641	12,480	18,804	898	650	3,374	23,725	41.4	9.1	1.3	47.4
4. Kawit	6,802	155	694	3,279	30.0	10,929	3,041	0	0	3,041	9,843	155	694	3,279	13,971	69.1	100.0	100.0	78.2
5. Noveleta	1,022	6	107	486	30.0	1,621	3,059	0	0	3,059	4,080	6	107	486	4,680	25.0	100.0	100.0	34.6
6. Rosario	2,366	46	207	1,123	30.0	3,742	6,542	441	6,481	13,464	8,908	487	6,688	1,123	17,205	26.6	9.5	3.1	21.7
III. RIZAL	47,536	5,109	3,347	20,750	27.0	76,743	71,104	10,559	87,131	168,794	118,640	15,668	90,479	20,750	245,537	40.1	32.6	3.7	31.3
1. Angono	3,115	623	196	694	15.0	4,628	1,156	0	925	2,081	4,271	623	1,121	694	6,709	72.9	100.0	17.5	69.0
2. Antipolo	11,090	765	2,145	6,000	30.0	19,999	19,774	3,499	14,543	37,816	30,864	4,264	16,688	6,000	57,818	35.9	17.9	12.9	34.6
3. Baras	127	25	8	28	15.0	188	558	0	38	596	685	25	46	28	784	18.5	100.0	17.4	23.9
4. Binangonan	7,008	1,402	442	1,562	15.0	10,414	3,109	0	2,081	5,190	10,117	1,402	2,523	1,562	15,604	69.3	100.0	17.5	66.7
5. Cainta	6,273	569	58	3,716	35.0	10,616	18,589	4,018	43,748	66,356	24,862	4,587	43,807	3,716	76,972	25.2	12.4	0.1	13.8
6. Cardona	490	98	31	109	15.0	728	966	0	146	1,112	1,456	98	177	109	1,840	33.7	100.0	17.5	39.6
7. Jala-Jala	73	15	5	16	15.0	109	542	0	22	564	615	15	27	16	673	11.9	100.0	18.5	16.2
8. Montalban	3,903	53	21	1,704	30.0	5,680	3,232	1,069	3,557	7,918	7,135	1,122	3,578	1,704	13,599	54.2	4.7	0.6	41.8
9. Morong	955	191	60	213	15.0	1,419	861	0	284	1,145	1,816	191	344	213	2,564	52.6	100.0	17.4	55.3
10. Pililla	703	141	44	157	15.0	1,045	993	0	209	1,202	1,696	141	253	157	2,247	41.5	100.0	17.4	46.5
11. San Mateo	4,352	235	66	1,994	30.0	6,648	6,278	494	730	7,502	10,630	729	796	1,994	14,150	40.9	32.2	8.3	47.0
12. Tanay	2,170	434	137	484	15.0	3,225	1,656	0	645	2,301	3,826	434	782	484	5,526	56.7	100.0	17.5	58.4
13. Taytay	6,798	462	105	3,966	35.0	11,331	12,754	1,478	20,059	34,291	19,552	1,941	20,164	3,966	45,622	34.8	23.8	0.5	24.8
14. Teresa	480	96	30	107	15.0	713	575	0	143	718	1,055	96	173	107	1,431	45.5	100.0	17.3	49.8
TOTAL	1,218,158	455,291	118,068	950,068	34.7	2,741,584	436,105	118,941	418,793	973,839	1,654,262	574,232	536,861	950,068	3,715,423	73.6	79.3	22.0	73.8

TABLE 6.2.8 SUMMARY OF PROJECTED WATER DEMAND IN 2000 (CASE 3)

CITY/ MUNICIPALITY	MWSS SERVED WATER DEMAND (M3/D)						PRIVATELY SERVED WATER DEMAND (M3/D)				TOTAL WATER DEMAND (M3/D)					MWSS SERVICE RATIO (%)			
	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	LOSS %	TOTAL	DOMESTIC	COMMERCIAL	INDUSTRIAL	TOTAL	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	TOTAL	D	C	I	T
I. NCR	1,420,202	561,191	146,218	911,833	30.0	3,039,444	211,812	110,761	369,650	692,223	1,632,014	671,952	515,868	911,833	3,731,667	87.0	83.5	28.3	81.5
1. Manila	267,682	205,861	27,560	214,759	30.0	715,862	17,415	4,665	5,786	27,866	285,097	210,526	33,346	214,759	743,728	93.9	97.8	82.6	96.3
2. Pasay City	52,747	30,375	2,742	36,799	30.0	122,662	7,448	8,795	3,375	19,618	60,195	39,170	6,116	36,799	142,280	87.6	77.5	44.8	86.2
3. Quezon City	307,254	148,563	41,310	213,055	30.0	710,182	21,462	27,641	32,368	81,471	328,717	176,204	73,677	213,055	791,653	93.5	84.3	56.1	89.7
4. Caloocan City	110,825	19,650	15,174	62,421	30.0	208,070	30,123	3,674	4,665	38,462	140,948	23,324	19,839	62,421	246,532	78.6	84.2	76.5	84.4
5. Las Pinas	68,920	959	222	30,043	30.0	100,145	23,463	5,686	29,864	59,013	92,383	6,646	30,086	30,043	159,158	74.6	14.4	0.7	62.9
6. Makati	92,691	79,903	8,074	77,429	30.0	258,098	5,740	11,721	3,383	20,844	98,432	91,624	11,458	77,429	278,943	94.2	87.2	70.5	92.5
7. Malabon	40,574	5,060	14,698	26,285	30.0	87,616	10,723	2,016	14,565	27,304	51,297	8,076	29,263	26,285	114,921	79.1	75.0	50.2	76.2
8. Mandaluyong	41,038	18,491	13,386	31,250	30.0	104,166	2,314	2,128	5,353	10,395	43,352	20,620	18,739	31,250	114,560	93.4	89.7	71.4	90.9
9. Marikina	61,462	5,999	2,004	29,770	30.0	99,235	4,194	2,164	9,736	16,094	65,656	8,163	11,739	29,770	115,328	93.6	73.5	17.1	86.0
10. Muntinlupa	48,677	120	114	20,962	30.0	69,874	16,821	12,723	48,844	78,387	65,498	12,843	48,958	20,962	148,261	74.3	0.9	0.2	47.1
11. Navotas	29,978	3,484	3,621	15,893	30.0	52,977	2,401	621	1,739	4,761	32,379	4,105	5,360	15,893	57,737	92.6	84.9	67.6	91.8
12. Paranaque	92,068	10,372	2,393	44,928	30.0	149,761	23,296	7,597	25,207	56,100	115,364	17,969	27,600	44,928	205,861	79.8	57.7	8.7	72.7
13. Pasig	79,047	14,448	11,511	45,003	30.0	150,009	5,536	10,292	85,602	101,430	84,583	24,741	97,113	45,003	251,439	93.5	58.4	11.9	59.7
14. Pateros	7,638	86	5	3,312	30.0	11,041	3,311	0	2,502	5,813	10,949	86	2,507	3,312	16,854	69.8	100.0	0.2	65.5
15. San Juan	30,409	12,732	1,735	19,232	30.0	64,108	1,732	97	59	1,888	32,141	12,829	1,794	19,232	65,996	94.6	99.2	96.7	97.1
16. Taguig	39,371	558	13	17,118	30.0	57,060	17,185	5,650	58,702	81,537	56,556	6,208	58,715	17,118	138,597	69.6	9.0	0.0	41.2
17. Valenzuela	49,820	3,528	1,656	23,573	30.0	78,578	18,048	5,291	37,902	61,241	67,868	8,819	39,558	23,573	139,818	73.4	40.0	4.2	56.2
II. CAVITE	78,768	1,892	1,637	35,270	30.0	117,566	32,641	8,000	8,391	49,032	111,409	9,892	10,027	35,270	166,598	70.7	19.1	16.3	70.6
1. Bacoor	34,252	415	100	14,900	30.0	49,666	8,626	1,087	0	9,713	42,878	1,502	100	14,900	59,379	79.9	27.6	100.0	83.6
2. Cavite City	14,987	1,124	339	7,050	30.0	23,500	4,270	5,379	0	9,649	19,255	6,503	339	7,050	33,149	77.8	17.3	100.0	70.9
3. Imus	12,683	100	10	5,483	30.0	18,277	9,600	996	755	11,351	22,283	1,096	766	5,483	29,628	56.9	9.1	1.3	61.7
4. Kawit	9,723	189	818	4,598	30.0	15,328	1,855	0	0	1,855	11,578	189	818	4,598	17,183	84.0	100.0	100.0	89.2
5. Noveleta	3,057	8	126	1,367	30.0	4,558	1,702	0	0	1,702	4,759	8	126	1,367	6,260	64.2	100.0	100.0	72.8
6. Rosario	4,066	56	244	1,871	30.0	6,238	6,590	538	7,635	14,763	10,656	595	7,879	1,871	21,001	38.2	9.5	3.1	29.7
III. RIZAL	96,991	7,396	5,440	39,070	26.2	148,897	61,900	12,889	103,472	178,262	158,891	20,285	108,913	39,070	327,159	61.0	36.5	5.0	45.5
1. Angono	5,138	1,028	555	1,186	15.0	7,907	1,124	0	1,295	2,419	6,262	1,028	1,850	1,186	10,326	82.1	100.0	30.0	76.6
2. Antipolo	17,690	934	2,527	9,064	30.0	30,215	23,877	4,271	17,134	45,283	41,567	5,205	19,661	9,064	75,498	42.6	17.9	12.9	40.0
3. Baras	189	38	20	44	15.0	291	610	0	48	658	799	38	68	44	949	23.7	100.0	29.5	30.6
4. Binangonan	10,902	2,180	1,177	2,516	15.0	16,775	2,873	0	2,747	5,620	13,775	2,180	3,924	2,516	22,395	79.1	100.0	30.0	74.9
5. Cainta	24,761	695	68	10,939	30.0	36,463	10,715	4,905	51,541	67,162	35,476	5,600	51,610	10,939	103,625	69.8	12.4	0.1	35.2
6. Cardona	631	126	68	146	15.0	971	1,005	0	159	1,164	1,636	126	227	146	2,135	38.6	100.0	30.0	45.5
7. Jala-Jala	269	54	29	62	15.0	414	542	0	68	610	811	54	97	62	1,024	33.2	100.0	29.9	40.4
8. Montalban	5,644	64	24	2,457	30.0	8,189	3,070	1,305	4,191	8,566	8,714	1,370	4,215	2,457	16,755	64.8	4.7	0.6	48.9
9. Morong	1,253	251	135	289	15.0	1,928	900	0	316	1,216	2,153	251	451	289	3,144	58.2	100.0	29.9	61.3
10. Pililla	1,161	232	125	268	15.0	1,786	1,010	0	292	1,302	2,171	232	417	268	3,088	53.5	100.0	30.0	57.8
11. San Mateo	6,883	287	78	3,106	30.0	10,354	6,381	603	860	7,844	13,264	890	938	3,106	18,198	51.9	32.2	8.3	56.9
12. Tanay	3,924	785	424	906	15.0	6,039	1,570	0	989	2,559	5,494	785	1,413	906	8,598	71.4	100.0	30.0	70.2
13. Taytay	17,754	565	124	7,904	30.0	26,346	7,683	1,804	23,632	33,120	25,437	2,369	23,756	7,904	59,466	69.8	23.8	0.5	44.3
14. Teresa	792	158	86	183	15.0	1,219	539	0	200	739	1,331	158	286	183	1,958	59.5	100.0	30.1	62.3
TOTAL	1,535,962	570,479	153,295	986,173	29.8	3,305,908	306,353	131,651	481,513	919,517	1,902,314	702,129	634,808	986,173	4,225,424	83.9	81.2	24.1	78.2

TABLE 6.2.9 SUMMARY OF PROJECTED WATER DEMAND IN 2005 (CASE 2 & 3)

CITY/ MUNICIPALITY	MWSS SERVED WATER DEMAND (M3/D)						PRIVATELY SERVED WATER DEMAND (M3/D)				TOTAL WATER DEMAND (M3/D)					MWSS SERVICE RATIO (%)			
	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	LOSS %	TOTAL	DOMESTIC	COMMERCIAL	INDUSTRIAL	TOTAL	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	TOTAL	D	C	I	T
I. NCR	1,634,341	672,476	176,380	827,932	25.0	3,311,129	180,476	119,593	411,846	711,915	1,814,818	792,069	588,226	827,932	4,023,044	90.1	84.9	30.1	82.3
1. Manila	277,955	243,494	32,276	184,575	25.0	738,301	17,021	4,665	5,786	27,472	294,976	248,160	38,062	184,575	765,773	94.2	98.1	84.8	96.4
2. Pasay City	61,177	37,377	3,607	34,054	25.0	136,214	4,538	8,795	3,375	16,708	65,715	46,172	6,981	34,054	152,922	93.1	81.0	51.7	89.1
3. Quezon City	338,611	180,061	51,730	190,134	25.0	760,536	21,866	27,641	32,368	81,874	360,477	207,702	84,097	190,134	842,410	93.9	86.7	61.5	90.3
4. Caloocan City	134,651	23,820	17,980	58,817	25.0	235,267	25,631	3,674	4,665	33,970	160,282	27,494	22,644	58,817	269,237	84.0	86.6	79.4	87.4
5. Las Pinas	103,932	1,131	254	35,105	25.0	140,422	18,894	6,702	34,087	59,684	122,826	7,833	34,341	35,105	200,105	84.6	14.4	0.7	70.2
6. Makati	98,362	96,282	9,694	68,113	25.0	272,451	5,816	11,721	3,383	20,920	104,178	108,003	13,078	68,113	293,371	94.4	89.1	74.1	92.9
7. Malabon	47,256	7,504	18,836	24,532	25.0	98,128	8,770	2,016	14,565	25,351	56,026	9,519	33,401	24,532	123,479	84.3	78.8	56.4	79.5
8. Mandaluyong	44,675	22,177	16,036	27,629	25.0	110,518	2,913	2,128	5,353	10,394	47,587	24,305	21,389	27,629	120,911	93.9	91.2	75.0	91.4
9. Marikina	69,793	7,071	2,287	26,384	25.0	105,535	4,426	2,551	11,113	18,090	74,219	9,622	13,400	26,384	123,625	94.0	73.5	17.1	85.4
10. Muntinlupa	67,217	142	130	22,496	25.0	89,985	12,477	14,997	55,751	83,225	79,694	15,139	55,882	22,496	173,211	84.3	0.9	0.2	52.0
11. Navotas	33,300	4,218	4,379	13,966	25.0	55,863	2,377	621	1,739	4,737	35,677	4,839	6,118	13,966	60,600	93.3	87.2	71.6	92.2
12. Paranaque	104,101	12,226	2,731	39,686	25.0	158,744	18,593	8,955	28,772	56,320	122,694	21,181	31,503	39,686	215,064	84.8	57.7	8.7	73.8
13. Pasig	90,921	17,031	13,139	40,364	25.0	161,455	5,377	12,132	97,208	115,717	96,298	29,163	110,347	40,364	277,172	93.9	58.4	11.9	58.3
14. Pateros	9,815	102	6	3,307	25.0	13,229	2,489	0	2,856	5,346	12,304	102	2,862	3,307	18,575	79.8	100.0	0.2	71.2
15. San Juan	31,086	15,025	1,988	16,033	25.0	64,133	1,733	97	59	1,888	32,818	15,122	2,047	16,033	66,020	94.7	99.4	97.1	97.1
16. Taguig	51,771	658	15	17,481	25.0	69,925	13,245	6,660	67,004	86,909	65,016	7,318	67,019	17,481	156,834	79.6	9.0	0.0	44.6
17. Valenzuela	69,719	4,158	1,891	25,256	25.0	101,024	13,812	6,237	43,262	63,311	83,531	10,395	45,153	25,256	164,335	83.5	40.0	4.2	61.5
II. CAVITE	104,412	2,230	1,868	36,170	25.0	144,680	25,861	9,430	9,577	44,868	130,273	11,660	11,445	36,170	189,548	80.1	19.1	16.3	76.3
1. Bacoor	44,303	489	114	14,968	25.0	59,874	7,858	1,281	0	9,140	52,161	1,770	114	14,968	69,014	84.9	27.6	100.0	86.8
2. Cavite City	19,634	1,325	387	7,115	25.0	28,461	1,440	6,341	0	7,781	21,074	7,666	387	7,115	36,242	93.2	17.3	100.0	78.5
3. Imus	17,516	118	12	5,882	25.0	23,527	8,309	1,174	863	10,346	25,825	1,292	874	5,882	33,873	67.8	9.1	1.3	69.5
4. Kawit	12,720	222	934	4,626	25.0	18,502	603	0	0	603	13,323	222	934	4,626	19,105	95.5	100.0	100.0	96.8
5. Noveleta	4,154	9	143	1,436	25.0	5,742	1,284	0	0	1,284	5,439	9	143	1,436	7,027	76.4	100.0	100.0	81.7
6. Rosario	6,085	66	278	2,143	25.0	8,573	6,366	635	8,715	15,715	12,451	701	8,993	2,143	24,288	48.9	9.5	3.1	35.3
III. RIZAL	139,950	10,320	9,149	45,319	22.1	204,739	60,142	15,193	118,375	193,711	200,092	25,513	127,524	45,319	398,449	69.9	40.4	7.2	51.4
1. Angono	7,927	1,585	1,284	1,905	15.0	12,701	1,022	0	1,570	2,592	8,949	1,585	2,854	1,905	15,293	88.6	100.0	45.0	83.1
2. Antipolo	25,514	1,101	2,884	9,833	25.0	39,332	26,583	5,035	19,557	51,175	52,097	6,136	22,441	9,833	90,506	49.0	17.9	12.9	43.5
3. Baras	401	80	65	96	15.0	642	629	0	79	708	1,030	80	144	96	1,350	38.9	100.0	45.1	47.6
4. Binangonan	15,915	3,183	2,578	3,825	15.0	25,501	2,520	0	3,151	5,671	18,435	3,183	5,729	3,825	31,172	86.3	100.0	45.0	81.8
5. Cainta	35,617	819	78	12,171	25.0	48,686	9,014	5,782	58,831	73,627	44,632	6,601	58,909	12,171	122,313	79.8	12.4	0.1	39.8
6. Cardona	841	168	136	202	15.0	1,347	1,021	0	167	1,188	1,862	168	303	202	2,535	45.2	100.0	44.9	53.1
7. Jala-Jala	568	114	92	137	15.0	911	526	0	112	638	1,094	114	204	137	1,549	51.9	100.0	45.1	58.8
8. Montalban	7,538	76	28	2,547	25.0	10,188	2,614	1,539	4,784	8,936	10,152	1,614	4,811	2,547	19,124	74.3	4.7	0.6	53.3
9. Morong	1,768	354	286	425	15.0	2,833	940	0	350	1,290	2,708	354	636	425	4,123	65.3	100.0	45.0	68.7
10. Pililla	2,161	432	350	519	15.0	3,462	928	0	428	1,356	3,089	432	778	519	4,818	70.0	100.0	45.0	71.9
11. San Mateo	10,166	338	89	3,531	25.0	14,124	6,141	711	982	7,833	16,307	1,049	1,071	3,531	21,958	62.3	32.2	8.3	64.3
12. Tanay	5,882	1,176	953	1,414	15.0	9,425	1,497	0	1,165	2,662	7,379	1,176	2,118	1,414	12,087	79.7	100.0	45.0	78.0
13. Taytay	24,509	665	141	8,439	25.0	33,754	6,203	2,127	26,975	35,304	30,712	2,792	27,116	8,439	69,058	79.8	23.8	0.5	48.9
14. Teresa	1,143	229	185	275	15.0	1,832	504	0	226	730	1,647	229	411	275	2,562	69.4	100.0	45.0	71.5
TOTAL	1,878,704	685,026	187,397	909,422	24.8	3,661,148	266,479	144,216	539,798	950,493	2,145,183	829,242	727,195	909,422	4,611,641	87.6	82.6	25.8	79.4

TABLE 6.2.10 SUMMARY OF PROJECTED WATER DEMAND IN 2005 (CASE 2 & 3)

CITY/ MUNICIPALITY	MWSS SERVED WATER DEMAND (M3/D)						PRIVATELY SERVED WATER DEMAND (M3/D)				TOTAL WATER DEMAND (M3/D)					MWSS SERVICE RATIO (%)			
	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	LOSS %	TOTAL	DOMESTIC	COMMERCIAL	INDUSTRIAL	TOTAL	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	TOTAL	D	C	I	T
I. NCR	1,814,246	784,697	206,731	935,225	25.0	3,740,899	172,531	126,498	452,655	751,685	1,986,777	911,195	659,386	935,225	4,494,583	91.3	86.1	31.4	83.2
1. Manila	284,993	281,444	36,837	201,092	25.0	804,366	16,908	4,665	5,786	27,359	301,901	286,109	42,623	201,092	831,725	94.4	98.4	86.4	96.7
2. Pasay City	65,993	44,438	4,443	38,291	25.0	153,165	4,567	8,795	3,375	16,736	70,560	53,233	7,818	38,291	169,901	93.5	83.5	56.8	90.1
3. Quezon City	365,702	211,824	61,807	213,111	25.0	852,444	22,654	27,641	32,368	82,662	388,355	239,464	94,175	213,111	935,106	94.2	88.5	65.6	91.2
4. Caloocan City	159,456	28,024	20,693	69,391	25.0	277,565	19,621	3,674	4,665	27,960	179,077	31,698	25,358	69,391	305,524	89.0	88.4	81.6	90.8
5. Las Pinas	133,361	1,303	284	44,983	25.0	179,932	23,990	7,728	38,171	69,889	157,351	9,031	38,455	44,983	249,821	84.8	14.4	0.7	72.0
6. Makati	102,768	112,798	11,262	75,609	25.0	302,437	5,932	11,721	3,383	21,036	108,700	124,519	14,645	75,609	323,473	94.5	90.6	76.9	93.5
7. Malabon	53,787	8,959	22,839	28,528	25.0	114,113	6,398	2,016	14,565	22,979	60,185	10,975	37,404	28,528	137,092	89.4	81.6	61.1	83.2
8. Mandaluyong	47,748	25,894	18,599	30,747	25.0	122,989	2,975	2,128	5,353	10,456	50,723	28,022	23,952	30,747	133,445	94.1	92.4	77.7	92.2
9. Marikina	77,453	8,153	2,561	29,389	25.0	117,556	4,726	2,941	12,444	20,112	82,179	11,094	15,005	29,389	137,668	94.2	73.5	17.1	85.4
10. Muntinlupa	79,750	163	146	26,687	25.0	106,746	14,542	17,291	62,432	94,265	94,292	17,454	62,578	26,687	201,011	84.6	0.9	0.2	53.1
11. Navotas	36,199	4,958	5,112	15,423	25.0	61,692	2,427	621	1,739	4,787	38,626	5,578	6,852	15,423	66,479	93.7	88.9	74.6	92.8
12. Paranaque	107,742	14,096	3,059	41,632	25.0	166,529	19,178	10,324	32,220	61,722	126,920	24,420	35,278	41,632	228,251	84.9	57.7	8.7	73.0
13. Pasig	102,053	19,636	14,713	45,467	25.0	181,869	6,322	13,987	109,417	129,726	108,375	33,623	124,130	45,467	311,595	94.2	58.4	11.9	58.4
14. Pateros	12,158	117	6	4,094	25.0	16,376	1,401	0	3,198	4,600	13,560	117	3,205	4,094	20,975	89.7	100.0	0.2	78.1
15. San Juan	31,298	17,338	2,234	16,956	25.0	67,826	1,724	97	59	1,880	33,022	17,435	2,293	16,956	69,706	94.8	99.4	97.4	97.3
16. Taguig	65,410	758	17	22,062	25.0	88,247	7,704	7,679	75,033	90,416	73,114	8,437	75,050	22,062	178,664	89.5	9.0	0.0	49.4
17. Valenzuela	88,373	4,794	2,117	31,761	25.0	127,045	11,464	7,191	48,446	67,101	99,837	11,985	50,564	31,761	194,147	88.5	40.0	4.2	65.4
II. CAVITE	129,167	2,571	2,092	44,610	25.0	178,439	20,120	10,873	10,725	41,718	149,287	13,443	12,817	44,610	220,157	86.5	19.1	16.3	81.1
1. Bacoor	52,721	564	128	17,804	25.0	71,216	9,322	1,477	0	10,799	62,043	2,041	128	17,804	82,015	85.0	27.6	100.0	86.8
2. Cavite City	22,414	1,528	433	8,125	25.0	32,500	0	7,310	0	7,310	22,414	8,838	433	8,125	39,810	100.0	17.3	100.0	81.6
3. Imus	24,886	136	13	8,345	25.0	33,381	4,498	1,354	966	6,818	29,385	1,490	979	8,345	40,199	84.7	9.1	1.3	83.0
4. Kawit	15,032	256	1,045	5,444	25.0	21,778	0	0	0	0	15,032	256	1,045	5,444	21,778	100.0	100.0	100.0	100.0
5. Noveleta	5,296	10	161	1,822	25.0	7,289	816	0	0	816	6,112	10	161	1,822	8,105	86.6	100.0	100.0	89.9
6. Rosario	8,818	77	312	3,069	25.0	12,275	5,484	732	9,759	15,975	14,302	808	10,071	3,069	28,250	61.7	9.5	3.1	43.5
III. RIZAL	192,815	13,854	14,834	62,289	21.9	283,791	53,161	17,517	131,930	202,608	245,976	31,370	146,764	62,289	486,399	78.4	44.2	10.1	58.3
1. Angono	11,583	2,317	2,502	2,894	15.0	19,296	848	0	1,668	2,516	12,431	2,317	4,170	2,894	21,812	93.2	100.0	60.0	88.5
2. Antipolo	35,948	1,269	3,230	13,482	25.0	53,929	27,675	5,805	21,901	55,380	63,623	7,074	25,130	13,482	109,309	56.5	17.9	12.9	49.3
3. Baras	699	140	151	175	15.0	1,165	630	0	101	731	1,329	140	252	175	1,896	52.6	100.0	59.9	61.4
4. Binangonan	22,135	4,427	4,781	5,531	15.0	36,874	2,063	0	3,187	5,250	24,198	4,427	7,968	5,531	42,124	91.5	100.0	60.0	87.5
5. Cainta	48,671	944	88	16,567	25.0	66,270	5,580	6,667	65,880	78,127	54,251	7,610	65,968	16,567	144,397	89.7	12.4	0.1	45.9
6. Cardona	1,095	219	237	274	15.0	1,825	1,020	0	158	1,178	2,115	219	395	274	3,003	51.8	100.0	60.0	60.8
7. Jala-Jala	988	198	213	247	15.0	1,646	490	0	142	632	1,478	198	355	247	2,278	66.8	100.0	60.0	72.3
8. Montalban	9,288	87	31	3,135	25.0	12,542	2,187	1,774	5,357	9,318	11,475	1,861	5,388	3,135	21,860	80.9	4.7	0.6	57.4
9. Morong	2,447	489	529	611	15.0	4,076	966	0	352	1,318	3,413	489	881	611	5,394	71.7	100.0	60.0	75.6
10. Pililla	3,067	613	662	766	15.0	5,108	882	0	442	1,324	3,949	613	1,104	766	6,432	77.7	100.0	60.0	79.4
11. San Mateo	14,476	390	100	4,989	25.0	19,954	5,274	819	1,099	7,193	19,750	1,209	1,199	4,989	27,147	73.3	32.2	8.3	73.5
12. Tanay	8,385	1,677	1,811	2,095	15.0	13,968	1,366	0	1,208	2,574	9,751	1,677	3,019	2,095	16,542	86.0	100.0	60.0	84.4
13. Taytay	32,453	767	158	11,126	25.0	44,504	3,721	2,452	30,207	36,380	36,174	3,219	30,365	11,126	80,884	89.7	23.8	0.5	55.0
14. Teresa	1,581	316	342	395	15.0	2,634	458	0	228	686	2,039	316	570	395	3,320	77.5	100.0	60.0	79.3
TOTAL	2,136,228	801,121	223,657	1,042,123	24.8	4,203,129	245,812	156,888	595,310	998,010	2,382,040	958,009	818,967	1,042,123	5,201,139	89.7	83.6	27.3	80.8

TABLE 6.2.11 ASSUMPTION IN EACH PUMPING SCENARIO

Scenario No.	MWSS Surface Water Supply Projects	Future Pumpage of Commercial & Industrial Private Wells	CDS Connection in Cavite MSA
1	On-schedule completion of ongoing projects	Increasing(1	Bacoor 100% covered, Kawit 50%, others 0%
2	Same as Scenario 1	Increasing(2 up to year-2000, thereafter pumpage is constant	All municipalities covered
3	Same as Scenario 1	Increasing(2 up to year-1995, thereafter pumpage is constant	All municipalities covered
4	Two years delay of completion of ongoing projects	Same as Scenario 1	Same as Scenario 1

NOTE: (1 With respect to future demand increases but maintaining year-1990 percentage shares

(2 With respect to future demand increases and up to the year indicated

Groundwater Pumpage (m^3/day)

Year	2000			2010		
	MWSS	PRIVATE	TOTAL	MWSS	PRIVATE	TOTAL
Scenario 1	201,855	919,517	1,121,372	280,159	998,010	1,278,170
Scenario 2	201,855	919,517	1,121,372	247,128	892,062	1,139,190
Scenario 3	183,465	919,517	1,102,982	228,738	835,304	1,064,041
Scenario 4	194,508	1,000,620	1,195,128	272,756	1,022,363	1,295,119
Year-1990	89,739	840,702	930,441			

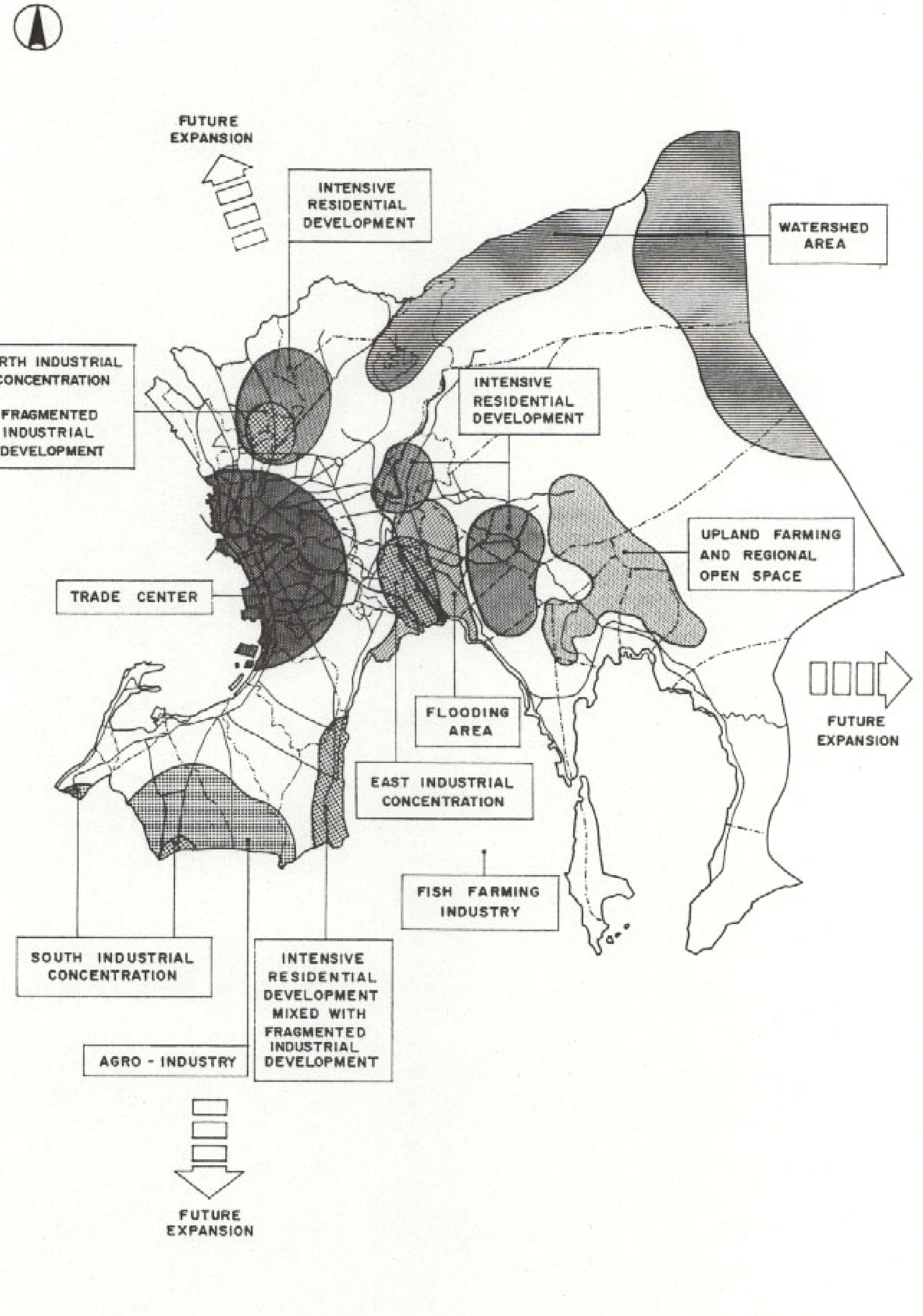
TABLE 6.2.12 SUMMARY OF GROUNDWATER DISCHARGE (SCENARIO 1)

