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 III-A
MAIN REPORT
FOR
UBON RATCHATHANI
AND
WARIN CHAMRAP

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.

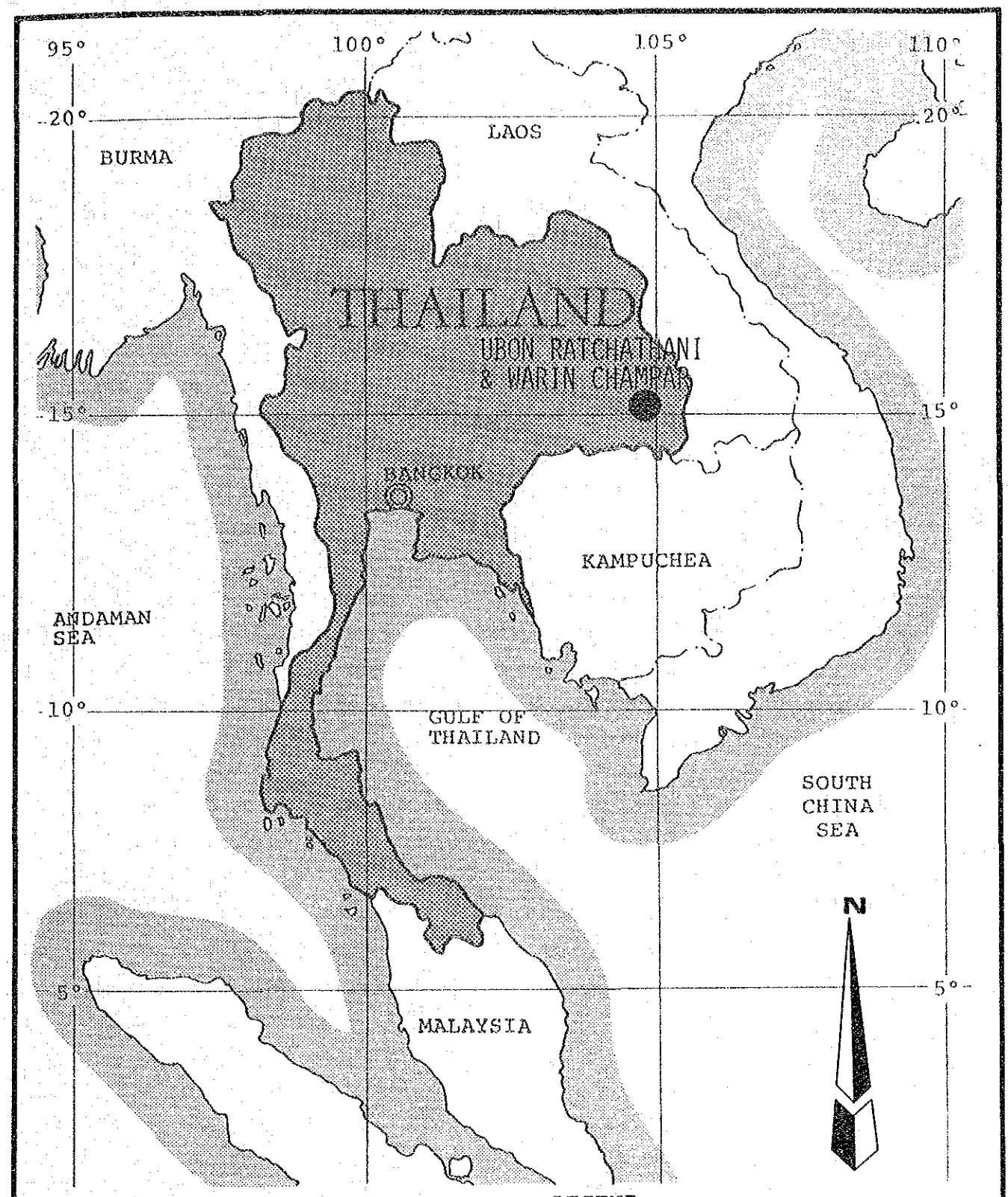
The team had discussions with the officials concerned of the Government of the Thailand and conducted a field survey in the Study Areas and Bangkok. After the team returned to Japan, further studies were made and the present report has been prepared.

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

● : UBON & WARIN MUNICIPALITIES

◎ : CAPITAL CITY

SCALE 1 : 10,000,000

FIGURE	LOCATION MAP
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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, UBON RATCHATHANI AND WARIN CHAMRAP".

Ubon Ratchathani and Warin Chamrap located approximately 500 km northeast of Bangkok, are neighboring municipalities which almost constitute one township served by a single water-supply system operated by Ubon-Warin Waterworks. The project area covers, other than these two municipalities, their adjacent districts including Ubon Sanitary District and five villages where no water supply services are provided and 74 % of the residents there are willing to be connected to PWA system.

The combined population of the study area is projected to increase from 152,000 in 1985 to 196,400 by 2010, the target year of the current project.

The current project purports to mitigate such immediate requirements, as well as to improve the service ratio in the long-run from 40 % at present to 75 % in 2010.

In view of the uncertainties in the future development of the study area 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.

The existing facilities are suffering from deterioration which is reducing operation efficiency and increasing the unaccounted-for ratio. To cope with this situation, the Development Plan proposes an immediate improvement program to rehabilitate the existing system, together with immediate modification works to promptly 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 a part of its initial phase.

B. Strategies to the Targets

Water consumption will be increased to two and half times as large as the present level in the coming 13 years, from 12,400 cu m/day in 1985 to 31,100 cu m/day in 2000, and further to 48,700 cu m/day in 2010. Domestic demand will increase reflecting both population growth and per-capita consumption increase (from 142 lpcd in 1985 to 177 lpcd in 2000), and public demand is projected to expand at a slightly higher rate than the domestic one.

Strategic plans are illustrated in Fig-ES.1 and the estimated costs - therefor are summarized in Table-ES.1.

Table-ES.1 TOTAL COST FOR MASTER 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	13,400	145,900	159,300	139,100	298,400
Engineering Services	1,500	15,800	17,300	14,700	32,000
Administration Cost	100	1,600	1,700	1,500	3,200
Physical Contingencies	1,100	11,400	12,500	10,900	23,400
Price Contingencies	2,000	26,400	28,400	87,300	115,700
Total	18,100	201,100	219,200	253,500	472,700

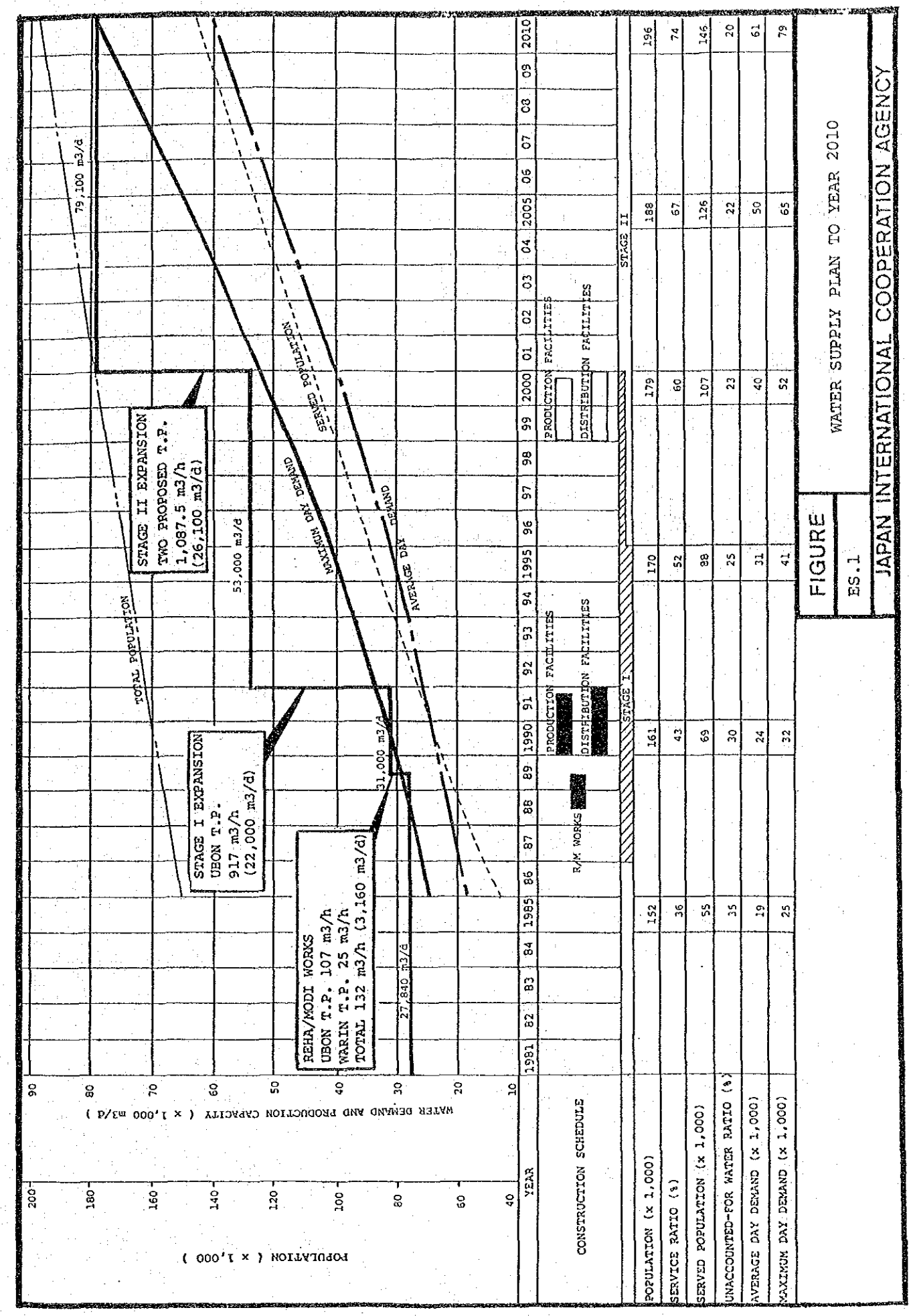

FIGURE ES.1

WATER SUPPLY PLAN TO YEAR 2010

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C. Proposed Water Supply, 1987-2000

The proposed water supply system for Stage I will cover the service area shown in Fig-ES.2. The rehabilitation and modification will provide needed improvement of existing facilities. The Stage I Expansion is designed to meet projected maximum day demand of 52,400 cu m/d, to serve 107,400 people by 2000, and to expand the service area to 3,900 ha. Additional 53 km distribution pipelines will be installed, with approximately 7,300 service connections. Implementation is proposed to proceed as Fig-ES.3.

