CHAPTER 3.

PLANNING CHARACTERISTICS AND FORECASTS

Chapter 3 PLANNING CHARACTERISTICS AND FORECASTS

3-1 NATIONAL AND REGIONAL ECONOMIC CONTEXTS

3-1.1 General Economic Situation of Ecuador

Historically the Ecudorian Economy has been characterized by the rather large influence of a few exports commodities that have been the driving force behind cyclical surges of rapid, but unsustained growth. Likewise, their decline has usually brought about a period of sluggish growth. Such was the case in the 1960's with bananas and in the 1970's with petroleum.

This last decade (1970's) has been one of unprecedented economic changes brought about by the discovery, extraction and export of petroleum. The Gross National Product, exports and imports all grew at a very high rate and it made GNP have grown at an average rate of about 9% / year in net value, second only to Brazil's in South America.

This period of petroleum-led growth has been drastic changes in the productive structure of the Economy. While Ecuador has traditionally been an agricultrally oriented society, the share of the sector (agriculture, hunting, fishing, forestry) in the GNP decreased from 22.4% in 1972 to 17.9% in 1975 and 15% by 1978. Mining in the mountain has gone from 2% of GNP in 1972 to a high of 23.3% in 1974, and has stabilized around 11% of GNP by 1978[1].

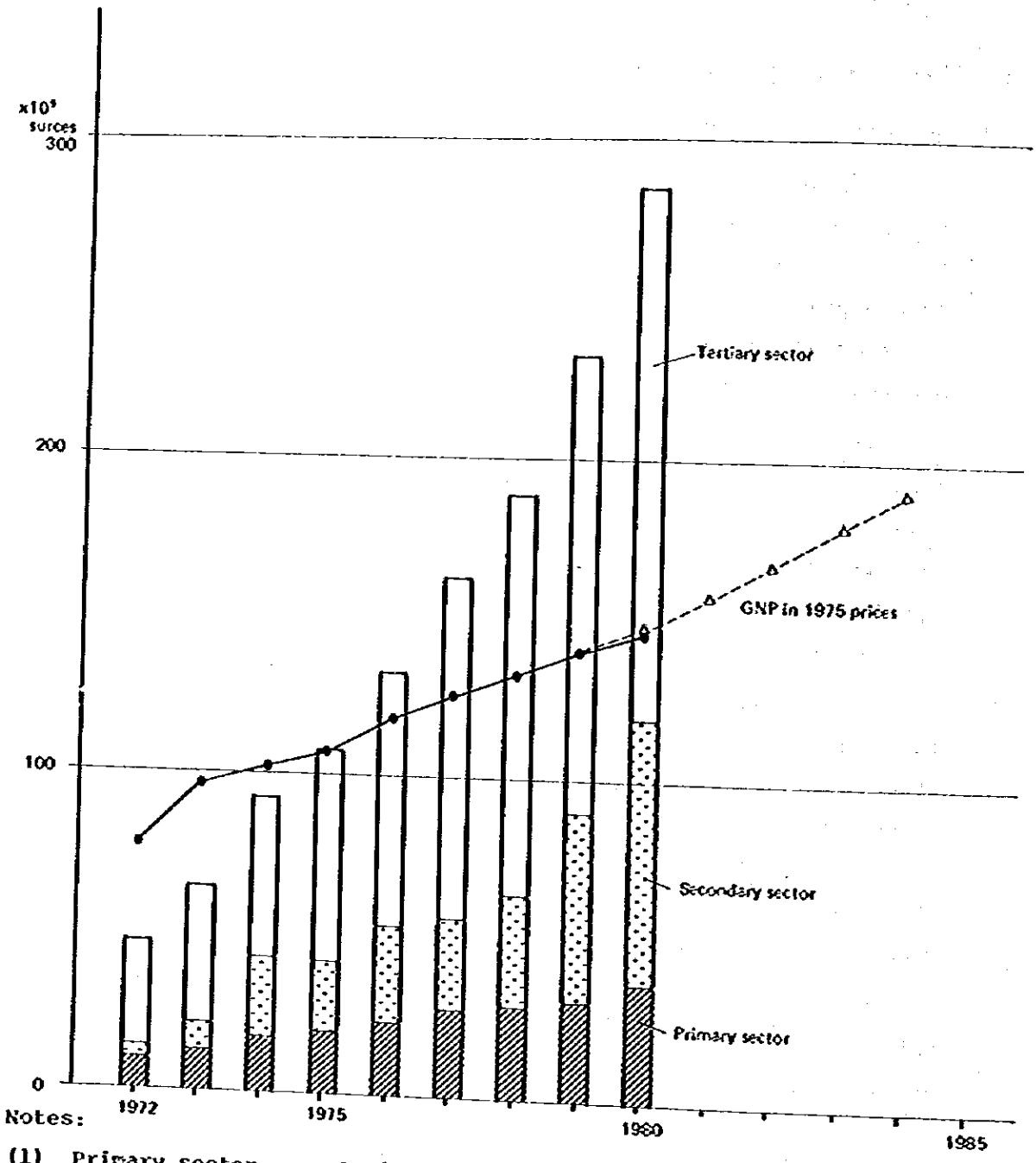
The share of manufacturing industries (excluding petroleum refining) managed to remain at about 16% over the whole period, despite the rapid growth shown by the Gross National Product.

In Million of U.S. dollars, the Gross National Product grew from 4,310 dollars in 1975 and had increased to 11,378 dollars by 1980. The per capita income category also showed significant increase over the decade. In dollar terms GNP per capita increase from 294 dollars in 1972 to 610 in 1975 and had reached 1,365 by 1980.

Although the decade of the 1970's was one of drastic increases in most of the principal Macro Economic aggregates, but nowadays problems faced by prices for petroleum and some agricultural com-

1) Banco Central del Ecuador. Cuentas Nacionales. 1981.

Figure 3-1.1 TREND OF GROSS NATIONAL PRODUCT BY ECONOMIC SECTOR



Notes:

(1) Primary sector: Agriculture, hunting, fishing + mining

Secondary sector: Manufacturing + construction

Tertiary sector: Electricity, gas, water + commerce + transportation warehousing + financial establishments + services.

(2) ●——● Actual GNP in 1975 prices

△- - - -△ Expected GNP by the same incremental rate shown in The National Development Plan (1979-84)

(3) Sources: a. Memoria Anual del Gerente General del Banco Control, Año 1980

b. Plan Nacional de Desarrollo 1979-1984, Primera Parte

modities such as coffee and bananas, due to the recent economic stagnation over the world, seem to have resulted in both lower than expected foreign exchange reserves and to hamper the carrying-out of development plans mentioned under.

Figure 3-1.1 shows the course of economic development in Gross National Product by economic sectors both in prices at each year and in 1975 value.

3-1.2 National Development Plan (1980 - 1984)

The National Development Plan (1980 - 1984)[2], manifesting the objective of the New Government Policy and achieving the National goals for the planning period, will suggest very important target and index to the framework for the long term in this master plan.

Its planning goals are summarized as shown at the next page.

Note:

As for the relation between the National Development Plan and this Study, it describes among Urban Development Program in its Plan that such studies should be put into action immediately as they could realize the introduction of new systems which actually optimize mass transport, increase the capacity, economize fuel and diminish contamination, both in Quito and Guayaquil. (Segunda Parte, Tomo V, Politicas y Programas Sectoriales; Recursos Naturales, Infraestructura Fisica y Desarrollo Urbano, page 201, 202)

3-1.3 Economic Situation of Province of Guayas

The province of Guayas occupies a prominant position in the economic structure of Ecuador, and within the urban area of Canton and its surroundings, corresponding to the Study Area, are the predominant economic factor.

Guayaquil is the main part in the country, handling close to

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2) Plan Nacional de Desarrollo 1980-1984 del Gobierno Democrático, Primera Parte.
CONADE - 1980.

NATIONAL DEVELOPMENT PLAN

1980-1984

ITEM	OBJECTIVE (in 1979 prices)
National Product	Gross National Product growth of 6.5% annually. An increase in the per capita GNP from 1,114 dollars (27,850 sucres) to 1,312 dollars (32,800 sucres) in 1984.
Investment	Total private and public investment of 15,049.5 millions of US dollars (376,238 million sucres) implying an average annual growth of 6.8%. A change in the investment share of GNP from 26.9% in the 1976-1979 period,to 27.1 in 1980-1984.
Employment	Creation of 490,000 jobs, to absorb the total increase in economically active population 439,000, and reduce unemployment of 50,000 persons. Additionally, average productivity gains of 2.6% annually.
Savings	National savings of 12,799.2(for 5 years) millions of US dollars.
Income Distributions	An increase in the share of wages and salaries in GNP from 35% in 1978 to 40% in 1984.
Exports	To export the equivalent of 13,948 millions of US dollars, representing an average annual growth of 4.2% as opposed to 1.5% in the 1975-1978 period.

Source: Plan Nacional de Desarrollo.
Primera Parte.
CONADE - 1980

90% of import traffic and a large proportion of non-petroleum exports. In the two major economic areas of the country (Guayas and Pichincha) growth in the number of commercial and industrial enterprises averaged 6% annually in the 1964-1980 period.

The Guayaquil area contains the largest concentration of houses of these enterprises in Ecuador, of 178,708 recorded in 1980[3] for the whole country, 29.5% exist in the Guayaquil area. Second was the province of Pichincha with 23% of the total. The remaining 47.5% being distributed among the other eighteen provinces in the country.

Together with its importance as an import/export center and a major position in commerce and industry a complementarily large financial sector has developed in guayaquil. Of the top 10 banks in the country six have their headquarters in Guayaquil, and so do half of the 10 existing private finance companies.

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3) Source: Coyuntura Ecuatoriana.
Fedesarrollo - Ecuador 1981

3-2 FORECASTS OF PLANNING PARAMETERS

3-2-1 Population

1) Outline of Ecuadorian Population

The first estimates of the population of Ecuador start from 1890, when it was estimated to have reached one million inhabitants. By the first decade of this century it had already reached 1,280,000, growing at an average rate of 1.0% annually, and this rate increased to 1.5% in the period between 1910 and 1929. Growth dating from 1930 started to accelerate rapidly, reaching 6,830,000 in mid-1974. (According to the 1974 census adjusted).

Recently the population growth rate has increased further. According to the 1950 and 1962 censuses, which provided the first credible figures, the growth rate was 2.8%, approximately. But for the period 1962 to 1974 it has been calculated at 3.3%; if this growth rate should continue, it is to be expected that population will double in 21 years. The increase in the growth rate has been caused by a rapid decrease in mortality, together with a high birth rate, which has not shown significant decreases.

2) Population Forecasts

a. Premises for Population Forecasts by CAD (1974 - 2009)

CAD (Centro de Análisis Demográfico) prepared three population projections until the year 2009 in the Report "Proyección de la Población del Ecuador 1974-2009, May 1976", using the adjusted population figures from the 1974 census as a base. Each corresponds to one alternative premise about fertility, the main cause for population growth, as shown at Table 3-2.1.

The Team did not have any doubt on premises in respect to mortality (expected life) and international migration through looking up the above projection, but as for fertility would like to call attention to a possibility that it might change more rapidly than Hypothesis-II in Table, occationally than III, as results of improvements in the level of

Table 3-2.1 FORECAST OF POPULATION IN EACH HYPOTHESIS BY CAD

Total Ecuador

1,000 Persons

YEAR / HYPOTHESIS	1974	1985	1990	1995	2000	74-2000 %/Year
Hypothesis -I	6,830	10,069	12,075	14,509	17,468	-
%/Year	-	3.59	3.70	3.74	3.78	3.68
-II	6,830	9,878	11,676	13,764	16,198	-
(Adopted in this study)	-	3.41	3.40	3.35	3.31	3.38
-III	6,830	9,752	11,345	13,106	15,037	-
%/Year	-	3.29	3.07	2.93	2.79	3.08

Premises for each hypothesis.

a. Gross reproduction rate (Number of females by a woman).

HYPOTHESIS	1974 1979	1984 1989	1994 1999	2004 2009
I. (high)	3.28	3.28	3.28	3.28
II. (recommended)	3.17	2.95	2.75	2.58
III. (rapid decrease)	3.05	2.61	2.21	1.87

b. Expected life from birth

(Common to 3 hypotheses)

Years

YEAR	1974	1984	1994	2004
Man	59.11	62.84	65.47	67.50
Woman	61.83	65.21	67.84	69.93

c. Internacional migratory figures are supposed to be nil in common to 3 hypotheses since the Ecuadorian population is almost closed.

education, higher urbanization and by an inclination that the young generation would not care for many children.

In spite of the possibility the Team decided to adopt II, the recommended one by CAD, due to the difficulty of drawing a different conclusion from the trend and the fact that many studies related had adopted the same, mentioned later.

b. Population Forecast in Whole Ecuador

Based on Hypothesis-II above, population will go from an estimated 6,830,000 in 1974 to 16,198,000 in the year 2000, which implies an increase of about 150% in 26 years.

The average rate of population increase would be reduced very slightly, from 3.4% in 1974-1979 to 3.3% in the 1995-2000 period. By the year 2000 the group under 15 years of age would represent 44.2% as opposed to 45.7% in 1974; while the group from 15 to 64 would go from 50.9% in 1974 to 52.5% in the year 2000, and finally the proportion of over 65 years of age would be 3.3%, which is close to the 3.4% of 1974.

c. Population Forecast for Province of Guayas and Each of its Cantons.

Based on the projections by CAD and using INEC's breakdown[1] until 1996 for province level and 1986 for canton level, and by the least-squares method, to derive projections for the period 1985-2000, population forecasts were prepared for cantonal criteria in the province of Guayas (Table 3-2.2, 3).

3) Population Growth in Study Area

a. Population in Study Area

The Study Area consists of the whole urban area of Canton Guayaquil and its surroundings, as described later. The surroundings, parts of the rural areas of its canton

1) Proyección de la Población del Ecuador por áreas Urbana y Rural, Provincias y Cantones 1974-1994, Abril de 1978/INEC (Instituto Nacional de Estadísticas y Censos)

Table 3-2.2 FORECAST OF POPULATION IN EACH CANTON IN GUAYAS

YEAR / CANTON	1974	1980	1982	1985	1990	1995	2000	1974-2000 %/Year
BALZAR	56,112	69,526	66,999	72,244	83,100	95,600	109,900	2.76
DAULE	131,250	144,571	153,285	166,691	191,800	219,600	251,300	2.84
DURALDE	54,128	79,450	83,885	107,306	133,600	166,400	198,900	5.13
GUAYAQUIL	982,651	1,215,773	1,337,362	1,516,891	1,873,800	2,302,900	2,822,900	4.31
MILAGRO	84,333	109,333	119,261	135,143	165,600	202,100	245,000	4.20
NARANJAL	33,720	42,444	45,018	51,153	60,600	70,800	82,500	3.50
NARANJITO	16,517	16,903	17,032	17,143	18,300	19,400	21,000	0.93
PALESTINA	50,412	69,141	76,606	89,941	108,500	133,400	157,200	4.44
PEDRO CARBO	24,122	32,324	35,633	41,052	49,300	58,700	69,200	4.14
SANTA ELENA	73,818	85,413	91,052	98,653	111,900	127,400	144,700	2.62
URBINA JADO	39,779	48,693	48,457	49,013	54,800	61,200	68,400	2.11
YAGUACHI	99,057	124,074	133,722	149,943	174,500	202,800	233,600	3.35
	1,558,543	2,038,703	2,219,317	2,492,503	3,025,900	3,656,500	4,405,600	3.93

Table 3-2.3 FORECAST OF POPULATION IN RURAL AND URBAN AREA

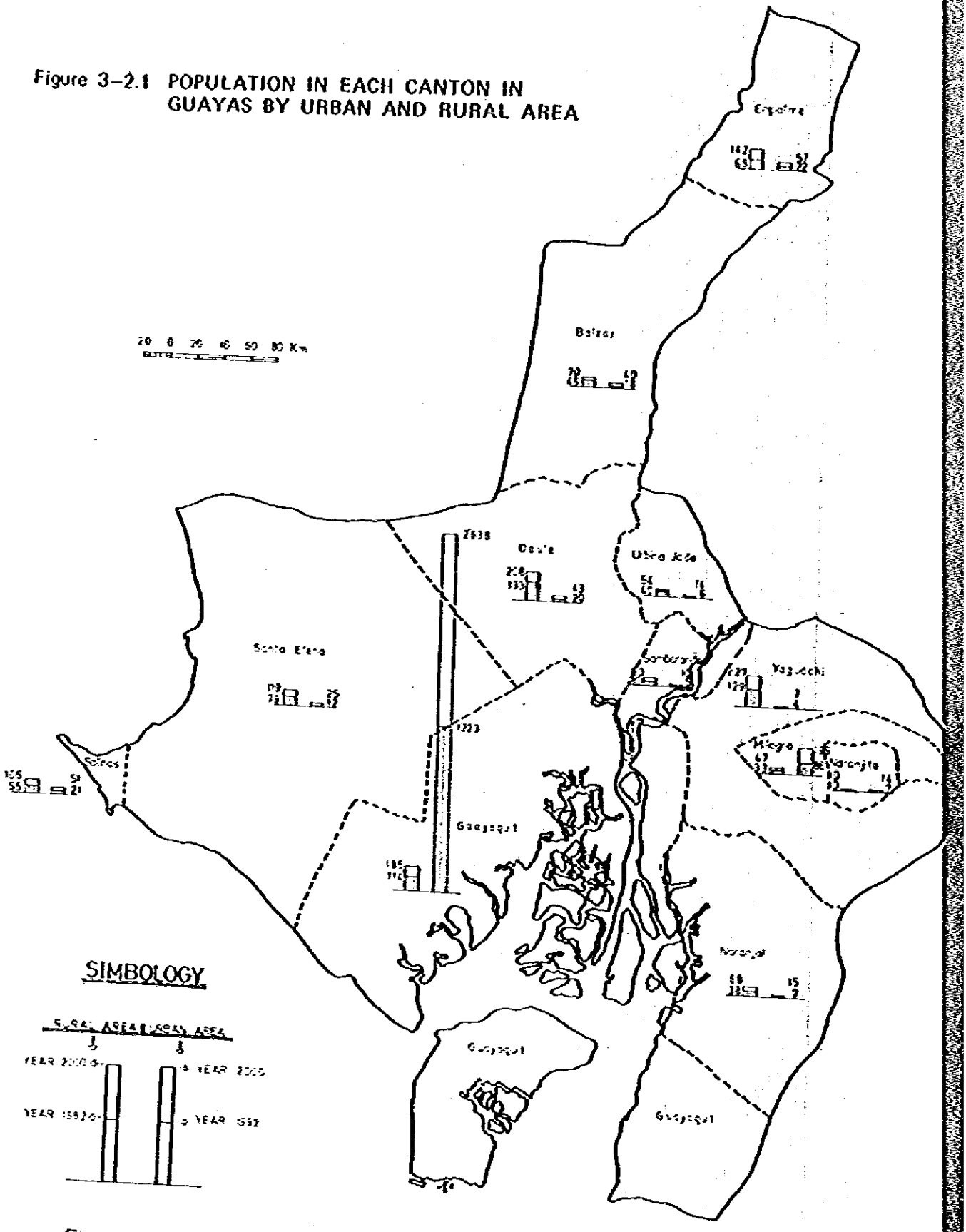
RURAL AREA

YEAR / CANTON	1974	1980	1982	1985	1990	1995	2000	1974-2000 %/Year
BALZAR	31,774	35,692	37,636	39,454	45,700	37,200	43,000	4.84
DAULE	13,799	18,354	19,932	22,764	28,200	34,800	42,900	4.45
DURALDE	32,211	38,933	21,842	26,738	34,800	44,900	57,100	6.11
GUAYAQUIL	853,069	1,116,280	1,223,310	1,392,848	1,733,900	2,143,100	2,638,600	4.44
MILAGRO	55,593	76,901	85,731	100,295	126,900	159,500	199,100	5.03
NARANJAL	5,653	7,003	7,521	8,369	10,300	12,300	15,000	3.82
NARANJITO	6,552	7,143	7,378	7,606	8,700	9,800	11,300	2.12
PALESTINA	12,833	18,434	20,692	24,861	31,800	43,500	58,900	5.45
PEDRO CARBO	5,162	5,693	5,913	6,269	6,900	7,800	9,000	2.16
SANTA ELENA	8,141	10,682	11,720	13,372	16,600	20,600	25,400	4.47
URBINA JADO	4,070	5,545	6,159	7,155	9,000	11,300	14,000	4.87
YAGUACHI	3,971	4,332	4,448	4,594	5,200	6,000	6,900	2.15
TOTAL	992,733	1,325,057	1,432,492	1,655,316	2,035,000	2,519,800	3,110,000	4.43

