A-4 Catchment:	An old tributary of the Aur River
S-5 and S-7 catchments:	One retention pond in S-6 catchment is utilized for three catchments along the Kelang River.
S-9 Catchment:	Retention pond is to be constructed in the swampy area in the neighboring S-11 catchment.
S-10 Catchment:	It would be necessary to acquire the sports ground belonging to the Malayan Railway.
A-5 Catchment	It would be necessary to acquire open space in the downstream.

5.2.3. Decreasing Stormwater Discharge

Inundation upstream and midstream of each catchment is caused by inadequate capacity of drains. Countermeasures for preventing such inundation are: a) to increase the existing capacity of drains and b) to decrease the stormwater discharge so as to compensate the inadequate capacity of the drain to the extent possible.

In order to decrease stormwater discharge, four measures are considered as follows:

(1) Construction of retention pond upstream to enable storage of part of the stormwater discharge to decrease peak discharge.
(2) Provision of as much open space as possible to prevent increase in runoff coefficient and to hold water during heavy rainfall.
(3) Use of highly permeable material as pavement material, to prevent increase in runoff coefficient.
(4) Construction of diversion channel.

Table 5.2. Comparison of Construction Cost between Pump and Retention Pond

(Unit: M$1,000)

Catchment Code No.	Item	Pumping Station	Retention Pond
S-6	Installation or Construction	25,300	2,000
	Land Acquisition	200	2,960
	Total	25,500	4,960
S-9	Installation or Construction	23,200	960
	Land Acquisition	144	960
	Total	23,344	1,920
S-10	Installation or Construction	26,000	1,160
	Land Acquisition	153	1,230
	Total	26,153	2,390
A-4	Installation or Construction	12,300	0
	Land Acquisition	160	0
	Total	12,460	0
A-5	Installation or Construction	17,000	770
	Land Acquisition	172	1,080
	Total	17,172	1,850

Note: 1. Engineering fee and contingency cost are not included.

2. Construction cost of retention pond for A-4 catchment is practically nil because the existing swampy area can be used as retention pond.

1) Upstream Retention Pond

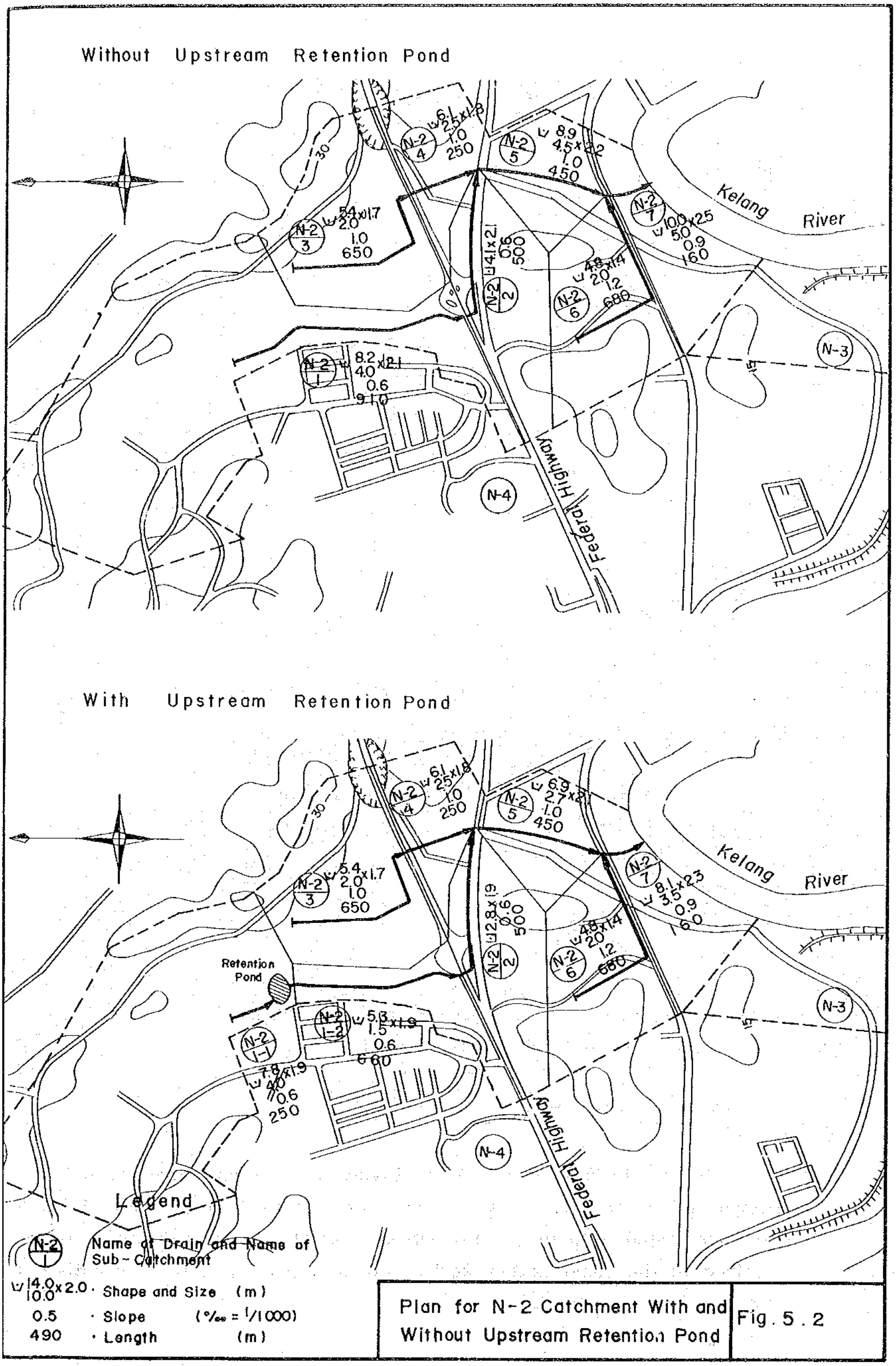
A retention pond, planned for an upstream drain, would serve to mitigate or decrease peak stormwater runoff downstream, and therefore would not require a large drain. Taking N-2 catchment as an example, the required land is available so that hampering envisaged town planning is avoided. The total estimated cost, including an upstream retention pond, becomes cheaper by about 2 percent than originally planned. (Ref.: Table 5.3. and Fig. 5.2.) However, a system with this type of retention pond is not proposed, considering the extensive land required for development of the town of Kelang, when only seven-tenths of the population, which is estimated to reach 500,000 in the year 2000, is planned within the Project Area. If the population of a certain catchment were to be limited due to decrease in land space used for a retention pond, it would become necessary for part of its population to be shifted to another catchment. This, in turn, would necessitate improvement of that catchment, as well as such present problems as commuting to the shifted population.

Table 5.3. Construction Costs for the N-2 Catchment

(Unit: M$1,000)

Description	Without Upstream Retention Pond		With Upstream Retention Pond	
A. Facilities	Range in Size:		Range in Size:	
Trunk Drain	R 8.2/4.0 x 2.1 ~ R 10.0/5.0 x 2.5	4,485	R 7.8/4.0 x 1.9 ~ R 8.1/3.5 x 2.3	3,979
Pump Station		-		-
Retention Pond		-	(V=9,700 m³)	250
Sub-Total		4,485		4,229
B. Engineering Fee		673		634
C. Contingency Cost		1,032		973
D. Land Acquisition				
Trunk Drain		2,835		2,400
Retention Pond		-	(A=5,000 m²)	1,000
Sub-Total		2,835		3,400
Grand Total		9,025		9,236

R: Rubble Wall Channel



Plan for N-2 Catchment With and Without Upstream Retention Pond

Fig. 5.2

2) Diversion Channel (N-6 Catchment)

a) N-6 Catchment

The N-6 catchment downstream is the developed commercial area in Kelang North, where the Federal Highway runs through. A box culvert of one meter diameter is laid in this area. Replacement of this box culvert would be more difficult than enlarging the existing open channel, taking into account the developed area and heavy flow of traffic.

i) Alternative A.

Therefore, the downstream route is shifted west of the Federal Highway, as shown in Fig.5.3., in order to provide ease of construction.

ii) Alternative B.

Another alternative is to make a diversion channel to reduce peak storm discharge. One possible route is along Lorong Sireh in N-5 catchment in the direction of the N-4 trunk drain, as shown in Fig. 5.4. The connection is made with N-4 trunk drain, rather than the neighboring N-5 trunk drain because of higher elevation in N-4 catchment to avoid the flow of stormwater into the lower N-5 catchment. It is noted that there is sufficient open space downstream in N-4 catchment, which would facilitate expansion of N-4 catchment trunk drain. (Ref.: Fig. 5.4.)

iii) Alternative C.

Another alternative route leads toward N-7 catchment, including provision of a tunnel to cross the more than 30 meter-high hill, which lies in N-6 and N-7 catchments. (Ref.: Fig. 5.5.)

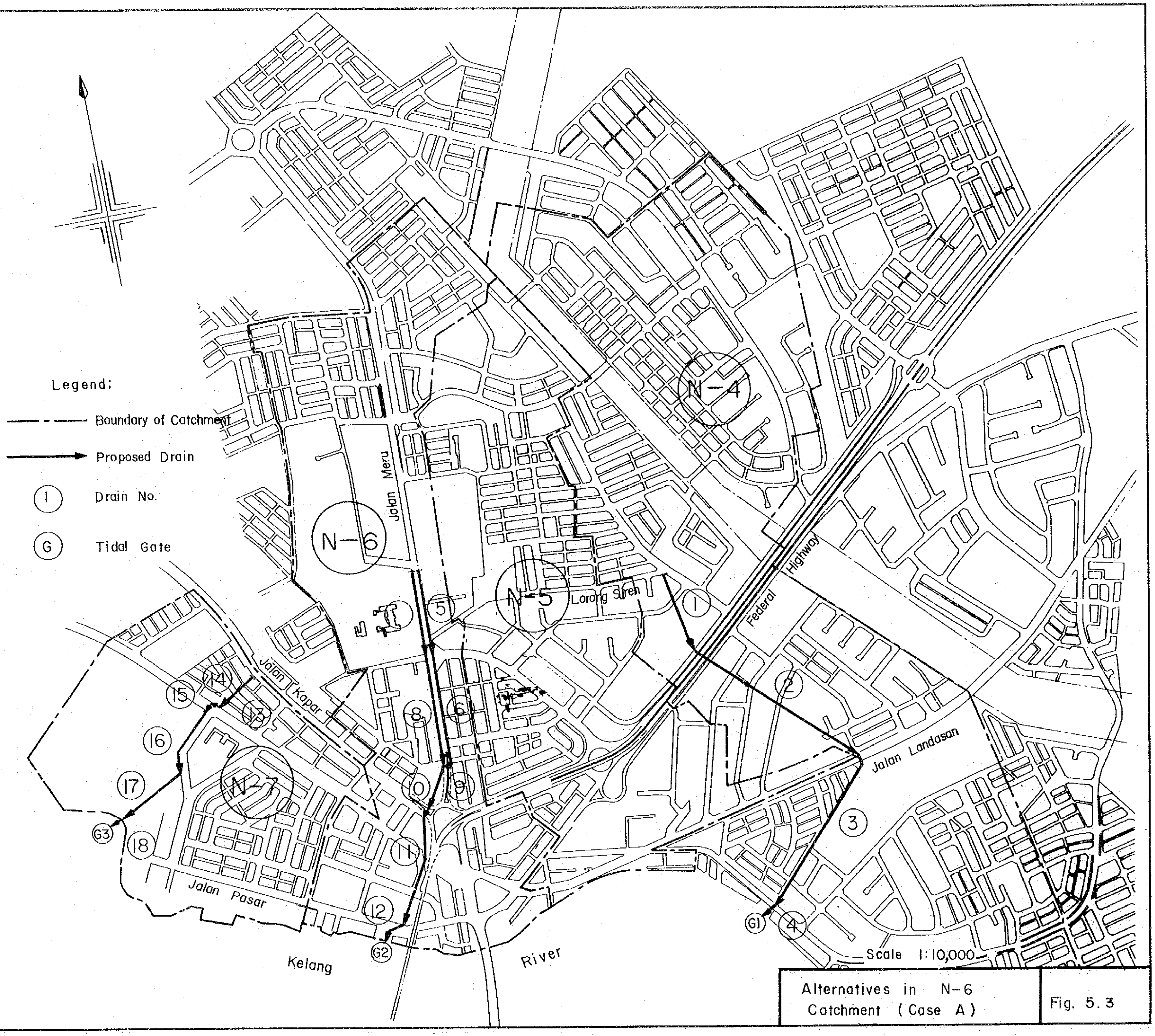
iv) Evaluation of Alternatives

Of the three alternatives, A involves the least expense, followed by Alternatives B and C. However, the Alternative A route runs through the most congested area in the Project Area so that extra precaution would be required in the construction work. Construction work in Alternative B would be easier than in A, despite its route along Lorong Sireh in a developed residential area.

