2.2.6 Incidence of Water Borne Diseases

For the purpose of rating on incidence of water borne diseases, in the year 1974 is considered in terms of the whole Project Area, and then the number of diseases occurred in each sewerage zone is estimated by the ratio of served population to the total population of Project Area, as indicated in Table H-14.

For an assessment, 50 points are assigned to each of sewerage zones according to the level of incidence estimated as follow:

Assessment Point	Number of Incidence of Diseses
50	10 more
25	5 - 10
0	0 - 5

The results of the assessment for each of sewerage zones are shown in Table H-15.

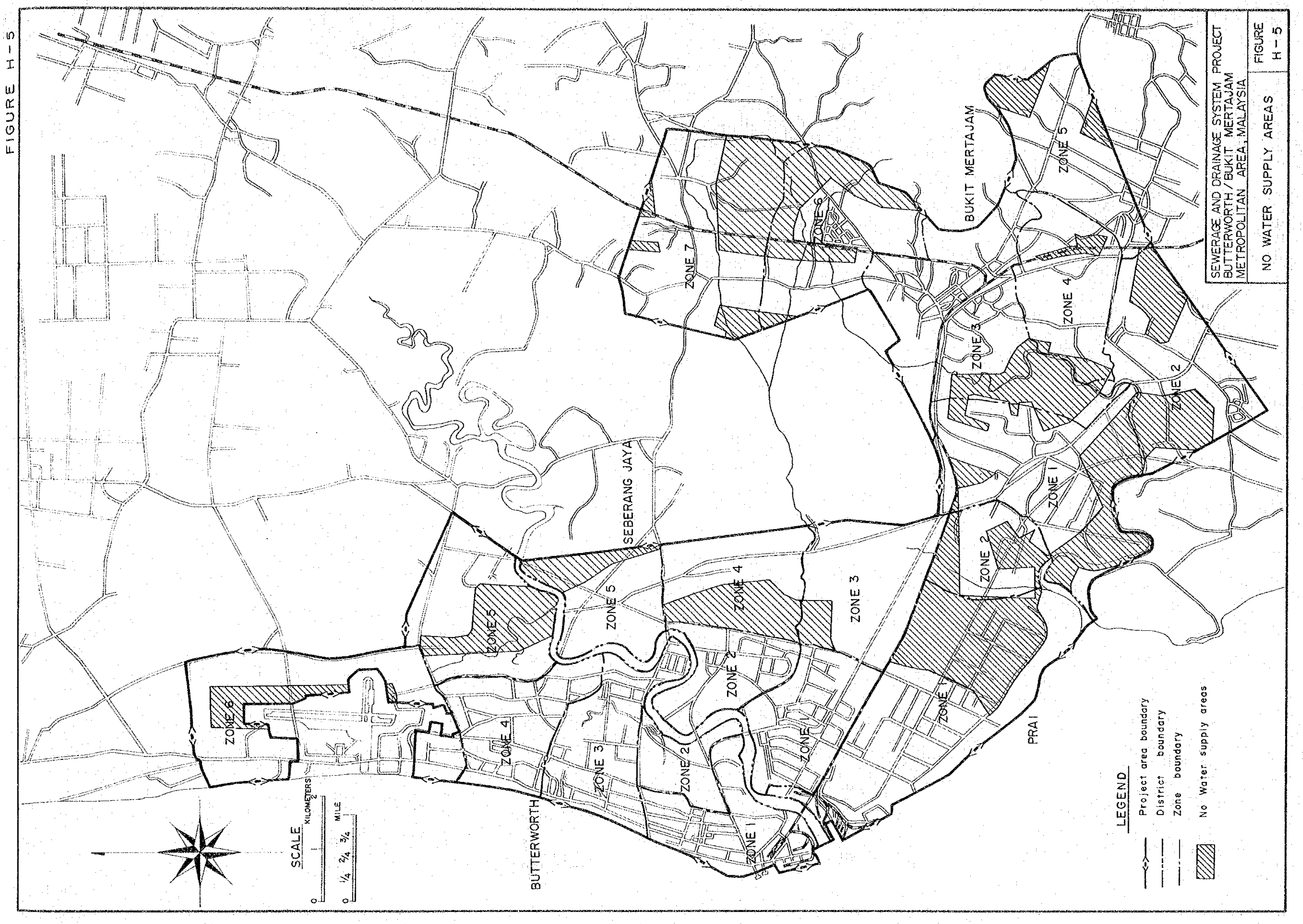


FIGURE H - 5
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
NO WATER SUPPLY AREAS
FIGURE H - 5
BUKIT MERTAJAM
SEBERANG JAYA
BUTTERWORTH
PRAI
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
ZONE 6
ZONE 7
SCALE
KILOMETERS
0 1 2
MILE
0 1/4 2/4 3/4
LEGEND
Project area boundary
District boundary
Zone boundary
No Water supply areas

TABLE H-13 Numbers of Patient of Water Borne Disease

Disease	1970	1971	1972	1973	1974	1975
Cholera	62	-	7	-	10	-
Dysentery	1	6	11	35	19	11
Infectious Hapatitis	-	-	-	67	49	53
Leptospiral Infectious	-	-	-	1	-	-
Typhoid Fever	3	18	51	58	11	13
Total	66	24	69	161	89	77

The data was obtained from Medical and Health Department of Penang.

TABLE H-14 Distribution of Water Borne Disease in 1974 by Sewerage Zone

District	Zone	Population at 1976	Ratio of Population (a) (%)	Incidence of disease presumed (persons) (a) x 89
Butterworth	1	37,920	16	14
	2	3,585	1	1
	3	28,255	12	10
	4	26,332	11	10
	5	3,961	2	2
	6	8,902	4	3
Seberang Jaya	1	13,657	6	5
	2	69	0	0
	3	2,991	1	1
	4	7,518	3	3
	5	4,369	2	2
Prai	1	1,860	1	1
	2	1,974	1	1
Bukit Mertajam	1	7,559	3	3
	2	6,387	3	3
	3	45,540	19	17
	4	6,077	2	2
	5	7,257	3	3
	6	13,840	6	5
	7	9,947	4	3
Total		238,000	100	89

TABLE H-15 Result of Assessment for Incidence of Water Borne Disease

District	Zone	Assessment Points
Butterworth	1	50
	2	0
	3	50
	4	50
	5	0
	6	0
Seberang Jaya	1	25
	2	0
	3	0
	4	0
	5	0
Prai	1	0
	2	0
Bukit Mertajam	1	0
	2	0
	3	50
	4	0
	5	0
	6	25
	7	0

CHAPTER 3

EVALUATION AND SUMMARY OF RATING SYSTEM

The consideration of rating on the basis of six elements as stated earlier in determining construction stages of sewerage systems of Butterworth/Bukit Mertajam Metropolitan Area is summarized in Table H-16 with the following comments and conclusion.

(a) The densely populated areas exist in the Project Area and undoubtedly will increase by the year 2000. As such areas will have greater impact of the environmental sanitation and maximum beneficiaries of the population by the satisfactory sewerage system, higher rating is justified.

(b) Sewerage zones which make the heaviest contributions to the waste load production are surrounded by the areas of industrial estate and combination of residential and industrial area, like in case of zone 1 of Prai district, which produces most heavy waste load, and is assessed accordingly. However, the overall priority is lower due to the fact that this is industrial area and has no served population. In our opinion, industrial waste control should have special consideration for itself in addition to the municipal sewerage system facilities.

(c) In view of lack of exact data on existing excreta disposal systems, an assessment of urban and rural area has been given arbitrarily 150 and 75 points in proportion to the population who have no served excreta disposal system in each of sewerage zones.

High ratings are given to each of the sewerage zones where the existing excreta disposal system is not functioning well or does not exist. The rating reflects the actual sanitary conditions in the Project Area.

(d) With respect to flooding, the rating is considered according to the extent of flood in connection with drainage facilities. Inclusion of flooding in the evaluation appears to be appropriate for the areas without adequate facilities for storm drainage.

(e) Availability of water supply are given fewer assessment points than other factors because it is deemed less meaningful in determining the priority of sewerage system construction.

(f) The results of the rating on incidence of water borne disease indicates that the congested and high population density zones get higher assessment points. Generally speaking, rate of incidence of such diseases are low in the Project Area.

The results of the rating indicate that the zone 1 of Butterworth District has the highest total number of points, representing the combined ratings for all six elements, followed by the zone 3 and 4 of Butterworth, and zone 3 of Bukit Mertajam as listed in the following.

TABLE H-16 Results of Rating for Overall Aspects

District	Zone	Population Density	Waste Load Production Aspects	Excreta Disposal System	Flooding	Availability of Water Supply	Incidence of Water-Borne Diseases	Total
Butterworth	1	400	165	150	50	50	50	865
	2	200	65	0	0	50	0	315
	3	250	150	75	100	50	50	675
	4	250	90	75	50	50	50	565
	5	100	40	0	0	42	0	182
	6	100	40	0	0	46	0	186
Seberang Jaya	1	250	65	0	0	47	25	387
	2	150	90	0	0	50	0	290
	3	100	40	0	0	48	0	188
	4	50	40	0	0	40	0	130
	5	100	40	0	0	45	0	185
Prai	1	0	225	0	0	40	0	265
	2	100	40	0	0	40	0	180
Bukit Mertajam	1	100	40	0	0	41	0	181
	2	100	40	0	0	41	0	181
	3	200	65	75	100	45	50	535
	4	100	40	0	0	48	0	188
	5	100	40	0	0	46	0	186
	6	100	40	0	0	40	25	205
	7	100	40	0	0	42	0	182

Priority of Construction	District	Zone	Assigned Points
1	Butterworth	1	865
2	"	3	675
3	"	4	565
4	Bukit Mertajam	3	535
5	Seberang Jaya	1	387
6	Butterworth	2	315
7	Seberang Jaya	2	290
8	Prai	1	265
9	Bukit Mertajam	6	205
10	Seberang Jaya	3	188
10	Bukit Mertajam	4	188
12	Butterworth	6	186
12	Bukit Mertajam	5	186
14	Seberang Jaya	5	185
15	Butterworth	5	182
15	Bukit Mertajam	7	182
17	"	1	181
17	"	2	181
19	Prai	2	180
20	Seberang Jaya	4	130

It is concluded that the rating system adopted in this study, while arbitrary in many respects, reasonably reflects and quantifies both present and future conditions of the Project Areas with respect to need for sanitary and drainage sewerage. The results are considered as a good indication of the overall needs of the various zones and should be taken into consideration in determining the staging of the sewerage construction programme.

APPENDIX I

STORMWATER QUANTITY

Table of Contents

CHAPTER 1

RUNOFF COEFFICIENT

It has been generally recognized that the values assigned to the runoff coefficient depend mainly upon the surface characteristics including the imperviousness and the slope.

On the basis of numerous experiences in the past, the surface characteristics in terms of the impervious factor of the different types of surface such as roof, road, yard and others, can be estimated.

Using these impervious factors of individual type of surface, the composite runoff coefficients, expressed by the following equation, have been developed for this Project.

$$C = \sum_{i=1}^{m} CiAi \ / \sum_{i=1}^{m} Ai$$

where

C = composite runoff coefficient

Ci= impervious factor by the type of surface

Ai= area by surface type, in ha

m = number of the surface type

1.1 Selected Representative Area

Four districts representing typical patterns of the land use were selected in the Project Area and their coefficients in the future were estimated as follows:

Type of land use		Representative area (refer to Figure - I-1)
1) Residential-A (residential area with semi-detached houses)	------	planned housing development area along Juru river

2) Residential-B (residential area with detached houses) ---------outskirt of Bukit Mertajam

3) Commercial area --------------------central part of Bukit Mertajam

4) Industrial area --------------------Mak Mandin area in Butterworth

1.2 Runoff Coefficient by Surface Type

Coefficients with respect to surface type currently in use are shown below.

TABLE I-1 Runoff Coefficient with respect to Surface Type

Type of Surface	Runoff Coefficient	
	Range	Used
Roofs	0.85 - 0.95	0.90
Paved Roads	0.80 - 0.90	0.85
Other pavement	0.75 - 0.80	0.80
Vacant lots	0.10 - 0.30	0.20
Lawns	0.05 - 0.20	0.10

Source: WPCF Manual of Practice No. 9 (USA) (1970)
Manual of Sewerage Facility Design, 1972, JAPAN

1.3 Estimation of Coefficients in the Selected Areas

The various types of surfaces were calculated, in percentage of total surface, for each of the selected four representative districts. After that the runoff coefficients of representative district were calculated and shown in Table I-2.

TABLE I-2 Percentage of Individual Surface Type and Runoff Coefficient

(in year 2000)

Type of Surface	Runoff Coefficient of Individual Type of Surface	Residential area (semi-detached)	Residential area (detached)	Commercial area	Industrial area
Roofs	0.90	0.30/0.27	0.25/0.23	0.28/0.25	0.18/0.16
Paved roads	0.85	0.35/0.30	0.35/0.30	0.26/0.22	0.30/0.25
Other pavement	0.80	0.05/0.04	0.05/0.04	0.46/0.37	0.05/0.04
Vacant lots	0.20	0.05/0.01	0.05/0.01	- / -	- / -
Lawns	0.10	0.25/0.03	0.29/0.03	- / -	0.47/0.05
Total	-	1.00/0.65	1.00/0.61	1.00/0.84	1.00/0.50

Note: percentage of individual type of surface/runoff coefficient

Sparsely inhabited residential area, with population density of 53 persons/ha, is proposed in the future land use plan. 1/

The runoff coefficient in such areas are determined on the basis of an assumption in which a habitation would take place in association with the housing development project with population density around 120 persons/ha in some parts of the areas. The percentage of areas with 120 persons/ha is $\frac{53}{120} = 0.44$ and remaining part (1 - 0.44 = 0.56) would be areas non habited with runoff coefficient of 0.1. The composite coefficient in the sparsely inhabited area, therefore, can be estimated as follows:

1/ This residential area is defined as the residential-C in the discussion of runoff coefficients.

$$\frac{53}{120} \times 0.65 + \frac{(120-53)}{120} \times 0.10 \fallingdotseq 0.35$$

In this Project the runoff coefficient of 0.35 is used for sparsely inhabited residential area.

1.4 Runoff Coefficient at Present

Existing land use types in the Project Area are the residential area with detached house, commercial area and industrial area. The runoff coefficient of individual land use mentioned above is calculated in the same manner as that used in the case of future coefficient estimation.

In Table I-3, the present runoff coefficient is shown.

TABLE I-3 Present Runoff Coefficient

Type	Runoff coefficient of Individual Surface	Residential area	Commercial area	Industrial area
Roofs	0.90	0.10/0.09	0.35/0.31	0.11/0.10
Paved Roads	0.85	0.10/0.09	0.35/0.30	0.18/0.15
Other pavement	0.80	- / -	- / -	0.05/0.04
Vacant lots	0.20	0.30/0.06	0.30/0.06	- / -
Lawns	0.10	0.45/0.05	- / -	0.66/0.07
Palm tree coverage	0.10	0.05/0.01	- / -	- / -
Total	-	1.00/0.30	1.00/0.67	1.00/0.36

Note: Percentage of individual type of surface/runoff coefficient

Remaining parts of the Project Area are mountenous areas and agricultural areas. The runoff coefficient of those areas are 0.5 and 0.1 respectively.

1.5 Comparison with Other Areas

The calculated coefficients are also compared with those used for other cities.

TABLE I-4 Coefficients Adopted in Other Areas

Type of Land Use	Coefficient proposed for this Project	Standard in Malaysia	Practice in U.S.A.	Standard in Japan
Residential	0.65	0.75	0.60 - 0.75	0.65
Commercial	0.85	0.90	0.70 - 0.95	0.80
Industrial	0.50	0.80	0.50 - 0.80	0.65

As indicated in the above table, the coefficients for the Project Area coincide substantially with those in other places.

1.6 Recommended Runoff Coefficients

Taking the facts and assumptions mentioned above into account, the following runoff coefficient are recommended for drainage system planning.

