3-8 LAND USE PLAN IN THE STUDY AREA

The Greater Bangkok Area (GBA) has increased its population year by year and is still in a state of growing period.

Land uses in the area are versatile and working places are generally adjacent to residence and work related trips are comparatively small.

Each of living cores are shaped in a small circle with a radius of 5 Km, and conglomerated into a poly-centric city of Bangkok. (See Fig. 3-9)

Planning area of the Greater Bangkok Area is about 732 sq. km. including 4 changwats of Bangkok, Thonburi, Nonthaburi and Samutprakarn. Each of Chagwats has a close economic relation with Bangkok.

Thonburi located in the west of Bangkok is a twin city separated by the chao Phraya River and is expected to grow in the future.

Distinguished expansion of GBA has been made in the directions of east and north and growth in the north-east and south is foreseen in the future. In the whole area, a great area of undeveloped land exist as major object area in terms of land use planning. (See Fig. 3-10)

This expansion will be accelerated by the Middle Ring Road under construction and the Outer Ring Road in the planning.

Major land uses in GBA are as follows:

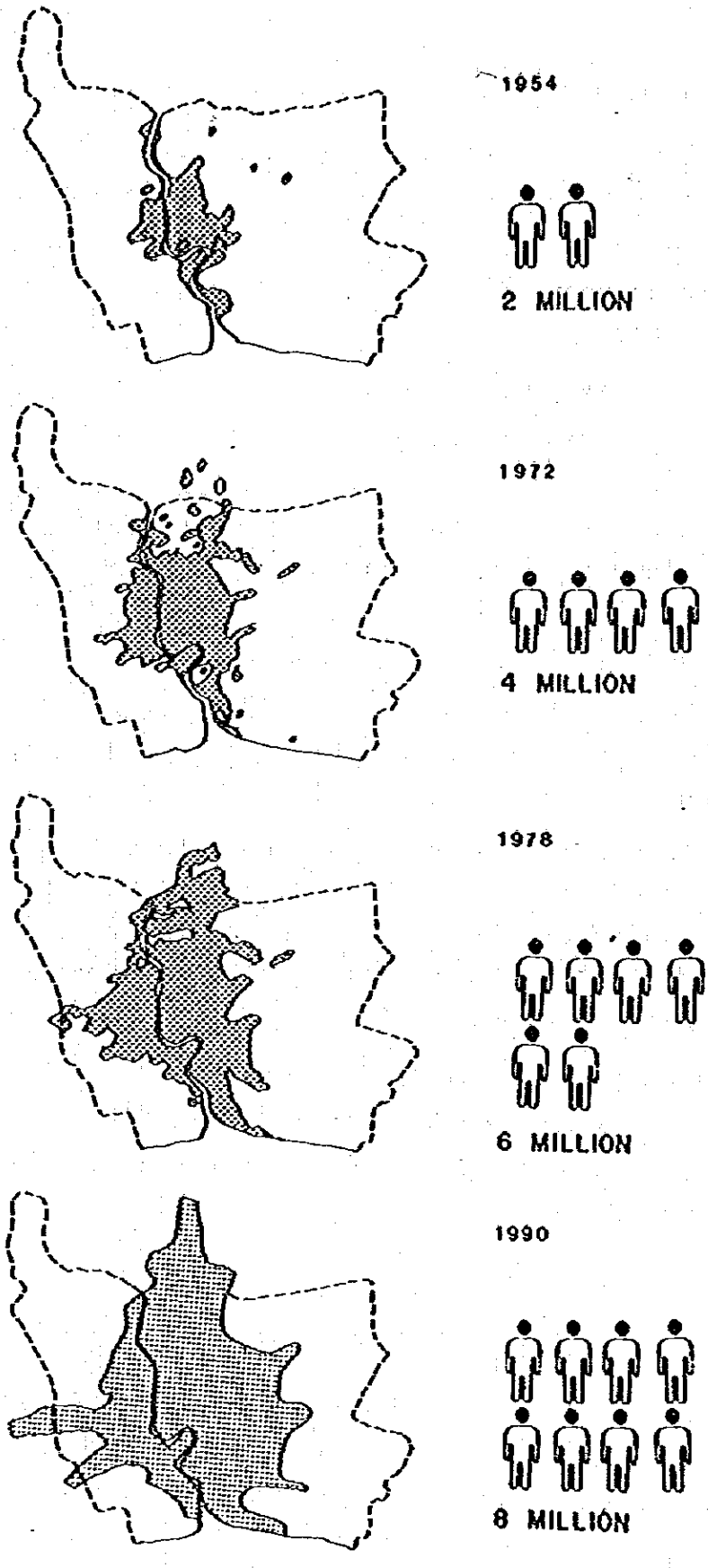


FIG. 3-9 BANGKOK EXPANSION PATTERN

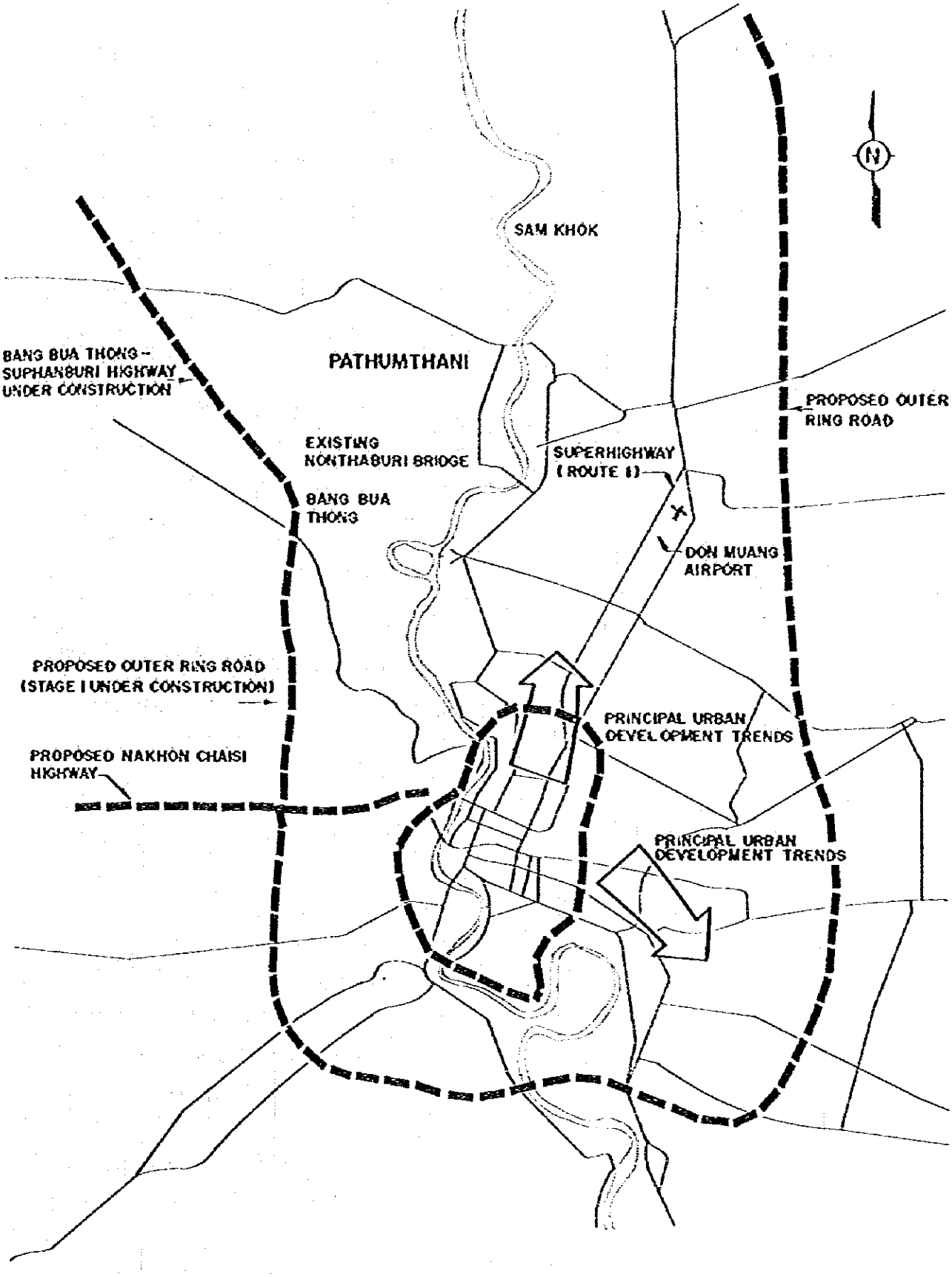


FIG. 3-10 DEVELOPMENT FEATURES

1) Residential Area 416 sq.km.

Residential area can be classified in three area types which are high-density, mixed-use density and low density area. Area of each type density area is 32,224 and 160 sq.km. and population is 1.04, 3.57 and 1.2 million respectively.

2) Commercial Area 44.3 sq.km.

Conglomerated commercial centers has been under construction centralizing mercantile activities.

3) Industrial Area 54.3 sq.km.

Pollution-prone industry is separated from residential area.

4) Governmental Facility Area 63.1 sq.

5) Park and Green Area 62.4 plus 41.6 sq.km.

62.4 sq.km. is aggregated into 14 parks, the remaining 41.6 sq.km. of parks are dispersed among residential area. (See Fig. 3-11)

The present (1977) and future (2000) land use plan regarding the area of 316,600 ha of GBA can be described as in Fig. 3-12. (See Table 3-4)

Table 3-4 Greater Bangkok Area Land Use

Land Use \ Year	1977	2000
Mixed-use low density	32,457	72,523
Mixed-use high density	4,571	13,977
Institutional	5,027	3,467
Industrial	4,293	9,400
Agricultural	225,334	203,047
Others	14,918	14,186
Total	316,600	316,600

Source: Greater Bangkok Plan

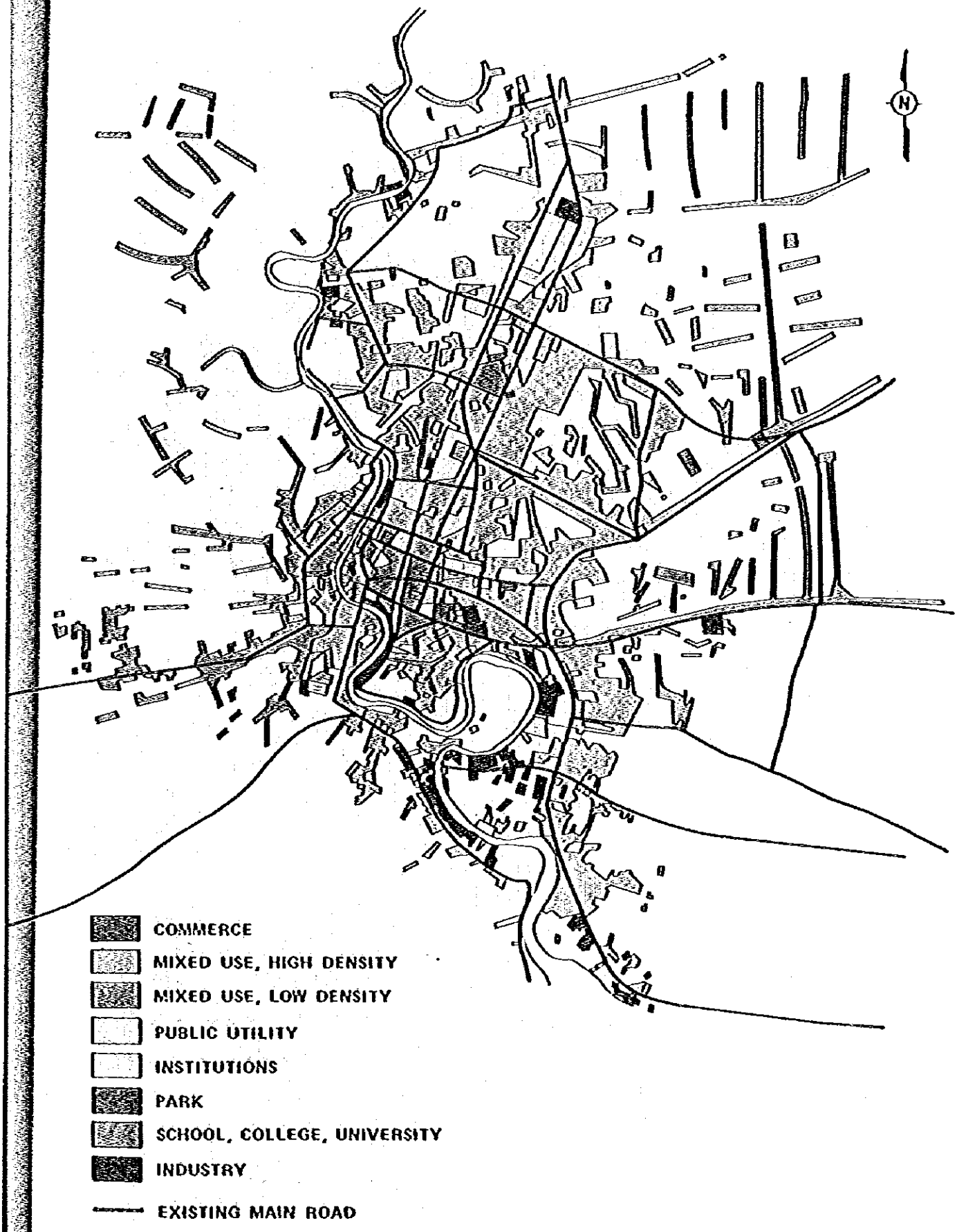


FIG. 3-11 GREATER BANGKOK LANDUSE

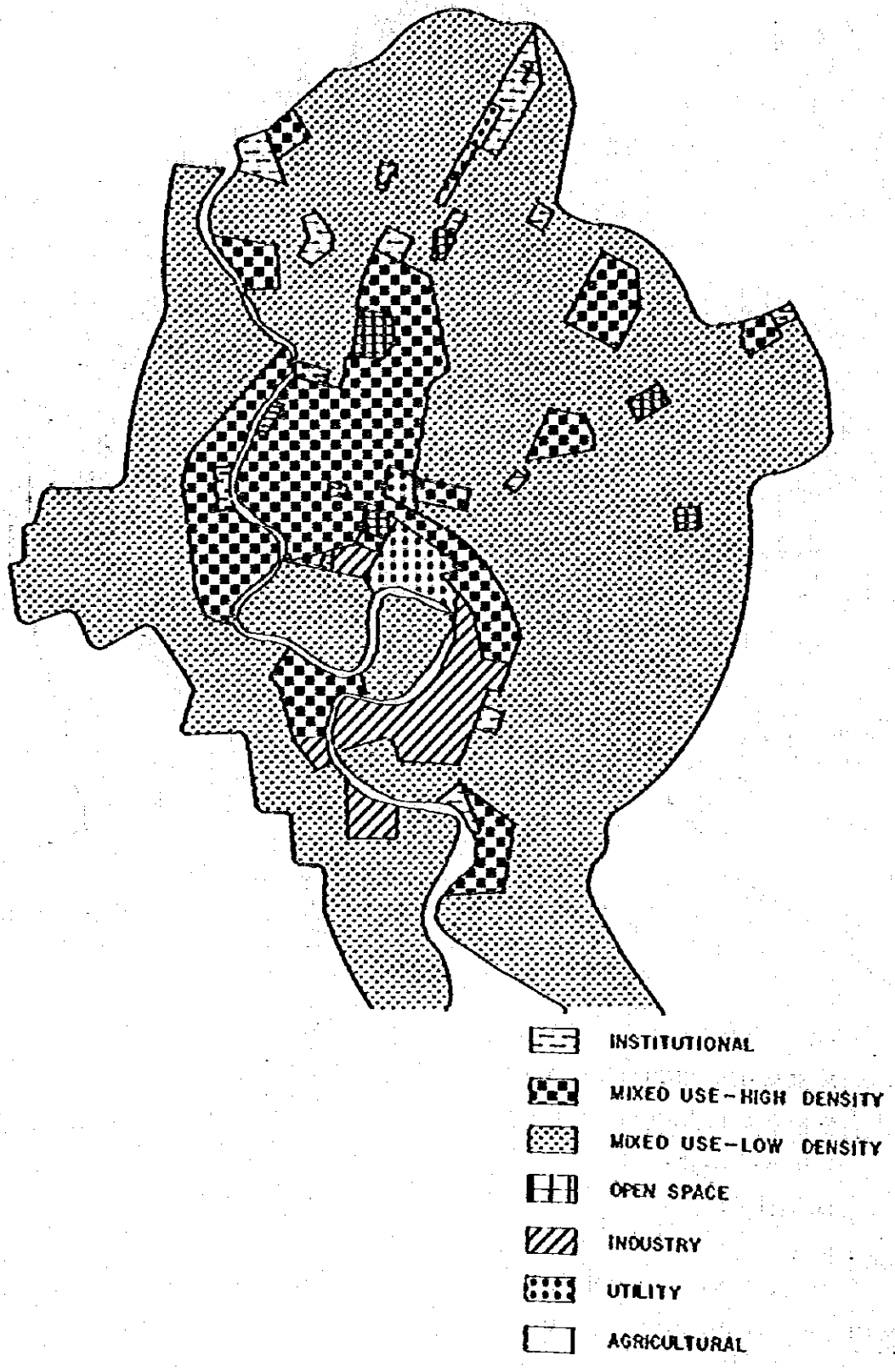


FIG. 3-12 GREATER BANGKOK PLAN 2000

3-9 FUTURE ROAD NETWORK IN THE STUDY AREAS

Major transport projects which are currently under construction of planned in the study area are listed as follows;

1) Middle Ring Road (MRR) Project

This provides a circular route around the central area of Bangkok crossing the Chao Phraya River at Krung Thep Bridge and the RAMA VI Bridge which is the object of the present study.
The Ring Road is expected to be completed in the middle of 1983. Traffic forecast in the study uses traffic flow after the completion of the MRR.

2) Sathorn Bridge Project (under construction)

This Bridge links east and west of the Chao Phraya River at southern part of the city center. Scheduled for completion in the end of 1982.

3) Two major road projects

This projects link Bang Bua Thong - Suphanburi and Sam Khok-Sena are scheduled for completion until 1985.

4) The proposed Bangkok Noi - Nakhon Chaisi Road

This road provides a direct route north of the Phet Kasem Highway to Nakhon Pathom in the west.

5) The Urban Expressway Project

This project proposed as a toll road, is under construction in the three routes: Viphavadi Rangsit Highway at Din Daeng the Port at Khlong Toei.
Thonburi-Pak Tho Highway the Port at Khlong Toei.
The port to Bang Na-Trad Highway.

6) Outer Ring Road (ORR) Project

This project runs from Bang Bua Thong in the northwest, west and south of Thonburi, to cross the Chao Phraya River at South of Phra Pradaeng, then lead its way to south east of Bang Na and east of Bang Kapi and finally to join with Route 1 and 32 in north of Klong Rangsit. Project now on detailed design stage.

7) Mass Transit Project

This project has been implemented by ERAT together with the expressway project of 4) in order to improve public transport service on separate right of way, initially as an elevated busway and later as an elevated rapid train system. Project now under detailed designing.

The above described projects have been taken into considerations in forecasting future traffic volume for this study. The future road networks for the years of 1980, 1985 and 1990 are shown in Fig. 3-13.

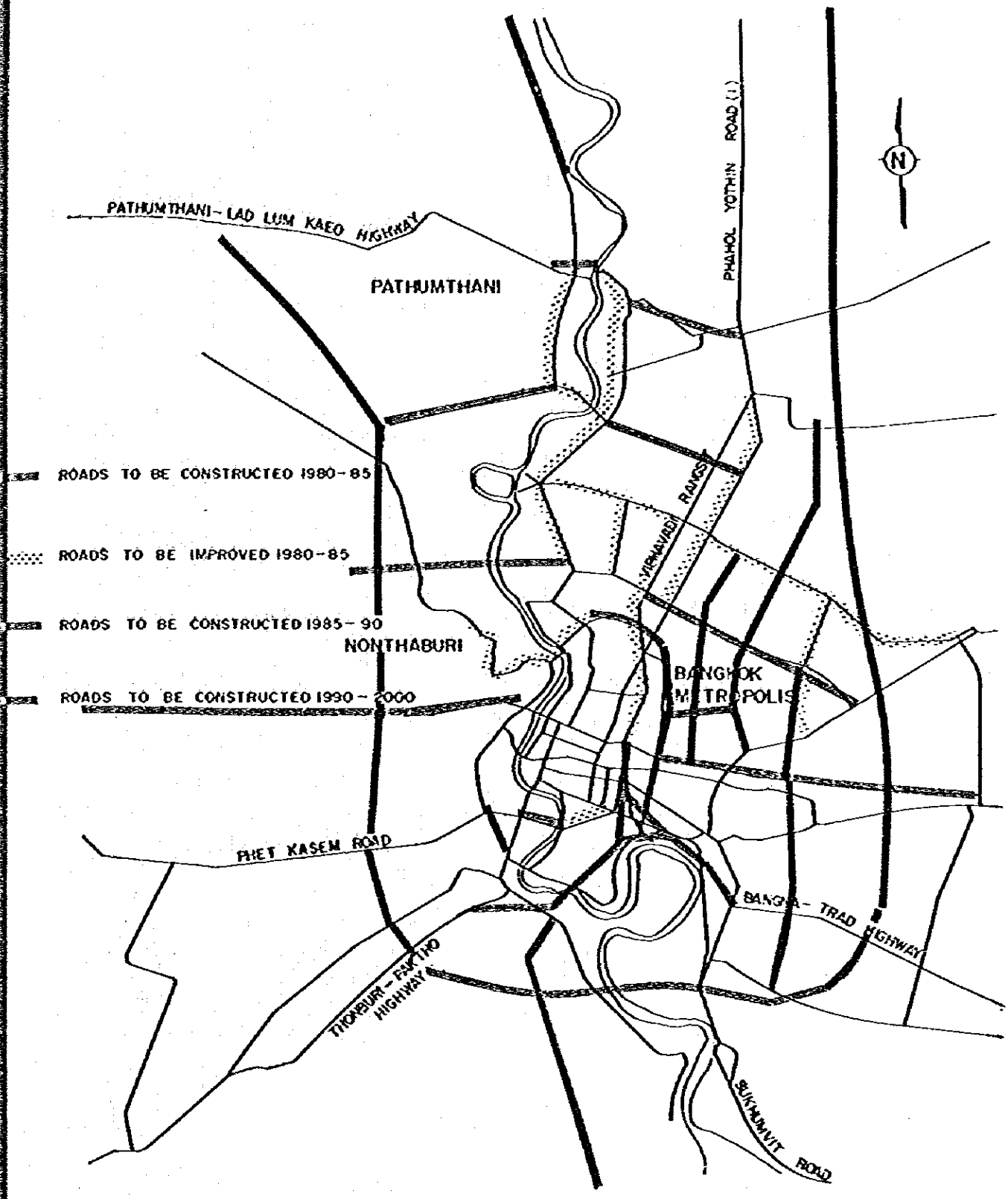


FIG. 3-13 ROAD NETWORK

CHAPTER 4
TRAFFIC SURVEY

CHAPTER 4 TRAFFIC SURVEY

4-1 PURPOSES OF TRAFFIC SURVEY

The purposes of the traffic survey are two fold; one is to investigate the present traffic conditions and other is to furnish data for forecasts of future traffic volume. All of traffic survey data will be usefull in planning of traffic treatment and overall traffic improvement.

In the present traffic survey the items of investigation has been given as follows :

- Traffic counts at road section
- Traffic counts at each approachs of intersections
- Queue (waiting cars) length measurement at each approaches of intersections
- Roadside interview for O-D Survey
- Travel time survey

Classification of vehicle types is defined according to the Table 4-1 shown below.

Locations of survey station are shown in Fig. 4-1 and schedule of survey is given in Fig. 4-2. The results of the survey are in Appendixes 4-1, 4-2

Table 4-1 Classification of Vehicle Type

Vehicle Type			Remark
Large Class	Medium Class	Small Class	
Motorcycle	Motorcycle	Motorcycle	
Vehicles with 3 or more Wheels	Cars	Passenger Cars	Including station wagon and jeep
		Taxies	Includes sanlor
	Buses	Light and Medium Buses	
		Heavy Bus	
	Trucks (Commercial Vehicles)	Light and Medium Truck	Pickup (Van) and 4 wheel truck
		Heavy truck	

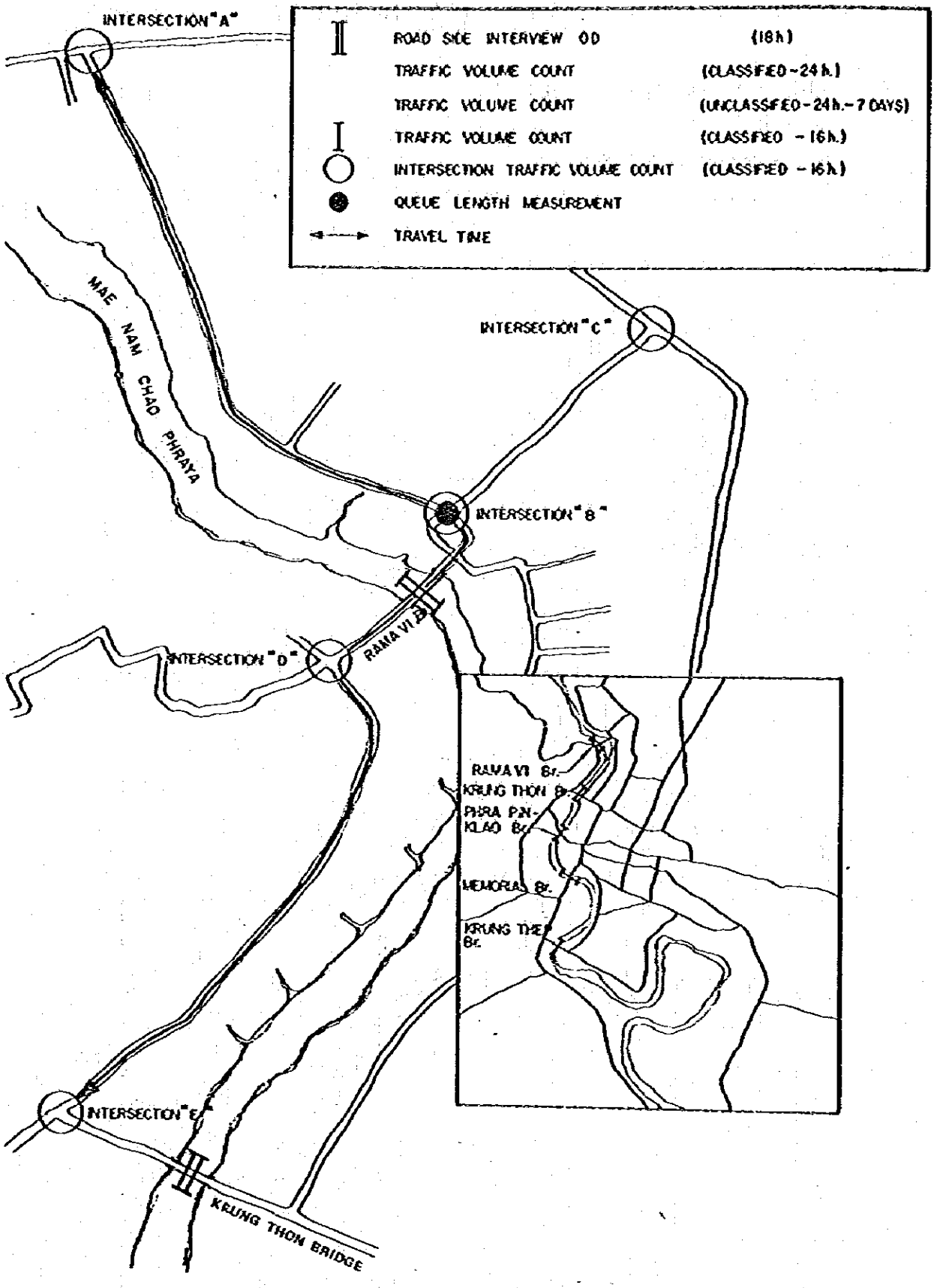
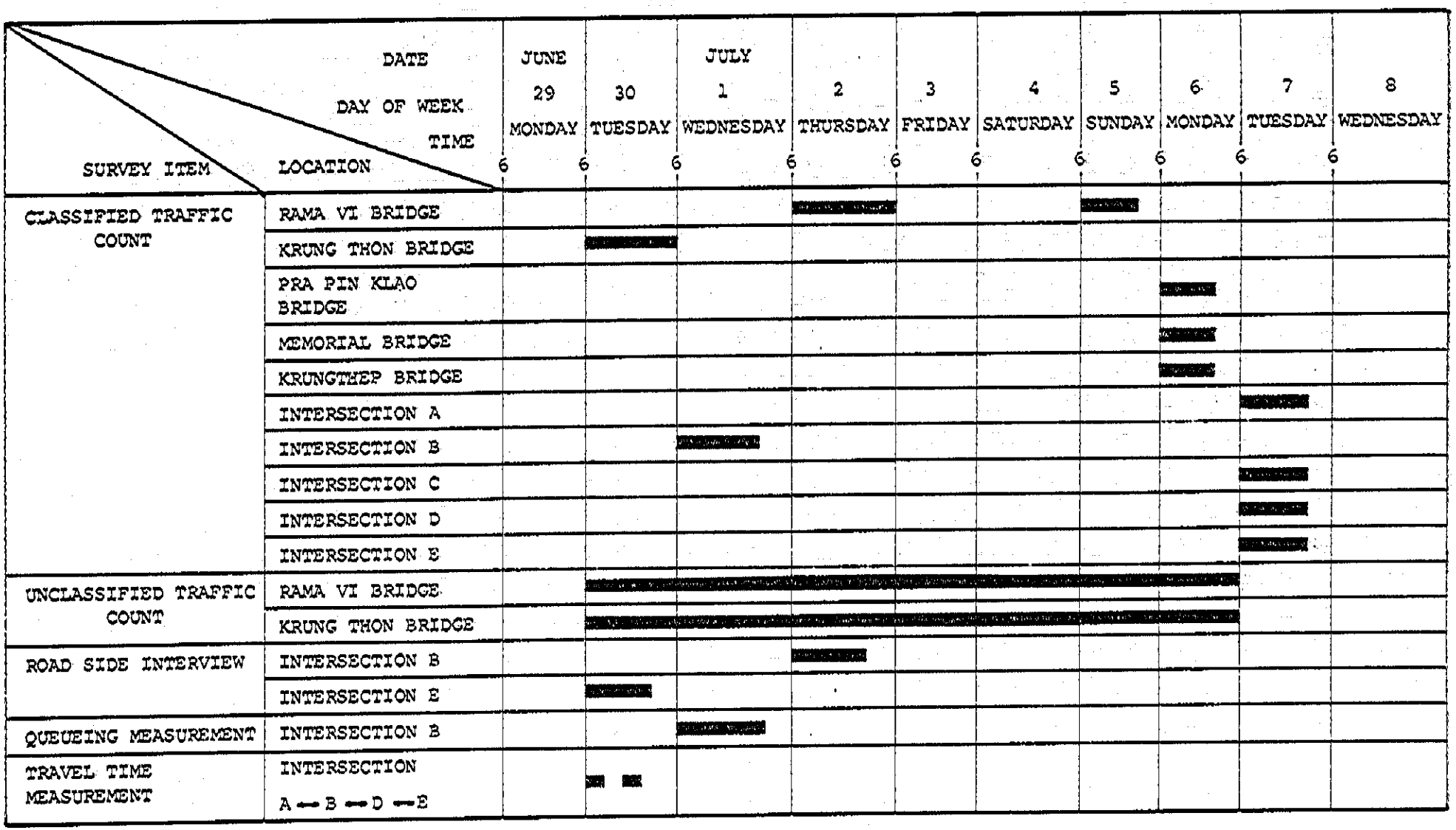


FIG. 4-1 LOCATION OF SURVEY STATION

FIG. 4-2 TRAFFIC SURVEYS SCHEDULE



4-2 TRAFFIC CROSSING SCREEN LINE (THE CHAO PHRAYA RIVER)

The Chao Phraya River runs in the middle of the Greater Bangkok Area and divides the Study Area into two parts, namely Bangkok Side and Thonburi Side. The River has six bridges including the present RAMA VI Bridge.

Geographycally and topographically, the Chao Phraya River thus constitutes the most desirable screen line for the present traffic survey.

The characteristics of the screen line in terms of traffic counting are described as follows:

1) The break-down of the total cross sectional traffic volume of the screen line is given in Table 4-2.
   Total vehicle volume (excluding motorcycles) is approx. 260,000 veh/day with the breakdown of 177,000 veh/day of passenger cars, 30,000 veh/day of buses and 53,000 of trucks. Counts of Motorcycles are 90,000 veh/day.

2) In order to show the degree of congestion in each bridge the traffic volume in one lane is compared in Table 4-3.

   One lane volume on the Memorial Bridge is extremely high exceeding 17,000 veh/day thus causing the worst congested traffic conditions in the vicinity area. Traffic on four other bridges with an exception of Nonthaburi Bridge all exceed 10,000 veh/day level causing considerable congestion at the present.

