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

VOLUME V

DRAINAGE FEASIBILITY STUDY

MARCH 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

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

VOLUME V

DRAINAGE FEASIBILITY STUDY

MARCH 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

DRAINAGE FEASIBILITY STUDY REPORT

ON

MASTER PLAN AND FEASIBILITY STUDY

FOR

SEWERAGE AND DRAINAGE SYSTEM PROJECT

IN

ALOR SETAR AND ITS URBAN ENVIRONS

MALAYSIA

Guide to the Reports

The Reports consist of the following,

VOLUME I	:	SUMMARY
VOLUME II	:	SEWERAGE MASTER PLAN REPORT
VOLUME III	:	DRAINAGE MASTER PLAN REPORT
VOLUME IV	:	SEWERAGE FEASIBILITY STUDY REPORT
VOLUME V	:	DRAINAGE FEASIBILITY STUDY REPORT
VOLUME VI	:	INSTITUTIONAL STUDY REPORT
VOLUME VII	:	APPENDICES (FOR VOLUME II)
VOLUME VIII	:	DRAWINGS (FOR VOLUME II, IV & V)

VOLUME V - DRAINAGE FEASIBILITY REPORT

ORDER OF PRESENTATION

TABLE OF CONTENTS

DRAINAGE FEASIBILITY STUDY REPORT

Table of Contents

Chapter | Page

ANNEXES

LIST OF TABLE

LIST OF FIGURE

Figure No.

LIST OF ABBREVIATIONS

ACP	- Asbestos cement pipe
ASTM	- American Society for Testing Materials
BOD	- Biochemical oxygen demand (3-day, 30 degrees C)
CRCP	- Centrifugally cast reinforced concrete pipe
DE	- Department of Environment, Ministry of Science, Technology and Environment
DID	- Drainage and Irrigation Department, Ministry of Agriculture and Fisheries
DO	- Dissolved oxygen
DWF	- Dry weather flow
EHEU	- Environmental Health and Engineering Unit, Ministry of Health
EPU	- Economic Planning Unit, Prime Minister's Office
ft	- feet
FTCP	- Federal Town and Country Planning
g/cap	- grammes per capita
g/day	- grammes per day
gal	- Imperial gallons
gal/cap	- gallons per capita
gal/day	- gallons per day
GDP	- Gross Domestic Product
GSD	- Federal Geological Survey Department
ha	- hectares
hr	- hours
IBRD	- International Bank for Reconstruction and Development
IMF	- International Monetary Fund
kg	- kilogrammes
km	- kilometres
l/day	- litres per day
l/day/cap	- litres per day per capita
l/sec	- litres per second
m	- metres
m^2	- square metres
m^3	- cubic metres

LIST OF ABBREVIATIONS (Continued)

MADA	- Muda Agricultural Development Authority
mg/l	- milligrames per litre
mil	- miles
MLG	- Ministry of Local Government
mm	- millimetres
MPKS	- Majlis Perbandaran Kota Setar (Municipal Council Kota Setar)
MPN	- Most probable number
MS	- Meterological Station
MSWL	- Mean Sea Water Level
NEB (LLN)	- National Electricity Board (Lembaga Letrik Negara)
p/ha	- persons per hectare
pH	- Hydrogen iron potential
ppm	- parts per million
PVCP	- poly Vinyl chloride pipe
PWD (JKR)	- Public Works Department, Ministry of Works and Utilities (Jabatan Kerja Raya)
RCP	- Reinforced concrete pipe
SDID	- State Drainage and Irrigation Department
SEDC	- State Economic Development Corporation
SEPU	- State Economic Planning Unit
SLO	- State Land Office
SMHD	- State Medical and Health Services Department
SS	- Suspended solids
STCP	- State Town and Country Planning
VCP	- Vitrified clay pipe
WHO	- World Health Organization
yr	- years

CONVERSION FACTORS

Multiply imperial unit by figures in multiplier column to obtain metric (S1) equivalent; multiply metric (S1) unit by reciprocal to obtain imperial equivalent.

Imperial Unit	Multiplier	Metric unit	Reciprocal
acre	0.4047	hectare (ha)	2.471
ft	0.3048	m	3.281
ft/s	0.3048	m/s	3.281
ft^2	0.0929	m^2	10.76
ft^3	0.02832	m^3	35.31
ft^3/s (cusec)	0.02832	m^3/s (cumec)	35.31
gal	4.546	litre	0.220
gal	0.004546	m^3	220
hp	0.7457	kW	1.341
in	25.40	mm	0.03937
lb	0.4536	kg	2.205
lb/ft^2	4.881	kg/m^2	0.2049
lb/ft^3	16.03	kg/m^3	0.06243
mile	1.609	km	0.6214
$mile^2$	2.589	km^2	0.3862
ton	1.016	tonne	0.9842
yd	0.9144	m	1.094
yd^2	0.8361	m^2	1.196
yd^3	0.7646	m^3	1.308

CHAPTER 1
SUMMARY

1. The purpose of this study is to develop the drainage feasibility study in the most technically and economically feasible manner to meet both immediate and future requirements for solving the flood problems in the Study Area. All the works under this study are established in principle in accordance with the scope of work acknowledged by the Government of Malaysia which defines in developing the plan for the secondary drainage system in line with the trunk drainage system recommended in the Master Plan prepared by SDID, with the preliminary engineering design for both trunk and secondary drainage system in the area.

2. The Study Area covers the total area of 187 ha (462 acres) which is basically identical to the area for sewerage feasibility study presented in separated report, Volume IV "Sewerage Feasibility Study". Due to the topographic conditions of the area, approximately 170 ha (420 acres) of tributary outside of the Study Area is also considered for calculating the drain capacities because the tributary contributes its storm runoff to the Study Area, with consideration on strengthening existing trunk drain in the tributary area. Hence, the total area concerned to this study is 357 ha (882 acres).

3. For the drainage study, all available information and data have been collected from the various agencies concerned, including topographic and street maps, augmented by actual field survey on nuisance flood prone area and conditions of existing drainage systems. The results of the survey and investigation, and their evaluation of existing drainage conditions are concluded as follows:

- Since the Study Area is situated in low-lying and flat with ground elevation ranging from 1.4 m (4.6 ft) at the lowest, to 2.4 m (8 ft) at the highest, major parts of this area are subject to be effected by back-water from the two rivers, namely Sg. Kedah and Sg. Anak Bukit, and are flooded frequently by river inundation, especially when the river water reaches in the more than five year flood levels. This is one of the main causes of local flooding in the Study Area.

- The existing drainage system consists of two trunk drains, namely Sg. Raja and Sg. Derga, and various types of secondary and infrastructural drains, including those facilities of bridges, box culverts and pipes. The trunk drains are basically natural stream with earth channel with various width and depth, and are heavily silted with about 1 meter or more in depth, with insufficient capacities to cater for the surface runoff from the present ground conditions, thus resulting in the need for immediate improvement. The secondary and infrastructural drains have generally been well provided and working satisfactorily so far, under suitable construction and appropriate maintenance carried out by the concerned agencies, some of which, however, require to be enlarged and lined to increase it capacity to cope with the runoff increases in the future, due mainly to the progress of urbanization of the area.

- In view of the overall existing drainage system, the Study Area can be divided into 3 independent drainage basins consisting of one major basin and two minor basins same as the delineation made in the Master Plan prepared by SDID. Out of these basins, the major basin lies in the centre of the town covering major part of commercial and residential areas, and the others are situated at both side of the major basin. The storm runoff originating from the major basin is first collected by many of smaller drains and then drained out into the existing trunk drains referred above. These trunk drains are connected finally to the Sg. Kedah. In the minor basins, collected stormwater by many of existing smaller drains flows directly into either Sg. Kedah or Sg. Anak Bukit without trunk drain.

4. On the basis of the findings and evaluation of the existing drainage system, and taking into consideration of the Master Plan proposals prepared by SDID, the most desirable layout of the drainage system has been first made and then preliminary engineering desing for the facilities required in the layout has been provided for solution of flood problems in the following:

- The design works of the drainage facilities proposed is basically in accordance with those recommended in DID's "Planning and Design Procedure No. 1 Urban Drainage Design Standards and Procedure for Peninsular Malaysia", and Master Plan proposals by SDID.

- In three independent basis mentioned earlier which are named as Sg. Raja Basin, Langgar Basin and Putera Basin, the trunk drain would be considered only in Sg. Raja basin which is the largest basin among the three, using the existing Sg. Raja and Sg. Derga, while the minor basins have no provision of the trunk drain, since, within these basins, there is no per catchment area exceeding more than 40 ha (100 acres) in which the trunk drain should be provided. These minor basins shall be provided with the secondary and infrastructural drains.

- In developing the most desirable layout of trunk drainage system, two alternatives of trunk drainage system have been considered based on a review and evaluation on the trunk drainage system proposed in the Master Plan by SDID including those facilities of floodway, pumping station and reservoir, and evaluated on the basis of the economic analysis and adequacy of the preliminary engineering design for the required facilities for the system. The proposed drainage facilities covering the need for foreseeable future include trunk and secondary drains, floodway, pumping station, reservoir, embankment and other related facilities as shown in Figure 7.3 of the present report. The proposed route of the trunk drain is basically same as that of the existing

Sg. Raja and Sg. Derga. The type of this drain is of rubble wall with mortar linning using wire nets by way of improving the existing natural water courses, taking into account the advantage on hydraulic, economic and esthetic points. To protect the whole Study Area from backing up of the river water, the outlet gates have been proposed to be installed at the outlet of trunk and secondary drains. Further, for protection of river flooding especially in low-lying area along the Sg. Kedah, embankment is proposed from Jl. Raja to railway along the Sg. Kedah. In order to drain out the storm runoff to the Sg. Kedah, pumping station and reservoir are required at the upstream of Sg. Kedah. These facilities shall be operated after closing the outlet gate when the river water flows affect to the urban drains. In connection with these facilities, the floodway has also been proposed to convey the storms from the outlet of trunk drain to the reservoir. In the area not surved by trunk drain, and recommended. The networks proposed for the secondary drain which shall surve per area of approximately 4 ha (10 acres) is basically in accordance with the existing network system identified based on the findings of the survey carried out during the course of the field works.

5. On the basis of the preliminary engineering design, and procedure for estimating the cost as developed in this study, the total construction cost, and operation and maintenance cost per year of proposed drainage system are estimated to be approximately M$ 16,800,000 and M$ 225,000 per year at 1979 price level respectively, including trunk, secondary and infrastructural drains, pumping station, reservoir, floodway and embankment. The estimated total construction cost is to be all shouldered by the Government, because the Study Area is already urbanized area, and consequently no facility is expected to be constructed by private contribution.

6. Although the facilities required for provision of an adequate drainage system for the Study Area have been identified and recommended, together with their cost required, as mentioned above, the implementation of these facilities depends on the order of priority together with the reasonable amount of capital investment, taking the time factors involved for construction into account. Thus careful analysis has been made to establish the most appropriate implementation schedule for the first phase programme covering the 5 years from 1981 to 1985 among the possible alternative consideration, and then, a reasonable disbursement programme for the first phase implementation has been developed, including the construction, and operation and maintenance costs. The cost required for the programme over the 5 years from 1981 to 1985 is to be approximately M$ 4.4 million at 1979 price, M$ 6.1 million at escalated price with 8 percent per annum escalation factor from 1979 price level of construction works, and M$ 0.2 million of operation and maintenance works for the same period, with those facilities of trunk and secondary drains, embankment and other related facilities excluding the floodway, pumping station and reservoir.

7. The financing arrangement is proposed to meet the total capital cost required for 5 years construction of the proposed drainage facilities with due consideration on existing funding practices for the drainage works.

Municipal Council Kota Setar, the proposed executive agency of the drainage project, is recommended to arrange the funding under the provisions of the Local Government Act, in accordance with the disbursement programme as shown in the Table 10.3 of this report either by the funding assistance from Federal Government or its own annual budgetary allocation.

8. Various types of benefit will be derived from the implementation of the recommended drainage programme. The anticipated benefits include the prevention of the occurrence of flood damage, improvement of public health and convenience of community, increase of land value. Although most of the benefits are not fully quantifiable, it is evident that there will be high social benefits together with the environmental improvement of the area.

CHAPTER 2
INTRODUCTION

The purpose of this report is to present the drainage feasibility study which will be technically sound and economically feasible from among the considerable alternative programmes in order to provide adequate drainage system to meet both immediate and future requirements including flood problems for the Study Area.

Since the comprehensive drainage master plan covering the area of Alor Setar and its urban environs including the Study Area has been prepared by Drainage and Irrigation Department (SDID), State Government of Kedah, the basic concept and works necessary for this study are identified on the basis of those recommendation of the Master Plan. The principle for the work considered for this study, therefore, is as defined in the scope of work acknowledged by the Government of Malaysia, to develop the plan for the secondary drainage system in line with the trunk drainage system recommended by SDID, and to provide the preliminary engineering design of both trunk and secondary drainage system for the Study Area.

The studies carried out under the Project include the following:

a) Delineation of the Study Area considering the contribution area,
b) Projection of land use pattern,
c) Development of design basis,
d) Evaluation of existing system and review of Master Plan,
e) Development of overall layout planning and preliminary engineering design,
f) Estimation of construction, and operation and maintenance costs for the facilities of the overall system,
g) Establishment of construction and disbursement programme for the 5 years implementation of which selected among the facilities of the overall system,

h) Consideration of financial arrangement

i) Evaluation of benefits

During the course of field works under the Project, detailed field reconnaissance and surveys have been carried out to identify the problems as to the present condition of the drainage system for the Study Area, and then requirements for drainage improvement have been evaluated.

On the basis of findings on evaluation of the existing system, a review of the trunk drainage system proposed in the Master Plan in terms of the Study Area has been undertaken carefully considering the possible alternatives with respect to the layout and capacity of the system, and the most appropriate drainage system has been then established for the Study Area together with development of the preliminary engineering design of the system.

Using the results of the preliminary engineering design and cost estimates for the facilities required in the overall system, a desirable magnitude for the first phase programme which will meet the immediate requirement for alleviation of the existing flood problems for the Study Area has been first made considering the order of priority for implementation together with a reasonable amount of investment to be financed by the Government, and then the most preferable disbursement programme has been developed for the first 5 years drainage implementation, as recommended in this study. Although the benefits to be expected from the proposed drainage system are intangible and difficult to be quantified, various types of benefits have been also given on the basis of the recommendation made in this Study.

