

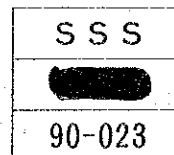
THE GOVERNMENT OF THE KINGDOM OF THAILAND

THE FEASIBILITY STUDY
ON
PURIFICATION OF KLONG WATER
IN
BANGKOK

SUMMARY

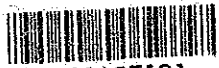
FEBRUARY 1990

JAPAN INTERNATIONAL COOPERATION AGENCY



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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Japanese Government decided to conduct a Feasibility Study on Purification of Klong Water in Bangkok and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a study team headed by Mr. Naohito Murata of Pacific Consultants International, comprising members from Tokyo Engineering Consultants from December 1987 to March 1988, from June 1988 to March 1989 and from July to August 1989.

The team held discussions with concerned officials of the Government of Thailand and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

February, 1990



Kensuke Yanagiya

President

Japan International Cooperation Agency

THE FEASIBILITY STUDY
ON
PURIFICATION OF KLONG WATER IN BANGKOK

Mr. Kensuke YANAGIYA
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

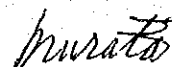
We are pleased to submit herewith the final report entitled "THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK". This report has been prepared by the Study Team in accordance with the contract signed on 7 December 1987, 31 May 1988 and 18 May 1989 between the Japan International Cooperation Agency and the Joint Venture of Pacific Consultants International and Tokyo Engineering Consultants.

The report examines the existing condition of klongs in Bangkok and the pollution load generation, and presents the results of the feasibility study on an urgent klong water purification project consisting of dilution water introduction from the Chao Phraya River, dredging of klongs and aerated lagoon treatment.

The report consists of the Executive Summary, Main Report, and Supporting Study Reports. The Summary summarizes the results of all studies. The Main Report contains background conditions, urgent klong water purification project, recommendations and further studies. The Supporting Study Report includes data and technical details. In addition, a Data Book has been prepared and is submitted herewith.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, and Embassy of Japan in Thailand, and also to officials and individuals of the Government of Thailand for all assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the enhancement of the aesthetics of the klong environment and the improvement of health and hygiene in Bangkok.

