MINISTRY OF INTERIOR
PROVINCIAL WATERWORKS AUTHORITY

FINAL REPORT
FOR
DEVELOPMENT PLAN AND FEASIBILITY STUDY
ON
PROVINCIAL WATER SUPPLY PROJECTS
IN
THE KINGDOM OF THAILAND

VOLUME II-A

MAIN REPORT
FOR
CHIANGMAI

MARCH 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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P R E F A C E

In response to the request of the Government of the Kingdom of Thailand, the Japanese Government has decided to conduct Development Plan and Feasibility Study on Provincial Water Supply Projects and entrusted the Study to the Japan International Cooperation Agency (JICA). JICA sent to the Thailand a study team headed by Mr. Osamu Wakamoto, Nihon Suido Consultants Co.,Ltd. from December 1985 to December 1986.

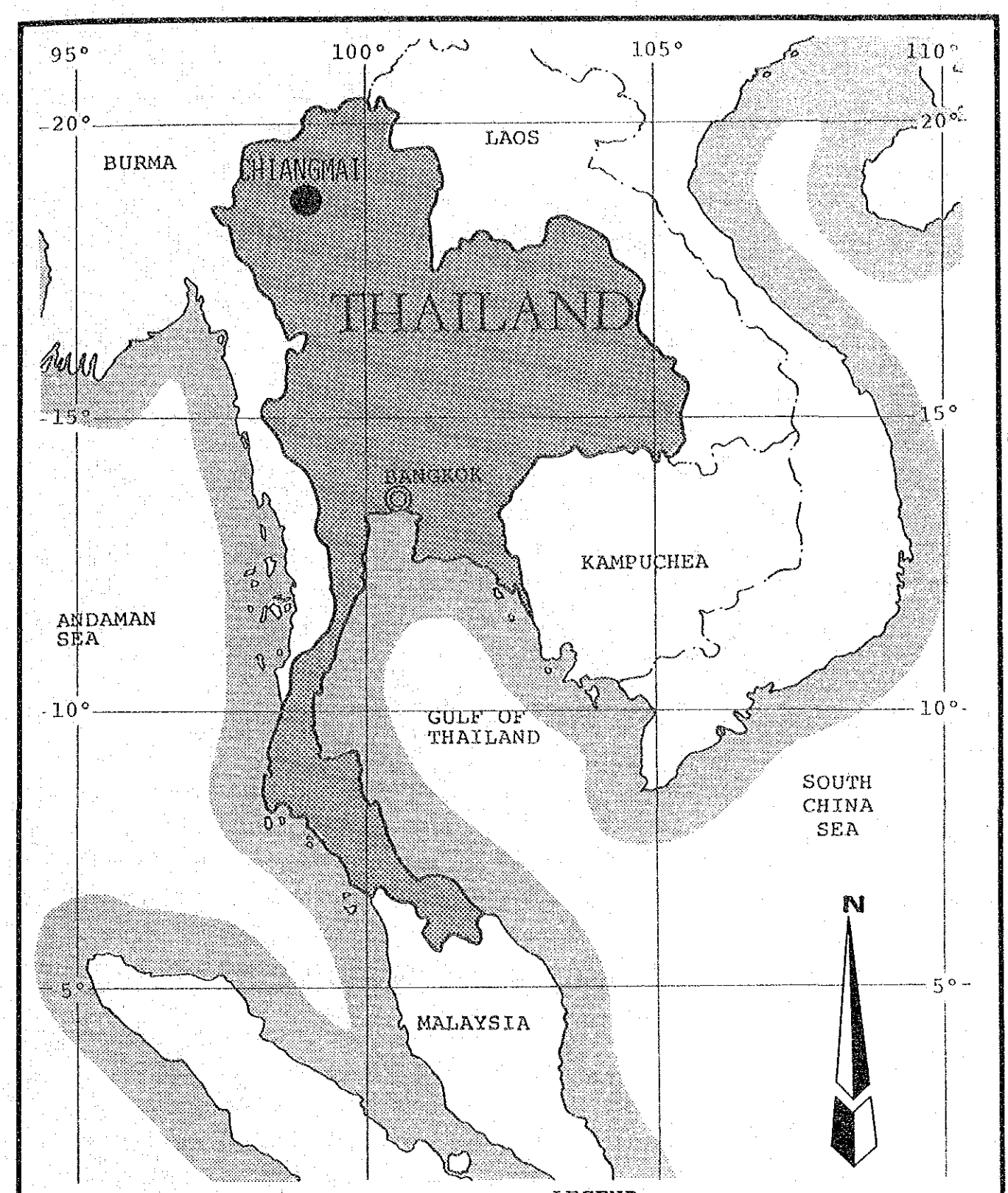
The team had discussions with the officials concerned of the Government of the Thailand and conducted a field survey in the Study Areas and Bangkok. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries. I wish to express my deep appreciation to the officials concerned of the Government of the Thailand for their close cooperation extended to the team.

March 1987

Keisuke Arita

Keisuke ARITA
President
Japan International Cooperation Agency



LEGEND

● : CHIANGMAI MUNICIPALITY

◎ : CAPITAL CITY

SCALE 1 : 10,000,000

FIGURE	LOCATION MAP

JAPAN INTERNATIONAL COOPERATION AGENCY

A C K N O W L E D G E M E N T S

The members of JICA study team, Nihon Suido Consultants, express their sincere appreciation for the kind assistance and cooperation given by PWA staff especially to Dr. Wanchai Ghooprasert, Deputy Governor in charge of Planning and Finance; Khun Virusah Mahakkapong, Director of Operation and Maintenance (Area I); Khun Sitthichai Pissathanporn, Director of Operation and Maintenance (Area II); and Khun Virayu Amornlectrakul, Director of Accounting & Finance Department (AFD).

The Study Team is grateful for the assistance and participation of Khun Orapin Assavanig, Chief, International Cooperation Section, Corporate Planning Department; Khun Wanchai Lowatanatakul, Project Coordinator, Corporate Planning Department (CPD); Khun Jaroon Upanan, Water Supply Engineer, CPD; Khun Wirawan Kaeopradith, System Analyst, Planning Division, CPD; Khun Pinporn Phongsri, Economist, Planning Division, CPD; Khun Thavorn Nitipavachon, Water Resource Development Project, CPD; Khun Somkiat Piriyakakul, Water Resource Development Project, CPD; Khun Prathom Khoysomboon, Technician, Planning Div., CPD; Khun Supannee Thongsri, Clerk, Planning Div., CPD; Khun Anu Songsakchai, Typist, Planning Div., CPD; Khun Vanida Taechasaen, Chief of Accounting Division, AFD; Khun Prakit Chanurai, Chief of Work Plan Analysis Work, CPD; Khun Damrong Ratanasaengsakulthai, Coopers Lybrands' officer; Khun Sompis Amornrojanawonse, Head of Loan Account, AFD; Khun Chindarat Suwanapak, Analysis and Evaluation Dept.; Khun Chantira Jurotok, Head of General Ledger, AFD; Khun Somsong Pantaranontaka, Acting Director of Budget Division, AFD.

We would also like to take this opportunity to express our appreciation to all of the PWA staff (in Chonburi Regional Office No. I and Pattaya Waterworks; Saraburi Regional Office No. II and Suphanburi Waterworks; Ubon Ratchathani Regional Office No. VIII and Ubon-Warin Waterworks; Chiangmai Regional Office No. IX, Chiangmai, Mae Rim and San Kamphaeng Waterworks).

EXECUTIVE SUMMARY

A. Introduction

This report summarizes the results of a comprehensive master plan and feasibility study conducted by a study team of the Japan International Cooperation Agency (JICA), which are presented in this volume of the Report entitled "DEVELOPMENT PLAN AND FEASIBILITY STUDY ON PROVINCIAL WATER SUPPLY PROJECTS IN THE KINGDOM OF THAILAND, CHIANGMAI".

The study area covers Chiangmai Municipality and its neighboring Sanitary Districts, Mae Rim, San Kamphaeng, San Sai, Saraphi and Hang Dong, located some 700 km north of Bangkok. Chiangmai is a well known tourist spot in Asia and the second largest city in Thailand, and also serves as a center of administration, education, commerce and traffic in the northern districts. The city is expanding steadily and expected to absorb the surrounding five sanitary districts in the future. Of these five sanitary districts, those connected to PWA System are only two, Mae Rim and San Kamphaeng. Among the rest three, Hang Dong has a public water system not belonging to PWA, but other two have no water supply.

The current project purports to prepare a comprehensive development plan of water supply in the study area mentioned above up to the year 2010, and to study the feasibility of the early stage of the plan for implementation.

The population and water supply service ratio of Chiangmai and each of the five sanitary districts are forecast as in Table-ES.1.

In view of the uncertainties in the future development of Chiangmai and five sanitary districts as well as of the internal administrative reasons of PWA, project implementation is planned to be divided into two stages, i.e., Stage I up to the year 2000 and Stage II through 2010.

Table-ES.1 POPULATION AND SERVICE RATIO FORECAST

Area	1985		2010	
	Population	Service Ratio	Population	Service Ratio
Chiangmai	155,000	52 %	199,000	75 %
Mae Rim	11,100	42 %	13,600	70 %
San Kamphaeng	17,000	34 %	26,100	65 %
San Sai	22,200	-	24,700	50 %
Saraphi	8,800	-	13,000	50 %
Hang Dong	5,200	-	6,700	50 %
Total	219,300		283,100	

The Development Plan also proposes an immediate improvement program to rehabilitate the existing system, together with immediate modification works to increase the production-supply capacity of the existing facilities. These immediate actions are required to be carried out prior to the Stage I expansion program, or as part of its initial phase.

This is because the existing production facilities of Chiangmai, Mae Rim and San Kamphaeng whose nominal capacity exceeds demand are failing to supply safe water unceasingly, hindered by deteriorations in treatment facilities and damages in pipelines.

B. Strategies to the Targets

Of the five Sanitary Districts, Stage I implementation will be extended only to Mae Rim and San Kamphaeng which are already PWA member waterworks. Both of them are proposed to be merged with Chiangmai Waterworks, the reason being that Mae Rim service area actually crosses over a part of Chiangmai jurisdiction, and San Kamphaeng has a high prospect to be connected with Chiangmai in future because of an industrial zone planned to be developed in their midway. In addition, merger will reduce their operation expenses in total.

Because of their unreadiness, the development of water supply in San Sai, Saraphi and Hang Dong sanitary districts is planned to be postponed to Stage II of the Development Plan.

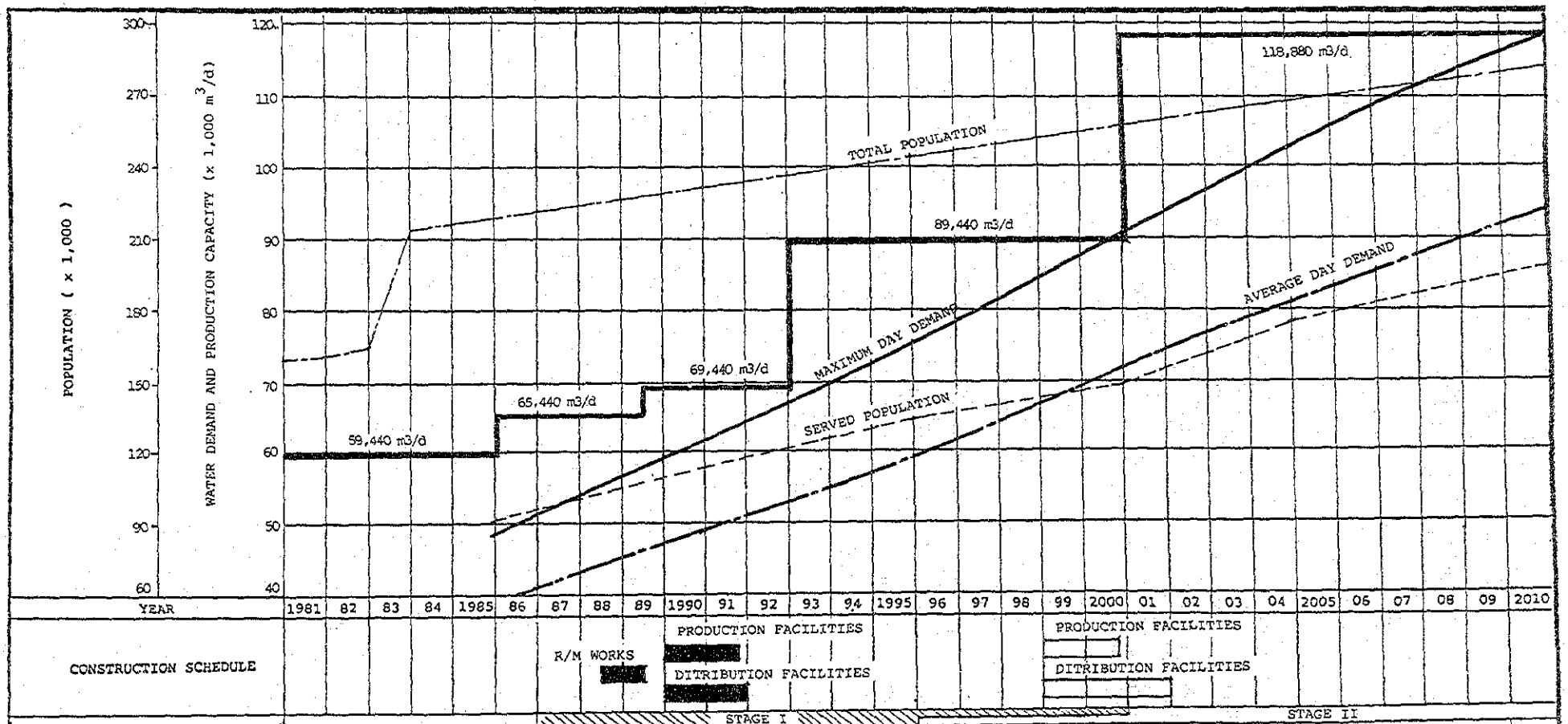
Composite water consumption is projected to be increased up to two times as large as the present level in coming 13 years, from 26,200 cu m/day in 1985 to 53,000 cu m/day in 2000, and further to 74,900 cu m/day in 2010. Domestic demand will increase reflecting both population growth and per capita consumption increase (from 143 lpcd in 1985 to 185 lpcd in 2000), and tourism demand is projected to expand at a higher rate than the domestic one.