Table 4-2 Screen Line (Caho-Phraya River) Present Traffic Volume (Veh/day)

Vehicle Type / Bridge	Motor cycle	Car	Bus	Truck	Total (Excl. m.c.)
Nonthaburi	610	1780	1400	4100	7280
RAMA VI	3260	14580	3440	4240	22260
Krung Thon	7350	30250	4470	6420	41140
Phra Pin Klao	14550	52580	6560	7750	72890
Memorial	48580	45680	10680	12210	68570
Krung Thep	16080	26490	3360	17920	47770
Total	90430	177360	29910	52640	259910

Footnote 1: The data for 1980 has been quoted for Nonthaburi Br. using multi. factor of 1.0

2: Night traffic on Phra Pin Klao, Memorial and Krung Thep Brs. computed using data of Krung Thon Br.

Table 4-3 Traffic Per One Lane and Rate of Motorcycle

Bridge	No. of Lanes	One Lane Volume	Motorcycle Rate
Nonthaburi	2	3,910	7.7%
RAMA VI	2	11,130	12.8%
Krung Thon	4	10,285	15.2%
Phra Pin Klao	6	12,150	16.6%
Memorial	4	17,140	41.5%
Krung Thep	4	11,940	25.2%
Average(Total)	22	11,815	25.8%

Note: Rate of Motorcycle is number of Motorcles/ Traffic volume + Motorcycles.

3) Viewing the Motorcycle Rate shown in Table 4-3, it can be seen that the highest rate is occuring on Memorial Bridge followed by Krung Thep Bridge. Both the bridges are situated downstream of the river. The higher rate of motorcycles can be explained by:

   a) Most of commuter traffic between Yawarat District (China Town District) and Wongwienyai residential districts use motorcycles as the most convenient vehicle.

   b) Inadequate parking facility for cars in Yawarat District.

   c) Congested road conditions in the vicinities of both bridges which prevent use of passenger cars.

4) Traffic of hourly variation in a day for each bridge is given in Fig. 4-3. These upstream bridges of RAMA VI, Krung Thon and Phra Pin Klao Bridges are showing typical peaks in the morning and evening while down stream bridges of Memorial and Krung Thep have no significant variations.
   These indicate that at the two downstream bridges, congestion has already reached its critical point, and also in conform with above stated 1) - 3) descriptions.

5) On the Phra Pin Klao Bridge, distinguished peaks are taking place because large numbers of detour traffic are coming from more congested downstream bridge.

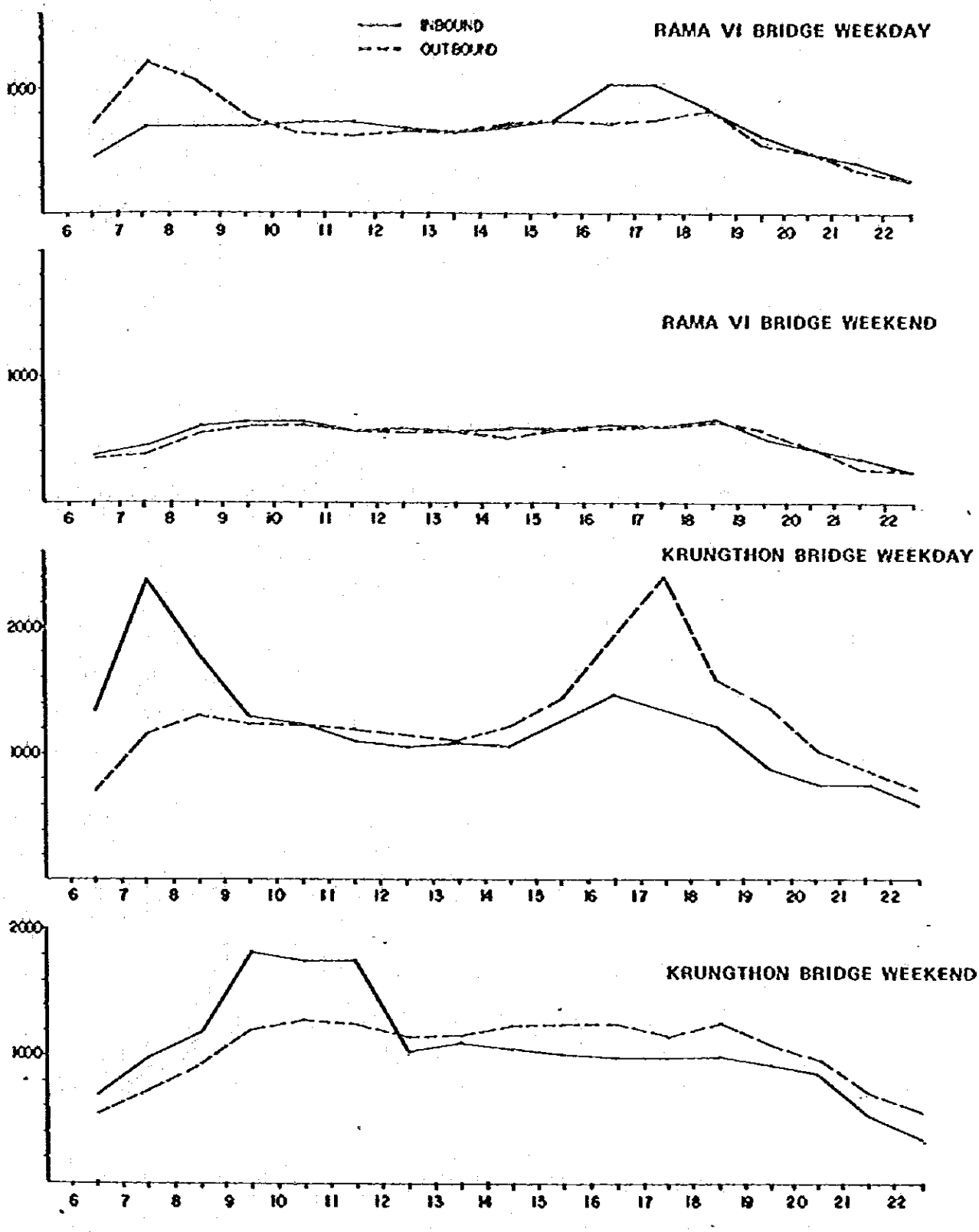


FIG. 4-3(1) TRAFFIC OF HOURLY VARIATION IN A DAY

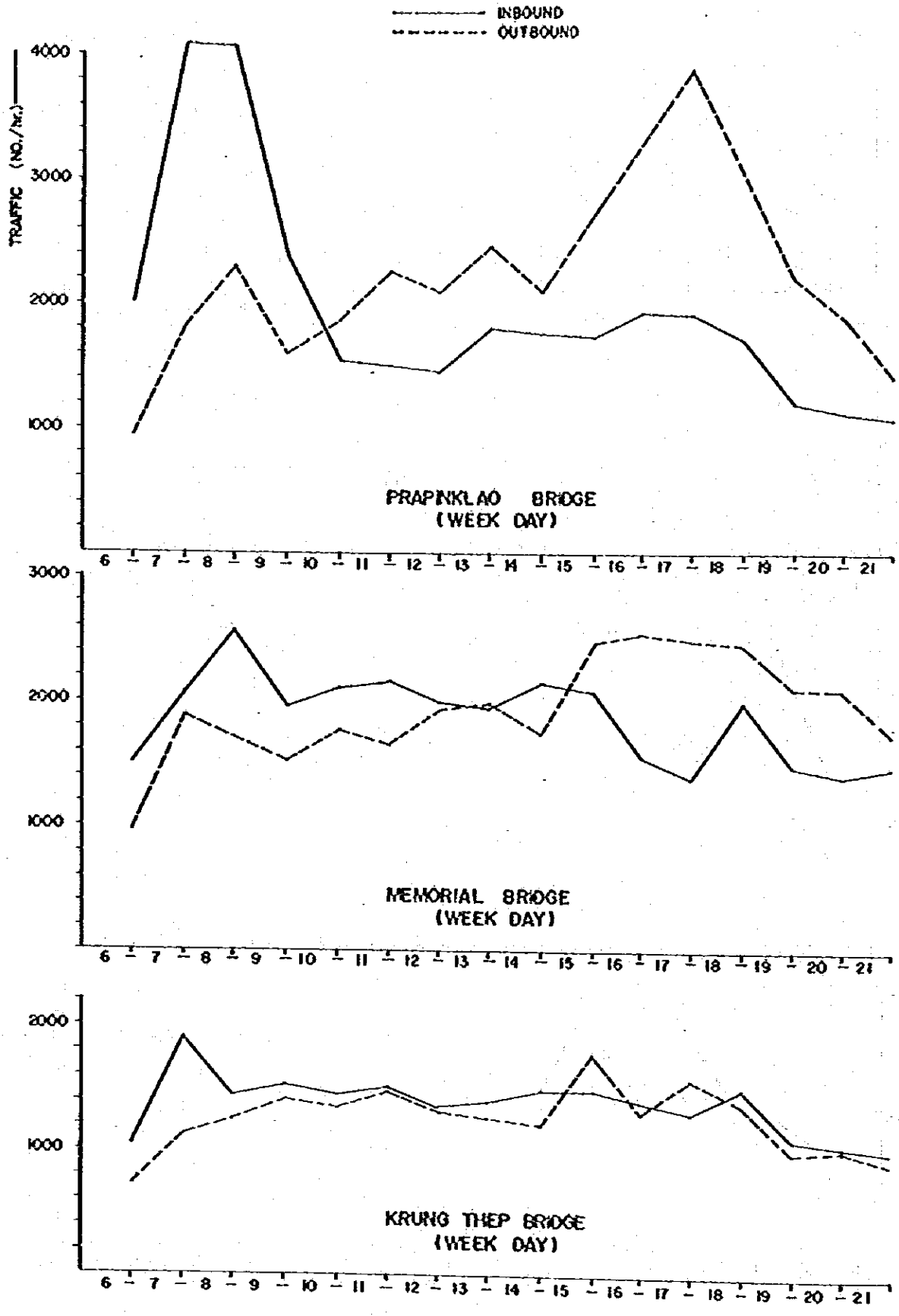


FIG. 4-3(2) TRAFFIC OF HOURLY VARIATION IN A DAY

4-3 TRAFFIC THROUGH THE RAMA VI BRIDGE

1) Daily Variation

Daily Traffic Variations in a week which goes through the RAMA VI Bridge are shown in Table 4-4 and Fig. 4-4. Average Weekday traffic of 24,000 veh/day has been observed with Monday and Friday shaping two peaks. Variation on a weekday is very small.
Weekend traffic, especially that of Sunday is far less than that of weekdays.

2) Hourly Variations

The hourly Traffic variations of in-bound (i.e. from Thonburi towards Bangkok) and out-bound traffics are shown by classified verhicle types. (See Fig. 4-6)
For in-bound traffic, one-time peak after 18.00 hr.occures in the evening while for out-bound traffic, on the other hand, one early morning peak takes place. The rate of peak hour is 10.5% (7-8 hr.).

3) Vehicle Composition

The vehicle composition is given in Fig. 4-5. comparatively large percentage of buses and smaller percentage of motorcycles are the characteristics. Extremely high rate of passenger cars has been seen at peak hours and very small number of trucks has been counted possibly as a result of traffic ban regulation which is being imposed only on trucks.

4) Pedestrians

Comparatively small number of pedestrians including bicycles has been observed on weekdays, being counted as 770 persons/24 hr (730 persons/16 hrs) and 300 persons/16 hrs on Sunday. More than half of weekday pedestrians are the students going to schools on Thonburi side.
Apparent peaks of 7-8, 11-13 and 16-19 hours have been seen because the school has two sessions everyday.

TABLE 4-4 DAILY TRAFFIC ON RAME VI BRIDGE

	MON.	TUE.	WED.	THURS	FRI.	SAT.	SUN.	AVERAGE OF WEEK
IN BOUND	12143	11634	11598	11139	12255	10392	9000	11164
OUT BOUND	12269	11956	12141	12040	12083	9675	8835	11285
TOTAL	24412	23590	23739	23179	24338	20067	17835	22450
INDEX TO AVERAGE	1.087	1.051	1.057	1.032	1.084	0.893	0.794	1.000

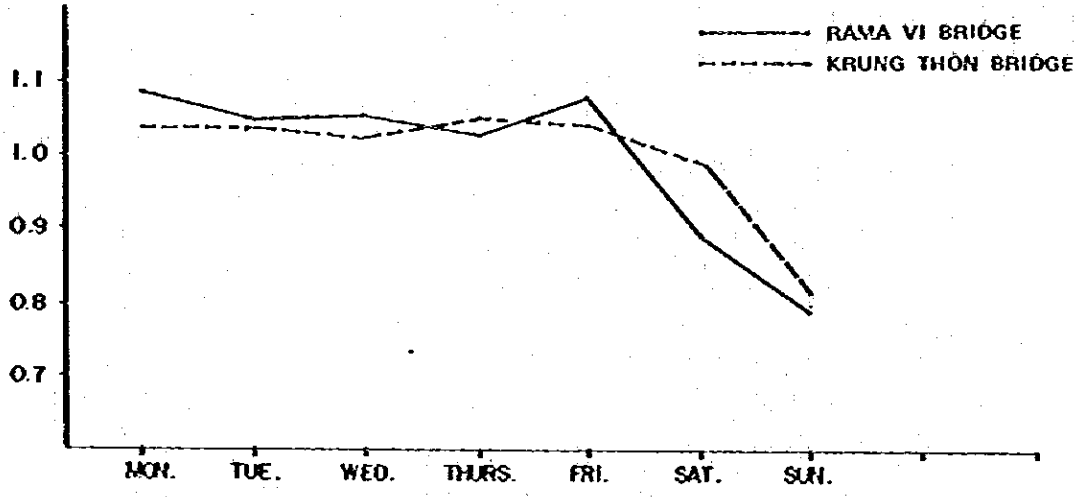
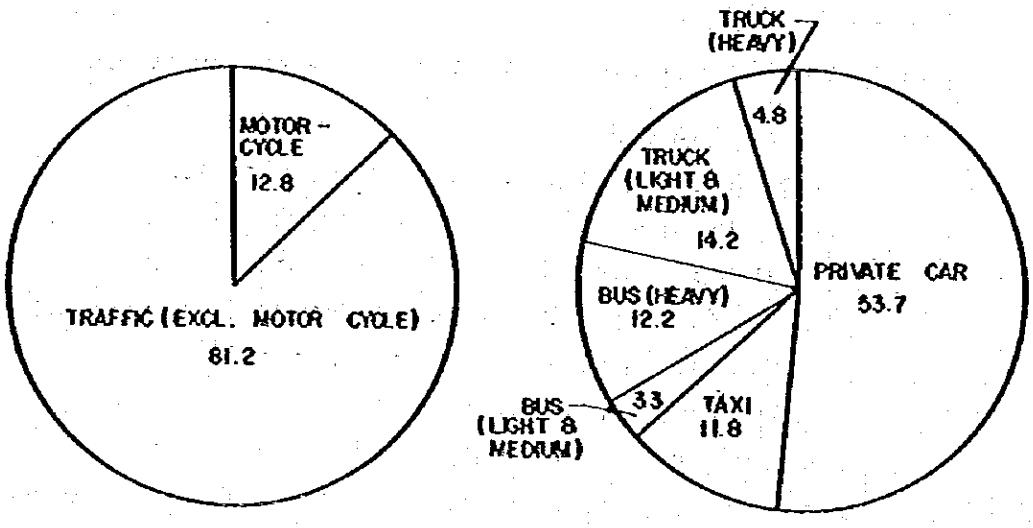


FIG. 4-4 TRAFFIC OF DAILY VARIATION IN A WEEK ON RAMA VI BRIDGE



RATE OF MOTORCYCLE(%) COMPOSITION EXCL. MOTORCYCLE (%)

FIG. 4-5 VEHICLE COMPOSITION ON RAMA VI BRIDGE

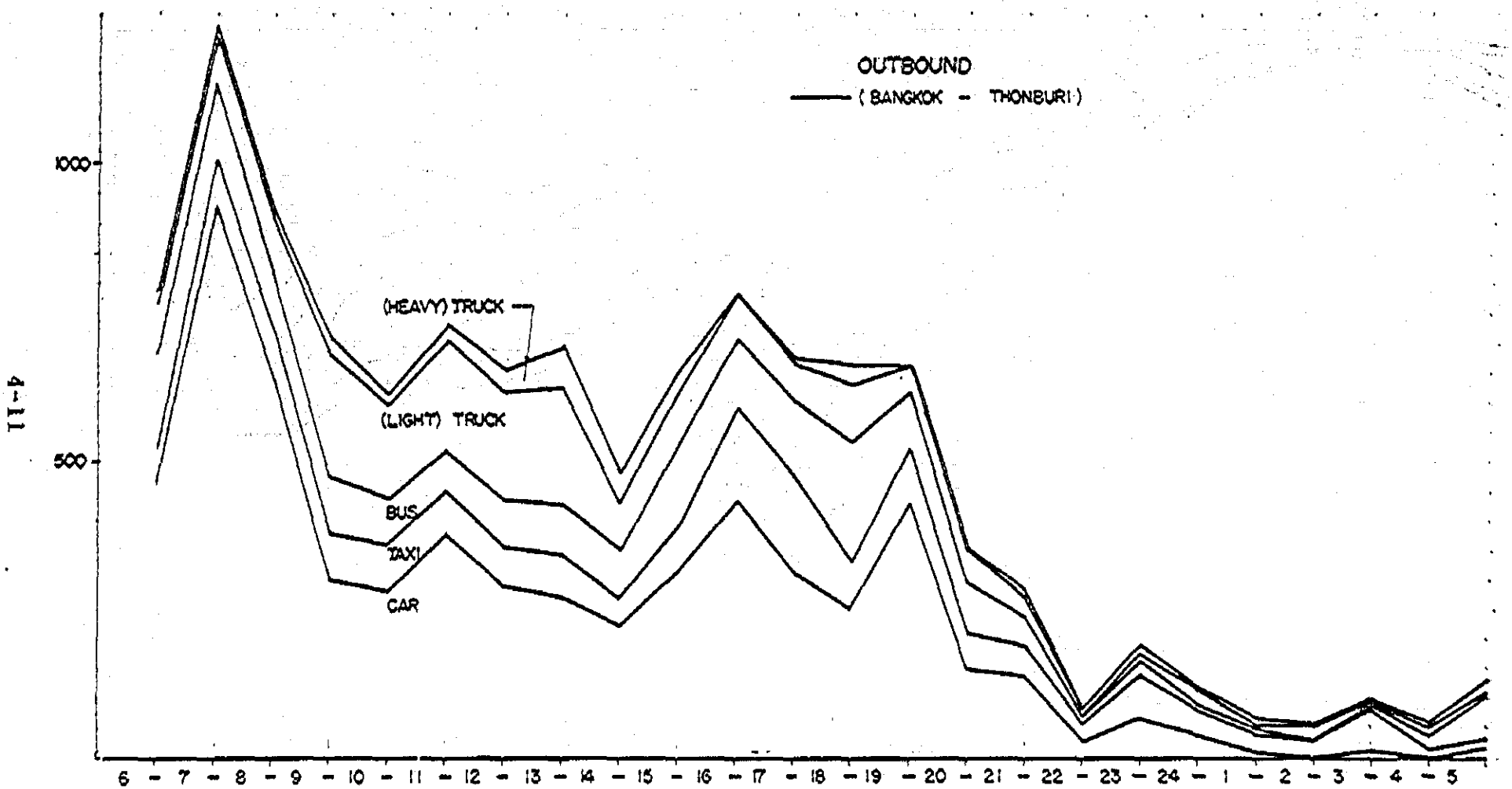


FIG. 4–6(1) TRAFFIC OF HOURLY VARIATION BY VEHICLE TYPE IN A WEEK DAY ON RAMA VI BRIDGE

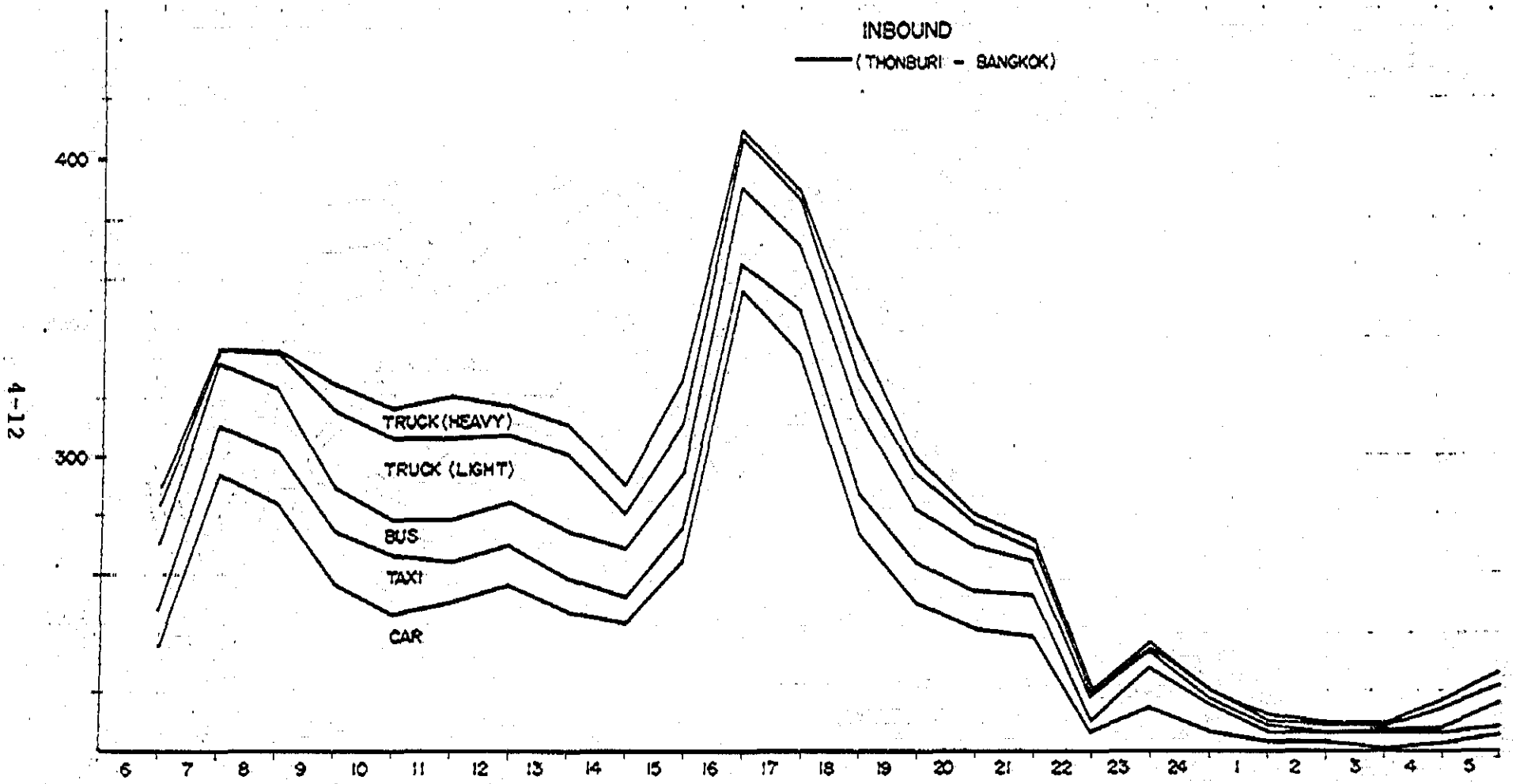


FIG. 4-6(2) TRAFFIC OF HOURLY VARIATION BY VEHICLE TYPE IN A WEEK DAY ON RAMA VI BRIDGE

4-4 TRAFFIC AROUND THE RAMA VI BRIDGE

In order to comprehend the present traffic conditions around the RAMA VI Bridge, directional traffic countings have been carried out on major intersections in the Study Area. The results are shown in Fig. 4-7. Present traffic flow by direction of intersection are attached as Appendixes 4-3.

BANGKOK SIDE:

1) Krung thep - Nonthaburi Road is being under improvement works and running condition is not good, while that of Pibul Songkhram and Pracharat I roads are good due to its 4-6 lanes cross section.
   The traffic from R 306, R3099 going to Bangkok or RAMA VI Bridge makes the use of Pibul Songkhram Road at the rate of 2:1.

2) At intersection B adjacent to RAMA VI Bridge, 54% of bridge relevant traffic use Pibul Songkhram and 30% Wongsawang Roads and 16% Pracha Rat I Road. Excluding RAMA VI related traffic, the volume of right and left turn traffic at Pibul Songkhram - Pracha Rat I Roads is dominating.

   NOTE: Locations of Intersection A.B.C.D.E are shown in Fig. 4-1.

THONBURI SIDE:

1) Only the traffic of Charan Sanitwong Road on the Thonburi side is in full controll. The section between RAMA VI and the railway crossing has 2-lane roadway only and from the crossing southwards, traffic increases due to its 6-lane roadway.

2) 22% of Traffic via RAMA VI Bridge has its origin or destination in the section between the Bridge and the railway crossing or Route 3215.

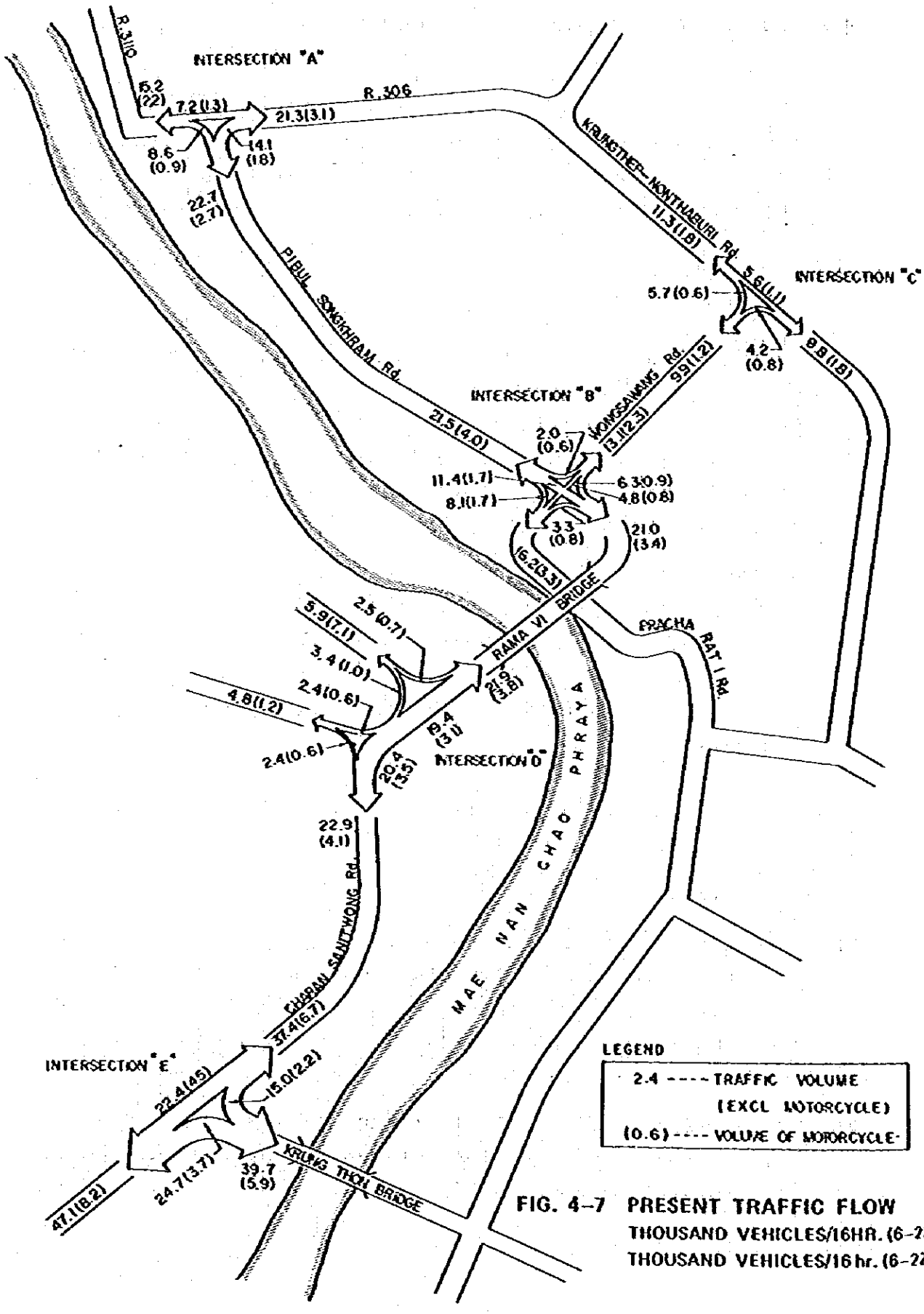


FIG. 4-7 PRESENT TRAFFIC FLOW
THOUSAND VEHICLES/16HR. (6-22)
THOUSAND VEHICLES/16 hr. (6-22)

4-5 RUNNING CONDITIONS AROUND THE RAMA VI BRIDGE

A survey for queue length measurement at the intersection B and running speed measurements at the adjacent sections of the RAMA VI Bridge has been conducted.

1) Queue length at intersection B

Intersection B is located at the end of approach section of RAMA VI Bridge thus constituting a bottleneck of traffic in the Study Area.

Queue lengths in each directional lane at peak hour have been observed and its results in graphs are given in Fig. 4-8. All of entering sections of the intersection consist of 3-lane and each lane is numbered as 1st, 2nd and 3rd lane from the outside side-walk toward the center.

No waiting has been observed on 1st lane because it is used by left-turn traffic only.

Waiting conditions of each directional traffic will be described below;

a) Flow-in traffic from RAMA VI Bridge

Approximately 100 meters long waiting line has been observed between 16:30 to 18:00 in the evening.

Very slow movement of cars which is typical for 2-lane roadway follows the tail of the waiting line.

b) Flow-in traffic from Pibul Songkhram Road

During the morning hour of 6:45 to 8:15, approximately 150 meters long queues on 2nd and 3rd lanes have been observed.

Only short waiting takes place in the evening peak. This is mainly caused by the lack of capacity at the intersection B and also by the stagnated traffic on RAMA VI Bridge and situations has been aggravated by parking and stopping of buses on the soft roadside shoulders in the section.

c) Flow in traffic from Wongsawang Road
The same phenomenon described in b) has occurred in 2nd lane.

d) Flow-in traffic from Pracha Rat I Road
100 meters long queues have been frequently observed in the evening peak.

2) Travel Speed Analysis

Travel speed survey is carried out for the bridge section including its approaches (intersection B--the railway crossing) during both morning and evening peak hours. The relation of travel speed and traffic volume is shown in Fig. 4-9. In out-bound direction, travel speed has a good inverse correlation with traffic volume.

Out-bound traffic flow

a) High correlation between speed and volume indicates that the traffic can move rather freely without having effects of any other outside factors such as the capacity of intersections, especially intersection B in this case.

b) The possible upper limit of traffic volume in out-bound direction at the existing RAMA VI bridge can be estimated to be 1200-1300 Veh/hr.

In-bound traffic flow

Regarding in-bound traffic flow, travel speed and traffic volume correlationship widely varies between in the morning and in the evening.

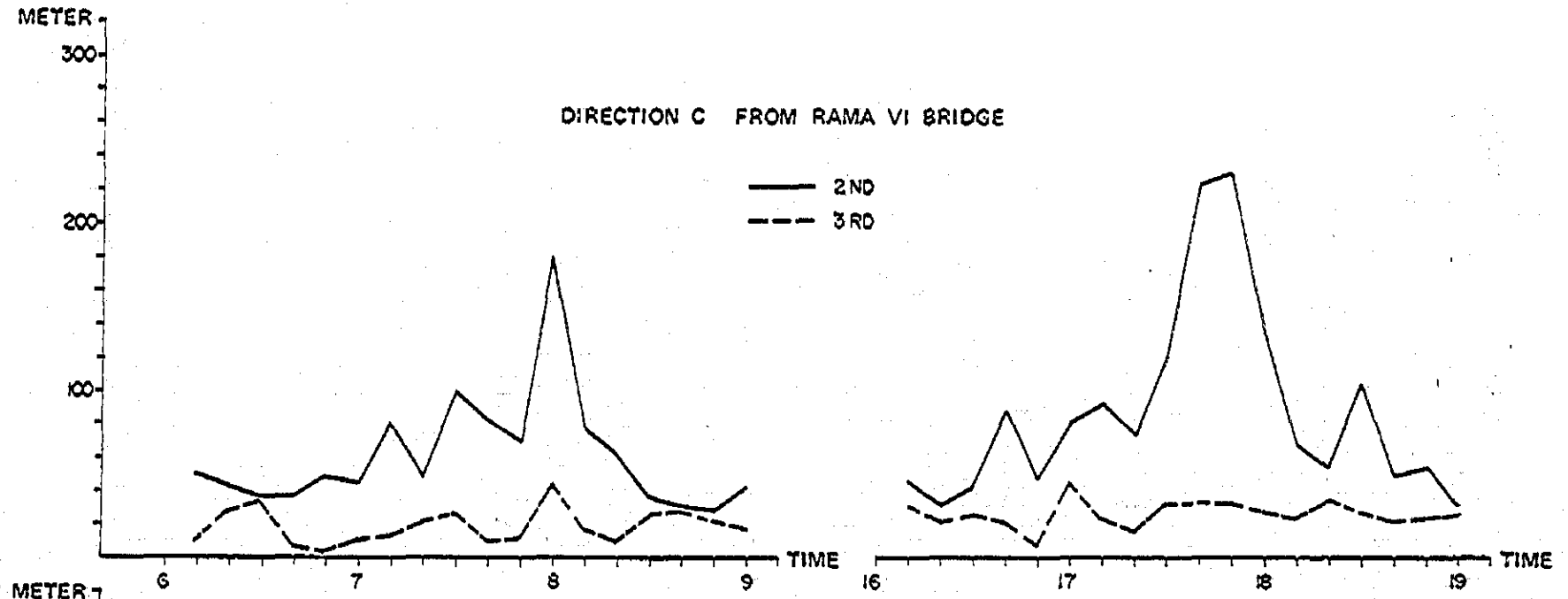
a) This difference has derived from the performance of intersection B in terms of traffic control.
In the morning peak hours, traffic flow from RAMA VI bridge becomes very large and traffic signal has to be split in a very short interval thus slowing down the efficiency of in-bound traffic flow, causing heavy congestion even in rather smaller traffic volume.

b) In the evening peak hours in-bound traffic from RAMA VI bridge is large and more split time is allowed for traffic signal to attain more capacity. It can be seen that the same level of upper limit of 1200 - 1300 veh/hr. has been easily attained for in-bound traffic flow.

