5.2.2 Comparison of Alternative Treatment Methods

Three technically and economically feasible alternative treatment methods are studied in detail (Ref. Appendix E, "Alternative Sewerage System Considered"), namely (1) stabilization pond process, (2) aerated lagoon process, and (3) oxidation ditch process to select the most appropriate treatment method in the Study Area. The study includes the local conditions such as possibility of land acquisition, availability of skilled labours, and capability for recurrent costs of the facilities. These alternative methods are described below.

(1) Stabilization Pond Process

Treatment by stabilization pond by natural conditions involves the action of algae and bacteria under the influence of sunlight (photo-syntheses) and temperature. In order to facilitate easy repairs, maintenance and flexibility in operation, stabilization pond is provided with at least more than two ponds in parallel, depending upon the magnitude of the flow and the topography of the site, with facultative and maturation ponds arranged in series.

(2) Aerated Lagoon Process

Aerated Lagoon process consists of aerated lagoon and maturation pond. This is the activated sludge units operated without sludge returns. Aerators are used to supply the necessary oxygen and mixing power.

The effluent from aerated lagoon is to be treated further in a maturation pond which will achieve a high degree of bacteriological purification and suspended solid removal. Both the aerated lagoon and maturation pond are provided with at least two or more ponds in parallel for easy repairs and maintenance and also flexibility in operation.

(3) Oxidation Ditch Process

Oxidation ditch is essentially a modification of the activated sludge process. This method of aerobic stabilization circulates wastewater in a closed circuit ditch aerated by mechanical aerators. After circulation in the ditch, the mixed liquor is led to the final sedimentation basin and solids are removed, then supernatant water is discharged to receiving water bodies after disinfection. The excess sludge produced in final sedimentation basin should be withdrawn into drying beds. Oxidation ditch process consists of oxidation ditch, sedimentation basin, and drying beds.

In these three treatment systems mentioned above, the treated water is designed to flow by gravity into the receiving water body with the expected BOD removal of more than 75 per cent if the systems (either stabilization pond process, aerated lagoon process, or oxidation ditch process) are properly designed and efficiently operated.

To compare the alternatives, each type of treatment is designed for the flow rate of 5,000, 10,000, 30,000 and 50,000 m^3 daily, then the cost of each of the alternatives are estimated using cost functions developed. (Ref. Appendix G, "Method for Construction and Recurrent Cost Estimates").

Table 4.5 shows the results of comparison of cost. The cost of each selected alternative is estimated in terms of total annual cost with respect to construction, land acquisition, operation and maintenance at 1979 price level taking into account of the life of the facilities provided.

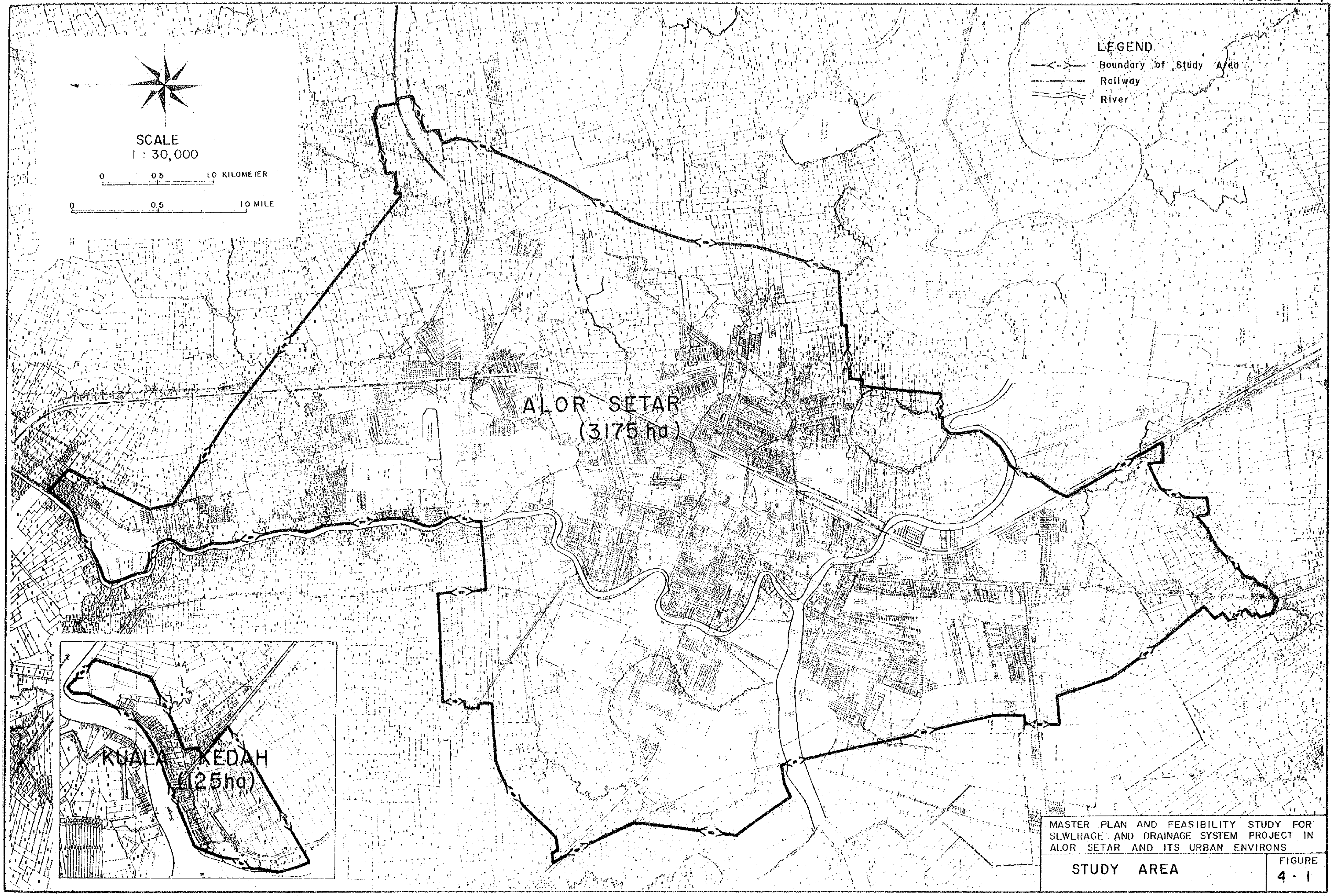
The result of cost analysis indicates that the stabilization pond process will be the most suitable treatment and disposal system for the Study Area in case flow rates are below 30,000 m^3/day. However, aerated lagoon process will be most economical in case flow rates become 30,000m^3/day or above. Due consideration should be given therefore in case of the implementation of phased programme and the expansion according to the increased demand in the future.

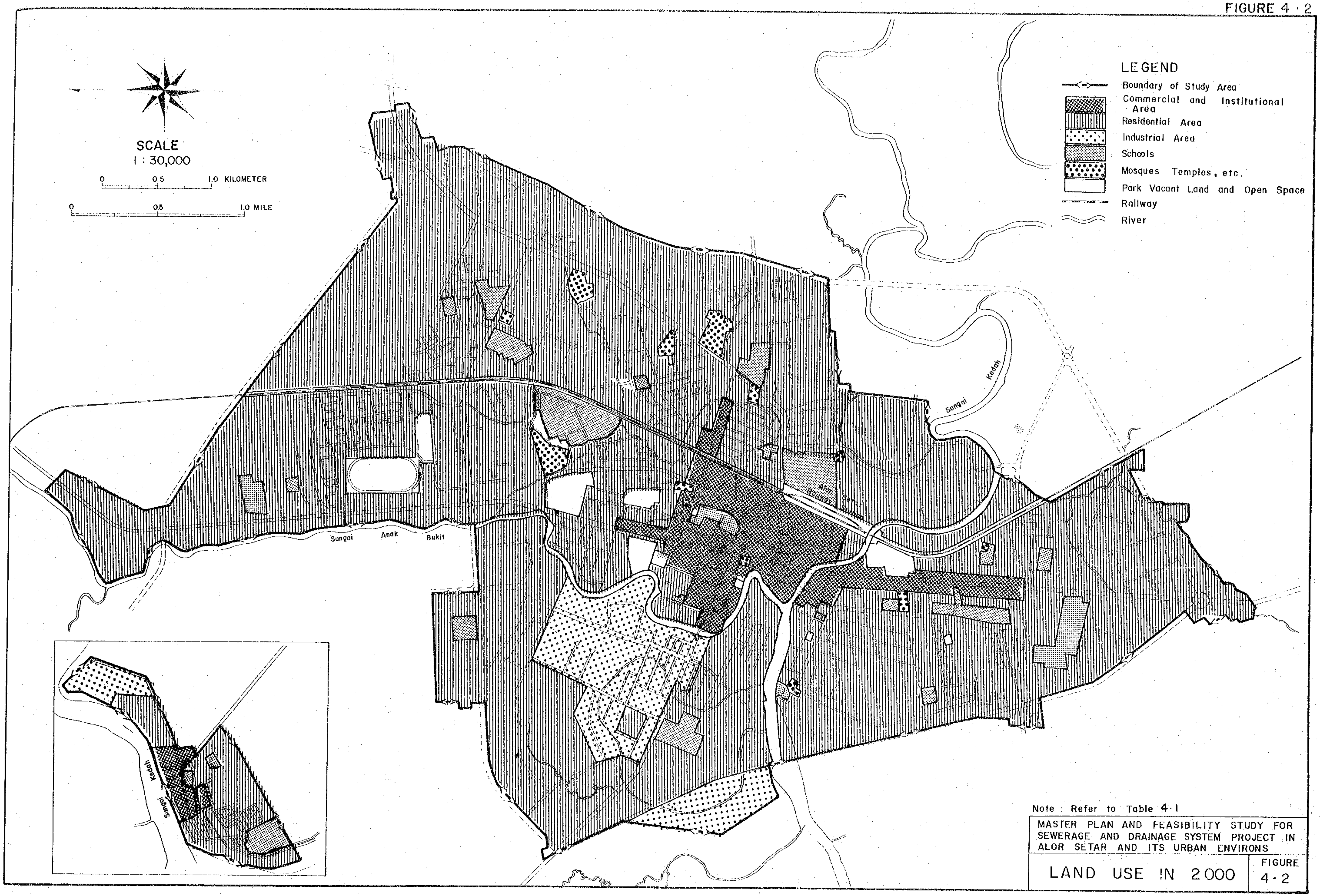
Table 4.5 Cost Comparison of Alternative Treatment/Disposal Systems by Annual Cost Basis

(M$1,000, 1979 price level)

Alternative	Flow Rate (m^3/day)			
	5,000	10,000	30,000	50,000
Alt.I Stabilization Pond Process	535.87	836.19	2,761.02	4,415.19
Alt. II Aerated Lagoon Process	633.55	1,167.54	2,723.10	4,144.53
Alt. III Oxidation Ditch Process	877.35	1,660.56	4,513.83	7,575.07

Note: Refer to Appendix E in detail


SCALE
1 : 30,000
0 0.5 1.0 KILOMETER
0 0.5 1.0 MILE
LEGEND
Boundary of Study Area
Railway
River
ALOR SETAR
(3175 ha)
KUALA KEDAH
(125ha)
MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS
STUDY AREA
FIGURE
4·1



Note : Refer to Table 4·1

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

LAND USE IN 2000

FIGURE 4·2

CHAPTER 5
MASTER PLANNING

1. STUDIES CARRIED OUT IN THE MASTER PLAN

A sewerage master plan is developed in the Study Area of 3,300 ha for the target year 2000, on the basis of fundamental planning and design elements set out in the preceding chapters as to future land use, population forecast and its distribution, collection system and treatment and disposal system.

The sewerage master plan covers for (1) sewerage zones and sub-zones (refer to Section 2), (2) population distributed in sewerage zones and sub-zones (refer to Section 3), (3) estimation of wastewater quantities and qualities with respect to proposed land uses (refer to Section 4), (4) establishment of design criteria (refer to Section 5), (5) proposed sewerage system and facilities (refer to Section 6), (6) Priority considerations (refer to Section 7), (7) financial considerations including potential source of funds and proposed magnitude of capital investment (refer to Section 8), (8) estimated construction and recurrent costs by phases (refer to Section 9) and (9) benefits anticipated by implementation of the proposed sewerage construction programme (refer to Section 10).

The recommendations for some of the foregoing planning and design elements are supported by detailed studies for key items as shown in Appendices.

2. PROPOSED SEWERAGE ZONES AND SUB-ZONES

2.1 Proposed Sewerage Zones and Sub-zones

The physical characteristics of the Study Area are (1) populated urban areas are limited, (2) huge rural area still remains to be paddy field at present will be developed in the future, and (3) mostly the Area has flat ground surface.

If a single sewerage system is planning for a large flat ground surface as described above, large-sized deep trunk sewers are required to convey sewage from individual houses all the way to the treatment plant, causing high initial investment in addition to the difficulties in implementing construction programme particularly in the built-up areas.

Under the circumstance, it is considered practical, that the Study Area be properly divided into sewerage zones and sub-zones as shown in Table 5.1 and Figure 5-1 to be dealt with separately, rather than planning a area-wide system to cover the whole Study Area. The advantages of this independent system by sewerage zone basis would be:

(a) Design of sewer facilities can be possible according to the characteristics of each area.

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

(c) Long distant conveyance of sewage can be averted to avoid inconvenience in construction and to enable better control of sulfide build-up.

(d) The future development area will be flexible for future modification.

2.2 Present Condition of Sewerage Zones and Sub-zones

(1) Alor Merah Sewerage Zone (or Zone A)

This sewerage zone lies extreme north of the Study Area with a total area of 822 ha exclusive of rivers and railway, surrounded by the Sg. Anak Bukit in the west, by Sg. Bakar Bata and Jl. Sultanah in the south, and by the bypass roads in the east and north.

Topography of this zone is almost flat with a very gentle declivity from south to north and from east to west with ground elevations ranging from 2.7 m (9 ft.) to 1.8 m(6 ft.) above MSWL.

Further, Jl. Bakar Bata, federal road, runs west part of this zone from north to south. Similary the railway runs central part from north to south.

Sullage water generated in this zone pours into either the Sg. Hujong Alor Merah or Sg. Barkar Bata, and then finally into the Sg. Anak Bukit.

This sewerage zone is divided into two sub-zones, namely A-1 and A-2. The former comprizes mainly urbanized and/or urbanizing area and the latter mainly future development area.

(a) Sub-zone A-1

This sub-zone consists of 385 ha with a resident population of over 15,100 at the time.

The newly built housing areas, such as Taman Golf and Taman Uda, together with kampung area along the Sg. Hujong Alor Merah exist in this sub-zone in addition to public utilities such as Kedah Club, Horse Race Course, Park, General Hospital, Prison and Schools Complex.

(b) Sub-zone A-2

This sub-zone covers 437 ha with a resident population of approximately 3,700 at present. Most of the population concentrates along Jl. Bakar Bata and the remaining scatters to the area still remains to be paddy field. The Sultan's place is also situated on Jl. Bakar Bata of this sub-zone.

(2) Kota Setar Sewerage Zone (or Zone B)

This sewerage zone lies in the central part of Alor Setar area with a total area of 971 ha exclusive of rivers and railway, surrounded by the Sg. Anak Bukit in the west, and by Sg. Kedah in the south, also by future bypass road (or Jl. Lenchong Timor) in the east and finally by both Sg. Bakar Bata and Jl. Sultanah in the north.

The sewerage zone is extremely flat ranging from 1.2 m (4 ft) to 1.8 m (6 ft) above MSWL, with a few fragmentary areas along Jl. Sultan and Jl. Langgar and along the Sg. Anak Bukit, which lie approximately from one to two feet higher than the rest of the area.

Several waterways run through either from east to west, or from south to north. The Sg. Derga is the former case and Sg. Raja, Sg. Tanjong Bendahara and Sg. Alor Gedok the latter case. Some low laying areas are subject to frequent flooding caused by unimproved main watercourses receiving the flows charged from the upstream watercourses.

As in the case of the Kota Setar Sewerage Zone this sewerage zone is divided into sub-zones B-1 and B-2, the former comprising mainly urbanized and/or urbanizing area, the latter future development area. In addition, the triangular northeastern part of this zone surrounded by railway, the Sg. Alor Malai and Jl. Jirat China, is identified as B-3, wherein a large scale housing development scheme by SEDC has been undertaken and is separated from other sub-zones, and a sewerage facilities in the area is already being developed by the agency.

(a) Sub-zone B-1

This sewerage sub-zone consists of 459 ha with a resident population of over 44,400 at present. This sub-zone has been almost urbanized compared to any other areas in Alor Setar area with the highest average population density of approximately 97 persons per ha.

