B.6.3 Investment Requirements

The annual investment requirements of the Project Road are set based on the implementation schedule. The amount of annual investment required consists of land acquisition and compensation and construction of roadway and structures.

The yearly investment requirements are presented in 1980 prices and broken down into foreign and local currency. The investment requirements of the Project Road by phase and stage are shown in Table B.6.2. The annual investment requirements of the Project Road are shown in Table B.6.3.

Table B.6.2 SUMMARY OF FINANCIAL COST

(In thousand M$ at 1980 prices)

	Foreign	Local	Total
Detailed Engineering and Construction Supervision	3,297	6,001	9,298
Phase 1			
Land Acquisition	-	19,200	19,200
Construction	28,786	34,365	63,151
Sub-Total	28,786	53,565	82,351
Stage 1			
Land Acquisition	-	10,144	10,144
Construction	7,705	7,584	15,289
Sub-Total	7,705	17,728	25,433
Stage 2			
Land Acquisition	-	0	0
Construction	10,953	15,043	25,996
Sub-Total	10,953	15,043	25,996
Stage 3			
Land Acquisition	-	9,056	9,056
Construction	10,128	11,738	21,866
Sub-Total	10,128	20,794	30,922
Phase 2			
Land Acquisition	-	24,426	24,426
Construction	14,871	18,770	33,641
Sub-Total	14,871	43,196	58,067
Total Land Acquisition	-	43,626	43,626
Construction	43,657	53,135	96,792
Total	43,657	96,761	140,418
Grand Total	46,954	102,762	149,716

Note : Tax is included in the 'Local' portion.

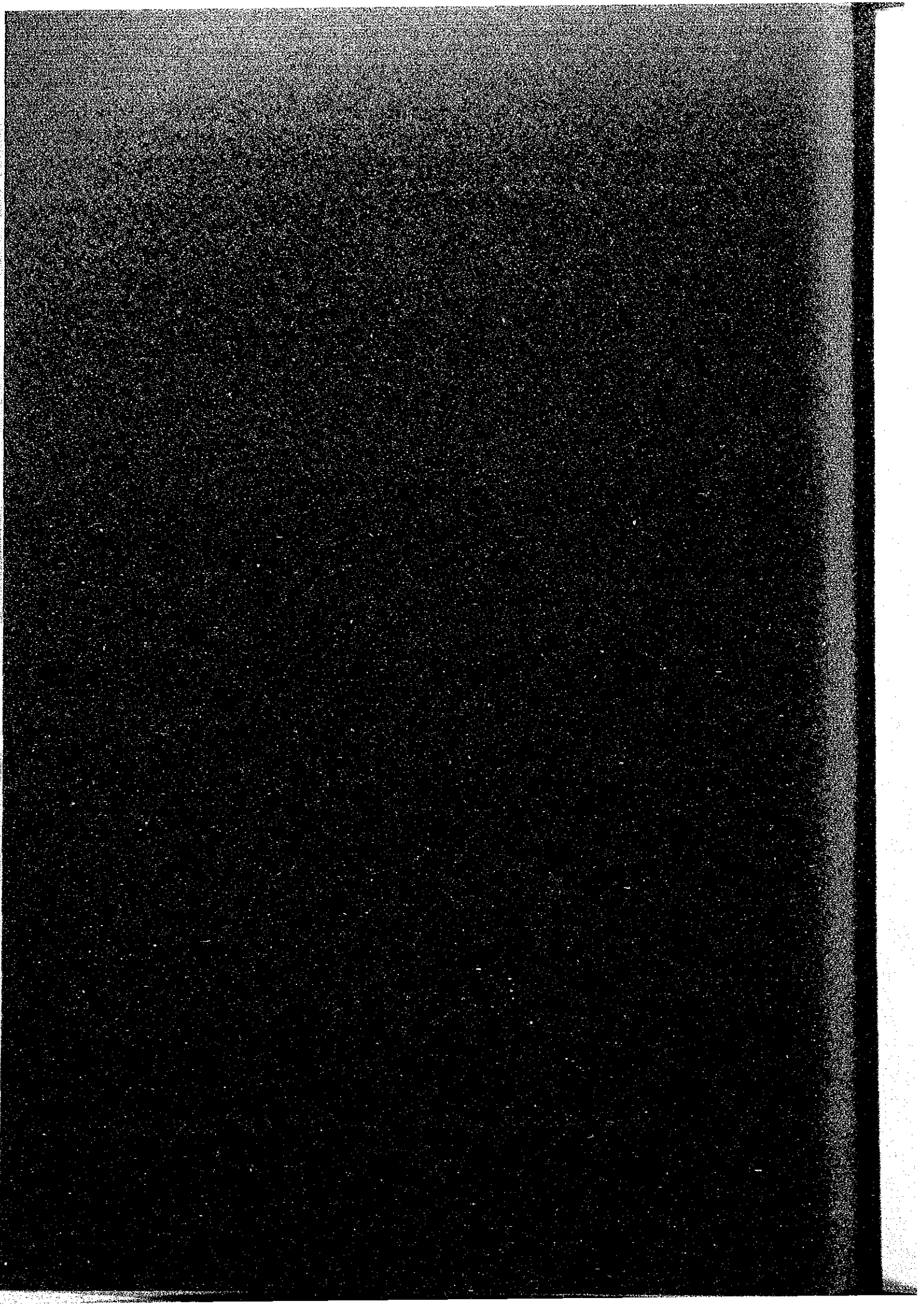
Table B.6.3 ANNUAL INVESTMENT REQUIREMENTS FOR PHASE 1 AND PHASE 2

(In thousand M$ at 1980 Prices)

	Land Acquisition (Local)	Road Construction			Total		
		Foreign	Local	Total	Foreign	Local	Total
1982	-	603	1,170	1,773	603	1,170	1,773
1983	-	604	1,170	1,774	604	1,170	1,774
1984	6,763	3,070	3,521	6,591	3,070	10,284	13,354
1985	3,381	6,140	7,043	13,182	6,140	10,424	16,564
1986	6,037	7,832	9,956	17,788	7,832	23,825	31,657
1987	11,161	6,747	8,502	15,249	6,747	19,663	26,410
1988	8,142	8,260	9,495	17,755	8,260	25,897	34,157
1989	8,142	7,158	8,628	15,786	7,158	16,770	23,928
1990	-	4,356	5,370	9,726	4,356	5,370	9,726
1991	-	2,184	4,281	6,465	2,184	4,281	6,465
Total	43,626	46,954	59,136	106,090	46,954	102,762	149,716

Note : The construction cost includes the detailed engineering and construction supervision.

MAIN VOLUME



1. INTRODUCTION

1.1 Background

The Government of Japan, in compliance with the request of the Government of Malaysia, has agreed to extend technical cooperation on the Urban Transport Study in the Greater Metropolitan Areas of George Town, Butterworth and Bukit Mertajam (hereinafter called the "Study").

Based on this decision, the Japan International Cooperation Agency ("JICA"), an official agency responsible for the execution of the technical cooperation program of the Japanese Government, carried out the Study jointly with the Government of Malaysia.

In November 1978, JICA dispatched a preliminary survey mission with the scope of work for the Study being agreed upon by both Governments.

The Study is divided into two phases. Phase I of the Study (hereinafter called the "Phase I Study") is aimed at formulating a master-plan of urban transport systems for the Metropolitan Area while Phase II of the Study (hereinafter called the "Phase II Study") is aimed at studying the feasibility of the project selected from the Phase I Study's recommendations.

The Phase I Study, conducted over a period of one year, from March, 1979, has established the following set of recommendations for the implementation of its transport infrastructure.

A. Long-Term Transport Plans

   1. Construction of New Roads and Improvement of Existing Roads
   2. Improvement of Public Transport
   3. Private Vehicle Restraints
   4. Construction of Transport Terminal Complex

B. Short-Term Actions

   1. Implementation of Traffic Engineering and Management Measures
   2. Construction and Improvement of Roads

3. Improvement of Bus Transport

Among both the short and long-term plans and projects, it is recommended that the following roads should be constructed or improved as short-term measures.

In Penang Island:

a) Gurney Drive Extension

b) Outer Ring Road from Bagan Jermal to Ayer Itam

c) Widening of Green Lane

d) Scotland Road and Western Road from Ayer Itam Road to Gottlieb Road

e) Bayan Lepas Road

f) Jelutong Road

g) Leboh McNair

h) Maxwell Road

i) Dato Keramat-Ayer Itam Road to Ayer Itam Intersection

j) Paired Road

In Province Wellesley:

a) Sungai Dua Road from Kg. Bagan Ajam to S.Dua

b) West Coastal Road from Kg. Bagan Ajam to the new port

c) West Coastal Road from the new port to intersection at Alor Star-Changkat Jering Highway

d) Federal Route 1 at intersection of Alor Star-Changkat jering Highway and Jalan Muthupalaniappa

e) Prai Road

f) Permatang Pauh Road

In the Phase II Study, the Outer Ring Road from Bagan Jermal the North Coastal Road through Ayer Itam, and the Gurney Drive Extension are selected for the study under the name of the Outer Ring Road Project.

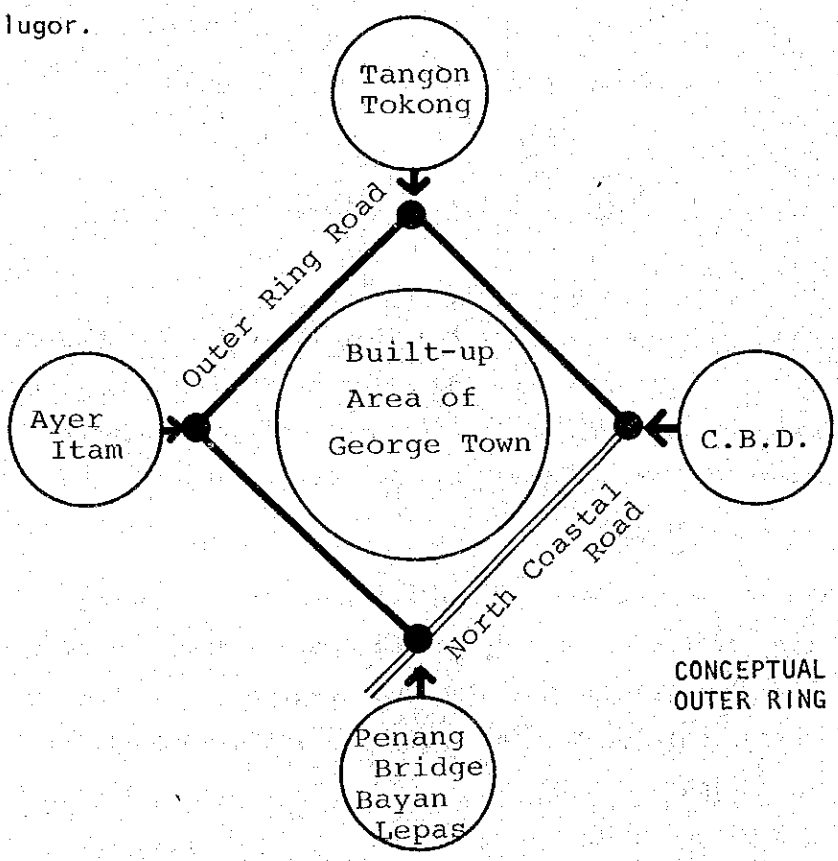
1.2 Description of the Outer Ring Road Project

Due to intensive industrial and other urban development activities undertaken in this area, as well as in the rapid increase in the number of private vehicles, the Penang Metropolitan Area must improve its transport system immensely. George Town in particular must meet the future traffic demand efficiently, especially when the Penang Bridge is opened even though little space remains for the further development of roads in its C.B.D.

Therefore, the Outer Ring Road Project proposed for George Town, functions to disperse traffic moving to and from the Penang Bridge and the surrounding areas of the town undergoing intensive development.

The route of the Project Road proposed in the Phase I Study begins at the intersection of the existing Pengkalan Weld with the proposed North Coastal Road of the Penang Dispersal Study, continues along Pengkalan Weld, Gurney Drive, Jalan Bagan Jermal and Jalan Gottlieb then passes behind the Batu Gantong Cemetery and connects to Jalan Ayer Itam.

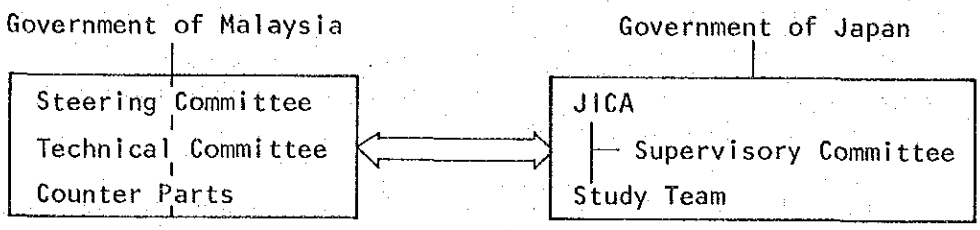
From Jalan Ayer Itam it proceeds along the foot of Bukit Relau, cuts across Green Lane and then joins up with the North Coastal Road at Glugor.



CONCEPTUAL MAP OF OUTER RING ROAD

1.3 Study Organization

The project is being carried out jointly by JICA and the Government of Malaysia in co-ordination with other agencies. The organization for the project is as follows:



The members of each organization are presented in Appendix IV.

1.4 Study Approach

1.4.1 Study Items

The general approach adopted for the Study is illustrated in Fig. 1.1. and consists of the following principal activities.

(1) Route Location

(2) Traffic Projection

(3) Preliminary Engineering and Cost Estimates

(4) Environmental Study

(5) Economic Evaluation

(6) Implementation Program

A brief description of each activity is presented below.

(1) Route Location

In order to derive the most feasible route for the Project Road, alternatives are prepared and selected through the various reconnaisance surveys such as topographic, soil and material investigation, landuse and environmental surveys.

(2) Traffic Projection

The traffic demand for the Project Road is forecasted by modifying the traffic projection of the Phase I Study so as to obtain a more precise forecast with the results of the traffic projection being mainly used for preliminary engineering and benefit calculation.

