It should be noted that a projected urban population figure of 350,000 in 1990 is used in other studies, such as the Kelang Valley Review (Kelang District population is estimated as 344,600 in 1980 and as 511,700 in 1990) and the State FMP, and that this was brought up and discussed with the Government officers concerned. However, the projection shown in Table 3.2. is considered to be more realistic for the purpose of Project planning for the following reasons:

i) Data from 1980 Census was not available for the other studies, and over-estimation of population in the Kelang District is obvious.

ii) Target year of the Master Plan is the year 2000, and the planning of the sewerage and drainage facilities will be based on a projected population of 500,000. Therefore, the discrepancy in the projected figure of 20,000 in 1990 is considered to be insignificant from the planning point of view.

3.1.3. Project Area

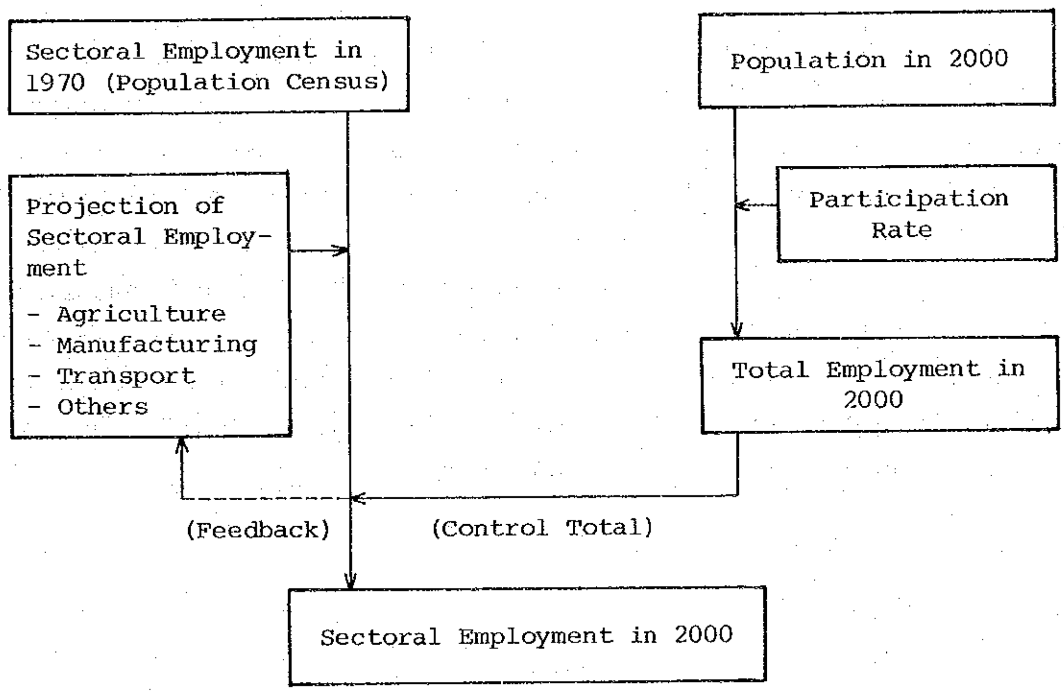
From the analysis stated above, it is obvious that the population of the Urban Area in Kelang District coincides with that of the Project Area in 1980. However, as the urbanization progresses and the population increases accordingly as estimated in the future, the Urban projected population figures are expected to exceed that of the Project Area, which is limited to an aera of 7,669 ha. Therefore, land use plan, which can accommodate the entire projected urban population of 500,000, is to be developed to cover not only the Project Area but also surrounding areas. This is to form the basis for estimating the Project Area population. Result of the projection is shown under Section 3.4. "Population Distribution" of the present Chapter based on the land use plan.

3.2. Employment Projection

3.2.1. Urban Area

Based on the Population Census conducted in 1970 together with the projected population presented in the last section, the sector-wise employment projection in the Urban Area in 2000 is considered to provide basis for future land use planning. Firstly, employment population in each sector is estimated independently by using various related factors, including land use and productivity projected in such other plans as Kelang Valley Review and State FMP. On the other hand, total employment population in the year 2000 is separately estimated as control total, based on the projected population and participation rate. The independently estimated sectoral employment total is then adjusted to the control total to arrive at the final employment population in each sector. The projection method outline is presented in the following chart.

Fig. 3.1. Sectoral Employment Projection Method in the Urban Area



The details on "Participation Rate," "Total Employment in 2000," and "Projection of Sectoral Employment" in the above chart are tabulated in Appendix A, Vol. IV: Population Projection and Land Use. Sectoral employment for the Kelang District and the Urban Area in 2000 is summarized in the following Table 3.3.

Table 3.3. Sectoral Employment in the Year 2000

Sector	Kelang District				Urban Area	
	1970		2000		2000	
	No. of Employees	Percentage	No. of Employees	Percentage	No. of Employees	Percentage
Agriculture, Forestry and Fishing	13,361	22.7	11,000	4.9	1,000	0.5
Mining and Quarrying	36	0.0	-	0	-	0
Manufacturing	14,432	24.5	89,000	39.4	81,000	41.5
Construction	1,964	3.4	8,000	3.5	7,000	3.6
Electricity, Gas and Water	841	1.4	3,000	1.4	3,000	1.5
Transport, Storage and Communications	9,796	16.6	43,000	18.9	38,000	19.5
Wholesale and Retail Trade	7,900	13.4	31,000	13.7	28,000	14.4
Services	10,567	18.0	41,000	18.2	37,000	19.0
Total	58,897	100.0	226,000	100.0	195,000	100.0

Source: 1970 Population Census

3.2.2. Project Area

For the same reason as described in the Section 3.1.3., "Population Projection," the employment projection for the Project Area is presented under Section 3.4. "Population Distribution."

3.3. Land Use Plan

3.3.1. Demand for Space in the Year 2000

1) Calculation of Land Use by Category

Demand for space of each land use category is worked out based on the following procedures.

a) Residential

To calculate the space for residential area, total projected population of 500,000 in 2000 is fully taken into account. Average population density in typical new housing schemes is estimated as 120 persons/ha. Taking into account the variation of population densities existing in the Project Area, population density of 100 persons/ha is considered to be a realistic estimate for calculating generally future space demand.

b) Industrial, Commercial and Institutional

To calculate required land space for industrial, commercial and institutional use, the number of sectoral employment as well as total population are used.

2) Summary

Additional land requirement is estimated based on the existing land use and future demand for space. Detailed calculations are tabulated in Appendix A: Population Projection and Land Use, and summarized in Table 3.4.

Table 3.4. Demand for Space in the Year 2000

Land Use Category	Requirement in 2000	Additional Requirement (1980 - 2000)
Residential Area	5,000 ha	3,400 ha
Industrial Area	2,000 ha	1,300 ha
Commercial Area	280 ha	190 ha
Institutional Area	600 ha	370 ha

3.3.2. Conceptual Development Pattern

Three alternative patterns are developed to identify desirable future development policy in order to cope with the space demand in 2000. These are (1) concentric pattern, (2) polycentric pattern and (3) linear pattern, as shown in Fig. 3.2. to Fig. 3.4. Relevant development projects (such as industrial, commercial and housing development and expressway, which are described in Section 2.3.2.), as well as present land use, are taken into account to develop these three alternative plans. Descriptions of these patterns are as follows:

1) Pattern A: Concentric Pattern

This Pattern will accelerate the concentration of urban facilities to Kelang North and Kelang South. Port Kelang, Kapar and Meru will remain as independent urban centers. The disadvantage of this Pattern is that it may create traffic congestions, particularly in the center of the Kelang town area because of the Kelang River flowing across the area. (Ref.: Fig. 3.2. Pattern A.)

2) Pattern B: Polycentric Pattern

This Pattern has the advantage of accelerating the growth rate of the less-developed districts; i.e., Kapar and Meru. However, as the Pattern calls for a development program for four different areas, which will cause problems concerning investment efficiency, it is therefore not advisable to be applied for Project planning at present. However, this pattern should be considered on a long-range basis in the future after certain development of urban functions in the Project Area. (Ref.: Fig. 3.3. Pattern B.)

3) Pattern C: Linear Pattern

This Pattern will accelerate the functional composition of the Project Area based on three axes; i.e., 'Industrial Axis', 'Urban Axis' and 'Reserve Axis'. Linear pattern in general is considered to promote rapid urbanization, thus favorable for the area where rapid development is anticipated. Taking into account the size of the urban area and its population and the rapid development progress taking place in the Project Area, pattern C is considered to be the most suitable for determining land use plan. (Ref.: Fig. 3.4. Pattern C.)

Fig. 3.2.

PATTERN : A

CONCENTRIC PATTERN

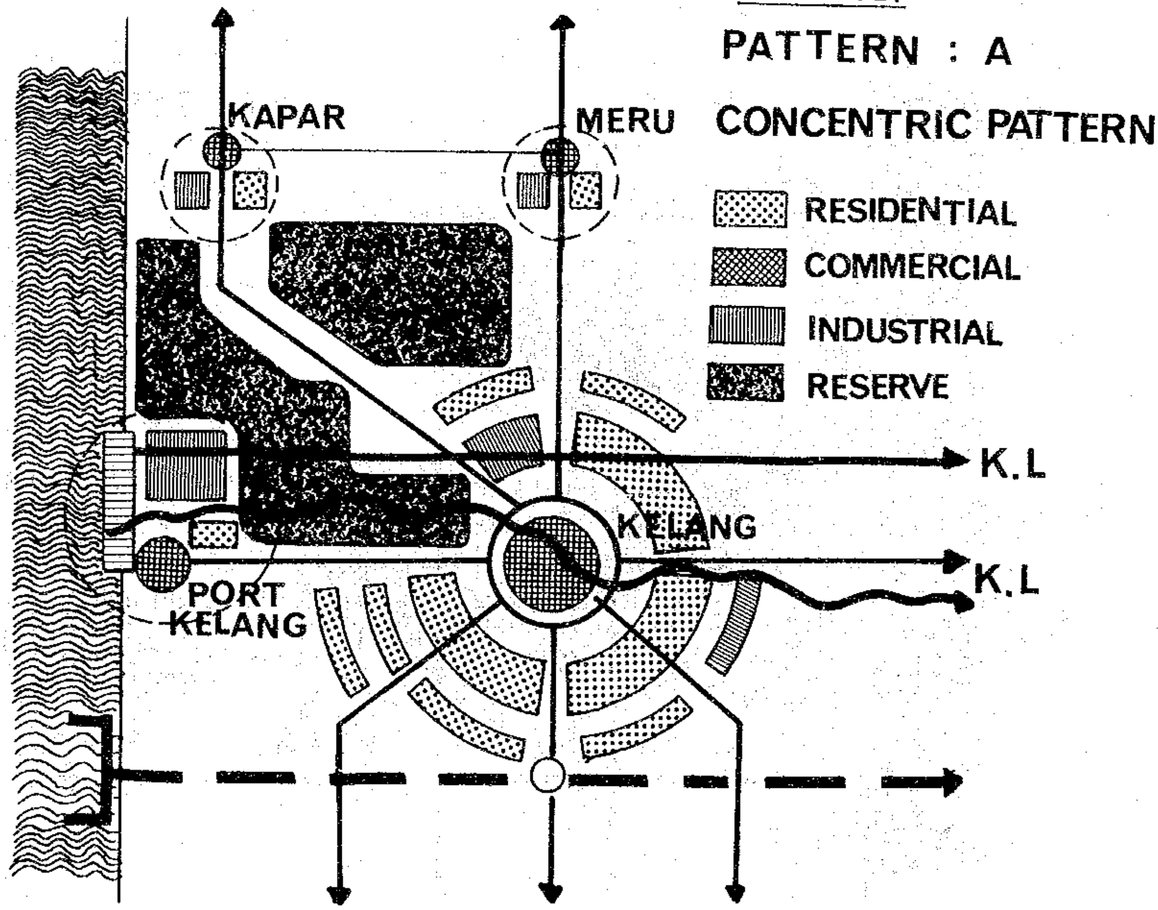


Fig. 3.3.