SYSTEM	MWSS WELL					PRIVATE WELL					TOTAL				
CITY/MUNICIPALITY	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010
I. NCR	32,961	44,898	44,898	44,898	44,898	640,937	666,580	692,223	711,915	753,685	673,898	711,478	737,121	756,813	798,583
1. Manila	0	0	0	0	0	12,665	20,265	27,866	27,472	27,359	12,665	20,265	27,866	27,472	27,359
2. Pasay City	4,461	5,082	5,082	5,082	5,082	17,997	18,807	19,618	16,708	16,736	22,456	23,889	24,700	21,790	21,818
3. Quezon City	14,186	18,326	18,326	18,326	18,326	91,324	86,397	81,471	81,874	82,662	105,510	104,723	99,797	100,200	100,986
4. Caloocan City	0	0	0	0	0	27,476	32,969	38,462	33,970	27,960	27,476	32,969	38,462	33,970	27,960
5. Las Pinas	1,527	1,734	1,734	1,734	1,734	81,778	70,395	59,013	59,684	69,889	83,305	72,129	60,747	61,418	71,623
6. Makati	3,772	7,360	7,360	7,360	7,360	25,179	23,012	20,844	20,920	21,036	28,951	30,372	28,204	28,280	28,396
7. Malabon	554	1,244	1,244	1,244	1,244	18,473	22,889	27,304	25,351	22,979	19,027	24,133	28,548	26,595	24,223
8. Mandaluyong	0	0	0	0	0	8,976	9,685	10,395	10,394	10,456	8,976	9,685	10,395	10,394	10,456
9. Marikina	0	0	0	0	0	13,573	14,833	16,094	18,090	20,112	13,573	14,833	16,094	18,090	20,112
10. Muntinlupa	5,777	7,019	7,019	7,019	7,019	91,618	85,003	78,387	83,225	94,265	97,395	92,022	85,406	90,244	101,284
11. Navotas	106	313	313	313	313	4,051	4,406	4,761	4,737	4,787	4,157	4,719	5,074	5,050	5,100
12. Paranaque	1,147	1,768	1,768	1,768	1,768	70,158	63,129	56,100	56,320	61,722	71,305	64,897	57,868	58,088	63,490
13. Pasig	49	256	256	256	256	75,958	88,694	101,430	115,717	129,726	76,007	88,950	101,686	115,973	129,982
14. Pateros	0	0	0	0	0	1,756	3,785	5,813	5,346	4,600	1,756	3,785	5,813	5,346	4,600
15. San Juan	0	0	0	0	0	408	1,148	1,888	1,888	1,880	408	1,148	1,888	1,888	1,880
16. Taguig	640	847	847	847	847	66,367	73,952	81,537	86,909	90,416	67,007	74,799	82,384	87,756	91,263
17. Valenzuela	742	949	949	949	949	33,180	47,210	61,241	63,311	67,101	33,922	48,159	62,190	64,260	68,050
II. CAVITE	28,970	47,610	70,858	84,961	103,890	57,927	53,479	49,032	44,868	41,718	84,897	101,090	119,890	129,829	145,608
1. Bacoor	6,314	7,556	7,556	7,556	7,556	32,210	20,961	9,713	9,140	10,799	38,524	28,517	17,269	16,696	18,355
2. Cavite City	6,714	11,926	20,988	27,133	32,500	4,328	6,988	9,649	7,781	7,310	11,042	18,914	30,637	34,914	39,810
3. Imus	1,654	9,965	18,277	23,527	33,381	4,443	7,897	11,351	10,346	6,818	6,097	17,862	29,628	33,873	40,199
4. Kawit	4,329	7,529	10,730	11,101	10,889	2,830	2,342	1,855	603	0	7,159	9,872	12,585	11,704	10,889
5. Noveleta	7,070	7,070	7,070	7,070	7,289	5,659	3,680	1,702	1,284	816	12,729	10,750	8,772	8,354	8,105
6. Rosario	889	3,563	6,238	8,573	12,275	8,457	11,610	14,763	15,715	15,975	9,346	15,173	21,001	24,288	28,250
III. RIZAL	29,808	58,898	86,098	105,008	131,371	141,838	160,050	178,262	193,711	202,808	171,646	218,948	264,360	298,718	333,979
1. Angono	-	0	0	0	0	-	1,210	2,419	2,592	2,516	-	1,210	2,419	2,592	2,516
2. Antipolo	11,621	19,999	28,381	30,760	35,780	44,155	44,719	45,283	51,175	55,380	55,776	64,718	73,664	81,934	91,160
3. Baras	-	145	291	642	1,165	-	329	658	708	731	-	474	949	1,350	1,896
4. Binangonan	-	8,388	16,775	25,501	36,874	-	2,810	5,620	5,671	5,250	-	11,198	22,395	31,172	42,124
5. Cainta	3,785	4,768	5,766	5,786	5,786	48,619	57,891	67,162	73,627	78,127	52,404	62,676	72,948	79,413	83,913
6. Cardona	-	485	971	1,347	1,825	-	582	1,164	1,188	1,178	-	1,067	2,135	2,535	3,003
7. Jala-Jala	-	207	414	911	1,646	-	305	610	638	632	-	512	1,024	1,549	2,278
8. Montalban	3,243	5,680	6,684	6,684	6,684	8,030	8,298	8,566	8,936	9,318	11,273	13,978	15,250	15,620	16,002
9. Morong	-	964	1,928	2,833	4,076	-	608	1,216	1,290	1,318	-	1,572	3,144	4,123	5,394
10. Pililla	-	893	1,786	3,462	5,108	-	651	1,302	1,356	1,324	-	1,544	3,088	4,818	6,432
11. San Mateo	4,706	6,648	8,130	8,130	8,130	3,641	5,743	7,844	7,833	7,193	8,347	12,391	15,974	15,963	15,323
12. Tanay	-	3,019	6,039	9,425	13,968	-	1,280	2,559	2,662	2,574	-	4,299	8,598	12,087	16,542
13. Taytay	6,453	7,074	7,695	7,695	7,695	37,393	35,256	33,120	35,304	36,380	43,846	42,330	40,815	42,999	44,075
14. Teresa	-	609	1,219	1,832	2,634	-	370	739	730	686	-	979	1,958	2,562	3,320
TOTAL	89,739	151,406	201,855	234,866	280,159	840,702	880,109	919,517	950,493	998,010	930,441	1,031,515	1,121,372	1,185,360	1,278,170

TABLE 6.2.13 WATER DEMAND AND SUPPLY IN THE BASIN

(UNIT: CU.M/DAY)

YEAR	ANTIPOLO BASIN: DEMAND	ANTIPOLO BASIN: SUPPLY				ANTIPOLO BASIN: SHORTAGE	MWSS SERVICE AREA: DEMAND	MWSS SERVICE AREA: SUPPLY				MWSS SERVICE AREA: NET SHORTAGE	
	DAILY AVERAGE	MWSS EX. WELL	PRIVATE WELL	MWSS REHAB.	MWSS AUGMENT.	DAILY AVERAGE	DAILY AVERAGE	MWSS EX. WELL	PRIVATE WELL	MWSS REHAB.	MWSS AUGMENT.	DAILY AVERAGE	DAILY MAXIMUM
1990	19,456	9,809	9,647	--	--	--	--	9,809	2,434	--	--	--	--
1995	23,147	9,809	9,647	2,070	5,810	(4,189)	14,116	9,809	2,434	2,070	5,810	(6,007)	1,051
1996	24,622	9,809	9,647	2,070	5,810	(2,714)	16,763	9,809	3,512	2,070	5,810	(4,439)	3,943
1997	26,096	9,809	9,647	2,070	5,810	(1,240)	19,409	9,809	4,591	2,070	5,810	(2,871)	6,834
1998	27,571	9,809	9,647	2,070	5,810	235	22,056	9,809	5,669	2,070	5,810	(1,303)	9,725
1999	29,045	9,809	9,647	2,070	5,810	1,709	24,702	9,809	6,748	2,070	5,810	265	12,617
2000	30,520	9,809	9,647	2,070	5,810	3,184	27,349	9,809	7,826	2,070	5,810	1,834	15,508
2005	36,749	9,809	9,647	2,070	5,810	9,413	34,773	9,809	8,512	2,070	5,810	8,572	25,958
2010	46,000	9,809	9,647	2,070	5,810	18,664	45,485	9,809	9,647	2,070	5,810	18,149	40,892



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 6.1.1 STRUCTURE PLAN

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 6.1.2
FUTURE LAND USE MAP, 2010 ANTIPOLO AREA

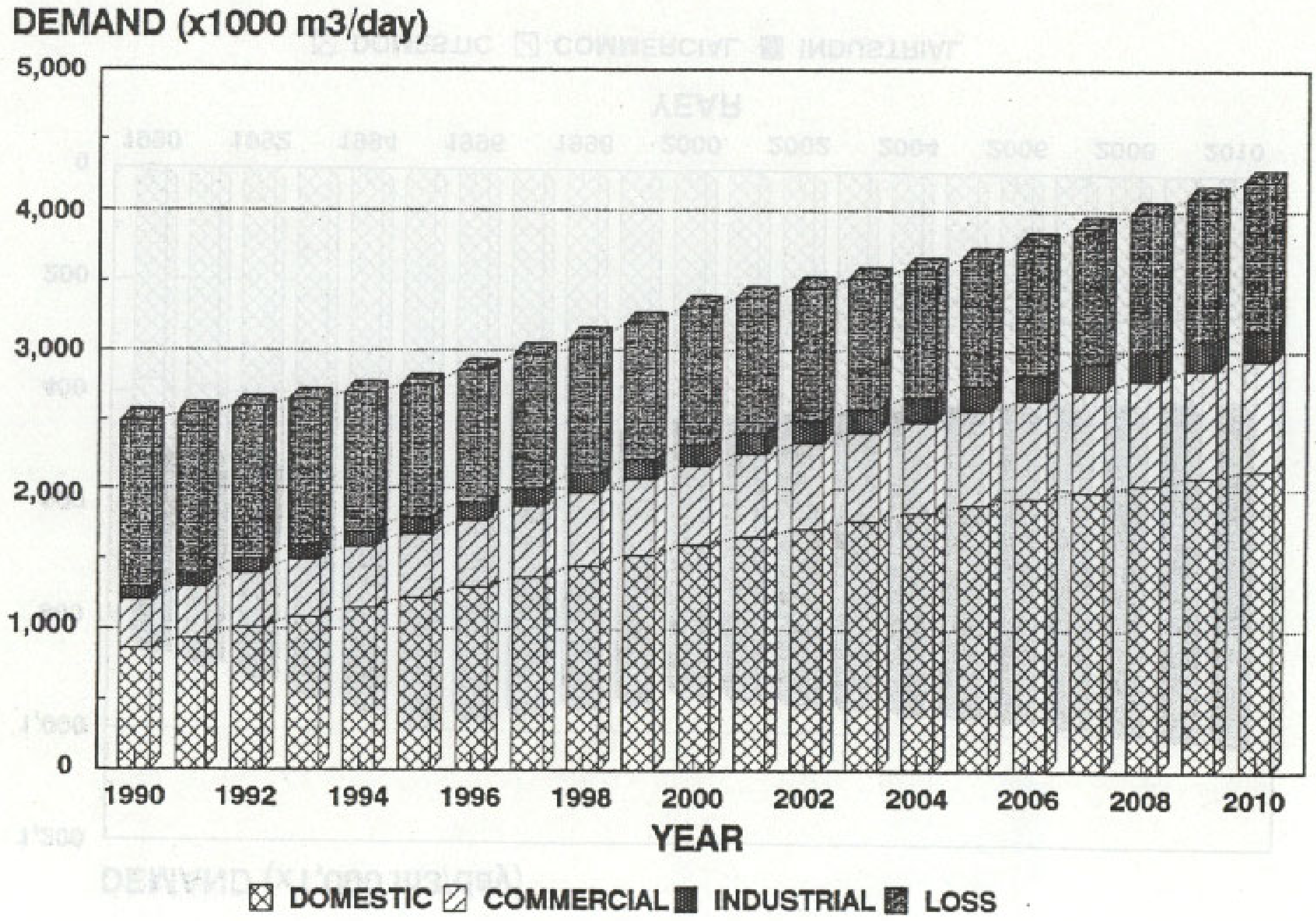


FIGURE 6.2.1 MWSS WATER DEMAND

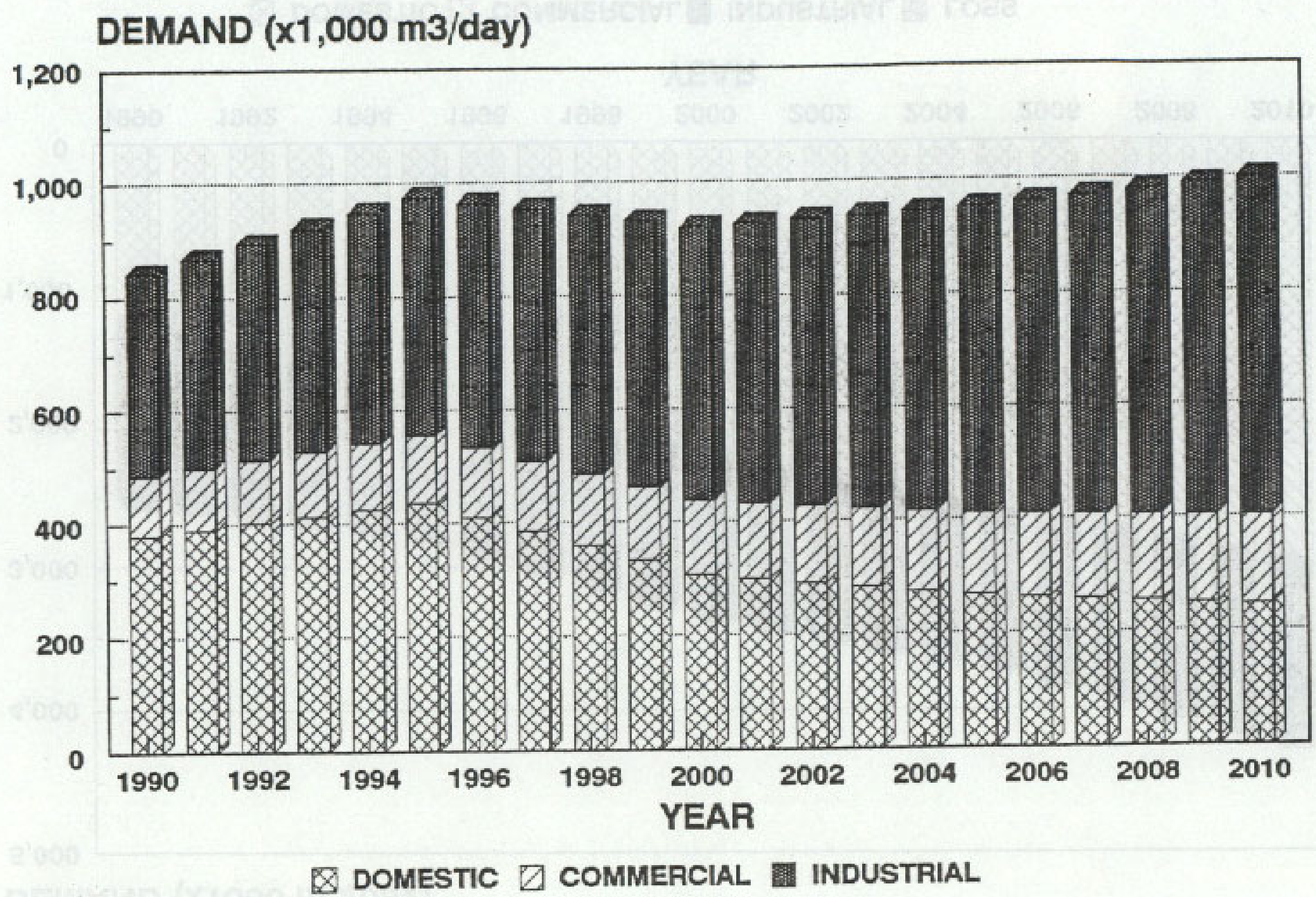


FIGURE 6.2.2 PRIVATE WATER DEMAND

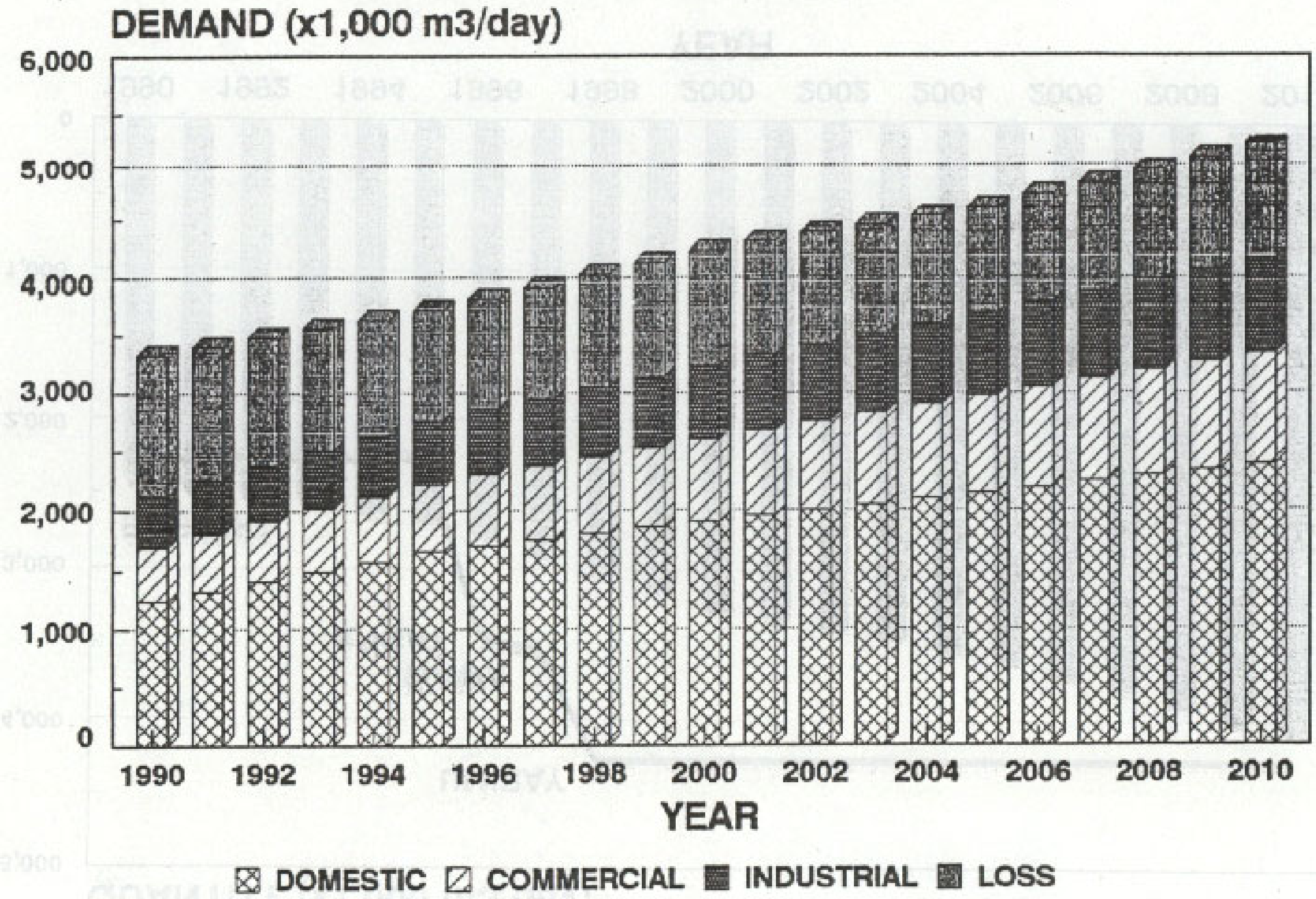


FIGURE 6.2.3 TOTAL WATER DEMAND (MWSS+PRIVATE)

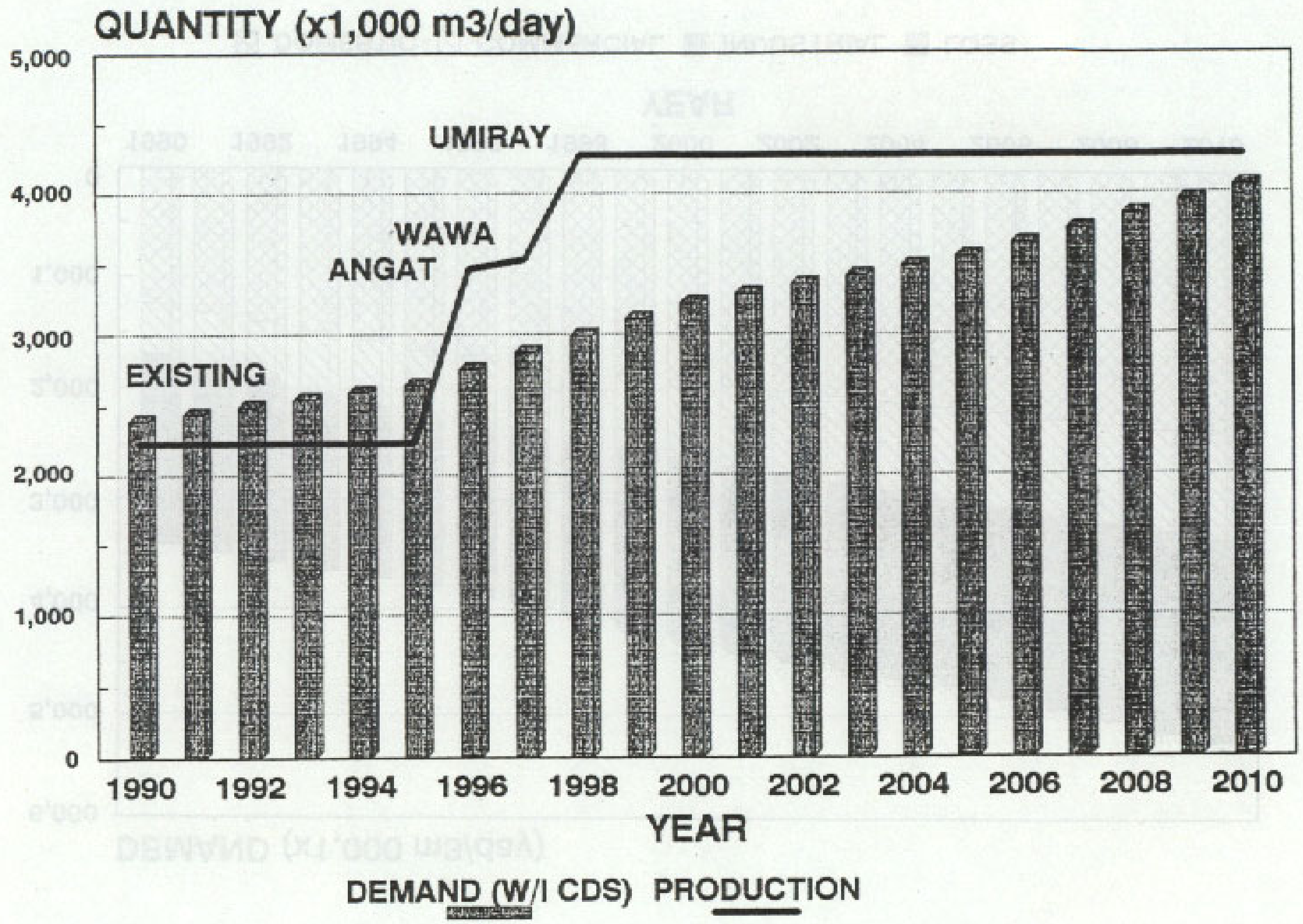


FIGURE 6.2.4 DEMAND VS. SUPPLY CAPACITY

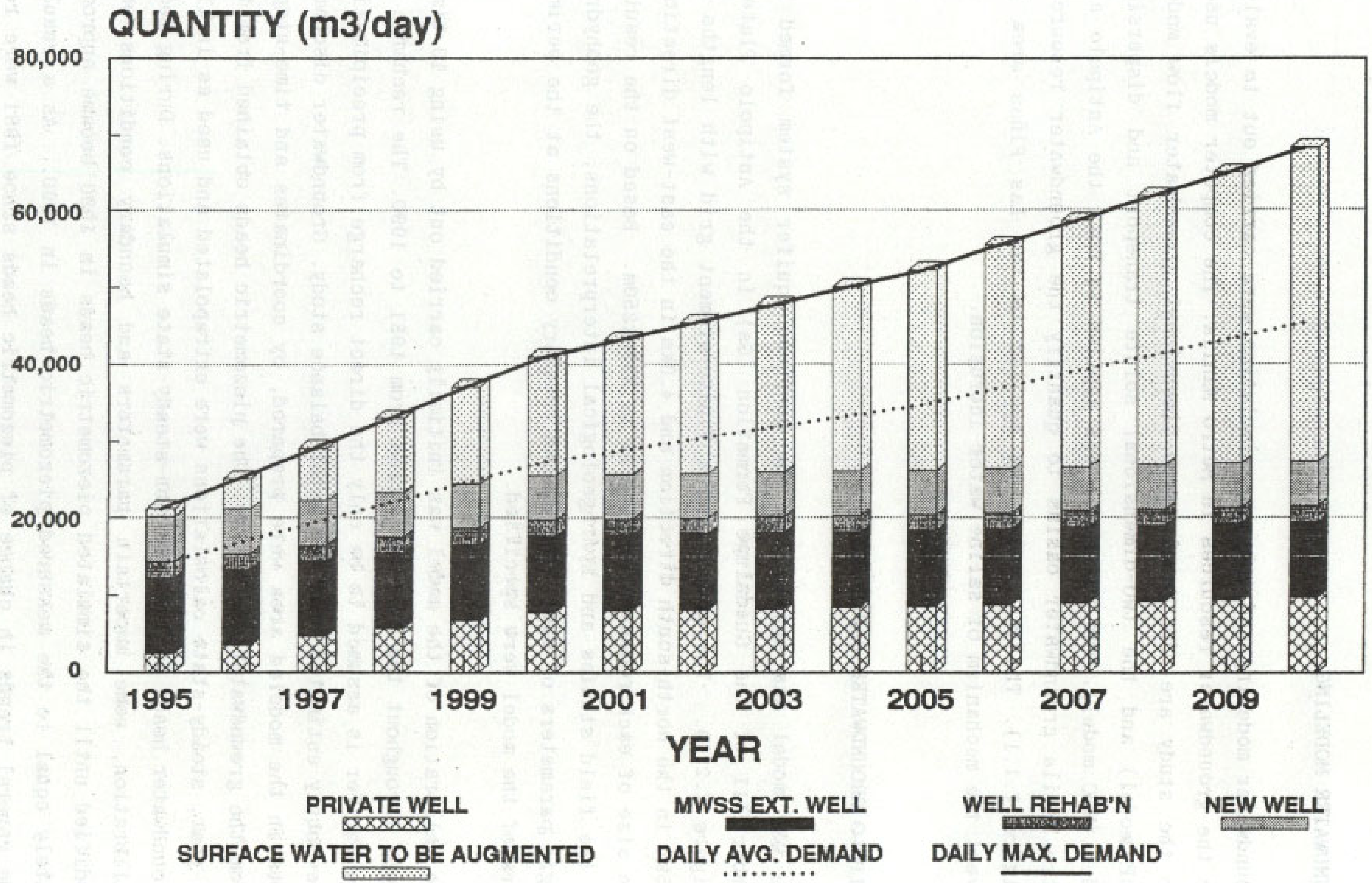


FIGURE 6.2.5 DEMAND VS. SUPPLY CAPACITY
(WITHIN MWSS SERVICE AREA IN ANTIPOLO)

CHAPTER 7 EVALUATION OF GROUNDWATER RESOURCES

7.1 GROUNDWATER MODELING

Groundwater modeling and computer simulation were carried out to evaluate the groundwater resources in Metro Manila. The computer models used for the study are the quasi three-dimensional groundwater flow model (Q3P model) and the two-dimensional solute transport and dispersion model (MOC model). The Q3P model was applied to both the Antipolo and Metro Manila groundwater basins to quantify the groundwater resources (Figure 7.1.1). The MOC model was applied to the Las Piñas area to reveal the mechanism of saline water intrusion.

7.2 ANTIPOLO GROUNDWATER BASIN MODEL

The Q3P model was applied to the confined aquifer system formed by Member III of the Guadalupe Formation (Gs) in the Antipolo Plateau (Figure 7.2.1). The model used a finite-element grid with lengths of 8.5km in the north-south direction and 4.0km in the east-west direction. The size of each rectangular element is 250mx250m. Based on the results of the field studies and hydrogeological interpretations, the geohydrologic parameters of each element and boundary conditions at the perimeters of the model were specified.

The calibration of the model was initially carried out by using 10 time-steps throughout the 10-year period from 1981 to 1990. The recharge to the aquifer is assumed to be only the direct recharge from precipitation previously estimated from the water balance study. Groundwater discharge data in the modeled area were prepared, by coordinates and time-steps, from the groundwater use survey. The piezometric heads obtained from the 30-year, steady-state calculations were extrapolated and used as initial groundwater heads in 1981 for non-steady-state simulations. During model calibration, some uncertain parameters and boundary conditions were modified until the simulated piezometric heads in 1990 became approximately equal to the measured piezometric heads in 1990. As a result, the general trends in change of piezometric heads since 1981 were reasonably simulated, e.g., the maximum drawdown of 16.4m which is the result of the increment in discharge (from 11,419 CMD to 19,456 CMD) during the 10-year period.

In order to design an optimal pumpage plan for the basin, the Antipolo groundwater flow model, calibrated as mentioned, simulated future piezometric heads up to year-2010. Obtained from the 62-year water balance computations, the recharge value of 418.8 mm/yr (or 28,183 CMD) corresponding to a 5-year drought probability was used as the future recharge. The following three (3) cases were prepared for the simulation of future piezometric heads, with the assumption that the discharge of existing private wells shall be the same as that for 1990 and no new private wells are constructed.

