BASIC DESIGN STUDY
FOR
THE CONSTRUCTION
OF
THE NATIONAL WATERWORKS TECHNOLOGY TRAINING INSTITUTE
IN THE KINGDOM OF THAILAND

MAY 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

BASIC DESIGN STUDY

FOR

THE CONSTRUCTION

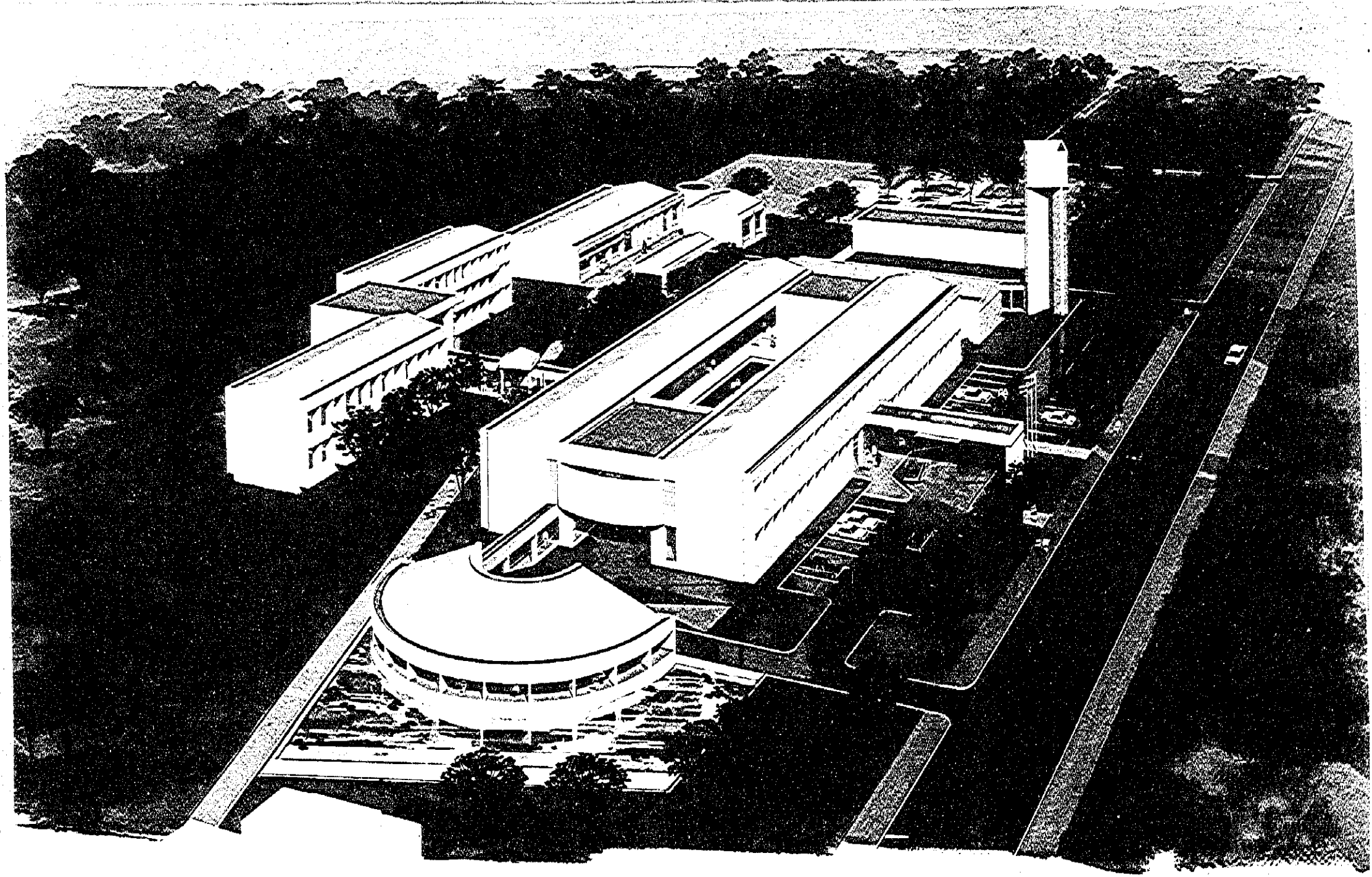
OF

THE NATIONAL WATERWORKS TECHNOLOGY TRAINING INSTITUTE

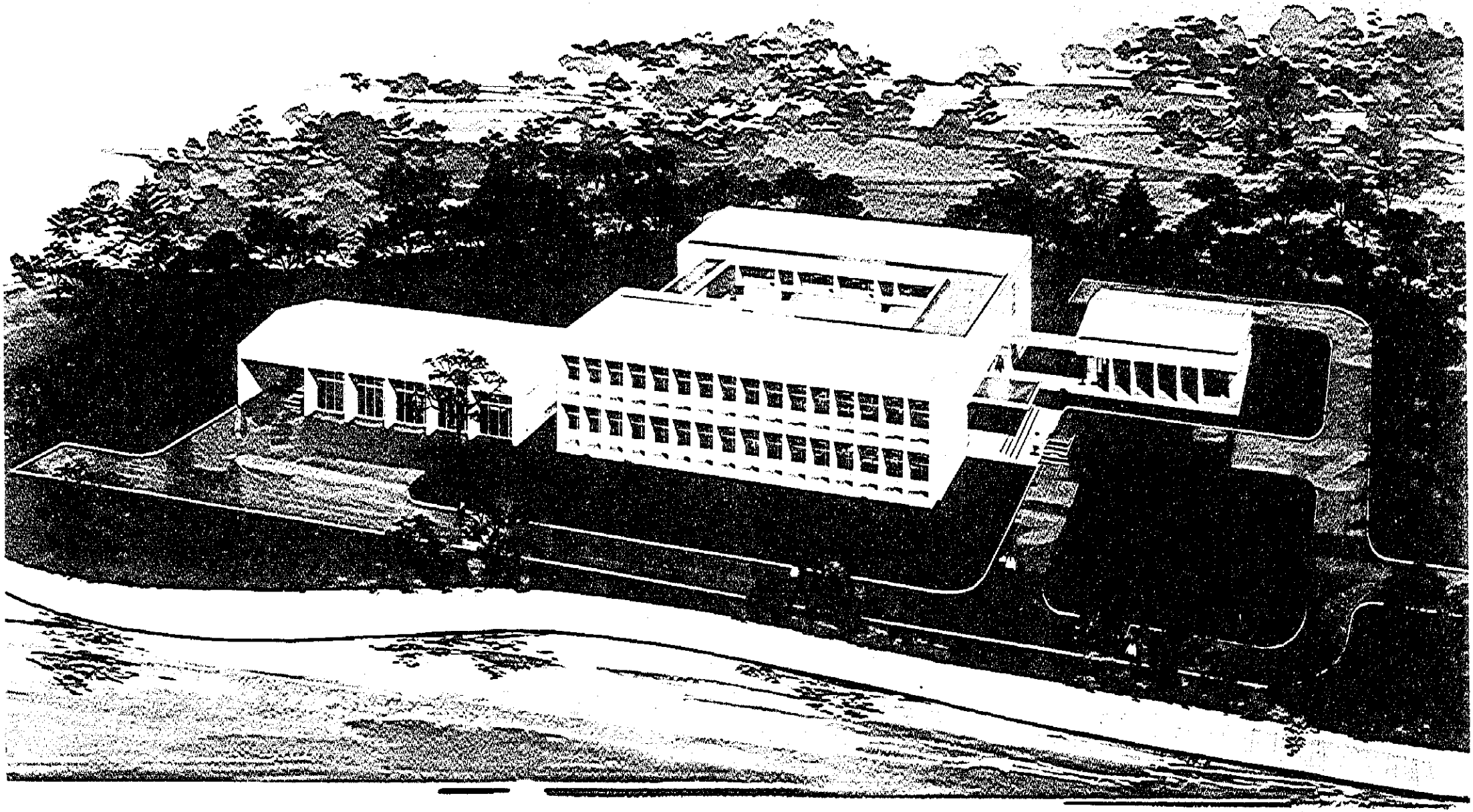
IN THE KINGDOM OF THAILAND

MAY, 1985

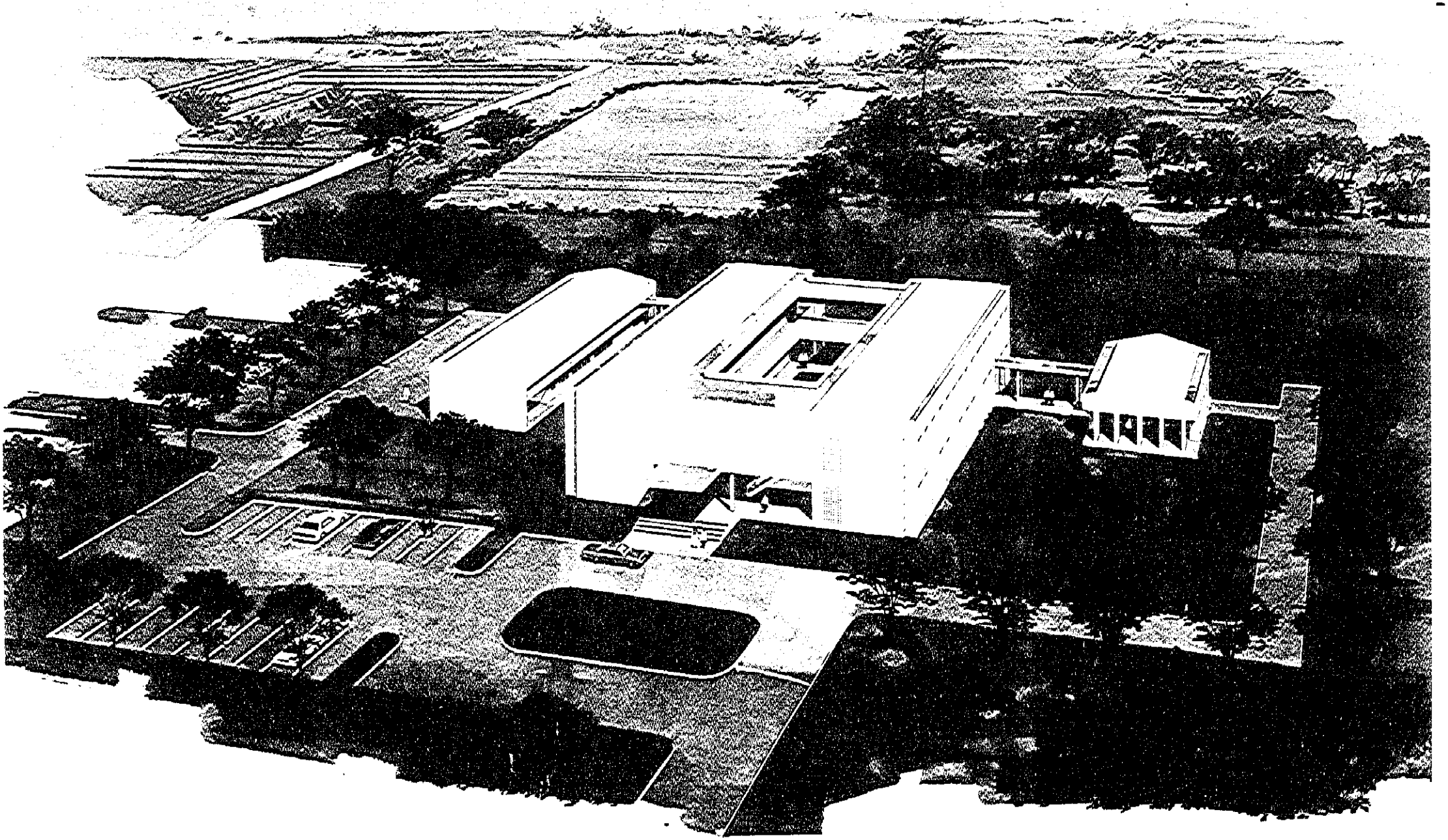
JAPAN INTERNATIONAL COOPERATION AGENCY



CENTRAL TRAINING CENTER

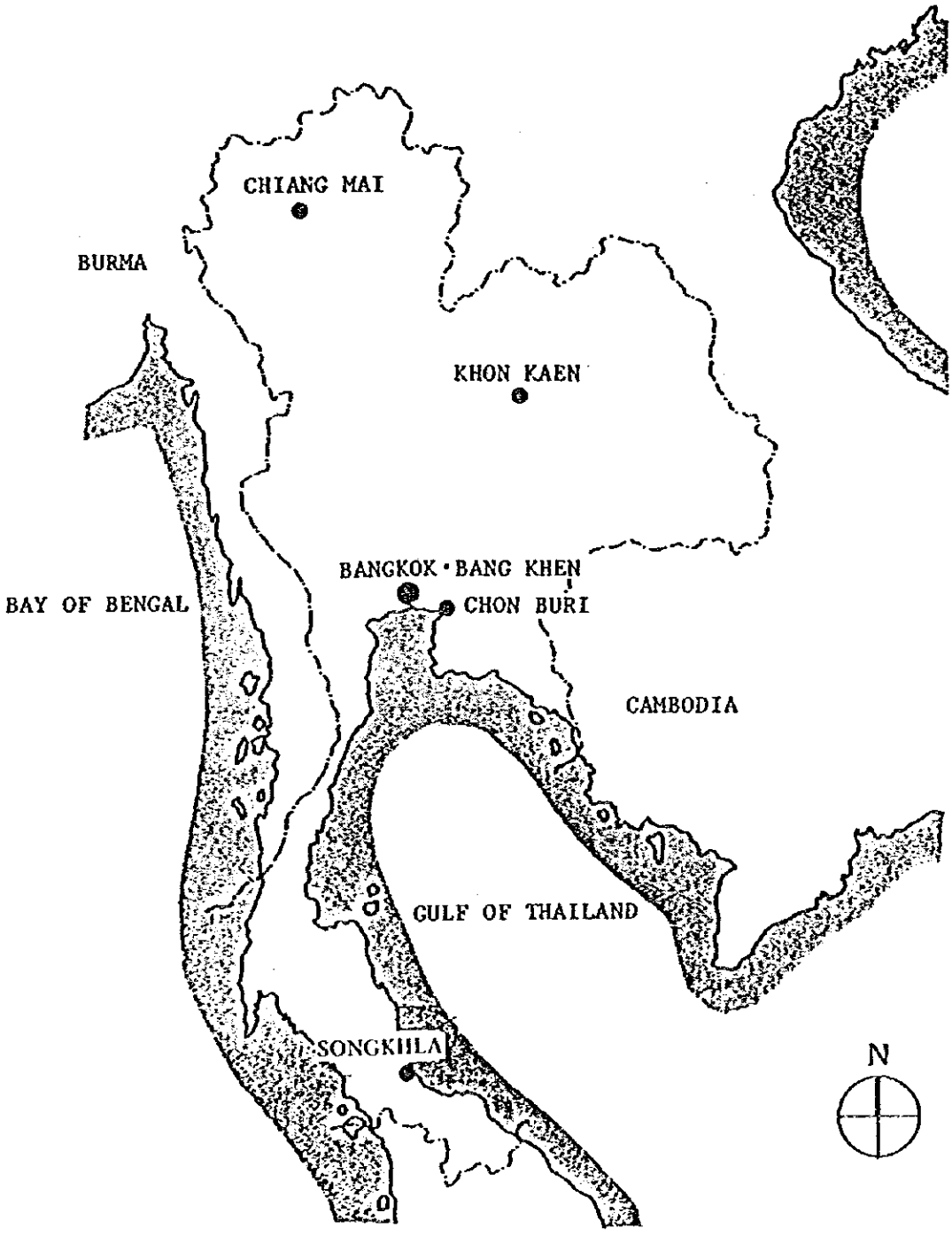


REGIONAL TRAINING CENTER (CHIANG MAI)



REGIONAL TRAINING CENTER (KHON KAEN)

MAP OF THAILAND



PREFACE

In response to the request of the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a basic design study on the Project for the Construction of the National Waterworks Technology Training Institute and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Thailand a study team headed by Mr. Kazuyoshi OKAZAWA, Deputy Director of Water Supply Division, Environmental Health Bureau, Ministry of Health and Welfare from January 8 to 28, 1985.

The team had discussions on the Project with the officials concerned of the Government of Thailand and conducted field surveys in Bang Khen, Chiang Mai, Khon Kaen and Songkhla areas.

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 Kingdom of Thailand for their close cooperation extended to the team.

May, 1985

Keisuke Arita

President

Japan International Cooperation Agency

SUMMARY

In Thailand, about 65% of the population in the Bangkok metropolitan area and 10% of the rural population are served by public waterworks. These waterworks are mostly managed by the Metropolitan Waterworks Authority (MWA) for the Bangkok metropolitan area and by the Provincial Waterworks Authority (PWA) for other regions. MWA is being urged to expand and upgrade its water supply capacity. The demand is due to the increasing density of population in the metropolitan area. MWA is currently implementing an expansion plan for water supply facilities, targeted for the year 2000. PWA is also expanding its water supply facilities under its own ten-year plan (1981-1990), which plan aimed at water supply to unserved areas. These undertakings are in accordance with the national policy for equal provision of public services.

To expand water supply facilities sufficiently and to maintain and operate existing facilities, properly competent engineers and technicians and adequate financial backing are essential. MWA and PWA have been carrying out their own manpower training programs, but they have not produced satisfactory results, due to shortages in training facilities, equipment, staff (instructors) and budget allocation. In an attempt to train the needed engineers and technicians in a more effective and integrated manner, MWA and PWA planned to establish the nationwide waterworks technology training center as their joint project. The Government of Thailand requested grant aid assistance from the Government of Japan for the construction of facilities and the supplying of training equipment.

Having received this request, the Government of Japan sent a basic design study team to Thailand from January 8 to 28 in 1985 through Japan International Cooperation Agency. The purpose of the study is to review the content of the request from the Government of Thailand, MWA, and PWA; to study the project's eligibility for grant aid assistance; to carry out field reconnaissance at sites proposed; to examine the supporting infrastructures required for the facilities; to plan the scale and layout of facilities in coordination with their designed functions; and to select the appropriate equipment and materials.

In this project, MWA and PWA will work together to establish the National Waterworks Technology Training Institute for training engineers and technicians in an effective and unified manner. Their objectives are to upgrade their technical knowledge and skills, and to develop the manpower necessary for providing better water supply services throughout the country.

The Institute consists of a central training center and two regional training centers (Chiang Mai and Khon Kaen). The proposed site for the Central Training Center (CTC) is located within the MWA Bang Khen Purification Plant, located about 15 km north of Bangkok. The proposed site covers approximately 15,500 m^2 of generally flat land that requires filling and leveling work to prevent flooding. The proposed site for The Chiang Mai Regional Training Center is located within the PWA Umong Purification Plant, located at the east end of Chiang Mai. The city now serves as a center of the northern region. The project site covers approximately 7,000 m^2 of generally flat land that requires filling and leveling work for flood control, especially in its low parts. The proposed site for The Khon Kaen Regional Training Center is located within the Nong Waeng Purification Plant, located at the west end of Khon Kaen, about 450 km northeast of Bangkok. This city is a center of the northeastern region. The proposed site covers approximately 7,000 m^2 of generally flat land. It, too requires filling and leveling work for flood control. These sites have ready access to both electricity and water.

The central training center consists of a training building, a dormitory, a workshop, a pump operation training building, a mini purification plant, a leakage survey training yard and others. The reginal training centers each consist of a training building, a dormitory, a workshop and others.

Details of each facility are listed below.

