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THE GOVERNMENT OF THE REPUBLIC OF INDONESIA

THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

FEASIBILITY STUDY

MAIN REPORT

MARCH 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

THE GOVERNMENT OF THE REPUBLIC OF INDONESIA

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PREFACE

In response to a request from the Government of the Republic of Indonesia, the Japanese Government decided to conduct a Study on Urban Drainage and Wastewater Disposal Project in the City of Jakarta and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Indonesia a study team headed by Mr. Ryuji Yanai, and composed of members from Pacific Consultants International and Nippon Koei Co., Ltd, three times between September 1989 and December 1990.

The team held discussions with the officials concerned of the Government of Indonesia 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 Republic of Indonesia for their close cooperation extended to the team.

March, 1991

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

THE STUDY ON URBAN DRAINAGE
AND
WASTEWATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

Mr. Kensuke YANAGIYA
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

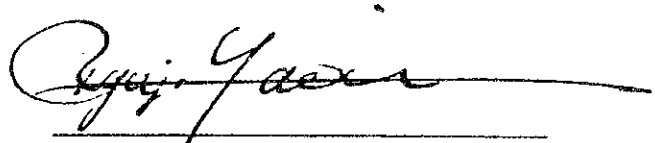
We are pleased to submit to you the final report entitled "THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL PROJECT IN THE CITY OF JAKARTA". This report has been prepared by the Study Team in accordance with the contract signed on 25 August 1989 and 17 May 1990 between the Japan International Cooperation Agency and the Joint Venture of Pacific Consultants International and Nippon Koei.

The report examines the existing conditions of urban drainage and wastewater disposal in the city of Jakarta, presents a master plan of drainage, sanitation and sewerage development and the results of a feasibility study on drainage and sewerage development for the priority areas selected by the master plan.

The report consists of the Executive Summary, Main Report, and Supporting Study Report. The Summary summarizes the results of all studies. The Main Report contains background conditions, overall drainage, sanitation and sewerage development plan, urgent drainage and sewerage development project, conclusions and recommendations. 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 Indonesia, and also to officials and individuals of the Government of Indonesia for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the socio-economic development and the improvement of health and hygiene in Jakarta.

Yours faithfully,



Ryuji YANAI
Team Leader

SUMMARY

EXECUTIVE SUMMARY

1. Introduction

Jakarta, the capital of Indonesia, is undergoing rapid urbanization in recent years, resulting in an intense population growth that has almost doubled from 4.6 million in 1975 to 8.8 million in 1988, which is further expected to reach 12.8 million in 2010.

As the consequence, new flood prone areas are being created due to change in landuse even in the relatively undeveloped fringes of Jakarta. Furthermore, the city virtually lacks an environmentally and sanitarily acceptable means of wastewater disposal in commensuration with its urbanization and high growth of population.

Hence, the formulation of both the urban drainage, and sanitation and sewerage development plans has become necessary.

The Study Area, shown in Fig. 1.1, encompassed the entire administrative region of DKI, Jakarta with an area of about 650 sq.km.

This Study on urban drainage and wastewater disposal in Jakarta was carried out by the Study Team of the Japan International Cooperation Agency (JICA) in collaboration with the Directorate General of Human Settlements (Cipta Karya), Ministry of Public Works and Jakarta Metropolitan Government (DKI, Jakarta) of the Government of Indonesia from September 1989 to January 1991.

The objectives of the Study are as follows:

- Formulation of a master plan of drainage, sanitation and sewerage development encompassing the whole Study Area for the target year of 2010.
- Conduct a feasibility study for drainage and sewerage development for the priority areas selected by the master plan.

Based on the master plan study, conducted during September 1989 ~ August 1990, the respective priority areas for drainage and sewerage developments are identified along western fringe and central regions of the Study Area as shown in Fig. 1.2.

The feasibility study area of both drainage and sewerage, termed as Project Areas, that were selected based on detailed consideration of the respective priority areas are also shown in Fig. 1.2.

The Project Area for urban drainage development covers an area of 5,000 ha located in the north western fringe of Jakarta City. The urban drainage project consists of four (4) sub-projects, Cengkareng West Drainage, Sepak River Improvement, Bojong Drainage Improvement and Maruya Ilir Drainage Improvement.

The Project Area for sewerage development covers an area of 4,300 ha located in central Jakarta and excludes an area of about 2,000 ha of the master plan priority area lying south of the existing Banjir Canal, which consist of Kec. Setia Budi and Tebet Manggarai, where a pilot sewerage development project is ongoing by JSSP.

The whole study, including the executive summary, consists of the following reports:

(1) MASTER PLAN STUDY (MAIN REPORT)
(2) MASTER PLAN STUDY (SUPPORTING REPORT, VOLUME I)
(3) MASTER PLAN STUDY (SUPPORTING REPORT, VOLUME II)
(4) FEASIBILITY STUDY (MAIN REPORT)
(5) FEASIBILITY STUDY (SUPPORTING REPORT)
(6) DATA BOOK
(7) DRAWING
(8) EXECUTIVE SUMMARY

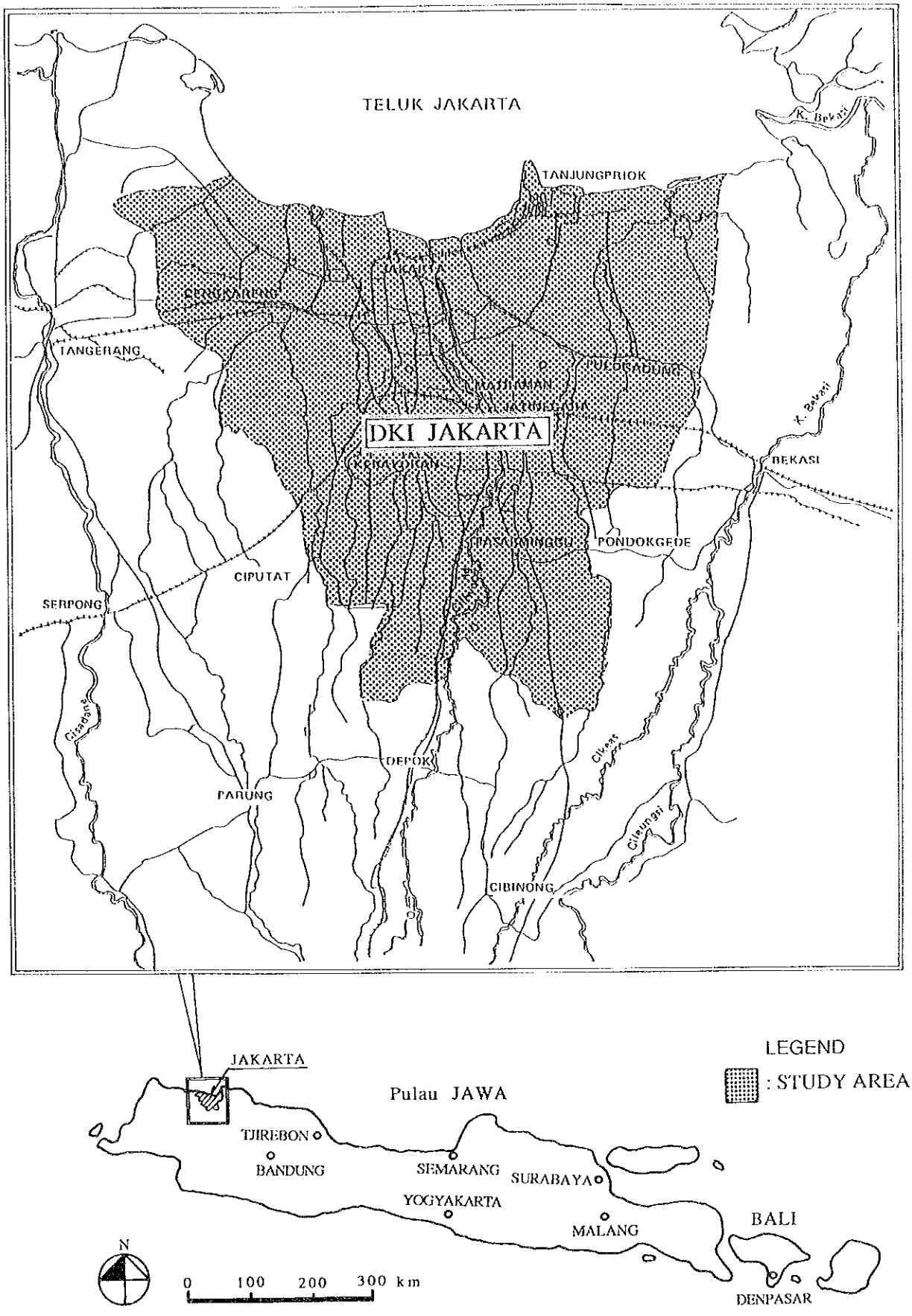
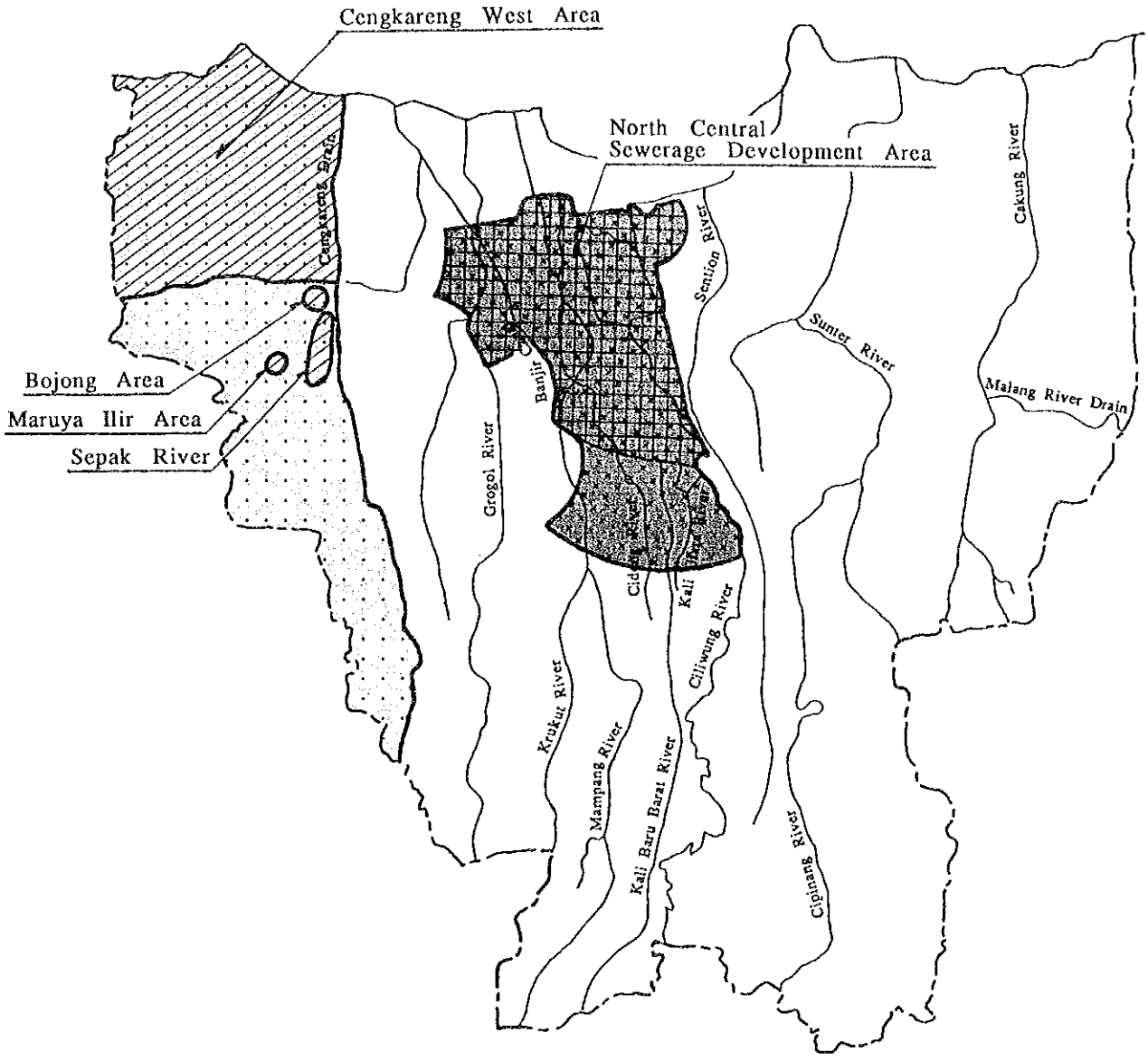


FIG. 1.1 STUDY AREA OF MASTER PLAN

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA



LEGEND

: Priority Area of Drainage Development (Drainage Zone No.1)

: Project Area of Drainage Development

: Priority Area of Sewerage Development (Central Sewerage Zone)

: Project Area of Sewerage Development

FIG. 1.2 PROJECT AREAS OF URBAN DRAINAGE AND SEWERAGE DEVELOPMENT

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

2. Drainage Development Master Plan

2.1 Objective Urban Drainage Channel

The Study covers the whole major urban drainage channels only, excluding both the minor drainage channels and the flood control rivers. According to Indonesian governmental regulation, a flood control river is defined as a river that originates outside the objective urban area, while an urban drainage channel drains local rainfall within the objective urban area.

Among the water courses in the Study Area, the following 11 rivers are the flood control river.

- Mookervart, Angke, Pesanggrahan, Grogol, Krukut, Ciliwung, Cipinang, Sunter, Buaran, Jati Kramat and Cakung

Among the above rivers, six (6) rivers are diverted by the existing Cengkareng Floodway and Banjir Canal into the Bay of Jakarta. The remaining five (5) rivers will also be cut off by the on-going East Banjir Canal in the near future. Hence, the downstream reaches of the above rivers are all dealt as urban drainage channel.

The objective urban drainage channel networks consist of the main channels, tributaries and distributaries of 158 in total. Among them, 50 channels are on-going, under detailed design or under construction.

Location of the flood control rivers and objective urban drainage channels are shown in Fig. 2.1.

2.2 Floods and Flood Damages

The floods of the major urban drainage channels are caused by local rainfall and/or high tide of the Bay of Jakarta. The potential flood areas are located at 96 places out of which 79 locations are habitually inundated. The potential and habitual inundation areas sum up to 11,099 ha or 17.0% of the Study Area and 3,835 ha or 5.9%.

The expected major flood damages in the Study Area are:

(i) Direct damages to house, shop, factory and other properties
(ii) Income losses due to closure of shop, factory and other enterprises
(iii) Damage to traffic
(iv) Damage to infrastructure

The expected average annual flood damages without project in 1988 and 2010 are Rp. 47.1 billion and Rp. 161.0 billion at 1990 price respectively. The share of damage to house property is the highest of about 70%.