PATTERN : B

POLYCENTRIC PATTERN

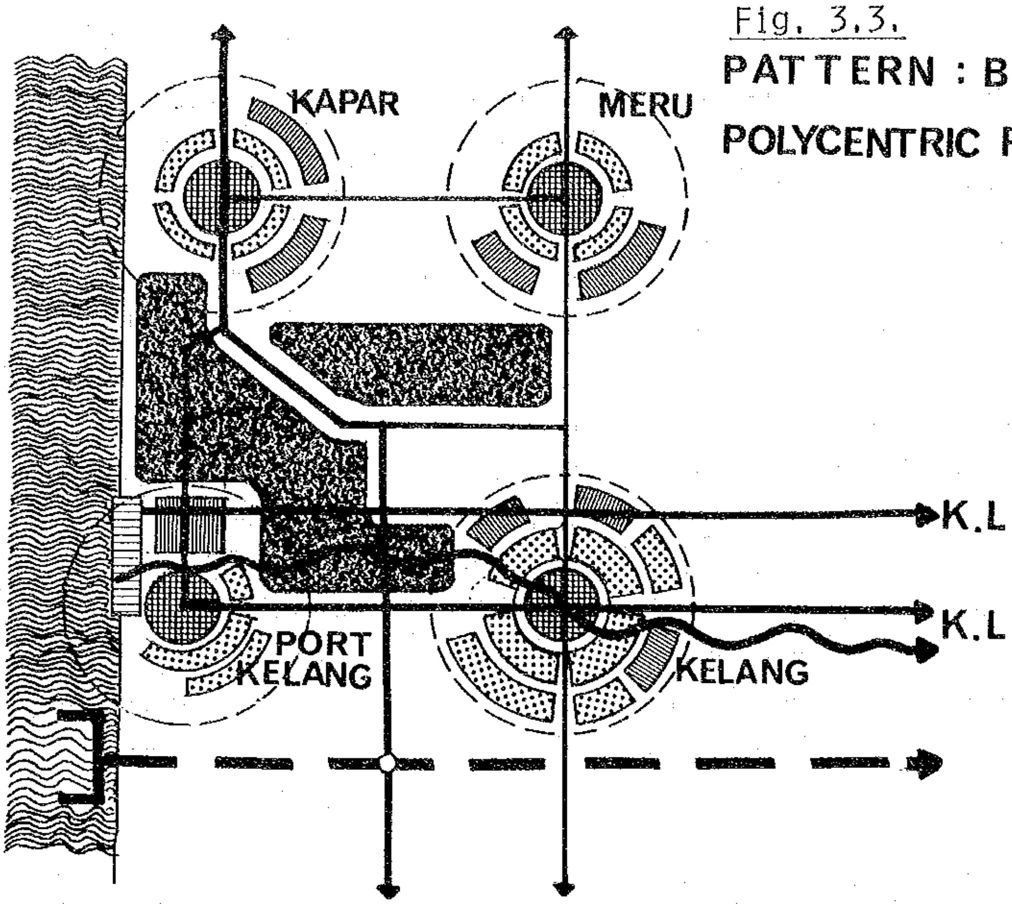
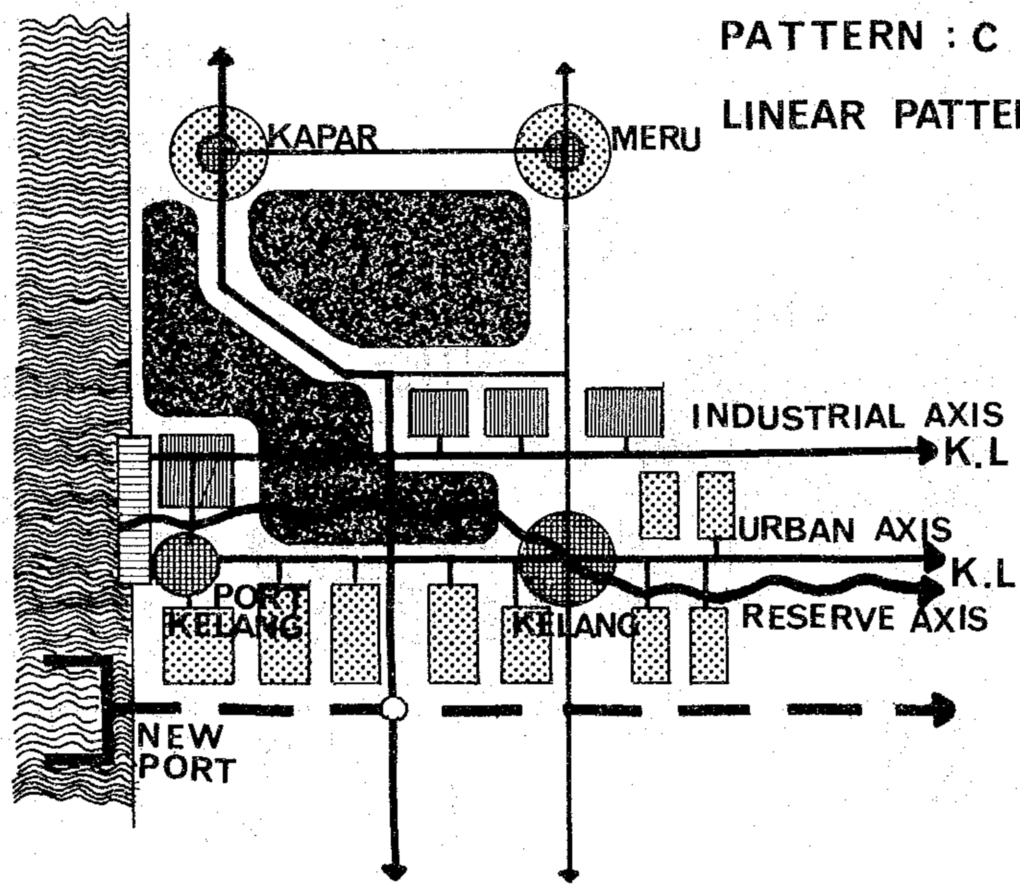


Fig. 3.4.

PATTERN : C

LINEAR PATTERN



3.3.3. Land Use Plan in the Year 2000

1) Allocation of Space

Taking into account the Conceptual Development Pattern C and the land requirement in the year 2000, the future land use plan is shown in the following Fig. 3.5.

a) Basic Policy

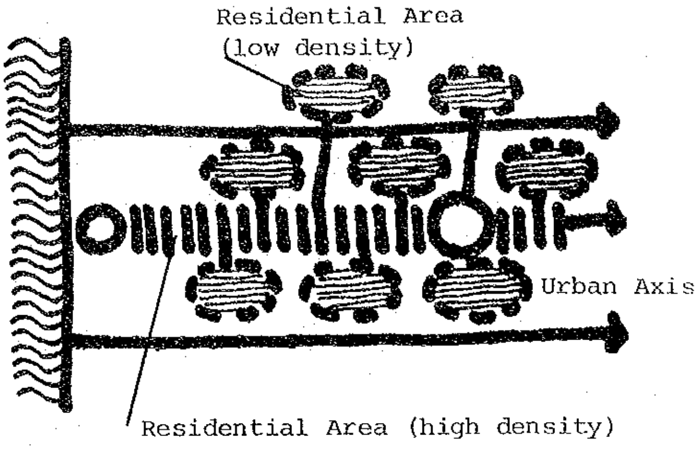
On the basis of the above consideration, the demand for space, including desirable open space and vacant land in the urban area, is estimated at about 10,000 ha in the year 2000, which exceeds the Project Area of 7,669 ha by nearly 3,000 ha. This figure is allocated for the Project Area on the basis of Conceptual Pattern C and taking into account the current trend of urbanization. Accordingly, present urbanization is expected to extend to the Malay Reserve adjoining the Project Area, and future urbanization to take place between the North and South expressways under this pattern.

On the other hand, the Project Area which was determined on the basis of agreement between the Malaysian Government and the Japanese Government excludes somes small parts of the present developing area but includes the rural areas surrounding Kapar and Meru. However, urbanization is not expected to take place in either Kapar or Meru, being located above the North Expressway, which forms the upper boundary of the future urbanization area.

Therefore, it is considered reasonable that the northern part of the Project Area should be allocated for open space or for agricultural land but not for urban area. Instead, the Malay Reserve adjoining the Project Area is recommended to be allocated for the urban area.

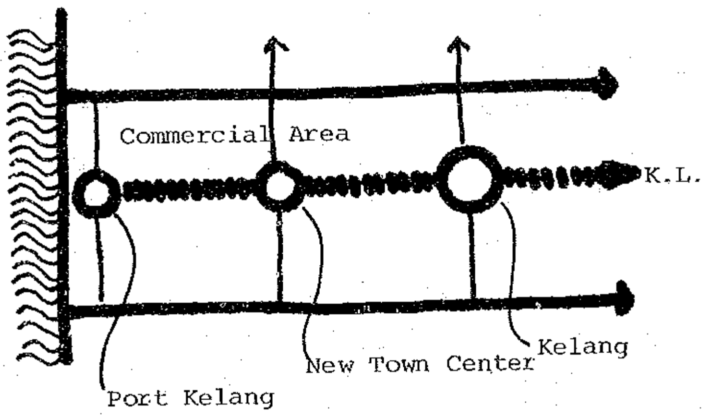
i) <u>Residential Area</u>

The residential areas are allocated in connection with the Urban Axis; i.e., federal Route II.



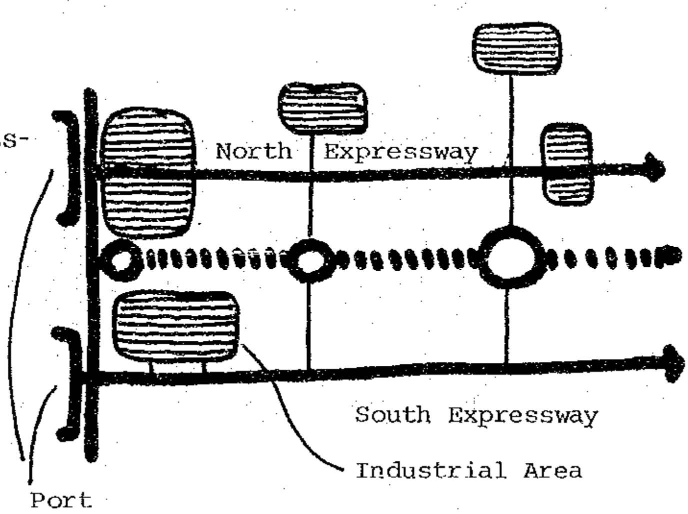
ii) <u>Commercial Area</u>

The commercial areas are allocated along the Urban Axis, especially the new town center which is planned between Kelang and Port Kelang.



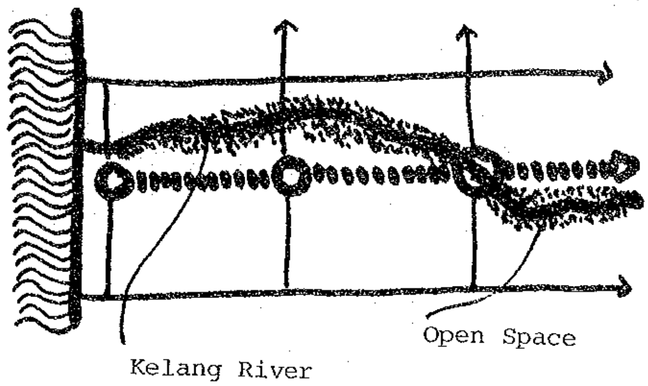
iii) <u>Industrial Area</u>

The industrial areas are allocated in connection with North Kelang Straits Expressway and South Expressway.



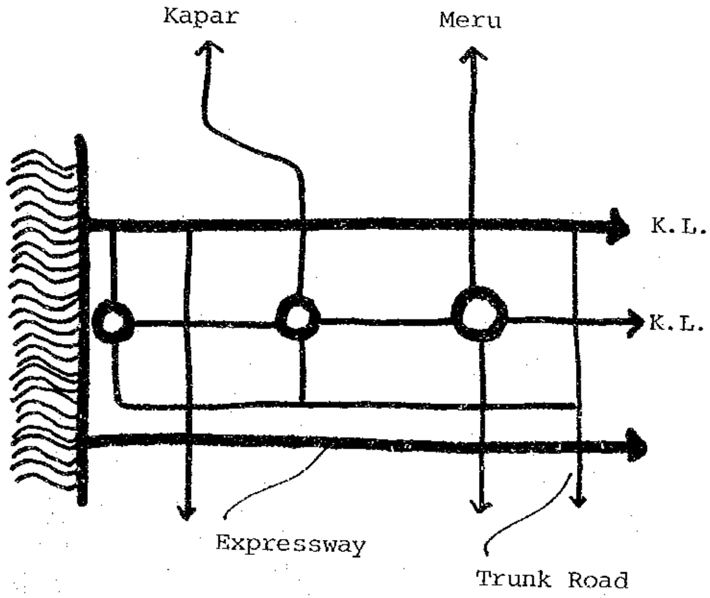
iv) Open Space

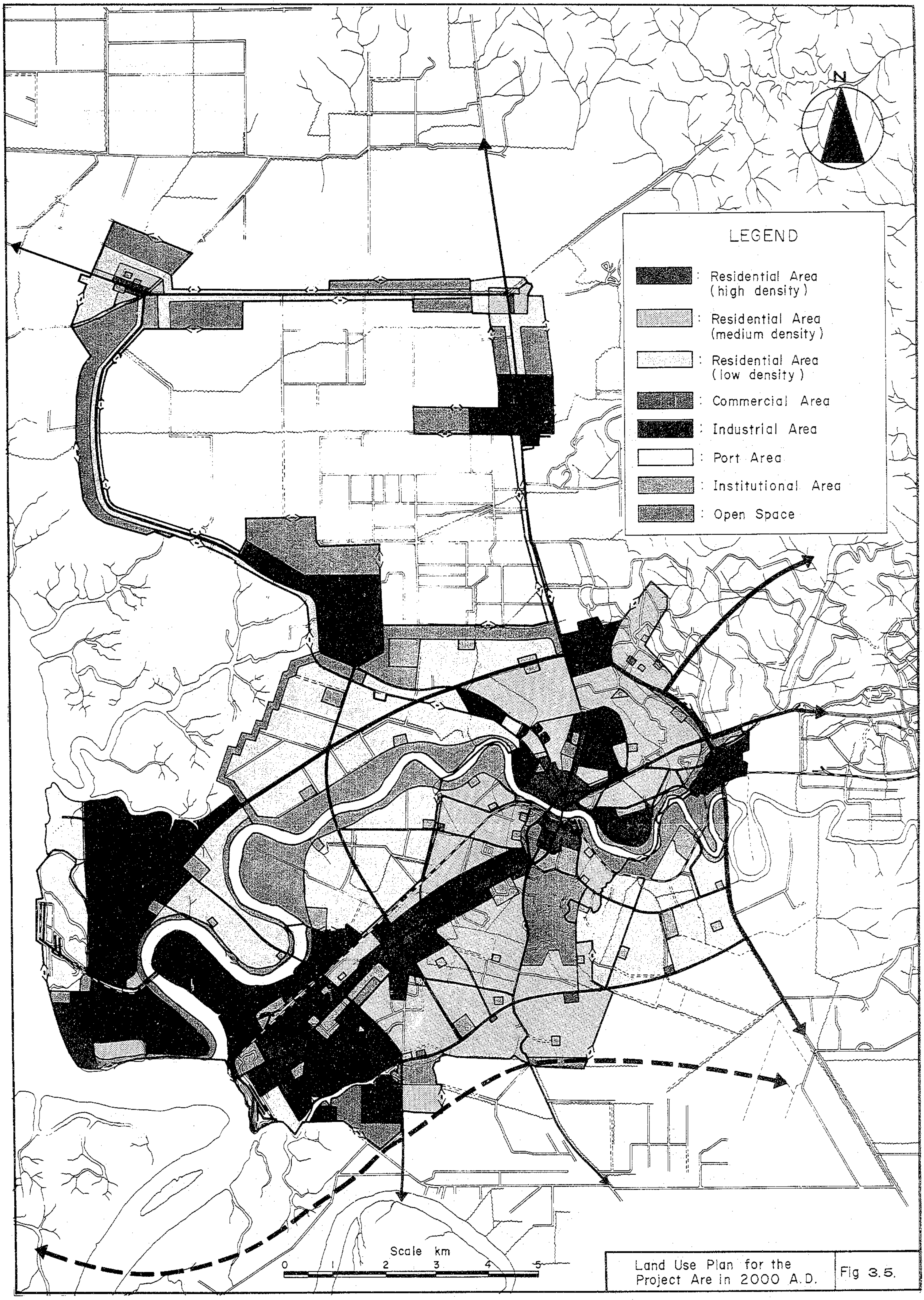
The open spaces are allocated along the Kelang River.



v) Road Network

The road network of the Project Area is composed of the grid pattern.





Land Use Plan for the Project Are in 2000 A.D. Fig 3.5.

2) Future Land Use

On the basis of the land use plan shown in Fig. 3.5., details of the areas to be allotted for various land use purposes are tabulated in Table 3.5, and 3.6, followed by further details on population distribution.

Table 3.5. Future Land Use

	Urban Area	Project Area	Outer Area
Residential	5,000 ha	3,200 ha	1,800 ha
Commercial	280	275	5
Industrial	2,000	1,530	470
Port Area	400	280	120
Institutional/ Government	600	450	150
Open Space/ Agriculture/ Vacant Land	2,520	1,934	586
Total	10,800	7,669	3,131

(Note: Urban covers total projected population of 500,000 in 2000 for different land use purposes as indicated. Project Area shows allocation of the same purposes in the Project Area and the rest under Outer Area.)