The proposed project and its costs are summarized in Table-ES.2. The estimated capital investment cost of the project, totaling 219,200 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.

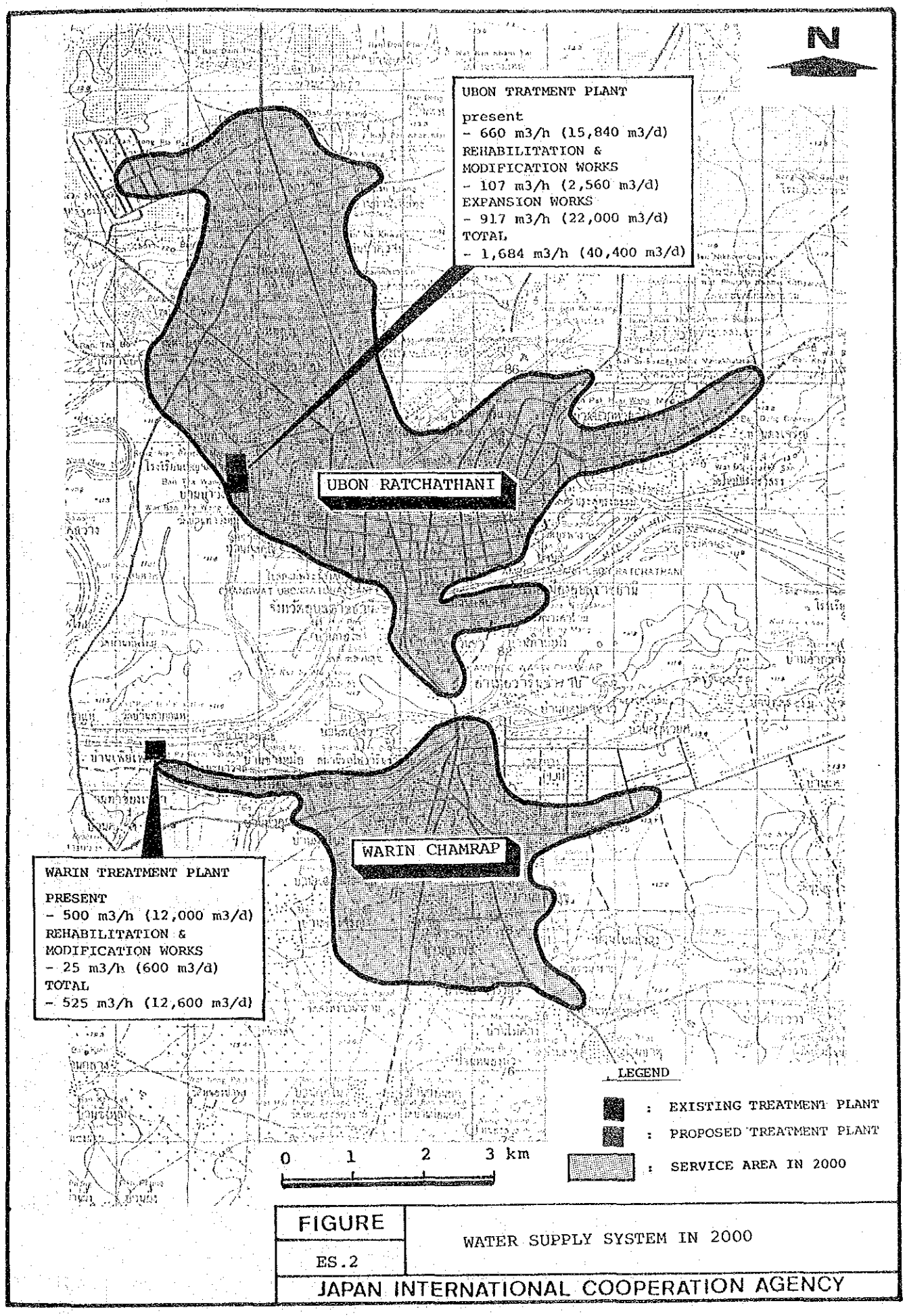

FIGURE ES.2 — WATER SUPPLY SYSTEM IN 2000

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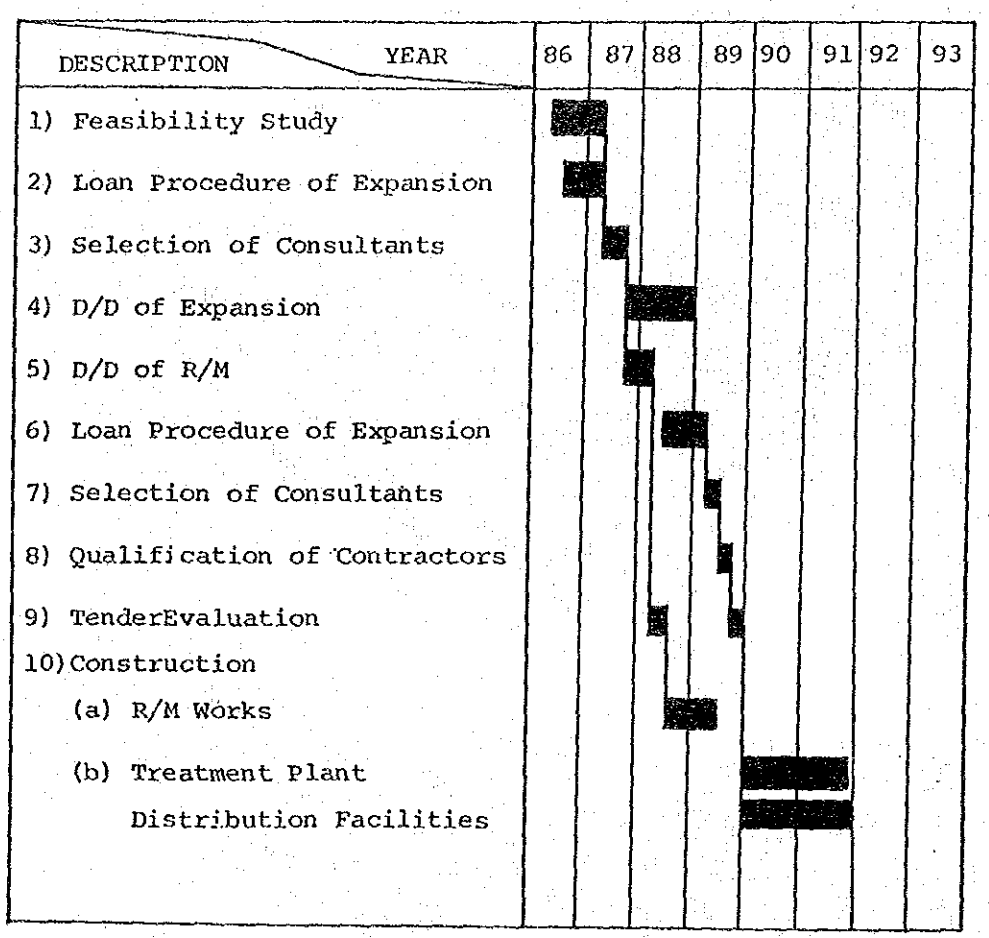

NOTE : D/D Detailed Design
R/M Rehabilitation and Modification

FIGURE ES.3 IMPLEMENTATION SCHEDULE

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Table-ES.2 ESTIMATED PROJECT COSTS FOR STAGE I IMPLEMENTATION

(x 1,000 Baht)

A.	Rehabilitation and Modification	13,400
	Land Acquisition	-
	Ubon Treatment Plant	5,800
	Warin Treatment Plant	3,400
	Distribution Facilities	4,200
B.	Expansion	145,900
	Land Acquisition	2,900
	Ubon No.4 Treatment Plant	89,100
	Warin Treatment Plant	5,600
	Distribution Facilities	48,300
C.	Engineering Services	17,300
D.	Administration Cost	1,700
E.	Physical Contingencies	12,500
F.	Price Contingencies	28,400
	Total	219,200

The tentative financing plan, summarized in Table-ES.3, assumes loans from a foreign financial institution such as OECF totaling 175,400 thousand Baht, or 80 % of capital expenditure, and local loans totaling 43,800 thousand Baht, or 20 % of capital expenditure. The total fund requirement through the project period is projected to amount to 399,100 thousand Baht, on a cash-flow basis, of which 45.1 % will be covered by internal cash generation and the rest (54.9 %) will be financed with foreign and local loans, and with no internal financial help of PWA.

