Further, 7 effluent samples suspected of bad quality were collected during the visits of the factories, which were analyzed by Department of Chemistry and Indus Laboratories.

2.2.2 Findings of Wastewater Surveys

Concerning with water consumption and discharge, effluent quality, number of employees, and factory site area, the findings of the industrial wastewater surveys carried out independently by Ministry of Environment, MPSP, and by survey team were summarized in Table F-11 with their factory code numbers. All of the data summarized in Table F-11 are based on the year 1976 except some of water consumption data which is that of 1975 from PWA.

Malaysia Science University and MPSP carried out a survey of small scale industry in Butterworth Town through the field visits in 1976. Table F-12 shows number of small scale factories in Butterworth, which are mainly metal-processing, woodworking, motor-work-shop, and food factories. As most of these factories are as small as home size, it is expected that they would not cause any serious problems in terms of pollution. The similar situation prevails in the other areas regarding the small scale factories.

TABLE F-10 List of Industries Classified

Code No. Class	Group	Name of Industry Classified	Remarks
1		Foods	
	11	Sea Products	Frozen Foods, Tinned Foods
	12	Oil Products	Palm Oils, Refined Oils
	13	Other Foods	including Feeds
2		Textile	
	21	Spinning	Yarn, Thread
	22	Weaving	Fabrics
	23	Dyeing	
	24	Apparel	
3		Chemicals	
	31	Fertiliser	
	32	Synthetic Chemistry	
	33	Other Chemicals	
4		Rubber & Plastics	
	41	Rubber	Latex
	42	Rubber & Plastics Processing	
5		Stone & Clay Products	
	51	Glass	
	52	Concrete	
	53	Others	Pottery
6		Metals	
	61	Iron & Steel	
	62	Non-Ferous Metals	
	63	Fabricated Metals	
	64	Other Metal Works	
7		Electrics	
	71	Electronics	
	72	Other Electric Goods	
8		Machinery & Equipments	
	81	Machinery	
	82	Assembling	
	83	Others	Parts/Tools Making
9		Others	
	91	Battery	
	92	Plating	
	93	Woodworking	
	94	Other Processing	
	95	Others	

TABLE F-11 The Summary of the Industrial Wastewater Surveys

	Quantity		Quality (mg/1)		Number of Employee	Site Area (ha)	Factory Code No.
	Q_c*	Q_d**	BOD	SS			
1	8,182.8	8,182.8	130.0	61.7	875	28.4	2-23-15
2	3,182.2	2,273.0	-	79.0	739	21.6	3-32-02
3	2,500.0	2,200.0	-	102.5	310	7.1	1-13-11
4	718.3	-	-	-	3,036	4.7	2-22-04
5	609.2	591.0	2.0	70.0	104	2.0	3-33-07
6	609.1	436.4	20.0	30.0	587	4.8	2-21-02
7	371.9	-	-	-	453	2.1	2-22-05
8	318.2	181.8	55.0	30.0	267	2.4	2-21-03
9	308.9	234.1	26.0	49.0	90	4.1	3-32-04
10	297.0	53.5	-	-	440	2.8	6-64-06
11	245.5	122.8	78.6	900.0	50	-	3-33-08
12	218.2	8.1	122.0	42.0	137	6.1	1-12-05
13	216.5	214.9	85.0	171.0	900	8.1	4-42-04
14	136.4	113.7	-	-	-	-	1-11-03
15	131.8	-	-	-	434	16.2	2-21-01
16	113.7	-	410.0	100.0	137	1.6	1-11-02
17	107.7	-	265.0	170.0	147	1.3	1-11-01
18	104.9	104.9	-	-	-	-	2-22-13
19	90.9	27.3	325.0	78.0	47	2.0	3-32-03
20	90.9	78.2	3.0	10.0	108	4.2	6-63-01
21	79.7	76.6	-	-	238	1.0	2-22-07
22	75.8	63.2	-	-	417	2.6	4-42-05
23	73.3	-	15.0	110.0	-	-	1-11-08
24	69.2	41.6	-	-	239	2.4	1-13-09
25	68.2	63.6	2,680.0	12,460.0	96	2.0	1-12-04
26	63.6	-	575.0	10.0	-	-	4-41-01
27	59.1	59.1	120.0	1,260.0	60	2.0	1-13-13
28	58.7	-	5.0	30.0	-	-	9-92-03
29	53.8	53.8	-	-	165	2.8	5-51-01
30	45.5	-	25.5	10.0	79	0.4	9-92-02
31	45.6	-	140.0	230.0	-	-	2-22-16
32	44.6		-	-	160	4.1	6-64-05
33	40.2	9.8	25.0	20.0	186	2.0	1-12-06
34	39.1	-	-	-	140	0.4	2-22-08
35	36.8	36.8	-	-	36	0.6	1-11-16
36	36.4	1.8	-	-	27	1.8	3-33-09
37	35.2	16.5	55.0	110.0	-	-	2-22-10
38	29.9	-	25.0	30.0	-	-	9-94-09
39	28.6	28.4	138.0	118.0	216	1.2	9-94-07
40	27.3	-	-	-	118	3.2	2-22-06

TABLE F-11 The Summary of the Industrial Wastewater Surveys (Continued)

	Quantity		Quality (mg/l)		Number of employee	Site Area (ha)	Factory Code No.
	Q_c *	Q_d **	BOD	SS			
41	26.4	6.6	-	-	-	-	2-22-12
42	25.6	-	-	2,430.0	110	-	1-13-10
43	25.6	-	3.0	20.0	16	5.1	3-31-01
44	25.0	18.2	-	-	82	1.3	8-82-01
45	24.1	-	-	-	150	4.1	6-64-02
46	22.7	-	-	-	215	0.6	3-33-06
47	20.5		-	-	131	4.0	9-93-05
48	20.0	20.0	-	-	210	1.7	9-93-06
49	19.4		10.0	40.0	52	3.9	3-33-05
50	19.2	13.6	30.0	65.0	-	-	6-64-08
51	18.4	-	3.0	80.0	-	-	6-64-07
52	18.0	-	615.0	3,455.0	-	-	1-12-07
53	17.3	13.6	-	-	137	6.1	6-64-03
54	16.7	-	-	-	105	1.7	1-13-12
55	15.9	3.2	-	-	-	-	9-95-13
56	14.1	14.1	-	-	-	-	9-94-12
57	13.6	3.0	-	-	-	-	4-42-06
58	13.3	-	-	-	535	2.2	7-71-01
59	12.9	10.3	25.0	20.0	72	0.4	2-22-09
60	11.5	-	-	-	98	0.8	9-93-04
61	11.5	-	20.0	80.0	-	-	1-13-14
62	11.4	-	320.0	130.0	-	-	4-41-02
63	11.4	-	85.0	475.0	-	-	4-41-03
64	10.8	-	740.0	40.0	-	-	2-22-09
65	10.2	10.2	4.0	15.0	64	0.4	8-83-02
66	9.1	9.1	-	-	20	1.2	9-95-10
67	8.0	-	13.0	10.0	-	-	9-91-01
68	7.2	7.2	-	-	157	0.4	6-64-09
69	3.2	3.2	20.0	460.0	-	-	9-94-08
70	1.9	1.0	43.0	113.0	34	0.4	9-94-08
71	0.7	0.7	-	-	-	-	6-64-04
72	0.5	0.5	-	-	-	-	2-22-11
73	0.2	0.2	-	-	-	-	1-11-15

* Q_c : Water Consumption (cu m/day)

** Q_d : Water Discharge (cu m/day)

TABLE F-12 Number of Small Scale Factories in Butterworth

Class* No.	Type of Factories	No. of Factories	Remarks
1	Food	79	
2	Textile (Apparel)	22	
3	Chemicals	15	
4	Rubber & Plastics	31	Manufacturing
5	Stone & Clay Products	15	
6	Metals	121	Manufacturing
7	Precision Equipment	-	
8	Transport Equipment	83	Motor Work Shop
9	Others		
	Woodworking	94	
	Paper	19	Processing
	Printing	8	
	Others	67	
	General Service	15	
	Junk Yard	37	
	Store	28	

After Malaysia Science University and MPSP, "Survey of Small Scale Industries in Butterworth Town" (1976)

* Industrial Classification Number (see Table F-10)

2.3 Quantity of Industrial Wastewater

2.3.1 Industrial Water Consumption

Review of the information through questionnaires carried out by LPKT-SP and survey team together with those by PWA-data enables to undertake assumption on the existing industrial water consumption in the Area.

Table F-13 and F-14 show industrial water consumption per capita-employee and per factory-site-area by industrial classification. Although the number of samples are not enough to estimate water consumption by each industrial classification, the figures of water consumption per employee and/or per site area indicates the characteristics of each industires. Both of the Tables F-13 and F-14 indicate that food, textile, and chemical industries are water-demand type industries.

TABLE F-13 Water Consumption VS Factory Site Area

Class No.	Water Consumption (cu m/day)	Site Area (ha)	Per Unit Area Water Consumption (cu m/ha/day)	Number of Samples
1	3,229.8	26.8	120.6	10
2	10,400.2	62.8	165.7	10
3	4,295.3	40.1	104.6	8
4	292.3	10.7	27.3	2
5	53.8	2.8	19.0	1
6	481.1	21.6	22.3	6
7	13.3	2.2	5.9	1
8	35.2	1.7	20.6	2
9	137.1	9.7	14.2	7
	18,938.4	179.4	105.6	47

TABLE F-14 Industrial Water Consumption per Capita Employee

Class No.	Water Consumption (cu m/day)	Number of Employees	Per Capita Water Consumption (cu m/cap/day)	Number of Samples
1	3,255.7	1,564	2.08	11
2	10,400.2	6,220	1.67	10
3	4,540.8	1,340	3.39	9
4	292.3	1,317	0.22	2
5	53.8	165	0.33	1
6	481.1	1,152	0.42	6
7	13.3	535	0.02	1
8	35.2	146	0.24	2
9	137.9	788	0.17	7
	19,209.5	13,227	1.45	49

Average industrial water consumption per site area of major factories in the Project Area is shown in Table F-13. And total existing factory site area estimated in the Area is estimated at approximately 350 ha. Therefore, total industrial water consumption is estimated as:

105.6 (cu m/ha/day) x 350 (ha) = 36,960 (cu m/day).

2.3.2 Industrial Wastewater Discharge

A part of industrial water used is lost by evapolation (boiler, etc.) and leakage, and the rest is discharged with and without pollutants. In this report, only polluted industrial wastewater is considered.

Industrial wastewater discharged is estimated on the following process for calculation;

(1) to calculate the water consumption per site area by using all data obtained (see Table F-13),

(2) to calculate the ratio of water discharge/water consumption by using all of the sample data obtained (see Table F-15),

and then,

(3) water discharge was calculated by (1) x (2),

that is, 105.6 (cu m/ha/day) x 0.861 = 90.9 (cu m/ha/day). So that, total industrial wastewater discharged by existing factories in the Project Area is estimated at:

90.9 (cu m/ha/day) x 350 (ha) = 31,815 (cu m/day).

TABLE F-15 The Ratio of Water Discharge/Water Consumption by Industrial Classification

	Food	Textile	Chemical	Others	Total
Water Consumption (C)	3,081.5	9,373.9	4,472.6	919.4	17,847.4
Water Discharge (D)	2,496.1	9,019.1	3,250.0	608.4	15,373.4
Ratio (D/C) %	81.7	96.2	72.7	66.2	86.1
No. of Samples	8	9	6	18	41

2.4 Quality of Industrial Wastewater

As shown in Table E-11, industrial wastewater quality varies between 2.0 and 2,680 mg/l of BOD and between 10 and 12,460 mg/l of SS, depending upon the difference of industry type and wastewater qualities of each factories. Average wastewater qualities of each industry types are shown in Table F-16.

Table F-16 Average Wastewater Quality of Each Industry Types

	Food	Textile	Chemical	Others
Average Concentration (mg/l)				
BOD	200	122	73	67
SS	299	58	106	127
Wastewater (cu m)	2,341	8,828	3,248	336
(%)	16	60	22	2
Amount of Waste (kg/day)				
BOD	468	1,077	237	26
SS	934	516	345	43
Number of Sample	5	5	5	6

The estimated quality of industrial wastewater is 122 mg/l of BOD and 125 mg/l of SS as shown in Table F-17. Thus, unit wastewater production, which is defined as the amount of wastes produced per site area, is estimated at:

BOD: 122 (g/cu m) x 90.9 (cu m/ha/day) = 11,089.8 (g/ha/day)
say 11 kg/ha/day

SS: 125 (g/cu m) x 90.9 (cu m/ha/day) = 11,362.5 (g/ha/day)
say 11 kg/ha/day

So that, total amount of BOD and SS produced by existing factories in the Project Area are estimated at:

11 (kg/ha/day) x 350 (ha) = 3,850 (kg/day) of BOD and SS respectively.

TABLE F-17 Wastewater Loadings

Concentration (mg/l)		Volume (cu m/ha/day)	Unit Production (kg/ha/day)	
BOD	SS		BOD	SS
122	125	90.9	11	11

2.5 Estimation of Future Industrial Wastewater Production

Major industrial development in the Project Area is concentrated in three areas. After completion of development, the total of the industrial areas will be 1,289 ha, of which approximately 30% has already been occupied by existing factories under operation.

Although detailed planning for the whole industrial areas has not been completed, it is possible to estimate the future condition by studying existing industrial areas on the basis of assumption that the constituent of industrial classification will be kept identical even in the future.

The results of questionnaire survey including visits of major factories representing each industry types show that most of major factories are almost fully working in their capacity, and that the factories under operation and/or construction are equipped with fully advanced installations, which warrant that the unit wastewater production in the future would remain to be constant in the foreseeable future in spite of the accelarated industrialization programme.

On the basis of the above assumption, followings are considered reasonable prediction of the future unit industrial wastewater production:

(a) Increase of industrial wastewater volume would be less than 10% in unit area production,

(b) BOD produced from some food factories would be reduced by improvement of their processing, but total BOD produced from entire factories would increase about 30% in unit area production as area-productivity is increased.

