(1) Mastranto : Covering 78.5 hectares to accommodate 11,800 persons
(2) Universidad : Covering 14.0 hectares
(3) Los Llanos de La Chorrera : Covering 600 hectares to accommodate 6,000 persons
(4) San Antonio : Covering 11.5 hectares to accommodate 600 persons
(5) El Limon (Including an industrial estate) : Covering 75 hectares to accommodate 1,900 persons

These projects will perform important roles in the process of future urbanization up to 1990, but, subsequently, additional new development projects will become necessary, particularly towards Area de Guadalupe (P.T. Zone 49) south of Autopista.

The two projects being implemented in the northeastern part of La Chorrera urbanized area – Mastranto-Universidad and El Limon-Parque Industrial – are important in that they will create new cores for the development of this Zone. Therefore, basic facilities to form the cores will be located under emphatic efforts.

(5) Development Schedule

The state of development in 1990 is envisaged as a mid-point goal on the way toward the completion of the urbanization program by the year 2000, and areas for which priority measures are particularly needed and projects that should be implemented during the next ten years in order to realize the picture envisaged for 1990 will be identified below.

(i) Urbanized Area in 1990

Urbanized areas which are expected to exist in 1990 and their ratios to the 2000 situation in terms of the size of urbanized land are presented in Table 8-36.

A sizeable amount of land will be urbanized from now on to 1990, and the pace of urbanization will be fast, particularly in Juan Diaz–Pedregal, Tocumen, Las Cumbres – Chilibre, Ancon Este, and Arraijan. A large amount of land will be urbanized in San Miguelito and La Chorrera during the two decades from now to the year 2000.

TABLE 8-36 URBANIZED AREA IN 1990

Integrated Zone	1990 Population	1990 Area	1990 Density	Area Increase* 1980–1990	1980–1990 / 1980–2000
Panama Urban Area (01–22)	319,700	3,510	91.1	–	– (%)
Juan Diaz Pedregal (23–25)	132,200	3,070	43.1	690	53.3
Tocumen (26–27)	35,900	1,958	18.3	443	50.2
San Miguelito (28–34)	205,820	2,996	68.7	496	33.7
Las Cumbres Chilibre (35–36)	47,600	1,237	38.5	527	69.3
Ancon Este (37–42)	49,400	960	51.5	290	58.0
Ancon Oeste (43)	870	18	48.3	18	60.0
Arraijan (44–46)	62,010	1,289	48.1	319	52.6
Chorrera (47–49)	70,400	1,305	53.9	745	45.2
Planning Area Total	923,900	16,343	56.5	3,528	49.0

* See Table 8-3 for area size in 1980.
Source : ESTAMPA

(ii) Major Projects

The above urbanization will be achieved through the implementation of the following projects:

Housing Development

The estates to be developed in the reverted area (Albrook Norte, Campo de Antenas de Curundu, Camino de la Amistad, Ricardo J. Alfaro) will accommodate, by 1990, 80%of the planned population of 53,500.

- The formation of a 100,000-people town and of a regional core in the eastern part of San Miguelito will prepare for their full functioning after 1990.

- Residential area development in Arraijan will progress in line with its population increase and will be completed by the year 2000.

- Projects planned for La Chorrera will be completed by about 1990.

- The development projects for the mangroved area in Juan Diaz will be partially implemented by 1990.

- Zoning (designation of land use) will be effected immediately in the parts of Pedregal where population increase will be very fast.

Industrial Estate Development

- Tocumen Industrial Estate (30 hectares)
- Albrook Business Estate (170 hectares)
- Vacamonte Port Industrial Estate (60 hectares)
- La Chorrera Industrial Estate

In order to meet rapid population increases, the above industrial estates will be opened at least partially by 1990, if their full functioning is to be delayed until after 1990.

Formation of Commercial Centers

- The formation of a commercial nucleus will be started Nuevo Arraijan (46) in Arraijan District before 1990.

- Efforts will be made to introduce additional commercial activities to the existing commercial area in San Miguelito. Plans will be formulated for the formation of a regional core in the eastern part.
- Commercial centers will be developed in line with residential area development in the reverted area.

Public Buildings and Educational Facilities

- The locating of the local offices of government agencies and the Panama Institute of Technology and other educational facilities along Corredor Norte will be about 50% completed, and Albrook Business Estate will be completed about 20% by 1990.

- At least one distribution center will be established in the reverted area after 1990.

Urban Renewal

- Urban renewal in all of the four MIVI-designated areas will be completed by 2000, provided that the public building portion of El Maranon Area is completed by 1990.

- The locating of service industries will be accelerated and projects for public facilities development in residential areas will be implemented in the whole neighborhood of Curundu (03), in line with the development of a transportation network to Curundu with the reverted area.

- Corregimiento de San Felipe and Panama Viejo will be developed as tourist industry bases through IPAT's projects for the restoration of historical memorials in these locations.

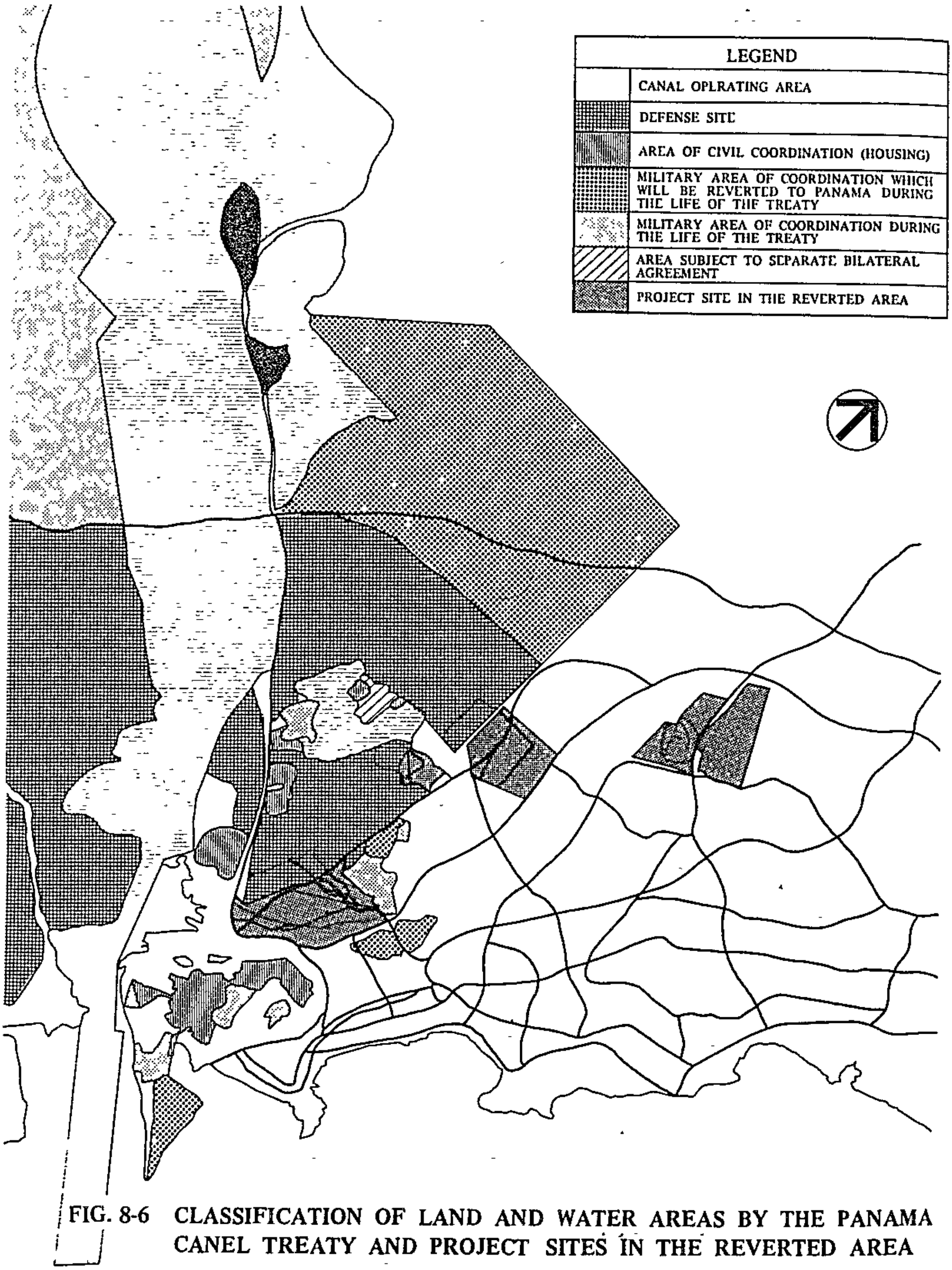


FIG. 8-6 CLASSIFICATION OF LAND AND WATER AREAS BY THE PANAMA CANEL TREATY AND PROJECT SITES IN THE REVERTED AREA

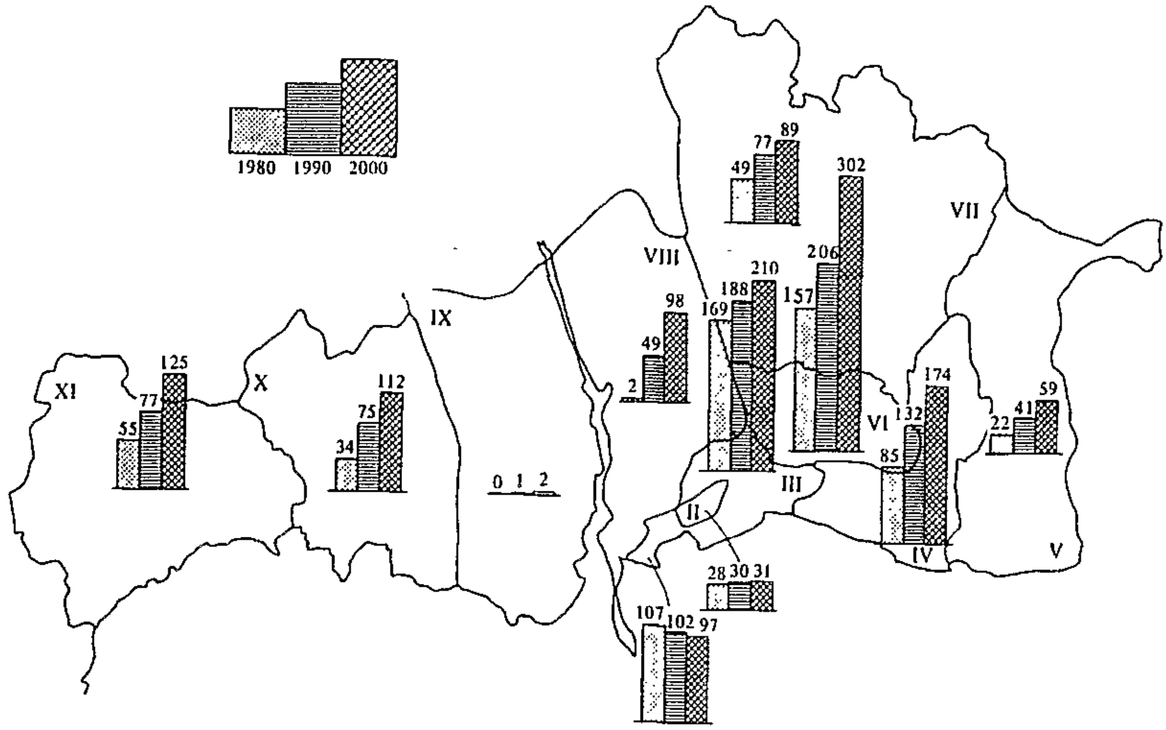


FIG. 8-7 POPULATION OF INTEGRATED ZONES (1980, 1990, 2000)

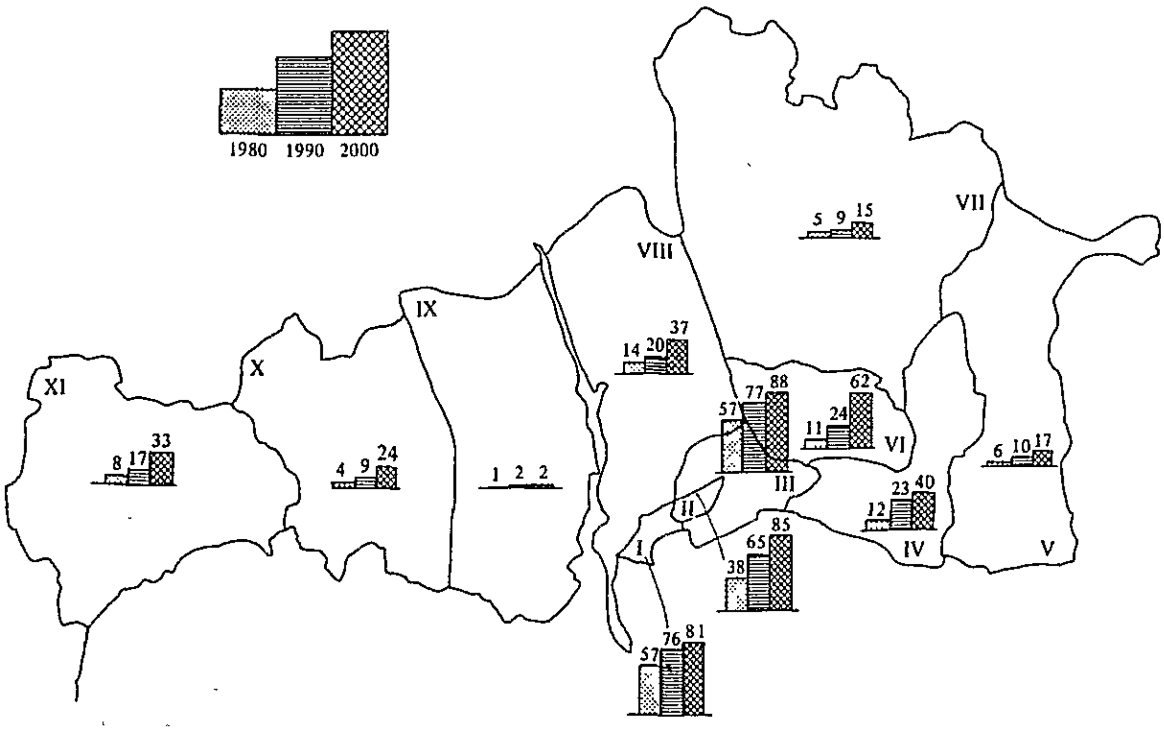


FIG. 8-8 EMPLOYMENT IN INTEGRATED ZONES (1980, 1990, 2000)

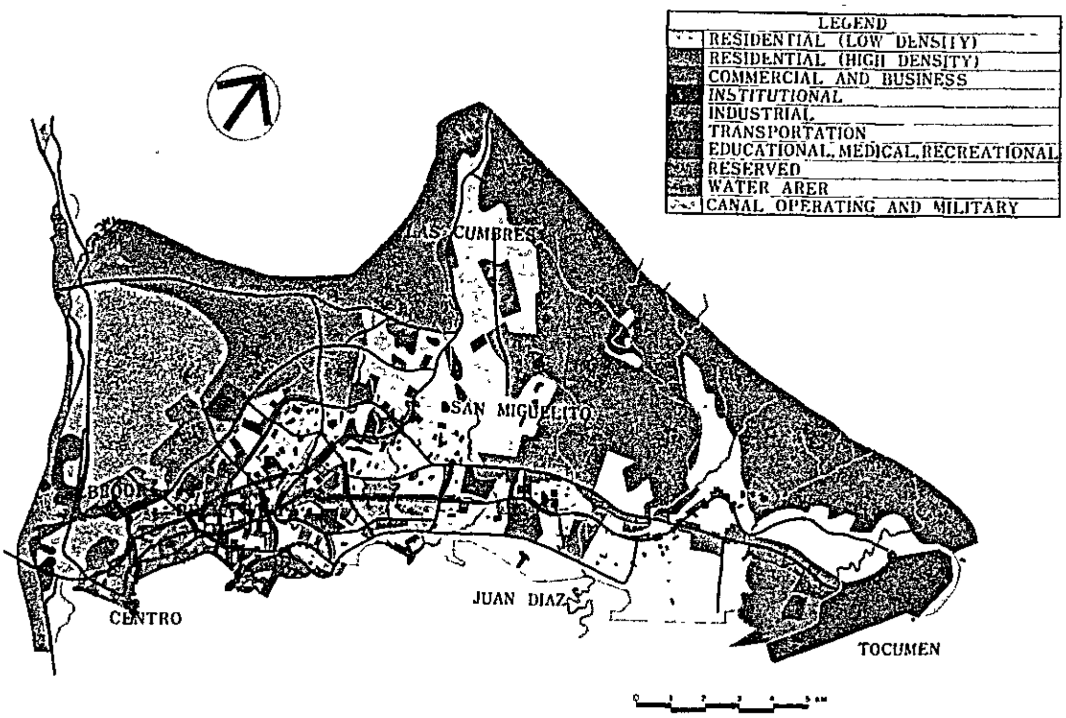


FIG. 8-9 LAND USE PLAN (PANAMA-SAN MIGUELITO) 1990

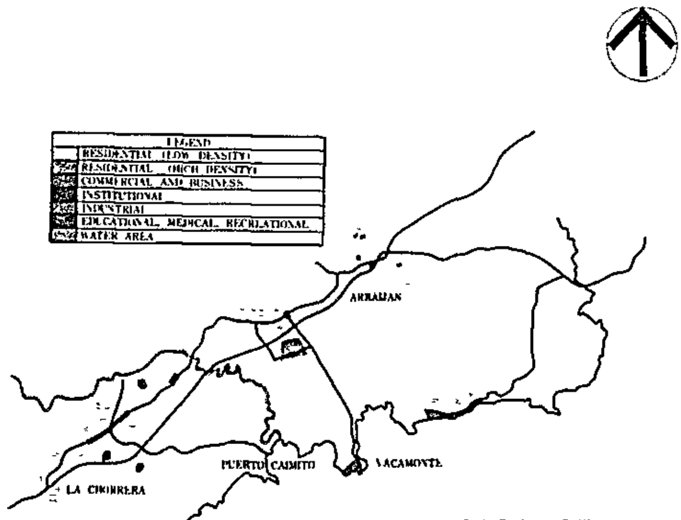


FIG. 8-10 LAND USE PLAN (ARRAIJAN-CHORRERA) 1990

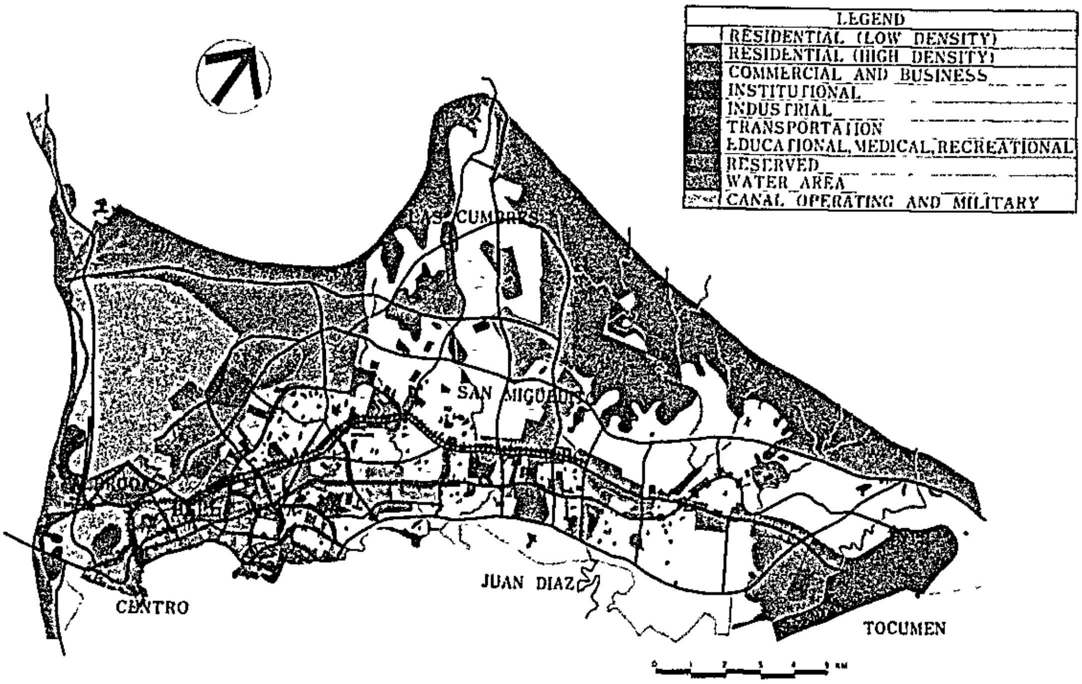


FIG. 8-11 LAND USE PLAN (PANAMA-SAN MIGUELITO) 2000

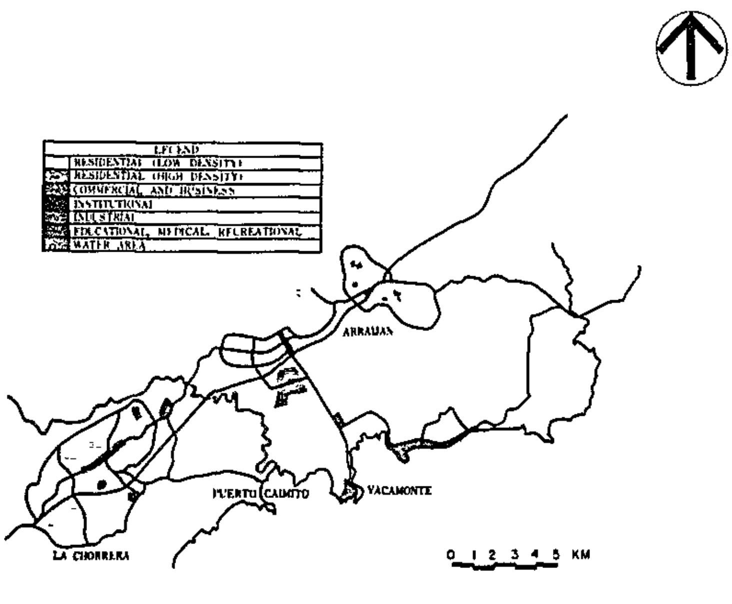


FIG. 8-12 LAND USE PLAN (ARRAJIAN-CHORRERA) 2000

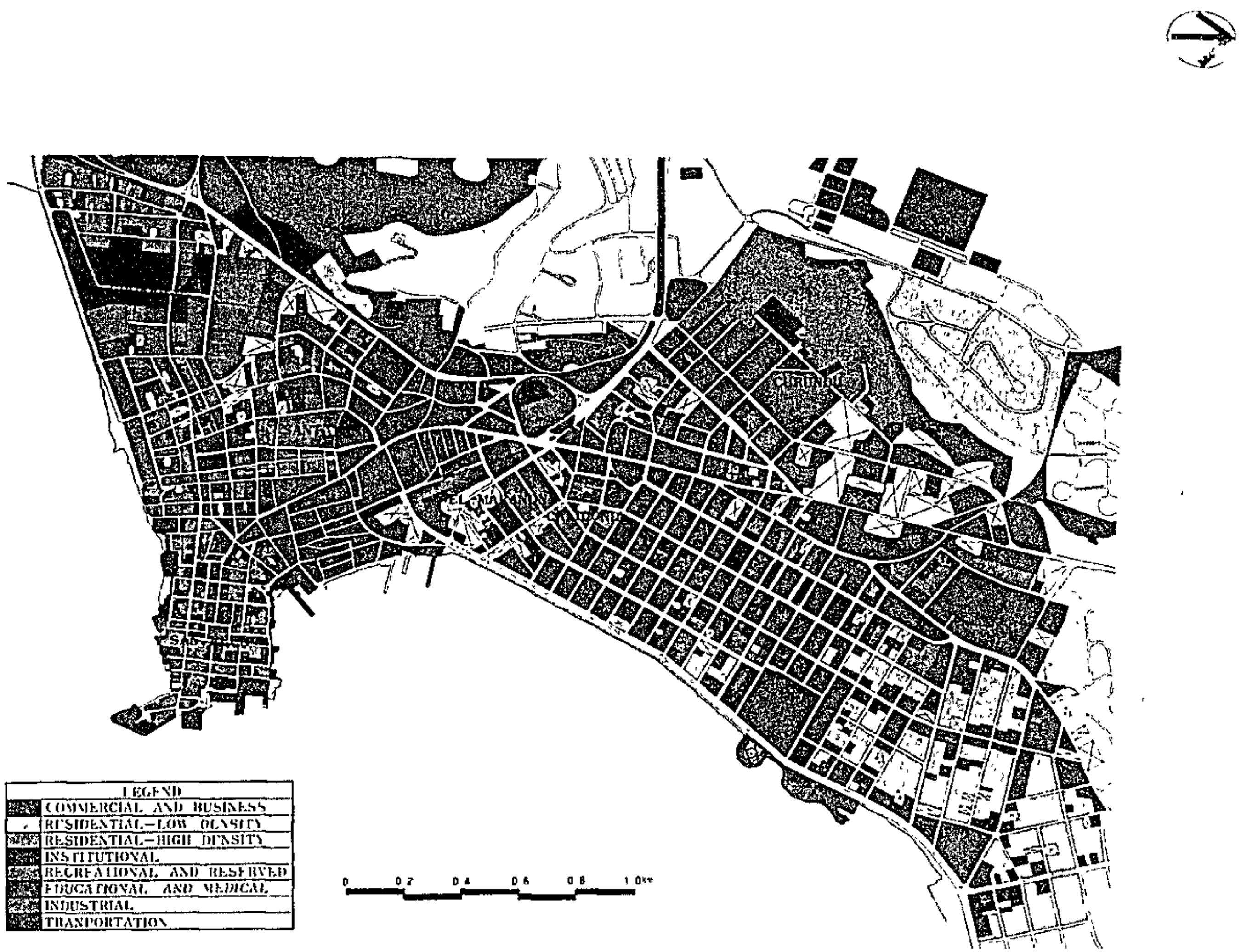


FIG. 8-13 CURRENT LAND USE IN CENTRO

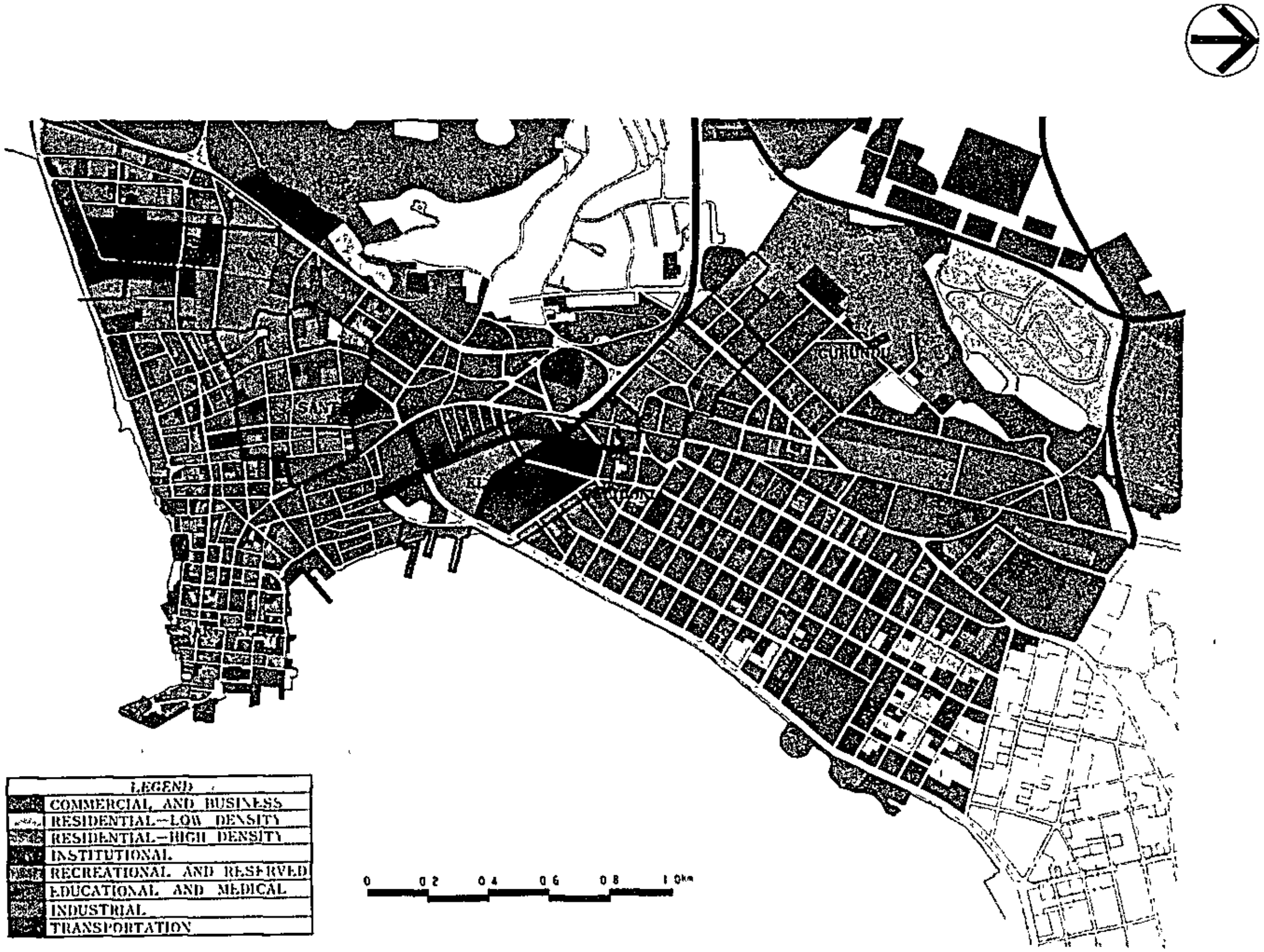


FIG. 8-14 LAND USE PLAN FOR CENTRO (1990)

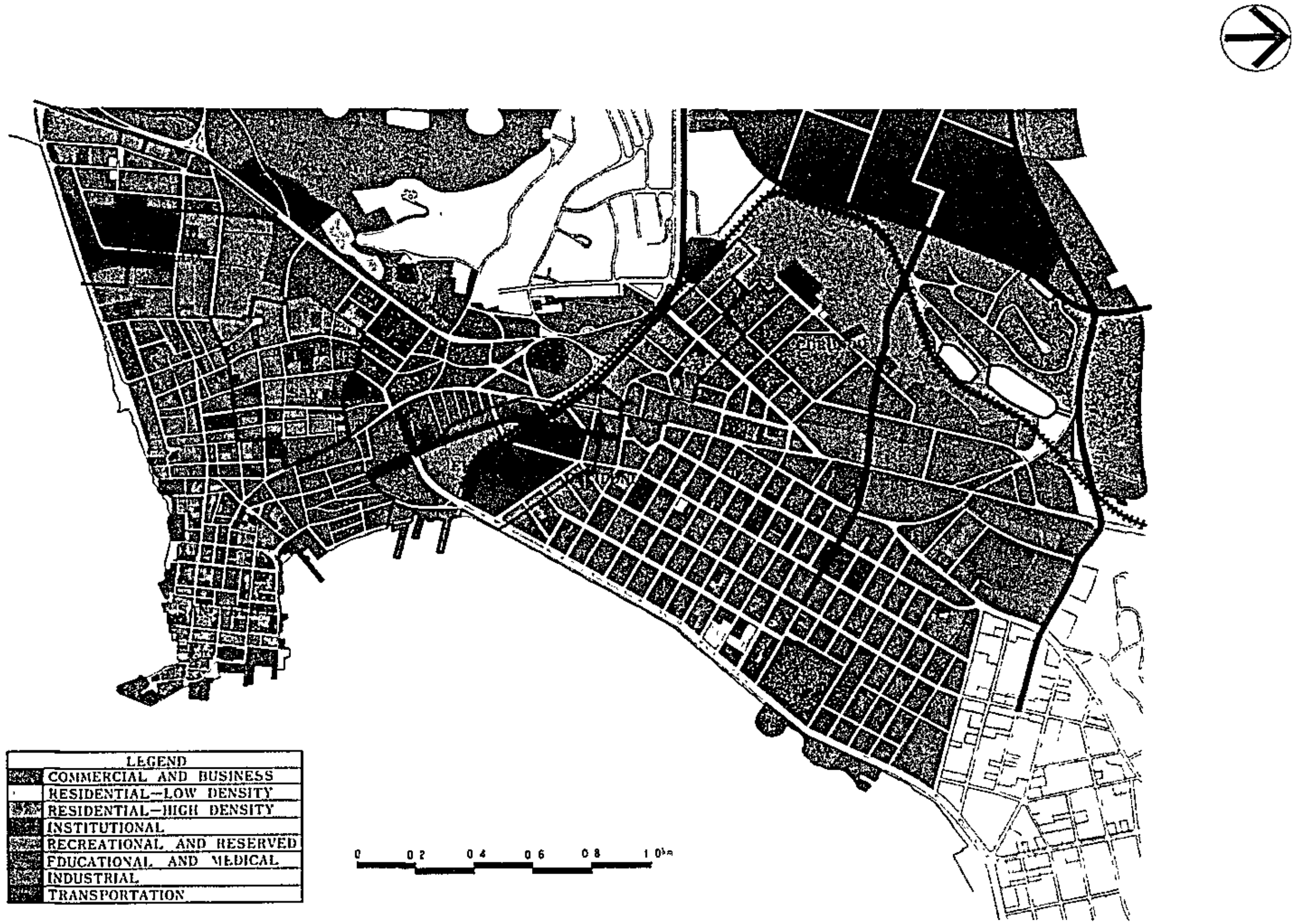


FIG. 8-15 LAND USE PLAN FOR CENTRO (2000)

