โครงการประปาระบบอิสระ

FEASIBILITY STUDY FOR THE SEPARATE SYSTEM OF METROPOLITAN WATER SUPPLY IN BANGKOK, THAILAND

METROPOLITAN
WATER WORKS
AUTHORITY

PROGRESS REPORT

MARCH 2520 (1977)

JAPAN INTERNATIONAL COOPERATION AGENCY

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MEMORANDUM REQUESTED BY MR. VIBUL TAWEESUP

(Director
Project Planning & Control Division
Metropolitan Water Works Authority)

1. Pg. 36 Under Bang Bo insert

(iv) Others: MWWA has an improvement project to dig a deep well w/capacity of 200 CM per hour and a 120 CM reinforced concrete elevated tank and also reinstall the distribution system. The construction is expected to be finished in this comming September.

2. Pg. 66 Table 4-3 should revised as attached Table sheet.

(page ii)

Revision of Table 4-3, page 66

Water Production of MWWA in Central System

Year	Water Production			
	Treatment Plant cu.m. / day	Ground Water cu.m. / day	Total cu.m. / day	Ground Water as percentage
1975	850,000	350,000	1,200,000	29.2
1976	850,000	327,000	1,177,000	27.6
1977	850,000	476,000	1,326,000	35.9
1978	850,000	566,000	1,416,000	40.0
1979	1,650,000	540,000	2,190,000	24.6
1980	1,650,000	486,000	2,136,000	22.8
1981	2,050,000	436,000	2,486,000	17.5
1985	3,250,000	282,000	3,532,000	8.0
1990	4,450,000	-	4,450,000	-
1995	5,450,000	-	5,450,000	-
2000	5,450,000	-	5,450,000	-

Notes :

1. Assume 10 % decreasing per year for existing deep wells.
2. The construction of five (5) deep wells with capacity of 200 cu.m./hr. and twenty seven (27) deep wells with capacity of 300 cu.m./hr. will be finished in 1977.
3. The construction of twenty (20) deep wells with capacity of 300 cu.m./hr. will be finished in 1978.

PPCD March 24, 1977

LIST OF ERRATUM

1.	Pg. 1 line 21	Should read mentioned in the Scope of Works.
2.	Pg. 6 line 8	Delete Miss Usalee Wongchiep : Typist
3.	Pg. 9 line 12	Delete water quality analysis, insert all electric prospecting.
4.	Pg. 13 line 8	Should read And the prediction of water demand at AD 2000 for separate System have been prepared including a comprehensive water supply system.
5.	Pg. 13 line 21	Should read However, it is also necessary to.
6.	Pg. 14 line 5	Should read each Amphoe seems not to be considered.
7.	Pg. 14 line 23	Delete Table 2-14, insert Table 2-15.
8.	Pg. 19 line 1	Delete Table 2-5, insert Table 2-6.
9.	Pg. 20 line 1	Delete Table 2-6, insert Table 2-7.
10.	Pg. 21 line 1	Delete Table 2-7, insert Table 2-8.
11.	Pg. 22 line 1	Delete Table 2-8, insert Table 2-9.
12.	Pg. 23 line 1	Delete Table 2-9, insert Table 2-10.
13.	Pg. 24 line 1	Delete Table 2-10, insert Table 2-11.
14.	Pg. 25 line 1	Delete Table 2-11, insert Table 2-12.
15.	Pg. 26 line 1	Delete Table 2-12, insert Table 2-13.
16.	Pg. 27 line 1	Delete Table 2-13, insert Table 2-14.
17.	Pg. 28 line 1	Delete Table 2-14, insert Table 2-15.
18.	Pg. 29 line 6	Delete Table 2-15, insert Table 2-16.
19.	Pg. 29 line 12	Delete in the follwing chapter.
20.	Pg. 29 line 16	Delete Table 2-16 to Table 2-18, insert Table 2-17 to Table 2-19.
21.	Pg. 29 line 18	Delete Table 2-16, insert Table 2-17.

22.	Pg. 30	line 1	Delete Table 2-15, insert Table 2-16.
23.	Pg. 31	line 1	Delete Table 2-17, insert Table 2-18.
24.	Pg. 32	line 1	Delete Table 2-18, insert Table 2-19.
25.	Pg. 36	line 6	Delete 200 CM 2 unit, insert 120 CM 1 unit and 100 CM 1 unit.
26.	Pg. 36	line 7	Delete 23 meter, insert 23 meter and 18 meter.
27.	Pg. 36	line 12	Should read 2000 AD for all Amphoes including additional areas,
28.	Pg. 50	line 25	Should read comparatively low at northen part of both Nong Chok and Kin Buri, and southern part of both Bang Phli and Bang Bo.
29.	Pg. 52	line 2	Should read at eastern part of both Bang Yai and Bang Bua Trong.
30.	Pg. 56	line 11	Delete Effluent, insert Recharge.
31.	Pg. 56	line 12	Delete chapter 2,2-1, insert previous report.
32.	Pg. 65	line 22	Insert and its locations are shown on Fig. 4-4.
33.	Pg. 100	line 6	Should read Bangkok, Thonburi, Nonthaburi, Samut Prakan and.

Contents

1. Preface and General Consideration

1-1 Preface

The water supply system of the suburban area of Metropolitan Bangkok was studied from various angles in the previous feasibility study of a separate system which study carried out in March,1973 to include five (5) Amphoes (Nong Khaem, Bang Bua Thong, Bang Yai, Sai Noi and Lat Krabang) out of nine (9) Amphoes which consist of the suburban area of Metropolitan Water Works Authority. The previous survey was carried out by Japan International Cooperation Agency (JICA) - successor of Overseas Technical Cooperation Agency (OTCA). Field survey has been conducting from 23rd January in 1977 by twelve (12) members of Japanese Survey Team and objectives of study are as follows;

(1) To carry out a feasibility study of the water supply system in the four (4) Amphoes of Minburi, Nong Chok, Bang Phli and Bang Bo;

(2) To review, and if necessary to revise, the feasibility study of the water supply system in five (5) Amphoes of Nong Khaem, Bang Bua Thong, Bang Yai, Sai Noi, and Lat Krabang which was carried out in 1973 by OTCA (JICA'S Predecessor);

(3) To carried out a feasibility study for the additional district which were requested by MWWA as being mentioned scope works.

(4) To recommend a master plan for the water supply system of the nine (9) Amphoes above mentioned until the target year of A.D 2000, including layout and characteristics of the main facilities.

It was generally agreed that the major problem of Separate System would be the water sources. It is said the 350,000 CMD of ground water for Central System and 400,000 CMD of ground water for private use are obtained from existing wells, and also new deep wells are still going to be installed in Central System.

On the other hand, unrestricted use of ground water had led to the rapid expansion of unfortunate area such as the contaminated area with sea water and the subsidence by the heavy lifting of water, and it is expected that phenomenon abovementioned will extend to larger scale unless some legal provisions are made to restrict the heavy use of ground water.

Meanwhile, sources of surface water can be found in Chao Phraya River and Nakhon Chai Si River. However, the plan cannot be put into practice due to problems related with the scale and geographical position of Separate System.

In view point of economical condition, field survey for scurces of surface water was carried out putting importance to find a reasonable intake site of river and/or khlongs. As for wells, it seems that capacity of wells are good enough to cover only Amphoe's demand excluding new projects such as housing, industries and new airport. Therefore, it is consided that wells are suitable to be used as water sources for the use of Amphoe town, taking economical condition into consideration.

1-2 The Status of Separate System in relation to the Central System

At the commencement of field survey, it has been discussed that it is necessary to serve water to the new projects such as housings, industries and new airport as parts of the area of Separate System. Comparing with total amount of nine (9) Amphoe's demand , demand of new projects are more than two times as much. Therefore, it seems difficult to cover satisfactorily all demand of water including new project from deep well.

On the other hand, it is considered to be feasible to send clear water to Separate System from proposed service reservoir of Central System, even including great demand of new projects mentioned in detail on 4-3. Since Central System has been implementing of the 1st Phase

construction at the 1st Stage program and detailed design of 2nd Phase at the 1st Stage program has already been made, it will be impossible to change the design concerning to 1st Phase. Therefore, the review of Central System will be only concentrated into the 2nd Phase and 2nd Stage taking the demand of Separate System into consideration.

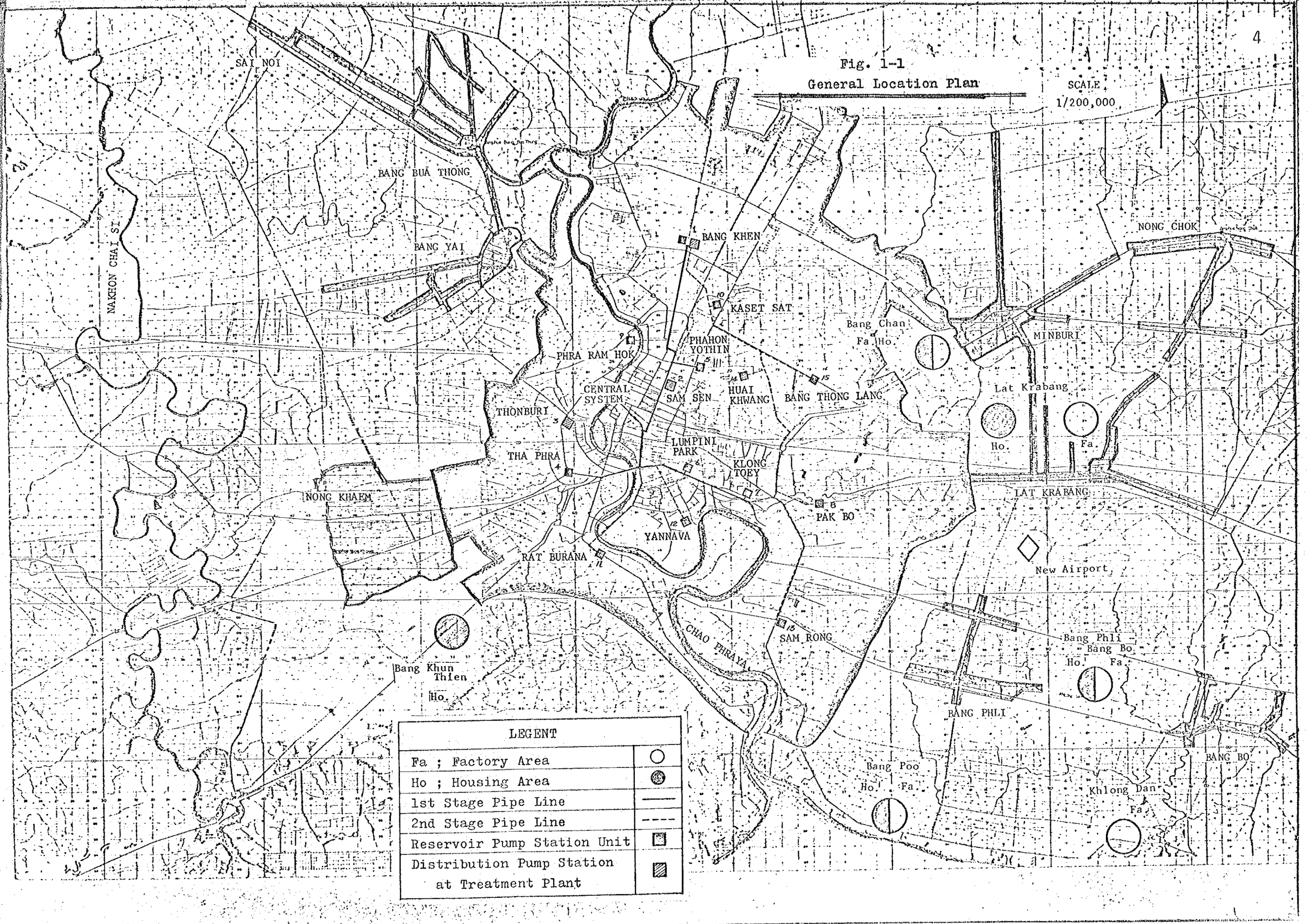
1-3 Emergency Works

To establish concrete plan for each Amphoe, the first step is to predict the water demand in 2000 A.D. and then draw out a water work project corresponding to the future demand. And then, the construction work was designed to be carried out in three stages, so that emergency works will be preceded to rehabilitate present condition as a first step of the first stage in which the construction was limited to Amphoe Town and its vicinity where the population was concentrated and new pipes were scheduled to be installed stage by stage.

