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 V-A
MAIN REPORT
FOR

PATTAYA

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.

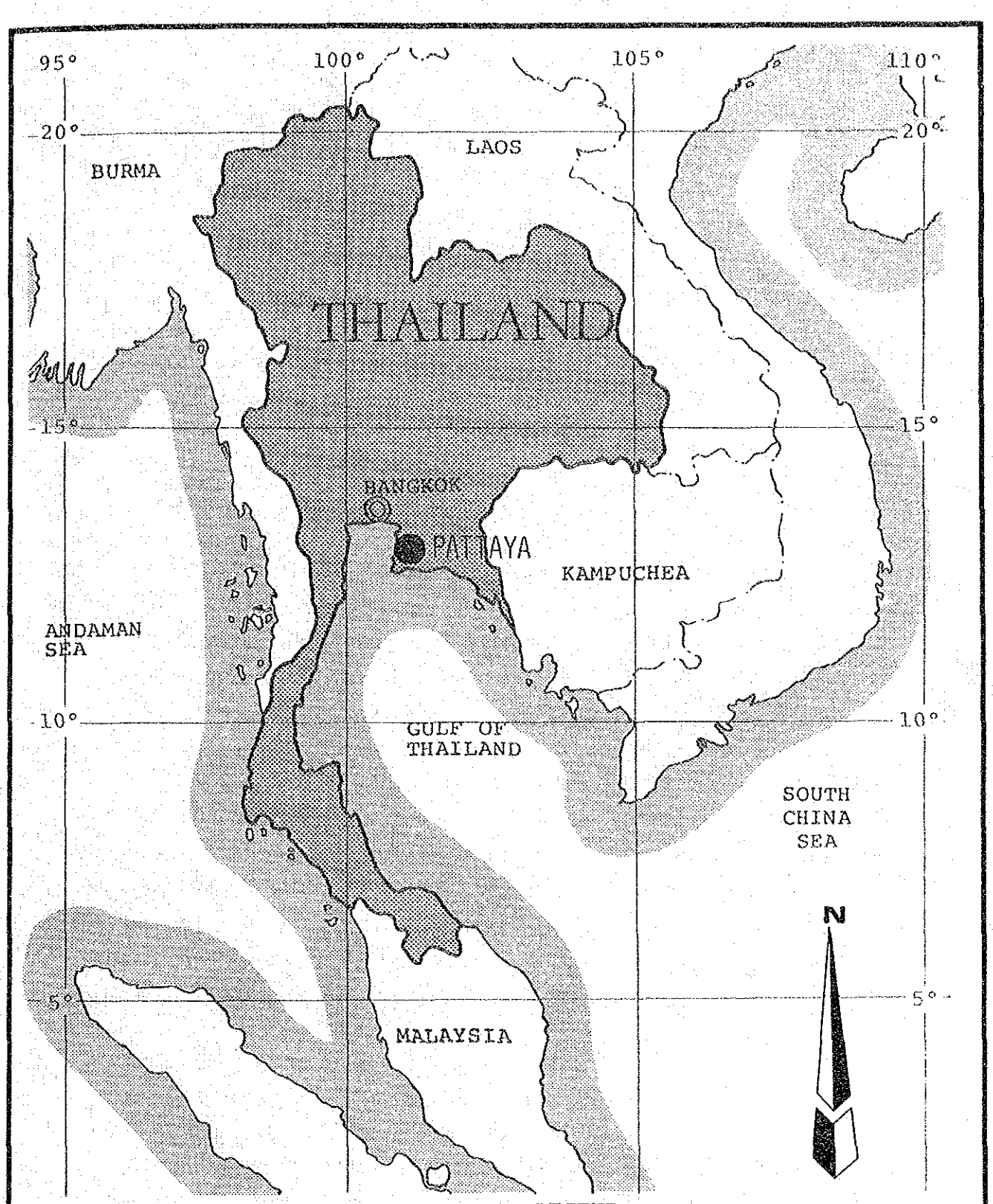
The team had discussions with the officials concerned of the Government of the Thailand and conducted a field survey in the Study Areas and Bangkok. After the team returned to Japan, further studies were made and the present report has been prepared.

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

● : PATTAYA CITY

◎ : 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, PATTAYA".

The study area covers Pattaya City, Nong Preo Sanitary District, and Ban Rong Po located approximately 150 km southeast of Bangkok. Pattaya is one of the premier beach resorts in Southeast Asia where more than 700,000 tourists visit a year.

The combined population of Pattaya City, Nong Preo Sanitary District and Ban Rong Po is projected to increase from 58,740 in 1985 to 114,010 by 2010, the target year of the current project.

The current project purports expansion of the capacity of production-distribution facilities to meet such rapid increase in water demand, as well as to improve the service ratio from 34 % at present to 76 % 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 improvement program to rehabilitate the existing system, together with 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.

B. Strategies to the Targets

Water consumption in the study area is projected to grow more than two times as large as the present level from 13,810 cu m/day in 1985 to 31,890 cu m/day in 2000, and further to 40,640 cu m/day in 2010, reflecting the increasing numbers of both tourists and domestic population. Domestic water consumption will increase with growth in population and per-capita consumption (from 148 lpcd in 1985 to 210 lpcd in 2000). Tourist water consumption will increase with increases in the number of tourists, though per tourist water consumption is expected to stay almost unchanged. Public and commercial water consumption is projected to increase proportionally to the growth of domestic and tourism water consumption.

Strategic plans are illustrated in Fig-ES.1, and the estimated costs for implementing them 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	25,700	250,700	276,400	117,500	393,900
Engineering Service	2,800	27,600	30,400	13,600	44,000
Administration Cost	300	2,800	3,100	1,300	4,400
Physical Contingencies	2,000	19,700	21,700	9,300	31,000
Price Contingencies	3,600	45,600	49,200	74,400	123,600
Total	34,400	346,400	380,800	216,100	596,900

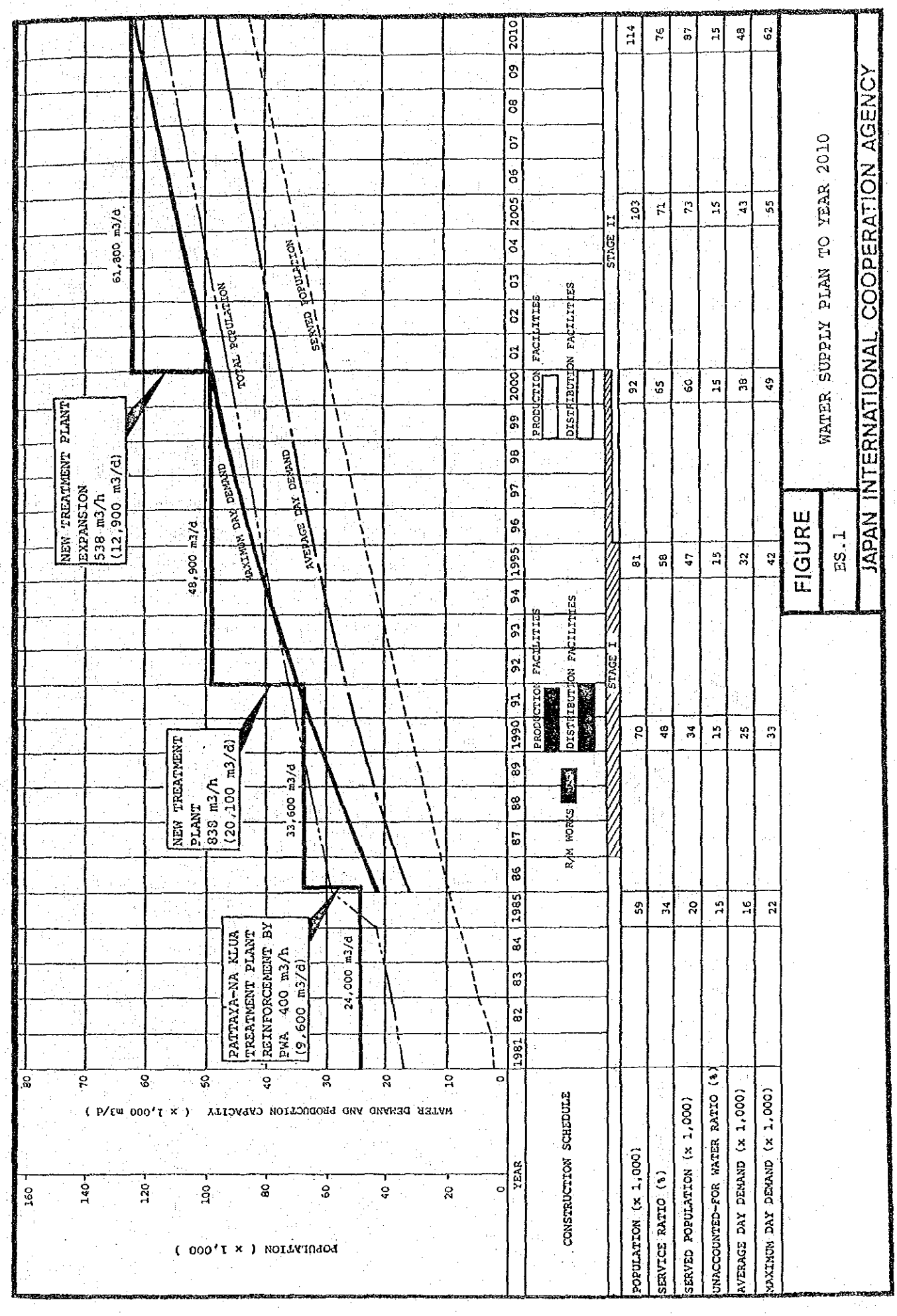


FIGURE ES.1

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 works will provide needed improvement of existing facilities. The Stage I Expansion is designed to meet projected maximum day demand of 48,900 cu m/d, to serve 59,800 people by 2000, and to expand the service area to 2,700 ha. Additional 78 km distribution pipelines will be installed, with approximately 5,150 service connections.

The future water supply system endowed with enough capacity to meet future water demand will need steady raw water sources. It should however be noted that the capacity of the Mab Prachan Reservoir, the existing water source of the Pattaya-Na Klua Treatment Plant, will not be suffice to meet future raw water requirements. Study of all available data and reports as well as site investigations by the Study Team on a number of alternative water sources have concluded that the Nong Kho Reservoir water through Laem Chabang Receiving Well which is under detailed design work as a part of Nong Kho-Laem Chabang Pipeline Project should be the best and final selection from both technical and financial viewpoints. In addition, construction of a new Thung Sukla Treatment Plant near the receiving well is proposed, instead of expanding the existing treatment plant. 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 380,800 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.

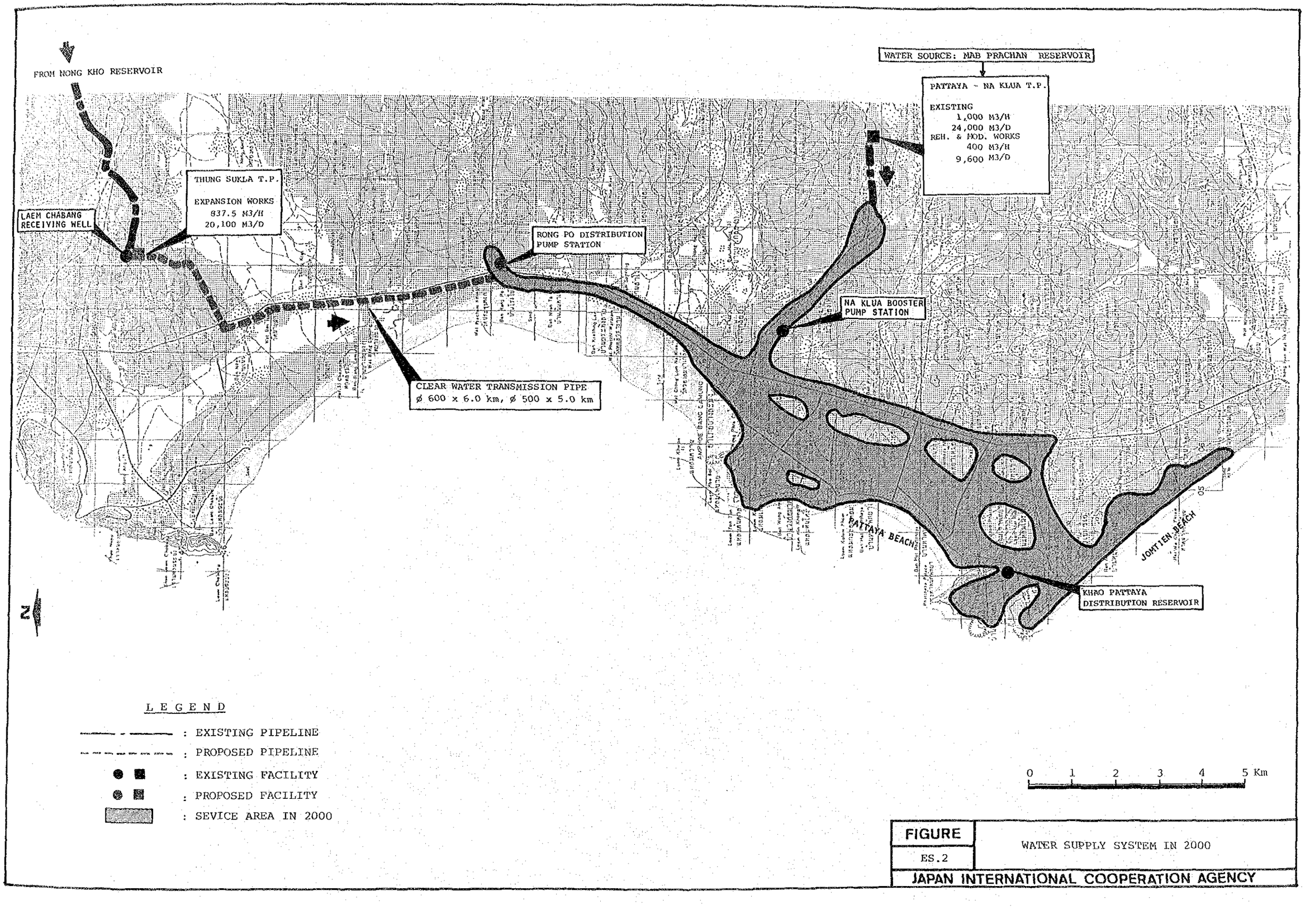

FIGURE ES.2 WATER SUPPLY SYSTEM IN 2000

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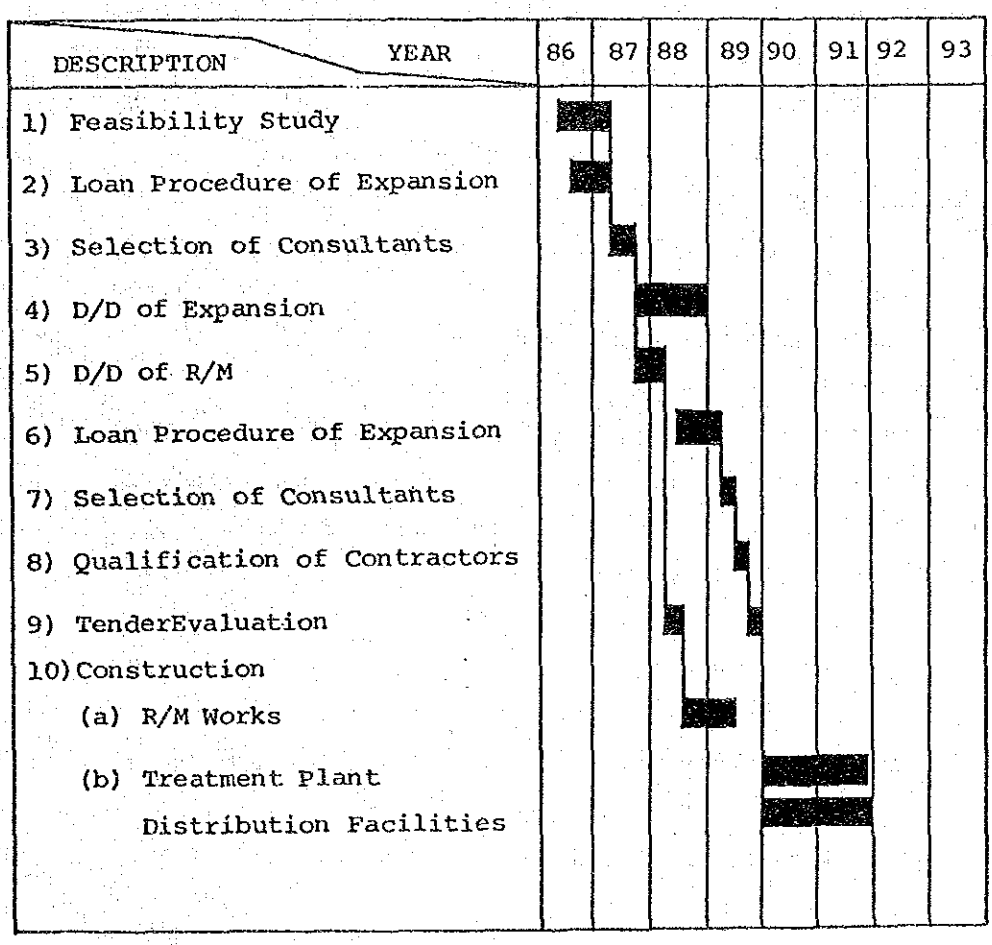