Yours faithfully



Naohito MURATA
Team Leader

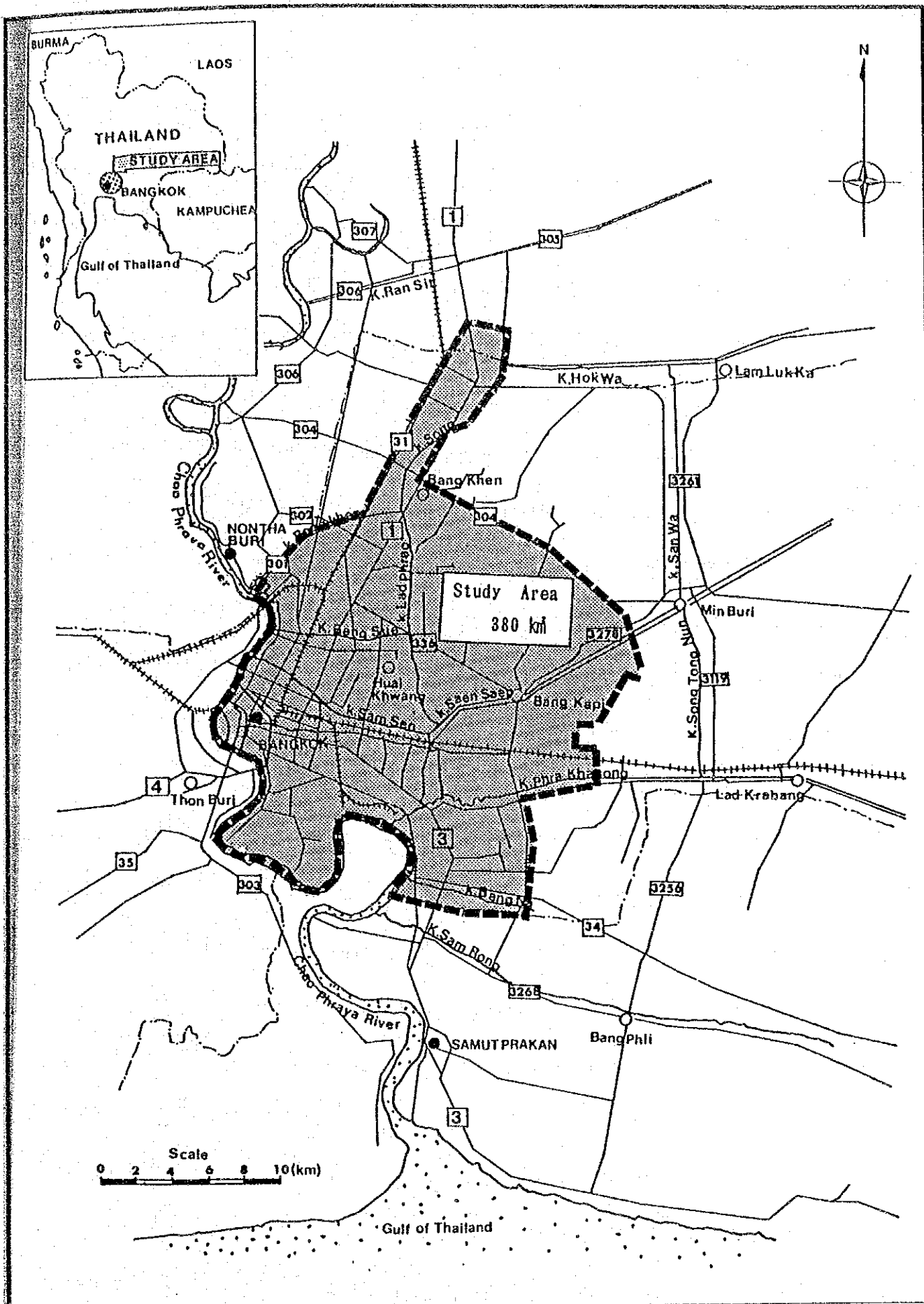


FIG. 1

LOCATION OF STUDY AREA

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

Proposed Remodelled Pump Stations into Reversible Type

Name of P.S.	Pump Capacity		
	Existing (Set) x (m ³ /s)	Reversible (Set) x (m ³ /s)	Additional (Set) x (m ³ /s)
Bang Sue	17 x 3 = 51	4 x 3 = 12	-
Sam Sen	15 x 3 = 45	4 x 3 = 12	-
Tavate	5 x 1 = 5	-	2 x 3 = 6
Sathorn	2 x 3 = 6	-	2 x 3 = 6
Total	107	24	12

Proposed Klong Dredging

Name of Klong	Dredging Plan		
	Length(m)	Width(m)	Volume(m ³)
Chong Non Sri	3,600	60~10.0	77,000
			Red EL (MSL.m)
			-1.5~-2.0