Table-ES.3 TENTATIVE FINANCING PLAN FOR STAGE I IMPLEMENTATION
[UBON-WARIN WATERWORKS] x 1,000 Baht

Item	Before Depreciation	% of Total
1. Sources of Funds		
Internal Cash Generation	179,900	45.1%
Outside Sources:		
- Foreign Financial Institution such as OECF	175,400	43.9%
- Local Financial Institution	43,800	11.0%
Total	399,100	100.0%
2. Application of Funds		
Capital Expenditure	219,200	54.9%
Debt Service	179,900	45.1%
Total	399,100	100.0%

This financial situation, together with the Financial Internal Rate of Return of 8.8 % and the Economic Internal Rate of Return of 14.4 %, demonstrates financial and economic justification of the project, in view of the terms of finance applicable to the project and the prevailing cost of capital in Thailand.

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 is now being suspended temporarily for Government budgetary reasons. Such subsidy will reduce the capital cost of the project.

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. PWA should secure the land proposed as a site for the treatment plant which is located next to the Ubon Treatment Plant and make necessary arrangements for the use of land, including evacuation of resident houses and relocation of the raw water pipe there now being used by the Air Force.

4. 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.

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 Ubon and Warin.

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 III-A) represents a main report relating to Ubon and Warin, 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

CHAPTER 1 AUTHORIZATION

CHAPTER 2 OBJECTIVES AND SCOPE OF WORK

CHAPTER 3 WATER SUPPLY ADMINISTRATION IN THAILAND

PART ONE

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

2.1 Objectives of the Study

2.2 Coverage of the Report

2.3 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 Ubon Ratchathani Municipality, Warin Chamrap Municipality, Ubon Sanitary District and surrounding villages, 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 Ubon-Warin 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 Ubon-Warin Waterworks in PWA

Ubon-Warin Waterworks is under the supervision of Regional Office No. 8, one of the 10 Regional Offices, through which PWA is controlling its 181 urban waterworks in Thailand.

Regional Office No. 8 controls 23 waterworks under its jurisdiction and the combined revenue of these 23 waterworks assumed the weight of 7.66 % in the total PWA revenue for 1985.

Ubon-Warin Waterworks is one of the largest waterworks in the jurisdiction of the Regional Office, sharing 11.02 % of the 1985 combined total sales of the waterworks in the jurisdiction and 0.84 % of the total PWA revenue.

PART TWO
DEVELOPMENT PLAN

CHAPTER 4 DESCRIPTION OF THE STUDY AREA

CHAPTER 5 EXISTING WATERWORKS

CHAPTER 6 POPULATION AND WATER DEMAND

CHAPTER 7 PROPOSED WATER SUPPLY SYSTEM

CHAPTER 8 PROJECT COST AND IMPLEMENTATION SCHEDULE

CHAPTER 9 ORGANIZATION AND FINANCE

CHAPTER 10 SCOPE OF THE PROJECT FOR FEASIBILITY STUDY

PART TWO

CHAPTER 4 DESCRIPTION OF STUDY AREA

4.1 Natural Features

4.1.1 Coverage

4.1.2 Location and Geography

4.2 Socio-Economic Features

CHAPTER 4

CHAPTER 4 DESCRIPTION OF STUDY AREA

4.1 Natural Features

4.1.1 Coverage

The study area covers Ubon Ratchathani Municipality (hereinafter called Ubon) and Warin Chamrap Municipality (hereinafter called Warin) and their surrounding areas, i.e., Ubon Sanitary District and five villages composed of Ban Pak Huai Wang Nong, Ban Don Klang, Ban Tha Bong Mang, Ban Hat Suan Ya and Ban Mai Klang, as shown in Fig-4.1.

4.1.2 Location and Geography

Ubon is located in the northeastern part of Thailand, and neighbors Warin , with the Mun River flowing between them. Ubon and Warin, if combined, assumes the position of the third largest city in all Thailand and is situated in the eastern edge of the Khorat Plateau, and some 500 km northeast of Bangkok and located approximately at longitude 104° 50' east and latitude 15° 15' north. Their elevation is approximately 110 m to 120 m above the sea level.

The meteorological data for the last 10 years register their average precipitation at 1,500 - 2,200 mm/year. The weather is divided into two seasons, dry one lasting from November to February and rainy one from May to September. The temperature ranges from 13 - 33 degree C yearly.

The Mun River and its tributary, the Mun Noi River, which flow across Ubon and Warin, have large drainage areas extending some 107,000 sq km in the northeastern Thailand. Their flows are being utilized for many purposes including irrigation and water supply, thanks to their abundance throughout the year.

Groundwater as well is available in the area. Most of wells are 20 to 65 m in depth and each produces 250 to 500 cu m/d, although their quality is not always acceptable due to high contents of salinity and iron. Also shallow wells of about 10 m depth detect high nitrate concentration and low pH in

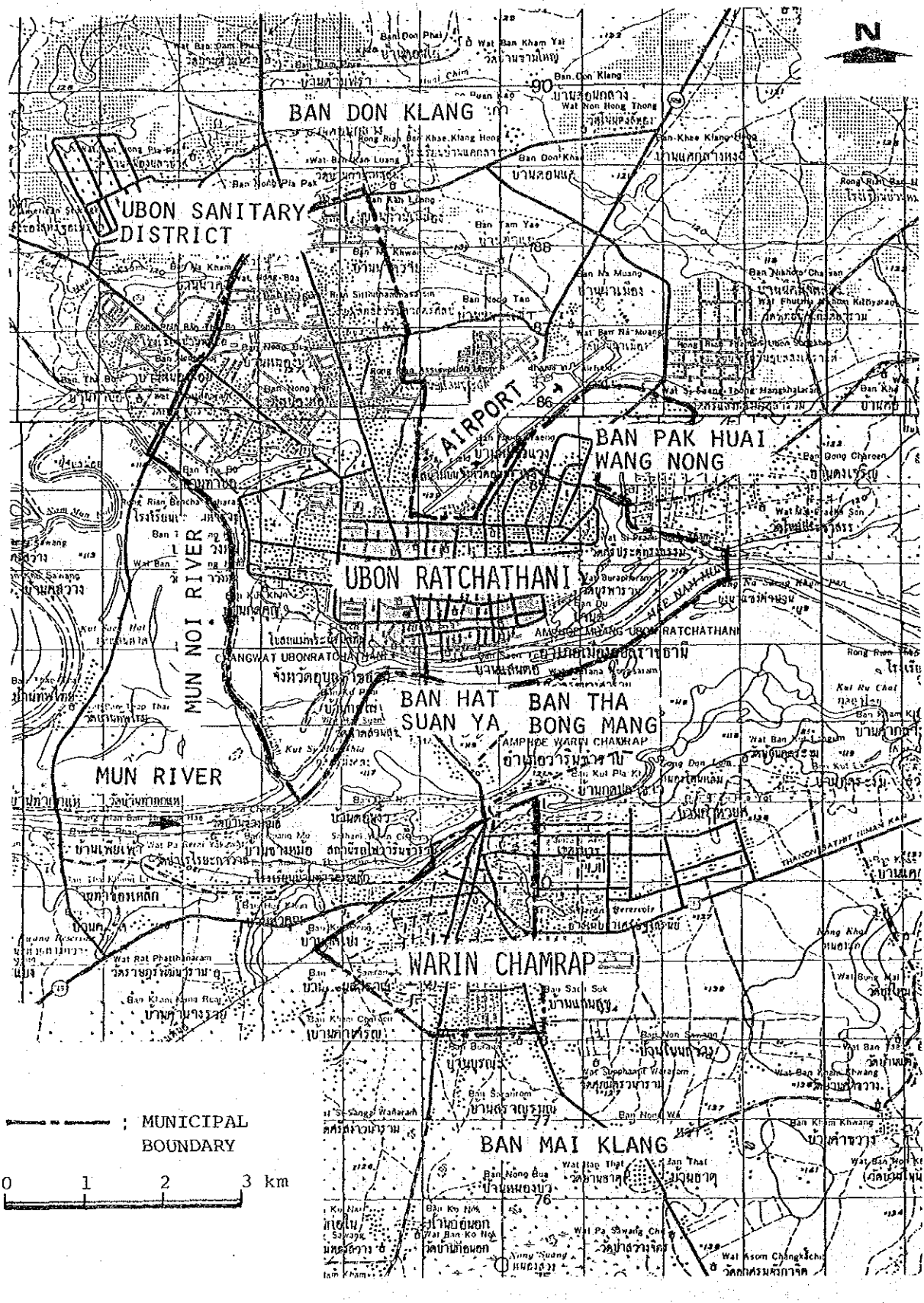

FIGURE	STUDY AREA
4.1	

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some locations.

4.2 Socio-Economic Features

If the out-of-town area is included, nearly half of Ubon's land use (41%) is directed to governmental purposes, of which around 70 % is occupied by the army and air force camps as shown in Table-4.1. This characterizes Ubon as a military town.