NOTE : D/D Detailed Design
R/M Rehabilitation and Modification

FIGURE	IMPLEMENTATION SCHEDULE
ES.3	
JAPAN INTERNATIONAL COOPERATION AGENCY	

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

(x 1,000 Baht)

A.	Rehabilitation and Modification	25,700
	Land Acquisition	-
	Intake and Raw Water Transmission Pipeline	600
	Pattaya-Na Klua Treatment Plant	4,950
	Distribution Facilities	20,150
B.	Expansion	250,700
	Land Acquisition	2,100
	Intake and Raw Water Transmission Pipeline	2,500
	Thung Sukla Treatment Plant	52,900
	Clear Water Transmission Pipeline	80,500
	Distribution Facilities	112,700
C.	Engineering Services	30,400
D.	Administration Cost	3,100
E.	Physical Contingencies	21,700
F.	Price Contingencies	49,200
	Total	380,800

The tentative financing plan, summarized in Table-ES.3, assumes loans from foreign financial institutions such as OECF totaling 304,700 thousand Baht, or 80 % of capital expenditure, and local loans totaling 76,200 thousand Baht, or 20 % of capital expenditure. The total fund requirement through the project period is projected to amount to 689,200 thousand Baht, on a cash-flow basis, of which 44.7 % will be covered by internal cash generation and the rest(55.3 %) 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
[PATTAYA] x 1,000 Baht

Item	Before Depreciation	% of Total
1. Sources of Funds		
Internal Cash Generation	308,300	44.7%
Outside Sources:		
- Foreign Financial Institution	304,700	44.2%
- Local Financial Institution	76,200	11.1%
Total	689,200	100.0%
2. Application of Funds		
Capital Expenditure	380,800	55.3%
Debt Service	308,300	44.7%
Depreciation		
Total	689,200	100.0%

These financial condition, together with the Financial Internal Rate of Return of 5.56 % and the Economic Internal Rate of Return of 11.4 %, demonstrate 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. PWA should made necessary arrangements with Government agencies concerned for the entitlement of PWA's use of Nong Kho Reservoir water, inclusive of arrangement for appropriate raw water charges for the PWA use of the water.

2. 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.

3. 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).

4. PWA should secure the land proposed as a site for the new treatment plant and distribution pump station which are located in Ban Thung Sukla and Ban Rong Po respectively.

5. A leakage survey 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 Pattaya.

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 V-A) represents a main report relating to Pattaya, 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.

TABLE OF CONTENTS

PART TWO : DEVELOPMENT PLAN

PART THREE : FEASIBILITY STUDY

CHAPTER 14 FINANCIAL AND ECONOMIC ANALYSIS

LIST OF TABLES

LIST OF FIGURES

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

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 Pattaya City, Nong Preo sanitary district and Ban Rong Po, 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 Pattaya 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 approximately 180 waterworks, inclusive of 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 Pattaya Waterworks in PWA

Pattaya Waterworks is under the supervision of Regional Office No. 1, one of the 10 Regional Offices, through which PWA is controlling its 181 urban waterworks in Thailand.

Regional Office No. 1 controls 14 waterworks located in the areas neighboring Chonburi Province and the total revenue of waterworks under its jurisdiction assumed the weight of 16.45 % in the total PWA revenue for 1985.

Pattaya Waterworks is one of the largest waterworks in the jurisdiction of the Regional Office, sharing 26.56 % of the 1985 combined total sales of the waterworks in the jurisdiction and 4.37 % of the total PWA revenue.

PART TWO
DEVELOPMENT PLAN

PART TWO

CHAPTER 4 DESCRIPTION OF THE STUDY AREA

4.1 Natural Features

4.2 Socio-Economic Features

CHAPTER 4

CHAPTER 4 DESCRIPTION OF THE STUDY AREA

The study area covers Pattaya City and its two neighboring areas i.e., Nong Preo Sanitary District and Ban Rong Po, which extend northeast and east of Pattaya, respectively, as shown in Fig-4.1.

4.1 Natural Features

Pattaya is located in the east coast of the Gulf of Thailand, some 150 km southeast of Bangkok and nearly 50 km south of Chonburi, capital city of Chonburi Province.

The study area is a flat land with gentle slopes extending from its central part. Pattaya Hill (100 m above the sea level) extends along the central seashore. A belt between Sukumvit Highway and Highway 3135 is composed of swamps where lotus and other vegetable grow. The downtown area and the southern beach are composed of sand strands, and the area behind them is characterized by a flat alluvial land. A granitic hill extends from the central part of the area to form an inland terrace.

The project area is a tropical forest zone, with the weather clearly divided into dry (November - April) and wet (May - October) seasons. The yearly average temperature is around 27 degree C, highest in April and lowest in December. Pattaya's average temperature is usually 1 degree C or so lower than Bangkok's. The number of rainy days and the amount of rainfalls are comparatively less than other areas in Thailand.

Thanks to its location, Pattaya has seldom suffered from the damages from tropical typhoons which in most cases originate in South China Sea during the months from June to December and pass through the northern part of Thailand from June to September and its southern part from October to December.

There are two river basins in and adjacent to the study area, i.e., Pattaya River Basin and Laem Chabang River Basin. Pattaya River Basin covers an area of about 40 sq km and the Laem Chabang River Basin extends about 330 sq km. Both basins are embanked. The former by the Nong Kho Dam of the Nong Kho River was constructed in 1983 and the latter by the Mab Prachan

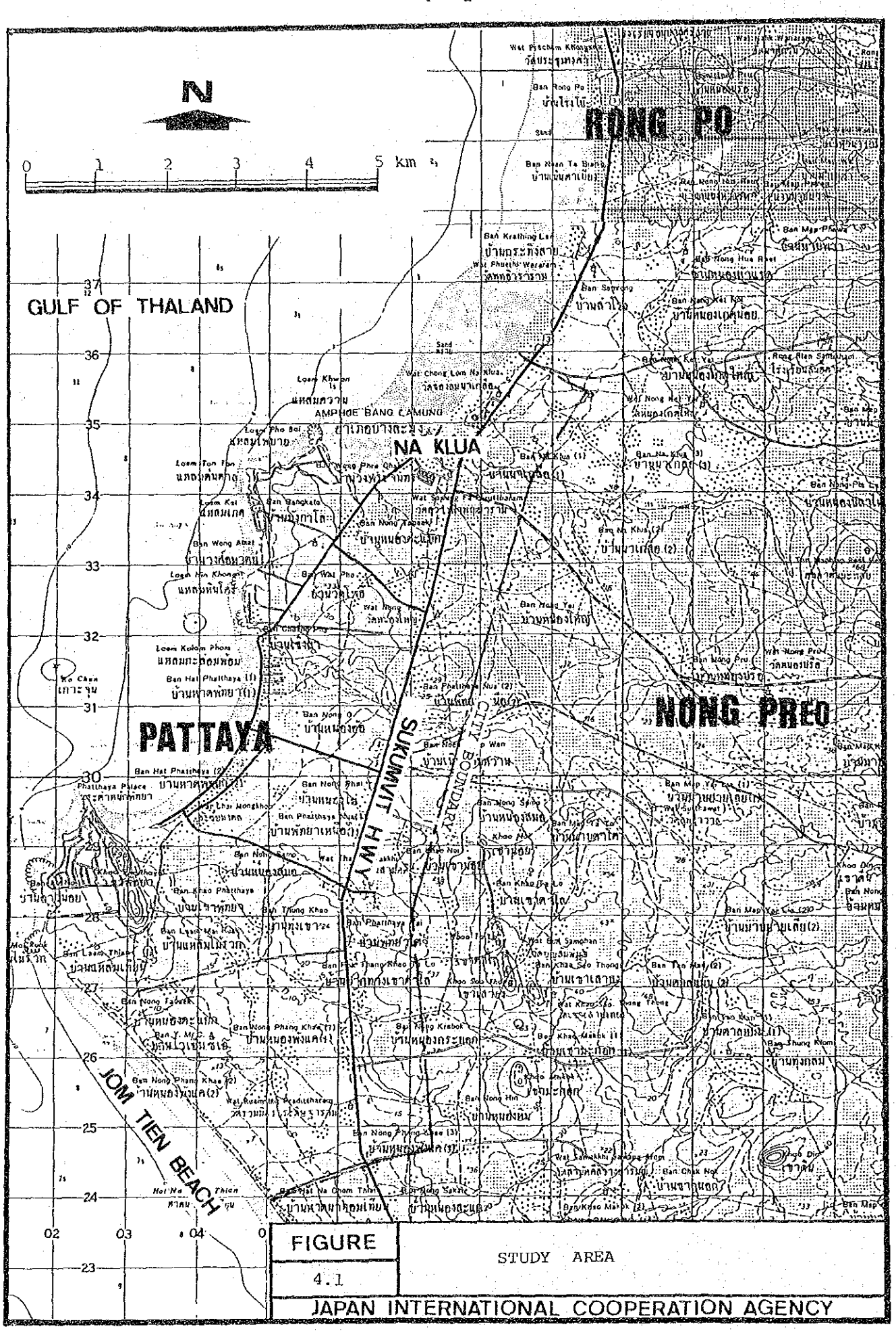

FIGURE 4.1 STUDY AREA

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Dam of the Mab Prachan and Tao Kiat Rivers constructed in 1979.

The availability of groundwater in Pattaya is limited due to the poor productivity of the aquifer.

4.2 Socio-Economic Features

Pattaya was only a small fishing village about 20 years ago and has achieved rapid growth to become one of the premier resorts in Southeast Asia. In the Eastern Seaboard Development Program (ESDP), Pattaya assumes an important role as a tourism and commercial center of Chonburi, one of the three major provinces covered by ESDP. As located in the proximity of Bangkok, Pattaya's tourism is expected to maintain stable growth. The tourist authority in Thailand estimated that Pattaya had 600,000 tourists in 1982, each with a stay of 5.6 days on average.

The leading economic activity of the study area is tourism with relevant commerce. Main agriculture-fishery products are cassava, shrimps and squids. Industries are of mainly small-scale such as cement, tapioca, food mills, boat-vehicle repair and woodcraft.

There are access by a national highway and railway to Pattaya from Bangkok.

The total population of the study area in 1984 was approximately 56,000 inclusive of Rong Po and Nong Preo areas. PWA supplies potable water to the area with a service ratio of around 30 %. The Provincial Electricity Authority (PEA) supplies electricity to nearly all parts of the municipal areas.

CHAPTER 5 EXISTING WATERWORKS

CHAPTER 5

CHAPTER 5 EXISTING WATERWORKS

The study area consists of Pattaya City, Nong Preo Sanitary District and Ban Rong Po. Populated seaside area and its surrounding area which are shown in Fig-5.1 are supplied water from PWA system set up in 1971. Most people in the study area receive water from the PWA system and/or their own private groundwater facilities or other water sources. At present 20,000 people which corresponds to 34 % of the total population 59,000 are utilizing PWA system water.

The remaining 39,000 persons use rivulet water, stored rain water, or groundwater which is very low in potentiality and salinity along the beach area.

In this chapter, the conditions of the waterworks are described below:

5.1 Water Supply Conditions

History of public water supply start from construction of the Na Klua Treatment Plant. Years of commencement and capacity of treatment plants in Pattaya are shown in Table-5.1.

Table-5.1 TREATMENT PLANT IN PATTAYA

Treatment Plant	Year of Commencement	Design Capacity	Remark
Na Klua Treatment Plant	1971	80 cu m/h (1,920 cu m/d)	Abandoned
Pattaya-Na Klua Treatment Plant	1981	1,000 cu m/h (24,000 cu m/d)	

The Na Klua Treatment Plant was constructed at Ban Nong Preo near Sukumvit Highway. This Na Klua Treatment Plant was modeled after the PWA Standard Design, with full treatment provided with flocculation, sedimentation, and filtration at one plant, and was accompanied with a high lift pump station and a clear water reservoir.

The Na Klua Treatment Plant depended for its water source on Nong Preo Reservoir having a capacity of 60,000 cu m and located 1 km southeast of treatment plant.

To cover the insufficient supply from the water source and to cope with a ceaselessly increasing water demand, the Mab Prachan Dam-Reservoir was constructed by RID in 1979 at the upstream of the Huai Nong Preo River in line with the national tourism developing policy.

The Pattaya-Na Klua Treatment Plant was constructed beside the Mab Prachan Reservoir. At present the Na Klua Treatment Plant is not used because of limited capacity of Nong Preo Reservoir, and the premises are used for the booster pump station. Figs-5.1 and 5.2 show the present service area, location of treatment plants, and the scheme of present water supply conditions, respectively.

Comparing water balance at the treatment plant, 8,76 MCM (treatment plant capacity: 24,000 cu m/d x 365 days = 8.76 MCM) and net draft rate of available water at Mab Prachan Reservoir, 9.12 MCM/year, it is apparent that when water requirement increases in near future, available water source is not enough.

As of the average in 1984, the production capacity, production and water sales are 24,000 cu m/d, 18,055 cu m/d (6,590,375 cu m/year) and 16,190 cu m/d (5,909,651 cu m/year), respectively.

75 % of the rated production capacity is being used now, and considering future growth of the water demand, shortage of production shall be concerned about for near future.

The unaccounted-for water ratio is counted as 10.3 % from the above-mentioned figures.