The estimated costs are summarized in Table-ES.2 for implementing the strategic plans as shown in Fig-ES.1.

Table-ES.2 TOTAL COST FOR DEVELOPMENT PLAN

Unit:1,000 Baht

Item	Stage I			Stage II	Total
	Rehabili. and Modifi.	Expansion	Sub-Total	(2000-2010) Expansion	Stages I and II
Land and Facilities	22,400	202,400	224,800	260,000	484,800
Engineering Service	2,500	22,200	24,700	28,200	52,900
Administration Cost	200	2,300	2,500	2,900	5,400
Physical Contingencies	1,800	15,800	17,600	20,400	38,000
Price Contingencies	3,100	36,800	39,900	220,600	260,500
Total	30,000	279,500	309,500	532,100	841,600



POPULATION (x 1,000)	219.3	232.2	244.9	256.9	269.9	283.1
SERVICE RATIO (%)	41.5	49.2	54.5	57.5	67.2	69.9
SERVED POPULATION (x 1,000)	91.0	144.3	133.5	147.7	181.4	197.9
UNACCOUNTED-FOR WATER RATIO (%)	32	27	25	23	21	20
AVERAGE DAY DEMAND (x 1,000)	38.4	48.2	59.6	72.0	83.2	93.6
MAXIMUM DAY DEMAND (x 1,000)	48.5	60.8	75.2	91.0	105.3	118.6

Note : Chiangmai Waterworks Combined with Five Sanitary Districts.

FIGURE ES.1

WATER SUPPLY PLAN TO YEAR 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

C. Proposed Water Supply, 1987-2000

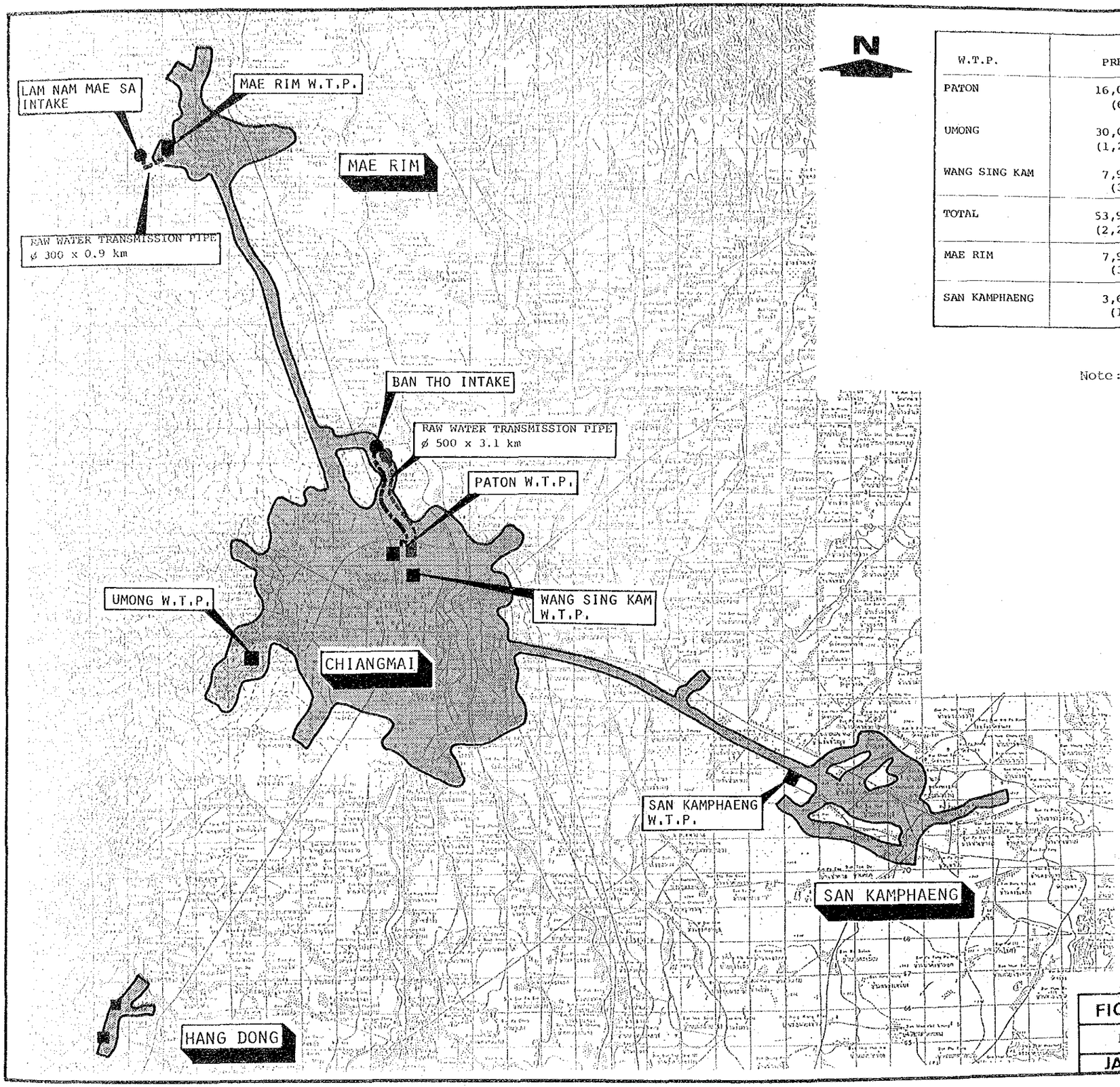
The components of the proposed water supply system for Stage I together with the service area to be covered are illustrated in Fig-ES.2. Rehabilitation and modification works will provide needed improvement of the existing facilities, particularly to increase the supply capacity to meet water demand which is expected to intensify around 1990.

The Stage I Expansion for Chiangmai, Mae Rim and San Kamphaeng is designed as shown on Table-ES.3, with implementation proposed to proceed as Fig-ES.3.

Table-ES.3 SUMMARY OF STAGE I EXPANSION

Item	Chiangmai	Mae Rim	San Kamphaeng	Total
Service Area (ha)	50,400	9,200	13,400	73,000
Served Population	126,700	8,200	12,800	147,658
Water Source	Ping River & Irrigation Canal	Lam Nam Me Sa	Groundwater	
Max. Day Demand (m3/d)	76,500	6,700	3,800	87,000
Distribution Pipeline (km)	105	21	9	135
Service Connection	4,900	310	1,000	6,210

The proposed project and its costs are summarized in Table-ES.4. The estimated capital investment cost of the project, totaling 309,500 thousand Baht at current prices allowing for price increases of 3.3 percent per annum is realistic, based on preliminary designs plus an allowance of 7 % for physical contingencies.



W.T.P.	PRESENT	INCREASED CAPACITY IN REHA/MODI WORKS	INCREASED CAPACITY IN EXPANSION WORKS	TOTAL
PATON	16,000 m3/d (666 m3/h)	4,000 m3/d (167 m3/h)	20,000 m3/d (833 m3/h)	40,000 m3/d (1,666 m3/h)
UMONG	30,000 m3/d (1,250 m3/h)	-	-	30,000 m3/d (1,250 m3/h)
WANG SING KAM	7,920 m3/d (330 m3/h)	-	-	7,920 m3/d (330 m3/h)
TOTAL	53,920 m3/d (2,246 m3/h)	4,000 m3/d (167 m3/h)	20,000 m3/d (833 m3/h)	77,920 m3/d (3,246 m3/h)
MAE RIM	7,920 m3/d (330 m3/h)	-	-	7,920 m3/d (330 m3/h)
SAN KAMPHAENG	3,600 m3/d. (150 m3/h)	-	-	3,600 m3/d (150 m3/h)

Note: Hang Dong Sanitary District has its own water supply system not belonging to PWA.

LEGEND

: EXISTING PIPELINE
: PROPOSED PIPELINE
: EXISTING FACILITY
: PROPOSED FACILITY
: SERVICE AREA IN 2000

0 2 4 6 km

FIGURE ES. 2 WATER SUPPLY SYSTEM IN 2000

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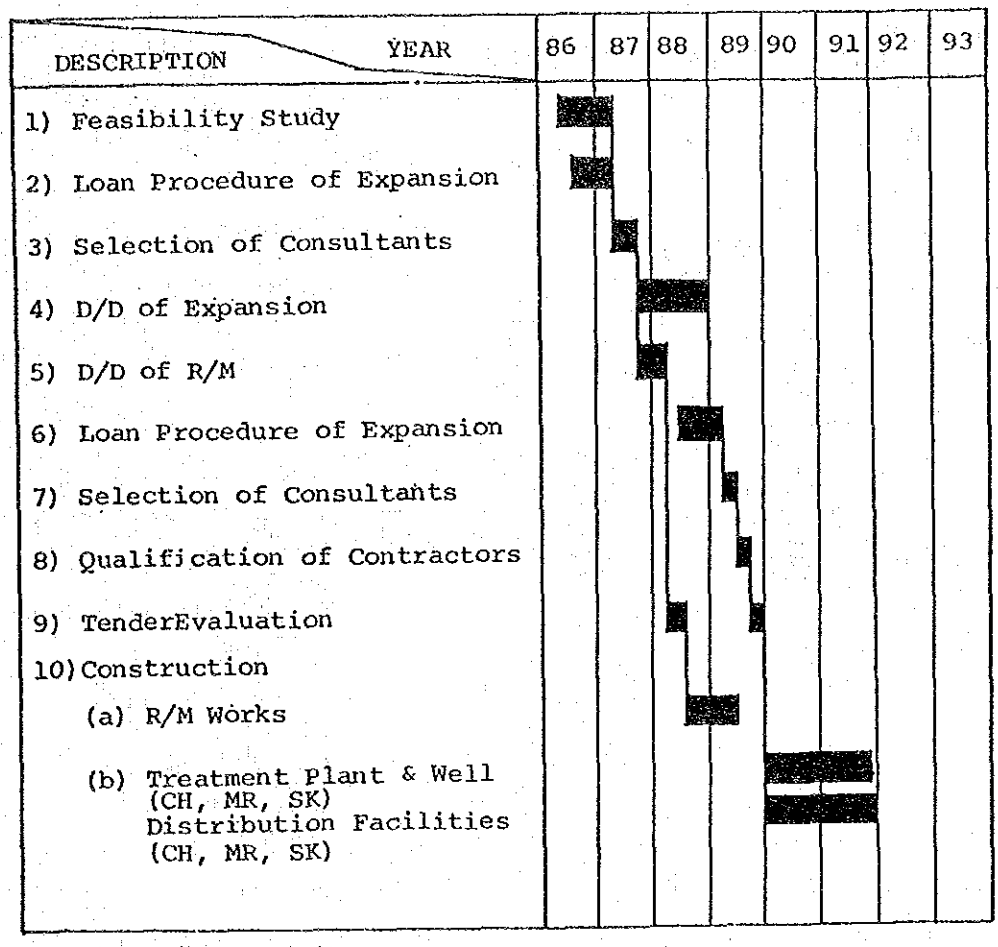

NOTE : D/D Detailed Design
R/M Rehabilitation and Modification
CH Chiangmai
MR Mae Rim
SK San Kamphaeng

FIGURE ES.3 IMPLEMENTATION SCHEDULE

JAPAN INTERNATIONAL COOPERATION AGENCY

Table-ES.4 ESTIMATED PROJECT COSTS FOR STAGE I IMPLEMENTATION

	(x 1,000 Baht)
A. Rehabilitation and Modification	22,400
Chiangmai	22,000
Mae Rim	200
San Kamphaeng	200
B. Expansion	202,400
Land Acquisition	1,800
Chiangmai	176,100
Mae Rim	18,200
San Kamphaeng	6,300
C. Engineering Services	24,700
D. Administration Cost	2,500
E. Physical Contingencies	17,600
F. Price Contingencies	39,900
Total	309,500

The tentative financing plan, summarized in Table-ES.5, assumes loans from a foreign financial institution such as OECF totaling 247,600 thousand Baht, or 80 % of capital expenditure, and local loans totaling 61,900 thousand Baht, or 20 % of capital expenditure. The total fund requirement through the project period is projected to amount to 705,000 thousand Baht on a cash-flow basis (inclusive of debt service) of which 56.1 % will be covered by internal cash generation and the rest(43.9 %) will be financed with foreign and local loans, and with no internal financial help of PWA.

