

JAPAN INTERNATIONAL COOPERATION AGENCY

**Final Evaluation Study on
Mini-Project-Type Technical Cooperation for
Improvement of Water Analysis Technique for Wastewater
Treatment Work's Reinforcement**

Prepared by

MACRO CONSULTANTS CO., LTD.

May 1995

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1. Introduction

1.1 Background

In Thailand, the water pollution problem has become one of the major issues in the society. Domestic wastewater discharge in the community plays a significant role in deteriorating the water quality of public water bodies. Public Works Department is one of the active governmental agencies providing solutions to the problem of wastewater management systems throughout the country except Bangkok Metropolis. The first municipal wastewater treatment plant (WWTP) under the initiation of PWD came into operation in 1986 at Pattaya City and it still provides the treatment service to Pattaya community with a daily capacity about 8,000 cubic meters. At present, 10 WWTPs are actively operated, 6 WWTPs are under construction, and 21 projects are to be constructed in the 1995 Fiscal Year. At the same time, efficient operation and maintenance is also essential for the management of the treatment facilities successfully. To this regard, PWD requested a technical cooperation project from Japan International Cooperation Agency in 1991. From November 1991, PWD received financial and technical supports from JICA for a 3-year project of "Mini-Project-Type Technical Cooperation for Improvement of Water Analysis Technique for Wastewater Treatment Work's Reinforcement". The project specifically concentrated on the efficiency improvement of operation and maintenance as well as water quality analysis related to the wastewater treatment facilities.

After completion of the Mini-Project, JICA engages Macro Consultants Co., Ltd (the Consultant) to conduct a final evaluation study on the output and achievement of the project.

1.2 Objectives and Scope of Study

The main objective of the study is to verify the achievement of technical improvements on operation, maintenance and water quality analysis of wastewater treatment plant for PWD's operating staff involved in the Mini-Project. The study will also include the potential of JICA to provide additional support related to the project to PWD.

The scope of the study comprises :

- 1) The study of background information regarding the Mini-Project.
- 2) Interview study and field visit for PWD's staff and operating personnel of WWTP in 5 regional cities.
- 3) Compilation of data, final evaluation as well as conclusion and recommendation.

1.3 Composition of the Study Report

Duration of the evaluation study covers about one month from February 24-March 27, 1995 This evaluation report consists in series of the following topics :

- Details of the Mini-Project
- Project site visits and interview study of the concerned authorities and staff.
- Evaluation study of the collected data and obtained information.
- Conclusion and recommendations

2. Project Outline

2.1 Project Description

Under the mutual agreement on technical cooperation between the Government of Japan and the Government of Thailand signed on November 5, 1981, JICA provided the financial and technical assistance to PWD as part of "Mini-Project-Type Technical Cooperation on Improvement of Water Quality Analysis Technique for Wastewater Treatment Work's Reinforcement." Duration of the project covered 3 years from November 1, 1991 to October 31, 1994. The project activity sites included Bangkok (PWD's Water Quality Analysis Laboratory) and WWTPs in 5 regional cities, i.e. Pattaya, Hua Hin, Phuket, Nakornrachasima and Khon Kaen.

2.2 Objectives of Project

- 1) To improve the efficiency of water quality analysis related to wastewater treatment works.
- 2) To increase the effectiveness of application of water analysis data to the operation and maintenance (O & M) of wastewater treatment plants.
- 3) To improve O & M practices of wastewater treatment plants.
- 4) To prepare a tentative guideline for the O & M of wastewater treatment plants.
- 5) To improve the technical skill of engineers who will provide technical support for local governments.

2.3 Project Responsibilities

Both the Governments of Japan and Thailand share their responsibilities for implementing the project through the normal procedures under its Technical Cooperation Scheme in accordance with the laws and regulations stipulated in corresponding country.