On the other hand, the work involved for Alternative C would be easier, since its route runs mainly along an area which is presently vacant, although tunneling would be required.

From an overall technical and economical viewpoint, Alternative A is recommended on the premise that the difficulties presented by its congested location are surmountable through current advanced technology.

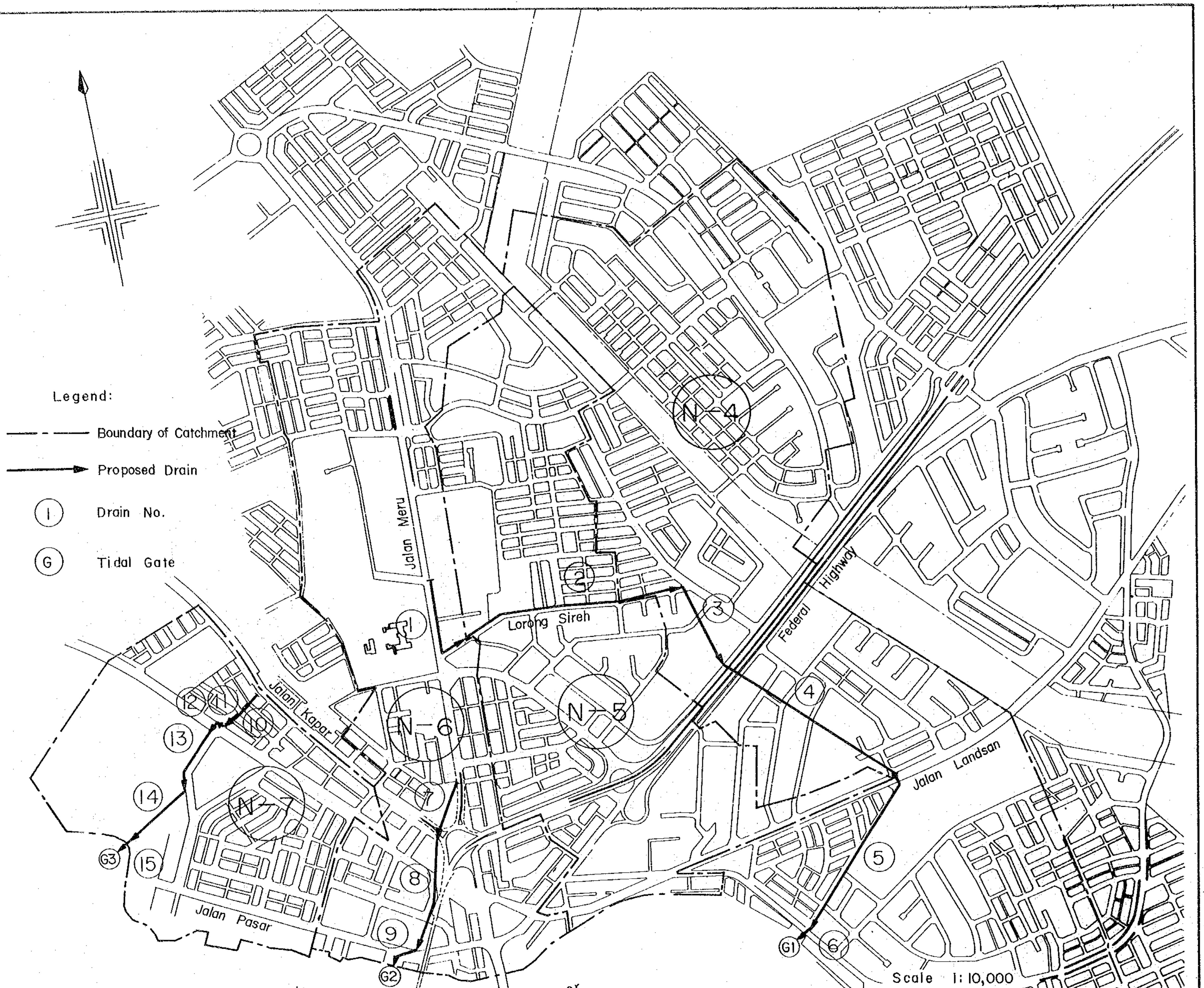
Facility	Size(m)	Length (m)	Construction Cost (M$)
Drain (1)	⊔ 7.2/3.0 x 2.1	225	224,000
〃 (2)	⊔ 7.9/3.5 x 2.2	400	410,000
〃 (3)	⊔ 8.6/4.0 x 2.3	370	394,000
〃 (4)	⊔ 9.8/5.0 x 2.4	80	89,000
〃 (5)	⊔ 1.7 x 1.7	250	238,000
〃 (6)	⊔ 1.8 x 1.8	340	350,000
〃 (7)	⊔ 1.7 x 1.7	230	219,000
〃 (8)	⊔ 1.8 x 1.8	320	330,000
〃 (9)	⊡ 2.1 x 2.1	125	244,000
〃 (10)	⊡ 2.1 x 2.1	35	82,000
〃 (11)	⊡ 2.1 x 2.1	295	693,000
〃 (12)	⊡ 2.4 x 2.4	85	225,000
〃 (13)	⊔ 1.2 x 1.2	125	75,000
〃 (14)	⊔ 1.4 x 1.4	25	18,000
〃 (15)	⊔ 1.6 x 1.6	20	17,000
〃 (16)	⊔ 1.9 x 1.9	180	198,000
〃 (17)	⊔ 2.1 x 2.1	220	275,000
〃 (18)	⊔ 2.9 x 2.9	20	37,000
Gate (G1)			225,000
〃 (G2)			155,000
〃 (G3)			155,000
Total			4,653,000



Alternatives in N-6 Catchment (Case A)

Fig. 5.3

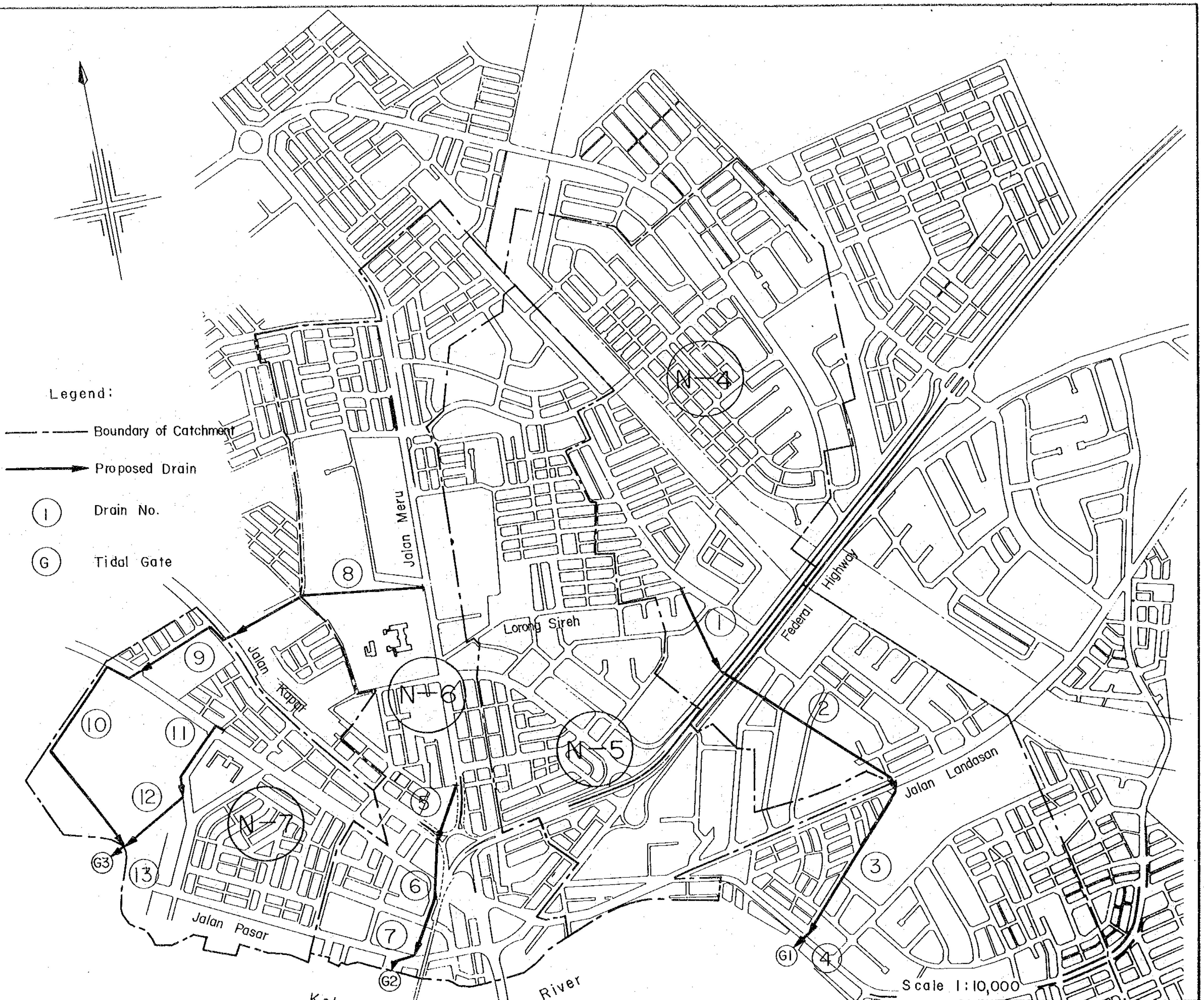
Facility	Size(m)	Length (m)	Construction Cost (M$)
Drain ①	⊔ 2.4 x 2.4	270	397,000
〃 ②	2.4 2.4	580	1,305,000
〃 ③	⊔ 8.3/3.5 x 2.4	225	245,000
〃 ④	⊔ 8.5/3.5 x 2.5	400	444,000
〃 ⑤	⊔ 9.0/4.0 x 2.6	370	414,000
〃 ⑥	⊔ 9.9/4.5 x 2.7	80	94,000
〃 ⑦	⊡ 1.5 x 1.5	155	279,000
〃 ⑧	⊡ 1.5 x 1.5	295	531,000
〃 ⑨	⊡ 2.1 x 2.1	80	188,000
〃 ⑩	⊔ 1.2 x 1.2	125	75,000
〃 ⑪	⊔ 1.4 x 1.4	25	18,000
〃 ⑫	⊔ 1.6 x 1.6	20	17,000
〃 ⑬	⊔ 1.9 x 1.9	180	198,000
〃 ⑭	⊔ 2.1 x 2.1	220	275,000
〃 ⑮	⊔ 2.9 x 2.9	20	37,000
Gate (G1)			260,000
(G2)			155,000
(G3)			155,000
Total			5,087,000