Central Training Center

Training Building	: Secretary General's Room, Deputy Secretary General Room, Director's Office, Administration Office, Instructors' Office, Experts' Office, Meeting Room, Library, Lecture Rooms (General Lecture Rooms, Audio/Visual Room, Seminar Room), Training Rooms (Drafting, Computer Training, Instrumentation), Water Quality Examination Room, etc.	: 2,335 m^2
Dormitory	: Bed Rooms for 60 Persons, Laundry Room, Shower Room, etc.	: 1,044 m^2
Workshop	: Electrical Workshop, Mechanical Workshop, Lecture Room, Instructors' Room, etc.	: 412 m^2
Pump Operation Training Building	: Pump Operation Room, Piping Room, etc.	: 272 m^2
Garage and Storage	: Garage, Storage	: 150 m^2
Cafeteria	: Dining, Kitchen	: 230 m^2
Covered way	: Covered way	: 100 m^2
		Total: 4,543 m^2
Training Plant	: Mini Purification Plant, Pump Operation Training Plant, Leakage Survey Training Yard, Piping Training Yard (work to be done Thai side)	
Training Equipment	: Electrical, Mechanical, Instrumentation, Leakage Survey, Water Quality Examination, Audio/Visual, Printing, etc.	

Regional Training Centers (Chiang Mai and Khon Kaen)

Training Building	: Director's Office, Administration Office, Instructors' Room, Meeting Room, Lecture Rooms (General Lecture Rooms, Audio/Visual Room), Water Quality Examination Room, etc.	: 650 m^2
Dormitory	: Bed Rooms for 32 Persons, Laundry Room, Shower Room, etc.	: 616 m^2
Workshop	: Electrical Workshop, Mechanical Workshop, Instructors' Room, etc.	: 160 m^2
Garage	: Garage	: 48 m^2
Cafeteria	: Dining, Pantry	: 96 m^2
Covered way	:	(Chiang Mai): 24 m^2
		(Khon Kaen) : 66 m^2
	Total	:
		(Chiang Mai): 1,594 m^2
		(Khon Kaen) : 1,636 m^2
Training Equipment	: Electrical, Mechanical, Testing, Leakage Survey, Water Quality Examination, Audio/Visual, Printing, etc.	

The Government of Japan will be responsible for construction of the facility and supply of equipment and material. On the other hand, the Government of Thailand will be responsible for the cost of the site filling work, provision of supporting infrastructures and provision of furniture etc. estimated at approximately Japanese Yen 148 million.

The estimated project period is 26 months; 4 months for detail design, 2 months for tender and contract, and 20 months for construction.

The execution agency for the Government of Thailand is planned to be the joint executive committee organized by MWA and PWA. Meanwhile, the working group organized by MWA and PWA had discussion with the study team. The working group will be reorganized to the joint executive committee in charge of planning and implementation of the project. Personnels of MWA and PWA appointed by Governors of MWA and PWA will be co-signatory for the detail design and supervisory service contract and the construction contract of the project.

This project is one of the most urgent ones, because an adequate supply of waterworks engineers and technicians with sufficient knowledge and skill is needed to expand and upgrade the waterworks, and thereby ensure better water supply to a wide range of population. For this reason, the project is considered to be highly eligible for grant aid assistance allocated by the Government of Japan to meet the country's needs.

CONTENTS

ABBREVIATIONS

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ASTM	Americal Society for Testing and Materials
BOD	Biochemical Oxygen Demand
CTC	Central Training Center
DTEC	Department of Technical and Economic Cooperation
E/N	Exchange of Notes
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
MOI	Ministry of the Interior
MWA	Metropolican Waterworks Authority
PWA	Provincial Waterworks Authority
PWD	Public Works Department, Ministry of the Interior
R/D	Record of Discussions
RTC	Regional Training Center

CHAPTER 1. INTRODUCTION

The Government of Thailand is making efforts to shift from an agricultural economy to a semi-industrial economy by utilizing natural gas and other domestic resources under the 5th National Social/Economic Development Five-Year Plan (1981-1986). It plans to become an industrial country under the 6th Plan (1986-1990), while maintaining balanced economic growth and structure.

With rapid industrialization and the accompanying concentration of population in Bangkok and the regional cities, the present water supply cannot meet the increasing demand for domestic and industrial water in terms of quantity and quality. As a result, the development of waterworks is becoming an essential factor to promote the economic development meet this need, MWA and PWA, as the principal water supply agencies, established facilities expansion plans and are making efforts to expand and upgrade the water supply capacity.

To implement the facilities expansion plans, and to operate and maintain new and existing water supply facilities, appropriate technology and manpower are essential (in addition to financial backing). Nevertheless, both MWA and PWA face an extreme shortage of manpower required for management, operation, and maintenance of their facilities. To provide the urgently needed manpower, MWA and PWA have recently started training programs for their own personnels. Nevertheless, these programs are neither well developed nor sufficient in terms of duration and scope, due to shortages in training staff, equipment, facilities, and budget.

To overcome this difficult situation and to improve waterworks engineering in effective ways, MWA and PWA planned the National Waterworks Technology Training Institute as their joint project, and made a request for grant aid assistance to the Government of Japan.

ABBREVIATIONS

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ASTM	Americal Society for Testing and Materials
BOD	Biochemical Oxygen Demand
CTC	Central Training Center
DTEC	Department of Technical and Economic Cooperation
E/N	Exchange of Notes
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
MOI	Ministry of the Interior
MWA	Metropolican Waterworks Authority
PWA	Provincial Waterworks Authority
PWD	Public Works Department, Ministry of the Interior
R/D	Record of Discussions
RTC	Regional Training Center

CHAPTER 1. INTRODUCTION

The Government of Thailand is making efforts to shift from an agricultural economy to a semi-industrial economy by utilizing natural gas and other domestic resources under the 5th National Social/Economic Development Five-Year Plan (1981-1986). It plans to become an industrial country under the 6th Plan (1986-1990), while maintaining balanced economic growth and structure.

With rapid industrialization and the accompanying concentration of population in Bangkok and the regional cities, the present water supply cannot meet the increasing demand for domestic and industrial water in terms of quantity and quality. As a result, the development of waterworks is becoming an essential factor to promote the economic development meet this need, MWA and PWA, as the principal water supply agencies, established facilities expansion plans and are making efforts to expand and upgrade the water supply capacity.

To implement the facilities expansion plans, and to operate and maintain new and existing water supply facilities, appropriate technology and manpower are essential (in addition to financial backing). Nevertheless, both MWA and PWA face an extreme shortage of manpower required for management, operation, and maintenance of their facilities. To provide the urgently needed manpower, MWA and PWA have recently started training programs for their own personnels. Nevertheless, these programs are neither well developed nor sufficient in terms of duration and scope, due to shortages in training staff, equipment, facilities, and budget.

To overcome this difficult situation and to improve waterworks engineering in effective ways, MWA and PWA planned the National Waterworks Technology Training Institute as their joint project, and made a request for grant aid assistance to the Government of Japan.

In response to the request, the Government of Japan sent a basic design study team headed by Mr. Kazuyoshi Okazawa, Deputy Director of Water Supply Division, Environmental Health Bureau, Ministry of Health and Welfare through Japan International Cooperation Agency (JICA), to Thailand in January 1985.

The basic design study was carried out in Thailand during January 8-28, 1985, to investigate, and discuss with the responsible personnels of the Government of Thailand, MWA and PWA, the various conditions for project formulation. Actual works included confirmation of the request made by the Government of Thailand, identification of needs for training waterworks engineers and technicians (along with the present state of training), identification of project execution body, and field reconnaissance of proposed sites and related facilities.

All matters agreed to by both governments were confirmed in the minutes, which were signed by Mr. Suvich Futrakul, Deputy governor of MWA for the Governor of MWA, Mr. Anant Tantidhamma, Deputy Governor of PWA for the Governor of PWA, and Mr. Kazuyoshi Okazawa, head of Basic Design Team. (See Appendix I, attached)

This report is a compilation of the results of the basic design study for "The Construction of the National Waterworks Technology Training Institute".

CHAPTER 2. BACKGROUND OF THE PROJECT

2-1 General Condition of Waterworks in Thailand

In Thailand, the development of the economy and the regions is closely related to domestic and industrial water. In the past, the government promoted industrial development with less concern for infrastructure. As a result, deficiencies in domestic water supply occur in Bangkok and in regional cities, due to rapid increases in population. Uncoordinated water supply systems have been developed for industrial uses, due to the rapid advance in industrialization.

Waterworks in Thailand were first installed in selected areas of Bangkok, when the Fifth King of the Mahachakri Dynasty ordered the construction of "The Siam Waterworks" in 1897.

Since then, the Public Works Department of the Ministry of Interior has been expanding waterworks throughout the country. In 1967, MWA was established to manage the waterworks in Bangkok, Thonburi, Nonthaburi, and Samut Prakan in an integrated manner. In 1979, PWA was established to manage the waterworks in the rest of country.

Water supply agencies in Thailand can be divided into three types shown in Table 1; MWA is responsible for urban type water supply to the Bangkok Metropolitan Area, while PWA supplies water to municipalities of more than 5,000 population other than the Bangkok Metropolitan Area. Local authorities are responsible for water supply to rural type municipalities of 1,500 - 5,000 population, 15 other agencies for villages of less than 1,500 population.

The 5th National Social/Economic Development 5-year Plan

■ PROJECTS IN SPECIFIC AREAS

(Figure shows loan amount
Unit: Million Yen (Million Baht))

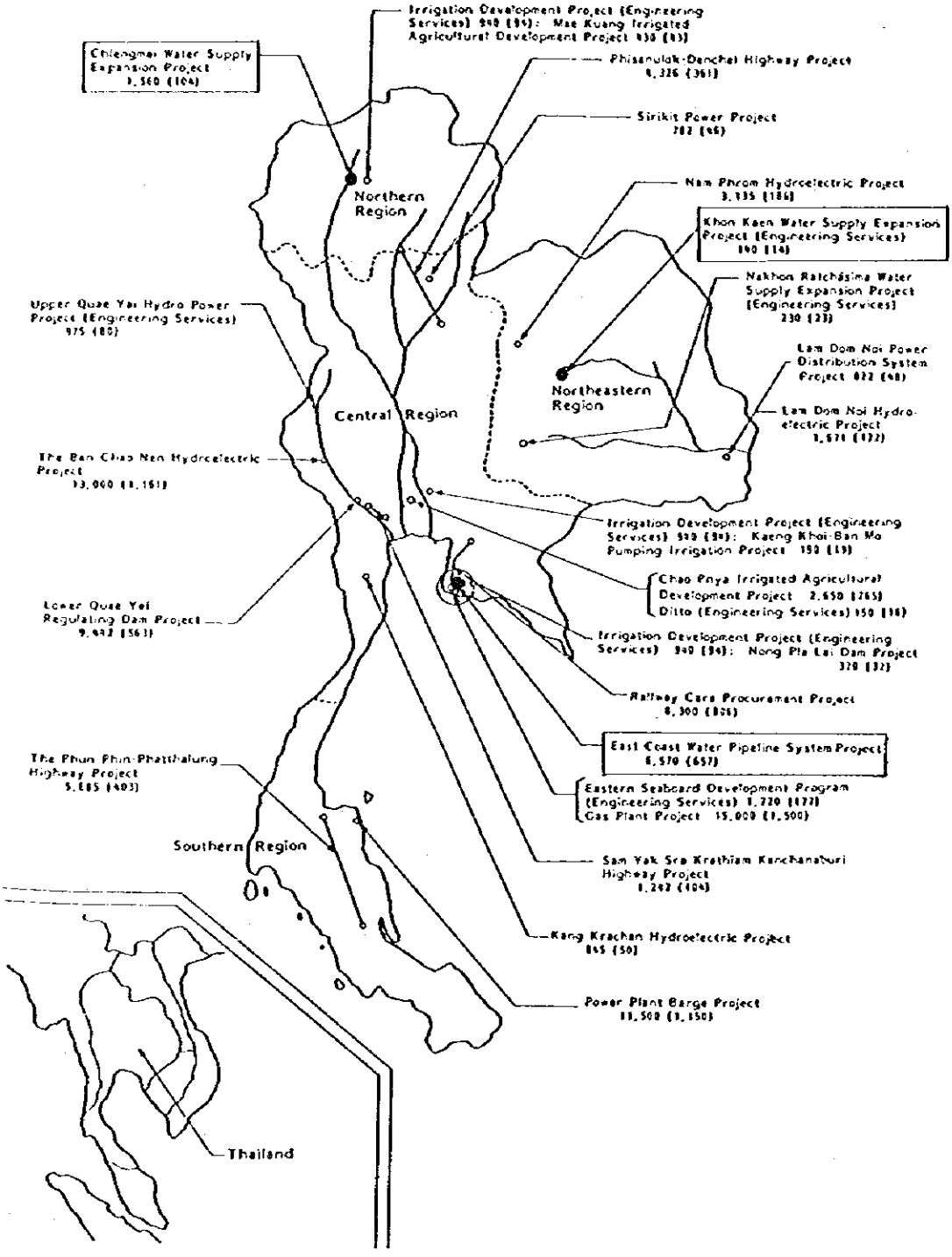


Table 1 Responsible Water Supply Agencies in Thailand

Type & Size of Community	Responsible Agenty	Type of Supply	Number	Served Total Population
Urban (Population 5,000 and above):				
Bangkok Metropolitan	MWA	piped supply	1	4,000,000
Provincial	PWA	piped supply	178	3,850,000
Rural (Population 1,500-5,000)	*PWA + local authorities	piped supply	663	2,130,000
Village (Population under 1,500)	15 other agencies	point source (deep well, surface pond, etc.)	20,000	

* Local authorities are responsible for operation and management; PWA provides technical services.

In June 1984, Thailand had a population of 50 million, of which 6.2 million were living in the Bangkok metropolitan area, and the remaining 43.8 million in other regions. About 65% of the population in the Bangkok metropolitan area and 10% of the population in other regions are served by waterworks. The low service ratio in regions other than Bangkok is attributable not only to deficiencies in water supply facilities (owing to insufficient financial resources), but also to people's habits. Thai people obtain their drinking water from a variety of sources, including commercially-sold drinking water, municipal water services, rain, rivers, and small wells. This is partly because people do not have much confidence in running water (maintaining the habit of boiling the water before drinking), and partly because water rates are relatively high. (3-5% of the average income).

Services Provided by MWA and PWA

MWA (Metropolitan Waterworks Authority)

MWA supplies water to the Bangkok metropolitan area, Nonthaburi Changwat, and Samut Prakhan Changwat. The water supply system can be roughly divided into two segments: a central system in, which raw water is collected from Chao Phraya River and then treated in purification plants at Bang Khen, Sam Sen, and Thonbori before being supplied to the central part of the metropolis; and various small waterworks, which supply water from deep wells to the suburbs on a district basis.

In 1985, MWA had a supply capacity of 2,118,000 m^3/day, serving 85.3% of population within its service areas and about 65% of the total population in the metropolis. However, the actual amount of water supply is estimated at half of the capacity, due to a considerable amount of leakage caused by deterioration of the Sam Sen Purification Plant and distribution pipelines, as well as pipes damaged by land settling in the Bangkok area.

Table 2 Water Supply by MWA

Year	Supplied Area (km^2)	Total Population in Service Area	Capacity of Facilities (m^3/day)	Ratio of Service Pervasion (%)
1976	242	2,469,000	1,300,000	
1982	280	3,200,000	1,967,000	
1985	485	5,132,000	2,118,000	85.3

PWA (Provincial Waterworks Authority)

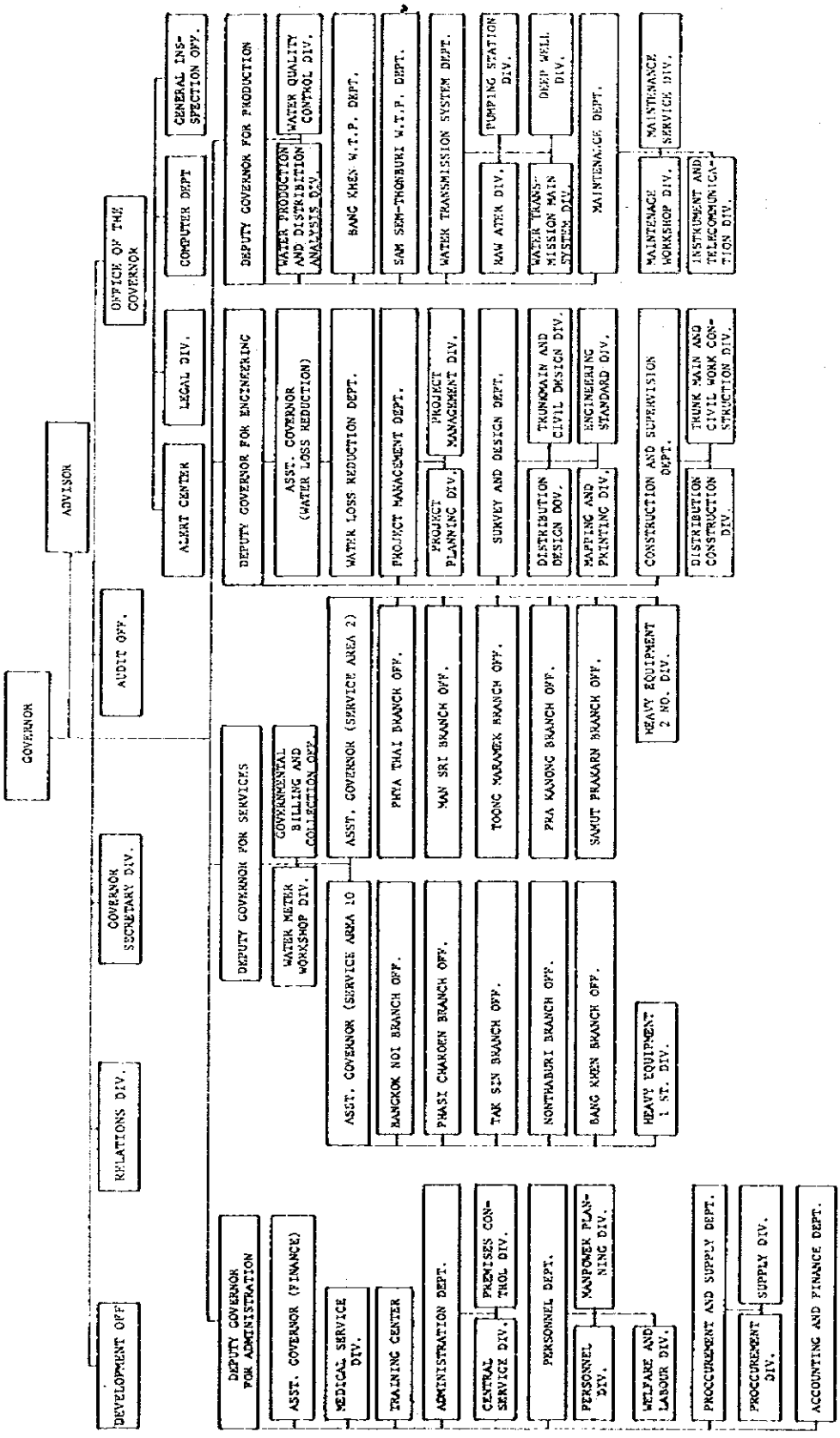
PWA's water supply activities consist of the Urban Water Supply Program and the Rural Water Supply Program.

The Urban Water Supply Program is to supply water for municipalities of more than 5,000 population (other than Bangkok). One the other hand, the Rual Water Supply Program is to provide technical services (land survey, design, cost estimation, construction management, and manpower training) for local authorities that are responsible for water supply in municipalities of 1,500 - 5,000 population. In 1985, PWA operates 176 purification plants throughout the country, serving some 4,370,000 population, and provides technical services for the other 663 local authorities. Both services were provided through 15 regional offices (reorganized into 10 offices in mid-January 1985). As of 1985, the Urban Water Supply Program operated by PWA itself has a capacity of 891,800 m^3/day, serving 59.5% of population in its services area (about 10% of the total population) in 1985.