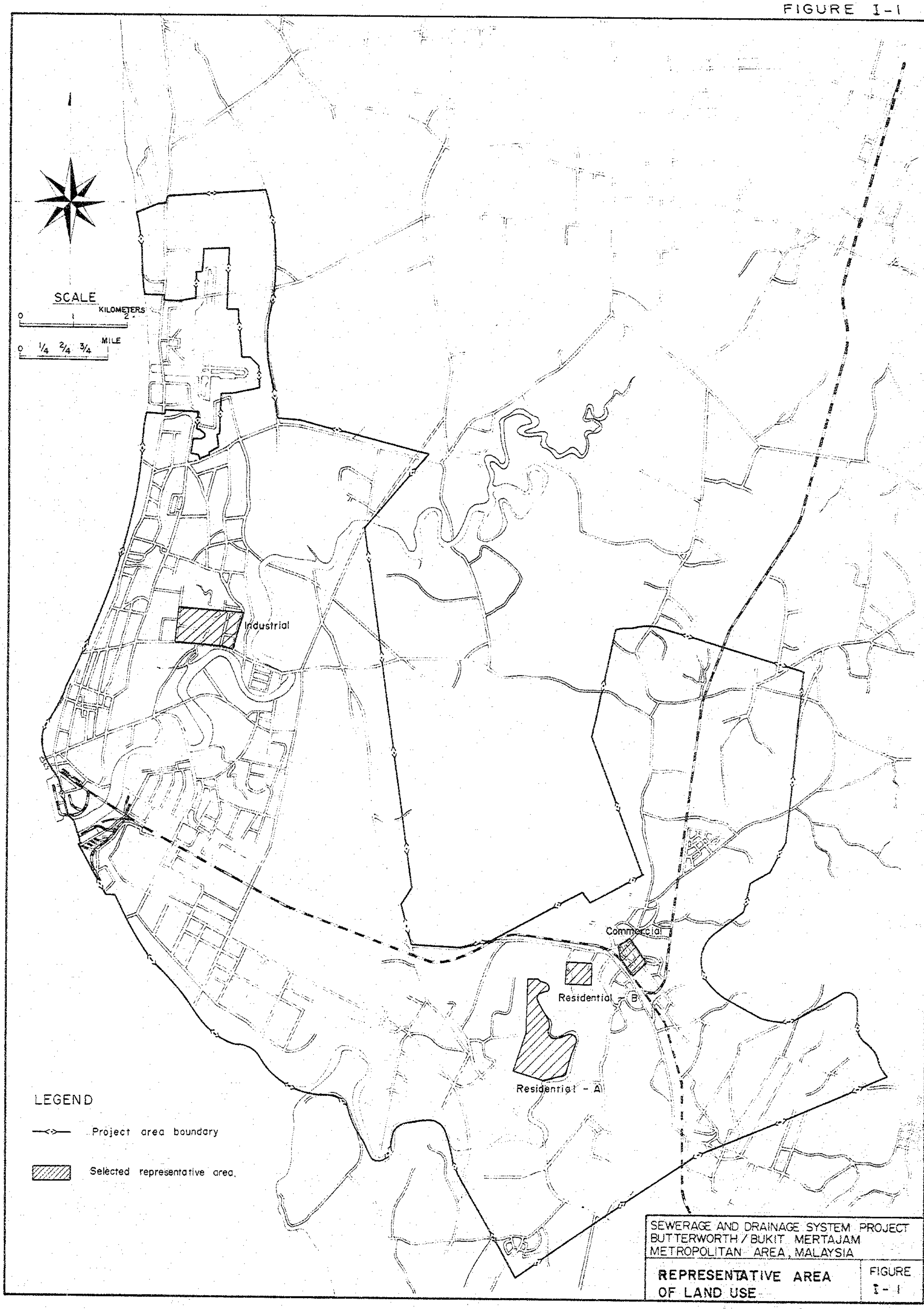
TABLE I-5 Recommended Runoff Coefficients

Land Use		in 1976	in 2000
Residential area	Residential-A	0.65	0.65
	Residential-B	0.30	0.65
	Residential-C	-	0.35
Commercial area		0.70	0.85
Industrial area		0.35	0.50
Agricultural area		0.10	0.10
Mountainous		0.50	0.50

Note : Residential-A----- residential area with semi-detached houses and population density of 120 persons per hectare in 2000.

Residential-B----- residential area with detached houses and population density of 120 persons per hectare in 2000.

Residential-C----- residential area with population density of 53 persons per hectare in 2000.


SCALE
KILOMETERS
0 1 2
MILE
0 1/4 2/4 3/4
Industrial
Commercial
Residential - B
Residential - A
LEGEND
Project area boundary
Selected representative area.
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
REPRESENTATIVE AREA
OF LAND USE
FIGURE
I-1

CHAPTER 2

TIME OF CONCENTRATION

An estimation of the time for the flow to concentrate at the point under consideration must be made for the purpose of application of the national method. For urban storm sewers, the time of concentration consists of inlet time plus time of flow in the sewer from the most remote inlet to the point under consideration.

The time of flow in the sewer is dependent upon the distance, slope and type of conduits or channels, and is calculated in individual sewer line when it is designed. However, the inlet time is in similar range in areas in which surface slope, nature of surface cover, and length of path of surface flow are in the same charactor. Therefore it is general practice to use the fixed inlet time in areas with similar characteristics.

In this project the inlet time has been estimated as follows.

2.1 Inlet Time

An equation which represents the inlet time for urban sewer design was originally proposed by Horton 1/ and later modified and formulated by Kerby 2/ in the form:

$$T_i = \left[\frac{2}{3} \times 3.28 \times L \times \left(\frac{n}{\sqrt{s}} \right) \right]^{0.467}$$

where T_i = inlet time, minutes

1/ R.E. Horton, The Role of Infiltration in the Hydrologic Cycle. Trans. AGU, Vol. 14, 1933.

2/ W.S. Kerby, Civil Engineering 29,174 (1959).

L = distance from the most remote point to the point of inlet, meters

n = coefficient of roughness, similar to runoff coefficient, as given in table below

TABLE I-6 Coefficient of Roughness in Kerby's Equation

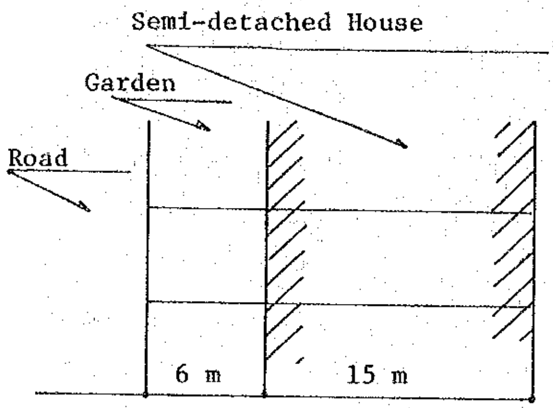
Character of Surface	Coefficient of Roughness
Smooth pavement	0.02
Bare, packed soil, free of stone	0.10
Poor grass cover	0.20
Moderately rough bare surface	0.20
Average grass cover	0.40
Forest (deciduous tree)	0.60
Dense grass cover	0.80
Forest (deciduous tree, with deep dead leaves)	0.80
Forest (needle-leaved tree)	0.80

The surface slope in the Project Area except Bukit Mertajam area is around 0.3/1000 and length of path of surface flow was decided for individual type of land use. The inlet time of individual land use is been estimated as described below.

2.1.1 Inlet Time of Individual Land Use

(1) Residential Area

From the layout plan of a new housing development area the distance from the remote point of the premise is estimated as shown in the figure below.



The inlet time can be calculated as:

L = 6.0 m   n = 0.2

$$t = \left[\frac{2}{3} \times 3.28 \times 6 \times \frac{0.2}{\sqrt{0.0003}} \right]^{0.467}$$

$$= 10.4 \text{ minutes}$$

(2) Commercial Area

The commercial area in Butterworth and Bukit Mertajam are served with roads which run in parallel approximately in every 50 meters or so. The average width of these roads is approximately 10 meters.

Based on the condition above, the distance from the center of an area between two roads is assumed to be 20 meters.

The inlet time of 6.2 minutes is calculated when the distance of surface flow is 20 meters and "n" = 0.02.

(3) Industrial Area

In case of industrial area, Mak Mandin area was investigated and the average distance of the surface flow is determined to be 15 meters. When coefficient "n" is 0.2, the inlet time is 16.0 minutes.

(4) Mountainous Area

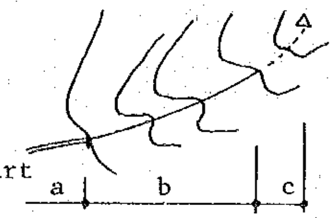
The path of surface flow consists of two parts with different characteristics as shown in the figure below.

part "a": established drainage channels

part "b": natural water way

part "c": path of overland flow

The inlet time consists of the time of flow of part "b" plus part "c".



For the purpose of estimation of the inlet time Rziha formula is used for the part "b" and Kerby formula for the part "c".

The Rziha formula is in the current use for the estimation of the average velocity in mountainous area and expressed as;

$$V = 20 \ (H/L)^{0.6}$$

where V = velocity of flood, m/sec
L = horizontal distance of the part "b", m
H = head in the part "b", m

The time of flow in the part "b" is, therefore, calculated as follows.

$$Tb = \frac{L}{V} \times 60$$

where

Tb = time of flow in the part "b" in minutes.

By applying Kerby formula, the time of flow in the part "c" was investigated in eight existing major streams in the Project Area. The range of results is 17 - 21 minutes with the average of 19.5 minutes. It is concluded that the use of 20 minutes for the inlet time would yield the satisfactory results.

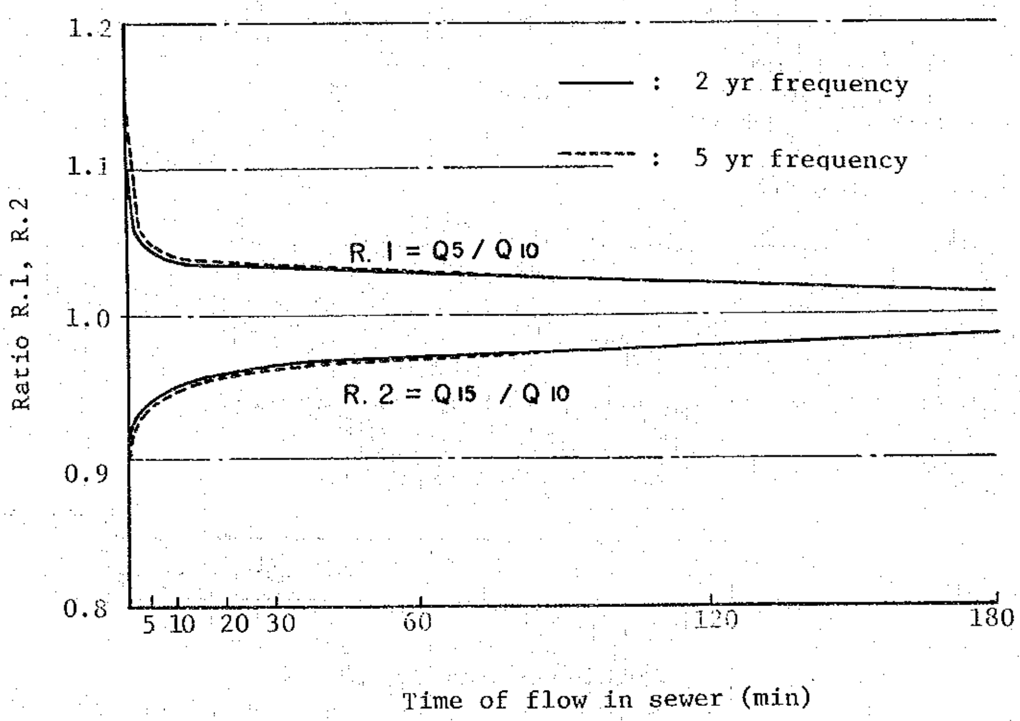
The inlet time discussed is summerized as follows:

Residential area ----------- 10 minutes
Commercial areas ----------- 5 "
Industrial area ----------- 15 "
Mountainous area ----------- 20 + Tb"

In order to simplify the application of the inlet time, an comparison of results derived by using 5, 10 and 15 minutes was carried out. The ratio $\frac{Q_5}{Q_{10}}$ = R.1, $\frac{Q_{15}}{Q_{10}}$ = R.2 were calculated and is shown in Figure I-2.

The subscripts denote the inlet time, so Q_5 represents the stormwater runoff quantity of any rainfall, which will be expected in the drainage systems with the inlet time of 5 minutes.

Figure I-2 Ratio of Stormwater Qualities with Different Inlet Time



From Figure I-2, it is understood that the different between stormwater quantities yielded with the inlet time of 5, 10 and 15 minutes is not noticeable.

It was concluded, therefore, the same inlet time of 10 minutes is used for residential, commercial and industrial areas in this Project.

2.1.2 Comparison with Practice in Other Areas

The inlet time recommended for this project is compared with practices in USA and Japan as shown in Table I-7.

TABLE I- 7 Comparison of Inlet Time

(in minutes)

Definition of Area	Recommendations for this Project	Practice in Japan	Standards in ASCE
Densely populated area with paved roads and drainage systems	10	5	5
Sparsely populated area	10	10	10 - 15

2.1.3 Recommended Inlet Time

The recommended inlet time is shown in Table I-8.

TABLE I-8 Inlet Time

(in minutes)

Area	Inlet time
Urban area	10
Mountainous area	20 + Tb

APPENDIX J

DRAINAGE SYSTEM CONSIDERATION

Table of Contents

CHAPTER 1

ALTERNATIVE DRAINAGE SYSTEMS CONSIDERED IN BUTTERWORTH AREA

Studies on alternative drainage systems have been carried out including the construction diversion drains to the sea and the provision of reservoirs.

Following principles are applied for the study.

i) Because the area is low-lying, it is preferable for the drainage systems proposed here to have characteristics in which the least head loss is required. In other words, the gradient of water surface should be as small as possible. The type of drainage system described above would make it possible to graviate stormwater runoff into the Prai River or the sea. Thus the construction of pumping stations would be avoided, resulting in the savings of the initial costs.

ii) For the lowest areas, it is considered that filling-up of land would be required.

iii) The involvement of constructions of reservoirs as the past of drainage systems is taken into consideration.

Three alternatives have been considered and investigated as described below.

(1) Alternative-I (Ref. Figure J-3)

Except slight alignment of meandering parts, existing routes of major drains are left unchanged. However, extention of the Butterworth Drain C (hereafter called as B.D.C.) in its upstream portion is proposed, for providing smooth collection and removal of stormwater runoff of the tributary area. Because the considerable parts of the area have already been built-up, the land availability would have limitations to such degree as to prevent application of trapezoidal cross section. The reinforced concrete rectangular channel, therefore, is proposed to use.

It is found, as a result of investigation, that existing channels have to be widened and deepened considerably. The water level in proposed ditch comes up as high as +1.94 meters (+6.36 ft) at the area of lowest ground elevation of about +1.80 meters (+5.9 ft). Considering 0.3 meter's head loss expected in branches, land fill up to +2.30 meters (+7.5 ft) will be required around this area in order to cope with expected flooding due to backing up from the sea resulted from the highest sea water level of +1.68 meters (+5.5 ft). It can be concluded that the current recommendation of DID for land fill saying that the newly developed areas should be filled up to +2.30 meters (+7.5 ft), is completely justified with this investigation.

The construction costs of this alternative is lower than costs required for alternative-II. (Ref. Table J-1 Construction Costs of Alternatives).

(2) Alternative-II (plan: Ref. Figure J-4)

The diversion channels of B.D. (A), (B) and (C) are weighted in this alternative. Because the space for the construction of diversion ditches is not available except existing major roads, a construction of box culverts is considered and the costs are estimated.

As can be seen from Table J-1, the construction costs are higher than other alternatives.

It is found that the cross section at down stream of individual drain is not reduced by the diversion to the sea of discharges from upstream tributaries. For example drain 1.D.4 with drainage area of 437 hectares in alternative-I conveys stormwater runoff of 18 cu m/sec and after the diversion of the upstream parts to the sea, the same drain with 212 hectares, designated 2.D.2 in alternative-II, is still to convey runoff of 15 cu m/sec which is 85 percent of the 18 cu m/sec. This means that although the drainage area are reduced to about 50 percent of the alternative-I, stormwater runoff quantities are reduced only 15 percent. The results might be mainly from characteristics of rainfalls in the tropical zone, i.e., intense and short shower type. It is apparent that the effect of diversion to reduce the cross section in down stream is not conspicuous.

The engineering difficulties expected in this alternative are the construction of box culverts under trunk roads for considerably long period and the countermeasure to consider for preventing accumulation of sea sand at the outfall of diversion drains.

Serious inconveniences for the traffic are expected at the time of constructions of box culverts. On top of that the space assigned for roads will be occupied by the diversion culverts with large cross sections required and least space for other utilities can be assigned.