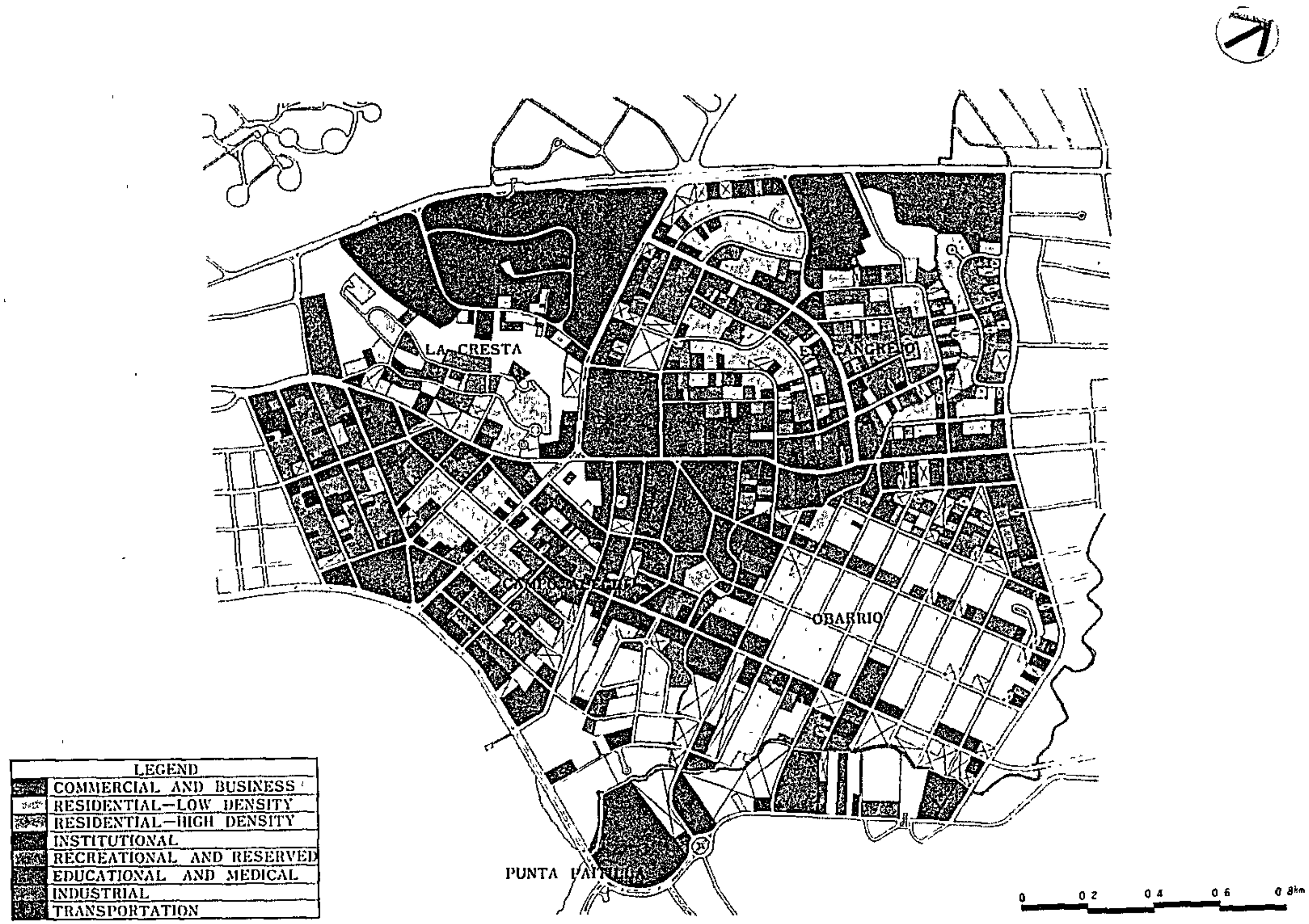


FIG. 8-16 CURRENT LAND USE IN BELLA VISTA

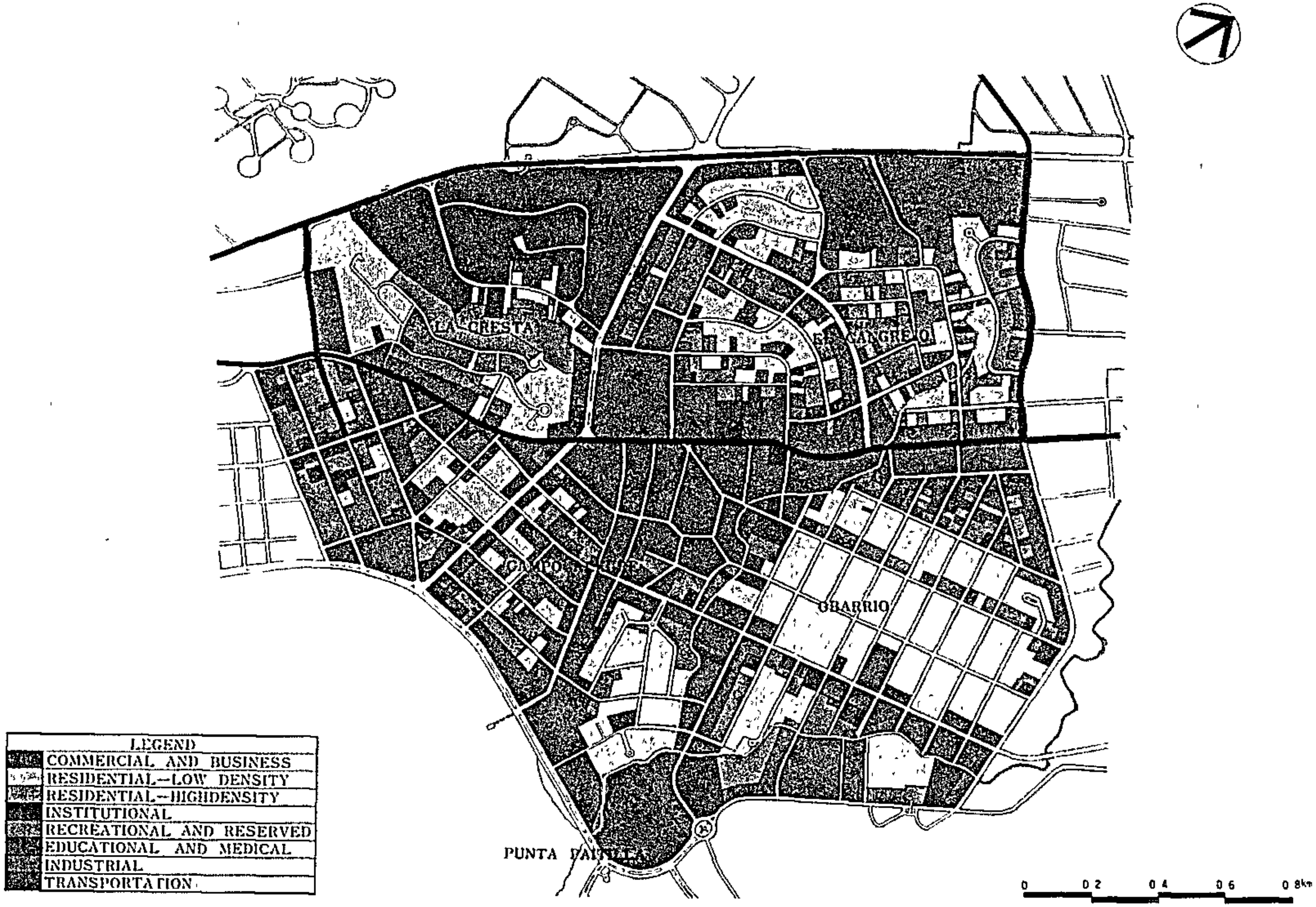


FIG. 8-17 LAND USE PLAN FOR BELLA VISTA (1990)

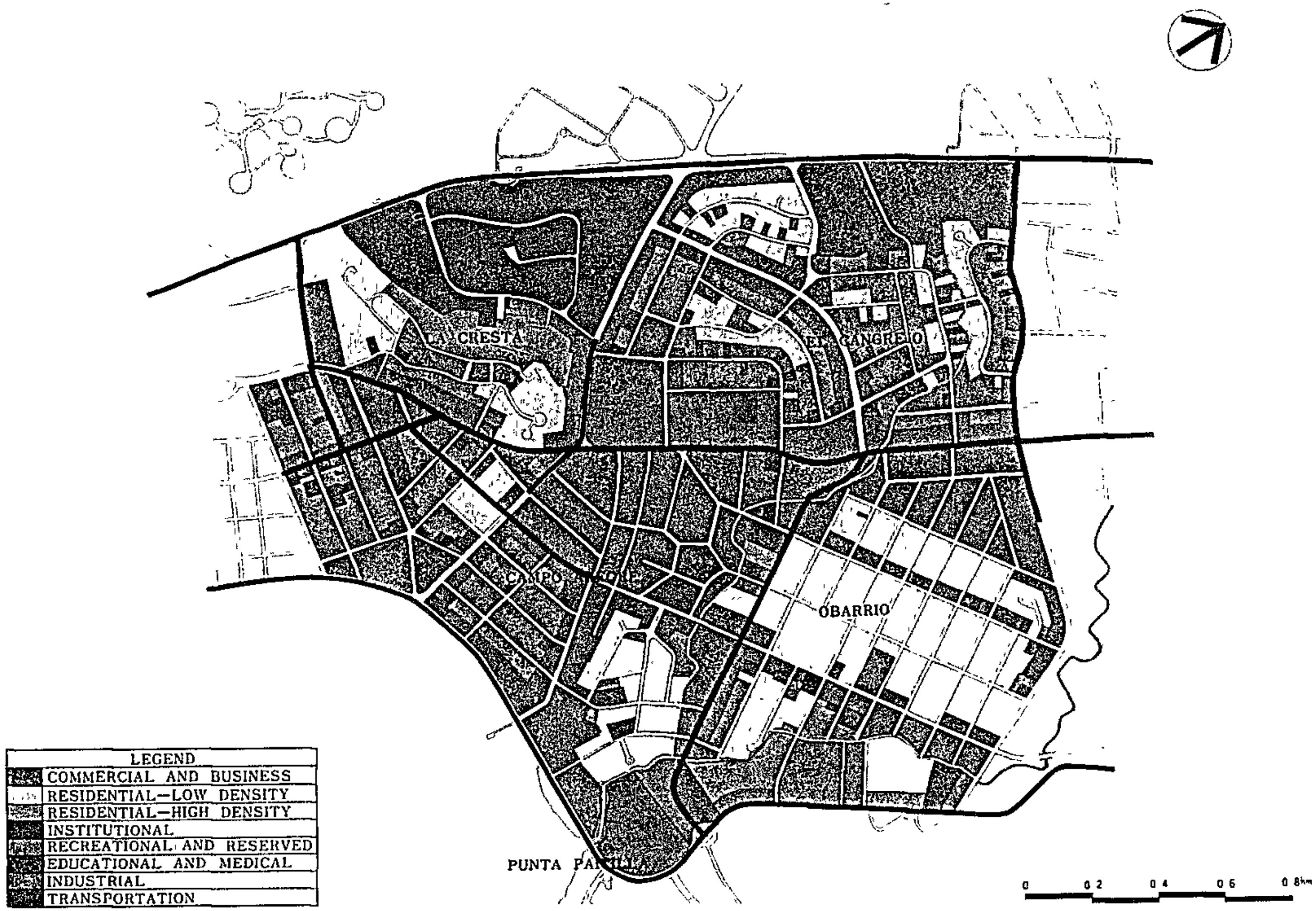


FIG. 8-18 LAND USE PLAN FOR BELLA VISTA (2000)

CHAPTER 9.

TRANSPORTATION DEMAND FORECAST

9. TRANSPORTATION DEMAND FORECAST

1) Procedure and Model Building

(1) Procedure

In the formualtion of transportation plans, forecasting of future transportation demand is one of the most important tasks and is accomplished for the purpose of deciding the location, scale, and the time of construction of transportation facilities and testing the fitness of contemplated transportation projects. Therefore, the latter part of the forecasting task will have close relations with transportation facility plans and investment plans.

The flow of future transportation demand forecasting process is shown in Figure 9-1. The most fundamental and direct information for the task of forecasting comes from person-trip survey finding. For "what purpose" people in the Planning Area go "from where" "to where" "when" by using "what" could be known from person-trip survey. Though the analysis of the survey finding, various trip data are compared against the attributes of trip makers, population indicators for each zone, and inter-zonal distance, thus clarifying the structure of regional transportation demand. Of relationships between transportation data and regional data, those which are universal and are considered to remain unchanged are formualted into numerical models and used for the forecasting of future transportation demand. To be input to the model are future national population, population at work, motor vehicle ownership, and other social indicators, which are obtained through the work of socio-economic framework for the Planning Area and of land use planning.

The forecasting of future transportation demand is to answer the question: "In the future, how many people will move from where to where by which route and by what means?"

People travel for certain purpose. Transportation is the means of achieving this purpose. Then, the most fundamental question of "For what purpose?" must be added to th above. This Study will adopt the generally followed practice of achieving estimation, by trip purpose, down to the Step 3 of the above 4-Step method. This method is applied only to internal trips made by the inhabitants of the Planning Area. Their trips to outside the Planning Area (External trips) and trips by non-residents into the Planning Area are estimated based simply on annual growth rates and added to the assigned traffic volume arrived at in Step 4. This is because, while information available on external trips is inadequate, the volume of external trips account for only 3% of the total traffic volume in the Planning Area and, therefore, low precision of external trip estimation will have little effect on the overall precision.

(2) Forecast Model

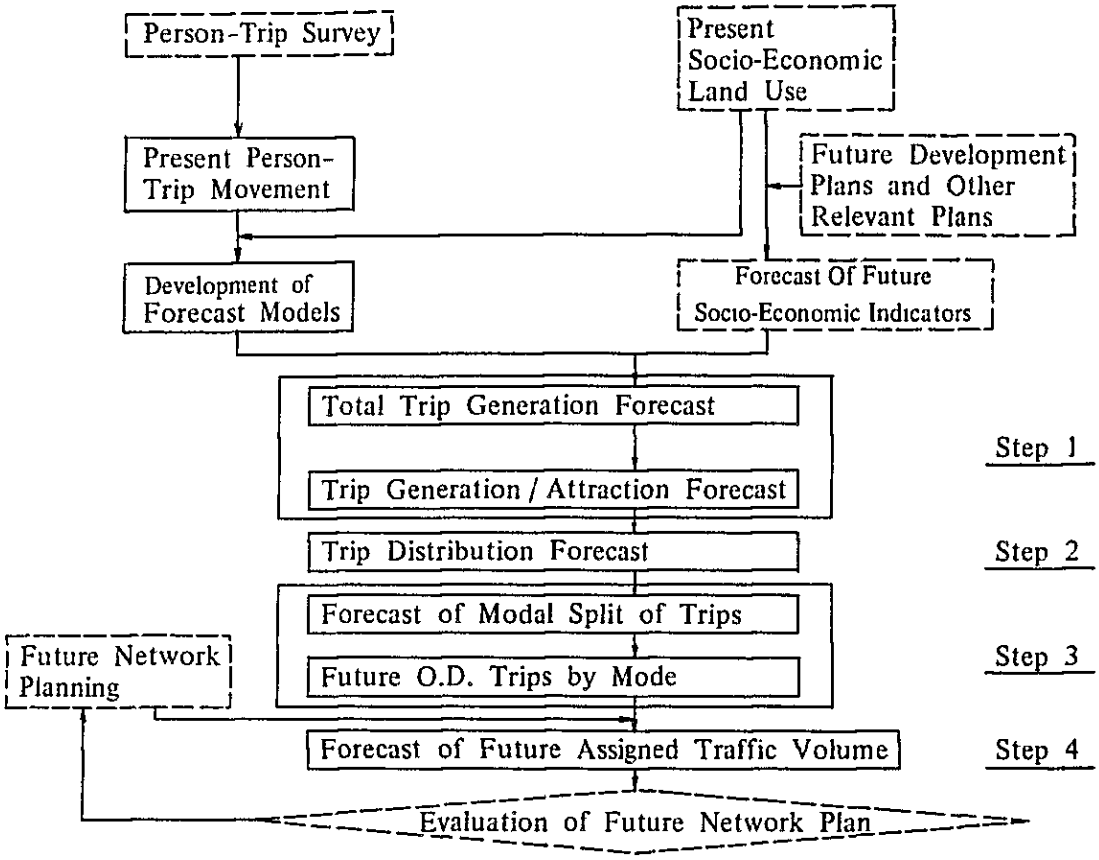
i) Trip Generation/Attraction Model

First, the quantity of trips generated in the Planning Area – or total trip production – is forecast and used as the control total for the forecasting of zonal trip generation/attraction, as forecast using attributes of trip makers and trip production rate. This rate comes in either gross rate or net rate, and relationship between the two is as follows:

Gross Trip Rate = Net Trip Rate × Trip Maker Ratio

Where:

Trip Maker Ratio = Those who made at least one trip ÷ Total Population



Source : ESTAMPA

Step 1 "How many trips?"

Sub-Step 1-1 "In the Planning Area as a whole?"
This is the estimation of total generated trips in the Planning Area, the data being used as a control total.

Sub-Step 1-2 "By Zone?"
This is the estimation of generated/attracted trips by zone.

Step 2 "Where will these trips go?"
This is the estimation of distributed trips.

Step 3 "By what mode of travel?"
This is the estimation of number of trips by mode of travel.

Step 4 "Through which route?"
This is the estimation of assigned traffic.

FIG. 9-1 FUTURE TRAFFIC VOLUME FORECAST PROCESS

Assuming that trip maker ratio by attribute will remain unchaged in the future, gross trip production rate is used here. Selected for forecast must be an attribute of trip makers (1) which is stable throughout zones, in terms of rate by the category of attribute, (2) population composition by whose category will show a significant difference between present and future, and (3) future population by whose category can be forecast. Population at work, population by industrial sector, car-owning population, non-car-owning population, and so forth were studies against these conditions, and car ownership has been selected as the attribute of trip makers.

Gross trip rate of car owners ....3.393 trips/day
Gross trip rate of non-car owners ....1.941 trips/day

Zonal trip generation/attraction is forecast using the linear regression model which utilizes various population indices as explanatory variables. This method facilitates the selection of a combination of variables which are fully explanatory and the identification of unusual zones, if any. A combination up to three explanatory variables is considered out of nine indices: population by zone, population at work (workers) by industrial sector (primary, secondary, and tertiary), and employment by industrial sector. Variables selected for each trip purpose and regression equations are presented in Table 9-1.

TABLE 9-1 TRIP GENERATION / ATTRACTION MODEL

	Trip Purpose	Regression Equation	Correlation Coefficient
Trip Generation	Work	$G = 583.5 + 1.0495\,W_0$	0.8883
	School	$G = 332.3 + 0.2991\,P$	0.9808
	Home	$G = -857.8 + 0.1615\,P + 2.5663\,E_0$	0.8886
	Business **	$G = 1000.0 + 0.2040\,E_0$	0.8524
	Shopping	$G = -290.6 + 0.0319\,P + 0.2619$	0.9118
	Private	$G = -606.8 + 0.7733\,W_3 + 0.3925\,E_2 + 0.5556\,E_3$	0.9593
Trip Attraction	Work	$A = -218.4 + 0.7306\,E_2 + 1.4258\,E_3$	0.9693
	School *	$A = 1121.9 + 0.1874\,P$	0.6568
	Home	$A = 372.9 + 0.1513\,P + 3.0862\,W_3$	0.9801
	Business **	$A = 835.0 + 0.2110\,E_0$	0.9378
	Shopping	$A = -1234.3 + 0.0511\,P + 0.5508\,E_3$	08218
	Private	$A = -1171.6 + 0.3670\,W_3 + 1.2489\,E_3$	0.9190

Where ;
P : Total population of each zone
W : Number of Workers
Wi : Number of workers in the i-th industry
E : Number of employment
Ei : Number of employment in the i=th industry
G : Generated trips from each zone
A : Attracted trips to each zone

Note : * Excluding data for zones 7 and 11.
** Developed by using data for integrated zones

Source : ESTAMPA

Regression analysis is first done with all zones (primary model) and, then, the analysis is done against the remainder of zones after excluding those which do not very well fit (secondary model). The zones excluded are Zone 7 (Urb. La Cresta, where the University of Panama is located) and Zone 11 (Urb. Punta Paitilla, where high schools are concentrated), both in "school" model. With regard to "business" model, regression equations for integrated zones were used for forecasting the volume is broken down to person-trip survey zones, because data on truck trips showed little reliability and weak correlation.

ii) Distribution Model

Distribution model is for the distribution of trip generation/attraction to zones for obtaining origin-destination (O–D) traffic volume. Generally, the model uses either the present pattern method or the numerical model method. The former method forecast future O–D volume by applying growth rates of generated traffic volume and of attracted traffic volume to the present O–D traffic volume. This method is suitable for short period forecast but may not be used for the forecast of 20 years later in an area where land use and urban structure are expected to change substantially.

Numerical model method assumes that the basic structure of trip distbitution (O–D volume) remain unchanged in the future and incorporates such structure into the parameter of model for the forecast of future volume of trips. The most common model of this method is gravity model. For this Study, a Voorhee's type gravity model is used.

$$T_{ij} = G_i \frac{K_{ij} A_j D_{ij}^{-r}}{\sum_k K_{ik} A_k D_{ik}^{-r}}$$

Where:

Tij	=	Number of trips from Zone i to Zone j
Gi	=	Number of trips generated in Zone i
Aj	=	Number of trips attracted to Zone j
Dij	=	Distance between Zone i and Zone j
r	=	Parameter
Kij	=	Adjustment factor accounting for the peculiarity of socio-economic ties between Zone i and Zone j

The above model is applied to the total number of inter-integrated zonal trips, arrived at by deducting intrazonal trips of each zone from both generated trip volume and attracted trip volume.

$$Tii = KGi^{\alpha} Ai^{\beta}$$

Where:

Tii	=	Number of intrazonal trips in Zone i
Gi	=	Number of trips generated in Zone i
Ai	=	Number of trips attracted to Zone i
K, α, β	=	Parameters

These parameters are obtained for each purpose of trip based on the O–D table developed based on the findings of 1981 Person-Trip Survey (see Table 9-2). The values of interzonal trips, when broken down by trip purpose, are small – many O–D pairs showing no trips – and therefore the data reliability is impaired. In this regard, following care was used in the application of the distribution model:

a) When future intrazonal trip ratio forecast for any zone differs substantially from the present ratio, the cause and justification of the variance is looked into, and, when the forecast ratio is believed unjustified, is adjusted, making reference to the present ratio and the ratios of similar zones.

b) Gravity models tend to over-estimate long distance trips. Relative errors in long-distance trips were rather significant in this Study, too, and therefore trips betwen O–D pairs more than 10 kilometers apart are adjusted by applying the adjustment factor obtained based on deviation of theroretical value from the value of actual O–D traffic volume. The adjustment factors are

TABLE 9-2 PARAMETER OF GRAVITY MODEL

Trip Purpose	Parameter of distance resistance (r)	Correlation Coefficient
Work	0.45	0.7795
School	0.80	0.7572
Home	0.45	0.8082
Business	0.70	0.3781
Shopping	0.85	0.8072
Private	0.65	0.8508
Total	0.45	0.8138

Note: Parameter r satisfies:

$$T_{ij} = G_i \frac{K_{ij} A_j D_{ij}^{-r}}{\sum_k K_{ik} A_k D_{ik}^{-r}}$$

Source : ESTAMPA

different for different purposes and different trip lengths but resulted in the downward adjustment of theoretical values by 10 to 15% on the average.

c) The fitting of the gravity model with the present status data was generally good, with sporadic exceptions of O–D pairs where theoretical value was substantially higher than the acutal value due to the presence of some peculiar socio-economic ties between the zones which could not be explained by the model. When such ties are, after examination, believed to continue in the future, the ratio of actual value to the theoretical value is used as Kij and incorporated into the model. Otherwise, the ratio 1.0 is used for Kij.

iii) Modal Split Model

Modal split models are generally classified into the so-called "trip end model", which divides zonal trip generation into various means of transportation by considering trip purposes, the attributes of trip makers, and zone characteristics, and the so-called "trip interchange model", estimates the quantity of inter-zonal trips first and, then, converts the quantity of distributed trips into trips by means of transportation based on the level of convenience of various means for each zone pairs. The former is believed unsuited to this Study, which expects to examine the feasibility of introducing new traffic facilities which will substantially modify traffic convenience between zones, such as expressway and railroad. Therefore, it was decided that the trip interchange model be developed.

The division of the qunatity of O–D trips into various means of transportation is accomplished by the classification, and by following the process of binary choices, presented in Figure 9-2. Also, because it is known from the analysis of transportation demand structure that the ownership/non-ownership of car is an important factor behind modal choice, modal split model is constructed for and applied separately to the "owners" (to be exact, the members of car owning families) and to the "non-owners."

Taxi is a means of public transport by nature, but is grouped into private mode in consideration of its capacity.

Future modal shares will depend on the present traffic policy: the share of cars in total trips will rise if roads and parking facilities are developed under a polity to encourage the use of cars, and the share of mass transit (bus, rail) will conversely ascend under a policy to discourage the use of cars. Therefore, modal split models must be sensitive to the effect of whatever traffic policy to be taken. Models for modal splits from A to E in Figure 9-2 are explained below.

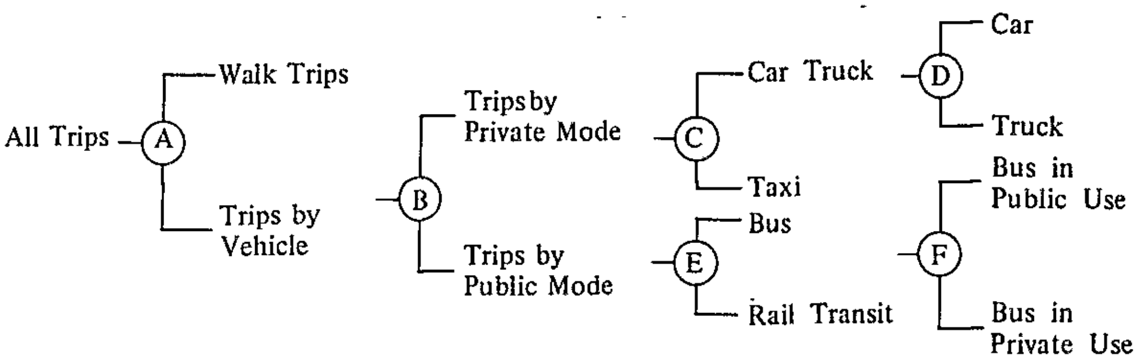


FIG. 9-2 PROCESS OF BINARY CHOICES

A. Model of Walk Trips

A review of the distribution of walk trips by trip distance group and by trip purpose, presented in Figure 9-3, indicates that for any purpose, the frequency of walk trips quickly falls as trip distance increases and that walking trip is rarely engaged in for over five or six kilometers. The following model was obtained by the parabolic regression of this trip distribution:

$$Y = a + bx + cx^2$$

Where: Y : Share of walk trips
X : Trip length (Kilometers)
a, b, c : Parameters (See Table 9-3)

B. Public Modes/Private Modes Split Model

This model, which determines the split of all motor vehicle trips between public and private transportation modes, is the most important of modal split models in terms of the quantity of subject trips and of the influence of its result on transportation masterplan.

A review of the shares of public and private transportation modes in the trips of car owners and in the trips of non-car owners in the Planning Area, shown in Figure 9-4 by trip distance and by trip purpose, indicates that, regardless of trip purpose, a predominant majority of trips of car owners are made by private modes and the reserve is true with non-car owners. It is also noted from said Figure that the share curves remain flat across many trip length groups, indicating that modal choice is little affected by trip length; hence, it is difficult to construct a good model for this modal split.

TABLE 9-3 MODAL SPLIT MODEL FOR WALKING AND TWO WHEELERS TRIP

	Trip Purpose	Regression Equation	Dmax (km)	Correlation Coefficient
Car Owning Group	Work	$y = 0.1507-0.0697X+0.0080X^2$	3.9	0.8974
	School	$y = 0.3909-0.1421X+0.0144X^2$	5.0	0.9158
	Home	$y = 0.2760-0.1179X+0.0133X^2$	4.6	0.9123
	Business	$y = 0.0359-0.0152X+0.0020X^2$	4.2	0.9141
	Shopping	$y = 0.4199-0.1871X+0.0217X^2$	4.5	0.9158
	Private	$y = 0.1869-0.0956X+0.0119X^2$	3.3	0.9095
Non-Car Owning Group	Work	$y = 0.5929-0.2130X+0.0193X^2$	5.7	0.9814
	School	$y = 0.8462-0.1953X+0.0103X^2$	6.0	0.8942
	Home	$y = 0.7638-0.2149X+0.0150X^2$	6.0	0.9763
	Business	$y = 0.1049+0.0073X-0.0051X^2$	5.2	0.9344
	Shopping	$y = 0.9764-0.3406X+0.0302X^2$	5.7	0.9961
	Private	$y = 0.6844-0.2323X+0.0196X^2$	5.4	0.9953

Note : y = Modal share of walking and two-wheeler trips
x = Trip distance (km)
Source : ESTAMPA

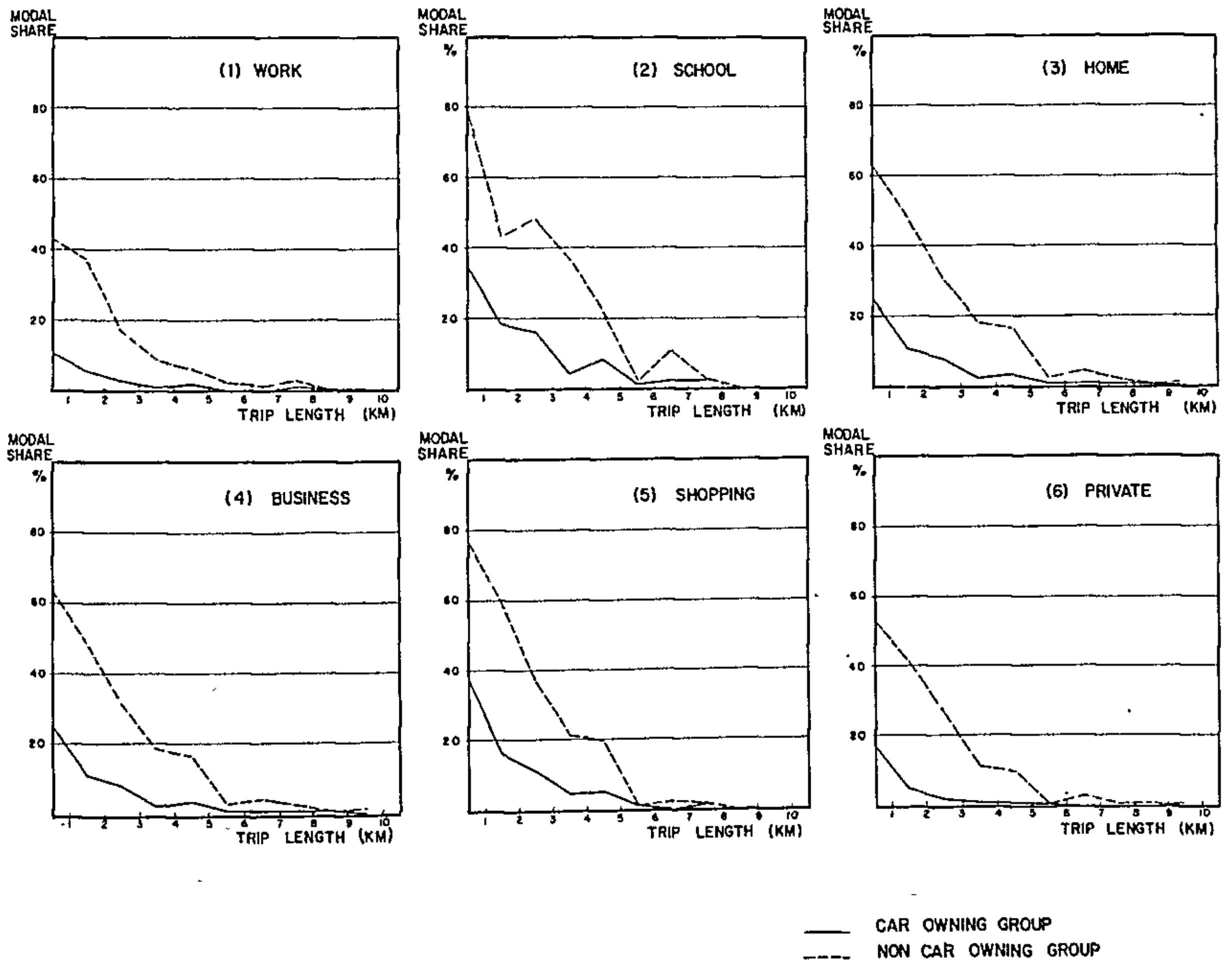


FIG. 9-3 MODAL SHARE OF WALK TRIPS, 1981

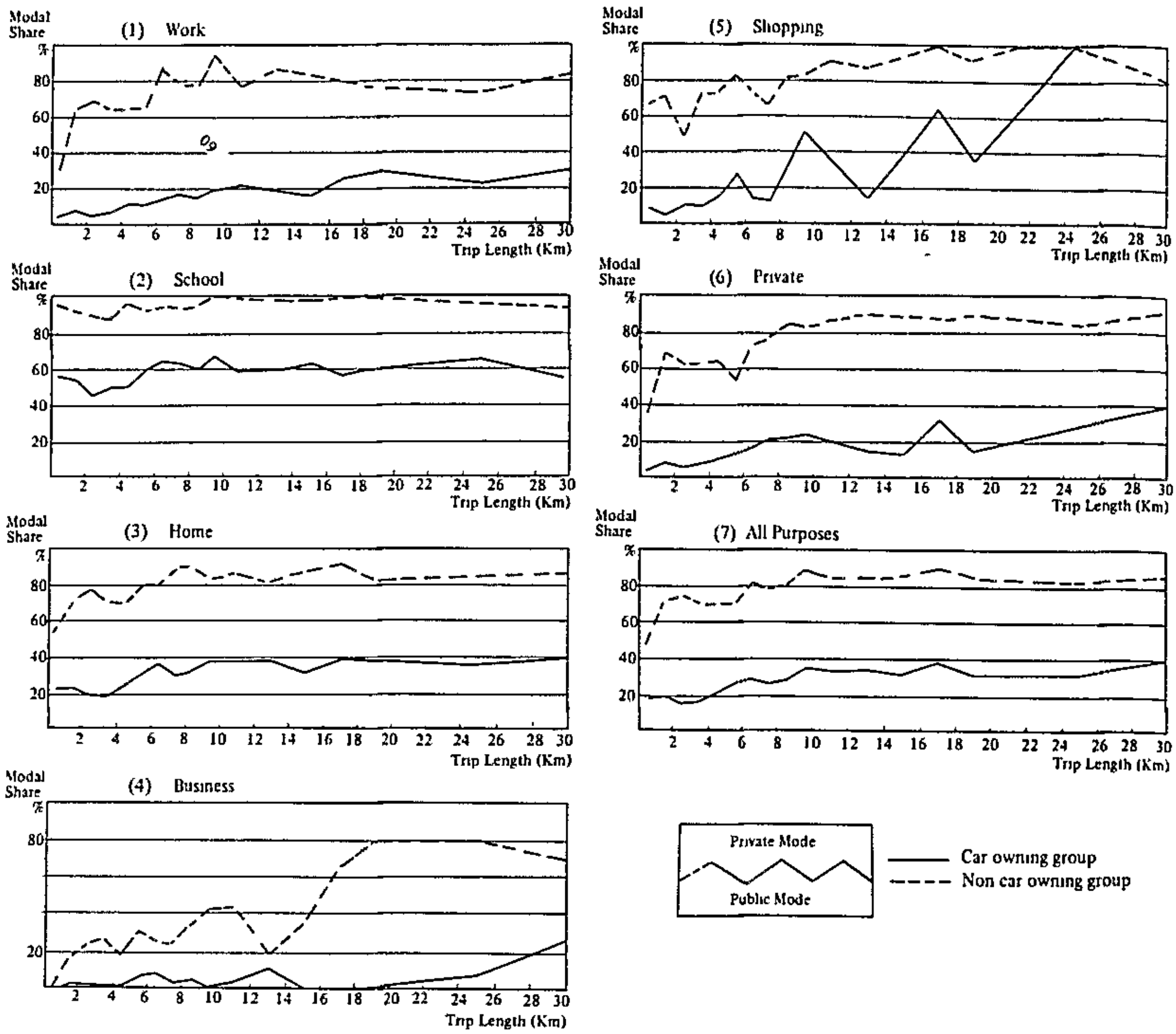


FIG. 9-4 SHARES OF PRIVATE AND PUBLIC MODES BY S&R OWNERSHIP, 1981

After reveiwing the fitness of various models, a model which explains the shares of public and private modes by travel time, bus fares, and car fuel cost has been adopted.

$$y = \frac{1}{1 + a\,(C\,pub/C\,car)^{b}}$$

$$C\,pub = Ktp + Cp$$
$$C\,car = Ktp + Cc$$

Where; y : trips share of public mode
Cpub : aggregate travel cost by public mode
Ccar : aggregate travel cost by private mode
tp : travel time by public mode, including access time, waiting time and transferring time
tc : travel time by private mode

Cp	:	bus fare
Cc	:	fuel cost of car trip
K	:	unit time cost
a, b	:	parameters

As for the zone pairs where the theoretical value is different from the present survey value, the forecast values obtained by this model was adjusted by the alienation between said two values as the adjustment coefficient. Parameters of the model are shown in Table 9-4.