Proposed Aerated Lagoon Treatment

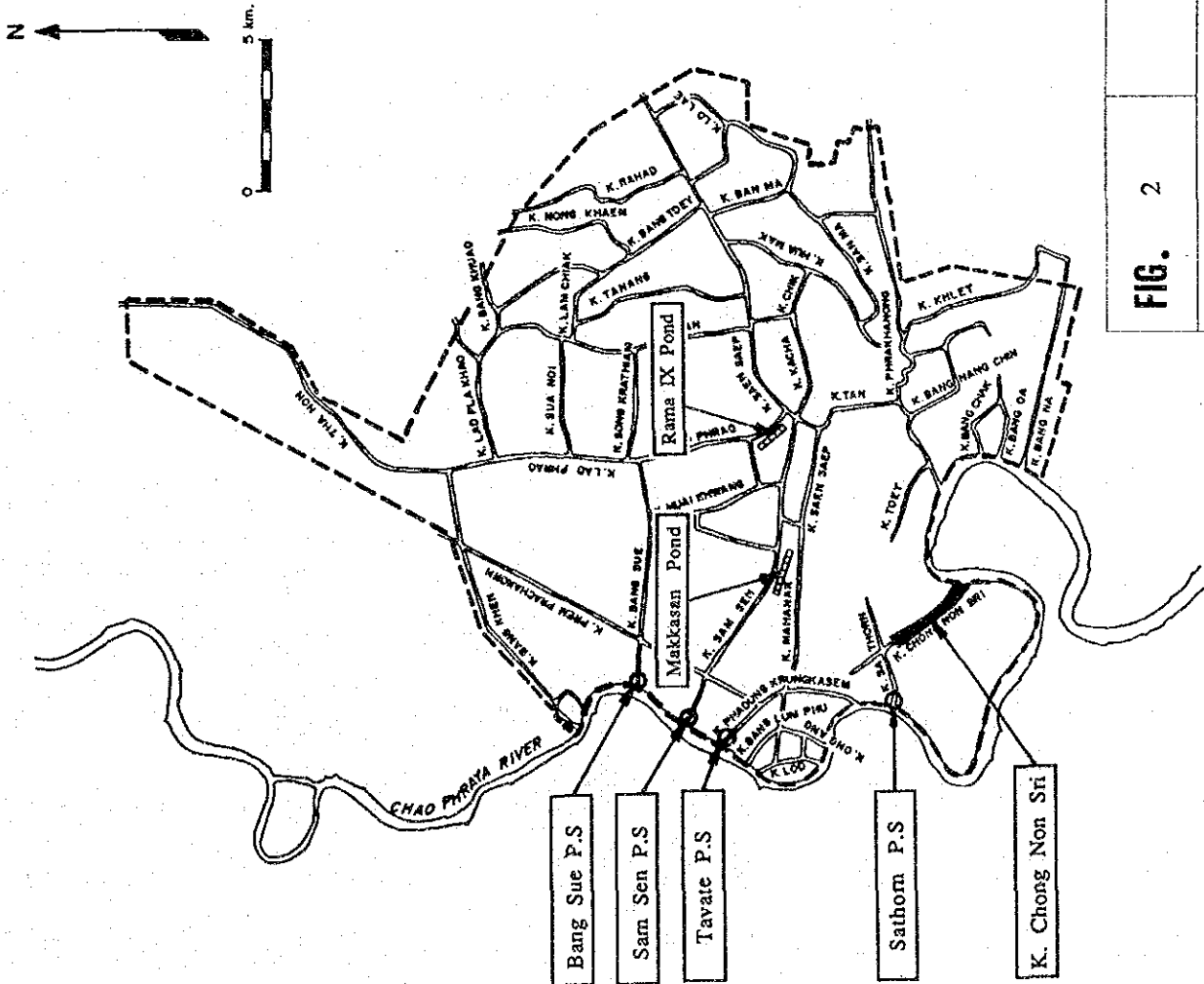
Name of Pond	Pond Area	Pump Capacity	Aerator
Makkasan Pond	16 ha	60 m ³ /min x 3 units	11 kw x 10 units
Rama IX Pond	20 ha	60 m ³ /min x 3 units	11 kw x 10 units*

* Includes the three(3) existing aerators

MAIN FEATURES OF THE PROPOSED FACILITIES

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

FIG. 2



SUMMARY

1. Introduction

The Bangkok Metropolitan area has been undergoing rapid urbanization and industrialization since 1960, which contributed to an impressive annual average economic growth rate of 8% in 1960-1980. However this has also caused serious environmental degradation. Water pollution of the klongs is one of such serious environmental issue confronting Bangkok Metropolis which is in need of urgent remedial measures.

This Study on Purification of Klong Water in Bangkok was carried out by the Study Team of the Japan International Cooperation Agency (JICA) in collaboration with the officials concerned of the Bangkok Metropolitan Administration (BMA) of the Government of Thailand from December 1987 to February 1990.

The Study proposed, as an urgent remedial measure of klong water quality improvement, the introduction of dilution water from Chao Phraya River along with aerated lagoon treatment in two (2) existing ponds, the Makkasan Pond and Rama IX Pond. Sewerage development is recommended to be necessary as a long term measure of klong water quality improvement.

2. Study Area

The Study Area, shown in Fig. 1, forms a portion of deltaic alluvial plain of the Chao Phraya River lying along its left bank. It covers the city core and eastern suburban areas of Bangkok with a total area of approximately 380 km², and is characterized by very low and flat land. The water stage of the Chao Phraya River exceeds the ground elevation during the period of high tide and floods.

Bangkok is affected by a severe land subsidence, which is estimated to be progressing at an average rate of about 5 cm/year.

Average annual rainfall is 1,477 mm. The wet season extends from May to October during which approximately 70% of the annual rainfall occurs. The heaviest rainfall occurs in September and October.

The population of Bangkok metropolitan area increased from 3.44 million in 1970 to 5.47 million in 1986. It is expected to increase further to 6.4 million in 1990 and 7.7 million in 2000. Consequently the urbanized area has expanded from 183 km² in 1971 to 350 km² in 1984, with a sprawl expansion along major roads and klongs.

3. Objectives of the Study

The objectives of the Study are:

- 1) to prepare an urgent water purification plan for the main klongs in central Bangkok.
- 2) to conduct technology transfer to the Thailand counterpart personnel.

4. Existing Conditions of Chao Phraya River and Klongs

4.1. Existing Conditions of River

The Chao Phraya River, flowing southerly through the central part of Thailand into the Gulf of Thai, has a total trunk length of 980 km and drains an area of 162,600 km², about one-third of the whole country.