Most of the government offices for the State Government together with the Municipal Council of Kota Setar are located in this sub-zone along with a largest portion of commercial area in Alor Setar.

The low lying region along the Sg. Raja, especially the upstream area which is one of the highest density areas, is subject to frequent flooding.

(b) Sub-zone B-2

This sub-zone covers 410 ha with a current population of over 11,400. This sub-zone lies in the east from Jl. Langgar extending to the northeastwards from the Sg. Kedah.

Urbanization in the ribbon has been in progress along Jl. Langgar, Jl. Derga and Jl. Tanjong Bendahara, while a kampung zone has been formed along the Sg. Tanjong Bendahara. The remaining area, except for several localized newly developed areas, is still paddy field.

It is considered that urbanization can be accelerated by implementing bypass road plan running through a part of the paddy field area which is conveniently situated adjacent to central portion of Alor Setar.

(c) Sub-zone B-3

This sub-zone is encircled by railway, Jl. Sultanah, Jl. Langgar and the Sg. Alor Malai with a total area of 102 ha, 34 ha of which has been reserved for a large scale housing area by SEDC.

In the north wastern portion of this sub-zone with a present resident population of over 1,300, both Taman Syed Mohamad and Sultanah Bahiyah Schools exist. The remaining area, except occupied by several buildings such as MADA, is either paddy field or untilled land.

The SEDC's sewerage plan covering the 34 ha has provided 5.2 acres (or 2.1 ha) for the sewage treatment facility at the southwestern corner of this sub-zone.

(3) Mergong Sewerage Zone (or Zone C)

This sewerage zone lies in the north of the Sg. Kedah and west of the Sg. Anak Bukit, comprizing 614 ha demarcated by the Sg. Kedah in the south, similarly by the Sg. Anak Bukit, Western Bypass (or Jl. Lencong Barat) and proposed road (to be connected to Jl. Sultanah) in the east, west and north respectively. This sewerage zone is also flat with ground elevation ranging from 1.5 m (5 ft) to 1.8 m (6 ft) above MSWL.

The Sg. Gunong Sali runs the western part of this zone towards south, and similarly the Sg. Terus runs the central part of this zone towards south, both of which finally pour into the Sg. Kedah.

The northern part of Jl. Seberang Putera, which runs eastwestwards at one-third portion of the zone from the Sg. Kedah, is the North Mergong Industrial Area.

The South Mergong Industrial Area with a total area of 43 ha ha bounded by the Sg. Kedah (in the south), Jl. Lencong Barat (in the east) and the high tension line (in the west and north) has been developed by SEDC as a large scale industrial estate.

Low cost houses are scheduled to be built by the Federal Government in the extreme northern portion of this zone from the MADA irrigation canal running from northwest to southeast, but their construction schedule is not yet finalised.

Considering the above urbanizing situation of this zone, this sewerage zone is divided into two sub-zones, C-1 and C-2, the former covering mainly of urbanized and/or urbanizing area and the latter mainly of future development area including the South Mergong Industrial Area.

(a) Sub-zone C-1

This sub-zone covers the North Mergong Industrial Area and urbanized area lying in the east of the Sg. Terus and south of Jl. Seberang Putera. The total area of this sub-zone is 187 ha with a present resident total population of over 9,000.

Most of the factories in the North Mergong Industrial Area are either cottage industry (or home industry) or car dealer's shop, therefore, the industrial wastewater discharged is not significant in volume. However, the grease and oil wastes generated from car repairing shops are causing pollution by the indiscriminate discharge into nearby road side ditches.

The southern side of Jl. Seberang Putera, except the ribbon area along the road, is residential area.

In the central portion of the North Mergon Industrial Area, a block of flats for employees in the industrial area has already been in existence with complete sewerage system including stabilization ponds.

(b) Sub-zone C-2

This sub-zone lies in the peripheral area of Sub-zone C-1 comprising 427 ha with a total population of approximately 2,900.

Most of the area is still paddy field except for the South Mergong Industrial Area and the low cost housing area as described previously.

(4) Pengkalan Kundor Sewerage Zone (or Zone D)

This sewerage zone is located in the southern part of Alor Setar, demarcated by the Sg. Kedah in the north , the Western bypass in the west and the Sg. Alor Bangsa in the south and east , comprizing 658 ha with a total present population of a little less than 42,700.

Same as in the case of other sewerage zones, this sewerage zone is almost flat with ground elevation ranging from 1.5 m (5 ft) to 2.1 m (7 ft) above MSWL. However, the area inclines very gently from south to north.

Jl. Sungai Korok, a federal road, runs through the middle of the zone from south to north.

The urbanized and/or urbanizing area along Jl. Sungai Korok and the Sg. Kedah are one of the oldest blocks in Alor Setar. The remaining are also urbanizing very fast.

The sullage water generated in this sewerage zone finally flows into the Sg. Kedah either through the Sg. Korok Wan Mohamed Saman, Sg. Alor Bangsa or roadside ditches.

This sewerage zone is divided into two sub-zones, D-1 and D-2, the former comprizing mainly of urbanized and/or urbanizing area and the latter for future development area.

(a) Sub-zone D-1

The sub-zone consists of urbanized and/or urbanizing area mixed with old and new housing blocks comprizing 388 ha with a population of a little over 35,000. Some housing development schemes have been undertaken in this sub-zone.

Although population was concentrated along Jl. Seberan Perak and Jl. Sungai Korok in the past, it is foreseen that population distribution would be levelled out like sub-zone B-1 in the very near future.

(b) Sub-zone D-2

This sub-zone covers 270 ha with a current approximate population of 7,700. Most of this sub-zone area remains to be paddy field yet except an eastern part of the railway and a part of the area along Jl. Sungai Korok.

(5) Kuala Kedah Sewerage Zone (or Zone E)

This sewerage zone is located at about 8 km (or 5 miles) west of Alor Setar town centre and is lying at the mouth of the Sg. Kedah, developing as a town of fishing port. The zone extends approximately 2 km along the Sg. Kedah with average width of 0.7 km, covering 125 ha with a population of over 9,100.

Most recently, town remodelling programme has been in progress in this area according to TCP's proposed plan and also an regional development has been undertaken as a large scale marine product industry complex outlined by SEDC.

The sewerage zone is almost flat ranging from 1.8 m (6 ft) to 2.1 m (7 ft) with several spotted depressions. The MADA paddy field in the background lies from 0.9 to 1.2 m (3 to 4 ft) level.

The remodelled town area as well as new housing development areas is provided with either communal septic tank or individual septic tank, whereas the old kampung area is provided with either pit privy or river latrine.

The sullage water generated in this zone pours into the Sg. Kedah directly or through the Sg. Tok Pasai.

Sub-zone is not established in this zone because this zone covers very small area (125 ha) and most of the area is considered to be urbanized in the immediate future.

3. POPULATION DISTRIBUTION IN SEWERAGE ZONES AND SUB-ZONES

The 2000-year population distributed into the Study Area (as shown in Table 4.3, Section 4.2, Chapter 4) according to future land use plan is grouped by sewerage zones and sub-zones as shown in Table 5.1 and Figure 5.1.

Further, population in sewerage zones and sub-zones for future key years are estimated as shown in Table 5.2.

Table 5.1 2000-year Population in Sewerage Zones and Sub-zones

Zones and Sub-zone	Land Use / Population Density (persons/ha) (*)	Residential Area A	Residential Area B	Residential Area C	Commercial Area	Institutional Area	Industrial Area North Mergong	Industrial Area South Mergong Kuala Kedah	School	Park, Vacant Land, Open Space	Mosque, Temple	Total
		120	70	(**) 5 - 800	200	0	100	0	0	0	0	
A (Alor Merah)	A-1	238.1 28,600		55.1 1,100		17.4 0			36.9 0	28.7 0	8.8 0	385.0 29,700
	A-2	190.0 22,850	214.8 15,000	25.2 150					7.0 0			437.0 38,000
B (Kota Setar)	B-1	251.9 30,220		3.4 780	116.0 23,200	14.6 0			34.5 0	25.7 0	12.9 0	459.0 54,200
	B-2	242.7 29,040	152.2 10,700	1.2 960					5.7 0		8.2 0	410.0 40,700
	B-3	92.9 11,100							8.1 0		1.0 0	102.0 11,100
C (Mergong)	C-1	62.9 7,600		5.0 2,000			119.1 11,900					187.0 21,500
	C-2	142.2 17,100	199.0 13,900				26.9 2,700	43.0 0	15.9 0			427.0 33,700
D (Pengkalan Kundor)	D-1	315.5 37,840		1.5 660	40.0 8,000				19.3 0	9.6 0	2.1 0	388.0 46,500
	D-2	249.6 30,000							20.4 0			270.0 30,000
E (Kuala Kedah)	E	77.8 9,300			18.0 3,600			18.0 0	11.2 0			125.0 12,900
Total		1,836.6 223,650	556.0 39,600	91.4 5,650	174.0 34,800	32.0 0	146.0 14,600	61.0 0	159.0 0	64.0 0	33.0 0	3,190.0 318,300

Note: (1) 2000-year population for Sewerage Sub-zone A-1 in Residential Area A, for example, is calculated as approximately 28600 by multiplying 120 and 238.1.
(2) Figures of upper row in each sewerage sub-zone are component areas of land use.
(3) * Refer to Section 4.2 and Table 4.3 in Chapter 4.
(4) ** Refer to Table 4.3 in chapter 4.

Table 5.2 Population in Sewerage Zones and Sub-zones for Future Key Years

(persons)

Sewerage Zone	Sewerage Sub-Zone	1979 (base year)	1980	1985	1900	1995	2000 (target year)
A (Alor Merah)	A-1	15,100	15,800	19,300	22,700	26,200	29,700
	A-2	3,700	4,100	5,500	8,100	11,900	38,000
	Sub-total	18,800	19,900	24,800	30,800	38,100	67,700
B (Kota Setar)	B-1	44,400	44,900	47,200	49,500	51,900	54,200
	B-2	11,400	12,900	17,200	25,100	37,100	40,700
	B-3	1,300	1,300	6,500	8,100	9,600	11,100
	Sub-total	57,100	59,100	70,900	82,700	98,600	106,000
C (Mergong)	C-1	9,000	9,600	12,600	15,600	18,500	21,500
	C-2	2,900	3,000	8,400	16,800	25,300	33,700
	Sub-total	11,900	12,600	21,000	32,400	43,800	55,200
D (Pengkalan Kundor)	D-1	35,000	35,600	38,300	41,000	43,800	46,500
	D-2	7,700	8,700	11,600	17,000	25,100	30,000
	Sub-total	42,700	44,300	49,900	58,000	68,900	76,500
E (Kuala Kedah)	E	9,100	9,300	10,100	11,100	12,200	12,900
	Sub-total	9,100	9,300	10,100	11,100	12,200	12,900
Total		139,600	145,200	176,700	215,000	261,600	318,300

Note: (1) The population for future key years between 1979 and 2000 in sub-zones A-1, B-1, C-1 and D-1 are calculated in proportion to increase between 1979 and 2000.

(2) The population of future key years for both B-3 and C-2 is considered only for natural increase at an annual rate of 2.7% till 1985 and 5,000 population is added in 1985, reflecting development schemes for these area. Then population between 1985 and 2000 in the same sub-zones are calculated in proportion to the increase between 1979 and 2000.

(3) The remaining population (subtracting the population in (1) and (2) from the total population) for future key years are distributed in sub-zones A-2, B-2, D-2 and E by reflecting the present population rates of these areas.

4. WASTEWATER QUANTITIES AND QUALITIES

Wastewater quantity for the future years up to the year 2000 differs according to the water usage and categories of land use.

Data of water consumption are collected from the JKR's meter reading records for the past one year for typical residential, commercial, institutaional and industrial areas inclusive of schools, the general hospital and the prison.

Future wastewater quantity for each of the areas categorized in future land use is estimated based on the JKR's data and various available studies in sewerage plans undertaken in Malaysia and other Asian countries, as resulted in Table D-3 in Appendix D.

Wastewater qualities for the future years up to the year 2000 are also forecast according to categories of land use on the basis of the outcome of water quality analysis carried out at selected typical areas including residential, commercial, institutional and industrial. Reference is also made for the estimated future wastewater qualities in various previous sewerage studies in Malaysia and other Asian countries as resulted in Table D-3 in Appendix D.

4.1 Domestic Wastewater

Three typical residential areas are selected as shown in Table D-1, Figure D-1 in Appendix D and per capita water consumption rates are calculated for the past one year. Average per capita water consumption rate in 1979 is estimated to be 170 litres per day. No significant difference in water consumption rate is acknowledged according to types of house.

Taking into account of increasing trend of water consumption in urban area, the 2000-year flow rate is reasonably estimated at 230 l/cap/day (refer to Appendix D, Wastewater Quantities and Qualifies).

According to the wastewater quality analysis from several typical blocks in residential area, wastewater concentration in terms of BOD as well as SS is resulted in 200 mg/l, which is equivalent to 34 g/cap/day of BOD (and SS) generation with per capita water consumption rate of 170 litres per day. It is reasonable to assume that the 2000-year wastewater concentration will be 200 mg/l because per capita water consumption rate as well as per capita BOD (and SS) generation could increase in the almost same ratio as shown in Table 5.3-1.

Table 5.3-1 Domestic Wastewater Quantity and Quality
Estimated for the Years 1979 and 2000

Wastewater Quantity		Wastewater Quality (both for BOD/SS)
1979 (l/cap/day)	2000 (l/cap/day)	1979 - 2000 (mg/l)
170	230	200

Note: (1) Refer to Appendix D for detail.
(2) Both BOD and SS generated for 1979 and 2000 are assumed to be 34 and 46 (g/cap/day) respectively

4.2 Commercial Wastewater

Water consumption data are collected for 59 units of various kinds of business as shown in Table D-4 and Figure D-1 in Appendix D in two typical blocks in the commercial area for the past one year, including eating shops, restaurants, electrical appliance shops, cloth shops, book stores, etc. The buildings are ranging from two to four stories and some of them are used jointly for business and dwelling.

Present average per capita wastewater generation rate in commercial area is thus estimated at 340 litre per day. The 2000-year per capita wastewater generation rate is assumed to be 460 litre per day in the same manner done in the residential wastewater in Section 4.1 above.

Wastewater concentration in commercial area is assumed to be 200 mg/l from 1979 to 2000.

Table 5.3-2 Commercial Wastewater Quantity and Quality Estimated in the Years 1979 and 2000

Wastewater Quantity		Wastewater Quality(both for BOD/SS)
1979 (l/cap/day)	2000 (l/cap/day)	1979 - 2000 (mg/l)
340	460	200

Note: (1) Refer to Appendix D for detail.

(2) Both BOD and SS generated for 1979 and 2000 are assumed to be 68 and 92 (g/cap/day) respectively.

4.3 Institutional Wastewater

There are various government buildings near MPKS office because Alor Setar is the seat of State government in Kedah. In the government buildings, no resident is assumed as shown in Table 4.3 (Section 4.2, Chapter 4). However, daytime population is considered in the plan with an average of 23 litres of water consumed per head per day based on the past one year metre reading record for several selected government buildings (refer to Table D-5), and Figure D-1 in Appendix D). The water consumption rate of the institutional buildings is considered invariable up to year 2000. The wastewater concentration in institutional area is reasonably assumed to be 200 mg/l from 1979 to 2000.

Table 5.3-3 Institutional Wastewater Quantity and Quality Estimated up to the Year 2000

Wastewater Quantity	Wastewater Quality(both for BOD/SS)
1979 - 2000 (l/cap/day)	1979 - 2000 (mg/l)
23	200

Note: Both BOD and SS generated from 1979 and 2000 are estimated to be 4.6 g/cap/day.

4.4 Industrial Wastewater

Amount of industrial waste generated in the three industrial areas, namely North Mergong, South Mergong and Kuala Kedah, is estimated independently due to different characteristic of wastewater. However, wastes generated from small scale (home-scale) factories scattered in the residential and commercial areas are not considered conspicuous, and could be averaged out with the residential and commercial wastewater in these areas.

4.4.1 North Mergong Industrial Area

Sixteen typical factories as shown in Table D.7 and Figure D.1, in Appendix D, are selected for on-the-spot survey to gauge effluent amount and to analyze wastewater sampled. The factories are adequately selected representing categories in industrial classification including such industries as foodstuffs, rubber and plastic, metal, electrical, automobile repair and overhauling, and the others.

Average wastewater generation from unit of gross area (ha) is estimated at 19.2 m^3 per day, assuming to be invariable up to 2000. Wastewater strength originated here is assumed to be 60 mg/l for BOD, and 100 mg/l for SS till 2000, based on the various available data obtained in Malaysia and Japan.