2.3 On-going Project

To cope with the above flood hazards, 25 urban drainage development projects are on-going, under detailed design or under construction for the 50 major drainage channels mostly by the Jakarta Flood Control Project. The projects include channel improvement of about 120 km, construction of eight (8) pump stations with a total capacity of 98 m^3/s, and construction of other facilities such as regulation pond, polder, gate, etc.

Location of the on-going projects are shown in Fig. 2.2.

2.4 Proposed Plan

The proposed drainage development plan is formulated for the drainage channels other than the 50 on-going channels, by dividing the whole Study Area into six (6) drainage zones. The division of the drainage-zones was made based on natural boundary of drainage (ref. Fig. 2.3).

The proposed major projects are improvement of existing channel, construction of new channel and installation of pump station. The project works for each drainage zones are summarized below.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Total
Existing Channel Impr.							
Number of Channel	10	3	3	-	1	15	32
Total Length (km)	30.6	8.1	8.9	-	1.2	27.3	76.1
New Channel Const.							
Number of Channel	-	-	-	-		3	3
Total Length (km)	-	-	-	-		11.4	11.4
P.S. Installation							
Number of P.S.	-	1	1	-		-	2
Total Capacity (m^3/s)	-	2.5	6.2	-		-	8.7

Location of the proposed projects are also shown in Fig. 2.3.

2.5 Project Evaluation

(i) Project Cost

The total project costs are estimated to be Rp. 676.7 billion with a break-down of Rp. 543.0 billion for the on-going project and Rp. 133.7 billion for the proposed project at 1990 price. Its break-down by drainage zone is shown below.

(Unit: billion Rp.)

Zone No.	On-going	Proposed	Total
1	1.8	59.6	61.4
2	84.6	9.7	94.3
3	5.2	14.6	19.8
4	165.9	-	165.9
5	-	0.8	0.8
6	285.5	49.0	334.5
Total	543.0	133.7	676.7

(ii) Economic Evaluation

The economic efficiency of the total project including on-going and proposed ones is evaluated as follows.

- Net Present Value (NPV) : Rp. 435 billion
- Benefit Cost Ratio (B/C) : 2.15
- Economic Internal Rate of Return (EIRR) : 20.2%

2.6 Priority Area

Priority sequence of the six (6) drainage zones for the proposed project was assigned from the integral view points of needs/benefits, regional equality, environmental quality improvement and poverty alleviation. Accordingly, Drainage Zone No. 1 was selected as the priority area for feasibility study (ref. Fig. 1.2).

2.7 Recommendation

(1) Progressing of land subsidence in coastal areas of Jakarta has been recognized in recent years. Artificial infiltration of storm water is an effective means for a concurrent realization of both flood run-off and land subsidence controls. Hence, it is recommended to investigate on-site flood control by means of artificial infiltration of storm water.

(2) The existing hydrological observation networks shall be improved to attain an effective management of the urban drainage system.

(3) The existing operation and maintenance activities of urban drainage shall be strengthened to maintain expected functions of the drainage system. The present organization of the urban drainage in DKI, Jakarta shall be strengthened to meet the increasing operation and maintenance requirements.

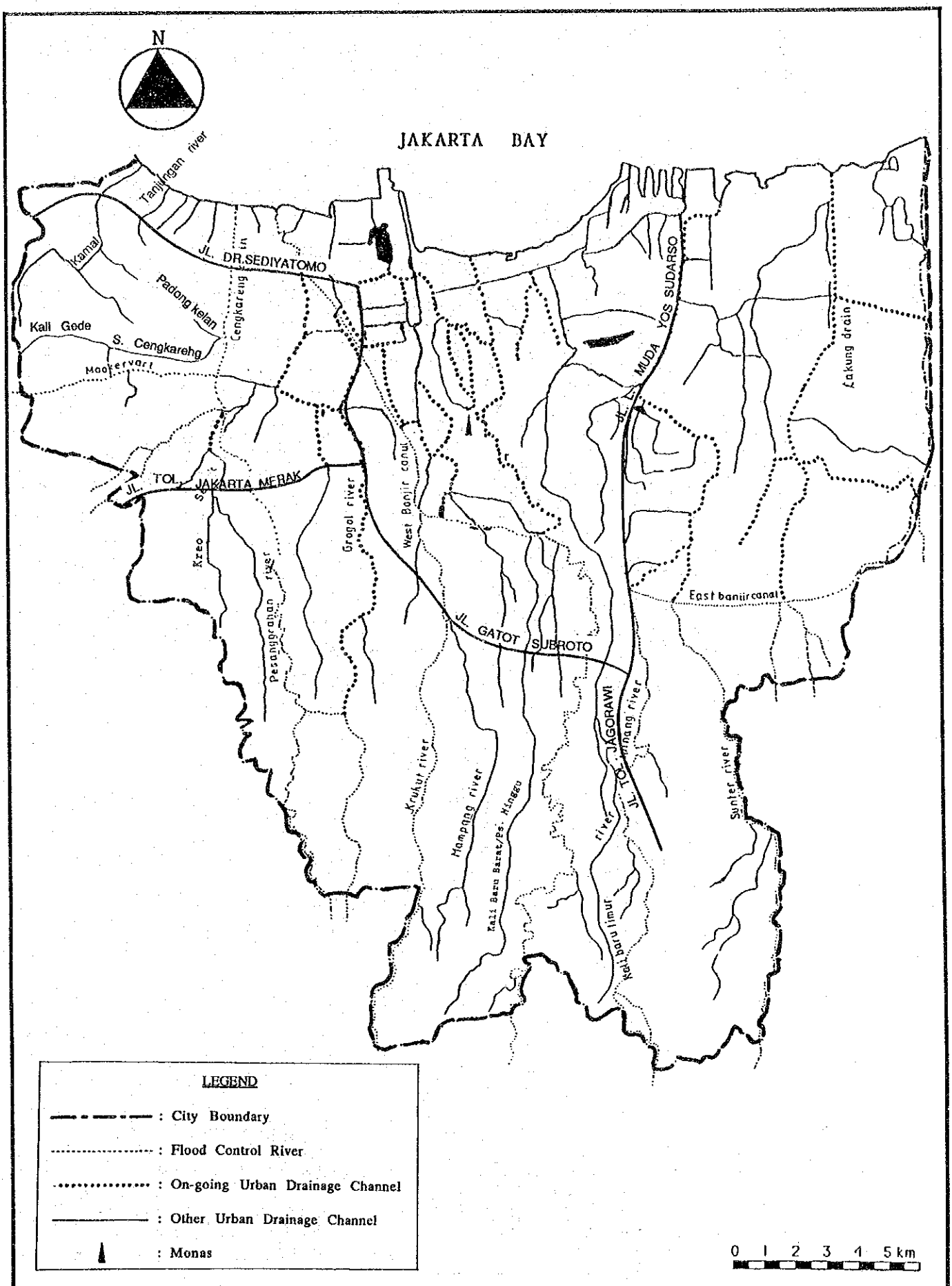


FIG. 2.1 OBJECTIVE URBAN DRAINAGE CHANNELS

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

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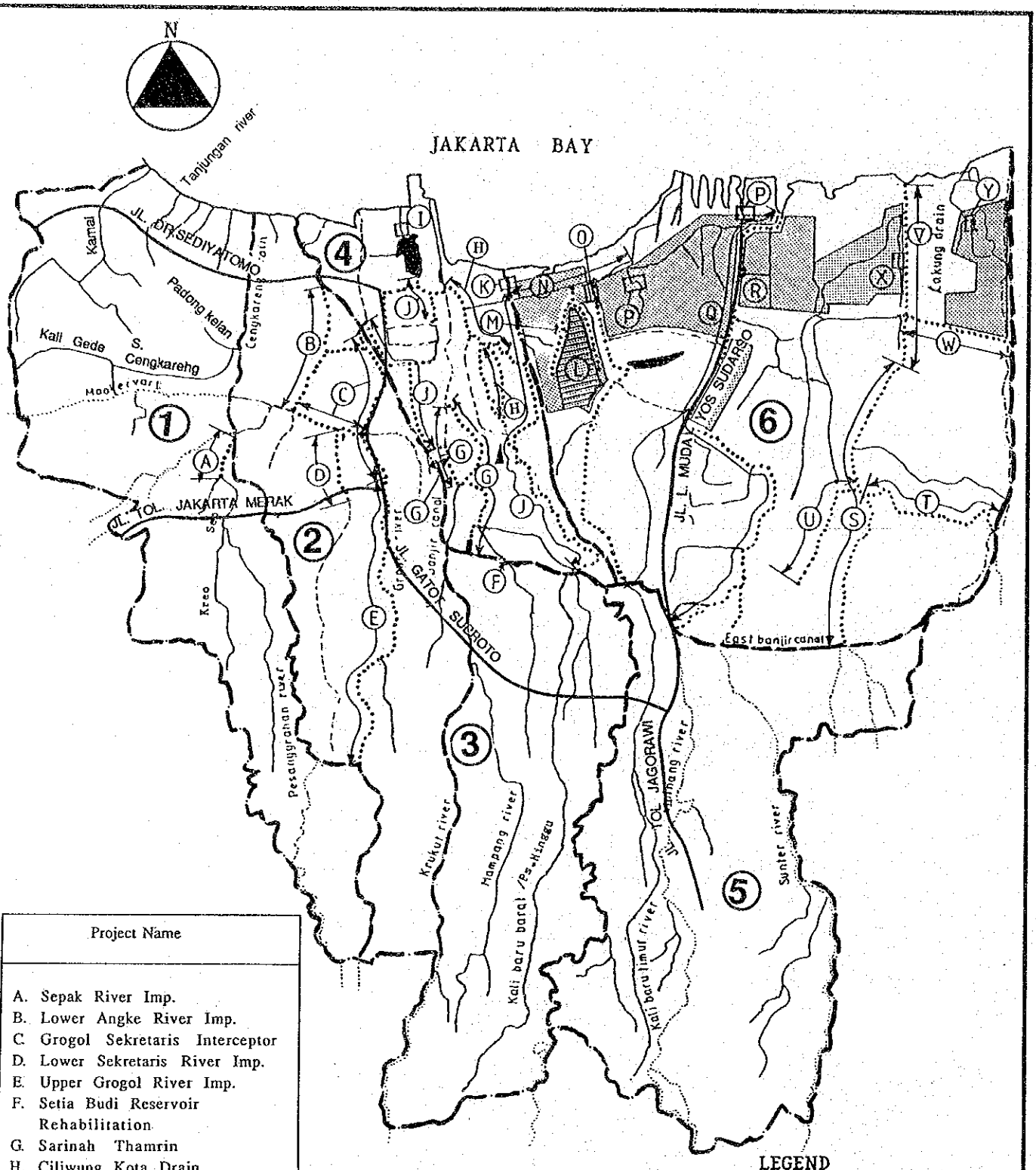


Project Name	
A. Sepak River Imp.	R. Sunter East III Polder
B. Lower Angke River Imp.	S. Buaran River Imp.
C. Grogol Sekretaris Interceptor	T. Cakung River Imp.
D. Lower Sekretaris River Imp.	U. Petukangan Canal
E. Upper Grogol River Imp.	V. Cakung Floodway Imp.
F. Setia Budi Reservoir Rehabilitation	W. Marunda Canal
G. Sarinah Thamrin	X. Sunter East II polder
H. Ciliwung Kota Drain	Y. Marunda Polder
I. Pluit Rehabilitation	
J. K. Besar &Duri Canal Imp.	
K. Ciliwung River Imp.	
L. Kemayoran Airport Drainage	
M. Pademangan Canal Imp.	
N. Ancol Canal Imp.	
O. Sentiong Cut-off Channel	
P. Sunter West Polder	
Q. Sunter River Imp.	

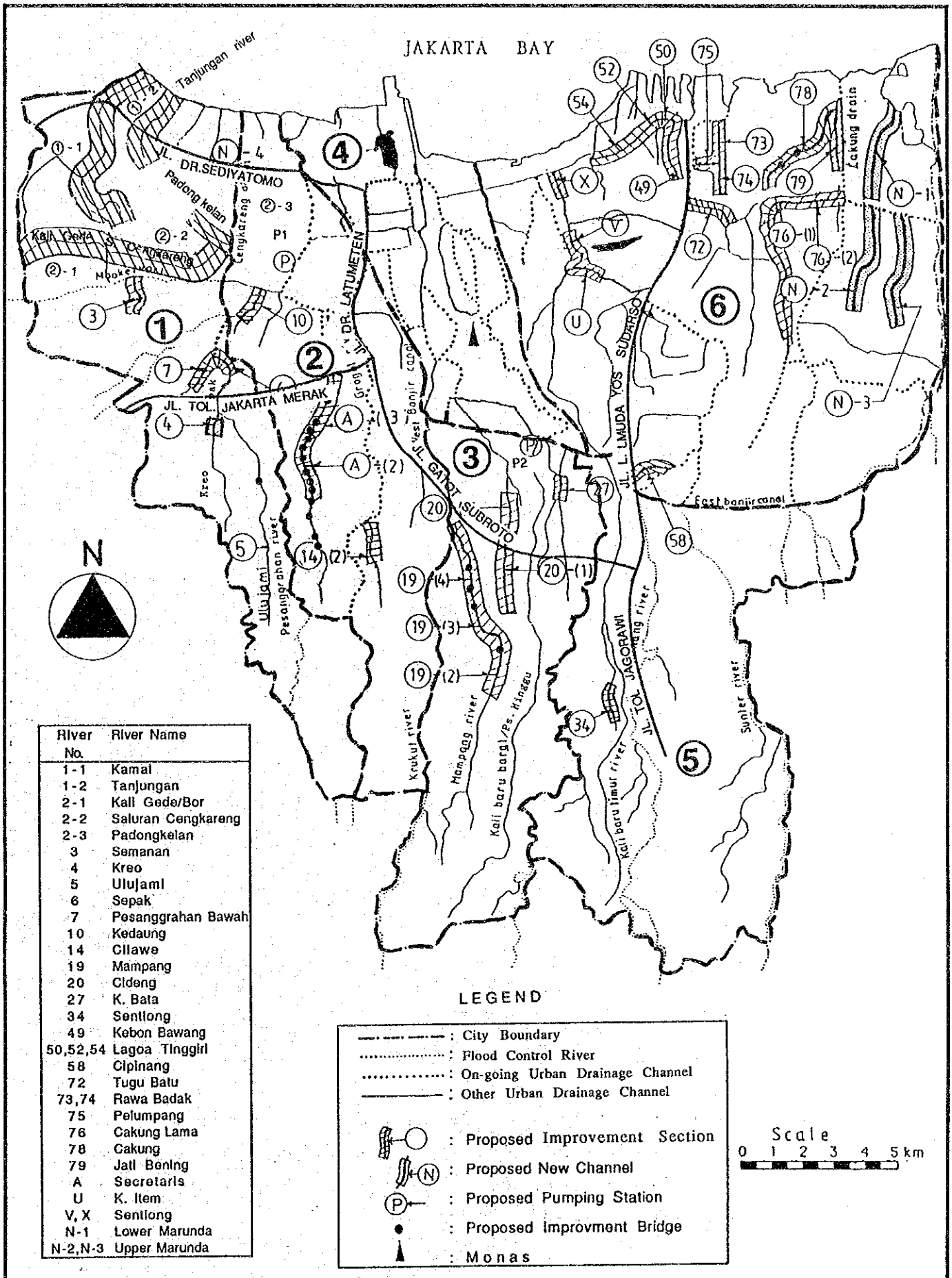
LEGEND

- City Boundary
- Flood Control River
- Group I Urban Drainage
- Group II Urban Drainage
- Group III Urban Drainage
- Inner Area of Polder

