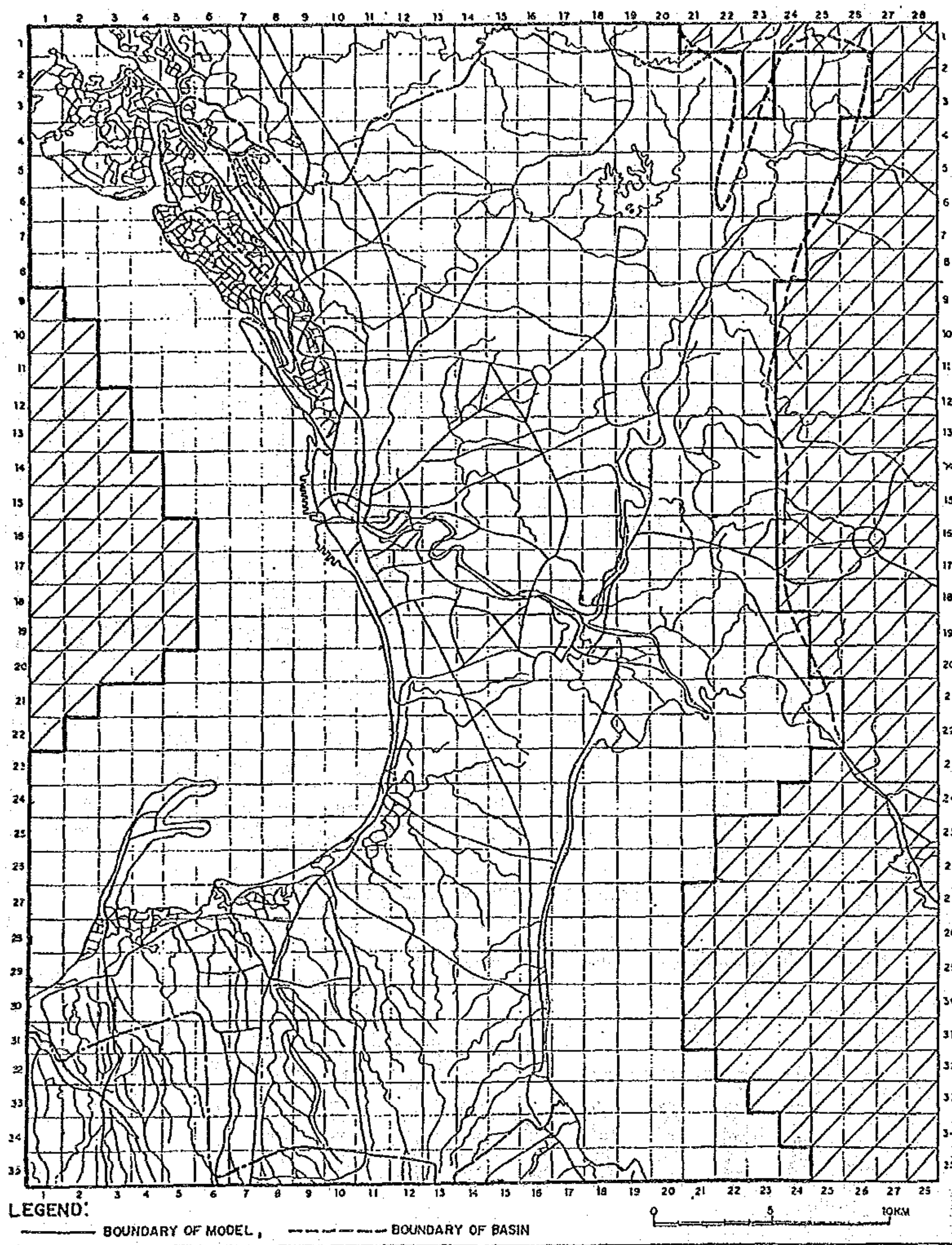
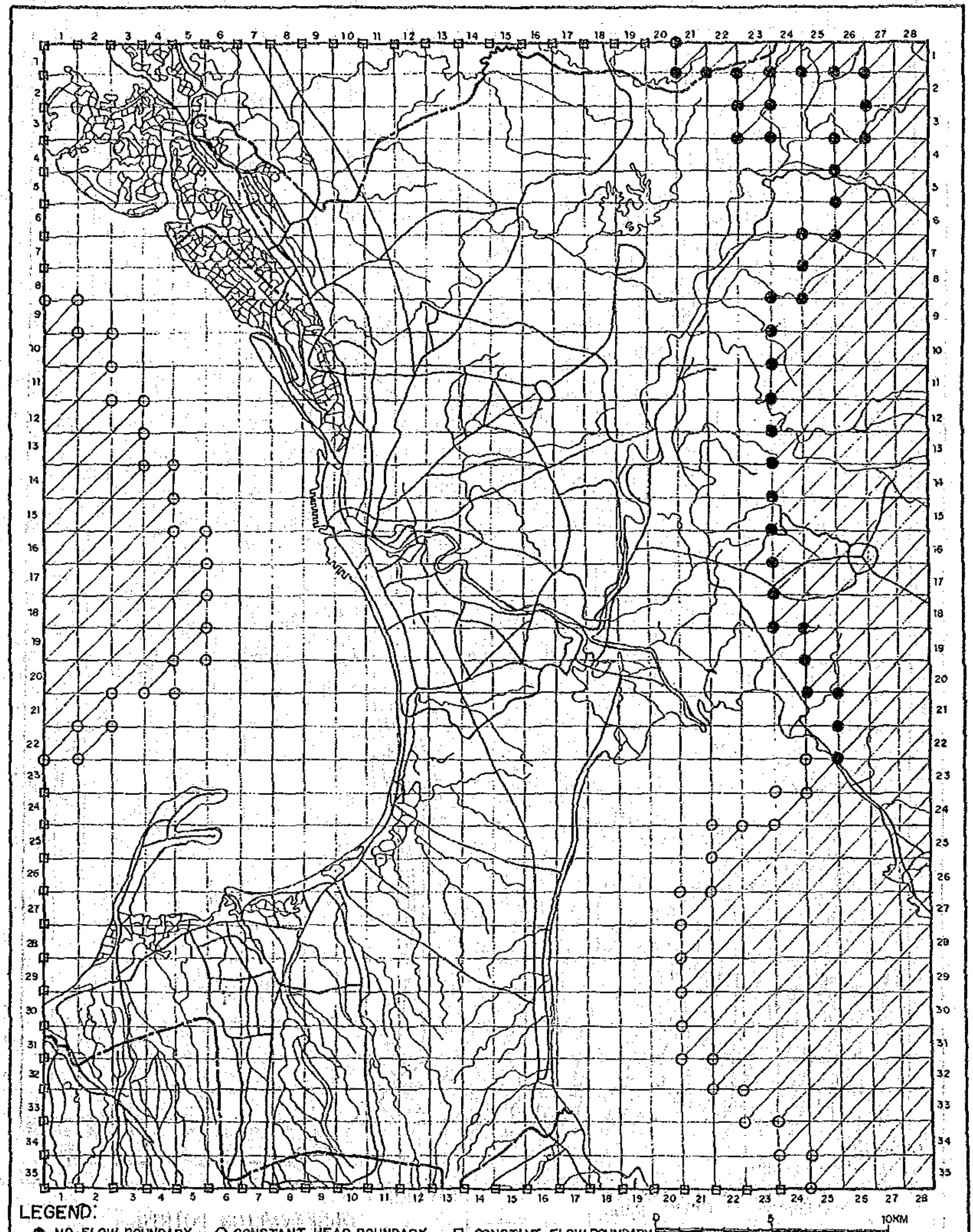


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.1
FINITE-ELEMENT GRID USED TO MODEL THE METRO MANILA BASIN

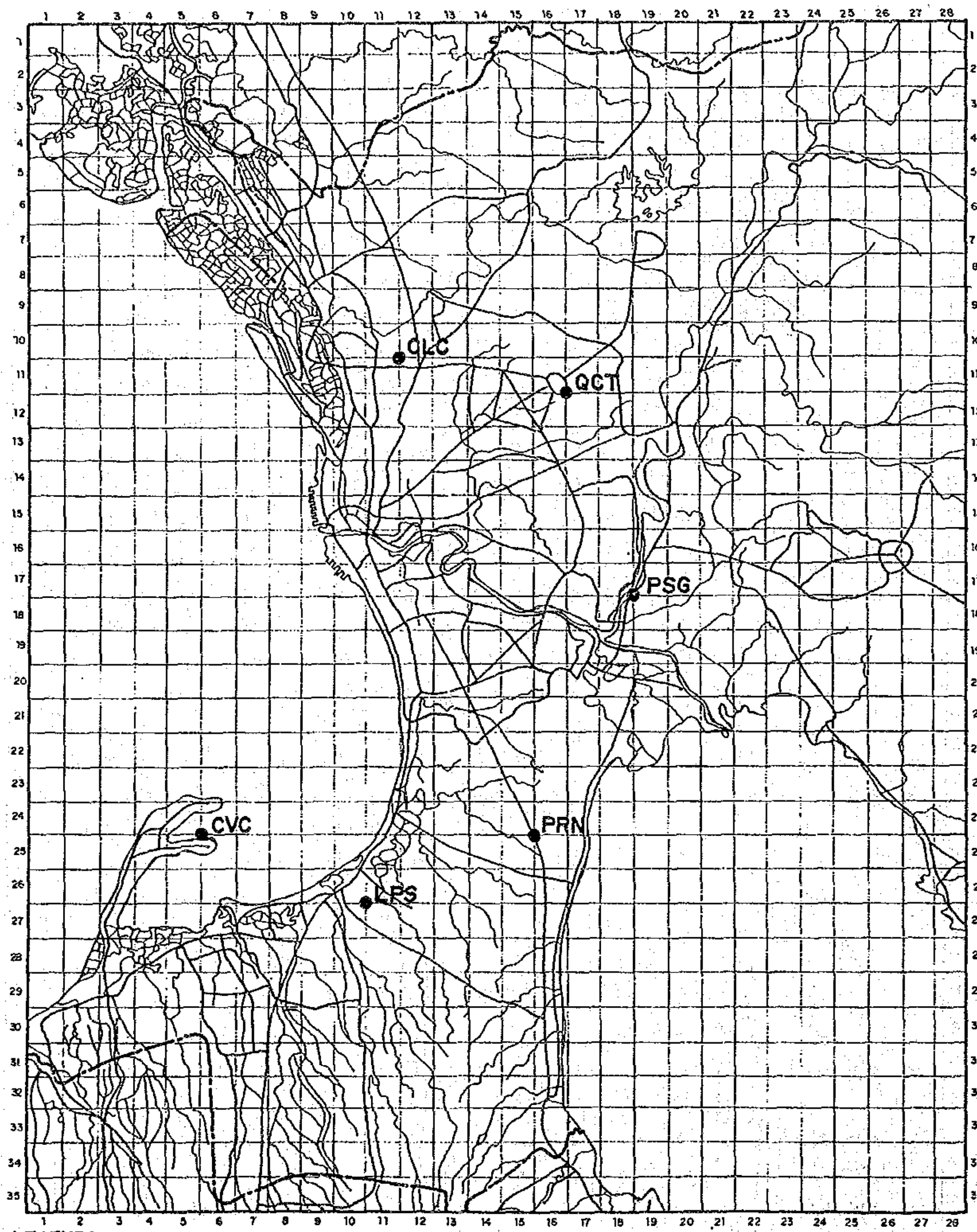


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.2

BOUNDARY CONDITIONS FOR THE METRO MANILA GROUNDWATER BASIN MODEL

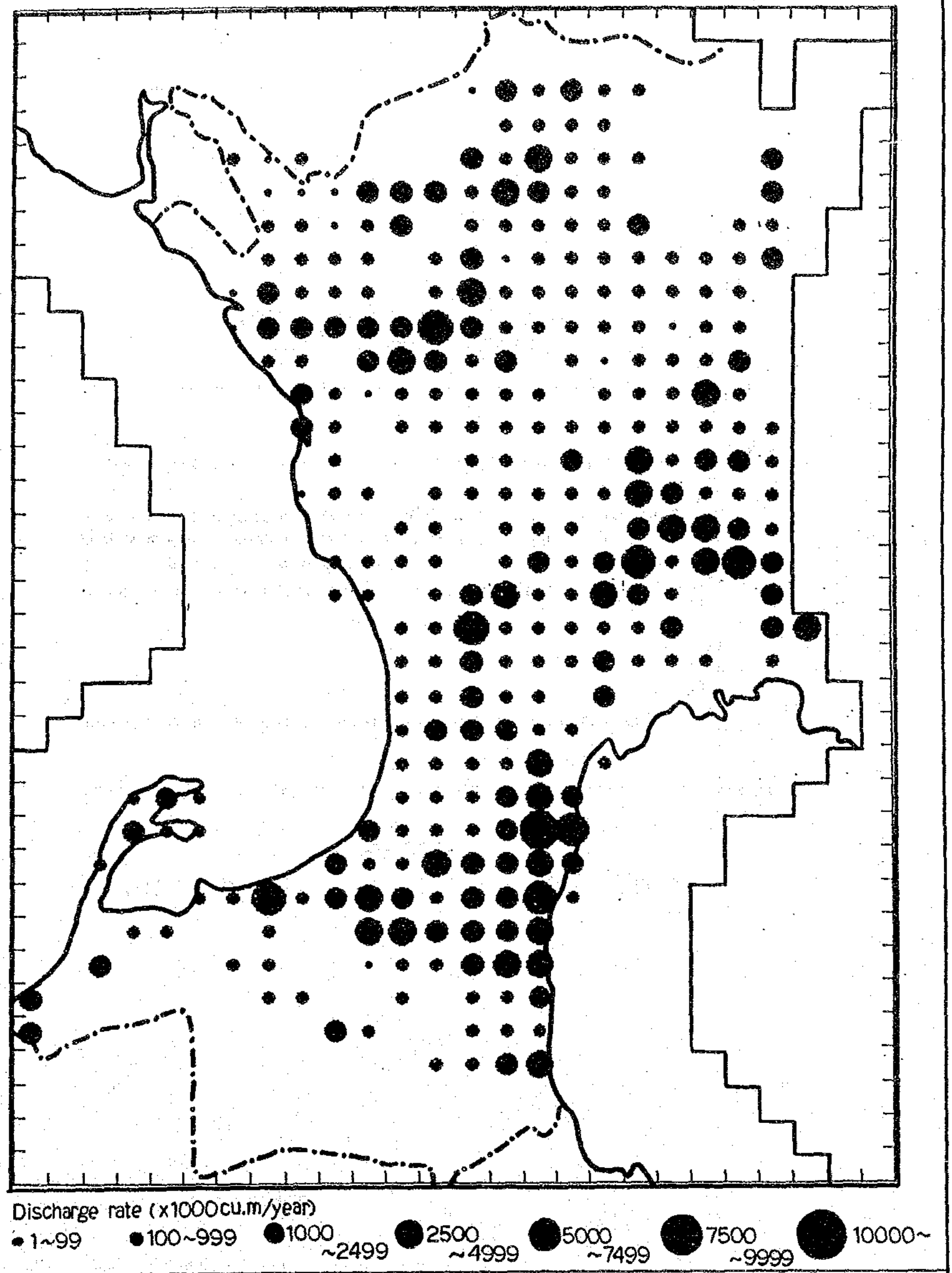


LEGEND:

● OBSERVATION POINT

0 5 10KM

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 7.3.3 OBSERVATION POINTS

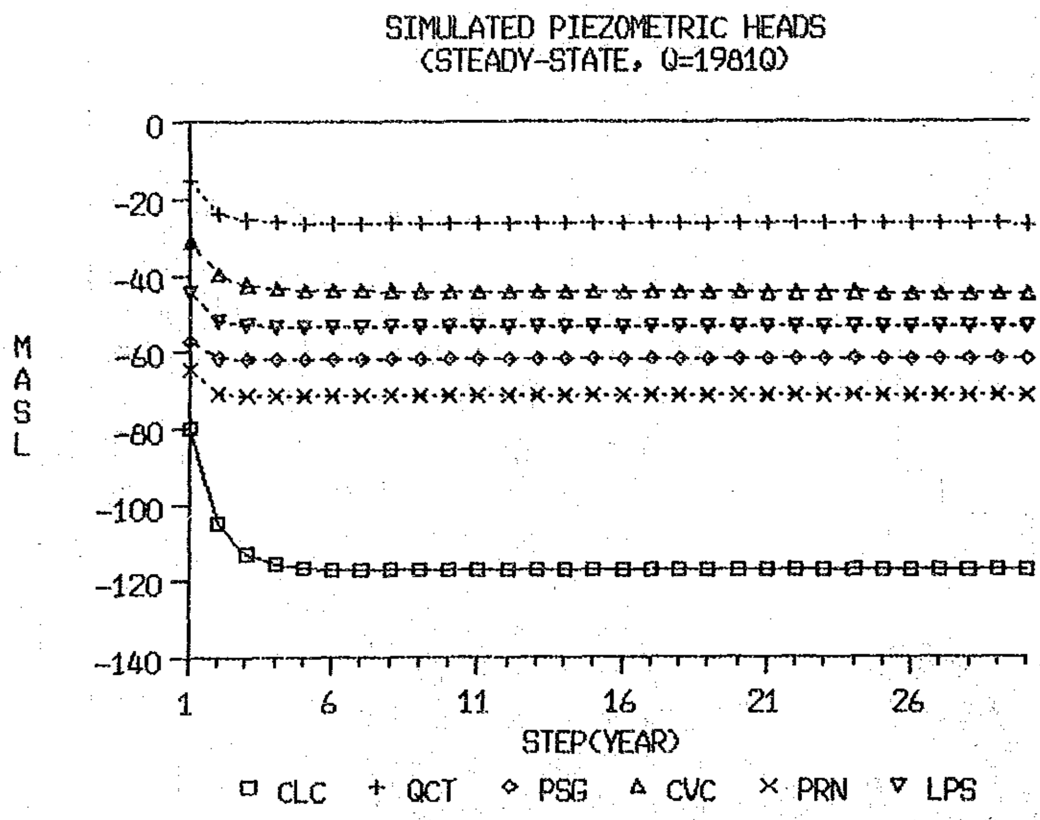


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

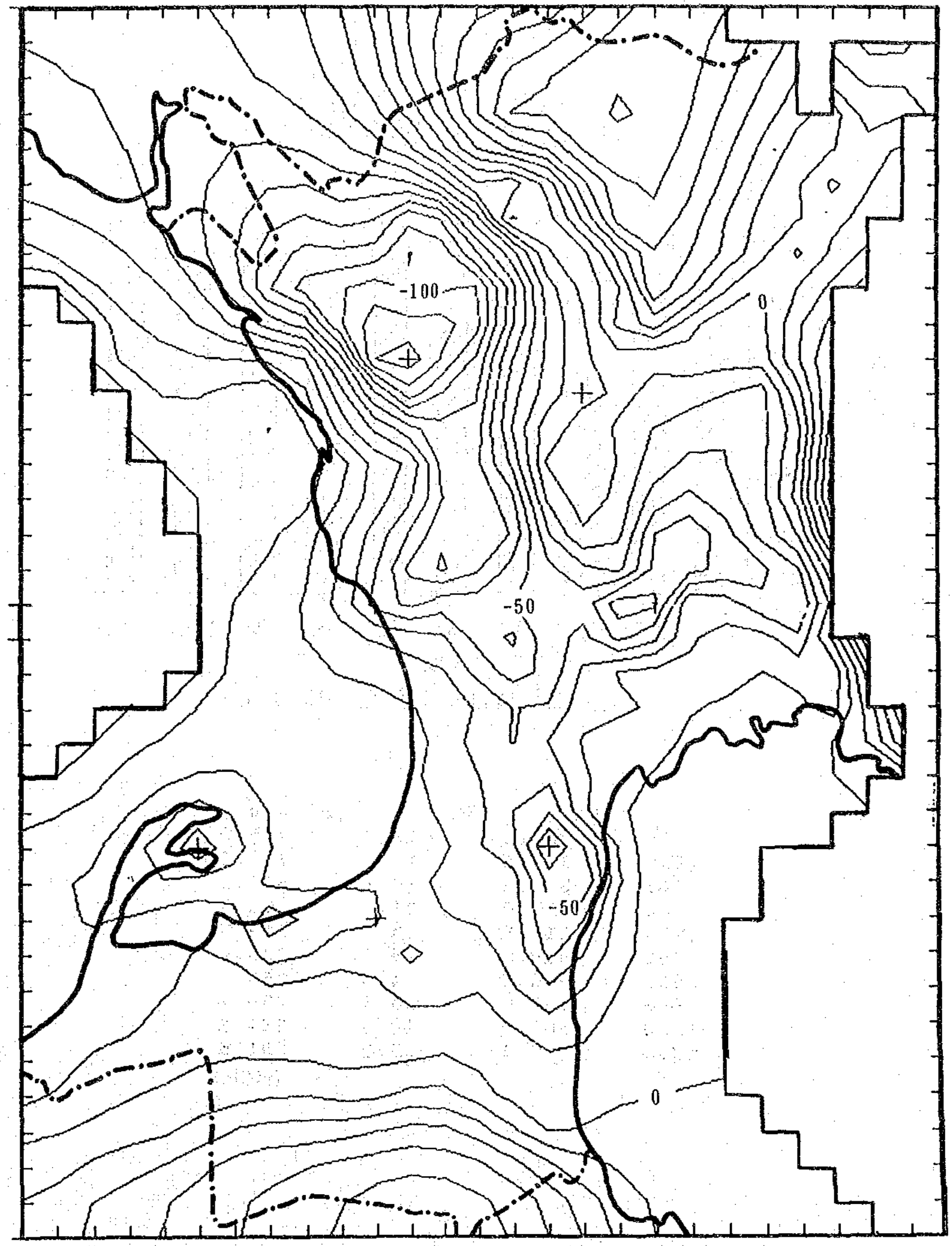
JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.4