Table 5.3-4 North Mergong Industrial Wastewater Quality and Quality Estimated up to the Year 2000

Wastewater Quantity	Wastewater Quality	
	BOD	SS
1979 - 2000 (m^3/ha*/day)	1979 - 2000 (mg/l)	1979 - 2000 (mg/l)
19.2	60	100

Note: *Gross area

4.4.2 South Mergong Industrial Area

Out of gross South Mergong Industrial Area of 43 ha, net 36.24 ha is planned to be occupied by industries, of which 21.24 ha has already been allocated for four big scale industries manufacturing automobile tires, toilet papers and shielding materials, and processing animals as shown in Table D-10 in Appendix D. The remaining 15 ha is assumed to be occupied by the same kinds of industries categorized in the North Mergong Industrial Area. Therefore, wastewater generation from unit of gross area (ha) is estimated at 33.9 m^3 per day up to the year 2000.

Average wastewater concentration generated in the South Mergong Industrial Area is estimated at 280 mg/l for BOD and 270 mg/l for SS, up to the year 2000, taking weighted average considering wastewater amount and waste loads from the industries concerned. The waste load or wastewater concentration generated from unit of area for each relevant industry is assumed adequately adjusting the data obtained in Japan and western countries.

Table 5.3-5 South Mergong Industrial Wastewater Quantity and Quality Estimated up to the Year 2000

Wastewater Quantity	Wastewater Quality	
	BOD	SS
1979 - 2000 (m^3/ha*/day)	1979 - 2000 (mg/l)	1979 - 2000 (mg/l)
33.9	280	270

Note: (1) Refer to Table D-11 in Appendix D for detail.
(2) *Gross area.

4.4.3 Kuala Kedah Industrial Area

Date are collected as to the amount of wastewater generated from three fish processing and freezing industries in operation, resulting 111.4 m^3 per day ha as detailed in Table D-12 in Appendix D. This figure is applied over total planned Kuala Kedah Industrial Area of 18 ha with 24 factories specialized in either fish processing or freezing industry.

Wastewater strength of the raw wastewaters discharged from the three existing factories are separately measured as to BOD and SS, and assumed to be 2,000 mg/l and 500 mg/l respectively up to the year 2000.

Table Kuala Kedah Industrial Wastewater Quantity and Quality Estimated up to the Year 2000

Wastewater Quantity	Wastewater Quality	
	BOD	SS
1979 - 2000 (m3/ha*/day)	1979 - 2000 (mg/l)	1979 - 2000 (mg/l)
111.4	2,000	500

Note: *Gross area

4.5 Wastewater from Schools

Same as in the case of institutional area, resident population in schools is considered negligible from planning purpose as shown in Table 4.3 (Section 4.2, Chapter 4). However, daytime population (inclusive students, teachers, etc) is estimated to contribute five percent of sewage amount generated per person in residential area, based on the JKR's recent one year water meter reading record for the selected four schools of various sizes as discussed in Appendix D in detail. Total population according to schools for both 1979 and 2000 conditions are estimated in Table D-15 in Appendix D.

Wastewater concentration generated in schools is reasonably assumed to be 200 mg/l for BOD and SS, equal to that of residential area up to the year 2000.

Table 5.3-7 Estimated Wastewater Quantities and Qualities from Schools in the years 1979 and 2000

Wastewater Quantity		Wastewater Quality (both for BOD/SS)
1979 (l/cap/day)	2000 (l/cap/day)	1979 - 2000 (mg/l)
8.5	11.5	200

Note: Both BOD and SS generated in 1979 and 2000 are estimated to be 1.7 and 2.3 g/cap/day respectively.

4.6 Wastewater from General Hospital and Prison

Although the general hospital and the prison lie in residential area, these two places are treated independently because of their large areas.

People in the general hospital and the prison is not treated as resident population in Table 4.3 (Section 4.2, Chapter 4), but wastewater generated by these people is counted for sewerage system planning.

Average water consumption rates in these two places are 316 and 110 m3/day respectively based on the past one year record. The sewerage amount from the general hospital will be increased by 1.5 times by the year 2000 assuming the population in the area concerned of the general hospital is expected to increase in the same rate, while the sewage amount from the present prison will not be increased up to year 2000 because the accommodation for criminals is fully occupied and no expansion of facility is expected in the future.

Wastewater concentrations from the two places are assumed to be 200 mg/l, invariable up to the Year 2000

Table 5.3-8 Estimated Wastewater Qualities and Quantities from General Hospital and Prison up to the Year 2000

Wastewater Quantity			Wastewater Quality (both for BOD/SS)	
General Hospital		Prison	General Hospital	Prison
1979 (m^3/day)	2000 (m^3/day)	1979 - 2000 (m^3/day)	1979 - 2000 (mg/l)	1979 - 2000 (mg/l)
316	500	110	200	200

4.7 Extraneous Water

Since no sewerage system is available within or near the Study Area for reasonable estimation of the extraneous water allowance into sewers, the values set out in the Butterworth/Bukit Mertajam Metropolitan sewerage study, State of Penang, by an extensive field survey in a selected existing sewerage system in the Metropolitan area is applied in this Study considering the similarity of physical characteristics of the two. The extraneous water allowances applied in this study are shown in Table 5.3-9.

Table 5.3-9 Design Extraneous Water Allowances

Type of Area	Allowance (m^3/ha/day)	Allowance (m^3/m of pipe length/day)
Residential	6.3	0.045
Commercial	4.5	0.045
Industrial	4.5	0.045

Note: Referred to extroneour water allowance values applied in the Butterworth/Bukit Mertajam Metropolitan sewerage study as discussed in Section 6, Appendix D.

5. DESIGN CRITERIA

This section summalizes the design criteria necessary for master planning for sanitary sewers, manholes, pumping stations and treatment and disposal system.

5.1 Sewers

5.1.1 Flow Friction Formula

The Manning's equation is adopted for design of sewers and conduits in the form:

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

where

V = velocity of flow, in m/sec

n = coefficient of roughness, 0.013 for new sewers and 0.015 for existing sewers

R = hydraulic radius, in m

S = slope

5.1.2 Peak Flow Rate

The ratio of the peak flow rate to the average for the day is given in the following formula:

$$M = \frac{5}{P^{1/7}}$$

where

M = ratio of peak flow to average flow

P = design population, in thousand

Then the design sewage flow rate for sewer design is expressed in the form:

$Q = P' \times q \times M$

where

Q = design flow rate, m^3/day

P' = population served, persons

q = daily average flow rate, m^3/day. cap

5.1.3 Velocity of Flow

All sewers shall be designed to maintain a mean flow velocity, when flowing full or half full, of not less than 0.6 m/sec (2 ft/sec) for VCP, based on the Manning's equation using an 'n' value of 0.013. However, for centrifugally cast reinforced concrete pipe or any other cement-bonded pipe materials, a minimum design flow velocity of 0.75 m/sec (2.5 ft/sec) shall be applied using the 'n' value of 0.013.

Velocity shall not exceed 3.0 m/sec (10 ft/sec) in any type of sewer, to protect from erosion. Where the ground surface slope is steep and velocity of more than 3.0 m/sec will result, special consideration shall be given on the protection of pipes against erosion and shock.

5.1.4 Sulfide Corrosion

All sewers shall be so designed and constructed that mean velocities of flow will not be less than 0.6 m/sec for VCP and 0.75 m/sec for CRC and cement-bonded pipes to protect from sulfide corrosion.

5.1.5 Design Depth of Flow

All circular pipes shall be designed on the basis of 100 per cent full capacity for the peak flow rate.

5.1.6 Minimum Size of Sewer

House connection shall be not less than 150 mm (6 in.) in dia. For public sanitary sewers, a minimum size of 225 mm (9 in.) in dia. is recommended to facilitate maintenance.

5.1.7 Manhole

The following maximum manhole spacings are proposed:

Pipe diameter	Maximum spacing
600 mm (24 in.) or less	100 m (328 ft)
675 mm (27 in.) or more	150 m (492 ft)

The spacings mentioned above are recommended on the basis of the field investigations and evaluation of the types of sewer cleaning equipment such as rod type widely in use in the sewerage system in Georgetown of Penang. The rod type cleaning equipment, which normally has a cleaning performance up to 150 m of pipe length per day, will be used as a major cleaning device for the new sewerage system, instead of highly mechanized equipment such as hydraulic sand ejectors. This is because the rods are generally far lower in cost and easy to handle as compared with the mechanized equipment.

Except for very shallow depth of sewers, all manholes are planned to have adequate dimensions for entry and for operation of the cleaning rods. The minimum diameters of manholes shall be as follows:

Pipe diameter	Minimum manhole diameter
Less than 900 mm	1,200 mm (47 in.)
900 - 1,200 mm	1,500 mm (59 in.)
More than 1,200 mm	1,800 mm (71 in.)

Watertight manhole covers of either cast iron or concrete shall be used wherever the manhole tops is subject to flooding by street runoff or high water. Manholes of brick or segmented block shall be waterproofed on the exterior wall with plaster coatings where necessary. Manhole steps shall be a sulfide corrosion resistant material such as cast iron or equivalent provided at 30 cm intervals and embedded to reach the dome wall.

5.1.8 Depth of Sewer

The external crown of public sewers shall be at least one metre (3.3 ft) below the ground surface, with an exception for specific situations that prove shallower depths are preferable. Main and submain sewers shall be sufficiently deep so as to receive sewage from branch and lateral sewers.

5.2 Pumping Station

For the provision of pumping stations, basic considerations on location, layout, type of equipment and structure are given. Following are the major elements to be considered for the proper design of pumping station.

5.2.1 Design Flow

The design of pumping station shall be based on the peak flow of the sewage, unless lower rate of flow for design is justified. All pipes and conduits shall also be designed to carry the expected peak flow plus some allowance for abnormal flow increase.

Appropriate storage capacity shall be provided in wells, where automatic controls and variable speed drives are not furnished to match pumping rates exactly with inflow rates.

5.2.2 Type and Structure

In view of the local availability of circular caisson for small structures, it is recommended that the circular type be used for small capacity stations and rectangular type for large capacity stations.

5.2.3 Grit Removal Units and Screening Devices

For sanitary sewage pumping stations, no grit removal units are recommended. Coarse bar screens (100 mm clearance between the screen bars) manually cleaned shall be provided prior to the pump well, to prevent large objects from entering into the wet well.

5.2.4 Ventilation and Prevention of Odour and Noise

Pumping stations shall be enclosed in a concrete structure to prevent the diffusion of odour and noise to the nearby residences. However, a suitable ventilation shall be provided for all stations to ventilate the screening room or any other portion requiring maintenance or inspection.

5.2.5 Pumps

Pump capacity shall be increased according to the phases of implementation of the system, although the structure shall be designed for the year 2000.

For the selection of type of pumps, care is given on alternative types including screw, centrifugal and submersible pumps. In view of the present conditions of the area and also easiness in installation and operation and maintenance, submersible non-clogging pumps are recommended.

5.2.6 Pump Drives

In selecting a type of pump drives, careful considerations are given on the frequency of electrical power suspension and its duration as well as on cost comparison between electric motor and engine. The experience indicates that generally the use of electricity is more economical and dependable than engine or other source of power. Further, electricity has been used for years in Malaysia without much trouble, therefore, it is recommended that pump drives in all pumping stations be of electric motor.

5.3 Treatment and Sludge Disposal System

Recommended design criteria for the three treatment process, namely for stabilization pond, aerated lagoon and oxidation ditch, are shown in Tables 5.4,5.5 and 5.6 respectively, based on the various data obtained in Malaysia and other countries. (Refer to Appendix E of Vol. VII in detail)

Table 5.4 Design Basis for Stabilization Pond

Item	Design Value
1. Scum Chamber	
Depth	1.5 - 2.5 m (max.)
2. Facultative Pond	
Surface BOD Loading	300 kg/day.ha (268 lb/day acre)
Depth	1.5 m (5 ft)
3. Maturation Pond	
Detention	3 days
Depth	1.5 m
4. Expected Effluent Quality	
BOD	50 mg/l (max.)
Coliforms	1,000 N/ml

Table 5.5 Design Basis for Aerated Lagoon

Item	Design Value
1. Scum Chamber	
Depth	1.5 - 2.5 m (max.)
2. Aerated Lagoon	
Surface BOD Loading	1,500 kg/day. ha (1,326 lb/day.acre)
Depth	3 m (10 ft)
3. Maturation Pond	
Detention Time	4 days
Depth	1.5 m (5 ft)
4. Expected Effluent Quality	
BOD	50 mg/l (max.)
Coliforms	1,000 N/ml

Table 5.6 Design Basis for Oxidation Ditch

Item	Design Value
1. Oxidation Ditch	
Volumetric BOD Loading	0.4 kg/m^3
Depth	1.5 m (5 ft)
2. Sedimentation Basis	
Detention Time	2 hr.
3. Chlorination Tank	
Detention Time	15 min.
4. Area of Drying Beds	0.10 m^2/m^3/day
5. Expected Effluent Quality	
BOD	50 mg/l 9max.)
Coliforms	1,000 N/ml

6 PROPOSED SEWERAGE FACILITIES

6.1 Location of Major Facilities

Sewerage facilities should be properly located for the best use of each facility such as sewers, pumping stations and treatment facilities considering economy, possibility for construction, and availability of lands for the facilities.

6.1.1 Selection of Treatment Facility Sites

Sewerage layout plan is worked out in order to minimize the overall cost, inclusive of both costs for construction and operation/maintenance. Since the Study Area is almost flat, it is most economical to locate the treatment facilities near the central portion of each sewerage zone. However, the layout plan is decided, heavily influenced by the availability of the land for such facilities.

Several alternative treatment sites are brought into discussion with the agencies concerned as indicated in Section 3 of Appendix E and, as a consequence, finally proposed plan is attached in Figure 5.2 with land available for treatment facility in each sewerage zone as shown in Table 5.7.

Table 5.7 Land Available for Treatment Facility in Each Sewerage Zone

Sewerage Zone	ha (acres)
A	14.7 (36)
B	22.5 (56)
C	12.4 (31)
D	18.8 (46)
E	19.6 (48)

6.1.2 Selection of Trunk Sewer Routes and Pumping Station Sites

Proposed trunk sewer routes and locations of pumping stations are indicated in Figure 5.2 taking account of;

(1) topographical condition

(2) minimum number of pumping stations installed and availability of land for pumping stations

(3) size of investment required

(4) availability of land for trunk sewers and

(5) traffic condition

It is a basic engineering consideration to minimize the number of pumping stations by properly selecting trunk sewer routes. Due to flat terrain of the area and the limited availability of treatment facility sites, all of which are located at the outside of the Study Area, installation of some number of pumping stations is unavoidable. When sewer invert depth becomes at the neighbourhood of seven meters, a pumping station should be necessary to avoid excessive extra cost for lying deep sewers.

6.2 Joint Treatment of Municipal Wastewater and Industrial Wastes

6.2.1 Consideration on Joint Treatment of Domestic and Industrial Wastes

Joint treatment including both domestic and industrial wastes will be the most desirable in this study although certain problems have to be carefully considered.

First, as industrial wastes include objectionable matters, such as oils, grease, flameable solvents, excessive acidity or alkalinity and poisonous substances, it is necessary to give due consideration for protection of a conduit system from corrosion, clogging, explosion, and other damages, and for adequate maintenance of treatment facility.

Since the treatment facilities for joint treatment use some form of biological treatment, it is essential for satisfactory operation that particular industrial waste qualities be avoided and the waste mixture be (1) as homogeneous in composition and uniform in flow rate as possible and free from shock loads, (2) not highly loaded with floatable and suspended matters, (3) free from excessive acidity or alkalinity, (4) free from undecomposable materials and toxic metals, (5) not too high BOD materials, such as carbohydrates, sugar, starch and cellulose and (6) low in oil and grease content.

In most of sewerage zones, industrial wastes are comparatively little compared to domestic wastewater, and pretreatment process will not necessarily be required because the treatment problem caused by industrial wastes could be significantly decreased by overwhelming domestic wastewater in treatment plant.

For Kuala Kedah sewerage zone, where a large scale of fishery industries are under consideration, however, care should be taken on the characteristics of the wastes, and adequate measures will be required to meet the actual needs as follows;

(a) To lengthen the detention time of the wastes on treatment process.

(b) To modify or supplement treatment facilities by provision of oil skimming tank and pretreatment facility, sludge return system, etc.

6.2.2 Treatment for Wastewaters from Industrial Areas

(1) North and South Mergong Industrial Areas

Since light industries are dominant in both the North and South Mergong Industrial Area, it is estimated not to affect a joint treatment of the wastewater with domestic wastewater, if grease and oil is removed by installing oil trap before discharging into the public sewers as suggested in Appendix B.

(2) Kuala Kedah Industrial Area

Twenty-four (24) large fish processing industries are planned to be established in this industrial area in the near future, out of which three factories are already in operation.

