4.4 Treatment Facilities

Cost functions for three different treatment processes, namely statilization pond, aerated lagoon, and oxidation ditch, are developed.

In developing the cost functions for treatment facilities, the following assumption are made;

(a) Daily average number of operator is 2 (two) persons for 5,000 m^3/day plant and 2.5 persons for 50,000 m^3/day plant for stabilization pond and aerated lagoon processes, and for oxidation ditch process, 4 (four) persons for 5,000 m^3/day plant and 8 (eight) persons for 50,000 m^3/day plant are required,

(b) Electricity is M¢8/kWh and average salary of operator is M$20/day, and

(c) Repairs and overhauling of parts are estimated at one percent of capital cost of civil works and two percent of machanical and electrical works.

The operation and maintenance costs by capacity and treatment process are then estimated as shown in Table G-13 and Figures G-7, G-8 and G-9.

On the basis of these figures in Table G-13, functions for annual operation and maintenance costs of the three treatment plants are obtained as follows;

(1) For stabilization pond process

$$C_{MS} = 1.263 \times 10^{-3} Q + 14.55$$

(ii) For aerated lagoon process

$$C_{MA} = 6.768 \times 10^{-3} Q + 31.29$$

(iii) For oxidation ditch

$$C_{MO} = 1.793 \times 10^{-2} Q + 22.29$$

where C_{MS}, C_{MA}, C_{Mo} : Annual operation and maintenance costs, M$ 1,000/year

Q : Daily average flow, m^3/day

Table G-13 Annual Operation and Maintenance Costs for Three Treatment Process by Capacity

(M$1,000)

Item \ Capacity (m^3/day)	5,000	10,000	30,000	50,000
(a) Stabilization Pond				
. Salary	14.60	14.97	16.79	18.25
. Electricity, etc.	-	-	-	-
. Repairs & Replacement of Parts	7.05	10.62	37.22	58.81
Total	21.65	25.59	54.01	77.06
(b) Aerated Lagoon				
. Salary	14.60	14.97	16.79	18.25
. Electricity, etc.	31.54	63.07	189.22	278.43
. Repairs & Replacement of Parts	10.99	20.73	46.68	62.80
Total	57.13	98.77	252.69	359.48
(c) Oxidation Ditch				
. Salary	29.20	43.80	51.10	58.40
. Electricity, etc.	61.25	122.50	407.16	685.80
. Repairs & Replacement of Parts	19.53	37.12	102.92	174.10
Total	109.98	203.42	561.18	918.30

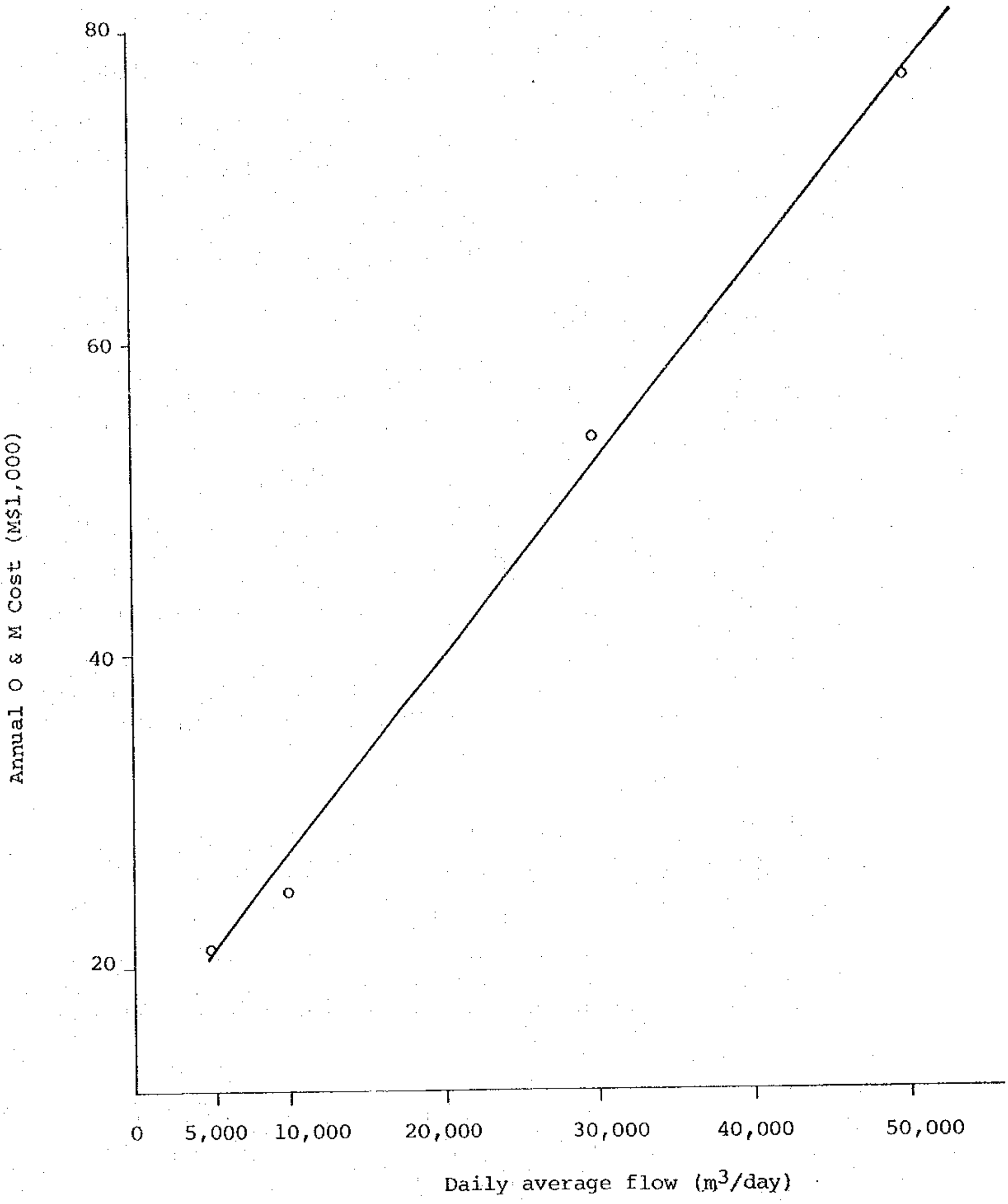


Figure G-7 Annual operation and maintenance cost for stabilization pond

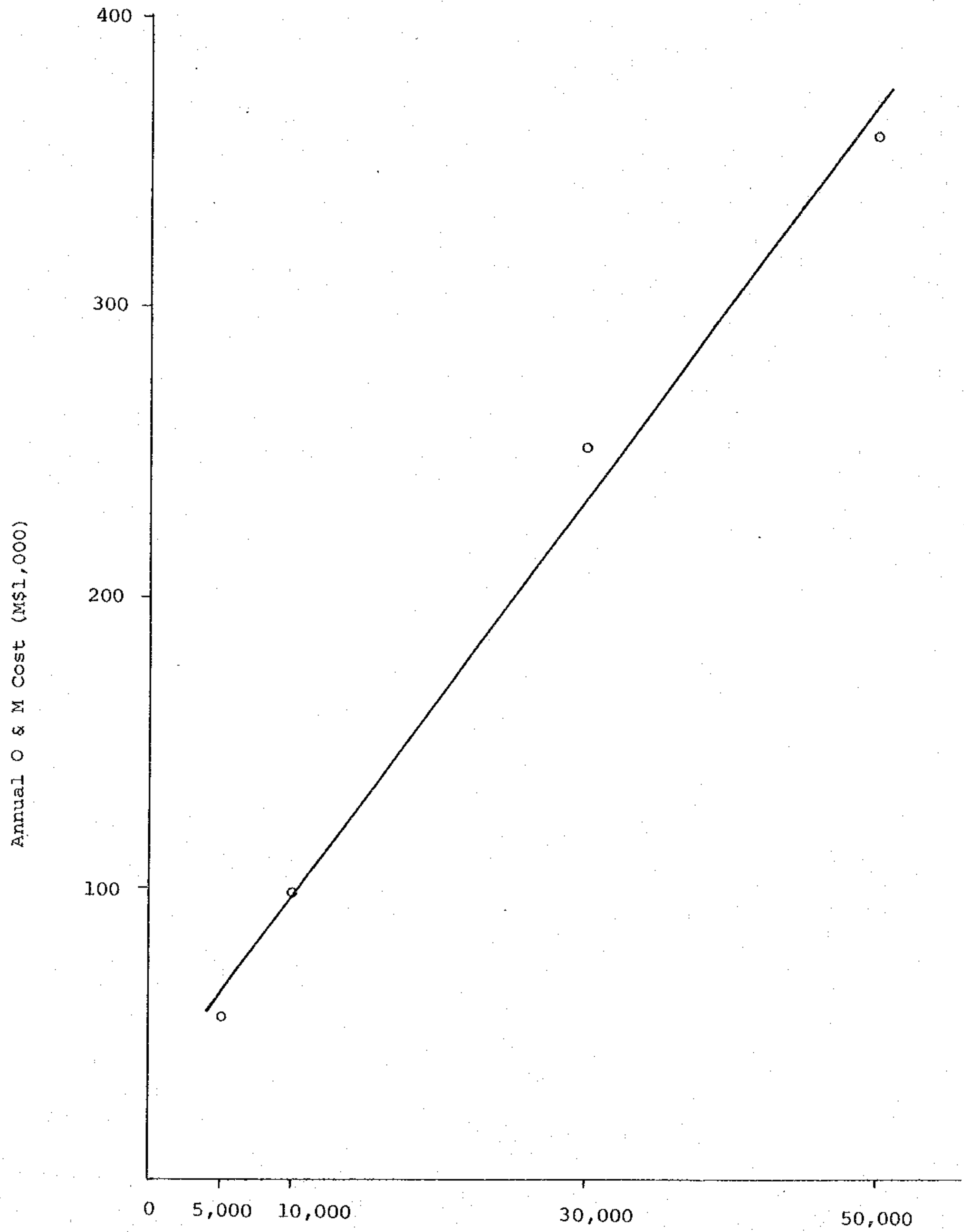


Figure G-8 Annual operation and maintenance cost for aerated lagoon

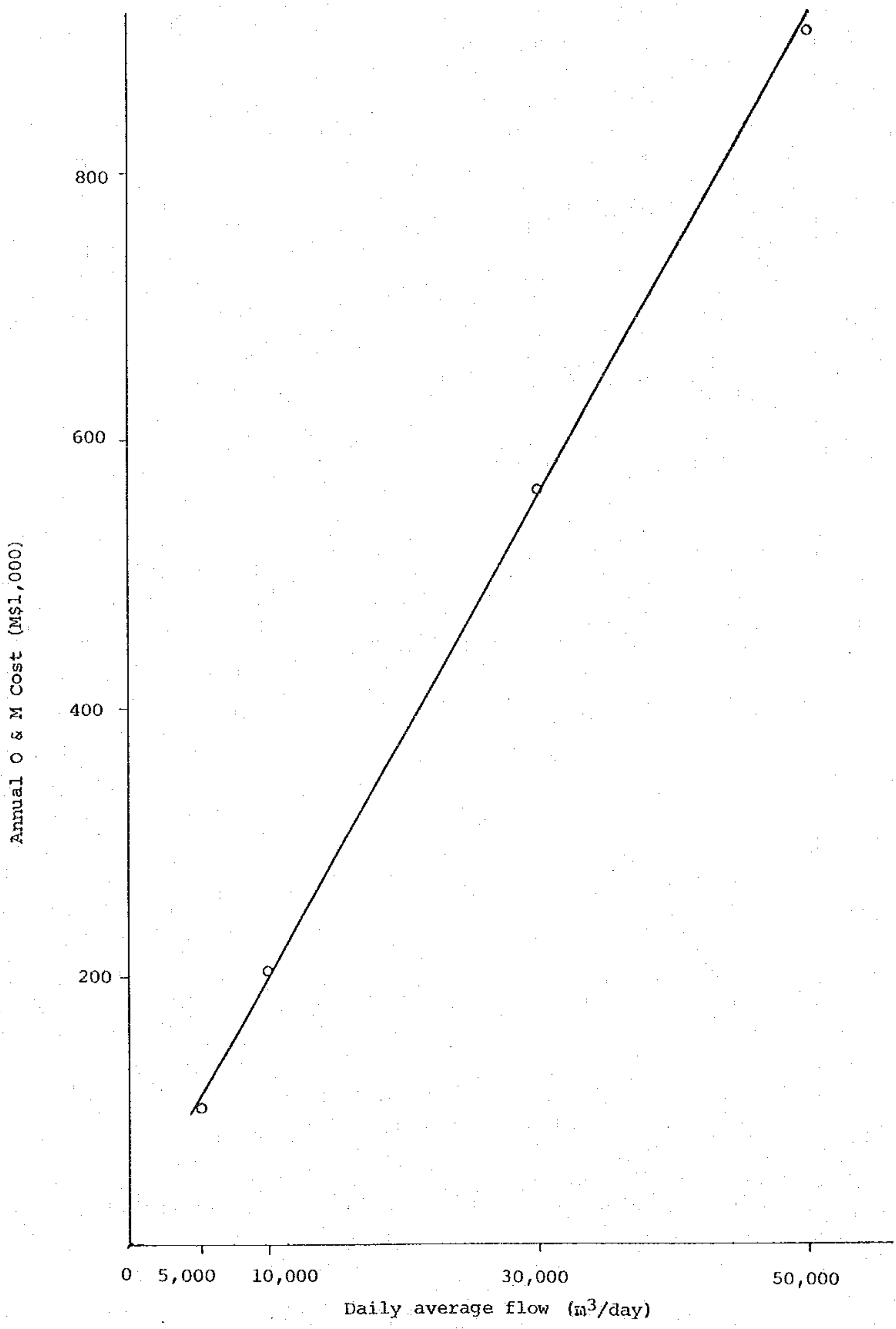
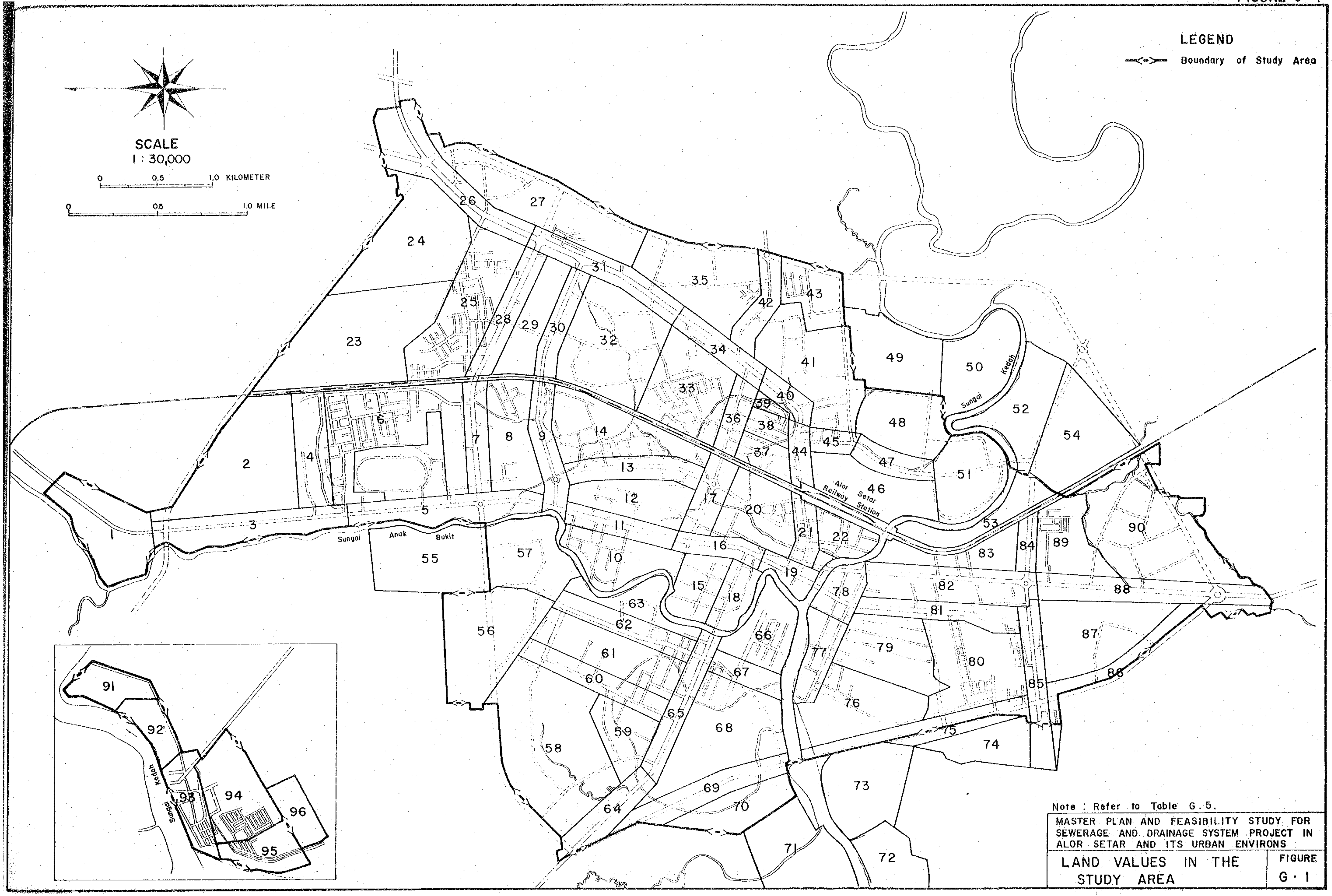


Figure G-9 Annual operation and maintenance cost for oxidation ditch process



MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

LAND VALUES IN THE STUDY AREA

FIGURE G · 1

APPENDIX H

ESTIMATION OF CONSTRUCTION COST FOR BRANCH AND LATERAL SEWERS

1. Unit Construction Cost Estimates for Branch and Lateral Sewers

The construction costs for the trunk sewers, which are described in Section 9 of Chapter 5 in the main report, are estimated by utilizing the method discussed in Section 1, Appendix G. On the other hand, the construction costs of branch/lateral sewers in "urbanized and/or urbanizing areas" and "the future development areas" are estimated by applying the basic unit costs as derived in section 9 of chapter 5 to the estimated branch and lateral lengthes by the reasonable preliminary engineering design of sewer networks upon the areas representing typical conditions of the two areas as shown in Figure H-1 and Figure H-2 respectively.

Based on Figure H-1, entire sewer lengths for branch and lateral sewers are measured in varying sizes in a typical urbanized and/or urbanizing area as shown in Table H-1 with additional major items for further construction cost estimates.

Table H-1 Unit Construction Cost for Branch/Lateral Sewers in Urbanized and/or Urbanizing Area

Total area ... (1)	167.8 ha
Area of open space, mosque etc. .... (2)	24.6 ha
(1) - (2)	143.2 ha
Sewers	225-300 mm dia. Total length: 15,760 m
Sewer length per ha	110 m/ha
Total construction cost for sewer	M$ 3,672,080
Construction cost per ha	M$ 25,643/ha

It should be noted that the branch/lateral sewers in public areas (such as schools, mosques, open spaces, etc.) as well as housing development areas completed/planned are excluded from the sewer lengths measured and from unit construction cost estimates in Table H-1.

Similarly, based on Figure H-2, entire sewer lengths for branch and lateral sewers are measured in varying sizes in a typical existing housing development area as shown in Table H-2 with additional major items for further construction cost estimates as follow.

Table H-2 Unit Construction Cost for Branch/Lateral Sewers in Future Development Area

Total Area ... (1)		122.0 ha
Area of Open Space, School, Mosque, etc. ... (2)		15.9 ha
(1) - (2)		106.1 ha
Government Portion	Sewer Facilities	225-300 mm dia. Length: 3,225 m
	Sewer Length per ha	30 m/ha
	Construction Cost	M$1,035,225
	Construction Cost per ha	M$9,757/ha
Private Portion	Sewer Facilities	225 mm dia. Length: 13,475 m
	Sewer length per ha	127 m/ha
	Construction Cost	M$2,681,525
	Construction Cost per ha	M$25,273/ha

It should be noted that the construction cost for the branch sewers (shown in thick line) connecting the branch/ lateral sewers (shown in thin line) serving for sectional areas to the trunk lines in Figure H-2, will be contributed by the Government, and the remaining cost for branch/lateral (shown in thin line) sewers are considered to be raised from direct beneficiaries. These sectional areas mostly within a range of 5 to 10 ha area assumed to be developed by developers based on a survey data obtained.

Table H-3 shows the component areas of sewerage zones as to (1) urbanized and/or urbanizing area, (2) future development area, and public areas and housing development areas completed/planned.

Table H-3 Component Areas in Sewerage Sub-zones

Name of Sub-zone	Total Area (ha)	(1) Urbanized and/or Urbanizing Area (ha)	(2) Future Development Area (ha)	(3) Public Areas & Housing Development Areas Completed/Planned				
				School (ha)	Mosque (ha)	Open Space (ha)	Housing Estates (ha)	Sub-total (ha)
A - 1	385	251	51	36.9	8.8	28.7	8.6	83.0
A - 2	437	99	331	7.0	0	0	0	7.0
B - 1	459	358.1	10	34.5	12.9	25.7	17.8	90.9
B - 2	410	113.1	281.8	5.7	8.2	0	1.2	15.1
B - 3	102	49.9	43	8.1	1.0	0	0	9.1
C - 1	187	160.7	26	0	0	0	0.3	0.3
C - 2	427	90.1	321	15.9	0	0	0	15.9
D - 1	388	324.3	26	19.3	2.1	9.6	6.7	37.7
D - 2	270	95.6	154	20.4	0	0	0	20.4
E	125	60.1	52.4	11.2	0	0	1.3	12.5
Total	3,190	1,601.9	1,296.2	159	33	64	35.9	291.9

Note: (1) and (2) do not include public areas as well as new housing estates.

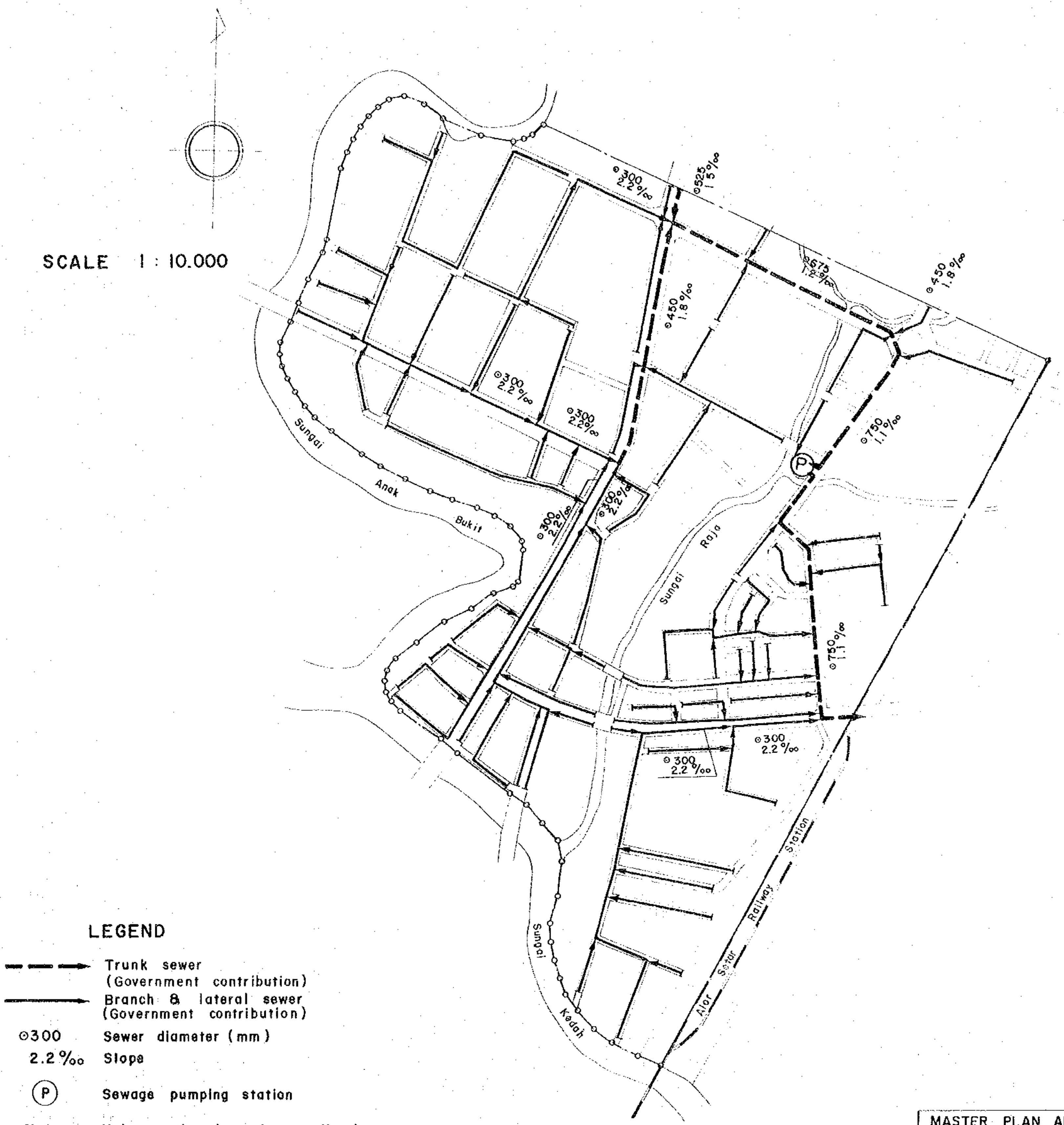
2. Proposed Financial Sources Constructing Branch and Lateral Sewers in the Study Area

Table H-4 summarizes estimated total lengths of branch/lateral sewers in both "urbanized and/or urbanizing areas" and "future development areas" for each sewerage zone. Further, the same table provides construction costs to be contributed by both the Government and Private sources.