DISCHARGE DISTRIBUTION IN 1981



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.5
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC HEADS (30-STEP STEADY-STATE CALUCULATION)



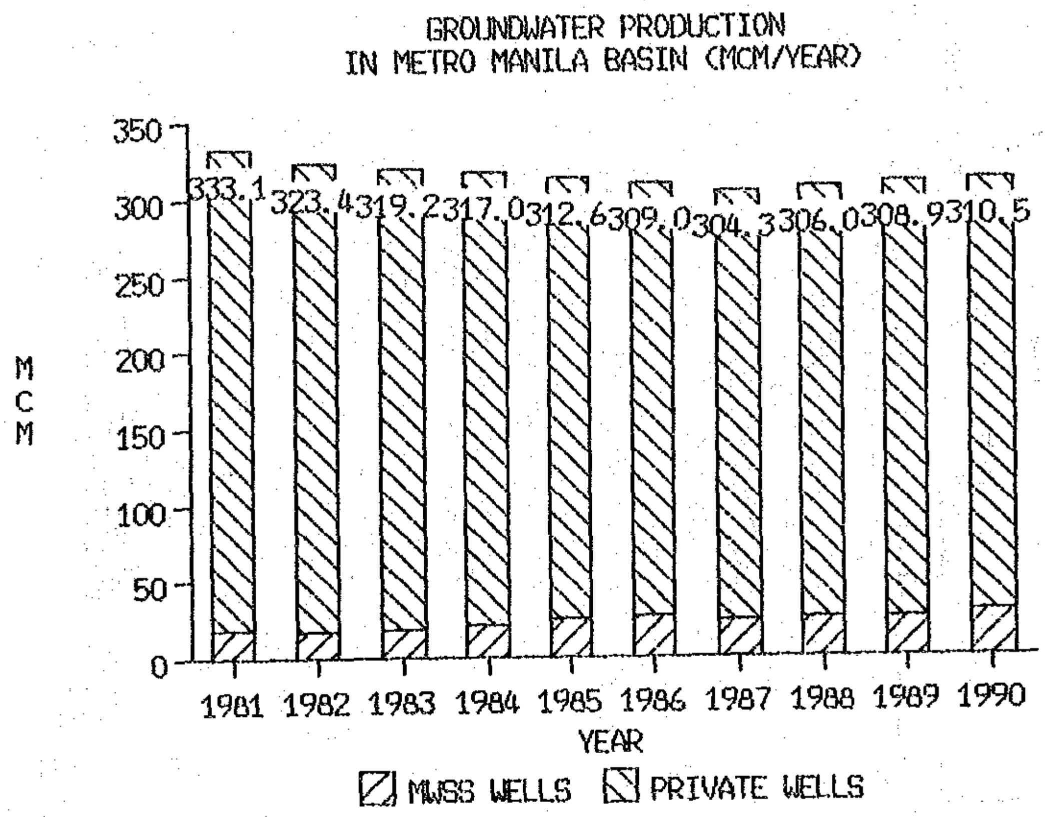
(Contour Interval: 10m, Unit: masl)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.6

SIMULATED PIEZOMETRIC HEADS IN 1981



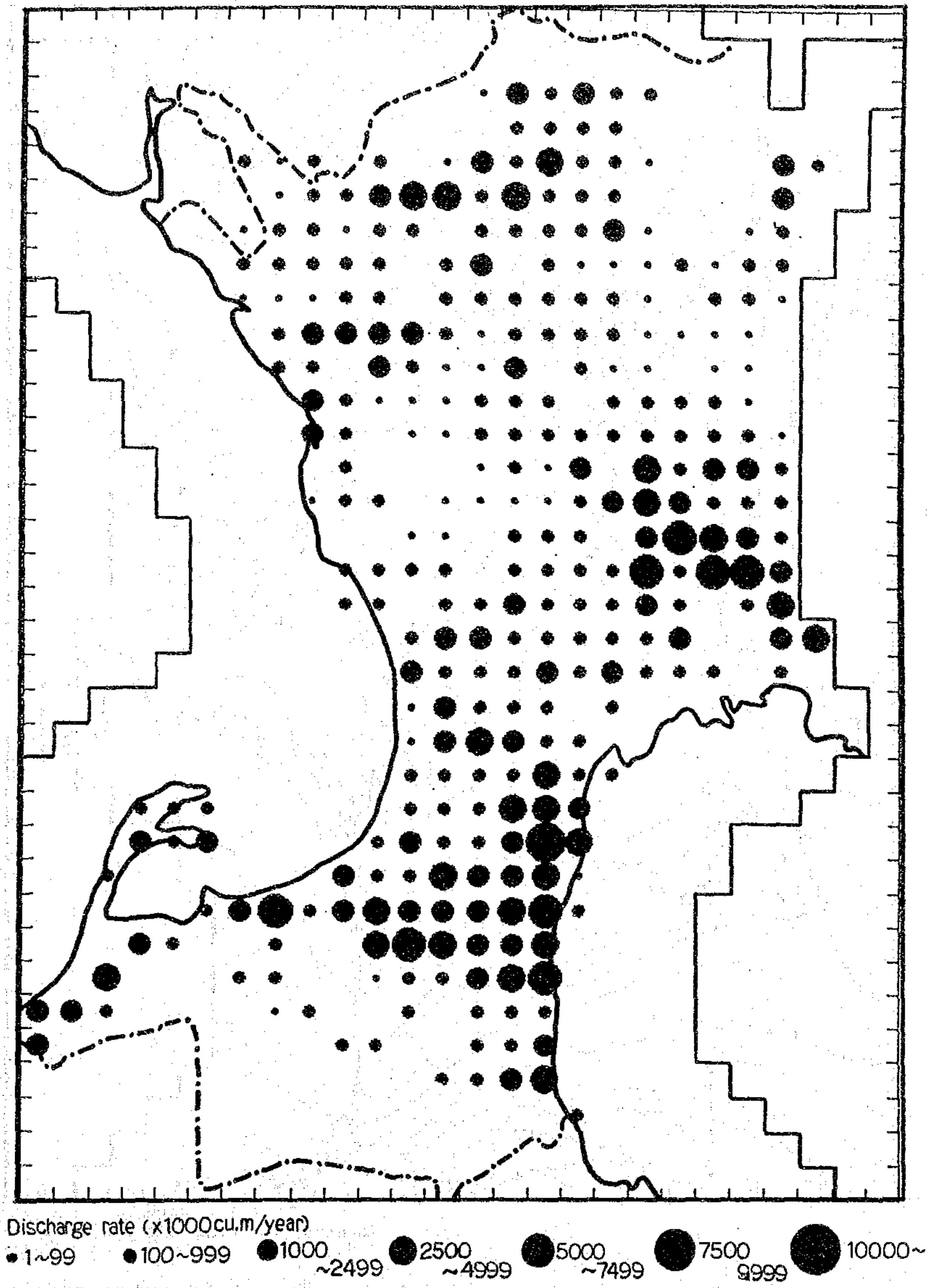
	Total	MWSS	Private
1981	333.1	18.2	315.0
1982	323.4	17.6	305.8
1983	319.2	18.1	301.1
1984	317.0	21.9	295.2
1985	312.6	25.1	287.5
1986	309.0	26.0	283.0
1987	304.3	24.3	280.0
1988	306.0	25.3	280.7
1989	308.9	24.7	284.2
1990	310.5	29.0	281.5

(MCM)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.7 GROUNDWATER PRODUCTION IN THE METRO MANILA BASIN

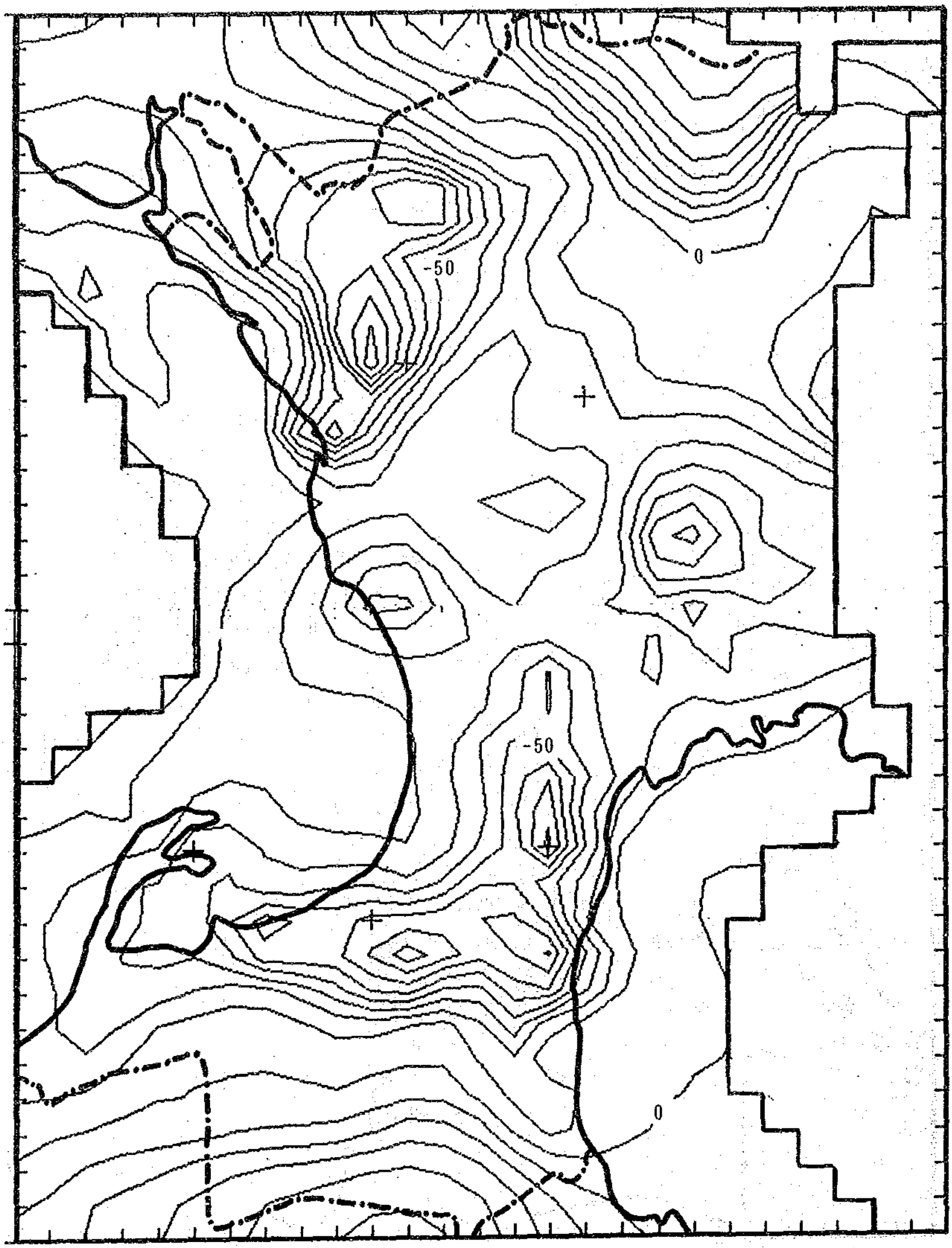


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

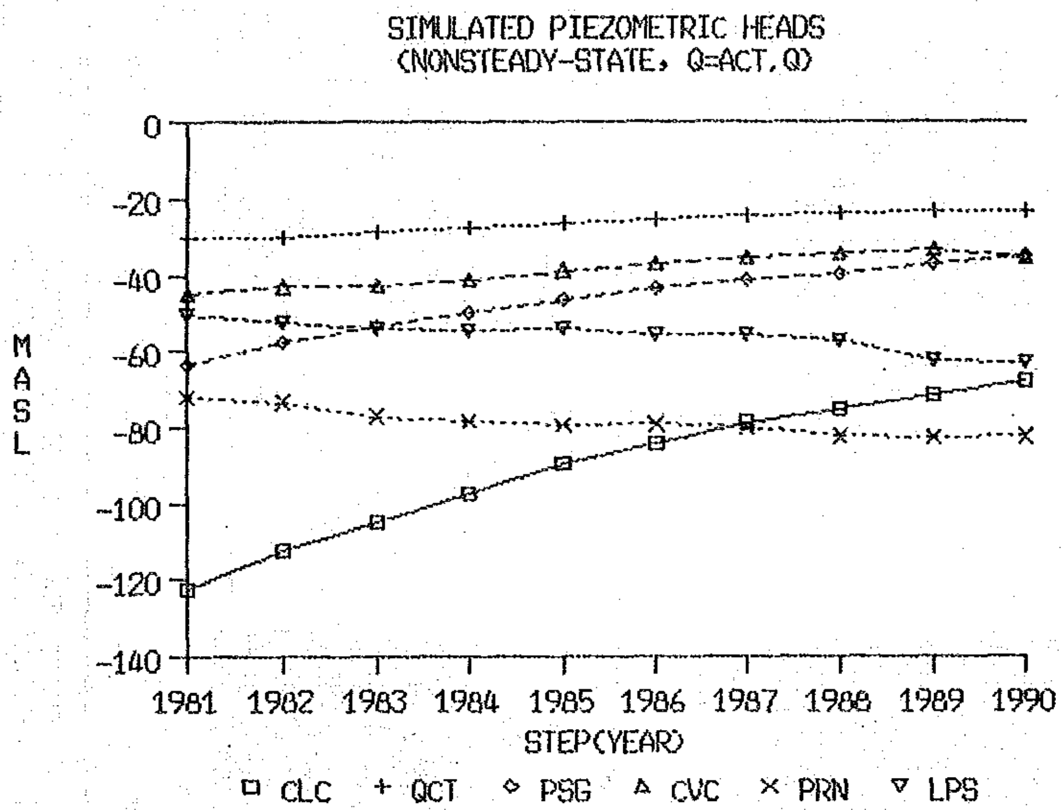
FIGURE 7.3.8

DISCHARGE DISTRIBUTION IN 1990

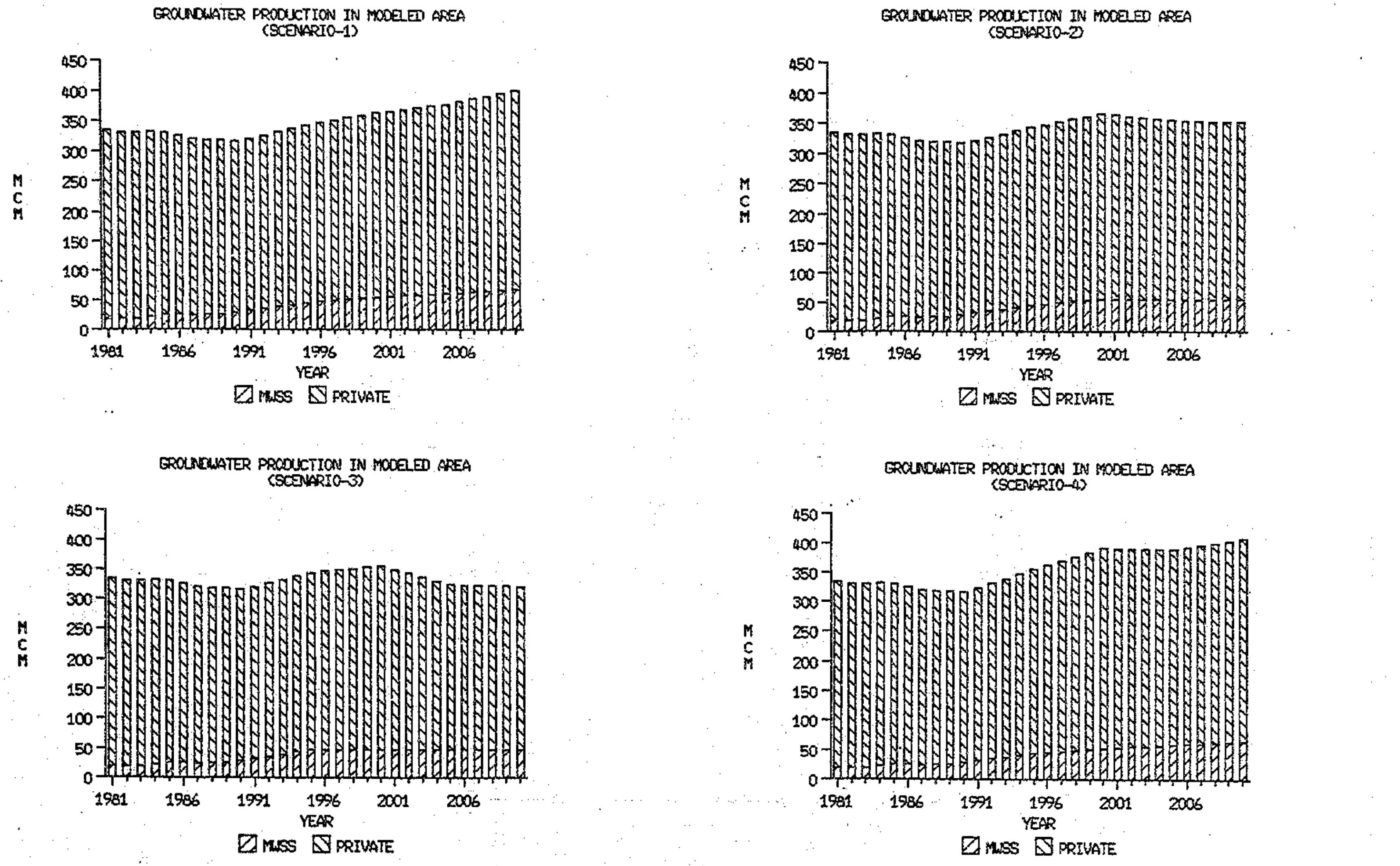


(Contour Interval: 10m, Unit: masl)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.9
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC HEADS IN 1990



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.10
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC HEADS BY NONSTEADY-STATE CALCULATION

