CHAPTER 9

CONSTRUCTION AND DISBURSEMENT PROGRAMME FOR THE FIRST PHASE PROGRAMME

Due to the constraint of time of implementation and availability of financial sources, the following construction and disbursement programme is recommended as the first phase programme for the drainage implementation covering the 5 years from 1981 to 1985.

9.1 Implementation Programme

In order to establish the most realistic drainage implementation schedule for the first phase programme, following basic concept is given for determination of the works necessary to meet the order of priority for the drainage requirements.

(1) Prepare the immediate measures including rehabilitation and improvement of trunk and secondary drains together with reconstruction of bridges and box culverts for alliviation of the existing flood problems.

(2) Provide the embankment along the Sg. Kedah and install the gates at the outlets of drains, to protect the low-lying area from the nuisance flooding causing by the backing up of water from the high river water level.

(3) Provide the pumping station, reservoir and floodway to protect the flooding when critical storms coincide with the high river water level.

(4) Establish the total drainage system to meet estimated increase of runoff as the future requirements.

On the basis of the results of the preliminary engineering design, the facilities required for each work itemized the above are classified as shown in Table 9.1.

Using the above classification, an implementation schedule for the first phase programme is developed taking the order of priority among those facilities referred above into account. However, the facilities required in item 4) are eliminated in the works necessary for the first phase drainage implementation programme, since those facilities would be provided to meet the future urban development programme. Thus, the development of the implementation programme for the first phase drainage requirements is made based on the works required from item 1) to 3). In determining the schedule, three sets of alternative construction programme are considered, identifing their advantages and disadvantages. The three alternatives are as follows:

Alternative 1: Minimum improvement requirements to alleviate the existing flood problems by constructing the trunk and secondary drains, at a cost of about M$3.7 million on 1979 price level as shown in Table 9.2 and Figure 9.1.

Alternative 2: Alternative 1 plus protection of flooding in low-lying area from river water, by provision of embankment and installation of gates, at a total cost of M$4.4 million on 1979 price level as shown in Table 9.3 and Figure 9.2.

Alternative 3: Alternative 2 plus construction of pumping station reservoir and floodway to protect the flooding caused when critical storms coincide with the high river water level, at the cost of M$11.4 million on the same price level as above, as shown in Table 9.4 and Figure 9.3.

Alternative 1 covers only for solving the existing inundation problems caused by short duration of high intensity local storm. However, in view of the actual situation of the area, the first phase programme is considered not advisable to limit only to remedy the problem of local inundation but rather to include river flooding which occurs in long duration low intensity storm. On the other hand, although Alternative 3 is the most comprehensive of all the measures purposed, the flood problems in the Study Area which have been experienced so far are caused mainly by the short duration and magnitude of the flooding does not necessarily warrant the investment required for this Alternanative 3.

In view of the above conditions, Alternative 2 is considered sufficiently adequate, and the cost required for this alternative seems to be reasonable to implement as the first phase programme. It is therefore recommended that Alternative 2 is selected and be implemented as the first phase programme starting from 1981 to 1985.

Table 9.1 Classified Facilities Required for Determination of First Phase Implementation Schedule

<table>
<tr><th>Description</th><th>Proposed Activities</th><th>Length</th><th>Existing Size (m)</th><th>Proposed Size (m)</th><th>Remarks</th></tr>
<tr><td rowspan="4">(1) Immediate Measure for Alleviation of the Existing Flood Problems</td><td>Construction of trunk drains
R20, R19, R18, R17, R16, R15, R14, R13, R7, R6, R5, R4, R3, R2, R1</td><td>Total 2,655 m</td><td>E 7.0/2.0 x 0.9
~
E 20.0/6.0 x 1.5</td><td>RB 5.4/3.5 x 1.9
~
RB 11.0/8.0 x 2.2</td><td>E : Earth Drain
RB: Rabble Wall Drain
(Upper width)/(Bottom width) x (Depth)</td></tr>
<tr><td>Reconstruction of bridges
R14, R5, R1</td><td>-</td><td>3.0 x 7.0
~
5.0 x 30.0</td><td>6.0 x 20.0
~
9.0 x 40.0</td><td>(Width) x (Length)</td></tr>
<tr><td>Construction of secondary drains
R14-1, R26</td><td>Total 440 m</td><td>nil
~
E 2.5/1.0 x 1.0</td><td>RB 1.80/0.84 x 1.44
~
RB 3.50/2.57 x 1.40</td><td></td></tr>
<tr><td>Conversion of pipe to box culvert
R27, R23</td><td>Total 30 m</td><td>⊙ 0.11
⊙ 0.10</td><td>2x [·] 1.68 x 1.53
~
2x [·] 1.22 x 1.22</td><td>2x: 2 Nos. Parallel
⊙: R.C. Pipe
[·]: Box Culvert</td></tr>
<tr><td rowspan="2">(2) Protection of the Low-Lying Area from River Flooding</td><td>Installation of gates at outlet of drains
R20, R28, L6</td><td>-</td><td>nil</td><td>1.0 x 2.0 x 2
~
2.0 x 2.0 x 5</td><td>(Width) x (Height) x (Nos.)</td></tr>
<tr><td>Construction of Band along Sg. Kedah between Jalan Raja and railway</td><td>600 m</td><td>nil</td><td>Refer to Figure 7.6</td><td></td></tr>
<tr><td rowspan="3">(3) Protecting the Flooding occurred when Critical Storms Coincide with the High River Water Level</td><td>Construction of Pumping Station</td><td>-</td><td>nil</td><td>120 m³/min.</td><td></td></tr>
<tr><td>Construction of Reservoir</td><td>-</td><td>nil</td><td>127,000 m³
5.7 ha</td><td></td></tr>
<tr><td>Construction of Floodway</td><td>800 m</td><td>nil</td><td>RB 11.0/8.8 x 2.2</td><td>(Upper width)/(Bottom width) x (Depth)</td></tr>
<tr><td rowspan="3">(4) Establish the Total Drainage System to Meet the Predicted Increase of Runoff as Future Requirements</td><td>Construction of secondary drains
R15-1, R11-5, R11-4, R11-2, R11-1, R10-1, R8-1, R1-1, R21, R22, R24, R28, P2, P4, P7, P9, P11, P13, P15, L6, L5, L4, L3, L2</td><td>Total 4,390 m</td><td>E 1.1/0.5 x 1.1
~
E 5.5/1.0 x 0.6</td><td>RB 1.5/0.7 x 1.2
~
RB 5.5/3.7 x 1.8</td><td>E : Earth Drain
RB: Rabble Wall Drain
(Upper width)/(Bottom width) x (Depth)</td></tr>
<tr><td>Construction of bridge R11-5</td><td>-</td><td>5.0 x 10.0</td><td>6.0 x 25.0</td><td>(Width) x (Length)</td></tr>
<tr><td>Construction of box culvert
R11-3, R25, P3, P6, P8, P10, P14, P16, L1</td><td>Total 295 m</td><td>[·] 1.4 x 0.4
~
E 5.5/1.0 x 0.6</td><td>[·] 1.37 x 1.37
~
2x [·] 1.83 x 0.92</td><td>[·]: Box Culvert
E : Earth Drain
2x: 2 Nos. Parallel
(Upper width)/(Bottom width) x (Depth)</td></tr>
</table>

Table 9.2 Implementation Schedule, Alternative 1
(at 1979 Price Level)

(M$ x 1,000)

Item	1981		1982		1983		1984		1985		Total Cost
	Facilities	Cost	Facilities	Cost	Facilities	Cost	Facilities	Cost	Facilities	Cost	
Engineering Design		270									270
Construction of Trunk Drain	R20, R19	255	R18, R17, R16	589	R15, R14, R13 R11	280	R10, R9, R8 R7, R6, R5	398	R4, R3, R2 R1	344	1,866
Construction of Secondary Drain					R14-1	91			R26	51	142
Reconstruction of Bridge					R14	240	R5	260	R1	146	646
Construction of Box Culvert									R27, R23	41	41
Installation of Gates at Outlet of Drain											0
Construction of Embankment											0
Construction Cost Engineering Fee Contingency Sub-Total Land Cost		255 283 108 646 0		589 29 124 742 0		611 31 128 770 0		658 33 138 829 0		582 29 122 733 0	2,695 405 620 3,720 0
Grand Total		483		742		770		829		733	3,720

Table 9.3 Implementation Schedule, Alternative 2
(at 1979 Price Level)

(M$ x 1,000)

Item	1981		1982		1983		1984		1985		Total Cost
	Facilities	Cost	Facilities	Cost	Facilities	Cost	Facilities	Cost	Facilities	Cost	
Engineering Design		309									309
Construction of Trunk Drain	R20	225	R19, R18, R17 R16, R15	648	R14, R13	171	R11, R10, R9 R8, R7, R6, R5	478	R4, R3, R2 R1	344	1,866
Construction of Secondary Drain					R14-1	91			R26	51	142
Reconstruction of Bridge					R14	240	R5	260	R1	146	646
Construction of Box Culvert									R27, R23	41	41
Installation of Gates at Outlet of Drain	R20	200							R28, L6	50	250
Construction of Embankment					Land Acquisition for Embankment	(230)			Between Jalan Raja and Railway	144	144 (230)
Construction Cost Engineering Fee Contingency Sub-Total Land Cost		425 330 151 906 0		648 32 136 816 0		502 25 105 632 230		738 37 155 930 0		776 39 163 978 0	3,089 463 710 4,262 230
Grand Total		906		816		862		930		978	4,492

Note: Figures in brankets are costs for land acquisition.

Table 9.4 Implementation Schedule, Alternative 3
(at 1979 Price Level)

(M$ x 1,000)

Item	1981		1982		1983		1984		1985		Total Cost
	Facilities	Cost	Facilities	Cost	Facilities	Cost	Facilities	Cost	Facilities	Cost	
Engineering Design		796									796
Construction of Trunk Drain	R20, R19, R18 R17	350	R16, R15, R14 R13, R11, R10 R9, R8	1,025	R7, R6, R5, R4, R3, R2, R1	491					1,866
Construction of Secondary Drain			R14-1	91	R26	51					142
Reconstruction of Bridge			R14	240	R5, R1	406					646
Construction of Box Culvert					R27, R23	41					41
Installation of Gate at Outlet of Drain	R20	200			R28, L6	50					250
Construction of Embankment					Embankment	144 (230)					144 (230)
Construction of Floodway							Floodway	2,508 (60)			2,508 (60)
Construction of Reservoir									Reservoir	1,010	1,010
Construction of Pumping Station									Pumping Station	1,350 (171)	1,350 (171)
Construction Cost Engineering Fee Contingency Sub-Total Land Cost		550 824 275 1,649 0		1,356 68 285 1,709 0		1,183 59 248 1,490 230		2,508 125 527 3,160 60		2,360 118 496 2,974 171	7,957 1,194 1,831 10,982 461
Grand Total		1,649		1,709		1,720		3,220		3,145	11,443

Note: Figure in brankets are costs for land acquisition.