2.3.1 The Government of Japan

(1) Dispatch of Japanese Experts

JICA will provide at its own expense the long-term and short-term Japanese experts for the purpose of technical cooperation in the following fields of specialization :

- Long-term - Chemical engineering
- Short-term - Wastewater treatment works engineering
- Environmental science/engineering
- Chemical engineering
- Mechanical engineering

Followings are the listings of Japanese experts involved in the Mini-Project :

Expert Names	Long/ Short Term	Field of Specialization	Duration in Thailand
1 Mr. Eiichi Nakamura Director, Sewerage Planning Division, Public Works Department Shiga Prefectural Government	Short Term (Team Leader)	Wastewater Engineering	Nov. 1-Dec.17, 1992 and Nov. 24-Dec.3, 1993
2 Mr. Koya Komori Researcher, Water Quality Division, Water Quality Control Department, Public Works Research Institute, Ministry of Construction	Long Term	Chemical Engineering	Jan.3,1992-Jan.7 1994
3 Mr.Masayuki Nagamochi JICA Expert, MRD/PWD Section Chief for Industrial Waste- water Control Western Area Office Sewage Works Bureau, Osaka Municipal Government	Long Term	Sanitary Engineering	Oct.28,1993-Oct.27 1994
4 Mr.Hideaki Katayama Staff Engineer, Planning Division, Construction Department Sewage Works Bureau, Osaka Municipal Government	Short Term	Mechanical Engineering	Feb 25-Mar 19 1994 and Aug.21- Sept.3, 1994
5 Mr.Hiroaki Tanaka Chief, Water Quality Division, Water Quality Control Department Public Works Research Institute,Ministry of Construction	Short Term	Chemical Engineering	Nov 24-Dec.17, 1992 and Aug.21- Sept.3, 1994

Expert Names	Long/ Short Term	Field of Specialization	Duration in Thailand
6 Mr. Shigeo Takeda Chief, Industrial Sewage Control Section, Water Quality Control Division, System Administration Department, Sewerage Bureau, City of Nagoya	Short Term	Chemical Engineering	Nov.24-Dec.8, 1993 and Aug.21- Sept.3, 1994
7 Mr. Yukio Kawaguchi Assistant Director, Technical Assistance Division, Business Affairs Department, Japan Sewage Works Agency	Short Term	Chemical Engineering	Nov.1-Dec.17,1992 and Nov.24-Dec.8, 1993
8 Mr. Kazuyuki Ono JICA Expert, MRD/PWD Assistant Manager, Tobu Sewage Treatment Plant, System Admini- stration Department, Sewerage Bureau, City of Kitakyushu.	Short Term	Mechanical Engineering	Oct.18,1994-Mar.31 1995

Remarks Mr. Ono was appointed at the end of the Mini-Project to follow-up the completion of project.

(2) Provision of machinery, equipment and materials

JICA will provide at its own expense the following machinery equipment and other materials necessary for the project implementation :

No.	Description	Quantity
1	Equipment for water quality analysis - Atomic absorption spectrophotometer - Spectrophotometer - TOC analyzer	1 1 1
2	Glasswares for water quality analysis	
3	Equipment for data analysis - Personal computer - Printer	1 1

No	Description	Quantity
4	Experimental treatment apparatus	
	- Settling basin	1
	- Aeration tank	1
	- Aeration pump	1
	- Pump	2
5	Flow measuring tools	
	- Level gauge	1
	- Electromagnetic current meter	1
	- Recorder	1
6	Vehicle (Wagon-Type)	1
7	Other necessary machinery, equipment and materials which may be mutually agreed upon.	

(3) Training of counterpart staff in Japan

PWD's Thai staff involved in the project will receive technical training and tour visits in wastewater treatment plant operation in Japan as part of technology transfer.

2.3.2 The Government of Thailand

- 1) Provision of land and facilities
- 2) Provision of equipment and materials other than those provided by JICA under item 2.3.1(2).
- 3) Running expenses necessary for implementation of the project. (house rental of expert, secretary's salary etc.)
- 4) Assignment of counterparts at least one PWD staff to each Japanese expert.
- 5) Provision of urban transportation facilities for Japanese experts. (gasolene, repair and maintenance, driver's salary).

2.4 Project Work Plan

During the 3-year period from November 1,1991 to October 31,1994, the following activities will be performed :

Project Activities	1st year	2nd year	3rd year
1. Improvement of water quality analysis system			
1) Evaluation of the existing water quality analysis system			
2) Improvement of water quality analysis technique and technology for application of water quality analysis data			
3) Enhancement of the capability of water quality analysis facilities			
2. Improvement of O&M practices of wastewater treatment plants			
1) Evaluation of current O&M practice of wastewater treatment plants			
2) Improvement of O&M practices of wastewater treatment plants			
3) Preparation of a tentative guideline for O&M practices of wastewater treatment plants			

3. Interview Study and Site Visits

During the course of evaluation study, the Consultant carried out interviews with PWD counterparts in Bangkok concerning the achievement and general comments of the Mini-Project. Site visits and interview study of concerned O&M staff at WWTPs in 5 regional cities were also conducted.