Table-ES.5 TENTATIVE FINANCING PLAN FOR STAGE I IMPLEMENTATION
[CHIANGMAI WATERWORKS] x 1,000 Baht

Item	Before Depreciation	% of Total
1. Sources of Funds		
Internal Cash Generation	395,500	56.1%
Outside Sources:		
- Foreign Financial Institution such as OECF	247,600	35.1%
- Local Financial Institution	61,900	8.8%
Total	705,000	100.0%
2. Application of Funds		
Capital Expenditure	309,500	43.9%
Debt Service	395,500	56.1%
Total	705,000	100.0%

The above financial conditions, together with the Financial Internal Rate of Return and the Economic Internal Rate of Return as high as 10.8 % and 16.6 % respectively demonstrate the financial and economic justification of the project.

Several key actions are necessary if the project is to succeed.

1. Financing for project implementation must be confirmed. This confirmation includes the checking of a possibility of obtaining Government subsidies for project capital investment, which are now being suspended temporarily for Government budgetary reasons. Such subsidies will ease the financial conditions of waterworks in making capital investment.

2. Changes in structure of PWA's water tariff, as recommended in the Main Report, are needed together with periodic increases in tariffs (to cover the effects of price escalation).

3. Arrangements should be made with RID to secure in the dry seasons the necessary volumes of raw water from the Ping River and the irrigation canal, both of which are under the control of RID.

4. Suitable land site should be secured at the earliest time possible for the Ban Tho intake facilities which are proposed to be constructed in the Stage I.

5. A leakage team should be formed in the waterworks to pursue a program of reducing water leakage in accordance with the Framework prepared by JICA Team.

6. PWA should campaign the enlightenment of the residents in San Sai, Saraphi and Hang Dong on the necessity of potable piped water and the benefits of PWA service, as to pave a way for the planned Stage II implementation in these districts.

The project is technically feasible and provides the least cost solution for providing water supply as needed in the project area through the year 2000. The project is also significant to improve the existing facilities which are deteriorating. Implementation of the project will significantly improve the water supply and other environmental situation and health of the people in Chiangmai.

COMPILATION OF THE REPORT

The Development Plan and Feasibility Study of the Provincial Water Supply Projects cover four areas; Chiangmai, Ubon and Warin, Suphanburi, and Pattaya. The study report on the Development Plan and Feasibility Study is composed of the following nine volumes.

Volume I	Summary
Volume II-A	**Main Report for Chiangmai**
Volume II-B	Appendices for Chiangmai
Volume III-A	Main Report for Ubon and Warin
Volume III-B	Appendices for Ubon and Warin
Volume IV-A	Main Report for Suphanburi
Volume IV-B	Appendices for Suphanburi
Volume V-A	Main Report for Pattaya
Volume V-B	Appendices for Pattaya

This report (Volume II-A) represents a main report relating to Chiangmai, and consists of the following four parts;

Executive	Summary
Part I	Background
Part II	Development Plan
Part III	Feasibility Study

The report conforms to the Scope of Work given in the Appendices, but does not always follow that of the order of the Scope of Work, both for the convenience of report preparation and better understanding for the readers.

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ABBREVIATIONS, ACRONYMS AND UNITS

EGAT	Electricity Generating Authority of Thailand
LAD	Local Administration Department
NESDB	National Economic and Social Development Board
NHA	National Housing Authority
NSO	National Statistical Office
PCDA	Population and Community Development Association
PWA	Provincial Waterworks Authority
PWD	Public Works Department
MWA	Metropolitan Waterworks Authority
RID	Royal Irrigation Department
RTG	Royal Thai Government
DOH	Department of Health
NEB	National Environmental Board
TAT	Tourist Authority of Thailand
DTCP	Department of Town and City Planning
WHO	World Health Organization
AWWA	American Water Works Association
JICA	Japan International Cooperation Agency
OECF	Overseas Economic Cooperation Fund
NSC	Nihon Suido Consultants Co., Ltd., Tokyo Japan
A.D.	Christian Era
B.E.	Buddhist Era; (B.E.) - 543 = (A.D.)
EIRR	Economic Internal Rate of Return
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GNP	Gross National Product
NNP	Net National Product
MSL	Mean Sea Level
DWS	Drinking Water Standard OF PWA
S.D.	Sanitary District
Fig-	Figure
L.M.	Linear Meter
L.S.	Lump Sum
D.T.	Detention Time
NPV	Net Present Value
CMD	cubic meters per day
MCM	million cubic meter
El.	elevation
ø or D	diameter
O & M	Operation and Maintenance
d	depth
h	height or hour
H	Head
hr	hour
%	percentage
฿	Thai Baht
$	US Dollar
¥	Japanese Yen

mm	millimeter
cm	centimeter
m	meter
km	kilometer
sq cm or cm2	square centimeter
sq m or m2	square meter
sq km or km2	square kilometer
ha	hectare
Rai	area unit of Thailand (1 Rai = 1,600 sq m)
cu mm or mm3	cubic millimeter
cu cm or cm3	cubic centimeter
cu m or m3	cubic meter
ml	milliliter
l	liter
mg	milligram
g	gram
kg	kilogram
t	metric ton
kg/sq cm or kg/cm2	kilogram per square centimeter
t/sq m or t/m2	metric ton per square meter
cm/s	centimeter per second
m/s	meter per second
m/d	meter per day
cu m/s or m3/s	cubic meter per second
cu m/min or m3/min	cubic meter per minute
cu m/h or m3/h	cubic meter per hour
cu m/d or m3/d	cubid meter per day
l/s	liter per second
mg/l	milligram per liter
ppm	parts per million
V	volt
kV	kilovolt
kW	kilowatt
A	ampere
kVA	kilovolt ampere
DC	direct current
AC	altering current
rpm	revolutions per minute
Q	flow
V	volume
DIP	Ductile Cast Iron Pipe
ACP	Asbestos Cement Pipe
PVC	Polivinyl Chloride Pipe
SP	Steel Pipe
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
ABS	Alkyl Benzyl Sulfonates

Pt-Co scale	Platinum-Cobalt Scale
NTU	Nephelometric Turbidity Units
JTU	Jackson Turbity Units
CaCO3	Calcium Carbonate
KMnO4	Potassium Permanganate
M-Alkalinity	Methylorange-Alkalinity
P-Alkalinity	Phenolphthalein-Alkalinity
T-Hardness	Total-Hardness
SiO2 Units	Silica Scale Units
Ammonia-N	Ammonia-Nitrogen
Nitrite-N	Nitrite-Nitrogen
Nitrate-N	Nitrate-Nitrogen
No.	number
N/ml	number per milliliter
N/100 ml	number per 100 milliliter
g/cu m or g/m3	gram per cubic meter
MPN	most probable number
ST.	station
N.D.	not to be detected
C	degrees Celsius

PART ONE
BACKGROUND

PART ONE

CHAPTER 1 AUTHORIZATION

CHAPTER 1

CHAPTER 1 AUTHORIZATION

On the basis of the arrangements for the Provincial Water Supply Projects in Thailand made between the Governments of Thailand and Japan, the Japan International Cooperation Agency (JICA) dispatched a study team headed by Mr. Osamu Wakamoto, Nihon Suido Consultants Co., Ltd. under the assistance and guidance of the Technical Advisory Committee. The Study Team was engaged in preparation of the said Projects over the period from November 1985 to March 1987 based on the Scope of Works agreed between PWA and JICA.

CHAPTER 2 OBJECTIVES AND SCOPE OF WORKS

CHAPTER 2

CHAPTER 2 OBJECTIVES AND SCOPE OF WORKS

2.1 Objectives of the Study

The objectives of the study are firstly to prepare a long term water supply expansion program to A.D. 2010 for each of the provincial areas named in 2.2 below, identified as the "Development Plan", and secondly to conduct feasibility study for the first phase of the Development Plan, hereinafter called Stage I.

The terminology "Development Plan" has been adopted for this study in lieu of master plan to reflect the conceptual nature of the long term planning which can be appropriately refined in the future when more extensive studies are conducted separately in each of the provincial areas.

The planning is based on the best judgment on existing facts combined with historical trends, government policies, most reasonable assumptions and professional experience. In view of the changing situation, however, the plan is subject to periodic review and updating and refinement as appropriate.

2.2 Coverage of the Report

The present report covers Chiangmai Municipality and surrounding sanitary districts, one of the four study areas of the Provincial Water Supply Projects, which are listed below.

Study Areas : - Chiangmai Municipality and surrounding sanitary districts, San Sai, San Kamphaeng, Saraphi, Hang Dong and Mae Rim,

- Ubon Ratchathani Municipality and Warin Chamrap Municipality, including Ban Pak Huai Wang Nong, Ubon Sanitary District (including Ban Don Klang), Ban Tha Bong Mang, Ban Hat Suan Ya, and Ban Mai Klang.

- Suphanburi Municipality, and Phophraya Sanitary District.

- Pattaya City, Nong Preo Sanitary District and Ban Rong Po.

The areas underlined in the above list were not originally included in the study area. During the course of study, however, they were added from the viewpoint of optimizing the effects of the project, with the consent of both JICA and PWA.

2.3 Scope of Works

Development Plan

The scope of works for the Development Plan is defined as follows:

Target Year : A.D. 2010

Outline of the Study :

1) Basic Survey
   a) Data collection and analysis
   b) Study of existing water supply system

2) Served Population and Water Demand
   a) Delineation of served area
   b) Projection of population and water demand

3) Planning of Water Supply System
   a) Study of water sources
   b) Planning of appropriate water supply system

4) Construction Cost and Finance
   a) Cost estimation for construction and operation/maintenance
   b) Study of financial aspects
   c) Preparation of implementation schedule

5) Identification of Stage I Project for Feasibility Study (including immediate improvement and rehabilitation)

Feasibility Study

As regards the urgently required stage of the Development Plan identified as 2.3 5) above, Feasibility Study will be carried out as described below:

Study Areas : Identified Areas

Target Year : A.D. 2000

Outline of the Study :

1) Served Population and Water Demand
   a) Delineation of service area
   b) Estimation of served population
   c) Estimation of water demand

2) Rehabilitation and Improvement
   a) Study for improvement of existing facilities
   b) Leakage survey and estimation of unaccounted-for water

3) Plan of Water Supply Systems
   a) Study of water sources
   b) Preliminary design
   c) Study of alternative plans and layout of facilities
   d) Study of construction materials and labor force
   e) Study for the construction method and procurement method of material/equipment

4) Construction and Management

   a) Cost estimation of construction and operation/maintenance

   b) Study of water revenue and cost

   c) Study of water tariff

   d) Economic and financial analysis

   e) Study of organization and operation/maintenance plan

   f) Implementation schedule

CHAPTER 3 WATER SUPPLY ADMINISTRATION IN THAILAND

3.1 Water Supply Sector

3.2 Role of PWA

3.3 Status of Chiangmai Waterworks in PWA

CHAPTER 3

CHAPTER 3 WATER SUPPLY ADMINISTRATION IN THAILAND

The following is the description of the water supply sector and the role of PWA therein, which owns and administers the four waterworks of Chiangmai, Ubon and Warin, Suphanburi and Pattaya, i.e., the study areas of the Provincial Water Supply Projects in Thailand.

3.1 Water Supply Sector

The Government of Thailand has been taking positive steps to organize the sector of water supply and upgrade its efficiency. The sector is under the responsibility of the Ministry of Interior. The Metropolitan Water Works Authority, whose jurisdiction covers the Bangkok Metropolitan area and its suburbs, started its activity under the name of "The Siam Waterworks" in the Fifth Reign of Maha Chakri Dynasty. Its activities were first assigned to be under the responsibility of the Public Works Department, Ministry of Interior. In 1967, a greater part of the waterworks was taken over by the Metropolitan Waterworks Authority (MWA). Prior to the creation of the Provincial Waterworks Authority (PWA) by the Act of February 28, 1979, the water supply activities in the entire country except the Bangkok Metropolitan Area were under the responsibility of the Public Works Department of Ministry of Interior and Public Health Department of Ministry of Health.