Based on the water quality analysis of the three existing factories, BOD and SS values are assumed to be 2,000 mg/l and 500 mg/l respectively at present and in the future as discussed in Section 4.4.3 of Chapter 5.

Taking into consideration of the social contribution of the particular enterprises producing a high priority commodities for the society and the degree of contribution for the local economy, and realistic ability of individual factories for pretreatment and appropriate operation and maintenance, it is proposed to regulate each factory to pretreat by installing preliminary treatment facilities (or plain sedimentation tank) with a removal rate of 20% for BOD and 60% for SS as shown in table 5.8. Thus estimated wastewater effluent qualities from the Kuala Kedah factories are calculated in Table 5.9 (Sewerage Zone E). It should be noted that materials recovered by the pretreatment will be returned to the production process of the factories for the sake of economy.

Table 5.8 Proposed Effluent Quantities from Kuala Kedah Fish Processing Industries

	Quality of Raw Wastewater (mg/l)	Proposed Removal Rate (%)	Proposed Effluent Quality from Industry (mg/l)
BOD	2,000	20	1,600
SS	500	60	200

6.3 Proposed Treatment Method

6.3.1 Wastewater Quantity and Quality

On the basis of discussions in the previous sections (Sections 3 and 4), wastewater quantity (volume) and quality (strength), which are discharging into treatment facility in each sewerage zone, are estimated in Table 5.9. The wastewater quantity is shown with respect to daily average flow while wastewater quality is shown in terms of both BOD and SS for both in 1979 and 2000 conditions. These quantities and qualities are used for preliminary engineering design of treatment facilities.

Table 5.9 Estimated Wastewater Qualities and Quantities Generated from Sewerage Sub-zones in the Years 1979 and 2000

Sewerage Zone	Sewerage Sub-zone	1979 Condition			2000 Condition		
		Daily Average Flow (m^3/day)	BOD Concentration (mg/l)	SS Concentration (mg/l)	Daily Average Flow (m^3/day)	BOD Concentration (mg/l)	SS Concentration (mg/l)
A (Alor Merah)	A - 1	5,480	111	111	10,020	152	152
	A - 2	3,410	38	38	11,550	152	152
	Sub-total	8,890	83	83	21,570	152	152
B (Kota Setar)	B - 1	14,330	163	163	21,130	175	175
	B - 2	4,560	87	87	12,030	157	157
	B - 3	880	53	53	3,220	160	160
	Sub-total	19,770	140	140	36,380	168	168
C (Mergong)	C - 1	3.140	87	102	5,460	106	123
	C - 2	3,090	34	34	11,740	160	161
	Sub-total	6,230	61	68	17,200	143	149
D (Penkalan Kundor)	D - 1	9,410	150	150	15,020	168	168
	D - 2	3,050	89	89	8,710	161	161
	Sub-total	12,460	135	135	23.730	166	166
E (Kuala Kedah)	E	2,876	258	168	6,140	634 #(532)	253 #(176)
Total		50,220			15,020		

Note: (1) Refer to Appendix D in detail.
(2) #Figures in parentheses are estimated by assuming 20% (BOD) and 60% (SS) removal rates by pretreatment. Refer Section 7.2.2 (2) ,Chapter 5.

6.3.2 Proposed Treatment Method

As discussed in Appendix E, stabilization pond process is considered most economical treatment method if amount of wastewater treated is less than 30,000 m^3/day, and areated lagoon process for the amount over 30,000 m^3/day, taking into account of construction, operation and maintenance and land acquisition cost.

It is evident, however, that the available land for stabilization pond process for each sewerage zone except zone E is almost half of the requirement for the 2000-year condition as shown in table 5.10, which necesitates to modify stabilization pond to aerated lagoon process, since land requirement of this process is approximately 60 percent to that by stabilization pond process.

By comparing the 2000-year daily average flow in each sewerage zone and sub-zone in Table 5.9 and total treatment capacity by stabilization pond process using the land available in Table 5.10, it is clear that the 2000-year wastewater from only urbanized and/or urbanizing areas (A-1, B-1, C-1, D-1,and E) can be safely treated by stabilization pond process except for B-1 and E.

Unless additional land space becomes available, the modification should be taken place before the stabilization ponds are overloaded by the additional wastewater from the future development areas such as A-2, B-1 itself, B-2, C-2, and D-2 as indicated in Table 5.11-2.

Table 5.10 Treatment Capacity by Stabilization Pond Process in Full Land Use Available

Name of Sewarage Zone	Daily Average Inflow into Treatment Facility by 2000 (refer to Table 5.9) (m^3/day)	Required Land Space by Stabilization Pond or aerated lagoon Process by 2000 (ha)	Available Land Space for Treatment Facility (ha)
A	21,570	25.4	14.7
B	36,380	41.5	22.5
C	17,200	20.5	12.4
D	23,730	27.8	18.8
E	6,140	19.6	19.6
Total	105,030	134.8	88.0

6.4 Design of Sewers and Pumping Stations

6.4.1 Sewers

The separate system, proposed in Section 5.1 of Chapter 4, collects and conveys all wastewaters from residential, commercial, institutional and industrial areas to treatment facility 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 infiltration. For industrial areas, wastewater flows are estimated using the unit flow rate per hectare plus some extraneous inflow.

Sewer capacity has been determined using the design criteria as discussed in Section 5, Chapter 5. The proposed routes of trunk sewers and flow direction with diameters and slopes are shown in Figure 5.2. Hydraulic computations and profiles for trunk sewers are shown in Appendix K.

As the above design includes the sewerage system in the future development areas, when new development plans are submitted with sewerage systems for approval, MPKS should review the developers' plan as to sewer size, branch and lateral sewers' routes, flow direction, slope and invert elevation, and location of temporary treatment facilities, in accordance with the design criteria developed under the current study.

6.4.2 Pumping Stations

A total of 18 pumping stations are required for the sewerage system covering the entire Study Area, five stations in Zone A, and five, four, three, and one stations in Zones B, C, D and E respectively as shown in Figure 5.2. Each of these pumping stations is designed on the basis of the design criteria discussed in Section 5, Chapter 5.

6.5 Proposed Sewerage Facilities

On the basis of discussions in previous sections in this Chapter and other Chapters concerned, proposed layout plan for sewerage facilities including trunk sewers, pumping stations and treatment facilities are shown in Figure 5.2, and in Tables 5.11-1 and 5.11-2.

Table 5,11-1 Proposed Sewerage Facilities

Name of Sub-zone	(*) Government Contribution				(**) Private Contribution			
	Trunk Sewer		Branch and Lateral Sewer		Branch and Lateral Sewer		House Connection	
	Dia. (mm)	Length (m)	Dia. (mm)	Length (m)	Dia. (mm)	Length (m)	Dia. (mm)	Length (m)
A - 1	375 - 900	4,135	225 - 300	29,140	225	6,480	150	80,930
A - 2	375 - 525	6,345	225 - 300	20,820	225	42,040	150	103,580
Sub-Total		10,480		49,960		48,520		184,510
B - 1	375 - 1,050	11,060	225 - 300	39,690	225	1,270	150	147,850
B - 2	375 - 600	2,665	225 - 300	20,900	225	35,790	150	111,100
B - 3	375 - 450	1,085	225 - 300	6,780	225	5,460	150	30,400
Sub-Total		14,810		67,370		42,520		289,350
C - 1	375 - 900	4,635	225 - 300	18,460	225	3,300	150	58,520
C - 2	375 - 600	3,640	225 - 300	19,540	225	40,770	150	91,870
Sub-Total		8,275		38,000		44,070		150,390
D - 1	375 - 900	6,360	225 - 300	36,450	225	3,300	150	126,870
D - 2	375 - 600	4,295	225 - 300	15,140	225	19,560	150	81,090
Sub-Total		10,655		51,590	450	22,860		208,560
E	375 - 600	2,940	225 - 300	8,180	225	6,650	150	35,280
Total	-	47,160	-	215,100	-	164,620	-	868,090

Note: (*), (**) Refer to Section 9.2 in Chapter 5.

Table 5.11-2 Proposed Pumping Stations and Treatment Facilities

Name of Zone	Refer No. (refer to Fig. 5.2)	Pumping Station		Treatment Facility		
		Peak Flow *1) (m^3/s)	Required Land Area (m^2)	Treatment Method	Design Flow *2) (m^3/day)	Available Land Area (ha)
A	P1	0.11	210	*5) SP → AL	21,570	14.7
	P2	0.09	200			
	P3	0.17	230			
	P4	0.14	220			
	P5	0.57	*3)			
B	P1	0.48	370	SP → AL	36,380	22.5
	P2	0.11	*4)			
	P3	0.22	260			
	P4	0.35	310			
	P5	0.94	580			
C	P1	0.19	240	SP → AL	17,200	12.4
	P2	0.51	380			
	P3	0.10	200			
	P4	0.69	470			
D	P1	0.29	280	SP → AL	23,730	18.8
	P2	0.46	360			
	P3	0.24	260			
E	P1	0.21	*3)	SP	6,140	19.6

Note: *1) Peak Flow in the Year 2000

*2) Daily Average Flow in the Year 2000

*3) Within the Treatment Site

*4) Within the proposed SECD's treatment site

*5) SP → AL indicates that stabilization pond in the early stage will be modified to aerated lagoon in the future.

6.6 Monitoring Programme

Since the waste stabilization pond is proposed for sewage treatment, it is necessary to monitor the influent and effluent quantities and qualities to obtain continuous records for proper operation and as design reference for future expansion. Items to be monitered include (1) Sewage incoming quantity, (2) temperature, (3) pH, (4) DO, (5) BOD, (6) SS, (7) coliforms, and (8) heavy metals if necessary.

Minimum sampling frequencies may be daily for sewage quantity, pH and DO; weekly for BOD (both total and filtrate), and SS; and monthly or seasonally for coliforms, oil/grease and heavy metals, as suggested in Table 5.12.

Table 5.12 Suggested Monitoring Programme for Waste Stabilization Pond

Parameter	Frequency of Test or Measurement		
	Daily	Weekly	Monthly or Seasonally
Quantity of flow	*		
Quality of flow			
Temperature	*		
pH	*		
DO	*		
BOD (total)		*	
BOD (filtrate)		*	
SS		*	
Coliforms (fecal)			*
Oil/grease			*

The sampling programme should specify for (1) sampling points, (2) number of samples to be analyzed by parameter, and (3) sampling method: either by grab method, or 2-, or 8-, or 24 hour composite method. These should be worked out in detail during the design stage.

Since the suggested parameters and frequencies for pond system in Table 5.12 are a minimum requirement, additional samplings may be needed depending upon the specific conditions of the pond system proposed.

7. PRIORITY CONSIDERATIONS

For overall evaluation of the urgency of sub-zones in order to determine priority for implementation, six assessment elements are considered, namely, (1) population density, (2) development condition, (3) waste load generation aspect, (4) excreta disposal system, (5) flood condition, and (6) incidence of waterborne diseases.

A rating procedure is developed by assigning reasonable relative weights to these major controlling parametres as follows:

		Point assigned
(1)	Population density	300
(2)	Development condition	200
(3)	Waste load generation	300
(4)	Excreta disposal system	100
(5)	Flood condition	50
(6)	Incidence of water-borne diseases	50
	Total	1,000

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.

Detailed explanation for each of the elements is described in the following:

(1) Population Density

Most important element of sewerage system is the improvement of environment level for the welfare of the maximum population which will be benefited by the system. It is, therefore, particularly important to provide sewerage facilities in high population density area, in order to gain the maximum benefit with the minimum expenditure thus making the benefit cost ratio highest. Hence, the 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.

(3) Waste Load Generation

Three hundred (300) points is assigned to this element. The waste load generated from the housing, commercial and industrial areas are generally discharged into near by drains and rivers without any treatment except septic tanks. It is, therefore, necessary to consider the quality (or the waste load) generated 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, practically all of the excreta produced in the area is disposed of either by septic tank, bucket, pit privy or directly to waterways, causing water pollution at many places in the Study Area. The existing excreta disposal system is, therefore, analyzed, and 100 points is given for the rating.

(5) Flood Condition

Due to the incomplete condition of the existing rivers and drains, flood has occurred frequently and caused substantial damage in the built-up areas. Sanitary conditions in these areas have been significantly deteriorated by the flood, and improvement by the provision of the sewerage system would be significant.

(6) Incidence of Water-borne Diseases

Incidence of water-borne diseases is also influenced by sanitation conditions, but this is less critical than the above five elements, as incidence of Cholera is not significant in the Study Area.

The evaluation result over the entire sewerage sub-zones is given in Table 5.13, with each assessment points of six items. As indicated "Implementation Priority" column in the same table, it deserves to note that the urbanized and/or urbanizing areas, namely sewerage sub-zones B-1, D-1, C-1 and A-1, and zone E are ranked in higher priority than the future developing areas such as D-2, B-3, B-2, A-2 and C-2 as shown in Figure 5.3.

Table 5.13 Overall Evaluated Points by Sub-Zone

Sub-zone	Population Density	Urbaniza-tion	Waste Loading	Existing Excreta Disposal System	Flooded Area	Distribution of Water Borne Disease	Total	Implementation Priority
A - 1	90	150	100	0	0	0	340	5
A - 2	30	50	50	0	0	25	155	9
B - 1	300	200	300	100	50	0	950	1
B - 2	90	50	50	50	0	0	240	8
B - 3	90	100	50	0	0	25	265	7
C - 1	180	200	0	0	0	0	380	4
C - 2	0	50	50	0	0	50	150	10
D - 1	270	200	200	100	25	0	795	2
D - 2	150	100	50	0	0	0	300	6
E	180	100	250	100	50	0	680	3

Note: Refer to Appendix J for detail.

8. FINANCIAL CONSIDERATIONS

8.1 Potential Source of Funds

The substantial amount of capital is normally required for sewerage works which involves the extensive construction. It is, therefore, necessary for the Government to consider the specific arrangement to generate the funds to meet the capital requirements for the construction as well as operation of the system after completion.

The viability of the Project is largely dependent on adequately arranged source of funds including less burdensome long term and low interest loans, the Government's grant, equitable sewer use charge and other revenue sources. The specific arrangement for funding would be needed during the early years of the programme when there is virtually no means to generate revenue through services.

It is to be noted that there are two different kinds of costs, that is, (1) to be borne by public sector which should be financed by the Government's own capital source or arrangement of external loan either from multilateral or bilateral lending agency, and (2) to be recovered from developers and those individuals who will receive the direct benefits from systems construction including household and property owner.

The followings are potential sources of capital for construction and revenue required for operation of the system.

(1) Capital Sources from Public Sector

(a) Long-term Loans

Prior to the construction, the funding arrangement will be necessary through one of several alternative sources, loans from Federal Government or State Government, multi-lateral and bi-lateral lending agencies.

It is desirable to arrange long term and low interest loans to support the viability of the Project with deferred repayment of principal to mitigate the cash flow problem in early years of construction while there are no means to raise the funds through connections to the sewerage system. The World Bank and Asian Development Bank are examples of multilateral sources of loans. The recent loans provided by both World Bank and Asian Development in Malaysia indicate interest rate 7-9%, and repayment terms of 20 years with grace period of 5 years. The World Bank has recently been providing loans to Malaysia with favourable terms. Bi-lateral loans are also considered from such countries as U.S.A., Japan, Germany, Canada and others, those of which have aid programmes for developing nations, sometimes with more favourable conditions than those from the multi-lateral sources.

(b) Government Grant

Since the sewerage works contribute to the improvement of sanitary as well as environmental condition of the community which provide favorable benefits to the population at large, some form of support from the Government should reasonably considered for the construction works such as trunk sewers and pumping stations, treatment facilities and land acquisitions, as in case of other public works for infrastructure development such as road construction.

The direct grant from the Government will enable the construction of major sewerage facilities earlier than those through the funds raised by other sources.

In addition to direct grant, there are indirect grants in various forms such as interest-free advances, advance payment of direct benefit charges against Government properties or the establishment of special favourable loan terms from the Government sources, and setting up a revolving fund to assist houseowners who may have difficulty in paying the required cash for the house connection and relevant plumbing costs.

(2) Capital Sources from Private Sector

The capital to be obtained from the individuals who will receive the direct benefits from the systems usage will significantly contributes to reduce the amount of loan required for the project and decrease the financial burden on the Government. There are several alternative methods to raise such capital.

(a) Benefit Assessment

Benefit assessments are basically applied to cover the costs for branch and lateral sewers which provide benefits to the property served by improving the sales value of the properties. The assessments can be levied against all property owners based on front footage, or the area of property or assessed value, or annual equivalent rental value of the properties.