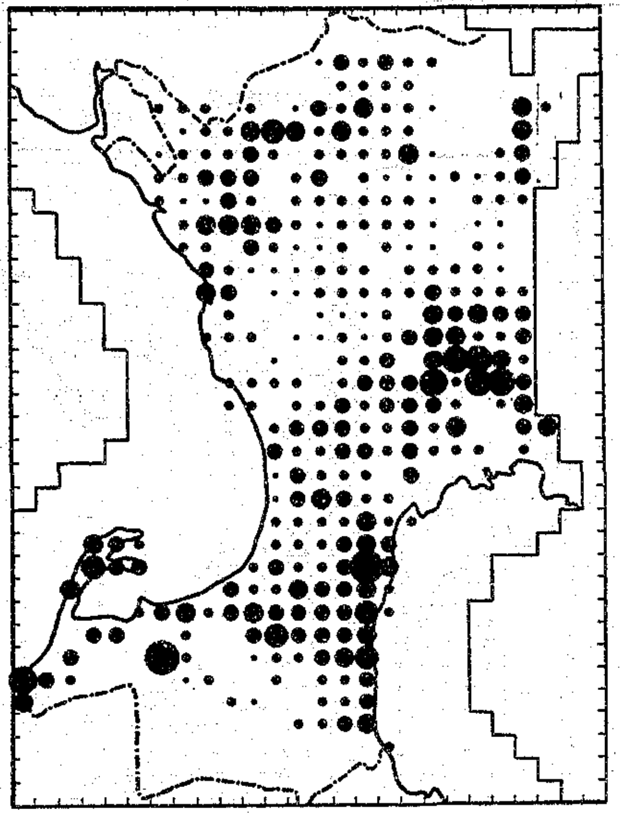


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

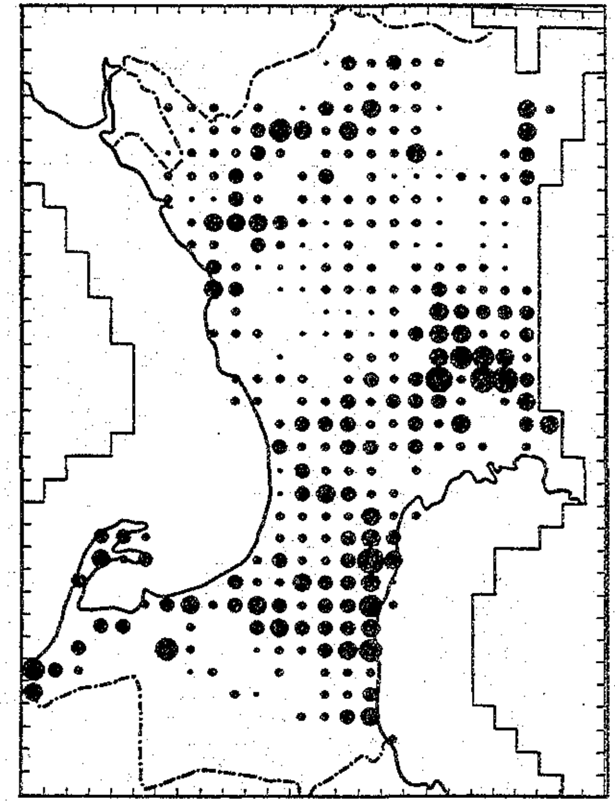
JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.11

GROUNDWATER PRODUCTION OF EACH SCENARIO



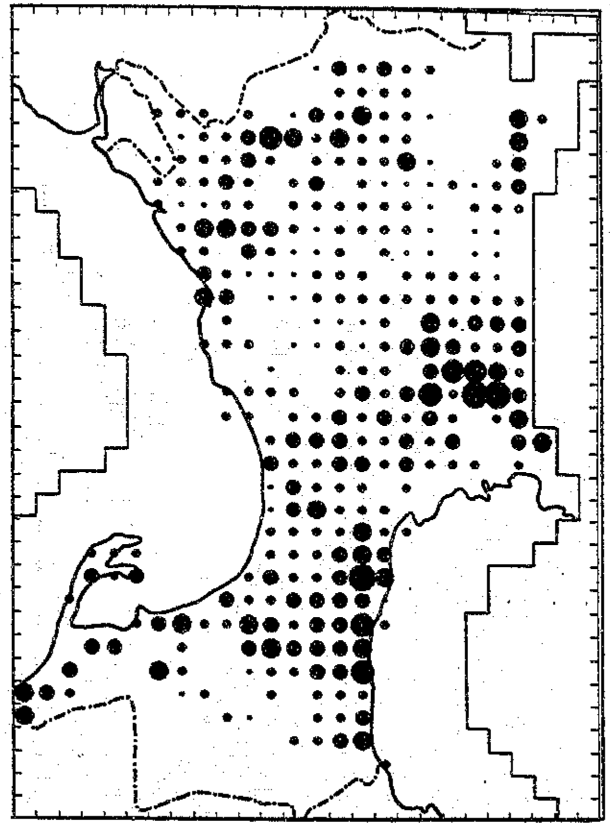
a) Scenario 1



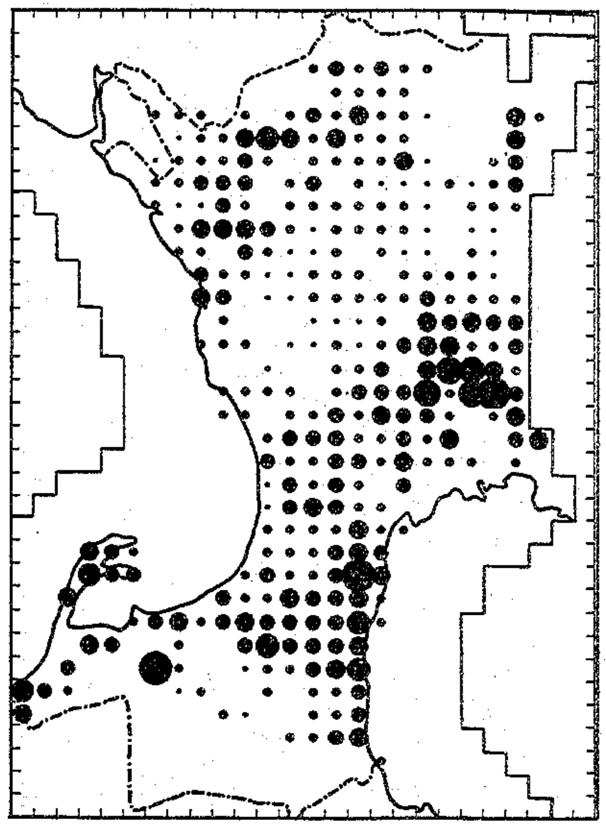
b) Scenario 2

Discharge rate (x1000cu.m/year)
• 1~99 • 100~999 ● 1000~2499 ● 2500~4999 ● 5000~7499 ● 7500~9999 ● 10000~

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.12
JAPAN INTERNATIONAL COOPERATION AGENCY	DISCHARGE DISTRIBUTION IN 2010 (Scenario 1, Scenario 2)

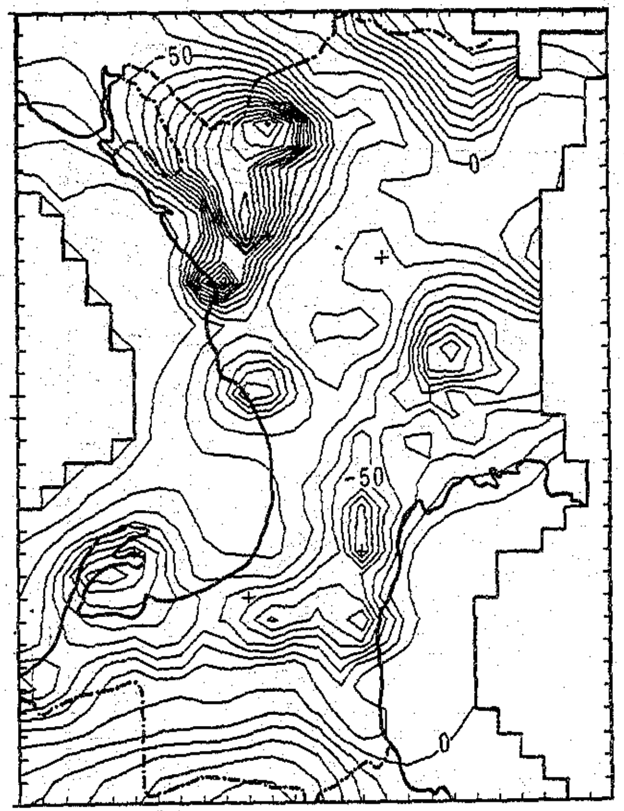


a) Scenario 3



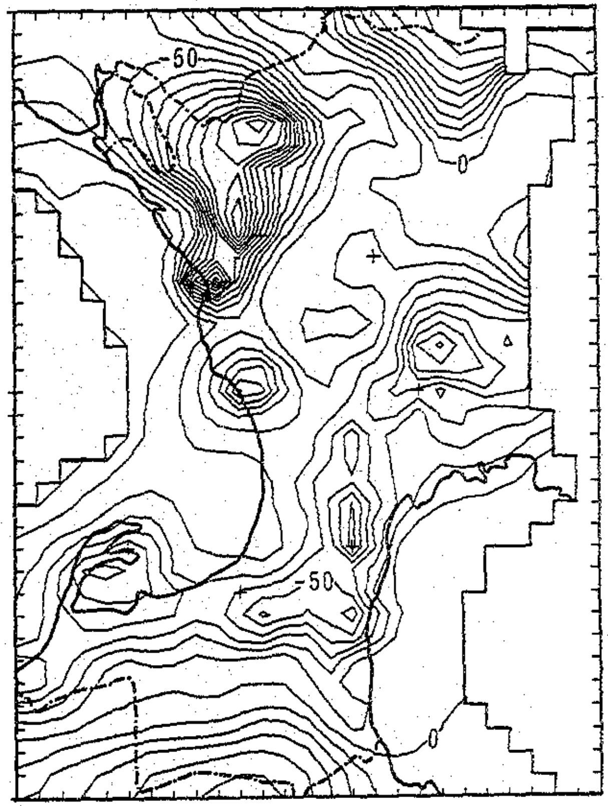
b) Scenario 4

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.13
JAPAN INTERNATIONAL COOPERATION AGENCY	DISCHARGE DISTRIBUTION IN 2010 (Scenario 3, Scenario 4)



a) Scenario 1

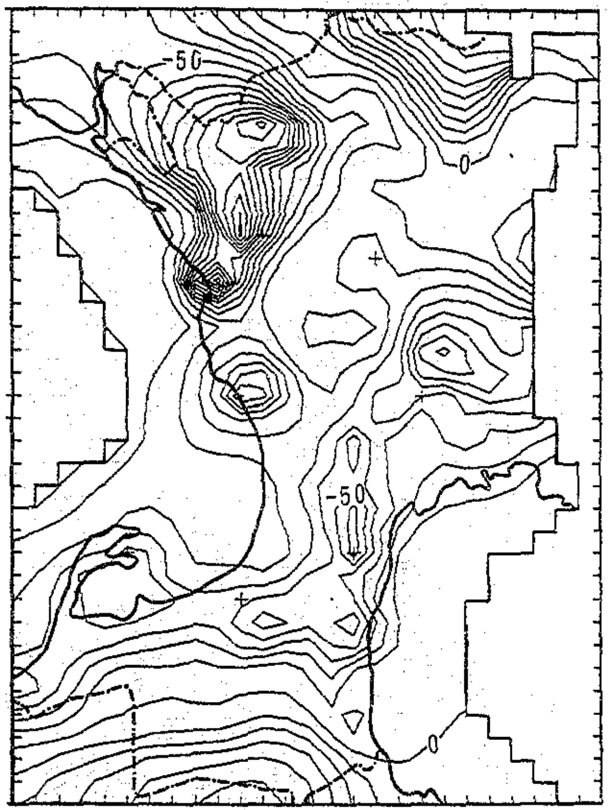
(Contour Interval: 10m, Unit: masl)



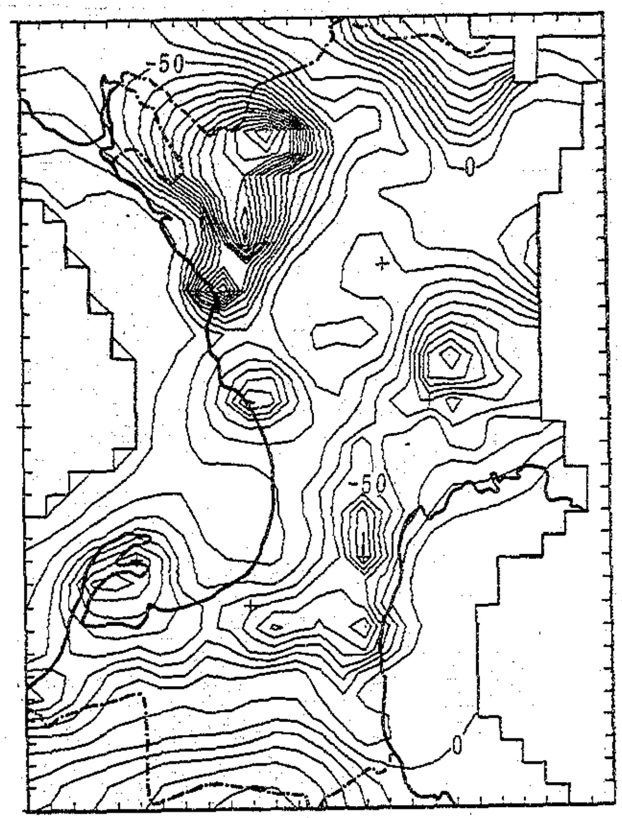
b) Scenario 2

(Contour Interval: 10m, Unit: masl)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.14
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC HEADS IN 2010 (Scenario 1, Scenario 2)

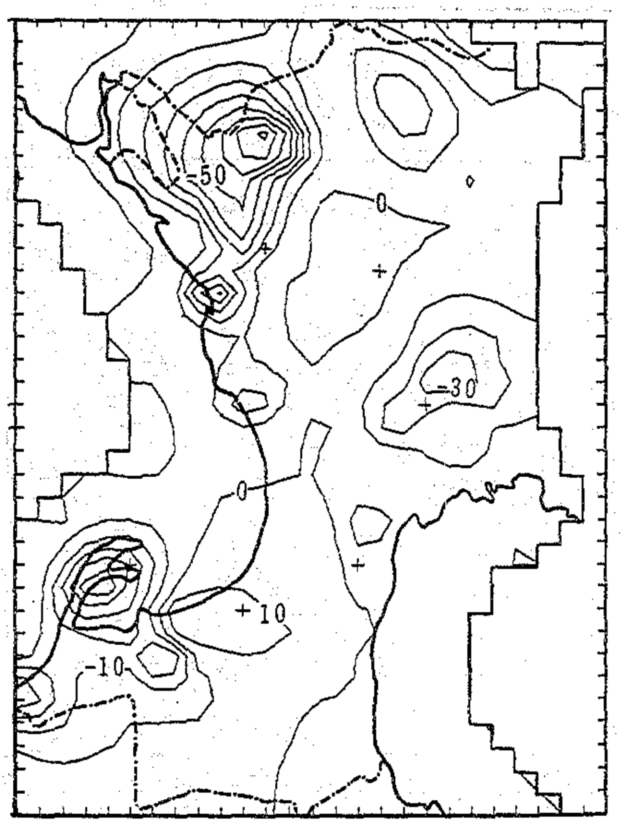


a) Scenario 3
(Contour Interval: 10m, Unit: masl)

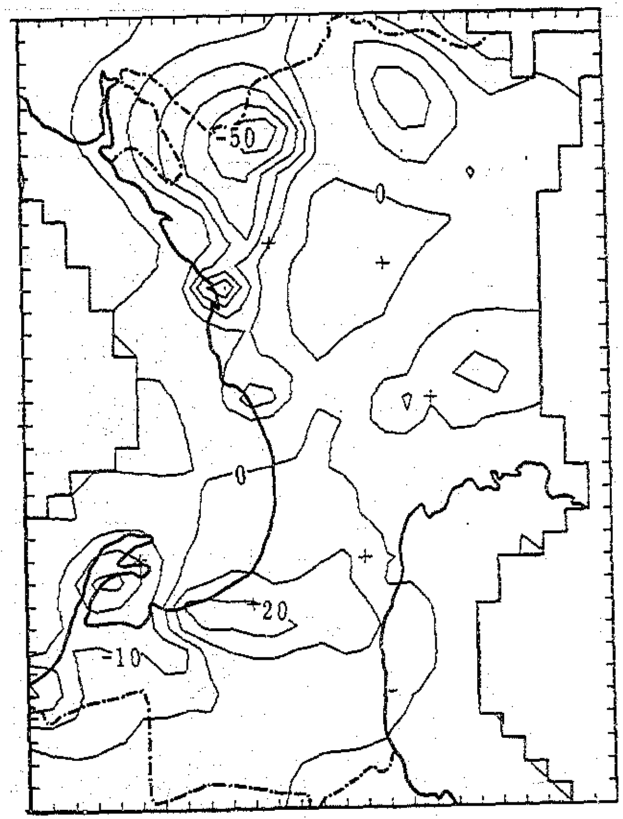


b) Scenario 4
(Contour Interval: 10m, Unit: masl)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.15
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC HEADS IN 2010 (Scenario 3, Scenario 4)



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



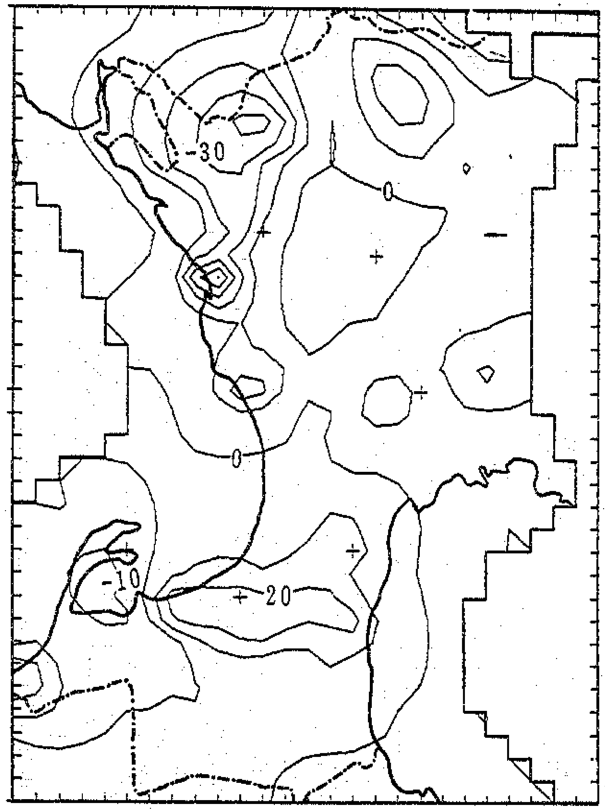
b) Scenario 2
(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