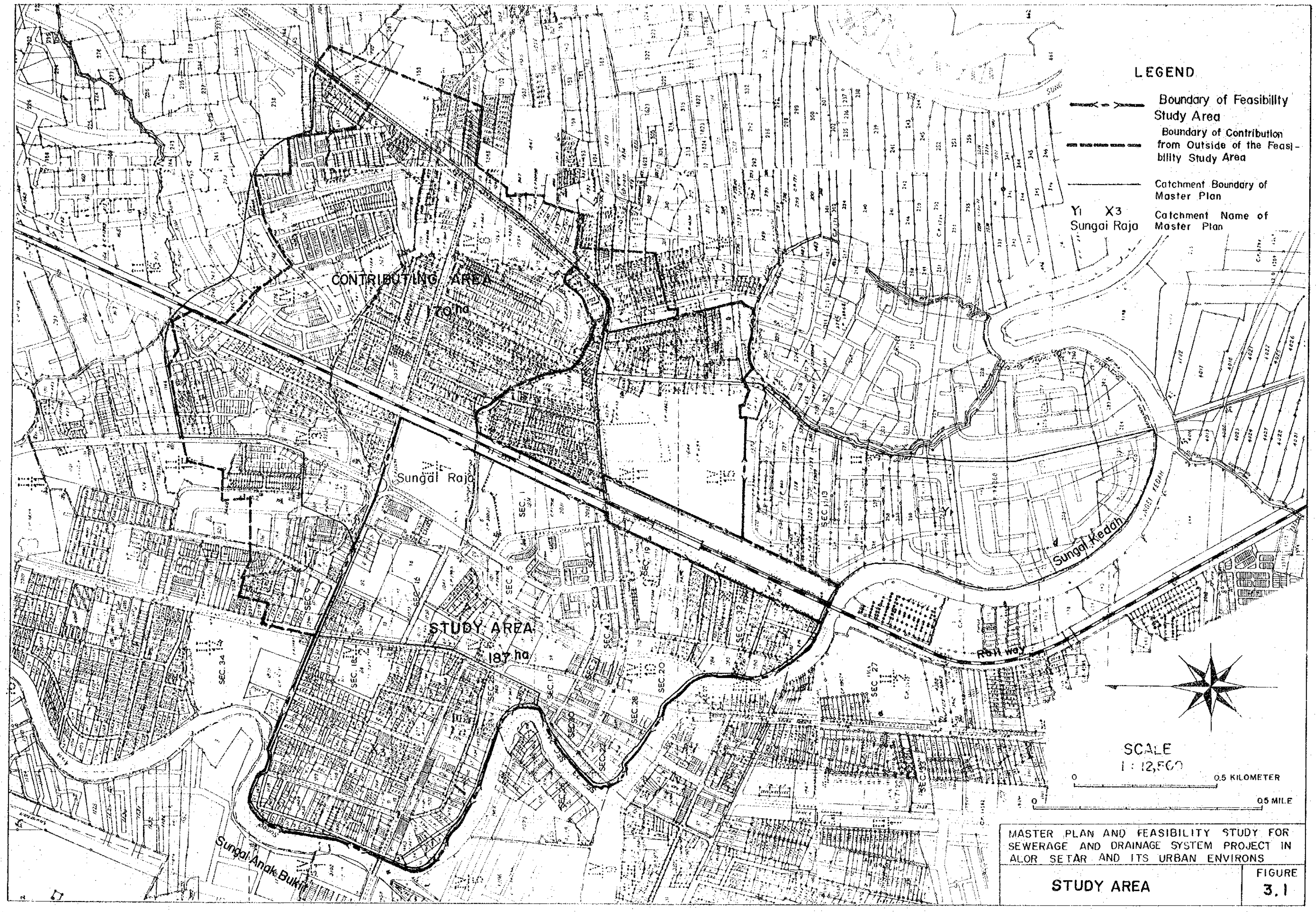
CHAPTER 3
STUDY AREA

As determined by the scope of work agreed between both of the Governments, the area for drainage feasibility study is basically identical to the area for Sewerage Feasibility Study presented in separated volume which covers an area of 187 ha (462 acres). Also, according to the delineation made in the Master Plan by SDID, this area is further identified with independent drainage basins which are minor catchment 'X3', and a part of minor catchment 'Y1' and Sg. Raja catchment.

The basic idea for delineation of the Study Area is therefore, to cover the area necessary for alleviation of the existing flood problems in terms of the urbanized area, since the urbanized area which lies within the centre of Alor Setar town comprising the main commercial and residential areas has been currently experienced of the flood problems during the monsoon season, and to cover the area which will be expected the sanitary improvement by means of the provision of both sewerage and drainage concurrent to be implemented in the first phase programme.

Due to the topographic conditions of the area, approximately 170 ha (420 acres) of tributary outside of the Study Area is further considered for calculating the drain capacities because the tributary contributes its storm runoff to the Study Area.

Hence, the total area concerned for this drainage feasibility study under this Project is 357 ha (882 acres) approximately as shown in Figure 3.1. The development of the drainage system including trunk and secondary drains will however be for the Study Area covering the area of 187 ha referred above, but the trunk drainage system in the tributary area will also be considered in connection with the drainage system in the Study Area.



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

STUDY AREA	FIGURE 3.1

CHAPTER 4
LAND USE

The characteristics of the storm water runoff is significantly affected by the land use pattern of the area, and the description in this chapter is to serve the requirement for the design basis for this study. The estimated land use pattern in both present and future for this study is as follows:

4.1 Present Land Use

As has been discussed in the Sewerage Study on both Master Plan and Feasibility Study presented in separate volumes, the present land use pattern in the Study Area is divided appropriately into six categories namely (1) residential, (2) commercial, (3) institutional, (4) mosques, (5) schools, and (6) open space. Further, since the drainage study concerns the area of tributary outside of the Study Area, land use of such area is also evaluated, on the basis of the latest available information and data obtained during the course of the survey, with due consideration on two other categories, namely (1) railway and (2) agricultural area.

The estimated acreage of the present land use for those areas including the Study Area and tributary area according to the identified categories is presented in Table 4.1.

Table 4.1 Present Land Use in 1979

Land Use	Study Area (ha)	Tributary Area (ha)	Total (ha)	Prorated Ratio (%)
Residential area	75.6	129.2	204.8	57.4
Commercial area	55.9	3.1	59.0	16.5
Institutional area	14.8	0	14.8	4.1
Mosques	1.5	6.6	8.1	2.3
Schools	30.7	1.8	32.5	9.1
Railway	0	21.0	21.0	5.9
Open Space	8.5	6.0	14.5	4.1
Agricultural area	0	2.3	2.3	0.6
Total	187.0	170.0	357.0	100.0

4.2 Future Land Use

Since the Study Area has been almost urbanized, the future land use pattern may not change significantly from the present pattern. However, certain modification has to be considered along the line of the expansion of mainly in the commercial areas, due to the increase of commercial activities and accordingly the population growth is considered significant.

On the basis of the above consideration, discussion was made with the Government officials concerned to the Project, and consultation has been given as some of the present residential area be converted into the commercial area. Accordingly, future land use pattern is modified from the present land use pattern.

The estimated acreage of the land use in the future according to the each categories identified in the present land use pattern is presented in Table 4.2.

Table 4.2 Future Land Use in 2000

Land Use	Study Area (ha)	Tributary Area (ha)	Total (ha)	Prorated Ratio (%)
Residential area	45.6	122.9	168.5	47.1
Commercial area	97.0	15.3	112.3	31.5
Institutional area	12.2	0	12.2	3.4
Mosques	1.5	6.6	8.1	2.3
Schools	30.7	1.8	32.5	9.1
Railway	0	21.0	21.0	5.9
Open Space	0	2.4	2.4	0.7
Total	187.0	170.0	357.0	100.0

CHAPTER 5
DESIGN BASIS

Design basis presented herein are basically in accordance with those recommended in DID's Planning and Design Procedure No. 1, "Urban Drainage Standards and Procedure for Peninsular Malaysia", and also the results of the discussion made with the Government officials concerned to the Project. Followings are brief description on the design basis adopted for the study.

5.1 River Water Level Used for Design

Since the Study Area lies within the tributaries of two rivers namely Sg. Kedah and Sg. Anak Bukit, the discharge of the stormwater runoff originating from the Study Area is significantly affected by the river water levels, so that the river water levels should be taken into consideration in this study, in order to carry out the actual design of drainage system for the Study Area.

In accordance with the study in the Master Plan prepared by SDID, 1-year river flood levels resulted from the hydrological analysis of river flood flows on the basis of the statistical data is applied as the basis for our design of urban drainage system. This water levels is when 1-year frequency river flood flows coincide with the high water level spring tide as 1.68 m (5.5 ft) at Kuala Kedah, and also would be equivalent to the levels caused when the river flood flows with 5 year frequency coincide with the mean high water spring tide of 1.5 m (5.0 ft) at Kuala Kedah.

The river water level applied as 1-year river flood level mentioned above is 1.71 (5.6 ft) at the confluence of two rivers namely Sg. Kedah and Sg. Anak Bukit. Further, the 100-year frequency river flood flows are also considered and applied for the purpose of checking the trunk drainage system together with the bund alignments same as the recommendation made in the Master Plan. This water level applied at the confluence of two rivers referred above is 2.23 m (7.3 ft).

5.2 Stormwater Quantities

5.2.1 Runoff Formula

The "Rational Formula" with a storage coefficient is applied for estimating the stormwater runoff, which is expressed below:

$$Q = \frac{1}{360}\, Cs.C.I.A.$$

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 tc and a return period T-year (mm/hr)

A : catchment area (ha)

C : runoff coefficient

Cs: storage coefficient which is expressed as

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

tc: time of concentration (min.)

td: time of flow in the drain (min.)

5.2.2 Rainfall Frequency for Drain

The national standard for the average frequencies of rainfall occurrence is used for the drainage design for the respective land use pattern as follows:

Residential area	2-year
Commercial area	5-year

For main drains serving wider tributary area, only 5-year frequency is recommended because they generally flow through areas comprising various types of land use pattern.

5.2.3 Rainfall Intensity - Duration - Frequency Formula

Rainfall intensity is expressed in the form of intensity-duration-frequency curves developed for Alor Setar as follows:

2-year frequency	$I_2 = \frac{6,350}{t + 32}$ (mm/hr)
5-year frequency	$I_5 = \frac{9,145}{t + 49}$ (mm/hr)
100-year frequency	$I_{100} = \frac{16,500}{t + 66}$ (mm/hr)

5.2.4 Runoff Coefficient

The recommended runoff coefficients are as follows:

Residential area	0.65
Commercial & Institutional area	0.85

5.2.5 Time of Concentration

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. The recommended inlet time of flow is 7 min, but the time of flow in drains is estimated depending upon the hydraulic properties of the individual conduit.

5.3 Drainage Facilities

5.3.1 Storm Drain

(a) Flow Friction Formula

For the hydraulic design of open channels, the Manning's Formula is applied and expressed as follows:

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

where V: velocity (m/sec)
n: roughness coefficient
R: hydraulic radius (m)
I: gradient

The value of "n" is depending upon the type of drains 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

(b) Velocity of Flow

Considering the prevention of deposition of grit and sand in storm drains, and of erosion of drains, the minimum and maximum velocities for various types of drain are recommended below:

Recommended Maximum and Minimum Velocities

Type of Drain	Design Velocity (m/sec)	
	Minimum	Maximum
Concrete Drain	0.6	3.0
Stone Drain	0.6	2.5
Grass Lined Drain	0.6	2.2 (1)
Earth Drain	0.6	1.0 (2)

Note: Data Source (1) DIS's Procedure
(2) Portier Sroby

(c) Drain Facilities

Facilities for the drain may include open channels, box culvert, pipe and bridge. The details of the requirements of these facilities will be made in the actual design, taking into consideration of the local situation as presented in the succeeding chapters. Discussions necessary for design basis of these facilities as required in this study are made as follows:

(i) Open channels

Open channels considered for this study include, (1) trapezoidal earthen channels, (2) trapezoidal rubble wall channels, and (3) U-shaped channels either of precast or cast-in-place.

Side slopes of trapezoidal drains are determined conforming to the standards as illustrated in Figure 5.1.

Increase of the ratio of depth to width will raise the direct construction cost, but cut down the cost of land acquisition. The optimum ratio of the two is therefore selected in the preliminary engineering design, taking specific local condition into account, so the drains are designed most economically.

For the rubble wall drains with surface linning using wire nets is recommended. The advantages of linning is of (1) increased capacity with smooth surface, (2) reduced land requirement and (3) easy maintenance.

(ii) Box culvert
At a road crossing, box culvert is generally used. Where traffic is heavy, it is preferable to use precast box culvert available in Malaysia. Currently the available market size of the precast box culvert is limited to small ones, hence multiple numbers of box culvert may be laid in parallel to flow the stormwater in large capacity drains.

(iii) Pipe
Pipe are also used for road crossing of small drains. The pipes should generally be of centrifugally case reinforced concrete with sufficient strength to sustain the heavy traffic loads expected.

5.3.2 Pumping Station and Reservoir

In developing the plan for the trunk drainage system for the Study Area, pumping station and reservoir are considered at the outlets of trunk drainage system for cutting off back water from rivers, lifting out stormwater runoff and reducing the peak stormwater runoff discharged within the area. These facilities shall be provided as an incorporate system together with provision of levees of gate.

Generally, it is however noted that the pumping station and reservoir would not be used so often, mainly depending upon the intensity and frequency of rainfall within the area. Further, construction of the pumping station may require considerable amount of initial investment including procurement of equipment and their spare parts, and careful operation and maintenance services would be required for maintaining proper function of the stations. Also, a storage of stormwater requires generally considerable land space.

Thus, the provision of these facilities should be determined carefully taking into account above mentioned disadvantages. Further, care should be taken as to the storing volumes of stormwater together with the capacity and type of pump equipment, when the actual design works are carried out. Considering the above mentioned basic design factors, the most preferable facilities are determined as presented in details in Annex A of this report.

5.3.3 Gate

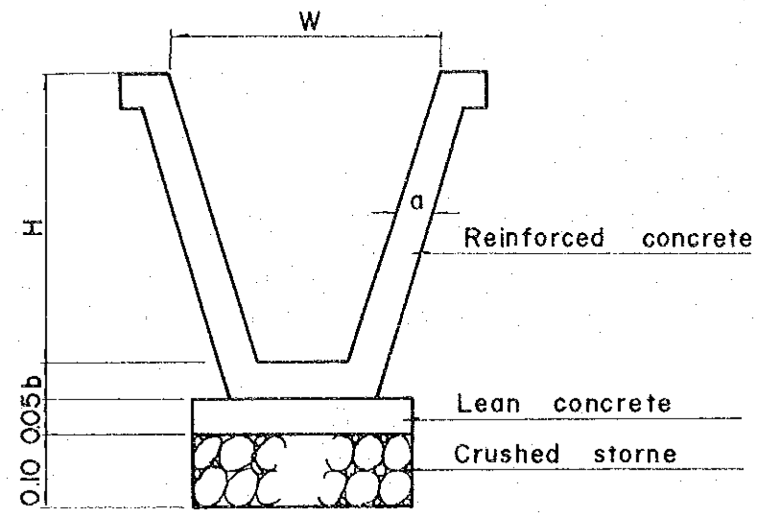
Flap gates are preferable at the drain outlet, because the flap gates open automatically to outflow or close against backflow with only a slight difference in head when properly installed. For outlets of the large drain, where flap gates are not preferable in terms of available size of gates, sluice gate is used. Typical gate structure of these gate are presented in Figure 5.2.

5.3.4 Bridge

Where a large drain crosses a road, a bridge over the drainage channel should be provided to maintain the smooth traffic. An adequate clearance should be maintained between the design flow water surface and the bottom of the bridge deck so that accumulation of debris can be avoided. The application of bridges for crossing the channel is described in detail in Section 7.2, Chapter 7, and also illustrated in Figure 7.5.

For detail of the procedures of hydraulic analysis of bridge water way, refer to DID's "Design Standard and Procedures".