Table H-4 Proposed Financial Sources Constructing Branch/ Lateral Sewers in the Study Area

(M$1,000 at 1979 prive level)

Name of Sewerage Sub-zone	Government Contribution			Private Contribution		
	Dia. (mm)	Length (mm)	Construction Cost	Dia. (mm)	Length (mm)	Construction Cost
A - 1	225-300	29,140	6,933	225	6,480	1,288
A - 2	225-300	20,820	5,768	225	42,040	8,365
B - 1	225-300	39,691	9,279	225	1,270	252
B - 2	225-300	20,900	2,863	225	35,790	7,121
B - 3	225-300	6,780	1,699	225	5,460	1,086
C - 1	225-300	18,460	4,374	225	3,300	657
C - 2	225-300	19,540	5,442	225	40,770	8,112
D - 1	225-300	36,450	8,569	225	3,300	657
D - 2	225-300	15,140	3,954	225	19,560	3,892
E	225-300	8,180	2,052	225	6,650	1,324
Total		215,100	50,933		164,620	33,754



LEGEND

Trunk sewer (Government contribution)

Branch & lateral sewer (Government contribution)

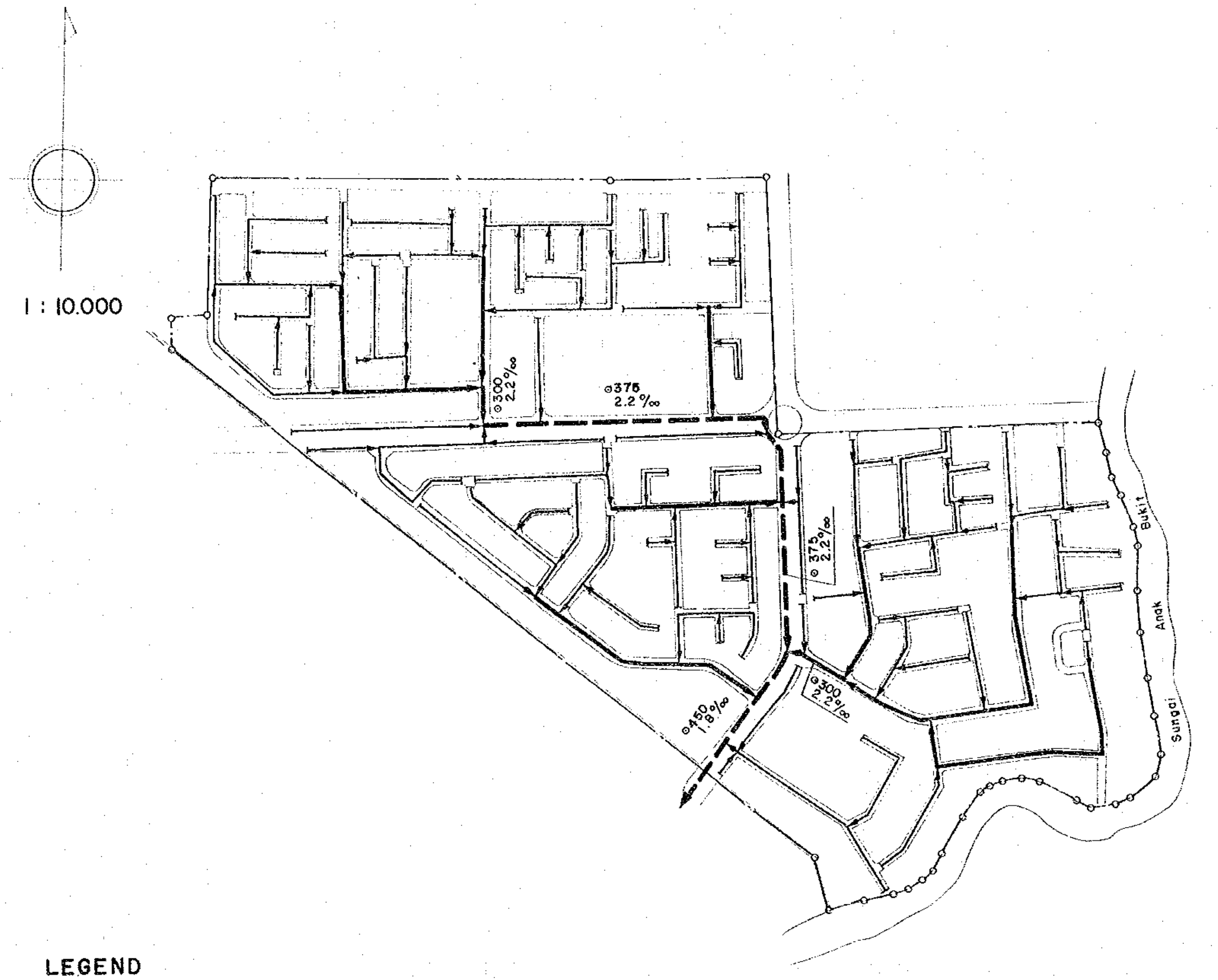
⊙300 Sewer diameter (mm)

2.2 ‰ Slope

(P) Sewage pumping station

Note : Unless otherwise shown, all pipes are 225 mm in diameter

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS	
SEWER LAYOUT PLAN IN TYPICAL URBANIGED AND/OR URBANIZING AREA	FIGURE H · 1



SCALE 1 : 10.000

LEGEND

- Trunk sewer
- Branch & lateral sewer (Government contribution)
- Branch & lateral sewer (Private contribution)
- ⊙300 Sewer diameter (mm)
- 2.2 ‰ Slope

Note : Unless otherwise shown, all pipes are 225 mm in diameter

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS	
SEWER LAYOUT PLAN IN TYPICAL HOUSING DEVELOPMENT AREA	FIGURE H · 2

APPENDIX I

SULFIDE CONTROL METHODS

1. Introduction

Hydrogen sulfide and other undesirable gases associated with the operation of sanitary sewers are produced in an anaerobic environment. Therefore, the key to their control is keeping the wastewater aerobic. It has been observed that the rate of hydrogen sulfide buildup is closely related to sludge accumulation in the sewer. In other words, a well-designed, self-cleansing sewers should have little trouble from hydrogen sulfide.

Hence, the following three methods are brought into discussion for sulfide control;

a. Keep sufficient flow velocity in sewers to prevent sulfide buildup without special sulfide corrosion protection measures.

b. Use anti-sulfide corrosion pipe or lining pipe without special velocity control where sulfide buildup is expected.

c. Inject air to keep sewage aerobic without special considerations on flow velocity and pipe material.

2. Sulfide Controlling Velocities

The equation relating flow velocities to marginal EBOD (effective BOD) is:

$$\text{Marginal EBOD} = 787\ V^{3/4}\ b/P$$

where

$$\text{EBOD} = \text{BOD}_5 \times 1.07^{(T-20)},$$

T : temperature, °C
V : flow velocity, m/sec
b/P: surface width/wetted perimeter,dimentionless

The BOD concentration of the sewage for the year 2000 has been estimated at 200 mg/l. Therefore, the equivalent EBOD for the year 2000, at a temperature of 27°C, will be

$$200 \times 1.07^{27-20} = 321 \text{ mg/l}$$

Sulfide control velocity curve for the year 2000 condition is then developed, as shown in Figure I-1.

If peaking factor is expresses as $P.F.=5/P^{1/7}$ (where P: population in thousand persons), and population is estimated at 4,800 persons, the P.F. will be 4.0, that is, the daily average flow will be one fourth of peak flow in such areas which has population of 4,800. Because, for sanitary sewer, full pipe capacity of the design peak flow rate is provided, the pipe diameter for this population will be 300 mm. (Per capita sewage flow is estimated at 230 l/cap/day). This is the upper limit of VCP market size. The minimum design flow velocity should be determined at least on the basis of the daily average flow velocity of above pipe size. Hence, the minimum design flow velocity is determined at 75 cm/sec.

The Figure indicates that if the minimum design flow velocity is decided at 75 cm/sec, the sulfide generation will be controlled from 0.25 to 0.70 of peak design flow rate. The problem of sulfide control is much more severe during the initial year of service of sewer pipeline when flows are considerably less than future design flows. However, as shown in Figure I-1, it is impossible to keep the sulfide control velocity to meet all flow variations.

3. Anti-Corrosion Pipe

VCP, RCP, ACP, and Pitch Fibre Pipe are available in Malaysia. Among them VCP is the best pipe against sulfide corrosion. However, the available VCP market size is up to 300 mm in diameter, and larger sewers will be of concrete-bonded pipes, either centrifugally cast or cast in place, which are likely subject to sulfide attack.

Coatings and linings of acid-resistant materials, such as vinyl and epoxy resins, PVC sheet, and high alumina cement mortar, will be effective for protecting concrete pipes against the acid attack.

4. Air Injection to Sewer

This method is useful only in the force main.

5. Conclusions

In view of the above considerations especially for future operation and maintenance problems of the sewerage system, it is concluded that all sanitary sewers shall be so designed and constructed to give mean velocity, when flowing full or half-full, of not less than 60 cm/sec for VCP, and for RCP or any cement-bonded pipe the minimum design flow velocity should be 75 cm/sec, and suitable lining or coating pipes should be used.

Figure I-1

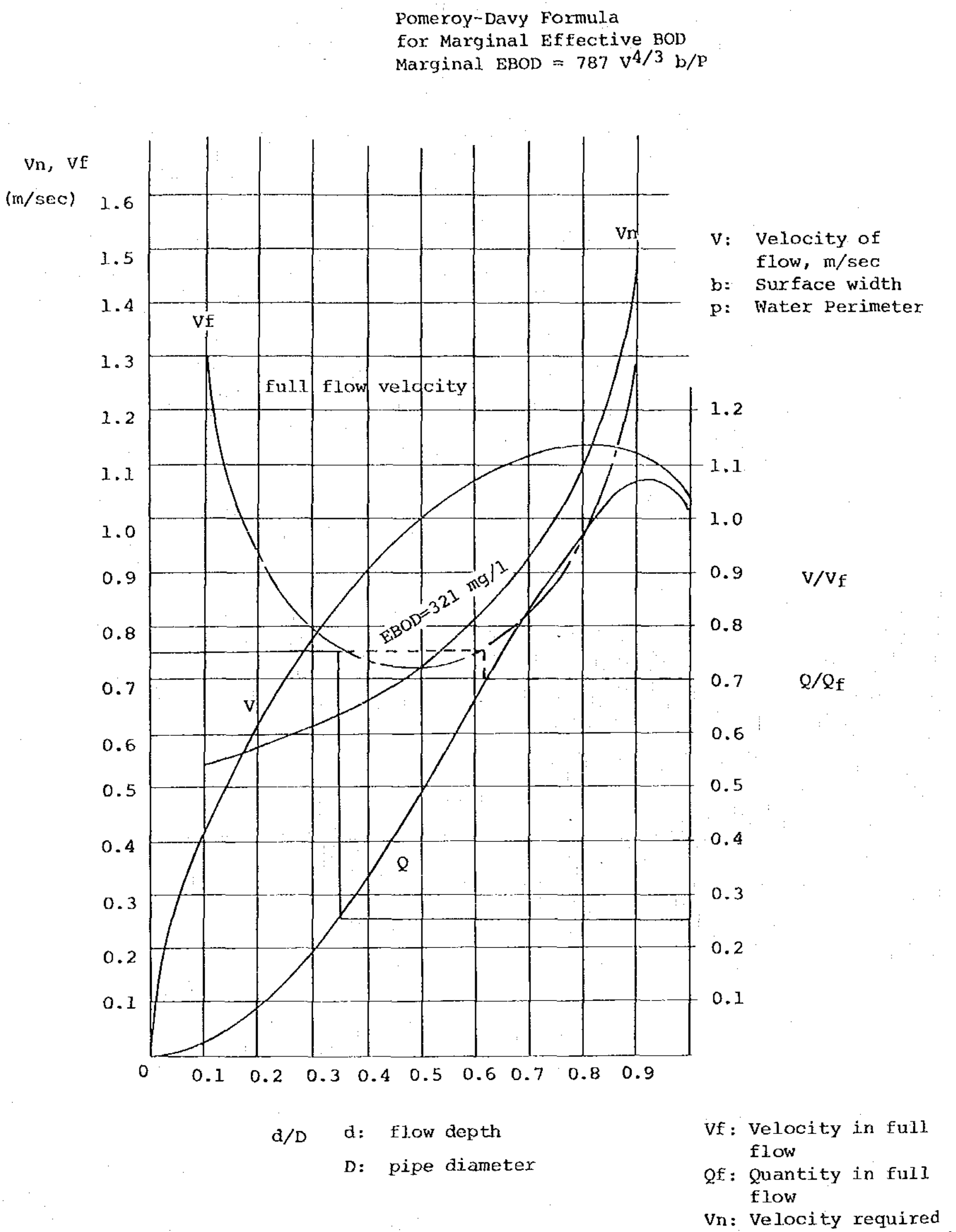


FIGURE I-1 Sulfide control velocity curve

APPENDIX J

PHASING CONSIDERATIONS

1. Introduction

It is a task of tremendous magnitude to provide a complete sewerage system for entire Study Area with its large and expanding population.

A consideration is, therefore, given to build the required facilities in phases, according to the urgency of need and benefits to be derived. Phased construction will spread capital expenditure over an extended period of years, as well as saving interest on borrowed capital and reducing initial costs.

A study, hereunder, provides to determine the priority of implementation and the desirable phases of the sewerage sub-zones, taking into account the various important elements which affect sanitary conditions in the Study Area, applying a reasonable rating procedure.

2. Rating of Sanitary Conditions

2.1 Basic Consideration for Rating

The elements considered in the implementation priority of swerage sub-zones up to the year 2000 include the following six items, each of which has impacts on environmental sanitation in the Study Area.

1) Population density

2) Development condition

3) Waste load generation aspect

4) Excreta disposal system

5) Flooding condition

6) Incidence of water-borne diseases

Note: An evaluation item "availability of water supply" is not considered for this particular situation because the Study Area is almost uniformly served by the water supply system.

The above-mentioned six elements are assigned by the different evaluation points to reflect their relative importance to the sanitation, and each of the ten sewerage sub-zones is evaluated carefully and graded according to the rating for each element for the purpose of establishing sewerage implementation priority.

It is, however, noted that re-evaluation of these sewerage sub-zones should be made at the beginning of each implementation phase to reflect urbanization of these areas at the time, especially in the future development area.

2.2 Application of Rating System

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

(1) Population density

One of the most important factors is the number of persons who will be benefited by the system. It is, therefore, particularly 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) Development Condition:

Development condition of the Study Area differs largely according to areas and land uses. The greater portion of the future development area lying periphery of the Study Area remains to be paddy field yet, thus unabling to provide sewerage system for the time being and in the immediate future.

(3) Waste load generation aspect:

Three hundred points is assigned to the item of waste load generation. The waste load generated from the housing, commercial and industrial areas are generally discharged into drains and rivers without any treatment except septic tanks. It is, therefore, necessary to quantify the waste load in each of the sewerage zones to determine the urgency of the need of sewerage facilities.

(4) Excreta disposal system:

Since there is no sanitary sewerage system in the Study Area, except a few local systems, most of the excreta produced in the area is disposed of either septic tank, bucket pit privy or directly to waterways, causing water pollution at many places in the Area. The existing excreta disposal system is, therefore, analyzed as to the present excreta disposal.

(5) Flooding Condition:

Although the Government has undertaken improvement works for the existing rivers and drains, flooding has occurred frequently and caused substantial damage in the built-up areas. Sanitary conditions in these areas have been significantly deteriorated, which can only be improved by the provision of the sewerage system.

(6) Incidence of water-borne diseases:

Incidence of water-borne diseases, has also effected to sanitation conditions, but this is less critical than the above five elements, these giving the lowest points of 50.

In view of these factors, the six elements, all of which affect sanitary conditions, are given points arbitarily for the years 1979 and 2000 according to their importance for the rating.

The rating points are shown as followings:

		Point assigned
a)	Population density	300
b)	Development condition	200
c)	Waste load generated	300
d)	Excreta disposal system	100
e)	Flooding condition	50
f)	Incidence of water-borne diseases	50
	Total	1,000

Further applications on these factors are discussed in the following section.

2.2.1 Population Density

Population densities, both present and future, by sewerage sub-zones, range approximately from 6.8 to 125.1 persons per hectare, as presented in Table J-1 and Figures J-1 and J-2. For purpose of rating, 150 points are given to both present and future population densities respectively:

Assigned Point	Present Population Density (Persons/ha)	Future Pppulation Density (Persons/ha)
150	100 or more	120 or more
120	80 - 100	110 - 120
90	60 - 80	100 - 110
60	40 - 60	90 - 100
30	20 - 40	80 - 90
0	0 - 20	70 - 80

As shown in Table J-1, sub-zone B-1 gains 300 points, followed by sub-zone D-1 and Sub-zone C-1 and Sub-zone E.

Table J-1 Evaluated Points for Population Density by Sewerage Sub-Zone

Sewerage Sub-Zone	Area * (ha)	1979		2000		Evaluated Points		
		Population (Persons)	Population Density (Persons/ha)	Population (Persons)	Population Density (Persons/ha)	1979	2000	Total
A - 1	356.3	15,100	42.3	29,700	83.3	60	30	90
A - 2	437.0	3,700	8.5	38,000	87.0	0	30	30
B - 1	433.3	44,400	102.5	54,200	125.1	150	150	300
B - 2	410.0	11,400	27.8	40,700	99.3	30	60	90
B - 3	102.0	1,300	12.7	11,100	108.8	0	90	90
C - 1	187.0	9,000	48.1	21,500	115.0	60	120	180
C - 2	427.0	2,900	6.8	33,700	48.9	0	0	0
D - 1	378.4	35,000	92.5	46,500	122.9	120	150	270
D - 2	270.0	7,700	28.5	30,000	111.1	30	120	150
E	125.0	9,100	72.8	12,900	103.2	90	90	180
Total	3,126.0	139,600	44.7	318,300	101.8	-	-	-

Note:

* These figures do not include rivers, railway , parks and open spaces, etc.

2.2.2 Development Condition

Evaluation is made for each sub-zone in terms of percentage of estimated urbanization or industrialization for the coming several years as shown in Table J-2 and Figure J-3. Since the Study Area is assumed to be urbanized by 2000, evaluation for the year 2000 is not made.

Assigned Point	Percentage of Urbanization and Industrialization (%)
200	80 or more
150	60 - 80
100	40 - 60
50	20 - 40
0	0 - 20

Table J-2 Evaluated Points for Development by Sewerage Sub-Zone

Sewerage Sub-Zone	Area			Evaluated Points
	Total Area * (ha)	Developed and Developing Area (ha)	Ratio (%)	
A - 1	385	305	79	150
A - 2	437	106	24	50
B - 1	459	423	92	200
B - 2	410	127	31	50
B - 3	102	59	58	100
C - 1	187	161	86	200
C - 2	427	102	24	50
D - 1	388	352	91	200
D - 2	270	116	43	100
E	125	64	51	100
Total	3,190	1,815	57	-

Note: * These figures do not include areas of rivers and railway.

2.2.3 Waste Load Generated

According to the investigation carried out in the Study Area, streams are generally polluted by the deposit of organic matters and industrial wastes, hence it is necessary to control the waste load discharging into waterways. For the purpose of rating, waste load originating in each sewerage sub-zone is estimated at per ha waste load generation basis both for 1979 (present) and 2000. Evaluated points are shown in Table J-3 and Figures J-4 and J-5.

In this rating, a maximum of 300 points is assigned, 150 points each for 1979 and 2000 waste load generation rates of 6-8 kg BOD/d/ha and 8 or more kgBOD/d/ha respectively, and a minimum of 0 point in case 0-2 kgBOD/d/ha and 2-4 kgBOD/d/ha for 1979 and 2000 respectively as shown below:

Assigned Point	Waste Load Generated in 1970 (kg BOD/d/ha)	Waste Load Generated in 2000 (kg BOD/d/ha)
150	6 - 8	8 or more
100	4 - 6	6 - 8
50	2 - 4	4 - 6
0	0 - 2	2 - 4

Table J-3 Evaluated Points for Waste Load Generated by Sewerage Sub-Zone

Sewerage Sub-Zone	Area * (ha)	1979		2000		Evaluated Points		
		Waste Load (kg BOD/day)	Waste Load per ha (kg BOD/d/ha)	Waste Load (kg BOD/day)	Waste Load per ha (kg BOD/d/ha)	1979	2000	Total
A - 1	356.3	611.2	1.7	1,519.6	4.3	50	50	100
A - 2	437.0	130.6	0.3	1,760.2	4.0	0	50	50
B - 1	433.3	2,327.6	5.4	3,685.0	8.5	150	150	300
B - 2	410.0	397.4	1.0	1,894.4	4.6	0	50	50
B - 3	102.0	46.8	0.5	516.0	5.1	0	50	50
C - 1	187.0	273.1	1.5	578.8	3.1	0	0	0
C - 2	427.0	104.4	0.2	1,879.4	4.4	0	50	50
D - 1	378.4	1,407.4	3.7	2,529.8	6.7	100	100	200
D - 2	270.0	270.2	1.0	1,401.8	5.2	0	50	50
E	125.0	741.6	5.9	3,888.8	31.1	100	150	250
Total	3,126.0	6,310.3	-	19,653.8	-	-	-	-

Note: * These figures do not include areas of rivers, railways, parks and open spaces, etc.

2.2.4 Excreta Disposal System

The existing excreta disposal system in the Study Area is represented by two systems, namely septic tank and bucket system. Most of the population in the new housing development areas use flush toilets with individual or communal septic tank and most of the population in the build-up areas are served by mixture of individual septic tank and bucket system , while rural population use bucket system dominantly.

Table J-4 shows estimated number of houses served either by bucket system or by various kinds of latrines (such as pit privy, over-river latrine, etc.) according to data in Section 8 in Chapter 3 with additional assumptions based on the field investigations. Assessment as to present excreta disposal situation is made considering the availability of bucket and latrine system which should be higher in priority to be replaced into sewerage system than septic tank system exists.

For the purpose of rating, a maximum of 100 points is assigned to sewerage sub-zones wherein more than 10 percent of households provided either bucket or latrine system, that is, the remaining 90 percent of households were provided with septic tanks, while a minimum of 0 point to sub-zones wherein 0 - 5 percent of households provided either bucket or latrine system or the remaining 95 - 100 % of households were provided with septic tanks as shown below.

Assigned Point	Households Served by Bucket System or Latrine (%)
100	10 or more
50	5 - 10
0	0 - 5

Each sewerage sub-zone is evaluated as shown in Table J-4 and Figure J-6. B-1, D-1 and E come top in priority as to excreta disposal aspect gaining 100 points, followed by A-2 and B-2.

Table J-4 Evaluated Points for Existing Excreta Disposal System by Sewerage Sub-Zone

Sub-Zone	Number of Houses	Bucket System including over-river latrine System		Evaluated Points
		Number	Ratio (%)	
A - 1	2,748	42	1.5	0
A - 2	667	45	6.7	50
B - 1	8,296	1,347	16.2	100
B - 2	2,074	170	8.2	50
B - 3	226	0	0	0
C - 1	1,423	50	3.5	0
C - 2	527	15	2.8	0
D - 1	6,368	1,009	15.8	100
D - 2	1,398	10	0.7	0
E	1,656	255	15.4	100
Total	25,383	2,938	-	-

2.2.5 Flooding Condition

As shown in Figure J-7, flooding occurs in the Study Area except in zone C. However, sewerage zones (or sub-zones) heavily affected by flooding are limited into three, namely B-1, D-1 and E. More than 20 percent of area in sub-zone B-1 and zone E is liable to flooding and more than 14 percent of area in sub-zone D-1.

An assessment point for rating is given according to the extent of flooding in sewerage sub-zones as follows;

Assigned Point	Percentage Area Flooded
50	20 or more
25	10 - 20
0	0 - 10

All sewerage sub-zones are evaluated based on the assessment points given in the above table as resulted in Table J-5.

Tabel J-5 Evaluated Points in terms of Flooding

Sub - Zone	Area			Evaluated Points
	Area (ha)	Flooded Area (ha)	Ratio (%)	
A - 1	385	4.2	1.1	0
A - 2	437	14.7	3.4	0
B - 1	459	93.4	20.3	50
B - 2	410	28.9	7.0	0
B - 3	102	9.3	9.1	0
C - 1	187	-	-	0
C - 2	427	-	-	0
D - 1	388	55.8	14.4	25
D - 2	270	8.0	3.0	0
E	125	29.5	23.6	50
Total	3,190	243.8	-	-

2.2.6 Incidence of Water Borne Diseases

For the purpose of rating on incidence of water borne diseases, cholera cases are taken as the indicator.

Cholera patients recorded are listed below on Mukim (administrative unit) basis in Alor Setar Areas, including the Study Area ;

Mukim	Cholera Patient
Hutan Kampong	11
Anak Bukit	9
Alor Merah	2
Alor Malai	11
Kota Setar	19
Pumpong	7
Mergong	9
Pengkalan Kundor	25
Kuala Kedah	13
Total :	106

A maximum of 50 points are assigned and each of sewerage sub-zones are evaluated according to assessment points and the level of incidence as follows :

Assessment Point	No. of Cholera Patient
50	More than 2
25	1 - 2
0	0 - 1

The result of the assessment for each of sewerage sub-zones are shown in Table J-6 and Figure J-8.