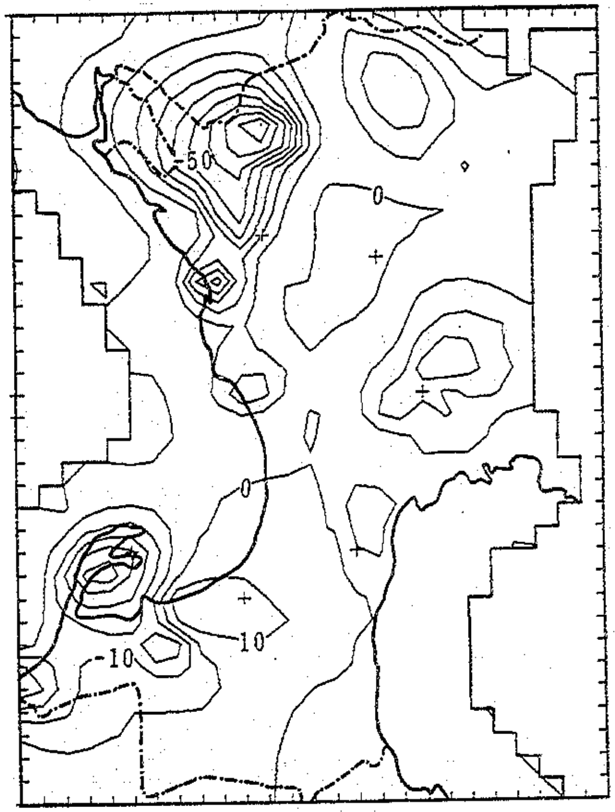
FIGURE 7.3.16

SIMULATED PIEZOMETRIC CHANGES FROM 1991 TO 2010
(Scenario 1, Scenario 2)



a) Scenario 3

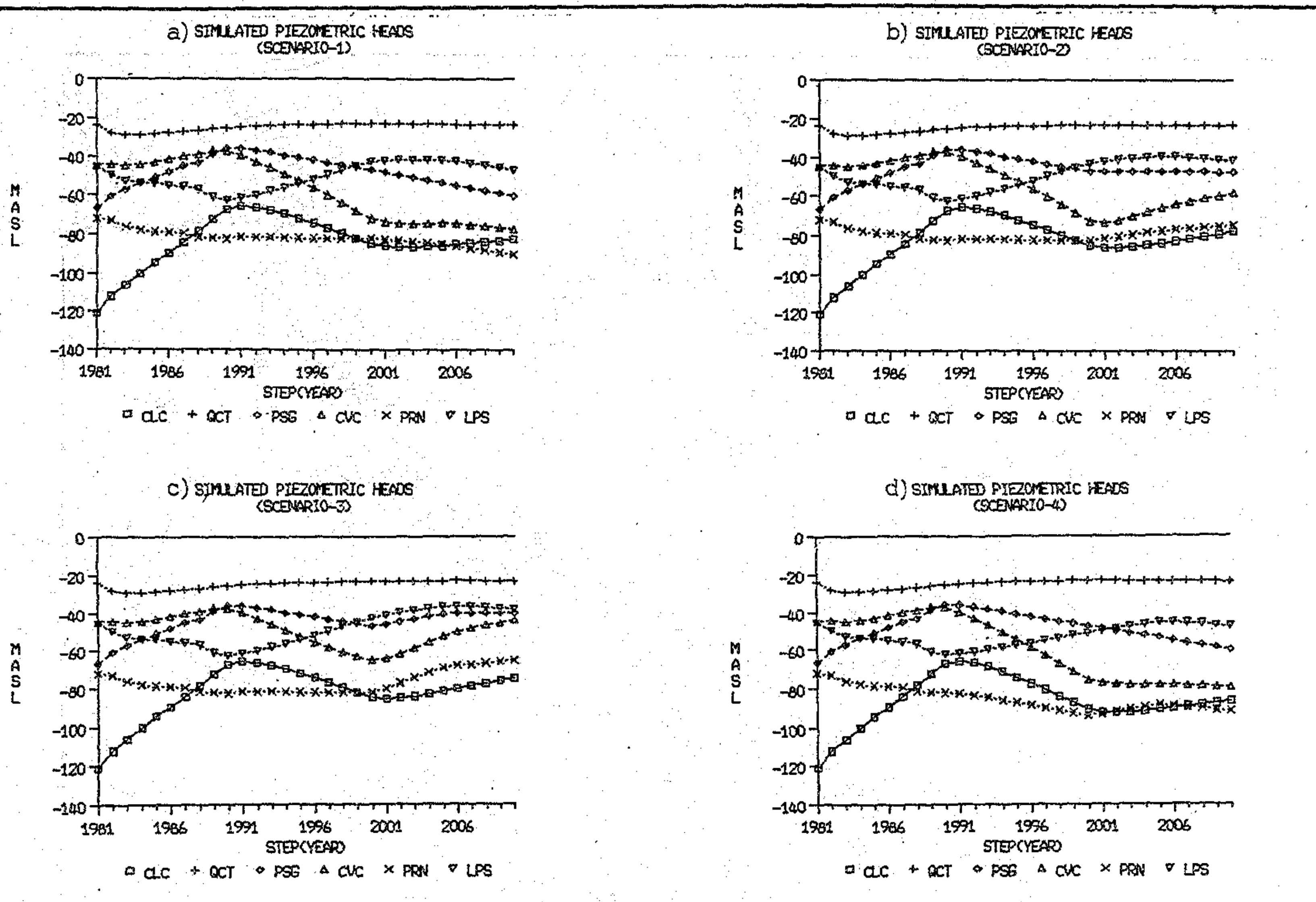
(Contour Interval: 10m, Unit: m)



b) Scenario 4

(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.17
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC CHANGES FROM 1991 TO 2010 (Scenario 3, Scenario 4)

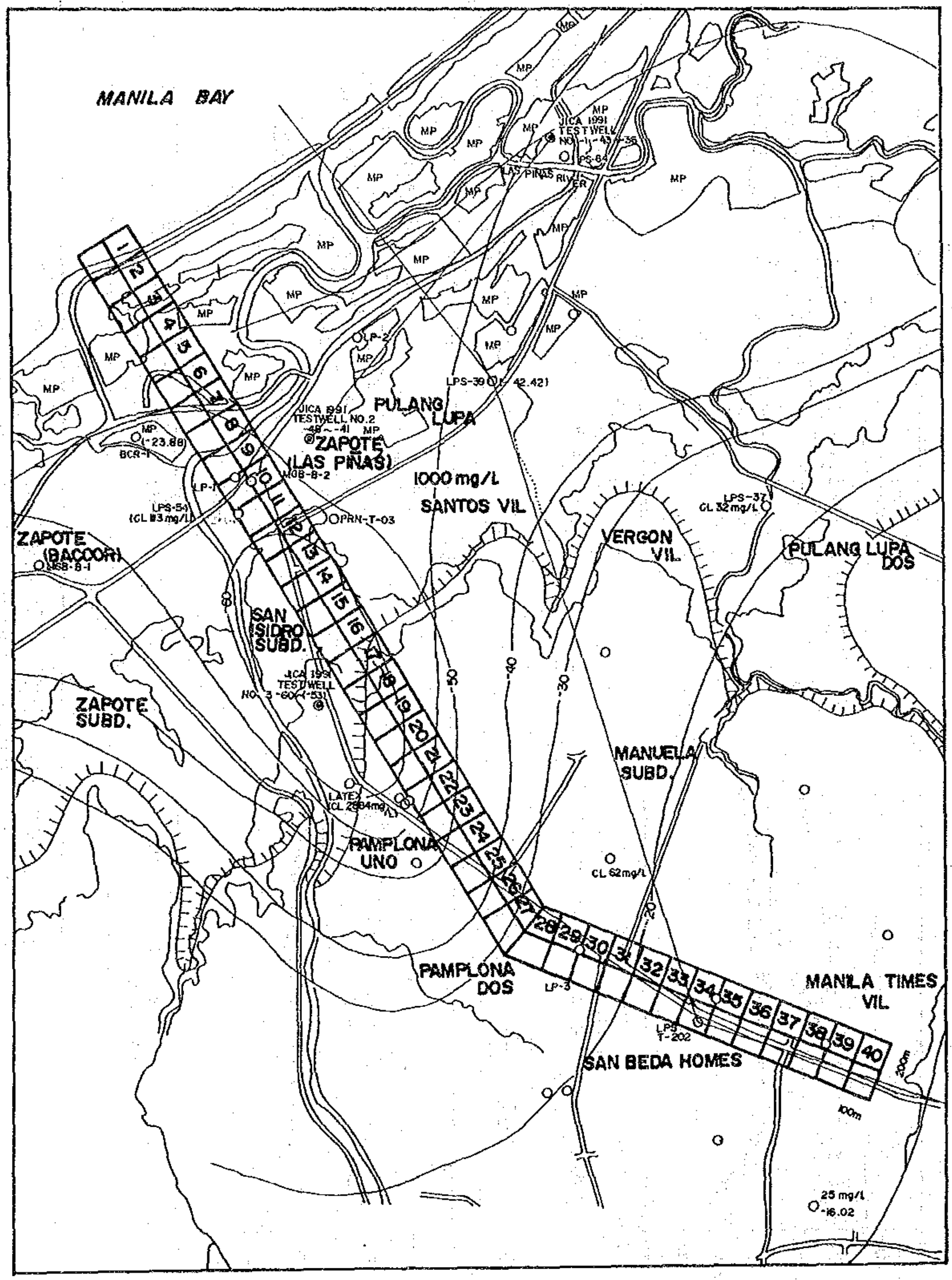


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

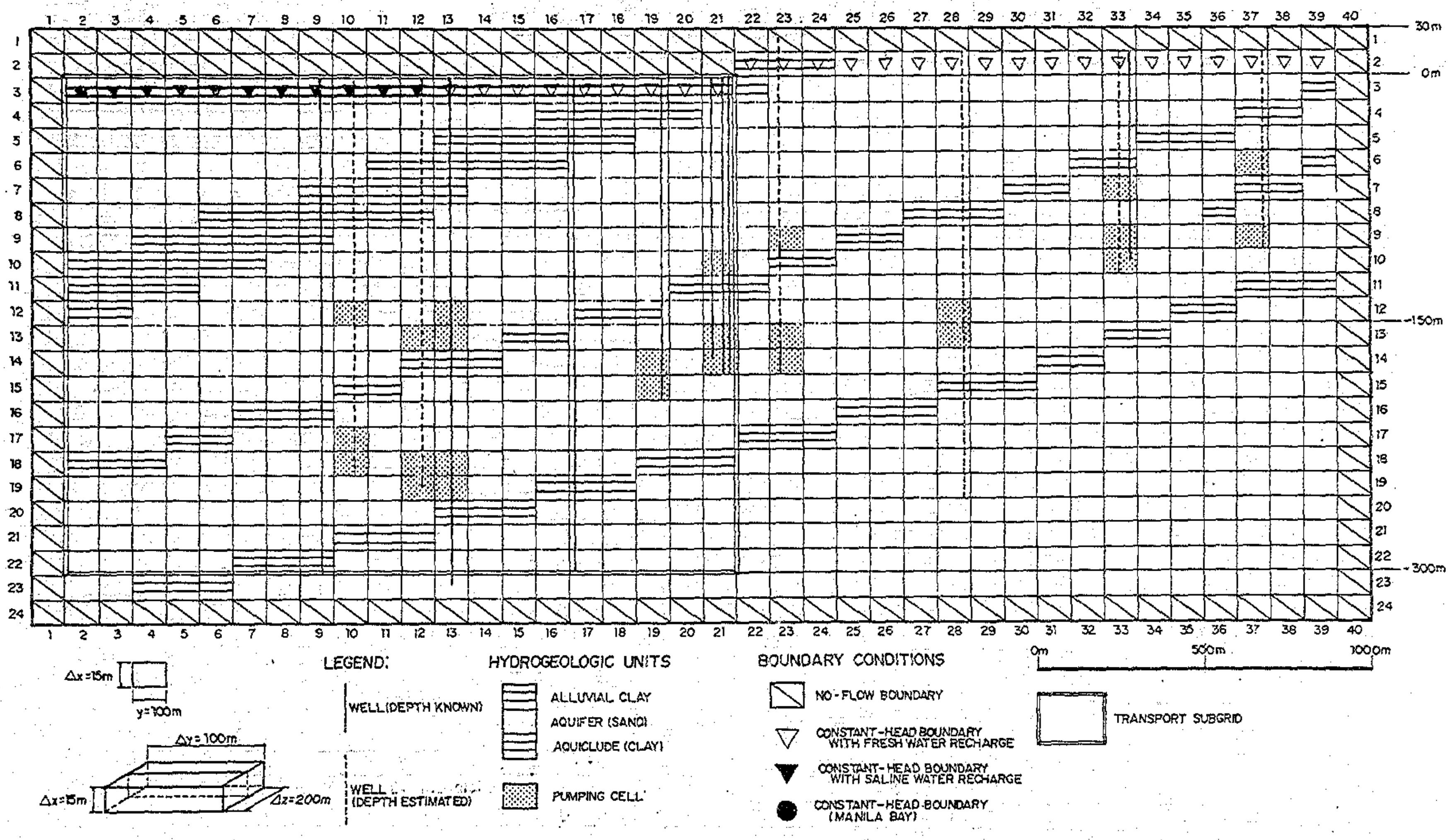
JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.18

SIMULATED PIEZOMETRIC CHANGES OF THE SCENARIOS



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.4.1 LOCATION OF VERTICAL TWO-DIMENSIONAL MODEL FOR SALTWATER INTRUSION ANALYSIS
JAPAN INTERNATIONAL COOPERATION AGENCY	



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 PIÑAS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
2	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
3	NF	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	C	C	C
4	NF	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C
5	NF	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	D	D
6	NF	B	B	B	B	B	B	B	B	C	C	C	C	C	C	D	D	D	D	D
7	NF	B	B	B	B	B	B	C	C	C	C	C	C	D	D	D	D	D	D	D
8	NF	B	B	B	B	C	C	C	C	C	C	D	D	D	D	D	D	D	D	D
9	NF	B	B	C	C	C	C	C	C	D	D	D	D	D	D	D	D	D	D	D
10	NF	C	C	C	C	C	C	D	D	D	D	D	D	D	D	D	D	D	D	D
11	NF	C	C	C	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D	E
12	NF	C	C	D	D	D	D	D	D	D	D	D	D	D	D	D	E	E	E	F
13	NF	D	D	D	D	D	D	D	D	D	D	D	D	D	E	E	F	F	F	F
14	NF	D	D	D	D	D	D	D	D	D	D	E	E	E	F	F	F	F	F	F
15	NF	D	D	D	D	D	D	D	D	E	E	F	F	F	F	F	F	F	F	F
16	NF	D	D	D	D	D	E	E	E	F	F	F	F	F	F	F	F	F	F	F
17	NF	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	F
18	NF	E	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	F	G	G
19	NF	F	F	F	F	F	F	F	F	F	F	F	F	F	F	G	G	G	H	H
20	NF	F	F	F	F	F	F	F	F	F	F	F	G	G	G	H	H	H	H	H
21	NF	F	F	F	F	F	F	F	F	G	G	G	H	H	H	H	H	H	H	H
22	NF	F	F	F	F	F	G	G	G	H	H	H	H	H	H	H	H	H	H	H
23	NF	F	F	G	G	G	H	H	H	H	H	H	H	H	H	H	H	H	H	H
24	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF

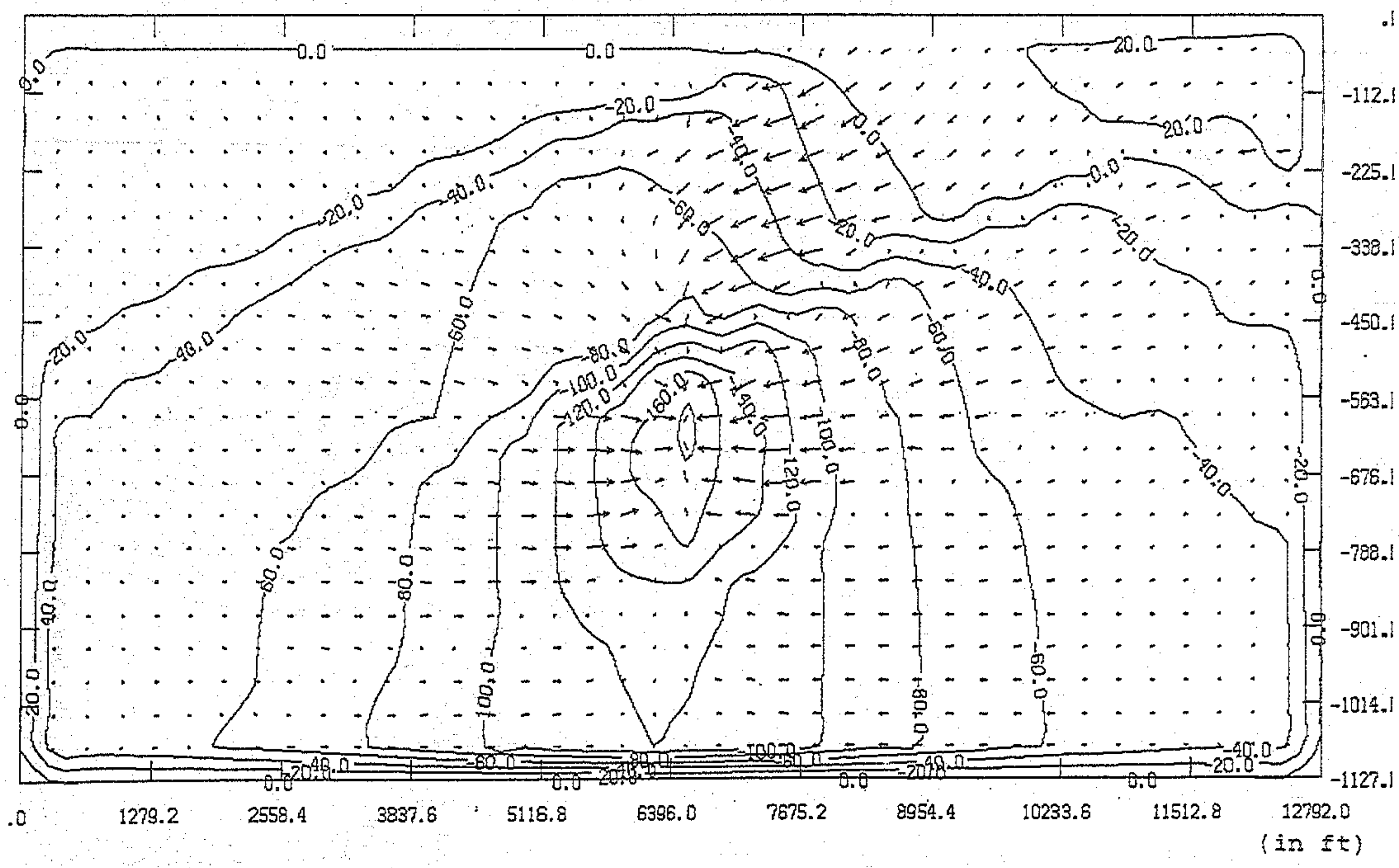
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
2	NF	C	C	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	NF
3	C	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	E	NF
4	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	E	E	F	NF
5	D	D	D	D	D	D	D	D	D	D	D	D	D	E	E	E	F	F	F	NF
6	D	D	D	D	D	D	D	D	D	D	D	E	E	F	F	F	F	F	E	NF
7	D	D	D	D	D	D	D	D	D	E	E	F	F	F	F	F	E	E	F	NF
8	D	D	D	D	D	D	E	E	E	F	F	F	F	F	F	E	F	F	F	NF
9	D	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	NF
10	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	NF
11	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	F	G	G	G	NF
12	F	F	F	F	F	F	F	F	F	F	F	F	F	F	G	G	H	H	H	NF
13	F	F	F	F	F	F	F	F	F	F	F	F	G	G	H	H	H	H	H	NF
14	F	F	F	F	F	F	F	F	F	F	G	G	H	H	H	H	H	H	H	NF
15	F	F	F	F	F	F	F	G	G	G	H	H	H	H	H	H	H	H	H	NF
16	F	F	F	F	G	G	G	H	H	H	H	H	H	H	H	H	H	H	H	NF
17	F	G	G	G	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	NF
18	G	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	NF
19	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	NF
20	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	NF
21	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	NF
22	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	NF
23	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	NF
24	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF

Label	Hydrogeologic Unit
A	Alluvium
B	Aquifer-1
C	Aquiclude-1
D	Aquifer-2
E	Aquiclude-2
F	Aquifer-3
G	Aquiclude-3
H	Aquifer-4
NF	No-Flow Boundary

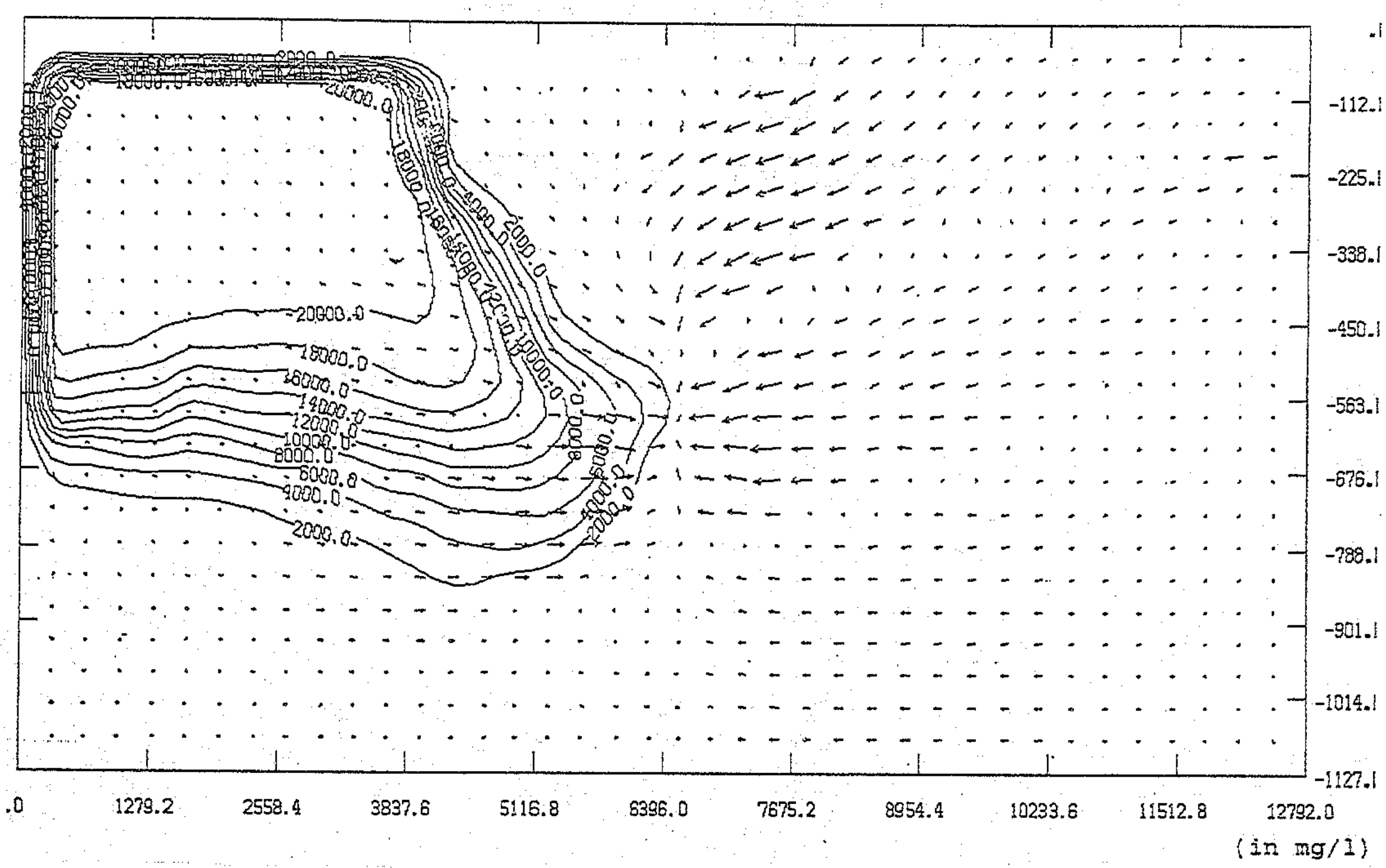
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.4.3
MODELED HYDROGEOLOGIC UNIT