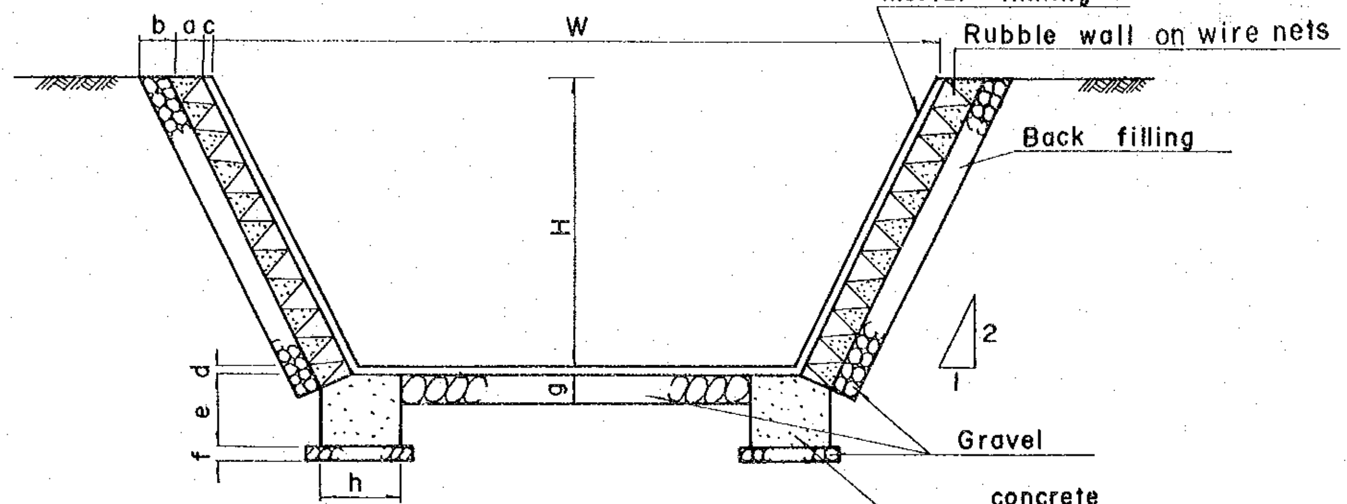
Precast U-Shape Drain



m

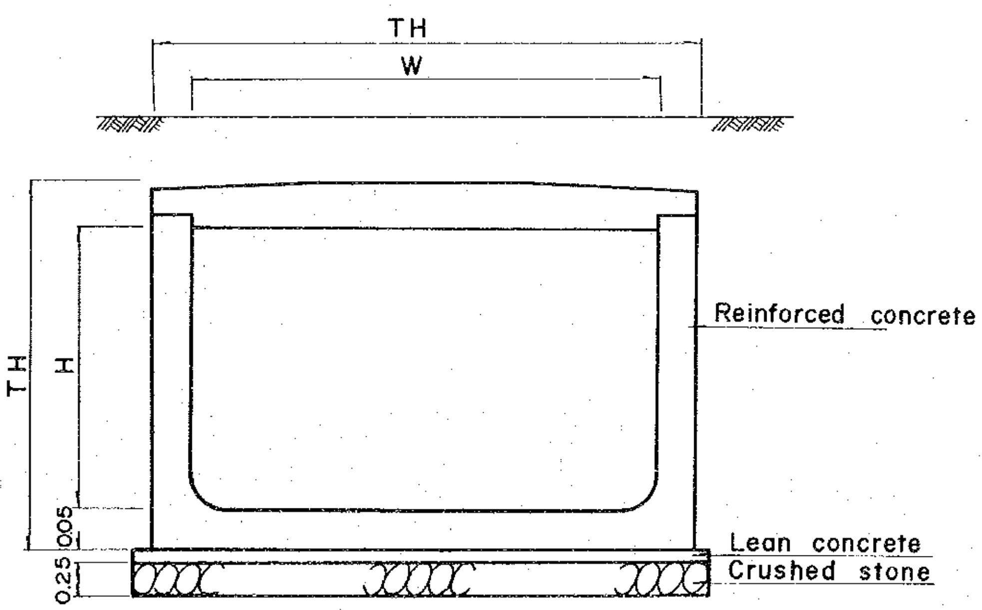
W	0.33 ~ 0.61	a	0.05 ~ 0.06
H	0.30 ~ 0.61	b	0.05 ~ 0.08

Rubble Wall Channel With Mortar Linning



W	–	d	0.05
H	0.7 ~ 3.0	e	0.50
a	0.15 ~ 0.30	f	0.20
b	0.15 ~ 0.25	g	0.20
c	0.02	h	0.50

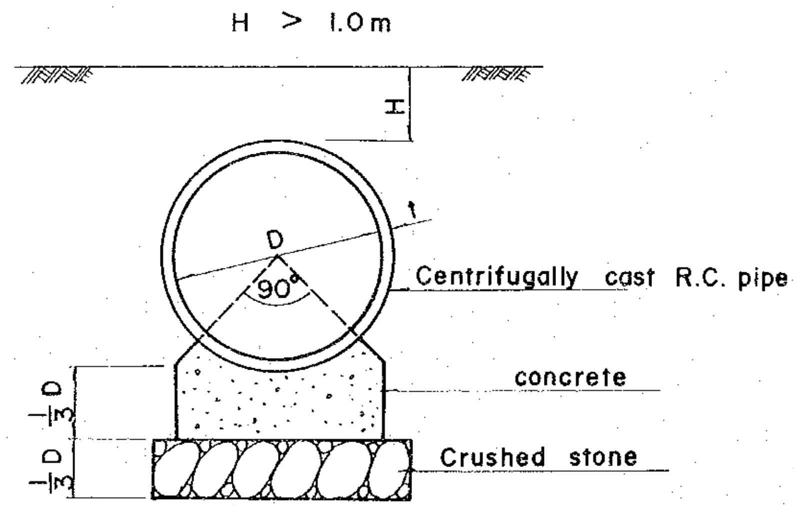
Precast Box Culvert



m

TW	0.76 ~ 2.03	TH	0.40 ~ 2.12
T	0.61 ~ 1.83	H	0.26 ~ 1.82

Centrifugally Cast R.C. Pipe



m

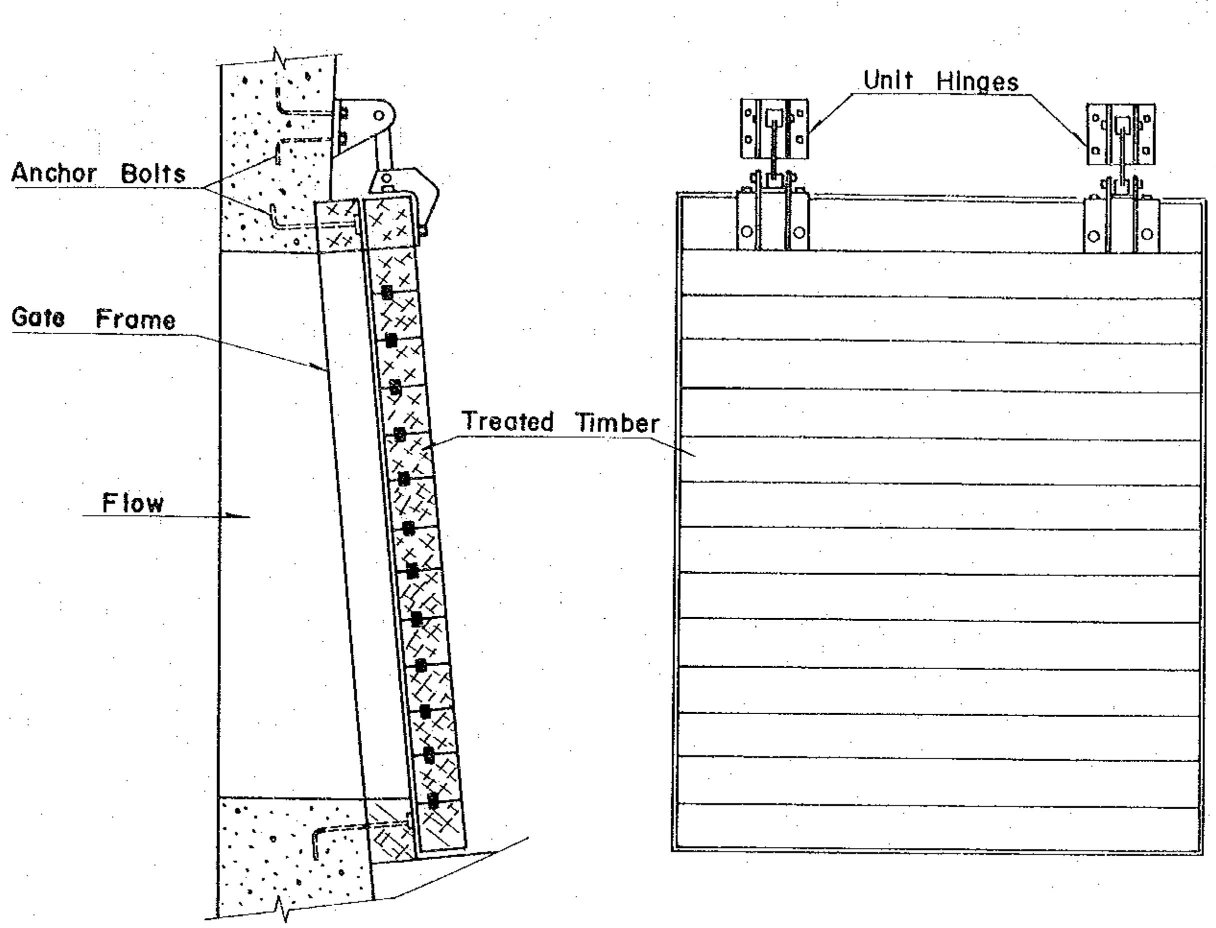
D	0.225 ~ 1.800	t	0.03 ~ 0.13

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

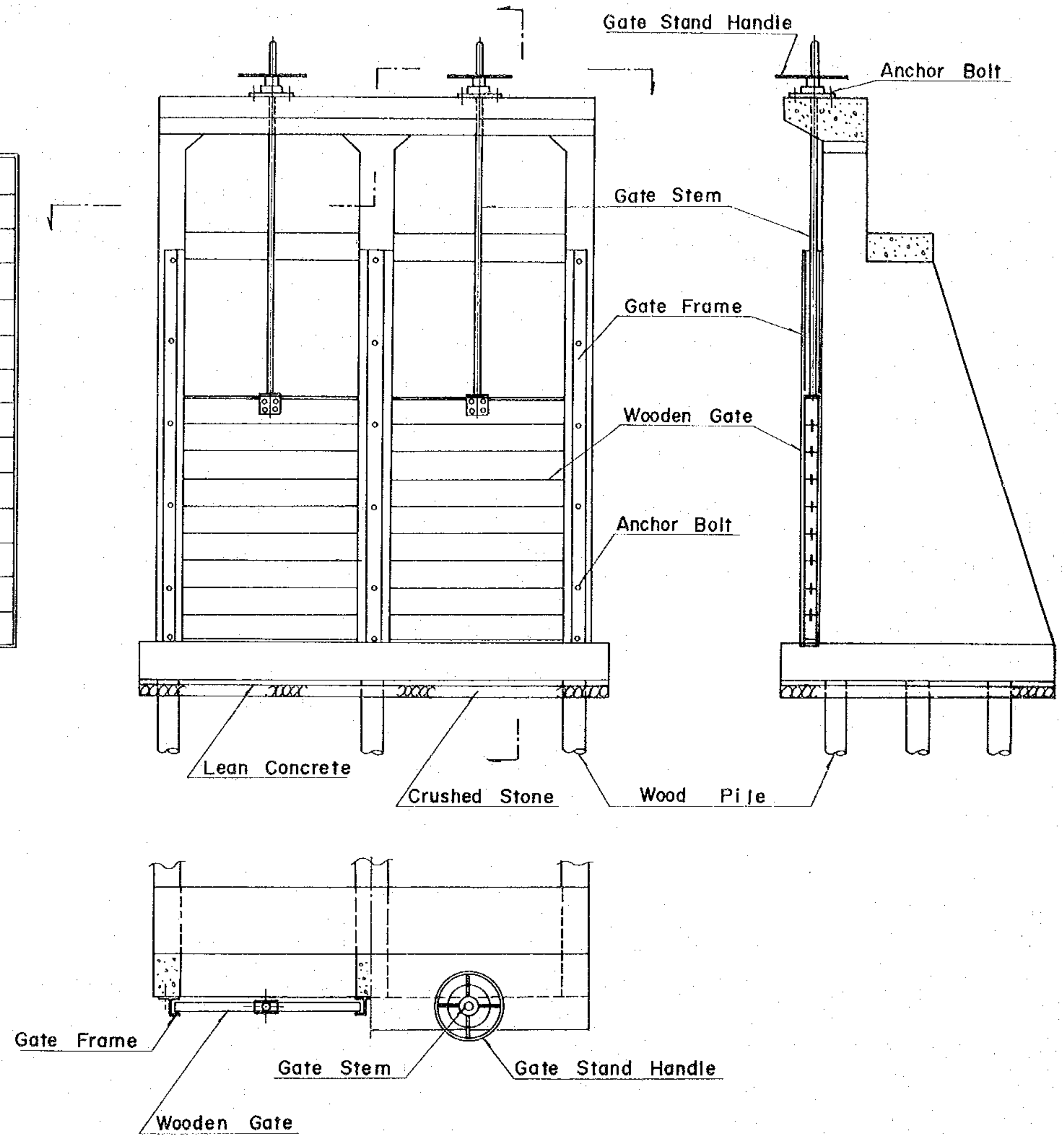
TYPICAL CROSS SECTION OF DRAIN

FIGURE 5.1

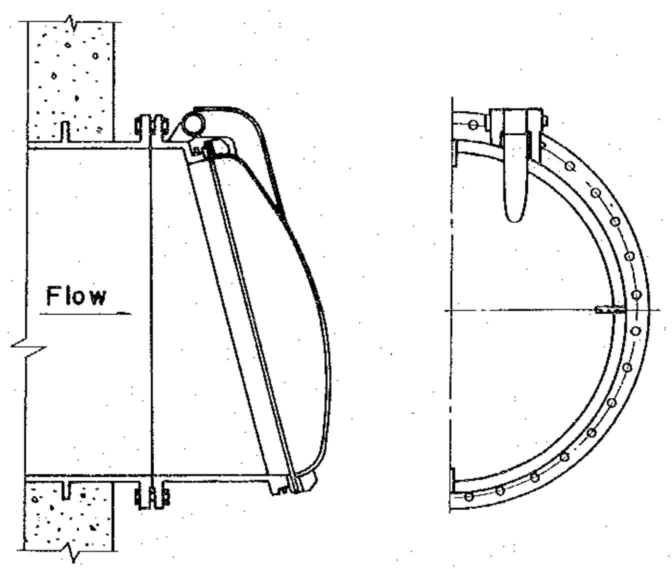
Fabricated Wooden Flap Gate



Sluice Gate



Cast Iron Circular Flap Gate



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

TYPICAL GATE STRUCTURE

FIGURE 5.2

CHAPTER 6

FACTORS AFFECTING THE ENGINEERING CONSIDERATION

The development of an adequate plan for the drainage system requires an analysis of the existing drainage system. The field reconnaissance and surveys have been therefore undertaken during the course of the field works, and then a review and evaluation on the existing system have been made in details for determination of the drainage requirements.

Since there exists a comprehensive drainage master plan for Alor Setar town including the Study Area prepared by SDID, the basic concept and approach for the study are determined with due consideration on the results of the Master Plan. It is, however, noted that the preliminary engineering design would require the more detailed analysis with respect to the trunk drainage system than that of the Master Plan, for practical implementation of the system, properly reflecting the latest local condition in the Study Area, and therefore a review, evaluation and modification of the system proposed by the Master Plan are also carried out in this study.

6.1 Existing Drainage System and It's Evaluation

The field survey carried out includes the investigation of flow direction in each existing drains, measurement of cross section including maintenance access area to be reserved for drain, and levelling of the existing drains. The results of the above survey are presented as shown in Figure DF-1 of Volume VIII.

On the basis of the above survey results, the existing drainage system and its evaluation, in order to ascertain the drainage requirements for the Study Area, are described in the followings:

6.1.1 Present System

According to the findings on the present drainage conditions, the existing drainage system for the Study Area can be identified into three independent drainage basins, namely Sg. Raja Basin, Putera Basin and Langgar Basin, which correspond basically to the delineated basin in the Master Plan as mentioned previously. The system of these individual drainage basins together with its evaluation is described below:

(a) Sg. Raja Basin

This basin has an area of 252 ha (623 acres) which lies at the centre of Alor Setar town including the major part of the institutional and commercial areas. Out of this area, an area of 94 ha (232 acres) lies within the Study Area, and rest are tributary outside the Study Area.