The maximum, minimum and average seasonal river discharges in 14 years (1963-1976), recorded at Bang Sai located at about 50 km upstream of the Study Area, are as follows:

	Dry Season (Jan. - April)	Rainy Season (Aug. - Oct.)
Maximum	233 m ³ /s	2,172 m ³ /s
Minimum	120	264
Average	174	1,095

With due consideration to the river water demand for water supply, the maximum quantity of river water that could be withdrawn for klong water quality improvement by dilution is estimated at 70-80m³/sec.

The water quality of the Chao Phraya River is affected by tide, river discharge and wastewater from Bangkok city.

The river water quality in rainy season varies very little along the whole river distance. However during dry season the water quality at downstream of 60 km of river distance deteriorates in comparison to upstream reaches. The overall variation of DO and BOD are as follows:

		<u>River Distance</u>	
		<u>0 - 60 km</u>	<u>60 - 130 km</u>
DO	Rainy Season	3 - 4 mg/l	3 - 4 mg/l
	Dry Season	1 - 2 mg/l	3 - 5 mg/l
BOD	Rainy Season	1 mg/l	1 mg/l
	Dry Season	2 - 3 mg/l	1 mg/l

Salinity intrusion is considered to be limited to a river distance of 40 km upstream of the river mouth.

4.2 Existing Conditions of Klongs

The klongs run in all directions through the whole Study Area with a high density of one (1) km/km² approximately. Out of all the existing klongs, 37 klongs were selected for the Study. The total length of the networks is 219.1 km. The width of the klongs ranges from a few meters to 50 m. Major klongs with a width of more than 20 m are K. Saen Saep, K. Lad Phrao, K. Phadung Krung Kasem and K. Phra Khanong.

The actual discharge capacity of the klongs varies depending on their downstream water level which is largely affected by the water stage of the Chao Phraya River. The maximum discharge capacity of the klongs are in the range of about 5 m³/s to 50 m³/s.

At present, the quantity of dilution water introduced from the Chao Phraya River to the klongs is about 16m³/sec.

The water quality of the klongs in the Study Area varies both locally and seasonally to a large extent. During dry season, klongs in the vicinity of the Chao Phraya River and those at eastern suburban areas show a moderate BOD level, less than 20 mg/l. However, high BOD levels of 20-50 mg/l are observed in the klongs of inner areas with high population density.

A qualitative evaluation of existing klong water quality was conducted, both during dry and rainy seasons, by the observation of color and odor in the klongs. There was a significant variation in klong water quality between dry season and rainy season, in the klongs along the Chao Phraya River. These klongs were greenish with no odor in dry season, but were blackish with strong odor in rainy season. However, the water quality of the klongs in inner areas are polluted with blackish color and strong odor throughout the year.

The relationship between klong appearance and klong water quality expressed as BOD are as follows.

- 1) Color
 - Green or brown : BOD<15mg/l
 - Black or black-gray : BOD>20mg/l

- 2) Odor
 - No odor or faint odor : BOD<15mg/l
 - Strong odor or offensive odor : BOD>20mg/l

4.3 Existing Drainage Systems

The river banks and polders in the Study Area are provided with gates and pumps at the inlets or outlets of the klongs to prevent flood waters entering from outside and to drain inner water.

In rainy season, all the gates are closed, in principle, and no river water enters into the Study Area. In dry season, the gates are kept open and dilution water from the Chao Phraya River is introduced into the klongs.

4.4 Pollution Load Generation

There are three (3) major sources of pollution load generation in the Study Area. These are of residential, commercial and industrial in origin.

The total pollution load generation in the Study Area under the existing conditions in the year 1986 is estimated at 119,000 kg.BOD/day.

The corresponding total future pollution load generation in the year 2000 is estimated at 230,000 kg.BOD/day.

5. Proposed Project

The proposed urgent project of klong water purification consists of the two (2) project components, introduction of dilution water to the klongs from the Chao Phraya River and aerated lagoon treatment of klong water in two (2) ponds, the Makkasan Pond and Rama IX Pond. The project facilities are illustrated in Fig. 2.

5.1 Dilution Water Introduction

The target klong water quality with respect to stream BOD is set at 15 mg/l. Based on the simulation analysis of klong water quality carried out assuming a dilution water introduction amounting 35m³/sec from the Chao Phraya River, it is determined that the water quality of

almost all the klongs in the Study Area, during dry season, can be improved to the target stream BOD level not exceeding 15 mg/l which is sufficient to alleviate the existing color and odor problems. This will result in aesthetic enhancement of the klong environment.