TABLE 9-4 PARAMETER OF THE MODAL SPLIT MODEL FOR TRIPS BY PUBLIC MODE

	Trip Purpose	a	b	Correlation Coefficient
Car Owning Group	Work	0.9506×10^{1}	1.3763	0.8638
	School	0.9614×10^{0}	0.7295	0.7449
	Home	0.3304×10^{1}	0.8918	0.8180
	Business	0.1418×10^{4}	0.8556	0.8677
	Shopping	0.9146×10^{1}	2.4254	0.9324
	Private	0.9194×10^{1}	1.5373	0.9347
Non-Car Owning Group	Work	0.3897×10^{0}	1.3713	0.7411
	School	0.8385×10^{-1}	1.9307	0.7426
	Home	0.3064×10^{0}	0.9645	0.7576
	Business	0.6829×10^{1}	2.4586	0.7828
	Shopping	0.4281×10^{0}	1.7195	0.7127
	Private	0.5309×10^{0}	1.7923	0.9028

Note : $y = \frac{1}{1 + a\,(C\,pub\,/\,C\,car)^{b}}$

y = Modal share of public mode

C pub = Aggregate travel cost by public mode C car = Aggregate travel cost by car

Source : ESTAMPA

C. Car & Truck/Taxi Split Model

The share of taxi is estimated by the following model, of which parameters are shown in Table 9-5:

$$y = a + bx \quad (x \leqq Dmax)$$
$$y = 0 \quad (x > Dmax)$$

Where;
- y : share of taxi trip in private mode trip (%)
- x : trip length (km)
- Dmax : maximum distance of taxi trip
- a, b : parameters

D. Car/Truck Split Model

The share of trucks, shown in Table 9-6, was calculated based on the assumption that the split remains constant for same trip purpose regardless of zone pair.

E. Bus/Rail Split Model

TABLE 9-5 MODAL SPLIT MODEL FOR TAXI TRIPS

	Trip Purpose	Regression Equation	Dmax (km)	Correlation Coefficient
Car Owning Group	Work*	y = 0.0420X	24	–
	School*	y = 0.0780X	16	–
	Home*	y = 0.0750X	24	–
	Business*	y = 0.0210X	12	–
	Shopping*	y = 0.0480X	12	–
	Private*	y = 0.0710X	20	–
Non-Car Owning Group	Work	y = 0.3667X – 0.0146	24	0.7732
	School*	y = 0.3980X	16	–
	Home	y = 0.5404X – 0.0211	24	0.8352
	Busines*	y = 0.0410X –	12	–
	Shopping*	y = 0.3590X	12	–
	Private	y = 0.6791X – 0.0293	20	0.6801

Note : * Not regression equation, but average share of taxi trip
y = share of taxi trip x = trip length (km)
Source : ESTAMPA

TABLE 9-6 AVERAGE SHARE OF TRUCK TRIPS IN CAR-TRUCK MODE

Trip Purpose	Car Owning	Non Car Owning Group
Work	0.0940	0.6210
School	0.0000	0.0000
Home	0.1050	0.4440
Business	0.5070	0.8630
Shopping	0.0490	0.2220
Private	0.0360	0.1450

Source : ESTAMPA

The Panama Canal Railroad and small-scale railroads for transporting bananas in Chiriqui Province and in Bocas del Toro Province are the only railroads presently existing in Panama Country, but none of them is being used for urban passenger transport.

Therefore, in the absence of information on Panama citizens' preference of railroad, no bus/rail split model may be constructed. For this reason, public mode passengers (bus and rail together) are assigned to traffic network (including railroad), and the quantity of passengers thus assigned to railroad is assumed to represent demand for railroad. In other words, competition between bus and railroad was introduced in the process of traffic assignment, and it was assumed that passengers would prefer whichever mode by which they will reach the destination sooner.

F. Public Bus/Private Bus Split Model

For the share of private-use buses, the same type of simple regression model (with maximum distance for the utilization of private buses) as for taxi was used. (Parameters are presented in Table 9-7).

TABLE 9-7 MODAL SPLIT MODEL FOR TRIPS BY PRIVATE USE BUS

	Trip Purpose	Regression Equation	Dmax (km)	Correlation Coeficient
Car Owning Group	Work*	y = 0.0780X	20	–
	School	y = 0.6099X – 0.0192	18	0.6201
	Home	y = 0.4352X – 0.0185	20	0.7668
	Business*	y = 0.1810X	10	–
	Shopping*	y = 0.0190X	10	–
	Private*	y = 0.0350X	10	–
Non-Car Owning Group	Work*	y = 0.0310X	20	
	School	y = 0.1675X – 0.0041	18	0.5680
	Home	y = 0.0815X – 0.0033	20	0.7908
	Business*	y = 0.1000X	10	–
	Shopping*	y = 0.0110X	10	–
	Private*	y = 0.0070X	10	–

Note : * Not regression equation, but average share of trips by private use bus.
y = share of trips by private use bus. x = trip length (km)
Source : ESTAMPA

iv) Traffic Assignment

Traffic assignment is a task to load the road network with O–D traffic volume as broken down by the mode of transportation. Such volume is assigned via the shortest route between zone of origin and zone of destination. It may be assigned in lump sum under "all or nothing" method, or it may be assigned under the capacity restraint method which assumes that the required travel time for each road link vary depending on the volume of traffic. The latter method must be used for the traffic simulation, but the former is useful for estimating potential road traffic demand. In this Study, results from both of these methods are compared.

Assigned is interzonal traffic other than pedestrian traffic. Because the degree of load on the road is different depending on the type of vehicle, traffic quantities of different types must be made comparable in order that they may be added together. Therefore, quantities of other than passenger car are converted into "passenger car equivalent" by the conversion factor expressed in terms of "passenger car unit (pcu)," presented in Table 9-8.

Under the capacity constraint method, O–D traffic is assigned over a number of repetitious times (in this Study, in total of five times, 20% each time). As traffic volume increases on a given road (as traffic assignment continues), vehicle operation speed on that road drops finally to nearly zero. The equation which defines this relationship between the quantity of traffic and the speed

TABLE 9-8 PASSENGER CAR EQUIVALENT

Mode	Average No. of Passengers per unit	Passenger Car Equivalent
Car	1.5	1.0
Taxi	0.8	1.0
Truck	2.1	1.75
Bus (Public Use)	27.0	2.0
Chiva	12.0	1.0
Bus (Private Use)	16.0	2.0

Source : ESTAMPA

(velocity) of traffic is represented by Q–V curve. While a typical slope of Q–V curve is shown in Figure 9-5, 34 different Q–V curves reflecting different situation existing in various road sections are used for this Study.

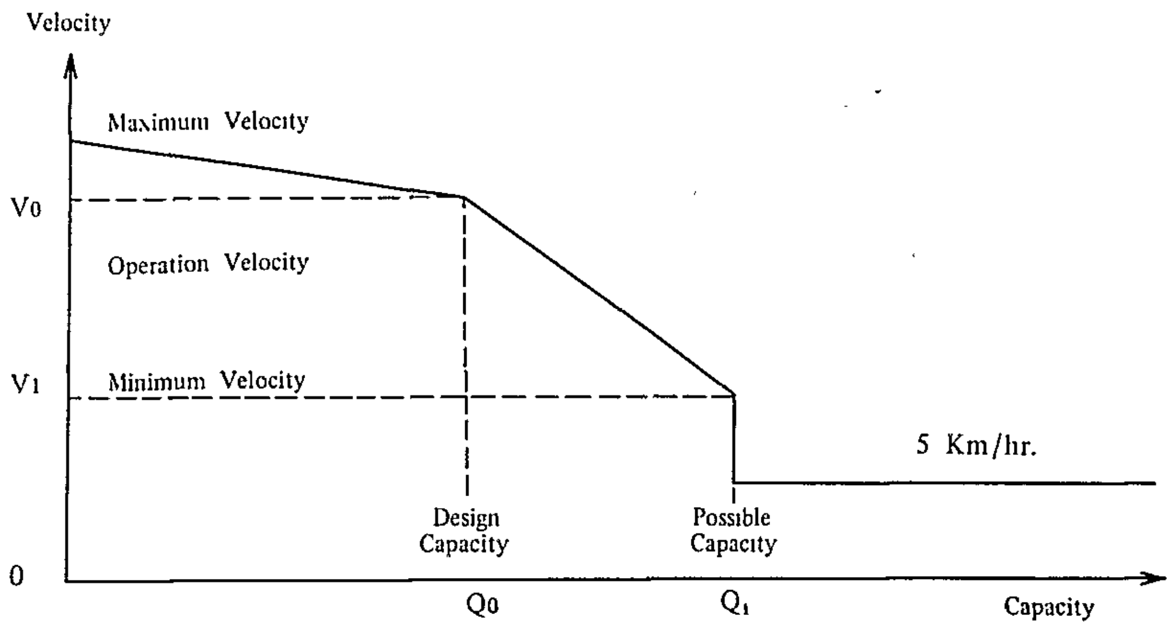


FIG. 9-5 ILLUSTRATION OF Q-V CURVE

(a) Network Conditions

The network is largely divided into two: (a) network for the assignment of personal means of transportation, and (b) mass transit network for the assignment of mass transit demand. The assignment of both passenger cars and mass transit was done in terms of PCU. Bus network was used to represent mass transit network, and bus lanes, exclusive bus express way, and rail transit routes were added as necessary, but the fundamental was the same as bus network.

(b) Traffic Assignment Conditions

The traffic assignment model utilized the minimum pass method with capacity restraint. The relationship between operating speed and traffic volume/traffic capacity rate is translated into a pattern (QV pattern).

Major conditions for the establishment of the Q–A pattern are:

A. Road Capacity is conceived to be fundamentally in accordance with the Highway Capacity Manual.

B. The traffic volumes of all types of vehicles are expressed in terms of PCU and, therefore, only the element of road geometric structure was considered, disregarding the reduction of road capacity depending on the mixture of trucks and buses.

C. The areas in which road passes through are classified into rural area, urban area, and downtown area. The year 2000 breakdown of the areas by this classification is not the same as the present breakdown.

D. The following rates of road capacity reduction due to traffic signal, intersection, and so forth were assumed for other than rural areas:

In urbanized areas: 0.55
In downtown areas: 0.45

E. Levels of service which determines the design traffic capacity of a road, is established as follows:

Area	Service Level*	V/C Ratio
Rural	C	0.70
Urban	C	0.80
Downtown	C	0.80
Urban Expressway	D	0.90

Note: Level of Service C: instable flow zone but most drivers restricted by traffic condition.
Level of Service D: approaches unstable flow; drivers have little freedom to manuever

F. Coefficients for the conversion of hourly road capacity to daily road capacity.

– Following directional distribution rates were assumed:

Rural Areas: 0.60
Urban Areas: 0.60
Downtown Areas: 0.50

– Following rates of the 30th highest hour traffic to annual average of daily traffic were assumed:

Rural Areas: 0.12
Urban Areas: 0.09
Downtown Areas: 0.09

G. Daily road capacity is calculated as follows:

Multilane road

$$D.R.C. = \frac{100}{K} \times \frac{50}{D} \times H.R.C.$$

2 lanes road 2 directions

$$D.R.C. = \frac{100}{K} \times H.R.C.$$

D.R.C.: Daily road capacity
H.R.C.: Hourly road capacity
K : Rate of 30th highest hour traffic to annual average daily traffic
D : Directional distribution rate

H. Coefficients for the conversion of hourly road capacity to daily road capacity are as follows:

Area	Multilanes	2 lanes 2 directions
Rural Area	6.94	8.33
Urban Area	9.26	11.11
Downtown Area	11.11	11.11

2) **Future Traffic Demand Forecast Result**

Discussed here will be the result of forecast in "do nothing" case, using the models, and by following the procedure, described in the previous section. "Do nothing" case is the case which assumes no changes to the method of traffic administration, public transport systems, and transport facilities up to the forecast year, and the reason for assuming such an unlikely case for forecasting is because (1) the foreseeing of difficulties and problems that can arise from leaving urban transportation alone without any policy measures will facilitate the identification of problem areas and plan objectives, (2) the effects of alternative land use plans must be evaluated from a traffic standpoint under the same set of conditions, and (3) "do nothing" case will offer a base for the evaluation of alternative traffic networks.

(1) Forecast of Motor Vehicle Ownership

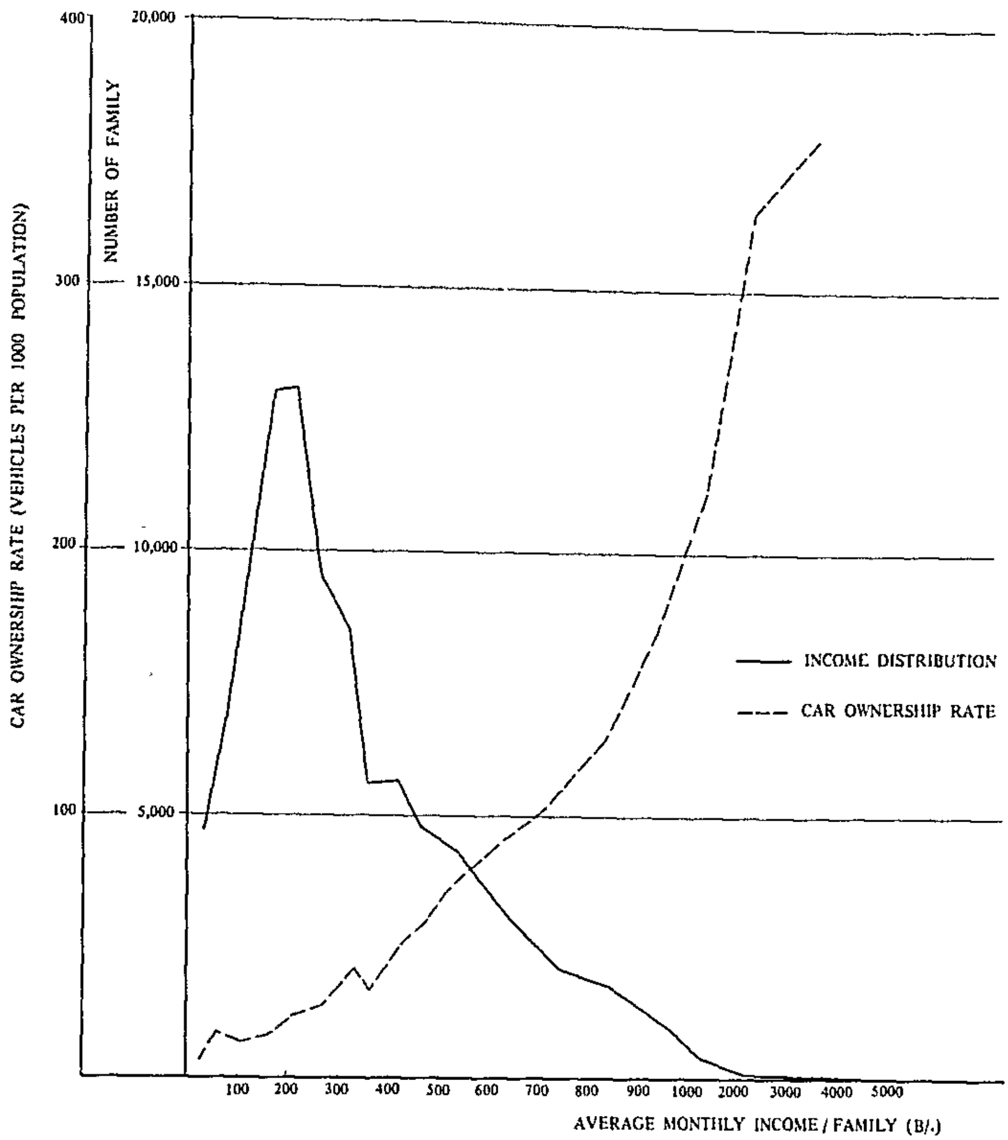
The total number of motor vehicles in Panama Province increased by 8 to 10% each year in the 1960s, but such annual increase rate dropped to 4 or 5% since the oil crisis of 1974. The total motor vehicle ownership was 73,000 in 1980, about 58,000 of which was private vehicles and 15,000, commercial vehicles. In addition, government motor vehicles counted about 7,000 and those owner by foreign families in the Canal Area, about 15,500 (which were disregarded for the purpose of forecast discussed below).

TABLE 9-9 INCREASE OF VEHICLES IN PANAMA PROVINCE

Year	Number of Vehicles			Annual Rate of Increase		
	Private	Commercial	Total	Private	Commercial	Total
1958	10,101	3,445	13,545			
				3.30	5.24	3.81
1960	11,882	4,448	16,330			
				11.07	5.84	9.74
1965	20,085	5,907	25,992			
				9.49	7.02	8.95
1970	31,605	8,293	39,898			
				7.05	10.75	8.25
1975	44,431	14,864	59,295			
				5.66	0.00	4.35
1980	58,514	14,853	73,367			
1970	31,605	8,293	39,898			
				6.35	6.00	6.28
1980	58,514	14,853	73,367			

Note : Excluding official vehicles and vehicles in the Canal Area.
Source: Contralona General

The findings of the 1981 person-trip survey and the 1980 census data on household incomes are matched against each other in an attempt to find a relationship between income level and motor vehicle ownership. It is observed that from 20 to 25% of households with a monthly income of 300 to 500 balboas own a motor vehicle, and more than half of households with a monthly income of 700 to 800 balboas own a motor vehicle. The rate of motor vehicle ownership suddenly rises as monthly family income exceeds 1,000 balboas; most of families on such income level own a motor vehicle (see Figure 9-6). Panamenians show a high propensity to own a motor vehicle as evidenced by the facts that their motor vehicle ownership rates are relatively high vis-a-vis their income levels and that over 20% of car owning families own two or more vehicles. (Overall average monthly income of families in the planning Area was 461 balboas in 1980, average income of car owning families was 850 balboas, and that of non-car owning families, 322 balboas).



Source : ESTAMPA

FIG. 9-6 INCOME DISTRIBUTION AND CAR OWNERSHIP IN 1981, PANAMA CITY

For statistical reasons, the future number or motor vehicles in Panama Province is first estimated, and, then, the numbers for the Study Area and Project Area are estimated. The following four approaches to the forecasting were used.

a) Average Annual Increase Rate

The past trend of annual increase rates is extrapolated to future. It is unreasonable to think that the trend of recent years, in which such rates were low, can be applied to future years up to 2000, because high (over 5%) real economic growths were achieved in, for instance, 1980 and 1981. Therefore, the trend of past decade (average annual increase rate of 6.35% for private vehicles, 6.00% for commercial vehicles, and an overall 6.28%) is used for extrapolation.

b) Time Series Regression Model

Of various curves, the index curve was found to show the greatest conformity with the past trend, and, therefore, the following equation is obtained:

Private Vehicles: Y=18,560 (1.0583)t (r=0.9856)

Commercial: Y= 4,630 (1.0605)t (r=0.8753)

Overall: Y=23,900 (1.0560)t (r=0.9776)

Where; Y= Number of motor vehicles

t = year (1960 = 0)

c) Logistic Curve

Time series data of average ownership rate (number of motor vehicles per 1,000 persons) is first obtained, and a logistic curve is drawn on this data in arriving at the following equation:

$$Y = \frac{200}{1 + 7.2963e^{-0.04762}} \quad (r = 0.9679)$$

Where: Y = number of motor vehicles per 1,000 persons

t = year (1950 = 0)

The future population of Panama Province, which is needed for the application of the above equation, has been estimated as presented in Table 9 – 10, based on the Study Area population and the Project Area population which have been adopted for the purpose of social framework.

TABLE 9-10 FORECAST OF POPULATION AND NUMBER OF FAMILIES IN THE PANAMA PROVINCE

Population	1980	1985	1990	1995	2,000
Panama Province	830,828	980,992	1,132,160	1,291,352	1,460,898
Study Area	732,840	874,200	1,018,000	1,170,800	1,334,800
Planning Area	707,725	846,000	987,000	1,137,300	1,298,800
Family	**1980**	**1985**	**1990**	**1995**	**2,000**
Panama Province	176,654	208,721	240,885	274,755	310,829
Study Area	162,853	194,266	226,222	260,177	296,622
Planning Area	157,056	188,000	219,333	252,733	288,622

Note: As for the rural area of the Panama Province outside of the Study Area, the same population growth rate are assumed as those of the rural area of Metropolitan Region; 9.6% for 1980–85, 6.9% for 1985–1990, 5.6% for 1990–95 and 4.6% for 1995–2,000 respectively.

d) Regression Equation on GDP

Because the estimation of the future family income is difficult, relationship between per capita GDP and motor vehicle ownership rate is analyzed in view that such rate and income are strongly correlated and, in turn, income and Gross Domestic Products are usually strongly correlated. From said analysis, the following equation was arrived at:

$$Y = 0.03655X^{1.1421} \quad (r = 0.9016)$$

Where: Y = number of vehicles per 1,000 persons

X = Per capita GDP (1960 prices)

Used in the application of this equation were the future values of explanatory variables presented in Table 9-11 (average annual GDP growth rate up to the year 2000 was set at 3.5%, and the national population forecast by MIPPE was slightly adjusted by the 1980 population census data.)

TABLE 9-11 GDP PER CAPITA, 1980-2000

	1980	1985	1990	1995	2,000
GDP (million B.)	1,398	1,660	1,972	2,342	2,782
Population (1,000 pop.)	1,830	2,010	2,199	2,387	2,576
Per capita GDP (B)	764	826	897	981	1,080

Note : GDP are shown in 1960 constant price.
Source: ESTAMPA

The result of forecast by the above described method is presented in Figure 9-7. The forecast value (number of motor vehicles) varied from the largest 248,000 forecast under Case 1 (based on average annual increase rate) to the smallest 193,000 forecast under Case 4 (in correlation with GDP). Cases 1 and 2 are based merely on past trends and, therefore, their representation is weak.

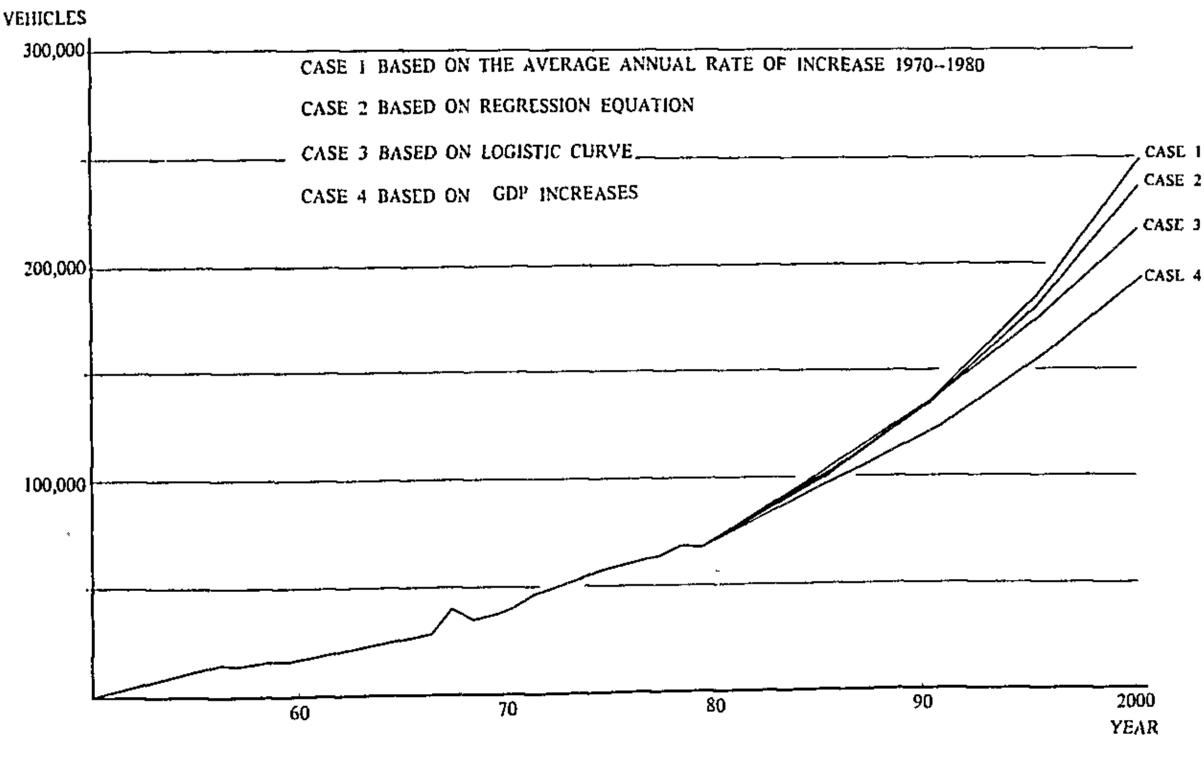


FIG. 9-7 PROJECTION OF VEHICLE INCREASES IN PANAMA PROVINCE

Case 4, which assumes an average annual economic growth of 3.5%, may result in underestimation, in view of the 5% real growths registered in 1980 and 1981, when the Panama economy had taken off from the stagnation of the latter half of 1970s, and if the long-term objective of the Panama Government to sustain 3 to 5% growths will become a reality. Therefore, Case 3, which considered future population and the ceilings of motor vehicle ownership rate, is adopted.

TABLE 9-12 PROJECTION OF VEHICLES IN THE STUDY AREA AND THE PLANNING AREA

(1) Vehicles in Panama Province

	1980	1985	1990	1995	2,000
Private	58,514	82,501	107,645	139,156	174,533
Commercial	14,853	20,599	26,437	33,620	41,476
Total	73,367	103,100	134,082	172,776	216,009

(2) Vehicles in the Study Area (Zone 1–53)

	1980	1985	1990	1995	2,000
Private	53,506	76,002	99,810	129,800	163,707
Commercial	14,608	20,289	26,071	33,192	40,992
Total	68,114	96,291	125,881	162,992	204,699

(3) Vehicles in the Planning Area (Zone 1–49)

	1980	1985	1990	1995	2,000
Private	52,163	74,211	97,597	127,103	160,509
Commercial	14,536	20,599	25,959	33,059	40,838
Total	66,699	94,810	123,556	160,162	201,347

Source : ESTAMPA

The future number of motor vehicles in the Study Area and that in the Project Area have been estimated based on the forecast value of Case 3 and the future population from Table 9–11 provided that the values prorated to population were adjusted under the assumption that the substantial gap in ownership rates existing between the urban part and the rural part of the Study Area (the former shows 2.5 times greater private vehicle ownership rate and 8.2 times greater commercial vehicle ownership rate) will continue to remain in the future. The result of this estimation is presented in Table 9–13.

In terms of average number of motor vehicles per household, the rate of car ownership in the planning Area is estimated to rise from the present 33.2% to 55.6% by the year 2000, while the ratio of car owning family is estimated to ascend from the present 28.7% to 48.1% (the gap between the two sets of figures is explained by the fact that some households own two or more vehicles) (see Tables 9–14 and 9–15). Including commercial vehicles, the ratio of vehicle owning family will also rise from the present 36.7% to 60.3% by the year 2000.

Next, the number of motor vehicles in the Planning Area is distributed to zones respectively by multiplying the future number of households in the zone (established for social framework purposes) by the future motor vehicle ownership rate of the zone as estimated using the following growth curve:

$$Y_i = \frac{1.0}{1 + 3.013e^{-0.077t_i}}$$

Where: Y_i = Motor vehicle ownership rate of zone i

t_i = The hypothetical year assigned to zone i depending on how many years zone i is ahead of or behind the present Planning Area in terms of motor vehicle ownership rate.

The result is presented in Table 9–15.

TABLE 9-13 NUMBER OF VEHICLES PER FAMILY PLANNING AREA

	1980	1985	1990	1995	2,000
Private	0.332	0.395	0.445	0.503	0.556
Commercial	0.093	0.109	0.118	0.131	0.142
Total	0.425	0.504	0.563	0.634	0.698

Source : ESTAMPA

TABLE 9-14 RATIO OF CAR OWNING FAMILY PLANNING AREA

	1980	1985	1990	1995	2,000
Private	0.287	0.342	0.385	0.435	0.481
Commercial	0.080	0.094	0.102	0.113	0.122
Total	0.367	0.436	0.487	0.548	0.603

Source : ESTAMPA

(2) Trip Increase

While the Planning Area population will increase from the present 710 thousand to 1,330 thousand by the year 2000, the number of internal trips generated in the Area is forecast to increase by 2.3 times from 1,430 thousand to 3,050 thousand. This disparity between population growth and trip growth is explained by the increase in people's mobility expected from rise in car ownership rate resulting from rise of income level. It is expected that the total car ownership in the Planning Area will expand from the present 90 thousand to about 200 thousand by the end of this century, and trip production rate will consequently rise from the present 2.34 trips per person per day to 2.60 trips per person per day.

On the other hand, external trips are expected to increase by about 2.6 times from the present 43 thousand to 114 thousand by the year 2000. Thus, the total number of trips in connection with the Planning Area is forecast to swell from the present 1,470 thousand to 3,160 thousand.

The forecast result of trip generation by trip purpose is presented in Table 9-16. Although this forecast was done separately for car owners (that is, those who belong to a car-owning household) and non-car owners, the pattern of trip distribution by purpose presently differ little between the two groups and will remain practically unchanged in the future with the following exceptions. The

TABLE 9-15 RATIO OF CAR OWNING FAMILY BY ZONE

(Percent)

Zone	Year	1981	1990	2000
1	San Felipe	13.6	27.8	46.2
2	El Chorrillo	7.5	16.5	30.6
3	Santa Ana	12.5	25.9	43.7
4	Calidonia Sur	28.2	48.9	68.0
5	Calidonia Norte	18.4	35.5	55.0
6	Curundú	2.0	4.7	9.9
7	La Cresta	100.0	97.9	99.0
8	Urracá-Campo Alegre	74.4	87.7	94.0
9	Obarrio	75.2	88.1	94.3
10	El Cangrejo	83.8	92.7	96.6
11	Punta Paitilla	42.2	64.1	79.9
12	San Francisco	70.7	85.5	92.9
13	El Golf	42.9	64.7	80.3
14	Vista Hermosa	49.0	70.1	83.9
15	Pueblo Nuevo	31.4	52.8	71.3
16	Locería	46.3	67.8	82.4
17	El Dorado	74.7	87.8	94.1
18	Betania	57.2	76.5	87.9
19	Parque Lefevre	33.1	54.8	72.9
20	Chanis	51.5	72.1	85.2
21	Rio Abajo	24.5	44.2	63.8
22	Villa Lorena	28.3	49.1	68.2
23	Hipódrómo	33.5	55.1	73.2
24	Juan Díaz	35.9	57.8	75.3
25	Pedregal	18.8	36.1	55.7
26	Nuevo Aeropuerto	–	48.2	67.4
27	Tocumen	12.8	26.3	44.3
28	Area de Paraíso	20.2	38.2	57.9
29	Amelia Denis de Icaza	15.8	31.5	50.5
30	Samaria	6.9	15.4	28.8
31	San Isidro	6.0	13.4	25.6
32	Los Andes N°2	22.9	42.0	61.7
33	La Pulida	25.5	45.5	65.0
34	Cerro Viento	79.8	90.6	95.6
35	Las Cumbres	23.5	42.9	62.5
36	Chilibre	15.3	30.6	49.5
37	Fuerte Amador	100.0	97.9	99.0
38	La Boca	–	48.2	67.4
39	Balboa	–	48.2	67.4
40	Albrook Field	–	48.2	67.4
41	Fuerte Clayton	100.0	97.9	99.0
42	Pedro Miguel	51.1	71.8	85.0
43	Cocolí	–	48.2	67.4
44	Arraiján Cabecera	12.2	25.3	42.9
45	Veracruz	8.5	18.5	33.5
46	Nuevo Arraiján	14.0	28.4	46.9
47	Barrio Colón y Puerto Caimito	16.4	32.4	51.6
48	Barrio Balboa	18.5	35.7	55.2
49	Area de Guadalupe	13.3	27.3	45.5

Source : ESTAMPA

distribution share of "school" trips will shrink slightly, reflecting relative reduction in future school age population due to birth rate drop, but this will be compensated for by minor increase in the share of "work" trips. Thus, the combined share of the two major contributors to morning rush will shift from the present 33.3% only to 32.6% by the year 2000. It follows that the morning peak rate of 12% will neither be changed much in the future. "Private" trips, which encompasses social and recreational activities, is the category which will be most affected by the expected future rise in the people's mobility, stemming from increased car ownership. The share of this category is forecast to expand from the present 14.3% to 15.3%.