9.2 Disbursement Programme

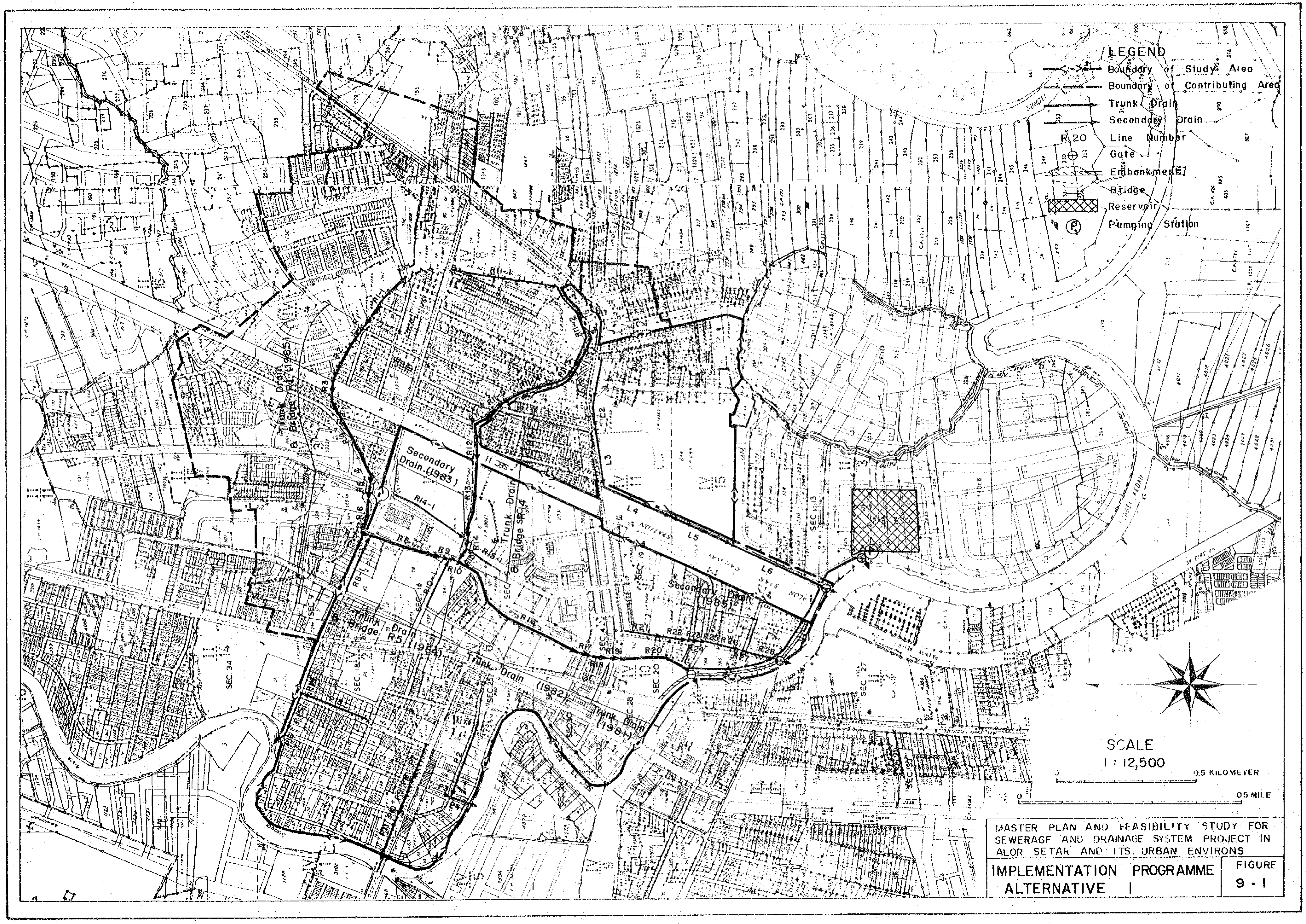
On the basis of the construction schedule and cost estimates as developed previously, a reasonable disbursement programme including both construction and maintenance costs over the 5 years span of the first phase drainage implementation programme is made as shown in Table 9.5. The disbursement programme for the construction works includes those costs of detailed engineering design, supervisional works for construction, construction of trunk and secondary drains and bund alignments, contingency allowance and land acquisition for bund. At starting the Project in 1981, the detailed engineering design is required prior to the commencement of the construction works. The cost allocated in 1981 for this work is to the all design works for facilities required in the first phase programme. The maintenance costs include payroll for the staff required in the works, cost of cleaning and desilting works and repairing cost for facilities.

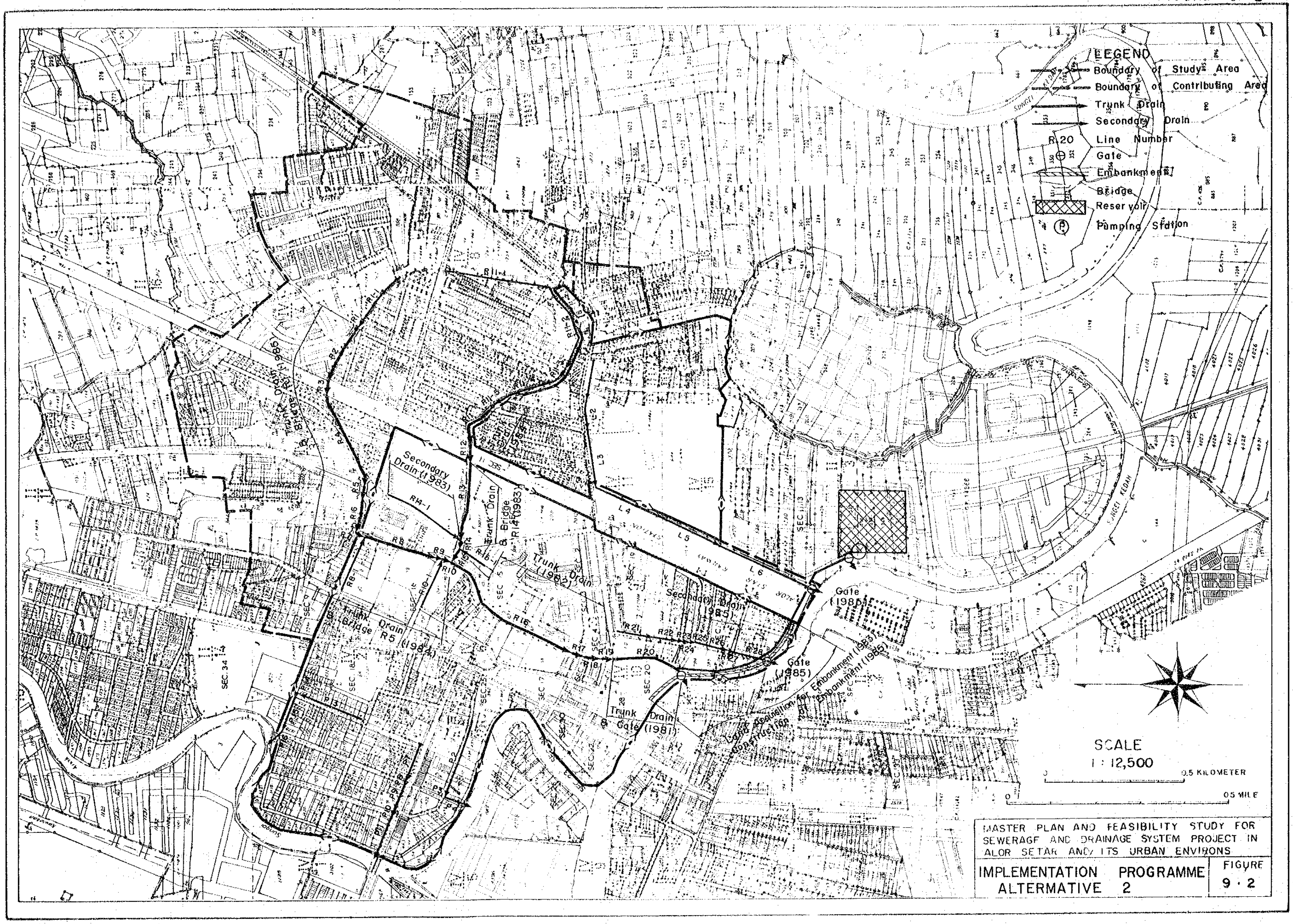
Table 9.5 Disbursement Programme (at 1979 Price Level)

(M$ x 1,000)

	Description / Year	1981	1982	1983	1984	1985	Total
Construction Cost	**Engineering** Design	309					309
	Trunk Drain (Including Bridge & Gate)	425	648	411	738	490	2,712
	Engineering Fee (Supervision)	21	32	21	37	25	136
	Contingency	89	136	86	155	103	569
	Sub-Total	535	816	518	930	618	3,417
	Secondary Drain (Including Box Culvert & Gate)			91		142	233
	Engineering Fee (Supervision)			5		7	12
	Contingency			18		28	46
	Sub-Total			114		177	291
	Embankment					144	144
	Engineering Fee (Supervision)					7	7
	Contingency					29	29
	Land Acquisition			230			230
	Sub-Total			230		180	410
	Total	844	816	862	930	975	4,427
Maintenance Cost	Payroll	15	15	15	15	15	75
	Trunk Drain (Including Bridge & Gate		7	25	33	51	116
	Secondary Drain (Including Bridge & Gate)				2	2	4
	Embankment						0
	Total	15	22	40	50	68	195
	Grand Total	859	838	902	980	1,043	4,622

FIGURE 9·1

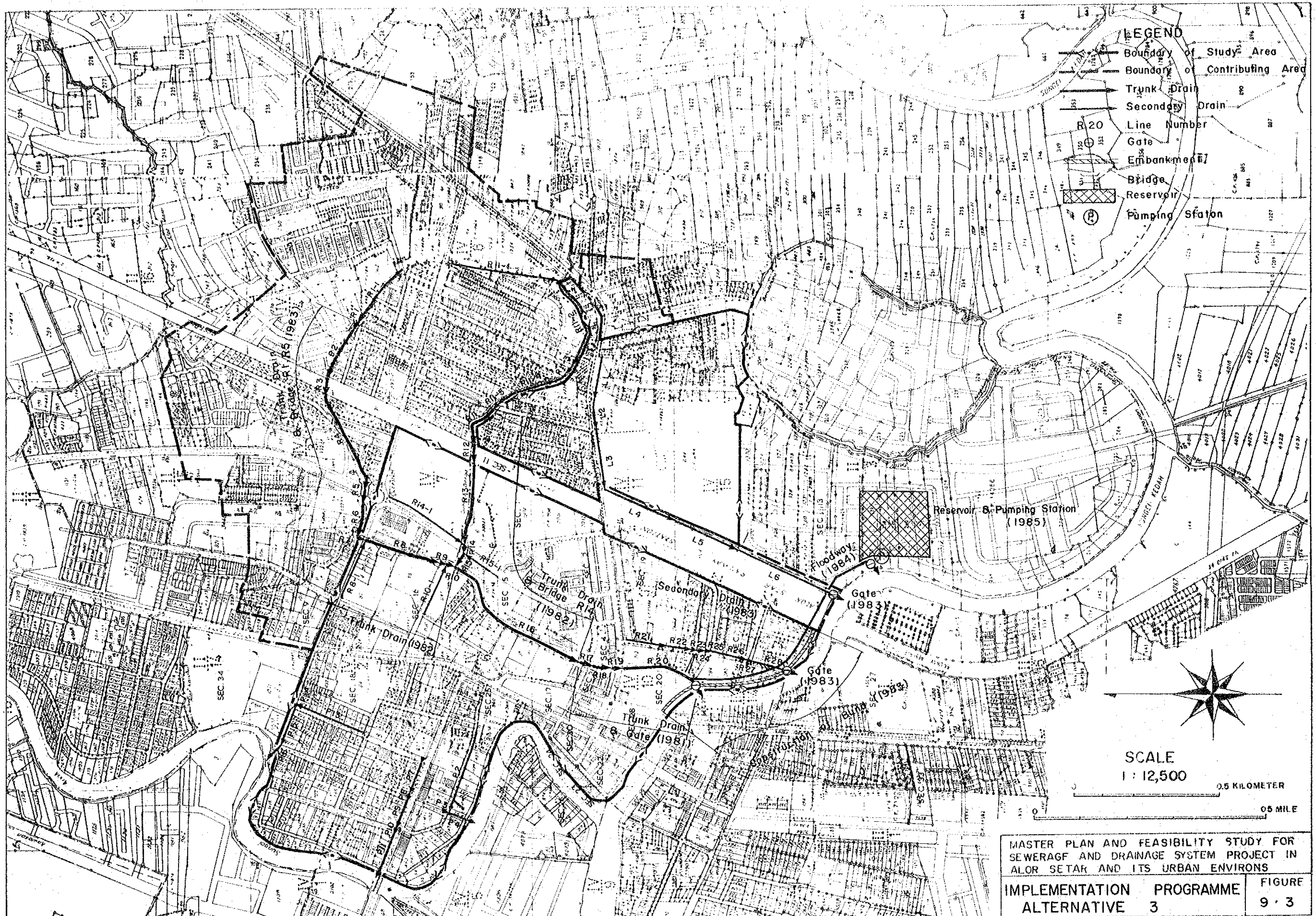

LEGEND
Boundary of Study Area
Boundary of Contributing Area
Trunk Drain
Secondary Drain
R 20 Line Number
Gate
Embankment
Bridge
Reservoir
Pumping Station
Secondary Drain (1983)
Trunk Drain
Secondary Drain (1985)
Trunk Drain (1984)
Trunk Drain (1982)
Trunk Drain (1981)
SCALE
1 : 12,500
0.5 KILOMETER
0.5 MILE
MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS
IMPLEMENTATION PROGRAMME ALTERNATIVE I
FIGURE 9·1



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

IMPLEMENTATION PROGRAMME ALTERMATIVE 2

FIGURE 9・2



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

IMPLEMENTATION PROGRAMME ALTERNATIVE 3

FIGURE 9·3

CHAPTER 10
FINANCIAL CONSIDERATION

10.1 Required Capital

The capital costs required for the proposed drainage construction to be implemented for five years from 1981 to 1985 and subsequent maintenance/operation expenditures are estimated including allowance for price escalation assumed at 8 percent per annum as shown in Table 10.1 - 10.4. Such costs estimation are broken down largely to three categories of works each related to trunk drain, secondary drain and bund alignment to indicate the substance of the required fund for the project.