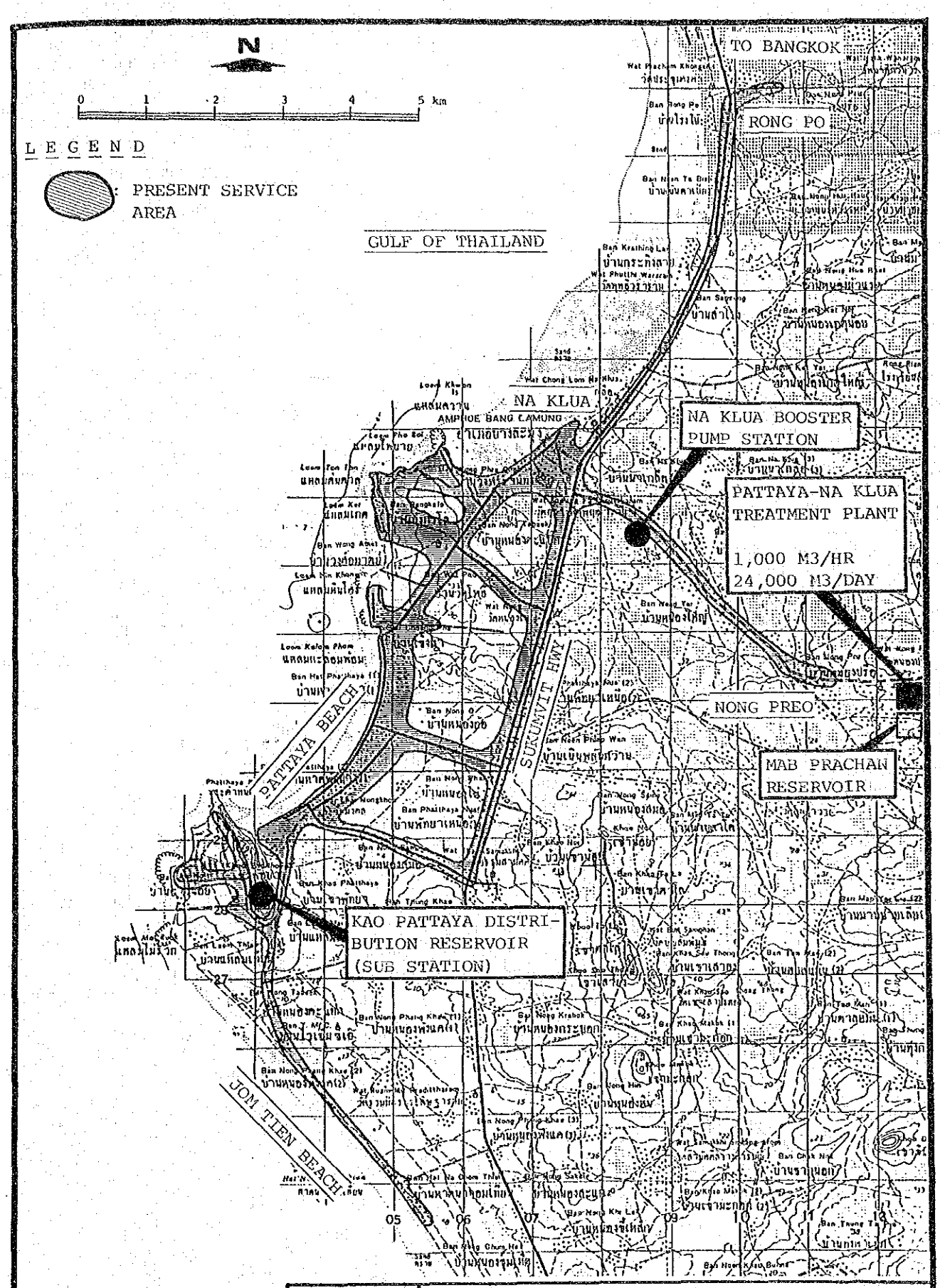

FIGURE	PATTAYA WATER SUPPLY SYSTEM
5.1	

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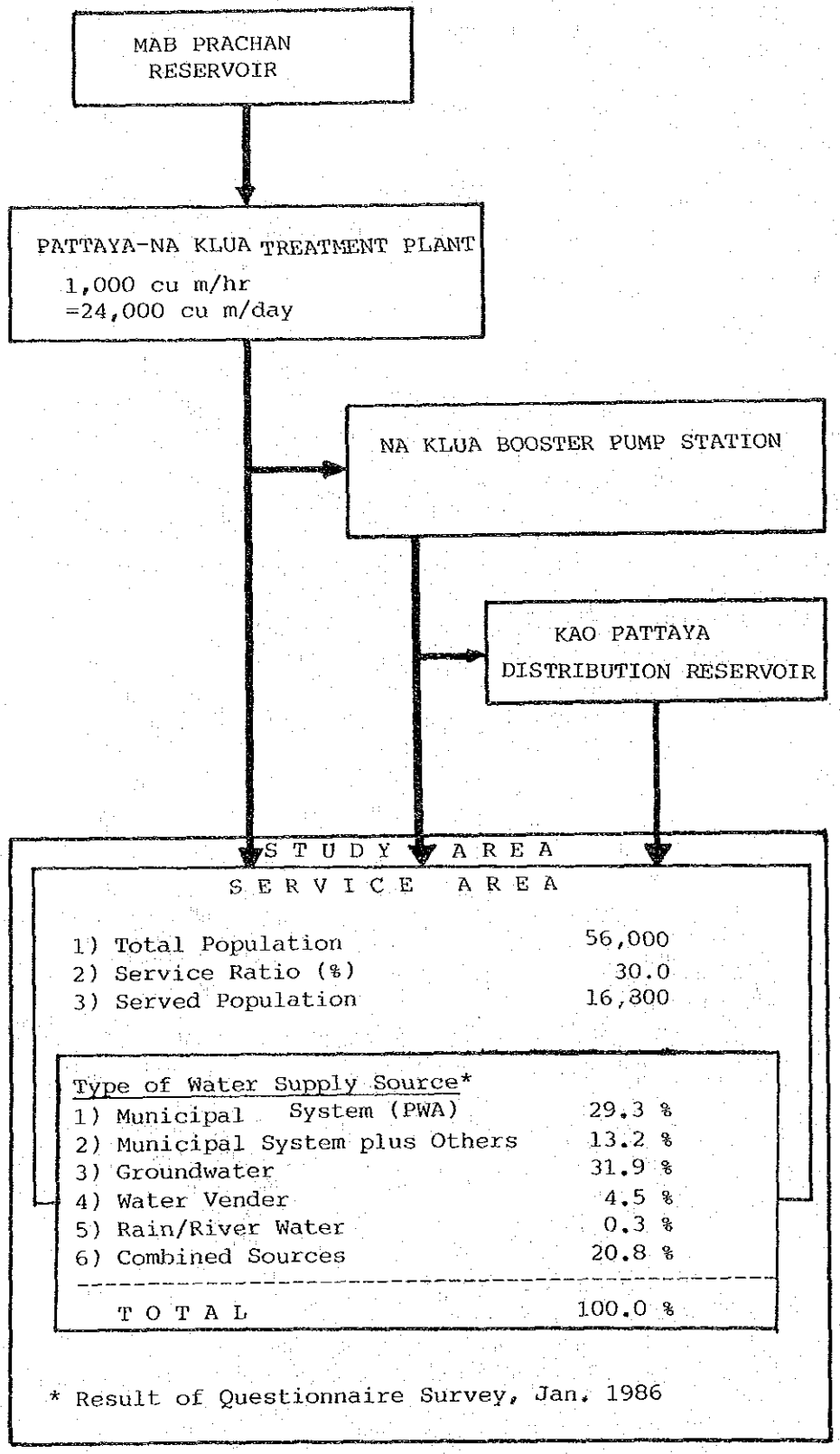

FIGURE 5.2 SCHEME OF PRESENT WATER SUPPLY CONDITION

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5.2 Water Sources

The Mab Prachan Reservoir is a sole water source for Pattaya-Na Klua Treatment Plant as mentioned in the preceding section. This source has a storage capacity of 14.8 MCM in 1985, not necessarily sufficient for Pattaya water supply. Annual mean run-off to the Reservoir from the catchment area of 37.9 sq km is estimated at 16.08 MCM from the available data at Bang Phra Reservoir during the period of 1968-1984 and a little run-off data on Mab Prachan were obtained during the period of 1979 - 1986. Because of its limited storage capacity, an excess run-off over the capacity is wasted by flowing out from the spillway of the Reservoir.

To resolve this situation, RID planned to raise the crest of the spillway by 50 cm in 1985. This work, expected to complete by 1989, will benefit increase of its storage capacity as follows:

Table-5.2 NET DRAFT

Item	Present	After 1989
Max Storage (MCM/Year)	14.80	16.50
Gross Draft (MCM/Year)	11.04	11.53
Reservoir Loss (MCM/Year)	1.92	1.92
Net Draft (MCM/Year)	9.12	9.61

(Note) Reservoir loss includes leakage and evapolation

The above net draft contains raw water for industrial and river maintenance use (1.8 MCM) in addition to water supply. Therefore, raw water available for water supply is computed at 7.81 MCM. If the river maintenance use (0.9 MCM) can be disregarded only in severe drought years, 8.71 MCM or 23,900 m3/day will be available, almost same as the present production capacity of the Pattaya-Na Klua Treatment Plant (24,000 m3/day).

To examine whether the Reservoir has any room for expansion, the Team conducted the field investigation and comprehensive study. There may be two probable plans : 1) relocation of suction pipe by lowering its level

to utilize raw water stored in dead zone of the Reservoir and 2) additional uplifting of the crest. It is the study result that plan 1) is not a fundamental solution since raw water to be available is more or less 1 MCM/year, approximately 10% of the current production of the existing plant and plan 2) that requires reinforcing whole concrete structure is not considered practical and cost-effective.

From all the above, it is concluded that future large scaled augmentation for water supply in Pattaya should depend on some other water source than the Mab Prachan Reservoir.

Water sampling and testing conducted concurrently by the Team at the Mab Prachan Reservoir revealed that is bacteriological and physical characteristics are generally in an acceptable level as water source. However, it showed high concentration of nitrogen and phosphorus, major nutrients for plankton and algae growth. These plankton and algae may often cause clogging of filter media, which will be focused on later in Chapter 7.

5.3 Intake and Water Treatment Facilities

5.3.1 Intake Facilities

Raw water is taken from a concrete intake tower constructed off the shore of Mab Prachan Reservoir. This intake tower, designed according to the PWA standard, has hexagonal cross-section and its upper structure is used as a pump station where pumps including the standby are installed.

A concrete bridge connecting the intake tower and the shore supports a raw water transmission main on a side of it and the other side is planned for use of supporting another main in the future expansion.

Two electric pumps and one stand-by diesel pump are installed in the pump station which has enough space for future installation of additional pumps, at least for three of the same size as the existing ones.

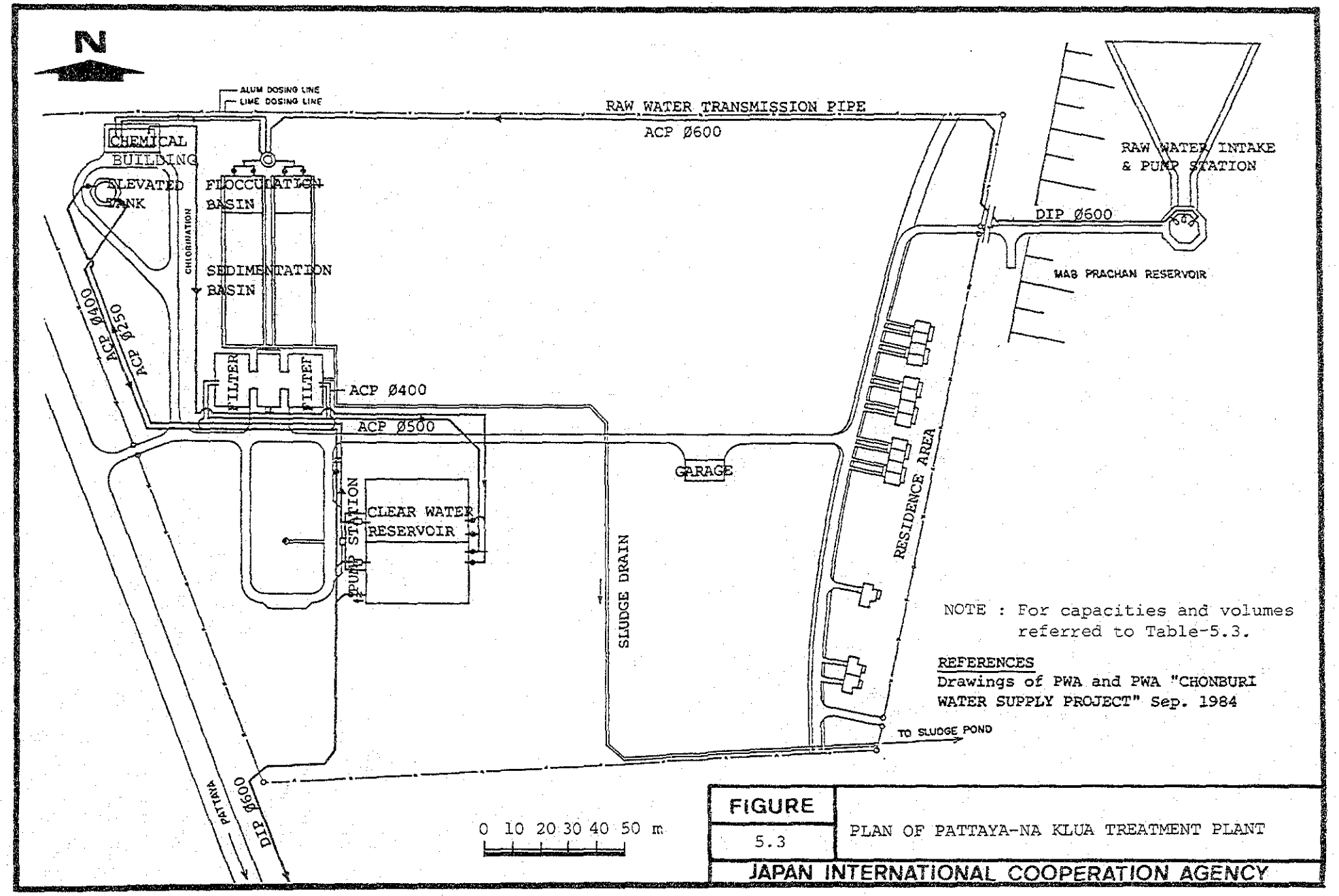
During the period of studying Development Plan, a 400 cu m/h intake pump and a 250 mm DIP transmission line were installed additionally to meet the peak demand in tourism season.

The additional system is said to be used only for a short term future, according to the regional and waterworks offices.

5.3.2 Treatment Facilities

The plan of Pattaya-Na Klua Treatment Plant including intake facilities is shown on Fig-5.3. As it is seen in the figure, the existing treatment plant occupies a small portion of the whole area, leaving enough space for possible expansion in future.

As it is seen in Table-5.3 which shows the operating conditions of the major facilities, detention time of Mixing Well and Flocculation/Sedimentation Basins exceeds considerably the design criteria to be discussed later in Chapter 12, because they are oversized in a way. The capacity, though rated at 1,000 cu m/h presently, can be increased by reasonable modification works.



NOTE : For capacities and volumes referred to Table-5.3.