(c) The ratio of BOD/SS is nearly equal to one in the present whole industrial condition in the Project Area, and this is similar to the value of highly industrialized countries. Therefore the ratio in considered to be kept the same in the future.

(d) Total factory site area is considered to occupy 80% of whole industrial area in the future.

The future industrial wastewater production from unit industrial area is estimated as shown in Table F-18.

TABLE F-18 Future Wastewater Loadings

Concentration (mg/l)		Volume (cu m/ha/day)	Unit Production (kg/ha/day)	
BOD	SS		BOD	SS
150	150	80	12	12

CHAPTER 3

EXTRANEOUS WATER

In spite of the fact that a sewerage system is designed sewage only, because of many thousands of pipe joints, manholes and inspection covers, etc., a certain amount of extraneous water will find its way into the sewers.

In view of these conditions, for the separate sewer system, an infiltration allowance is considered in determining sewer capacities. The infiltration allowance, 18 cu m/km/day, is considered to be a fair estimate of the extraneous flows to sewers, including ground water and surface water infiltration from public sewers and house connections through manhole covers, etc. This should be adequate since the sewer joints specified for the Project are of rubber ring type for concrete pipes and of the factory applied resilient type for clay pipes.

The infiltration allowance, 18 cu m/km/day, is based on analysis of infiltration from George Town Sewerage Study*. George Town Sewerage Study used figure of 0.002 cubic feet per second per acre for infiltration. This is equivalent to 12 cu m/ha/day. In consideration of these conditions, it is recommended that an allowance of 18 cu m/km/day be allowed in addition to peak sanitary sewer flow, and an infiltration allowance by land use is calculated as follows:

Infiltration Allowance by Land Use

Land Use	Total Sewer Length	Infiltration Allowance
Residential		
High density	600 m/ha	12 cu m/ha/day (18 cu m/km/day)
Low density	450 m/ha	8 cu m/ha/day (18 cu m/km/day)
Industrial	250 m/ha	5 cu m/ha/day (18 cu m/km/day)

* George Town Sewerage Study: A colombo Plan Project for the Government of Canada and the Government of Malaysia, Nov. 1968

APPENDIX G

SEWERAGE SYSTEM CONSIDERATION

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CHAPTER 1

BASIC CONSIDERATION

1.1 General

To examine all reasonable alternatives and to select the most cost-effective system therefrom, network models were developed, and sewage treatment methods of sewerage system were considered for application to the Project Area. Using these models, all feasible alternative combinations of sewerage systems were developed and each of the alternatives was studied with respect to its initial investment, operation, and maintenance costs as well as effects on flexibility and speed of implementation to identify the most economical system achieving the desired results. The economic analysis considered sewage flow rates and costs incurred over 20-year period to the year 2000.

Result of these studies indicates that an alternative, essentially independent treatment plant to be constructed in each zone, is the most economical sewerage system.

1.2 Sewerage Districts and Zones

Initially, two alternative sewerage systems, the one that whole Project Area to be covered by one comprehensive sewerage system, and the other that more than one sewerage systems for the Project Area, are considered. Desirability of either one of the system depends upon the characteristics of the Area with due consideration on economical impact.

The physical characteristics of the Project Area are (1) populated urban areas are limited, (2) huge rural areas still remain at present to be developed in the future, and (3) mostly flat ground surface.

If comprehensive sewerage system is planned in a huge flat ground surface as described above, large sized deep main sewers are required to convey sewage from individual house all the way to the treatment plant, causing high initial investment in addition to the difficulties in implementing construction programme particularly in the built-up areas. Consequently, immediate implementation of the sewerage system construction will be delayed with added difficulties in obtaining sufficient funds for small sewers such as laterals and branches.

Under the circumstance, it is considered practical, as WHO Assignment Report recommends, that the Project Area be properly divided into districts and zones to be dealt with separately, rather than planning area-wide system to cover the whole Project Area. The advantages of this system considered would be:

(a) It is possible to design sewer facilities according to the characteristics of each of such areas.

(b) Implementation of construction plan will be flexible to adjust according to the degree of requirement and availability of financial resources in the future.

(c) Long conveyance of sewage can be avoided, which will avoid inconvenience in construction and enable better control of sulfide build-up later.

(d) Rural areas, in which no urbanized plan is done, will remain flexible for future modification.

The Project Area has, as indicated earlier, a total of 11,600 ha altogether, but, excluding watercourses, swamps and other non-habitable areas, total area for sewerage planning purpose is 10,854 ha. For the convenience of planning, an attempt is made to divide the total area available into 4 districts, namely, Butterworth, Seberang Jaya, Prai and Bukit Mertajam, in accordance with the geographical conditions. They are further divided into zones with due consideration of the followings.

(i) Population density by area.

(ii) Existence of rivers, railways, and roads.

(iii) Land use situation.

(iv) Administrative boundaries (Mukim boundaries).

(v) Condition of built-up areas.

(vi) Topography.

Several alternative delineations are considered, but with due note of the advantages for smaller delineation as stated earlier, the following is considered to serve the purpose.

	Name of District	Name of Zone	Area (ha)	To be covered by Sewerage (ha)
1.	Butterworth	Zone - 1	390	367
2.	"	" - 2	200	182
3.	"	" - 3	490	457
4.	"	" - 4	450	444
5.	"	" - 5	570	551
6.	"	" - 6	670	670
7.	Seberang Jaya	Zone - 1	480	438
8.	"	" - 2	360	305
9.	"	" - 3	510	510
10.	"	" - 4	430	430
11.	"	" - 5	420	368
12.	Prai	Zone - 1	1,230	1,063
13.	"	" - 2	280	268
14.	Bukit Mertajam	Zone - 1	940	892
15.	"	" - 2	730	715
16.	"	" - 3	980	927
17.	"	" - 4	470	467
18.	"	" - 5	490	459
19.	"	" - 6	660	573
20.	"	" - 7	850	768
	Total		11,600	10,854

NOTE: The area covered by sewerage of 10,854 ha is estimated from excluding nonhabitable areas such as mountains, rivers, and cemeteries from the entire Project Area of 11,600 ha.

The detailed descriptions of present condition of each sewerage zone are as follows:

(1) Butterworth Sewerage District

This district is the northern part of the Butterworth/Bukit Mertajam Metropolitan Area and the southern end is limited by the Prai river. It covers an area of 2,671 ha (excluding the airforce base), with a present population of approximately 109,000. The town area of Butterworth is included within this district. For more detailed planning consideration, the district is deemed appropriate to divide into 6 zones, on the basis of roads, administrative subdistrict boundaries, and town area boundaries.

Zone	Area (ha)	Population	Population density (persons/ha)
Zone-1	367	37,920	103
-2	182	3,585	20
-3	457	28,225	62
-4	444	26,332	59
-5	551	3,961	7
-6	670	8,902	13
Total	2,671	108,925	41

Small stormwater drains into which kitchen wastes are discharged directly at present, are provided in the town area. Ground elevations in this district are low, ranging between 1.8 to 3.5 m (5.9 to 11.5 ft) above mean sea level (RL).

In most of housing areas in the town area and new housing development areas, flush toilet systems with septic tanks are commonly used, while in the rural area bucket toilet systems are commonly used. Wastewater produced within this district finally flow into the Prai river through its branches and drains.

Comments on some of the zones are as follows:

(a) Zone-1 covers the center of this district, in which there are both commercial and residential areas.

(b) Zones -2 and 3 are covered by residential, industrial, and partly rural areas, and is within town area.

(c) A part of zone-4 is town area, however this zone is still rural at present.

(d) Zones -5 and 6 are rural areas at present, and are partly under housing development programmes.

(2) Seberang Jaya Sewerage District

This district lies between the Prai river and the railway, and covers an area of approximately 2,051 ha with a present population of 28,600. Most areas of this district are under the industrial and housing development plans. The district is proposed to be divided into 5 zones in accordance with new planning roads.

The area, population, and population density by zone at present are as follows:

Zone	Area (ha)	Population	Population Density (persons/ha)
Zone-1	438	13,657	31
-2	305	69	0.2
-3	510	2,991	6
-4	430	7,518	17
-5	368	4,369	12
Total	2,051	28,604	14

There are drainage system including wide and flat grade open channels and pumping station which has not been operated yet. Ground elevations in this district are also low, ranging between 1.5 to 2.5 m (4.9 to 8.2 ft) above mean sea level (RL).

In new housing development area of this district, flush toilet systems followed by the stabilization pond are installed, while in the rural area bucket toilet systems are commonly used. Wastewater produced within this district is finally discharged into the Prai river through drains.

Comments on these zones are as follows:

(a) New industrial and housing complexes are under construction in zones-1 and 2.

(b) Zones -3, 4 and 5 are covered by rubber farms, rural housing areas, and wilds at present.

(3) Prai Sewerage District

This district is the south-west part of the Metropolitan Area limited by the railway, and covers an area of approximately 1,331 ha with a present population of 3,800. Most of the district is covered by the industrial development plan, and under construction.

The district is proposed to be divided into 2 zones by new planning boundaries of industrial area.

The area, population and population density by zone at present are as follows:

Zone	Area (ha)	Population	Population density (persons/ha)
Zone - 1	1,063	1,860	2
Zone - 2	268	1,974	7
Total	1,331	3,834	3

Ground elevations in this district are low, ranging between 1.1 to 1.8 m (3.6 to 5.9 ft) above mean sea level (RL). Wide and flat grade open drains and pumping stations (one is functionning and the other one is under planning) are installed. Wastewater produced within this area is discharged into the ocean through drains and pumping station.

Comments on these zones are as follows:

(a) Zone - 1 is covered by the Prai industrial complex and the industrial development area.

(b) Zone - 2 is rural housing area and is wild at present.

(4) Bakit Mertajam Sewerage District

This district is the eastern half of the Metropolitan Area and covers an area of 4,801 ha, with a present population of approximately 96,600. The town area of Bukit Mertajam is included within this district. The district is proposed to be divided into 7 zones on the basis of roads, administrative sub-district (mukim) boundaries, town area boundaries, and topographical conditions.

The area, population, and population density by zone are as follows:

	Area (ha)	Population	Population density (Persons/ha)
Zone - 1	892	7,559	8
Zone - 2	715	6,387	9
Zone - 3	927	45,540	49
Zone - 4	467	6,077	13
Zone - 5	459	7,257	16
Zone - 6	573	13,840	24
Zone - 7	768	9,947	13
Total	4,801	96,607	20

Small stormwater drains consisting mainly of side ditches have been provided in the town areas. In other areas natural drainage systems are functioning well because of adequate slope of ground surface at present. Ground elevations in this district are ranging between 1.8 to 16 m (5.9 to 52.5 ft) above mean sea level (RL).

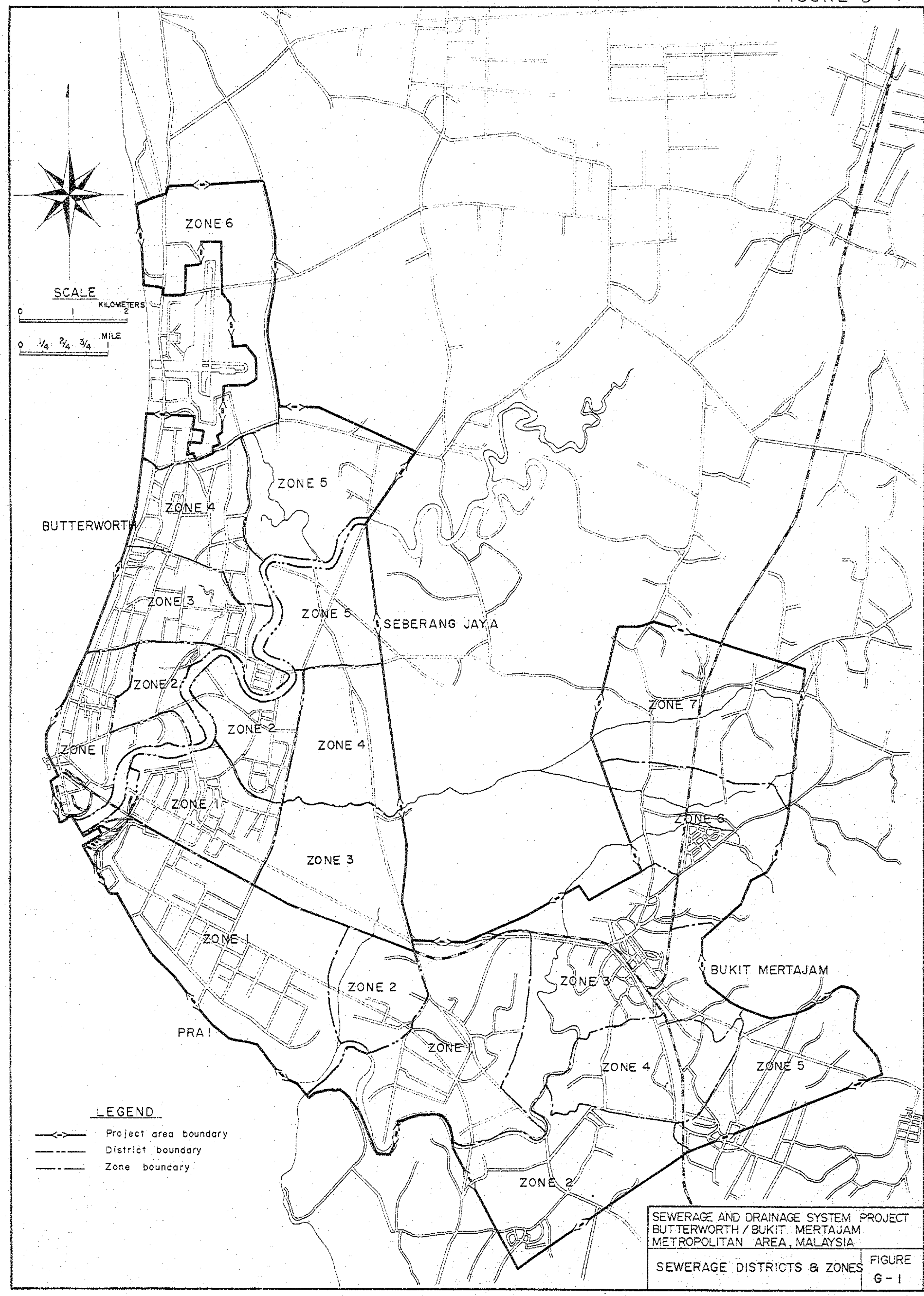
In most of housing areas in the town area and new housing development areas, flush toilet systems with septic tanks are commonly installed, while in the rural and mountainous areas bucket or pit privy toilet systems are commonly used. Wastewater produced within this district is discharged finally into the Juru river through its branches and drains.

