THE GOVERNMENT OF THE REPUBLIC OF INDONESIA

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

FEASIBILITY STUDY

SUPPORTING REPORT

MARCH 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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I-1 CENGKARENG WEST URBAN DRAINAGE

Chapter 1 PROJECT AREA

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 (See Fig. 1.1.1). The following eight (8) Kelurahans are included in the Project Area.

- Kamal Muara, Kamal, Tegal Alur, Pegadungan, Kali Deres, Cengkareng Timur, Kapuk and Cengkareng Barat

The population of the Project Area was estimated to be 263,281 in 1988. It is expected to increase to 455,740 in 2010.

The Project Area is undergoing a rapid land development. 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.1.1.2.

The urban land developments will increase properties in the flood prone areas on one hand and on the other hand, will increase flood runoff peak of the drainage basin. It will results n 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.

1.2 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 based on the map of "Atlas DKI Jakarta" published in 1990 as shown in Fig. 1.1.2.

Land area of the respective categories are shown below.

Land Use	Area (ha)	Ratio (%)
Residential	1,410	30
Commercial & Insitutional	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 1.1.3.

Those detailed future land classifications are summarized as follows.

Land Use	Area (ha)	Ratio (%)
Residential	2,350	50
Commercial & Insitutional	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.

1.3 Objective Drainage Basin

The southern fringe area of 570 ha in 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.

Moreover, the Mandar Permai Resort Development Area of 430 ha, which is located in the north east fringe of the Project 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 and storm water of the area will be discharged directly into the Jakarta Bay.

Based on the above considerations, the objective drainage basin of 3,800 ha for drainage planning is delineated as shown in Fig 1.1.4.

The objective drainage basin is divided into five (5) sub-drainage basins based on the existing drainage system (See Fig. 1.1.5).

(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.

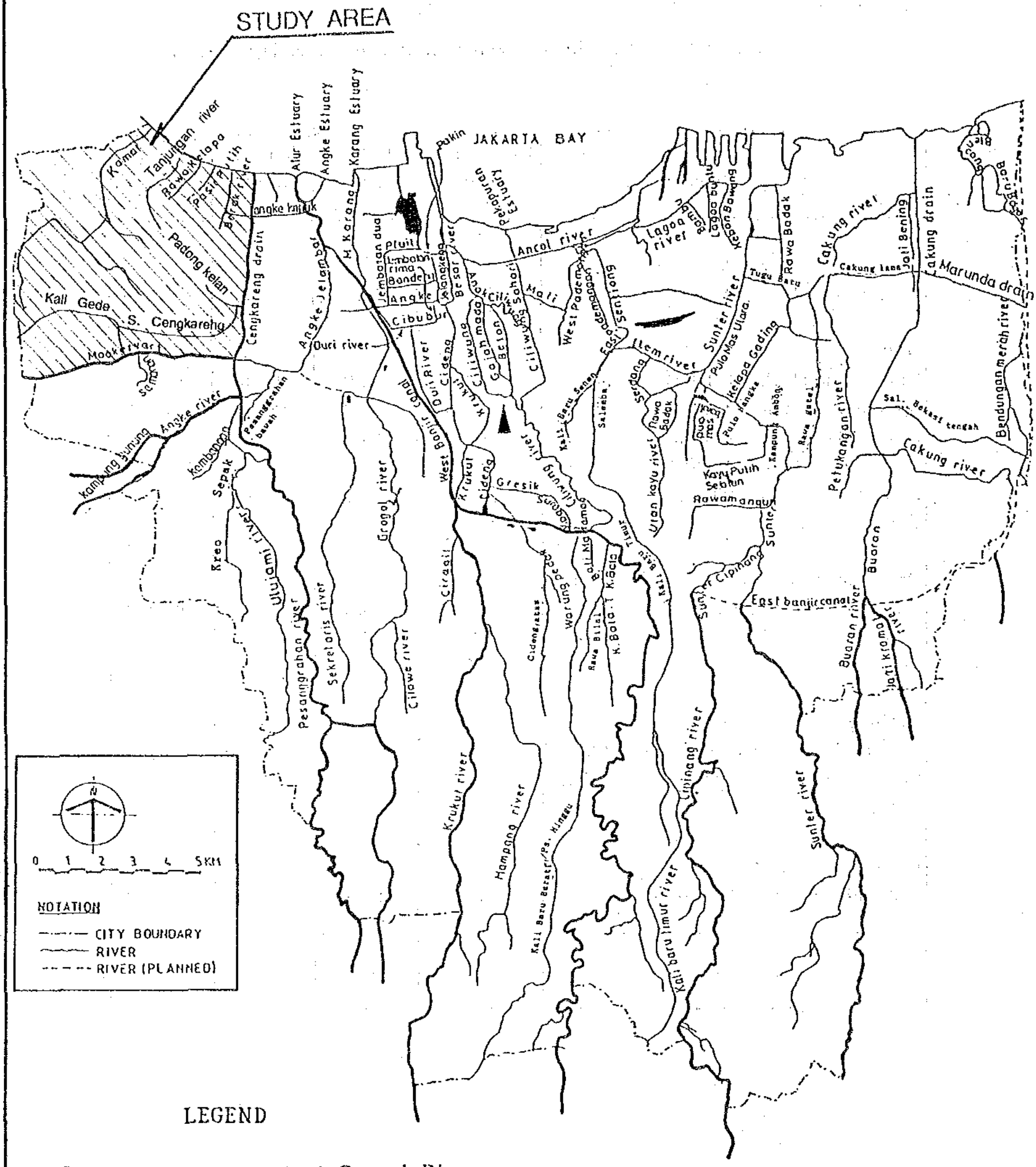
(5) Drainage basin E drains a catchment area of 515 ha of the Padongkelan channel into the Cengkareng Floodway. Most part of the basin is undergoing housing development. A sluice gate is provided at the confluence to the Cengkareng Floodway to control backwater of the Cengkareng Floodway. Total length 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. 1.1.5.

The main features the existing drainage system are summarized in Table 1.1.1.