Case A: The discharge of MWSS wells in 1990 will continue up to 2010.

Case B: New MWSS wells (discharge rate = 830 CMD per well) will be constructed.

Case C: The existing ten (10) MWSS wells will be augmented by 207 CMD per well by well rehabilitation, and new MWSS wells will be constructed.

For Cases B and C, the criteria for locating new wells are:

i. New wells should be located where the simulated piezometric heights of Case A in 2010 are more than 30m because the drawdown of new wells are assumed to be 21m from the static level.

ii. Existing pumping grids should be avoided for the location of new wells.

iii. The combined total discharge of existing and new wells should not exceed the recharge to the basin.

iv. The simulated piezometric heights at the sites of new wells should be more than 21m using the new discharge up to the year 2010.

In Case A, the simulated piezometric heads will decline even though the discharge is the same as that in 1990. A maximum drawdown of 52.4m is expected for the period 1991 to 2010.

The results show that for Case B as many as ten (10) wells can be constructed. For Case C, seven (7) new wells can be constructed and an augmentation of 2,070 CMD can be realized by rehabilitation of the existing wells. In Case C, the total discharge is 27,334 CMD, which is smaller than the recharge value that is equivalent to a drought with a return period of 5 years.

The optimal plan for groundwater development in the Antipolo basin therefore calls for the rehabilitation of 10 existing MWSS wells and the construction of seven new wells. Figure 7.2.2 shows the discharge distribution for Case C. Figure 7.2.3 shows simulated piezometric changes. The simulated piezometric heads in 1990 and 2010 are shown in Figures 7.2.4 and 7.2.5, respectively. It is noted, however, that the optimal groundwater pumpage is limited so that the water demands after 1998 cannot be supplied by the groundwater in the basin.

7.3 METRO MANILA GROUNDWATER BASIN MODEL

The Q3P model was applied to the Guadalupe confined aquifer system in the Metro Manila groundwater basin (see Figure 7.1.1). The finite-element grid used in the model has respective lengths of 48.3km and 37.8km in the north-south and east-west directions. The size of each rectangular element is 1380m by 1350m. Geohydrologic parameters and boundary conditions were assigned based on results of field studies and hydrogeological interpretations, and then modified/identified throughout calibration of the model.

The calibration of the model was done in the same manner as that for the Antipolo Groundwater Basin Model. The modeled domain was divided into a direct recharge area and a leakage recharge area based on the pattern of the measured piezometric surface. Groundwater discharge data were prepared, by coordinates and time-steps, from the results of the groundwater use survey. The measured piezometric heads in 1981 were employed as initial piezometric heads for the simulations. The boundary conditions and some uncertain parameters, such as leakance and storage coefficient, were modified throughout the calibration of the model until the simulated piezometric heads for 1990 were approximately equal to the measured piezometric heads in that year. As a result, the recovery of the piezometric heads in the central part of Metro Manila, as well as their decline in the outskirts, were reasonably simulated.

Future piezometric heads were predicted using the calibrated model.

Five (5) future groundwater pumpage scenarios were made:

Scenario 1: Future pumpage based on Scenario 1 of the water demand projections. (See Table 6.2.11 and Figures 7.3.1 and 7.3.2.)

Scenario 2: Future pumpage based on Scenario 2 of the water demand projections. (See Table 6.2.11 and Figures 7.3.1 and 7.3.2.)

Scenario 3: Future pumpage based on Scenario 3 of the water demand projections. (See Table 6.2.11 and Figures 7.3.1 and 7.3.3.)

Scenario 4: Future pumpage based on Scenario 4 of the water demand projections. (See Table 6.2.11 and Figures 7.3.1 and 7.3.3.)

Scenario 5: Discharge in 1990 continues up to 2010.

The results are summarized as follows:

Scenario 1: (Refer to Figures 7.3.4 and 7.3.6.) Piezometric heads in 2010 shall rise at the southern part of Quezon City and Metro Manila (Parañaque, Las Piñas and Bacoor). A maximum rise of 20m of piezometric head is predicted at the coastal area of Las Piñas because of decrement in pumpage. However, piezometric heads will go down at the northern and southwestern parts of Metro Manila. Significant drawdowns such as 83m in north Valenzuela, 57m in Cavite and 37m in Pasig are predicted. Piezo-

1991 to 2000, then stabilize after 2000. A constant decline shall be seen in Pasig for the period 1991 to 2010. Piezometric heads in Las Piñas for the period 1991 to 2000 shall rise but will go down gradually after 2005.

Scenario 2: (Refer to Figures 7.3.4 and 7.3.6.) From year-1991 onward, the piezometric heads shall go down 59m north of Valenzuela and 33m in Cavite. Piezometric heads will decline in most of Metro Manila for the period 1991 to 2000, then stabilize or slightly recover after 2001.

Scenario 3: (Refer to Figures 7.3.5 and 7.3.7.) Piezometric heads in 2010 shall be higher than those in 1990 for north Valenzuela and Cavite; respectively, 50m and 29m for the years 2010 and 1990. Recovery of piezometric heads shall occur in almost all areas of Metro Manila for the period 2001 to 2005 due to decreasing pumpage.

Scenario 4: (Refer to Figures 7.3.5 and 7.3.7.) This is the scenario where the maximum groundwater discharge can be found. The discharge shall increase for the periods 1991 to 2000 and 2005 to 2010. The drawdowns of piezometric heads are estimated at 90m in north Valenzuela and 56m in Cavite. Piezometric heads in most of Metro Manila shall show significant declines until the year-2000, afterwhich the declines become gradual or stable.

Scenario 5: Piezometric heads in 2010 relative to piezometric heads in 1990 shall recover at a maximum of 10.7m at the central part of Metro Manila. Decline of piezometric heads shall be seen at the northern, eastern (along Marikina River), and southern to southwestern parts of Metro Manila. The maximum drawdowns are predicted at 21.7m at the northern part of Quezon City and 16.9m in Rosario that is at the southwestern part of Metro Manila.

Simulation results show that the maximum drawdown of 50m will occur even in Scenario 3 where the discharge is the smallest among the future groundwater use plans. This may cause severe saline water intrusion and may damage even inland areas.

7.4 SALINE WATER INTRUSION MODEL

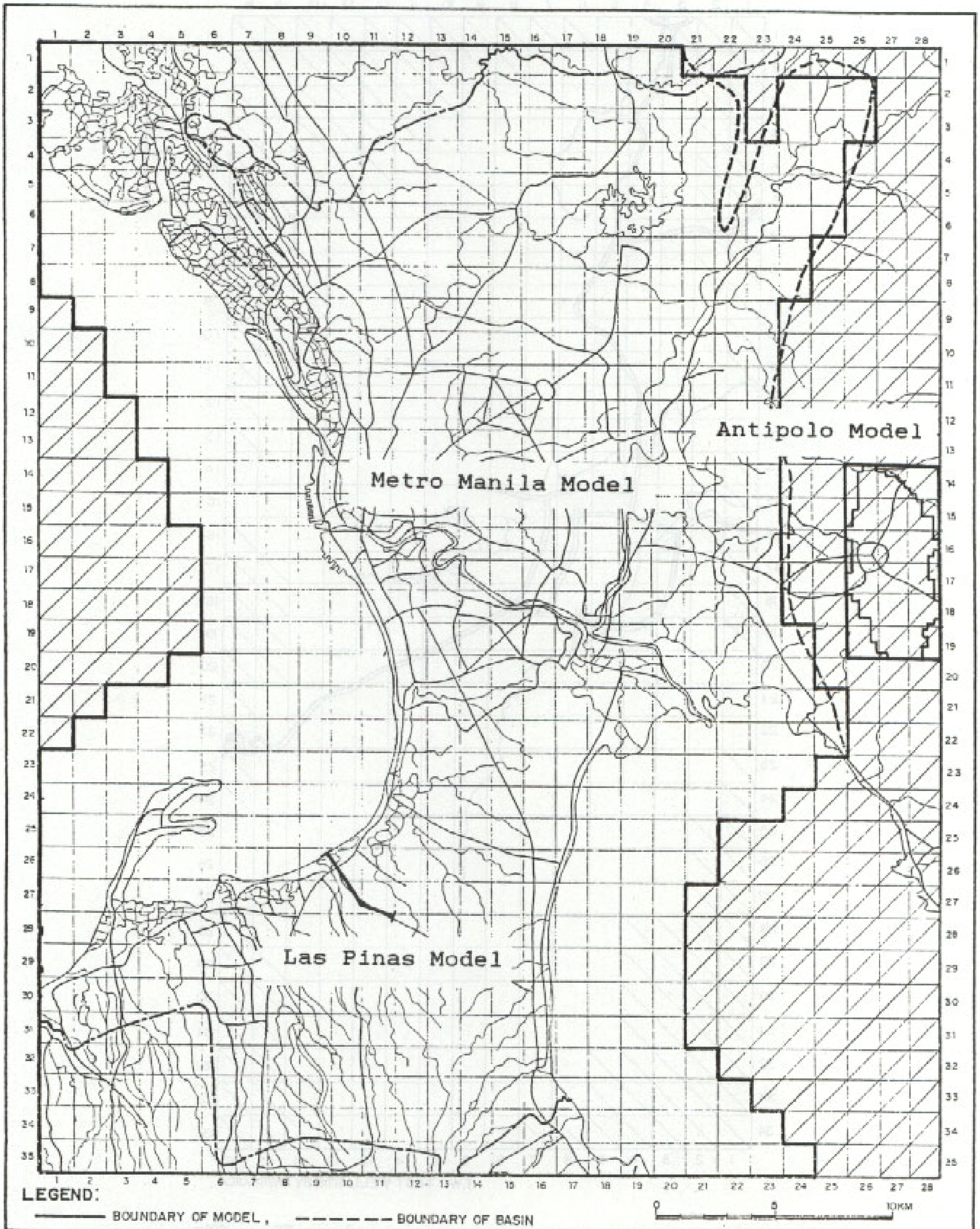
The MOC model was employed to analyze the saline water intrusion mechanism in the Las Piñas area--one of the areas most affected by saline water intrusion in Metro Manila (Figure 7.4.1). A vertical two-dimensional model was made based on a hydrogeological section from the shoreline towards inland. The model is 4km in length, 300m in depth and 200m in width. Each cell is 100m long, 15m thick and 200m wide. The geohydrologic parameters of each aquifer unit were specified based on the results of well loggings, pumping tests and core analysis conducted in the JICA test wells in Las Piñas. The boundary conditions were specified from the results of hydrogeological analyses (Figure 7.4.2).

Steady-state simulation was initially carried out for model identification. This was done by checking geohydrologic parameters and boundary conditions through comparison of simulated and measured piezometric heads. Direct recharge from rainfall was applied to the uppermost cells of the model. Pumpage data obtained from the groundwater use survey were also used, considering well locations and screen positions. Except in the uppermost cells, initial piezometric heads were taken as 0. The results show good agreement of values of simulated piezometric heads and observed heads, accomplished without modifying any hydrogeologic parameters.

After fixing the groundwater flow, the solute transport model was calibrated to compute the chloride concentrations. From the facies of each aquifer unit, transport parameters were estimated. The origins of saline water were assumed to be at Manila Bay and the alluvial lowlands where marine ponds are located. Several sets of parameters were employed in the model to compare the movements of saline water. For this comparison, the location of the source was also varied.

The results of simulation using the solute transport model show that saline water originated from the Manila Bay and marine ponds; it then moved and dispersed inland towards piezometric head depressions created by heavy pumpage (Figures 7.4.3 and 7.4.4). Also, the simulated distribution of chloride concentration shows good agreement with the observed distribution of the same. And further, not only was it Manila Bay which played a significant role in the occurence of saline water in the area, but also the marine ponds and rivers where saltwater is present. It is predicted that if the center of the piezometric head depression, which is presently located at the central part of the model, moves more inland as a result of groundwater abstraction by new wells, the direction of saline water intrusion shall subsequently be towards inland. Deeper aquifers located below -300m, where no saline water exists at present, could become contaminated. Further lowering of piezometric heads should be avoided.

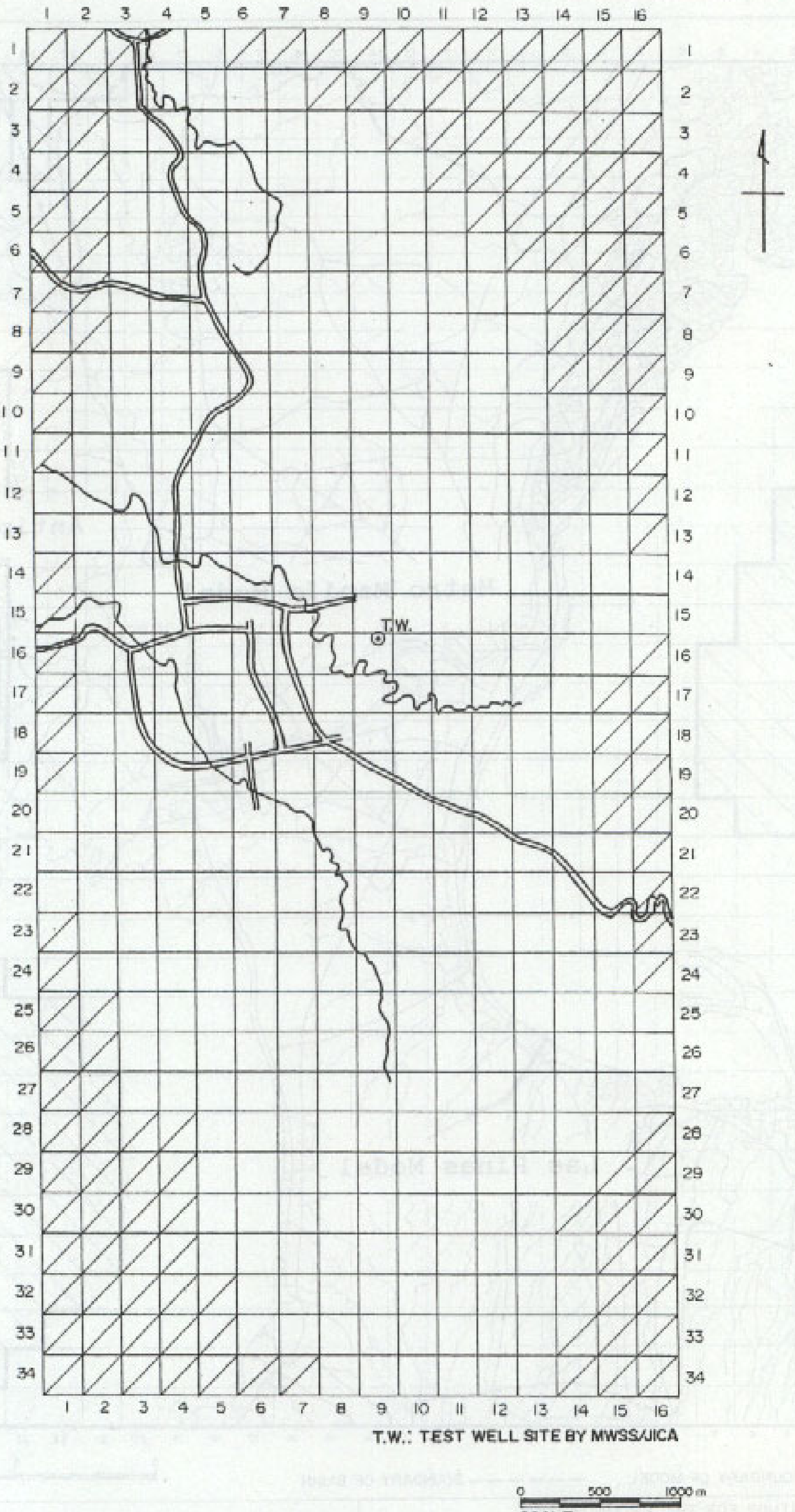
The mechanics of saline water intrusion just discussed should be considered in the assessment, development and management of groundwater resources in the area. Location of new wells, well depths and pumpage should be carefully evaluated to arrest the further spread of saline water.



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.1.1 FINITE-ELEMENT GRID USED TO MODEL METRO MANILA BASIN



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.2.1

FINITE-ELEMENT GRID USED TO MODEL ANTIPOLO BASIN

ATP Q MAP (m^3/d)

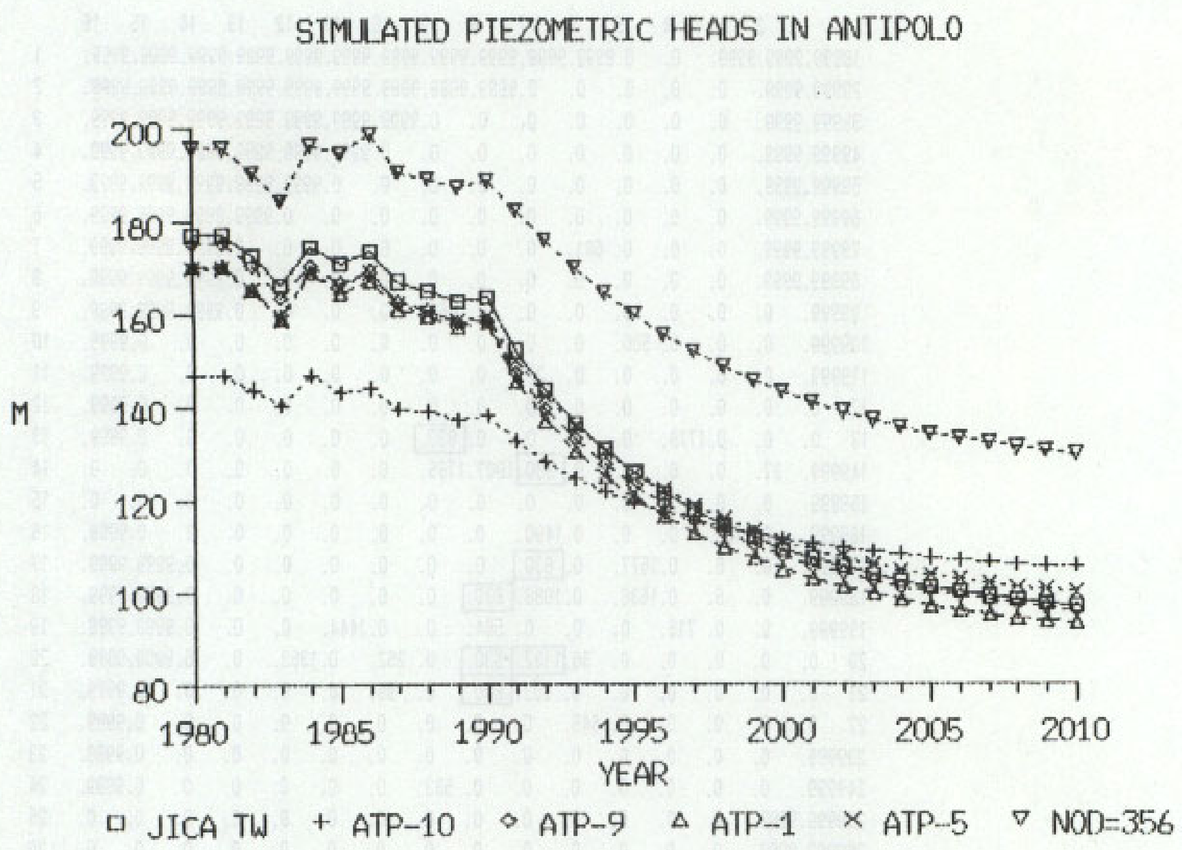
YEAR: 1991

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1	9999.	9999.	9999.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	1
2	9999.	9999.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	2
3	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	3
4	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	4
5	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	5
6	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	6
7	9999.	9999.	0.	0.	0.	681.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	7
8	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	8
9	9999.	0.	0.	0.	0.	0.	0.	0.	454.	0.	0.	0.	0.	9999.	9999.	9999.	9
10	9999.	0.	0.	0.	500.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	10
11	9999.	0.	0.	0.	0.	0.	27.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	11
12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	12
13	0.	0.	0.	1778.	0.	0.	0.	0.	830.	0.	0.	0.	0.	0.	0.	9999.	13
14	9999.	27.	0.	0.	0.	0.	830.	1907.	1765.	0.	0.	0.	0.	0.	0.	0.	14
15	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15
16	9999.	0.	1125.	0.	0.	0.	1490.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	16
17	9999.	0.	0.	0.	1577.	0.	830.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	17
18	9999.	0.	6.	0.	1636.	0.	1088.	830.	0.	0.	0.	0.	0.	0.	9999.	9999.	18
19	9999.	0.	0.	716.	0.	0.	0.	584.	0.	0.	1444.	0.	0.	0.	9999.	9999.	19
20	0.	0.	0.	0.	0.	36.	1132.	830.	0.	252.	0.	1363.	0.	0.	9999.	9999.	20
21	0.	0.	0.	0.	0.	0.	302.	830.	0.	99.	0.	0.	0.	0.	0.	9999.	21
22	0.	0.	0.	0.	0.	648.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	22
23	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	23
24	9999.	0.	0.	0.	0.	0.	0.	0.	533.	0.	0.	0.	0.	0.	0.	9999.	24
25	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	25
26	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	26
27	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	27
28	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	5.	45.	0.	0.	0.	9999.	28
29	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	29
30	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	30
31	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	1134.	0.	0.	9999.	9999.	31
32	9999.	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	32
33	9999.	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	33
34	9999.	9999.	9999.	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	34
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	

TOTAL Q IN MODELED AREA = 27334.m^3/d

□ : Location of New MWSS Wells

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.2.2
JAPAN INTERNATIONAL COOPERATION AGENCY	OPTIMAL DISCHARGE PLAN IN ANTIPOLO BASIN



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.2.3
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC HEADS (DISCHARGE FROM 1991 TO 2010 = OPTIMAL PLAN)

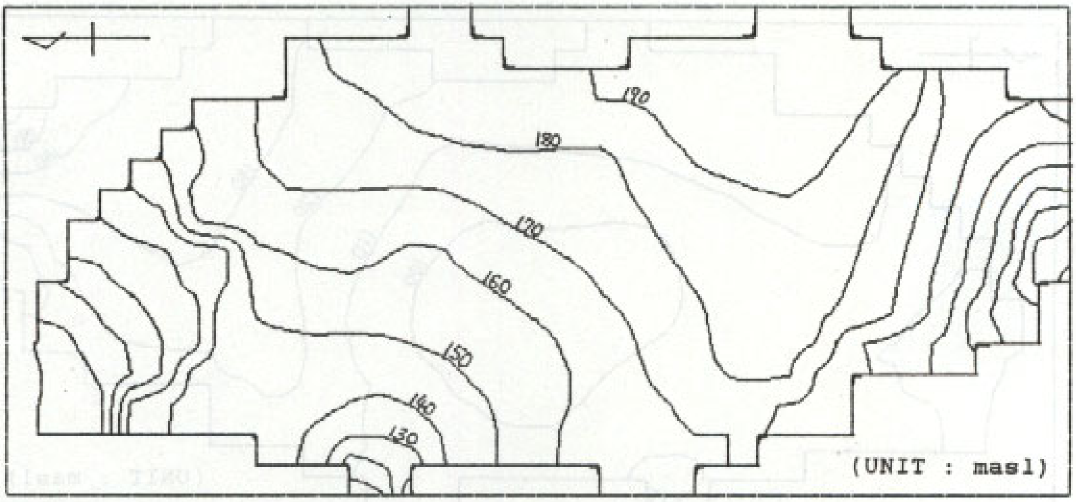


FIGURE 7.2.4(1) SIMULATED PIEZOMETRIC HEADS IN 1990

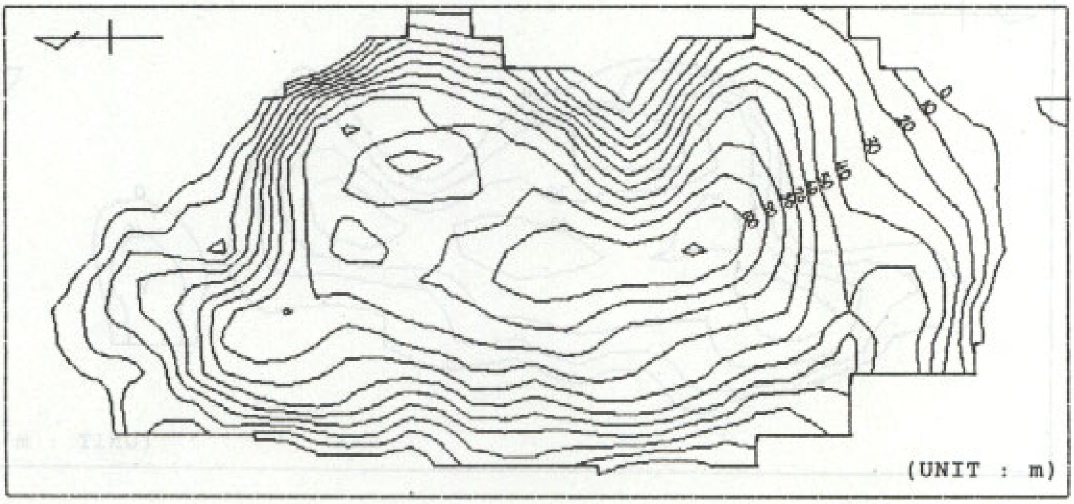


FIGURE 7.2.4(2)
SIMULATED PIEZOMETRIC HEIGHTS FROM BOTTOM OF THE AQUIFER IN 1990

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	JAPAN INTERNATIONAL COOPERATION AGENCY

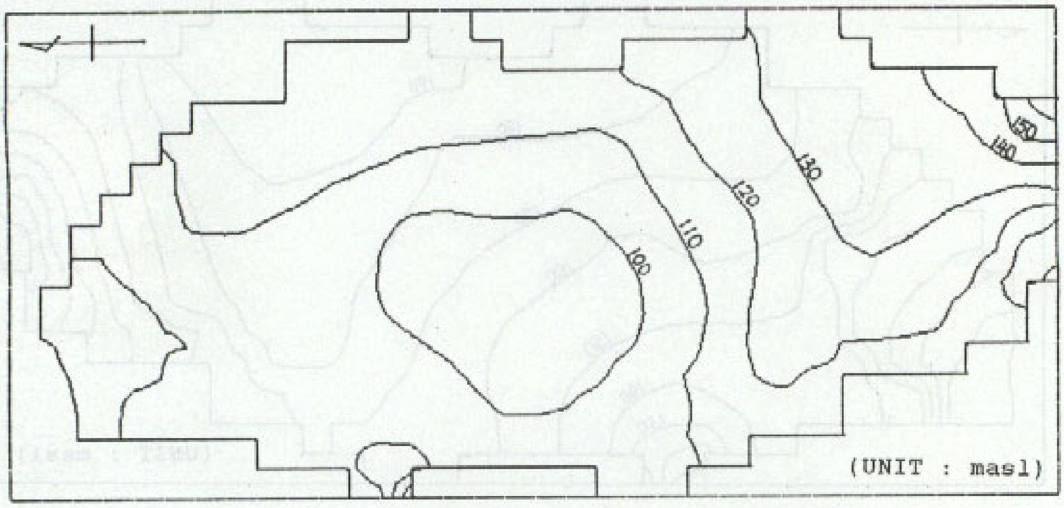


FIGURE 7.2.5(1) SIMULATED PIEZOMETRIC HEADS IN 2010
(DISCHARGE FROM 1991 TO 2010 = OPTIMAL PLAN)

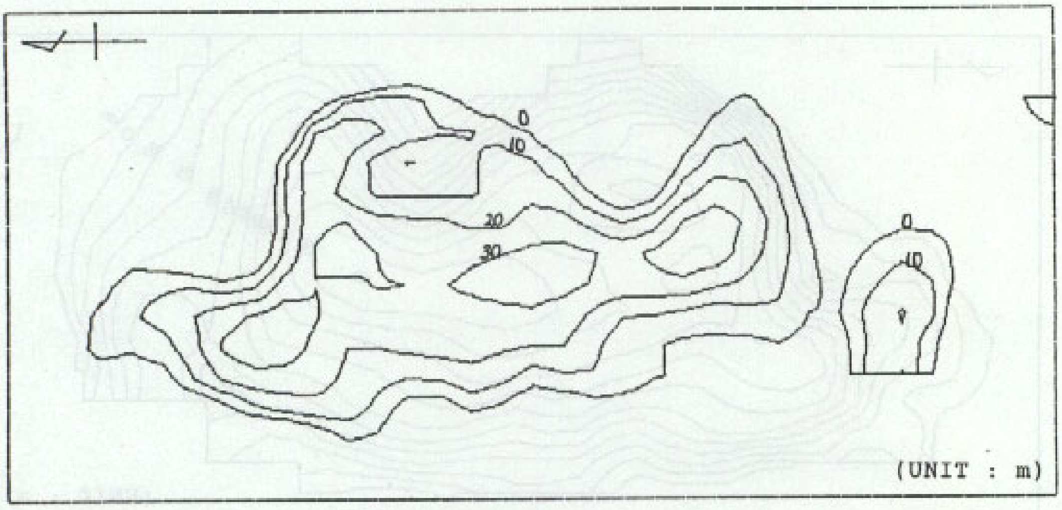
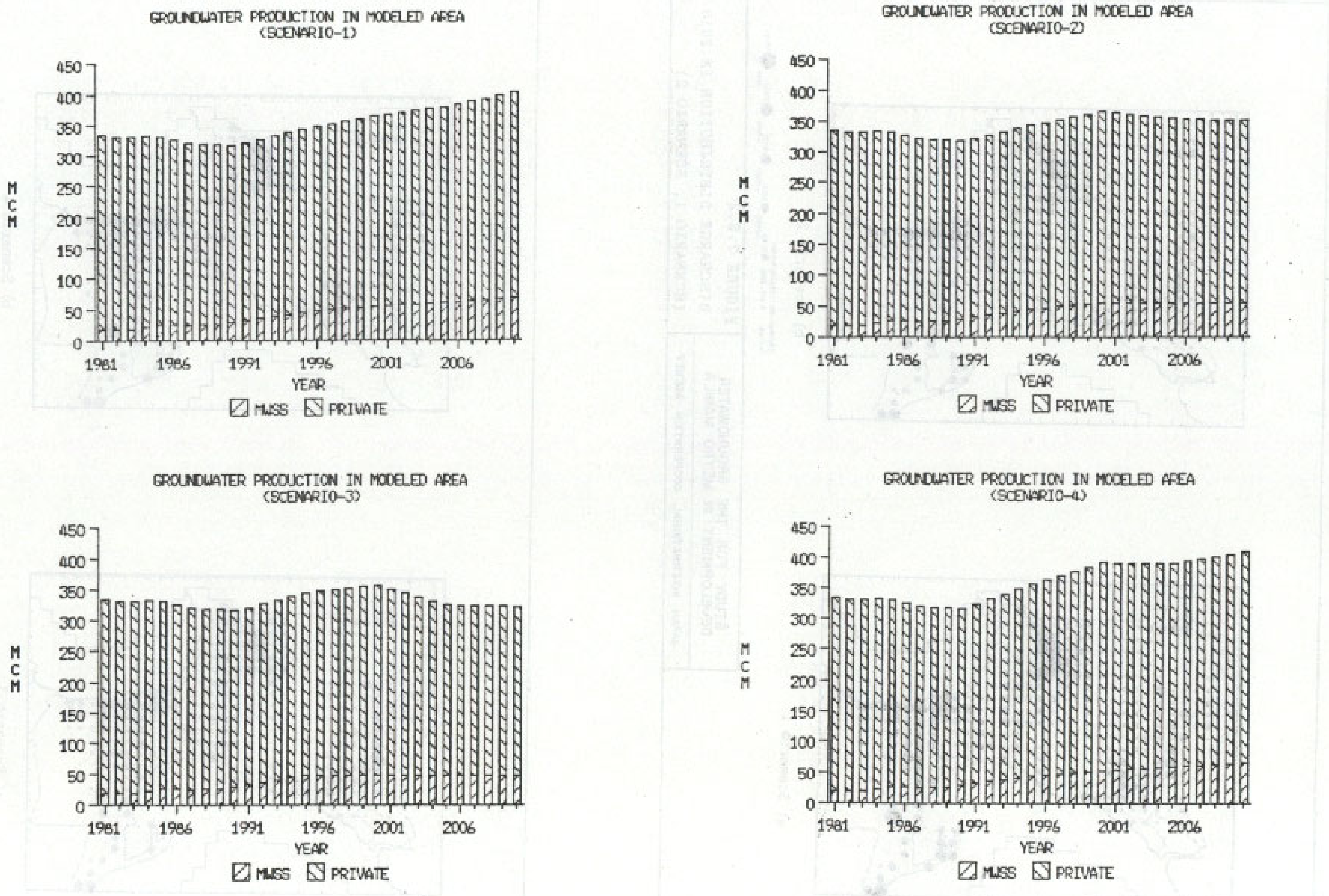