3.2 Role of PWA

When PWA was established, 182 urban waterworks operating in provincial town areas were transferred to the PWA from the Public Works Department and Public Health Department, with exception of some designated local waterworks and sanitary districts, which still continue to remain under the responsibility of the Public Works Department.

The activities of PWA are divided into two categories: (1) the Urban Water Supply Program and (2) the Rural Water Supply Program.

Under the Urban Water Supply Program, PWA constructs, invests, owns and operates water supply systems in provincial districts or sanitary districts with 5,000 residents or more, which meet the following requirements as PWA

waterworks. The requirements are (1) substantial population density; (2) suitable water resources; (3) relatively good economic and social status; and (4) suitability for investment which involves special political and national securities as well as the residents ability to pay.

The Rural Water Supply Program relates to small sanitary districts or communities with populations of approximately 1,500 or more and other rural areas in need of water supply service. Under this Program, PWA finances part of the investment, with the remainder by the communities in need of water supply. PWA also undertakes the necessary investigation, design, cost estimating, construction and training. Upon completion of construction, the systems are handed over to the communities for operation. Thereafter, PWA furnishes technical guidance only.

At the end of 1985, PWA provided services to 181 provincial towns (with integration of some water supply activities for efficiency in operation), including 90 areas within municipalities, 154 sanitary districts and 25 other districts. In addition, technical service was furnished to 675 water supply systems. The total production capacity was about 700,000 cu m per day, serving a total of approximately 405,000 consumers (connections).

3.3 Status of Chiangmai Waterworks in PWA

Chiangmai Waterworks is under the supervision of Regional Office No. 9, one of the 10 Regional Offices, through which PWA is controlling its 181 urban waterworks in Thailand.

Regional Office No. 9 controls 24 waterworks under its jurisdiction and the combined revenue of these 24 waterworks assumed the weight of 12.85 % in the total PWA revenue for 1985.

Chiangmai Waterworks is one of the largest waterworks in the jurisdiction of the Regional Office, sharing 34.51 % (39.62 %, if Mae Rim and San Kamphaeng Waterworks are included) of the 1985 combined total sales of the waterworks in the jurisdiction and 4.43 % (4.94 % if Mae Rim and San Kamphaeng Waterworks are included) of the total PWA revenue.

PART TWO
DEVELOPMENT PLAN

PART TWO

CHAPTER 4 DESCRIPTION OF STUDY AREA

CHAPTER 4

CHAPTER 4 DESCRIPTION OF STUDY AREA

4.1 Natural Features

4.1.1 Coverage

The study area covers the present jurisdiction of Chiangmai Waterworks, which almost coincides with the administration jurisdiction of Chiangmai Municipality (hereinafter called Chiangmai) and 5 Sanitary Districts surrounding Chiangmai, i.e., San Sai, San Kamphaeng, Saraphi, Hang Dong and Mae Rim, which are planned to be included in the jurisdiction of Chiangmai Waterworks after the implementation of this Master Plan. Their location is as shown in Fig-4.1.

4.1.2 Location and Geography

Chiangmai and the surrounding Sanitary Districts are situated some 700 km northward from Bangkok approximately in long. 98 degrees east and in lat. 18 degrees north. The elevation ranges approximately from 300 m to 320 m above the sea level in the urban area of Chiangmai. In the area, humid monsoons blow from May to September, and cool but dry monsoons from November to February. The annual average precipitation of the area is about 1,100 mm/year.

Chiangmai is formed of a flat plain surrounded by hills, and develops along the Ping River which is derived from the northern mountainous drainage areas extending nearly 6,500 sq km. The Mae Ngat River, which is a tributary of the Ping River and has some 1,300 sq km of drainage areas, joins the Ping about 35 km North of Chiangmai. A dam named Mae Ngat was completed in March 1986 adjacent to the midstream of the river. The Mae Tang River, another main tributary of the Ping River, has about 1,900 sq km drainage areas and delivers water to an irrigation canal which is used also as a water source for Chiangmai and located at about 45 km northern upstream from the Municipality.

4.2 Socio-Economic Features

Chiangmai is the second largest city in Thailand, only next to Bangkok. Not only as an administration center of the Northern Thailand, it also serves as a center of commercial, industrial and educational activities of the Northern Thailand.

With its background as an ancient city, it boasts of its cultural inheritances including old buddhist temples with various cultural events. Together with beautiful sceneries and comfortable weather, it attracts more than one million tourists a year.

Chiangmai is an important traffic center, being connected with a number of national highways including those from Lampang and Nakhon Sawan, with its airport functioning as international aviation cross-routes as well as local ones.

Chiangmai is also a center of commercial transactions particularly of agricultural products such as rice, tobacco, potatos, and sugar-canes farmed in non-municipality areas around the city. The manufacturers of the municipality engage in rice mills, tobacco, plywood, cement, and other light industries including cotton fabrics.

Mae Rim is a transit town between Chiangmai and northern tourist spots. Mae Rim is also surrounded by a number of tourist spots including Mae Sa Waterfall, Nature Park and Mae Sa Valley. Mae Rim is also famous for the Elephant Camp which attracts both local and foreign tourists.

Sam Kamphaeng is well known as a center of souvenir shops, and a number of manufacturers producing such souvenir articles gather in this district. Thus souvenir articles include woodcarvings, silverware, china ware and bamboo handicrafts.

Mae Rim and San Kamphaeng are served by PWA, with the service ratios of 42 % and 34 %, respectively. Those residents not receiving PWA services are mostly depending upon groundwater.

San Sai, Saraphi and Hang Dong are farming districts, with rice, tobacco and fruits as their main crops. Hang Dong has a water supply system self-

operated by a group of residents. San Sai and Saraphi have no centralized water supply systems.

According to DTCP Socio-Economic Survey in 1981, those economically employed consisted 46.19 % of the labor force, with the rest composed of 26.1 % uneconomically employed and 73.9 % unemployed. The same survey showed that household income in urban district of Chiangmai stood as 4,220 Baht compared with 6,270 Baht for Bangkok and 4,630 Baht for all municipalities excluding central regions and Bangkok, reflecting the economic backwardness of the Northern Thailand.

These two factors, the high rate of unemployment and the low level of urban household income, are working to increase labor outlet, both temporary and permanent, from Chiangmai to Bangkok and other central regions. It is told that actual population in Chiangmai is therefore lower than the registered figure, which was reported as 155,000 as of 1985.

Electricity is supplied to almost all areas covering Chiangmai and Sanitary Districts by Provincial Electricity Authority (PEA) which is responsible for power supply to provincial areas. PWA supplies potable water to the area, and the service ratio was about 68 % in 1982, although the ratio decreased to 45% after the 1983 expansion of the administrative jurisdiction of the Municipality.

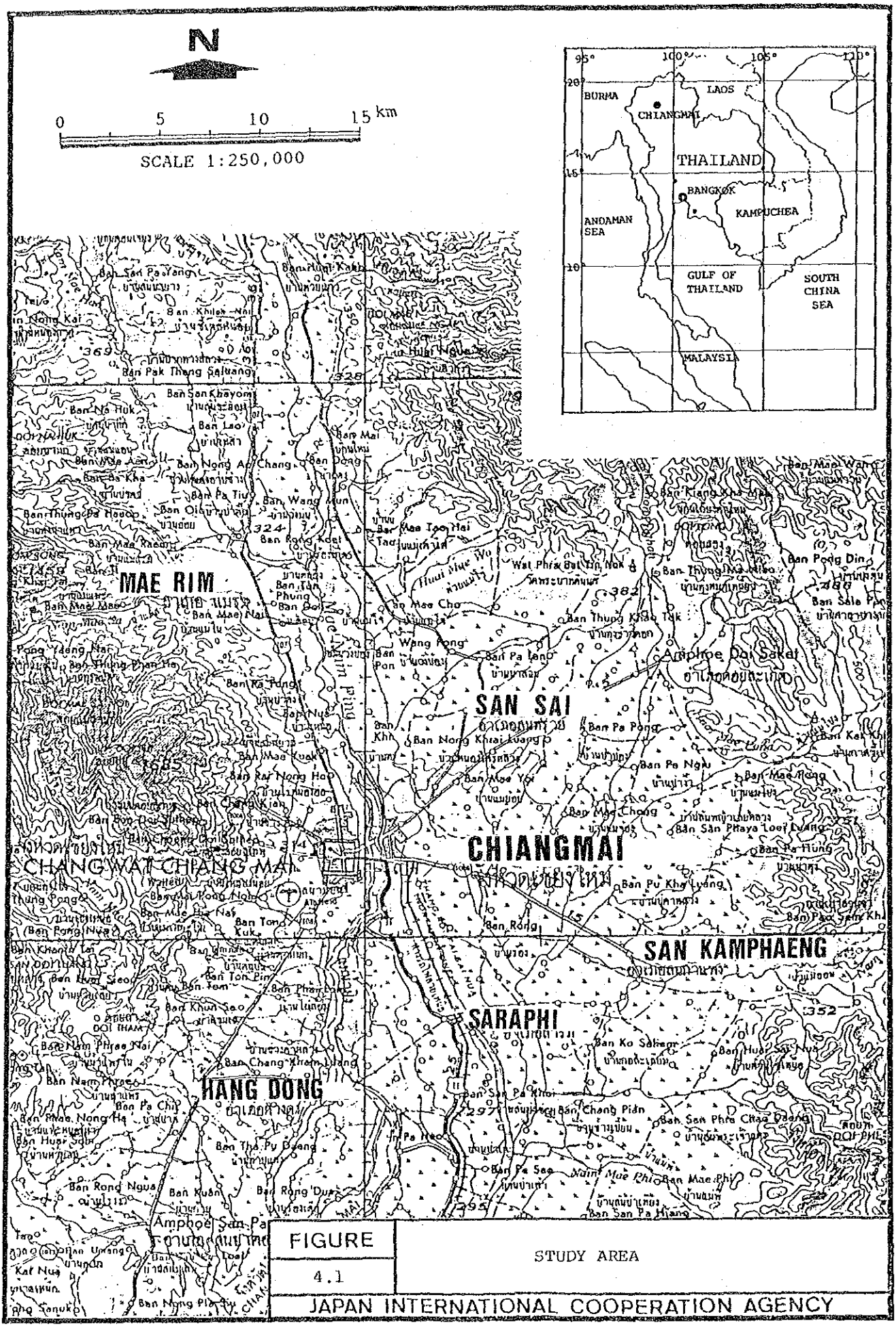

FIGURE	STUDY AREA
4.1	

JAPAN INTERNATIONAL COOPERATION AGENCY

CHAPTER 5 EXISTING WATERWORKS

CHAPTER 5 EXISTING WATERWORKS

The study areas mentioned in the preceding chapter have their own water supply systems, except for San Sai and Saraphi. About 50% of the total population (155,000) in Chiangmai are benefited by the water supply in 1985, while no more than 16% of the combined population (104,000) of the five sanitary districts are benefited.

Of those people who are not benefited by the water supply systems, about 90% in Chiangmai and about 97 % in the sanitary districts depend on groundwater.

The following are the background and the existing conditions of the waterworks in Chiangmai and the Sanitary Districts.

5.1 Water Supply Conditions

5.1.1 Chiangmai

The supply of potable water to Chiangmai Municipality started in February 1956 by the Public Works Department (PWD), then responsible for administrating provincial water supply systems. The water was supplied from the Wang Sing Kam Treatment Plant with a treatment capacity of 40 cu m/h or 960 cu m/d, constructed at a site close to the Ping River, one of the Chao Praya River tributaries.

The Umong and Paton Treatment Plants have been constructed to meet the ever-increasing water demands due to the increased per capita water consumption and also to the expansion of administration districts and water service areas in 1983, as shown in Table-5.1. The Umong Treatment Plant takes raw water from the Irrigation Canal while the Paton Treatment Plant relies its source on the Ban Tho Intake of the Ping River. When the Wang Sing Kam Treatment Plant was constructed, the water source was changed to the Ban Tho Intake, as the water of the Ping River has become seriously polluted by the industrial wastewater discharges to the river, particularly the portion between the Ban Tho Intake and Wang Sing Kam.

Table-5.1 TREATMENT PLANTS OF CHIANGMAI WATERWORKS

NAME OF PLANTS	WATER SOURCE	CONSTRUCTED & EXPANDED IN	CAPACITY (cu m/h)	REMARKS
WANG SING KAM (No.1)	PING RIVER	1956	(40)	Abandoned
		1964	80	
		1968	250	
		Sub-Total	330	(7,920 cu m/d)
UMONG (No.2)	MAE TONG CANAL	1968	200	
		1976	1,000	
		Sub-Total	1,250	(30,000 cu m/d)
PATON (No.3)	PING RIVER	1981	660	
		Sub-Total	660	(15,800 cu m/d)
	TOTAL		2,200	(53,760 cu m/d)

The service areas and locations of the major water supply facilities as of 1984 are shown in Fig-5.1. The water supply system covers 80,800 population or approximately 52 per cent of the total 155,300 inhabitants within the service area extending about 40 sq km. The total water sold is estimated at 23,500 cu m/d with an unaccounted-for water ratio of 32 per cent. The ratio of maximum day flow to average day is estimated to be 1.25, with the maximum day demand amounting to 43,000 cu m/d.