From Table J-1, it is noted the construction of box culverts hikes the total initial costs of the alternative. Shallow shoreline of Butterworth makes it difficult to construct any deep structures without problems of sand accumulation to them. The constructions of larger outfalls of diversion ditches will raise the initial cost up and will increase difficulties on maintenance work.

(3) Alternative-III (plan: Ref. Figure J-5
profile: Ref. Figures J-6, 7 and 8)

This alternative differs from the alternative I in providing reservoir. The total construction costs of this alternative is lowest among three alternatives, and special technical problem will not be expected.

This alternative is therefore proposed for the drainage system in Butterworth area, because of its lower initial cost and absence of any special engineering difficulties.

TABLE J-1 Construction Costs of Alternatives

(1,000 M$)

	Open Channel	Box Culvert	Land Acquisition	Total
Alternative I	39,500	-	3,220	42,720
Alternative II	27,100	23,300	1,970	52,370
Alternative III	37,030	350 (Reservoir)	3,400	40,780

Note: Construction cost of individual line in each alternative is shown in Tables J-2, 3, and 4.

: Calculation of required volume of the reservoir is described in the following chapter.

TABLE J-2 Construction Costs of Alternative-I

(1,000 M$)

Line No.	Construction Cost		Land Acquisition	Total
	Open channel	Box culvert		
1.A.1 - 2	3,800	-	530	4,330
1.B.1 - 7	15,600	-	1,610	17,210
1.C.1 - 6	11,400	-	680	12,080
1.D.1 - 4	8,700	-	400	9,100
Total	39,500		3,220	42,720

TABLE J-3 Construction Costs of Alternative-II

(1,000 M$)

Line No.	Construction Cost		Land Acquisition	Total
	Open channel	Box culvert		
2.A.1	200		50	250
2.B.1	2,200		330	2,530
2.C.1 - 2	4,900		40	4,940
2.D.1 - 3	4,800		30	4,830
2.E.1 - 3	3,100	4,800	140	8,040
2.E.4	1,600		300	1,900
2.F.1 - 6	4,300	13,100	440	17,840
2.F.7 - 8	3,300		210	3,510
2.F.9 - 10	2,700		430	3,130
2.G.1 - 2	-	5,400	-	5,400
Total	27,100	23,300	1,970	52,370

TABLE J-4 Construction Costs of Alternative-III

(1,000 M$)

Line No.	Construction Cost		Land Acquisition	Total
	Open channel	Reservoir		
BWA 1 - 7	15,600	-	1,610	17,210
BWB 1 - 6	10,400	150	790	11,340
BWC 1 - 4	8,600	200	600	9,400
BWD 1	230	-	70	300
BWE 1	2,200	-	330	2,530
Total	37,030	350	3,400	40,780

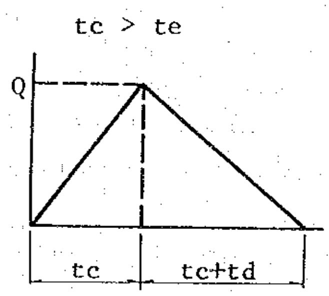
CHAPTER 2

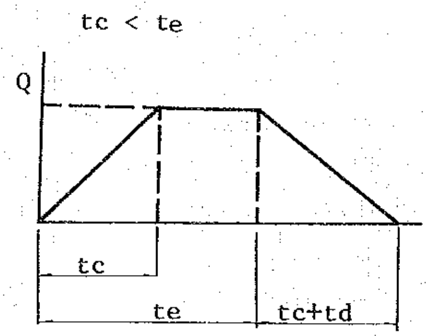
CALCULATION OF RESERVOIR

In the Alternative-III, (Ref. Section 4.1, PART-IV) the construction of two reservoirs is included. The volume of these is calculated as follows:

(1) Inflow hydrograph

Two types of inflow hydrograph are developed as described below;





Where tc: Time of concentration

te: Storm duration (critical storm duration is determined by trial and error.)

td: Time of flow in channel

1) Reservoir in Butterworth Drain B

For this reservoir following three cases are calculated.

tc = 60 min.	Q = 6.5 cu m/sec
te = 80 min.	Q = 5.7 cu m/sec
te = 100 min.	Q = 5.1 cu m/sec

Cumulative inflow curves are developed as shown in Figure J-1.

2) Reservoir in Butterworth Drain C

For following three cases, the inflow hydrographs are considered.

tc = 70 min. Q = 8.9 cu m/sec

te = 90 min. Q = 7.9 cu m/sec

te = 110 min. Q = 7.1 cu m/sec

Cumulative inflow curves for these three cases are developed as shown in Figure J-2.

(2) Outlet discharge rate

The relationship between outlet discharge rate and construction costs of facilities concerned have to be investigated on various cases for the purpose of difining the economical volume of reservoirs. However, in this Master Plan two cases of discharge rate are considered for comparison purpose and elaborate study will be carried out in the feasibility studies of the Project Area.

1) Reservoir in Butterworth Drain B

A 3 cu m/sec and 5 cu m/sec are considered as outlet discharge rate and 3 cu m/sec is selected.

2) Reservoir in Butterworth Drain C

A 4 cu m/sec is taken to be suitable discharge rate on the basis of results of the comparison in the reservoir in Butterworth Drain B.

(3) Volume of Reservoir

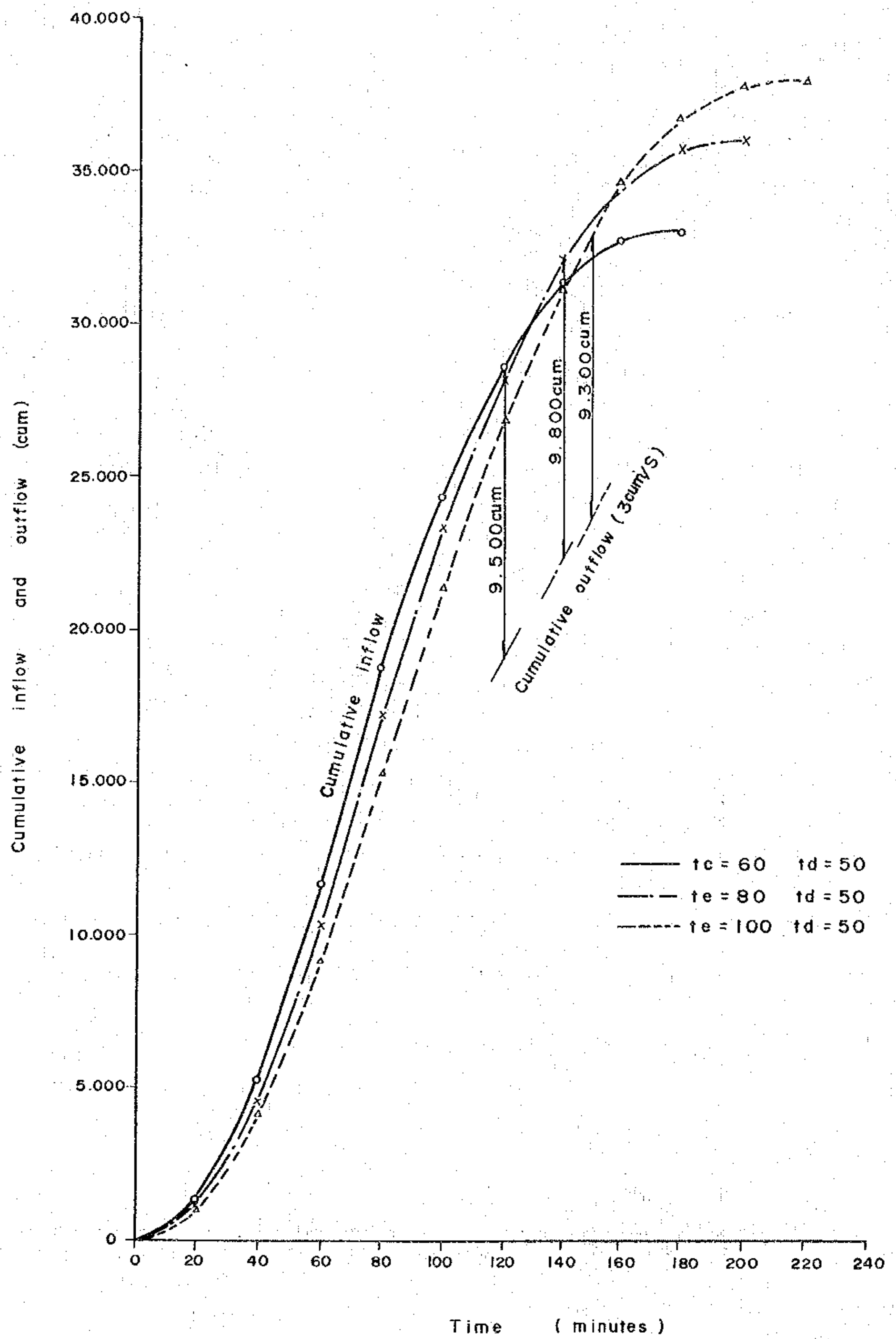
From Figure J-1 and J-2, the volume of each reservoir is determined as follows.

Reservoir in B Drain B. V = 10,000 cu m

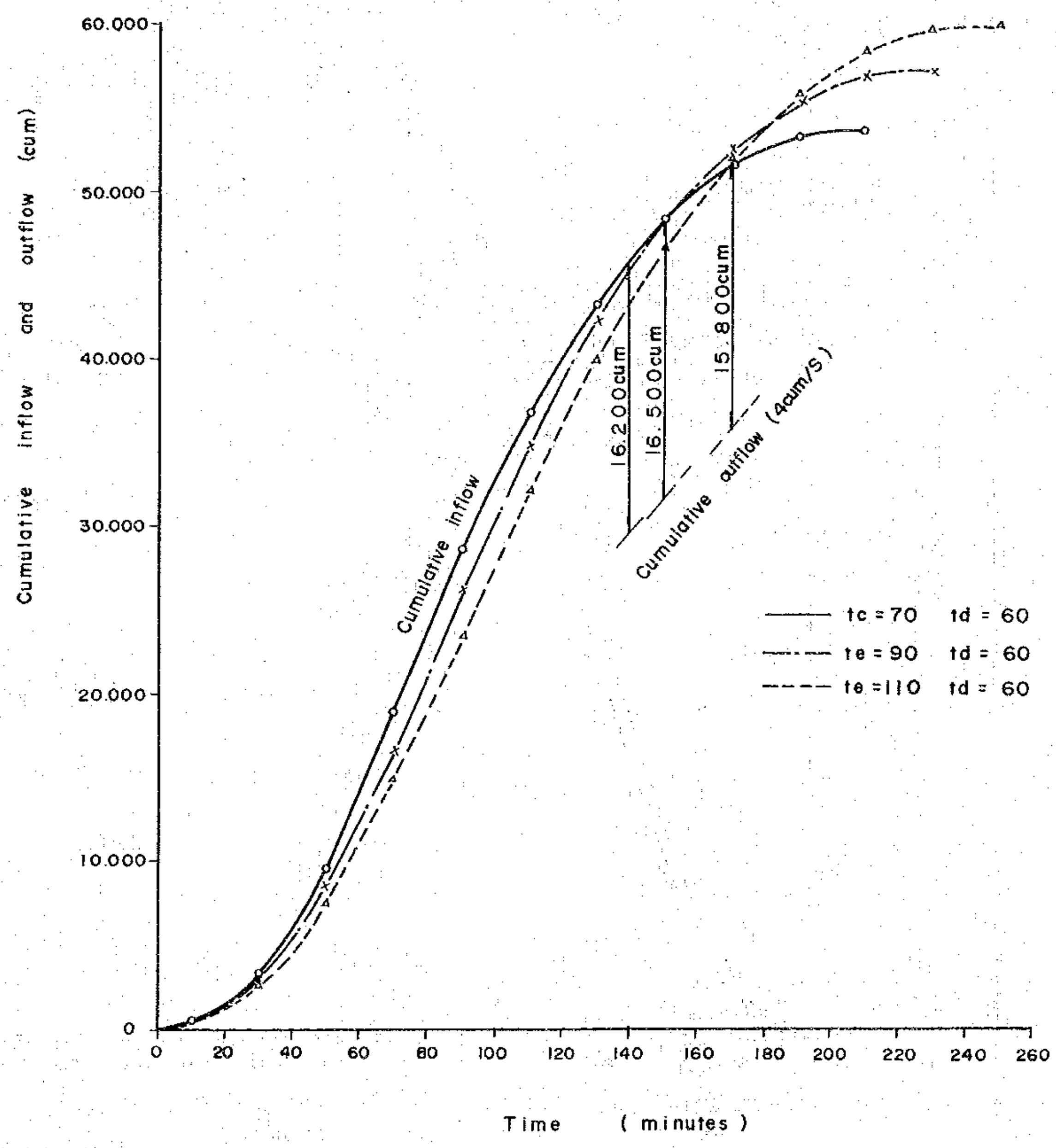
Size: 65 m x 65 m x 2.8 m (depth)

Reservoir in C Drain C. V = 17,000 cu m

Size: 80 m x 80 m x 3.2 m (depth)



SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH/BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA	
CUMULATIVE INFLOW AND OUTFLOW CURVE FOR THE RESERVOIR IN B.W.B	FIGURE J-1



SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH/BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA

CUMULATIVE INFLOW AND OUTFLOW CURVE FOR THE RESERVOIR IN B.W. C	FIGURE J-2

CHAPTER 3

SUPPLEMENTAL FIGURES AND TABLES OF DRAINAGE SYSTEM PLANNING

Following Figures and Tables are supplement of the drainage system master planning.

<u>Figure No.</u>

J-3 Drainage System Alternative-I in Butterworth Area (B-IV) (Ref. Section 4.1 PART-IV)

J-4 Drainage System Alternative-II in Butterworth Area (B-IV) (Ref. Section 4.1, PART-IV)

J-5 Drainage System Alternative-III in Butterworth Area (B-IV) (Ref. Section 4.1 PART-IV)

J-6 Profile of Butterworth drain A (Ref. Section 4.1, PART-IV)

J-7 Profile of Butterworth drain B and D (Ref. Section 4.1, PART-IV)

J-8 Profile of Butterworth drain C and E (Ref. Section 4.1, PART-IV)

J-9 Design Sketches of Reservoir (Ref. Section 4.2.3, PART-IV)

Trapezoidal section is applied for the reservoir considered which has compacted earth face of slope.

Gate is made of woods, which presently is the common type in the Project Area.

J-10 Construction Cost Curve (Ref. Section 5.1, PART-IV)

J-11 Estimated Space Required for Maintenance Work (Ref. Section 5.1, PART-IV).

Desilting from larger size drain of more than 6.0 meters will require the major equipments such as draguraln and clamshell grabbing crane. The estimated space for maintenance work is on the basis of the dimension of these equipments.

In case of drains of the width less than 6.0 meters, desilting will be carried out by hand. The space for equipments to carry out removed desposits is also required. If there is no road beside the drains the spaces mentioned in Figure J-11 has to be assigned.

J-12 Representative Network of Smaller Drains in Residential Area

The Figure is used for the construction cost estimates of network of smaller drains in the residential area.