FIGURE 7.2.5(2)
SIMULATED PIEZOMETRIC HEIGHTS FROM BOTTOM OF THE AQUIFER IN 2010
(DISCHARGE FROM 1991 TO 2010 = OPTIMAL PLAN)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	JAPAN INTERNATIONAL COOPERATION AGENCY

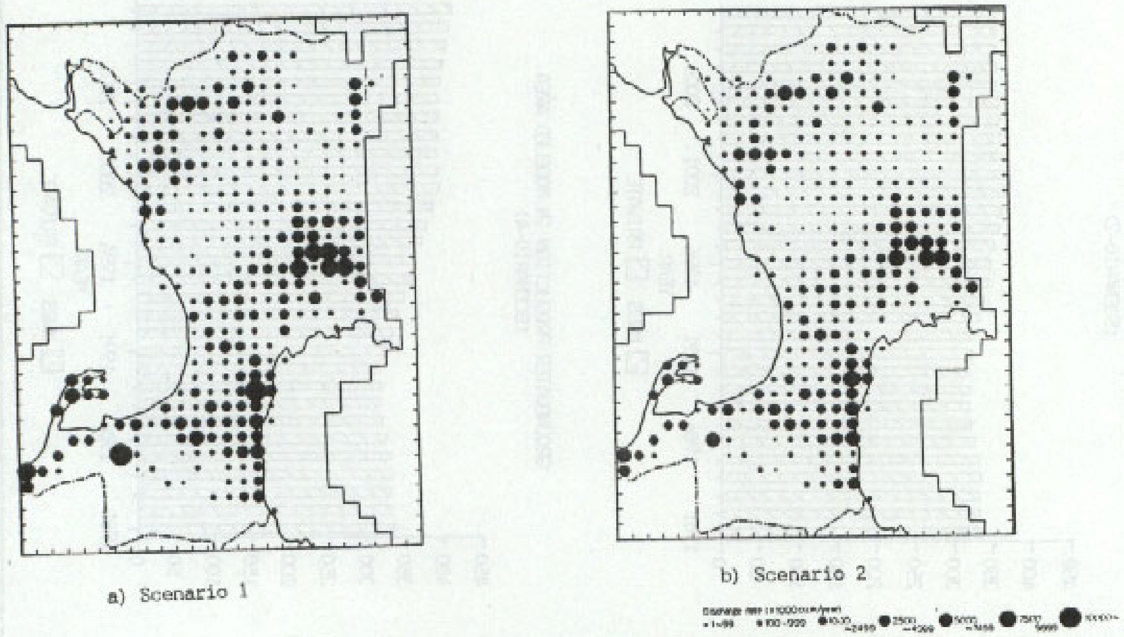


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.1

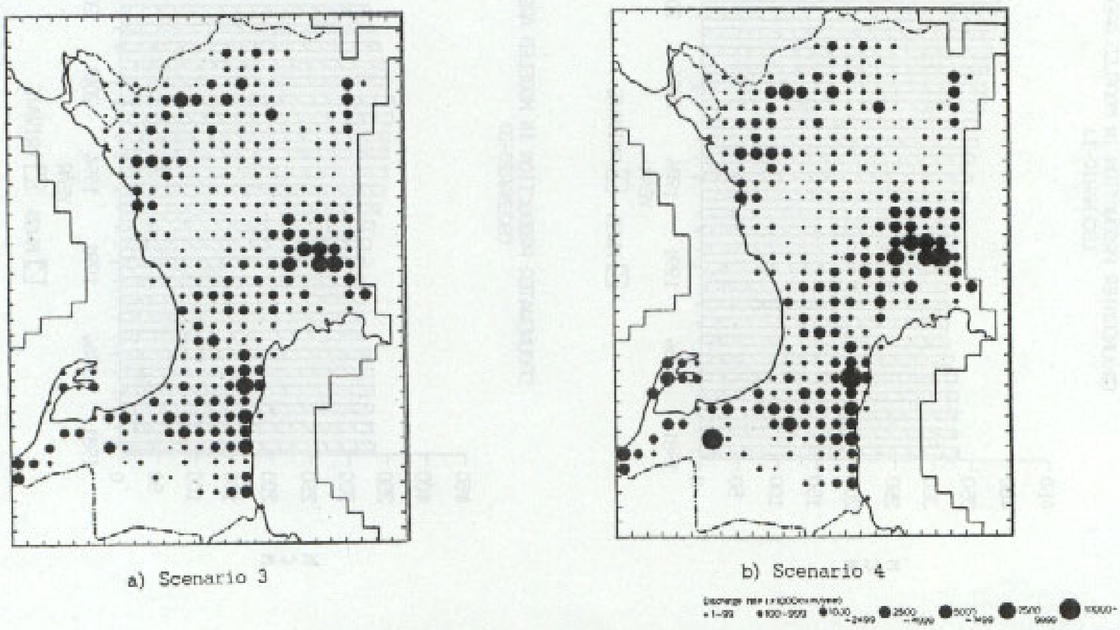
GROUNDWATER PRODUCTION OF EACH SCENARIO



a) Scenario 1

b) Scenario 2

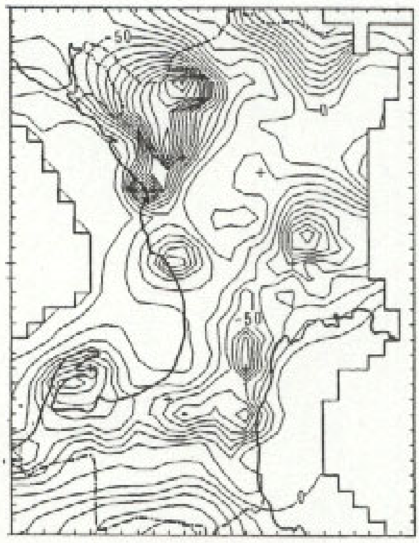
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.2 DISCHARGE DISTRIBUTION IN 2010 (SCENARIO 1, SCENARIO 2)
JAPAN INTERNATIONAL COOPERATION AGENCY	



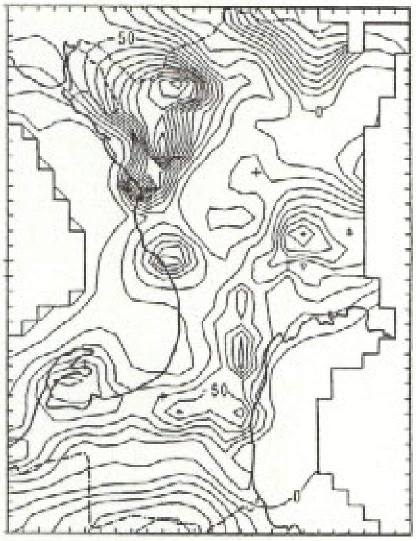
a) Scenario 3

b) Scenario 4

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.3 DISCHARGE DISTRIBUTION IN 2010 (SCENARIO 3, SCENARIO 4)
JAPAN INTERNATIONAL COOPERATION AGENCY	



a) Scenario 1
(Contour Interval: 10m, Unit: masl)

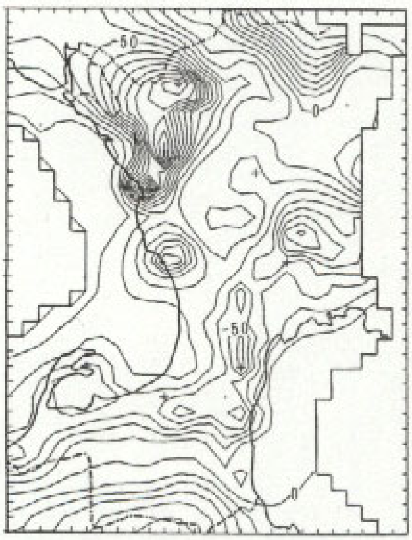


b) Scenario 2
(Contour Interval: 10m, Unit: masl)

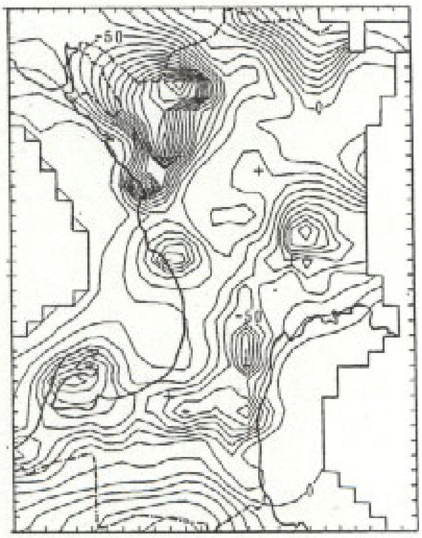
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.4
DISCHARGE DISTRIBUTION IN 2010
(SCENARIO 1, SCENARIO 2)



a) Scenario 3
(Contour Interval: 10m, Unit: masl)

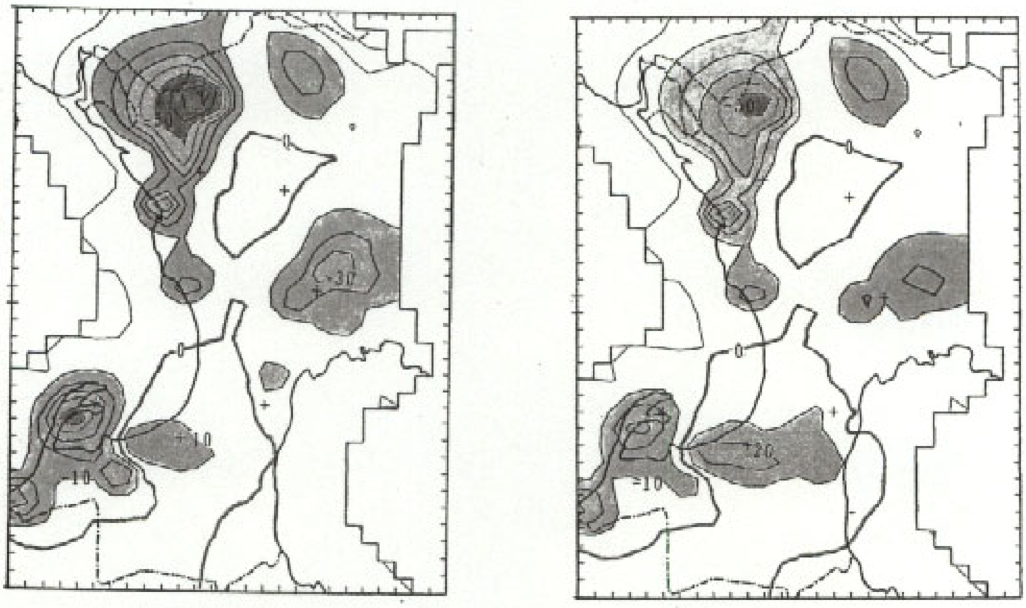


b) Scenario 4
(Contour Interval: 10m, Unit: masl)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.5
DISCHARGE DISTRIBUTION IN 2010
(SCENARIO 3, SCENARIO 4)



a) Scenario 1
(Contour Interval: 10m, Unit: m)

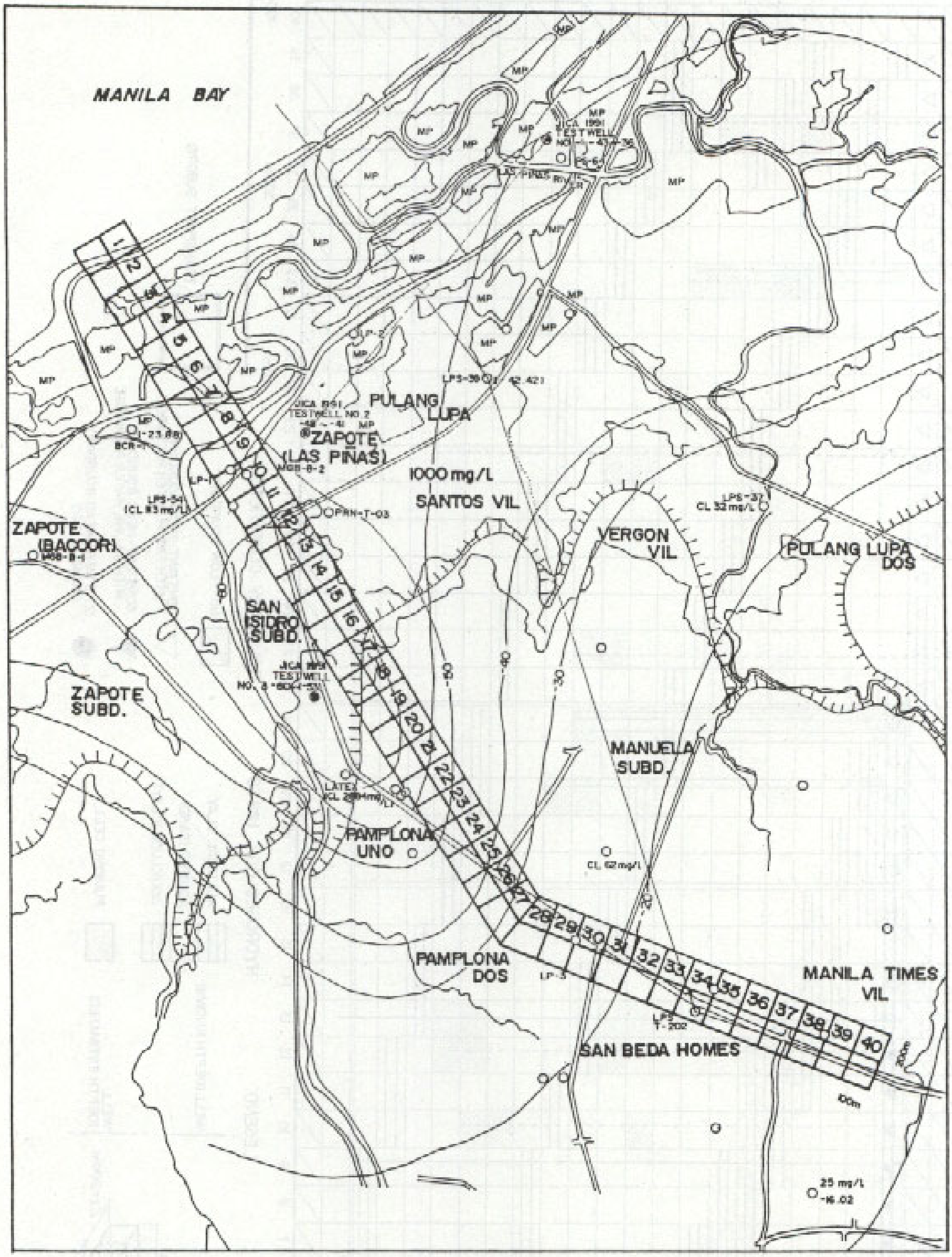
b) Scenario 2
(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.6
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC CHANGES FROM 1991 TO 2010 (SCENARIO 1, SCENARIO 2)

a) Scenario 3
(Contour Interval: 10m, Unit: m)

b) Scenario 4
(Contour Interval: 10m, Unit: m)

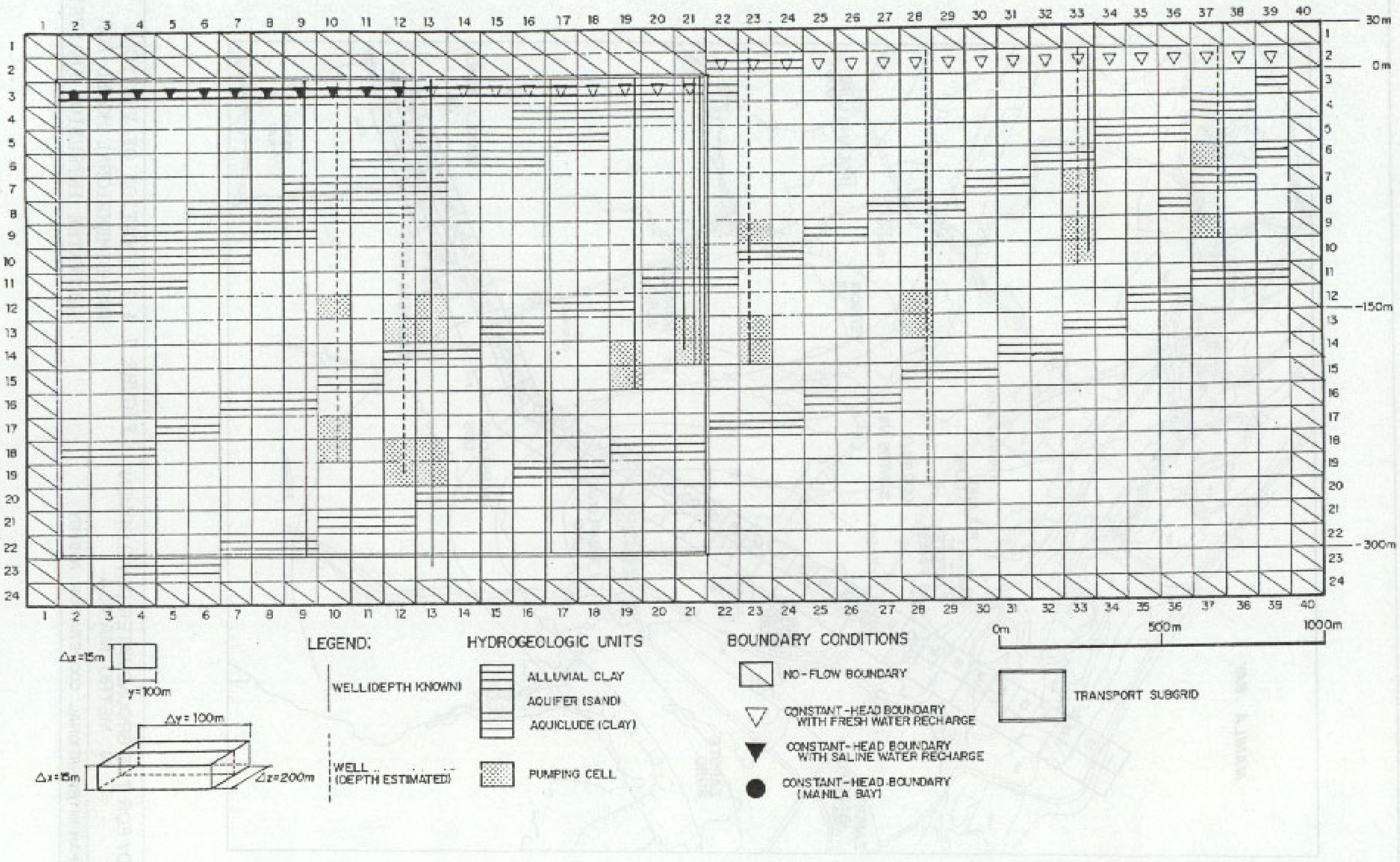
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.7
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC CHANGES FROM 1991 TO 2010 (SCENARIO 3, SCENARIO 4)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

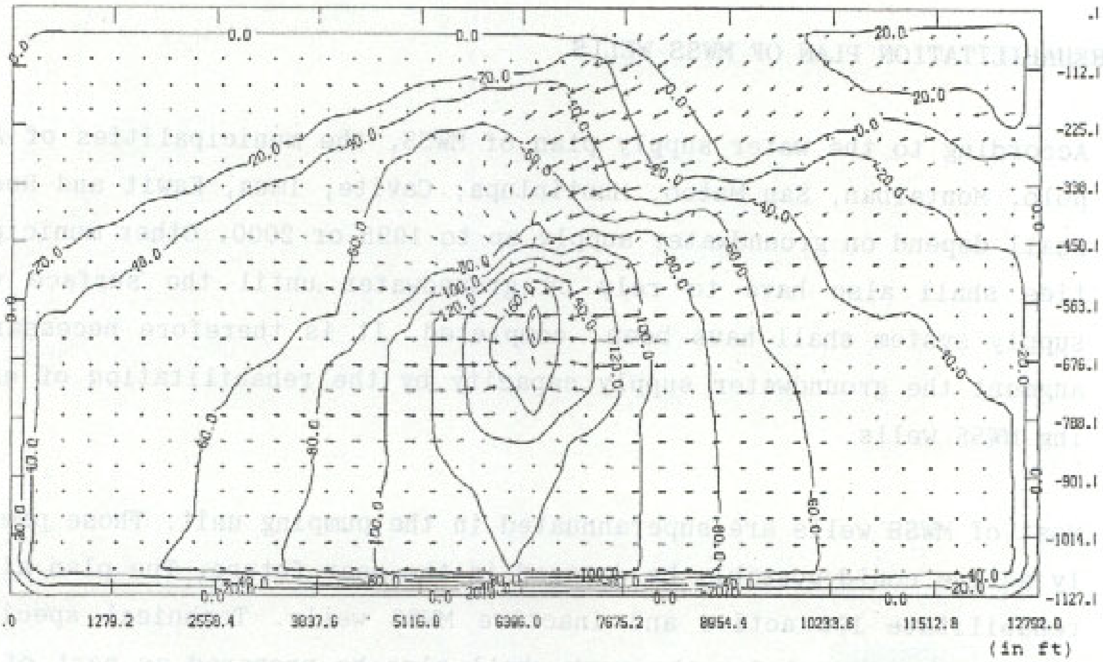
FIGURE 7.4.1 LOCATION OF VERTICAL TWO-DIMENSIONAL MODEL FOR SALTWATER INTRUSION ANALYSIS



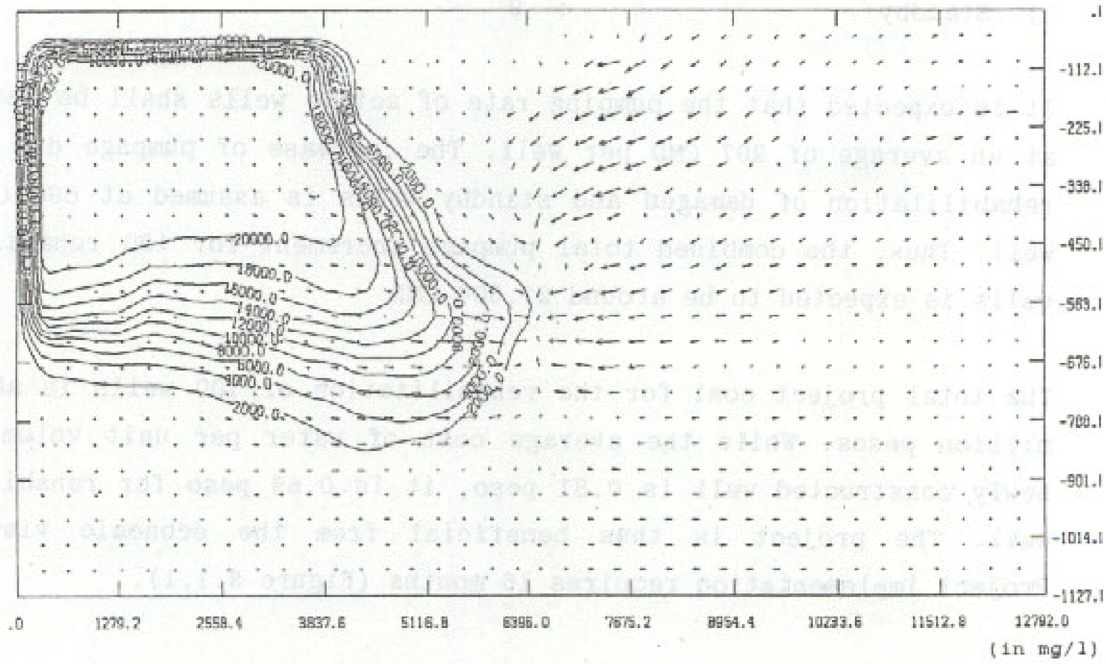
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.4.2
VERTICAL TWO-DIMENSIONAL GRID FOR THE SOLUTE TRANSPORT AND DISPERSION MODEL IN LAS PINAS



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.4.3
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC HEADS IN STEADY-STATE CONDITION



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.4.4
JAPAN INTERNATIONAL COOPERATION AGENCY	COMPUTED CHLORIDE CONCENTRATION AFTER 10 YEARS SIMULATION

CHAPTER 8 GROUNDWATER DEVELOPMENT PLAN

8.1 REHABILITATION PLAN OF MWSS WELLS

According to the water supply plan of MWSS, the municipalities of Antipolo, Montalban, San Mateo, Muntinlupa, Cavite, Imus, Kawit and Rosario shall depend on groundwater supply up to 1995 or 2000. Other municipalities shall also have to rely on groundwater until the surface water supply system shall have been completed. It is therefore necessary to augment the groundwater supply capacity by the rehabilitation of existing MWSS wells.

Most of MWSS wells are superannuated in the pumping unit. Those presently active could possibly be damaged in the near future. The plan aims to rehabilitate 100 active and inactive MWSS wells. Technical specifications and a manual for the work shall also be prepared as part of this plan.

The number of target wells are as follows.

1) Operated at present : 73
2) Defective pumping unit : 18
3) Standby : 9

It is expected that the pumping rate of active wells shall be increased at an average of 207 CMD per well. The increase of pumpage due to the rehabilitation of damaged and standby wells is assumed at 690 CMD per well. Thus, the combined total pumpage increment for 100 rehabilitated wells is expected to be around 27,500 CMD.

The total project cost for the rehabilitation of 100 wells is about 53 million pesos. While the average cost of water per unit volume of a newly constructed well is 0.81 peso, it is 0.69 peso for rehabilitated well. The project is thus beneficial from the economic viewpoint. Project implementation requires 16 months (Figure 8.1.1).

8.2 GROUNDWATER DEVELOPMENT PLAN IN ANTIPOLO

A new groundwater development plan in Antipolo is proposed based on the anticipated growth of population and the consideration that the Antipolo area shall solely rely on groundwater sources until after the extension of CDS shall have been completed.

As estimated through computer simulations, the optimal pumpage of the Antipolo groundwater basin is about 28,000 CMD. Since existing deep wells presently abstract groundwater at about 19,500 CMD, the exploitable volume of groundwater amounts to a maximum of about 8,000-8,500 CMD. After rehabilitation, the increase in water volume is expected to be about 2,000 CMD. Therefore the increase in pumpage as a result of the contribution of the newly constructed wells is about 6,000 CMD. The total pumpage of the Antipolo groundwater basin should be able to meet the water demand in the area until 1998.

As part of the groundwater development plan, a standard design for the seven new wells was made. This standard well is 8 inches in diameter and 150 m in depth. It also has a wire wound screen. Total pumpage of these new wells is 5,810 CMD. The wells are distributed at the central part of the groundwater basin, with the distribution duly considering the thickness of the aquifer (Figures 8.2.1 and 8.2.2).

The project cost of the groundwater development is estimated at 48.3 million pesos including the expenditures for 6 elevated water tanks(Figure 8.2.3), land aquisition and engineering cost. Sixteen months are required for the project implementation.

8.3 SURFACE WATER SUPPLY PLAN IN ANTIPOLO

It is anticipated that groundwater sources cannot meet the water demand after 1999. Therefore, a plan of augmentation of water supply from the CDS is proposed. The plan calls for the conveyance of surface water to the Antipolo area through extension of the transmission line that will be constructed in AWSOP. The transmission route is proposed to be laid from Pasig to Antipolo town passing by the side of Cogeo Village along the Marcos and Sumulong Highways. Since the area is located in the

Antipolo Plateau, which is more than 200m in elevation, two (2) booster pumping stations and two (2) distribution reservoirs shall be constructed (Figures 8.3.1 to 8.3.5). Two (2) mini-booster pumping stations will be provided for distribution to high-elevated area.

The project implementation period has two phases. Phase 1 shall transmit water at an average of 1,800 CMD and a maximum of 15,500 CMD. Phase 2 shall transmit an average of 18,100 CMD and a maximum of 40,900 CMD. The cost of the project is estimated to be 406 million pesos for phase 1 and 455 million pesos for phase 2 (Tables 8.3.1 and 8.3.2). Considering that two years and six months shall be needed for planning and design and four years for construction, the project must commence in 1994 (Figure 8.3.6).

8.4 Project Evaluation

From the financial and the economic viewpoints, the phase 1 project was evaluated. The phase 1 project involves rehabilitation of existing wells, construction of new wells, and construction of surface water supply system.

Financial Analysis

The major potential sources of funds for the proposed project are the operating and the non-operating sources. Operating sources are the excess of revenue over expenses. Non-operating sources include loans, government equity, and grants. It is assumed that the loans will come from the Asian Development Bank (ADB) with a rate of interest at 6.36% per annum. The contribution of the Philippine government to equity is also assumed to be not more than 30 % of the total project cost.

The total project cost is P802.97 million, the breakdown of which is shown in Table 8.4.1. The breakdown of foreign and local cost is also presented in Table 8.4.1.

The project's revenues will be generated from water sales. Estimation of water sales is based on demand for water (or Billed Water). Only augmented water, however, is accounted for in the projection of revenues.

The computed financial internal rate of return (FIRR) for the 30-year project life used for analysis is 4.46% as presented in Table 8.4.2. Though this value is rather small, it is higher than the 3.47% of the Weighted Average Cost of Capital (WACC).

As reference, the financial feasibility of a part of the proposed project, the rehabilitation and new well construction, i.e., the groundwater development portion, was verified (Tables 8.4.3 and 8.4.4). Eighty percent (80%) of initially proposed cost for the distribution system was also included in this case for the reduction of leakage and distribution of increased water. In this case, FIRR was indicated at 11.43% and estimated WACC was 3.46%.

Economic Analysis

In the economic benefits of the projects were measured in terms of:

a) Economic Value of Water - Satisfaction of consumer
b) Health Benefit - Decrease of water-borne diseases
c) Fire Protection - Installation of more fire hydrants and increased water pressure
d) Land Value Increase - Increase of productivity

The shadow pricing system was devised for items that are not economically valued by the purely financial price mechanism. Thus, it was assumed that the true cost of foreign exchange will be increased by 20%. Likewise, unskilled labor costs was reduced by 50%. Skilled labor was valued at its going rate. The economic project cost is P491.02 million.

The total economic cost is expressed as the adjusted project cost plus replacement cost plus operating and maintenance cost. The present value of the total economic cost is P1,449.74 million for 30-year project life.

Since the EIRR of 17.19% exceeds the desirable opportunity cost of capital of 15%, the project is considered economically feasible (Table 8.4.5).

As reference, the economic feasibility of the groundwater development portion was also verified as presented in Table 8.4.6. In this case, EIRR was computed at 17.20% due to insufficient augmentation of water to meet demand--assuming a slower increase of land value than that possible under full-scale project implementation.