Table J-6 Evaluated Points for Distribution of Cholera Cases by Sewerage Sub-Zone

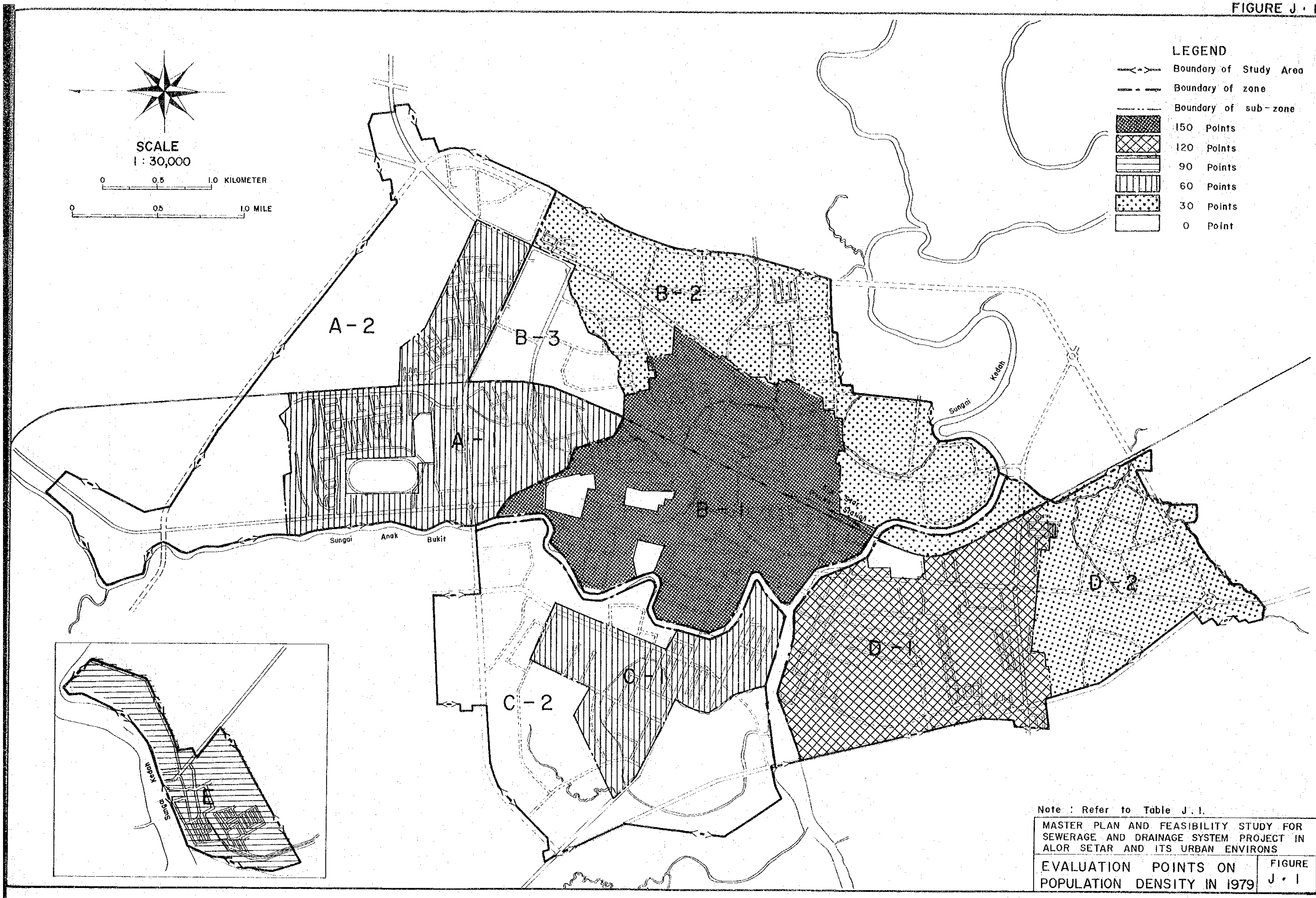
Sub-Zone	Population at 1979 (Persons)	Number of Cholera Patients	Ratio (Person/1,000 Perns)	Evaluated Points
A - 1	15,112	2	0.13	0
A - 2	3,666	5	1.36	25
B - 1	45,629	9	0.20	0
B - 2	11,407	10	0.88	0
B - 3	1,243	2	1.61	25
C - 1	7,827	1	0.13	0
C - 2	2,897	6	2.07	50
D - 1	35,025	3	0.09	0
D - 2	7,689	3	0.39	0
E	9,105	4	0.44	0
Total	139,600	45	-	-

2.2.7 Overall Evaluated Points by Sewerage Sub-Zone

All points evaluated for six major items are listed in Table J-7 and Figure 5.3, Volume II, according to sewerage sub-zones.

Table J-7 Overall Evaluated Points by Sub-Zone

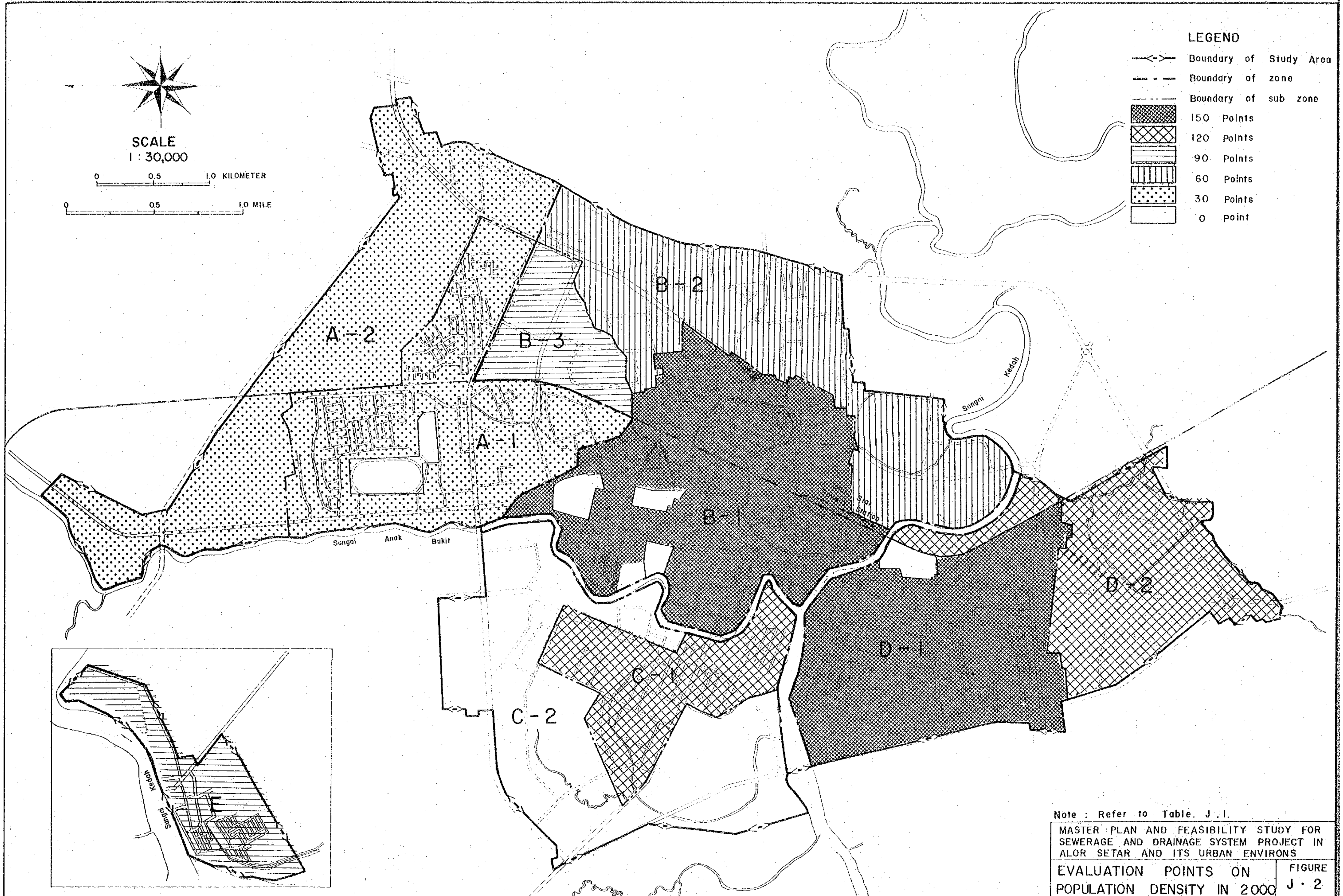
Sub-Zone	Population Density	Development Condition	Waste Load Generation	Excreta Disposal System	Flooding Condition	Incidence of Water-borne Disease	Total
A - 1	90	150	100	0	0	0	340
A - 2	30	50	50	50	0	25	205
B - 1	300	200	300	100	50	0	950
B - 2	90	50	50	50	0	0	240
B - 3	90	100	50	0	0	25	265
C - 1	180	200	0	0	0	0	380
C - 2	0	50	50	0	0	50	150
D - 1	270	200	200	100	25	0	795
D - 2	150	100	50	0	0	0	300
E	180	100	250	100	50	0	730



MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

EVALUATION POINTS ON POPULATION DENSITY IN 1979

FIGURE J・1

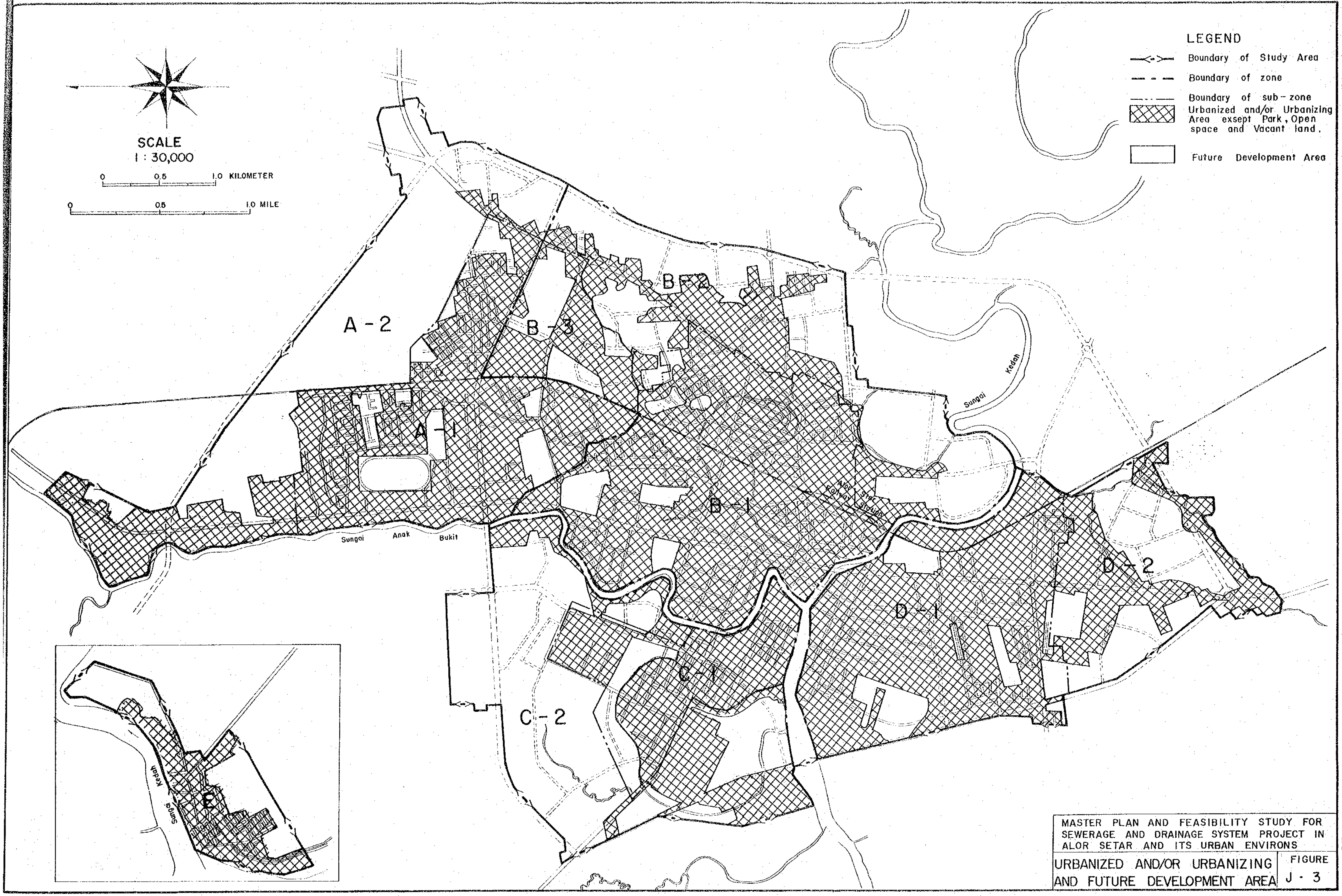


Note : Refer to Table. J. I.