Finally, the running conditions in adjacent section of RAMA VI Bridge can be summerized as follows.

1) In the section between Intersection E and SRT railway crossing, travel condition is very good because of its 6-lane roadway.
RAMA VI Bridge, on the other hand, becomes the bottleneck for north bound traffic while Intersection E is acting as a brake for south bound traffic and reduction of speed can be often observed on both the bottlenecks. In the north-bound traffic, which is affected directly by congestion on RAMA VI Bridge, stopping time of as long as 5 to 6 minutes is observed.

2) For the section between Intersection A and B, no congestion takes place for north-bound traffic, while an extremely sharp reduction in travel speed occurred for south-bound traffic due to the effects of Intersection B. Especially, in the morning rush hours between 7:30 and 8:30, at the entrance sections of the Intersection B, 10-30 minutes long halts have been recorded in the survey.



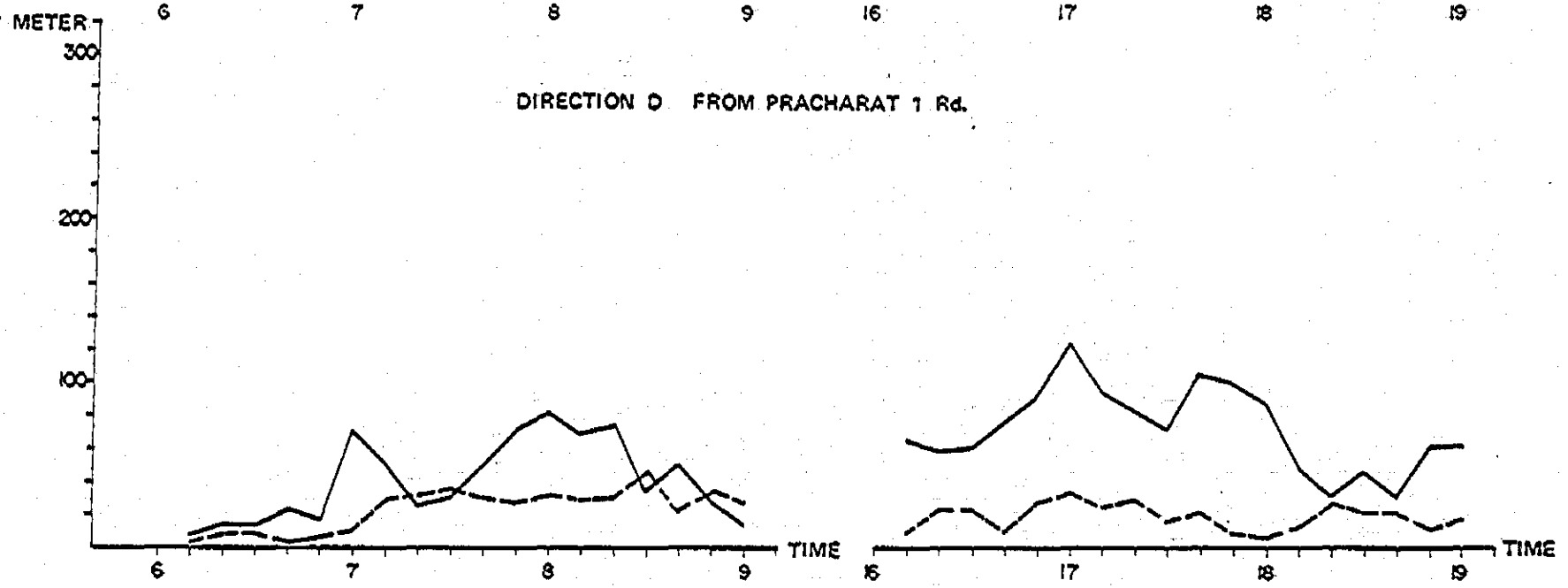


FIG. 4–8(1) QUEUE LENGTH AT INTERSECTION B

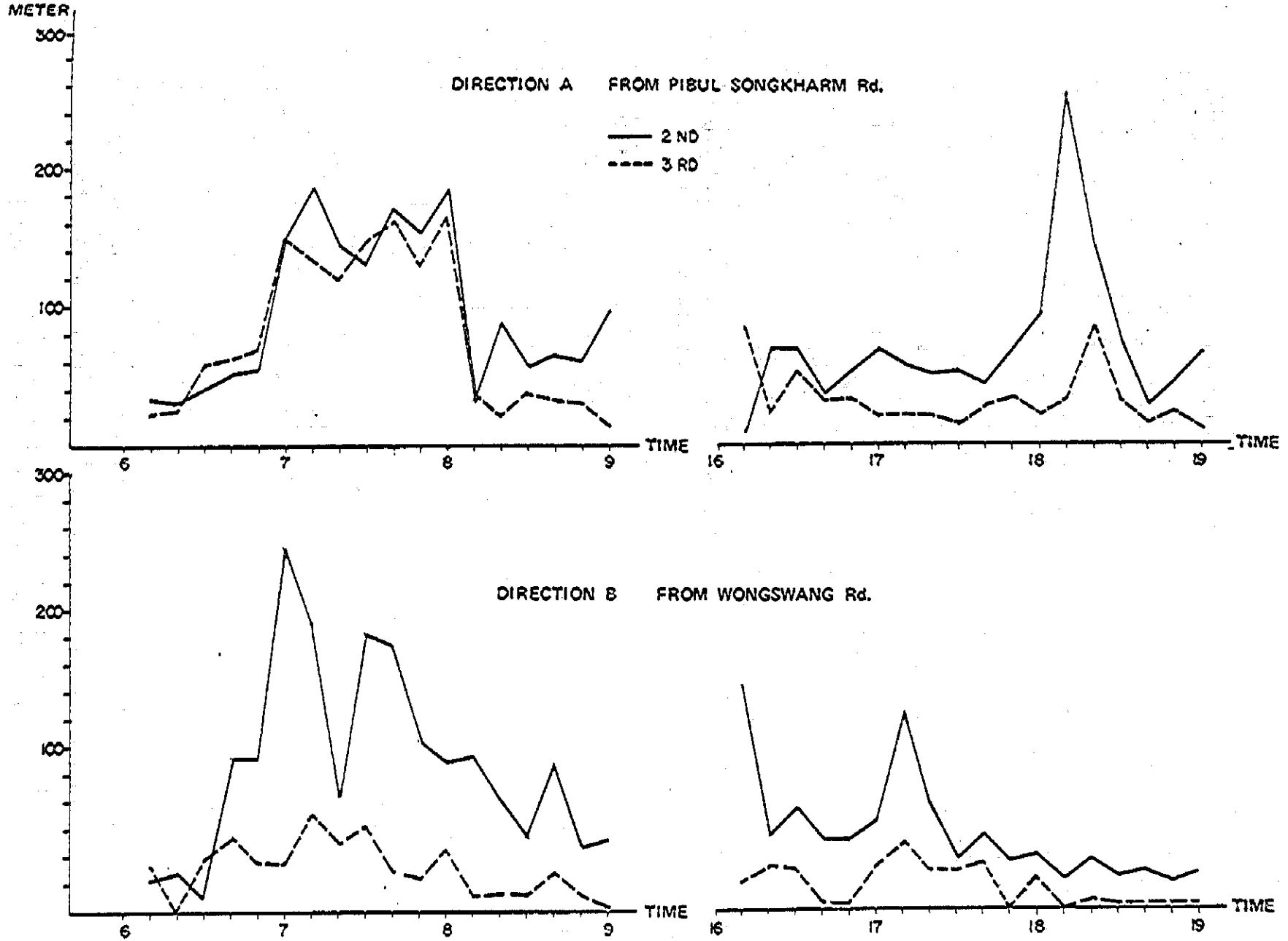


FIG. 4-8(2) QUEUE LENGTH AT INTERSECTION B

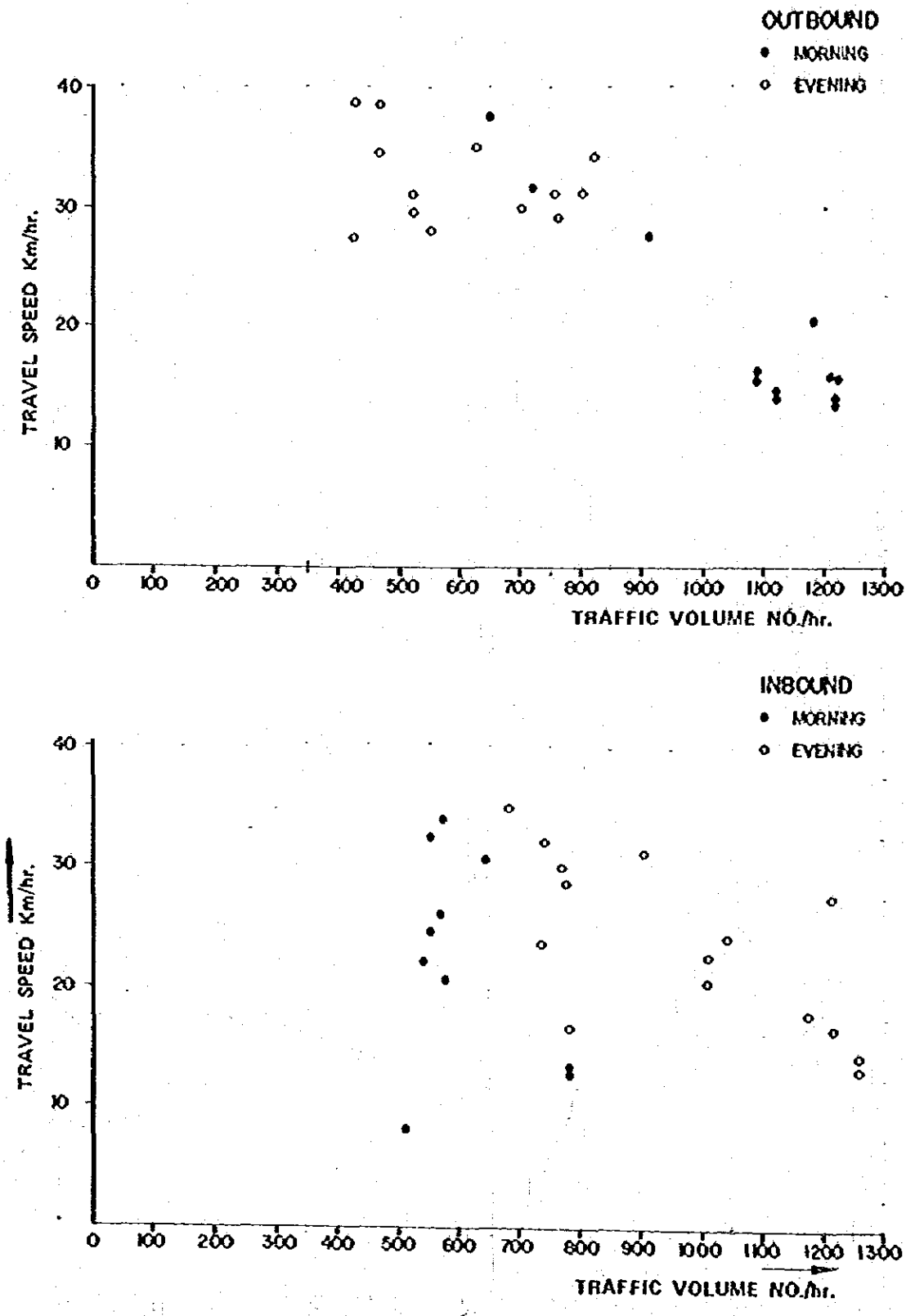


FIG. 4–9 RELATIONSHIP BETWEEN TRAFFIC VOLUME AND TRAVEL SPEED ON THE RAMA VI BRIDGE

4-6 O-D SURVEY BY ROADSIDE INTERVIEW

1) Roadside interviews for Origin and Destination Survey has been conducted at RAMA VI and Krung Thon Bridges site stations both of which selected on Thonburi side of the River. Sampling rates and expansion factors used for each classification of vehicle types are given in Table 4-5 below.

At RAMA VI interview station, a target of 20% sampling has been attained while on the Krung Thon station samplings has not reached the 20% level, with that of passenger cars being as low as 10%.

TABLE 4-5 SAMPLING RATE AND EXPANSION FACTOR (ROAD SIDE INTERVIEW O-D SURVEY)

Location	Vehicle Type	Traffic Volume		No.of Sample.	Sampling Rate(%)	Expension factor
		No./16h	No./24h			
RAMA VI BR.	Motor Cycle	3108	3259	922	29.7	3.53
	Car	12567	14582	3001	23.9	4.86
	Truck	3869	4238	1488	38.5	2.85
	Bus	3148	3438	2073	65.9	1.66
	Total	22692	25517	7484	33.0	3.41
KRUNT THON BR.	Motor Cycle	6869	7354	1225	17.8	6.00
	Car	26580	30247	2651	10.0	11.41
	Truck	5539	6420	1736	31.3	3.70
	Bus	4040	4471	2440	60.4	1.83
	Total	43028	41138	6827	15.9	6.03

2) Results of roadside interviews

The results of roadside interviews can be described as follows:

a) O-D traffic flow using RAMA VI Bridge is shown in Fig. 4-10.

b) Average occupants for each vehicle type is shown in Table 4-6.

c) Purposes of trip

The composition of trip purposes for passenger car and motorcycle are given in Table 4-7 for the traffic using both bridges. Each of home-to work and business purposes occupies almost a half of the total trips.

TABLE 4-6 Average Occupancy

PERSON

Vehicle Type	Average of Occupants	
	Rama VI Br.	Krung Thon Br.
Motorcycle	1.35	1.35
Private car	2.10	2.35
Taxi	2.85	2.45
Light & Medium Bus	5.10	8.20
Heavy Bus	23.80	38.40
Light & Medium Truck	2.75	3.45
Heavy Truck	2.45	2.45

TABLE 4-7 COMPOSITION OF TRIP PURPOSE

Trip purpose	Rama VI Br.		Krung Thon Br.	
	Motor Cycle	Private Car	Motor Cycle	Private Car
Home ot work	44.9	43.2	38.8	44.5
Business	51.4	51.6	57.0	49.4
Home to school	3.7	5.2	4.2	6.1
Total	100.0	100.0	100.0	100.0

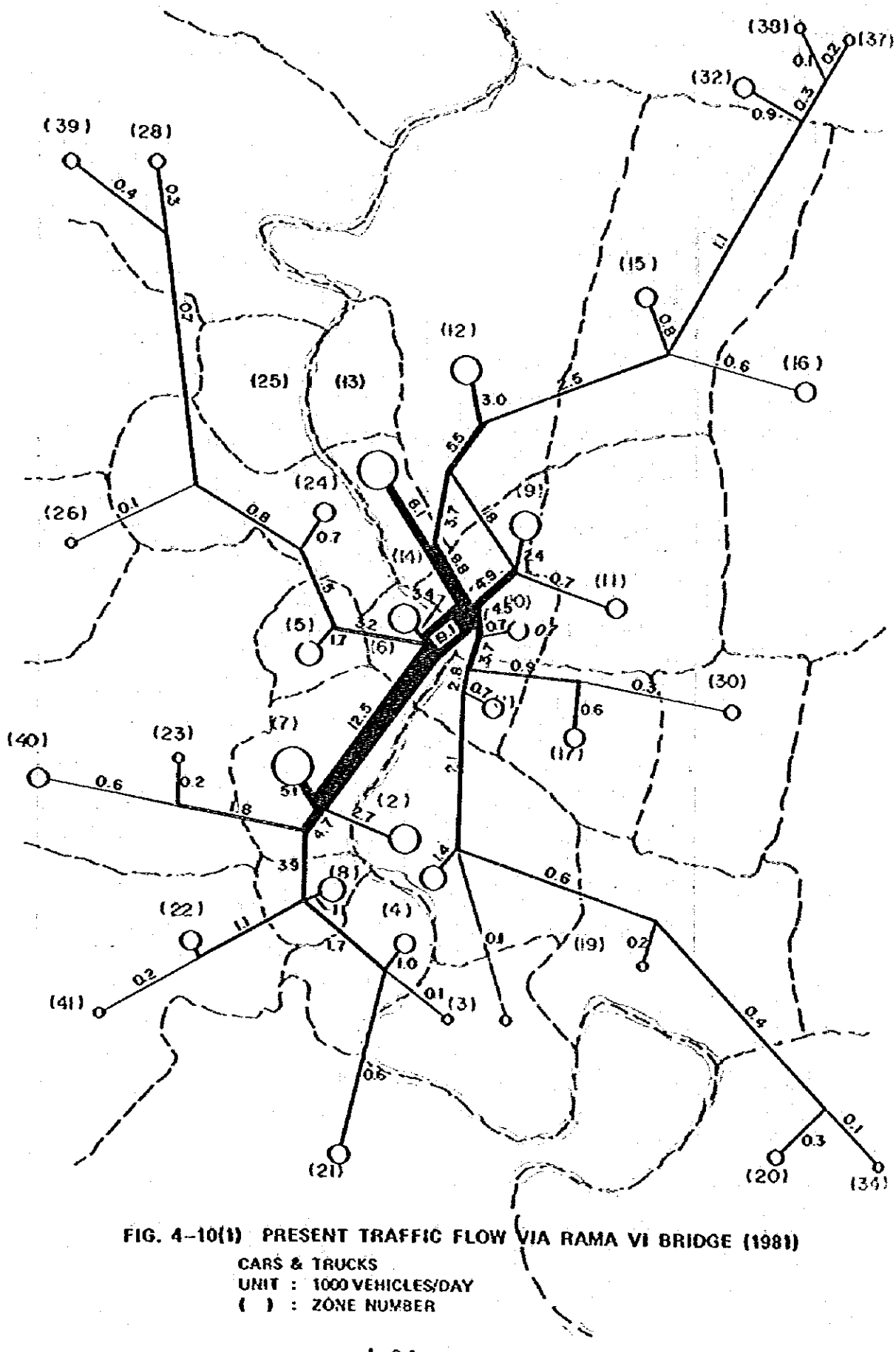


FIG. 4-10(1) PRESENT TRAFFIC FLOW VIA RAMA VI BRIDGE (1981)

CARS & TRUCKS
UNIT : 1000 VEHICLES/DAY
( ) : ZONE NUMBER

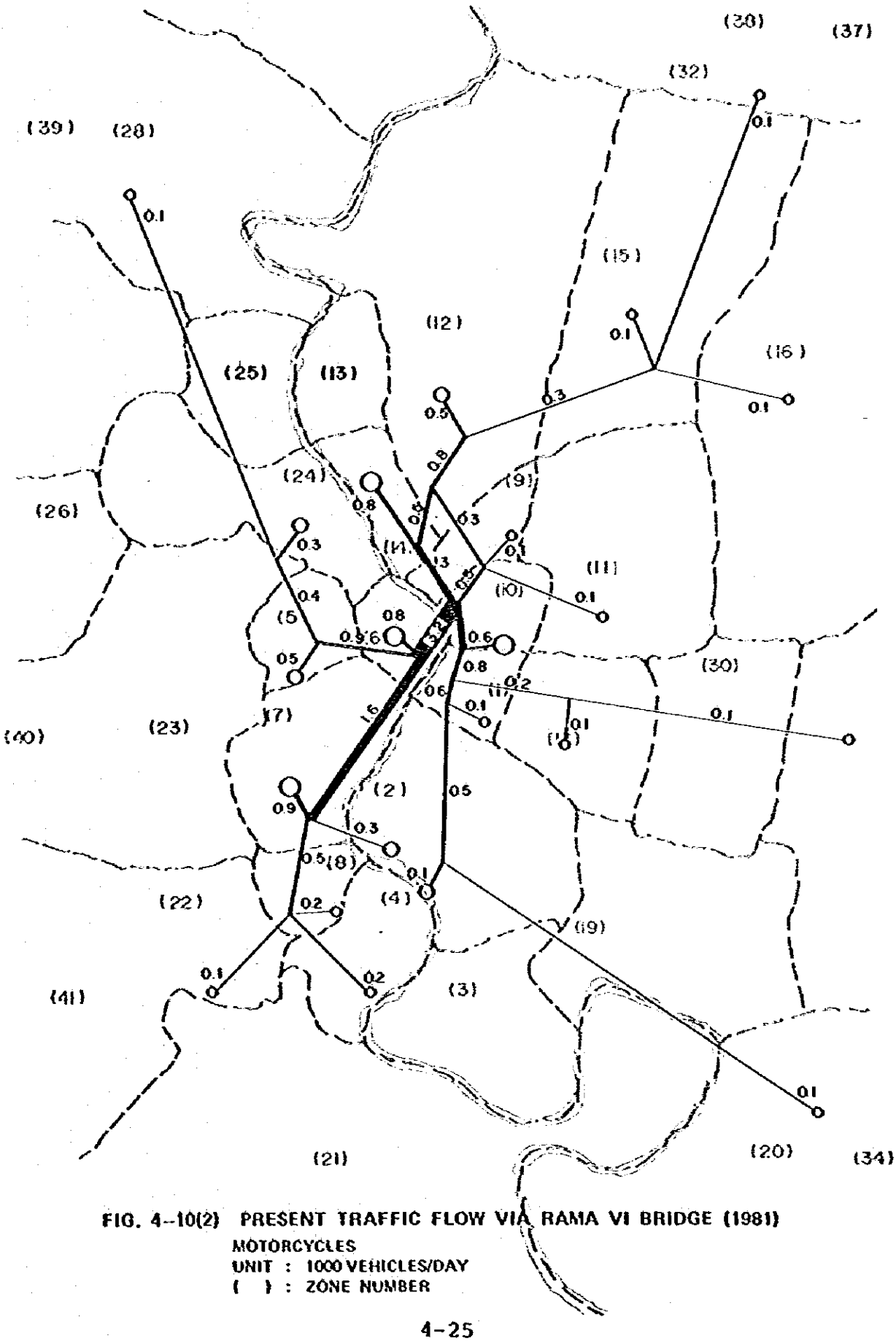


FIG. 4-10(2) PRESENT TRAFFIC FLOW VIA RAMA VI BRIDGE (1981)

MOTORCYCLES
UNIT : 1000 VEHICLES/DAY
( ) : ZONE NUMBER

CHAPTER 5
TRAFFIC FORECAST

CHAPTER 5 TRAFFIC FORECAST

5-1 PURPOSE AND METHODOROGY

The objectives in this section are to make investigation of the present traffic conditions and to make estimates of future traffic volume in the vicinities of RAMA VI Bridge and its relevant roads on basis of available traffic-data. The principal purposes of the forecast have been set as:

a) To determine basic number of lanes.

b) To obtain basic design factors in the design of main bridge and its relevant roads and intersections.

c) To estimate users benefits.

In establishing the methods of forecast in this chapter, the complied results of Feasibility Study of the Nonthaburi and Pathumthani Bridges Construction Project (hereinafter referred as NPB Study) and The Outer Ring Road Feasibility Study (referred as ORR Study) and The Bangkok Suburban Transportation Study (referred as BT Study) have been fully utilized.

Some corrections and adjustments on these data and forecasting methods have been made since the zoning and purpose of forecasting used in the previous studies were different from the present study and also new data have been obtained during the traffic survey performed in an earlier stage of this study.

Procedures of analysis of the study in flow chart are described in Fig. 5.1.

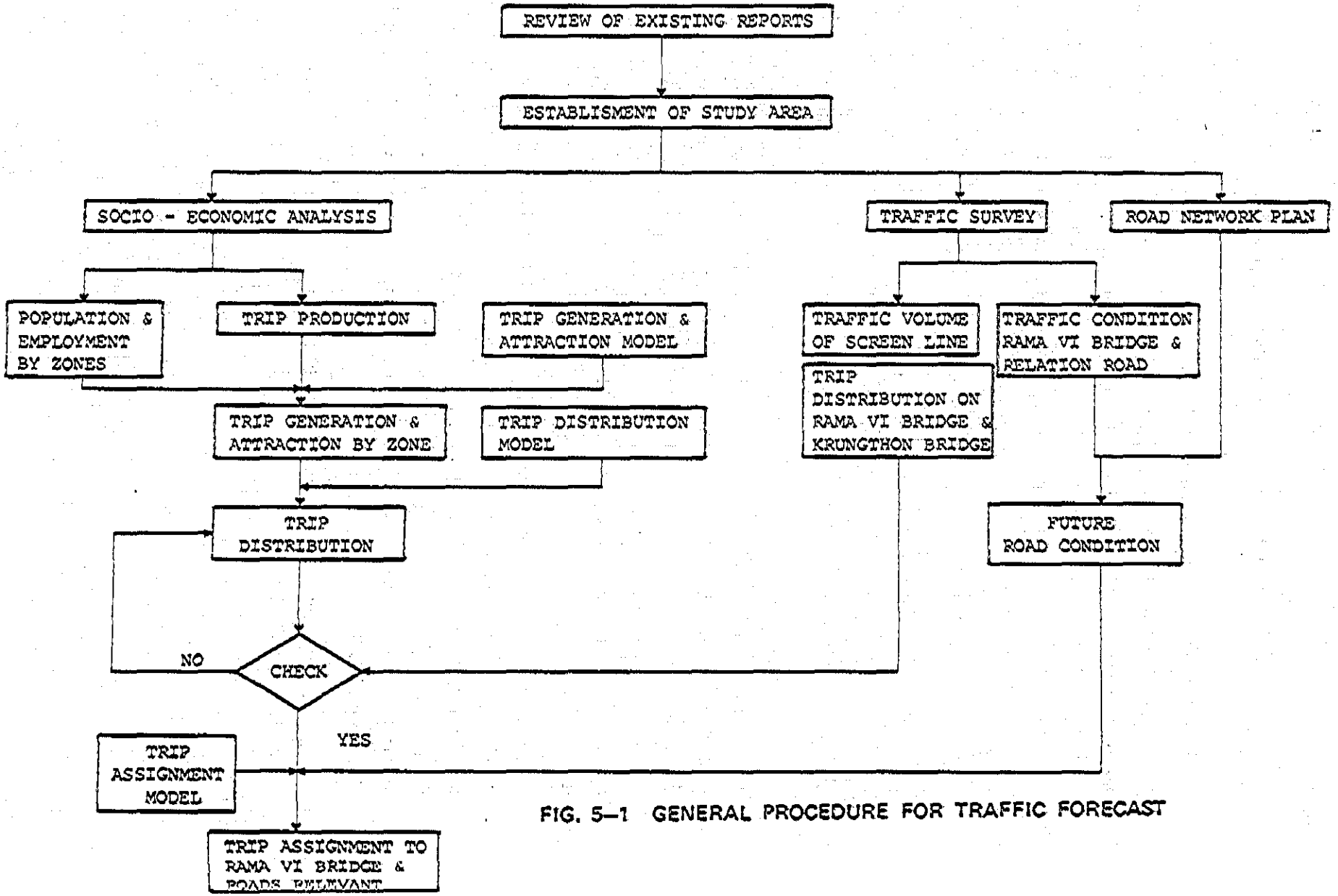


FIG. 5–1 GENERAL PROCEDURE FOR TRAFFIC FORECAST

5-2 STUDY AREA AND PLANNING ZONES

The study area which has been established in almost a duplicate of the previous NPB and ORRS Studies including Greater Bangkok Metropolis and three Changwats of Nonthaburi, Pathumthani and Samut Prakan and is shown in Fig. 5.2. The whole study area is then aggregated and divided into 33 internal zones using the planning zones (28 zones) of NPB study as shown in Fig. 5-3 in order to forecast a proper future traffic volume of RAMA VI Bridge.

The whole Thailand outside of the study area is devided into 8 external zones which is also a duplicate of NPB study as shown in Fig. 5-4.