Table 1.1.1 Main Features of Existing Drainage System

River Reaches	Catchment Area (ha)	River Length (km)	River Width (m)	River Gradient
Drainage System A				
Tanjungan R. (a0-a3)	777	3.15	2-5	1:3,000
Drainage System B				
Upper Kamal R. (b1-b2)	464	2.30	3-10	1:2,000
Middle Kamal R. (b2-b5)	590	3.18	10-14	1:3,000
Lower Kamal R. (b5-b6)	184	1.88	14-18	1:3,000
Right Tributary (b7-b3)	152	1.60	3-4	1:3,000
Left Tributary (b8-b2)	247	2.80	4-10	1:3,000
Total	1,637	11.76		
Drainage System C				
Kali Gede R. (c0-c2)	563	3.43	2-4	1:2,000
Kali Bor R. (c2-c4)	0	1.33	4	1:2,000
Total	563	4.76		
Drainage System D				
Upper Saluran Cengkareng (d0-d1)	139	1.65	2-4	1:2,000
Lower saluran Cengkareng (d1-d2)	192	2.88	4-6	1:2,000
Total	331	4.53		
Drainage System E				
Padongkelan R. (e2-e4)	515	1.14	2-5	1:2,000
Total	3,813	25.34		



LEGEND

Existing Flood Control River
Future Flood Control River
Existing Urban Drainage Channel
Monas

FIG. 1.1.1	LOCATION OF PROJECT AREA

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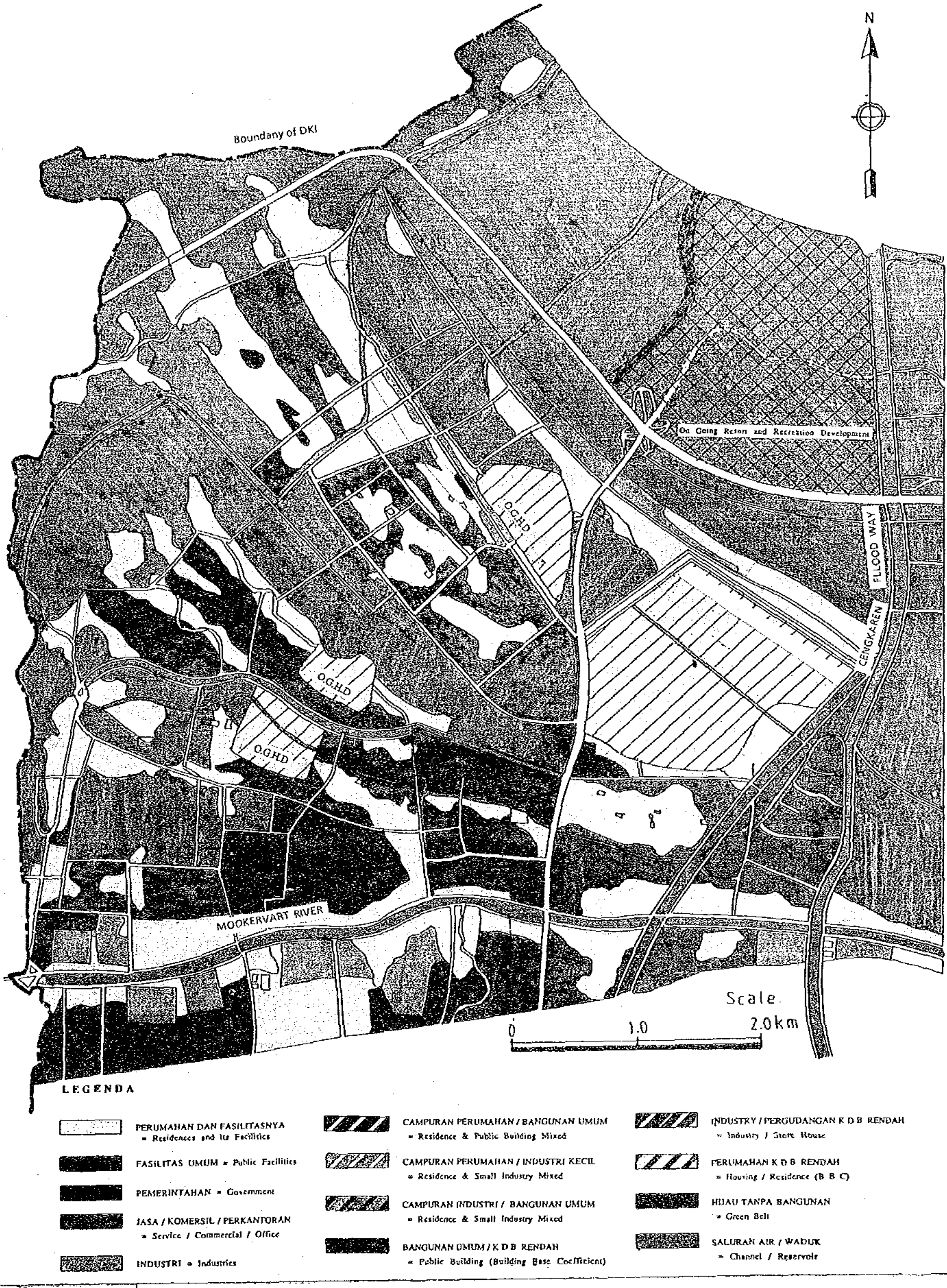

FIG. 1.1.2 EXISTING LAND USE OF PROJECT AREA(1990)

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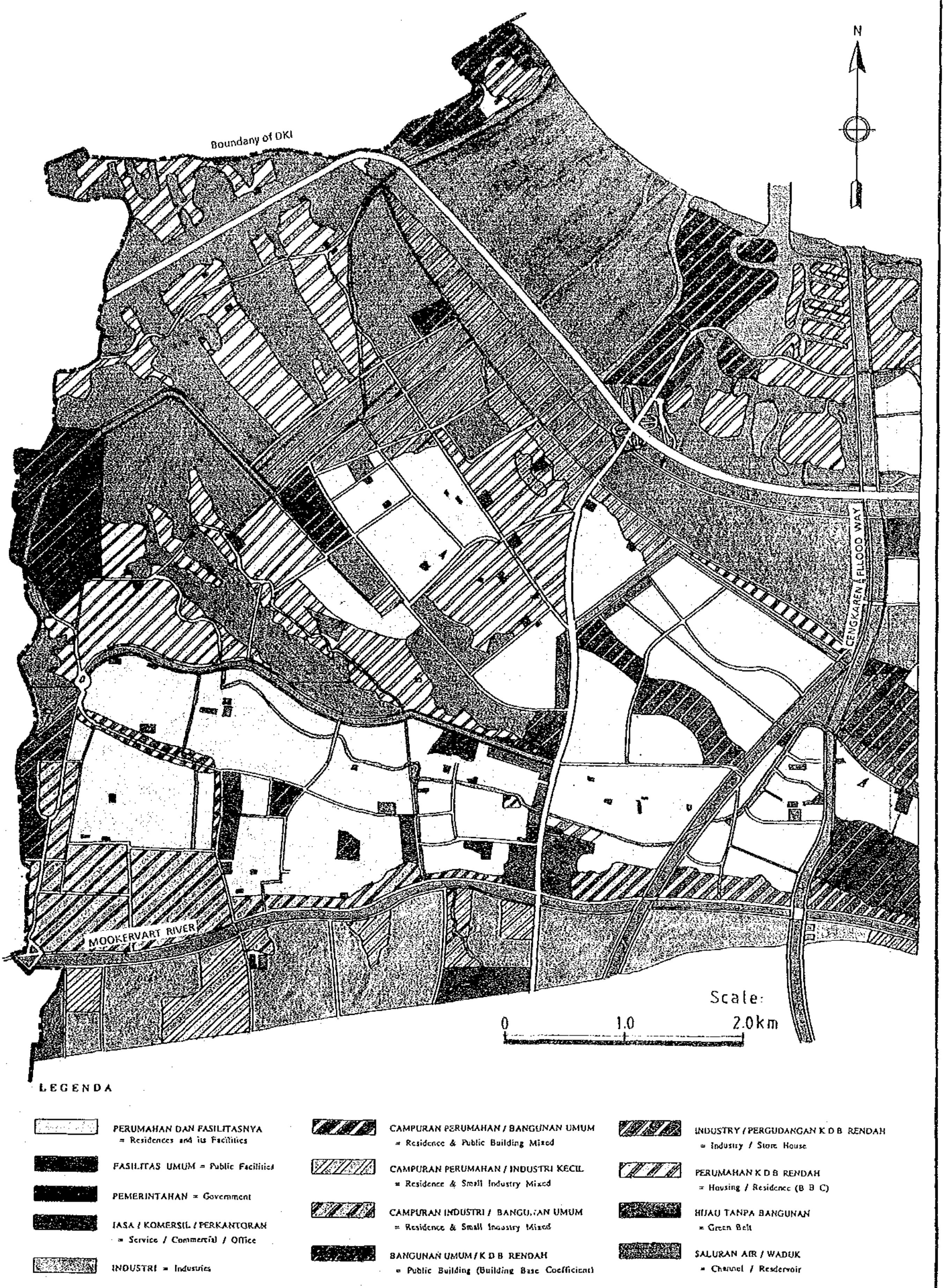