This is a low cost option involving basically remodeling of some of the existing pump stations along the Chao Phraya River to reversible type in order to facilitate in dilution water introduction, even during low river tide. However, the benefit of this option is limited to only the dry season.

5.2 Aerated Lagoon Treatment

The introduction of dilution water to the klongs alone, though could improve the water quality of the klongs by dilution effect, would result in increase in pollution load discharge to the Chao Phraya River, and hence the water quality deterioration of the river. This is because of the reduction in self purification potential of the klongs anticipated by the increased stream flow velocity, and decreased pollutant concentration and sedimentation caused by the dilution water introduction.

In order to realize a net pollution load reduction of klong water, aerated lagoon treatment method was identified for detailed evaluation due to the availability of large ponds in the vicinity of major klongs, and simplicity of the system operation and maintenance and low cost.

Experimental studies were conducted utilizing the Rama IX Pond with wastewater influent from Klong Lad Phrao to evaluate the aerated lagoon treatment efficiency and other design requirements. It was found out that a 50% reduction in BOD along with significant color and odor removal could be achieved in aerated lagoon with a hydraulic detention time of one (1) day.

Finally, the following two (2) ponds were selected for aerated lagoon treatment:

- 1) Makkasan Pond to treat klong water from K. Sam Sen.
- 2) Rama IX Pond to treat klong water from K. Lad Phrao.

The above two aerated lagoons are estimated to contribute to a pollution load reduction of 4,470 kg.BOD/day, which is higher than the anticipated increase in pollution load discharge of 3,800 kg.BOD/day to the Chao Phraya River by dilution water introduction.

5.3 Project Cost

The total project cost, consisting of direct construction cost, engineering and administration costs, and physical contingency, amounts to 203.0 million Baht at October 1988 prices as given below (฿223.0 million including price escalation). The annual operation and maintenance cost is estimated at 56.3 million Baht.

Cost Item	Amount (10 ³ B)
A. Direct Const. Cost	167,790
(1) Reconst. of Ban Sue P.S.	9,280
(2) Reconst. of Sam Sen P.S.	7,910
(3) Reconst. of Tavate P.S.	10,370
(4) Reconst. of Sathorn P.S.	10,420
(5) Dredging of Klong	11,010
(6) Const. of Makkasan Pond Aerated Lagoon	59,500
(7) Const. of Rama IX Pond Aerated Lagoon	59,300
B. Engineering & Administration Costs (10%)	16,779
C. Physical Contingency (10%)	18,456
Sub-Total	203,025
D. Price Escalation (10%)	19,975
Total	223,000
E. Annual OM Cost	56,300

5.4 Project Evaluation

(1) Economic Evaluation

The expected major tangible benefits of the Project are as follows:

	Annual Benefit (10 ³ B)
- Beneficial effects on klong transport and floating market	21,600
- Beneficial effects on health and hygiene	12,900
- Increased use of klong water for living	27,200
- Increased use of klong for recreation	100
Total	61,800

These benefits are expected to be fully realized since 1992 onwards, after the completion of this klong water purification project, and the total annual benefit is estimated at 61.8 million Baht.

The economic rate of return (EIRR) of the Project is determined to be 5.5%.

(2) Impact on the Chao Phraya River Water Quality

A slight beneficial effect as improvement in the Chao Phraya River water quality, with no adverse effects, by the Project is expected, because the reduction of pollution load in the two (2) aerated lagoons could more than offset the increase in pollution load discharge to the river by dilution water introduction.

(3) Necessity of Sewerage Development in Future

The klong water quality in the year 2000 is projected to deteriorate to 15-24 mg/l as stream BOD even with the continued functioning of the proposed project due to the rapidly increasing pollution load generation in Bangkok. Under such a future conditions, the stream BOD of the Chao Phraya River is forecasted to increase up to 6.5 mg/l from the present level of 3 mg/l.

Moreover, in rainy season, the klong water quality will be much deteriorated to a stream BOD level of 20-50 mg/l in the year 2000 due to lack of dilution water introduction from the Chao Phraya River.

To cope with this future water pollution problems, sewerage development is essentially required.

6. Recommendations and Further Studies

6.1 The Proposed Project

The proposed project will produce fruitful effects at a low investment cost with simple operation and maintenance requirement.

The dilution water introduction will improve the klong water quality in the Study Area to a stream BOD level of 15 mg/l resulting in a very significant improvement of color and odor. While the aerated lagoon treatment will marginally improve the water quality of the Chao Phraya River.