URBAN AREA

YEAR / CANTON	1974	1980	1982	1985	1990	1995	2000	1974-2000 %/Year
BALZAR	42,338	43,834	43,363	51,790	57,400	63,400	69,900	1.94
DAULE	117,451	126,217	133,353	143,827	163,600	185,000	208,400	2.58
DURALDE	41,917	69,511	69,043	80,568	98,800	119,500	141,800	4.80
GUAYAQUIL	69,593	109,493	114,052	124,043	147,900	162,800	184,500	2.82
MILAGRO	28,760	32,432	33,530	34,848	38,700	42,600	45,900	1.90
NARANJAL	28,068	35,441	38,297	42,853	50,300	58,500	67,500	3.43
NARANJITO	9,965	9,763	9,654	9,543	9,600	9,600	9,700	-0.10
PALESTINA	38,005	50,687	55,914	64,080	76,700	90,900	106,300	4.04
PEDRO CARBO	18,960	26,623	29,720	34,813	42,400	50,900	60,200	4.54
SANTA ELENA	65,692	75,731	79,337	84,681	95,300	106,800	119,300	2.32
URBINA JADO	35,709	39,148	42,298	41,858	45,800	49,900	54,400	1.63
YAGUACHI	95,086	119,742	129,274	144,355	169,300	196,800	226,700	3.43
TOTAL	651,626	713,645	785,625	859,287	990,600	1,136,700	1,295,600	2.93

Figure 3–2.1 POPULATION IN EACH CANTON IN GUAYAS BY URBAN AND RURAL AREA



Figures: 1,000 persons

and other cantons, include Parroquia Pascuales (a parish zone), Parroquia Eloy Alfaro (usually called Durán), and additional parts without any urban component and being scarcely inhabited at present.

Accordingly, the whole size of the population in the Study Area shall be acquired actually by adding the projection in both Durán and Pascuales to that in the urban area of canton Guayaquil, which was already prepared in Table 3-2.3. Thus, population forecasts have been made as below in Table 3-2.4.

Table 3-2.4 FORECAST OF POPULATION IN THE STUDY AREA

	1974	1982	1985	1990	1995	2000
Guayaquil	853,060	1,223,300				
Duran	23,556	34,800	1,439,000	1,788,000	2,211,000	2,726,000
Pascuales	4,017	5,900				
Additional* parts	-	-				
Total	880,663	1,264,000	1,439,000	1,788,000	2,211,000	2,726,000
Increase	-	4.62	4.42	4.44	4.34	4.27
% / Year	-	4.40 for 82 - 2000				

* Additional parts include a part of the rural area in canton Guayaquil, a part of the peninsula in canton Sarborondón and a little bit of the southern part of canton Yaguachi. Their population was supposed to be nil due to being scarcely inhabitated at present without any urban component.

b. Comparison with Other Projections in Related Studies

Table 3-2.5 shows the results of other estimations found in the related projects to the Study Area, and all of them had forecast 2,700,000 or more than that in the year 2000 with an increase rate between 4.5% - 5.5% / Year.

c. Results by Other Hypotheses of CAD

Table 3-2.6 shows the projections based on the other Hypotheses by CAD. Hypothesis -I and -III have resulted in by about 200,000 of inhabitants more or less than II

respectively, corresponding to an increase or decrease of 7% of II. The difference seems to be rather small if the length of the period for projection until 2000 year would be taken into consideration.

Table 3-2.5 FUTURE POPULATION OF GUAYAQUIL IN RELATED STUDIES

The objective area in each project is actually the same as in this study.

(Each forecast on the different base year).

Sources	% /year	1980	1985	1990	1995	2000
This study	4.40 %	1,155	1,439	1,788	2,211	2,726
1. Master Plan for water supply,1961	4.51 %	1,123	1,393	1,740	2,174	2,715
2. I.E.O.S. 1978	4.97 %	-	1,508	-	-	3,122
3. Department of Urban Planning	4.5 %	1,110	1,383	1,724	-	2,676
4. Department of Urban Planning	5.5 %	1,142	1,458	1,860	-	3,428
5. Master Plan for water supply,1979	4.49 %	1,125	1,401	1,745	2,173	2,707

Notice

1.- This study was prepared by SEURECA.

2.- Ecuadorian Institute of Sanitary Works(Instituto Ecuatoriano de Obras Sanitarias).

3.4- Department of Urban Planning in the Municipal Government recommended a rate between 4.5%-5.5% in the Working Document "Report on the Proposals for Regulations of the Sub-Region and the Guayaquil Metropolitan Area, 1978".

5.- Prepared by G.B.C.R.(1979).

Table 3-2.6 FORECAST OF POPULATION IN THE STUDY AREA BASED ON THREE HYPOTHESES

Study Area

Year / Hypothesis	1974	1985	1990	1995	2000	74-2000 %/Year
Hypothesis-I	880.6	1,467	1,849	2,331	2,940	-
%/Year	-	4.75	4.74	4.74	4.75	4.75
Hypothesis-II	880.6	1,439	1,788	2,211	2,726	-
(See Table 4-1.12)	-	4.57	4.44	4.34	4.28	4.44
Hypothesis-III	880.6	1,421	1,737	2,105	2,531	-
%/Year	-	4.45	4.10	3.92	3.75	4.14

Figures in hypothesis-I and -III were derived by applying the same share of the Study Area in total Ecuador in hypothesis-II to others.

3-2-2 Economically Active Population (EAP)

1) Outline of EAP in Ecuador

The EAP of Ecuador has been projected to grow in the 1974-1986 period by about one million, by INEC,[1] that is the amount of jobs that need to be generated in the 12 year period just to maintain the present level of employment. Expected growth in the EAP is different by sex and area. For the 1974-1986 period, growth in the urban EAP has been estimated at 565,000 people. In the rural area the increase would be 440,000 people.

The National Development Plan (1980-1984) has, as one of its main goals, the provision of jobs for all those entering the work force and depending on the successful implementation of the programs devised, the economy would have generated 490,000 new jobs by 1984, which represents an average annual increase of 3.6% which would be sufficient to absorb the predicted increase in the EAP and reduce unemployment to some extent.

2) Economically Active Population in Study Area

Developments in the economically active population, of the Study Area should follow the same general pattern as urban EAP for the whole country. The percentage of EAP in relation to total population of the Study Area was 29.9% in 1974 and shall be expected to remain at almost similar levels through 1986.

From the 1962 and 1974 census results the Team can conclude that the occupational structure, by sectors, of the urban EAP does not change significantly over the time. Likewise, it is reasonable to assume that since overall population is expected to grow at about 3.4% for the whole country until the end of the century, and EAP at about 3-4%, the percentage of economically active population to total population will remain around 30% until the year 2000.

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1) Source: Proyecciones de la población económicamente activa por áreas, grupos de edad, sexo y ramas de actividad: 1974 - 1986. (INEC)

EAP Estimation:

Ratios of EAP to total population in the Study Area were set as follows, then Table 3-2.7 was calculated.

1982: 30% for Guayaquil, 29% for Durán + Pascuales
1985 - 1990: 30% for the whole Study Area
1995 - 2000: 31% for the whole Study Area

These relations were derived from observation of the trends established by the 1962 and 1974 censuses and the slightly higher participation was expected in EAP by the turn of the century.

3) Distribution of EAP by Sectors

a) The EAP of Guayaquil was considered "Urban" throughout the whole 1974-2000 period. It is characterized by a very large tertiary sector where commerce and services predominate, an important secondary sector where manufacturing is the determining factor, and a reduced agricultural sector in the share.

b) The EAP of Durán was considered "Near Urban" at the beginning, with slight difference, in the primary (higher) and tertiary (lower) sectors in comparison to Guayaquil.

c) Pascuales was assumed "Rural" initially, but rapidly approaching urban characteristics, and having done so by the turn of the century.

Table 3-2.7 ESTIMATED EAP IN STUDY AREA
Year: 1974 - 2000

Year	Population	EAP	EAP/Population
1974	850,792*	254,822	30.0%
1982	1,264,000	378,800	30.0
1985	1,439,000	431,500	30.0
1990	1,788,000	536,400	30.0
1995	2,211,000	685,400	31.0
2000	2,726,000	845,100	31.0

* Before adjusted by INEC (adjusted figure is 880,633).

Table 3-2.8 ESTIMATED EAP IN STUDY AREA

By Primary, Secondary & Tertiary Sector

Year: 1974 - 2000

Year \ Sector	Primary	Secondary	Tertiary	Total
1974	7,453	64,994	182,375	254,822
%	2.9	25.5	71.6	100.0
1982	7,400	92,600	278,800	378,800
%	2.0	24.4	73.6	100.0
1985	7,400	104,200	319,900	431,500
%	1.7	24.2	74.1	100.0
1990	7,400	127,700	401,300	536,400
%	1.4	23.8	74.8	100.0
1995	7,400	160,400	517,600	685,400
%	1.1	23.4	75.5	100.0
2000	7,400	194,400	643,300	845,100
%	0.9	23.0	76.1	100.0

Notes: (1) Primary sector: Agriculture, hunting, fishing+mining
Secondary sector: Manufacturing + construction
Tertiary setor : Electricity, gas, water + commerce + transportation & warehousing + financial establishments + services.

(2) Total EAP in each year is from Table 3-2.13.

(3) Primary sector was supposed to be non-changeable in figures.

(4) The share in Secondary in 2000 was supposed to be 23.0% in consideration of the decreasing tendency from 74 to 2000 in the same sector.

(5) Shares in secondary in other years were supposed to decrease with the same percentage from 84 to 2000.

(6) Figures in Tertiary = Total - (in Primary + in Secondary).

(7) Item j. Non-specified activities and k.New workers were distributed to 3 - Sectors according to each share.

3-2.3 Family Income

1) Data Base

Families with private cars and those with no-cars behave differently on selecting transport modes, and there is a close connection between car ownership and family income. Therefore, it is very important, for residents in each zone to select the modes, to forecast the number of vehicles owned in each zone in the future. The data on the family income level by zone are used to decide both the future car ownership by zone and time value of the utilizers in each mode.

On the other hand, there exist very few data on average incomes by zone only except the ones in 1975 obtained from the Guayaquil Municipality, since the family income is strongly concerned with individuals' secret. In fact, the questionaires were not satisfactorily filled up to this item in the trip production survey carried out by the Study Team, July 1982. As for the family income, 1,376 of about 3,600 valid answers were obtained, and this is less than one by third of all answers. Its sampling rate is only 0.53% of the whole family number in the Study Area (the number of families is estimated to be about 260,000 in 1982). These are, however, very valuable data since the samples were collected uniformly over the whole area in Guayaquil. The size of family income closely relates to GNP (Gross National Product) per capita, but the latter is not complete since the GNP per capita does not reflect the local condition in Guayaquil and the relation between family income and GNP is not clear, either.

Based on the family income data in 1975 and 1982, the following forecast premises that the increase of the family income in the future will be equal to that of GNP per capita.

2) Trends of Family Income until Present

Table 3-2.9 shows the data in 1975 and enlarged ones in 1982. These two kinds of data were obtained by the different methods, however overall trends through 75 - 82 outline as under:

a. The growth rate of the family income for the above period in the whole urban area amounted to 23.1%/year, while that of GNP per capita was estimated to be 21.0%/year.

b. As for the growth rate by zones, zones with the low income in 1975 showed the higher growth rate, while those with the high income in 1975 had the lower rate. As the result, imbalance in income between zones in 1975 reduced for the last 7 years.

c. The income of families with private vehicles is equal to 1.8 times of those with non-vehicles in 1982.

3) Forecast

Based on the similar growth rate shown in the above between the family income and GNP per capita, that of the family income in the future was assumed to be equal to the growth rate of GNP per capita until 1984, targeted in the National Development Plan (1979 - 84) by CONADE. Then, the actual growth rate of the family income shall be 3.3%/year. Though this rate is only a half of 6.3%/year, which has been actually achieved for the last 7 years, it is a target which shall be not optimistically accomplished in the future, judging from the recent economic stagnation over the world.

It is more difficult to forecast the growth rate after 1985 to 2000, but it was assumed that the same growth should continue, taking into account the population increase rate to 2000. Then, the growth rate both in the GNP per capita and the family income shall be 3.3%/year until 2000 year. It necessitates the growth rate with 6.7%/year in GNP in the whole Ecuador since the population grows at 3.4%/year until 2000.

The results of the forecast are shown in Table 3-2.10.

Table 3-2.9 MONTHLY AVERAGE FAMILY INCOME BY A-ZONE

Sucres/Month

Zone \ Year	(1) 1975	(2) 1982		
		Family with vehicles	Family without vehicles	Average (b)
A - 1	3,683	30,180	16,250	19,220
- 2	3,683	25,760	14.430	16,650
- 3	2,821	20,180	13,260	13,950
- 4	8,559	21,790	17,630	18,890
- 5	-	18,490	12,150	12,470
- 6	2,821	18,810	15,210	15,920
- 7	12,478	38,350	16,980	26,740
- 8	9,751	21,140	14,500	16,650
- 9	-	19,500*	14,200*	14,900*
- 10	-	20,700*	13,900*	15,300*
Average (a)	3,840	26,180	14,240	16,460

(1) Sources; Ingreso Familiar Promedio de la Ciudad de Guayaquil, 1975 by Departamento de Planeamiento Urbano, Municipalidad de Guayaquil.

(2) Sources; Results of Trip Production Survey in this Study, July 1982.

(3) As for population and family size in zones, see page 51 in Progress Report, September 1982.

(a) Average multiplied by family sizes in each zone; 4.87 persons/family in 1982, 4.98 in 1975.

(b) Average multipled by family sizes with vehicles and without vehicles.

* These figures were calculated as averages between zone -3 and -6 for zone-9, and between -3 and -8 for zone -10.

Table 3.2.10 TREND AND FORECAST OF GNP AND FAMILY INCOME

/Year

Item \ Year	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1990	1995	2000
1. Population (1,000 person)	7,063	7,306	7,556	7,814	8,078	8,354	8,644	8,945	9,251	9,559	9,878	11,676	13,764	16,198
2. Population growth rate (%)	–	3.44	3.42	3.41	3.38	3.42	3.47	3.48	3.42	3.33	3.34	3.44	3.35	3.31
3. Family size supposed (person)	4.98							4.87			4.78	4.64	4.50	4.36
4. GNP (10^9 sucres)	107.7	132.9	162.4	189.0	231.7	284.4	341.0*	410.0*						
5. GNP growth rate (%)	–	23.4	22.2	16.4	22.6	22.7	20.0	20.0						
6. GNP/Capita (1,000 s.)	15.25	18.19	21.49	24.18	28.69	34.05	39.50	45.80						
7. Individual income (1,000 s.)	9.21							40.56						
8. Family income (1,000 s.)	45.9							197.5						
9. GNP in 1975 price (10^9 s.)	107.7	117.7	125.0	131.8	139.5	145.9								
10. GNP growth rate (%)	–	9.22	6.20	5.48	5.80	4.63								
11. GNP/Capita in 1975 price (1,000 s)	15.25	16.11	16.54	16.87	17.27	17.47								
12. GNP/Capita growth rate (%)		5.64	2.67	2.00	2.37	1.16								
13. GNP by N.D.P. in 1979 pr. (10^9 s)					229.3	242.1	257.3	275.8	297.1	313.5				
14. GNP by N.D.P. growth rate (%)					–	6.5	6.5	6.5	6.5	6.5				
15. GNP/Capita by N.D.P. in 1979 pr. (1,000 s)					27.85	28.78	29.73	30.72	31.74	32.80				
16. GNP/Capita growth rate (%)					–	3.3	3.3	3.3	3.3	3.3				
17. Forecast of growth rates for GNP/Capita & Family income (%)						3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3

Sources: (1) Progress Report, September 1982 for item 1, 2, 3

(2) Memoria Anual del Gerente General del Banco Central del Ecuador, 1980 for item 4, 9

(3) Plan Nacional de Desarrollo, 1980–1984, Primera Parte for item 13–16

*: Extrapolation by the average growth rate through 1978–80

3-2.4 Vehicle Ownership

1) Present Condition

Table 3-2.11 shows the present number of vehicles existing in the Study Area. There are total 105,000 vehicles matriculated in the Study Area. About 38,000 (36%) of them are ordinary cars, 41,000 (39%) are light trucks, 5,000 (5%) are heavy trucks, 3,500 (3%) are buses and the rest (17%) are taxis and motorcycles.