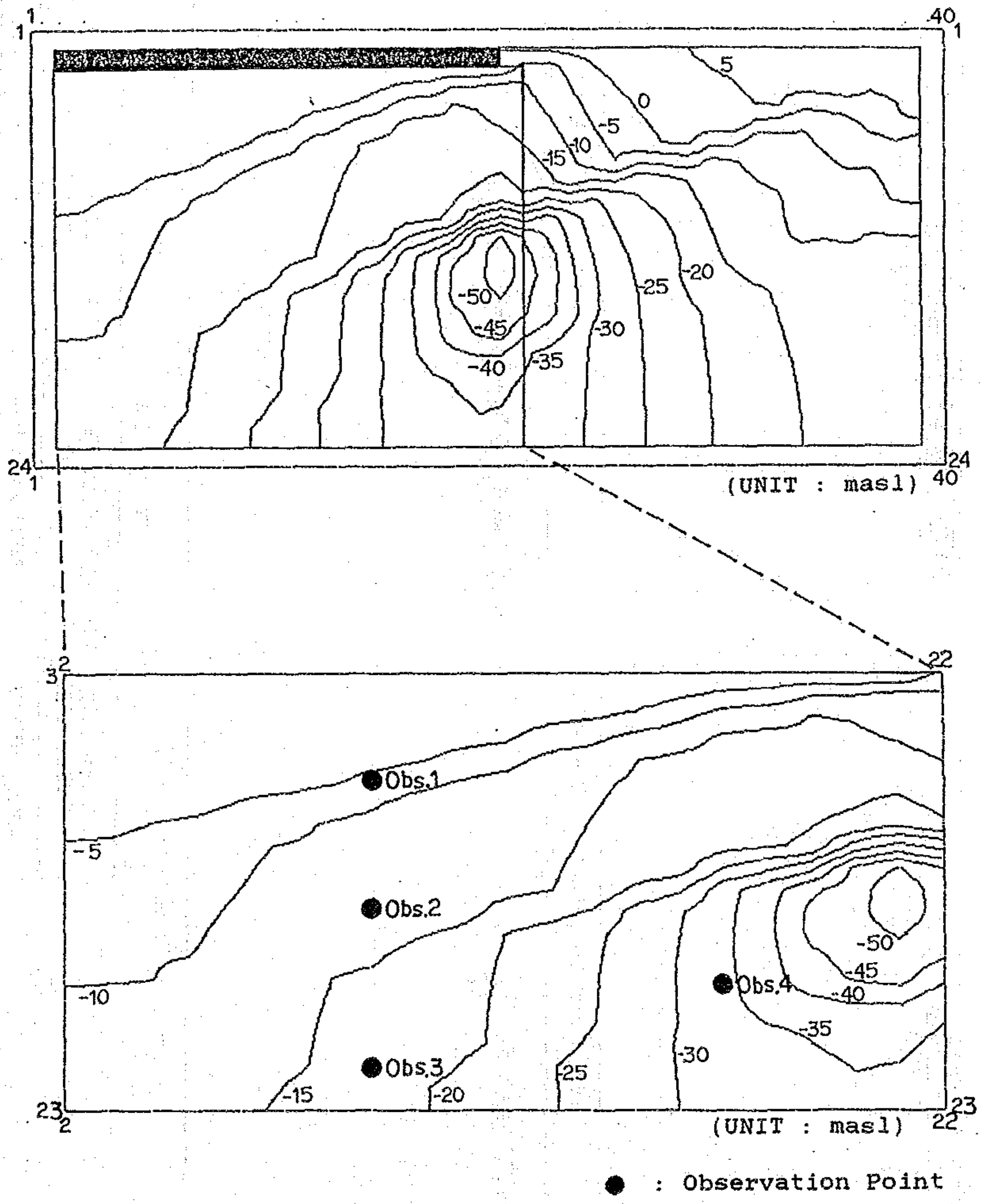
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.4.4 SIMULATED PIEZOMETRIC HEADS IN STEADY-STATE CONDITION
JAPAN INTERNATIONAL COOPERATION AGENCY	



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

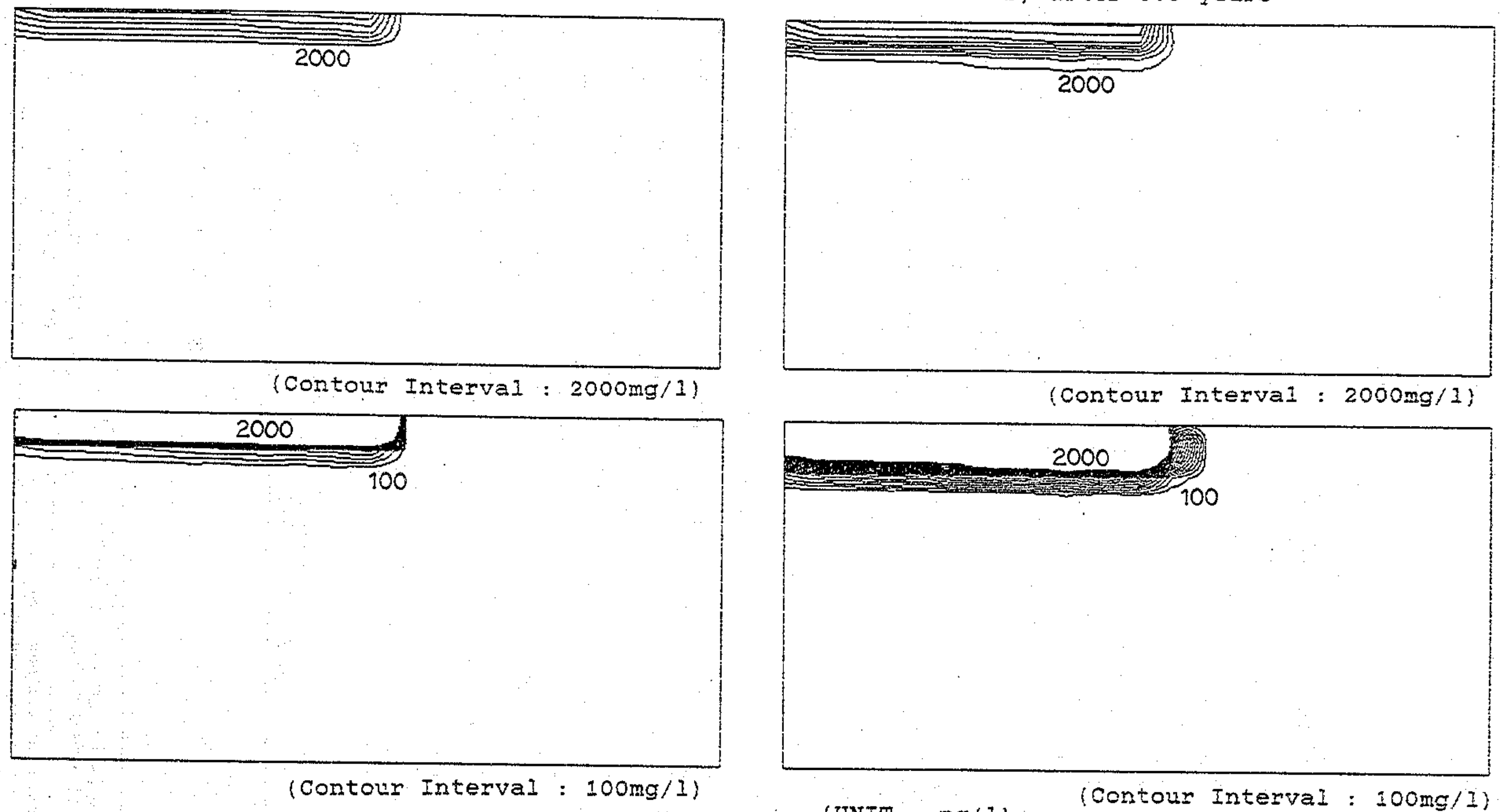
FIGURE 7.4.5
COMPUTED CHLORIDE CONCENTRATION AFTER 10 YEARS SIMULATION



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.4.6 SIMULATED PIEZOMETRIC HEADS IN TRANSPORT GRID
JAPAN INTERNATIONAL COOPERATION AGENCY	

a) after 0.4 years

b) after 0.9 years

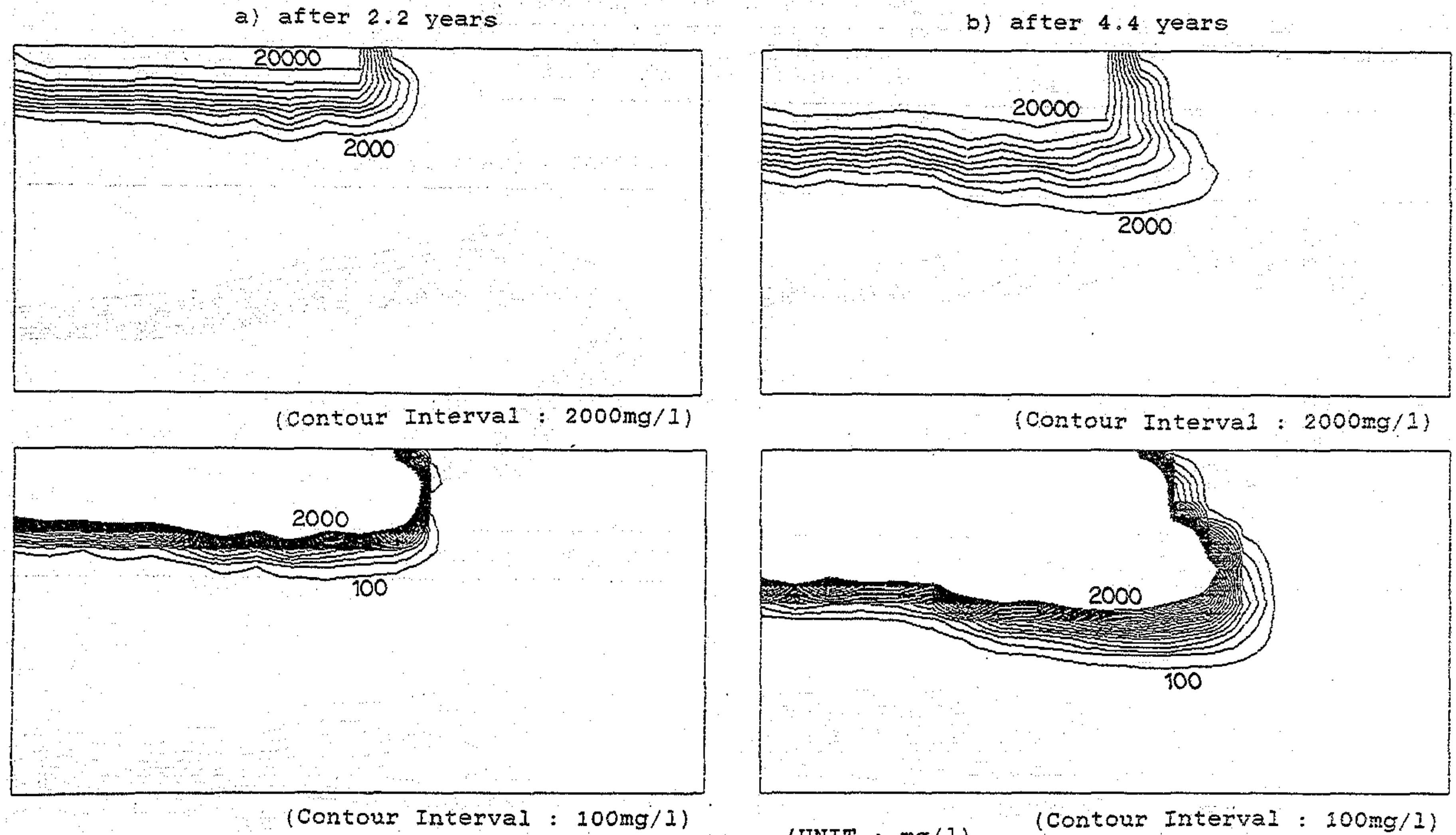


(UNIT : mg/l)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.4.7 SIMULATED CHLORIDE CONCENTRATION (after 0.4 year, 0.9 year)

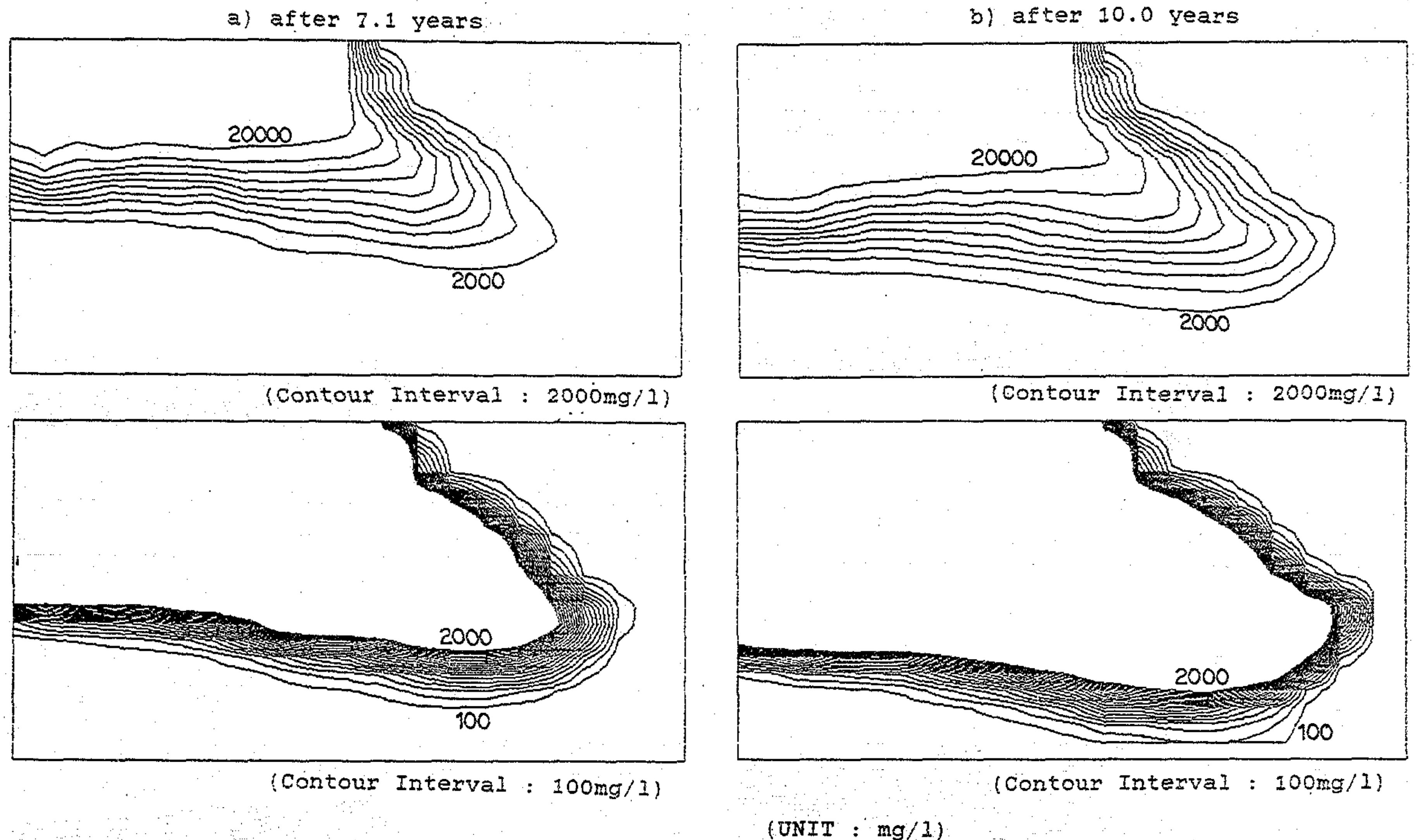


(UNIT : mg/l)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.4.8
SIMULATED CHLORIDE CONCENTRATION
(after 2.2 years, 4.4 years)