At present, most of the area of this basin within the Study Area has been already urbanized by residential and commercial areas. This urbanization would be further progressed by the improvement of the town, according to the development plan prepared by STCP. The development within the tributary outside the Study Area also has been undertaken for residential and commercial areas, especially, the area along Jl. Telok Wan Jah which lies at the upstream of the Sg. Raja has been almost developed for residential purpose, and area which is situated along Jl. Stadium is also under the development for the same purpose.

The ground elevation in this basin, especially the residential area along Jl. Telok Wan Jah at the upstream of the Sg. Raja, is generally flat in low-lying with an average of 1.5 m (5 ft) above mean sea water level (MSWL). Even the ground elevation in the institutional and commercial areas situated at the center of town is low and insufficient to cater for the 5-year frequency flood level of the Sg. Kedah.

The existing drainage system in this basin consists of two trunk drains namely Sg. Raja and Sg. Derga, and various types of secondary and infrastructural drains. The Sg. Raja runs from tributary area on the north to the Sg. Kedah on the south throughout the centre of Alor Setar town, while the Sg. Derga starts from eastern region of this basin and then connects finally to the Sg. Raja at the centre of the town.

These trunk drains are basically natural stream which are earth channel with varied width and depth, and are heavily silted with about 1 meter or more in depth. The capacities of these drains have both about 2 m^3/s at upstream to 12 m^3/s at downstream, but these are not sufficient to cater for the surface runoff, even the 1-year storm frequency be occurred under the present ground condition. Actually, the region at the upstream of the Sg. Derga along Jl. Telok Wan Jah has been thus experienced of the flooding at least twice a year. Further, since no gate in protecting backing up the water from the river exist at the outlets of trunk drains, the regions at the upstream of trunk drains are subject to be effected by high river water level.

Throughout the built-up urban area, open channel system of either U-shape or rectangular section has been provided, as the secondary and infrastructural drainage system. The networks of these drains are shown in Figure DF-1 of Volume VIII. Although these secondary and infrastractural drains have generally been working well so far, some of them especially earth drains are insufficient to accommodate the flow capacities under the present conditions.

(b) Putera Basin

This basin has an area of 62 ha (153 acres) which covers mainly built-up area comprising residential and commercial areas along Jl. Putera and Jl. Pekan Melayu. Whole area of this basin lies within the Study Area.

The ground elevation in this basin is relatively high in comparison with other basins, which is sufficient to cater for the design flows.

The existing drainage system in this basin has no trunk drains. Only secondary and infrastructural drains do exist in this basins. Out of these drains, about 70 percent are of concrete with U-shaped or ractangular cross section, and the rest are earth channels. Generally, these drains have been well maintained, and working well so far, having sufficient capacities to cater for the runoff from the area under the present ground condition. The storm runoff originated in this basin are presently discharged into the Sg. Anak Bukit at the 8 outlets of these drains.

(c) Langgar Basin

This basin is occupied mostly by Kolej Sultan Abdhul Hamid and Iskandar schools, and tributary area along the railway. The total area of this basin is 43 ha (106 acres). The most of the area for this basin have relatively high ground elevations, which do not cause the significant flooding. However, some in which there exist the residential area along Jl. Langgar lie in low-lying and flat situations, thus causing frequent flooding. The existing drainage system in this basin consists of only one main drains which is routed along the railway, and many of secondary and infrastructual drains. These drains are generally poor, with natural stream and even the main drain is earth channel.

6.1.2 Flood Problems and Drainage Requirements

In order to ascertain the flood problems and drainage requirements for the Study Area, the conditions of the existing drainage system have been evaluated in details on the basis of the data and information collected from SDID and MPKS, and also through the field survey including investigation and house-to-house visit carried out during the course of the field works as discussed in previous section.

In the evaluation, it is apparent that since the Study Area is generally flat and low-lying in the tributaries of the two rivers, namely Sg. Kedah and Sg. Anak Bukit, major part of the Study Area are subject to be effected by backing up of the water from the rivers referred above, thus causing nuisance flooding in many places throughout the Study Area. Especially, when the flood flows occurred during the high intensity storms coincided with the high spring tides, flooding areas shall be spreading within the Study Area. The location of the present flood prone area is shown in Figure 6.1. The causes of this flooding are due to inadequate capacity of drains and its poor maintenance together with ground condition in low-lying as mentioned above. Particularly. the existing trunk drains have insufficient capacity to cater for the runoff originating from the area, under the present ground condition, but the capacities of the secondary and infrastructural drains have generally sufficient to flow the surface runoff discharge on the present land use condition, if the better maintenance such as desiltings are carried out. Even if such conditions however exist as mentioned above, redevelopment of the town including the Study Area, which is undertaking now, would be resulted in the increase of surfacewater runoff which cannot be handled by the existing system unless necessary improvement measures are taken. Therefore, the situation will be evidently deteriorated.

In view of the above overall findings and evaluation for the present drainage conditions for the Study Area, the following measures are considered and studied to be taken for the improvement of the drainage situation in the area.

(1) Improvement of the Sg. Raja and Sg. Derga to alleviate the existing flood problems for the area at the upstream of these two trunk drains.

(2) Provision of bund alignment along the Sg. Kedah between railway and Jl. Raja for protection of the backwater from the river, since the area nearby the coastal of the Sg. Kedah has been currently experienced the flood problems by the river water, even the 1-year river water level occurs.

(3) Installation of gate at reasonable drain outlets for protection of the nuisance flooding caused by the backwater from the high river water level.

(4) Establishment of the drainage improvement programme to meet the anticipated increase of runoff in future condition of the area.

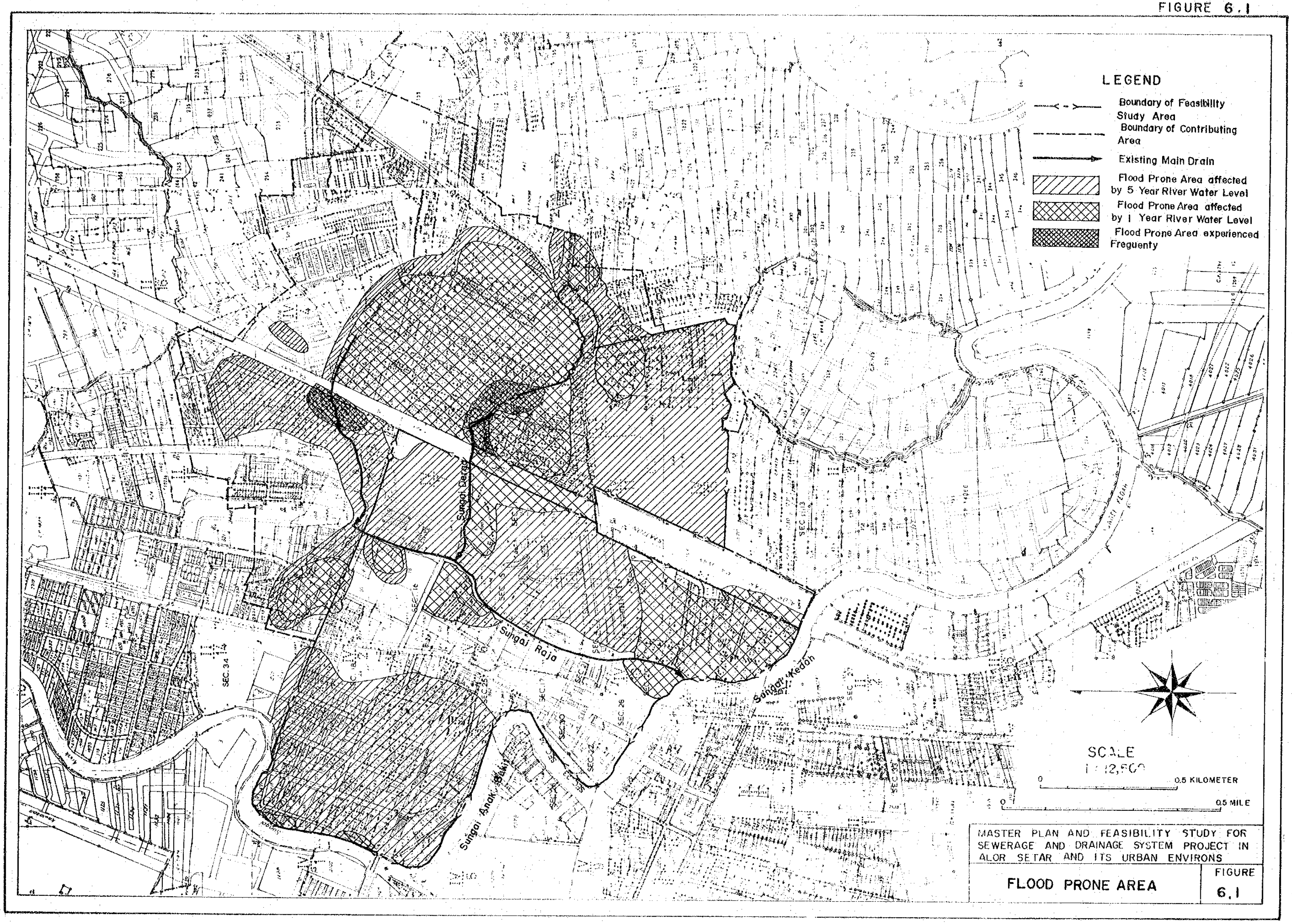
6.2 Review and Evaluation of Existing Study

The study carried out by the Master Plan prepared by SDID includes the plans on the flood mitigation measures and trunk drainage system covering the total area of 3,584 ha (14 sq. miles) of Alor Setar conurbation. The flood mitigation measures propose the river flood protection by way of provision of the bund alignments along the major portion of both Sg. Kedah and Sg. Anak Bukit, to protect the town from the high water levels in the rivers, especially when coincidence of high spring tide level and high flood flows in the upstream of trunk drain within the area during the monsoon period occurs, and study on the trunk drainage system is to establish adequate drainage system together with the provision of facilities necessary for the area in connection with the flood mitigation measures.

Out of these studies referred above, only the planning of the trunk drainage system recommended in the Master Plan are reviewed for this study in order to develop and adequate secondary drainage system in line with the most preferable trunk drainage system, and further to undertake preliminary engineering of both trunk and secondary drainage system based on further detailed analysis than the Master Plan proposals.

According to the Master Plan, the entire area of Alor Setar conurbation has been devided into 16 major catchments and 8 minor catchments. From the above delineation, the Study Area of this Feasibility Study covers a part of 'Sg. Raja' catchment and minor catchment 'Y1' and whole of minor catchment 'X3', all of which are then identified into three basins as Sg. Raja, Langgar and Putera as discussed previously in this study. Among those independent drainage basins, Sg. Raja basin, will have the trunk drainage system as recommended in the Master Plan, consisting of those facilities of trunk drain, floodway, pumping station and reservoir.

FIGURE 6.1



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

FLOOD PRONE AREA

FIGURE 6.1

CHAPTER 7
PRELIMINARY ENGINEERING ANALYSIS FOR PROPOSED DRAINAGE SYSTEM

In development of the drainage system, preliminary engineering analysis including the selection of the most suitable layout and determination of the capacities necessary to the facilities is required taking into consideration of findings on evaluation of the existing conditions and also through review and evaluation of the Master Plan recommendations, as discussed in previous chapter. The analysis made, and its recommendation and proposals are described below:

7.1 Drainage System Layout Planning

For the purpose of the preliminary engineering design of both trunk and secondary drainage system, the layout of the drainage system established in the Master Plan is carefully reviewed in connection with Study Area and its tributary, and further detailed analysis is made by considering the possible alternative for the selection of the most desirable route of trunk drains, using the updated information and data derived from extensive field investigations carried out during the course of the field works.

7.1.1 Alternative Routes of Trunk Drain

As discussed previously, the Master Plan defines the facilities necessary for establishment of an adequate drainage system for the area of Sg. Raja catchment including drains, floodway, pumping station and reservoir together with the provision of bund alignments along the rivers to protect the river flooding, although no secondary drainage system has been included in the Master Plan, due to the fact that the purpose of the Master Plan is to develop the trunk drainage system.

Out of these facilities mentioned as recommended in the Master Plan, attention is given to the facilities for reservoir and floodway in connection with the selection of the alternative routes of trunk drain.

The plan for reservoir as proposed in the Master Plan is to provide the protection of the flooding due mainly to the backwater from the rivers during the critical storms within the area especially when coincided with the high spring tide level in the rivers thus reducing the peak stormwater runoff to discharge to downstream. This plan is considered useful for implementation, but since no available open land for the reservoir exists within the area of Sg. Raja catchment, the area necessary to function as reservoir is proposed to be accommodated at Kampung Severang Keretopi along the Sg. Kedah, which is under, at present, paddy cultivation outside of Sg. Raja catchment. In connection with the provision of this reservoir, a floodway is required to convey the storms from the outlet of Sg. Raja to the reservoir crossing the railway along the Sg. Kedah.

However it is considered that the construction of the floodway at the crossing of the railway would cause certain technical problems and initial investment has to be carefully evaluated. Therefore the following two alternative proposals with respect to both routes of trunk drain and construction method are considered and studied in details on the basis of the economic analysis and preliminary engineering design.

Alternative 1 - To propose the same route with that recommended in the Master Plan as shown in Figure 7.1. However, taking into consideration of the disadvantages of the construction as mentioned above, applicable method of construction is considered, and Fronte Jacking Method be applied for the construction of floodway at the crossing of the railway. Details of this method are presented in Annex B of this report.

Alternative 2 - To provide the new trunk drain along the railway, thus eliminating the floodway as proposed in Alternative 1, as shown in Figure 7.2. This is to reduce the amount of discharge into the Sg. Raja by cutting down Sg. Raja catchment at the upstream of the Sg. Raja. For this system, pumping station and small reservoir are provided at the outlet of Sg. Raja.

In addition, since the pumping station will be incorporated with the reservoir, study on the pumping station and reservoir is also made as presented in Annex A, and included for the above mentioned alternative study.

In view of the above conditions mentioned, the results of the study including facilities required and its cost estimation for both Alternatives 1 and 2 are presented in Figures 7.1 & 7.2. From the above study it is apparent that although Alternative 1 requires construction of the floodway at the crossing of the railway which needs significant high investment, the total construction costs for the system is lower than that of Alternative 2. Further, the system of Alternative 1 consists of only one pumping station and reservoir, while the Alternative 2 has two pumping stations and two reservoirs, thus requiring the high maintenance cost and possibilities for frequent maintenance troubles. In view of the above results, Alternative 1 is finally selected as the most feasible system for the Study Area.

7.1.2 Recommended Layout Planning for Drainage System

On the basis of the results of the alternative study and analysis of the existing condition especially for secondary drainage system as discussed previously, the layout planning for drainage system including trunk and secondary drains, and other relevant facilities is developed for the preliminary engineering design purpose, as shown in Figure 7.3 and DF-2 of Volume VIII.