The trend of the number of vehicles registered is shown in Table 3-2.12. The total vehicle number increases about 2.5 times in 1974 to 75,000 in 1981. However there are some differences in growth rate by vehicle type. The increase of bus and furgoneta remains lower than the other vehicles. Present vehicle ownership in the Study Area is estimated to be 82 vehicles per 1,000 capita.

2) Relationship between Car Ownership and Family Income

Generally speaking, it's assumed that there is a close relationship between the car ownership and family income. This assumption was proved by the results of the trip production survey, and its curve was obtained as shown in Figure 3-2.2.

The curve shows the positive correlation between car ownership and the family income, and it is recognized that the number of vehicles per family depends on its monthly income.

3) Future Car Ownership

The number of vehicles per population was forecast by applying the car ownership ratio in each income group in 1982 to the same income group in future. The result is shown in Table 3-2.13.

Future car ownership ratio is estimated to be 150 car per 1,000 inhabitants in 2000 from 82 cars in 1982. The future volumes of vehicles in the Study Area is also estimated to be 408,900 vehicles in 2000. Figure 3-2.3 shows the changes of socio-economic indicators in the Study Area. The growth

rate of car ownership is much higher than the other indicators, i.e., individual income or population.

Table 3-2.11 NUMBER OF VEHICLES REGISTERED IN STUDY AREA

A Zone	(1) Car	Light Truck (2)			Heavy Truck (3)			Bus, Micro bus (4)			(5) Taxi	(6) Motor cycle	(1)+(2)+(3)+(6) Total
		Passenger	Cargo	Total	Private	Company	Total	Private	Commercial	Total			
1	(43.7) 14,153	13,580	880	(44.6) 14,460	1,638	193	(5.7) 1,831	848				(6.0) 1,955	32,399
2	(38.0) 6,228	6,512	466	(42.8) 7,008	752	83	(5.1) 835	380				(14.1) 2,315	16,386
3	(23.1) 2,708	4,866	505	(45.8) 5,371	386	116	(4.3) 502	192				(26.8) 3,147	11,728
4	(44.9) 2,351	2,177	155	(44.5) 2,332	166	7	(3.3) 173	86				(7.3) 382	5,238
5	(22.9) 220	502	26	(55.1) 528	58	7	(6.6) 65	16				(15.2) 146	959
6	(19.1) 433	1,473	103	(69.8) 1,592	119	83	(8.9) 202	31				(2.2) 49	2,266
7	(54.0) 8,651	5,269	530	(36.2) 5,799	984	21	(6.3) 1,005	508				(3.5) 562	16,008
8	(45.7) 2,198	2,080	168	(46.8) 2,248	292	0	(6.1) 292	141				(1.4) 67	4,805
9	(17.1) 167	490	116	(62.0) 606	152	0	(15.6) 152	78				(5.3) 52	977
10	(28.1) 469	742	77	(43.0) 819	116	21	(8.2) 137	91				(14.7) 245	1,670
Total	(40.7) 37,578	37,718	3,026	(41.1) 40,744	4,683	531	(5.6) 5,194	2,334	1,179	3,513	9,020	(9.6) 8,920	92,436

Note: Each figures are obtained on the basis of 10% random sampling from the matriculated cards in C.T.G. in 1982.

Table 3-2.12 TREND OF VEHICLE NUMBER IN CANTON GUAYAQUIL

Year / Type of Vehicle	1974	1975	1976	1977	1978	1979	1980	1981
Car	(49.4) 15,578	(50.3) 17,274	(49.9) 17,658	(46.8) 21,313	(44.3) 23,610	(44.8) 24,971	(45.9) 27,625	(46.1) 34,611
Light Truck	(39.2) 12,375	(38.9) 13,351	(39.8) 14,087	(42.6) 19,421	(43.8) 23,347	(43.4) 24,198	(43.2) 25,956	(43.5) 32,646
Bus	(3.9) 1,245	(3.6) 1,229	(3.4) 1,192	(3.2) 1,458	(2.8) 1,504	(2.7) 1,487	(2.4) 1,461	(2.3) 1,703
Furgoneta (Micro bus)	(2.4) 754	(2.4) 825	(2.3) 829	(2.7) 1,251	(2.7) 1,449	(2.7) 1,512	(2.3) 1,398	(2.0) 1,474
Heavy Truck	(5.0) 1,592	(4.7) 1,601	(4.5) 1,604	(4.6) 2,117	(6.3) 3,348	(6.5) 3,627	(6.2) 3,705	(6.2) 4,639
Total	(100.0) 31,544	(100.0) 34,280	(100.0) 35,370	(100.0) 45,560	(100.0) 53,258	(100.0) 55,795	(100.0) 60,145	(100.0) 75,073

Note: Matricular vehicle

( ) shows column percent

Figure 3-2.2 RELATIONSHIP BETWEEN CAR OWNERSHIP AND FAMILY INCOME

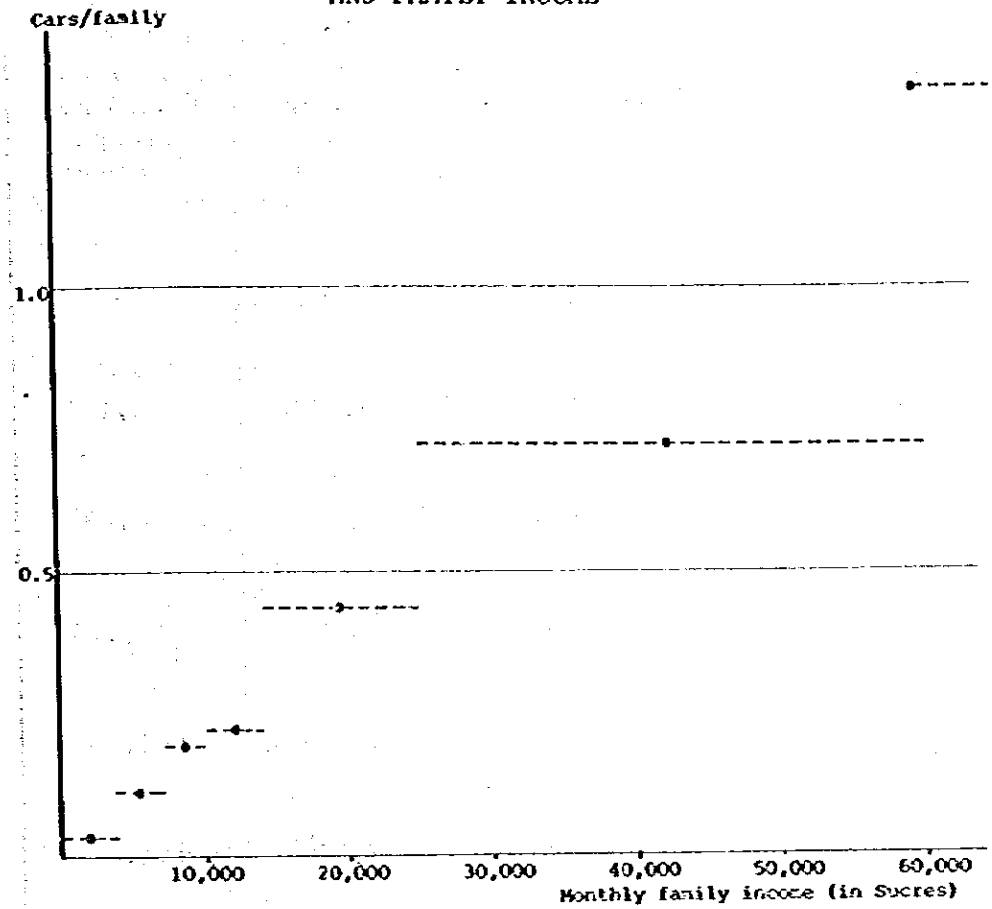


Figure 3-2.3 CHANGES OF SOCIO-ECONOMIC INDICATORS

Base year: 1974=100

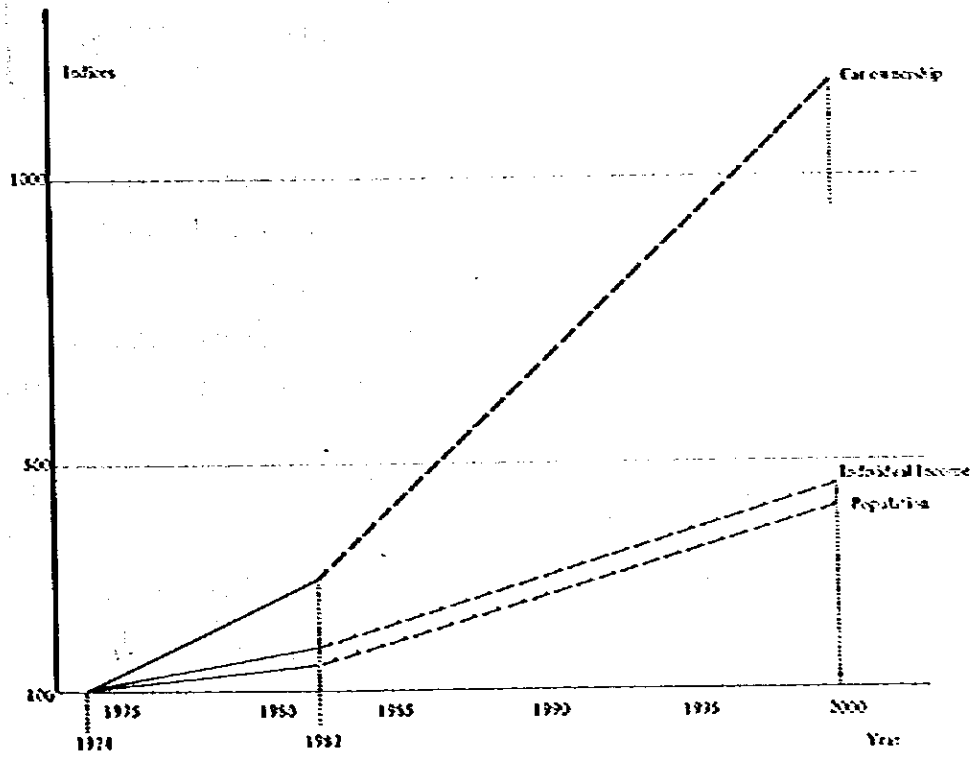


Table 3-2.13 FUTURE CAR OWNERSHIP ESTIMATION RESULT

Income group	Monthly income (Sucres in 1982 price)	Average family car ownership rate 1/	No. of cars owned by groups (Present) 2/	No. of cars owned by groups (Future) 3/
Lowest	∿ 3,999	0.065	506	-
Lower	4,000 ∿ 6,999	0.115	3,940	2,157
Medium lower	7,000 ∿ 9.999	0.194	7,049	8,493
Medium	10,000 ∿ 13,999	0.224	10,988	14,005
Medium higher	14,000 ∿ 24,999	0.444	32,613	80,782
Higher	25,000 ∿ 59,999	0.754	37,770	154,627
Highest	60,000 ∿	1.347	11,887	152,435
Total		0.403	104,753	412,498

Note) 1. Source: Trip production survey, July 1982.

2. The present number of cars owned in each income group was derived from the average car ownership rate, and its total was verified by the actual registered one.

3. The future car ownership rate per 1000 capita was obtained from dividing the total number of cars by future population.

3-3 LAND USE

3-3.1 General View of Existing Land Use in Study Area

In this Study Area, the characteristics of the three main parts, one big and two small, should be looked upon with special attention paid to the following relations:

a - Present condition and recent changes in the urban area of Guayaquil.

b - Relation between Parroquia Pascuales and the urban area of Guayaquil.

c - Relation between Parroquia Eloy Alfaro (Durán) and the urban area of Guayaquil.

Each of the above is outlined as below (See Figure 3-3.1).

1) Concerning the urban area of Guayaquil, the urban population increases very rapidly both by natural causes and immigration from other districts. The suburban area is changing into urban area, the urban area into more urbanized, and expanding itself along the principal roads toward three directions, north, south and west.

2) Parroquia Pascuales is changing from agriculture to industry, and the expansion of the urban area of Guayaquil has almost reached to the Parroquia. With the development of industries along Av. Daule, the relation between Pascuales and the urban area of Guayaquil is becoming stronger in economic activities.

3) Parroquia Durán is an entrance for products from the southern, eastern and northern regions of Ecuador to the urban area of Guayaquil, through the principal roads and railway. With the recent industrial and residential developments, Durán is regarded as a part of the urban area of Guayaquil.

3-3.2 Present Condition of Population and Housing Units

According to the report prepared by INEC, the recent number of housing units is 232,000 in the whole Study Area.

As for the average family size (population/houses), there are

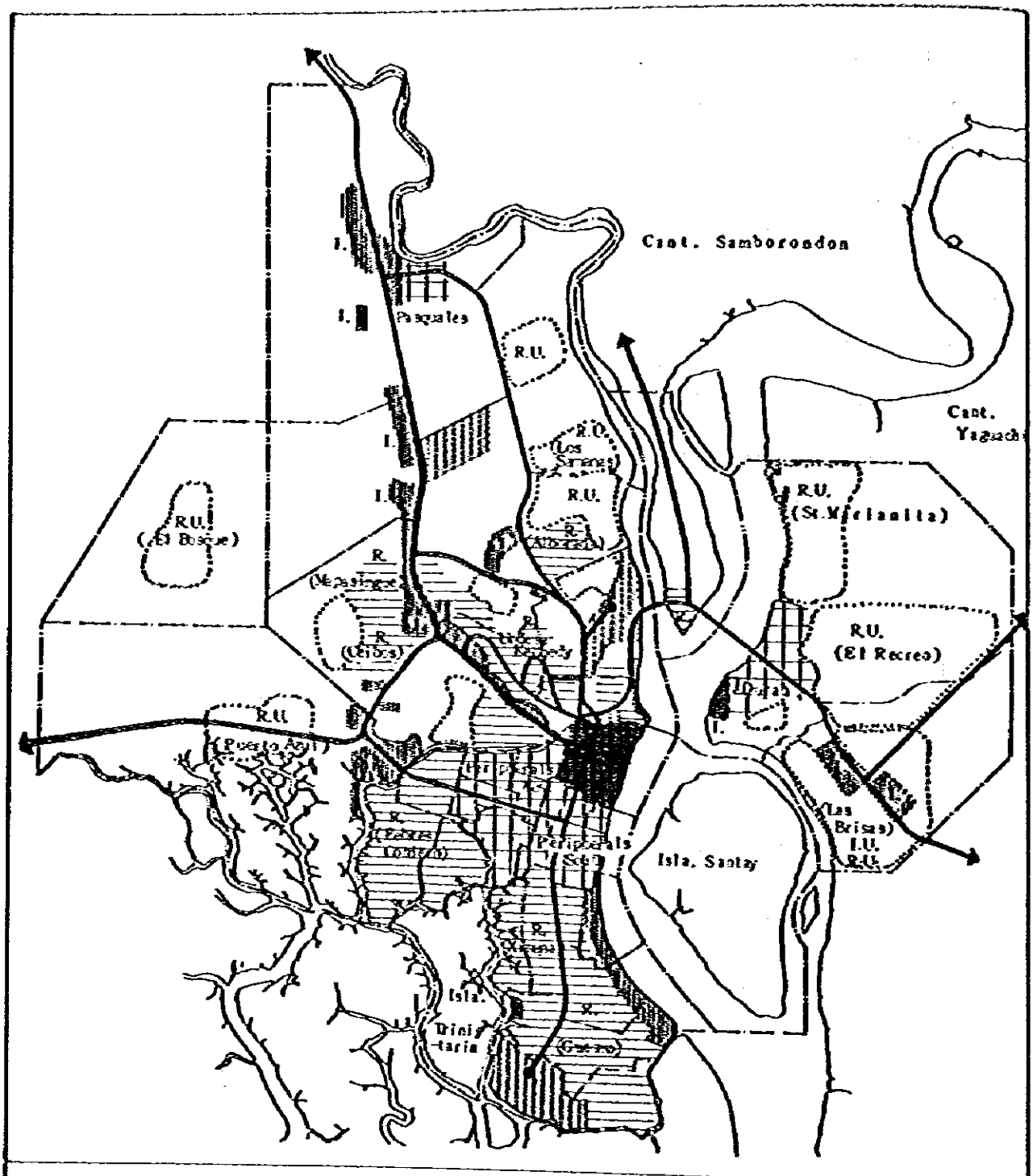


Figure 3–3.1 PRESENT CONDITION OF LAND USE

two estimates; one by INEC in the 1974 Census (Case -I), the other derived from the results of Trip Production Survey in this study (Case -II) which will be mentioned later.

Case -I projects a total population of 1,320,000 in 1982 in the Study Area, (a higher estimate), while Case -II projects 1,190,000, (a lower estimate). On the other hand, the population Study by the Team projected a medium estimate of 1,264,000.

Finally the distribution of population by zones was decided by Case -III: a medium estimate of 1,264,000, taking into account the existing conditions by the field survey. Figure 3-3.2 and 3.3 show population distribution and its density in each zone in 1982.

3-3.3 Classification of Present Land Use Pattern in Each Zone

1) Classification of the Present Land Use Pattern

Based on the general view of the present land use pattern and the indices in each zone, the following classifications are made.

Zone A-1 Central Urban Area (CUA)

- High concentration of all sorts of industrial activities, public and business offices, services and commercial shops, etc.
- Middle class residences with high density.

Zone A-2 Southern Peripherals of CUA

- Supporting CUA with industrial activities, located along the Guayas river.
- Middle class residences with high density.

Zone A-3 Western Peripherals of CUA

- Supporting CUA with commerce and services, and middle class residences with high density.