TABLE 8.3.1 PROJECT COST FOR PHASE 1

(in Thousand Pesos)

Construction Cost			
1. Transmission Pipeline			58,343
2. Booster Pumping Station No.1			
	Civil & Arch. Work	8,227	
	Mechanical Work	14,976	
	Electrical Work	19,020	
	Sub Total		42,223
3. Booster Pumping Station No.2			
	Civil & Arch. Work	7,249	
	Mechanical Work	19,104	
	Electrical Work	22,848	
	Sub Total		49,201
4. Communication Wiring (for telecontrol system)			5,383
5. Distribution Reservoir			
	Civil & Arch. Work	11,412	
	Mechanical Work	2,896	
	Sub Total		14,308
6. Distribution System			
	Distribution Main	65,355	
	Inner Network	23,761	
	Fire Hydrant	3,461	
	Service Connection	58,570	
	Sub Total		151,147
Construction Cost Total			320,605
Engineering Cost	(D/D 8%, C/S 4%)		38,473
Land Acquisition	(B.P.S. 1 & 2, Reservoir)		9,585
Total			368,663
Physical Contingency	10%		36,866
GRAND TOTAL			405,529

TABLE 8.3.2 PROJECT COST FOR PHASE 2

(in Thousand Pesos)

Construction Cost			
1. Transmission Pipeline			95,862
2. Booster Pumping Station No.1			
	Civil and Arch. Work	7,652	
	Mechanical Work	14,492	
	Electrical Work	19,020	
	Sub Total		41,164
3. Booster Pumping Station No.2			
	Civil and Arch. Work	6,583	
	Mechanical Work	18,620	
	Electrical Work	22,848	
	Sub Total		48,051
4. Distribution Reservoir No.1			
	Civil and Arch. Work	11,412	
	Mechanical Work	3,795	
	Sub Total		15,207
5. Distribution Reservoir No.2			
	Civil and Arch. Work	3,494	
	Mechanical Work	1,168	
	Sub Total		4,662
6. Booster Pumping Station No.3			
	Pump House	826	
	Mech. and Elec. Work	273	
	Sub Total		1,099
7. Booster Pumping Station No.4			
	Pump House	560	
	Mech. and Elec. Work	190	
	Sub Total		750
8. Distribution System			
	Distribution Main	88,168	
	Inner Network	25,603	
	Fire Hydrant	2,005	
	Service Connection	45,192	
	Sub Total		160,968
Construction Cost Total			367,763
Engineering Cost	(D/D 8%, C/S 4%)		44,132
Land Acquisition	(Reservoir 1 & 2)		1,760
Total			413,655
Physical Contingency	10%		41,365
GRAND TOTAL			455,020

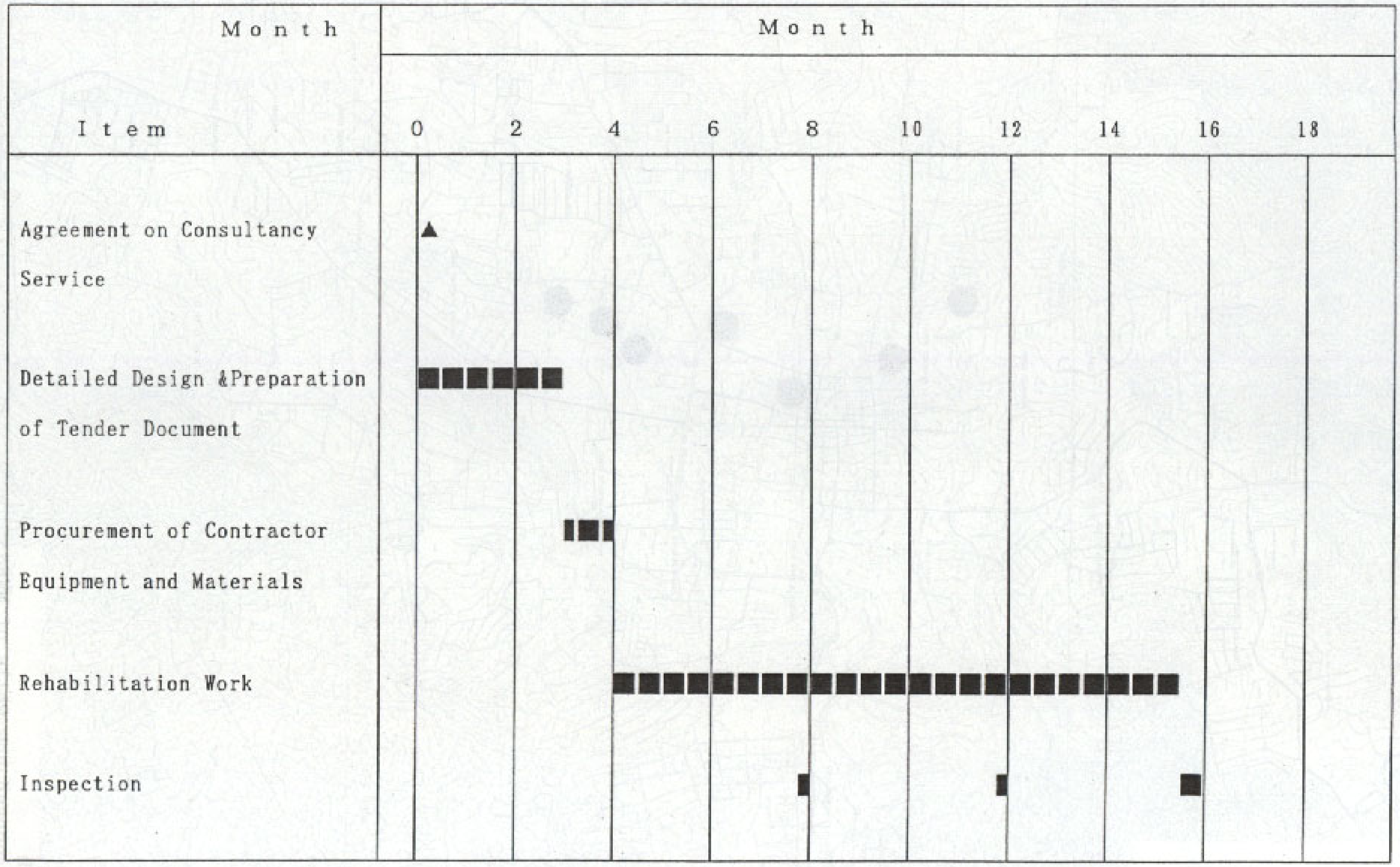


FIGURE 8.1.1 REHABILITATION SCHEDULE

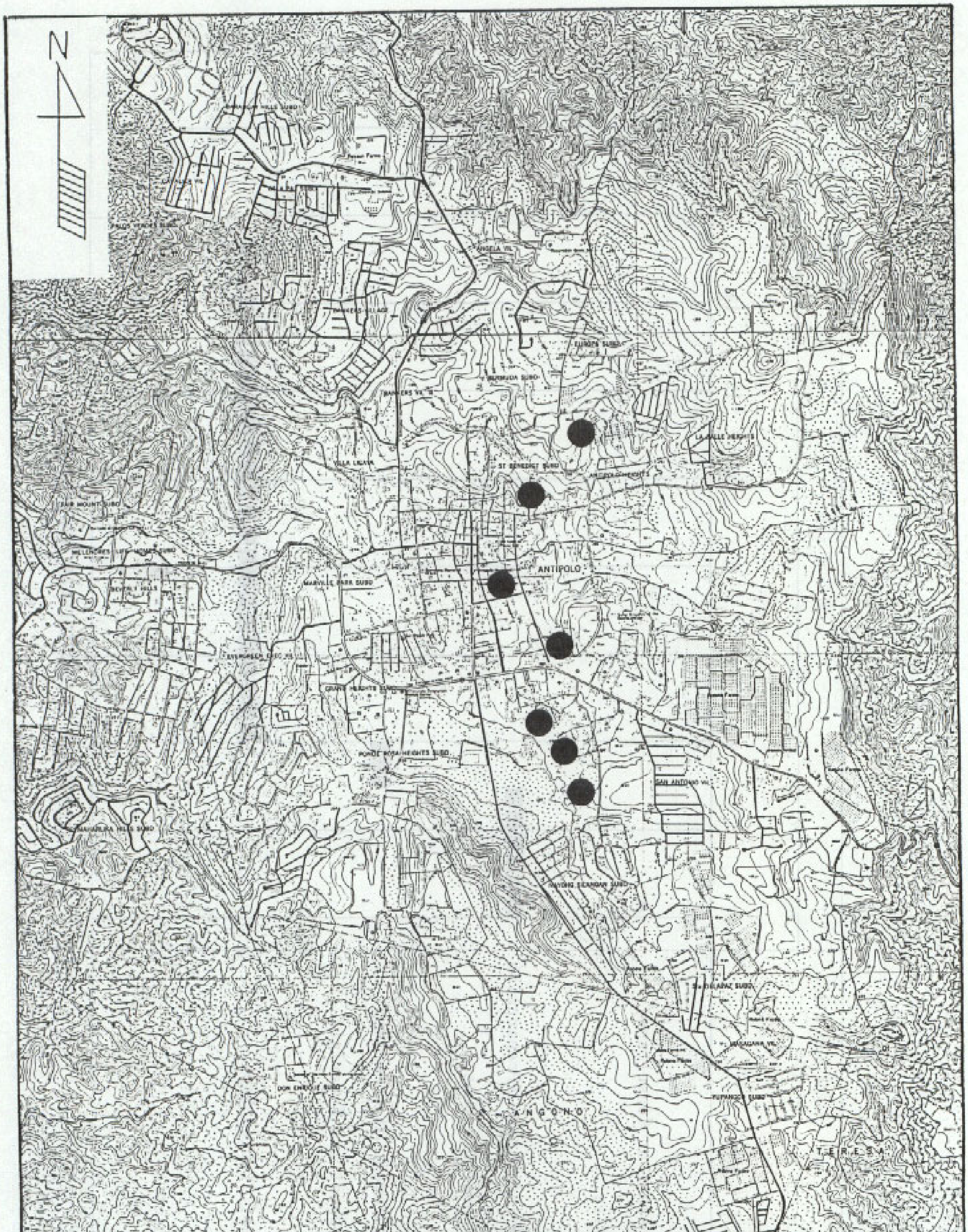
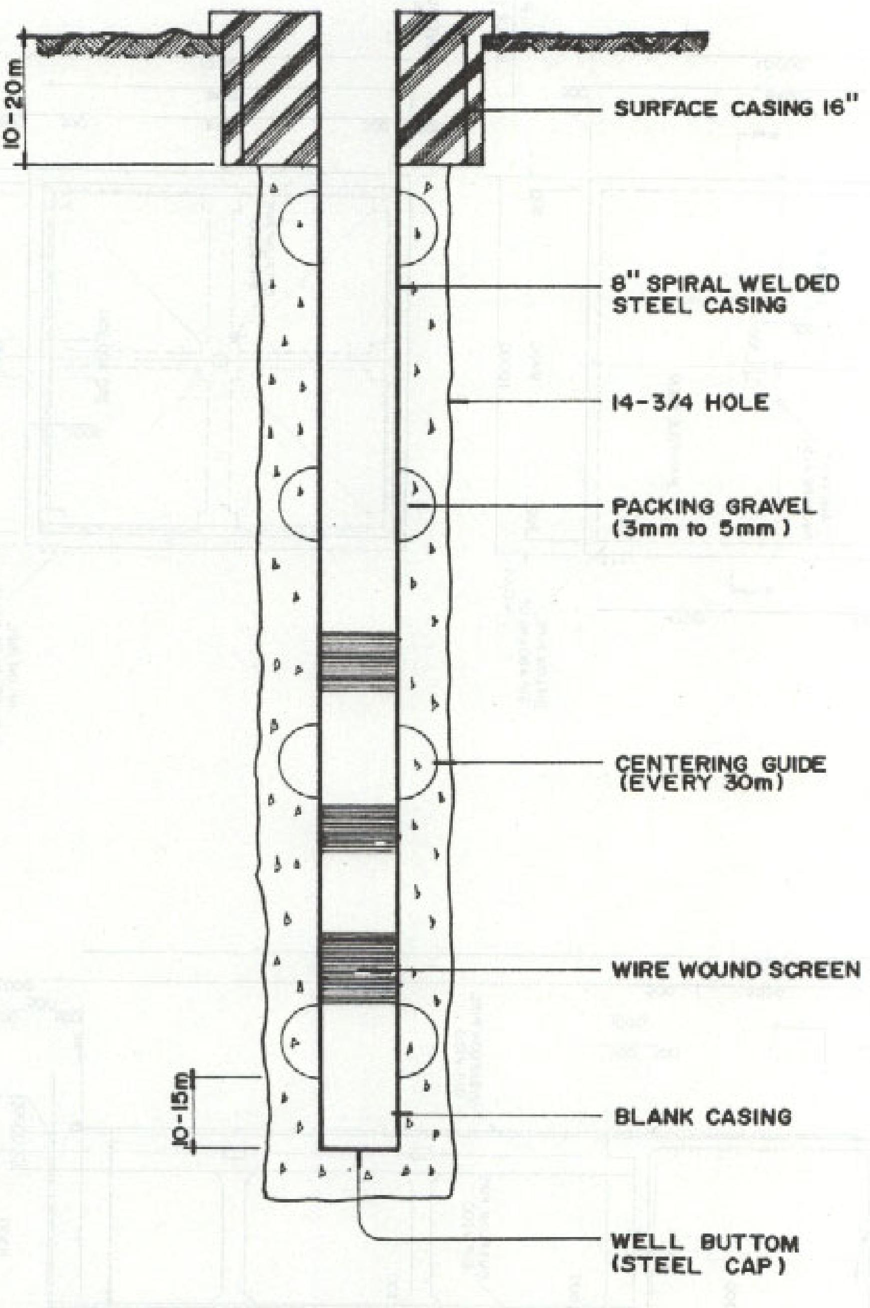
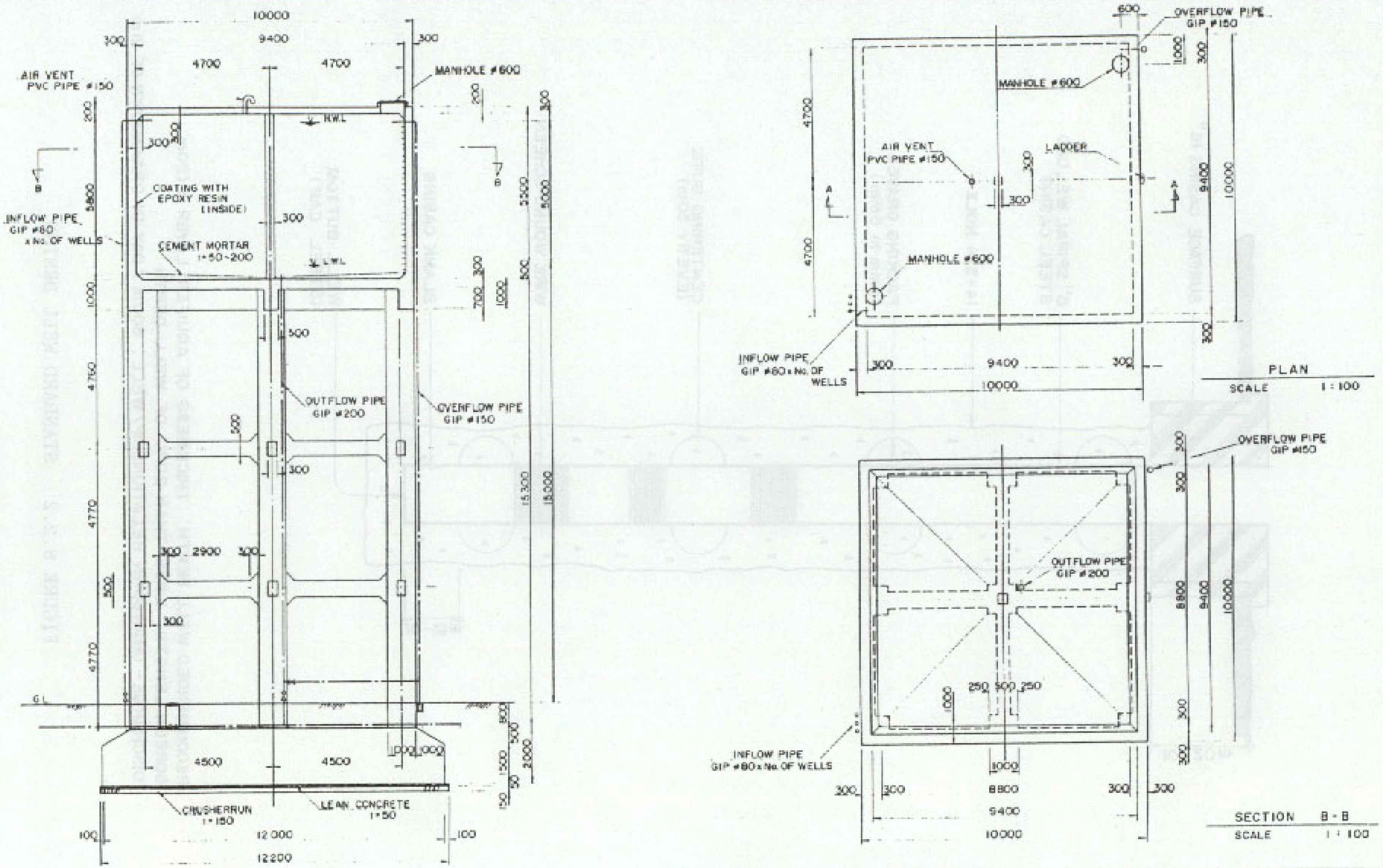


FIGURE 8.2.1 LOCATION MAP OF PLANNED NEW WELLS

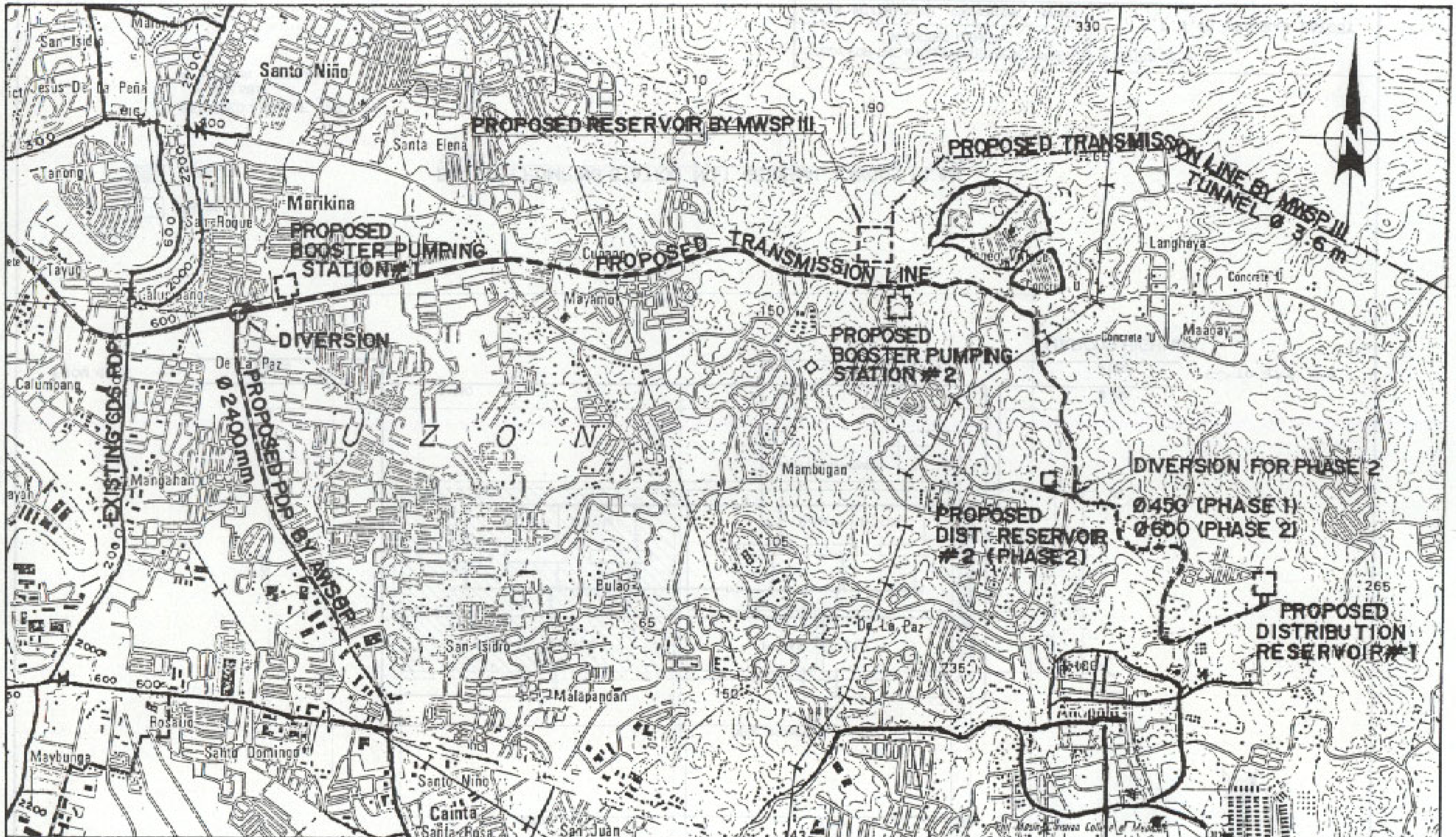


RECOMMENDED WELL DEPTH: THICKNESS OF AQUIFER LAYER + (20m
SCREEN LENGTH: LESS THAN 20% OF WELL DEPTH
DISCHARGE - DRAWDOWN RELATIONSHIP/WELL: 800m / DAY IN DRAWNDOWN OF 21m

FIGURE 8.2.2 STANDARD WELL DESIGN



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 8.2.3
JAPAN INTERNATIONAL COOPERATION AGENCY	ELEVATED WATER TANK

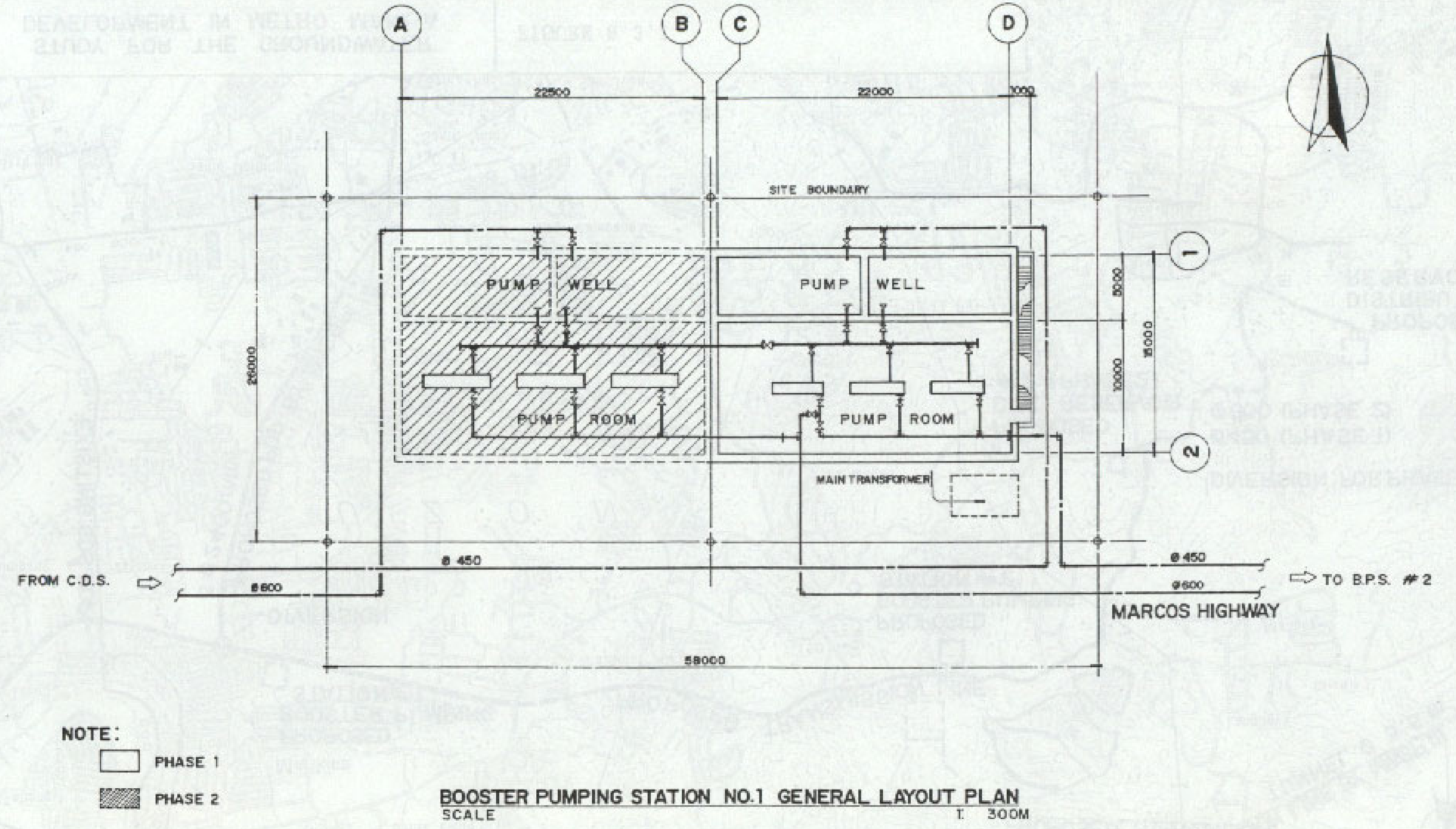


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 8.3.1

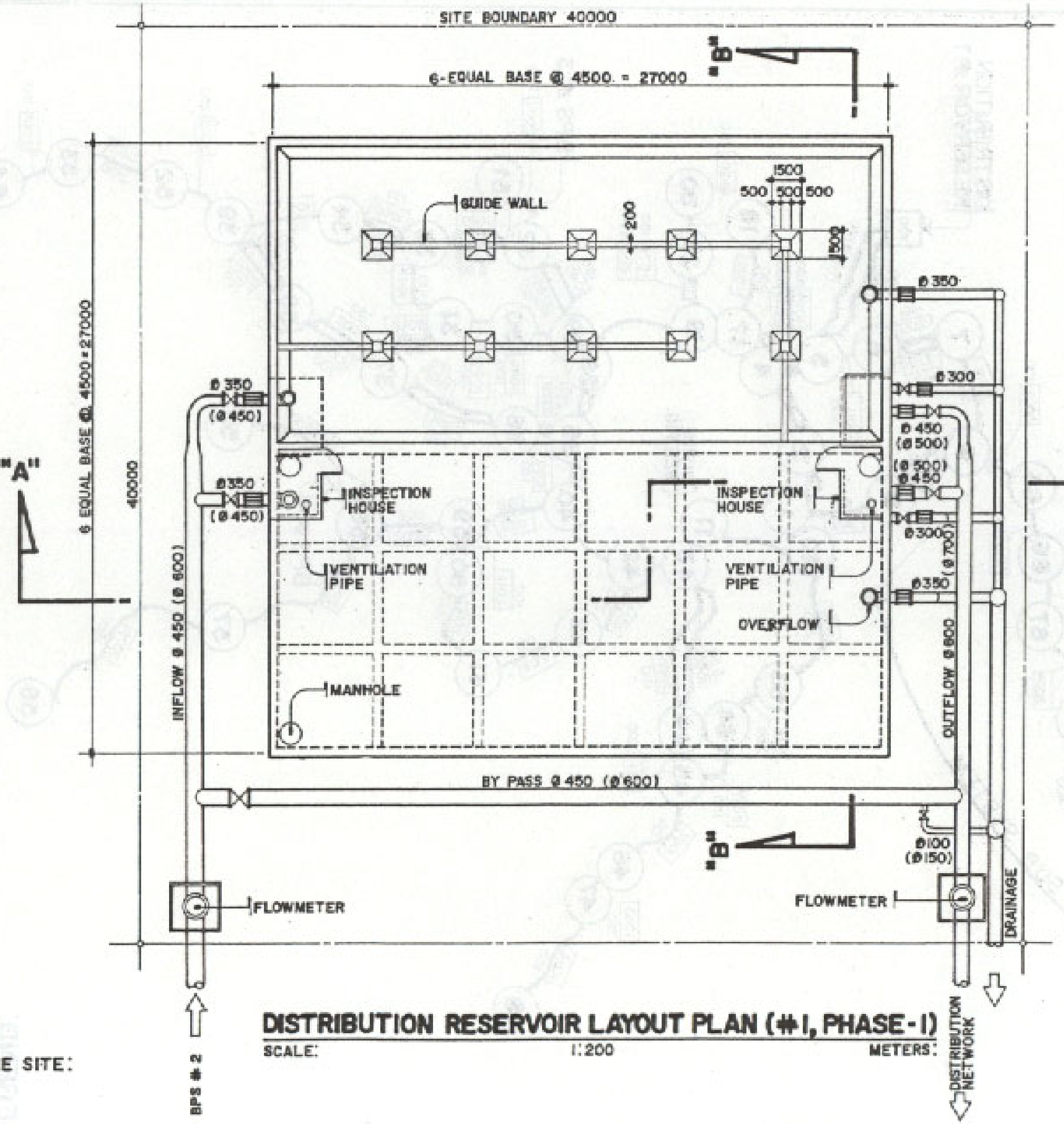
PROPOSED TRANSMISSION SYSTEM



BOOSTER PUMPING STATION NO.1 GENERAL LAYOUT PLAN
SCALE 1 : 300M

∴ REQUIRED AREA OF THE SITE
= 26 x 58 m
A = 1,510 m (MINIMUM)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 8.3.2
JAPAN INTERNATIONAL COOPERATION AGENCY	B.P.S.#1 GENERAL LAYOUT



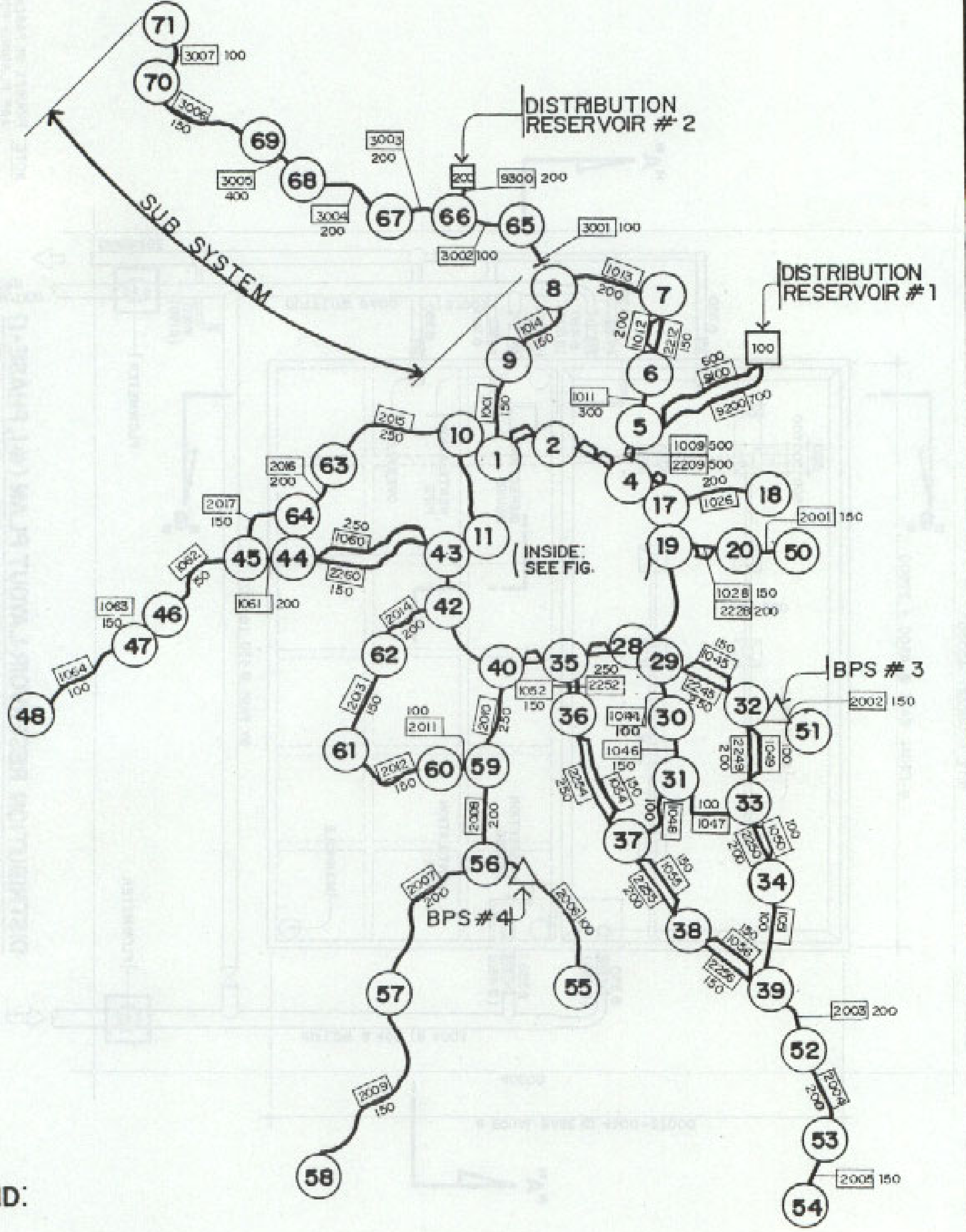
DISTRIBUTION RESERVOIR LAYOUT PLAN (#1, PHASE-I)