TABLE 9-16 TRIP GENERATION BY PURPOSE

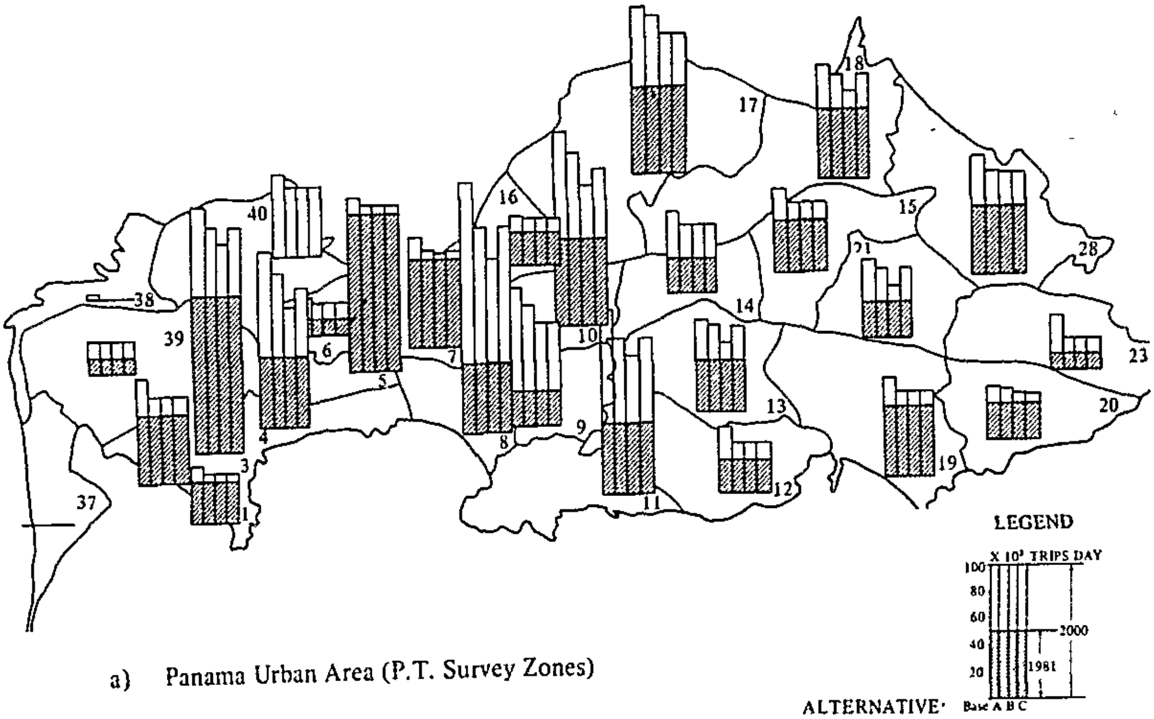
Purpose	Generated Trips			
	1981	(%)	2000*	(%)
Work	262,907	17.8	573,993	18.2
School	227,838	15.5	453,791	14.4
Home	639,714	43.4	1,348,286	42.7
Business	65,727	4.5	150,734	4 8
Shopping	66,224	4.5	145,225	4.6
Private	211,260	14.3	484,553	15.3
All Purpose	1,473,690	100.0	3,156,582	100.0

Note : *Base Case
Source : ESTAMPA

Results of zonal trip generation/attraction forecast and subsequent forecast process will vary depending on which of the alternative land use plans (A, B or C) will be adopted. Figure 9-8 compare the existing trip generation by zone and the future value under each of the three alternatives. Increase in trip generation by zone will follow the pattern of increase in zonal inhabitants as forecast based on land use plans, and will be relatively low in the built-up areas (integrated zones I, II and III) and very high in suburban a~eas; particularly, increases under these alternatives will be over three times in Juan Diaz-Pedregal (Zone IV) and San Miguelito (Zone VI), into which the built-up area will expand. Among the alternatives, Alternative A, which emphasizes the past trend, rests somewhat in between Alternative C – under which 38,000 trips, which compares to the situation existing in Area Residencial (Zone III), are estimated for Ancon Este (Zone VIII) while increases in Tocumen (Zone V), Arraijan (Zone X), and La Chorrera (Zone XI) will not be over two or three times – and Alternative B, which emphasizes development in east-west direction and under which increases in said three integrated zones will be four to five times. As for the built-up area, predictions under these alternatives similarly show that rise in trip generation will be slight in PT zones where little room remains for development, such as San Felipe (Zone 1), Calidonia Norte (Zone 5), Urb. La Cresta (Zone 7) and Urb. Loceria (Zone 16), while it will be substantial in Bella Vista (Zone II, or PT Zones 8 through 10), excepting Urb. La Cresta and Urb. Punta Paitilla (PT Zone 11).

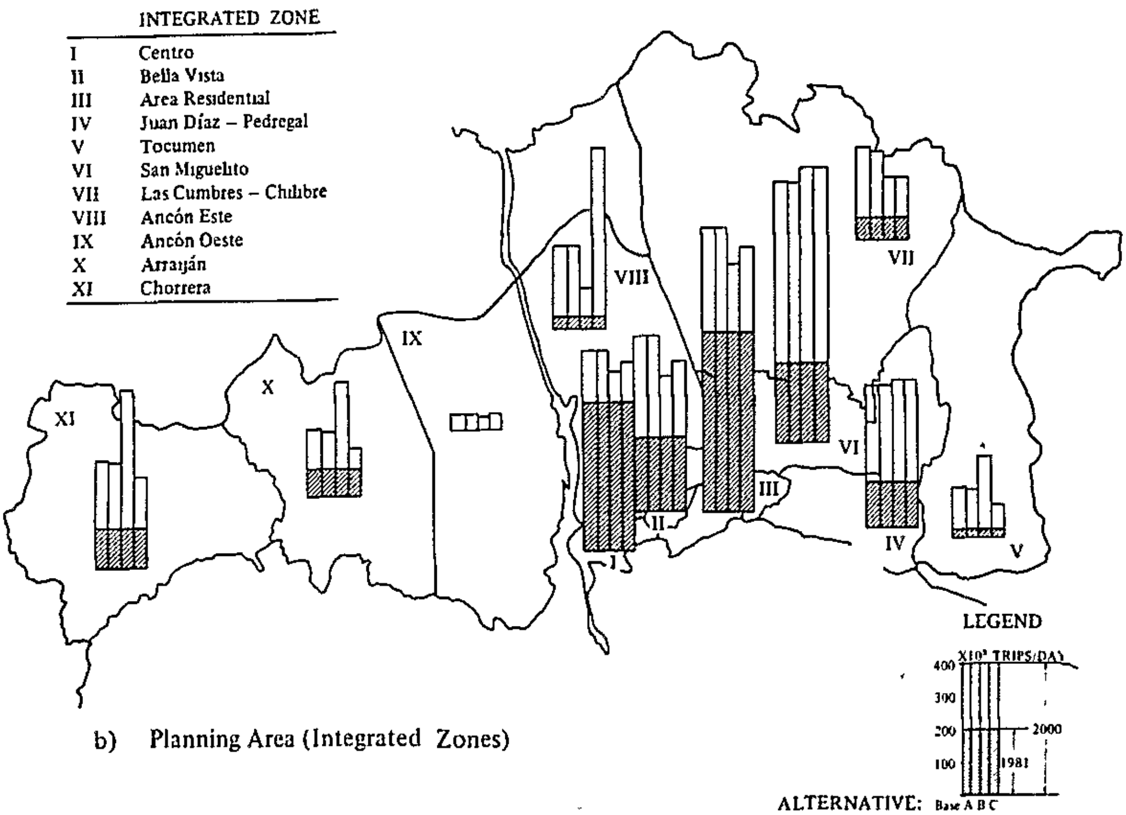
Table 9-17 compares the present O-D table against O-D tables in the year 2000 under each of the alternatives. This comparison offers a most important information for the analysis of future transportation demand structure. Based on this table, trip length and traffic flow at major cross sections will be discussed in the below.

Under Alternative A, proportions of internal trips in the built-up area, internal trips in the rest (suburban areas) of the Planning Area, and trips between them will shift from the present 49:24:27 to 27:45:28 by the year 2000. Internal trips will only creep from the present 720,000 to 807,000



a) Panama Urban Area (P.T. Survey Zones)

Source : ESTAMPA



b) Planning Area (Integrated Zones)

Source : ESTAMPA

FIG. 9-8 INCREASE OF TRIP GENERATION BY ZONE

TABLE 9-17 O–D TABLE OF PERSON TRIPS FOR INTEGRATED ZONES

(1) PRESENT O–D TABLE IN 1981

Origin \ Destination	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
1 Centro	154035.	33955	71649.	15273.	2267.	30192.	5606.	5215.	387.	6596.	2901.	1160.	355.	845.	3175.	5016.	32.	−339659
2 Bella Vista	35342.	42973.	56873.	10163.	2294.	13814.	3994.	2803.	0.	1719.	2538.	69.	26.	83.	789.	291.	0.	−173771
3 Area Residencial	72638.	60502.	192594.	20163.	3202.	35127.	6432.	7898.	684.	3153.	1698.	371.	118.	462.	2167.	881.	18.	−408108
4 Juan Diaz	15631.	10570.	21079.	41779.	3677.	6372.	536.	1875.	89.	419.	726.	409.	104.	207.	590.	324.	33.	−104420
5 Tocumen	2353.	1415.	3324.	3692.	14154.	3277.	260.	145.	0.	78.	87.	507.	7.	45.	333.	47.	0.	−29724
6 San Miguelito	28414.	14173.	36942.	5174.	3181.	81963.	6290.	2320.	765.	472.	372.	186.	84.	89.	1070.	224.	32.	−181751
7 Las Cumbres-Chilibre	5113.	3370	7049.	496.	288.	5814.	29883.	1227.	51.	45.	122.	52.	12.	39.	938.	131.	0.	54640
8 Ancón Este	6331.	2571.	7838.	1881.	113.	2126.	1050.	3158.	143.	786.	693.	10	30.0	4.	602.	65.	0.	27401
9 Ancón Oeste	396.	0.	1334.	45.	28.	103.	0.	166.	0.	290.	133.	2.	0.	0.	9.	0.	0.	2506
10 Arraiján	6580.	1726.	3295.	402.	78.	471.	45.	823.	243.	9429.	1835.	2.	510.	12.	90.	49.	0.	35590
11 Chorrera	3515.	2432.	1788.	200.	135.	341.	143.	677.	99.	1802.	77471.	16.	1456.	2.	136.	1003.	18.	91234
12 Pacora	1023.	97.	488.	246.	535.	193.	51.	18.	4.	23.	11.	0.	5.	0.	32	73.	0.	2799
13 Nuevo Emperador	221.	20.	130.	92.	2.	83.	14.	38.	0.	318.	1292.	2.	48.	7.	18.	32.	0.	2317
14 Sector Este	561.	80.	327.	180.	45.	140.	22.	22.	0.	0.	0.	0	9.	19.	5.	37.	0.	1447
15 Sector Norte	4004.	1027.	1889.	494.	369.	995.	1115.	626.	15.	106.	125.	34.	19.	50.	186.	121.	0.	11175
16 Sector Oeste	4366.	172.	534.	139.	71.	299.	102.	30.	0	123.	938.	10.	28.	19.	155.	30.	2.	7018
17 Islas del Golfor de Pmá	32.	0.	18.	33.	0.	47.	0.	0.	0.	0.	0.	0.	0	0.	0	0.	0.	130
Total	340555.	175083.	407151.	101452.	30439.	181357.	55543.	27041.	2480.	35359.	90942.	2840.	2811.	1883.	10295.	8324.	135.	1473690

Source : ESTAMPA

(2) O–D TABLE IN 2000 PROJECTED ON BASE CASE

Origin \ Destination	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
1 Centro	141936.	36087.	66900.	30571.	8611.	52466.	18295.	18860.	3527.	19734.	9761.	2374.	436.	1127.	4305.	6528.	34.	421552
2 Bella Vista	35033.	96560.	85034.	32968.	6605.	42193.	25270.	11633.	2318.	11329.	12926.	180.	61.	136.	1513.	608.	0.	364367
3 Area Residencial	62130.	86048.	244485.	43234.	12105.	69607.	24369.	22098.	3865.	12104.	7468.	661.	162.	676.	3289.	1289.	25.	593615
4 Juan Diaz	25183.	27428.	41254.	123537.	21271.	34375.	4806.	9982.	1678.	3102.	1237.	1589.	304.	614.	1910.	973.	97.	299340
5 Tocumen	5983.	7444.	11731.	15700.	34277.	15577.	3147.	3457.	319.	1093.	1135.	1983	19.	175.	924.	63.	0.	103027
6 San Miguelito	50618.	43681.	71945.	28610.	9374.	283538.	29744.	15941.	2330.	5140.	2159.	730.	265.	286.	2781.	476.	204.	547822
7 Las Cumbres-Chilibre	14104.	16204.	23761.	4750.	2371.	33428.	78834.	12952.	1360.	934.	1765.	265.	43.	185.	3472.	446.	0.	194874
8 Ancón Este	23689.	15954.	26848.	11734.	4065.	18995.	12951.	41850	1388.	8457.	4168.	71.	635.	6.	2831.	309.	0	173951
9 Ancón Oeste	3619.	2798.	3910.	1053.	493.	1813.	485	1241.	13204.	2262.	1471.	69.	0.	0.	1256.	0.	0	33674
10 Arraiján	17128.	9799.	10664.	3006.	895.	5113.	1342.	8704.	2287.	70916.	8943	5.	1407.	80.	451.	208	0.	140948
11 Chorrera	7081.	8635.	5585.	1952.	1675.	3716.	1585.	4644.	1719.	10250.	171719.	24.	2644.	3.	392.	2223.	41.	223888
12 Pacora	2156.	210.	861.	878.	2206.	601.	143.	1323.	9.	97.	46.	0.	11.	0	60.	128.	0	8729
13 Nuevo Emperador	286.	25.	174.	259.	2.	281.	63.	499.	0.	1131.	2177.	3.	56.	10.	29.	48.	0.	5043
14 Sector Este	785.	125.	449.	551.	148.	478.	89.	1754.	0.	0.	0.	0	12.	0.	10.	54.	0	4455
15 Sector Norte	5509.	1844	2793.	1433.	640.	2751.	3072.	9586.	21.	463.	305.	63.	30.	65.	178.	196.	0.	28949
16 Sector Oeste	5940.	256.	746.	462.	150.	1286.	273.	143.	0.	579.	1858.	20.	49.	29.	263.	0.	5.	12059
17 Islas del Golfor de Pmá	30.	0.	23.	87.	0.	149.	0.	0.	0.	0.	0.	0.	0	0.	0.	0.	0.	289
Total 18	401210.	353098.	597163.	300785.	104888.	566367.	204468.	164667.	34025.	147591.	227138.	8037.	6134.	3392.	23664.	13549.	406	3156582

Source : ESTAMPA

(3) O–D TABLE IN 2000, ALTERNATIVE A

Origin \ Destination	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
1 Centro	135366.	34311.	65011.	29665.	8445.	49525.	17982.	17748.	3183.	17966.	6224.	2367.	432.	1121.	4251.	6506.	34.	400137.
2 Bella Vista	33219.	87335.	80209.	30051.	6303.	37822.	23508.	10241.	1942	8847.	7513.	165.	56	130.	1406.	559.	0.	329306.
3 Area Residencial	59187.	80356.	232276.	41927.	12340.	66513.	23589.	21157.	3483.	12755.	5293.	641.	160	664.	3205.	1249.	25.	564770.
4 Juan Diaz	24153.	25306.	40181.	132181.	24057.	38299.	5336.	10407.	1755.	4117.	1463.	1706.	313.	629.	1984.	1081.	97.	313065.
5 Tocumen	6294.	6261.	12573.	18444.	36420.	18301.	3665.	3759.	358.	1353.	1155.	2149.	25.	188	1096.	65.	0.	112106.
6 San Miguelito	49300.	40694.	69268.	34564.	10905.	293852.	31530.	16042.	2370.	6986.	3211.	775.	267.	286.	2799	484.	204.	563537.
7 Las Cumbres-Chilibre	13913.	13873.	23467.	5780.	2734.	34823.	79537.	13232.	1336.	1497.	1403.	265.	44.	185.	3481.	448.	0.	196018.
8 Ancón Este	22159.	14834.	25735.	11477.	3977.	17758.	12630.	40805.	1254.	8215.	3257.	67.	558.	6.	2737.	300.	0.	165769.
9 Ancón Oeste	3416.	2546	3762.	1136.	515.	1563.	483.	1230.	13014.	2354.	1357.	68.	0.	0.	1253.	0.	0.	32697.
10 Arraiján	16591.	8507.	10985.	3793.	1200.	9082.	1815.	9984.	2776.	81648.	13130.	5.	1554.	94.	466.	231.	0.	161861.
11 Chorrera	4567.	6752.	3950.	1883.	1592.	4911.	1465.	4614.	2293.	14960.	205843.	33	2881.	3.	404.	2440.	41.	258642.
12 Pacora	2130.	199.	828	927.	2396	610.	144.	1323.	9.	97.	50.	0.	11.	0	60.	128.	0.	8912.
13 Nuevo Emperador	281.	24.	172.	264.	2.	282.	63.	490.	0.	1267.	2346.	3.	56.	10.	29.	48.	0.	5337.
14 Sector Este	776.	118.	443.	577.	152.	478.	39.	1754.	0.	0.	0.	0.	12.	0.	10	54.	0.	4463.
15 Sector Norte	5467.	1722.	2705.	1476.	675.	2783.	3079.	9539.	21.	541.	313.	63.	30.	65.	178.	196.	0.	28853.
16 Sector Oeste	5927.	247.	728.	491.	152.	1322.	274.	143.	0	744.	2031.	20.	49.	29.	263.	0.	5.	12025.
17 Islas del Golfor de Pmá	30.	0.	23.	87.	0.	149.	0.	0.	0.	0.	0.	0	0.	0.	0.	0.	0.	289.
Total	382776.	323085.	572316.	314723.	111865.	578073.	205139.	162468.	33794.	163347.	254589.	8327.	6448.	3410	23622.	13789.	406.	3158177.

Source : ESTAMPA

(4) O–D TABLE IN 2000, ALTERNATIVE B

Origin \ Destination	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
1 Centro	132926.	32004.	62249.	27100.	11381.	45242.	11429.	8445.	571.	23550.	7625.	2362.	427.	1115.	4193.	6478.	36.	378133.
2 Bella Vista	30490.	74554.	73087.	25526.	8101.	31792.	13297.	3130.	58.	13685.	7633.	146.	48.	122.	1266.	489.	0.	283824.
3 Area Residencial	56056.	72052.	218679.	38854.	17170.	63788.	15376.	11809.	898.	19024.	7380.	618.	156.	646.	3096.	1198.	25.	526925.
4 Juan Diaz	22433.	22231.	38355.	131272.	34752.	38380.	3862.	5764.	221.	6539.	3247.	1706.	313.	629.	1984.	1081.	97.	312866.
5 Tocumen	11208.	10328.	19747.	27986.	52366.	28350.	3774.	2518.	97.	5025.	4119.	3281.	46.	280.	1793.	72.	0.	170990.
6 San Miguelito	47531.	33841.	69508.	35063.	20140.	313103.	25847.	8978.	469.	13126.	7305.	850.	271.	286.	2787.	493.	204.	579802.
7 Las Cumbres-Chilibre	9025.	8479.	15940.	4321.	3828.	28365.	57275.	3797.	154.	2369.	1961.	177.	34	124.	2407.	324.	0.	138680.
8 Ancón Este	12145.	5438.	15065.	8158.	3139.	11591.	5569.	5764.	111.	7595.	2667.	41.	558.	6.	1678.	120.	0.	79645.
9 Ancón Oeste	304.	24.	841.	177.	203.	201.	24.	39.	676.	846.	703.	5.	0.	0.	22.	0.	0.	4065.
10 Arraiján	22304.	14964.	14702.	8419.	5316.	17804.	3996.	4831.	540.	115105.	36055.	5.	2281.	142.	647.	337.	0.	24,7448.
11 Chorrera	6409.	8266.	7599.	4238.	7992.	9763.	2045.	1954.	204.	37951.	281889.	45.	3767.	3.	595.	3304.	55.	278079.
12 Pacora	2098.	183.	787.	928.	3650.	606.	109.	25.	9.	97.	92.	0.	11.	0.	60.	128.	0.	8783.
13 Nuevo Emperador	277.	23.	168.	264.	2.	280.	46.	113.	0.	1961.	2916.	3.	56.	10.	29	48.	0.	6196.
14 Sector Este	770.	111.	435.	577.	216.	474.	61.	32.	0.	0.	0.	0.	12.	0.	10.	54.	0.	2752.
15 Sector Norte	5438.	1564.	2598.	1476.	822.	2774.	2254.	1711.	21.	860.	436.	63.	30.	65.	178	195.	0.	20486.
16 Sector Oeste	5927.	235.	707.	491.	192.	1316.	201.	28.	0.	1225.	2621.	20.	49.	29.	263.	0.	5.	13309.
17 Islas del Golfor de Pmá	33.	0.	23.	87.	0.	149.	0.	0.	0.	0	0.	0	0.	0.	0.	0.	0.	292.
Total	366874.	284297.	540490	314937.	169270.	594078.	145165.	58938.	4029.	248958.	366649.	9322	8059.	3457.	21008	14322	422	3150275

(5) O–D TABLE IN 2000, ALTERNATIVE C

Origin \ Destination		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
1	Centro	136498.	32932.	60934.	28709.	5118.	48292.	11007.	43772.	3058.	10872.	3900.	2368.	431.	1123.	4249.	6504.	36.	399803.
2	Bella Vista	31361.	83225.	75215.	29528.	4409.	37078.	14247.	29538.	1872.	5344.	4871.	161.	53.	127.	1373.	542.	0.	318944.
3	Area Residencial	55324.	76226.	222753.	41064.	7866.	68187.	14890.	49767.	3387.	7210	3589.	637.	160.	659.	3182.	1237.	25.	556163.
4	Juan Diaz	22822.	24267.	38351.	133919.	16206.	40865.	3753.	20926.	1793.	3093.	1215.	1706.	313.	629.	1984.	1081.	97.	313010.
5	Tocumen	4251.	3527.	7528.	13430.	24806.	11157.	1084.	5079.	258.	695.	577.	1449.	15.	130.	730.	62.	0.	74778
6	San Miguelito	46604.	37353.	68346.	34485.	7470.	306008.	22620.	42113.	2475.	4887.	2567.	850.	271.	286.	2787.	493.	204.	579819.
7	Las Cumbres-Chilibre	7894.	8114.	13659.	3437.	866.	23452.	54243.	21924.	816.	618	641.	177.	34.	124.	2407.	324.	0.	138730.
8	Ancón Este	48353.	35683.	60112.	21013.	4653.	43334.	19184.	122476.	2840.	11946.	4989.	72.	558.	6.	3883.	611.	0.	379713.
9	Ancón Oeste	3227.	2437.	3675.	1181.	336.	1672.	344.	2899.	13014.	1613.	973.	68.	0	0.	1253.	0.	0.	32692.
10	Arraiján	11010.	4260.	6952.	2752.	445.	4541.	597.	17438.	1911.	51932.	6960.	5.	1144.	58.	317.	161.	0.	110533.
11	Chorrera	3247.	3790.	2879.	1412.	519.	3576.	576.	11994.	2326.	8380.	147439.	26	2431.	3.	302.	1959.	30.	190889.
12	Pacora	2123.	196.	819.	928	1620.	606.	109.	1390.	9.	97.	41.	0.	11.	0.	60.	128.	0.	8137.
13	Nuevo Emperador	282.	24.	171.	264.	2.	280.	46.	1853.	0.	886	1942.	3.	56.	10.	29.	48.	0.	5896
14	Sector Este	778.	117.	441.	577.	107.	474.	61.	1844.	0.	0.	0.	0.	12.	0.	10.	54.	0.	4475.
15	Sector Norte	5479.	1685.	2683.	1476.	591.	2774.	2254.	9949.	21.	363.	224.	63.	30.	65.	178.	196.	0.	28031.
16	Sector Oeste	5937.	243.	723.	491.	123.	1316.	201.	506.	0	496.	1643.	20.	49.	29.	263.	0.	5.	12045.
17	Islas del Golfor de Pmá	33.	0.	23.	87.	0.	140.	0.	0.	0	0.	0.	0.	0	0.	0.	0	0	292.
Total		385223.	314079.	565264.	314753.	75137.	592761.	145216.	383468.	33780	108472.	181571.	7605	5569.	3249.	23007.	13400	397.	3153950.

Source : ESTAMPA

with a resultant halving of share in the built-up area, and such trips will become quadruple from the present 349,000 to 1,379,000, with a resultant swell in share in the suburban areas. On the other hand, trips between the built-up area and suburban areas are estimated to double from the present 403,000 to 858,000. Forecasts under Alternative B and C show similar trends.

In this view, middle/long-term transportation planning involves two major questions of (i) how to cope with the traffic which will flow from suburban areas into the built-up area, and (ii) what transportation facilities and services should be provided to accommodate the swelling traffic in suburban area.

Future values of distributed traffic is estimated in terms of O-D trips and reduced to average length of trip for each purpose under each of the Alternatives, as presented in Table 3-18. Trip lengths are predicted to extend generally to more than 1.5 times the present values, the greatest extension being the length of "work" trips, which is forecast to grow from the present 8.6 kilometers to 12 or 13 kilometers as urban expansion progress. Lengths much in excess of what is normally expected are shown for "school" and "shopping" trips, and this is because the calculation excludes intrazonal trips, thereby excluding pedestrian trips of school children and housewives.

TABLE 9-18 AVERAGE TRIP LENGTH BY PURPOSE

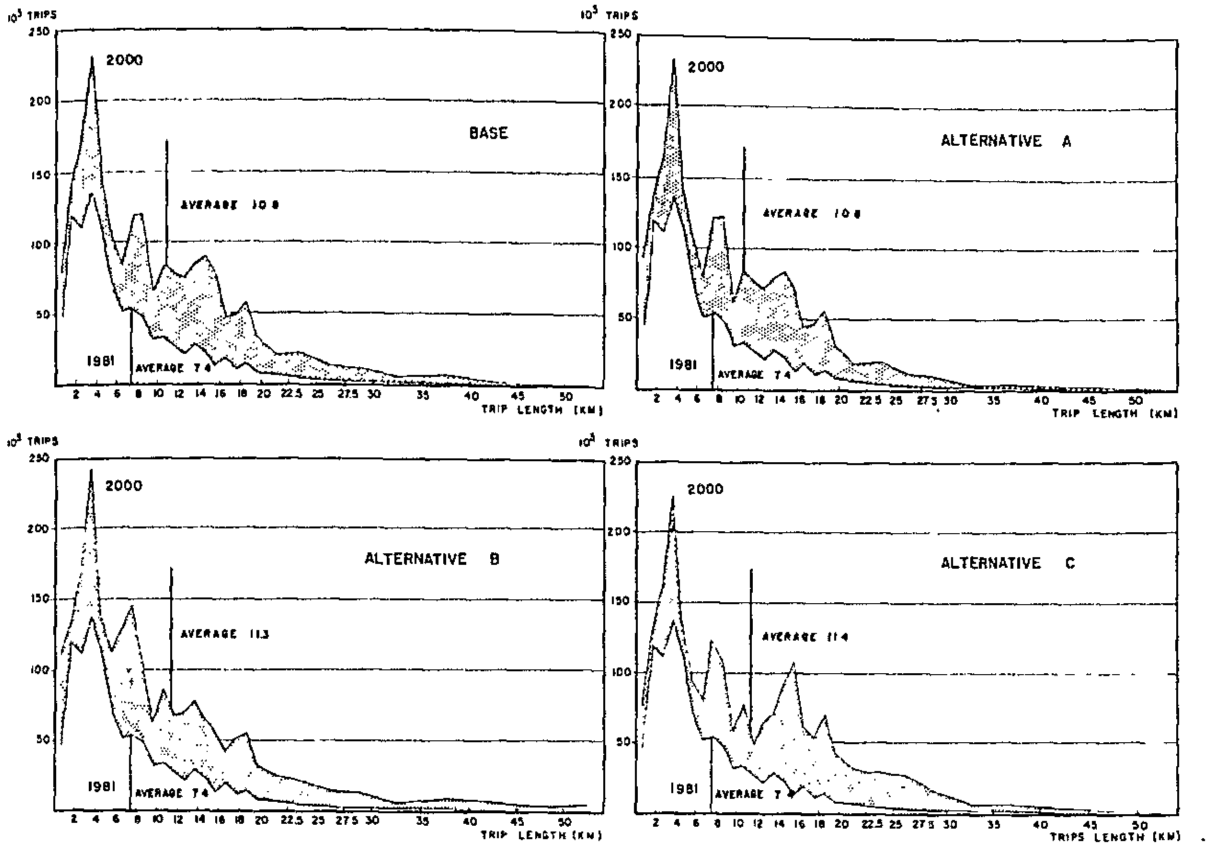
(Km)

Trip Purpose	1981	2000			
		Base	Alternative A	Alternative B	Alternative C
Work	8.6	12.23	12.10	12.82	12.42
School	6.4	9.56	9.56	9.48	10.64
Home	7.8	11.35	10.91	11.89	11.89
Business	6.4	7.66	8.03	8.40	8.42
Shopping	5.6	8.11	8.52	8.69	9.42
Private	6.5	9.67	9.86	10.26	10.62
All Purpose	7.4	10.76	10.61	11.26	11.40

Source : ESTAMPA

The distribution of various trip lengths for each Alternative in Figure 9-9 shows that the present pattern - with the highest frequency occuring in the domain of three to four kilometers of trip length and, therefore, five kilometers or shorter trips representing a large proportion of total trips - will remain little changed in the future, but middle range trips of 10 to 20 kilometers will increase by a large margin. The minor peak which will result from a 2.0 to 2:6 times increase in the number of trips of six to eight kilometers will be due to population increases in San Miguelito (Zone VI) and vicinity.

The predicted increase in the number of trips and the predicted extension of the length of trips will have a compound effect on the quantity of future transportation demand. Practically, the present quantity of 8.2 million passenger-kilometers estimated to increase by 2.8 to 3.0 times to 23.4 million passenger-kilometers under Alternative A, 24.6 million passenger-kilometers under Alternative B, and 25.0 million passenger-kilometers under Alternative C. This means that, because traffic burden on road transportation facilities and services is considered approximately proportional to the passenger-kilometer quantity of demand, such facilities and services will have to be more than doubled, if the present level of service is to be sustained in the future under the same modal split. The existing urban traffic infrastructure is a result of accumulation over a long period of time, and to double it by the end of this century will be nearly impossible. New orientation of trans-

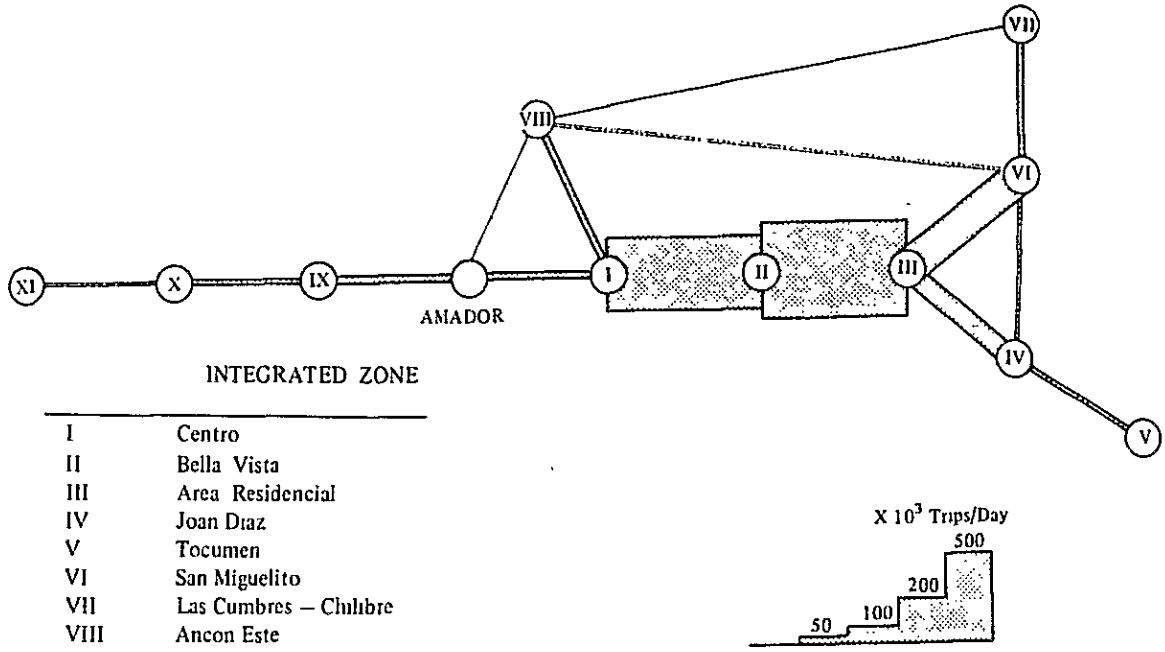


Source: ESTAMPA

FIG. 9-9 TRIP LENGTH DISTRIBUTION

portation policy will be essential for the future.