Table 3.6. Size of Land Use According to Catchment

(Unit: ha)

Catchment Code No	Total	Project Area: Residential High	Residential Middle	Residential Low	Commercial	Industrial	Port Area	Institutional	Open Space	Sub Total	Contributing Area
N-1	2,751.0	-	222.9	-	2.4	71.6	-	10.0	65.8	372.7	1,536.3 Mountain 842.0 Plantation
2	210.1	8.4	190.1	-	-	-	-	3.3	8.3	210.1	-
3	25.5	19.9	-	-	0.5	-	-	-	5.1	25.5	-
4	162.0	72.1	43.2	-	7.6	-	-	15.7	23.4	162.0	-
5	69.5	21.2	23.0	-	20.2	-	-	1.6	3.5	69.5	-
6	72.3	14.6	3.1	-	37.7	-	-	8.4	8.5	72.3	-
7	48.2	3.6	-	-	22.6	17.0	-	2.0	3.0	48.2	-
8	255.0	5.8	181.4	11.1	14.2	36.3	-	3.8	2.4	255.0	-
9	382.1	-	66.3	132.0	-	86.5	-	8.6	49.3	342.7	39.4
S-1	128.6	-	20.6	-	-	-	-	-	44.5	65.1	57.2 Low Residential 2.2 Institutional 4.1 Open Space
2	177.5	-	21.6	-	10.0	-	-	16.8	121.4	169.8	
3	11.8	-	-	-	8.8	-	-	-	3.0	11.8	7.7 Open Space
4	53.9	-	-	-	16.8	-	-	18.6	18.5	53.9	-
5	156.1	16.1	101.5	-	7.3	-	-	5.2	26.0	156.1	-
6	96.7	-	51.4	-	-	-	-	7.1	38.2	96.7	-
7	110.8	-	100.2	-	1.6	-	-	-	9.0	110.8	-
8	539.2	184.0	249.8	-	34.6	-	-	20.8	50.0	539.2	-
9	120.5	67.4	35.2	-	5.8	-	-	12.1	-	120.5	-
10	144.6	47.8	-	-	21.1	35.5	-	40.2	-	144.6	-
11	299.5	-	-	-	-	268.3	-	20.7	6.5	295.5	-
A-1	2,353.3	5.6	638.3	-	7.6	-	-	27.8	82.4	761.7	1,591.6
2	133.6	5.7	76.1	-	-	15.5	-	25.2	11.1	133.6	-
3	106.9	80.1	-	-	-	-	-	26.8	-	106.9	-
4	52.5	14.7	0.8	-	26.0	5.5	-	3.0	2.5	52.5	-
5	100.9	19.8	-	-	-	5.5	75.6	-	-	100.9	-
6	310.4	32.7	-	-	-	200.7	-	-	77.0	310.4	-
O-1	1,237.0	-	-	126.7	-	85.2	-	29.0	126.0	366.9	15.5 Industrial 854.6
2	260.7	-	-	11.6	-	54.5	-	-	30.6	96.7	91.5 Industrial 72.5
3	1,216.9	-	-	13.2	-	27.5	-	-	167.9	208.6	1,008.3
4	675.2	-	-	23.8	-	-	-	-	54.0	77.8	597.4
5	2,054.4	-	-	17.7	-	153.9	-	-	131.7	303.3	1,751.1
6	8,938.3	-	59.3	271.5	13.6	-	-	27.8	414.5	786.7	2,197.1 Mountain 5,954.5
Total	23,251.0	619.5	2,084.8	607.6	258.4	1,063.5	75.6	334.5	1,584.1	6,628.0*	16,623.0

* North Port Area (810 ha) and River Surface (231 ha) are excluded.

3.4. Population Distribution

The projected future population of the Urban Area is distributed over the Project Area on the basis of the land use plan. The method of distribution is based on the following criteria of population density:

Residential area (low density):	60 persons/ha
Residential area (medium density):	100 persons/ha
Residential area (high density):	150 persons/ha
Commercial area:	120 persons/ha

The present population density of corresponding areas in the Project Area is used to determine the above figures.

The average population density of the residential area is 120 persons/ha, including the squatter residents and about 100 persons/ha, excluding the same. The population density for the residential area of medium density is therefore determined to be 100 persons/ha.

The present population densities of central areas in Kelang North, Kelang South and Port Kelang range from 130 persons/ha to 180 persons/ha Accordingly, the figure for the residential area of high density is set at 150 persons/ha.

From the present population densities of Kelang environs, which range from 30 to 80 persons/ha, the population density for the residential area of low density is determined to be 60 persons/ha.

The present population density of the commercial area is approximately 150 persons/ha. Since the tendency to separate the residence from the workplace is expected to accelerate in the future, the figure for the commercial area is fixed at 120 persons/ha.

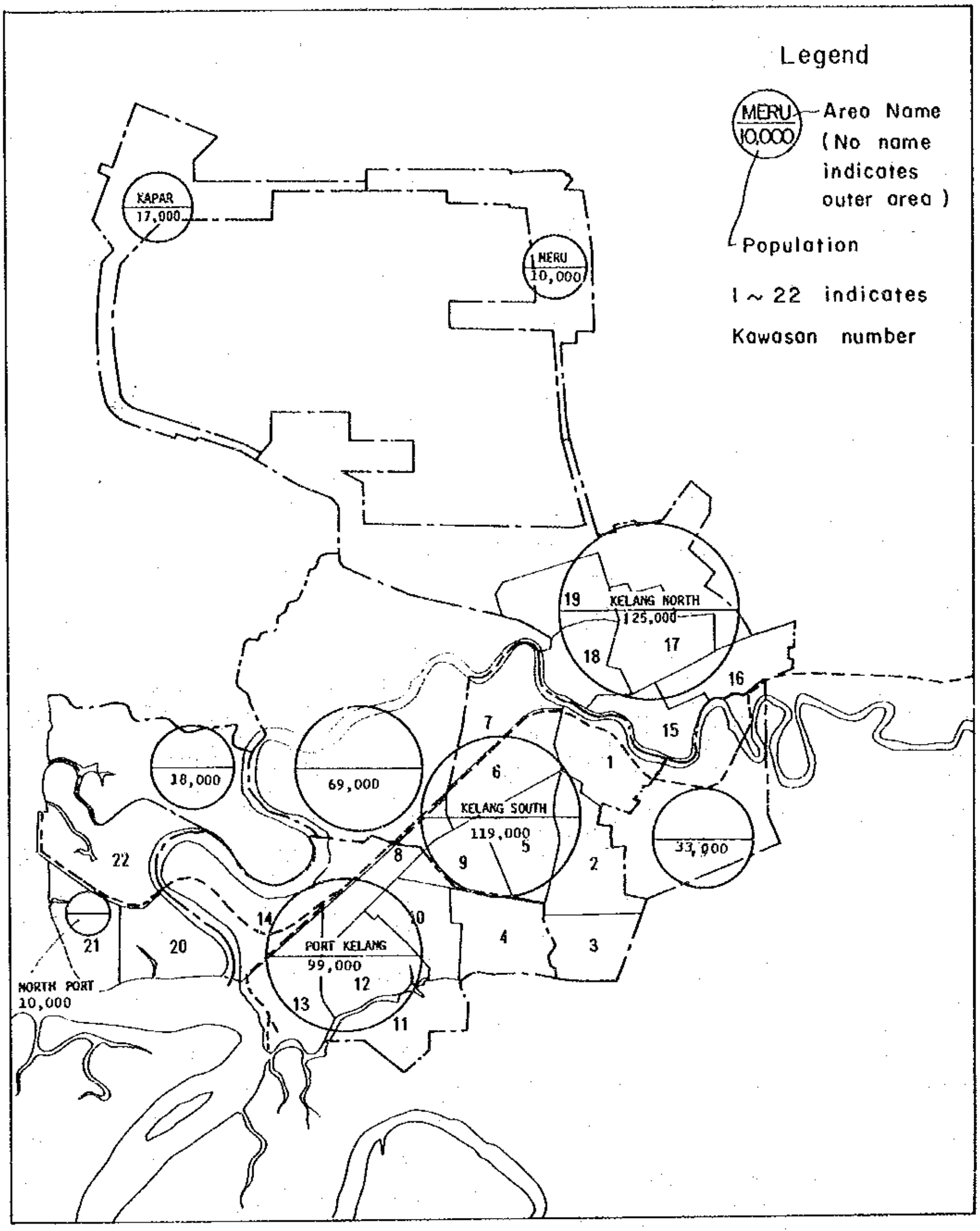
Since few resident is expected in such areas as industrial, port area, institutional and open space, population density in these area is considered to be negligible.

On the basis of the above-mentioned figures, the following are calculated for population distribution projection of the Project Area in the year 2000. (Ref.: Table 3.7. and Fig. 3.6.)

Table 3.7. Population Projection for the Project Area in the year 2000

Area	Population in 2000
Project Area	380,000 persons
Outer Area	120,000 persons
Urban Area	500,000 persons

Fig. 3.6. Project Area Population Distribution in the Year 2000



CHAPTER 4

DESIGN CONSIDERATIONS

CHAPTER 4 DESIGN CONSIDERATIONS

4.1. Design Storm Recurrence Intervals

Storm drains should be designed to carry discharge from the maximum stormwater expected for a given location. However, the actual design of the drainage facilities should be made on the basis of average frequency of rainfall occurrence with due consideration for reasonable investment for implementation. Hence, determination of rainfall frequencies will be necessary for design purposes.

The national standards for rainfall frequencies as a basis for design of urban drainage systems are 2-year (for residential areas) and 5-year (for commercial and industrial areas) return period. These figures are acceptable for the size of the municipality in the Project Area and also in line with design practice. For this Project, therefore, the same rainfall frequencies as those of the national standards are applied.

In addition, 100-year rainfall frequency is also considered in this study for checking the trunk drainage system. The basic consideration in design for the drainage system is that there should be neither flooding from the initial storm (2- or 5-year return period) nor extreme damage from a major storm (100-year return period).

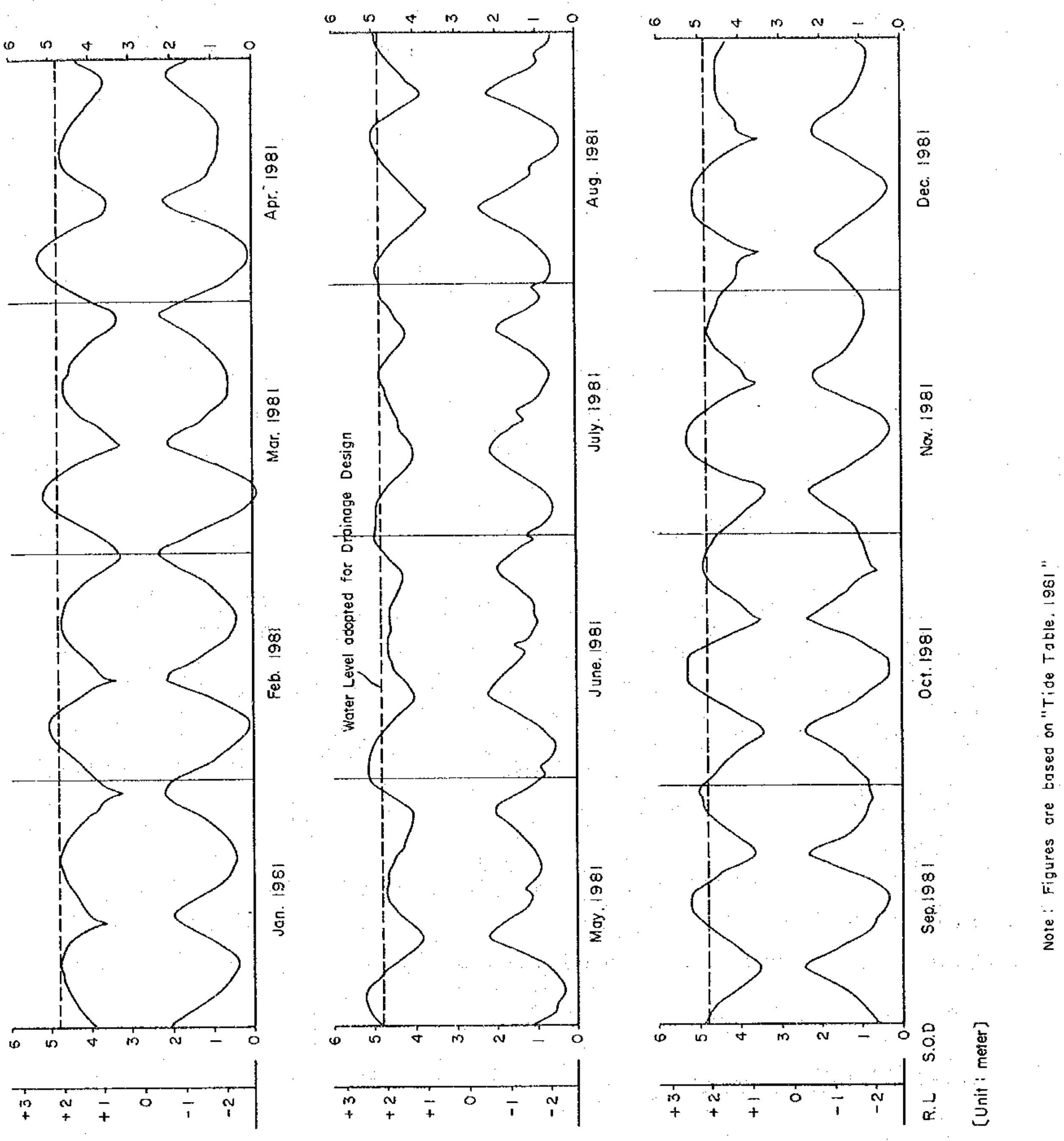
4.2. Design Water Level

Since the Project Area lies in the most downstream basin of two rivers; namely, the Kelang River and the Aur River, the discharge of the stormwater runoff originating from the Project Area is significantly affected by the river water levels. The river water levels, therefore, should be taken into consideration in this Master Plan to enable carrying out the actual design for the Project Area drainage system.

Furthermore, considering the close proximity of the Project Area to the sea, special attention should be given to sea level. The mean high water springs of R.L. +2.1 m is used although this is not the highest level; for example, water level reaches about R.L. +2.6 m according to the Tide Tables - 1981. This is because frequency of flood level usually occurs twice a day, but frequency of flood level exceeding mean high water springs is only about one-seventh. (Ref.: Fig. 4.1. Highest and Lowest Daily Sea Level at Port Kelang)

The highest water level is ideal from the standpoint of completely overcoming flood problems. Provided the highest water level of R.L.+3.0 m is adopted, a drainage system including either pumping station or retention pond would become inevitable, since the Project Area is low and flat, the height of which is below R.L. +4.0 m. However, the large amount of funds required for the Project would make it impracticable.