Comments on some of the zones are as follows:

(a) Town area which is built-up populated area, and new housing development area along the upper-stream of the Juru river are in zone-3.

(b) Remainders, Zones - 1, 2, 4, 5, 6 and 7 are rural or mountainous areas.

FIGURE G-1


ZONE 6
SCALE
KILOMETERS
0 1 2
MILE
0 1/4 2/4 3/4 1
ZONE 5
ZONE 4
BUTTERWORTH
ZONE 3
ZONE 5
SEBERANG JAYA
ZONE 2
ZONE 2
ZONE 1
ZONE 4
ZONE 1
ZONE 7
ZONE 6
ZONE 3
ZONE 1
ZONE 2
BUKIT MERTAJAM
ZONE 3
PRAI
ZONE 1
ZONE 4
ZONE 5
LEGEND
Project area boundary
District boundary
Zone boundary
ZONE 2
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
SEWERAGE DISTRICTS & ZONES
FIGURE
G-1

CHAPTER 2

SYSTEMS MALAYSIA

2.1 General

Considering the sewerage master plan objectives, many special investigations were carried out during this study, and evaluation of the results have led to the formulation of general design criteria for desirable optimum system. On the basis of these, alternative systems were designed and cost estimates were made for comparative analysis.

It is apparent that a sewerage system serving the Project Area will involve conveyance and treatment of raw sewage flows and disposal of treated sewage effluents through the combination of most appropriate locations. To examine all reasonable alternatives and to select the most cost-effective system therefrom, a network model was developed to facilitate the analysis. Using this model, all feasible alternative combinations of sewerage systems were defined and each of the alternatives was studied with respect to its initial investment, maintenance and operation costs as well as easiness of implementation and the effect on future flexibility in order to determine the best solution.

2.2 Alternative Sewerage System Considered

2.2.1 Conveyance Network

Initially, on the basis of several reasons as described in Chapter 1 of this Appendix, the entire Project Area was divided into 20 sewerage zones. Then, several cases of conveyance networks were studied on a preliminary basis, considering topographical and economic aspects both for present and future conditions.

As the result of preliminary considerations, followings are concluded:

To avoid high initial investment due to construction of long conveyance system to collect sewage of wide area, and because the sewerage system should be flexible for future development programme, the conveyance networks should be established in each sewerage zone independently.

2.2.2 Sewage Treatment and Disposal System

(1) General

Sewage treatment plant is the facility to convert a raw waste water into an acceptable final effluent, and to dispose of the solid removed in the process. It is fundamental, therefore, first to determine the characteristics of the raw waste water and the required degree of the effluent or the required treatment, before proceeding with the design of treatment plant.

In the design of treatment plants of study area, it is necessary to determine the most desirable treatment system from among the various methods, to meet the degree of the required effluent on the basis of economical analysis.

This section deals briefly with alternative methods of treatment system such as stabilization pond, aerated lagoon and oxidation ditch, and to recommend the desirable treatment method from both the technical and economical view point.

(2) Alternative methods of treatment

1) Stabilization Pond

Stabilization pond has been sucessfully used in many countries, which is sometimes referred as "oxidation pond" or "lagoon."

They are recognized means of sewage treatment and have considerable advantages particularly as regards the costs and maintenance requirments and the removal of faecal bacteria.

They are without doubt the most important method of sewage treatment in hot climates where sufficient land is available and where the temperature is most favourable for their operation.

Major types of pond, namely, facultative, maturation and anaerobic ponds, while the type of pond considered for the stabilization pond in this study are facultative and maturation pond as described below.

a) Facultative Pond

Facultative pond is the system in which the upper layers of the pond are aerobic and the bottom layers are either devoid of dissolved oxygen or are anaerobic. At present most of the existing waste stabilization pond installations are of the facultative type.

The facultative pond is oxygenated principally by the photosynthetic activity of algae under the influence of solar radiation, although in the larger ponds surface aeration by the wind action contributes significantly to the total oxygen budget.

The dissolved oxygen concentration is greater during daylight period than at night. The measurement of oxidation-reduction potential shows the tendency towards true aerobic or anaerobic conditions.

The reducing environment will be found near the bottom, indicating true anaerobic conditions. For the facultative pond, temperature is of great importance because it affects the rate of biochemical degradation. The average temperature, daily fluctuations, and yearly variations all influence the biological, physical and chemical processes in the pond.

The practical design of a facultative pond depends on difference of local conditions, but a number of useful and rational design procedures are available. The most important factors on stabilization pond design are areal load and depth of the pond. On the basis of the K.L. sewage treatment plant operation, 300 kg-BOD/ha/day [1/] of areal load and 1.5 m of pond depth are proposed for this study. This corresponds to 10 days of mean retention time.

b) Maturation Pond

The main purpose of maturation pond is to provide a high-quality effluent which is used as a second stage to facultative pond. The principal factor for the design of the maturation pond is detention time, but for efficient reduction of the faecal bacteria it is essential that the pond be arranged in series with the preceding pond. The detention time in the maturation pond, as well as the number of ponds, is determined primarily by the degree of bacterial purification required. In design of maturation pond the reduction of faecal coliform in a pond has been found to follow first order kinetics. The appropriate equation is as follow.

$$Ne = \frac{Ni}{1 + K_{b(t)} \cdot T}$$

$$K_{b(t)} = 2.6\ (1.19)^{t-20}$$

where

- Ne : effluent coliform, N/ml
- Ni : influent coliforms, N/ml
- $K_{b(t)}$: dieoff coefficient of coliforms at t°C, 1/day
- T : retention time, days

From the above mentioned equation the estimated number of effluent coliform from facultative pond (Ne) is 4,500/ml, assuming the $Ni = 4 \times 10^5$/ml, $K_{b(27)} = 8.8\ d^{-1}$, and T = 10 days.

1/ Ref. "Master Plan for Sewerage and Sewage Disposal "for Kuala Lumpur and Environs.

This value (Ne = 4,500/ml) is unsatisfied on sanitary aspects, so that the facultative pond may be followed by a maturation pond (retention time is 3 days) for further reduction of coliforms.

This is

$$Ne = \frac{4 \times 10^5}{(1 + 8.8 \times 10)\ (1 + 8.8 \times 3)} = 164/ml$$

This may be satisfied for environmental protection from coliform contamination by treatment plant effluent.

2) Aerated Lagoon

Aerated lagoon is activated sludge units operated without sludge return. This is historically developed from stabilization pond.

Low cost mecahnical aeration is the most important matter to be the useful engineering alternative when waste loads increase, when land is limited, and when high-quality effluent is required. Commonly, floating aerator for surface aeration is used to supply the necessary oxygen and mixing power for bio-oxidation and for mixing lagoon contents.

In common with all activated sludge systems, aerated lagoon is not particulary effective in removing faecal colofirms, faecal coliform reduction is only 90-95 percent and further treatment may therefore be necessary, hence it is considered that maturation pond needs for required effluent.

For the design of aerated lagoon in this study, the retention time is assumed as 4 days and the depth of lagoon is assumed as 3.0 m.

3) Oxidation Ditch

The oxidation ditch is modification of the activated sludge process, generally followed by sedimentation tank except for small size plant. The oxidation ditch is a long continuous channel usually oval in plan and 1.0 - 1.5 m deep. The ditch liquor is aerated by one or more brush or rotors placed across the channel.

At present, there are few oxidation ditches in the hot climate due to the fact that stabilization ponds are usually more favourable both in terms of cost and the removal of faecal coliform, although where there is a reliable electricity supply with insufficient land for pond, they are being increasingly used.

A design of oxidation ditch is purely empirical at the present time. According to the Mara report,[1/] the depth is in the range 1 - 2 m and the volume is dependent on the retention time which in turn is based on the sludge loading factor. This is the weight of BOD applied to the ditch liquor suspended solids per day.

There, the sludge loading factor is given by following equation.

$$r = \frac{Li}{St}$$

Where

r = sludge loading factor, 1/d
Li = influent BOD, mg/l
S = ditch liquor suspended solids, mg/l
t = detention time, days

Then, ditch volume is estimated as follow.

$$V = \frac{LiQ}{Sr}$$

Where

V = ditch volume, cu m
Q = flow, cu m/day

1/ "Sewage Treatment in Hot Climate", by Duncan Mara

The design values of this study are taken as $r = 0.1\ d^{-1}$, $S = 4{,}000$ mg/1 and detention time (t) = 0.5 days and, depth is assumed as 1.5 m.

(3) Comparison of Alternative Treatment and Disposal Systems

For the purpose of cost comparison of alternative treatment and disposal systems for the (1) stabilization pond, (2) aerated lagoon and (3) oxidation ditch, firstly each type of treatment facilities were designed to flow rate of waste water from 5,000 to 200,000 cu m daily average flow with associated facilities, due to the required effluent quality.

The waste water quality of each treatment was estimated with the influent BOD as 200 mg/1 and the effluents that expected BOD is of 75-90 percent removal of influent BOD for the design values.

The each type of treatment was analysed and/or made of all costs accruing to alternative considered. Considered each type of methods of treatment and disposal systems for alternative study are furnished as described below and illustrated as Figure G-2.

1) A method of stabilization pond process shall consist of the facultative pond and maturation pond.

2) A method of aerated lagoon process shall consist of the aerated lagoon and maturation pond.

3) A method of oxidation ditch process shall consist of oxidation ditch, sedimentation tank, and drying bed.

The capital costs of the each selected alternative of sewage treatment on the flow rate from 5,000 to 200,000 cu m daily average flow were estimated with associated quipment in plants on the basis of cost functions developed for the purpose of Master Plan as discussed in Appendix E."Design Data"and annual operation and maintenance costs for these facilities also estimated.

Table G-1 shows the estimation of construction, operation and maintenance costs of the treatment and disposal systems and required land area for the system. All costs are at 1976 level in the Penang site, but no consideration is given to cost escalation for purpose of economic comparison between alternatives.

For comparison purpose, all costs are then expressed on an annual basis, using the following weighted average lives of facilities.

(a) pond, tank	30 years
(b) pump, aerator	7 years

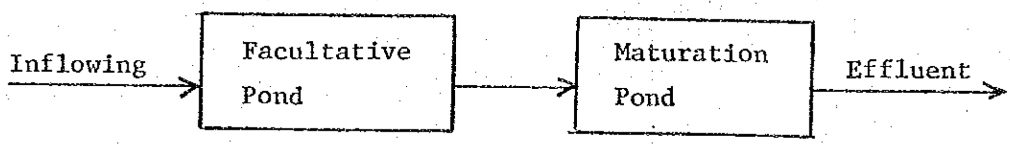
These overall useful lives are estimated on the basis of the useful lives of component facilities, 30 years for civil works and 7 years for machinery of equipment. It is assumed that the fund is available at 10 percent interest and that annual depreciation payments into the sinking fund would grow the some rate.

Depreciated capital costs of the alternative systems are summarized in Table G-2, and total annual costs for the alternatives are shown in Table G-3.

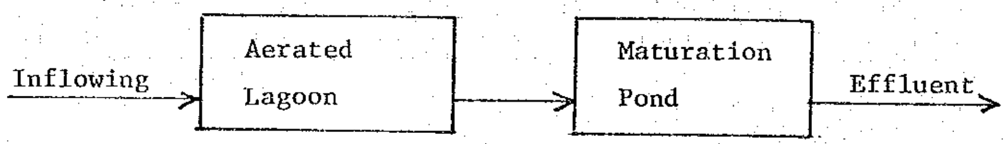
The results of cost analysis indicate that alternarive (i) (method of stabilization pond process) would be the most economical method for treatment and disposal system, in terms of total annual cost.

FIGURE G-2 Flow Sheet

(1) Stabilization pond process



(2) Aerated lagoon process



(3) Oxidation ditch process

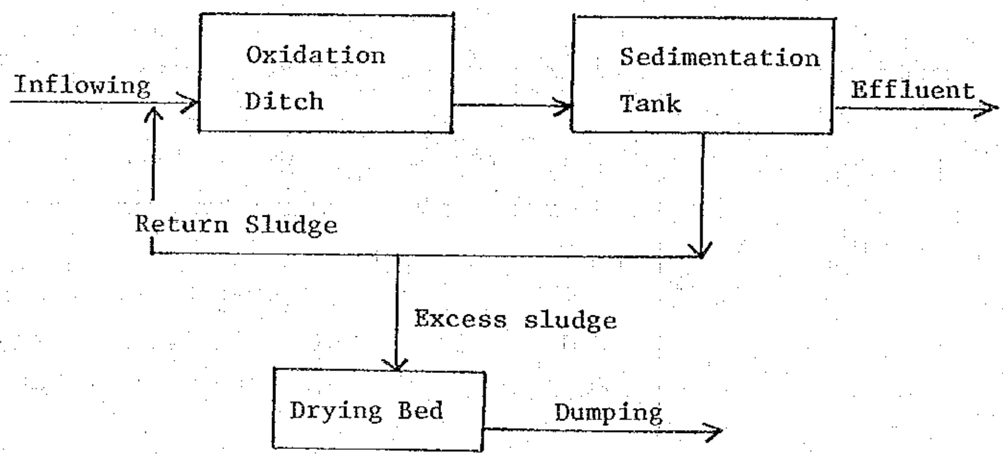


TABLE G-1: Comparison on Alternative Treatment/Disposal Systems

Alternative	Flow Rate (cu m/day)				
	5,000	10,000	50,000	100,000	200,000
1) Construction Costs (1,000 M$)					
Alt. I Stabilization Pond Process	524	1,048	5,240	10,480	20,960
Alt. II Aerated Lagoon Process	1,141	2,276	11,350	22,640	45,280
Alt. III Oxidation Ditch Process	982	1,887	9,051	17,333	34,666
2) Operation & Maintenance Costs (1,000 M$/year)					
Alt. I Stabilization Pond Process	10.95	11.20	13.50	16.30	21.90
Alt II Aerated Lagoon Process	28.35	45.76	177.55	344.16	677.39
Alt. III Oxidation Ditch Process	75.98	142.93	588.06	1,101.23	2,167.42
3) Land Area Required (ha)					
Alt. I Stabilization Pond Process	6.0	11.2	52.4	98.7	197.3
Alt. II Aerated Lagoon Process	2.3	4.3	20.2	38.0	76.1
Alt. III Oxidation Ditch Process	0.6	1.1	4.9	9.2	18.5

Note: Estimated construction costs do not include the costs required for land of treatment Plant.