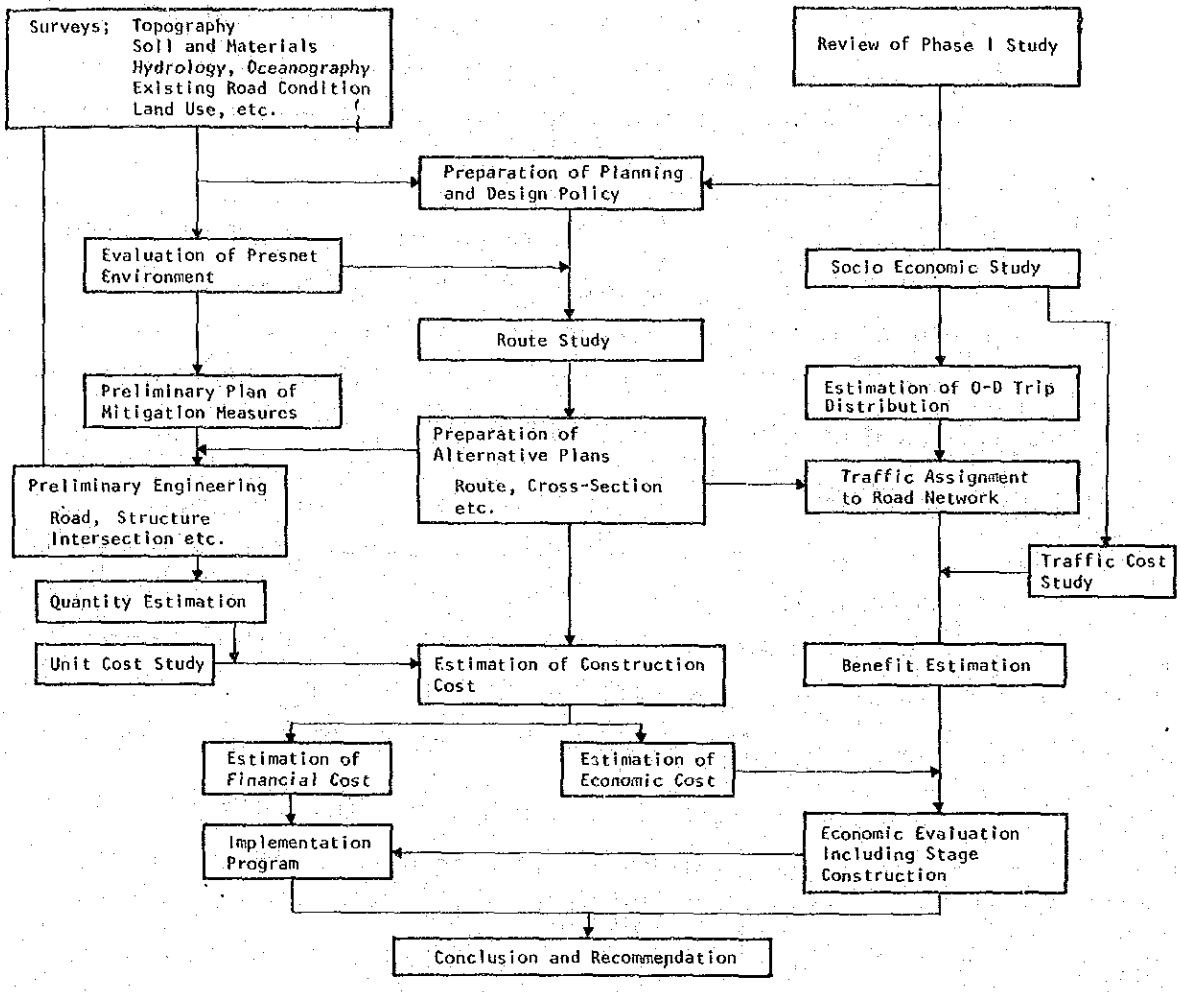


Fig. 1.1 GENERAL FLOW CHART

(3) Preliminary Design and Cost Estimate

The preliminary road and bridge design is elaborated using a basic scale of 1 to 3000, taking into account the result of the route location study and the traffic projection, after which construction and maintenance costs of the Project Road are calculated by estimating a unit cost for each work item.

(4) Environmental Study

The environmental study is conducted not only in consideration of the qualitative impacts on land use, landscape and community segregation by the road and providence of an adequate mitigation measure, but also to suggest a proper road design by evaluating the present environmental conditions.

(5) Economic Evaluation

The economic analysis is made using the results from benefit and economic cost estimates, after which based on this analysis, the alternative plans are evaluated and the investment timing is determined.

(6) Implementation Program

Based on the above-mentioned studies, the implementation program of the Project Road is proposed taking realistic conditions into account.

1.4.2 Alternatives

In these steps, various alternatives of the Project Road are proposed and evaluated through the results of studies and discussions at the technical and steering committee meetings.

The major viewpoints of evaluation and the alternative items are as follows.

Major Alternative / Evaluation Viewpoint	Route	Cross-Section	Interchange	Construction Stage	
Environment Study City Planning	X				
Engineering (Design, Cost)	X	X	X		1st Screening
Traffic Planning	X	X	X		
Economic	X	X	X	X	2nd Screening

The alternatives prepared in these two screening steps are actually those shown in the schematic in Fig. 1.2.

1.5 Study Schedule

The Phase II Study began on 17th April, 1980. A Steering Committee Meeting was held between the Government of Malaysia, the Supervisory Committee of JICA and the Study Team to discuss the Inception Report that would put the study into execution.

Since then, the following Committee Meetings have been held.

Steering Committee Meeting

Date	Comments
5th August, 1980	Submission of Progress Report.
12th December, 1980	Submission of Interim Report.
12th March, 1981	Submission of Draft Final Report.

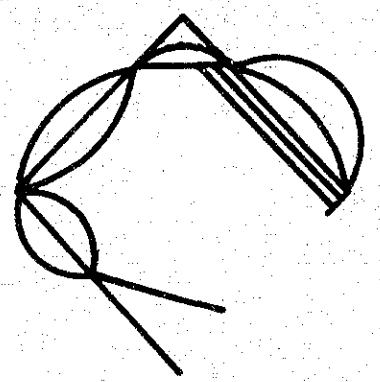
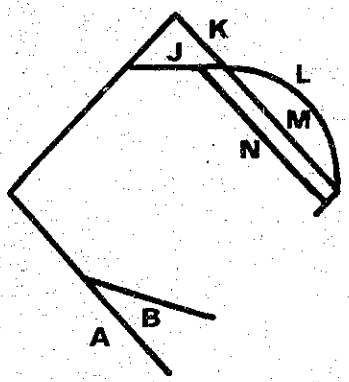
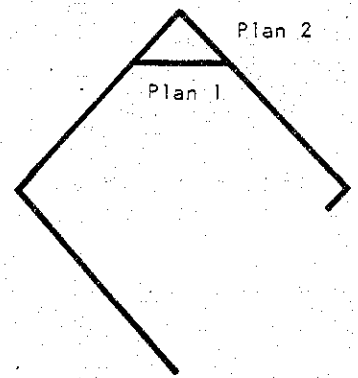
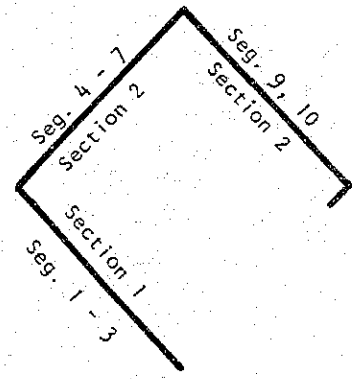
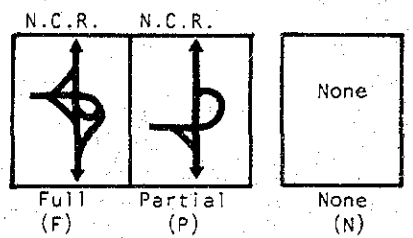
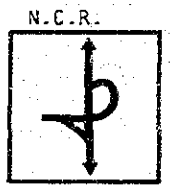
Environmental Study	Engineering Study	Economic Evaluation	Recommendation
			
Route: Various Possibilities	Route A or Route B Route J or Route K Route L or Route M or Route N	Plan 1 : Route A, J, M Plan 2 : Route A, K, M	Plan 2
Cross Section:	Preparation of Typical Cross Sections	2 Lane or 4 Lane	4 Lane
Access to North Coastal Road:	Additional Interchange (Route A) No Additional Interchange (Route B)		
Stage Construction		Section 1, Section 2 Segments 1 - 10	Higher Priority: Section 2 Segments 4, 7

Fig. 1.2 PROCESS FOR SCREENING OF ALTERNATIVES

Technical Committee Meeting

Date	Comments
30th May, 1980	Discussion on Route Location etc.
26th June, 1980	Discussion on Progress Report.
25th September, 1980	Discussion on the result of Traffic Projection.
10th December, 1980	Discussion on Interim Report.
10th March, 1981	Discussion on Draft Final Report.

2. Present Transport Conditions

2.1 Road Network

The major road network in the Study Area consists mainly of partially developed radial and ring roads of which Jalan Northam and Jalan Burma running from the Central Business District (CBD) to the north-west, Jalan Ayer Itam from the CBD to the west and Jalan Jelutong to the south, are radial roads.

The ring roads consist of 3, the first ring road is made up of Jalan Maxwell and Penang Road, the second ring road Jalan Sungai Pinang, Jalan Perak and Jalan Pangkor and the third ring road Green Lane, Jalan Scotland and Western Road. (See Fig. 2.1)

The right of way (ROW) of these major roads ranges from 40' to 100' in width. Among them, the ROW of the major roads such as Jalan Northam, Green Lane is 100' in width with wide single carriageways.

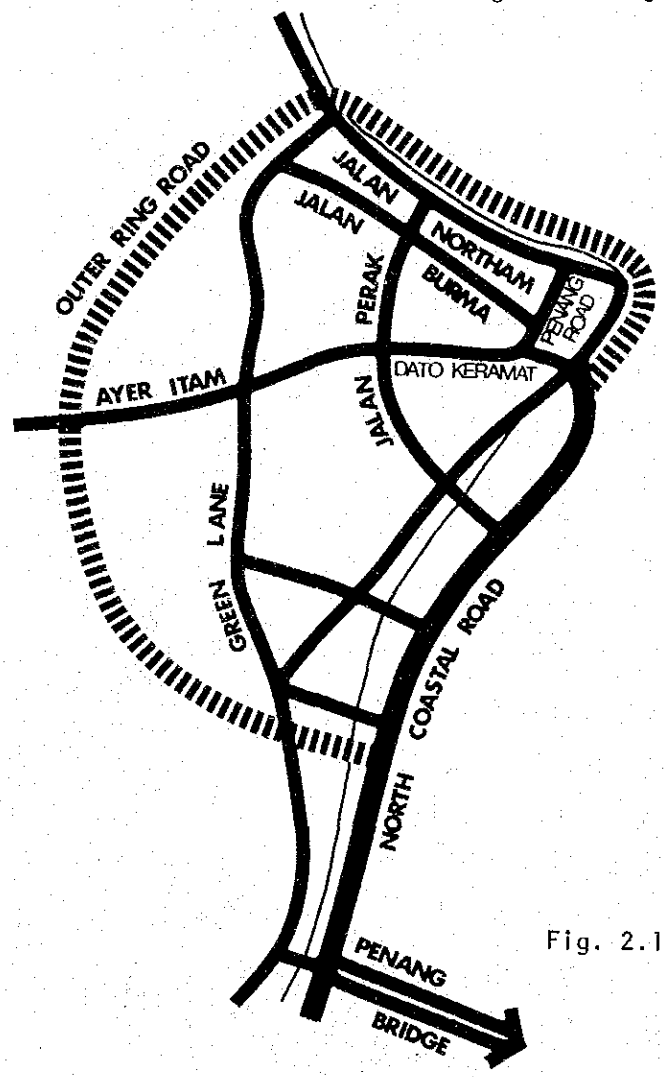


Fig. 2.1 ROAD NETWORK PATTERN

2.2 Characteristics of Traffic

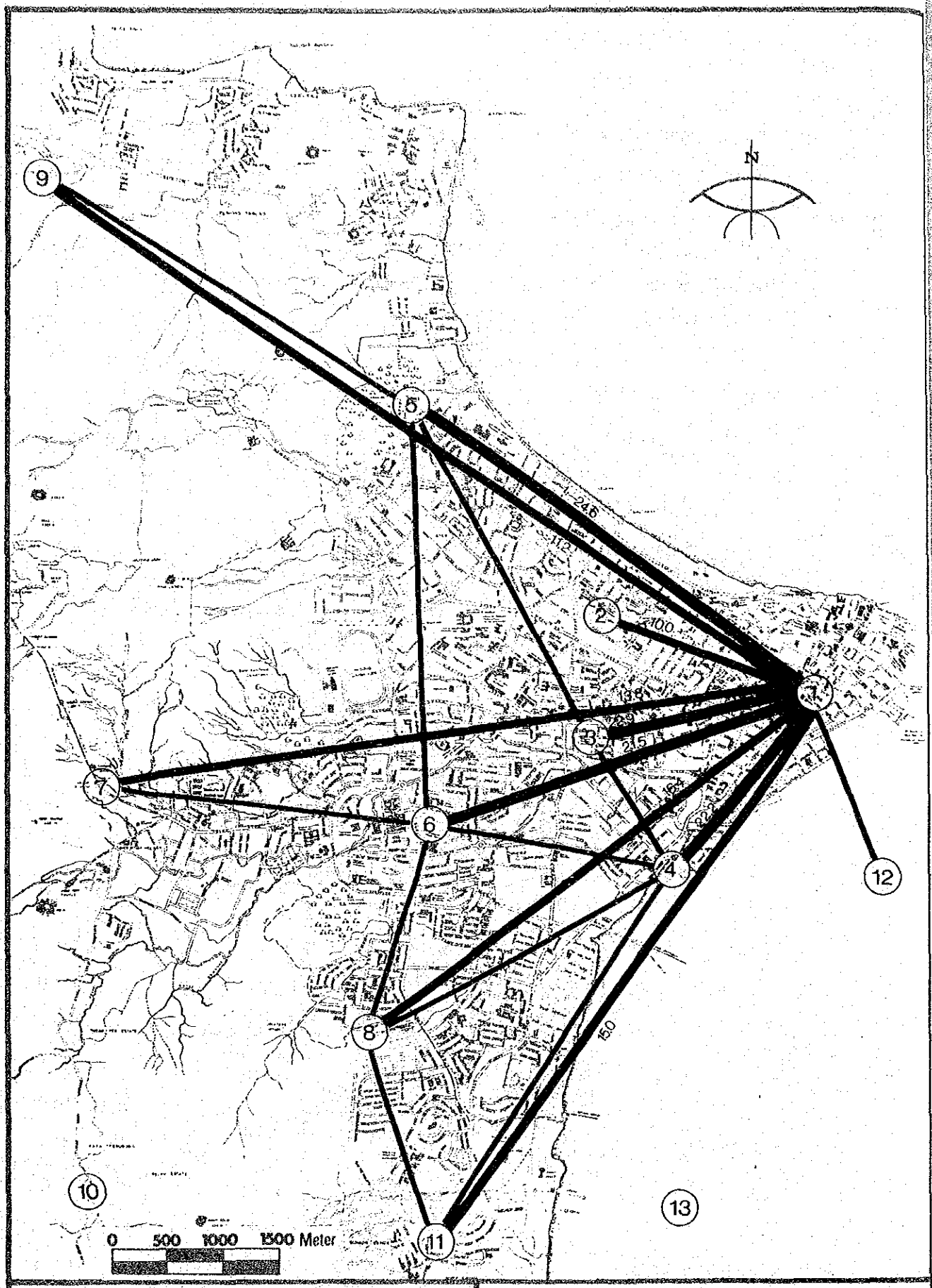
2.2.1 Traffic Flow Pattern

Fig. 2.2 presents the desired lines showing the existing traffic movement between traffic sections which divide the Study Area geologically. By this chart the following can be observed.

(1) The main traffic flow appears as traffic movement from the Central Sector (CBD) and shows the traffic pattern convergent point.

(2) In comparison with the volume of traffic flow in the radial direction that of the volume of traffic flow in the circular direction is relatively smaller.

(3) Among traffic flows to and from the central district, those having the largest volumes are generated from the fringe areas of the central district due to the large population there. On the other hand, the traffic flows from the other districts is relatively smaller.