FIG. 1.1.3 FUTURE LAND USE OF PROJECT AREA (2005)

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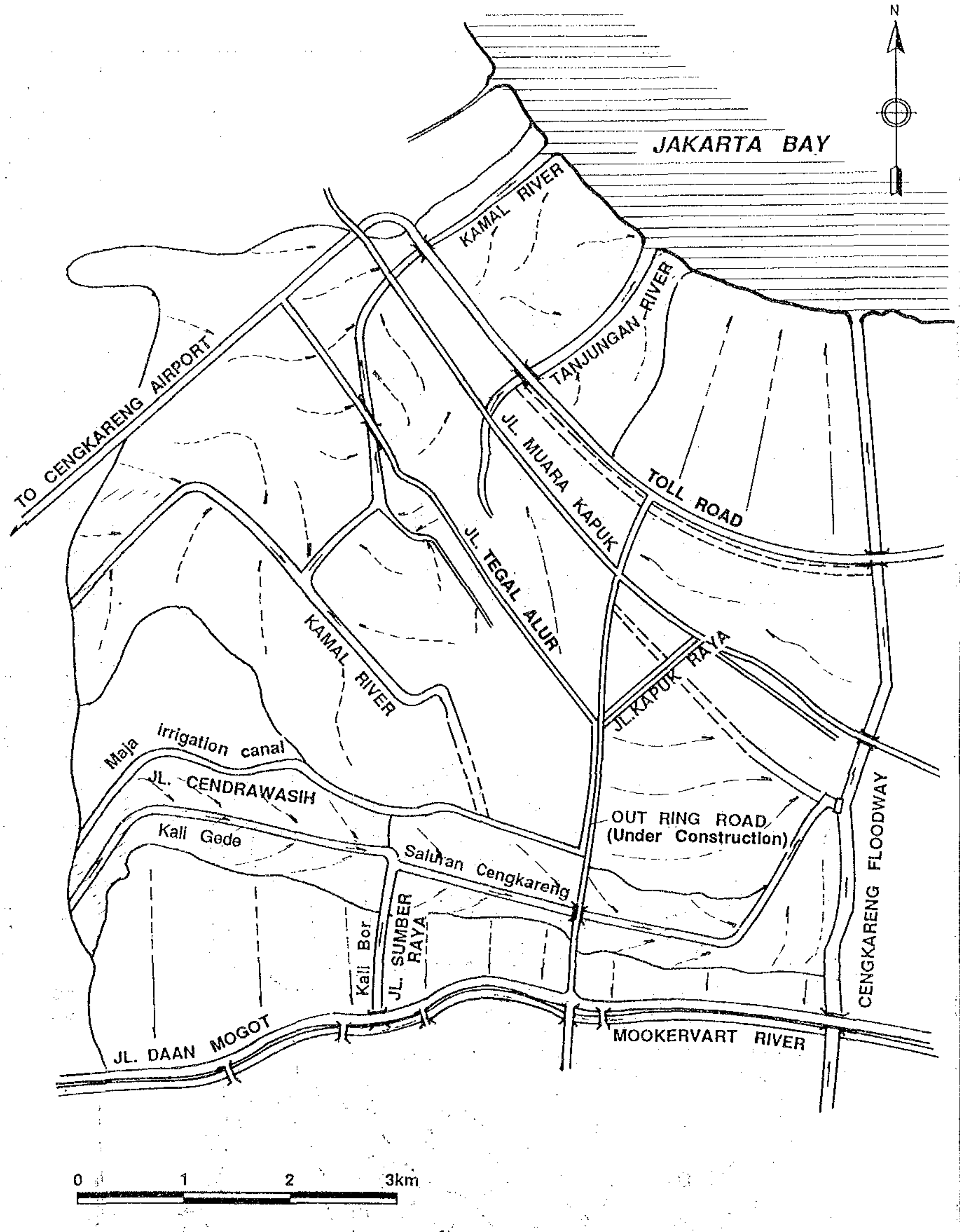