An early implementation of the Project is recommended.

As another means of klong water quality improvement, feasibility on direct aeration of the klong water itself to enhance the assimilative capacity of the klongs is recommended for further studies.

6.2 Reconstruction of Phra Khanong Pump Station

The dilution water introduced from the Chao Phraya River to the klongs is again discharged into the Chao Phraya River by the Phra Khanong and Krung Kasem pump stations.

In the year 2000, the ground elevation of the Study Area is expected to become lower than the low water level of the Chao Phraya River due to the progressing land subsidence activities affecting Bangkok.

By that time, a 24-hour pump drainage will be required by the Phra Khanong and Krung Kasem pump stations to discharge the introduced dilution water.

The Phra Khanong pump station, which is only a temporary type, shall be remodelled into a permanent type as early as possible to meet the requirement of long-time continuous operation.

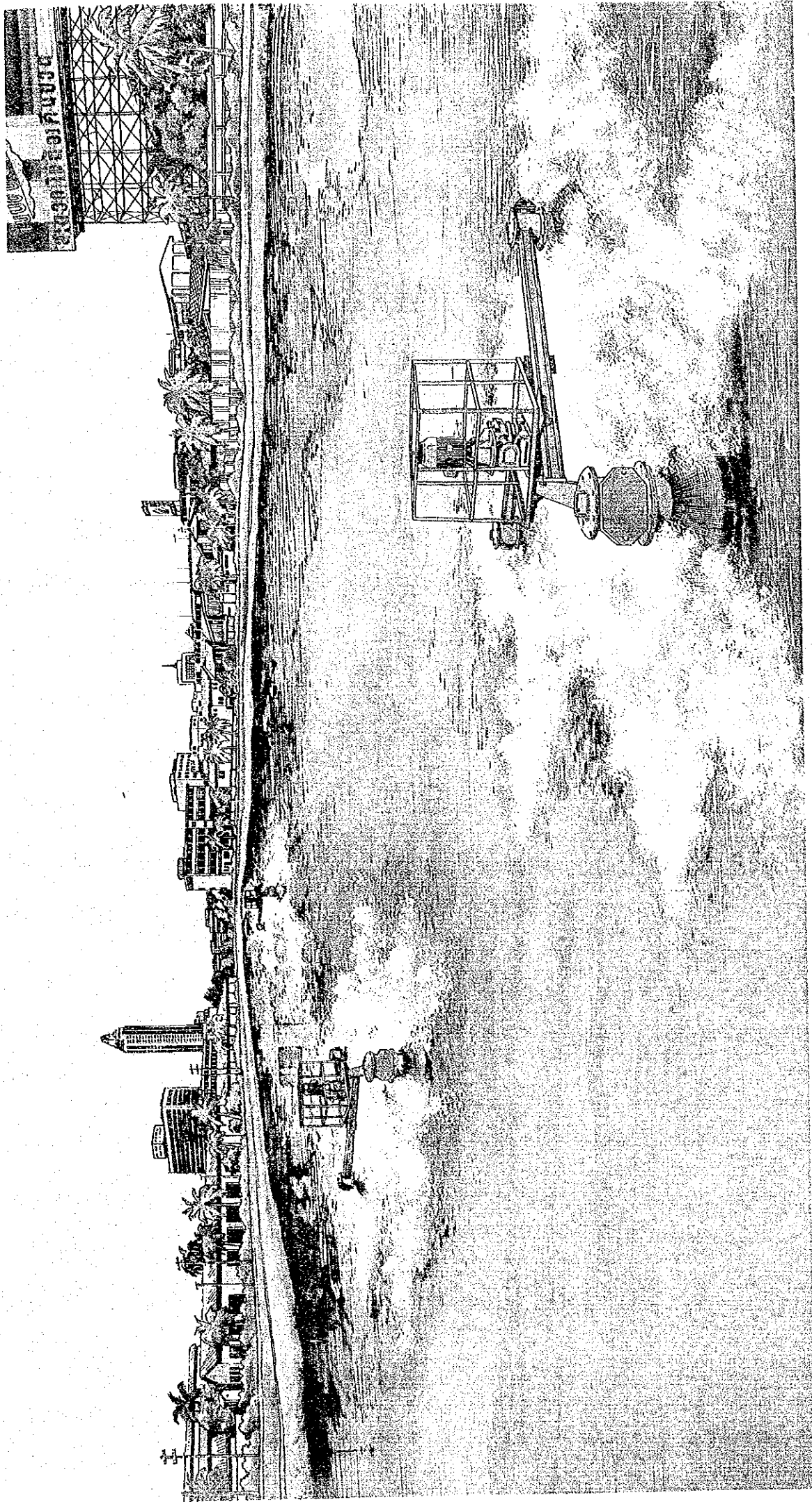
6.3 Sewerage Development

The existing major pollution sources in central Bangkok are domestic wastes, wastes of toilet origin and commercial wastes. The domestic and commercial wastes are collected through the storm water drains consisting of road side ditches and main pipes and discharged into the klongs with no treatment. Toilet wastes are intended to be treated by septic tanks. However, overflow from septic tank is also discharged into the klongs through the storm water drains.

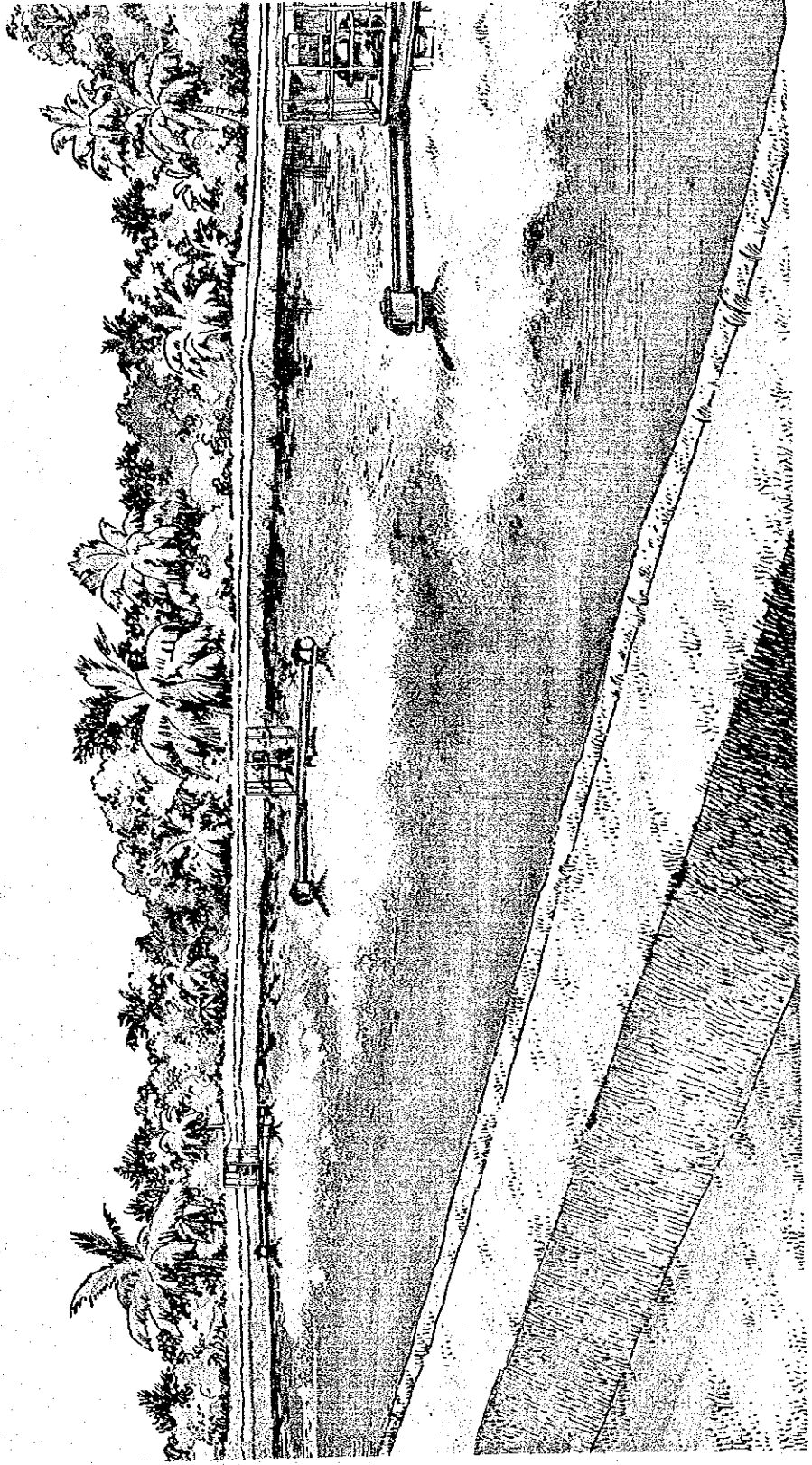
Since a full-scale conventional sewerage development in central Bangkok would require a high cost, a stage-wise implementation program shall be devised. A sewerage development focussing on abatement of water pollution of the klongs and the Chao Phraya River is recommended as the first step.