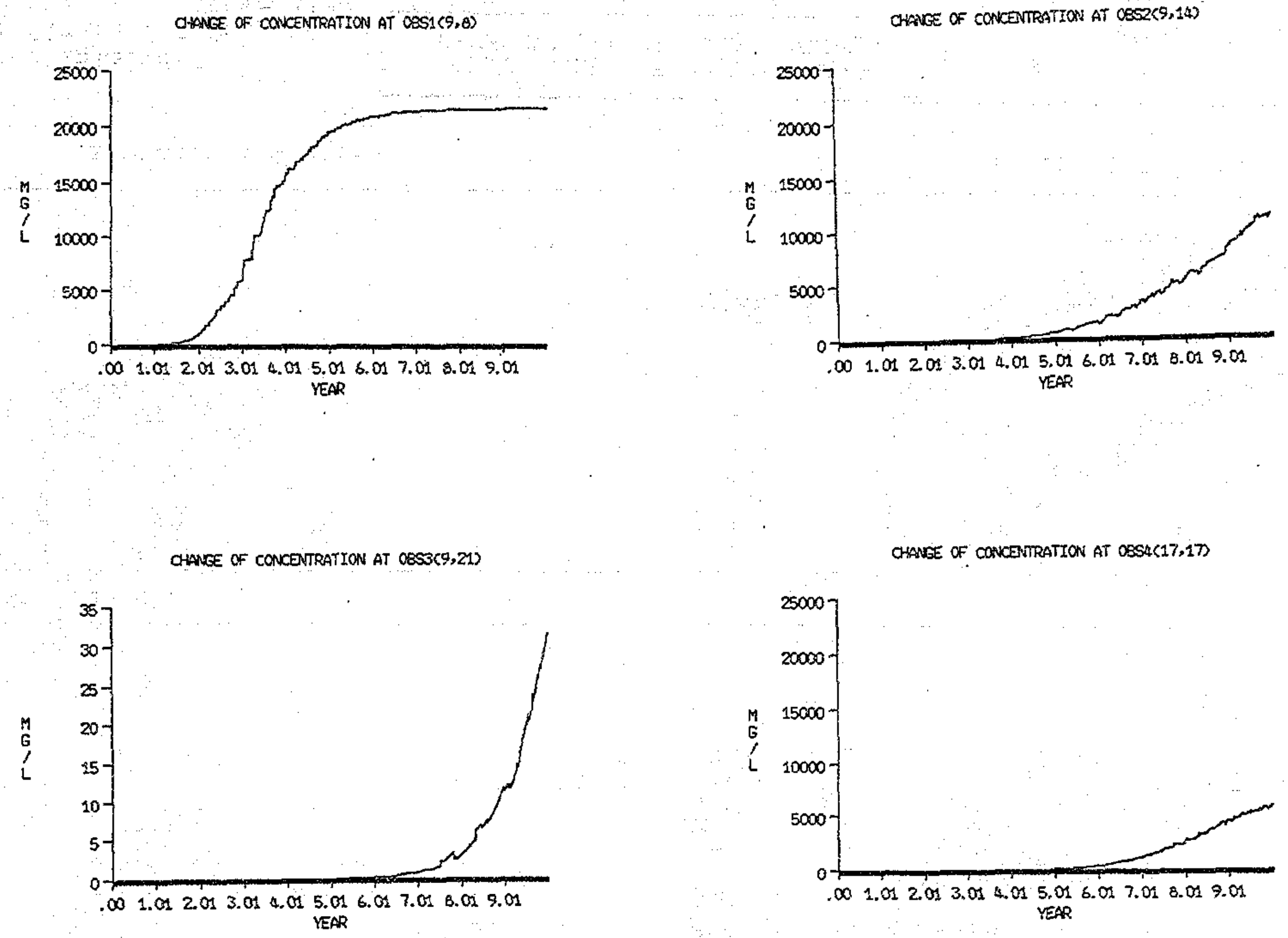


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.4.9

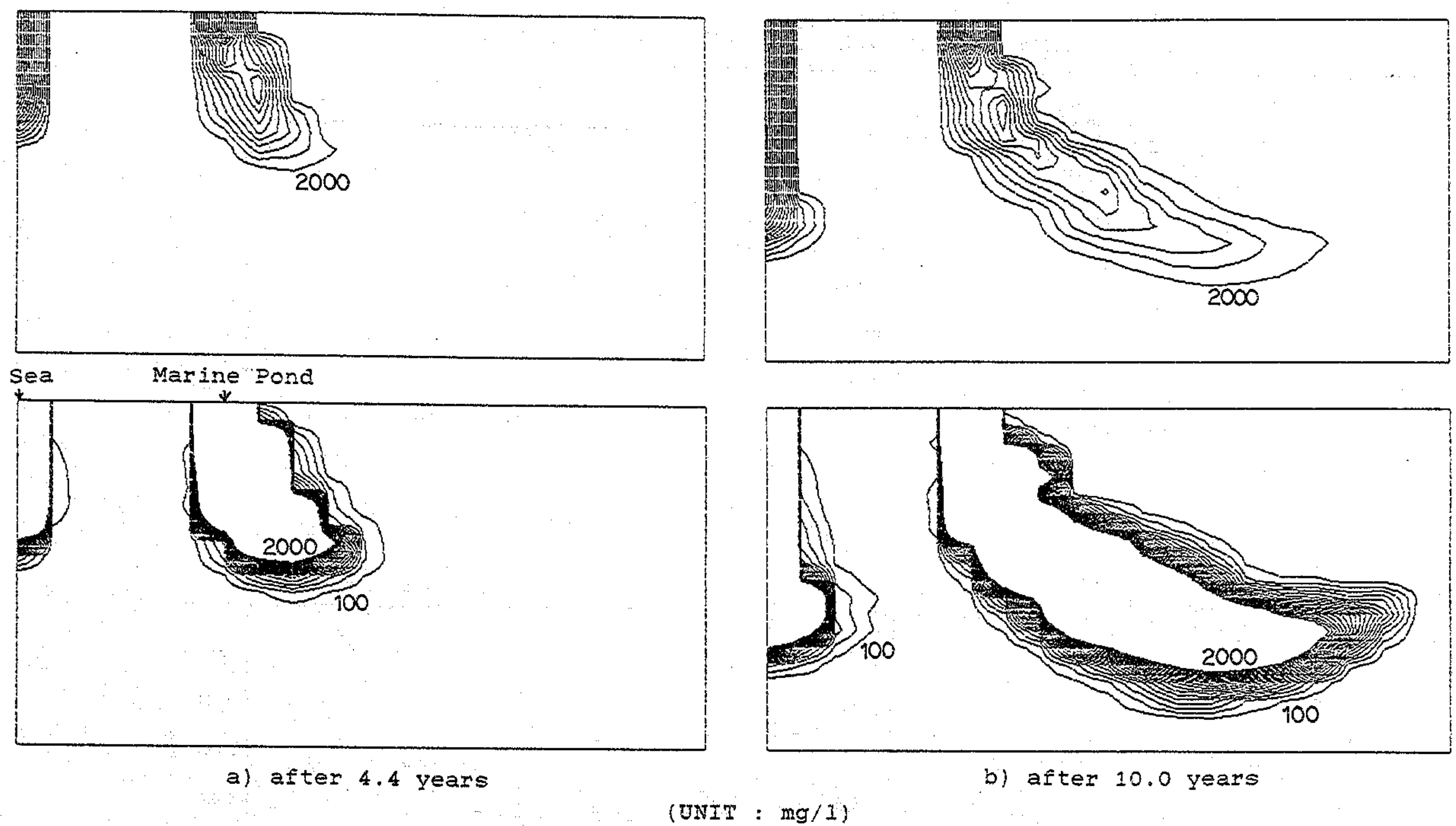
SIMULATED CHLORIDE CONCENTRATION
(after FIGURE 7.1 years, 10.0 year)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.4.10
CHANGE OF CONCENTRATION AT OBSERVATION POINTS



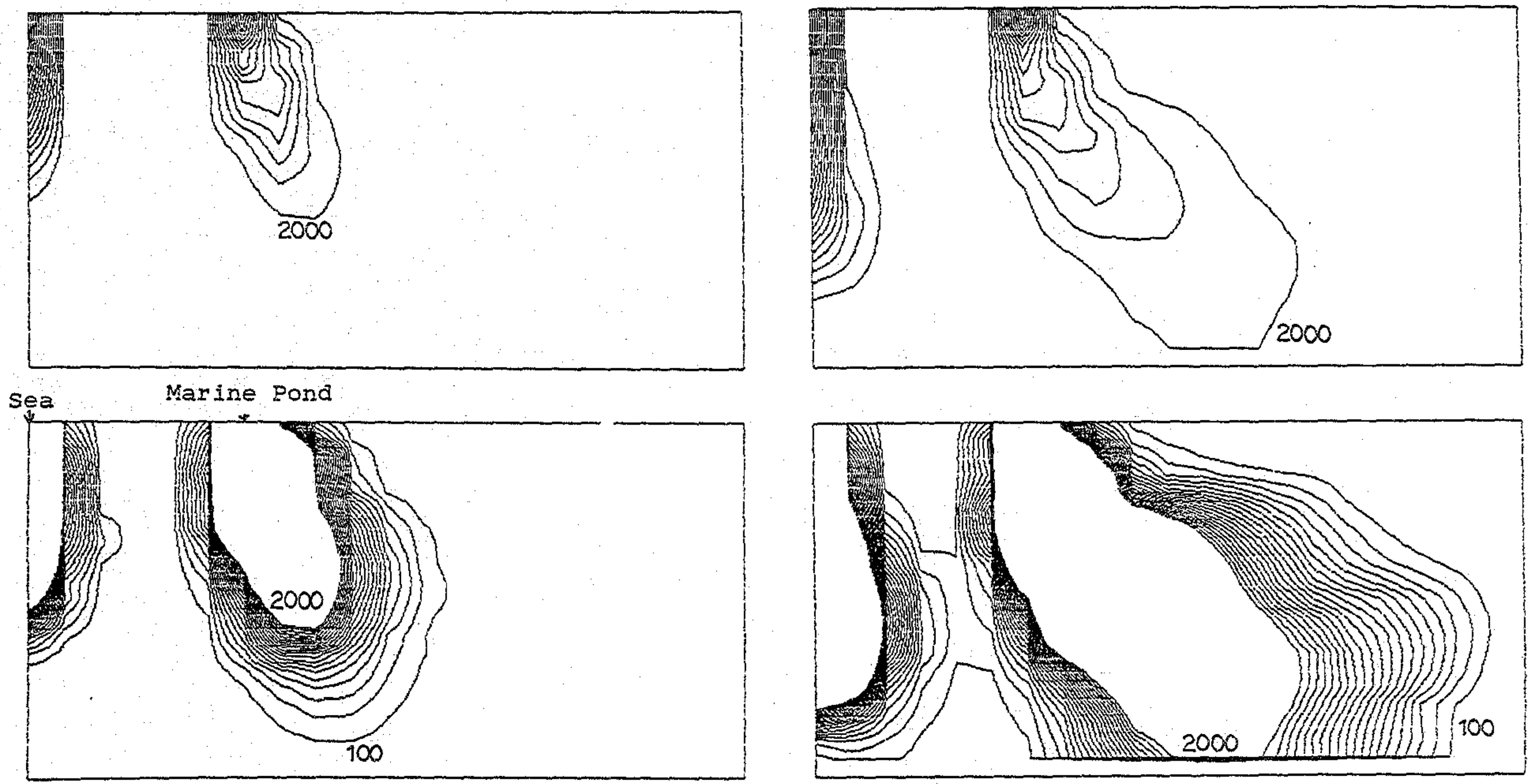
[Contour Interval]
(Upper figure : 2000mg/l)
(Lower figure : 100mg/l)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.4.11

SIMULATED CONCENTRATION
(Dispersivity = FIGURE 7.0ft)



a) after 4.4 years

b) after 10.0 years

(UNIT : mg/l)

[Contour Interval]
(Upper figure : 2000mg/l)
(Lower figure : 100mg/l)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.4.12

SIMULATED CONCENTRATION
(Dispersivity = 33.0 ft)

CHAPTER 8

GROUNDWATER DEVELOPMENT PLAN

CHAPTER 8 GROUNDWATER DEVELOPMENT PLAN

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8.1 REHABILITATION OF MWSS DEEP WELLS

8.1.1 Framework of the Rehabilitation Plan

According to the short-term water supply plan of MWSS, the municipalities of Antipolo, Montalban, San Mateo, Muntinlupa, Cavite, Imus, Kawit and Rosario shall still depend on groundwater sources up to year 1995 or 2000. Other municipalities shall also have to rely on groundwater sources until the expansion of surface water supply system and its distribution pipelines shall have been completed. Therefore, the rehabilitation of MWSS wells in these municipalities are particularly important not only to maintain but also to augment the present supply.

During the rehabilitation survey and the experimental rehabilitation work, it was observed that many active and inactive wells were damaged because of defective submersible pump units, riser pipes, etc. Therefore, the rehabilitation plan shall include those active wells presently in good condition, for they could be damaged in the near future as most pumping units have not been pulled out since the time they were installed.

Excluded from the plan are wells damaged by saline water and well cave-in, wells yielding dirty water, and dried-up wells. These wells will not be completely rehabilitated, and the cost of rehabilitating them may exceed the cost of drilling new wells.

Based on the above considerations, 100 wells were selected as candidate-wells for rehabilitation (see Table 8.1.1 for details):

1) In good condition at present : 73
2) Defective unit : 18
3) Standby/under MWSS rehabilitation : 9

The present average pumping rate of an active MWSS well is about eight (8) lps or 480 l/min or 690 CMD. This average was assumed for a rehabilitated inactive well. Based on the result of the experimental work, the pumpage increment for a rehabilitated active well is expected to be about 207 CMD. Thus the combined total pumpage increments for 100 rehabilitated wells is expected to be around 27,462 CMD (see Table 8.1.2).

8.1.2 Work Procedure, Equipment and Materials

The work procedure for rehabilitation is summarized hereunder. Details can be found in the Appendices.

1) Preparation and mobilization
2) Pulling out of existing pumping unit
3) Measuring 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 after overhaul and repair, or installation of new pumping unit
10) Demobilization

Equipment and materials necessary for the work are:

1) Well service machine (truck-mounted)
2) Submersible motor pump for pumping test
3) Clamp meter
4) Multi-tester
5) Riser pipes
6) Triangular weir box
7) 3/4"Ø sounding tubes
8) Conductivity meter
9) Compressor
10) Water level indicator and wires
11) Bailor
12) Wedge block
13) Fishing tools

Submersible pumps and riser pipes are provided by the contractor.

8.1.3 Project Cost

The rehabilitation cost per well is estimated as follows:

1) Construction cost			P483,800
Rehabilitation work			187,400
Equipment and materials			296,400
Submersible pump	1 unit		100,000
Riser pipe	20 pcs.		84,800
Submersible cables	120 m		87,600
Sounding tube	20 pcs.		24,000
2) Engineering Cost [12% of 1)] (Detailed Design and Construction Supervision)		58,156	
Total		P541,956	

Thus the total project cost for the rehabilitation of 100 wells is P54,195,600.

8.1.4 Implementation of the Project

(1) Organization

The MWSS shall be the principal implementing agency for the rehabilitation project. It shall be responsible for the execution of this project. It shall manage the budgets as well and, with the cooperation of the Consultant, guide the Contractor regarding the rehabilitation work.

The Consultant shall be responsible for: (1) planning related to the procurement of equipment and materials; (2) preparation of the tender documents; (3) execution of the tendering; (4) analysis and evaluation of bids; (5) contract negotiations with the chosen bidder; (6) procurement of equipment and materials; and (7) supervision of the rehabilitation work.

The Contractor shall be responsible for the procurement of equipment and the execution of the rehabilitation work.

(2) Schedule

A detailed project schedule for the rehabilitation work shall be prepared in the detailed design study. Described below is a tentative project schedule for the rehabilitation work.

a) The detailed design study for the investigation of candidate wells, preparation of tender documents, and tendering shall require three (3) months.

b) The procurement of contractor, equipment and materials shall require one (1) month.

c) The rehabilitation work can be done at a rate of around 10 wells per month. The construction shall require approximately 12 months, with two (2) months allowance.

8.1.5 Cost Evaluations

The well rehabilitation plan aims at augmenting the groundwater supply by approximately 27,400 CMD through 100 MWSS wells. Approximately 40 new wells (with an average yield of 700 CMD per well) must be drilled in order to supply the same volume of water.

The cost of water may be calculated by the following equation.

$$C = (A*a+B)/Q$$

where C: cost of water per volume; A: project cost; a: capital reduction rate; B: annual operation and maintenance cost; and Q: annual pumpage.

The capital reduction rate can be expressed as:

$$a = (i(i+1)^n)/((i+1)^n-1)$$

where i: rate of interest; and n: useful life in years.

Assuming i=0.055, n=20 years for a new well and n=10 years for a rehabilitated well, a = 0.080 for n=20

a = 0.129 for n=10

The construction cost of a deep well is estimated at 12,700 pesos per meter, including submersible pump and pump house (see Section 8.2.2). Assuming a well depth of 200m, the construction cost shall be 2.54 million pesos. The cost of water, excluding the cost of operation and maintenance, is calculated as follows:

For a new well:

C= 2,540,000*40*0.08/27,400*365= 0.81 peso

For a rehabilitated well:

C= 542,000*100*0.129/27,400*365= 0.70 peso

Therefore, the rehabilitation of existing wells is more cost effective than the construction of new wells for a 10-year operation.

8.2 GROUNDWATER DEVELOPMENT IN ANTIPOLO

8.2.1 Groundwater Development Plan

(1) Existing Wells

There are ten (10) operational MWSS deep wells and twenty-six (26) private deep wells in the Antipolo area. Private wells supply water for their owners' domestic and industrial use. The MWSS wells supply water directly to Antipolo consumers via a pipeline system. As per water meter reading, MWSS charges Antipolo consumers with rates identical to those in areas where surface water is supplied. The system in Antipolo has no booster pumps, no reservoir, nor ground or elevated tanks.

MWSS deep wells are operated and monitored 24 hours a day. The location of these wells are shown in Figure 8.2.1, while their details are listed in Table 8.2.1. Details of privately-owned wells are shown in Table 8.2.2.

(2) Present Water Supply

As mentioned in the previous chapter, the year-1990 total municipal population of Antipolo is 207,842. Of this population figure, 84,823 live in the Antipolo Plateau, and of which only 34% (i.e. 28,000) are supplied with water from the distribution system.

Effective volume of water supply, excluding non-revenue water, is 3,288 CMD. Thus, with the above population data, the actual water consumption is 114 lpcd.

(3) Service Area

The service area is limited to a part of the Antipolo Plateau. The existing distribution pipelines run along the main roads near the poblacion of Antipolo. The service area is shown in Figure 6.2.5 in Section 6.2.

(4) Future Groundwater Supply

In planning the future water supply, the target year is set in the year 2000 and year 2010.

As estimated through computer simulations, the optimal pumpage of the Antipolo groundwater basin is about 28,000 CMD. This amount can meet the water demand until year 1998, after which the water demand must be supplied jointly by groundwater and surface water. The surface water shall be provided by the future expansion of the CDS. Since the present abstraction of existing deep wells is around 20,000 CMD of groundwater, the maximum exploitable volume of groundwater is about 8,000 CMD. After the rehabilitation of the 10 existing MWSS wells in Antipolo, water supply is expected to increase by about 2,000 CMD. Therefore, the total pumpage of the planned new wells to be drilled in the basin cannot exceed 6,000 CMD.

(5) Number of New Wells and Their Locations

The number of wells and their pumping rates were determined by the computer simulations described in the previous chapter. The pumping rate of one well was assumed to be 830 CMD and the drawdown was estimated to be 20m. The planned wells are to be located in the area where the difference between the top ground surface and the computed groundwater level in the year 2010 is more than 20m.

The present pumping rates of private and MWSS wells were assumed to remain constant until the year 2010. Considering a pumping duration of 20 years, the optimal number of new wells that can be constructed in the Antipolo basin is seven (7), as computed by the simulation model.

Since 10 MWSS wells already exist in the basin, the construction of 7 new wells is limited to the area where the main aquifer, Guadalupe formation III, is thickest. This siting of wells also takes into consideration the depth of the hydrogeologic basement and future drawdown. The locations of the planned new wells are illustrated in Figure 8.2.2.

(6) Well Design

The casing diameter for a standard well design is based on the design of existing MWSS wells. The most common casing diameter is 8 inches. For ease of operation and maintenance, this casing diameter is adopted the standard well design.

The well depth is determined from the iso-depth contour map. Screen length is estimated to be less than 20% of the total well depth. A wire-wound slotted type is proposed for the screen in view of well efficiency. Centering guides are designed to be set every 30m.

The diameter of packing gravel is designed to range from 3mm to 5mm. A steel well cap is to be installed at the bottom, with suitable wall thickness.

Only one casing diameter, constant from top to bottom of the well, is to be installed in order to easily change the pump setting in case of a regional decline of groundwater level in the future. This is the reason why the telescopic type of well design is not adopted. The standard well design is illustrated in Figure 8.2.3.

(7) **Pump House**

The pump house design is a modified design of the MWSS pump house. Materials for the construction of the planned pump house are planned to be procured in the Philippines (Figure 8.2.4).

The planned pump house is to be made of concrete block walls, reinforced concrete foundations, slabs and columns, and galvanized roofing. Louver-type doors and concrete blocks shall be used for air ventilation. The door and window frames shall be made of iron or aluminum.

(8) **Elevated Water Tanks**

The water tank is provided for each group of wells aiming at effective operation of wells. Number of tanks is 6 in total. The water pumped from wells in the same group is transmitted to the same elevated tank respectively. Then stored water is distributed from the tank through one outflow pipe.

The planned elevated water tanks are to be made of reinforced concrete with rectangular shape (Figure 8.2.5). Heights of the tank is about 20m to acquire desirable minimum water head at the connection of customers. Effective water depth of the tank is designed at 5m. Required volume of the tank is as follows:

Required volume for sufficient distributions:
15 % of daily maximum water supply amount
(based on the result of actual condition survey by LWUA)

17,689 m^3/day (total capacity of wells) *0.15=2,653 m^3
2,653 m^3/ 6 tanks (No. of well group)= 442 m^3/tank

dimensions of tank 9.4mW*9.4m*L*5mH = 442 m^3

(9) **Equipment and Materials**

Equipment and materials shall be basically procured in the Philippines.

8.2.2 Construction Cost

The construction cost of the planned 7 new wells, including the pump houses ,pumping units and 6 elevated water tanks was estimated based on a cost survey conducted in Manila. Details are as follows:

I. Well Construction

	ITEMS	QUANTITY	COST
(1)	General mobilization, demobilization and site cleaning	LS	P 55,600
(2)	Drilling of 450mm hole/15m (dia. 16"), 375mm hole/135m (dia. 14-3/4")	150m	701,900
(3)	Furnishing and installation of dia. 16" conductor pipes/15m and dia. 8" casing pipes/ 135m and wire wound screen and installation of well bottom	LS	231,300
(4)	Electric logging	LS	14,300
(5)	Gravel packing	LS	62,000
(6)	Well development (Airlift & Overpumping)	LS	39,500
(7)	Pumping test o step-drawdown test (2 hrs x 5 steps) o continuous test (48 hours) o recovery test (8 hours)	LS	52,800
(8)	Water analysis and reporting	LS	5,400
(9)	Overhead (1,162,800x0.04)	LS	46,500

	Sub-Total			P1,209,300
II.	Pump house		LS	190,900
III.	Furnishing and installation of equipment			
	(1)	Submersible pump 150gpm, TDH 150m, (27.9 KW) including riser pipes, submersible cable, and sounding tube 3/4"ø	1 unit	423,400
	(2)	Water meter 4"ø	1 unit	26,300
	(3)	Check valve 4"ø, 3"ø	1 unit	7,900
	(4)	Gate valve 4"ø, 3"ø	1 unit	4,400
	(5)	Flap valve 3"ø	1 unit	1,300
	(6)	Pipe and fittings	LS	13,600
	(7)	Others	LS	6,100
	(8)	Overhead (P483,000x0.04)		19,320
	Sub-total			P 502,300
	WELL TOTAL			P 1,902,500
		7 wells		P 13,317,500
IV	Elevated Water Tanks 6 tanks			P 23,448,000
	GRAND TOTAL			P 36,765,500

Thus, the construction cost of one well is estimated to be P1,902,500. The total construction cost of the planned 7 new wells and 6 elevated water tanks is P36,765,500.