As also revealed in Table-4.1, government offices and commercial firms assume important roles in the municipality. Another feature of the municipality is a center of education, occupying 14 % of the town area. Its educational activities are expected to be furthered by the establishment of Ubon University with four departments,i.e., medicine, agriculture, nursing, and engineering, and Ubon Skill Development Institute, both being planned to be constructed in Tambon Dongfa.

Commerce concentrates on dealings in farm products and necessities for farmers such as fertilizer and farming tools. Manufacturers are mostly small scaled, engaging in sawing, manufacture of fixtures and furnitures and food processing.

A number of national, provincial and local roads from Municipalities extend to various strategic centers and are connected to Bangkok, together with national railway and airway services.

Electricity is supplied to about 90 % of the municipal areas by the Provincial Electricity Authority. A drainage system is being planned for both Ubon and Warin with their discharge into the Mun River. PWA supplies potable water both to Ubon and Warin, and their combined service ratio was about 40 % in 1984. The total population of Ubon and Warin is about 129,000, with the served population amounting to about 51,500 as of 1984.

The project area also includes four villages neighboring Ubon and Warin Municipalities, i.e., Ban Pak Huai Wang Nong, Ban Tha Bong Mang, Ban Hat Suan Ya and Ban Mai Klang as well as Ubon Sanitary District which includes another village named Ban Don Klang. The population in these areas totals 13,800. The households there are mostly engaged in agriculture but a

considerable number of residents are also serving as commuter-workers in Ubon and Warin Communities. Ubon Sanitary District extends along a main street which leads the Municipality to northern towns, and embraces a large market area, though a substantial part of the District has been absorbed into Ubon Municipality by the recent several expansions of the Municipalities jurisdiction. The Sanitary District is gaining importance, with Ubon University and Ubon Skill Development Institute being planned to be opened in its neighboring northern space where the Refugee Camp once existed.

Table-4.1 EXISTING LAND USE OF UBON RATCHATHANI IN 1982

Category of Land Use	Town Area (Rai*)	% of Total Town Area	Area excl. Roads, Rivers & Space	% of Town Area excl. Roads, Rivers & Spaces	In and Out of Town Area excl. Roads, Rivers & Spaces	% of In and Out of Town Area excl. Roads, Rivers & Spaces
Residence	3,540.1	22.92%	3,540.1	53.13%	4,811.2	36.27%
Commerce	432.5	2.80%	432.5	6.49%	457.4	3.45%
Government & Administration	851.9	5.51%	851.9	12.79%	5,433.1	40.96%
Industry	158.1	1.02%	158.1	2.37%	239.3	1.80%
Warehouses	137.5	0.89%	137.5	2.06%	164.4	1.24%
Religion	345.6	2.24%	345.6	5.19%	648.1	4.89%
Public Utility	45.6	0.30%	45.6	0.68%	77.5	0.58%
Recreation	187.5	1.21%	187.5	2.81%	282.5	2.13%
Husbandry	32.5	0.21%	32.5	0.49%	48.1	0.36%
Education	931.2	6.03%	931.2	13.98%	1,102.4	8.31%
Roads	590.0	3.82%				
Rivers & Canals	1,485.6	9.62%				
Space	6,710.2	43.44%				
Total Area	15,448.3	100.00%	6,662.5	100.00%	13,264.0	100.00%

Source: Survey Division, DTCP
Note: Rai = 1,600 sq m

CHAPTER 5 EXISTING WATERWORKS

5.1 Water Supply Conditions

5.2 Water Sources

5.3 Intake and Water Treatment Facilities

5.3.1 Ubon Treatment Plant

5.3.2 Warin Treatment Plant

5.4 Distribution Facilities

5.5 Rehabilitation and Modification Works

CHAPTER 5

CHAPTER 5 EXISTING WATERWORKS

The PWA service covers presently the most of the Ubon and Warin Municipalities area and a part of the villages at the Mun River's south bank. About 40 % of the total population (129,000) in these areas are served by the water supply, as of 1984.

Of the unserved population, more than 95 % depends on groundwater, according to the results of questionnaire survey.

In this chapter, the conditions of the waterworks are described.

5.1 Water Supply Conditions

For the first time in 1959, two water treatment plants of 40 cu m/h (960 cu m/d) and 20 cu m/h (480 cu m/d) were constructed in the Ubon Municipality and Warin Municipality respectively. These two treatment plants were abandoned due to deterioration of the facilities afterwards, and the present Ubon Treatment Plant was constructed in 1965 and expanded further in 1970, to meet the increased water demand. The present Ubon & Warin Treatment Plant (hereinafter called Warin Treatment Plant) was constructed in 1978 to meet the water demand in Warin. Both of the treatment plants are currently in operation by the Ubon-Warin Waterworks of PWA.

The Ubon Plant located on the left bank of the Mun Noi River takes water from the River, has a total production capacity of 660 cu m/h (15,840 cu m/day) and supplies water to Ubon area. The Warin Plant of 500 cu m/h (12,000 cu m/d) production capacity, supplying water to Warin area, was constructed on the right bank of the Mun River in the West Warin area. These constructed and expanded plants are listed in Table-5.1.

The past water production and sales are summarized below (cu m/d):

Year	1965	1970	1975	1980	1984
Production	2,000	5,000	17,000	17,900	22,000
Sales	1,200	4,300	7,400	10,100	14,000

The sharp increase of production and sales from 1965 to 1975 was caused possibly by the Vietnam War which ended in 1975. After 1980, such a trend has been calmed and the production and sales have resumed a steady growth. However, the total unaccounted-for water which is the difference between total water production and total water sales remains high, as the unaccounted-for water ratio is estimated at 36 % in 1984.

Table-5.1 LIST OF TREATMENT PLANT

Name of Plant	Capacity (cu m/h)	Constructed in	Location	Water Sources
	(40)	1955	Former Water-works Office	Abandoned
	(20)	1959	Former Regional Office	Abandoned
Ubon (No.1)	80	1965	Ubon Treatment Plant	Mun Noi River
Ubon (No.2)	80	1965	Ubon Treatment Plant	Mun Noi River
Ubon (No.3)	500	1970	Ubon Treatment Plant	Mun Noi River
Warin	500	1978	Warin Treatment Plant	Mun River
Total	1,160 cu m/h	-	-	-

(Note) The plants are called by the name or the number in the bracket.

Figs-5.1 and 5.2 show the present service area including location of treatment plants and the scheme of present water supply conditions, respectively.

The unserved areas including the five villages and Ubon Sanitary District are mostly depending on shallow wells for their water sources. In the two villages, Ban Tha Bong Mang and Ban Hat Suan Ya, however, which are located