The location of each Amphoe and additional district area show on Fig. 1-1.

Fig. 1-1
General Location Plan

SCALE
1/200,000



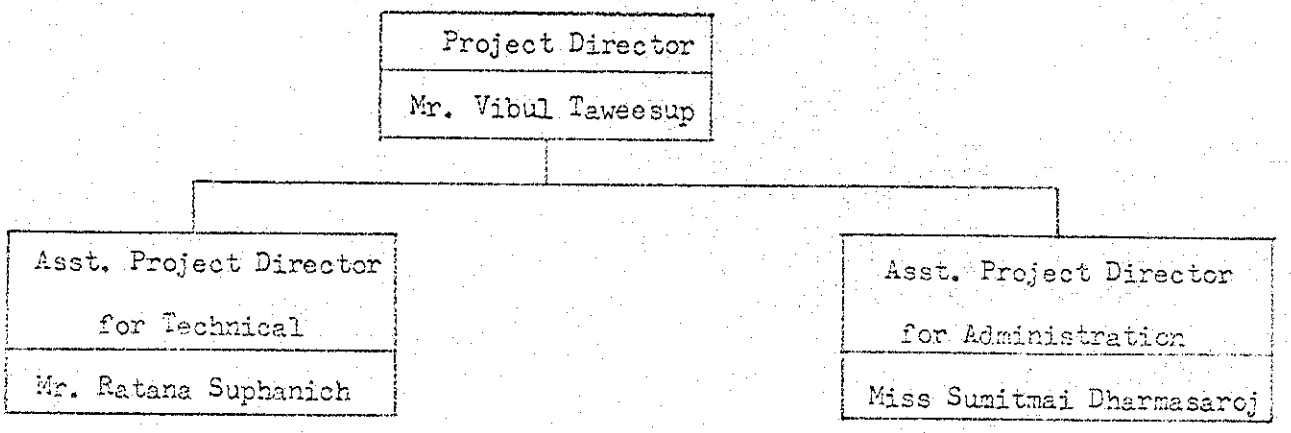
LEGENT	
Fa ; Factory Area	○
Ho ; Housing Area	◉
1st Stage Pipe Line	——
2nd Stage Pipe Line	- - - -
Reservoir Pump Station Unit	□
Distribution Pump Station at Treatment Plant	▨

1-4 Persons concerned

JAPANESE SURVEY TEAM FOR THE SEPARATE SYSTEM OF METROPOLITAN WATER SUPPLY WORKS

Dr. S. Naito	Technical Adviser	Japan Water Works Association (Chairman of the Mission)
Mr. K. Okazawa	Technical Adviser	Ministry of Health & Welfare (Vice-chairman of the Mission)
Mr. K. Shiozawa	Director	Nakanihon Engineering Consultants Co., Ltd. (General Planning)
Mr. K. Kawamura	Head	Nakanihon Engineering Consultants Co., Ltd. (Water Supply Planning Economics)
Mr. N. Muto	Staff	Pacific Consultants International (Ground Water)
Mr. T. Ogawa	Staff	Pacific Consultants International (Ground Water)
Mr. S. Komatsu	Staff	Pacific Consultants International (Intake & Treatment)
Mr. E. Kawabata	Staff	Pacific Consultants International (City Planning)
Mr. Y. Nakamura	Staff	Nakanihon Engineering Co., Ltd. (Intake & Treatment)
Mr. K. Miyakura	Staff	Pacific Consultants International (Water Supply Planning)
Mr. Y. Hashizi	Staff	Nakanihon Engineering Co., Ltd. (Distribution System)
Mr. H. Takemoto	Staff	Pacific Consultants International (Distribution System)

ORGANIZATION CHART OF SEPARATE WATER SUPPLY SYSTEM IN MWA



Mr. Borirak Tasanon	:	Engineer
Mr. Prasart Silphiphat	:	Engineer
Mr. Warawuth Wongwisej	:	Engineer
Miss Thidachan Chaiyapruk	:	Economist

Mrs. Boonruang Khwanboon	:	Clerk
Mr. Damrong Hase	:	Driver
Mr. Sanong Poothong	:	Driver
Mr. Pratheep Songphsook	:	Driver
Mr. Nate Sheiwka	:	Driver

The contents of the survey work are shown in the following list of schedule. The survey was conducted during the mid-summer period in Thailand between January and March.

Date	Schedule	Contents of Survey Work
Jan. 23, Sun.	Haneda-Bangkok by LH flight	Dr. Naito, Mr Okazawa and other two engineers arrived in Bangkok.
Jan. 24, Mon.	In Bangkok	Visit MWWA, Japanese Embassy and JICA for courtesy call.
Jan. 25, Tues.		Consultation between MWWA about scope of works.
Jan. 26, Wed.	Haneda-Bangkok by JL flight	Other eight members arrived in Bangkok.
Jan. 27, Thurs.	In Bangkok	preparation of the office and maps. Meeting and preparation within team.
Jan. 28, Fri.		Discussion with MWWA about The Inception Report and schedule. Inspection of Bang Phli and Bang Bo areas, study of existing waterworks and water sources.
Jan. 29, Sat.		Tracing of maps and preparation of field survey.
Jan. 30, Sun.		Consultation among team members.
Jan. 31, Mon.		Inspection of Min Buri, Nong Chok and Lat Krabang on the left bank, study of existing water works and water sources.
Feb. 1, Tues.		Inspection of Nong Khaem on the right bank, study of existing water works and water sources.
Feb. 2, Wed.		Inspection of Bang Yai, Bang Bua Thong and Sai Noi on the right bank, stusy of existing water works and water sources.

Feb. 3, Thurs.		Work schedule for each categories of the team discussed among team members.
Feb. 4, Fri.		Making data sheet for detailed field and discussion among teams. Discussion with MWWA with work schedule.
Feb. 5, Sat.		Adjusting field data.
Feb. 6, Sun.	Team chairman Dr. Naito left for Japan.	Consultation among team members.
Feb. 7, Mon.		Discussion about new additional areas. Inspection in hearing at Sai Noi area. Preparation and arrangement for electric prospecting.
Feb. 8, Tues.		Discussion with MWWA about five additional areas. Electric prospecting at Lat Krabang.
Feb. 9, Wed.		Preparation for water quality analysis Inspection at Bang Bua Thong. Electric prospecting on site.
Feb. 10, Thurs.		Consultation with Industrial Estate Authority (IEA) and National Housing Authority (NHA) Inspection at Bang Kum Chang. Electric Prospecting on site.
Feb. 11. Fri.		Water sampling at Khlong Thawi Watthana Inspection at Bang Kum Chang (additional area) Ground water by Electric prospecting and hearing.
Feb. 12, Sat.		Preparation for collecting data for additional areas.
Feb. 13, Sun		Meeting and Discussion among team members.

Feb. 14, Mon.	Discussion with Air Port Office. Study of Nong Khaem Area, and Inspection on Bang Phli. Analysis for ground water and electric prospecting on site.
Feb. 15, Tues.	Adjusting additional Area data. Inspection on Bang Bo on water sources. Electric Prospecting on site.
Feb. 16, Wed.	Discussion with NHA and study of data on I.E.A. Analysis of ground water and electric prospecting on site, the right bank finished water quality analysis.
Feb. 17, Thurs.	Pre-study for Bang Phli and Bang Po. Checking the water source around Klong 13th and 6th. Water analysis and adjusting electric Prospecting.
Feb. 18, Fri.	Pre- study the right bank. Checking the water source and surrounding at Lat Krabang.
Feb. 19, Sat.	Tracing the map and data collection.
Feb. 20, Sun.	Consultation among the team members.
Feb. 21, Mon.	Consultation distribution plan for all areas. Analysis of ground water and electric Prospecting.
Feb. 22, Tues.	Discussing about ground water consultation with MWWA. Adjusting and studying feasi-blity plan.
Feb. 23, Wed.	Adjusting and analysis of data. Discussion for additional Erectrical prospecting.

Feb. 24, Thurs.		Electric prospecting and inspecting at Sai Noi, Bang Bua Thong and Bang Yai.
Feb. 25, Fri.		Discussion with M.W.W.A. Electric prospecting as same as 24th February .
Feb. 26, Sat.		Consulting among team member with ground water , blocking an area and studying with Control System.
Feb,27, Sun.	Ground water team left for Japan.	Tracing and preparing the drawings.
Feb. 28, Mon.		Studying the blocking. Preparation for water sampling.
Mar. 1, Tues.		Studying the distribution plans. Preparation and discussion at Samsen Water Purification Plant.
Mar. 2, Wed.		Studying each separate system. Water sampling at Nakhon Chai Si River.
Mar. 3, Thurs.		Preparation and studying for separate supply system. Water sampling at Khlong Mae Nam Om.
Mar.4, Fri.		Preparation and studying for supply system.
Mar. 5, Sat.		Consultation and adjusting the data collected.
Mar. 6, Sun.		Tracing and preparing the study.
Mar. 7, Mon.		Preparation and studying for supply system for each Amphoe.
Mar. 8, Tues.		Water sampling at Chao Phraya River. Preparation and studying for water supply system for each Amphoe.

Mar. 9, Wed.		Discussing for each supply system. Preparation for specification . Water sampling at Nakhon Chai St. River.
Mar. 10, Thurs.		Re-inspection for delivery system at the right bank. Water sampling at Min Buri, Nong Chok and Lat Krabang. Preparation for specification.
Mar. 11, Fri.		Reinspection for delivery system at the left bank. Water sampling at Bang Phli and Bang Bo. Preparation for specification.
Mar. 12, Sat.		Preparation for specification and relating drawing.
Mar. 13, Sun.	Team chairman Dr. Naito and two members arrived to Bang--kok	Preparation for specification and relating drawing.
Mar. 14, Mon.		Visiting JICA and MWWA. Preparation for specification and relating drawing.
Mar. 15, Tues.		Visit P.W.D. and DTEC Preparation for specification and relating drawing.
Mar. 16, Wed.		Preparation for specification and relating drawing. Translation of specification.
Mar. 17, Thurs.		Translation of specification.
Mar. 18, Fri.		Ditto
Mar. 19, Sat.		Typing for specification
Mar. 20, Sun.		Ditto
" 21, Mon.		Ditto

Mar. 22 Tue.		Bookbinding for specification.
Mar. 23, Wed.		Survey for Bang Khen treatment plant.
Mar. 24, Thurs.		Final consultation with MWWA and DTEC.
Mar. 25, Fri.		Visit of courtesy to MWWA. Japanese Embassy and JICA etc.
Mar. 26, Sat.	Leave for Japan.	

2. Water Demand

The Survey has been carried out to check the water demand for nine (9) Amphoes, which are included in Separate System around Metropolis and suburbs. To collect the necessary data for predicting the new water demand at additional area such as industrial areas, housing areas and new airport those which are additionally requested by the Scope of Works, the survey has been undertook.

In addition to the prediction of water demand at A.D. 2000 for Separate System, comparative plans have been prepared including a comprehensive water supply system.

2-1 Water Demand for Each Amphoe

Although water demand for nine (9) Amphoes were already estimated in our previous report at 1973, the Scope of Works have brough additional survey such as revision of water supply area, served popullation and water demand, in order to provide basic plans for water supply system.

2-1-1 Area to be served

The selection of the area to be served is considered to be rather difficult because of isolate location of the houses along the khlong. In general speaking, the size of the served area are usually set as wider as possible, in order to manage the water supply undertakings economically. However, it also necessary to consider several factors such as the cost limit for construction, living pattern of houses, conditions for high-way passing through the each Amphoe and social or economical condition.

These served area for each Amphoe are shown on the Fig.2-1 and its area are shown as Table - 2-1 .

2-1-2 Density of Population

Comparing the population prediction estimated in 1973 and the acutal population collected from each Amphoe office, it is possibly said that minor difference are found except Bang Phli area. The population at the center of each Amphoe are considered and required to modify or change the last figures made in 1973.

On the contrary, the population increase seems to be expected along the khlong and outside of the Amphoe Town. Consequently, the density of population at A.D. 2000 for each Amphoe is predicted as much as the figure estimated in the previous report. The density of population and the number of population are shown on Table - 2-2.