7.2 Overall Drainage Facilities for Long Term Requirement

On the basis of the results of the study on development of the best suited layout planning for the drainage system as discussed previously, design consideration on the facilities is made for the long term requirement, employing the basic engineering design criteria as presented in previous Chapter, which comprises open channels including trunk and secondary drains, floodway, box culverts, bridges, gates, pumping station, reservoir and embankment, while facilities for the immediate requirements are described in details in Chapter 9. Recommended overall facilities for long term requirement of the system are follows:

Trunk Drain	2,655 m	$\frac{5.40}{3.50}$ x 1.90 − $\frac{11.00}{8.80}$ x 2.20 (m)
Floodway	800 m	$\frac{11.00}{8.80}$ x 2.20
Secondary Drain	5,155 m	$\frac{1.50}{0.70}$ x 1.20 − $\frac{4.00}{2.90}$ x 1.60
Bridge	4 Nos.	See Figure 7.5
Gate	4 Nos.	See Figure 5.2
Pumping Station	1 No.	120 m^3/min
Reservoir	1 No.	127,000 m^3 5.70 ha
Embankment	600 m	See Figure 7.6

(a) Trunk and Secondary Drains, Box Culvert, and Bridge

The hydraulic computations and recommended profiles of the trunk and secondary drains which route in the layout planning are shown in Tables of Annex C, and Figure DF-4 and DF-5 Volume III respectively.

Due to the fact that the existing ground conditions in the Study Area are extremely flat, the gradients for the proposed drains especially trunk drain are gentle, and the design velocity is low ranging from 0.8 m/s to 1.1 m/s. Thus, a large cross sectional area is required to accommodate peak discharge. In view of the above conditions, rubble wall channel is recommended, with mortar linning of surface of drains using wire nets, to reduce the cross sectional area necessary and land requirements for drain, taking into consideration of the advantages on hydraulic, economic and esthetic points of view.

The maintenance access should be reserved in the form of road or green belt on either side of the drain depending upon physical condition of the area served by the drain, and this should always be given due note at the time of land acquisition. However, it is found that although no available existing road to exist presently along the trunk drains, proposed trunk drains which is routed on the same as the existing natural water course have enough space for the maintenance access. Also, since the proposed secondary drains run along the existing and planning roads, no land acquisition is required for the maintenance access for the all secondary drains. Thus, land acquisition cost for maintenance purpose of the all drains shall not be required in the cost estimation of the Project. The typical cross sections of the recommended reserve width for the maintenance together with the width of drain structure are shown in Figure 7.4.

When part of the channel crosses a roadway, bridge or box culvert is provided. Many of existing channels at the roads crossing are undersized box culverts and cause the flooding under heavy rain. These should be replaced by newly recommended ones with enough capacity.

In case of larger size, however, the bridge is preferable and recommended, since box culvert shall be multicell boxes and consequently would cause obstruction for channel flows and/or accumulation of flooting materials in upstream of culverts. The application of bridges is for the channel which sizes with upper width of 5.0 m (16.4 ft) or more. The locations of bridges are shown in Figure 7.3. Other road crossings are to be provided with box culverts.

In both cases, a sufficient hydraulic opening area should be provided. Preferably, free board from designed tailwater level to the bottom of bridge's beam or culvert slab, should be around 30 cm (1 ft). Under the existing topographic conditions in the Study Area, while it may be difficult to reserve 30 cm as recommended above, bridge beam or culvert slab should not atleast be below designed tailwater level.

Typical bridge structure and box culvert are indicated in Figure 7.5. These figures are prepared as the base of cost estimation and explanatory purposes. At the time of final design, individual site of the construction has to be investigated further and proper type of structures should be selected accordingly.

(b) Drainage Gates

To protect the backwater from the rivers during high river water levels, drainage gates are required at the reasonable outlets of trunk and secondary drains since land filling is not applicable due to the fact that the Study Area has already been well urbanized. The principle of the gate installation required in the proposed drainage system is to protect the low-lying areas which are affected by the backing up of water, even the 1-year river flood level occurs. In case of smaller sized outlets, flap gates are preferable and recommended taking into consideration of advantages on easy operation and maintenance, together with economic points of view, while sluice gates are required at the larger outlets, with manual operation. The proposed size of the gate and it's locations are shown in Table 7.1 and Figure 7.3 respectively.

Table 7.1 Proposed Gates

Basin	Type	Size (m x m)	No.	Remarks
Sg. Raja	Sluice	2.0 x 2.0	5	(For outlet of trunk drain No. R20)
	"	"	5	(For outlet of floodway)
	"	"	5	(For inlet of reservoir)
	Flap	2.0 x 1.6	5	(For drain No. R28)
Langger	Flap	1.6 x 2.0	2	(" No. L6)

(c) Embankment

The idea for recommending and designing urban drainage system for solution of the flood problems is to meet the design flows when the design frequencies of rainfall occurrence coincide with the 1-year river flood flows. However, since the area along the river is very low-lying, problems of flooding would not be solved even if the drainage system for above area would be provided to meet the local storms, due to the backing up of water from the river even before the water level reaches to 1-year river flood level. Thus, bund alignments are required and proposed for protecting the coastal area of the Sg. Kedah. The location of bund alignments proposed is shown in Figure 7.3.

The crest level of the embankment is determined based on the 100-year river flood level as discussed previously, while urban drainage system proposed is to meet to the surface runoff for the storm of 2-year frequency for residential areas and 5-year frequency for residential areas and 5-year frequency for commercial areas. Typical bund structure and crest level proposed are presented in Figure 7.6.

(d) Pumping Station and Reservoir

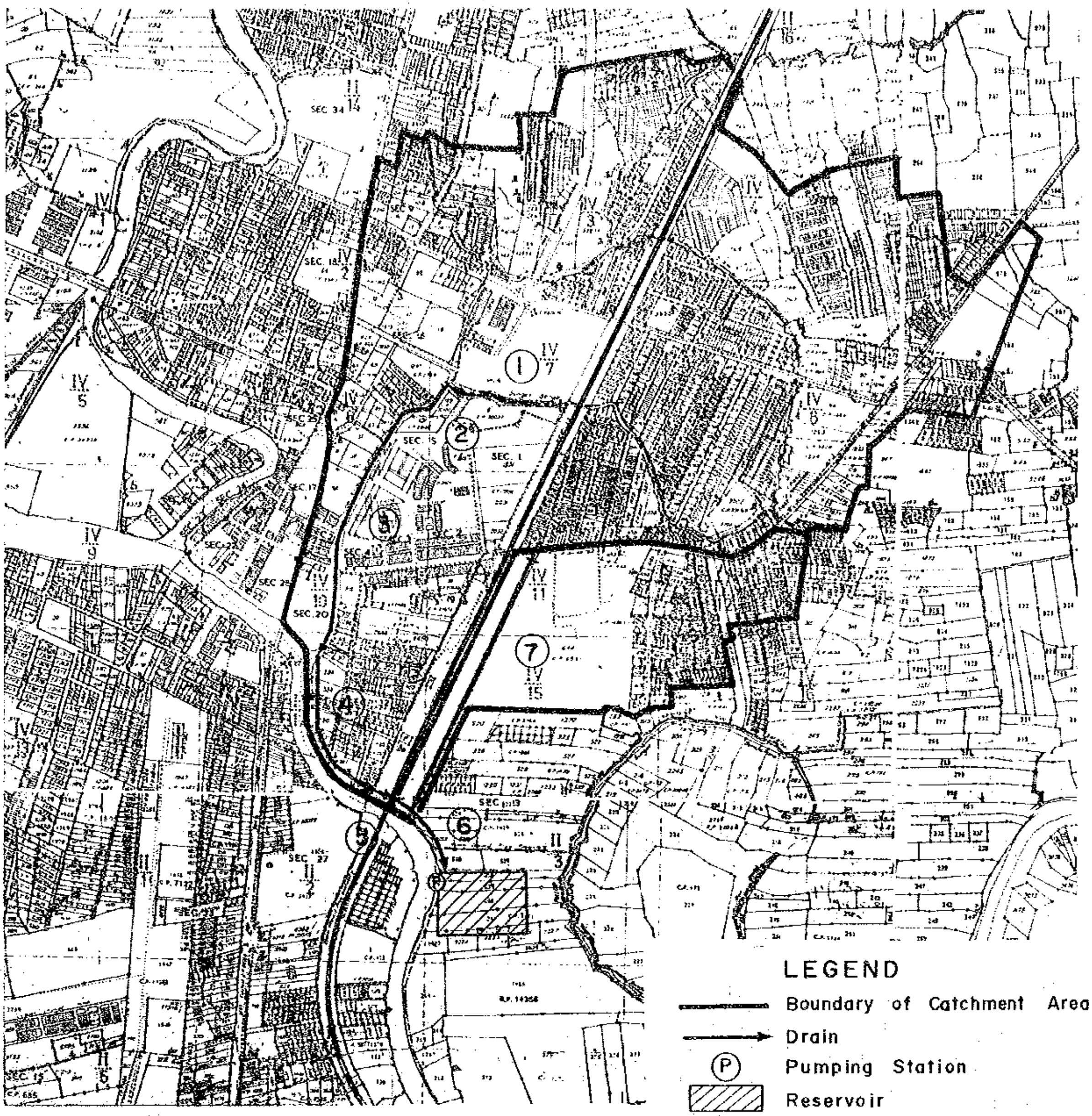
As the results of the previous studies, pumping station and reservoir are required and recommended to be established at the Sg. Kedah for receiving the discharge from Sg. Raja and Langgar basins, while no pumping station and reservoir are provided for Putera Basin due to the fact that the area of this basin has relatively high ground elevations which is sufficient to meet the design flows, so that the storm runoff originating from this basin is well discharged through many of outlets into the river directly. The proposed pumping station and reservoir will be functioned together after closing the gates of the drain outlets, especially when the flood flows occurred during the high intensity storms coincide with the high spring tide.

The determination of the capacity of the pumping station and reservoir is based on the Master Plan proposal which applied the critical storm of 2-year frequency. The critical storm of 2-year frequency is considered sufficient to protect the Study Area from the flooding, since the occurrence of 2-year local storm with a 1-year river flood level would occur at about 10-year return period as discussed in the Master Plan prepared by SDID.

To reduce the storage area of the reservoir, pump will be operated immediately when stormwater runoff discharged into the reservoir after closing the drain outlets, thus maintaining the low water level in the reservoir.

In order to provide the adequate pumping station and reservoir system under the above mentioned operating conditions, two types of pump, screw and centrifugal, are compared considering the characteristics of each of them including the method of operation and maintenance, and economical point of view as to the construction, and operation and maintenance costs. (See Annex A).

The result of the comparison study is concluded that centrifugal pump is superior to screw pump on above mentioned aspects. Thus, centrifugal pump is selected, and recommended for use of the recommended drainage pumping station.



Facility	Size or Capacity	Const-ruction Cost	Land Cost	Total Cost
Drain ①	⊔ 5.5/3.5 x2.0	148	–	148
〃 ②	⊔ 6.5/4.5 x2.0	53	–	53
〃 ③	⊔ 11.0/8.8 x2.2	845	–	845
Floodway ④	⊔ 11.0/8.8 x2.2	610	40	650
〃 ⑤	⊡ 11.0x3.0	780	–	780
〃 ⑥	⊔ 11.0/8.8 x2.2	470	20	490

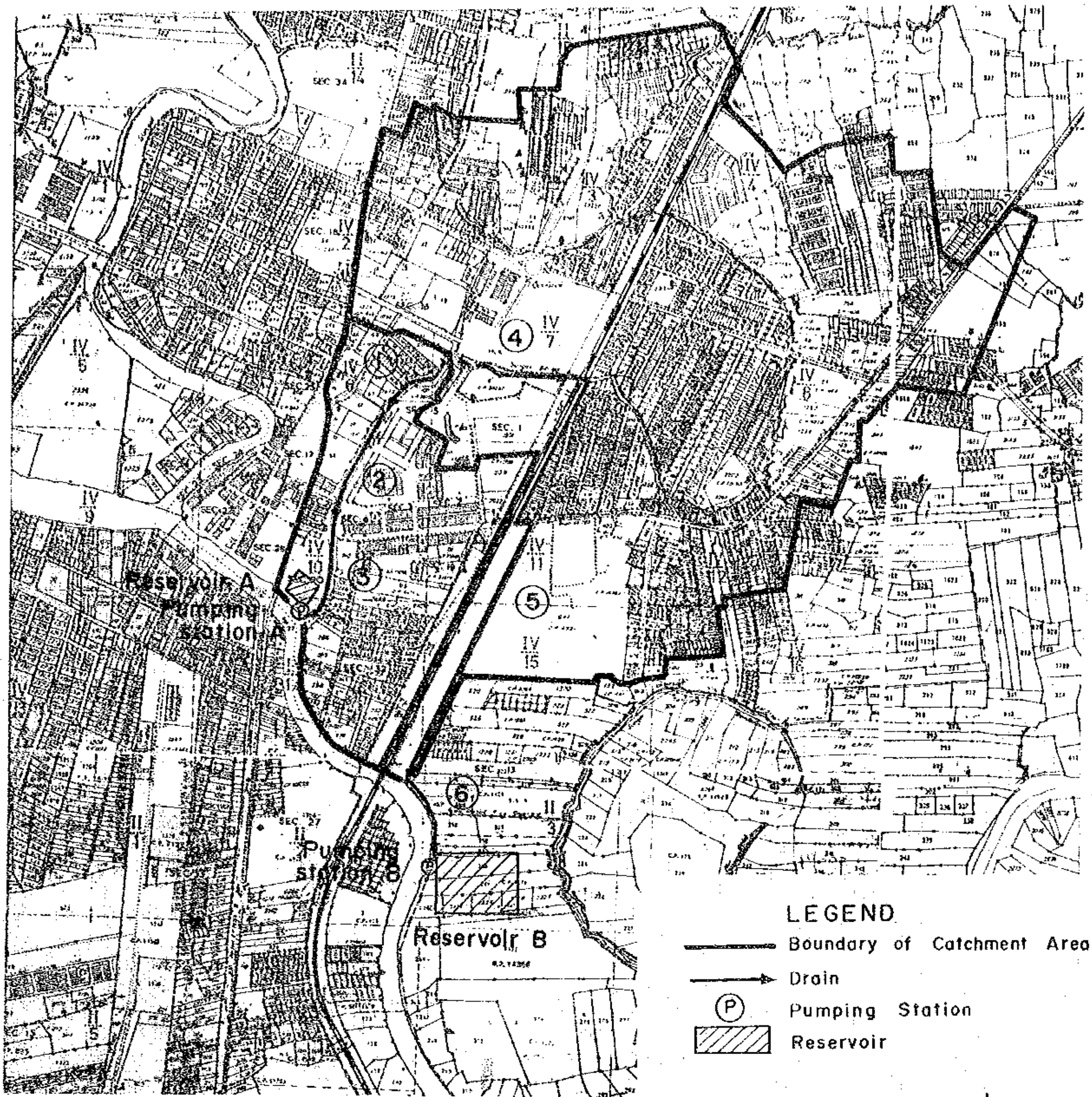
(1,000 M$)

Facility	Size or Capacity	Const-ruction Cost	Land Cost	Total Cost
Drain ⑦	⊔ 3.2/1.9 x1.9	340	–	340
Pumping station	120 m^3/min	1.350	171	2.286
Reservoir	127.000 m^3	765		
Total				5.592

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

TRUNK DRAINAGE SYSTEM OF ALTERNATIVE I

FIGURE 7.1



Facility	Size or Capacity	Construction Cost	Land Cost	Total Cost
Drain ①	⊔ $\frac{3.0}{1.8}$ x1.2	101	—	101
〃 ②	⊔ $\frac{4.5}{2.7}$ x1.8	180	—	180
〃 ③	⊔ $\frac{5.0}{3.0}$ x2.0	145	—	145
〃 ④	⊔ $\frac{9.0}{7.0}$ x2.0	201	—	201
〃 ⑤	⊔ $\frac{10.5}{8.4}$ x2.1	1.185	134	1.319
〃 ⑥	⊔ $\frac{10.5}{8.4}$ x2.1	123	7	130