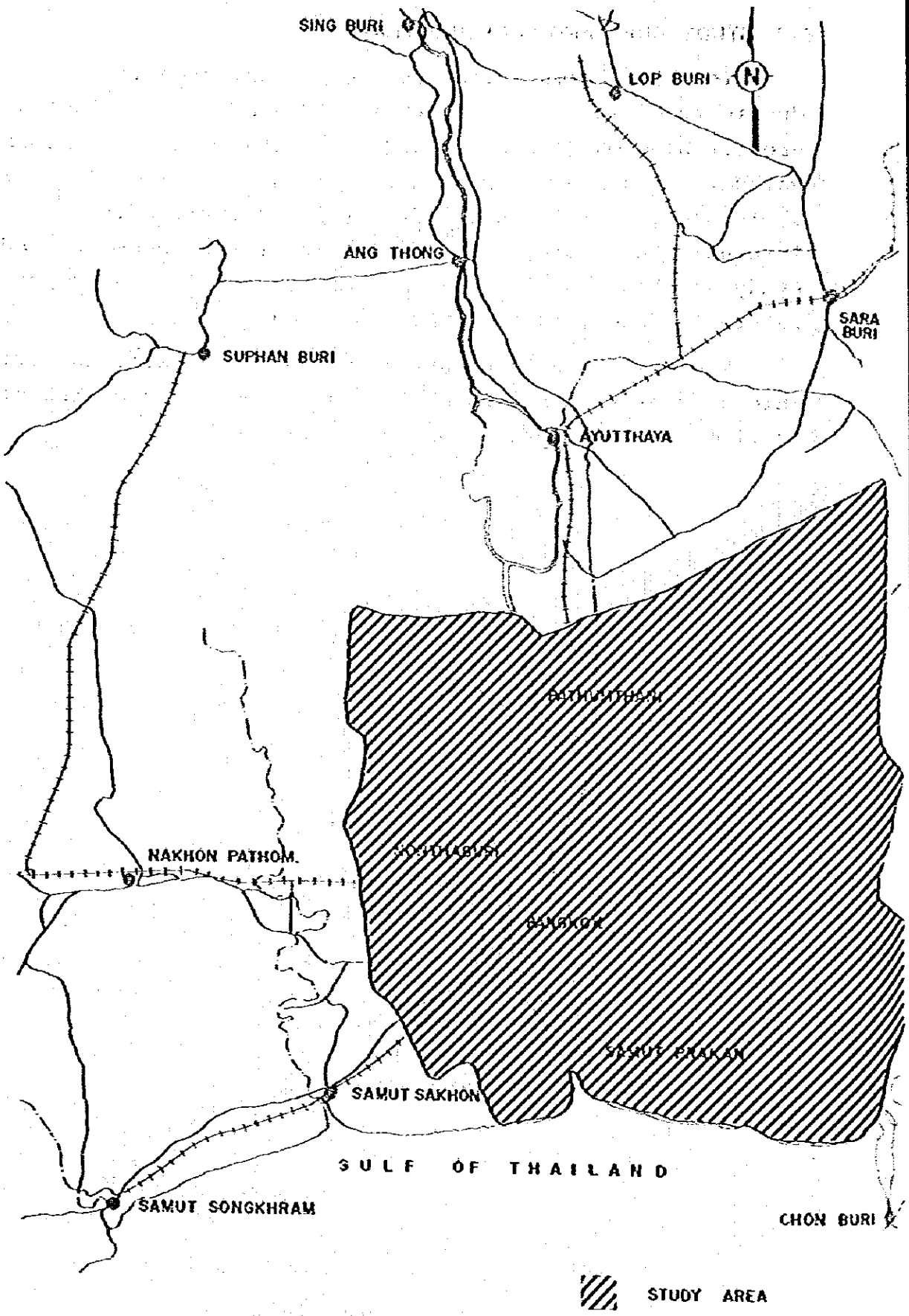


FIG. 5-2 STUDY AREA

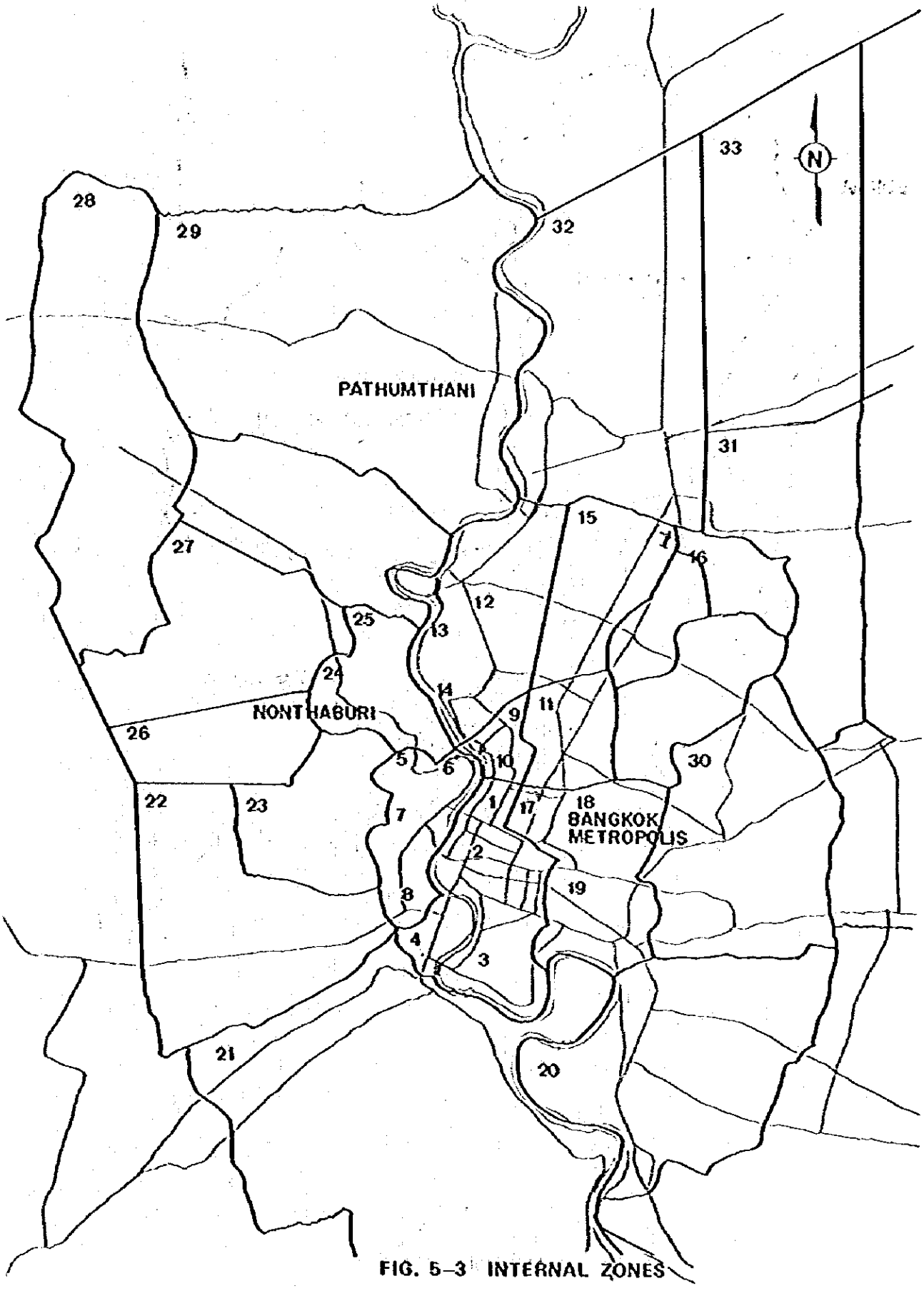


FIG. 5-3 INTERNAL ZONES

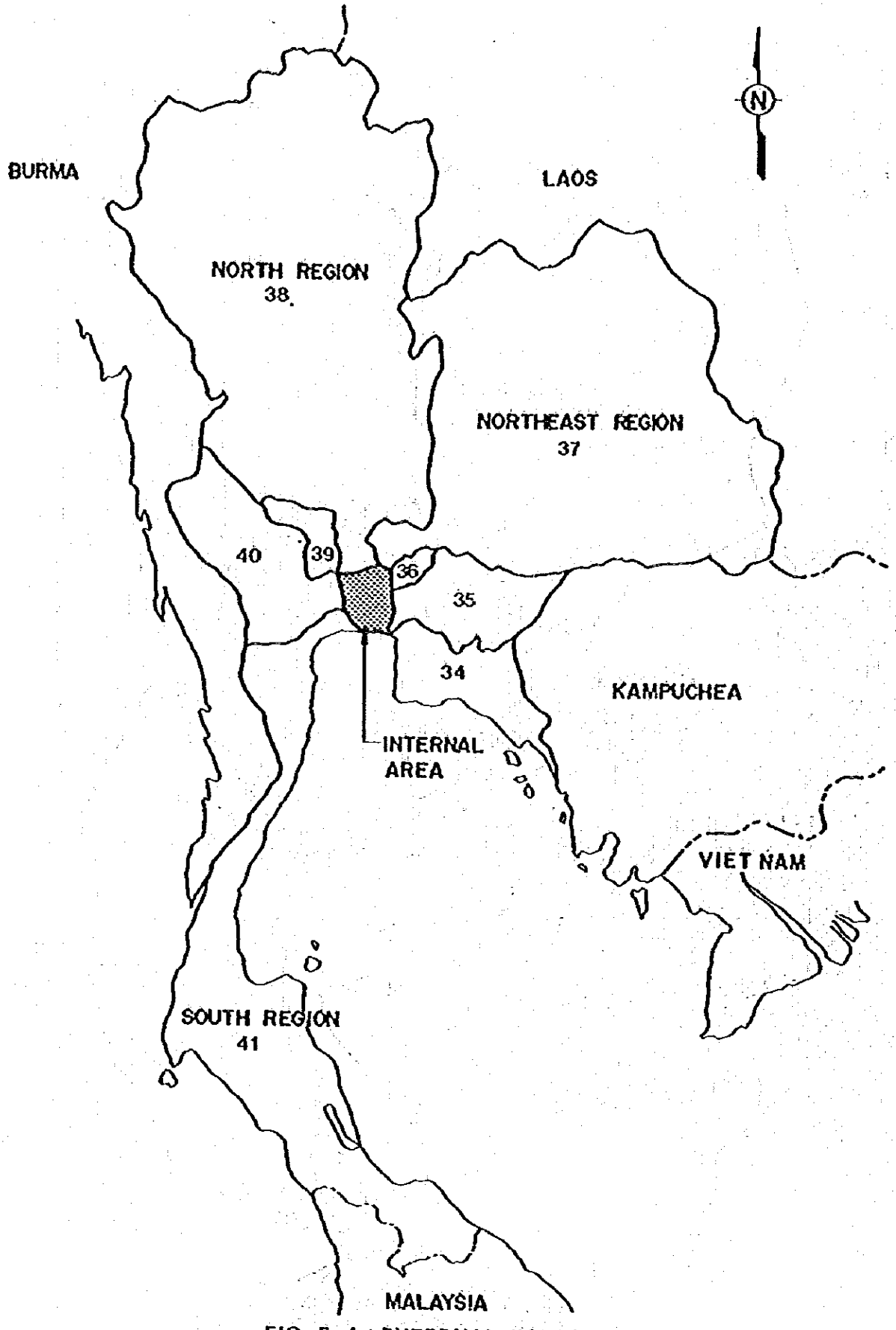


FIG. 5-4 EXTERNAL ZONES

6-3 FORECAST OF POPULATION AND EMPLOYMENT BY ZONES

The number of daily trip generation and attraction will be closely related with the population and employment of inhabitants in the study area.

Population forecast by zones

The population figures by zones for the four changwats in the study area in each target year are shown in Table 2-2 on the basis of which the zonal distribution of the population in each year has been calculated.

Year 1978 and 1990

Population figures by amphoe have been calculated on basis of the actual figures in 1978 and estimated figures in 1990 both adopted in BT Study.

Year 1980 and 1985

The population by zones in 1980 and 1985 has been figured out using linear interpolation between 1978 and 1990 of the zonal distribution figures.

Year 2000

The zonal distribution of population in year 2000 has been estimated on basis of land use plan using the below listed average population densities

High density mixed land use	:	375 persons/ha
Low density mixed land use	:	75 persons/ha
Agricultural land	:	6 persons/ha

The calculated figures in each zone in each target year is presented in Table 5-1 and in Fig. 5-5.

The future distribution of population is expected a decrease in central districts of the city and an increase in its outer fringe areas.

Particularly sharp increase is expected to occur in the

neighbouring and relevant areas of Middle Ring Road and Outer Ring Road.

Employment

In determining job frequency and JOB distribution to each zone of the study area, the calculation methods used in BT and ORR Studies have also been adopted.

Attentions should be paid to the following findings:

I) The job frequency (i.e. rate of employment against population) is expected to increase from 22% in 1978 to 28% in 1990 and 30% at the turn of the century.

II) Minor adjustments have been made in distributing JOBs to each zones where major industrial growth or large scale residential development are expected.

Results of estimate are as follow in Table 5-2, Fig. 5-6.

Table 5-1 Population Projections in the Study Area by Zone

Zone	Population (Thousand)				
	1978	1980	1985	1990	2000
1	137.2	141.6	130.9	120.2	92.9
2	1233.6	1275.4	1185.8	1095.9	861.7
3	365.1	381.9	365.7	349.3	297.8
4	265.2	285.1	291.5	297.9	292.1
5	26.8	29.0	30.0	31.0	34.3
6	42.5	45.6	46.4	47.3	50.9
7	314.6	337.6	344.1	350.5	377.3
8	98.6	105.7	107.6	109.5	117.6
9	51.5	56.1	57.4	59.4	74.7
10	120.3	128.0	122.6	116.5	112.0
11	163.8	189.7	263.2	336.7	580.1
12	102.0	112.5	124.1	135.6	161.6
13	23.5	25.0	25.3	25.7	27.0
14	41.2	43.3	42.8	42.3	42.3
15	84.3	98.2	162.7	227.2	332.2
16	131.1	153.4	246.9	340.3	621.4
17	249.2	269.6	297.7	325.6	404.2
18	131.2	146.1	170.8	195.5	259.4
19	289.2	307.4	327.0	346.5	408.4
20	476.8	522.2	717.8	949.0	1061.0
21	354.0	385.8	470.2	554.1	839.8
22	229.9	251.6	286.1	321.8	412.0
23	71.1	76.0	95.3	114.5	116.8
24	29.0	31.6	37.3	43.0	129.1
25	11.0	11.5	12.4	13.2	35.4
26	19.3	19.4	20.5	21.5	29.4
27	23.2	23.3	26.1	28.8	33.9
28	68.2	68.9	74.3	79.6	97.6
29	66.7	68.1	79.0	89.8	111.1
30	350.2	410.1	789.5	1132.5	2013.9
31	113.4	124.5	136.5	148.4	218.6
32	75.7	83.0	99.9	116.7	190.1
33	107.4	114.6	120.1	125.5	135.3
Total Study Area	5866.8	6321.8	7307.5	8291.3	10571.9

TAble 5-2 Employment Projections in the Study Area by Zone

Zone	Employment (Thousand)				
	1978	1980	1985	1990	2000
1	20.8	21.4	23.0	24.5	25.8
2	480.8	499.2	498.6	497.7	464.2
3	63.8	72.0	85.6	99.2	118.2
4	32.5	41.3	59.5	77.6	106.6
5	6.1	6.8	8.9	11.0	12.7
6	5.5	6.8	10.2	13.5	16.9
7	41.9	49.0	67.4	85.9	102.9
8	15.9	17.2	20.8	24.3	26.3
9	10.3	12.0	13.1	14.2	15.8
10	24.1	26.7	26.1	25.4	23.8
11	41.0	47.4	73.2	99.0	114.0
12	17.5	20.9	32.0	43.1	54.6
13	2.5	2.6	3.3	3.9	4.3
14	8.3	9.0	12.0	15.0	17.6
15	15.2	17.7	47.9	78.1	122.9
16	21.3	25.6	44.2	62.6	127.8
17	51.0	52.6	58.1	63.5	75.7
18	28.6	37.1	59.5	81.8	128.7
19	88.5	92.4	104.7	116.9	143.8
20	106.6	122.4	169.8	216.7	317.0
21	59.4	64.6	102.2	139.3	215.1
22	28.4	29.6	51.4	72.9	108.0
23	5.0	5.3	13.2	21.0	23.4
24	2.4	3.2	5.3	7.4	24.4
25	1.6	2.0	3.1	4.2	13.4
26	1.5	1.7	2.2	2.6	3.8
27	1.2	1.4	2.2	2.9	3.7
28	5.2	5.9	8.3	10.6	14.1
29	4.0	4.1	9.7	15.3	21.1
30	65.1	96.3	189.5	280.5	610.6
31	7.9	9.6	13.0	16.3	25.7
32	7.6	9.1	25.0	40.9	72.2
33	8.2	9.9	11.9	13.7	16.1
Total Study Area	1278.9	1422.8	1854.9	2281.5	3171.2

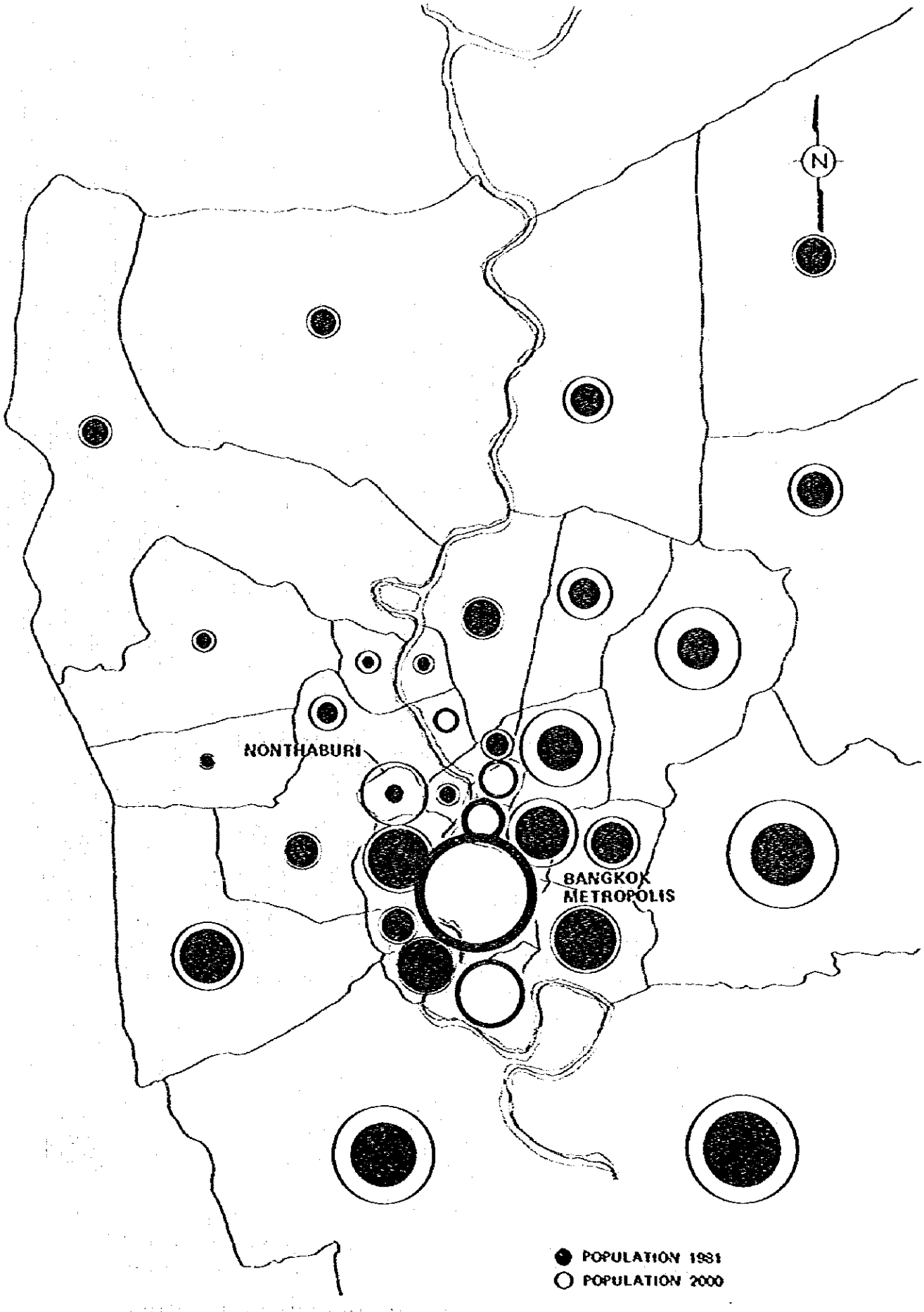


FIG. 5-5 POPULATION DISTRIBUTION

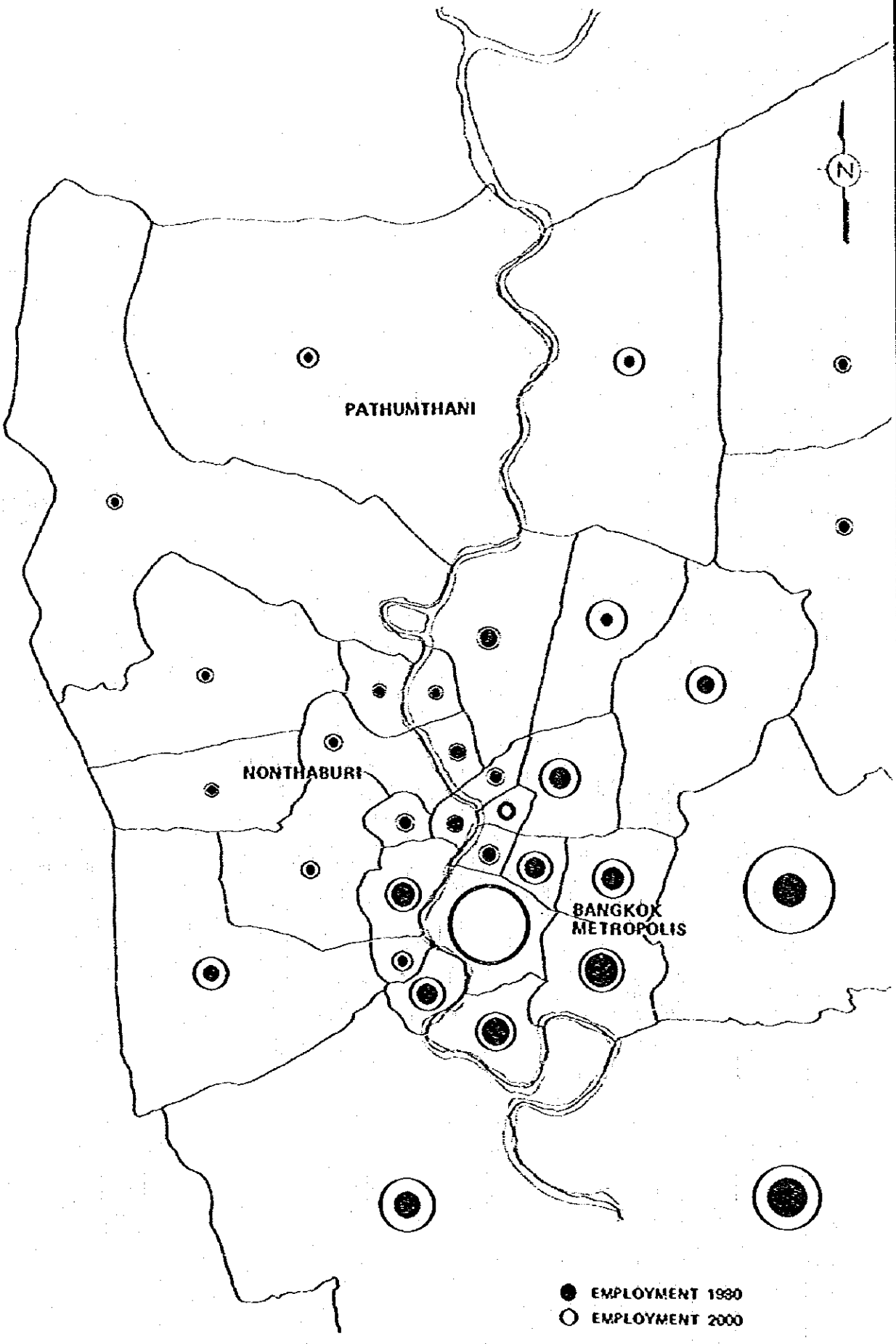


FIG. 5-6 EMPLOYMENT DISTRIBUTION

6-4 FORECAST OF TRIP PRODUCTION

The procedures used in forecasting trip production in the study area are duplication of NPB Study which is also based on the previous ORR Study and are shown in Fig. 5-7.

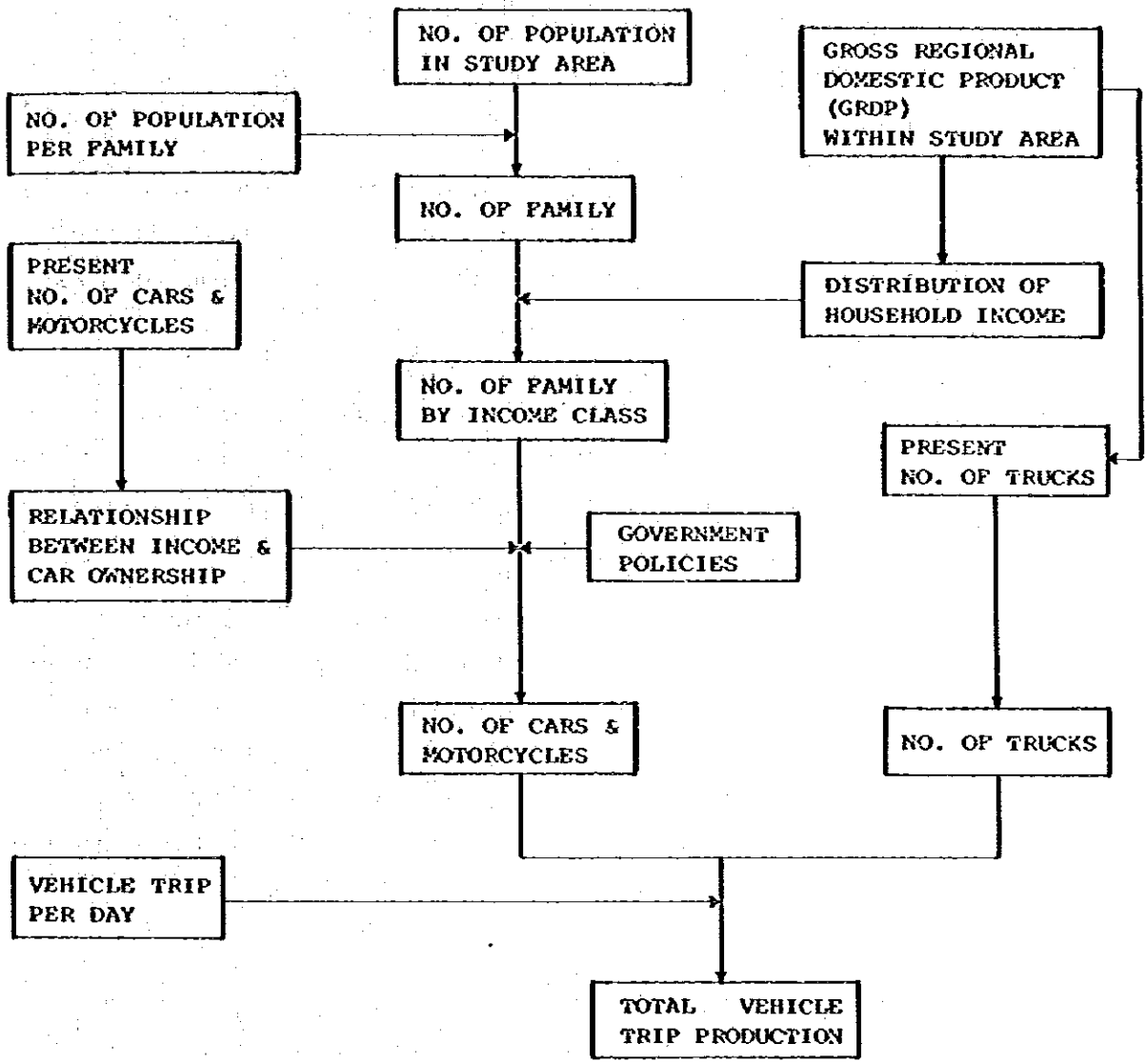


FIG. 5-7 PROCEDURE OF TRIP PRODUCTION FORECAST

The established and forecast figures used in each procedures described in Fig. 5-7 are shown as below:

I) Number of presons per family has been assumed as the present value of 5-7 to be remained unchanged in the foreseeable future.

II) The level of motorization and its growth rate estimated in 1978 in ORR Study are as shown in Table 5-3.

III) Projections of relationship between household income and car ownership made in 1978 ORR Study are shown in Fig. 5-8. Also a projection of distribution of income in 1978 and 2000 is summarised in Fig. 5-9. All projections are based on the assumption that Gross Regional Domestic Product (GRDP) within the study area will increase at the annual rate of 4.3% between 1990 and 2000.

IV) The effect of relative price change in cars and fuel and restraint policies implemented by the Government, however, would cut the estimated growth in the passeneer car ownership by half and would cause 75% of those household which preferred to own a car under the "no-restraint" policy, to purchase a motorcycle instead. A comparison of the effects of the two alternative cases is given in Table 5-4.

V) The growth rate of vans and trucks ownership has been assumed to be the same as the growth in GRDP and resulting vehicles ownership forecasts are given in Table 5-5.

VI) Vehicle trip rates have been determined by both rural and urban zones as shown in Table 5-6.

VII) Forecasts of the total vehicle trip productions (i.e. total number of daily vehicle trips) in each of forecast years are given in Table 5-7.

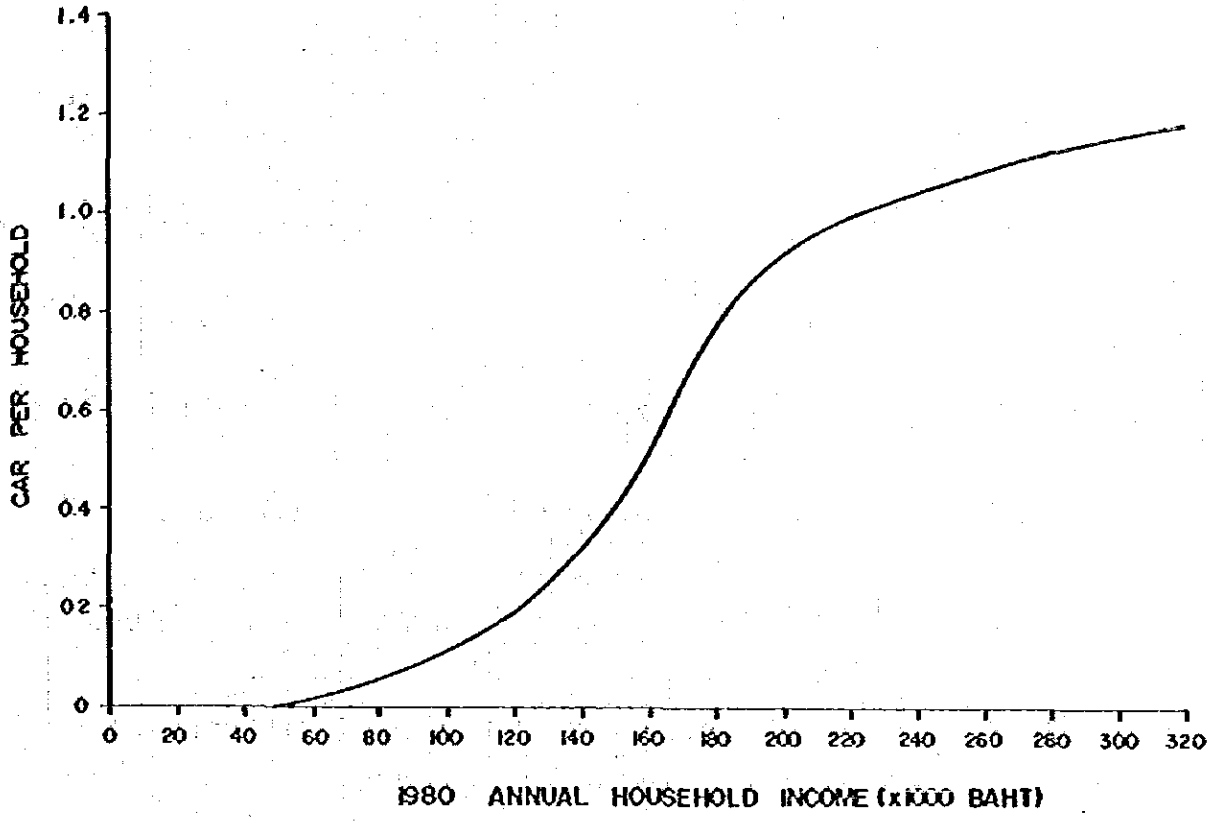


FIG. 5-8 RELATIONSHIP BETWEEN HOUSEHOLD INCOME AND CAR OWNERSHIP (1978)

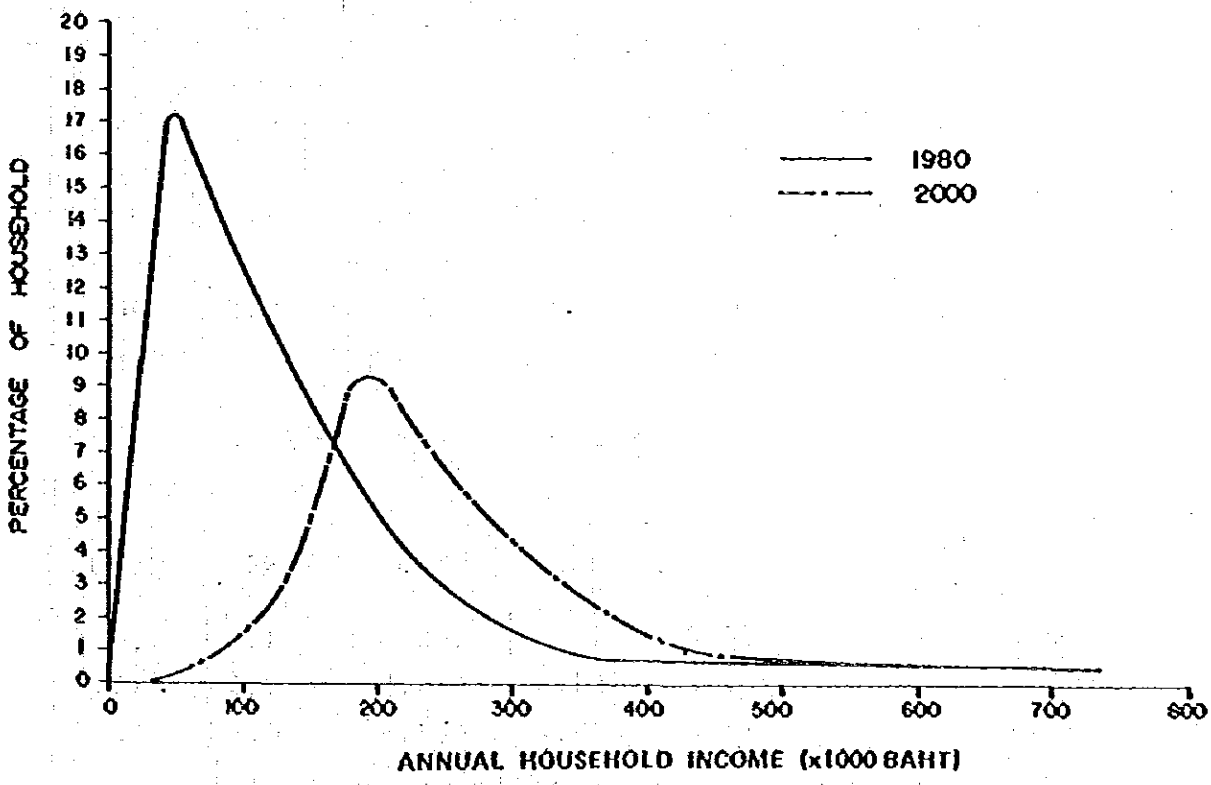


FIG. 5-9 PROJECTED HOUSEHOLD INCOME DISTRIBUTION

Table 5-3 Present Level of Motorization and Growth rate in the Study Area

Description	Metropolitan Bangkok	Nontha-buri	Pathum-thani	Samut-Prakan	Study Area
Cars 1978	243,100	6,460	1,460	4,500	255,520
Cars per 1000 Population 1978	51.3	18.2	4.8	9.7	43.6
Growth rate 1966-78(% per a.n.)	11.3	20.7	31.1	23.1	11.6

Table 5-4 Level of Motorization under Alternative Pricing and Policy Options

Description \ Year		1978	1980	1985	1990	2000
GRDP (billion Baht 962 prices)		69.2	81.1	108.7	130.6	203.0
No Restraint on car ownership	Cars per 1000 Population	44	51	62	75	96
	Motorcycles per 1000 population	23	22	21	19	16
	Total	67	73	83	94	112
Restraint on car ownership	Cars per 1000 Population	44	48	53	60	70
	Motorcycles per 1000 population	23	24	28	31	36
	Total	67	72	81	91	106

Table 5-5 Vehicle Ownership Forecast in Study Area

(Thousand)