0 1 2 3 4 5 km

FIG. 2.2 LOCATION OF ON-GOING PROJECT

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA



River No.	River Name
1-1	Kamal
1-2	Tanjungan
2-1	Kali Gede/Bor
2-2	Saluran Cengkareng
2-3	Padongkelan
3	Semanan
4	Kreo
5	Ulujaml
6	Sepak
7	Pesanggrahan Bawah
10	Kedaung
14	Cllawe
19	Mampang
20	Cldeng
27	K. Bata
34	Sentlong
49	Kebon Bawang
50,52,54	Lagoa Tinggirl
58	Clpinang
72	Tugu Batu
73,74	Rawa Badak
75	Pelumpang
76	Cakung Lama
78	Cakung
79	Jatl Bening
A	Secretarls
U	K. Item
V, X	Sentlong
N-1	Lower Marunda
N-2,N-3	Upper Marunda

FIG. 2.3 LOCATION OF PROPOSED PROJECT

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

3. Feasibility Study of Drainage Development

3.1 Project Area

The Project Area covers the north west low-lying area of Jakarta City with an area of 5,000 ha (ref. Fig. 1.2) and comprised of four (4) sub-project areas of Cengkareng West, Bojong, Sepak River and Maruya Ilir. However, the major project facilities are confined to Cengkareng West area, and hence it is only briefed in this Chapter.

The Cengkareng West Project Area of 4,700 ha is encompassed by the administrative boundary of DKI to the west, Mookervart River to the south and Cengkareng Floodway to the east. Total population of the Area was 0.263 million in 1988. It is expected to increase to 0.456 million in 2010.

The Area is undergoing a rapid land development to accommodate the increasing population. Urban land area including residential, commercial & institutional and industrial ones of the Project Area will increase from 2,350 ha or 50% in 1990 to 3,525 ha or 75% in 2005.

The objective drainage basin for facility planning with a total area of 3,823 ha is selected from the Project Area as shown in Fig. 3.1. It excludes the southern fringe area of 470 ha, located along the Mookervart River and Mandar Permai Resort Development Area of 430 ha located in the north east coastal area. The objective drainage basin consists of the following five (5) sub-drainage basins (ref. Fig. 3.1).

(1) Drainage basin A covers a catchment area of 777 ha. Storm water is drained directly into the Jakarta Bay through the Tanjungan River with a total length of 3.2 km. The river width is in the range of 2 m and 5 m. The river gradient is approximately 1/3,000.

(2) Drainage basin B drains a catchment area of 1,637 ha of the Kamal River and its tributaries also into the Jakarta Bay. The total river length is 11.8 km. The river width ranges from 3 m to 18 m. The river gradient is 1/2,000 - 1/3,000.

(3) Drainage basin C consists of the channels of Kali Gede and Kali Bor. Storm water of the basin of 563 ha is drained into the Mookervart River. The total river length is 4.8 km. The river width and slope are 2 - 4 m and 1/2,000 respectively.

(4) Drainage basin D covers a catchment area of 331 ha of the Saluran Cengkareng channel. Storm water is drained into the Cengkareng Floodway through the Padongkelan channel of the drainage basin E. Total length of the Saluran Cengkareng channel is 4.5 km. Its river width and slope is 2 - 6 m and 1/2,000 respectively.

(5) Drainage basin E drains a catchment area of 515 ha of the Padongkelan channel into the Cengkareng Floodway. Most part of the basin is undergoing housing development. A sluice gate is provided at the confluence to the Cengkareng Floodway to control backwater of the Cengkareng Floodway. Total length of the Padongkelan channel is 1.1 km. Its river width and gradient is 2 - 5 m and 1/2,000 respectively.

3.2 Floods and Flood Damages

There are ten (10) potential inundation areas in the Project Area, out of which six (6) areas are habitually inundated. The total hectarage of the potential areas reaches 474 ha, while that of the habitual inundation areas 273 ha.

The major flood damages in the Study Area are as follows.

- Damages to properties including house, shop and factory
- Income losses due to closure of shop and factory
- Damages to traffic
- Damages to infrastructure and others

Those were estimated in monetary terms. The total average flood damage in 1988 is estimated to be Rp. 1,262 million. It is expected to increase to Rp. 7,085 million in 2010. The damage to properties is predominant, accounting for approximately 80% in both cases.

3.3 Proposed Drainage Improvement Plan

(1) Drainage System

The proposed drainage system of the Cengkareng West Area consists of the following five (5) sub-systems of the basin A, B, C, D and E.

(i) Basin A : Tanjungan River drainage system
(ii) Basin B : Kamal River drainage system
(iii) Basin C : Kali Gede and Kali Bor channel drainage system
(iv) Basin D : Saluran Cengkareng channel drainage system
(v) Basin E : Padongkelan channel drainage system

All the above basins are drained by gravity. No pump drainage is proposed. The existing main river and channel sections in all the above drainage systems will be widened/deepened to increase carrying capacity. The existing river/channel reaches will be extended to drain the upstream areas in the drainage systems of the Basin A, B and E. For extension, excavation of new drainage channel is proposed. Moreover, the existing sluice gate at the confluence of the Padongkelan channel to the Cengkareng Floodway will be improved.

All the drainage channels and facilities are designed to meet 10-year floods.

The proposed design flood discharge, length of channel improvement, channel gradient, channel width and channel depth for the five (5) drainage systems are summarized below.

Design System	Catch-ment Area (ha)	Design Dis-charge (m^3/s)	Channel Improvement			
			Length (km)	Gradient	Width (m)	Depth (m)
(A) Tanjungan	777	13-24	7.2	1/3,000	7.0-16.0	2.5
(B) Kamal	1,637	22-47	8.1	1/1,600-1/3,000	8.9-25.2	2.4
(C) Kali Gede/Kali Bor	563	23-27	4.8	1/2,000	8.2-8.5	2.5-3.0
(D) Salurang Cengkareng	331	13-18	4.5	1/2,000	6.5-7.5	2.5
(E) Padongkelan	515	12-30	2.8	1/2,000	5.9-10.7	2.5
Total	3,823		27.4			

Location of the channel improvement is shown in Fig. 3.2. The design flood distribution for the respective channels are also given in Fig. 3.2.

(2) Construction Works and Land Acquisition

The proposed major construction works, and required land acquisition and compensation are summarized as follows.

(i) Construction Works

- Channel excavation : 469,000 m^3
- Embankment : 106,000 m^3
- Revetment works : 46 km, 195,000 m^2
- Bridge improvement : 15 places, 700 m^2
- Highway crossing : 2 places, 360 m^2
- Inspection road : 35 km, 138,000 m^2
- Sluice gate improvement : 1 place

(ii) Land Acquisition and Compensation

- Land Acquisition : 42 ha
- Resettlement Compensation : 230 houses

3.4 Project Evaluation

(1) Project Cost

The total project cost is estimated to be Rp. 51,200 million at July, 1990 prices. Its break-down by cost item is given below.

(Unit: million Rp.)

Item	Cost
Direct Construction	19,880
Land Acquisition/Compensation	26,646
Engineering Service	1,988
Administration	698
Physical Contingency	1,988
Total	51,200

(2) Economic Evaluation

The economic efficiency of the proposed project is evaluated as follows.

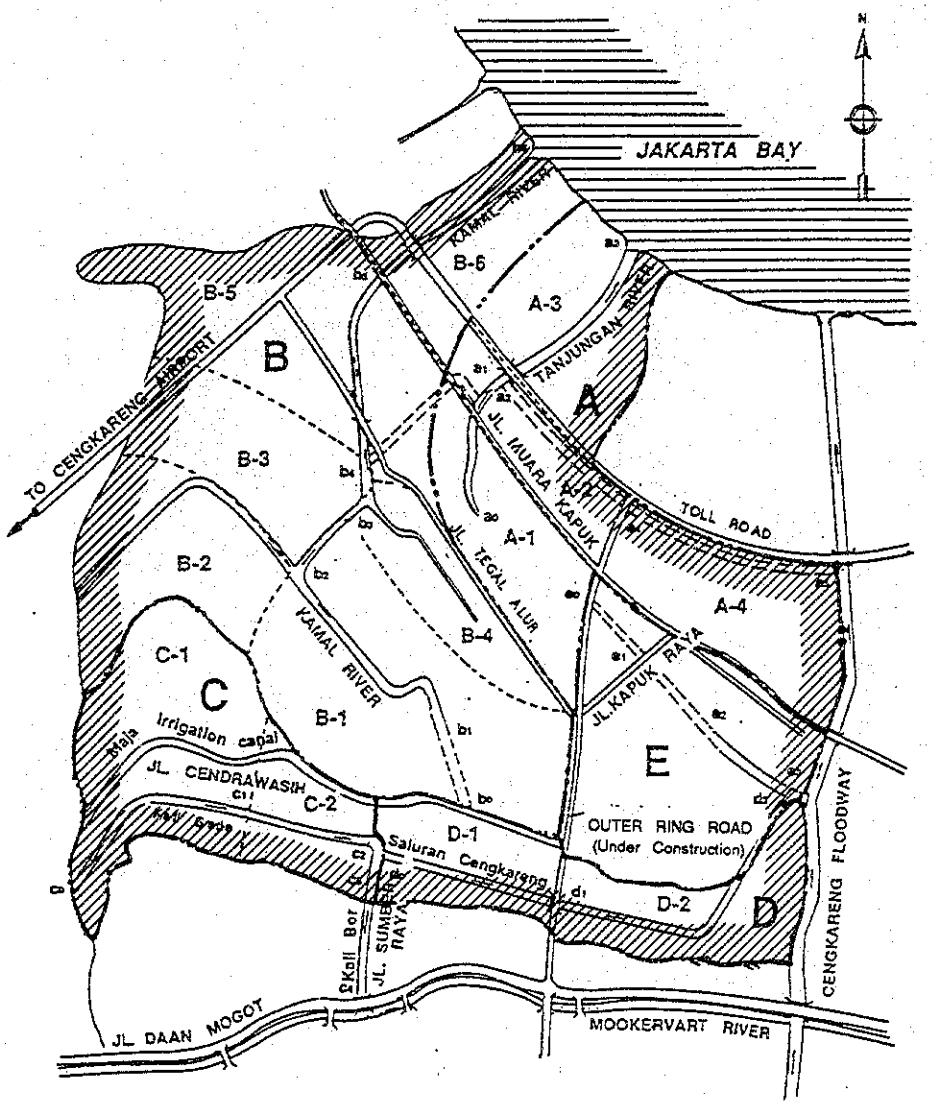
- Net Present Value (NPV) : Rp. 20,822 million
- Benefit Cost Ratio (B/C) : 2.15
- Economic Internal Rate of Return (EIRR): 20.0%

(3) Environmental Assessment

No significant adverse effects on the environments are anticipated in consideration to the similar projects completed recently.

3.5 Recommendation

An immediate implementation of the project is recommended in consideration to the progressing and future land development activities and the resultant increase in rainfall runoff. Hence, it is recommended to commence the necessary financial procurement at the earliest.



Length of Drainage Channel

Basin	Route	Length(km) Existing	Length(km) New Channel
A	a0-a1	1.10	
	a1-a2	0.45	
	a2-a3	1.60	
	a4-a2		1.70
	a5-a4		2.30
	Sub Total	3.15	4.00
B	b0-b1		0.68
	b1-b2	2.20	
	b2-b3	1.00	
	b3-b4	0.30	
	b4-b5	1.88	
	b5-b6	1.88	
	b7-b3	(1.60)	
	b8-b2	(2.80)	
	Sub Total	11.76	0.68
C	C0-C1	1.95	
	C1-C2	1.48	
	C2-C3	0.45	
	C3-C4	0.88	
	Sub Total	4.76	
D	d0-d1	1.65	
	d1-d2	2.88	
	Sub Total	4.53	
E	e0-e1		0.75
	e1-e2		1.00
	e2-e3	0.95	
	e3-e4	0.10	
	Sub Total	1.05	1.75
	Total	20.94	6.43