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

EVALUATION POINTS ON POPULATION DENSITY IN 2000

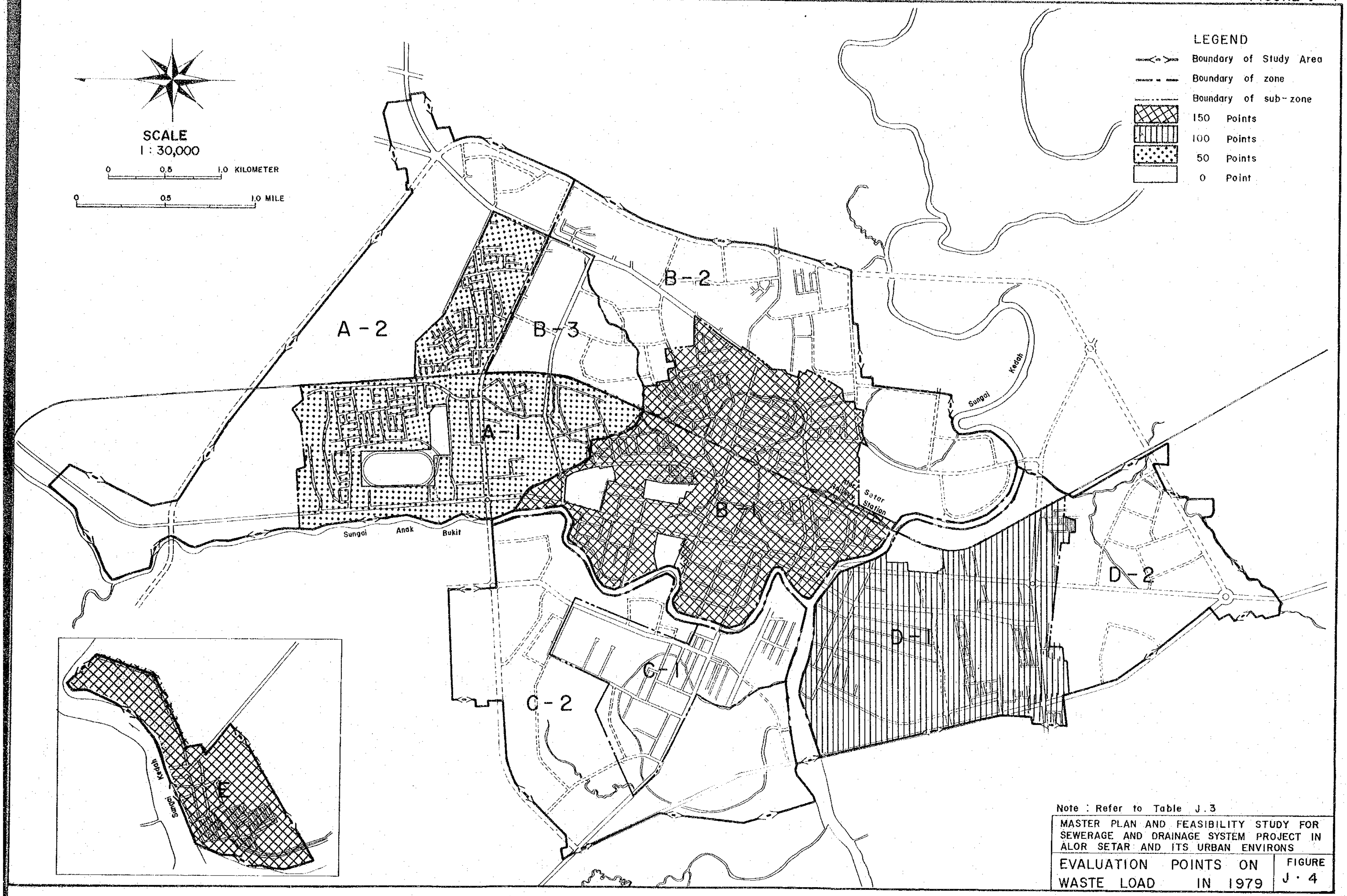
FIGURE J・2



MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

URBANIZED AND/OR URBANIZING AND FUTURE DEVELOPMENT AREA

FIGURE J - 3

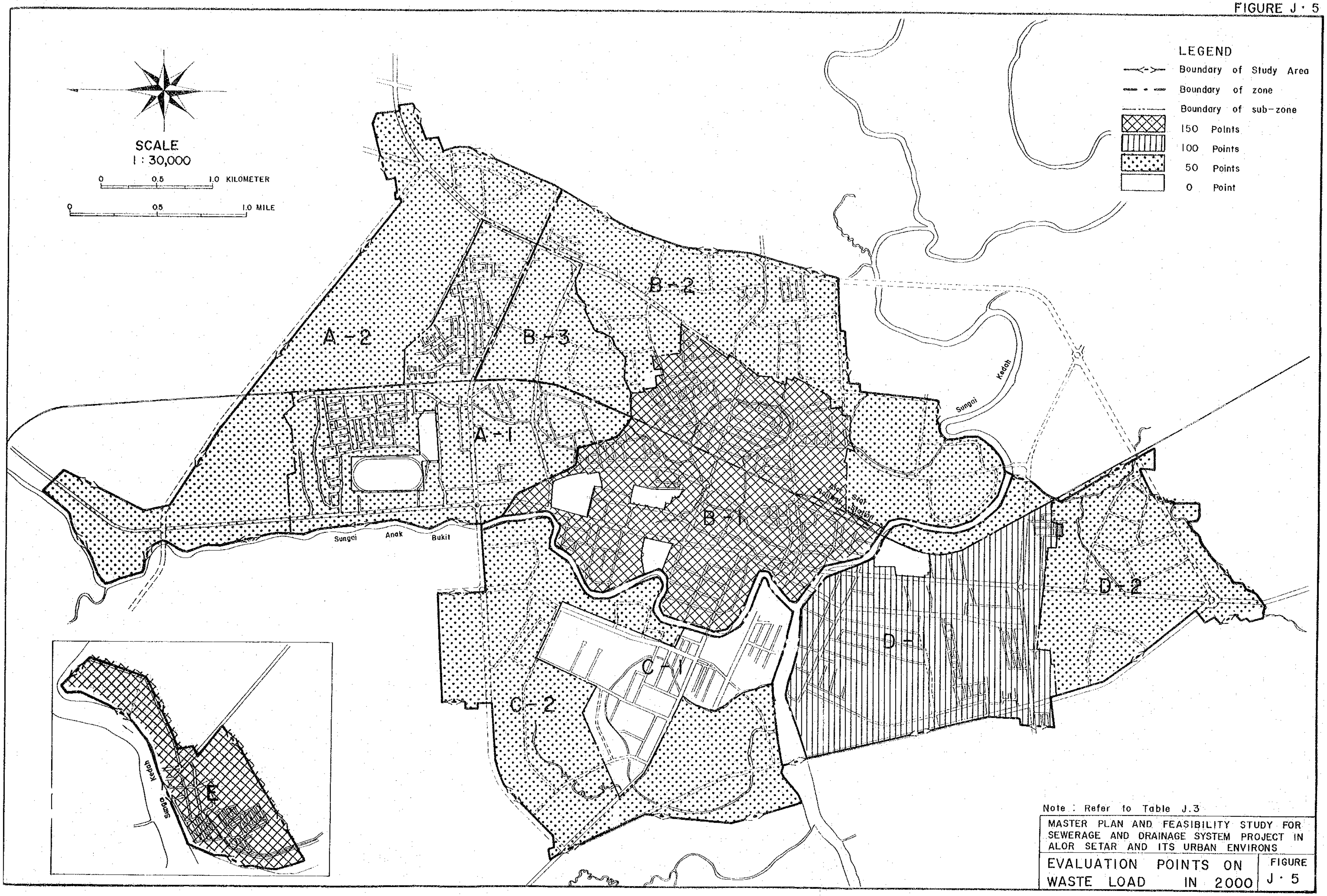


Note : Refer to Table J.3

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

EVALUATION POINTS ON WASTE LOAD IN 1979

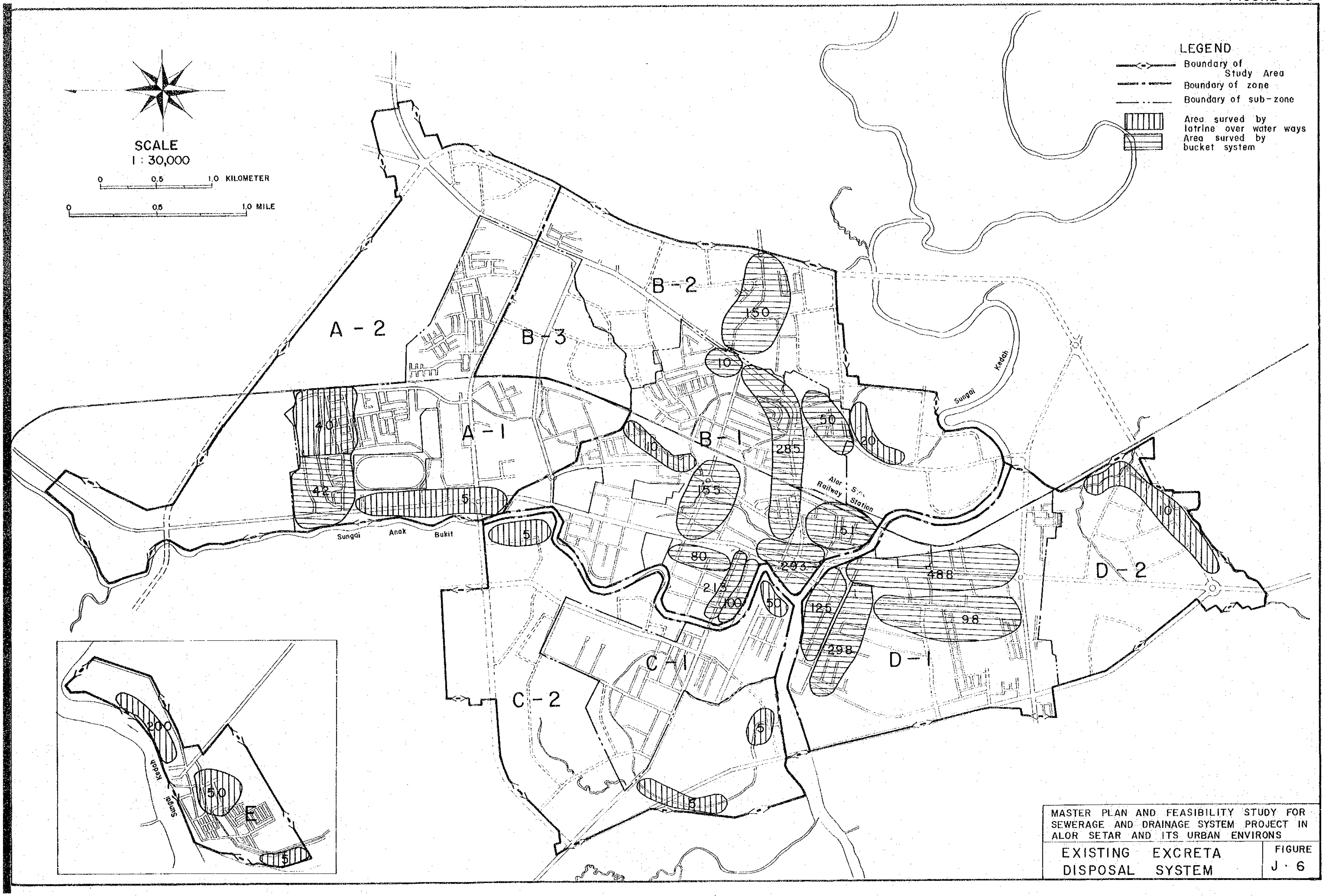
FIGURE J・4



MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

EVALUATION POINTS ON WASTE LOAD IN 2000

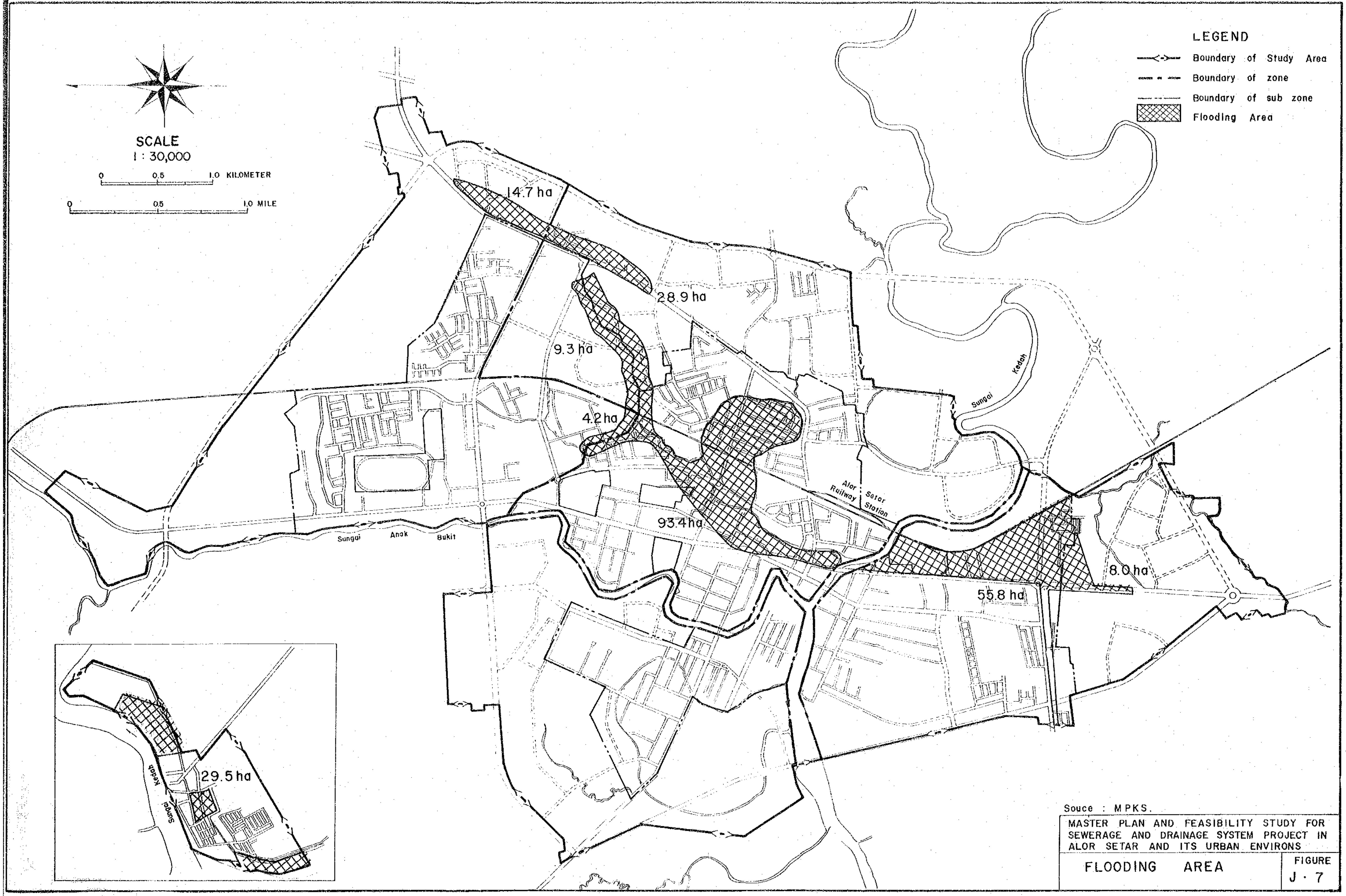
FIGURE J・5



MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

EXISTING EXCRETA DISPOSAL SYSTEM

FIGURE J · 6

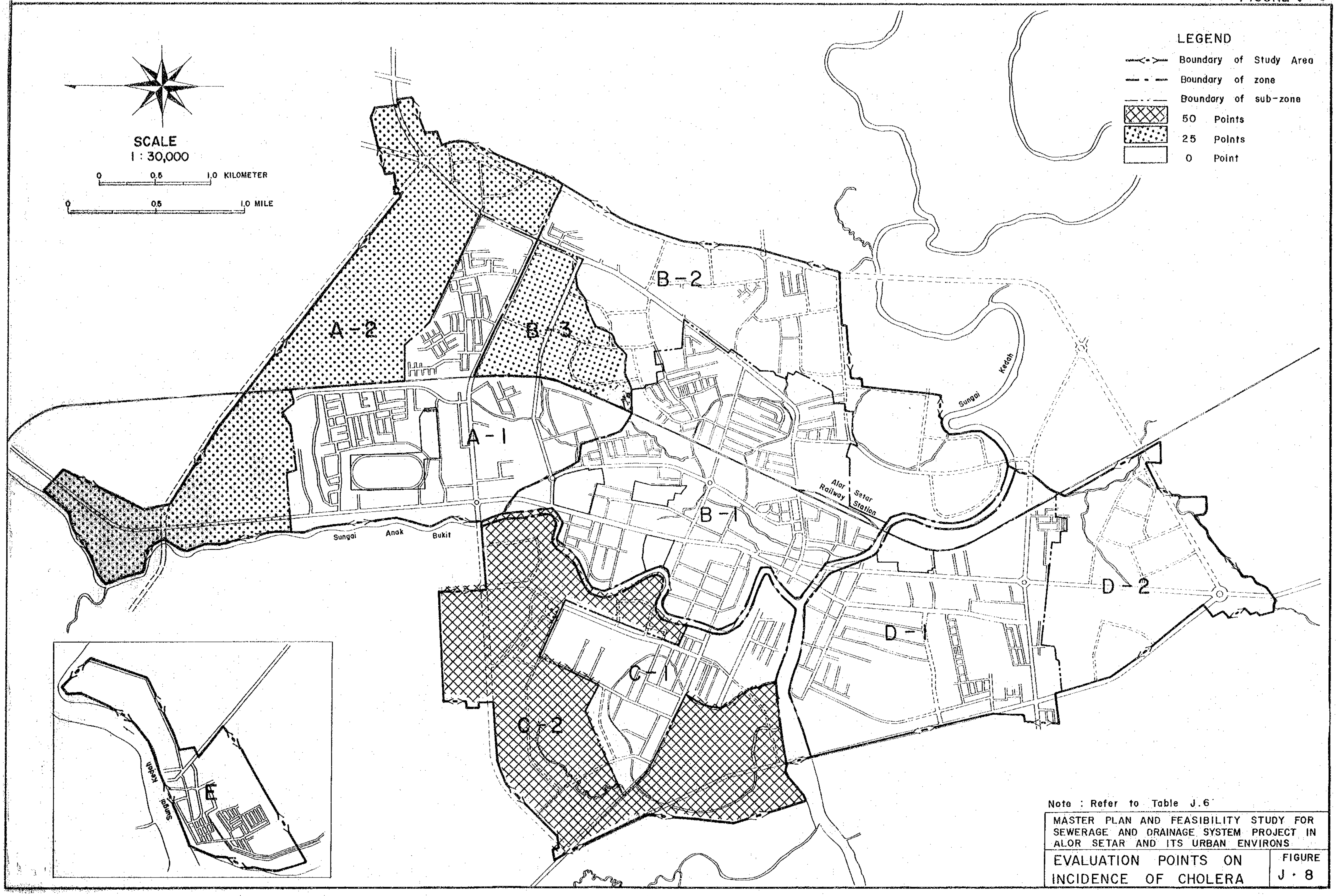


Souce : MPKS.

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

FLOODING AREA

FIGURE J・7



Note : Refer to Table J.6

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

EVALUATION POINTS ON INCIDENCE OF CHOLERA

FIGURE J・8

APPENDIX K

COMPUTATION FOR TRUNK SEWER DESIGN

Separate sewerage system proposed collects and conveys all wastewaters from residential, commercial and industrial areas to stabilization ponds provided at the terminal of the system.

The design sewage flows are calculated for the conditions in the year 2000, including extraneous flows such as groundwater infillration.

Sewer capacity has been determined using the design criteria as discussed in Section 5, Chapter 5, Sewerage Master Plan Report.

Hydraulic computations are shown in Table K-1 for the trunk sewers in every sewerage zone shown in Figure 5- 2 of the main report, applying the conveniently provided hydraulic computation chart in Table K-2 on the basis of Manning's Formula.

Table K-1

Computation for Design of Sewers

Zone — A

Area by Land Use and Population

No. of Sewers	Residential 120 persons/ha: Area Increment (ha)	Residential 120 persons/ha: Area Total (ha)	Residential 120 persons/ha: Population (persons)	Residential 70 persons/ha: Area Increment (ha)	Residential 70 persons/ha: Area Total (ha)	Residential 70 persons/ha: Population (persons)	Residential: Area Increment (ha)	Residential: Area Total (ha)	Residential: Population (persons)	Institution 15 persons/ha: Area Increment (ha)	Institution 15 persons/ha: Area Total (ha)	Institution 15 persons/ha: Population (persons)	School: Area Increment (ha)	School: Area Total (ha)	School: Population (persons)	Mosque 0 person/ha: Area Increment (ha)	Mosque 0 person/ha: Area Total (ha)	Mosque 0 person/ha: Population (persons)
1	3.28		394										26.20		448			
2	15.70	18.96	2278											26.20	448	7.80	7.80	
3	3.76	22.72	2729				2.50		50	4.80		72		26.20	448		7.80	
	to 7																	
4	6.73		808				6.40		128							14.40	14.40	
5	8.23	14.96	1795				1.85	8.25	165				0.60		30		14.40	
6	6.73	21.69	2603				26.40	34.65	692	12.60		188		0.60	30	6.60	21.00	
7	21.69	66.12	7934				1.20	38.35	766		17.40	260		26.80	448		21.00 / 7.80	
	to P1 Pumping Station																	
P1		66.12	7934					38.35	766		17.40	260		26.80	448		21.00 / 7.80	
	force main sewer																	
8		66.12	7934					38.35	766		17.40	260		26.80	448		21.00 / 7.80	
9	8.23	74.35	8922				4.00	42.35	846		17.40	260		26.80	448		21.00 / 7.80	
	to 15																	
10	8.98		1078															
11	23.10	32.08	3850										2.10		100			
12	28.99	61.07	7328										6.50	8.60	257			
13	10.47	71.54	8585	0.90		63								8.60	257			
	to P2 Pumping Station																	
P2		71.54	8585		0.90	63								8.60	257			
	Force main sewer																	
14		71.54	8585		0.90	63								8.60	257			
15	26.18	172.07	20648		0.90	63	7.80	50.15	1002		17.40	260		35.40	734		21.00 / 7.80	
	to 19																	
16	8.70		1044				2.59		52							7.70	7.70	
17	15.62	24.32	2918				2.48	4.95	98								7.70	
18	16.36	40.68	4882					4.95	98								7.70	
19	1.34	214.09	25691		0.90	63		55.10	1,100		17.40	260		35.40	734		28.70 / 7.80	
20	24.01	238.10	28,572		0.90	63		55.10	1,100		17.40	260	1.50	36.90	789	1.00	28.70 / 8.80	
21		238.10	28,572		0.90	63		55.10	1,100		17.40	260		36.90	789		28.70 / 8.80	
22		238.10	28,572	46.50	47.40	3318		55.10	1,100		17.40	260		36.90	789		28.70 / 8.80	

Area, Population, Design Flow and Designed Sewer

No. of Sewers	Area: Increment (ha)	Area: Total (ha)	Population (persons)	Peaking Factor	Domestic Waste (m^3/sec)	Other (m^3/sec)	Infiltration I: Area (ha)	Infiltration I: Flow (m^3/sec)	Infiltration II: Area (ha)	Infiltration II: Flow (m^3/sec)	Total (m^3/sec)	No. of Sewers	Diameter (mm)	Length (m)	Slope (‰)	Velocity (Full) (m/sec)	Capacity (Full) (m^3/sec)	Ground Surface Elevation (m)	Sewer Invert Elevation (m)	Earth Covering (m)	Remarks
1	29.48		842	5.12	0.011				29.48	0.002	0.013	1	225	495.00	2.8	0.61	0.025	2.50 / (2.80)	1.255 / -0.181	1.00 / 2.59	
2	23.50	52.98	2,726	4.33	0.031				52.98	0.004	0.035	2	300	545.00	2.2	0.65	0.047	(2.80) / (2.70)	-0.921 / -2.120	3.40 / 4.50	U-0# Drain
3	11.06	64.04	3,277	4.22	0.037	0.002	4.80	0.001	59.24	0.004	0.044	3	300	420.00	2.2	0.65	0.047	(2.70) / 2.89	-2.120 / -3.044	4.50 / 5.61	
													to 7								
4	27.53		936	5.05	0.013				27.53	0.002	0.015	4	225	460.00	2.8	0.61	0.025	(2.70) / (2.90)	1.455 / 0.167	1.00 / 2.49	
5	10.68	38.21	1990	4.53	0.024				38.21	0.003	0.027	5	300	400.00	2.2	0.65	0.047	(2.90) / 3.06	-1.287 / -2.167	3.87 / 4.91	U-0# Drain
6	52.33	90.54	3518	4.18	0.039	0.005	12.60	0.001	77.94	0.006	0.051	6	375	780.00	2.2	0.75	0.086	3.06 / 2.89	-2.042 / -3.848	4.90 / 6.33	
7	22.89	177.47	9,408	3.63	0.091	0.007	17.40	0.001	160.07	0.012	0.111	7	450	140.00	2.0	0.81	0.133	2.89 / 2.94	-3.928 / -4.203	6.33 / 6.66	
													to P1 Pumping Station								
P1		177.47	9,408	3.63	0.091	0.007	17.40	0.001	160.07	0.012	0.111	P1									
													force main sewer								
8		177.47	9,408	3.63	0.091	0.007	17.40	0.001	160.07	0.012	0.111	8	300	70.00				2.94 / 3.05	1.619 / 1.729	1.00 / 1.00	
9	12.23	189.70	10,476	3.58	0.100	0.007	17.40	0.001	178.30	0.013	0.121	9	450	610.00	2.0	0.81	0.133	3.05 / 2.22	1.562 / 0.342	1.00 / 1.39	
													to 15								
10	8.98		1078	4.95	0.014				8.98	0.001	0.015	10	225	775.00	2.8	0.61	0.025	3.29 / (3.00)	2.045 / -0.165	1.00 / 2.88	
11	25.20	34.18	3,950	4.11	0.043				34.18	0.003	0.046	11	300	545.00	2.2	0.65	0.047	(3.00) / (2.70)	-0.800 / -1.899	2.88 / 3.78	
12	35.49	69.67	7,585	3.74	0.076				69.67	0.005	0.081	12	375	535.00	2.2	0.75	0.086	(2.70) / (2.20)	-1.474 / -2.651	3.77 / 4.44	
13	11.37	81.04	8,905	3.64	0.087				81.04	0.006	0.093	13	450	130.00	2.0	0.81	0.133	(2.20) / (1.80)	-2.786 / -2.986	4.44 / 4.30	
													to P2 Pumping Station								
P2		81.04	8,905	3.66	0.087				81.04	0.006	0.093	P2									
													Force main sewer								
14		81.04	8,905	3.66	0.087				81.04	0.006	0.093	14	300	430.00				(1.80) / 2.22	0.479 / 0.899	1.00 / 1.00	Crossing Railway
15	207.98	304.72	22,707	3.20	0.193	0.007	17.40	0.001	287.32	0.021	0.222	15	600	750.00	1.6	0.88	0.257	2.22 / (2.00)	0.192 / -1.078	1.88 / 2.44	
													to 19								
16	10.93		1094	4.74	0.014				10.93	0.001	0.015	16	225	400.00	2.8	0.61	0.025	(2.70) / 2.44	1.455 / 0.279	1.00 / 1.92	
17	18.04	36.97	3016	4.27	0.034				36.97	0.003	0.037	17	300	585.00	2.2	0.65	0.047	2.44 / (2.00)	0.206 / -1.083	1.92 / 2.96	
18	16.36	53.33	4980	3.98	0.053				53.33	0.004	0.057	18	375	510.00	2.2	0.75	0.086	(2.00) / (2.00)	-1.158 / -2.280	2.95 / 3.87	
19	1.34	359.39	27,849	3.11	0.231	0.007	17.40	0.001	341.99	0.025	0.264	19	675	75.00	1.4	0.89	0.327	(2.00) / 1.83	-2.580 / -2.685	3.86 / 3.79	
20	26.51	385.90	30,784	3.06	0.251	0.007	17.40	0.001	368.50	0.027	0.286	20	675	90.00	1.4	0.89	0.327	1.83 / (1.83)	-2.685 / -2.727	3.79 / 3.83	
21		385.90	30,784	3.06	0.251	0.007	17.40	0.001	368.50	0.027	0.286	21	675	60.00	1.4	0.89	0.327	(1.83) / (1.83)	-2.727 / -2.811	3.89 / 3.92	Crossing Railway
22	46.50	432.40	34,039	3.02	0.274	0.007	17.40	0.001	415.00	0.030	0.312	22	675	605.00	1.4	0.89	0.327	(1.83) / 1.73	-2.811 / -3.770	3.92 / 4.78	U-180# Drain

Zone - A

Area by Land Use and Population

No. of Sewers	Residential 120 persons/ha Area Increment (ha)	Residential 120 persons/ha Area Total (ha)	Residential 120 persons/ha Population (persons)	Residential 70 persons/ha Area Increment (ha)	Residential 70 persons/ha Area Total (ha)	Residential 70 persons/ha Population (persons)	Residential Area Increment (ha)	Residential Area Total (ha)	Residential Population (persons)	Institution 15 persons/ha Area Increment (ha)	Institution 15 persons/ha Area Total (ha)	Institution 15 persons/ha Population (persons)	School Area Increment (ha)	School Area Total (ha)	School Population (persons)	Mosque 0 person/ha Area Increment (ha)	Mosque 0 person/ha Area Total (ha)	Mosque 0 person/ha Population (persons)
	to 39																	
23	0.10		12	9.60		672												
24	16.58	16.68	2002	13.00	22.60	1582												
25	21.15	37.83	4540	6.20	28.80	2016												
26	40.60	78.43	9412	0.30	29.10	2037												
	to P3 Pumping Station																	
P3	18.60	97.03	11644	48.30	77.40	5418												
force main sewer 27		97.03	11644		77.40	5418												
28		97.03	11644	41.70	119.10	8337												
	to 39																	
29	16.15		1938															
30	18.91	35.06	4207				25.20		150									
31	10.20	45.26	5431	1.40	1.40	98		25.20	150									
	to 34																	
32	19.60		1632	1.10		77							5.70		129			
33	33.15	46.75	5610	21.50	22.60	1582							1.30	7.00	159			
34		92.01	11041	0.40	30.40	2268		25.20	150					7.00	159			
	to P4 Pumping Station																	
P4		92.01	11041		32.40	2268		25.20	150					7.00	159			
force main sewer 35		92.01	11041		32.40	2268		25.20	150					7.00	159			
36	0.96	92.97	11156	10.60	43.00	3010		25.20	150					7.00	159			
37		92.97	11156		43.00	3010		25.20	150					7.00	159			
38		92.97	11156	5.30	48.30	3381		25.20	150					7.00	159			
39		428.10	51,372		214.80	15,036		80.55	1350		17.40	260		42.90	948		28.70	0.00
	to P5 Pumping Station																	
P5		428.10	51,372		214.80	15,036		80.80	1350		17.40	260		42.90	948		28.70	0
	to Waste Stabilization Pond																	

Area, Design Flow and Designed Sewer

No. of Sewers	Area Increment (ha)	Area Total (ha)	Population (persons)	Peaking Factor	Domestic Waste (m³/sec)	Other (m³/sec)	Infiltration I Area (ha)	Infiltration I Flow (m³/sec)	Infiltration II Area (ha)	Infiltration II Flow (m³/sec)	Total (m³/sec)	No. of Sewers	Diameter (mm)	Length (m)	Slope (‰)	Velocity (Full) (m/sec)	Capacity (Full) (m³/sec)	Ground Surface Elevation (m)	Sewer Invert Elevation (m)	Earth Covering (m)	Remarks
													to 39								
23	9.70		684	5.90	0.011				9.70	0.001	0.012	23	o 225	775.00	2.8	0.61	0.025	240 / (220)	1.155 / -1.015	1.00 / 2.97	
24	29.58	39.28	3584	4.17	0.040				39.28	0.003	0.043	24	o 300	265.00	2.2	0.65	0.047	(220) / (220)	-1.090 / -1.673	2.97 / 3.55	
25	27.35	66.63	6555	3.82	0.067				66.63	0.005	0.072	25	o 375	395.00	2.2	0.75	0.086	(220) / 214	-1.748 / -2.617	3.54 / 4.35	
26	40.90	107.53	11449	3.53	0.108				107.53	0.008	0.116	26	o 450	545.00	2.0	0.81	0.133	214 / 225	-2.692 / -3.782	4.84 / 5.54	
													to P3 Pumping Station								
P3	56.90	174.43	17,062	3.34	0.152				174.43	0.019	0.165	P3									
27		174.43	17,062	3.34	0.152				174.43	0.013	0.165	27	force main sewer o 375	575.00				225 / (210)	0.693 / 0.693	1.15 / 1.00	
28	41.70	216.13	19,981	3.26	0.173				216.13	0.016	0.189	28	o 525	1095.00	1.8	0.85	0.191	(210) / 1.73	0.534 / -1.487	1.00 / 2.60	U-600 Drain
													to 39								
29	16.15		1938	4.55	0.024				16.15	0.001	0.025	29	o 225	440.00	2.8	0.61	0.025	275 / 275	1.505 / 0.161	1.00 / 2.94	
30	44.11	60.26	4357	4.05	0.047				60.26	0.004	0.051	30	o 375	635.00	2.2	0.75	0.086	275 / 244	0.011 / -1.396	2.39 / 3.42	
31	11.60	71.86	5679	3.90	0.059				71.86	0.005	0.064	31	o 375	725.00	2.2	0.75	0.086	244 / 240	-1.396 / -2.981	3.42 / 4.97	
													to 34								
32	20.40		1761	4.61	0.022				20.40	0.002	0.024	32	o 225	840.00	2.8	0.61	0.025	240 / (240)	1.155 / -1.197	1.00 / 3.35	
33	55.95	76.35	7351	3.76	0.074				76.32	0.006	0.080	33	o 375	405.00	2.2	0.75	0.086	(240) / 240	-1.947 / -2.298	3.34 / 4.29	U-0 Drain
34	0.40	156.61	13618	3.44	0.125				156.61	0.012	0.137	34	o 525	45.00	1.8	0.85	0.191	240 / 240	-3.131 / -3.212	4.97 / 5.05	
													to P4 Pumping Station								
P4		156.61	13618	3.44	0.125				156.61	0.012	0.137	P4									
35		156.61	13618	3.44	0.125				156.61	0.012	0.137	35	force main sewer o 900	345.00				240 / (240)	1.079 / 1.079	1.00 / 1.00	
36	11.56	168.17	14,475	3.41	0.132				168.17	0.012	0.144	36	o 525	295.00	1.8	0.85	0.191	(240) / (240)	0.834 / -1.201	1.00 / 3.14	U-150 Drain
37		168.17	14,475	3.41	0.132				168.17	0.012	0.144	37	o 525	80.00	1.8	0.85	0.191	(240) / 240	-1.301 / -1.445	3.14 / 3.28	crossing Railway
38	5.30	173.47	14,646	3.40	0.134				173.47	0.013	0.147	38	o 525	540.00	1.8	0.85	0.191	240 / 1.83	-1.445 / -2.417	3.28 / 3.58	U-850 Drain
39		882.00	68,866	2.73	0.501	0.007	17.40	0.001	804.60	0.059	0.568	39	o 900	45.00	1.0	0.91	0.598	1.73 / (1.73)	-3.995 / -4.040	4.76 / 4.81	
													to P5 Pumping Station								
P5		882.00	68,866	2.73	0.501	0.007	17.40	0.001	804.60	0.059	0.568	P5									

Zone – B

Area by Land Use and Population

No. of Sewers	Commercial 400 persons/ha: Area Increment (ha)	Commercial: Area Total (ha)	Commercial: Population (persons)	Residential 120 persons/ha: Area Increment (ha)	Residential 120: Area Total (ha)	Residential 120: Population (persons)	Residential 70 persons/ha: Area Increment (ha)	Residential 70: Area Total (ha)	Residential 70: Population (persons)	Residential: Area Increment (ha)	Residential: Area Total (ha)	Residential: Population (persons)	Institution: Area Increment (ha)	Institution: Area Total (ha)	Institution: Population (persons)	School: Area Increment (ha)	School: Area Total (ha)	School: Population (persons)
1				5.81		697							2.40		5			
2				7.47	13.28	1,594								2.40	5			
3				12.45	25.73	3,088								2.40	5			
4	9.61		3,844	17.33	43.06	5,167								2.40	5	1.80		39
5	6.95	16.56	4,224		43.06	5,167								2.40	5	2.00	3.80	212
6	3.07	13.63	5,452		43.06	5,167								2.40	5		3.80	212
	to 12																	
7	3.61		1,444															
8	5.05	8.66	3,464															
9	2.16	10.82	4,328	12.61		1,513										0.95		69
10	18.90	29.72	11,888	2.51	15.12	1,814							1.50		15	0.72	1.67	415
11	9.05	38.77	15,508		15.12	1,814								1.50	15		1.67	415
12	0.99	52.79	21,116		58.18	6,982								3.90	20		5.47	629
	to 16																	
13	3.61		1,444															
14	3.61	7.22	2,888										0.70		7			
15	7.22	14.44	5,776										5.20	5.90	58			
16	0.09	67.32	26,928		58.18	6,982								9.80	78	4.93	10.40	994
	to 22																	
17				17.43		2,092												
18				15.67	33.10	3,972												
19				18.17	51.27	6,152												
20	2.15		860	1.83	53.10	6,372												
21	10.44	12.79	5,116		53.10	6,372												
22		80.11	32,044		111.28	13,354								9.80	78		10.40	994
	to P1 Pumping Station																	
P1		80.11	32,044		111.28	13,354								9.80	78		10.40	994
force main sewer 23		80.11	32,044		111.28	13,354								9.80	78		10.40	994
24	8.03	88.14	35,256		111.28	13,354				3.40		780	4.50	14.30	129		10.40	994