REFERENCES

Drawings of PWA and PWA "CHONBURI WATER SUPPLY PROJECT" Sep. 1984

FIGURE	PLAN OF PATTAYA-NA KLUA TREATMENT PLANT
5.3	

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Table-5.3 MAJOR FACILITIES OF WATER TREATMENT PLANT

Facilities	Type/Capacity
Water Source	Mab Prachan Reservoir
Design Capacity	1,000 m3/h
Facilities	
Mixing Well	Mechanical Flush Mixer
	D.T. : 3 min
Flocculation Basin	Mechanical Vertical Flocculator
	2 Basins
	Volume : 450 m3/basin
	D.T. : 54 min
Sedimentation Basin	Horizontal Flow
	2 Basins
	Volume : 2,500 m3/basin
	D.T. : 5.0 h
Filter	Rapid Sand Filter
	8 Beds
	Bed Surface : 49.0 m2/bed
	F.R. : 61 m/d
Clear Water	Rectangular Type
Reservoir	Volume : 6,000 m3
	D.T. : 6.0 h
Elevated Tank	Volume : 250 m3
Chemical Application	
Coagulant	Aluminium Sulfate
Chlorine	Chlorine Gas

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

Sixteen motorized agitators installed in the flocculation basins are not continuously in use for saving energy cost. However, they are to be operated continuously in producing large size, easily settlable flocs for effective sedimentation.

Cleaning of the sedimentation basins is carried out periodically, three times a year, after emptying the basins.

Through the field survey, mud-balls and cracks were observed on the filters. The unsatisfactory condition was obvious from that the filter sand was soiled even right after washing.

The clear water reservoir with a flat roof covered by earth is partitioned into two parts. A few ventilation openings and a level indicator are equipped on the roof, however, the indicator is found to be out of order.

The chemical building located near the mixing well houses a chemical system consisting of solution tanks, a chlorinator and storage area. Four dosing pumps, two for each of alum and lime, are provided, Alum feeding is done continuously, but pre-lime feeding to regulate pH is practiced only when the turbidity becomes high.

Appropriate chemical dosage rate should be determined by water quality test. For this purpose, qualitative analysis of both raw and treated water is recommended to be conducted more frequently and regularly. Furthermore, comparative checking of the recommended and actually-dosed rate shall be practiced.

The actual consumption, and consequently dosage, of chemicals can be checked by regular measuring of the drop in the solution tanks, level and the decrease of the chlorine container weight.

Two flow meters are installed in the raw water transmission pipe and distribution main, outflow of the treatment plant, after clear water reservoir. Digital indicators of these two flow meters are installed in the filter building. The indicators show unimaginable data sometimes and the recorders were out of order at the time of field survey.

5.4 Distribution Facilities

Fig-5.4 shows the existing distribution networks.

Treated and disinfected water is transmitted, by gravity, from the treatment plant to the network, through a 7 km long 600 mm diameter DIP pipeline, along the access road from Mab Prachan Reservoir to the Sukumvit Highway.

About one-sixth of the water, before entering the network, is diverted to the booster pump station located at Na Klua, the site of treatment plant abandoned now. Fig-5.5 shows the plan of Na Klua Booster Pump Station. From the booster pump station, diverted water is conveyed to the so-called substation, Kao Pattaya distribution reservoir at Ong Phra Hill, through a 350 mm diameter SP pipeline. Distribution reservoir with the storage of 1,500 cu m at the substation, water is distributed, by gravity, to the service area including three large hotels near the Hill and to Jom Tien Beach area where a new beach resort will be developed in near future.

Distribution pipelines are provided for the most part of the beach resort area and residential area. Mainly made of ductile cast iron, the pipeline is about 100 km in overall length. For small sized pipelines, the asbestos cement made is used widely. Table-5.4 lists the distribution pipelines.

Mostly the distribution pipelines are kept in good physical conditions. However, in Na Klua area among other areas, many class 15 asbestos cement pipes, designed for low pressure service, are still in use since installation in 1971 and, according to the waterworks staff's report, leakage has been observed on the part of these pipes.

About 80 % of the consumers answering the questionnaire survey showed that they were satisfied with the supply pressure and water quality.

Sluice, air and drain valves are installed at appropriate points. However, some of them are not indicated in the reticulation maps, as they are completely buried under the road pavement and some are found to be defective.

The present service connections are numbered more than 5,000. Although all of them are metered, accuracy of measurement is questionable, because they are replaced only when they are found out of order after many years of service.

Large size meters are placed in covered and locked meter boxes. All meters are sealed with marked lead and wire for protection against wrong handling.

Table-5.4 LIST OF DISTRIBUTION PIPELINES

Dia(mm)	Material	Length(m)
100	Asbestos Cement	16,720
150	"	28,090
200	"	13,020
300	"	11,250
350	Steel	10,930
400	Ductile Iron	8,120
500	"	2,400
600	"	9,250
Total		99,780

5.5 Rehabilitation and Modification Works

The facilities stated above are to have been operated for future as important ones to meet water demand. To cope with the increasing demand, rehabilitation and modification of the existing facilities are necessary together with expansion works of water supply system. These works will be explained in the succeeding Chapter 7, in detail.

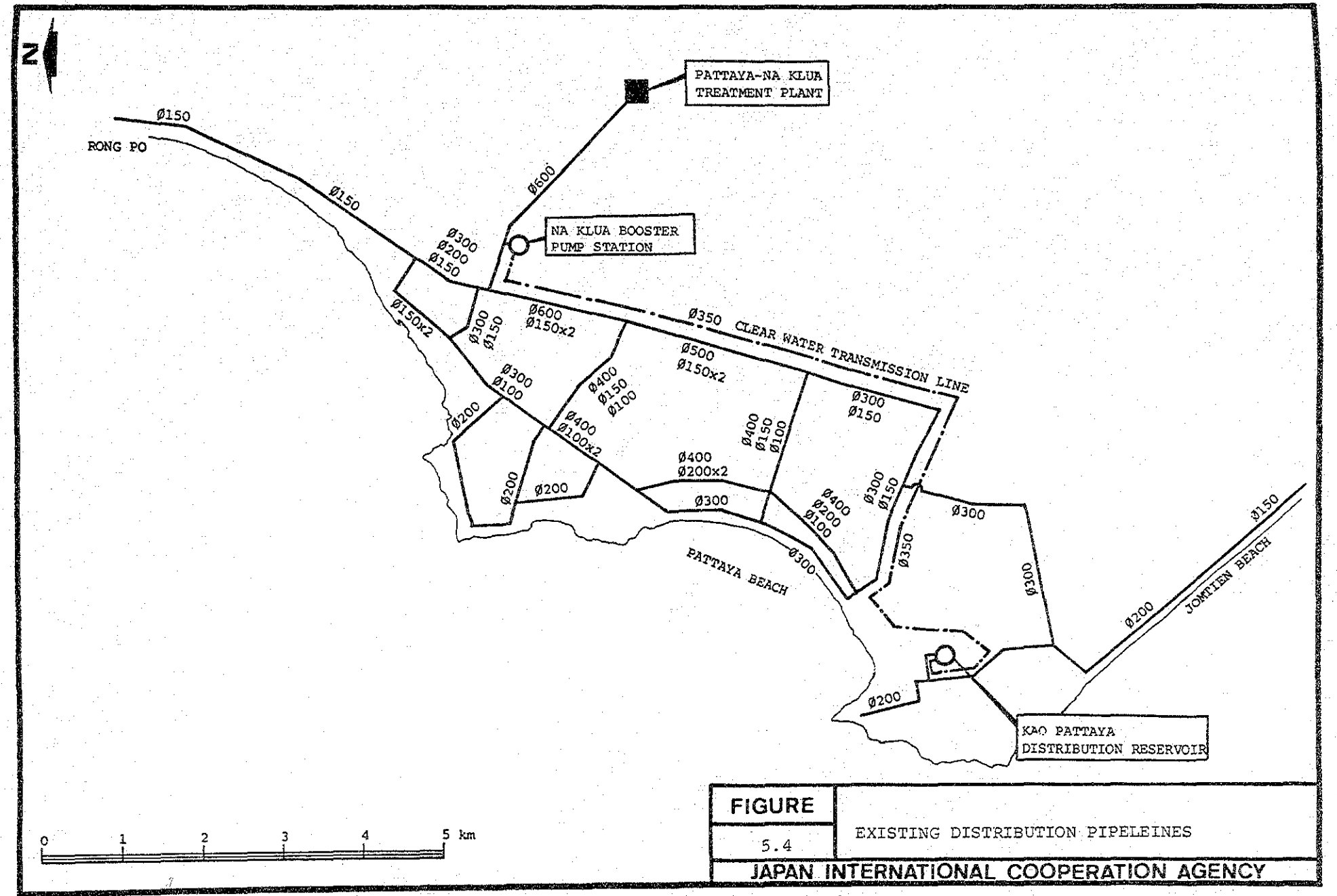

FIGURE	
5.4	EXISTING DISTRIBUTION PIPELEINES

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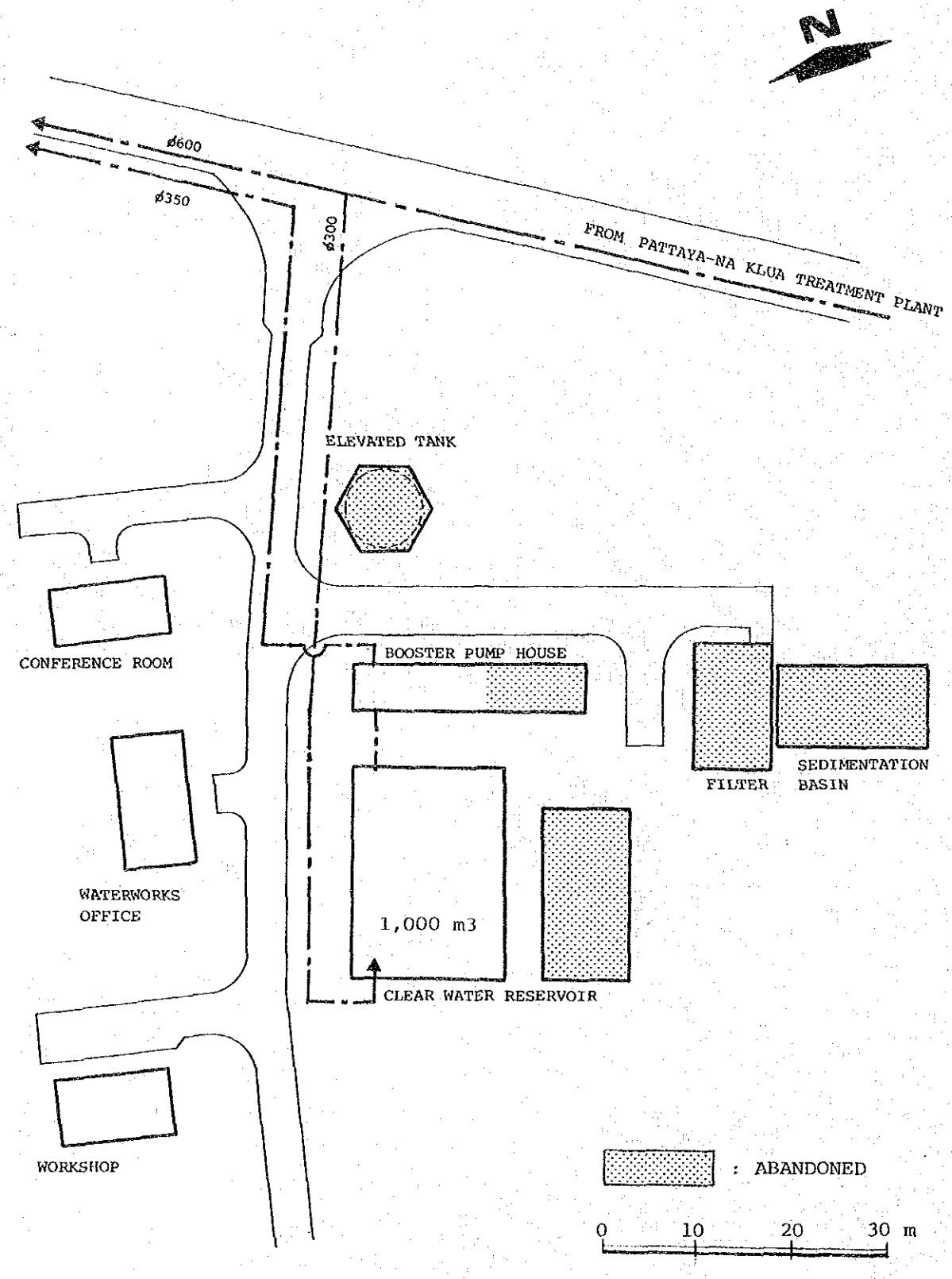

FIGURE 5.5 PLAN OF NA KLUA BOOSTER PUMP STATION

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CHAPTER 6 POPULATION AND WATER DEMAND

CHAPTER 6 POPULATION AND WATER DEMAND

6.1 General

In this chapter forecasted are the future population in study area and water demand in service area. The area, as defined in the scope of work, consists of three districts, namely Pattaya City, Ban Rong Po and Nong Preo Sanitary District. 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 projecting the served population. For each category of water uses, such as domestic, public, commercial and industrial, the past trend was studied and the future water demands were estimated category-wise. Since the City is a center of tourism industry in the country, the water requirements by tourism are also analyzed and included in the forecast.

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 Pattaya City, Ban Rong Po and Nong Preo Sanitary District are shown in Table-6.1. The recorded period differs for each of the three, however.

The population of Pattaya City showed an average increase of 2,050 persons per year in the last 5 years, indicating the city has been developing in tourism and related economic activities. The population of Ban Rong Po, a town adjacent to Pattaya and located by the Sukumvit Highway connecting the area with Bangkok, has been increasing population at a rate of 130 persons

per year, owing to the same reason.

Nong Preo Sanitary District, a village occupying the hilly land, shows decreasing trend of population increase, possibly attributable to increasing emigration to urban area.

Table-6.1 DATA OF PAST POPULATION

YEAR	Area		
	Pattaya	Ban Rong Po	Nong Preo S.D.
1975		6,489	
1976		7,396	
1977		7,494	
1978	29,726	7,633	
1979	31,777	7,761	5,710
1980	34,867	7,921	5,220
1981	36,507	8,019	5,390
1982	38,525		5,544
1983	40,475		
1984	42,009		

DATA SOURCES :

Pattaya : Institute of Population Studies, Chulalongkorn University

Rong Po : PWA Survey Report on Pattaya Waterworks, 1982

Nong Preo : - ditto -

6.2.2 Future Population Forecast

1) Pattaya City

The future population of Pattaya City will increase linearly at a similar rate as in the past, affected by the development of tourism.

2) Ban Rong Po

The future population will grow in the same manner as in Pattaya, following the trend of linear increase.

3) Nong Preo Sanitary District

The rate of population increase will decrease in future and the population will be saturated at around 6,000 after 2005.

The total population of the project area consisting of Pattaya City, Ban Rong Po and Nong Preo Sanitary District is shown on Table-6.2 and plotted in Fig-6.1.