Construction of wastewater interceptors along the klongs is considered to be one of the cost-effective methods for abatement of the water pollution.

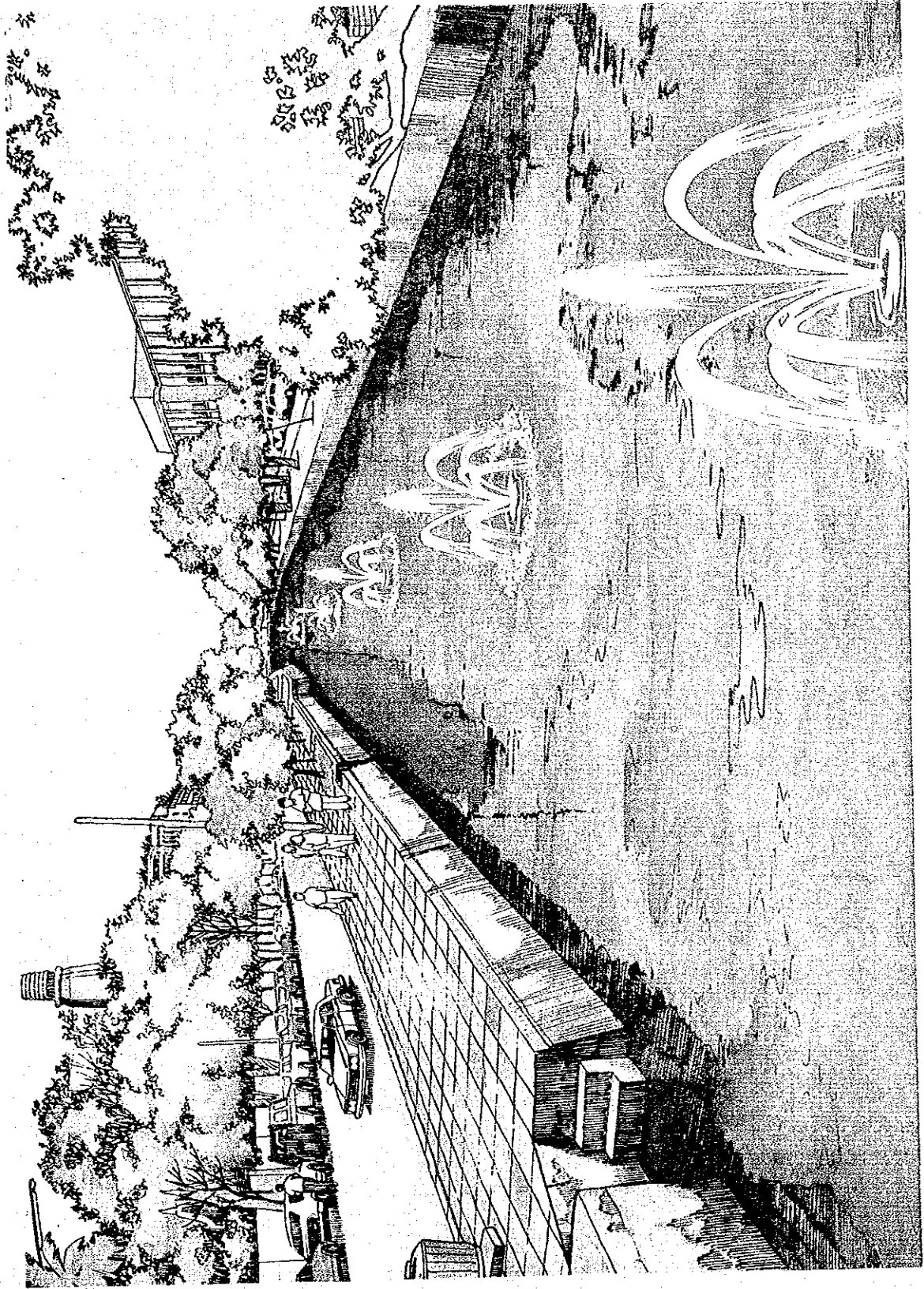
An early execution of the feasibility study on sewerage development is strongly recommended.



AERATED LAGOON (Makasan Pond)



AERATED LAGOON (Rama IX Pond)



AERATED TREATMENT FACILITY

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