Alternatives in N-6 Catchment (Case B)

Fig. 5.4

Facility	Size(m)	Length (m)	Construction Cost (M $)
Drain ①	⊔ 7.2/3.0 x 2.1	225	224,000
〃 ②	⊔ 7.9/3.5 x 2.2	400	410,000
〃 ③	⊔ 8.6/4.0 x 2.3	370	394,000
〃 ④	⊔ 9.8/5.0 x 2.4	80	89,000
〃 ⑤	⊡ 1.5 x 1.5	155	279,000
〃 ⑥	⊡ 1.5 x 1.5	295	531,000
〃 ⑦	⊡ 2.1 x 2.1	80	188,000
〃 ⑧	Tunnel ⌀ 2.6	200	2,600,000
〃 ⑧	⊔ 2.4 x 2.4	305	448,000
〃 ⑨	⊔ 2.4 x 2.4	300	441,000
〃 ⑩	⊔ 2.5 x 2.5	675	1,046,000
〃 ⑪	⊔ 1.5 x 1.5	225	180,000
〃 ⑫	⊔ 1.8 x 1.8	220	227,000
〃 ⑬	⊔ 3.1 x 3.1	20	40,000
Gate (G1)			225,000
〃 (G2)			155,000
〃 (G3)			155,000
Total			7,632,000



Kelang River

Alternatives in N-6 Catchment (Case C)

Fig. 5.5

b) <u>S-5 Catchment</u>

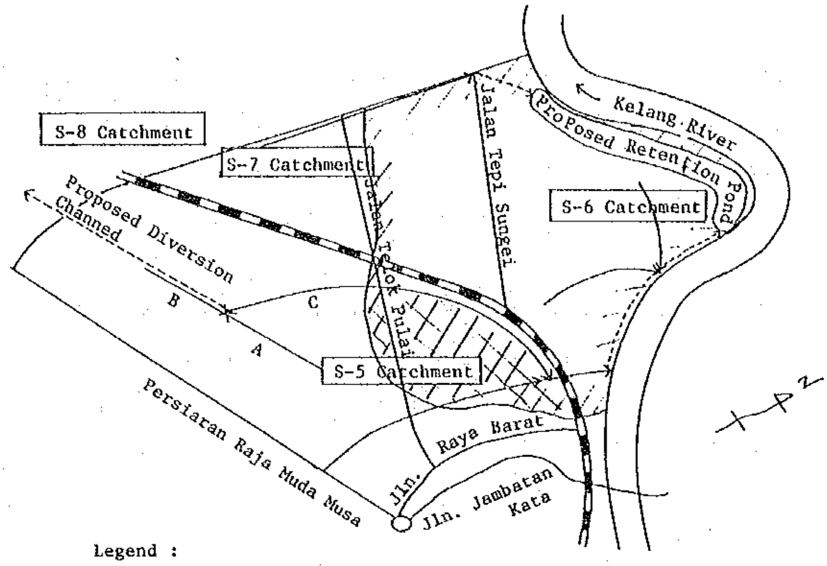
In the case of S-5 catchment, since expansion of the midstream trunk drain ("C" in Fig. 5.6) is difficult, the trunk drain is planned to be diverted into the S-8 catchment trunk drain in order to combat flooding midstream (indicated as "A" and "B" in Fig. 5.6).

Additionally, in the western part of Kelang South, the low elevation of land extends so widely that a pumping or retention pond system needs to be applied in lieu of gravity system. While the retention pond system is more economical than the pumping system as compared in the preceding section, the land available exists only along the Kelang River, as shown in Fig. 5.6.

This particularly low area, which is indicated in Fig. 5.6 is lower than downstream, which makes drainage difficult. It is inevitable that the planned drain water level in this catchment should be low for proper drainage. Thus, the drain water level of R.L. +1.0 to +1.5 m is far lower than the planned Kelang River water level of R.L. +2.1 m. As a result, a larger area would be required to accommodate the shallow depth of the proposed retention pond. To avoid these disadvantages, the existing upstream trunk drain of S-5 catchment is planned to be diverted into that of S-8.

Landfilling in this area might be an effective alternative method to overcome localized flooding but housing development, which has already taken place, including drainage system to meet existing topographical condition, presents difficulties.

Fig. 5.6. Layout of Existing Drains in S-5 Catchment



Legend :

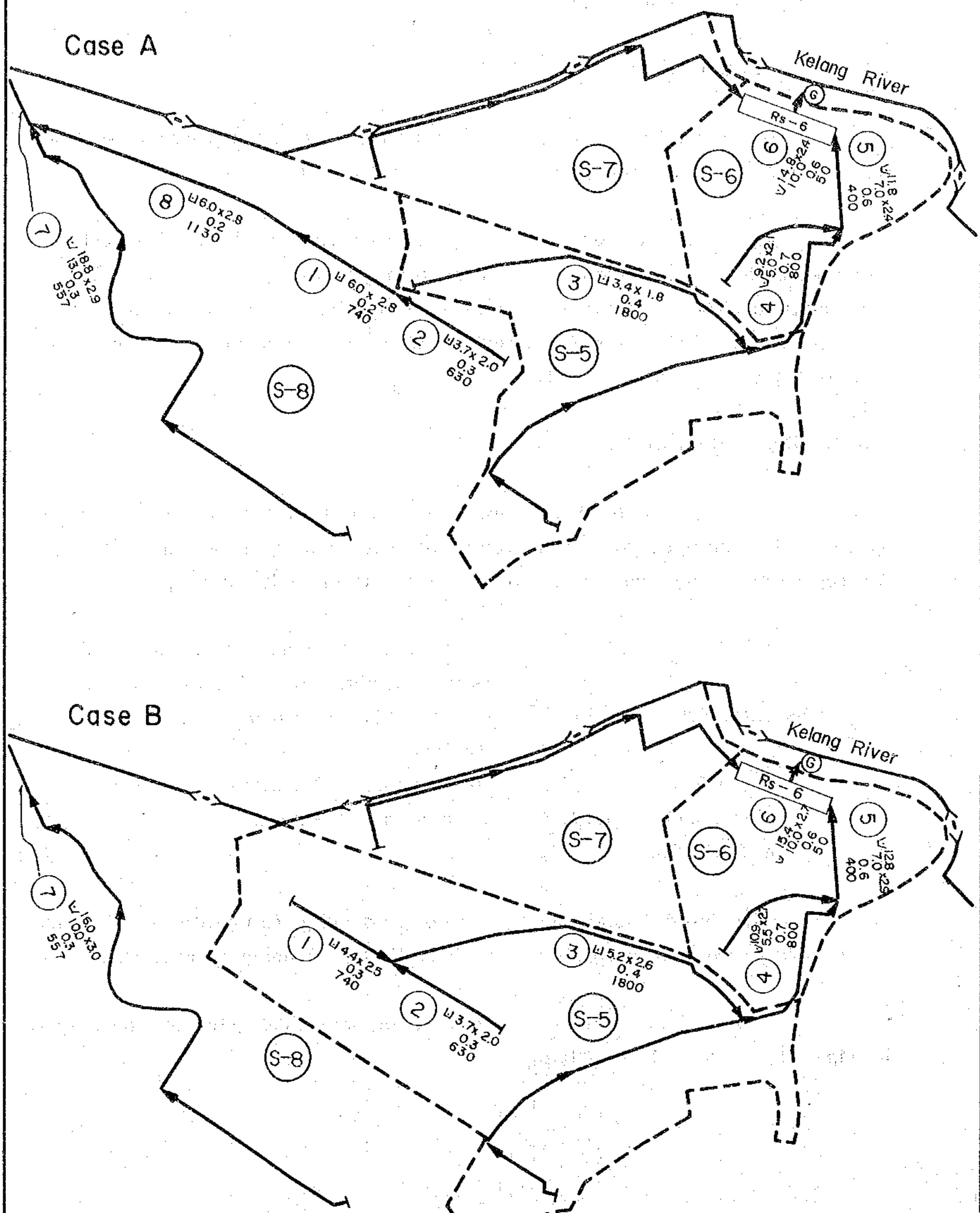
- ——→ Existing Main Drain
- - - -→ Proposed Main Drain
- (hatched) Below R.L. + 2.5 m

Table 5.4. Construction Cost for S-5 to S-8 Catchment

Line*1 No.	Length (m)	Case A: Width x Height (m)	Case A: Construction Cost (M$)	Case B: Width x Height (m)	Case B: Construction Cost (M$)
1	740	C 6.0 x 2.8	2,690	C 4.4 x 2.5	1,598
2	630	C 3.7 x 2.0	1,077	C 3.7 x 2.0	1,077
3	1,780	C 3.4 x 1.8	2,706	C 5.2 x 2.6	5,340 (342)
	20	B 2-1.7 x 1.8	46	B 2-2.6 x 2.6	78
4	780	R 9.7/5.5 x 2.1	800	R 10.9/5.5 x 2.7	936
	20	B 3-3.3 x 2.0	630	B 3-3.6 x 2.7	900
5	400	R 12.1/7.5 x 2.3	444 (170)	R 12.8/7.0 x 2.9	512 (181)
6	50	R 12.1/7.5 x 2.3	56	R 12.8/7.0 x 2.9	64
7	557	R 18.8/13.0 x 2.9	785 (189)	R 16.0/10.0 x 3.0	766 (141)
	10	Br. 18.8	1,045	Br. 16.0	930
8	1,070	C 6.0 x 2.8	3,880	-	-
	60	B 2-3.0 x 2.8	325	-	-
Tidal Gate for S-6		-	235	-	310
Tidal Gate for S-8		-	390	-	340
Retention Pond		V = 118,000 m^3 A = 54,000 m^2	1,480 (2,160)	V = 225,000 m^3 A = 103,000 m^2	2,650 (4,120)
Total*2			16,589 (2,519)		15,501 (4,784)
		Total	19,108	Total	20,285

*1 Line Nos. are shown in Fig. 5.7.
*2 Engineering fees and contingency costs are not included.
*3 Figures in parentheses are land acquisition cost.

C: Concrete Channel   R: Rubble Wall Channel
B: Box Culvert   Br: Bridge



Alternatives in
S-5, S-6, S-7, S-8 Catchments

Fig. 5.7

5.3. Proposed Drainage System

5.3.1. General Background

Based on the general consideration stated in the previous section, this section describes the proposed Master Plan program.

The recommended plan includes improvement of existing facilities and installation of new facilities such as bunds, tidal gates, retention ponds and trunk drains. Gravity flow system is applied in the catchments wherever possible. In a few catchments where gravity cannot be employed, retention pond is recommended.