FIG. 1.1.4 OBJECTIVE DRAINAGE BASIN

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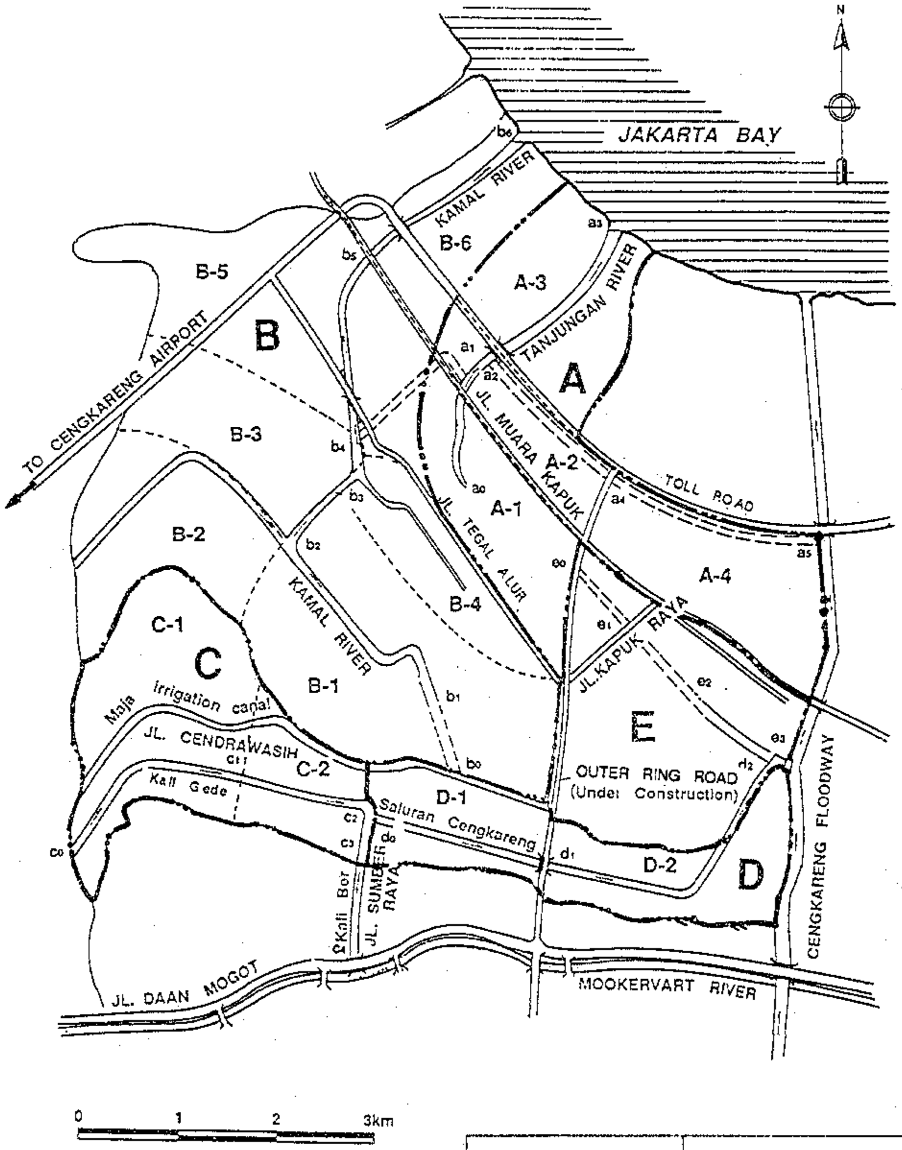

Length of Drainage Channel

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	2.30	
	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

FIG. 1.1.5 EXISTING DRAINAGE SYSTEM

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Chapter 2 FLOOD AND FLOOD DAMAGES

2.1 Flood Conditions

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. (Refer to Fig. 1.2.1 and 1.2.2)

Habitual flooding occurs twice a year on average, while the return period of potential flooding is estimated at approximately 40 years.

2.2 Flood Damage

2.2.1 Methodology for Estimation of Average Annual Flood Damages

The steps to arrive at the estimation of average annual flood damages are presented in Appendix B, Supporting Report of Master Plan. Firstly inundation areas by return period are determined through the past inundation maps and on-the-spot interview survey. Also, based on such a survey, average inundation depth and duration by return period and by inundation area are estimated.

Secondly, based on the survey results, the quantitative relationships between inundation depth/duration and direct flood damage ratio by type of property are established.

Thirdly, the relationships between return period and inundation depth/duration are formulated. It means that the relationships between return period and inundation depth/duration by inundation area are established. Also, it means that the relationships between return period and flood damage ratio by type of property and inundation area are established.

Fourthly, average unit value of property by type in 1988 and 2010 is estimated. At the same time, the number of property by type and by inundation area in 1988 and 2010 is estimated.

Fifthly, the third and fourth steps are combined together. Employing probability density functions, average annual flood damages to property by inundation area in 1988 and 2010 are estimated. Eventually, average annual flood damages to property in the Project Area in the two (2) years are worked out (for details ref. Appendix B, Supporting Report of Master Plan).

Average annual flood damages in terms of income losses due to the closure of shops and factories in time of floods are estimated in the same manner.

As the third component, flood damages to traffic is significant. In time of floods, the drivers of vehicles are usually forced to slow down their vehicle operating speed. Unit vehicle operating cost rises as the speed is lessened. Also, it takes a longer time for a driver to reach destination due to lower speed and/or round-about routes he is forced to take.

That is to say, incremental vehicle operating cost and time cost will be incurred when flood hits the Project Area. From the average traffic damages per vehicle by type and the number of vehicles on road by type by inundation area in 1988 and 2010, traffic damages by type of vehicles by inundation area in the two (2) years will be estimated (ref. Appendix B, Supporting Report of Master Plan).

Besides the above-mentioned three kinds of flood damages, flood damages to unspecified property and infrastructure were taken into account using fixed coefficients.

2.2.2 Average Annual Flood Damages

The number of property by type and by inundation area for 1988 and 2010 is shown in Table 1.2.1. The figures for 2010 were estimated based on the land use plan and economic forecast. Also, the number of vehicles by type and by inundation area for the two (2) years is shown in Table 1.2.2. The figures for 2010 are projected based on the economic forecast.

As Table 1.2.3 shows, average annual flood damages in terms of direct damages to properties amount to Rp. 999 million as of 1988. Likewise, income losses due to shop closure and damage to traffic amount to Rp. 12 million and Rp. 8 million, respectively. In the target year of 2010, direct damages to properties will reach Rp. 5,352 million. Similarly, income losses and traffic damages will reach Rp. 124 million and Rp. 29 million, respectively. It is to be noted that flood damages are estimated to increase by five (5) to 10 times from 1988 to 2010.

As is shown in Table 1.2.4, average annual flood damages as of 1988 are estimated at Rp. 1,262 million, which would multiply by 5.6 times to Rp. 7,085 million in 2010 if no urban drainage projects were implemented.

Table 1.2.1 Estimated Number of Properties in Inundation Areas
- Cengkareng West Urban Drainage -

Inundation Area No.	House	Shop	Factory
1 Year 1988			
1	15	1	1
2	672	6	4
3	208	2	1
4	1,217	5	4
5	957	7	7
6	467	4	4
7	352	4	1
8	508	4	4
9	301	4	1
10	191	0	1
Total	4,888	37	28
2 Year 2010			
1	98	5	4
2	1,130	12	14
3	350	4	4
4	2,401	91	14
5	1,453	18	16
6	709	9	8
7	607	10	4
8	772	9	8
9	534	9	7
10	339	6	4
Total	8,393	173	84

Sources : Statisitik Wilayah 1988 and JICA

Table 1.2.2 Estimated Number of Vehicles on Road by Type and by Inundation Area - Cengkareng West Urban Drainage -

Inundation Area No.	Passenger Car	Bus	Truck	Motor Cycle	Total
1 Year 1988					
1	13	4	6	25	49
2	53	18	23	102	197
3	17	6	7	32	61
4	199	68	86	382	735
5	47	16	20	91	174
6	23	8	10	44	85
7	44	15	19	85	163
8	25	9	11	48	93
9	19	7	8	37	71
10	12	4	5	23	45
Total	453	154	195	870	1,673
2 Year 2010					
1	39	19	21	79	158
2	159	76	85	322	642
3	49	24	26	100	199
4	592	285	316	1,203	2,396
5	141	68	75	286	569
6	69	33	37	139	278
7	132	63	70	267	533
8	75	36	40	152	302
9	57	27	31	116	231
10	36	17	19	74	147
Total	1,348	648	720	2,739	5,455

Sources : Statistik Wilayah 1988 and JICA

Table 1.2.3 Average Annual Flood Damages by Inundation Area
- Cengkareng West Urban Drainage -

(Unit : Rp.)