SCALE: 1:200 METERS:

NOTE: FIGURES IN PARENTHESIS ARE PLANNED FOR PHASE-2

* REQUIRED AREA OF THE SITE:
- 40 x 40 m.
- 1600m² (MINIMUM)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 8.3.3
JAPAN INTERNATIONAL COOPERATION AGENCY	DISTRIBUTION RESERVOIR #1 (PHASE-I) GENERAL LAYOUT



LEGEND:

PIPE LINE

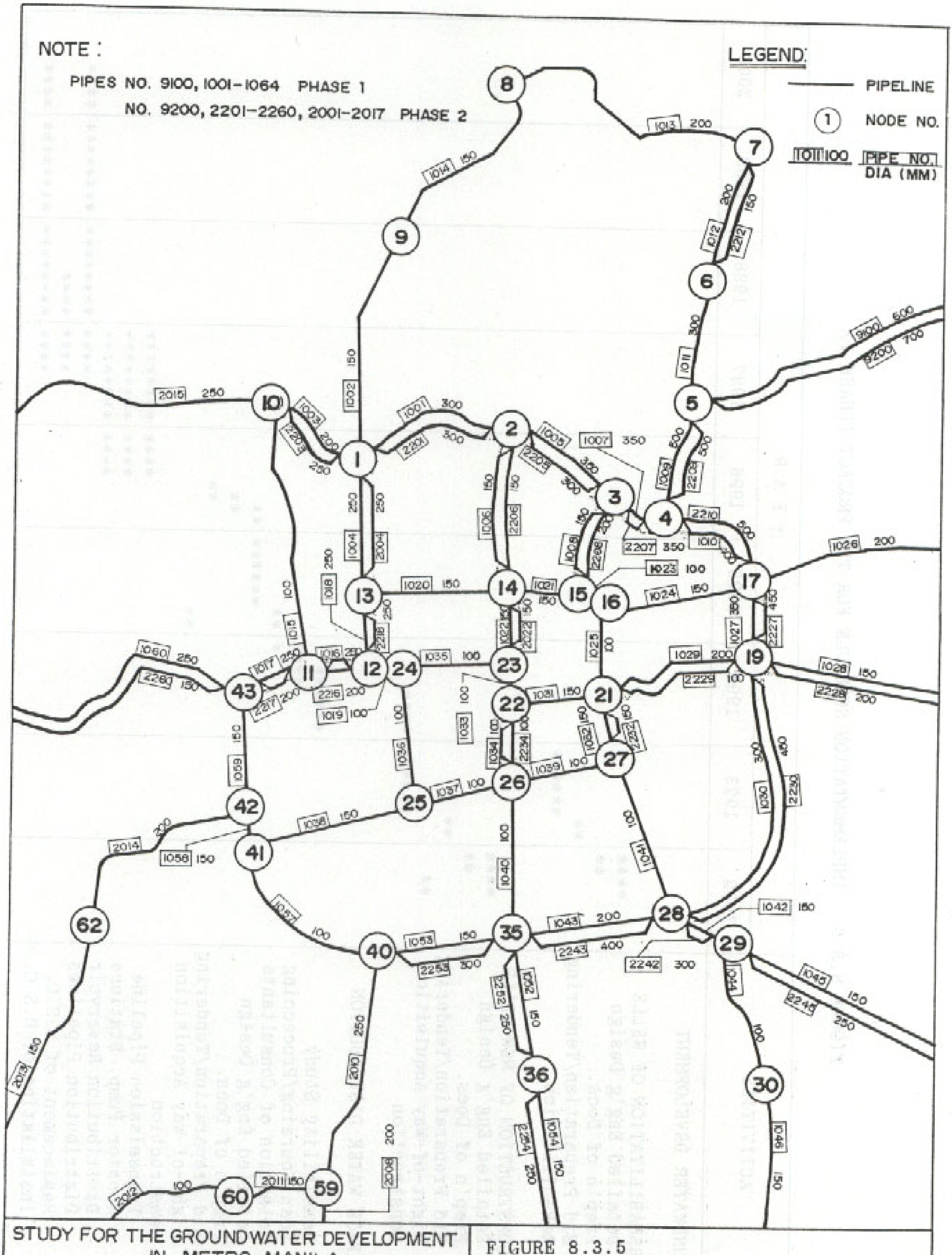
(1) NODE NO.

1011 100 — PIPE NO. / DIA. (MM)

NOTE: CONSTRUCTION PHASE

PIPES NO. 9100, 1001-1064 PHASE 1
NO. 9200, 2201-2260, 2001-2017
9300, 3001-3007 } PHASE 2

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 8.3.4
JAPAN INTERNATIONAL COOPERATION AGENCY	DISTRIBUTION NETWORK ANALYSIS-1



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 8.3.5

DISTRIBUTION NETWORK ANALYSIS-2

FIGURE 8.3.6 IMPLEMENTATION SCHEDULE FOR THE PROJECT (PHASE 1)

ACTIVITIES	1992	1993	1994	1995	1996	1997	1998	1999	2000
GROUNDWATER DEVELOPMENT									
1. REHABILITATION OF WELLS									
Detailed Eng'g Design	****								
Prep'n of Docs.	**								
Bid Preparation/Tendering		**							
Rehabilitation		******							
2. CONSTRUCTION OF NEW WELLS									
Detailed Eng'g Design	****								
Prep'n of Docs.	**								
Bid Preparation/Tendering		**							
Right-of-Way Acquisition	**								
Construction		******	****						
SURFACE WATER DISTRIBUTION									
Feasibility Study			******						
Loan Sourcing/Proceccing			****						
Selection of Consultants			*	**					
Detailed Eng'g Design				******	**				
Prep'n of Docs.					**				
Bid Preparation/Tendering					**				
Right-of-Way Acquisition				**					
Construction									
Transmission Pipeline					****	********			
Booster Pump. Stations					****	********			
Distribution Reservoir					****	********			
Distribution Pipelines						****	********	********	****
Replacement of H.S.C.						****	****		
Installation of H.S.C.						****	********	********	****

TABLE 8.4.1 ESTIMATED PROJECT COST AND FINANCING (GROUNDWATER AND SURFACE WATER)

COMPONENTS		TOTAL COST	1992 FOREX P	1992 LOCAL P	1992 TOTAL COST	1993 FOREX P	1993 LOCAL P	1993 TOTAL COST	1994 FOREX P	1994 LOCAL P	1994 TOTAL COST	1995 FOREX P	1995 LOCAL P	1995 TOTAL COST	1996 FOREX P	1996 LOCAL P	1996 TOTAL COST
<<PROJECT COST>>																	
1. Materials	Rehab.	1,552	0	0	0	466	1,086	1,552	0	0	0	0	0	0	0	0	0
	New Well	26,407	0	0	0	4,150	9,684	13,834	3,772	8,801	12,573	0	0	0	0	0	0
	Surface W.	93,844	0	0	0	0	0	0	0	0	0	0	0	0	5,782	10,427	16,209
Materials Sub Total		121,802	0	0	0	4,616	10,770	15,385	3,772	8,801	12,573	0	0	0	5,782	10,427	16,209
2. Labor																	
Skilled	Rehab.	141	0	0	0	0	141	141	0	0	0	0	0	0	0	0	0
	New Well	1,461	0	0	0	0	751	751	0	710	710	0	0	0	0	0	0
	Surface W.	27,788	0	0	0	0	0	0	0	0	0	0	0	0	0	2,422	2,422
Skilled Labor Sub Total		29,390	0	0	0	0	892	892	0	710	710	0	0	0	0	2,422	2,422
Unskilled	Rehab.	422	0	0	0	0	422	422	0	0	0	0	0	0	0	0	0
	New Well	3,212	0	0	0	0	1,668	1,668	0	1,544	1,544	0	0	0	0	0	0
	Surface W.	20,649	0	0	0	0	0	0	0	0	0	0	0	0	0	2,220	2,220
Unskilled L. Sub Total		24,283	0	0	0	0	2,089	2,089	0	1,544	1,544	0	0	0	0	2,220	2,220
3. Equipment	Rehab.	2,724	0	0	0	2,315	409	2,724	0	0	0	0	0	0	0	0	0
	New Well	5,685	0	0	0	2,209	872	3,081	1,803	801	2,604	0	0	0	0	0	0
	Surface W.	178,325	0	0	0	0	0	0	0	0	0	0	0	0	4,173	5,923	10,096
Equipment Sub Total		186,733	0	0	0	4,524	1,281	5,805	1,803	801	2,604	0	0	0	4,173	5,923	10,096
SUB TOTAL-A (1+2+3)		362,208	0	0	0	9,139	15,032	24,172	5,575	11,856	17,431	0	0	0	9,954	20,993	30,947
4. Land Acquisition		12,335	0	2,750	2,750	0	0	0	0	0	0	0	9,585	9,585	0	0	0
5. Eng'g Serv. (D/D)	Rehab.	387	62	248	310	15	62	77	0	0	0	0	0	0	0	0	0
	New Well	2,941	471	1,882	2,353	118	471	588	0	0	0	0	0	0	0	0	0
	Surface W.	25,648	0	0	0	0	0	0	0	0	0	10,259	10,259	20,519	2,565	2,565	5,130
6. Eng'g Serv. (C/S)	Rehab.	194	0	0	0	39	155	194	0	0	0	0	0	0	0	0	0
	New Well	1,471	0	0	0	168	672	840	126	504	630	0	0	0	0	0	0
	Surface W.	12,824	0	0	0	0	0	0	0	0	0	0	0	0	641	641	1,282
SUB TOTAL-B (4+5+6)		55,800	533	4,880	5,413	340	1,360	1,700	126	504	630	10,259	19,844	30,104	3,206	3,206	6,412
6. Physical Contingency		41,801	53	488	541	948	1,639	2,587	570	1,236	1,806	1,026	1,984	3,010	1,316	2,420	3,736
7. Price Contingency		203,020	21	488	509	774	3,442	4,216	712	4,091	4,803	1,743	9,210	10,952	2,851	14,065	16,916
8. Taxes		73,837	0	488	488	0	3,612	3,612	0	2,109	2,109	0	1,984	1,984	0	4,203	4,203
SUB TOTAL-C (6+7+8)		318,657	75	1,464	1,539	1,721	8,694	10,415	1,282	7,436	8,718	2,769	13,179	15,947	4,167	20,688	24,855
GRAND TOTAL (A+B+C)		736,665	607	6,344	6,951	11,201	25,085	36,286	6,983	19,797	26,780	13,028	33,023	46,051	17,328	44,886	62,214
ADD: IDC		66,304	0	0	0	0	0	0	1,939	0	1,939	0	0	0	0	0	0
PROJECT COST TOTAL		802,969	607	6,344	6,951	11,201	25,085	36,286	8,922	19,797	28,719	13,028	33,023	46,051	17,328	44,886	62,214
<<FINANCING>>																	
1. Government Equity		240,675			6,951			5,795			2,985			46,051			13,814
2. Inter'l Cash Generation		124,874			0			0			1,939			0			0
3. Foreign Loan		437,420			0			30,491			23,795			0			48,400
FINANCING TOTAL		802,969			6,951			36,286			28,719			46,051			62,214

TABLE 8.4.1 (CONTINUATION)

COMPONENTS	TOTAL COST	1997 FOREX P	1997 LOCAL P	1997 TOTAL COST	1998 FOREX P	1998 LOCAL P	1998 TOTAL COST	1999 FOREX P	1999 LOCAL P	1999 TOTAL COST	2000 FOREX P	2000 LOCAL P	2000 TOTAL COST
<<PROJECT COST>>													
1. Materials Rehab.	1,552	0	0	0	0	0	0	0	0	0	0	0	0
New Well	26,407	0	0	0	0	0	0	0	0	0	0	0	0
Surface W.	93,844	21,564	26,448	48,012	4,431	7,080	11,511	4,373	6,553	10,925	2,905	4,280	7,186
Materials Sub Total	121,802	21,564	26,448	48,012	4,431	7,080	11,511	4,373	6,553	10,925	2,905	4,280	7,186
2. Labor													
Skilled Rehab.	141	0	0	0	0	0	0	0	0	0	0	0	0
New Well	1,461	0	0	0	0	0	0	0	0	0	0	0	0
Surface W.	27,788	0	15,763	15,763	0	3,802	3,802	0	3,509	3,509	0	2,291	2,291
Skilled Labor Sub Total	29,390	0	15,763	15,763	0	3,802	3,802	0	3,509	3,509	0	2,291	2,291
Unskilled Rehab.	422	0	0	0	0	0	0	0	0	0	0	0	0
New Well	3,212	0	0	0	0	0	0	0	0	0	0	0	0
Surface W.	20,649	0	10,057	10,057	0	3,542	3,542	0	2,957	2,957	0	1,874	1,874
Unskilled L. Sub Total	24,283	0	10,057	10,057	0	3,542	3,542	0	2,957	2,957	0	1,874	1,874
3. Equipment Rehab.	2,724	0	0	0	0	0	0	0	0	0	0	0	0
New Well	5,685	0	0	0	0	0	0	0	0	0	0	0	0
Surface W.	178,325	73,322	24,515	97,837	20,527	8,890	29,417	16,353	8,671	25,024	10,207	5,744	15,951
Equipment Sub Total	186,733	73,322	24,515	97,837	20,527	8,890	29,417	16,353	8,671	25,024	10,207	5,744	15,951
SUB TOTAL-A (1+2+3)	362,208	94,887	76,782	171,669	24,958	23,315	48,273	20,726	21,689	42,416	13,112	14,189	27,301
4. Land Acquisition	12,335	0	0	0	0	0	0	0	0	0	0	0	0
5. Eng'g Serv. (D/D) Rehab.	387	0	0	0	0	0	0	0	0	0	0	0	0
New Well	2,941	0	0	0	0	0	0	0	0	0	0	0	0
Surface W.	25,648	0	0	0	0	0	0	0	0	0	0	0	0
6. Eng'g Serv. (C/S) Rehab.	194	0	0	0	0	0	0	0	0	0	0	0	0
New Well	1,471	0	0	0	0	0	0	0	0	0	0	0	0
Surface W.	12,824	3,206	3,206	6,412	385	1,539	1,924	385	1,539	1,924	256	1,026	1,282
SUB TOTAL-B (4+5+6)	55,800	3,206	3,206	6,412	385	1,539	1,924	385	1,539	1,924	256	1,026	1,282
6. Physical Contingency	41,801	9,809	7,999	17,808	2,534	2,465	5,020	2,111	2,323	4,434	1,337	1,521	2,858
7. Price Contingency	203,020	26,026	56,610	82,636	8,007	20,985	28,092	7,781	23,040	30,821	5,659	17,516	23,175
8. Taxes	73,837	0	36,902	36,902	0	10,405	10,405	0	8,655	8,655	0	5,478	5,475
SUB TOTAL-C (6+7+8)	318,657	35,835	101,511	137,346	10,541	33,875	44,416	9,892	34,018	43,910	6,996	24,516	31,512
GRAND TOTAL (A+B+C)	736,665	133,928	181,499	315,427	35,883	58,729	94,612	31,003	57,246	88,249	20,365	39,730	60,095
ADD: IDC	66,304	3,078	0	3,078	18,193	0	18,193	20,381	0	20,381	22,712	0	22,712
PROJECT COST TOTAL	802,969	137,006	181,499	318,505	54,076	58,729	112,805	51,384	57,246	108,630	43,077	39,730	82,807
<<FINANCING>>													
1. Government Equity	240,675			63,139			39,695			36,961			25,285
2. Inter'l Cash Generation	124,874			17,721			38,692			35,024			31,498
3. Foreign Loan	437,420			237,646			34,418			36,646			26,024
FINANCING TOTAL	802,969			318,505			112,805			108,630			82,807

TABLE 8.4.2 FINANCIAL INTERNAL RATE OF RETURN (GROUNDWATER AND SURFACE WATER)

YEAR	CASH RECEIPTS FROM OPER'N (1000P)	CASH EXPENSES FOR O & M (1000P)	INVESTMENT IN PROJECT (1000P)	FINANCIAL NET BENEFIT FLOW (1000P)
1992	0	0	6,951	(6,951)
1993	0	0	36,286	(36,286)
1994	5,394	1,337	28,719	(24,662)
1995	9,993	1,948	46,051	(38,006)
1996	14,375	3,173	62,214	(51,012)
1997	19,315	5,020	318,505	(304,210)
1998	24,957	12,624	112,805	(100,472)
1999	31,375	16,349	108,630	(93,604)
2000	38,663	23,533	82,807	(67,677)
2001	46,804	29,931	0	16,873
2002	56,083	36,571	0	19,512
2003	66,682	55,177	0	11,505
2004	78,763	52,104	0	26,659
2005	92,509	61,147	0	31,362
2006	105,478	69,914	0	35,564
2007	119,430	79,580	0	39,850
2008	134,940	90,230	0	44,710
2009	152,167	101,960	0	50,207
2010	171,287	114,873	0	56,414
2011	186,162	122,274	0	63,888
2012	201,055	130,199	0	70,856
2013	217,140	160,219	0	56,921
2014	234,511	147,784	0	86,727
2015	253,272	157,533	0	95,739
2016	273,534	167,983	0	105,551
2017	295,416	179,189	0	116,227
2018	319,050	191,209	0	127,841
2019	344,574	204,105	0	140,469
2020	372,139	217,945	0	154,194
2021	401,911	232,801	0	169,110
NPV at 3.47% WACC				100,120
FIRR				4.46%

TABLE 8.4.3 ESTIMATED PROJECT COST AND FINANCING (GROUNDWATER ONLY)

(unit: P1000)

COMPONENTS	TOTAL COST	1992 FOREX P	1992 LOCAL P	1992 TOTAL COST	1993 FOREX P	1993 LOCAL P	1993 TOTAL COST	1994 FOREX P	1994 LOCAL P	1994 TOTAL COST	1995 FOREX P	1995 LOCAL P	1995 TOTAL COST	1996 FOREX P	1996 LOCAL P	1996 TOTAL COST
<<PROJECT COST>>																
1. Materials Rehab.	1,552	0	0	0	466	1,086	1,552	0	0	0	0	0	0	0	0	0
New Well	26,407	0	0	0	4,150	9,684	13,834	3,772	8,801	12,573	0	0	0	0	0	0
Surface W.	29,915	0	0	0	2,371	3,846	6,217	3,545	5,664	9,209	3,498	5,242	8,740	2,324	3,424	5,749
Materials Sub Total	57,874	0	0	0	6,987	14,616	21,603	7,317	14,465	21,782	3,498	5,242	8,740	2,324	3,424	5,749
2. Labor																
Skilled Rehab.	141	0	0	0	0	141	141	0	0	0	0	0	0	0	0	0
New Well	1,461	0	0	0	0	751	751	0	710	710	0	0	0	0	0	0
Surface W.	9,749	0	0	0	0	2,067	2,067	0	3,042	3,042	0	2,808	2,808	0	1,833	1,833
Skilled Labor Sub Total	11,351	0	0	0	0	2,959	2,959	0	3,752	3,752	0	2,808	2,808	0	1,833	1,833
Unskilled Rehab.	422	0	0	0	0	422	422	0	0	0	0	0	0	0	0	0
New Well	3,212	0	0	0	0	1,668	1,668	0	1,544	1,544	0	0	0	0	0	0
Surface W.	8,666	0	0	0	0	1,967	1,967	0	2,834	2,834	0	2,365	2,365	0	1,499	1,499
Unskilled L. Sub Total	12,299	0	0	0	0	4,057	4,057	0	4,378	4,378	0	2,365	2,365	0	1,499	1,499
3. Equipment Rehab.	2,724	0	0	0	2,315	409	2,724	0	0	0	0	0	0	0	0	0
New Well	5,685	0	0	0	2,208	872	3,081	1,803	801	2,604	0	0	0	0	0	0
Surface W.	72,588	0	0	0	11,504	4,771	16,275	16,421	7,112	23,534	13,083	6,937	20,019	8,165	4,595	12,761
Equipment Sub Total	80,997	0	0	0	16,028	6,052	22,080	18,224	7,913	26,137	13,083	6,937	20,019	8,165	4,595	12,761
SUB TOTAL-A (1+2+3)	162,521	0	0	0	23,015	27,683	50,698	25,541	30,508	56,049	16,581	17,352	33,932	10,490	11,351	21,841
4. Land Acquisition	2,750	0	2,750	2,750	0	0	0	0	0	0	0	0	0	0	0	0
5. Eng'g Serv. (D/D) Rehab.	387	62	248	310	15	62	77	0	0	0	0	0	0	0	0	0
New Well	2,941	471	1,882	2,353	118	471	588	0	0	0	0	0	0	0	0	0
Surface W.	9,673	1,548	6,191	7,739	387	1,549	1,935	0	0	0	0	0	0	0	0	0
6. Eng'g Serv. (C/S) Rehab.	194	0	0	0	39	155	194	0	0	0	0	0	0	0	0	0
New Well	1,471	0	0	0	168	672	840	126	504	630	0	0	0	0	0	0
Surface W.	4,837	0	0	0	531	531	1,061	309	1,236	1,545	271	1,086	1,357	175	699	874
SUB TOTAL-B (4+5+6)	22,252	2,080	11,071	13,151	1,257	3,438	4,695	435	1,740	2,175	271	1,086	1,357	175	699	874
6. Physical Contingency	18,477	208	1,107	1,315	2,427	3,112	5,539	2,598	3,225	5,822	1,685	1,844	3,529	1,066	1,205	2,271
7. Price Contingency	44,358	83	1,107	1,190	1,981	6,535	8,516	3,243	10,674	13,918	2,863	8,557	11,419	2,310	7,004	9,314
8. Taxes	32,340	0	1,107	1,107	0	9,520	9,520	0	10,433	10,433	0	6,909	6,909	0	4,370	4,370
SUB TOTAL-C (6+7+8)	95,175	291	3,321	3,613	4,408	19,168	23,576	5,841	24,332	30,173	4,548	17,310	21,858	3,377	12,579	15,956
GRAND TOTAL (A+B+C)	279,948	2,372	14,392	16,764	28,680	50,289	78,969	31,817	56,580	88,398	21,400	35,747	57,147	14,041	24,629	38,570
ADD: IDC	11,399	0	0	0	0	0	0	3,129	0	3,129	3,106	0	3,106	5,164	0	5,164
PROJECT COST TOTAL	291,347	2,372	14,392	16,764	28,680	50,289	78,969	34,946	56,580	91,527	24,506	35,747	60,253	19,205	24,629	43,834
<<FINANCING>>																
1. Government Equity	74,682			16,764			18,054			18,082			13,070			8,712
2. Inter'l Cash Generation	58,255			0			11,714			19,529			14,820			12,192
3. Foreign Loan	158,410			0			49,201			53,916			32,363			22,930
FINANCING TOTAL	291,347			16,764			78,969			91,527			60,253			43,834

TABLE 8.4.4 FINANCIAL INTERNAL RATE OF RETURN
(GROUNDWATER ONLY)

YEAR	CASH RECEIPTS FROM OPER'N (1000P)	CASH EXPENSES FOR OPER'N (1000P)	INVESTMENT IN PROJECT (1000P)	FINANCIAL NET BENEFIT FLOW (1000P)
1992	0	0	16,764	(16,764)
1993	2,634	96	78,969	(76,431)
1994	5,921	1,932	91,527	(87,538)
1995	9,993	3,080	60,253	(53,340)
1996	14,375	4,856	43,834	(34,315)
1997	19,315	6,573	0	12,742
1998	24,957	8,139	0	16,818
1999	30,744	9,608	0	21,136
2000	33,823	10,089	0	23,734
2001	37,230	10,598	0	26,632
2002	41,107	11,136	0	29,971
2003	45,365	22,945	0	22,420
2004	50,042	12,310	0	37,732
2005	55,176	12,949	0	42,227
2006	59,781	13,627	0	46,154
2007	64,563	14,346	0	50,217
2008	69,728	15,109	0	54,619
2009	75,307	15,919	0	59,388
2010	81,331	16,780	0	64,551
2011	87,838	17,695	0	70,143
2012	94,865	18,668	0	76,197
2013	102,454	41,233	0	61,221
2014	110,650	20,805	0	89,845
2015	119,502	21,980	0	97,522
2016	129,063	23,231	0	105,832
2017	139,388	24,566	0	114,822
2018	150,539	25,990	0	124,549
2019	162,582	27,511	0	135,071
2020	175,588	29,135	0	146,453
2021	189,635	30,870	0	158,765
NPV at 3.46% WACC				565,807
FIRR				11.43%

NOTE: To reduce the NRW, distribution network replacement and construction was assumed to be implemented with an amount of 80% of initial proposed project from 1993.

TABLE 8.4.5 ECONOMIC INTERNAL RATE OF RETURN (GROUNDWATER AND SURFACE WATER)

YEAR	ECONOMIC BENEFITS WATER REVENUE (P1,000)	HEALTH BENEFITS (P1,000)	FIRE PROTECTION (P1,000)	LAND VALUE INCREASE (P1,000)	TOTAL ECONOMIC BENEFITS (P1,000)	TOTAL ECONOMIC COSTS (P1,000)	ECONOMIC NET BENEFITS (P1,000)
1992	0	0	0	0	0	6,071	(6,071)
1993	0	0	0	0	0	30,777	(30,777)
1994	6,687	25	485	50,400	57,597	22,108	35,489
1995	10,046	51	1,010	50,400	61,507	38,200	23,307
1996	13,140	89	1,760	0	14,989	47,084	(32,095)
1997	16,229	124	2,460	82,125	100,938	221,493	(120,555)
1998	19,322	158	3,129	82,125	104,734	70,151	34,583
1999	22,411	190	3,776	82,125	108,503	66,694	41,809
2000	25,504	222	4,409	82,125	112,261	50,971	61,290
2001	28,517	240	4,750	0	33,506	20,061	13,445
2002	31,598	257	5,090	0	36,945	27,796	9,149
2003	34,749	274	5,431	0	40,454	25,131	15,323
2004	37,969	291	5,771	0	44,031	27,667	16,365
2005	41,259	308	6,112	0	47,679	29,695	17,984
2006	43,341	318	6,302	0	49,960	31,725	18,236
2007	45,423	327	6,491	0	52,242	33,756	18,486
2008	47,506	337	6,681	0	54,524	38,603	15,921
2009	49,588	347	6,871	0	56,805	40,187	16,619
2010	51,670	356	7,061	0	59,087	37,815	21,272
2011	51,670	356	7,061	0	59,087	46,559	12,528
2012	51,670	356	7,061	0	59,087	133,016	(73,930)
2013	51,670	356	7,061	0	59,087	64,633	(5,546)
2014	51,670	356	7,061	0	59,087	60,451	(1,364)
2015	51,670	356	7,061	0	59,087	52,209	6,878
2016	51,670	356	7,061	0	59,087	37,815	21,272
2017	51,670	356	7,061	0	59,087	37,815	21,272
2018	51,670	356	7,061	0	59,087	37,815	21,272
2019	51,670	356	7,061	0	59,087	37,815	21,272
2020	51,670	356	7,061	0	59,087	37,815	21,272
2021	51,670	356	7,061	0	59,087	37,815	21,272
NPV at 15.00%							5,592
EIRR							17.19%

TABLE 8.4.6 ECONOMIC INTERNAL RATE OF RETURN (GROUNDWATER ONLY)

YEAR	ECONOMIC BENEFITS WATER REVENUE (P1,000)	HEALTH BENEFITS (P1,000)	FIRE PROTECTION (P1,000)	LAND VALUE INCREASE (P1,000)	TOTAL ECONOMIC BENEFITS (P1,000)	TOTAL ECONOMIC COSTS (P1,000)	ECONOMIC NET BENEFITS (1000P)
1992	0	0	0	0	0	14,972	(14,972)
1993	3,591	0	0	0	3,591	65,950	(62,359)
1994	6,687	25	485	50,400	57,597	70,111	(12,513)
1995	10,046	51	1,010	50,400	61,507	45,268	16,240
1996	13,140	89	1,760	0	14,989	31,764	(16,775)
1997	16,229	124	2,460	18,720	37,533	6,254	31,280
1998	19,322	158	3,129	18,720	41,329	7,143	34,186
1999	21,889	184	3,654	18,720	44,447	7,143	37,304
2000	21,889	184	3,654	18,720	44,447	7,143	37,304
2001	22,387	184	3,654	0	26,225	7,143	19,082
2002	22,885	184	3,654	0	26,723	12,344	14,379
2003	23,383	184	3,654	0	27,221	7,143	20,078
2004	23,882	184	3,654	0	27,719	7,143	20,577
2005	24,380	184	3,654	0	28,218	7,143	21,075
2006	24,380	184	3,654	0	28,218	7,143	21,075
2007	24,380	184	3,654	0	28,218	7,143	21,075
2008	24,380	184	3,654	0	28,218	25,724	2,494
2009	24,380	184	3,654	0	28,218	32,235	(4,017)
2010	24,380	184	3,654	0	28,218	26,362	1,856
2011	24,380	184	3,654	0	28,218	19,393	8,825
2012	24,380	184	3,654	0	28,218	12,344	15,874
2013	24,380	184	3,654	0	28,218	7,143	21,075
2014	24,380	184	3,654	0	28,218	7,143	21,075
2015	24,380	184	3,654	0	28,218	7,143	21,075
2016	24,380	184	3,654	0	28,218	7,143	21,075
2017	24,380	184	3,654	0	28,218	7,143	21,075
2018	24,380	184	3,654	0	28,218	7,143	21,075
2019	24,380	184	3,654	0	28,218	7,143	21,075
2020	24,380	184	3,654	0	28,218	7,143	21,075
2021	24,380	184	3,654	0	28,218	7,143	21,075
NPV at 15.00%							11.207
EIRR							17.20%

CHAPTER 9 GROUNDWATER MANAGEMENT PLAN

9.1 TARGET OF GROUNDWATER MANAGEMENT

Water supply in the Metro Manila shall for a long time depend on groundwater sources, not only for domestic use but also for commercial and industrial uses. A groundwater management plan is proposed for the twin purpose of effective use and conservation of groundwater.