5.3.2. Description of Facilities

Figures 5.8 to 5.10 show the layouts of the ultimate drainage system. Descriptions of the improvement work and proposed new facilities for the drainage system are given in the following tables and figures:

Table 5.5.	Dimensions of Trunk Drain and Tidal Gate according to catchments
Figs. 5.8. to 5.10.	General Plan of proposed Drainage System
Table 5.6.	Dimensions of Retention Pond
Figs. 5.11. - 5.12. & Table 5.7.	Dimensions of Bund

The longitudinal sections and hydraulic computations of trunk drains are presented in Appendix F, Vol. VIII: Planning of Facilities

Standard structures of trunk drain and tidal gate are presented in Figs. 4.2. and 4.4. of Chapter 4.

Table 5.5. Dimensions of Trunk Drain and Tidal Gate According to Catchment

Catchment Code No.	Trunk Drain: Length (m)	Trunk Drain: Range of Width (m) and Height (m)	Tidal Gate (m^2)
N-1	6,140	11.2 / 6.0 x 2.6 to 29.5 / 23.5 x 3.0	87
2	3,600	4.1 x 2.2 " 10.0 / 5.0 x 2.5	19
3	780	5.0 / 2.0 x 1.5 " 6.3 / 2.5 x 1.9	6
4	2,660	6.4 / 3.0 x 1.7 " 9.5 / 4.5 x 2.5	18
5	1,425	1.4 x 1.4 " 2.8 x 2.3	11
6	2.985	1.5 x 1.5 " 2.4 x 2.4	11
7	1,455	1.2 x 1.2 " 2.9 x 2.9	11
8	5,070	6.8 / 3.0 x 1.9 " 13.0 / 8.0 x 2.5	26
9	5,510	7.2 / 3.0 x 2.1 " 14.0 / 9.0 x 2.5	29
S-1	180	8.0 / 4.0 x 2.0	12
2	1,790	7.8 / 4.0 x 1.9 to 9.0 / 5.0 x 2.0	14
3	350	1.6 x 1.6	3
4	700	2.7 x 2.0	5
5	4,335	4.1 / 1.5 x 1.3 to 9.2 / 5.0 x 2.1	10
6	1,300	7.6 / 4.0 x 1.8 " 12.1 / 7.5 x 2.3	23
7	1,600	5.4 / 2.0 x 1.7 " 9.5 / 5.5 x 2.0	19
8	4,167	3.7 x 2.0 " 18.8 / 13.0 x 2.9	46
9	3,030	2.3 x 1.7 " 8.5 / 4.5 x 2.0	18
10	3,680	2.5 x 1.9 " 10.5 / 5.5 x 2.5	20
A-1	10,810	6.8 / 3.0 x 1.9 " 25.4 / 20.0 x 2.7	61
2	3,230	1.9 x 1.5 " 5.0 x 2.3	14
3	4,200	1.8 x 1.5 " 9.1 / 4.5 x 2.3	14
4	1,595	1.1 x 1.1 " 2.9 x 2.9	11
5	1,830	2.5 x 1.7 " 8.2 / 4.0 x 2.1	13
O-1	7,647	4.9 x 2.5 " 13.9 / 7.5 x 3.2	-
2	1,380	3.0 x 2.0 " 11.2 / 6.0 x 2.6	-
3	4,387	1.6 x 1.6 " 12.7 / 6.5 x 3.1	-
4	3,080	2.2 x 1.5 " 13.0 / 6.0 x 3.5	-
5	3,127	2.1 x 2.1 " 16.4 / 10.0 x 3.2	-
6	15,100	2.3 x 2.0 " 34.2 / 26.0 x 4.1	-
Total	107,147		

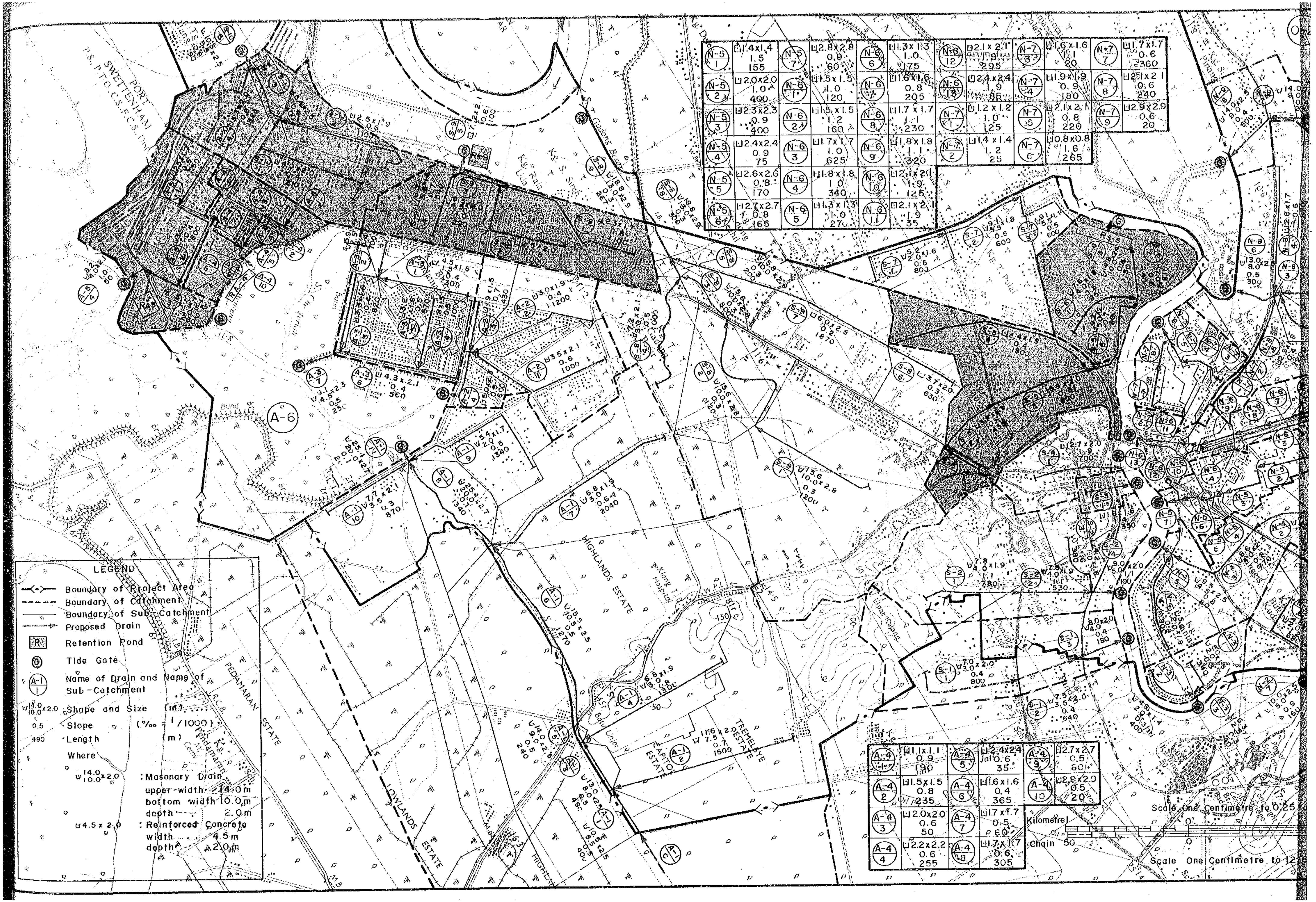
All facilities are presented in Appendix H.

Table 5.6. Dimensions of Retention Pond According to Catchment

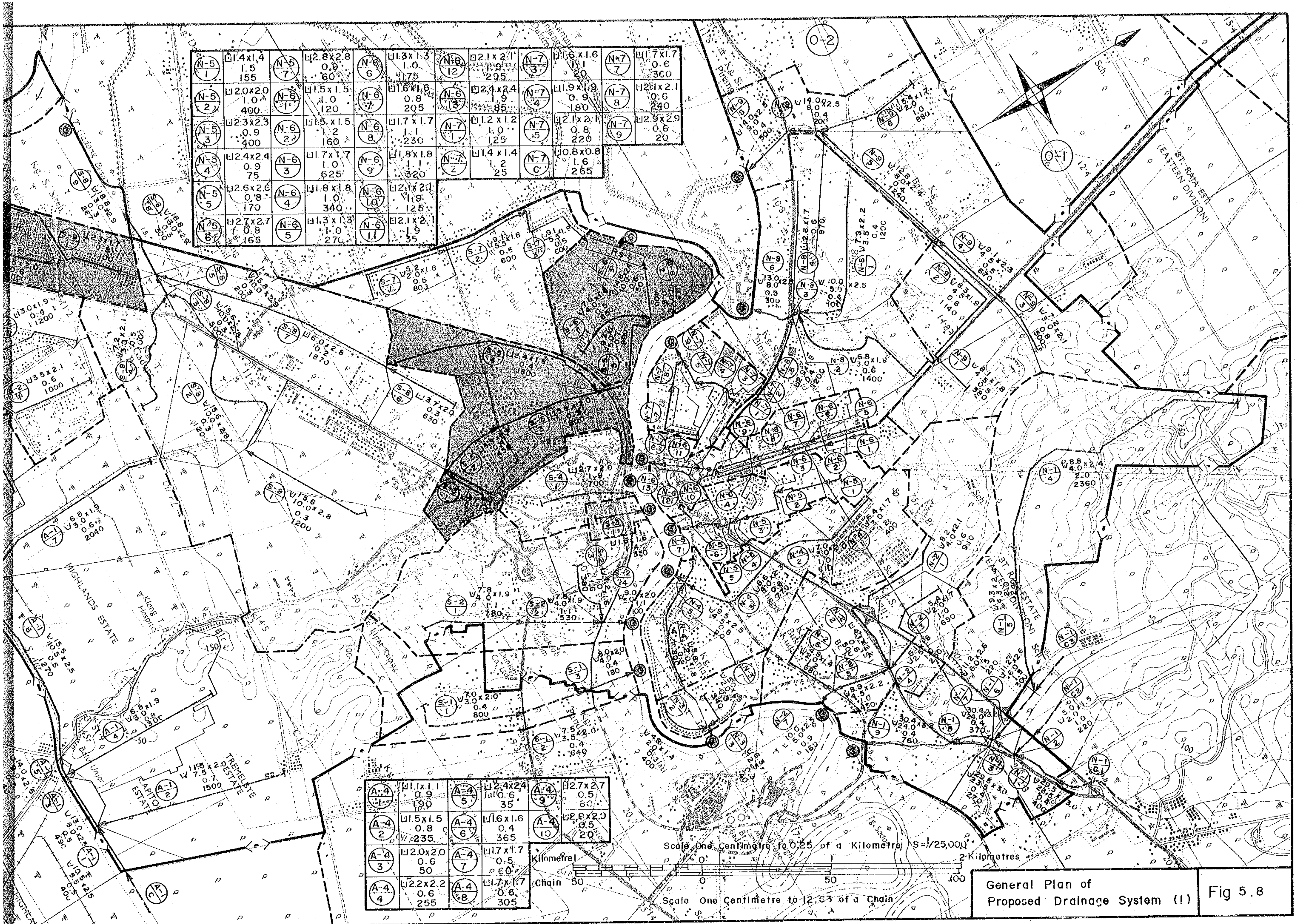
Catchment Code No.	Required Volume (m^3)	Depth (m)	Remarks
S-6	118,000	2	For S-5 and S-6 catchments
S-9	70,000	2	
S-10	88,000	2	
A-4	-	-	Existing swampy area is used as retention pond
A-5	53,000	2	