Inundation Area No.	Direct Damages to Properties *	Income Losses due to Shop Closure **	Damages to Traffic
1 Year 1988			
1	7,641,000	707,000	229,000
2	55,461,000	877,000	929,000
3	0	95,000	288,000
4	779,666,000	6,093,000	3,467,000
5	92,247,000	2,709,000	823,000
6	43,054,000	1,059,000	402,000
7	0	91,000	771,000
8	20,584,000	692,000	437,000
9	0	98,000	335,000
10	0	62,000	213,000
Total	998,653,000	12,482,000	7,894,000
2 Year 2010			
1	99,570,000	7,184,000	832,000
2	232,089,000	7,559,000	3,378,000
3	0	827,000	1,047,000
4	4,410,645,000	82,034,000	12,599,000
5	365,171,000	14,622,000	2,991,000
6	166,975,000	5,712,000	1,460,000
7	0	699,000	2,801,000
8	77,673,000	3,716,000	1,589,000
9	0	1,299,000	1,217,000
10	0	825,000	773,000
Total	5,352,123,000	124,477,000	28,687,000

Note : * Related properties : house, shop and factory
** Related properties : shop and factory

Source : JICA

Table 1.2.4 Summary of Estimated Average Annual Flood Damages ("Without Project" Case) - Cengkareng West Urban Drainage -

(Unit : Rp.)

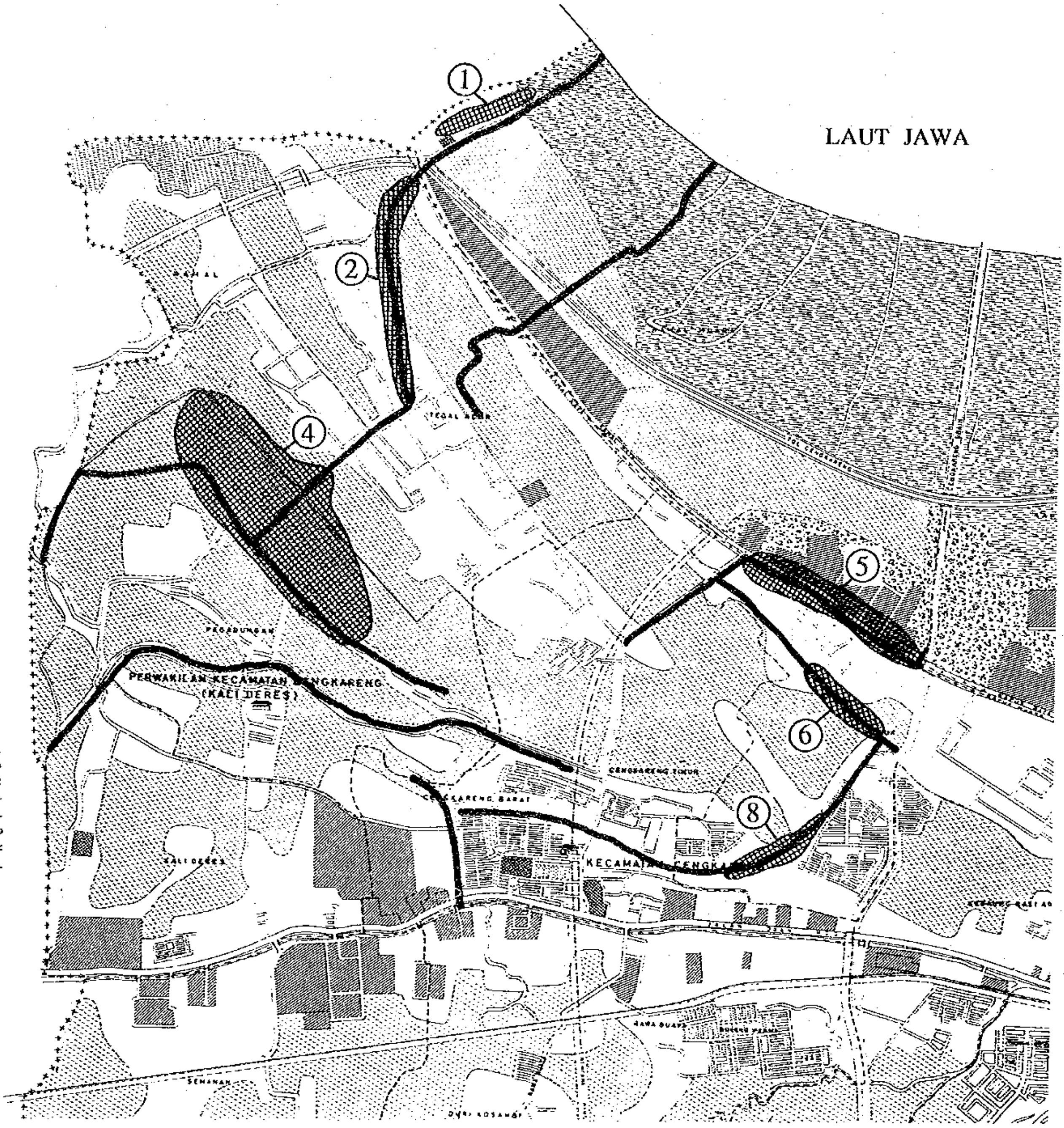
Item	1988	2010
1 Direct Damages to Property		
1) House	934,091,000	4,416,614,000
2) Shop	14,154,000	499,171,000
3) Factory	50,407,000	436,338,000
4) Other Specified Property 1/	31,712,000	392,072,000
Sub-Total	1,030,364,000	5,744,195,000
2. Indirect Damages		
1) Income Losses due to Shop Closure		
(1) Shop	926,000	32,671,000
(2) Factory	11,555,000	91,805,000
(3) Other Specified Property 2/	837,000	7,120,000
Sub-Total	13,318,000	131,596,000
2) Traffic Damages		
(1) Time Cost	2,373,000	8,492,000
(2) Incremental VOC	5,520,000	20,195,000
Sub-Total	7,893,000	28,687,000
Total (1.+2.)	1,051,575,000	5,904,478,000
3. Damages to Other Unspecified Property Including Infrastructure		
(1. + 2.) x 20 %	210,315,000	1,180,896,000
Grand Total (1.+2.+3.)	1,261,890,000	7,085,374,000

Note : 1/: Hotel, Restaurant, Hospital, Office, School, (Primary, Junior General Hight & High) and Religious Facilities (Mosque, Church & Temple)

2/: Hotel, Restaurant and Hospital

Damages to other specified property were estimated based on the ratios between the number of shops/factories and that of other specified property.