The estimated maximum day demand is about 80 per cent of the total production capacity of the three treatment plants, and the systems is therefore considered to have 20 percent allowance in production capacity.

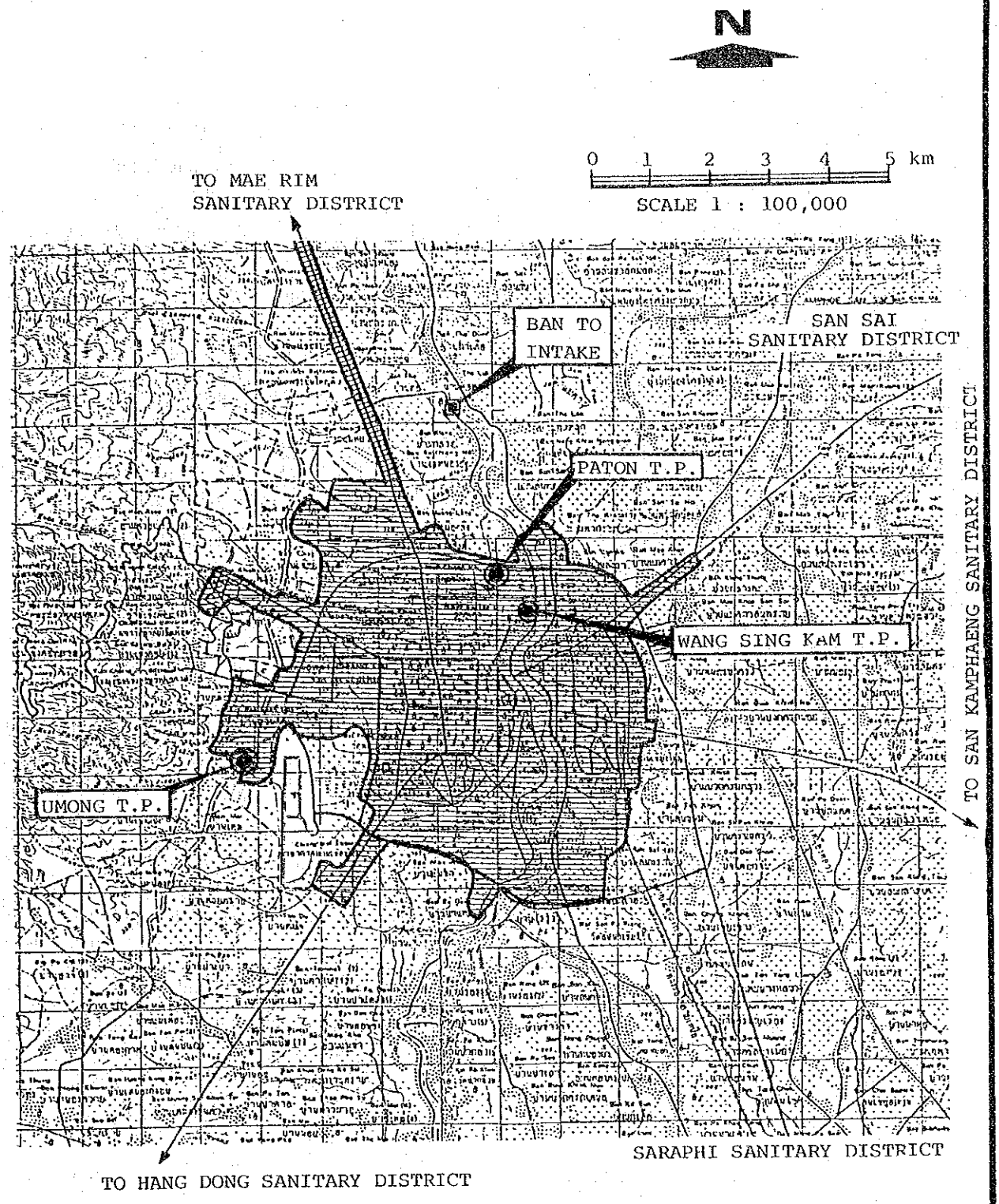

FIGURE	EXISTING WATER SUPPLY SYSTEM OF CHIANGAMI
5.1	

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The existing water supply conditions are outlined in Fig-5.2.(1).

The study team conducted a questionnaire survey to study the relation between water supply and related socio-economic conditions phenomena. The results of the survey are summarized in Appendix 5.

5.1.2 Sanitary Districts

The water supply conditions of two Waterworks, Mae Rim and San Kamphaeng, are outlined in Fig-5.2.(2).

1) Mae Rim

The water supply system started its services when the water treatment of a 1,920 cu m/d capacity was put in operation in 1975, with raw water taking from the Mae Sa Rivulet. As the treatment capacity could not catch up with the increasing demand, additional facilities of 6,000 cu m/d were constructed and was put in operation in February 1986, making its total capacity increased to 7,920 cu m/d, more than twice of the existing water demand, 3,900 cu m/d.

The service area of the system is as shown in Fig-5.3 approximately 4.6 sq km, where 4,700 residents or about 42 percent of the total population (11,100) are receiving water supply services. The total water sold is estimated at 2,000 cu m/d with an unaccounted-for ratio of 33 percent, according to the record of the Waterworks.

The service area of Mae Rim is already connected with that of Chiangmai. Large consumers along the main road connecting to Chiangmai are supplied by the Mae Rim Waterworks.

2) San Kamphaeng

San Kamphaeng Treatment Plant started its operation in 1970 using abundant groundwater available in and around the San Kamphaeng Sanitary District. Because the groundwater contains iron and manganese, the water treatment

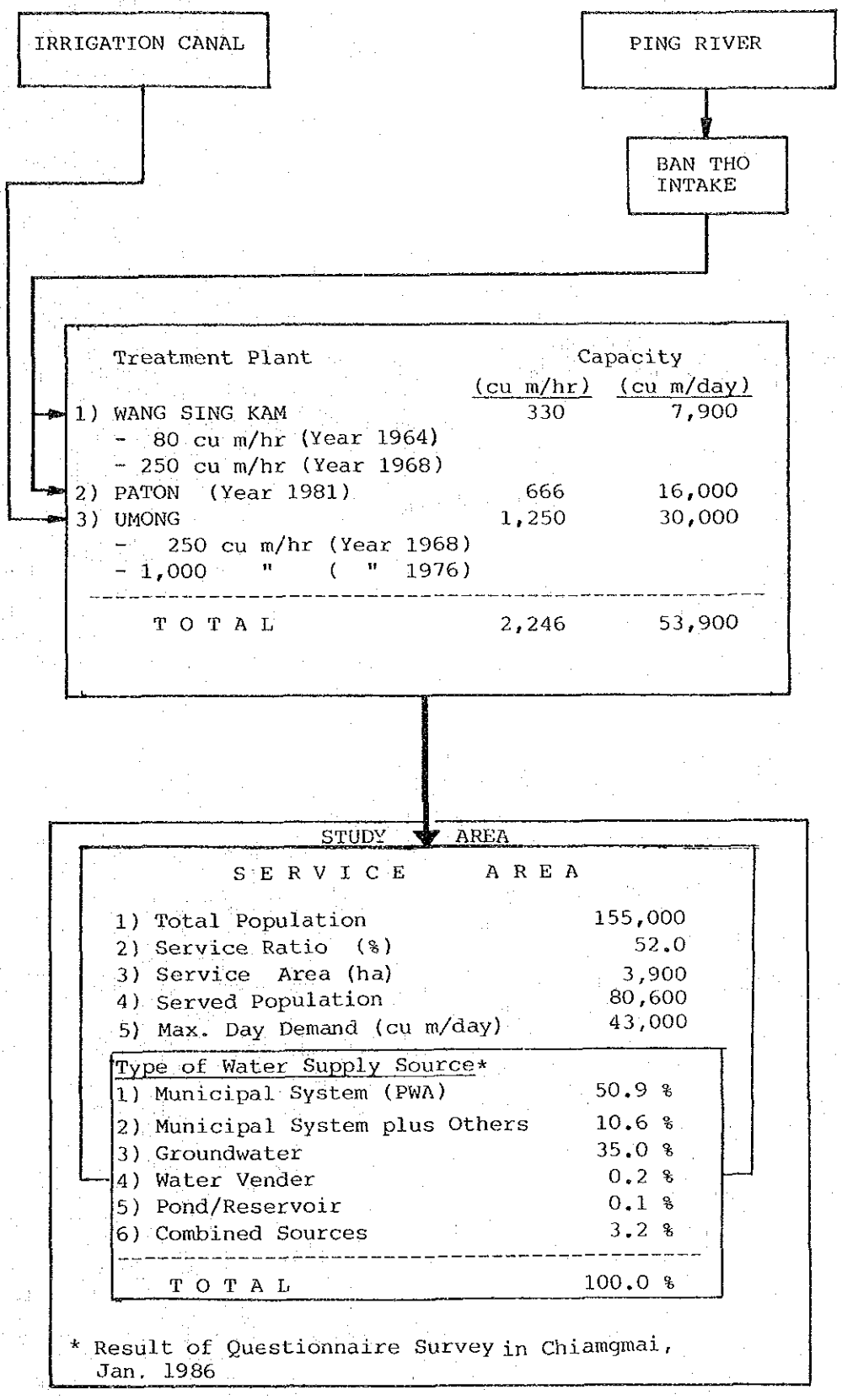

FIGURE	SCHEME OF PRESENT WATER SUPPLY CONDITION (CHIANGMAI)
5.2.(1)	