(b) House Connection

The full costs of connecting a property to a branch or lateral sewer including relevant replumbing costs are borne by or recoverable from the individual houseowners since the benefits derived from such connection accrue to the properties connected. However, specific arrangements such as a revolving fund for loan to the housewoners unable to pay immediately connections may be necessary to expedite use of the system reluctance or difficulties.

(c) Developers Contribution

The infrastructure system including sewerage system should preferably be developed prior to the other construction on the new housing and industrial development areas, otherwise, it will cause inconventience and extra costs such as rebuilding and remodelling of existing systems. In order to avoid such inconvenience, the developers are commonly required to construct such infrastructure systems when they develop the areas. The costs incurred from such constructions are normally incorporated in the sales price of the land/houses sold. The installation of the necessary facilities can be made either by developers themselves or by the Government who may recover the costs from the developers.

(3) Potential Sources of Operation Revenue

The well planned revenue sufficient to sustain the Project on a financially viable base will be necessary during the whole life of the Project. The revenues are basically required to meet the recurrent cost (which includes operation and maintenance cost and administration expenses) plus long term debt service payment. Among the several methods commonly applied to raise the revenue, the Project should select well suited method with simple, logical, practicable, enforceable and equitable nature.

(a) Service Charge

The service charges are applied to individual users of the systems in proportion to the use they make. In calculating the charge, the following methods are available;

i) Pedestal Charge

The flat rate is multiplied by the numbers of water closet (WC) pedestal in a household to calculate the charge on the theory that the waste volume is linked with pedestal. The collection of the charge is administratively easy, but it does not appear that the waste discharge is closely related to the pedestal.

ii) Fixture-unit Charge

The numbers of water fixtures, such as faucets, water heaters, air coolers, and flush toilets, are multiplied by flat rate so as to calculate required charge based on the theory that volume of waste discharge is related to the volume of water consumption, hence to the numbers of fixtures. The households which have many fixtures do not necessarily consume much water in proportion to the numbers of fixtures.

iii) Per Capita Charge

The charge is calculated multiplying the numbers of residents or employees in the households or commercial property by a flat rate based on the theory that volume of waste discharge is in proportionation to the numbers of residents. This method has also a disadvantage in obtaining the accurate waste discharge as the above method.

iv) Surcharge on Water Rate

The surcharge on water rate is service charge related to water use which is calculated by adding a fixed rate to metered water consumption. This method would appear to be the best alternative closely satisfying the required nature as recommendable method. The volume of waste discharge is closely related to water consumption which is accurately metered. The collection of the charge is enforceable by suspending the water supply in the event of non-payment. The collection of charge can be made without difficulty in combination of billing procedure for water supply already in existence. There will be certain cases where water consumption is difficult to measure as consumers draw water from private sources (wells). However, the most water in the Project area is supplied by pipe, and there will be no setback in adopting this method.

(b) Annual Subsidies from Government

The self-supporting system without any Government subsidies is desirable in operation of public utility systems, including sewerage system, but it depends on the ability of the users to pay the required charge sufficient to cover all the costs for the systems. As the fund collectable from the users is always limited in the amount to defray all the expenses for operation and maintenance expenses and debt service payment, certain amount of Government subsidies will be necessary, and justified as a social cost for improvement of public health and sanitation as well as protection of water pollution of the area.

8.2 Proposed Magnitude of Capital Investment

A reasonable magnitude of capital invested for each construction phase of four is studied in this section considering both engineering and financial aspects. For the engineering side, the most effective sewerage system is planned by ranking the sewerage zones and sub-zones for the sake of implementation taking into consideration of the various factors as discussed in Section 7, Chapter 5.

The financial viability requires to justify the appropriate magnitude of capital invested for each phase, consideration the availability of fund in the local government authority from different sources and economical background of the community such as income level of the sewer users to pay the charges.

Three sources of fund are, therefore, considered: (1) grant/loan by the Federal Government and/or multilateral or bilateral sources, (2) allocation of a portion of the land tax from the local government or state government authority for the increased benefit by the provision of sewerage system,(3) sewerage fee to be charged on the metered water consumption in the sewerage service area. However, the land tax additionally raised may mainly be utilized for the debt service payment for capital investment, and the sewer fee for covering the recurrent costs (inclusive of operation, maintenance and administration costs).

Therefore, capital investment cost for all construction phased should be mainly financed either by the Federal Government grant/loan and/or by bilateral/multilateral loans.

On the basis of the above consideration, the area technically feasible and financially viable has to be identified for the first phase in order to estimate reasonable magnitude of capital investment. Three alternatives are considered as discussed hereunder.

Alternative I

This covers the area (1) along the Sg. Kedah, Sg. Anak Bukit, Jl. Pelan Melayu, Jl. Raja, Jl. Langgar and Jl. Putera, as shown in Figure 5.4, comprising 187 ha with the built-up area, state and municipal government offices, department stores, hotels and market places, including busy commercial centres. This area is already so developed that the average population density in the area is reaching to a level of 180 persons per ha. The present population of 22,450 is projected to reach 25,200 in 2000. Most of the wastewater generated in this area is discharged into near-by roadside ditches and/or the Sungai Raja, resulting in heavy pollution.

Alternative II

This covers the area (2) in addition to the area (1) as shown in Figure 5.4, comprising 338 ha with a total population of 34,150 and average population density of 101 persons per ha. The present population is projected to reach 40,600 in 2000.

The additional area (2) of 151 ha includes the residential area developed along Jl. Bakar Bata, newly developed residential areas, police complex and the stadium Darulaman, and a small portion of the commercial area with the population of 11,700 and average population density of 96 persons per ha.

Alternative III

This covers the area(3) in addition to areas(1) and (2) as shown in Figure 5.4, comprising 459 ha with a total population of 44,400 and average population density of 97 persons per ha. This figure is projected to reach 54,200 in 2000.

The additional area(3) had been mostly farmland except the very narrow strip of the residential area along Jl. Langgar until the recent active housing development. Presently, most of the area is being turned into residential area except the small farmland of 20 ha located at the north. The present population in this area(3) is approximately 10,000 with an average population density of 83 persons per ha.

Communal septic tanks have been employed in the old residential area such as Kawasan Perumahan Jl. Shariff, and individual septic tanks in the newly developed area such as Taman Setia Berjaya. Those wastewaters from the above septic tanks and kitchens are discharged directly either into the upper reaches of the Sg. Derga or Sg. Raja, thus contributing greatly for pollution of the rivers downstream.

The comparison of the alternatives is resulted in the following table and results of the evaluation are presented as follows:

Cost per population: Among three alternatives, alternative I is the lowest in cost which means the most economical construction scale.

Revenue per cost : Alternative I has the highest potentiality to generate the revenue to cover the cost.

Debt service Payment: Among alternatives alternative I is considered to be the least financial burden to be added on the local authority under its present financial capability.

Table 5.14 Comparison of Alternative Magnitudes of Investment

	Alt. 1	Alt. 2	Alt. 3
Served Area (ha)	187	338	459
Population Equivalent	47,300	65,200	80,200
Construction Cost (1,000 M$) 1)	17,136	23,702	29,402
Estimated Annual Water Charge (1,000 M$)	1,574	2,022	2,375
Annual Sewerage Charge (1,000 M$) 2)	1,259	1,618	1,900
Construction Cost per capita (1,000 M$)	0.362	0.364	0.367
Annual Sewerage Fee/ Construction Cost (1,000 M$)	0,074	0,068	0,065
Annual Debt Service Payment (1,000 M$) 3)	1,238	1,713	2,125

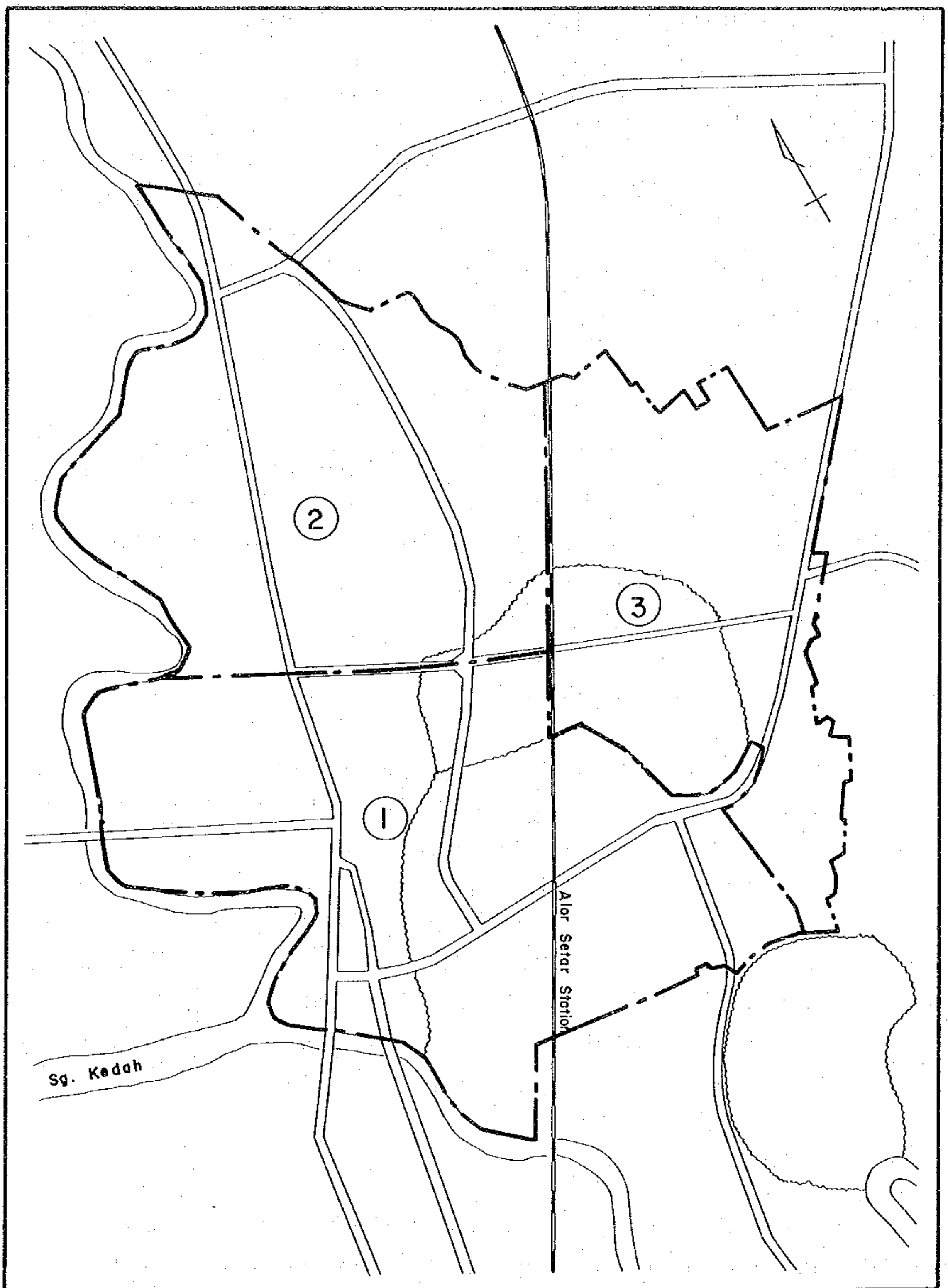
Note: 1) includes land acquisition costs for future treatment facilities

2) estimated on lower side to be 80% of annual water charge for the comparison purpose providing further computation is made in detailed financial plan

3) estimated for the comparison purpose on the assumption that total capital cost is financed by loan of annual 6% interest with 30 years equal installment repayment.

As it is apparent from above comparison the Alternative I with total construction cost of about M$ 17 million at 1979 price is assumed to be the most adequate in terms of construction magnitude with respect to financial capability of MPKS and engineering soundness in covering high priority area of the First Phase zone.

The magnitude of investment for the constructions of subsequent phases are also assumed, based on the economic growth and reasonablly phases development of the area, to be the M$ 18.5 million, M$ 21.8 million, M$ 26.7 million for the second, third and fourth phases respectively.



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

AREA OF ALTERNATIVE CONSTRUCTION MAGNITUDE

FIGURE 5-4

9 ESTIMATED CONSTRUCTION AND RECURRENT COSTS BY PHASES UP TO THE YEAR 2000

9.1 Procedure for Estimating Construction and Operation and Maintenance Costs

9.1.1 Construction Costs

(a) Sewers

Trunk Sewers

All construction costs for the proposed trunk sewers in Figure 5.2 are estimated on the basis of the procedures described in Chapter 1 in Appendix G. Construction costs for each size of sewer pipes are derived from unit construction costs which correspond to the designated sewer depth. All costs are estimated at 1979 price level.

Branch and Lateral Sewers

For estimating construction costs of branch and lateral sewers which are not shown in Figure 5.2, each total length of sewer by size is obtained by preliminary engineering design of sewers from the selected blocks of typical residential areas which are considered to be representing an average future condition in these areas as studied in Appendix H. Then, the construction costs for all the branch and lateral sewer sizes are estimated, multiplying the unit costs to the lengthes, thus finally estimated sewer construction cost for a unit of area.

House Connections

For cost estimation of house connections, it is assumed that each household has an average total length of 15 meter pipe with a 150 mm diameter, and then the total length of these pipes are calculated taking into account of the population served and the average size of a family.
The average construction cost for house connection is estimated to be M$ 40 per metre.

(b) Pumping Stations

Pumping stations will be provided in all phases, three stations (inclusive of one station in the SEDC housing development area in sewerage Sub-zone B-3) in the First Phase, similary two, two, five stations in Second, Third, and Fourth Phase respectively, on the basis of the phased implementation schedule in Table 5.15 in Section 9.3.

All construction costs for these stations are estimated by applying the cost function developed in chapter 2 in Appendix G derived on the basis of the unit costs for building, civil works and equipment, assuming that most of equipment including pumps, controlling devices, electric equipment, screens, gates and piping materials will be imported, but materials for building and civil works will be available in Malaysia.

(c) Treatment Facilities

All construction costs for treatment facilities and access roads to the treatment sites are estimated by using the cost function developed in Chapter 3 in Appendix G derived on the basis of the unit costs developed for civil works and equipment assuming that most of equipment, including pumps, flow measuring devices, electric equipment, and others will be imported, but materials for civil works will be available in Malaysia.

9.1.2 Operation and Maintenance Costs

(a) Sewers

Operation and maintenance costs for sewer pipes are estimated based on reasonable assumptions as discussed in Chapter 4 in Appendix G derived from data obtained in Malaysia and Japan, assuming that all sewers will be cleaned at least every four years by use of thrusting rods and/or bucket machines.

(b) Pumping Stations

Operation and maintenance costs for pumping stations are estimated by using the cost function developed in Chapter 4 in Appendix G derived from the current costs for labour and materials, power, fuel, water for cooling and sealing, lubrication, grit and screening removal, overhauling and repairing of mechanical equipment and repairing of the structure by estimating on the basis of peak flow rates.

(c) Treatment Facilities

Operation and maintenance costs for treatment facilities are estimated by using the cost function developed in Chapter 4 in Appendix G derived from the current costs for labour and materials, power, fuel, water for cooling, sealing lubrication, overhauling and repairing of mechanical equipment, and repairing of the civil works and structures.

9.2 Government and Private Contribution

Sewerage facilities in the "urbanized and/or urbanizing area" will be provided by the Government contribution, excluding the areas undertaken by developers in this area. In addition, the trunk sewers in the future development area as shown in Figure 5.2 and the branch sewers connecting from the trunk sewers to the terminal sewers (provided by developers in the development areas) will be also provided by the Government contribution.

The remainder of the sewers, (i.e. branch and lateral sewers in the future development areas and all house connection) will be provided by private contribution.

9.3 Proposed Implementation Schedule and Construction Costs by Phase

On the basis of "Construction Priority for Sewerage Sub-zones" (Section 7 Chapter 5) and "Proposed Magnitude of Capital Investment" (Section 9.3, Chapter 5), an implementation schedule is proposed up to year 2000 with four phases as set out in Section 2, Chapter 4.

The priority areas to be implemented in the four phases are tentatively indicated in Table 5.15 and Figure 5.5. Table 5.15 shows both the Government and private developers contribution portions. The table further shows the areas and populations served in the four phases.

The total construction cost (inclusive of contingency, engineering fee and land acquisition cost) providing sewerage facilities in the sewerage sub-zones to be implemented in the four phases is proposed to be 114.73 million; 84.16 million to be raised from the Government and 30.57 million from private sources as shown in Table 5.15 and Tables 5.17 through 5.20. It is noted that construction cost for the sewerage facilities by SEDC's housing development scheme now underway are not included.

Table 5.15 Priority Areas to be Implemented and Estimated Construction Costs in Four Phases.