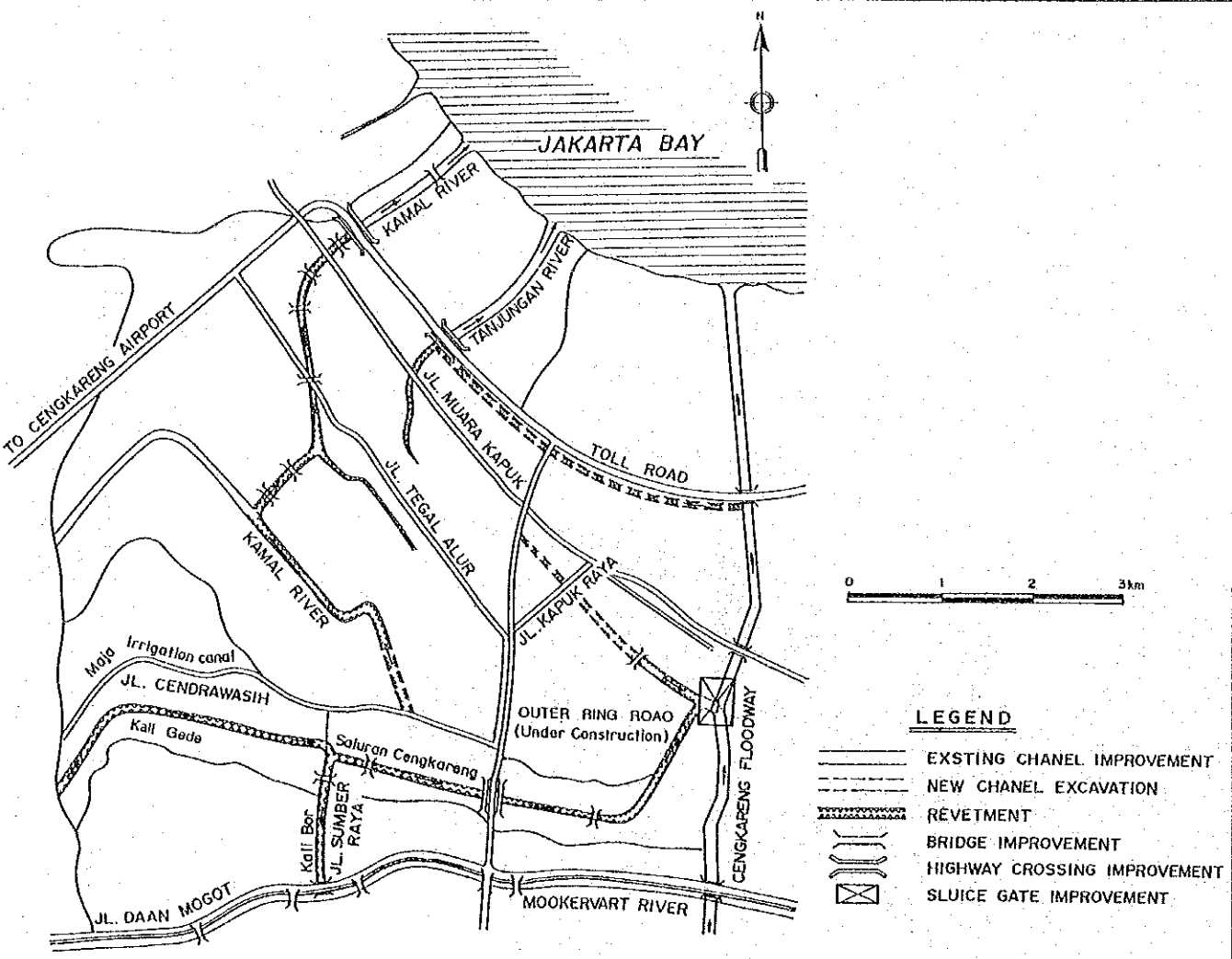
Catchment Area of Sub Basin

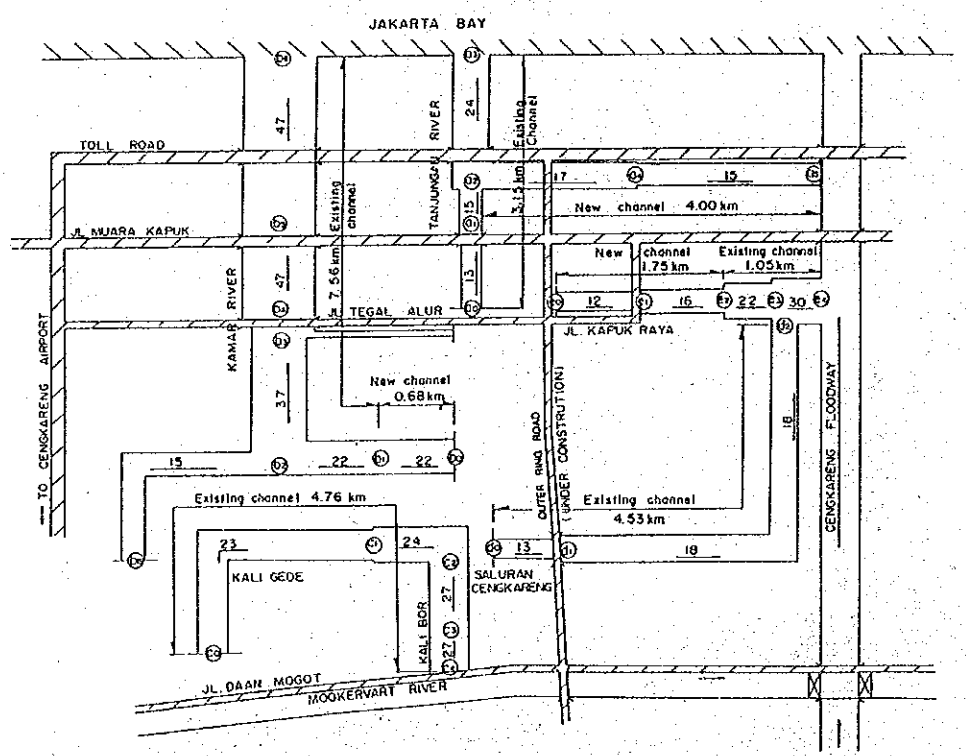
Basin	Sub-basin	Area(km2)
A	A-1	1.9
	A-2	1.41
	A-3	2.11
	A-4	2.35
	Sub Total	7.77
B	B-1	4.64
	B-2	2.47
	B-3	2.18
	B-4	1.52
	B-5	3.72
	B-6	1.84
	Sub Total	16.37
C	C-1	3.32
	C-2	2.31
	Sub Total	5.63
D	D-1	1.39
	D-2	1.92
	Sub Total	3.31
E	Sub Total	5.15
	TOTAL	38.23

: Objective Drainage Basin

FIG. 3.1 OBJECTIVE DRAINAGE BASIN AND EXISTING DRAINAGE SYSTEM

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA





(DESIGN FLOOD DISCHARGE DISTRIBUTION OF PROPOSED CHANNEL)

FIG. 3.2 LOCATION OF PROPOSED CHANNEL IMPROVEMENT

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

JICA A.D 1991

4. Sanitation and Sewerage Development Master Plan

4.1 Delineation of Sanitation and Sewerage Development Areas

The plan of sanitation and sewerage development in the Study Area is aimed both at the improvement of sanitary condition of the communities and abatement of water pollution of public waterways.

Based on existing data on population density and river water quality, it is established that increase in water pollution as BOD is linearly correlated to that of increase in population density. A similar pattern may be reasonably assumed for sanitary condition of communities.

Accordingly, in the Study Area, river water quality remained less than 30 mg/l as BOD in those areas with population density less than 100 person/ha, 30 mg/l ~ 80 mg/l for population density in the range of 100 ~ 300 person/ha, and higher than 80 mg/l as BOD for population density greater than 300 person/ha.

The target river water quality of sanitation and sewerage master plan is set at 30 mg/l as stream BOD in 2010, conforming the least permissible standards, stipulated to maintain aquatic biota, by the Governor's Decree No. 1608, 1988.

Conforming the criteria dealt above, the Study Area is divided into three (3) areas, Area A, Area B and Area C, based on Kelurahan-wise future population density in 2010 as shown in Fig. 4.1.

(i) Area A: Simple On-site Treatment System Development Area

The population density in this area is less than 100 person/ha. Sanitary disposal of toilet waste is only considered, in principle, and gray water be discharged with no treatment, which is adequate to maintain river water quality not to exceed 30 mg/l as stream BOD. This area having a total population of 1,482,000 in 2010 covers 37 Kelurahans with an area of 21,159 ha.

(ii) Area B: High Level On-site Treatment System Development Area

The population density is in the range of 100 ~ 300 person/ha. On-site system to treat both the toilet waste and gray water, typically septic tank with upflow filter, is proposed as it is found to be more economical than sewerage. This is to produce a moderate effluent quality of 60 mg/l as BOD in order to conform the target river water quality of 30 mg/l as stream BOD. The area covers 89 Kelurahans with a total area and future population of, respectively, 27,386 ha and 4,967,000.

(iii) Area C: Sewerage Development Area

This area covers the central region of the Study Area with high future population density of more than 300 person/ha. Sewerage development is proposed for this area, to conform the target river water quality, as it is found to be more economical than on-site system to produce an effluent quality of 30 mg/l as BOD. The number of Kelurahans covered, total area and future population in 2010 are respectively, 140, 16,604 ha and 6,351,000.

4.2 Proposed Sewerage Development Plan

Based on alternative study, carried out by dividing the sewerage area (Area C) into nine (9) independent small scale sewerage zones to one (1) single large zone, the optimum zoning was selected as the one that comprised of six (6) independent sewerage zones as shown in Fig. 4.2.

A sewage collection system consisting of conventional separate system and interceptor system is applied, along with aerated lagoon as the treatment system, in principle, wherever sufficient land/pond area is available. The main features of project facilities in each sewerage zone is summarized in Table 4.1.

The total project cost of sewerage development is estimated at Rp. 1,814.5 billion (Rp. 1,930.5 billion including the cost of house connection) and the

annual O&M cost is Rp. 18.1 billion, both at 1990 price. The cost breakdown is shown in Table 4.2.

4.3 Proposed Sanitation Development Plan

The sanitation development plan encompasses the whole Study Area, and specifically the on-site system areas of Area A and Area B and the interceptor sewerage zones of Area C.

(1) Proposed On-site Facilities

The on-site sanitation systems planned are individual toilets and treatment units, and public toilets. However, the provision of public toilets is restricted to those existing population, living in relatively high population density areas, with no access to sanitation facilities. Hence, Area A with low population density is excluded.

Accordingly, for simple on-site treatment system development area of Area A (ref. Section 4.1) leaching pit/septic tank and septic tank with mound are proposed for respectively the deep and shallow groundwater zones, to treat toilet waste only, in principle.

Similarly, for Area B of high level on-site treatment system to treat both the toilet waste and gray water, conventional septic tanks and septic tank with upflow filter are proposed respectively for deep and shallow groundwater zones. For interceptor zones of the sewerage development area (Area C), septic tank is proposed to treat toilet waste only.

(2) Sludge Treatment

The Study Area is divided into ten (10) number service areas of desludging, transport and treatment of sludge desludged from the on-site facilities, as shown in Fig. 4.3. For sludge treatment, in addition to the planned six (6) wastewater treatment plants (Service Area 1 ~ 6) and the two existing and planned sludge treatment plants of Pulo Gebang and Duri Kosambi (Service Area 10 and Service Area

7), two (2) new sludge treatment plants are planned in Kec. Pasar Minggu and Pasar Rebo. The main features concerning desludging, transport and treatment of each service area is summarized in Table 4.3.

(3) Project Cost

The total project cost is estimated to be Rp. 1,411 billion with a break-down of Rp. 89 billion for public sector and Rp. 1,322 billion for private sector at 1990 price. The annual O&M cost is estimated at Rp. 4.6 billion.

4.4 Alleviation of Water Pollution

The future pollution load discharge of the Study Area in 2010 with no project is estimated at 545,245 kg/d with a break-down of 101,494 kg/d in Area A, 213,940 kg/d in Area B and 229,811 kg/d in Area C.

The total pollution load reduction by sanitation and sewerage development is estimated to be 297,570 kg·BOD/d with a break-down of 105,391 kg·BOD/d by sanitation development in Area B and 192,251 kg·BOD/d by sewerage development in Area C.

Existing average river water quality in the central part of the Study Area is 67 mg/l as stream BOD and it would further aggravate to more than 88 mg/l in 2010, under the condition of no project. The proposed sewerage and sanitation development along with industrial pollution control would enhance the river water quality to the target level of 30 mg/l as stream BOD, conforming the water quality standards by Governor's Decree No. 1608, 1988.

4.5 Financial Aspects

The required initial cost of sewerage and sanitation development by public sector is estimated at Rp. 1,904 billion at 1990 price. The O&M cost under full operational condition of all facilities is estimated at Rp. 22,662 million/ annum.

The initial cost is high, hence it is not reasonable to burden the beneficiaries with the entire cost. However, the beneficiaries shall bear the entire O&M cost, a criteria already adopted by the Government of Indonesia concerning sewerage development. Based on the questionnaire survey of people's willingness to pay for the sewerage/on-site sanitation service, sum total of the willingness to pay for all properties over the whole Study Area works out at Rp. 39,167 million per annum in 1988 and it will reach Rp. 97,562 million in the year 2010 at 1990 prices. These amounts are enough to burden the annual O&M costs of the proposed sewerage/on-site sanitation development systems.

Based on the past ratio of 4.8% of urban development funds of DKI Jakarta to its gross domestic product (GDP), urban development funds of DKI Jakarta over the 18 years of the project construction period from 1993 to 2010 is estimated at Rp. 12,280,910 million at 1990 price. This amount is adequate to carry out the proposed sewerage and sanitation development with the initial cost of Rp. 1,904 billion.

4.6 Priority Area of Sewerage Development

Priority sequence of the six (6) proposed sewerage development zones (ref. Fig. 4.2) was assigned based on integral viewpoints of demand/benefit, adverse effect and constraint by the project. Accordingly, Central Sewerage Zone was selected as the priority area for feasibility study (ref. Fig. 1.2).

4.7 Recommendation

Enhancement of public awareness on environmental pollution issues is extremely necessary not only to improve the environmental condition of Jakarta but also to gain public support for sewerage development. It is recommended to conduct public campaign by DKI Jakarta or other related organization to enhance the awareness of general populace on the importance of environmental quality improvement and its relation to alteration of behavioral pattern.