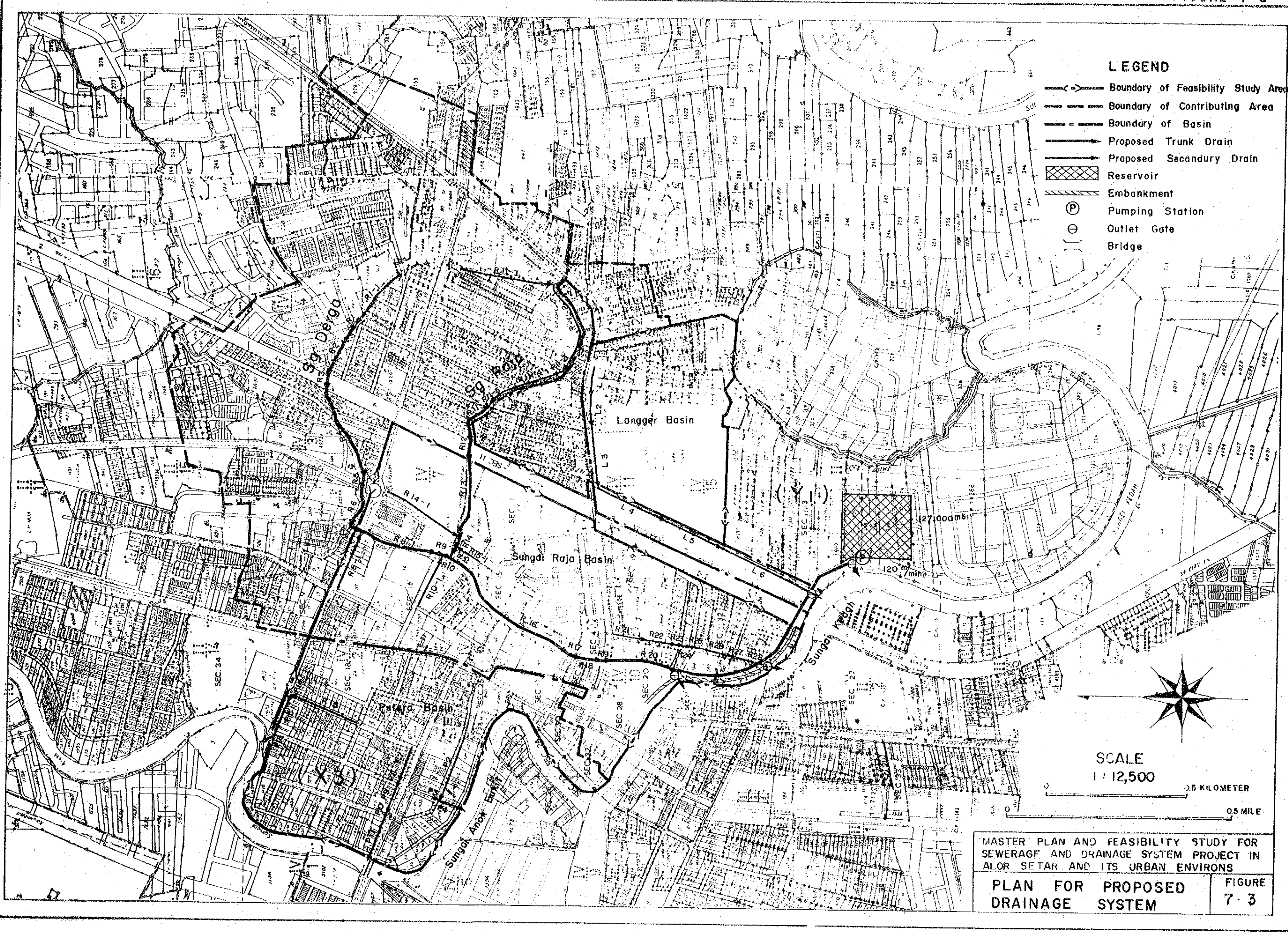
(1,000 M$)

Facility	Size or Capacity	Construction Cost	Land Cost	Total Cost
Pumping station A	120 m^3/min	1.350	90	1.725
Reservoir A	20.000 m^3	285		
Pumping station B	60 m^3/min.	1.060	150	1.900
Reservoir B	111.000 m^3	690		
Total				5.710

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

TRUNK DRAINAGE SYSTEM OF ALTERNATIVE 2

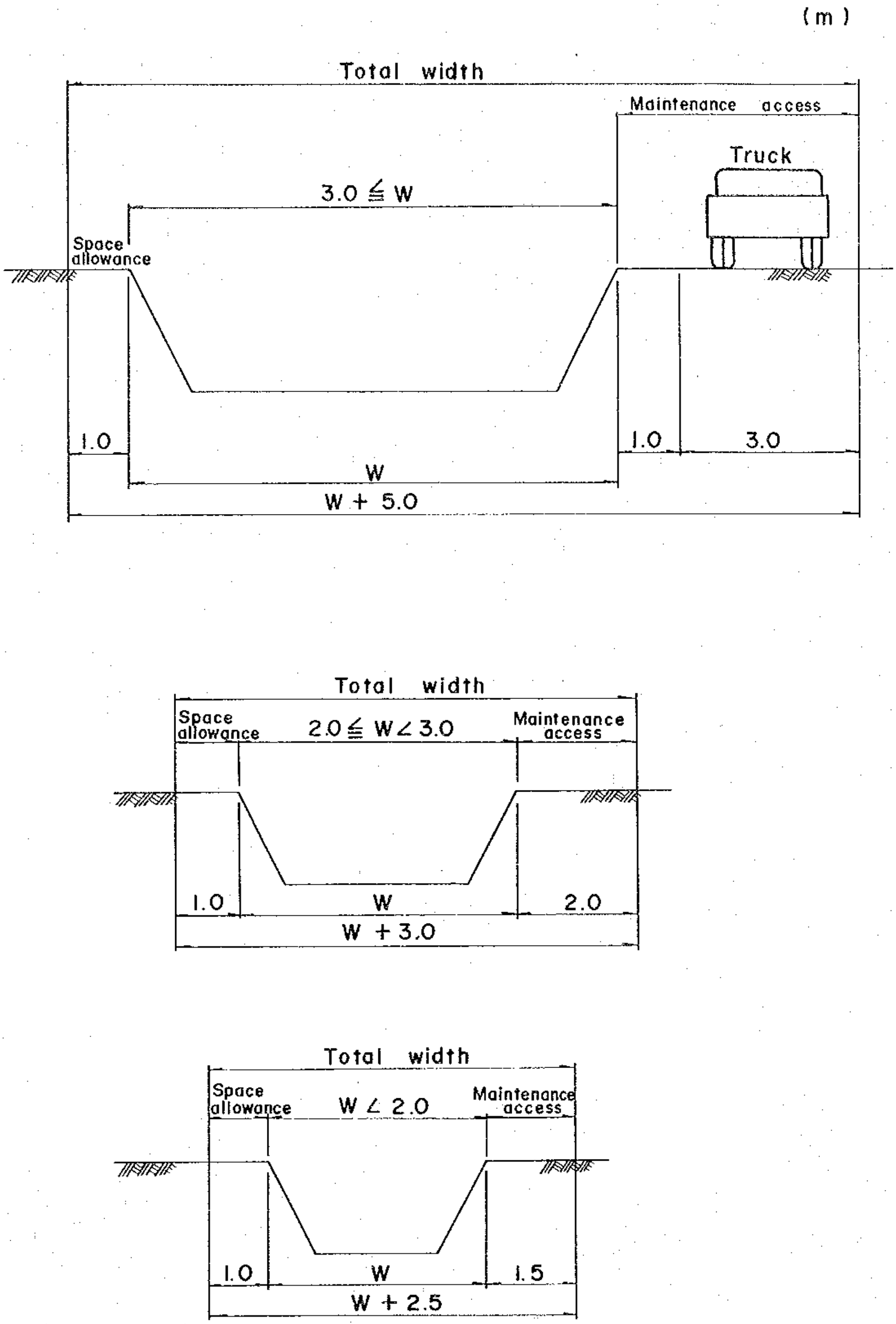
FIGURE 7.2



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

PLAN FOR PROPOSED DRAINAGE SYSTEM

FIGURE 7·3

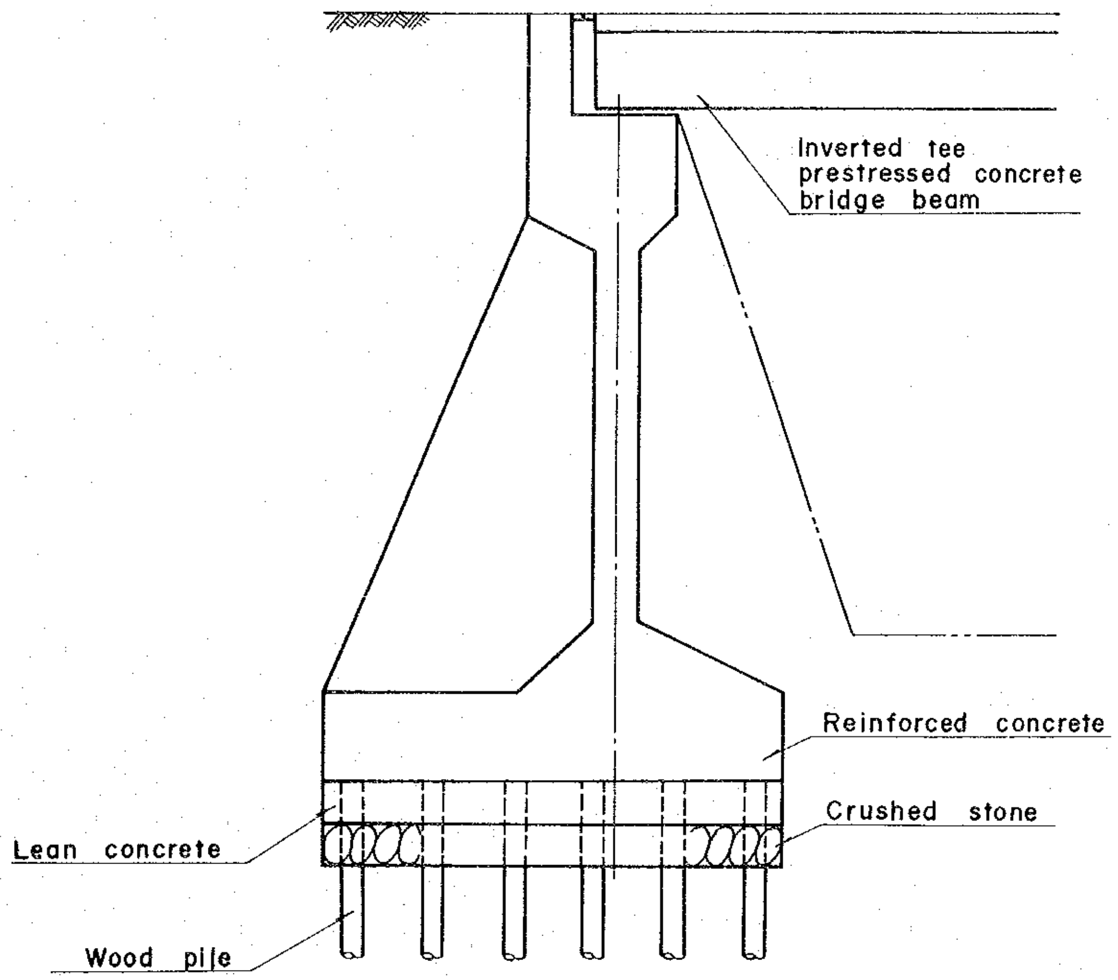


MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

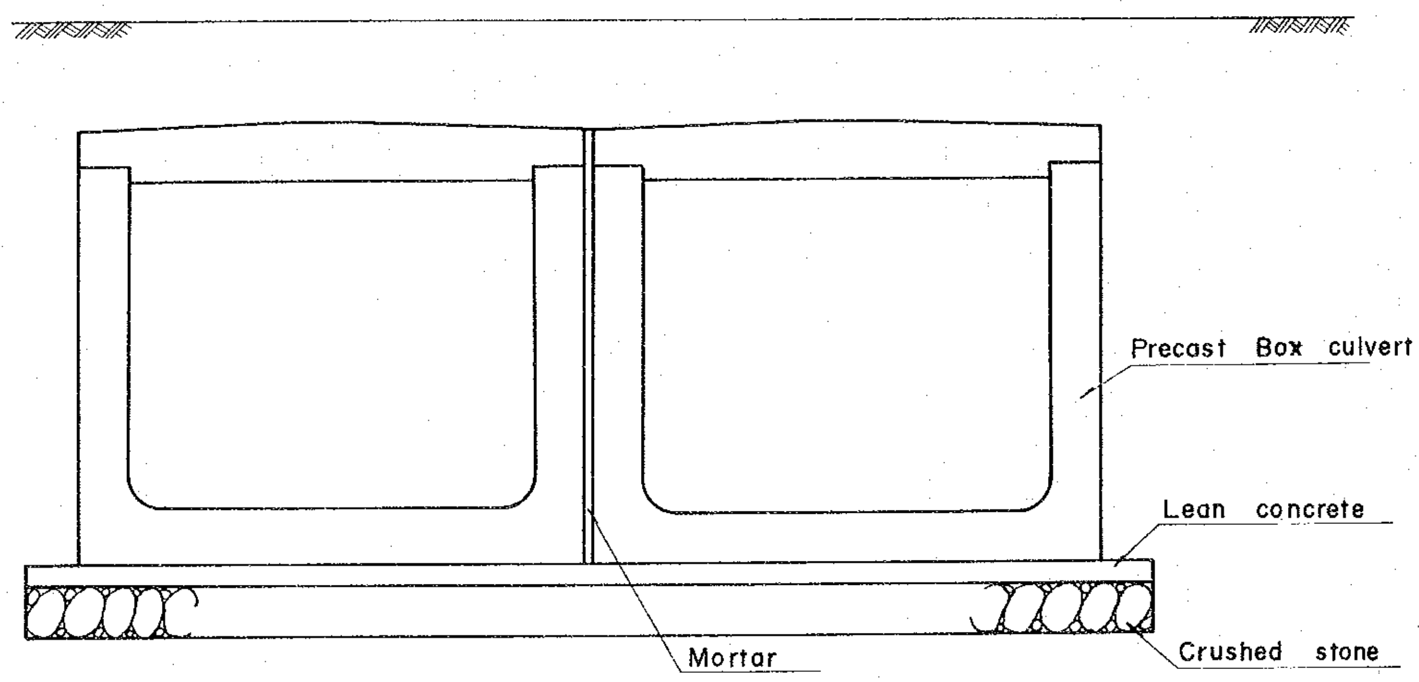
DRAIN RESERVE

FIGURE 7.4

Typical Abutment

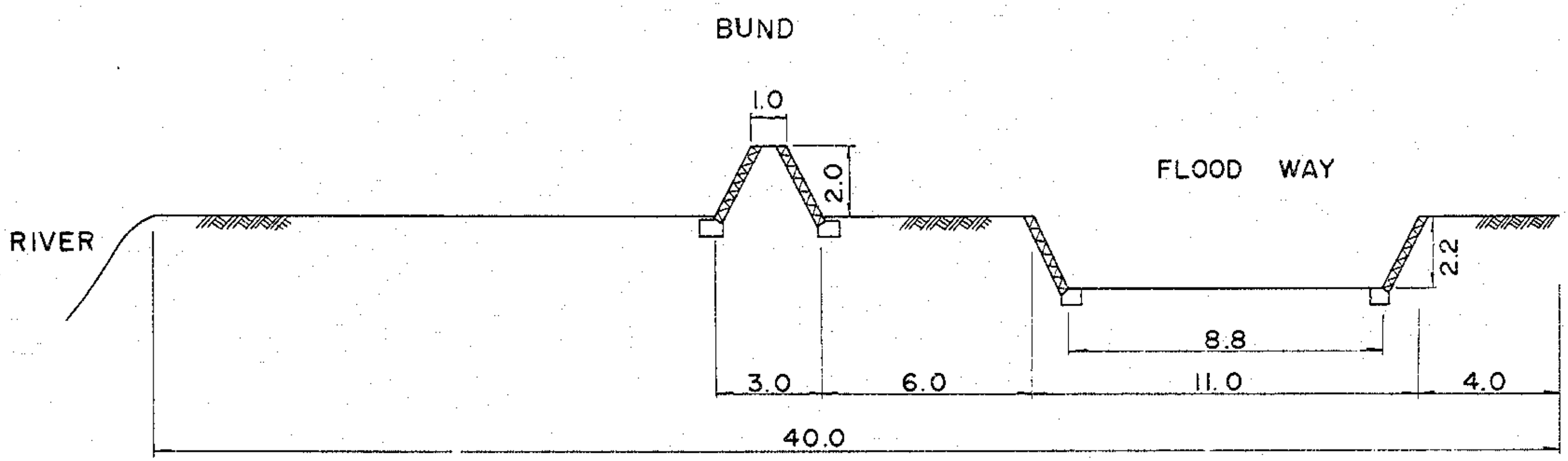


Cross Section of Multicell Box Culverts



MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS	
TYPICAL ABUTMENT AND CROSS SECTION OF MULTICELL BOX CULVERTS	FIGURE 7.5