Phase	Construction Cost (M$ 1,000 at 1979 Price Level)		Sewerage Sub-Zone to be Implemented	Area Served (ha)	Population (Person in 2000)
	Government Contribution	Private Contribution			
First Phase (1981-1985)	17,136	3,835	A part of B-1	187	25,200
Second Phase (1986-1990)	18,534	6,019	The remaining B-1, A part of D-1	272 68	29,000 8,900
Third Phase (1991-1995)	21,775	10,338	The remaining D-1, and E	313 125	37,600 12,900
Fourth Phase (1996-2000)	26,713	10,380	C-1 A-1	187 385	21,500 29,700
Total	84,158 114,730	30,572	-	1,537	164,800

Note: Average branch and lateral sewer length in urbanized and/or urbanizing area is estimated at 110 m/ha, while in future development area is 127 m/ha (refer to Appendix H)

It should be noted that there remain several areas, for which land use plan has not yet finalized. Under the circumstance, such areas are not included in any of the phases of implementation but the work and the cost for implementation is indicated in Tables 5.16, 5.21 and Figure 5.5 with 1979 price level as a basis.

Table 5.16 Non-Phased Sewerage Sub-zones with Estimated Construction Cost

(M$ 1,000 at 1979 Price Level)

Name of Sub-zone	Construction Cost		Area Served (ha)	Population (Person in 2000)
	Government Contribution	Private Contribution		
A - 2			437	38,000
B - 2			410	40,700
B - 3*	49,093	61,908	68	6,900
C - 2			427	33,700
D - 2			270	30,000
Total	49,093	61,908	1,612	149,300
	111,001			

Note: * Excluded the SEDC developed area in Sewerage Sub-zone B-3.

Table 5.17-1 Summary of Sewerage Construction Costs for First Phase Programme (1981 - 1985) (Government Contribution)

(M$1,000 at 1979 Price Level)

Description	Local Currency	Foreign Currency	Total	Remarks
a. Trunk Sewer	2,660	469	3,129	
b. Branch & Lateral Sewer	3,136	554	3,690	
c. Pumping Station	784	1,078	1,862	
d. Treatment Facilities	1,377	344	1,721	
e. Cleaning Machine	38	189	227	
f. Sub-Total	7,995	2,634	10,629	
g. Engineering Cost				
Design	532	531	1,063	(f) x 0.10
Supervision	266	266	532	(f) x0.05
h. Contingency	1,781	664	2,445	(f + g) x0.20
i. Land Acquisition	2,467	-	2,467	
Total	13,041	4,095	17,136	

Note: 15 percent of sewer construction cost., 20 percent of construction cost for treatment facilities, and 50 percent of engineering cost are estimated as foreign currency, based on the detailed component cost breakdown and data obtained from the same kinds of project. Similary, in case of pumping station, construction cost of mechanical and electrical works is estimated as foreign currency.

Table 5.17-2 Summary of Sewerage Construction Costs for First Phase Programme (1981 - 1985) (Private Contribution)

(M$1,000 at 1979 Price Level)

Description	Local Currency	Foreign Currency	Total	Remarks
a. Branch & Lateral Sewer	-	-	-	
b. House Connection	2,362	417	2,779	
c. Sub-Total	2,362	417	2,779	
d. Engineering Cost Design	278	-	278	(c)x 0.10
Supervision	139	-	139	(c)x0.05
e. Contingency	556	83	639	(c+d)x0.20
Total	3,335	500	3,835	

Note: 15 percent of construction cost is estimated as foreign currency based on the detailed component cost breakdown, and no foreign currency is estimated for engineering cost.

Table 5.18-1 Summary of Sewerage Construction Costs for Second Phase Programme (1986 - 1990) (Government Contribution)

(M$1,000 at 1979 Price Level)

Description	Local Currency	Foreign Currency	Total	Remarks
a. Trunk Sewer	3,142	554	3,696	
b. Branch & Lateral Sewer	6,158	1,087	7,245	
c. Pumping Station	708	256	964	
d. Treatment Facilities	1,084	271	1,355	
e. Sub-Total	11,092	2,168	13,260	
f. Engineering Cost				
Design	663	663	1,326	(e) x 0.10
Supervision	332	331	663	(e)x0.05
g. Contingency	2,417	632	3,049	(e+f)x0.20
h. Land Acquisition	236	-	236	
Total	14,740	3,794	18,534	

Note: 15 percent of sewer construction cost, 20 percent of construction cost for treatment facilities based on the detailed component cost breakdown and data obtained from the same kinds of project, and 50 percent of engineering cost are estimated as foreign currency.
Similary, in case of pumping station, construction cost of mechanical and electrical works is estimated as foreign currency.

Table 5.18-2 Summary of Sewerage Construction Costs for Second Phase Programme (1986 - 1990) (Private Contribution)

(M$1,000 at 1979 Price Level)

Description	Local Currency	Foreign Currency	Total	Remarks
a. Branch & Lateral Sewer	214	38	252	
b. House Connection	3,493	617	4,110	
c. Sub-Total	3,707	655	4,362	
d. Engineering Cost				
Design	436	-	436	(c)x 0.10
Supervision	218	-	218	(c)x0.05
e. Contingency	872	131	1,003	(c+d)x0.20
Total	5,233	786	6,019	

Note: 15 percent of construction cost is estimated as foreign currency based on the detailed component cost breakdown and data obtained from the same kinds of project, and no foreign currency is estimated for engineering cost.

Table 5.19-1 Summary of Sewerage Construction Costs for Third Phase Programme (1991 - 1995) (Government Contribution)

(M$1,000 at 1979 Price Level)

Description	Local Currency	Foreign Currency	Total	Remarks
a. Trunk Sewer	2,167	382	2,549	
b. Branch & Lateral Sewer	7,620	1,345	8,965	
c. Pumping Station	613	774	1,387	
d. Treatment Facilities	2,218	555	2,773	
e. Sub-Total	12,618	3,056	15,644	
f. Engineering Cost				
Design	784	783	1,567	(e)x0.10
Supervision	417	416	833	(e)x0.05
g. Contingency	2,764	851	3,615	(e+f)x0.20
h. Land Acquisition	86	-	86	
Total	16,669	5,106	21,775	

Note: 15 percent of sewer construction cost, 20 percent of construction cost for treatment facilities, and 50 percent of engineering cost are estimated as foreign currency based on the detailed component cost breakdown and data obtained from the same kinds of project. Similary, in case of pumping station, construction cost of mechanical and electrical works is estimated as foreign currency.

Table 5.19-2 Summary of Sewerage Construction Costs for Third Phase Programme (1991 - 1995) (Private Contribution)

(M$ 1,000 at 1979 Price Level)

Description	Local Currency	Foreign Currency	Total	Remarks
a. Branches Lateral Sewer	1,684	297	1,981	
b. House Connection	4,683	827	5,510	
c. Sub-total	6,367	1,124	7,491	
d. Engineering Cost				
Design	749	-	749	(C)x0.10
Supervision	375	-	375	(C)x0.05
e. Contingency	1,498	225	1,723	(C+d)x0.50
Total	8,989	1,349	10,938	

Note: 15 percent of construction cost is estimated as foreign currency based on the detailed component cost breakdown and data obtained from the same kinds of project, and no foreign currency is estimated for engineering cost.

Table 5.20-1 Summary of Sewerage Construction Costs for Fourth Phase Programme (1996 - 2000) (Government Contribution)

(M$ 1,000 at 1979 Price Level)

Description	Local Currency	Foreign Currency	Total	Remarks
a. Trunk Sewer	3,058	540	3,598	
b. Branch & Lateral Sewer	9,611	1,696	11,307	
c. Pumping Station	1,532	891	2,423	
d. Treatment Facilities	1,389	347	1,736	
e. Cleaning Machine	-	112	112	
f. Sub-total	15,590	3,586	19,176	
g. Engineering Cost				
Design	959	959	1,918	(f) x 0.10
Supervision	480	479	959	(f) x 0.05
h. Contingency	3,406	1,005	4,411	(f+g)x0.20
i. Land Acquisition	249	-	249	
Total	20,684	6,029	26,713	

Note: 15 percent of sewer construction cost, 20 percent of construction cost for treatment facilities, and 50 percent of engineering cost are estimated as foreign currency based on the detailed component cost breakdown and data obtained from the same kinds of project. Similary, in case of pumping station, construction cost of mechanical and electrical works is estimated as foreign currency.

Table 5.20-2 Summary of Sewerage Construction Costs for Fourth Phase Programme (1996 - 2000) (Private Contribution)

(M$1,000 at 1979 Price Level)

Description	Local Currency	Foreign Currency	Total	Remarks
a. Branch & Lateral Sewer	1,556	389	1,945	
b. House Connection	4,740	837	5,577	
c. Sub-Total	6,296	1,226	7,522	
d. Engineering Cost				
Design	752	-	752	(c)x0.10
Supervision	376	-	376	(c)x0.05
e. Contingency	1,485	245	1,730	(c+d)x0.20
Total	8,909	1,471	10,380	

Note: 15 percent of construction cost is estimated as foreign currency based on the detailed component cost breakdown and data obtained from the same kinds of project, and no foreign currency is estimated for engineering cost.

Table 5.21-1 Summary of Sewerage Construction Costs for Non-Phased Sub-Zones (A-2, B-2, B-3(1), C-2, and D-2)

(Government Contribution)

(M$ 1,000 at 1979 Price Level)

Item	Trunk Sewer		Branch & Lateral Sewer		Pumping Station		Treatment Facilities		(A) Sub-Total		(B) Engineering Cost Design & Supervision		(C) Contingency		Land Aquisition	Total	
Name of Sub-zone	Local Cur-rency	Foreign Cur-rency	Local Cur-rency	Foreign Cur-rency	Local Cur-rency	Foreign Cur-rency	Local Cur-rency	Foreign Cur-rency	Local Cur-rency	Foreign Cur-rency	Local Cur-rency	Foreign Cur-rency	Local Cur-rency	Foreign Cur-ency	Local Cur-rency	Local Cur-rency	Foreign Cur-rency
A-2	1,883	332	4,903	865	418	567	364	729	7,568	2,493	755	755	1,655	650	1	9,987	3,898
B-2	737	130	2,434	429	259	876	518	1,007	3,948	2,442	479	479	885	584	43	5,355	3,505
B-3	296	52	1,162	205	201	91	122	289	1,781	637	181	181	392	164	-	2,354	982
C-2	1,434	253	4,626	816	442	610	306	624	6,808	2,303	683	683	1,498	597	42	9,031	3,583
D-2	1,595	281	3,361	593	295	233	393	781	5,644	1,888	565	565	1,242	491	1	7,452	2,974
Total	5,945	1,048	16,486	2,908	1,615	2,377	1,703	3,430	25,749	9,763	2,663	2,663	5,682	2,486	87	34,181	14,912

49,093

Note: (1): Excluding SEDC developed area

(B): Detailed fee and supervision cost are estimated as (A) x 0.15

(C): (A + B) x 0.20

Construction costs of pumping stations are estimated on peak flow in the each sub-zones in the year 2000.

Construction costs of treatment facilities are estimated for modification cost of ponds and installation cost of aerators.

Table 5.21-2 Summary of Sewerage Construction Costs for Non-Phased Sewerage Sub-Zones (A-2, B-2, B-3[(1)], C-2 and D-2)

(Private Contribution)

(M$1,000 at 1979 Price Level)

Item / Name of Sub-Zone	Branch & Lateral Sewer		House Connection		(A) Sub-Total		(B) Engineering		(C) Contingency		Total	
	Local Currency	Foreign Currency	Local Currency	Foreign Currency	Local Currency	Foreign Currency	Local Currency	Foreign Currency	Local Currency	Foreign Currency	Local Currency	For'n Currency
A - 2	7,110	1,255	3,522	621	10,632	1,876	1,876	-	2,502	375	15,010	2,251
B - 2	6,053	1,068	3,777	667	9,830	1,735	1,735	-	2,313	347	13,878	2,082
B - 3	923	163	643	114	1,566	277	276	-	368	55	2,210	332
C - 2	6,895	1,217	3,123	551	10,018	1,768	1,768	-	2,357	354	14,143	2,122
D - 2	3,308	584	2,777	490	6,085	1,074	1,074	-	1,432	215	8,591	1,289
Total	24,289	4,287	13,842	2,443	38,131	6,730	6,729	-	8,972	1,346	53,832	8,076

61,908

Note: (1): excluding SEDC development area

(B): (A) x 0.15

(C): (A+B) x 0.20

15 percent of sewer construction cost is estimated as foreign currency, and no foreign currency is estimated for engineering Cost.

9.4 Recurrent Costs by Phase

Recurrent cost including operation and maintenance cost plus payroll and administration costs by Construction Phase, is shown in Table 5.22 at 1979 price level, based on Tables 5.17, 5.18, 5.19, 5.20, 5.23, and operation and maintenance cost estimate procedure explained in 9.1.2, Chapter 5, and schedule of estimated staff requirement in Section 2.1, Institutional Study Report.

Table 5.22 indicates the recurrent costs by phases incurred by the contributions both by the Government and private sectors separately.

It is expected that all sewerage facilities as indicated "Public Portion" in Table 5.22 except for house connection (private sewer) be operated and maintained by the MPKS.

Recurrent costs for the sewerage facilities which are not included in the phased construction programme (non-phased sewerage facility) in Table 5.21 are not estimated in this report because of uncertainty for future development of those areas.

Table 5.22 Recurrent Costs for Sewerage System by Phase

(Cumulative)

(M$1,000 at 1979 price level)

Description	First Phase (1981-1985)	Second Phase (1986-1990)	Third Phase (1991-1995)	Fourth Phase (1996-2000)
(1) Public Portion (Operated by MPKS)				
(a): Operation and Maintenance Cost				
(1) Trunk Sewer	110	315	495	710
(2) Branch & Lateral Sewer	90	370	835	1,440
(3) Pumping Station	510	1,165	1,690	2,740
(4) Treatment Facility	115	300	470	650
(b): Administration and Payroll	920	1,070	1,395	1,395
(c): Contingency	92	107	140	140
Total	1,837	3,327	5,025	7,075
(2) Private Portion: House Connection (Operated by Individual)	65	145	255	365

Table 5.23 Average Annual Recurrent Costs for Sewerage System by Phase

(M$1,000 at 1979 price level)

Description	First Phase (1981-1985)	Second Phase (1986-1990)	Third Phase (1991-1995)	Fourth Phase (1996-2000)
(1) Public Portion(Operated by MPKS):				
(a) Operation and Maintenance Cost				
(i) Trunk Sewer	22	63	99	142
(ii) Branch & Lateral Sewer	18	74	167	288
(iii) Pumping Station	102	233	338	548
(iv) Treatment Facility	23	60	94	130
(b) Administration and Payroll(*)	184	214	279	279
(c) Contingency(**)	18	21	28	28
Total	367	665	1,008	1,415
(2) Private Portion: House Connection	13	29	51	73

Note: (1)(*) Payroll is estimated from "Schedule of Estimated Staff Requirement" in Section 2.5 "Staff Requirement" of Volume VI (Institutional Study).

(2)(**) Contingency is estimated to be 10% of payroll.

10. BENEFITS

10.1 Anticipated Benefits

Significant benefits to public health of the community can be derived from installation of an adequate sewerage system. The benefits can be grouped into several categories, namely (1) health benefits, (2) environmental benefits, (3) economic benefits, and (4) miscellaneous benefits.

It should be noted that other less tangible benefits associated with sewerage servicing will include a pleasant community environment, a greater attraction for tourism, opportunity for more intensive land use and opportunities to facilitate housing and industrial developments.

10.2 Recognition and Measurement of Benefits

Major benefits resulting from the improvement of health conditions, environmental aspect, increas increasing land value, and reducing expenditure for sanitary facilities are quantified as follows.

10.2.1 Health and Sanitation Benefits

One of the major benefits from the proposed sewerage system will be the sanitation improvement resulting from removal of human excreta and other wastes from the community.

The benefit can be measured if the cause and effect relationship of the sewerage system to incidence of the water-borne diseases and to the levels of mortality and morbidity of the populations served by the system, are determined, and if reduction of pertinent diseases are estimated on the basis of reasonable assumptions.

A statistical data obtained from the State Medical and Health Services Department indicates that the average number of water-borne diseases including cholera, typhoid and gastro-entritic diseases in the Study Area is 4,917 per year occurred in the past two years (1977 and 1978) as presented in previous Chapter (Section 5, Chapter 3). Also, a survey on the cost for treatment of the diseases indicates that the expenses for treating water-borne diseases, including the amount spent for medical care, cost about M$ 31 per person per day for an average of two weeks hospitalization at 1979 price level. Assuming that approximately 50 percent of these is attributable to unsatisfactory excreta disposal, and if this can be eliminated by the sewerage system, then the quantifiable cost is estimated at about M$ 1,067,000 per year (4917/2 x 31 M$ x 14 days).