Table 3 Water Supply by PWA (Urban Water Supply)

Year	Supplied Area (km^2)	Total Population in Service Area	Capacity of Facilities (m^3/day)	Ratio of Service pervasion (%)	Number of Waterworks
1979	-	3,367,051	646,320	48.29	182
1983	1,955	4,280,320	878,640	50.43	175
1985	1,960	4,370,000	891,800	59.50	176

Figure 1 Organization of MWA



2-2 Organization of Water Supply Agencies

MWA

In 1985, MWA was reorganized to the organization shown in Fig. 1; the agency is headed by a governor, with four deputy governors who are responsible for administration, customer services, engineering and operation. The existing MWA training center is under the responsibility of the deputy governor in charge of general administration, and the purification facilities are under the responsibility of the deputy governor in charge of operation.

As of 1984, MWA employed 5,952 persons and increased by 140 persons over 1979, since the agency was instructed to reduce the employment by the government due to financial difficulties.

According to MWA project, 7,240 personnels will be necessary in 1990 and 14,094 persons in 2000 while expanding its water supply services and facilities.

Table 4 MWA Personnels

Category of Personnel	1979	1984	1990	2000
Top Management	13	42	42	57
Senior Staff	47	75	75	120
Supervisor	141	329	329	539
Engineers	231	196	238	217
Scientists/Lab. Technicians	15	18	22	35
Waterworks Managers	-*2	-*2	-*2	-*2
Neter Readers	155	320	468	748
Bill Collectors	437	403	468	748
Electricians/Mechanics	-*3	-*3	-*3	-*3
Other Technicians	139	144	175	341
Ledgers	54	64	78	152
Operator/Service Inspector	168	185	225	438
Secretary	-*4	-*4	-*4	-*4
Management Inspector/Auditor	21	26	32	62
Administration	565	473	574	1117
Finance/Accounting	30	34	29	56
Others	3795	3644	4485	9464
Total	5812	5952	7240	14094

*1

*1 Demand Projection

*2 Waterworks Management including with top management

*3 E/M including with Engineers

*4 Secretary including with other Technicians

o Approximately 10% of the engineers and technicians are female.

PWA

Local water supply services are operated by 15 regional offices which cover the entire country other than the Bangkok. (Regional offices were reorganized to 10 in mid-January 1985).

PWA is headed by a governor, with three deputy governors who are responsible for engineering department (engineering, construction, project and water quality control) and two blocks of regional office. PWA training center within the staff training department is under the responsibility of the Office of the Governor.

As of 1984, PWA employed 5,131 persons. Like MWA, the agency was instructed by the government to reduce the personnels. Thus, PWA projects its manpower requirements relatively low; 5,457 persons in 1990 (6% increase) and 6,082 persons in 2000 (18.5% increase) to deal with expanding water supply services and facilities.

Figure 2 Organization of PWA

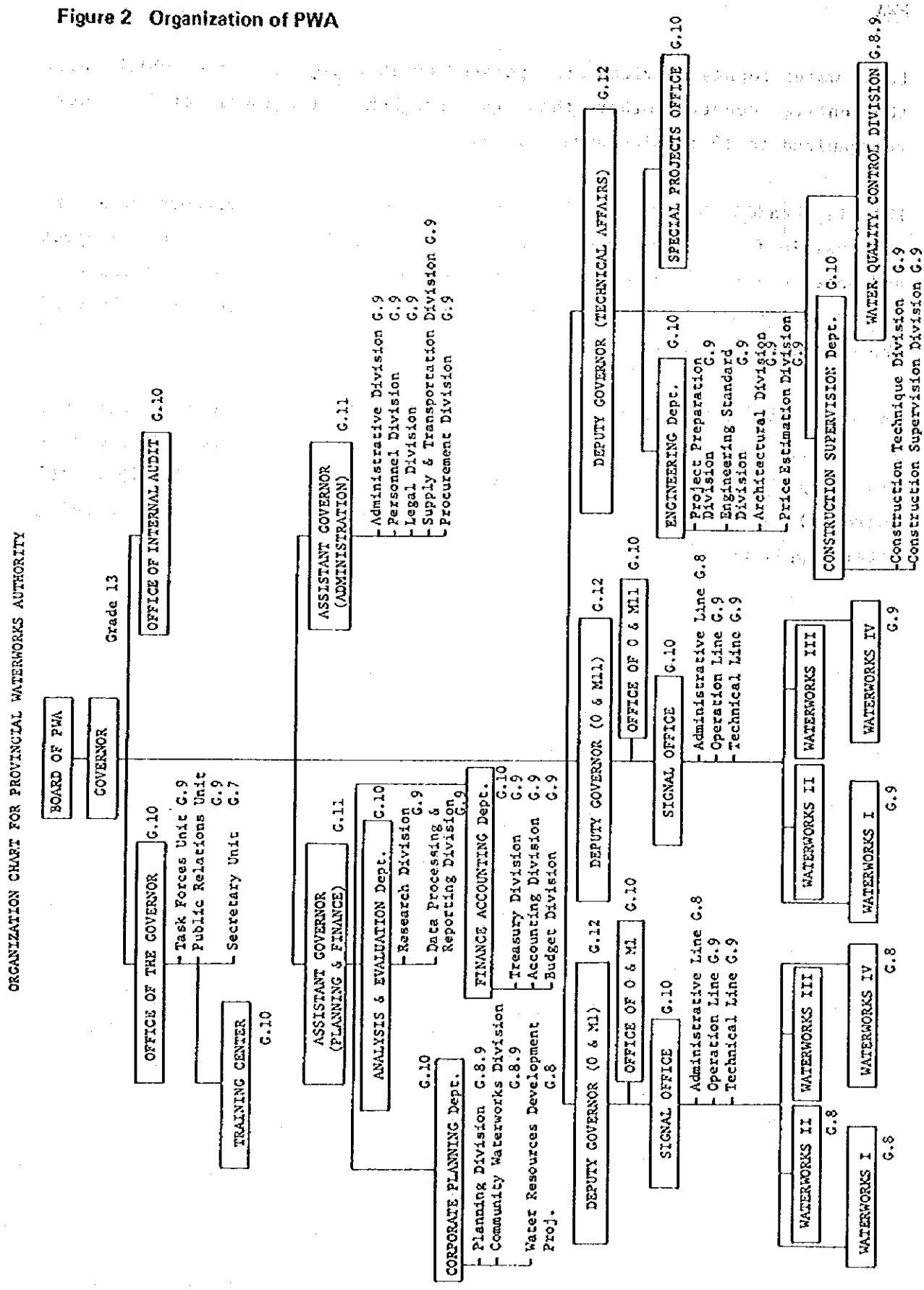


Table 5 PWA Personnels

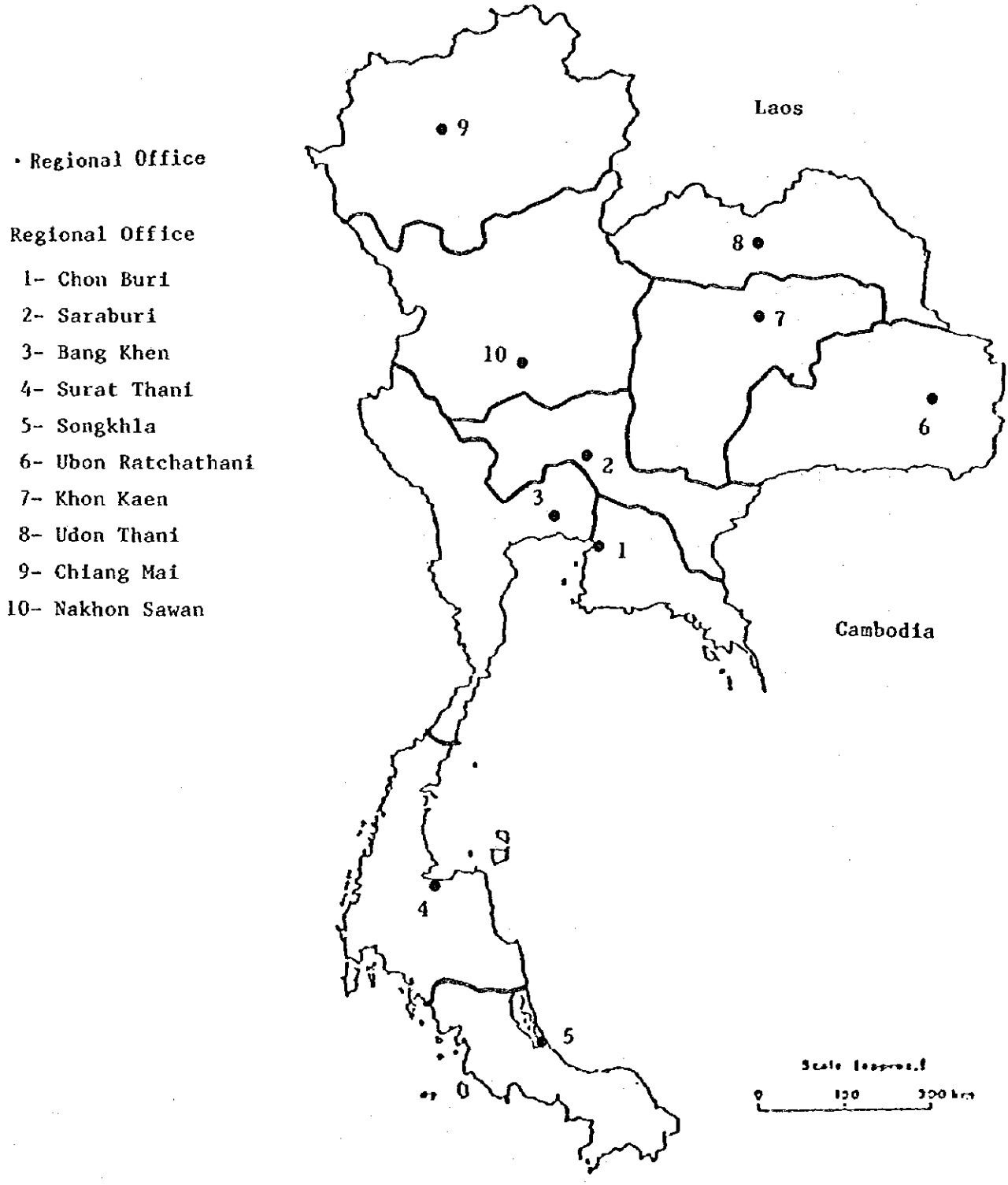
Category of Personnel	1984	1990	2000
Top Management	24	30	30
Senior Staff	52	57	62
Supervisors	602	620	638
Engineers	35	91	104
Scientists/Lab.Technicians	22	50	55
Waterworks Managers	171	200	226
Meter Readers	216	281	365
Bill Collectors	210	-	-
Electricians/Mechanics	171	231	311
Other Technicians	214	238	264
Ledgers	264	175	175
Secretary	1	1	1
Auditor	29	33	36
Administration			
- General Administration	16	17	18
- Clerial Wokers	256	281	309
Finance/Accounting	198	237	252
Others	2650	2915	3106
Total	5131	5457	6082

*1

*1 Demand Projection

o Approximately 10% of the engineers and technicians are female.

Figure 3 Location of PWA Regional Office



2-3 Development Program for Waterworks

MWA (Metropolitan Waterworks Authority)

In recent years, a large population has concentrated in the Bangkok metropolitan area, accompanied by considerable expansion of urban areas. As a result, there are urgent needs for increasing the water supply to serve all the population. The situation is aggravated by water leakage, due to deterioration of existing purification facilities and distribution pipelines damaged by land settling in the Bangkok area. This causes low water pressure and deteriorates water quality.

Likewise, water supply from deep wells is decreasing in both amount and quality, due to the lowered water table. Particularly, rust water caused by saline contamination and deterioration of distribution pipelines has become a serious problem, making good and abundant water supply difficult.

To secure stable water sources, to increase the supply capacity, and to improve the water quality, MWA is implementing a development program targeted for the year 2000; from supplied area of 485 km^2 in 1985, to 670 km^2 in 1990 and 835 km^2 in 2000. Population in service area of 5,132,000 in 1985, to 6,530,000 in 1990 and 8,114,000 in 2000. Supply capacity of 2,118,000 m^3/day, to 3,100,000 m^3/day (46% increase over 1985) in 1990 and 4,500,000 m^3/day (112% increase over 1985) in 2000. Ratio of service pervasion of 85.3% in 1985, to 92.7% in 1990 and 96.1% in 2000. (Table 6)

Table 6 MWA's Development Program

Year	Supplied Area (km^2)	Total Population in Service Area	Capacity of Facilities (m^3/day)	Ratio of Service Pervasion (%)
1976	242	2,469,000	1,300,000	
1982	280	3,200,000	1,967,000	
1985	485	5,132,000	2,118,000	85.3
1990	670	6,530,000	3,100,000	92.7
2000	835	8,114,000	4,500,000	96.1

PWA (provincial Waterworks Authority)

PWA formulated a ten-year development program to meet the needs of each region, in accordance with the national policy for equal provision of public services to areas other than Bangkok. The program was designed to expand water supply facilities and to secure water sources, in order to achieve the government's target "to supply water to more than 50 million population, or more than 95% of the total population by 1990" as set forth in the International Drinking Water Supply and Sanitation Decade Plan 1981-1990. However, the target was modified downward due to financial difficulties; targeted for expansion from supplied area of 1,960 km^2 in 1985, to 2,239 km^2 in 1990 and 2,518 km^2 in 2000. Population in service area of 4,370,000 in 1985, to 4,500,000 in 1990 and 5,450,000 in 2000. Supply capacity of 891,800 m^3/day in 1985, to 1,044,000 m^3/day (17% increase over 1985) in 1990 and 1,200,000 m^3/day (35% increase over 1985) in 2000. Ratio of service pervasion of 59.5% in 1985, to 90% in 1990 and 81.50% in 2000. (Table 7)

Table 7 PWA's Development Program

Year	Supplied Area (km^2)	Total Population in service Area	Capacity of Facilities (m^3/day)	Ratio of Service Pervasion (%)	Number of Waterworks
1979	-	3,367,051	646,320	48.29	182
1983	1,955	4,280,320	878,640	50.43	175
1985	1,960	4,370,000	891,800	59.50	176
1990	2,239	4,500,000	1,044,000	90.00	200
2000	2,518	5,450,000	1,200,000	81.50	226

2-4 Current Training Conditions of Waterworks Technology

In implementing water supply development programs and in operating existing facilities, appropriate technology and manpower (as well as adequate financial resources) are essential. However, both MWA and PWA suffer an extreme shortage of personnel required for management, operation, and maintenance of their facilities. They need training of a sufficient number of people as early as possible.

Recently, MWA and PWA started training programs for their own personnel. However, due to shortages in training staff, equipment, facilities, and budget, these programs are limited in scope and duration, and therefore insufficient to meet the need.

MWA's Training Program

Expendables and general expenses for training in 1982-1985 are summarized in Table 8, to provide training for 2,000 - 3,000 persons annually; 2,035 persons in 1982, 3,132 persons in 1983, 1,994 persons in 1984 and 2,300 persons in 1985. The training expenses increased from 568,113 bahts in 1982 to 1,400,000 bahts in 1985 (146% increase over 1982). Accordingly, the training expense per person increased by 2.3 times during the same period, to appear that MWA started its full-scale training in 1985. The total training budget in 1985 is 4,187,000 bahts.

MWA's training programs are conducted mainly at the MWA Training Center located within the Bang Khen Purification Plant in a suburb of Bangkok. The training center consists of a training building and workshop, operated by 29 employees (including 5 training staff). Training is given in 60 classes annually, with a duration of 3-5 days each. A total of 2,000-3,000 persons are trained each year.

Table 8 MWA's Expendables & General Expenses for Training

Fiscal Year	MWA		
	Number of Trainee	Budget Spent (Bahts)	Average Cost per Trainee (Bahts)
1982	2,035	568,113	279
1983	3,132	698,876	223
1984	1,994	560,013	280
1985	2,300	1,400,000	608

Breakdown of MWA's Training Budget in 1985

Category of Breakdown	Amount (Bahts)
Personnel expenses (Salaries and wages)	1,874,000.-
Travelling expenses (included staying expenses)	121,000.-
Operation expenses Facility operation expenses (electricity, fuel, etc.)	747,000.-
Maintenance expenses	45,000.-
Expendables and general expenses	1,400,000.-
Total	4,187,000.-

Note:
1. Figures under "Personnel expenses" excluded regional trainers' salaries

2. Expendables and general expenses included Training Fee, Training Materials etc.

However, different technical levels of class are not offered. The medium- and long-term training required for intermediate and advanced levels is not offered, due to shortages of training staff (instructor) and equipment. Together with the small size of the facilities, only beginner's level of training (mainly lectures) is given at the center, insufficient to meet requirements.

PWA's Training Program

Training budgets and numbers of trainees in 1982-1985 are summarized in Table 9. As seen in this table, a full-scale training program was started in 1984 with 1,781 trainees and 2,768,000 bahts annually. In 1985, the training budget was considerably increased to 8,157,200 bahts, with 1,926 trainees. In the 1985 budget, traveling expenses (including staying expenses) represent 58.5%. This is because PWA covers the whole of the country and trainees must come to the PWA head office or to regional offices in Chonburi, Chiang Mai, Khon Kaen, or Songkhla, etc. for training. Thus sufficient financial resources are not left for such necessary training costs as course materials and management. To increase the actual training funds by reducing traveling expenses, there is a need for dividing the country into several blocks and establishing training facilities with a dormitory in the center of each block.

Training programs of PWA are given at its training center (located at the head office) and at regional offices. Due to shortages of training facilities and equipment, actual training programs are limited to the beginner's level. Most of training programs at regional office begun in 1984. There are many employees who cannot read water meters, and therefore the condition require basic-level training as early as possible.

Table 9 PWA's Training Budgets

Fiscal Year	PWA		
	Number of Trainee	Budget Spent (Bahts)	Average Cost per Trainee (Bahts)
1982	82	45,650	550
1983	456	235,480	516
1984	1,781	2,768,000	1,550
1985	1,926	8,157,200	4,235

Breakdown of Training Budget in 1985

Category of Breakdown	Amount (Bahts)
Personnel expenses (Salaries and wages)	2,624,000.-
Travelling expenses (included staying expenses)	4,771,100.-
Operation expenses Facility operation expenses (electricity, fuel, etc.)	-
Maintenance expenses Expendables and general expenses	- 761,700.-
Total	8,157,200.-

According to the study carried out by the study team, the following training programs are conducted at regional offices:

Chiang Main Regional Office

Lectures are given at Chiang Mai University by Professor Yano (JICA expert) and other teaching staff. The regional office does not have its own training facilities or equipment.

Khon Kaen Regional Office

The training programs at this office started in 1984. In the previous year, the following three courses (mainly lectures) were conducted at a hotel:

- Finance 7 days
- Operation of Waterworks 7 days
- Water Analysis 5 days

Because this regional office does not have its own training facility or equipment, long-term training programs have not been established. Training staff mostly come from the training center at the PWA head office.

Songkhla Regional Office

Training programs are conducted using part of the newly built regional office. Because no training equipment is available, training courses are mainly conducted in the form of lectures given by training staff from the PWA head office. In addition, the regional office sends teaching staff to various areas under its jurisdiction for about three-week trainings.