Table 5.7. Dimensions of Bund According to Catchment

Catchment Code No.	Height of Bund (m)	Length (m)	Catchment Code No.	Height of Bund (m)	Length (m)
N-3	1.0	450	S-2	1.0	400
	0.5	600		1.5	630
N-4	0.5	170	S-3	1.0	210
	1.0	240	S-4	1.0	280
	1.5	720	S-5	1.0	300
N-5	0.5	270		1.5	380
N-6	0.5	830	S-6	0.5	1,240
N-7	0.5	580		1.5	650
	1.0	110	S-7	0.5	400
	1.5	190	A-3	0.5	980
N-8	1.5	240	A-6	1.0	1,130
Out of Project Area	1.0	530	Total		11,530

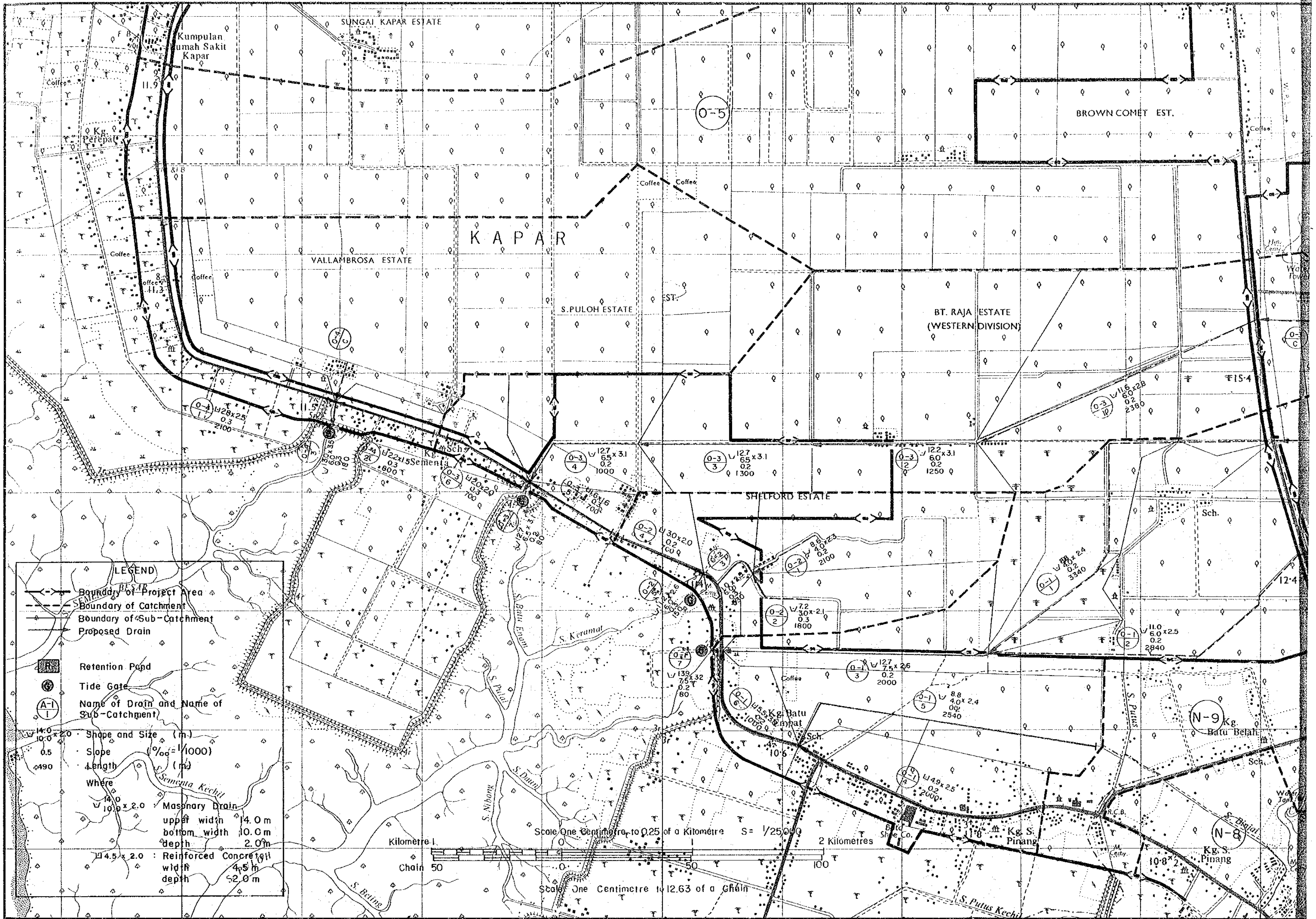


LEGEND
Boundary of Project Area
Boundary of Catchment
Boundary of Sub-Catchment
Proposed Drain
R Retention Pond
G Tide Gate
A-1/1 Name of Drain and Name of Sub-Catchment
14.0/10.0 x 2.0 Shape and Size (m)
0.5 Slope (‰ = 1/1000)
490 Length (m)
Where
14.0/10.0 x 2.0 : Masonary Drain
upper width 14.0 m
bottom width 10.0 m
depth 2.0 m
4.5 x 2.0 : Reinforced Concrete
width 4.5 m
depth 2.0 m
N-5/1 1.4x1.4 1.5 155
N-5/2 2.0x2.0 1.0 400
N-5/3 2.3x2.3 0.9 400
N-5/4 2.4x2.4 0.9 75
N-5/5 2.6x2.6 0.8 170
N-5/6 2.7x2.7 0.8 165
N-5/7 2.8x2.8 0.9 60
N-6/1 1.5x1.5 1.0 120
N-6/2 1.5x1.5 1.2 160
N-6/3 1.7x1.7 1.0 625
N-6/4 1.8x1.8 1.0 340
N-6/5 1.3x1.3 1.0 270
N-6/6 1.3x1.3 1.0 175
N-6/7 1.6x1.6 0.8 205
N-6/8 1.7x1.7 1.1 230
N-6/9 1.8x1.8 1.1 320
N-6/10 2.1x2.1 1.9 125
N-6/11 2.1x2.1 1.9 35
N-6/12 2.1x2.1 1.9 295
N-6/13 2.4x2.4 1.9 85
N-7/1 1.2x1.2 1.0 125
N-7/2 1.4x1.4 1.2 25
N-7/3 1.6x1.6 1.1 20
N-7/4 1.9x1.9 0.9 180
N-7/5 2.1x2.1 0.8 220
N-7/6 0.8x0.8 1.6 265
N-7/7 1.7x1.7 0.6 360
N-7/8 2.1x2.1 0.6 240
N-7/9 2.9x2.9 0.6 20
A-4/1 1.1x1.1 0.9 190
A-4/2 1.5x1.5 0.8 235
A-4/3 2.0x2.0 0.6 50
A-4/4 2.2x2.2 0.6 255
A-4/5 2.4x2.4 0.6 35
A-4/6 1.6x1.6 0.4 365
A-4/7 1.7x1.7 0.5 60
A-4/8 1.7x1.7 0.6 305
A-4/9 2.7x2.7 0.5 60
A-4/10 2.8x2.0 0.5 20
A-6
HIGHLANDS ESTATE
LOWLANDS ESTATE
PEDAMARAN ESTATE
TREMELBYE ESTATE
CAPITOL ESTATE
PORT SWETTENHAM
Scale One Centimetre to 0.25
Kilometre
Chain 50
Scale One Centimetre to 12

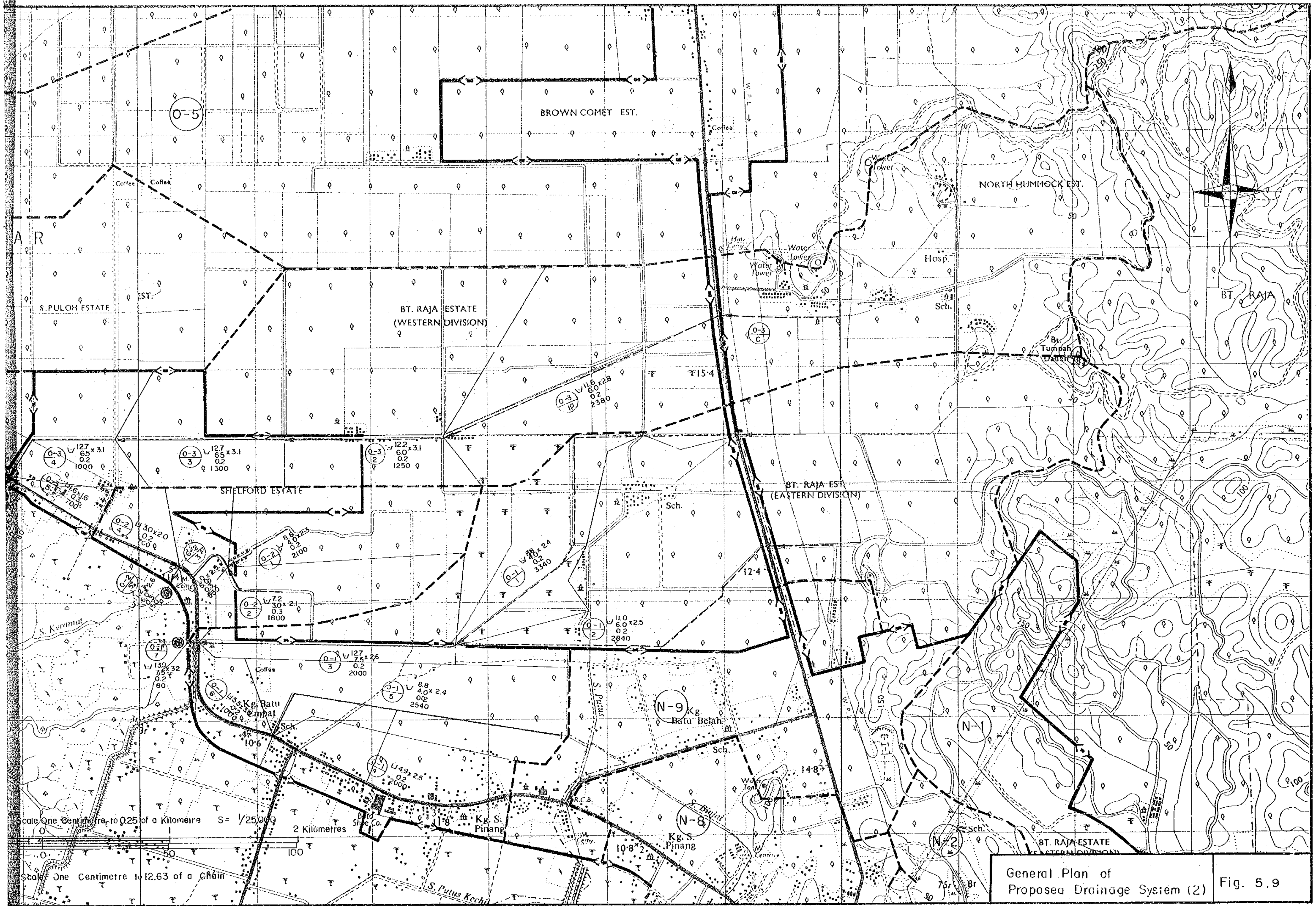


General Plan of Proposed Drainage System (I)