2-1-3 Changes of Population in the Served Area

In spite of the confirmation about population prediction in AD 2000 mentioned above, population increase shall be checked again through calculation of population prediction. The result of calculation are shown on Table - 2-3.

2-1-4 House Connection and Daily Maximum Consumption

The estimation for house connection and daily maximum consumption of the previous report are considered to be reasonable and shown as Table - 2-4 to Table- 2-5.

2-1-5 Water Demand

Providing these values above mentioned, the water demand for each year are listed on Table - 2-6 through Table - 2-14. Among these, the water demand has increased great deal, because it has included additional area which locates in north-each direction of Nong Khaem. And also, Bang Bo area has included Bang Poo area which locates about seven (7) kilometers away to the south of this area.

Fig. 2-1

Served Areas and Water Demands (at 2543 (2000))

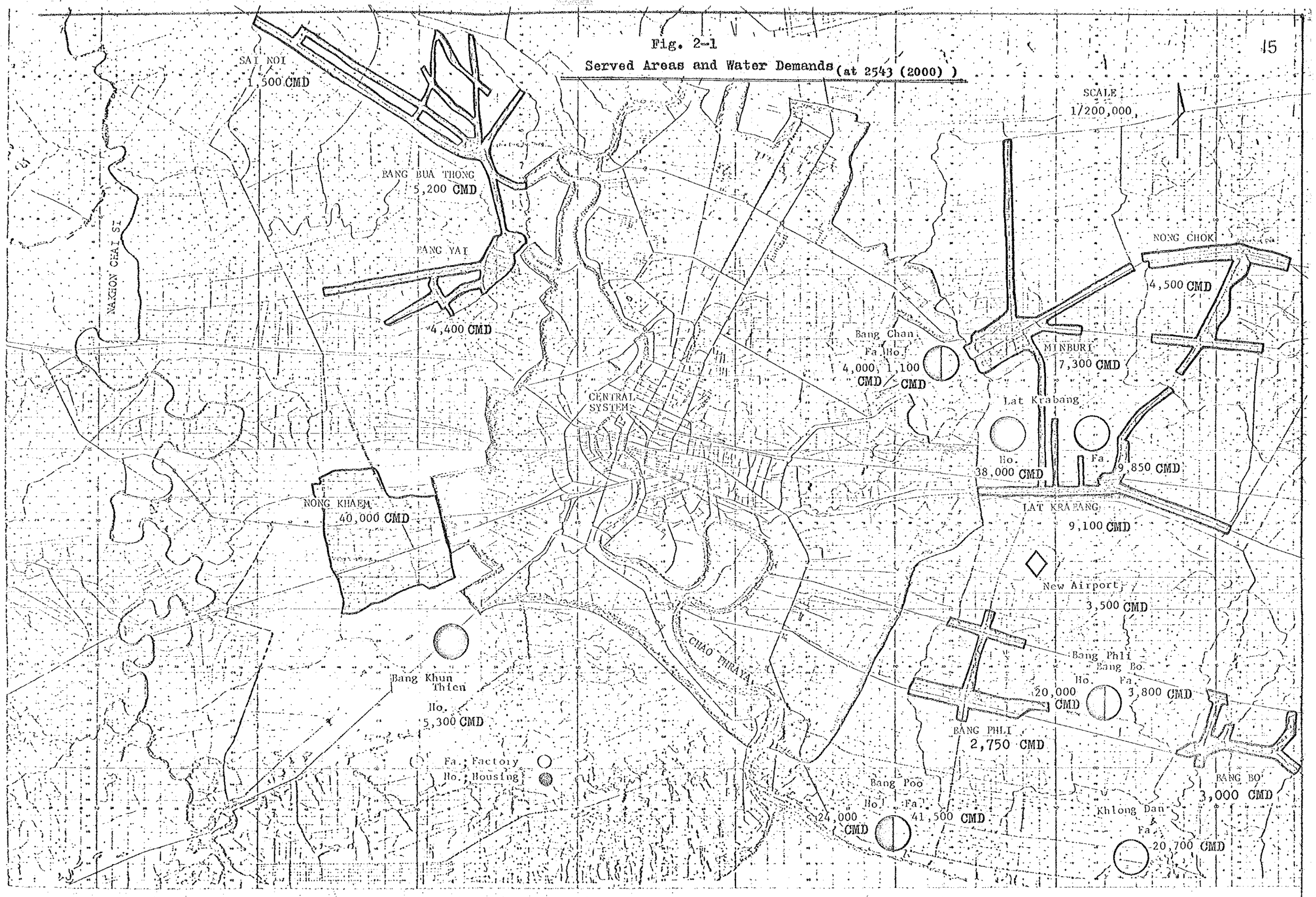


Table 2-1

Water Surved Area of 9 Amphoes

	Amphoe	Water Surved Area (Km^2)	Remarks
Right Bank	Sai Noi	6	
	Bang Bua Thong	18	
	Bang Yai	16	
	Nong Khaem	55.2	
Left Bank	Nong Chok	18	
	Min Buri	22	
	Lat Krabang	22	Adjacent of New Air Port
	Bang Phli	11	
	Bang Bo	7	

Table 2-2

The Density of Population and Population in the Area
(at 2,000 AD)

	Amphoe	Water Served Area (Km^2)	Density of Population (per/km^2)	Population in the Area (person)
Right Bank	Sai Noi	6	1,500	9,000
	Bang Bua Thong	18	1,750	31,500
	Bang Yai	16	1,650	26,500
	Nong Khaem	55.2	2,500	138,000
Left Bank	Nong Chok	18	1,500	27,000
	Min Buri	22	2,000	44,000
	Lat Krabang	22	2,500	55,000
	Bang Phli	11	1,500	16,500
	Bang Bo	17	1,500	10,500

Table 2-3 Presumption of Population around Water Supply Area for nine (9) Amphos

	Amphoe	1975	1980	1985	1990	1995	2000	Remarks
Right Bank	Sai Noi	2,018	3,414	4,811	6,207	7,604	9,000	
	Bang Bua Thong	11,773	15,719	19,664	23,609	27,554	31,500	
	Bang Yai	5,935	10,048	14,161	18,274	22,387	26,500	
	Nong Khaem	32,000	44,000	59,000	79,000	105,000	138,000	
Left Bank	Nong Chok	7,000	11,000	15,000	19,000	23,000	27,000	
	Min Buri	17,800	23,000	28,200	33,400	38,700	44,000	
	Lat Krabang	18,242	25,592	32,944	40,296	47,648	55,000	
	Bang Phli	7,000	8,900	10,800	12,700	14,600	16,500	
	Bang Bo	5,500	6,500	7,500	8,500	9,500	10,500	

(person)

Table 2-4 Presumption of House Connection (percent)

Year	1975	1980	1985	1990	1995	2000
House Connection (per cent)	62.5 %	65.0	67.5	70.0	72.5	75.0

Table2-5 Daily Maximum Quantity Consumed (ℓ/c.d.)

Year	Less than 50,000 Persons	50,000-100,000 Persons	More than 100,000 Persons
1975	182.5	190	225
1980	190	210	240
1990	205	230	270
2000	220	250	300

Table 2-5' Summary of Population to be Served and Daily Maximum Water Demand

	Amphoe		1980	1985	1990	1995	2000	Remarks
Right Bank	Sai Noi	Po	2,219	3,247	4,345	5,513	6,750	
		Da	500	700	900	1,200	1,500	
	Bang Bua Thong	"	10,217	13,273	16,526	19,977	23,625	
		"	2,000	2,700	3,400	4,300	5,200	
	Bang Yai	"	6,531	9,559	12,792	16,231	19,875	
		"	1,300	1,900	2,700	3,500	4,400	
	Nong Khaem	"	28,600	39,825	55,300	76,125	103,500	
		"	8,000	14,000	20,000	28,000	40,000	
	Sub-Total	"	47,567	65,904	88,963	117,846	153,750	
		"	11,800	19,300	27,000	37,000	51,100	
Left Bank	Nong Chok	"	7,150	10,125	13,300	16,675	20,250	
		"	1,400	2,000	2,800	3,600	4,500	
	Min Buri	"	14,950	19,035	23,380	28,058	33,000	
		"	2,900	3,800	4,800	6,000	7,300	
	Lat Krabang	"	16,635	22,237	28,207	34,545	41,250	
		"	3,200	4,400	5,800	7,400	9,100	
	Bang Phli	"	5,785	7,290	8,890	10,585	12,375	
		"	1,100	1,450	1,850	2,250	2,750	
	Bang Bo	"	4,225	5,063	5,950	6,888	7,875	
		"	1,500	1,700	2,100	2,550	3,000	
	Sub-Total	"	48,745	63,750	79,727	96,751	114,750	
		"	10,100	13,350	17,350	21,800	26,650	
TOTAL		Po	96,312	129,654	168,690	214,597	268,500	
		Da	21,900	32,650	44,350	58,800	77,750	

Note: Po, Population to be Served (person)

Da, Daily Maximum Water Demand (CMD)

Table 2-6

Basic Plan -SAI NOI-

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area(person)	2,018	3,414	4,811	6,207	7,604	9,000
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be Served (person)	1,261	2,219	3,247	4,345	5,513	6,750
Daily Maximum (l/c.d)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (CMD)	300	500	700	900	1,200	1,500

Table 2-7

Basic Plan -BANG BUA THONG-

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area(person)	11,773	15,719	19,664	23,609	27,554	31,500
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be Served (person)	7,358	10,217	13,273	16,526	19,977	23,625
Daily Maximum (l/c.d)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (CMD)	1,400	2,000	2,700	3,400	4,300	5,200

Table 2-8

Basic Plan -BANG YAI-

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area(person)	5,935	10,048	14,161	18,274	22,387	26,500
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be Served (person)	3,709	6,531	9,559	12,792	16,231	19,875
Daily Maximum (l/c.d)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (CMD)	700	1,300	1,900	2,700	3,500	4,400

Table 2-9

Basic Plan -NONG KHAEM-

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area(person)	32,000	44,000	59,000	79,000	105,000	138,000
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be Served (person)	20,000	28,600	39,825	55,300	76,125	103,500
Daily Maximum (ℓ/c.d)	225.0	240.0	255.0	270.0	285.0	300.0
Daily Maximum (CMD)	4,500	6,864	10,155	14,931	21,695	31,050
Out of Nong Khaem Area (CMD)	500	1,136	3,845	5,069	6,305	8,950
Total	5,000	8,000	14,000	20,000	28,000	40,000

Table 2-10

Basic Plan -NONG CHOK-

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area(person)	7,000	11,000	15,000	19,000	23,000	27,000
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be Served (person)	4,375	7,150	10,125	13,300	16,675	20,250
Daily Maximum (l/c.d)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (CMD)	800	1,400	2,000	2,800	3,600	4,500

Table 2-11

Basic Plan -MIN BURI-

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area(person)	17,800	23,000	28,200	33,400	38,700	44,000
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be Served (person)	11,125	14,950	19,035	23,380	28,058	33,000
Daily Maximum (l/c.d)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (CMD)	2,100	2,900	3,800	4,800	6,000	7,300

Table 2-12

Basic Plan -LAT KRABANG-

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area(person)	18,242	25,592	32,944	40,296	47,648	55,000
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be Served (person)	11,401	16,635	22,237	28,207	34,545	41,250
Daily Maximum (l/c.d)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (CMD)	2,100	3,200	4,400	5,800	7,400	9,100

Table 2-13

Basic Plan -BANG PHLI-

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area(person)	7,000	8,900	10,800	12,700	14,600	16,500
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be Served (person)	4,375	5,785	7,290	8,890	10,585	12,375
Daily Maximum (l/cd)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (CMD)	800	1,100	1,450	1,850	2,250	2,750

Table 2-14

Basic Plan -BANG BO-

	1975	1980	1985	1990	1995	2000
Population in Water Supply Area(person)	5,500	6,500	7,500	8,500	9,500	10,500
House Connection (%)	62.5	65.0	67.5	70.0	72.5	75.0
Population to be Served (person)	3,438	4,225	5,063	5,950	6,888	7,875
Daily Maximum (ℓ/c d)	182.5	190.0	197.5	205.0	212.5	220.0
Daily Maximum (CMD)	700	850	1,000	1,250	1,500	1,750
Out of Bang Bo Area (CMD)	500	650	700	850	1,050	1,250
Total	1,200	1,500	1,700	2,100	2,550	3,000

2-2 Water Demand for Additional Area

According to the Scope of Works, new developing plans such as five (5) factory areas, five (5) housing areas and new airport shall be included in Separate System. In this respect, the water demand are based on the estimation prepared by Industrial Estate Authority and National Housing Authority. All these summary are shown on Table - 2-15.