10.2 Source of Fund

As indicated in the Table 10.1 the substantial portion of the construction cost is related to the trunk drains equivalent to approximately 80 percent of the total cost and this might be borne by MPKS which is to be responsible to undertake the project implementation as proposed in "Institutional Study Report" (Volume VI). It may therefore necessary for MPKS to ensure the required fund and establish an annual disbursement programme prior to the project implementation.

The various funds for the public utilities works are normally considered to be financed by the income from general taxation of the public office concerned supplemented by subsidies or loans from federal and/or state government or by revenue collection from the beneficiaries of such utilities. Such funding arrangement is, however, dependent on the nature of the works and financial capability of executive agency. The drainage construction and improvement works are normally considered for improvement of environmental sanitation of the community as a whole by way of mitigation of floods and elimination of general nuisance which are caused by natural phenomena such as stormwater runoffs. The tax payers normally regards such drainage works as public services to be undertaken by the government funds and such funds are to be provided from the governments of different level out of their general revenues as implementation programme of national development plan.

Table 10.4 shows projected statement of receipts and expenditures of MPKS for proposed drainage construction and maintenance. MPKS is to receive a loan from the federal government for capital works under the condition now available in the country. No operating revenues are included in the statement since MPKS has not found it feasible to levey direct charges on beneficiaries of drainage services. MPKS is proposed to cover the costs of the services by general tax revenues of 5 percent to the property tax in accordance with the provisions of the Local Government Act.

According to the table, deficit is expected after 1986 and thereafter. However accumulated cash surplus from 1981 to 1985 can cover such deficit upto 1991. In order to cover expected expenditures after 1991, MPKS is expected to prepare fund to recover such deficit.

It is noted in the annual report of State Budget for 1979 that State Government received subsidy amounting to M$ 13 million from the Federal Geovernment and approximately M$ 4 million was allocated to drainage activities. It is therefore recommended that a certain arrangement be made between the State Government and the Federal Treasury to finance the agreed amount of fund for the project in a form of annual allocation to MPKS.

Table 10.1 Project Cost Estimates at 1979 Price (Escalated Price) (a)

(M$1,000)

Description / Year	1981	1982	1983	1984	1985	Total
Engineering Design	309(360)					309(360)
Trunk Drain (Including Bridges & Gates)	425	648	411	738	490	2,712
Engineering Fee	21	32	21	37	25	136
Contingency	89	136	86	155	103	569
Sub-Total	535(624)	816(1,028)	518(705)	930(1,366)	618(981)	3,417(4,704)
Secondary Drain (Including Box Culvert & Gates)			91		142	233
Engineering Fee			5		7	12
Contingency			18		28	46
Sub-Total			144(155)		177(281)	291(436)
Band Alignment					144	144
Engineering Fee					7	7
Contingency					29	29
Land Acquisition			230			230
Sub-Total			230(313)		180(286)	410(599)
Total	844(984)	816(1,028)	862(1,173)	930(1,366)	975(1,548)	4,427(6,099)

(a): Figures in brackets are prices escalated at 8% per annum from 1979 price level.

Table 10.2 Maintenance Costs at Escalated Prices (M$1,000) (a)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Salaries	17	19	20	22	24	26	28	30	32	35	38
Trunk Drain (b) (Including Bridges & Gates)		9	34	48	65	81	120	130	140	152	164
Secondary Drain (b) (Including Bridges & Gates)				3	3	5	6	6	6	7	8
Band Alignment (b)							2	2	2	2	3
Total	17	28	54	73	92	112	156	168	180	196	213

(a) Escalated at 8% per annum from 1979 price level.
(b) Cost related to repair and improvement works to be done by local contractors.

Table 10.3 Estimated Annual Disbursement at Escalated Prices (M$1,000)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Construction	984	1,028	1,173	1,366	1,548						
Maintenance	17	28	54	73	108	112	156	168	180	196	213
Total	1,001	1,056	1,227	1,439	1,656	112	156	168	180	196	213

Table 10.4 Receipts and Expenditures
(M$1,000)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Receipts											
Drainage Tax	550	605	666	732	805	886	974	1,072	1,179	1,297	1,427
Municipal Fund Allocation	-	-	-	-	-	-	-	-	-	-	-
Federal Government Loan	989	1,028	1,173	1,366	1,548	-	-	-	-	-	-
Total Receipts	1,534	1,633	1,839	2,098	2,353	886	974	1,072	1,179	1,297	1,427
Expenditures											
Capital Expenditure	984	1,028	1,173	1,366	1,548						
Maintenance	17	28	54	73	108	112	156	168	180	196	213
Dept Service											
Principal						77	83	87	92	97	98
Interest						366	361	356	346	345	339
Total Expenditures	1,001	1,056	1,227	1,439	1,656	555	600	611	618	638	650
Cash Surplus (Deficit)	533	577	612	659	697	(331)	(374)	(461)	(561)	(659)	(777)
Cash Accumulated	-	533	1,110	1,720	2,381	3,078	2,748	2,373	1,912	1.351	692
Total	533	1,110	1,720	2,381	3,078	2,748	2,373	1,912	1,351	692	-85

CHAPTER 11
BENEFITS

11.1 Anticipated Benefits

Proper construction and operation of drainage systems are expected to result in certain types of benefits towards inhabitants of the areas concerned. These benefits include either quantifiable or non-quantifiable benefits as follows:

(a) Reduction of flood damage
(b) Improvement of Public Health and Convenience of Community
(c) Increase of Land Value

The items above are discussed in the following sections.

11.2 Recognition and Measurement of Benefits

11.2.1 Reduction of Flood Damage

On urban area, local flooding can and does cause considerable nuisance and hardship to those affected, which can be alleviated by proper remedial work on the drainage system. The implementation of such works will result in considerable benefit to the community at large, in terms of public road and private properties becoming flood free, and also, in a more significant benefit, on the living condition of people whose houses and business premises are previously flood prone.

The quantifiable benefit expected by preventing flooding is equivalent to the amount of damages due to the flood. In the absence of data concerning flood damages the quantity of benefit is not figured. However, it should be kept in mind that the expenditure to recover flood damage is the recurrent cost upon residents or the municipality and will increase unless flood relief measures are undertaken, whereas initial investment with comparatively small amount of fund for operative and maintenance will be sufficient for prevention of the floodings.

11.2.2 Improvement of Public Health and Convenience of Community

Benefits under this item can be understood easily when situations in which certain area is flooded and all kinds of waste water including sullage, human excreta and discharge from industry, are mixed each other spreading coliforms, disease germs and toxic materials.

It is generally recognized through abundant experiences in the past that after flooding the cases of waterborne disease increase. Together with that of the sewerage system, contribution of the drainage system to public health improvement can be expected to be very significant, especially in areas where people depend on bucket system and pit privies for disposal of excreta.

11.2.3 Increase of Land Value

With the provision of infrastructure including drainage system, development programme, for both public and private sectors, will be greatly stimulated and land values increased. The value added to the land tends to equal or exceed the prorated share of the total investment involved.

The added land value will be major economic benefit which will stimulate larger scale of financial transaction, and will cause additional source of taxation for the revenue in favour of the government agencies concerned.

11.3 Benefits Justification

As has already been described in the previous paragraph, major portion of the benefits by the drainage improvement is hardly quantifiable in monetary terms. Nevertheless, there will no doubt be high social benefits if the project is completed because the system will make significant floodfree land for further development, upgrade the existing living environment, and also contribute to improving the inconvenience of the community life.

ANNEX A. PUMPING STATION AND RESERVOIR

B. FRONTE JACKING METHOD

C. ANALYSIS OF PROPOSED DRAINAGE SYSTEM

ANNEX A
PUMPING STATION AND RESERVOIR

1. General

In providing an adequate drainage system for the Study Area, pumping station and reservoir are required to drain off the runoff when the volume of the runoff exceeds the storage capacities of drains. The provision of these facilities shall be incorporate system together with installation of the outlet gate. In order to select the most suitable pumping station and reservoir, following comprehensive study is made including selection of types of pump, and determination of the reasonable capacities of pump and reservoir to be applied for the drainage system.

2. Selection of Pump Type

For selection of the drainage pump, two types of pump namely centrifugal and screw pump are considered and studied with due attention to their advantages and disadvantages as the drainage pump to be applied to the Study Area including characteristics of the operating conditions and construction, and operation and maintenance costs to be required.

2.1 Construction, and Operation and Maintenance Costs

2.1.1 Construction Cost

Using the typical structure of each type of pumping station as proposed in Figures A.1 and A.2, construction costs are estimated based on the basic costs described in Table 8.1 of Chapter 8. The estimated construction costs are expressed in cost function curves for easy reference. The costs reflected by cost function curves include civil works, plumbing, mechanical equipment and other miscellaneous items.

In developing the cost function curves, four different capacities of 60 m^3/min, 240 m^3/min, 420 m^3/min and 600 m^3/min are considered and their construction costs for each of pumping station are made as summarized in Table A.1 with the cost function curves presented in Figure A.3.

Table A.1 Construction Costs of Each Pumping Station by Different Capacity

(at 1979 Price Level, M$1,000)

Types of Pump \ Capacity	60 m^3/min	240 m^3/min	420 m^3/min	600 m^3/min
Centrifugal Pump	1,056	1,789	2,407	3,861
Screw Pump	1,242	2,455	3,300	5,310

2.1.2 Operation and Maintenance Costs

Operation and maintenance costs are also estimated by use of the cost function curves. In developing the function curves, following assumption is made;

(1) Frequency of operation is 15 times a year in working of per 3 hours.

(2) Heavy oil used for diesel engine is calculated in the following equation.

$$V = 0.44 \times Hp \times N$$

where V : Required heavy oil (gal/hour)

Hp : Horsepower of engine

N : Number of pump

0.44: Constant

(3) Unit cost of heavy oil is M$1.8/gal

(4) Three operators are required at the pumping station with three working shifts.

(5) Wage of operator is M$800/month

(6) Repairing and replacement costs of equipment are to be 1 percent of capital cost of civil works and 2 percent of mechanical equipments.

On the basis of the above assumption, the operation and maintenance costs of each type of pumping station in terms of the four different capacities as in the estimation of construction cost are estimated as shown in Table A.2. Using these results, cost function curves are then developed as presented in Figure A.4.

Table A.2 O & M Costs of Each Pumping Station by Different Capacity

(at 1979 Price Level, M$1,000)

Type of Pump	Item \ Capacity	$60m^3/min$	$240m^3/min$	$420m^3/min$	$600m^3/min$
Centrifugal Pump	Wage	28.8	28.8	28.8	28.8
	Heavy Oil	3.6	12.8	20.0	29.9
	Repair & Replacement	15.5	26.0	41.4	68.3
	Total	47.9	67.6	90.2	127.0
Screw Pump	Wage	28.8	28.8	28.8	28.8
	Heavy Oil	3.6	14.3	26.6	46.5
	Repair & Replacement	21.5	36.7	49.3	79.4
	Total	53.9	79.8	104.7	154.7

2.2 Comparison and Recommendation on Drainage Pump

Although, screw pump is generally simple, easy to overhauling and maintenance works and comparatively free from corrosion even operation is in low speed revolution, the screw pump is essentially high construction cost to be required as shown in Table A.1, in comparison with the centrifugal pump. From the cost comparison, centrifugal pump are thus recommended as the drainage pump in the Study Area. The advantages of the centrifugal pump especially axial flow pumps are applied to the wide range of head fluctuations, and free from cavitations in pump.

3. Reservoir

The reservoir incorporated with the pumping station is the most considerable measure to reduce the expenditure required for the drainage system to drain off the runoff. In determining the desirable capacity of the reservoir, various sizes of reservoir are considered on the basis of the design volume of stormwater runoff discharging from each catchment area delineated in the actual design works, and compared in selection of the most adequate capacity of reservoir together with the pumping capacity. Details are presented in the succeeding section.

For the study, cost estimates are required. The estimated costs are to those capacities varying from 500 m^3 to 150,000 m^3 using the typical structure as presented in Figure A.5, and basic cost described previously. Those costs are expressed by cost function curve as presented in Figure A.6.

4. Case Study for Pumping Station and Reservoir

In the study on selection of "Alternative Routes of Trunk Drain" as reference in section 7.1, Chapter 7 of this report, three sets of pumping station and reservoir are required by the alternative consideration. In this conditions, the capacity required for the reservoir for each case are computed by use of the inflow hydrograph curves developed as presented in Figure A.7. Parameters of three case used in this study are summarized in Table A.3.

Table A.3 Parameters Used for Case Study

Alternative	Item	Area (ha)	Inlet Time (min.)	Flow time (min.)	Composite Runoff Coefficient
Alternative 1	Case 1	295	7	80	0.61
Alternative 2	Case 2	239	7	80	0.56
	Case 3	56	7	17	0.84

Using the above inflow hydrograph curves, the estimated storage capacity of reservoir by alternative pump capacity for each case is summarized as shown in Table A.4.