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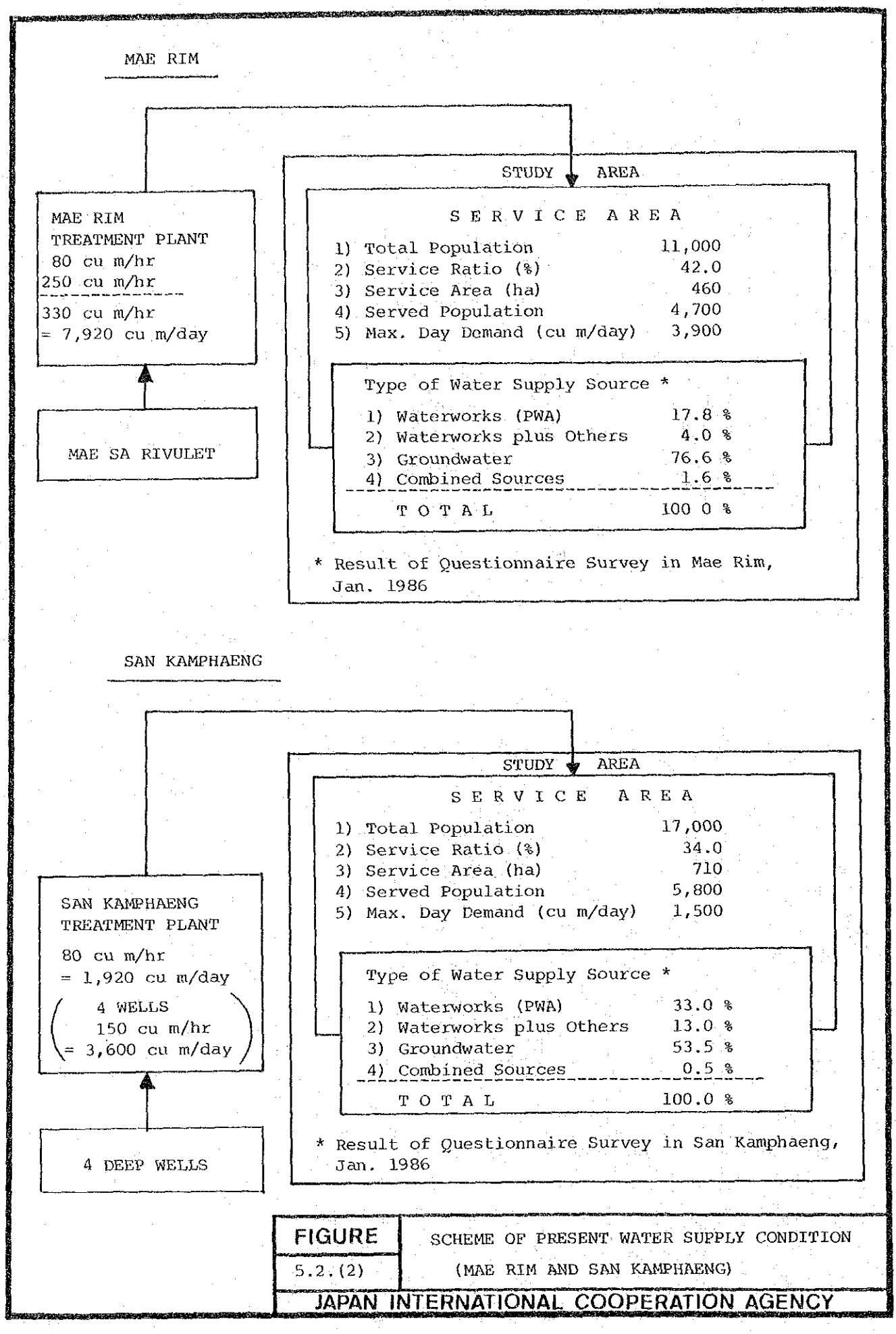
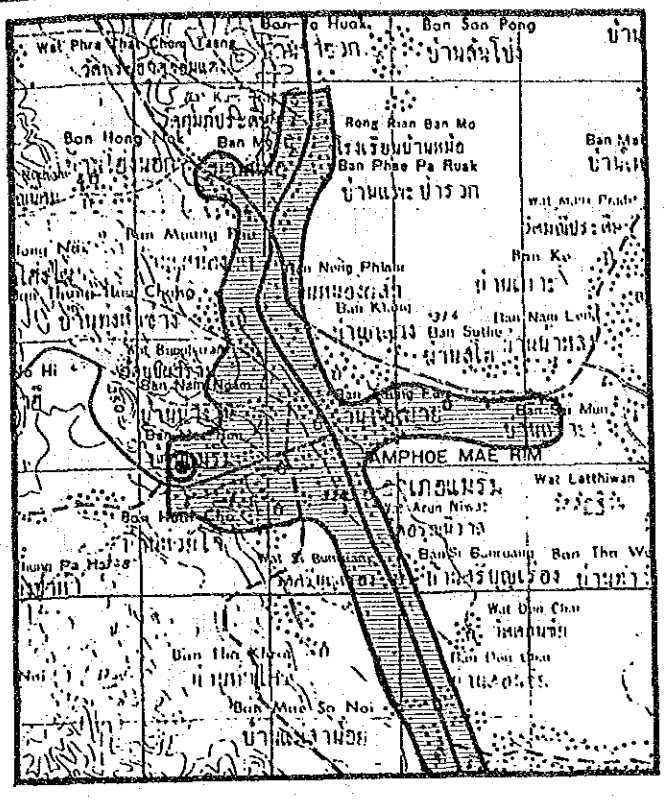
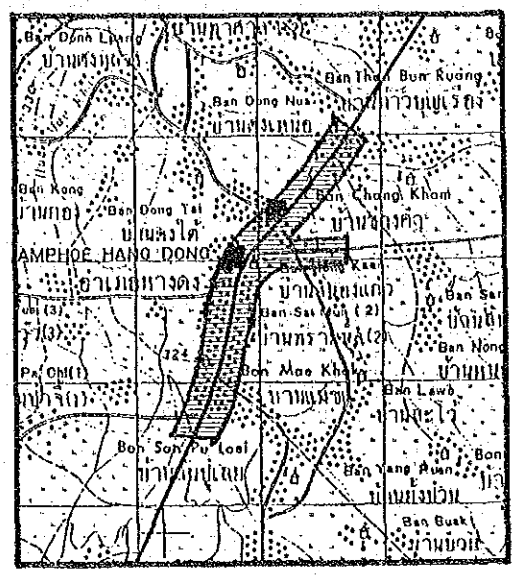


FIGURE	SCHEME OF PRESENT WATER SUPPLY CONDITION
5.2.(2)	(MAE RIM AND SAN KAMPHAENG)

JAPAN INTERNATIONAL COOPERATION AGENCY



MAE RIM



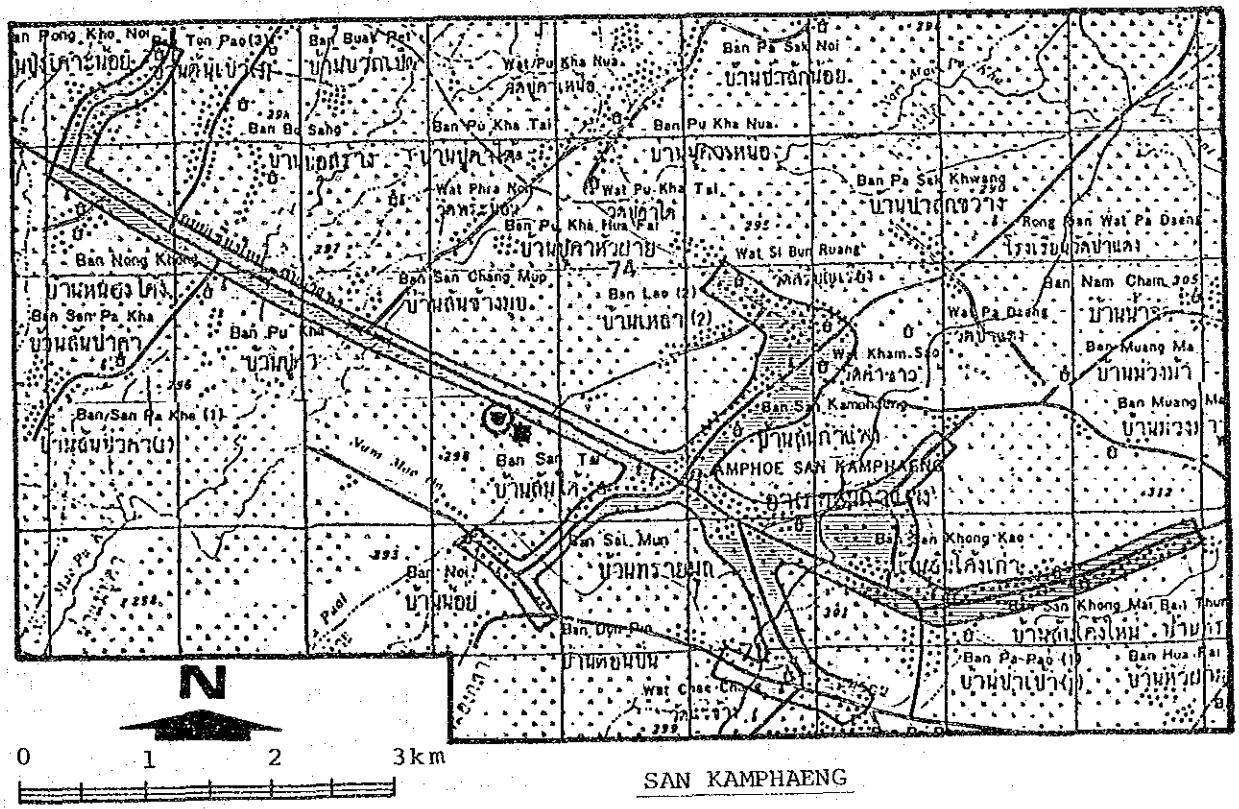
HANG DONG

LEGEND

: PRESENT SERVICE AREA

: TREATMENT PLANT

: WELL



SAN KAMPHAENG

FIGURE	EXISTING WATER SUPPLY SYSTEM OF THREE SANITARY DISTRICTS
5. 3	

JAPAN INTERNATIONAL COOPERATION AGENCY

plant of 1,920 cu m/d is equipped with pre-chlorination and aeration facilities to remove them and produce water quality meeting the requirements of DWS of PWA. There are now four 90 m deep wells producing a total of 3,600 cu m/d, which is about twice of the present water demands in the area.

The service area, as shown in Fig-5.3, is about 7.0 sq km as of 1985. Approximately 5,800 people, or about 34 per cent of 17,000 people living within the area, are receiving water supply service, consuming a total of 750 cu m/d water (sold water) with an unaccounted-for water ratio of 33 percent.

Along the main road connecting Chiangmai and San Kamphaeng, there are many factories and shops.

3) Hang Dong

Hang Dong Sanitary District started its independent water supply service in 1976, with a deep well as water source. The number of consumers households totals only about 70 at present. The service area of the system lies along the district main road, as shown in Fig-5.3.

The total supplying capacity with the existing two wells is 1,260 cu m/d, of which 840 cu m/d is from the old well and 420 cu m/d from the new well drilled in 1986. Total water consumption of the 70 households is estimated to be about 50 cu m/d, with sufficient surplus in the capacity of the existing system.

4) San Sai and Saraphi

There is no water supply systems in these Sanitary Districts at present, and most of the population rely on groundwater for their water sources. Groundwater in the San Sai Sanitary District contains iron to some extent so that all the wells are provided with filters to remove it. Water quality of the groundwater in Saraphi is better than the San Sai's.

The questionnaire survey concerning the people's interest about public supply service showed that they were less interested especially in Saraphi,

as their willingness to have house connection with a public supply service was as low as 30 %.

5.2 Water Sources

This section delineates the present water sources for the Chiangmai Waterworks and the five Sanitary Districts. Fig-5.4 illustrates the hydrogeographic features of the Ping River Basin around Chiangmai Municipality, as clarified by the review of available data and field survey conducted by the team.

5.2.1 Chiangmai

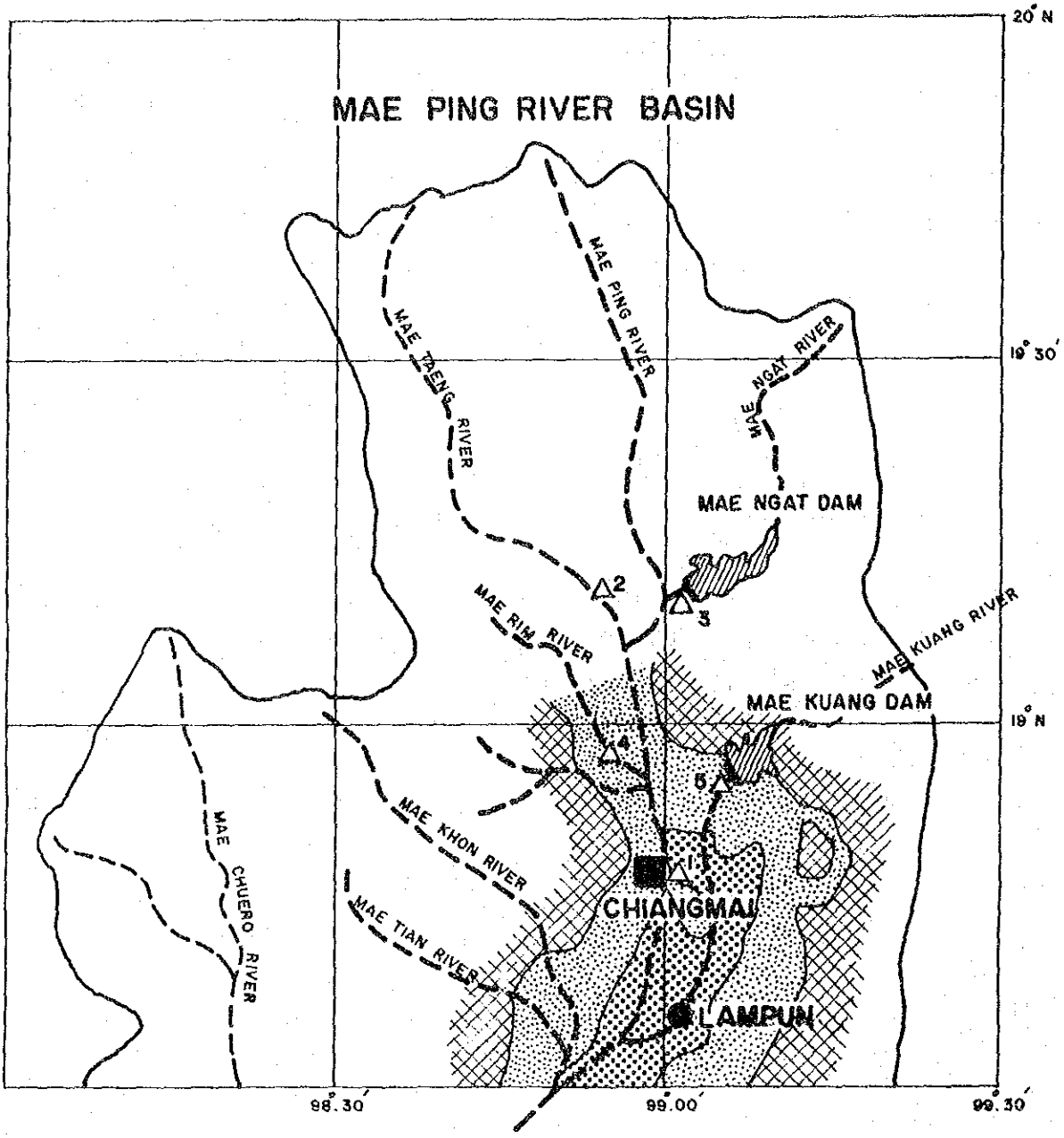
The major water sources for the Chiangmai Waterworks are the Ping River and its major tributaries of the Mae Taeng River. The Ping River supplies raw water at a rate of 23,760 cu m/day or 8,67 MCM/year to the Paton and Wang Sing Kam Treatment Plants. The Mae Taeng Irrigation Canal, another water source, supplies raw water at a rate of 30,000 cu m/day (10.95 MCM/year) to the Umong Treatment Plant.