2-3 Summary for Water Demand

The water demand at 2000 AD is calculated as 249,500 CMD for the whole Separate System, that is 56,400 CMD for the right bank and 193,100 CMD for the left bank of Chao Phraya River. To meet satisfactorily the water demand, a most suitable plan for comprehensive water supply system will be suggested in following chapter. It will be included for the considerations of the water source, arrangement of water distribution and possibility of getting water from the Central System.

The water demand for Amphoe and additional area are summarised as Table - 2-16 to Table - 2-18.

Table 2-16
Summary of Water Demand (2000 AD)

		Right Bank	Left Bank	Total
Population to be served(person)		153,750	114,750	268,500 (9 Amphoes)
Water Demand	Amphoe (CMD)	51,100	26,650	77,750
	Additional Area (CMD)	5,300	166,450	171,750
	Total (CMD)	56,400	193,100	249,500

Table 2-15 Water Demend for Additional Area (CMD)

	Location		1980	1985	1990	1995	2000
Right Bank	Bang Khun Thien	Fa	-	-	-	-	-
		Ho	5,300	5,300	5,300	5,300	5,300
	Total		5,300	5,300	5,300	5,300	5,300
Left Bank	Bang Chan	Fa	4,000	4,000	4,000	4,000	4,000
		Ho	1,100	1,100	1,100	1,100	1,100
	Lat Krabang	Fa	5,200	5,200	9,850	9,850	9,850
		Ho	2,700	13,300	26,000	38,000	38,000
	New Airport		1,500	2,000	2,500	3,000	3,500
	Bang Phli Bang Bo	Fa	1,100	3,800	3,800	3,800	3,800
		Ho	4,000	12,000	20,000	20,000	20,000
	Bang Poo	Fa	1o,400	1o,400	20,700	31,200	41,500
		Ho	5,040	17,760	24,000	24,000	24,000
	Khlong Dan	Fa	5,200	12,450	20,700	20,700	20,700
		Ho	-	-	-	-	-
	Total		40,240	82,010	132,650	155,650	166,450

Fa: Factory Area

Ho: Housing Area

Table 2-17 Water Demand of the right bank of Chao Phraya River (CMD)

	Location / Year		1980	1985	1990	1995	2000	Remarks
North 3 Districts	Amphoe	Sai Noi	500	700	900	1,200	1,500	
		Bang Bua Thong	2,000	2,700	3,400	4,300	5,200	
		Bang Yai	1,300	1,900	2,700	3,500	4,400	
	Sub Total		3,800	5,300	7,000	9,000	11,100	
Nong Khaem District	Amphoe	Nong Khaem	8,000	14,000	20,000	28,000	40,000	
	Development Program	Bang Khun Thien Ho	5,300	5,300	5,300	5,300	5,300	
	Sub Total		13,300	19,300	25,300	33,300	45,300	
Right Bank Total			17,100	24,600	32,300	42,300	56,400	

Table 2-18 Water Demand of the left bank of Chao Phraya River (CMD)

	Location			1980	1985	1990	1995	2000	Remarks
East 3 Districts	Amphoe	Nong Chok		1,400	2,000	2,800	3,600	4,500	
		Min Buri		2,900	3,800	4,800	6,000	7,300	
		Lat Krabang		3,200	4,400	5,800	7,400	9,100	
	Sub Total			7,500	10,200	13,400	17,000	20,900	
	Development Program	Bang Chan	Fa	4,000	4,000	4,000	4,000	4,000	
			He	1,100	1,100	1,100	1,100	1,100	
		Lat Krabang	Fa	5,200	5,200	9,850	9,850	9,850	
			He	2,700	13,300	26,000	38,000	38,000	
		New Air Port		1,500	2,000	2,500	3,000	3,500	
	Sub Total			14,500	25,600	43,450	55,950	56,450	
South 2 Districts	Amphoe	Bang Phli		1,100	1,450	1,850	2,250	2,750	
		Bang Bo		1,500	1,700	2,100	2,550	3,000	
	Sub Total			2,600	3,150	3,950	4,800	5,750	
	Development Program	Bang Phli -Bang Bo	Fa	1,100	3,800	3,800	3,800	3,800	
			He	4,000	12,000	20,000	20,000	20,000	
		Bang Poo	Fa	10,400	10,400	20,700	31,200	41,500	
			He	5,040	17,760	24,000	24,000	24,000	
		Khlong Dan	Fa	5,200	12,450	20,700	20,700	20,700	
	Sub Total			25,740	56,410	89,200	99,700	110,000	
	Left Bank Total			50,340	95,360	150,000	177,450	193,100	

Fa : Factory Area

He : Housing Area

3. Review for Existing Water Supply Facilities

In case of water supply planning for nine (9) Amphoes, the field survey has been carried out for one month particularly at February, 1977 to check the existing facilities. As the result, hereinafter, the present status of the existing facilities are briefly described, in view of possible continuity to be in service.

3-1 Existing Facilities

3-1-1 The Right Bank of Chao Phraya River

1) Sai Noi

Deep Well has been abandoned since 10 years ago, following with the reason which has the high content of chloride ion and iron. At present, the rain water are used for drinking, and water from khlong are utilizing for other purposes for living.

2) Bang Bua Thong

In 1963, the water treatment plant was constructed purifying the Khlong water named Khlong Phra Phimon. However, the quality of the Khlong water has been gradually worsening year by year, so that it has been reported that the ground water reconnaissance will be made in near future.

(i) Outline of the existing treatment plant

a. Purification method: Chemical Sedimentation and Rapid Sand Filtration

b. Capacity of treatment: 2,000 CMD

c. Mean turbidity of raw water: 1,000 milligram/liter

d. Dosing rate (average):

Alum : 132 ppm

Lime: 250,000 g/month

Chlorine: 2 ppm

e. Rate of filtration: 100 meter/day

f. Washing: Back wash (once a day)

(ii) Elevated Tank: a. Capacity: 50 CM, 1 unit

b. Effective Height: 20 meters

(iii) Distribution Pipe: Main pipes, 100 mm A.C.P.

(iv) Others: The pressure of backwash has not been kept in stable, so that the gravel of sand bed has been exposed and the breakthrough has been presented. As the result, treated water contains higher turbidity rather than normal figure.

3) Bang Yai

Since long time ago, last well was abandoned because of sand intrusion into pipe. Since 1976, the new well has been in operation at the location of about 500 meters away from last one.

(i) Capacity of Well: 1,200 CMD (Submerged Pump)

(ii) Elevated Tank: a. Capacity: 60 CM, 1 unit

b. Effective Height: 20 meters

(iii) Distribution Pipe: Main Pipes, 100 mm A.C.P.

4) Nong Khaem

Although, the feasible plan was suggested at 1973, it has not been implemented yet. One deep well are now operating, however, quality of the well water contains chloride ion more than 200 ppm. Therefore, it can be said that any deep well of same aquifer is not to be feasible.

3-1-2 The Left Bank of Chao Phraya River

1) Nong Chok

Two deep wells are operating now having less lifting amount, so that it is not used for drinking purpose but for the other, after being mixed with khlong water. The facilities shall not be considered to be in service of a new water supply system.

(i) Capacity of Well: unknown

(ii) Elevated Tank: a. Capacity 60 CM, 1 set

b. Effective Height: 20 meters

(iii) Distribution Pipe: Main Pipes, 100 mm A.C.P.

2) Min Buri

Two deep wells are operating now, however it is too old something like about 15 years. Therefore, the facilities seems to be out of order.

(i) Capacity of Well : 2,800 CMD and 1,900 CMD

(ii) Elevated Tank: Capacity: 50 CM, 1 unit; 70 CM, 1 unit

Effective Height: 20 meters

(iii) Distribution Pipe: Main Pipes, 200 mm A.C.P.

3) Lat Krabang

Land subsidence caused by lifting ground water are observed about 10 CM during 8 years after being constructed. The reason of subsidence is caused by closed location of two wells each other. Therefore, some counter measure must be considered as soon as, before the heavy draw down would be recorded.

(i) Capacity of Wells: 1,000 CMD, 3 units

(ii) Elevated Tank: a. 50 CM, 1 unit

b. 60 CM, 1 unit

(iii) Distribution Pipes: Main Pipes, 100 mm A.C.P.

4) Bang Phli

The lifting amount of existing deep well is very little, so that Khlong water has been used for living.

(i) Capacity of Well: 720 CMD

(ii) Elevated Tank: Capacity: 100 CM, 1 unit

Effective Height: 23 meters

(iii) Distribution Pipe: Main Pipes, 100 mm A.C.P.

5) Bang Bo

The deep well water is supplied to not only Bang Bo but also Khlong Dam where is located out of Bang Bo area.

(i) Capacity of Well: a. 1,200 CMD, 1 unit

b. 500 CMD, 1 unit

(ii) Elevated Tank: Capacity 200 CM, 2 unit

Effective Height: 23 meters

(iii) Distribution Pipe: Bang Bo Area: 150 mm A.C.P.

Khlong Dam Area: 200 mm A.C.P.

3-2 Consideration and Suggestion

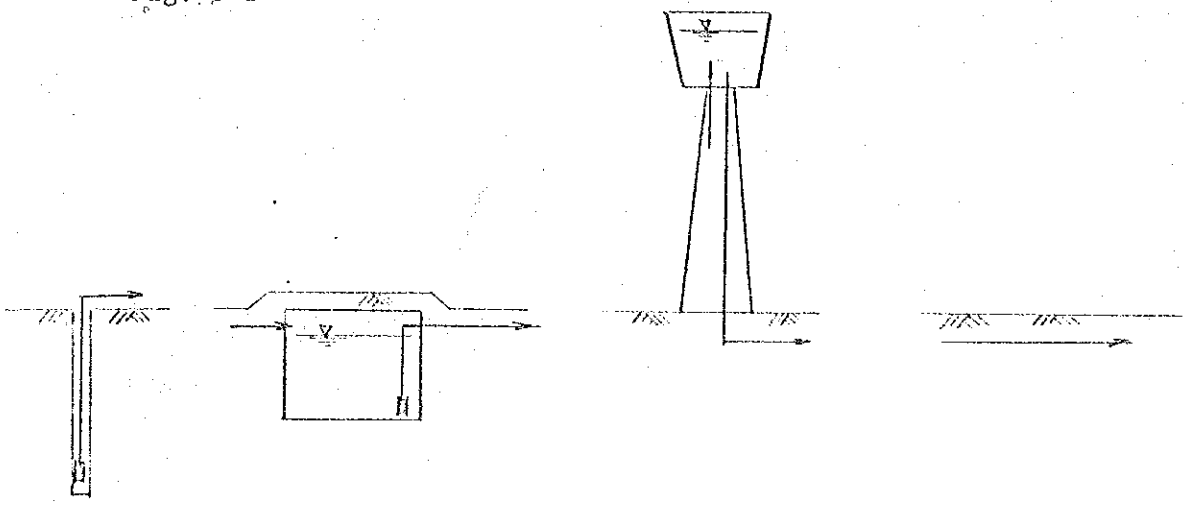
3-2-1 General

The water demand of 249,500 CMD in 2000 AD, as being listed in Chapter 2, would not be able to be supplied satisfactorily by ground water only. Consequently, the water sources in furture water supply system shall be selected to use a surface water or central system alternately. Although future water supply system shall be planned as a comprehensive water supply, it seems to be difficult to implement right now a comprehensive system. From this point of view, a ground water supply system will be much feasible than the other, in order to rehabilitate present status in earliest convenience.

3-2-2 Basic Water Flow Diagram for Water Supply System

The water flow diagram will be suggested basically for each Amphoe as shown on Fig. 3-1.

Fig. 3-1



Well Reservoir Elevated Tank Distribution Pipe

3-2-3 Suggestion for Existing Facilities

1) Well

Since existing well was constructed about 5 to 10 years ago without setting up useful control equipments, new flow meter and water level meter shall be installed.

2) Elevated Tank

Elevated tanks are located nearby the center of each Amphoe and it shall be considered to be an desirable location for present supply but also the furture one.