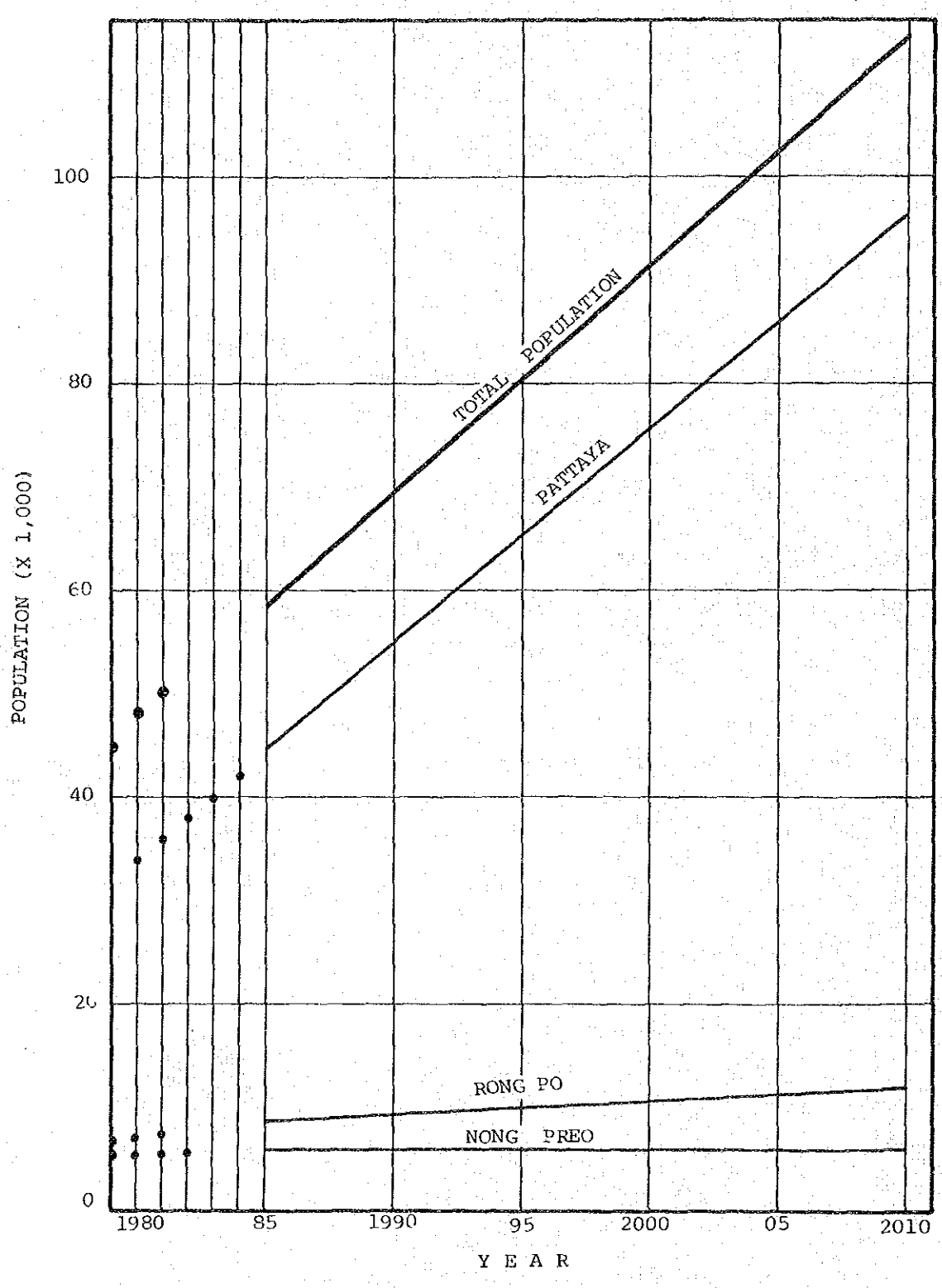

FIGURE 6.1	TOTAL POPULATION OF THE PROJECT AREA

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Table-6.2 TOTAL POPULATION OF PROJECT AREA

YEAR	AREA			
	PATTAYA	RONG PO	NONG PREO	TOTAL
1985	44,540	8,540	5,660	58,740
1990	54,880	9,190	5,850	69,920
1995	65,220	9,840	5,930	80,990
2000	75,560	10,480	5,970	92,010
2005	85,900	11,130	5,990	103,020
2010	96,240	11,780	5,990	114,010

6.3 Service Area and Served Population

6.3.1 Service Area

The present and future service areas, planned on the basis of future land use plan and information of waterworks and City office for 2000 and 2010, are shown in Fig-6.2.

As this area faces the sea to the west, expansion in future is limited to three directions. Na Klua's growth will be directed to the north and development will proceed along the Sukumvit Highway. The central area, already developed fully and populated densely, will be expanded to the east.

Developers are looking for new beach resort area to the south, along the Jom Tien Beach to make it a new center in the future. In recent years, a few large hotels have been constructed along the beach.

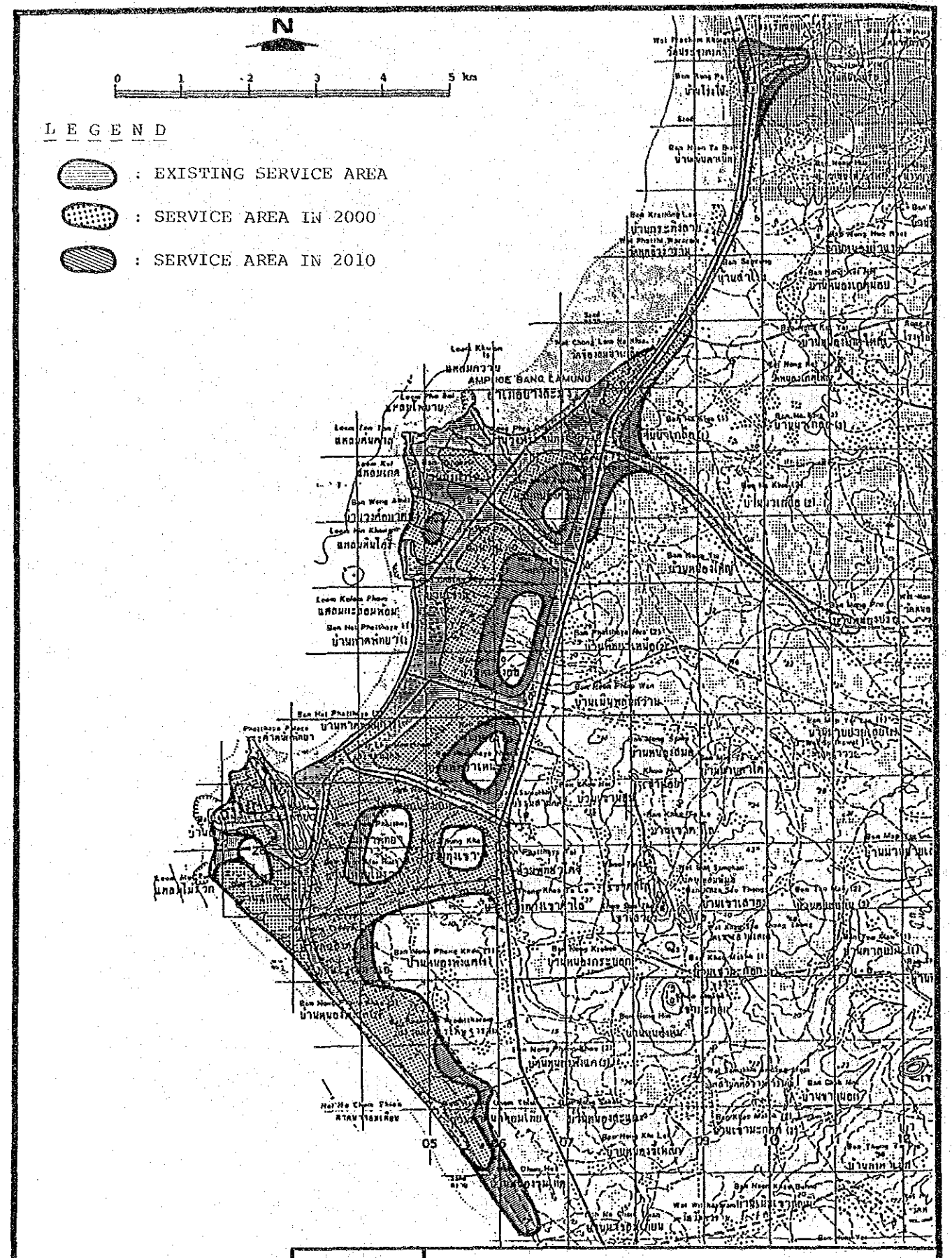

FIGURE 6.2 EXISTING AND FUTURE SERVICE AREA

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6.3.2 Served Population

The service ratio in future was estimated upon consideration of customers' income level and people's willingness for house-connection. Estimated future served population is shown in Table-6.3 and Fig-6.3.

Table-6.3 FUTURE SERVICE RATIO AND SERVED POPULATION

YEAR	TOTAL POPULATION	SERVICE RATIO	SERVED POPULATION
1985	58,750	34	20,000
1990	69,920	48	33,600
1995	80,990	58	47,000
2000	92,010	65	59,800
2005	103,020	71	73,100
2010	114,010	76	86,700

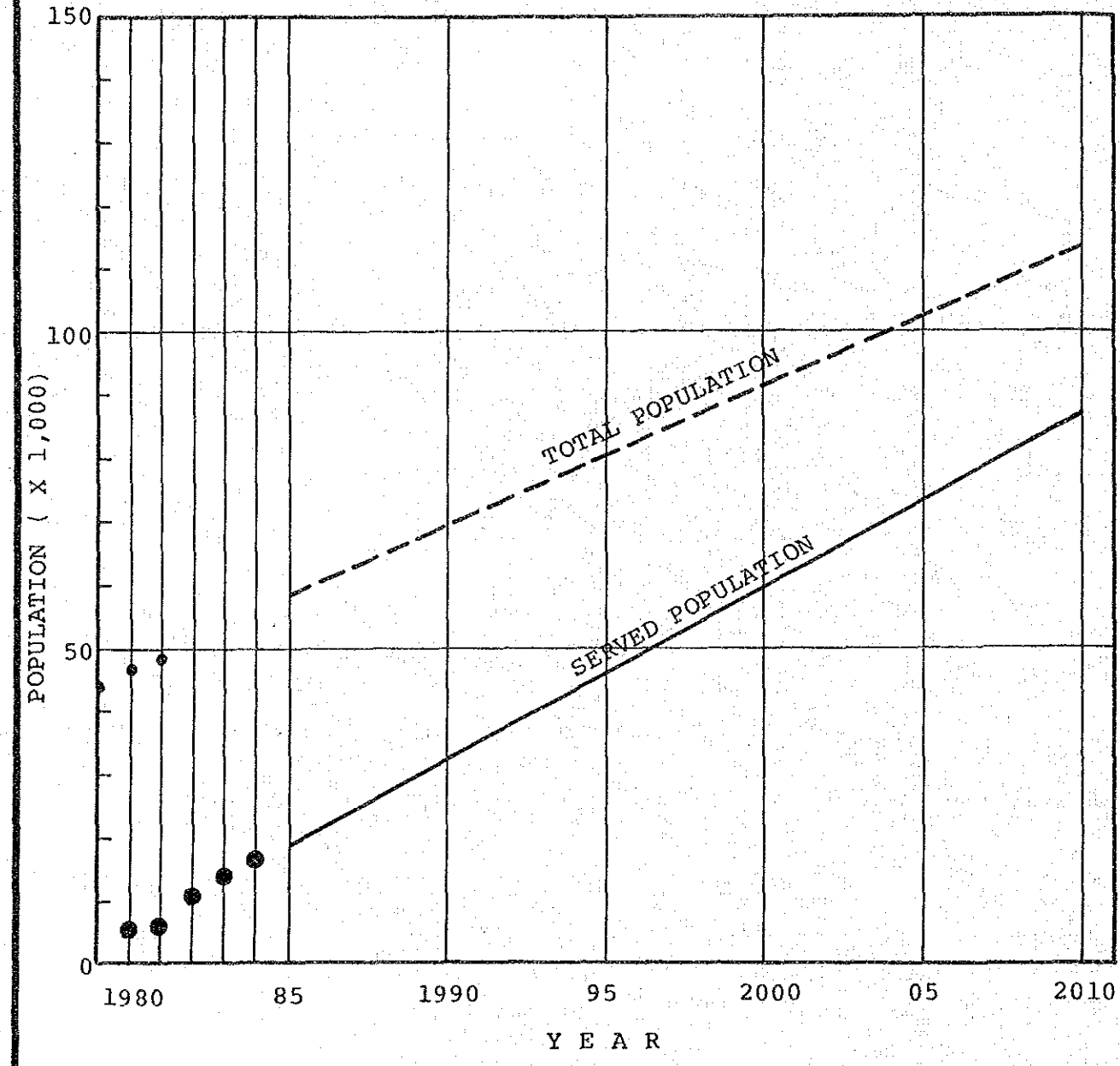

FIGURE	SERVED POPULATION FORECAST
6.3	

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6.3.3 Tourist Forecast

In this section, the average number of tourists staying in the area is studied to use it for forecasting the future water demand in Section 6.4.

Based on the discussion made between the study team and TAT, DTCP and the Municipal Office and studying the tourism-related reports, the tourists' number per year, average length of stay, annual total stay and average number of tourists per day were estimated.

The forecasted number of tourists per year is plotted in Fig-6.4 and the above-said estimates are listed in Table-6.4.