URBAN TRANSPORT STUDY

Fig. 2.2 DESIRED LINES IN 1979

2.2.2 Traffic Volume

A series of traffic volume counting surveys at major roads for periods of 16-hours (6am. - 10pm.) and at major intersections for periods of 12-hours (7am. - 7pm.) is being conducted in the city of George Town in order to grasp the major traffic flow pattern. Fig. 2.3 illustrates the major traffic flow for the 12-hour period (7am. - 7pm.) in George Town where traffic volume is indicated by Passenger Car Unit (P.C.U), and reveals the following.

(1) As the traffic from both directions has only a limited choice of roads by which to enter the C.B.D, the result is that the traffic volume on certain sections reaches high levels, for example on Jalan Tanjong Tokong, Jalan Air Itam and Jalan Glugor.

(2) The traffic volume on the road sections in the C.B.D. is also relatively high, for example on Jalan Burma, Jalan Northam, Penang Road, Jalan Macalister, etc.

2.2.3 The Fluctuation of Traffic Volume

From the surveys, the fluctuation of traffic volume is obtained on the particular road sections.

(1) Daily Variation

Fig. 2.4 illustrates the daily variation of traffic volume at survey stations on Jalan Northam and Jalan Dato Keramat with a similarity seen at both stations.

(2) Hourly Variation

Fig. 2.5 illustrates the hourly variation at the Magazine Circus on Jalan Macalister. According to this figure, there are three daily peaks, in the morning, at noon and in the evening with the ratio of the peak hour traffic volume to the 16-hour period volume being about 12 per cent.

2.2.4 Vehicle Composition

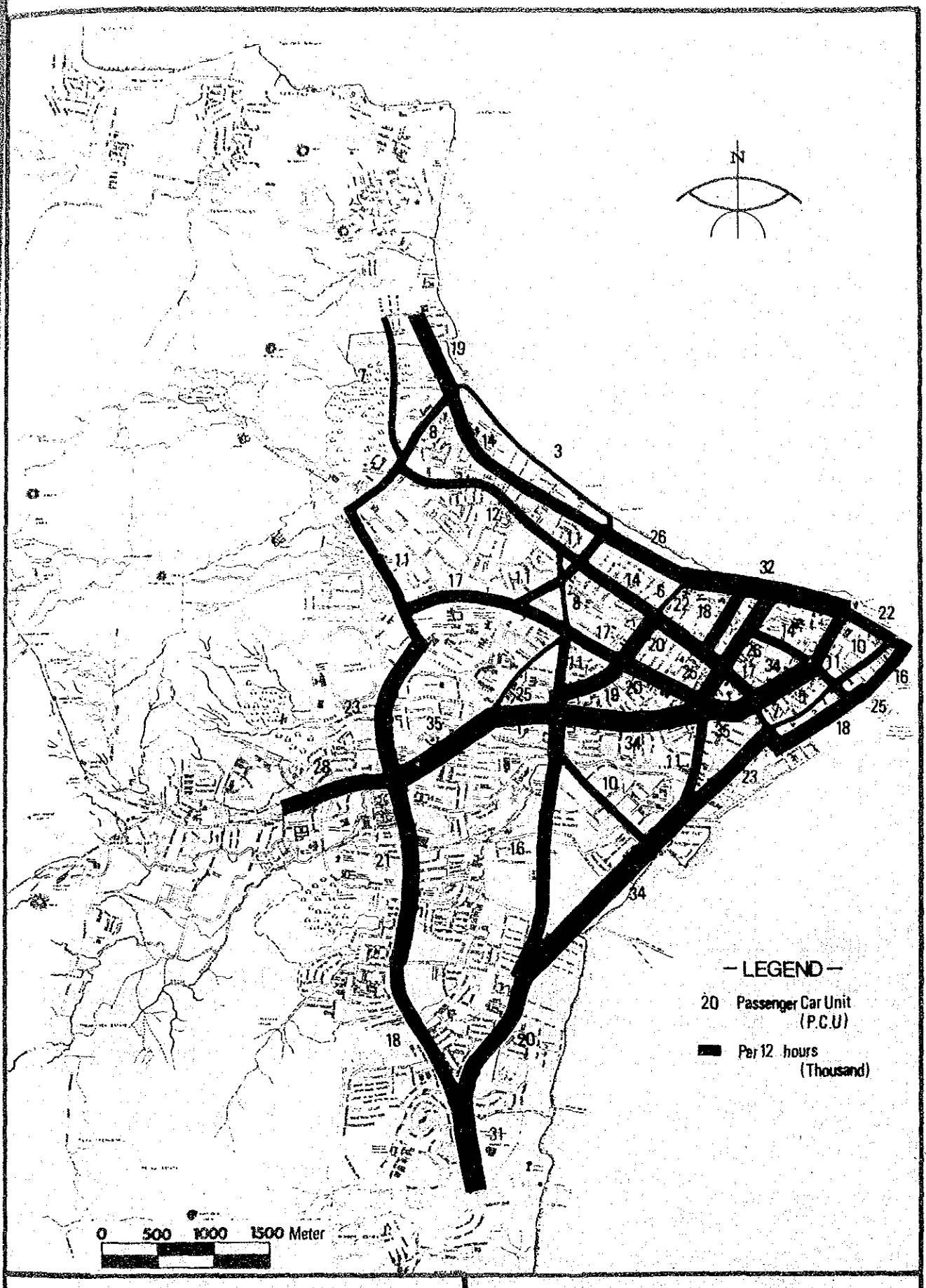
Fig. 2.6 illustrates the vehicle composition at the intersections where according to the figures, the following can be observed:

(1) The composition of light car traffic on Jalan Northam and Jalan Burma is comparatively higher than that on the other roads.

(2) On the other hand, the share of motor-cycle traffic on Jalan Jelutong is comparatively higher.

2.2.5 Travel Time

In George Town, traffic congestion at several intersections occurs in peak hours with increases in travel time. Taking cases of the slowest speed as examples, in the morning peak hours all of the approach speeds record from 8 km/h to 11 km/h to the intersection of Jalan Ayer Itam and Jalan Dato Keramat crossing Jalan Perak while in the evening peak hours, on Jalan Scotland adjacent to the intersection with Jalan Ayer Itam and Green Lane the travel speed recorded is 6 km/h.



URBAN TRANSPORT STUDY

Fig. 2.3
MAJOR TRAFFIC FLOW PATTERN IN GEORGE TOWN
(Jun. - Aug. 1980)

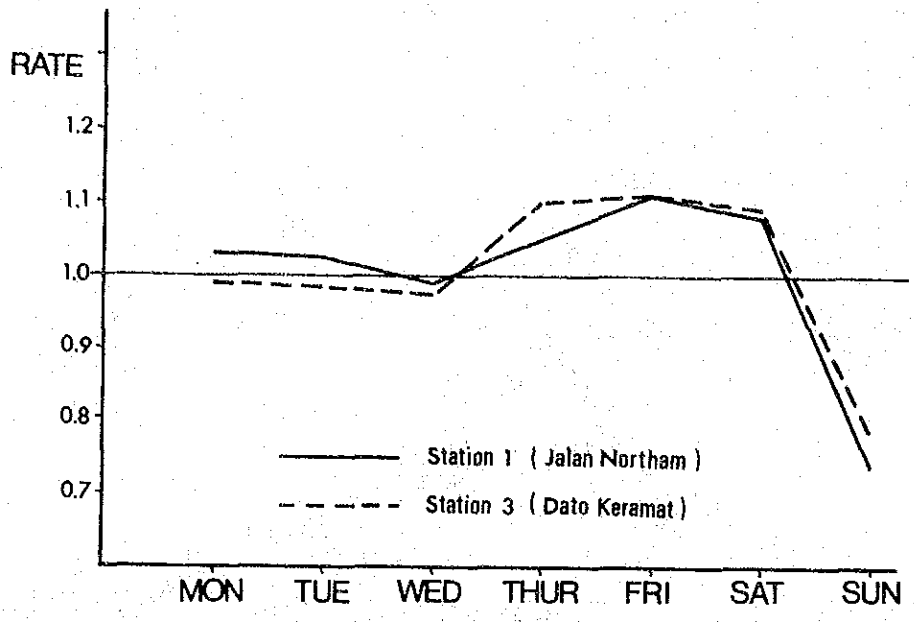
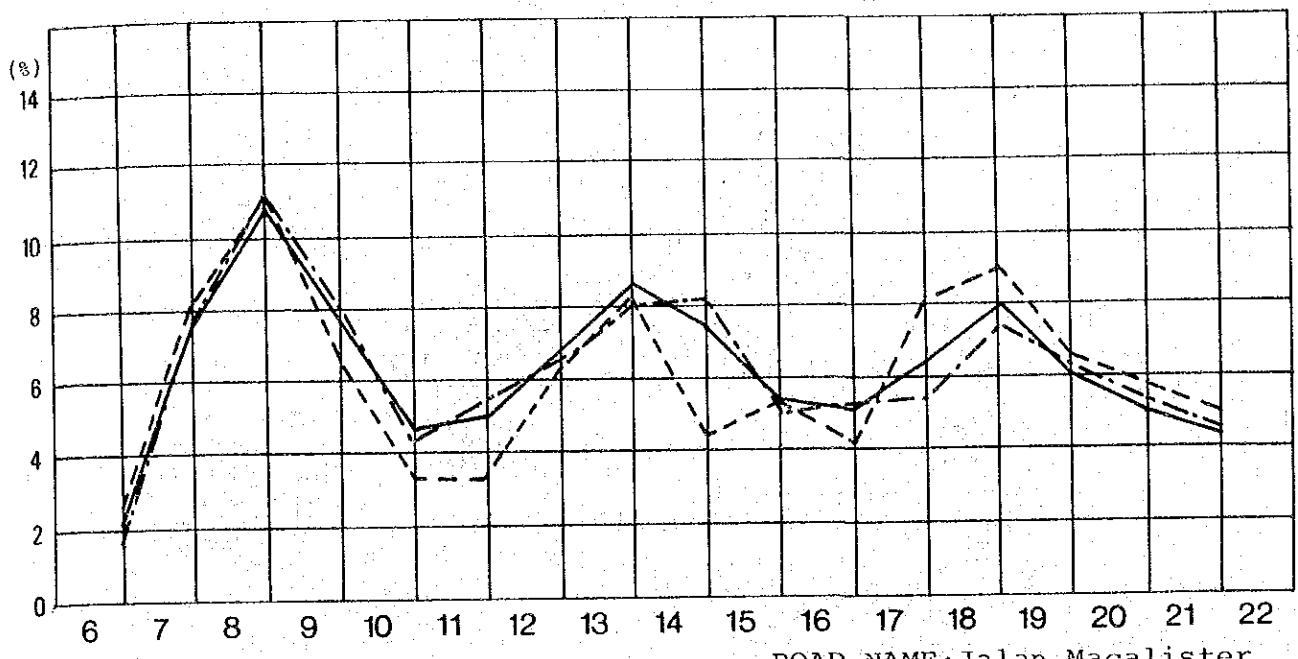
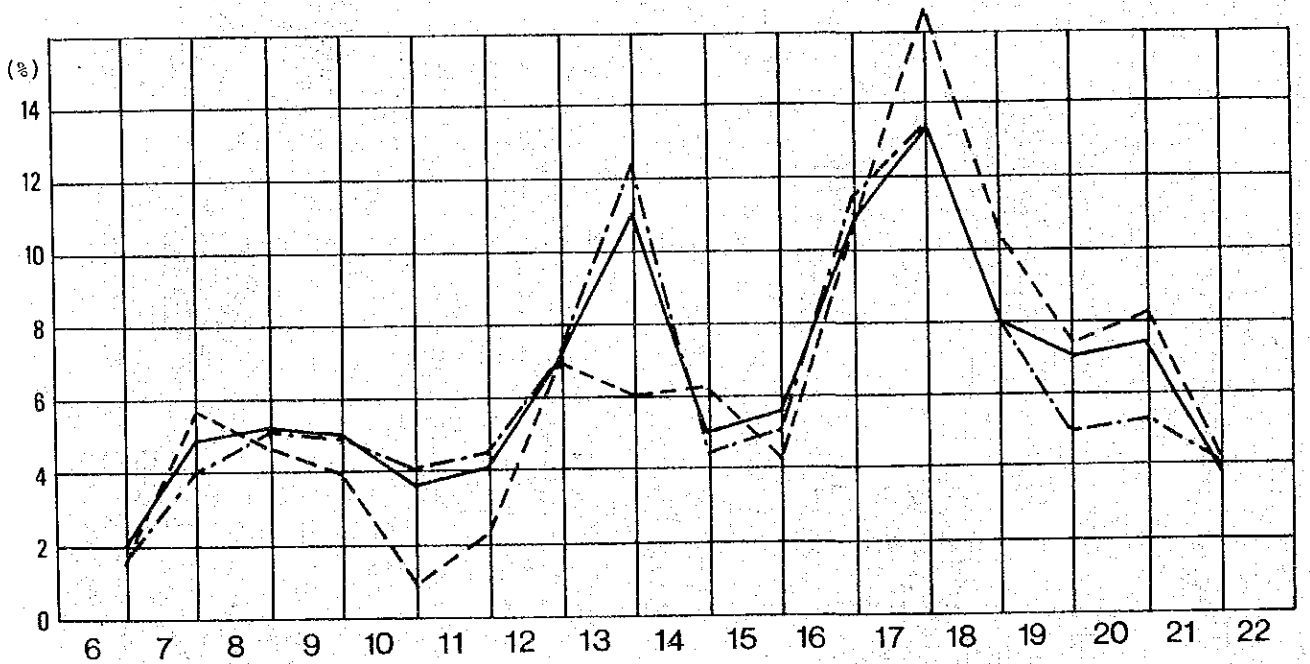