Table A.4 Combinations of Pump and Reservoir

Alternative	Case	Pump Capacity (m^3/min.)	Storage Capacity (m^3)
Alternative 1	Case 1	60	151,000
		120	127,000
		180	108,000
Alternative 2	Case 2	60	110,000
		120	83,000
		180	67,000
	Case 3	60	31,000
		120	20,000
		180	15,000

For each cases referred in the above Table, the total construction costs of pumping station and reservoir including land acquisition cost are estimated as shown in Table A.5, and compared for determination of the most desirable capacity of reservoir together with the pumping capacity.

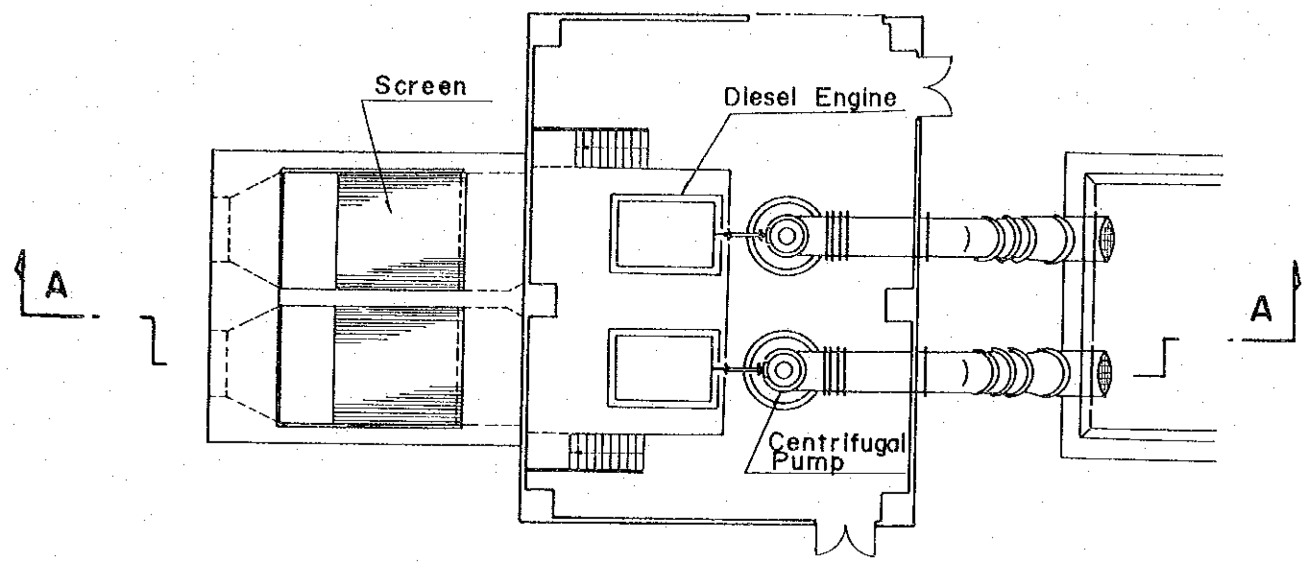
According to Master Plan proposals prepared by SDID, practical size of storage pond is to be not more than 2 percent of the total area concerned by the system, so that same ratio is applied for determination of the reservoir capacity. The recommended pump and reservoir capacities for each alternative cases are presented in Table A.5 with indication of the under line.

Table A.5 Construction Costs of Pumping Station and Reservoir by Alternatives (at 1979 Price Level M$1,000)

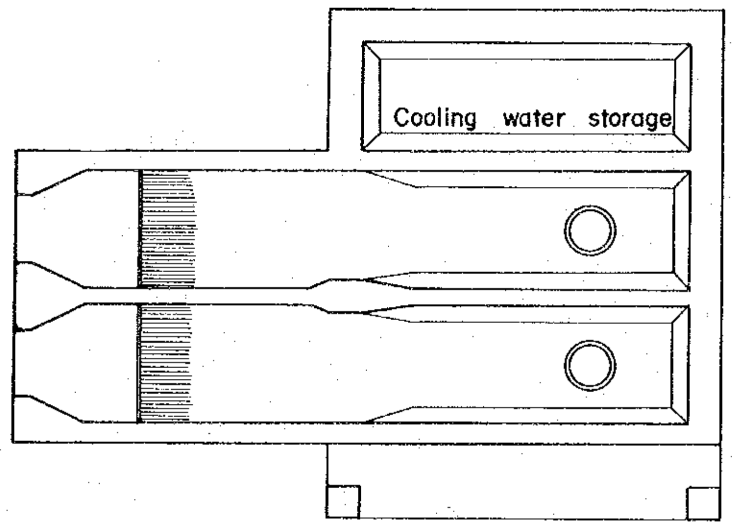
Alternative	Case	Pump Capacity (m^3/min.)	Construction Cost of Pumping Station (m$)	Storage Volume (m^3)	Construction Cost of Reservoir (M$)	Required Area (ha)	Land Acquisition Cost (M$)	Total Cost (M$)
Alternative 1	Case 1	60	1,060	151,000	870	6.80	204	2,134
		120	1,350	127,000	765	5.70	171	2,286
		180	2,750	108,000	680	4.80	144	3,574
Alternative 2	Case 2	60	1,060	111,000	690	5.00	150	1,900
		120	1,350	83,000	575	3.80	114	2,039
		180	2,750	67,000	510	3.10	93	3,353
	Case 3	60	1,060	31,000	335	1.50	135	1,530
		120	1,350	20,000	285	1.00	90	1,725
		180	2,750	15,000	260	0.81	73	3,083

PUMPING STATION (Centrifugal Pump)

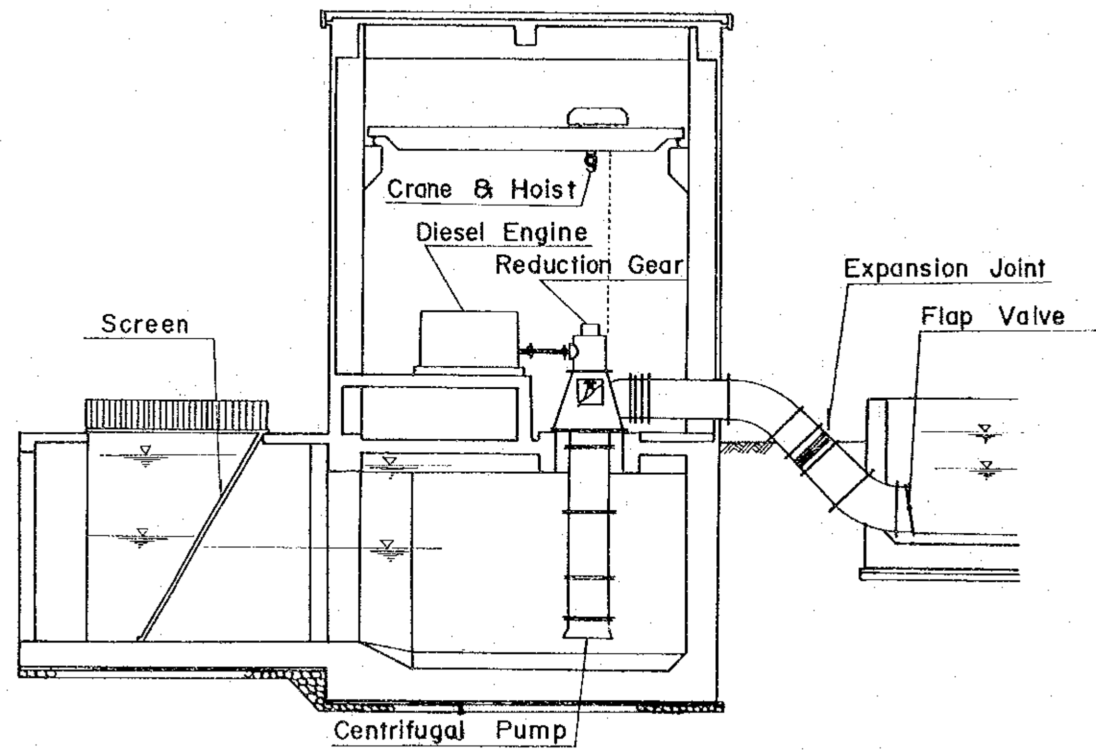
PLAN VIEW



GROUND FLOOR LEVEL



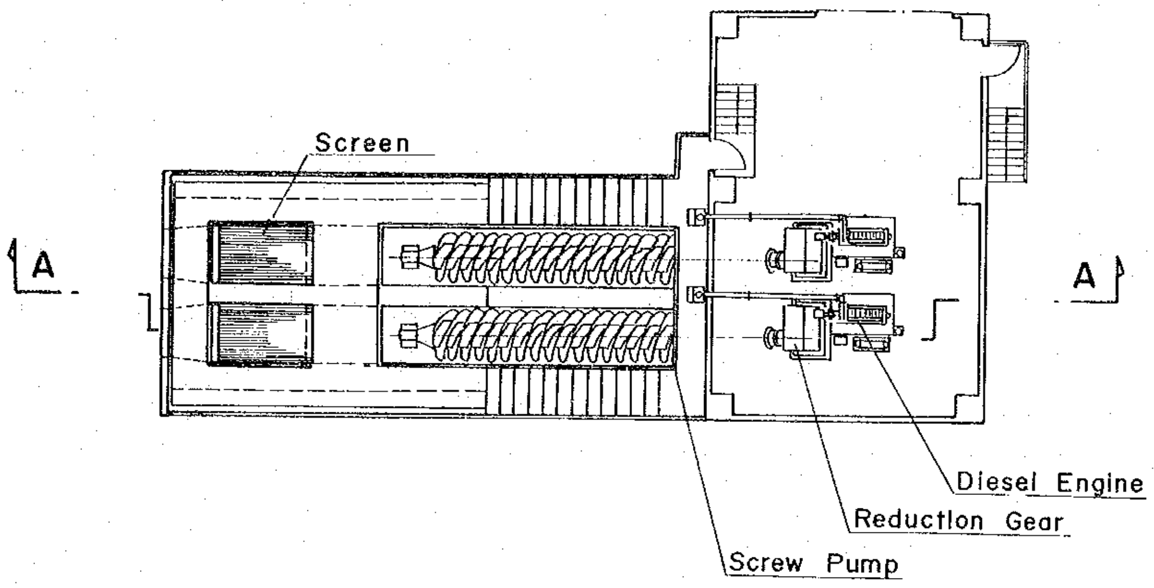
SECTION A – A



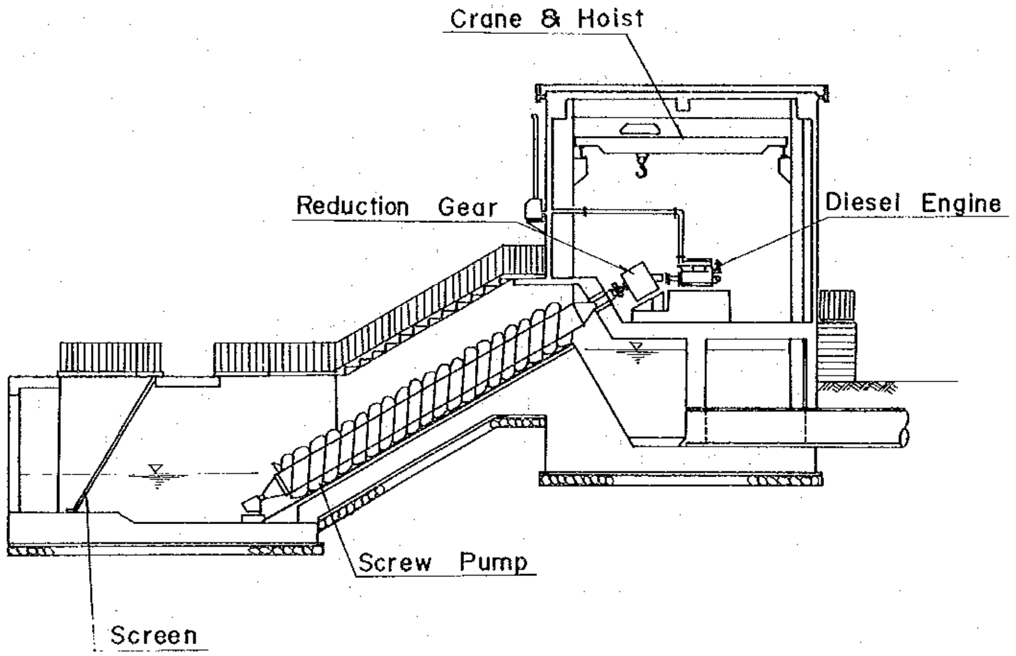
MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS	
TYPICAL PUMPING STATION (Centrifugal Pump)	FIGURE A・I

PUMPING STATION (Screw Pump)