Table-6.4 FORECAST OF TOURISTS IN PATTAYA

YEAR	ANNUAL TOURISTS (persons)	AVERAGE LENGTH OF STAY (days)	ANNUAL TOTAL STAY (man-days)	AVERAGE DAILY TOURISTS (persons/day)
1985	734,686	4	2,938,744	8,050
1990	961,816	4	3,847,264	10,540
1995	1,090,924	4	4,363,696	11,960
2000	1,150,018	4	4,600,072	12,600
2005	1,174,370	4	4,697,480	12,870
2010	1,183,968	4	4,735,872	12,980

NOTE : (ANNUAL TOTAL STAY) = (ANNUAL TOURISTS) X (AVERAGE LENGTH OF STAY)

(AVERAGE DAILY TOURISTS) = (ANNUAL TOTAL STAY)/365

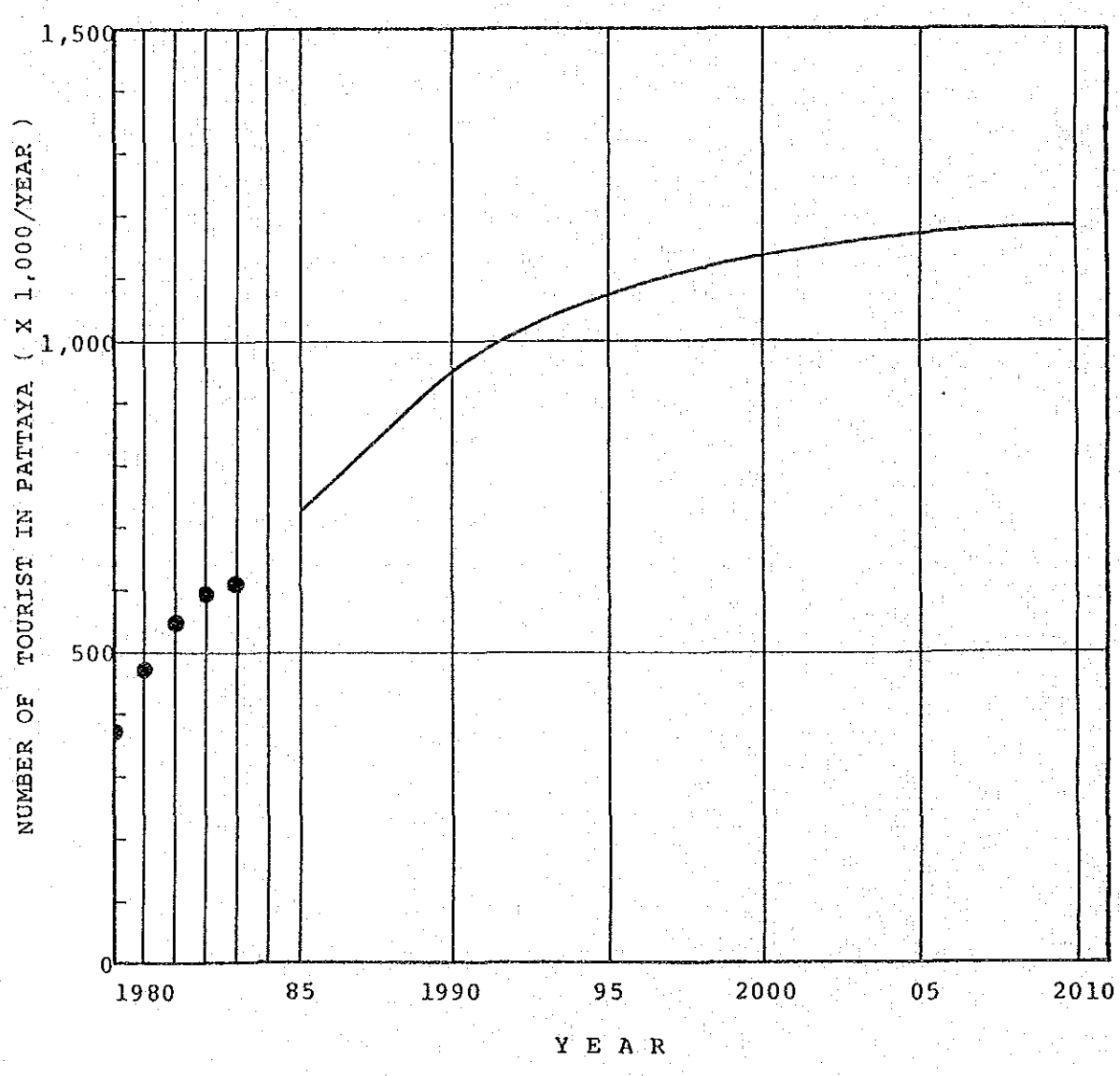

FIGURE	FORECAST OF THE NUMBER OF TOURIST
6.4	

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6.4 Water Demand

6.4.1 Past and Present Water Consumption

Obtained records of the water production and water sales in 1978 - 1984 and a sample of breakdown of the water consumption, are as shown in Table-6.5 and Table-6.6 respectively.

As seen in Table-6.5, the water production and water sales suddenly increased in 1982, when Pattaya-Na Klua treatment plant started its operation. At the same time, the monthly water consumption per connection also doubled, due to increase of relatively large consumers. According to the officials of the waterworks most of the modern hotels in Pattaya changed their water source from groundwater to the piped water, asking for reliability in both quantity and quality.

Table-6.6 clearly characterize the consumption in Pattaya. The consumption by hotels and commercial shops accounts for more than 80% of the total. On the other hand, the consumption by institutions including the government offices, hospitals, schools, temples and industries is merely 4.5%.

Table-6.5 WATER PRODUCTION AND WATER SALES

YEAR	WATER PRODUCTION (cu m/year)	WATER SALES (cu m/year)	NUMBER OF CONNECTION	CONSUMPTION PER CONNECTION (cu m/month)
1978	258,745	193,956	798	243
1979	301,689	205,148	886	232
1980	294,282	260,544	966	270
1981	915,515	733,487	1,342	547
1982	3,327,949	2,978,433	2,571	1,158
1983	5,199,565	4,573,615	3,683	1,242
1984	6,590,375	5,909,651	4,239	1,394

DATA SOURCE : PWA

Table-6.6 BREAKDOWN OF WATER CONSUMPTION

CATEGORY	WATER CONSUMPTION (cu m/month)	(%)
Government Office	3,463	1.4
Hospital	2,379	1.0
School	792	0.3
Temple	660	0.3
Industry	3,678	1.5
Domestic	34,748	14.0
Commercial	57,349	23.1
Hotel	145,089	58.4
Total	248,203	100.0

SOURCE : PWA Survey Report on Pattaya Water-works in 1982

6.4.2 Future Water Consumption

1) Domestic Water Consumption

The domestic water consumption is estimated on the per capita basis. Currently it is estimated at 136 lpcd in 1984. The future per capita consumption is assumed to gradually increase to 210 lpcd in 2000 and 220 lpcd in 2010. From the assumed per capita consumption and estimated served population, the future domestic water consumption was estimated as shown in Table-6.7.

Table-6.7 DOMESTIC WATER CONSUMPTION

YEAR	SERVED POPULATION	PER CAPITA CONSUMPTION (lpcd)	DOMESTIC WATER CONSUMPTION (cu m/day)
1985	19,980	148	2,956
1990	33,560	190	6,377
1995	46,970	205	9,630
2000	59,810	210	12,559
2005	73,140	215	15,726
2010	86,650	220	19,062

2) Non Domestic Water Consumption

Non-domestic water consumption is categorized in the public, tourism, commercial and industrial. Each category is further described below:

a) Public Water Consumption

Public water consumption includes the water consumptions by such institutions as the government offices, hospitals, schools and temples. It was estimated to be proportional to the domestic water consumption.

b) Tourism Water Consumption

The tourism water consumption is the water used by and for tourists staying at hotels and similar facilities. Most of hotels and these facilities, which are existing and will be constructed in future, will be included in service area. It is estimated, therefore, on the number of tourists, as shown in Table-6.8, and the per capita consumption. After studying the available data, the consumption has been assumed as 875 lpcd in 1985 - 1990 and 900 lpcd in 1995 - 2010.

Table-6.8 summarizes the tourism water consumption.

Table-6.8 TOURISM WATER CONSUMPTION

YEAR	NUMBER OF TOURIST/DAY	CONSUMPTION PER TOURIST (l/day)	TOURISM WATER CONSUMPTION
1985	8,051	875	7,040
1990	10,540	875	9,220
1995	11,955	900	10,800
2000	12,603	900	11,340
2005	12,870	900	11,580
2010	12,975	900	11,700

c) Commercial Water Consumption

The commercial water consumption is the water used by commercial businesses like restaurants, bars, shops and bazaars. It is proportional to the tourism water consumption assumingly, as the commercial activities in Pattaya are principally for the tourists.

d) Industrial Water Consumption

The economy in the area will continue to depend largely on tourism and the City is committed to no long-term industrial development program at present. The industrial water consumption will stay at the present level.

3) Total Water Consumption

The domestic and non-domestic consumptions are summed up and shown in Table-6.9.

Table-6.9 TOTAL WATER CONSUMPTION

	WATER CONSUMPTION (cu m/day)					
CATEGORY	1985	1990	1995	2000	2005	2010
Domestic	2,960	6,380	9,630	12,560	15,730	19,060
Public	800	1,720	2,600	3,390	4,250	5,150
Tourism	7,040	9,220	10,800	11,340	11,580	11,700
Commercial	2,610	3,410	4,000	4,200	4,290	4,330
Industry	400	400	400	400	400	400
Total	13,810	21,130	27,430	31,890	36,250	40,640

6.4.3 Average Day and Maximum Day Water Demands

As the total water consumption estimated above is the net delivery, the unaccounted-for water shall be added to it in computing the demand for production. The average day and maximum day demands are defined as the production demand here.

The unaccounted-for water ratio has been very low in the Project Area, as it was 10.5, 12.0 and 10.3 % in 1982, 1983 and 1984 respectively. The low ratio comes from the fact that distribution networks were built rather recently.

As the unaccounted-for water ratio planned for 1985 - 2010 is 15%, the Pattaya Waterworks will have to pay consistent attention to leakage control, in order to maintain the desirable condition as existing.

For Pattaya, two peak factors, the ratio of maximum day demand to average day demand, have been found necessary due to the city's characteristic as a tourism center.

Studying the monthly fluctuation of tourists' number, the peak factor for tourism water consumption was made 1.4, while that of domestic consumption, referring comparable data of Chiangmai, was assumed as 1.25.

Table-6.10 and Fig-6.5 show the average day water demand and maximum day water demand.

Table-6.10 AVERAGE DAY AND MAXIMUM DAY WATER DEMAND

WATER DEMAND	WATER DEMAND (cu m/day)					
	1985	1990	1995	2000	2005	2010
AVERAGE DAY	16,241	24,863	32,270	37,510	42,640	47,810
MAXIMUM DAY	21,544	32,706	42,240	48,900	55,340	61,830

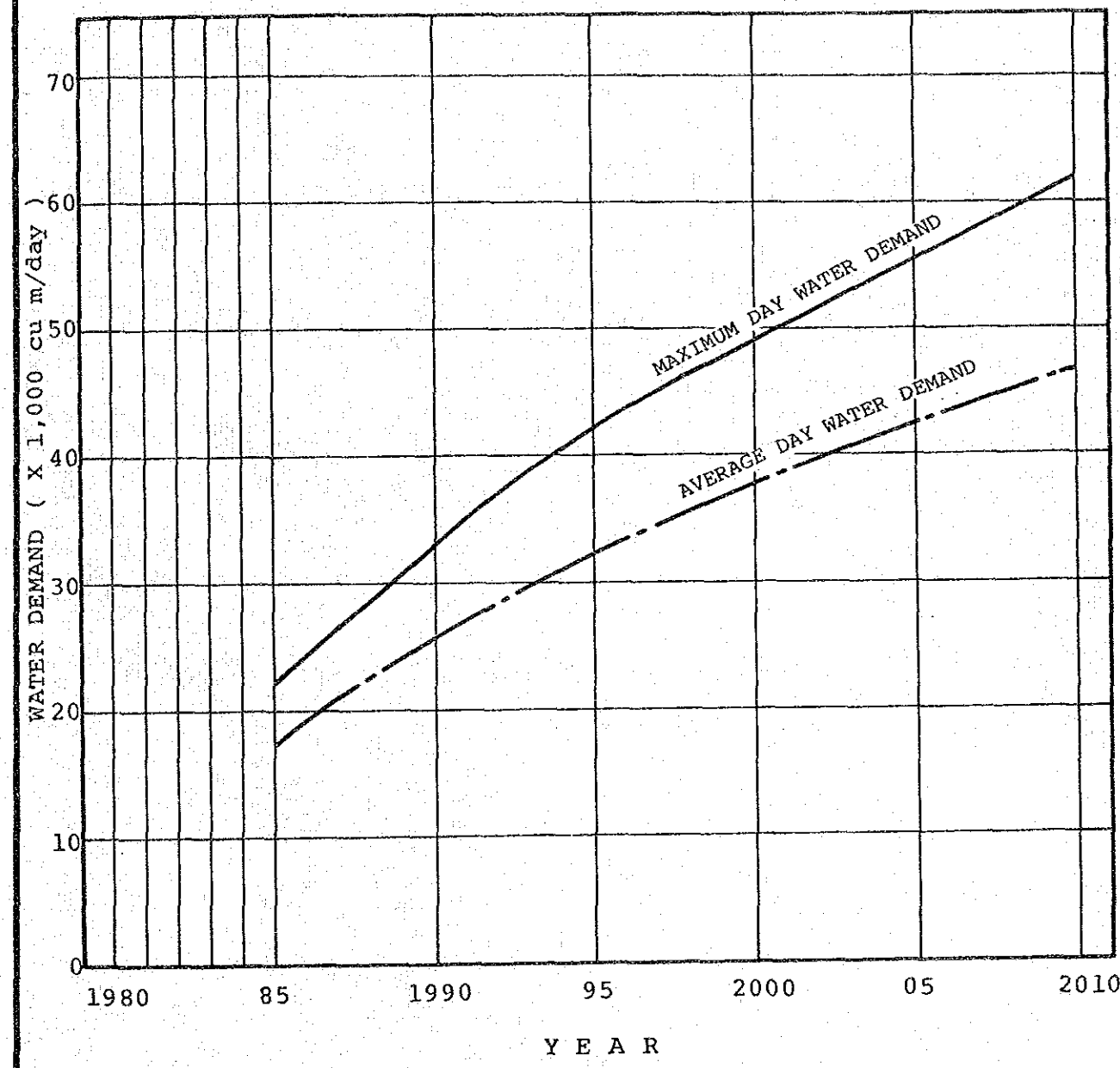

FIGURE	ESTIMATED FUTURE AVERAGE DAY WATER DEMAND AND MAXIMUM DAY WATER DEMAND
6.5	

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CHAPTER 7 PROPOSED WATER SUPPLY SYSTEM

CHAPTER 7

CHAPTER 7 PROPOSED WATER SUPPLY SYSTEM

In the previous Chapters, all basic factors governing the planning of the long-term development plan of the water supply systems have been studied, including the prevailing conditions of the supply area, the existing water supply conditions, the trends of population growth and water requirements. Taking all results of the studies into account, the development plan will be worked out hereinafter, which is most appropriate, technically and economically, for the study area.

7.1 Basic Considerations for Development Plan

Formulation of the long-term development plan of the Pattaya Water Supply Project will be based on the following basic considerations:

1) Earliest Possible Realization of Water Supply

Emphasis will be placed on earliest possible realization of water supply to the areas where supply is insufficient or supply is urgently required, by means of rehabilitation and modification of the existing facilities.

a) Deteriorated equipment in the treatment plant and obsolete pipelines as described in Chapter 5 will be rehabilitated, and the problems of operation and maintenance will be so solved as to enable supplying safe water continuously.

b) To reduce leakage from the water main, leak detectors will be provided and a leakage control program will be prepared.

c) Inexpensive and effective improvement works for uprating production will be carried out.

2) Phased Implementation of Project

To achieve cost-effective implementation of the whole project, the service

area will be expanded, or the pipelines will be extended according to the urgency of supply in the area.

In accordance with the future plans of the City, Regional Office and Waterworks and in consideration of the development of the service area and water demand, the development plan of the study area will be phased into two stages, i.e., Stage I up to 2000 and Stage II up to 2010.