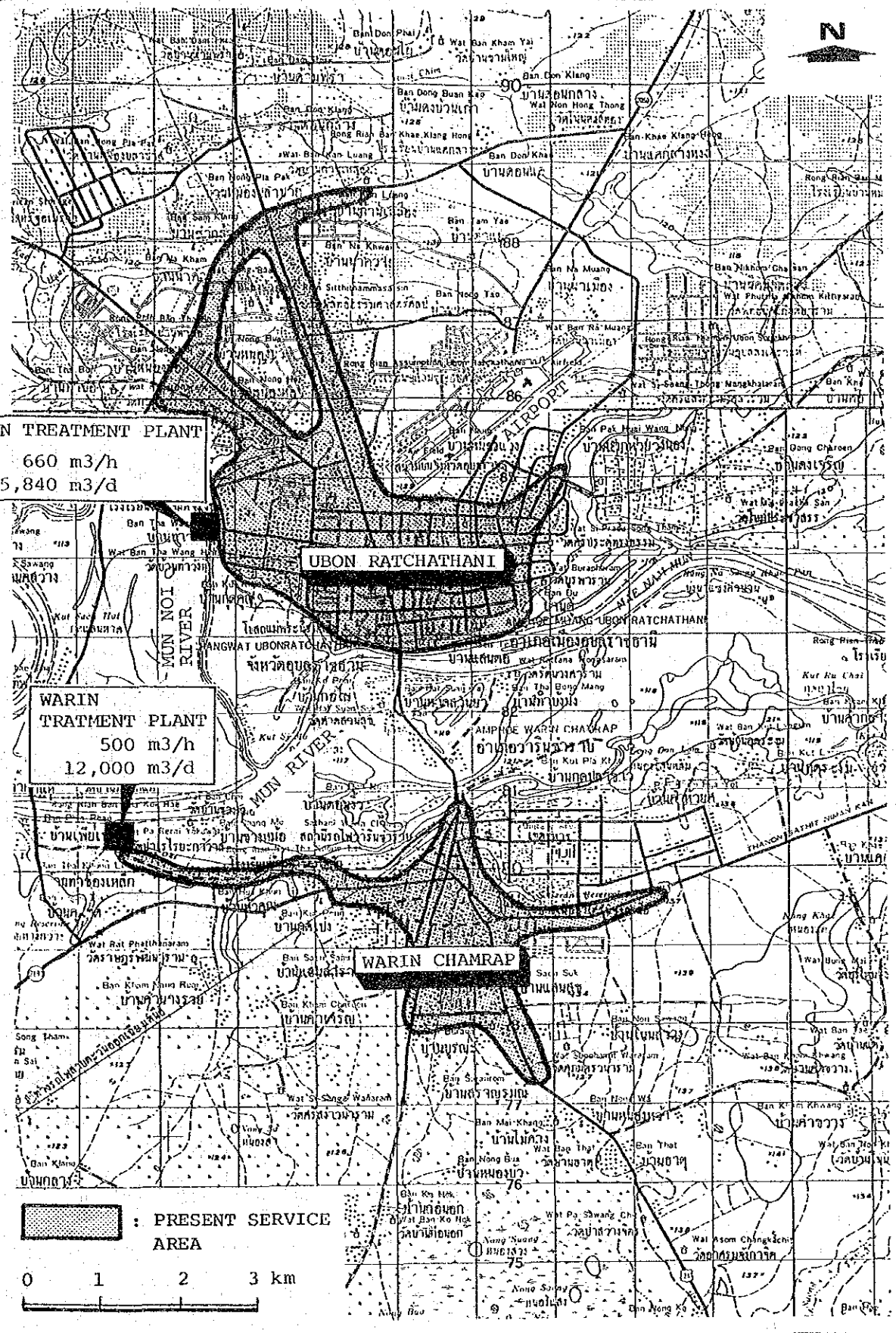

FIGURE 5.1 PRESENT WATER SUPPLY SYSTEM

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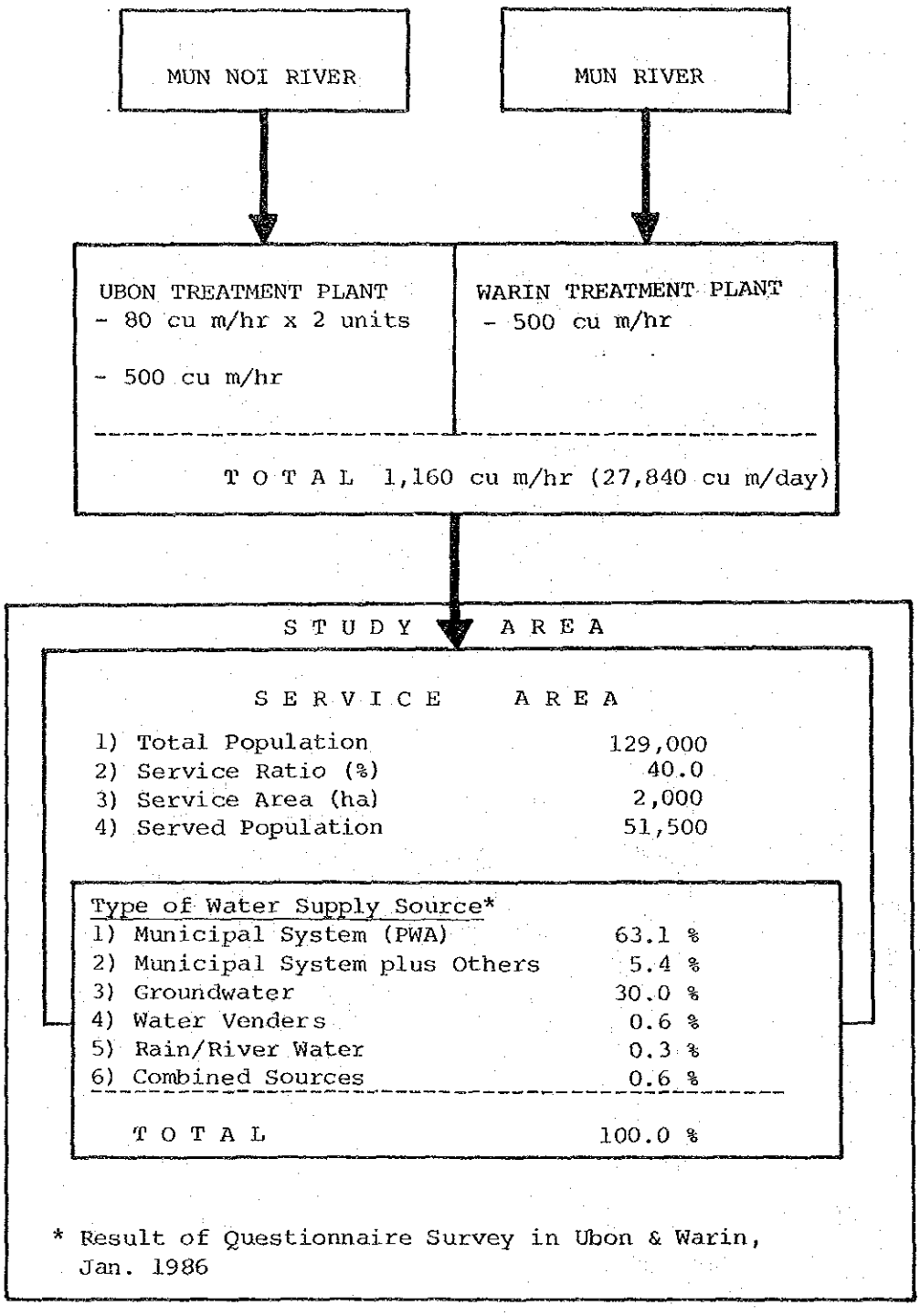


FIGURE	SCHEME OF PRESENT WATER SUPPLY CONDITION
5.2	

JAPAN INTERNATIONAL COOPERATION AGENCY

along the Mun River which runs between Ubon and Warin Municipalities, the residents have to use rain water or buy expensive water from water vendors for drinking purpose, as shallow well water available there is of an unsanitary quality which they are using only for washing and bathing.

5.2 Water Sources

As listed in Table-5.1, the raw water is taken from the Mun River and Mun Noi River, its tributary. Large fluctuation occurs in the flow and level of the Mun River, the maximum level fluctuation being about 8 m. In 1968, a drought year, the maximum and minimum flow recorded 2,400 and 44.8 cu m/sec respectively. The minimum flow is more than enough for the present intake flow of 0.32 cu m/sec (27,800 cu m/day).

Turbidity of the Mun River and Mun Noi River water is generally high in rainy season and the beginning of dry season, while very low in the middle of dry season. The turbidity ranges from 2.4 to 54 SiO2 units, and pH, ranging from 6.6 to 8.0, staying on the low side in rainy season. Alkalinity ranges from 10 to 84 mg/l as CaCO3 and it tends to remarkably decrease in rainy season. The water quality of the Mun River is given in Appendix 4.

5.3 Intake and Water Treatment Facilities

The both treatment plants are constructed on the basis of PWA standardized design. Main treatment units of the plant facilities are composed of a rapid mixing well, flocculation basins, sedimentation basins, filters, clear water reservoirs, mechanical and electrical facilities, and operation & maintenance buildings. The major facilities are summarized in Table-5.2.

Table-5.2 MAJOR FACILITIES OF WATER TREATMENT PLANTS IN UBON-WARIN WATERWORKS

Item	Ubon Treatment Plant	Warin Treatment Plant
Water Source	Mun Noi River	Mun River
Design Capacity	a) 80 m3/h x 2	500 m3/h
	b) 500 m3/h	
Facilities		
Flocculation Basin	a) Hydraulic Mixing	Hydraulic Mixing
	1 Basin	4 Basins
	Volume : 50 m3	Volume : 64 m3/basin
	D.T. : 38 min	D.T. : 30 min
	b) Hydraulic Mixing	
	2 Basins	
	Volume : 115 m3/basin	
	D.T. : 28 min	
Sedimentation Basin	a) Horizontal Flow	Horizontal Flow
	1 Basin	8 Basins
	Volume : 223 m3	Volume : 195 m3/basin
	D.T. : 2.8 h	D.T. : 3.1 h
	b) Horizontal Flow	
	2 Basins	
	Volume : 1,044 m3	
	D.T. : 4.2 h	
Filter Bed	a) 2 Beds	8 Beds
	F.R. : 4.3 m/h	F.R. : 6.7 m/h
	b) 2 Beds	
	F.R. : 4.3 m/h	
Chemical Application		
Coagulant	Aluminium Sulfate	Aluminium Sulfate
Chlorine	Chlorine Gas	Chlorine Gas

Note D.T. : Detention Time
F.R. : Filtration Rate

5.3.1 Ubon Treatment Plant

The intake tower is built in the Mun Noi River and accessible through a bridge. The fence is installed upstream of the tower to protect it from drift woods and river-going boats. The raw water pump has 100 % stand-by capacity.

As shown in Fig-5.3, the Ubon Treatment Plant has three independent treatment plants, No.1, 2 and 3.