J-13 Representative Network of Smaller Drains in Industrial Area

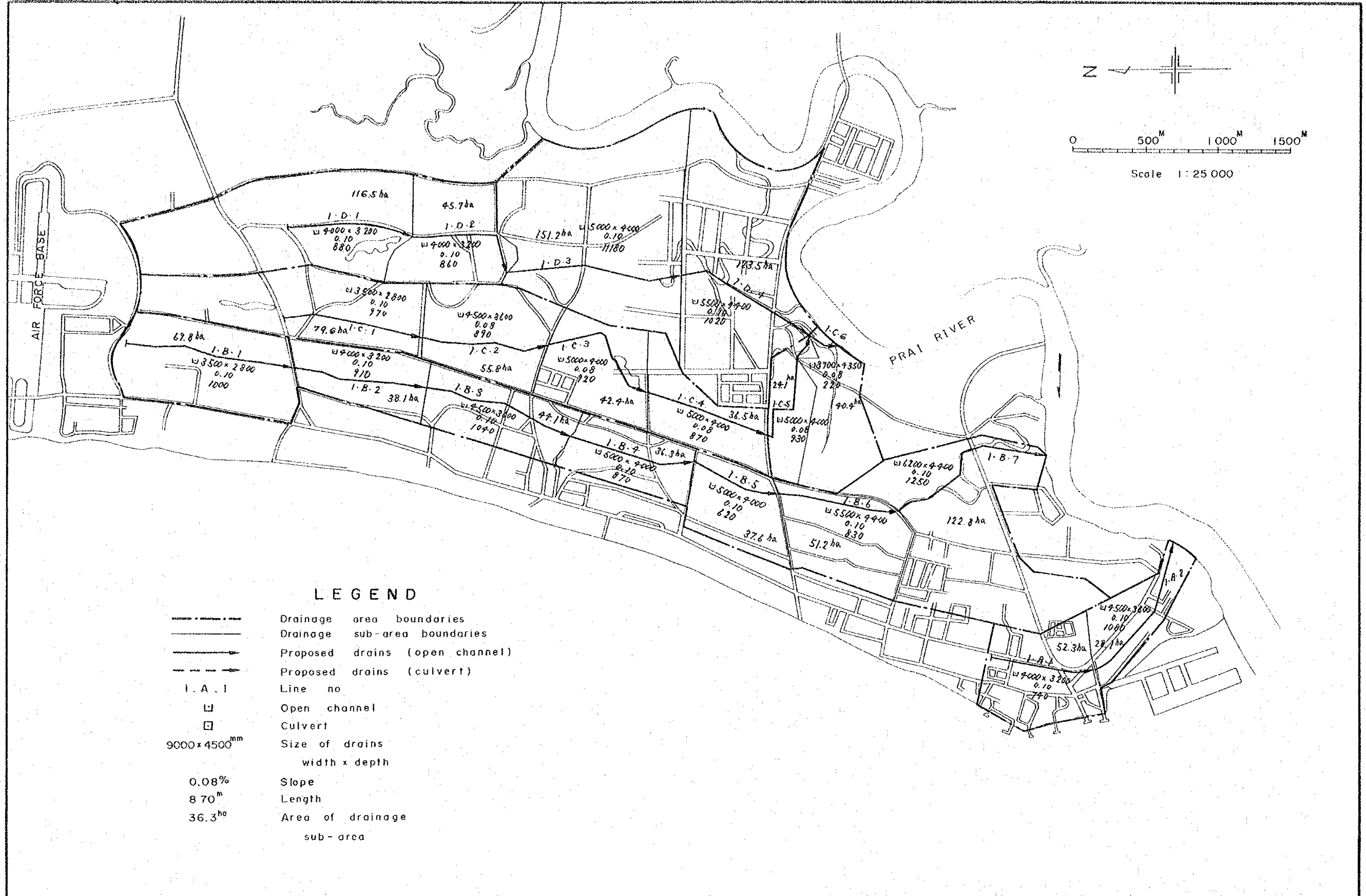
The estimated construction costs of network of smaller drains in the industrial area are based on this Figure. (Ref. Section 5.1, PART-IV).

Table No.

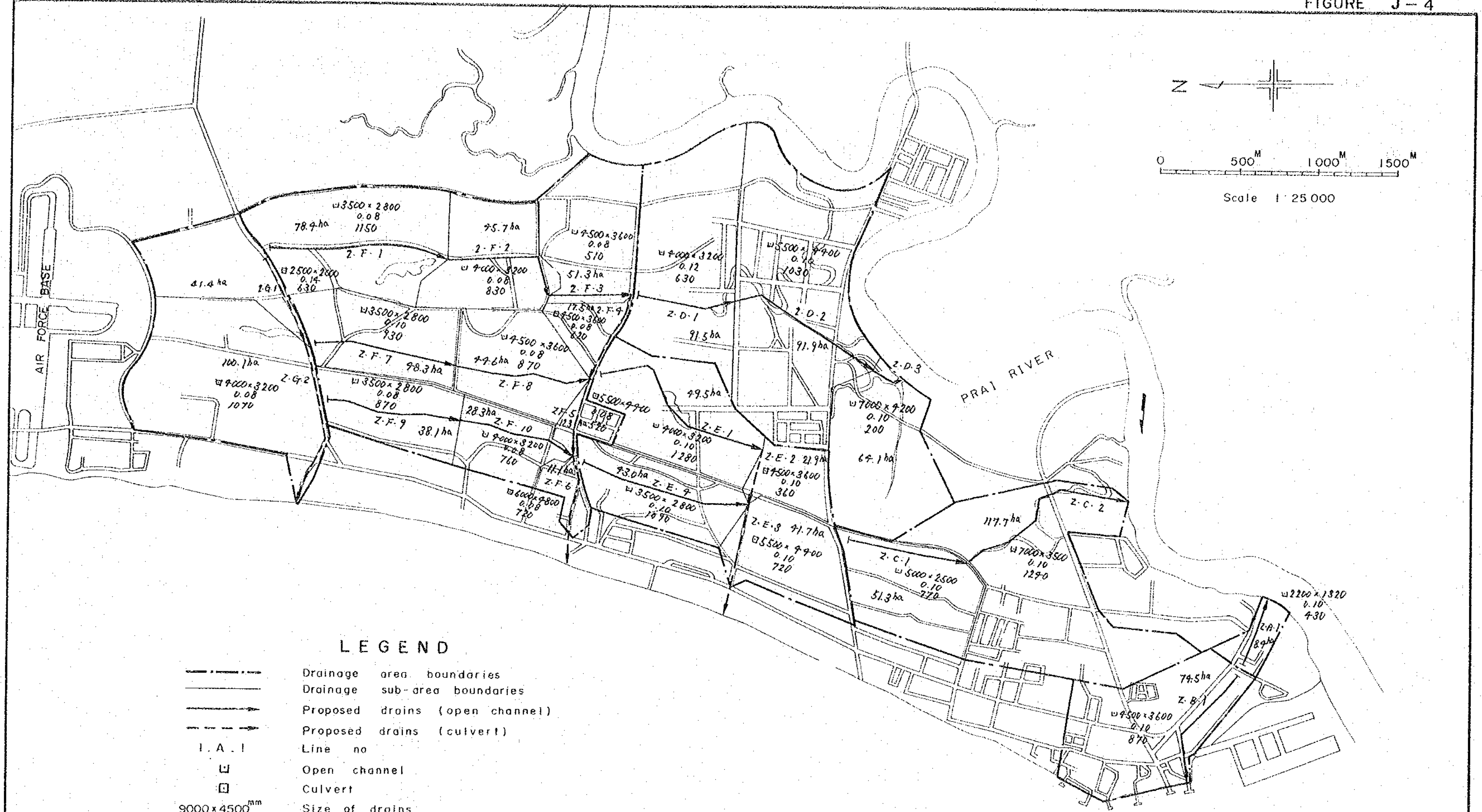
J-5 Analysis of Proposed Drainage System
(Ref. Chapter 4 PART-IV)

J-6 Construction Cost of Facilities by Stage
(Ref. Chapter 5 PART-IV)

J-7 Construction Cost of Network of Smaller Drains by Stage
(RNf. Chapter 5 PART-IV)



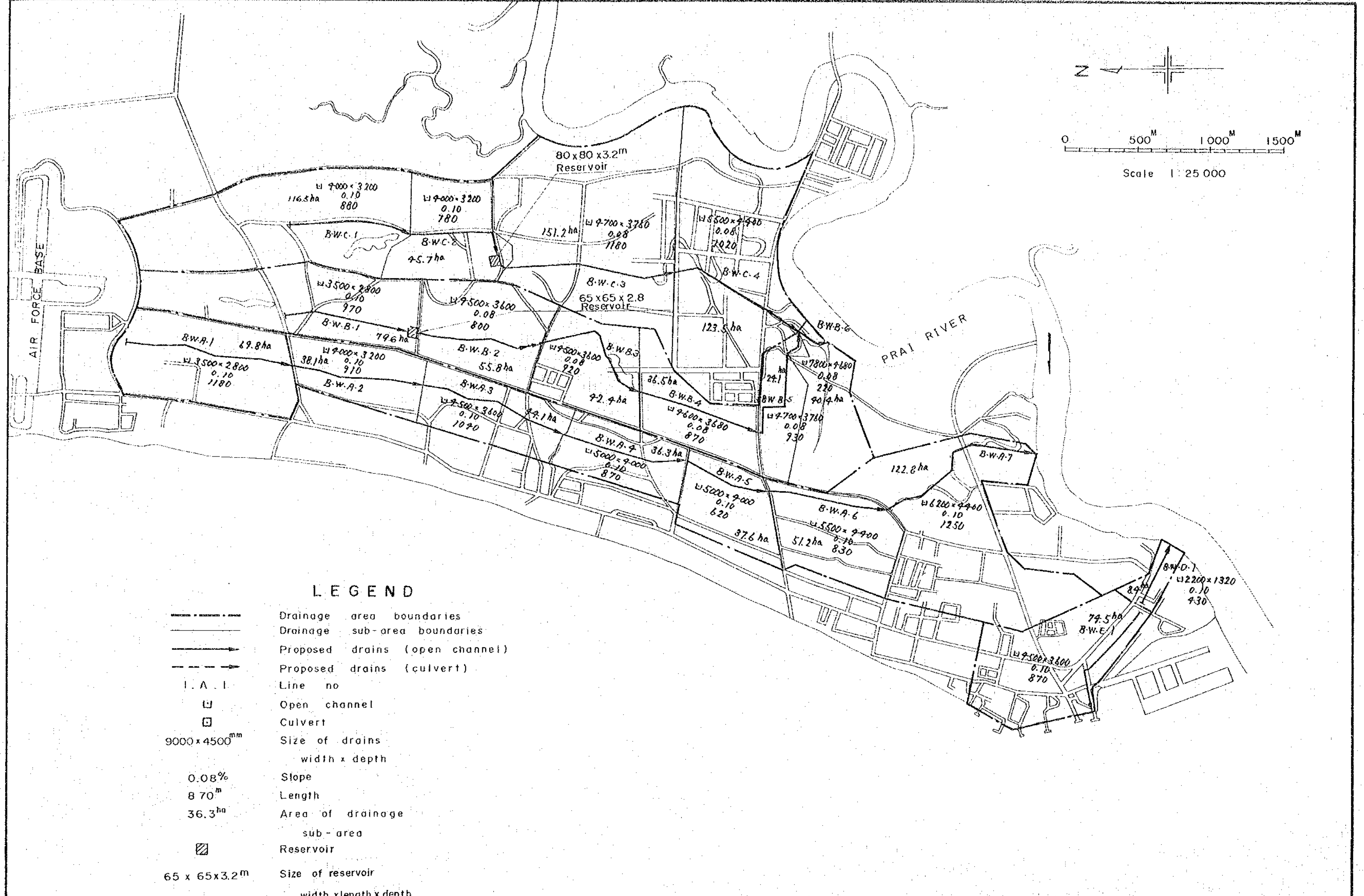
SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH / BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA	
DRAINAGE SYSTEM ALTERNATIVE-I IN BUTTERWORTH AREA (B-IV)	FIGURE J-3



LEGEND

—·—·—	Drainage area boundaries
———	Drainage sub-area boundaries
——→	Proposed drains (open channel)
- - -→	Proposed drains (culvert)
I.A.I	Line no
⊔	Open channel
⊡	Culvert
9000×4500mm	Size of drains width × depth
0.08%	Slope
870m	Length
36.3ha	Area of drainage sub-area

SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH / BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA	
DRAINAGE SYSTEM ALTERNATIVE-II IN BUTTERWORTH AREA (B－IV)	FIGURE J－4

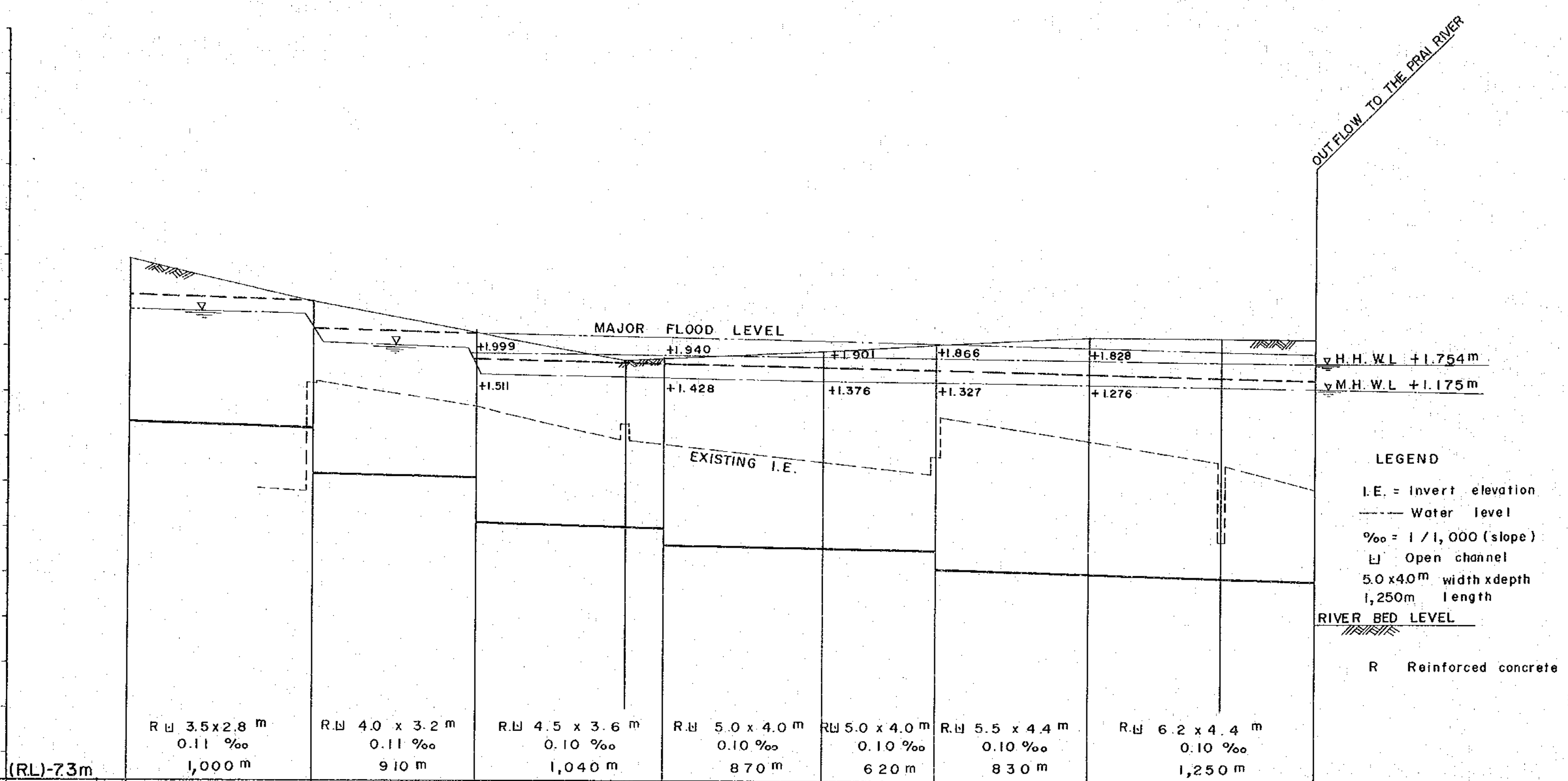


SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH / BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA

DRAINAGE SYSTEM ALTERNATIVE-III IN BUTTERWORTH AREA (B–IV)