Fig. 2.4 DAILY VARIATION OF TRAFFIC VOLUME



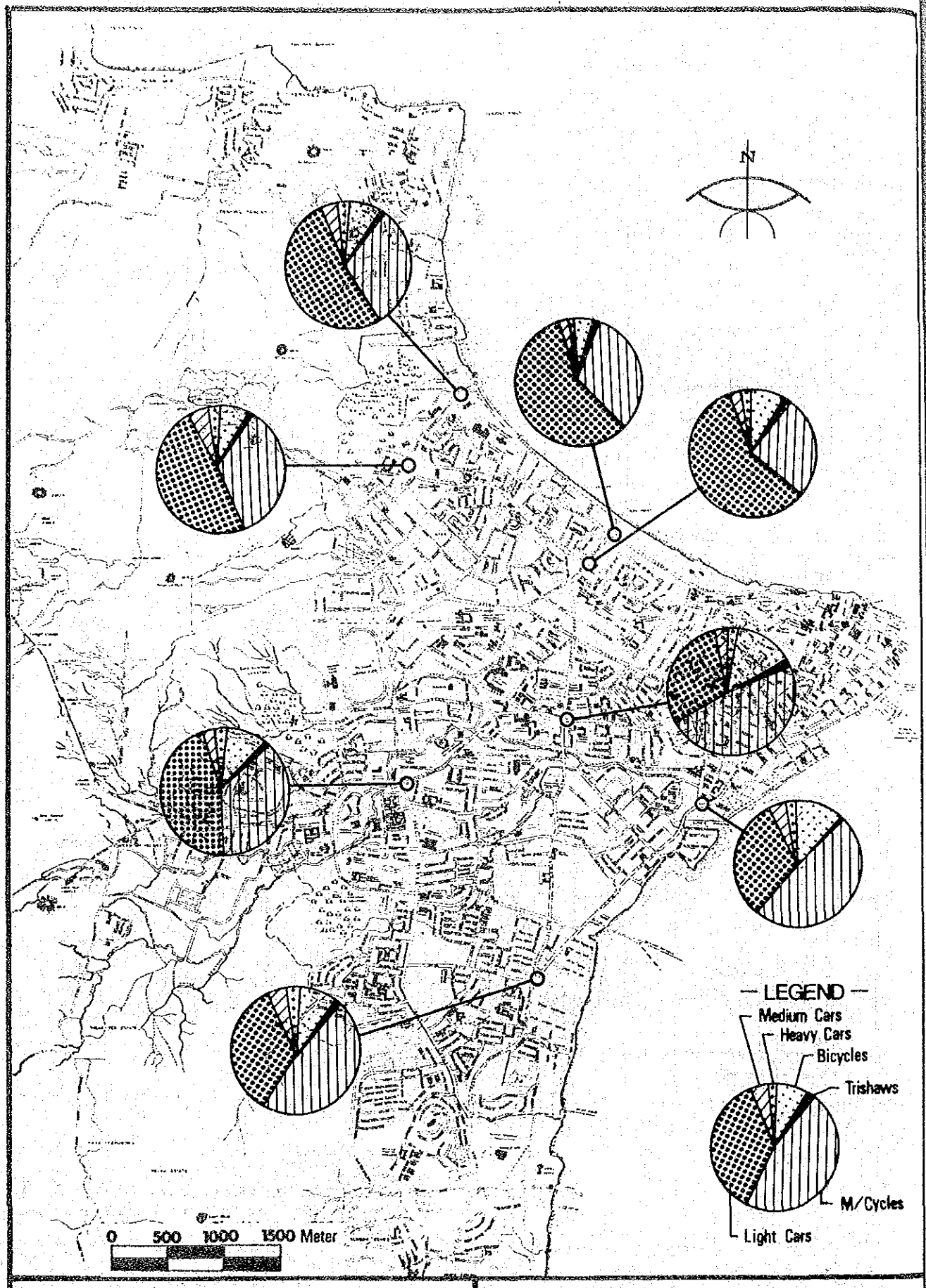
ROAD NAME:Jalan Macalister
STATION NO:9
DIRECTION:Jalan Macalister to
Magazine Circus.



ROAD NAME:Jalan Macalister
STATION NO:9
DIRECTION:Magazine Circus to
Jalan Macalister

——— ALL VEHICLES
—·—·— CARS (incl. large car)
– – – – – MOTORCYCLES

Fig. 2.5 THE HOURLY FLUCTUATION OF TRAFFIC VOLUME



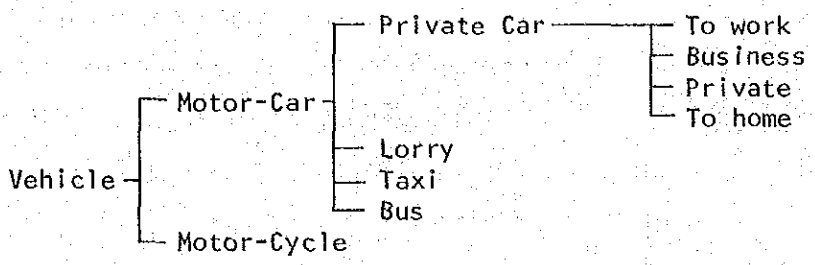
URBAN TRANSPORT STUDY

Fig. 2.6 VEHICLE COMPOSITION

3. PROJECTION OF TRAFFIC DEMAND

3.1 Procedure

This Study employs basic data and traffic projection models the same as those developed in the Phase I Study while the future traffic demand is given according to the following categories by vehicle type and trip purpose also similar to the Phase I Study.



The procedure of the traffic demand projection is shown in Fig. 3.1 with the major steps being described as follows:

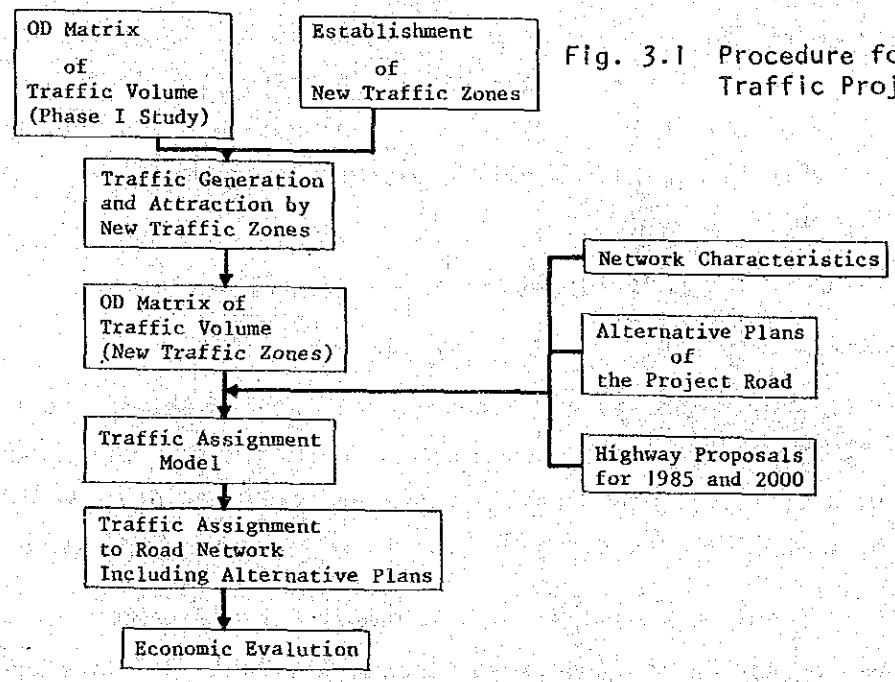


Fig. 3.1 Procedure for Traffic Projection

3.1.1 Establishment of O-D Matrix

Since it is necessary to project precise traffic demand on the Project Road, the traffic zones used in the Phase I Study are further divided when used in the Phase II Study. (See Fig. 3.3)

Corresponding to the new zoning, trip generation and attraction as well as trip distribution are estimated by adoption of a simple dividing method.

3.1.2 Traffic Assignment

In order to find the traffic volume on the Project Road, the following traffic assignment model is used.

a. For each link of the network to which vehicles are assigned, the relationship between traffic volume and travel time is established. In this relationship, travel time increases with the increase in traffic volume. When the traffic volume exceeds the rated capacity, the travel time increases sharply which limits the further rise of traffic volume.

b. It is assumed that an O-D pair traffic volume is assigned on a route of minimum travel time (or cost).

c. Vehicular O-D traffic volume is divided into two (2) categories (motor-cars and motor-cycles) and are further subdivided into five (5) parts after which the first part is assigned on the road network and the result of travel time obtained for each link to meet the traffic volume allocated, the next part is assigned to the resulting road network with this being subsequently repeated for the following three (3) parts.

3.2 Framework Plan for Traffic Projection

3.2.1 General

In line with the Phase I Study, a framework plan for the Phase II Study is used for traffic projection. However, zonal socio-economic indicators projected in the Phase I Study are divided into new ones taking into account the local conditions. The framework plan used is as follows.

3.2.2 Population

The population in Study Area as shown in Table 3.1 is expected to increase from 469,700 in 1979 to 519,300 in 1985 and 677,000 in the year 2000 with the annual average growth rate between 1979 and the year 2000 being 1.8%.

Table 3.1 POPULATION PLAN

	Population				Annual Growth Rate (%)	
	1970	1979	1985	2000	1985/1979	2000/1979
Study Area		469,700	519,300	677,000	1.7	1.8
Penang Island	430,702	513,300	569,100	750,000	1.7	1.8
Penang State	776,000	946,600	1,090,100	1,555,800	2.4	2.4

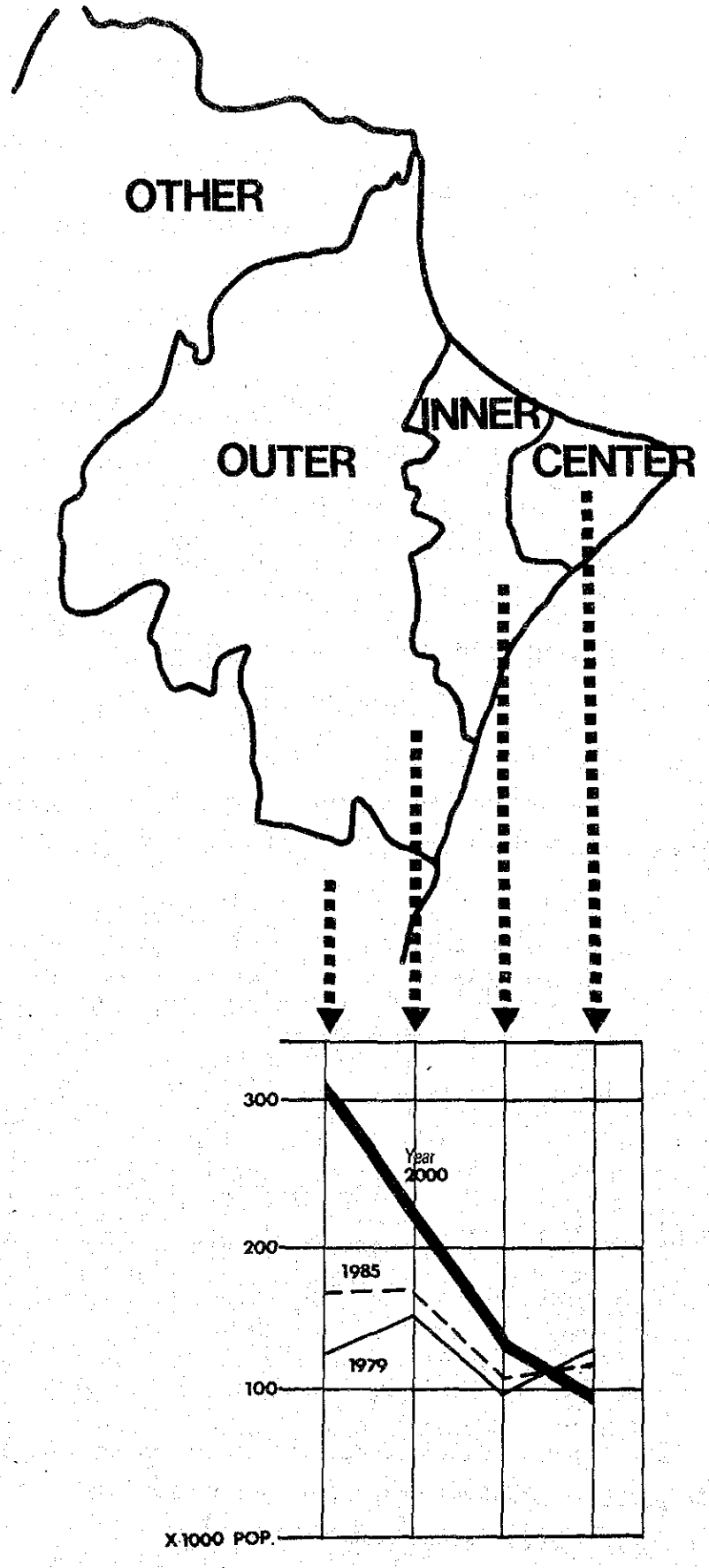


Fig. 3.2 CHANGE IN URBAN POPULATION STRUCTURE

3.2.3 Employed Population

The employed population in the Study Area and in Penang State is shown in Table 3.2 with that in the Study Area expected to increase from 136,000 in 1979 to 162,500 in 1985 and 240,900 in the year 2000 with the average growth rate between 1979 and the year 2000 being 2.8 percent.

Table 3.2 EMPLOYED POPULATION

	Population				Annual Growth Rate (%)	
	1970	1979	1985	2000	1979/1985	1979/2000
Study Area		136,000	162,500	240,900	3.0	2.8
Penang Island		147,600	173,800	252,600	2.8	2.6
Penang State	214,900	294,000	350,700	541,700	3.0	3.0

Source: Phase I Study Report

3.2.4 Landuse

The Phase II Study follows the landuse plan proposed in the Phase I Study based on the interim zoning plan with the result of the future landuse plan being tabulated into the following tables:

Table 3.3 FUTURE LANDUSE DISTRIBUTION Unit: ha

Area	Penang Island		Province Wellesly		Total		Change 1979 - 2000
	1979	2000	1979	2000	1979	2000	
Residential	2,700 (18.4%)	5,100 (23.6%)	3,100 (14.0%)	5,100 (22.6%)	5,800 (15.8%)	10,000 (26.5%)	+4,200
Commercial	210 (1.4%)	600 (3.9%)	160 (0.7%)	420 (1.9%)	370 (1.0%)	1,020 (2.7%)	+ 650
Industrial	360 (2.5%)	320 (2.1%)	1,020 (4.6%)	1,930 (8.6%)	1,380 (3.7%)	2,250 (6.0%)	+ 870
Institutional	730 (5.0%)	1,140 (7.5%)	- (-)	700 (3.1%)	730 (2.0%)	1,840 (4.9%)	+1,110
Open Space	390 (2.6%)	740 (4.9%)	1,620 (7.3%)	1,280 (5.7%)	2,010 (5.5%)	2,020 (5.4%)	+ 10
Others	10,300 (70.1%)	7,300 (48.0%)	16,200 (73.4%)	13,100 (58.1%)	26,500 (72.0%)	20,400 (54.7%)	-6,100
Total	14,690 (100.0%)	15,200 (100.0%)	22,100 (100.0%)	22,530 (100.0%)	36,790 (100.0%)	37,730 (100.0)	+ 940*

* Supplied from reclamation of land.

Source: Phase I Study Report

3.2.5 Number of Vehicles

The number of vehicles in the Study Area is as projected in the Phase I Study and shown in Table 3.4 being based on the hypothesis that the increase in per capita income will enable people to be able to purchase a car rather than a motor-cycle.

In addition, the Phase II Study prepares a case where the number of motor-cycles will grow at the same rate as in the past in spite of the increase in per capita income.

In table 3.4, the former case is called case 'A' and the later case 'B'.

Table 3.4 NUMBER OF VEHICLES (In thousand vehicles)

		Vehicles			Average Annual Growth Rate	
		1979	1985	2000	1979 - 1985	1979 - 2000
Case A	Motor Car					
	Study Area	50.7	67.5	102.5	4.9	3.4
	Penang State	78.3	109.9	193.8	5.8	4.4
	Motor-Cycle					
	Study Area	67.8	72.6	87.4	1.1	1.2
	Penang State	125.0	140.3	199.0	1.9	2.2
Case B	Motor Car					
	Study Area	50.7	63.7	86.9	3.9	2.6
	Penang State	78.3	102.6	153.0	4.6	3.2
	Motor-Cycle					
	Study Area	67.8	85.9	152.4	4.0	3.9
	Penang State	125.0	158.2	280.8	4.0	3.9

3.2.6 Zoning

The Study Area in Phase II covers only the internal area of Penang Island as defined in the Phase I Study.