Source : JICA



	Depth (m)	Area (ha)	Duration
1	0.3	20.3	2 days
2	0.3	40.5	4 hours
4	0.5	133.6	7 days
5	0.2	44.5	1 day
6	0.2	20.3	1 day
8	0.2	14.2	5 hours

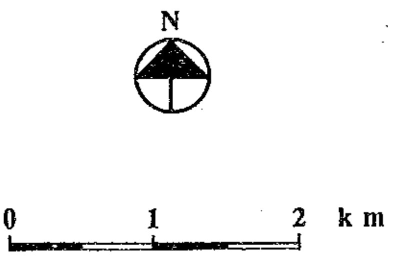


FIG. 1.2.1 HABITUAL INUNDATION AREA
(CENGKARENG WEST URBAN DRAINAGE)

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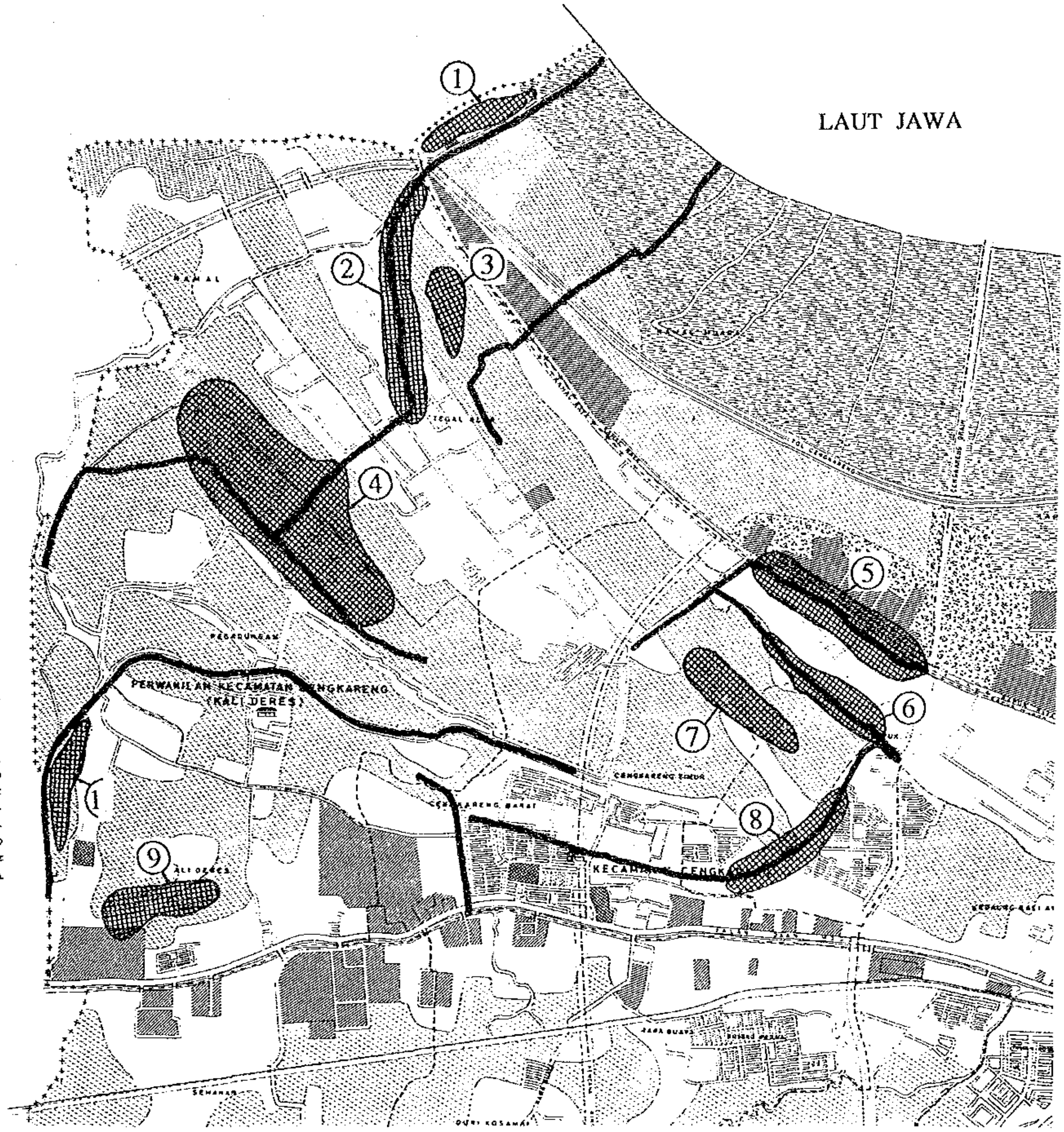

	Depth (m)	Area (ha)	Duration
1	0.4	22.5	7 days
2	0.3	66.8	1 day
3	0.5	20.7	1 days
4	0.6	169.5	10 days
5	0.3	62.3	4 days
6	0.5	30.4	1 day
7	0.5	27.3	1 day
8	0.4	33.1	1 day
9	0.5	25.5	1 day
10	0.5	16.2	1 day

FIG. 1.2.2 POTENTIAL INUNDATION AREA (CENGKARENG WEST URBAN DRAINAGE)

Chapter 3 DRAINAGE IMPROVEMENT PLAN

3.1 Design Flood Discharge

3.1.1 Design Flood Frequency

The design flood frequency of the urban drainage channels located outside the Banjir Canals is determined as shown below based on the guidelines of the Government of Indonesia (Refer to Appendix G, Supporting Report of Master Plan).

Catchment Area (ha)	Frequency (Year)
Less than 10	1
10 < A < 100	2
100 < A < 500	5
Greater than 500	10

While, the objective drainage basin is drained by five (5) existing drainage systems of which respective catchment areas are shown below (See Fig.1.1.5).

Existing 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
	Total	3,823

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. The 10-year flood frequency is also applied for the drainage system D although its catchment area is smaller than 500 ha. This is because the drainage systems of D and E are hydraulically connected.

3.1.2 Flood Run-off Calculation

(1) Calculation Method

Flood peak run-off of the objective urban drainage channels are calculated by using the following Rational Formula.

$$Q_p = \frac{1}{3.6} \cdot f \cdot ra. A$$

Where,

- Q_p : Flood peak run-off (m^3/s)
- f : Run-off coefficient
- r a : Basin average rainfall intensity during flood concentration time (mm/hr)
- A : Catchment area (km^2)

(i) Run-off Coefficient (f)

The flood run-off coefficient varies according to the land use patterns of the basin. It is assumed as given below.

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

(ii) Basin Average Rainfall Intensity

Point rainfall intensity curve with a 10-year frequency of the Project Area is given below.

$$rp : \frac{8571}{t^{1/1.02} + 50.1} \quad \text{for} \quad t \leq 180 \text{ min.}$$

$$rp : \frac{8973}{t^{1/1.02} + 68.0} \quad \text{for} \quad t > 180 \text{ min.}$$

Where,

rp = Point rainfall intensity (mm/hr)
t = Duration time (min.)