TABLE G-2: Depreciated Costs for Alternative Treatment/Disposal Systems

(1,000 M$)

Alternative	Flow Rate (cu m/day)				
	5,000	10,000	50,000	100,000	200,000
Alt. I Stabilization Pond Process	3.19	6.37	31.86	63.72	127.44
Alt. II Aerated Lagoon Process	7.68	15.32	76.39	152.37	304.73
Alt. III Oxidation Ditch Process	45.92	88.24	423.22	810.49	1,620.98

TABLE G-3: Total Annual Cost of Alternative Treatment/ Disposal Systems

(1,000 M$)

Alternative	Flow Rate (cu m/day)				
	5,000	10,000	50,000	100,000	200,000
Alt. I Stabilization pond Process	66.8	122.7	571.0	1,131.4	2,252.0
Alt. II Aerated Lagoon Process	150.2	288.8	1,389.3	2,761.2	5,511.4
Alt. III Oxidation Ditch Process	220.1	419.9	1,916.3	3,644.9	7,254.7

CHAPTER 3

COST ANALYSIS OF SYSTEMS

3.1 General

Economic analysis was made of the alternatives sewerage systems, which would indicate competitive solutions for provisions of sewerage facilities in the sewerage implementation area up to the year 2000. Descriptions of the physical features and comparative analysis of these alternatives are presented in this chapter, and conclusions are drawn as to the most effective sewerage system. In the analysis, sewage flows and costs incurred are studied over 20-year period to the year 2000.

3.2 Design Basis of Facilities

Design basis used in this study are presented in chapter 5. part III, "Sewerage Master Plan." The possible routes of conveyance facilities and locations of sewage treatment sites for the sewerage system are shown in Figure G-3. Ground elevations and sewer service areas for each of these sewer lines are estimated on the basis of the available topographic maps in the scale of 1:7500 to 1:25000, and sewage flow rates in this sewer lines are computed to determine the size of the facilities. The design criterias used are summarized in Table G-4.

For the cost estimates, sewage quantities for the conveyance facilities are estimated from the projected populations and sewage flow rates for the year 2000 as presented in Table G-6, G-7 and rough profiles of major sewers are prepared.

TABLE G-4 Estimated Wastewater Flow Rates (2000)

Type of Wastewater	Estimated Flow Rates
1. Per Capita Sewage Flow	230 liter/day
2. Industrial Wastewater in Zone	80 cu m/ha/day
3. Infiltration	
° Residential of High density	12 cu m/ ha/day
° " of Low density	8 cu m/ ha/day
° Industrial	5 cu m/ ha/day

TABLE G-5 Population Density (2000)

Land Use	Residential		Social and Commercial	Industrial
	High density	Low density		
Population Density (persons/ha)	160-120	52	0, 120, 160	0

TABLE G-6: Population of Sewerage Zone (in 2000)

Name of Sewerage Zone		Area(ha)	Population
Butterworth	1	367	45,440
	2	182	21,840
	3	457	37,039
	4	444	37,514
	5	551	33,705
	6	670	37,316
Sub-total		2,671	212,854
Seberang Jaya	1	438	46,748
	2	305	25,178
	3	510	26,543
	4	430	20,818
	5	368	19,152
Sub-total		2,051	138,439
Prai	1	1,063	0
	2	268	13,948
Sub-total		1,331	13,948
Bukit Mertajam	1	892	47,512
	2	715	39,794
	3	927	73,729
	4	467	24,917
	5	459	23,889
	6	573	32,948
	7	768	39,970
Sub-total		4,801	282,759
Total		10,854	648,000

TABLE G-7: Design Sewage Flow Rate of Sewerage Zone (in 2000)

Sewerage Zene		Area (ha)	Wastewater Domestic (cu m/day)	Wastewater Industrial (cu m/day)	Extraneous (cu m/day)	Total (cu m/day)
Butterworth	1	367	10,450	1,600	3,700	15,750
	2	182	5,020	-	2,190	7,210
	3	457	8,520	8,560	4,440	21,520
	4	444	8,630	-	4,400	13,030
	5	551	7,750	-	4,700	12,450
	6	670	8,580	-	5,510	14,090
Sub-total		2,671	48,950	10,160	24,940	84,050
Seberang Jaya						
	1	438	10,750	160	4,920	15,830
	2	305	5,790	4,000	3,120	12,910
	3	510	6,110	-	4,080	10,190
	4	430	4,790	-	3,560	8,350
	5	368	4,400	-	2,950	7,350
Sub-total		2,051	31,840	4,160	18,630	54,630
Prai	1	1,063	-	85,040	5,320	90,360
	2	268	3,210	-	2,150	5,360
Sub-total		1,331	3,210	85,040	7,470	95,720
Bukit Mertajam						
	1	892	10,930	-	7,200	18,130
	2	715	9,150	-	5,870	15,020
	3	927	16,960	-	8,920	25,880
	4	467	5,730	-	3,770	9,500
	5	459	5,500	-	3,670	9,170
	6	573	7,580	-	4,770	12,350
	7	768	9,190	-	6,110	15,300
Sub-total		4,801	65,040	-	40,310	105,350
Total		10,854	149,040	99,360	91,350	339,750

(a) Collection System

In determining the required capacities of conveyance facilities, the following factors are considered.

i) Peak flow rates of domestic sewage
ii) Peak flow rates of industrial wastewater.
iii) Groundwater infiltration
iv) Depth of excavation
v) Location of treatment facilities
vi) Pumping requirement
vii) Design velocities and other design criteria.

(b) Pumping Stations

Pumping stations are designed to raise sewage from deep sewers, generally those with more than 7 m of earth covering, to higher elevation sewers in order to permit continuing flow by gravity. These intermediate pumping stations are provided with suitable structures, grit and/or debris facilities, and pumping equipment to lift the peak sewage flow rates.

(c) Sewage Treatment Facilities

For comparison purposes, sewage treatment plants are considered at the terminal of each zones. In determining locations and process of treatment for treatment plants for each zone, an evaluation is made of the effects of the waste discharges on the receiving water environment.

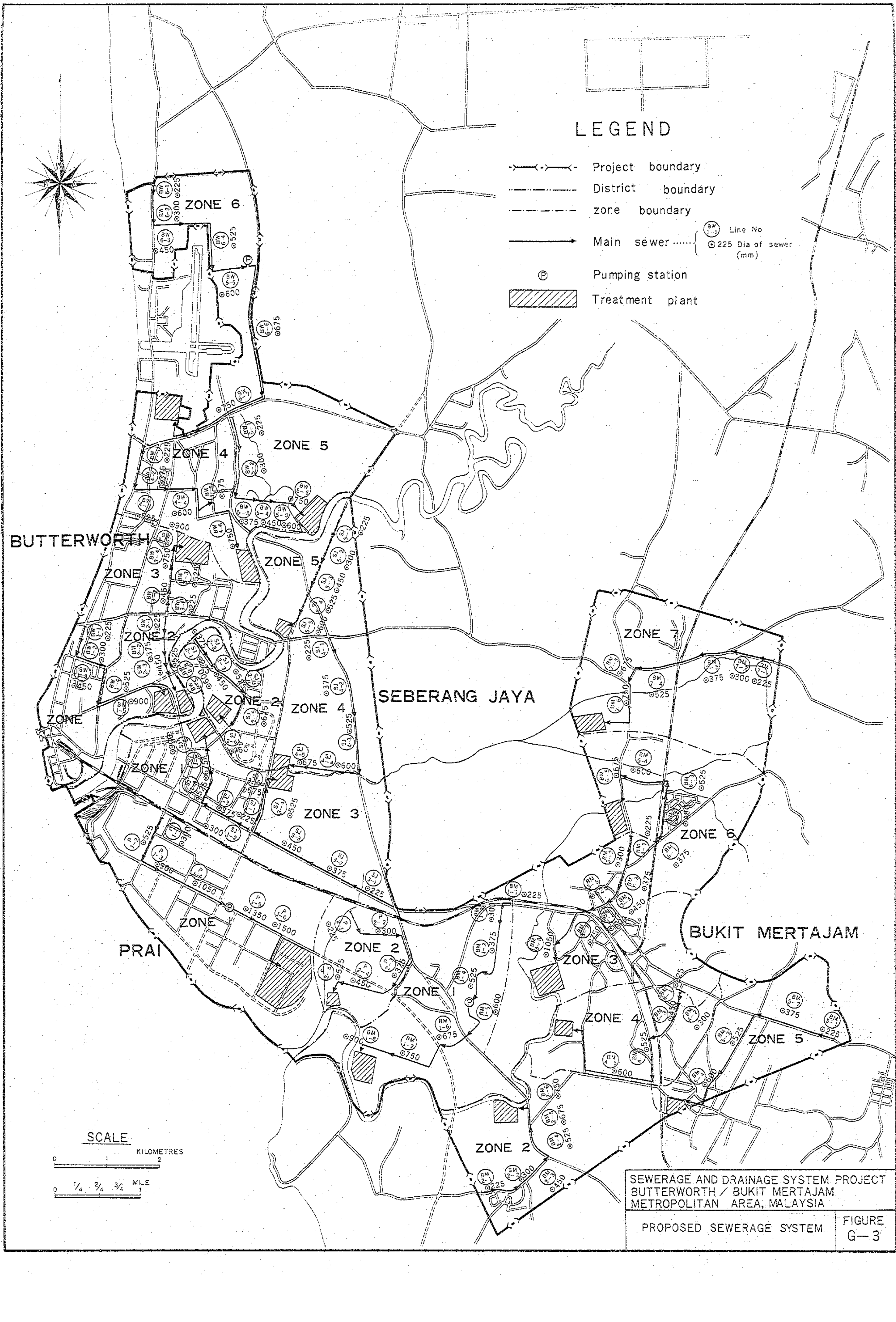
For practical purposes for cost comparisons, the costs are determined using the cost functions for treatment facilities for all treatment plants discharging to rivers and waterways. The design capacities of these plants are determined on the basis of the daily average flow.

3.3 Cost Estimates of the Systems

On the basis of the designed sewerage systems, costs of sewage conveyance, pumping stations, and treatment facilities are estimated for cost comparison.

The cost estimating procedures are on the basis of cost functions developed in Appendix E,"Design Data"based on recent costs for constructing major projects in the State of Penang, and from up-to-date materials cost quotations from manufactures in Malaysia.

Proposed sewerage facilities by zone (illustrated in Figure B-3), construction cost, and operation and maintenance cost at 1976 price of proposed sewerage system is tabulated in Tables G-8, G-9, and G-10 respectively.


LEGEND
Project boundary
District boundary
zone boundary
Main sewer
Line No
⊙225 Dia of sewer (mm)
Pumping station
Treatment plant
BUTTERWORTH
SEBERANG JAYA
BUKIT MERTAJAM
PRAI
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
ZONE 6
ZONE 7
SCALE
KILOMETRES
0 1 2
MILE
0 1/4 2/4 3/4 1
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
PROPOSED SEWERAGE SYSTEM
FIGURE G-3

TABEL G-8: Proposed Sewerage Facilities by Zone

Name of Sewerage Zone	Public Sewer		House Connection		Pumping Station		Treatment Plant		
	Dia. (m)	Length (m)	Dia. (m)	Length (m)	Peak flow (cu m/s)	Req'd land area (sq m)	Pro-cess	Average flow (cu m/day)	Req'd land area (ha)
Butterworth, Zone-1	225-900	92,200	150	110,800			S.P.	15,800	17.6
2	" -600	54,600	"	65,500			"	7,200	8.4
3	" -900	116,800	"	125,700			"	21,500	23.6
4	" -750	133,200	"	111,100			"	13,000	14.6
5	" -750	165,300	"	98,200			"	12,500	14.1
6	" -750	201,000	"	108,000	0.18	100	"	14,100	15.8
Seberang Jaya, Zone-1	225-900	131,000	"	140,000			"	15,800	17.6
2	" -750	82,000	"	88,700			"	12,900	14.5
3	" -675	153,000	"	76,500			"	10,200	11.6
4	" -675	129,000	"	70,800			"	8,400	9.7
5	" -600	110,400	"	55,200			"	7,400	8.6
Prai, Zone-1	225-1,500	116,900	"	148,800	0.89	1,540	"	90,400	92.0
2	" - 525	80,400	"	40,200			"	5,400	6.4
Bukit Mertajam, Zone-1	225 - 900	267,600	"	137,200	0.14	90	"	18,100	20.0
2	" - 750	214,500	"	115,200			"	15,000	16.8
3	" -1,050	278,100	"	217,800			"	25,900	28.1
4	" - 600	140,100	"	71,900			"	9,500	10.9
5	" - 600	137,700	"	68,900			"	9,200	10.5
6	" - 675	171,900	"	95,600			"	12,400	14.0
7	" - 750	230,400	"	115,200			"	15,300	17.1

Note: S.P. ---------- Stabilization Pond

TABLE G-9: Construction Cost of Proposed Sewerage System at 1976 Price

(1,000 M$)