FIGURE J –5

BUTTERWORTH DRAIN A



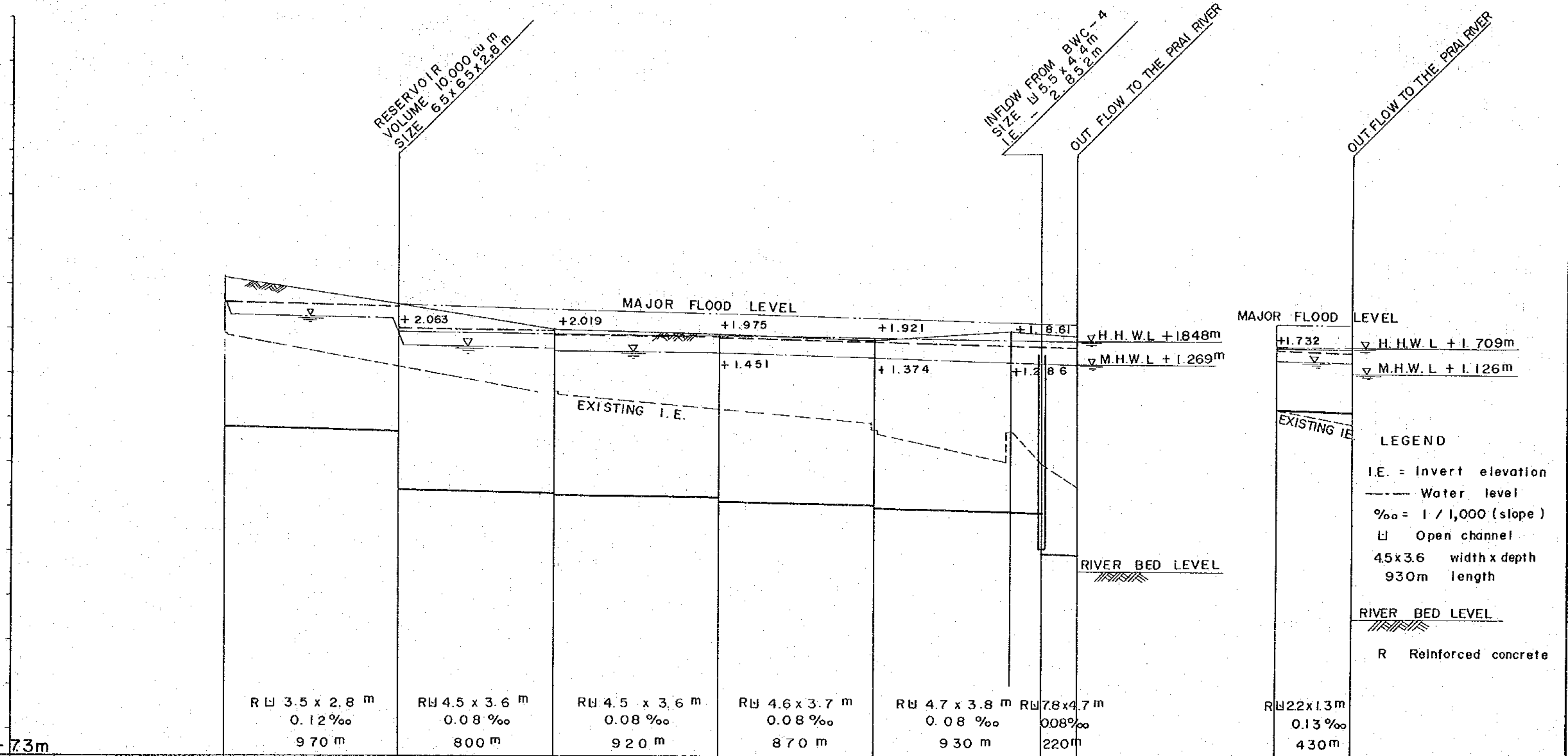
Line No.	BWA - 1	BWA - 2	BWA - 3		BWA - 4	BWA - 5	BWA - 6	BWA - 7		
Elevation Ground Surface (m)	4.00	3.088	2.40	1.795	1.83	2.00	2.131	2.30	2.320	2.32
Sewer Invert Elevatin (m)	0.398	-0.288 / -0.700	-0.800 / -1.796		-1.900 / -2.300	-2.387	-2.439 / -2.839	-2.922		-3.047
Total Length (m)	0	1,000	1,910	2,740	2,950	3,820	4,440	5,270	6,000	6,520

Scale : Horizontal 1:25,000
: Vertical 1: 100

SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH/BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA

PROFILE OF BUTTERWORTH DRAIN A

FIGURE J-6



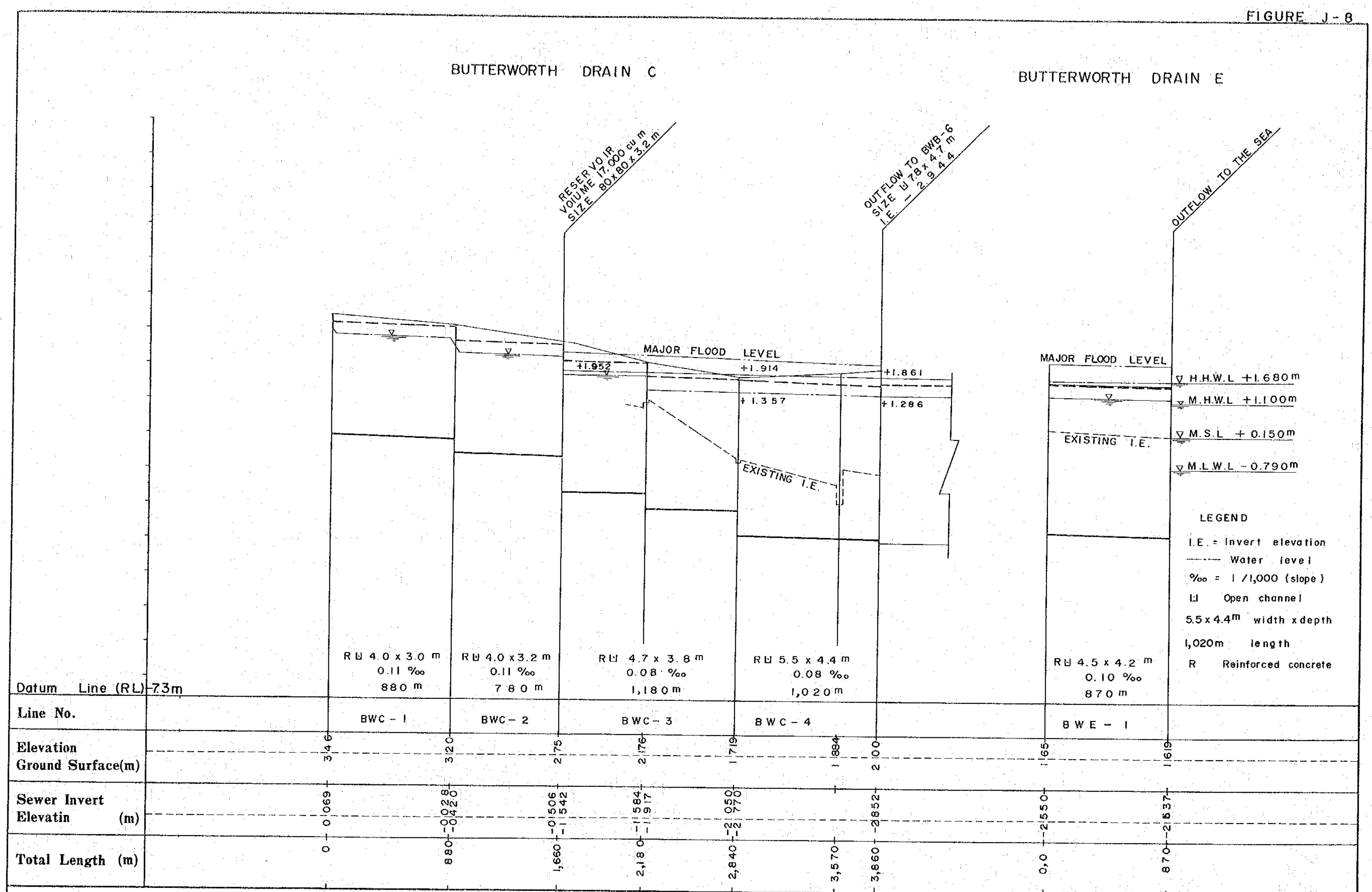
Line No.	BWB-1		BWB-2	BWB-3	BWB-4	BWB-5		BWB-6		BWD-1	
Elevation Ground Surface (m)	3.191	2.162	2.045	1.90	1.82	2.049	2.00	1.90		1.65	1.65
Sewer Invert Elevatin (m)	-0.090	-0.206 / -1.562	-1.626	-1.700 / -1.800	-1.870 / -1.950		-2.024 / -2.944	-2.962		0.343	0.287
Total Length (m)	0	970	1,770	2,690	3,560		4,490	4,710		0.0	430

Scale : Horizontal 1 : 25,000
: Vertical 1 : 100

SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH / BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA

PROFILE OF BUTTERWORTH DRAIN B & D

FIGURE J - 7

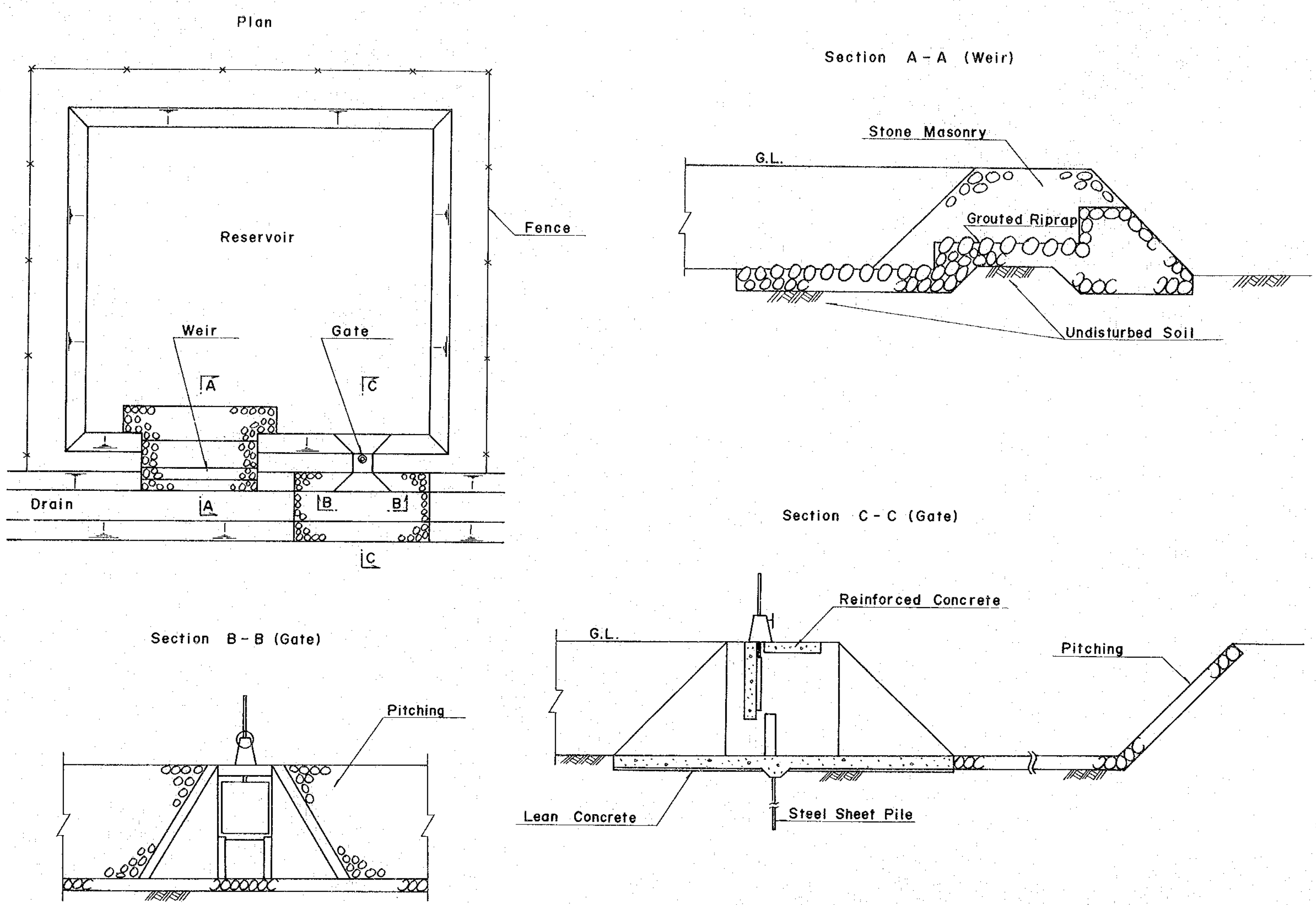


Scale : Horizontal 1:25,000
: Vertical 1: 100

SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH/BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA

PROFILE OF BUTTERWORTH DRAIN C & E

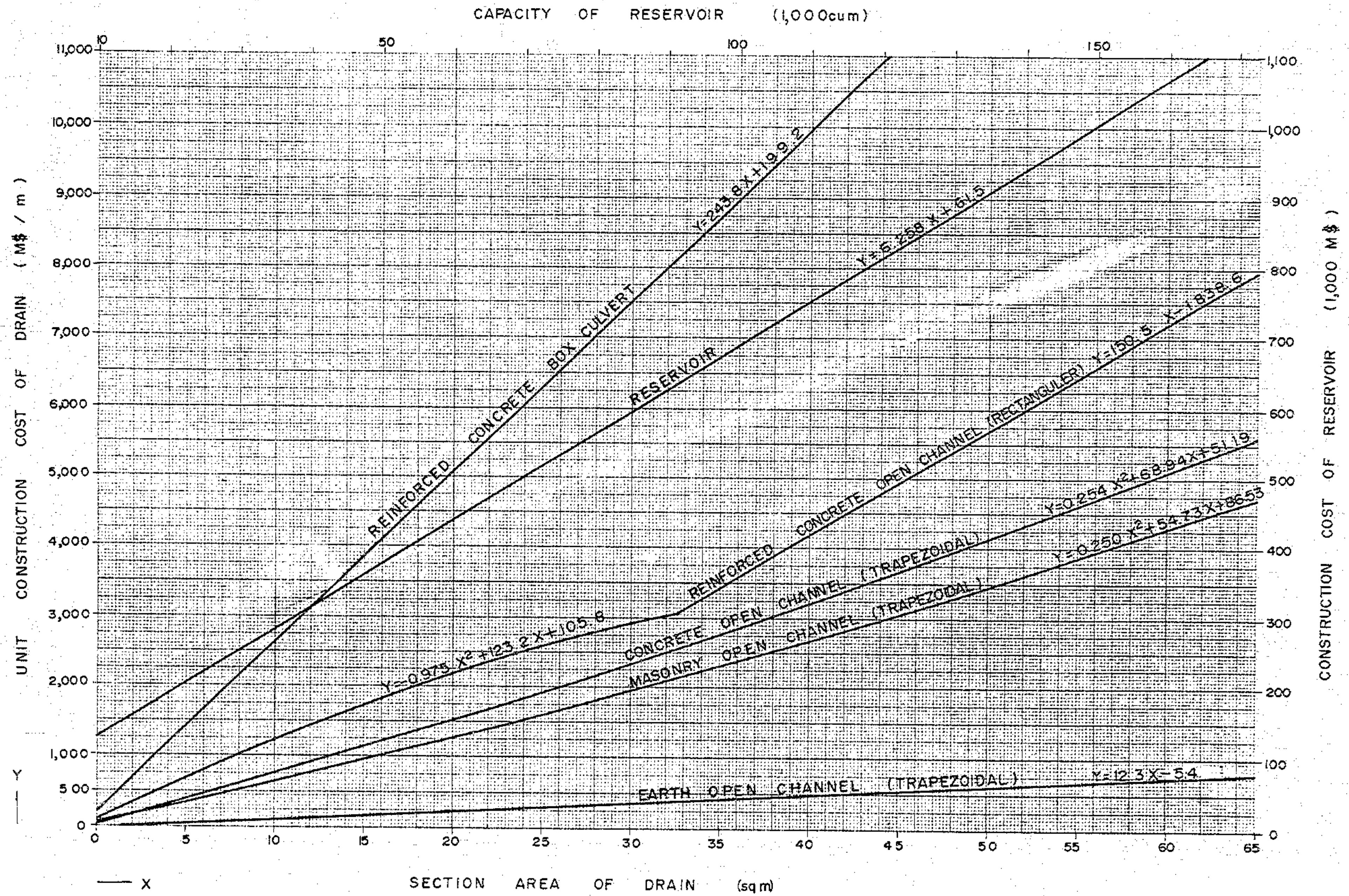
FIGURE J-8

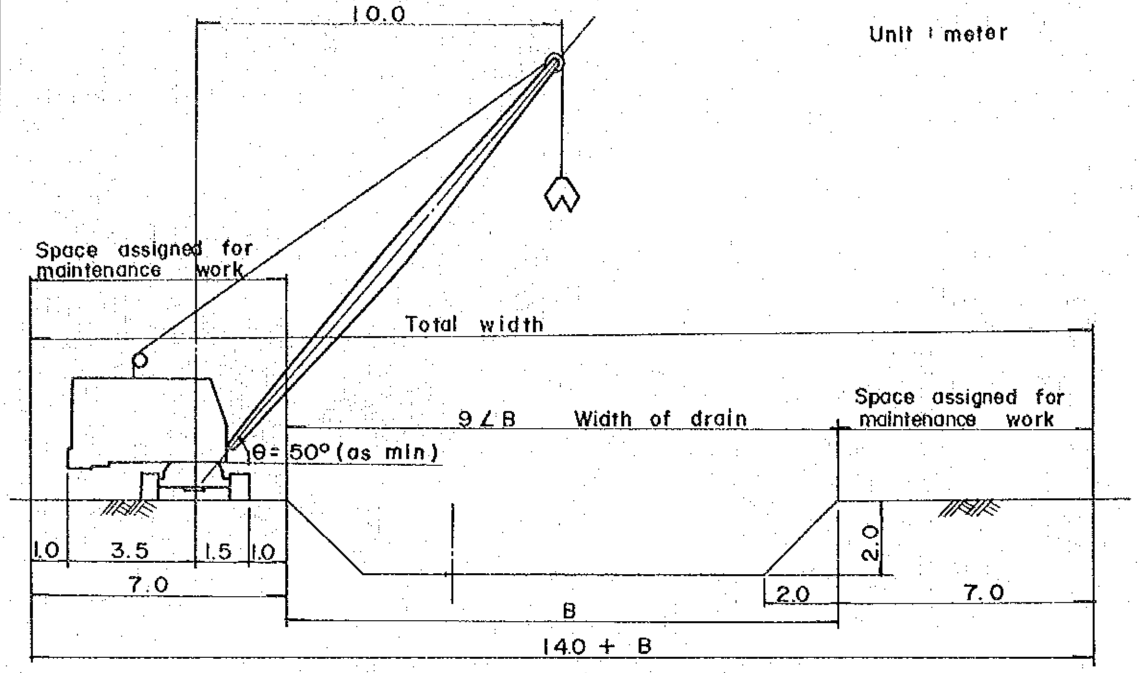


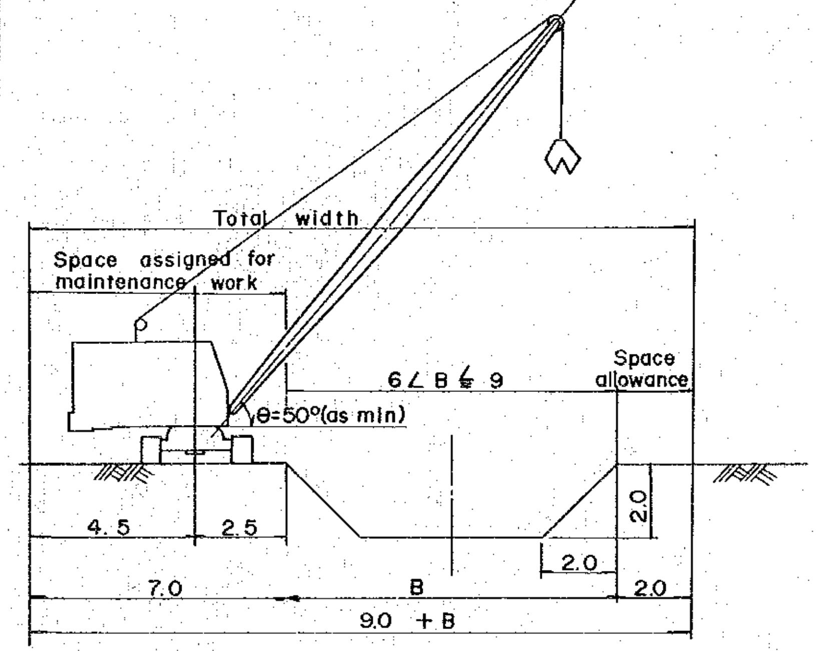
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH/BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA

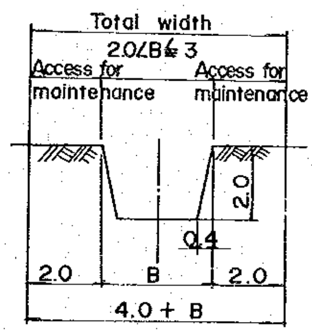
DESIGN SKETCHES OF RESERVOIR	FIGURE J - 9

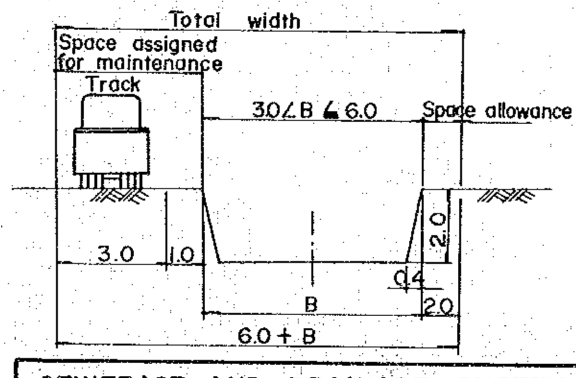
FIGURE J - 10 CONSTRUCTION COST CURVE OF DRAIN & RESERVOIR

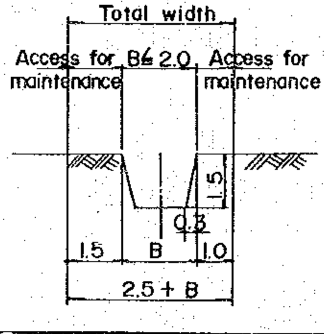










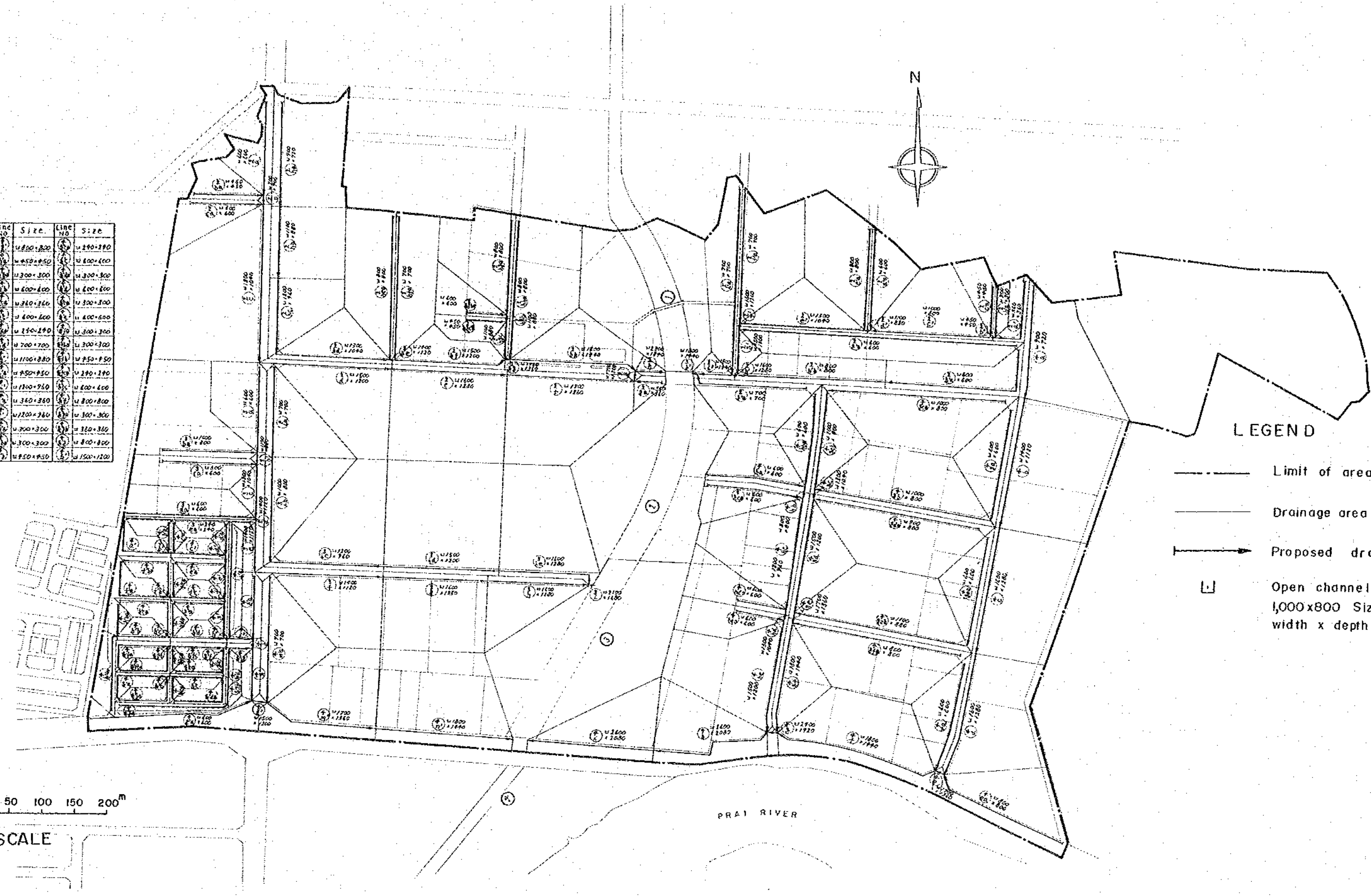


SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH / BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA	
ESTIMATED SPACE REQUIRED FOR MAINTENANCE WORK	FIGURE J - 11

SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH / BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA

REPRESENTATIVE NETWORK OF SMALLER DRAINS IN RESIDENTIAL AREA	FIGURE J - 12

Line No	Size	Line No	Size	Line No	Size
[illegible]	⊔ 360×360	[illegible]	⊔ 800×800	[illegible]	⊔ 240×240
[illegible]	⊔ 240×240	[illegible]	⊔ 450×450	[illegible]	⊔ 600×600
[illegible]	⊔ 450×450	[illegible]	⊔ 300×300	[illegible]	⊔ 300×300
[illegible]	⊔ 240×240	[illegible]	⊔ 600×600	[illegible]	⊔ 600×600
[illegible]	⊔ 600×600	[illegible]	⊔ 360×360	[illegible]	⊔ 300×300
[illegible]	⊔ 240×240	[illegible]	⊔ 600×600	[illegible]	⊔ 600×600
[illegible]	⊔ 600×600	[illegible]	⊔ 250×240	[illegible]	⊔ 300×300
[illegible]	⊔ 300×300	[illegible]	⊔ 700×700	[illegible]	⊔ 300×300
[illegible]	⊔ 600×600	[illegible]	⊔ 1100×880	[illegible]	⊔ 950×950
[illegible]	⊔ 360×360	[illegible]	⊔ 950×950	[illegible]	⊔ 240×240
[illegible]	⊔ 360×360	[illegible]	⊔ 1100×950	[illegible]	⊔ 600×600
[illegible]	⊔ 450×450	[illegible]	⊔ 360×360	[illegible]	⊔ 800×800
[illegible]	⊔ 240×240	[illegible]	⊔ 1200×960	[illegible]	⊔ 300×300
[illegible]	⊔ 600×600	[illegible]	⊔ 300×300	[illegible]	⊔ 360×360
[illegible]	⊔ 800×800	[illegible]	⊔ 300×300	[illegible]	⊔ 800×800
[illegible]	⊔ 300×300	[illegible]	⊔ 950×950	[illegible]	⊔ 1500×1200



LEGEND

- Limit of area considered
- Drainage area boundaries
- Proposed drain
- ⊔ Open channel 1,000x800 Size of channel width x depth (mm)

SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH/BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA

REPRESENTATIVE NETWORK OF SMALLER DRAINS IN INDUSTRIAL AREA

FIGURE J - 13

TABLE J – 5 ANALYSIS OF PROPOSED DRAINAGE SYSTEM

Design Master Plan

Line NO.	YEAR 1976 Total Area ha	Runoff Coefficient	Storage Coefficient	Runoff cu m/S	YEAR 2000 Total Area ha	Runoff Coefficient	Storage Coefficient	Runoff cu m/S	Details of Proposed Drains to accept runoff: Length m	Slope of Sewer ‰	Velocity m/S	Time of Concentration min	Capacity cu m/S	Size m	Existing Drain: Size m	Capacity cu m/S	Runoff Major Storm (C=0.65) m/S	Reserve Width m	Volume of Reservoir 1000cu m
RAM – 5	※499 53	0.20	0.72	16.20	※499 53	0.35	0.70	17.4	660	0.14	0.6	126.0	25.6	E⊔ 19.5/13.9 x2.8	E⊔ 5.2x1.7	10.0	21.4	40	—
– 6	501	0.22	0.72	32.20	501	0.42	0.70	36.7	70	0.14	0.7	127.7	39.1	E⊔ 25.0/19.0 x3.0	E⊔ 5.9x1.8	12.4	70.4	42	—
ARA – 1	60	—	—	—	60	0.48	0.89	10.4	860	1.10	2.0	27.2	13.4	R⊔ 3.0x3.0	—	—	22.3	8	—
– 2	223	—	—	—	223	0.40	0.79	21.4	1,400	1.00	1.5	43.6	21.5	M⊔ 6.5/5.5 x2.6	—	—	57.6	15	—
– 3	448	0.26	0.77	25.40	448	0.43	0.78	45.4	1,220	1.00	1.8	44.9	46.5	M⊔ 10.0/8.8 x3.0	E⊔ 2.3x1.4	4.2	112.9	19	—
TAN	77	—	—	—	77	0.48	0.88	12.9	960	1.10	2.0	28.0	13.4	R⊔ 3.0x3.0	—	—	27.6	8	—
PAY – 1	78	—	—	—	78	0.42	0.87	11.6	970	1.60	2.3	28.3	12.2	R⊔ 2.7x2.2	—	—	27.9	8	—
– 2	128	0.27	0.82	9.70	128	0.48	0.83	18.0	830	1.60	2.6	33.6	19.1	R⊔ 3.2x2.6	E⊔ 2.3x1.4	4.2	40.1	8	—
BUK – 1	44	—	—	—	44	0.45	0.87	6.6	1,090	6.50	2.4	28.4	7.6	M⊔ 2.8/2.2 x1.4	—	—	15.7	8	—
– 2	120	0.31	0.84	10.8	120	0.61	0.81	19.5	1,390	3.50	2.5	37.7	21.0	M⊔ 4.6/3.7 x2.3	R⊔ 4.8/2.2 x1.2	12.5	34.6	9	—
PAS – 1	64	—	—	—	64	0.48	0.90	11.0	660	1.60	2.3	25.9	12.2	R⊔ 2.7x2.2	—	—	24.6	10	—
– 2	106	0.33	0.83	10.5	106	0.45	0.85	15.1	660	1.50	2.4	30.5	15.6	R⊔ 3.0x2.4	E⊔ 3.8/3.1 x1.7	5.1	35.7	10	—
– 3	186	0.26	0.77	10.7	186	0.43	0.79	19.7	980	0.90	1.5	41.4	20.4	M⊔ 6.5/5.5 x2.6	E⊔ 6.6x1.7	10.0	49.7	14	—
PEK – 1	71	—	—	—	71	0.47	0.92	12.6	410	1.50	2.4	24.7	15.6	R⊔ 3.0x2.4	—	—	28.5	8	—
– 2	157	0.28	0.79	11.0	157	0.41	0.81	17.3	1,260	1.20	1.6	37.8	19.0	M⊔ 6.0/5.0 x2.4	E⊔ 3.1x1.2	3.4	45.2	14	—
– 3	210	0.27	0.74	10.4	210	0.40	0.77	17.6	1,320	1.20	1.6	51.6	19.0	M⊔ 6.0/5.0 x2.4	E⊔ 5.9x1.2	6.4	48.1	14	—
BKD	132	0.14	0.70	3.1	132	0.43	0.71	10.8	1,300	0.10	0.5	53.3	11.0	E⊔ 13.0/7.8 x2.6	E⊔ 8.0/3.0 x2.5	4.6	27.4	24	—
BKC	113	0.10	0.70	1.8	113	0.44	0.70	8.0	1,360	0.10	0.4	66.7	8.1	E⊔ 10.0/4.0 x3.0	E⊔ 8.0/3.0 x2.5	4.6	19.9	19	—
BWD	8	0.33	0.72	0.6	8	0.56	0.77	1.4	430	0.13	0.5	24.3	1.4	R⊔ 2.2x1.3	E⊔ 3.3/1.5 x0.6	0.3	2.7	7	—
BWE	75	—	—	—	75	0.62	0.76	14.1	870	0.10	0.8	26.1	14.4	R⊔ 4.5x4.2	—	—	23.5	9	—
BWA – 1	70	—	—	—	70	0.35	0.73	6.0	1,000	0.11	0.7	38.1	6.4	R⊔ 3.5x2.8	—	—	18.0	10	—
– 2	108	0.20	0.69	2.7	108	0.45	0.71	8.0	910	0.11	0.8	57.1	9.1	R⊔ 4.0x3.2	E⊔ 2.3/1.1 x1.3	1.2	21.4	10	—
– 3	152	0.16	0.68	2.5	152	0.51	0.70	11.2	1,040	0.10	0.8	78.8	11.9	R⊔ 4.5x3.6	E⊔ 2.3/1.1 x1.3	1.2	24.0	10	—
– 4	188	0.18	0.68	3.0	188	0.54	0.69	12.6	870	0.10	0.9	94.9	15.7	R⊔ 5.0x4.0	E⊔ 3.5/2.0 x1.6	0.8	25.5	10	—
– 5	226	0.20	0.68	3.6	226	0.56	0.69	14.3	620	0.10	0.9	106.4	15.7	R⊔ 5.0x4.0	E⊔ 5.5/4.0 x1.9	2.1	28.2	10	—
– 6	277	0.22	0.68	4.5	277	0.57	0.69	16.1	830	0.10	0.9	121.8	20.3	R⊔ 5.5x4.4	M⊔ 7.5/5.5 x0.9	1.3	31.1	10	—
– 7	400	0.23	0.68	5.9	400	0.60	0.69	21.4	1,250	0.10	1.0	142.6	24.0	R⊔ 6.2x4.4	E⊔ 10.5/7.0 x1.5	3.4	39.5	11	—
BWB – 1	80	—	—	—	80	0.46	0.71	6.5	970	0.12	0.7	59.8	6.7	R⊔ 3.5x2.8	—	—	15.4	9	10
– 2	135	—	—	—	135	0.60	0.70	7.8	800	0.08	0.7	78.9	10.6	R⊔ 4.5x3.6	—	—	21.2	9	—
– 3	178	—	—	—	178	0.62	0.69	10.2	920	0.08	0.7	100.8	10.6	R⊔ 4.5x3.6	—	—	23.0	9	—
– 4	214	—	—	—	214	0.63	0.69	11.7	870	0.08	0.8	118.9	12.0	R⊔ 4.6x3.7	—	—	24.5	9	—
– 5	238	—	—	—	238	0.63	0.68	12.1	930	0.08	0.8	138.3	12.6	R⊔ 4.7x3.8	—	—	23.7	9	—
– 6	716	—	—	—	716	0.52	0.68	29.0	220	0.08	1.0	142.0	31.7	R⊔ 7.8x4.7	—	—	27.3	14	—
BWC – 1	117	—	—	—	117	0.35	0.71	7.7	880	0.11	0.8	54.0	9.1	R⊔ 4.0x3.0	—	—	24.0	11	—
– 2	162	—	—	—	162	0.35	0.70	8.9	780	0.11	0.8	70.3	9.1	R⊔ 4.0x3.2	—	—	27.7	11	17
– 3	313	—	—	—	313	0.38	0.69	11.0	1,180	0.08	0.8	98.4	12.6	R⊔ 4.7x3.8	—	—	41.4	12	—
– 4	437	—	—	—	437	0.43	0.69	16.2	1,020	0.08	0.8	119.7	18.1	R⊔ 5.5x4.4	—	—	49.7	12	—