Vehicle class \ Year	1978	1980	1985	1990	2000
Motorcycles	136.0	147.4	188.6	244.3	380.4
Cars	255.2	294.1	376.5	473.6	740.0
Trucks	72.6	85.0	113.8	136.8	212.7

Table 5-6 Vehicle Trip Rates

(Trip per day)

Vehicle Class	Rural zone	Urban zone
Motorcycle	3.50	5.93
Cars	3.50	4.50
Truck	4.00	5.80

Table 5-7 Total Vehicle Trip Productions in Study Area

(Thousand Vehicle Tripends per day)

Vehicles class / Year	Motorcycles	Cars	Trucks
1978	1582.2	2276.0	816.2
1980	1706.4	2610.6	950.4
1981	1808.4	2759.1	1010.1
1985	2216.4	3340.0	1248.0
1990	2816.7	4194.1	1548.8
2000	4467.4	6620.5	2446.0

5-5 FORECAST OF TRIP GENERATION AND ATTRACTION BY ZONES

Trip generation and attraction by zones for each classified type of vehicles can be obtained by breaking down the total trip production in the whole study area estimated in the previous section 5-4. The same method was used in NPB Study and the steps of analysis can be shown as below:

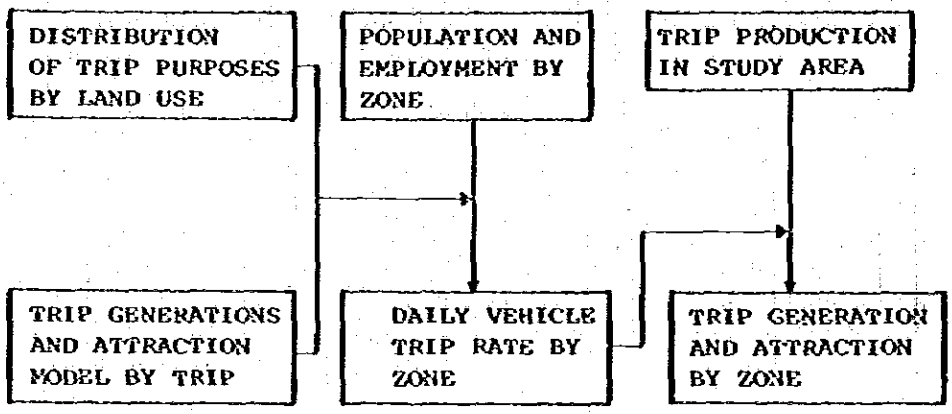


Fig. 5-10 Procedures in Forecasting Trip Generation and Attraction by Zone

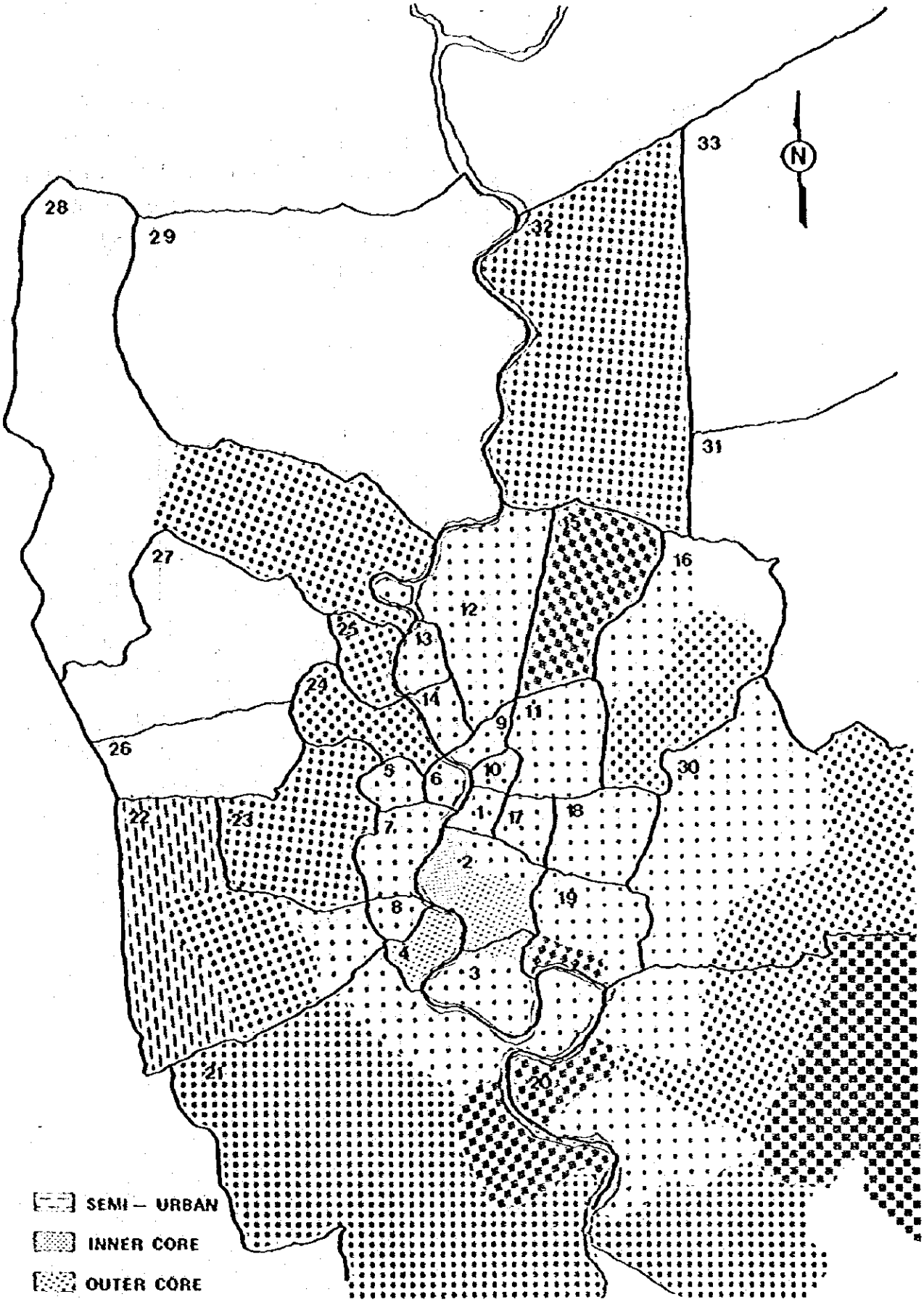


FIG. 5–11 ZONE CLASSIFICATION(2000)

I) Passenger vehicle trips including those of taxi and motorcycle have been subseqently broken down by trip purposes according to the percentages described in BT Study and adjusted for each category of land use. Those percentages are given in Table 5-8 and land use by zone is shown in Fig. 5-11.

Table 5-8 Distribution of Car and Motorcycle Trips by Trip Purpose

Zone Type	Trip purpose		
	HBW	OHB	NHB
Core	27	41	32
Urban	33	38	29
Rural	40	35	25
Inner Core	27	41	32
Outskirt	33	38	29
Special	33	38	29
Semi-urban	33	38	29

Note: NBW ... Home-Based Work
OHB ... Other Home-Based
NHB ... Non Home-Based

II) A regression formula method was adopted in calculating trip generation and attraction in each zone.

The equation is described as follows:

$$Y = aX_1 + bX_2$$

where Y : Trip generation and attraction in the zone

X_1 : Number of employment in the zone

X_2 : Number of population in the zone

a,b : parameters

Table 5-9 Parameters of Model of Trip Generation and Attraction by Trip Purpose

Zone Type	Passenger vehicle trips					Comm.veh. trip (COMM)
	HBW	OHB		NHB		
	a	a	b	a	b	a
Core	0.99	1.01	0.224	1.65	0.138	2.62
Urban	0.64	0.64	0.077	1.31	0.071	1.57
Rural	0.18	0.16	0.015	0.50	0.017	1.71
Inner Core	0.65	0.57	0.190	0.01	0.126	1.40
Outskirt	0.30	0.30	0.037	0.89	0.040	2.10
Special	0.65	0.30	0.037	1.01	0.126	2.62
Semi-Urban	0.18	0.16	0.015	1.50	0.017	2.10

The structural parameters were derived from O-D Surveys conducted for ORR Study.

The total trip generation and attraction can be obtained by summing up trips in each zone and subsequently adjusted during the total trip production in the study area as a control total.

III) Trip generation and attraction in each zone classified by type of vehicles for each of forecast years is given in Table 5-10.

TABLE. 5-10 FORECAST OF TRIP GENERATION & ATTRACTION IN THE STUDY AREA

(TRIP-ENDS/DAY)

ZONE	MOTOR CYCLE				CAR				TRUCK			
	1981	1985	1990	2000	1981	1985	1990	2000	1981	1985	1990	2000
1	45730	47610	50320	56600	63400	70540	74630	83810	22110	23990	25720	30120
2	640160	637940	654160	679210	971480	945160	970190	1005710	309500	321390	334360	361410
3	136270	152350	171090	203770	206790	225710	253750	301710	65880	76750	87450	108430
4	92370	114260	130840	192450	140170	169290	194040	284950	44660	57570	66880	102400
5	8400	10600	13380	18680	12780	16000	19820	27670	3500	4290	5420	7120
6	10440	15140	19110	26680	15880	22860	28310	39530	4340	6120	7730	10170
7	75930	95370	122310	173410	115530	143380	181160	256940	31580	38530	49480	66110
8	25190	30280	36310	48020	38330	45710	53790	71160	10480	12240	14690	18310
9	15110	17240	19230	19240	22990	25990	28330	28550	7000	7380	7950	10150
10	33930	35000	35700	28860	51650	52770	52610	42820	15730	14970	14760	15220
11	69700	96550	134250	214110	104200	145570	195690	316540	30720	41720	56800	73000
12	27050	33310	56920	92850	41160	59390	84260	137400	13100	17800	24210	34790
13	4670	6040	8370	11770	7100	9090	12400	17420	2260	2700	3560	4410
14	11090	14480	18420	26160	16870	21820	27260	38710	5370	6470	7840	9800
15	28780	51860	83000	145780	44930	84250	122360	215310	23050	45560	74890	131340
16	29580	44500	82820	169800	45930	71690	123000	282120	22780	34700	62300	95920
17	80470	93880	110770	160670	122410	141550	164160	237720	40060	43330	49020	69420
18	49350	70410	92900	160670	75080	106170	137680	237720	24570	32500	41110	69420
19	113280	129090	153640	214230	172340	194630	227700	316950	56390	59580	67930	92560
20	93750	147570	227540	376470	143360	224220	338570	558220	93720	112840	146000	253000
21	57590	91950	149300	292850	88550	138320	224320	433240	47680	70380	91100	167920
22	33290	54070	74200	125010	53500	81540	109450	184880	23090	34360	50600	86000
23	4360	7320	11500	27920	7610	12820	20110	41180	4360	8200	13200	20040
24	2530	5770	9520	41080	4050	8750	13860	60370	2670	4420	6320	22930
25	1230	2590	3890	16780	1960	3930	5660	24660	1290	1990	2590	9390
26	810	1190	1300	2100	1540	1750	2200	3790	1160	1360	1700	2660
27	1020	1230	1700	2740	1570	2080	2190	4630	1000	1360	1900	2580
28	3620	5290	7500	20840	6120	9130	13260	31530	4080	5160	6700	11360
29	2190	3730	5900	10270	3850	6230	9730	16400	3360	6200	9600	14720
30	92050	172940	300820	802500	143050	265160	450010	1186590	73680	122600	189500	454220
31	5220	6810	8380	17410	8810	11650	15270	29530	6560	8060	10300	17940
32	4220	8620	14500	58500	7150	14130	23740	88680	7780	15520	25600	61840
33	4040	4870	6500	9980	6920	8480	10960	16080	6570	7380	8600	11240
TOTAL	1808420	2216420	2816690	4467410	2759060	3340960	4194070	6620520	1010080	1248920	1545780	2446000

6-6 FORECAST OF TRIP DISTRIBUTION

Forecasting of trip distribution in this study has been carried out according to the flow chart shown below:

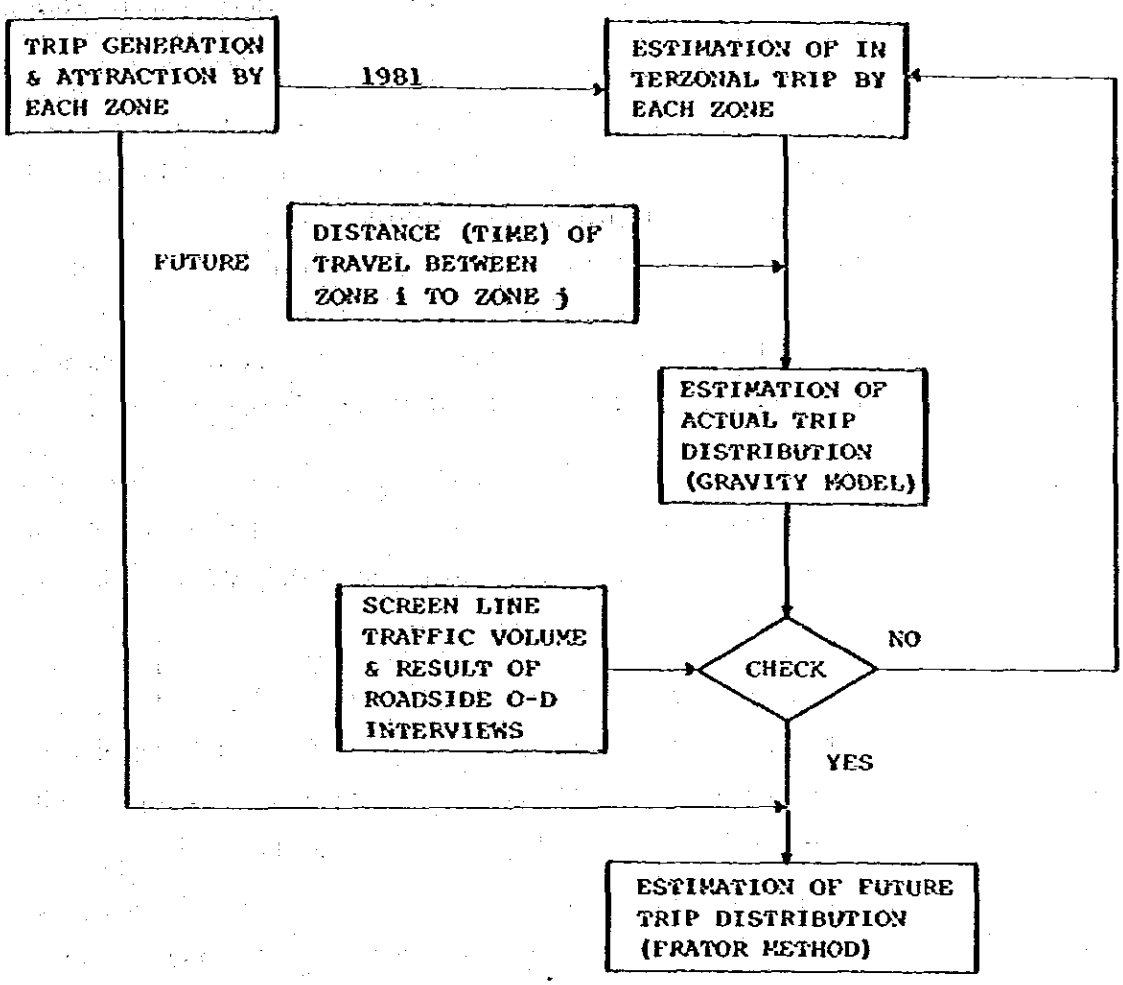


Fig. 5-12 Procedures in Forecasting Trip Distribution

In the calculating process described in the previous sections, i.e. calculation of trip production, trip generation and attraction in each zone and further analysis of trip distribution by a gravity model, the existing forecast data in NPB, ORR and BT Studies has been fully and freely utilized. However, in order to achieve more accuracy and refinement in traffic forecasts, the following adjustments have been added to this study.

I) A screen line has been assumed on the Chao Phraya River line and actual traffic counts at all of existing six bridges were conducted.
Then the actual traffic countings on the screen line were compared with the cross-screen-line traffic volume obtained from O-D traffic matrices pairs, thus correcting the O-D traffic volume.

II) Finally specific present 1981 year O-D traffic data has been adjusted using the results obtained from actual traffic counts at both of RAMA VI and Krung Thon Bridges.

The resulting final 1981 O-D traffic matrices forecast in this traffic study can be dualy considered to be as more accurate and appropriate than those presented in the previous NPB and ORR Studies for the present studies purposes.

Based on thus obtained present O-D traffic matrices, a future O-D traffic volume has been estimated with steps of computation given below:

a) The precentage of intra-zonal trips against trip generation and attraction of each zone has been set by type of zone. These intra-zonal trip rates which were used and established for the ORR Study are shown in Table 5.11 below.

Nevertheless, intra-zonal trip rate for this study has been established as less than the above rate values.

Table 5-11 Intra-zonal Trips Estimated by ORRS Expressed as a Precentage of Generation & Attraction Trips

Zone Type	Motorcycle & Car			Truck
	HBW	OHB	NHB	
Core	65	70	80	75
Urban	60	65	75	65
Rural	60	65	70	65
Inner Core	65	70	80	75
Outskirt	60	60	70	75
Special	60	60	65	60
Semi-Urban	70	70	80	80

b) The present distribution of traffic is calculated using a gravity model. As a gravity model the equation below has been used.

$$T_{ij} = a \frac{A_i \cdot A_j}{t_{ij}^{b}}$$

where T_{ij} : Number of daily vehicle trips between zone i and zone j

A_i, A_j : Number of trips generation and attraction by zone i, j

t_{ij} : Total travel time between zone i and zone j

a, b : parameters

The value of b has been determined in ORR study of 1978. Each value by trip purposes are shown below:

Table 5-12 Classified Value of b

Class of Vehicles	Trip Purpose	Value of b
Motorcycle	Home-Based Work	1.2
Private car	Other Home-Based	1.5
Taxi	Non Home-Base	1.8
Truck		2.0

Present origin destination tables which are adjusted by present survey are shown Appendix 5-1.

c) The future trip distribution was estimated from the present traffic pattern using the Prator Method. In the calculation of future traffic distributions, the effects of time shortening and economy of running cost due to improvement of the future road network, have not been taken into considerations.

It is considered necessary to estimate induced traffic due to highway network improvement, especially those of Middle Ring Road and RAMA VI bridge in a further study.

Future origin destination tables are shown Appendix 5-2,4.

5-7 FORECAST OF TRAFFIC IN THE STUDY AREA

5.7.1 Forecast Method

1) Forecast Principle

The present RAMA VI Bridge is located at the northern part of central district of Bangkok city and constitutes a portion of urban arterial highway route.

Therefore the traffic volume of the RAMA VI Bridge is affected by not only RAMA VI Bridge relevant traffic but also by traffic condition of central Bangkok.

In this view, it is desirable to adopt a distribution method using relation of speed and traffic volume applying for the whole net work of GBA, in order to forecast traffic volume of RAMA VI Bridge. This method has not been adopted in this study, however, due to limit of time and need of large computer and more staffs.

The forecasting method used in this study is

a) to assume traffic conditions (speed) in the study area.

b) to sum up traffic volume using RAMA VI Bridge from O-D traffic volume in compliance with the established speed in a)

Calculation of converted traffic has been therefore limited to that of RAMA VI Bridge in this study.

2) Forecast case

Forecasting year has been set as the years of 1985, 1990 and 2000.

Since the completion year for the Outer Ring Road, which affects greatly to RAMA VI related traffic, has not been certain, "with" and "without" cases are studied for the year 1990.

3) Composition of traffic

Vehicle classification, forecast composition of vehicle and forecasting method used in this study are given below.

Table 5-13 Vehicle Composition and Forecasting Method

Vehicle	Composition	Forecast Method
CAR & TRUCK	Traffic Proper to RAMA VI Bridge	Assignment Without RAMA VI Project
	Diverted Traffic	Assignment With - Without Project
	Induced	Rate of induction
BUS		Increase Rate Method
MOTORCYCLE		Assignment

5.7.2 Establishment of Road Net Work

Road net works assumed for each of forecast year are shown in Fig. 3-14, 15, 16 (Chapter 3)
Highway improvement which affects RAMA VI relevant traffic will be mostly completed except the Outer Ring Road in 1985 and changes in road net work of 1990 and 2000 are almost invisible.

Therefore, as link condition, two different cases are prepared in forecast.

Without ORR 1985, 1990
With ORR 1990, 2000

Travel speed for each link has been assumed as shown in Fig. 5-13. Reasons for assuming are as below.

(1) Streets in the central parts

Area within the Middle Ring Road is a congested area at the present. For this reason, increase of automobile traffic and improvement of streets will be counter-balanced and future speed of traffic is assumed as it is at the present. (12.5 or 17.5)

(2) Middle Ring Road

For the proposed northern area and also for the southern part in undeveloped area, running condition is favorable and speed is set as 25 km/hr. However, for the existing parts of east side and west side (Thonburi) area, traffic congestion is taking place at the present. Considering future traffic increase, speed is set as 12.5 km/hr.

(3) Outside area of Middle Ring Road

The condition in outside area of MRR, which is suburban area running condition, is good and speed of 17.5 - 40 km/hr can be assumed.

(4) Expressway

Expressway will be used for automobiles only. Although speed of 50 km/hr can be maintained on roadway, resistance by toll-collecting will reduce its overall speed to 25 km/hr.

(5) Super Highway and Outer Ring Road speed of 50 km/hr has been applied.

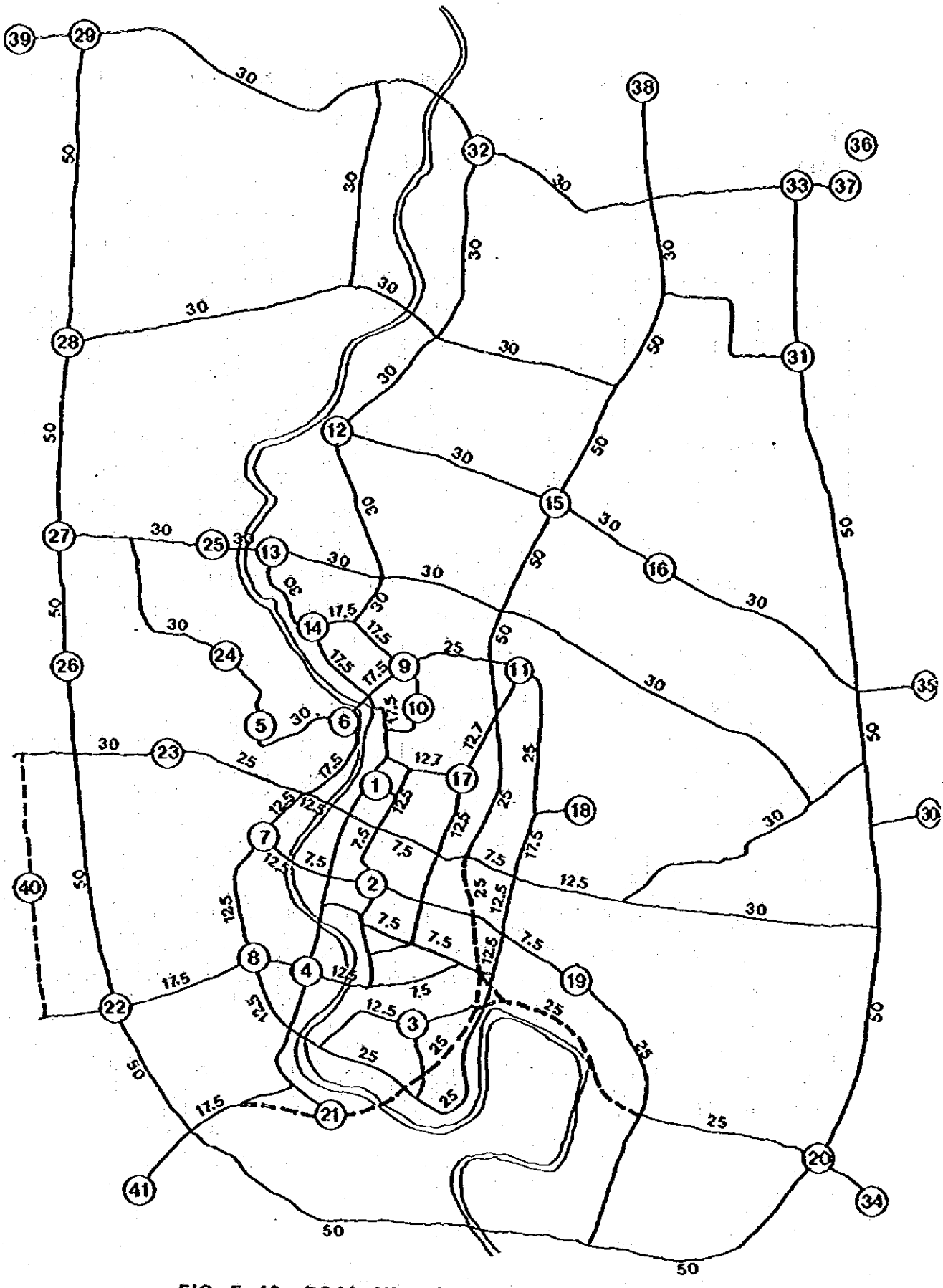


FIG. 5-13 ROAD NETWORK & TRAVEL SPEED (Km/hr.) (2000)

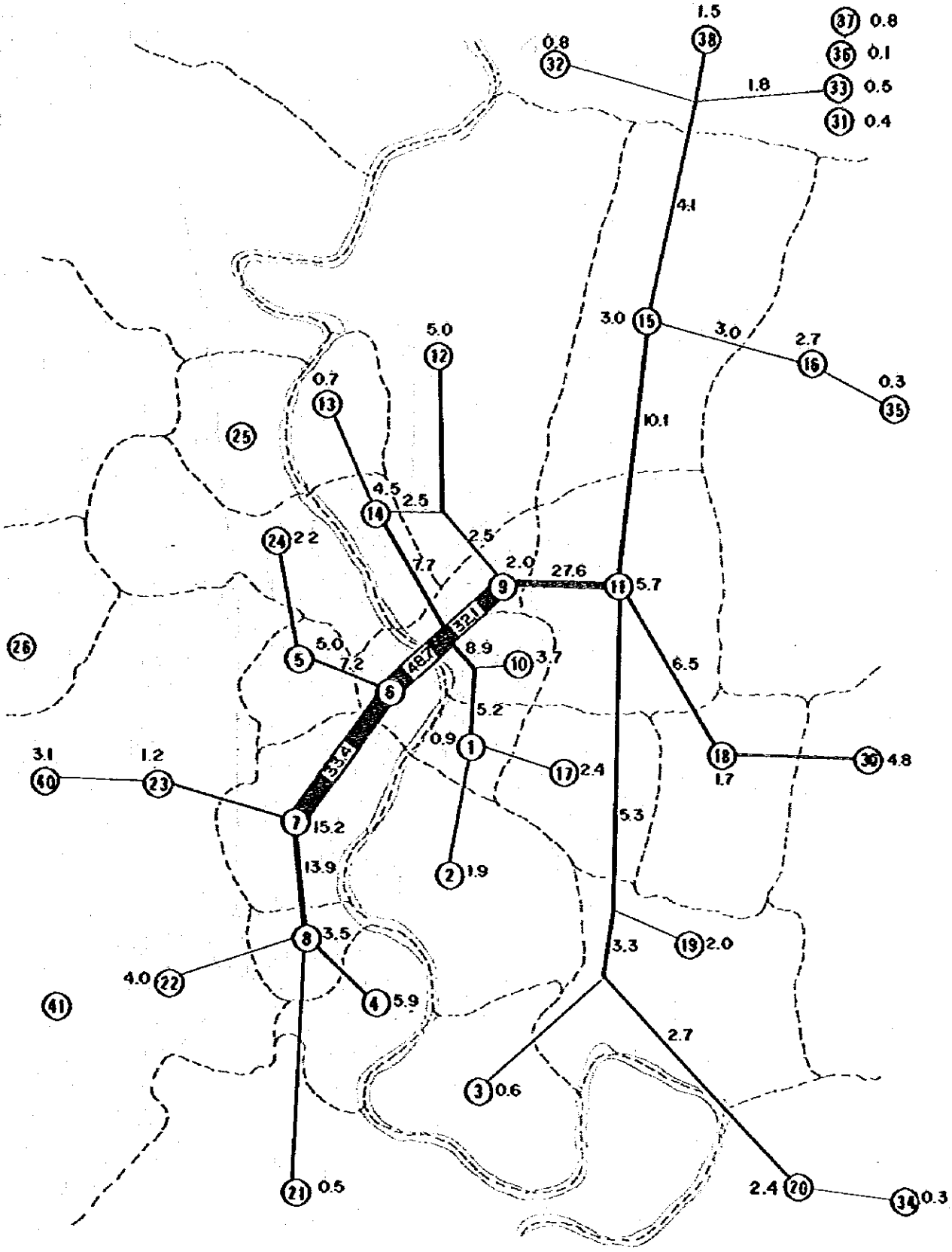


FIG. 5-14(1) FORECAST TRAFFIC FLOW VIA RAMA VI BRIDGE (1985)
CARS & TRUCKS (THOUSAND VEH./DAY)

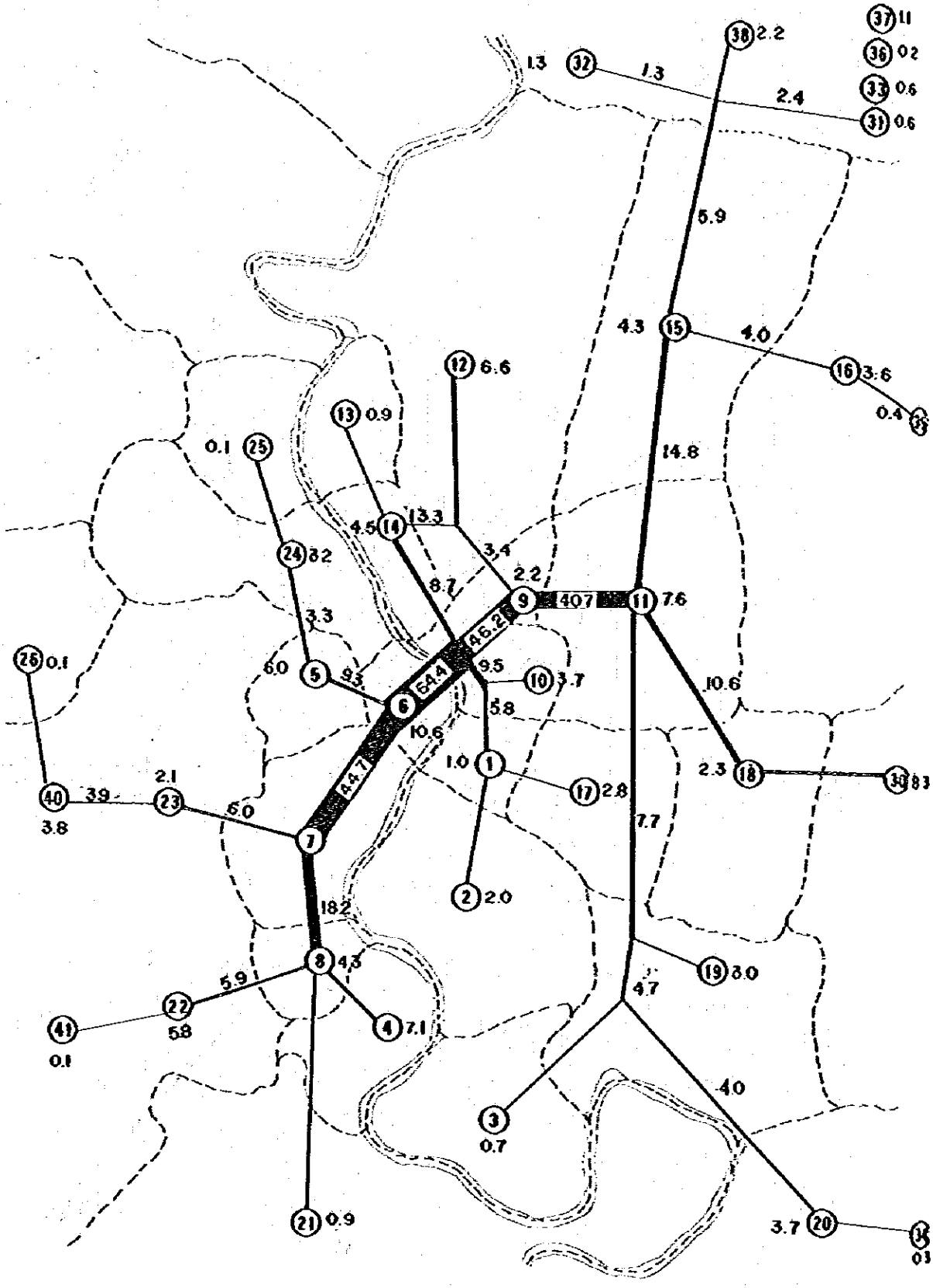


FIG. 5--14(2) FORECAST OF TRAFIC FLOW VIA RAMA VI BRIDGE (1990)

------ WITHOUT OUTER RING ROAD ------

CARS & TRUCKS (THOUSAND VEH/DAY)