The reduced number of patients will accrue an additional indirect benefit, that will save wage loss by disability. The wage loss is estimated to be about M$ 174,000 per year in average at 1979 price level, assuming from the data collected that the average income of labor participation group is M$ 275 per person per month, and the incidence and age distribution of diseases to be affected will be limited to the labor force, which is approximately 55 percent of the total population.

In addition, other benefits, although mostly unquantifiable, will be (1) reduction of discomfort and distress, (2) improvements in environmental aesthetics from elimination of the present sewage odours emanating from drains and sludge accumulation, (3) reduction of groundwater contamination resulting from improved measures for handling sanitary wastes.

10.2.2 Water Pollution Control Benefits

From the current extensive survey of the drains and rivers (Ref. Appendix B), most of drains in urbanized area of the Study Area have been polluted and are expected to become much polluted in the future. Rivers will be also polluted by the flow from the drains. Currently, these drains and rivers are used for fishing, etc.

The reduction of waste loads or improvement of water quality in the drains and river is, therefore, a major benefit to be derived from the sewerage system.(Ref. to Appendix L)

10.2.3 Values Added to Land

Investment for sewerage facilities will have the effect of raising the intrinsic values of the parcels of land served by the system. These additional land values contribute as a major benefit of the Project by improving the sanitary and aesthetic quality of the community, being not only to contribute to the quality of life of the beneficiaries, but also to contribute as an additional source of revenue for the Government. The value of such benefit can be measured by the additional price observed in the areas where similar projects have been carried out. The additional cost reflects buyers' willing to pay for the properties on which such physical improvements have been made.

The existing land values for various categories in the Study Area is obtained from the Federal Valuation Department, being M$ 0.5/m^2 for agricultural area, M$ 53/m^2 for built-up urban area (inclusive of commercial, institutional and residential area) and M$ 170/m^2 for developed industrial area.

The present land value is averaged out to be M$ 30/m^2 considering various categories of land composed of 70 ha of institutional and commercial area, 1,218 ha of residential area, 46.5 ha of industrial area and 1,290 ha of agricultural area, excluding 675.5 ha of public spaces such as public land, schools, mosques, temples, public roads, rivers and railway in Table 3.2 , Chapter 3.

Hence, the land value of the whole area excluding the public spaces is estimated to be about M$ 770 million at 1979 price level.

After the Study Area was developed as envisaged in Figure 4.2 future land use in the year 2000, the land value would be increased to an average of M$ 60/m^2 from present level of M$ 30/m^2, assuming 3.5 per cent of annual increase of land in real terms taking into account of recent trend of land value increase plus additional value derived from installation of sewerage facility in the area. Then, land value for the whole area is estimated to increase to M$ 1,760 million approximately.

Hence, quantifiable net benefit by land evaluation is estimated to be approximately M$ 198 million at 1979 price level[(1,760 - 770) x 0.2] assuming that 20 percent of land value increase is attributed by the construction of sewerage system.

10.2.4 Benefits by Reduced Expenditure for Sanitary Facilities

As discussed in Section 8, Chapter 3, the existing excreta disposal system in the Study Area are mainly represented by two systems, namely, septic tank and bucket. For operation and maintenance of these facilities, MPKS has to expend approximately M$ 64,500 so far in the year 1979, including the average monthly service fee of M$ 5,400 paid to the contractors to maintain 2,533 bucket system. For septic tank, no data has been available in the Study Area. However, the available data in Malaysia indicate that an annual expenditure for operation and maintenance for septic tank is of M$ 12.2 per capita at 1976 price level(Ref. Butterworth/Bukit Mertajam Sewerage Study Report).

Hence, the cost for operation and maintenance of the septic tank in terms of per capita burden is estimated to be approximately M$ 15 per year at 1979 price level, considering 5 per cent annual inflation factor during 1976 and 1979, thus the total expense for the septic tank covering population of 108,735 in the whole Study Area is estimated at M$ 1,631,025 per year in 1979.

Using these costs, a cost comparative analysis for operation and maintenance is made between the existing sanitary system (septic tank and bucket) and modern public sewerage system, as presented in Table 5.24. The results of the analysis indicate that the cost required for sewerage system is lower than those required for the existing sanitary system, in terms of per capita burden. In addition, sewerage system has greater advantage to the existing sanitary system in that the former contributes significantly for pollution control of waterways by receiving all kinds of wastewaters and discharging a higher quality effluent, while the latter receives only human excreta and discharges a lower degree of effluent.

Table 5.24 Cost Comparison for Operation and Maintenance between Existing Sanitary System and Proposed Sewerage System

(M$ at 1979 price levels)

	Existing Sanitary System			Sewerage System
	Septic Tank (1)	Bucket System (2)	(1)+(2)	
Served (1) Population (persons)	108,735	26,620	135,355	318,300
Annual O & M Cost (2) (M$ 1,000/year)	1,631,025	106,480	1,737,505	2,355,000
Per Capita Cost (O & M) (M$/year.cap)	15.0	4.6	12.8	7.4

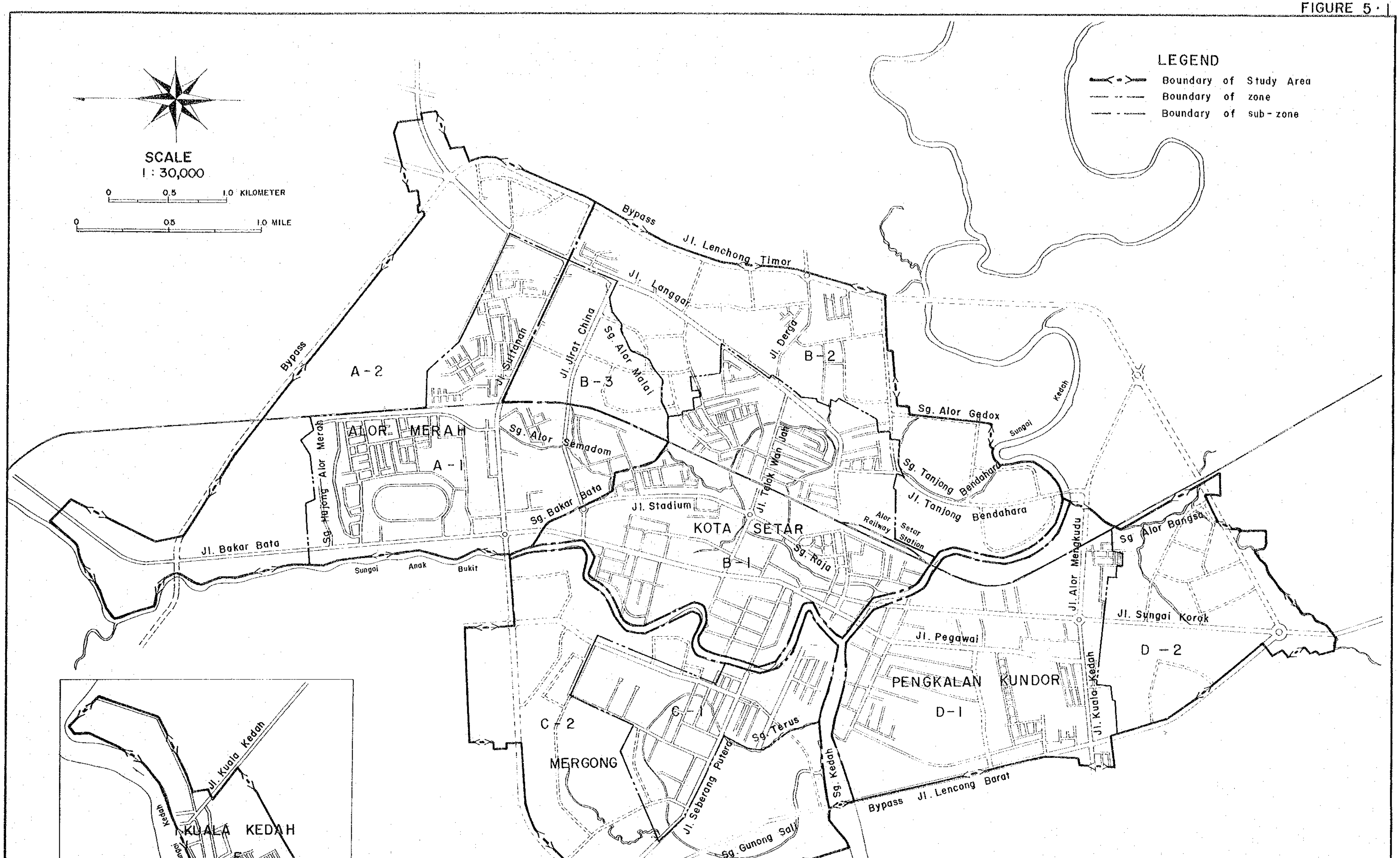
Note: (1) Population served by either septic tank or bucket system is estimated by assuming of 5.5 persons/household.

(2) Estimated annual operation and maintenance cost for proposed sewerage system includes all cost for trunk, branch and lateral, house connection, pumping station and treatment facilities.

10.3 Benefit Justification

On the basis of the results of benefit evaluations for the proposed sewerage system in the Study Area, both tangible and intangible, it is concluded that the Project is definitely justifiable. If no sewerage system were provided in the area, sanitary conditions, which are already deplorable in many areas of the city, will become progressively worse. Moreover, if this Project is not undertaken at this time, the cost for implementation at later times will become increasingly higher. Thus the accumulated total cost could become so high that the Project could become almost unmanageable. The Project, therefore, is indeed timely now.