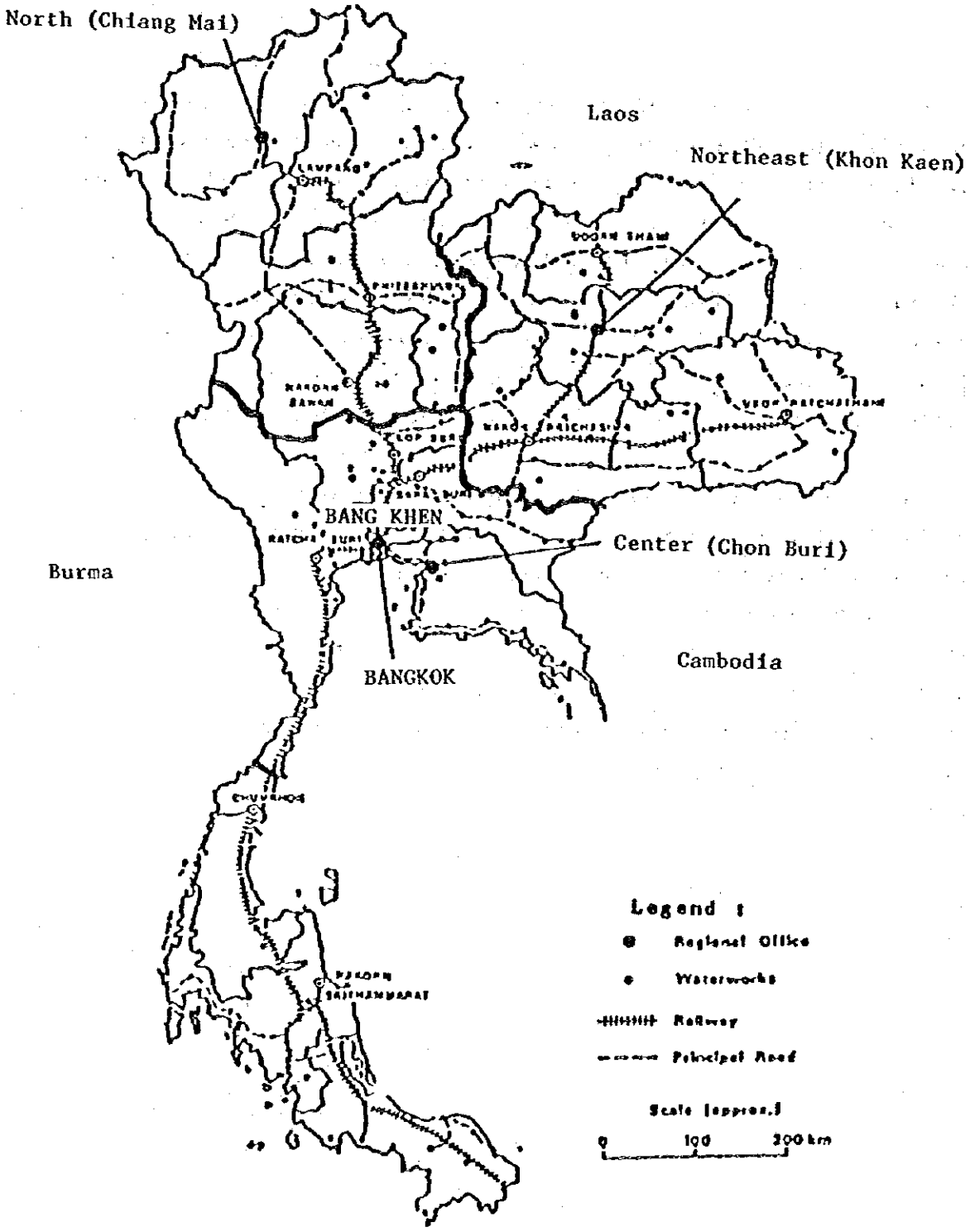
CHAPTER 3 CONTENTS OF THE PROJECT

3-1 Objectives of the Project

Although MWA and PWA formulated development programs to meet the needs in their service areas and to implement the expansion of their supply capacities accordingly, there is a severe shortage of the manpower required by both agencies for program implementation, facility management, maintenance, and operation. To improve this situation, MWA and PWA started their own training programs, but they appear to be inadequate because of shortages in training staff, facilities, equipment, and budget. To overcome this situation and to develop waterworks engineers and technicians in a more effective and integrated way, MWA and PWA jointly devised a project to construct the National Waterworks Technology Training Institute.

The proposed institute consists of a Central Training Center (CTC) and two Regional Training Centers (RTC). At the CTC, training staff (instructors) for the CTC and RTCs will be educated with technical cooperation provided by the government of Japan. Training programs for MWA and PWA staff (for the latter, limited to those working in the central part of the country) will be conducted for various levels and job types. At the RTCs, short-term training programs will be conducted (by training staff educated at the CTC) to train local PWA staff in accordance with different levels and job types.

Figure 4 Location Map of the Proposed Institute



3-2 Formation of the Institute

CTC will be constructed within the MWA Bang Khen Purification Plant located in a suburb of Bangkok. The RTCs will be constructed in Chiang Mai (Northern region) and Khon Kaen (Northeast region).

Originally, the Government of Thailand proposed to establish four RTCs to cover the Northern, Northeastern, Central, and Southern regions. In consideration of the needs for training, the present state of training, and the availability of training facilities and equipment in each region, new RTCs will be established only in the Northern and Northeastern regions. The CTC will be utilized to train personnel in the Central Region, and existing facilities will be utilized to train personnel in the Southern region.

According to the following study by the study team, the RTCs will be constructed in Chiang Mai and Khon Kaen.

- Needs for training

Basic-level training is required in all four regions. Many middle management and staff personnel, in all the regional offices, are not trained to read water meters, detect water leakage, or analyze water quality.

- Availability of training facilities

There is no training facility in the Northern and Northeastern regions. However, a new Songkhla regional office in the Southern region has space for training, and is currently utilizing it.

Thus, RTCs need to be constructed in Chiang Mai and Khon Kaen, whereas there is no urgent need for new training facilities in Songkhla.

There is little training equipment available in any of the regions.

Table 10 Regional Distribution of PWA's Waterworks

Region	No. of Regional Office	No. of Waterworks	Capacity of Facilities (Designed) m^3/day	Total Population in Service Area person	No. of Connection
North (Chiang Mai)	4 (27%)	44 (25%)	187,200 (21.3%)	957,460 (22.4%)	82,198 (23.2%)
	2 (20%)	44 (25%)	187,200 (21.3%)	957,460 (22.4%)	82,198 (23.1%)
Northeast (Khon Kaen)	4 (27%)	55 (31.5%)	221,280 (25.2%)	1,339,210 (31.3%)	109,627 (30.9%)
	3 (30%)	55 (31.5%)	221,280 (25.2%)	1,339,210 (31.3%)	109,627 (30.9%)
South (Songkhla)	3 (20%)	28 (16%)	157,440 (17.9%)	789,600 (18.4%)	62,489 (17.6%)
	2 (20%)	25 (14.5%)	143,040 (16.3%)	707,890 (16.5%)	56,745 (16.0%)
Center (Chon Buri)	4 (27%)	48 (27.5%)	312,720 (35.6%)	1,194,050 (27.9%)	100,626 (28.3%)
	3 (30%)	51 (29%)	372,120 (37.2%)	1,275,760 (29.8%)	106,370 (30%)
Total	15	175	878,640	4,280,320	354,940
	10	175	878,640	4,280,320	354,940

- o Figures in lower columns denote the number of new regional offices.
- o Regional offices were reorganized from 15 to 10 in mid-January 1985
- o It should be noted that some purification plants changed jurisdiction from the Southern region to the Central region.
  No changes were made in the Northern and Northeastern regions.

- Proposed sites

The proposed sites in Chiang Mai and Khon Kaen have sufficient space for accommodating RTC facilities, but the proposed site in Songkhla is too small to accommodate RTC facilities proposed by the Thai side.

- Regional distribution of PWA waterworks

PWA's waterworks are distributed regionally as shown in Table 10. In terms of the number of purification plants, population served and number of connections, the Northern region represents 22-25% of the totals, the Northeastern region represents about 31%, and the Southern region represents 16-18% (indicating the relatively low weight of the Southern region).

Table 11 Jurisdiction of RTCs (Changwat)
(Proposed by PWA)

Since mid-January 1985, PWA's regional offices were reorganized into ten offices.

			Changwat
Chiang Mai RTC	Regional Office (Chiang Mai)	9 :	Chiang Mai, Mae Hong Son, Lamphun, Lamphang, Phrae, Payao, Nan, Chiang Rai
	Regional Office (Nakhon Sawan)	10 :	Nakhon Sawan, Phetchabun, Phichit, Phitsanulok, Uttaradit, Sukhothai, Kamphaeng Phet, Tak, Uthai Thani, Chai Nat
Khon Kaen RTC	Regional Office (Ubon Ratchathani)	6 :	Ubon Ratchathani, Roi Et, Buri Ram, Surin, Si Sa Ket, Yasothorn
	Regional Office (Khon Kaen)	7 :	Khon Kaen, Chaiyaphum, Kalasin, Nakhon Ratchasima, Maha Sarakham
	Regional Office (Udon Thani)	8 :	Udon Thani, Loei, Nong Khai, Sakon Nakhon, Nakhon Phanom, Mukdahan
Songkhla RTC	Regional Office (Surat Thani)	4 :	Surat Thani, Chumphon, Ranong, Phangnca, Phuket, Krabi, Nakhon Si Thammarat
	Regional Office (Songkhla)	5 :	Songkhla, Phatthalung, Trang, Satun, Yala, Narathiwat, Pattani
Chon Buri RTC	Regional Office (Chon Buri)	1 :	Chon Buri, Chachoengsao, Chanthaburi, Trat, Rayong
	Regional Office (Saraburi)	2 :	Saraburi, Nakhon Nayok, Prachin Buri, Lop Buri, Sing Buri, Ang Thong, Suphan Buri
	Regional Office (Bang Khen)	3 :	Kanchanaburi, Ratchaburi, Phetchaburi, Prachuap Khiri Khan, Nakhon Pathom, Samut Songkhram, Samut Sakhon, Ayuttaya, Pathum Thani

3-3 Outline of the Project

The training programs to be conducted in the Institute can be roughly divided into two groups; one is education for Thai training staff (instructors) who will teach Thai staffs at the CTC and RTCs by Japanese experts (to be sent under technical cooperation under the program proposed by Thai side) and the other is training for MWA and PWA personnel (provided by the Thai training staff educated by Japanese experts).

	Location	Number of training courses	Number of trainees per year
Education for Thai training staff	CTC	6	315 - 400 persons
Training for MWA and PWA personnel	CTC	35	2,182
	RTC (Chiang Mai)	18	650
	RTC (Khon Kaen)	18	730
	RTC (Songkhla)	17	640 *1
	RTC (Chonburi)	29	388 *2

* 1 Training is conducted at existing facilities.

* 2 Training for RTC Chonburi will be conducted at the CTC facilities.

The number of trainees per year can be further divided as follows:

	MWA personnel	PWA personnel	Total
Education for Thai training staff (a)	210 - 267	105 - 133	315 - 400 persons
Training for MWA and PWA personnel (b)	2,182	2,408*	4,590
(b)/(a)	10.4 - 8.2	22.9 - 18.1	14.6 - 11.5

* including RTC (Songkhla)

Table 12 Classification of Trainees by Educational Level/Professional Career (Proposed by Thai side)

Category of Personnel	MWA personnel		PWA Personnel	
	Experience	Education	Experience	Education
			years	
Executives	Over 10 years	Bachelor-Doctor	12-16	Doctor Degree
			14-20	Master Degree
			14-20	Bachelor Degree
			12-22	5 year vocational Certificate
Senior Staff	Over 10 years	Bachelor-Master	8-10	Doctor Degree
			10-12	Master Degree
			10-12	Bachelor Degree
			12-14	5 year Vocational Certificate
Junior Staff	Over 10 years	5 year Technical	2	Doctor Degree
			4	Master Degree
			6	Bachelor Degree
			8	5 year Vocational Certificate
			10	3 year Vocational Certificate
Engineers	3-10	College-Master Bachelor-Master	10-12	
Technicians	5-10	3 year-Technical College-Bachelor		365 year Vocational Certificate
Supervisor	Over 10 years	Secondary Sch.-3 year Technical College	6-8	Doctor Degree
			8-10	Master Degree
			8-10	Bachelor Degree
			10-12	5 year Vocational Certificate
			12-14	3 year Vocational Certificate
Operators	Over 10 years	Primary Sch.-5 year Technical College	8-12	Primary & Secondary School
Semi Skill Labour	Over 10 years	Primary Sch. Secondary Sch.	12	Primary & Secondary School
Employees	3	3 year Technical College	10	Primary & Secondary School

The number of training staff to be educated appears to be sufficient for maintaining the project. However, the number of trainees per year accounts for only 30% of the number of MWA staff (7,240 persons) in 1990, and 44% of the number of PWA staff (5,457 persons) in 1990, projected as necessary to satisfy training requirements for both agencies.

Training courses can be classified by technical levels and job types to cover nine classes from executives to semi-skilled labor, as shown in Table 12.

Training requirements for MWA and PWA personnel are:

MWA personnel	-	once every five years
PWA personnel	-	once every three years for executives, senior staff, and engineers

Training staff

The training courses for MWA and PWA personnel are conducted by Thai training staff who have completed the education program taught by Japanese experts. The training staff will receive education in accordance with the following schedule proposed by Thai side:

CTC training staff (instructors)	Education (6 months) →	Teaching (2 years) →	Education (6 months)
RTC training staff (instructors)	Education (3 - 6 months) →	Teaching (2 years) →	Education (3 - 6 months)

The training staff will be selected from university degree holders (Bachelor, Master, or Doctor). In addition, outside training staff from universities and other institutions will be employed.

According to the proposed plan by the Thai side, 13 training staff will be employed at the CTC and 10 will be employed at each RTC.

Proposed composition of training staff

CTC	Number	RTC (each center)	Number
Management	2	Management	
Civil Eng.	3	Civil Eng.	
Sanitary Eng.	2	Sanitary Eng.	3
Environment Eng.	-	Environment Eng.	
Electrical Eng.	2	Electrical Eng.	
Mechanical Eng.	2	Mechanical Eng.	
Others	2	Others	7
Total	13	Total	10

Training Courses (Proposed by Thai side)

A. Education for Thai training staff (at CTC)

Courses	Duration weeks	Activities Per Year times	Number of Trainees per course	Technical Level of Trainess
1) Water Supply Training	24	2	25-30	Engineers
- Mater Planning	8	2	(25-30)	Engineers
- Facility Planning	8	2	(25-30)	Engineers
- Distribution Planning	8	2	(25-30)	Engineers
2) Management Course (Seminar)	8	1	25-30	Senior officlas
3) Water Purification and Sanitation Course	24	2	15-20	Scientists and Engineers/Technicians
- Water Purification	8	2	(15-20)	Scientists and Engineers/Technicians
- Water Quality Analysis	8	2	(15-20)	Scientists and Engineers/Technicians
- Water Quality Control	8	2	(15-20)	Scientists and Engineers/Technicians
4) Pipleline Maintenance Course	12	3	25-25	Technicians & Skill workers
- Piping	4	3	(20-25)	Technicians & Skill workers
- Pipeline Maintenance	4	3	(20-25)	Technicians & Skill workers
- Leakage Prevention	4	3	(20-25)	Technicians & Skill workers
5) Mechanical and Electrical Installation Course	12	3	20-25	Technicians Skill workers
- Mechanical Installation	4	3	(20-25)	Technicians Skill workers
- Electrical Installation	4	3	(20-25)	Technicians Skill workers
- Instrumentation	4	3	(20-25)	Technicians Skill workers
6) Seminar	1	3	30-40	All levels
Total number of trainees per year			315-400 persons	

B. Training for MWA and PWA personnel (Proposed by Thai side)
Training courses at CTC (including training courses of Chon Buri RTC)

	Courses	Duration days	Activities Per Year times	Number of Trainees per course	Technical Level of Trainess
B-1)	Planing in Water Suplly and Sanitation	10	2	30	Engineers
2)	Feasibility Study	10	2	30	Junior Officer
3)	Top Management Training (Seminar)	3	1	25	Executives
4)	Middle Management Training (Seminar)	6	3	30	
5)	Low Level Training	6	2	40	
6)	Waterworks Managers Training	-	-	-	
7)	Management Workshop	5	1	35	Executives Senior Officer
8)	Training Management Techniques	5	1	20	
9)	Chemical Dosage and Operation and maintenance of chemical posing equipment Electrical Mechanical Equipment	100	1	20	Operator Scientist
10)	Water Treatment and filtration operations	10	2	35	Operators
11)	Introduction to Water Quality control	5	2	35	Engineers Senior technicians Supervisor
12)	Water chemistry for non-specialist	5	1	35	Senior Administrative
13)	The Maintenance of Pipe Work Systems	5	2	35	Engineers Technicians
14)	Leakage Water Inspection (house inspection duties)	5	3	35	Employees
15)	Leakage Water Inspection (leakage water metering)	5	2	35	Employees
16)	Leakage Water Inspection (distribution, recording and	5	1	35	Employees
17)	Water Pipe Laying and Jointing (trench operation) - level 1	5	4	35	Employees
18)	" - level 2 (pipe laying and jointing)	5	3	35	Employees
19)	" - level 3 (pipe repair and modifications)	5	2	35	Employees
20)	Water Meters Operation and Maintenance Training	10	4	30	Employees

Courses	Duration days	Activities Per Year times	Number of Trainees per course	Technical Level of Trainess
21) Training Specific Subject for Trainers	-	-	-	
22) Electrical Workshop Practice I	5	2	35	Semi-Skill labour
23) " II	5	2	35	Semi-Skill Technicians
24) Mechanical Workship Practice I	5	3	35	Semi-Skill labour
25) " II	5	2	35	Semi-Skill Technicians
26) Pneumatic Process Instrumentation	20	2	35	Engineers Technicians
27) Process Instrumentation Theory & Practice I (measurement)	20	2	35	Engineers Technicians
28) " (control)	20	2	35	Engineers Technicians
29) Measurement & Control in Water and Waste Water Treatment Process	10	3	35	Engineers Technicians
30) Computer Applications (Seminar)	20	2	25	Engineers Middle level Management
31) Computer in Management (Seminar)	10	1	25	Executives
32) Digital Electronics	20	1	35	Technicians
33) Introduction to Computer	20	2	25	Technicians Supervisors
34) Office Managemetn Training	10	3	30	Officers
35) Office Supply Management	5	2	30	Storeman
36) Meter Readers and Bill Collectors Training	5	5	30	Meter readers Bill Collectors
37) Labour, Relation	3	4	50	Employee

Total number of trainees per year 2,570 persons

CTC (2,182)
Chon Buri RTC (388)

Training courses at RTCs (Originally the Government of Thailand proposed to establish 4 RTCs as Chiang Mai, Khon Kaen, Songkhla and Chen Buri.)