Fig 5.8

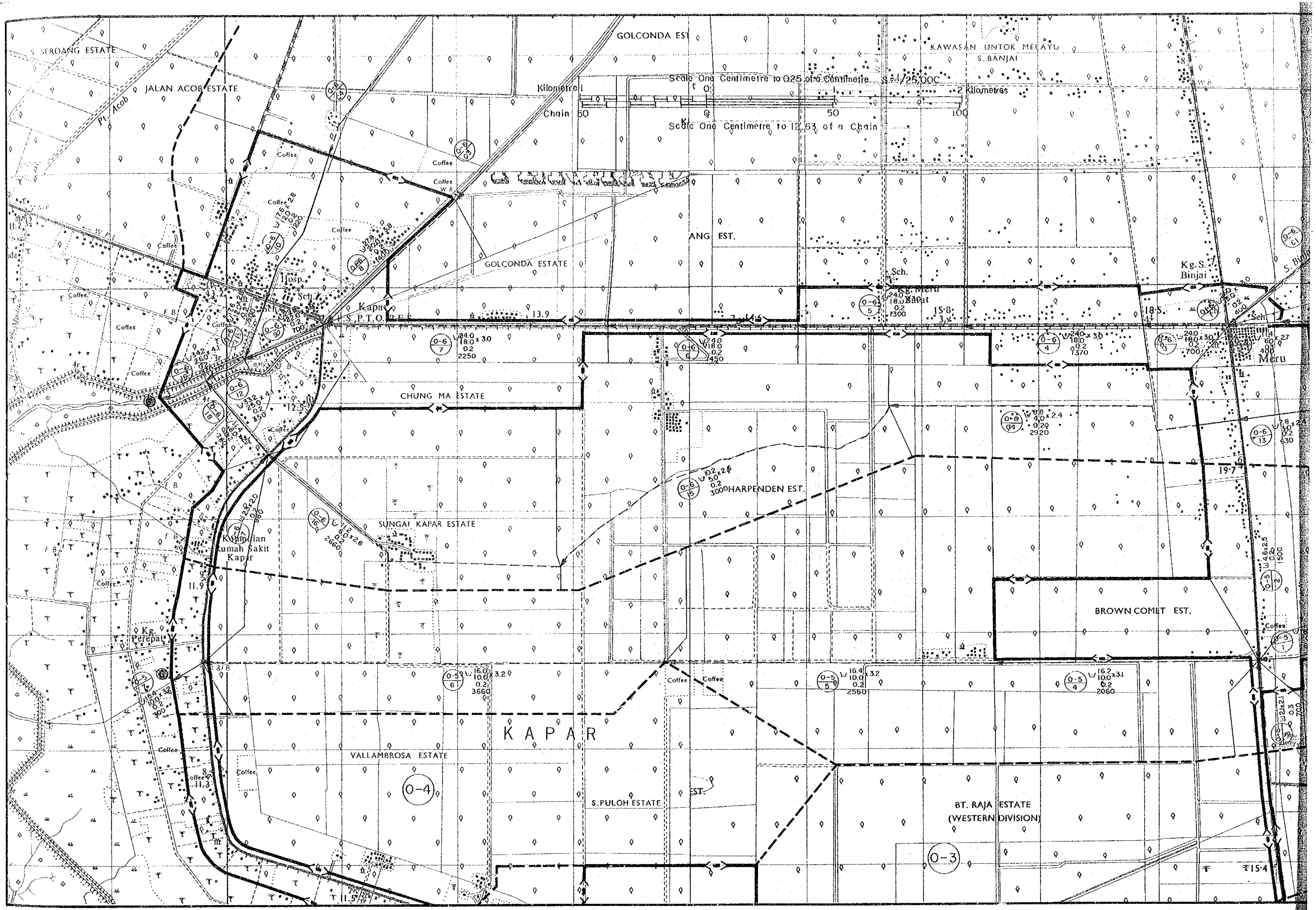


SUNGAI KAPAR ESTATE
Kumpulan Rumah Sakit Kapar
Kg. Perepat
KAPAR
VALLAMBROSA ESTATE
S.PULOH ESTATE
BROWN COMET EST.
BT. RAJA ESTATE (WESTERN DIVISION)
SHELFORD ESTATE
Kg. Sementa
Kg. Batu Belah
Kg. S. Pinang
S. Keramat
S. Sementa Kechil
S. Putus Kechil
O-5
N-9
N-8
LEGEND
Boundary of Project Area
Boundary of Catchment
Boundary of Sub-Catchment
Proposed Drain
Retention Pond
Tide Gate
Name of Drain and Name of Sub-Catchment
Shape and Size (m)
Slope (‰ = 1/1000)
Length (m)
Where
Masonary Drain
upper width 14.0 m
bottom width 10.0 m
depth 2.0 m
Reinforced Concrete
width 4.5 m
depth 2.0 m
Scale One Centimetre to 0.25 of a Kilometre S= 1/25,000
Kilometre 1
2 Kilometres
Chain 50
Scale One Centimetre to 12.63 of a Chain

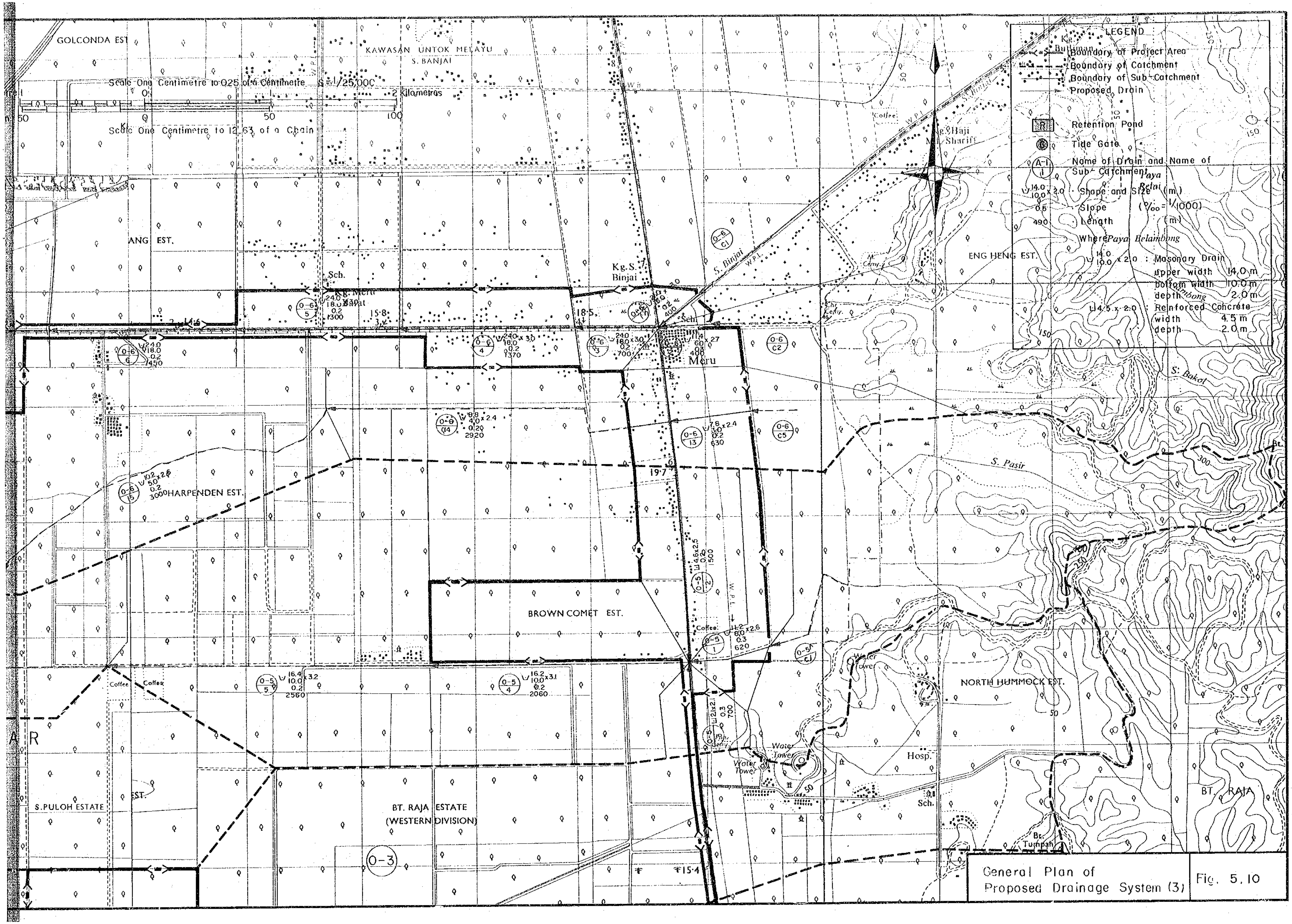


General Plan of Proposed Drainage System (2)

Fig. 5.9



SERDANG ESTATE
JALAN ACOB ESTATE
Pt. Acob
GOLCONDA EST
KAWASAN UNTOK MELAYU
S. BANJAI
Kilometre
2 Kilometres
Chain 50
50
100
Scale One Centimetre to 12.63 of a Chain
ANG EST.
GOLCONDA ESTATE
Coffee
Hosp.
Sch.
Kapar
13.9
15.8
18.5
Kg. S. Binjai
Meru
CHUNG MA ESTATE
HARPENDEN EST.
SUNGAI KAPAR ESTATE
19.7
11.9
Kg. Perepat
BROWN COMET EST.
KAPAR
VALLAMBROSA ESTATE
O-4
11.3
S.PULOH ESTATE
BT. RAJA ESTATE
(WESTERN DIVISION)
O-3
15.4