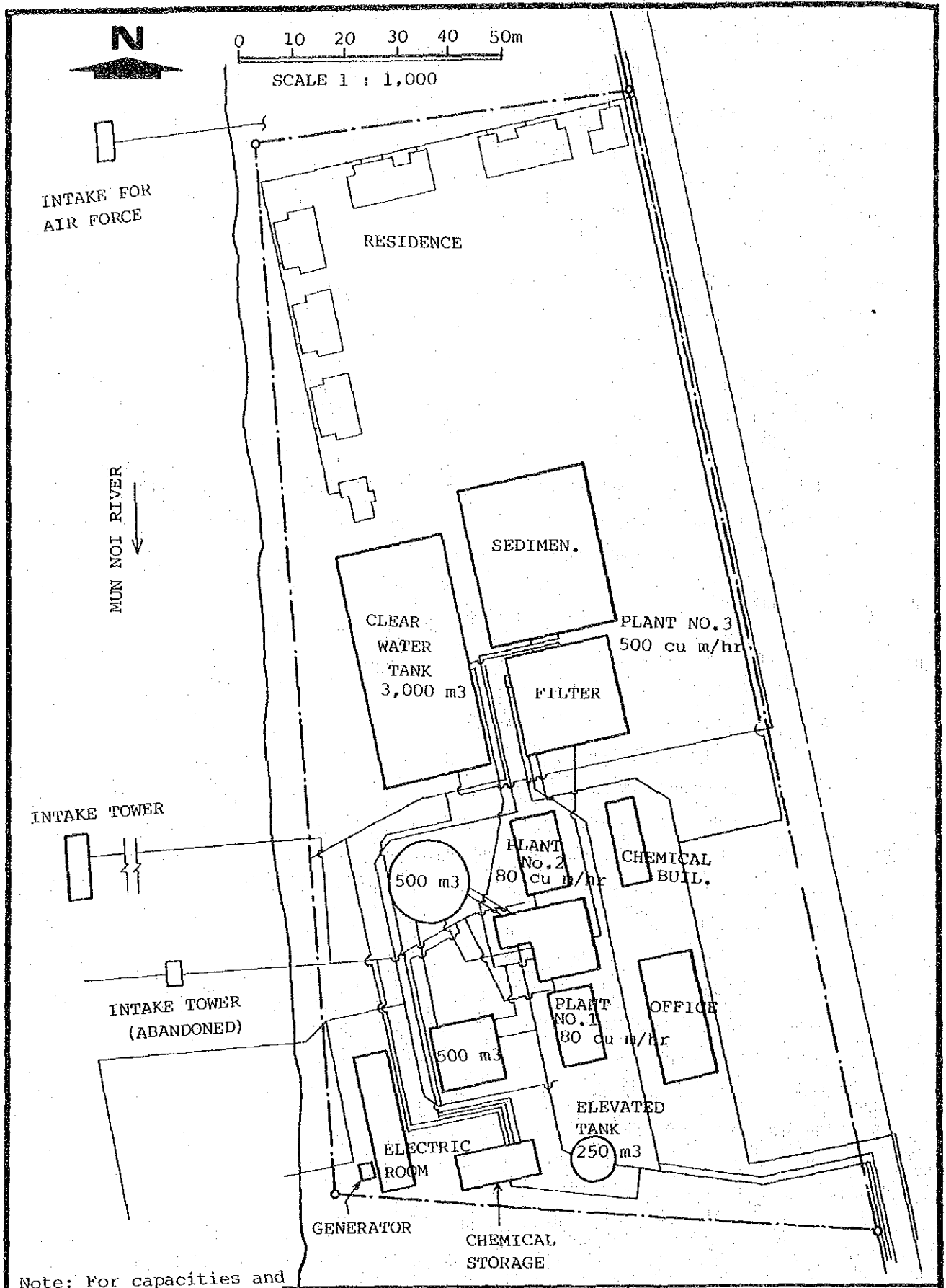
1) No.1 and No.2 Plants

The production capacity of both No.1 and 2 plants is 80 cu m/h (1,920 cu m/d) each. They are identical in the dimensions and in each plant, built as a single structure, the flocculation/sedimentation basins are laid symmetrically on both sides of the grouped filters.

For flash mixing, waterfall over a weir is used and for flocculation, up-and-down baffled flow. The sedimentation basins are the conventional horizontal flow type with perforated baffle walls. Settled sludge from the flocculation basins and sedimentation basins is taken out through drain pipes provided at the side walls of the basins. Sludge drawn from the basins is collected into an open channel and discharged to the Mun Noi River. The flocculation and sedimentation basins are periodically emptied for inspection, manual cleaning with pressure water and repair work if necessary.

The water treated by sedimentation is led to the filters through connecting pipes. The filters are of the conventional rapid sand type. As a surface wash system is not provided, only backwashing with water is used. Perforated pipes are used in the main-and-lateral type underdrain. The filter media consists of filter sand of 65 cm thickness and gravel of 40 cm thickness.

Recently, the filter media and the underdrain of No.1, 2 and 3 treatment plants were totally replaced to improve the deteriorated conditions, as a part of a PWA project called the Immediate Improvement Program (IIP).



Note: For capacities and volumes referred to Table-5.2.

FIGURE 5.3

LAYOUT OF UBON TREATMENT PLANT

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Right before entering the reservoir, chlorine is added to the filtered water for disinfection. At present, chlorine gas is used for disinfection but the container scale is not equipped. pH control is not practiced. Coagulation is not always satisfactory.

The treated water is supplied directly from the reservoir to the service area by distribution pumps. The distribution water meter is presently not functioning and fails to record production.

The field investigation confirmed that the Ubon Plant of No.1, No.2 and No.3 still has a surplus capacity as compared with the designed capacity.

2) No.3 Plant

No.3 plant has a capacity of 500 cu m/h (12,000 cu m/d) and consists of 2 sets of a PWA standardized 250 cu m/h plant.

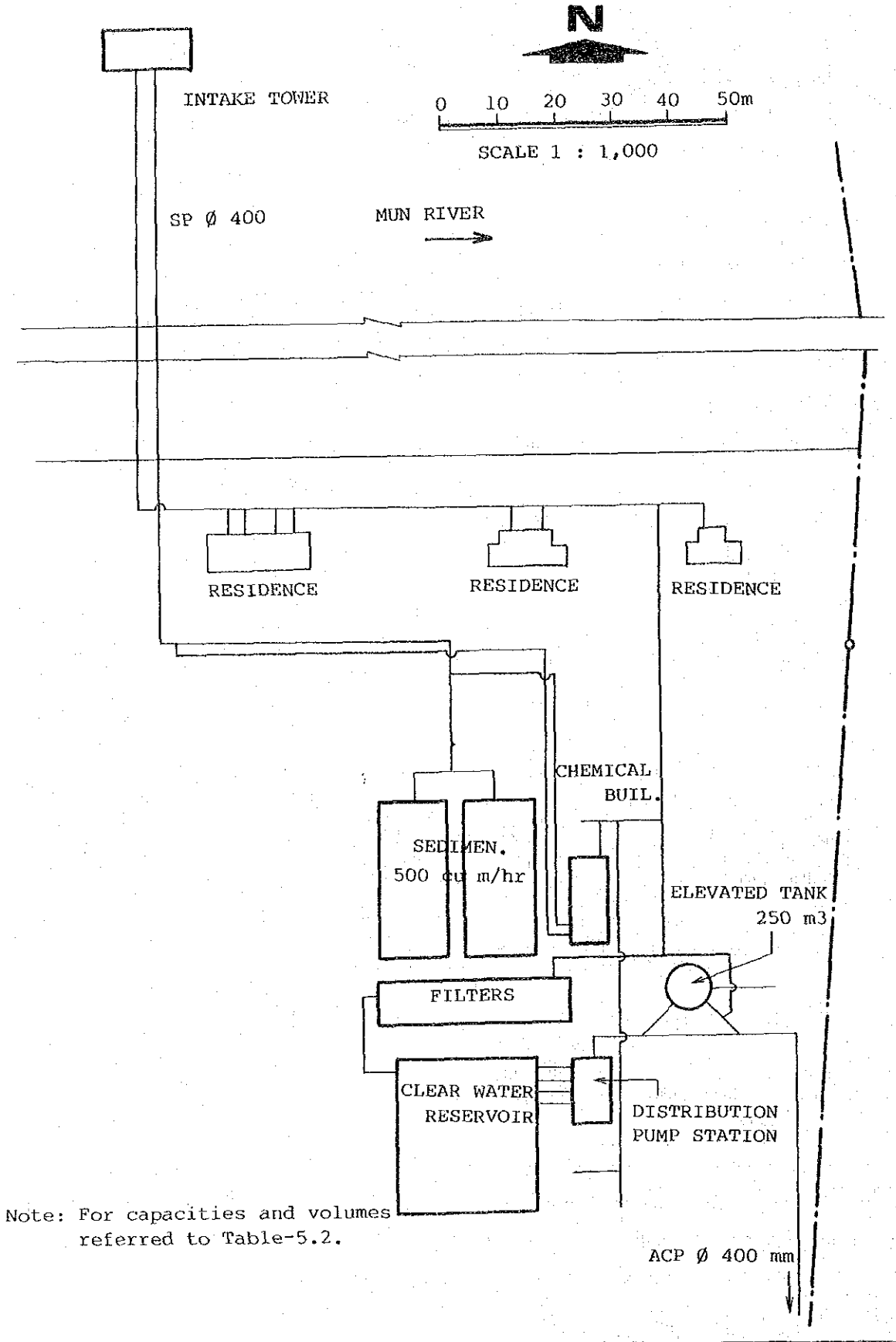
For flash mixing, waterfall over a weir is used and for flocculation, up-and-down baffled flow. The sedimentation basins are the conventional horizontal flow type with perforated baffle walls. Desludge system is as same as No.1 and 2's. The flocculation and sedimentation basins are periodically emptied and cleaned.

Disinfection and distribution are made similarly as in No. 1 and No. 2 plants.

5.3.2 Warin Treatment Plant

The plant consists of two independent units of 250 cu m/h (6,000 cu m/d) capacity which are arranged in parallel from flash mixing to sedimentation as shown in Fig-5.4. For flash mixing, waterfall over a weir is used and up-and-down baffled flow is applied to flocculation.

The plant was designed based on the PWA standard, and therefore, the treatment facilities are operated in the same way as mentioned before on the



Note: For capacities and volumes referred to Table-5.2.

FIGURE	LAYOUT OF WARIN TREATMENT PLANT
5.4	

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Ubon Treatment Plant. The plant are operated for only 8 hrs a day as the capacity exceeds the present demand in Warin.