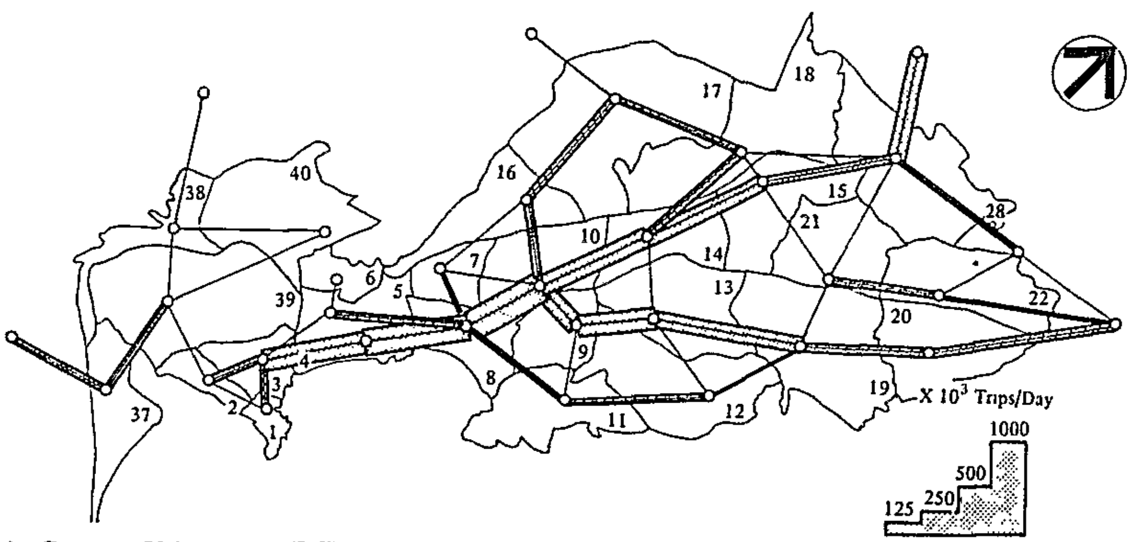
The existing traffic volume (O-D person-trips) is loaded onto the spider network of the Planning Area and the spider network of the Panama Urban Area in Figure 9–10. Forecast future traffic under Alerrnative A is likewise loaded onto such spider networks in Figure 9-11, respectively. Based on the data of these four Figures, the volume of traffic at cross sections in the built-up area is shown in Figure 9-12. The highest traffic demand exist and will in the future occur between Bella Vista (Zone II) and Area Residencial (Zone III). Traffic at Via Brasil cross section will inflate from the present 535 thousand person-trips to over one million person-trips. Traffic crossing the Canal will increase by four to five times from the present 64 thousand trips to, under Alternative B, 311 thousand trips. The burden of this traffic will have to be shared by the Puente de Las Americas and the new bridge on Autopista whose construction will start in the near future, and whether the capacity of these two bridges will be sufficient or the construction of a third bridge will become necessary will be focus point of the future transportation planning. Traffic is estimated to increase by less than two times at both the Corregimientos de Santa Ana – Calidonia cross section and Corregimientos de Calidonia – Bella Vista cross section, but Centro and vicinity is the area in which transportation planning to cope with demand increase is most difficult due to heavy population, building densities and the lack of space for road construction. Total traffic flowing into the build-up area from the direction of Corregimientos Tocumen and the direction of San Miguelito District is predicted to increase from the present 351 thousand trips to almost one million trips by the year 2000 under any of the Alternatives. Therefore, another focus of future transportation planning will be the orderly handling and accommodation, within the built-up area, of the traffic influx from these two directions.



INTEGRATED ZONE

I	Centro
II	Bella Vista
III	Area Residencial
IV	Joan Diaz
V	Tocumen
VI	San Miguelito
VII	Las Cumbres – Chilibre
VIII	Ancon Este
IX	Ancon Oste
X	Arraijan
XI	Chorrera

(a) Planning Area (Integrated Zones)

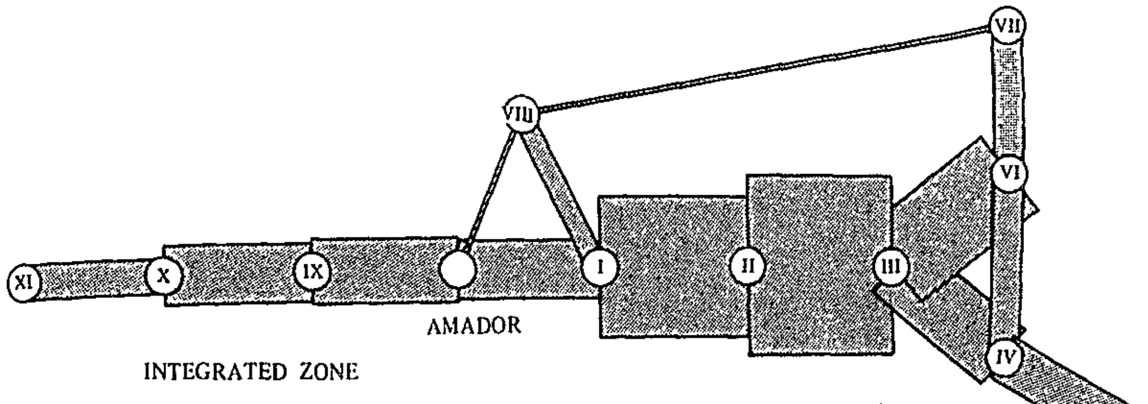


(b) Panama Urban Area (P.T. Survey Zones)

Source : ESTAMPA

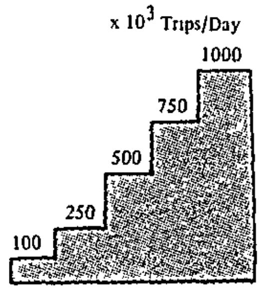
Note: See zone name in Table 5-2.

FIG. 9-10 PRESENT PERSON-TRIPS LOADED ONTO SPIDER NETWORK, 1981

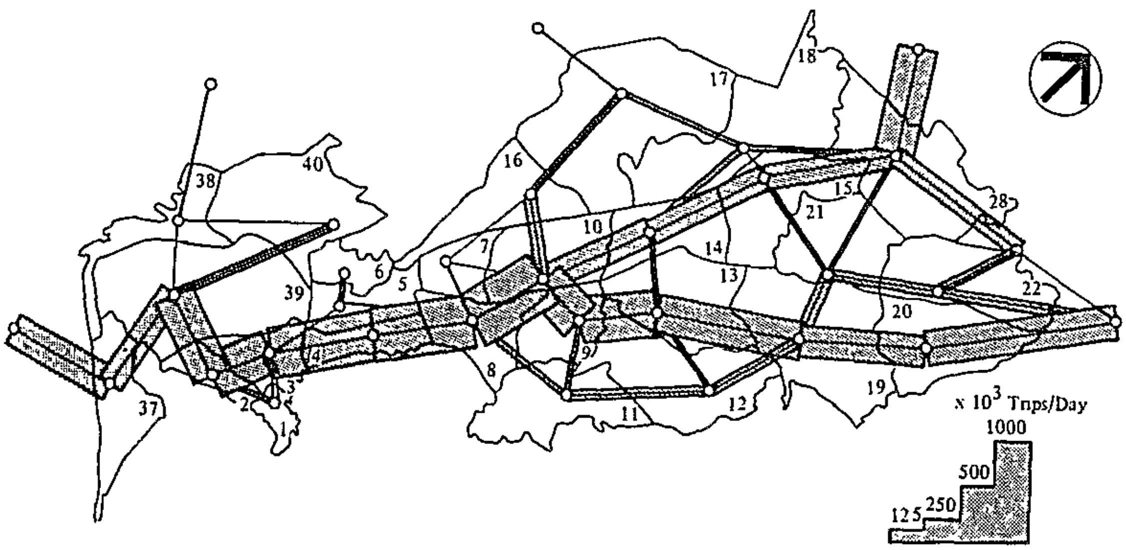


INTEGRATED ZONE

I	Centro
II	Bella Vista
III	Area Residencial
IV	Juan Diaz – Pedregal
V	Tocumen
VI	San Miguelito
VII	Las Cumbres – Chilibre
VIII	Ancon Este
IX	Ancon Oeste
X	Arraijan
XI	Chorrera



(a) Planning Area (Integrated Zones)



(b) Panama Urban Area (P.T. Survey Zones)

Note: See zone names in Table 5-2

FIG. 9-11 FUTURE PERSON-TRIPS LOADED ONTO SPIDER NETWORK, 2000 (ALTERNATIVE A)

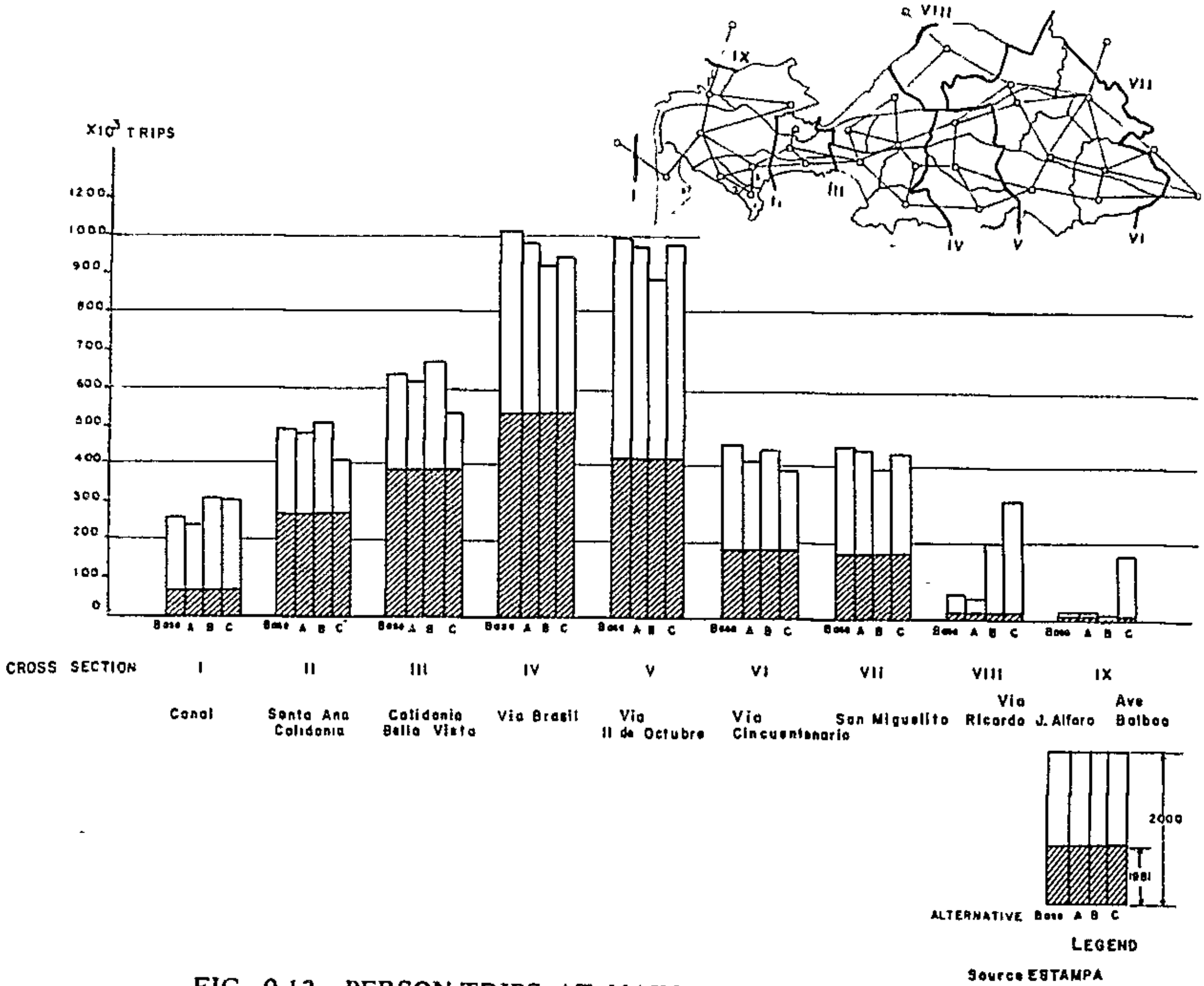


FIG. 9-12 PERSON-TRIPS AT MAIN CROSS SECTIONS

(3) Traffic Volume Increase

Under any of the Alternatives, the total traffic volume in terms of vehicle-trips is estimated to increase by about 2.3 times – particularly, passenger car traffic by 2.7 times (See Table 9-19. The share of cars in total traffic will rise from the present 54% to about 63%, while that of public use buses will drop from 7.6 to 6.7%.

This trend of change in modal share is more acute when seen in terms of person-trips (See Table 9-20). The share of cars will rise from 35% to 42%, while that of public buses will drop from 44% to 40%. Thus, passenger cars will emerge as the major means of transportation in the future.

Reflecting the future outward extension of the urban area, average trip length is forecast to increase with regard to all types of vehicles: in the case of passenger cars, average trip length is estimated to increase 54% from the present 6.5 kilometers to about 10 kilometers and in the case of public use buses, increase will be 35% from the present 9.6 kilometers to about 13 kilometers.

Motor traffic volume (vehicle––trips) is loaded onto spider networks for ghe convenience of analysis. Comparison between the present situation and the future (under the Alternatives) suggests moderate change in the traffic pattern but shows that the flow line will be thickened one or two times in average.

TABLE 9-19 CHANGE IN MODAL SHARE OF VEHICLE-TRIPS

Mode	1981		2000							
			Base		Alternative A		Alternative B		Alternative C	
	a	(b)	a	(b)	a	(b)	a	(b)	a	(b)
1. Car	265,700	(54 2)	723,336	(63.3)	717,457	(62.9)	705,559	(62.5)	721,609	(63.5)
2. Taxi	91,179	(18.6)	181,467	(15.9)	184,391	(16 2)	186,502	(16.5)	182,809	(16 0)
3. Truck and Others	87,786	(17.9)	145,375	(12.7)	146,873	(12.9)	145,450	(12.9)	140,627	(12.4)
4. Bus-Chiva (Public)	37,752	(7.6)	76,116	(5.7)	75,497	(6.6)	75,202	(6.7)	76,237	(6.7)
5. Bus (Private)	8,170	(1.7)	16,048	(1.4)	16,221	(1.4)	16,181	(1.4)	15,597	(1.4)
Total	490,587	(100.0)	1,142,342	(100.0)	1,140,439	(100.0)	1,128,894	(100.0)	1,136,879	(100.0)

Note : a: No. of trips (b): Composition (%)
Source : ESTAMPA

TABLE 9-20 CHANGE IN MODAL SHARE OF PERSON-TRIPS

(1) Including walk, 2-Wheelers, others

	1981		2000							
			Base		Alternative A		Alternative B		Alternative C	
Mode	a	(b)	a	(b)	a	(b)	a	(b)	a	(b)
Walk, 2-Wheelers, others	330,006	(22.4)	594,958	(18.9)	607,668	(19.2)	620,308	(19.7)	598,986	(19.0)
Car	395,895	(26.9)	1,077,776	(34.1)	1,069,043	(33.9)	1,051,314	(33.4)	1,075,221	(34.1)
Taxi	71,120	(4 8)	214,571	(6.8)	218,023	(6.9)	220,508	(7.0)	216,136	(6.9)
Truck a d others	102,297	(6.9)	113,392	(3.6)	114,565	(3.6)	113,446	(3.6)	109,687	(3 5)
Bus-Chiva (Public)	509,013	(34.5)	1,028,070	(32.6)	1,019,836	(32.3)	1,015,953	(32.2)	1,029,832	(23.6)
Bus Private	65,359	(4.4)	127,815	(4.0)	129,042	(4.0)	128,746	(4.1)	124,088	(3.9)
Total	1,473,690	(100.0)	3,156,582	(100.0)	3,158,177	(100.0)	3,150,375	(100.0)	3,153,950	(100.0)

Note : a : N° of trips (b) : Composition (%)

(2) Excluding walk, 2-Wheelers, others

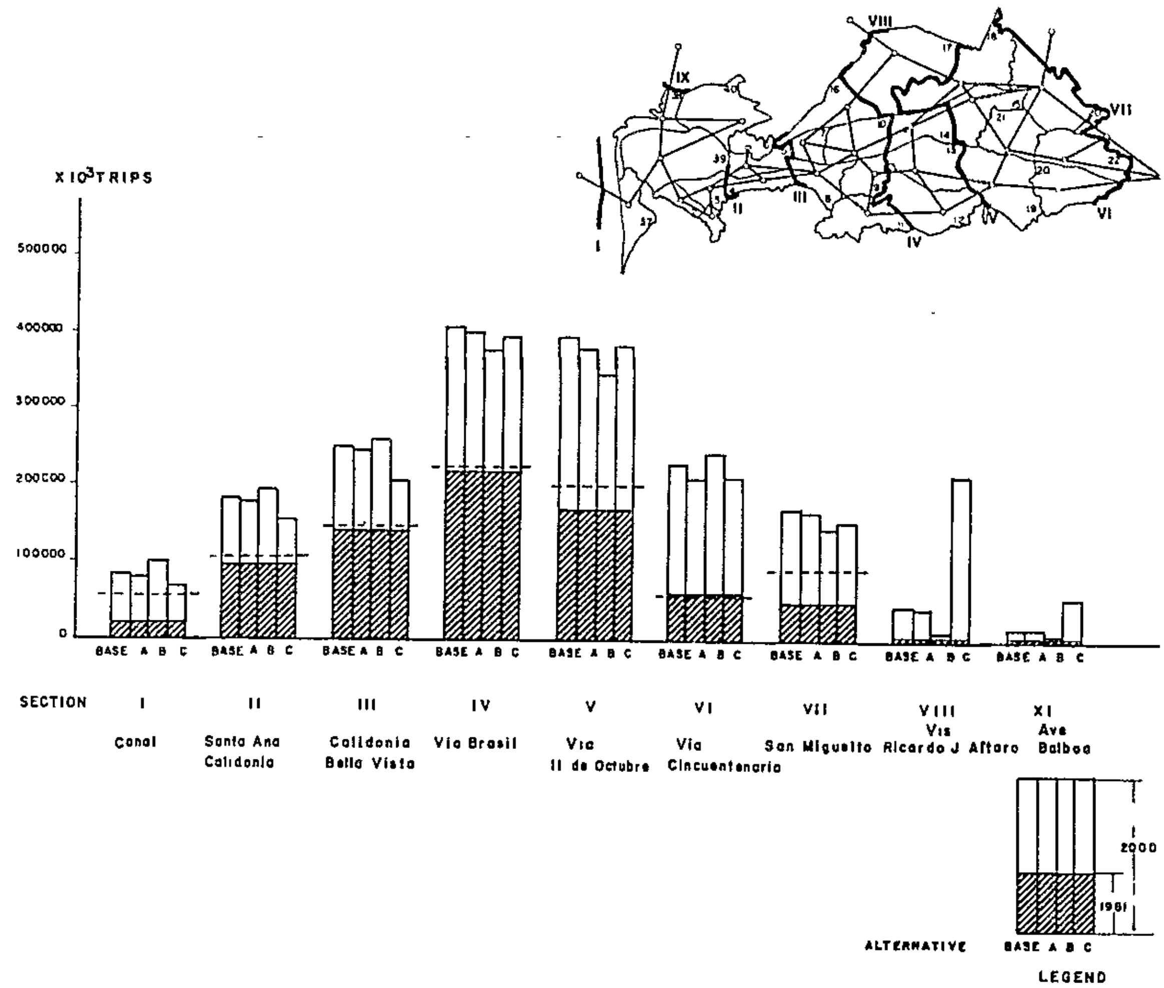
	1981		2000							
			Base		Alternative A		Alternative B		Alternative C	
Mode	a	(b)	a	(b)	a	(b)	a	(b)	a	(b)
Car	395,895	(34.6)	1.077,776	(42.0)	1,069,043	(41.9)	1,051,314	(41.6)	1,075,221	(42.1)
Taxi	71,120	(6.2)	214,571	(8.4)	218,023	(8 5)	220,508	(8.7)	216,136	(8.5)
Truck a d others	102,297	(8.9)	113,392	(4.4)	114,565	(4.5)	113,446	(4.5)	109,687	(4.3)
Bus-Chiva (Public)	509,013	(44.5)	1,028,070	(40 1)	1,019,836	(40.0)	1,015,953	(40 2)	1,027,832	(40.2)
Bus (Private)	65,359	(5.7)	127,815	(5.0)	129,042	(5.0)	128,746	(5.1)	124,088	(4.9)
Total	1,143,684	(100.0)	2,561,624	(100.0)	2,550,509	(100.0)	2,529,967	(100.0)	2,554,964	(100.0)

Note : a: No. of trips (b): Composition (%)
Source : ESTAMPA

NOTE: Hereafter in this sub-chapter, vehicle traffic volume will be expressed in terms of passenger car units (PCU), unless otherwise noted.

The feature of traffic flow under each alternative reflects the feature of land use and population distribution under each alternative. Under Alternative A, traffic from all directions will increase, but increase from San Miguelito (Zone VI) and Las Cumbres-Chilibre (Zone VII) is greater than under other alternatives.

Nine cross sections are considered in the built-up area and vicinity, and present and future motor traffic volume (as loaded onto the spider networks) at these cross sections are compared in Figure 9-13.



Source ESTAMPA

FIG. 9-13 TRAFFIC VOLUME AT MAIN CROSS SECTIONS

At cross sections Via Brasil (Cross Section IV) and Via 11 de Octubre (Cross Section V), both in Panama Urban Area, the estimated traffic increase factors are moderate at 2.0 or 3.0, but the absolute volume is large and it is predicted that nearly 400 thousand vehicle-trips per day will cross these lines. The increase factors at Canal (Cross Section I) is estimated at 4.0 under Alternative A, 5.0 under B, and 3.0 under C. At Via Cincuentenario (Cross Section VI), which is the line across which traffic flow into Panama Urban Area from Juan Diaz-Pedregal (Zone IV) and Tacumen (Zone V) in the east, motor traffic is forecast to increase by about 4 times under either of the alternatives. Increase (greatest under Alternative A) will be about three times at Via Ricardo J. Alfaro (Cross Section VIII), across which traffic will flow from San Miguelito (Zone VI) in the north. At Cross Sections (VIII and IX) in the north, facing Canal Area, future traffic increase factor ranges from the lowest under Alternative B to the highest at about 9.0 under Alternative C, but the extension of Autopista will result in an additional several tens of thousand trips at this Cross Section.

Figure 9-14 illustrates the linkage between each zone of Panama Urban Area (Integrated Zone I to III) and other zones under Alternative A.

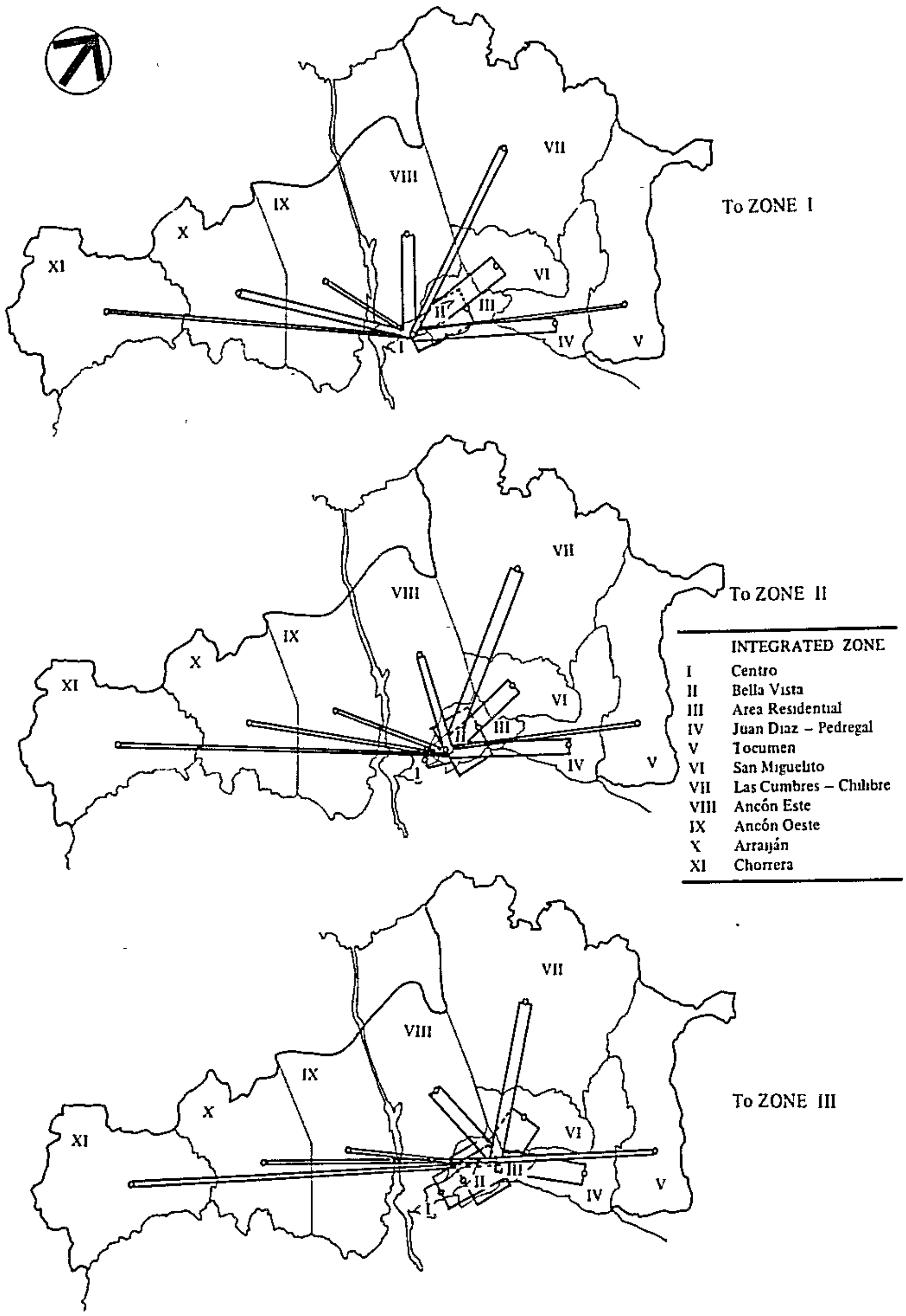
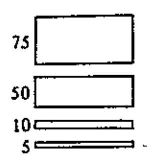


FIG. 9-14 CONCENTRATION OF TRAFFIC VOLUME TO PANAMA URBAN AREA - ALTERNATIVE A



Within Panama Urban area (Integrated Zones I through III), Centro (Integrated Zone I) has the greatest communication in terms of motor traffic with, naturally, Bella Vista (Integrated Zone II) and Area Residencial (Integrated Zone III), followed by San Miguelito (Integrated Zone VI), Ancon Este (Integrated Zone VIII), and Juan Diaz-Pedregal (Integrated Zone IV). In addition, about 10,000 vehicle-trips flow from Arraijan (Integrated Zone X) and Las Cumbres-Chilibre (Integrated Zone VII).

In the case of Bella Vista (Integrated Zone II), traffic connection is strong (excluding neighboring zones) with San Miguelito (Integrated Zone VI), followed by Juan Diaz-Pedregal (I. Zone IV), Las Cumbres-Chilibre (VII), and Ancon Este (VIII),

Excepting those in Panama Urban Area, those which have a strong traffic connection with Area Residencial (Integrated Zone III) is San Miguelito (VI), followed by Juan Diaz-Pedregal (about 30,000 vehicle-trips).

Given the variations under the alternatives, the traffic flows discussed in the above can be summarized as: the flow from east, which is the largest of flows from all directions, and a slightly smaller flow from north combine in the built-up area and become a heavy traffic flowing in east west direction, or the major flow in Bella Vista (II) and Area Residencial (III). This phenomenon suggests the need of development of enhancement of a road network axis which traverses, from east to west, or surrounds the built-up area.

The volume of traffic flowing from west across the Canal is less than one-tenth of volumes from other directions, and it seems, therefore, that the construction of a third bridge will not have to be considered.

3) Planning Needs to Meet Transport Demand Expansion

Future transport demand forecast under the land use plan (modified Alternative A, or Final Plan) adopted for the formulation of the Transport Masterplan will naturally be different from the above-discussed demand, forecast under the assumption that no traffic policy measures will be taken (that is, "do nothing" case). Also, if no control is applied to the future rise of car ownership, either transport demand will explode, necessitating a huge amount of transport facilities investment, or daily traffic congestion will result and serious social problems will arise. Therefore, it is essential that planning needs to meet such transport demand explosion be identified, that transportation policy be formulated, that alternative networks be selected for evaluation, and that planning policy be determined for the masterplan concept.

First, the following problems are identified from the result of transport demand forecast:

- o The rise in car ownership ratio will result in an improved mobility, which, in turn, will lead to an increased average quantity of trip production.

- o Increases in population, working population, and jobs will bring about greater increases in the number of trips in the suburban areas than in Panama Urban Area, although trips generating in or terminating in Panama Urban Area will continue to be of a considerable magnitude.

- o Reflecting the geographical expansions of the urban areas, average trip length will increase and transport load (number of trips multiplied by trip length) as an indicator of transport demand will become relatively heavier.

- o The rise in car ownership ratio will much affect modal preference and the consequential passenger car trips and gain in road traffic, thus entailing huge amounts of road investments.

- A third bridge over the Canal may become necessary, depending on the degree of increase in traffic between Panama Urban Area and La Chorrera/Arraijan in th west of the Canal.

- With regard to traffic flow into Panama Urban Area from the suburbs to be urbanized in the future, the largest flow will be from the east (the direction of Juan Diaz Pedregal), followed by that from the north (the direction of San Miguelito). Then, the greatest cross-section traffic volume will occur at the confluence of these two traffic flows.

Future planning tasks to meet the above identified problems are discussed hereunder.

(1) Urban Structure

The achievement of a higher employment/worker ratio and the development of commercial and other urban functions in each zone will result in a higher ratio of intra-zonal trips to total trips, with a resultant shorter average trip length and lessened burdens on arterials—–a departure from the existing traffic distribution pattern consisting chiefly of thick flows into Panama Urban Area. It follows that an important task of land use planning is to disperse urban functions for a more evenly distributed traffic load on the road network.

In urban structure planning, on the other hand an important task is to achieve the distribution of land uses in conformity with the public transport network development pattern, inasmuch as the extension of urban areas along the routes of public transport is more desirable from the standpoint of transportion efficiency, rather than the spread of relatively low population density urban areas, which will only increase reliance on motor vehicles.

To alleviate the heavy traffic flow from La Chorrera District and Arraijan District and the consequential need of a third bridge over the Canal, fairly self-sufficient towns are to be developed west of the Canal.

(2) Modal Shares of Transport Demand

Inclination toward owning a car is so strong in Panama City that, with no control, the volume of motor traffic will swell to the extent of making huge road investment mandatory, as already pointed out. If such investments are to be avoided, the same quantity of transport demand must be satisfied with less number of total trips, through the effective transition of passengers from the transport mode with a small unit capacity (cars) to a transport mode with a large unit capacity (public transport, such as buses). In order to achieve such a transition, it will be essential that the mass transit system be made more attractive by assuring reliable, inexpensive, fast, safe, and comfortable conveyance to destrinations and that both the propensity to own a car and the use of cars are discouraged by taxing car ownership, by imposing a higher motor fuel tax (to make it costlier to operate cars), and by strictly enforcing parking restrictions in urban centers (to make it more inconvenient for car drivers).

(3) Transport Network Formulation

Major traffic flows in the future will be those into Panama Urban Area from the east and north, and the greatest traffic flow is expected at the confluence of the two. Then, the most important task of transport network formulation will be achieve the efficient management of said east-west flow and north-south flow. Alternative transport networks should, therefore, be designed with a focus on Panama Urban Area and sourrounding areas where urbanization will progress vigorously, before the final masterplan network may be selected.

CHAPTER 10.

ALTERNATIVE TRANSPORTATION NETWORKS: FORMULATION AND EVALUATION

10. ALTERNATIVE TRANSPORTATION NETWORKS: FORMULATION AND EVALUATION

1) Basic Planning Policy

The identification of a planning philosophy based on the existing facts and problems of and future demand for traffic in Panama Metropolitan Area will be essential for the subsequent formulation of alternatives, evaluation, the drawing of a masterplan.

(1) Plan Objectives

Three planning objectives are proposed:

(i) The formulation of a Transportation infrastructure to offer a base for the future socio-economic development of Panama Metropolitan Area

(ii) The achievement of equal access to transportation services for all citizens

(iii) The preservation of an environment suitable to Panama City as the Republic capital

(2) Plan Targets

The above objectives are translated into the following concrete targets·

(i) A transportation network which will be capable of growing as an integral part of the future land use and urban structure.

(ii) Quantitative satisfaction of future transportation demands

(iii) Correction of service gaps between regions and between classes of users

(iv) Safety

(v) High efficiency with a minimum investment

(vi) Minimization of petroleum consumption

(vii) Minimization of detrimental effects on the environment

2) Formulation of Alternative Transportation Network

(1) Essentials in Alternatives Formulation

It is essential on one hand that alternative transportation networks dramatically differ from each other, inasmuch as the process of formulation and comparison of any set of alternatives will be of little significance when the alternatives lack distinctive features, while on the other hand every alternative network is a possible candidate for the prototype of the masterplan to be finally established and, as such, must satisfy certain needs which are common to all the alternatives. In fact, the transportation network proposed for Panama Urban Area must:

A. Be compatible with the future land use and urban structure, and

B. Satisfy future transportation demands

Hence, the below discussed points must be kept in mind in the formulation of alternative networks.

i) Compatibility with Urban Structure

The urban structure of the Panama Metropolitan Area is that of an upside-down "T" shape, consisting of a traffic flow axis extending in a long east-west direction and Via Transistmica as an axis in the north-south direction. This pattern will become more distinct under Alternative Land Use Plan A.

In a wider perspective, Pan American Highway and Via Transistmica will continue to be the two major axes in the future.

With the extension of Autopista by the addition of an Arraijan – Panama section in the west, Autopista will become a major axis, accommodating long distance traffic, as well as traffic flowing to and from La Chorrera and Arraijan. Thus, an important question is whether or not to upgrade the La Chorrera and Arraijan sections of Pan American Highway to a 4-lane road.

It is expected that Autopista will take over the function of Pan American Highway as an inter-city highway, and, therefore, the need of upgrading the La Chorrera and Arraijan sections should be investigated in view of their functioning as urban arterials. Urbanization of La Chorrera and Arraijan toward the north is limited by topographical reasons and that toward the south is limited by the presence of Autopista, and, therefore, urbanization in these areas will inevitably extend in a long east-west direction. Thus, the upgrading of said sections will be planned in order to provide basic streets for the urban formation. As for areas where urbanization will not progress as much, the upgrading of roads to multi-lane roads will be considered in relation to the future increase in traffic demand.

Most important in connection with the west is the bridge to cross the Canal. At this cross-section, traffic demand is estimated at about 80,000 PCU for the year 2000, which will be in excess of the total capacity of the existing bridge and the bridge to be constructed upon the construction of the Arraijan – Panama City Section of Autopista, which is now under plan. The excess of demand over capacity will be less than enough to justify the construction of a third 4-lane bridge and, therefore, the construction of such a third bridge is believed to be still premature in the year 2000 and not recommended.