(to be continued)

LEGEND

- E : Earth Drain
- M : Masonry Drain
- R : Reinforced Concrete Drain
- ⊔ : Open Channel
- ⊡ : Box Culvert
- ‰ : 1/1,000
- ※ : Contributing Agricultural Area

TABLE J - 5 ANALYSIS OF PROPOSED DRAINAGE SYSTEM

Preventative Master Plan

Line NO.	YEAR 1976 Total Area (ha)	Runoff Coefficient	Storage Coefficient	Runoff (cu m/S)	YEAR 2000 Total Area (ha)	Runoff Coefficient	Storage Coefficient	Runoff (cu m/S)	Details of Proposed Drains to accept runoff: Length (m)	Slope of Sewer (‰)	Velocity (m/S)	Time of Concentration (min)	Capacity (cu m/S)	Size (m)	Existing Drain: Size (m)	Capacity (cu m/S)	Runoff Major Storm (C=0.65) (m/S)	Reserve Width (m)	Volume of Reservoir (1000cu m)
KUB -1	181	—	—	—	181	0.41	0.90	20.0	1.420	2.60	2.2	44.7	22.2	M 5.5 ⊔ 4.6x2.2	—	—	52.8	40	—
-2	392	—	—	—	392	0.37	0.85	33.0	1.290	2.40	2.4	53.7	33.5	M 7.5 ⊔ 6.6x2.3	—	—	96.7	50	—
-3	554	—	—	—	554	0.37	0.84	44.8	340	2.00	2.4	56.1	45.4	M 8.7 ⊔ 7.7x2.6	—	—	131.5	50	—
-4	717	0.15	0.74	17.4	717	0.36	0.79	44.8	700	0.15	0.7	72.8	47.5	E 30.8 ⊔ 24.9x2.8	E ⊔ 10.0 x 1.3	12.1	134.8	50	—
-5	854	0.15	0.73	18.3	854	0.36	0.77	46.3	500	0.15	0.7	84.7	47.5	E 30.8 ⊔ 24.9x2.8	E ⊔ 10.0 x 1.3	12.1	140.6	50	560
ULU	115	—	—	—	115	0.35	0.86	13.1	860	1.40	1.5	29.6	13.3	M 4.6 ⊔ 3.7x2.3	—	—	39.9	40	—
TEN -1	91	—	—	—	91	0.35	0.89	11.1	630	1.30	1.5	27.0	11.4	M 4.4 ⊔ 3.5x2.2	—	—	33.8	40	—
-2	156	—	—	—	156	0.35	0.84	16.2	560	1.00	1.5	33.2	17.4	M 6.0 ⊔ 5.0x2.4	—	—	49.7	40	—
PET	92	—	—	—	92	0.35	0.82	8.9	580	0.25	0.6	36.1	9.7	E 9.0 ⊔ 3.6x2.7	—	—	27.3	30	—
TUA -1	85	—	—	—	85	0.36	0.84	9.2	1.360	2.80	1.9	31.9	9.8	M 3.6 ⊔ 2.9x1.8	—	—	27.6	30	—
-2	153	—	—	—	153	0.36	0.80	14.0	940	2.80	2.0	39.7	14.3	M 4.6 ⊔ 3.9x1.8	—	—	42.4	40	—
-3	206	0.11	0.77	4.6	206	0.35	0.76	14.5	660	0.20	0.7	55.4	14.8	E 14.7 ⊔ 10.7x2.0	E 3.2 ⊔ 3.0 x 1.1	2.8	44.6	40	120
RAM -1	95	—	—	—	95	0.44	0.88	14.2	780	0.70	1.8	27.9	15.8	R ⊔ 4.0x2.4	—	—	34.6	40	—
-2	215	—	—	—	215	0.45	0.80	24.9	990	0.70	1.4	39.7	25.2	M 8.5 ⊔ 7.5x2.6	—	—	59.5	40	—
-3	258	—	—	—	258	0.43	0.77	24.9	860	0.70	1.4	49.9	25.2	M 8.5 ⊔ 7.5x2.6	—	—	60.3	40	—
-4	300	0.27	0.77	16.6	300	0.42	0.75	24.9	330	0.14	0.6	59.1	25.6	E 19.5 ⊔ 13.9x2.8	E ⊔ 1.3 x 1.2	1.0	61.4	40	190
PAS -4	503	0.22	0.72	15.7	503	0.40	0.74	33.0	780	0.16	0.7	70.2	33.2	E 20.3 ⊔ 13.1x3.0	E ⊔ 9.0 x 1.5	7.4	90.8	50	320
KEL -1	88	—	—	—	88	0.46	0.88	13.9	590	1.40	1.6	27.6	14.9	M 4.8 ⊔ 3.8x2.4	—	—	32.2	40	—
-2	167	—	—	—	167	0.41	0.79	16.5	1.530	1.40	1.7	42.6	16.6	M 5.0 ⊔ 4.0x2.5	—	—	43.9	40	—
-3	515	0.28	0.75	26.6	515	0.41	0.75	39.0	1.920	1.00	1.8	60.4	40.0	M 9.5 ⊔ 8.4x2.9	E ⊔ 4.5 x 0.9	7.7	104.2	50	—
-4	1.097	0.24	0.73	37.4	1.097	0.36	0.72	50.7	1.550	0.11	0.7	97.3	52.9	E 31.2 ⊔ 22.0x3.0	E ⊔ 6.0 x 1.6	11.9	152.6	60	—
-5	1.345	0.26	0.70	34.9	1.345	0.40	0.70	50.7	2.050	0.11	0.7	146.1	52.9	E 31.2 ⊔ 22.0x3.0	E ⊔ 7.5 x 2.7	13.6	132.3	60	960
BIN -1	195	—	—	—	195	0.48	0.86	32.3	900	1.10	1.8	28.3	33.0	M 7.5 ⊔ 6.3x3.0	—	—	69.0	40	—
-2	225	—	—	—	225	0.41	0.79	21.9	1.300	0.80	1.5	42.7	23.4	M 7.0 ⊔ 5.6x2.8	—	—	58.6	40	—
UBI -1	151	—	—	—	151	0.46	0.80	17.1	1.900	1.00	1.5	41.0	17.4	M 6.0 ⊔ 5.0x2.4	—	—	40.9	40	—
-2	478	—	—	—	478	0.41	0.73	29.7	3.300	0.90	1.6	75.4	29.9	M 7.5 ⊔ 6.3x3.0	—	—	81.0	40	—
GHE	141	—	—	—	141	0.46	0.80	16.5	1.700	1.00	1.5	38.9	17.4	M 6.0 ⊔ 5.0x2.4	—	—	39.5	40	—
BHA	200	—	—	—	200	0.38	0.82	22.2	1.450	0.80	1.5	36.0	23.4	M 7.0 ⊔ 5.9x2.8	—	—	59.7	40	—
MIN -1	125	—	—	—	125	0.35	0.75	12.5	680	0.20	0.6	28.9	12.6	E 12.0 ⊔ 7.2x2.4	—	—	38.1	40	—
-2	258	—	—	—	258	0.35	0.71	17.3	880	0.18	0.6	53.3	18.0	E 14.0 ⊔ 8.4x2.8	—	—	53.7	40	160
PMT	*503 225	—	—	—	*503 225	0.35	0.78	38.6	1.700	0.14	0.7	70.5	53.2	E 41.0 ⊔ 36.1x2.5	—	—	80.7	40	460
JUR -1	331	—	—	—	331	0.19	0.88	6.9	1.030	0.10	0.4	153.8	8.1	E 12.0 ⊔ 7.2x2.4	—	—	39.3	40	—
-2	439	—	—	—	439	0.25	0.84	10.2	660	0.10	0.5	175.8	13.4	E 14.0 ⊔ 8.4x2.8	—	—	44.5	40	320
BKB -1	50	—	—	—	50	0.35	0.71	3.1	1.110	0.10	0.4	56.3	3.1	E 7.0 ⊔ 2.8x2.1	—	—	10.0	30	—
-2	169	—	—	—	169	0.35	0.69	7.9	710	0.10	0.4	85.9	8.9	E 12.0 ⊔ 7.2x2.4	—	—	24.7	40	—
-3	224	—	—	—	224	0.35	0.69	10.3	50	0.10	0.5	87.6	11.0	E 13.0 ⊔ 7.8x2.6	—	—	32.3	40	140

LEGEND

- E : Earth Drain
- M : Masonry Drain
- R : Reinforced Concrete Drain
- ⊔ : Open Channel
- ⊡ : Box Culvert
- ‰ : 1/1,000
- ※ : Contributing Agricultural Area

(to be continued)

TABLE J - 5 ANALYSIS OF PROPOSED DRAINAGE SYSTEM

YEAR 1976 YEAR 2000

3

Plan	Line NO.	YEAR 1976 Total Area ha	Runoff Coefficient	Storage Coefficient	Runoff cum/S	YEAR 2000 Total Area ha	Runoff Coefficient	Storage Coefficient	Runoff cum/S	Details of Proposed Drains to accept runoff: Length m	Slope of Sewer ‰	Velocity m/S	Time of Concentration min	Capacity cum/S	Size m	Existing Drain: Size m	Capacity cum/S	Runoff Major Storm (C=0.65) m/S	Reserve Width m	Volume of Reservoir 1000cum
	BKA - 1	58	—	—	—	58	0.35	0.71	13.5	1.230	0.10	0.4	61.3	3.8	E 7.5 ⊔ 3.0 x 2.3	—	—	11.0	30	—
	- 2	275	—	—	—	275	0.35	0.70	12.7	820	0.10	0.5	88.6	13.4	E 14.0 ⊔ 8.4 x 2.8	—	—	39.9	40	—
	- 3	381	—	—	—	381	0.35	0.70	17.3	50	0.10	0.5	90.3	19.2	E 16.0 ⊔ 9.6 x 3.2	—	—	54.4	40	250
	DEJ - 1	184	—	—	—	184	0.35	0.75	19.7	750	0.20	0.6	30.8	20.0	E 20.0 ⊔ 16.0 x 2.0	—	—	60.2	40	—
	- 2	467	—	—	—	467	0.35	0.70	28.3	1.280	0.16	0.6	66.4	29.0	E 24.0 ⊔ 19.2 x 2.4	—	—	88.1	50	310
	- 3	467	—	—	—	467	0.35	0.69	20.2	1.300	0.16	0.6	102.5	29.0	E 24.0 ⊔ 19.2 x 2.4	—	—	88.1	50	—
	DER - 1	※1759 604	0.15	0.89	55.1	※1759 604	0.35	0.89	63.2	2.150	0.12	0.6	229.7	66.8	E 46.0 ⊔ 40.5 x 2.8	E 17.0 ⊔ 12.0 x 2.5	52.1	98.2	50	2.100
	- 2	924	0.15	0.83	57.4	924	0.43	0.83	73.0	2.100	0.55	1.4	254.7	73.0	E 25.0 ⊔ 18.0 x 3.5	E 25.0 ⊔ 18.0 x 3.5	95.3	107.1	50	—
	SEB - 1	107	0.10	0.71	2.0	107	0.35	0.71	6.7	1.150	0.10	0.4	57.9	7.1	E 9.5 ⊔ 3.8 x 2.9	E 10.4 ⊔ 5.0 x 2.3	6.3	21.0	30	—
	- 2	216	0.10	0.69	2.4	216	0.40	0.69	10.2	1.310	0.10	0.4	101.6	11.0	E 13.0 ⊔ 7.8 x 2.6	E 10.4 ⊔ 5.0 x 2.3	6.3	28.0	30	—
	SAM - 1	※222 168	—	—	—	※222 168	0.35	0.78	23.3	1.780	0.18	0.6	89.4	24.4	E 22.0 ⊔ 17.6 x 2.2	—	—	41.6	40	—
	- 2	292	—	—	—	124	0.35	0.76	26.9	800	0.18	0.6	111.6	27.5	E 23.0 ⊔ 18.4 x 2.3	—	—	53.1	40	350
	LUB	220	0.23	0.75	14.8	220	0.57	0.78	42.2	960	0.45	1.3	22.3	43.8	M 13.0 ⊔ 11.8 x 3.0	E 10.0 ⊔ 6.0 x 1.8	11.2	78.1	40	—
	SAN - 1	195	—	—	—	195	0.32	0.97	8.1	360	0.25	0.6	128.0	8.3	E 8.5 ⊔ 3.4 x 2.6	—	—	9.4	30	—
	- 2	210	—	—	—	210	0.35	0.92	30.4	480	0.14	0.6	141.3	30.4	E 25.0 ⊔ 20.0 x 2.5	—	—	32.6	40	—
Master Plan	- 3	308	—	—	—	308	0.35	0.84	35.2	1.700	0.14	0.6	188.5	37.1	E 27.0 ⊔ 21.6 x 2.7	—	—	45.2	40	—
	- 4	526	—	—	—	526	0.35	0.83	55.7	530	0.14	0.6	203.2	60.3	E 43.0 ⊔ 37.8 x 2.6	—	—	78.7	40	—
	- 5	757	—	—	—	757	0.40	0.81	62.2	900	0.12	0.6	228.2	66.8	E 46.0 ⊔ 40.5 x 2.8	—	—	93.0	50	1.300
	JAY	※553 7	—	—	—	※553 7	0.35	0.97	21.9	250	0.20	0.6	126.9	22.7	E 21.0 ⊔ 16.8 x 2.1	—	—	22.6	30	—
	MER	※45 24	—	—	—	※45 24	0.35	0.82	6.6	550	0.25	0.6	35.3	7.1	E 8.0 ⊔ 3.2 x 2.4	—	—	11.5	30	—
	LOK	※465 199	—	—	—	※465 199	0.35	0.87	21.5	2.000	0.14	0.6	185.6	21.5	E 22.0 ⊔ 17.6 x 2.2	—	—	35.1	40	—
	MAN - 1	79	—	—	—	79	0.35	0.80	7.0	740	0.25	0.6	40.6	7.1	E 8.0 ⊔ 3.2 x 2.4	—	—	21.6	30	—
	- 2	164	—	—	—	164	0.35	0.74	9.7	1.000	0.25	0.6	68.4	9.7	E 9.0 ⊔ 3.6 x 2.7	—	—	30.1	40	—
Preventative Plan	BEN - 1	84	—	—	—	84	0.32	0.71	4.8	1.150	0.10	0.4	57.9	5.2	E 8.5 ⊔ 3.4 x 2.6	—	—	16.5	30	—
	- 2	111	—	—	—	111	0.30	0.69	4.8	650	0.10	0.4	85.0	5.2	E 8.5 ⊔ 3.4 x 2.6	—	—	16.5	30	—
	- 3	180	—	—	—	180	0.31	0.69	5.8	800	0.10	0.4	118.3	7.1	E 9.5 ⊔ 3.8 x 2.9	—	—	20.6	30	120
	BAG - 1	83	—	—	—	83	0.35	0.72	6.1	850	0.10	0.4	45.4	6.1	E 9.0 ⊔ 3.6 x 2.7	—	—	19.1	30	—
	- 2	121	—	—	—	121	0.37	0.69	6.1	1.130	0.10	0.4	92.5	6.1	E 9.0 ⊔ 3.6 x 2.7	—	—	19.1	30	—
	- 3	380	—	—	—	380	0.30	0.68	10.5	1.300	0.10	0.5	135.8	13.4	E 14.0 ⊔ 8.4 x 2.8	—	—	38.6	40	—
	GEL - 1	※90 68	—	—	—	※90 68	0.35	0.79	13.9	850	0.16	0.6	43.6	13.9	E 13.0 ⊔ 7.8 x 2.6	—	—	25.7	30	—
	- 2	113	—	—	—	113	0.35	0.74	14.6	1.030	0.18	0.6	72.2	14.8	E 13.0 ⊔ 7.8 x 2.6	—	—	28.1	30	—