Courses	RTC: CHIANG MAI	RTC: KHON KAEN	RTC: SONGKHLA	Duration days	Activities Per Year times	Number of Trainees percourse	Technical Level of Trainees
B- 1) Planning in Water Supply and Sanitation				10			Engineers
2) Feasibility Study				10			Junior Officer
3) Top Management Training	o			5	1	25	Executives
4) Middle Management Training	o		o	5		30	
5) Low Level Training	o	o	o	5	3	30	
6) Waterworks Managers Training	o	o	o	22	1	30	Manager
7) Management Workshop			o	5	1	25	Executives Senior Officer
8) Training Management Techniques				5			
9) Chemical Dosage and Operation and maintenance of chemical posing equipment Electrical Mechanical Equipment	o	o	o	30	1	30	Operator Scientist
10) Water Treatment and filtration operations	o	o	o	5	2	30	Operators
11) Introduction to Water Quality Control				5			Engineers Senior technicians Supervisor
12) Water chemistry for non-specialist				5			Senior Administrative
13) The Maintenance of Pipe Work System				5			Technicians
14) Leakage Water Inspection (house inspection duties)	o	o	o	5	1	30	Employees
15) Leakage Water Inspection (leakage water metering)		o	o	5	1	30	Employees
16) Leakage Water Inspection (distribution, recovering and		o	o	5	1	30	Employees
17) Water Pipe Laying and Jointing (trench operation) - level 1	o	o	o	5	1	30	Employees
18) " - level 2 (pipe laying and jointing)	o		o	5	1	30	Employees
19) " - level 3		o		5	1	30	Employees
(pipe repair and modifications)	o	o	o	10	2	30	Employees

Courses	RTC			Duration	Activities Per Year	Number of Trainees	Technical Level of Trainees
	CHIANG MAI	KHON KAEN	SONGKHLA	days	times	percourse	
20) Training Specific Subject for Maintenance Training	o			25	1	30	Trainers
21) Training Specific Subject for	o	o	o	5	1	30	Semi-Skill
22) Electrical Workshop Practice I		o	o	5	1	30	Semi-Skill labour
23) " II		o		5	1	30	Semi-Skill Technicians
24) Mechanical Workshop Practice I	o	o		5	1	30	Semi-Skill labour
25) " II		o		5	1	30	Semi-Skill Technicians
27) Process Instrumentation Theory & Practice I (measurement)				20			Engineers Technicians
28) " (control)				20			Engineers Technicians
29) Measurement & Control in Water and Waste Water Treatment Process				10			Engineers Technicians
30) Computer Applications	o			20	1	20	Engineers Middle level Management
31) Computer in Management	o			10	1	15	Executives
32) Digital Electronics				20			Technicians
33) Introduction to Computer				20			Technicians Supervisors
34) Office Managemetn Training	o	o	o	5	1	30	Officers
35) Office Supply Management	o	o	o	5	1	30	Storeman
36) Meter Readers and Bill Collectors Training	o	o	o	5	1	30	Meter readers Bill
37) Labour Relation	o	o	o	3	1 - 2	50	Employee

Total number of trainees per year

Chiang Mai RTC 650 persons
Khon Kaen RTC 730
Songkhla 640

The Institute consists of a CTC, Chiang Mai RTC and Khon Kaen RTC.

Training courses at the Institute will be planned as the above except the training courses of Songkhla. The study team design scale of facilities of the Institute in accordance with the above training courses.

3-4 Facility Contents

1. Facilities at the CTC will be planned to serve as a national training center with education for training staff, particularly focused on practical training.

a) Training building:
Including lecture rooms, drafting room, water quality examination room, instrumentation room, audio/visual room and administrative rooms

b) Dormitory:
Designed to accommodate trainees from remote areas who take educational courses to become training staff (course A)

c) Workshop:
Used for training on maintenance and repair of mechanical/electrical systems in purification plants

d) Pump operation training plant:
Used for training on pump operation and maintenance in pufirication plants

e) Mini purification plant:
Designed to enable trainees to understand the treatment process through actual operation

f) Leakage survey training yard:
Designed to simulate leakage survey work

g) Piping training yard: (work to be done Thai side)
Designed to carry out training on piping works

h) Other:
Cafeteria, covered way and other required facilities

2. Facilities at the RTCs will be designed to provide lectures and basic training courses on fundamental waterworks technology. Practical training will be carried out by training staff educated at the CTC, using audio/visual materials. Thus, audio/visual rooms need to have a variety of equipment.

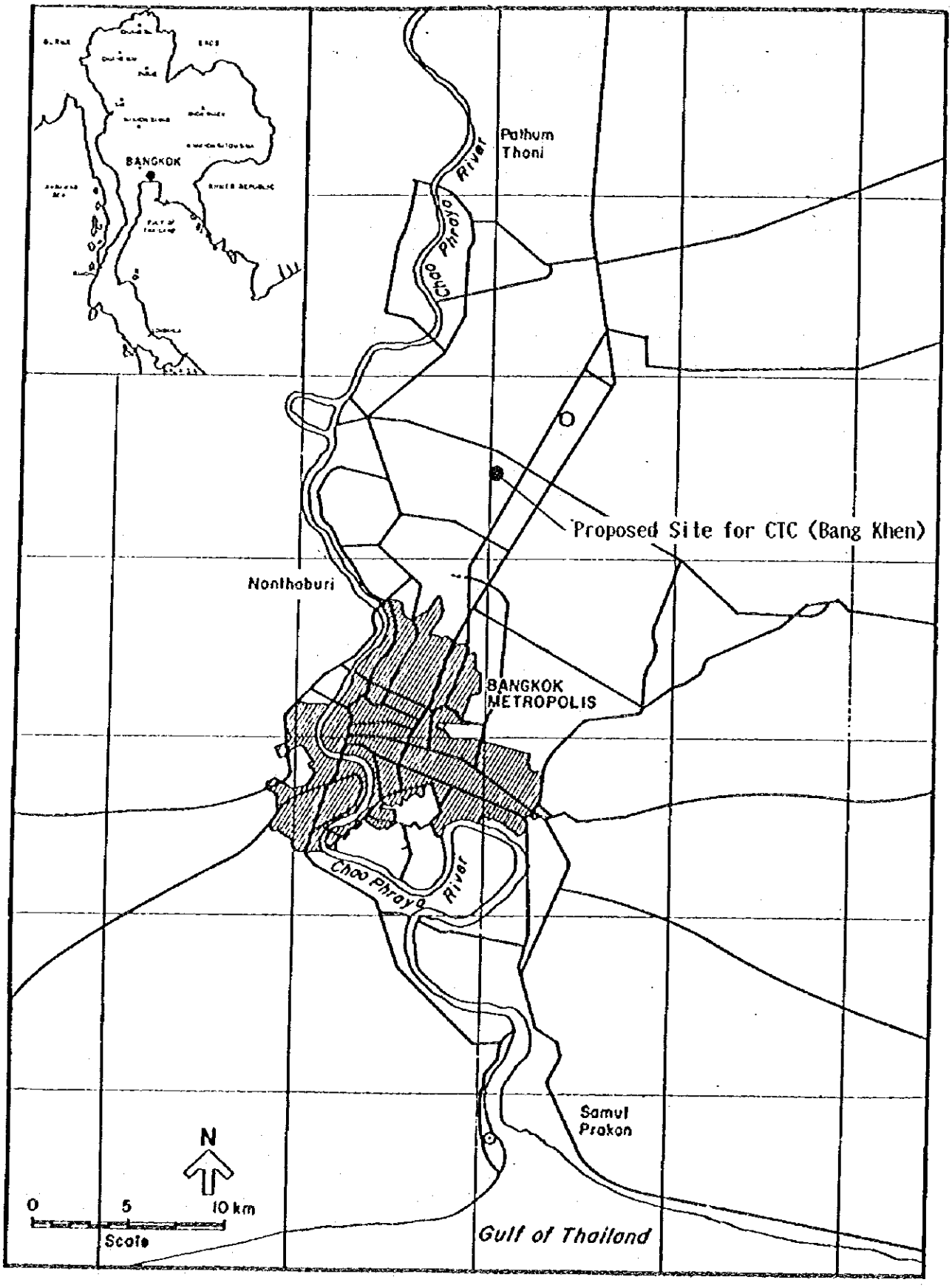
a) Training building:
Lecture rooms, audio/visual room, administrative offices

b) Dormitory
Designed to accommodate trainees from remote areas, or 60% of the total number in each session (30 persons)

c) Workshop
Designed to carry out training on maintenance and repair of water meters, motors, motor vehicles, and other equipment/machinery used in regional offices

d) Other:
Cafeteria, covered way, and other facilities

Figure 5 Bang Khen Proposed Site for CTC



CHAPTER 4. PROJECT SITE

4-1 Locations and Environmental Conditions

The proposed site for the Central Training Center (CTC) is located at Bang Khen, a suburb of Bangkok. The proposed sites for the RTCs are located at Chiang Mai in the Northern region, and at Khon Kaen in the Northeastern region.

CTC

The proposed site is located at the north end of the MWA Bang Khen Purification Plant along Klong Propa, approximately 15 km north of Bangkok. The plant is located within the Bang Khen district, where Kasetsart University, testing facilities for the Ministry of Agricultural Cooperatives, the Thai Central Forest Research Center, and other research and educational institutions are situated. Recently, the district has developed into a residential area, due to the expansion of the Bangkok metropolitan area. Regular bus service and roads connected to Bangkok are provided. Also, an access road to the plant is well-developed, making the transportation of construction equipment/material possible.

RTC (Chiang Mai)

The proposed site is located within PWA Umong Purification Plant, at the east end of Chiang Mai, which is a center of the Northern region and was an ancient capital during the Chiang Mai Dynasty. Chiang Mai airport is located on the east, Chiang Mai University on the north, and Doi Suthep on the west.

The plant can be reached from the city via small truck (major passenger service available) within 15 minutes. A road to the plant is well-developed, permitting easy transportation of construction equipment and materials.

Figure 6 Map of Chiang Mai

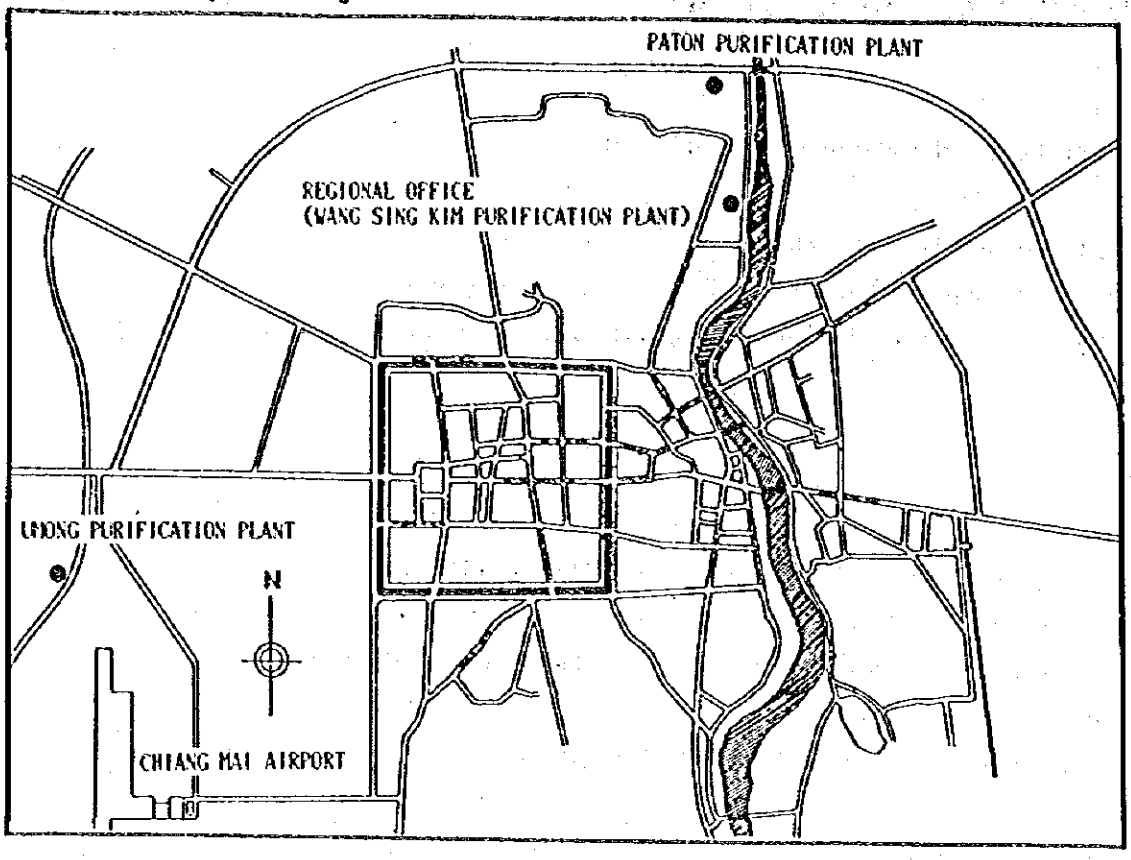
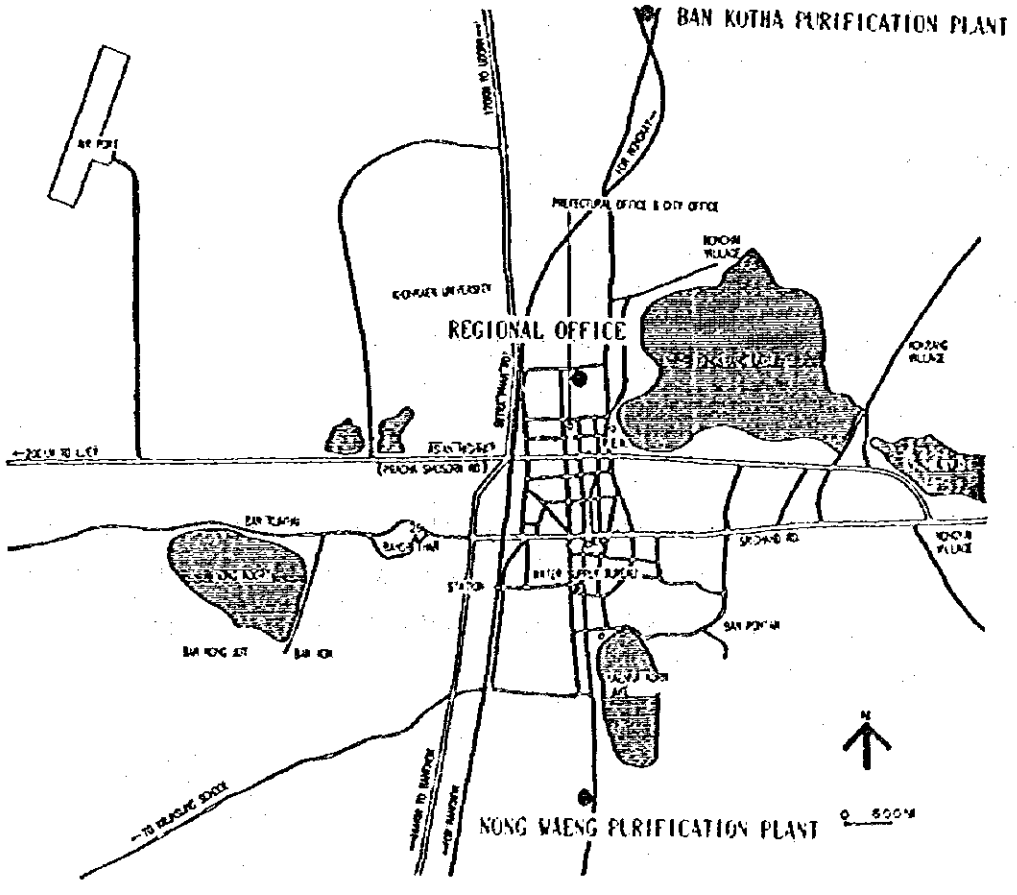


Figure 7 Khon Kaen



RTC (Khon Kaen)

The proposed site is located within the PWA Nong Waeng Purification Plant, at the west end of Khon Kaen. This location is approximately 450 km away from Bangkok, and is a center of the Northeastern region. The plant is located some 2 km from the city center, accessible by small truck or tricycle. Public facilities in the city include the Agriculture Development & Research Center, the Khon Kaen Institute for Skill Development, and the Primary Health Care RTC Khon Kaen, all of which have been constructed under grant aid assistance from the Government of Japan.

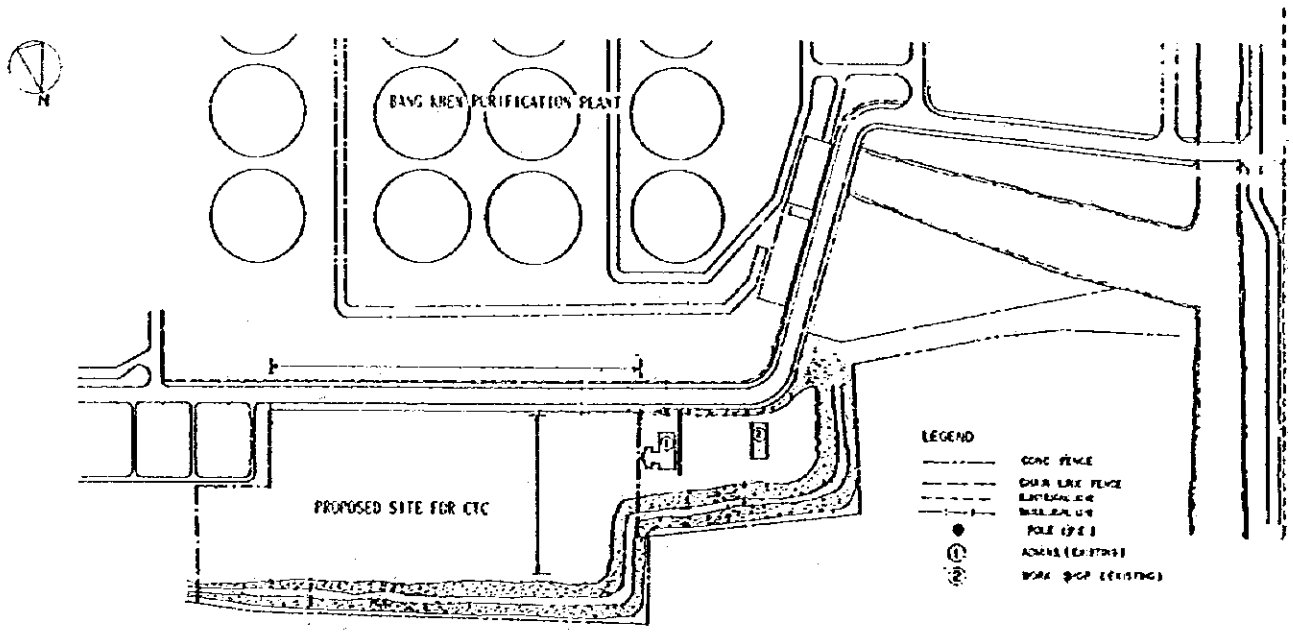
A road to the plant is well-developed, permitting easy transportation of construction equipment and material.

4-2 Conditions of the Construction Sites

CTC

The proposed site covers approximately 15,500 m^2, extending about 185 m in the east-west direction and 84 m in the north-south direction. It is now being used as a football field. The site is adjacent to the MWA Training Center on the west, and staff houses for the Bang Khen Purification Plant on the east. Bang Khen district is usually flooded during the rainy season so that the site needs to be filled to the ground level of the adjacent training center. A request is made to the Thai side for filling the site by 1.2 m, starting from the road that fronts the site on the south side. Furthermore, the site is not large enough to arrange all the facilities proposed by the Thai side in an appropriate layout so that part of the vacant land at the back of the staff houses has been incorporated into the site (after consultation with the Thai side).