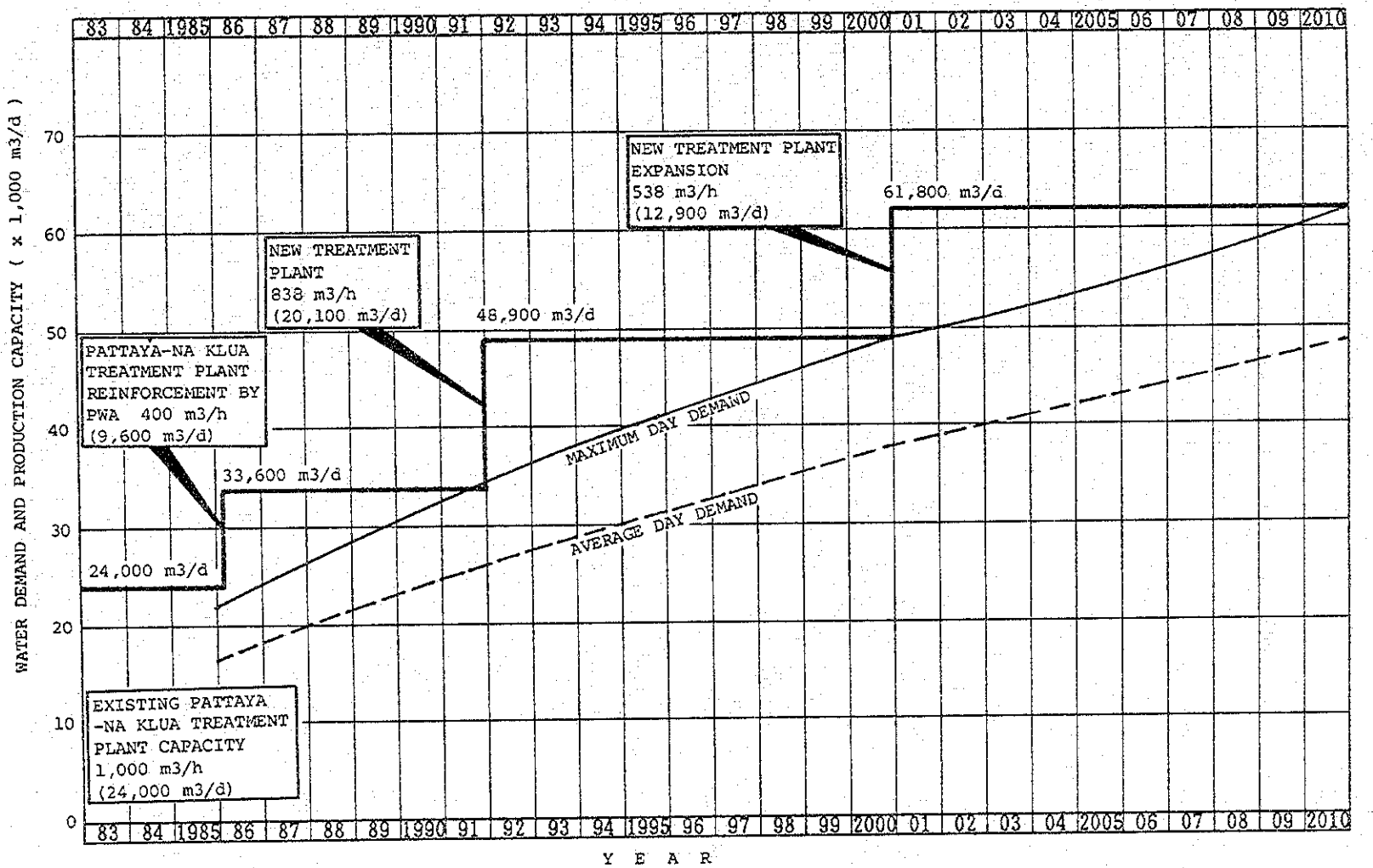
3) Most Appropriate Technology

Strictly in compliance with the design criteria established by PWA, least cost designs will be employed, rather placing emphasis on labor intensive technology.

a) In planning and designing the present water supply system, the plan of PWA now under way or under construction will be studied for reference.

b) Construction methods, and mechanical/electrical equipment, currently employed widely in Thailand, will be used as much as practicable. Emphasis will be placed on easy and failsafe operation and maintenance.

In the succeeding sections the proposed water sources for the long-term development plan will be described at first. Then, the rehabilitation and modification works of existing facilities to be executed under Stage I are outlined. Finally described are the Stage I and Stage II expansion works for the future water supply system. The water supply plan summarizing the above description is presented in Fig-7.1.



Note : Daily maximum production of Pattaya-Na Klua T.P. is assumed as 28,800 cu m/d after 1992 due to restriction on raw water abstraction. The maximum draft rate of raw water is 8.71 MCM/year or 23,900 cu m/d after 1992.

FIGURE 7.1	WATER SUPPLY PLAN TO YEAR 2010
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7.2 Water Source and Water Supply System

7.2.1 Water Source

As described in Chapter 5, the Mab Prachan Reservoir, the existing water source of the Pattaya-Na Klua Treatment plant, does not have enough capacity to supply raw water for its future extension. To determine future water source for Pattaya Waterworks, review of the available data and reports and site investigations were conducted as detailed in Appendix 3. Consequently, the Nong Kho Reservoir was finally selected as the most promising water source because of the following reasons:

1) The East Coast Water Resource Development Report prepared by JICA in 1983 recommends that Pattaya water zone should depend on the Mab Prachan Reservoir, the Nong Kho Reservoir and/or Huai Kong Dai Intake of the Huai Kon Dai River, all located in vicinity of Pattaya City.

2) Pipeline to convey 0.8 cu m/sec from Nong Kho to Laem Chabang is currently under construction and will be completed by year 1988. The quantity of raw water conveyed is sufficient to meet incremental water demands of Pattaya City till 2000 if merely one third of the raw water be diverted for the Pattaya Waterworks.

3) Nong Kho - Laem Chabang Pipeline Project plans to install additional pipeline by 1998, after construction of Nong Pla Lai Reservoir and installation of Nong Pla Lai - Nong Kho pipeline which are also planned under the East Coast Water Resources Development Project as shown in Fig-7.2. Therefore, the Nong Kho Reservoir even after year 2000 will be able to provide Pattaya and Laem Chabang water zones with sufficient raw water to be conveyed from the Nong Pla Lai Reservoir.

4) Huai Kong Dai Intake will be worthwhile for studying further as one of the possible future water source systems from the technical and economic standpoints. At present, however, no solid data are available as to basic items such as climateological, topographical and hydrological data. Thorough study for Huai kong Dai is required on such matters.

5) Other probable water sources such as the Bang Bun, Bang Phra and Dok Krai Reservoirs are all located too far to convey raw water to Pattaya.

From all the above, the current project will depend on the Nong Kho Reservoir as future water source up to 2010.

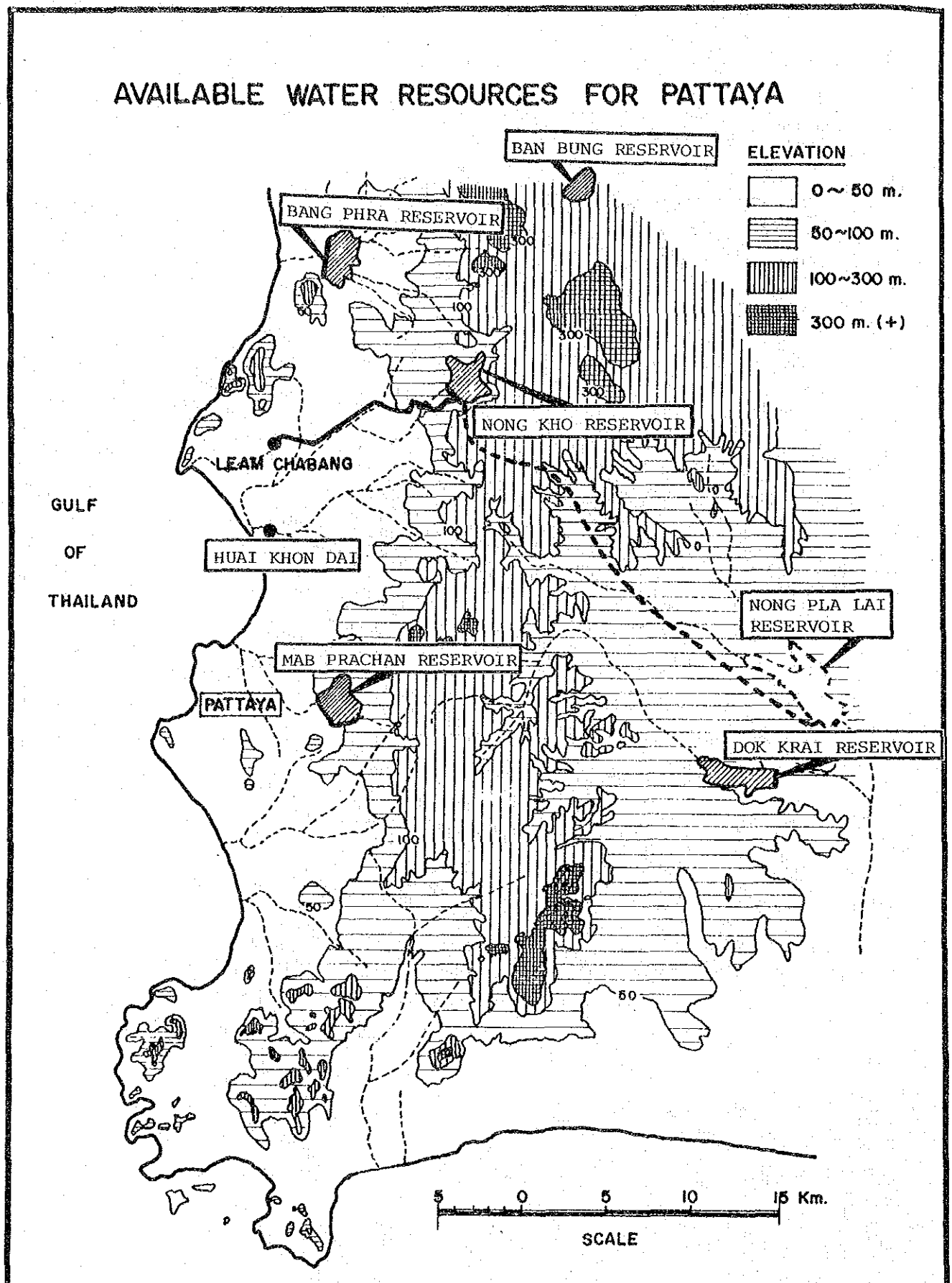

FIGURE	AVAILABLE WATER RESOURCES FOR PATTAYA
7.2	

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7.2.2 Water Supply System

The location of the proposed treatment plant together with method of conveying water is a key factor to establish a development plan to meet the increasing water demands up to the year 2010. The comparative study was conducted among these alternatives on the basis of least cost solutions. (Refer to Appendix-7 Alternative Study for details of the comparative Study)

Among the alternatives, the following method is found most cost effective:

- the proposed treatment plant should be located near Laem Chabang Receiving Well through the Stages I and II.

- Treated water should be conveyed by gravity to a proposed distribution pump station at Ban Rong Po and pumped to the service area.

The long-term development plan is shown on Fig-7.3, and discussed in the following sections.

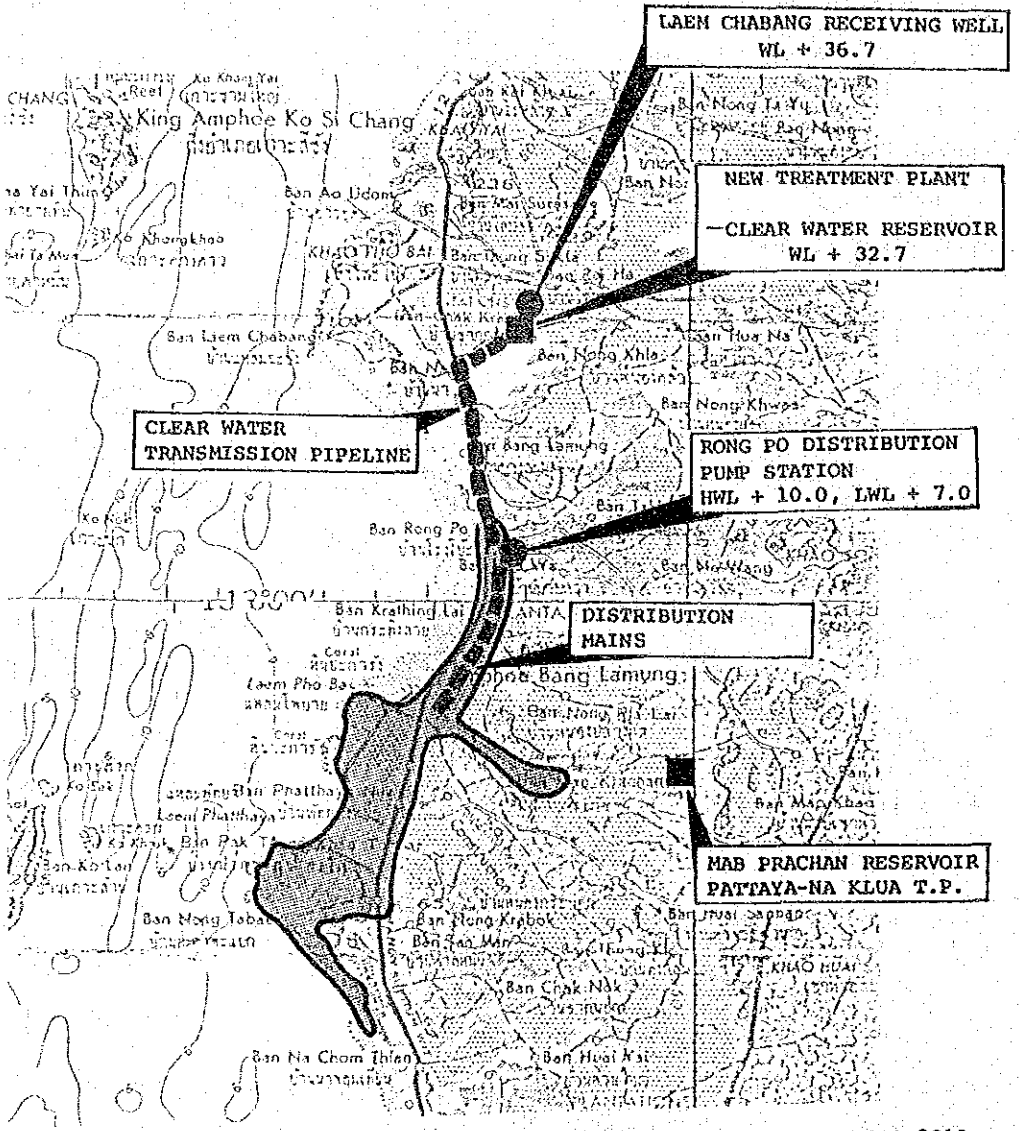
7.3 Stage I Rehabilitation and Modification Works

The rehabilitation/modification works are focused upon the Pattaya-Na Klua Treatment Plant to increase the supply capacity, replacement of obsolete pipelines to reduce unaccounted-for water and addition of a distribution main to feed the treated water planned for increase. The 400 cu m/h increase plan was partly realized by installation of a raw water pump and a transmission line and to complete it, additional chemical feeding system is needed.

The items recommended for immediate attention to initiate the rehabilitation/modification are summarized below:

(1) Install additional alum and lime feeding equipment;

(2) Relocate the raw water pump, installed in March 1986, in the pump house of the intake tower;



	YEAR 2000	YEAR 2010
RAW WATER TRANSMISSION PIPELINE (BY GRAVITY)	ø700, 0.4 km	ø600, 0.4 km
NEW TREATMENT PLANT	20,100 m3/d	12,900 m3/d
CLEAR WATER TRANSMISSION PIPELINE	ø600, 6 km ø500, 5 km	ø500, 8 km ø400, 3 km
RONG PO DISTRIBUTION PUMP STATION	1 LS	1 LS
DISTRIBUTION MAINS (BY PUMPING)	ø600, 4.2 km ø500, 1.8 km	ø500, 4.2 km ø400, 0.8 km

FIGURE 7.3	LONG TERM DEVELOPMENT PLAN
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(3) Replace water meters and indicators for raw water and treated water;

(4) Replace level gauges of the clear water reservoir and the elevated tank;

(5) Provide a chlorine gas container scale;

(6) Replace or thoroughly wash filter media and underdrain of the filter;

(7) Replace obsolete pipelines of the distribution system and lay a distribution main connecting the plant with the distribution network;

(8) Purchase leakage detecting equipment, initiate a leakage control program and immediately replace defective mains if any;

(9) Purchase a filter media washer and undertake regular wash of filter media.