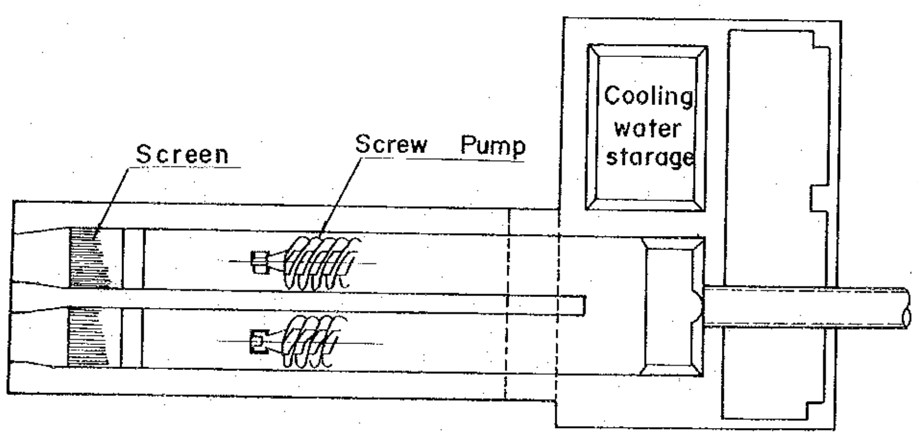
PLAN VIEW



SECTION A-A

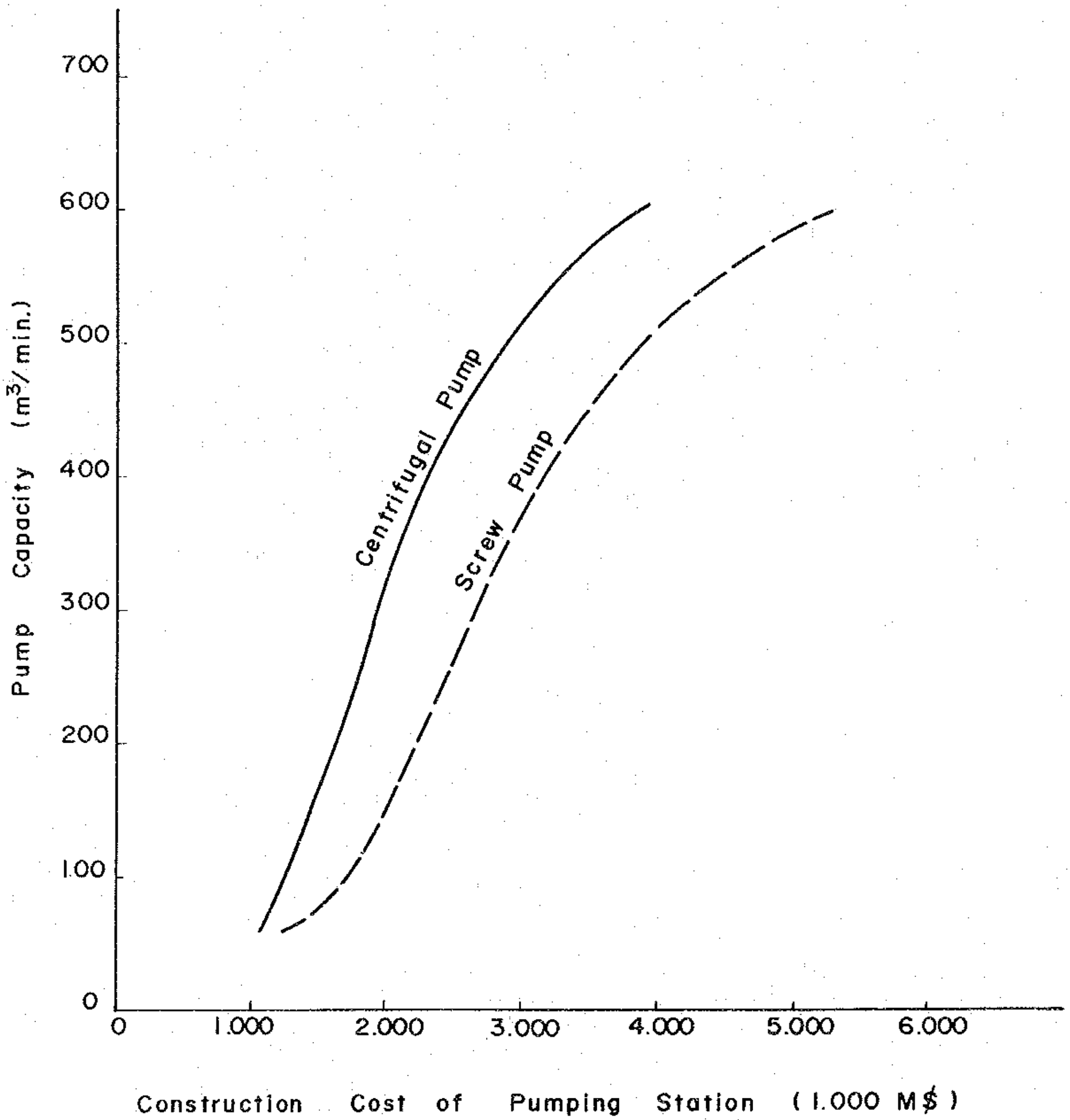


GROUND FLOOR LEVEL



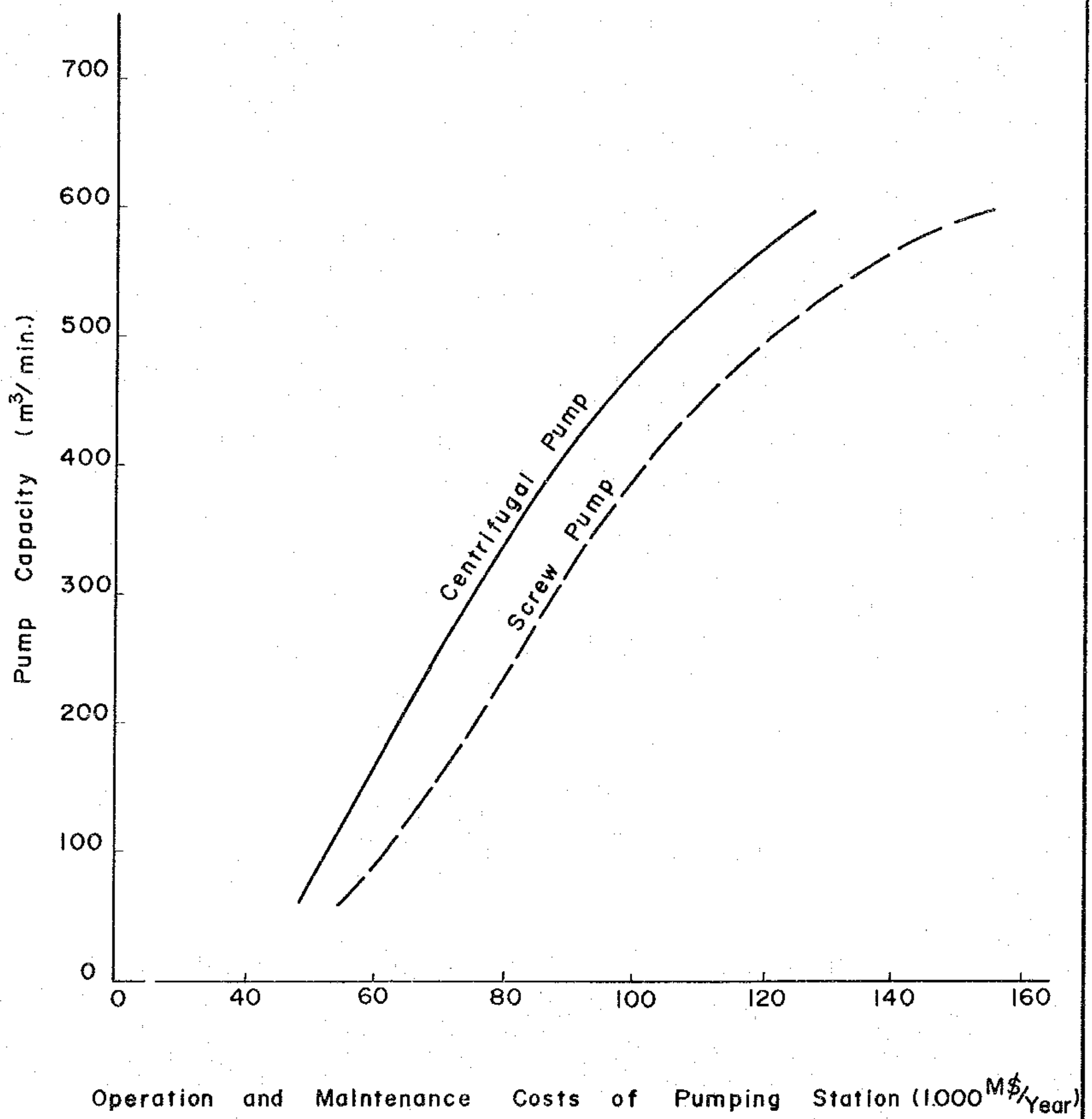
MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS	
TYPICAL PUMPING STATION (Screw Pump)	FIGURE A · 2

FIGURE A・3



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

CONSTRUCTION COST FUNCTION CURVES OF PUMPING STATION	FIGURE A・3

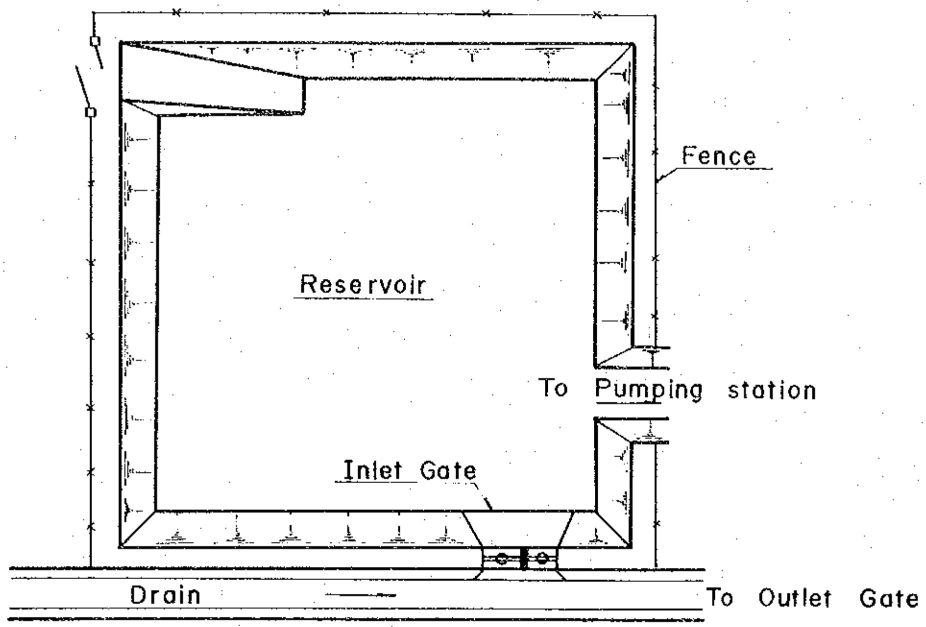


MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

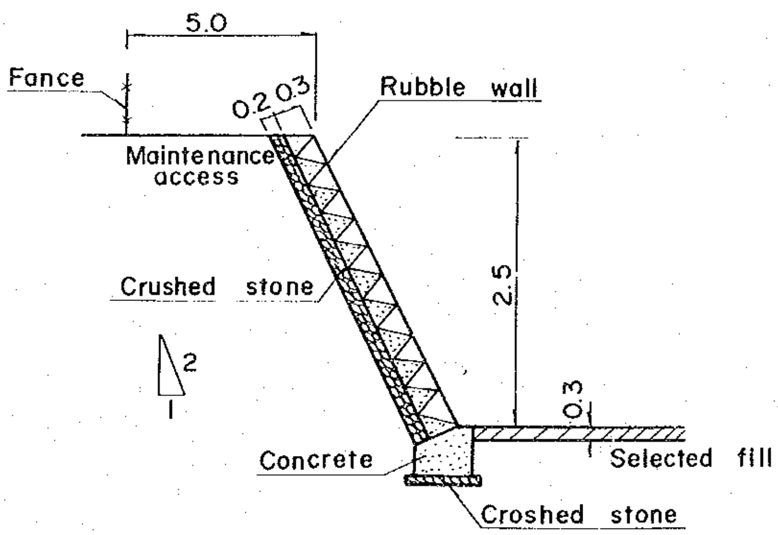
O & M COSTS FUNCTION CURVES OF PUMPING STATION