Fig-8 Bang Khen Proposed Site for CTC



LAY-OUT

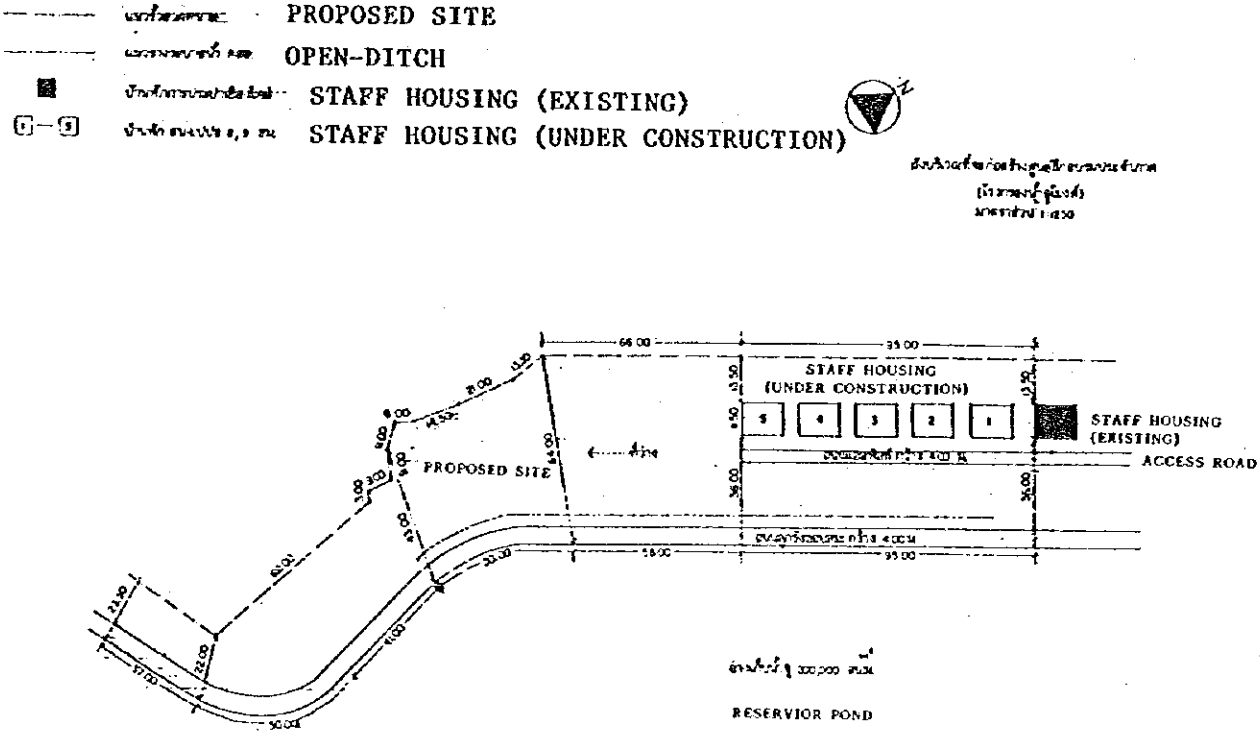
BANG KHEN PROPOSED SITE FOR CTC

RTC (Chiang Mai)

The proposed site is an irregular shaped lot, located at the most inner part of the Umong Purification Plant. The site is generally flat, covering approximately 7,000 m^2. It faces a reservoir on the east, a farm on the west, and staff houses on the northeast, with a beautiful view of Doi Suthep. Although the site has not been flooded, filling work is requested to the Thai side for the part of the north side that is 50 cm below the surrounding ground. Furthermore, the proposed site does not have enough area for the appropriate layout of all the facilities planned by the Thai side so that a request is made to the Thai side for acquiring part of the farmland on the west side. Also, a request is made for relocating some of the staff houses in order to widen the access road that runs beside them.

Although the most suitable site was found in the Paton Purification Plant (one of three purification plants in the Chiang Mai district), that site was not selected because it was designated for future expansion of the plant.

Fig-9 Chiang Mai Proposed Site for RTC (Umong Purification Plant)



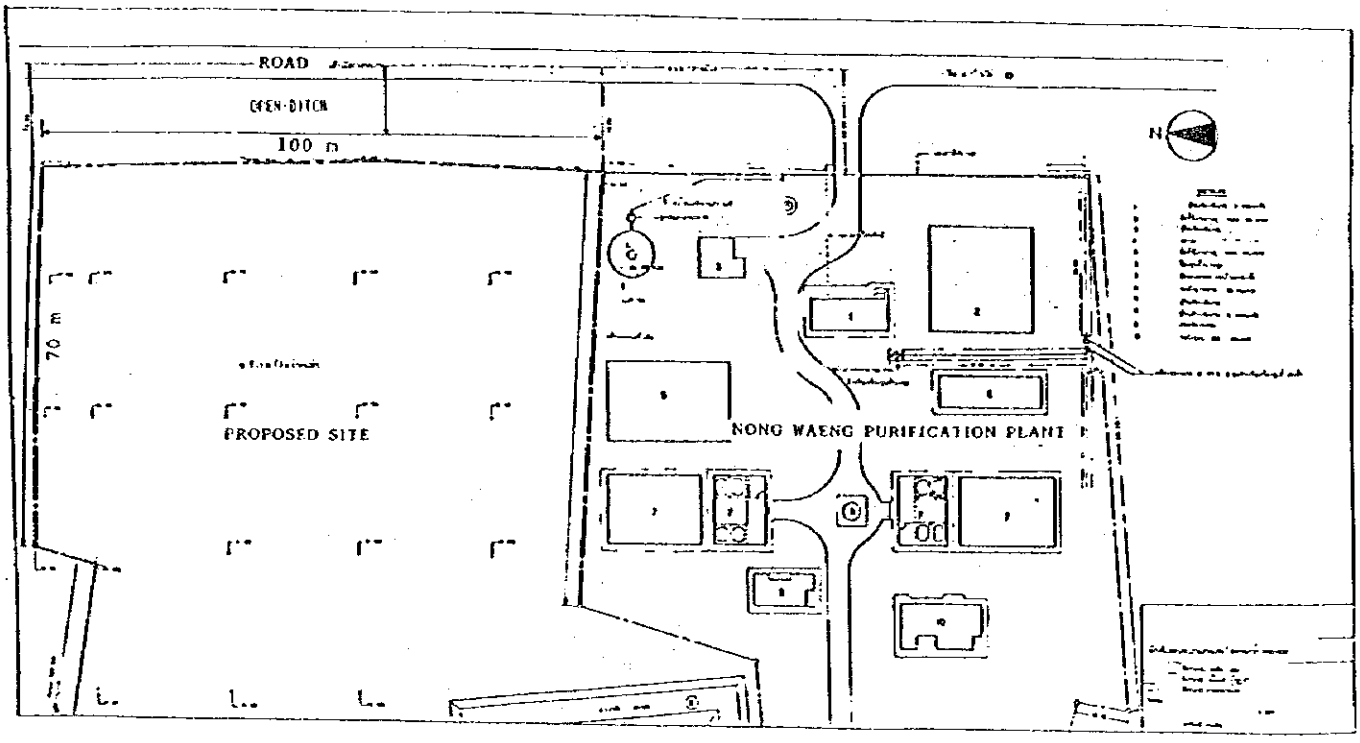
RTC (Khon Kaen)

The proposed site is flatland on the east side of the Nong Waeng Purification Plant, extending approximately 100 m in the north-south direction and 70 m in the east-west direction. The site is adjacent to a school, and faces a road to Khon Kaen city across an open ditch on the east side.

The site and surrounding areas are flooded during the rainy season so that filling of an additional 1.0 m is requested to the Thai side.

Originally, the Thai side proposed another site, but the site in the Nong Waeng Purification Plant was considered to be better for various reasons and was selected after consultation with the Thai side.

Fig-10 Khon Kaen Proposed Site for RTC (Nong Waeng Purification Plant)



4-3 Conditions of Infrastructures

CTC

1) Power supply

Electric power required for the center will be obtained from existing transmission lines (6.6 kv, 50 Hz) within the plant, through the south side of the site.

2) Water supply

Water required for the center will be supplied from purification facilities at the plant, through a 100 ϕ pipe that will be newly installed.

Raw water required for the mini purification plant will be pumped from a water intake on the southwest side of the site and then transported through a pipe.

3) Drainage

Drainage from the center will be discharged to an open ditch at the north of the site. Because the plant and surrounding area are generally flat, the size and shape of the open ditch should be planned in consideration of the highest water level and rainfall during the rainy season. The sewage and wastewater that are used for experiments will be treated in septic and neutralization tanks before discharge to the open ditch.

4) Telephone

The facilities will require three lines. These can easily be provided, judging from the service conditions in the Bangkok metropolitan area.

RTC (Chiang Mai)

1) Power supply

At present, electric power is supplied to the Umong plant through 11 kv, 50 Hz transmission lines. However, there is a plan to upgrade the power to 22 kv for the area around the plant from end of 1985. The 22KV, 50Hz transmission line will be extended to the site.

2) Water supply

Water required for the center will be supplied from the purification facilities at the plant, through a 75 ϕ pipe that will be newly installed.

3) Drainage

Water used in the center will be discharged to an overflow for the plant's reservoir, located at the northeast of the site. An open ditch will be constructed to connect the discharge points at the facilities to the overflow. The sewage and wastewater used for experiments will be treated in septic and neutralization tanks before being discharged to the overflow so as not to pollute a reservoir at the east of the site.

4) Telephone

The facilities will require one line. This can easily be provided, judging from the service conditions in Chiang Mai.

RTC (Khon Kaen)

1) Power supply

At present, electric power is supplied to the Nong Waeng plant through 22 kv, 50 Hz transmission lines, which will be extended to the site.

2) Water supply

Water required for the center will be supplied from purification facilities at the plant, through a 75 ϕ pipe that will be newly constructed.

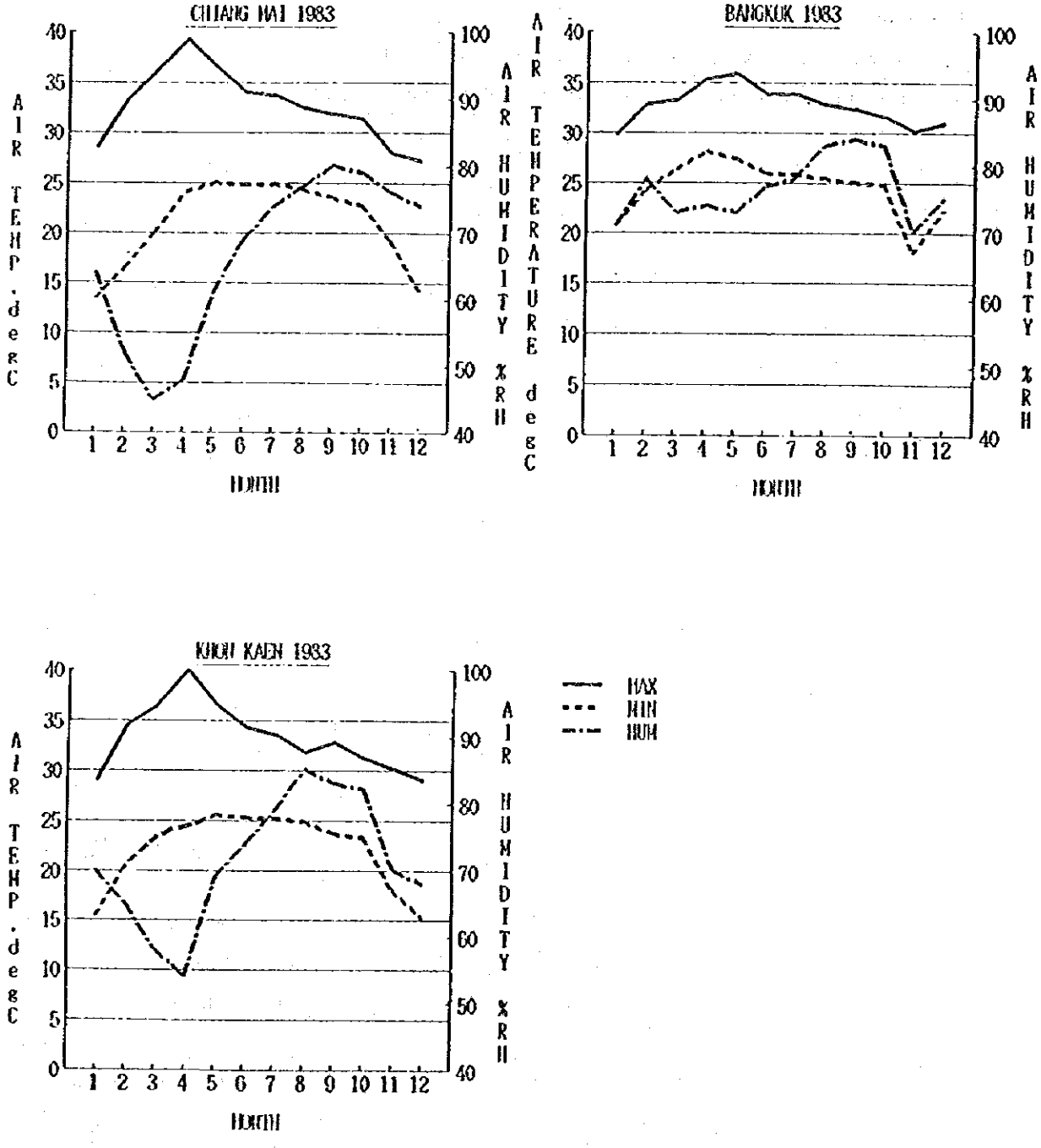
3) Drainage

General wastewater from the center will be discharged to an open ditch along the east side of the site. The sewage and wastewater used for experiments will be treated in septic and neutralization tanks before being discharged to the open ditch.

4) Telephone

The facilities will require one line. It can easily be provided, judging from the service conditions in Khon Kaen.

Monthly Mean Temperature and Humidity in 1983



4-4 Climatic Conditions

Thailand is located in a tropical monsoon zone, characterized as a high temperature and heavy rain. Wind directions vary with seasons throughout the country, primarily being from the south and southwest during February-September, and from the north and northeast during October-January. Annual rainfall varies by region, but is always greater than 1,000 mm, 80% of which is concentrated in the rainy season (May-October). The sunlight is very strong, with an average annual duration of 12 hours. Appropriate sunshades, ventilation, and drainage (during the rainy season) should be carefully considered in the architectural planning.

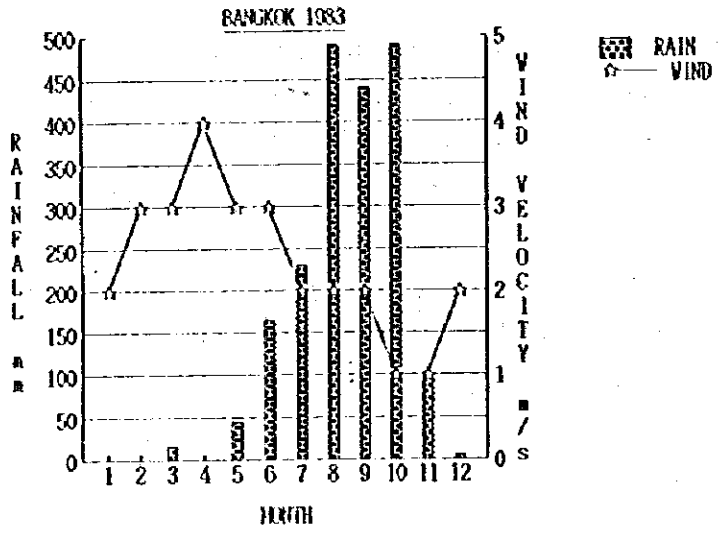
A request is made to the Thai side to carry out soil surveying (boring survey) at the sites by the end of February 1985.

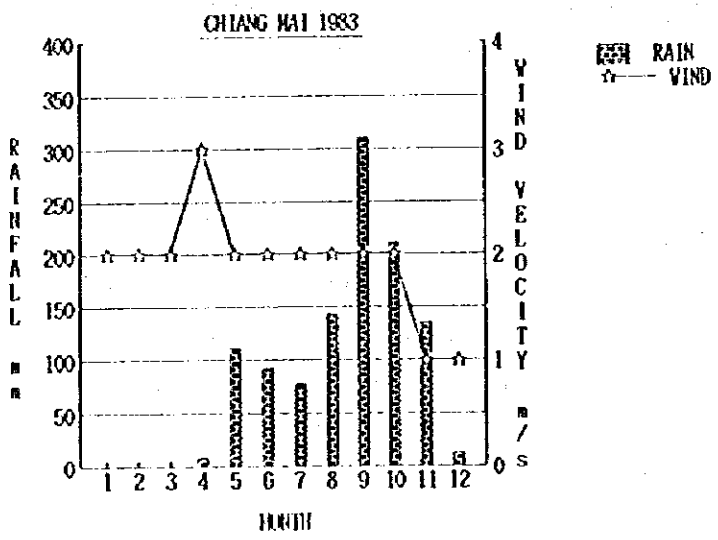
CTC

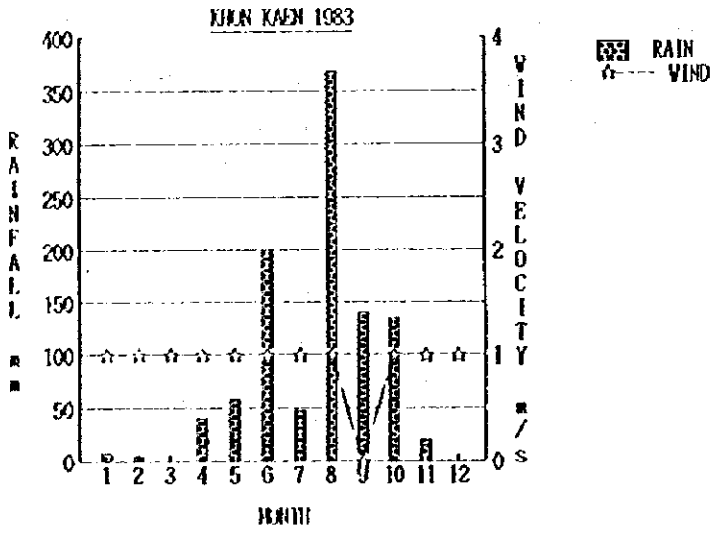
The proposed site, located in a suburb of Bangkok, is under climatic conditions of high temperature/humidity. In 1983, the annual mean temperature was 28.5°C, the annual mean humidity 74.7%, and the annual rainfall approximately 2,177 mm. There are squalls that last an hour or two during the rainy season. The prevailing wind direction is from the south February-September, and from the northeast October-January.

Bang Khen district has generally poor ground conditions (like Bangkok), and is subject to land settling at an annual rate of 5 cm. The District is flooded during the rainy season. Thus, care should be taken to deal with these problems in the land around buildings.

Rainfall and Wind Velocity in 1983







RTC (Chiang Mai)

Located inland and relatively northward, Chiang Mai experiences a larger variation in temperature than Bangkok; in 1983, the monthly maximum temperature was 39°C in April, and the minimum was 13°C in January. During January-May, the temperature in Chiang Mai is generally higher than that in Bangkok, but the humidity is lower (less than 60%), making for more comfortable weather. In 1983, the annual mean temperature was 25.1°C, the annual mean humidity 74%, and the annual rainfall approximately 1,100 mm. Southerly winds blow throughout the year.

RTC (Khon Kaen)

Located inland (like Chiang Mai), Khon Kaen experiences a large variation in temperature, with a monthly maximum temperature of 40°C in April, and a minimum of 15°C in January (1983). The humidity is generally less than 70% between January and May, making for more comfortable weather than that in Bangkok. In 1983, the annual mean temperature was 27.1°C, the annual mean humidity 71.1%, and the annual rainfall approximately 1,030 mm. The prevailing winds are southerly February-September, and northerly October-January.

The proposed site is located in the lowlands, and has been flooded in the past. Therefore, filling is necessary.

CHAPTER 5. BASIC DESIGN

5-1 Basic Design Policies

The basic design policies for the proposed training centers call for efficient facilities with a simplified design, adaptation to the climate, locality, and economy of the country, and minimal operation/maintenance costs.

Because the CTC (Bang Khen in a suburb of Bangkok) and the RTCs (Chiang Mai in the Northern region and Khon Kaen in the Northeast region) are located within existing purification plants, it is important to design new facilities which coordinate well with the existing ones.

The CTC is designed to function as a central training center by providing integrated training courses for MWA and PWA personnel who come from all over the country.

Facilities at the RTCs will be designed with simple and maintenance-free systems to accommodate their geographical disadvantage in obtaining prompt and adequate maintenance services. In addition, both RTCs will be planned under identical design (with a few variations in details), which will be helpful in construction management, as well as in cost saving.

Design policies common to the CTC and RTCs are as follows:

1. All of the facilities will be designed with 1-2 stories, to minimize the cost of foundation work.

2. Interior spaces of the facilities will be designed with ceilings more than 3.5 m high so as to use natural lighting and ventilation as much as possible and to minimize maintenance costs (mainly electricity costs).