8.2.3 Project Implementation

(1) Implementation Schedule

The project implementation schedule for the construction of 7 wells and pumping stations, excluding the distribution pipelines and elevated tanks, is shown in Figure 8.2.5

This schedule has four stages: (1) Preparation; (2) Tendering; (3) Procurement of contractor; and (4) Construction of wells and elevated water tanks.

The preparation stage includes the detailed design and review of the construction plan, as well as the preparation of tender documents and the acquisition of land. Tendering consists of the bidding process and the evaluation of bids. A contractor is chosen in accordance with the evaluation. Well construction work includes the procurement of equipment and materials and the construction itself of wells and pump houses.

The construction period for one well requires two months. In the work program, two (2) drilling teams and two (2) civil work teams are proposed for the construction of seven wells and pumping stations.

(2) Operation and Maintenance (O&M)

Operation and maintenance of the existing MWSS deep wells must be conducted by the present groups of operators. Two new O&M groups must be organized for the seven new wells. The groupings are shown in Figure 8.2.6 and are listed below:

Group 1 - existing wells no.1 and no.2 plus one new well
Group 2 - existing wells no.4, no.5, and no.7
Group 3 - existing well no.10 well plus one new well
Group 4 - existing wells no.3, no.6 plus one new well
Group 5 - 3 new wells
Group 6 - existing wells no.8 and no.9 plus one new well

(3) Operation and Maintenance Cost

Existing Wells

a) Manpower cost

(1 Engineer, 3 Pump Operators (PO Foremen, 3 Sr. POs, 9 POs, 3 Casual POs)
= P1,154,280/year

b) Electric charge

(Includes generation, distribution and energy charges)
= P2,787,671/year

New Wells

a) Manpower cost

(2 Sr. POs, 6 POs)
= P456,480/year

b) Electric charge

(Includes generation, distribution and energy charges)
= P3,645,062/year

Funds for Repairs

Funds for repairs, which include the acquisition of small tools such as electrical pliers, screw drivers and pipe wrenches, (one unit for every operator):
= P31,600/year

Operation and maintenance cost for the seven new wells is P4,133,141. Total operation and maintenance cost for both existing and new wells amounts to P8,075,092.

8.3 SURFACE WATER SUPPLY PLAN IN ANTIPOLO

8.3.1 Water Supply Plan

(1) Water Source

As mentioned in Subsection 6.2.3, it is indispensable for the development of the water supply system in the Antipolo study area to have the water source augmented.

The most reliable water resource in the basin at present is groundwater. But due to the hydrogeologic characteristics of the area as mentioned previously, its yield is limited. Thus, fully utilizing the available water source yield of groundwater in the basin means pumping up through deep wells.

Other available water resources are the creeks and springs flowing down from the basin to the outside. But these creeks are already contaminated with wastewater and their flow quantity is limited, thus making them unsuitable for additional water sources.

Some springs which are also flowing down from the Antipolo plateau along the boundary of the basin may be potential sources. Most of them, however, have limited yields, especially during the dry season, and hence are not suitable as water sources for Antipolo. One of these springs, named Love Spring, had been relied upon by the people of Teresa in the 1950's and 1960's. However, the Teresa Waterworks which was tapping this spring has had to shift to deepwells in the 1980's because of the inadequate spring yield. Furthermore, after groundwater development in the future proceeds as mentioned in Sections 8.1 and 8.2, yield of springs will be poorer due to full utilization of the groundwater resource.

Thus, as far as water sources for the MWSS system in the basin is concerned, the augmentation of water means tapping sources other than the surface water in and adjacent to the basin.

In this regard, RPWSIP is considered where the construction of a treatment plant with a capacity of some 39,800 m3/day was planned for the water supply system of Angono-Taytay. The water source for this system is the Laguna de Bay. One alternative is to enlarge this plan and to transmit treated water from the plant to the basin. This alternative seems to be attractive. However, a basic requisite for carrying out this alternative is a good road from a candidate site of the planned treatment plant to the basin, but as this road has yet to be constructed, a long time would be needed before said alternative could materialize.

In addition to the problem about road access, there is also the concern about the great influence the abovesaid alternative could exert on the plan for the treatment plant itself due to the significant increase of treatment capacity that such alternative requires. Furthermore, the cost for construction and operation of the transmission line in the alternative just considered is not really much different from that of the plan which contemplates transmission from CDS. This is so because the difference in elevation is almost identical in both RPWSIP option and CDS plan, with the option having the slight advantage of cutting by less than 20% the length of the transmission line to the center of the basin. Seen under the light of these considerations, the inadequacy of the alternative on expanding the above treatment plant's capacity follows. The more viable option then for the source of additional water, with groundwater sources excluded, is to get this water through the CDS.

In the plan of MWSP III, treated surface water is to be transmitted from a treatment plant in Pantay to the reservoir near Cogeo Village. Transmission from this reservoir to the basin using booster pumps is deemed to be effective as costs are reduced and savings are freed for construction and operation of required facilities. However, the implementation of MWSP III has been deferred due to its large cost, but it is targeted to be completed in the year 2011.

Therefore, the most realistic and practical measure that can be immediately implemented is the transmission of the additional water from CDS.

(2) Transmission System from CDS

The nearest point to withdraw water from the CDS is on the primary distribution pipeline (PDP) with a diameter of 2,400 mm. This pipeline is planned to be constructed in AWSOP and it will cross the Marcos Highway at Pasig or the existing PDP with a diameter of 2,000 mm near the AWSOP's proposed PDP. These crossing points are recommended locations for an intake structure.

Since the difference in elevation between the basin and the nearest point of the CDS primary distribution pipe is about 200m, several booster pumping facilities shall be provided for the transmission line.

Transmission route will be laid from Pasig to the basin, passing by Cogeo Village along the Marcos Highway and the Sumulong Highway with a total length of about 13km as illustrated on Figure 8.3.1.

At the time of implementation of MWSP III, a part of this transmission line can be utilized as a transmission line from the Cogeo reservoir to CDS. The point of origin of the transmission line to the basin will be transferred to the Cogeo reservoir at that time.

The rate of 150% of Daily Average Water Demand was adopted for the estimation of Daily Maximum Water Demand based on FAWSP study.

The outline of the proposed transmission system mentioned above is as follows:

Water Volume to be transmitted:

Based on the computation result discussed in Subsection 6.2.3, water volume to be transmitted is:

2000	1,834 m^3/day	(daily average)
	15,508 m^3/day	(daily maximum)
2010	18,149 m^3/day	(daily average)
	40,892 m^3/day	(daily maximum)

Phasing of Construction:

2-phased implementation for the years 2000 and 2010

Diameters and Material of Pipes:

Phase 1 (2000); 450mm steel pipe

Phase 2 (2010); 600mm steel pipe

Length of Pipeline and Elevation Difference:

from Pasig to Cogeo 6.2 km, 95 m

from Cogeo to Poblacion 6.4 km, 145 m

Number of Booster Pumping Stations:

2 ---- Cainta and Cogeo (along the Marcos Highway)

Required Pump Capacity:

Booster Pumping Station No.1;

(Phase 1)

Type	Motor driven volute pump
Total Pumping Head	115m
Discharge	5.40 m^3/min./unit x 2 units (+1 stand-by unit)

Total Required Output of Motors

P = 0.163x5.4x115/0.65x1.15 = 179 say 200 kW

ø250 x 5.40 m^3/min. x 115 m x 200 kW x 3 (1)

(A stand-by pump will be fully used in phase 2.)

(Phase 2)

Type	Motor driven volute pump
Total Pumping Head	115m
Discharge	6.16 m^3/min./unit x 2 units (+1 stand-by unit)

Total Required Output of Motors

P = 0.163x6.15x115/0.65x1.15 = 204 say 220 kW

ø250 x 6.15 m^3/min. x 115 m x 220 kW x 3 (1)

Booster Pumping Station No.2;

(Phase 1)

Type	Motor driven volute pump
Total Pumping Head	170m
Discharge	5.40 m^3/min./unit x 2 units (+1 stand-by unit)

Total Required Output of Motors

P = 0.163x5.40x170/0.65x1.15 = 265 say 280 kW

ø250 x 5.40 m^3/min. x 170 m x 280 kW x 3 (1)

(A stand-by pump will be fully used in phase 2.)

(Phase 2)

Type	Motor driven volute pump
Total Pumping Head	170m
Discharge	6.15 m^3/min./unit x 2 units (+1 stand-by unit)

Total Required Output of Motors

P = 0.163x6.15x170/0.65x1.15 = 284 say 315 kW

ø250 x 6.15 m^3/min. x 170 m x 315 kW x 3 (1)

Measure against Water Hammering Phenomenon:

Flywheel and Check valve

Volume of Pump Well: about 30 minutes operation

Control System: Automatic On-Off Control by water level of distribution reservoirs.

Design concept for Booster Pumping Stations are illustrated on Figures 8.3.2 to 8.3.8.

(3) Distribution System

The distribution system in the basin consists of a distribution reservoir, distribution pipeline network, service connections, fire hydrants and other miscellaneous fixtures.

Two types can be considered for the distribution system in Antipolo. One is a pressurized system using pumping facilities; the other, a gravity flowing system. In the former, pumping facilities capable of meeting peak water demand shall be furnished. The latter will not require pumping facilities. However, location of the site shall have enough elevation to distribute water. Energy costs for the pumping up of water to end-users will not be different at each system theoretically because the necessary energy is the same in both systems. However, and if a suitable site is available, the latter is generally applied because of its lower capital and maintenance cost and stability. Since there are suitable places with appropriate elevations in the background of the Antipolo study area, the gravity flowing system was opted for by this study.

In Phase 1, one distribution reservoir will be provided in Barangay San Luis. A distribution pipeline will be installed from this reservoir.

Another distribution reservoir will be augmented at the same location in Phase 2. In addition, a small-scale reservoir will be provided in Barangay Sta. Cruz for the northwestern district of the study area. Distribution pipelines will be laid from those reservoirs separately. Thus, there will be two distribution systems in Phase 2--the main system and the sub-system. Water for the sub-system will be diverted from the transmission pipeline on the way to the main system.

The rate of 200% of Daily Average Water Demand was adopted for the estimation of Peak Hour Water Demand based on FAWSP study. Based on the analysis of the daily variation pattern of water demand in several areas conducted by LWUA, required capacity of the reservoir was determined to be equivalent to 4 hours operation of daily maximum demand. However, 5 hours was adopted for the sub-system because of its rather small-scale.

Groundwater pumped from deepwells will be injected into the distribution pipeline network through elevated water tanks.

Outline of the distribution system is as follows:

a) Phase 1

Capacity of Distribution Reservoir:

4 hours operation of daily maximum demand

Based on the hydraulic analysis of the distribution network, required capacity is:

247.77 LPS (peak flow)/ 2 x 1.5 x 4 hours.

= 2,676 m3

Dimensions of proposed reservoir is;

27mL x 13.5mW x 4.4mH x 2 (3,200 m^3)

Design concept for the reservoir is illustrated on Figures 8.3.9 to 8.3.10.

Required pipeline and fixtures will be as follows:

Distribution Main Pipeline (Figure 8.3.11):

ø100mm	VP	8,950m
ø150mm	VP	10,390m
ø200mm	VP	3,500m
ø250mm	VP	2,190m
ø300mm	SP	1,600m
ø350mm	SP	740m
ø400mm	SP	390m
ø500mm	SP	370m
ø600mm	SP	900m
Total		29,030m

Valves:

ø100mm - ø600mm 31 units

Air Valves:

Single Type 27 units

Double Type 2 units

Pressure Reduction Valves:

ø150mm 1 unit

ø250mm 1 unit

Drain Valves:

ø100mm 27 units

ø150mm 2 units

Fire Hydrant:

ø100mm 145 units

Internal Distribution Pipeline:

ø75mm 14,515m (50% of distribution main)

ø100mm 14,515m (50% of distribution main)

Service Connections:

Replacement

Residential 3,535 units

Others 203 units

Installation

Residential 13,016 units

Others 389 units

b) Phase 2

Capacity of Distribution Reservoir:

4 hours operation of daily maximum demand

Based on the hydraulic analysis on the distribution network, required capacity was calculated at;

Main System

(233.30+350.07) LPS (peak flow)/ 2 x 1.5 x 4 hours

= 6,300 m3

Necessary capacity to be augmented is:

6,300 - 3,200 = 3,100 m3

Dimensions of proposed reservoir is:

27mL x 13.5mW x 4.4mH x 2 (3,200 m3)

Sub System

50.13 LPS / 2 x 1.5 x 5 hours

= 677 m3

Dimensions of proposed reservoir is:

9mL x 9mW x 4.4mH x 2 (712 m3)

Required pipeline and fixtures will be as follows:

Distribution Main Pipeline (Figure 8.3.12):

ø100mm	VP	4,410m	(Main 3,080, Sub 1,330)
ø150mm	VP	9,860m	(Main 8,420, Sub 1,440)
ø200mm	VP	7,800m	(Main 6,680, Sub 1,120)
ø250mm	VP	4,540m	(Main)
ø300mm	SP	1,310m	(Main)
ø350mm	SP	180m	(Main)
ø400mm	SP	430m	(Main)
ø450mm	SP	1,090m	(Main)

ø500mm	SP	760m	(Main)
ø700mm	SP	900m	(Main)
Total		31,280m	(Main 27,390, Sub 3,890)

Valves:

ø100mm - ø700mm 33 units

Air Valves:

Single Type 28 units

Double Type 3 units

Pressure Reduction Valves:

ø100mm 1 unit

ø150mm 1 unit

Drain Valves:

ø100mm 28 units

ø150mm 3 units

Fire Hydrant:

ø100mm 88 units

Internal Distribution Pipeline:

ø75mm 15,640m (50% of distribution main)

ø100mm 15,640m (50% of distribution main)

Service Connections:

Residential 11,368 units

Others 407 units

For the main system, 2 small-scale booster pumping stations shall be provided for highly elevated districts as follows:

B.P.S No. 3 ø80 x $0.9m^3$/min. x 10m x 3.7kW x 2(1)

B.P.S No. 4 ø32 x $0.1m^3$/min. x 10m x 0.4kW x 2(1)

(4) Project Cost

Cost for the project, including land acquisition cost, is presented in Tables 8.3.1 and 8.3.2, and is summarized as follows:

a) Phase 1

Facilities	Cost (x1,000peso)
Transmission Pipeline	58,343
Booster Pumping Station No.1	42,223
Booster Pumping Station No.2	49,201
Communication Wiring	5,383
Distribution Reservoir	14,308
Distribution Pipelines	89,166
Fire Hydrants	3,461
Service Connections	58,570
Construction Cost Total	320,605
Engineering Cost 12%	38,473
Land Acquisition	9,585
Total	368,663
Physical Contingency 10%	36,866
GRAND TOTAL	405,529

b) Phase 2

Facilities	Cost (x1,000peso)
Transmission Pipeline	95,862
Booster Pumping Station No.1	41,164
Booster Pumping Station No.2	48,051
Distribution Reservoir No.1	15,207
Distribution Reservoir No.2	4,662
Booster Pumping Station No.3	1,099
Booster Pumping Station No.4	750
Distribution Pipelines	113,771
Fire Hydrants	2,005
Service Connections	45,192
Construction Cost Total	367,763
Engineering Cost 12%	44,132
Land Acquisition	1,760
Total	413,655
Physical Contingency 10%	41,365
GRAND TOTAL	455,020

8.3.2 Implementation Plan

As mentioned in Section 6.2, groundwater supply capacity will be enough to meet the demand--on a daily average basis--until the year 1998, if it is fully developed by that year and the water leakage control program is conducted so as to decrease the ratio to 30% of total supply amount. The project cost estimated in Subsection 8.3.1 includes the installation cost of the new pipes along the existing pipes that will be used as temporary water supply pipes during the construction stage and which shall be removed after completion of replacement. This replacement of existing pipes will substantially decrease water leakage.

The project will be divided into two phases as mentioned before. The target year of Phase 1 is the year 2000 and that of Phase 2 is the year 2010. The Phase 1 project has enough time to be implemented, excepting the time expended for the booster pumping facilities and distribution pipeline network. However, it is recommended that the Phase 2 project be implemented as soon as the Phase 1 project is completed since the supply capacity to be furnished by the latter project is aimed at meeting the demand only till the year 2000 and it will not be able to meet the demand soon after that. The implementation schedule of the Phase 1 project was roughly planned as follows:

<u>Groundwater Development</u>

Rehabilitation of Existing Wells	1993
Construction of New Wells	1993 - 1994

<u>Surface Water Development</u>

Installation of Transmission Line	1996 - 1997
Construction of Booster Pumping Stations	1996 - 1997
Construction of Distribution Reservoir	1996 - 1997
Installation of Distribution Pipelines	1997 - 2000

In this schedule, the following considerations were taken into account:

a. Preparations for the rehabilitation of existing wells will begin as soon as possible so as to complete the work by 1993.
b. Preparations for the construction of new wells will begin in 1992 sothat all 7 wells are completed by the middle of 1994.

c. Surface water distribution project will be implemented to supply water by the year 1998 because the water shortage in daily average basis will happen from the year 1999.

d. Feasibility study and detailed engineering design will entail a total time of two and a half (2.5) years, including that expended on loan sourcing/processing, bid preparation, tendering, etc.

e. Construction of the transmission line, booster pump stations, and distribution reservoirs will take one and a half years.

f. Installation of the distribution pipelines will be continuous for 3 years.

In accordance with the above considerations, the time schedule of the project in Phase 1 was prepared as presented in Figure 8.3.13.

8.4 PROJECT EVALUATION

8.4.1 Financial Feasibility Analysis

(1) General

This section discusses the financial feasibility of the project in Phase 1 and develops a financing plan in which the project will be viable. In particular, the following aspects taken into consideration:

a) the costs associated with the proposed project, which include the investment costs and the annual operating and maintenance costs;

b) the potential sources of funds, which are the operating sources (internal cash generation) and the non-operating sources (loans and government equity);

c) the required Financial Internal Rate of Return (FIRR) in projecting the annual revenue; and

d) the costs and revenues that are counted on as additional basis by execution of the project.

(2) Water Tariff

The present water tariff is shown in Table 8.4.1. In the analysis, the Overall Average Tariff projected by CORPLAN, P6.43/m^3, was adopted. In 1990, the average unit production cost per cubic meter was P2.21, based on the data presented in MWSS Annual Report 1990.

(3) Project Financing

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 was assumed that the loans will come from the Asian Development Bank (ADB). The project cost financing is assumed as shown in Table 8.4.2 and the terms include:

Principal	:	US$16.82M (P437.42M) (US$1=P26)
Interest	:	6.36 % interest rate
Repayment Period	:	Twenty years with grace period of five years

It has been assumed that the contribution of the government to equity should not reach more than 30 % of the total project cost.

(4) Cost Analysis

a) Project Cost

The total project cost is P802.97 million, the breakdown of which is shown in Table 8.4.3. The breakdown of foreign and local costs is also presented in Table 8.4.3. The assumptions used are as follows:

a. Engineering/detailed design: 8% of basic costs
b. Construction supervision: 4% of basic costs
c. Physical contingencies: 10% of materials and supplies
d. Price contingencies are based on the following:
   for local costs: 10% up to 1995 and 8% from 1996 onward;
   for foreign component: 4% throughout the period

e. Taxes: 30% of foreign component of equipment/machineries cost plus 10% VAT for all foreign components except engineering cost and for all local cost except labor cost

f. Interest during construction (IDC) : 6.36% per annum

g. Exchange rate: US$1 = P26.00

b) Operation and Maintenance Costs

The operation and maintenance costs include all necessary expenses at the production and distribution levels, based on the projected augmented water amount. The projected annual operation and maintenance cost from 1992 up to 2021 is presented in Table 8.4.4.