In connection with the north, the upgrading of Via Transistmica to a 6-lane road is now being accomplished, but other arterials will become necessary when urbanization will progress in San Miguelito District and Corregimiento De Las Cumbres in the future, provided that a 4-lane road will be called upon to meet traffic demand between the north of Corregimiento De Las Cumbres to Colon Province.

Development of the east will be accelerated in the future, and new arterials will become necessary for Corregimientos De Juan Diaz, Pedregal and Tocumen, in addition to the existing arterial of Via Domingo Diaz. Little urbanization further east of Corregimiento De Tocumen is predicted, and the existing Pan American Highway will be considered to remain the main arterial in this area in the future.

No characteristic alternatives are conceivable for the suburban areas discussed in the above. Rather, traffic network pattern in the built-up area and the adjacent areas where urbanization will be most vigorous in the future will become the main theme of the Masterplan. In other words, the main consideration will be traffic network at the root of the vertical bar of the upside-down "T" where east-west traffic and north-south traffic merge.

ii) Meeting Traffic Demand

Seen from the results of its assignment to spider networks and to the present road network, the largest traffic flux into the built-up area will be that flowing from the east, which will be about 200,000 PCU or 4 times that of the present at the cross-section of Via Cincuentenario, followed by about 160,000 PCU, or over three times the present, flowing from the north along Via Transistmica. These fluxes merge at the cross-sections Via 11 de Octubre and Via Brasil, where the volume of traffic will be almost 400,000 PCU, or about twice the present road capacity. In order to meet such substantially increased future traffic demand, it will be essential that a new road network be developed which will not only offer sufficient road capacities at said cross-sections and in other necessary sections (through the construction of new roads and upgrading of existing roads) but will also accomplish division of work between the component roads, each performing a distinct functional role to meet specific traffic characteristics (such as trip length).

iii) Ways and Means of Curbing Passenger Car Utilization

The estimation of future transport demand preconditioned to policy measures for curbing propensity to own passenger cars. However, any measure to make the use of passenger cars more inconvenient, which will impair the attractiveness of the city as an international metropolise, will not be considered in view of the fact that Panama City has grown as a center of international commerce and finance, and of the realization of the need of the City to continue to develop as such in the future. Therefore, the motor vehicle tax and gasoline diesel fuel tax, which were proposed as the sources of land transportation development funds in Chapter 15 are hereby adopted as the practical ways and means of curbing passenger car trips.

(2) Alternatives Formulation

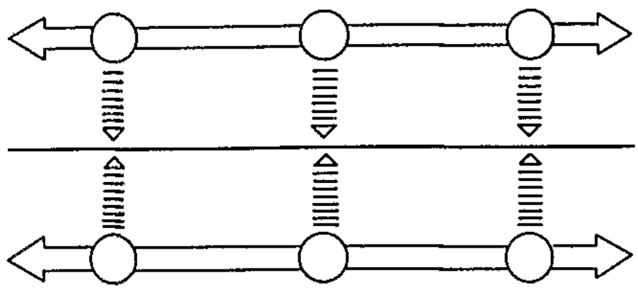
Alternative road networks to be suggested for the Panama Metropolitan Area will center around the built-up area, namely Centro (Integrated Area I) in the east of the Canal to Bella Vista (II) and Area Residencial (III), and the vicinity areas where urbanization will progress actively, such as Juan Diaz-Pedregal (IV) and San Miguelito. Alternatives will be formulated with regard to:

(a) Physical pattern and

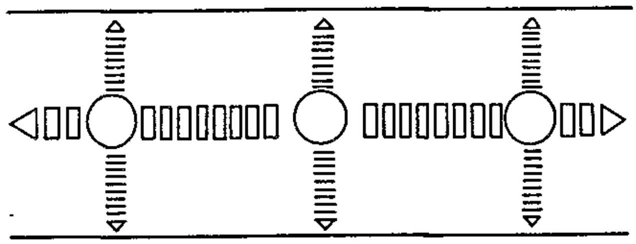
(b) Choice of major means of transportation.

The physical road network pattern is a question of system for dispersion of traffic flows in the urban areas, which will be closely related to the land use in, particularly the urban structure of, the Panama Metropolitan Area. The land use and traffic network patterns of the Panama Metropolitan Area is, and will basically continue to be in the future, that of an upside down "T". Also, in view of the presence of the sea on the south, the Canal Area in the west, and hills in the north, a road network of a ladder pattern is believed to be the most suitable.

A transportation network of a ladder and upside down "T" pattern may be formulated either (a) by establishing major traffic axes outside the central downtown area and arterials stemming in both north-south and east-west directions from the major axes, or (b) by establishing a major traffic axis right through the downtown area and establishing arterials as in (a).



(1) Dispersion pattern



(2) CENTRAL AXISIS PATTERN

Fig. 10-1 **ALTERNATIVES OF PHYSICAL NETWORK PATTERN**

(a) Above will lead to an urban structure of more widely distributed low density towns than (b), and (b) will facilitate the development of a high density urban area along the road axis.

As for the choice of major means of transportation, the strengthening of public transport was already recommended in the discussion of transport policy. However, because motor vehicle traffic demand will vary depending on whether or not a firm transport policy is present, the following two cases will be considered:

(a) That no specific transport policy be taken, and transportation facility be developed to the extent necessary to meet future traffic demand as estimated on the extension of the present trend.

(b) That, as previously recommended, the use of privately owned cars be discouraged and the speed of mass transit by public transport be improved under preferential treatment, and that facilities be developed to meet the demand as estimated under such policy efforts.

The combinations of these alternatives may be summarized as follows:

TABLE 10-1 ALTERNATIVES FORMULATION CONCEPT

	1 No specific transport policy	2 Policy fosteration of public transport and discouragement* of private passenger car use
X Two major axes	Alternative 1	Alternative 3
Y One major axis	Alternative 2	Alternative 4 Alternative 5

Note * : In alternative 3, 4 and 5, are assumed new taxes on gasoline consumption and on car-ownership, of which schedule is shown in Table 13-4.

o X-1

Alternative 1

Nearly clean ladder shape. Streets be widened as much as possible, thereby increasing road capacity, while constructing new road(s) in the north of the urban area.

o Y-1

Alternative 2

An expressway be introduced onto Via Transistmica, which transverses about the center of the urban area.

o X-2

Alternative 3

Less road widening and less road capacity than under Alternative 1.

o Y-2

Alternative 4

The urban expressway of Alternative 2 be used as a deducted route for mass transit (that is, high speed bus-only lane).

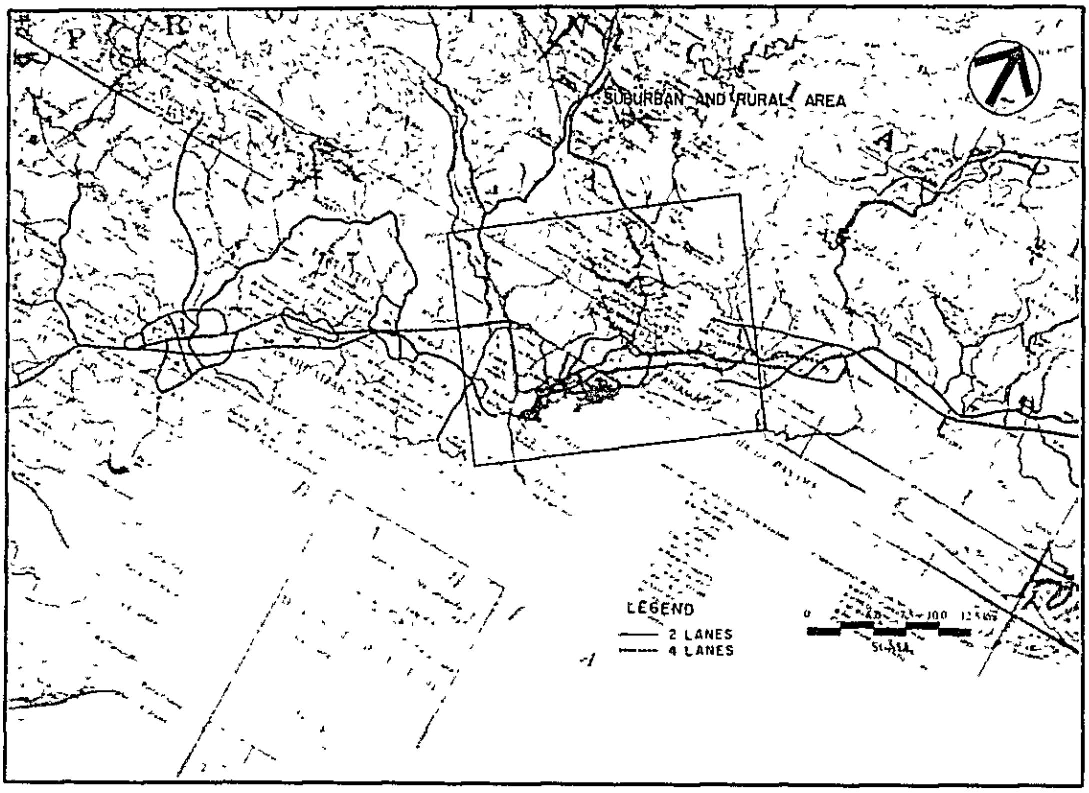
Alternative 5

A rail transit axis route be introduced starting from Albrook Airport, a terminal of Canal Railway, through the central part of the urban area, and reaching Tocumen Airport.

Alternatives are shown in Figure 10-2 through 10-10.

(3) Construction Costs of Alternative Networks

The construction cost of each alternative traffic network is estimated under the calculation method, unit costs, and other standards discussed in the next Chapter. The construction costs of the proposed alternatives, as thus estimated, are compared in Table 10-2.



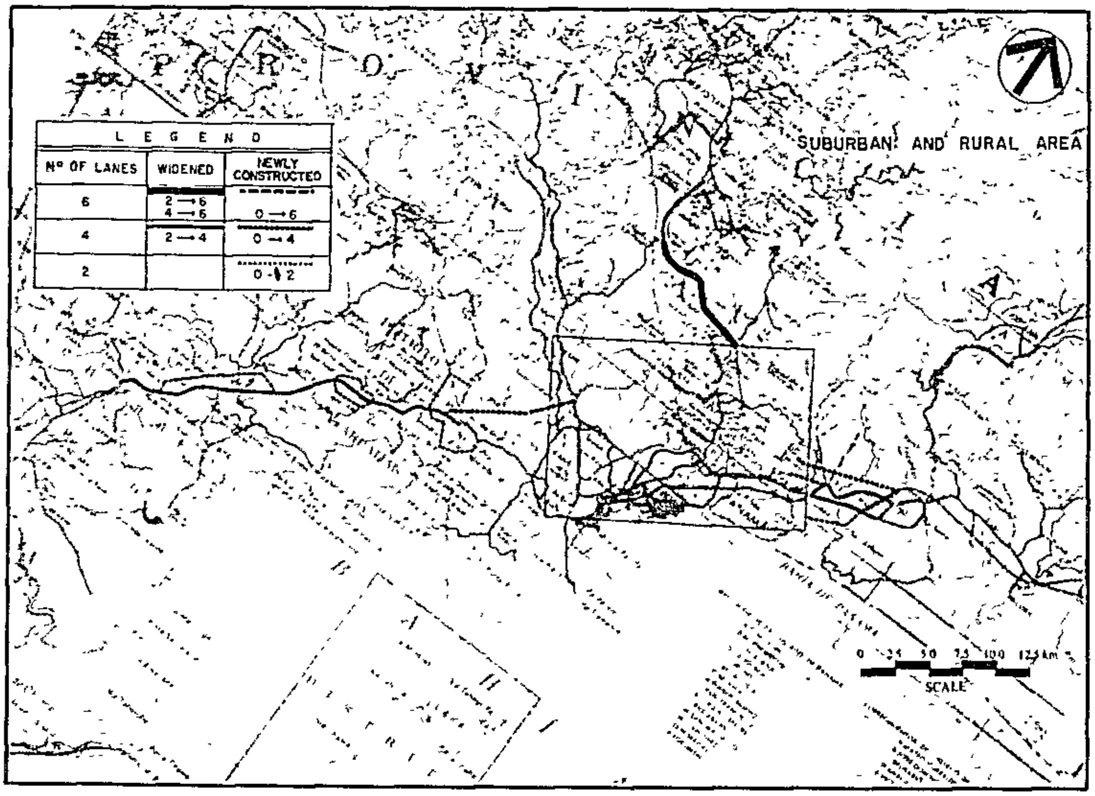
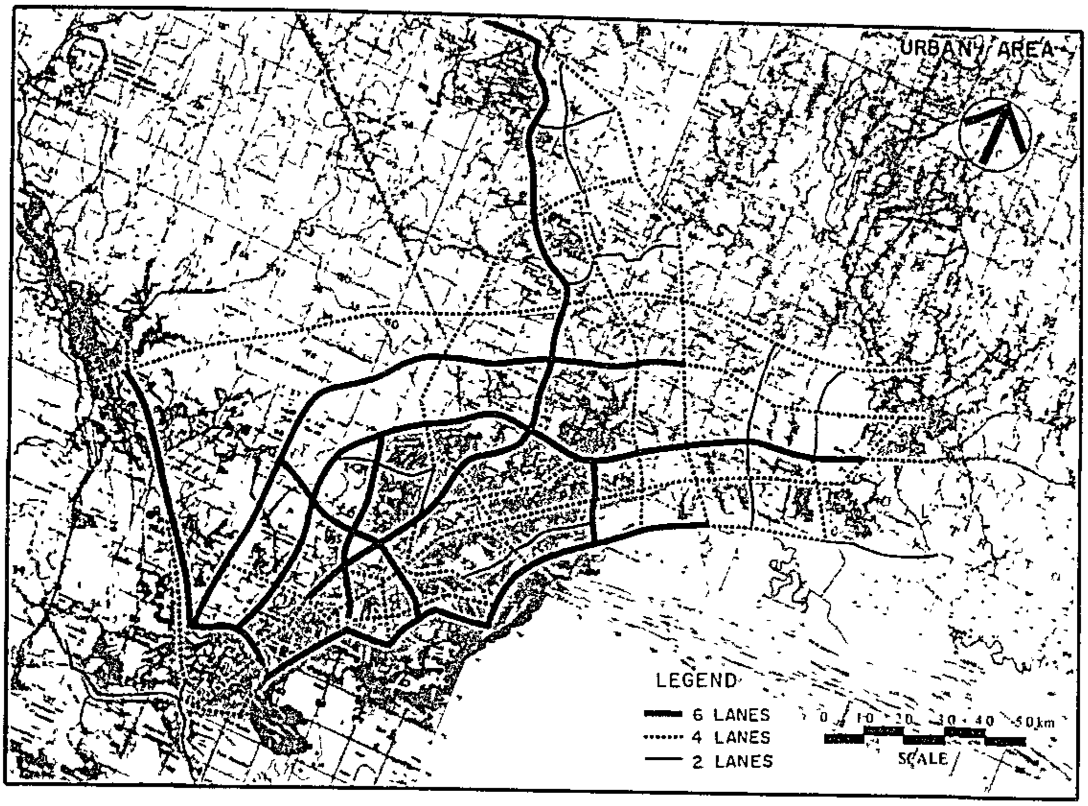


FIG. 10-2 NETWORK AND TRANSPORTATION PROJECTS : ALTERNATIVES 1 & 2 IN SUBURBAN AND RURAL AREAS



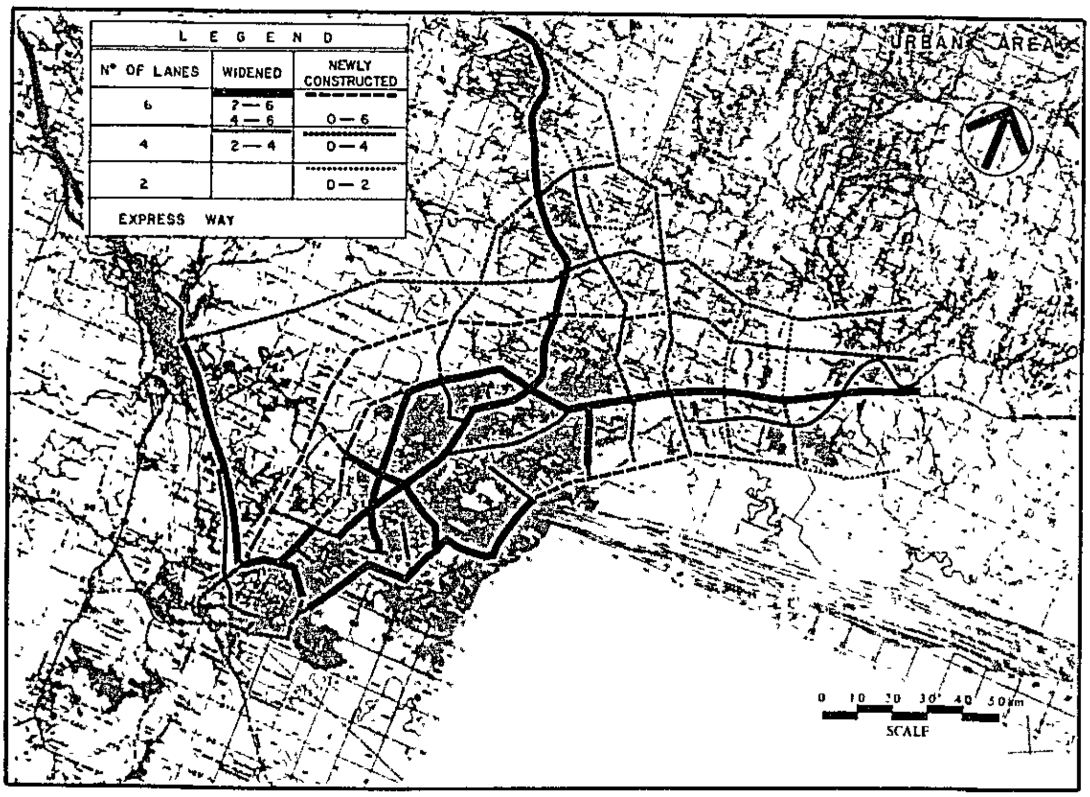
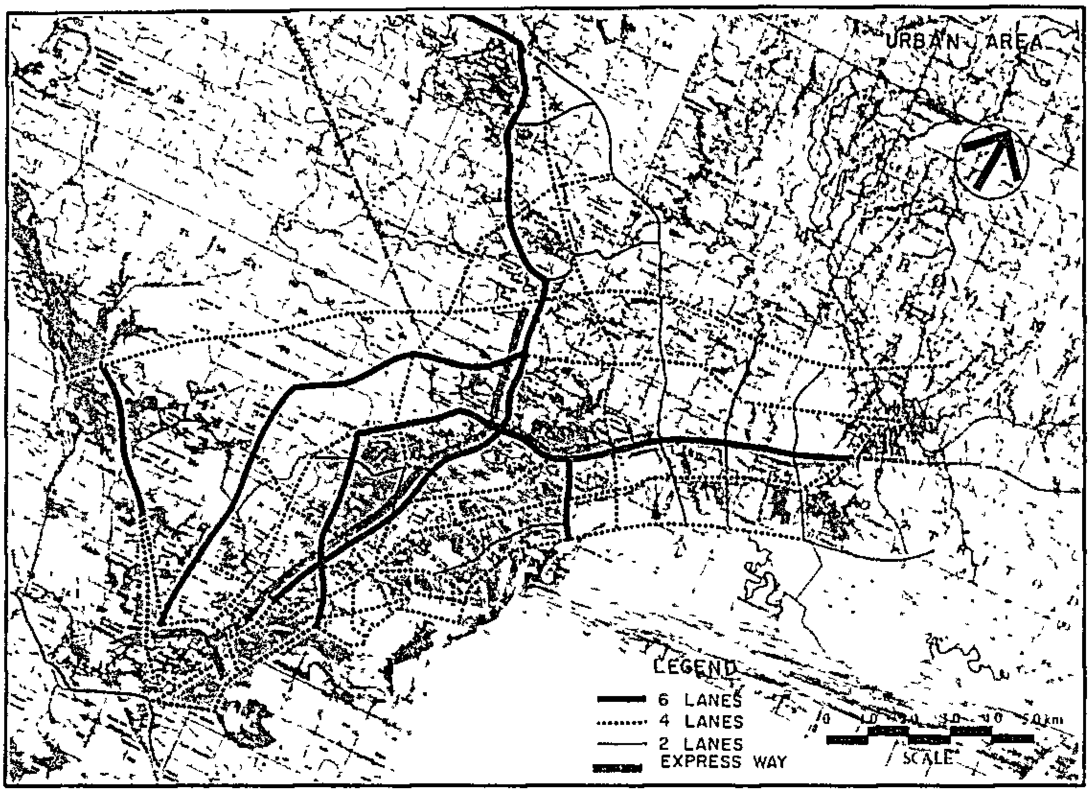


FIG. 10-3 NETWORK AND TRANSPORTATION PROJECTS : ALTERNATIVE A IN URBAN AREA



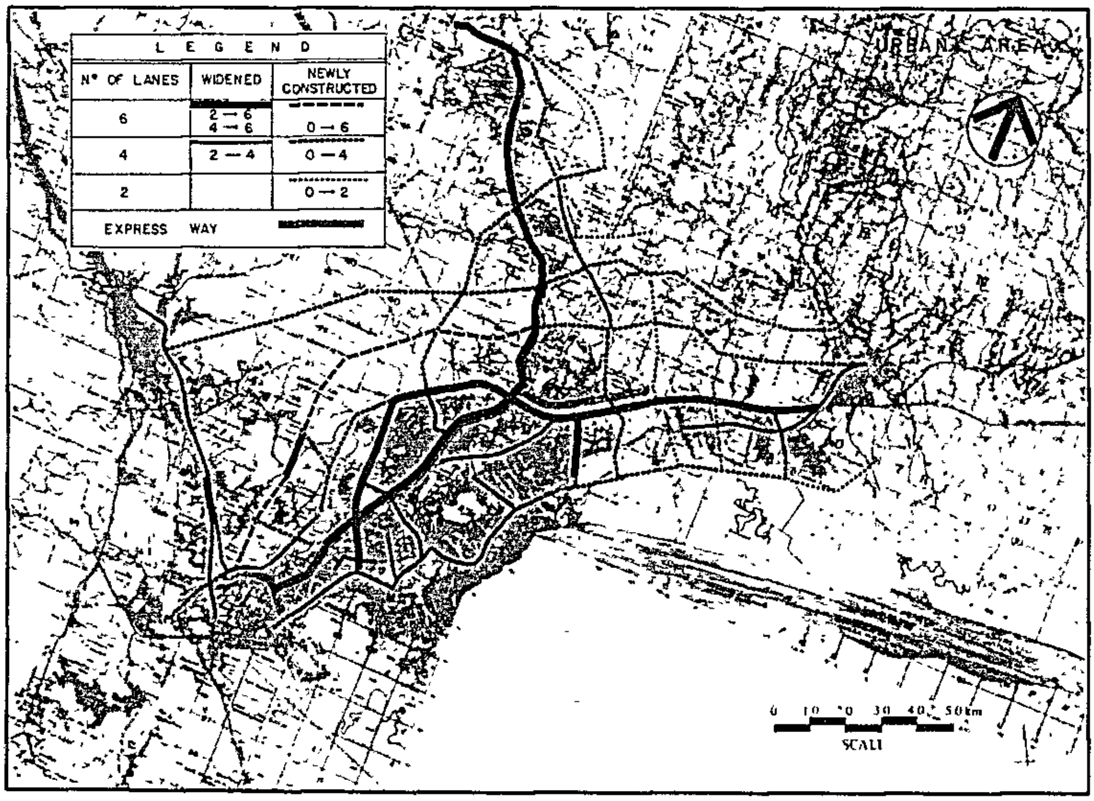
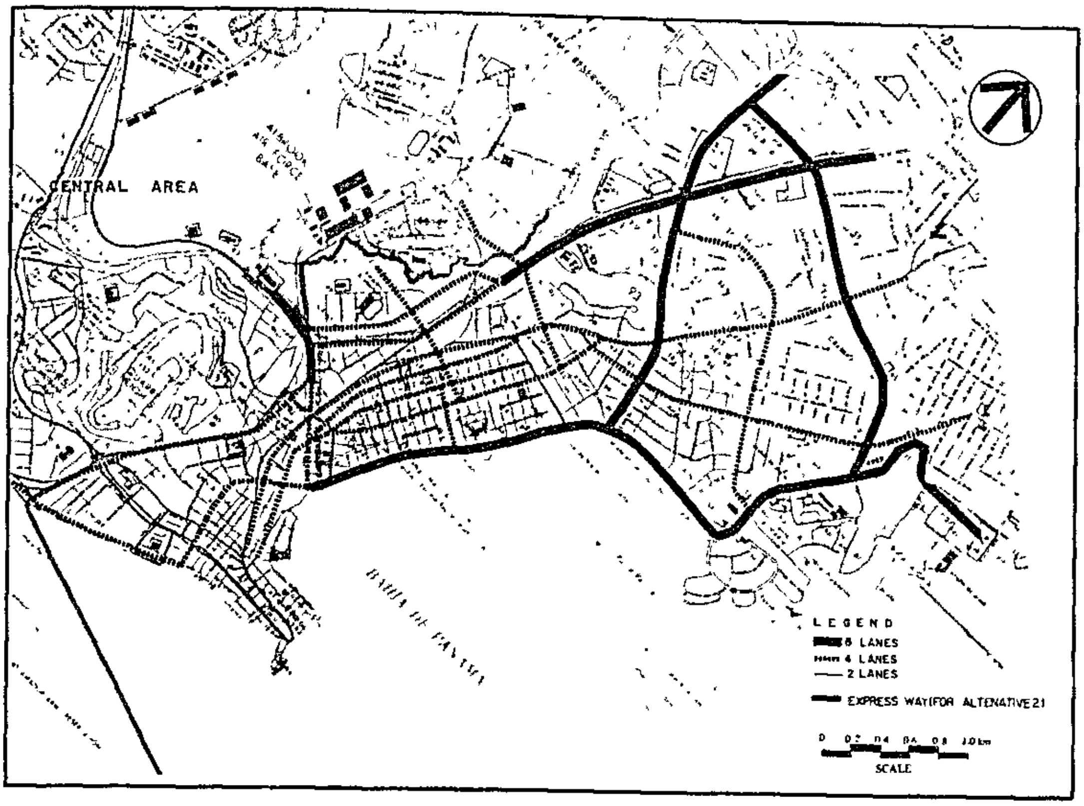


FIG. 10-4 NETWORK AND TRANSPORTATION PROJECTS ALTERNATIVE (2) (3) IN URBAN AREA



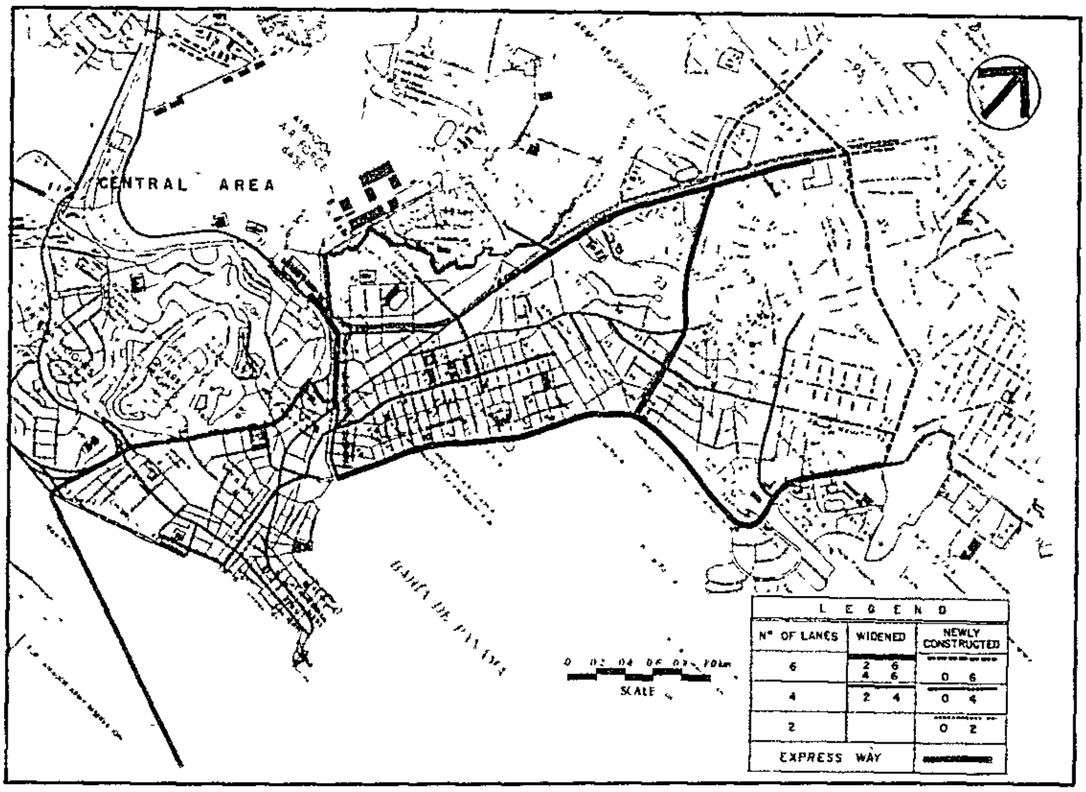
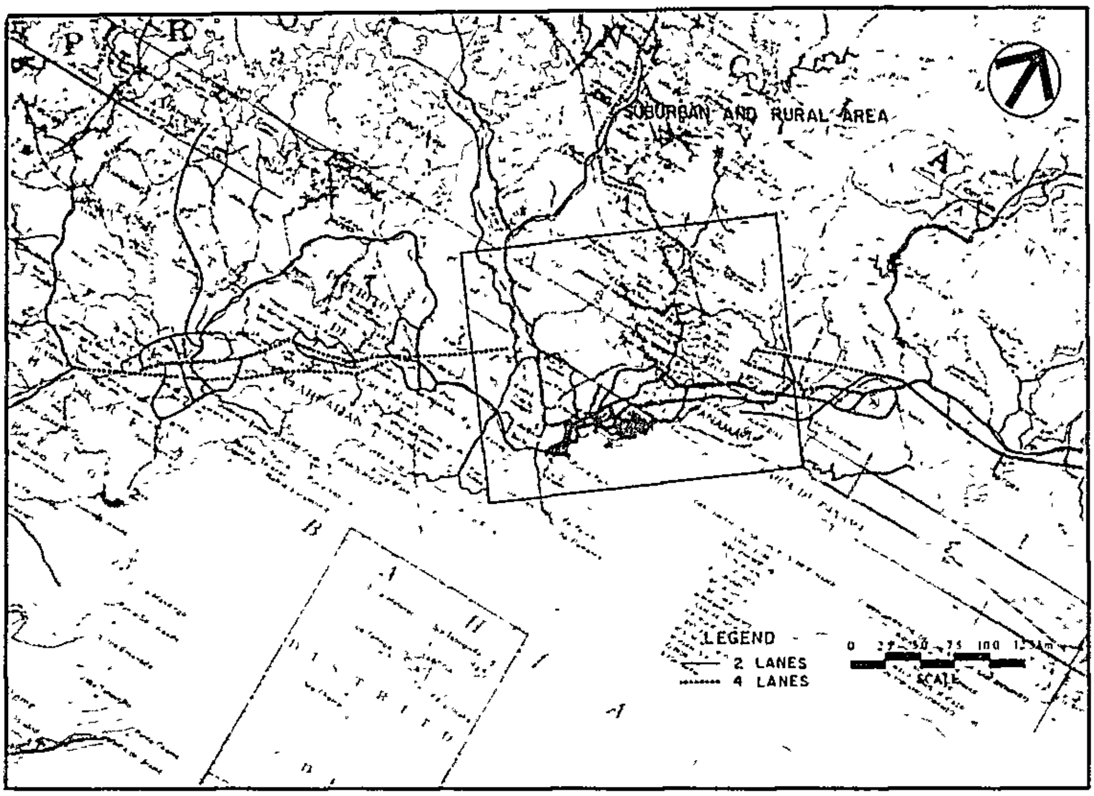