3) Distribution Pipe

For each Amphoe, the existing distribution system main might be considered not to be enough to cover future demand, so that the new distribution pipe shall be installed in accordance with the new capacity.

3-2-4 Suggestions for Making Plans

1) Construction for Service Reservoir

At each Amphoe, the capacity of elevated tank is relatively small and the water balance between lifting and delivering are seems not to be good. This brings that the operation of lifting water are interrupted irregularly, so that the life of deep well shall be shortened. At the same time, the distribution of water are seems to be unstable all the time. In order to improve these circumstances, the service reservoir (six (6) hours detention) shall be suggested to be constructed. The capacity of service reservoir in each Amphoe shall be estimated on Table 3-1.

2) Observation Well

The intrusion of sea water may be expected at Amphoe Bang Phli and Bang Bo, so that the observation well will be constructed at the same time of new deep well construction.

3) Installation of Equipment

Chlorinator shall be installed at the point of influent pipe, and flow meter for each wells are suggested to be installed.

4) Construction Plan

The construction plan shall be considered as following figures. (Fig.-3-2 - Fig. -3-10)

Table-3-1

Capacity of Service Reservoir in each Amphoe

Amphoe	Capacity of Service Reservoir (CM)	Daily Maximum Water Demand (CMD)
Sai Noi	400	1,500
Bang Bua Thong	1,300	5,200
Bang Yai	1,100	4,400
Nong Khaem	10,000	40,000
Min Buri	1,800	7,300
Nong Chok	1,100	4,500
Lat Krabang	2,300	9,100
Bang Phli	700	2,750
Bang Bo	450	1,750
Klong Dan	300	1,250

Fig. 3-2

Basic Plan -SAI NOI-

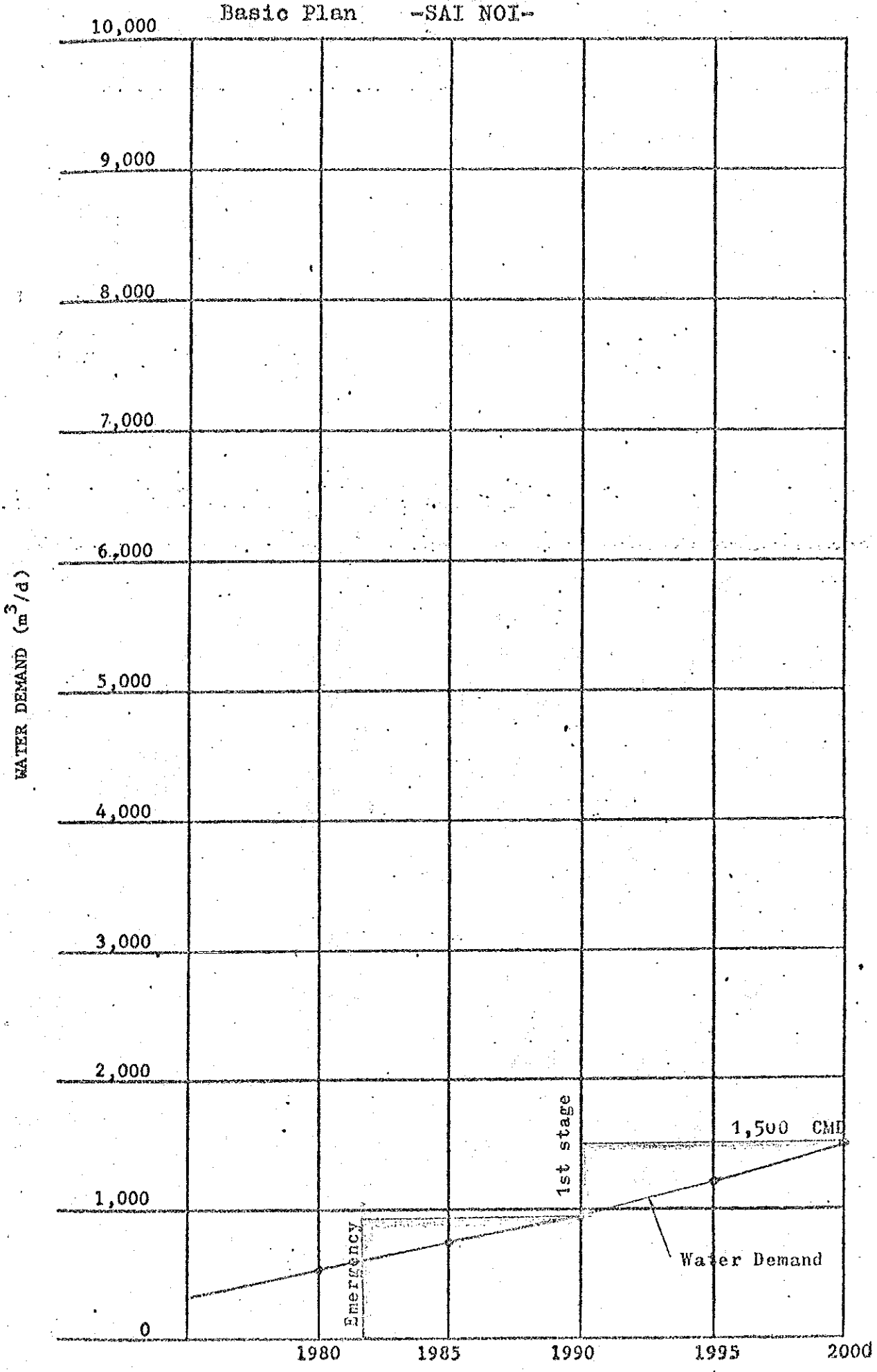


Fig. 3-3

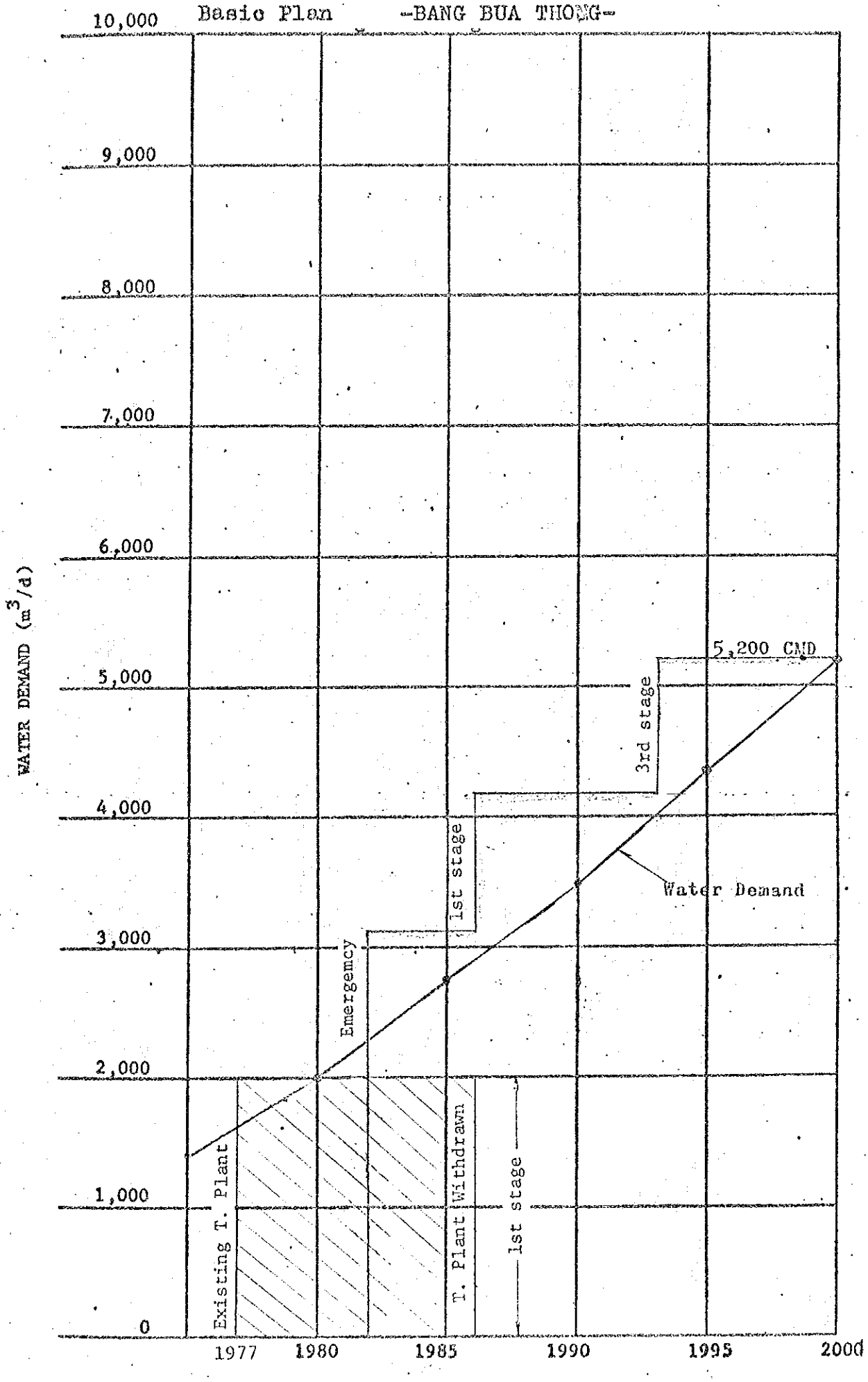

Basic Plan -BANG BUA THONG-
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
WATER DEMAND (m³/d)
5,200 CMD
3rd stage
1st stage
Water Demand
Emergency
Existing T. Plant
T. Plant Withdrawn
1st stage
1977
1980
1985
1990
1995
2000