Table 4.1 Main Features of Sewerage Zones

Zone	Central	North West	South West	North East	South East	Tanjung Priok	Total
Served Area (ha)	6,107	2,016	2,170	3,566	1,243	1,502	16,604
Conventional Area (ha)	3,422	530	938	1,610	307	700	7,507
Interceptor Area (ha)	2,595	1,332	1,232	1,886	936	802	8,783
No Sewerage Area (ha)	90	154	0	70	0	0	314
Population Served in 2010	2,466,000	642,000	674,000	1,383,000	523,000	663,000	6,351,000
Conventional Area	1,149,000	185,000	244,000	527,000	137,000	337,000	2,579,000
Interceptor Area	1,317,000	457,000	430,000	856,000	386,000	326,000	3,772,000
Population Density (person/ha)	410	345	311	396	421	441	382
Conventional Area	336	349	260	327	446	481	344
Interceptor Area	508	343	349	424	412	406	429
Lift Pump Station	1	3	5	0	0	1	10
Treatment Plant							
Plant Area (ha)	88.0	18.0	16.0	14.0	13.0	37.0	186.0
System	A.L & F.P	A.L	A.L	A.S	A.L	A.L & F.P	-
Capacity (m3/d)	529,000	124,000	117,000	261,000	101,000	120,000	1,252,000
Discharge to	Jakarta B.	Cengka.	Pesangg.	Sunter	Sunter	Cakung	-

Note : A.L means aerated lagoon
: A.L & F.P means aerated lagoon & facultative pond
: A.S means conventional activated sludge

Table 4.2 Project Cost and Annual O&M Cost of Sewerage Zones

(Project Cost)

(Unit: Rp. million)

Sewerage Zone	Central	North West	South West	North East	South East	Tanjung Priok	Total
Cost Item							
A. Direct Construction Cost	523,883	169,154	193,510	398,559	97,110	141,850	1,524,066
(1) Collection Sewer Line	479,801	137,645	149,816	271,808	68,393	115,072	1,222,535
(2) Lift Pump Station	-	10,373	15,747	-	5,251	6,068	37,439
(3) Treatment Plant	44,082	21,136	27,947	126,751	23,466	20,710	264,092
B. Land Acquisition Cost	568	1,944	2,721	710	1,012	1,401	8,356
C. Administration Cost	7,867	2,566	2,943	5,989	1,472	2,149	22,986
D. Engineering Cost	36,672	11,841	13,546	27,899	6,798	9,930	106,685
E. Physical Contingency	52,388	16,915	19,351	39,856	9,711	14,185	152,407
Total	621,378	202,421	232,071	473,013	116,103	169,514	1,814,500
F. House Connection Cost	51,696	8,316	10,980	23,724	6,156	15,156	116,028
Grand Total	673,074	210,737	243,051	496,737	122,259	184,670	1,930,528

(Annual O&M Cost)

Sewerage Zone	Central	North West	South West	North East	South East	Tanjung Priok	Total
A.Collection System	191	49	62	104	30	45	481
B.Lift Pump Station	-	488	581	-	89	127	1,285
C.Treatment Plant	6,698	1,285	1,382	4,113	1,208	1,615	16,301
Total	6,889	1,822	2,025	4,217	1,327	1,787	18,067

Table 4.3 Service Area, Desludging and Transport of Sludge

Service Area / Treatment Plant		Area (ha)	Average Quantity of Desludging (m3/d)		Vacuum Truck (Nos.)
			Whole Service Area	On-site Area (Area A + Area B)	
	1	10,523	411	121	48
	2	3,597	234	142	16
Wastewater	3	5,931	383	298	30
Treatment	4	5,106	283	98	22
Plant	5	1,243	78	0	5
	6	7,964	237	170	28
	7(DK.)	6,950	300	300	23
Sludge	8	8,245	304	304	35
Treatment	9	9,441	299	299	35
Plant	10(PG.)	6,149	310	310	24
Study Area (Total)		65,149	2,839	2,042	266

Note : DK. : Sludge treatment plant under construction in Duri Kosambi
PG. : Existing sludge treatment plant at Pulo Gebang
All others to be newly constructed

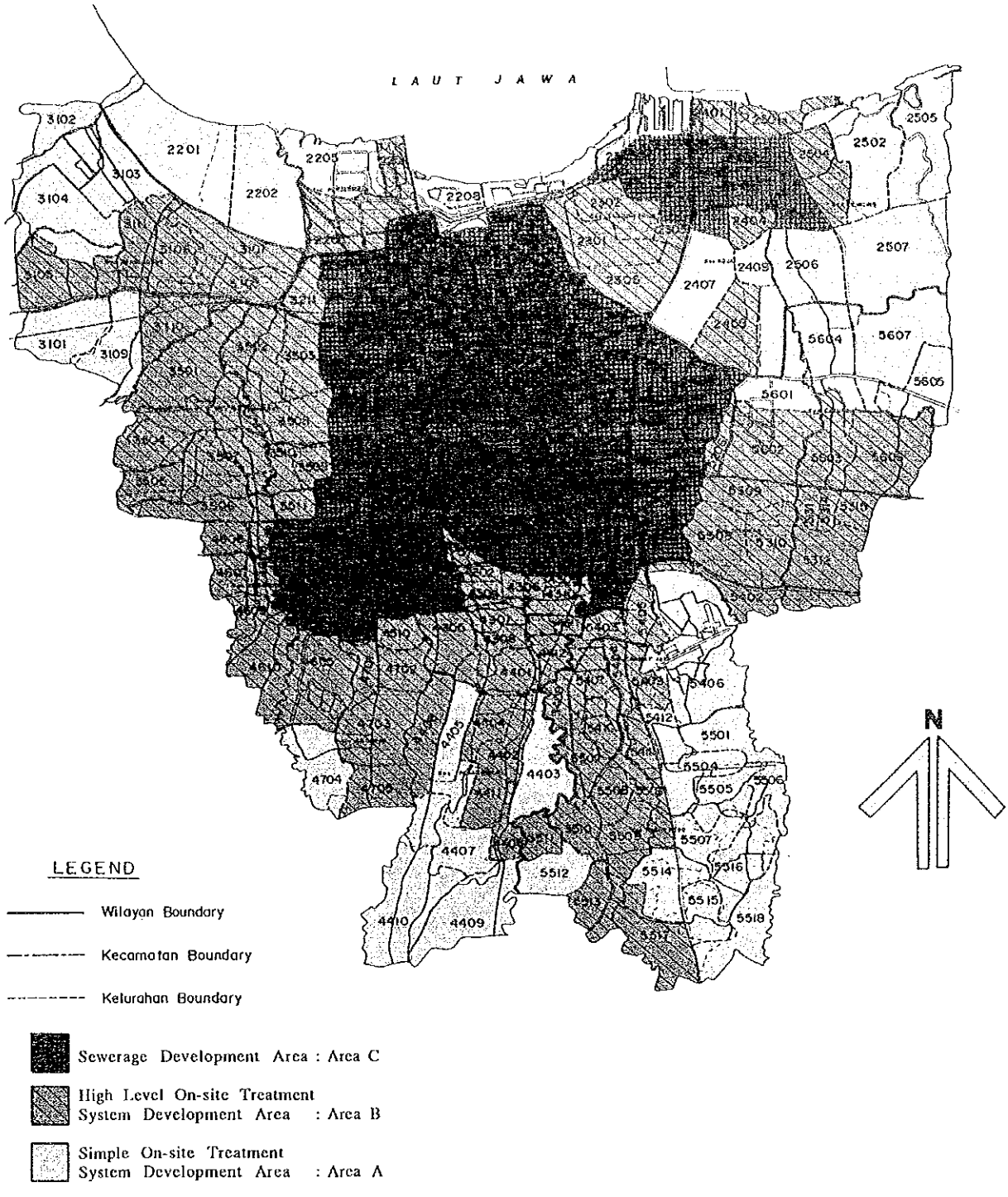
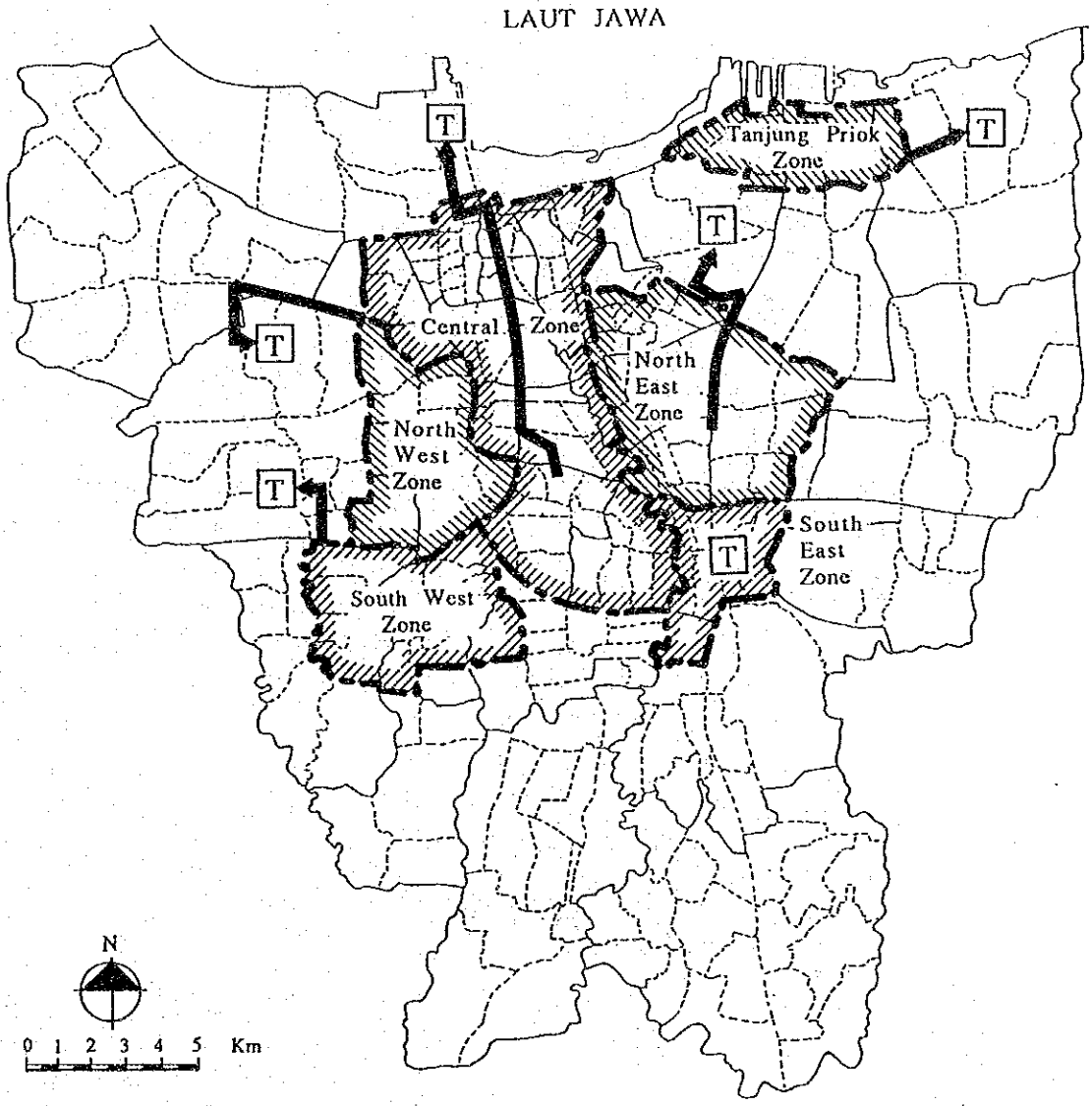


FIG. 4.1 DIVISION OF PROJECT AREA BY SANITATION SYSTEM

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA



LEGEND

——— : Wilayah Boundary

– · – · – : Kecamatan Boundary

– – – – – : Kelurahan Boundary

▬ • ▬ : Boundary of Sewerage Development Zone

▬▶ : Conveyance Sewer Line

[T] : Sewerage Treatment Plant

FIG. 4.2 PROPOSED SEWERAGE DEVELOPMENT SYSTEM

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

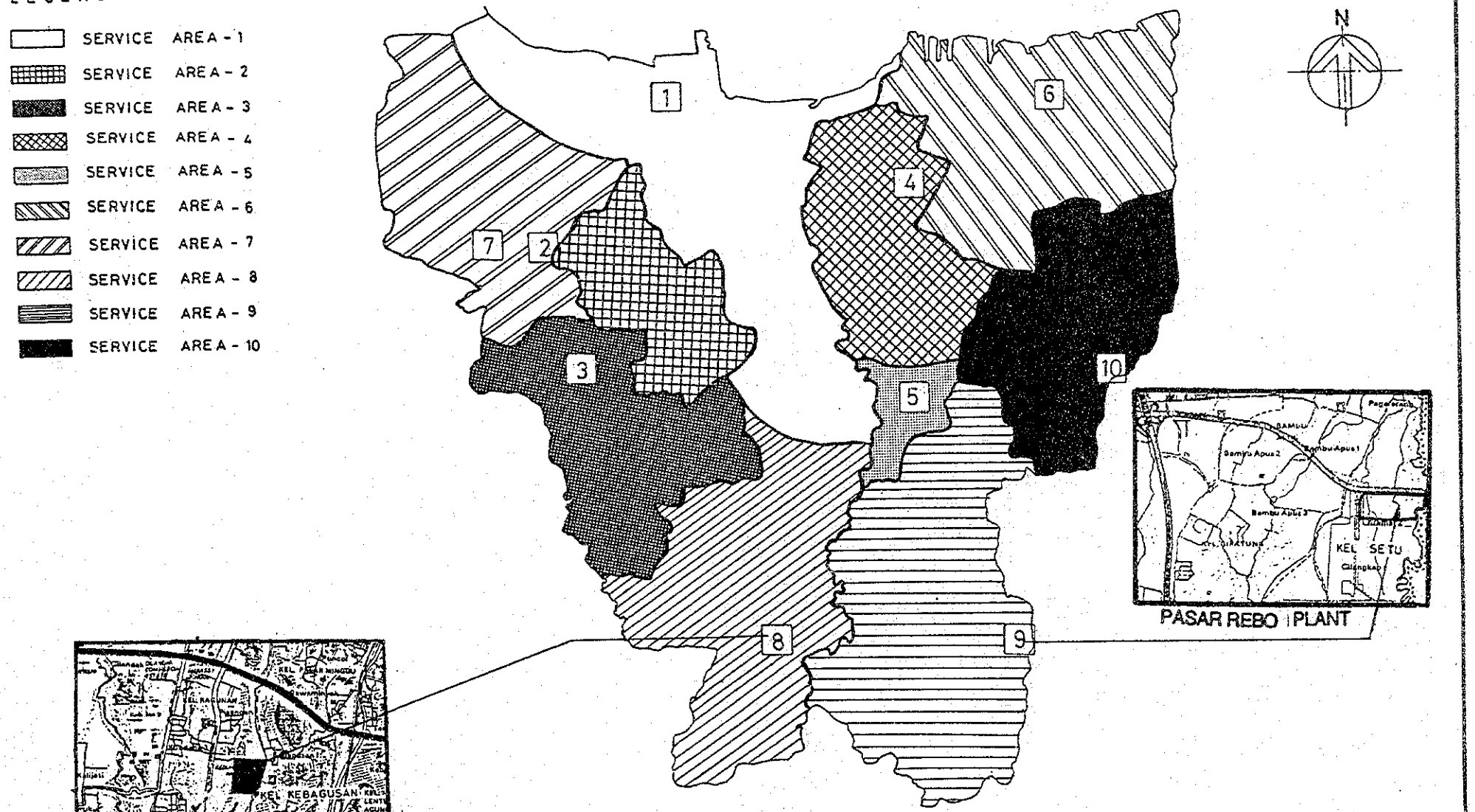


FIG. 4.3 SERVICE AREA OF DESLUDGING AND TREATMENT

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

JICA A.D 1991

5. Feasibility Study of Sewerage Development

5.1 Project Area

The Project Area covers the northern portion of central sewerage zone with an area of 4,300 ha, defined as North Central Sewerage Development Area, excluding the ongoing pilot sewerage development area by JSSP (ref. Fig. 1.2). The Project Area encompasses 47 Kelurahans with a total existing and future population, in 1988 and 2010, of respectively 1,548,520 and 1,659,200.

The proposed sewerage development system, as shown in Fig. 5.1, covers the entire project area other than those of rivers, parks, ponds and reserved areas. Accordingly, the area covered by sewerage development system becomes 3,847 ha.