3. Washed terrazzo, brick, concrete block, exposed concrete, and other materials that have less discoloration and fading will mainly be used for finishing so that exterior painting can be avoided as much as possible.

4. Patios will be used as a major point of architectural design, so as to take advantage of green spaces and to keep harmony with the natural environment.

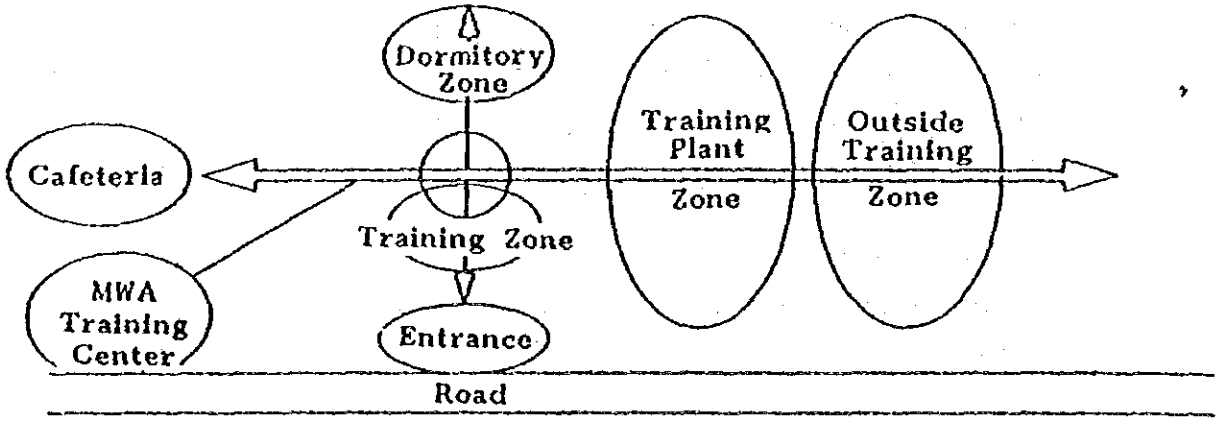
5-2 Layout Planning

CTC

The proposed site is adjacent to the existing MWA training center at the north side of the MWA Bang Khen Purification Plant. The site is rectangular in shape, extending 185 m in the east-west direction and 84 m in the north-south direction. It is along the plant's northern boundary, next to a discharge channel for storm water and facing an on-site road (9 m wide) on the south. The site is approximately 200 m from the main gate of the plant, which is checked by security guards.

The primary facilities to be constructed at the site can be classified into four zones: a) training zone, b) dormitory zone, c) training plant zone, and d) outside training zone.

The basic concept of the facilities planning is based on two circulation axes intersecting each other: a north-south axis (I) consisting of entrance - training zone - dormitory zone, and an east-west axis (II) consisting of training zone - training plant zone - outside training zone.



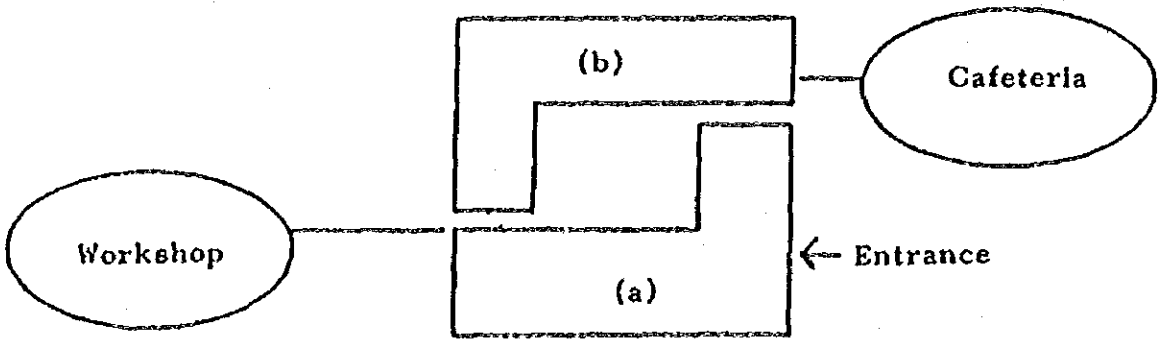
The east-west axis will be connected to the MWA training center via the cafeteria, for convenience of the instructors.

RTC

The Chiang Mai RTC will be constructed within the Umong Purification Plant operated by the Chiang Mai Regional Office. The proposed site is located along a reservoir (1 km in perimeter), with mountains at the back providing beautiful scenery.

The proposed site for the Khon Kaen RTC is located on flat land within the Nong Waeng Purification Plant, which is the closest plant to the city among those operated by the Khon Kaen Regional Office. The site is directly accessible from the front road of the plant.

Both RTCs will be smaller in facility scale than the CTC, and will consist of a) training building, b) dormitory, c) workshop, and d) cafeteria. To arrange the facilities as efficiently as possible, the training building and dormitory will be connected, sharing common spaces where possible, with the cafeteria and workshop to be arranged between them.



5-3 Facilities Planning and Scale

The facilities at the CTC and RTCs should be planned to differentiate roles of each center clearly and to reflect the training courses and scale. For the CTC, facilities should be designed in consideration of its function as a national training center and of the need for efficient investment. For these reasons, its training plants will be designed to have sufficient quality and quantity.

For the RTCs, lectures will be a main part of the training, because basic training courses on fundamental waterworks technology appear to be needed. Practical training will mainly be conducted by instructors who are educated at the CTC, using course materials. For this purpose, audio/visual rooms will be designed at the CTC level. Because both centers (Chiang Mai and Khon Kaen) have similar training courses, their facilities will be planned with the same quality and quantity.

1) Scale of CTC Facilities

1-1 Training Building

No.	Room Name	No. of rooms	Floor area per unit (m^2)	Designed floor area (m^2)	General requirements
1	Lecture room	7	56	392	For 30-35 trainees ($1.6-1.8m^2$/person) Course A: 3 rooms Course B: 3 rooms Reserve : 1 room
2	Audio/Visual room	1		112	Also used as a lecture Rm (50 trainees) Including control, storage and staff room ($28m^2$)
3	Drafting room	1		84	Equipped with 25 drafting table A-1 size
4	Water quality examination room	1		168	Chemistry Lab. : $56m^2$ Biology Lab. : $56m^2$ Preparation room : $20m^2$ Instructor's room: $36m^2$
5	Computer training room	1		84	Lecture room: $56m^2$ Computer traiing room : $28m^2$
6	Instrumentation room	1		84	Instrumentation training room (25 person) : $56m^2$ Equipment room : $14m^2$ Instructor's room: $14m^2$
7	Team leader's office	1		28	One person, including a reception space
8	Expert's office	1		56	5 persons $11.2m^2$/person
9	Instructor's office	1		112	12 persons $9.3m^2$/person
10	Seminar room	1		84	For 30 persons: $28m^2$ x 3 (can be used as separate rooms)

11	Library	1	56	Reading room for 15 persons: 28m^2 Book room: 28m^2, 5,000 books (178 books/m^2)
12	Secretary General's Office	1	28	One person w/lavatory
13	Deputy Secretary General's Office	1	28	One person w/lavatory
14	Director's office	1	28	One person, including a reception space w/lavatory
15	Meeting room	1	28	For 15 persons (1.8m^2/persons)
16	Administration office	1	112	22 persons (5m^2/person)
17	Document storage	1	28	
18	Printing room	1	28	
	Sub-total		1,540	
19	Common spaces		795	Including corridors, stairs, hall and Lavatories (51% of the sub-total)
Total for training building			2,335 m^2	

1-2 Dormitory

1	Bedrooms	15	32	480	Total capacity of 60 persons (4 persons/room); To accommodate 50 persons, or 1/3 of the trainees in course A per session (called from other regions), plus 10 persons in other categories.
2	Washroom, Shower room, Laundry and Lavatory			129	
3	Linen storage			64	
	Sub-total			673	
4.	Common spaces			371	Including corridors, stairs and hall (55% of the sub-total)
	Total for dormitory			1,044 m^2	

1-3 Workshop

1	Mechanical workshop	1		192
2	Electrical workshop	1		96
3	Lecture room	1		32
4	Training staff office	1		32
5	Tool storage	1		32
6	Locker/shower room	1		28
	Total for workshop			412 m^2

1-4 Pump Operation Training Building

1	Pump operation room	1	160	
2	Electric room	1	64	
3	Piping room	1	48	
	Total for pump operatin training building		272 m^2	

1-5 Garage and Storage

1	Garage	1	75	
2	Storage	1	75	
	Total for garage and storage		150 m^2	

1-6 Others

1	Cafeteria	1	230	To serve 250 persons two serving times) 125 persons x 1.2m^2 = 150m^2 Kitchen: 50m^2, Lavatory
2	Covered way	1	100	2m x 50m
	Total for others		330 m^2	
	Total floor area for CIC		4,543 m^2	

2) Scale of RTC Facilities (Each Center)

2-1 Training Building

No.	Room Name	No. of rooms	Floor area per unit (m^2)	Designed floor area (m^2)	General requirements
1	Lecture room	2	56	112	For 30-35 trainees ($1.6-1.8m^2$/person) Either of two rooms will be reserved
2	Audio/Visual room	1		112	Also used as a lecture room (50 trainees) Control room: $14m^2$ Staff room : $14m^2$
3	Water quality examination room	1		84	Chemistry Lab.: $28m^2$ Biology Lab. : $28m^2$ Equipment room: $28m^2$ (use as preparation room)
4	Instructor's office	1		28	For 3 persons ($9.3m^2$/person)
5	Director's office	1		28	One person, including a reception space
6	Meeting room	1		28	For 15 persons ($1.8m^2$/person)
7	Administration office	1		28	For 5 persons ($5.6m^2$/person)
8	Printing room/storage	1		28	
	Sub-total			448	
9	Common spaces			202	Including corridors, stairs, halls (45% of the sub-total)
	Total for training building			650 m^2	

2-2 Dormitory

1	Bed rooms	8	32	256	Accommodating 32 persons (8 four-bed rooms), or 64% of the max. number of trainees per session.
2	Washroom, shower room, laundry and lavatory	1		110	
3	Linen storage	1		32	
4	Corridors, stairs and halls	1		218	
	Total for dormitory			616 m^2	

2-3 Workshop

1	Workshop	1		96	
2	Staff room	1		32	For 3 persons
3	Tool storage			16	
4	Locker/shower room			16	
	Total for workshop			160 m^2	

2-4 Garage

48 m^2

2-5 Others

Chiang mai	120 m^2	Cafeteria: 96m^2 (for 50 persons)
Khon kaen	162 m^2	Covered way Chiang mai: 24m^2 Khon kaen : 66m^2

Total floor area for each RTC	Chiang mai	1,594 m^2
	Khon kaen	1,636 m^2

Total Floor Area in Major Facilities

Building name	CTC (m^2)	RTC (Chiang Mai) (m^2)	RTC (Khon Kaen) (m^2)	
Training building	2,335	650	650	
Dormitory	1,044	616	616	
Workshop	412	160	160	
Pump operation training building	272	-	-	
Garage and storage	150	48	48	
Others	330	120	162	Total
Total	4,543	1,594	1,636	7,773

5-4 Building Element Planning

In architectural element planning, the local climate conditions and the operation/maintenance plan are determinant factors. For this project, it is important to adopt maintenance-free features in each element of the proposed facilities so as to minimize maintenance/operating costs after completion. At the same time, due consideration must be given to the impact of the high temperature/humidity climate at the sites, particularly in terms of sunlight, ventilation, and rainfall.

1) Roofs

Roofs are most severely affected by sunlight and rainfall, and so require that the highest priority be given to their maintenance-free and durability aspects. Roofing structures generally found in the country are of wooden frame on the top, with corrugated asbestos cement sheets forming the slopes. This structure is selected for cost saving purposes. However, the asbestos sheets are not very durable under severe climatic conditions, being subject to weathering only 10-15 years after installation. For the proposed facilities, therefore, the asbestos sheets will be used as roof covers for heat insulation purposes, with concrete slabs used as the primary roofing materials.

2) Exterior walls

In consideration of the sunshine conditions and the ease of natural ventilation provided by prevailing winds, the buildings in the centers will be arranged lengthwise in an east-west direction, with windows installed on the south and north sides. No openings will be provided on the side walls (east and west sides), each of which will have a double wall structure with air conditioning in between. Openings on the north and south sides will be provided with eaves or sun shield louvers to prevent direct sunlight from coming into the interior spaces.

Exterior walls will be finished with paints that are carefully selected to prevent fading or moss growing (due to the high temperature/humidity). They will be combined with exposed concrete, concrete block and washed terrazzo finishes.

3) Floor

Corridors in the facilities will be planned as open structures, into which squalls will blow. Thus, details of the entrances to rooms should be designed to prevent rain water from entering the rooms. Also, care should be taken to prevent the sputtering of rain water dripped from the roof. The level of the first floor should be determined in consideration of post maximum water levels.

5-5 Material Planning

1) Because the proposed facilities will be used by a number of people, construction materials should be selected to create functional and durable spaces.

Also, priority should be given to materials that will ensure early construction, low construction costs, and low operating/maintenance costs.

2) Criteria for selecting construction materials

High durability: materials which will withstand long-term use without deformation, distortion, discoloration, or deterioration.
Locally produced materials: encouraging of local industries, ease of construction by local skilled labourers, and ease of maintenance and procurement.
High safety factor: fire-proof, water-resistant, and water-proof materials where required.

3) Materials plan

(1) Structural materials (major structural parts)
Column, beam, floor, and stair: reinforced concrete
Walls: concrete blocks or bricks

(2) Exterior finish materials

Roofs:	double structure using heat insulation materials
Exterior finish:	washed terrazzo, exposed concrete, concrete blocks
Fixtures:	aluminum or wood
Eaves:	concrete panels or asbestos sheet

(3) Interior finish materials (major rooms)

a) Lecture room

Floor:	PVC tile
Wall:	paint
Ceiling:	sound-absorbing board

b) Training room

Floor:	PVC tile
Wall:	paint
Ceiling:	sound-absorbing board

c) Audio/visual room

Floor:	PVC sheet
Wall:	sound-absorbing board
Ceiling:	sound-absorbing board

d) Meeting room

Floor:	PVC tile
Wall:	paint
Ceiling:	sound-absorbing board or other materials

e) Hall

Floor:	washed aggregate
Wall:	washed terrazzo
Ceiling:	wood

f) Administration office

Floor:	PVC tile
Wall:	paint
Ceiling:	sound-absorbing board

g) Bedroom:

Floor:	PVC sheet
Wall:	paint
Ceiling:	paint on gypsum board

h) Workshop

Floor:	monolithic finished concrete
Wall:	paint
Ceiling:	exposed structure frame

5-6 Structural Planning

Structural planning for the centers will be based on the following policies:

1) Buildings will be of rigid structure, in consideration of their public uses.

2) Because an earthquake or typhoon seldom strikes, very little horizontal force is expected to work on the building. Therefore, the structural body of the proposed buildings will be a type that supports against vertical load (both dead and live loads).

3) In consideration of localities, the buildings will have simple and articulated structures, as far as possible.

4) Building materials will be selected in accordance with the supplying capacity, qualities, and ease of construction of locally produced materials.

5) The buildings will be made as economical as possible.

5-6-1 Building Codes and Structural Design Standards

In Thailand, building design is regulated by the Building Bye-Laws of the Bangkok Metropolis, and building materials are regulated by the Thai Industrial Standards. The Building Bye-Laws provides for external forces and their combination, and for allowable and maximum stresses on structural materials. In addition, there are various structural design standards (similar to the ACI Building Code with regard to reinforced concrete structure, and to the AISC Code with regard to steel structure). The proposed buildings in all of the centers will be designed in accordance with the Building Bye-Laws in regard to external forces (including wind and live loads), and with the ACI Building Code in regard to the calculation of stress and the design of structural member sections. In addition, the applicable structural design standards of Japan will be used where necessary.

5-6-2 External Forces and Loads

The following loads will be considered as external forces working on the buildings (excluding seismic forces).

1) Dead load

Loads from structural and finish materials, as well as from other permanent materials for the buildings, will be determined.

2) Live load

Live loads specified in the Building Bye-Laws will be used as design loads, supplemented by the Building Standard law of Japan.

Room Name	Live Load (kg/m^2)
Lecture room	300
Laboratory	400
Administration/meeting room	300
Workshop	500
Bed room	200
Roof	50

Live loads from transformers and other heavy equipment will be considered separately.

3) Wind load

Wind load will be calculated as the product of the shape coefficient and the velocity pressure. The shape coefficients for the facilities will be obtained from the Building Standard Law of Japan, and the velocity pressures will be obtained from the Building Bye-Laws of the Bangkok Metropolis, as follows.

Building hight	Max. wind velocity pressure (Kg/m^2)
Less than 10m	50
10m - 20m	80
20m - 40m	120
Over 40m	160

4) Earth and water pressures

These will be considered in the design of water tanks and underground structures, where applicable.

5-6-3 Upper Structures

Upper structures for the facilities will be of reinforced concrete and concrete block, which is widely used in the country and very economical. Roofs over rooms that require large column spans for functional purposes will be supported by steel trusses.

The exterior and interior walls do not need to be shear-walls, and so will be of concrete block.

The columns will be appropriately arranged to support vertical loads with even spacing in order to simplify the building structures.

Building	Structure type	Basic column span
Training building	RC structure	4.00 m x 7.00 m
Dormitory	RC structure Concrete block Structure	3.20 m x 6.50 m
Workshop	RC structure for columns	4.00 m x 14.00 m (CTC)
	Steel structure for roofs	4.00 m x 8.00 m (RTC)

5-6-4 Foundation Structures

Because the proposed site for CTC and its surrounding area are located on very poor ground, the buildings and training plants will be supported by PC piles. Also, because the existing water level is high and land settling is continuing at an annual rate of 5 cm, the impact of settling on auxiliary facilities must be taken into consideration.

The proposed sites for both RTCs are located on relatively tight ground, so that the buildings and other structures will be supported directly by the soil bearing power of the ground. However, if the soil surveys reveal deficiencies in bearing strength or spots with a high tendency to settle, pile foundations will be considered.

5-6-5 Structural Materials

Most ordinary structural materials are available in Thailand, except for steel products (prices are higher than in Japan because the raw materials have to be imported). Structural materials for the facilities will be planned in consideration of supplying capacity, quality, workability, and price, as follows:

1) Concrete

Locally produced ready-mixed concrete or mixed-in-place concrete will be used. Because the concrete will be mixed and placed under high temperatures, appropriate provisions should be made for material selection, proportioning, mixing, transportation, placing, and curing.

Type:	Normal weight concrete
Design strength:	210 kg/cm^2
Slump:	Around 10 cm
Cement:	Normal type
Fine aggregate:	River or mountain sand
Coarse aggregate:	Crushed stones (20 mm at maximum) or pebbles

2) Reinforcing bars

Reinforcing bars manufactured in Thailand in accordance with ASTM or JIS will be used. However, if these reinforcing bars are found to be in short supply or of high price, bars manufactured in Japan will be used. Thus, reinforcement design will accommodate both types.

Manufactured in Thailand	SD 30:	10 mm, 12 mm
	SD 40:	16 mm, 20 mm, 25 mm, 28 mm
Manufactured in Japan	SD 30:	10 mm, 13 mm
	SD 40:	16 mm, 19 mm, 22 mm, 25 mm, 29 mm

3) Structural steel

Lightweight steel gauge will be manufactured locally, including material adjustment. Heavyweight steel gauge, although locally available, will be fabricated in Japan to assure the required quality and construction period. All will be erected on site.