TYPICAL RUBBLE WALL WITH A FLOODWAY



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

TYPICAL BUND SECTION — FIGURE 7.6

CHAPTER 8
CONSTRUCTION, OPERATION AND MAINTENANCE COSTS

8.1 Construction Cost

Cost for the construction may be divided into direct and indirect items, including civil works, installation of the equipment, contractor's profits and overhead, and all related construction works. In view of the above sound, the estimated construction cost of the proposed drainage facilities are presented below:

8.1.1 Procedure for Estimating Construction Costs

For estimating the construction costs of the proposed drainage facilities, the information and data on the basic costs including materials and labour costs have been collected from various sources including MPKS and JKR in Alor Setar, MPPP in Penang, and various local contractors and manufacturers, during the course of the field work. All basic costs collected from the sources referred above are expressed in 1979 price level in Malaysia. Using these basic costs obtained, unit costs for construction including both labour and materials are estimated with due consideration on the suitable materials and methods for construction including availability of local materials and ability of local contractors. These estimated unit costs together with the basic prices of materials are presented in Table 8.1.

On the basis of the above mentioned unit costs as estimated, and using them, construction costs of each facilities proposed are estimated according to the following:

(a) Trunk and Secondary Drains

For estimating the construction costs for trunk and secondary drains, cost function curves for various type of drain have been developed using the unit costs. The cost reflected by the curves includes excavation, dewatering, backfilling, restoration of pavings of roads and material for structures. The developed cost function curves are shown in Figure 8.1.

Since the recommended drain facilities include the gates and box culvert structures, construction costs for these structures are also estimated, and included in the costs of drain facilities. Construction costs of box culvert are based on the cost function curve developed together with cost function curves for trunk and secondary drains as mentioned above, while the costs for gate are estimated in the actual expenditure for construction, on the basis of the proposed structure as shown in Figure 5.2.

As discussed in previous chapter, the Fronte Jaking Method has been proposed for use of the construction of floodway at crossing the railway, on the basis of careful analysis on determination of the methods of construction. Since an adoption of this method seem to be difficult to local contractor, and no mechanical equipments required for use of this method are available presently in Malaysia, an assumption is made that the construction of floodway by use of the Fronte Jaking Method shall be consigned to the foreign contractor together with import mechanical equipment, and costs for this shall be included in the estimation of construction costs.

(b) Infrastructural Drain

Although no preliminary engineering design has been made for the infrastructural drains, the cost for infrastructural drain is also considered and estimated on the basis of the

the reasonable assumption for estimation of the total project. Construction costs of infrastructural drains are derived from the unit construction cost on per hectare basis.

Factors affecting the costs are ground surface conditions, road density and condition of the existing drains in the area concerned. In order to reflect the actual conditions of the Study Area, representative typical area comprising commercial and residential areas is first selected, and requirements of the infrastructural drains are then identified for the new construction and improvement of the existing drains.

The recommended infrastructural drains in the selected area are of U-shape pre-cast concrete and rubble wall open channels, with due consideration on the economical view point and easiness of construction. At road intersections, either centrifugally cast reinforced concrete pipe or box culvert is considered. From the above study, construction costs of infrastructural drains are estimated by use of the unit costs estimated previously. The estimated cost, in terms of the per hectare, for the construction of infrastructural drains is approximately M$15,000/ha. Representative networks of these drains for the selected area are presented as shown in Figure 8.2.

(c) Pumping Station and Reservoir

Construction costs of pumping station and reservoir are estimated based on the cost function curves developed as shown in presented in Annex A. The costs reflected by the curves are all civil and building works, including materials and labour for both pumping station and reservoir, and electrical and mechanical equipment for pumping station.

For estimating the construction costs of pumping station, an assumption is made that most of mechanical and electrical equipments including pumps, diesel engine, controlling devices, piping materials, and crane and hoist be imported from foreign countries, thus requiring foreign currency, while materials for building and civil works are available in Malaysia. The estimated costs of those electrical and mechanical equipment are based on the reasonable assumption through quotation obtained from reliable foreign manufacturers.

(d) Embankment

Construction cost of embankment is derived from the unit construction cost on per length basis. The works required for construction of embankment are land filling, compaction and rubble pitching. Thus construction costs of embankment are estimated based on the unit cost estimated previously for the above works required.

(e) Bridge

Estimation of construction cost for bridge is based on the proposed typical structure as shown in Figure 7.5. Bridge structure comprises both superstructure and substructure. The superstructure is made of precast reinforced concrete beams and floor slabs with pavement. The substructure consists of retaining abutment with reinforced concrete and piling. With the above work's requirement for bridge construction, the estimated construction costs in terms of unit basis are as follows:

Superstructure	:	M$660/m^2 of surface area
Substructure	:	
abutment	:	M$4,500/m of width
counterfort (at every 3 m)	:	M$300/unit
miscellaneous work for piling	:	M$720 (lump sum)

8.1.2 Construction Cost of Overall Drainage Facilities

Total construction costs for the overall drainage facilities are estimated by totalling the costs required in recommended structure, on the basis of the procedure for estimating the cost by use of either cost function curve or unit basis as described previously. The costs comprise materials and labour, contingency allowance, engineering fee, and land acquisition. As the contingencies, 15 percent of the estimated actual construction costs is added, and 10 percent of the total cost is assumed for engineering fee. Out of the engineering fee, 50 percent is considered for detailed engineering design and the remaining for supervision services for construction. The estimated total construction cost for overall drainage facilities is to be approximately M$16.8 million at 1979 price levels as shown in Table 8.2.

As indicated in this Table, the cost estimated for land acquisition is to purchase the necessary land for the facilities required in the overall drainage system including embankment, floodway, pumping station and reservoir, based on the data on land costs obtained from Valuation Office of the State Government, Kedah, as presented in Sewerage Study Report.

It is noted that since the Study Area has been already urbanized, most of the area has been already served by the provision of drains either trunk and smaller drains even in insufficient capacities. Therefore, no private contribution shall be expected for the drainage construction. All new construction and improvement of the drainage facilities as recommended herein shall be contributed by the Government. Thus, estimated construction costs for the overall drainage facilities have not been made for the private contribution.

Table 8.1 Schedule of Unit Construction Costs (at 1979 price level)

(1) Basic Price of Material

Nominal Size	Price per 0.61 m (2') including transportation
U shape	
300 mm (12")	M$ 3.50
380 mm (15")	4.80
460 mm (18")	6.20
610 mm (24")	8.50

Box culvert	Price per 1.22 m (4') including transportation
610 x 445 (24" x 18")	M$ 183.80
760 x 610 (30" x 24")	217.00
915 x 760 (36" x 30")	251.50
1,220 x 760 (48" x 30")	324.60
1,220 x 915 (48" x 36")	342.70
1,830 x 1,220 (72" x 48")	665.80
1,830 x 1,525 (72" x 60")	742.30
1,830 x 1,830 (72" x 72")	802.00

(2) Unit Construction Cost

Item	Description	Unit	Cost (M$)
Concrete	1 : 2 : 4	m^3	156.90
	1 : 3 : 6	"	124.20
Reinforced Concrete	1 : 2 : 4	m^3	313.70
Mortar	1 : 2	m^3	186.50
	1 : 3	"	182.10
Trench Excavation (by hand)	depth		
	0 - 1.5 m	m^3	4.70
	1.5 - 3.0	"	8.60
	3.0 - 4.5	"	11.50
	4.5 - 6.0	"	15.10
	6.0 - 7.5	"	18.90
	7.5 - more	"	22.50
Excavation (by machine)	Irrespective of depth	m^3	2.30
Backfilling and Compaction		m^3	3.00
Form Works		m^3	8.20
Masonry Works		m^3	71.00
Dewatering		hr	3.00

Table 8.2 Construction Costs for Overall Drainage Facilities
(at 1979 Price Level)

(M$ x 1,000)

Items	Trunk Drain (m)	Secondary Drain (m)	Infrasturc-tural Drain (ha)	Flood-way (m)	Pumping Station (m^3/min.)	Reservoir (m^3)	Embank-ment (m)	Total
Facility Length or Capacity	2,655 m	5,155 m	187 ha	800 m	120 m^3/min.	127,000 m^3	600 m	-
Construction Cost	2,712	2,160	2,805	1,900	1,350	765	144	11,836
Engineering Fee	407	324	421	285	203	115	22	1,777
Contingency	624	497	645	437	311	176	33	2,723
Sub-Total	3,743	2,981	3,871	2,622	1,864	1,056	199	16,363
Land Acquisition								
Area (ha)	-	-	-	1.2	-	5.7	3.8	10.7
Cost	0	0	0	60	0	171	230	461
Total	3,743	2,981	3,871	2,622	1,864	1,227	429	16,797

Note: The total costs for floodway and pumping station are divided into local and foreign currencies. The estimated foreign currencies for these facilities are to be M$460,000 for floodway and M$1,300,000 for pumping station.

8.2 Operation and Maintenance Costs

As has been discussed in the Master Plan prepared by SDID, and in accordance with the results of the study made in "Institutional Study", Volume VI as presented in this Project, it is considered that the management of the drainage system in the future will be under the responsibility of MPKS which will look after construction and maintenance of trunk, secondary and infrastructural drains, except the roadside drains along the federal and state roads which would be constructed and maintained by JKR. Generally, maintenance works for the drainage system consist of removing deposits from drains and reservoir, operation of gates and pumping station, and repair of damaged parts of all drainage facilities. For these works, operation and maintenance methods considering the number of personnel required for the works for MPKS are first analysed, and then their costs for the proposed drainage system are estimated using the reasonable assumption.

8.2.1 Procedure for Estimating Operation and Maintenance Costs

For estimating the operation and maintenance costs of the overall drainage facilities, comparable information obtained from other similar cities in Malaysia and Japan has been reviewed together with the data on the actual expenditures in the past experience for the existing drainage system with the Study Area, and the results are used as the basis for estimating the operation and maintenance costs. Basis for operation and maintenance costs is described below:

(1) Drains

The maintenance works for drainage facilities including drains, box culverts, gates consist mainly of repairing of broken part of the facilities and removing deposits from drains. The annual repairing cost for drain facilities is assumed to be 0.25 percent of each facility's construction cost, on the basis of the actual expenditure experienced in the similar cities both in Malaysia and Japan. This ratio is also applied to estimate the maintenance cost for bridge facility as repairing cost.

For estimating the cost of removing deposits from the drain, following assumption is made dividing into four types of drains namely trunk, secondary, and infrastructural drains and floodway as recommended in the drainage system, with due consideration on the method of maintenance works.

(a) Trunk Drain and Floodway

An assumption made for the estimation is as follows:

(i) Frequency of dredging for trunk drain is once a year in dry season.

(ii) Dradging is carried out by hand after drained out the water in the drain. For performance of the work, an assumption is also made that the drain is closed by 50 m per length of the drain using the sandbags or slit as shown in Figure 8.3 and then water is drained out by use of submersible pump. For drain out the water, dewatering cost as shown in Table 8.1 is applied.

(iii) Unit cost for desilting work is to be 20 percent increase to the unit cost of excavation estimated in unit construction cost, considering the difficultly of work required in muddy condition.

(iv) The average volume of accumulation of silt to be removed in terms of annual basis is 10 percent of the cross sectional area of drain.

On the basis of the above assumption, unit cost of removing deposits from the trunk drain, consisting of the component works including damming up, dewatering and desilting, is estimated to be M$22 per one meter length of drain annually.

(b) Secondary Drain

Dredging work for the secondary drain will also be carried out in the same manner with that of trunk drain as discussed previously. For estimation of the average volume of removal deposits in the secondary drain, the average cross sectional area between trunk and secondary drains is first compared, and is found that the average volume of deposits for the secondary drain is to be 25 percent of that of trunk drain. Using this ratio between trunk and secondary drains, the annual unit dredging cost of secondary drain is estimated to be M$5.5 per one meter length of drain.

(c) Infrastructural Drain

The work required for removing deposits for the infrastructural drain would be carried out by the hand of labours employed by MPKS, thus estimating the number of labour to be required for the work, and cost of removing deposits for the infrastructural drain is estimated directly by the wage of labour. For estimating the number of labour to be required for the work, following assumption is made:

(i) Frequency of cleaning or desilting of the drain is once a year.

(ii) Working hours and days of labour are 6 hours/day and 250 days/year respectively.

(iii) Ability of one labour to clean or desilt the drain is 200 meter length per day of drain.

Based on the above assumption and estimated total length of infrastructural drains within the Study Area as approximately 40,000 m, with one labour assigned for this work, the total period of work for cleaning or desilting of the drain is estimated to be 200 days which will sufficiently meet with the above requirement. It is, therefore, concluded that the maintenance of infrastructural drains within the Study Area would be performed by only one labour. The annual salary of the labour is of M$3,000.

(2) Pumping Station

Operation and maintenance costs for the pumping station are estimated by use of the cost function curve developed as presented in Annex A of this report. The cost reflected by the curve includes labours, materials, overhauling and repairing of mechanical equipment, and repairing of structures. All basic costs used for developing the cost function curve are based on the reasonable data obtained from various sources and manufacturers mentioned previously in both Malaysia and Japan. Details for developing the cost function curve are referred in Annex A of the present report.

(3) Reservoir

Maintenance work for the reservoir shall mainly be consisted of removing deposits from reservoir including carrying those deposits from the site to dumping place same as the maintenance work of drains mentioned previously. For estimating the cost of this work, following assumption is made; the work for removing deposits will be in once a year, and machine excavation will be applied. Thus, unit cost of this work is applied same as that of cost for excavation by machine estimated in unit construction cost as indicated in Table 8.1.

On the basis of the assumption mentioned above, the annual unit cost of removing deposits for reservoir is estimated to be M$2.30/$m^3$ of deposits volume. In connection with the above unit cost estimated, it is further considered that the estimated average volume of deposits is based on the assumption that the part of accumulation of silt to be removed on annual basis would be 10 percent of the storage capacity of reservoir.