If the works is successfully completed, water demands will be met by the present system up to 1991.

7.4 Stage I Expansion Works

The Stage I Expansion Works provides for projected maximum day water demand of 48,900 cu m/d, serves 59,800 people and the service areas extend to 2,700 ha by the end of the target year 2000.

Features of the proposed works are as follows:

7.4.1 Treatment Plant

It is recommended that the proposed treatment plant be located near the Laem Chabang Receiving Well and raw water be conveyed from the well through 700 mm main of 400 m length to the plant. A flow meter should be installed

on the main for determining the amount of raw water.

The water treatment process will consist of pre-chlorination, chemical coagulation, flocculation, sedimentation, filtration, post-liming and post-chlorination. In addition to the process above, the plant is proposed to have pumps, motors, substations, sludge treatment lagoons, chemical storage, a mechanical maintenance shop, a spare parts warehouse, offices, and housing complex. The layout of the plant is shown on Fig-7.4.

7.4.2 Transmission Mains and Distribution Pump Station

The Stage I Expansion Works will require 11 km transmission main of 500 mm and 600 mm in diameter to convey treated water from the plant by gravity to the proposed distribution reservoir of 5,000 cu m capacity. Treated water will be pumped to the service area from the reservoir.

7.4.3 Distribution Mains

It is envisaged that the distribution system will be divided into two isolated zones: the southern height and the other area. The southern height will be served from the Kao Pattaya Distribution Reservoir with gravity flow, while the other area, most of the service area will be served by the existing Pattaya-Na Klua Treatment Plant with gravity flow and by Rong Po Reservoir/Pumping Station with pumped supply. This arrangement is expected to allow a minimum service pressure of 1.0 kg/sq cm during the peak hour demand through the service area.

The Stage I proposes the installation of 5,150 additional service connections to meet 19,000 incremental served population.

7.5 Stage II Expansion Works

The Stage II Expansion Works will provide additional 12,900 cu m/d production to meet the maximum day water demand of 61,800 cu m/d by 2010.

7.5.1 Treatment Plant

It is proposed that the raw water be conveyed from Laem Chabang Receiving Well through the proposed ϕ600 mm main to the treatment plant where the Stage I facilities be expanded by 12,900 cu m/d such as a mixing well, flocculation basins, sedimentation basins, filters, electrical equipment, sludge lagoon, and chemical feeding equipment.

7.5.2 Transmission Main

The treated water will be conveyed from the above-mentioned treatment plant through the additional ϕ500 and ϕ400 mm diameter pipeline of 8 and 3 km length to the distribution reservoir located at Ban Rong Po. The distribution reservoir and the pumping station will be constructed in the proximity of the Stage I reservoir with the additional capacity of 3,300 cu m which is equivalent to 6 hour of the additional maximum day demand.

7.5.3 Distribution Main

The distribution system was analyzed with a computer model to optimize the system up to the year 2010. As a result, the proposed system of the Stage II includes installation of 32 km mains ranging from 500 mm to 100 mm diameter.

The Stage II Expansion Works proposes the installation of 7,200 additional service connections to serve 27,000 incremental population.

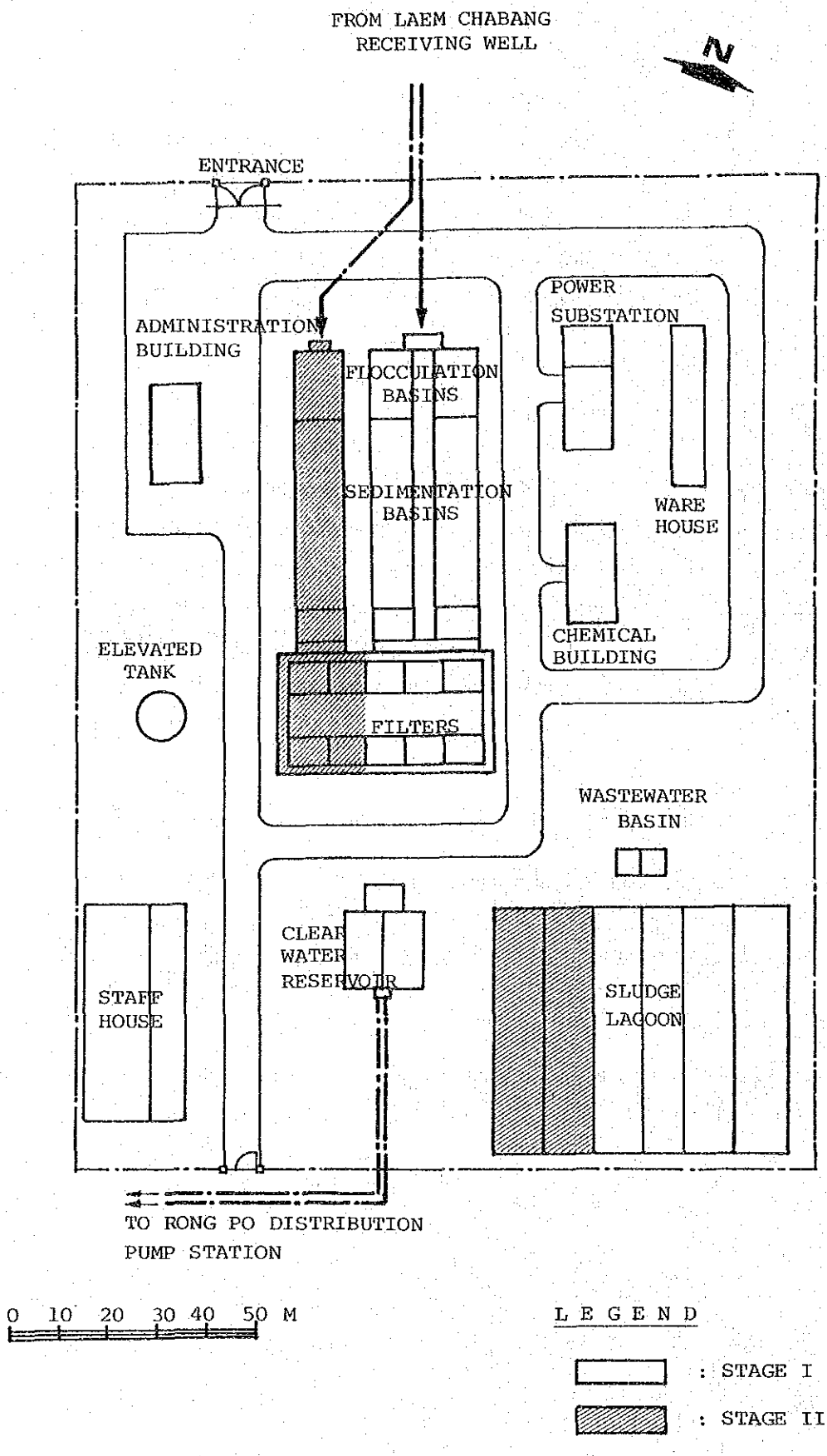

FIGURE 7.4	LAYOUT OF PROPOSED TREATMENT PLANT

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CHAPTER 8 PROJECT COST AND IMPLEMENTATION SCHEDULE

CHAPTER 8 PROJECT COST AND IMPLEMENTATION SCHEDULE

In this chapter, principal matters concerning the project cost and implementation schedule related to the water supply system, as proposed in Chapter 7, are described.

8.1 Price Level and References

Price level: Costs are valued at 1986 prices.

Unit cost : Those Unit costs in the PWA price lists are generally employed and where such price lists are not available, the prevailing market prices are referred to.

8.2 Division of Project Cost

The project cost is divided into two parts, as follows, to be estimated separately.

1) Construction costs; and

2) Other associated costs such as engineering and administrative costs, inclusive of physical and price contingencies.

8.3 Method of Estimation

The above mentioned costs are estimated in the following manner.

8.3.1 Construction Costs

The costs are estimates for each of the following three:

1) Stage I Rehabilitation and Modification Works
2) Stage I Expansion Works
3) Stage II Expansion Works

Construction costs shall include the cost of acquiring land necessary for the planned facilities. The land acquisition cost was estimated separately from the direct construction cost.

Summary of cost estimation is shown in Table-8.1.

8.3.2 Associated Costs

The costs of engineering services, inclusive of detailed design, soil investigation and field survey, and supervision are estimated together with administrative cost, physical and price contingencies, as shown below. The coefficient used in the calculation is taken after the cased of on-going projects or the figures widely accepted in Thailand.

Where (A): Construction Cost, and

(B): Engineering Services Cost,

Detail Design (D/D)	= (A) x 5.2 %
Soil Investigation and Field Survey	= (D/D) x 11 %
Supervision	= (A) x 5.3 %

Administrative Cost (C) = (A + B) x 1 %

Physical Contingencies (D) = (A + B + C) x 7 %

Price Contingencies (E) = (A + B + C + D) x 3.3 % price escalation per annum for the construction period

Table-8.1 SUMMARY OF COST ESTIMATES

Unit : x 1,000 Baht

Description	Stage I		Stage II
	Rehabilitation and Modification	Expansion	Expansion
1) Land Acquisition	-	2,100	200
2) Construction of New Water Supply System	25,700	248,600	117,300
3) Engineering Services	2,800	27,600	13,600
Sub total (A)= 1)+ 2)+ 3)	28,500	278,300	131,100
4) Administration Cost (1% of Sub total (A))	300	2,800	1,300
Sub total (B) = (A)+ 4)	28,800	281,100	132,400
5) Physical Contingency (7% of Sub total (B))	2,000	19,700	9,300
Sub total (C) = (B)+ 5)	30,800	300,800	141,700
6) Price Contingency (3.3% per annum of total yearly disbursments)	3,600	45,600	74,400
Grand Total {(C) + 6)}	34,400	346,400	216,100

8.4 Implementation Schedule

8.4.1 Target Year

The development plan is phased into two stages, Stage I and II targeting 2000 and 2010 respectively, because of the following considerations:

- As many other cities waterworks under PWA management need similar development program also, dividing the period into more stages will be less appropriate administratively.

- Two stages' implementation will be appropriate from the viewpoint of size of investment.

- As other municipal plans for future set the target around 2000, the Stage I will be coordinated with them.

The Stage I is further phased into rehabilitation/modification of the existing system and expansion involving new construction works.

8.4.2 Implementation Schedule of Stage I

In the Stage I, rehabilitation and modification works is executed in advance of expansion works.

The rehabilitation and modification works are intended for improving and updating the existing facilities at the earliest timing, laying a groundwork on which the following expansion works are to be constructed.

The rehabilitation and modification works are planned for completion in the middle of 1989.

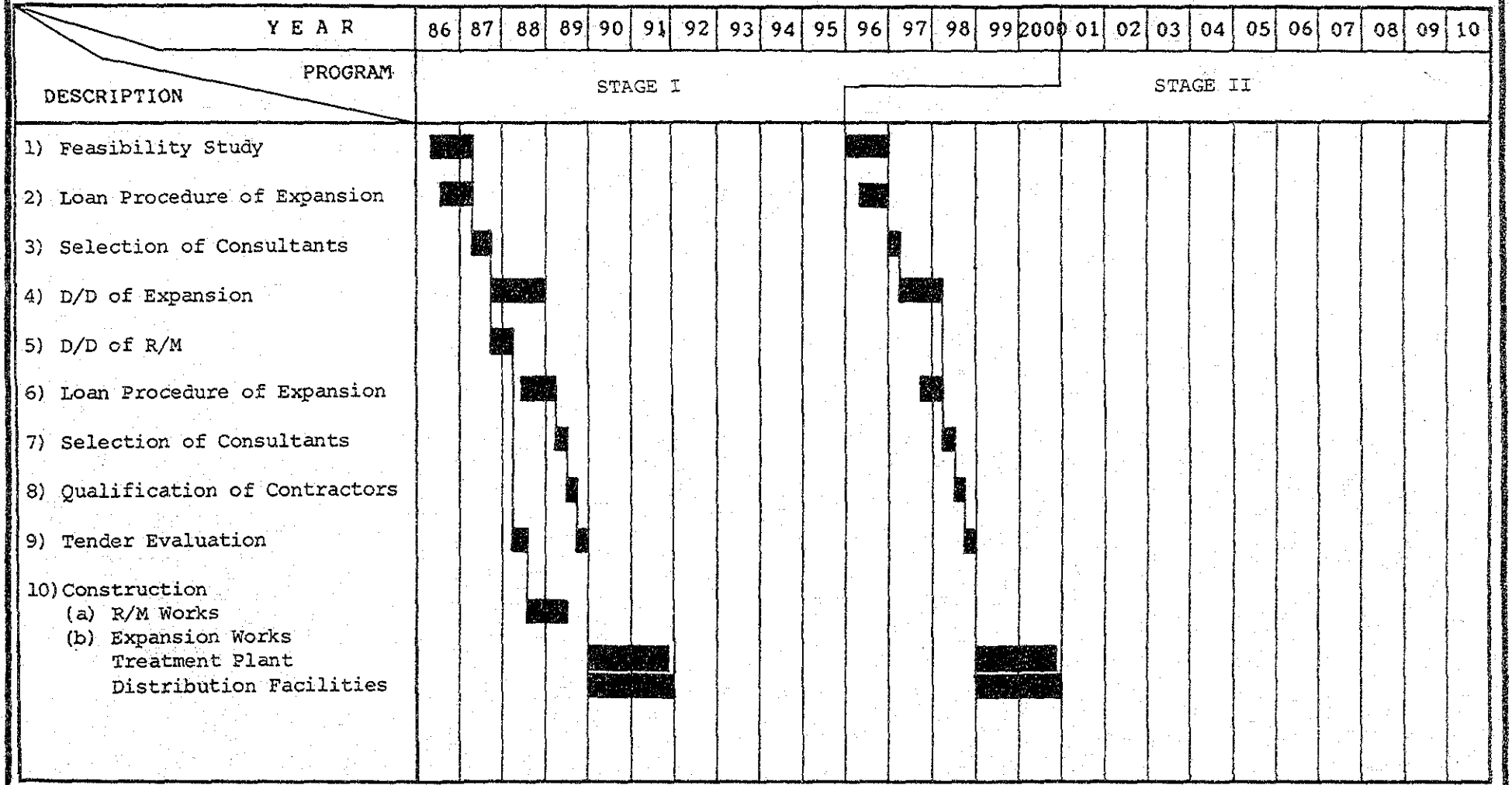
The expansion works and the rehabilitation and modification works shall be detail-designed coincidentally, as immediately after the completion of the rehabilitation and modification works the expansion works is to be commenced.

Two years' period is planned for the expansion works which involve a treat-

ment plant, distribution pump and reservoir station and a sizable length of pipeline. The whole works will have to be divided into a number of lots so that they can be progressed in parallel.

8.4.3 Implementation Schedule of Stage II

It is deemed necessary to complete the Stage II Project around the end of 2000, considering the water demand increase. Taking two years' period for the construction work as in the case of the Stage I Project, it will be required to commence the construction work at the beginning of 1999. Counting back from this time and allowing for a time period similar to the case of Stage I for feasibility study, loan procedure, etc., the commencement of feasibility study of Stage II is planned at the beginning of 1996, as detailed in Fig-8.1.



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

FIGURE 8.1 IMPLEMENTATION SCHEDULE

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