As the first step for flood alleviation, the mean high water springs of R.L.+2.1 m is used for this Project, as shown in the following figure.



Highest and Lowest Daily Water Level at Port Kelang	Fig. 4. 1.

4.2.1. Sea Level Used for Design

Tide tables for Malaysia obtained from data published by the Institute of Oceanographic Sciences, Birkenhead, U.K., containing the time and height of high and low tides at Port Kelang, are quoted below:

	Chart Datum	Land Survey Datum (R.L.)
Lowest Astronomical Tide	-0.1 m	-2.84 m
Mean Low Water Springs	+0.7	-2.04
Mean Low Water Neaps	+2.3	-0.44
Mean Sea Level	+2.9	+0.16
Mean High Water Neaps	+3.6	+0.86
Mean High Water Springs	+4.8	+2.06

4.2.2. Flood Frequency Concerning Design

Basically, major rivers are designed to sustain major storms with a 100-year return period. Part of the Kelang River, upstream from the Puchong Weir including Kuala Lumpur, has already been planned to meet such flood frequencies. Improvement planning downstream from the Puchong Weir to the estuary was begun by the DID, and longitudinal and cross sections of the Kelang River have been prepared.

On the other hand, urban drains can be designed to carry the initial storm based on a 2- or 5-year return period, which is considered sufficient for handling flood discharges of the river for the Project Area.

4.2.3. Flood Discharge

The DID's analysis of the Kelang River flood discharge, conducted upstream at the Puchong Weir, results in an estimate of about 1,000 m^3/sec at Puchong Weir which is presumed to be equivalent to that for a 100-year return period. Therefore, a flood discharge with a 2- or 5-year return period was estimated by the Study Team, based on the data from

"National Water Resources Study" conducted by JICA of specific discharges in the west coast area, including the Kelang River catchment area. These estimates for the river mouth are as follows (Ref.: Appendix B, Vol VIII: Estimation of Kelang River Water Level):

Flood Discharge (m^3/sec)	Return Period (years)
260	2
360	5

These figures for the river mouth are used as being those for Puchong Weir as a safety measure in calculating water level.

4.2.4. Water Level of the Kelang River

The water level of the Kelang River throughout the Kelang Municipality is about the same as that of the estuary; that is, the Kelang River in Kelang Municipality is strongly affected by tidal waves. Accordingly, the estimated Kelang water level of +2.10 m to +2.30 m is used.

4.3. Combined System and Separate System

In general, there are two methods for disposal of sewage and storm water; namely, the combined system and the separate system. In this Master Plan, the separate system is adopted, considering the rainfall conditions in the Project Area and the cost advantage compared with the combined system.

4.4. Drainage Facilities

4.4.1. Open Channel

Of the two types of drains -- open channel and closed conduit -- the open channel is used for the proposed drains.

Existing drains in the Project Area consist mostly of open channels, due to its many advantages over the closed conduit. These advantages include low cost, ease of maintenance, shallow excavation and elimination of hazardous problems concerning manholes. In addition, the shallow construction would minimize crossings with sewer pipes.

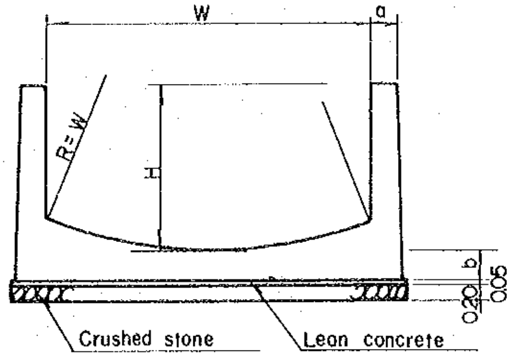
The major disadvantage, on the other hand, is that residents can easily dispose refuse into the open drains, resulting in blockage in many places. This disadvantage should be dealt with by an educational campaign, although it would be a time-consuming undertaking.

Of the two types of sections, unlined and lined, the unlined channel is inexpensive to construct but requires more land. Downstream discharges of the unlined channel are less because of increased storage and longer attenuation of peak flow. Although considered most suitable for trunk drains wherever sufficient land space is available, the unlined channel is not recommended basically for the present Project because of insufficient land available due to the progress in land development.

In designing the channels, 1 to 1 side slopes for masonry drains, as well as vertical slope for concrete channel, are adopted, because the soils range from soft to very soft clay except in a few hilly areas. This is considered suitable for general approach, but may require modification during detailed design or construction work in some specific areas according to the actual soil condition encountered.

Although brick-walled drains are now used even for trunk drains, for economical reason, this type of drain cannot sustain heavy traffic load and therefore is not recommended.

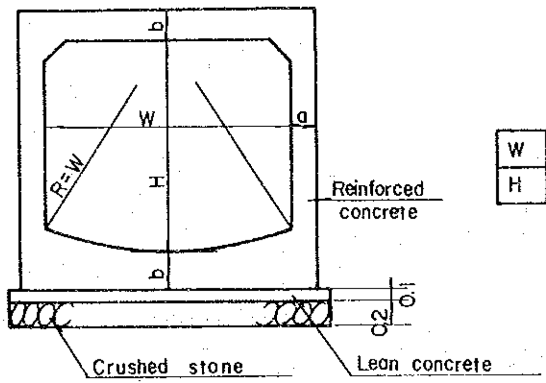
R.C. Open Channel



m

W	0.8 ~ 2.9	a	0.10 ~ 0.25
H	0.8 ~ 2.9	b	0.10 ~ 0.25

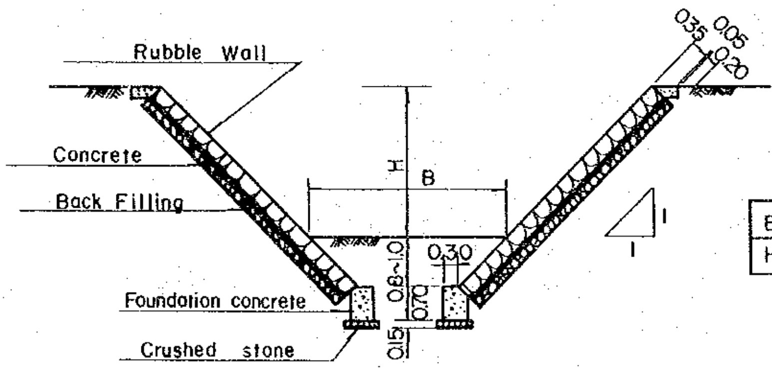
R.C. Box Culvert



m

W	1.3 ~ 2.8	a	0.15 ~ 0.25
H	1.3 ~ 2.8	b	0.15 ~ 0.25

Rubble Wall Channel

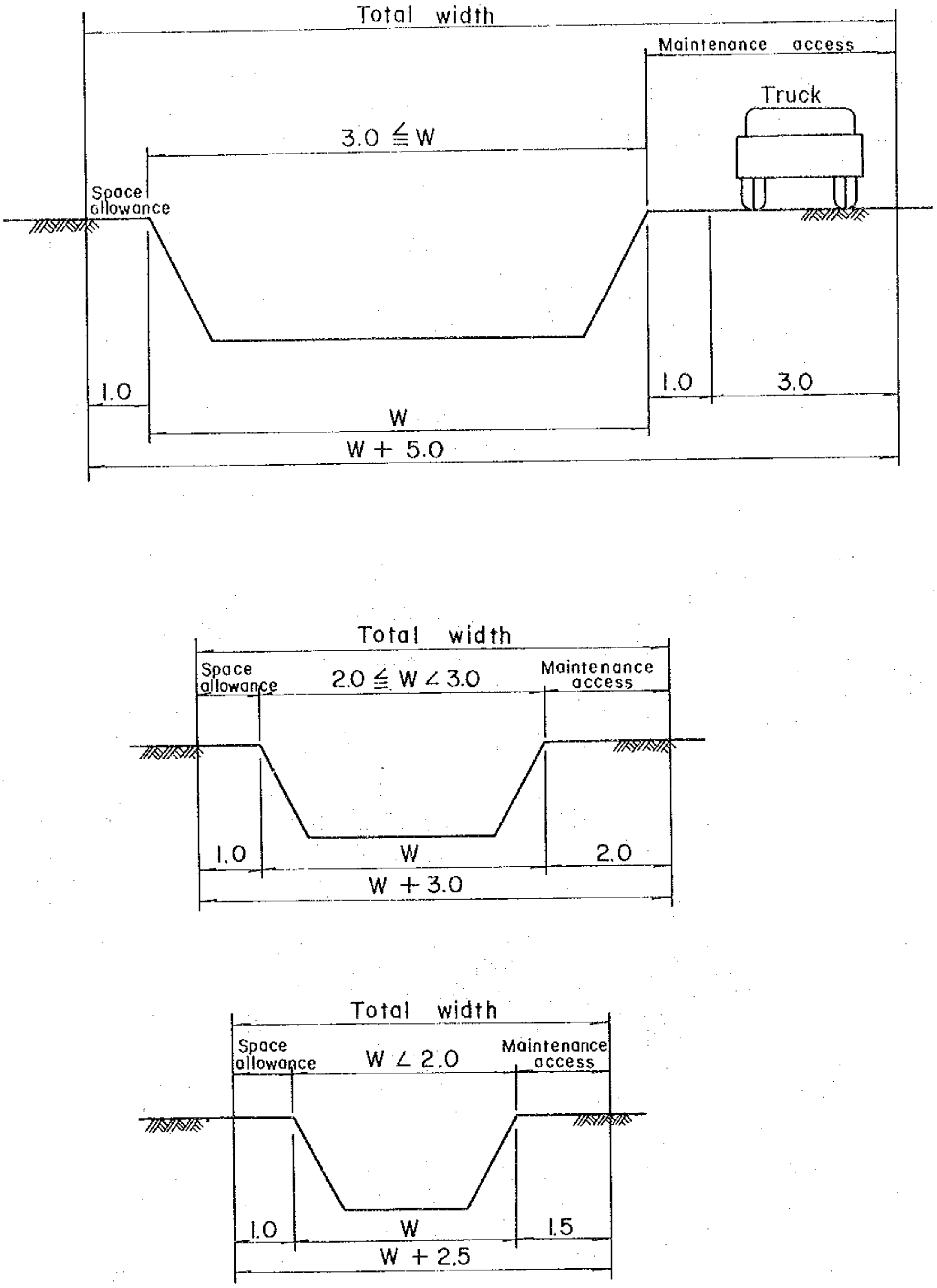


m

B	2.5 ~ ∞
H	2.1 ~ 2.7

Cross-Section of Standard Drain

Fig. 4.2



[Unit : meter]

Cross-Section of Standard Drain Reserve	Fig. 4. 3

In sparsely populated areas, masonry or rubble pitching trapezoidal channels will be used. In densely populated areas, reinforced concrete rectangular sections with side walls designed to retain lateral loads are adopted. Also, a dry weather flow section will be provided for self-cleansing and flushing of channels with extensive sedimentation when minor storms occur.

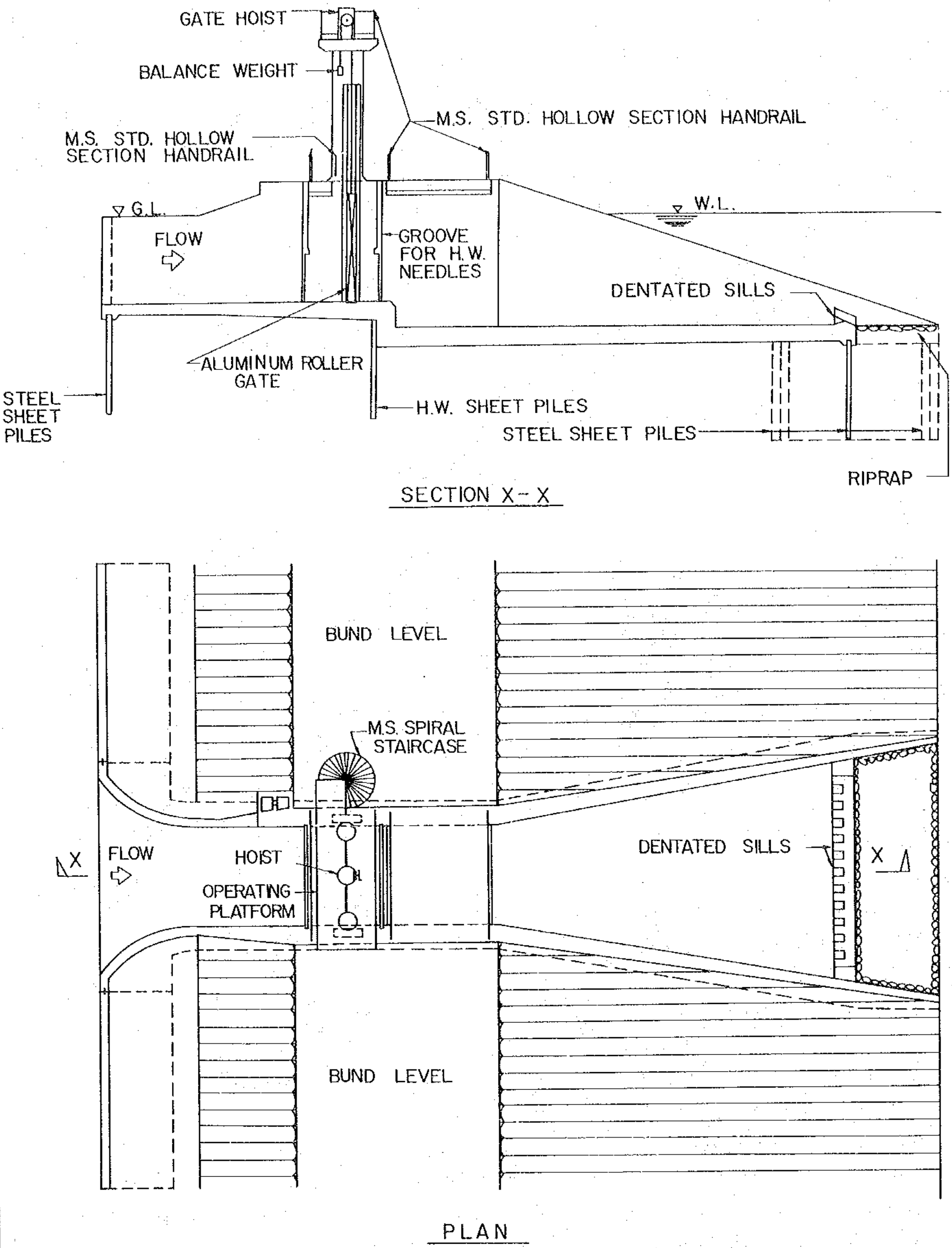
The size of drains is based on provision of an additional allowance of 20 percent of the stormwater discharge, and the water level is decided on 90 percent of actual depth, providing 10 percent freeboard, because of probable reduced effectiveness of section area of drain. This is especially to allow for large amounts of storm flow with heavy debris, which could clog the drain during heavy storms.