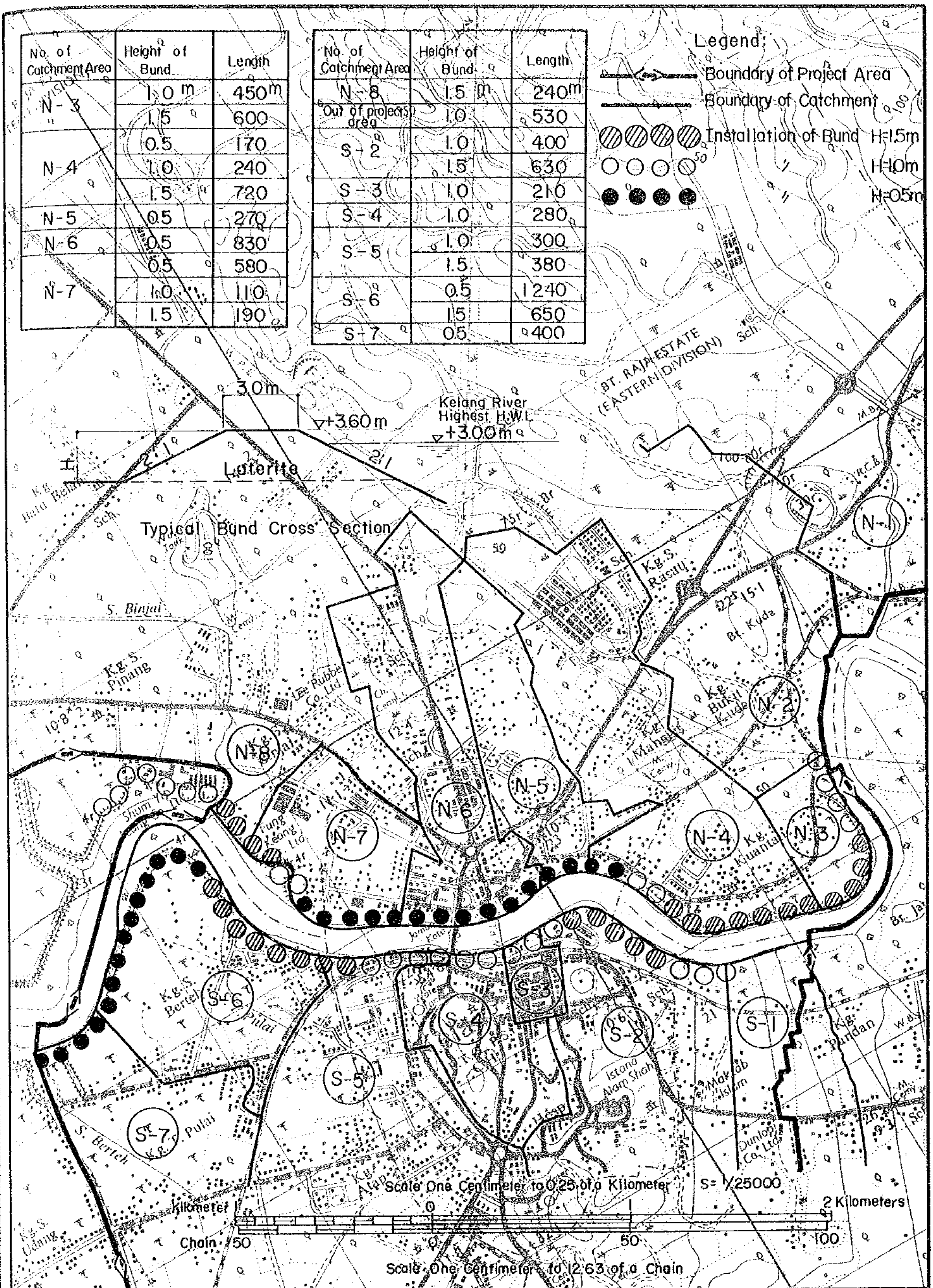


General Plan of Proposed Drainage System (3)

Fig. 5.10

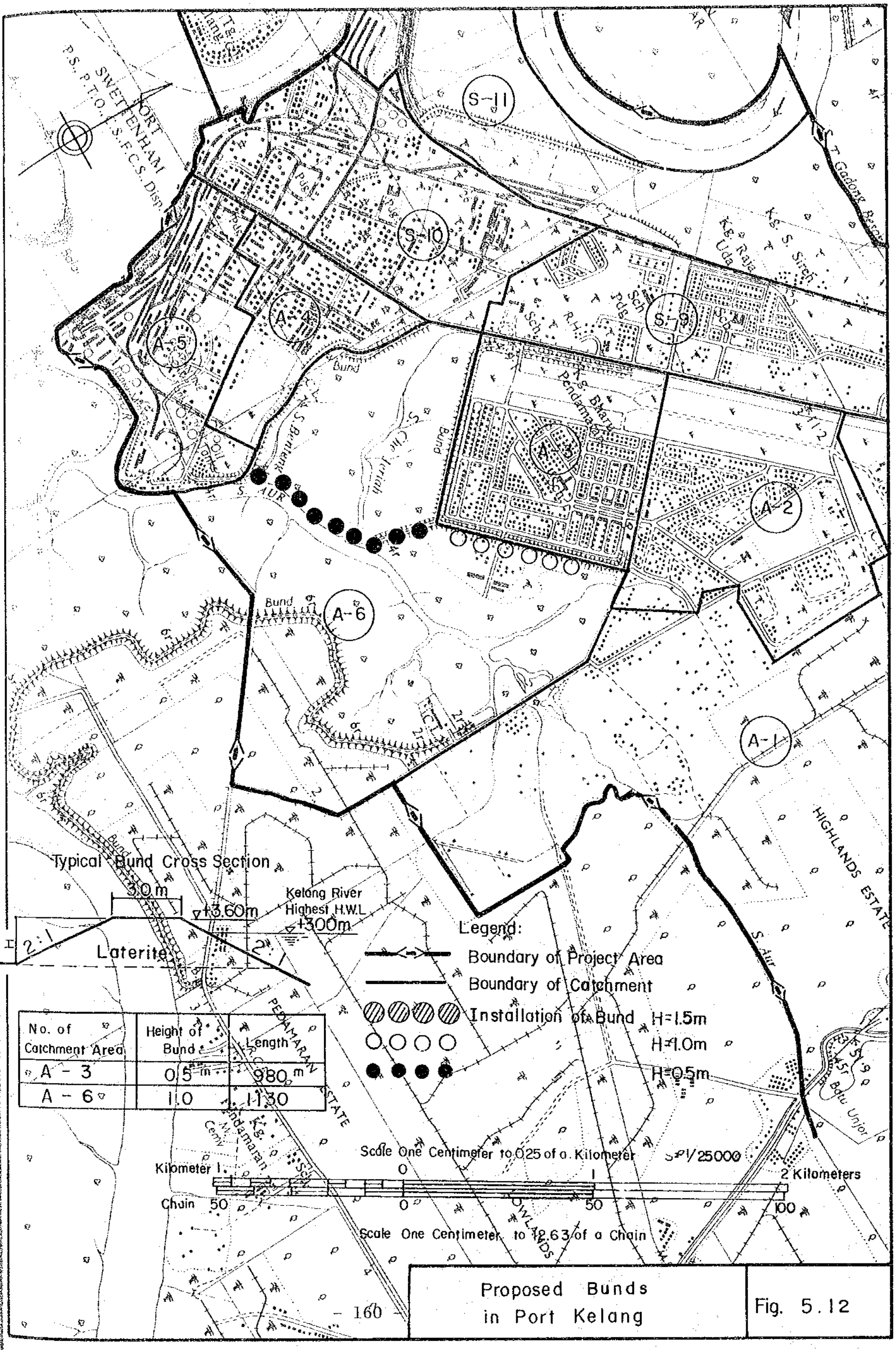
No. of Catchment Area	Height of Bund	Length
N-3	1.0 m	450 m
	1.5	600
N-4	0.5	170
	1.0	240
	1.5	720
N-5	0.5	270
N-6	0.5	830
N-7	0.5	580
	1.0	110
	1.5	190

No. of Catchment Area	Height of Bund	Length
N-8	1.5 m	240 m
Out of project area	1.0	530
S-2	1.0	400
	1.5	630
S-3	1.0	210
S-4	1.0	280
S-5	1.0	300
	1.5	380
S-6	0.5	1240
	1.5	650
S-7	0.5	400



Proposed Bunds in Kelang North & South

Fig. 5.11



No. of Catchment Area	Height of Bund	Length
A - 3	0.5 m	980 m
A - 6	1.0	1130

Proposed Bunds in Port Kelang

Fig. 5.12

5.3.3. Layout Planning

1) Drainage System with Gravity Flow

(Catchments: N-1, N-2, N-3, N-4, N-5, N-6, N-7, N-8 and N-9
S-1, S-2, S-3, S-4, S-7 and S-8 (S-11)
A-1, A-2 and A-3 (A-6)
O-1, O-2, O-3, O-4, O-5 and O-6)

Adoption of the gravity flow system is recommended wherever possible, which includes all of the above catchments.

As for O-1, O-2, O-3, O-4, O-5 and O-6 catchments, drains are planned with slopes corresponding to the ground surface slope to carry stormwater runoff in the drain to the border of the Project Area, and not to the sea, since the sea is about 3 to 6 km away from the Project Area.

As to A-6 and S-11 catchments, landfilling is considered since development is not possible now due to topographic conditions. Therefore, drainage facilities are not planned in these catchments, but drainage systems utilizing gravity flow can be planned.

2) Drainage System Utilizing Retention Pond

(Catchments: S-5, S-6, S-9, S-10, A-4 and A-5)

Construction of the retention pond is recommended because of low ground level in the above catchments.

3) Bunds

At present, bunds are in existence but their poor condition requires improvement to prevent the sea or river water from flowing onto the areas, since the Project Area is situated at low elevation and easily affected by tide and/or river. These works would have to be undertaken at an early stage.

The bund crown is to be R.L. +3.6 m with 0.5 meter freeboard based on the highest Kelang River water level of R.L. +3.03 m recorded at Jambatan Kota on November 13, 1981, which is higher by 0.5 meter than the predicted R.L. +2.5 m in Tide Table, 1981.

Bunds stretch along almost all areas facing the Kelang River, the Aur River and sea, as shown in Figs. 5.11. to 5.12.

4) Tidal Gates

At present, many tidal gates are installed for every trunk drain but they are not only undersized but are defective in watertightness. Thus, improvement of the tidal gates is necessary to provide adequate relief from tide-caused flooding.

The improvement work includes tidal gates to be generally installed near the river to utilize swampy areas, although some existing tidal gates are installed quite far from the river.

5.3.4. Cost Estimation

Capital cost estimates are prepared for the proposed drainage facilities by use of cost curves, as presented in Section 4.7.

Construction cost for the Project can be defined as the sum of all expenditures required to bring the Project to completion. These expenditures are divided into direct and indirect items, including civil works, procurement and installation of equipment, contractor's profits, overhead fees, and all related construction work. Hence, in preparing the estimates, allowances of 15 percent and 20 percent of the capital cost of works have been included to cover the cost of engineering fees (including design, survey and supervision) and contingencies, respectively.

A summary of the costs for each catchment is given in Table 5.8. The construction costs for A-6 and S-11 catchments are not included as there are no definite development plans for these swampy areas, although landfilling is recommended.

The estimated total cost is M$292 million at 1981 price level.

A summary of the costs for each catchment is given in Table 5.8. The construction costs for A-6 and S-11 catchments are not included as there are no definite development plans for these swampy areas, although landfilling is recommended.

The estimated total cost is M$292 million at 1981 price level.

Table 5.8. Estimated Construction Cost

(Unit: M$1,000)

Catchment Code No.	Construction Cost					Land Acqui-sition Cost	Engine-ering Fee	Contin-gency Cost	Total
	Trunk Drain	Tidal Gate	Reten-tion Pond	Bund	Total				
N-1	10,066	665	-	-	10,731	8,596	1,610	2,468	23,405
2	4,275	210	-	-	4,485	2,835	673	1,032	9,025
3	668	140	-	112	920	76	138	212	1,346
4	3,695	200	-	117	4,012	511	602	923	6,048
5	2,130	155	-	8	2,293	-	344	527	3,164
6	3,563	155	-	24	3,742	-	561	861	5,164
7	1,386	155	-	50	1,591	115	239	366	2,311
8	6,253	260	-	71	6,584	439	988	1,514	9,525
9	6,564	275	-	-	6,839	1,044	1,026	1,573	10,482
S-1	176	165	-	-	341	33	51	78	503
2	2,278	180	-	112	2,570	388	386	591	3,935
3	434	100	-	15	549	83	82	126	840
4	996	120	-	-	1,136	82	170	261	1,649
5	7,172	0	-	72	7,424	502	1,080	1,656	10,662
6	1,351	238	1,480	122	3,191	2,499	1,107	1,698	8,495
7	1,691	185	-	12	1,888	229	450	688	3,255
8	15,288	390	-	-	15,678	5,988	2,352	3,606	27,624
9	5,820	185	960	-	6,965	1,151	1,045	1,602	10,763
10	6,977	215	1,160	-	8,352	1,361	1,253	1,921	12,887
A-1	12,208	495	-	83	12,786	5,889	1,918	2,941	23,534
2	5,385	155	-	-	5,540	-	831	1,274	7,645
3	5,181	190	-	29	5,400	-	810	1,242	7,452
4	1,633	155	0	-	1,788	-	268	411	2,467
5	2,587	170	770	-	3,527	1,160	529	811	6,027
O-1	15,145	-	-	-	15,145	2,022	2,272	3,483	22,922
2	2,066	-	-	-	2,066	185	310	475	3,036
3	5,903	-	-	-	5,903	974	885	1,358	9,120
4	4,876	-	-	-	4,876	82	731	1,121	6,810
5	6,027	-	-	-	6,027	484	904	1,386	8,801
6	24,987	-	-	-	24,987	7,423	3,748	5,747	41,905
Telemeter System		-	-	-	910	-	136	209	1,255
Total	166,781	5,338	4,370	827	178,246	44,151	27,499	42,161	292,057

CHAPTER 6

IMPLEMENTATION SCHEDULE

CHAPTER 6 IMPLEMENTATION SCHEDULE

It is only prudent and sound to plan the construction of required facilities in phases, according to their respective urgency and benefits to be derived, due to constraints of financial resources and construction scheduling. Furthermore, a phased construction schedule would enable distribution of capital expenditure over an extensive period of years and facilitate implementation.