The basin average rainfall intensity (ra) is obtained by multiplying the point rainfall intensity by the rainfall reduction factors.

For the rainfall reduction factors, refer to Appendix G, Supporting Report of Master Plan.

(iii) Concentration Time (tc)

Concentration time (tc) of flood run-off consists of overland time (t_1) and drain time (t_2).

$$t_c = t_1 + t_2 \text{ (min.)}$$

The overland time is a flood concentration time along the longest time route from the catchment boundary to the uppermost point of the objective urban drainage channel. The overland time is estimated by assuming that :

$$\text{Route Length} = \frac{\text{Catchment Area}}{\text{Length of Objective Drainage Channel}}$$

Flow Velocity = 0.4 m/s.

The drain time is flood concentration time in the objective urban drainage channel. In the drain time calculation, flow velocity is assumed as follows.

Velocity	Channel Gradient
v = 2.0 m/s	$\frac{1}{200} < I$
v = 1.5	$\frac{1}{500} < I \leq \frac{1}{200}$
v = 1.0	$\frac{1}{1000} < I \leq \frac{1}{500}$
v = 0.5	$I \leq \frac{1}{1000}$

3.2 Design Boundary Water Level

Drainage of the Project Area 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.

3.2.1 Tide Level

According to the Master Plan for Drainage and Flood Control of Jakarta, 1973, the tidal movement in the Jakarta bay is mainly a single day tide with one high and one low tide per 24 hours. The tide levels applied for the Master Plan are as follows.

Spring Tide (High High Water)	:	P.P. + 1.15
Average High Water (H. W.)	:	P.P. + 0.90
Slack Tide High Water	:	P.P. + 0.80
Mean Sea Level (M.S.L.)	:	P.P. + 0.60
Slack Tide Low Water	:	P.P. + 0.40
Average Low Water	:	P.P. + 0.25
Spring Tide (Low Low Water)	:	P.P. + 0.00

Note: P.P. (Priok Pile) means the tidal gauging station located at the Tanjung Priok harbour.

In 1988, a check survey of the sea water level was conducted for the East Jakarta Flood Control Project. It confirmed that the tide levels applied for the 1973 Master Plan is still valid. (See, East Jakarta Flood Control Project, Design Report I, Vol. IV Hydrology and River, Feb. 1989).

Based on the above information, design tide level of this drainage plan is determined as P.P. + 1.20.

3.2.2 Cengkareng Floodway

The Cengkareng floodway constructed in 1983 drains floods of the rivers of Pesanggrahan, Upper Angke, Sepak and Mookervart into the Bay of Jakarta. Its catchment area is 445 km^2 at the confluence of the Mookervart River. It is 7.5 km in length and has a discharge capacity of 390 m^3/s, equivalent to a 100-year floods. The river profile is shown in Fig. 1.3.1.

(1) Flood Discharge

Flood discharge with 100-year, 25-year and 2-year is estimated as follows (Refer to Cengkareng Drain System Study, April 1981).

100-year floods :	Q_{100}	=	390 m^3/s (Design flood discharge)
25-year floods :	Q_{25}	=	280 m^3/s
2-year floods :	Q_2	=	150 m^3/s

Further, JICA Study Team estimated the 10-year flood discharge at Q_{10} = 220 m^3/s.

(2) Flood Water Level at Estuary and Cengkareng Weir Downstream

Flood water levels at the estuary and at just downstream of the Cengkareng Weir were also estimated for the 100-year, 25-year and 2-year floods as follows, in the above-mentioned study (See Fig.1.3.1). The Cengkareng Weir is located at 5.82 km river distance from the estuary.

	Estuary	Cengkareng Weir Downstream
100-year floods	P.P. + 1.80 m	P.P. + 3.25 m
25-year floods	P.P. + 1.50 m	P.P. + 2.45 m
2-year floods	P.P. + 1.25 m	P.P. + 1.75 m

JICA Study Team estimated the water level of 10-year floods as follows.

	Estuary	Cengkareng Weir Downstream
10-year floods	P.P. + 1.40 m	P.P. + 2.10 m

(3) Flood Water Level at Padongkelan Barat Drain Outlet

The outlet of the Padongkelan Barat Drain is located at 4.26 km river distance from the estuary. Based on the above-mentioned water levels, the water level of various frequency floods at the outlet of the Padongkelan Barat Drain is estimated as follows.

100-year floods (390 m^3/s)	:	P.P + 2.90 m
25-year floods (280 m^3/s)	:	P.P + 2.20 m
10-year floods (220 m^3/s)	:	P.P + 1.90 m
2-year floods (150 m^3/s)	:	P.P + 1.65 m

3.2.3 Mookervart River

The Mookervart River drains an area of 72 km^2. Its water level is affected by the backwater of the Cengkareng Floodway.

The water level at the confluence to the Cengkareng Floodway is estimated for various frequency floods of the Cengkareng Floodway as follows (Refer to Cengkareng Drain System Study April, 1981).

Cengkareng Flood	Mookervart Water Level
100-year	P.P. + 3.55 m
25-year	P.P. + 2.70 m
2-year	P.P. + 1.90 m

The river slope of the Mookervart is also estimated at 0.0003 in the above-mentioned study.

Based on the above information, JICA Study Team estimated water level of the Mookervart River at the confluence of Kali Bor (4.5 km upstream from the confluence to the Cengkareng Floodway) for various frequency floods as follows.

Flood Frequency	Confluence of Kali Bor
100-year	P.P. + 4.90 m
25-year	P.P. + 4.05 m
10-year	P.P. + 3.80 m
2-year	P.P. + 3.25 m

3.3 Alternative Studies for Drainage Basin (A)

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

(i) Improvement of existing drainage system
(ii) Diversion to Cengkareng Floodway

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

(1) General

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.

Location of the proposed channel improvement is shown in Fig. 1.3.2.

(2) Design Flood Discharge

The design flood discharge for the respective sections along the existing Tanjungan River and proposed new drainage channel is estimated based on the calculation method described in the previous Section 3.1 as shown in Table 1.3.1(1).

(3) Main Features of Proposed Channel

The main features including length, gradient, width and depth for the respective sections of the proposed channel are also shown in Table 1.3.1(1).

3.3.2 Diversion to Cengkareng Floodway (Case A-II)

(1) General

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. 1.1.3). In fact, industrial land development by reclamation has been completed in some parts and is on-going in other parts. Elevation of such land reclamation is P.P. 3.0 - 4.0 m which is higher than the design flood water level of the Cengkareng Floodway of P.P. 2.9 m (Refer to Section 3.2.2). Hence, gravity drainage to the Cengkareng Floodway is applied in this plan.

This plan includes the following drainage improvements.