Zone A-4 Southern Area (Ximena)

- Manufacturings located along the coast of the Guayas river.
- Middle-high class residences with low density.

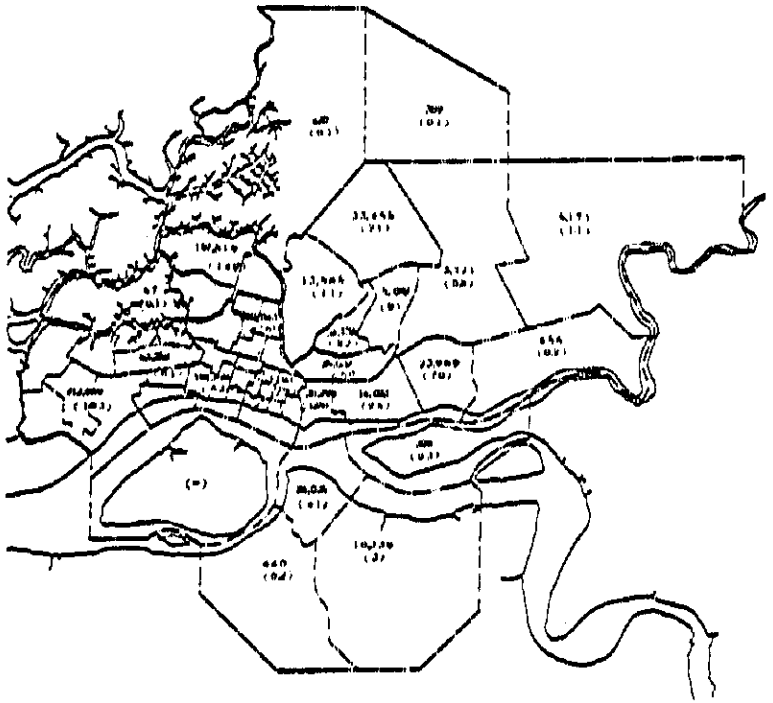


Figure 3-3.2 LOCATION OF POPULATION IN EACH ZONE IN 1982

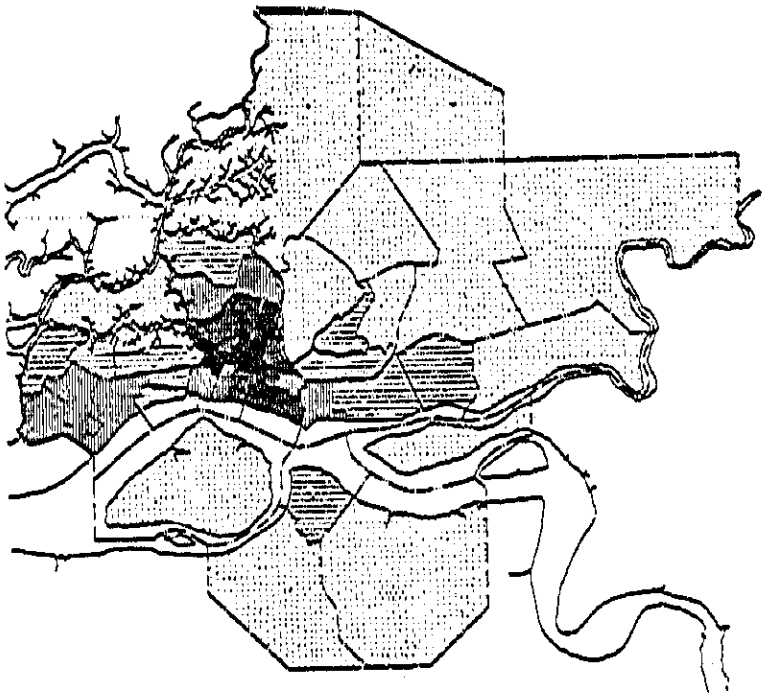


Figure 3-3.3 DENSITY IN EACH ZONE IN 1982

Zone A-5 Southern Area (Guasmo)

- The Port (Autoridad Portuaria) located at the edge of the south-west.
- Low class residences with medium density.

Zone A-6 Western Area

- Still not urbanized in the area further than Estero Salado.
- Low class residences with medium density.

Zone A-7 North West Area

- New complex urban area with manufacturing and business along Av. Carlos Julio Arosemena, commerce and services in Urdesa.
- High class residences in Urdesa, Los Ceibos and Kennedy, and low class in Mapasingue.

Zone A-8 Air Port and its Surrounding Area

- The airport (for international, domestic and air force).
- Middle-upper class residences with low density in Alborada and Atarazana, and low class with low density on Cerro el Carmen.

Zone A-9 Far North Area

- A vast area designated for future development, with the western part along Via Daule developing into manufacturing, while the eastern part along Via Pascuales into residential.

Zone A-10 Durán, Isla Santay, and the Peninsula of Sarborondón.

- An area planned for future development, with a small commercial and service center in Durán, and manufacturings along Via Triunfo.
- Several big areas for residential development are under construction or planning in El Marianita, El Recreo, and Las Brisas.

2) Situation of Central Urban Area (CUA)

By the present indices, 69% of the main facilities for the urban activities such as business, commerce, service, public

office, school, and manufacturing, are concentrated in CUA (Zone A-1). The present conditions of the building are as follows.

. Rate of the open space	5%
. Occupancy rate by buildings	95%
. Average floors of the buildings	2.38 Floors
. Residential area	67%
. Business, commerce and services	28%
. Public office, education and religions	3%
. Manufacturings and warehouses	2%

The rate of the floor space for business, commerce and services is more than 30% in the sector 101, 102, 103, 104, and these four sectors are defined as CBD (Central Business District) shown in Figure 3-3.4.

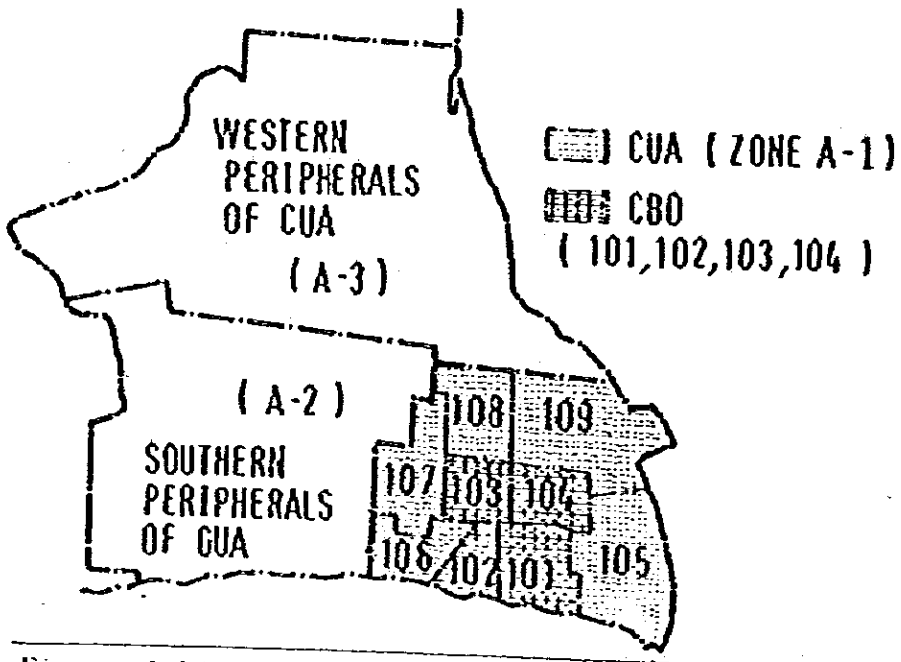


Figure 3-3.4 DEFINITION OF CUA AND CBD

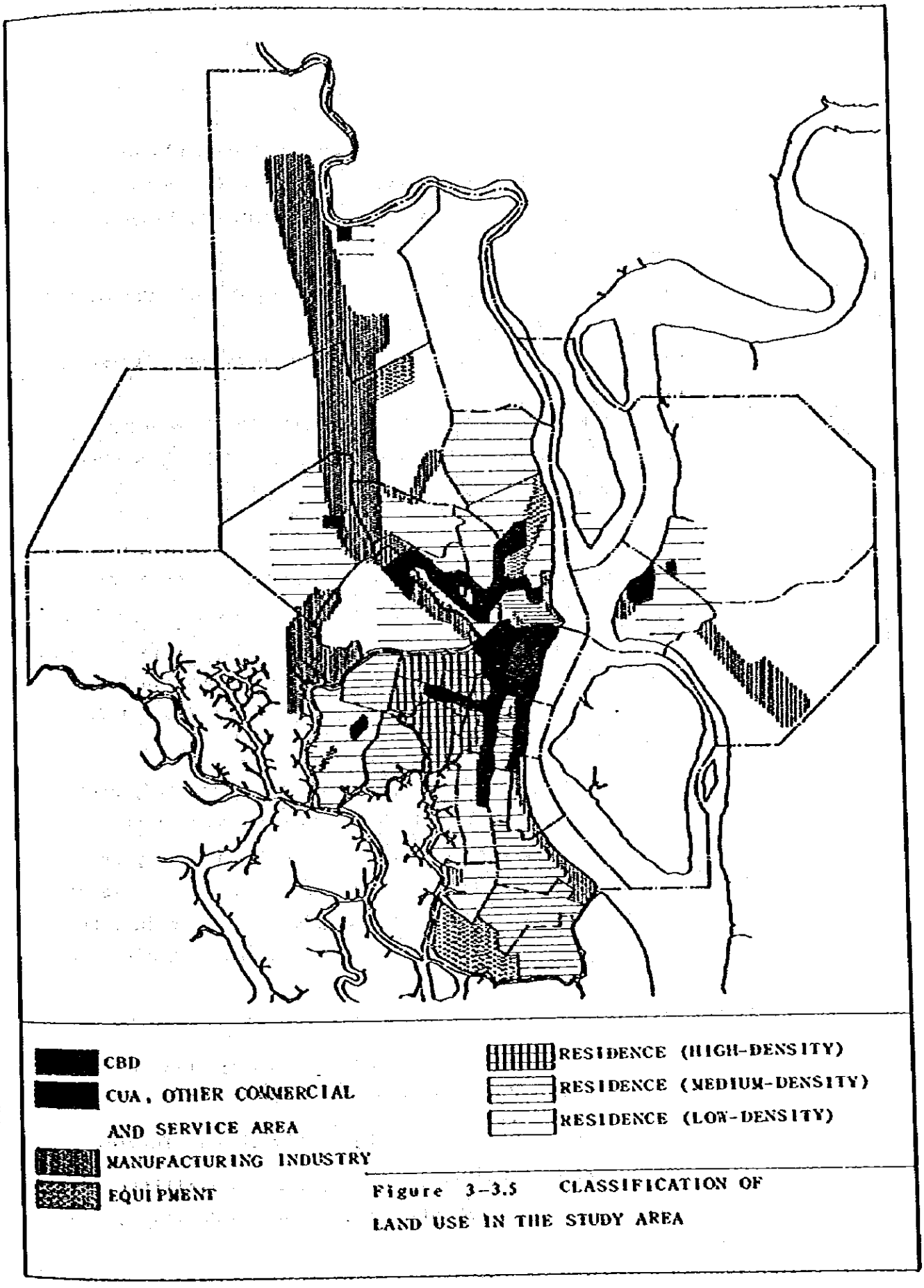


Figure 3-3.5 CLASSIFICATION OF LAND USE IN THE STUDY AREA

3-3.4 Determinants for Future Land Use

1) Land Use Laws and Regulations

Land development is controlled by the "Urban Planning Department, Guayaquil Municipality" (Departamento de Planeamiento Urbano de la Municipalidad de Guayaquil, D.P.U.), based on the following documents.

a - Ordenanza de Desarrollo Urbano (1969) by Concejo Cantonal de Guayaquill (C.C.G.)

b - Ordenanza Preventiva-Esquema Urbano de Guayaquil (1975) by C.C.G.

c - Plan de Desarrollo Urbano de Guayaquil (1977) by D.P.U.

d - Plan de Ordenamiento Zonificación de Usos del Suelo (1978) by C.C.G.

2) Development Trends

a - Constructions of new residences toward the Far North Area (Zone A-9), in Durán (Zone A-10) and the western area (Sector 604).

b - The expansion and construction of high buildings in the CUA.

c - Development of manufacturings along Vía Daule (Zone A-9) and Vía Triunfo (Zone A-10).

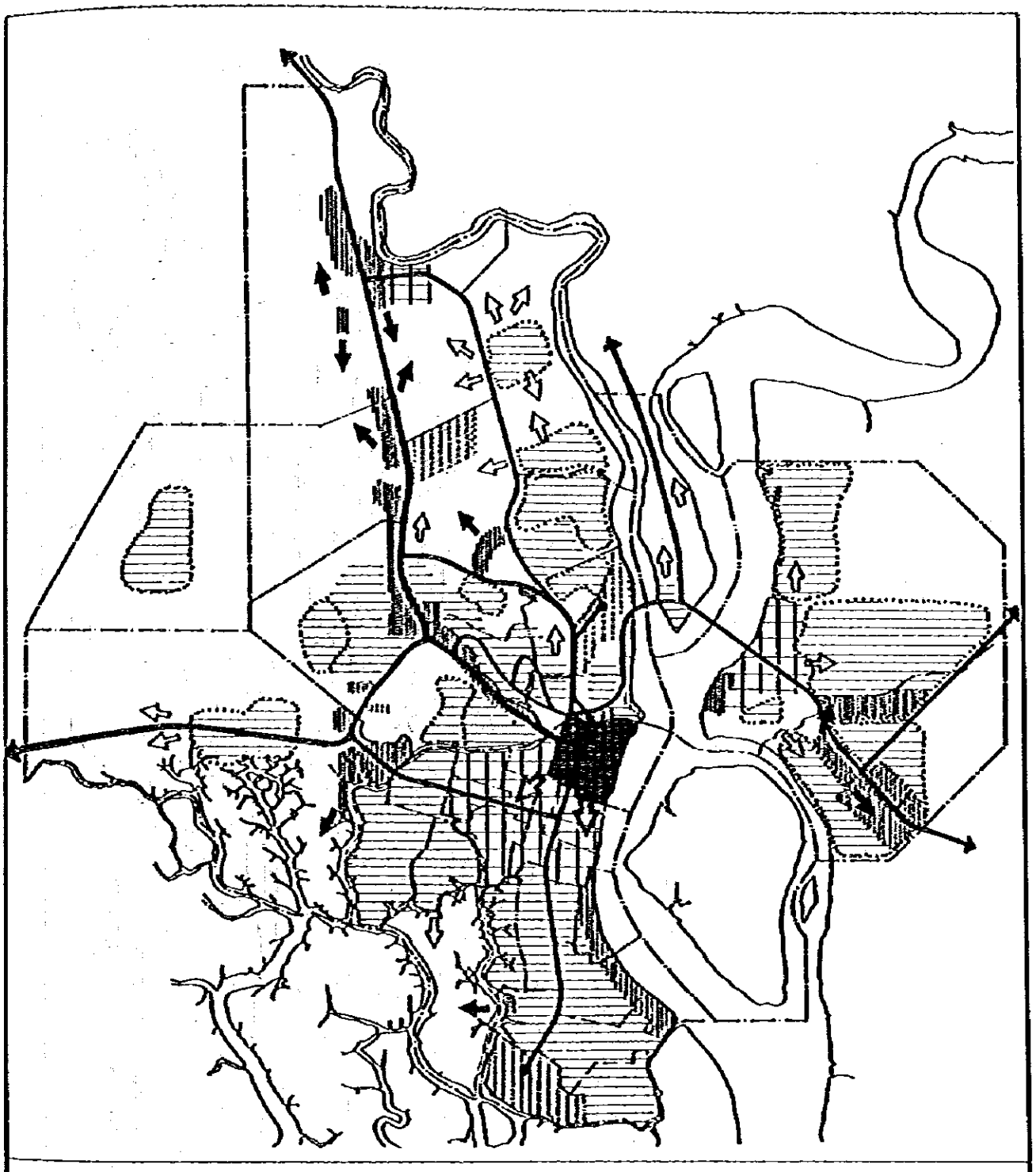
Figure 3-3.6 shows these trends on land use in the Study Area. Figure 3-3.7 shows a likely allocation to each zone of the total population of 2,737,000, projected in the target year 2000, based on the residential development plans. The size of the population in the Far North Area, almost equal to that in CUA, makes apparent the necessity of a new urban center there.

3-3.5 Developing Principles for Future Land Use

The following items are considered as the main points in the development for future land use in the Study Area.

a. Improvement of CUA for effective urban activities in future.

- Improvement of the mixed land usage by various facilities. Factories, warehouses, schools, etc. should be developed outside CUA.