Area, Population and Design Flow

No. of Sewers	Area Increment (ha)	Area Total (ha)	Population (persons)	Peaking Factor	Domestic Waste (m³/sec)	Mosque (ha)	Infiltration I Area (ha)	Infiltration I Flow (m³/sec)	Infiltration II Area (ha)	Infiltration II Flow (m³/sec)	Total (m³/sec)
1	8.21		702	5.25	0.001 / 0.010		2.40	0.001	5.81	0.001	0.013
2	7.47	15.68	1,599	4.67	0.001 / 0.020		2.40	0.001	13.28	0.001	0.022
3	12.45	28.13	3,093	4.26	0.001 / 0.035		2.40	0.001	25.73	0.002	0.039
4	29.74	57.87	6,655	3.81	0.001 / 0.068	7.00	6.01	0.001	51.86	0.004	0.074
5	27.65	85.52	9,608	3.62	0.001 / 0.093	18.70 (25.70)	12.96	0.001	72.56	0.005	0.100
6	3.07	88.59	10,880	3.56	0.001 / 0.103	(25.70)	16.03	0.001	72.56	0.005	0.110
7	3.61		1,444	4.74	0.018		3.61	0.001			0.019
8	5.05	8.66	3,464	4.19	0.039		8.66	0.001			0.040
9	15.72	24.38	5,910	3.88	0.061		10.82	0.001	13.56	0.001	0.063
10	25.13	49.51	14,132	3.42	0.129	1.50	31.22	0.002	18.29	0.001	0.132
11	9.05	58.56	17,752	3.32	0.157	(1.50)	40.27	0.002	18.29	0.001	0.160
12	0.99	147.54	28,747	3.09	0.001 / 0.237	(87.20)	56.69	0.003	90.85	0.007	0.248
13	3.61		1,444	4.74	0.018		3.61	0.001			0.019
14	4.31	7.92	2,895	4.30	0.033		7.92	0.001			0.034
15	12.42	20.94	5,834	3.89	0.060		20.94	0.001			0.061
16	5.02	172.90	34,982	3.01	0.001 / 0.280	(87.20)	77.12	0.004	95.78	0.007	0.292
17	17.43		2,092	4.50	0.025				17.43	0.001	0.026
18	15.67	33.10	3,972	4.11	0.043	1.50			33.10	0.002	0.045
19	19.67	52.77	6,162	3.86	0.053				52.77	0.004	0.067
20	3.98	56.75	7,232	3.77	0.073	(1.50)	2.15	0.001	54.60	0.004	0.078
21	10.44	67.39	11,488	3.53	0.108	(1.50)	12.79	0.001	54.60	0.004	0.113
22		240.29	46,470	2.89	0.001 / 0.357	(88.70)	89.91	0.005	150.38	0.011	0.374
P1		240.29	46,470	2.89	0.001 / 0.357	(88.70)	89.91	0.005	150.38	0.011	0.374
23		240.29	46,470	2.89	0.001 / 0.357	(88.70)	89.91	0.005	150.38	0.011	0.374
24	15.93	256.22	50,507	2.86	0.001 / 0.384	(88.70)	108.44	0.005	159.78	0.011	0.401

Designed Sewer

No. of Sewers	Diameter (mm)	Length (m)	Slope (‰)	Velocity (Full) (m/sec)	Capacity (Full) (m³/sec)	Elevation Ground Surface (m)	Sewer Invert Elevation (m)	Earth Covering (m)	Remarks
1	○ 225	565.00	2.8	0.61	0.025	2.83 / 2.45	1.585 / 0.171	1.00 / 2.09	
2	○ 225	285.00	2.8	0.61	0.025	2.45 / 2.40	0.171 / -0.627	2.63 / 2.78	
3	○ 300	325.00	2.2	0.65	0.047	2.40 / 2.25	-0.708 / -1.417	2.78 / 3.35	
4	○ 375	590.00	2.2	0.75	0.086	2.25 / 1.80	-1.492 / -3.010	3.34 / 4.40	U~0m Drain
5	○ 450	135.00	2.0	0.81	0.133	1.80 / 2.00	-3.400 / -3.570	4.71 / 5.16	
6	○ 525	155.00	1.8	0.85	0.191	2.00 / 2.20	-3.745 / -4.024	5.18 / 5.66	U~155m Storm Sewer
	to 12								
7	○ 225	410.00	2.8	0.61	0.025	1.58 / 1.92	0.335 / -0.818	1.00 / 2.49	U~145m Drain
8	○ 300	360.00	2.2	0.65	0.047	1.92 / 1.77	-0.888 / -1.680	2.49 / 3.12	
9	○ 375	140.00	2.2	0.75	0.086	1.77 / 1.83	-1.755 / -2.063	3.12 / 3.48	
10	○ 450	410.00	2.0	0.81	0.133	1.83 / 2.36	-2.138 / -2.958	3.48 / 4.83	
11	○ 525	95.00	1.8	0.85	0.191	2.36 / (2.20)	-3.033 / -3.204	4.83 / 4.84	
12	○ 600	80.00	1.6	0.88	0.257	2.20 / (2.15)	-4.099 / -4.227	5.56 / 5.73	
	to 16								
13	○ 225	510.00	2.8	0.61	0.025	(2.47) / 2.46	1.239 / -0.652	0.99 / 2.87	U~55m Storm Sewer
14	○ 300	120.00	2.2	0.65	0.047	2.46 / 2.40	-0.727 / -0.991	2.87 / 3.07	
15	○ 375	605.00	2.2	0.75	0.086	2.40 / (2.15)	-1.066 / -2.397	3.06 / 4.14	U~62m Storm sewer
16	○ 675	215.00	1.4	0.89	0.327	(2.15) / 1.95	-4.302 / -4.603	5.73 / 5.82	U~175m Drain
	to 22								
17	○ 225	750.00	3.0	0.69	0.026	(2.60) / 2.29	1.455 / -0.795	1.00 / 2.84	
18	○ 300	190.00	2.2	0.65	0.047	2.29 / 2.26	-0.970 / -1.388	2.94 / 3.32	
19	○ 375	370.00	2.2	0.75	0.086	2.26 / 2.10	-1.463 / -2.277	3.32 / 3.77	
20	○ 375	80.00	2.2	0.75	0.086	2.10 / 1.85	-2.270 / -2.453	3.97 / 3.90	U~0m Drain
21	○ 450	400.00	2.0	0.81	0.133	1.85 / 1.95	-2.528 / -3.328	3.89 / 4.79	
22	○ 750	18.00	1.4	0.95	0.435	1.95 / 1.95	-4.678 / -4.692	5.88 / 5.84	
	to P1 Pumping Station								
P1									
23	○ 525	Force main sewer 20.00				1.95 / 1.95	1.950 / 1.950	— / —	U~30m Drain
24	○ 450	495.00	1.4	0.95	0.435	1.95 / 2.04	0.046 / -1.134	1.10 / 2.27	

Note: (1) Figure in parenthesis in the column Mosque indicates total area of Mosque.
(2) Upper figure in Domestic Waste column indicates wastewater discharged from a hospital

Zone - B

No. of Sewers	Area by Land Use and Population: Commercial 400 persons/ha, Area Increment (ha)	Commercial Area Total (ha)	Commercial Population (persons)	Residential 120 persons/ha, Area Increment (ha)	Residential 120 Area Total (ha)	Residential 120 Population (persons)	Residential 70 persons/ha, Area Increment (ha)	Residential 70 Area Total (ha)	Residential 70 Population (persons)	Residential, Area Increment (ha)	Residential Area Total (ha)	Residential Population (persons)	Institution, Area Increment (ha)	Institution Area Total (ha)	Institution Population (persons)	School, Area Increment (ha)	School Area Total (ha)	School Population (persons)	Area Increment (ha)	Area Total (ha)	Population (persons)	Peaking Factor	Design Flow: Domestic Waste (m³/sec)	Mosque (ha)	Infiltration I Area (ha)	Infiltration I Flow (m³/sec)	Infiltration II Area (ha)	Infiltration II Flow (m³/sec)	Total (m³/sec)	No. of Sewers	Designed Sewer: Diameter (mm)	Length (m)	Slope (‰)	Velocity (Full) (m/sec)	Capacity (Full) (m³/sec)	Ground Surface Elevation (m)	Sewer Invert Elevation (m)	Earth Covering (m)	Remarks
	to	29																													to	29							
25	1.80		720	4.15		498													5.95		1218	4.86	0.016		1.80	0.001	4.15	0.001	0.018	25	○ 225	380.00	2.8	0.51	0.025	1.60 1.60	0.047 -1.817	1.91 2.97	U~290m Drain
26	2.16	3.96	1584		4.15	498													2.16	8.11	2088	4.50	0.025		3.96	0.001	4.15	0.001	0.027	26	○ 300	105.00	2.2	0.65	0.047	1.60 (1.65)	-1.092 -1.323	2.97 2.65	
27	11.55	15.51	6204		4.15	498													11.55	19.66	6702	3.81	0.068		15.51	0.001	4.15	0.001	0.070	27	○ 375	485.00	2.2	0.75	0.086	(1.65) 1.99	-1.398 -2.368	2.64 3.95	U~390m Drain
28	5.77	21.28	8512		4.15	498													5.77	25.43	9010	3.65	0.088		21.28	0.001	4.15	0.001	0.090	28	○ 450	205.00	2.0	0.81	0.133	1.99 2.04	-2.443 -2.812	3.95 4.56	
29	0.18	109.50	43,840		115.49	13,852					3.40	780	0.30	14.60	125		10.40	994	0.48	282.13	59,591	2.79	0.001 0.442	(28.70)	124.20	0.007	157.93	0.012	0.462	29	○ 900	70.00	1.0	0.91	0.598	2.04 2.01	-3.262 -3.332	4.34 4.38	
30		109.50	43,840		115.43	13,852					3.40	780		14.60	125		10.40	994		282.13	59,591	2.79	0.001 0.442	(28.70)	124.20	0.007	157.93	0.012	0.462	30	○ 900	100.00	1.0	0.91	0.598	2.01 2.06	-3.332 -3.522	4.38 4.64	Crossing Railway
31		109.60	43,840	4.15	119.58	14,350					3.40	780		14.60	125		10.40	994	4.15	286.28	60,089	2.79	0.001 0.446	(28.70)	124.20	0.007	162.08	0.012	0.466	31	○ 900	75.00	1.0	0.91	0.598	2.06 2.03	-3.522 -3.697	4.64 4.76	
	to	35																													to	35							
32	2.20		880	7.99		959													10.19		1,839	4.58	0.022		2.20	0.001	7.99	0.001	0.024	32	○ 225	465.00	2.8	0.51	0.025	(1.50) 1.63	0.855 -1.047	1.00 2.43	
33	4.20	6.40	2560	18.69	26.68	3,226													23.09	33.08	5,786	3.89	0.060		6.40	0.001	16.69	0.001	0.062	33	○ 375	320.00	2.2	0.75	0.086	1.63 1.53	-1.197 -1.901	2.42 3.02	
34		6.40	2560	4.15	31.03	3,724										1.99		107	0.14	39.42	6,391	3.84	0.065		6.40	0.001	38.02	0.002	0.068	34	○ 375	960.00	2.2	0.75	0.086	1.53 2.03	-2.500 -3.281	3.62 4.90	U~10m Drain
35		116.00	46,400	19.28	163.89	19,667					3.40	780		14.60	185	20.67	32.06	1,459	39.75	359.65	68,431	2.79	0.001 0.478	(28.70)	190.60	0.007	229.05	0.017	0.522	35	○ 900	700.00	1.0	0.91	0.598	2.03 1.79	-3.697 -4.297	4.76 5.22	
	to	67																													to	67							
36				7.67		920													7.67		920	5.06	0.012	1.00			7.67	0.001	0.013	36	○ 225	525.00	2.8	0.61	0.025	3.36 (2.50)	2.115 0.965	1.00 1.89	
37				26.27	33.94	4,073													27.27	34.94	4,075	4.09	0.044				34.94	0.008	0.047	37	○ 300	305.00	2.2	0.65	0.047	(2.50) 2.14	0.890 -0.381	1.89 2.20	
38				14.57	48.51	5,821										8.10		120	22.67	57.51	5,941	3.88	0.061	(1.00)			57.51	0.004	0.065	38	○ 375	115.00	2.2	0.75	0.086	2.14 (2.10)	-0.456 -0.709	2.19 2.40	
39				11.89	60.40	7,248											8.10	120	11.89	69.50	7,368	3.76	0.074	(1.00)			69.50	0.005	0.079	39	○ 450	395.00	2.0	0.81	0.133	(2.10) (2.20)	-0.784 -1.554	2.40 3.27	
40				11.89	72.29	8,675											8.10	120	11.89	81.39	8,795	3.57	0.086	(1.00)			81.39	0.006	0.102	40	○ 450	340.00	2.0	0.81	0.133	(2.20) (2.20)	-1.554 -2.234	3.27 3.95	
41				20.61	92.90	11,148											8.10	120	20.61	102.00	11,267	3.54	0.106	(1.00)			102.00	0.007	0.119	41	○ 450	265.00	2.0	0.81	0.133	(2.20) (2.20)	-2.234 -2.724	3.95 4.44	
	to	P2 Pumping Station																													to	P2 Pumping Station							
P2					92.90	11,148											8.10	120		102.00	11,267	3.54	0.106	(1.00)			102.00	0.007	0.119	P2									
force	main sewer																														○ force main sewer					(2.20)	2.200		U~70m Drain
42					92.90	11,148											8.10	120		102.00	11,267	3.54	0.106	(1.00)			102.00	0.007	0.119	42	300	115.00				2.40	2.400		
43				9.28	102.18	12,262										1.10	9.20	170	10.38	112.38	12,482	3.49	0.115	(1.00)			112.38	0.008	0.122	43	○ 450	520.00	2.0	0.81	0.133	2.40 (2.60)	0.912 -0.128	1.00 2.24	
44				33.50	135.68	16,288										0.50	9.70	200	36.30	148.68	16,488	3.35	0.147	2.30 (3.30)			148.68	0.011	0.158	44	○ 525	460.00	1.8	0.85	0.191	(2.60) 3.03	-0.203 -1.381	2.24 4.50	
	to	49																													to	49							
45							8.90		623										8.90		623	5.35	0.009				8.90	0.001	0.010	45	○ 225	750.00	2.8	0.61	0.025	2.40 (2.40)	1.155 -0.973	1.00 3.19	
46				8.20		984	11.61	20.51	1,436										19.81	20.71	2,420	4.41	0.028				20.71	0.002	0.030	46	○ 300	490.00	2.2	0.65	0.047	(2.40) (2.40)	-1.048 -2.126	3.19 4.21	
47				18.04	26.24	3,149	18.53	39.04	2,733	1.20		960							37.77	66.48	6,842	3.80	0.069				66.48	0.005	0.074	47	○ 375	425.00	2.2	0.75	0.086	(2.40) (3.00)	-2.201 -3.136	4.19 5.79	

Zone - B

No. of Sewers	Commercial 400 persons/ha Area Increment	Commercial Area Total	Commercial Population	Residential 120 persons/ha Area Increment	Residential 120 Area Total	Residential 120 Population	Residential 70 persons/ha Area Increment	Residential 70 Area Total	Residential 70 Population	Residential Area Increment	Residential Area Total	Residential Population	Institution Area Increment	Institution Area Total	Institution Population	School Area Increment	School Area Total	School Population	Area Increment	Area Total	Population	Peaking Factor	Domestic Waste	Mosque	Infiltration I Area	Infiltration I Flow	Infiltration II Area	Infiltration II Flow	Total	No. of Sewers	Diameter	Length	Slope	Velocity (Full)	Capacity (Full)	Ground Surface Elevation	Sewer Invert Elevation	Earth Covering	Remarks
	ha	ha	persons	ha	ha	persons	ha	ha	persons	ha	ha	persons	ha	ha	persons	ha	ha	persons	ha	ha	persons		m³/sec	ha	ha	m³/sec	ha	m³/sec	m³/sec		mm	m	‰	m/sec	m³/sec	m	m	m	
48				6.56	32.80	3,936		39.04	2,733		1.20	960							11.96	78.44	7,629	3.74	0.076	5.40			78.44	0.006	0.082	48	○ 375	75.00	2.2	0.75	0.086	(3.00) 3.03	-3.136 -3.361	5.73 5.92	
49				1.87	170.35	20,442		39.04	2,733		1.20	960					9.70	200	1.87	228.99	24,335	3.17	0.205	(8.70)			228.99	0.017	0.222	49	○ 600	30.00	1.6	0.88	0.257	3.03 3.03	-3.526 -3.574	5.91 5.96	
	to	P3 Pumping Station																													to P3 Pumping Station								
P3					170.35	20,442		39.04	2,733		1.20	960					9.70	200		228.99	24,335	3.17	0.205	(8.70)			228.99	0.017	0.222	P3									
force main sewer																															force main sewer								
50					170.35	20,442		39.04	2,733		1.20	960					9.70	200		228.99	24,335	3.17	0.205	(8.70)			228.99	0.017	0.222	50	○ 450	315.00				3.03 (3.00)	1.542 1.512	1.00 1.00	
51				11.52	181.87	21,824		39.04	2,733		1.20	960					9.70	200	19.72	248.71	25,717	3.14	0.215	8.20 (16.90)			248.71	0.018	0.233	51	○ 600	540.00	1.6	0.88	0.257	(3.00) 2.42	1.356 0.492	1.00 1.28	
52				44.73	228.60	27,192		39.04	2,733		1.20	960					9.70	200	44.73	293.44	31,085	3.06	0.253	(16.90)			293.44	0.021	0.274	52	○ 675	85.00	1.4	0.89	0.327	2.42 2.29	0.417 0.298	1.28 1.27	
	to	61																													to 61								
53							7.13		499										7.13		499	5.52	0.007				7.13	0.001	0.008	53	○ 225	355.00	2.8	0.61	0.025	2.40 (2.40)	1.155 0.161	1.00 1.99	
54				0.22		26	11.86	18.99	1,329										12.08	19.21	1,355	4.79	0.017				19.21	0.001	0.018	54	○ 225	925.00	2.8	0.61	0.025	(2.40) (2.40)	0.161 -0.777	1.99 2.98	
55				16.40	16.62	1,994	8.16	27.15	1,901										24.56	43.77	3,895	4.12	0.043				43.77	0.003	0.046	55	○ 300	395.00	2.2	0.65	0.047	(2.40) (2.40)	-0.852 -1.721	2.93 3.80	
56				1.76	18.38	2,201	6.68	33.83	2,368										8.44	52.21	4,569	4.02	0.049				52.21	0.004	0.053	56	○ 375	150.00	2.2	0.75	0.086	(2.40) (2.30)	-1.796 -2.126	3.79 4.02	U~150m Drain
	to	60																													to 60								
57							15.10		1,057										15.10		1,057	4.96	0.014				15.10	0.001	0.015	57	○ 225	600.00	2.8	0.61	0.025	(1.80) (2.00)	0.555 -1.795	1.00 3.55	U~380m Drain
58				10.83		1,300	13.34	29.44	1,991										24.17	39.27	3,291	4.22	0.037				39.27	0.003	0.040	58	○ 300	675.00	2.2	0.65	0.047	(2.00) (2.30)	-1.870 -3.355	3.35 5.33	
59				1.99	12.82	1,538	2.18	31.22	2,185										4.77	44.04	3,723	4.14	0.041				44.04	0.003	0.044	59	○ 300	20.00	2.2	0.65	0.047	(2.30) (2.30)	-3.355 -3.399	5.33 5.38	
60				6.75	37.95	4,554		65.05	4,554										6.75	103.00	9,108	3.65	0.088				102.00	0.008	0.096	60	○ 450	430.00	2.0	0.81	0.133	(2.30) 2.29	-3.549 -4.409	5.36 6.21	
61				3.74	268.29	32,195		104.09	7,286		1.20	960					9.70	200	9.74	400.18	40,641	2.95	0.319	(16.90)			400.18	0.029	0.348	61	○ 750	165.00	1.4	0.95	0.435	2.29 2.40	-4.709 -4.940	6.20 6.55	
	to	P4 Pumping Station																													to P4 Pumping Station								
P4					268.29	32,195		104.09	7,286		1.20	960					9.70	200		400.18	40,641	2.95	0.319	(16.90)			400.18	0.029	0.348	P4									
62				6.64	274.93	32,992		104.09	7,286		1.20	960				5.54	15.24	604	13.88	414.06	41,842	2.93	0.327	1.70 (18.60)			414.06	0.030	0.357	62	○ 750	410.00	1.4	0.95	0.435	2.40 2.29	0.599 0.025	1.00 1.46	
63				13.01	287.94	34,553		104.09	7,286		1.20	960					15.24	604	13.01	427.07	42,403	2.92	0.337	(18.60)			427.07	0.031	0.360	63	○ 750	590.00	1.4	0.95	0.435	2.29 (1.50)	-0.913 -1.789	2.40 2.44	U~0m Drain
	to	66																													to 66								
64				12.30		1,476	0.36		25										12.66		1,501	4.72	0.019				12.66	0.001	0.020	64	○ 225	640.00	2.8	0.61	0.025	(2.00) (1.60)	0.755 -1.097	1.00 2.39	
65				25.30	37.60	4,512	4.45	4.81	337										29.75	42.41	4,849	3.99	0.052				42.41	0.003	0.055	65	○ 375	575.00	2.2	0.75	0.086	(1.60) (1.50)	-1.187 -2.452	2.38 2.55	
66				9.95	305.49	40,259		108.90	7,623		1.20	960					15.24	604	9.95	479.43	49,446	2.86	0.377	(18.60)			479.43	0.035	0.412	66	○ 750	435.00	1.4	0.95	0.435	(1.50) 1.79	-2.827 -4.071	3.53 5.06	
67		116.00	46,400	0.42	499.80	59,976		108.90	7,623		4.50	1,740		14.60	185		48.90	2,069	0.92	840.00	117,927	2.53	0.001 0.790	0.50 (47.80)	190.60	0.007	709.40	0.052	0.854	67	○ 1050	400.00	1.0	1.01	0.899	1.79 2.03	-4.547 -4.947	5.21 6.75	
	to	P5 Pumping Station																													to P5 Pumping Station								
P5		116.00	46,400	87.70	587.50	70,500	49.30	158.20	10,654		4.50	1,740		14.60	185		48.90	2,069	131.00	971.00	131,482	2.49	0.001 0.872	(47.80)	190.60	0.007	840.40	0.061	0.941	P5									

Zone - B

No. of Sewers	Commercial 400 persons/ha: Area Increment (ha)	Commercial: Area Total (ha)	Commercial: Population (persons)	Residential 120 persons/ha: Area Increment (ha)	Residential 120: Area Total (ha)	Residential 120: Population (persons)	Residential 70 persons/ha: Area Increment (ha)	Residential 70: Area Total (ha)	Residential 70: Population (persons)	Residential: Area Increment (ha)	Residential: Area Total (ha)	Residential: Population (persons)	Institution: Area Increment (ha)	Institution: Area Total (ha)	Institution: Population (persons)	School: Area Increment (ha)	School: Area Total (ha)	School: Population (persons)	Area: Increment (ha)	Area: Total (ha)	Population (persons)	Peaking Factor
Force	main sewer																					
68		116.00	46,400		587.50	70,500		152.20	10,654		4.60	1,740		14.60	125		48.30	2,063		971.00	131,482	2.49
	to	Waste	Stabelezation	Pond																		

No. of Sewers	Design Flow: Domestic Waste (m³/sec)	Mosque (ha)	Infiltration I: Area (ha)	Infiltration I: Flow (m³/sec)	Infiltration II: Area (ha)	Infiltration II: Flow (m³/sec)	Total (m³/sec)	No. of Sewers	Designed Sewer: Diameter (mm)	Length (m)	Slope (‰)	Velocity (Full) (m/sec)	Capacity (Full) (m³/sec)	Ground Surface Elevation (m)	Sewer Invert Elevation (m)	Earth Covering (m)	Remarks
Force	0.001								Force main sewer					2.03	0.403	1.00	
68	0.872	(47.80)	190.60	0.007	840.40	0.051	0.941	68	⌀600×2	1620.00				1.20	0.779	--	

Zone – C

No. of Sewers	Residential 120 persons/ha Area Increment (ha)	Residential 120 persons/ha Area Total (ha)	Residential 120 persons/ha Population (persons)	Residential 70 persons/ha Area Increment (ha)	Residential 70 persons/ha Area Total (ha)	Residential 70 persons/ha Population (persons)	Residential Area Increment (ha)	Residential Area Total (ha)	Residential Population (persons)	North Mergong Industrial Area Increment (ha)	North Mergong Industrial Area Total (ha)	North Mergong Industrial Population (persons)	South Mergong Industrial Area Increment (ha)	South Mergong Industrial Area Total (ha)	South Mergong Industrial Population (persons)	School Area Increment (ha)	School Area Total (ha)	School Population (persons)	Area Increment (ha)	Area Total (ha)	Population (persons)	Peaking Factor	Domestic Waste (m³/sec)	Other (m³/sec)	Infiltration I Area (ha)	Infiltration I Flow (m³/sec)	Infiltration II Area (ha)	Infiltration II Flow (m³/sec)	Total (m³/sec)	No. of Sewers
1				6.77		474													6.77		474	5.56	0.007				6.77	0.001	0.008	1
2				20.21	26.98	1,889										6.80		10	21.01	27.78	1,899	4.56	0.023				27.78	0.002	0.025	2
3	2.50		300	27.79	54.77	3,834										3.20	4.00	50	33.49	61.27	4,184	4.08	0.045				61.27	0.005	0.050	3
4	40.50	43.00	5,160	14.45	69.22	4,845											4.00	50	54.95	116.22	10,055	3.60	0.096				116.22	0.009	0.105	4
5		43.00	5,160	36.39	105.61	7,393				26.90		8,070					4.00	50	63.29	179.51	20,673	3.24	0.179				179.51	0.013	0.192	5
	to P1 Pumping Station																													
P1		43.00	5,160		105.61	7,393					26.90	8,070					4.00	50		179.51	20,673	3.24	0.179				179.51	0.013	0.192	P1
force main sewer 6		43.00	5,160		105.61	7,393					26.90	8,070					4.00	50		179.51	20,673	3.24	0.179				179.51	0.013	0.192	6
7		43.00	5,160		105.61	7,393				20.60	47.50	14,250					4.00	50	20.60	200.11	26,859	3.13	0.223				200.11	0.015	0.238	7
	to 12																													
8										9.97		2,991							9.97		2,991	4.28	0.034				9.97	0.001	0.035	8
9										23.77	33.74	10,122							23.77	33.74	10,122	3.59	0.097				33.74	0.008	0.100	9
10	5.68		682				5.00		2,000	34.68	68.42	20,524							45.36	79.10	23,208	3.19	0.197				79.10	0.006	0.203	10
11	3.04	8.72	1,046					5.00	2,000	17.82	86.24	25,872							20.86	99.96	28,918	3.09	0.238				99.96	0.007	0.245	11
12	54.18	105.90	12,708		105.61	7,393		5.00	2,000	12.26	146.00	43,800					4.00	50	56.44	366.51	65,951	2.75	0.483				366.51	0.027	0.510	12
	to P2 Pumping Station																													
P2		105.90	12,708		105.61	7,393		5.00	2,000		146.00	43,800					4.00	50		366.51	65,951	2.75	0.483				366.51	0.027	0.510	P2
force main sewer 13		105.90	12,708		105.61	7,393		5.00	2,000		146.00	43,800					4.00	50		366.51	65,951	2.75	0.483				366.51	0.027	0.510	13
14	36.68	142.58	17,110		105.61	7,393		5.00	2,000		146.00	43,800				10.60	14.60	243	47.28	413.79	70,546	2.72	0.511				413.79	0.030	0.541	14
	to P4 Pumping Station																													
15				8.89		622													8.89		622	5.35	0.009				8.89	0.001	0.010	15
16				19.81	28.70	2,009													19.81	28.70	2,009	4.53	0.024				28.70	0.002	0.026	16
17	9.39		1,120	17.79	46.49	3,254										1.00		74	28.12	56.82	4,448	4.04	0.048				56.82	0.004	0.052	17
	to 21																													
18				8.09		566													8.09		566	5.48	0.008				8.09	0.001	0.009	18
19				29.92	38.01	2,661													29.92	38.01	2,661	4.35	0.031				38.01	0.003	0.034	19
20	2.06		247	8.89	46.90	3,283													10.95	48.96	3,530	4.18	0.039				48.96	0.004	0.043	20
21	13.58	24.97	2,996		93.39	6,537											1.00	74	13.58	119.36	9,607	3.62	0.093				119.36	0.009	0.102	21
	to P3 Pumping Station																													