1) Ping River

The Ping River originates in the mountains of the Chiang Dao Northern Districts and flows down through the eastern part of Chiangmai Municipality. The river has a drainage area of 6,355 sq km with a mean annual rainfall of 1,200 mm, of which 74 % is lost by evapo-transpiration in the basin.

The Ping River's mean annual runoff at Chiangmai Municipality is measured at 2,026 MCM/year (1821-1980 by RID) and only a fraction of the run-off, about 19.6 MCM/year, is being used by the Chiangmai Waterworks. According to information obtained during a site survey at the Ban Tho intake, the Ping River's flow decreases in the dry season with the river water sometimes declining to a critical level of a few centimeters. The operators on such occasions have to dig the river beds to collect water.

AVAILABLE WATER RESOURCES FOR CHIANGMAI



LEGEND

- STREAM
- AMPHOE CENTER
- GAUGING STATION
- DAM
- GROUNDWATER HIGH POTENTIAL AREA
- GROUNDWATER MODERATE POTENTIAL AREA
- GROUNDWATER LESS POTENTIAL AREA

FIGURE	AVAILABLE WATER RESOURCES FOR CHIANGMAI
5.4	

JAPAN INTERNATIONAL COOPERATION AGENCY

2) Mae Taeng Irrigation Canal

The Mae Taeng Irrigation Canal constructed by RID is one of the important water sources and the sole source for the Umong Treatment Plant. A problem of the canal is that the water flow has to be stopped for about 50 days every year for inspection and repair purposes. To cope with the canal flow suspension, PWA procured a set of pumps and pipes recently. They are used to provide a temporary pipeline which can bypass the section of the canal under repair.

The raw water quality at the intake sites of Ban Tho (Ping River) and Umong (Mae Taeng Irrigation Canal) is discussed, in detail, in the study on water quality (Appendix 4). The tests of water from the two sites showed similar and acceptable results. The raw water is being treated satisfactorily by the present facilities.

5.2.2 Mae Rim and San Kamphaeng

1) Mae Rim

A rivulet called Lam Mae Sa flowing into the Mae Rim Sa is the water source for the Mae Rim Sanitary District. This rivulet originates from Mae Sa Valley in the western side of mountains and provides raw water for the treatment plant at a capacity of 330 cu m/hr which the field survey found to be sufficient enough to meet the demand in the area.

The present raw water quality is considered satisfactory to be utilized for public water supply.

2) San Kamphaeng

Groundwater is utilized as the water source for public water supply to this Sanitary District. There are 4 deepwells with depth of 90 m. The production capacity of each well is about 1,000 cu m/day.

The quality of above groundwater is considered allowable, although concentrations of iron and manganese are sometimes relatively high.

5.3 Intake and Water Treatment Facilities

5.3.1 Chiangmai

1) Ban Tho Intake and Transmission Pipelines

As for water source, the Chiangmai Waterworks now relies on two water intakes. Raw water of the Ping River is taken at the Ban Tho Intake and transmitted by pumps to both Wang Sing Kam and Paton Treatment Plants, while raw water for the Umong Treatment Plant is pumped from an Irrigation Canal and stored in a raw water reservoir before transmitting to the Plant.

As shown in Fig-5.5, the Ban Tho Intake comprises screens, grit chambers, raw water pumps and a pump house, as well as transformer, generator, and flow meters with indicators. The major features of the grit chambers are as follows:

- Dimensions: 15.0 m x 4.5 m x 1.5 m (effective depth)
- Number of Basin: 2
- Detention time: 11.1 min. (*)
- Capacity: 101.5 cu m/basin

(*) The detention time for the flow rate of 26,310 cu m/d. The flow rate is the sum of treatment capacity of the Paton and Wang Sing Kam Treatment Plants, inclusive of 10 per cent of the amount as water losses.

The grit chambers are oversized about 10 % in capacity, when compared with the design criteria generally adopted, and the pump house has a space for installation of two additional pumps.

Because the two existing flow meters with indicators have been out of order, the water transmitted to these two treatment plants has been estimated on the basis of pumps' nominal capacity and their operating time.

In case of power suspension, which usually occurs once a month, electricity is supplied to pumps by a generator. Settled grit in the grit chambers is periodically removed and the facilities are relatively well operated and maintained.

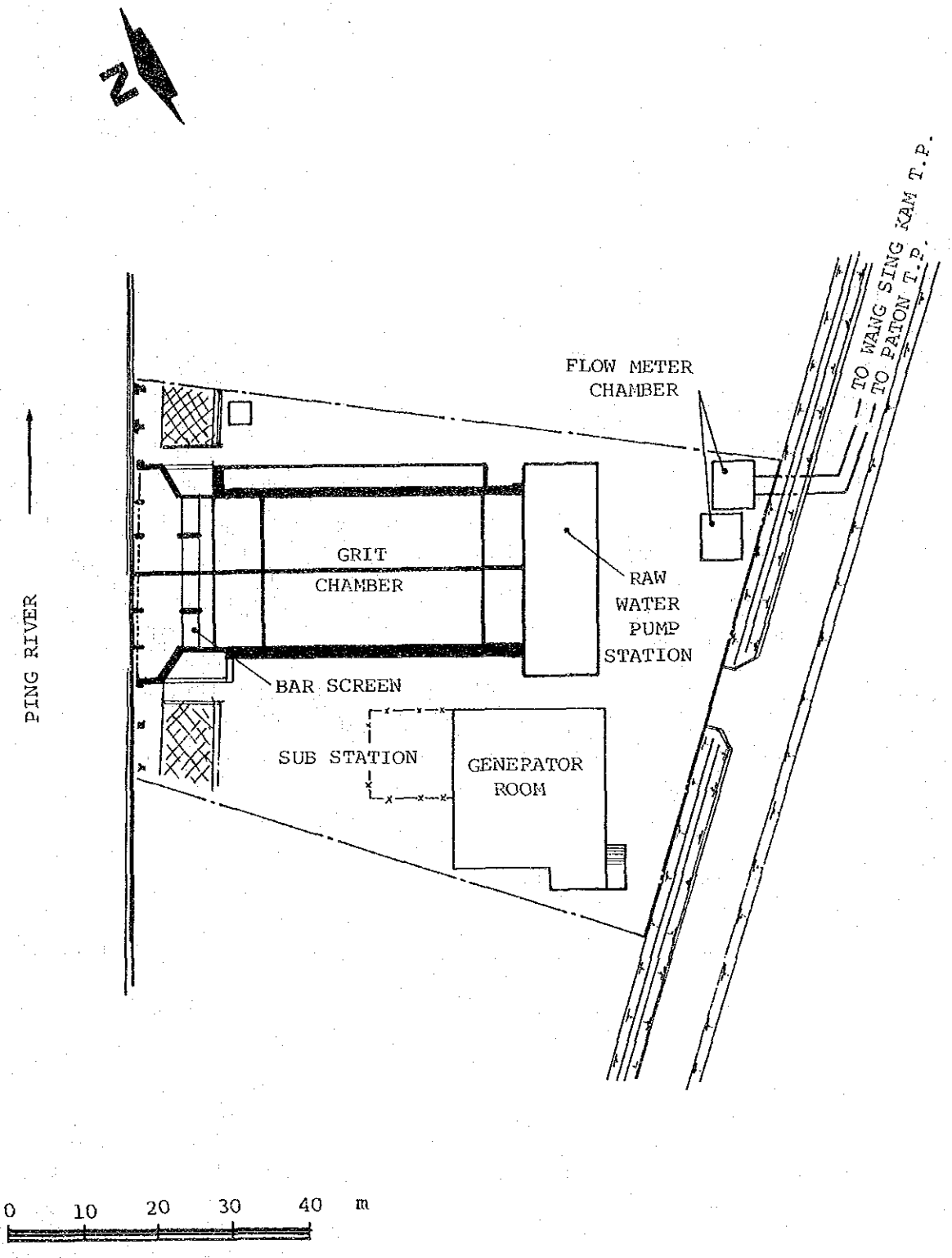


FIGURE	GENERAL PLAN OF BAN THO INTAKE
5.5	

JAPAN INTERNATIONAL COOPERATION AGENCY

A 500 mm diameter transmission pipeline around 3,100 m in length connects the Ban Tho Intake to the Paton Treatment Plant, and another 300 mm diameter pipeline 4,200 m long to the Wang Sing Kam Treatment Plant. Both pipelines are interconnected on the way to the plants.

2) Wang Sing Kam Treatment Plant

The general layout plan of the Wang Sing Kam Treatment Plant is shown in Fig-5.6. The Treatment Plant has two separate series of treatment systems, one with a capacity of 80 cu m/h and the other 250 cu m/h, with combined capacity of 330 cu m/h or 7,900 cu m/d. As the Chiangmai Waterworks' production capacity has at present a surplus of 10,000 cu m/d over demand, this treatment plant is operated intermittently, that is, only when the operation of the Umong Treatment Plant is suspended. The Regional Office No.9, built in the lot, was expanded in 1986.

The results of the field survey indicate the following problems and suggest that rehabilitations and improvement of the existing facilities are immediately required if the facilities are to be utilized till the target year of 2010.

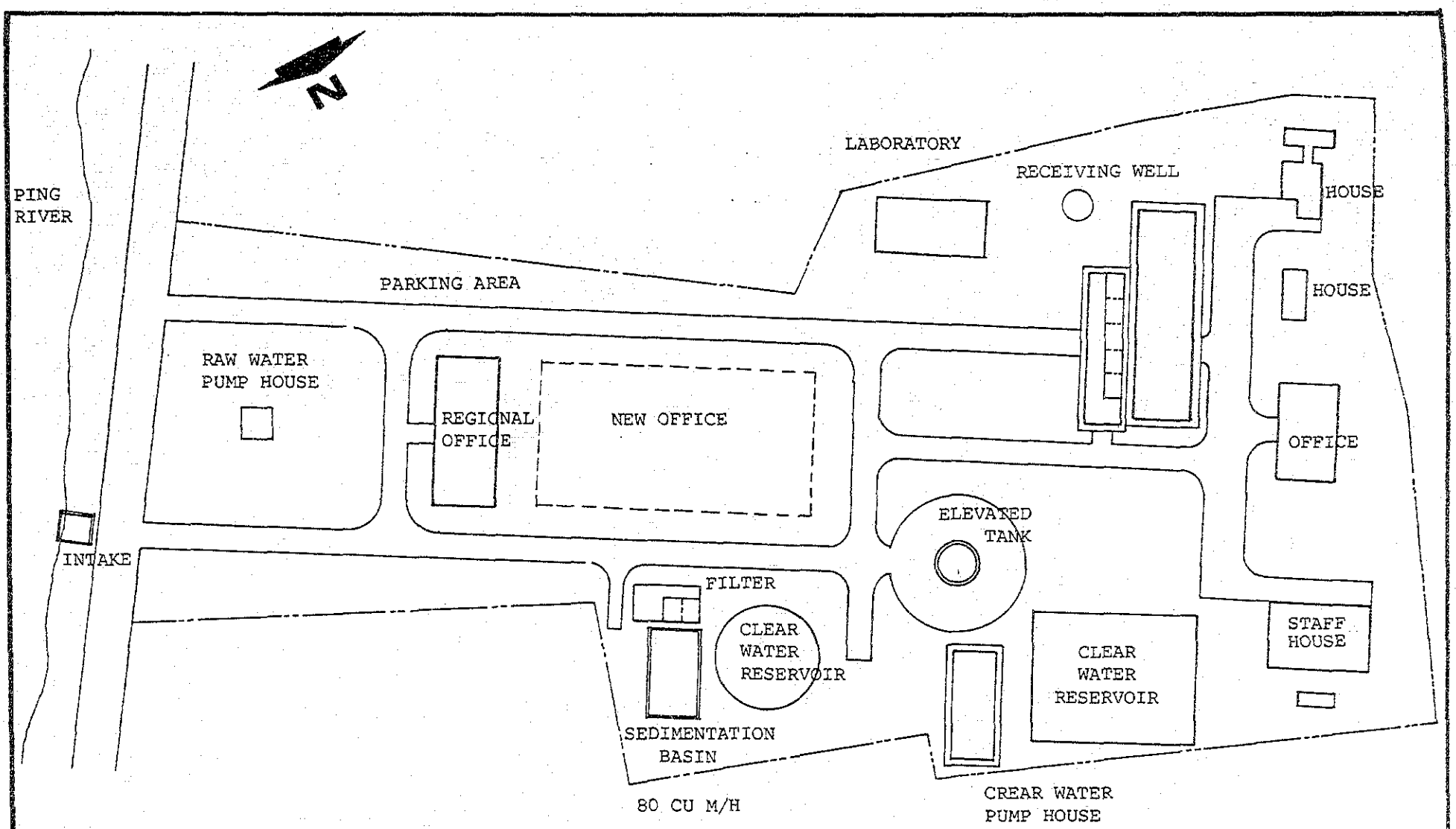
(1) As the existing alum dosing equipment is outdated, accurate dosage of chemicals cannot be made, corresponding to the changing raw water quality

(2) The flow meters for raw and treated water found impossible to be read as they are covered by a building constructed later. With no chlorine container scale, the left-over weight of chlorine cannot be measured.