4.4.2. Tidal Gate

The tidal gate is the outlet structure of the drainage system for stormwater discharge. The gate is closed during periods of high tide when the water level in the river or sea is higher than the water level in the drain and is opened only when discharge from the drains is possible.

The Kelang River water level is greatly affected by the sea level but is not affected by upstream floods as long as the rainfall intensity falls within a 5-year return period. Thus, operation of the tidal gate is based on the sea level. Provision of the retention pond would enable the use of smaller tidal gates, as the stored water in the pond could be drained as required, whenever the river water level is lower. However, storage is not recommended, since prompt drainage prevents flooding, especially in low areas. Therefore, the size of the gate is made the same as that of the downstream drain to allow prompt drainage.

The manually-operated gates are not only defective but tedious and time-consuming to operate, requiring unnecessary manpower. It is therefore recommended that all existing tidal gates be replaced with mechanically-operated types, centrally inspected for proper operation of the desired number of gates. This would enable rapid operation necessary to prevent backflooding as well as quick and efficient drainage.



Typical Gate Structure	Fig. 4.4

4.4.3. Bund

The bund is an embankment for preventing river water from spilling over, and the bund crown is used generally for monitoring and also for other activities to protect the bund itself during floods. Therefore, the bund crown is designed to be 3.3 meter wide to enable the passage of vehicles to conduct various activities.

The Kelang River high water level for planning purpose has not been determined yet and the Kelang River water level is dominated by the sea water level. The highest high tide was predicted at R.L. +2.6 m, according to the 1981 tide table. On the other hand, the highest water level in the Jambatan Kota, Kelang, was R.L. +3.1 m, according to the DID survey started in May 1981. The height of the bund crown is designed to be R.L. +3.6 m with freeboard of 0.5 m.

Although the side slope of the bund should be determined on the basis of such conditions as infiltration, slide and sinking, side slope of 2:1 to 3:1 is usually used, based on experience. Side slope of 2:1 is considered to be generally safe. Since the bund in Kelang will be constructed close to urbanized area, it is designed with 2:1 side slope. In addition, 6.6 meter-wide land is required for maintenance of the bund.

Bund will be made from clay, similar to those existing, since clay has advantageous characteristics, such as ease of construction, crack-free and slide-free. Furthermore, clay is readily available in and around Kelang, which reduces construction cost.

4.4.4. Retention Pond

Although storage of stormwater generally requires considerable land space, it is one of the most effective means to reduce peak stormwater runoff. This facility would, therefore, be normally considered in the planning of a drainage system for undeveloped areas where enough land space is still available.

In Kelang Municipality, where development has already progressed widely, land for storing stormwater can be acquired only in swamp areas, such as in the northern part of South Kelang and a part of Port Kelang.

The following procedure is taken for computing the required capacity of the retention pond:

(1) Calculate duration of gate closure
(2) Develop inflow hydrograph
(3) Calculate accumulated inflow
(4) Calculate required storage capacity of retention pond

4.5. Materials and Methods of Construction

4.5.1. Construction Materials

1) Structural Materials

Most construction material for drainage are available in Malaysia except equipment required for pumping stations and tidal gates, such as pumps, electric and control facilities and larger gates.

Sand and gravel suitable for concrete aggregate are available in adequate quantity in and around the town of Kelang. Portland cement and steel bar are also manufactured in Malaysia, suitable for drainage construction, such as civil and building works for open channels and box culverts.

2) Channel Materials

As pointed out previously (Section 4.4.1. Open Channel) open channel is mainly used for the proposed drain, except where drains pass through a road or railway, in which case the box culvert or bridge is used. The open channel consists of those made of several types of material; namely, earth drain, masonry drain and concrete drain. These materials are available in Malaysia.

4.5.2. Drain Construction Methods

The major part of drain construction is excavation. However, as most of the proposed drains are expansions of those already existing, use of the existing drainage system at the time of construction becomes an important factor. Schedule of construction work should be carefully planned to be performed during the dry season or the period when excess water can be avoided.

4.5.3. Capabilities of Local Contractors and Manufacturers

Civil work in the construction sector expanded during the last decade in response to the nation's requirements according to the progress of the development program. Investment in architectural construction and civil work accounted for about 40 percent of the total private investment in 1980. Therefore local contractors have had abundant opportunities to gain experience and are now capable of carrying out different types of construction, including drainage facilities, as demonstrated in other areas such as Kuala Lumpur.

4.6. Basis of Design

Design criteria presented herein are basically in accordance with those in DID's "Planning and Design Procedure No.1, Urban Drainage Design Standards and Procedures for Peninsular Malaysia."

4.6.1. Runoff Formula

The "Rational Formula" is widely used in current practice for computing quantities of stormwater runoff. Although it is normal to apply the "Rational Method" in which storage effects inside drains are not considered, the Malaysian Standards recommend the use of the "Rational Method" with a storage coefficient as expressed below:

$$Q = \frac{1}{360} C_s CIA$$

where

Q : Peak discharge of return period T-year (m^3/sec)

I : Average intensity of rainfall for duration equal to the time of concentration and a return period T-year (mm/hr)

A : Catchment area (ha)

C : Runoff coefficient

C_s: Storage coefficient which is expressed as

$$C_s = \frac{2tc}{2tc+td}$$

tc: Time of concentration (min)

td: Time of flow in the drain (min)

The application of a runoff formula modified by a storage coefficient is preferable in the Project Area which is totally flat and low.

The relationship between C_s, tc and td in the Malaysian Standards is derived on the basis of internationally acceptable theory, and the result of its practical application to four drainage basins in Kuala Lumpur coincides with those obtained by the more elaborate routing procedure based on computer calculation. The derivation of C_s as a function of tc and td is explained in "Flood Estimation for Urban Areas in Peninsular Malaysia: Hydrological Procedure No. 16," published by the Ministry of Agriculture and Rural Development, Malaysia.

4.6.2. Rainfall Intensity - Duration - Frequency Formula

For expression of rainfall intensity - duration - frequency curves, the following equations are developed on the basis of figures given in "Rainfall Intensity -Duration - Frequency Relationship", in DID's "Planning and Design Procedure No. 1, Urban Drainage Design Standards and Procedures for Peninsular Malaysia".

Although those figures were developed for Kuala Lumpur, it has become evident that the rainfall relationship ranging from 1 to 30 days in Kelang is almost the same as that in Kuala Lumpur. Therefore, those figures for Kuala Lumpur ranging up to 24 hours are adopted for Kelang.

2-year frequency $I_2 = \frac{5,850}{t + 28}$ (mm/hr)

5-year frequency $I_5 = \frac{7,000}{t + 29}$ (mm/hr)

100-year frequency $I_{100} = \frac{10,240}{t + 32}$ (mm/hr)

where

t: Time of concentration (min.)

4.6.3. Runoff Coefficient

Runoff coefficients to be used for designing are determined, taking into account the various types of surfaces of the Project Area. The recommended coefficients for the Area by type of land use are as follows: (Ref: Appendix C, Vol. VIII: Stormwater Quantity).

Table 4.1. Runoff Coefficient by Type of Land Use

Land Use	Runoff Coefficient
Residential Area (Densely populated)	0.75
Residential Area (Moderately populated)	0.55
Residential Area (Sparsely populated)	0.45
Commercial Area	0.90
Industrial Area	0.65
Institutional Area	0.50
Port Area	0.90
Open Space	0.30
Plantation	0.30
Mountainous Area	0.50

4.6.4. Time of Concentration

The concept of time of concentration is used for estimation of peak discharge derived from the rainfall duration relationship curve for the given frequency.

The time of concentration consists of the inlet time of runoff flow over the ground surface to the nearest drain plus the time of flow in the drain from the most remote inlet to the point under consideration, as expressed in the following equation:

$$tc = to + td$$

where

tc: Time of concentration (min)

to: Inlet time (min)

td: Time of flow in the drain (min)

Inlet time is estimated to be 10 minutes on the basis of the situation in the area concerned. Appendix C "Stormwater Quantity", describes in detail the estimation of inlet time. The time of flow in the drain is estimated according to the hydraulic properties of the individual channels.

4.6.5. Flow Friction Formula

For the hydraulic design of open channels, Manning formula is applied as expressed below:

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

where

V : Velocity (m/sec)

n : Roughness coefficient

R : Hydraulic radius (m)

I : Gradient

The value of "n" is determined according to the type of drain as defined below:

Concrete Drain	
Cast-In-Place	n = 0.015
Precast	n = 0.013
Wet Masonry Drain	n = 0.025
Earth Drain	n = 0.030

4.6.6. Velocity of Flow

To prevent deposition of grit and sand in storm drains, the velocity of flow should not be lower than 0.6 meter per second (2ft./sec) in any type of drain.

Care should also be given to maximum velocity of flow to prevent erosion of drains. The recommended minimum and maximum velocities for various types of drain are summarized below:

Table 4.2. Design Velocity by Type of Drain

Type of Drain	Design Velocity (m/sec)	
	Minimum	Maximum
Concrete Drain	0.6	3.0
Masonry Drain	0.6	2.5
Earth Drain	0.6	1.0

4.7. Basis of Cost Estimates

4.7.1. General Basis

Cost for drainage improvement consists of construction cost, operation and maintenance cost and engineering fees. For estimating these costs, information and data on material and labor cost in and around the Project Area were collected during the course of field studies from such sources as MPK, DID, JKR, LLN, WWD, KTM, JT, the Statistics Department, local manufacturers and local contractors.

The data on labor costs and material cost are presented in Table 4.3 and Table 4.4 respectively. All basic cost collected from the above sources are expressed at 1981 price level in Malaysia. Using the basic cost obtained, unit cost for construction, including both labor and materials, are estimated with due consideration for construction methods and suitable materials, including the capabilities of local contractors and suitability of local materials. These estimated unit costs, including material and labor costs and management cost and profit (but excluding engineering fees and contingency cost), are summarized in Table 4.5.

4.7.2. Costs of Constructing Structures

Based on the unit construction costs of Table 4.5, the costs of constructing structures such as drains and tidal gates are estimated as follows:

Table 4.3. Labor Cost

Type of Labor	Labor Cost (M$/day) (@8 hrs./day)
Common Laborer	17.0
Skilled Laborer	24.0
Welder	27.0
Mason	27.0
Carpenter	27.0
Mechanic	27.0
Brick Layer	28.0
Concrete Worker	28.0
Steel Bender and Fixer	28.0
Painter	28.0
Lorry Driver	30.0
Equipment Operator	35.0
Foreman	45.0

Table 4.4. Cost of Basic Materials

Item	Unit	Price (M$)	Remarks
Cement	t	196.18	
Sand	m^3	11.00	
Laterite	"	3.00	
Aggregates			
9 - 13mm	m^3	35.00	
25 - 38mm	"	31.00	
Crusher-Run	"	25.00	
Diesel Oil	liter	0.46	
Light Oil	"	0.50	
Steel Bar	t	960.00	
Timber	m^3	210.00	Grade A
Timber	"	260.00	Grade B
Ready-Mixed Concrete			
1 : 1½ : 3 mix	m^3	160.00	
1 : 2 : 4 mix	"	152.00	
1 : 3 : 6 mix	"	141.00	
Mortar	"	164.00	
H-shape Beam	t	1,100.00	
Sheet Pile	"	1,034.43	
Bakau Pile			
10 cm	6 m	6.90	
11.3 cm	"	7.50	
12.5 cm	"	8.50	
15 cm	"	10.30	
Box Culvert			
610mm x 455mm (24"x18")	1.22 m	185.50	
760 x 610 (30"x24")	"	217.50	
915 x 760 (36"x30")	"	247.50	
1,220 x 915 (48"x36")	"	328.00	
1,830 x 1,220 (72"x48")	"	609.50	
1,830 x 1,525 (72"x60")	"	691.00	
1,830 x 1,830 (72"x72")	"	745.00	
Tidal Gate (Aluminum Roller)			
4,267mm x 3,658mm (14'x12')	set	39,000	
3,962 x 3,658 (13'x12')	"	38,000	
3,658 x 3,658 (12'x12')	"	36,500	
3,353 x 3,658 (11'x12')	"	35,500	
3,048 x 3,658 (10'x12')	"	34,000	

Table 4.5. Unit Construction Cost

Item	Unit	Rate (M$)
1. Excavation		
Backhoe	m^3	1.61
Clamshell	"	7.08
2. Transporting Soil (average distance of 2 km)	m^3	3.91
3. Transporting, Placement and Compacting of Soil (Bulldozer)	m^3	1.36
4. Transporting, Placement and Compacting of Soil (Bund)	m^3	14.64
5. Supply and Placement of Concrete		
1 : 1½ : 3 mix	m^3	243.51
1 : 2 : 4 mix	"	233.11
1 : 3 : 6 mix	"	218.81
6. Supply, Cutting, Bending and Placement of Mild Steel		
13.0 mm and below	kg	1.74
16.0 mm and above	"	1.65
7. Forming		
Timber for small structure	m^2	2.66
Timber for other structure	"	14.28
Metal	"	14.95
8. Installing Box Culvert		
1,500 mm x 1,500 mm	m	766.34
2,500 x 2,500	"	1,375.94
3,000 x 3,000	"	1,702.94
9. Pitching and Driving Bakau Pile (3)		
100 mm x 3 m	each	21.15
113 mm x 3 m	"	21.75
125 mm x 3 m	"	22.75
150 mm x 3 m	"	24.55
125 mm x 5 m	"	26.44
150 mm x 5 m	"	28.24
10. Supply and Placement of Mortar		
1 : 2, 20 mm thickness	m^2	11.90
1 : 3, 30 mm thickness	"	10.97
11. Steel Sheet Piling Work		
2.0 m depth (= 2.5 m)	m	98.55
2.5 " (= 3.0 m)	"	108.72
3.0 " (= 3.5 m)	"	118.92
3.5 " (= 5.0 m)	"	172.61
4.0 " (= 6.0 m)	"	200.22
5.0 " (= 7.0 m)	"	225.51
5.5 " (= 8.0 m)	"	250.84
6.0 " (= 9.0 m)	"	280.76
7.0 " (= 10.0 m)	"	306.06
7.5 " (= 11.0 m)	"	335.99

Note: Cost includes not only labor but also material.

1) Trunk Drain

The cost of constructing trunk drains of various sizes are computed and plotted in Figs. 4.5 to 4.8.

Factors included in the consideration of cost are excavation, reinforced concrete, rubblestone, dewatering, steel sheet piling, etc. The major cost items for these drains are reinforced concrete and sheet piling which constitute 50 percent and 20 percent of the cost respectively.

Since the recommended drain facilities include gates and box culverts, construction cost for these items are also estimated. Construction cost of box culverts are developed as shown in Fig. 4.7.