FIG. 10-5 NETWORK AND TRANSPORTATION PROJECTS : ALTERNATIVE 1 IN CENTRAL AREA



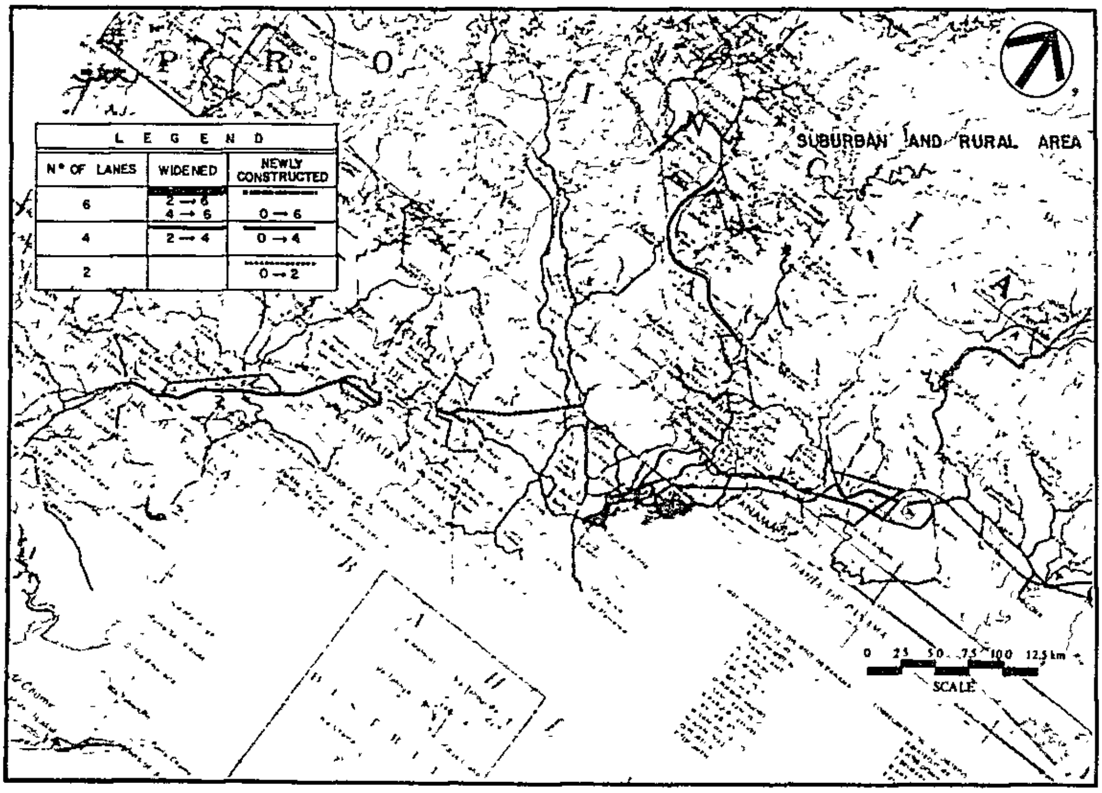
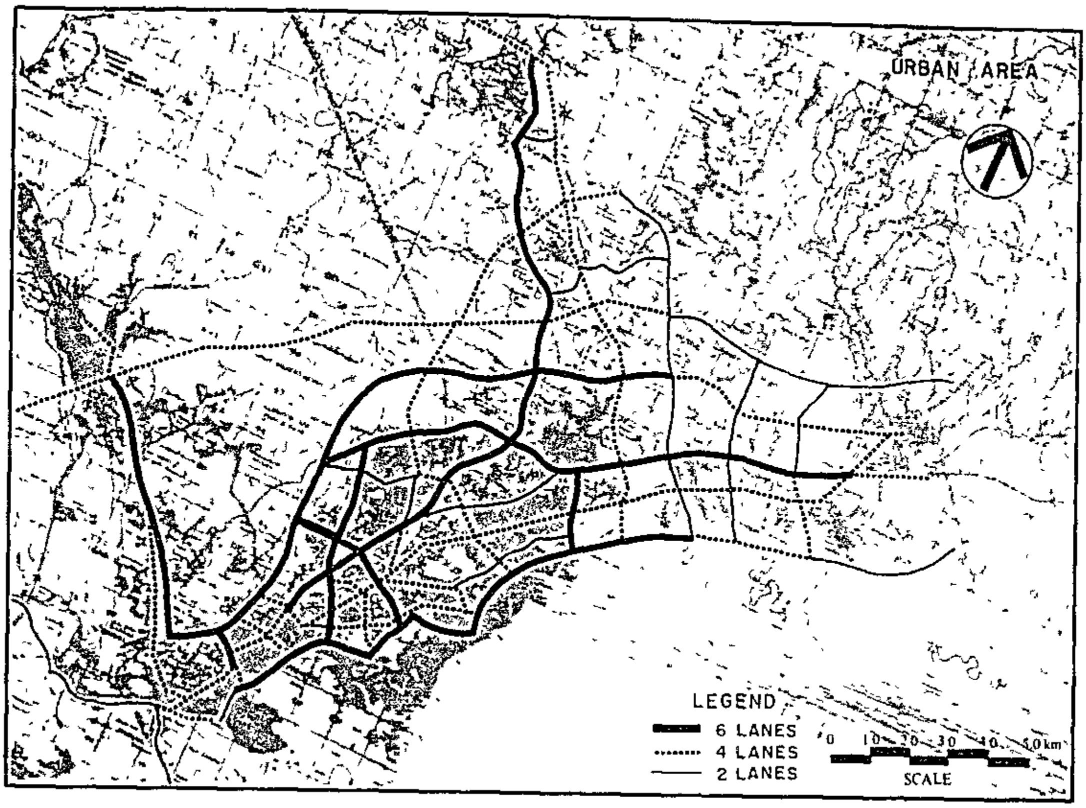


FIG. 10-6 NETWORK AND TRANSPORTATION PROJECTS – ALTERNATIVE 3, 4 & 5 IN SUBURBAN AND RURAL AREA



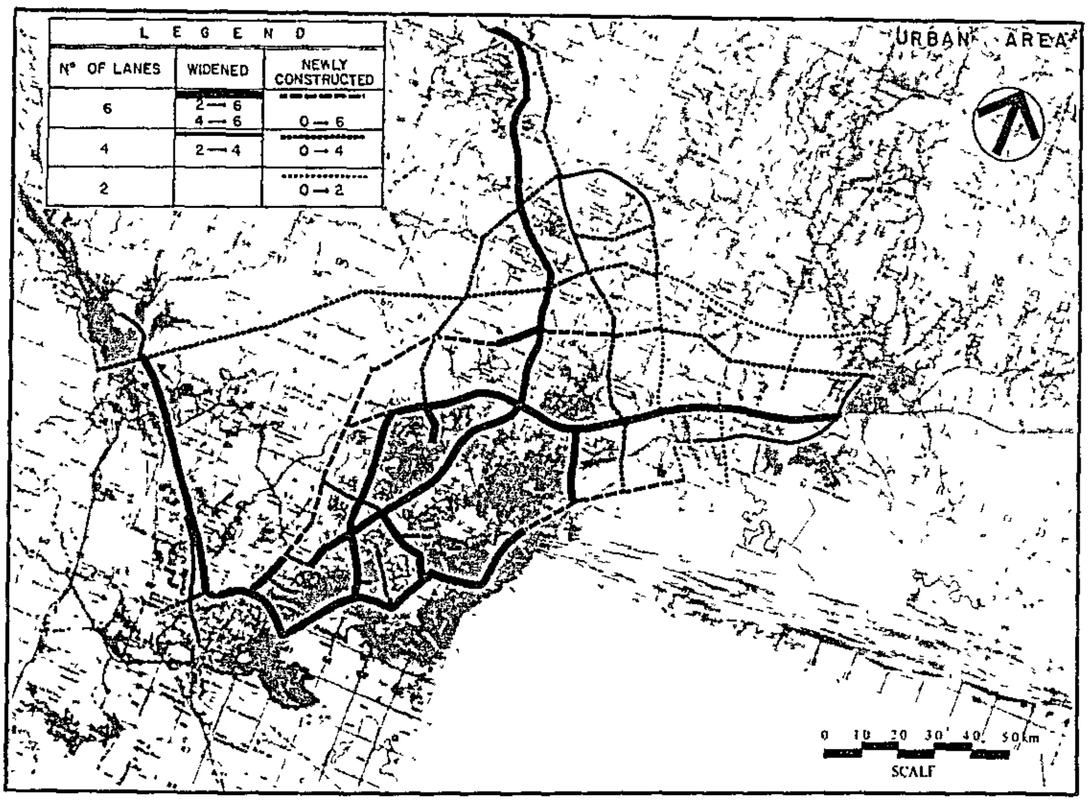
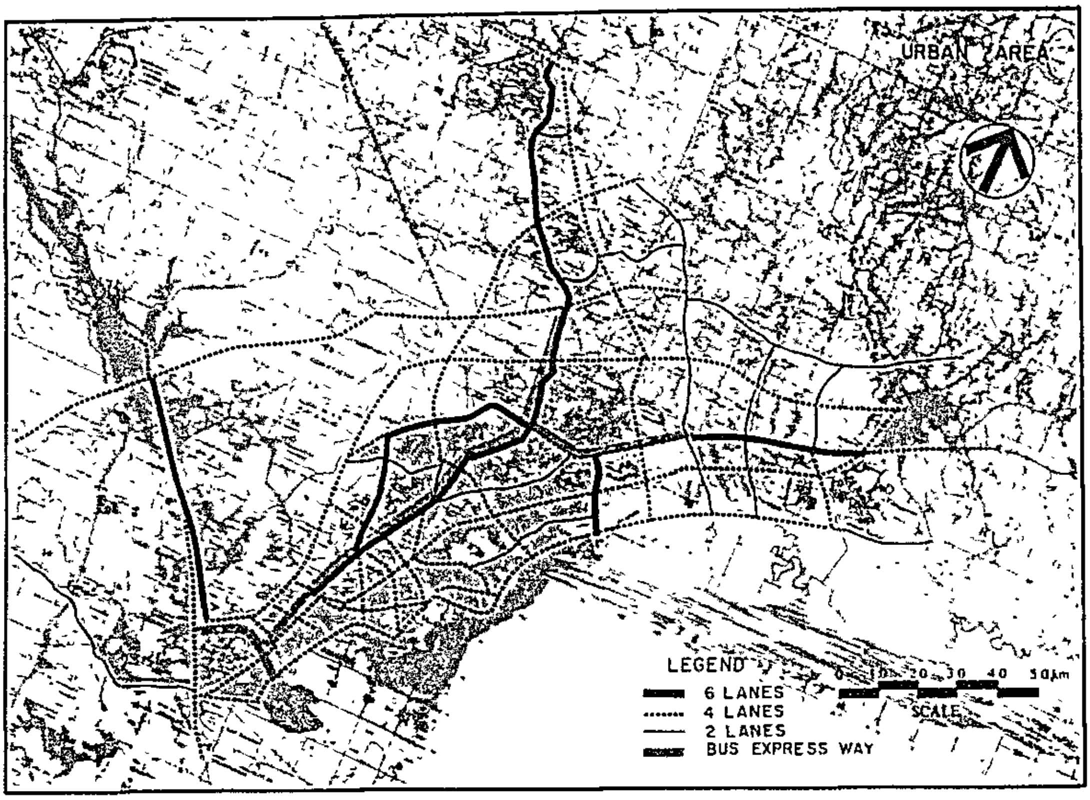


FIG. 10-7 NETWORK AND TRANSPORTATION PROJECTS – ALTERNATIVE 3 IN URBAN AREA



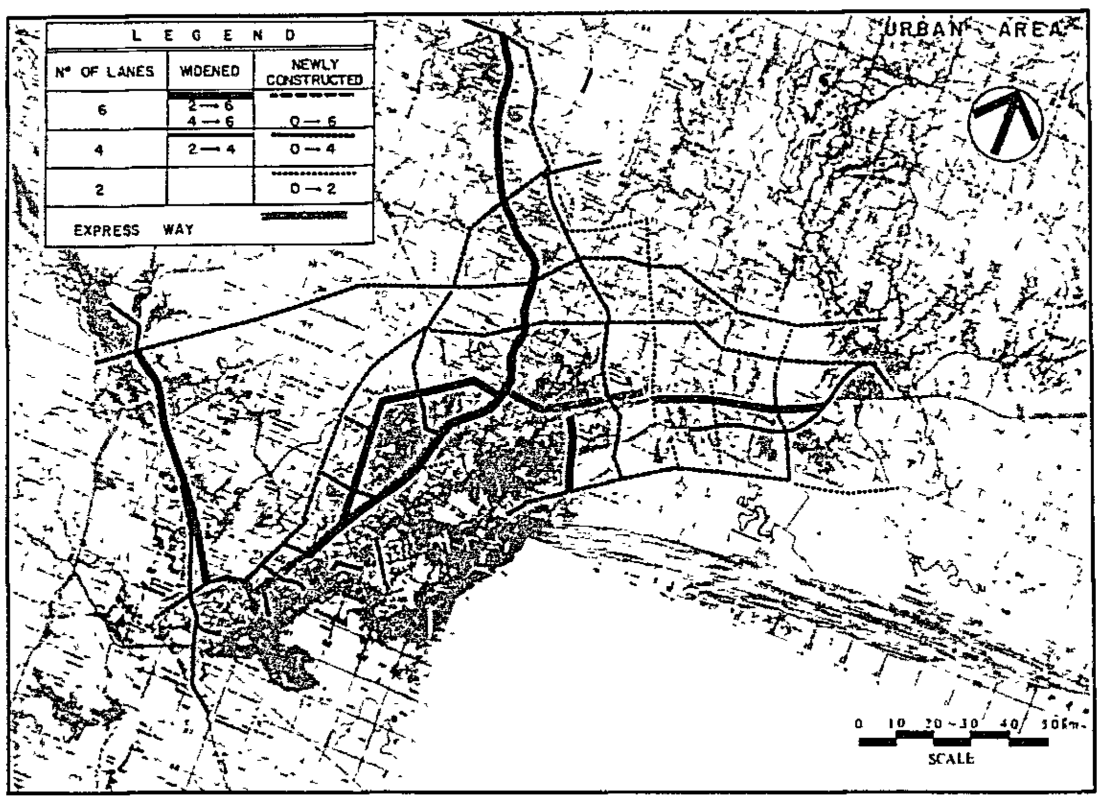


FIG. 10-8 NETWORK AND TRANSPORTATION PROJECTS : ALTERNATIVE 4 IN URBAN AREA

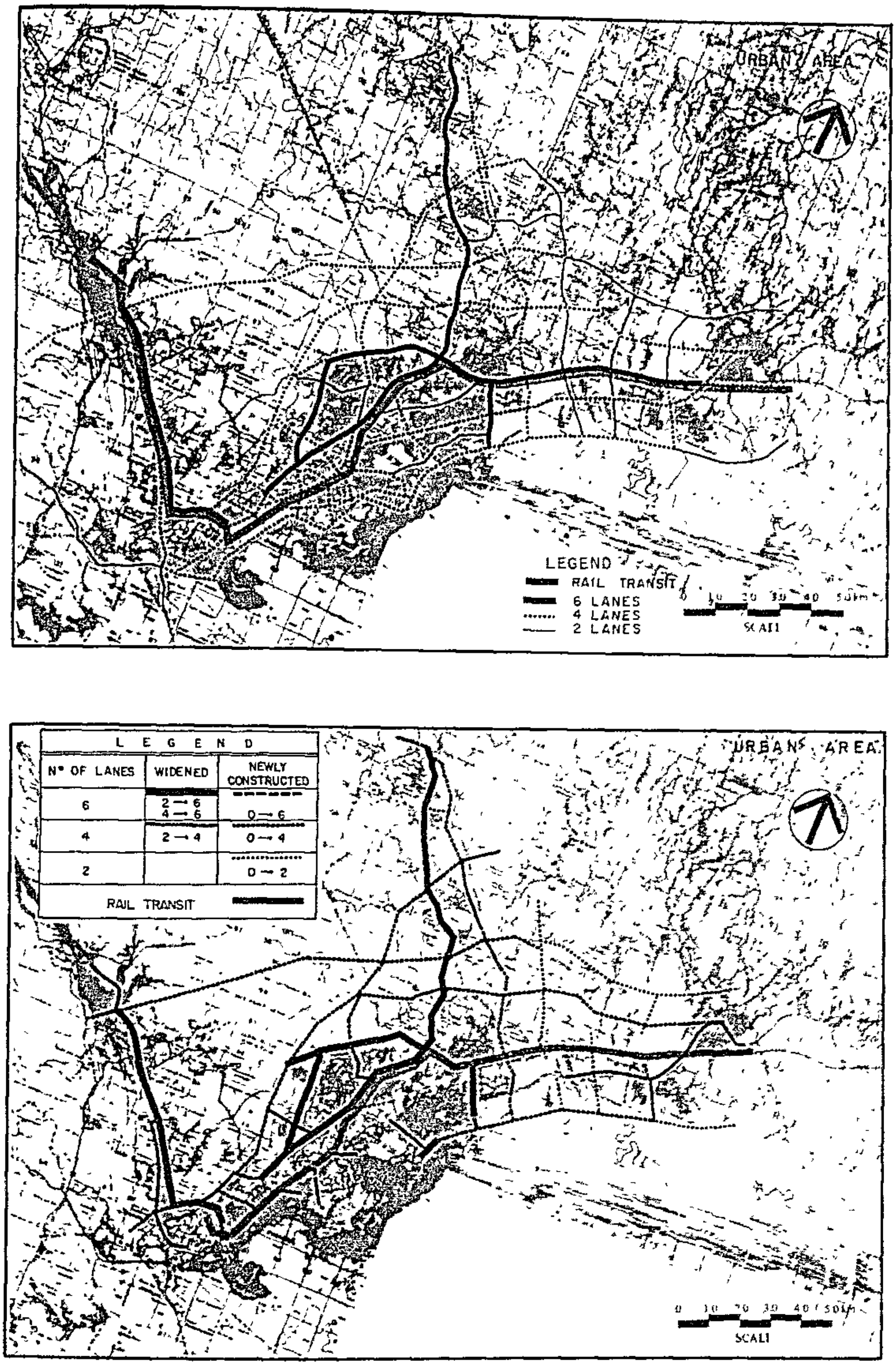
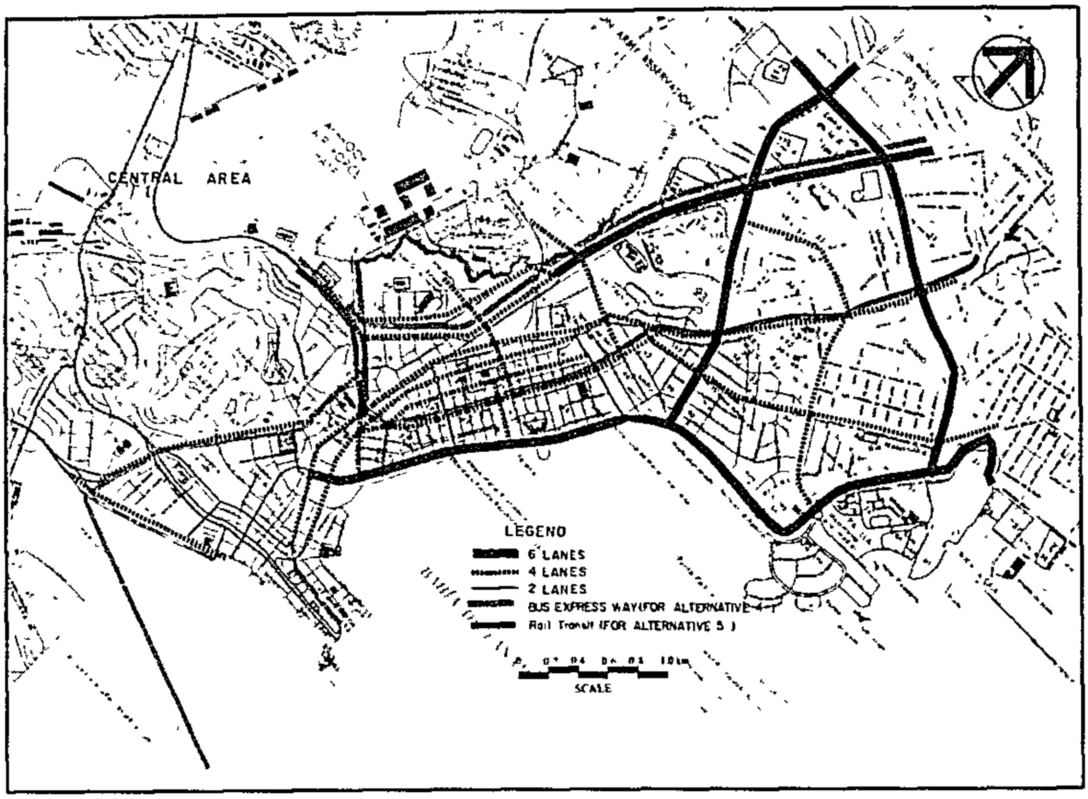


FIG. 10-9 NETWORK AND TRANSPORTATION PROJECTS : ALTERNATIVE 5 IN URBAN AREA



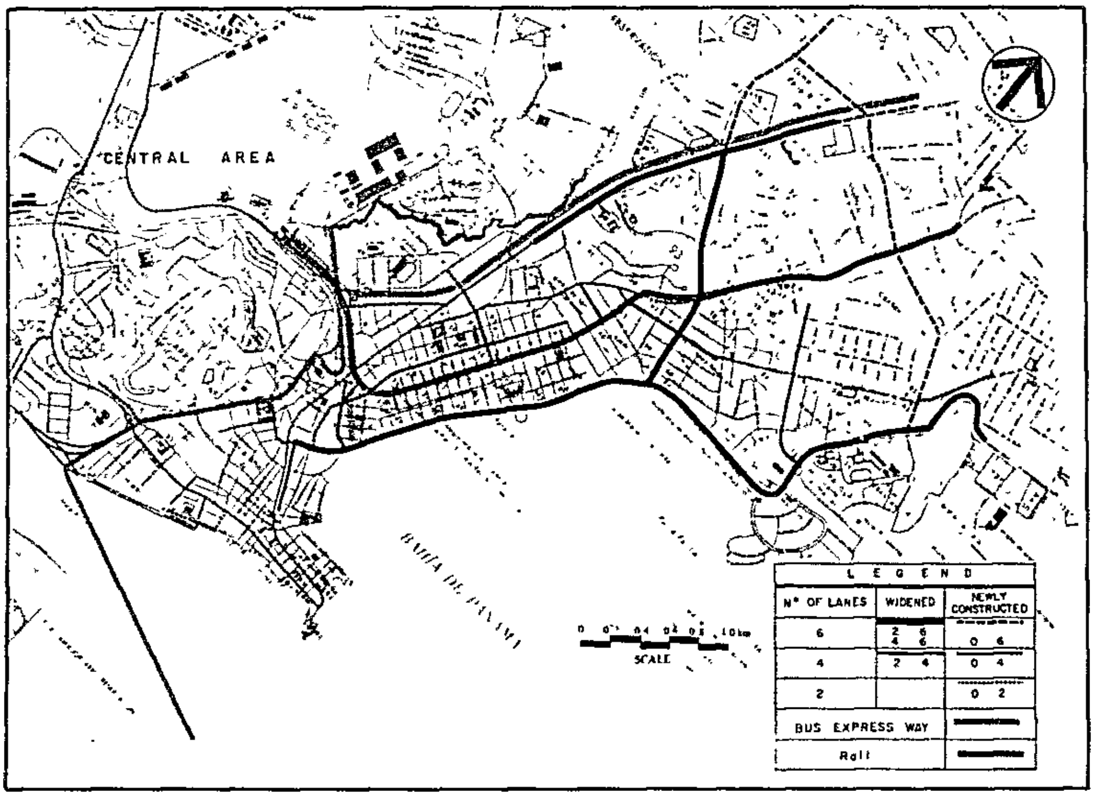


FIG. 10-10 NETWORK AND TRANSPORTATION PROJECTS : ALTERNATIVE 3, 4 AND 5 IN URBAN AREA

TABLE 10-2 COSTS OF EACH ALTERNATIVE

(Million Balboas)

	Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5	
	Economic Cost	Financial Cost	Economic Cost	Financial Cost	Economic Cost	Financial Cost	Economic Cost	Financial Cost	Economic Cost	Financial Cost
Road	401.1	444.7	382.6	426.3	347.4	385.1	355.9	395.9	296.2	328.3
Intersection	81.2	89.4	60.8	66.9	76.5	84.1	46.0	50.6	41.0	45.0
Land	–	28.1	–	25.1	–	18.8	–	18.4	–	15.0
Compensation	47.6	47.6	45.1	45.1	22.2	22.2	18.2	18.2	16.9	16.9
Sub Total	529.9	609.8	488.5	563.4	446.1	510.2	420.1	482.9	354.1	405.2
Express Way	–	–	244.0	268.4	–	–	244.0	268.4	–	–
Rail Way	–	–	–	–	–	–	–	–	335.6	442.2
Total	529.9	609.8	732.5	831.8	446.1	510.2	664.1	751.3	752.6 (689.7*)	487.4
	New Road Construction 145.4 Km		New Road Construction 164.4 Km		New Road Construction 123.9 Km		New Road Construction 149.0 Km		New Road Construction 128.4 Km	
	Existing Road Widening		Existing Road Widening		Existing Road Widening		Existing Road Widening		Existing Road Widening	
	2 → 4** 113.0 Km		2 → 4** 117.8 Km		2 → 4** 141.8 Km		2 → 4** 138.2 Km		2 → 4** 121.6 Km	
	2 → 6 61.6 Km		2 → 6 53.3 Km		2 → 6 155.8 Km		2 → 6 19.1 Km		2 → 6 14.3 Km	
	4 → 6 41.5 Km		4 → 6 29.5 Km		4 → 6 41.5 Km		4 → 6 27.7 Km		4 → 6 20.1 Km	
			Express Way 20.9 Km				Express Way 20.9 Km		Rail Way 24.8 Km	

Source : ESTAMPA

* Excluding Rolling Stock
** Lanes

3) Transportation Demands on Alternative Network

Alternative transportation networks are evaluated from a transportation planning standpoint by assigning to each network the motor traffic demand estimated through the modal split of total transportation demand. The results obtained from this traffic assignment constitute fundamental indicators for economic evaluation accomplished in the next sub-Chapter.

The result obtained from assigning traffic to each of the alternative transportation networks are presented in Fig. 10-11~16 and a summary thereof in Table 10-3.

TABLE 10-3 RESULT OF TRAFFIC ASSIGNMENT ON ALTERNATIVE NETWORKS

	Present Situation	Do Nothing Case	Alternative Network 1	2	3	4	5
Total length of Network (Km)	415	415	568	589	553	553	553
Traffic Load (1000 Veh. Km)	3,651	12,021	10,308	10,335	9,224	9,162	9,112
Total Travel Time (1000 Veh. H)	218	2,087	533	577	473	478	478
Average Travel Speed (Km/H)	16.8	5.8	19.3	17.9	19.5	19.2	19.0
Average Congestion Rate (Whole Area)	0.5	1.8	0.6	0.6	0.6	0.6	0.6
Average Congestion Rate (Zone 1~10)			0.7	0.7	0.7	0.8	0.7
Total Length of Congested Section (Km)							
Congestion Rate 1.0 or more	54	249	126	122	137	128	130
Congestion Rate 1.5 or more	21	197	8	9	8	13	9
Traffic Volume on Congested Sections (1000 Veh·Km)							
Congestion Rate 1.0 or more	1,287	10,930	4,405	4,421	4,408	4,164	4,206
Congestion Rate 1.5 or more	702	10,209	1,486	1,785	1,254	1,286	1,307

Source : ESTAMPA

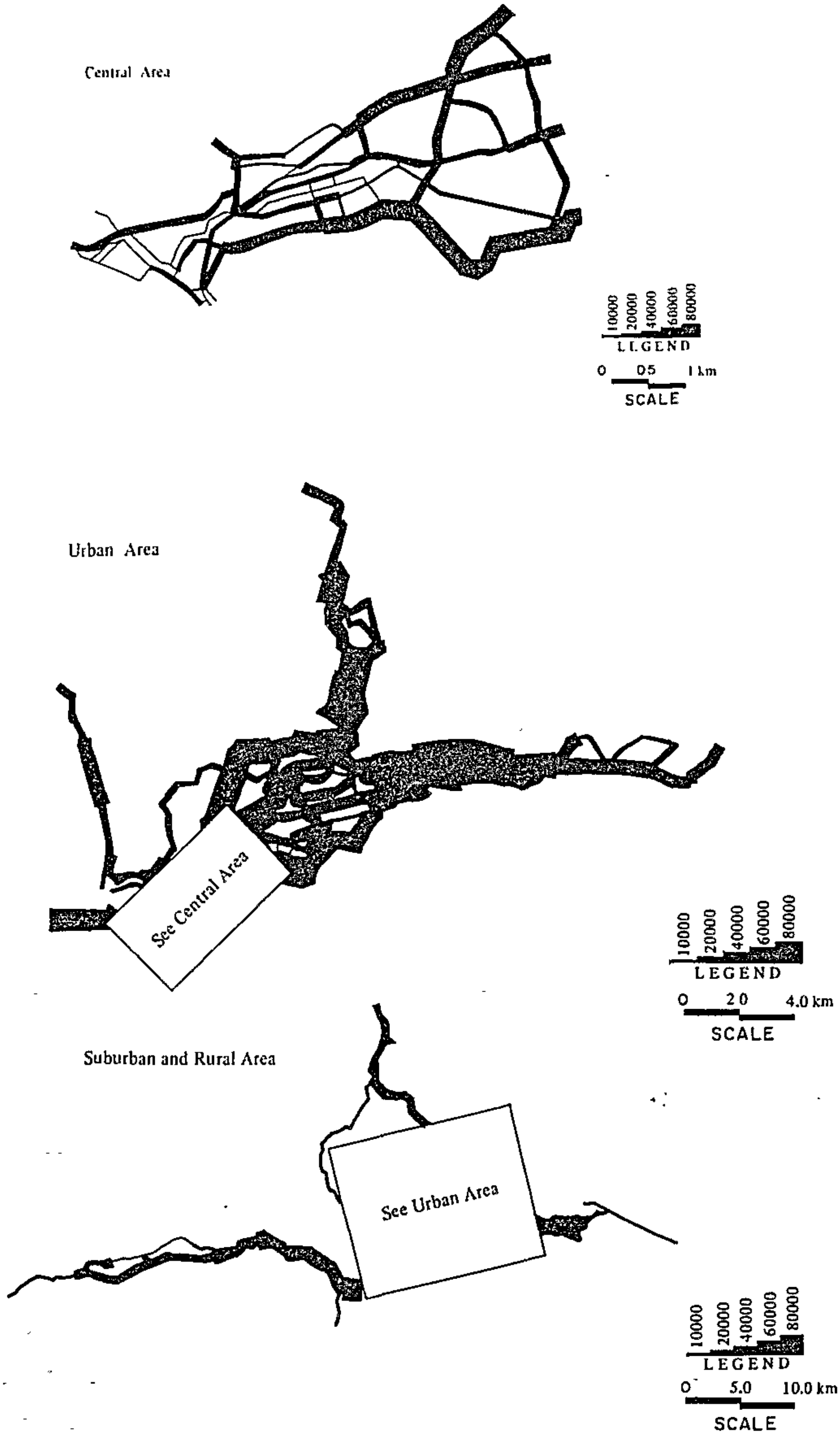


FIG. 10-11 ASSIGNED TRAFFIC VOLUME ONTO EXISTING NETWORK

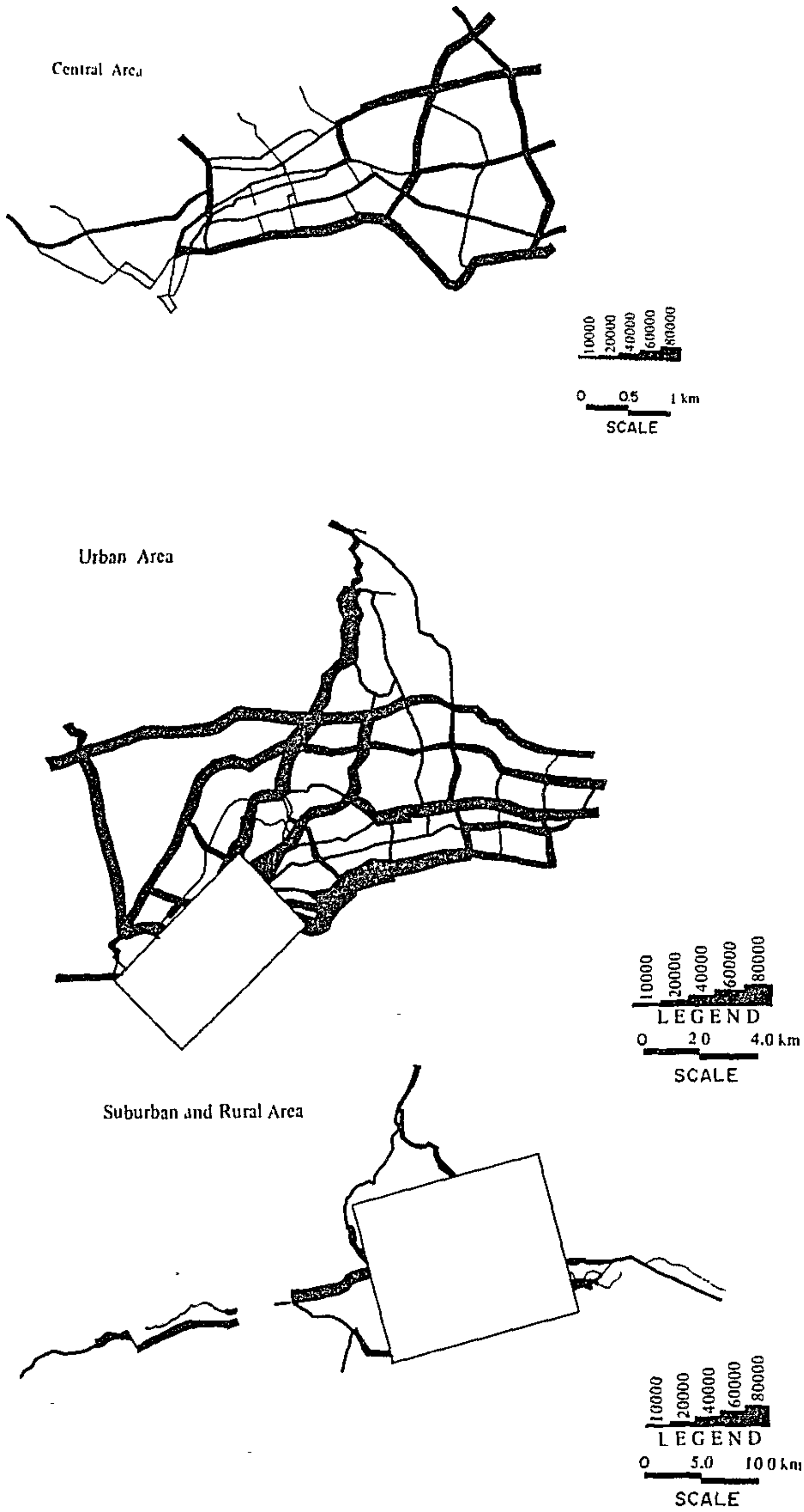
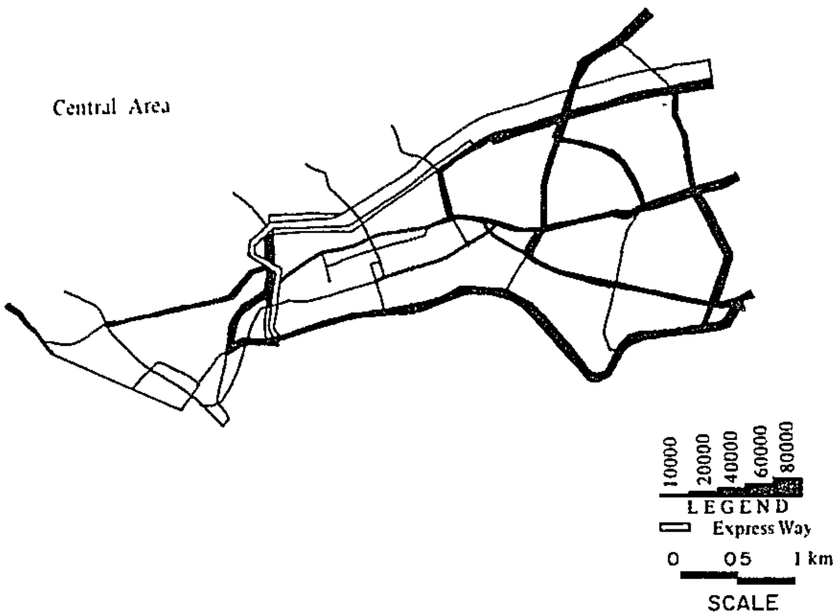