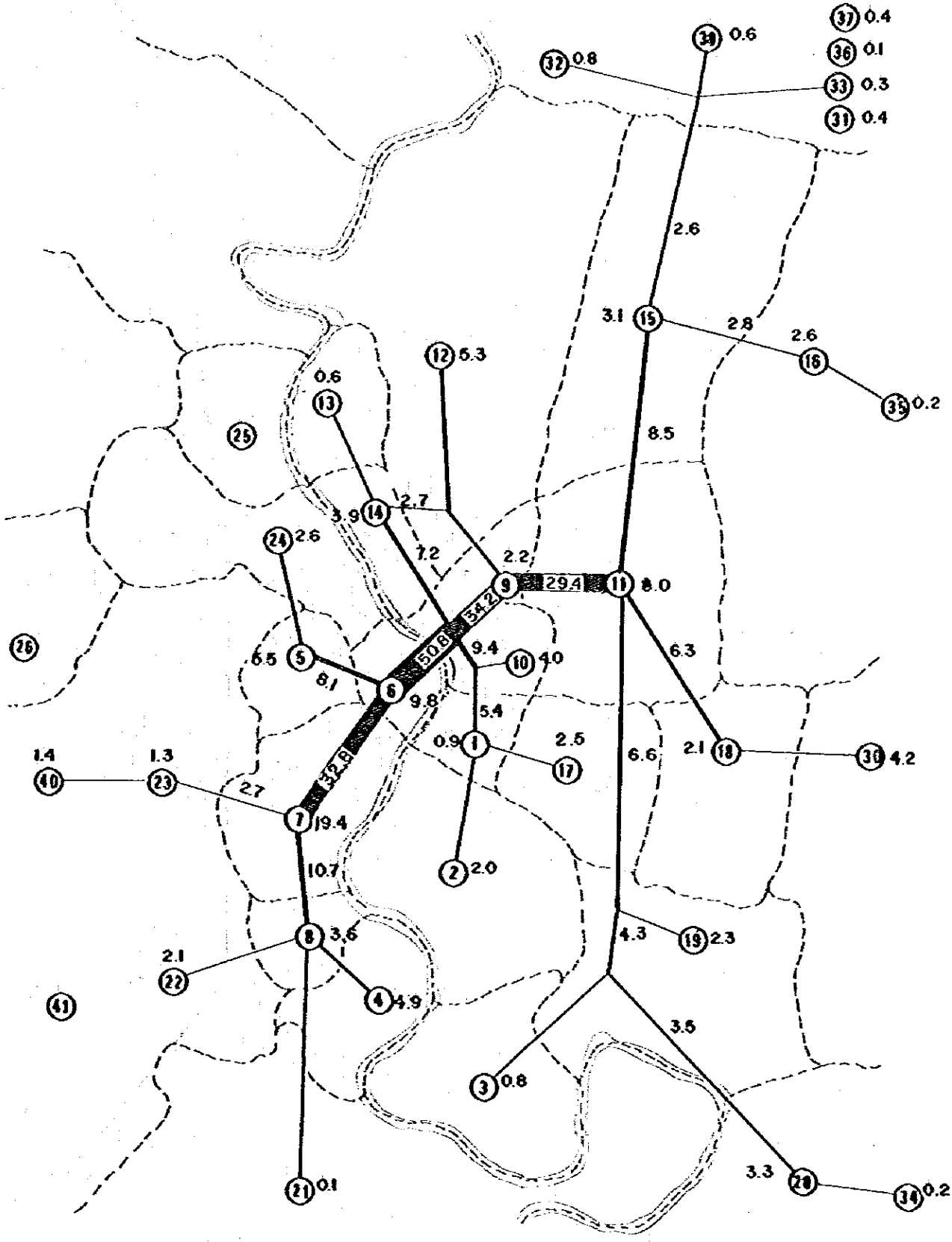


FIG. 5-14(3) FORECAST OF TRAFFIC FLOW VIA RAMA VI BRIDGE (1990)

CARS & TRUCKS (THOUSAND VEH./DAY)

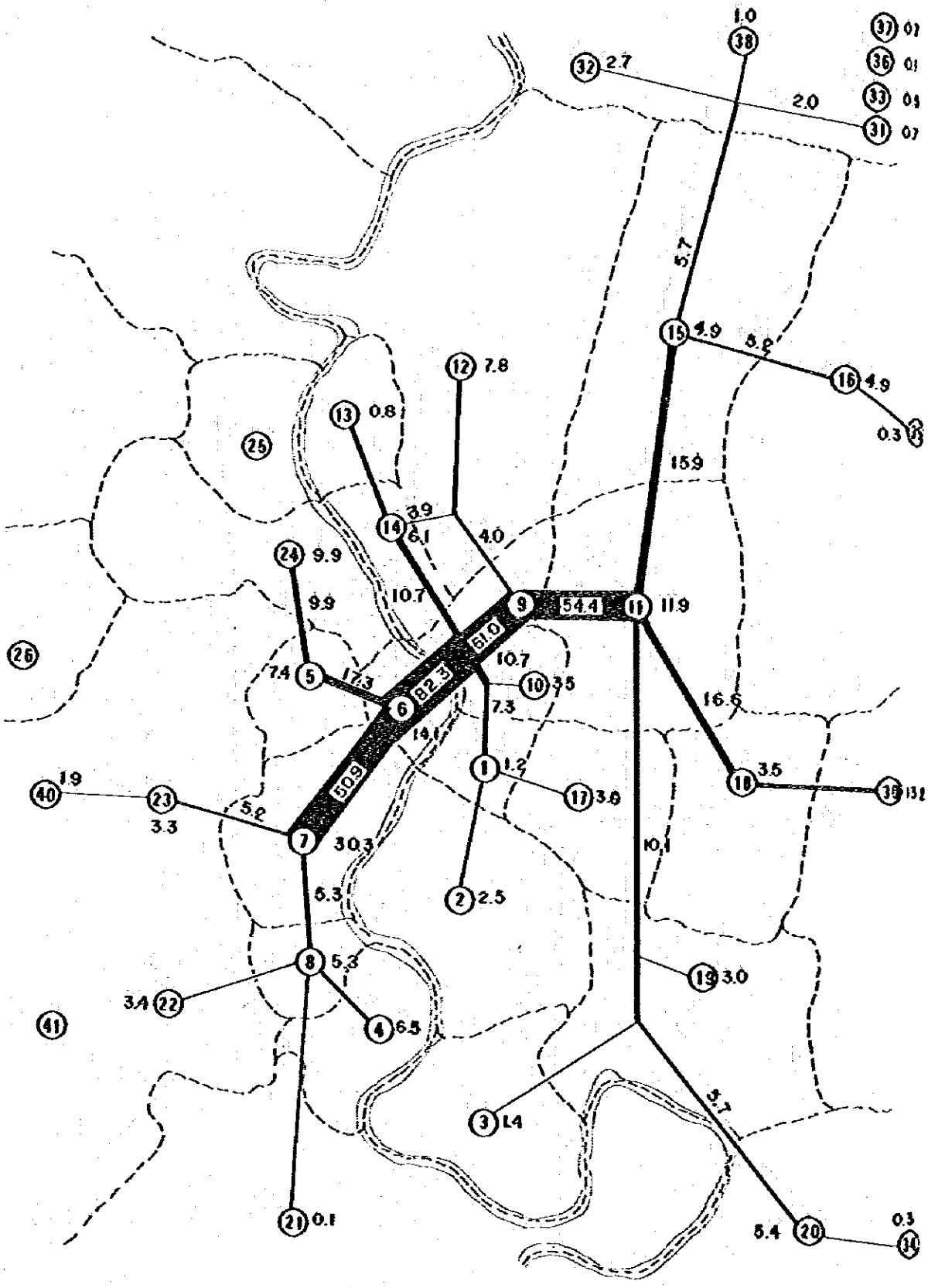
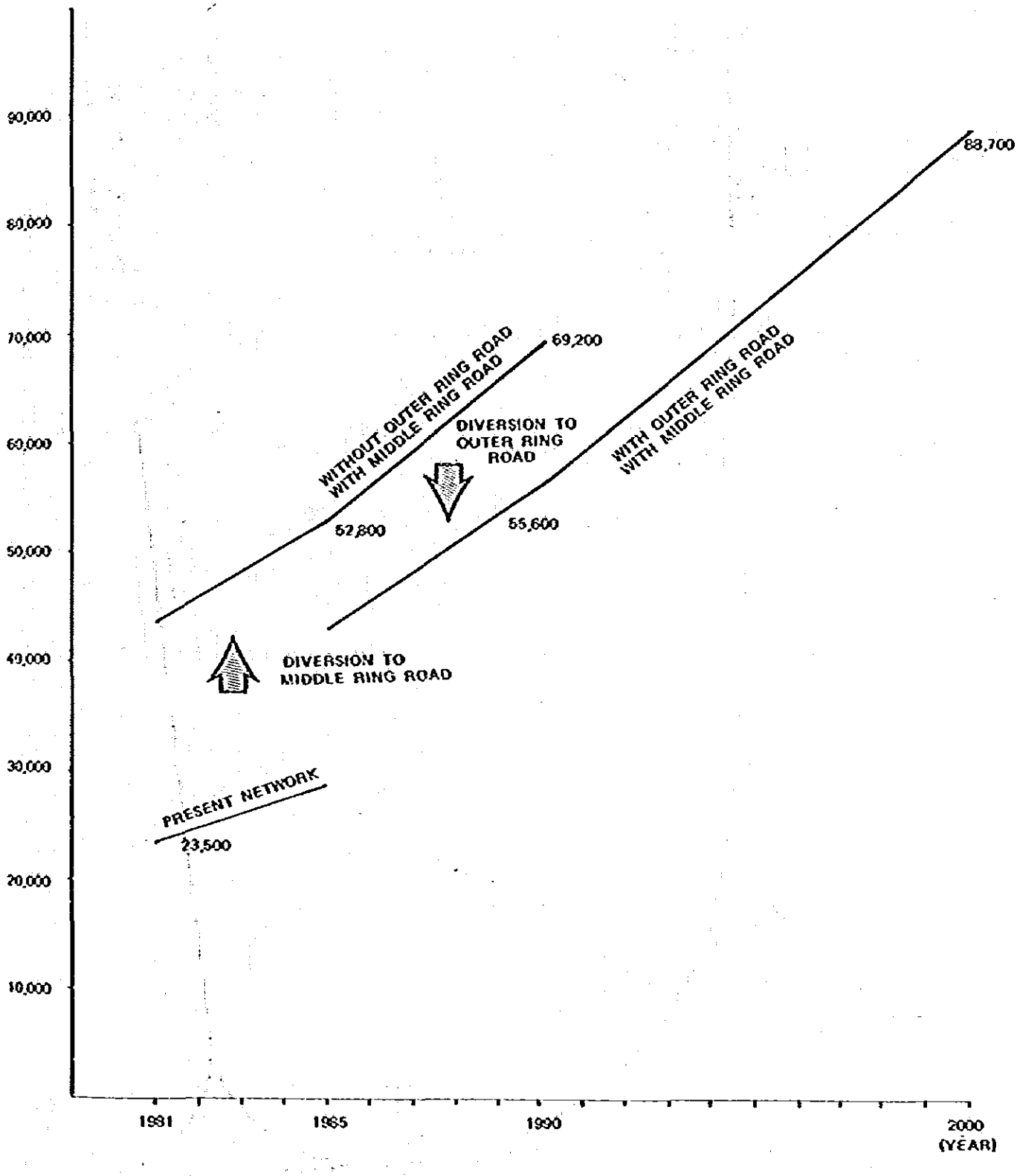


FIG. 5-14(4) FORECAST OF TRAFFIC FLOW VIA RAMA VI BRIDGE (2000)
CARS & TRUCKS (THOUSAND VEH./DAY)

FIG. 6-15 TREND OF TRAFFIC ON RAMA VI BRIDGE



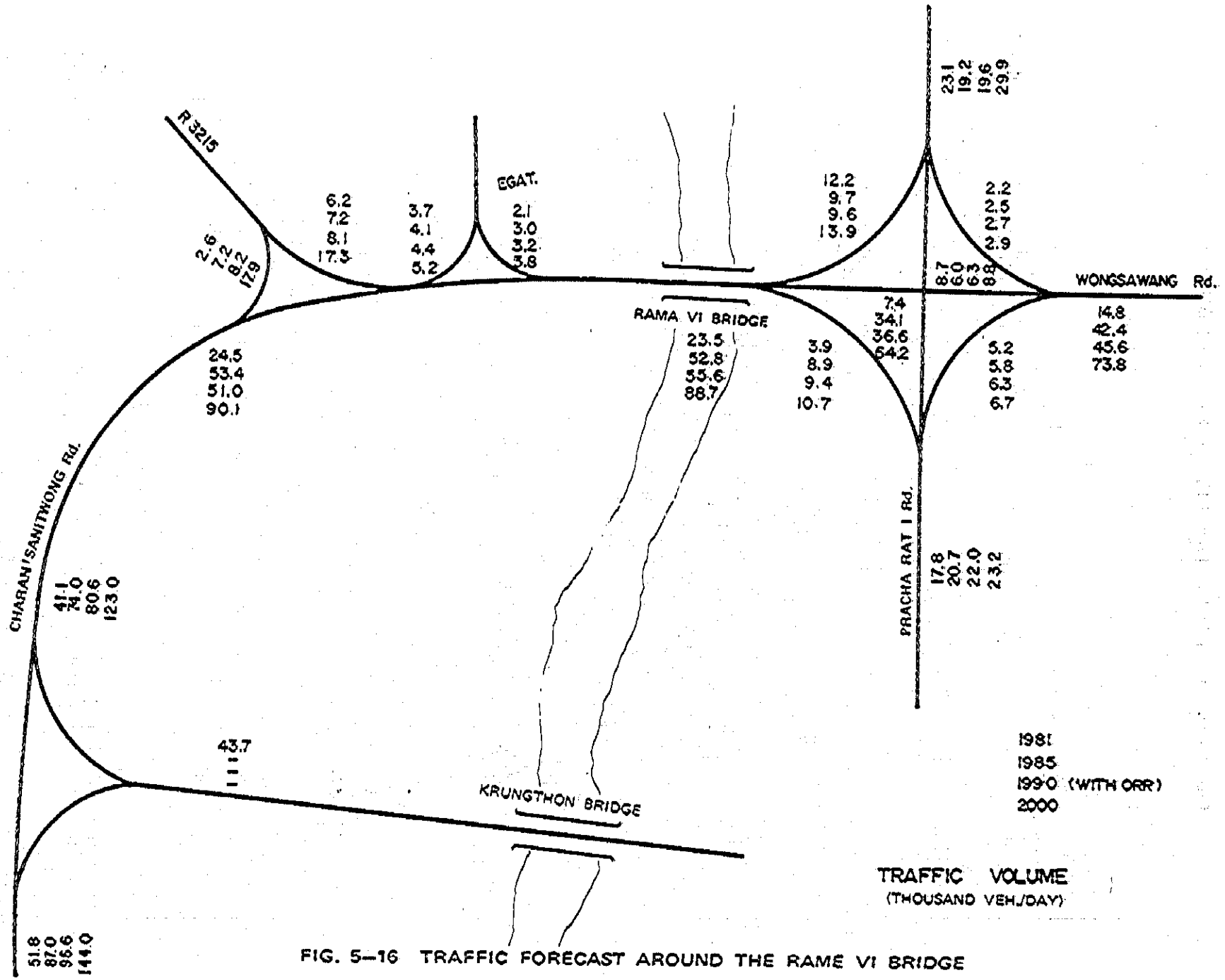


FIG. 5–16 TRAFFIC FORECAST AROUND THE RAME VI BRIDGE

5-7-3 FORECASTING METHOD FOR RAMA VI BRIDGE TRAFFIC

1) Composition of Traffic

Traffic forecast has been conducted on 3 classifications of vehicles: car, truck and motercycle.

Traffic of cars and trucks consisted of three categories namely, traffic proper to RAMA VI, diverted traffic, and induced traffic.

For traffic proper, assignment will be made for "With RAMA VI Bridge Project" case.

Diverted traffic is calculated as the difference of "With project" assignment result and "Without project" assignment result.

2) Calculation of Traffic Proper to RAMA VI and Diverted Traffic

a) Traffic Allocation to Rama VI Bridge

A route research is made to find out the shortest travelling time required between two zones on different sides of the Chao Phraya River, covering all zones and comparing trips via all other bridges against those across Rama IV Bridge.

Traffic allocation to the Rama VI Bridge was derived based on the difference of time required between the two compared cases, making use of the rate of used models shown in Table 5-14.

Table 5-14 Utilization Rate Model (Car & Truck)

Travel time Via RAMA VI Bridge minus Travel time Via Other Bridge	Use Rate of RAMA VI Bridge
Below - 12.5 minutes	100%
- 7.5 ... -12.5	80
- 2.5 ... - 7.5	65
- 2.5 ... 2.5	50
7.5 ... 2.5	35
12.5 ... 7.5	20
More than 12.5	0

b) The time required for the fastest routes has been determined as follows. In the case of "With Rama VI Project", travel speeds are calculated as shown in Table 5-14, whereas in the case of "without Project", 5 minutes are added to a trip across the Rama VI Bridge since travelling conditions of the existing Rama VI Bridge is poor.

According to the result of this calculation however, there is a discupency that the total traffic volume on "the Rama VI Bridge without Project", which is the sum of the main traffic (proper) of cars and trucks, and the bus traffic which is mentioned later, turns out to be larger than the daily traffic volume of the existing two lane bridge. In view of this, recalculation of the traffic volume on RAMA VI Bridge is made taking the daily traffic volume of the existing bridge, as stated in c), as the controlling limit value.

c) The Daily capacity of the existing Rama VI Bridge is established at 32,000 V.P.D.

- The present hourly traffic capacity of the existing Rama VI Bridge is approximately 1,300 vehicle per lane, per hour, as illustrated in Fig. 4-9, Relation between traffic volume and speed.
- The peak ratios of Rama VI Bridge at present are 10.5% for inbound and 10.0% for at out bound traffic. These peak ratios are expected to decrease in the future along with the growth of traffic demand. The present peak ratio of the Memorial Bridge is about 7%. Rama VI Bridge is located farther off from the center of city than the Memorial Bridge, and has a higher proportion of commuting traffic. For this reason the peak ratio of RAMA VI at the time when traffic demand reaches its capacity is assumed at 8%.

  The daily traffic volume therefore is:

  $$1,350 \div 0.08 \times 2 \fallingdotseq 32,000 \text{ VPD.}$$

For details of the Differences in traveling time, the rate of assignment for RAMA VI Bridge the traffic forecast for RAMA VI bridge, and the traffic allocation to RAMA VI Bridge. See Appendixes 5-5, 5-6, 5-9, and 5-10 respectively.

3) Calculation of Induced Traffic

Since present pattern method has been used in calculating future O-D traffic volume, increase in O-D traffic assumed by completion of Ring Roads (MRR and ORR) and new RAMA VI Bridge has not been taken into considerations.

In this section, induced traffic volume, future O-D traffic which is expected to increase by the effects of highway improvements, will be calculated.

In calculation, concept of a gravity model has been used. The gravity model is shown in previous 5-7, and formula used for induced traffic volume is:

$$\Delta T_{ij} = T'_{ij} - T_{ij}$$

$$= T_{ij} \left\{ \left(\frac{t_{ij}}{t'_{ij}} \right) - 1 \right\}$$

where ΔT_{ij} : Induced traffic between zone i to zone j

T_{ij} : Number of daily vehicle trips between zone i to zone j (without improvements case)

T'_{ij} : Number of daily vehicle trips between zone i to zone j (with improvements case)

t_{ij} : Travel time between zone i to zone j (with improvements case)

t'_{ij} : Travel time between zone i to zone j (without improvements case)

Rate of induced traffic and the result of calculation are as shown in APPENDICES 5-7 and 5-11.

4) Motorcycle

Substantial reduction of travel time does not occurred even in congested road for motorcycle. Therefore the shortest route is selected in consideration for motorcycle. Utilization rate of RAMA VI Bridge is established on a basic of difference of distance against via other bridge travel as 3 categories of 100%, 50% and 0%.

Results of calculation is shown in Appendix 5-6, 5-8.

5) Bus

Future traffic volume of bus may be changed according to the below stated factors.

a) Increase of bus traffic due to population and employment increase along existing bus routes.
b) Extension of bus routes due to improved Middle Ring Road.
c) Relative reduction of bus due to increased traffic by privately owned vehicle traffic.

It is difficult to estimate the effects of b) and c) and both effects can be counter-balanced.

Only forecast of increase factor in a) has been made in this study.

Bus routes passing through the existing RAMA VI Bridge have their origin and destination in wide area of GBA and further expansion of bus routes network can be expected after completion of Middle Ring Road.

Future bus traffic volume will increase as population and employment grow up in GBA. Therefore, the following formula has been set up to forecast future bus traffic.

$$\text{Future Bus } (B_f) = B_p \times \frac{1}{2}\left[\frac{P_f}{P_p} + \frac{E_f}{E_p}\right]$$

Where B_f : Future Bus Traffic on RAMA VI Bridge
B_p : Present "
P_f : Future Population in the Study Area
P_p : Present "
E_f : Future Employment in the Study Area
E_p : Present "

The results shown in Table.5-15.

Table 5-15 Forecast of Bus Traffic on RAMA VI Bridge

	Population (1,000)	Employment (1,000)	Bus Traffic
1981	6,518.9 (1.00)	1,509.2 (1.00)	3,440 (1.00)
1985	7,307.5 (1.12)	1,854.9 (1.23)	4,100 (1.19)
1990	8,291.3 (1.27)	2,281.5 (1.51)	4,800 (1.40)
2000	10,571.9 (1.62)	3,171.2 (2.10)	6,400 (1.86)

The growth rate of bus traffic will be somewhere between those of population and employment.

5-7-4 Results of Traffic Forecast on RAMA VI Bridge

A summary table of forecast is shown in Table 5-16. The traffic flow using the New RAMA VI Bridge is given in Fig. 5-14.

1) Relation with Ring Roads.

Since the RAMA VI Bridge is a part of the Middle Ring Road, the former is affected by the improvement of the latter. The Outer Ring Road is planned to be located outside the MRR and is in a competitive relation with the MRR. Consequently the ORR affects the RAMA VI Bridge.

The future trend of RAMA VI and relationship between the construction of the Ring Roads are shown in Fig. 5-15.

a) In case the MRR and the New RAMA VI Bridge has been completed by 1985, the traffic volume at the RAMA VI Bridge is increased from 29,000 veh/day to 53,000 veh/day. The increase directly affected by the MRR completion is approximately 24,000 veh/day.

O-D_S of increased traffic are inter zonal traffic between Thonburi side zones of (7) (8) (22) (23) (40) (41) to

North Bangkok zones of (11) (12) (15) (16) (31) (32) (33) (35) (36) (37) and West zones of (18) (19) (20) (30) (34).

b) If the ORR could be completed by 1990, the new RAMA VI Bridge traffic would decreased to 56,000 veh/day from 69,000 veh/day. Approximately 13,000 veh/day would divert to the ORR.
The main O-D_S pair of these diverted traffic are between (22) (23) (40) (41) and (12) (13) (15) (16) (30) (32) (34) (37).
Therefore, the time schedule of the ORR construction is very important since the traffic of RAMA VI is greatly influenced by the ORR.

2) Traffic volume and number of lanes
In views of survey results of the present traffic volume and also those of the traffic congested Memorial Bridge, the critical traffic capacity can be estimated at 16,000 veh/day for one lane of a bridge on the Chao Phraya River. The design level of service C of AASHTO is calculated as 0.8 of maximum capacity, design capacity is determined as 16,000 x 0.8 = 13,000 veh/day/lane. Hence, design traffic capacity for a bridge on the Chao Phraya River is 52,000 veh/day for 4-lane bridge and 78,000 veh/day for 6-lane bridge.

a) The traffic of the RAMA VI Bridge will reach its 4-lane design capacity in 1985. Considering traffic after 1985, 4-lane bridge is insufficient. Nevertheless, in case of the ORR's earlier construction, 4-lane will be sufficient enough until 1990.

b) In 2000, the RAMA VI Bridge traffic will exceed its design capacity and almost reach at its critical traffic capacity.

Table 5-16 Result of Traffic Forecast on RAMA VI Br.

(VEH/DAY)

	CASE	1985	1990		2000
			without O.R.R.	with O.R.R.	
CAR	Traffic Proper To RAMA VI Br.	22,700	22,100	22,900	21,800
	Diverted Traffic	14,300	27,700	17,500	44,700
	Induced Traffic	2,300	2,300	2,300	2,300
	Total	39,300	52,100	42,700	68,800
TRUCK	Traffic Proper To RAMA VI Br.	5,200	5,100	4,300	3,800
	Diverted Traffic	3,600	6,600	3,200	9,100
	Induced Traffic	600	600	600	600
	Total	9,400	12,300	8,100	13,500
BUS		4,100	4,800	4,800	6,400
GRAND TOTAL		52,800	69,200	55,600	88,700
MOTORCYCLE		2,500	3,500	3,500	5,400

NOTE : O.R.R. OUTER RING ROAD.

5-7-5 Traffic Flow around RAMA VI Bridge

Future traffic volume forecast around the RAMA VI bridge is shown in Fig. 5-16. This forecast traffic volume has been estimated using both assigned traffic and present traffic flow.

Viewing this estimate, improvement of relevant roads around the RAMA VI bridge has been studied.

BANGKOK SIDE:

Traffic flow at the Pracha Rat I Intersection adjacent to the approach of the RAMA VI bridge shows its overwhelmingly large volume in through traffic to the Wongsawang Road followed next by right and left turn traffic. Therefore the traffic treatment at this Intersection becomes one of the most important problem in this study. Intersection traffic treatment such as a flyover should be taken into engineering considerations. Same kind of problems have to be considered on the intersection between the Wongsawang Road and Krung Thep - Nonthaburi Road.

THONBURI SIDE :

Since a residential development has been planned along route 3215, future traffic will increase on R3215 especially in the year of 2000. Traffic treatment at the intersection between Route 3215 and Charan Sanitwong Road has to be planned in near future. The Charan Sanitwong Road is the only arterial highway in the district of Thonburi side and it constitutes a part of the Middle Ring Road, so traffic demand on this arterial road increases as it goes to the south. Especially beyond Pracha Rat I Road to the south, future traffic volume becomes as much as 97,000 veh/day in 1990 and 144,000 veh/day in 2000 which are both far exceeding its serviceable capacity.

Viewing the above stated circumstances, it is strongly recommended that the whole networks of streets in Thonburi side including the Middle Ring Road should be studied for its renovation in the future.

CHAPTER 6
DESIGN PRINCIPLES

CHAPTER 6 DESIGN PRINCIPLES

6-1 GENERAL

The scope of the study area has been set as follows:
Thonburi side .....
The point connecting with Charan Sanitwong Road or the starting point of improvement work of Charan Sanitwong Road.
Bangkok side .....
Wongsawang - Pibul Songkhram Intersection.
The following basic design principles have been determined and adopted at the start of these engineering studies.

1) The study area for this project constitutes an important section of the Middle Ring Road, a crossing over Chao Phraya River.
Therefore, the design should be in good harmony with the whole configuration of Middle Ring Road.

2) Middle Ring Road is principally a surface arterial street system. The adaptation of intersections at grade will not be excluded in the design.

3) To achieve smooth traffic movement at intersections to increase intersection traffic capacity is highly important. Otherwise any appropriate design standard used for travel roadways of Middle Ring Road will become meaningless.

6-2 BASIC NUMBER OF LANES

The basic number of lanes to be used for the New RAMA VI Bridge has been deliberately studied. The adoption of 6 lane has been determined as the result. Designing a 4 lane bridge has also been investigated for the undermentioned reasons.

1) Provided with rather lower capacity of intersections at grade, a 4 lane bridge may be more harmonious in terms of capacity.

2) In urban arterial surface steets, the outermost curb lane is often used for parking, loading and unloading purposes. For roadways of a bridge, such uses are impossible and unnecessary. In these cases the number of lanes of a bridge can be reduced logically.

On the other hand, the reasons to adopt a 6-lane bridge are as follows:

1) The Middle Ring Road has been designed as 8-lane urban arterial highway in its eastern and southern portions, the former of which has been opened on 26 August 1981. The half of remaining sections have been planned with 6-lane cross-section and already are being in use as 6-lane arterial. Therefore the use of 4-lane design on the New RAMA VI Bridge section will not be in harmony with the rest of Middle Ring Road design.

2) Forecast traffic volumes described in the previous chapter are 53,000 veh/day in 1985 and 92,000 veh/day in 2000 the latter of which is appropriate volume for 6-lane roadway.

3) For the whole length of Middle Ring Road on the Thonburi side the outside curb lane of 6-lane roadway is being used as an exclusive bus lane or a preferential bus lane at the present. Also the bus traffic on the existing RAMA VI Bridge is observed as much as 3,400 veh/day and almost 15% of the whole traffic using the bridge. Thus importance of bus transportation as public mass transit will be more and more emphasized in the future.

In view of above considerations, the use of a 4-lane bridge for the project has been considered improper because a bus lane can not be provided on a 4-lane bridge.

Furthermore, in designing the New RAMA VI Bridge as a 6-lane bridge, the possibility of adopting stage construction has been studied.

Stage construction methods are conceivable in two different ways. The one is to build a 3-lane bridge to be used as one way traffic roadway and utilize the existing bridge as one-way for opposite traffic.

The second method is to build a 3-lane bridge to be used for two-way operation.

The Team has entirely eliminated the adoption of stage construction for this project on the following reasons.

1) The whole Middle Ring Road has been, or will be, in service as a 6-lane arterial circumferential highway system in the very near future.

2) The forecast traffic volume of 53,000 veh/day in the year 1985 is already proportionate with the design capacity of 4-lane highway. Therefore traffic congestion will occur in case of 3-lane roadway application.

3) Adoption of a 6-lane bridge can well be justified as sufficient economic benefit can be achieved.

4) The first idea of stage construction has been abandoned because the existing RAMA VI Bridge will not be able to be in service for long period of time, since the substructure of the bridge has been deteriorated severely and already 12-ton limits of loading have to be applied at the present.

5) Although concrete slab of the existing bridge can be rebuilt immediately after the completion of the New RAMA VI Bridge, it will not be economical in case the bridge could only be used for foreseeable short period of time.

6) Since the time of dual track improvement of the railway has been set at rather near future, the space of time between first and final stages of construction would be too short for justifying stage construction methods.

7) The second idea of stage construction method has been also eliminated from our study choice due to the reasons that the traffic volume of the existing bridge has already exceeded 20,000 veh/day level which is the design service level for 2-lane highway.

8) The traffic volume of the proposed RAMA VI Bridge has been estimated to exceed 50,000 - 60,000 veh/day design service level which necessitates 4-lane highway within only 10 year period of time from the completion of the proposed new bridge, thus reducing merits of stage construction methods to a lower degree.

6-3 DESIGN CRITERIA

6-3-1 Geometric Design Criteria for the Project

The geometric design criteria for the project have been selected in accordance with "A Policy on Geometric Design of Rural Highways" (AASHTO)

The design criteria to be adopted are,

Minimum Right of way width	30 m
Lane width	3.25 m
Outer shoulder width	0.5 m
Inner shoulder width	0.5 m
Median width (6 lane road)	4.0 m
Design speed	
- Bridge and Intersection	60 km/h
- Ramp way	30 km/h

Horizontal alignment

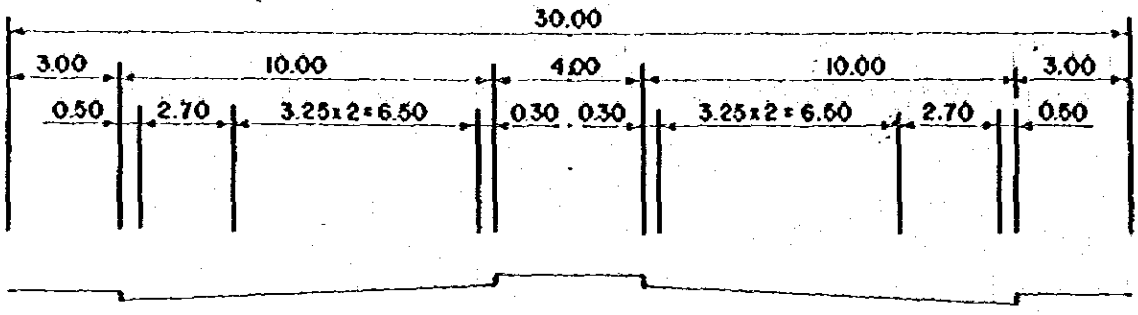
- Absolute minimum		130	m
- Desirable minimum		200	m

Vertical alignment

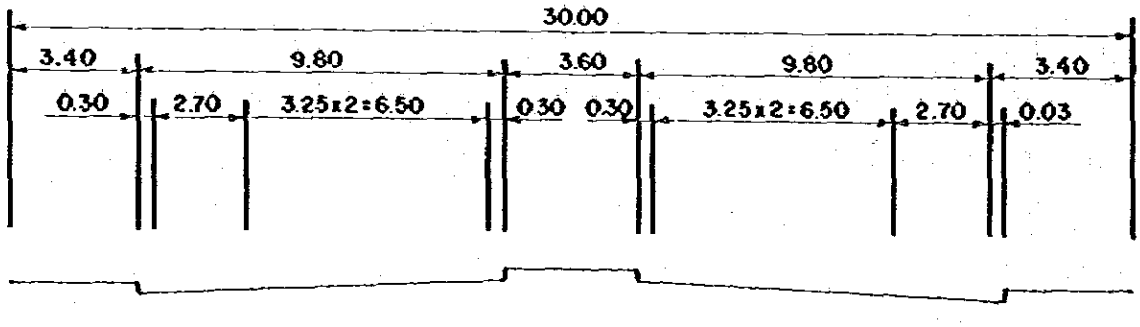
- Absolute minimum	(60km/h)	5	%
	(30km/h)	7	%
- Desirable minimum	(60km/h)	4	%
	(30km/h)	5	%

Spiral transition curves will be provided to horizontal circular curves and parabolic vertical curves will be provided at all changes of grade. The requirements with regard to minimum sight distances on horizontal and vertical curves will be in accordance with AASHTO recommendations.