2) Tidal Gate

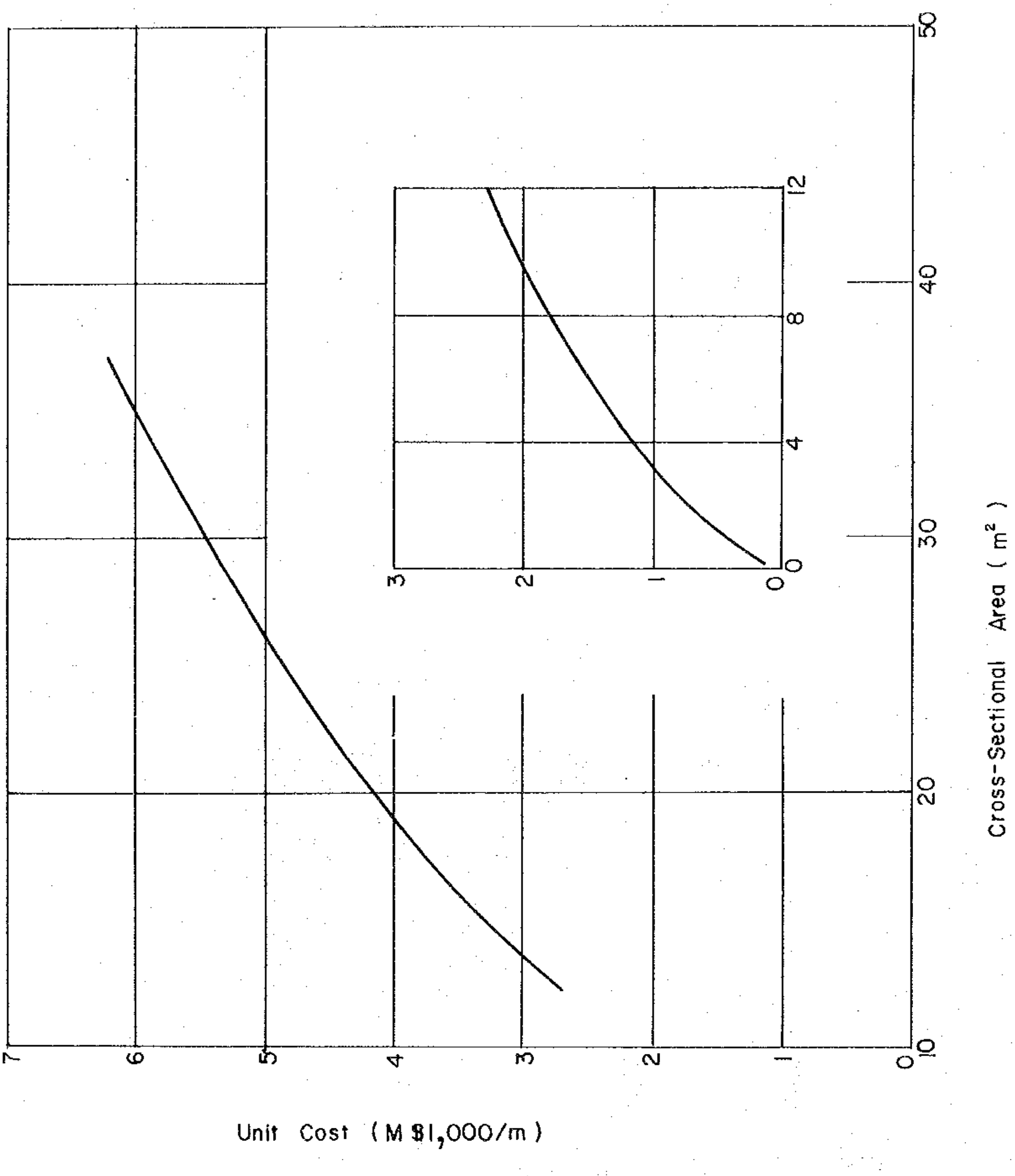
The cost of constructing tidal gates is computed and plotted in Fig. 4.9.

3) Bund

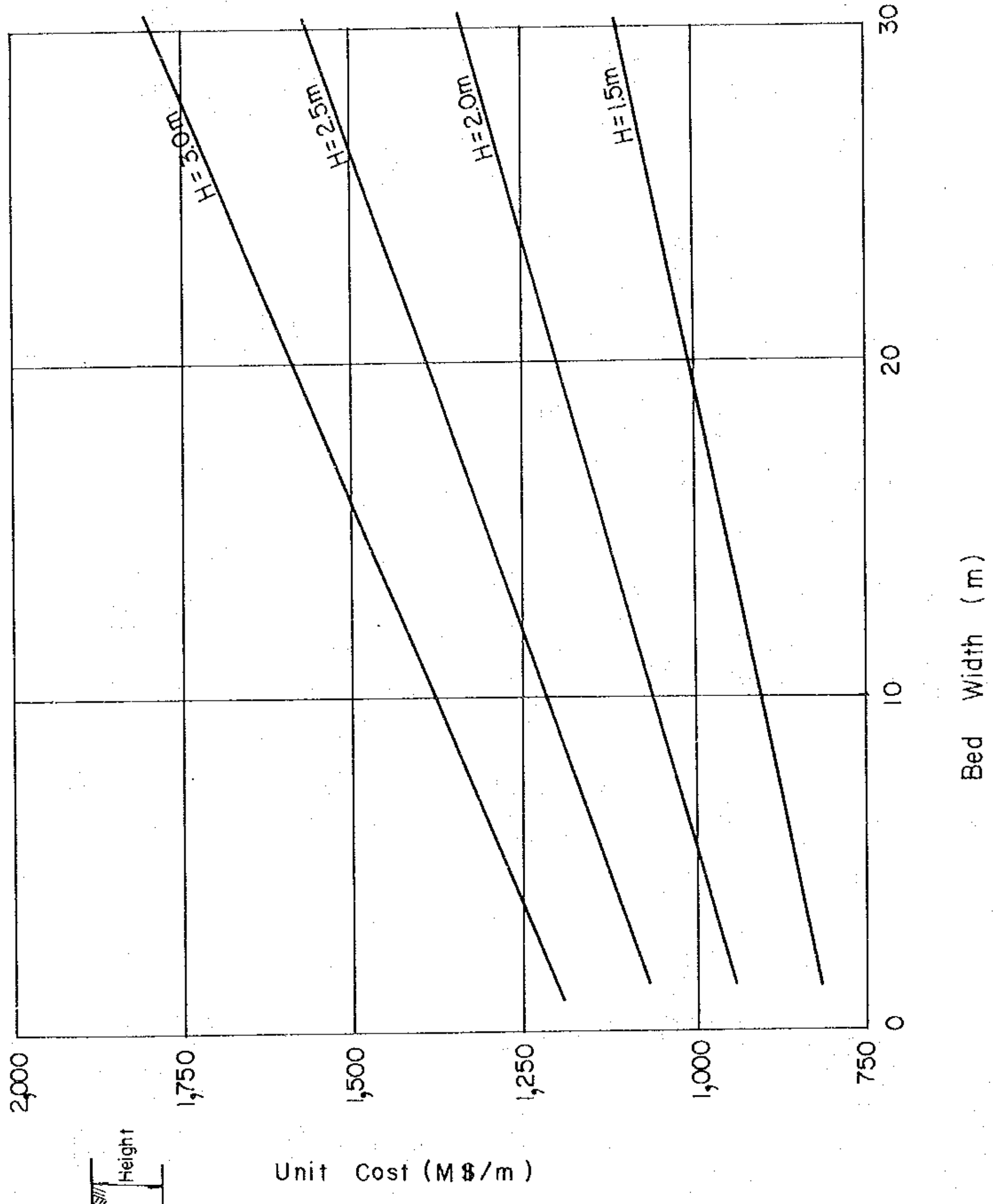
Unit construction cost of bunds is estimated on the basis of length. The work required for their construction includes landfilling and compaction. Unit costs of bunds are as follows: M$29.28 per meter length for 0.5 m height, M$73.20 per meter length for 1.0 m height, and M$131.76 per meter length for 1.5 m height.

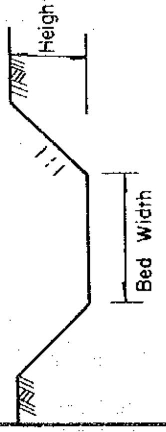
4) Retention Pond

The cost curve for the retention pond is developed, calculating that 1) its depth is roughly 2.5 m to enable water to discharge by gravity flow after flood recession, and 2) it is constructed with masonry. (Ref.: Fig. 4.10.)



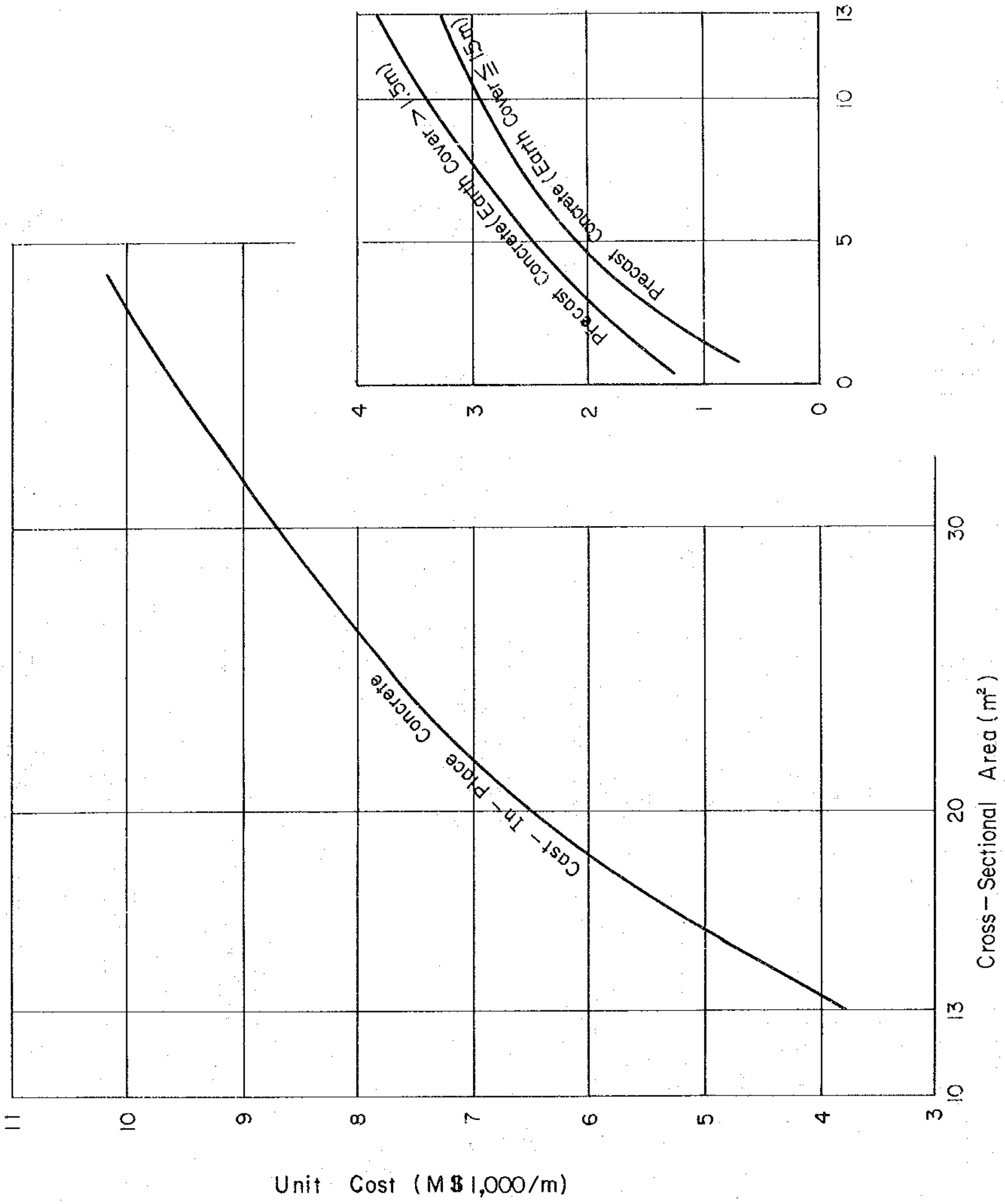
Cost Curve for Concrete Rectangular Open Channel	Fig. 4. 5