3.1 Interview Study

Counterparts and long-term Japanese experts involved in the Mini-Project are as follows :

- Japanese experts : 1. Mr. Koya Komori
 2. Mr.Masayuki Nagamochi

Counterparts	:	1	Mrs. Vanida Bunopas Director of Water Analysis Sub-Division
		2.	Mrs. Uthai Sa-Ngiampong Chief of Biological Section
		3.	Mr. Pornsukdi Jevasuwon Chief of Wastewater Quality Analysis Section.

Major topics selected in the interview study of PWD counterparts were stressed on the achievement for improvements of water quality analysis system and O&M practices of WWTPs. General comments from the counterparts can be summarized as follows :

- 1) be willing and eager to accept new water analysis techniques
- 2) can improve and enhance the capability of existing water and wastewater analysis procedures and data interpretation such as BOD, TOC, Transparency etc. In addition, the new technique can apparently speed up the analysis time with accurate results.
- 3) the improved techniques will be undoubtedly beneficial to the O&M of WWTP
- 4) the basic constraints of the project include :
 - each counterpart is not able to do full-time work with the experts due to his/her routine duty
 - to improve and adapt oneself to the Japanese strict working practice but the counterparts considered it was a worthwhile experience.
 - the delay of English communication among the experts and counterparts especially during the preparation of the O&M manual.

3.2 Site Visits

WWTPs in 5 regional cities, i.e. Pattaya City (Middle Pattaya and South Pattaya), Hua Hin, Phuket (Patong) , Nakornrachasima and Khon Kaen were visited during the evaluation study. For each one-day visit of the 5 cities, the following activities were performed :

- To collect background information of the WWTP
- To obtain existing data on the operation of the WWTP.
- To observe the overall operation performance of the WWTP
- To interview the key operating personnel concerning the existing obstacles, constraints for implementing the WWTP.

Tables 1 to 3 summarize the collected data of the 6 WWTPs during the site visits at 5 cities. List of problems and obstacles encountered in the plant operation are grouped and presented in Table 4.

Table 1
Summary of Collected Information for
the Visited WWTPs at Pattaya City

Description	Middle Pattaya	South Pattaya
1. Background data		
1.1 Treatment system	Rotating Biological Contactor	RBC
1.2 Design capacity, m ³ /d	8,000	5,000
1.3 Area of plant, rai	8	1
1.4 Investment cost, MB	28	42
1.5 Year of operation	1986	1991
1.6 Service area, km ²	15	0.8
1.7 Treatment fee collection	Yes	Yes
2. Plant operation data		
2.1 Existing waste flow, m ³ /d	6000 - 7,000	4,000 - 5,000
2.2 Influent BOD, mg/l	120	100
Effluent BOD, mg/l	10	10 - 16
2.3 Available laboratory	Yes	No
2.4 No. of operating staff		
- permanent	3	-
- temporary	10	-
2.5 O&M cost, B/m ³	1.90	1.90
2.6 Routine monitoring		
- Flow	Yes	Yes
- Water quality	Yes	Yes
- Equipment	Yes	Yes

Remarks

- 1) Information of South Pattaya WWTP is from the upgraded RBC plant; previously, an extended aeration A.S. plant was installed and operated since 1983 with design capacity of 1,000 m³/d.
- 2) Existing 13 operating staff of WWTPs in Pattaya City are responsible for the operation of 3 plants in Middle Pattaya, South Pattaya and Na Jomtian.
- 3) Na Jomtian is a new WWTP in Pattaya at Na Jomtian area. Treatment system is the combined fixed film & A.S. with design capacity of 20,000 m³/d and has been operated since October 1994.