The treated water is pumped to the elevated tank of 250 cu m, then distributed to the area by the gravity.

5.4 Distribution Facilities

Almost all of the distribution pipelines are made of locally produced asbestos cement pipes. The total length of the pipelines is 116 km. Of the total, about 9 km length was installed during the period of the water supply foundation in 1950s and has been used until now. The distribution system forms a grid system as shown in Fig-5.5, so that the water pressure is balanced.

Necessary valves, air release valves, drain valves and fire hydrants are provided at appropriate places. Recently, more than 160 valves have been replaced or newly installed in the pipelines for the convenience of operation and maintenance as a part of the IIP Projects. The size and length of the distribution pipelines are shown below:

Table-5.3 DISTRIBUTION PIPELINES

Dia. (mm)	Material	Approximate Length (km)
400	Asbestos Cement	17
300	- do -	9
250	- do -	12
200	- do -	22
150	- do -	31
100	- do -	25
	Total	116 km

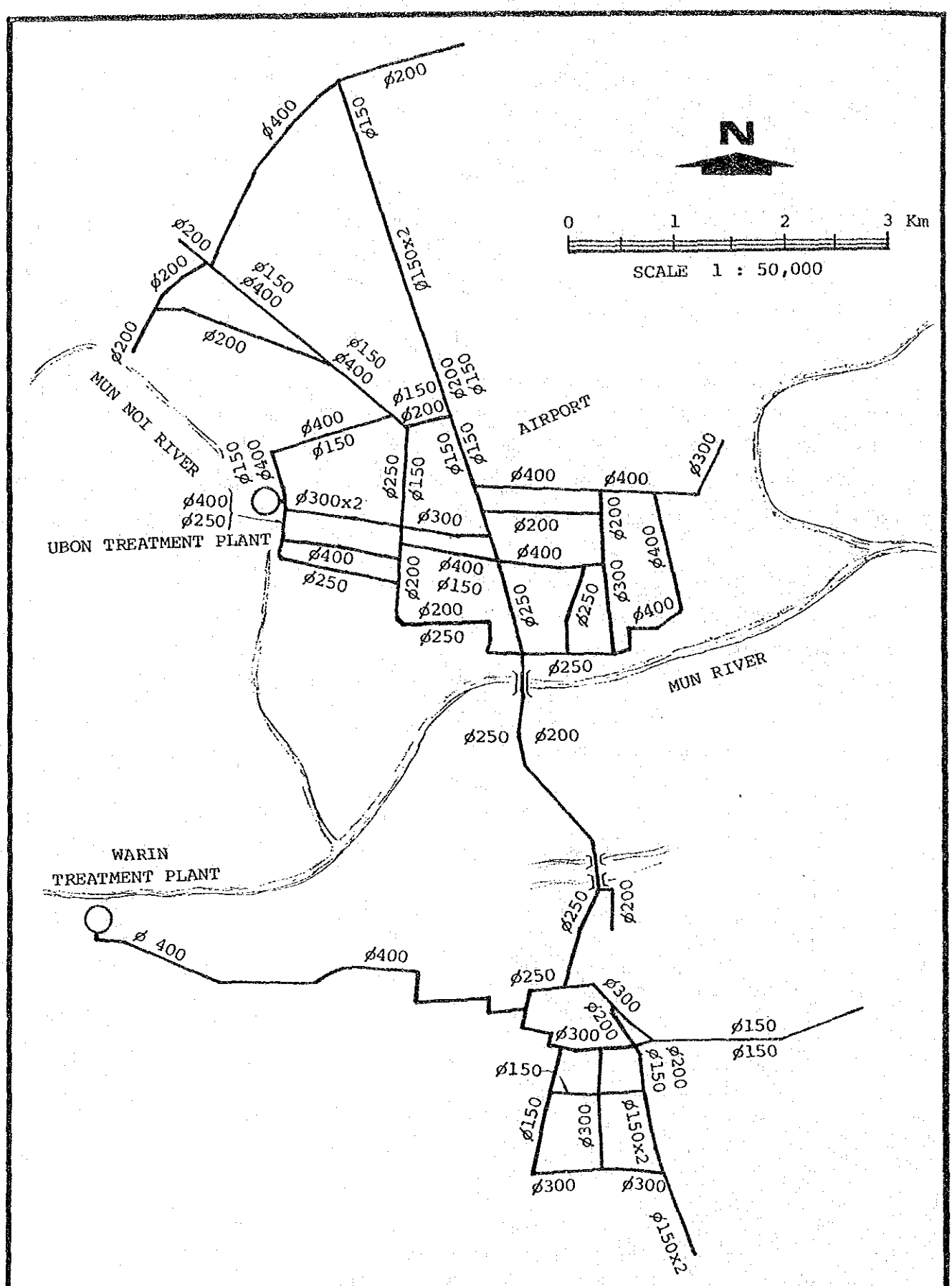

FIGURE 5.5 EXISTING DISTRIBUTION PIPELINES

JAPAN INTERNATIONAL COOPERATION AGENCY

The service pipes are mainly of galvanized steel made.

As for the house connections, the number has increased steadily year by year and it amounts to more than 10,000 at present. All the house connections are equipped with water meters and stop valves.

5.5 Rehabilitation and Modification Works

The facilities described heretofore are planned for use in future.

To prepare for the future increase of water demand, rehabilitation and modification of the existing facilities are of absolute necessity as well as expansion of them.

The planned rehabilitation, modification and expansion works will be detailed in Chapter 7 later.

CHAPTER 6 POPULATION AND WATER DEMAND

6.1 General

6.2 Population
- 6.2.1 Past and Present Population
- 6.2.2 Future Population Forecast

6.3 Service Area and Served Population
- 6.3.1 Service Area
- 6.3.2 Served Population

6.4 Water Demand
- 6.4.1 Past and Present Water Consumption
- 6.4.2 Future Water Consumption
- 6.4.3 Average Day and Maximum Day Water Demands

CHAPTER 6 POPULATION AND WATER DEMAND

6.1 General

In this chapter forecasted are the future population in the study area and water demand in the service area. The area, as defined in the scope of work, consists of eight districts, Ubon Ratchathani Municipality, Warin Chamrap Municipality, Ubon Sanitary District, Ban Pak Huai Wang Nong, Ban Don Klang, Ban Tha Bong Mang, Ban Hat Suan Ya, and Ban Mai Klang. The estimated served population will be utilized as an input to the water demand projection.

The future water demands were estimated based on, analyzing the past water consumptions data provided by PWA and comparing the data of other towns which have similar characteristics as Ubon and Warin, and projecting the served population. For each category of water uses, such as domestic, public, and large business, the future water demands were estimated category-wise.

For forecasting the future population and water demand, PWA Design Criteria was referred and taken into consideration.

The details of the forecast are to be referred to Appendix 1 POPULATION FORECAST and Appendix 2 FUTURE WATER DEMAND and the results are reported herein.

6.2 Population

6.2.1 Past and Present Population

Available records of the population of Ubon and Warin Municipalities are shown in Table-6.1.

As for the records of the past population of Ubon Sanitary District and five villages, only the data in 1984 were available and they are shown in Table-6.2.

Regarding the population in Ubon Municipality, as shown in Table-6.1, it is found that two big fluctuations occurred in the past. The sharp increase in 1972 - 1973 and gradual decrease in 1976 - 1977 probably indicates the Vietnam War's influence which ended in 1975. The sudden jump in 1981 - 1982 resulted from merging with neighboring villages.

Warin's population increased linearly at a slow and steady rate, seemingly unaffected much by the War.

Table-6.1 DATA OF PAST POPULATION

YEAR	AREA	
	UBON	WARIN
1965	31,189	8,968
1966	32,052	21,427
1967	34,619	22,500
1968	35,224	22,652
1969	37,005	23,609
1970	38,744	24,854
1971	40,710	24,815
1972	41,755	25,290
1973	52,690	25,950
1974	52,713	26,507
1975	52,281	27,393
1976	52,159	27,845
1977	49,883	27,720
1978	48,227	28,180
1979	48,208	29,183
1980	48,466	29,183
1981	48,596	29,643
1982	99,469	30,201
1983	100,219	30,143
1984	98,319	30,535

DATA SOURCE : PWA

Table-6.2 POPULATION OF UBON SANITARY DISTRICT AND FIVE VILLAGES IN 1984

AREA	POPULATION
UBON SANITARY DISTRICT	8,929
FIVE VILLAGES TOTAL	4,844
1. BAN PAK HUAI WANG NONG	779
2. BAN DON KLANG	1,958
3. BAN THA BONG MANG	1,143
4. BAN HAT SUAN YA	
5. BAN MAI KLANG	964

DATA SOURCE : PWA

6.2.2 Future Population Forecast

The future population of Ubon and Warin Municipalities will increase linearly at a similar rate as in the past, when the population was unaffected by the war and merger.

The future population of Ubon Sanitary District is estimated, applying the same ratio as that of Ubon Municipality. The sanitary district shares the boundary with the municipality, thus, the future trend of population increase will be similar to the trend of Ubon Municipality.

For the five villages, the future population is estimated introducing the same increasing ratio as that of Phophraya Sanitary District of Suphanburi area which seems to have similar characters of a rural area.

The total population of the project area is shown on Table-6.3 and plotted in Fig-6.1.