Name of Sewerage Zone	Sewer			Pumping Station		Treatment Plant			Total		
	Public (Main) *	Public (Branch & Lateral)	House Connection	Land Cost *	Const'n Cost *	Process	Land Cost *	Const'n Cost *	(1)	(2)	(1)+(2)
Butterworth,											
Zone - 1	6,370	8,820	3,320			S.P.	2,270	2,100	10,740	12,140	22,880
2	2,480	5,350	1,970			"	1,080	1,050	4,610	7,320	11,930
3	6,290	10,290	3,770			"	1,530	2,750	10,570	14,060	24,630
4	7,690	13,050	3,330			"	950	1,740	10,380	16,380	26,760
5	8,710	16,200	2,950			"	60	1,670	10,440	19,150	29,590
6	13,570	19,700	3,240	0.3	230	"	3,400	1,870	19,070	22,940	42,010
Seberang Jaya,											
Zone - 1	7,150	12,820	4,200			"	3,780	2,080	13,010	17,020	30,030
2	4,970	7,500	2,660			"	3,120	1,730	9,820	10,160	19,980
3	7,830	14,990	2,300			"	2,490	1,400	11,720	17,290	29,010
4	6,740	12,640	2,120			"	2,090	1,200	10,030	14,760	24,790
5	5,690	10,820	1,660			"	1,850	1,070	8,610	12,480	21,090
Prai Zone - 1	19,910	-	4,460	40	4,750	"	19,780	16,610	61,090	4,460	65,550
2	3,580	7,880	1,210			"	190	830	4,600	9,090	13,690
Bukit Mertajam											
Zone - 1	13,300	26,220	4,110	0.3	200	"	100	2,340	15,940	30,330	46,270
2	9,400	21,020	3,460			"	500	1,970	11,870	24,480	36,350
3	12,130	27,250	6,530			"	840	3,270	16,240	33,780	50,020
4	6,300	13,730	2,160			"	330	1,320	7,950	15,890	23,840
5	6,120	13,490	2,070			"	320	1,280	7,720	15,560	23,280
6	7,490	16,850	2,870			"	420	1,660	9,570	19,720	29,290
7	10,170	22,580	3,460			"	260	2,010	12,440	26,040	38,480
Total	165,890	281,200	61,850	40	5,180		45,360	49,950	266,420	343,050	609,470

Note: (1)--- government contribution
(2)--- private contribution
* --- included in (1)

TABLE G-10: Operation & Maintenance Cost of Proposed Sewerage System at 1976 Price Level

(1,000 M$/year)

Name of Sewerage Zone	Sewer		Pumping Station	Treatment Plant	Total
	Public Portion	Private Portion			
Butterworth, Zone-1	50	190	-	60	300
2	30	110	-	40	180
3	70	210	-	70	350
4	70	240	-	50	360
5	80	270	-	40	390
6	100	320	30	50	500
Sub-Total	400	1,340	30	310	2,080
Seberang Jaya, Zone-1	70	260	-	60	390
2	50	150	-	50	250
3	80	230	-	40	350
4	70	200	-	40	310
5	60	170	-	40	270
Sub-Total	330	1,010	-	230	1,570
Prai, Zone-1	200	100	110	160	570
2	40	130	-	30	200
Sub-Total	240	230	110	190	770
Bukit Mertajam, Zone-1	140	420	20	60	640
2	110	340	-	50	500
3	140	480	-	70	690
4	70	220	-	40	330
5	70	210	-	40	320
6	90	270	-	50	410
7	120	350	-	50	520
Sub-Total	740	2,290	20	360	3,410
Total	1,710	4,870	160	1,090	7,830

ANNEX G-1

COMPUTATION FOR DESIGN OF MAIN SEWERS

The following table is computation form for design of a part of main sewers in Butterworth Zone-1 illustrated in Figure G-3. Other main sewers, branch, and lateral sewer are also designed as same manner.

COMPUTATION FOR DESIGN OF MAIN SEWERS

Butterworth Zone - 1

Line No.	Sewer Length (m)	Area		Ave. Daily Flow (1)			(2) Peak Flow Total (cu m/s)	Design of Sewer				Sewer Invert Elevation		Elevation Grand Surface		Earth Covering		Remark
		Increment (ha)	Total (ha)	Domestic (cu m/d)	Industrial (cu m/d)	Extraneous (cu m/d)		Dia. (mm)	Slope of Sewer (o/oo)	Velocity Full (m/s)	Capacity Full (cu m/s)	Upper End (m)	Lower End (m)	Upper End (m)	Lower End (m)	Upper End (m)	Lower End (m)	
BW1-1	440	9.0	-	330	-	110	0.019	θ 225	3.0	0.62	0.025	1.215	-0.105	2.44	2.55	1.00	2.13	
BW1-2	210	10.0	19.0	700	-	230	0.038	θ 300	2.4	0.67	0.047	-0.180	-0.684	2.25	2.20	2.13	2.58	
BW1-3	640	46.0	65.0	2,390	-	780	0.109	θ 450	1.8	0.76	0.121	-0.834	-1.986	2.20	2.45	2.58	3.99	
BW1-4	690	35.0	100.0	3,680	-	1,200	0.159	θ 525	1.5	0.77	0.167	-2.061	-3.096	2.45	2.41	3.99	4.98	
BW1-5	1,350	220.0	320.0	10,450	1,600	3,700	0.451	θ 900	0.9	0.85	0.543	-3.471	-4.686	2.41	2.10	4.98	5.89	
	To Treatment Plant																	

Note: (2) = (1) x Peaking factor (See Appendix E)

ANNEX G-2

DISCHARGE TABLE

(for Circular Pipe MANNING'S FORMURA n=0.013)

The following tables are used for determining the required pipe diameter and slope based on the sewage flow rate.

Dia. of Sewer (m)	0.150		0.225		0.300		0.375		0.450		0.525		0.600	
Sectional area (sq.m)	0.018		0.040		0.071		0.110		0.159		0.216		0.283	
Wetted perimeter (m)	0.471		0.707		0.942		1.178		1.414		1.649		1.885	
Hydraulic radius (m)	0.037		0.056		0.075		0.094		0.112		0.131		0.150	
Slope of sewer (o/oo)	Velocity Full (m/s)	Capacity Full (cu m/s)	Velocity Full (m/s)	Capacity Full (cu m/s)	Velocity Full (m/s)	Capacity Full (cu m/s)	Velocity Full (m/s)	Capacity Full (cu m/s)	Velocity Full (m/s)	Capacity Full (cu m/s)	Velocity Full (m/s)	Capacity Full (cu m/s)	Velocity Full (m/s)	Capacity Full (cu m/s)
14.0	1.020	0.018	1.336	0.053	1.619	0.114	1.878	0.207	2.121	0.337	2.351	0.509	2.569	0.727
13.0	0.983	0.017	1.288	0.051	1.560	0.110	1.810	0.200	2.044	0.325	2.265	0.490	2.476	0.700
12.0	0.944	0.017	1.237	0.049	1.499	0.106	1.739	0.192	1.964	0.312	2.176	0.471	2.379	0.673
11.0	0.904	0.016	1.184	0.047	1.435	0.101	1.665	0.184	1.880	0.299	2.084	0.451	2.278	0.644
10.0	0.862	0.015	1.129	0.045	1.368	0.097	1.587	0.175	1.793	0.285	1.987	0.430	2.172	0.614
9.0	0.818	0.014	1.071	0.043	1.298	0.092	1.506	0.166	1.701	0.270	1.885	0.408	2.060	0.583
8.5	0.795	0.014	1.041	0.041	1.261	0.089	1.464	0.162	1.653	0.263	1.832	0.396	2.002	0.566
8.0	0.771	0.014	1.010	0.040	1.224	0.086	1.420	0.157	1.603	0.255	1.777	0.385	1.942	0.549
7.5	0.746	0.013	0.978	0.039	1.185	0.084	1.375	0.152	1.552	0.247	1.720	0.372	1.881	0.532
7.0	0.721	0.013	0.945	0.038	1.145	0.081	1.328	0.147	1.500	0.239	1.662	0.360	1.817	0.514
6.5	0.695	0.012	0.910	0.036	1.103	0.078	1.280	0.141	1.445	0.230	1.602	0.347	1.751	0.495
6.0	0.668	0.012	0.875	0.035	0.060	0.075	1.230	0.136	1.389	0.221	1.539	0.333	1.682	0.476
5.5	0.639	0.011	0.838	0.033	1.015	0.072	1.177	0.130	1.329	0.211	1.473	0.319	1.611	0.455
5.0	0.609	0.011	0.799	0.032	0.967	0.068	1.123	0.124	1.268	0.202	1.405	0.304	1.536	0.434
4.5	0.578	0.010	0.758	0.030	0.918	0.065	1.065	0.118	1.203	0.191	1.333	0.288	1.457	0.412
4.0	0.545	0.010	0.714	0.028	0.865	0.061	1.004	0.111	1.134	0.180	1.256	0.272	1.373	0.388
3.5	0.510	0.009	0.668	0.027	0.809	0.057	0.939	0.104	1.061	0.169	1.175	0.254	1.285	0.363
3.0	0.472	0.008	0.619	0.025	0.749	0.053	0.869	0.096	0.982	0.156	1.088	0.236	1.189	0.336
2.8	0.456	0.008	0.598	0.024	0.724	0.051	0.840	0.093	0.949	0.151	1.051	0.228	1.149	0.325
2.6	0.439	0.008	0.576	0.023	0.698	0.049	0.809	0.089	0.914	0.145	1.013	0.219	1.107	0.313
2.5	0.431	0.008	0.565	0.022	0.684	0.048	0.794	0.088	0.896	0.143	0.993	0.215	1.086	0.307
2.4	0.422	0.007	0.553	0.022	0.670	0.047	0.778	0.086	0.878	0.140	0.973	0.211	1.064	0.301
2.2	0.404	0.007	0.530	0.021	0.642	0.045	0.745	0.082	0.841	0.134	0.932	0.202	1.019	0.288
2.0	0.385	0.007	0.505	0.020	0.612	0.043	0.710	0.078	0.802	0.128	0.888	0.192	0.971	0.275
1.9	0.376	0.007	0.492	0.020	0.596	0.042	0.692	0.076	0.781	0.124	0.866	0.187	0.947	0.268
1.8	0.366	0.006	0.479	0.019	0.580	0.041	0.674	0.074	0.761	0.121	0.843	0.182	0.921	0.261
1.7	0.355	0.006	0.466	0.019	0.564	0.040	0.655	0.072	0.739	0.118	0.819	0.177	0.895	0.253
1.6	0.345	0.006	0.452	0.018	0.547	0.039	0.635	0.070	0.717	0.114	0.795	0.172	0.869	0.246
1.5	0.334	0.006	0.437	0.017	0.530	0.037	0.615	0.068	0.694	0.110	0.769	0.167	0.841	0.238
1.4	0.322	0.006	0.423	0.017	0.512	0.036	0.594	0.066	0.671	0.107	0.743	0.161	0.813	0.230
1.3	0.311	0.005	0.407	0.016	0.493	0.035	0.572	0.063	0.646	0.103	0.716	0.155	0.783	0.221
1.2	0.299	0.005	0.391	0.016	0.474	0.033	0.550	0.061	0.621	0.099	0.688	0.149	0.752	0.213
1.1	0.286	0.005	0.375	0.015	0.454	0.032	0.527	0.058	0.595	0.095	0.659	0.143	0.720	0.204
1.0	0.273	0.005	0.357	0.014	0.433	0.031	0.502	0.055	0.567	0.090	0.628	0.136	0.687	0.194
0.9	0.259	0.005	0.339	0.013	0.410	0.029	0.476	0.053	0.538	0.086	0.596	0.129	0.651	0.184
0.8	0.244	0.004	0.319	0.013	0.387	0.027	0.449	0.050	0.507	0.081	0.562	0.122	0.614	0.174
0.7	0.228	0.004	0.299	0.012	0.362	0.026	0.420	0.046	0.474	0.075	0.526	0.114	0.575	0.162
0.6	0.211	0.004	0.277	0.011	0.335	0.024	0.389	0.043	0.439	0.070	0.487	0.105	0.532	0.150
0.5	0.193	0.003	0.253	0.010	0.306	0.022	0.355	0.039	0.401	0.064	0.444	0.096	0.486	0.137
0.4	0.172	0.003	0.226	0.009	0.274	0.019	0.317	0.035	0.359	0.057	0.397	0.086	0.434	0.123