FIGURE A・4

PLAN

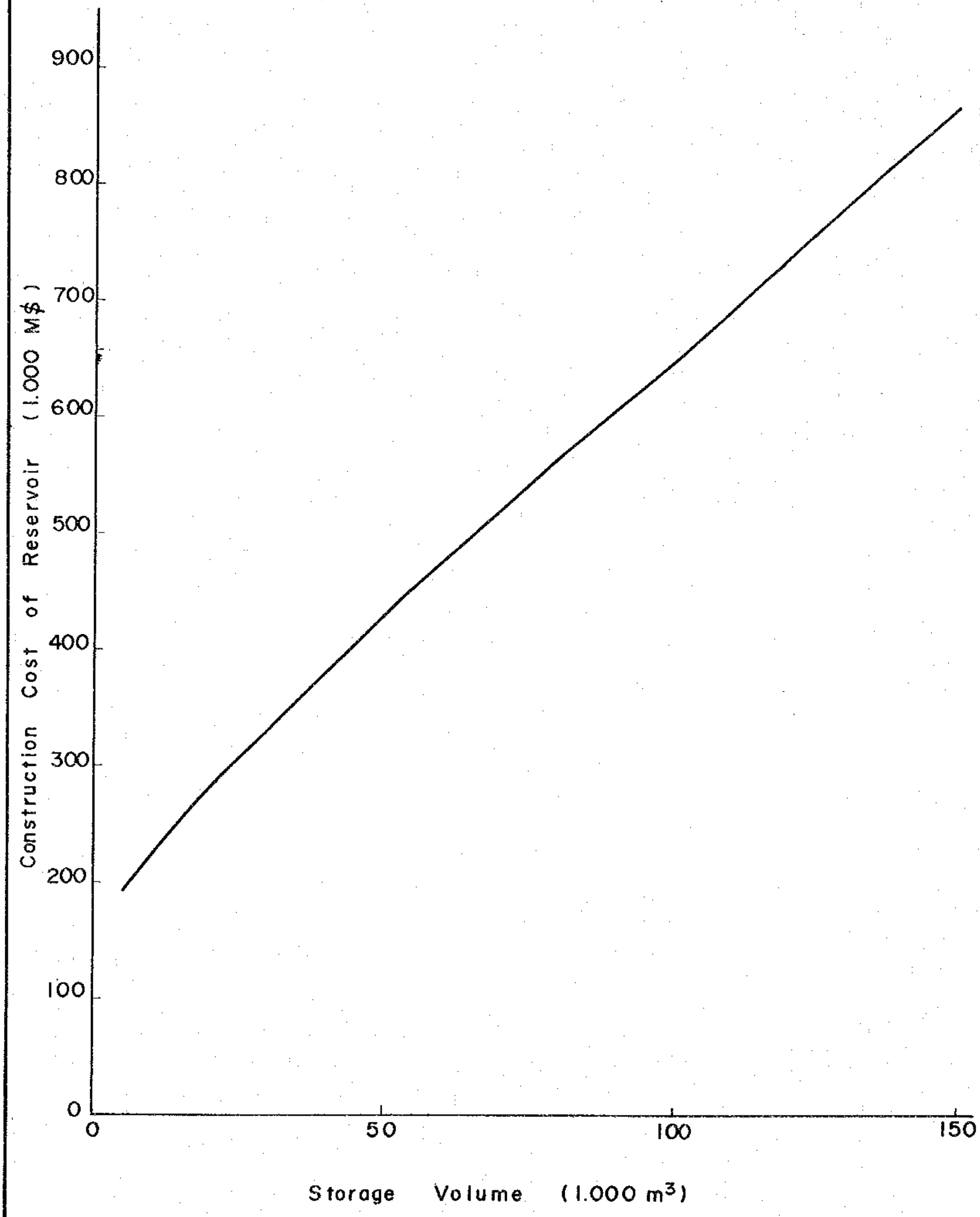


Sectional Area of Wall



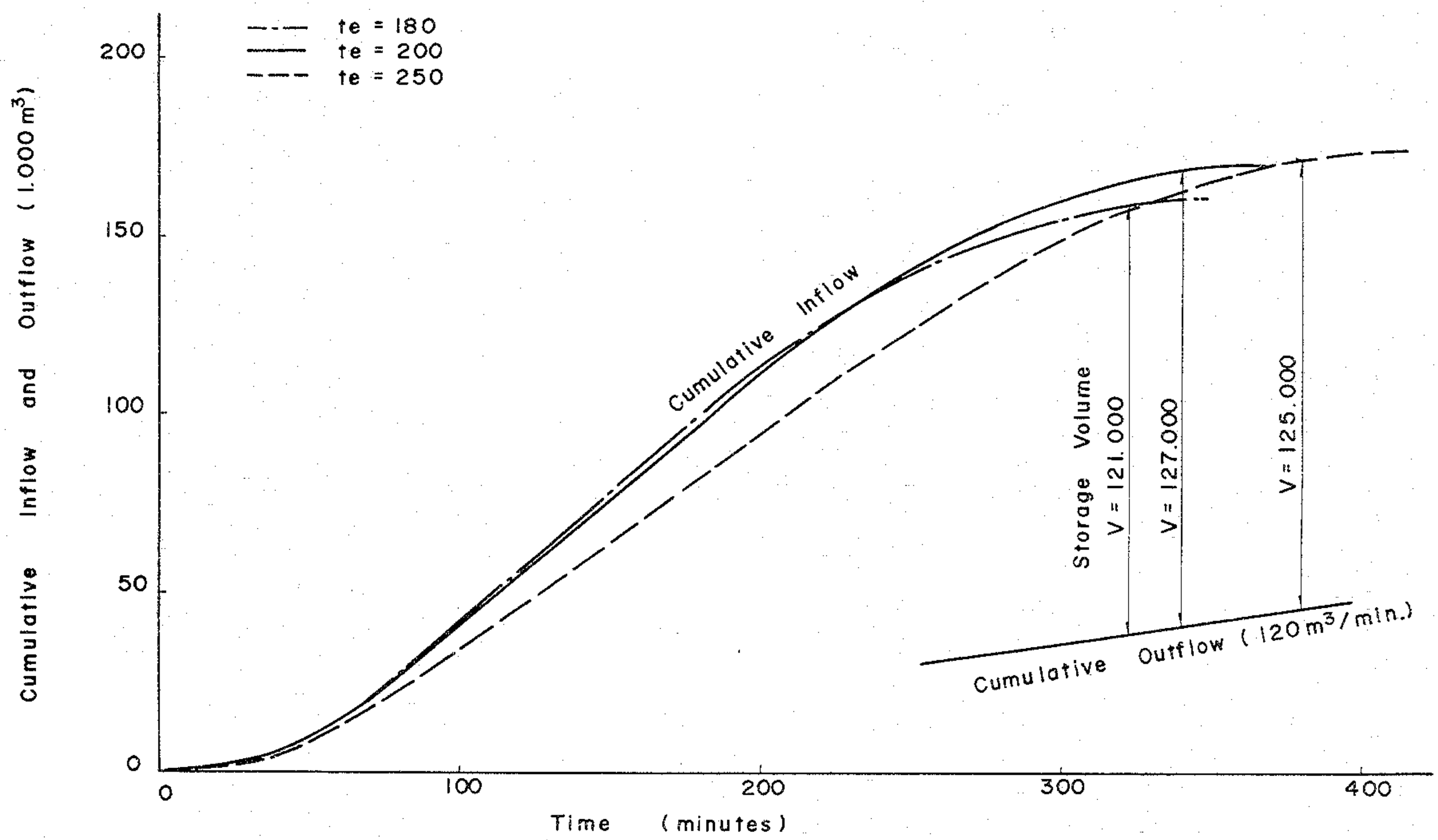
MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

TYPICAL RESERVOIR STRUCTURE	FIGURE A・5



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

CONSTRUCTION COST CURVE OF RESERVOIR	FIGURE A · 6



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

CUMULATIVE INFLOW AND OUTFLOW CURVES

FIGURE A-7

ANNEX B
FRONTE JACKING METHOD

1. General

The "Fronte Jacking Method" is the unique method of tunnelling without the application of open-cut method or pipe jacking method. The types of structures which can be used by this method are steel pipes, concrete pipes, steel segments, reinforced concrete boxes, H-type steel I-type steel etc. The diameters of pipes used by this method are ranged from ∅150 mm to ∅3,500 mm and the lengths from 20.0 m to 100.0 m. Also, box-type reinforced concrete structures of various sizes (width=1.5 m, height 2.0 m, length=15.0 m of small size to width=21.0, height=10.0 m, length=30.0 m of giant type) have been applied by this method. This method, even in case of the soft ground, can manifest tremendous force without need of ground reaction, by using the reciprocal pulling system.

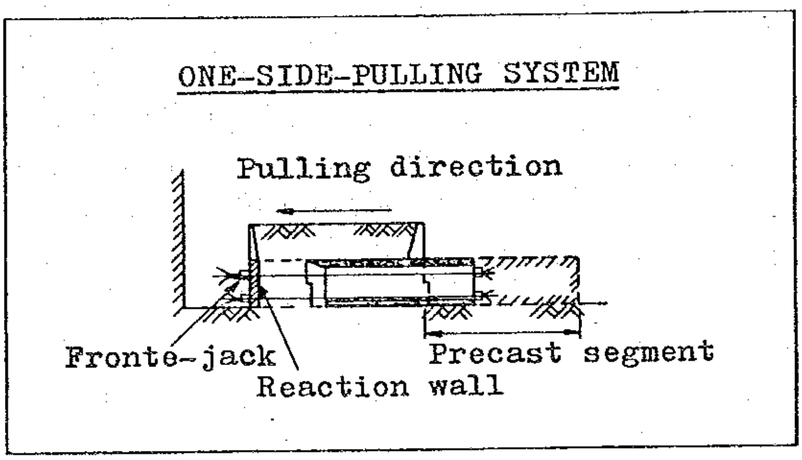
2. Advantage of the Method

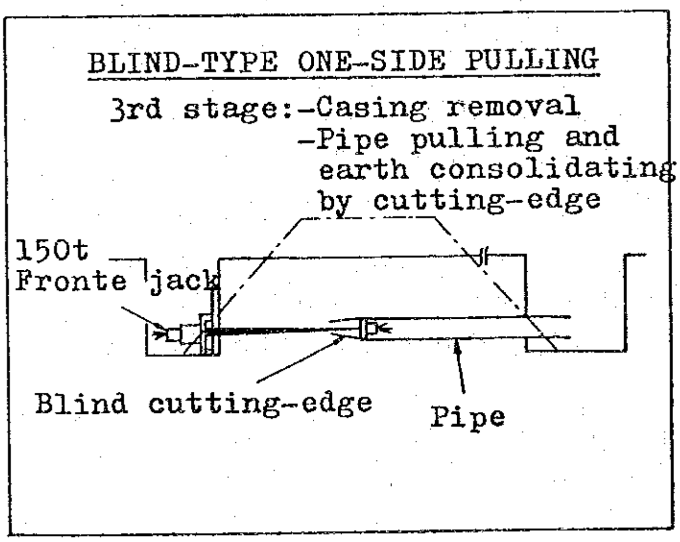
(1) No fear of earth sinking or earth depression.
(2) There is no pipe buckling comparing to the other drive method.
(3) For the construction, there is no subsidy of either chemical grouting, or well point, or freezing operations.
(4) There is no need of reaction wall, even in soft ground conditions.
(5) Large underpass beneath thin earth-covering railway can be construct safely with this method by using pipe-roofing and guide-rail system.
(6) Law cost of pulling materials because of its simplicity.
(7) Works can be arranged safely, economically and rapidly.

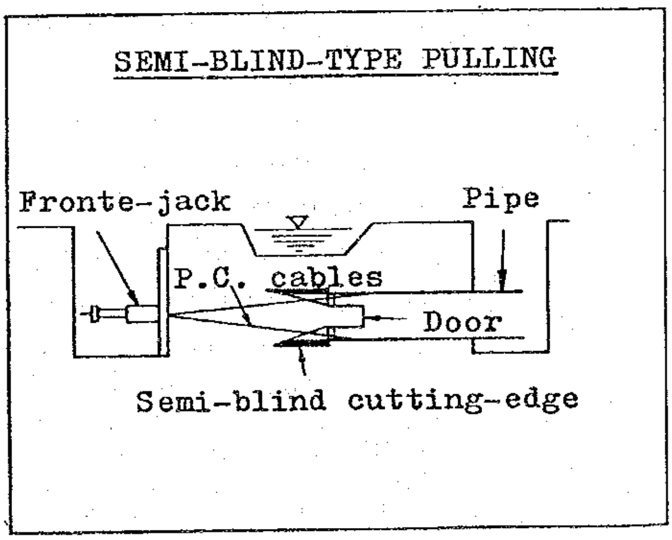
3. Kind of the Method

(1) One-side-pulling Method

Set pulling jack device to one side of the pre-arranged pulling material, and to the opposite side fasten the structure. Then pull forwardly in one direction. Reaction force is received from the ground. This method is used to pull pipes or other small type structures.