5.2 Sewerage Development Plan

(1) Collection System

Conventional separate collection system and interceptor collection system are applied for wastewater collection in the Project Area. Conventional sewage collection system collects both toilet waste and gray water through a complete sewer pipe networks. While the interceptor system collects gray water only through the existing road side drainage ditches. The toilet waste in this area will be treated by on-site septic tank systems.

Conventional sewage collection system covers the following areas:

(i) Commercial and institutional areas located along main roads.

(ii) Residential areas where redevelopment has been completed and besides, the existing road width is wider than 2 m, which is the minimum width required for laying sewer lines and other appurtenances.

Interceptor collection system is applied for the following areas in principle:

(i) High population density Kampung areas as there exist no road networks wide enough for sewer installation

(ii) Residential areas where land readjustment has not been completed even where the existing road width is more than 2 m in order to avoid future sewer reconstruction.

Service area and population served in the year 2000 by both the conventional and interceptor sewerage collection systems are respectively 2,285 ha and 1,562 ha, and 765,000 and 894,000.

Conveyance sewer of diameter 1,900 mm ~ 2,900 mm is proposed along the M.H. Thamrin Rd. and Gajah Mada Rd. Its total length, from Kel. Menteng located at southern boundary of the Project Area to the treatment plant at Pluit Pond, is 10.34 km.

(2) Treatment Plant

Aerated lagoon treatment system with facultative/anaerobic pond is proposed in the Pluit Pond used for storm water drainage at present.

Aerated lagoon system is selected because of its economics and ease of operation and maintenance, when sufficient land/pond area is available.

The treatment plant will serve not only the Project Area but also the JSSP Area. Wastewater of the JSSP Area will be transferred to the treatment plant by the above mentioned conveyance sewer.

Required capacity of the treatment plant in the year 2000 and 2010 are 441,000 m^3/d and 529,000 m^3/d. Those capacities include wastewater of the JSSP Area of 124,800 m^3/d in 2000 and 140,000 m^3/d in 2010 respectively (ref. Fig. 1.2).

Treatment plant consists of inflow pump station of capacity 454 m^3/min, aerated lagoon of storage capacity 1,075,000 m^3 with 24 units of aerator, facultative/anaerobic pond with storage capacity 2,096,000 m^3 and drying bed for sludge treatment.

The design detention time of aerated lagoon and facultative/ anaerobic pond in 2000 is respectively 2.4 days and 4.8 days.

The wastewater treatment system in Pluit Pond is designed so that it does not interfere with the established function of storm water drainage and flood control of Pluit Pond.

5.3 Project Cost

Project cost of sewerage development is estimated to be Rp. 445.3 billion at 1990 price and break-down is shown below.

		(Unit: Rp. billion)
1.	Construction Cost	375.3
	Collection Sewer	221.9
	Conveyance Sewer	117.0
	Treatment Plant	36.4
2.	Land Acquisition	0.6
3.	Administration Cost	5.6
4.	Engineering Services	26.3
5.	Physical Contingency	37.5
	Total	445.3

Annual operation and maintenance cost of the project in 2000 is estimated at Rp. 3.6 billion, consisting of sewer maintenance cost of Rp. 164 million, O&M cost of lift pump station of Rp. 114 million and that of treatment plant of Rp. 3,311 million at 1990 price.

Implementation of the Project is divided into two (2) phases because of the high amount of project cost. First phase is scheduled from 1992 to 1996 followed with the second one from 1996 to 2000.

5.4 Project Evaluation

(1) Pollution Load Reduction

The total pollution load reduction by sewerage development in the Project Area is estimated at 49,659 kg/d as BOD, which represents a reduction efficiency of 84% with respect to the total pollution load discharge of 59,145 kg/d in the year 2000.

The sewerage development is further expected to contribute to the pollution load reduction of 21,210 kg/d from 24,960 kg/d to 3,750 kg/d as BOD in the JSSP Area.

(2) Environmental Assessment

No significant long term adverse environmental effects by the project are identified other than foam pollution due to operation of wastewater treatment plant. As the major mitigatory measure, instituting of green belt around the pond is proposed along the already reserved green area.

5.5 Affordability and Willingness to Pay for Sewerage

(1) Willingness to Pay

The monthly average willingness to pay by a household for sewerage service is estimated to be Rp. 1,846. Accordingly, the total annual amount of household willingness to pay in the Project Area becomes Rp. 6,227 million in 1988 and Rp. 9,435 million in 2000. This accounts for respectively 86.7% and 77.1% of the total willingness to pay by all beneficiaries in the Project Area in 1988 and 2000.

(2) Affordability and Contribution of High Rise Building

Affordability of a high rise building, a building having more than four (4) stories, to sewerage development is considered to be

Rp. 10,000 per m^2 floor area of building. The corresponding total revenue from high rise buildings as capital work charge in the project area between 1993 and 2000 is estimated at Rp. 9.5 billion in present value which accounts for about 3.7% of the total construction cost by the year 2000.

(3) Sewerage Charge

The proposed sewerage charge consists of sewerage service charge and capital works charge. Sewerage service charge is levied on all the beneficiaries having direct connection to the sewers, based on floor area of building, as applied for the JSSP Project. The proposed charge is summarized below.

Resident	Rp. 28/m^2
Shop, Office, School and Others	Rp. 40/m^2
Restaurant	Rp. 60/m^2
Factory, Hotel and Hospital	Rp. 100/m^2
High rise building on average	Rp. 140/m^2

Capital works charge is imposed on high rise building only. The proposed charge is Rp. 10,000/m^2 on a lump sum basis.

5.6 Financial and Institutional Aspects

Of the total project cost of Rp. 445.3 billion at 1990 price, disbursed between the project implementation period of 1992 ~ 2000, it is proposed that the central government shall subsidize 60% of the cost and DKI, Jakarta a 30%. The remaining 10% of the capital cost and the whole O&M cost including depreciation shall be borne by the sewerage enterprise and hence the beneficiaries.

PDAL Jakarta, the permanent sewerage enterprise to be created in 1991 from the existing interim organization of BPAL of JSSP Project, is recommended to take charge of this project as well. It shall also formulate the necessary sewerage tariff to meet the above financial requirement

based on the affordability and willingness to pay briefed in foregone section, in addition to be in charge of the project implementation.

5.7 Recommendation

(1) An immediate implementation of the project is necessary for both the river water quality and overall sanitary improvements of the Project Area. Hence it is recommended to commence the necessary financial procurement, at the earliest.

(2) PDAL Jakarta is recommended to be the executing agency of the Project along with that of JSSP Project by IBRD. Hence, it is necessary to strengthen the institutional and financial management of the organization so that it can take over this project implementation smoothly and to eventually become capable to conduct the feasibility studies for subsequent sewerage developments as proposed in the Master Plan.

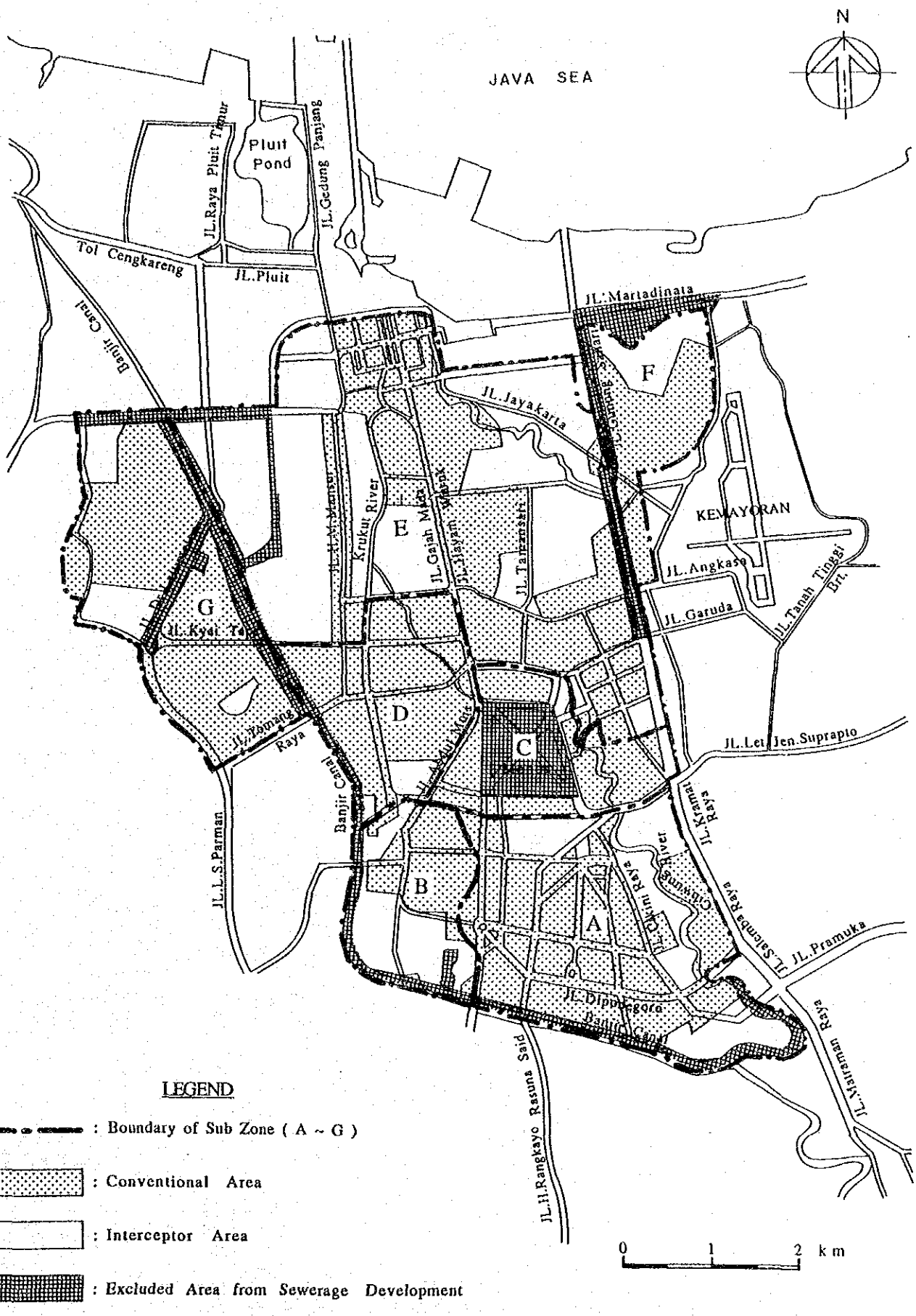


FIG. 5.1 DELINEATED CONVENTIONAL AND INTERCEPTOR AREA

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

MAIN REPORT

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III. SEWERAGE

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I. INTRODUCTION

1. General

This is the feasibility study of drainage and sewerage development conducted in those priority areas as identified by the prior master plan study. The study area of master plan, shown in Fig. I.1, encompassed the entire administrative region of DKI, Jakarta with an area of about 650 sq.km.

The master plan study, compiled as separate volumes of both main report and supporting report, was carried out from September 1989 to August 1990. Subsequently, this feasibility study was conducted until January 1991, marking the completion of the whole Study.

The feasibility study area of both drainage and sewerage, termed as Project Areas, that were selected based on detailed consideration of the respective priority areas as identified in the master plan study, are shown in Fig. I.2, along with those priority areas concerned.

The Project Area for urban drainage development covers an area of 5,000 ha located in the north western fringe of Jakarta City. The urban drainage project consists of four (4) sub-projects, Cengkareng West Drainage, Sepak River Improvement, Bojong Drainage Improvement and Maruya Ilir Drainage Improvement.

The Project Area for sewerage development covers an area of 4,300 ha located in central Jakarta and excludes an area of about 2,000 ha of the master plan priority area lying south of West Banjir Canal, which consist of Kec. Setia Budi and Tebet Manggarai, where a pilot sewerage development project is ongoing by JSSP.

2. Implementation of the Study

Directorate General of Human Settlements (Cipta Karya), Ministry of Public Works and Jakarta Metropolitan Government (DKI, Jakarta) were assigned as the counterpart executing agencies of the Government of Indonesia,

while the Japan International Cooperation Agency (JICA) was assigned as the official agency responsible for the implementation of the technical cooperation program of the Government of Japan.

The personnel involved in the conduct of this feasibility study are listed below.

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3. Composition of Report

This Feasibility Study Report consists of two (2) volumes: Main Report and Supporting Report.

The Main Report presents the summarized results of the feasibility study on urban drainage development in part II and that of sewerage development in part III, independently. While the Supporting Report deals with in details, the urban drainage development projects in part I and the sewerage development project in part II.

The whole study, including the prior master plan study, consists of the following reports:

(1) MASTER PLAN STUDY
(MAIN REPORT)
(2) MASTER PLAN STUDY
(SUPPORTING REPORT, VOLUME I)
(3) MASTER PLAN STUDY
(SUPPORTING REPORT, VOLUME II)
(4) FEASIBILITY STUDY
(MAIN REPORT)
(5) FEASIBILITY STUDY
(SUPPORTING REPORT)
(6) DATA BOOK
(7) DRAWING
(8) EXECUTIVE SUMMARY