Dia. of Sewer (m)	0.675		0.750		0.900		1.050		1.200		1.350		1.500	
Sectional area (sq.m)	0.358		0.442		0.636		0.866		1.131		1.431		1.767	
Wetted perimeter (m)	2.121		2.356		2.827		3.299		3.770		4.241		4.712	
Hydraulic radius (m)	0.169		0.188		0.225		0.262		0.300		0.337		0.375	
Slope of sewer (o/oo)	Velocity Full (m/s)	Capacity Full (cu m/s)	Velocity Full (m/s)	Capacity Full (cu m/s)	Velocity Full (m/s)	Capacity Full (cu m/s)	Velocity Full (m/s)	Capacity Full (cu m/s)	Velocity Full (m/s)	Capacity Full (cu m/s)	Velocity Full (m/s)	Capacity Full (cu m/s)	Velocity Full (m/s)	Capacity Full (cu m/s)
14.0	2.779	0.995	2.982	1.317	3.367	2.142	3.731	3.231	4.079	4.613	4.412	6.315	4.733	8.364
13.0	2.678	0.958	2.873	1.269	3.245	2.064	3.596	3.114	3.930	4.445	4.252	6.086	4.561	8.060
12.0	2.573	0.921	2.760	1.220	3.117	1.983	3.455	2.991	3.776	4.271	4.085	5.847	4.382	7.744
11.0	2.464	0.882	2.643	1.168	2.985	1.899	3.308	2.864	3.615	4.089	3.911	5.598	4.195	7.414
10.0	2.349	0.841	2.520	1.113	2.846	1.810	3.154	2.731	3.447	3.899	3.729	5.337	4.000	7.069
9.0	2.228	0.797	2.391	1.056	2.700	1.717	2.992	2.591	3.270	3.699	3.537	5.063	3.795	6.706
8.5	2.166	0.775	2.323	1.026	2.624	1.669	2.907	2.518	3.178	3.594	3.438	4.921	3.688	6.517
8.0	2.101	0.752	2.254	0.996	2.545	1.619	2.821	2.442	3.083	3.487	3.335	4.774	3.578	6.323
7.5	2.034	0.728	2.182	0.964	2.464	1.568	2.731	2.365	2.985	3.376	3.229	4.622	3.464	6.122
7.0	1.965	0.703	2.108	0.931	2.381	1.515	2.639	2.285	2.884	3.262	3.120	4.466	3.347	5.914
6.5	1.894	0.678	2.032	0.898	2.294	1.460	2.543	2.202	2.779	2.143	3.006	4.303	3.225	5.699
6.0	1.820	0.651	1.952	0.862	2.204	1.402	2.443	2.115	2.670	3.020	2.888	4.134	3.099	5.476
5.5	1.742	0.623	1.869	0.826	2.110	1.343	2.339	2.025	2.557	2.891	2.765	3.958	2.967	5.242
5.0	1.661	0.594	1.782	0.787	2.012	1.280	2.230	1.931	2.438	2.757	2.637	3.774	2.829	4.998
4.5	1.576	0.564	1.690	0.747	1.909	1.214	2.116	1.832	2.312	2.615	2.501	3.580	2.683	4.742
4.0	1.486	0.532	1.594	0.704	1.800	1.145	1.995	1.727	2.180	2.466	2.358	3.376	2.530	4.471
3.5	1.390	0.497	1.491	0.659	1.683	1.071	1.866	1.616	2.039	2.307	2.206	3.158	2.367	4.182
3.0	1.287	0.460	1.380	0.610	1.559	0.992	1.727	1.496	1.888	2.135	2.042	2.923	2.191	3.872
2.8	1.243	0.445	1.333	0.589	1.506	0.958	1.669	1.445	1.824	2.063	1.973	2.824	2.117	3.740
2.6	1.198	0.429	1.285	0.568	1.451	0.923	1.608	1.392	1.758	1.988	1.901	2.722	2.040	3.604
2.5	1.175	0.420	1.260	0.557	1.423	0.905	1.577	1.365	1.724	1.949	1.864	2.669	2.000	3.534
2.4	1.151	0.412	1.235	0.545	1.394	0.887	1.545	1.338	1.689	1.910	1.827	2.615	1.960	3.463
2.2	1.102	0.394	1.182	0.522	1.335	0.849	1.479	1.281	1.617	1.829	1.749	2.503	1.876	3.316
2.0	1.051	0.376	1.127	0.498	1.273	0.810	1.410	1.221	1.542	1.744	1.668	2.387	1.789	3.161
1.9	1.024	0.366	1.098	0.485	1.240	0.789	1.375	1.190	1.503	1.699	1.625	2.327	1.744	3.081
1.8	0.997	0.357	1.069	0.472	1.207	0.768	1.338	1.159	1.463	1.654	1.582	2.264	1.697	2.999
1.7	0.969	0.347	1.039	0.459	1.173	0.746	1.300	1.126	1.421	1.607	1.537	2.201	1.649	2.915
1.6	0.940	0.336	1.008	0.445	1.138	0.724	1.261	1.092	1.379	1.559	1.492	2.135	1.600	2.828
1.5	0.910	0.326	0.976	0.431	1.102	0.701	1.221	1.058	1.335	1.510	1.444	2.067	1.549	2.738
1.4	0.879	0.315	0.943	0.417	1.065	0.677	1.180	1.022	1.290	1.459	1.395	1.997	1.497	2.645
1.3	0.847	0.303	0.909	0.401	1.026	0.653	1.137	0.985	1.243	1.406	1.344	1.924	1.442	2.549
1.2	0.814	0.291	0.873	0.386	0.986	0.627	1.092	0.946	1.194	1.351	1.292	1.849	1.386	2.449
1.1	0.779	0.279	0.836	0.369	0.944	0.600	1.046	0.906	1.143	1.293	1.237	1.770	1.327	2.344
1.0	0.743	0.266	0.797	0.352	0.900	0.572	0.997	0.864	1.090	1.233	1.179	1.688	1.265	2.235
0.9	0.705	0.252	0.756	0.334	0.854	0.543	0.946	0.819	1.034	1.170	1.119	1.601	1.200	2.121
0.8	0.664	0.238	0.713	0.315	0.805	0.512	0.892	0.772	0.975	1.103	1.055	1.510	1.131	1.999
0.7	0.621	0.222	0.667	0.295	0.753	0.479	0.834	0.722	0.912	1.032	0.987	1.412	1.058	1.870
0.6	0.575	0.206	0.617	0.273	0.697	0.443	0.772	0.669	0.844	0.955	0.913	1.307	0.980	1.732
0.5	0.525	0.188	0.563	0.249	0.636	0.405	0.705	0.611	0.771	0.872	0.834	1.193	0.894	1.581
0.4	0.470	0.168	0.504	0.223	0.569	0.362	0.631	0.546	0.689	0.780	0.746	1.067	0.800	1.414

APPENDIX H

STAGING OF SEWERAGE CONSTRUCTION

Table of Conents

CHAPTER 1

INTRODUCTION

The provision of a complete wastewater and stormwater sewerage system for an area of the size of the proposed Project Area with its large and expanding population, is a task of tremendous magnitude.

Therefore, it is only prudent and sound to build the required facilities in stages, according to the urgency of need and benefits to be derived. Stage construction will spread capital expenditure over an extended period of years, as well as saving interest on borrowed capital and reducing initial costs. In addition, experience gained in the early construction programme will permit necessary review and re-evaluation of the plan for any continuing construction programme.

A study has therefore been made to determine the priority of work and the desirable stages of sewerage construction, taking into account the various important elements which affect sanitary conditions in the Project Area, based on use of a reasonable rating procedure.

CHAPTER 2

RATING OF SANITARY CONDITIONS

2.1 Basic considerations for Rating

The elements considered in selecting the priority of sewerage districts for implementation of sewerage construction up to the year 2000 include for following six items, each of which has impacts on environmental sanitation in the Project Area.

1) Population Density
2) Waste Load
3) Excreta Disposal System
4) Flooding
5) Availability of Water Supply
6) Incidence of Water-borne Diseases

The above-mentioned six elements are each assigned by the different evaluation points to reflect their relative importance to the sanitation, and each of the twenty sewerage zones, divided out of Butterworth, Seberang Jaya, Prai, and Bukit Mertajam sewerage districts, is evaluated carefully and graded according to the rating for each element for the purpose of establishing sewerage priority for implementation.

In addition to these six elements, another important element, housing and industrial development programme conducted by State Government is taken into account on staging of sewerage implementation. The areas under development programme will be given high priority on the request of State Government not concerned with the result of this rating procedure.

2.2 Application of Rating System

For the purpose of rating system, a total of 1,000 points is assigned to each of six major elements, according to order of importance, as described below.

(1) One of the most important factors is the number of persons who will be benefited by the system. It is therefore particulary significant to provide sewerage facilities in high population density area, in order to gain the maximum benefit to the maximum population with the minimum expenditures thus making the benefit-cost ratio higher. Hence, highest point is assigned for the population density.

(2) Second highest point is assigned for the waste load production aspects. According to the current situation of Project Area, waste load produced from the housing, commercial and industrial area are generally discharged into drains and rivers without passing through the treatment plant, except the septic tank, while no comprehensive water pollution control programme covering the whole area has been provided, hence it is necessary to give high priority on the maximum control of the waste load currently discharged into drains and rivers.

(3) Since there is no sanitary sewerage system in the Project Area, except a few loacl systems, practically all of the excreta produced in the area is disposed of either by septic tank, bucket, pit privy or directly to waterways. As the existing excreta disposal system is not satisfactory from the view point of enviornmental sanitation, the third highest point is assigned to this item.

(4) Although the government has undertaken improvement of existing streams and drains, flooding has frequently occurrred causing damage to the built-up urban areas. These areas which have signigicantly affecting the sanitary conditions should be improved by provision of sewerage system. Therefore, flooding factor is given the fourth highest weighted points.

The remaining element, namely (5) availability of water supply, and (6) incidence of water borne diseases also affect to sanitation problems but these are less critical than four other categories, and are given the same weighted points to both of them.

In view of these factors, the six elements, all of which affect sanitary conditions, are given points arbitarily according to their importance for the rating in terms of the year 1976 & 2000, as given below:

1)	Population Density	400
2)	Waste Load	250
3)	Excreta Disposal System	150
4)	Flooding	100
5)	Availability of Water Supply	50
6)	Incidence of Water-Borne Disease	50
	Total	1,000 points

Further comments on these factors are discussed in the following section:

2.2.1 Population Density

Population densities, both present and future, by sewerage zones, range approximately from 0 person per hectare in zone 2 of Seberang Jaya district and zone 1 of Prai district to 124 persons per hectare in zone 1 of Butterworth district, as presented in Table H-1 and Figures H-1 & 2. For purpose of rating, 200 points given both to present and future population densities as follows:

Assigned Points	Present and/or Future population density
200	100 p/ha or more
150	75 - 100 p/ha
100	50 - 75 "
50	25 - 50 "
0	0 - 25 "

As shown in Table H-2, the highest rating zone is 1 of Butterworth district, which is assigned as full 400 points, followed by the zones 3 and 4 of Butterworth, and zone 1 of Seberang Jaya district.

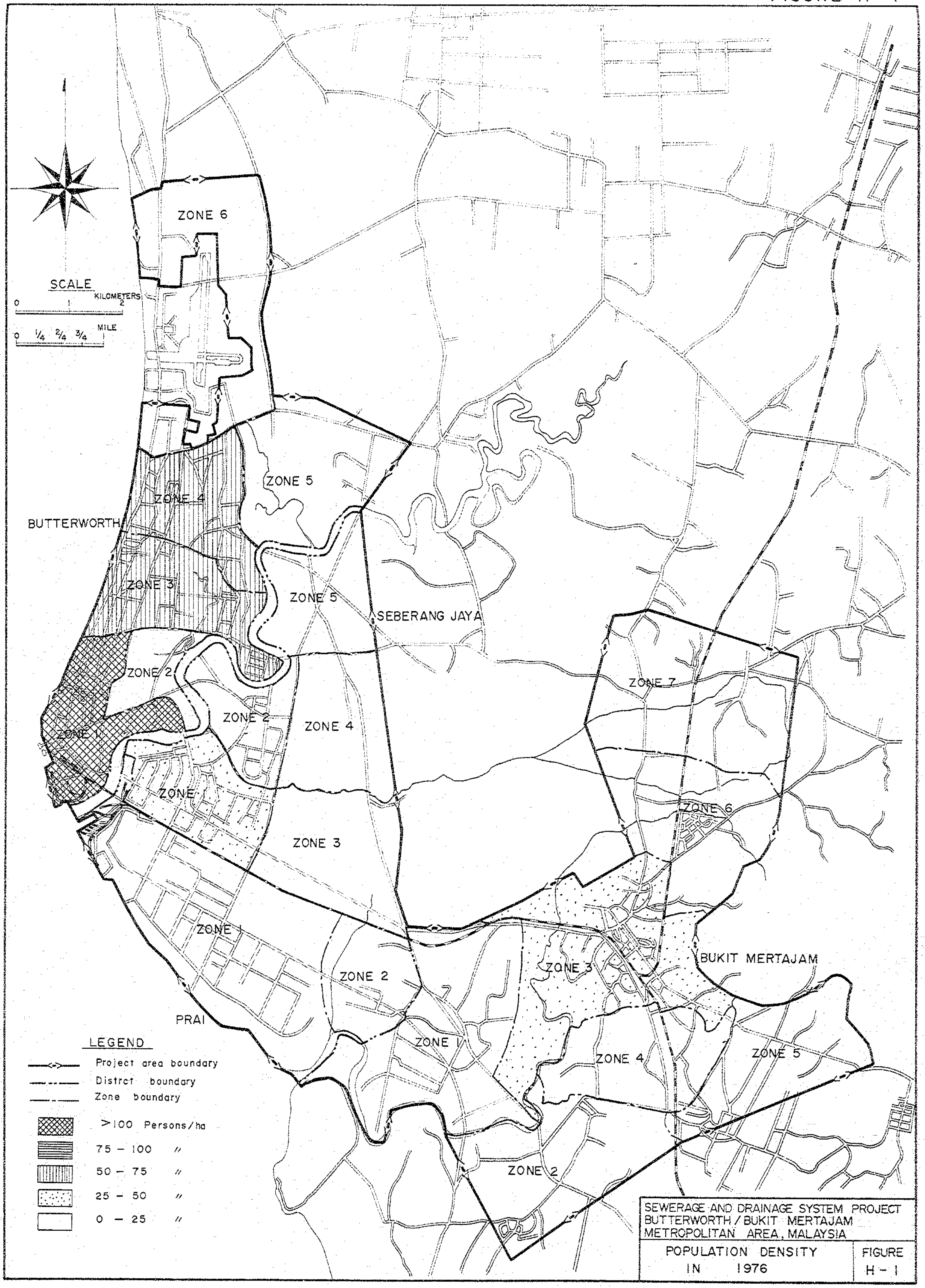
TABLE H-1 Population Density by Sewerage Zones

District	Zone	Sewerage Area Considered	1976		2000	
			Population	Population Density	Population	Population Density
		* (ha)	(persons)	(persons/ha)	(persons)	(person/ha)
Butterworth	1	367	37,920	103.3	45,440	123.8
	2	182	3,585	19.7	21,840	120.0
	3	457	28,255	61.8	37,039	81.0
	4	444	26,332	59.3	37,514	84.5
	5	551	3,961	7.2	33,705	61.2
	6	670	8,902	13.3	37,316	55.7
Seberang Jaya	1	438	13,657	31.2	46,748	106.7
	2	305	69	0.2	25,178	82.6
	3	510	2,991	5.9	26,543	52.0
	4	430	7,518	17.5	20,818	48.4
	5	368	4,369	11.9	19,152	52.0
Prai	1	1,063	1,860	1.7	0	0
	2	268	1,974	7.4	13,948	52.0
Bukit Mertajam	1	892	7,559	8.5	47,512	53.3
	2	715	6,387	8.9	39,794	55.7
	3	927	45,540	49.1	73,729	79.5
	4	467	6,077	13.0	24,917	53.4
	5	459	7,257	15.8	23,889	52.0
	6	573	13,840	24.2	32,948	57.5
	7	768	9,947	13.0	39,970	52.0
Total		10,854	238,000	21.9	648,000	59.5

* These figures do not include areas of mountain, rivers and ponds.