Table 2
Summary of Collected Information for
the Visited WWTPs at Hua Hin and Phuket

Description	Hua Hin	Phuket (Patong)
1. Background data		
1.1 Treatment system	Rotating Biological Contactor	Oxidation Ditch
1.2 Design capacity, m ³ /d	8,000	5,250
1.3 Area of plant, rai	1.75	13.50
1.4 Investment cost, MB	53	38
1.5 Year of operation	December 1991	May 1989
1.6 Service area, km ²	1.1	1.6
1.7 Treatment fee collection	No	Yes
2. Plant operation data		
2.1 Existing waste flow, m ³ /d	N.A.	4,500
2.2 Influent BOD, mg/l	55	35
Effluent BOD, mg/l	11	4
2.3 Available laboratory	No	No
2.4 No. of operating staff		
- permanent	2	2
- temporary	9	3
2.5 O&M cost, B/month	181,000	914,000
2.6 Routine monitoring		
- Flow	No	Yes
- Water quality	No	No
- Equipment	Yes	Yes

Table 3
Summary of Collected Information for
the Visited WWTPs at Khon Kaen and Nakornrachasima

Description	Khon Kaen	Nakornrachasima
1. Background data		
1.1 Treatment system	Stabilization Pond	Stabilization Pond
1.2 Design capacity,m3/d	25,500	32,000
1.3 Area of plant,rai	143	300
1.4 Investment cost, MB	65.3	75.2
1.5 Year of operation	May 1989	October 1990
1.6 Service area, km2	30.0	4.5
1.7 Treatment fee collection	No	No
2. Plant operation data		
2.1 Existing waste flow, m3/d	9,000	30,000
2.2 Influent BOD, mg/l	53	69 *
Effluent BOD, mg/l	10	7 *
2.3 Available laboratory	No	No
2.4 No.of operating staff		
- permanent	4	1
- temporary	3	19
2.5 O&M cost, B/month	250,000	283,000
2.6 Routine monitoring		
- Flow	Yes	No
- Water quality	Yes (monthly)	Yes (2-3 times a year)
- Equipment	Yes	Yes

Remarks

- * The BOD concentrations of influent and effluent were collected and analyzed by MACRO in February 1995.

Table 4
List of Problems Encountered in the Operation of WWTPs

Description	Pattaya	Hua Hin	Phuket	Khon Kaen	Nokornrachasima
1 Inadequate manpower	X	X	X	X	X
2 Lack of technical knowledge and skill in plant operation	X	X	X	X	X
3 Lack of scientist stationed at laboratory in the plant		X	X	X	X
4 System breakdown occasionally		X			
5 Refuse blockage in pipe collection system	X	X		X	X
6 Inadequate budget for equipment maintenance	X	X		X	
7 Unavailability of equipment spareparts in local market			X		X

4. Evaluation Study

The methodology of evaluation study of the Mini-Project will be based on the follow-up of achievement of duties and responsibilities carried out by both Japanese expert team and Thai counterparts during the 3-year period in fulfillment of the project objectives. Personal interviews with each of the 3 counterparts and his/her comment on obtained experiences are also used in the evaluation in order to enhance the degree of project achievement. The following activities carried out during the project period will be assessed for their outputs and corresponding objectives.

(1) Operation Investigation of WWTPs

The Japanese experts, counterparts and concerned PWD staff visited WWTPs in 5 regional cities. i.e. Pattaya City, Hua Hin, Phuket (Patong), Nakornrachasima and Khon Kaen during the project period in order to evaluate the overall treatment performance of each WWTP. The following monitorings at each plant were performed :

- Flow measurement of incoming wastewater
- Water quality analysis of influent, effluent and some control points in the system. The parameters included pH, Temperature, DO, SS, BOD, COD, NO₃-N, Phosphate, Total Coliform and Fecal Coliform.
- New analytical parameters and methods were introduced, i.e. Transparency, Total Organic Carbon (TOC) , DO meter for BOD test.
- Biota check by microscopic examination.
- Investigation of existing O&M practices of the plant.

(2) Transfer of Technology

New application of water quality analysis data was introduced to facilitate and control the operation of WWTP .

- Relationships between transparency and BOD, transparency and COD, transparency and SS.
- Relationship between BOD 20 and BOD 30.
- Counterpart training in Japan : There were totally 5 PWD's staff received training in Japan namely :

	Name	Period of Training	Topics of Training/Visits
1.	Mr.Pornsukdi Jevasuwon	Mar.29-May.1, 1992	- Lectures and practices on Sewage Works in Japan, Application of Water Quality Analysis Data - Visits several sewage treatment plants in various cities. - Obtained Certificate of Individual Training Course in Water Analysis
2.	Mrs. Vanida Bunopas and Mrs.Uthai Sa-ngiampong	Oct. 12-29, 1992	- Lectures and practices on Sewage Works in Japan, Application of Water Quality Analysis Data. - Visits several sewage treatment plants - Obtained Certificate of Individual Training Course in Water Analysis
3.	Mrs.Nittaya Rattanasuwan	Jan.6-Mar.27, 1994	- Lectures and practices on Water Pollution Control in Japan, Water Resource Management of Lake, Basin and Coastal Area, Water Sampling and Analysis Technique. - Visits several water and sewage treatment plants - Obtained Certificate of Group Training Course in Lake Water Quality Management
4.	Ms.Nuchanapang Saefoo	Jan.9-Mar.12, 1995	- Lectures and practices on Sewage Treatment and Water Quality Control in Japan, Chemical and Biological Analysis of Wastewater, Sewage Works Control