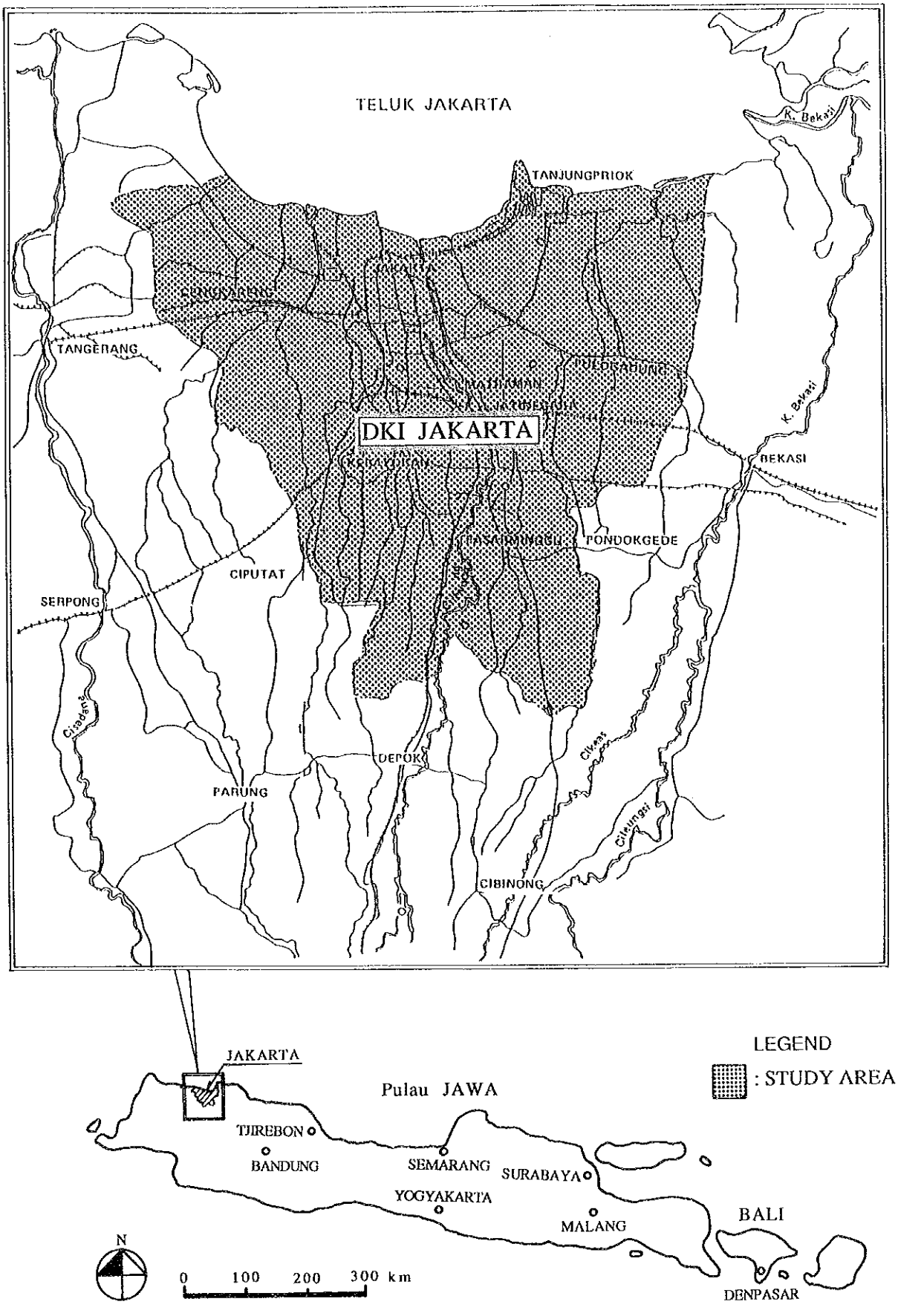
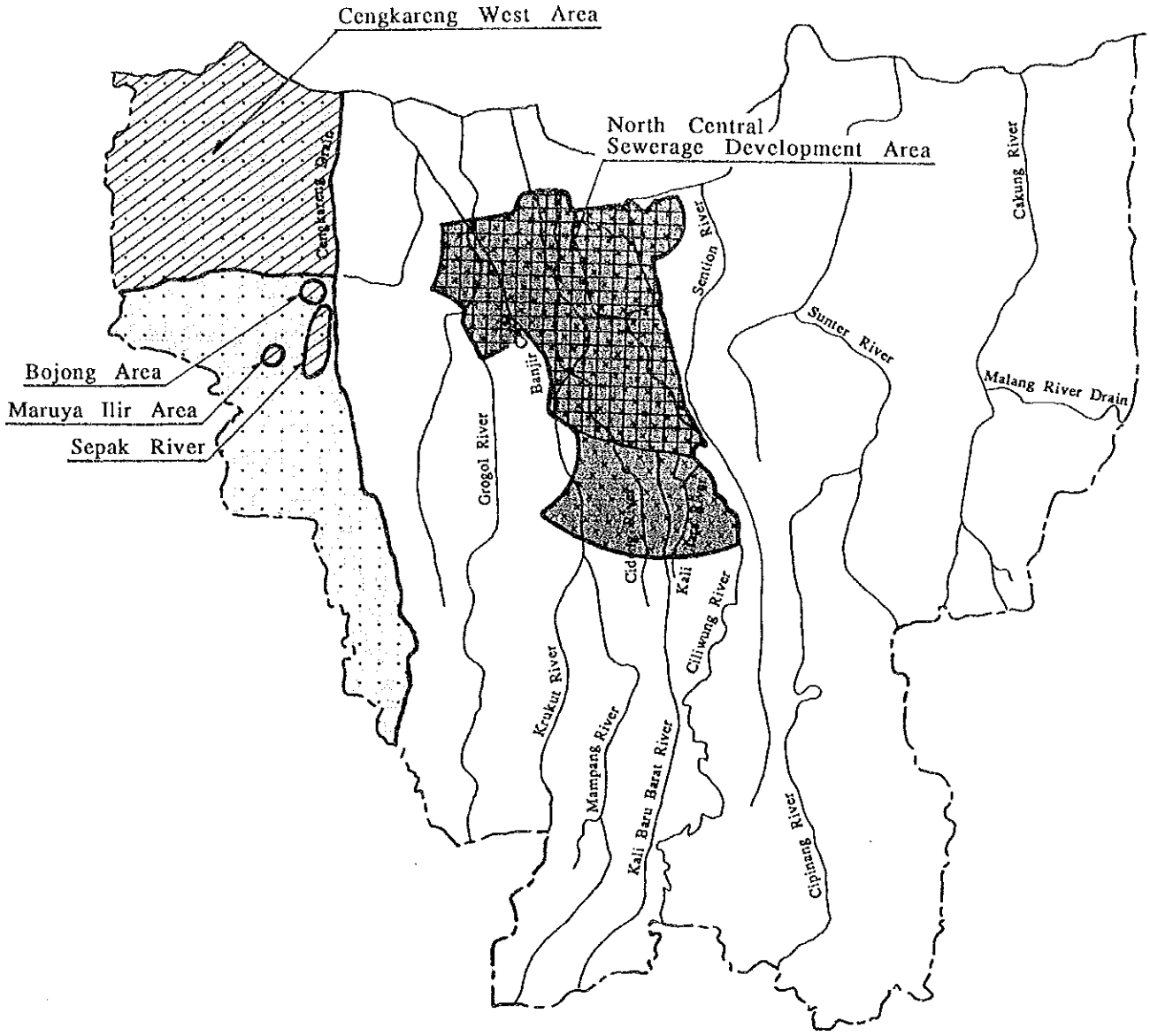


FIG. I.1 STUDY AREA OF MASTER PLAN

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA



LEGEND

: Priority Area of Drainage Development (Drainage Zone No.1)

: Project Area of Drainage Development

: Priority Area of Sewerage Development (Central Sewerage Zone)

: Project Area of Sewerage Development

FIG. I.2 PROJECT AREAS OF URBAN DRAINAGE AND SEWERAGE DEVELOPMENT

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

II. URBAN DRAINAGE

II. URBAN DRAINAGE

Chapter 1 CENGKARENG WEST URBAN DRAINAGE

1.1 Project Area

1.1.1 General

The Project Area covers the north west low-lying area of Jakarta City with an area of 4,700 ha. It is encompassed by the administrative boundary of DKI Jakarta to the west, Mookervart River to the south and Cengkareng Floodway to the east. Eight (8) Kelurahans are included in the Area.

Total population of the Area was 0.263 million in 1988. It is expected to increase to 0.456 million in 2010.

The Area is undergoing a rapid land development to accommodate the increasing population. The on-going major land development projects are:

(1)	Padongkelan Barat Housing Development by PERUM PERUMNAS	:	340 ha
(2)	Taman Kencana Housing Development by Private Company	:	55 ha
(3)	Taman Surya Housing Development by Private Company	:	30 ha
(4)	Citra Garden Housing Development by Private Company	:	80 ha
(5)	Mandar Permai Resort Area Development by Private Company	:	430 ha

Location of the above development areas are shown in Fig. 1.1.

The urban land developments will increase properties in the flood prone areas on one hand and on the other hand, will increase flood run-off peak of the drainage basin. It will results in creation of new flood problems.

New urban drainage system shall be constructed in advance of such urban developments to cope with expected new flood problems in the future.

1.1.2 Existing and Future Land Use

The existing land use pattern of the Project Area is classified into four (4) categories: residential area, commercial & institutional area, industrial area and green area as shown in Fig. 1.1.

Land area of the respective categories are shown below.

Land Use	Area (ha)	Ratio (%)
Residential	1,410	30
Commercial & Institutional	705	15
Industrial	235	5
Green	2,350	50
Total	4,700	100

The future land use pattern in 2005 were estimated in DKI Jakarta Structure Plan 2005. In the Structure Plan, the future land use is classified into 13 categories as shown in Fig. 1.2.

Those detailed future land classifications are summarized as follows.

Land Use	Area (ha)	Ratio (%)
Residential	2,350	50
Commercial & Institutional	705	15
Industrial	470	10
Green	1,175	25
Total	4,700	100

Urban land area including residential, commercial & institutional and industrial ones of the Project Area will increase from 2,350 ha or 50% in 1990 to 3,525 ha or 75% in 2005.

1.1.3 Objective Drainage Basin

The southern fringe area of 470 ha of the Project Area, which is located along the Mookervart River, drains directly into the Mookervart River through the existing minor drainage networks. No significant flood problems are identified in this area at present. It is considered that this area will be free from flooding even in future due to its advantageous topographical conditions. Hence, this area is excluded from the objective drainage basin for facility planning.

Morcover, the Mandar Permai Resort Development Area of 430 ha, which is located in the north east fringe of the Study Area, is also excluded from the objective drainage basin. It is because this area will be provided with an independent drainage system by the developer concerned, and storm water of the area will be discharged directly into the Jakarta Bay.

Based on the above considerations, the objective drainage basin of 3,823 ha for facility planning is delineated as shown in Fig. 1.3.

The objective drainage basin is divided into five (5) sub-drainage basins based on the existing drainage system (See Fig. 1.4).

(1) Drainage basin A covers a catchment area of 777 ha. Storm water is drained directly into the Jakarta Bay through the Tanjungan River with a total length of 3.2 km. The river width is in the range of 2 m and 5 m. The river gradient is approximately 1/3,000.

(2) Drainage basin B drains a catchment area of 1,637 ha of the Kamal River and its tributaries also into the Jakarta Bay. The total river length is 11.8 km. The river width ranges from 3 m to 18 m. The river gradient is 1/2,000 - 1/3,000.

(3) Drainage basin C consists of the channels of Kali Gede and Kali Bor. Storm water of the basin of 563 ha is drained into the Mookervart River. The total river length is 4.8 km. The river width and slope are 2 - 4 m and 1/2,000 respectively.

(4) Drainage basin D covers a catchment area of 331 ha of the Saluran Cengkareng channel. Storm water is drained into the Cengkareng Floodway through the Padongkelan channel of the drainage basin E. Total length of the Saluran Cengkareng channel is 4.5 km. Its river width and slope is 2 - 6 m and 1/2,000 respectively.

(5) Drainage basin E drains a catchment area of 515 ha of the Padongkelan channel into the Cengkareng Floodway. Most part of the basin is undergoing housing development. A sluice gate is provided at the confluence to the Cengkareng Floodway to control backwater of the Cengkareng Floodway. Total length of the Padongkelan channel is 1.1 km. Its river width and gradient is 2 - 5 m and 1/2,000 respectively.

The above five (5) drainage basins and five (5) channels are further divided into 15 sub-basins and 18 channel sections respectively, as shown in Fig. 1.4.

1.2 Floods and Flood Damages

An on-the-spot interview survey was conducted to know the flood conditions of the Project Area. It was found out that there are 10 potential inundation areas, out of which six (6) areas are habitually inundated. The total hectareage of the potential inundation areas reaches 474.3 ha, while that of the habitual inundation areas comes to 273.4 ha.

The depth of inundation in the potential inundation areas ranges from 30 cm to 60 cm, and the duration of inundation in the same areas falls between one (1) day to 10 days. In the habitual inundation areas, inundation depth and duration are 20 to 50 cm, and one (1) to seven (7) days, respectively.

The above flood conditions by flood location are shown in Fig. 1.5.

It is estimated that habitual flood occurs twice a year on an average, while the return period of potential flood is approximately 40 years.

In this Study, the following damages were estimated in monetary terms.

- Damages to properties including house, shop and factory
- Income losses due to closure of shop and factory
- Damages to traffic
- Damages to infrastructure and others

The number of the properties in the inundation areas in 1988 are estimated to be 4,888 for house, 37 for shop and 28 for factory. They will increase to 8,393 for house, 173 for shop and 84 for factory in 2010.

The total average annual flood damage in 1988 is estimated to be Rp. 1,262 million. It is expected to increase to Rp. 7,085 million in 2010. The damage to properties is predominant, accounting for approximately 80% in both years.

Break-down by type of damage is shown in Table 1.1.

1.3 Drainage Improvement Plan

1.3.1 Design Criteria

(1) Design Flood Frequency

The objective drainage basin of 3,823 ha is drained by five (5) drainage systems, the respective catchment areas of which are shown below (See Fig. 1.4).

Drainage System	Catchment Area (ha)
Basin A : Tanjungan River	777
Basin B : Kamal River	1,637
Basin C : Kali Gede/Kali Bor Channel	563
Basin D : Saluran Cengkareng Channel	331
Basin E : Padongkelan Channel	515

The drainage systems of A, B, C and E cover a catchment area larger than 500 ha. Design flood frequency of 10-year is applied for these drainage systems based on the guidelines of the Government of Indonesia (Refer to Appendix G, Supporting Report of Master Plan). The 10-year flood frequency is also applied for the drainage system D although it has a catchment area smaller than 500 ha. It is because the drainage systems of D and E are hydraulically connected.

(2) Flood Runoff Calculation

Flood peak run-off of the objective drainage channels are calculated by using the Rational Formula. In this calculation, the flood run-off coefficient of the drainage basin is assumed as follows.

Residential Area	:	f=0.50
Commercial & Institutional Area	:	f=0.70
Industrial Area	:	f=0.60
Other Areas (farmland/open space)	:	f=0.20

(3) Design Boundary Water Level

Drainage of the objective drainage basin is affected by water level of the sea, Cengkareng Floodway and Mookervart River. The design boundary water level at the sea, Cengkareng Floodway and Mookervart River are determined as follows based on the data and information obtained from "Master Plan for Drainage and Flood Control of Jakarta, 1973" and "Cengkareng Drain System Study, 1981".

(i) Water Level at the Sea

Spring tide = P.P. + 1.15 m ≒ P.P. + 1.20 m

(ii) Flood Water Level at Padongkelan Barat Drain Outlet of Cengkareng Floodway

100-year flood	:	P.P. + 2.90 m
25-year flood	:	P.P. + 2.20 m
10-year flood	:	P.P. + 1.90 m
2-year flood	:	P.P. + 1.65 m

(iii) Flood Water Level at Kali Bor Outlet of Mookervart River

100-year flood	:	P.P. + 4.90 m
25-year flood	:	P.P. + 4.05 m
10-year flood	:	P.P. + 3.80 m
2-year flood	:	P.P. + 3.25 m

1.3.2 Alternative Studies for Drainage Basin (A)

The following two (2) alternative plans are considered for the drainage improvement of the drainage basin (A).