No. of Sewers	Diameter (mm)	Length (m)	Slope (‰)	Velocity (Full) (m/sec)	Capacity (Full) (m³/sec)	Ground Surface Elevation (m)	Sewer Invert Elevation (m)	Earth Covering (m)	Remarks
1	⊙225	265.00	2.8	0.61	0.025	(2.40) / (2.40)	1.155 / 0.135	1.00 / 2.02	
2	⊙225	470.00	2.8	0.61	0.025	(2.40) / 2.40	0.130 / -1.188	2.02 / 3.34	
3	⊙375	925.00	2.2	0.75	0.086	2.40 / (2.60)	-1.223 / -3.368	3.53 / 5.56	
4	⊙450	250.00	2.0	0.81	0.133	(2.60) / (2.60)	-3.443 / -3.962	5.56 / 6.25	
5	⊙600	72.00	1.6	0.88	0.257	(2.60) / (2.60)	-4.093 / -4.205	6.25 / 6.56	U~30m Drain
	to P1 Pumping Station								
P1									
6	force main sewer ⊙375	40.00				(2.80) / 2.82	1.493 / 1.413	1.00 / 1.00	
7	⊙600	1350.00	1.6	0.88	0.257	2.82 / 2.20	1.176 / -0.984	1.00 / 0.54	
	to 12								
8	⊙300	590.00	2.2	0.65	0.047	(2.00) / (1.50)	0.679 / -0.487	1.00 / 1.67	
9	⊙450	390.00	2.0	0.81	0.133	(1.50) / (1.00)	-0.637 / -1.417	1.67 / 1.48	
10	⊙600	685.00	1.6	0.88	0.257	(1.00) / 2.19	-1.567 / -2.567	1.48 / 4.11	U~0m Drain
11	⊙600	610.00	1.6	0.88	0.257	2.19 / 2.20	-2.567 / -3.548	4.11 / 5.10	U~260m Drain
12	⊙900	145.00	1.0	0.91	0.598	2.20 / 1.91	-3.643 / -3.988	5.08 / 4.94	
	to P2 Pumping Station								
P2									
13	force main sewer ⊙600	425.00				1.91 / 1.81	0.166 / 1.810	1.10	U~425m Drain
14	⊙900	675.00	1.0	0.91	0.598	1.81 / (2.12)	-0.153 / -0.808	1.00 / 1.99	
	to P4 Pumping Station								
15	⊙225	415.00	2.8	0.61	0.025	(2.40) / (2.40)	1.155 / -0.007	1.00 / 2.16	
16	⊙300	525.00	2.2	0.65	0.047	(2.40) / (2.40)	-0.082 / -1.237	2.16 / 3.32	
17	⊙375	580.00	2.2	0.75	0.086	(2.40) / 2.62	-1.312 / -2.808	3.31 / 5.02	
	to 21								
18	⊙225	195.00	2.8	0.61	0.025	(2.00) / (2.00)	0.755 / 0.377	1.00 / 1.38	
19	⊙300	560.00	2.2	0.65	0.047	(2.00) / (2.30)	0.302 / -0.930	1.38 / 2.91	
20	⊙300	370.00	2.2	0.65	0.047	(2.30) / 2.62	-0.930 / -1.744	2.91 / 4.04	U~860m Drain
21	⊙450	540.00	2.0	0.81	0.133	2.62 / 2.61	-2.888 / -3.969	5.02 / 5.09	
	to P3 Pumping Station								

Zone - C

No. of Sewers	Residential 120 persons/ha Area Increment (ha)	Residential 120 persons/ha Area Total (ha)	Residential 120 persons/ha Population (persons)	Residential 70 persons/ha Area Increment (ha)	Residential 70 persons/ha Area Total (ha)	Residential 70 persons/ha Population (persons)	Residential Area Increment (ha)	Residential Area Total (ha)	Residential Population (persons)	North Mergong Industrial Area Increment (ha)	North Mergong Industrial Area Total (ha)	North Mergong Industrial Population (persons)	South Mergong Industrial Area Increment (ha)	South Mergong Industrial Area Total (ha)	South Mergong Industrial Population (persons)	School Area Increment (ha)	School Area Total (ha)	School Population (persons)
P3		24.97	2,996		93.39	6,537											1.00	74
force main sewer																		
22		24.97	2,996		93.39	6,537											1.00	74
23	37.55	62.52	7,502		93.39	6,537							43.00			0.30	1.30	79
to P4 Pumping Station																		
P4		205.10	24,612		199.00	13,930		5.00	2,000		146.00	43,800		43.00			15.90	327
force main sewer																		
24		205.10	24,612		199.00	13,930		5.00	2,000		146.00	43,800		43.00			15.90	328
to Waste Stabilezation Pond																		

No. of Sewers	Area Increment (ha)	Area Total (ha)	Population (persons)	Peaking Factor	Design Flow Domestic Waste (m³/sec)	Design Flow Other (m³/sec)	Infiltration I Area (ha)	Infiltration I Flow (m³/sec)	Infiltration II Area (ha)	Infiltration II Flow (m³/sec)	Total (m³/sec)	No. of Sewers	Designed Sewer Diameter (mm)	Length (m)	Slope (‰)	Velocity (Full) (m/sec)	Capacity (Full) (m³/sec)	Ground Surface Elevation (m)	Sewer Invert Elevation (m)	Earth Covering (m)	Remarks
P3		119.96	9,607	3.62	0.093				119.96	0.009	0.102	P3									
													force main sewer					2.61	0.799	1.49	U=150 Drain
22		119.96	9,607	3.62	0.093				119.96	0.009	0.102	22	ø900	215.00				2.12	0.799	1.00	
													ø					2.12	0.476	1.00	
23	80.85	200.21	14,118	3.42	0.129	0.051			200.21	0.015	0.195	23	500	920.00	1.6	0.88	0.257	2.13	-0.996	2.48	
													to P4 Pumping Station								
P4		614.00	84,664	2.65	0.598	0.051			614.00	0.045	0.694	P4									
													force main sewer					(2.13)	-0.105	1.22	
24		614.00	84,664	2.65	0.598	0.051			614.00	0.045	0.694	24	ø675	815.00				1.54	-0.183	1.00	

Zone - D

Area by Land Use and Population

No. of Sewers	Commercial 400 persons/ha Area Increment (ha)	Commercial Area Total (ha)	Commercial Population (persons)	Residential 120 persons/ha Area Increment (ha)	Residential 120 Area Total (ha)	Residential 120 Population (persons)	Residential Area Increment (ha)	Residential Area Total (ha)	Residential Population (persons)	School Area Increment (ha)	School Area Total (ha)	School Population (persons)	Park Area Increment (ha)	Park Area Total (ha)	Park Population (persons)	Mosque 0 person/ha Area Increment (ha)	Mosque Area Total (ha)	Mosque Population (persons)
1				2.10		252	1.50		660							0.30		
2				6.73	8.83	1060		1.50	660								0.30	
3	2.75		1100	14.20	23.03	2764		1.50	660	0.80		40					0.30	
	to	10																
4				17.65		2118												
5				5.88	23.53	2824												
6				0.42	23.95	2874												
7				17.86	41.81	5017				1.40		50				0.40		
8				22.17	63.98	7678					1.40	50					0.40	
9				11.45	75.43	9052					1.40	50					0.40	
10		2.75	1100	13.14	111.60	13,392		1.50	660		2.20	90					0.70	
	to	13																
11				22.17		2660				2.20		50						
12				5.88	28.05	3366					2.20	50						
13		2.75	1100	33.00	172.65	20,718		1.50	660		4.40	140					0.70	
14	15.64	18.39	7356	22.80	195.45	23,454		1.50	660	1.40	5.80	164				1.10	1.80	
15	5.73	24.12	9648	1.01	196.46	23,575		1.50	660		5.80	164	9.60				1.80	
	to	P1	Pumping Station															
P1		24.12	9648		196.46	23,575		1.50	660		5.80	164		9.60			1.80	
16	7.64	31.76	12704	9.25	205.71	24,685		1.50	660		5.80	164		9.60			1.80	
	to	22																
17				14.29		1,715				0.50		36						
18				27.85	42.14	5,057				11.20	11.70	293						
	to	21																
19				15.13		1,816												
20				7.57	22.70	2,724												
21	6.69		2676	12.08	76.92	9,230					11.70	893						
22	1.55	40.00	16000	32.67	315.52	37,860		1.50	6.60	1.8	19.30	546		9.60		0.30	2.10	
23		40.00	16,000	25.84	341.36	40,961		1.50	6.60		19.30	546		9.60			2.10	

Area, Design Flow and Designed Sewer

No. of Sewers	Area Increment (ha)	Area Total (ha)	Population (persons)	Peaking Factor	Domestic Waste (m³/sec)	Other (m³/sec)	Infiltration I Area (ha)	Infiltration I Flow (m³/sec)	Infiltration II Area (ha)	Infiltration II Flow (m³/sec)	Total (m³/sec)	No. of Sewers	Diameter (mm)	Length (m)	Slope (‰)	Velocity (Full) (m/sec)	Capacity (Full) (m³/sec)	Ground Surface Elevation (m)	Sewer Invert Elevation (m)	Earth Covering (m)	Remarks
1	2.90		912	5.07	0.012				3.90	0.001	0.013	1	⊙ 225	230.00	2.8	0.61	0.025	1.22 / (1.70)	-0.025 / -0.669	1.00 / 2.12	
2	6.73	10.63	1,720	4.63	0.021				10.63	0.001	0.022	2	⊙ 225	250.00	2.8	0.61	0.025	(1.70) / 2.12	-0.669 / -1.369	2.12 / 3.24	
3	17.75	28.38	4,564	4.03	0.049		2.75	0.001	25.63	0.002	0.052	3	⊙ 375	585.00	2.2	0.75	0.086	2.12 / (1.90)	-1.519 / -2.806	3.29 / 4.30	
													to	10							
4	17.65		2,118	4.49	0.025				17.65	0.001	0.026	4	⊙ 300	60.00	2.2	0.65	0.047	(1.50) / 1.53	0.179 / 0.069	1.00 / 1.14	
5	5.88	23.53	2,824	4.31	0.032				23.53	0.002	0.034	5	⊙ 300	310.00	2.2	0.65	0.047	1.53 / (2.00)	0.069 / -0.613	1.14 / 2.29	
6	0.42	23.95	2,874	4.30	0.033				23.95	0.002	0.035	6	⊙ 300	120.00	2.2	0.65	0.047	(2.00) / (2.00)	-0.618 / -0.877	2.29 / 2.56	
7	19.66	43.61	5,067	3.97	0.054				43.61	0.003	0.057	7	⊙ 375	80.00	2.2	0.75	0.086	(2.00) / (2.00)	-0.952 / -1.128	2.55 / 2.79	
8	22.17	65.78	7,728	3.73	0.077				65.78	0.005	0.082	8	⊙ 375	430.00	2.2	0.75	0.086	(2.00) / (1.90)	-1.128 / -2.074	2.73 / 3.57	
9	11.45	77.23	9,102	3.65	0.088				77.23	0.006	0.094	9	⊙ 450	220.00	2.0	0.81	0.133	(1.90) / (1.90)	-2.149 / -2.569	3.56 / 4.00	
10	13.14	118.75	15,242	3.39	0.138		2.75	0.001	116.00	0.009	0.148	10	⊙ 525	365.00	1.8	0.85	0.191	(1.90) / (1.70)	-2.956 / -3.613	4.29 / 4.75	
													to	13							
11	24.37		2,710	4.34	0.031				24.37	0.002	0.031	11	⊙ 300	655.00	2.2	0.65	0.047	(2.50) / 1.53	1.177 / -0.262	1.00 / 1.47	
12	5.88	30.25	3,416	4.20	0.038				30.25	0.002	0.040	12	⊙ 300	260.00	2.2	0.65	0.047	1.53 / (1.70)	-0.262 / -0.854	1.47 / 2.21	
13	33.00	182.00	22,618	3.20	0.193		2.75	0.001	179.25	0.013	0.207	13	⊙ 600	465.00	1.6	0.88	0.257	(1.70) / 2.04	-3.688 / -4.432	4.74 / 5.89	
14	40.94	222.94	31,634	3.05	0.257		18.39	0.001	204.55	0.015	0.273	14	⊙ 675	395.00	1.4	0.89	0.327	2.04 / (2.80)	-4.507 / -5.060	5.62 / 7.14	
15	16.84	239.28	34,047	3.02	0.274		24.12	0.001	215.16	0.016	0.291	15	⊙ 675	30.00	1.4	0.89	0.327	(2.80) / (2.80)	-5.060 / -5.102	7.14 / 7.18	
													to P1	Pumping Station							
P1		239.28	34,047	3.02	0.274		24.12	0.001	215.16	0.016	0.291	P1									
16	16.89	256.17	38,213	2.97	0.302		31.76	0.002	224.41	0.016	0.320	16	⊙ 675	825.00	1.4	0.89	0.327	(2.80) / 3.04	1.023 / -0.132	1.05 / 2.45	
													to	22							
17	14.79		1,751	4.62	0.022				14.79	0.001	0.023	17	⊙ 225	545.00	2.8	0.61	0.025	(2.50) / 2.35	1.255 / -0.271	1.00 / 2.38	
18	39.05	53.84	5,350	3.94	0.056				53.84	0.004	0.060	18	⊙ 375	450.00	2.2	0.75	0.086	2.35 / 2.50	-0.421 / -1.411	2.36 / 3.50	
													to	21							
19	15.13		1,816	4.59	0.022				15.13	0.001	0.023	19	⊙ 225	575.00	2.8	0.61	0.025	2.40 / 2.38	1.155 / -0.455	1.00 / 2.59	
20	7.57	22.70	2,724	4.37	0.031				22.70	0.002	0.033	20	⊙ 300	345.00	2.2	0.65	0.047	2.38 / 2.50	-0.590 / -1.289	2.59 / 3.47	
21	18.77	95.31	12,199	3.50	0.114		6.69	0.001	88.62	0.007	0.122	21	⊙ 450	375.00	2.0	0.81	0.133	2.50 / 3.04	-1.486 / -2.836	3.50 / 4.79	U-375ᵐ Drain
22	36.52	388.00	55,066	2.82	0.413		40.00	0.002	348.00	0.025	0.440	22	⊙ 900	680.00	1.0	0.91	0.598	3.04 / (2.00)	-2.686 / -3.366	4.86 / 4.40	Crossing Railway
23	25.84	413.84	58,167	2.80	0.433		40.00	0.002	373.84	0.027	0.462	23	⊙ 900	20.00	1.0	0.91	0.598	(2.00) / (2.00)	-3.366 / -3.386	4.40 / 4.42	

Zone – D

No. of Sewers	Commercial 400 persons/ha Area Increment (ha)	Commercial Area Total (ha)	Commercial Population (persons)	Residential 120 persons/ha Area Increment (ha)	Residential 120 Area Total (ha)	Residential 120 Population (persons)	Residential Area Increment (ha)	Residential Area Total (ha)	Residential Population (persons)	School Area Increment (ha)	School Area Total (ha)	School Population (persons)	Park Area Increment (ha)	Park Area Total (ha)	Park Population (persons)	Mosque 0 person/ha Area Increment (ha)	Mosque Area Total (ha)	Mosque Population (persons)	Area Increment (ha)	Area Total (ha)	Population (persons)	Peaking Factor	Design Flow Domestic Waste (m³/sec)	Other (m³/sec)	Infiltration I Area (ha)	Infiltration I Flow (m³/sec)	Infiltration II Area (ha)	Infiltration II Flow (m³/sec)	Total (m³/sec)	No. of Sewers	Designed Sewer Diameter (mm)	Length (m)	Slope (‰)	Velocity (Full) (m/sec)	Capacity (Full) (m³/sec)	Ground Surface Elevation (m)	Sewer Invert Elevation (m)	Earth Covering (m)	Remarks
	to	P2 Pumping Station																													to P1 Pumping Station								
P2 Force main sewer		40.00	16,000		341.34	40,961		1.50	660		19.30	546		9.60		210				413.84	58,167	2.80	0.433		40.00	0.002	373.84	0.027	0.462	P2	Force main Sewer					(2.00)	0.356	1.00	U~260m Drain
24		40.00	16,000		341.34	40,961		1.50	660		19.30	546		9.60		210				413.84	58,167	2.80	0.433		40.00	0.002	373.84	0.027	0.462	24	○ 600	1440.00				(2.20)	0.556	1.00	
	to	Waste Stabilization Pond																																					
25				11.56		1,387				4.00		84							15.56		1,471	4.72	0.019				15.56	0.001	0.020	25	○ 225	560.00	2.8	0.61	0.025	(2.40) / (2.40)	1.155 / -0.419	1.00 / 2.57	
26				20.11	31.67	3,800					4.00	84							20.11	35.67	3,884	4.12	0.043				35.67	0.003	0.046	26	○ 300	500.00	2.2	0.65	0.047	(2.40) / (2.40)	-0.488 / -1.588	2.57 / 2.67	
	to	29																													to 29								
27				14.58		1,750				13.80		290							28.38		2,040	4.52	0.025				28.38	0.002	0.027	27	○ 300	1,000.00	2.2	0.65	0.047	(2.40) / (2.40)	1.079 / -1.121	1.00 / 3.20	
28				6.74	21.32	2,556					13.80	290							6.74	35.12	2,846	4.31	0.033				35.12	0.002	0.035	28	○ 300	440.00	2.2	0.65	0.047	(2.40) / (2.40)	-1.121 / -2.089	3.20 / 3.81	
29				10.46	63.45	7,614					17.80	375							10.46	81.25	7,989	3.72	0.079				81.25	0.006	0.085	29	○ 375	335.00	2.2	0.75	0.086	(2.40) / (2.40)	-0.164 / -2.901	4.16 / 4.89	U~110m Drain
	to	31																													to 31								
30				13.68		1,642													13.68		1,642	4.66	0.020				13.68	0.001	0.021	30	○ 225	110.00	2.8	0.61	0.025	(2.00) / (2.40)	0.755 / -2.359	1.00 / 4.51	
31				26.65	102.78	12,454					17.80	375							26.65	121.58	12,829	3.47	0.119				121.58	0.009	0.128	31	○ 450	835.00	2.0	0.81	0.139	(2.40) / (2.40)	-2.976 / -4.646	4.89 / 6.56	
	to	35																													to 35								
32				16.79		2,015				2.60		50							19.39		2,065	4.51	0.025				19.39	0.001	0.026	32	○ 300	750.00	2.2	0.65	0.047	2.14 / 2.40	0.819 / -0.853	1.00 / 2.99	
33				24.14	40.93	4,912					2.60	50							24.14	43.53	4,962	3.98	0.053				43.53	0.003	0.056	33	○ 375	460.00	2.2	0.75	0.086	2.40 / (2.40)	-1.617 / -2.629	3.61 / 4.62	U~0m Drain
34				14.78	55.71	6,685					2.60	50							14.78	58.31	6,735	3.81	0.068				58.31	0.004	0.072	34	○ 375	330.00	2.2	0.75	0.086	(2.40) / (2.40)	-2.629 / -3.356	4.62 / 5.35	
35				0.61	160.10	19,212					20.40	425							0.61	180.50	19,637	3.27	0.171				180.50	0.013	0.184	35	○ 525	590.00	1.8	0.85	0.191	(2.40) / (2.40)	-4.721 / -4.956	6.56 / 6.79	
	to	38																													to 38								
36				17.70		2,124													17.70		2,124	4.49	0.025				17.70	0.001	0.026	36	○ 300	1,000.00	2.2	0.65	0.047	(2.00) / (2.20)	0.679 / -1.647	1.00 / 3.58	
37				35.50	53.20	6,384													35.50	53.20	6,384	3.84	0.065				53.20	0.004	0.069	37	○ 375	430.00	2.2	0.75	0.086	(2.20) / (2.40)	-1.772 / -2.718	3.47 / 4.71	
38				10.46	223.76	26,851					20.40	425							10.46	244.16	27,276	3.12	0.226				244.16	0.018	0.244	38	○ 600	180.00	1.6	0.89	0.257	(2.40) / 2.40	-5.030 / -5.222	6.79 / 6.98	
	to	P9 Pumping Station																													to P9 Pumping Station								
P9 Force main sewer					223.76	26,851					20.40	425								244.16	27,276	3.12	0.226				244.16	0.018	0.244	P9	Force main sewer					2.40	2.400		U~0m Drain
39					223.76	26,851					20.40	425								244.16	27,276	3.12	0.226				244.16	0.018	0.244	39	○ 450	1,655.00				(2.20)	0.778	1.00	Crossing Rail way
	to	Waste Stabilization Pond																																					

Zone - E

No. of Sewers	Commercial 400 persons/ha Area Increment (ha)	Commercial Area Total (ha)	Commercial Population (persons)	Residential 120 persons/ha Area Increment (ha)	Residential Area Total (ha)	Residential Population (persons)	Industrial Area Increment (ha)	Industrial Area Total (ha)	Industrial Population (persons)	School Area Increment (ha)	School Area Total (ha)	School Population (persons)	Area Increment (ha)	Area Total (ha)	Population (persons)	Area Increment (ha)	Area Total (ha)	Population (persons)	Area Increment (ha)	Area Total (ha)	Population (persons)	Peaking Factor
1							18.00												18.00			
2				14.22		1,706		18.00											14.22	32.22	1,706	4.63
3	7.58		3,032		14.22	1,706		18.00											7.58	39.80	4,738	4.00
4	1.68	9.26	3,704	7.53	21.75	2,610		18.00		1.40		139							10.61	50.41	6,453	3.89
	to	7																				
5	8.74		3,496	9.62		1,154													18.36		4,650	4.01
6		8.74	3,496	22.59	32.21	3,865				3.50		20							26.09	44.45	7,381	3.76
7		18.00	7,200	19.96	73.62	8,834		18.00		1.20	6.10	225							20.86	115.72	16,259	3.36
8		18.00	7,200	4.18	77.80	9,336		18.00		5.10	11.20	225							9.28	125.00	16,791	3.34
	to		Waste	Stabilization		Pond																

No. of Sewers	Design Flow: Domestic Waste (m3/sec)	Industrial Waste (m3/sec)	Infiltration I Area (ha)	Infiltration I Flow (m3/sec)	Infiltration II Area (ha)	Infiltration II Flow (m3/sec)	Total (m3/sec)	No. of Sewers	Designed Sewer: Diameter (mm)	Length (m)	Slope (‰)	Velocity (Full) (m/sec)	Capacity (Full) (m3/sec)	Elevation Ground Surface (m)	Sewer Invert Elevation (m)	Earth Covering (m)	Remarks
1		0.054			18.00	0.001	0.055	1	○ 375	935.00	2.2	0.75	0.086	2.40 2.58	0.993 -1.064	1.00 4.05	
2	0.021	0.054			32.22	0.002	0.077	2	○ 375	420.00	2.2	0.75	0.086	2.58 2.19	-1.064 -2.010	4.05 3.80	
3	0.051	0.054	7.58	0.001	32.22	0.002	0.108	3	○ 450	370.00	2.0	0.81	0.129	2.19 1.80	-2.085 -2.885	3.79 4.14	
4	0.066	0.054	9.26	0.001	41.15	0.003	0.124	4	○ 450	625.00	2.0	0.81	0.139	1.80 (2.00)	-2.825 -4.095	4.14 5.61	
									to	7							
5	0.050		8.74	0.001	9.62	0.001	0.052	5	○ 375	780.00	2.2	0.75	0.086	(2.10) 1.94	0.693 -1.023	1.00 2.56	
6	0.074		8.74	0.001	35.71	0.003	0.078	6	○ 375	655.00	2.2	0.75	0.086	1.94 (2.00)	-1.023 -2.464	2.56 4.06	
7	0.145	0.054	18.00	0.001	92.72	0.007	0.207	7	○ 600	305.00	1.6	0.88	0.257	(2.00) 2.40	-4.245 -4.733	5.60 6.69	
8	0.149	0.054	18.00	0.001	107.00	0.008	0.212	8	○ 600	325.00	1.6	0.88	0.257	2.40 2.40	-4.733 -5.269	6.69 7.09	

Note : 1) All populations present equivalent value

2) For infiltration columns I and II in Design Flow indicate the commercial and institution area and the residential, school and mosque area respectively.