Name	Period of Training	Topics of Training/Visits
		- Visits several sewage treatment plants.
		- Obtained Certificate of Individual Training Course in Sewage Works Control

(3) Provision of Equipment and Materials

According to the agreement stipulated in the Mini-Project, JICA will provide PWD sets of equipment, machinery and materials necessary for implementation of the Project. The list of provisions as received from JICA is as follows :

No	Item	Quantity	Date of Received
1	Equipment for water quality analysis		
	1.1 BOD incubator	1	3/3/1992
	1.2 DO meter	1	5/3/1992
	1.3 Spectrophotometer	1	23/3/1992
	1.4 COD determination apparatus	1	31/7/1992
	1.5 pH meter	1	6/11/1992
	1.6 BOD probe	1	21/1/1993
	1.7 TOC analyzer	1	1/3/1993
	1.8 Microscope	1	8/3/1993
	1.9 Atomic absorption spectrophotometer	1	9/3/1993
	1.10 Transparency meter	1	17/11/1993
	1.11 Hydride generator	1	20/8/1994
2	Glasswares for water quality analysis		
	2.1 BOD bottle	1 set	6/11/1992
	2.2 Auto burette	1	2/2/1993
3	Equipment for data analysis		
	3.1 Personal computer and printer	1 set	31/3/1992
	3.2 Personal computer	1 set	27/11/1992
	3.3 Printer	1	10/2/1993
	3.4 Personal computer	2 sets	2/12/1993

No	Item	Quantity	Date of Received
4	Experimental treatment apparatus		
	4.1 Settling basin	1	10/9/1994
	4.2 Aeration tank	1	10/9/1994
	4.3 Aeration pump	2	20/9/1994
	4 4 Pump	3	20/9/1994
5	Flow measuring equipment		
	5.1 Current meter	1	9/3/1993
6	Vehicle (Wagon-Type)	1	25/11/1992
7	Other necessary equipment and materials		
	7.1 Vacuum pump	1	5/3/1992
	7.2 Copy machine	1	9/3/1992
	7.3 Facsimile	1	9/3/1992
	7 4 Refrigerator	1	11/3/1992
	7.5 Electronic typewriter	1	16/3/1992
	7.6 Facsimile	1	28/12/1992

Present condition of the above-mentioned equipment and materials is as follows

No.	Item	Location and Utilization
1.	- Equipment for water quality analysis, except microscope	- at Wastewater Quality Analysis Laboratory (WWQAL) - all are in use and in good condition
	- Microscope	- at Water Quality Analysis Laboratory (WQAL) - being used and in good condition
2.	Glasswares for water quality analysis	- at WWQAL - all are in use and in good condition
3.	Equipment for data analysis	
	- Personal computer set x 3	- at WWQAL, all are in use and in good condition.
	- Personal computer set x 1	- at WQAL, being used and in good condition.

No.	Item	Location and Utilization
4.	Experimental treatment apparatus	- at Deepwell Drilling and Development Division, PWD (Bang Khen) being used in laboratory-scale test run of activated sludge process.
5.	Flow measuring equipment	- at WWQAL, being used once in a while in field investigation of WWTPs and is in good condition.
6.	Vehicle (Wagon)	- at WWQAL, being used and in good condition.
7.	Other necessary equipment and materials	
	- all equipment except one facsimile	- at WWQAL, all are in use and in good condition.
	- facsimile x 1	- at WQAL, being used and in good condition.