TABLE H-2 Results of Assessment for Population Density Aspect

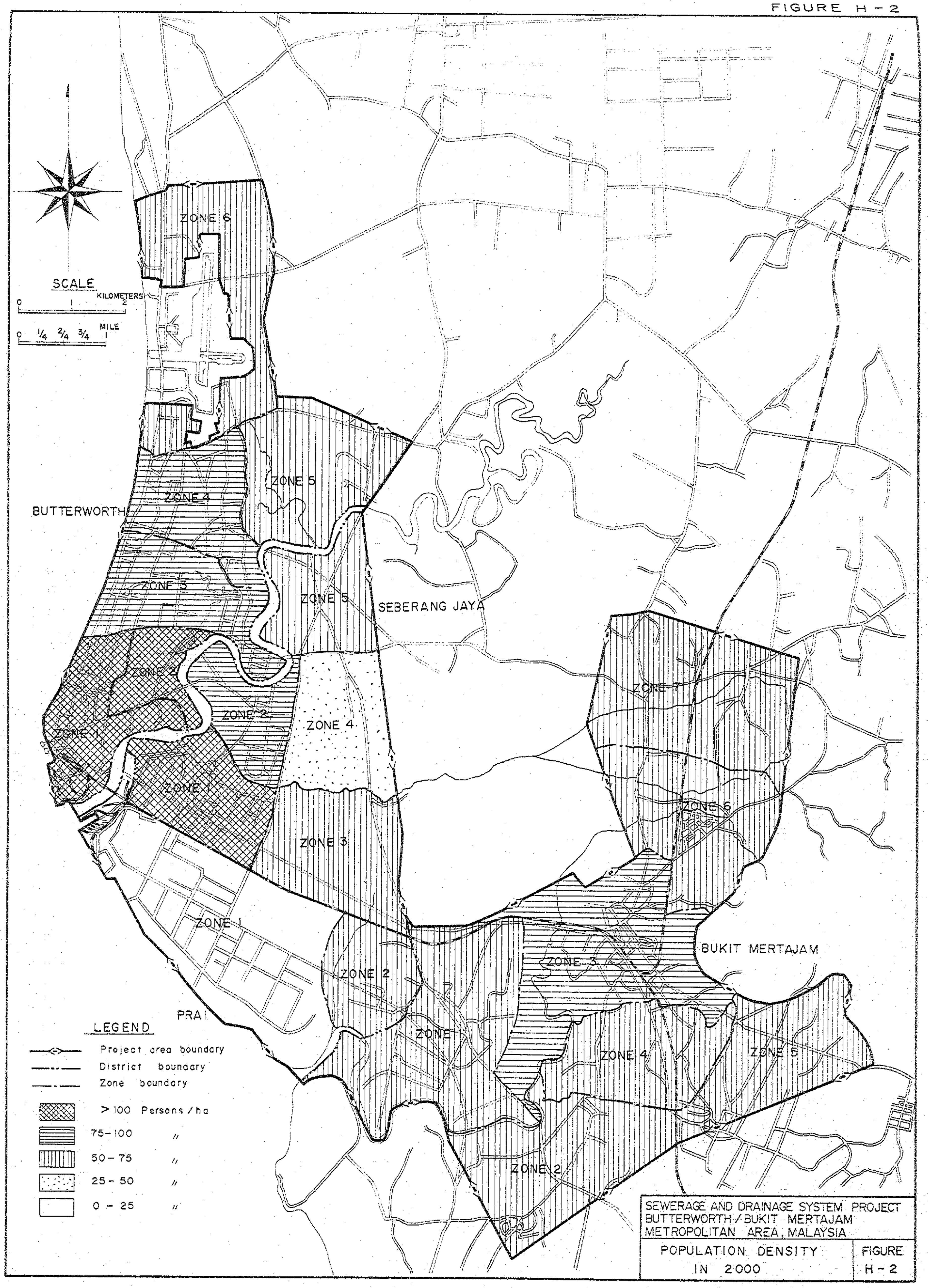
District	Zone	Assessment Points		
		1976	2000	Total
Butterworth	1	200	200	400
	2	0	200	200
	3	100	150	250
	4	100	150	250
	5	0	100	100
	6	0	100	100
Seberang Jaya	1	50	200	250
	2	0	150	150
	3	0	100	100
	4	0	50	50
	5	0	100	100
Prai	1	0	0	0
	2	0	100	100
Bukit Mertajam	1	0	100	100
	2	0	100	100
	3	50	150	200
	4	0	100	100
	5	0	100	100
	6	0	100	100
	7	0	100	100



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

POPULATION DENSITY IN 1976

FIGURE H-1


SCALE
KILOMETERS 0 1 2
MILE 0 1/4 2/4 3/4 1
ZONE 6
ZONE 5
ZONE 4
BUTTERWORTH
ZONE 3
ZONE 5
SEBERANG JAYA
ZONE 2
ZONE 1
ZONE 2
ZONE 4
ZONE 1
ZONE 3
ZONE 7
ZONE 6
ZONE 1
ZONE 2
BUKIT MERTAJAM
ZONE 3
PRAI
ZONE
ZONE 4
ZONE 5
ZONE 2
LEGEND
Project area boundary
District boundary
Zone boundary
> 100 Persons / ha
75-100 "
50-75 "
25-50 "
0-25 "
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
POPULATION DENSITY
IN 2000
FIGURE
H-2

2.2.2 Waste Loads

According to the investigation on present project carried out in the Project Area, streams are generally polluted by the depositary of domestic sewage, and industrial waste, hence it is necessary to establish the control of the waste load discharged into waterways. For the purpose of rating, waste load originating within the area of each sewerage zone is estimated from two view points considered, namely per hectare waste load production and per capita burden aspect, and then calculation of waste load is made both for the present and the year 2000 projections.

Table H-3 indicates the result of the per hectare waste load produced. The calculation of waste load within the residential area is made by served population, water consumption of 230 l/cap/day (50 IMG/cap/day) and waste load production of 200 mg/l in terms of BOD. For the industrial area, calculation also is made by multipling waste water production of 100 cu m/ha/day to the waste load production of BOD of 150 mg/l.

Table H-4 indicates the result of the per capita waste burden which will be benefited by the sewerage, in terms of BOD throughout residential and industrial areas.

As may be seen from Table H-3, zone 1 of Prai district of industrial area, shows the most heavily produced waste load on the basis of per hectare production, both at present and by the year 2000 on the basis of the expected development of industrial area, but there is no waste load production indicated in Table H-4, on the year 2000, in terms of per capita waste burden, because of this is an industrial area which have no served population. Therefore, an assessment for this sewerage zone will be given to the lower priority.

In this rating, a total of 250 points are assigned, divided into an assessment of 100 for the per hectare production, and 25 points for per capita burden production both for the present and the year 2000 respectively, and then an evaluation is made of each of sewerage zones with respect to the point of waste load produced in the project area in terms of BOD level, as presented in Table H-5 and H-6.

As shown in Tables H-5 and H-6, the calculation of evaluated number on the basis of per hectare production and per capita burden is indicated by the percentage of the waste loads to be produced in each of sewerage zone, to the total waste loads in Project Area.

Then for the rating of each of sewerage zone, the following points both for the present and the year 2000 is given, according to the above mentioned, and calculated numbers are:

(1) Based on Per Hectare Production

Assessment points	Evaluation Numbers	
	1976	2000
100	20 more	15 more
75	15 - 20	10 - 15
50	10 - 15	5 - 10
25	5 - 10	3 - 5
0	0 - 5	0 - 3

(2) Based on Per Capita Burden

Assessment Points	Evaluation Numbers	
	1976	2000
25	40 more	10 more
15	20 - 40	5 - 10
5	10 - 20	3 - 5
0	0 - 10	0 - 3

The results of the assessment is indicated in Table H-7.

TABLE H-3 Estimated Waste Load

District	Zone	Waste Load (Kg/ha/day) 1976	Waste Load (Kg/ha/day) 2000
Butterworth	1	8.6	8.4
	2	1.8	4.2
	3	7.2	7.2
	4	2.8	3.9
	5	0.6	2.8
	6	0.6	2.6
Seberang Jaya	1	1.8	5.0
	2	1.7	6.3
	3	0.3	2.4
	4	0.9	2.2
	5	0.8	2.4
Prai	1	11.7	15.0
	2	0.4	2.4
Bukit Mertajam	1	0.5	2.5
	2	0.4	2.6
	3	3.0	3.7
	4	0.6	2.5
	5	0.7	2.4
	6	1.1	2.6
	7	0.6	2.4
Total		46.1	83.5

TABLE H-4 Estimated Waste Load Production

District	Zone	Waste Load (g/cap/day) 1976	Waste Load (g/cap/day) 2000
Butterworth	1	73	68
	2	46	46
	3	103	89
	4	46	46
	5	46	46
	6	46	46
Seberang Jaya	1	48	47
	2	6,350	77
	3	46	46
	4	46	46
	5	46	46
Prai	1	5,199	0
	2	46	46
Bukit Mertajam	1	46	46
	2	46	46
	3	46	46
	4	46	46
	5	46	46
	6	46	46
	7	46	46
Total		12,415	924

TABLE H-5 Evaluation Numbers for Waste Load (per Hectare)

District	Zone	Evaluation Number	
		1976	2000
Butterworth	1	19	10
	2	4	5
	3	16	9
	4	6	5
	5	1	3
	6	1	3
Seberang Jaya	1	4	6
	2	4	8
	3	1	3
	4	2	3
	5	2	3
Prai	1	25	18
	2	1	3
Bukit Mertajam	1	1	3
	2	1	3
	3	7	4
	4	1	3
	5	2	3
	6	2	3
	7	1	3

TABLE H-6 Evaluation Numbers for Waste Load (per Capita)

District	Zone	Evaluation Number	
		1976	2000
Butterworth	1	1	7
	2	0	5
	3	1	10
	4	0	5
	5	0	5
	6	0	5
Seberang Jaya	1	0	5
	2	51	8
	3	0	5
	4	0	5
	5	0	5
Prai	1	42	0
	2	0	5
Bukit Mertajam	1	0	5
	2	0	5
	3	0	5
	4	0	5
	5	0	5
	6	0	5
	7	0	5

TABLE H-7 Results of Assessment for Waste Loads

District	Zone	Per hectare production		Per capita burden		Total Assesment Point
		1976	2000	1976	2000	
Butterworth	1	75	75	0	15	165
	2	0	50	0	15	65
	3	75	50	0	25	150
	4	25	50	0	15	90
	5	0	25	0	15	40
	6	0	25	0	15	40
Seberang Jaya	1	0	50	0	15	65
	2	0	50	25	15	90
	3	0	25	0	15	40
	4	0	25	0	15	40
	5	0	25	0	15	40
Prai	1	100	100	25	0	225
	2	0	25	0	15	40
Bukit Mertajam	1	0	25	0	15	40
	2	0	25	0	15	40
	3	25	25	0	15	65
	4	0	25	0	15	40
	5	0	25	0	15	40
	6	0	25	0	15	40
	7	0	25	0	15	40

2.2.3 Excreta Disposal System

The existing exreta disposal system in the Project Area is represented generally two systems, namely septic tank and bucket systems. Most of the population in the new housing development areas use the flush toilets with communal septic tank, while most of the rural population use the bucket system, and some of the built-up areas are covered by mixture of the septic tank and bucket systems.

Figure H-2 shows location of the present excreta disposal system covered by the septic tank and bucket systems. But, no information is available on the exact condition of these excreta disposal systems and its serving population throughout the sewerage zones.

However, according to the population and housing census in Malaysia in 1970, excreta disposal conditions relative to the sewerage district are shown in proportion to the types of toilet as follows:

Name of local council area	Type of Toilet in Percentage					
	Flush	Bucket	Pit	River	None	Total
Butterworth	31	60	6	1	2	100
Prai	24	67	3	4	2	100
Bukit Mertajam	28	69	2	-	1	100
Other*	28	64	16	5	8	100

* Other is the estimation by the weighted ratio of population density in the rural area of various Kampong.

For the purpose of rating, proportion of toilet systems in each sewerage zone is determined arbitrarily by distributing the same with the above percentages, with 150 points for the sewerage zones where no excreta disposal system exists, but for the areas where septic tank are generally functioning reasonably satisfactorily, proportionately lower points are given according to the functioning condition with the idea that the existing facilities will be reserved for the time being until further investment for complete sewerage system coverage warrants.

As indicated in Table H-8, the evaluation in each sewerage zone is thus made by the proportion of unsatisfactory excreta disposal system to the population density, and the following points are given by the number estimated.

Assessment Point	Evaluation Number
150	60 more
75	30 - 60
0	0 - 30

For all the sewerage zones, rating is given as summarized in Table H-9.