6.1. Phasing

The period scheduled for construction of the drainage system is 16 years (18 years, including preparatory work), which takes into consideration the following:

- Target year is 2000 A.D.
- Feasibility Study and Master Plan have been completed as of November 1982.
- Following the Feasibility Study, two years will be required to prepare for construction work, such as detailed design, land acquisition, and tender call and evaluation.
- Consequently, construction work will begin in 1985.

Implementation is recommended to be scheduled in three phases, corresponding with those of the Malaysia Economic Development Program as follows:

First Phase:	1983 - 1990 (including two years for preparatory work)
Second Phase:	1991 - 1995
Third Phase:	1996 - 2000

It should be noted that the implementation program for the second and third phases may not necessarily require waiting until completion of the preceding phase. In particular, budgetary provision, detailed design work, tender call and evaluation may proceed simultaneously with the preceding phase, provided applicable administrative procedures are adhered to.

6.2. Implementation Methods for Improving Drainage Facilities

6.2.1. Methods of Approach

Improvement of the existing drainage system, which was basically constructed between 30 to 40 years ago, has mainly been conducted wherever housing development has taken place. However, a drainage system independent of a developed area has proved at times to be suitable, particularly in relation to the topographical situation. For example, the formerly swampy undeveloped North Port area, the surrounding area of which was likewise undeveloped, has an independent drainage system. Its stormwater is drained directly to the sea and not through drains of other catchments. In an industrial zone of A-6 catchment, stormwater is also drained directly to the Aur River, so that it does not affect or cause any damage to other catchments.

However, such cases are not usual in drainage improvement. The improvement of the drainage system within a developed area actually takes place at the time of the housing development. This type of development, which occurred in so many parts of Kelang in the 1960's and '70s, has resulted in almost all drains becoming inadequate. Excess stormwater from a developed area is discharged through existing drains into the sea or the river, which causes flooding to some degree, due to inadequacy of the existing drains to accommodate excess stormwater. To prevent backflooding, bunds and tidal gates have been provided but they likewise have become deficient or defective.

The poor condition and inadequacy of the drainage system in Kelang results in many flooded areas; therefore, improvement of the entire system is strongly recommended. The problem is to determine the parts that need immediate improvement; i.e., to determine priorities for the improvement work. Ideally, implementation priority should be given to those work that reduce the most flood damage at minimum cost.

6.2.2 Small Drain

Drainage facilities consist of trunk drain, small drain, retention pond, tidal gate and bund. A small drain collects the rainfall from housing, commercial, industrial areas, etc. and leads it to a trunk drain, which then leads the runoff discharge down to the river or sea. A retention pond which is constructed downstream of a trunk drain retains the runoff volume when the river or sea water level is higher than the planned drain water level. The tidal gate and bund prevent the sea or river water from flowing back inland.

Since it is necessary for all the renovated above-mentioned facilities to overcome flooding problem, and to improve as many areas as possible, construction of small drains is delayed until after other facilities have been constructed, due to insufficient funds.

Improvement of all drainage facilities except small drains would alleviate flooding of wide areas on a long-range basis, although small floods of short duration might remain. Furthermore, construction of retention pond and tidal gate with bund would alleviate downstream inundation and backflow from the river or sea.

In a developing area, the developer is required to construct the small drain. In monetary terms, 92 percent of the existing small drains in the housing area and 39 percent in the commercial area are considered adequate to meet runoff discharge in 2000 A.D., according to the survey conducted in selected areas by the Study Team.

6.2.3. Implementation Order of Drainage Facilities

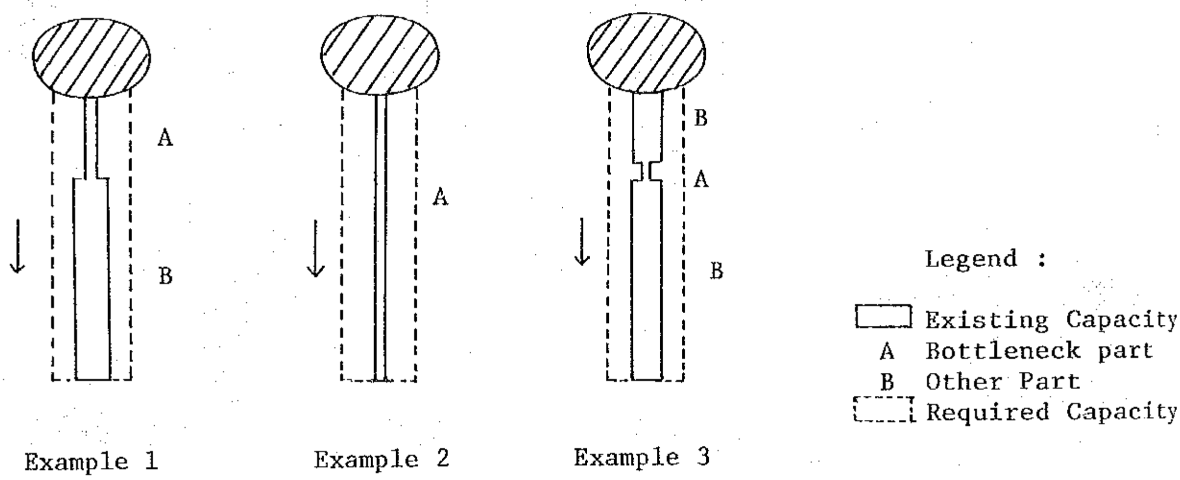
The major problem is determination of order in which the trunk drains, tidal gates and bunds should be constructed by the year 2000.

Drainage facilities for the town center, which is densely populated and highly developed for commercial and institutional use, should be constructed at an early stage.

Piecemeal improvement is not expected to overcome flooding problems, although it could mitigate flooding in terms of frequency, depth and duration. Instead, improvement of facilities, catchment by catchment, is recommended, since an improved catchment as a whole would not suffer from flooding either at present or in the future.

Runoff discharge is greatly affected by bottleneck parts of the drain. Should there be only one uppermost inflow point, as in the case illustrated in Fig. 6.1, the capacity of the three drains would be almost the same, dominated by the bottlenecked capacity of A, even if the capacity prior to A is considerably larger, as shown in Example 3.

Fig.6.1. Effect of Bottleneck in Capacity Flow of Drainage



To prevent flooding, the entire length of the truck drain from the uppermost point upstream to the lowest point downstream must be improved to adequate capacity.

Benefits from this method are as follows:

1) Each flooded area will undoubtedly be relieved, one by one.
2) Sanitary condition will be improved.
3) Flooded areas in a developed central area will be improved at an early stage, which will help in maintaining commercial activity.

4) Recurrence of inconvenience to the inhabitants will be prevented, because the drainage improvement work will be conducted only once instead of piecemeal, to meet the target year 2000.

5) In case of partial improvement, especially in upstream and midstream, flooding often shifts downstream.
But, improvement catchment by catchment would offset this adverse effect.

6) When a drainage boundary is changed, improvement of all related drainage facilities would result.

6.2.4. Rating Procedure for Determining Priority Areas

As the catchments are divided on the basis of topographical conditions, there is basically one trunk drain per catchment.

Hence, implementation order depends on the importance or degree of necessity for improvement of the catchment.

1) Parameters

In determining the priority for the drainage system improvement work, each of the 32 drainage catchments is assessed on the basis of the four most relevant parameters which affect flooding conditions in the Project Area, using an arbitrary rating procedure to assign reasonable relative weight to each parameter. The four parameters and assigned rating points are as follows:

			Rating Points
a)	Population Density	(Present)	200
		(Future)	200
b)	Flooding Condition	(Present)	200
		(Future)	200
C)	Land Use	(Future)	100
D)	Damage to Main Roads		100
	Total:		1,000

a) Population Density

One of the most important factors is the number of persons who will benefit from the system. It is therefore particularly important to provide drainage facilities in densely populated areas in order to provide the maximum benefit with the minimum expenditure, thus making the benefit - cost ratio higher. Thus, the highest rating is given to the most densely populated area.

Population densities, both present and future, by drainage catchments, range approximately from 0 to 140 persons/ha. For rating purpose, a maximum of 200 points is used for both present and future population densities as follows:

Rating Points	Present or Future Population Density (Persons/ha)
200	100 or more
160	80 - 100
120	60 - 80
80	40 - 60
40	20 - 40
0	20 or less

b) Flooding

The main purpose of reconstructing or improving a drainage system is undeniably to alleviate flooding. Hence, a high rating is given to areas where flooding has occurred or is expected to occur, as well as high-density population areas.

Flood areas shown in Fig. 2.10. represent those with past flood records, presently flooded or flood-prone. On the other hand, an indication of future flooding condition in the year 2000 is deduced from the ratio of estimated stormwater runoff to the existing drainage capacity. Generally, the high ratio area could be said to be more flood-prone than the low ratio area. For rating purpose, a maximum of 200 points is used for both past and future flood-prone areas as follows:

Table 6.4. Rating Points Based on Past and Future Flood Conditions

Rating Points	Past Flood-Prone Area Flooded Area/ Catchment)	Rating Points	Future Flood-Prone Area (Estimated Storm-water Runoff/Existing Drain Capacity)
200	over 80%	200	over 20 times
150	60 - 80	160	15 - 20
100	40 - 60	120	10 - 15
50	20 - 40	80	5 - 10
0	less than 20%	40	1 - 5

c) Land Use

The completion of a drainage system of an area of the size of the proposed Project Area with its large and expanding population is a task of tremendous magnitude. Therefore, it becomes necessary to build the required drainage facilities by phases, according to the urgency of need and benefits to be derived. The two factors, population density and flooding condition, were selected in that sense to help determine area priorities. However, while population density may represent the number of people who have suffered from floods, it cannot represent the degree of loss or suffering or alleviation from floods. For example, assuming that two areas with the same population density are flooded, one in a commercial area and the other in a residential area, the degree of damage will usually be different; i.e., the damage to the former will be larger than to the latter.

Land use is therefore considered as a factor for determining priorities. For rating purpose, a maximum of 100 points is used for future land use as follows:

Rating Points	Proportion of Area for Commercial and Industrial Use (%)
100	over 80
75	60 - 80
50	40 - 60
25	20 - 40
0	less than 20

d) Damage to Main Road

The Project Area is situated west of the capital connecting Kuala Lumpur, Petaling Jaya and Shah Alam for various strategic purposes. Therefore, any disruption of or damage to the transportation system connecting these cities would have serious effects. Due consideration to possible damage of the main road therefore deserves to be included in the assessment of priorities, and 100 points is assigned for this purpose.