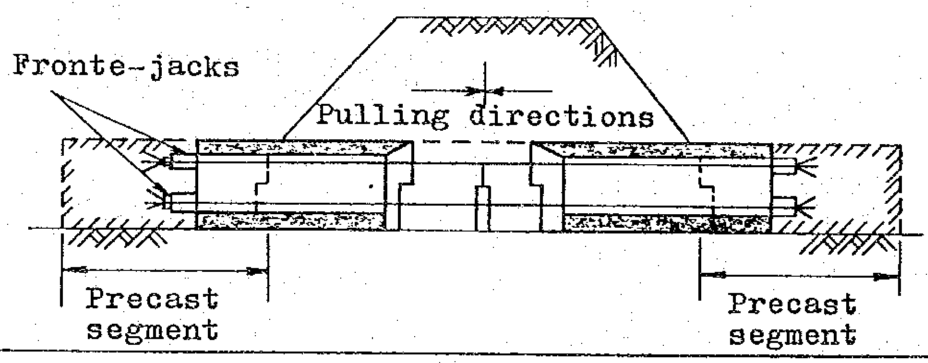




(2) Reciprocal Pulling System

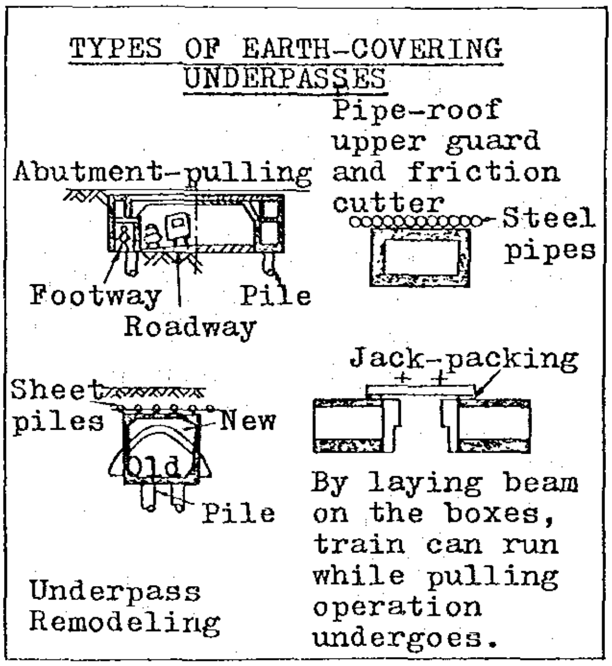
Set the structures to both sides of the pre-constructed pulling material, set pulling jack device to the structure of one side, fasten cone to the structure of another side. By reciprocally taking reaction force from the opposite structure, the structure are pulled reciprocally. This method is used for constructions of giant-type structures which need tremendous force.

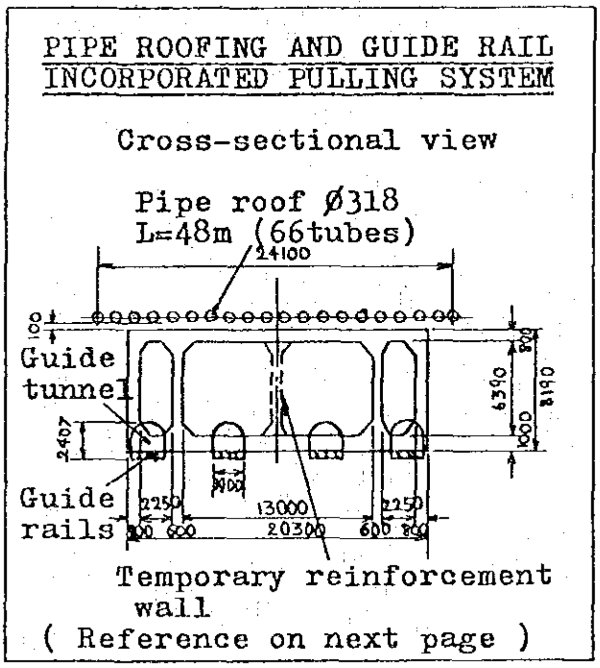
RECIPROCAL-PULLING SYSTEM



4. Pipe-roofing and Guide-rail-incorporated Box-type Underpass-pulling System

Under thin earth-covering railway, build horizontal roof-like structure with a number of pipes by arranging them is one row and inserting them transversally to the thin earth-covering railtrack. (this operation may be done by machine or by manpower.) At 10 to 30 cm below the pipes, dispose the upper slab of the box-type underpass, the main underpass is mounted on the guide-rails constructed through the small headings excavated during advance work. The lower slab of the underpass will slide on these guide-rails. It is a safe and practical method of pulling wide underpass straight along any inclination direction under thin earth-covering railway.





ANNEX C. ANALYSIS OF PROPOSED DRAINAGE SYSTEM

TABLE C-1 ANALYSIS OF PROPOSED DRAINAGE SYSTEM

refer to Figure 7.3

Line No.	Drain Length (m)	Area Each (ha)	Area Total (ha)	Composite Runoff Coefficient	Storage Coefficient	Time of Flow in the Drain Each tdi (min)	Time of Flow in the Drain Total td (min)	Time of Concentration tc (min)	Design Runoff Per ha (m^3/s)	Design Runoff Total Runoff (m^3/s)	Runoff Major Storm (m^3/s)	Proposed Drain Size (m)	Proposed Drain Slope (‰)	Proposed Drain Velocity (m/s)	Proposed Drain Capacity (m^3/s)	Proposed Drain Required Reserve Width (m)	Existing Condition Runoff (m^3/s)	Existing Drain Size (m)	Existing Drain Capacity (m^3/s)	Existing Drain Reserve Width (m)	Remarks
	Sungai Raja basin																				
R1-1	(1100) 240.00	39.95		0.60	0.71	(30.5) 5.0	35.5	42.5	0.132	3.744	7.176	5.0/4.0 × 1.0	0.25	0.9	3.825	10.0	2.780	5.0/2.0 × 0.9	0.851	5.00	0.098
R1	20.00	10.52	50.47	0.60	0.71	0.4	35.9	42.9	0.166	5.948	9.066	5.4/3.5 × 1.9	0.25	0.9	6.800	10.4	4.443	7.0/2.0 × 0.9	1.093	7.00	0.124
R2	190.00	9.80	60.27	0.60	0.70	3.5	39.4	46.4	0.160	6.750	10.378	5.4/3.5 × 1.9	0.25	0.9	6.800	10.4	5.105	7.0/3.0 × 1.0	1.500	7.00	0.121
R3	50.00	0.16	60.43	0.60	0.70	0.9	40.3	47.3	0.159	6.750 (6.726)	10.378 (10.321)	5.4/3.5 × 1.9	0.25	0.9	6.800	10.4	5.034	12.0/2.0 × 1.0	2.030	12.00	0.119
R4	340.00	19.42	79.85	0.60	0.70	6.3	46.6	53.6	0.148	8.272	12.856	7.0/5.0 × 2.0	0.25	0.9	8.800	12.0	6.204	4.0/2.0 × 1.0	3.270	4.00	0.111
R5	40.00	4.23	84.68	0.60	0.70	0.6	47.2	54.2	0.148	8.710	13.537	7.0/5.0 × 2.0	0.25	0.9	8.800	12.0	6.533	9.0/2.0 × 1.0	2.255	9.00	0.111
R6	160.00	13.55	96.63	0.60	0.70	3.0	50.2	57.2	0.144	9.740	15.152	8.0/6.0 × 2.0	0.25	0.9	10.800	13.0	7.846	9.0/2.0 × 1.0	2.255	13.00	0.116
R7	30.00	13.07	109.70	0.60	0.69	0.6	50.8	57.8	0.142	10.748	16.880	8.0/6.0 × 2.0	0.25	0.9	10.800	13.0	8.099	9.0/2.0 × 1.0	2.255	15.00	0.107
	To R8																				
R8-1	(420.00) 225.00	4.66		0.85	0.74	(11.7) 4.2	15.9	22.9	0.264	0.914	1.522	1.5/0.7 × 1.2	0.60	0.9	0.990	4.0	0.651	1.5/0.5 × 0.5	0.365	1.70	0.188
R8	270.00	3.04	117.42	0.65	0.69	5.0	55.8	62.8	0.147	11.910	18.797	9.5/7.5 × 2.0	0.25	0.9	13.000	14.5	10.127	8.0/2.0 × 1.3	2.210	10.00	0.125
R9	30.00	6.69	124.11	0.65	0.69	0.6	56.4	63.4	0.147	12.588	19.868	9.5/7.5 × 2.0	0.25	0.9	13.000	14.5	10.704	15.0/4.0 × 1.3	4.323	15.00	0.125
	To R10																				
R10-1	(460.00) 180.00	4.70		0.85	0.74	(12.8) 3.3	16.1	23.1	0.264	0.918	1.527	1.5/0.7 × 1.2	0.60	0.9	0.990	4.0	0.654	1.5/0.5 × 0.5	0.335	2.50	0.188
R10	30.00	0.18	128.99	0.65	0.69	0.6	57.0	64.0	0.146	12.994	20.471	9.5/7.5 × 2.0	0.25	0.9	13.000	14.5	11.036	15.0/4.0 × 1.3	4.323	15.00	0.124
	To R16																				
R11-1	(250.00) 380.00	6.01		0.60	0.74	(6.9) 9.0	15.9	22.9	0.173	0.769	1.379	3.0/1.8 × 0.6	0.40	0.7	0.884	8.5	0.516	5.5/2.5 × 0.6	0.576	7.00	0.116
R11-2	345.00	10.87	16.88	0.60	0.72	8.2	24.1	31.1	0.153	1.866	3.464	4.5/2.7 × 0.9	0.25	0.7	2.059	9.5	1.240	5.5/2.0 × 0.6	0.576	7.40	0.102
R11-3	25.00	7.61	24.49	0.60	0.72	0.5	24.6	31.6	0.151	2.663	4.972	2 × □1.83×0.92	0.30	0.8	2.668	—	1.781	5.5/1.0 × 0.6	0.410	8.00	0.101
R11-4	165.00	9.84	34.33	0.60	0.72	3.1	27.7	34.7	0.145	3.584	6.798	5.5/4.4 × 1.10	0.25	0.9	4.152	10.5	2.398	5.5/1.0 × 0.6	0.546	8.00	0.097