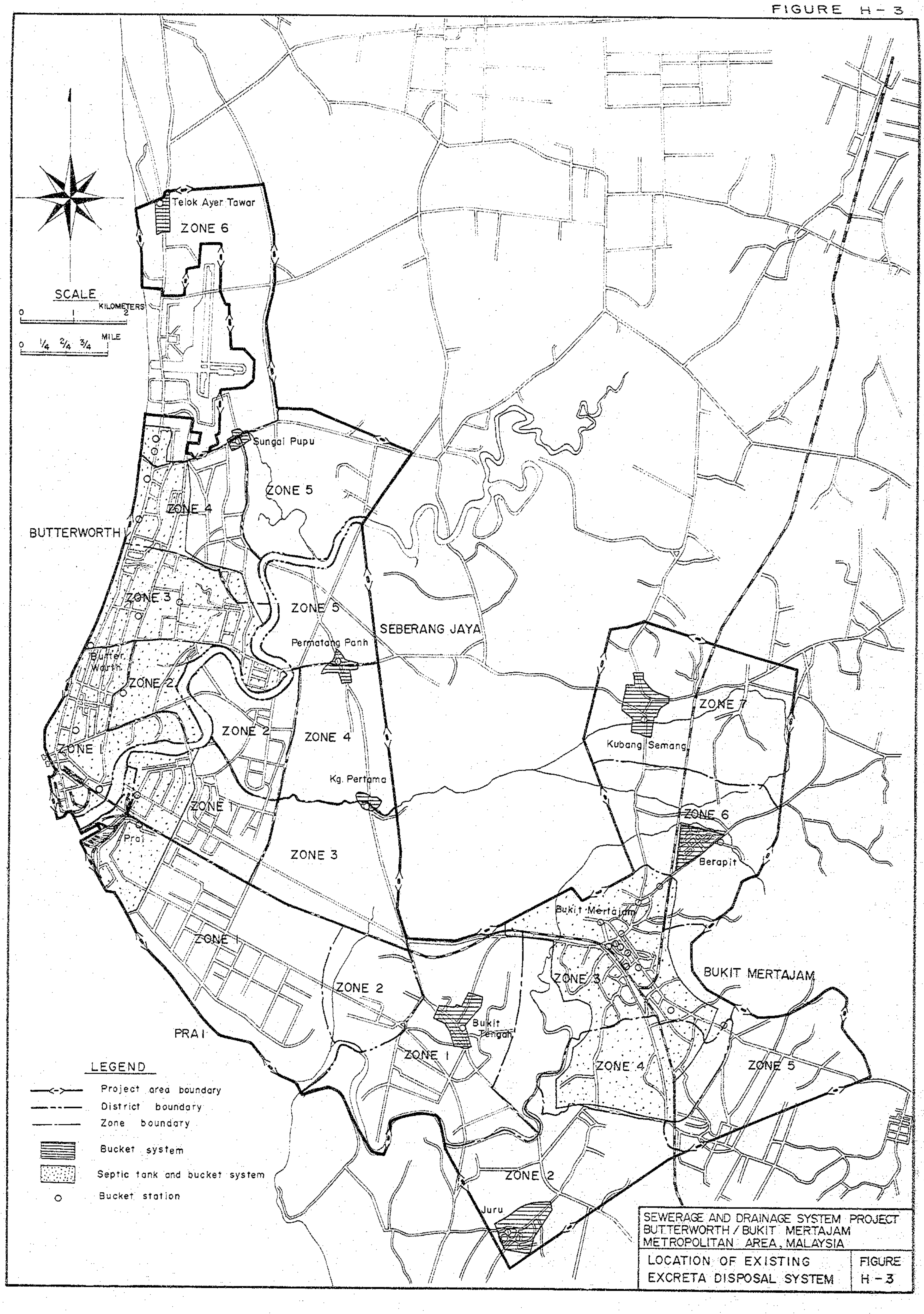
TABLE H-8 Evaluation Number for Excreta Disposed System

District	Zone	Percentage of un-satisfactory excreta disposal system (%) (a)	Population density on 1976 (b)	Evaluation Number by population density (a)x(b)x100
Butterworth	1	69	103.3	71
	2	69	19.7	14
	3	69	61.8	43
	4	69	59.3	41
	5	93	7.2	7
	6	93	13.3	12
Seberang Jaya	1	76	31.2	24
	2	93	0.2	0
	3	93	5.9	5
	4	93	17.5	16
	5	93	11.9	11
Prai	1	76	1.7	1
	2	93	7.4	7
Bukit Mertajam	1	93	8.5	8
	2	93	8.9	8
	3	72	49.1	35
	4	72	13.0	9
	5	93	15.8	15
	6	93	24.2	23
	7	93	13.0	12

TABLE H-9 Result of Assessment for Excreta Disposal System

District	Zone	Assessment Point
Butterworth	1	150
	2	0
	3	75
	4	75
	5	0
	6	0
Seberang Jaya	1	0
	2	0
	3	0
	4	0
	5	0
Prai	1	0
	2	0
Bukit Mertajam	1	0
	2	0
	3	75
	4	0
	5	0
	6	0
	7	0

FIGURE H-3


Telok Ayer Tawar
ZONE 6
SCALE
0 1 2 KILOMETERS
0 1/4 2/4 3/4 1 MILE
Sungai Pupu
ZONE 5
ZONE 4
BUTTERWORTH
ZONE 3
ZONE 5
SEBERANG JAYA
Permatang Panh
Butter-worth
ZONE 2
ZONE 2
ZONE 4
ZONE 1
Kg. Pertama
ZONE 1
Prai
ZONE 3
ZONE 7
Kubang Semang
ZONE 6
Berapit
Bukit Mertajam
ZONE 1
ZONE 2
ZONE 3
BUKIT MERTAJAM
Bukit Tengah
PRAI
ZONE 1
ZONE 4
ZONE 5
ZONE 2
Juru
LEGEND
Project area boundary
District boundary
Zone boundary
Bucket system
Septic tank and bucket system
Bucket station
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
LOCATION OF EXISTING EXCRETA DISPOSAL SYSTEM
FIGURE H-3

2.2.4 Flooding

As shown in Figure H-4, in the areas marked, flooding has occurred most frequently.

For the purpose of rating, only the areas marked in Butterworth and Bukit Mertajam districts are considered, because the other marked areas in Seberang Jaya, Prai and some areas of Bukit Mertajam district are defined to be the area of wet land, and these areas have yet to develop with the ponding, when there are incidences of heavy rainfall and hightides.

Therefore, following sewerage zones are given arbitrarily to be considered for the rating, even though there are no available records with regard to flood incidence on damage caused in these areas.

District	Zone	Flooded Area (ha)
Butterworth	1	7.9
	3	70.8
	4	4.1
Bukit Mertajam	3	70.0

Depending on conditions, a total of 100 points are assigned to the flooding aspect, and the ratio of extent of flooding to the total area of each sewerage zones is calculated for the assessment points as follows:

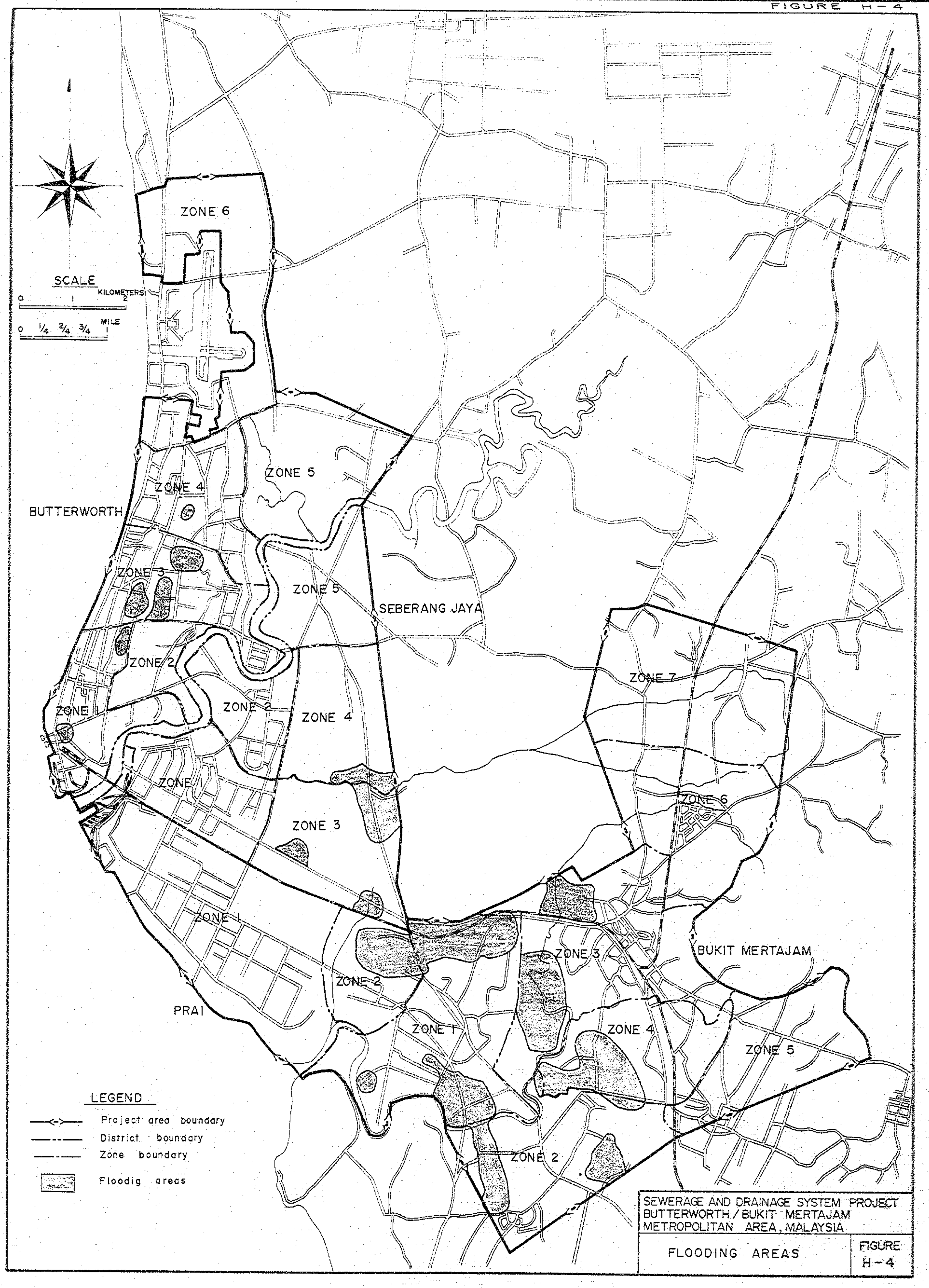
District	Zone	Area(ha)	Flooded Area(ha)	Ratio
Butterworth	1	390	7.9	2
	3	490	70.8	14
	4	450	4.1	1
Bukit Mertajam	3	980	70.0	7

Then, an assessment point for rating is given the following points according to the ratio of extent of flooding.

Assessment points	Ratio
100	5 more
50	1 - 5

The results of the rating are as follows:

District	Zone	Point
Butterworth	1	50
	3	100
	4	50
Bukit Mertajam	3	100


SCALE
KILOMETERS
0
1
2
MILE
0
1/4
2/4
3/4
1
ZONE 6
ZONE 5
ZONE 4
BUTTERWORTH
ZONE 3
ZONE 5
SEBERANG JAYA
ZONE 2
ZONE 1
ZONE 2
ZONE 4
ZONE 7
ZONE 1
ZONE 3
ZONE 6
ZONE 1
BUKIT MERTAJAM
ZONE 2
ZONE 3
PRAI
ZONE 1
ZONE 4
ZONE 5
ZONE 2
LEGEND
Project area boundary
District boundary
Zone boundary
Floodig areas
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
FLOODING AREAS
FIGURE
H-4

2.2.5 Availability of Water Supply

The master plan of water supply for the state of Penang including Project Area in Province Wellesley, prepared by Binnie & Partners, is programmed to be implemented by stages followed by the first, second and third stage projects.

The first stage is planned to construct the barrage, canal, pumping stations, pipelines in Penang Island, Butterworth and Prai which are covering Project Area, and 22,727 cu m (5 MIG) reservoirs at Bukit Dumbar and Bukit Indira Muda to be completed during the years from 1968 to 1977.

The second and third stages are planned to extend in predicting future water requirement up to the year 2000, and will be covered 100 percents of the served population area. Figure H-6 shows the existing water supply service area in Project Area, covering the main pipes of water supply.

On the basis of the review of the existing water supply and master plan, the entire area of sewerage zones are evaluated to determine their ratio of water supply service area to the sewerage zone area at present and the year 2000, as shown in Table H-11, and multiplied by the assigned points, 25 points for the sewerage zones where water supply system is available in 1976, 25 points for the sewerage zones to be provided by the year 2000. The result of rating is indicated in Table H-12.

TABLE H-11 Water Service Areas by Sewerage Zone

District	Zone	Area	Served Area (%) 1976		Served Area (%) 2000
Butterworth	1	367	367	(100)	(100)
	2	182	182	(100)	(100)
	3	457	457	(100)	(100)
	4	444	444	(100)	(100)
	5	551	375	(68)	(100)
	6	670	570	(85)	(100)
Seberang Jaya	1	438	381	(87)	(100)
	2	305	305	(100)	(100)
	3	510	474	(93)	(100)
	4	430	254	(59)	(100)
	5	368	298	(81)	(100)
Prai	1	1,063	617	(58)	(100)
	2	268	161	(60)	(100)
Bukit Mertajam	1	892	580	(65)	(100)
	2	715	458	(64)	(100)
	3	927	751	(81)	(100)
	4	467	425	(91)	(100)
	5	459	399	(87)	(100)
	6	573	350	(61)	(100)
	7	768	507	(66)	(100)

* The Numbers put in parentheses show the percentage of served water supply area.

TABLE H-12 Results of Assessment for Availability of Water Supply

District	Zone	Assessment Points		
		1976	2000	Total
Butterworth	1	25	25	50
	2	25	25	50
	3	25	25	50
	4	25	25	50
	5	17	25	42
	6	21	25	46
Seberang Jaya	1	22	25	47
	2	25	25	50
	3	23	25	48
	4	15	25	40
	5	20	25	45
Prai	1	15	25	40
	2	15	25	40
Bukit Mertajam	1	16	25	41
	2	16	25	41
	3	20	25	45
	4	23	25	48
	5	21	25	46
	6	15	25	40
	7	17	25	42