3) Figures in parentheses in the column "Elevation Ground Surface" are based on our survey on requirement for sewerage system

4) For the remarks,

a) U ~ 100m : indicates the distance from upstream of sewer.

b) Drain : indicates for an existing drain or a drain developed in the Drainage Study to cross at the above point

Table K-2

Chart of Manning's Formula for Circular Pipes, N=0.013

Dia. of Sewer (m)	0.153 (150)*		0.229 (225)*		0.304 (300)*		0.381 (375)*		0.457 (450)*		0.534 (525)*		0.610 (600)*	
Sectional Area (m^2)	0.018		0.041		0.073		0.114		0.164		0.224		0.292	
Wetted Perimeter (m)	0.481		0.719		0.955		1.197		1.436		1.678		1.916	
Hydraulic Radius (m)	0.038		0.057		0.076		0.095		0.114		0.133		0.152	
Slope of Sewer (0/00)	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
14.0	1.033	0.019	1.352	0.056	1.633	0.119	1.898	0.216	2.143	0.352	2.377	0.532	2.598	0.759
13.0	0.996	0.018	1.303	0.054	1.574	0.114	1.829	0.209	2.065	0.339	2.291	0.513	2.503	0.732
12.0	0.957	0.018	1.252	0.052	1.512	0.110	1.757	0.200	1.984	0.325	2.201	0.493	2.405	0.703
11.0	0.916	0.017	1.198	0.049	1.448	0.105	1.683	0.192	1.900	0.312	2.107	0.472	2.303	0.673
10.0	0.873	0.016	1.143	0.047	1.380	0.100	1.604	0.183	1.811	0.297	2.009	0.450	2.196	0.642
9.0	0.828	0.015	1.084	0.045	1.309	0.095	1.522	0.174	1.718	0.282	1.906	0.427	2.083	0.609
8.5	0.805	0.015	1.053	0.043	1.272	0.092	1.479	0.169	1.670	0.274	1.852	0.415	2.024	0.592
8.0	0.781	0.014	1.022	0.042	1.234	0.090	1.435	0.164	1.620	0.266	1.797	0.402	1.964	0.574
7.5	0.756	0.014	0.990	0.041	1.195	0.087	1.389	0.158	1.569	0.257	1.740	0.390	1.902	0.556
7.0	0.731	0.013	0.956	0.039	1.155	0.084	1.342	0.153	1.515	0.249	1.681	0.377	1.837	0.537
6.5	0.704	0.013	0.921	0.038	1.113	0.081	1.293	0.147	1.460	0.240	1.620	0.363	1.770	0.517
6.0	0.676	0.012	0.885	0.036	1.069	0.078	1.243	0.142	1.403	0.230	1.556	0.349	1.701	0.497
5.5	0.648	0.012	0.847	0.035	1.024	0.074	1.190	0.136	1.343	0.220	1.490	0.334	1.628	0.476
5.0	0.617	0.011	0.808	0.033	0.976	0.071	1.134	0.129	1.281	0.210	1.421	0.318	1.553	0.454
4.5	0.586	0.011	0.767	0.032	0.926	0.067	1.076	0.123	1.215	0.199	1.348	0.302	1.473	0.430
4.0	0.552	0.010	0.723	0.030	0.873	0.063	1.015	0.116	1.145	0.188	1.271	0.285	1.389	0.406
3.5	0.517	0.009	0.676	0.028	0.817	0.059	0.949	0.108	1.072	0.176	1.189	0.266	1.299	0.380
3.0	0.478	0.009	0.626	0.026	0.756	0.055	0.879	0.100	0.992	0.163	1.101	0.246	1.203	0.351
2.8	0.462	0.008	0.605	0.025	0.730	0.053	0.849	0.097	0.958	0.157	1.063	0.238	1.162	0.340
2.6	0.445	0.008	0.583	0.024	0.704	0.051	0.818	0.093	0.924	0.151	1.025	0.229	1.120	0.327
2.5	0.437	0.008	0.571	0.024	0.690	0.050	0.802	0.091	0.906	0.149	1.005	0.225	1.098	0.321
2.4	0.428	0.008	0.560	0.023	0.676	0.049	0.786	0.090	0.887	0.146	0.984	0.220	1.076	0.314
2.2	0.410	0.008	0.536	0.022	0.647	0.047	0.753	0.086	0.850	0.139	0.942	0.211	1.030	0.301
2.0	0.391	0.007	0.511	0.021	0.617	0.045	0.717	0.082	0.810	0.133	0.899	0.201	0.982	0.287
1.9	0.381	0.007	0.498	0.021	0.602	0.044	0.699	0.080	0.789	0.129	0.876	0.196	0.957	0.280

Note: V: Full Velocity (m/s)
Q: Full Capacity (m^3/s)

- continue -

Table K-2 (continue)

Dia. of Sewer (m)	0.153 (150)*		0.229 (225)*		0.304 (300)*		0.381 (375)*		0.457 (450)*		0.534 (525)*		0.610 (600)*	
Sectional Area (m^2)	0.018		0.041		0.073		0.114		0.164		0.224		0.292	
Wetted Perimeter (m)	0.481		0.719		0.955		1.197		1.436		1.678		1.916	
Hydraulic Radius (m)	0.038		0.057		0.076		0.095		0.114		0.133		0.152	
Slope of Sewer (0/00)	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
1.8	0.370	0.007	0.485	0.020	0.586	0.043	0.681	0.078	0.768	0.126	0.852	0.191	0.932	0.272
1.7	0.360	0.007	0.471	0.019	0.569	0.041	0.661	0.075	0.747	0.122	0.828	0.186	0.905	0.265
1.6	0.349	0.006	0.457	0.019	0.552	0.040	0.642	0.073	0.724	0.119	0.804	0.180	0.878	0.257
1.5	0.338	0.006	0.443	0.018	0.535	0.039	0.621	0.071	0.701	0.115	0.778	0.174	0.850	0.249
1.4	0.327	0.006	0.428	0.018	0.516	0.037	0.600	0.068	0.678	0.111	0.752	0.168	0.822	0.240
1.3	0.315	0.006	0.412	0.017	0.498	0.036	0.578	0.066	0.653	0.107	0.724	0.162	0.792	0.231
1.2	0.303	0.006	0.396	0.016	0.478	0.035	0.556	0.063	0.627	0.103	0.699	0.156	0.761	0.222
1.1	0.290	0.005	0.379	0.016	0.458	0.033	0.532	0.061	0.601	0.099	0.666	0.149	0.728	0.213
1.0	0.276	0.005	0.361	0.015	0.436	0.032	0.507	0.058	0.573	0.094	0.635	0.142	0.694	0.203
0.9	0.262	0.005	0.343	0.014	0.414	0.030	0.481	0.055	0.543	0.089	0.603	0.135	0.659	0.193
0.8	0.247	0.005	0.323	0.013	0.390	0.028	0.454	0.052	0.512	0.084	0.568	0.127	0.621	0.181
0.7	0.231	0.004	0.302	0.012	0.365	0.027	0.424	0.048	0.479	0.079	0.532	0.119	0.581	0.170
0.6	9.214	0.004	0.280	0.012	0.338	0.025	0.393	0.045	0.444	0.073	0.492	0.110	0.538	0.157
0.5	0.195	0.004	0.256	0.011	0.309	0.022	0.359	0.041	0.405	0.066	0.449	0.101	0.491	0.143
0.4	0.175	0.003	0.229	0.009	0.276	0.020	0.321	0.037	0.362	0.059	0.402	0.090	0.439	0.128

Note: V: Full Velocity (m/s)
Q: Full Capacity (m^3/s)

- continue -

Table K-2 (continue)

Dia. of Sewer (m)	0.685 (675)*		0.762 (750)*		0.838 (825)*		0.915 (900)*		1.066 (1,050)*		1.219 (1,200)*		1.372 (1,850)*	
Sectional Area (m^2)	0.369		0.456		0.552		0.658		0.892		1.167		1.478	
Wetted Perimeter (m)	2.152		2.394		2.633		2.875		3.349		3.830		4.310	
Hydraulic Radius (m)	0.171		0.191		0.210		0.229		0.266		0.305		0.343	
Slope of Sewer (0/00)	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
14.0	2.807	1.034	3.013	1.374	3.211	1.771	3.404	2.239	3.769	3.364	4.122	4.810	4.460	6.593
13.0	2.705	0.997	2.904	1.324	3.094	1.706	3.280	2.157	3.632	3.242	3.972	4.635	4.298	6.354
12.0	2.599	0.958	2.790	1.272	2.972	1.639	3.152	2.072	3.490	3.114	3.816	4.454	4.129	6.104
11.0	2.488	0.917	2.671	1.218	2.846	1.570	3.018	1.984	3.341	2.982	3.654	4.264	3.953	5.844
10.0	2.372	0.874	2.547	1.161	2.713	1.497	2.877	1.892	3.186	2.843	3.484	4.066	3.769	5.572
9.0	2.250	0.829	2.416	1.102	2.574	1.420	2.730	1.795	3.022	2.697	3.305	3.857	3.576	5.287
8.5	2.187	0.806	2.348	1.071	2.502	1.380	2.653	1.744	2.937	2.621	3.212	3.748	3.475	5.138
8.0	2.122	0.782	2.278	1.039	2.427	1.339	2.573	1.692	2.849	2.543	3.116	3.636	3.371	4.984
7.5	2.054	0.757	2.206	1.006	2.350	1.296	2.492	1.638	2.759	2.462	3.017	3.521	3.264	4.826
7.0	1.985	0.731	2.131	0.972	2.270	1.252	2.407	1.583	2.665	2.379	2.915	3.401	3.154	4.662
6.5	1.912	0.705	2.053	0.936	2.188	1.207	2.320	1.525	2.568	2.292	2.809	3.278	3.039	4.493
6.0	1.837	0.677	1.973	0.900	2.102	1.159	2.229	1.465	2.468	2.202	2.698	3.149	2.920	4.316
5.5	1.759	0.648	1.889	0.861	2.012	1.110	2.134	1.403	2.362	2.108	2.583	3.015	2.795	4.133
5.0	1.677	0.618	1.801	0.821	1.919	1.058	2.034	1.338	2.253	2.010	2.463	2.875	2.665	3.940
4.5	1.591	0.586	1.708	0.779	1.820	1.004	1.930	1.269	2.137	1.907	2.337	2.727	2.528	3.738
4.0	1.500	0.553	1.611	0.735	1.716	0.946	1.820	1.197	2.015	1.798	2.203	2.571	2.384	3.524
3.5	1.403	0.517	1.507	0.687	1.605	0.885	1.702	1.119	1.885	1.682	2.061	2.405	2.230	3.297
3.0	1.299	0.479	1.395	0.636	1.486	0.820	1.576	1.036	1.745	1.557	1.908	2.227	2.064	3.052
2.8	1.255	0.463	1.348	0.615	1.436	0.792	1.522	1.001	1.686	1.504	1.843	2.151	1.994	2.949
2.6	1.210	0.446	1.299	0.592	1.384	0.763	1.467	0.965	1.624	1.450	1.776	2.073	1.922	2.841
2.5	1.186	0.437	1.273	0.581	1.357	0.748	1.439	0.946	1.593	1.422	1.742	2.033	1.885	2.786
2.4	1.162	0.428	1.248	0.569	1.329	0.733	1.410	0.927	1.561	1.393	1.707	1.992	1.847	2.730
2.2	1.113	0.410	1.195	0.545	0.273	0.702	0.350	0.887	1.494	1.334	1.634	1.907	1.768	2.614
2.0	1.061	0.391	1.139	0.519	1.213	0.669	1.287	0.846	1.425	1.271	1.558	1.818	1.686	2.492
1.9	1.034	0.381	1.110	0.506	1.183	0.652	1.254	0.825	1.389	1.239	1.518	1.772	1.643	2.429

Note: V: Full Velocity (m/s)
Q: Full Capacity (m^3/s)

- continue -

Table K-2 (continue)

Dia. of Sewer (m)	0.685 (675)*		0.762 (750)*		0.838 (825)*		0.915 (900)*		1.066 (1,050)*		1.219 (1,200)*		1.372 (1,850)*	
Sectional Area (m^2)	0.369		0.456		0.552		0.658		0.892		1.167		1.478	
Wetted Perimeter (m)	2.152		2.394		2.633		2.875		3.349		3.830		4.310	
Hydraulic Radius (m)	0.171		0.191		0.210		0.229		0.266		0.305		0.343	
Slope of Sewer (0/00)	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
1.8	1.006	0.371	1.080	0.493	1.151	0.635	1.221	0.803	1.352	1.206	1.478	1.725	1.599	2.364
1.7	0.978	0.360	1.050	0.479	1.119	0.617	1.186	0.780	1.313	1.172	1.436	1.676	1.554	2.298
1.6	0.949	0.350	1.019	0.465	1.085	0.599	1.151	0.757	1.274	1.137	1.393	1.626	1.508	2.229
1.5	0.919	0.339	0.986	0.450	1.051	0.580	1.114	0.733	1.234	1.101	1.349	1.575	1.460	2.158
1.4	0.888	0.327	0.953	0.435	1.015	0.560	1.077	0.708	1.192	1.064	1.303	1.521	1.410	2.085
1.3	0.855	0.315	0.918	0.419	0.978	0.540	1.037	0.682	1.149	1.025	1.256	1.466	1.359	2.009
1.2	0.822	0.303	0.882	0.402	0.940	0.518	0.997	0.655	1.104	0.985	1.207	1.408	1.306	1.930
1.1	0.787	0.290	0.845	0.385	0.900	0.496	0.954	0.627	1.057	0.943	1.155	1.348	1.250	1.848
1.0	0.750	0.276	0.805	0.367	0.858	0.473	0.910	0.598	1.007	0.899	1.102	1.286	1.192	1.762
0.9	0.712	0.262	0.764	0.348	0.814	0.449	0.863	0.568	0.956	0.853	1.045	1.220	1.131	1.672
0.8	0.671	0.247	0.720	0.328	0.767	0.423	0.814	0.535	0.901	0.804	0.985	1.150	1.066	1.576
0.7	0.628	0.231	0.674	0.307	0.718	0.396	0.761	0.501	0.843	0.752	0.922	1.076	0.997	1.474
0.6	0.581	0.214	0.624	0.284	0.665	0.367	0.705	0.463	0.780	0.696	0.853	0.996	0.923	1.365
0.5	0.530	0.195	0.569	0.260	0.607	0.335	0.643	0.423	0.712	0.636	0.779	0.909	0.843	1.246
0.4	0.474	0.175	0.509	0.232	0.543	0.299	0.575	0.378	0.637	0.569	0.697	0.813	0.754	1.114

Note: V: Full Velocity (m/s)
*Q: Full Capacity (m^3/s)

APPENDIX L

ANALYSIS FOR WATER POLLUTION CONTROL

1. General

Alor Setar is a town developed in the tributary area of the Sg. Kedah and Sg. Anak Bukit. From the town wastewater including domestic, commercial and industrial wastes are discharged into the rivers through existing drains, and dominantly contribute to the present river pollution. Water pollution of the rivers is increasing with the expansion of Alor Setar. Thus it is evident that river pollution will become more severe in the future unless adequate pollution control measure is taken.

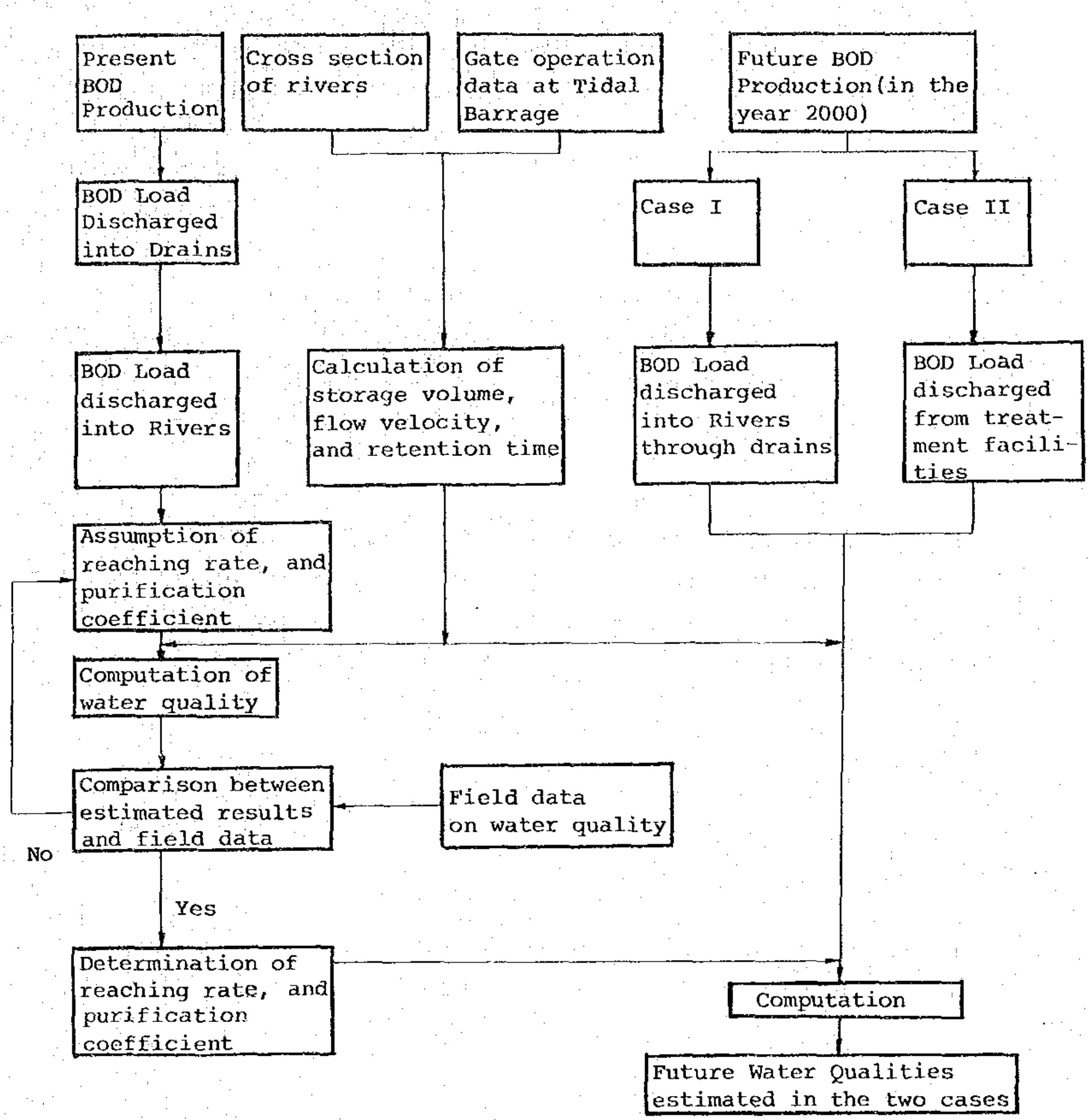
The two rivers had been tidal rivers before the barrage was constructed at the point of a little downstream from confluent point of the two rivers. After construction of the barrage, the flow rate and water quality of the rivers are greatly influenced by the gate operation.

The gate operation is largely changed by season. In rainy season, the gates are opened at least once a day, and especially in monsoon season, a whole day. In dry season, however, the gates are opened only once a few days, or for navigation of boats through the barrage (the gates operation data for past one year are attached at the end of this appendix).

In this Appendix the effects of sewerage system on water pollution control of the two major rivers are studied towards the future in contrast with the case without the system.

The system analysis on the simulation of BOD load to the river system is carried out on the flow sheet shown in Figure L-1.

Figure L-1 Flow Sheet for Waste Load Simulation



Note: Case I : No sewerage system is provided

Case II : Sewerage System is provided

2. Physical Conditions of the River System

2.1 Slope of River-bed and Cross Sectional Area

a. Slope of River-bed

Based on the data obtained from MPKS, average slope of river-bed is assumed as 0.0084% for both rivers, i.e. Sg. Kedah and Sg. Anak Bukit.

b. Cross section

For modelling the river system the two rivers in the Study Area are divided into three reaches as shown in Figure L-2, and the cross section of each is assumed as shown in Figure L-3.

Figure L-2 Schematic Plan of Rivers

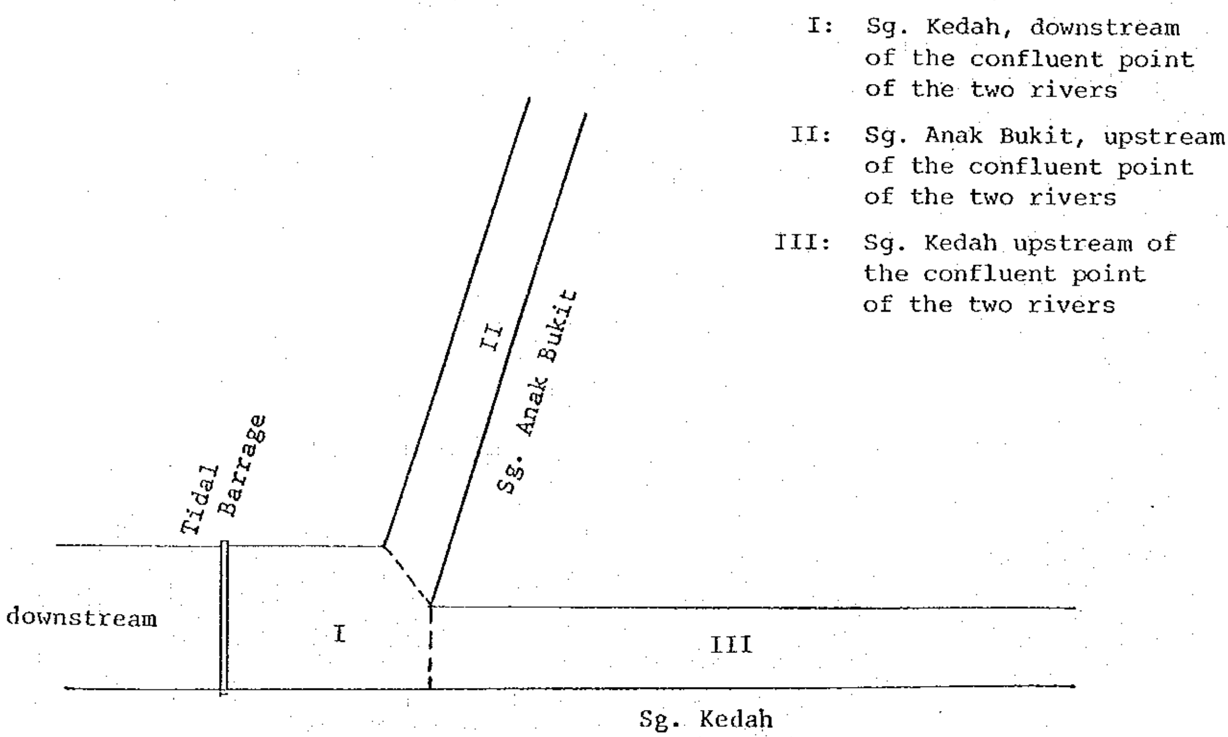
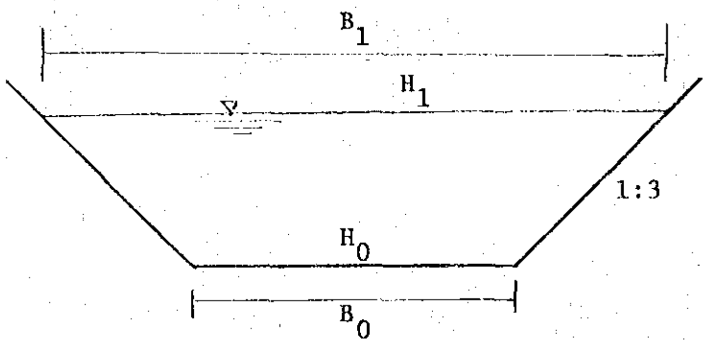


Figure L-3 Cross Section Model

I. Sg. Kedah (from the tidal barrage to the confluent point of the two rivers)



H_1: River stage (m)

H_0: River-bed elevation (m)

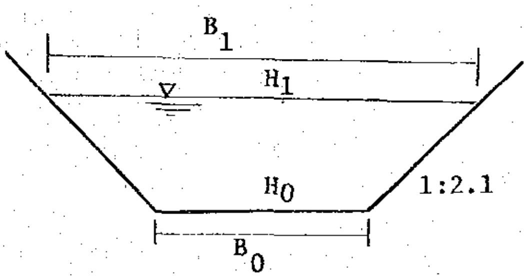
B_1: Width of water surface (m)

B_0: Width of river-bed (m)

$B_0 = (H_0 + 15.7) \times 6.0$

$B_1 = (H_1 + 15.7) \times 6.0$

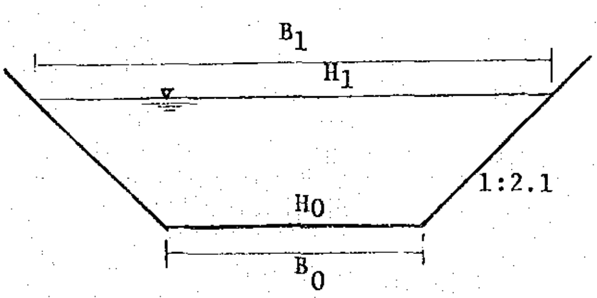
II. Sg. Anak Bukit



$B_0 = (H_0 + 8.6) \times 4.2$

$B_1 = (H_1 + 8.6) \times 4.2$

III. Sg. Kedah (upstream of the confluent point of the two rivers)



$B_0 = (H_0 + 13.4) \times 4.2$

$B_1 = (H_1 + 13.4) \times 4.2$

Based on the assumptions and formulae developed and shown in Figure L-3, the elevation and width of the river-beds at key points of each reaches are calculated as shown in Table L-1.