FIG. 10-12 ASSIGNED TRAFFIC VOLUME – ALTERNATIVE 1



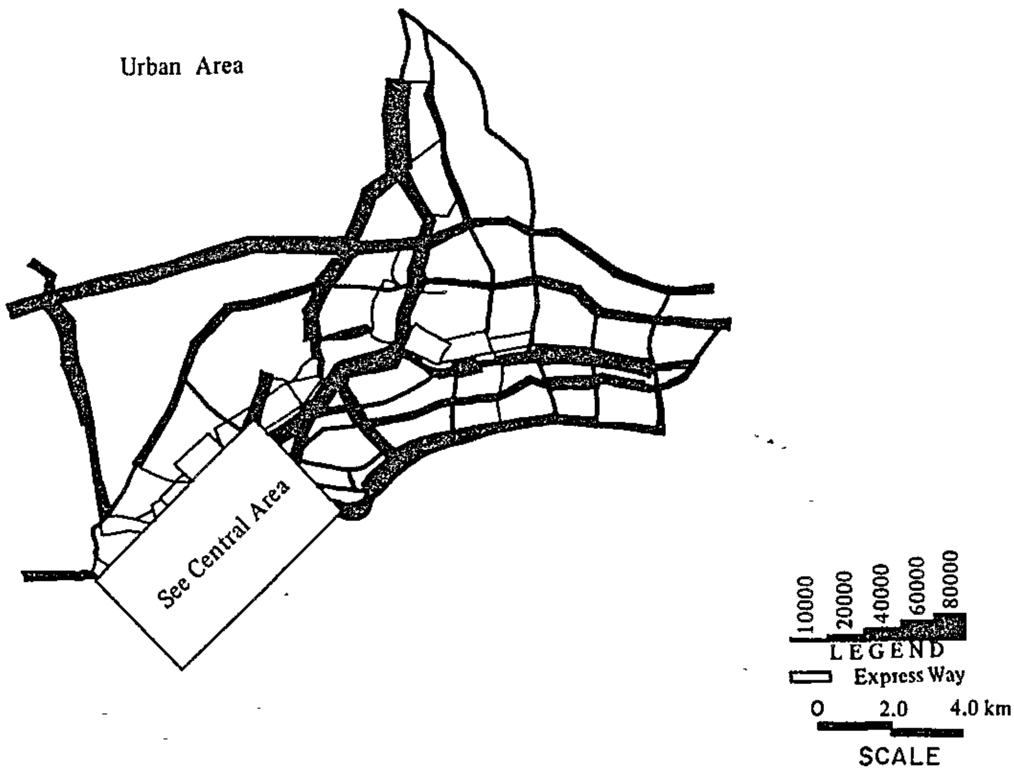


FIG. 10-13 ASSIGNED TRAFFIC VOLUME – ALTERNATIVE 2

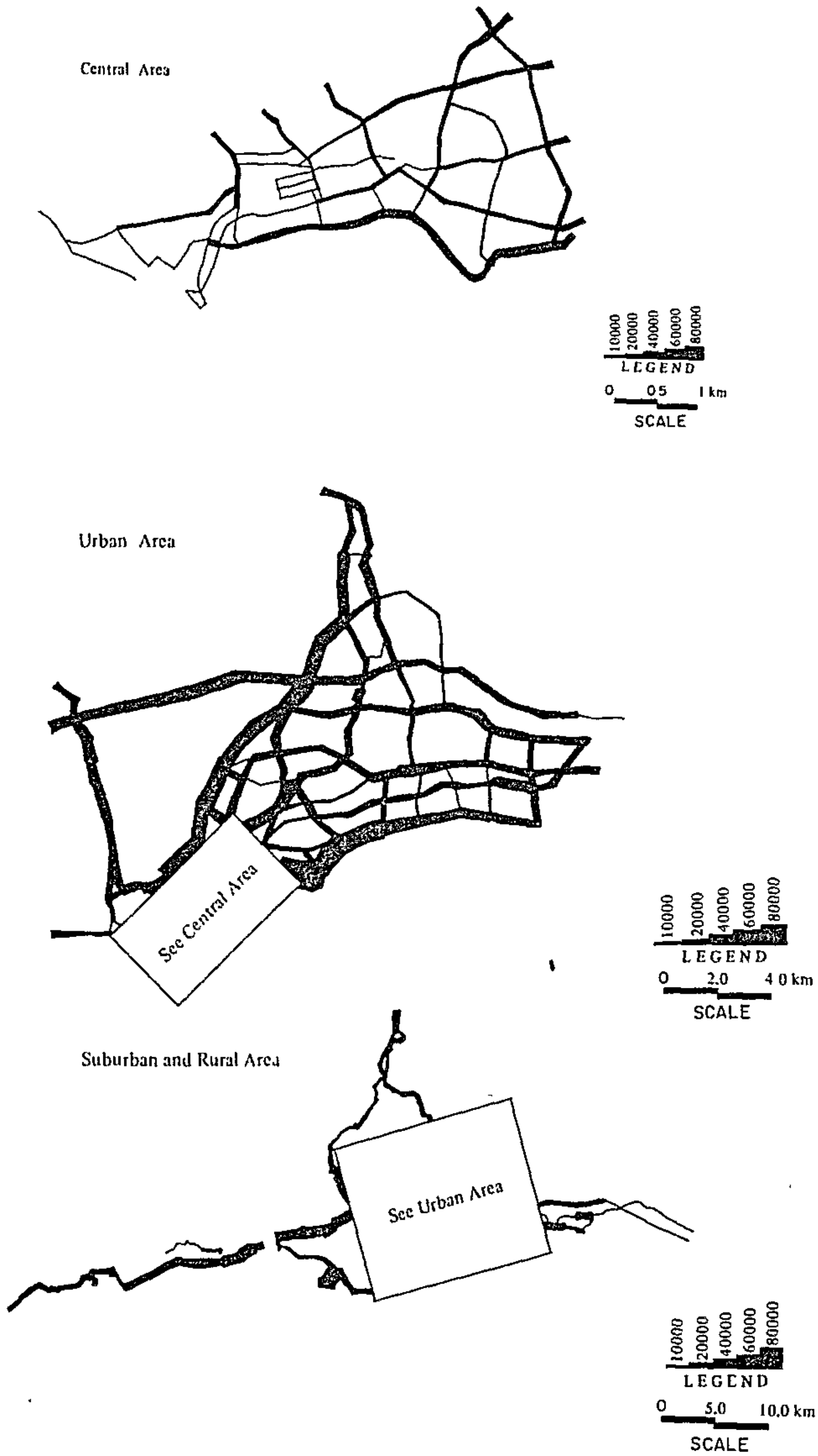
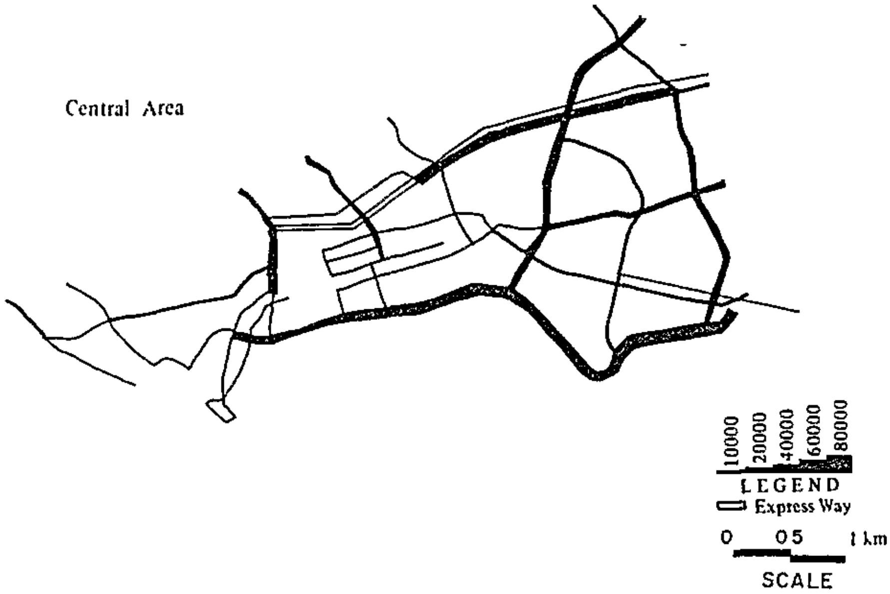


FIG. 10-14 ASSIGNED TRAFFIC VOLUME – ALTERNATIVE 3



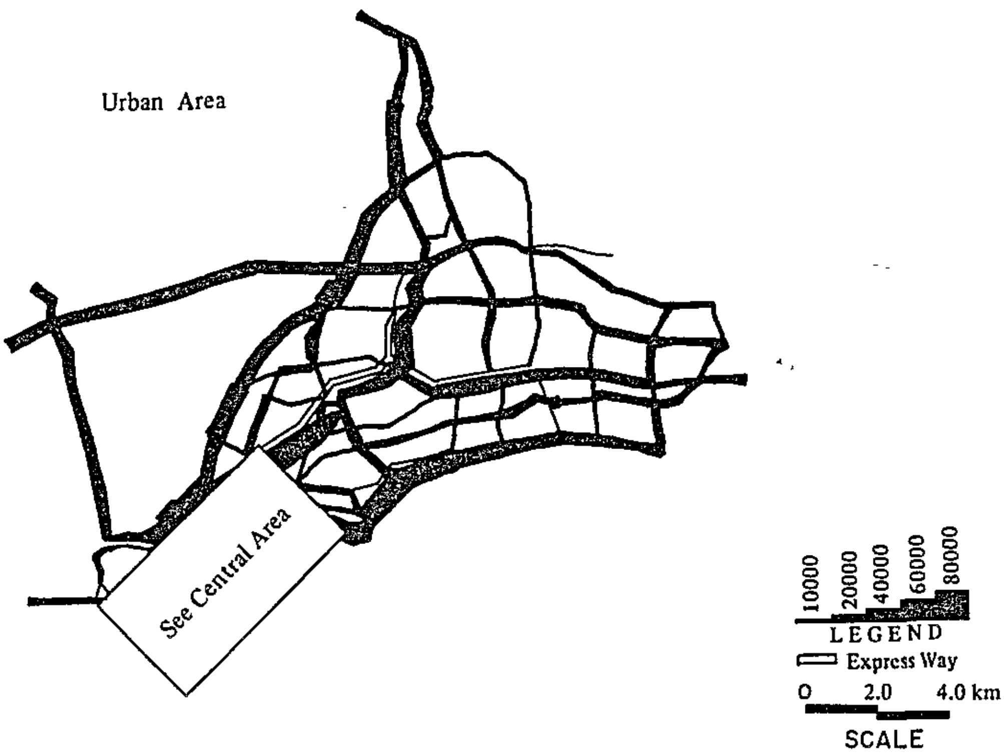


FIG. 10-15 ASSIGNED TRAFFIC VOLUME – ALTERNATIVE 4

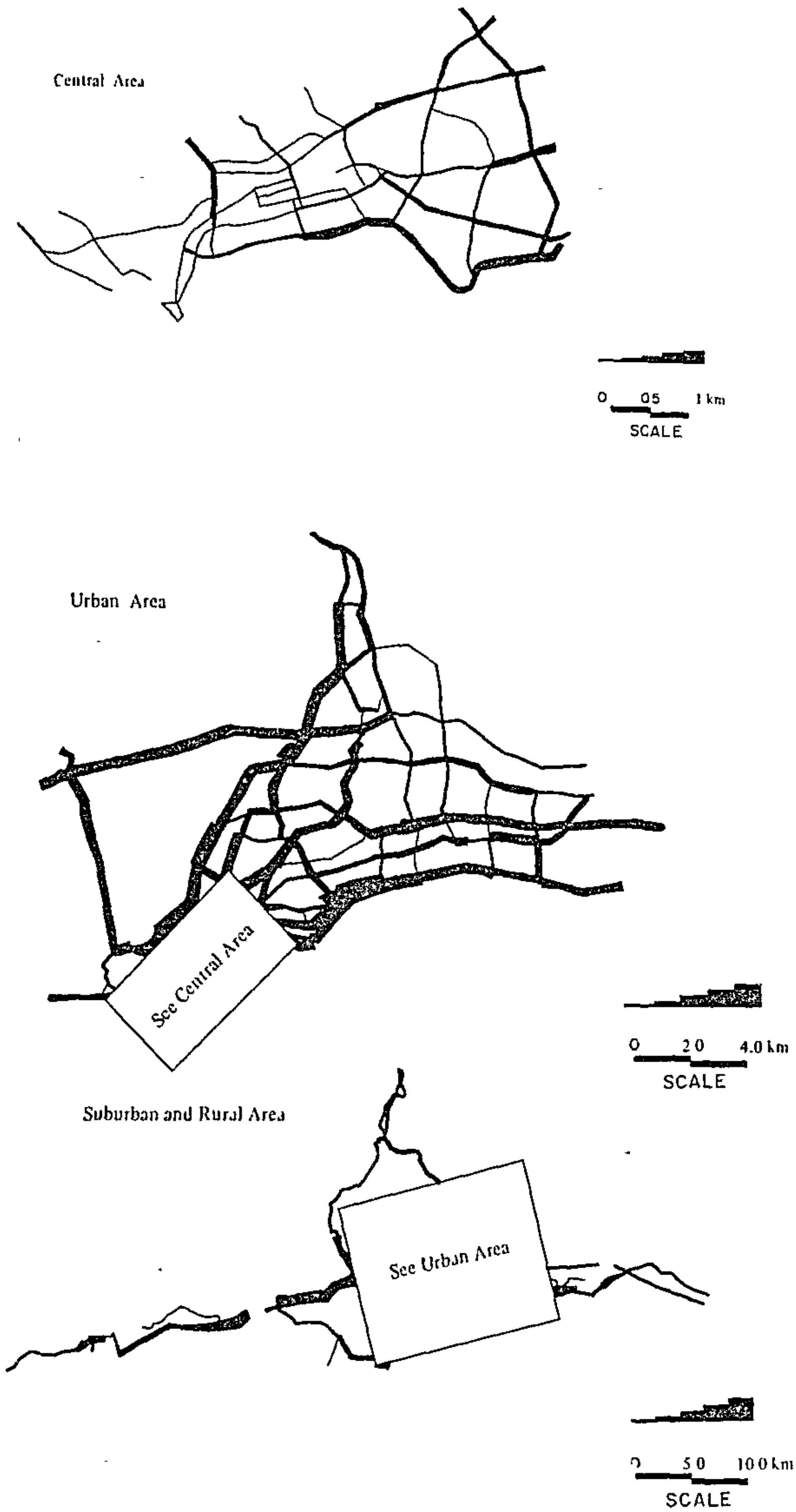


FIG. 10-16 ASSIGNED TRAFFIC VOLUME – ALTERNATIVE 5

The provision of the same level of service, in terms of congestion ratio, as presently provided was also aimed at in formulating the alternative networks. As a result, the alternatives similarly show an overall congestion ratio of 0.5 to 0.6 and a ratio of 0.7 to 0.8 even in Centro (I) and Bella Vista (II) Zones, which is in the proximity of the current Study Area ratio of 0.5.

Because these alternatives generally offer the same level of service, evaluation will have to be based chiefly on the comparison of cost items instead of the level of service.

Items for the evaluation of traffic assignment are as follows:

The car-restrictive Alternatives (3,4, and 5) show 12% to 13% lower total vehicle-kilometers than the non-car-restrictive Alternatives (1 and 2). Th same is true with total travel time. This is because the number of car trips is repressed through policy measures in the case of the car-restrictive Alternatives. As far as these indicators are concerned, the introduction of a rail transit system (Alternative 5) is relatively favorable.

The Alternatives except for Alternative 2 equally show an average travel speed of about 19 kilometers per hour, some two kilometers per hour improvement over the present speed of 16.8 kilometers per hour, which shows that service is improved under the Alternatives. The average travel speed is an unfaborable 17.9 kilometers per hour under the non-car-restrictive, central axis enhancement-type Alternative (2).

The length of congested road sections will be greater under the car-restrictive Alternatives than under the non-car-restrictive Alternatives, because under the former bus lanes are to be installed in sacrifice of general use lanes resulting in a reduced capacity for general traffic. However, the volume of traffic in the congested sections will be smaller under the car-restrictive Alternatives.

The modal shares of person-trips under each Alternative are presented in Table 10-4, and such shares of vehicle-trips are presented in Table 10-5. A review of these Tables indicates that the share of cars in the all-mode total of person-trips will rise by four to five points, even under a fairly stern restrictive policy on cars. On the other hand, the share of public transports will fluctuate by one point downward under the non-car-restrictive Alternatives and upward under the car-restrictive Alternatives, with the highest share obviously being under Alternative 5 due to the introduction of rail transit system.

The effect of a car-restrictive policy can be seen by an estimated reduction of car-trips by 42,000 PCU under the road-widening Alternative (3) an by 48,000 P.C.U. under the central axis enhancement Alternative.

A smaller number of public transport vehicle-trips under the car-restrictive Alternatives than under the non-car-restrictive Alternatives is attributable to the introduction of larger buses, which will mean a greater average number of passengers per bus.

TABLE 10-4 MODAL SHARE OF PERSON TRIP BY ALTERNATIVES

Mode	PRESENT		1		2		3		4		5	
	No. of Trip	Share	No. of Trip	Share	No. of Trip	Share	No. of Trip	Share	No. of Trip	Share	No. of Trip	Share
1. Walk, 2 Wheelers	330,006	22.4%	615,880	19.5%	616,465	19.5%	612,664	19 6%	612,324	19.6%	611,749	19.6%
2. Car	395,895	26.9	1,018,340	32.2	1,022,786	32.4	955,570	30.5	950,491	30.4	946,704	30.2
3. Truck	102,297	6.9	214,679	6.8	215,440	6 8	203,626	6 5	203,216	6.5	202,646	6.5
4. Taxi	71,120	4.8	118,077	3.7	118,847	3.8	108,831	3.5	108,197	3.4	107,594	3 4
5. Bus-Chiva (Public)	509,013	34.5	1,060,377	33.6	1,053,785	33.4	1,116,762	35.7	1,124,504	35.9	1,130,060	36.1
6. Bus (Private)	65,359	4.4	130,824	4.1	130,854	4.1	131,310	4.2	130,031	4 2	130,010	4.2
7. Total	1,473,690	100.0	3,158,177	100.0	3,158,177	100.0	3,128,763	100.0	3,128,763	100.0	3,128,763	100.0

TABLE 10-5 MODAL SHARES OF VEHICLE TRIP BY ALTERNATIVE NETWORKS

Mode	PRESENT		1		2		3		4		5	
	No. of Vehicle	Share	No. of Vehicle	Share	No of Vehicle	Share	No. of Vehicle	Share	No. of Vehicle	Share	No. of Vehicle	Share
1. Car	265,700	54.2%	683,436	61.5%	686,386	61.5%	641,289	62.7%	637,897	62 6%	635,343	62 6%
2. Truck	87,700	17.9	181,586	16 3	182,226	16.3	172,465	16 9	171,890	16 9	171,409	16.9
3. Taxi	91,179	18.6	151,382	13.6	152,364	13 7	139,545	13 6	138,733	13.6	137,956	13.6
4. Bus-Chiva (Public)	37,752	7.6	78,477	7.1	77,997	7.0	53,121	5.2	53,491	5.3	53,759	5.3
5. Bus (Private)	8,170	1.7	16,436	1.5	16,446	1.5	16,511	1 6	16,347	1 6	16,343	1.6
7. Total	490,587	100.0	1,111,317	100.0	1,115,419	100.0	1,022,708	100.0	1,018,358	100 0	1,014,810	100 0

Source: ESTAMPA

4) *Economic Evaluation of Alternatives*

In order to assess the economic efficiency of the alternative traffic networks, the so-called cost-benefit analysis was accomplished. In this analysis, investment schedule, traffic demands in mid-term years, and other necessary inputs are not yet available at the planning stage and therefore, had to be necessary roughly assumed. The appropriateness of such assumptions will be tested through the cost-benefit analysis of the final traffic network masterplans, but the assumptions must at this time remain merely "plausible" assumptions. For this reason, the result of cost-benefit analysis should be understood merely as a tool for comparing the economic efficiencies of the alternatives, and not as absolute values.

(1) Evaluation Method

Evaluation indices are set through the comparison of economic cost and benefit which will accrue up to the year 2000. The basic concept is explained as follows:

a) The cost consists of traffic facilities construction/improvement investments and their maintenance expense. The cost is calculated as economic cost by deducting materials and equipment import tax, transaction tax, enterprise tax, and other taxes from financial cost. Economic cost is from 85 to 90% of financial cost in this study.

b) The benefit is conceived of as saving in vehicle operating cost and passenger time resulting from the investment. Here, the savings are calculated as the differences by which total travel cost under each Alternatives is less than that in "do nothing case", that is, in case no investment be made in transportation sector up to the year 2000. This benefit is also calculated using economic cost.

c) Thus, the initial investment and maintenance expenses are calculated as the cost, and operating cost is incorporated into the benefit. Railroad is treated in the same way, and, into the benefit. Railroad is treated in the same way, and, therefore, the entire construction investment, sans rolling stock cost, is regarded as the cost, while the depreciation cost and opportunity cost of rolling stock are incorporated into operating cost.

d) Annual traffic investment is assumed to grow at the same rate as economic growth. In other words, the amount of investment in each year is calculated by the following equation:

$$It = \gamma t I_A = \frac{X(1+X)^{t-1}}{(1+X)^{18-1}} I_A$$

Where: It = Amount of investment in year t (t=0 in 1983)

I_A = Total amount of investments under Alternative A

γt = Total investments in year t

X = Yearly rate of investment increase = Yearly economic growth rate

It should be noted that the amounts of urban expressway and railroad construction cost are too large to be addressed by the above formula, and, therefore, are added afterwards by a separate schedule to its calculated amount.

e) Benefits are calculated up to the year 2000, and benefits to accrue in the next century are not calculated. Therefore, the residual value of investment assets as of the end of this century is deducted from the amount of investment.

$$It = \gamma t I_A \ (1-\alpha t)$$

$$= \gamma t I_A \left\{ 1 - \frac{N-(18-t+0.5)}{N(1+R)^{18-(t-0.5)}} \right\}$$

Where: αt = Rate of residual value in year 2000 of investment in year t

N = durable period for depreciation (30 years)

R = Discount rate (12%)

f) Benefit in the year 2000 is the only benefit which is to be accounted for by the method of b) above.

Year 1982 is the base year for analysis in which neither alternative has been implemented and, therefore, no benefit has accrued. The increments in benefit from 1983 up to the year 2000 can be estimated only on the basis of the result of traffic forecasts for mid-term years and on investment program for each project. The followings are assumed for the time being, because the marginal utility of additional investments usually diminishes, the rate of increase in benefit will also diminish, but, on the other hand, the demand itself will increase yearly and, therefore, yearly increments in benefit is simply assumed to be constant:

$$Bt = \beta t \ B_{A\,2000} = \frac{t}{18} B_{A\cdot 2000}$$

Where: Bt = Benefit in year t

$B_{A\cdot 2000}$ = Benefit in year 2000 under Alternative A

βt = Rate of benefit in year to benefit in year 2000.

g) The costs and benefits thus calculated up to the year 2000 are subjected to a discounted cash flow analysis (discount rate of 12% is used) in order to arrive at the B/C ratio and net present value. Because the cost will increase over a long period of time, unlike in the cases of project evaluation for ordinary feasibility study purposes, internal rate of return will be very large—too large to be suitable as an index for the evaluation of alternative masterplans.

The process of analysis as discussed in the above can be illustrated by a flow chart (see Figure 10-17).

(2) Vehicle Operating Cost

Motor vehicle operating cost consists of running costs, which are variable costs fluctuating in

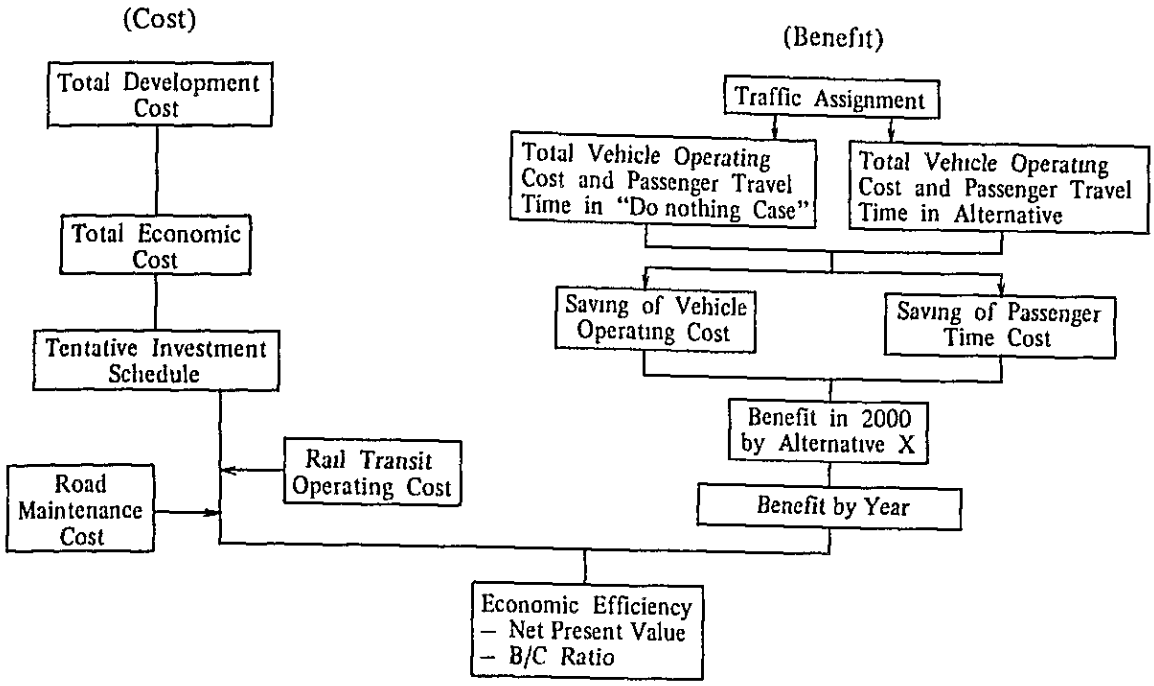


FIG. 10-17 ECONOMIC EVALUATION OF ALTERNATIVES

proportion to vehicle running distance, and fixed costs, which can be expressed in terms of unit costs per vehicle operating time. Vehicle operating cost in Panama in 1981 is estimated in terms of economic cost in Table 10-6 (see Technical Report Vol. 5, for details), with reference to:

a) Autopista Arraijan-Panama, estudio para la seleccion de la alternativa optima de empalme con la Ciudad de Panama, MOP, July, 1981.

b) Road Rehabilitation Project, Panama, The world Bank, April 14, 1981.

TABLE 10-6 ECONOMIC VEHICLE OPERATING COST, PANAMA 1981

Cost Item	Car, Taxi	Light Truck	Medium Sized Truck	Bus
Running Cost (Cents/Vehicle/Km)				
Fuel	3.92	6.72	9.92	9.28
Lubricant Oil	0.19	0.38	0.85	0.85
Tire	0.35	0.70	1.96	1.82
Spare Parts	0.51	0.75	2.26	11.77
Maintenance Labour	0.38	0.30	2.38	2.34
Depreciation (Distance)	1.72	1.52	3.03	5.61
Total	7.07	10.37	20.40	32.17
Fixed Cost (Cents/Vehicle/Hour)				
Depreciation (Time)	21.6	7.8	26.0	19.8
Capital Opportunity Cost	23.2	2.8	61.7	82.2
Crew Cost	–	153.0	237.5	162.0
Insurance	16.5	3.8	19.6	15.2
Overhead	–	–	34.4	–
Total	61.3	167.4	278.6	243.2

Source : ESTAMPA

(3) Railroad Operating Cost

The operating cost of ALWEG type monorail, discussed in the previous section, which is to be incurred for urban route (Centro - San Miguelito) starting in 1990 and for suburban route (San Miguelito - Tocumen) starting in 1995, is estimated in Table 10-7).

TABLE 10-7 RAIL TRANSIT OPERATING COST

(1000B./YEAR)

Cost Item	Financial			Economic		
	Urban	Suburban	Total	Urban	Suburban	Total
1. Salary and Wage	1950	2730	4680	1755	2457	4212
2. Direct Expense	2061	1668	3729	1855	1501	3356
1) Power	562	373	935	506	336	842
2) Rail Maintenance	200	280	480	180	252	405
3) Maintenance of Power Line	250	350	600	225	315	540
4) Maintenance of Rolling Stocks	600	400	1000	540	360	900
5) Transportation & Communication	262	113	375	236	102	338
6) Others	187	152	339	168	137	305
3. Depreciation Cost of Rolling Stocks	1440	960	2400	1296	864	2160
4. Opportunity Cost of Rolling Stocks	1800	1200	3000	1620	1080	2700
Total	7251	6558	13809	6526	5902	12428

Source : ESTAMPA

(4) Passenger Travel Time Cost

Average monthly family income estimated based on person-trip survey findings and population census data is 850 balboas for car owning households, and 322 balboas for non-car owning households. Based on this information, the passenger time costs of business and to/from work travels (1/2 of time cost for business trips) are estimated in Table 10-8, disregarding the time cost of travels for other purposes.

TABLE 10-8 PASSENGER TIME COST

(Balboa / Hour)

	Business	To / From Work	Other Purpose
Car, Taxi	3.24	1.62	0
Truck	1.55	0.78	0
Private Bus	1.55	0.78	0
Public Bus	1.55	0.78	0

Source : ESTAMPA

While savings in passenger travel time are usually regarded as a benefit, the logic of doing so is subject to challenge. Therefore, cost-benefit analysis is basically accomplished using benefit without savings in such time, provided that the result of similar analysis using benefit which includes such time savings is also listed in Table 10-9 for reference.

(5) Cost-Benefit Analysis Result

The net present value and benefit/cost ratio estimated for each Alternative are summarized in Table 10-9.

TABLE 10-9 SUMMARY OF ECONOMIC EVALUATION

ALTERNATIVE		COST (MILLION B/.)		NET PRESENT VALUE (MILLION B/.)2)		BENEFIT COST RAITO2)	
Code	Name	Economic Cost	Discounted Economic Cost3)	Inclu.SPTC1)	Excl.SPTC1)	Incl.SPTC1)	Excl.SPTC1)
1	Street Widening Plan without Policy	530.0	156.5	2495.4	517.0	16.95	4.31
2	Expressway Plan without Policy	732.5	251.9	2078.4	437.7	9.25	2.74
3	Street Widening Plan with Policy	446.0	133.4	2464.9	688.0	19.48	6.16
4	Exclusive Bus-Expressway Plan with Policy	664.1	232.7	2298.8	580.7	10.88	3.50
5	Rail Transit Plan with Policy	689.7	262.2 4)	2345.7	621.5	12.15	3.95

Note: 1) SPTC : Saving of Passenger Time Cost
2) Calculated under 12% of discount rate.
3) Including road maintenance cost and excluding the residual value in 2000
4) Including railway operating cost

Source: ESTAMPA

The result of calculation indicates that, as reflected by the net present values and benefit-cost ratios, the benefit substantially exceeds the cost (investment) in any of the cases and, therefore, that the alternatives are all economically feasible. The benefit-cost ratios–from 9 to 20 when travel time saving is considered and from 3 to 6 even if such saving is not considered––are substantially higher than such ratios usually indicated by feasibility studies of ordinary transportation infrastructure development projects, and this is because of the "without" case (a very unlikely case in which no transportation investment will be made in the future up to the year 2000) used in the evaluation. Therefore, the analysis result shows that each set of projects, when implemented as inseparable and integral parts of the alternative, are of a justifiable investment scale, but it does not necessarily mean that the investment scale of each project is, as a whole, optimum or that individual projects of the alternative are each feasible. These points will be further examined in connection with the masterplan to be finally recommended.

Benefits anticipated under these alternatives, which have been designed to secure about comparable levels of transport service, are also comparable, and, threfore, difference in cost (investment scale) is chiefly responsible for the difference in benefit-cost-ratio between the alternatives. In fact, the economy of road widening plans (Alternatives 1 and 3), which require relatively small cost, is better than the economy of plans which include the introduction of expressway or rail transit under huge amounts of investment. The cost of expressway plan and the cost of rail transit plan are about comparable, except that the economy of the latter is better than the economy of the former inasmuch as the number of those who utilize the latter (about 500,000 passengers/day) will be greater than the number of those who utilize the former (150,000 to 200,000 passengers/day).

(6) Conclusion

Based on the foregoing studies, it is concluded that the transportation masterplan be formulated in adherence to the followings:

a) That, with regard to road network, the road widening plan (alternatives 1 and 3), in view of its economy, be the key note of the master plan.

b) That the means of public transport be enhanced in preference to the means of private transport, because to do so will facilitate:

- o The minimization of road construction needs, and, therefore, public investment fund requirements
- o The better preservation of esthetic values of urban areas by restricting street widening to the minimum extent need to meet transport demand
- o Energy conservation
- o The mitigation of parking problems in urban centers
- o The securing of transport convenience for non-car owning families
- o The minimization of environmental problems (traffic accidents, noise, vibration)

c) That time will come when the introduction of a rail transit will become mandatory due to the limitations of public transport by buses in terms of transport capacity and of traffic handling at urban center terminals, and that the timing for the introduction of rail transit will depend on the passengers' ability to pay the fares and on the possibility of generating necessary construction funds.

d) That the introduction of rail transit, regardless of when it will be, be taken into consideration in the masterplan, because:

- o Unless effective advance measures be taken, the acquisition of land for railroad right-of-way will become more difficult as urbanization will progress
- o Unless harmony and coherence be maintained among road networks, but terminals, railroad routes and so forth, investment and technical effects will be impaired.

e) That the review of the alternatives and the following studies be necessary under a plan of introducing rail transit:

- o New urban formulation and the review of population distribution
- o The review of the need and location of new roads in suburbs
- o The review of plans for upgrading roads which will intersect with or run in parallel with railroad in the built-up area
- o Study for the determination of bus terminal locations
- o Coordination between bus service system and railroad service