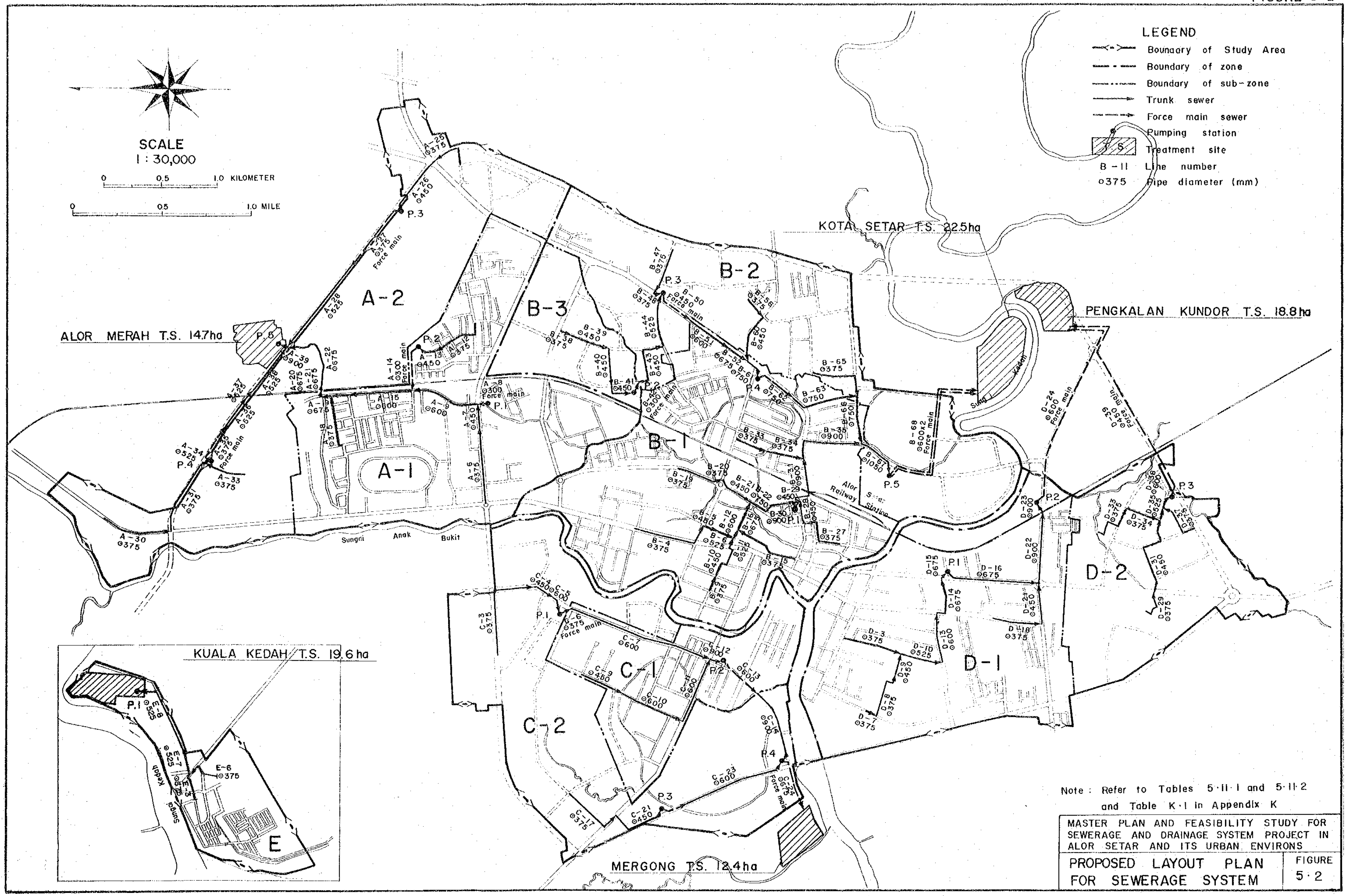
FIGURE 5·1

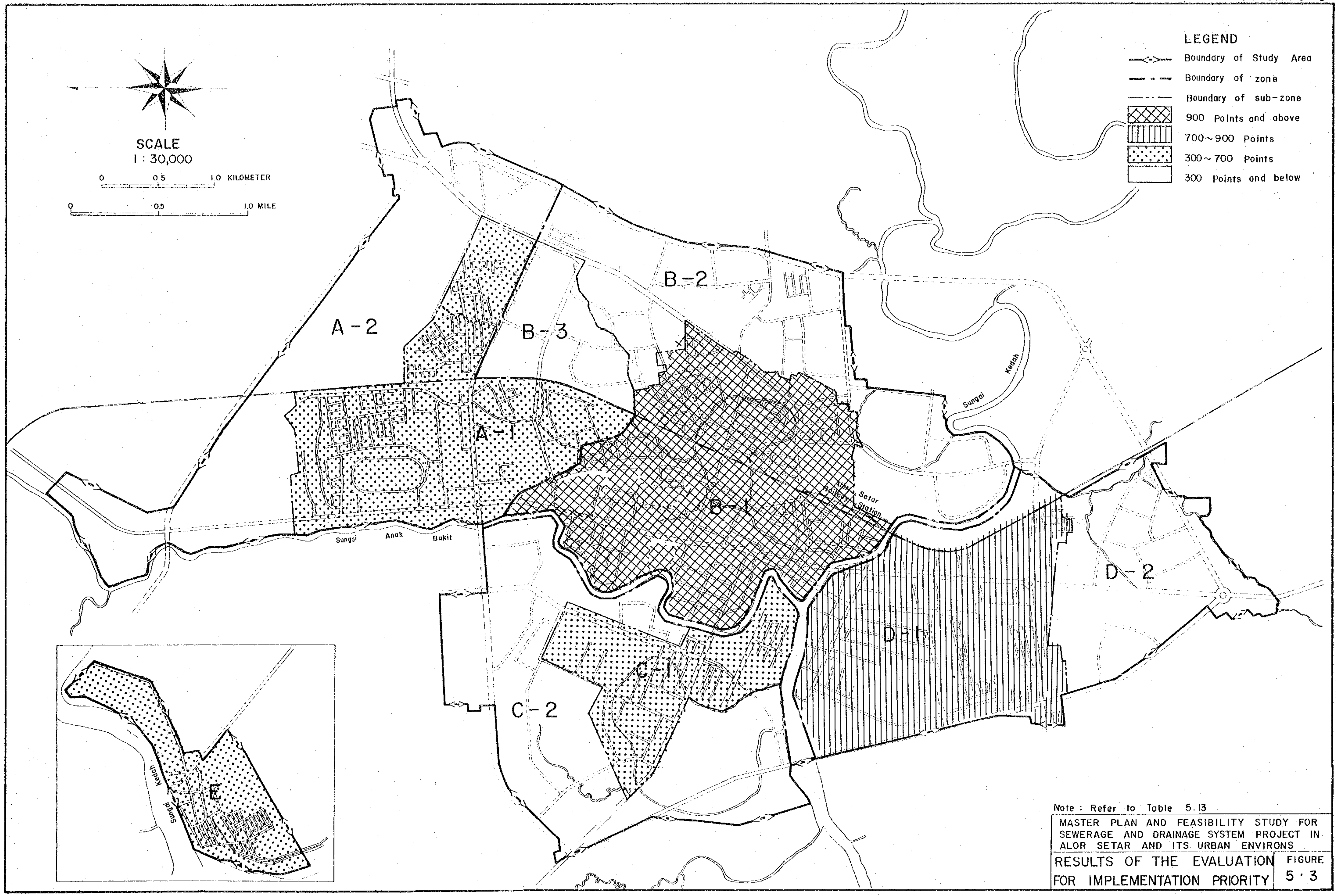


MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

PROPOSED SEWERAGE ZONE AND SUB-ZONE

FIGURE 5·1

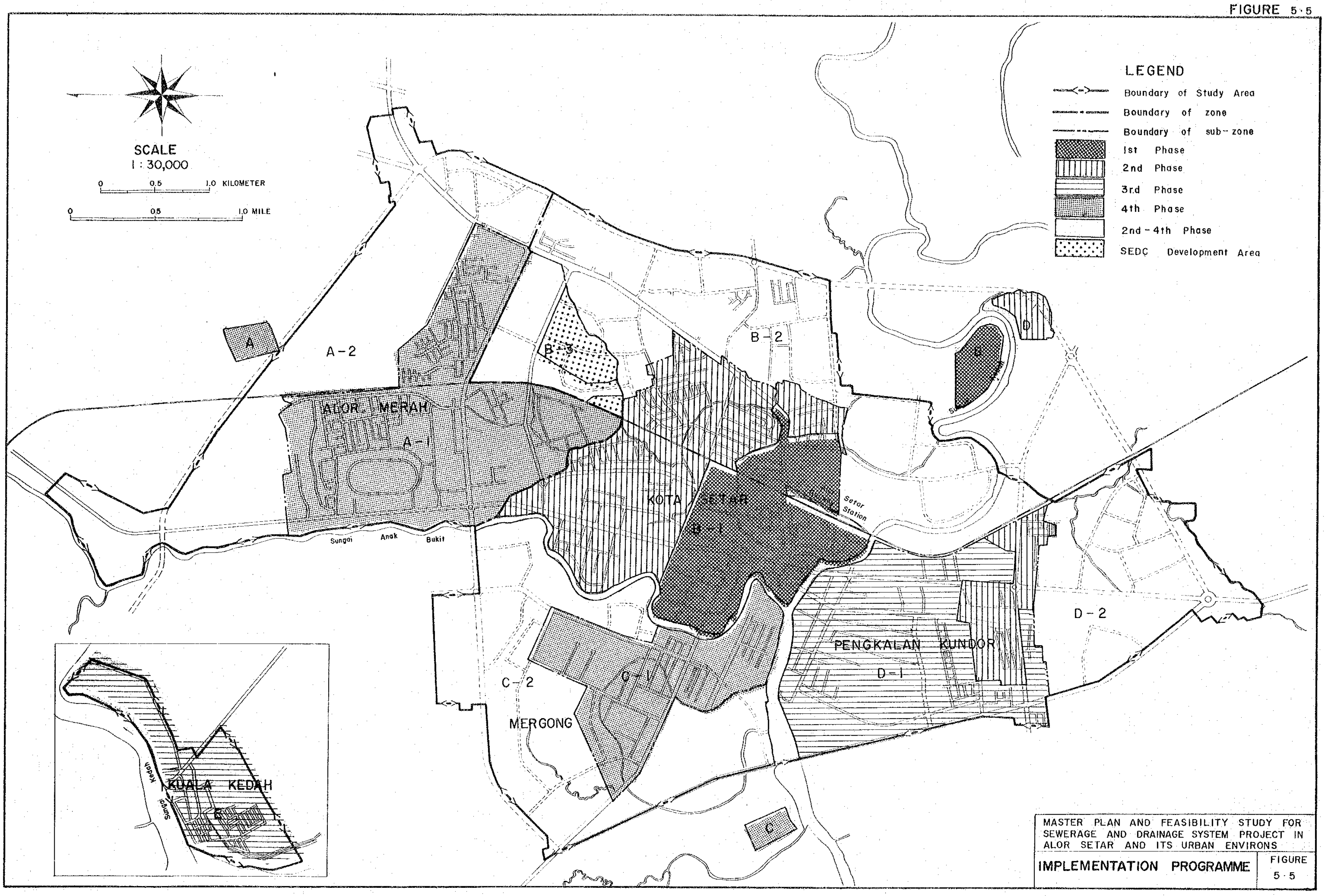

LEGEND
Boundary of Study Area
Boundary of zone
Boundary of sub-zone
Trunk sewer
Force main sewer
Pumping station
T.S Treatment site
B-11 Line number
o375 Pipe diameter (mm)
SCALE
1 : 30,000
0 0.5 1.0 KILOMETER
0 0.5 1.0 MILE
KOTA SETAR T.S. 22.5ha
PENGKALAN KUNDOR T.S. 18.8ha
ALOR MERAH T.S. 14.7ha
KUALA KEDAH T.S. 19.6ha
MERGONG T.S. 12.4ha
A-1
A-2
B-1
B-2
B-3
C-1
C-2
D-1
D-2
E
Sungai Anak Bukit
Note: Refer to Tables 5·11·1 and 5·11·2 and Table K·1 in Appendix K
MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS
PROPOSED LAYOUT PLAN FOR SEWERAGE SYSTEM
FIGURE 5·2



Note : Refer to Table 5.13

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

RESULTS OF THE EVALUATION FOR IMPLEMENTATION PRIORITY	FIGURE 5·3



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

IMPLEMENTATION PROGRAMME

FIGURE 5·5

CHPATER 6
INTERIM MEASURES

1. GENERAL

Since it takes time to complete adequate public sewerage system for the city as proposed in the Master Plan, implementation of practical interim measures should be necessary to help improving environmental condition by removing major sources of pollution with effective minimum capital expenses through proper administrative measures by MPKS.

Causes of pollution prevailing in the drains and roadside ditches, which have to be eliminated as soon as practicable, are identified by the field surveys conducted by the study team which are as follows:

A. Water pollutions caused by

(1) (i) operational defects of night soil facilities

(ii) sullage water discharged from domestic, commercial (restaurants and public eating places) and industrial origin .... BOD

(2) car repairing workshops .... oil/grease

(3) processing of poultry, fish and meat in the market place .... bleeding

(4) sullage water from domestic, commercial and industrial origins .... SS

B. Solid waste pollutions caused by

(5) solid waste disposed of by pedestrians and enterprises into drains and roadside ditches

(6) deposition of solid wastes at the bottom of drains and roadside ditches

2. INTERIM MEASURES

Major causes of water pollution for the proposed interim measures cover from A(1) to A(4) as listed above. Heavy pollutions caused by any of the four parameters can be substantially improved by the measures proposed in the subsequent sections with reasonable costs and time.

2.1 Improvement of Existing Sewerage/Sanitary Facilities for Domestic Wastewaters

Following four components are considered useful as the effective improvement measures for domestic wastewaters, and each of them is discussed in detail in the following sections:

(1) improvement and repairing of existing communal septic tanks
(2) desludging from existing individual septic tanks
(3) improvement of existing individual excreta disposal facilities
(4) intensification of cleaning activity of drains and ditches

2.1.1 Improvement of Existing Communal Septic Tanks

Field investigation revealed that 21 communal septic tanks exist in the Study Area (refer to Appendix A, Volume VII). Some of them have not been used due to heavy damage of tank or obsolete pumps and some of the used pumps are operated under unsatisfactory condition. Therefore, immediate measures are proposed according to the existing conditions of communal septic tanks as follows:

(1) periodical desludging for the tanks to ensure an significant improvement of the effluent quality (Nos. 7, 15, 16, 17 and 19 refer to Appendix A, Volume VII)

(2) replacement of the fixed distributors to ensure an significant improvement of the effluent quality (Nos. 3 and 12)
(3) repairing of tanks (Nos. 6, 8 and 18) for temporary improvement
(4) expansion of the facility and increased desludging frequency for tank (No. 21) to ensure an improvement of the effluent quality

It should be noted that all the 21 communal septic tanks are receiving human excreta only, sullage water being discharged directly into near-by drains. Therefore, these tanks should be discarded when the public sewerage system is provided.

2.1.2 Desludging from Individual Septic Tanks

It is estimated that approximately 12,000 septic tanks exist in the Study Area (refer to Section 8 of Chapter 3 in Volume II) and most of them have not been desludged ever since their construction. To maintain an acceptable level of treatment efficiency, average individual septic tank should require desludging every four years as estimated in the note below.

(Note) Frequency between desludging $= \frac{1,610 \times 0.60}{8.25 \times 30} = 3.9 = 4$ yr

where,

(i)	average tank volume (by MPKS data)	: 1.61 m^3
(ii)	per capita sludge production rate per annum (refer to Appendix B, Vol. VII)	: 30 l
(iii)	No. of users per tank	: 8.25 persons
(iv)	sludge depth to be accumulated	: 60%

For successful desludging operation, two vaccum trucks with 4.5 m^3 capacity should be provided in addition to one 4.5 m^3 truck presently available as estimated in the note below.

(Note) No. of vaccum trucks (4.5 m^3 capacity) needed

$$= \left(\frac{5,331.7\ (m^3)}{4.5(m^3/truck)x2(trips/day)x250(day/yr)} \right) = 2.4\ trucks$$

where,

(i) Sludge volume to be removed from individual septic tanks

- o sludge volume to be removed : 1.61 m^3/tank
- o annual total sludge generation to be removed (=12,000/4x1.61) : 4,830 m^3

(ii) sludge volume to be removed from communal septic tanks

- o frequency of desludging : 1 time/yr
- o annual total sludge generation to be removed (=9,700 persons x 0.03 m^3/day x 1.2) : 349.2 m^3

(iii) night soil volume to be removed from pit-privy

- o frequency of removal : 1 time/yr
- o annual total night soil generation to be removed (4,235 persons x 0.03 m^3/day x 1.2) : 152.5 m^3

(iv) Total sludge and night soil volume to be removed per annum (=4,830 + 349.2 + 152.5) : 5,331.7 m^3

2.1.3 Improvement of Existing Individual Excreta Disposal Facilities

In addition to the septic tanks and pit privies discussed above, over 400 other types of individual night soil disposal including overwater latrine and bore hole latrine, etc. are estimated to exist in the Study Area.

These types are recommended to be improved to either individual septic tank with filter bed or bucket system because of their possible pollution of the recipient water bodies and underground waters.

2.1.4 Intensification of Cleaning Activity of Drains and Ditches

Solid waste pollution can be removed by periodical dredging of the drains and ditches, together with cleaning out of the hyacinths which often out-grow to the level of nuisance contributing to the stagration of solid wastes. A stricker practice of the Kota Setar Municipal Council Anti litter By-low should help decrease the causes of (5) and (6) significantly (refer to 4.3 (1) for detail). In addition, it is highly recommended to continue the "Gotong-Royong: practice as the effective movement of cleaning environs by residents.

2.2 Improvement of Existing Industrial Facilities

Interim measures for industrial wastes will be focused on groups of industries affecting recipient water courses by their effluents significantly. The wastewater control from the public markets, the general hospital, groups of car repairing workshops in Mergong and the sea food factories in Kuala Kedah are recommended to be improved by the immediate measures by cutting the pollutants at the sources as follows:

2.2.1 Measure for Sea Food Processing Factories in Kuala Kedah

Three sea food processing factories are already in operation in Kuala Kedah polluting downstreams by discharging highly concentrated wastewater (appro. 2,000 mg/l) in terms of BOD (refer to Appendix B, Volume VII).

Considering economy and simple operation, installation of a sedimentation tank is recommended for each factory. This tank will continue to be used even when the municipal sewerage system is constructed in the future.

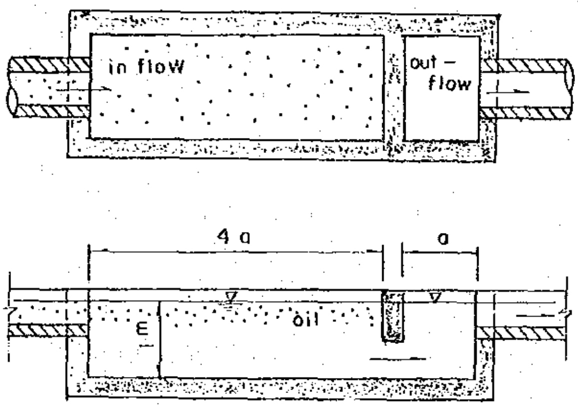
Proposed design criteria for the sedimentation tank are:

- o detention time : 2 hr
- o BOD removal rate : 20%
- o SS removal rate : 60%

2.2.2 Measure for Waste Oil from Car Repairing Workshops at Mergong Industrial Area

Many car repairing workshops are located in this area causing the resultant waste oil contamination in the drains.

Oil trap is recommended to be provided in front of the final discharging point of each workshop as shown in the following schematic drawing. This oil trap provided will be used even when the sewerage system is constructed in the future. The trapped oil is burnt out by each factory.



o detention time = 1 hr
o effective depth= 1 m

2.2.3 Measure for Public Market Wastes

Five public markets retail foodstuff including poultry, raw fish and meats in the Study Area. The bleeding from the processing poultry, meat and fish for sale contributes to high BOD effluents from the markets. The settled materials can be recovered and used as a fertilizer.

A sedimentation tank with one hour detention time should, therefore, be provided for each market.

3. MEASURES FOR NEW DEVELOPMENT SCHEMES

3.1 Sewerage System for New Housing Development Schemes

A number of housing development schemes have been undertaken by developers and by the SEDC in the Study Area. Small and medium size development schemes are mainly conducted by developers, while large scale development schemes by SEDC.

Development schemes conducted by developers have been provided with individual septic tanks only for human excreta (urine and excrement), but sullage water is directly discharged into a near-by drain without any treatment, whereas SEDC's schemes have been provided with stabilization ponds by which both human excreta and sullage water are treated prior to discharging into recipient waters courses.

For the sake of pollution control in the Study Area, each new individual septic tank should receive both sullage water and human excreta and each new housing development schemes, regardless of the size, should be provided with a temporary stabilization pond treating both human excreta and sullage water under guidance of MPKS. This temporary stabilization pond should be discarded when the terminal sewer is connected to the public sewerage system, and the land can be converted for public purpose such as a park.

Design criteria for temporary stabilization pond design are recommended in Table 6.1.

Table 6.1 Design Criteria for Temporary Stabilization Ponds

Item	Criteria
Detention time	Minimum 4 days
Effective depth	1.5 m
Top width of embankment	3.0 m
Effluent BOD	70 mg/l

3.2 Sewerage System for Industrial Development Schemes

3.2.1 North Mergong Industrial Area

Light industries dominated by car repairing workshops are expected to prevail even in the future. Therefore, provision of an oil trap is recommended to be obligatory for each new workshop by MPKS as in case of the existing shops described in subsection 2.2.2.

3.2.2 South Mergong Industrial Area

Out of the four large scale industries, the livestock processing plant and the toilet paper factory produce highly concentrated wastes. For assisting preservation of downstream environment, the combined wastewater should be treated by a stabilization pond constructed in the treatment facility site for Zone D in the Master Plan (refer to Figure 5-2, Volume II), which is located closely to the industries. The construction cost should, of course, be born by the relevant industries.

3.2.3 Kuala Kedah Industrial Area

Same as in the case of the existing sea food processing factories in subsection 2.2.1, the new additional factories (approx. 20 factories being planned by SEDC) should be provided with a oil trap as proposed in subsection 2.2.2. However, a large sedimentation tank receiving wastewaters from the factories will be constructed in the treatment site of zone E.

3.3 Continuation of Present Practices

There are useful practices already on-going, which are contributing to the general sanitation of the area. It would be useful to continue these practices with vigor, and they are referred briefly in the followings:

(1) Kota Setar Municipal Council Anti-Litter By-laws, 1979

The Anti-Litter By-laws 1979 enforced in February 1979 by the Municipal Council, is intended to keep the cleanliness and beauty in the locality of Kota Setar Municipal Council.

Any person found quality shall be liable to a fine not exceeding M$2,000 or imprisonment not exceeding one year. Amount of the fine collected from March to July 1979 is exceeding M$5,000.

Although the organization for inspection is not currently sufficient in MPKS, the implementation has proven to be useful and will increase its effectiveness against illegal dumping of garbage and others. The existing anti-litter by-laws should obligate to prepare oil trap for each car repairing shop and each sea food processing factory, and also to prepare sedimentation tank for each sea fool processing factory and public market, if necessary.

(2) Gotong-Royong

Gotong-Royong, involves cooperative and voluntary movement of cleaning environs by residents under leadership of MPKS, sending officers of MPKS and arranging cleaning equipments including lorries.

Although this movement could not be carried out frequently due to arranging schedule throughout Kota Setar, it is expected to interest residents in keeping their environs clean and is the effective media for public education.