(4) Preparation of a drafted operation and maintenance manual for wastewater treatment plant

Results from the field investigation of WWTPs in 5 regional cities and the standard acceptable O&M practices of different wastewater treatment systems were used in preparing a tentative guideline for the operators of WWTPs. The Japanese experts and counterparts as well as the PWD's concerned officials from the Sanitary Engineering Division and Mechanical and Electrical Engineering Division had mutually shared their experiences, effort and times to accomplish this final task of the Project. Eventually, the preparation of a drafted O&M manual for WWTP was completed. Major topics included in the manual comprise

- Introduction to Sewerage System and its O&M
- Office Requirements and Recordkeeping
- Waste Collection System and Pumping Station
- Wastewater Treatment Facilities
- Sludge Treatment System
- Water Quality Management
- Environmental Protection

At the end of the Mini-Project, PWD considered and realized that the number of experienced engineers, scientists and technicians in O&M of WWTP was very limited in both national and local governments. Consequently, PWD's staff still needs to be more trained on O&M to conduct their duties. Therefore, PWD requested the Government of Japan an expert in O&M of sewerage system to follow-up the result of the Mini-Project output. As the result, a Japanese expert (Mr. Kazayuki Ono) was assigned for the task for 5-month period from November 1, 1994 to March 31, 1995. In addition, the drafted O&M manual of WWTP was finally updated and revised by the Japanese expert in collaboration with the Thai counterparts. It was reported that the final O&M manual was completed in the end of March 1995 and was prepared in both English and Thai versions in separate volumes.

A summary of the evaluation study is presented in Table 5.

5. Conclusion and Recommendations

This evaluation study of the Mini-Project inevitably faced two basic constraints. First, the 1-month duration of study was quite short and secondly pertinent information of the Japanese experts outputs was not totally collected and evaluated.

Findings from the evaluation study of the Mini-Project reveal that as the beneficiary of the project, PWD and the concerned officials have obtained and benefited not only the sets of donated asset but also the technical knowledge, skill and experiences in the fields of water analysis technique as well as the O&M of WWTP. Consequently, the close collaboration between the Japanese expert team and PWD staff in preparation of the final O&M manual for WWTP is considered to be a successful output of the project. This manual will be in turn beneficial to the WWTP operators of the local governments in particular. As the government and local governments are seriously concerned about the water pollution problem created in the community coupled with the public awareness, the necessity for construction of the domestic waste treatment facilities seems to be unavoidable. At present, the number of municipal wastewater management projects under PWD's responsibility has reached 37 with an approximate total design capacity of 620,000 cubicmeter/day as tabulated in Table 6. Relevant informations of the projects under construction and to be constructed in the 1995 Fiscal Year are also presented in the Appendix.

From field investigation results on WWTPs in 5 regional cities, it is indicated that most operators lack in technical knowledge and skill to operate the plants properly and effectively. The prepared O&M manual alone, can not totally fulfill their deficiencies, but as a guiding tool of implementation. *Therefore, it is vital to upgrade the existing capability of WWTP operators to a desirable level which can run the plants successfully.*

To this regards, the following recommendations are proposed for PWD in order to improve and streamline the operation efficiency of WWTPs :

- 1) A human resource development program like a training center for WWTP operators should be set up as soon as possible.
- 2) PWD should pay more attention to the setup of laboratory and its facilities in every WWTP.

Table 5
Summary of Evaluation of the Mini-Project

Activities	Outputs	Project Objectives	Overall Goal	Output Achievement
1 Operation Investigation of WWTPs 1 1 Water analysis monitoring 1 2 Investigating existing O&M practices 1 3 Introduction of new analytical parameters and methods	1. Evaluation of existing water quality analysis system 2. Evaluation of existing O&M practices 3. Enhancement the capability of water quality analysis	1 To improve the efficiency of water quality analysis related to WWTP. 2 To increase the effectiveness of application of water analysis data to O&M of WWTP.	to upgrade the capability of PWD staff in O&M of WWTP.	A complete O&M manual for WWTP operators of local governments
2 Technology Transfer 2 1 Application of water quality data for control O&M of WWTP 2 2 Counterpart training in Japan	1. Improvement of O&M practices 2. Enhancement the capability of water quality analysis 3. Improvement of O&M practices	3. To improve O&M practices of WWTP. 4 To prepare a tentative guideline for O&M of WWTP.		
3 Provision of Equipment and Materials 3.1 Equipment for water quality analysis and experiment 3 2 Equipment for data analysis and other necessary equipment	1. Enhancement the capability of water quality analysis 2. Improvement of O&M practices	5 To improve the technical skill of engineers who will provide technical support for local governments.		