The traffic zones in Penang Island designed in the Phase I Study are subdivided into smaller zones in order to get more detailed traffic volume projections on the proposed road within the limitations of available data.

Through subdivision, Penang Island is divided into 78 zones as shown in Fig. 3.3.

3.2.7 Transport Plans for 1985 and 2000

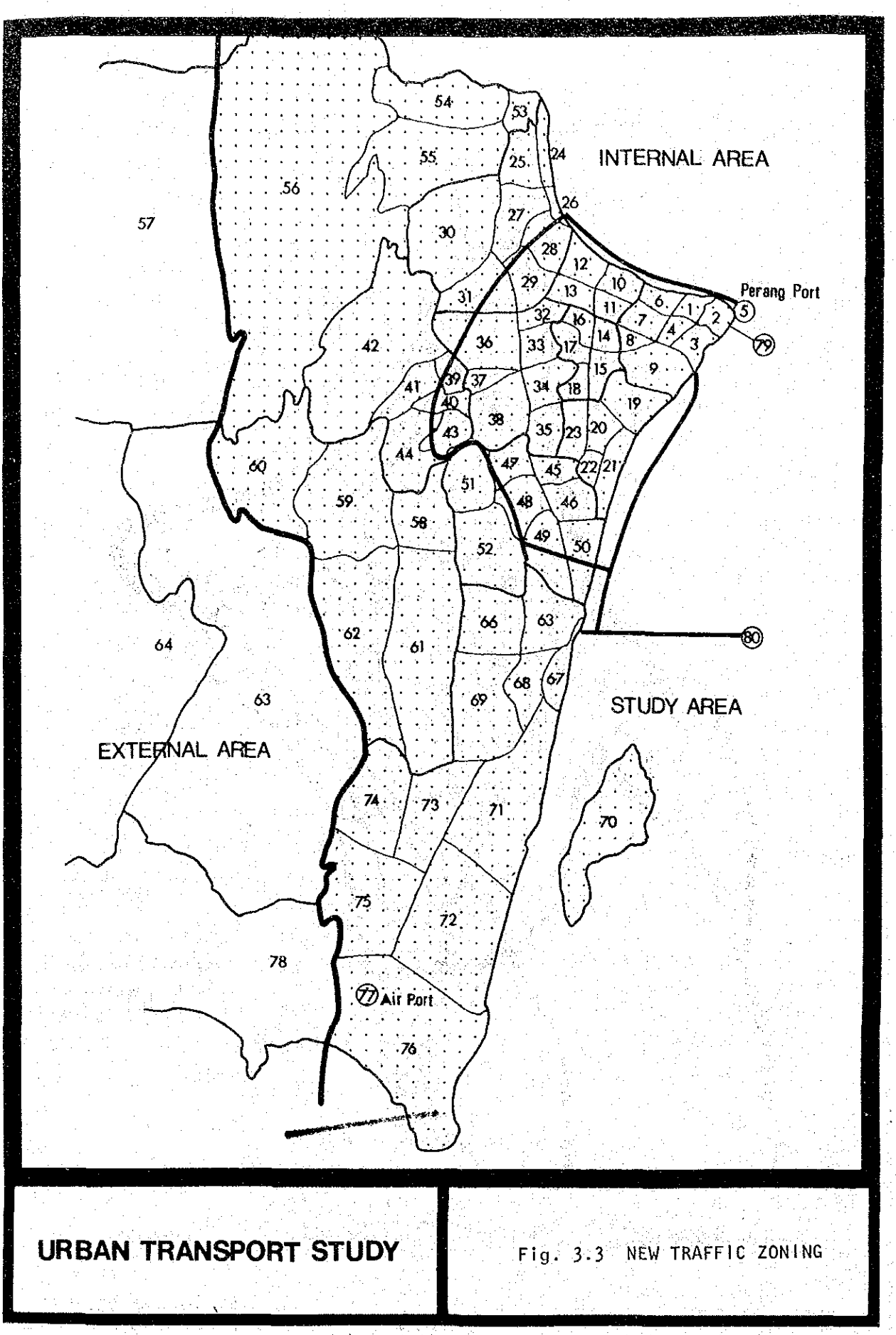
The transport plans of this Study for 1985 and the year 2000 are as recommended in the Phase I Study.

Table 3.5 TRANSPORT PLANS

	1985	2000
Traffic Control Measures	. Parking Control at C.B.D. . Introduction of Exclusive Bus Lane	- Do -
Ferry	. In Operation	In Operation
Penang Bridge	. Open for traffic	Open for traffic
The Traffic Dispersal Road	. North Coastal Road Opened	. South Coastal Road also opened

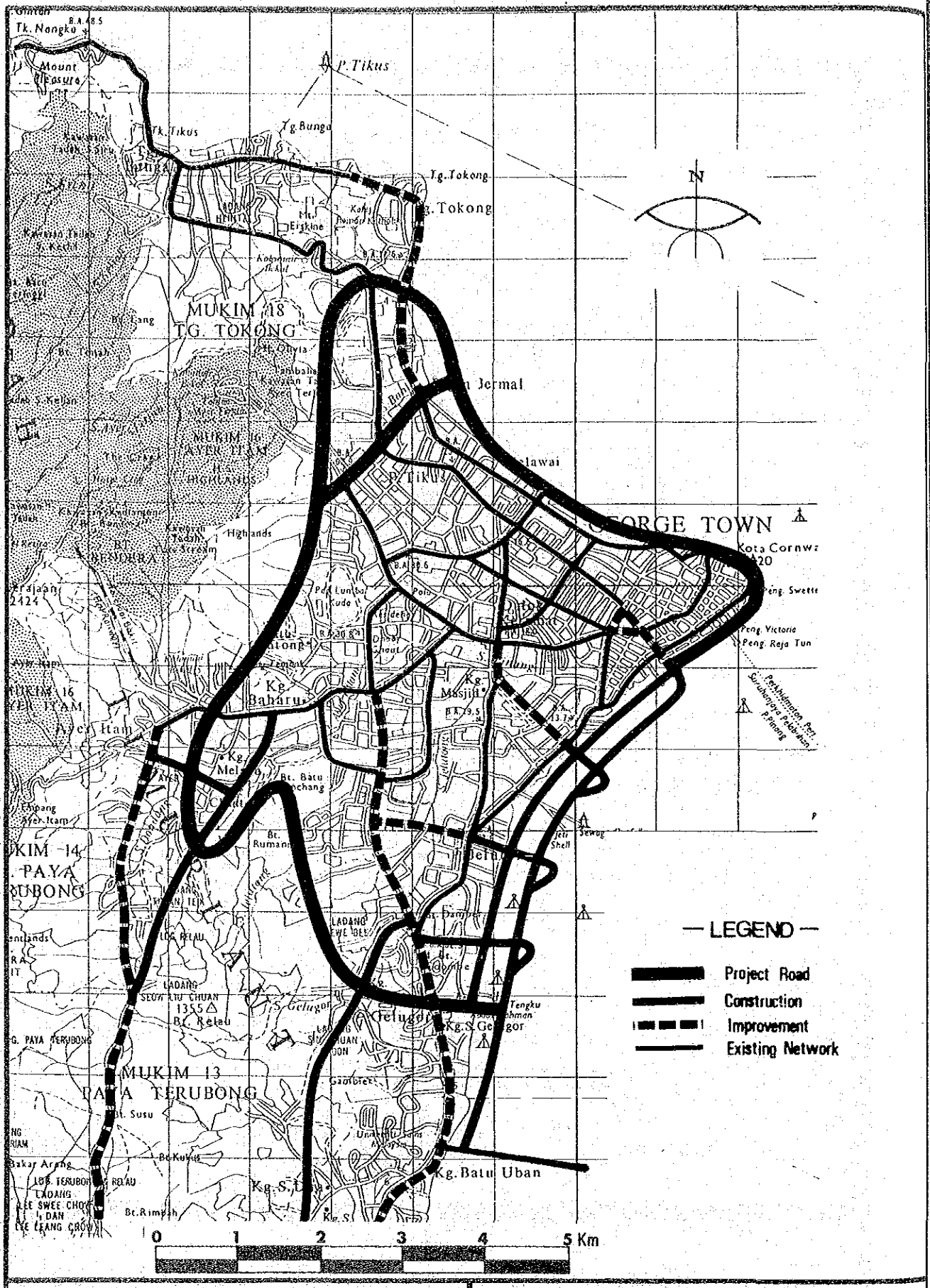
Regarding the road network plan, some parts of it from the Phase I Study are revised according to the route location study of the Project Road whilst in regard to the Weld Quay Extension, it is also included in the road network plan.

Figures 3.4 and 3.5 show the construction and the improvement of the highways.



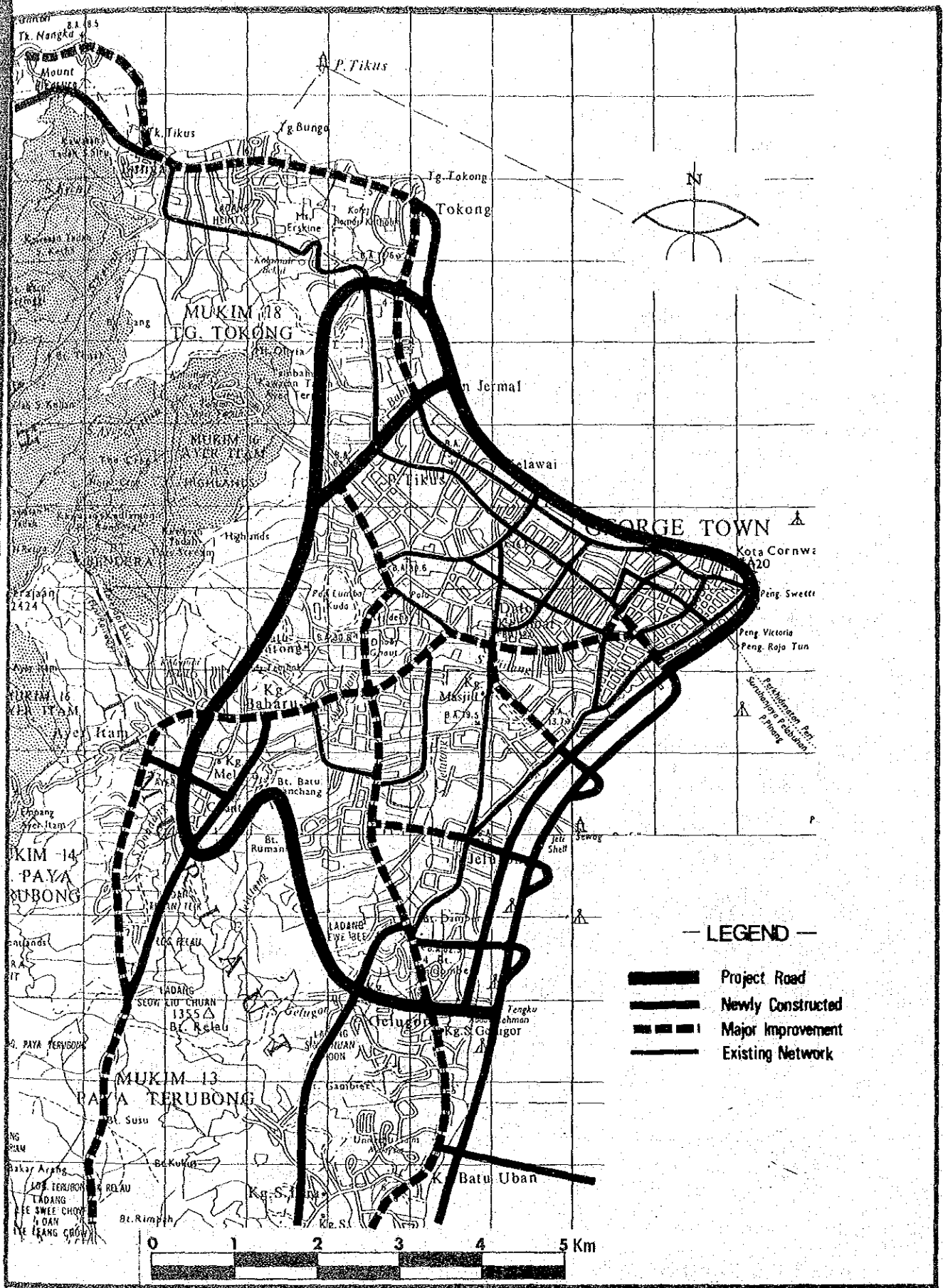
URBAN TRANSPORT STUDY

Fig. 3.3 NEW TRAFFIC ZONING



URBAN TRANSPORT STUDY

Fig. 3.4 HIGHWAY PROPOSAL IN 1985



URBAN TRANSPORT STUDY

Fig. 3.5 HIGHWAY PROPOSAL IN 2000

3.3 Trip Generation and Attraction

The trip generation and attraction for the years 1985 and the year 2000 is projected according to the two cases (case 'A' and 'B'). Case 'A' projects the trip generation in the Study Area for the year 2000 as 691 thousand p.c.u. of motorcar and 125 thousand p.c.u. of motor-cycle trips.

Case 'B' which assumes the constancy of the present number of trips per motor-cycle, shows 585 thousand p.c.u. of motorcar and 264 thousand p.c.u. of motor-cycle trips in the year 2000, as shown in Table 3.7.

Case 'A' is mainly used in this study but, in the sensitivity analysis of economic evaluation, case 'B' is also applied.

The passenger car unit adopted in this Study is shown in the following table.

Table 3.6 PASSENGER CAR UNIT

	CAR	LORRY	BUS	TAXI	MOTOR-CYCLE
P.C.U.	1.0	2.0	3.0	1.0	0.5

Based on "Roads in Urban Areas".
Scotish Development.

Table 3.7 VOLUME OF TRIP GENERATION

CASE A

(Unit: 1000 p.c.u.)

		1979	1985	2000
Motor Car	Internal Area	277.1	343.4	691.3
	External Area	4.7	7.4	27.1
	Penang Island	281.8	360.8	718.4
		(100)	(128)	(255)
Motor-Cycle	Internal Area	135.9	139.7	125.0
	External Area	1.2	1.3	1.4
	Penang Island	137.1	141.0	126.4
		(100)	(103)	(92)
Total	Internal Area	413.0	493.1	816.3
	External Area	5.9	8.7	28.5
	Penang Island	418.9	501.8	844.8
		(100)	(120)	(202)

Note: ( ) Growth Rate

CASE B

(Unit: 1000 p.c.u.)

		1979	1985	2000
Motor Car	Internal Area	277.1	333.8	585.4
	External Area	4.7	7.0	22.9
	Penang Island	281.8	340.8	608.3
		(100)	(121)	(216)
Motor-Cycle	Internal Area	135.9	164.9	263.7
	External Area	1.2	1.5	2.7
	Penang Island	139.1	166.4	266.1
		(100)	(121)	(194)
Total	Internal Area	413.0	498.7	849.1
	External Area	5.9	8.5	25.3
	Penang Island	418.9	507.2	874.4
		(100)	(121)	(209)

Note: ( ) Growth Rate

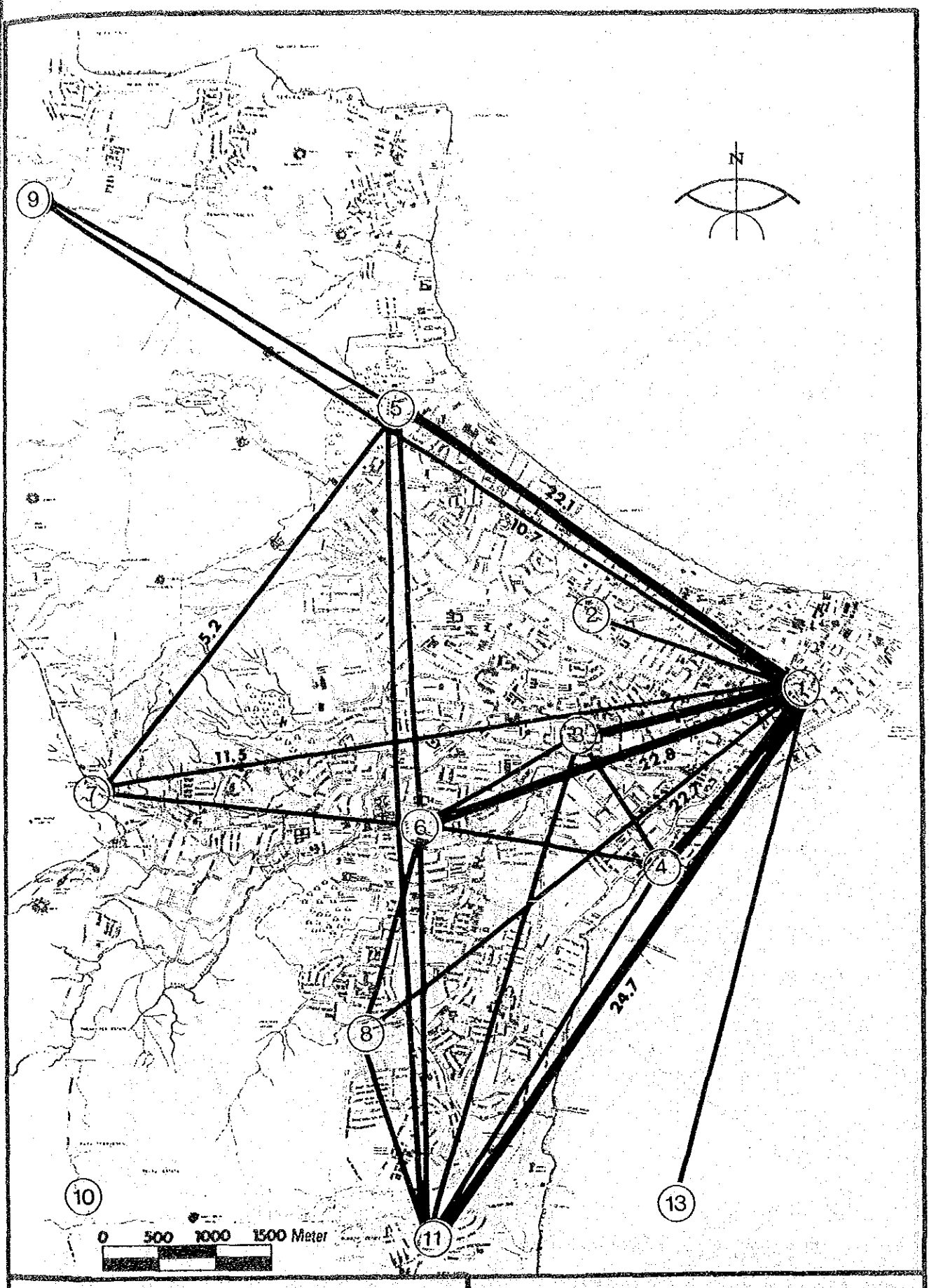
3.4 O-D Matrix of Traffic Volume

The future O-D matrix is obtained by using the trip generation, trip attraction and the time-distance between each zone pair in the form of the gravity model which was developed in the Phase I Study.

Figs 3.6 and 3.7 show the desired line of traffic demand for 1985 and the year 2000. From these figures, the following can be observed:

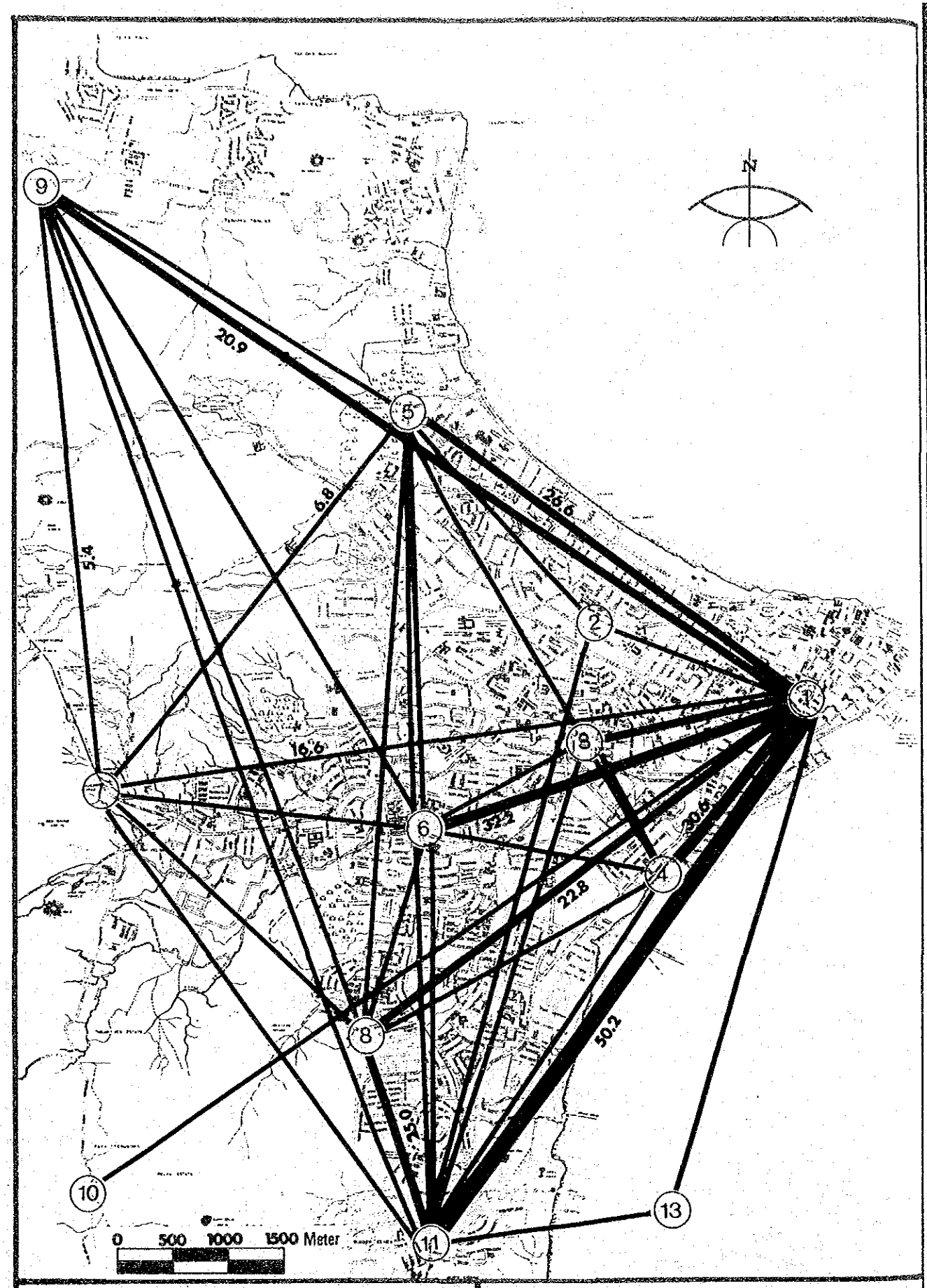
a. In 1985, the traffic volume to/from the Central Business District (CBD) is greater while the traffic volume of the other O-D pair is comparatively small.

b. In the year 2000, the traffic volume to/from the CBD is further increased especially, that from the CBD to Bayan Lepas being larger than that of other O-D pairs.



URBAN TRANSPORT STUDY

Fig. 3.6
DESIRED LINES IN 1985



URBAN TRANSPORT STUDY

Fig. 3.7
DESIRED LINES IN 2000

3.5 Premise of Assignment for Road Network

3.5.1 Road Network

The road networks for 1985 and the year 2000, as shown in Figs 3.4 and 3.5 are assumed for the assignment of traffic demand.

Regarding the route of the Project Road, two alternatives are , prepared through the engineering study described in Chapter 4 being as follows:

Plan 1 Seg. 1, 2, 3, 4, 6, 7, 8, 9, 10.
Plan 2 Seg. 1, 2, 3, 4, 5, 6, (7), 9, 10.
(See Fig. 3.8)

Depending on the future traffic demand, the Project Road can either be of two-lane of four-lane type.

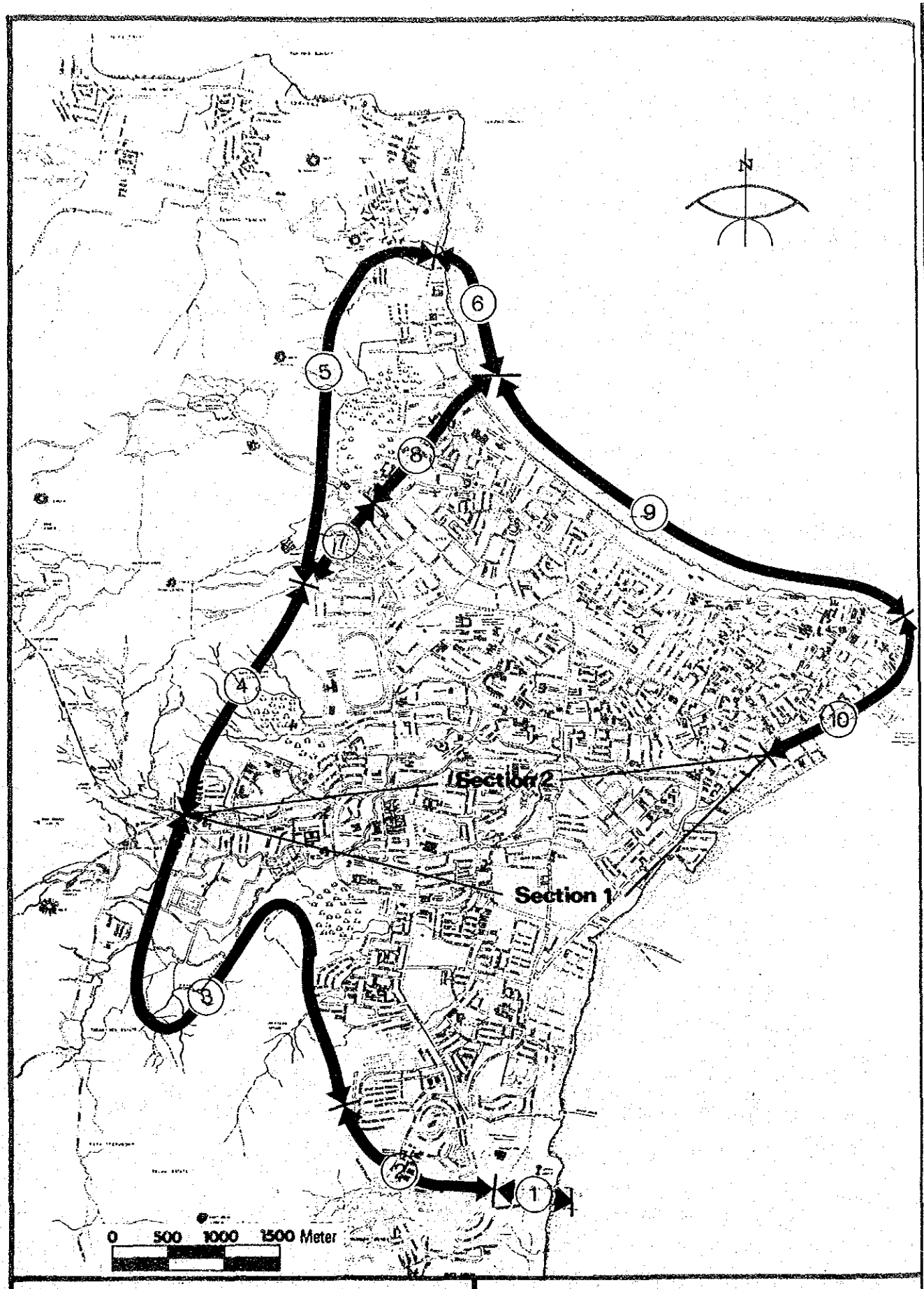
3.5.2 Capacity of Road

To establish the network model, the highway links including the planned highway are classified as follows:

Table 3.8 CLASSIFICATION OF ROAD TYPE

	No. of lane	2-lane			4-lane	
	Effective width of carriageway in feeet	20'	22'	24'	44'	48'
A	Urban Motorway	-	-	-	-	4-A
B	All purpose road with no standing vehicles permitted and negligible cross traffic	$2\text{-}B_2$	$2\text{-}B_1$	$2\text{-}B_0$	$4\text{-}B_1$	$4\text{-}B_0$
C	All purpose street with no restrictions at junctions	$2\text{-}C_2$	$2\text{-}C_1$	$2\text{-}C_0$	$4\text{-}C_1$	$4\text{-}C_0$
D	All purpose street restricated by junctions	$2\text{-}D_2$	$2\text{-}D_1$	$2\text{-}D_0$	$4\text{-}D_1$	$4\text{-}D_0$

The travel speed on each link is then determined by the Q-V formula which expresses the relationship between the traffic volume and the travel speed as shown in Fig. 3.9 and Table 3.9.



URBAN TRANSPORT STUDY

Fig. 3.8
THE PROJECT ROAD BY SECTION AND SEGMENT

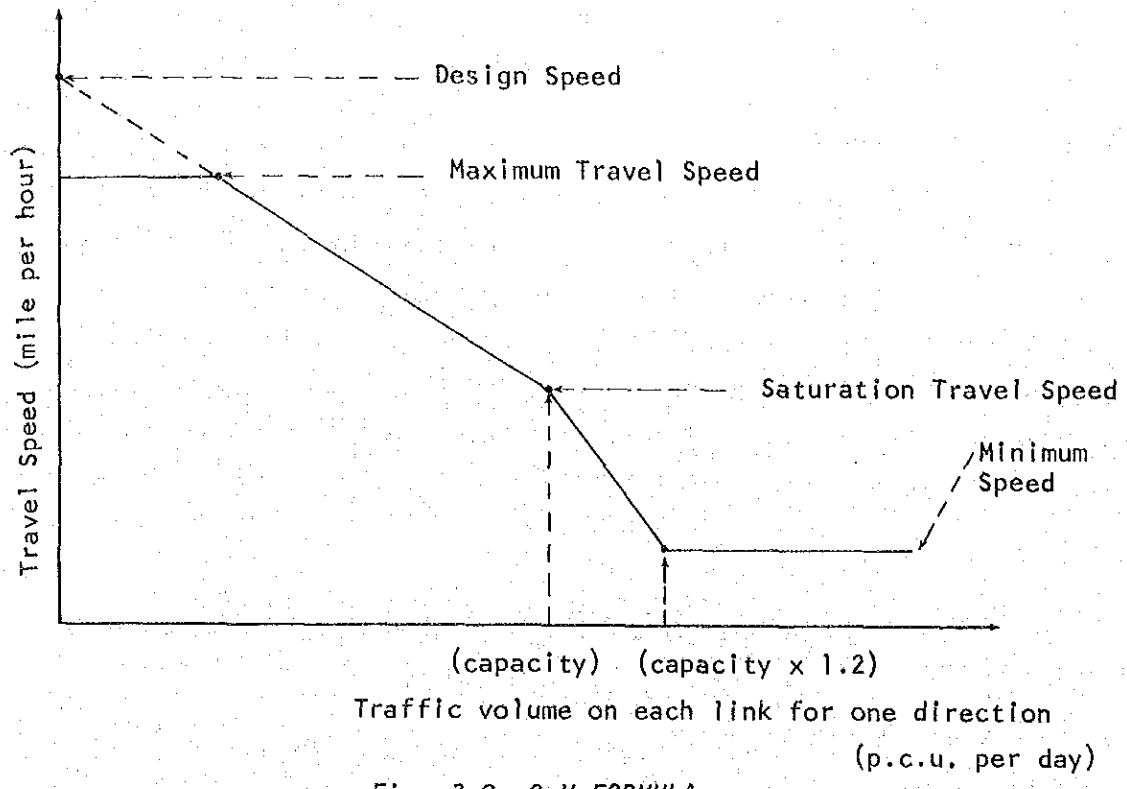


Fig. 3.9 Q-V FORMULA

Table 3.9 TRAVEL SPEED AND CAPACITY BY ROAD TYPE

No. of Lane	Type of Road	Maximum Travel Speed	Saturation Travel Speed	Minimum Travel Speed	Traffic Capacity/ day (p.c.u.)
4	$4\text{-}A_0$	50	15	7	50,000
	$4\text{-}B_0$	50	15	7	40,000
	$4\text{-}B_1$	50	15	7	36,700
	$4\text{-}C_0$	40	15	7	33,300
	$4\text{-}C_1$	40	12	7	28,300
	$4\text{-}D_0$	40	12	7	25,000
	$4\text{-}D_1$	40	12	7	22,500
2	$2\text{-}B_0$	40	15	5	20,000
	$2\text{-}B_1$	40	15	5	18,300
	$2\text{-}B_2$	35	12	5	16,700
	$2\text{-}C_0$	40	15	5	16,700
	$2\text{-}C_1$	35	12	5	13,300
	$2\text{-}C_2$	30	12	5	10,000
	$2\text{-}D_0$	35	12	5	11,700
	$2\text{-}D_1$	30	12	5	8,300
	$2\text{-}D_2$	30	10	5	5,000

3.6 Traffic Assignment

3.6.1 Result of Assignment

With regard to Plan 2 having a four (4)-lane road for the Project Road, it is estimated that the daily vehicle kilometer in 1985 and the year 2000 will be 352 thousand p.c.u. kms and 856 thousand p.c.u. kms, respectively. On a per-kilometer basis, the daily traffic volume in 1985 and the year 2000 are found to be 14,900 and 36,200 respectively while during this period, it is also estimated that the average annual traffic growth rate will be about 6.1 percent per annum. (See Table 3.10)

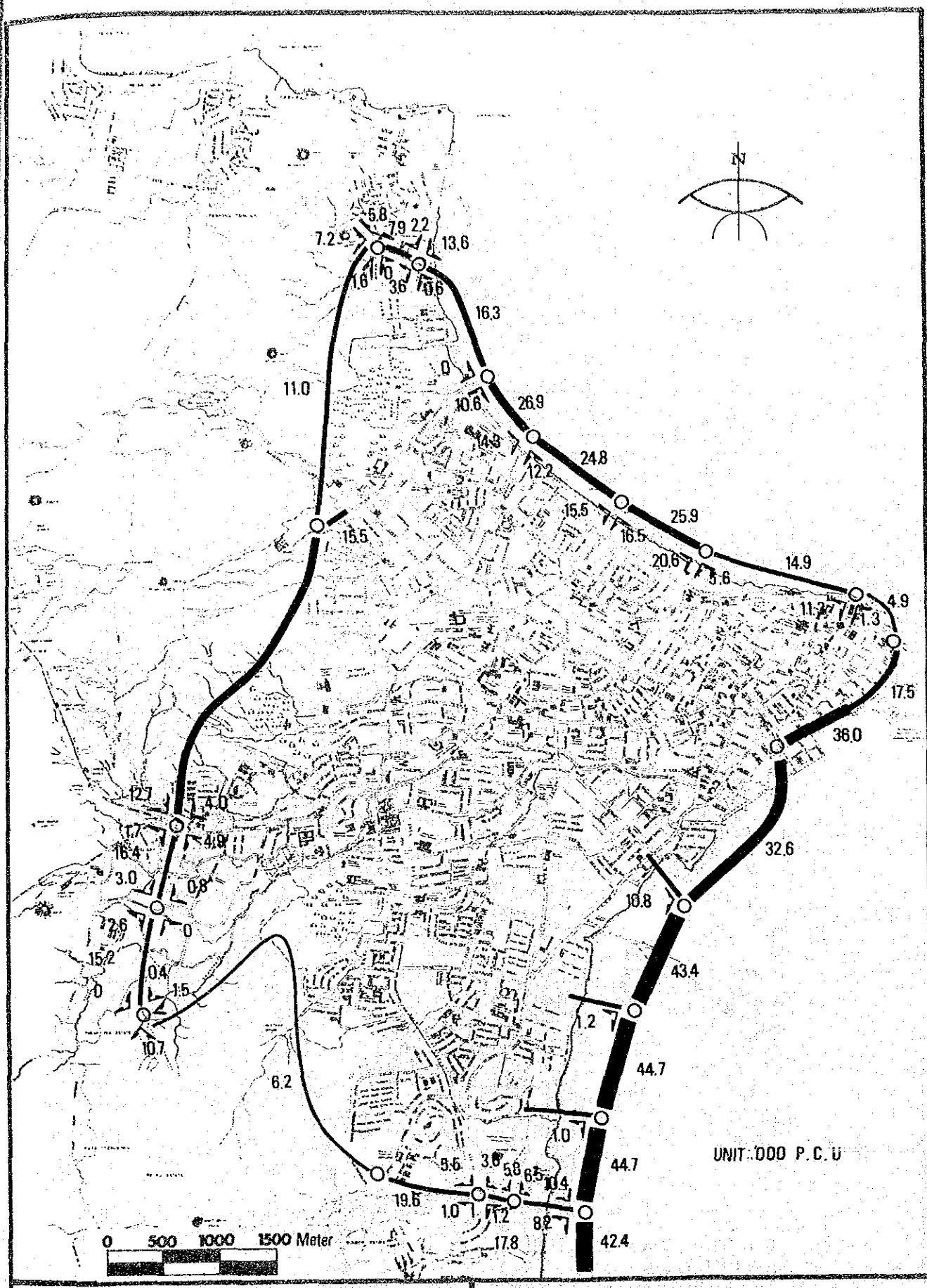
Table 3.10 DAILY TRAFFIC VOLUME ON THE PROJECT ROAD

Route	No. of Lanes	Year	Traffic Volume ('000 p.c.u.)	Vehicles Kilometer ('000 p.c.u.)
Plan 1	4	1985 2000	149.1 339.5	340.3 830.6
Plan 2	2	1985	122.6	268.3
	4	1985 2000	152.0 331.2	352.7 856.3

Figs 3.10 and 3.11 illustrate the flow of the daily traffic volume by road segments from which, the following can be observed.

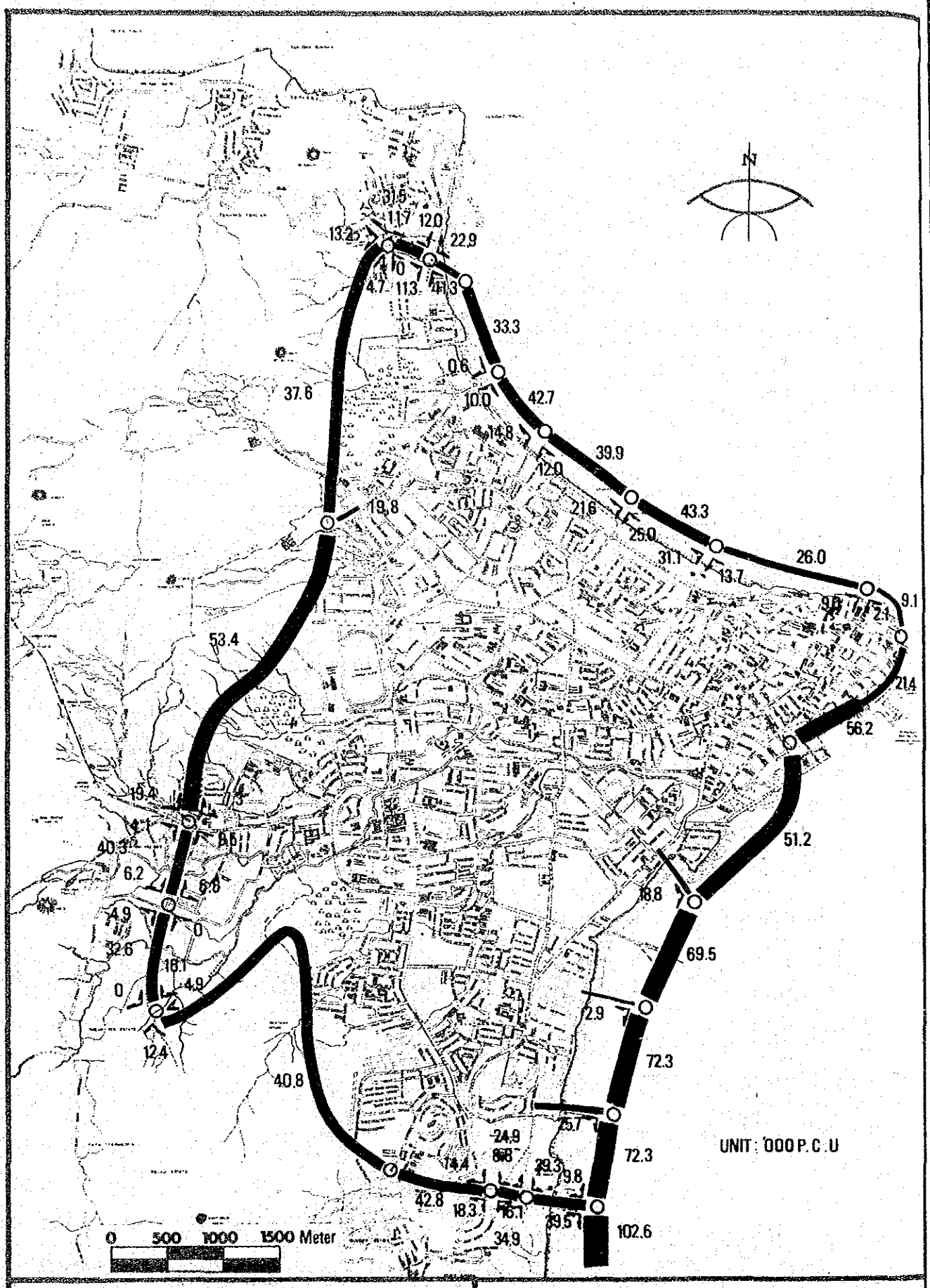
a. The forecasted traffic volume on the Project Road is comparatively large especially, that on segments 4 and 9 being much larger than that on the other segments.

b. The projected traffic volume of the southern section (section 1) is comparatively small.



URBAN TRANSPORT STUDY

Fig. 3.10
PROJECTED TRAFFIC VOLUME ON THE PROJECT ROAD
(PLAN 2-F, 1985) (4-LANE)



URBAN TRANSPORT STUDY

Fig. 3.11

PROJECTED TTRAFFIC VOLUME ON THE PROJECT ROAD (PLAN 2-F, 2000) (4-LANE)

3.6.2 Effects of the Project Road

Compared with the base case where the Project Road is not constructed, Plan 1 and Plan 2 are verified in being effective in decreasing the traffic congestion occuring in the Study Area.

Table 3.11 COMPARISON OF TRAFFIC CHARACTERISTICS BY PLAN FOR ENTIRE STUDY AREA

	Base		Plan 1		Plan 2	
	1985	2000	1985	2000	1985	2000
Vehicle Kilometers ('000 p.c.u. kms)	2,682.4	5,890.9	2,675.6	5,953.5	2,672.4	5,964.4
Vehicle Hours ('000 p.c.u. hrs)	66.3	199.9	59.0	175.5	58.4	172.9
Average Travel Speed (km/h)	40.5	29.5	45.4	33.9	45.7	34.5

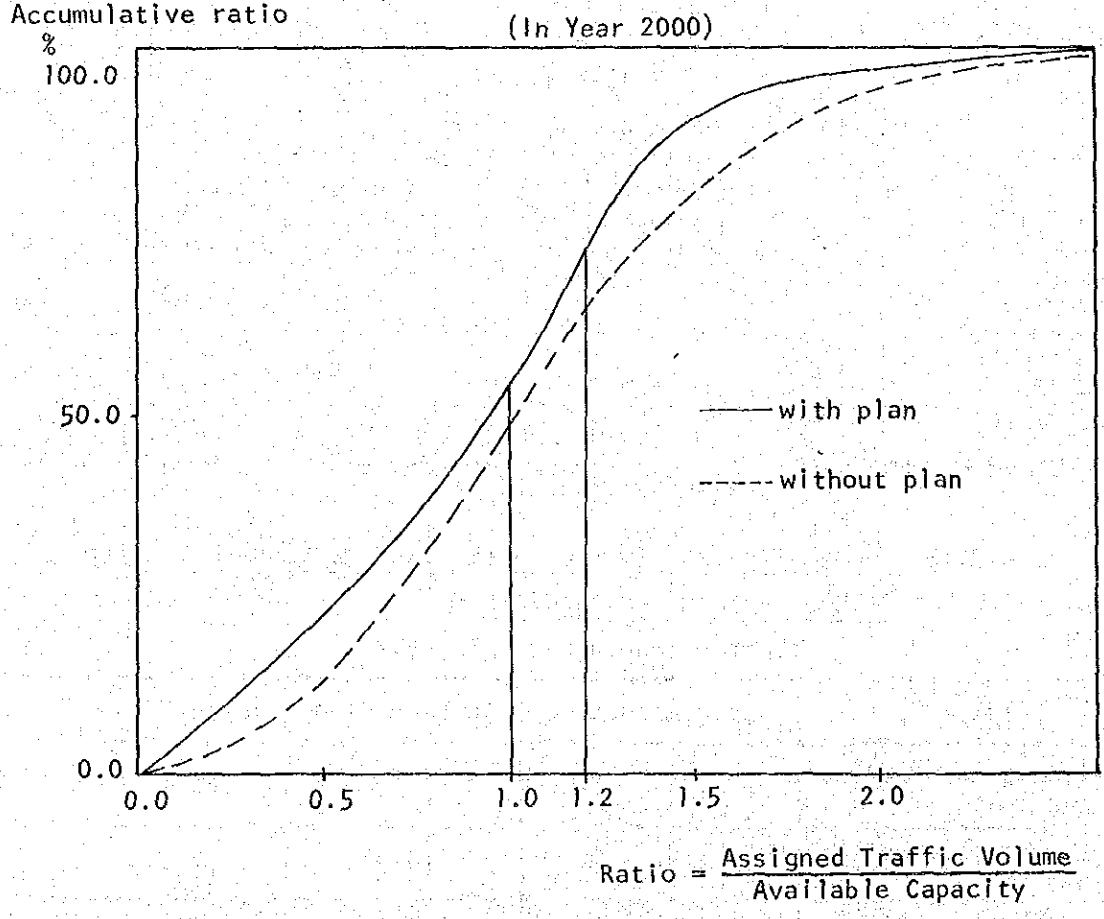


Fig. 3.12 DISTRIBUTION OF CONGESTION RATE ON ALL LINKS

In order to clarify the effects of the Project Road in greater detail, two lines, as shown in the following figure are prepared whereby the traffic volume with and without the Project Road is compared. (See Table 3.12 and 3.13)