(1) Improvement of Existing Drainage System (Case A-I)

In this plan, the existing Tanjungan River is improved for the reaches of 3.2 km from Point a_0 to the estuary (Point a_3). Moreover, 4.0 km of new drainage channel is excavated between Point a_2 and Point a_5 along the Toll Road to drain the upper catchment area.

(2) Diversion to Cengkareng Floodway (Case A-II)

This plan proposes to divert the uppermost sub-basin (A-4) of 235 ha to the Cengkareng Floodway to reduce the flood discharge in the downstream reaches.

This sub-basin is mostly covered by swamp land with a low elevation of 1.5 m at present. However, the swamp land will be fully developed for industrial use in future (See Fig. 1.2). In fact, industrial land development by reclamation has been completed in some parts and is on-going in others. Elevation of such land reclamation is P.P. + 3.0 - + 4.0 m which is higher than the design flood water level of 100-year at Cengkareng Floodway (P.P. + 2.90 m). Hence, gravity drainage to the Cengkareng Floodway is applied in this plan.

This plan includes the following drainage improvements.

- Improvements of the existing Tanjungan River of 3.2 km (a_0 - a_3)
- Excavation of a new drainage channel of 1.7 km (a_4 - a_2) to drain the sub-basin (A-2) to the Jakarta Bay
- Excavation of a new drainage channel of 2.3 km (a_4 - a_5) to divert the sub-basin (A-4) to the Cengkareng Floodway.

Location of the proposed channel improvements in the above two (2) alternatives are shown in Fig. 1.6.

The construction cost including direct construction cost, and land acquisition and compensation costs of both alternatives are as follows.

Case A-I : Rp. 9,752 million
Case A-II : Rp. 9,541 million

The construction costs for both cases are almost the same. No significant advantages are identified in the diversion to the Cengkareng Floodway.

Improvement of the existing drainage system (Case A-I) is recommended.

1.3.3 Alternative Plans for Drainage Basin (B)

The following two (2) alternative plans are considered for the drainage improvement of the drainage basin (B).

(1) Improvement of Existing Drainage System (Case B-I)

In this plan, the existing main courses of the Kamal River is improved for the reaches of 7.4 km from Point b_1, to the estuary (Point b_6). In addition, 0.7 km of new drainage channel is excavated between Point b_0 and Point b_1 to drain the uppermost area. No improvement works are proposed for the left tributary (b_8 - b_2) and right tributary (b_7 - b_3) since they have sufficient flow capacity.

(2) Diversion to Tanjungan River (Case B-II)

This plan diverts floods of the upstream basin of the Kamal River to the Tanjungan River. A diversion channel is constructed between Point b_4 of the Kamal River and Point a_1 of the Tanjungan River to divert the sub-basins of B-1, B-2, B-3 and B-4 with a total catchment area of 1,081 ha. Total length of the proposed diversion channel is 1.5 km.

Location of the proposed channel improvements in the above two (2) alternatives are shown in Fig. 1.6.

Economic efficiency of the above two (2) alternatives are compared in terms of the construction cost of the following two (2) cases.

(i) Total of the independent drainage improvement plans for drainage basin (A) and drainage basin (B) (Case A-I plus Case B-I)

(ii) Integrated drainage improvement plan of drainage basin (A) and drainage basin (B) (Case B-II)

The construction costs including direct construction cost, and land acquisition and compensation costs are estimated as follows.

Case A-I + Case B-I : Rp. 26,184 million
Case B-II : Rp. 26,379 million

As evident from the above cost comparison, improvement of the existing drainage system (Case B-I) is recommendable.

1.3.4 Alternative Studies for Drainage Basin (C and D)

The following two (2) alternative plans are considered for the drainage improvement of the drainage basin (C and D).

(1) Improvement of Existing Drainage System (Case C/D-I)

The drainage basin (C) of 563 ha is drained by the drainage channels of Kali Gede and Kali Bor into the Mookervart River. The drainage basin (D) of 331 ha is discharged by the Saluran Cengkareng drainage channel into the Cengkareng Floodway through the Padongkelan drainage channel.

The flood water levels of the Mookervart River and Cengkareng Floodway for 10-year floods are P.P. + 3.8 m and P.P. + 1.9 m respectively (Refer to Section 1.3.1). While, ground elevation of the drainage basin C and D are estimated as follows.

Sub-basin C-1 and C-2	}	Residential area	: higher than 4.5 m
Sub-basin D-1		Paddy field	: higher than 4.0 m
Sub-basin D-2	:	Mostly higher than 2.7 m lowest elevation is 2.0 m	

Based on the above facts, gravity drainage is applied for both drainage basins.

The proposed channel improvement reaches are:

(Drainage Basin C)
- Kali Gede : 3.4 km from Point c_0 to Point c_2
- Kali Bor : 1.3 km from Point c_2 to the confluence to Mookervart River (Point c_4)

(Drainage Basin D)
- Saluran Cengkareng: 4.6 km from Point d_0 to the confluence to Padongkelan drainage channel (Point d_2)

(2) Diversion to Mookervart River (Case C/D-II)

The sub-basin (D-1) of 139 ha of the drainage basin (D) is diverted into the Mookervart River through the drainage channel of Kali Bor. The drainage channel of Saluran Cengkareng drains only the sub-basin (D-2).

As a result, the catchment area of the drainage basin (C) increases from 563 ha to 702 ha, while that of the drainage basin (D) decreases from 331 ha to 192 ha.

The proposed channel improvement reaches are:

(Drainage Basin C)
- Kali Gede : 3.4 km from Point c_0 to Point c_2
- Diversion channel : 1.7 km from Point d_1 to Point d_0
- Kali Bor : 1.3 km from Point c_2 to the confluence to Mookervart River (Point c_4)

(Drainage Basin D)

- Saluran Cengkareng: 2.9 km from Point d_1 to the confluence to Padongkelan drainage channel (Point d_2)

Location of the proposed channel improvements in the above two (2) alternatives are shown in Fig. 1.7.

The construction cost including direct construction cost, and land acquisition and compensation costs of both alternatives are as follows.

Case C/D-I : Rp. 14,991 million
Case C/D-II : Rp. 14,575 million

The construction costs of both cases are almost the same. No significant advantages are identified in the diversion to the Mookervart River.

Improvement of the existing drainage system (Case C/D-I) is recommended.

1.3.5 Alternative Studies for Drainage Basin (E)

The drainage basin (E) covers 515 ha of the catchment area of the Padongkelan drainage channel of which 340 ha is being developed for housing estate.

Ground elevation of the drainage basin (E) is mostly higher than P.P. + 2.7 m. The lowest elevation is P.P. + 2.0 m equivalent to 15-year flood water level of the Cengkareng Floodway (Refer to Section 1.3.1). Pump drainage is not efficient because it will work only once in 15 years on an average.

Hence, the following two (2) alternatives are considered for the drainage improvement of this area.

(1) Improvement of Existing Drainage System (Case E-I)

This is a gravity drainage to the Cengkareng Floodway. The existing Padongkelan drainage channel is improved for the reaches of

1.1 km from Point e_2 to the confluence to the Cengkareng Floodway (Point e_4). In addition, the existing channel is extended upstream to Point e_0 to drain the upper catchment area of the drainage basin (E). A new drainage channel is excavated between Point e_0 and Point e_2.

(2) Diversion to Tanjungan River (Case E-II)

The existing Padongkelan drainage channel is provided with a sluice gate at the confluence to the Cengkareng Floodway to prevent flooding from the Cengkareng Floodway. The gate is closed when the water level of the Cengkareng Floodway exceeds P.P. + 2.0 m.

In this alternative plan, the existing Padongkelan drainage channel is diverted to the Tanjungan River to overcome the above problems.

The proposed plan includes the following channel improvement works.

- Improvement of the existing drainage channel for the reaches of 1.1 km from the confluence to the Cengkareng Floodway (Point e_4) to Point e_2.
- Excavation of a new drainage channel of 2.5 km from Point e_2 to Point a_4.
- Enlargement of the proposed drainage channel of the drainage basin (A) for the reaches of 7.3 km from Point a_4 to the estuary of the Tanjungan River (a_3).

Location of the proposed channel improvements in the above two (2) alternatives are shown in Fig. 1.7.

Economic efficiency of the above two (2) alternatives are compared in terms of the construction cost of the following two (2) cases.

(i) Total of the independent drainage improvement plans for drainage basin (E) and drainage basin (A) (Case E-I plus Case A-I)

(ii) Integrated drainage improvement plan of drainage basin (E) and drainage basin (A) (Case E-II)

Construction cost including direct construction cost, and land acquisition and compensation costs are estimated as follows.

Case E-I + Case A-I : Rp. 14,947 million
Case E-II : Rp. 20,733 million

The plan of Case E-I is more economical than Case E-II. In addition, it is considered difficult to maintain the design channel section of the plan of Case E-II due to its gentle slope of 1/8,500.

Improvement of the existing drainage system (Case E-I) is recommended.

1.3.6 Proposed Drainage Improvement Plan

(1) Proposed Drainage System

The proposed drainage system of the Cengkareng West Area consists of the following five (5) sub-systems of the basin A, B, C, D and E.

(i) Basin A : Tanjungan River drainage system
(ii) Basin B : Kamal River drainage system
(iii) Basin C : Kali Gede and Kali Bor channel drainage system
(iv) Basin D : Saluran Cengkareng channel drainage system
(v) Basin E : Padongkelan channel drainage system

All the above basins are drained by gravity. No pump drainage is proposed. The existing main river and channel sections in all the above drainage systems will be widened/deepened to increase carrying capacity. The existing river/channel reaches will be extended to drain the upstream areas in the drainage systems of the Basin A, B and E. For extension, excavation of new drainage channels is proposed. Moreover, the existing sluice gate at the confluence of the Padongkelan channel to the Cengkareng Floodway will be improved.

The proposed design flood discharge, length of the existing channel improvement and length of new channel excavation for the five (5) drainage systems are summarized below.

Drainage System	Catchment Area (ha)	Design Discharge (m^3/s)	Existing Channel (km)	New Channel (km)
(A) Tanjungan	777	13 - 24	3.2	4.0
(B) Kamal	1,637	22 - 47	7.4	0.7
(C) Kali Gede/Kali Bor	563	23 - 27	4.8	-
(D) Salurang Cengkareng	331	13 - 18	4.5	-
(E) Padongkelan	515	12 - 30	1.1	1.7
Total	3,823		21.0	6.4

Location of the existing channel improvement and new channel excavation is shown in Fig. 1.8.

The design flood discharge distribution for the respective channel sections are also given in Fig. 1.8.

(2) Proposed Profile and Cross Section of Channel

Design high water level is determined taking into consideration the land elevation of the existing developed areas and future urban development. Excavated type of channel is applied as much as possible. However, river embankment is proposed for the reaches with a low bank elevation.

The proposed river/channel banks will be protected by revetment of wet masonry type to prevent scouring, and to minimize land acquisition in the reaches of the already urbanized area and future urban development area. However, no bank protection works are proposed for the river reaches of the green area to minimize the project cost.

The length, gradient, width and depth of the proposed channels are summarized as follows.

Drainage System	Length (km)	Gradient	Width (m)	Depth (m)
Tanjungan	7.2	1/3,000	7.0 - 16.0	2.5
Kamal	8.1	1/1,600-1/3,000	8.9 - 25.2	2.4
Kali Gede/Kali Bor	4.8	1/2,000	8.2 - 8.5	2.5 - 3.0
Salurang Cengkareng	4.5	1/2,000	6.5 - 7.5	2.5
Padongkelan	2.8	1/2,000	5.9 - 10.7	2.5

The length, gradient, width and depth by channel section are shown in Table 1.2.

(3) Proposed Construction Works

The proposed major construction works are channel excavation, embankment, revetment works, bridge improvement, highway crossing improvement, sluice gate improvement and inspection road pavement. These are summarized as follows.

- Channel excavation : 469,000 m^3
- Embankment : 106,000 m^3
- Revetment works : 46 km, 195,000 m^2
- Bridge improvement : 15 places, 700 m^2
- Highway crossing : 2 places, 360 m^2
- Inspection road : 35 km, 138,000 m^2
- Sluice gate improvement : 1 place

(4) Required Land Acquisition and Compensation

The required land acquisition and compensation are summarized below.

(i) Land acquisition
- Residential area : 32.9 ha
- Green area : 9.1 ha

(ii) Resettlement compensation: 230 houses, 1.2 ha

Note: 1) Residential area includes future residential area.

1.4 Cost Estimate and Implementation Schedule

1.4.1 Basis of Cost Estimate

The estimation of the project cost, consisting of direct construction cost, land acquisition and compensation cost, engineering service cost, government administration cost, physical contingency and price escalation was carried out based on the following conditions.

(i) The estimates are made on the assumption that all construction works will be contracted to general contractors.

(ii) All base costs are expressed under the economic conditions that prevailed in July, 1990.

(iii) Engineering service cost is assumed at 10.0% of the direct construction cost.

(iv) Government administration cost is assumed at 1.5% of the total cost of direct construction, and land acquisition and compensation.

(v) A physical contingency is assumed to be 10.0% of the direct construction cost.

(vi) Annual price escalation for the project cost is assumed to be 6.0%.

1.4.2 Estimated Project Cost

The total project cost, consisting of direct construction cost, land acquisition and compensation cost, engineering service cost, government administration cost and physical contingency, amounts to Rp. 51,200 million at July, 1990 prices as given below.

(Unit: million Rp.)

Item	Cost
Direct Construction	19,880
Land Acquisition/Compensation	26,646
Engineering Service	1,988
Administration	698
Physical Contingency	1,988
Total	51,200

Its break-down by drainage basin and by construction works are given in Table 1.3.

1.4.3 Operation and Maintenance Cost

The operation and maintenance cost includes costs for dredging of channel, removal of dumped garbage and other debris, repairing of revetment, embankment and other structures, operation and repairing of gate.

The operation and maintenance cost at full operation stage of the facilities, after completion of the project, is assumed to be annually 0.5% (Rp. 99.4 million/year) of the direct construction cost at July 1990 price.

1.4.4 Implementation Schedule

The project will be completed within five (5) years from 1992 to 1996. The proposed implementation schedule is shown below.

	1992	1993	1994	1995	1996
Detailed Design	▬				
Land Acqusition/ Compensation		▬	▬		
Construction of Basin D & E		▬	▬		
Construction of Basin B			▬	▬	
Construction of Basin A & C				▬	▬

The disbursement schedule of the project cost are shown below.

(Unit: million Rp.)

Year	1992	1993	1994	1995	1996	Total
Project Cost (1990 price)	7,000	14,000	17,000	8,000	5,200	51,200
Price Escalation	865	2,674	4,463	2,706	2,177	12,885
Total	7,865	16,674	21,463	10,706	7,377	64,085