(3) Many cracks and mud balls are observed in the filter beds, though they are supposed to be backwashed periodically. Mixing of sand and gravel was also noticed.

(4) The distribution pumps have not been used over a long period, and they are found unrepairable.

(5) As the treatment facility has been suspended from operation



Note : For capacity and volume referred to Table-5.2.

FIGURE	LAYOUT OF WANG SING KUM TREATMENT PLANT
5.6	

JAPAN INTERNATIONAL COOPERATION AGENCY

frequently over a long period, a noticeable amount of deposit is found accumulated at the bottom of the flocculation/sedimentation basins.

In order to properly operate and maintain the treatment plant, the above conditions should be rectified, and necessary rehabilitation be made at the early stage of this project. The same improvement and rehabilitation works required for the Wang Sing Kam Treatment Plant can also be applied to Umong and Paton Treatment Plants.

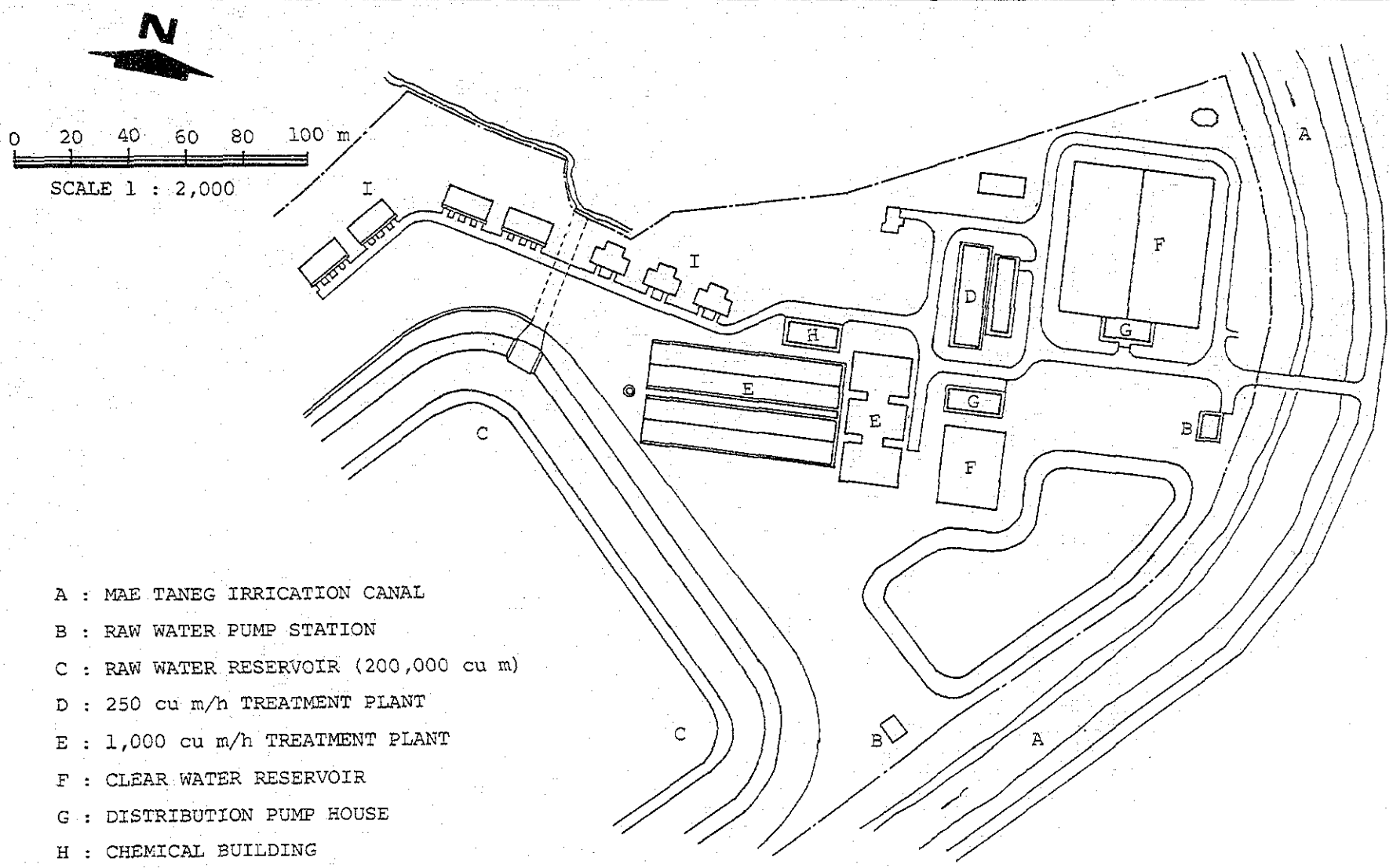
3) Umong Treatment Plant

As the layout plan of the Umong Treatment Plant shown in Fig-5.7 illustrates, the Treatment Plant comprises, within the plant site of about 82 rai (131,000 sq m), a raw water reservoir of 200,000 cu m capacity, two sets of treatment system each having a treatment capacity of 250 cu m/d and 1,000 cu m/d, and houses for the plant operators. Presently, a plan is underway to construct a staff training center in the plant site, under the Japanese Government's aid program.

The treated water has occasionally shown turbidities, slightly higher than that specified in DWS. However, this problem can be solved if the raw water quality is properly monitored and appropriate chemical dosing, determined by jar tests is applied to treatment. In view of these, the same items as those recommended to Wang Sing Kam Plant improvement will also apply, to this Treatment Plant including 1) chemical dosing system, 2) raw and treated water flow meters, 3) filter media and underdrain system, and 4) repair of the 1,000 cu m/h sedimentation basin drain pipe.

The 250 cu m/h capacity treatment system, planned and designed under the treatment plant standard design of PWA, employs gravitational up-and-down baffles flocculation process which is hydraulically difficult to be operated under higher capacities than the designed, because of the head loss increase.

The 1,000 cu m/h capacity system, although applicable to increased capacities, is restricted to the designed rate by the water right allocation and the flow capacity of the Irrigation Canal.



Note ; For capacity and volume referred to Table-5.2.

FIGURE	LAYOUT OF UMON TREATMENT PLANT
5.7	

JAPAN INTERNATIONAL COOPERATION AGENCY

4) Paton Treatment Plant

As shown in Fig-5.8, in the Paton Treatment Plant site of 7 rai (44,000 sq m) located are the treatment facilities of 16,000 cu m/d capacity and Chiangmai Waterworks Office. The treatment plant production capacity can be increased by about 25 percent of the design output, according to the updated PWA design criteria.

According to the available records of treated water quality, the turbidity sometimes exceeded the DWS when the raw water turbidity was high. However, if the raw water quantity is correctly measured, jar tests are frequently made, the determined chemical dosage is kept and the plant operation is properly made, the Plant would be able to produce the water of acceptable quality.

The planned increase of water production in future will be achieved by improving and rehabilitating the existing facilities as enumerated in the following:

(1) The Alum pumps and Lime solution tanks are deteriorated and liable to breakdown. These are unlikely to fit for long use and should be replaced by new equipment.

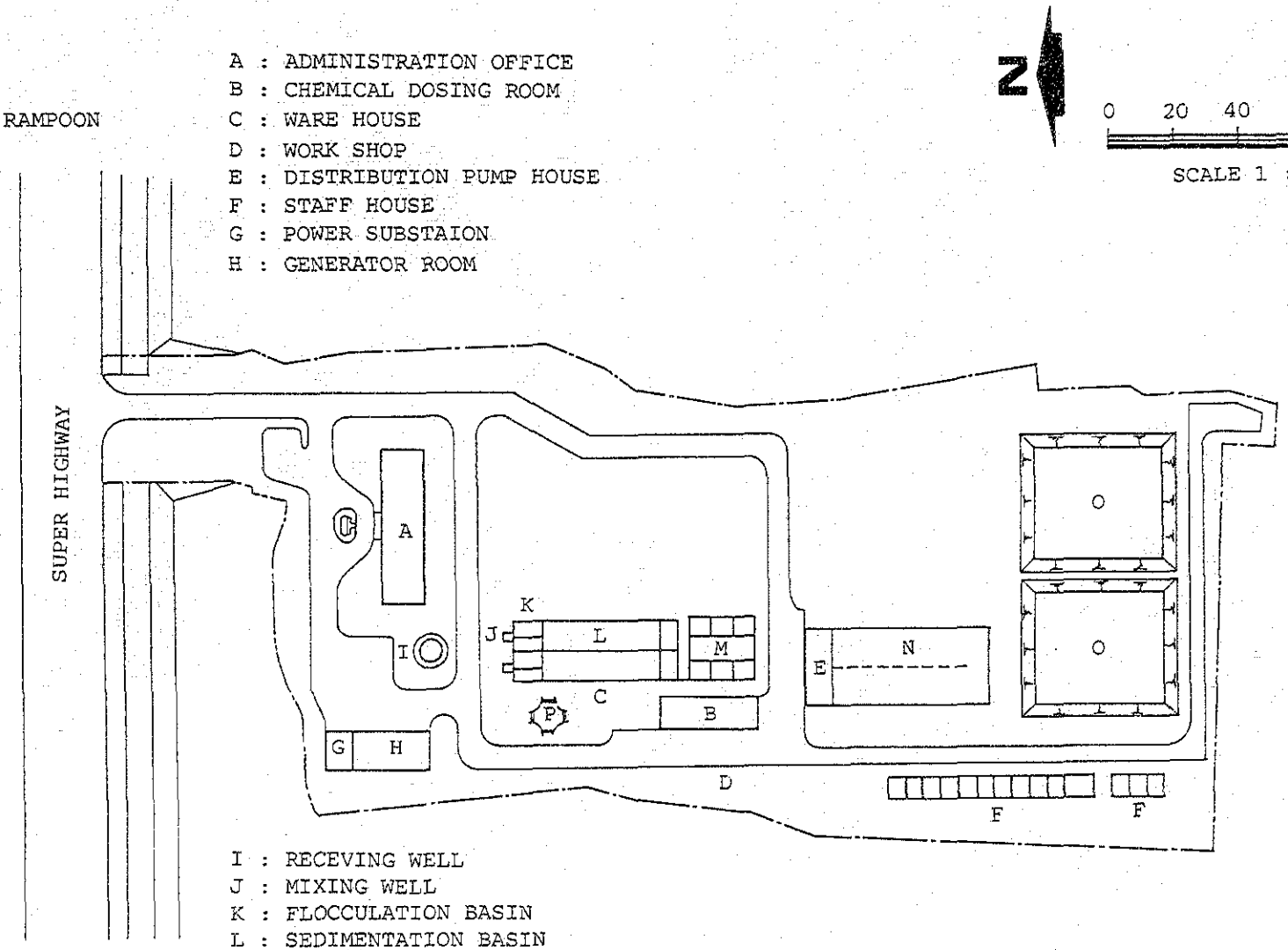
(2) As the meters measuring raw and treated water flow rate and water level gauges of the reservoir have been broken, the raw and treated water are not measured but are estimated by the duration of pump operation. The meters should be renewed.

(3) As the sedimentation basin is not provided with baffles, the density currents occur in the basin, causing floc carry-over as frequently observed. A simple device to control the flow condition is planned.

(4) There are cracks and mud balls in the filter beds. The sand is replaced.

(5) Because the valves for backwash of filter media and surface pipe control are manually operated and also the water pressures are

A : ADMINISTRATION OFFICE
B : CHEMICAL DOSING ROOM
C : WARE HOUSE
D : WORK SHOP
E : DISTRIBUTION PUMP HOUSE
F : STAFF HOUSE
G : POWER SUBSTAION
H : GENERATOR ROOM



I : RECEVING WELL
J : MIXING WELL
K : FLOCCULATION BASIN
L : SEDIMENTATION BASIN
M : RAPID SAND FILTER
N : CLEAR WATER RESERVOIR
O : LAGOON
P : ELEVATED TANK

Note : For capacity and volume referred to Table-5.2.

FIGURE	LAYOUT OF PATON TREATMENT PLANT
5.8	

JAPAN INTERNATIONAL COOPERATION AGENCY