- Improvement 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 direct the sub-basin (A-4) to the Cengkareng Floodway

Location of the proposed channel improvement is shown in Fig. 1.3.2.

(2) Design Flood Discharge

The design flood discharge for the respective sections along the existing Tanjungan River and proposed new channel is determined as shown in Table 1.3.1(1).

(3) Main Features of Proposed Channel

The main features for the respective sections of the proposed channel are also shown in Table 1.3.1(1).

3.3.3 Comparative Evaluation

The required major construction works, land acquisition area and construction costs for the above two (2) alternative plans are shown below (For details, refer to Table 1.3.2(1)).

Item	Case A-I	Case A-II
Channel Excavation (m^3)	111,000	94,200
Embankment (m^3)	26,000	27,000
Revetment Works (m^2)	38,500	38,500
Land Acquisition (ha)	10.9	10.5
Construction Cost (million Rp.)	9,752	9,541

Note: Construction cost includes direct construction cost, and land acquisition and compensation costs.

The construction costs of both cases are almost the same. No significant advantages of the diversion project are identified.

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

3.4 Alternative Studies for Drainage Basin (B)

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

(i) Improvement of existing drainage system

(ii) Diversion to Tanjungan River

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

(1) General

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 a sufficient flow capacity.

Location of the proposed channel improvement is shown in Fig. 1.3.2.

(2) Design Flood Discharge

The design flood discharge for the respective sections along the existing main courses of the Kamal River is shown in Table 1.3.1(2).

(3) Main Features of Proposed Channel

The main features for the respective sections of the proposed channel are also shown in Table 1.3.1(2).

3.4.2 Diversion to Tanjungan River (Case B-II)

(1) General

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 improvement is shown in Fig. 1.3.2.

(2) Design Flood Discharge

Design flood discharge distribution for the diversion channel is determined so that no channel improvement may be required for the downstream reaches of the Kamal River after completion of the diversion channel.

The design discharge for the downstream reaches of the Kamal River in the alternative plan Case B-I is 47 m^3/s. While, the existing flow capacity of the reaches is estimated to be 30 m^3/s. Hence, the exceeding discharge of 17 m^3/s shall be diverted. The design discharge of the Tanjungan River is increased by 17 m^3/s.

The proposed design flood discharge distribution for the Kamal River, diversion channel and Tanjungan River is shown in Table 1.3.1(2).

(3) Main Features of Proposed Channel

The main features of the proposed channels of the Kamal, diversion and Tanjungan are also shown in Table 1.3.1(2).

3.4.3 Comparative Evaluation

Economical efficiency of the above two (2) alternatives are compared in terms of 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 major construction works, land acquisition area and construction cost for the above two (2) cases are shown below (For details, refer to Table 1.3.2(2)).

Item	Case A-I+Case B-I	Case B-II
Channel Excavation (m^3)	340,000	399,000
Embankment (m^3)	50,000	102,000
Revetment Works (m^2)	91,400	92,900
Land Acquisition (ha)	28.4	24.1
Construction Cost (million Rp.)	26,184	26,379

Note: Construction cost includes direct construction cost, and land acquisition and compensation costs.

The construction costs of both cases are almost the same. No significant advantages of the diversion project are identified. Improvement of the existing drainage system (Case B-I) is recommended.

3.5 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).

(i) Improvement of existing drainage system
(ii) Diversion to Mookervart River

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

(1) General

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 flood are P.P. 3.8 m and P.P. 1.9 m respectively (Refer to Section 3.2). 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)

Location of the proposed channel improvements are shown in Fig. 1.3.3.

(2) Design Flood Discharge

The design flood discharge for the respective sections along the existing drainage channels of Kali Gede, Kali Bor and Saluran Cengkareng is shown in Table 1.3.1(3).

(3) Main Features of Proposed Channel

The main features for the respective sections of the proposed channel are also shown in Table 1.3.1(3).

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

(1) General

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 improvement is shown in Fig. 1.3.3.

(2) Design Flood Discharge

The design flood discharge for the respective sections of the drainage channels of Kali Gede, diversion, Kali Bor and Salurang Cengkareng is shown in Table 1.3.1(3).

(3) Main Features of Proposed Channel

The main features for the respective sections of the proposed channel are also shown in Table 1.3.1(3).

3.5.2 Comparative Evaluation

The major construction works, land acquisition area and construction cost of the above two (2) alternative plans for the Drainage Basin C and D are compared as follows (For details, refer to Table 1.3.2(3)).

Item	Case C/D-I	Case C/D-II
Channel Excavation (m^3)	95,000	87,000
Embankment (m^3)	42,100	42,100
Revetment Works (m)	81,100	81,100
Land Acquisition (ha)	9.5	9.1
Construction Cost (million Rp.)	14,991	14,575

Note: Construction cost includes direct construction cost, and land acquisition and compensation costs.

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

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

3.6 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 3.2). 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.

(i) Gravity Drainage to Cengkareng Floodway
(ii) Diversion to Tanjungan River

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

(1) General

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 e0 to drain the upper channel area of the Drainage Basin (E). A new drainage channel is excavated between Point e_0 and Point e_2.

Location of the proposed channel improvement is shown in Fig. 1.3.3.

(2) Design Flood Discharge

The design flood discharge for the respective sections along the existing Padongkelan drainage channel and extended drainage channel is determined as shown in Table 1.3.1(4).

(3) Main Features of Proposed Channel

The main features of the respective sections of the proposed channel are also shown in Table 1.3.1(4).

3.6.2 Diversion to Tanjungan River (Case E-II)

(1) General

The existing Padongkelan drainage channel is provided with a sluice gate at the confluence to the Cengkareng Floodway to prevent floods 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 a4 to the estuary of the Tanjungan River (a_3).

Location of the proposed channel improvement is shown in Fig. 1.3.3.

(2) Design Flood Discharge

The design flood discharge for the respective sections along the existing Padongkelan drainage channel, new drainage channel and proposed drainage channel of the Drainage Basin (A) is determined as shown in Table 1.3.1(4).

(3) Main Features of Proposed Channel

The main features for the respective sections of the proposed channel are also shown in Table 1.3.1(4).

3.6.3 Comparative Evaluation

Economical 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)

The major construction works, land acquisition area and construction cost for the above two (2) cases are shown below (For details, refer to Table 1.3.2(4)).

Item	Case E-I + Case A-I	Case E-II
Channel Excavation (m^3)	145,200	300,000
Embankment (m^3)	40,000	45,000
Revetment Works (m^3)	61,400	91,200
Land Acquisition (ha)	14.9	20.4
Construction Cost (million Rp.)	14,947	20,733

Note: Construction cost includes direct construction cost, and land acquisition and compensation costs.

The plan of gravity drainage to the Cengkareng Floodway is more economical than the diversion to the Tanjungan River. In addition, it is considered difficult to maintain the design channel section of the latter plan due to its gentle slope of 1/8,500.

Case E-I is recommended.