The typical cross sections for the connecting roads are shown in Fig. 6-1.



BANGKOK SIDE (BMA)



THONBURI SIDE (DOH)

FIG. 6-1 TYPICAL CROSS SECTION ON ROAD

6-3-2 Main Bridge Design

1) Bridge Type : Prestressed Concrete Bridge.

2) Road Widths on Bridges are shown in Fig. 6-2.

3) Clearance for Navigation on the Chao Phraya River.

Vertical Clearance 5.50 metres above HWL
(7.50 metres above MSL)

Horizontal Clearance 60.00 metres

* In case of a skew bridge, influence of skew angle of river stream and new bridge should be taken into considerations.

4) Design standard

The Standard Specifications of Highway Bridges of The American Association of State Highway and Transportation Officials (AASHTO) is adopted as design standard of the proposed Bridge. In compliance with the actual traffic involving those of heavy trucks in GBA, the British Standards of Steel, Concrete and Composite Bridges (BS 5400) is specifically adopted for live load instead of AASHTO.

The number of units of H.B. loading is 45 (BS 5400).

5) Loadings

The loadings which have to be considered on the design of New Rama VI Bridge are shown as follows:

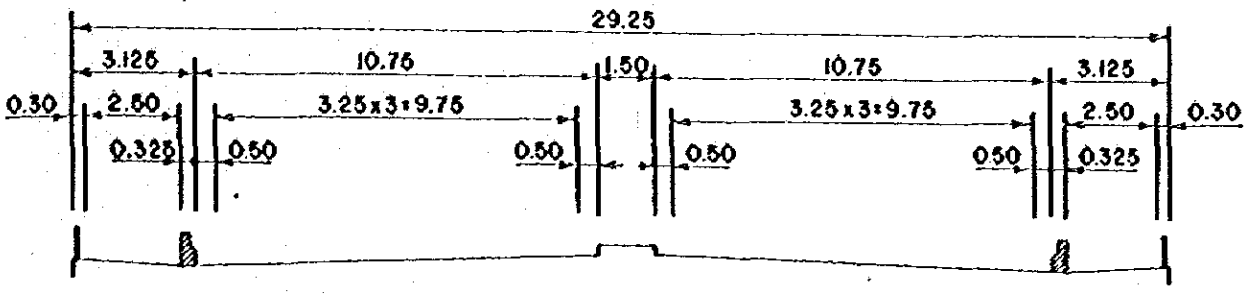
- Dead loads
- Traffic live load and impact (BS 5400 - 45 Units)
- Wind loads
- Stream current force
- Impact from river traffic
- Earth pressure
- Thermal force

In addition to those loadings, there are some specific loadings which have to be taken into accounts for a bridge in Bangkok area, such as:

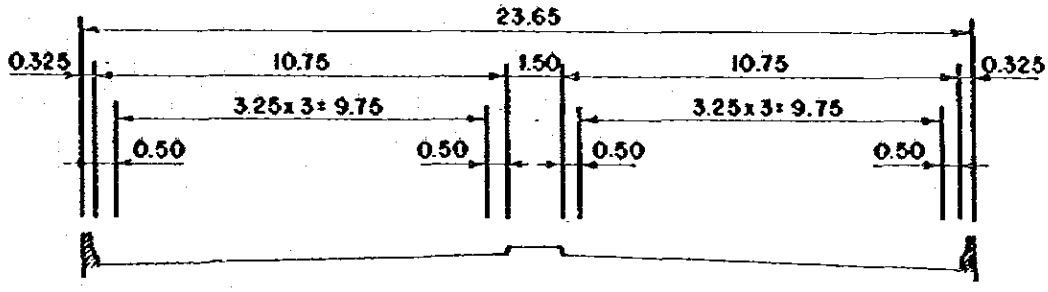
- Wind loads

W = 180 kg/s.m. for superstructure

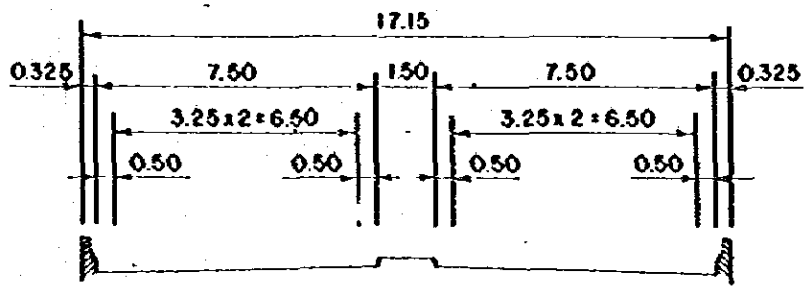
- Impact from river traffic
  A survey for river traffic in the vicinity of New Rama VI Bridge shows that a case of collision by a convoy of seven barges of 500 tons weight had occurred. In this study the influence of impact from a 500 ton barge and equivalent velocity of river stream shall be considered.
- Stream current force
  Stream current with velocity of 3 metres/sec. shall be considered in designing foundation.
- Thermal force
  Temperature fluctuation of from 5°C to 45°C shall be considered in design of the bridge. And temperature difference between upper deck slab and bottom slab of box girder shall be assumed as 10°C.



a) ON CHAO PHRAYA RIVER



b) ON LAND AT THONBURI SIDE



c) AT THE INTERSECTION OF BANGKOK SIDE

FIG. 6-2 TYPICAL CROSS SECTION ON BRIDGE

CHAPTER 7
SELECTION OF ROUTE

CHAPTER 7 SELECTION OF ROUTE

7-1 GENERAL

Since the environmental conditions around the present RAMA VI Bridge are so complicated that it is very difficult to determine the optimal solution as regards to the location and alignment, both horizontal and vertical, of the proposed bridge and its approaches without accompanying some degree of disadvantages.

The basic design principles for selection of routes have been set up as follows:

1) Route alternatives should be proposed and listed as many ways as possible.
2) Any alternative should be deleted from the list when even a single fatal disadvantage is found during the first stage of route selecting process.
3) The remaining alternatives as well as those of minor variations should be thoroughly studied in more careful and detailed procedure comparing every aspect of design factors. The characteristics of each alternative shall be described in more quantification.
4) A comprehensive comparison list will be prepared as regards to the selected alternatives which have remained through the first step of sieving and will be presented to PWD for review.
5) Final selection of the optimal route will be made, and it is subject to the final PWD approval.

7-2 ALTERNATIVES OF ROUTE

The following five major alternatives were proposed at the first stage of the study.

Alternative I (Widening of the existing bridge)

This alternative has been described in the Scope of Work, as either expanding the width of the

RAMA VI Bridge or building a new bridge in adjacent and parallel with the present bridge.

Alternative II (North Route No.1)

The plan is shown as a scheme in Fig. 7-1. This plan enables a smooth connections to Middle Ring Road making best use of the present alignment while expanding and improving into a wider cross-section. As a result, the main river bridge will have its horizontal alignment in a S-shaped curve.

Alternative III (North Route No.2)

The plan is shown as a scheme in Fig. 7-2. The right-angled alignment in vicinity of Highway R3215 will be improved. The radius of 300 m strong can be adopted, and a straight line alignment for the main bridge achieved.

In each of Alternative II and III, a different plan has been studied for the Bangkok side intersection respectively, thus making the total number of combination of alternatives as 4(2 x 2).

Alternative IV (South Route No.1)

As shown in Fig. 7-3, this route has been selected on the south side of the present bridge using a larger radius of curvature.
Although four intersection treatments near R3215 can be omitted, on the other hand, one connection with Charan Sanitwong Road and one intersection-at-grade must be added. Also a right-angled alignment at Wongsawang - Pibul Songkhram Intersection has to be used as a part of Middle Ring Road.

Alternative V (South Route No.2)

As shown in Fig. 7-4, this plan is to build a new bridge on the south side of old one taking

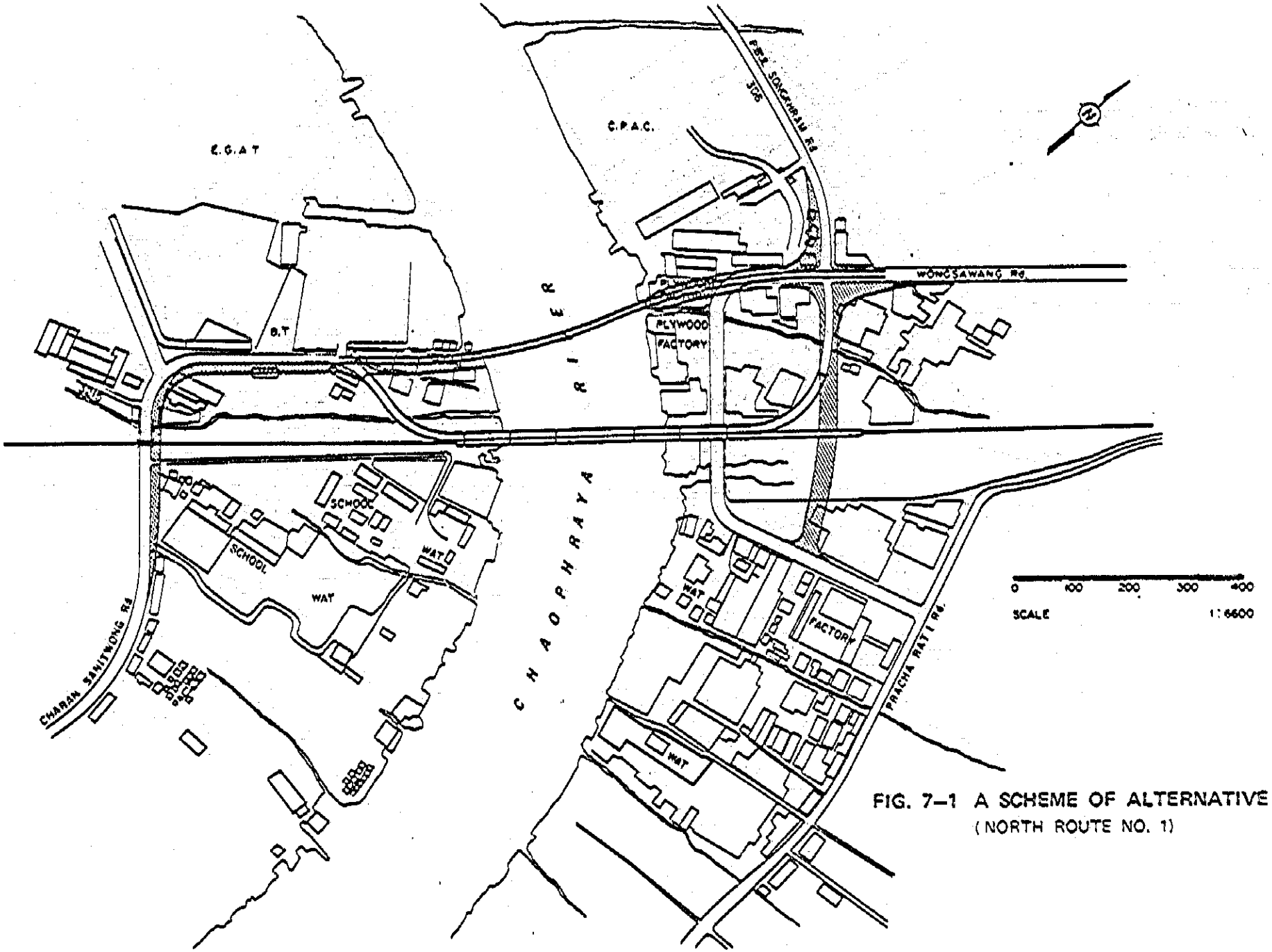


FIG. 7–1 A SCHEME OF ALTERNATIVE II
(NORTH ROUTE NO. 1)

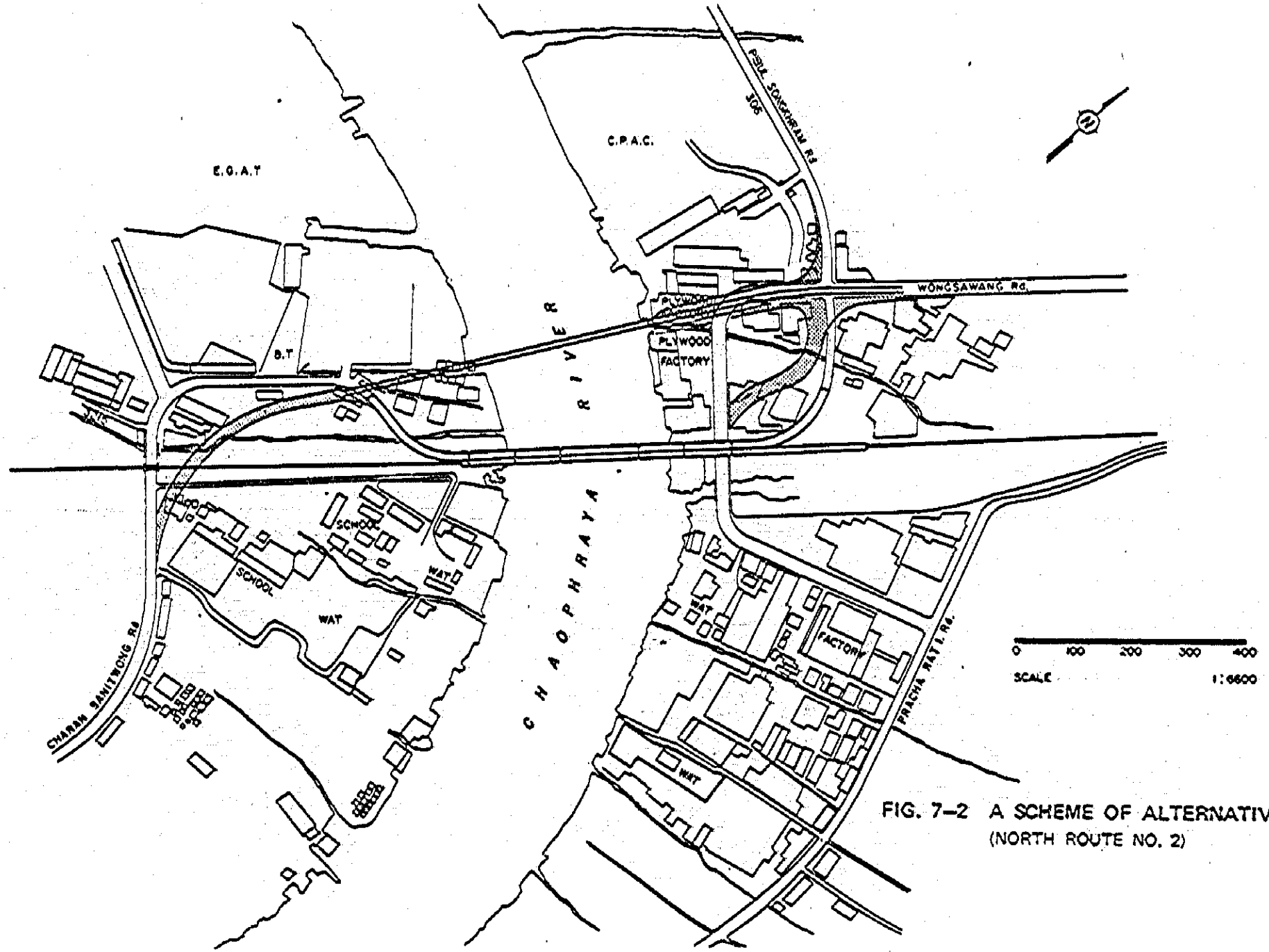


FIG. 7–2 A SCHEME OF ALTERNATIVE III
(NORTH ROUTE NO. 2)

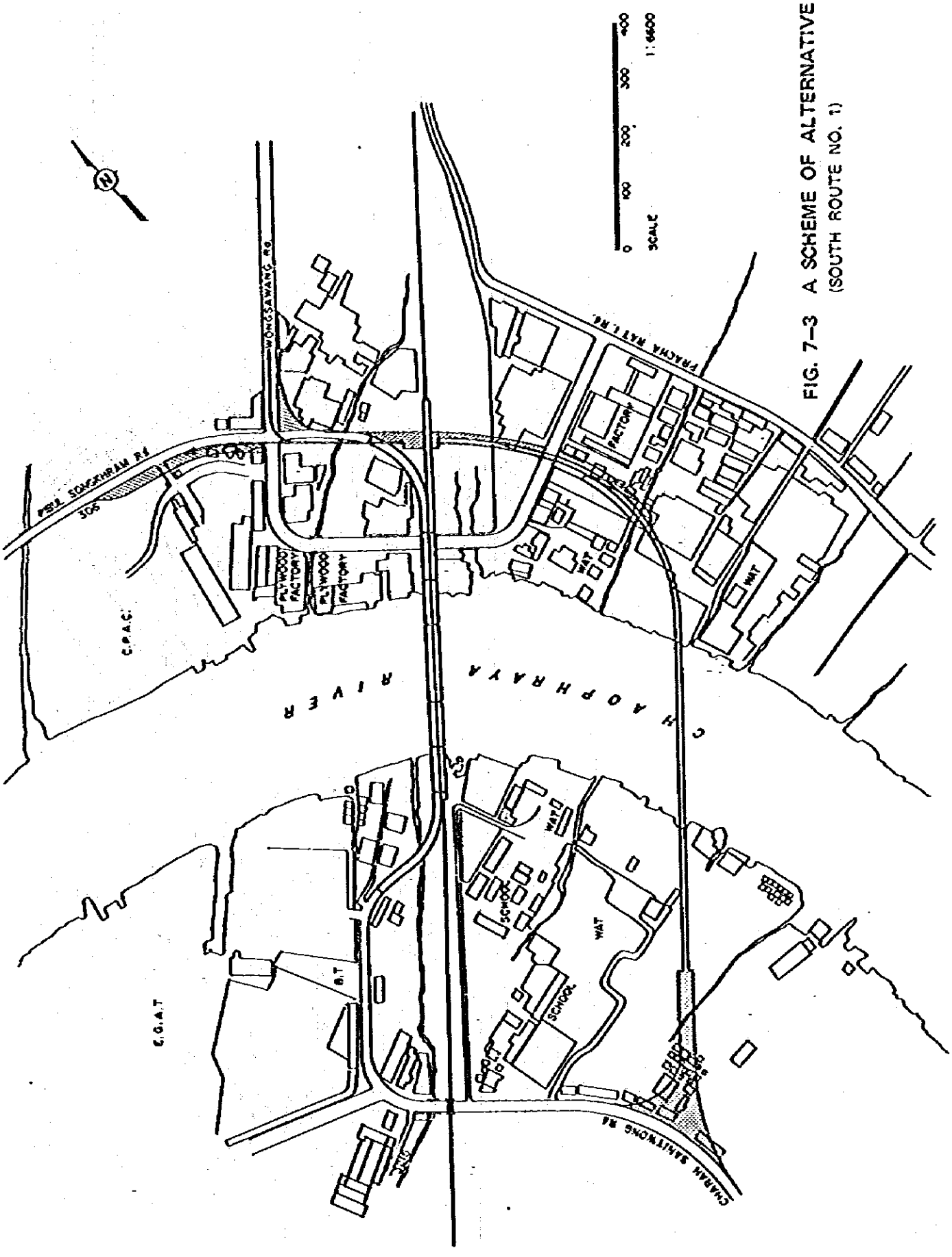


FIG. 7-3 A SCHEME OF ALTERNATIVE IV
(SOUTH ROUTE NO. 1)

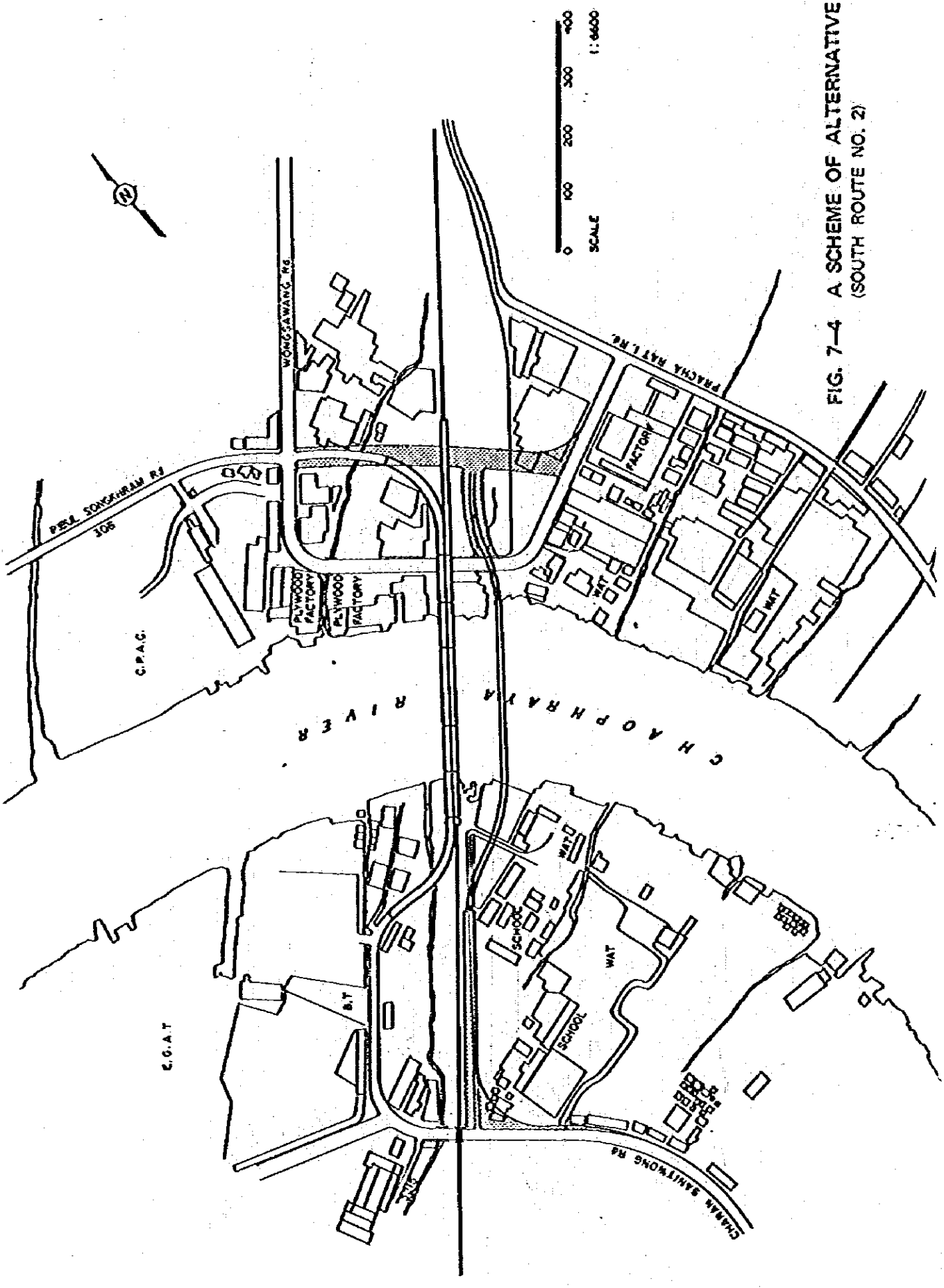


FIG. 7–4 A SCHEME OF ALTERNATIVE V
(SOUTH ROUTE NO. 2)

the minimum distance of 100 m (centre to centre) between the two bridges avoiding the risk of affecting present pier foundations.

7-3 REJECTION OF ALTERNATIVES

Among the five alternatives presented in the previous section 7-2, Alternative I, IV and V have been rejected from the list at earlier stage of comparative study while studying large-scale 1/6600 aerial maps.

The reasons for rejection are stated below.

1) Alternative I (Widening plan)
The substructure of the existing bridge is observed to be in a very dangerous condition, not only the bridge is impossible to be expanded into wider cross-section, but it will not be maintained safely to load the present road or railway traffic.
Vibration of the second Bangkok side pier can be easily felt while automobiles or trains are passing through the bridge.
To build a new bridge in parallel with the old bridge will be very risky in view of well-type foundation used for the bridge and also from possible scouring during construction. A new parallel bridge will have more demerits than its merits because no alignment improvement or shortening of distance in route planning can be achieved in this case. Even a single element of the above mentioned reasons has been considered to be fatal, and Alterantive I has been omitted from the choice in the stage of studying 1/6600 aerial maps.

2) Alternative V (South Route No.2)
The plan has an advantage of having less relocation problems. The sharp right-angled alignment used by Middle Ring Road traffic will be fatal enough to offset this merit. Also there exists a large lumber yard on

Bangkok side on the south of present railway line giving difficult compensation problem. The plan has been abandoned at 1/6600 map study stage.

3) Alternative IV (South Route No.1)
In this plan construction can be carried out without involving the present roads. Furthermore travelling distance connecting Charan Sanitwong Road with both Wongsawang Road and Pibul Songkhram Road can be shortened by about 200 m, and the distance of the former and Pracha Rat I Road will be reduced by as much 1,800 m.
Even in view of increased travelling distance on R3215. the total benefits for traffic users will be maximum. The plan, however, has a big drawback.

a) The construction cost will rise because most sections have to be newly built and also land acquisition will be expensive. The total area of land acquisition will be 46,000 sq.m., and equals to twice as much of North Routes plans.

b) On the Bangkok side, compensation will be necessary for relocating the lumber yard including its railway extension line, and there is another factory under construction.

c) The route will involve the low swamp area for which some special soil engineering considerations will become necessary.

d) Longer detour for R3215 and EGAT sub-station users will be inevitable.

Due to the reasons stated above, the Alternative IV was discarded at 1/6600 map studying stage.

7-4 SELECTION OF OPTIMUM ROUTE

The most attractive alternative has been selected after a overall evaluation of all alternatives comparing with 1/2500

scale maps of Alternatives II and III which had survived through investigation of earlier stages. The results of the comparison are described below as regards with the two separated study areas, one for Bangkok side and the other for Thonburi side plus the main river bridge area.

7-4-1 Bangkok Side

In both Alternative II and III of North Route plans, the west leg of Wongsawang - Pibul Songkhram intersection will be utilized as part of Middle Ring Road.

In case of extending the present Pracha Rat I Road into the above mentioned west leg, appropriate vertical clearance of ramps will not be attained. Also traffic treatment at intersection will be difficult in terms of traffic flow movements.

Therefore the extended section of Pracha Rat I has to be placed on the south leg which is being utilized by the present RAMA VI traffic.

As a result, two designs are conceivable for the new Wongsawang - Pibul Songkhram intersection. One solution will be the plan of extending the Pracha Rat I Road into south in a straight line as described previously in Fig. 7-1. The second is the plan in which the extension is made into south-west in a somewhat inclined alignment as shown in Fig. 7-2. The details are shown in Fig. 7-5 and Fig. 7-6 using scale map of 1/2500.

The Alternative II in which Pracha Rat I Road will be extended into south directly from Wongsawang - Pibul Songkhram Intersection will bring a shorter travelling distance for Pracha Rat I user, and also intersection traffic can be treated in somewhat more advantageous way.

The plan, however, will need more land purchases including lumber yard and its railway freight extension. Drainage under the railway viaduct will bring some engineering problems

in comparison with the Alternative III. Furthermore, traffic treatment during construction will be much more difficult in Alternative II than in Alternative III.

Upon consideration of all these factors, Alternative III has been basically considered to be a more practical and attractive plan for the design of Bangkok side approach area.

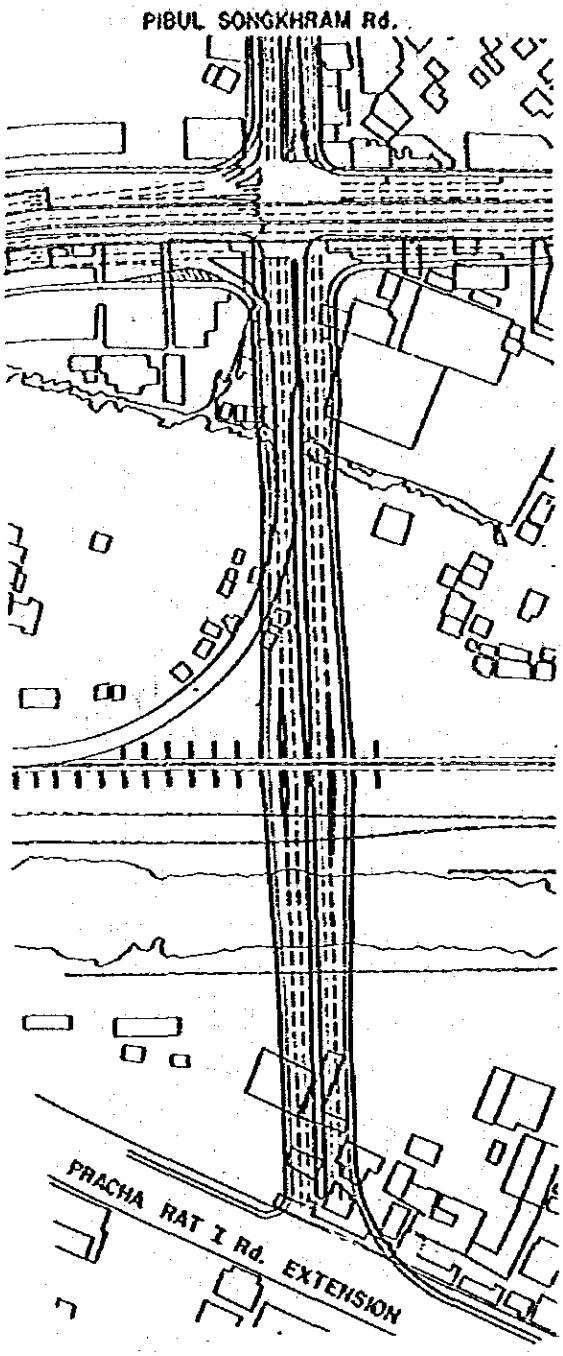


FIG. 7-5
DETAILED SCHEME OF ALTERNATIVE II

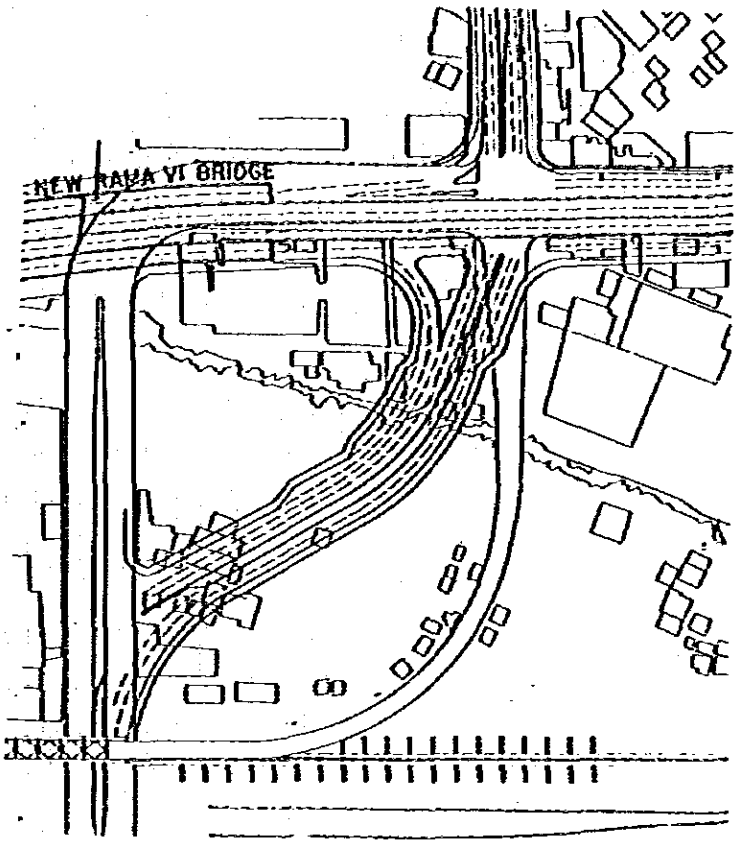


FIG. 7-6
DETAILED SCHEME OF ALTERNATIVE II

SCALE 1 : 2,500

7-4-2 Thonburi side Intersection and the Main Bridge

The characteristics and Design objective for the section including the existing RAMA VI Bridge and the existing railway crossing on Thonburi side has been deliberately studied. The main points of consideration are stated below.

1) Alternatives studies.

The three different alternatives compared are shown in Fig. 7-7, Fig. 7-8 and Fig. 7-9 using scale map of 1/2500.