Fig. 3-4

Basic Plan -BANG YAI-

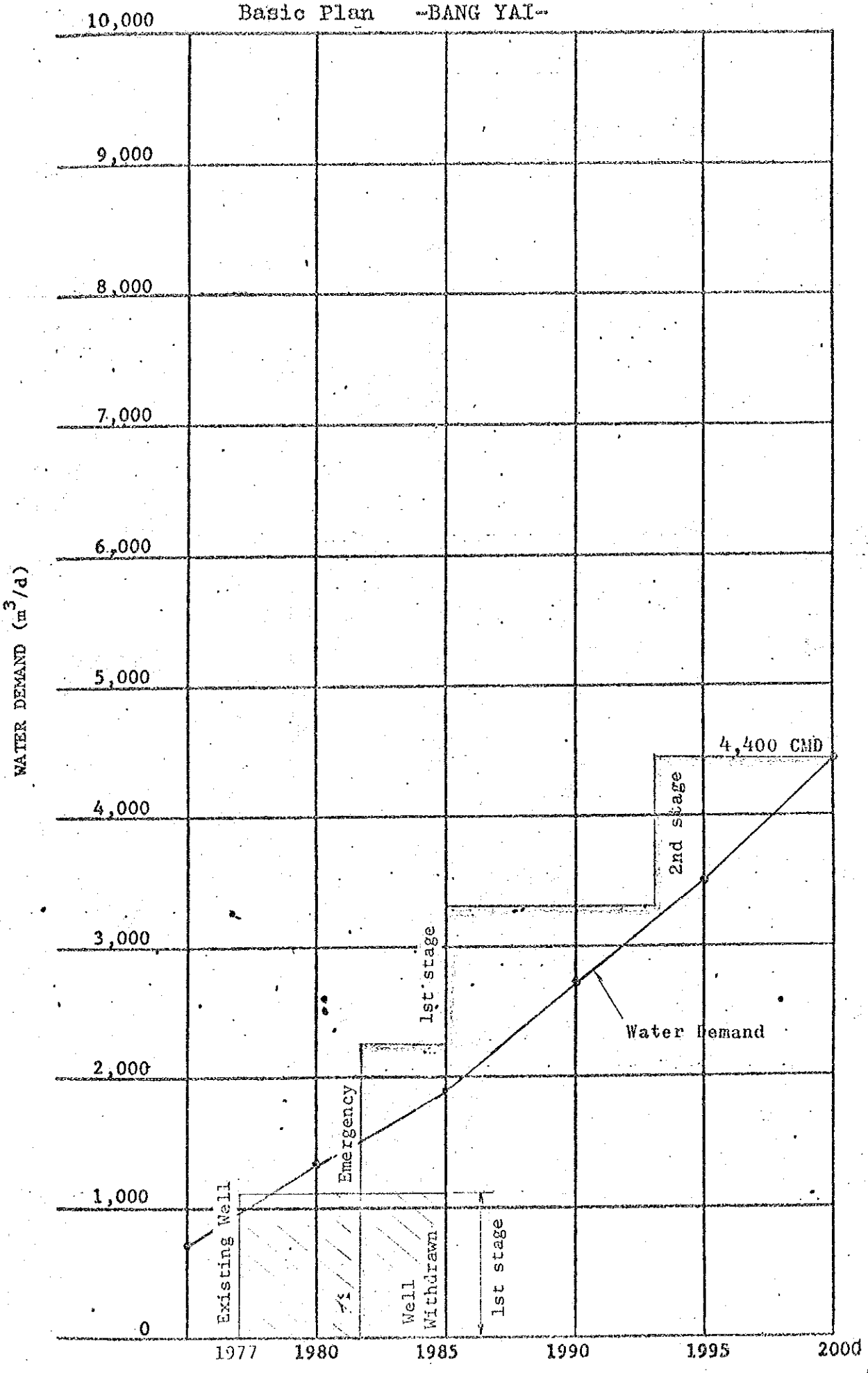


Fig. 3-5

Basic Plan - NONG KHAEM-

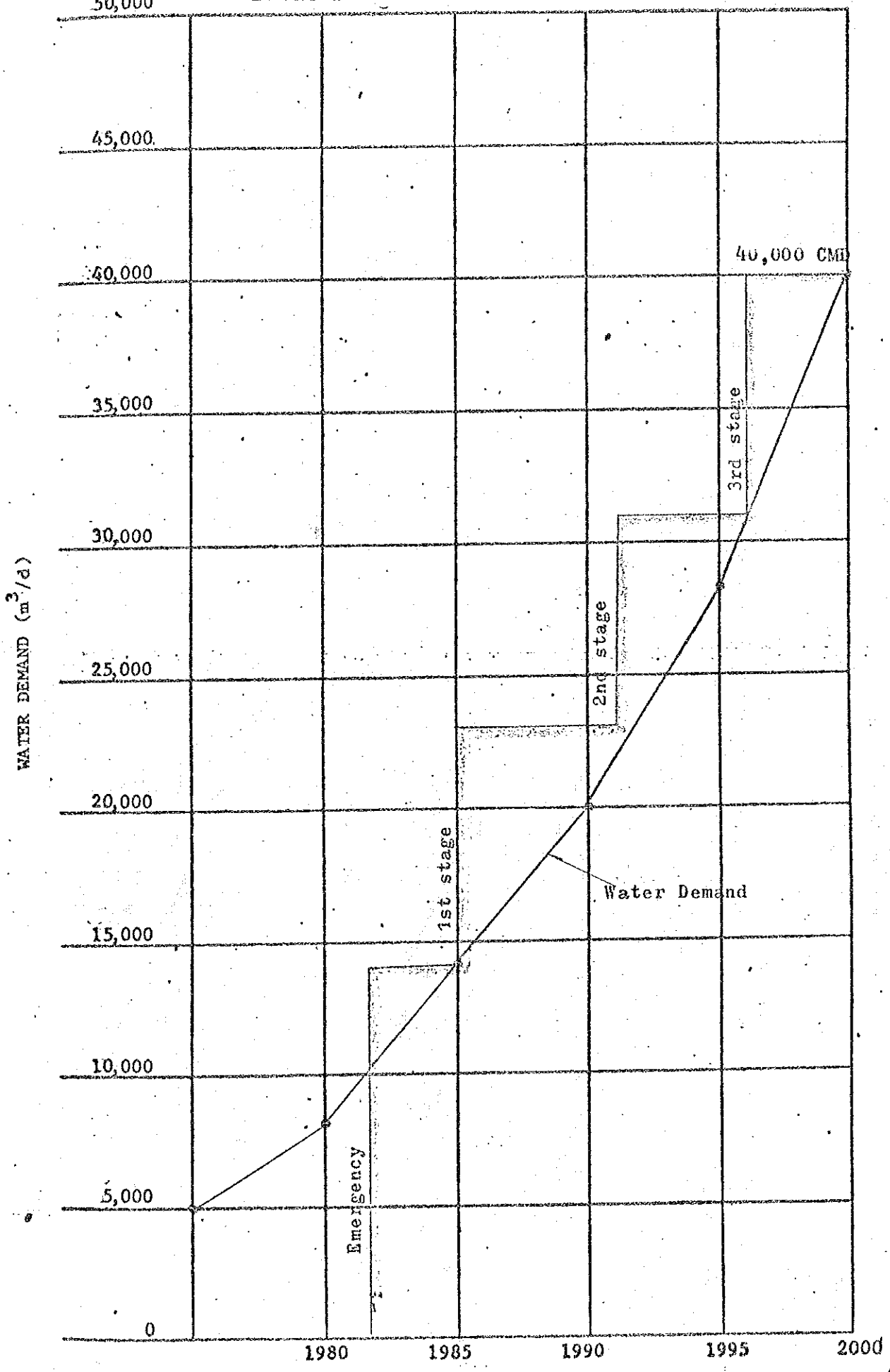


Fig. 3-6

Basic Plan -NONG CHOK-

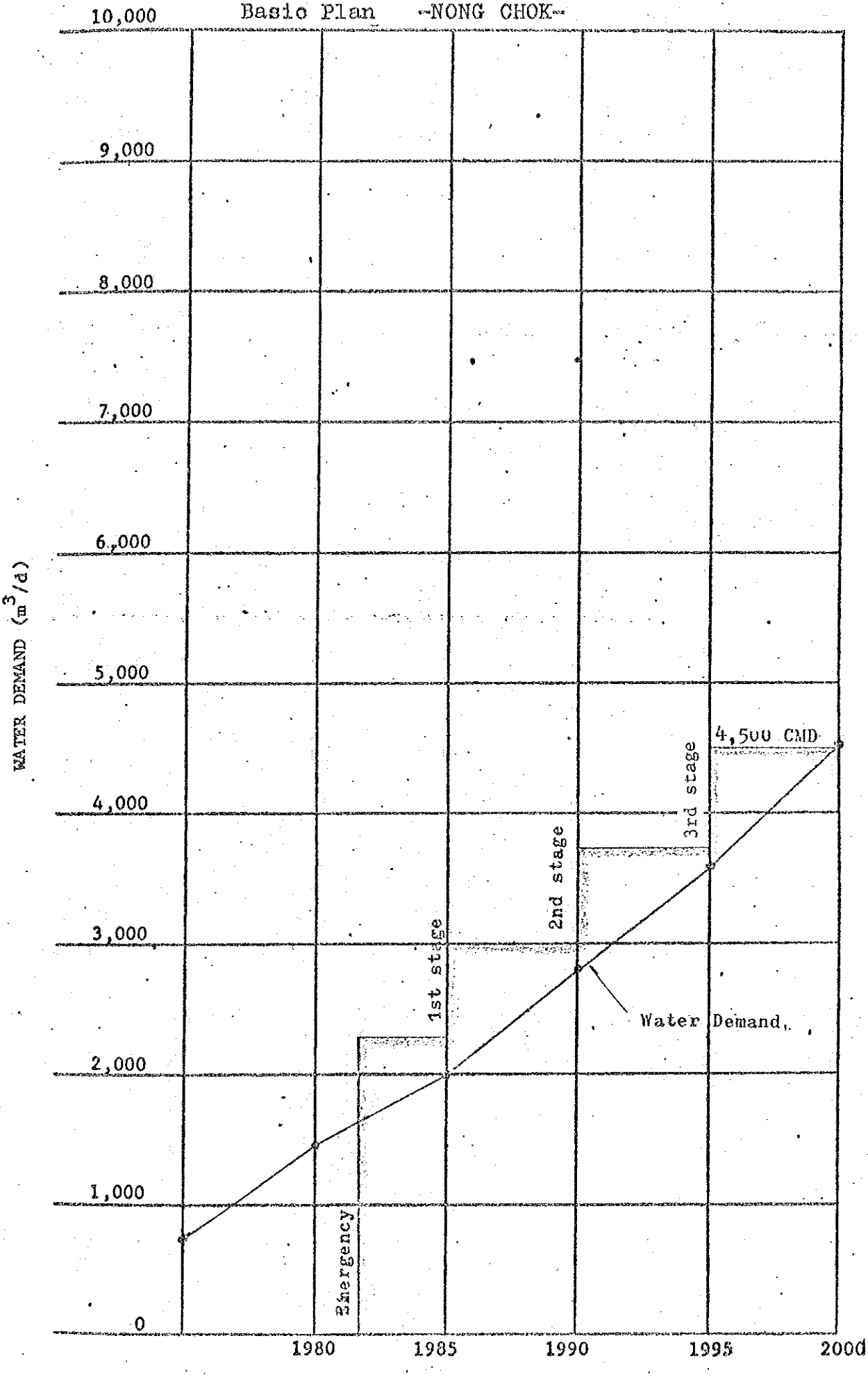


Fig. 3-7

Basic Plan -MIN BURI-

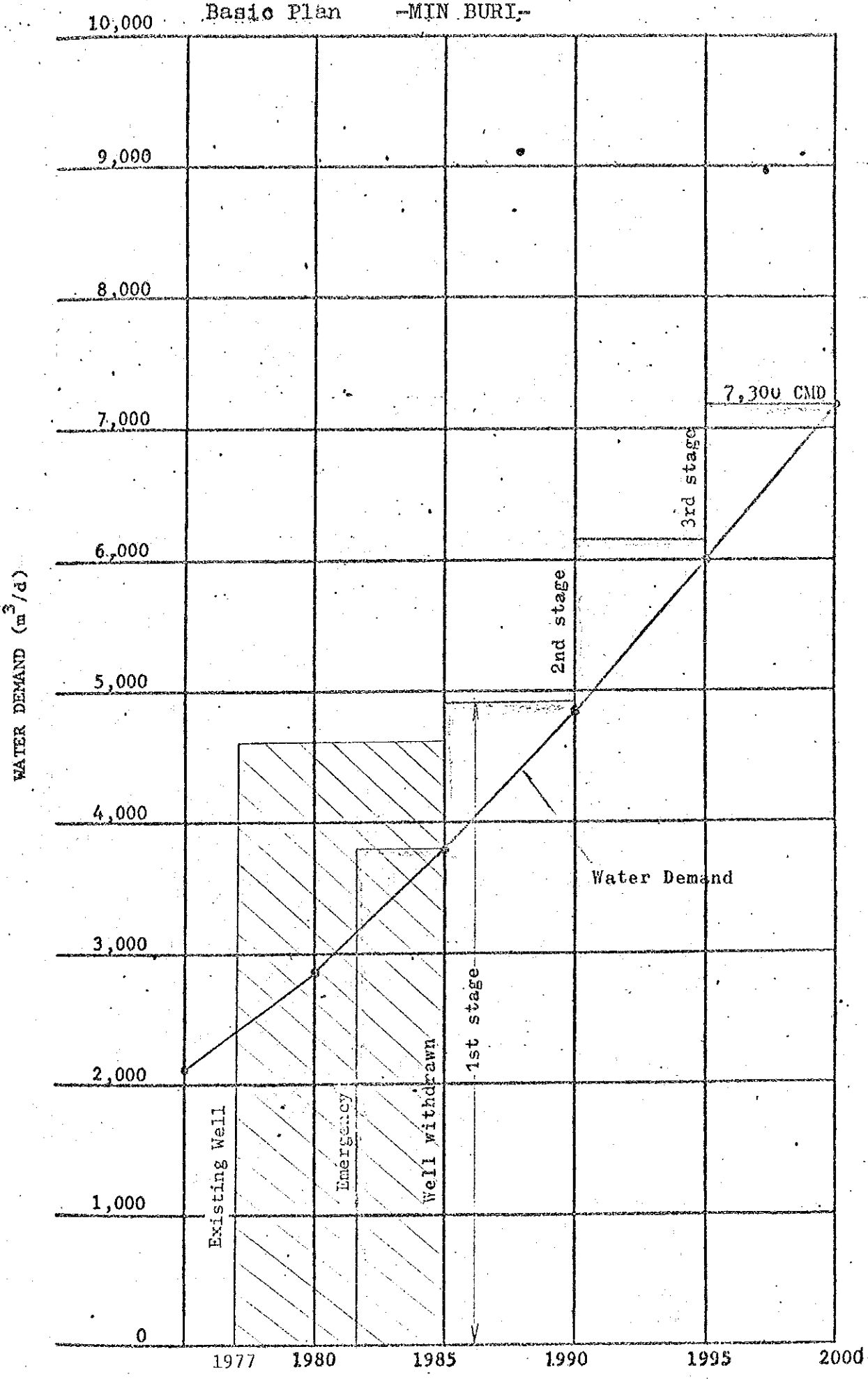


Fig. 3-8

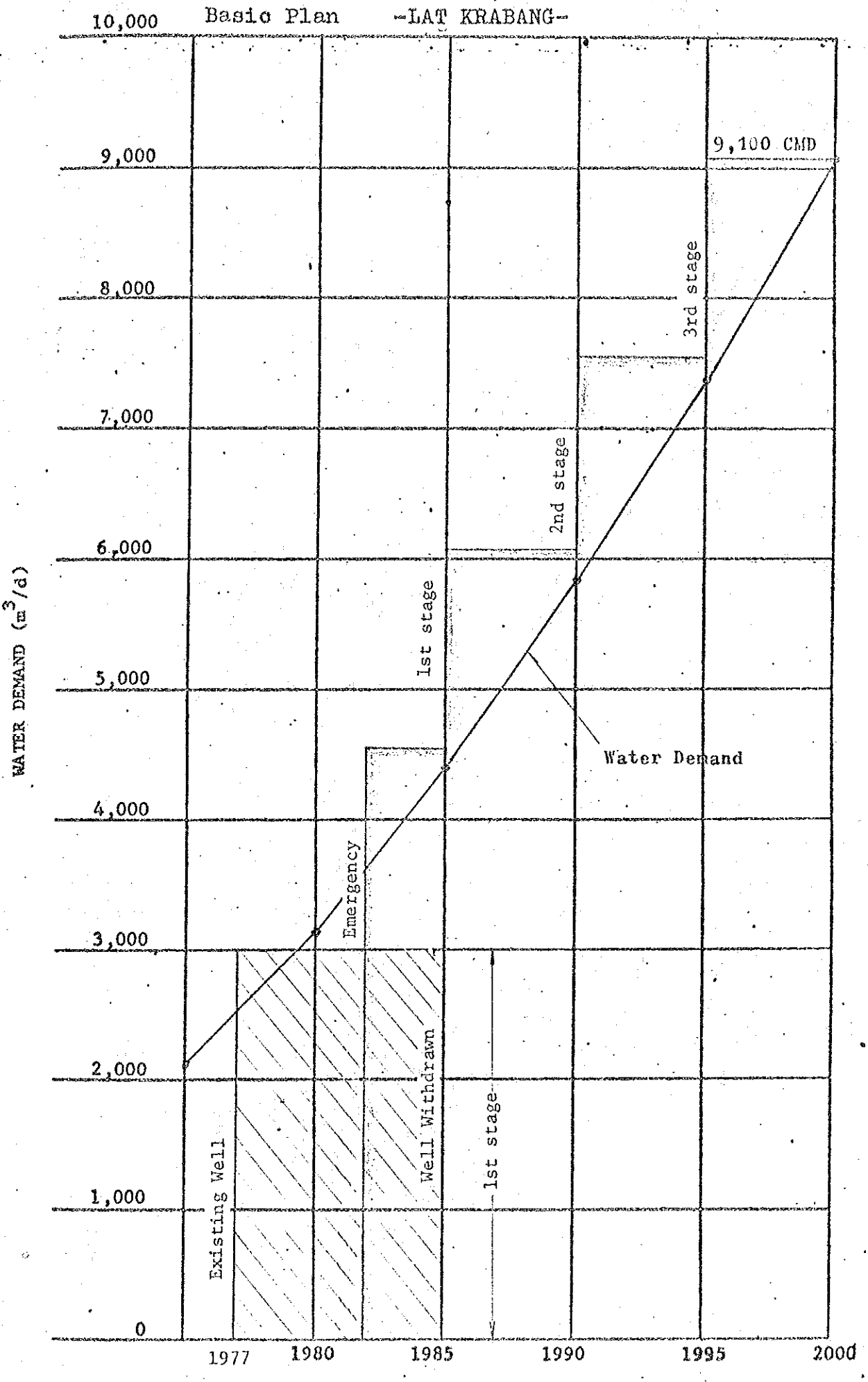

Basic Plan -LAT KRABANG-
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
WATER DEMAND (m³/d)
9,100 CMD
3rd stage
2nd stage
1st stage
Water Demand
Emergency
Well Withdrawn
Existing Well
1st stage
1977
1980
1985
1990
1995
2000

Fig. 3-9

Basic Plan -BANG PHLI-

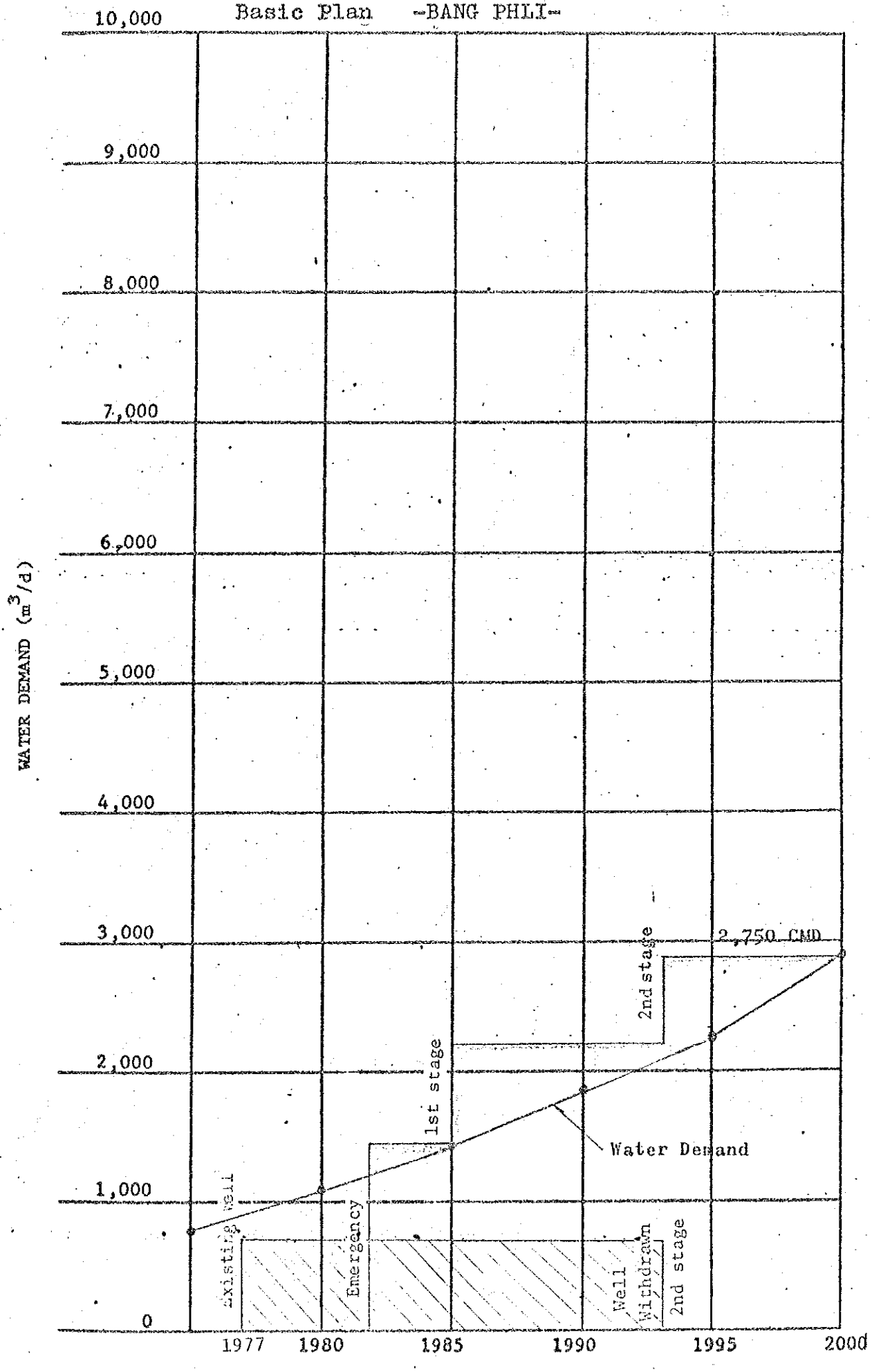