TABLE C-2 ANALYSIS OF PROPOSED DRAINAGE SYSTEM

refer to Figure 7.3

Line No	Drain Length (m)	In Year 2000: Area Each (ha)	Area Total (ha)	Composite Runoff Coefficient	Storage Coefficient	Time of Flow in the Drain: Each tdi (min)	Time of Flow in the Drain: Total td (min)	Time of Concentration tc (min)	Design Runoff: Per ha (m³/s)	Design Runoff: Total Runoff (m³/s)	Runoff Major Storm (m³/s)	Proposed Drain: Size (m)	Slope (‰)	Velocity (m/s)	Capacity (m³/s)	Required Reserve Width (m)	Existing Condition: Runoff (m³/s)	Existing Drain: Size (m)	Capacity (m³/s)	Reserve Width (m)	Remarks
R11 -5	25.00	2.13	36.46	0.66	0.71	0.5	28.4	35.4	0.145	3.754	7.067	5.5/4.4 × 1.10	0.25	0.9	3.862	—	2.511	5.5/1.0 × 0.6	0.546	—	0.097
R11	160.00	13.21	47.67	0.66	0.71	3.3	31.7	38.7	0.173	6.101	9.275	5.5/3.7 × 1.6	0.25	0.8	6.200	10.5	4.056	7.0/5.0 × 0.7	1.638	7.0	0.115
R12	55.00	2.24	49.91	0.66	0.71	1.2	32.9	39.9	0.171	6.101 (6.660)	9.275 (9.213)	3×0 1.80	0.50	0.9	6.200	—	4.040	3×0.18		—	0.114
R13	280.00	8.72	58.63	0.60	0.70	5.8	38.7	45.7	0.160	6.567	10.696	5.5/3.5 × 2.0	0.25	0.8	6.600	10.5	4.391	14.0/10.0 × 1.0	6.120	14.0	0.107
	To R14																				
R14 -1	(240.00) 305.00	4.86	0.75	0.85	0.75	(6.7) 7.3	14.0	21.0	0.271	0.988	1.637	1.8/0.84 × 1.44	0.30	0.7	1.137	4.3	0.169	—		—	0.194
R14	30.00	0.70	54.19	0.65	0.70	0.8	39.5	46.5	0.172	7.728	11.967	6.5/4.5 × 2.0	0.25	0.8	8.300		6.560	6.0/2.0 × 1.4	2.800	6.0	0.146
	To R15																				
R15 -1	(640.00) 105.00	4.51		0.65	0.73	(17.8) 2.2	20.0	27.0	0.252	0.848	1.413	1.5/0.7 × 1.2	0.50	0.8	0.903	4.0	0.592	1.1/0.5 × 1.1	0.546	1.300	0.176
R15	50.00	0.20	69.00	0.65	0.70	1.0	40.5	47.5	0.170	8.211	12.655	6.5/4.5 × 2.0	0.25	0.8	8.300	11.5	6.955	6.6/2.6 × 1.4	2.800	19.00	0.144
R16	570.00	15.56	213.55	0.65	0.69	9.5	66.5	73.5	0.134	19.745	31.533	11.0/8.8 × 2.2	0.25	1.0	20.000	16.0	16.798	20.0/6.0 × 1.5	3.976	20.00	0.114
R17	30.00	0.96	214.51	0.65	0.69	0.5	67.0	74.0	0.134	19.834	31.675	11.0/8.8 × 2.2	0.25	1.0	20.000	16.0	16.873	20.0/6.0 × 1.5	14.235	20.00	0.114
R18	80.00	0.63	215.14	0.65	0.69	1.3	68.3	75.3	0.133	19.834 (19.743)	31.675 (31.471)	11.0/6.8 × 2.2	0.25	1.0	20.000	16.0	16.774	16.0/6.0 × 1.9	19.380	18.00	0.113
R19	35.00	7.29	222.43	0.65	0.69	0.6	68.9	75.9	0.132	20.259	32.384	11.0/8.8 × 2.2	0.25	1.0	20.300	16.0	17.189	15.0/4.0 × 1.9	14.801	15.00	0.112
R20	250.00	5.60	228.03	0.70	0.69	4.3	73.2	80.2	0.138	21.713	34.772	11.0/8.8 × 2.2	0.25	1.0	21.800	16.0	16.993	14.0/4.0 × 1.9	14.022	14.00	0.108
		To Sungai Kedah																			
R21	(345.00) 140.00	4.81		0.85	0.76	(9.6) 3.3	12.9	19.9	0.275	1.005	1.663	2.0/1.2 × 1.2	0.30	0.7	1.200	4.5	0.091	1.65/0.35 × 0.9	0.297	1.65	0.025
R22	90.00	4.77	9.58	0.75	0.75	1.9	14.8	21.8	0.220	1.581	2.624	3.0/2.2 × 1.2	0.25	0.8	2.113	8.0	1.265	3.1/0.9 × 0.8	0.624	3.10	0.173
R23	15.00	1.22	10.80	0.75	0.74	0.4	15.2	22.2	0.220	1.758	3.141	2× □1.22×1.22	0.25	0.7	1.968	—	1.407	0.010		—	0.176
R24	30.00	0.52	11.32	0.75	0.74	0.6	15.8	22.6	0.216	1.626	3.217	3.0/2.2 × 1.2	0.25	0.8	2.113	8.0	1.449	2.5/1.0 × 1.0	0.735	2.50	0.173

TABLE C-3 ANALYSIS OF PROPOSED DRAINAGE SYSTEM

refer to Figure 7.3

In Year 2000

Line No	Drain Length (m)	Area Each (ha)	Area Total (ha)	Composite Runoff Coefficient	Storage Coefficient	Time of Flow in the Drain Each tdi (min)	Time of Flow in the Drain Total td (min)	Time of Concentration tc (min)	Design Runoff Per ha (m³/s)	Design Runoff Total Runoff (m³/s)	Runoff Major Storm (m³/s)	Proposed Drain Size (m)	Proposed Drain Slope (‰)	Proposed Drain Velocity (m/s)	Proposed Drain Capacity (m³/s)	Proposed Drain Required Reserve Width (m)	Existing Condition Runoff (m³/s)	Existing Drain Size (m)	Existing Drain Capacity (m³/s)	Existing Drain Reserve Width (m)	Remarks
P 25	15.00	0.62	11.94	0.75	0.74	0.4	16.2	23.2	0.218	1.926	3.393	2× □1.37×1.22	0.25	0.7	2.340	—	1.529	□1.4×1.4		—	0.173
P 26	135.00	5.38	17.32	0.75	0.73	2.8	19.0	26.0	0.207	2.617	4.741	9.56 2.57×1.40	0.25	0.8	9.188	8.5	2.086	2.50 1.00×1.00	0.735	2.50	0.165
P 27	15.00	1.38	18.70	0.75	0.73	0.3	19.3	26.3	0.207	2.826	5.119	2× □1.68×1.53	0.25	0.8	4.158	—	2.252	○ 0.11		—	0.165
P 28	140.00	5.27	23.97	0.70	0.73	2.6	21.9	28.9	0.184	3.219	5.932	4.00 2.93×1.00	0.25	0.9	4.553	9.0	2.310	4.7 1.65×1.45	2.622	4.70	Earth 0.132
		To Sungai Kedah																			
R 29		4.00		area served by infrastructural drains																	
		Total 256.0 ha																			

TABLE C-4 . ANALYSIS OF PROPOSED DRAINAGE SYSTEM

refer to Figure 7.3

Line No.	Drain Length (m)	Area: Each (ha)	Area: Total (ha)	Composite Runoff Coefficient	Storage Coefficient	Time of Flow in the Drain: Each tdi (min)	Time of Flow in the Drain: Total td (min)	Time of Concentration tc (min)	Design Runoff: Per ha (m^3/s)	Design Runoff: Total Runoff (m^3/s)	Runoff: Major Storm (m^3/s)	Proposed Drain: Size (m)	Proposed Drain: Slope (‰)	Proposed Drain: Velocity (m/s)	Proposed Drain: Capacity (m^3/s)	Proposed Drain: Required Reserve Width (m)	Existing Condition: Runoff (m^3/s)	Existing Drain: Size (m)	Existing Drain: Capacity (m^3/s)	Existing Drain: Reserve Width (m)	Remarks
	Putera	basin																			
P.1		7.96			area	served by		infrastructural drains													
P.2	(290) 290.00	4.43		0.85	0.75	(8.1) 6.0	14.1	21.1	0.271	0.900	1.405	1.50/0.70 × 1.20	0.50	0.8	0.903	4.0	0.645	1.30/0.70 × 0.80	1.144	1.30	
	To P.4																				
P.3	(540) 15.00	5.38		0.85	0.74	(15.0) 0.3	15.3	22.3	0.268	1.066	1.664	□1.37 × 1.37	0.30	0.8	1.463	—	0.760	○ 0.90	0.846	—	
P.4	90.00	2.43	12.24	0.85	0.74	1.7	17.0	24.0	0.261	2.364	3.705	2.60/1.68 × 1.68	0.25	0.8	2.668	5.8	1.676	1.80/1.60 × 1.60	2.774	1.80	
		To	Sungai Anok		Bkit																
P.5		2.61			area	served by		infrastructural drains													
P.6	(425) 15.00	5.59		0.85	0.76	(11.0) 0.3	12.1	19.1	0.279	1.185	1.839	□1.68 × 0.92	0.30	0.8	1.190	—	0.854	○ 0.60	0.240	—	
P.7	125.00	1.56	7.17	0.85	0.75	3.0	15.1	22.1	0.268	1.441	2.248	2.50/1.83 × 1.00	0.35	0.8	1.538	5.5	1.027	1.00/0.60 × 0.90	0.799	1.00	
P.8	15.00	2.57	9.74	0.85	0.74	0.3	15.4	22.4	0.268	1.932	3.013	□1.83 × 1.22	0.35	0.9	2.085	—	1.377	○ 0.60	0.240	—	
P.9	100.00	1.42	11.16	0.85	0.74	2.1	17.5	24.5	0.258	2.131	3.345	3.0/2.2 × 1.2	0.30	0.8	2.315	8.0	1.503	2.60/1.60 × 1.10	1.624	2.60	
P.10	20.00	0.95	12.11	0.85	0.74	0.3	17.8	24.8	0.258	2.312	3.629	□1.83 × 1.37	0.35	1.0	2.418	—	1.591	—	0.327	—	
P.11	150.00	3.38	15.49	0.85	0.73	2.8	20.6	27.6	0.249	2.816	4.433	3.50/2.57 × 1.40	0.25	0.9	3.186	8.5	1.968	5.10/0.80 × 1.30	3.610	5.10	

Column groups: "In Year 2 000" (Line No. to Required Reserve Width); "Existing Condition" (Runoff to Reserve Width).

TABLE C-5 . ANALYSIS OF PROPOSED DRAINAGE SYSTEM

refer to Figure 7.3

Line No	Drain Length (m)	In Year 2000: Area Each (ha)	Area Total (ha)	Composite Runoff Coefficient	Storage Coefficient	Time of Flow in the Drain: Each tdi (min)	Time of Flow in the Drain: Total td (min)	Time of Concentration tc (min)	Design Runoff: Per ha (m^3/s)	Design Runoff: Total Runoff (m^3/s)	Runoff: Major Storm (m^3/s)	Proposed Drain: Size (m)	Slope (‰)	Velocity (m/s)	Capacity (m^3/s)	Required Reserve Width (m)	Existing Condition: Runoff (m^3/s)	Existing Drain: Size (m)	Capacity (m^3/s)	Reserve Width (m)	Remarks
P.12		7.57			area	served	by	infrastructural		drains											
P.13	(360) 255.00	4.84		0.80	0.74	(10.1) 6.1	16.1	23.1	0.232	0.831	1.483	250 / 1.53 × 1.00	0.75	0.7	1.163	5.5	0.620	3.2 / 0.4 × 0.9	0.761	4.9	
P.14	15.00	3.69	8.53	0.80	0.74	0.3	16.4	23.4	0.232	1.464	2.613	0.168 × 1.22	0.30	0.8	1.714	—	1.692	4.2 / 1.0 × 0.9	1.100	—	
P.15	130.00	2.06	10.59	0.80	0.73	3.1	19.5	26.5	0.218	1.685	3.054	300 / 2.20 × 1.20	0.30	0.7	1.890	8.0	1.260	4.5 / 1.3 × 1.0	1.479	6.1	
P.16	45.00	1.54	12.13	0.80	0.73	1.1	20.6	27.6	0.214	1.895	3.462	2× 0.122 × 1.22	0.30	0.7	2.178	—	1.417	1.65 / 0.95 × 1.2	1.373	3.6	
		To	Sungai	Anak	Bukit																
		Total 5800 ha																			

TABLE C-6 . ANALYSIS OF PROPOSED DRAINAGE SYSTEM

refer to Figure 7.3

Line No	Drain Length (m)	Area Each (ha)	Area Total (ha)	Composite Runoff Coefficient	Storage Coefficient	Time of Flow in the Drain: Each td_i (min)	Time of Flow in the Drain: Total td (min)	Time of Concentration tc (min)	In Year 2 000 Design Runoff: Per ha (m^3/s)	Design Runoff: Total Runoff (m^3/s)	Runoff Major Storm (m^3/s)	Proposed Drain: Size (m)	Slope (‰)	Velocity (m/s)	Capacity (m^3/s)	Required Reserve Width (m)	Existing Condition: Runoff (m^3/s)	Existing Drain: Size (m)	Capacity (m^3/s)	Reserve Width (m)	Remarks -
	Langgar basin																				
L. 1	(395) 130.50	15.18		0.65	0.75	(11.0) 2.7	13.7	20.7	0.104	2.209	3.916	□1.83 × 1.53	0.25	0.8	2.348	—	1.366	—		—	
L. 2	115.00	5.06	20.24	0.65	0.74	2.1	15.8	22.8	0.188	2.816	5.032	3.20 × 1.90	0.25	0.9	3.838	8.2	1.737	—		—	
L. 3	200.00	13.03	33.27	0.50	0.73	3.7	19.5	26.5	0.136	3.303	5.999	3.20 × 1.90	0.25	0.9	3.836	8.2	1.967	U 0.61		0.6	
L. 4	265.00	2.92	36.19	0.50	0.72	4.9	25.4	32.4	0.126	3.303 (3.283)	6.123	3.20 × 1.90	0.25	0.9	3.838	8.2	1.980	1.8 0.5 × 0.7	0.373	1.8	-
L. 5	245.00	4.23	40.42	0.45	0.71	4.5	29.9	36.9	0.106	3.303 (3.642)	6.123 (5.768)	3.20 × 1.90	0.25	0.9	3.838	8.2	2.038	1.8 0.5 × 0.7	0.373	1.8	
L. 6	370.00	2.56	43.00	0.45	0.70	6.9	36.5	43.8	0.098	3.303 (2.950)	6.123 (5.659)	3.20 × 1.90	0.25	0.9	3.838	8.2	2.038 (1.957)	2.2 1.3 × 1.6	1.029	2.2	
		To Sungai Kedah																			

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