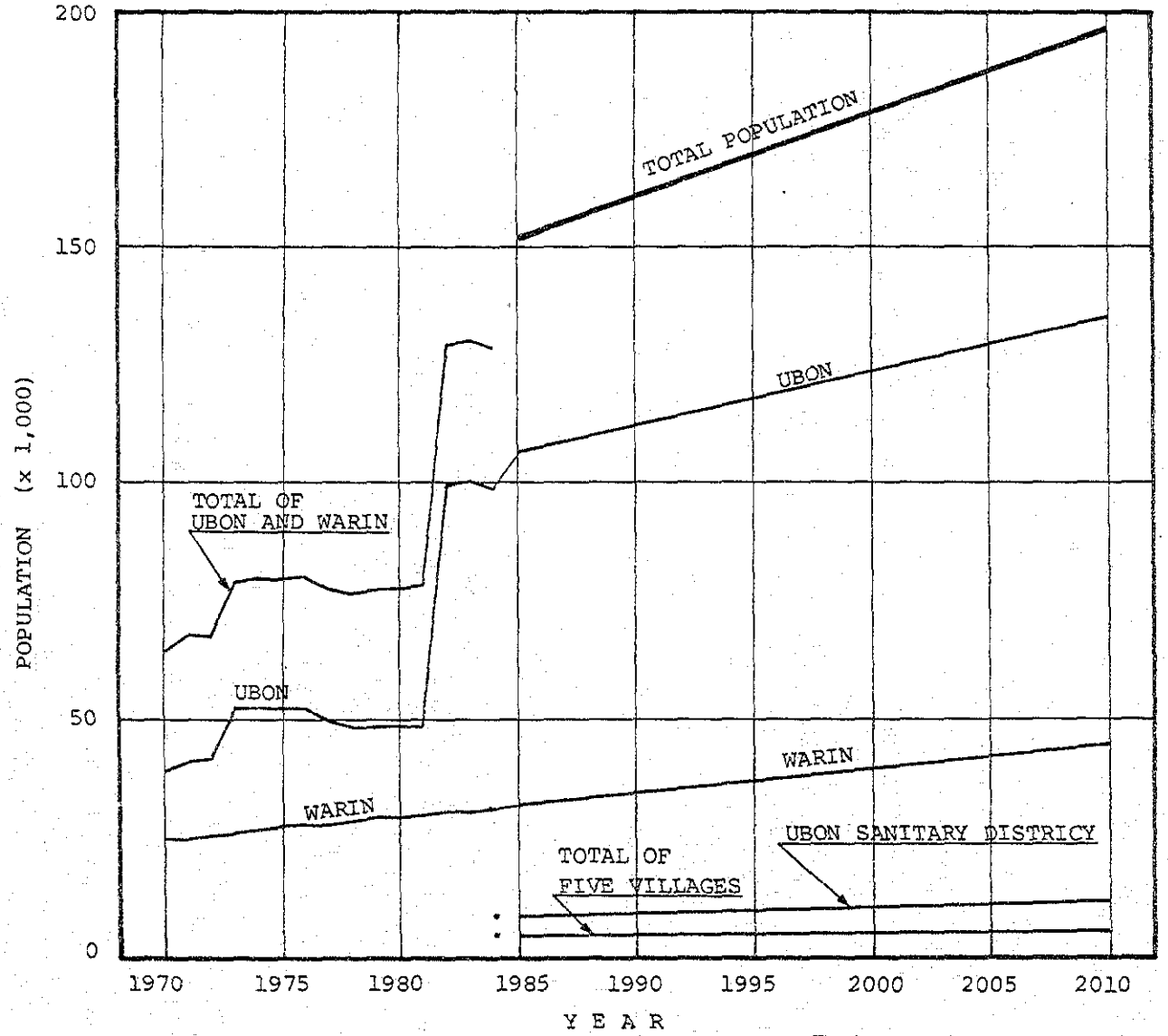

FIGURE	FUTURE POPULATION FORECAST
6.1	
JAPAN INTERNATIONAL COOPERATION AGENCY	

Table-6.3 TOTAL POPULATION OF PROJECT AREA

	A R E A				
YEAR	UBON MUNICIPALITY	WARIN MUNICIPALITY	UBON SANITARY DISTRICT	FIVE VILLAGES	TOTAL
1985	106,480	31,710	8,930	4,850	151,970
1990	112,230	34,220	9,470	4,950	160,860
1995	117,990	36,710	10,000	5,050	169,750
2000	123,750	39,210	10,540	5,150	178,650
2005	129,500	41,710	11,070	5,250	187,530
2010	135,260	44,210	11,600	5,360	196,430

6.3 Service Area and Served Population

6.3.1 Service Area

The present and future service areas, planned on the basis of the future land use plan and information of the waterworks and Municipality office are shown in Fig-6.2. The service area will expand year by year corresponding development of the municipalities and cover neighboring Ubon Sanitary District and five villages where the people will receive water supply service from 1992.

As shown in Fig-6.2, the future service area of Ubon Municipality will expand north-, northwest- and east-ward from the present service area.

The north- and northwest-ward service area expansion will cover Ban Don Klang, Ubon Sanitary District and the educational and institutional facilities which are planned in the northwest of the sanitary district. The east-ward expansion of service area will cover Ban Pak Huai Wang Nong.

The service area of Warin Municipality will expand east-, south- and west-ward. In the east-and west-ward expansion, residential area will be developed. The service area's south-ward expansion will cover Ban Mai Klang.

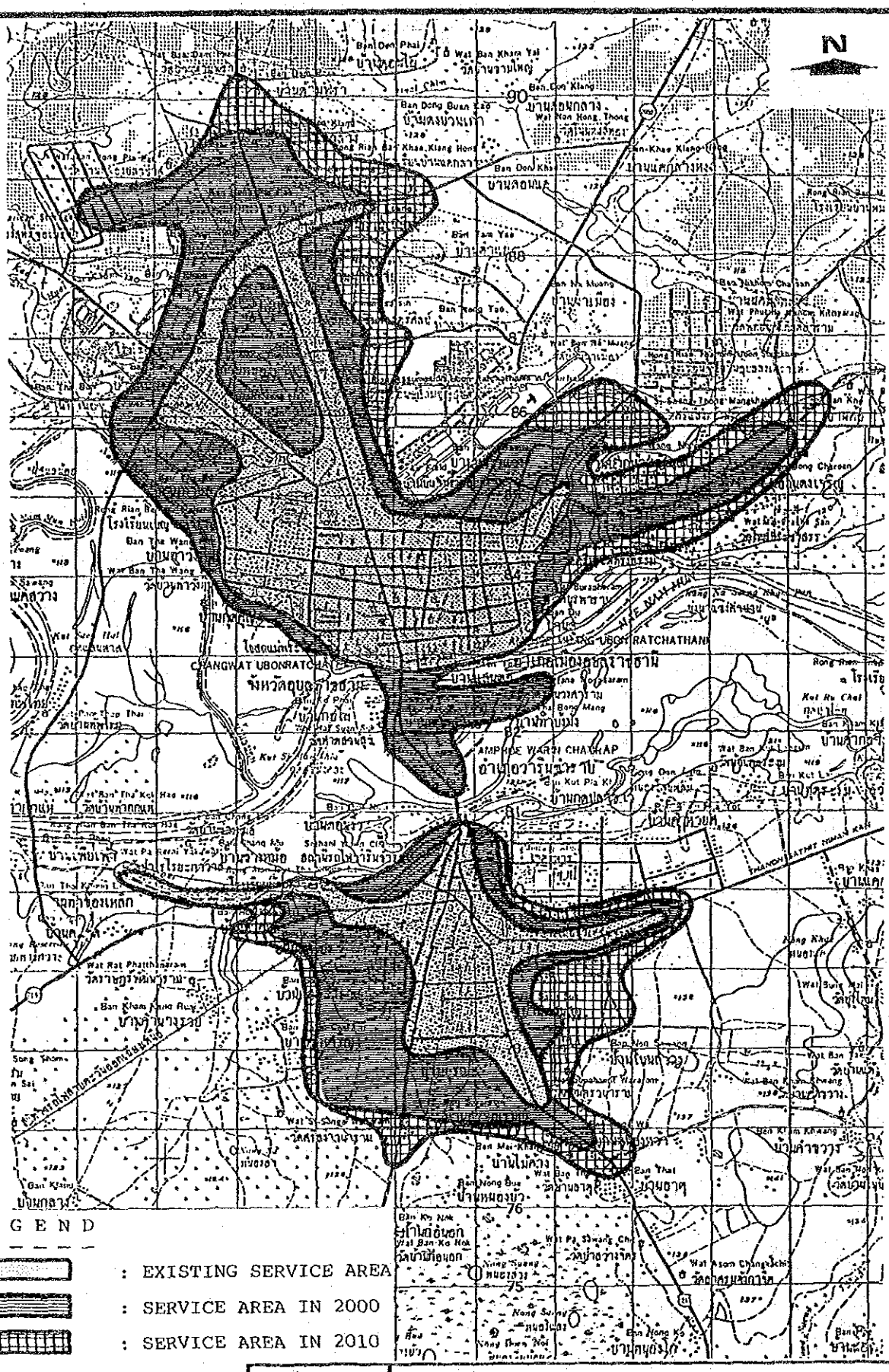

FIGURE 6.2 EXISTING AND FUTURE SERVICE AREA

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