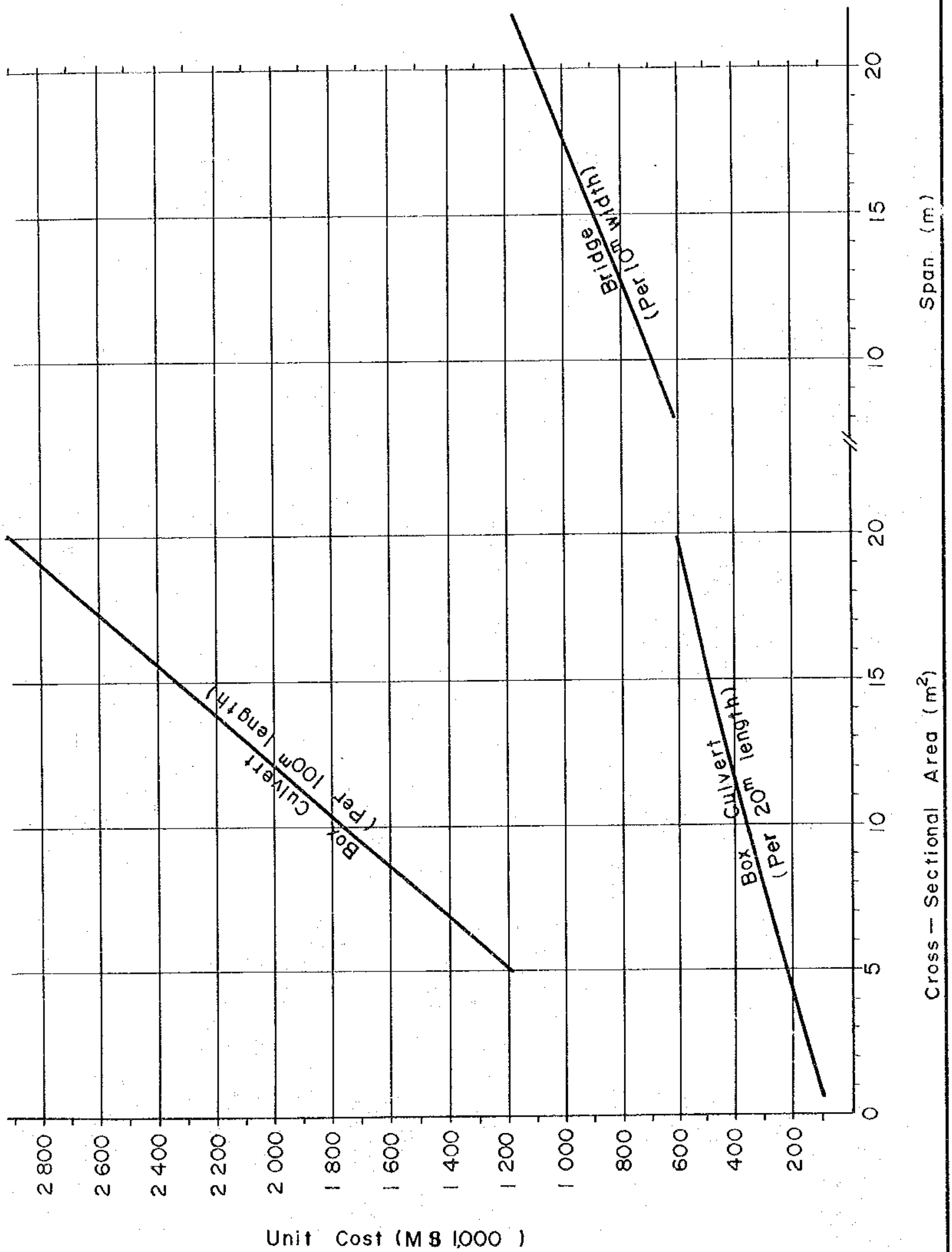


Cost Curve for Masonry Trapezoidal Channel with Side Slope 1:1

Fig. 4. 6

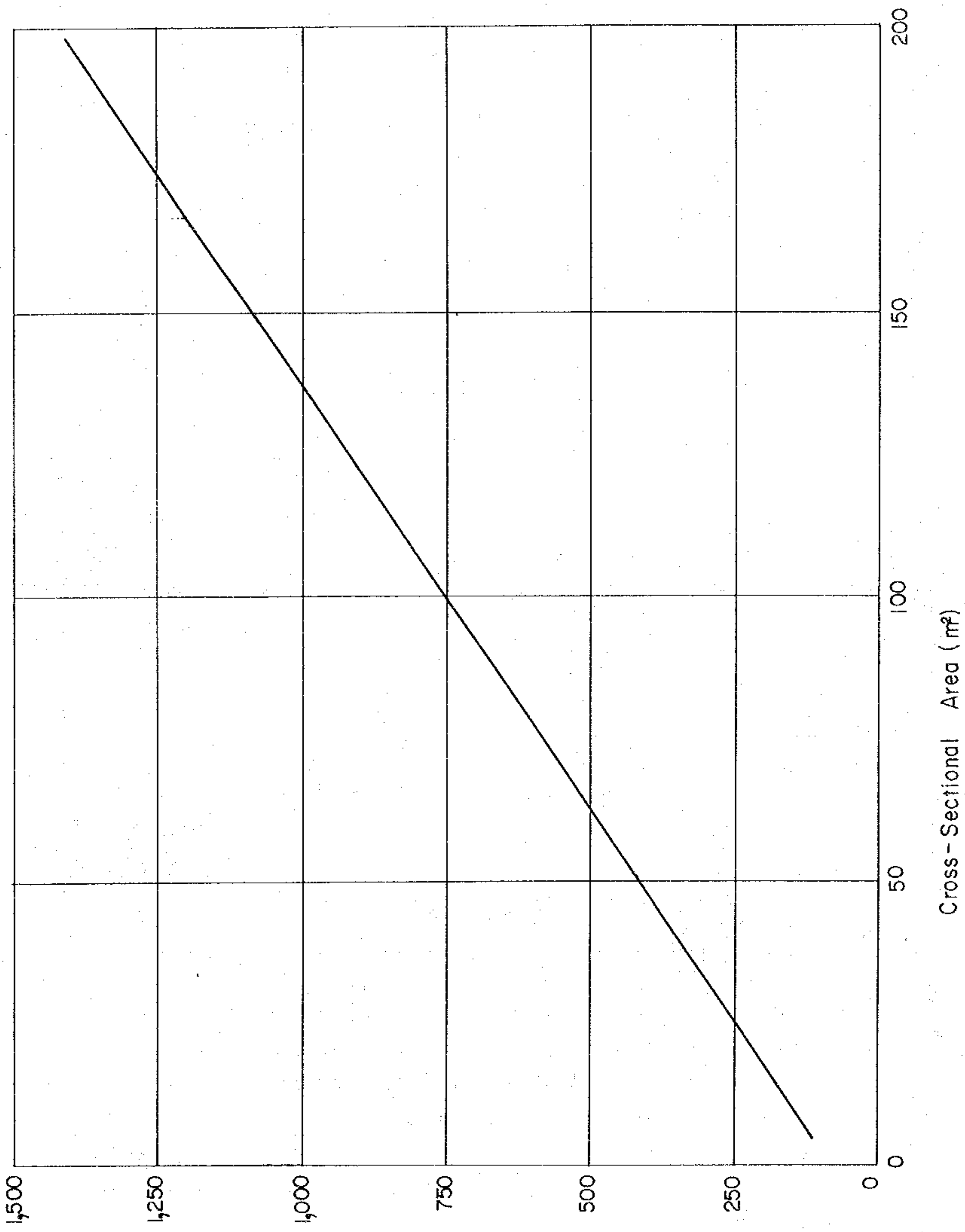


Cost Curve for Box Culvert	Fig. 4.7



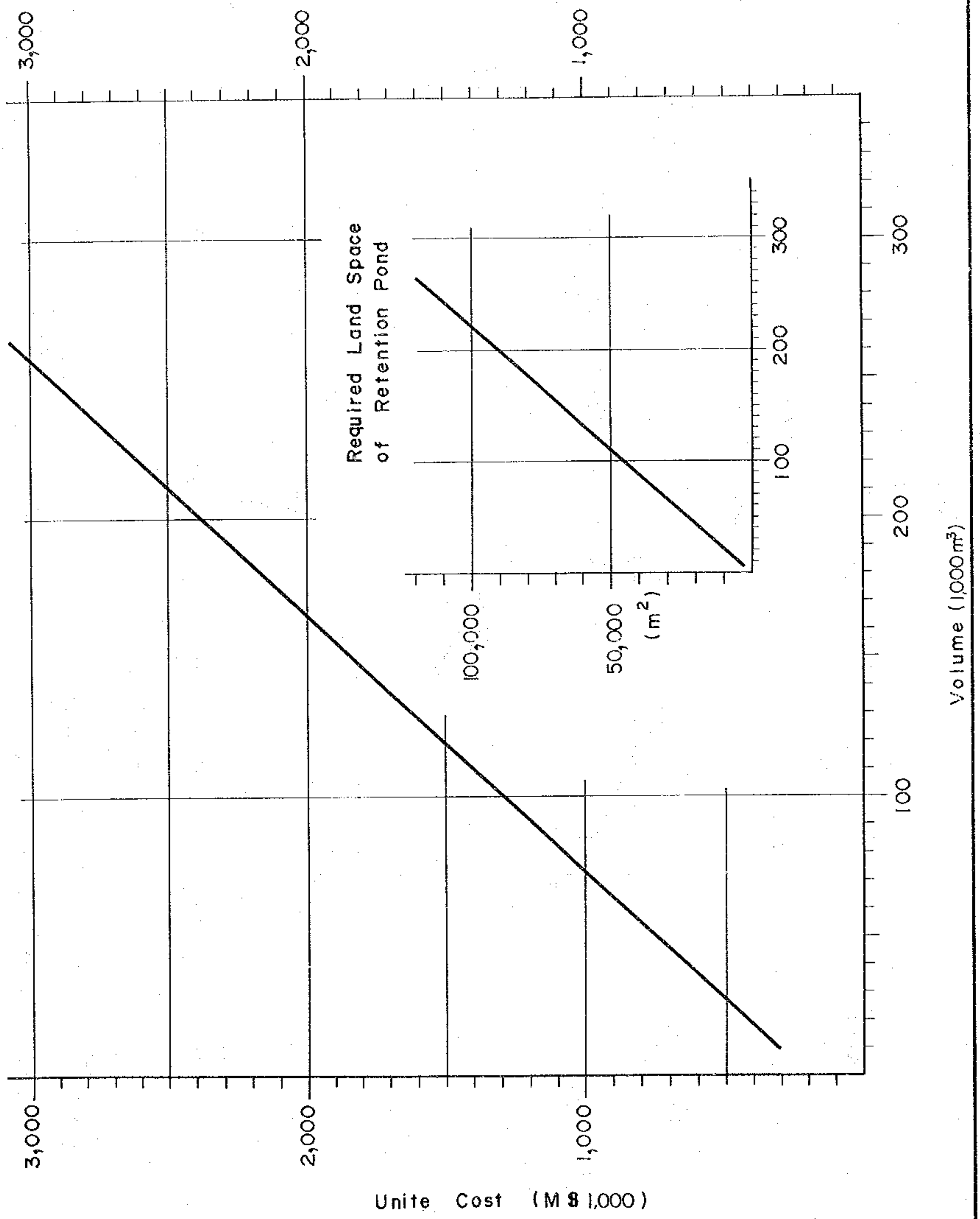
Cost Curve for Railway Crossing

Fig. 4.8



Unit Cost (M $ 1,000/each)

Cost Curve for Tidal Gate	Fig. 4. 9



Cost Curve for
Retention Pond

Fig. 4.10

4.7.3. Contingency Cost and Engineering Fees

Contingency cost to cover unforeseen conditions is included in the cost estimates as a separate item at the rate of 20 percent.

Engineering fees, which include detailed design with tender documentation and construction supervision, are also included as a separate item at a rate of 15 percent.

4.7.4. Land Acquisition Cost

Unit land acquisition cost in each area is presented in Fig. 4.11.

4.7.5. Unit Operation and Maintenance Cost

Currently, maintenance of the existing drainage system in the Project Area is being performed by the Kelang Municipality, while some of the agricultural drains and tidal gates are being controlled or operated and maintained by the State DID. Some M$1.1 million per year has been spent on cleaning about 410 km of channel by the Kelang Municipality, although this figure seems lower than what sufficient maintenance would require.

Operation and Maintenance work for the drainage system consists of the removal of deposits from drains, operation of gates, and repair of damaged parts of all drainage facilities.

1) Removal of Deposits

The unit cost of removing deposits is calculated on the assumption that a) an average volume in drain deposits is 10 percent of the cross-sectional area on an annual basis, b) machine excavation is applicable for trunk drains and retention pond, c) manual excavation is applicable for smaller drains, d) cost of removing deposits from drains is 20 percent higher than the excavation cost estimated in Table 4.4 and e) cost of transporting removed materials from the site to designated dumping sites is the same as that of excess earth disposal cited in Table 4.4.

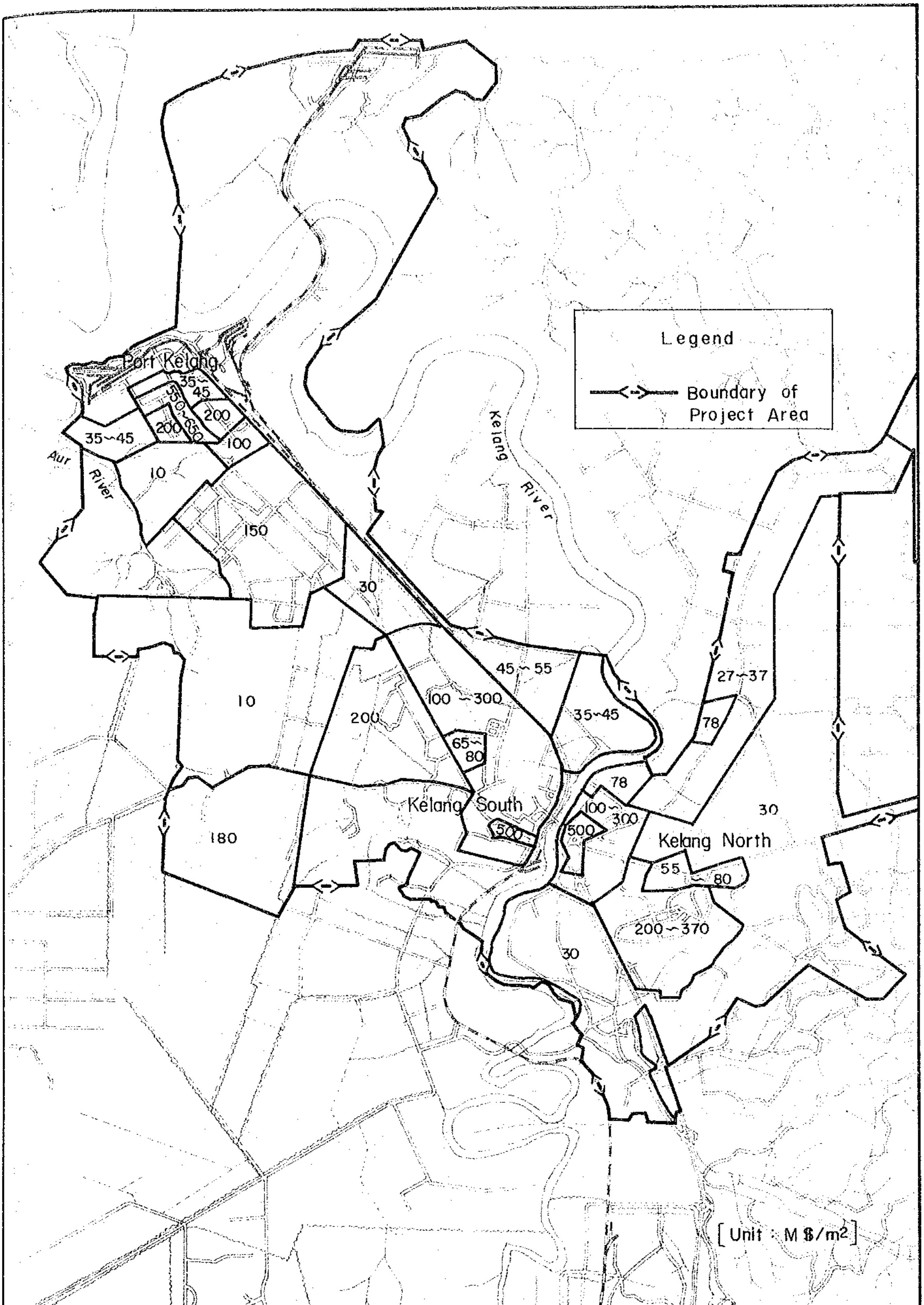
The unit cost for the removal of deposits, and disposing of refuse materials from trunk drains and retention ponds is estimated at M$19.13/$m^3$ with M$16.63/$m^3$ for small drains. The average volume of small drain is estimated at 11.4 m^3 per hectare.

2) Channel Repair

The annual repair cost for each drain is assumed to be 0.5 percent of the construction cost.

3) Operation of Gates and Inspection of Drains

A total of 15 laborers are required for operation of about 30 tidal gates, as well as inspection of all drains in the Master Plan area, covering 6,628 hectares.