As the first two of alternatives are in the same category of designing concept as with Alternative II, they will be named as Alternative II-a and II-b respectively. The last one which is in the same design category with the previous Alternative III will be refered as Alternative III.

a) The section defined above constitutes the only section of Middle Ring Road (MRR) having right-angled alignment. It is considered desirable, therefore, to acheive a larger curvature in horizontal alignment in design to conform with overall configuration of whole MRR system.

b) In the vicinity of the above-mentioned area, there exist 4 intersections at grade and 2 access openings utilized by traffic for the BMA Bus Terminal and North Bangkok Electricity Generating Substation of EGAT.

Therefore, the proposed new intersection should be utilized as smoothly as possible by traffic using these intersections and access openings. On the other hand, these intersections at grade and access openings should not be obstructive against the through traffic of MRR.

Alternative II-a is a plan of intersection improvement because the alignment is inevitably involved with the R3215 intersection vicinity. As the two of

access openings are treated in two-way frontage road, the number of intersection can be reduced from the present six to the future four. Also the plan can be characterized basically as a widening improvement of the present roads.

As a results, the new main bridge can be designed in a S-shaped alignment having a larger radius of 800-1200 m.

In Alternative II-b, on the other hand, the traffic from both R3215 and EGAT will use a round-about which results in increased need of weaving but reduced number of stoppages.

Having an one-way frontage road under the abutment of the main bridge, two access openings can be omitted in this plan.

The plan has been designed for a more aggressive use of one-way frontage road even with paying more sacrifices of making longer detours. It also can be pointed out that in this plan an over-all regional redevelopment plan should be carried out during and after construction since the land acquisition cost around present R3215 and EGAT will become overly expensive.

Alternative III is intended to use the existing roads and to make a connection from the new Middle Ring Road by building two intersection-at-grade, as a result, the Middle Ring Road can be placed in a better alignment having rather larger radius of curvature of 300 m strong. The new route in this plan has been selected in such a way as to avoid large building relocation, that unfavorable effects to the neighboring communities can be reduced to the minimum.

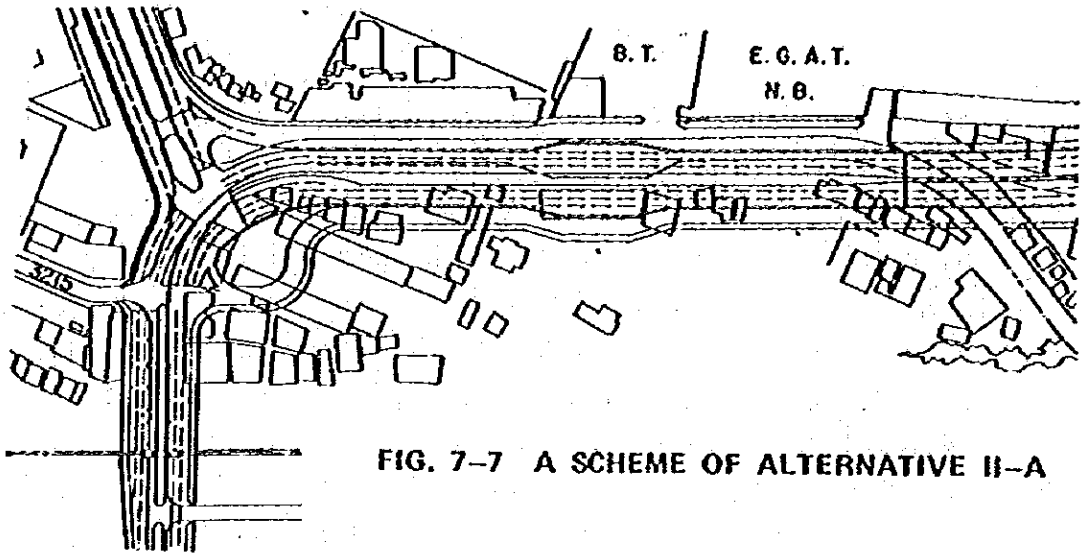


FIG. 7-7 A SCHEME OF ALTERNATIVE II-A

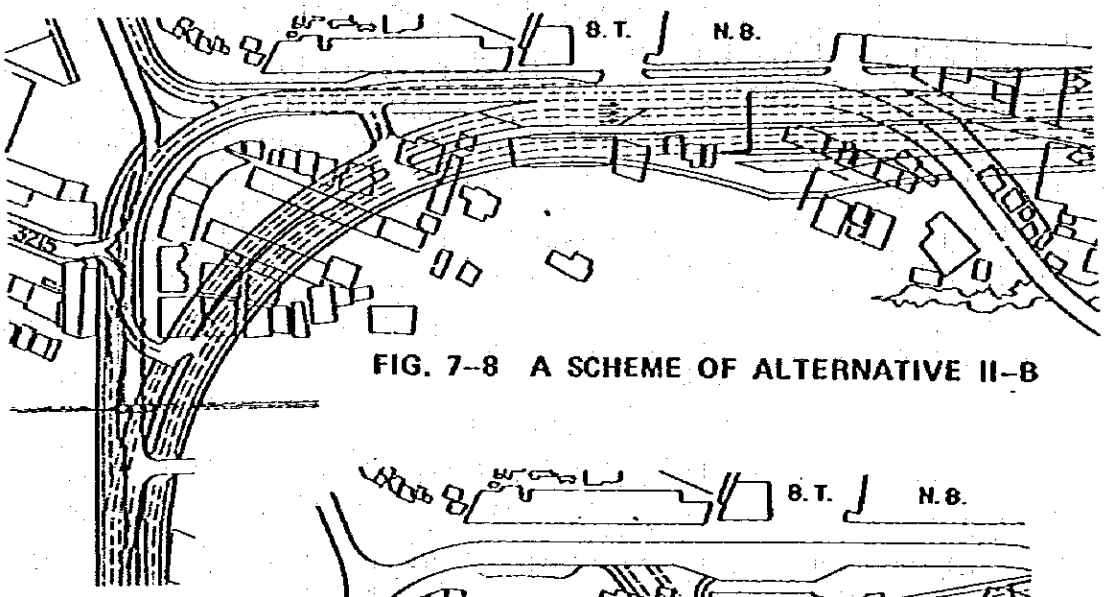


FIG. 7-8 A SCHEME OF ALTERNATIVE II-B

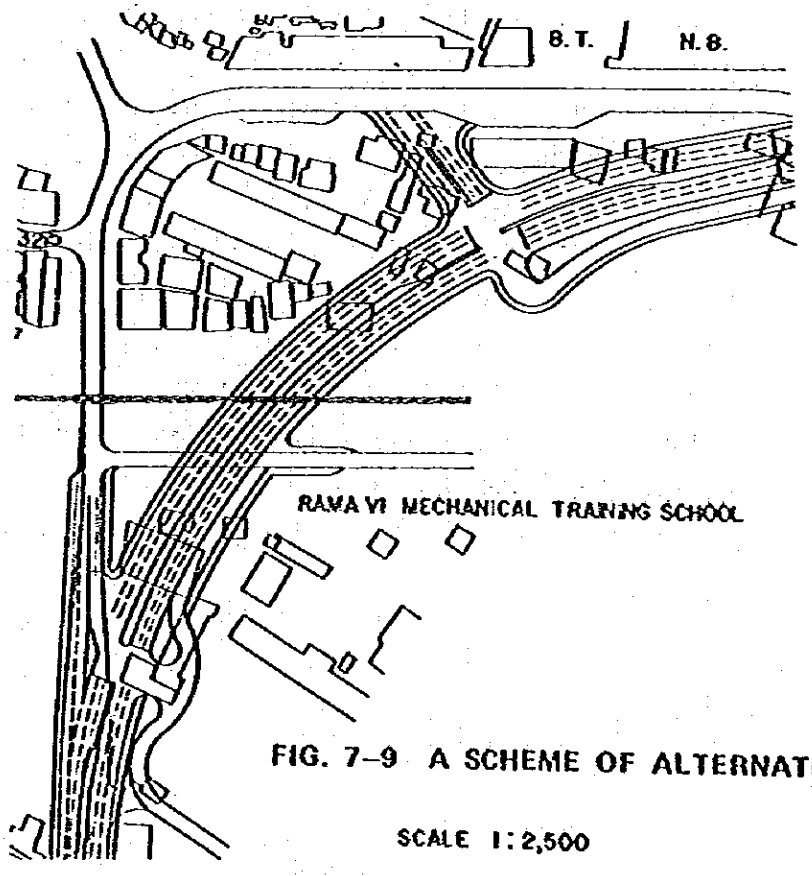


FIG. 7-9 A SCHEME OF ALTERNATIVE III

SCALE 1:2,500

2) Comparative Studies.

These three alternatives have been studied in an overall evaluation. (see Fig. 7-10, 11, 12)
The results of comparisons made are described in Table 7-1.

Table 7-1 (1) Comparative Evaluation List for 3 Alternatives

Item		Alternative 1	Alternative 2	Alternative 3
Concept		Altn 1:2 intersections at grade (ISAG) can be reduced. Traffic halts at intersections more frequent. Alignment improvement basically infeasible. Second degree of relocation nuisance involved. Altn 2:2 intersections treated as round-abouts. Numbers of intersections reduced, by adopting one-way frontage-roads (sideways) Must detour. Large scale relocation of inhabitants necessary. Altn 3: Horizontal alignment can be gradiose in conform with whole MRR system. Numbers of intersections can be limited to minimum. Shorter detour. Impacts to surrounding communities can be minimized.		
Minimum Radius of Curvature		65m	200m	320m
Horizontal Alignment of Bridge		R=800-1200	R=800-1200	straight
Number of Intersection	Signalized	2	2	2
	Not signalized	2	2	0
	Total	4	4	2
Superelevation at intersection		2%	4% (60km/h) 5% (80km/h)	3% (60km/h) 4% (80km/h)
Difference of speed between through and turning		Min	Medium	Max
Traffic safety		2 non signal inter-sections	2 non-signal inter-sections 4 weaving sections	only high speed is a problem

Table 7-1(2)

Difference of Veh.Kilometer in 1981 ($\times 10^6$)

Item		Altn.1.	Altn.2.	Altn.3.
through	Bangkok	-240	-305	-360
	Thonburi	-240	-305	-360
S.P.	Bangkok	-240	-305 -305 -305	-360 -360 -360
	Thonburi	0	0 0 0	+110 +130 +120
N.P.	Bangkok	-240	-305 -305 -305	-260 -260 -260
	Thonburi	0	0 0 0	- 35 - 35 - 35
3215	Bangkok	-240	-305 -207 -256	-310 -310 -310
	Thonburi	0	+240 +120	0 0 0
EGAT	Bangkok	-240	-305 -175 -240	-310 -310 -310
	Thonburi	0	+120 0 + 60	0 0 0
B.T.	Bangkok	+170 +210 +190	-305 +217 - 44	+190 +190 -190
	Thonburi	+ 20 0 + 10	+610 - 65 +270	0 0 0
N.B.	Bangkok	+370 +410 +390	+885 +425 +655	+ 70 + 70 + 70
	Thonburi	+ 20 0 + 10	+460 0 +230	0 0 0
through	Bangkok	-0.867	-1.102	-1.301
	Thonburi	-0.841	-0.841	-1.261
3215	Bangkok	-0.131	-0.167 -0.113 -0.140	-0.170 -0.170 -0.170
	Thonburi	0	+0.140 0 +0.070	0
EGAT	Bangkok	-0.149	-0.189 -0.096 -0.143	-0.118 -0.104 -0.111
	Thonburi	0	+0.110 0 +0.055	0
Total		-1.988	-1.471	-2.843

Number of stops in 1981 ($\times 10^6$)

through	Bangkok	(2) 6.21	(1) 3.10	(1) 3.10
	Thonburi	(2) 6.28	(2) 6.28	(1) 3.14
3215	Bangkok	(1)0.44 (2)0.88)0.66	(0) 0 (1)0.44) 0.22	(0) 0 (1)0.44) 0.22
	Thonburi	(1)0.47 (0) 0)0.24	(1)0.47 (0) 0) 0.24	(1)0.47 (0) 0) 0.24
EGAT	Bangkok	(0) 0 (1)0.44)0.22	(0) 0 (1)0.44) 0.22	(0) 0 (1)0.44) 0.22
	Thonburi	(2)1.39 (1)0.55)0.97	(1)0.69 (0) 0) 0.35	(1)0.69 (0) 0) 0.35
Total		14.58	10.41	7.27

Table 7-1(3)

	Altn.1.	Altn.2.	Altn.3.
Construction Difficulties	Altn. 1. Railway crossing most difficult. Altn. 2. Railway crossing difficult second (1). Cost almost same as (1). Altn. 3. Traffic treatment during const. much easier than other altns Railway crossing considerably easier. Cost lowest.		
Additional Right of Way (m^2)	16,000	17,000	28,000
Main buildings to be compensated	2 apartment house made of R.C.	ditto	2 building of Pramuk Village School

Note 1) S.P. = Southern Boundary Road of Pramuk Village School

Note 2) N.P. = Northern Boundary Road of Pramuk Village School

Note 3) 3215 = National Highway No.3215

Note 4) EGAT = Road to and from EGAT

Note 5) B.T. = Bus Terminal

Note 6) N.B. = North Bangkok Station of EGAT.

3) Conclusion

A conclusion was reached to the effect that the Alternative III has been preferred because of its overall advantages than its defects.

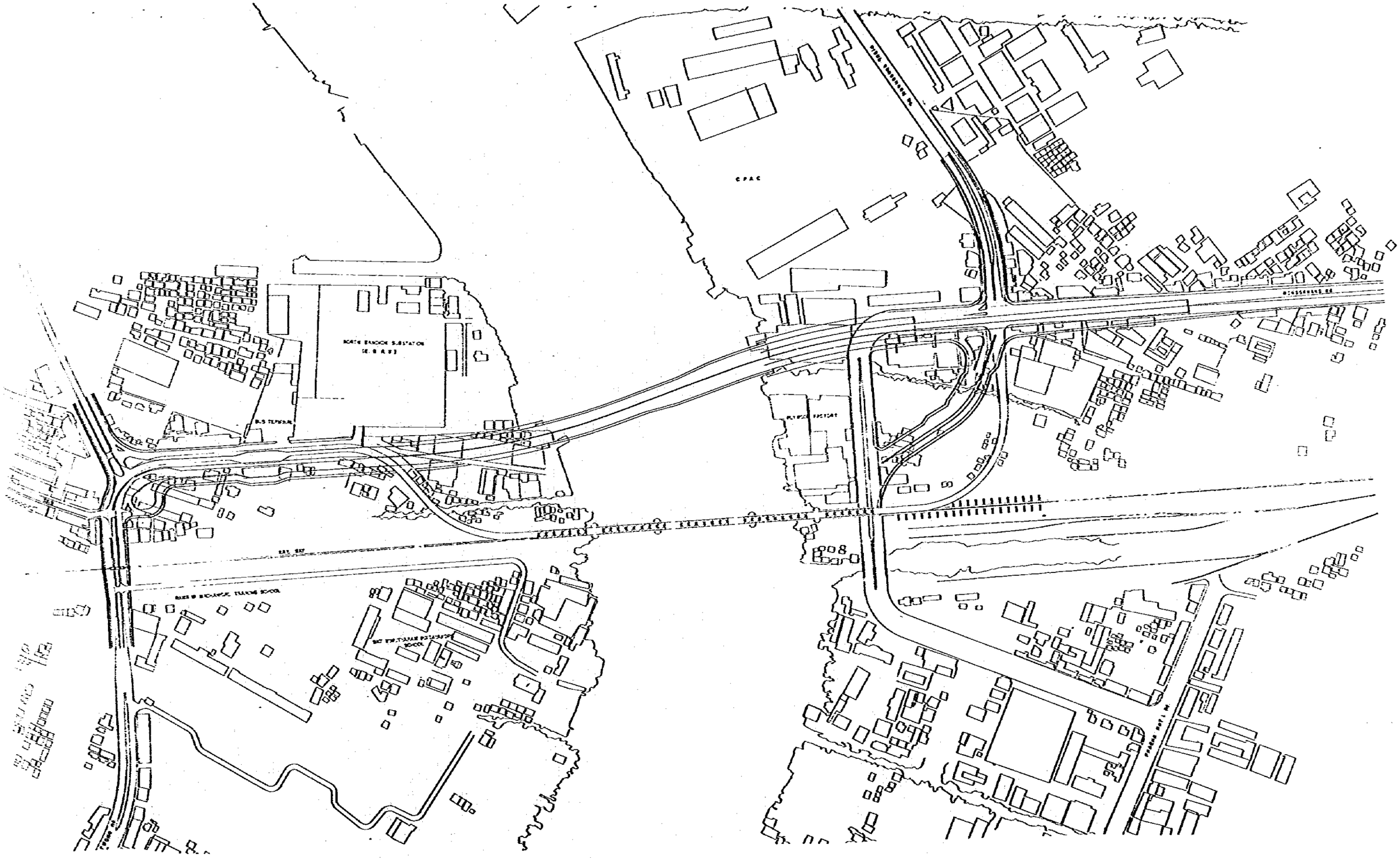


Fig. 7–10 PLAN OF ALTERNATIVE IIA

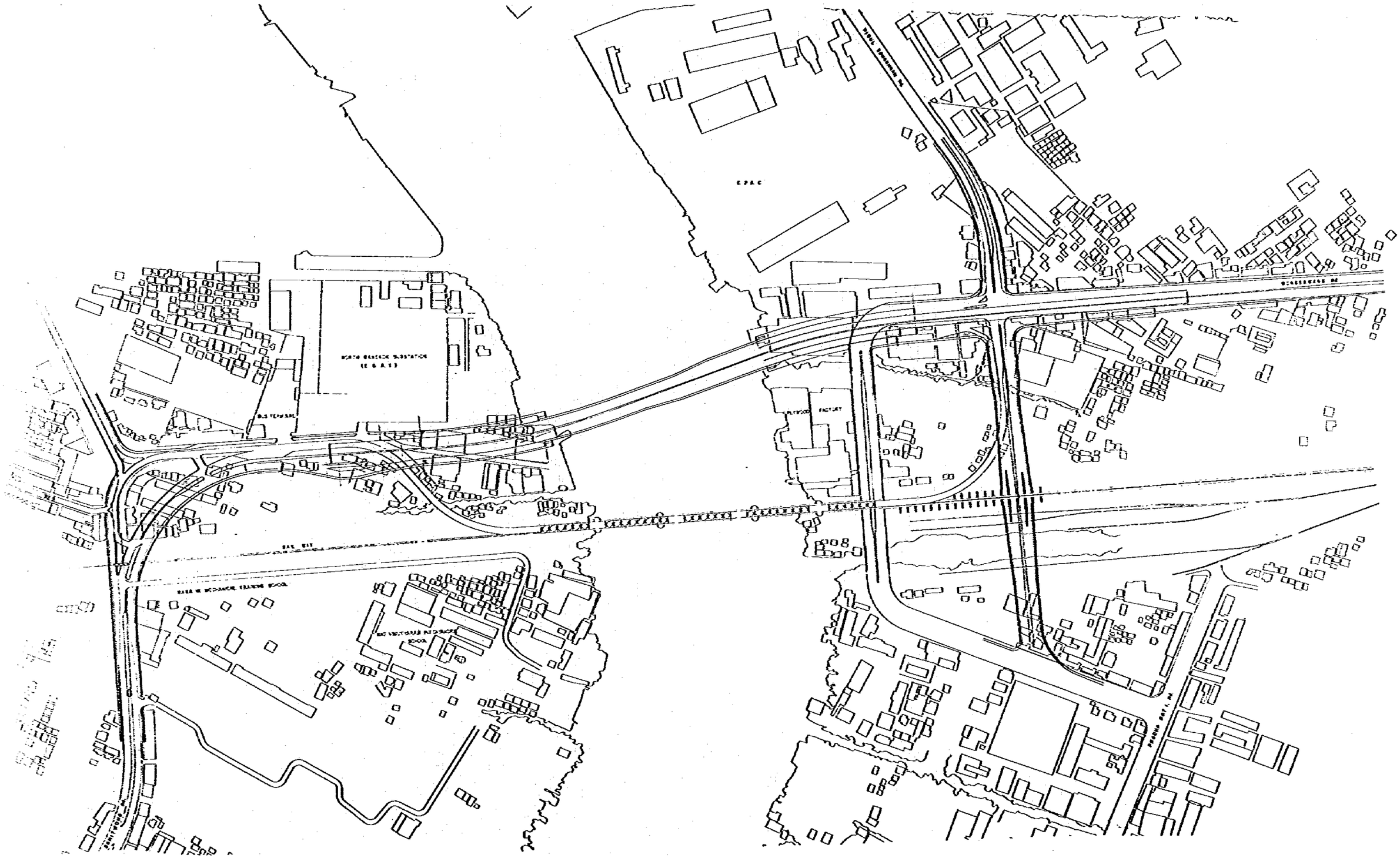


Fig. 7–11 PLAN OF ALTERNATIVE IIB

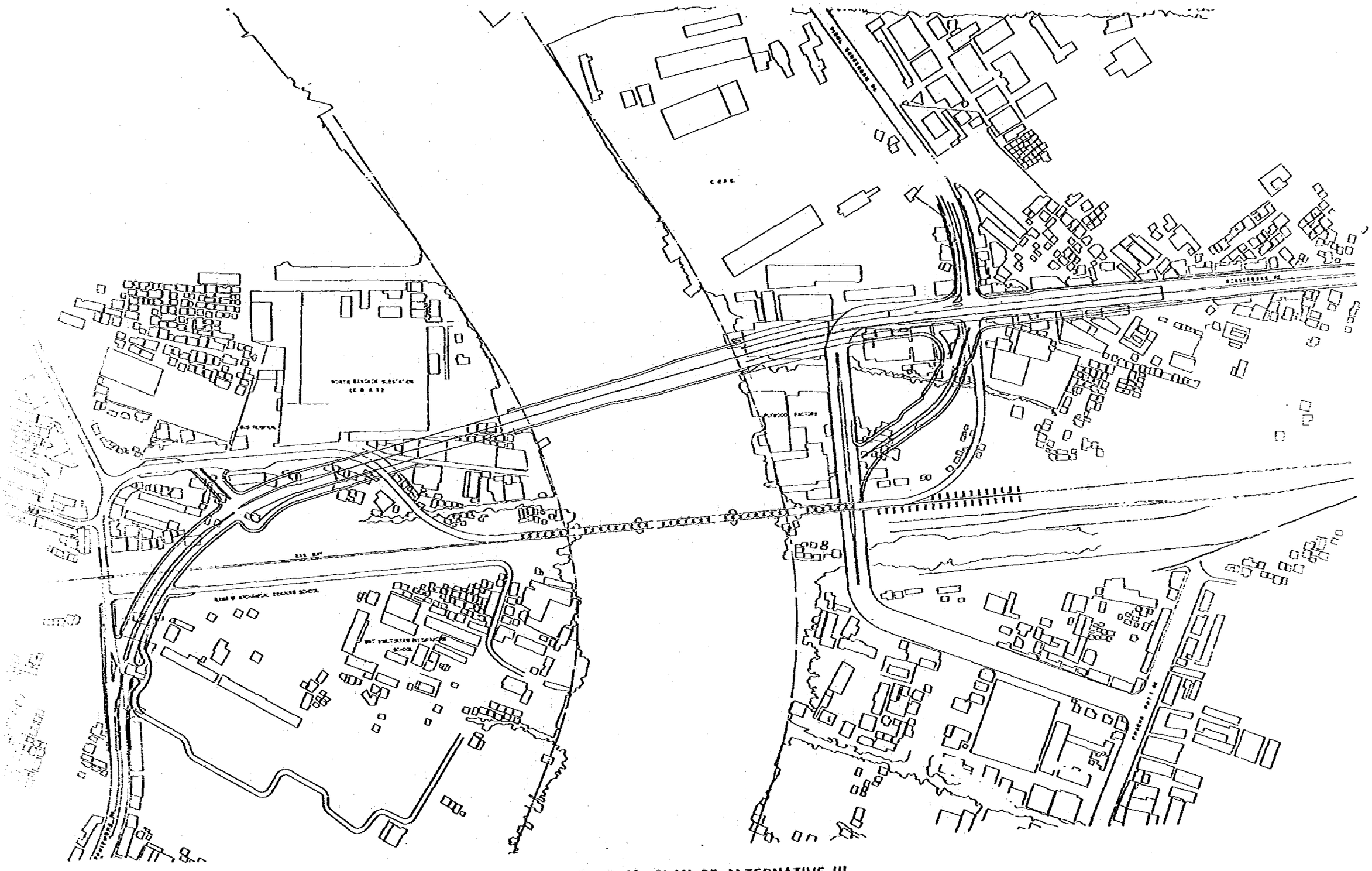
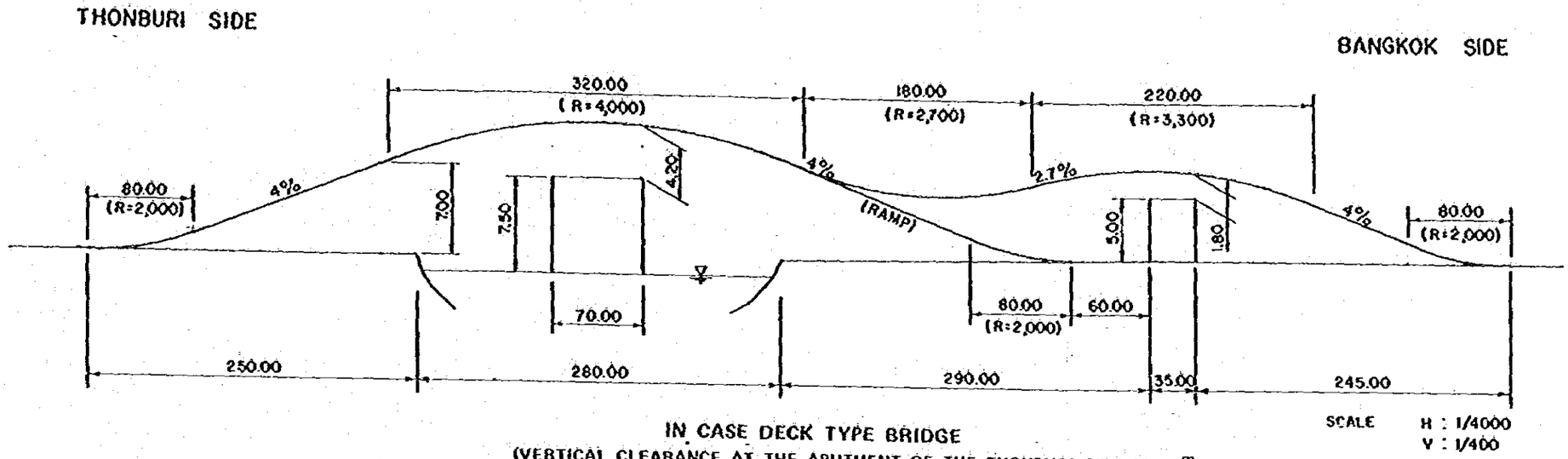


Fig. 7–12 PLAN OF ALTERNATIVE III

7-4-3 Vertical Alignment

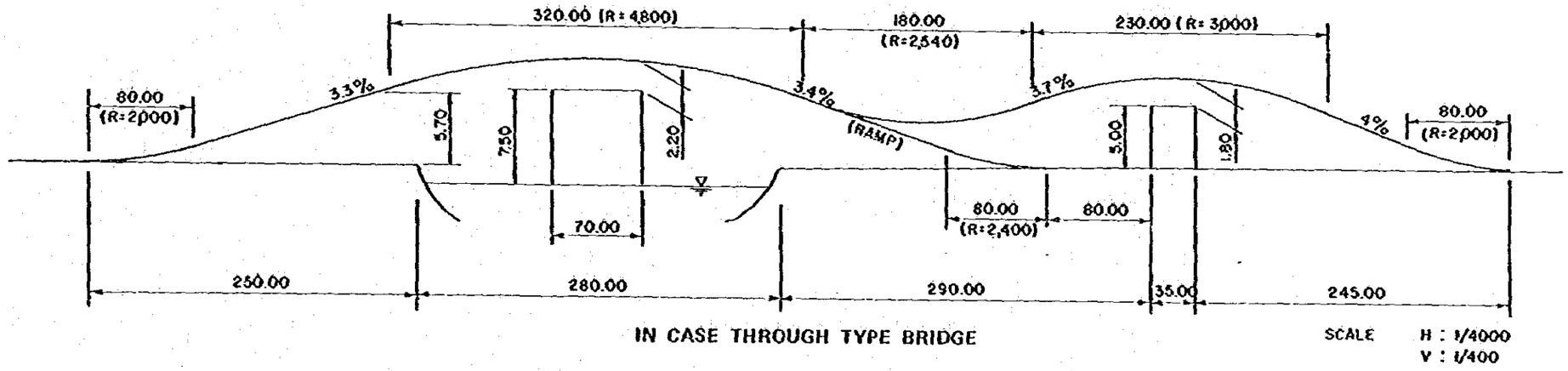
As regards with the selected route described in previous sections, vertical alignment has been planned as shown in Fig. 7-13.

The profile consists of two crest vertical curves of having 4,000 m radius and one sag vertical curve of 2500 m radius. The design has to be adopted in order to attain a slower grade for the ramp section and to obtain maximum length of distance between the intersection-at-grade and the ramp end, with both factors being considered as basically more important than to attain more simple and smooth vertical curve in design for this porject.



IN CASE DECK TYPE BRIDGE

(VERTICAL CLEARANCE AT THE ABUTMENT OF THE THONBURI SIDE IS 5.0^{m})



IN CASE THROUGH TYPE BRIDGE

Fig. 7-13 PROFILE OF DECK TYPE BRIDGE AND THROUGH TYPE BRIDGE

CHAPTER 8

OUTLINE DESIGN OF BRIDGE AND ROADS

CHAPTER 8 OUTLINE DESIGN OF BRIDGE AND ROADS

8-1 ENVIRONMENTS INVESTIGATION

8.1.1 Investigation for Existing Roads and Bridges in the Vicinity of New RAMA VI Bridge

Investigations of the existing roads and bridges in the vicinity of the New RAMA VI Bridge have been carried out in earlier stages of this study. The Public Works Department (PWD) has provided documents to the Study Team, as shown below:

- Drawings of future plan of Wongsawang Road (BMA)
- Drawings of Pracha Rat I Road (BMA)
- Drawings of Charan Sanitwong Road (DOH)
- Drawings of existing RAMA VI Bridge and small viaduct in Thonburi side (SRT)
- Drawings of general arrangement plan of existing water supply lines (MWWA)
- Drawings of general arrangement plan of existing electric cables and facilities (MEA)
- Drawings of general arrangement plan of North Bangkok substation (EGAT)
- Drawings of location and elevation of the bench marks on both ends of existing RAMA VI Bridge (BMA)
- Reports and drawings of Sathorn Bridge and New Memorial Bridge (PWD)

Also many useful informations have been collected by the Study Team and the PWD.

The results obtained from the investigations are described as follows:

- The elevation on the Wongsawang Road, the Pracha Rat I Road and the Charan Sanitwong Road is 2.20 to

2.80 metres above MSL.

- Several parts of the existing RAMA VI Bridge have severely deteriorated because of cracks in the concrete. Especially the pier bases are considered to have been seriously demaged.
- The superstructure of the existing RAMA VI Bridge is under consideration for use during double tracking of the railway, with minor strengthenings of stringers, bracings and others.
- The railway viaduct crossing the Charan Sanitwong Road has only 10 metres span length, so on improvement of the Charan Sanitwong Road (National highway No. 306), the railway viaduct should be designed with a longer span length.
- On Bangkok side, the electric transmission lines of 69 KV and 12 KV across the Pracha Rat I Road and the site of the proposed New RAMA VI Bridge. The lowest elevation of these cables is 10 to 12 metres above ground level, so these cables should be removed from the right of the way.

8.1.2 Field Check Surveying

The area of this project is in the north part of Bangkok. Many factories, schools, public facilities and buildings are located there. It is estimated that the amount of compensation and land acquisition cost will be approximately as much as 40% of the construction cost of the new bridge and roads.

Before selecting route alternatives, field reconnaissance survey has been carried out and the following major obstacles have been found in the neighborhood of the existing RAMA VI Bridge.

(1) On North side of the existing RAMA VI Bridge:

Thonburi side:

North Bangkok Electric Power Plant (EGAT)
North Bangkok Sub Station (EGAT)
Head Office of EGAT
Steel Tower and Electric 230 KV transmission Cables (EGAT)
Steel Tower and Electric 69 KV transmission Cables

Bangkok side:

Steel Tower and Electric Cable for 230 KV (EGAT)
Steel Tower and Electric Cables for 69 KV (MEA)
Main Factory of Concrete Products and Aggregate Co., Ltd. (CPAC)

(2) On South Side of the existing RAMA VI Bridge:

Thonburi side:

Wat
Factory

8.1.3 Hydrographic Investigation

In Phase I, much useful data and information have been provided by PWD. Using these documents, investigations have been carried out to obtain the following data.

- The elevation of HWL on the site of the New RAMA VI Bridge on the Chao Phraya River.
- The navigation clearance on New RAMA VI Bridge.
- Velocity of stream current of Chao Phraya River for bridge design.
- The elevation of river bed.