A target of groundwater management is the containment/prevention of saline water intrusion in Metro Manila. A fundamental measure for this is the recovery of groundwater levels. Additional measures are the construction of cutoff walls, artificial recharge, extraction and/or injection barrier, etc.

However, these additional measures are extremely costly and would prove difficult to implement, considering the mechanism and the areal extent of saline water intrusion. The reduction of pumpage therefore is the most viable option.

The computer simulations predicted that the groundwater level shall decline by more than 50m from its present level and the saline water-intruded area to expand even in the most optimistic scenario (Pumpage in 2010: 1,064,000 CMD). Thus considered, plans for the reduction of pumpage in the Metro Manila groundwater basin were prepared and evaluated through computer simulations. A pumpage reduction plan in terms of prevention of saline water intrusion was set up in which a reduced pumpage is proposed as a tentative permissive yield of the basin, a target of the groundwater management.

9.2 REGULATION OF PUMPAGE

9.2.1 Zoning of Regulated Area

The proposed plan has the Metro Manila groundwater basin subdivided into three (3) areas for groundwater regulation. It had considered the decline of water levels, the saline water intrusion and the completions of surface water supply projects, especially AWSOP.

(A) Area of Importance (the coastal area): The area where saline water has already intruded or there is an indication of saline water intrusion.

(B) Area of Semi-Importance (the inland): The area where groundwater levels had dropped heavily and where saltwater intrusion is anticipated to occur.

(C) Area of Surveillance: The rest of the area in the Metro Manila groundwater basin contiguous to the "A" and "B" areas, including the Antipolo groundwater basin.

9.2.2 Schedule of Regulation

The schedule of regulation is divided into three (3) stages:

(1) First Stage (Investigation): The groundwater level and pumping rates of all wells, except shallow wells for domestic use, will be measured and reported periodically. The groundwater monitoring system shall be installed as a minimum requirement. Based on the data from these activities, more definite targets of pumpage reduction in each area shall be set up. The construction of new wells in the "A" area is not allowed during this stage.

(2) Second Stage (Enforcement): The reduction of pumpage in "A" and "B" areas shall be enforced considering the progress of the substitutional water supply system. The groundwater monitoring system shall be expanded during this stage.

(3) Third Stage (Monitoring and Adjustment): Groundwater use shall be re-organized by purpose and by area, with consideration to the order of preference in the use of groundwater.

The first and second stages should be completed within five (5) years.

9.2.3 Control Area

In Art. 32 of the Philippine Water Code, the NWRB promulgates rules and regulations and declares the existence of a "Control Area" for the coordinated development, protection and utilization of groundwater and surface water. The concept of Control Area is applied to the regulated areas. Rules and regulations for the enforcement shall require further studies.

9.3 TARGET REGULATION OF PUMPAGE

To prevent or contain the saline water intrusion in Metro Manila, the groundwater pumpage control settings listed hereunder were investigated. These settings were made to simulate the relations between reduction of groundwater pumpage and piezometric changes.

9.3.1 Pumpage Control Settings

(1) Regulated Area

A regulated area for groundwater pumpage was established along the coastal area of Metro Manila (Figure 9.3.1), after considering the present piezometric heads, positions of saline water intrusion, future plans for surface water supply, etc. The area covers fifteen (15) municipalities viz. Caloocan City (south), Valenzuela, Malabon, Navotas, Manila, Makati (western part), Pasay City, Parañaque, Las Piñas (northern part), Bacoor (northern part), Imus (northern part), Cavite, Kawit, Noveleta and Rosario.

(2) Time Schedule

The reduction of pumpage is assumed to begin in 1996, with the target regulated pumpage being reached by year-2000. The 5-year period, 1991 to 1995, is considered for investigation and preparation. Pumpage in this period follows Scenario 1. After year-2000, the target regulated pumpage is maintained up to year-2010. Pumpage outside the regulated areas follows Scenario 1, i.e., from 1991 up to 2010.

(3) Regulated Pumpage

A target regulated pumpage is set based on the year-1990 pumpage. The reduction of pumpage will be done for both MWSS and private wells using uniform reduction rate. Seven (7) pumpage regulation plans were made for the simulations:

Plan (a) : Year-1995 pumpage of Scenario 1 is maintained up to 2010. (Figures 9.3.2 and 9.3.4)

Plan (b) : Target regulated pumpage by 2000 is the 1990 pumpage. (Figures 9.3.2 and 9.3.4)

Plan (c) : Target regulated pumpage by 2000 is 90% of the 1990 pumpage.

Plan (d) : Target regulated pumpage by 2000 is 80% of the 1990 pumpage. (Figures 9.3.3 and 9.3.5)

Plan (e) : Target regulated pumpage by 2000 is 70% of the 1990 pumpage. (Figures 9.3.3 and 9.3.5)

Plan (f) : Target regulated pumpage by 2000 is 60% of the 1990 pumpage. (Figures 9.3.3 and 9.3.5)

Plan (g) : Target regulated pumpage by 2000 is 50% of the 1990 pumpage. (Figures 9.3.3 and 9.3.5)

9.3.2 Simulation Results

The results are summarized in Table 9.3.1 and Figures 9.3.6 to 9.3.11.

Plan (a) is the most lenient plan. The pumpage in the regulated area increases by 14.4 MCM/year from 1991 to 1995. With this plan, maximum drawdowns of 40.2m and 25.8m are expected by 2010 in the northern and southern parts of Metro Manila, respectively.

Plan (b) reduces the 1995 pumpage to the 1990 pumpage level by year 2000. Maximum drawdowns of 9.7m in the north and 18.7m in the south are predicted, and these being principally due to the increase in pumpage between 1991 and 1995.

Plan (c) to Plan (g) reduce the 1995 pumpage to target regulated pumpages that are lesser than the 1990 pumpage level. The recovery of the piezometric heads depends upon the level of the target regulated pumpage in year 2000. Maximum recoveries of 55.3m in the north and 30.7m in the south are expected in Plan (g). In Plan (g), the lowest piezometric head is -50m in Valenzuela.

Regional piezometric head recovery may differ from place to place. While recoveries may be large in the northern part of Metro Manila, they may be small in the southern part. In Cavite, the piezometric head recovers only by 12.4m under Plan (g). In most cases, such phenomenon could be explained by the dynamic behavior of groundwater flow. That is, the groundwater in the regulated area of Cavite flows towards the piezometric head depressions in Muntinlupa and Parañaque where pumpage is greater and not regulated.

The present piezometric heads must recover to prevent further saline water intrusion in the future. Toward this end, the future discharge in the regulated area should be reduced to at least 50% of the year-1990 pumpage. However, and notwithstanding the recovery of piezometric heads in the coastal area, it is still possible for saline water to intrude further inland of southern Metro Manila due to the existence of abovesaid piezometric head depressions. The results of these simulations indicate the necessity of regulating pumpage not only in the coastal area but also in the inland area.

9.4 SUBSTITUTIONAL WATER SUPPLY

The substitutional water supply system must be constructed in the regulated areas prior to the enforcement of the relevant implementing rules and regulations of the Water Code. Measures for the substitutional water supply include the development of surface water in Kaliwa River and Laguna de Bay. A fundamental measure is the implementation of Manila Water Supply Project III (MWSP III).

However, considering the progress of water supply projects, it is difficult to depend only on the substitutional water source. Present industrial use alone accounts for about 40% of groundwater abstracted in Metro Manila. As the principal users of groundwater are for the foods, the chemical, the leather and the textile industries, such industries should be targetted for savings and rational use of groundwater. Here, additional empirical research is required.

9.5 GROUNDWATER MONITORING SYSTEM

The first step in groundwater management is the collection and arrangement of accurate observation data . An allocation plan for the groundwater monitoring wells was made in order to effectively monitor groundwater levels and quality of the Guadalupe aquifers in the Metro Manila groundwater basin (Figure 9.5.1).

A set of observation wells--one shallow and one deep--shall be constructed per monitoring location, except for ten sites where only one well shall be drilled (Figure 9.5.2). These wells are designed to facilitate automatic measurement of groundwater level and quality (EC) and periodic collection of water samples for laboratory analysis. The number of locations is 30 and that of wells 50. The total construction cost is estimated to amount to 72 million pesos.

It is expected that the groundwater monitoring system, together with the groundwater database and simulation models installed in MWSS, will be used as regular tools of groundwater management.

9.6 IMPLEMENTING BODY FOR GROUNDWATER MANAGEMENT

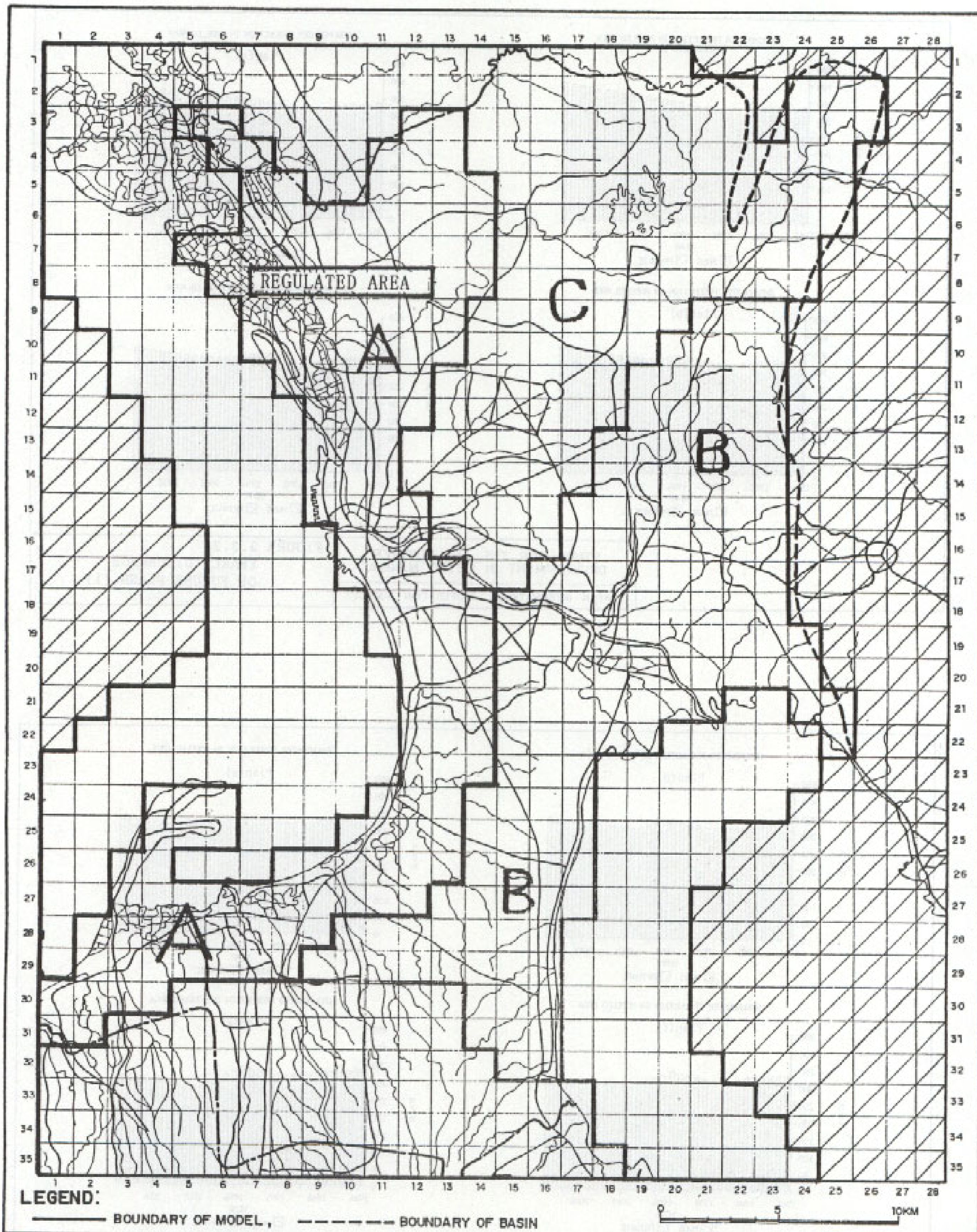
The lead agency for the implementation of the groundwater management plan should be the NWRB since it is the agency responsible for coordinating and integrating all activities related to water resources development and management in the country. The MWSS as the office responsible for the investigation, observation, analysis, and evaluation of groundwater resources in the MSA could be tasked with the technical aspects of the groundwater management plan. MWSS should therefore strengthen its organization that is responsible for groundwater studies.

TABLE 9.3.1 RESULTS OF REGULATED DISCHARGE SIMULATED

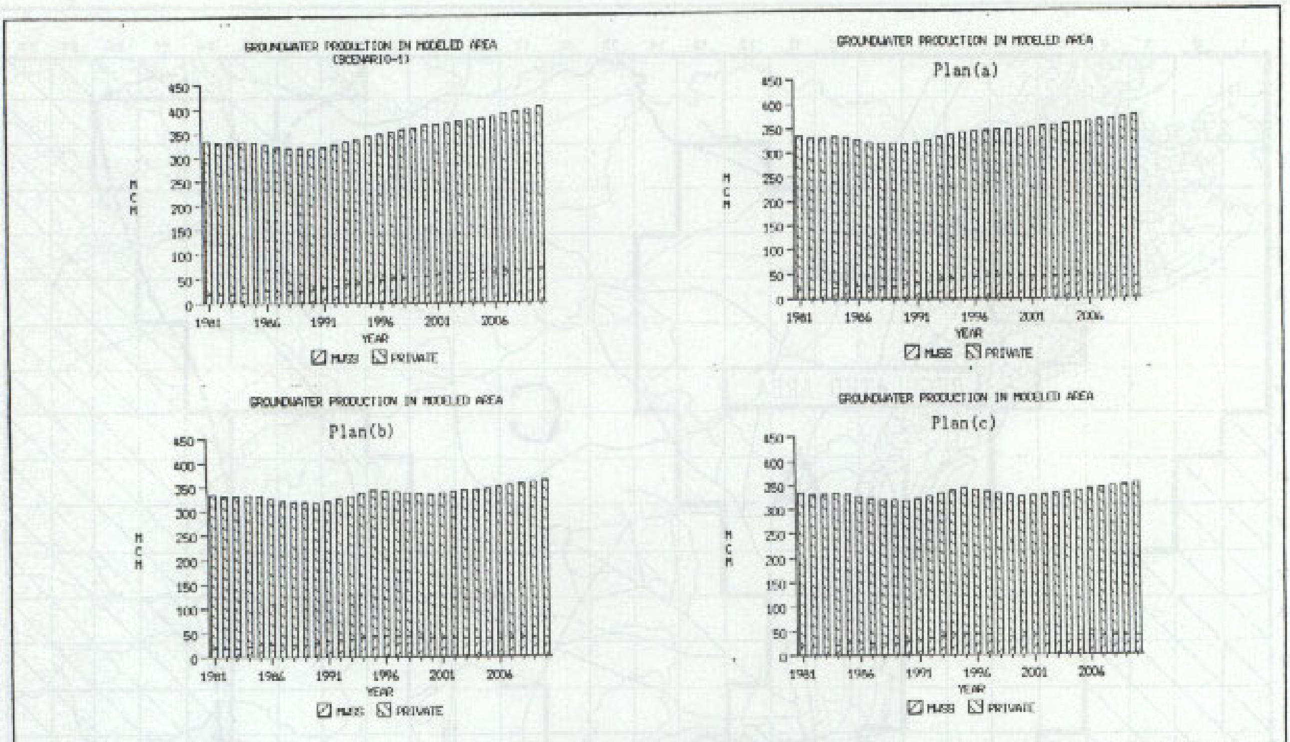
Regulation Plan	Pumpage in 2000 (upper:Metro Manila) (lower:Modeled area) (MCM)	Reduction of pumpage in regulated area (Compare to 1990) (MCM)	Lowest head in regulated area (in 2010)		Maximum head change in regulated area('10-'90)		Simulated head in 2010(upper)(masl) Head change since 1990(lower)(masl)			
			(north) (masl)	(south) (masl)	(north) (m)	(south) (m)	VLZ (masl)	CLC (masl)	MNL (masl)	CVC (masl)
(Scenario 1)	409.301 364.859	-39.653	-173.1 (VLZ)	-88.5 (CVC)	-83.1 (VLZ)	-57.4 (CVC)	-173.1 -83.1	-126.7 -51.1	-80.8 -26.7	-88.5 -57.4
a) The 1995's pumpage of Scenario 1 continues up to 2010.	394.039 349.597	-14.384	-130.2 (VLZ)	-74.2 (LPS)	-40.2 (VLZ)	-25.8 (ROS)	-130.2 -40.2	-102.1 -25.5	-63.7 -9.6	-47.5 -16.4
b) Regulated to the 1990's pumpage by 2000.	379.655 335.213	0.000	-102.7 (CLC)	-80.6 (LPS)	-9.7 (VLZ)	-18.7 (ROS)	-95.9 -5.9	-72.6 3.0	-45.2 8.9	-32.7 -1.6
c) Regulated to 90% of the 1990's pumpage by 2000.	369.857 325.415	9.798	-92.6 (CLC)	-76.4 (LPS)	14.7 (CLC)	12.8 (MNL)	-87.1 2.9	-65.6 10.0	-41.3 12.8	-29.9 1.2
d) Regulated to 80% of the 1990's pumpage by 2000.	360.060 315.618	19.595	-82.5 (CLC)	-72.2 (LPS)	24.8 (CLC)	16.7 (MNL)	-78.2 11.8	-58.3 17.3	-37.4 16.7	-27.1 4.0
e) Regulated to 70% of the 1990's pumpage by 2000.	350.260 305.818	29.393	-72.3 (CLC)	-68.0 (LPS)	35.0 (CLC)	20.5 (MNL)	-69.3 20.7	-51.1 24.5	-33.6 20.5	-24.3 6.8
f) Regulated to 60% of the 1990's pumpage by 2000.	340.462 296.020	39.190	-62.2 (CLC)	-63.8 (LPS)	45.1 (CLC)	24.4 (MNL)	-60.4 29.6	-43.9 31.7	-29.7 24.4	-21.5 9.6
g) Regulated to 50% of the 1990's pumpage by 2000.	330.653 286.211	48.988	-52.0 (CLC)	-59.6 (LPS)	55.3 (CLC)	30.7 (BCR)	-51.6 38.4	-36.7 38.9	-25.8 28.3	-18.7 12.4

BCR: Bacoor, CLC: Caloocan, CVC: Cavite, LPS: Las Piñas, MNL: Manila, ROS: Rosario, VLZ: Valenzuela

* The total discharge in entire Metro Manila is 339.611MCM in 1990, the dicharge in the modeled area is 316.572MCM in 1990.



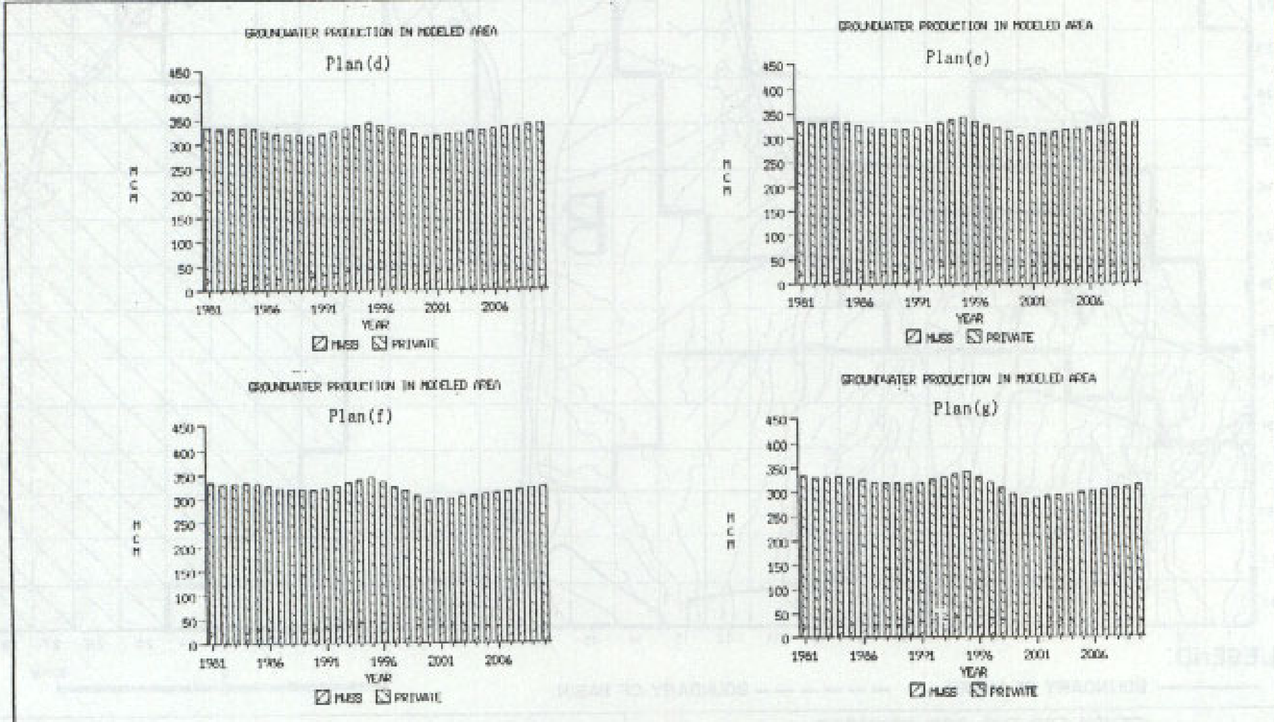
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 9.3.1 REGULATED AREA FOR GROUNDWATER PUMPAGE



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

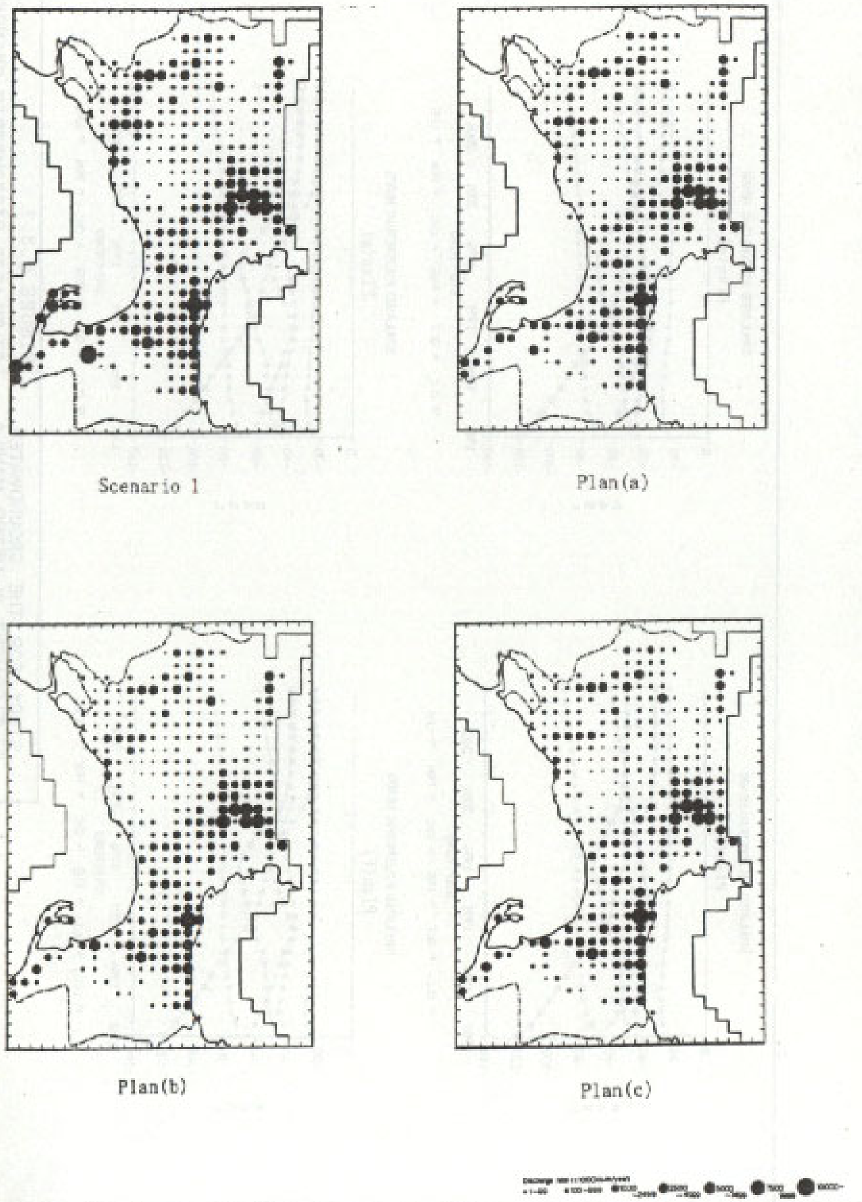
FIGURE 9.3.2
YEARLY DISCHARGE OF FUTURE PLANS (1)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

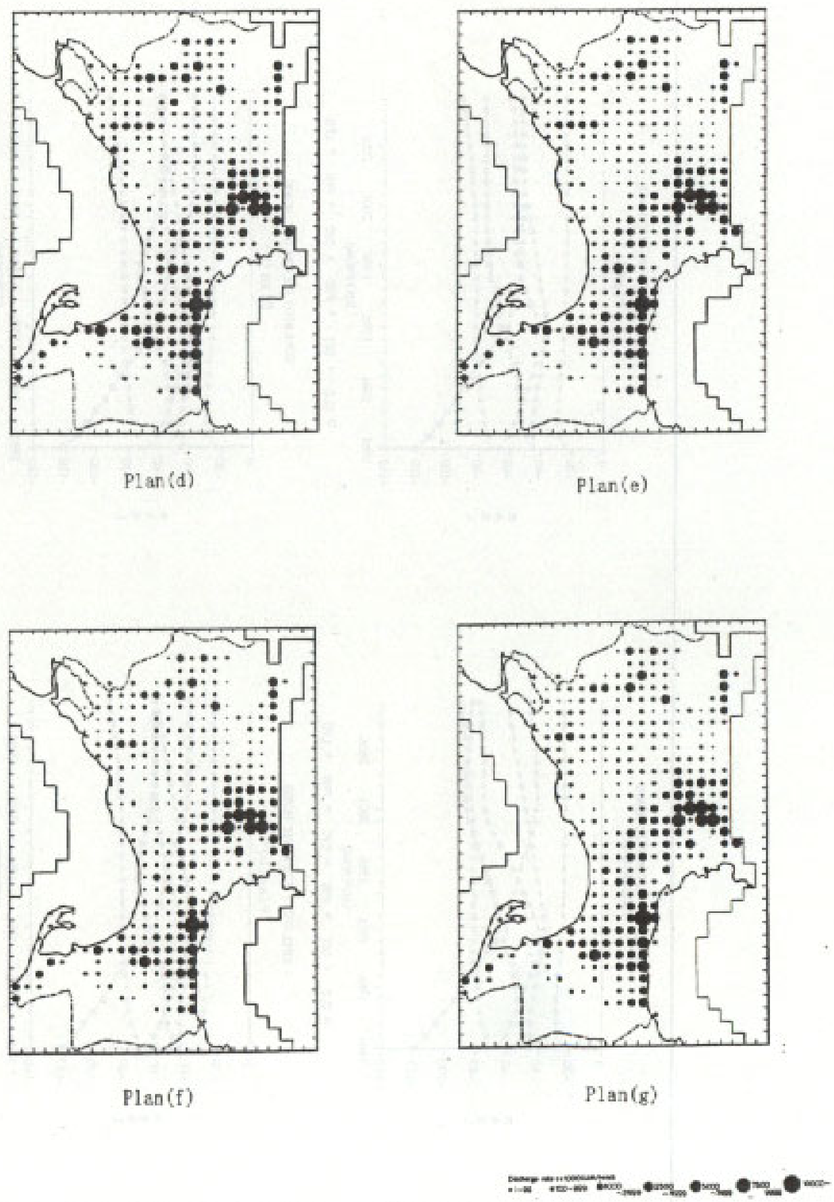
FIGURE 9.3.3
YEARLY DISCHARGE OF FUTURE PLANS (2)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

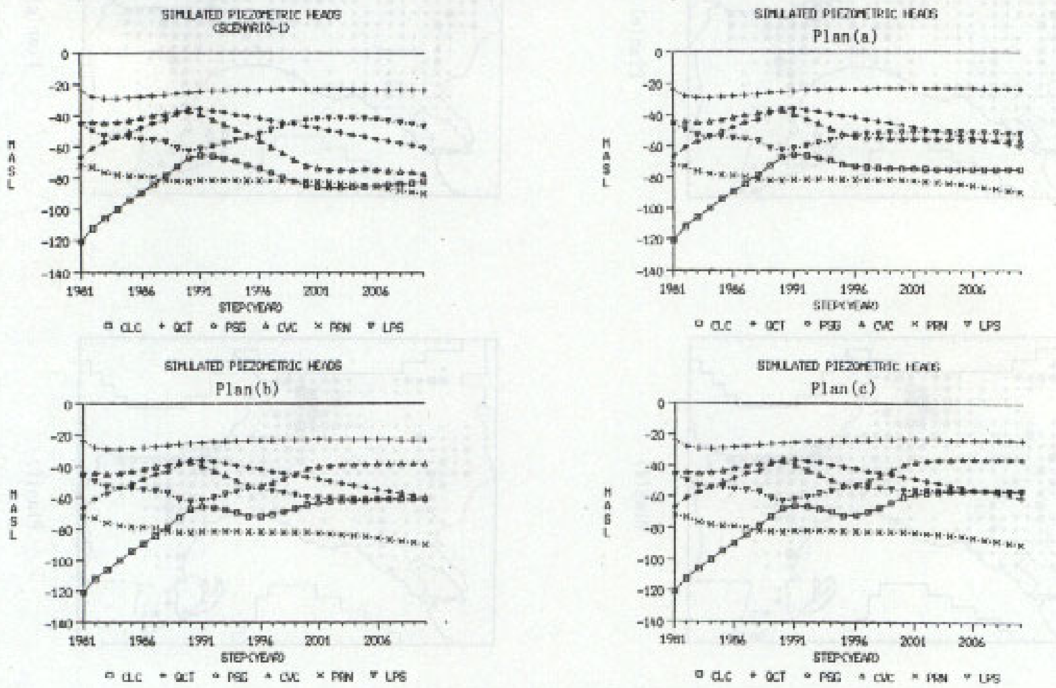
FIGURE 9.3.4
DISCHARGE DISTRIBUTION OF FUTURE PLANS IN 2010 (1)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9.3.5
DISCHARGE DISTRIBUTION OF FUTURE PLANS IN 2010 (2)