EXPANSION OF CUA

EXPANSION OF RESIDENTIAL AREA

EXPANSION OF MANUFACTURING AREA

Figure 3-3.6 CHANGES OF LAND USE IN THE STUDY AREA

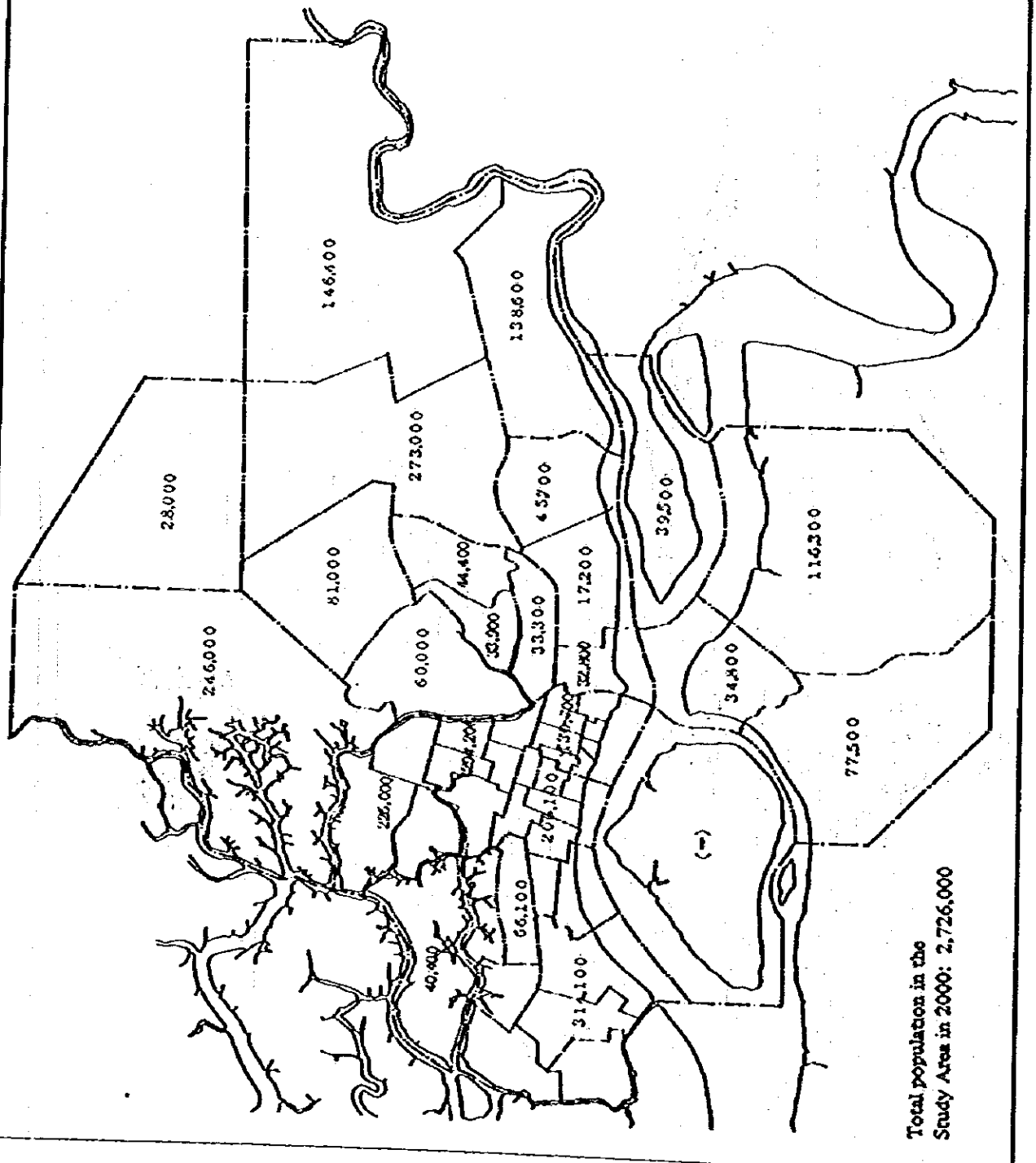


Figure 3-3.7 POPULATION BY ZONES IN 2,000

b. Improvement of the peripherals of CUA to augment more highly urbanized functions.

c. Improvement of houses and construction of sub-centers in the Southern and Western areas

d. Developing the Far North Area to the gradual construction of the new urban centers to avoid over-concentration on the existing CUA.

e. Development of regional centers both in Durán and the vast western area.

f. Development of manufacturing industries in the outskirts of CUA with convenient transport by road or ship. (Guasmo, Duran, Isla Trinitaria, western part further than Estero Salado, and along Via Daule).

g. Development of a new educational area in the western part.

3-3.6 Conceptional Development Patterns in year 2000

Taking into consideration the above items, three typical conceptional patterns for basic structures in the year 2000 are prepared as below and shown in Figure 3-3.8. The differences between these alternatives mainly depend on the allocations in each zone of EAP (Economically Active Population), especially those in the tertiary sector since the distribution of the population to zones does not permit much room for a big change, so are the EAPs in the primary and secondary sector, due to their rather small shares in EAP.

Alternative -I

Trend Type ---------- One big core structure

Alternative -II

Northern Development Type --- Two big cores structure

Alternative -III

Linear Development Type ----- Structure being developing linearly toward the northern area with one center.

Characteristics in each alternative are shown in Table 3-3.1. The alternative -III, Linear Development Type will be the most recommendable and should be tried to realize for the desirable development, which will be able to activate a city of 2.7 million of population in the year 2000. It shall be possible to change from III to II with more highly concentrating sub-centres in the Far North area after 2,000.

After the comparison of alternatives by such points as conveniences for urban activities in the existing CUA, the fulfillment of social services for the residential areas, and possibility to achieve the development for sub-central-axis, alternative III was adopted as the ultimate pattern for development in the year 2000.

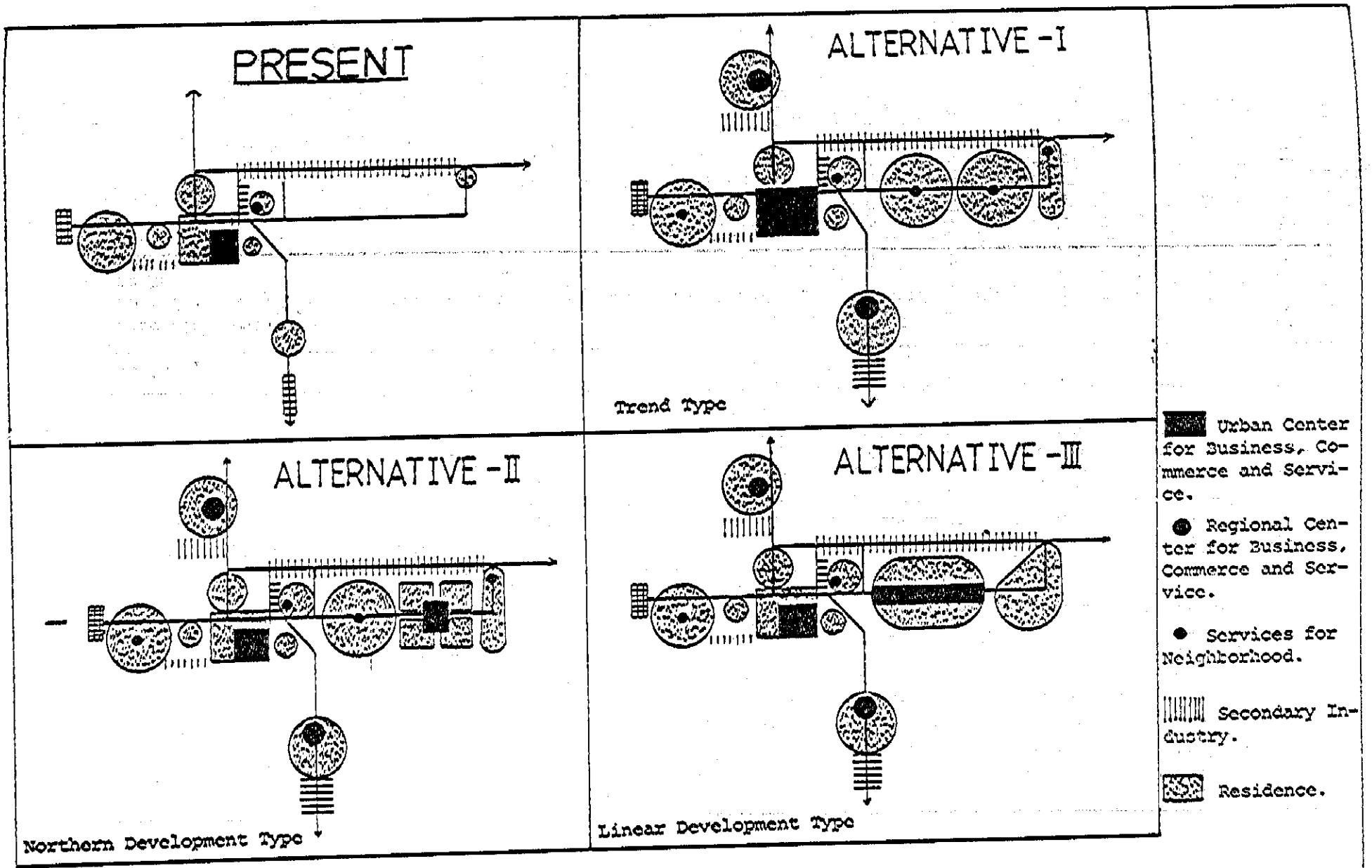


Figure 3—3.8 FUTURE STRUCTURE OF LAND USE IN 20000

Table 3-3.1 COMPARISON OF 3-ALTERNATIVES FOR CONCEPTIONAL DEVELOPMENT PATTERN

Target Year: 2000

	ALTERNATIVE -I	ALTERNATIVE -II	ALTERNATIVE -III
TYPE	TREND TYPE	NORTHERN DEVELOPMENT TYPE	LINEAR DEVELOPMENT TYPE
CHARACTERISTICS	. The existing central urban area (CUA), one big core, serving the whole Study Area.	. An additional new big core being developed in the center of the northern area. . Two big cores, the existing and the new, not linked each others.	. The compromise type between I and II. . Development being promoted linearly toward a new center, not big as in II, in the northern area.
POLICIES FOR DEVELOPMENT	. Widening the existing CUA to the peripherals, re-development and construction of highrise buildings	. Transfering the principal functions in CUA to the new core in the north. . Restraining additional economical activities in CUA.	. Strengthening the developments oriented to the whole northern area. . Transfering some of the functions in CUA to a new center.
Durán	Developing a sub-core as a district center.		
Pascuales and the Corridor along Vía Daule	Manufacturing industries to be developed in both areas.		

3-3.7 Future Land Use

1) Planning of Future Land Use

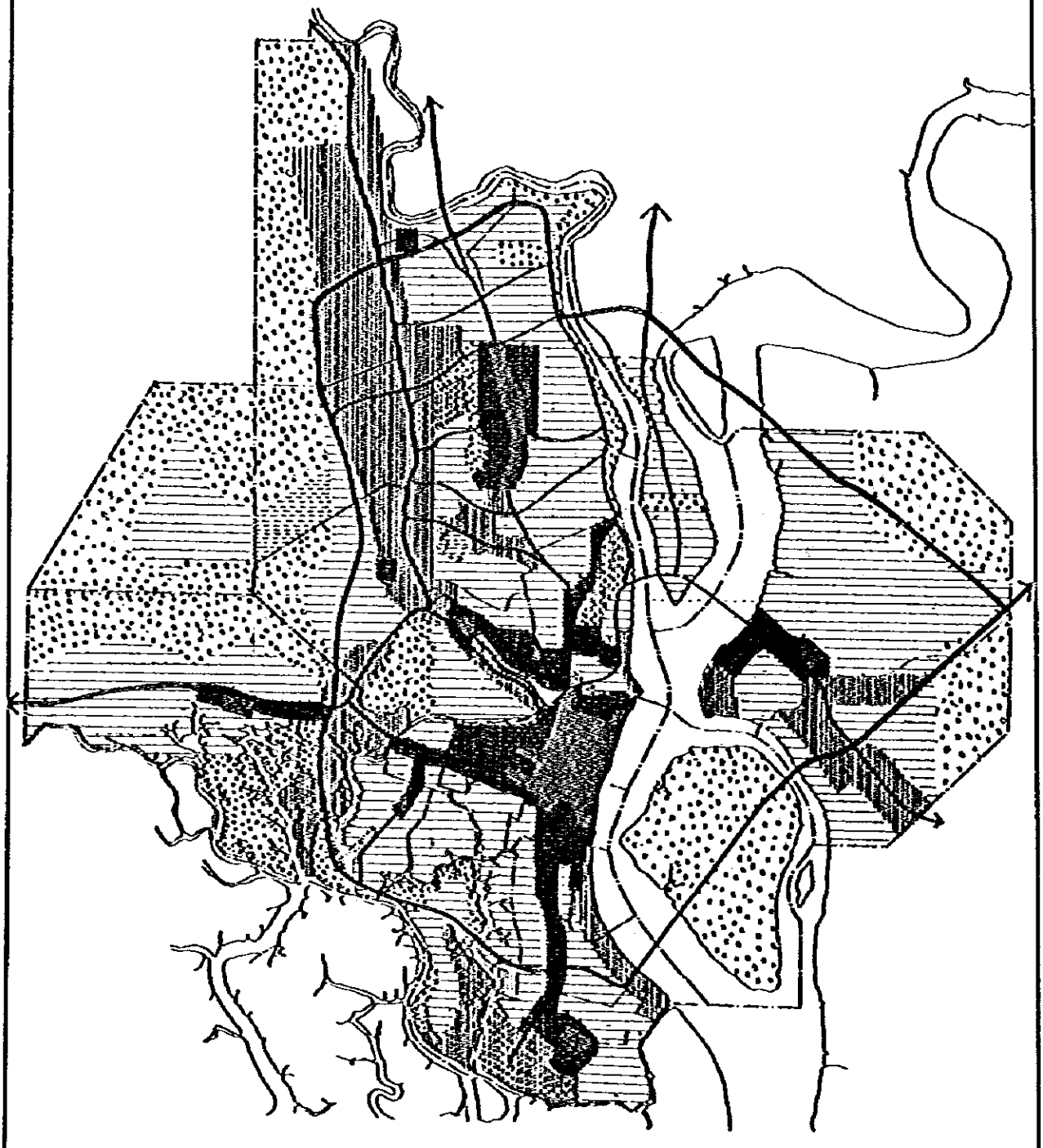
According to the development trends [3-3.4, 2)], the developing principles for future land use [3-3.5] and the adoption of Alternative-III as the urban structural pattern, future land use pattern of the Study Area in the year 2000 is planned as shown in Figure 3-3.9.

2) Future Changes in Indices of Urban Activities

Table 3-3.2, 3-3.3, 3-3.4, 3-3.5 show the future changes in such indices as population, EAP. and the number of students distributed to each B-Zone.

These distributions of indices of year 1982 are based on the existing recent statistical and registral data(*) and modified by the results of the Trip production survey or the Car Owner Interview survey, while those in future are based on the developing principles and urban structural pattern of Alternative-III.

(*) i. Census of Population 1974 by INEC.
ii. Houses in Guayaquil 1981 by INEC.
iii. Registrations of Cámara de Industrias de Guayaquil and Cámara de Comercios de Guayaquil 1981 - 82.
iv. Statistic of Education in Province Guayas 1980 - 81 by Ministerio de Educacion y Cultura.



CBD, SUB-CENTRE, REGIONAL-CENTRE

CUA, OTHER COMMERCIAL AND SERVICE AREA

RESIDENTIAL AREA

NEW EDUCATIONAL AREA

GREEN AREA

MANUFACTURING INDUSTRY

EQUIPMENT

Figure 3-3.9 FUTURE LAND USE OF THE STUDY AREA IN 2000

Figure 3-3.10 FUTURE CHANGES OF POPULATION AND EAP (1982, 1990, 2000)