Unit Land Cost

Fig. 4.11

CHAPTER 5

PROPOSED DRAINAGE SYSTEM AND CONSTRUCTION COST

CHAPTER 5 PROPOSED DRAINAGE SYSTEM AND CONSTRUCTION COST

5.1. Project Area

5.1.1. Introduction

The Project Area considered for the drainage system in the Master Plan is identical to that for the sewerage system covering an area of 7,669 ha.

However, for the purpose of planning the drainage system within the Project Area, it is necessary to consider the catchment areas outside the Project Area from where stormwater flows into the area due to topographical conditions. The total contributing areas are estimated to be 16,623 ha, but no facilities are planned for these areas.

Thus, the area concerning drainage system planning is estimated as summarized below:

Project Area:	7,669 ha
Contributing Area:	16,623 ha
Total:	24,292 ha

The North Port area is not included in the Drainage Master Plan, because part of this area is already being served by the existing drainage system and the rest by another proposed drainage system, being independent from the rest of the Project Area. Since the river surface area has to be excluded in the planning, the total areas excluded are:

North Port Area:	810 ha
River Surface Area:	231 ha
Total:	1,041 ha

Thus the area to be covered by the drainage system under this Project is: 24,292 - (16,623 + 1,041) = 6,628 ha. (Ref.: Fig. 5.1.)

5.1.2. Delineation of Catchments

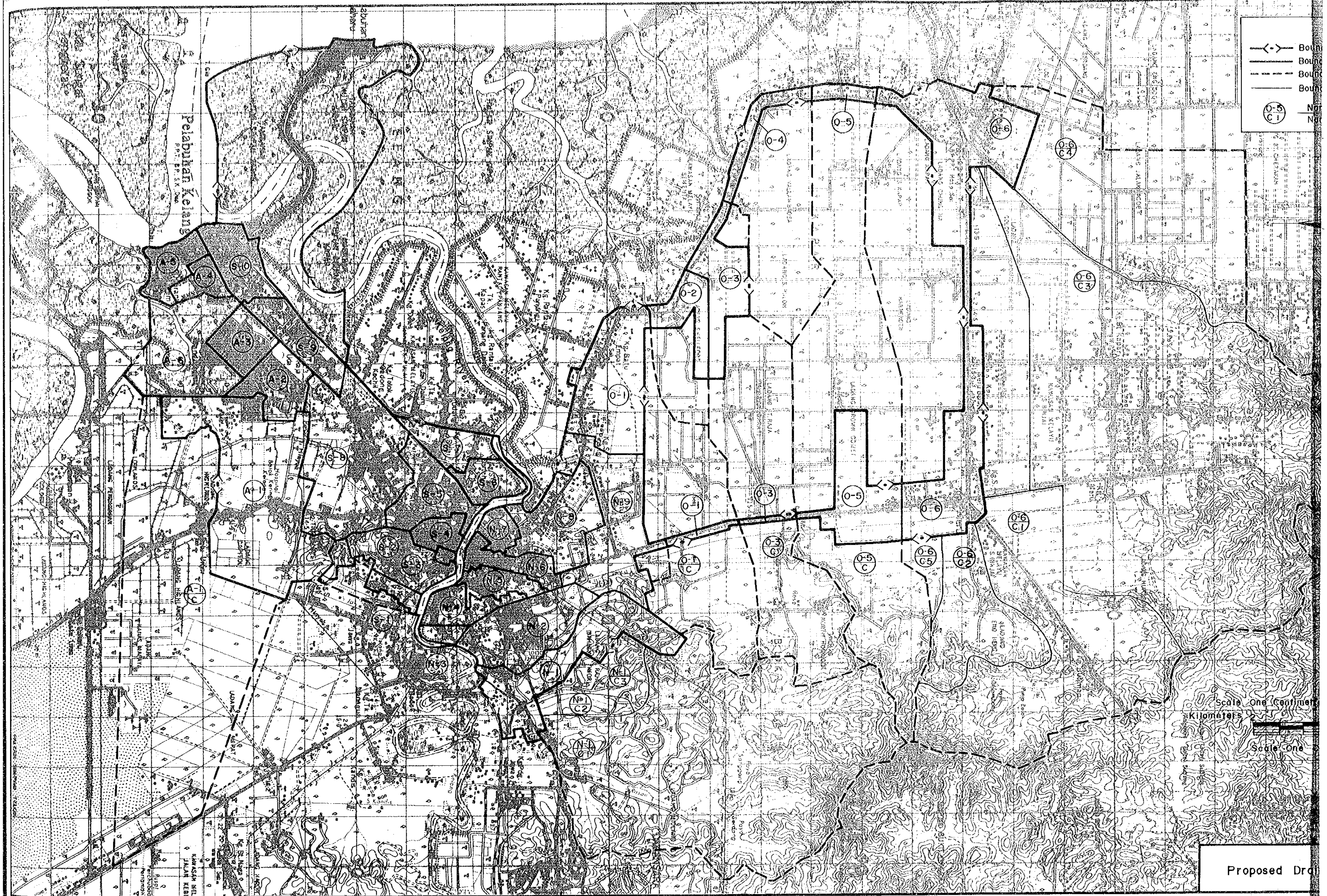
On the basis of careful reconnaissance of the existing drainage system and its condition, existing and future land use, and topographical conditions, the Project Area is divided into 32 catchments for planning purpose, which are mainly in accordance with the existing division, enabling coordination of the current program with those to be proposed in the Master Plan with the following exception (Ref.: Fig. 5.1. & Table 5.1.):

The upstream basin of the existing S-5 catchment, bordered by the railway line and Federal Highway, is incorporated in the S-8 catchment. (Ref.: Section 5.2.3. 2) b))

Each catchment is described in Appendix D, Vol. VIII: Catchments.

Table 5.1. Proposed Drainage Catchment Areas

Catchment Code No.	Size of Area Served by Drainage System (ha)	Size of Contributing Area (ha)	Total Area (ha)
N-1	372.7	2,378.3	2,751.0
N-2	210.1	-	210.1
N-3	25.5	-	25.5
N-4	162.0	-	162.0
N-5	69.5	-	69.5
N-6	72.3	-	72.3
N-7	48.2	-	48.2
N-8	255.0	-	255.0
N-9	342.7	39.4	382.1
S-1	65.1	63.5	128.6
S-2	169.8	7.7	177.5
S-3	11.8	-	11.8
S-4	53.9	-	53.9
S-5	156.1	-	156.1
S-6	96.7	-	96.7
S-7	110.8	-	110.8
S-8	539.2	-	539.2
S-9	120.5	-	120.5
S-10	144.6	-	144.6
S-11	295.5		299.5
A-1	761.7	1,591.6	2,353.3
A-2	133.6	-	133.6
A-3	106.9	-	106.9
A-4	52.5	-	52.5
A-5	100.9	-	100.9
A-6	310.4	-	310.4
O-1	366.9	870.1	1,237.0
O-2	96.7	164.0	260.7
O-3	208.6	1,008.3	1,216.9
O-4	77.8	597.4	675.2
O-5	303.3	1,751.1	2,054.4
O-6	786.7	8,151.6	8,938.3
Total	6,628.0	16,623.0	23,251.0



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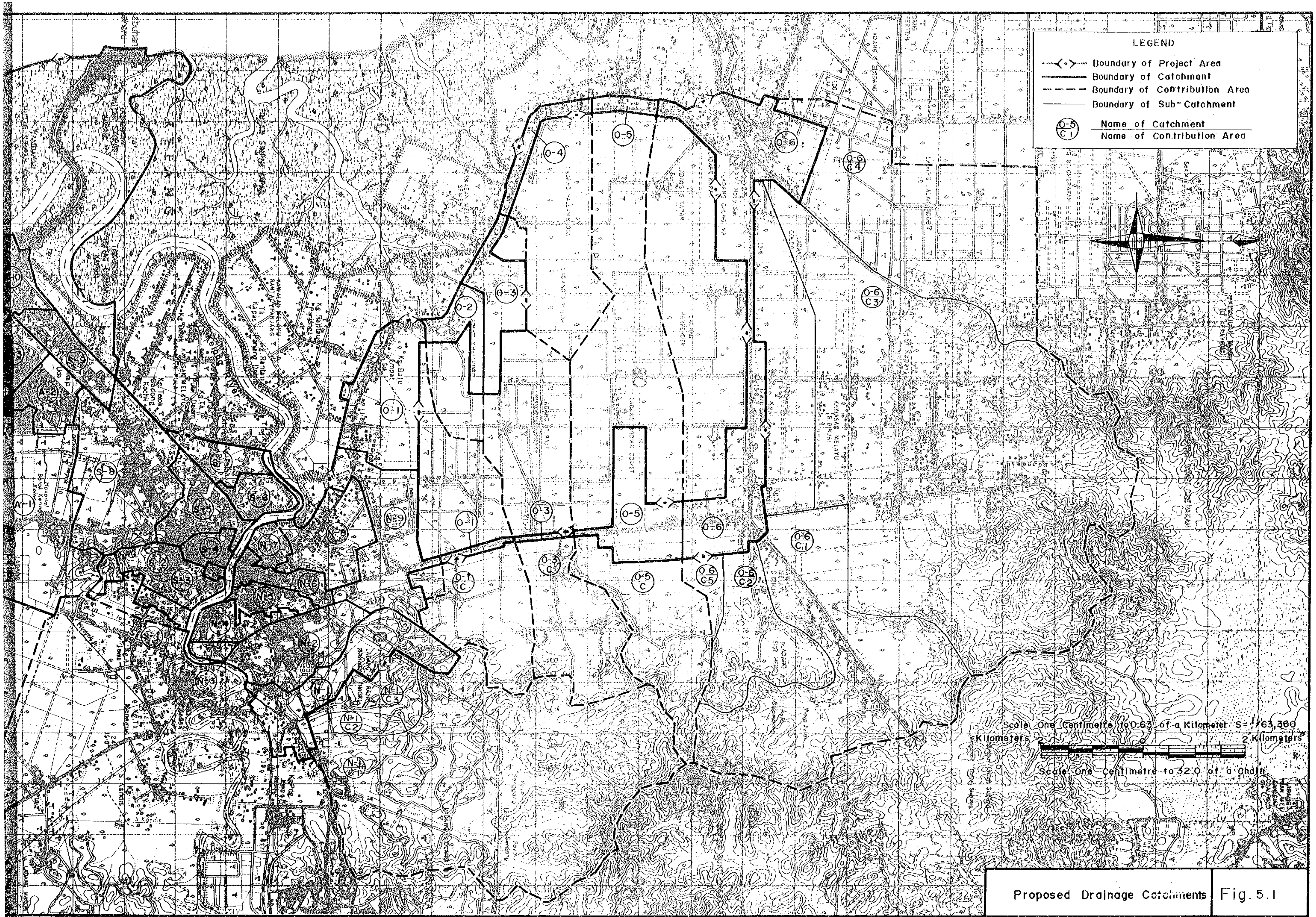

Proposed Drainage Catchments Fig. 5.1

5.2. Possible Measures to Alleviate Flooding

5.2.1. Improvement and Expansion of the Existing Channel Capacity

Basically, improvement and expansion of the existing channel capacity is widely considered, by utilizing the existing facilities to the maximum extent possible, for the sake of economy and efficiency of program implementation.

In considerable parts, especially upstream and midstream of each catchment, the existing drains are inadequate to accommodate runoffs from heavy rainstorms. The basic approach, requiring immediate implementation to alleviate resulting floods is, therefore, to improve and expand the existing facilities wherever necessary.

Such works include:

1) Vegetation and Debris Clearing and Desilting of Channels

Many of the existing drainage channels in the Project Area are severely clogged with vegetation growth and debris of all sorts. In addition, erosion caused by rainfall has created sedimentation problems in all reaches of the drains, presumably due to low velocity in the drain. Clearing, cleaning and desilting will significantly increase the channel capacity. While clearing of small drains has been properly conducted, it should be noted that clearing for trunk drains is also important.

2) Channel Expansion and Lining

The fact that the existing drainage system has been provided throughout the town of Kelang allows the major improvement work to be confined to widening, deepening and/or lining the existing channels, which will greatly increase its capacity. The lining work will have to be done with reinforced concrete sections for maximum capacity under minimum available space, due to the heavily developed condition of the town.

5.2.2. Drainage during High River Stages

1) General Considerations

Prevention of backflow from rivers or the sea is a serious problem, especially in the Project Area. River or tidal levels fluctuating from R.L. -2.4 m to 3.0 m sometimes exceed ground elevation ranging from R.L. +2.0 m to 4.0 m. Bunds, including tidal gates, have been constructed to prevent backflow and spillover, but the size and condition of both tidal gates and bunds are inadequate. Consequently, replacement of tidal gates of proper size, and repair and heightening of bunds are necessary as proposed in the following Section 5.3. During high river stages, these gates will be closed which will result in an accumulation of runoff volume in the drainage channel, thereby causing back-up and finally overspills. Four alternative solutions to this problem, in addition to the general policy of increasing drainage capacity, are:

(1) to raise the general ground level, by way of landfilling higher than flood level and do away with the tidal gates.

(2) to impound the excess volume in a retention pond and release it once the flood stage in the river has passed.

(3) to provide pumping facilities to lift the excess runoff over the bunds during flood stages.

(4) to allow localized flooding in the areas in the vicinity of the trunk drains.

2) Landfilling

Although landfilling requires considerable initial costs, no maintenance or accruing costs need be expected once land has been reclaimed. If the fund is available and wherever warranted by the topography, landfilling is the most effective means for alleviating floods caused by backflow, provided necessary consideration is given for control of the discharge rate from the area for prevention of adverse effects to downstream areas.

Landfilling has been and is being applied for port and industrial development in the North Port area. The average elevation for land reclamation is about +2.7 meters.

Landfilling is proposed in S-11 and A-6 catchments. These catchments, which are now swamps, are expected to become industrial areas, and PKNS is expected to be in charge of the development of these areas, as in the case for the North Port area. It is proposed that drainage system with landfilling be provided simultaneously when these catchments are developed.

Landfilling was conducted for housing development in parts of S-6, S-7 and A-4 catchments. Landfilling is desirable wherever possible, but it is actually to be applied only to S-11 and A-6 catchments, because of its applicability only where development has not taken place.

3) Retention Pond and Pump

Allowing localized flooding, impounding the excess stormwater volume in retention ponds or lifting the excess runoff over the bunds would be necessary except where landfilling is applied. While localized flooding of less-developed areas could be allowed, it could not be allowed in the Project Area, because the entire Project Area has already been developed so much that a large number of people would suffer from flooding. Thus, either construction of retention pond or pump installation must be considered. Of the two alternatives, the retention pond would require a larger area but less equipment cost than installation of pumps.

Therefore, a comparative study of retention pond and pump in S-6, S-9, S-10, A-4 and A-5 catchments is conducted. Table 5.2. shows that drainage system with downstream retention pond is preferable economically to that with pump in addition to the fact that land is available for making downstream retention ponds in these catchments, as follows: