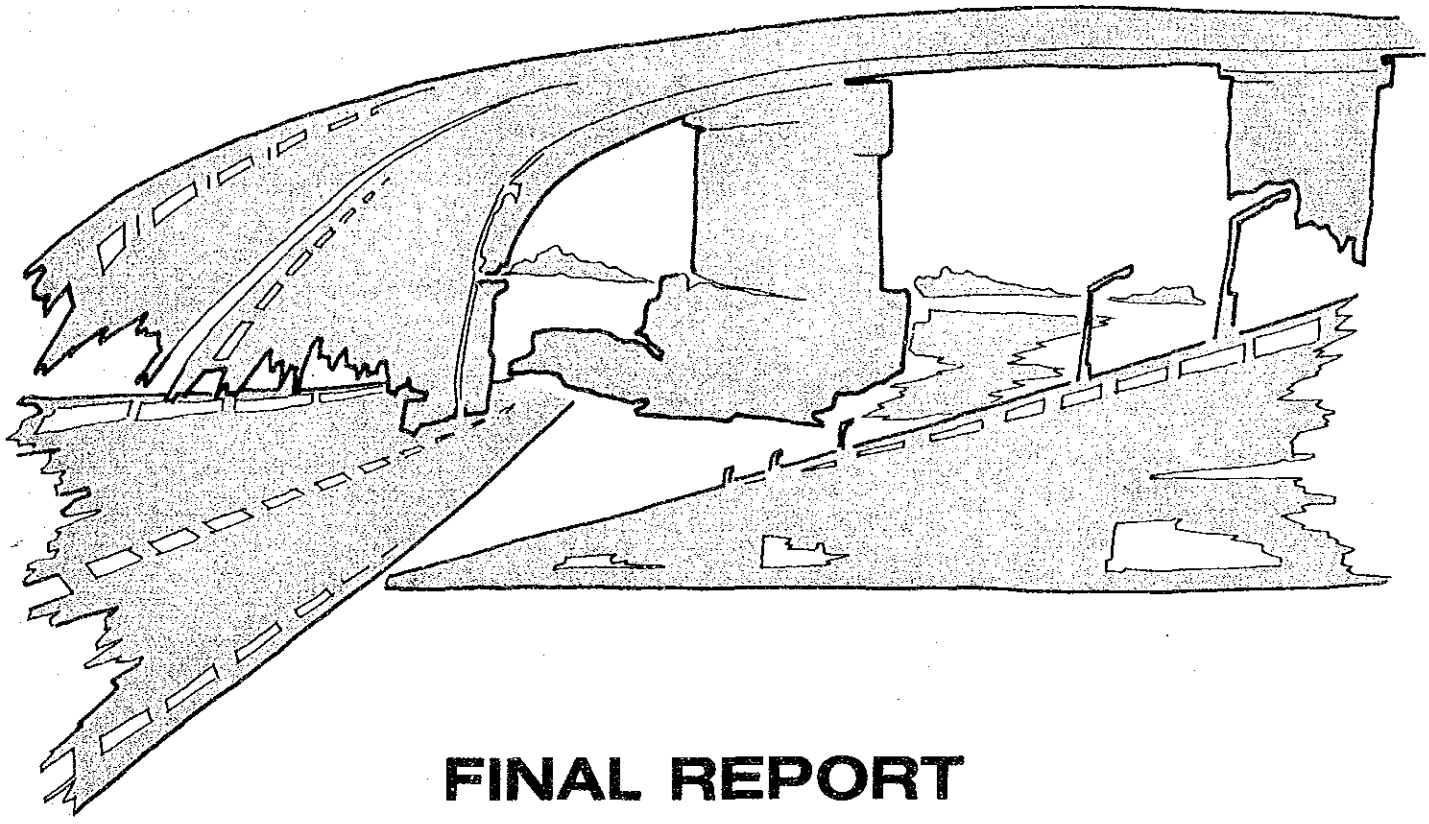
社会開発調査部報告書

No. 52

GOVERNMENT OF MALAYSIA
MALAYSIAN HIGHWAY AUTHORITY

LEMBAGA LEBUHRAYA MALAYSIA

STUDY ON TRAFFIC CONTROL AND MANAGEMENT SYSTEM OF MALAYSIAN EXPRESSWAYS AND TOLL HIGHWAYS



FINAL REPORT

MAIN VOLUME

DECEMBER 1989

JICA JAPAN INTERNATIONAL COOPERATION AGENCY

STUDY ON TRAFFIC CONTROL AND MANAGEMENT SYSTEM OF MALAYSIAN EXPRESSWAYS AND TOLL HIGHWAYS FINAL REPORT MAIN VOLUME DECEMBER 1989

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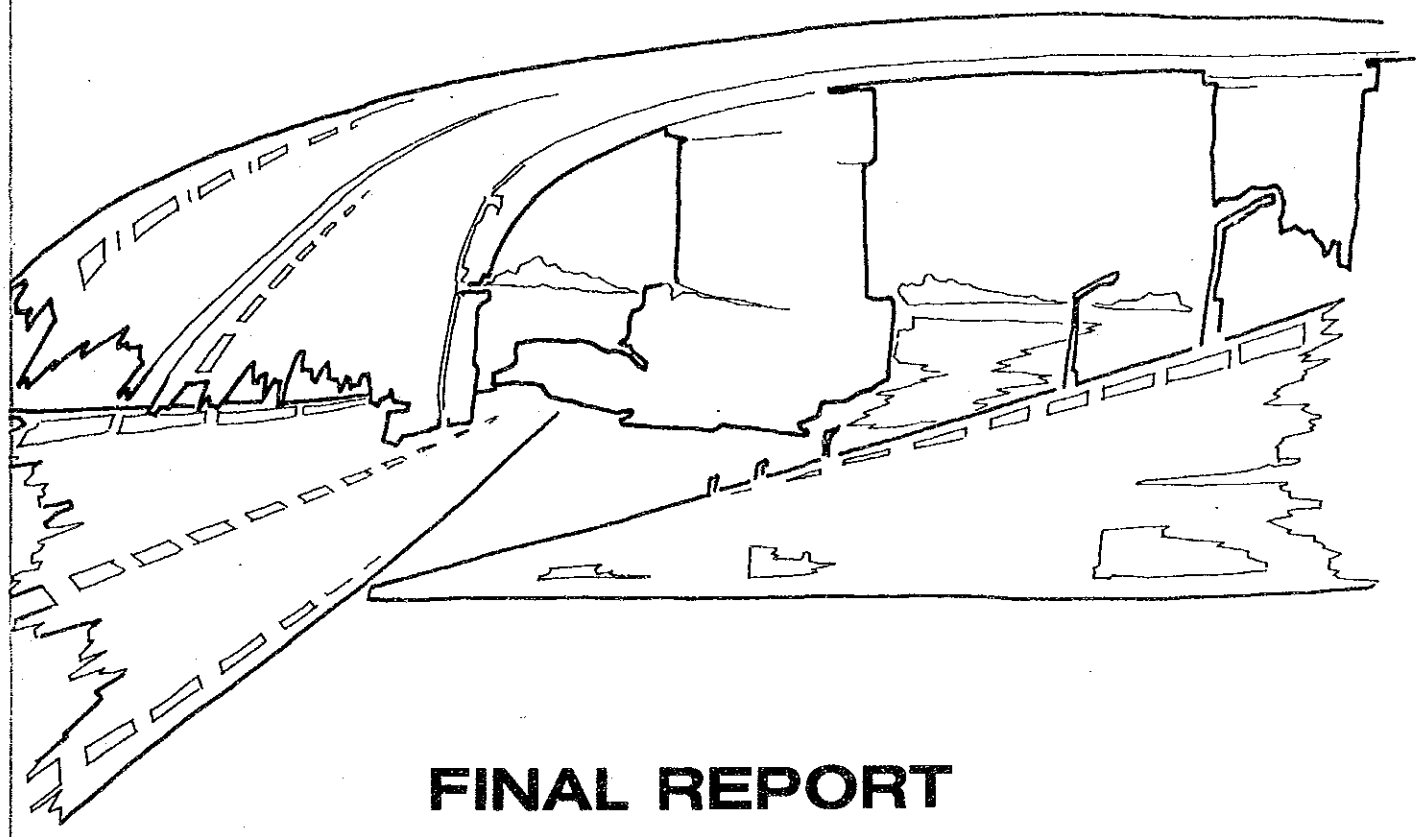

FINAL REPORT

MAIN VOLUME

DECEMBER 1989

JICA JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to a request from the Government of Malaysia, the Japanese Government decided to conduct a study on the Traffic Control and Management System of Malaysian Expressways and Toll Highways and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent to Malaysia a survey team headed by Mr. Kokuro Hanawa, Fukuyama Consultants International Co., Ltd. from December 1988 to September 1989.

The team held discussions with concerned officials of the Government of Malaysia, and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincerest appreciation to the officials concerned of the Government of Malaysia for their close cooperation extended to the team.

December, 1989

Kensuke Yanagiya

President

Japan International Cooperation Agency

STUDY ON TRAFFIC CONTROL AND MANAGEMENT SYSTEM
OF MALAYSIAN EXPRESSWAY AND TOLL HIGHWAY

FINAL REPORT

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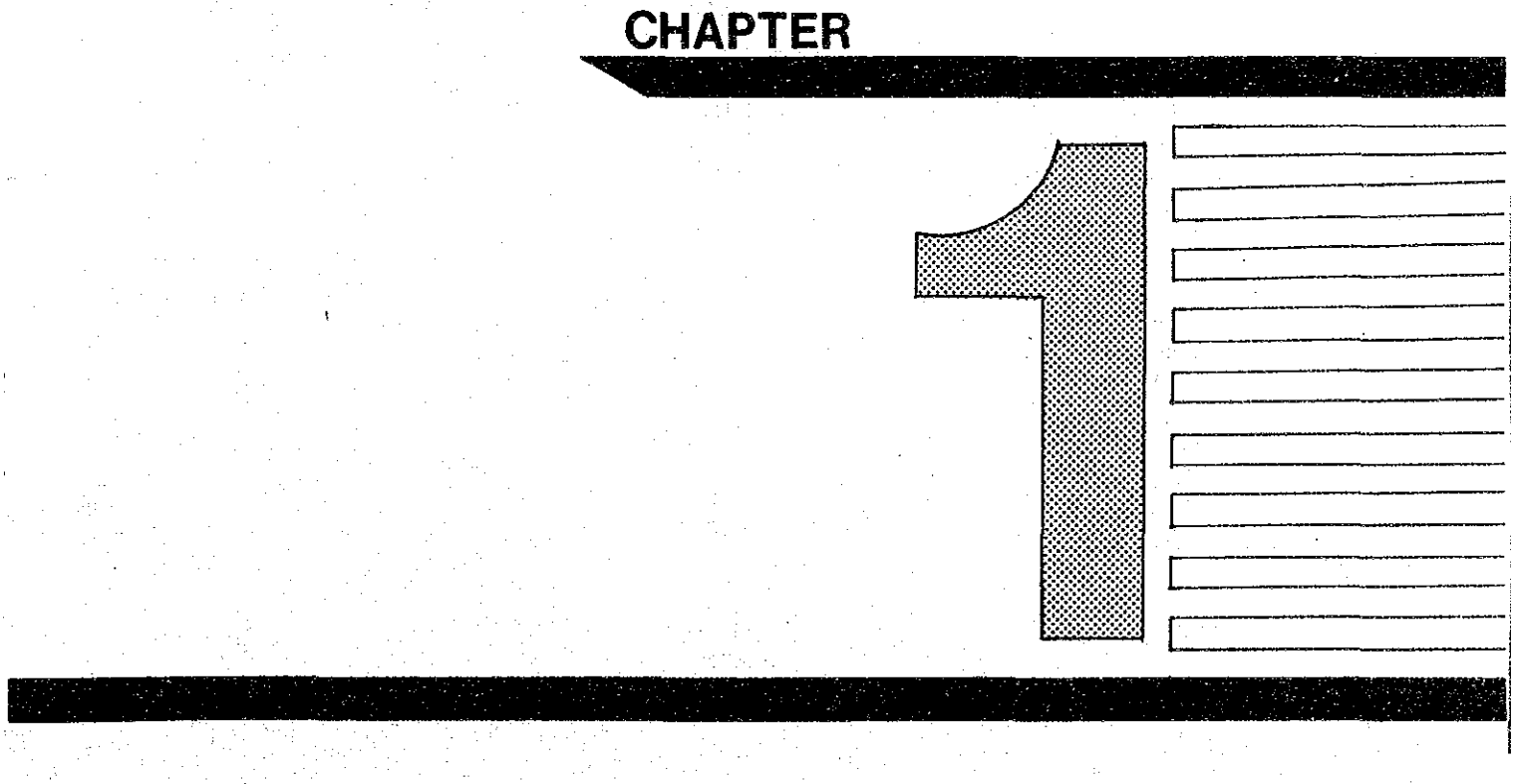

CHAPTER
1

1.0 INTRODUCTION

1.1 Background

Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of technical cooperation programmes of the Government of Japan has conducted jointly with the Government of Malaysia the "Study on Traffic Control and Management System of Malaysian Expressways and Toll Highways" (hereinafter called "the Study").

Malaysian Highway Authority is the main counterpart agency to undertake the Study in cooperation with other relevant Malaysian authorities.

In response to the request of the Government of Malaysia, the Government of Japan dispatched a team of experts to Malaysia to conduct the Study. The Study officially commenced on December 1988, after the contents of the Interim Report was accepted by the Government of Malaysia at the First Steering Committee Meeting.

1.2 Objectives of the Study

The objectives of the Study are:

(a) to formulate a traffic control and management plan (including short term and long term plans) of expressways and toll highways as specified within the Study area (see Figure 1.2.1);

(b) to prepare an Operation Manual on the proposed traffic control and management system of expressways and toll highways in Malaysia.

1.3 Study Area

The study area covers the expressways and toll highways under the jurisdiction of the Malaysian Highway Authority (MHA) as shown in Figure 1.2.1 and their corridors. Table 1.3.1 shows the list of sections of expressways and highways to be examined in this Study.

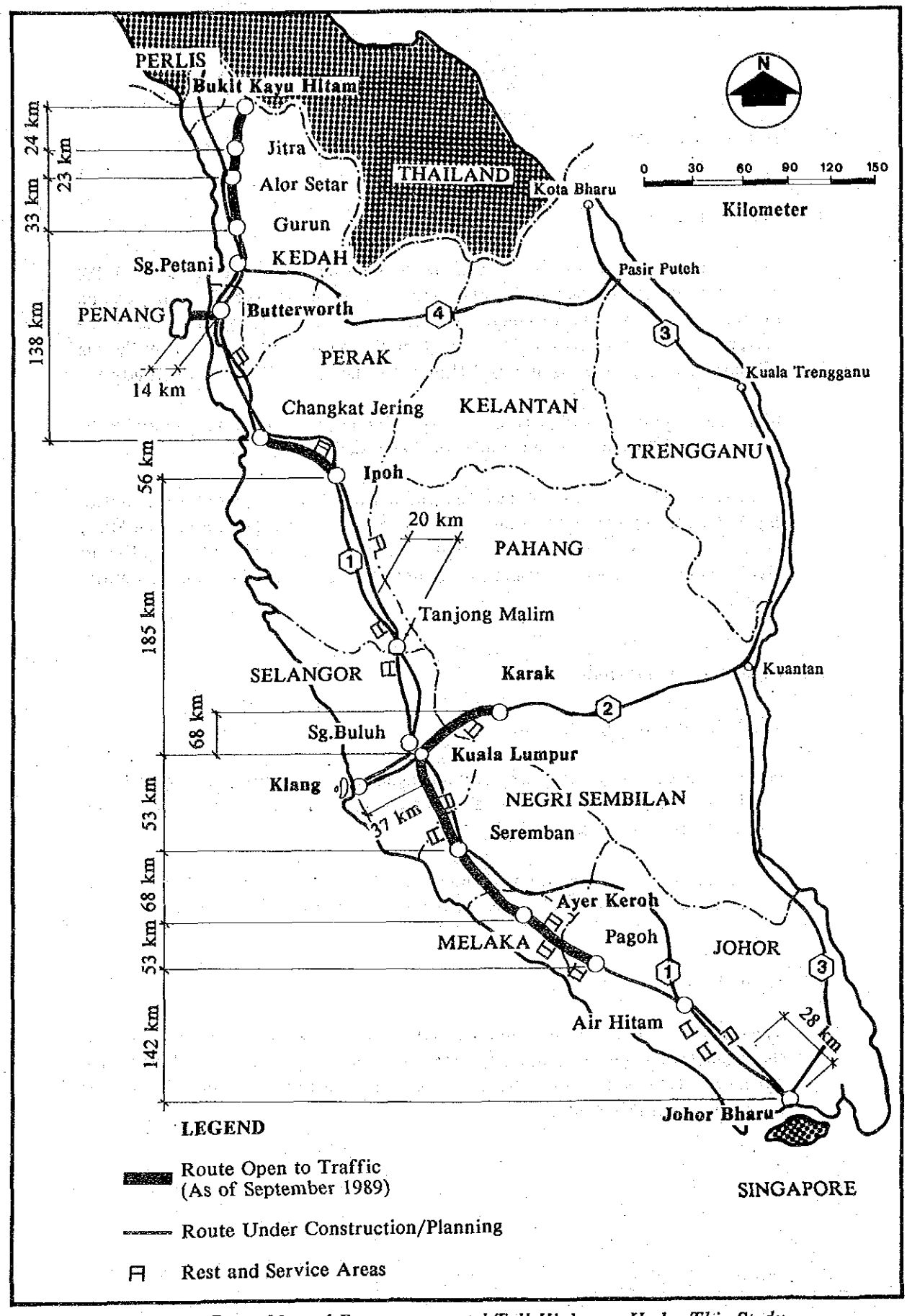


Figure 1.2.1: Route Map of Expressways and Toll Highways Under This Study

Table 1.3.1: Route/Sections of Expressways and Toll Highways Under this Study

Route/Sections	Approximate Length in km
NORTH-SOUTH EXPRESSWAY	
1. Bukit Kayu Hitam - Jitra	24
2. Jitra - Butterworth	107
3. Butterworth - Changkat Jering	87
4. Changkat Jering - Ipoh	56
5. Ipoh - Tanjung Malim	125
6. Tanjung Malim - Kuala Lumpur	60
7. Kuala Lumpur - Seremban	53
8. Seremban - Air Hitam	182
9. Air Hitam - Kota Tinggi	81
Sub-total	775
OTHER TOLL EXPRESSWAYS	
10. New Klang Valley Expressway	37
11. Penang Bridge	14
Sub-total	51
TOLL HIGHWAYS	
12. Kuala Lumpur - Karak	68
13. Senai - Johor Bharu	28
14. Improvement of Federal Highway (from Subang International Airport to Berkeley Roundabout)	15
Sub-total	111
TOTAL	937

The Study includes three expressways of North-South Expressway, New Klang Valley Expressway and Penang Bridge as well as three toll highways of Kuala Lumpur-Karak Highway, Senai-Johor Bharu Highway and improvement of Federal Highway.

The North-South Expressway is planned as a main interurban trunk route to run along the west coast of Peninsular Malaysia from the border with Thailand southward to Singapore. The total length of North-South Expressway is approximately 775 km. In August 1989, about 310 km has been opened to traffic and the whole stretch is planned to be completed by 1995.

In 1988, the North-South Expressway was privatized under the Malaysian Government's Privatization Policy and consequently the private concession company is responsible for the design, construction, management, operation and maintenance of the North-South Expressway while MHA is to play the monitoring, control, supervisory and advisory role to the concession company.

The New Klang Valley Expressway is planned as part of the intra-urban Expressway Network in Klang Valley Region, linking Klang to Kuala Lumpur.

The Penang Bridge, a 14 km bridge structure completed in 1985, links Penang Island with the main land. The Kuala Lumpur-Karak Highway is part of the Federal Route 2 which traversed Peninsular Malaysia from west to east. The Senai-Johor Bharu Highway connects the Senai International Airport to Johor Bharu and then to Singapore via Johor Causeway.

The improvement of Federal Highway which involves widening of 4-lane dual carriageway to 6-lane dual carriageway between Subang Airport Intersection and Berkeley Roundabout in Klang is to relieve existing serious traffic congestion.

1.4 Study Approach

This Study is to be conducted in three (3) phases (Figure 1.4.1).

Phase I, from December 1988 to March 1989, involves the collection and analysis of relevant data and information/reports. This leads to identification of problems and issues which then culminates in the proposal of a traffic control and management system masterplan for Malaysian Expressways and Toll Highways. The Status Report (1) was submitted to the Government of Malaysia in February 1989, reporting the progress of Phase I. The final result of Phase I Study was reported in the Interim Report which was submitted in March 1989.

Phase II, from May to mid-September 1989, covers the setting of traffic control and management system design standards, the preliminary design of various installations in the proposed traffic control and management system; preparation of an operation manual and lastly the evaluation of the proposed system. The Status Report (II), submitted to the Government of Malaysia in July 1989, mainly discusses the traffic control and management standard which includes organization set up and management level. The Draft Final Report contains all works done since December 1988 and presents the Study Team's conclusion and recommendations.

Lastly, Phase III involves the preparation of the Final Report in Japan based on the Draft Final Report after receiving comments from the Malaysian Government.

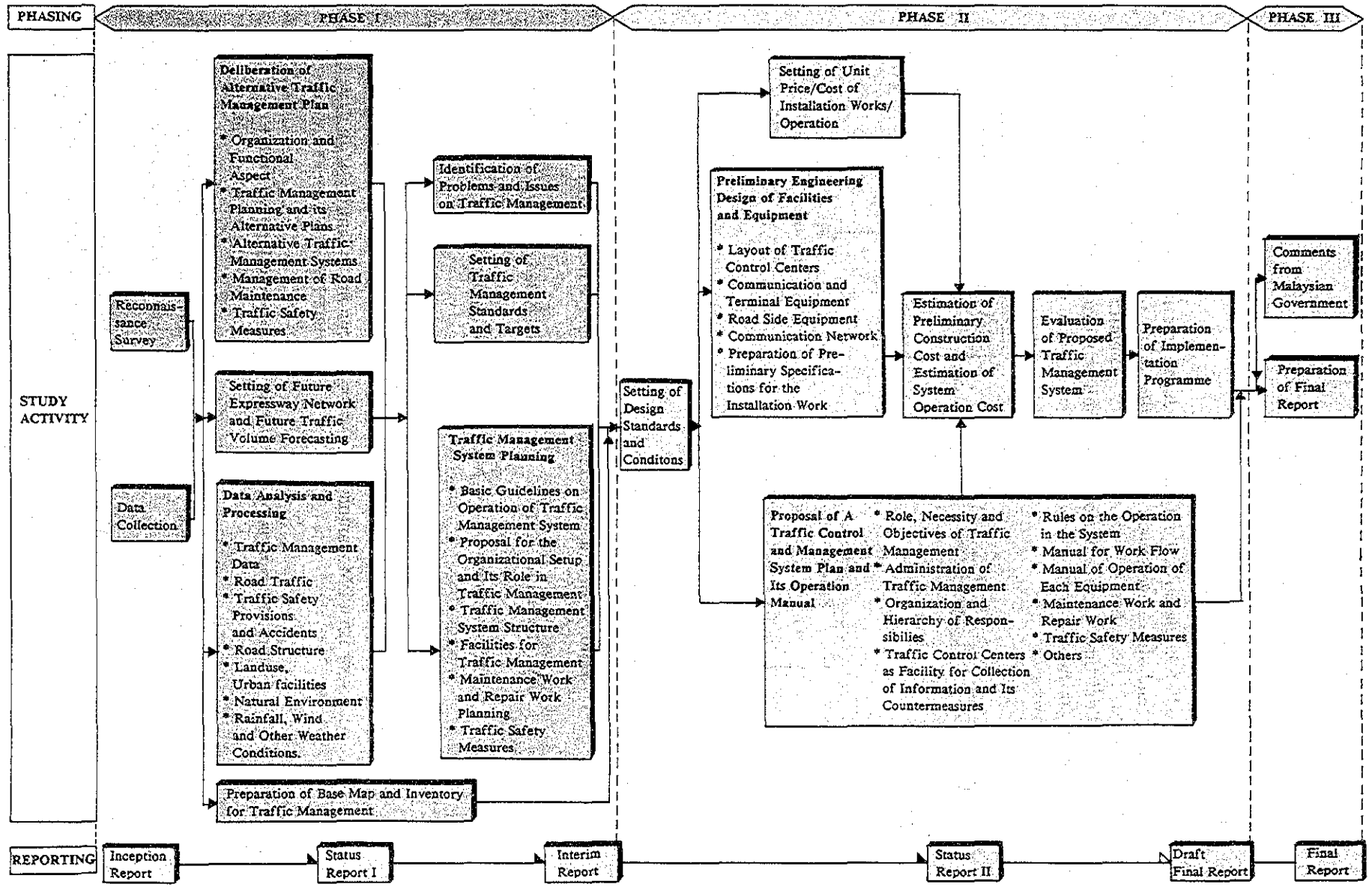
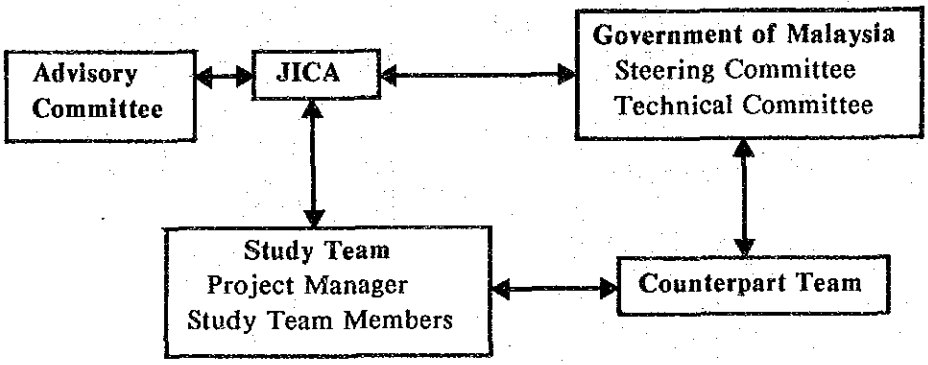


Figure 1.4.1: Study Approach

1.5 Organization of the Study

This study is being carried out jointly by Japan International Cooperation Agency (JICA) and the Government of Malaysia in coordination with other related agencies. JICA has set up an Advisory Committee in providing advice and suggestions through several steering committee meetings during the study period. The organization for the study and the lists of committees and their members are as follows:



Steering Committee, Government of Malaysia

Chairman	Dato' Mustaffa bin Ahmad	Malaysian Highway Authority
	Mr.Yeoh Eng Hun	Malaysian Highway Authority
	Mr.Mohammad bin Abdul Majid	Malaysian Highway Authority
	Mr.Chua Lee Boon	Malaysian Highway Authority
	Mr.Ismail Mohammad	Economic Planning Unit, Prime Minister's Department
	Puan Wan Norma bt Wan Daud	Economic Planning Unit, Prime Minister's Department
	Puan Rohani Omar	Economic Planning Unit, Prime Minister's Department
	Mr.Chew Swee Hock	Road Section, Public Works Department

	Mr.Zainal Abidin Ahmad	Road Section, Public Works Department.
	Mr.Heng Aik Koon	Highway Planning Unit, Ministry of Works.

Technical Committee, Government of Malaysia

Chairman	Ir.Yeoh Eng Hun	Malaysian Highway Authority
	Ir.Chua Lee Boon	Malaysian Highway Authority
	Ir.I.Dorairajoo	Malaysian Highway Authority
	Ir.Abdul Adzim Muhammad	Malaysian Highway Authority
	Ir.Zakaria Mat Nor	Malaysian Highway Authority
	Ir.Ismail Mohd.Salleh	Malaysian Highway Authority
	Ir.Mohd.Azman Ahmad	Malaysian Highway Authority
	Mr.Takeichi Sekiguchi	Malaysian Highway Authority
	Mr.Hirotaka Yamamura	Malaysian Highway Authority
	Mr.Taichi Seki	Highway Planning Unit
	Mr.Heng Aik Koon	Highway Planning Unit
	Mr.Zainal Abidin Ahmad	Public Works Department

Malaysian Counterpart Engineers

	Mr.Wan Shaari Wan Hassan	Malaysian Highway Authority
	Mr.Zailan Ramli	Malaysian Highway Authority

Advisory Committee, Government of Japan

Chairman	Mr.Hisakazu Oishi	Ministry of Construction
	Mr.Hiroshi Aoki	Japan Highway Public Corporation
	Mr.Hiroshi Kikkawa	Metropolitan Expressway Public Corporation

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Japanese Expert

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	Mr.Takashi Sato	Traffic Control and Surveillance System Design (I)
	Mr.Seiya Matsuoka	Traffic Control and Surveillance System Design (II)
	Mr.Akira Okita	Highway Facility/Maintenance Planning
	Mr.Yutaka Yamaguchi	Traffic Operation Planning
	Mr.Takasuke Tanno	System Design/Cost Estimate
	Mr.Tadamichi Hoshi	Traffic Safety Planning
	Mr.Chua Mok You	Transport Planning

Malaysian Engineers

	Mr.Ooi Peng Hong	Transport Planning

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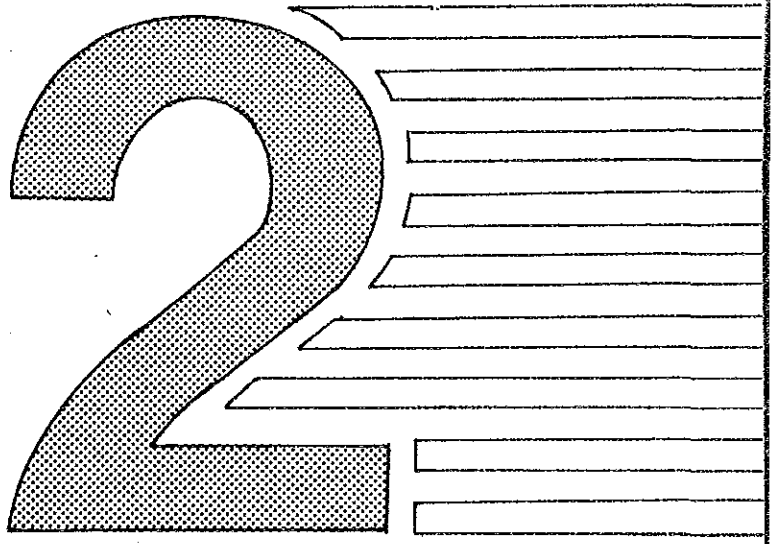
CHAPTER



2.0 EXISTING CONDITIONS AND CURRENT STATUS OF TRAFFIC MANAGEMENT

2.1 Outline of Study Area

2.1.1 Route Location

The Study area comprises the expressway and highway corridors along the west coast of Peninsular Malaysia. Figure 2.1.1 shows the alignment of the expressway and highways. The North-South Expressway passes through seven states on the west coast, namely the State of Kedah in the North, Penang, Perak, Selangor, Negeri Sembilan, Melaka and Johor and the Federal Territory of Kuala Lumpur while the Karak Highway connects Kuala Lumpur through the State of Pahang to the east coast.

The North-South Expressway covering a distance of approximately 775 km, crosses six major rivers, namely Kedah River, Perak River, Kinta River, Bernam River, Klang River, and Muar River (Figure 2.1.1).

The expressway connects the state capitals of Alor Setar, Georgetown, Ipoh, Seremban and Johor Bharu with the national capital of Kuala Lumpur. Other major towns, notably Sungai Petani and Butterworth in the north, Taiping, Bidor, Bangi Newtown, Ayer Hitam and Skudai also lie along the North-South Expressway route.

Through other toll highways, the North-South Expressway also connects two international airports (Subang International Airport in Selangor and Bayan Lepas International Airport in Penang) and Senai Airport in Johor. The expressway is further linked to major ports directly (Butterworth) or through other federal routes to Klang Port, Pasir Gudang and Kuantan Port. The expressway corridor thus consists of the most urbanized belt along the west coast of Peninsular Malaysia and by virtue of its location, the completion of this main trunk route will invariably brings about a greater boost of economic and social development.

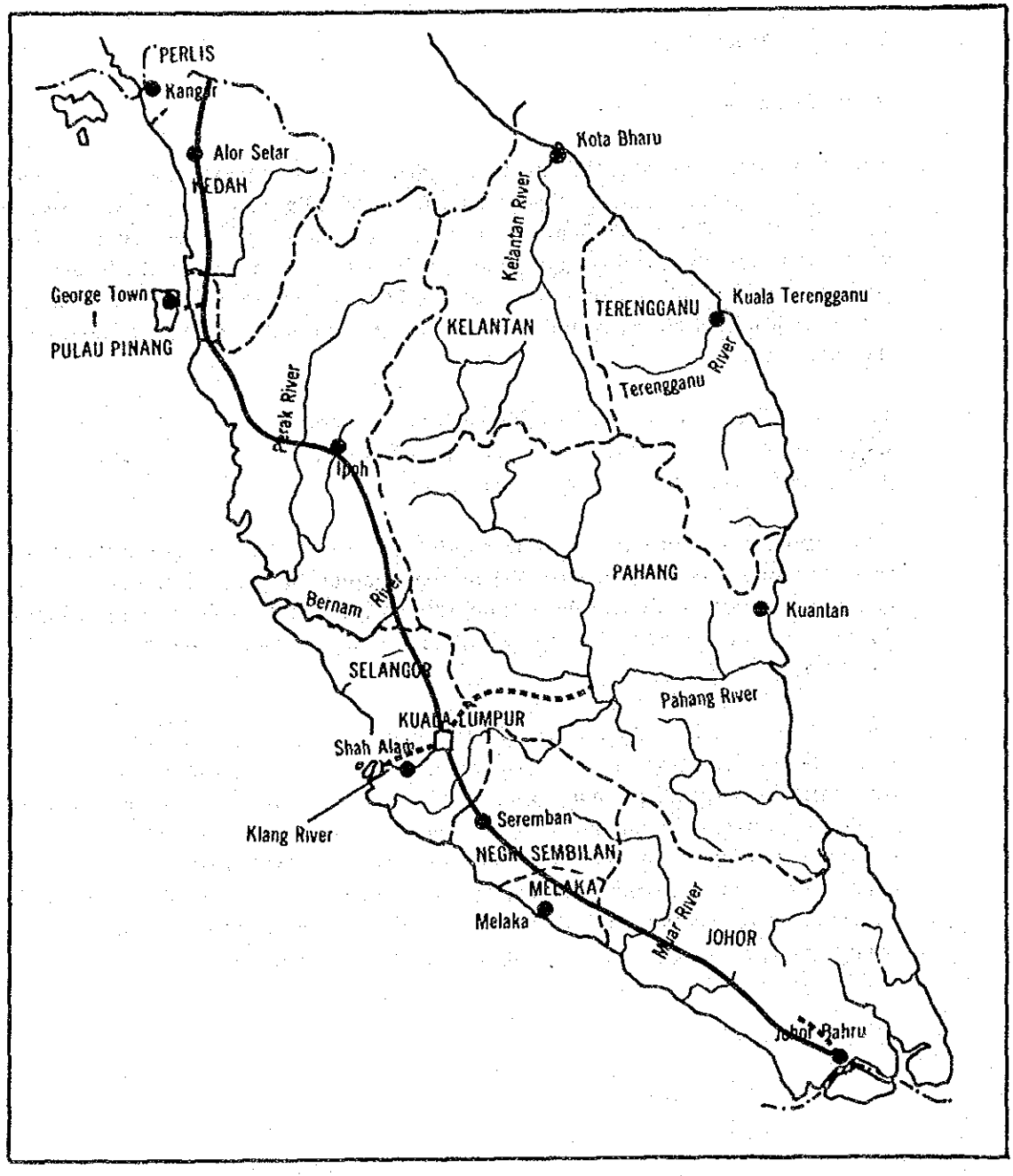


Figure 2.1.1: Expressway and Highway Routes Along the West Coast States of Peninsular Malaysia

2.1.2 Population of the Study Area

Population growth and distribution influence the volume of traffic on the North-South Expressway. Traffic will be predominantly generated from and attracted to the urban centers.

The population of Malaysia increased at an annual rate of 2.3% from 15.8 million in 1985 to 16.9 million in 1988.

The seven states through which the North-South Expressway passes contribute 77.8% of the total population of Peninsular Malaysia (Table 2.1.1). The population growth along the expressway corridor may be analyzed by dividing the corridor into three regions.

i) Northern Region .. Perak, Kedah and Penang

ii) Central Region .. Selangor, Kuala Lumpur, Negeri Sembilan and Melaka

iii) Southern Region .. Johor

Northern Region:

About 31.0% of the population of Peninsular Malaysia live in this region in 1988 compared to 33.9% in 1980. Comparing with the annual growth rate of 2.6% at national level, all states in this region experienced a lower population growth rate from 1980. Out-migration also contributed to the decline in the share of population of this region.

Central Region:

This region supports about 32.6% of the population of Peninsular Malaysia in 1988 compared to 22.3% in 1980. Being the most developed, industrialized and urbanized region, it draws substantial urban bound migrants from other regions, a fact which accounted for its increasing population share since the 1960s.

Southern Region:

This region contributes about 14.2% of Peninsular Malaysia's population in 1988, a share that has remained almost unchanged since 1980. Though the southern region has a well balanced economic structure, it also experienced a vast net out migration of population to the central region.

Table 2.1.1: Share of Population by Region to Peninsular Population

(In '000)

State	1980*	%	1988	%
Kedah	1116	9.8	1252.9	8.9
Penang	954	8.3	1096.0	7.8
Perak	1805	15.8	2002.3	14.3
Selangor	1515	13.2	3398.4	24.2
Negeri Sembilan	574	5.0	653.3	4.7
Melaka	465	4.1	117.7	3.7
Johor	1638	14.3	1983.9	14.2
Total	8067	56.2	10906.9	77.8
Peninsular	11427	100.0	14017.2	100.0

Note:
* 1980 .. Based on national population census
1988 .. Survey Research Malaysia

Figure 2.1.2 shows the population of major urban centers along the North-South Expressway corridor. Kuala Lumpur being the national capital has a population close to 1 million in 1980 and this has increased to 1.8 million by 1988. Next to the urban hierarchy are Johor Bharu, Ipoh and Georgetown with population of 250,000 to 300,000 in 1980. The next group of urban centers are Taiping and Seremban having about 150,000 population in 1980.

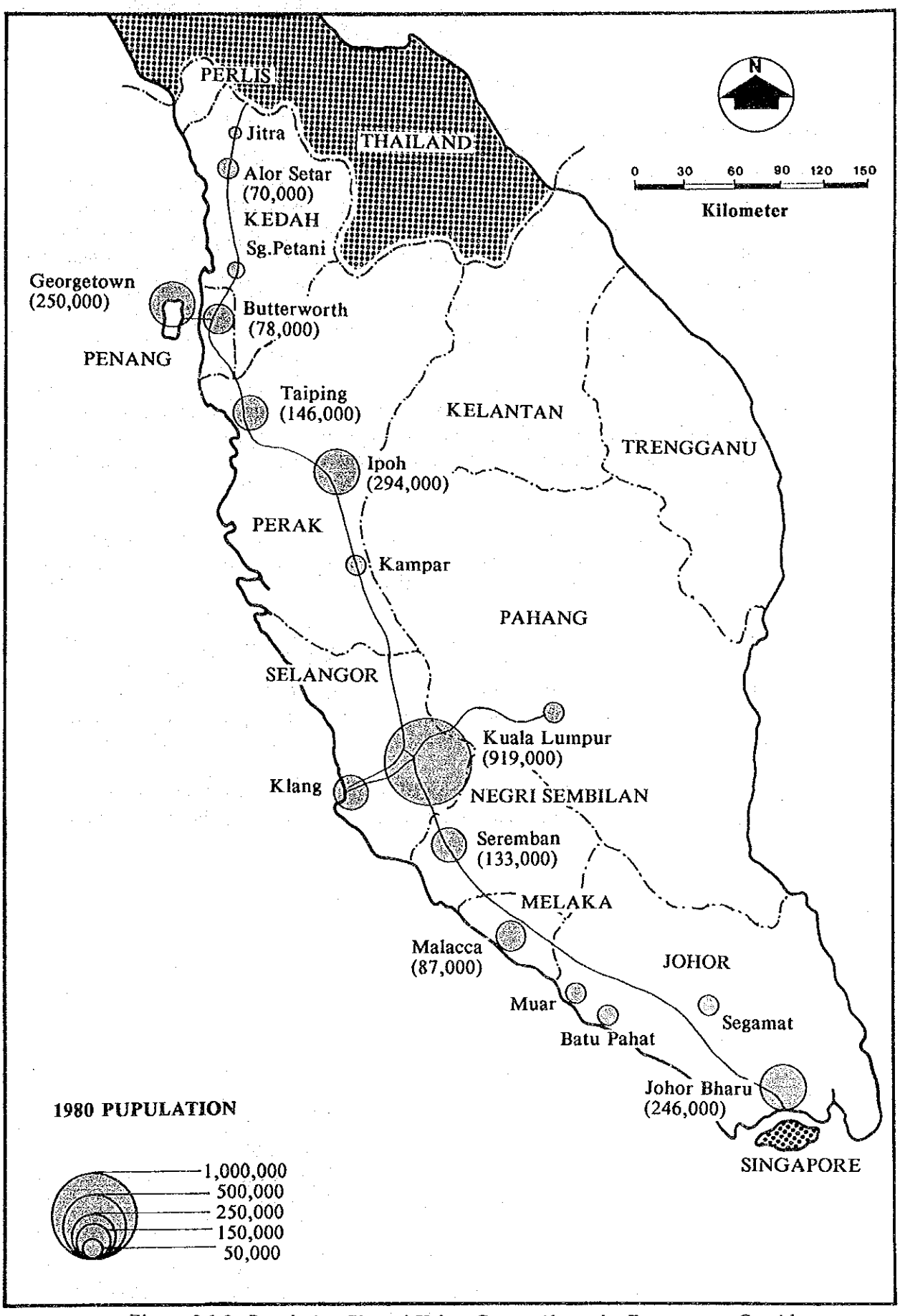


Figure 2.1.2: Population Size of Urban Center Along the Expressway Corridor

2.1.3 Geological and Topographical Condition

The topographic features of Peninsular Malaysia can be described as a central mountainous spine known as the Main Range that runs from the Thai Border southward to Negeri Sembilan, effectively separating the eastern part of the Peninsular from the western. The Main Range is mainly of Triassic and Permian granitic formation. This central mountainous spine slopes down towards the eastern and western coastal areas with sedimentary and volcanic rocks in between. The highest point of the Main Range reaches 2,187 meters or 7,175 feet as Gunung Tahan.

Another outstanding topographic feature of Peninsular Malaysia is the prominent vertically sided limestone hills near Kuala Lumpur, Kinta Valley near Ipoh and other areas in Kedah, Kelantan and Perlis. The coastal lowland are mainly of alluvial sediments.

As a result of the topographic configuration of the country and heavy rainfall, there are many rivers which start from the Main Range and flow towards the eastern and western coast of Peninsular Malaysia.

The North-South Expressway passes through mostly gentle terrain of the west coast of Peninsular Malaysia. Figure 2.1.3 shows the type of geological formation along the expressway alignment. The expressway passes through most of the alluvium and sedimentary rock formations. Igneous granite rocks lie only at a few points along the alignment in the State of Perak where two tunnels have to be designed.

The expressway corridor cuts through padi growing areas on the low land in the State of Kedah in the north and plantations of rubber and oil palm in the central and southern region.

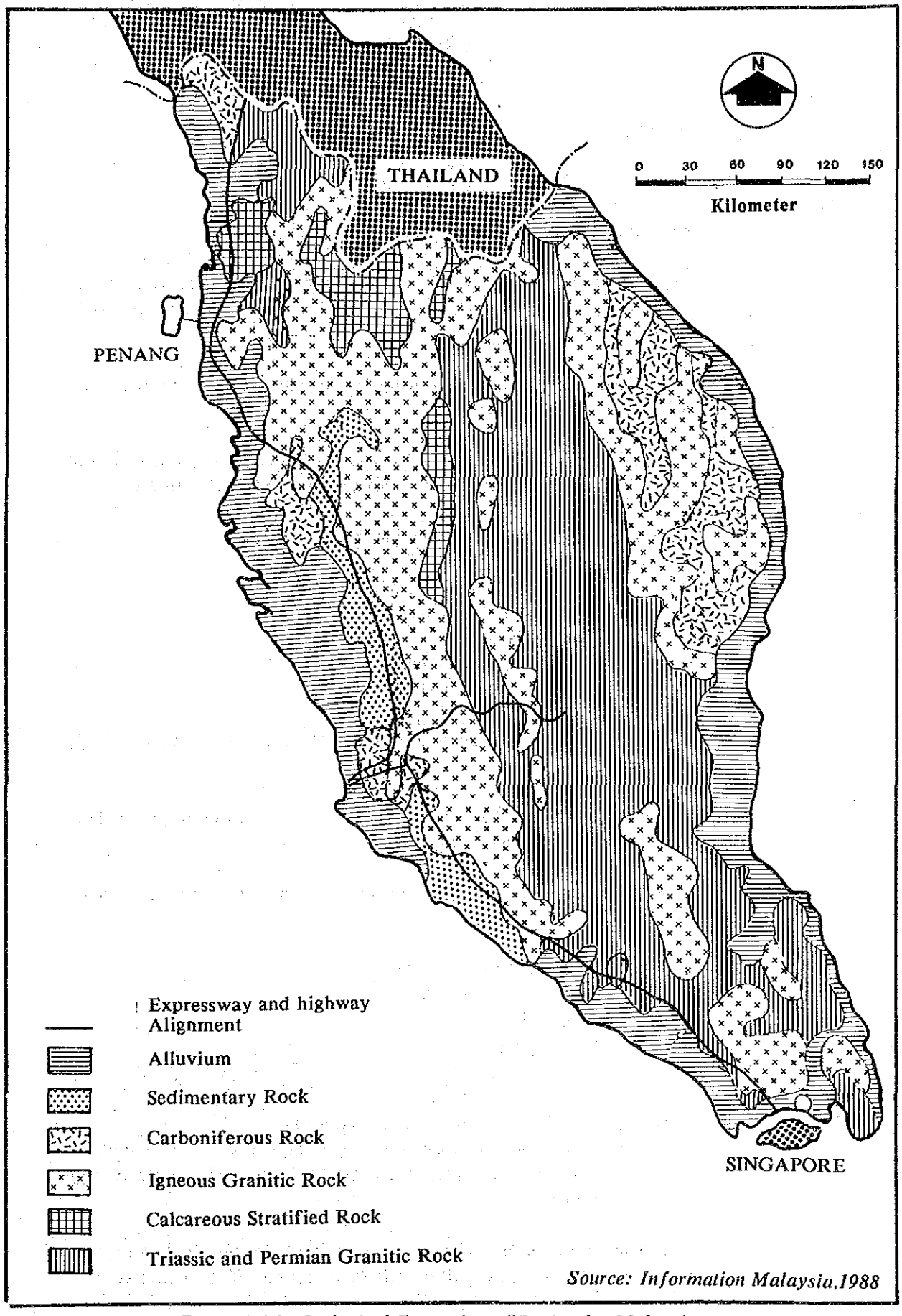


Figure 2.1.3: Geological Formation of Peninsular Malaysia

2.1.4 Weather Condition

1) Rainfall

a) Annual and Daily Average Rainfall

The annual average and maximum rainfall as well as daily average and maximum rainfall for the period 1975-1985 are illustrated figuratively in Figures 2.1.4 and 2.1.5.

The annual average rainfall during the last ten years along the study corridor is about 2200 mm.

The sections of the North-South Expressway with annual average rainfall exceeding the mean value (2200 mm) are depicted in Figure 2.1.6.

As illustrated, the concerned sections are:-

i) Alor Setar-Sungai Petani
ii) Taiping-Changkat Jering
iii) Ipoh-Kajang
iv) Yong Peng-Air Hitam
v) Simpang Renggam-Johor Bharu

The daily average rainfall is approximately 100 mm along the Study corridor.

Figure 2.1.6 presents the sections of North-South Expressway with daily average rainfall exceeding the mean value (100 mm).

From the figure, the area with rainfall exceeding the aforesaid mean are as follows:-

i) Alor Setar-Butterworth
ii) Taiping-Changkat Jering
iii) Ipoh-Bidor
iv) Rawang-Kajang
v) Yong Peng-Air Hitam

In short, the following points can be deduced:-

i) central region experiences higher annual average rainfall;
ii) northern and central regions experience higher daily average rainfall;

This leads to the need to consider the effect of short-period (daily) and long-period (annual) rainfall on different sections of the expressway.

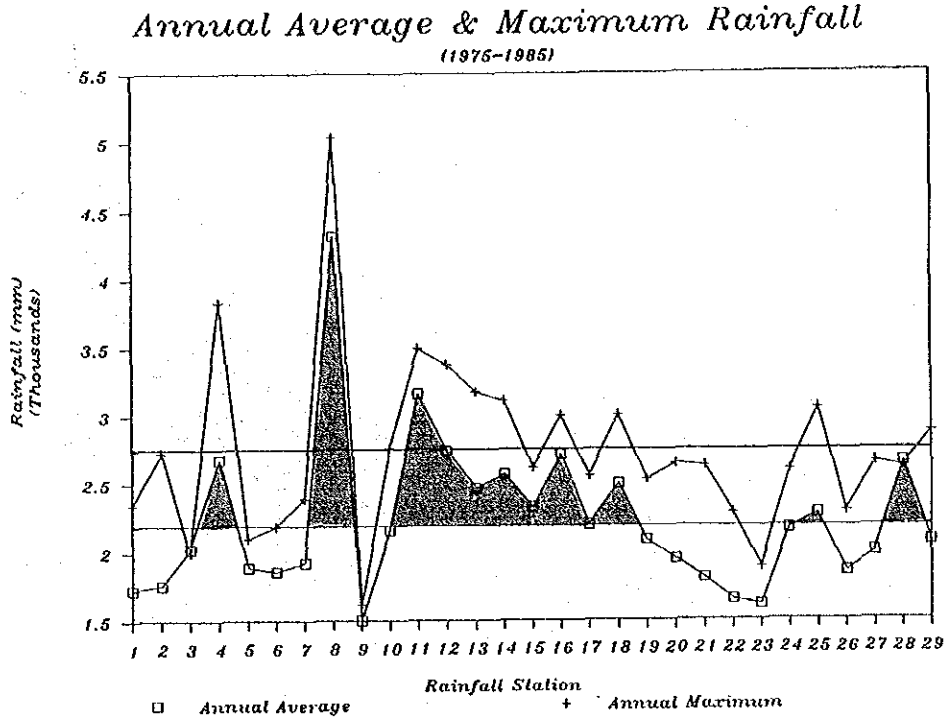


Figure 2.1.4: Annual Average and Maximum Rainfall Along Study Corridor

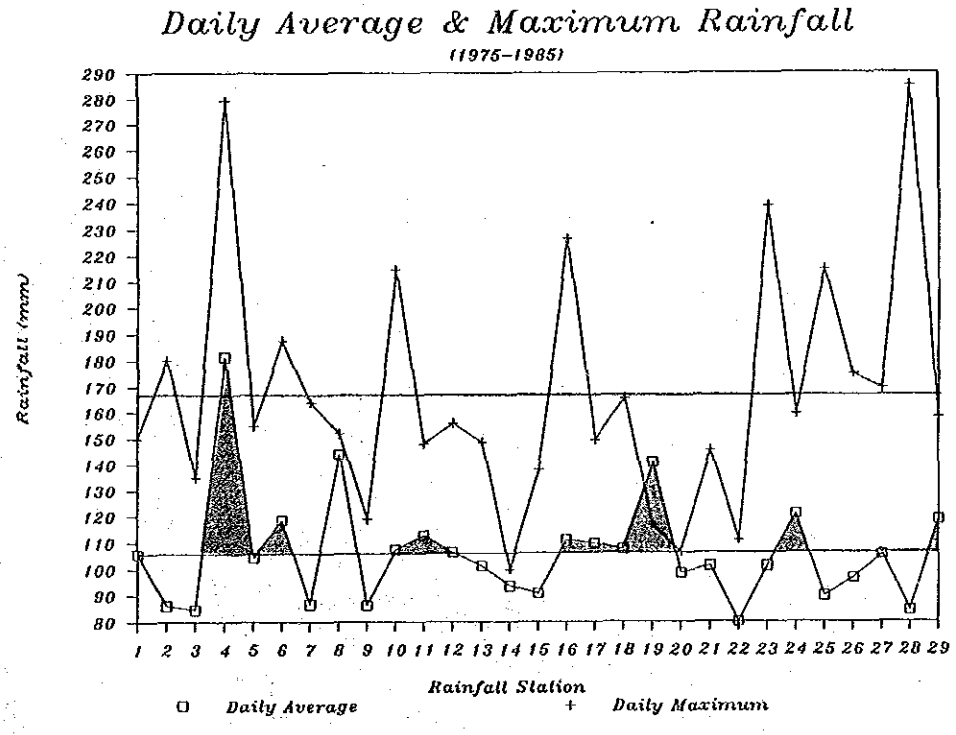


Figure 2.1.5: Daily Average and Maximum Rainfall Along Study Corridor

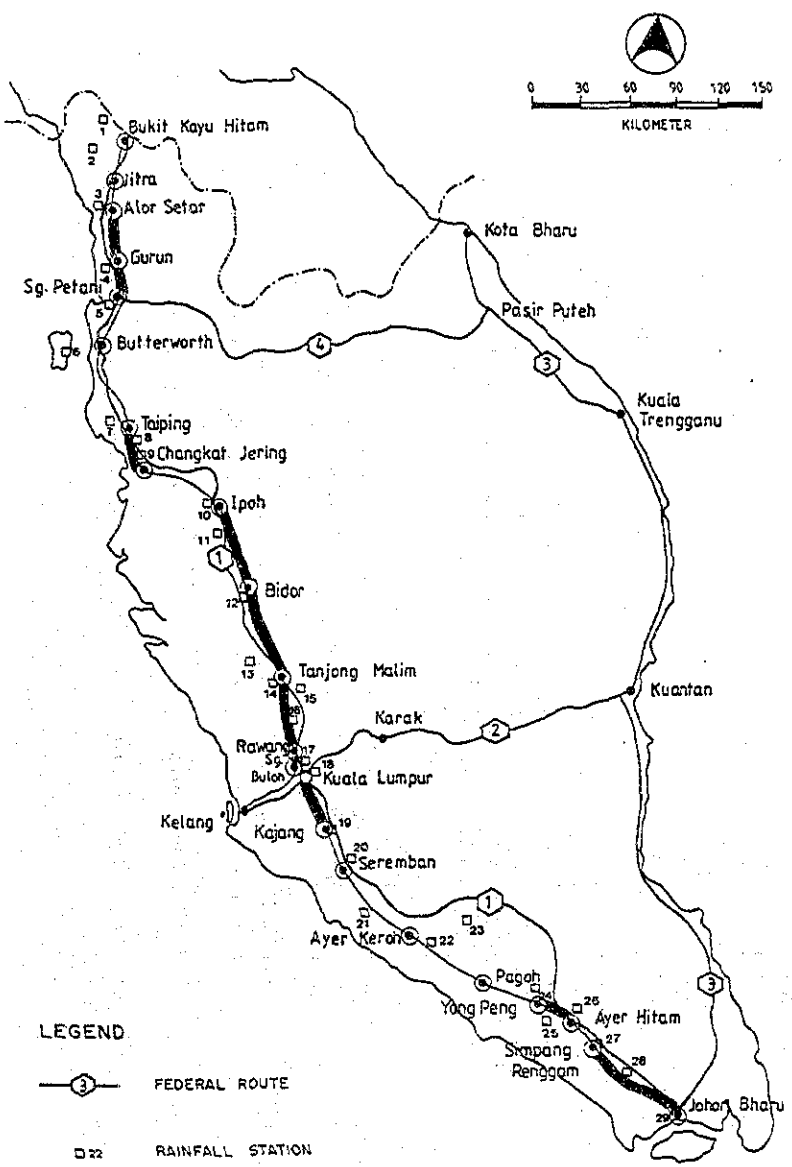


Figure 2.1.6: Sections of North-South Expressway with Annual Average Rainfall Exceeding Mean Value

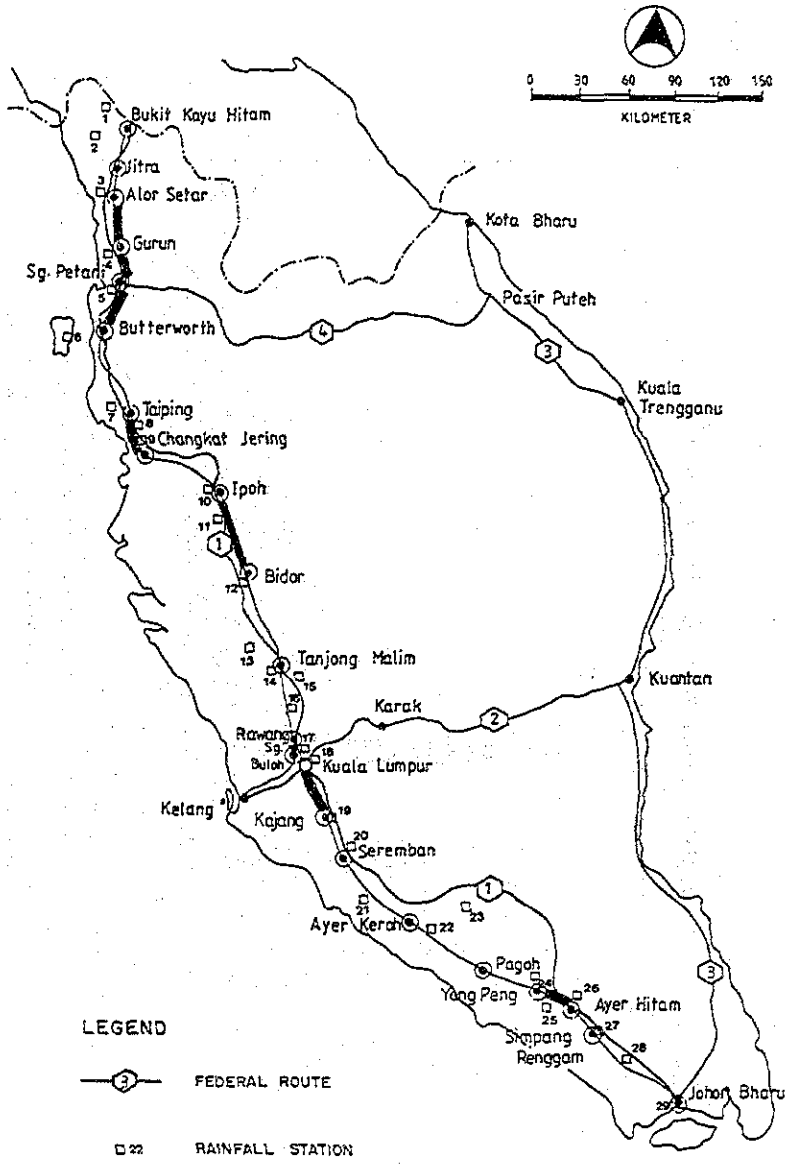


Figure 2.1.7: Sections of North-South Expressway With Daily Average Rainfall Exceeding Mean Value

b) Monthly Rain Days

Figure 2.1.8 depicts the monthly rain days with more than 10 mm and 50 mm along the study corridor.

Along the study corridor, the northern region experiences greater number of rain days with more than 10 mm in a month especially in September while the central region has more rain days with over 10 mm in a month in April. In general, the southern region encounter few days with rainfall greater than 10 mm in a month.

This rain day pattern is further illustrated by the monthly rain day curve with more than 50 mm. Overall, the study corridor experiences one to two rain days in a month but in the region north of Kuala Lumpur, the number of rain days with more than 50 mm is about three to six days.

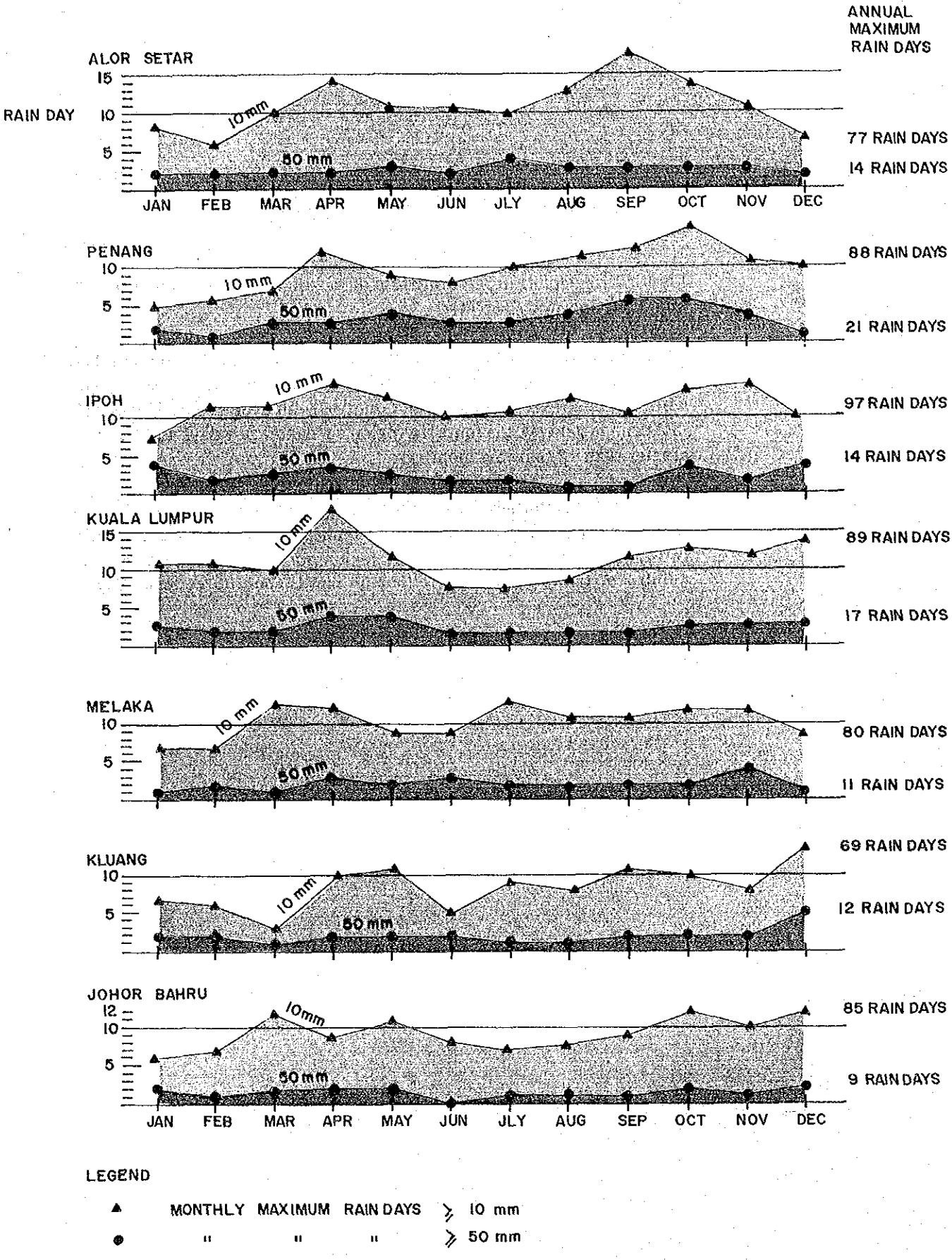


Figure 2.1.8: Monthly Rain Days with more than 10 mm and 50 mm Rainfall Along Study Corridor

2) Thunderstorm

The thunderstorm probability distribution at few major points along the study corridor is illustrated in Figure 2.1.9.

As clearly shown in the figures, thunderstorms mostly occur in the afternoon between 3 to 6 pm. Precipitate rainfall together with thunderstorm is a distinctive feature of Malaysian meteorological conditions.

3) Wind

The annual percentage breakdown of wind speed at few meteorological stations along the North-South Expressway for the 10 years period of 1968-1977 is presented in Table 2.1.2.

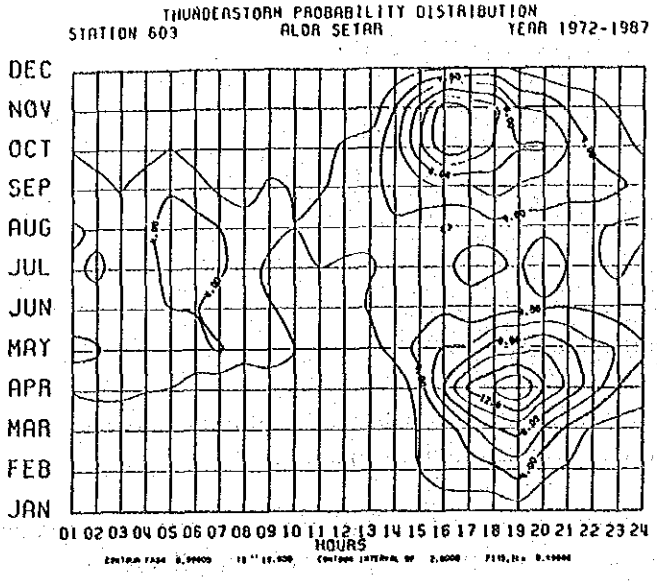
Table 2.1.2: Annual Percentage Breakdown of Wind Speed

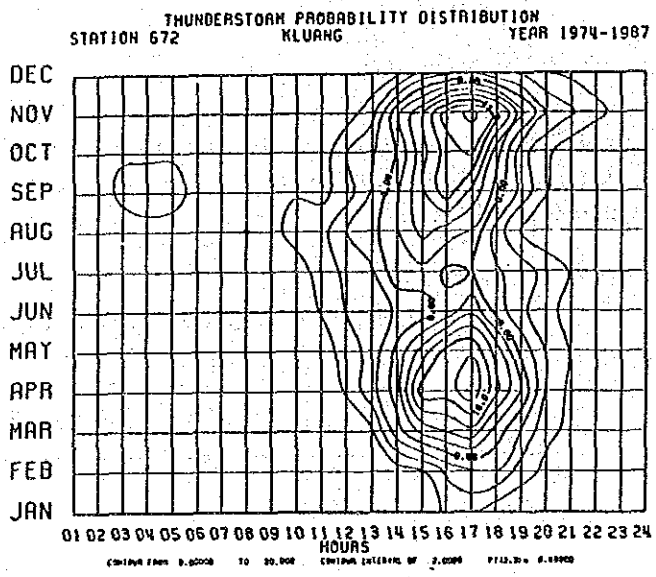
	Speed (m/s)					
Station	<0.3	0.3-1.5	1.6-3.3	3.4-5.4	5.5-7.9	>8.0
Alor Setar	28.0	57.2	13.6	1.2	0	0
Penang	23.0	34.4	26.0	15.2	1.4	0
Ipoh	12.6	37.9	29.0	15.8	2.7	0
Kuala Lumpur	57.1	20.7	12.0	8.6	1.6	0
Melaka	30.3	29.7	22.6	15.5	1.9	0

Period: 1969-1977
Time : 24 Hours

Generally, all the sections experience wind speed of not more than 1.6 m/s on most part of a typical day.

At certain spots, especially on expressway stretch with cut and embankment slopes as well as at bridge and viaduct, vehicles running more than 100 km/h may be affected by strong cross winds.





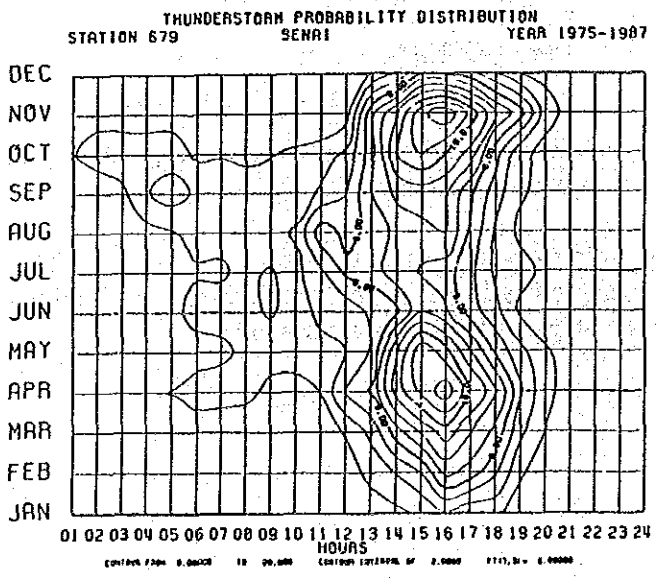


Figure 2.1.9: Thunderstorm Probability Distribution Along Study Corridor

2.2 Traffic Condition

2.2.1 Existing Traffic Characteristics on the North-South Expressway and Toll Highways

1) Average Annual Daily Traffic Volume (AADT)

The average annual daily traffic volume (AADT) on the North-South Expressway section and toll highways for 1988 are shown in Table 2.2.1 and Figure 2.2.1. The data is obtained from MHA's toll collection records and thus the traffic volume does not include motorcycles which are toll free. Moreover, toll for Penang Bridge and Bukit Kayu Hitam-Jitra are only collected in one direction.

Sungei Besi-UPM section has the highest AADT traffic volume along the North-South Expressway at 35,928 vehicles (without motorcycles) and the section with the smallest volume is Bukit Kayu Hitam-Jitra with 608 vehicles (one direction).

Table 2.2.1: AADT Volume on North-South Expressway Section and Toll Highways

(Unit: Vehicles)

Section	North Bound	South Bound	Total
NORTH-SOUTH EXPRESSWAY			
1) Bukit Kayu Hitam-Jitra	-	608	608
2) Alor Setar North-Alor Setar South	847	648	1495
3) Alor Setar South-Gurun	2053	1489	3542
4) Changkat Jering-Kuala Kangsar	1786	2975	4761
5) Kuala Kangsar-Ipoh	4010	4017	8027
6) Sungei Besi-Universiti Pertanian Malaysia	18375	17553	35928
7) Universiti Pertanian Malaysia-Kajang	18151	17551	35702
8) Kajang-Bangi	13470	12961	26431
9) Bangi-Nilai	11220	10689	21909
10) Nilai-Seremban	10577	10029	20606
11) Nilai-Port Dickson North	9691	8734	18425
12) Port Dickson North-Port Dickson South	7311	8729	16040
13) Port Dickson South-Senawang	7308	6774	14082
14) Senawang-Pedas Linggi	4498	4248	8746
15) Pedas Linggi-Simpang Ampat	4335	4085	8420
16) Simpang Ampat-Ayer Keroh	2840	2647	5487
TOLL HIGHWAYS	**East Bound**	**West Bound**	**Total**
1) Penang Bridge	-	13428	13428
2) Karak Highway	3987	4150	8137
	North Bound	**South Bound**	**Total**
3) Senai-Johor Bharu Highway	10709	10709	21418

Source: MHA

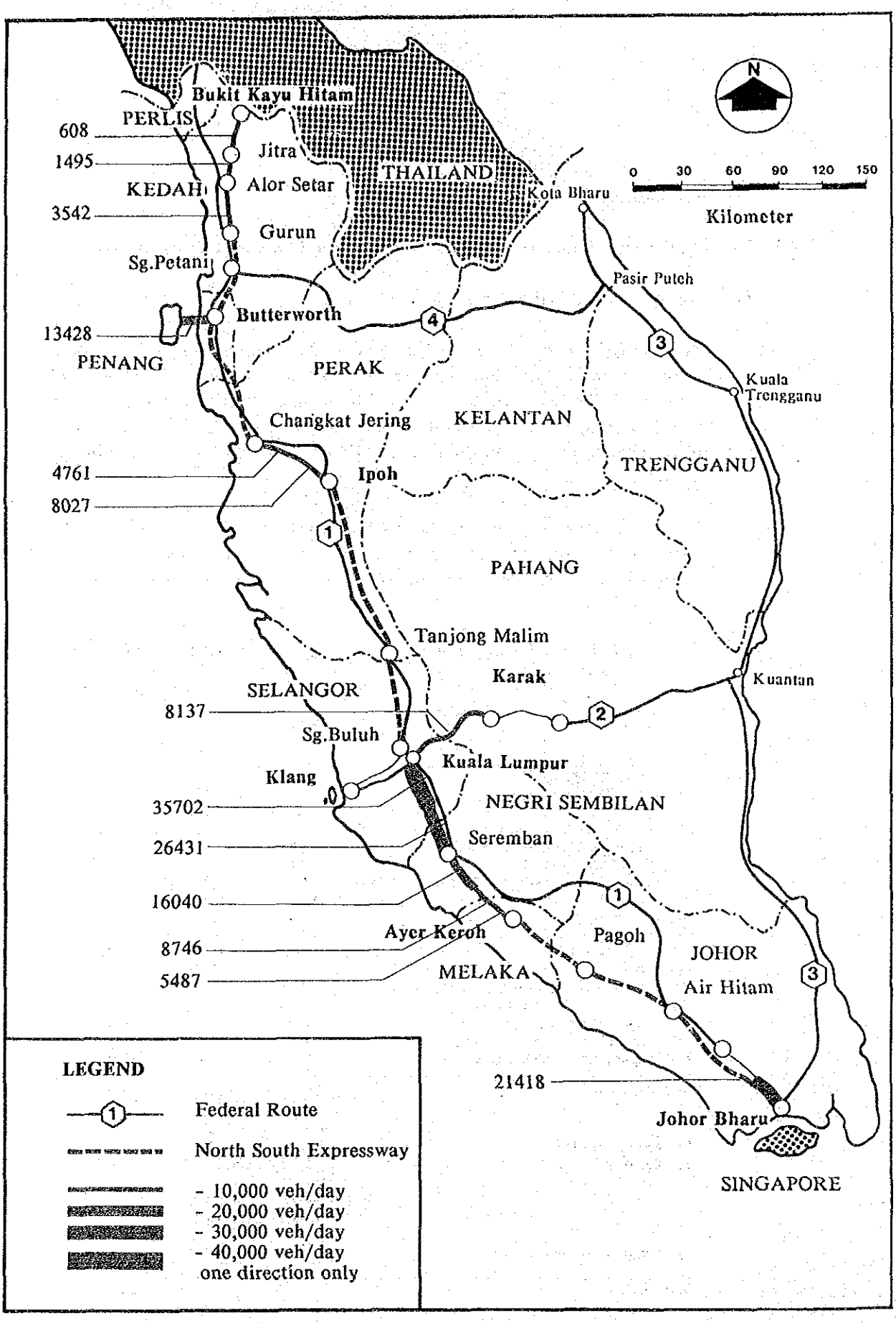


Figure 2.2.1: AADT Volume on the North-South Expressway and Toll Highways

To supplement the daily traffic volume information on the expressway and highways, a traffic counting survey on seven selected sections was carried out in January 1989. The results of the counting survey are shown in Table 2.2.2.

Table 2.2.2: Daily Traffic Volume on Selected Expressway Sections and Toll Highways

Section	Total Daily Traffic (a)	Daily Traffic Without Motor-cycle (b)	AADT* 1988	Ratio of (a)/(b)
NORTH-SOUTH EXPRESSWAY				
1) Alor Setar South-Gurun	3692	2864	3542	1.29
2) Changkat Jering-Ipoh	8926	8072	8027	1.11
3) Nilai-Seremban	19917	18501	20606	1.08
4) Simpang Ampat-Ayer Keroh	5666	5246	5487	1.08
TOLL HIGHWAYS				
1) Penang Bridge	28422	16941	13428	1.68
2) Karak Highway	11021	10534	8137	1.05
3) Senai-Johor Bharu Highway	25477	22092	21418	1.15

Source: Traffic Count Survey, January 1989
Note: * AADT without motorcycles

The daily traffic volume on the toll highways, namely Penang Bridge, Karak Highway and Senai-Johor Bharu Highway (including motorcycles) amounted to 28,422 veh/day, 11,021 veh/day and 25,477 veh/day respectively with the highest volume at Penang Bridge.

Traffic volume on the North-South Expressway range from 3,000 vehicles to 20,000 vehicles per day. Nilai-Seremban section recorded a daily traffic volume of 19,917 vehicles. Changkat Jering-Ipoh section recorded 8,926 veh/day. Simpang Ampat-Ayer Keroh section in the south has a traffic volume of 5,666 veh/day while Alor Setar-Gurun section in the north has 3,692 vehicles.

The above table also shows that motorcycle contributes significantly to the total traffic volume on Alor Setar-Gurun section and Penang Bridge.

The peak hour traffic volume on these seven sections are indicated in Table 2.2.3. Penang Bridge has a peak hour traffic volume of 2,665 vehicles or 9.4% of the total daily volume. Senai-Johor Bharu Highway has a 7.3% peak hour traffic volume while Karak Highway has 6.7%. Peak hour traffic volume on the North-South Expressway varies from 6.3% to 8.5%. One interesting encounter is that while all peak hour occur in the evening at all other sections, Senai-Johor Bharu Highway has a peak occurring at 2 to 3 p.m.

Table 2.2.3: Peak Hour Traffic Volume on Expressway and Toll Highways

(Unit:vehicles)

Section	Daily Traffic	Peak Hour Traffic	Percent of Peak Hour Traffic	Peak Hour
NORTH-SOUTH EXPRESSWAY				
* Alor Setar South-Gurun	3692	314	8.5%	(4 to 5 pm)
* Changkat Jering-Ipoh	8926	680	7.6%	(5 to 6 pm)
* Nilai-Seremban	19917	1550	7.8%	(5 to 6 pm)
* Simpang Ampat-Ayer Keroh	5666	356	6.3%	(6 to 7 pm)
TOLL HIGHWAYS				
* Penang Bridge	28422	2665	9.4%	(5 to 6 pm)
* Karak Highway	11021	743	6.7%	(5 to 6 pm)
* Senai-Johor Bharu Highway	25477	1848	7.3%	(2 to 3 pm)

Source: Traffic Count Survey, January 1989

2) AADT Volume at the Interchanges

The AADT volume at each interchange and toll barrier is shown in Table 2.2.4.

The toll barrier at Sungei Besi handles the highest volume of traffic a day. Besides motorcycles, it handled 35,928 vehicles a day in 1988. This is followed by Kajang Interchange which handled 12,039 vehicles a day. Pedas Linggi Interchange handled only a daily traffic of 533 vehicles.

Table 2.2.4: Average Annual Daily Traffic Volume at Interchanges in 1988

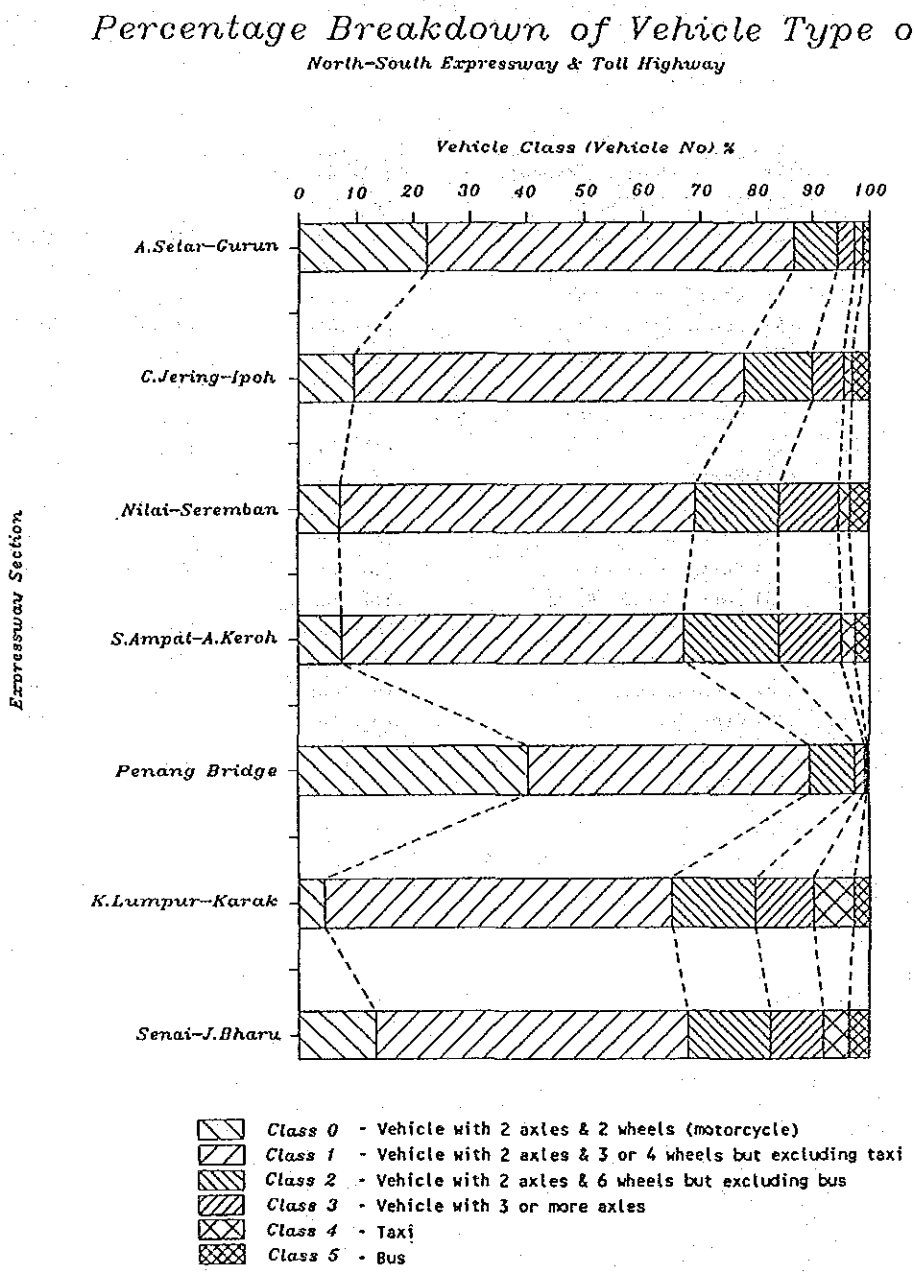
(Unit:vehicles)

Interchange	Type	Traffic In	Traffic Out	Total
1) Jitra (Hutan Kampung)	Toll Barrier	1880	2053	3933
2) Alor Setar North	Toll Gate	3610	1686	5296
3) Alor Setar South	Toll Gate	1149	1099	2248
4) Gurun	Toll Gate	2053	1489	3542
5) Changkat Jering	Toll Gate	2975	1786	4761
6) Kuala Kangsar	Toll Gate	2290	3472	5762
7) Ipoh (Jelapang)	Toll Barrier	4010	4017	8027
8) Sungei Besi	Toll Barrier	17553	18375	35928
9) Universiti Pertanian Malaysia	Toll Gate	4064	3843	7907
10) Kajang	Toll Gate	6065	5974	12039
11) Bangi	Toll Gate	3173	3195	6370
12) Nilai	Toll Gate	1896	1913	3809
13) Seremban	Toll Gate	5066	5474	10540
14) Port Dickson North	Toll Gate	3726	1351	5077
15) Port Dickson South	Toll Gate	1351	3303	4654
16) Senawang	Toll Gate	3484	3199	6683
17) Pedas Linggi	Toll Gate	268	265	533
18) Simpang Ampat	Toll Gate	1816	1759	3575
19) Ayer Keroh	Toll Gate	2840	2647	5487

Source: MHA

3) Traffic Composition

Figure 2.2.2 shows the traffic composition on the expressway and highway sections using data collected from the traffic survey.



Source: Traffic Count Survey, January 1989

Figure 2.2.2: Traffic Composition on Sections of North-South Expressway and Toll Highway

Traffic on Penang Bridge displays a distinctive different composition from the other sections. The share of motorcycle is very high at 40.4%. The Alor Setar-Gurun section has 22.4% of its daily traffic made up of motorcycles, while Senai-Johor Bharu Highway has 13.3%. The other sections have less than 10.0%. The share of truck also varies significantly between the different sections of expressway and highways. Nilai-Seremban section, Karak Highway and Senai-Johor Bharu Highway have about 15% of the daily traffic as trucks (Class 2) while Simpang Ampat-Ayer Keroh section has about 17%.

Heavy trucks (Class 3) make up over 10% of the total daily traffic on Nilai-Seremban, Simpang Ampat-Ayer Keroh section and Karak Highway.

Karak Highway has the highest percentage share of taxi at 7.0% followed by 4.5% on Senai-Johor Bharu Highway. The high percentage share of taxi on Karak Highway is probably due to taxis serving between Kuala Lumpur and Genting Resorts.

4) Ratio of 24-Hour to 16-Hour Traffic

The ratio of day time traffic to night time traffic is indicated by ratios of 24-hour traffic volume to 16-hour (6am to 10pm) traffic volume. Table 2.2.5 shows that Simpang Ampat-Ayer Keroh section has the highest ratio of 1.24 followed by Karak Highway, Changkat Jering-Ipoh and Nilai-Seremban section.

Table 2.2.5: Ratio of 24-Hour to 16-Hour Traffic

Section	Ratio
NORTH-SOUTH EXPRESSWAY	
* Alor Setar South-Gurun	1.06
* Changkat Jering-Ipoh	1.19
* Nilai-Seremban	1.16
* Simpang Ampat-Ayer Keroh	1.24
Average	1.16
TOLL HIGHWAYS	
* Penang Bridge	1.10
* Karak Highway	1.20
* Senai-Johor Bharu Highway	1.10
Average	1.13

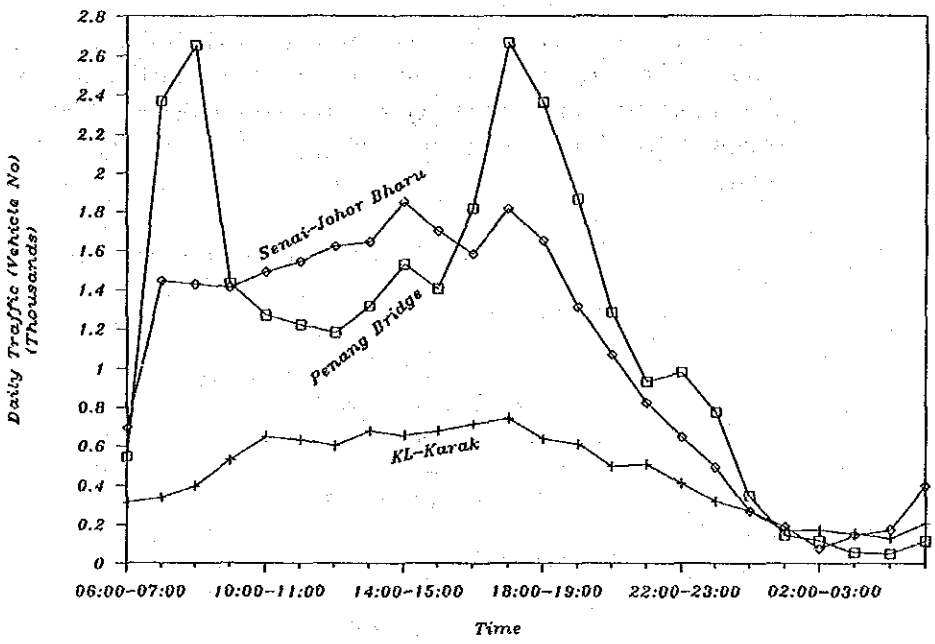
Source: Traffic Counting Survey, January 1989

At Simpang Ampat-Ayer Keroh section, of the total traffic between 10pm to 6am, 47.4% are trucks (Class 2 and 3) compared to 27.9% for the whole day. For Karak Highway, 38.0% of the night traffic are trucks compared to 25.2% for the whole day.

5) Hourly Traffic Variation

The traffic survey results are examined for the hourly traffic variations at the seven expressway and highway sections. Figures 2.2.3 and 2.2.4 show the hourly traffic variation pattern on the toll highways and North-South Expressway respectively.

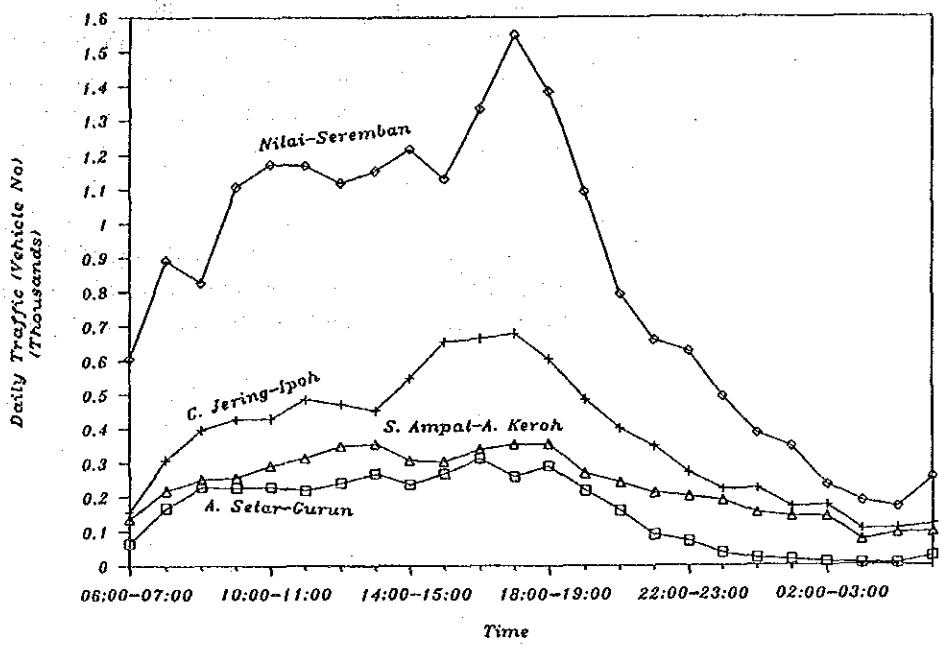
Traffic on Penang Bridge displays a distinctive 2-peak pattern, a typical hourly variation pattern of a commuter traffic. Traffic on Senai-Johor Bharu Highway is concentrated between 7am to 6pm with a highest peak in the early afternoon and lesser peaks in the evening and morning. This shows that there is therefore also a considerable amount of commuter traffic on this highway. Traffic on Karak Highway, on the other hand, is more evenly distributed throughout the day, a typical characteristic of inter-urban traffic.



Source: Traffic Count Survey, January 1989

Figure 2.2.3: Hourly Variation of Daily Traffic on Toll Highways

Figure 2.2.4 shows the hourly fluctuation of traffic on four sections of the North-South Expressway. Traffic on Nilai-Seremban section is distinctively different from the other three sections. The traffic distribution pattern shows that there is a considerable amount of commuter traffic on Nilai-Seremban section. Traffic pattern for the other three sections are more typical of inter-urban traffic.



Source: Traffic Count Survey, January 1989

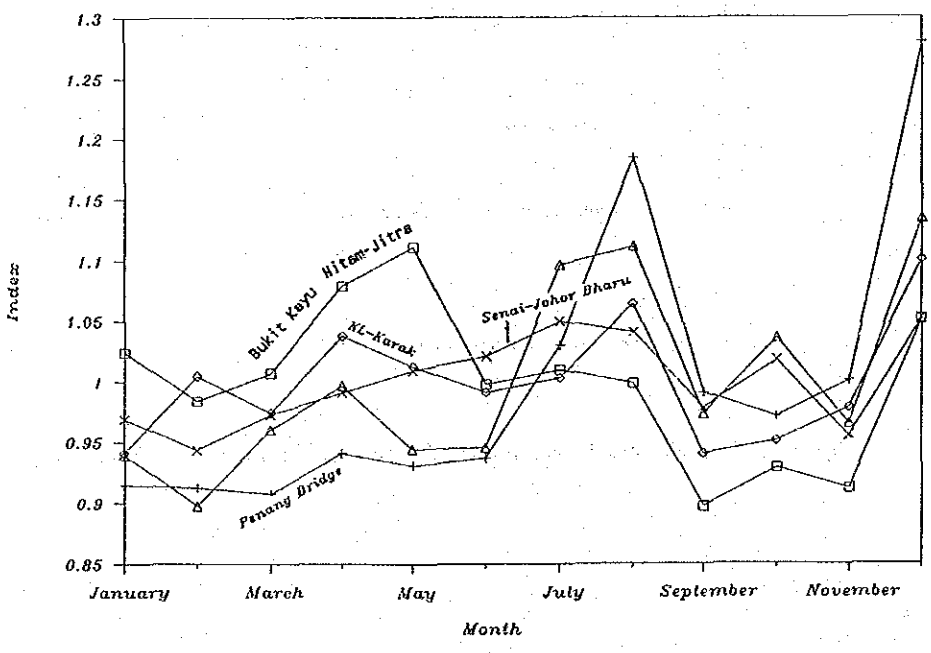
Figure 2.2.4: Hourly Variation of Daily Traffic on North-South Expressway

6) Monthly Traffic Fluctuation

The average monthly traffic fluctuations on the expressway sections and toll highways are described below using data from toll records (at the toll barriers only) from MHA. The following section however should be read with a note that the traffic does not include motorcycle.

The analysis of monthly traffic fluctuation is essential as it provides information for the planning of maintenance works or repairs. Such works can therefore be planned during months that have relatively little traffic so as to minimize disruption to traffic flow on the expressway or highways.

Since some of the sections of the expressway such as Changkat Jering-Ipoh section, Seremban-Ayer Keroh section are relatively new, specific monthly traffic fluctuation pattern cannot be concluded as traffic on these new sections are not stabilized. Traffic are more or less stabilized on older sections like Penang Bridge, Karak Highway and Kuala Lumpur-Seremban section. On these sections the month of December consistently shows up as the month throughout the year that has the highest traffic. This coincides with the holiday seasons as well as the long school holidays. On Karak Highway and Kuala Lumpur-Seremban section, traffic also increases significantly in the month of April and August which are the other shorter school holiday seasons. The monthly fluctuation for these five sections are shown in Figure 2.2.5.



Source: Traffic Count Survey, January 1989

Figure 2.2.5: Monthly Traffic Fluctuation on Selected Expressway Sections and Toll Highways

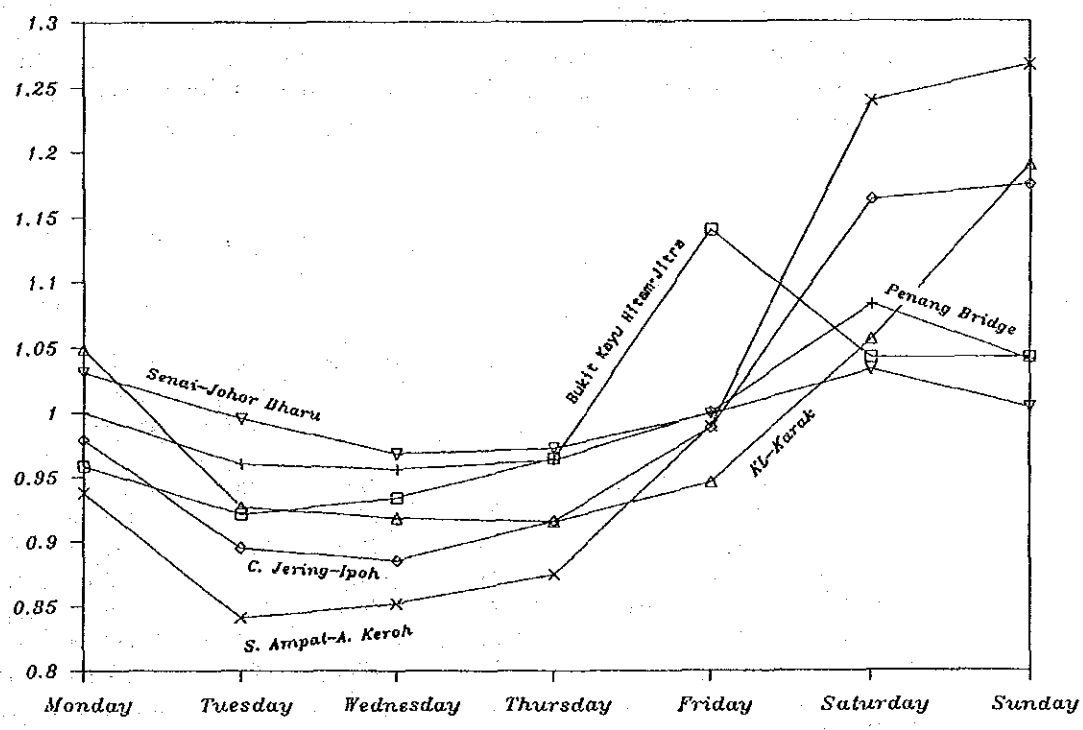
7) Weekly Traffic Fluctuation

The average daily traffic by day of week are analyzed to reveal the weekly traffic fluctuation on the expressways and highways. This analysis also uses data from MHA's toll collection records.

In general, weekly traffic fluctuation on all sections of the expressway and toll highways do display more consistent pattern compared to monthly fluctuation. All sections of expressways and highways show significant increases during the weekends. Social and recreation trips probably explain such a pattern.

The weekly traffic fluctuation on selected expressway sections and toll highways is presented in Figure 2.2.6.

The weekly traffic pattern for Penang Bridge and Senai-Johor Bharu Highway indicate a peak on Saturday and a trough in mid-week. Similar pattern is found on Karak Highway except that the weekend peak happens on Sunday.



Source: Traffic Count Survey, January 1989

Figure 2.2.6: Weekly Traffic Fluctuation on Selected Expressway Sections and Toll Highways

2.2.2 Traffic Characteristics on Federal Route 1

Federal Route 1 runs along side the North-South Expressway alignment and a large portion of inter-urban trips on the Federal Route 1 will undoubtedly be transferred to the expressway when the latter is open to traffic in the near future. Traffic volume on Federal Route 1 between Changkat Jering to Ipoh for example has dropped by about 50% since the expressway section between these two points was opened to traffic in 1987.

Traffic characteristics on an expressway is significantly different from an urban arterial road as it carries more long-distance inter-urban trips. However, for those sections of the North-South Expressway that have yet to be constructed, analysis of traffic characteristic on the Federal Route 1 will throw some light on the likely characteristics and travel pattern of future traffic on the expressway when it will be fully operational by 1995.

1) Average 16-Hour Traffic Volume

Station 73 on Federal Route 2 at Batu Tiga (section between Shah Alam and Kuala Lumpur) counted an average of 91,867 vehicle in 1988 (Table 2.2.6).

Sections of Federal Route 1 leading to Kuala Lumpur and Butterworth have traffic volume of about 20,000; while those between Ipoh to Tanjung Malim have about 10,000 vehicles. The section of Federal Route 1 towards Air Hitam from Segamat also has a traffic volume of about 10,000. The section from Tampin to Segamat has a low traffic volume of only 3125.

Table 2.2.6: Average 16-Hour Traffic and Peak Hour Traffic at Census Station in 1986

(Unit: Vehicles)

	Station	Average No.	Peak 16-Hour Traffic	Time Hour Traffic	%
1) Butterworth-Nibong Tebal	10	19701	1359	10-11 am	6.9
2) Bidor-Tanjung Malim	21	10648	817	4-5 pm	7.7
3) Tanjung Malim-Rawang	50	9537	765	4-5 pm	8.0
4) Rawang-Kuala Lumpur	24	21196	1478	1-2 pm	7.0
5) Shah Alam-Petaling Jaya	73	91867	8326	5-6 pm	9.1
7) Tampin-Segamat	38	3125	285	7-8 am	9.1
8) Segamat-Air Hitam	41	9716*	845	6-7 pm	8.7

Source: HPU
Note: * 1987 Figures

The peak hour traffic on the selected Federal Route 1 section are also shown in Table 2.2.6. Peak hour traffic on Federal Route 2 at Batu Tiga was high at over 8,000 vehicles. Such a high volume indicates probable frequent peak hour congestion on the 4-lane highway. On Federal Route 1, sections leading to Butterworth and Kuala Lumpur had peak hour traffic of about 1300 to 1500 vehicles, while those between Ipoh-Tanjung Malim and Segamat-Air Hitam had about 800 vehicles.

Figures 2.2.7 and 2.2.8 show the 16 hour traffic volume on Federal Route 1 in 1986 and 1988 respectively. Traffic is concentrated in the Klang Valley Region and towards major urban centers of Penang, Ipoh and Johor Bharu.

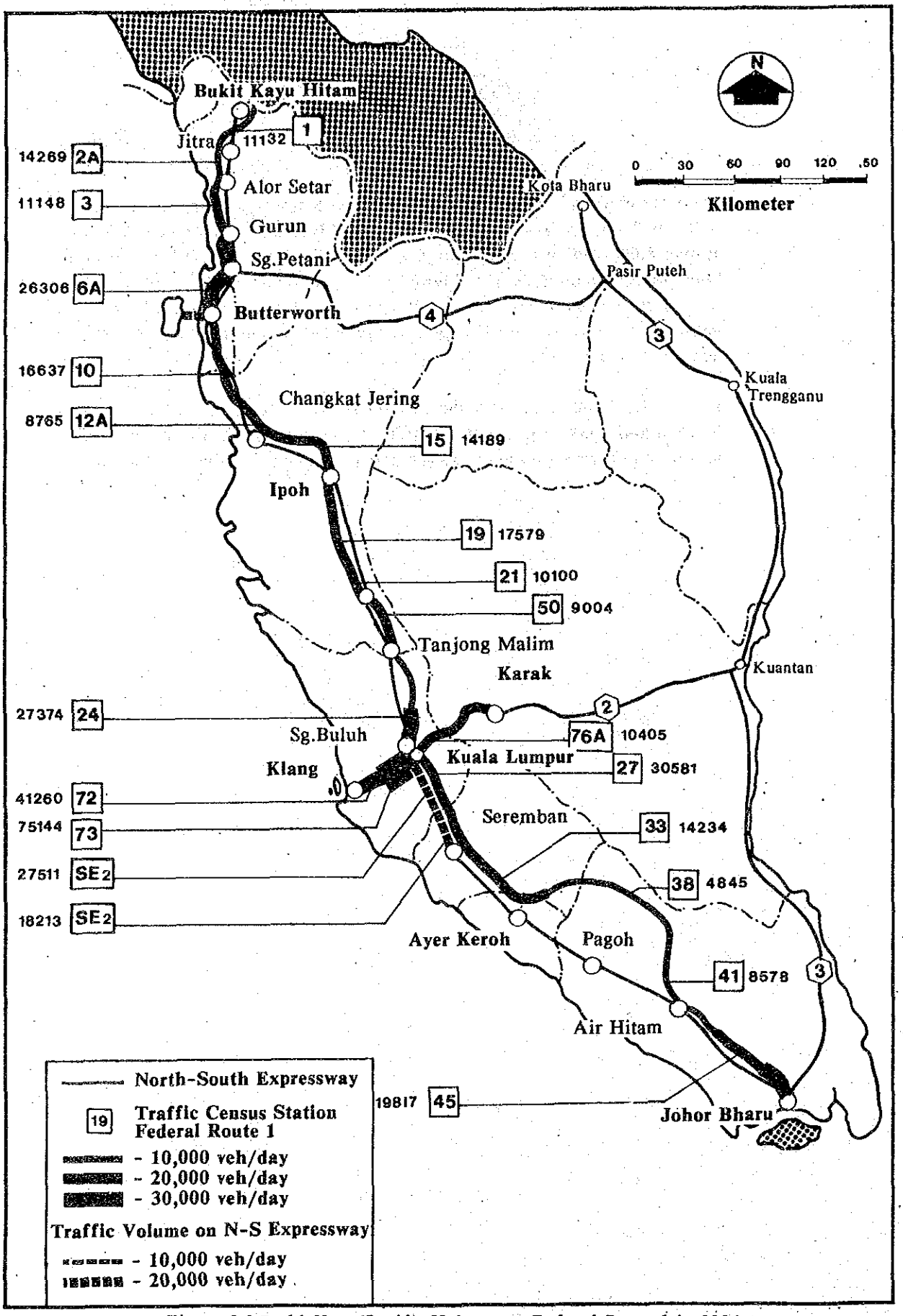


Figure 2.2.7: 16 Hour Traffic Volume on Federal Route 1 in 1986

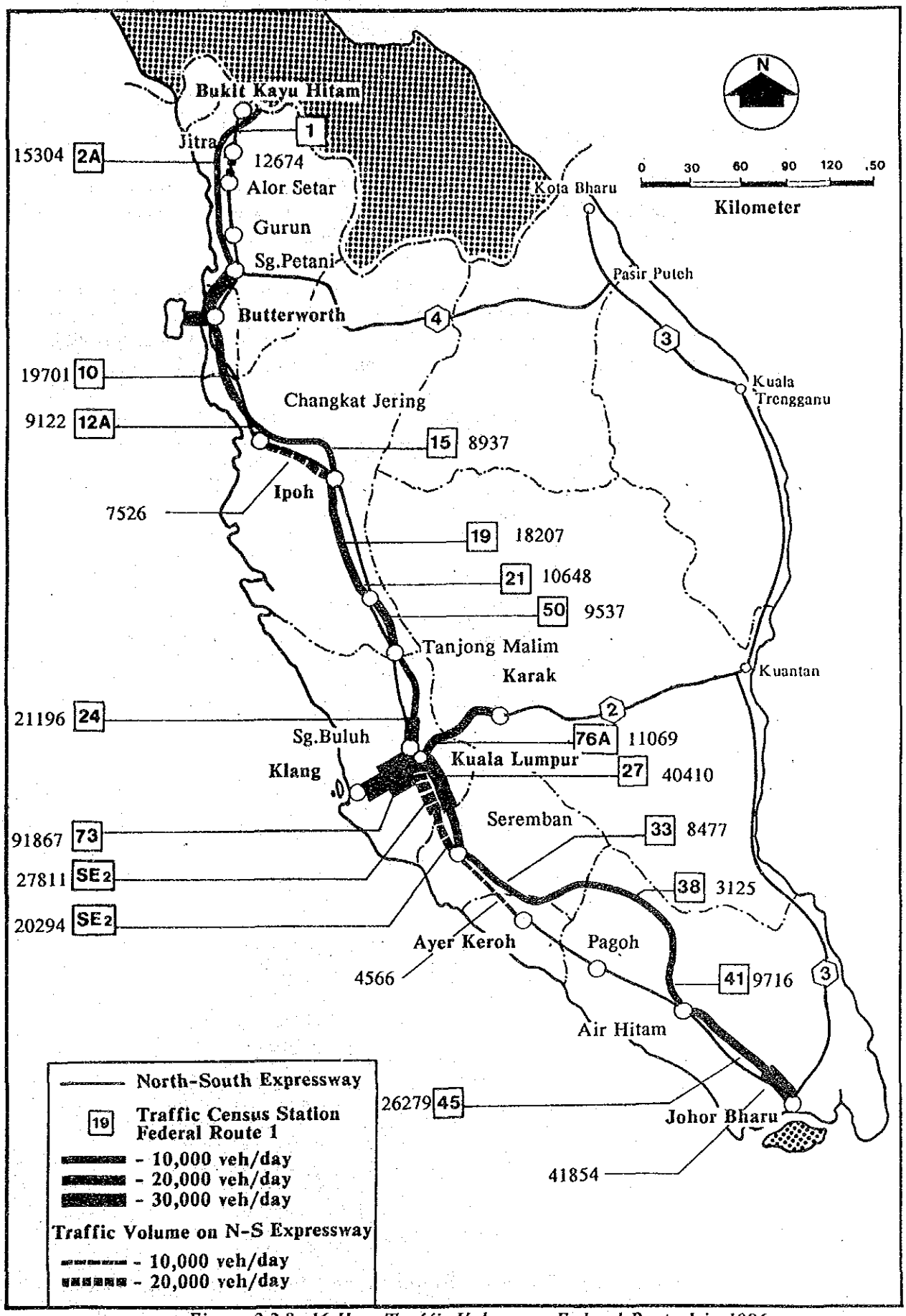


Figure 2.2.8: 16 Hour Traffic Volume on Federal Route 1 in 1986

2) Traffic Composition

Traffic composition at the seven selected census stations are shown in Table 2.2.7 and Figure 2.2.9. Station No.73 on Federal Route 2 counted an average 62.8% of cars and taxis and 16.7% motorcycles.

The six sections of Federal Route 1 have an average share for cars and taxis of over 40% and for motorcycle, over 12%. High percentage of large trucks are recorded for Segamat-Air Hitam (15.3%), Rawang-Kuala Lumpur (11.4%), Butterworth-Nibong Tebal (10.2%), Tampin-Segamat (10.1%).

Table 2.2.7: Traffic Composition at Selected Traffic Census Stations

HPU Traffic Census Station		Average Value	Vehicular Share (%)						
No	Section	for Year	Car & Taxi	Light Van	Medium Lorry	Heavy Lorry	Bus	Motorcycle	Total
10	B'worth-N. Tebal	1984-88	45.3	8.4	10.2	10.2	3.8	22.2	100.0
21	Bidor-Tg. Malim	1984-88	48.7	12.4	10.1	8.6	4.1	16.1	100.0
50	Tg. Malim-Rawang	1985-88	54.7	12.4	9.4	6.3	4.8	12.4	100.0
24	Rawang-KL	1984-88	43.9	14.0	11.3	11.4	3.8	15.6	100.0
73	Shah Alam-KL	1984-88	62.8	8.8	6.6	3.1	2.1	16.7	100.0
38	Tampin-Segamat	1984-88	44.7	9.7	10.0	10.1	2.2	23.2	100.0
41	Segamat-A. Hitam	1985-87	41.9	9.4	16.7	15.3	2.3	14.5	100.0

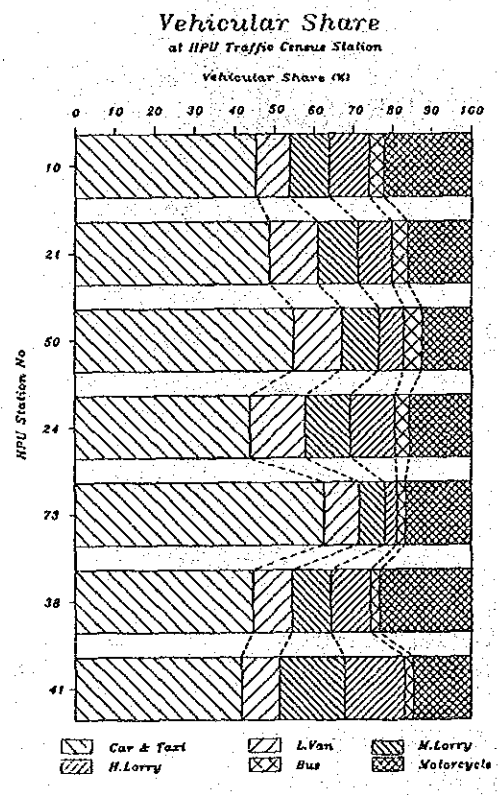


Figure 2.2.9: Traffic Composition at Selected Traffic Census Stations

2.2.3 Travel Speed on the Expressway and Highways

Spot speed survey by type of vehicles on selected expressway and highway sections were carried out using radar apparatus. Survey locations were set at fairly flat and straight stretches on the expressway and highways. The survey was carried out one hour each at different time periods (8-9 am, 1-2 pm, 5-6 pm and 10-11 pm) in order to capture travel speed at different flow conditions.

1) Spot Speed on Toll Highways

The results of spot speed surveys on the three toll highways are shown in Figure 2.2.10. The distribution on Karak Highway stands out with larger speed differences between types of vehicles, particularly between car and heavy truck, heavy and medium truck. Speed differences are less profound on Senai-Johor Bharu Highway. Only about 40% of passenger cars are found to travel at or below the speed limit of 80 km/hr on all the three toll highways.

2) Spot Speed on North-South Expressway

Results of the spot speed survey as from expressway section are shown in Figure 2.2.11.

About 85% of passenger cars are found to travel at and below the speed limit of 110 km/hr on straight stretches of Kuala Lumpur-Seremban Expressway, Alor Setar-Gurun and Changkat Jering-Ipoh sections. On Seremban-Ayer Keroh section, 75% of passenger car travels at or below the 110 km/hr speed limit.

Large differences in travel speed between vehicle types are more significant on Seremban-Ayer Keroh section and Alor Setar-Gurun section when compared to the other two sections.

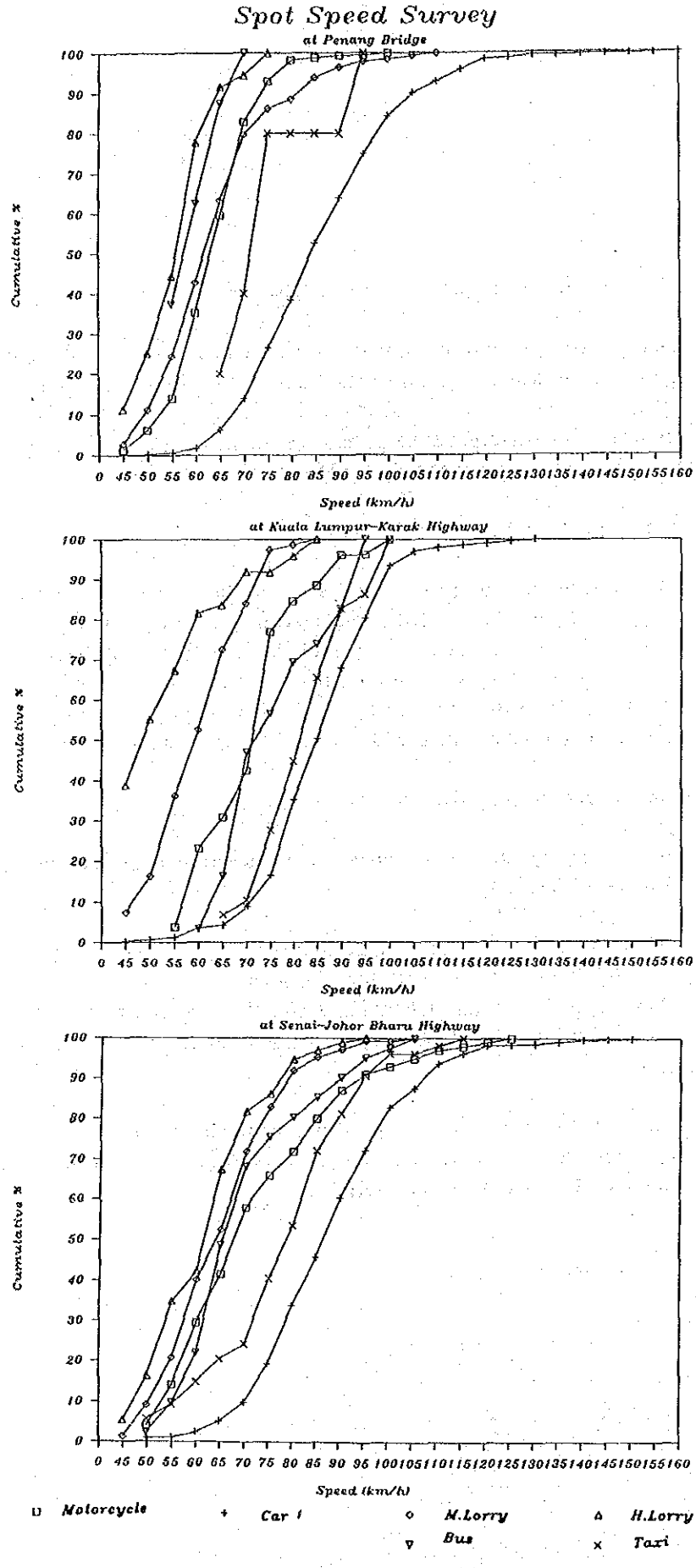


Figure 2.2.10: Cumulative Frequency of Travel Speed by Vehicle Type on Toll Highways

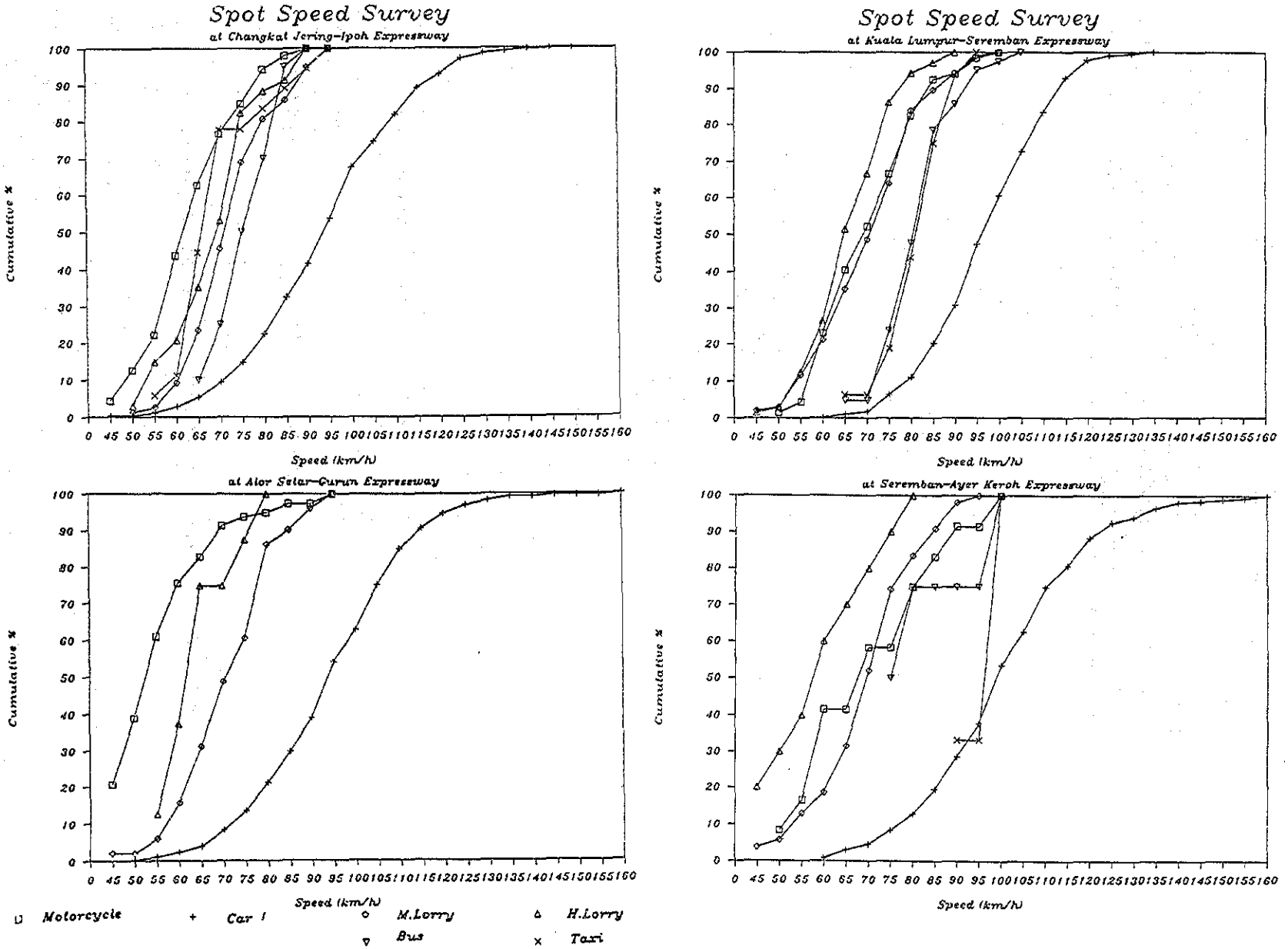


Figure 2.2.11: Cumulative Frequency of Travel Speed by Vehicle Type on North-South Expressway

3) Travel Speed Differences Between Expressway and Toll Highways

Figure 2.2.12 compares the travel speed frequency distribution between expressway sections and toll highways. Travel speed of passenger cars and medium trucks differ significantly between expressway section and toll highways. Travel speed of heavy truck and motorcycle are fairly similar in distribution between expressway and toll highways.

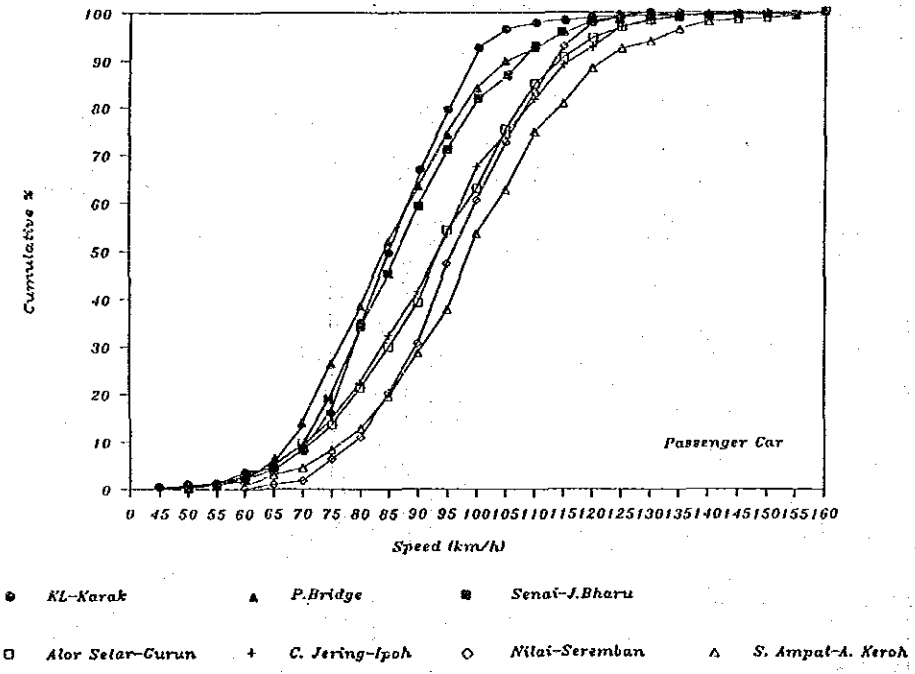


Figure 2.2.12: Cumulative Frequency of Travel Speed by Vehicle Type

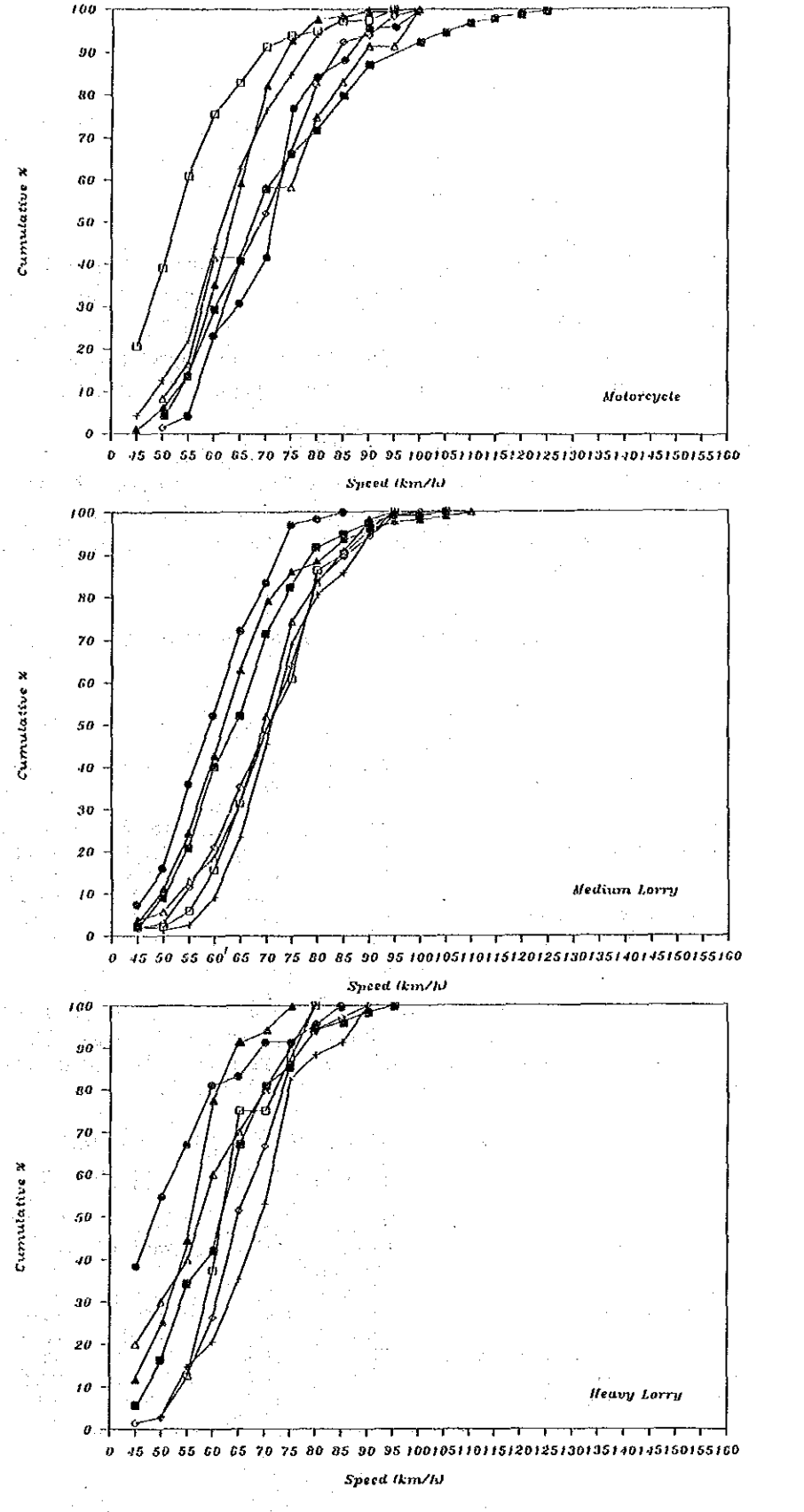


Figure 2.2.12 (Cont'd): Cumulative Frequency of Travel Speed by Vehicle Type

2.2.4 Running Speed of Heavy Goods Vehicles

The running speed of heavy goods vehicle on two particularly hilly stretches of expressway and highway, namely Karak Highway and Changkat Jering-Ipoh section of the North-South Expressway was carried out on January 1989. The survey was carried out using the floating car method whereby the survey car floats with the sampled truck and records the running speed for every 100 meter.

On the Changkat Jering-Ipoh section, the survey covers a distance of 47.0 km starting from 90.0 km post (start of steep vertical gradient) to Jelapang Toll Plaza at 137 km post. Four different types of heavy goods vehicle were sampled and the survey results are shown in Table 2.2.8. The maximum gradient along this expressway section is about 5.5%.

Table 2.2.8: Running Speed Survey of HGV at Changkat Jering-Ipoh Section

	Sample 1	Sample 2	Sample 3	Sample 4
Type of Vehicle	3-axle	3-axle	Container	3-axle
Type of Goods	Machinery	Gas Cylinder	(Unknown)	Construction
Estimated Load	19 tonnes	12 tonnes	20 tonnes	15 tonnes
Direction of Travel	North bound	North bound	South bound	South bound
Average Journey Speed (km/h)	38.6	52.0	43.7	53.0
Maximum Speed (km/h)	63.5	84.7	66.7	90.0
Minimum Speed (km/h)	6.0	9.7	17.1	18.0

On Karak Highway, the survey was conducted for a 42.8 km stretch from 18.9 km post (Gombak Toll Plaza) to 61.7 km post (Karak Toll Plaza). The maximum gradient along this stretch is about 8.0%. Four samples were also selected and the results of running speed survey are shown in Table 2.2.9.

Table 2.2.9: Running Speed Survey of HGV on Karak Highway

	Sample 1	Sample 2	Sample 3	Sample 4
Type of Vehicle	3-axle	3-axle	3-axle	3-axle
Type of Goods	Building Materials	General	Palm Oil	General
Estimated Load	27 tonnes	16 tonnes	28 tonnes	17 tonnes
Direction of Travel	East bound	East bound	West bound	West bound
Average Journey Speed (km/h)	33.6	33.8	32.5	40.0
Maximum Speed (km/h)	81.8	72.0	72.0	77.1
Minimum Speed (km/h)	1.3	10.3	3.5	3.9

The survey shows that there is a vast difference in maximum and minimum speed of heavy trucks on both stretches of highway and expressway. The difference is more profound on Karak Highway with its steeper vertical gradient. On the upslope, speed may fall to as slow as 2 km/hr. The overall average speed on Karak Highway is also lower than Changkat Jering-Ipoh section. On this section of the North-South Expressway, heavy truck running speed may drop to around 6 km/hr.

2.2.5 Accident Characteristics on Expressway and Highway

1) Accident on Expressway

A representative accident data on North-South Expressway was obtained for the stretch of Kuala Lumpur-Seremban (length 53 km).

The total number of traffic accident on Kuala Lumpur-Seremban Expressway increased from 280 in 1979 to 374 in 1986.

However, the highest accident number during the eight years (1979-1986) was 587 cases in 1985. In terms of fatal cases, the number has increased from 18 in 1979 to 23 in 1986 while the number of casualties has increased from 134 in 1979 to 234 in 1986 (Table 2.2.10).

In 1986, the accident rate was 110.9 per 100 million vehicle km and fatality rate was 76.2 per 100 million vehicle km.

Table 2.2.10: Expressway Traffic Accident Statistics (Kuala Lumpur-Seremban Expressway)

Year	No. of Casualty			No. of Non-Casualty	Total No. of Accidents	Total Expressway Length in Operation in Kilometers
	Fatal	Major	Minor			
1979	18	67	67	128	280	53
1980	14	86	53	122	275	53
1981	9	66	72	121	268	53
1982	22	98	108	185	413	53
1983	14	39	79	142	274	53
1984	11	22	67	100	200	53
1985	36	96	222	233	587	53
1986	23	78	156	117	374	53

2) Accident on Highway

For analysis on highway traffic accident statistics, accident data on Karak Highway is gathered. The total number of accident on Karak Highway increased from 179 in 1979 to 290 in 1986 which means an increase of 62% over the eight year period.

The number of fatality increased from 4 in 1979 to 12 in 1986 while the casualty cases increased from 86 in 1979 to 237 in 1986 (Table 2.2.11).

On the other hand, according to the data obtained from Bentong Police Station, 176 accident numbers were reported in 1986 on the stretch from 40 km to 48 km (Bukit Tinggi). This high accident occurrence clearly marks out this stretch as one of the killer section on Karak Highway.

Table 2.2.11: Highway Traffic Accident Statistics (Karak Highway)

Year	No. of Casualty			No. of Non-Casualty	Total No. of Accidents	Total Highway Length in Operation in Kilometers
	Fatal	Major	Minor			
1979	4	22	64	89	179	68
1980	10	35	45	100	190	68
1981	-	39	54	93	186	68
1982	15	25	41	71	152	68
1983	5	19	37	70	131	68
1984	9	8	19	33	69	68
1985	7	71	143	47	268	68
1986	12	104	133	41	290	68

2.3 Current Status of Traffic Management

2.3.1 Organization and its Role in Traffic Management

1) Headquarters, Regional and Maintenance Offices

The organization chart of Malaysian Highway Authority is illustrated in Figure 2.3.1.

The authority is headed by a Chairman and managed by a Director General with assistance from two Deputy Director Generals, one of them is responsible for technical affairs and the other administration and finance.

The technical department consists of regional division, operation division as well as quantity survey and contract administration division.

The administration and finance department encompasses administration division, finance division, legal section and enforcement division.

With regards to the regional division, there are four (4) regional directors in charge of each sub-divided sections of the expressways i.e. northern region (I), northern region (II), central region and southern region.

Under the regional division, maintenance depots are set up in the central and southern regions to undertake or oversee maintenance works on the expressways.

Apart from regional offices and maintenance offices, two tunnel control offices are set up, one at the eastern part of the Genting Sempah Tunnel on the Karak Highway (under MHA) and the other at the Menora Tunnel on the Changkat Jering-Ipoh stretch of the North-South Expressway (under PLUS). Its role is to manage the various facilities such as ventilation system, lighting system, emergency facilities, etc. provided in the tunnel. The tasks include monitoring and manual control of facilities, maintenance of facilities, etc.

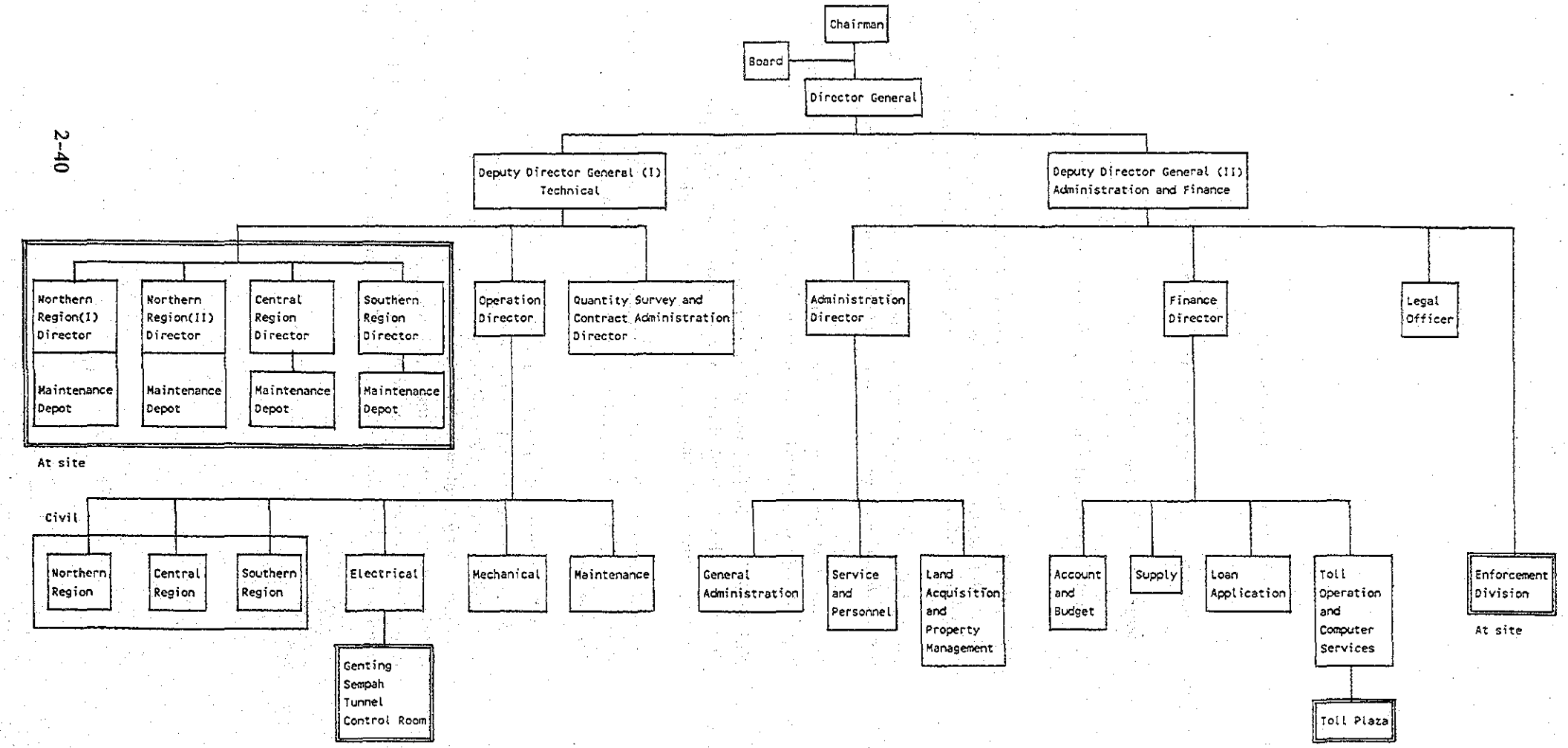


Figure 2.3.1: Organization Chart of Malaysian Highway Authority

As mentioned earlier, PLUS, the concession company is fully responsible for the financing, construction, maintenance and operation of all expressways except Karak Highway and Penang Bridge. As such, the role of Malaysian Highway Authority is to directly maintain and manage the Karak Highway and Penang Bridge as well as to oversee due performance of the company so that they take all their responsibilities and obligations under the concession. This includes all design and specification changes proposed by the company must have prior approval of the authority.

The location and coverage section of regional office and related office is illustrated in Figure 2.3.2.

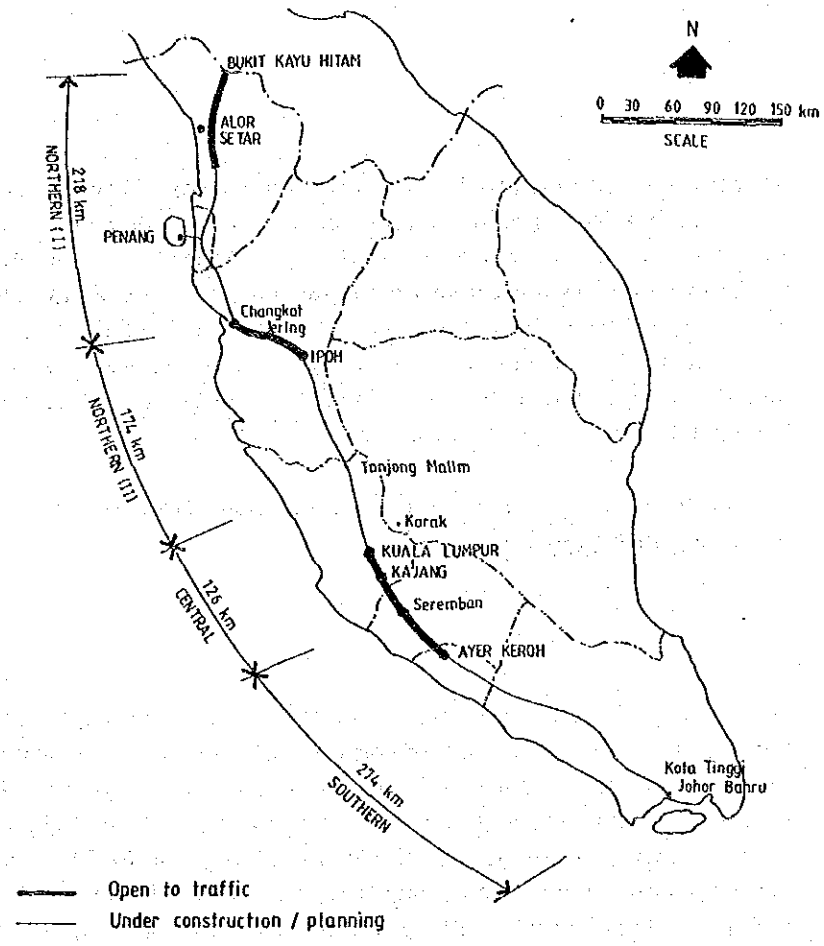
2) Toll Plaza

Under the present organizational structure of Malaysian Highway Authority, the toll plaza is under the toll operation and computer services unit which in turn is under the finance division. After privatization of the North-South Expressways to PLUS, all toll plazas except those on Penang Bridge and Karak Highway fall under the jurisdiction of PLUS. As such, MHA is only involved in the toll collection on the Penang Bridge and Karak Highway. The toll plaza is responsible not only for toll collection but also for traffic operation purposes whereby the emergency telephone service is linked to the toll plaza supervisors who will summon help immediately to render assistance to any user in distress.

3) Highway Police Unit

An important component in the traffic management of the interurban expressway is the Highway Police Unit which are stationed in the enforcement division under the administration and finance department.

This division is staffed with twenty-one (21) police personnel from the Police Headquarters, headed by an Assistant Superintendent Police (ASP) and assisted by an Inspector. The rest are one sergeant, two (2) corporals and fifteen (15) constables.



Region	Regional Office	Coverage Section	Maintenance Depot/ Control Room
Northern (I)	Alor Setar	Bukit Kayu Hitam-Changkat Jering (218 km)	
	Penang	Penang Bridge (14 km)	
Northern (II)	Ipoh	Changkat Jering-Tanjung Malim (174 km)	Meru-Menora Tunnel Control Room (PLUS)
Central	Kajang	Tanjung Malim-Seremban Utara (126 km)	Karak Highway Maintenance Depot Genting Sempah Tunnel Control Room
Southern	Ayer Keroh	Seremban Utara-Kota Tinggi (274 km)	Senai Maintenance Depot

Figure 2.3.2 : Location and Coverage Section of Regional Office and Related Office

Basically, the police personnel performs dual duties of patrol and enforcement of traffic regulation on Malaysian Expressways and toll highways. In detail, the coverage area of about four hundred (400) kilometers includes the sections of Bukit Kayu Hitam-Gurun, Penang Bridge, Ipoh-Changkat Jering, Tanjung Malim-Slim River, Kuala Lumpur-Ayer Keroh, Kuala Lumpur- Karak and Senai-Johor Bharu.

The members of this enforcement division is entrusted to carry out patrol duty on the expressways. Daily patrol is carried out on the sections of Kuala Lumpur-Seremban, Seremban-Ayer Keroh, Kuala Lumpur-Karak and Penang Bridge. The stretch of Bukit Kayu Hitam-Gurun and Ipoh- Changkat Jering are covered once every two weeks whereas the Senai-Johor Bharu Highway is patrolled once a month. In case of emergency, they receive message from the toll plaza through telephone and rush to the site to control traffic and give assistance to accident victim.

As police personnel, they are authorized to enforce traffic regulation of speeding, overloading of heavy vehicles, roadblock related to roadworthy, usage and construction, overloading of passengers and other traffic offenses.

2.3.2 Traffic Operation

Broadly, traffic operation encompassed traffic surveillance and control with support from police in traffic regulation and toll collection.

1) Traffic Surveillance

An important surveillance device is the emergency telephone which unfortunately is only located on certain sections of the expressways.

Another information source is through the patrol cars. However, only a few expressway sections are patrolled daily while the rest is patrolled once or twice a month. As such, there is still plenty of room to upgrade this surveillance method.

Under the existing system, only traffic volume data on the expressway is detected automatically by detectors installed at the toll gates. A centralized system of on-line data exchange is yet to be set up within the highway authority.

With the data collection system still in the infancy stage, the related data processing and conveying of information cannot be established. As such, there is lack or in most cases, absence of information readily available for expressway users as well as traffic related agencies. This undesirable situation exists despite of the frequent occurrence of stranded cars and accidents on the expressways.

Currently, the communication network only made use of the public telephone line. A radio communication system to provide communications between command station (for instance, toll plaza) and mobile telephones of patrol cars and service vehicles in emergency cases is being planned for Penang Bridge. For effective and prompt traffic management, exclusive telephone and radio systems are required.

2) Traffic Control

Lately, there is some traffic control measures on certain sections of the expressways.

For instance, daily patrol is carried out by patrol cars under the Enforcement Division of MHA on the stretches of Kuala Lumpur-Ayer Keroh, Kuala Lumpur-Karak and Penang Bridge. For other sections of expressways which have been opened to traffic, patrolling is conducted once or twice a month.

Besides, enforcement of speed limit and overloading vehicles is carried out regularly by the Enforcement Division.

The aforesaid traffic control measure is applicable under normal conditions. Inevitably, under adverse conditions, more comprehensive and stringent measures are needed. Recently, a version of this traffic control measure with its communication flow network is set up for the Kuala Lumpur-Ayer Keroh Expressway.

Figure 2.3.3 illustrates the communication flow network in case of incident, for example, occurrence of accident.

As illustrated, toll plaza is the activity centre of this traffic control system. Information regarding any accident or obstruction on the expressway is conveyed to the toll plaza through various means.

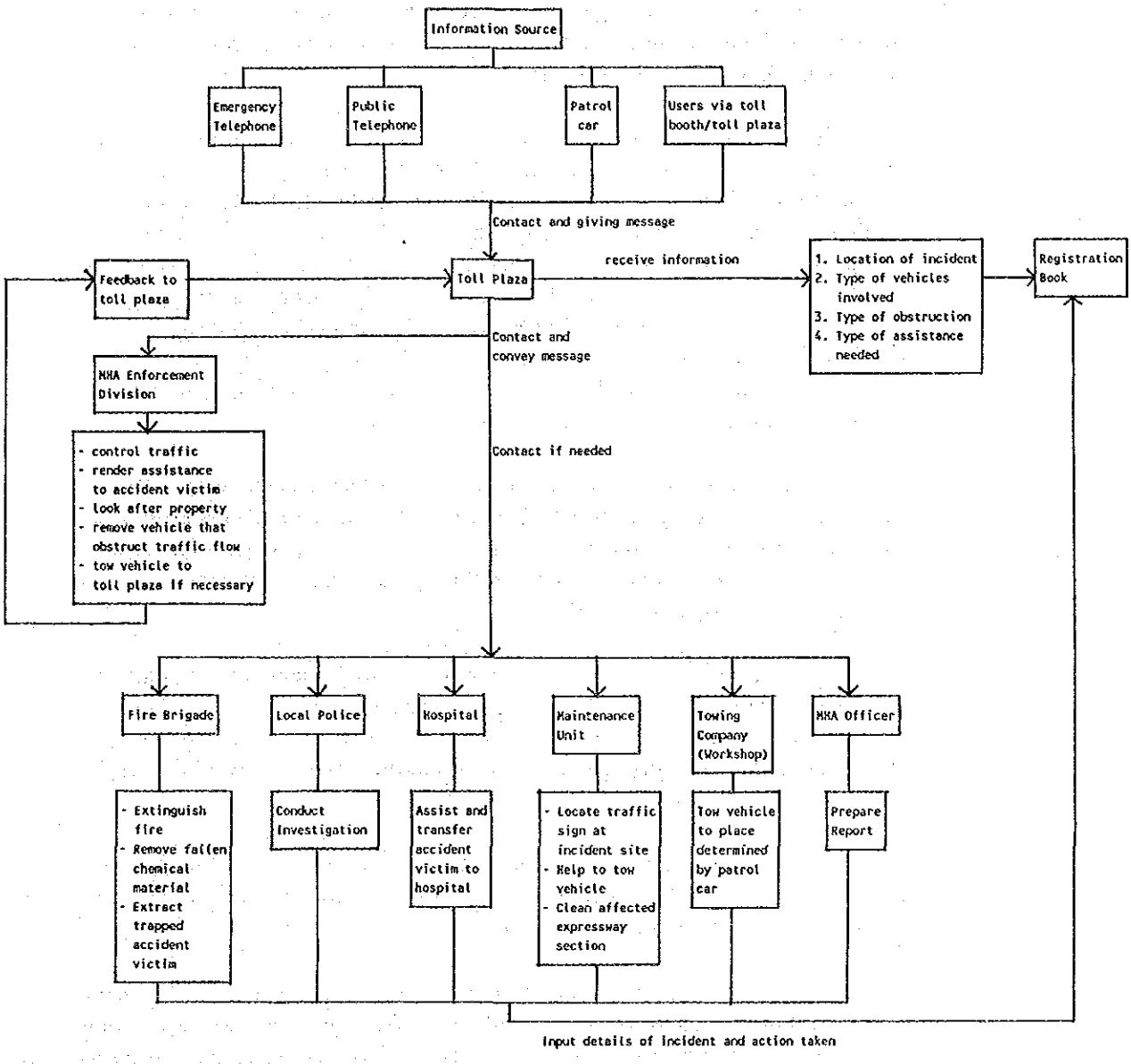


Figure 2.3.3 : Communication Flow Network Under Adverse Condition

2.3.3 Traffic Control and Safety Facilities

1) Emergency Telephone Facilities

Expressways are enclosed space with interchanges being the only outlet to other roads, hence emergency telephones are needed to inform the control room or toll plaza in case of accident or incident.

Presently, emergency telephones are provided to certain sections of the North-South Expressway; i.e. at the stretch between Senawang and Ayer Keroh and in the Meru-Menora Tunnel located north of Ipoh. The emergency telephone along the stretch from Senawang to Ayer Keroh is the first full-scale emergency telephone service extended to the expressway users in Malaysia. The Meru- Menora tunnel is also provided with various tunnel facilities including the emergency telephones since opened in 1987. Besides these aforesaid sections, the emergency telephone are also installed on the Penang Bridge and Genting Sempah Tunnel. Table 2.3.1 depicts the current status of existing emergency telephones in Malaysia.

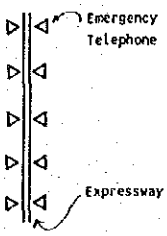
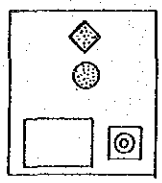
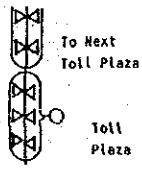
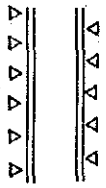
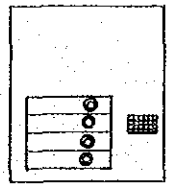
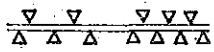
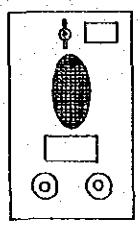
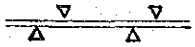
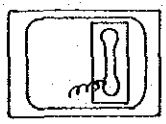
Even though 268 km of North-South Expressway have been completed and opened to traffic, only the stretch between Senawang and Ayer Keroh of 62 km and Meru-Menora Tunnel of about 1 km are equipped with emergency telephones. The large portion of the toll expressways are not provided with this essential emergency facilities.

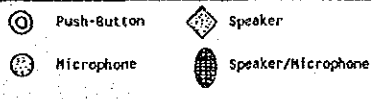
The current emergency telephone service is not widely known amongst expressway users, and some of them have no knowledge of using it. There are four (4) types of telephone on four (4) different sections of the expressways. This absence of uniformity causes confusion amongst expressway users thereby render its ineffectiveness.

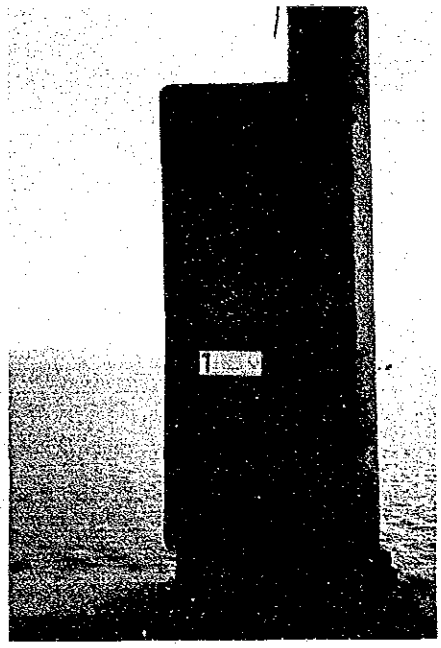
In addition, in the case of emergency telephones in the Genting Sempah Tunnel on the Karak Highway, the users cannot identify the location sign of the telephones as they are covered with dust.

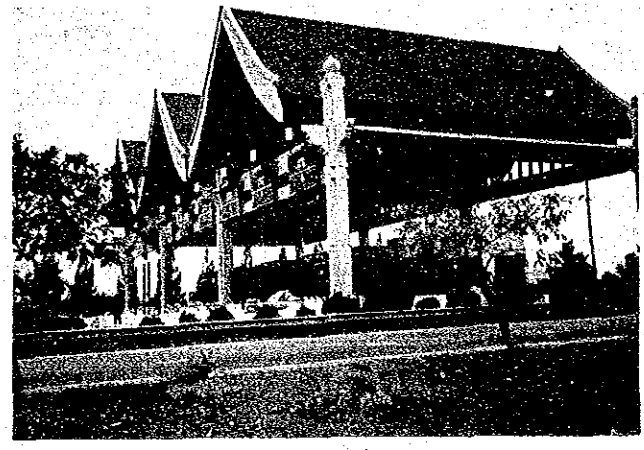
Besides the aforementioned shortcoming of the telephone services from the user's point of view, another major inadequacy from the administrator's point of view is the absence of proper communication flow system on some sections of the expressway that defines the cooperation amongst the highway authority, police, hospital, fire brigade and towing company.

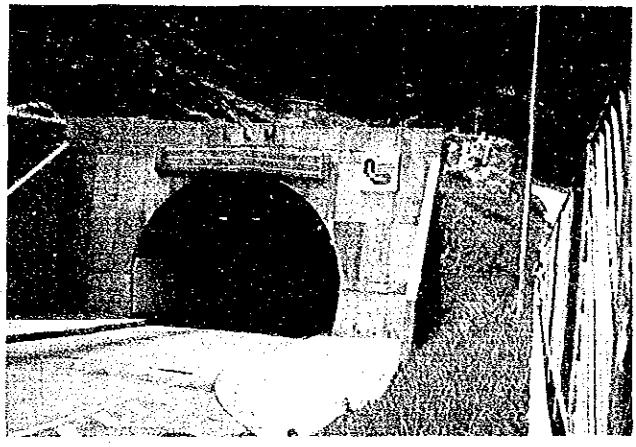
Table 2.3.1 : Existing Emergency Telephone System

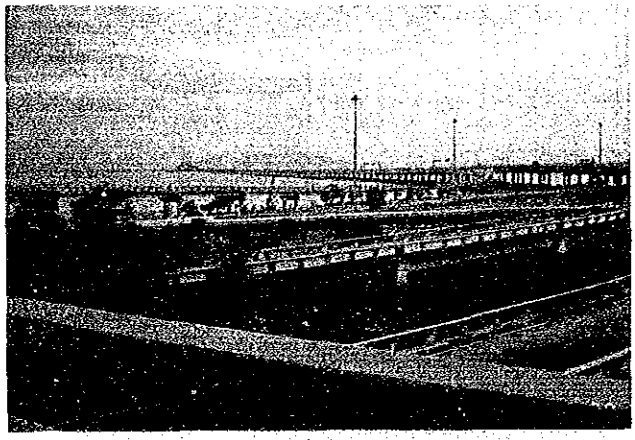
Items / Section	Length of Stretch	Numbers of Emergency Telephone	Location Layout	Interval of Location	Front Panel Layout	Information Receiving Office	Frequency In Use
Senawang - Ayer Keroh Expressway	62 km	62 (North Bound 31) (South Bound 31)		2 km		Nearest Toll Plaza (3 toll plaza) 	15/month/plaza
Keru-Menora Tunnel	830 m (Keru Tunnel) (South Bound) 880 m (Menora Tunnel) (North Bound)	11 (South Bound 5) (North Bound 6)		150 m		Control Room	20/month
Penang Bridge	13.5 km (Overall length) 8.4 km (Over water)	12 (East Bound 5) (West Bound 7)				Toll Plaza	30/month
Genting Sempah Tunnel	950 m	4 (East Bound 2) (West Bound 2)				Control Room	2/month

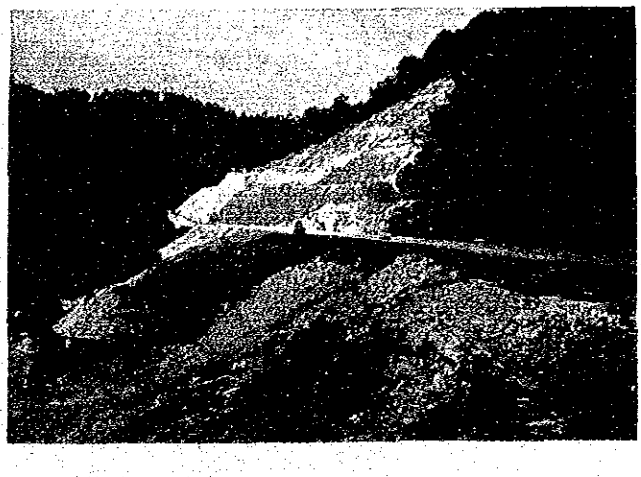












1 2 3 4 5 6 7

1. User-select push button type of emergency telephone installed along Penang Bridge.
2. Toll plaza at Penang Bridge.
3. An overall view of Penang Bridge and its approach from the Island.
4. Section of the North-South Expressway between Bukit Kayu Hitam and Jitra where there is no access control.
5. Entrance to the double-bore Menora Tunnel.
6. The Menora Tunnel is bright and with wall linings. The tunnel lighting is automatically adjusted to the brightness outside.
7. One of the poorly treated steep embankment slope along the Jelapang-Changkat Jering Section along the North-South Expressway.

2) Toll Collection System

Basically, the toll collection system adopted for the North-South Expressway is a closed toll system although open system is also adopted.

a) Closed Toll System

The closed toll system has been employed on 286 km of the North-South Expressway i.e. the sections of Jitra-Gurun (56 km), Changkat Jering-Ipoh (56 km), Kuala Lumpur-Ayer Keroh (121 km) and Ayer Keroh-Pagoh (53 km). Under the closed toll system, the user pays the amount of toll based on the distance travelled. Besides, the toll charge levied is also depended on the type of vehicles used. For the purpose of toll collection, the vehicles are classified into six (6) types.

b) Open Toll System

Open toll system is adopted on the 24 km of Bukit Kayu Hitam-Jitra, 14 km of Penang Bridge, 68 km of Karak Highway and 28 km of Senai-Johor Bharu Highway, giving a total of 134 km of toll expressways and highways in Malaysia.

In the case of this open toll system, the user pays a fixed amount regardless of the distance travelled by him. Similar to the closed toll system, the toll charge levied depends also on the vehicles classes. On all sections except Penang Bridge, the number of vehicle classifications is five (5). On Penang Bridge, the vehicles is classified into seven (7) categories.

Penang Bridge is the only place where toll charges are levied on motor-cycle.

Table 2.3.2 depicts the current status of toll collection system.

Table 2.3.2 : Existing Toll Collection System

	Length of Section (km)	Number of Toll Gate and Toll Lane	Type of Toll Collection System	Number of Vehicle Classification	Type of Transit Ticket	Toll Rate (Ringgit)
NORTH-SOUTH EXPRESSWAY						Class* 0 1 2 3 4 5
Bukit Kayu Hitam - Jitra	24	2 gates, 4 lanes	open	6	-	Free 1.2 1.8 2.4 0.6 1.2
Jitra - Gurun	66	4 gates, 15 lanes	closed	6	magnetic card	cents/km
Changkat Jering - Ipoh	55	3 gates, 25 lanes	closed	6	magnetic card	Free 5.0 7.5 10.0 2.5 5.0
Kuala Lumpur - Ayer Keroh	123	12 gates, 90 lanes	closed	6	magnetic card	
OTHER TOLL EXPRESSWAY						Class** 1 2 3 4 5 6 7
Penang Bridge	14	1 gate, 8 lanes	open	7	-	1.6 7.0 12.0 25.0 45.0 60.0 75.0
TOLL HIGHWAY						Class* 0 1 2 3 4 5
Kuala Lumpur - Karak	68	2 gates, 11 lanes	open	6	-	Gombak Free 1.0 2.0 3.0 0.5 1.0 Bentong Free 0.5 1.0 1.5 0.3 0.5
Senai - Johor Bharu	28	2 gates, 23 lanes	open	6	-	Free 1.0 2.0 3.0 0.5 1.0
Slim River - Tanjung Malim +	20	1 gate, 3 lanes	open	6	-	Free 1.0 1.5 2.0 0.5 1.0

Note : Class* 0 - Vehicle with 2 axles & 2 wheels (motorcycle)
1 - Vehicle with 2 axles & 3 or 4 wheels but excluding taxi
2 - Vehicle with 2 axles & 6 wheels but excluding bus
3 - Vehicle with 3 or more axles
4 - Taxi
5 - Bus

Class** 1 - Motorcycle
2 - Passenger car, side-car, taxi, jeep, landcruiser with 2 axles & 3 or 4 wheels
3 - Truck, van, bus with 2 axles & 4 wheels
4 - Truck, van, bus with 2 axles & 6 wheels
5 - Vehicle with 3 axles
6 - Vehicle with 4 axles
7 - Vehicle with 5 or more axles

+ Toll collection will be discontinued after 1996
(this highway is not included as part of the study route)

3) Tunnel Traffic Safety Facilities

a) Genting Sempah Tunnel

Genting Sempah Tunnel is located at kilometer post 37 on Karak Highway. It is a single bore tunnel with two lanes for both directional traffic. The tunnel length is 950 meters.

The slope of roadway is about 1.5% and the speed limit is set at 40 km/h in the tunnel.

In order to secure a safe and smooth traffic flow, various traffic safety facilities such as ventilation system, lighting facilities and emergency facilities are provided to the tunnel.

Besides, guardrails are found on both sides of roadway but passage between tunnel wall and guardrail is too narrow (about 70 cm)

For management of these facilities, a control room is set up at the eastern portal of the tunnel.

Figure 2.3.4 depicts the layout of equipment in the tunnel.

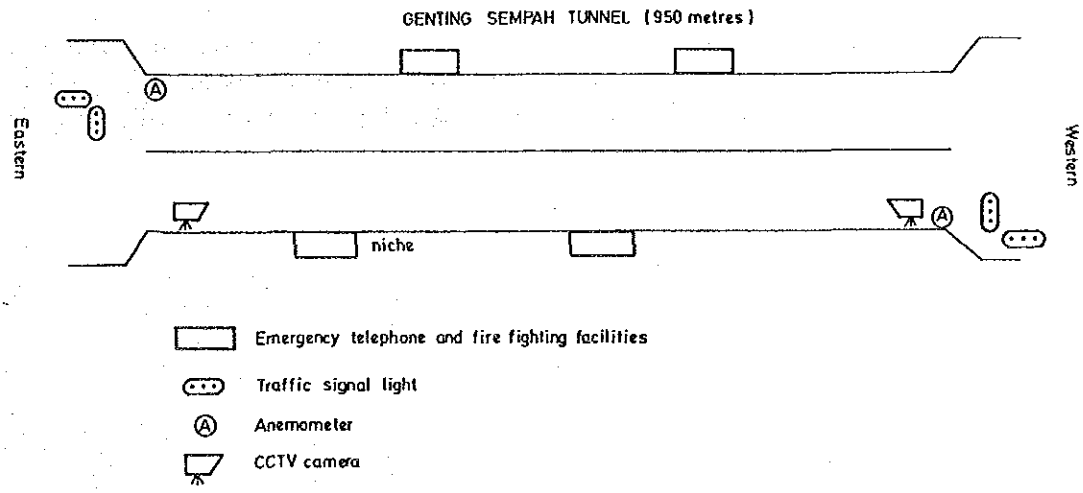


Figure 2.3.4 : Layout of Main Equipment in Genting Sempah Tunnel

b) Meru-Menora Tunnel

The first tunnel constructed on the North- South Expressway is the Meru-Menora tunnel, which is located about 12 km north of Ipoh, the capital of Perak state. The Meru-Menora Tunnel is a twin bore tunnel, with each bore carrying two lanes. The south bound bore i.e. Meru Tunnel has a length of 830 meters while the north bound bore i.e. Menora Tunnel is 880 meters long.

Similar to Genting Sempah Tunnel, the slope of roadway is about 1.5% but the speed limit is set at 65 km/h in this tunnel.

The two bores are linked to each other by a cross tunnel which also acts as an evacuation passage should an emergency occur in the tunnel. Unlike Genting Sempah Tunnel, the tunnel walls are furnished with linings.

A control room is constructed at the southern portal of the tunnel to manage the various facilities.

Figure 2.3.5 illustrates the layout of equipment in the tunnel.

4) Traffic Signs

The existing traffic signs are grouped into three functional classes:

i) Regulatory signs
ii) Warning signs
iii) Guide signs

Compare with guide signs, the regulatory and warning signs are designed and installed uniformly. There are, however, no uniformity of design and usage in the existing guide signs. The design of guide signs is outlined in Table 2.3.3.

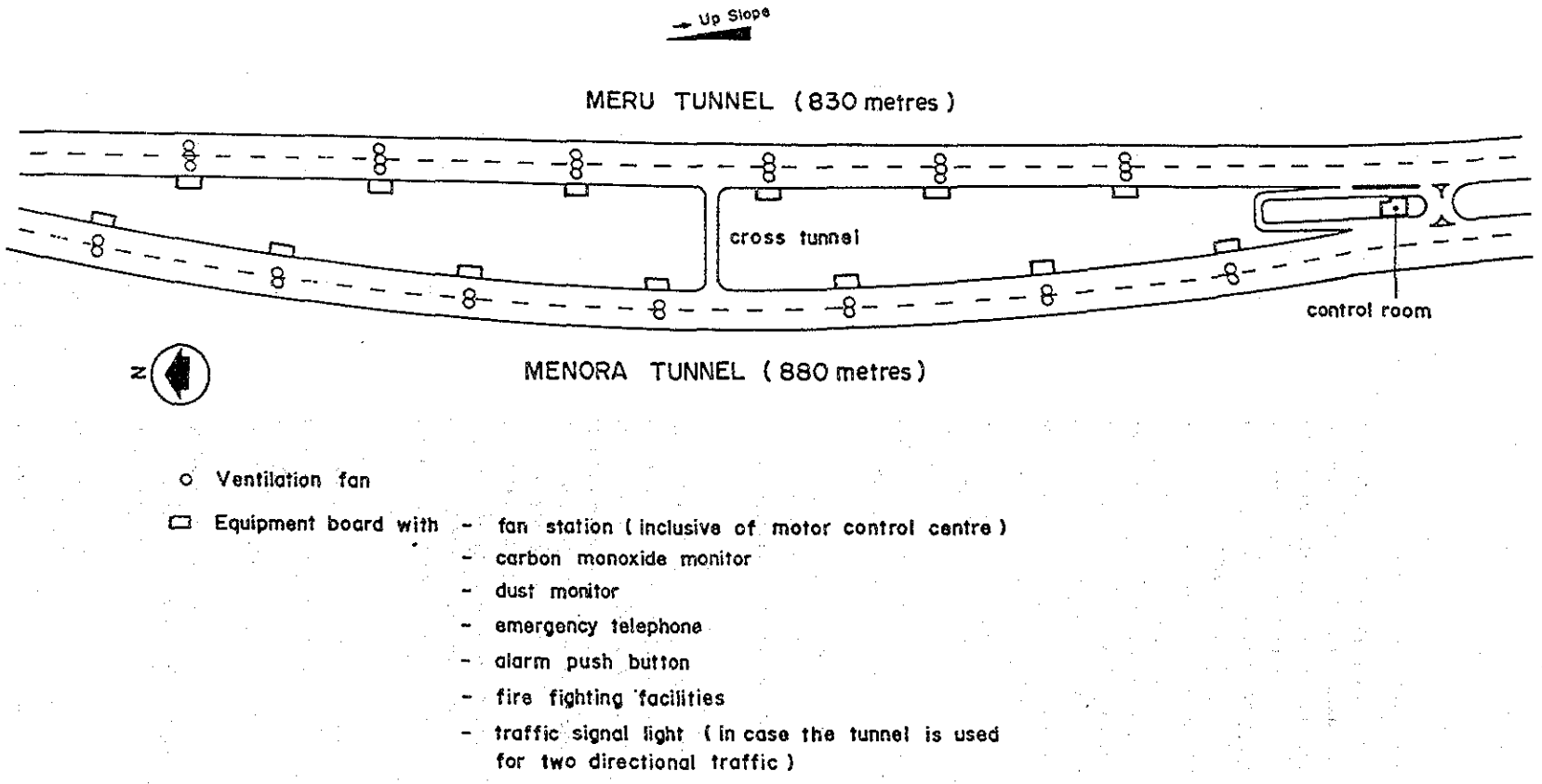


Figure 2.3.5: Layout of Equipment in Meru-Menora Tunnel

Table 2.3.3 : Design Outline of Guide Sign

Design Element		Characteristics
1. Shape	-	rectangular
2. Color	-	white letters, symbols and borders on green background.
3. Size	-	varies according to :
	.	legend
	.	lane width and roadway clearance /visibility requirements in case of overhead signs.
4. Legend	-	lower case letter with initial capitals and numerals at least 1 1/3 times the 'loop' height of the lower case letter.
	-	size of lettering varies.
	-	interline and edge spacing closely related to size of lettering.
	-	abbreviation is kept to a minimum except words of cardinal directions.
	-	different placement of arrows in relation to destination names.
5. Reflectorization	-	retro-reflective plastic sheeting or illumination
	-	overhead signs are illuminated
6. Sign location	-	interchange sign is placed at 2 km, 1 km and 500 m in advance of exit and at the exit ramp.
	-	distance/information sign is placed 200 m beyond the end of entry ramp.
	-	motorist services, parking area, rest area, scenic area, recreational, historical and cultural interest area signs are placed at 2 km, 1 km and 500 m in advance of the facilities and at the exit to these facilities.
	-	emergency telephone sign is placed at 250 m in advance of telephone.
	-	lane guide sign is placed at 500 m in advance of each toll plaza.
	-	hectometer marker is placed at interval of 100 m whereas kilometer marker is located at interval of 1 km

Some features of the existing guide signs are discussed below.

Presently, the size of lettering of the guide signs used on the North-South Expressway varies from sections to sections.

Another significant feature of the legend is the different placement of arrows in relation to the destination name. The general rule to locate traffic signs is on the left-hand side of the roadway.

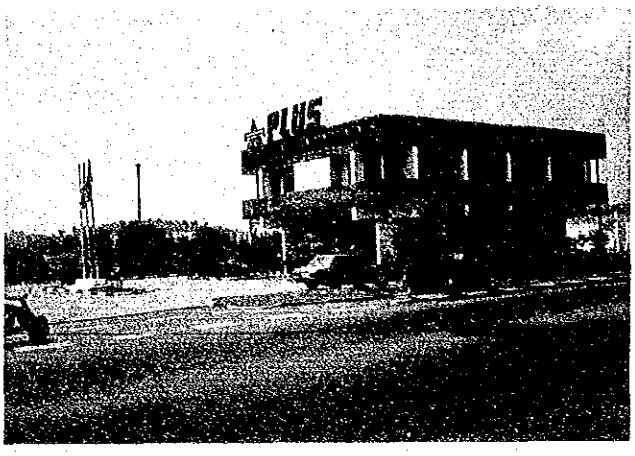
On the North-South Expressways, the number of interchange signs varies from sections to sections. For instance, on the Kuala Lumpur- Seremban Expressway, the interchange sign is made up of three (3) guide signs located at 1 km, 500 m successively in advance of the exit and at the exit ramp. On the other hand, on the Seremban-Ayer Keroh Expressway, the interchange sign consists of four (4) guide signs placed at 2 km, 1 km and 500 m successively in advance of the exit and at the exit ramp. Another obvious difference between the interchange signs on these two sections of the expressways is the type of guide signs used. On the Kuala Lumpur- Seremban Expressways, the interchange signs are all post mounted guide sign except the guide sign at the exit ramp which is of the overhead type. The interchange signs at the Seremban-Ayer Keroh Expressway is of the post mounted type.

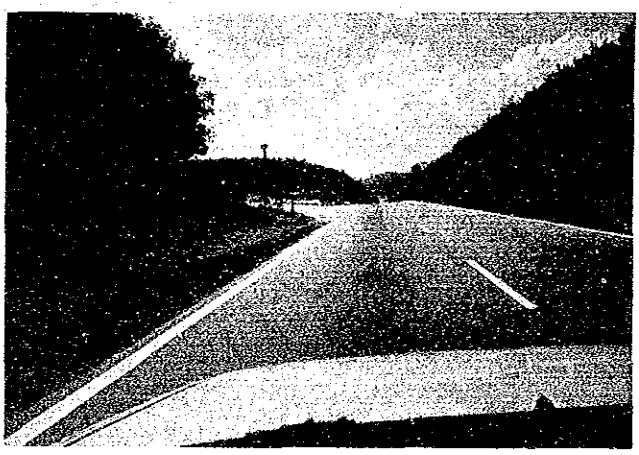
Distance/information signs is placed approximately 200 m beyond the end of the entry ramp. These signs carry the names of significant destination and the distances to those points.

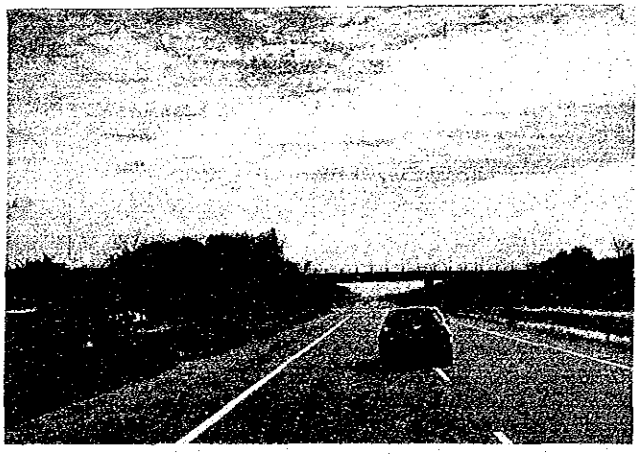
Other signs which are put on the expressways provide information on motorist services (fuel), parking area, rest area, scenic area, recreational, historical and cultural interest area. These signs are placed at a distance of 2 km, 1 km and 500 m in advance of the facilities and at the exit to these facilities. Besides, the emergency telephone sign is placed at 250 m in advance of the telephone whereas the emergency telephone indicator sign is installed between two telephones to indicate the nearest telephone. Lane guide sign is installed at about 500 m in advance of the each toll plaza.

Hectometer and kilometer markers are placed on the expressway for maintenance works and identification of failed areas, police operation and emergency and breakdown situations. The former is placed at interval of 100 m whereas the latter at interval of 1 km.

Photo Sheet B







1	5
2	6
3	7
4	

1. Toll office at Sungei Besi Toll Barrier.
2. An example of poor implementation of traffic control measure during facility maintenance work.
3. Insufficient taper for exiting to one of the fuel station along the Kuala Lumpur-Seremban Expressway.
4. Intrusion by animals into the expressway along the Senawang-Ayer Keroh Section is a potential accident hazard to road users.
5. Intrusion by human is also a problem along the Kuala Lumpur-Seremban Expressway. Notice the unpaved road shoulder.
6. An accident that occurs on the expressway.
7. Enforcement on over speeding on the expressway.

5) Road Markings

Markings used on the North-South expressways and toll highways consists of centre lines, lane lines, pavement edge lines, shoulder markings, pavement width transition markings, channelizing markings, nose area markings and others.

Table 2.3.4 depicts the existing road markings applied to those sections of the expressways that have been opened to traffic. At present, various dimensions are adopted for the same type of marking element.

In terms of material, the road pavements on the completed expressway sections are marked by reflectorized hot-applied thermoplastics material. This material, applied hot and sets on laying, has good durability.

6) Guardrail

In general, guardrail is installed at expressway sections with embankment slopes (at shoulder) as well as in advance of and beyond horizontal curve of the expressway (at shoulder and median). Expressway sections with cut slopes are usually not justified to install with guardrail. Guardrail installation on shoulders prevent vehicles access to steep embankments or fixed objects, whereas guardrail on median are used between the roadways of divided expressways to prevent 'across the median' collisions with opposing traffic.

Guardrail installation are only justified at certain sections of the expressway where the consequence of an errant vehicle leaving the roadway is judged to be more hazardous than the impact with the guardrail. As such, on the North-South expressway, certain portions are not equipped with guardrails.

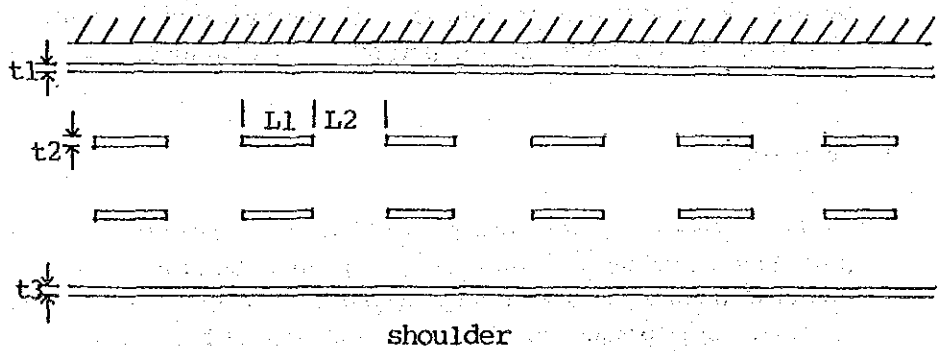
7) Delineators

On the North-South expressways, two kinds of delineators are adopted, i.e. post mounted delineators and guardrail mounted delineators. The guardrail mounted delineators are usually installed at expressway sections with embankment slopes and in advance of and beyond horizontal curve of the expressway.

The post mounted delineators are usually used at sections of the expressways with cut slopes.

Table 2.3.4 : Existing Road Marking

	L1 (mm)	L2 (mm)	t1 (mm)	t2 (mm)	t3 (mm)	Design Speed (km/h)
NORTH-SOUTH EXPRESSWAY						
Bukit Kayu Hitam - Jitra	5000	7500	100	100	150	100
Jitra - Alor Setar	4500	7500	200	150	200	120
Alor Setar - Gurun	4500	7500	100	100	150	120
Changkat Jering - Ipoh	5000	8000	100	100	150	120
Kuala Lumpur - Seremban	5000	8000	100	100	150	100
Seremban - Ayer Keroh	4500	7500	100	100	150	120
Ayer Keroh - Pagoh	4500	7500	100	100	150	120
OTHER TOLL EXPRESSWAY						
Penang Bridge	910	4570	100	100	150	100
TOLL HIGHWAY						
Kuala Lumpur - Karak	3000	5000	100	100	150	100
Senai - Johor Bharu	5000	8000	100	100	150	100
Slim River - Tanjung Malim +	4500	7500	100	100	150	100
Future sections of North-South Expressways	4500	6750	200	150	200	120



Note : L1 & L2 - length of lane lines
t1 - thickness of pavement edge lines
t2 - thickness of lane lines
t3 - thickness of shoulder marking
+ This highway is not included as part of the study route

8) Lighting facilities

The main function of lighting facilities is to produce a satisfactory visual environment allowing drivers to obtain exact visual information in order to avoid driving failure and to assure safe and smooth traffic flow.

On the existing stretch of the North-South Expressway, continuous lighting is provided along the full length of bridge and tunnel, for instance, Penang Bridge, Meru-Menora Tunnel and Genting Sempah Tunnel. However, as mentioned before, the luminance in the Genting Sempah Tunnel is greatly diminished by the dirt on the lighting facilities as well as on the ceiling and wall of the tunnel.

In addition, partial lighting is provided in sections where it is necessary to inform drivers travelling at night of the distance and direction to interchange ramps, toll gates, service and parking areas. The lighting facilities at the parking and service areas along the expressways are being improved to meet the requirement.

2.3.4 Maintenance

Apart from the traffic operation discussed earlier, traffic management on expressways encompasses maintenance activities.

1) Organization Set-up

Under the existing organization set-up of Malaysian Highway Authority, there is a maintenance section under the Operation Division as well as maintenance depot under the Regional Division. The former, responsible for planning of maintenance, is located in the headquarters while the maintenance depots, concern with conducting or oversee the task of maintenance, are situated at site.

The maintenance works of the Penang Bridge is under the responsibility of the Northern Regional Office in Penang while the maintenance tasks of Karak Highway is under the responsibility of Karak Highway Maintenance Depot of the Central Regional Office.

Both these Penang Bridge and Karak Highway are under the charge of MHA. In addition, MHA also supervise the works of the expressways in Malaysia which are, in fact, the responsibility of PLUS.

Presently, PLUS has just established an organization set-up with two levels to carry out maintenance works on the North-South Expressways, i.e. site level (operational level) and headquarters level (functional level). The former is in charge of inspecting expressway and following up the works leading to maintenance activities. The latter is responsible in defining the maintenance methods, preparing, studying and programming the works related to the budget, liaison with other departments and contractors. For the initial phase, the site level is divided into seven (7) sections:-

Section 1: Bukit Kayu Hitam-Alor Setar
Section 2: Alor Setar-Gurun
Section 3: Changkat Jering-Ipoh
Section 4: Slim River*
Section 5: Kuala Lumpur-Seremban
Section 6: Seremban-Ayer Keroh
Section 7: Senai-Johor Bharu*
(* not part of North-South Expressway)

The above-mentioned levels for maintenance tasks are set up by PLUS to cover those expressway sections in service. As such, it is highly probable that the set-up may change with the addition of more sections in service or the completion of the entire expressway.

2) Maintenance Tasks

a) Maintenance Activities

Presently, the maintenance activities are as follows:-

(i) Daily Inspection

(ii) Periodical Maintenance
* Inspection
* Cleaning (tunnel, roadside facilities, etc.)
* Painting (steel bridge, roadside facilities, etc.)
* Pavement (overlay, pot-hole, etc.)
* Marking
* Vegetation control (trimming of trees/shrubs, grass cutting, etc.)

(iii) Improvement
* Road improvement
* Environment conservation
* Facility improvement

(iv) Disaster prevention/restoration or incidental maintenance
* Embankment/cut slopes

At present, daily inspection is carried out by MHA personnel on Penang Bridge and Karak Highway while PLUS is in charge of the works on the North-South Expressway and other toll highways. For periodical maintenance, improvement and disaster prevention/restoration works, they are performed on a contract basis. At present, a major part of the contract work is on periodical maintenance.

Table 2.3.5: Frequency of Maintenance Activity

Item	Activity	Frequency	Standard of Judgement
1. GRASS CUTTING			
a) Shoulder		Once/4 weeks (max)	Height 50 mm
b) Slope		Once/10 weeks (max)	Height 100 mm
c) Loop area		Once/4 weeks	Height 100 mm
d) Special area (Town Council/Municipal Council areas)		Once/2 weeks at median and slope	
e) Lay Bye/Rest Area		Once/4 weeks at flat areas	Height 150 mm
		Once/10 weeks at slope	Height 100 mm
2. WEEDING	Removal/trimming	Once/10 weeks	
3. DRAINAGE			
a) Lined Drain	Cleaning/Desilting	Once/4 months	* Free flowing at design capacity * Silt built-up to 1/5 depth of drainage structureandnostand-ingwater/orcontinued flow for more than 24 hrs.
b) Unlined Drain	Reshaping	Yearly	
	Reshaping in Padi Field	Half yearly	
c) Horizontal Drain	Flushing with High Pressure Jet (30 psi)	Yearly	
d) Subsoil Drain	Outlet Cleaning	Yearly	
e) Weep Hole	Vegetation Cleaning		
f) Culvert	General Cleaning until its actual discharge point	Yearly	
	Inspection	Once/3 months	
4. PAVEMENT MARKING		Once/3 years	* Check with supplier on the life span
5. GUARDRAIL	Cleaning	Yearly	
6. BRIDGE PARAPET	Repainting of steel railing and post	Once/2 years	
7. RIGHT-OF-WAY FENCING	Vegetation removal on fences	Once/10 weeks	
8. TRAFFIC SIGN	Cleaning in heavy traffic areas	Half yearly	
	Cleaning in town areas	Once/3 months	
	Repainting of post	Once/2 years	
9. DELINEATORS	Cleaning	Half yearly	
10.KILOMETER POST/HECTOMETER MARKER	Cleaning	Once/3 years	
11.HECTOMETER POST	Repainting	Once/3 years	
12.TUNNEL LINING	Cleaning	Once/2 weeks	
13.ANIMAL CARCASSES	Removal	Daily, if any	
14.TOLL PLAZA & SURVEILLANCE BUILDING	Repainting	Once/3 years	
15.TOLL BOOTH	Cleaning	Daily	

b) Frequency of Maintenance Activities

Maintenance activities are performed on a regular time cycle depending on the type of items. Table 2.3.5 illustrates the frequency of maintenance activities. The maintenance activities may be done on a daily, weekly, monthly or yearly basis.

c) Maintenance Expenditure

The maintenance expenditure on Malaysian expressways and highways is depicted in Table 2.3.6 and Figure 2.3.6. It should be noted here that the following discussion is only limited to few expressway sections and covers the period before the handing over of the expressway from MHA to PLUS.

The expenditure pattern per kilometer ranges from M$87,600 for Kuala Lumpur-Seremban Expressway to M$46,400 for Senai-Johor Bharu Highway. The mammoth maintenance cost of M$545,000 for Kuala Lumpur-Karak Highway is due to the remedial works to cut and embankment slope.

Table 2.3.6: Maintenance Expenditure on Malaysian Expressways and Highways

Expressway Section	Length (km)	Expenditure* M$/year	Expenditure* M$/km	Breakdown of Expenditure Maintenance (%)	Improvement (%)	Disaster (%)
1. Bukit Kayu Hitam-Jitra Alor Setar-Gurun	57.6	3,200,000	55,500	63.2	1.9	34.9
2. Kuala Lumpur-Seremban	40.0	3,504,000	87,600	58.9	19.1	22.0
3. Senai-Johor Bharu	28.0	1,297,500	46,400	74.4	7.8	17.8
4. Kuala Lumpur-Karak**	46.5	25,360,000	545,000	5.5	-	94.5

Note: * Average annual value for year 1987-1988
** Includes remedial works to cut and embankment slopes for Kuala Lumpur-Karak Highway

For Bukit Kayu Hitam-Jitra and Alor Setar-Gurun sections, maintenance consumes 63.2% of the total expenditure, followed by disaster prevention/ restoration, 34.9% and improvement, 1.9%.

On the Kuala Lumpur-Seremban Expressway, maintenance constitutes 58.9% of the total cost, disaster prevention/restoration, 22.0% and improvement, 19.1%.

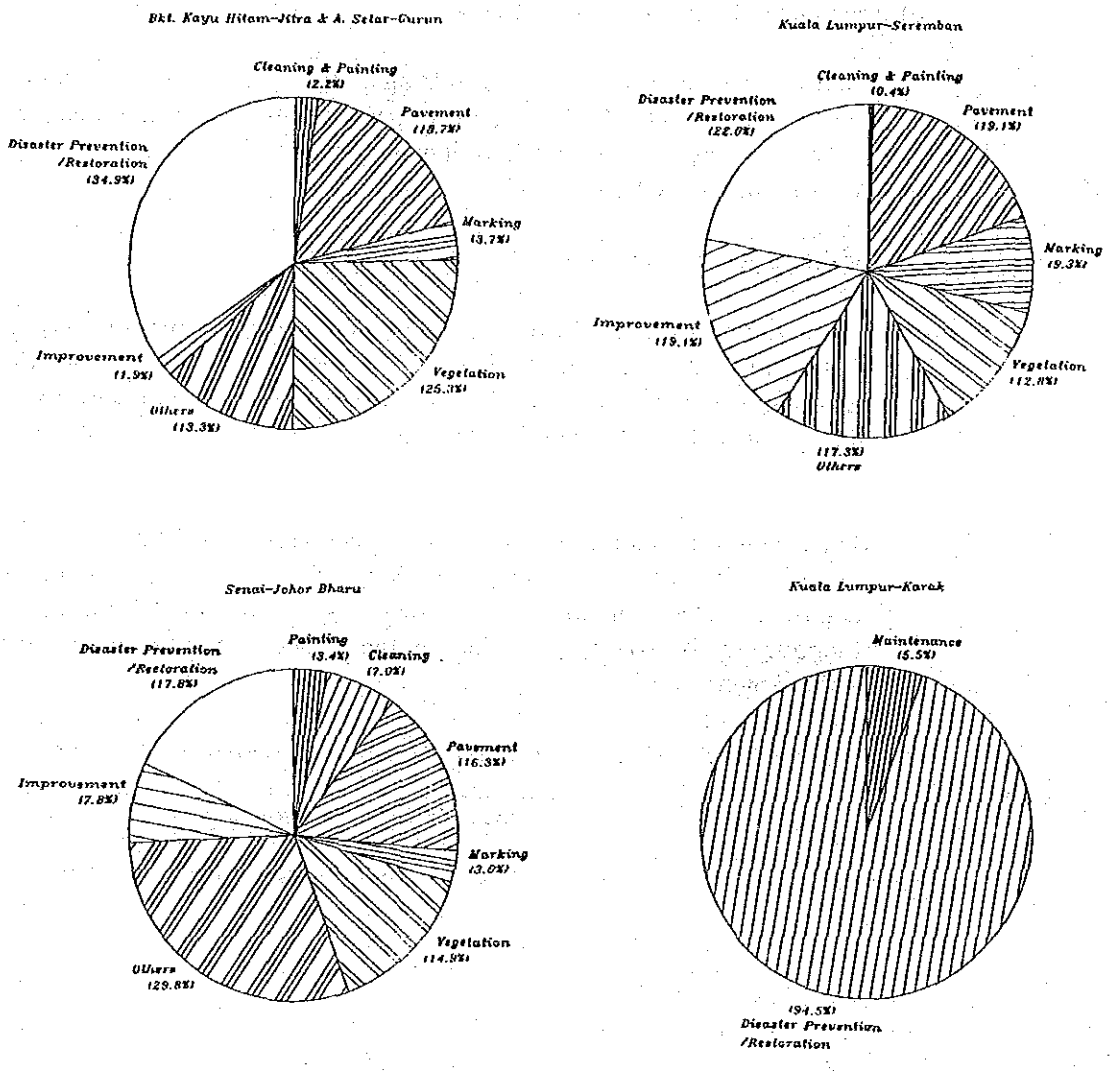


Figure 2.3.6: Breakdown of Maintenance Expenditure on Malaysian Expressway and Toll Highway

For Senai-Johor Bharu Highway, 74.4% of the total expenditure is spent on maintenance, 17.8% on disaster prevention/restoration and the rest of 7.8% on improvement.

However, disaster prevention/restoration takes up almost the entire maintenance expenditure, i.e. 94.5% on Karak Highway. It should be noted here that this mammoth sum may include the improvement works. The rest of 5.5% is spent on maintenance works.

3) Maintenance Manual

In 1988, a maintenance manual for toll expressway and highway was prepared by Malaysian Highway Authority.

This manual sets out:-

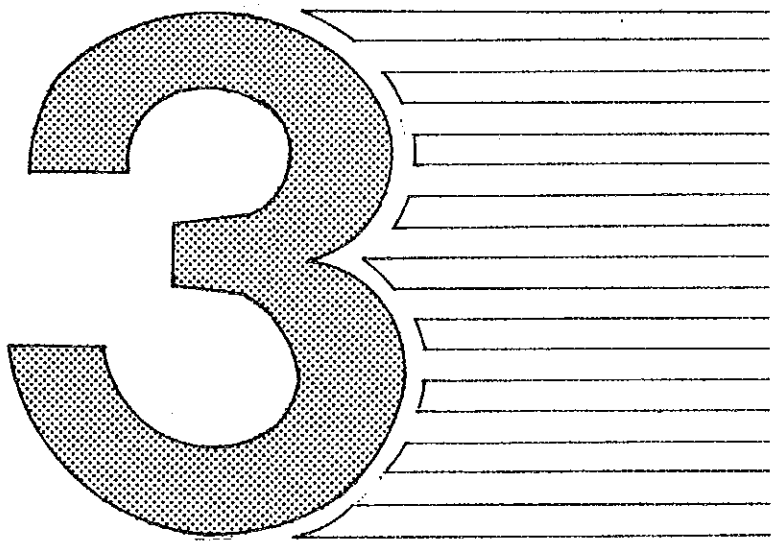
i) procedures and frequencies for routine and periodic maintenance of the expressway and highway and toll plaza and surveillance buildings;

ii) Standards of judgement to be used during daily and periodic detailed inspections of the expressway and highway.

Based on this manual, the relevant agency can formulate the necessary documents to perform the routine maintenance tasks on a contract basis.

On the other hand, PLUS has also prepared a maintenance manual. As such, effort is currently being undertaken to produce a common maintenance manual for use by MHA and PLUS. In other words, it is still at the planning stage but without any doubt, the manual is very useful and essential for the expressway.

CHAPTER



3.0 FUTURE TRAFFIC VOLUME AND EXPRESSWAY NETWORK

3.1 Future Expressway Network and Stage Plans

The expressway network as planned will extend from Bukit Kayu Hitam at the Thai border in the Northern State of Perlis, down along the west coast and running very close to the existing Federal Route 1 to Johor Bharu in the Southern State of Johor. This North-South inter-urban expressway is scheduled to be completed by May 1995.

Extension from this North-South Expressway is the New Klang Valley Expressway in an east-west axis in the Klang Valley Region and Penang Bridge in the North linking the Peninsular with Penang Island. The New Klang Valley Expressway (NKVE) is scheduled to be completed by September 1992. It thus provides the linkage from the North-South Expressway to Subang International Airport and further afield to Port Klang. The Penang Bridge was completed and opened to traffic in 1985 providing access to Penang Port and Bayan Lepas International Airport on the island.

The stage plan of highway and expressway construction is shown in Figure 3.1.1.

The sections of the North-South Expressway that have been opened to traffic as of August 1989 are:-

* Bukit Kayu Hitam-Gurun.....(80 km)
* Changkat Jering-Ipoh.....(56 km)
* Kuala Lumpur-Seremban.....(53 km)
* Seremban-Ayer Keroh.....(68 km)
* Ayer Keroh-Pagoh.....(53 km)

These add up to a total of 314 km of expressways in operation by August 1989. There are also a total of 145 km of toll highways. These are:-

* Penang Bridge.....(14 km)
* Karak Highway.....(68 km)
* Senai-Johor Bharu.....(28 km)
* Slim River-Tanjung Malim.....(20 km)
* North Klang Straits Bypass.....(15 km)

Another 173 km of expressway and 52 km of toll highways will be added by 1992. The expressway section scheduled to be completed are:-

* Gurun-Butterworth.....(51 km)
* Tanjung Malim-Kuala Lumpur.....(60 km)
* Pagoh-Air Hitam.....(62 km)

while the toll expressways/highways to be completed by 1992 are:-

* New Klang Valley Expressway.....(37 km)
* Federal Highway (Subang to Klang).....(15 km)

By 1995, the expressway and highway network in Peninsular Malaysia is as shown in Figure 3.1.2. The network will consist of the inter-urban North-South Expressway, Karak Highway linking Kuala Lumpur to Bentong and continues as Federal Route 2 to Kuantan on the east coast, New Klang Valley Expressway and Federal Highway; Senai-Johor Bharu Highway in the south and Penang Bridge in the north.

The total length of expressway and toll highways scheduled to be operational by 1995 will be 826 km and 111 km respectively. The total expressway and toll highway length will be some 937 km.

All sections of the North-South Expressway are to be constructed as 4-lane dual carriageway by 1995. Provisions, however, have been made in the design and construction on some sections for the construction of additional 2 lanes in future.

These sections are:

a) New Klang Valley Expressway (Bukit Raja to Subang)
b) New Klang Valley Expressway (Subang to Jalan Duta)
c) Sungai Dua-Butterworth
d) Butterworth-Juru North
e) Rawang-Bukit Lanjan
f) Seremban-Ayer Keroh Expressway

The Kuala Lumpur-Seremban Expressway which is the oldest section of the North-South Expressway is currently carrying large volume of traffic. At an average annual growth rate of 4-6% per year, this stretch of the expressway would require widening from the present 4 lane to 6 lane in the next five years. Provisions have also being taken by MHA under the privatization program for this improvement. The widening is scheduled to be completed by 1990.

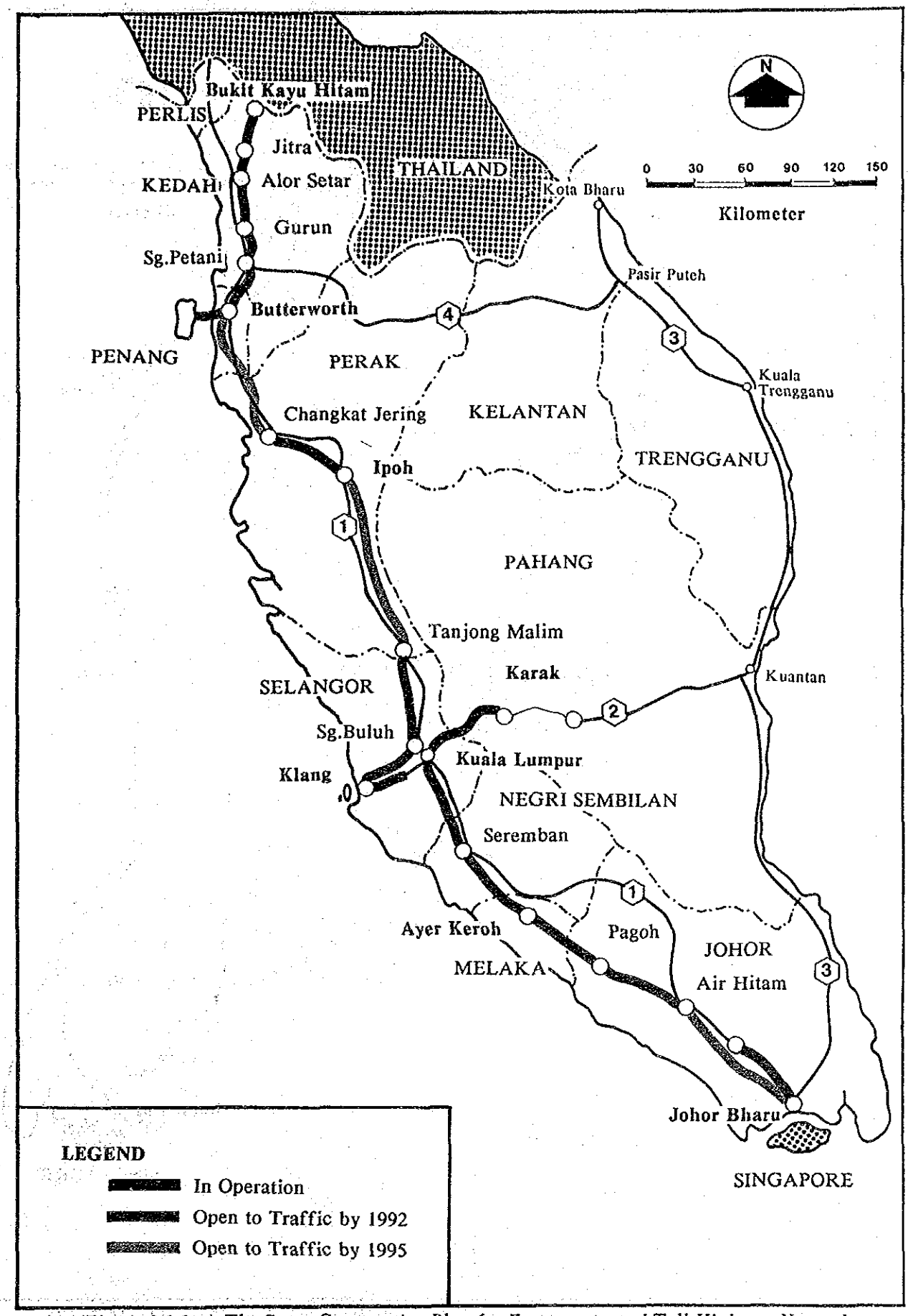


Figure 3.1.1: The Stage Construction Plan for Expressway and Toll Highway Network in Peninsular Malaysia to Year 1995

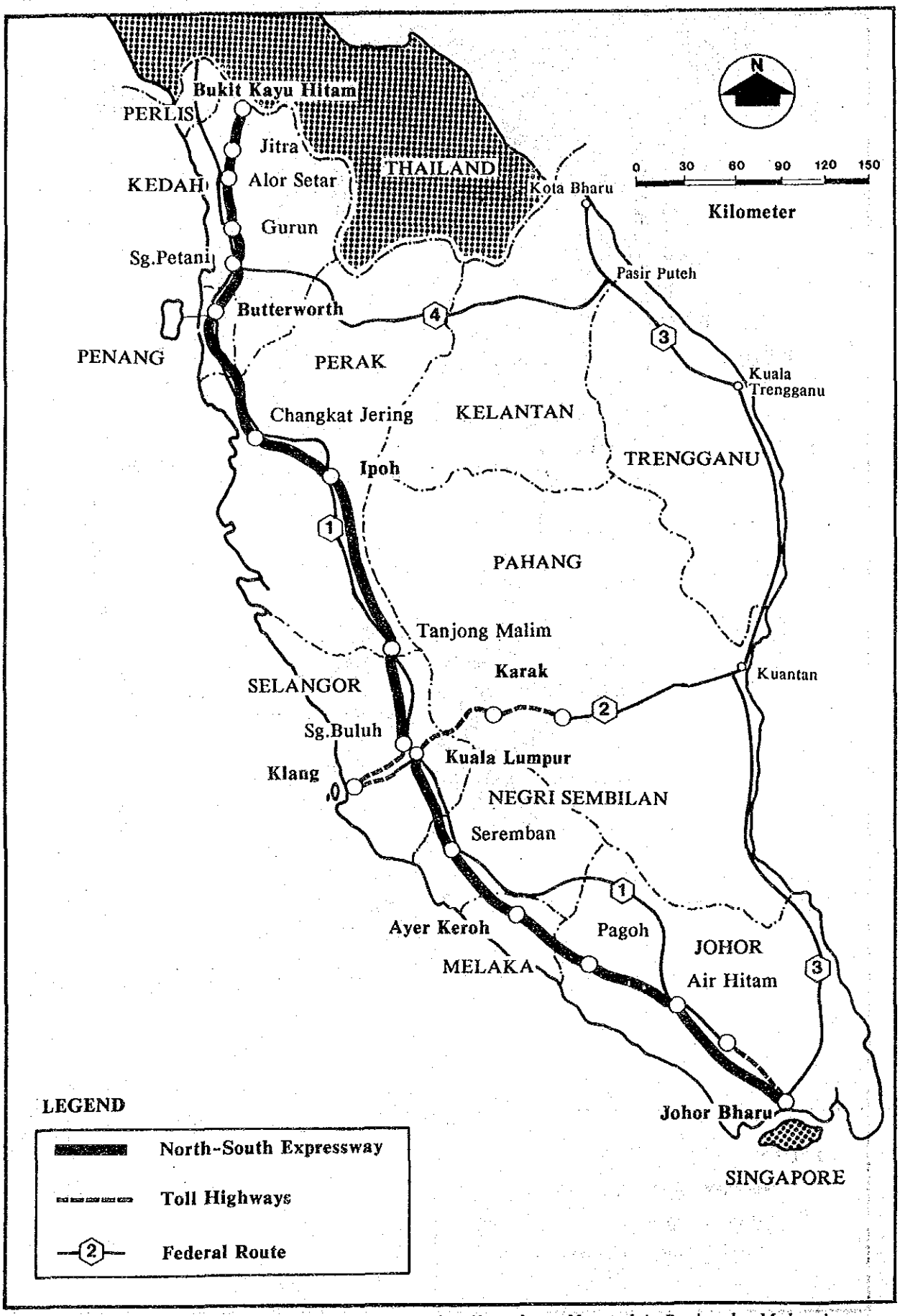


Figure 3.1.2: The Future Expressway and Toll Highway Network in Peninsular Malaysia Up To 1995

3.2 Ranking of Future Traffic Volume

Future traffic volume on the expressway sections represent an important factor for designing appropriate traffic management and control measures. The amount of traffic using a certain expressway section would first help determine the traffic management level that should be adopted to ensure users safety and mobility. The traffic management level in turn would determine the specific types of traffic control devices and maintenance measures required.

A section of the expressway that expects a high future traffic volume would generally require a higher traffic management level. Traffic surveillance by means of vehicle detectors, for example, would be more densely provided. Maintenance work such as inspection, repairs, cleaning would be more frequent so as to maintain the expressway in good condition.

Since the future traffic volume for the expressway sections have been set in the Concession Agreement, it follows that it would be reasonable to adopt these forecasts for the planning of the traffic control and management system in this study. However, toll units were used in the computation of pcu.km in the agreement. For planning purposes, these are duly converted into technical pcu.

In addition, traffic forecasts here have been adjusted to include the motorcycle traffic so as to reflect the total traffic volume on the expressways and highways. The final traffic volume in 1995 and 2005 to be adopted for the design of the traffic control and management system is ranked according to three categories as presented in Table 3.2.1.

The traffic distribution pattern for 1995 and 2005 are shown in Figures 3.2.1 and 3.2.2 respectively.

Table 3.2.1: Future Traffic Volume and Estimation V/C Ratios

Expressway Section	Code	(km)	Ranking of Traffic Volume			Volume/Capacity Ratio		
			1988	1995	2005	1988	1995	2005
NORTH-SOUTH EXPRESSWAY								
Bukit Kayu Hitam-Jitra	4A	24.0	1	1	1	0.03	0.04	0.06
Jitra-Alor Setar South	4B	23.0	1	1	1	0.08	0.12	0.21
Alor Setar South-Gurun	4C	33.6	1	1	1	0.10	0.14	0.25
Gurun-Sungai Petani North	5A	16.1	-	1	2	-	0.36	0.70
Sungai Petani North-Sungai Petani South	5B	7.9	-	1	1	-	0.27	0.55
Sungai Petani South-Sungai Dua	5C	22.6	-	1	1	-	0.34	0.66
Sungai Dua-Butterworth	5D	4.2	-	1	1	-	0.18	0.34
Butterworth-Bukit Tengah	6A	10.1	-	1	1	-	0.12	0.20
Bukit Tengah-Taiping	6B	61.6	-	1	1	-	0.25	0.52
Taiping-Changkat Jering	6C	14.9	-	1	1	-	0.32	0.63
Changkat Jering-Ipoh South	7	55.7	1	1	1	0.19	0.31	0.65
Ipoh South-Gopeng	8A	21.5	-	1	2	-	0.46	0.95
Gopeng-Bidor	8B	43.2	-	1	2	-	0.39	0.76
Bidor-Tanjong Malim	9	60.6	-	1	1	-	0.32	0.65
Tanjong Malim-Rawang	10A	43.3	-	1	1	-	0.30	0.59
Rawang-Sungai Buloh	10B	12.4	-	1	3	-	0.67	1.16
Sungai Buloh-Bukit Lanjan	10C	4.2	-	1	2	-	0.63	1.09
Kuala Lumpur-Kajang IC		12.6	3	3	3	1.34	2.21	4.51
Kajang IC-Bangi		6.3	2	3	3	0.99	1.53	2.84
Bangi-Seremban		33.8	2	2	3	0.80	1.11	1.77
Seremban-Simpang Ampat	11B	45.9	1	1	1	0.29	0.39	0.60
Simpang Ampat-Ayer Keroh	11C	21.5	1	1	1	0.19	0.25	0.38
Ayer Keroh-Pagoh	11D	53.0	-	1	1	-	0.22	0.33
Pagoh-Yong Peng South	12A	43.0	-	1	1	-	0.29	0.43
Yong Peng South-Ayer Hitam	12B	19.0	-	1	1	-	0.28	0.55
Ayer Hitam-Simpang Renggam	13A	21.4	-	1	2	-	0.37	0.74
Simpang Renggam-Skudai	13B	45.3	-	1	2	-	0.36	0.77
Skudai-Johor Bharu	14A	13.8	-	1	2	-	0.66	1.12
TOLL EXPRESSWAY AND TOLL HIGHWAYS								
Bukit Raja-Subang (NKVE)	1	16.2	-	2	3	-	0.92	1.50
Subang-Jalan Duta (NKVE)	2	20.8	-	3	3	-	1.66	2.48
Penang Bridge		14.0	1	2	3	0.57	0.75	1.22
Karak Highway		68.0	1	1	2	1.03	1.43	2.27
Senai-Johor Bharu Highway	14E	28.0	2	1	2	0.66	0.46	0.68
N.K.S.Bypass-Shah Alam (FR2)	3A	6.0	2	2	3	0.95	0.60	0.89
Shah Alam-Subang (FR2)	3B	9.0	3	3	3	2.58	2.02	2.56

Note:
* Ranking of Future Traffic Volume
  1 : <30,000 veh/day
  2 : 30,000 - 50,000 veh/day
  3 : >50,000 veh/day

* Karak Highway is a 2-lane highway
* Federal Route 2 is a 6-lane highway by 1995
* All others are 4-lane expressway and highways up to 2005

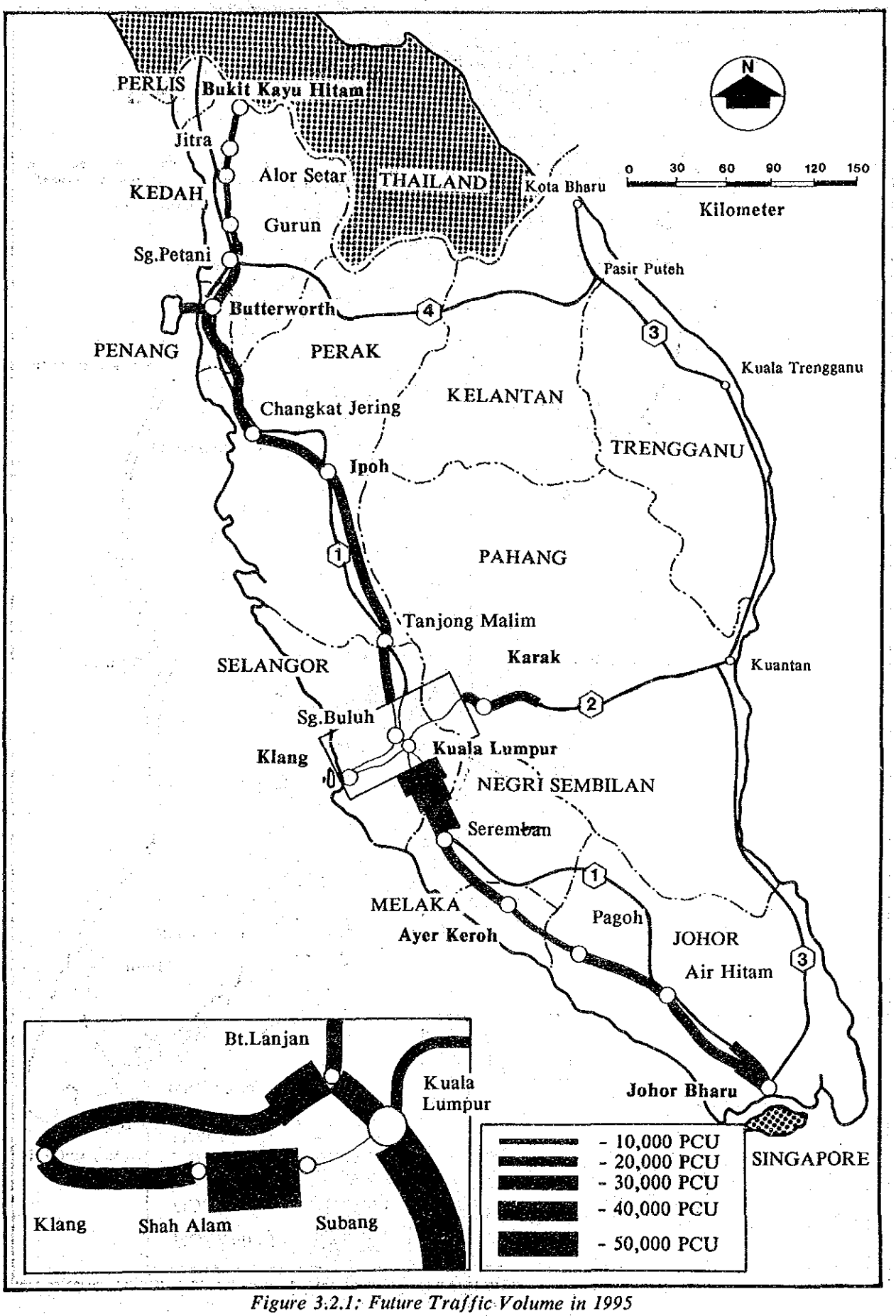


Figure 3.2.1: Future Traffic Volume in 1995

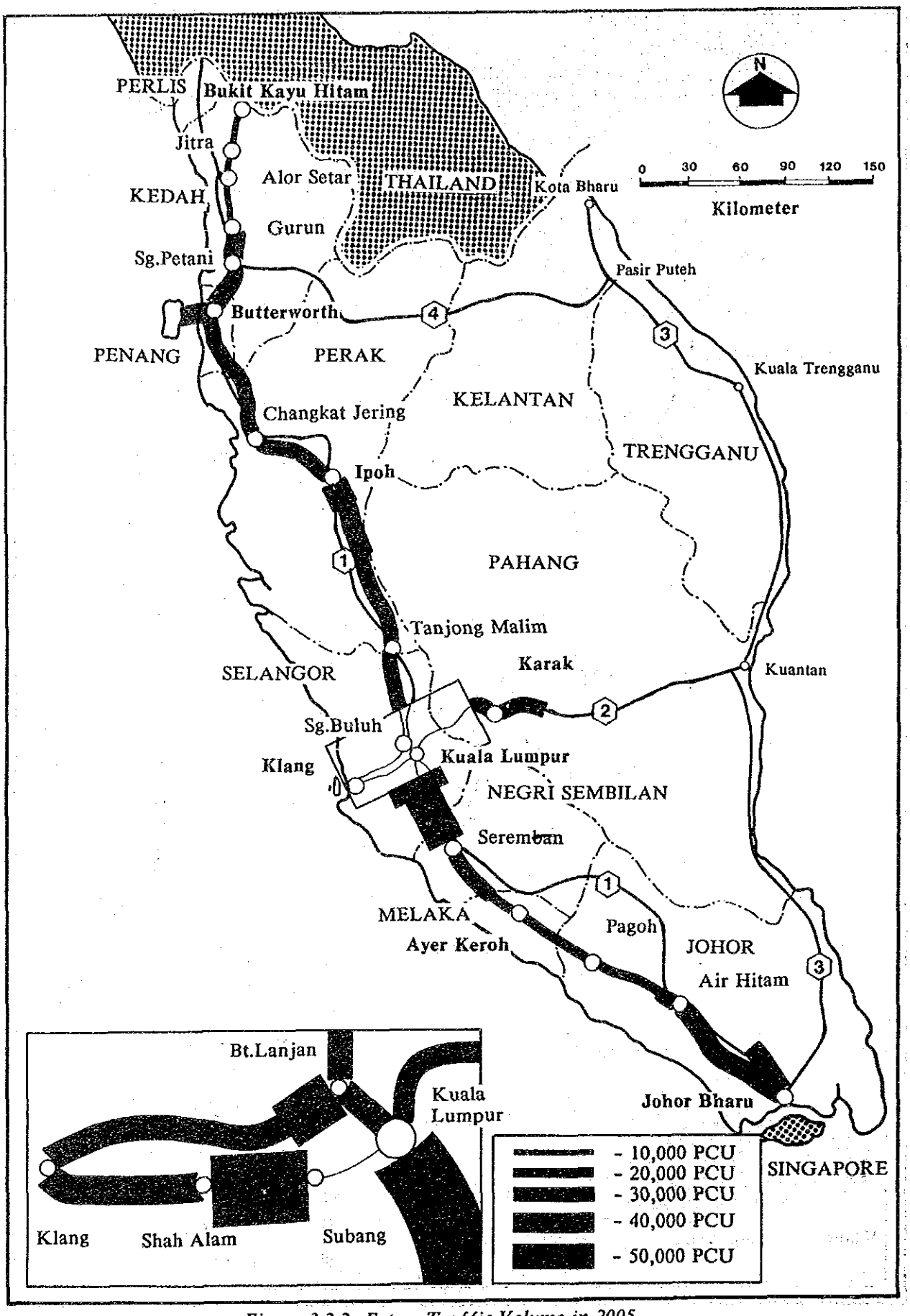


Figure 3.2.2: Future Traffic Volume in 2005