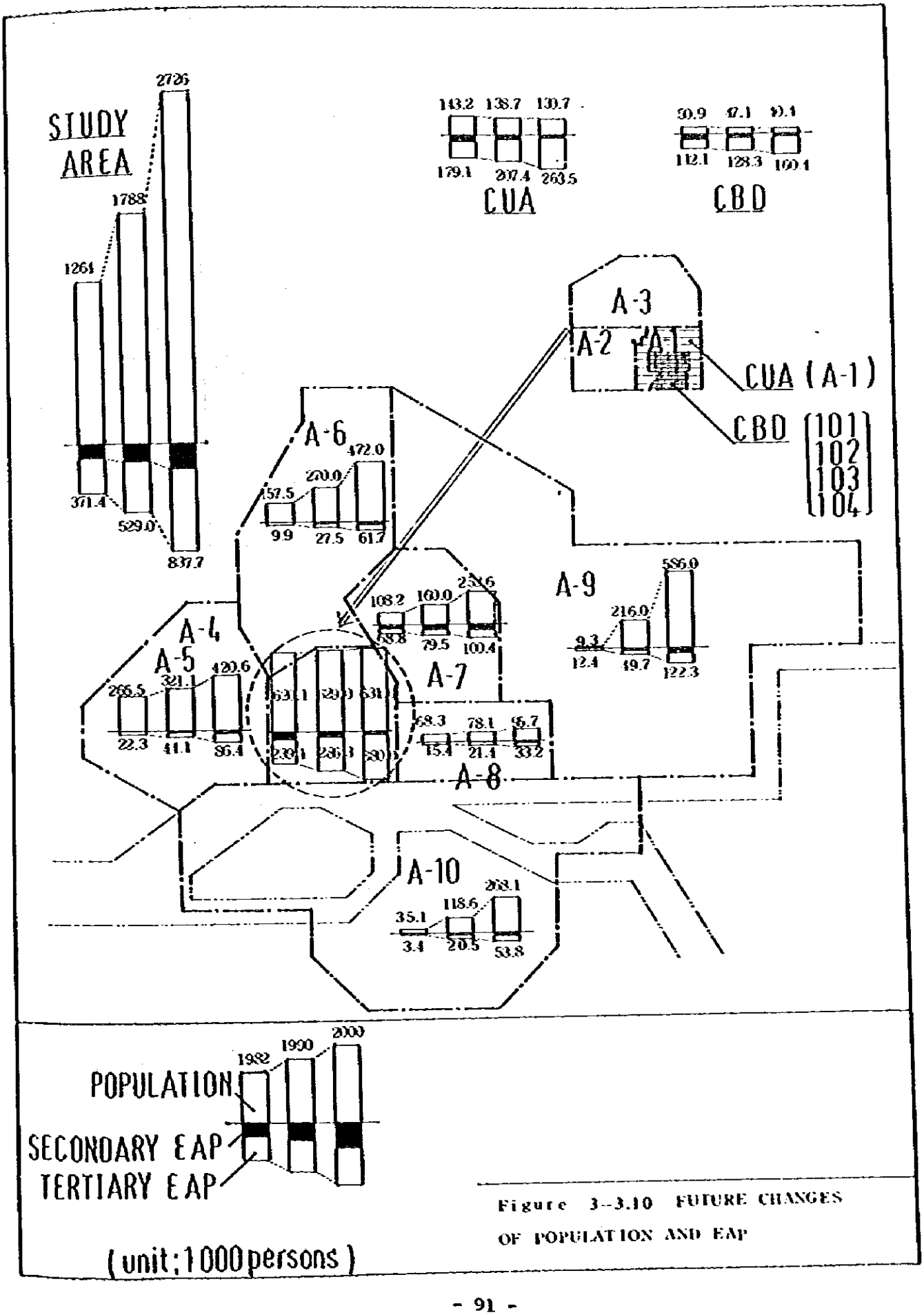


Figure 3-3.10 FUTURE CHANGES OF POPULATION AND EAP

Table 3-3.2 CHANGE OF POPULATION DISTRIBUTED TO B-ZONE

Zone A	Zone B	Population 1982	Population 1990	Population 2000
A-1	101	24,758	13,717	11,600
	102	9,458	8,685	7,300
	103	13,643	12,266	9,800
	104	13,031	13,492	11,500
	105	19,890	21,363	24,000
	106	12,434	11,815	10,600
	107	20,083	13,053	17,200
	108	18,619	18,110	17,200
	109	21,181	21,224	21,300
	S.T.	143,133	133,715	133,700
A-2	201	17,915	11,268	11,900
	202	31,376	30,232	28,100
	203	24,807	25,450	26,600
	204	30,667	31,852	33,700
	205	30,159	30,962	32,400
	206	66,700	63,131	73,400
	S.T.	154,924	158,665	206,100
A-3	301	42,095	41,953	43,700
	302	57,944	57,331	56,400
	303	83,143	87,106	94,200
	304	58,032	57,877	57,600
	305	40,829	42,073	44,300
	S.T.	282,043	286,430	296,200
A-4	401	4,262	4,333	4,600
	402	16,339	16,337	16,500
	403	20,637	21,412	22,800
	404	8,376	10,537	13,500
	405	3,138	5,132	8,700
	406	57	14,517	40,400
	S.T.	53,409	72,433	106,500
A-5	501	76,560	86,345	105,000
	502	45,426	58,755	82,600
	503	60,278	60,859	61,900
	504	25,138	37,706	63,200
	505	4,359	4,373	4,400
	S.T.	212,069	248,038	316,100
A-6	601	43,913	54,353	67,300
	602	48,492	50,818	55,000
	603	56,704	76,633	108,700
	604	420	89,433	245,000
	S.T.	157,519	270,233	476,000
A-7	701	25,032	27,955	33,300
	702	31,136	32,327	33,900
	703	13,583	30,273	60,000
	704	5,082	13,174	44,000
	705	33,455	50,456	81,000
	S.T.	108,288	160,012	252,600
A-8	801	30,290	31,330	32,800
	802	14,023	15,151	17,200
	803	23,969	31,758	45,700
	S.T.	68,282	78,139	95,700
A-9	901	3,321	39,978	273,000
	902	456	43,969	133,600
	903	5,171	55,763	145,400
	904	302	10,223	28,000
	S.T.	9,250	215,965	580,000
A-10	1001	24,635	27,833	34,900
	1002	10,339	45,317	116,300
	1003	443	28,059	77,500
	1004	0	0	0
	1005	309	14,356	39,500
	S.T.	35,723	115,625	268,100
Total		1,264,000	1,758,000	2,726,000

Table 3-3.3 CHANGE OF SECONDARY EAP DISTRIBUTED TO B-ZONE

Zone A	Zone B	Secondary EAP 1982	Secondary EAP 1990	Secondary EAP 2000
A-1	101	15,332	14,024	12,360
	102	4,242	3,641	2,652
	103	1,768	1,641	1,353
	104	4,351	3,760	2,634
	105	4,915	4,245	3,138
	106	2,133	1,819	1,374
	107	771	675	501
	108	1,025	953	615
	109	4,156	3,542	2,505
	S.T.	39,331	34,332	25,362
A-2	201	1,559	1,371	1,002
	202	675	558	437
	203	724	633	442
	204	1,354	1,193	854
	205	1,032	854	543
	206	581	454	432
	S.T.	5,925	5,114	3,766
A-3	301	651	647	583
	302	592	563	543
	303	259	257	255
	304	357	356	301
	305	242	233	233
	S.T.	2,101	2,172	2,171
A-4	401	302	312	312
	402	445	445	445
	403	505	533	531
	404	56	56	56
	405	21	21	21
	406	0	6,427	14,833
	S.T.	1,327	9,424	[illegible]
A-5	501	247	1,177	3,072
	502	99	733	1,382
	503	62	62	62
	504	358	358	358
	505	300	300	300
	S.T.	1,066	2,530	5,174
A-6	601	599	599	599
	602	159	159	159
	603	400	400	400
	604	25	6,522	14,557
	S.T.	1,183	7,680	15,715
A-7	701	3,132	3,132	3,132
	702	6,774	6,774	6,774
	703	6,367	6,367	6,367
	704	2,745	4,372	7,456
	705	13,802	13,802	13,802
	S.T.	32,423	32,247	35,131
A-8	801	1,045	1,045	1,045
	802	824	818	824
	803	547	547	547
	S.T.	2,416	2,416	2,416
A-9	901	4,343	7,416	19,767
	902	174	176	174
	903	2,685	14,833	30,336
	904	133	130	130
	S.T.	7,335	22,555	50,397
A-10	1001	255	255	255
	1002	130	130	130
	1003	192	9,900	28,483
	1004	0	0	0
	1005	75	75	75
	S.T.	652	10,360	28,900
Total		92,600	127,700	134,400

Table 3-3.4 CHANGE OF TERTIARY EAP DISTRIBUTED TO B-ZONE CORRESPONDING TO ALTERNATIVE-III

Zone A	Zone B	Tertiary EAP 1982	1990	2000
A-1	101	37,763	43,911	56,056
	102	17,873	20,790	26,541
	103	16,179	21,566	32,367
	104	14,140	18,923	28,375
	105	15,642	19,422	29,516
	106	10,961	12,745	16,270
	107	5,643	7,559	11,334
	108	9,722	12,342	18,505
	109	17,533	16,770	25,146
	S.T.	149,314	173,648	238,132
A-2	201	7,211	8,726	11,329
	202	4,423	6,242	9,623
	203	6,431	7,782	10,452
	204	7,963	9,636	12,941
	205	5,051	6,113	8,209
	206	4,327	5,212	7,000
	S.T.	35,332	43,711	59,145
A-3	301	3,856	6,517	11,955
	302	4,935	8,341	15,077
	303	2,270	3,838	6,933
	304	3,345	5,658	10,223
	305	2,168	3,664	6,621
	S.T.	16,573	28,018	50,622
A-4	401	1,433	1,726	1,735
	402	3,616	4,446	6,145
	403	4,885	6,009	8,267
	404	660	1,062	1,462
	405	153	226	311
	406	0	1,922	3,041
	S.T.	10,557	15,063	20,961

Zone A	Zone B	Tertiary EAP 1982	1990	2000
A-5	501	1,857	2,293	3,156
	502	1,683	10,118	26,761
	503	1,956	2,416	3,324
	504	372	954	1,312
	505	2,541	3,138	4,318
	S.T.	8,809	18,919	38,871
A-6	601	3,332	4,115	5,663
	602	1,649	2,037	2,803
	603	3,615	7,166	14,181
	604	162	6,493	13,000
	S.T.	8,758	19,811	41,647
A-7	701	11,003	13,588	18,698
	702	9,825	12,135	16,697
	703	6,814	8,413	11,582
	704	3,343	4,129	5,681
	705	7,423	9,168	12,615
	S.T.	38,336	47,423	65,253
A-8	801	4,600	5,681	7,816
	802	3,558	4,395	6,047
	803	4,856	8,897	16,681
	S.T.	13,014	18,973	30,744
A-9	901	1,883	8,098	29,819
	902	113	15,988	47,349
	903	2,189	2,703	3,719
	904	299	369	508
	S.T.	4,092	27,155	81,395
A-10	1001	2,545	2,527	3,477
	1002	457	6,483	18,227
	1003	159	159	221
	1004	0	0	0
	1005	57	1,026	2,360
	S.T.	2,719	10,193	24,315
Total		273,600	401,300	683,300

Table 3-3.5 DISTRIBUTION OF STUDENT (UNIVERSITY AND HIGHSCHOOL)

Zone A	Zone B	Student 1982	1990	2000
A-1	101	6,976	6,976	6,976
	102	11,398	11,398	11,398
	103	6,383	6,383	6,383
	104	4,019	4,019	4,019
	105	14,311	14,311	6,391
	106	2,762	2,762	2,762
	107	3,260	3,260	3,260
	108	6,211	6,211	6,211
	109	5,646	5,646	5,646
	S.T.	61,169	61,169	53,296
A-2	201	5,302	5,302	5,302
	202	7,749	7,749	7,749
	203	3,971	3,971	3,971
	204	3,652	3,652	3,652
	205	5,004	5,004	5,004
	206	2,097	2,097	2,097
	S.T.	27,675	27,675	27,675
A-3	301	7,884	7,884	7,884
	302	5,134	5,134	5,134
	303	3,612	3,612	3,612
	304	1,574	1,574	1,574
	305	1,361	1,361	1,361
	S.T.	19,625	19,625	19,625
A-4	401	350	350	350
	402	1,930	1,930	1,930
	403	5,053	5,053	5,053
	404	173	173	173
	405	147	147	147
	406	0	1,625	4,521
	S.T.	7,743	9,368	12,268

Zone A	Zone B	Student 1982	1990	2000
A-5	501	1,278	5,668	9,665
	502	582	2,513	4,811
	503	783	2,280	4,355
	504	235	2,218	4,235
	505	236	239	239
	S.T.	3,093	12,923	23,304
A-6	601	3,110	3,110	3,110
	602	1,926	1,926	1,926
	603	4,976	8,573	12,161
	604	679	3,535	27,524
	S.T.	10,691	29,504	44,721
A-7	701	43,139	43,139	43,242
	702	4,005	4,005	4,005
	703	7,415	7,518	9,457
	704	1,954	10,059	12,968
	705	3,590	3,634	3,683
	S.T.	60,103	68,354	73,355
A-8	801	10,213	10,213	10,213
	802	1,627	1,627	1,627
	803	784	2,573	4,548
	S.T.	12,624	14,413	16,388
A-9	901	2,159	30,856	127,545
	902	0	5,531	35,509
	903	1,170	6,242	16,381
	904	0	1,144	3,131
	S.T.	3,329	43,963	182,567
A-10	1001	1,245	3,121	3,933
	1002	845	5,406	13,213
	1003	0	3,143	9,672
	1004	0	0	0
	1005	0	1,606	4,423
	S.T.	2,631	13,233	29,335
Total		257,992	378,202	619,565

3-4 TRANSPORT DEMAND MODELS AND FORECASTS

3-4.1 General Flow of Traffic Forecast

1) Introduction

In this chapter traffic forecasting is done to find future traffic problems and to evaluate the transport alternative plans. First, it is mentioned that the traffic forecasting depends on its premise conditions such as socio economic framework, transport policy, etc., accordingly it should be borne in mind that the results of forecast shall be justified only under those conditions.

The traffic demand under the basic situation, which means no control and no physical investment in the traffic environment, is forecast. It is denominated "Basic case". Some traffic problems might be found out clear by examining its results. Then, several transport alternatives are added to the basic case to cope with the foreseeable problems and the corresponding traffic forecasting is conducted again. Next to that comparative analysis is carried out for each transport alternative based on the forecast results.

2) General Flow Chart

The general flow chart of traffic forecast is shown in Figure 3-4.1. The first step of traffic forecast is future socio-economic framework determination in zones by analyzing the past trend of socio-economic indicators such as population and economically active population, and making the future land use plan. Next to it, specific traffic models describing the present traffic conditions are established by the statistical analysis to examine traffic survey data and socio-economic data. Following it, various future traffic estimations starting from trip production to trip assignment are carried out by applying the future socio-economic data to the traffic models formulated. Each estimation is roughly explained as followings;

a. Trip production means the total trip volume produced in the Study Area in future. It is obtained by using the unit trip production method under the future socio-economic framework.

b. The trip generation/attraction means zonal distribution of trips made in the Study Area and its volume is calculated from the trip generation/attraction models.

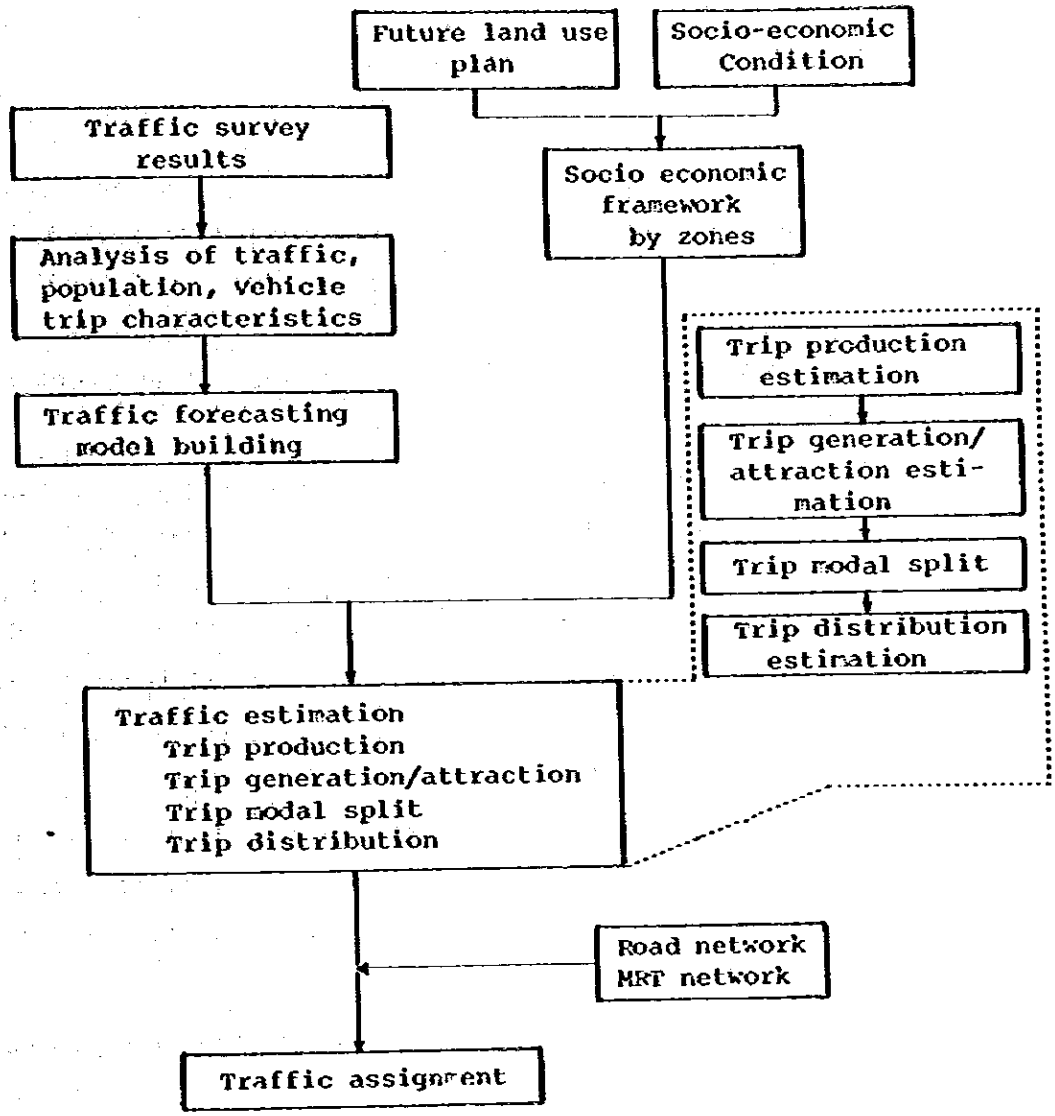


Figure 3-4.1 GENERAL FLOW CHART OF TRAFFIC FORECAST

c. Trip modal split is such a process as the total number of trip estimated is subdivided into each transport mode. Its estimation is done by the trip modal split model.

d. Trip distribution is the trip interchange between zones and estimated by the trip distribution models which are formulated by the statistical analysis of the present traffic data.

e. Traffic assignment is the process that trip interchanges between zones are allocated to the appropriate transport path which is determined through path finding algolythm.

3-4.2 Trip Production Model and Forecast

1) Outline

Trip production means the total trips made in the Study Area. On this context the trip production includes the whole daily trips such as commuting, visiting to friend's house, etc. In this study, however, walking trip is excluded a priori from the trip production because trips in any mode are main objects of this transport planning.

In general, trip production rate per person has such a stability as its characteristics is maintained wherever and whenever it is estimated. Future trip production is estimated by using average trip production rate which is based on the future framework. It is necessary to examine trip production characteristics because the trip production is the origin of trip forecasting.

Consequently analysis showed that there existed strong relationship between the average trip production and the family car-ownership. For the future estimation of trip production, the above assumption was also used.

Following results were obtained after the trip production estimate.

a. Present trip production within the Study Area

Total 2,312,867 trips were made in 1982: 1,050,907 trips were by private vehicles, 420,069 trips were by taxi and 841,891 trips by bus. Average trip production rate was 1.83 trips for one person.

b. Future trip production

4,980,000 trips were estimated as the trip production in 2000, and the trip growth rate was calculated 2.15 tires in 1982.

Table 3-4.1 TRIP PRODUCTION IN STUDY AREA

Vehicle type \ Year	1982 (Actual)	2000 (Estimate)
Private vehicle	1,050,907	
Bus	841,891	
Taxi	420,069	
Total	2,312,867	4,980,000

2) Trip Production Characteristics

The trip production survey was conducted to investigate the trip production characteristics by the Study Team. In general average trip production rate is related to the personal characteristics of travelers. For example it is very common that people who are engaged in some occupation make more trips than those who have no occupations. The purpose of this section is to clarify what are the main factors for the trip production and to measure the difference of trip production rate in each category of main factors.

a. Trip production rate by sex

Figure 3-4.2 shows the difference of trip production in sex. Though small difference is found yet, there is not significant between the trip production by sex.

b. Trip production rate by age

Figure 3-4.3 shows the difference of trip production in age group. Though the distribution pattern of the number of trips is almost same among all age groups, small difference can be found in the average trip production rate. The group of 20's has the highest trip production rate and it is found that people get older, their average trip production rate decreases.

c. Trip production rate by family income

There is obvious difference between the trip produc-

tion in income group. According to Figure 3-4.4 people who belong to the higher income group make more trips than those who have lower income. The average number of trip production increases serially as the income of group gets higher.

d. Trip production rate by occupation

Table 3-4.2 shows trip production by each occupation group including the housewives and students etc. The groups belonging to the professional occupations have the biggest trip production rate while the group of housewives has the lowest rate.