LEGEND

E : Earth Drain

M : Masonry Drain

R : Reinforced Concrete Drain

⊔ : Open Channel

⊡ : Box Culvert

‰ : 1/1,000

※ : Contributing Agricultural Area

TABLE J-6 Construction Cost of Facilities by Stage

Facility		Construction Cost (1,000 M$)	Land Cost (1,000 M$)	Total (1,000 M$)
1st Stage				
a) Main Drain				
	Length(m)			
RAM-5,6	730	510	500	1,010
ARA-1 - 3	3,480	5,200	550	5,750
TAN	960	1,300	140	1,440
PAY-1,2	1,800	1,900	200	2,100
PAS-1 - 3	2,300	2,500	80	2,580
BWD	430	230	70	300
BWE	870	2,200	330	2,530
BWA-2 - 7	5,520	14,100	1,230	15,330
BWB-1 - 6	4,710	10,400	630	11,030
BWC-1 - 4	3,860	8,600	380	9,190
b) Reservoir				
	Volume(1000 cu m)			
BWB	10	150	160	160
BWC	17	200	220	210
Sub-Total		47,290	4,490	51,780
Contingency				10,350
Engineering Fee				6,200
Total of 1st Stage				68,330
2nd Stage				
a) Main Drain				
	Length(m)			
LUB	960	2,000	-	2,000
BEN-1 - 3	2,600	620	-	620
BAG-1 - 3	3,280	1,080	-	1,080
BUK-1,2	2,480	1,350	330	1,680
b) Reservoir				
	Volume(1000 cu m)			
BEN	120	1,000	-	1,000
Sub-Total		6,050	330	6,380
Contingency				1,270
Engineering Fee				760
Total of 2nd Stage				8,410

(to be continued)

Facility		Construction Cost (1,000 M$)	Land Cost (1,000 M$)	Total (1,000 M$)
<u>3rd Stage</u>				
a) Main Drain				
	Length(m)			
TUA-1 - 3	2,960	1,470	-	1,470
RAM-1 - 4	2,960	4,420	-	4,420
PEK-1 - 3	2,990	2,950	250	3,200
BKD	1,300	320	-	320
BKC	1,360	220	-	220
BWA-1	1,000	1,500	380	1,880
SAN-1 - 5	3,970	3,910	-	3,910
JAY	250	130	-	130
MER	550	90	-	90
LOK-1,2	2,000	1,100	-	1,100
MAN-1,2	1,740	330	-	330
GEL-1,2	1,880	640	-	640
b) Reservoir				
	Volume(1000cu m)			
TUA	120	1,000	-	1,000
RAM	190	1,500	-	1,500
SAN	1,260	9,000	-	9,000
Sub-Total		28,580	630	29,210
Contingency				5,840
Engineering Fee				3,500
Total of 3rd Stage				38,550
<u>4th Stage</u>				
a) Main Drain				
	Length(m)			
KUB-1 - 5	4,250	4,560	-	4,560
ULU	860	640	-	640
TEN-1,2	1,190	990	-	990
PET	580	130	-	130
PAS-4	780	250	-	250
KEL-1 - 5	7,640	9,270	-	9,270
BIN-1,2	2,200	3,200	-	3,200
UBI-1,2	5,200	7,000	-	7,000
GHE	1,700	1,700	-	1,700
BHA	1,450	2,000	-	2,000
MIN-1,2	1,560	540	-	540
PMT	1,700	2,400	-	2,400
JUR-1,2	1,690	640	-	640
BKB-1 - 3	1,870	420	-	420
BKA-1 - 3	2,100	610	-	610
DEJ-1 - 3	3,330	1,530	-	1,530
DER-1	2,150	1.300	-	1,300
SEB-1,2	2,460	380	-	380
SAM-1,2	2,580	1,660	-	1,660

(to be continued)

Facility		Construction Cost (1,000 M$)	Land Cost (1,000 M$)	Total (1,000 M$)
b) Reservoir				
	Volume(1000 cu m)			
KUB	560	4,300	-	4,300
PAS	320	2,500	-	2,500
KEL	960	7,300	-	7,300
MIN	160	1,300	-	1,300
PMT	460	3,500	-	3,500
JUR	320	2,500	-	2,500
BKB	140	1,100	-	1,100
BKA	250	2,000	-	2,000
DEJ	310	2,400	-	2,400
DER	2,110	16,000	-	16,000
SAM	350	2,700	-	2,700
Sub-Total		84,820	-	84,820
Contingency				16,960
Engineering Fee				10,160
Total of 4th Stage				111,940
1st to 4th Stage				
Sub-Total		166,740	5,450	172,190
Contingency				34,420
Engineering Fee				20,620
Total of 1st to 4th Stage				227,230

TABLE J-7 Construction Cost of Network of Smaller Drains by Stage

Facility		Construction Cost (1,000 M$)	Land Cost (1,000 M$)	Total (1,000 M$)
<u>1st Stage</u>				
	Area (ha)			
S_{2-1}	53	700	-	700
2-2	287	5,400	-	5,400
2-4	139	2,400	-	2,400
2-7	229	4,400	-	4,400
4-1	18	270	-	270
4-2	28	440	-	440
4-3	52	830	-	830
4-4	47	1,500	-	1,500
4-5	231	3,500	-	3,500
4-6	330	7,300	-	7,300
4-8	248	7,300	-	7,300
4-9	378	4,600	-	4,600
4-10	37	1,200	-	1,200
Sub-Total		39,840	-	39,840
Contingency				7,960
Engineering Fee				4,780
Total of 1st Stage				52,580
<u>2nd Stage</u>	Area (ha)			
S_{3-2}	203	6,100	-	6,100
3-7	306	4,200	-	4,200
3-8	116	1,700	-	1,700
3-9	53	850	-	850
3-10	159	4,800	-	4,800
4-7	89	1,400	-	1,400
Sub-Total		19,050		19,050
Contingency				3,810
Engineering Fee				2,280
Total of 2nd Stage				25,140
<u>3rd Stage</u>				
	Area (ha)			
S_{1-4}	202	2,900	-	2,900
2-1	235	4,100	-	4,100
2-5	152	2,300	-	2,300
2-6	218	3,400	-	3,400
3-2	80	1,100	-	1,100
3-3	290	4,200	-	4,200
4-6	60	800	-	800
4-8	8	300	-	300
4-9	49	700	-	700

(to be continued)

Facility		Construction Cost (1,000 M$)	Land Cost (1,000 M$)	Total (1,000 M$)
B-V	551	6,900	-	6,900
S_{6-1}	155	2,200	-	2,200
6-2	293	4,400	-	4,400
6-3	96	930	-	930
Sub-Total		34,230	-	34,230
Contingency				6,840
Engineering Fee				4,100
Total of 3rd Stage				45,170
4th Stage	Area (ha)			
S_{1-1}	53	760	-	760
1-2	38	550	-	550
1-3	687	9,900	-	9,900
2-4	107	1,600	-	1,600
2-6	583	8,600	-	8,600
2-8	388	6,100	-	6,100
2-9	30	430	-	430
2-10	204	2,900	-	2,900
2-11	111	1,800	-	1,800
2-13	81	1,200	-	1,200
2-14	80	1,200	-	1,200
2-15	218	3,400	-	3,400
2-16	224	3,200	-	3,200
3-1	381	5,500	-	5,500
3-2	184	2,700	-	2,700
3-3	159	2,300	-	2,300
3-4	216	3,800	-	3,800
3-5	292	4,200	-	4,200
3-6	147	2,100	-	2,100
3-11	46	660	-	660
Sub-Total		62,900		62,900
Contingency				12,580
Engineering Fee				7,540
Total of 4th Stage				83,020
1st to 4th Stage				
Sub-Total		156,020	-	156,020
Contingency				31,190
Engineering Fee				18,700
Total of 1st to 4th Stage				205,910

CHAPTER 4

RECOMMENDED ELEVATION UP TO WHICH LAND BE FILLED

The water level in the Prai and Juru river under the critical situaiton in which the river is flooded with heavy rains while influenced by the highest sea level of +1.68 meters (+5.5 ft) has to be estimated for the purpose of identifying the elevation up to which land is to be filled.

The planned flood water level[1/] in the Prai river which is influenced by the tide with mean high sea level of +1.10 meters, is available in the "Project Report on Drainage and Reclamation of Sungai Prai Basin" prepared by JICA in 1973. According to the report, the water level at the point of Prai barrage, is +1.37 meters (+4.5 ft) under the influence of the tidal level of +1.10 meters (+3.6 ft). The gradient of river water surface at that time is 0.000035.[2/]

It is therefore considered that the use of 0.000035 as a gradient of water surface expected in the flooded river influenced by the tide of +1.68 meters (+5.5 ft) would yield the safe estimation of river water level.

The distance from the mouth of the Prai river to the boundary of the Project Area is about 13 kilometers. Estimated waterlevel at the boundary of the Project Area, therefore, is 1.68 + 0.455 = 2.14 (0.000035 x 13,000 = 0.455 m). If allowances in branches and main drains are added, the water level at upstream of the drainage channels would be about +2.30 meters (+7.5 ft).

In the tributary of the Juru river, land filling is also necessary for areas with least elevation. No data is available as to the water level in the Juru river in its flooded time. Further studies regarding needed cross section, water level at unusual time under the intense

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1/: The rainfall intensity applied is that of 10-yr frequency.

2/: $i = \frac{h}{L}$; $\frac{\text{Head loss}}{\text{Distance from river mouth to Prai barrage}}$

$= \frac{1.372 - 1.097}{7,900} = 0.000035$

rainfall, the highest sea level and the effect of existing tidal gate for the river water level have to be undertaken in order to clarify the required land elevation to be filled.

APPENDIX K

ALTERNATIVE ORGANIZATIONS

In conjunction with the implementation of sewerage and drainage systems programmed in Master Plan, the organization well conceived to achieve required objectives and functions is necessary. The matter has been taken up in PART V SOCIO-ECONOMIC ORGANIZATIONAL AND LEGISLATIVE STUDIES, but a few other alternatives were considered during the course of arriving at a proposal included in the above referred Master Plan Report. As a matter of information they are presented in the following:

1. Creation of new regional organization as Penang Sewerage & Drainage Authority

As mentioned previously, there are local government councils under State of Penang Authority, i.e., Municipal Council, Penang Island, and Municipal Council, Province Wellesley.

While no sewerage systems exist in Province Wellesley, sewage disposal system exists in urban area of Penang Island with corresponding organization responsible for operation of the system in the Council of Penang Island.

This alternative is considered based on the concept to create a new organization expanding already developed organization responsible for existing sewerage works in Penang Island to include the one proposed for Province Wellesley, recruiting available sanitary engineers in charge of sanitary systems for operation and management in both areas.

The status of this new organization is to be similar to the existing Penang Water Authority, the fully autonomous statutory body authorized by Federal legislation and intends to promote administrative control, self support and maintain uniform technical standards for sewerage and drainage systems through the combined areas of Penang Island and Province Wellesley.

The strong capability and centralized enforcement for overall performance and direct control for satisfactory management and operation will be characteristics by this single authority as opposed to two seperate organizations to be provided in two municipal councils.

The possible disadvantage of this approach is, however, that it may require time consuming initial efforts for legislative and administrative review for the creation of a new organization. This will naturally include consideration on reorganization of various department in the existing municipal councils, which will be involved technically and administratively for a creation of a new organization.

While the idea of establishing single organization for sewerage administration is the logical one, the problems involved for consideration and implementation are considered to be great.

2. Combined Penang Water Supply, Sewerage & Drainage Authority

This alternative is the expansion of the function of existing Penang Water Authority to include the sewerage & drainage administrative functions covering both Penang island and Province Wellesley. The development of the sewerage system needs to be coordinated with the growth of infrastructure, particularly water supply for residential, commercial and industrial use and demand for sewerage service is closely related to its consumption. Technically and administratively, it is considered sound to conceive single organization, which include services for water supply, sewerage and drainage, for better coordination among the staff concerned for the implementation of various programmes.

It is important to note that a practice successfully followed as an equitable method to generate the revenue for sound operation of sewerage & drainage works is to impose a sewer & drain charges based on the quantity of water used. In this connection, PWA has been demonstrating its capabilities not only in the operation and maintenance of the system, but also for financial management including its fee collection and debt service of both local and foreign currency loans since its formation on 1st, January,1977.

By placing water supply, sewerage and drainage works into an unified organization, sewer and drain charges can be collected with combination of water supply billing procedure. The delinquent users of service charges can be easily penalized by cutting off the water supply.

The additional advantage is that existing engineering and administrative key personnel in the established functional units are utilized to avoid the problem to recruite the experienced and qualified engineering and administrative man-power which are generally shorted.

In contrast to the advantages as mentioned above, there exist significant disadvantages in this approach similar to the disadvantage enumerated in the first alternative.

3. Expansion and Modification of existing Engineering Department, Province Wellesley

The all sanitary systems in the Project Area except for sewerage system are under the control of Municipal Council, P.W. in accordance with Municipal Ordinance enacted as Chapter 133 of the Straits Settlements in 1913 with its subsequent amendments.

The administrative authority has recently been strengthened by the amalgamation of previous three district councils into one local council, "Lembaga", and subsequent status promotion to Municipal Council from Local Council in December, 1976.

This ordinance empowers the Municipal Council to construct and maintain the sewerage and drainage disposal systems as well as all other sanitary systems within the Council's boundary.

The Ordinance also grants the power to the Council to raise the revenue for the sewerage and drainage works by levying the fees and other charges for the services to be provided.

Under this ordinance the Municipal Council would be able to undertake the sewerage and drainage development programme expanding the existing functions suited to meet planned sewerage and drainage systems without drastic jurisdictional reorganization as required in the first and second alternatives.

In addition, further expansion and development of administrative authority is expected for the Department in accordance with urban and industrial development in the area in line with the national policy, which will enable the reorganization in connection with the sewerage and drainage administration easier.

The major disadvantage may be a difficulty and disadvantage pertinent to the creation of a new functional units solely responsible for management and operation of proposed sewerage and drainage systems. The shortage of qualified and experienced personnel, together with the relationship with authorities in charge of agriculture, land development and health control programme, may impose a restraint for early implementation of satisfactory new public utility services.