Personnel Cost

The total personnel cost incurred in 1990 by the water supply system in the Poblacion of Antipolo was P1,154,280. As there were 19 technicians as of end-1990, the average salary per month of such MWSS personnel in 1990 was estimated at P5,063.

To compute the personnel cost, the unit salary per month was assumed to be P4,000 per employee and P5,000 per engineer/technician. Since the proposed project will be integrated with the MWSS central distribution system, its operation will require additional personnel which is estimated at 5 employees for every additional 1,000 connections.

Electricity

The electricity charge was calculated based on the following terms:

.Generation Charge: P1.985/kWH for electricity consumption
.Energy Charge: P0.160/kWH for electricity consumption
.Distribution Charge: P12.60/kVA for electricity demand

Chemicals

Though water transmitted from CDS is already disinfected at the treatment plant, a cost for additional disinfection chemicals was included considering the long time that elapses before water is distributed. In addition, water from deepwells shall be disinfected before distribution. The average dosage rate and cost of chlorine are assumed at 0.5ppm and P25.5/kg-chlorine.

Maintenance

The annual maintenance cost has been estimated as a percentage of cumulative investment amount for the considered year as shown below:

.Civil works	: 0.5% per year
.Equipment	: 4.0% per year
.Pipeline Networks	: 0.8% per year

Water from CDS

The transmitted water from the CDS has already incurred treatment and distribution costs before its diversion to the proposed system. This cost is estimated at P2.21 per cubic meter based on the data presented in MWSS Annual Report 1990.

c) Escalation of Costs

To account for the effects of inflation, the investment costs and the annual operating and maintenance costs are escalated by applying the corresponding local and foreign inflation factors computed from inflationary trends. The escalation rate used for local inflation is 10% annually upto 1995 and 8 % from 1996 ,and that for foreign inflation is 4% annually.

(5) Financial Projections

The Project's revenues will be generated from water sales. Estimation of water sales are based on demand for water (or Billed Water). Only augmented water, however, is accounted for in the projection of revenue. The projected revenue is shown in Table 8.4.5.
The result of the projected net cash benefit is presented in Table 8.4.6. The following assumptions are used in the projection:

a) Collection efficiency - 80%

b) Provision for Bad Debts - 4%
c) Accounts receivable - 16%

The Computed Financial Internal Rate of Return (FIRR) for the 30-year project life is 4.46% as presented in Table 8.4.6. Though this value is rather small, it is higher than the Weighted Average Cost of Capital (WACC) of 3.47% as calculated below:

WEIGHTED AVERAGE COST OF CAPITAL (WACC)

	FUNDING SOURCE	% TO TOTAL COST	INTEREST RATE	WEIGHTED RATE
1)	Loan	54.5%	6.36%	3.47%
2)	Gov't Equity	30.0%	0.00%	0.00%
3)	Internal Cash Generation	15.6%	0.00%	0.00%
			WACC =	3.47%

The WACC is based on the interest rate of ADB ordinary loan at 6.36% per annum.

(6) Financial Recommendation

The recommended project is financially feasible based on the results of the computed FIRR. The computed FIRR (4.46%) exceeds the estimated 3.47% WACC. Even though the computed FIRR for the proposed project is financially feasible, it is relatively small in comparison with the desirable level for project implementation in the Philippines.

The proposed project includes three components, namely, existing well rehabilitation, new well construction and construction of surface water distribution facilities. As a reference, the financial feasibility of the groundwater development portion of the proposed project,i.e., rehabilitation and new well construction, was verified as presented in Tables 8.4.7 to 8.4.9. In this case, the direct construction cost for the Inner Network and the Fire Hydrant was also assumed to be financed by the Loans. As a result,FIRR was indicated at 11.43% and estimated WACC was 3.46%.

WACC FOR GROUNDWATER COMPONENT

	FUNDING SOURCE	% TO TOTAL COST	INTEREST RATE	WEIGHTED RATE
1)	Loan	54.4%	6.36%	3.46%
2)	Gov't Equity	25.6%	0.00%	0.00%
3)	Internal Cash Gen'n	20.0%	0.00%	0.00%
			WACC =	3.46%

Based on this analysis, it is obvious that the groundwater development portion of the proposed project has higher feasibility than the whole proposed project. Thus, from the financial point of view, the groundwater development portion of the proposed project is recommended for implementation. However, and as stated in Subsection 8.3, the importance of surface water transmission in meeting the future demand of the people in the study area cannot be overemphasized.

8.4.2 Economic Feasibility Analysis

(1) General

Economic analysis involves the evaluation of the effectiveness of the project in terms of socio-economic factors not considered in the financial analysis. The analysis includes an evaluation of benefit and cost variables involved in the proposed improvements in the water supply system.

The implementation of the project will provide the following direct and indirect benefits:

a) Direct Benefits:

- Water is essential to life and to the general well being of society.

- Water is an essential input to any production.

b) Indirect Benefits:

- It can help boost employment and the economy because any program of expenditures has "economic multiplier" for domestic activities.

- It can help augment the government budget, as any development of productive activities generates new public revenue and, therefore, the opportunity for the government to carry out new expansion programs.

- It can reduce some social and economic costs, i.e., the morbidity and mortality rates of some diseases attributed to water shortage, damages caused by fires, etc.

Correspondingly, the realization of the project will produce, besides cost of the investment and of operation & management of the proposed water supply system, other direct and indirect costs depending on:

- Families who pay the water tariff and, therefore, must reduce other consumptions.

- The economy of the country, as large quantities of imports are required.

- The government, as it must give subsidies and grants to the MWSS to help it achieve financial self-sufficiency.

The comparison between the costs and benefits shall allow an assessment of the economic feasibility of the project.

(2) Method of Analysis

The method that was adopted to give an empirical measure of the effectiveness of the project is the Economic Internal Rate of Return (EIRR).

The EIRR is the rate required to balance the present value of the economic costs. This method avoids prior determination of the discount rate.

The project is considered economically feasible if the EIRR is higher than the opportunity cost of capital, or the rate of return that can be obtained from the best alternative use of the available capital. For public investment projects such as water supply projects, the desirable opportunity cost of capital in the Philippines is considered to be 15%.

(3) Economic Benefits of the Project

The economic benefits of the project can be measured as:

- The increment in income or value of some variables "before" and "after" the project; for these computations, the benefits arising from the present system have been deducted. The benefits in this category include increase in consumer satisfaction, increase in income in some productive sectors of the local population, and increase in value of land in the Project Area.

- The reduction in costs realized through the implementation of the project.

a) Consumer Satisfaction

The benefit derived from "consumer satisfaction" includes not only benefit brought about by the actual payments for water but also by how much more consumers are willing to pay for this essential commodity. In general, water prices charged by MWSS are lower than the real value of water; hence, the people in the Project Area are assumed to be willing to obtain water in sufficient quantities at a given price. The resulting economic value of water, assuming it is 1.2 times of the water price shown in Table 8.4.11, is P1,093.3 million.

b) Health

The economic loss to society caused by water shortage and bad water quality, such as death, productive time loss due to sick workers, and expenses entailed in treating water-borne diseases, will be reduced. However, quantification of health benefits is usually difficult because cost statistics on effects of water-borne diseases are in general not disaggregated. Thus, in quantifying health benefits for purposes of this study, three factors were taken into consideration: (a) the cost of time loss due to illness, (b) the income loss due to premature death, and (c) the cost of medical expenses.

In computing the cost of time loss due to illness, it was assumed that not all those afflicted with water-borne diseases are income-earners.

Using the data obtained from the 1980 Census, RPWSIP project staff projected the population that are economically active in 1990, which is estimated at 41.09% for Antipolo, Cainta and Taytay:

Economically Active Population

	Rizal	3 areas
1. Total Population	555,533	258,499
2. Population with gainful occupation	171,348	106,235
% (2/1)	30.84%	41.09%

(Source: F/S, RPWSIP)

In this study, the economically active population ratio of 40% was adopted for the analysis.

Morbidity rate of water-borne diseases in Metro Manila for 1990 was 345 per 100,000 population. The final figure for the cost of time loss due to illness was derived by taking the economically active portion of the population as earning the minimum wage of P118/day for 8 days, and based on the assumption that workers earning P118/day are unable to work for an average of 8 days per year.

The income loss due to premature death was calculated as the product of the following: mortality rate of 21.9 per 100,000, the served population and P155,760, which represents the estimated income to be earned by the average wage earner over a period of five years (P118/day x 264 days/year x 5 years).

The cost of medical expenses was derived by multiplying morbidity rate of the served population and the average annual expenditure for medical expenses of P3,500. This figure was based on the research findings of the RPWSIP project staff on the average medical expenses which are shown in Table 8.4.12.

Finally, the sum of all three economic costs related to health benefits was adjusted by 20% to account for the fact that not all water-borne diseases are caused by a poor water system but may also be due to poor personal hygiene or lack of sewerage facilities.

The total present value of health benefits as presented in Table 8.4.13 is P7.8 million.

c) Fire Protection

The installation of fire hydrants and the increased water pressure will possibly reduce losses due to fire. The extent of fire protection is held to be in proportion to the installation of fire hydrants for each construction period/year of the improvement program. Though 100% of the Project Area is covered by fire hydrants, 20% of fire protection coverage is considered as resulting from the project.

The reduction of fire damage is assumed to be 0.75% of the combined assessed value of structures in the Project Area. The average assessed value of each structure is P500,000, with the number of structure being derived from the total population in the Project Area assuming that each dwelling unit has an average of 7 members (based on the survey result by FAWSP). The present value of fire protection benefits is projected at P155.3 million as shown in Table 8.4.15.

d) Land Value Increase

The water supply improvement project will contribute to an increase in land value of the service area. However, this increased value could be the result of a general increase of productivity due to improved infrastructure which includes a water supply project.

The portion of land values attributable to the water supply system in the service area was determined by comparing the market values of land served and not-served by the water supply system. The market values of residential land in the study area range from about P500 to P800 per sq.m. Generally, it is assumed that 20% to 25% of the incremental value of land could be attributed to the water supply system.

In this study, a land value increase of 25% was also applied. However, for the Poblacion area which is already being served by the existing system, albeit inadequately, the land value increase was estimated at 5%.

The increase of land value was projected at P429.3 million as shown in Table 8.4.16.

(4) Economic Costs of the Project

The direct cost of the project which should be transformed into economic costs are: project cost, replacement cost and operating and maintenance costs.

a) Project Cost

Shadow pricing system was devised for items that are not economically valued by the purely financial price mechanism. This scheme includes making necessary adjustments inasmuch as the foreign exchange component of the project cost may adversely affect the economy because of the reduction in foreign exchange reserves. Thus, it was assumed that the true cost of foreign exchange would be increased by 20%. Likewise, unskilled labor costs should be reduced by 50% because the opportunity cost of unskilled labor is lower than the estimated cost in the project due to the widespread disguised unemployment in the Philippines. Skilled labor was valued at its going rate. It was assumed that skilled laborers were not looking elsewhere to obtain employment or better wage. Table 8.4.17 presents the economic project cost which is P491.0 million.

b) Replacement Costs

The replacement costs or the costs incurred in order to replace mechanical equipment and other items that have outlived their usefulness are considered part of the economic costs.

The economic life of mechanical and electrical equipment was assumed to be 15 years. And the value of the replacement cost was assumed to be equivalent to 80% of the initial investment costs for equipment. Shadow pricing system was also applied to the conversion of financial costs to economic costs. Total economic replacement cost for the analysis is P167.8 million (see Table 8.4.18).

c) Operation and Maintenance Costs

Only incremental costs of personnel, power, chemicals, maintenance, and water were considered in the economic analysis. This cost category was converted to economic costs by shadow pricing items for which the market price is not sufficient. The factors for converting operation and maintenance cost to economic costs were the same as those used for adjusting the project costs. Five percent (5%) was deducted from the local portion as tax. Out of personnel cost, 50% was assumed to be unskilled labor. The total incremental operation and maintenance cost is P753.1 million (see Table 8.4.19).

d) Summary of Economic Costs

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 as shown in Table 8.4.20 is P1,449.7 million.

(5) Economic Internal Rate of Return (EIRR)

Table 8.4.21 shows the computation of the EIRR. The EIRR is 17.19%. Since this rate exceeds the desirable opportunity cost of capital of 15%, the project is considered economically feasible.

As reference, the economic feasibility of a part of a proposed project was verified, i.e., the groundwater development portion that calls for the rehabilitation of some existing wells and the construction of new ones, and is presented in Tables 8.4.22 to 8.4.30. In this case, computed EIRR is at 17.2%, assuming a lower increase of land value due to insufficient augmentation of water to meet demand, which this increase of land value being higher under a full-scale project implementation.

TABLE 8.1.1 CANDIDATE WELLS FOR REHABILITATION OF MWSS DEEPWELLS (March, 1991)

UNIT: NUMBERS OF WELLS)

MUNICIPALITY	Total wells		ACTIVE WELLS						INACTIVE WELLS					
			Good		D-pump		Total		D-pump		Stand-by +Rehab		Total	
	C	F	C	F	C	F	C	F	C	F	C	F	C	F
ANTIPOLO	15	15	11	11	4	4	15	15	0	0	0	0	0	0
BACOOR	6	8	6	8	0	0	6	8	0	0	0	0	0	0
CALOOCAN	0	2	0	0	0	0	0	0	0	0	0	2	0	2
CAINTA	5	6	2	3	1	1	3	4	1	1	1	1	2	2
CAVITE	12	12	12	12	0	0	12	12	0	0	0	0	0	0
IMUS	2	2	2	2	0	0	2	2	0	0	0	0	0	0
KAWIT	6	6	4	4	0	0	4	4	0	0	2	2	2	2
LAS PINAS	1	4	0	0	1	1	1	1	0	1	0	2	0	3
MANDALUYONG	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAKATI	8	32	1	6	3	3	4	9	2	5	2	18	4	23
MALABON	1	3	0	1	0	0	0	1	0	0	1	2	1	2
MANILA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARIKINA	0	11	0	0	0	0	0	0	0	0	0	11	0	11
MONTALBAN	3	3	3	3	0	0	2	3	0	0	0	0	0	0
MUNTINLUPA	6	6	5	5	1	1	6	6	0	0	0	0	0	0
NAVOTAS	1	1	1	1	0	0	1	1	0	0	0	0	0	0
NOVELETA	0	9	0	9	0	0	0	9	0	0	0	0	0	0
PARANAQUE	3	5	3	5	0	0	3	5	0	0	0	0	0	0
PASAY	3	3	1	1	2	2	3	3	0	0	0	0	0	0
PASIG	1	1	1	1	0	0	1	1	0	0	0	0	0	0
PATEROS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUEZON	13	17	10	14	0	0	10	14	2	2	0	1	3	3
ROSARIO	3	3	1	1	0	0	1	1	0	0	1	2	2	2
SAN JUAN	0	0	0	0	0	0	0	0	0	0	2	0	0	0
SAN MATEO	3	3	3	3	0	0	3	3	0	0	0	0	0	0
TAGUIG	1	1	1	1	0	0	1	1	0	0	0	0	0	0
TAYTAY	6	7	5	6	1	1	6	7	0	0	0	0	0	0
VALENZUELA	1	2	1	2	0	0	1	2	0	0	0	0	0	0
TOTAL	100	162	73	99	13	13	85	112	5	9	9	41	14	50

Note: C- Candidate wells for rehabilitation
F- Feasible wells for rehabilitation

TABLE 8.1.2 REHABILITATION PLAN OF MWSS DEEPWELLS

(UNIT: NUMBERS OF WELLS AND DISCHARGE RATE=m3/day)

MUNICIPALITY	Groundwater demand in 1995 (m3/day)	Actual discharge in 1990 (m3/day)	Difference (m3/day)	Target wells for rehabilitation					Expected increased discharge after rehab. (m3/day)
				Active wells		Inactive wells		Total Wells	
				Nos	Increase (m3/day)	Nos	Increase (m3/day)		
ANTIPOLO	24,525	11,616	-12,409	15	3,105	0	0	15	3,105
BACOOR	0	6,329	6,329	6	1,242	0	0	6	1,242
CALOOCAN	0	0	0	0	0	0	0	0	0
CAINTA	0	3,781	3,782	3	621	2	1,380	5	2,001
CAVITE	20,675	8,942	-11,733	12	2,484	0	0	12	2,484
IMUS	13,795	1,644	-12,151	2	414	0	0	2	414
KAWIT	0	4,329	4,239	4	828	2	1,380	6	2,208
LAS PINAS	0	1,534	1,534	1	207	0	0	1	207
MANDALUYONG	0	0	0	0	0	0	0	0	0
MAKATI	0	3,753	3,753	4	828	4	2,760	8	3,588
MALABON	0	548	548	0	0	1	690	1	690
MANILA	0	0	0	0	0	0	0	0	0
MARIKINA	0	0	0	0	0	0	0	0	0
MONTALBAN	0	3,233	3,233	3	621	0	0	3	621
MUNTINLUPA	0	5,781	5,781	6	1,242	0	0	6	1,242
NAVOTAS	0	110	110	1	207	0	0	1	207
NOVELETA	3,584	7,069	3,485	0	0	0	0	0	0
PARANAQUE	0	1,151	1,151	3	621	0	0	3	621
PASAY	0	4,466	4,466	3	621	0	0	3	621
PASIG	0	55	55	1	207	0	0	1	207
PATEROS	0	0	0	0	0	0	0	0	0
QUEZON	0	14,192	14,192	10	2,070	3	2,070	13	4,140
ROSARIO	5,840	877	-4,963	1	207	2	1,380	3	1,587
SAN JUAN	0	0	0	0	0	0	0	0	0
SAN MATEO	0	4,712	4,712	3	621	0	0	3	621
TAGUIG	0	630	630	1	207	0	0	1	207
TAYTAY	0	6,466	6,466	6	1,242	0	0	6	1,242
VALENZUELA	0	740	740	1	207	0	0	1	207
TOTAL	68,419	91,958	23,539	86	17,802	14	9,660	100	27,462

Note: NO GOOD - No operational or no good conditioned wells

TABLE 8.2.1 DETAILS OF MWSS DEEPWELLS - ANTIPOLO AREA

Well No.	Casing Dia. (")	Well Depth (m)	Pumpage (MCM/year)
ATP- 1	6	83.82	0.1261
ATP- 2	8	163.06	0.2667
ATP- 3	6	150.87	0.3215
ATP- 4	8	100.00	0.3352
ATP- 5	6	151.78	0.1305
ATP- 6	8	135.32	0.1377
ATP- 7	6	91.44	0.5001
ATP- 8	8	121.94	0.6205
ATP- 9	8	121.94	0.5687
ATP-10	6	79.24	0.5733

Note: Pumpage data (1990) were derived from the Groundwater Use Survey

TABLE 8.2.2 DETAILS OF PRIVATE DEEPWELLS - ANTIPOLO AREA

Well No.	Well Name	Casing dia. (")	Well Depth (m)	Pumpage (MCM/year)
ATP-2102	STA.Lucia Realty			0.2486
ATP-2106	Assumption Grade Sch.			0.1657
ATP-2082	Citizen Dev. Realty			0.1824
ATP-2083	Dna. Angela Subd.			0.01
ATP-2006	Far East Asia Dev. Corp.			0.01
ATP-2101	Top Service Inc.#1			0.2985
ATP-2100	Top Service Inc.#2			0.2985
ATP-2065	Grand Heights Subd.			0.0821
		8	182.87	0.5271
			54.87	0.4974
ATP-2104	Unciano Medical Center			0.0552
ATP-2064	Milagros Subd.	8	183	0.0921
ATP-2093	Lores Realty #1			0.1104
ATP-2094	Lores Realty #2			0.1104
ATP-2105	Dalaya Construction			0.0132
ATP-2079	San Antonio Village			0.0363
ATP-2103	STA.Lucia Realty			0.2365
ATP-2016	Gloria HTS. Ass'n	8	121.95	0.1073
ATP-2035	Nayong Silangan #1	8	121.95	0.0221
ATP-2036	Nayong Silangan #2	8	121.95	0.0236
ATP-2037	Banaba Court Subd.	8	125.30	0.0414
ANG-2007	Maya Farms Inc.			0.0027
ANG-2008	Maya Farms Inc.			0.0069
ANG-2009	Maya Farms Inc.			0.0069
ANG-2006	Petro Finance Service I			0.0018
ANG-2010	Grand Valley Subd.			0.4139

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