Figure 3-4.2 NUMBER OF TRIPS BY SEX

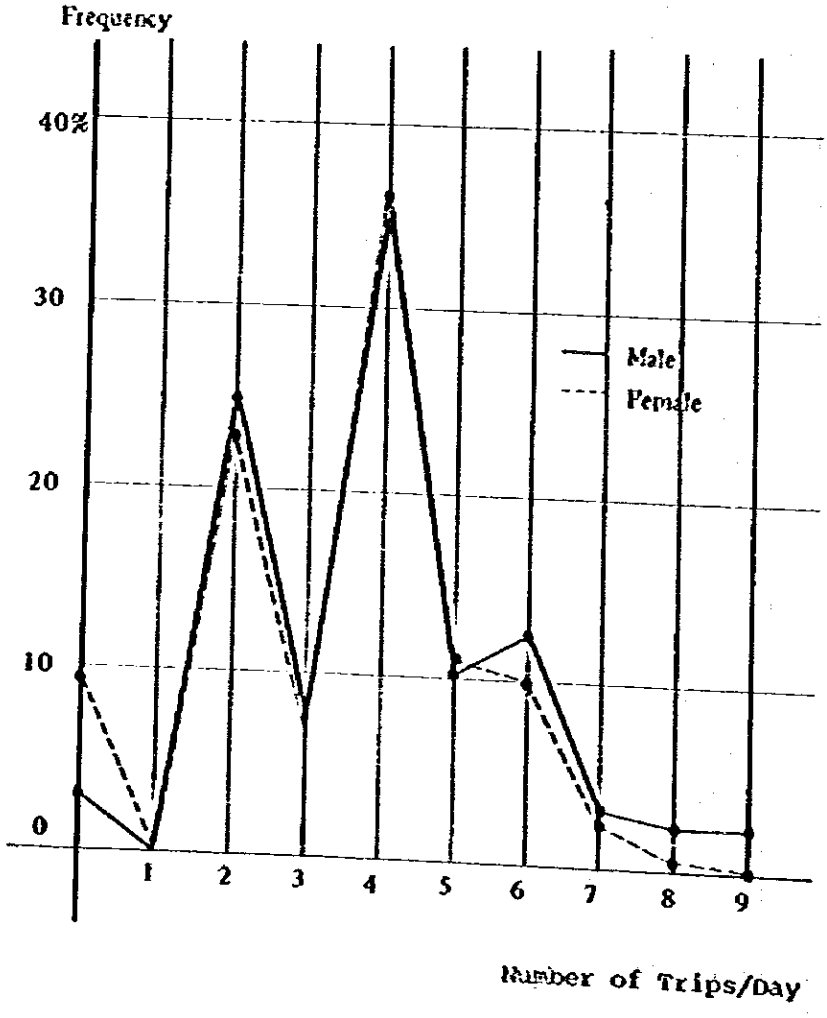


Figure 3-4.3 NUMBER OF TRIPS BY AGE GROUP

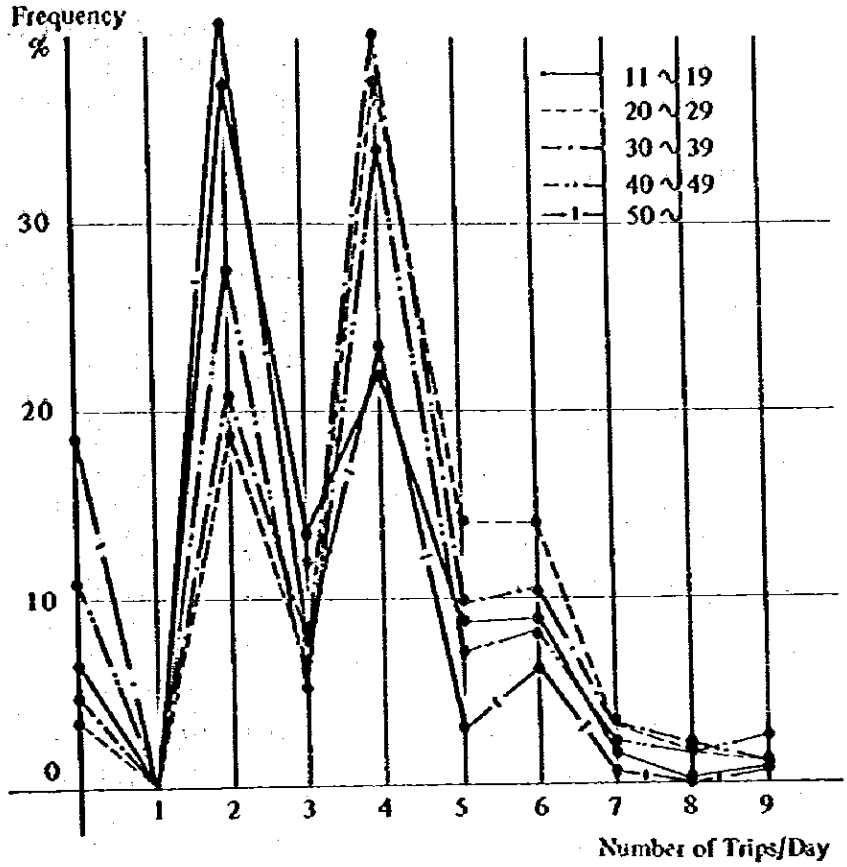


Figure 3-4.4 NUMBER OF TRIPS BY INCOME GROUP

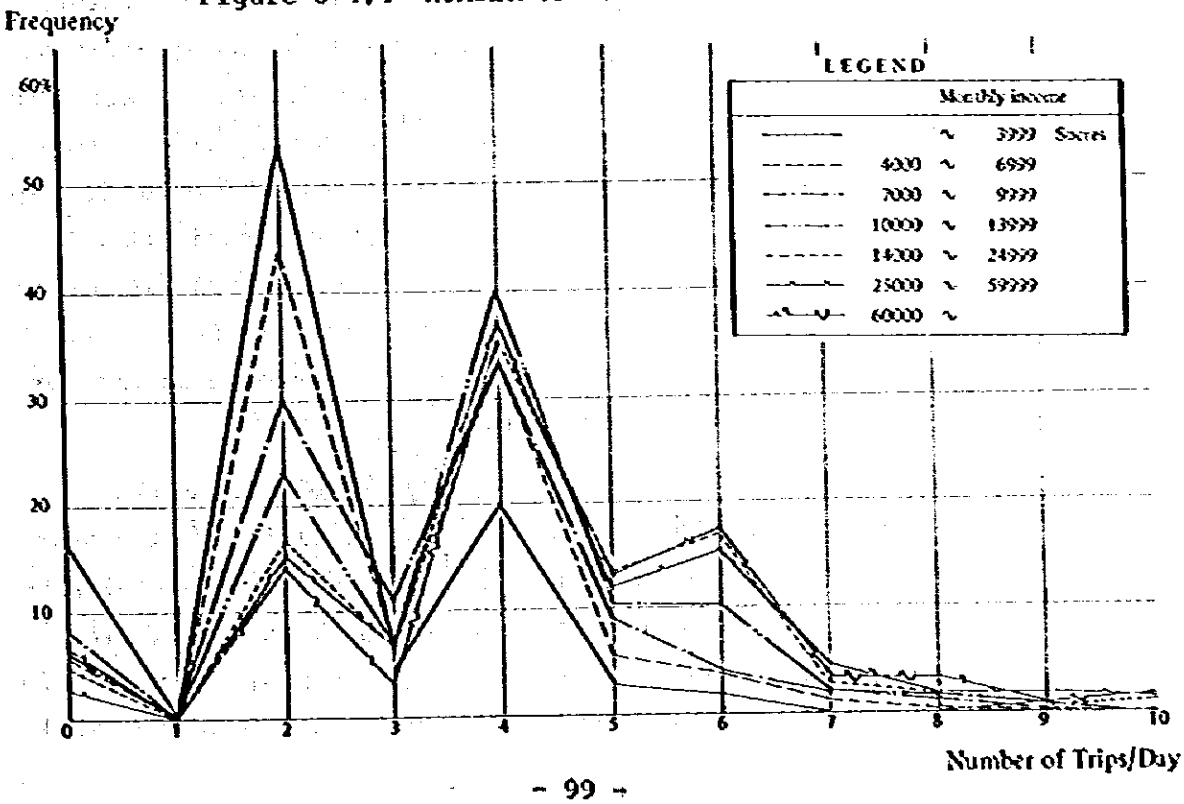


Table 3-4.2 AVERAGE TRIP PRODUCTION RATE BY OCCUPATION

Unit: Trips/Day

Occupation	Average trip production
Professional	4.503
Administrative	4.030
Office	4.396
Commercial	3.124
Agriculture	4.200
Driver	3.857
Mechanics	3.047
A day laborer	3.168
Private work	3.589
Student	3.349
Housewife	1.838
Others	2.543

Source; Trip Production Survey by the Study Team, July, 1982

3) Trip Production Model

Unit trip production method was employed for the trip production estimate. And the trip production unit was determined from the trip production survey results. As an additional factor the increase of family car-ownership was also taken into account. Table 3-4.3 shows the average trip production rate by occupation. Trip production rate is calculated by each trip purpose and also by family car ownership. As seen in this table, the average trip rate for the car-owned family is higher than the no-car family. From this observation it is assumed that the average trip production unit will increase as the car ownership in a family becomes larger.

However there is still uncertainty in future for the increase of trip production rate or some possibility of changes of the customs like decrease of Almuerzo. Therefore total production rate per person was fixed at the present level. The internal trip production was given by multiplying the unit trip production with the future population by each occupation, while

the external trip was estimated by the growth rate method.

Table 3-4.3 AVERAGE TRIP PRODUCTION RATE BY OCCUPATION

Unit; Trips/Day

Personal Characteristics		Trip Purpose						
		To work	To school	Business	Private	To home	Almuerzo	All Purposes
1. Professional	Car	1.185	0.119	0.607	0.595	1.304	0.714	4.524
	No Car	0.986	0.167	0.159	0.326	1.167	0.746	3.551
	Total	1.095	0.141	0.405	0.474	1.242	0.728	4.085
2. Administrative	Car	1.006	0.072	0.525	0.586	1.254	0.812	4.254
	No Car	0.820	0.124	0.191	0.270	0.888	0.382	2.674
	Total	0.945	0.089	0.415	0.482	1.133	0.670	3.733
3. Office worker	Car	1.018	0.331	0.191	0.444	1.267	1.259	4.510
	No Car	0.979	0.240	0.129	0.210	1.137	1.160	3.854
	Total	0.993	0.272	0.150	0.291	1.182	1.194	4.081
4. Commercial	Car	0.886	0.106	0.629	0.432	1.091	0.402	3.545
	No Car	0.819	0.076	0.161	0.188	0.934	0.145	2.322
	Total	0.839	0.085	0.303	0.262	0.982	0.223	2.692
5. Agriculture	Car	0.833	0.000	1.167	0.500	0.833	0.667	4.000
	No Car	0.750	0.000	0.000	0.750	1.250	0.500	3.250
	Total	0.800	0.000	0.700	0.600	1.000	0.600	3.700
6. Service worker	Car	0.863	0.113	0.450	0.775	1.075	0.288	3.563
	No Car	0.911	0.084	0.173	0.331	1.089	0.268	2.856
	Total	0.902	0.089	0.225	0.414	1.086	0.272	2.988
7. Student	Car	0.045	1.015	0.045	0.652	1.318	0.045	3.121
	No Car	0.070	0.978	0.022	0.586	1.177	0.043	2.876
	Total	0.063	0.988	0.028	0.603	1.214	0.044	2.940
8. Housewife	Car	0.027	0.009	0.045	1.009	0.802	0.009	1.901
	No Car	0.025	0.071	0.035	0.596	0.460	0.000	1.187
	Total	0.026	0.049	0.039	0.744	0.583	0.003	1.443
9. Others	Car	0.381	0.000	0.143	0.667	0.714	0.000	1.905
	No Car	0.632	0.043	0.034	0.248	0.718	0.188	1.863
	Total	0.594	0.036	0.051	0.312	0.717	0.159	1.869

Note; Excluding walking.

Source; Trip Production Survey by the Study Team

4) Future Trip Production Estimate

As mentioned in the previous section, future trip production is obtained by accumulating the trip production by each category of occupations. Basic assumption for its calculation is as followings.

(1) Average trip production unit by each category is maintained until future.

(2) Increase of car ownership is expected for all category.

(3) It is assumed that future composition of occupation for each industry is same as present.

a. Internal Trip

Table 3-4.4 shows the estimation result of trip production in the Study Area. The total internal trip production in 2000 is estimated to be 4,980,000 trips a day if the future taxi share does not change.

Table 3-4.4 FUTURE INTERNAL TRIP PRODUCTION

Trip purpose	1982	2000	Average annual growth rate
To work	307,111	601,900	3.8%
To school	122,195	227,700	3.5
Business	442,866	1,092,700	5.1
Private	410,626	907,400	4.5
To home	490,333	989,100	4.0
Almuerzo	119,667	254,700	4.3
Total	1,892,798	4,073,500	4.3

Note; Excluding taxi trips

b. External Trip and Trips from Terminals

The external trip is estimated by using the growth rate of the internal trip as mentioned before and it will be discussed in the later section. The trip related to the special facilities such as the port and the airport should be estimated in a different way.

b-1 Port

Present traffic volume concerned with the new port was also surveyed by the Study Team. According to it the present traffic volume from the port is estimated to be 5,840 vehicle trips in both ways.

These vehicle trip make 10,200 person trips/day. Examining this volume, carefully from the result of other surveys

conducted by the Study Team, it was found that the port traffic might be covered by the other surveys and estimation.

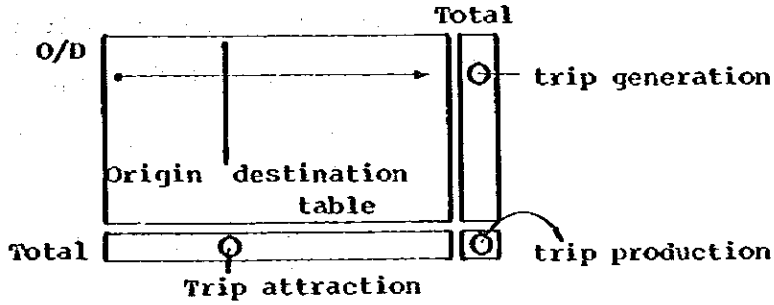
b-2 Air port

It is needless to say that flight passengers from the outside of the Study Area are not included into any internal traffic survey samples. To grasp the traffic related to the airport, a special airport traffic survey was also carried out. According to it the present access traffic to the airport totals 3,000 trips/day. It was projected 6,100 trip/day in future by using the average growth rate of population until 2000.

3-4.3 Trip Generation and Attraction Models and Forecast

1) Overview

Trip generation/attraction is the total number of tripends generated/attracted in a specific zone and given as a row/column total of an origin destination table as shown in the following example.



In general the trip generation/attraction is determined by using some formulas, after the trip production is established and total no. of trip generation/attraction is adjusted to it simultaneously. There are many types of methods developed for the trip generation/attraction estimation.

In this Study the model method was employed. As mentioned before, the future trip estimation of the external trips was done by using the growth rate of the internal trips. In addition to it, trip purpose is also taken into account when the trip model is formulated.

2) Model Building

The trip generation/attraction models use the following type.

$$T = a_1.P + a_2.E_2 + a_3.E_3 + a_4.S + b$$

where, T : Trip generation or attraction
P : Population
E_2, E_3 : Secondary, tertially EAP
S : No. of students measured on school basis
a_1, a_2, a_3, a_4 : Coefficients
b : Constant

As mentioned before, the trip generation/attraction models are formulated by each trip purpose and the stepwise regression method is employed to choose the most significant figures for the explanatory variables. Model justification is done by examining the correlation factor and the regression coefficient, especially testing the significance of parameters. Final result is shown in Table 3-4.5. Most of the correlation factors are over 0.80 except "to school purpose" and it is considered that the model formulation is very significant.

Table 3-4.5 TRIP GENERATION/ATTRACTION MODEL BUILDING

Vehicle Type	Trip Purpose	Gen. or Att.	Coefficient for explanatory variables					Constant	Correlative factor
			Population	EAP-2	EAP-3	Student	EAP-2+3		
CAR + BUS	To work	G	0.17031				0.18201	0.46615	0.82
	To school	"	0.04252		0.07821	0.06742		0.02618	0.83
	Business	"	0.07558		0.71183			2.86300	0.75
	Private	"	0.12843		0.71419			0.94585	0.87
	To home	"	0.02824		1.49892			0.70654	0.94
	Almuerzo	"	0.00750		0.39554			-0.00167	0.95
	ALL-P	"	0.47521		3.67921			5.12289	0.92
	To work	A		-0.00505	1.10146			0.00960	0.99
	To school	"			0.83201	0.01917		0.35541	0.54
	Business	"	0.04887		0.90481			2.47777	0.83
	Private	"	0.04295		1.23275			0.24325	0.94
	To home	"	0.24741		0.36641			1.45092	0.80
	Almuerzo	"	0.02691	0.06266	0.24520			0.22092	0.86
	ALL-P	"	0.37502		4.19692			4.78246	0.94
TAXI	ALL-P	G	0.03670	-0.17897	1.37706			0.12185	0.90
	ALL-P	A	0.03486	-0.11284	1.46206			-0.40692	0.91

(Note) EAP-2 shows the secondary Economically Active Population
EAP-3 shows the tertiary Economically Active Population

3) Trip Generation/Attraction Estimate

The future trip generation/attraction is calculated by using the future population and EAP distribution which are the explanatory variables of the trip model. Figure 3-4.5 shows the comparison of the trip generation by zone. A high growth of the trip generation takes place in the northern suburban area where the high population increase is foreseen in the future, while the trip generation growth in the CBD area remains at a lower level. As a whole, the trip generation tends to increase more in the surrounding area than the existing urban area because socio economic framework expects the future population development mainly in fringe areas.