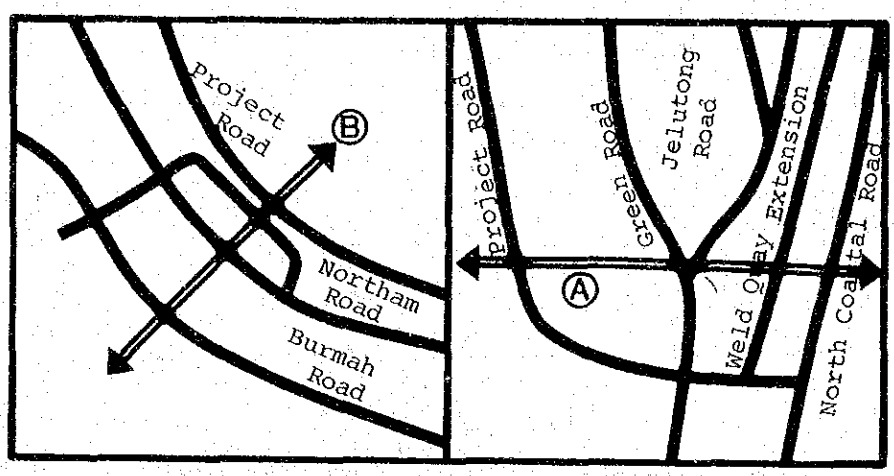


Table 3.12 COMPARATIVE ANALYSIS OF DAILY TRAFFIC VOLUME WITH AND WITHOUT PROJECT ROAD ON A-LINE

(In thousand p.c.u. per day)

1985	Outer Ring Road	Green Lane	Jelutong Road	Weld Quay Extension	North Coastal Road
Without the Project Road (A)	-	30.9	20.1	13.7	42.0
With the Project Road (B)	6.2	27.2	15.2	10.5	44.7
B/A	-	0.87	0.79	0.75	1.06

Table 3.13 COMPARATIVE ANALYSIS OF DAILY TRAFFIC VOLUME WITH AND WITHOUT PROJECT ROAD ON B-LINE

(In thousand p.c.u. per day)

1985	Outer Ring Road	Northam Road	Jalan Burma
Without the Project Road (A)	-	31.2	24.1
With the Project Road (B)	25.1	16.2	13.7
B/A	-	0.52	0.57

From these tables, the following are observed;

a. Regarding traffic volume on A-line, there is no significant reduction nor increase on the existing and planned roads affected by the construction of the Project Road.

b. In the case of the Project not being implemented, the traffic volume on Northam Road and Jalan Burma will exceed capacity even in 1985. When the Project is implemented, a significant reduction of the traffic volume on both the roads can be expected, resulting in a smooth traffic flow on the roads in the northern part of Penang Island.

4. ROUTE STUDY AND PRELIMINARY ENGINEERING

4.1 The Natural Conditions

4.1.1 Geography

The urbun area of George Town is situated at the north-eastern tip of the island, in a triangular configuration surrounded by the sea on two of its sides and by hilly hinterland on the other on the largest plain of this hilly island. The seaport is located close to the old part of town with expansion of new urban areas towards the inland hills to the west taking place, while in the urban fringe can be found small scattered knolls occupied by very old cemetries.

4.1.2 Climate

Penang Island is considered to have a mild maritime tropical climate, characterised by high temperatures and humidity. Land and sea breezes, however, temper daily temperature as compared to its counterparts on the mainland. Nevertheless, the average high temperature stands at 32.2°C and the average low temperature 23.3°C. The humidity ranges between 70% to 90% with annual rainfall measuring about 267 cm. There are no marked seasonal changes except for the short day season from February to March and the monsoon season from September to December in which there is heavy precipitation.

4.1.3 Wind

With the coast of George Town facing the northeast, winds blowing from the west and south do not affect the area and what winds that do exist are generally not violent in nature.

As tropical cylones from both hemispheres hardly approach the area, it is sufficient to consider gusts due to thunder storms as the only violent winds in the proposed site. The average wind speed being under 2.0 m/sec., indicating that weather conditions in the proposed site are generally calm in nature.

The maximum wind speeds recorded in the past 11 years from 1968 to 1978 are NW 22.4 m/sec. and SW 22.9 m/sec. In the final report, Vol. 4, on the Penang Island Traffic Dispersal Study, August 1977, a graph of the maximum wind speed for each return period has been drawn on the basis of the records of maximum wind speed from the easterly direction in the past 30 years.

According to the graph, the maximum wind speed in the 30 year return period is approximately 51 MPH (23 m/sec.).

4.1.4 Water Level at Penang

The water level at Penang is as follows:

		A.C.D	Survey dept. level
Highest high water	HHW	+ 3.05 m	+ 1.63 m
Mean high water springs	MHWS	+ 2.35 m	+ 0.93 m
Mean sea level	MSL	+ 1.42 m	Datum level
Mean low water springs	M.L.W.S	+ 0.40 m	- 1.02 m
Lowest low water	LLW	- 0.15 m	- 1.57 m

4.1.5 Tidal Current

According to the flow velocity pattern given in the Final Report Vol. 4 of the Penang Island Traffic Dispersal Study, in the center of the channel, relatively swift currents of a maximum speed of approximately 1 m/sec. occur in both the up and down streams. However, the drawings reveal that the current velocity is extremely slow in the shallow area along the North Beach Coast line.

4.2 Field Survey

4.2.1 Geotechnical Investigation

(1) Investigation Conducted

This geotechnical investigation consisted of:

a. Exploratory drilling with Standard Penetration Test and undisturbed sampling.

b. Laboratory tests on soil and material samples obtained from the site.

c. Study for coarse and fine aggregate and embankment material.

(2) Geological Outline

The proposed road alignments are laid out on the hilly topography from west to south of George Town where geologically, the area consists of a mass of granite, talus and alluvium with a swampy area in alluvium observed around the mouth of Sungei Pinang.

a. Granite

Granite bodies are extensively distributed throughout the country and commonly form topographic heights. The basic formation of Penang Island is also a single mass of granite isolated from the peninsular with it having seamingly been intruded during the Jurrassic period, radiometrically between 165 to 208 million years ago. The granite mass has been highly weathered by the tropical climate in this region, the surface portion of which changes into residual soil. The depth of weathered granite is great and a thickness in excess of 10 m is not uncommon. In the areas of massive granite, weathering produces rounded core boulders of granite which are "floating" in a thick layer of residual soil derived from heavily weathered granite. In drilling at field investigation, such core boulders pose a further difficulty in judging whether drilling has reached the bedrock or only at the core boulder.

b. Talus

Talus which is a collection of fallen disintegrated materials transported from weathered granite mass has formed slopes at the foot of steep hills and mountains.

c. Alluvium

About 20,000 years ago, the sea water-level was more than 100 m below the present level after which the level gradually started to rise while erosion worked severely and cut valleys through the area with the eroded materials simultaneously being deposited under water. About 6,000 years ago, encroachment of the sea ceased at about 5 m above the present sea level, while where the present town area now stands became a calm shallow sea where sedimentation continued. About 2,000 years ago, by regression to the present sea level the area became coastal plain through which the Sungai Pinang started to flow following its present course although with a much wider flood area, also formed was the present swampy area.

A geological outline is shown in Fig. 4.1.

(3) Results of the Survey

The outline of the soil condition is described as above with the detailed data on investigation works having been performed, the results of soil test, material test and so on are described in "Technical Report 03 - Soil Investigation".

4.2.2 Survey

(1) Site Survey

a. Sounding Survey

The sounding survey was conducted along the existing Gurney Drive for a width of 1.0 kilometers from the seashore line.

b. Levelling and Cross-section Survey

This survey was conducted along the existing Pengkalan Weld, Jalan Northam, Gurney Drive, Jalan Kelawei, Jalan Bagan Jermal and Jalan Gottlieb of which the total length of the area surveyed being about 12 kilometers.

c. Plane Table Survey

The plane table survey, covering an area of 80,000 m^2, was conducted on the mountain site when bridge construction seems necessary.

(2) Survey Results

The results of the sounding survey shows that the depth of the sea-bed is very shallow; being only 0.0 meter to -2.0 meter deep up to a distance of 500 meters from the seashore and -3.0 meter deep from a distance of 500 meters to 1,000 meter from the seashore. However, the seabed in front of M.P.P.P is very deep; it is -5.0 meter to -15.0 meter deep from the revetment of the sea up to a distance of 500 meters.

The results of levelling and the cross-section survey show that the heights of the existing Gurney Drive and Northam Road are about +2.5 meter to 3.0 meter respectively.

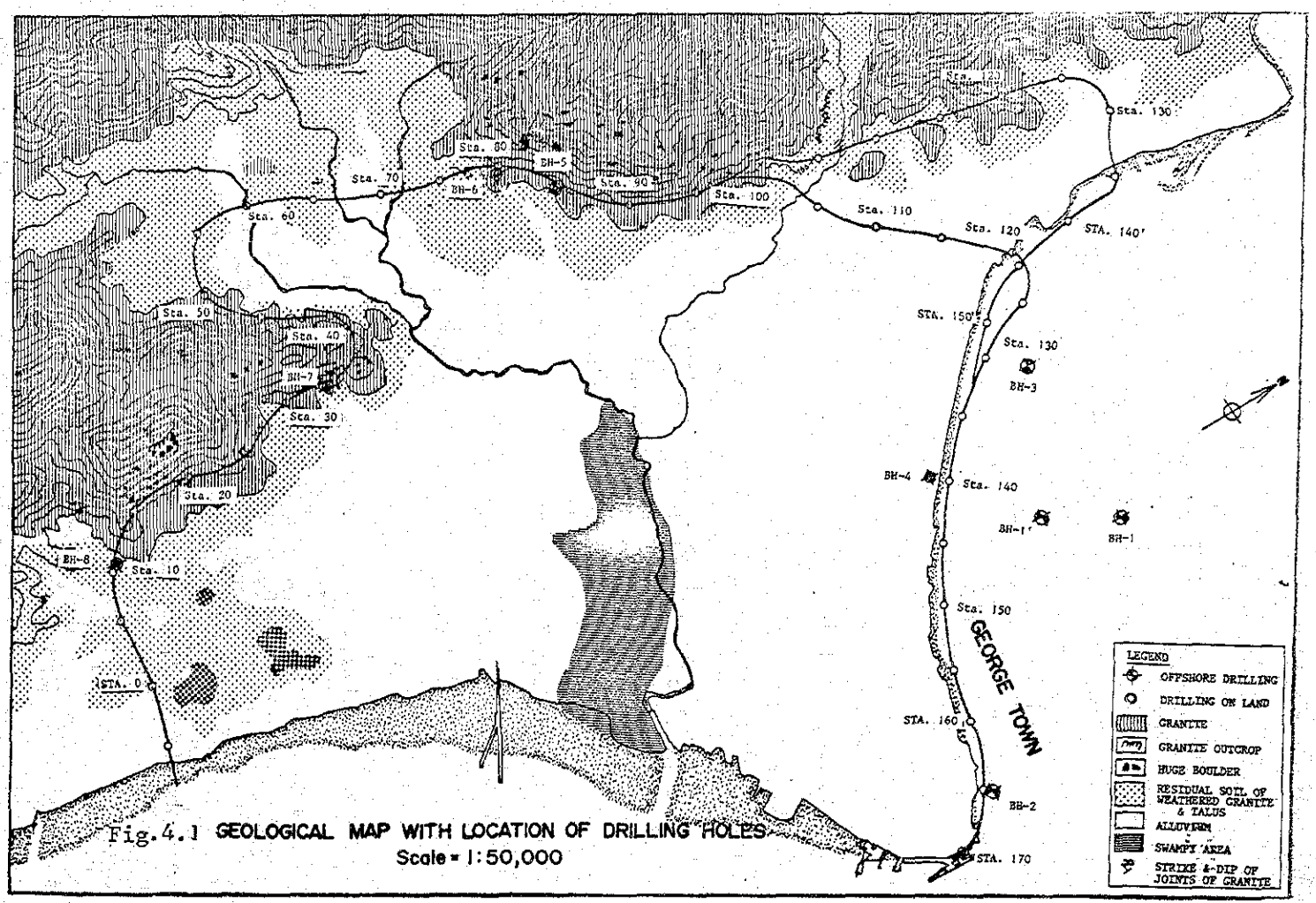


Fig.4.1 GEOLOGICAL MAP WITH LOCATION OF DRILLING HOLES
Scale = 1:50,000

The Bench Mark of this survey is taken from the Survey Department but the Admiralty Chart Datum is adopted as the Bench Mark of the Sounding Survey. The Admiralty Chart Datum 0 equals to 4.65 feet Survey Department Datum.

4.2.3 Construction Material Investigation

Construction of the road requires concrete materials, earth and also adequate dumping area for excavated soil.

(1) Fine Aggregate

Fine aggregate is available from several sand borrow pits in Penang Island being washed sand of heavily weathered granite with present approximate production capacity estimated to be 1,000 ton/day to 2,000 ton/day in Penang Island.

(2) Coarse Aggregate

Crushed aggregate of granite has been used for coarse aggregate construction work in Penang Island while presently there are about 8 quarry sites with a production capacity estimated to be 4,000 ton/day to 5,500 ton/day.

(3) Embankment Material

Earth materials are available in abundance from the foot-thrills being soils of residual sandy and clayey materials or talus deposits derived from heavily weathered granite, and are composed mainly of clayey sand with gravel or silty sand with gravel.

(4) Reclamation Material from the seabed

In order that reclamation work can be performed using dredging ship along Gurney Drive, the study of the material from the sea to be used for filling is required.

At BH-1 to BH-4, along Gurney Drive, a sandy layer about 600 m from the seashore is encountered and this layer deepens gradually with distance from the shore with the layer being found at the depth of 14.7 m from the seabed at BH-1' underneath a a soft to medium clayey layer.

According to the soil test results, sandy soil from the sea to be used as filling material will be obtained from around BH-3.

(5) Dumping Area of Waste Soil

During earth works of the road construction, a dumping area for waste soil will be required with the most likely areas being at this stage as follows:

a. Offshore Area of Tanjong Tokong.

b. Offshore Area of Jelutong.