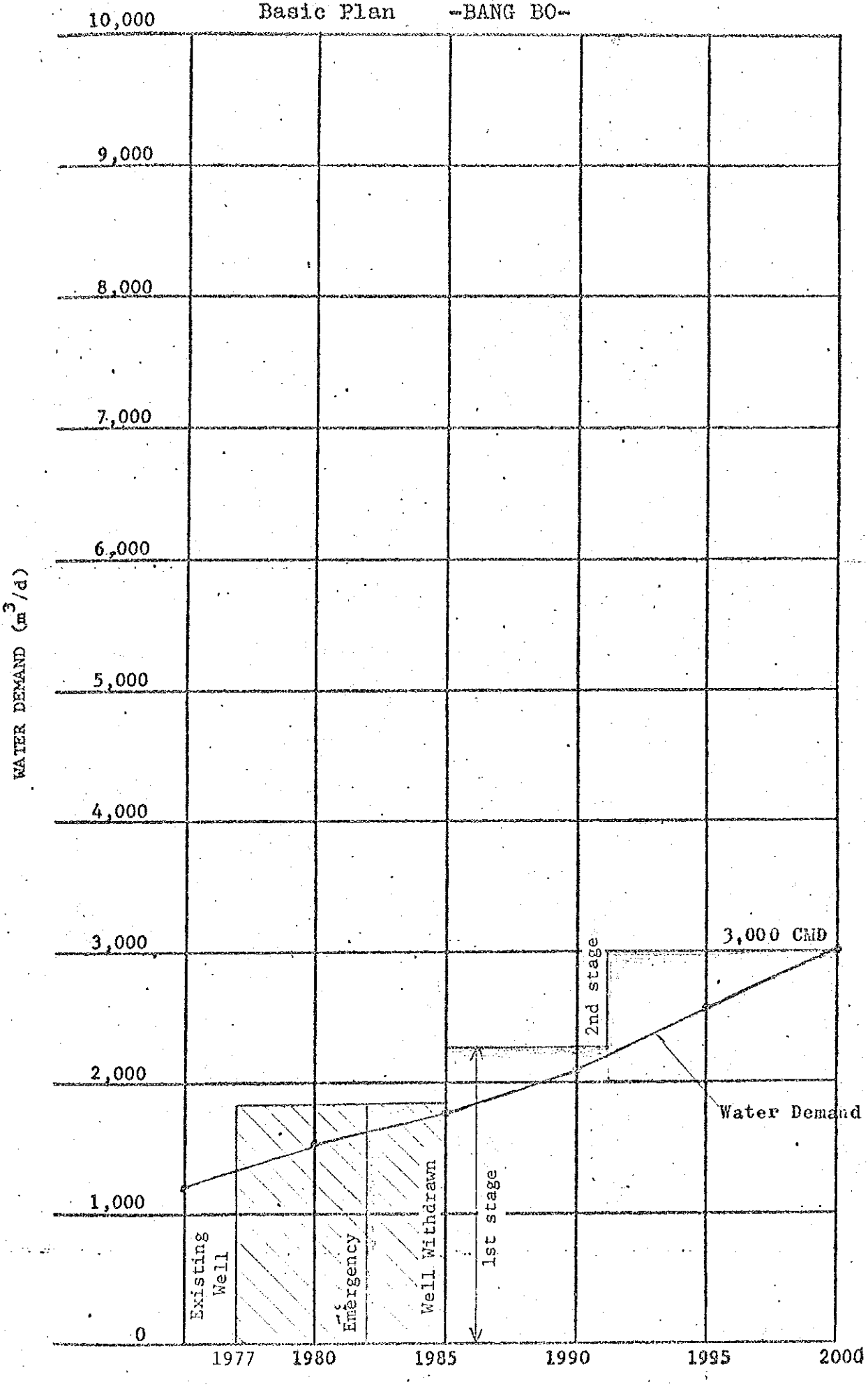


Fig. 3-10

Basic Plan -BANG BO-



4. Water Reconnaissance

4-1 Ground Water

The ground water survey has been carried out during almost one month mainly by means of electrical prospecting on thirty two (32) points, and simultaneously various informations have been collected through the Japanese Survey Team about the existing deep wells around the left bank and the northern part of the right bank of Chao Phraya River. As the result, the outline of soil strata which contains ground water around the suburbs of Bangkok has been understood and accordingly the possibility of using the water can be discussed.