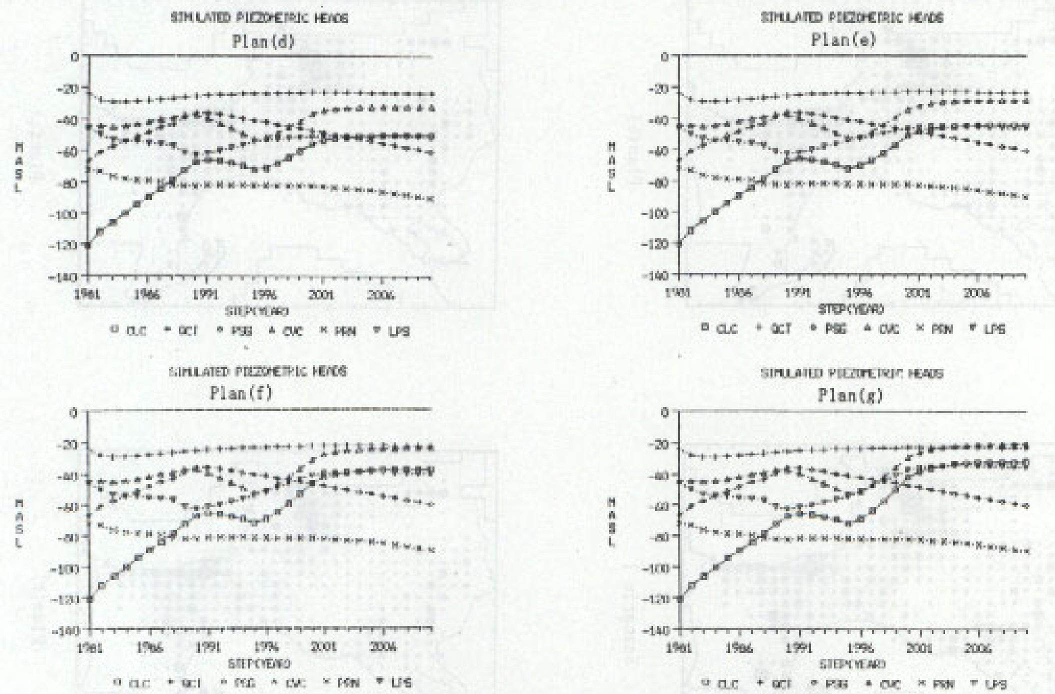


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9.3.6

SIMULATED PIEZOMETRIC CHANGES BY THE FUTURE DISCHARGE PLANS (1)

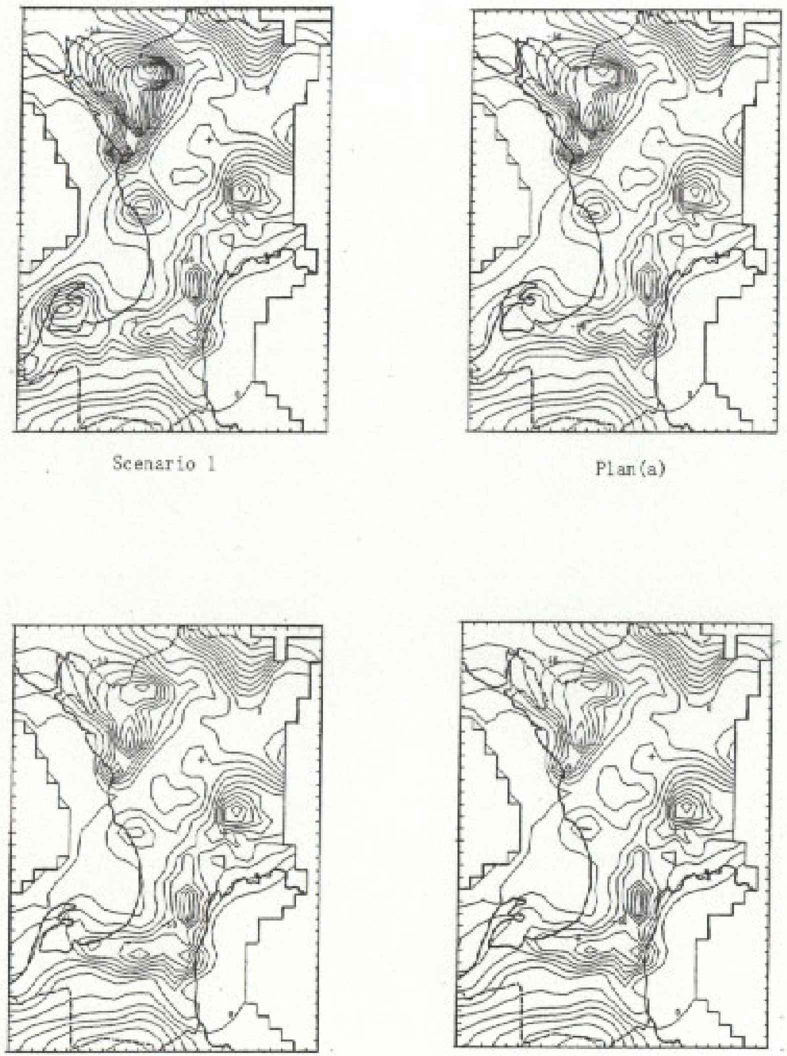


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9.3.7

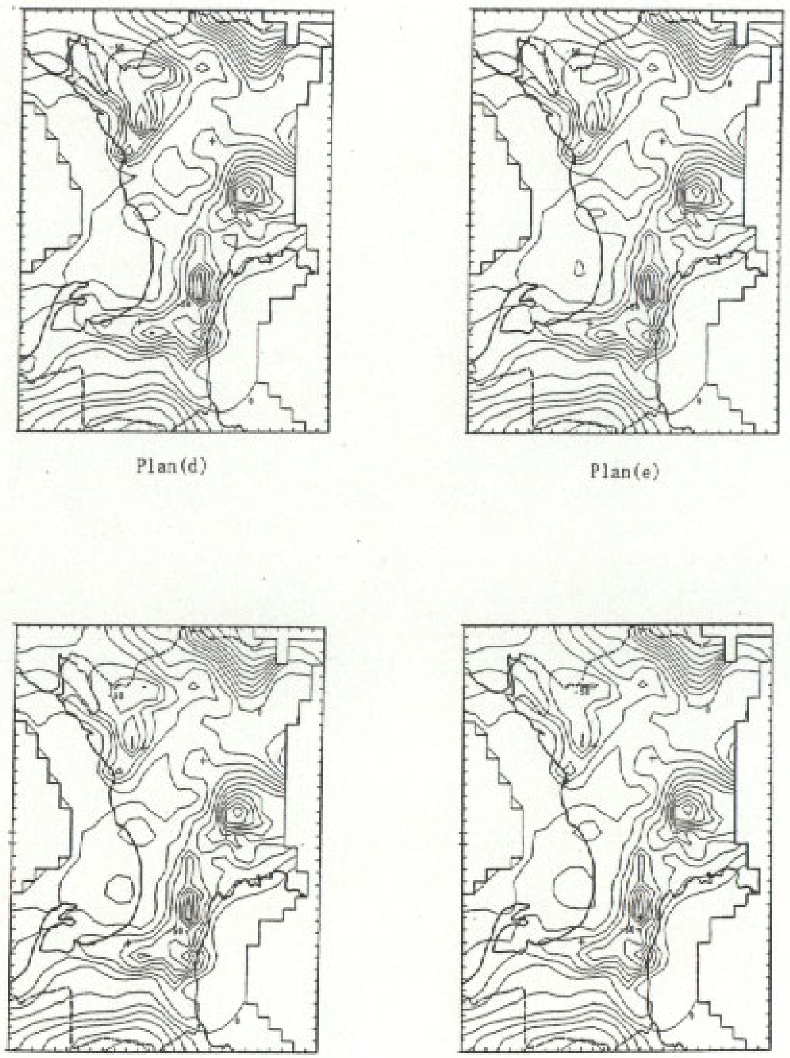
SIMULATED PIEZOMETRIC CHANGES BY THE FUTURE DISCHARGE PLANS (2)



Scenario 1 Plan(a) Plan(b) Plan(c)

(Contour Interval: 10m, Unit: masl)

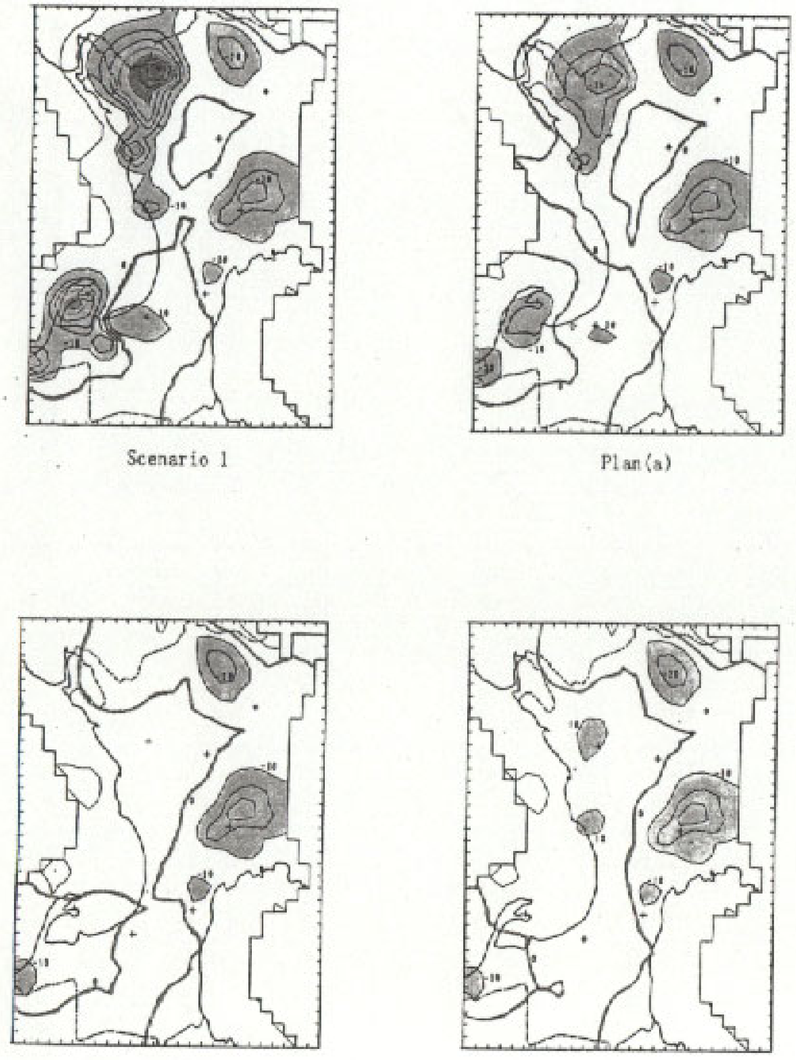
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.3.8
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC HEADS IN 2010 BY THE FUTURE DISCHARGE PLANS (1)



Plan(d) Plan(e) Plan(f) Plan(g)

(Contour Interval: 10m, Unit: masl)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.3.9
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC HEADS IN 2010 BY THE FUTURE DISCHARGE PLANS (2)



Scenario 1 | Plan(a) | Plan(b) | Plan(c)

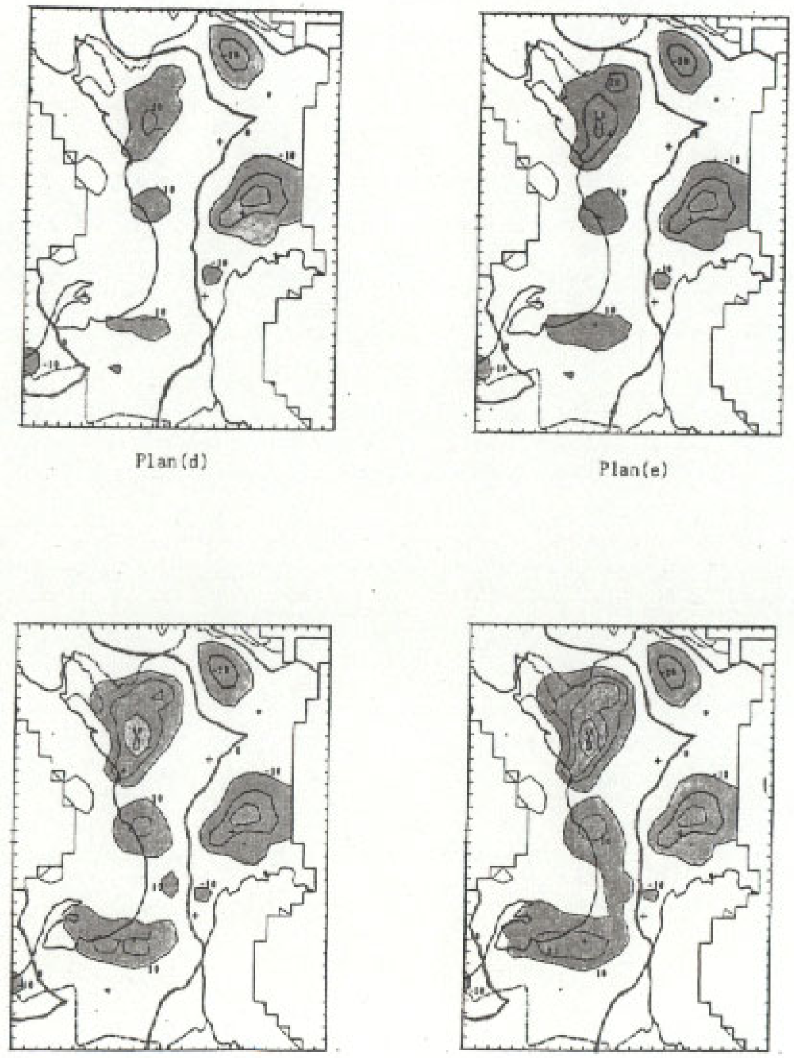
(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9.3.10

SIMULATED PIEZOMETRIC CHANGES FROM 1991 TO 2010 BY THE FUTURE DISCHARGE PLANS (1)



Plan(d) | Plan(e) | Plan(f) | Plan(g)

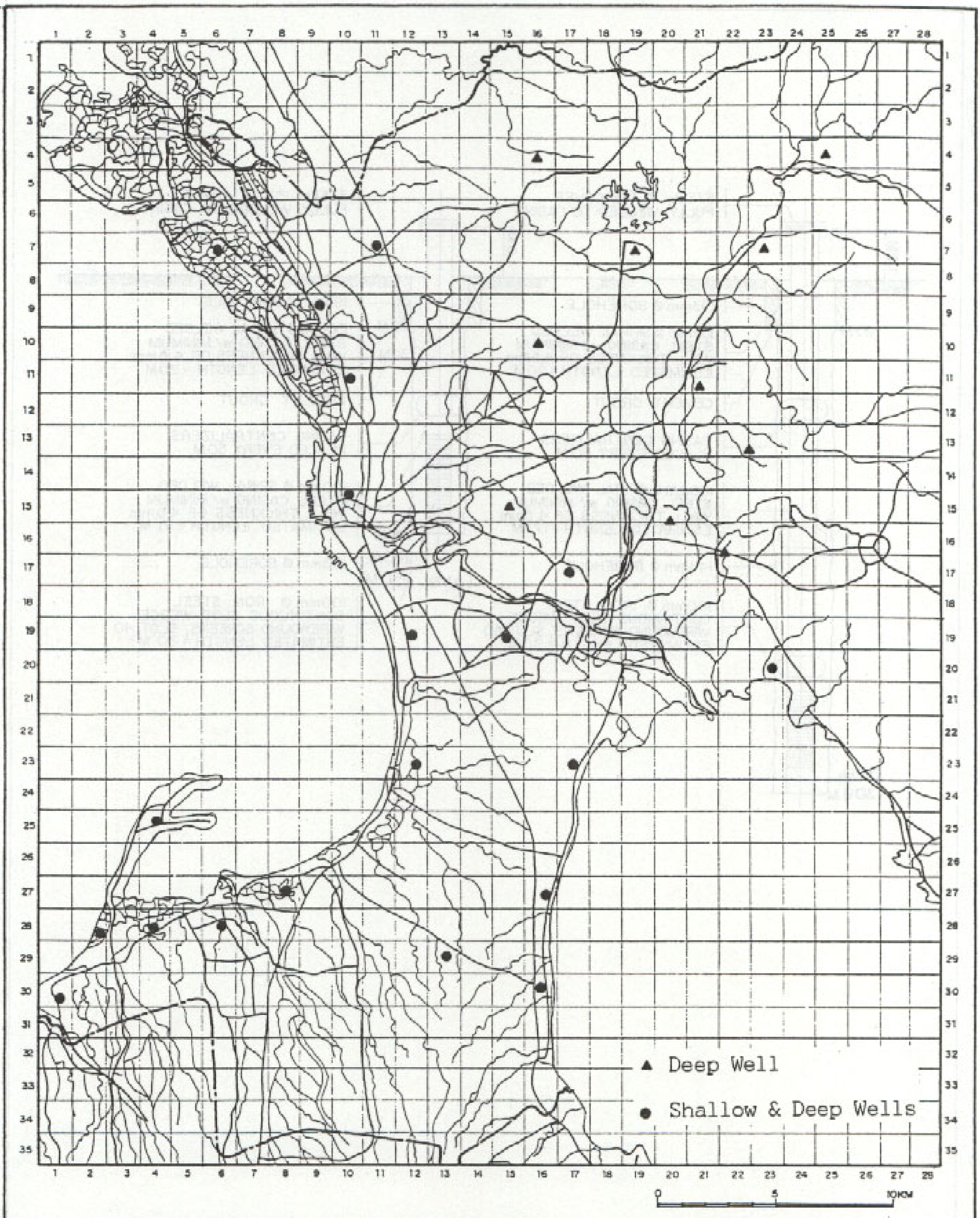
(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

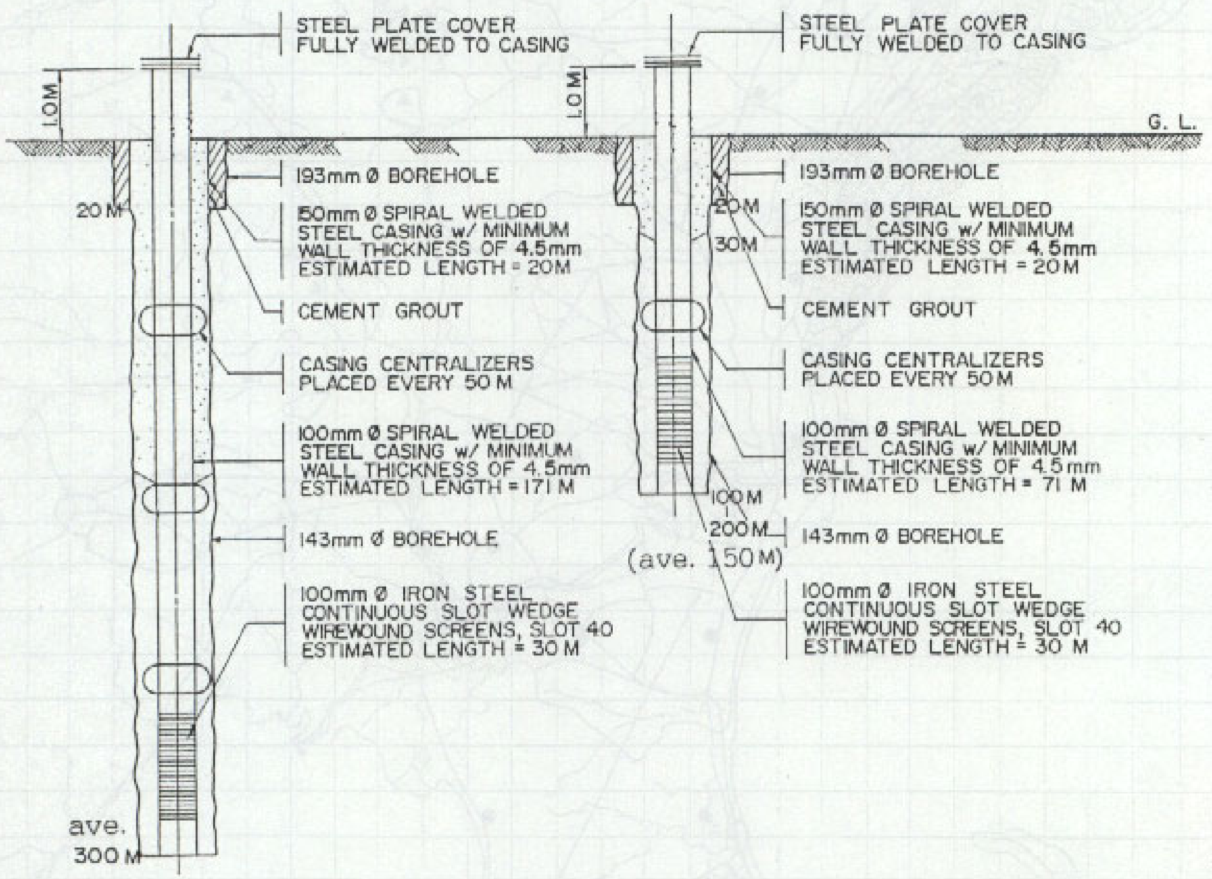
JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9.3.11

SIMULATED PIEZOMETRIC CHANGES FROM 1991 TO 2010 BY THE FUTURE DISCHARGE PLANS (2)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.5.1
JAPAN INTERNATIONAL COOPERATION AGENCY	LOCATION MAP OF PLANNED MONITORING WELLS



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.5.2
JAPAN INTERNATIONAL COOPERATION AGENCY	PROVISIONAL DESIGN OF MONITORING WELLS

CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS

10.1 CONCLUSIONS

10.1.1 Rehabilitation of MWSS Wells

MWSS wells were in most cases damaged by superannuation, defective pumping units and saline water intrusion. Of the 258 MWSS wells, 52 have already been abandoned.

The proposed rehabilitation plan calls for the rehabilitation of 100 MWSS wells whose primary damage was caused by defective pumping units. Particular importance is attached to the augmentation of pumpage in areas where groundwater is the only reliable water source.

As a result of rehabilitation, an increment of 27,000 CMD of pumpage is expected. The allocation of this increment however should be made in accordance with the tentative permissive yield. The plan will cost about 53 million pesos.

10.1.2 Groundwater Development in Antipolo

The subject area of groundwater development is the small groundwater basin constituted by the Antipolo area forming an isolated plateau at elevation of 200m plus.

Based on hydrogeologic surveys and computer simulations, said basin could yield an optimum of 28,000 CMD of groundwater. Since existing wells presently abstract groundwater at a volume of about 20,000 CMD, the exploitable volume therefore is 8,000 CMD. About 2,000 CMD of this exploitable volume would be accounted for by the increment in pumpage of rehabilitated MWSS wells. The remaining 6,000 CMD is to be tapped by the seven (7) new deepwells proposed to be constructed, as discussed elsewhere in this report.

The construction cost of the proposed new wells is about 14.7 million pesos.

It is further recommended that the plan for the transmission of surface water from the CDS to the Antipolo area be implemented. Although the groundwater supply can meet the water demand in the area in daily average base for about ten years, this supply would be critical come the year 2000. It is also necessary that the construction of new private wells be regulated and, as the basin is narrow and the recharge is limited, that groundwater level and quality be monitored to prevent the decline and deterioration of the groundwater resource.

10.1.3 Saline Water Intrusion Mechanism

The mechanism of saline water intrusion in the Las Piñas area was investigated through detailed hydrogeologic surveys and computer simulations. The investigation revealed the shallow aquifers in the area within 2km from the coastline, at depths less than 100m, to be extensively contaminated by saline water. This saline water migrates towards deeper aquifers at depths of more than 200m. Computer simulation results point to the Manila Bay and marine ponds along the coast to be origins of the saline water path. The saline water intrudes, moves and diffuses inland towards areas of depression of the piezometric head. Tidal rivers and salt beds were also identified as significant sources of saline water.

If pumpage is further increased in the near future, the contamination of the deeper aquifers at depths of more than 300m would likely result.

10.1.4 Groundwater Monitoring in Metro Manila

The pumpage in the MSA would become 1,121 CMD in the year 2000 and 1,278 CMD in the year 2010 at the scenario 1, as results of the on-schedule completion of proposed and ongoing water supply projects. Under this scenario, a maximum decline of 83m from the present groundwater level is predicted to occur at the northwestern part of Metro Manila. To prevent the expansion of the saline water-intruded area, which would surely result from this decline, it is necessary that a tentative yield of the groundwater basin be set. This tentative yield should also make possible the year-round utilization of groundwater.

The tentative yield of the groundwater basin is the amount of pumpage that brings no unwanted effects, like saline water intrusion for instance. The groundwater management plan targets reducing pumpage to this tentative yield, reallocating it by area, step-by-step, and properly considering coverage of the substitutional water supply.

If the year-1990 pumpage is reduced by 50% in the coastal area--that is, 905,900 CMD for the whole basin--the results of simulation studies indicate that maximum recoveries of groundwater levels can be expected to occur at the northern and southern parts of Metro Manila, respectively at 55.3m and 30.7m. This reduced pumpage, for practical reasons, can be the tentative target yield of the groundwater management plan for the Study Area. It is noted, however, that even if saline water intrusion could still occur using this yield, it would take 15 years for saline water to reach the piezometric head depressions in southern Metro Manila. By that time, a more realistic target yield should have already been in place and the measures incorporated in the groundwater management plan are fully operational.

Monitoring of groundwater pumpage, groundwater levels and quality are requisites for effective implementation of the groundwater management plan, and for the more accurate setting of the target yield as well. The groundwater monitoring program proposed in this study is deemed to have the capability to achieve such purpose.

10.2 RECOMMENDATIONS

10.2.1 Groundwater Development

(1) Promotion of Rehabilitation Program

Considering the constraints against the early completion of the short and medium-term surface water supply projects, it is urgent that implementation of the rehabilitation project proceed at once so that the present groundwater supply may be augmented.

(2) Development and Conservation of Groundwater in Antipolo

Antipolo area is located on an isolated plateau with limited water resources. The anticipated increase of water demand in the future due to population growth makes it indispensable to develop groundwater for a short to medium term water supply. Since the groundwater basin is small and recharge is limited, groundwater development must be within the optimal yield estimated in this study. This proposal assumes that the development of private wells shall be regulated. However, this shall be further studied as an integral part of the overall groundwater management program for the whole Metro Manila.

(3) Groundwater Investigation in Rizal Province

Except for Angono, the current dependence on groundwater of the nine (9) municipalities of Rizal Province under BP 799 shall continue in the future. These municipalities located along the northern and eastern coasts of Laguna de Bay will be developed in the future to constitute the eastern corridor of Metro Manila. But as the hydrogeology of the Guadalupe Formation in this area is not investigated yet, the possibility of groundwater development is still vague. Accordingly, it is recommended that a detailed hydrogeologic study of the area be carried out in order to clarify its groundwater potential.

Plans and projects proposed in the Study are summarized in Table 10.2.1. The earliest implementation of these projects is strongly recommended.

10.2.2 Groundwater Monitoring

(1) Monitoring of Groundwater Levels and Quality

A monitoring system is vital to the plan for the management of groundwater resources. A groundwater management system using computer simulation requires accurate groundwater data which are obtained by means of periodic observation of groundwater levels and quality. It is therefore recommended that the observation of JICA test wells in Las Piñas be continued and the proposed monitoring wells be constructed soonest.

(2) Application of the Database System

The database system established in MWSS processes meteorological and hydrological data, groundwater levels, water quality data, well inventory, etc. Groundwater data of Metro Manila must be stored continuously in the future. In particular, the MWSS well inventory together with those of other agencies like NWRB and LWUA must be used and operated jointly as a common database.

(3) Improvement and Application of Groundwater Simulation Models

Groundwater simulation models established in MWSS must be improved in the future. The accurancy and reliability of the models can be improved through clarification of the hydrogeology of the area, submission by users of their record of groundwater pumping, collection and analysis of more accurate aquifer parameters, observation of groundwater levels and quality, and so forth.

Jointly with the groundwater database system and the groundwater monitoring system, groundwater models shall be applied as tools in groundwater management; specifically, in assessing and predicting groundwater levels and quality and in evaluating the permissive yield of the basin.

(4) Regional Leveling

No clear evidence of the land subsidence phenomenon in Metro Manila has been found. However, based on the records of the tidal gauging station, the mean sea level of Manila Bay appears to have risen in the past 25 years. In order to clarify whether the rise of the mean sea level was due to vertical displacements of land, it is necessary to temporarily place an immovable point in a nearby mountainous area that is composed of base rocks and use such point to conduct periodic levelings of existing and newly constructed benchmarks.

10.2.3 Groundwater Management

In order that groundwater may be used as a perennial water source in Metro Manila, it is necessary that the present chaotic groundwater development situation in the area be righted without any further delay. In this sense, the implementation of the proposed groundwater management plan is strongly recommended. Since the details of this plan have already been described in the previous chapters, several recommendations can be summarized as follows:

(1) **Establishing Groundwater Management Committee**

Tasked to implement groundwater management in Metro Manila, the NWRB is recommended to establish a groundwater management committee within its organization. The committee shall deal with institutional and legal measures, socio-economic assessment, analysis and evaluation of groundwater data, revision of groundwater management policies in cooperation with other concerned government agencies.

(2) **Arrangement of Legislation**

The groundwater management plan necessitates the regulation of pumpage in the future . Prior to actual pumpage regulation, the practical application of the Philippine Water Code to this contemplated regulation and the enforcement of the water code itself must first be thoroughly studied.

It is considered that the water code is basically applicable to the regulation of pumpage. However, studies on the practical rules and regulations regarding the designation of areas where pumpage is to be regulated, the purpose of groundwater use, the facilities for abstracting groundwater, the standard physical measurements of the facilities in a certain designated area for water rights application, the reporting of pumpage in terms quantity and quality and groundwater levels by the users, the measures to be taken during the moratorium, the penalties to be imposed, etc., should be undertaken as a preparatory program for groundwater management.

The present water code requires the groundwater users to secure water permits, except users of shallow well for domestic purpose. Measurement and reporting of groundwater levels and pumping rate are now being neglected by the users. Prior to the proposed regulation therefore, each groundwater user must be required to install a water meter and to periodically measure the groundwater level before issuing a new water right or renewing existing water permit. This requirement is considered to be feasible by a slight amendment of the present implementing rules and regulations of the water code.

(3) Organization

The Groundwater Monitoring Unit (GMU) belonging to the Planning and Programming Department (PPD) of MWSS is tasked to conduct the investigation, observation, analysis and evaluation of groundwater in the MSA. Aside from this, as MWSS is deputized by NWRB to investigate and assess the water permit applications within the MSA, GMU does the studies and recommends the allowable groundwater pumpage. Considering the importance of the role of GMU in groundwater development and management in the MSA, the strengthening of its organization by elevation of its organizational level and increasing its manpower is necessary.

In addition, GMU shall be positioned as a technical task force in the groundwater management committee for Metro Manila in the observation, monitoring, analysis and evaluation of groundwater data.

(4) Education and Training of Groundwater Engineers

It is urgent to train groundwater engineers in order to strengthen or support the organization that shall implement the proposed groundwater management program. Government agencies such as MWSS, DPWH, LWUA, and NIA must cooperate with each other and transfer their engineers to said organization. Groundwater development and management have their own comprehensive technology, and the component technology alone is already extensive. Thus vast knowledge and experience are essential. These engineers shall participate in on-the-job training in groundwater projects, training in developed countries, groundwater seminars, etc.

10.2.4 Concluding Observations

Two final observations are offered with respect to the rational use and sustained adequacy of water supply in Metro Manila. First, additional attention should be devoted on the establishment of policies on groundwater development and management. Progress in this regard can be achieved if the present concerned offices are able to integrate their responsibilities and operations. Second, significant emphasis should be placed on water supply projects which answer in a fundamental way the progressively increasing water demand in the metropolis. The implementation of the Manila Water Supply Project III (MWSP III), for instance, should be vigorously pursued. It would also substantially ease the strain on groundwater resources.

TABLE 10.2.1 SUMMARY OF GROUNDWATER DEVELOPMENT AND MANAGEMENT PROGRAM

Program	Outline	Cost x1,000 peso	Duration months
1. Rehabilitation of MWSS Wells	Rehabilitation of 100 wells in MWSS	53,000	16.0
2. Groundwater Development in Antipolo	7 deep wells (depth:150m, dia.:8") Development of 5,800 m3/day	48,320	16.0
3. Groundwater Monitoring in Metro Manila	Monitoring wells:20 units of 150m well 30 units of 300m well Recording units & Computers	72,050	36.0
4. Groundwater Investigation in Rizal Province	Detailed hydrogeologic survey	25,000	12.0
Total		198,370	

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