In view of the all works required for operation and maintenance of the proposed drainage system, as discussed in the above, it is recommended that systematic programme for routine inspection of the works and collection of information be set up immediately. The information and data should be recorded, filed and used for establishing the proper maintenance schedule. For these purpose, especially for MPKS, (1) one assistant engineer for inspection, data collection and preparation of maintenance schedule, and (2) sufficient number of labour as recommended previously for routine job including cleaning and desilting works for drains, and operation of pumping station, are required and their salaries are added to the maintenance costs for the recommended drainage system.

For the work of dredging or cleaning of the drains, the major drains including trunk, secondary and floodway are considered to be given to the contractors on contractual basis, and only the work necessary for infrastructural drains will be carried out by MPKS's own personnel required as estimated in the previous study.

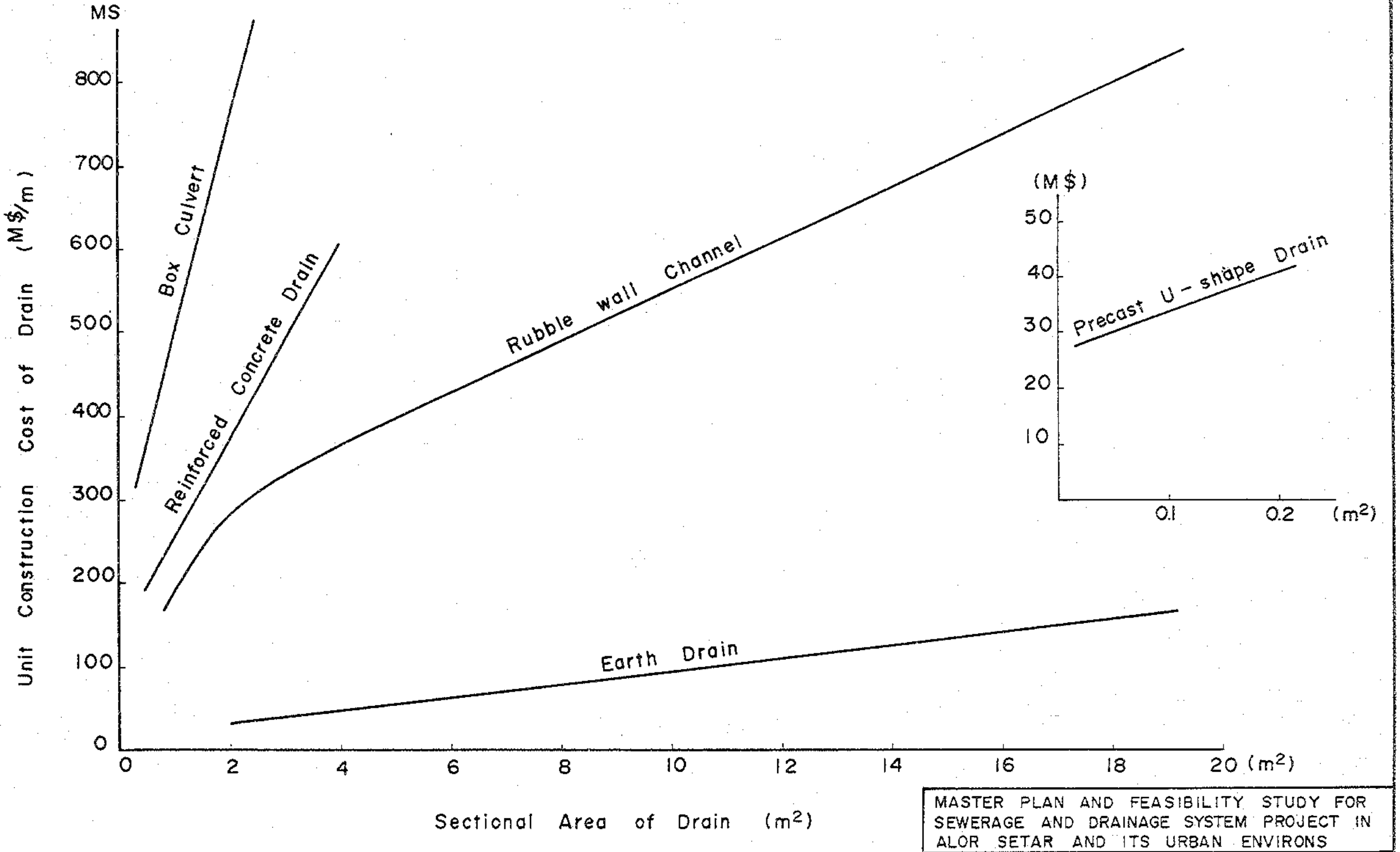
8.2.2 Maintenance Cost of Proposed Drainage Facilities

On the basis of the unit cost estimated as described in previous paragraph and amount of operation and maintenance works required for all drainage facilities developed in the preliminary engineering design including trunk, secondary and infrastructural drains, floodway, gate, bridge, embankment, pumping station and reservoir, together with required manpower for the administrative work but only for MPKS's staff, the total maintenance costs for the proposed drainage system in terms of annual basis are estimated as summarized in Table 8.3

Table 8.3 Annual Operation and Maintenance Costs for the Overall Drainage Facilities

(at 1979 Price Level M$1,000)

Facility \ Item	Repair & Replacement	Dredging	Operation	Sub-Total	Payroll	Total
Trunk Drain including Gates and Bridges	6.8	58.4	-	65.2		
Secondary Drain including Gates	5.4	28.4	-	33.8		
Infrastructural Drain	7.0	3.0	-	10.0	12.0	
Floodway	4.8	13.2	-	18.0		
Embankment	0.4	0	-	0.4		
Pumping Station	19.0	0	35.5	54.5		
Reservoir	1.9	29.2	-	31.1		
Total	45.3	132.2	35.5	213.0	12.0	225.0

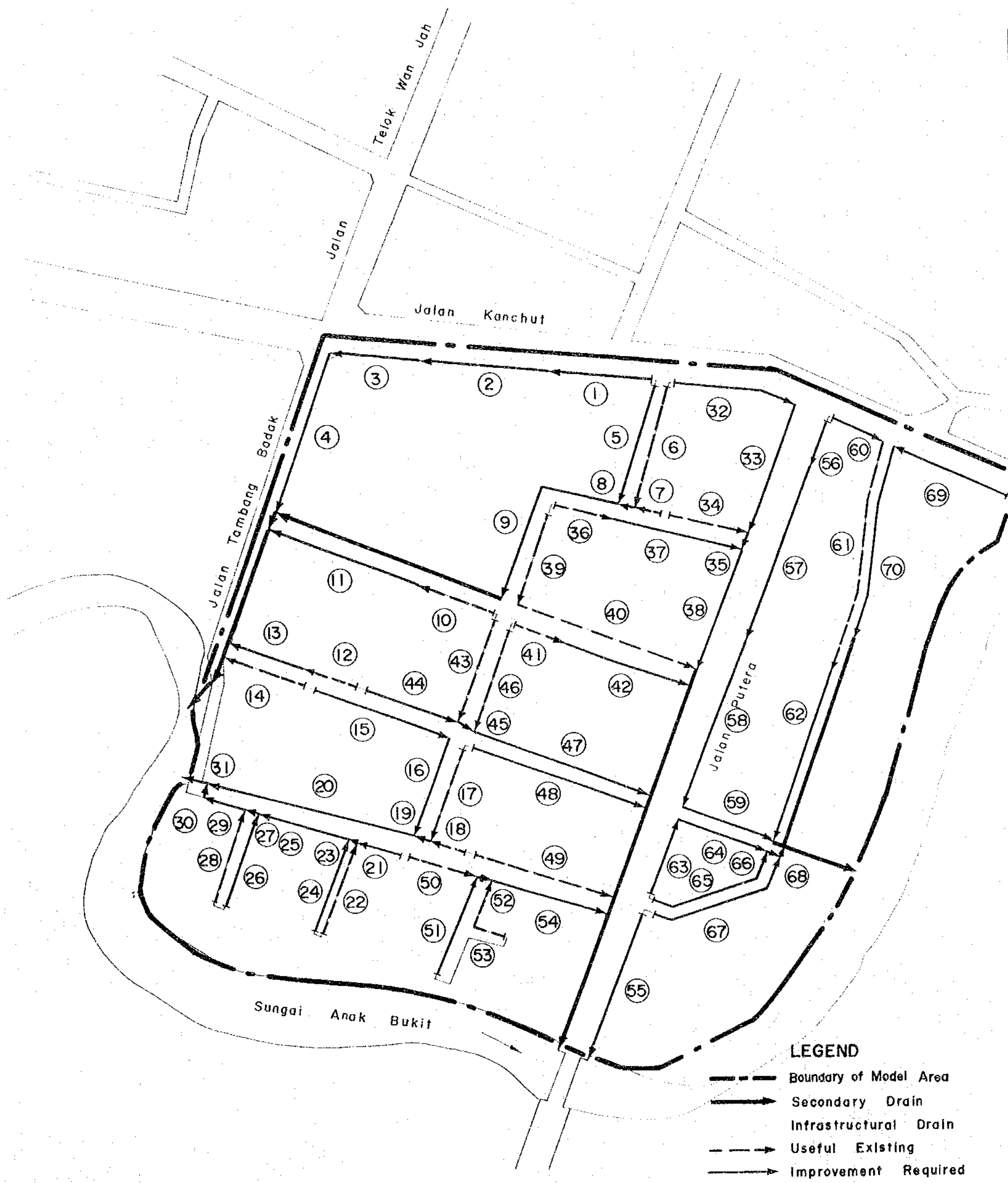


MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

CONSTRUCTION COST CURVES OF DRAIN

FIGURE 8.1

Line No	Existing Drain	Proposed. Drain
1	*	RB $\frac{800}{370}$x640
2	*	RB $\frac{1000}{470}$x800
3	*	RB $\frac{1500}{700}$x1200
4	E $\frac{2000}{500}$x1200	RB $\frac{1800}{840}$x1440
5	U360	U610
6	U460	〃
7	U310	〃
8	⊡300x300	⊡610x610
9	⊔380x380	RB $\frac{1500}{700}$x1200
10	U460	〃
11	E $\frac{1000}{300}$x600	RB $\frac{1000}{470}$x800
12	U460	〃
13	E $\frac{1000}{300}$x600	RB $\frac{800}{370}$x640
14	E $\frac{800}{200}$x600	〃
15	E $\frac{800}{200}$x600	RB $\frac{800}{370}$x640
16	E $\frac{800}{200}$x600	RB $\frac{1000}{470}$x800
17	U380	〃
18	E $\frac{600}{200}$x600	〃
19	2⊡1800x550	〃
20	E $\frac{1500}{500}$x900	RB $\frac{1500}{700}$x1200
21	—	U610
22	⊔300x700	〃
23	⊙600	〃
24	—	U610
25	E $\frac{1000}{400}$x600	RB $\frac{1000}{470}$x800
26	—	U610
27	⊙700	⊡1200x1200



Line No	Existing Drain	Proposed Drain	Line No	Existing Drain	Proposed Drain
28	U380	〃	54	E $\frac{1000}{400}$x600	〃
29	E $\frac{1500}{300}$x600	RB $\frac{1500}{700}$x1200	55	*	RB $\frac{1200}{560}$x960
30	—	⊡1370x1370	56	*	U380
31	E $\frac{1500}{600}$x900	RB $\frac{1800}{840}$x1440	57	*	RB $\frac{1000}{470}$x800
32	*	RB $\frac{1200}{560}$x960	58	*	RB $\frac{1500}{700}$x1200
33	*	RB $\frac{1200}{560}$x960	59	⊔ $\frac{1000}{500}$x1200	RB $\frac{1500}{700}$x1200
34	U380	〃	60	*	U600
35	*	⊡1370x1370	61	⊔ $\frac{1100}{500}$x1000	〃
36	U380	〃	62	⊔ $\frac{1100}{600}$x1000	RB $\frac{1500}{700}$x1200
37	U380	RB $\frac{800}{370}$x640	63	*	U380
38	*	RB $\frac{1800}{840}$x1440	64	U380	U610
39	U460	〃	65	*	U610
40	⊔ $\frac{1200}{400}$x1000	〃	66	⊡460x460	⊡920x920
41	U380	〃	67	*	RB $\frac{1000}{470}$x800
42	U380	RB $\frac{1000}{470}$x800	68	⊔400x700	RB $\frac{1500}{700}$x1200
43	U460	〃	69	*	RB $\frac{1200}{560}$x960
44	—	RB $\frac{1000}{330}$x560	70	⊔800x900	RB $\frac{1500}{700}$x1200
45	⊡1250x550	〃			
46	U380	〃			
47	E $\frac{1200}{300}$x1000	RB $\frac{1500}{700}$x1200			
48	—	RB $\frac{800}{370}$x640			
49	⊔ $\frac{600}{400}$x1400	〃			
50	E $\frac{600}{400}$x600	〃			
51	—	U460			
52	⊡600x400	〃			
53	U610	〃			

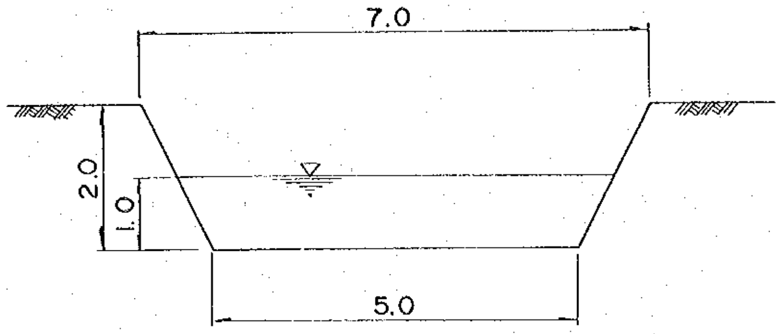
* ; Newly Construction Required by Road Expansion
〃 ; Useful Existing Drain
E ; Earth Drain
RB ; Rubble wall Drain
⊔ ; Concrete Drain
⊡ ; Box Culvert
U ; U shape Drain
⊙ ; Pipe

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

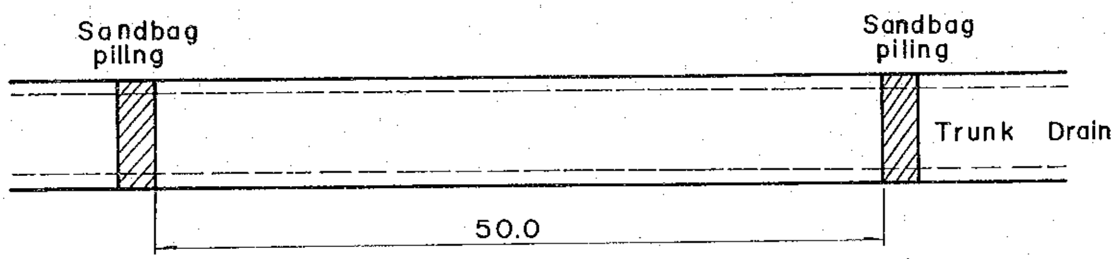
REPRESENTATIVE NETWORK OF INFRASTRUCTURAL DRATNS

FIGURE 8.2

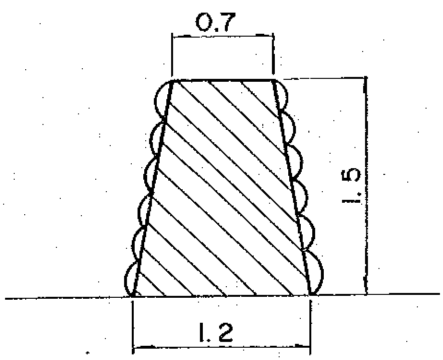
Typical Cross Section (m)



Typical Plan (m)



Sandbag Piling (m)



MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS	
MODEL USED FOR MAINTENANCE COST ESTIMATE OF TRUNK DRATN	FIGURE 8.3