Table L-1 Elevation and Width at Key Points along the Rivers

Distance from Tidal Barrage (km)	Sg. Kedah		Sg. Anak Bukit	
	Elevation of River-bed (m)	Width of River-bed (m)	Elevation of River-bed (m)	Width of River-bed (m)
0.00	-3.568	72.252	-	-
1.44	-3.537	72.978	-3.537	21.265
		41.425		
4.32	-3.295	42.441	-3.295	22.281
7.20	-3.053	43.457	-3.053	23.297
10.08	-2.811	44.474	-2.811	24.314

2.2 Hydraulic Model

The elements of the hydraulic model are considered on the serial stretches of the rivers as shown in Figure L-4, and are presented by the following equations;

$$V_{Ni} = V_{(N-1)o},$$

$$V_{Nn} = V_{N(n-1)} - V_{No} + V_{Ni} - V_{Ne} + V_{Nw},$$

where

V_{Ni} : Inflow volume into stretch N (m^3/day),

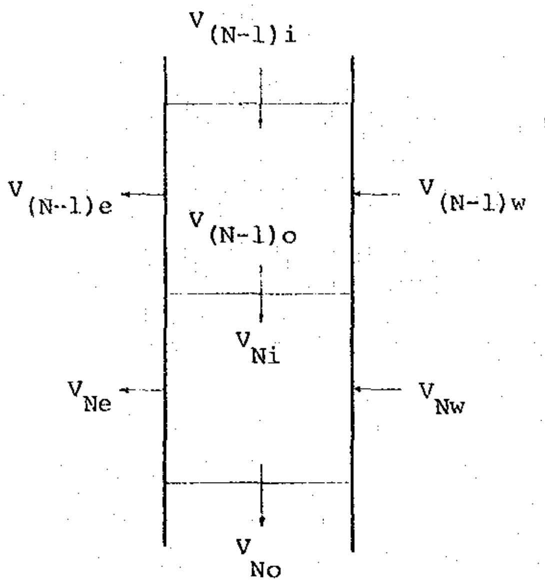
V_{No} : Outflow volume from stretch N (m^3/day),

V_{Nw} : Inflow volume of wastewater from the waterbed of stretch N (m^3/day),

V_{Ne} : Loss by evapo-transpiration (m^3/day),

V_{Nn} : Storage volume of stretch N on n th day (m^3)

Figure L-4 Schematic Hydraulic Model for a River System



V_{Nn} : Storage volume of stretch N on nth day (m^3)

V_{No} : Outflow volume (m^3/day)

V_{Ni} : Inflow volume (m^3/day)

V_{Nw} : Inflow volume of Waste-water (m^3/day)

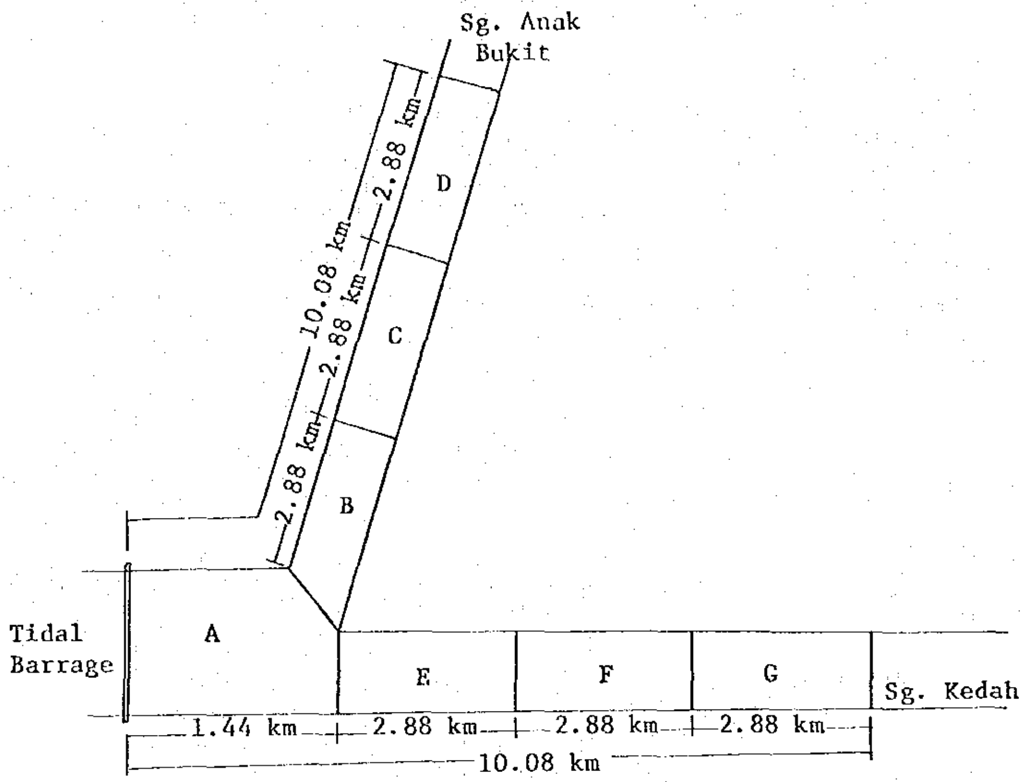
V_{Ne} : Loss by evapo-transpiration (m^3/day)

The study area of this river analysis is confined as the reaches from the tidal barrage to 10.8 km upstream of the rivers and their tributary areas inside the Study Area boundary of the Master Plan.

To make the hydraulic model of the river system, the reaches of the rivers are further divided into a 7 stretches as shown in Figure L-5. And the river stage of each stretch is assumed to be horizontal regardless upstream or downstream because the rivers can be considered as an isolated pond in the reaches studied.

Each element of the hydraulic model of the rivers are estimated as follows;

Figure L-5 Rivers Divided into Seven Stretches



a. Storage Volumes of Each Stretch

Based on the cross section model shown in Figure L-3 and average slope of river-bed of 0.0084%, storage volumes of each stretch in the river system are calculated by using the derived formulae as follows:

$$
\begin{aligned}
V_A &= 4.32\ H^2 + 135.70\ H + 432.44 \\
V_B &= 6.05\ H^2 + 104.05\ H + 284.75 \\
V_C &= 6.05\ H^2 + 104.05\ H + 269.25 \\
V_D &= 6.05\ H^2 + 104.05\ H + 253.04 \\
V_E &= 6.05\ H^2 + 162.14\ H + 483.11 \\
V_F &= 6.05\ H^2 + 162.14\ H + 453.56 \\
V_G &= 6.05\ H^2 + 162.14\ H + 423.31 \\
\Sigma V &= 40.62\ H^2 + 934.27 + 2599.46
\end{aligned}
\qquad (2-1)
$$

where

H : River stage (m)

V_A - V_G : Storage volume of each stretch (in 1,000 m^3)

b. Estimation of V_{Ni} and V_{No}

V_{Di} and V_{Gi} are the inflow volumes of the rivers, Sg. Anak Bukit and Sg. Kedah. Those volumes can be estimated from the flow records, and are shown in Figure L-8 together with the other estimated volumes of each element.

As mentioned previously, the tidal barrage which has the main gates and the navigation lock is intermittently opened for flood control and/or navigation.

To estimate the outflowing volume, V_{Ao}, through stretch A the records of the river stages and the gate operations were analyzed and summerized as follows:

(1) The gate opening period differs significantly between dry and rainy seasons

(2) The difference of the river stage before and after the gate opening ranges from 1.2 m to 0.25 m.

(3) Average gate opening frequency is once in 4.7 days in dry season, and once in 0.7 day in rainy season.

Based on the data mentioned above and applying the equation (2-1), outflow quantities through the tidal barrage were assumed as follows:

(a) Outflow quantity through a main gate operation: 256,000 m^3

(b) Outflow quantity through navigation lock: 3,000 m^3/day

Therefore, average daily outflow volume through the barrage, V_{Ao}, was obtained as follow:

(c) In dry season: 256,000/4.7 + 3,000 = 57,470 m^3/day

(d) In rainy season: 256,000/0.7 + 3,000 = 368,710 m^3/day

The gate operation frequency will be changed in the future by the increase of wastewater. The drequency and outflow volume in the year 2000 were estimated as follows.

(1) In case no sewerage system is provided: once per 3.21 days 82,690 m^3/day

(2) In case sewerage system is provided: once per 2.09 days 125,150 m^3/day

c. Estimation of V_{Nw}

Inflow volumes of wastewater to each stretch (V_{Nw}) were estimated on the basis of population and water consumption estimated, and are summerized in Table L-2.

Discharge points of wastewaters from tributary areas to each stretch of the rivers are assumed as shown in Figures L-6 and L-7 for two cases that sewerage system is not provided and is provided.

d. Estimation of V_{Ne}

Average evapo-tranpiration rates in dry and rainy seasons are assumed to be 5.1 mm/day and 3.3 mm/day respectively, based on the record obtained from the Meteorological Station, ALOR SETAR.

Infiltration rate of the river water is disregarded in this study due to lack of data applicable.

The hydraulic model of the river system at present and in the future are summarized in Figure L-8.

Figure L-6 Discharge Points of Wastewater from Tributary Areas (In case sewerage system is not provided)

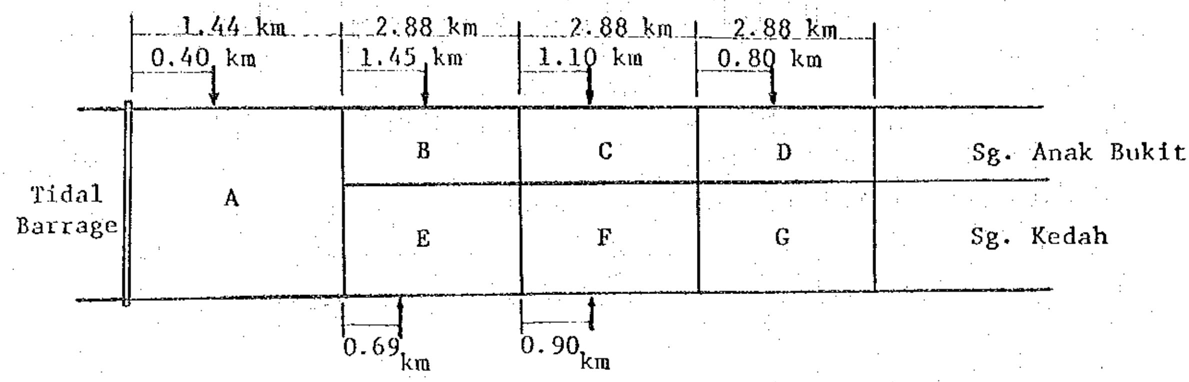
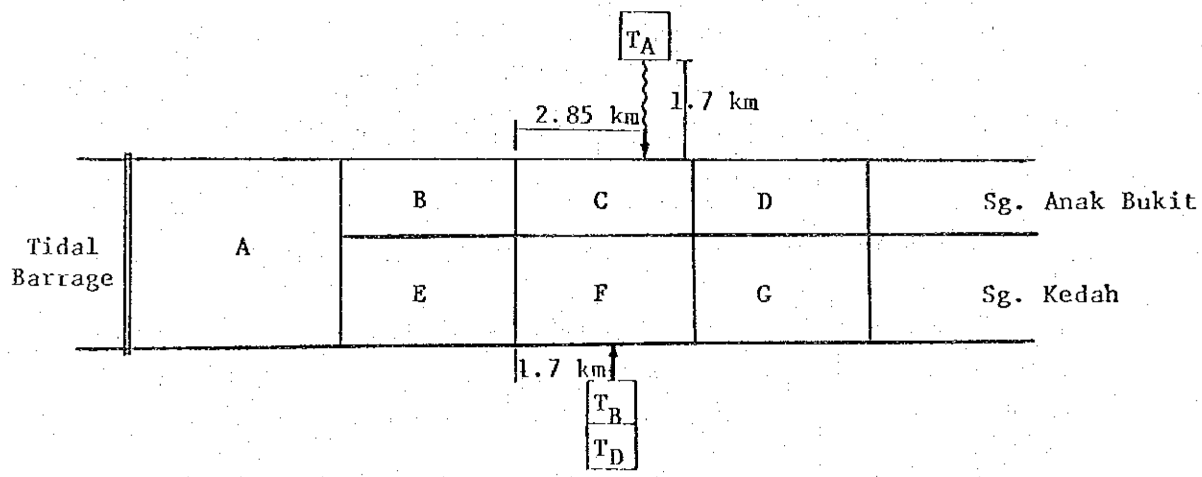


Figure L-7 Discharge Points of Wastewater through Treatment Facilities (In case sewerage system is provided)

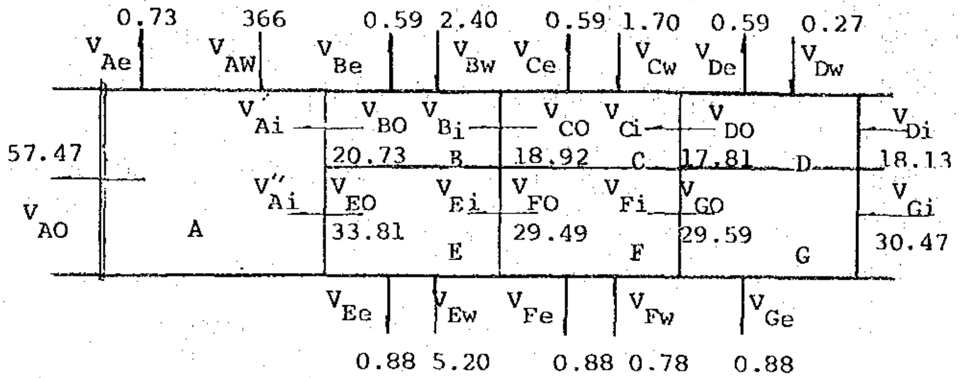


where

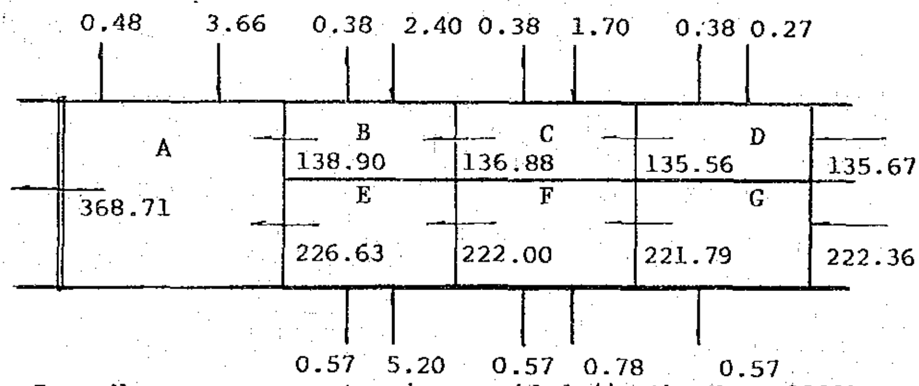
T: Treatment facilities

Figure L-8 Summary of Hydraulic Models in the River System

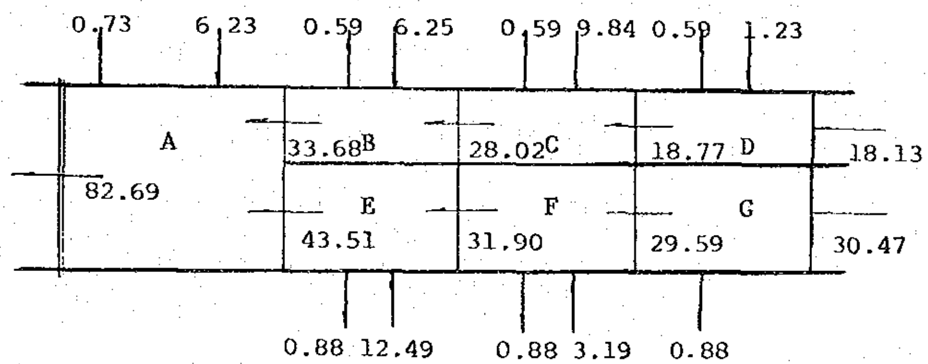
1. Dry season (Present Condition) Unit 1,000 m^3/day



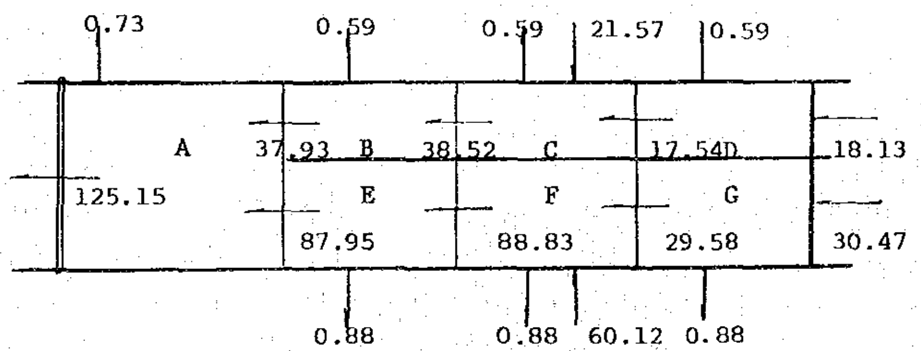
2. Rainy Season (Present Condition)



3. Case I : No sewerage system is provided (in the Year 2000)



4. Case II; Sewerage system is provided (in the Year 2000)



2.3 Flow Velocities in Each Stretch

Average flow velocity in a given stretch of the river system is obtained by dividing outflowing volume Vo by average sectional area of the stretch.

Estimated average flow velocities in each stretch of the rivers are summarized by case Table L-2.

Table L-2 Estimated Average Velocity in Stretches of the Rivers

(km/day)

Case		Stretch						
		A	B	C	D	E	F	G
Present	Dry season	0.145	0.151	0.144	0.141	0.150	1.137	0.144
	Rainy season	0.927	1.013	1.039	1.075	1.002	1.028	1.080
Future in dry season	In case no sewerage system is provided	0.208	0.246	0.213	0.149	0.192	0.148	0.144
	In case sewerage system is provided	0.315	0.277	0.292	0.139	0.389	0.411	0.144

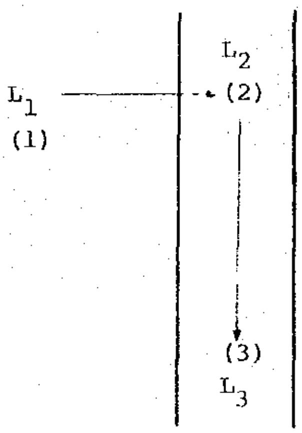
Note: Average river stage adopted is assumed to be 1.0 m.

3. Simulation Model for Waste Loads (BOD)

3.1 Model Develop

Waste organic load (L_1) originated in a town area (point 1) is reduced in the drain system and discharged into the river. The amount of the wastes (L_2) discharged into the river is further reduced by some mechanisms such as biodegradation and precipitation to the amount of L_3 during travelling in the river (from point 2 to point 3).

Figure L-9 Fate of Waste Organic Load



L_1 : BOD load Produced at Point (1)(kg/day)

L_2 : BOD load which reaches a main river, Point (2) (kg/day)

L_3 : BOD load which arrives at Point (3) (kg/day)

Although BOD reduction rate in a river (β) is affected by microbic condition, flow velocity, travelling time, etc. BOD content at a given point in the river (L_3) is obtained by following equation (3-1) which is usually applied to a stabilization pond because the river conditions are almost similar to that of a pond in dry season.

$$L_3 = \beta . L_2 = \frac{L_2}{1 + kt} \quad \text{.......................... (3-1)}$$

where

β : BOD reduction rate

k : purification coefficient

t : travelling time from inlet point to a given point

The value k = 0.23 (base e) is adopted at 20°C, and its variation with temperature is described by equation (3-2).

$$k(T) = k(20) \times \theta^{T-20} \quad \text{.......................... (3-2)}$$

where

k(T) : k value at T°C (1/day)

θ : Arrhenius coefficient, 1.08 for stabilization pond

Assuming water temperature as 30°C, k value is calculated as follow;

$$k(30) = 0.23 \times 1.08^{10}$$
$$= 0.495$$

Travelling time (t) is calculated by the following equation;

$$t = L/\nu \quad \text{(day)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3\text{-}3)$$

where

L : distance between points 2 and 3 (km)

ν : velocity (km/day)

3.2 BOD Load Discharged

Present and future BOD Loads originating each source, i.e. human excreta and sullage water, are estimated based on the following steps;

(1) to estimate present and future population in tributary areas of each stretch of the rivers,

(2) to estimate population and BOD Load with respect to human excreta disposal systems,

a. BOD load removed through septic tank is assumed to be 50 percent, thus BOD load discharged from sources is calculated to be 6.5 g/cap.day.

b. BOD load discharged by Buket system is assumed to be nil.

c. BOD load discharged through latrine over waterways is assumed to be 13 g/cap.day.

(3) to estimate BOD load with respect to sullage water.

(4) to estimate BOD load through the sewerage facilities to be provided.

BOD Loads discharged or to be discharged into each stretch in the rivers are calculated and summarized in Table L-3. For the future BOD Loads, it is assumed, in case no sewerage system is provided, that septic tank system will be provided to remove human excreta from the Study Area. While in case sewerage system is provided, all sanitary wastes, i.e. toilet wastes are sullage water, are discharged through treatment facilities with the effluent quality of 50 mg/l (BOD).

Table L-3 Present and Future Wastewater Volumes and BOD Loads

Stretch of River	Present		Future (2000)			
			Case I		Case II	
	Waste-water (1,000 m^3/day)	BOD (kg/day)	Waste-water	BOD Load	Effluent through Treatment Facility (1,000 m^3/day)	BOD Load through Treatment Facility (kg/day)
A	7.31	1,054.1	12.47	1,973.8	A 21.57	1,078.4
B	4.80	829.7	12.50	2,018.6	0	0
C	3.40	629.7	19.68	3,384.7	0	0
D	0.54	89.2	2.96	422.4	0	0
E	10.40	1,901.4	24.97	4,295.9	0	0
F	1.55	242.5	6.37	1,095.6	B 36.39 D 23.73	1,819.7 1,186.3
Total	28.00	4,746.6	78.45	13,191.0	81.69	4,084.4

Note: Case I : No sewerage facility is provided.
Case II : Sewerage facility is provided.

3.3 Existing Water Pollution in the River System

Field data on BOD content of the river water were obtained by the survey conducted for the Master Plan, and are summerized in Table L-4. The locations of the sampling points are shown in Figure L-10.

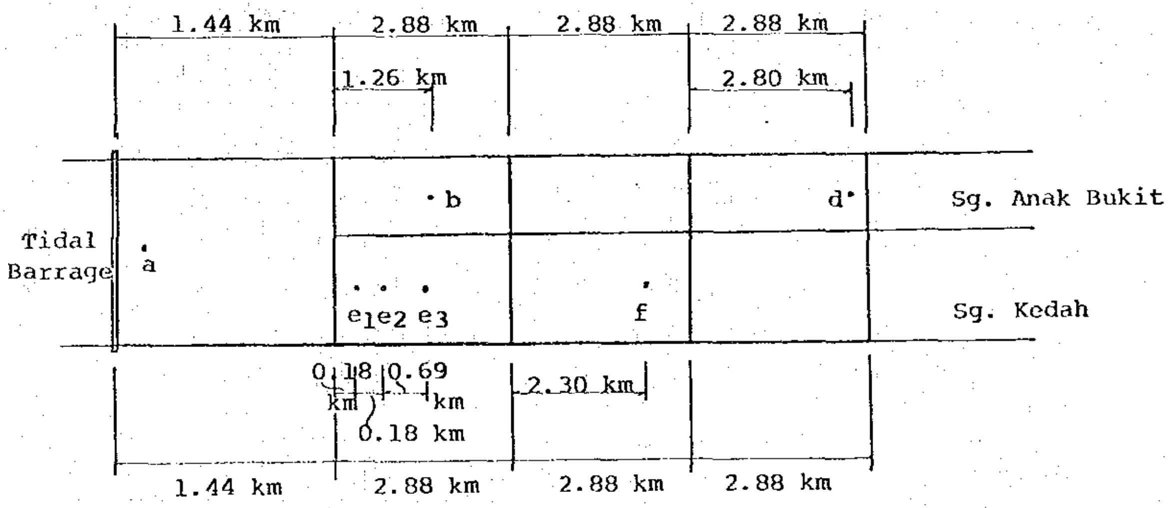
Table L-4 BOD Contents in Sg. Anak Bukit and Sg. Kedah

BOD (mg/l)

Sampling Point	Dry Season	Rainy Season
a	14 (21/3)	3.8 (17/6)
b	16 (21/3)	7.0 (17/6)
d		3.4 (8/7)
e1		3.6 (3/7)
e2	17 (21/3)	2.1 (18/6)
e3		2.3 (18/6)
f		1.4 (18/6)

Note: Figures in parentheses indicate the date surveyed.
Sampling points are shown in Figure L-10.

Figure L-10 Locations of Sampling Points



3.4 Fitting the Model to the Field Data

Three sampling points were selected as monitoring points of the water quality of the river system, which are Points a, b and e2 shown in Figure L-10. Those points are located at just upstream of the tidal barrage, Jl. Putera cross of Sg. Anak Bukit, and Jl. Sungai Korok cross of Sg. Kedah respectively.