4-1-1 Electrical Prospecting

After some calibration on site, NO. SHI-S Type Apparatus out of three different types of the electrical prospecting apparatus was selected as the best.

The number of electric prospecting tests were twenty four (24) points on the left bank of the river and eight (8) points on the right bank, as being shown on Fig. 4-1. Although rather thicker clay layers were existed just under the ground, the test was carried out carefully towards to successful result.

The outline of the test result are as follows.

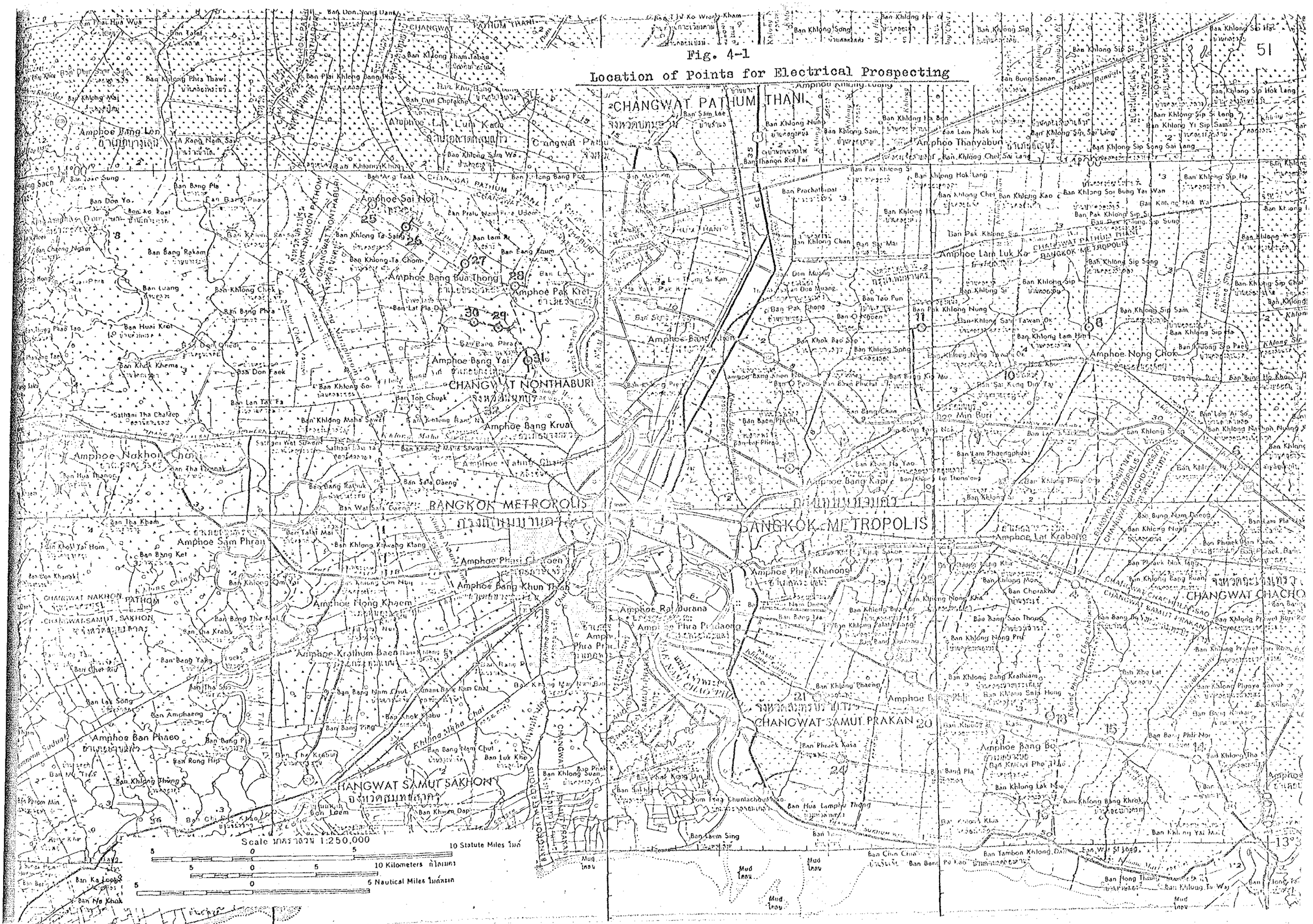
(1) Electric resistivity of stratum was relatively low, in consequence of understanding that the stratum consists of clay in all way through.

(2) On the left bank, electric resistivity of stratum is comparatively low at Nong Chok, northern part of Min Buri, Bang Phli and southern part of Bang Bo.

(3) The area where the condition of aquifer is considered to be good are along the high way No. 34 and east-west direction through Lat Krabang.

Fig. 4-1

Location of Points for Electrical Prospecting



(4) On the right bank of the river, the condition of aquifer are considered comparatively to be not so well at Bang Yai and eastern part of Bang Bua Thong. However, at the western part of the area such as Sai Noi is found to be good condition of aquifer.

The Sundberg Standard Curve Method has already been analyzed to have the result above mentioned, however, the analysis of Direct Interpretation of Resistivity Curve are now checking to correlate with the existing data of deep wells. After this analysis, the status of aquifer will be reported.

4-1-2 Analysis of Existing Data

Eight (8) aquifers can be known between Bangkok Aquifer (50 meters deep under ground) and Pak Nam Aquifer (550 meters deep). The upper two (2) aquifers have not so satisfactory quality of the water, and four (4) aquifers deeper than 300 meters under ground has not been yet tested enough.

There are two (2) deepest wells (about 500 meters deep) at the Electric Generating Authority of Thailand, however, it has discharged warmer water such as fourty nine (49) centigrade and higher content of sulfar ion (SO_4) although the capacity of discharge is said as 100 CM per hour. Judging from these phenomena, it is presumably considered that the recharge of these deeper aquifer is not sufficiently enough.

The two (2) other aquifers which are named Nakhon Luang Aquifer located around 150 meters deep and Nontaburi Aquifer around 200 meters deep, contain rather good water to be suitable for drinking, and it seems to be economical for construction of the well. Judging from the coefficient of transmissibility in these strata, the recharge of these aquifers is supposed to be sufficient, and it shall be considered as the water sources for the Separate System. However, it shall be

noticed that these aquifer has been contaminated by intrusion of sea water, particularly around the southern part of Bangkok.

The Japanese Survey Team would like to recommend that, in case of using the aquifer located more than 500 meters deep, subsequent negative pressure may bring serious land subsidence around rather wider area than the existing area, if the water discharge capacity would be more than the recharge capacity.

4-1-3 Present Condition of Ground Water at Bangkok Area

The lifting volume and the status of ground water table in Bangkok has been reported through various references. According to these reports, the static level of ground water in the center of Bangkok was reported as thirty (30) feet to fourty (40) feet below the ground at the period between 1958 and 1959, and sixty (60) feet to seventy (70) feet below the ground level at the period between 1968 and 1969. At this time, the center of lowering the ground water level was newly recognized around Phra Pradaeng Industrial Area. Further more, in the year of 1973 through 1974, the center of lowering the ground water level was proceedingly appeared towards to north, and the static level of ground water was one hundred (100) feet below the ground.

Lowering the ground water level towards to the northern part was considered to be caused by heavy lifting the ground water at Private Housing Projects. At the same time, the area of the lowering the ground water are expanding to the extent of suburbs of Bangkok. For example, the static level of ground water was reported as seventy (70) feet below the ground at Min Buri, sixty five (65) feet at Bang Phli and sixty (60) feet at Bang Bua Thong.

These lowering of the static level of ground water might be considered to be caused by excessive lifting of water in the result of significant intrusion of sea water. Following with the volume of lifting

ground water such as 175,000 CMD in 1960, 330,000 CMD in 1963, and 600,000 CMD or 700,000 CMD in 1976, lowering the static level of ground water are increasing year by year at the rate of 0.6 meters per year in 1960, 1.4 meters per year in 1968, 2.3 meters per year in 1973 and reccently 3 to 4 meters per year.

The ground water is recharging in vertically and holizontally and the recharge volume is generally estimated as five (5) or six (6) percent of amount of annual rainfall. Calculating approximately in the result, it would be said that only thirty (30) to thirty-five (35) percent of the whole lifting volume are recharged. If, the excessive lifting of ground water will not be discontinued, the shortage of the ground water and land subsidence would be presumably considered. Therefore, the water supply and/or industrial water supply shall be mainly covered by the surface water to preserve the natural water resources.

In addition, the time rate of intrusion of sea water (in term of 250 ppm as chloride content) has been considered as five hundred (500) to five hundred and fifty (550) meters per year.

4-1-4 Ground Water for Separate System

At the present, the static water level are lowering year by year in the center of Bangkok, and the area surrounding Bangkok will play an important role for recharging to the Bangkok area. This means that the using of ground water at these surrounding area is disagreeable. In the other word, lifting present amount of the ground water at the surrounding area, the ground water at Bangkok area would not be able to keep in good balance between lifting and recharging.

On the other hand, to improve the life of the peoples, the ground water is considered to be a good water source, because of economical construction cost. This means that the lifting amount of ground water at surrounding area shall be substitute to the same amount of lifting

ground water at central area. In other word, the lifting amount of ground water must be suggested as same as recharge amount at the surrounding area. And also, to prevent interferences between wells, location of wells shall be planned within a limitation of interference.

(1) Amount of Recharge

The amount of recharge is estimated as five (5) percent of annual rainfall. Although horizontal recharge must be taken into account, the volume of recharge is omitted because of less amount. If the annual rainfall is 1,400 mm per year, the recharge per year is as,

1400 x 0.05 = 70 mm/year

Considering one (1) square kilometer of recharging area, total amount is as,

70mm/year x 1,000,000m^2/1,000

= 70,000 cum/year/sq. kilometer

= 190 cum/day/sq. kilometer

(2) Safety Factor

The soil strata and hydraulic conditions of ground water must be considered and the safety factors at each bank of the river are assumed as follows.

(a) Left Bank

(i) Minburi and Nong Chok

The thick layer of clay exists around the northern part of these area, so that the safety factor is estimated as 2.0.

(ii) Bang Phli and Bang Bo

The possibility for intrusion of sea water seems to be relatively high, so that the factor is estimated as 2.0.

(iii) Lat Krabang

The condition seems to be good, as that the factor is estimated as 1.5.

(b) Right Bank

(i) Sai Noi

Taking into account the clay layer, the factor is estimated as 2.0.

(ii) Bang Bua Thong and Bang Yai

The conditions are satisfactory, so that the factor is assumed as 1.5.

(iii) Nong Khaem

The ground water has been intruded with sea water, so that it is not considered for the water source.

(3) Effluent Area Calculated by Water Demand on each District

The daily water demand are obtained from chapter 2, 2-1. Using these values, the recharge area will be shown on Table 4-1.

Table - 4-1

Location		Recharge Area
LEFT BANK	BANG PHLI	3,800 CMD ÷ 190 CM/day/km^2 x 2.0 = 40 km^2
	BANG BO	2,500 CMD ÷ 190 CM/day/km^2 x 2.0 = 26.3km^2
	MIN BURI	7,300 CMD ÷ 190 CM/day/km^2 x 2.0 = 76.8 km^2
	NONG CHOK	4,500 CMD ÷ 190 CM/day/km^2 x 2.0 = 47.3 km^2
	LAT KRABANG	7,500 CMD ÷ 190 CM/day/km^2 x 1.5 = 59.2 km^2
RIGHT BANK	SAI NOI	1,500 CMD ÷ 190 CM/day/km^2 x 2.0 = 15.8 km^2
	BANG BUA THONG	5,000 CMD ÷ 190 CM/day/km^2 x 1.5 = 41.1 km^2
	BANG YAI	4,400 CMD ÷ 190 CM/day/km^2 x 1.5 = 34.7 km^2
TOTAL		341.2 km^2