- 3) For the local governments, the high-ranked officials who are responsible for the operation of WWTP should pay a close attention to basic necessity and to find ways to run the plant smoothly and successfully, such as recruitment of adequate staff ; budget allocation for maintenance work and the proposed additional fringe benefit to the operators of WWTP as the attractive incentives. Nonetheless, the treatment fee collection program should be implemented in order to lessen the operation burden on the annual budget of each local government.

- 4) According to the proclamation of "Enhancement and Conservation of National Environmental Quality Act, B.E.2535", the government is trying to decentralize the environmental problem and mitigation measures to be responsible by the local governments. However, it is obvious that the concerned departments like Pollution Control Department and the Office of Environmental Policy and Planning (Ministry of Science, Technology and Environment) as well as the local governments are not ready and still lack the technical knowledge and adequate operating engineers to manage and handle the responsible tasks such as wastewater and solid waste management systems. Therefore the qualified personnel of the active implementing agency like PWD is definitely needed and to be fully involved in various responsibilities of the detailed design and O&M of the wastewater and solid waste management projects.

Table 6
Summary of Municipal Wastewater Management Projects of PWD

Description	No. of Projects	Total Design Capacity (m ³ /d)
1. Projects completed and in operation	10	132,750
2. Projects under construction	6	152,000
3. Projects to be constructed in 1995 Fiscal Year	21	336,400
Total	37	621,150

Ref: Sanitary Engineering Division, PWD (Jan 1995)

APPENDICES

A. Wastewater Management Projects under Construction of PWD

Local Governments	WWTP Process	Service Area (sq. km.)	Design Capacity (m ³ /d)
1. Tambol Saensook Municipality, Chonburi	Oxidation Ditch	35	23,000
2. Tambol Sriracha Municipality , Chonburi	Extended Aeration Activated Sludge	26	22,000
3. Nakorn Chiangmai Municipality (West Bank), Chiangmai	Aerated Lagoon	27	55,000
4. Muang Chantaburi Municipality , Chantaburi	Stabilization Pond	6	22,000
5. Muang Angtong Municipality , Angtong	Aerated Lagoon	12	8,000
6. Muang Ubonrachathani Municipality , Ubonrachathani	Aerated Lagoon	13	22,000

**B. Wastewater Management Projects to be constructed
in 1995 Fiscal Year of PWD.**

Local Governments	WWTP Process	Service Area (sq.km.)	Design Capacity (m3/d)
1 Muang Sakonnakorn Municipality (Phase 2), Sakonnakorn	Stabilization Pond	19	4,100
2 Muang Phuket Municipality, Phuket	Oxidation Ditch	12	36,960
3 Muang Rayong Municipality, Rayong	Aerated Lagoon	37	32,000
4 Samui Island, Suratthani	Oxidation Ditch	5	11,100
5 Karon Sanitary District, Phuket	Oxidation Ditch	5	9,000
6 Muang Trang Municipality, Trang	Stabilization Pond	15	24,000
7 Muang Phranakornsriyuthaya Municipality, Phranakornsriyuthaya	Oxidation Ditch	15	34,000
8 Muang Patumthani Municipality, Patumthani	Oxidation Ditch	12	9,800
9 Muang Supanburi Municipality, Supanburi	Aerated Lagoon	11	18,500
10 Muang Potharam Municipality, and Muang Banpoang Municipality, Rachaburi	Oxidation Ditch and Stabilization Pond	5	10,000
11 Muang Prachuabkirikan Municipality, Prachuabkirikan	Stabilization Pond	15	8,000
12 Ban Phe Sanitary District, Rayong	Oxidation Ditch	6	7,100
13 Muang Krabi Municipality, Krabi	Aerated Lagoon	10	10,300
14 Muang Pichit Municipality, Pichit	Stabilization Pond	2	3,000
15 Muang Pattani Municipality, Pattani	Stabilization Pond	11	21,000

Local Governments	WWTP Process	Service Area (sq.km.)	Design Capacity (m3/d)
16 Muang Songkla Municipality, Songkla	Aerated Lagoon	7	35,000
17 Muang Chumporn Municipality, Chumporn	Stabilization Pond	3	12,000
18 Muang Chachurngsao Municipality, Chachurngsao	Oxidation Ditch	13	24,000
19 Muang Chainat Municipality, Chainat	Stabilization Pond	6	3,500
20 Muang Payao Municipality, Payao	Stabilization Pond	4	8,000
21 Muang Nontaburi Municipality, (Pracharives Area), Nontaburi	Extended Aeration Activated Sludge	9	38,500