4) Pile

In Thailand, concrete piles of various sectional forms are manufactured. Because the maximum length of the piles is 25 m, they can be transported and driven without joints. In this project, double-half-moon piles (which have efficient end bearing capacity and skin friction) will be used for CTC.

5-7 Mechanical Planning

Mechanical systems for the proposed facilities will be planned in accordance with the following principles:

1) To ensure coordination with the architectural planning.
2) To fit environmental conditions in Thailand and site-specific requirements.

3) To select systems and equipment types that provide easy maintenance and inspection.

4) To minimize operating/maintenance costs.

5-7-1 Air Conditioning and Ventilation System

For the proposed facilities, natural ventilation will be used as far as possible to minimize operating costs. Because Thailand is located in a tropical zone and receives a large amount of solar heat, eaves and louvers will be provided in the architectural planning to minimize heat and to allow natural ventilation.

Air conditioning systems and equipment will be selected for easy operation, maintenance, and inspection, as well as for low operating costs.

1) Air conditioning system

For the CTC and RTCs, air conditioning systems will be installed only in rooms that require particular temperature and humidity, as listed below:

CTC: Audio/visual room, computer training room, drafting room, water quality examination room, instrumentation room, expert's office, seminar room, library, secretary general's room, deputy secretary general's room, director's office, meeting room, administration office, team leader's office, counterparts' office, and instructions' office

RTCs: Audio/visual room and water quality examination room

The systems will consist of independent units to allow separate operation in each room to save operation cost. Air cooling type package systems will be used for large rooms, and separate wind type cooler systems for small rooms.

2) Design criteria for air conditioning system

The following design criteria will be used for both the CTC and the RTCs:

Exterior design criteria ..... Temperature of 36°C and Humidity of 75%
Interior design criteria ..... 26°C ± 2°C and 55% ± 10%

3) Ventilation system

Forced ventilation systems will be installed in laboratories, lavatories, kitchens, storage, and printing room to remove gas, odors and moisture.

4) Ceiling fan system

Ceiling fan systems will be installed in the following rooms, which do not require air conditioning systems but do need ventilation or air convection for maintaining an appropriate environment:

CTC ..... Lecture rooms, bedrooms in dormitory
RTCs ..... None

5-7-2 Plumbing System

1) Water supply system

Method ..... Appropriate water supply can be provided for the CTC and RTCs because of their locations within purification plants. Because water will be supplied directly through pipes from the plants to the sites, water pressures can be maintained above 2 kg/cm^2. Also, maintenance will be simple because the buildings will be only one or two stories high. Connection will be made directly from water mains to faucets in each building.

Equipment ... Faucets will be provided with discharge spaces of more than 10 cm to prevent used water from flowing backward to water mains by negative inner pressure.

Amount of water supply and number of consumers:

CTC ..... Number of consumers ..... 300 persons
Amount to be supplied ..... 66 m^3/day
RTCs ..... Number of consumers ..... 75 persons
Amount to be supplied ..... 22 m^3/day

2) Drainage system

Water drainage systems will have separate flow systems for sewage, general wastewater, rain water, and effluent from laboratories. Appropriate pollution control measures will be provided for the CTC (which is located near the Bang Khen Purification Plant) and for the Chiang Mai RTC (which is located along a reservoir).

Sewer system ..... Sewage will be discharged to septic tanks for treatment, and then discharged into open ditches near the sites.

General wastewater and rain water ..... General wastewater, as well as rain water, will join the treated sewage outside the plant. All will then be discharged into the open ditches.

Effluent from laboratories ..... Effluent from laboratories, containing both acids and alkalis, will be diluted and neutralized in neutralization tanks, and then will join the general wastewater to be discharged into the open ditches.

3) Sanitary fixture

Sanitary fixtures will be provided in lavatories, wash rooms, and laboratories. Toilet stools will mainly be of local types, with some western types. Flushing systems will be of low or high tank type, rather than the flush valve type (which might cause backward flow to water mains because of its direct connection).

4) Sewage treatment system

CTC .... Number of users ..... 300 persons
Treatment system .... FRP-made long-time aeration system will be employed because a relatively large number of users will be involved, because the aeration blowers and pumps can easily be maintained and repaired, and because of the site's proximity to Bangkok.
Water quality after treatment .... BOD 90 PPM

RTCs ... Number of users ..... 75 persons
Treatment systems ... Primary treatment systems will be used in consideration of the relatively small number of users and the ease of maintenance.
Water quality after treatment .... BOD 90 PPM

5) Gas supply system

Because a small amount of special gases (LPG, hydrogen, oxygen, and nitrogen) will be used in the laboratories, small cylinders will be brought into the laboratories.

5-8 Electrical Planning

1) Power receiving/transformation/distribution systems

(1) Power receiving/transformation systems

a. Power receiving

Power lines for the CTC and RTCs will be branched from existing transmission lines along the front roads.

Receiving voltages

	3 Phases 3 Lines	6.6 kV	50 Hz
RTC (Chiang Mai)	3 Phases 3 Lines	22 kV	50 Hz
	(to be upgraded from 11kV to 22 kV)		
RTC (Khon Kaen)	3 Phases 3 Lines	22 kV	50 Hz

b. Power transformation/distribution systems

The transformers will be installed outside the facilities, with low voltage distribution panels installed inside the buildings. Low voltage lines for the CTC will be divided into five systems: training building, workshop, dormitory, cafeteria, and training plant (mainly for pumps).

Major loads will be as follows:

a) Lighting and outlets
b) Air conditioning and ventilation systems
c) Water supply and drainage systems
d) Training plants

(2) Telephone exchange system

a. Line leading

Judging from the facility sizes at the centers, the number of telephone lines will be as follows:

CTC	3 Lines
RTC (Chiang Mai)	1 Line
RTC (Khon Kaen)	1 Line

All of the lines will be led in from existing lines along the front roads of the sites.

b. Telephone exchange systems

For both the CTC and the RTCs, push button telephones will be installed, because they have economical and simple operation/maintenance.

2) General electric system

(1) Main power system

Power distribution systems for air conditioning, ventilation, plumbing, training equipment/materials, and lighting, etc. will be installed with the following voltages:

a) Lighting and outlets 3 Phases 4 Lines 380 V/220 V
b) Air conditioning, ventilation, and plumbing
3 Phases 3 Lines 380 V
c) Training plant 3 Phases 4 Lines 380 V/220 V

(2) Lighting fixture

a. Lighting sources and fixture

High efficiency fixture will be employed to reduce operating costs (mainly fluorescent-type with direct installation)

Lighting sources for major areas will be as follows:

Fluorescent lamps:
administration office, meeting room, lecture rooms, and laboratories
Incandescent lamps:
halls and bedrooms

Circuits will be divided for each room to allow separate turning on and off (for cost savings).

b. Planned luminous intensity

Luminous intensities in rooms and common spaces will be set in accordance with TIS (Thai Industrial Standards), as follows:

Administration office and meeting room	350 - 450 lx
Lecture rooms and laboratories	300 - 350 lx
Corridor and hall	100 - 150 lx

(3) Fire alarm system

Because many people use CTC throughout the year, there is a high risk of fire in the facilities. To enable immediate fire fighting activities, fire alarm systems will be provided for only CTC. The fire bells can be rung by pressing a button. This indicates the location of the fire on an indication panel installed in the administration office of CTC.

(4) Community TV antennas

Main antennas will be installed on the roofs, and will be connected to outlets in the audio/visual room.

5-9 Training Plant

1. Objectives

The major features of the project are simulated waterworks facilities for practical training, training buildings, and equipment. These facilities were requested by Thai side, and their usefulness was verified by the study team.

Waterworks start by taking in water from rivers, which goes through the intake facility - raw water facility - treatment facility - transmission facility - distribution facility before reaching consumers. In this project, (1) mini purification plant (treatment facility), (2) pump operation training plant (part of the intake and distribution facilities), and (3) leakage survey training yard (distribution facility) will be constructed to simulate the above process. These facilities constitute a main part of any waterworks, and are therefore the most important for technical training. The objectives of each facility are as follows.

(1) Mini Purification Plant

The purification plants in Thailand are operated and maintained by local staffs who do not have sufficient knowledge about waterworks and/or are not trained to carry out their work properly. As a result, water produced by the purification plants is not always safe for drinking.

Real waterworks cannot be established without treating water properly. Thus, the training plants to be constructed under the project are expected to provide trainees with the opportunity to experience the appropriate purification process at an actual plant.

(2) Pump Operation Training Plant

Without exception, waterworks require pumping equipment to obtain and transport water. Because the operation and maintenance of pumps are primary techniques for operating staffs to learn, the pump operation training plant will be constructed to provide practical training.

Pumps that are generally installed in water supply facilities can be classified as follows:

i) To pump up river water to purification plants
... Intake pump

ii) To distribute purified water to consumers
... Distribution pump

iii) To wash filters at purification plants
... Wash pump

iv) To perform other functions at purification plants
... Miscellaneous pumps

For this training plant, distribution pumps are selected. By understanding the operation of this type of pump, trainees can apply the knowledge to other pump types.

(3) Leakage Survey Training Yard

In Bangkok, only one half of the water produced reaches consumers to accrue water charges. (This is called the effective collection ratio. The ratio in Bangkok is 50%, while it is 80% in Japan.) This low ratio is mainly attributable to leakage from distribution pipes. Because improvement of the effective collection ratio is an urgent task for MWA and PWA, their staffs must be properly trained to understand basic leakage survey techniques (to find out how much water is leaking, where, and how the leakage can be repaired.) Because there is no leakage survey training facility in Thailand, the one constructed under this project will be the first.

5-9-2 Facility Scale

Because the proposed plants are used for practical training, they are necessarily not too large in scale. At the same time, they must not be so small as to be inappropriate for simulated training. Scales of the plants are established as follows:

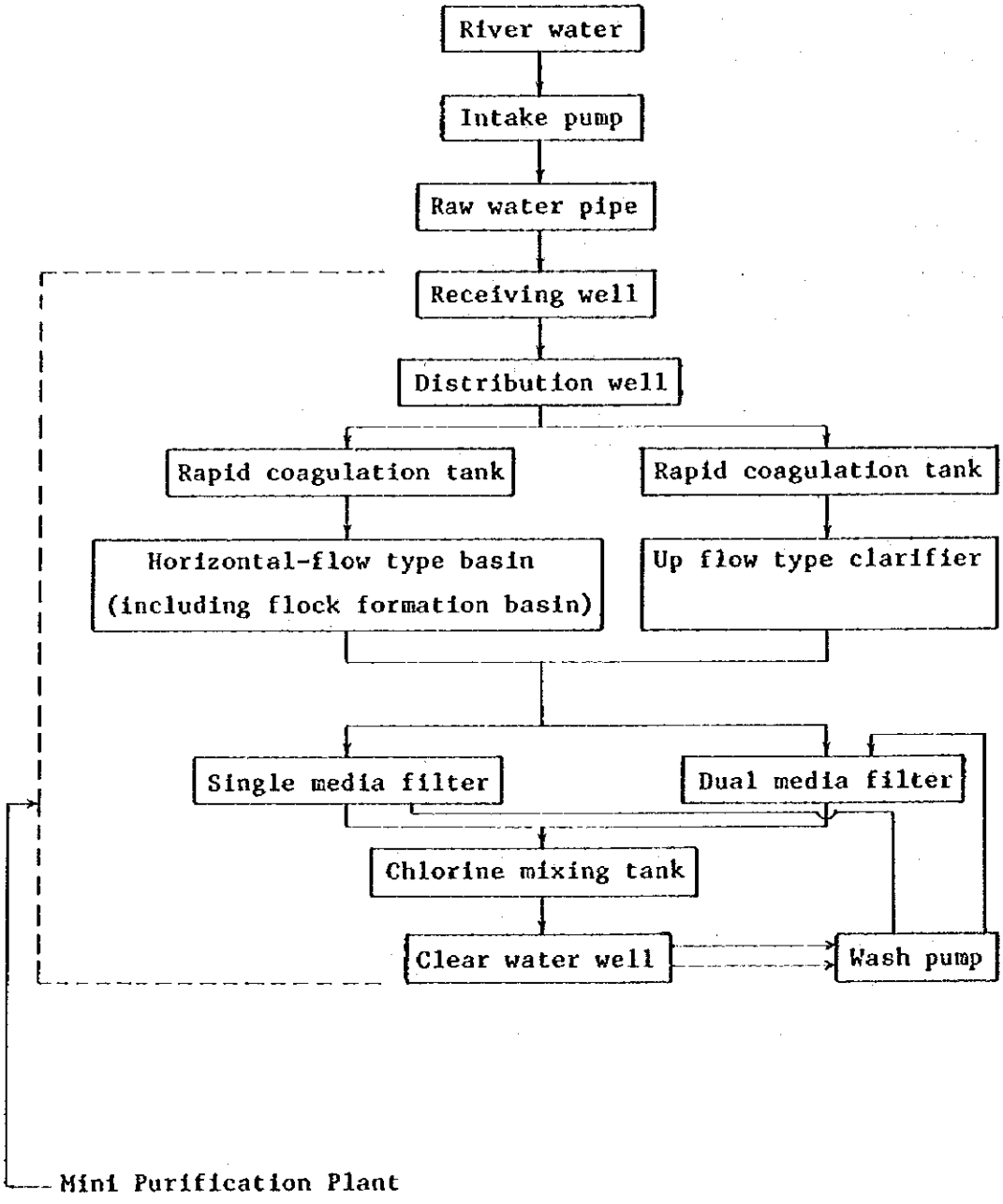
(1) Mini Training Plant

The Thai side requested the plant to have a capacity of 300 m^3/day. Because there are few purification plants of this size in Japan having rapid filters, the study team attempted to design a smaller plant to provide 100 m^3/day. It found that such a small plant cannot be constructed of RC, and therefore is not appropriate for training. The study team scaled up the plant size to 200 m^3/day, which again proved to be too small for adequate training. Finally, the team concluded that 300 m^3/day would be a reasonable capacity for training.

(Note 1) Although Japanese manufacturers make small purification plants of 50 m^3 - 100 m^3/day, they are made of steel plate, different from purification plants in Thailand (which are of RC structure). Moreover, the water producing system used in these plants is different from the one in Thailand. For these reasons, the study team concluded that these plants are not appropriate for training purposes.

(Note 2) MWA's purification plants in operation have a capacity of 1,000,000 m^3/day, and PWA's plants have a capacity ranging from 1,000 m^3/day to 20,000 - 30,000 m^3/day.

Flow Diagram for Mini Purification Plant



Like other purification plants, it is designed with a reinforced concrete structure. Each facility is exposed above ground to provide better identification of its shape, and has ample space around it for ease of observation and operation. The overall structure is about 10.0 m wide, 30.0 m long, and 4.6 m high, and contains all the purification facilities (receiving well, coagulation basin, sedimentation basin, filters, clear water well, chemical equipment, backwash pump, surface wash pump, air blower, and central control panel). Two types of sedimentation basin will be installed: an up-flow type clarifier (which is used in MWA's purification plants), and a horizontal-flow type basin (which is used in PWA's purification plants). Two types of filters will be provided for convenience of training: dual media filter (anthracite and sand) with air washing, and single media filter (sand only) with surface washing. In addition, the plant is designed to allow training with various types of coagulation chemicals.

(2) Pump Operation Training Plant

The plant will be operated under a recycling system, through which clear water in a suction well will be pumped to an elevated tank then come back to the suction well by gravity. The plant consists of a suction well, an elevated tank, a pump house, piping room, and an electric equipment room.

Among the many pump types available, volute pumps (double and single suction volute pumps) are selected because of their high versatility and wide use in Thailand. As for motors, a constant rate type is selected, as well as variable speed control types (which are currently used in Thailand), for the next phase of extension of water works.

Three horizontal pumps will be installed; one fixed rate pump and two speed control system pumps of different characteristics. At the same time, the pumps are classified into two types; one single suction volute and two double suction volute pumps.

The capacity of the pumps is set at 1 m^3/min, which is the typical capacity used in PWA's small water supply facilities. These pumps will be used in the training for leakage survey, because their capacities are suitable for the purpose. Finally, heads are to be set at 35 m, smaller than the actual ones (50 - 60 m), for convenience of the leakage survey training.

Delivery pipes to tank (pump to elevated tank) will be equipped with pressure gauges, flow meters (a venturi meter and a magnetic flow meter), control valves, stop valves and other devices required for controlling operation. The pipes will be accommodated in piping room for ease of training.

Next to the pump room, an electric equipment room will be provided to allow practical training on power receiving, transformation and distribution.

(3) Leakage Survey Training Yard

Training in this facility can be roughly classified into the following two items:

(1) to determine an amount of leakage
(2) to locate leakages in a pipeline

In this training yard, a meter pit will be installed to allow trainees to measure the amount of water supply in easier ways. Piping in the yard can be separated into two blocks, and in each of which leakage survey can be conducted.

To locate leakages, piping routes and valves must be located at first. In this yard, metallic and nonmetallic pipes are installed in various combination. Also, piping is so arranged as to allow trainees to locate buried valves. Throughout the buried pipes, eight leakage points are set up to allow trainees to identify leakage by noise, particularly differentiation of noises varied with water pressure, amount of leakage and type of pipe.

In addition, piping is designed with the following consideration:

(1) To prevent noise from occurring in valves which cannot be closed completely (frequently caused by pebbles and other foreign matters sucked into valves), pipes are arranged in such way to allow washing from two directions.

(2) Air valves will be installed at appropriate points to permit air discharge from pipes.

(3) Drain pipes will be installed to catch water from leakage points.

The maximum diameter of distribution pipes buried in the yard is 150 mm, which is a typical size for pipes buried in city areas. Four types of pipe that are used in Thailand are selected: ductile cast iron pipes (DIP), steel pipes (SP), galvanized iron pipes (GP), asbestos cement pipes (ACP), and vinyl pipes (VP).

The minimum size of the yard will be 40 m x 40 m in consideration of the minimum spacing of pipes (4.0 m), the flow meter room, the burying of various pipes, and the need for dividing distribution areas into blocks.

General List of Training Equipment and Training Courses

Name of Equipment	Room Name	Training Courses
Drawing Equipment	Drafting Rm.	Water Supply Training (A-1)
Audio Visual Equipment	Audio Visual Rm.	Whole Courses
Laboratory Equipment	Water Quality Examin. Rm.	Water Purification & Sanitation (A-3)
Mechanical Equipment	Workshop	Pipeline Maintenance (A-4)
		Management Workshop (B-7)
		Water Pipe Rapair & Modifications (B-19)
		Mechanical Workshop Practice I.II (B-24.25)
Electrical Equipment	Workshop	Management Workshop (B-7)
		Electrical Workshop Practice I.II (B-22.23)
Instrumentation Equipment	Instrumentation Rm.	Mechanical & Electrical Installation (A-5)
		Pneumatic Process Instrumentation (B-26)
		Process Instrumentation Theory & Practice (measurement) (B-27)
		(Control) (B-28)
Leakage Survey Equipment	Leakage Survey Training Yard	Pipeline Maintenance (A-4)
		Leakage Water Inspection (B-14.15.16)
Personal Computer	Computer Examin. Rm.	Introduction to Computer (B-33) and others
Printing Equipment	Printing Rm.	Product of Text

5-10 Training Equipment

Training equipment required for the centers, as shown in the Appendix, will be carefully selected by studying the needs of the training courses specified in Section 3-3. In addition, the following points will be considered in relation to the maintenance, inspection, and operation of the equipment.

1) The equipment should correspond to the equipment standards used by MWA and PWA, in order to facilitate practical application after training.

2) The equipment should be suitable for training courses by achieving effective results.

3) The equipment should be easy to operate and maintain, with low running costs. It should be maintained and repaired in Thailand.

4) The equipment should be supplied in the minimum required quantities by arranging training courses and class rooms to assure efficient use.

Note: The general list of the equipment on the left page shows the relationship between training courses and equipment.