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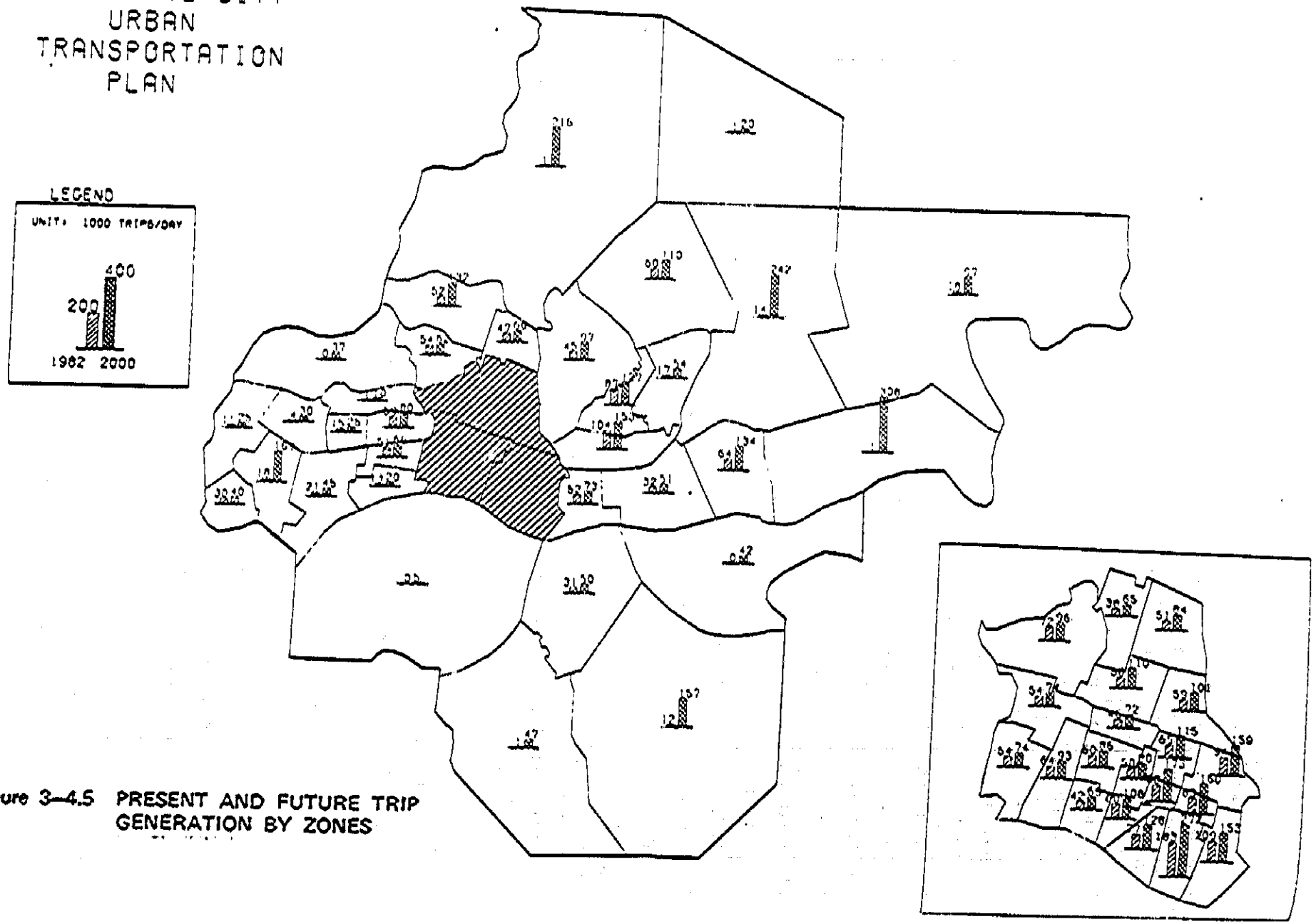


Figure 3–4.5 PRESENT AND FUTURE TRIP GENERATION BY ZONES

3-4.4 Modal Split

1) General Concept of Modal Split

Modal split is such a process that future trip, which is estimated by trip production and generation model etc., is subdivided into the trip by each mode, i.e., vehicle trip, bus trip and taxi trip.

In general there are two types of forecasting method for modal split. The first is the trip end modal split model, and this method presumes the modal split before trip distribution forecasting and its result is given in zonal trip distribution. The second one is called trip interchange model, and in this method the modal split is carried out just after trip distribution forecasting and each trip interchange is subdivided by mode. In this Study first type of method, i.e. trip end model is taken for the modal split estimation because of following reasons.

(1) Existing modal split characteristics indicates that zonal modal split tendency is quite different.

(2) Car ownership is not uniform by zone. Some specific zones have quite low car ownership and it is considered that many captive users in modes exist there.

(3) Generally, trip interchange method assumes the existence of choice riders whose trip mode selection depends on their trip purpose or destination rather than their car holding, but such situation seems to be quite rare, judging from the existing condition aforementioned.

(4) Therefore, it is thought that the trip end model is more suitable method for estimation unless the future traffic and socio-economic conditions changes drastically from the existing one.

2) Existing Modal Split

a. Area Characteristics

Table 3-4.6 shows the existing vehicle usage by zone.

The northern areas such as zone 7, 8, 9 and the CBD areas such as 1 and 2 zone have high car using rate while the car using rate is quite low in 5 and 6 zone. It is considered that this tendency mainly comes from the zonal gap of car ownership. The relationship between zonal vehicle usage and its car ownership situation is shown in Figure 3-4.6. According to this figure it is considered that the positive relationship exists between both factors.

Table 3-4.6 PRESENT CAR USING RATE BY ZONE

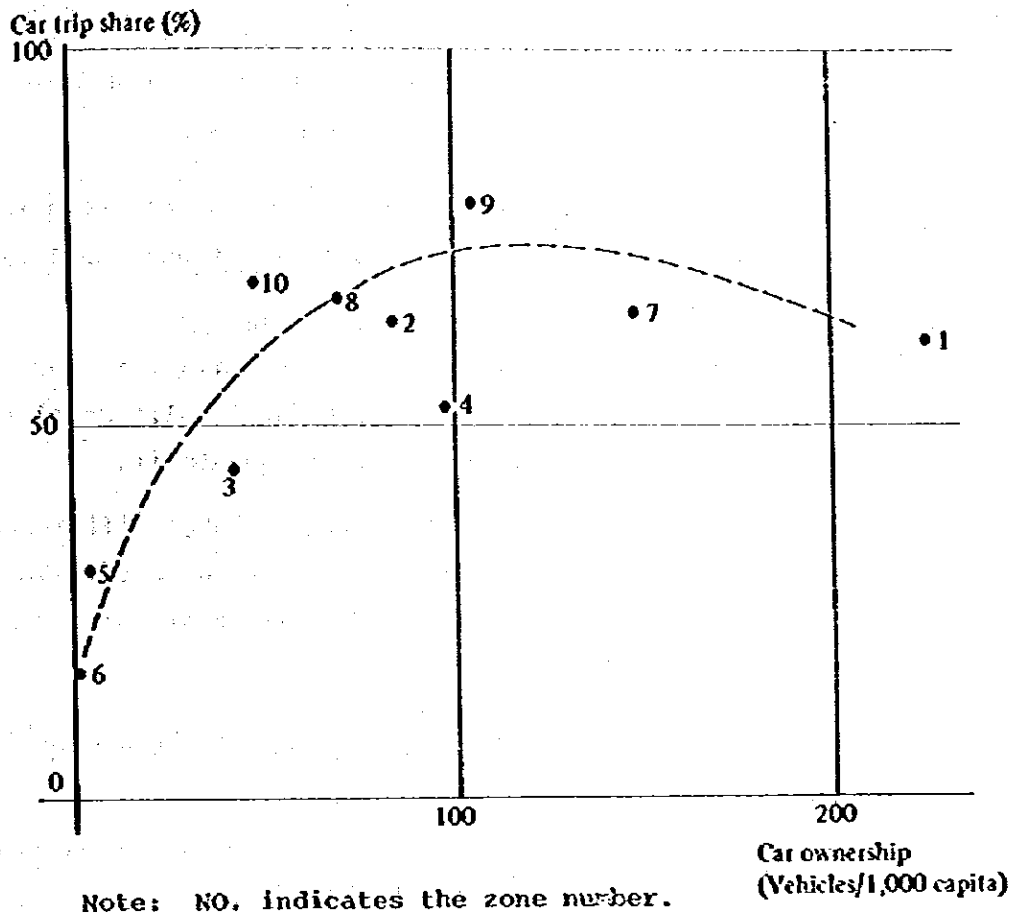
in 1982

Zone	Car using rate	Average car ownership
1	0.61	226.3
2	0.64	84.1
3	0.44	41.6
4	0.52	98.1
5	0.31	4.5
6	0.17	1.4
7	0.65	147.8
8	0.67	70.4
9	0.80	105.6
10	0.69	47.5
Study area	0.56	73.1

Note 1. Car using rate is shown in car trip share of total trip excluding taxi trip.

2. Average car ownership is shown in No. of vehicles, excluding buses and taxis, per 1000 capita.

Figure 3-4.6 RELATIONSHIP BETWEEN CAR TRIP SHARE AND ZONAL CAR OWNERSHIP



Note: NO. indicates the zone number.

b. Trip Purpose Consideration

Table 3-4.7 shows the vehicle usage by each trip purpose. There is different tendency in vehicle usage between trip purposes. Business trip expects high vehicle usage while low for going to school.

Table 3-4.7 PRESENT CAR USING RATE BY TRIP PURPOSE

Unit: Trips/Day (1982)

Trip Purpose	Car trip generation	Bus trip generation	Car using rate
To work	97,675	209,436	0.32
To school	19,510	102,685	0.16
Business	395,333	47,533	0.89
Private	230,782	179,844	0.56
To home	211,022	279,311	0.43
Almuerzo	96,585	23,082	0.81
All Purpose	1,050,907	841,891	0.56

Note; 1. Both trip generations stand for the total trips made within the Study Area.
2. Taxi trips are excluded.

3) Modal Split Model Building

It is considered that there are many factors concerned with trip modal split. Following aspects are taken into account for the model formulation.

(1) The existing traffic situation indicates that some relationship exists between trip modal split and zonal car ownership.

(2) It should be considered that network service factor by each mode is also included in the modal split model so as to reflect the future network change to it.

(3) Existing data indicates that there is large difference between the vehicle usages by each trip purpose. Therefore it is necessary to formulate the modal split model by each trip purpose.

Accordingly, the following type is employed for the trip modal split model.

$$P = a_1.C + a_2.R_1 + a_3.R_2 + b$$

where, P ; Vehicle using rate
Car trip/(Car + Bus trip)

C ; Zonal car ownership
(No. of vehicles per 1000 capita)

R_1, R_2 ; Population or EAP accessibility ratio
(Car accessibility/Bus accessibility)

a_1, a_2, a_3, b ; Regression coefficients

Regression method is used to get each coefficient.

Note) · Model is formulated by trip purpose as mentioned above.

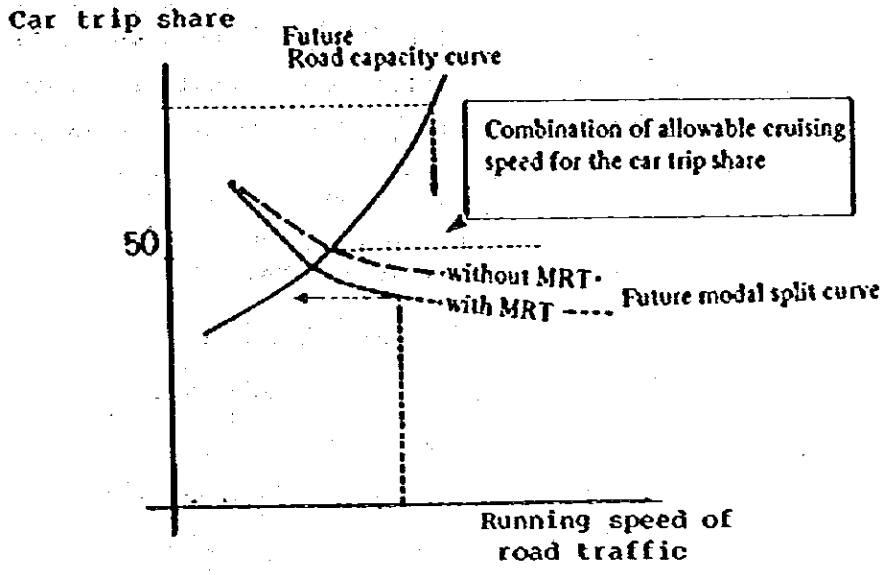
· The share of taxi trip is fixed in such a way as the future modal split rate is same as present since taxi trips can not be included in the modal split model.

4) Modal Split Estimation Result

a. Capacity Equilibrium

Following point should be taken into account for the modal split model application to future condition. There are two types of variables in the modal split model. The Accesibility ratio is a substantial dependent variable of the traffic volume because the network link speed is flow dependent, while the car ownership is independent of it. Therefore mathematical calibration is necessary to get the capacity equilibrium solution. An example of the relationship between trip demand and traffic capacity is shown in Figure 3-4.7.

Figure 3-4.7 CONCEPT OF CAPACITY EQUILIBRIUM IN TRIP MODAL SPLIT



b. Estimation Results

Final result of the trip modal split is shown and compared with the present situations in Table 3-4.8-1. According to it the future private vehicle using rate, including taxi, decreases from 64% in 1982 to about 58% in 2000 because of the capacity limitation in the road traffic.

Table 3-4.8-1 MODAL SPLIT ESTIMATION RESULT

Case	Car trip	Taxi trip	MRT trip	(Car + Taxi) Trip Share
Present	1,050,907	420,069	841,891	0.64
2000	1,996,800	906,300	2,076,500	0.58

c. External Trips

As mentioned before, future external trips are estimated by using average growth rate method. As future internal trip volume is obtained by each traffic mode, i.e., car, taxi and bus, the future external trip volume is also estimated as following, using the growth rate of the internal trip respectively.

Table 3-4.8-2 EXTERNAL TRIP ESTIMATION

Unit: Trips/Day

	1982	2000	Growth rate
Car	59,143	112,400	1.9
Taxi	2,982	6,400	2.2
Bus	86,546	213,500	2.5

Note) · Excluding through trips

· Growth rate is based on the traffic demand of "Basic Case".

The external bus trip mostly consists of the inter city bus trip and the Bus Terminal under construction now

is expected to control most of the external bus service in the future. Therefore the Bus Terminal is assumed to be a special traffic node which generates and attracts traffic related to the external bus trips.

3-4.5 Trip Distribution Model and Future O-D Tables

1) Outline

Trip distribution forecasting is the process to estimate inter zonal trips from the trip generation and attraction estimated already and the zonal interchange data like travel distance. There are two standard procedures used for this process. One is the present pattern method which uses the present origin destination pattern for the first estimate of future trip pattern. The other is the model method which estimates future trip pattern by using some models. In this Study the model method was selected because;

(1) The future trip growth takes place mainly in the surrounding parts of the Study Area where the present trip distribution is very few. Therefore it is necessary to give an initial trip interchange which is not obtained from the present data.

(2) It is foreseeable that the future trip interchange varies in related to the change of traffic condition.

Gravity model is applied to the trip distribution model, and final estimate is obtained by adjusting the initial estimate to the trip generation/attraction, using "Fratar" method.

2) Model Building

Gravity model is formulated analogically from the gravity theory and its form is simular to the dynamic model.

Model is shown as followings.

$$Tij = \alpha \frac{Xi^{\beta_1} \cdot Yj^{\beta_2}}{(\gamma ij)^{\gamma}}$$

where Tij ; Trip interchange from zone i to zone j

Xi ; Trip generation of zone i

Yj ; Trip attraction of zone j

Yij ; Traffic impedance from zone i to zone J

$\alpha, \beta_1, \beta_2, \gamma$; Coefficients

In this Study the distribution model is determined by each mode. Regression method is also employed to get a set of coefficients. Some explanation is needed since these gravity models can not give the value for the intra zonal trip. The intra zonal trip, i.e. such trip from zone i to zone i, is estimated by using the following growth method while the gravity model is applied to inter zonal trip.

$$T'ii = Tii \times \left(\frac{Xi'}{Xi} + \frac{Yi'}{Yi}\right) \times 1/2$$

where Tii ; Intra zonal trip

Xi ; Trip generation

Yi ; Trip attraction

Note) Accent mark shows future volume.

3) Trip Distribution Estimation

The future O-D table is estimated by applying the future trip generation and attraction to the gravity model formulated before. Table 3-4.9, 10 shows the comparison between the present and future O-D pattern and desired traffic lines in the future are also shown in Figure 3-4.8. Large traffic volume can be seen from the northern suburban area where high trip growth is expected. It is considered that the present O-D pattern, the main traffic concentrating to CBD, still remains in the future although some considerable traffic volume takes place between fringe zones.

Table 3-4.9 VEHICLE O-D PATTERN (PRESENT-FUTURE)

Unit: 1000 Trips/Day

Origin \ Destination		Existing Urban district	Western Part of Urban district	Western Suburban Area	Northern Suburban Area	Duran	Study Area
Existing Urban district	1982	714	18	0	202	22	956
	2000	1,026	47	61	359	66	1,559
Western part of Urban district	1982	19	8	0	3	0	30
	2000	45	13	4	22	5	89
Western sub-urban Area	1982	0	0	0	0	0	0
	2000	65	4	20	60	9	158
Northern sub-urban Area	1982	206	3	0	112	4	325
	2000	370	24	58	417	50	919
Duran	1982	20	0	0	3	7	30
	2000	70	5	9	51	43	178
Study Area	1982	959	29	0	320	33	1,341
	2000	1,576	93	152	909	173	2,903

Table 3-4.10 MRT O-D PATTERN (PRESENT-FUTURE)

Unit: 1000 Trips/Day

Origin \ Destination		Existing Urban district	Western part of Urban district	Western Suburban Area	Northern Suburban Area	Duran	Study Area
Existing Urban district	1982	420	64	0	88	7	580
	2000	824	91	20	244	46	1,225
Western part of Urban district	1982	88	17	0	12	0	117
	2000	101	23	2	32	5	163
Western sub-urban Area	1982	0	0	0	0	0	0
	2000	25	2	7	20	3	57
Northern sub-urban Area	1982	87	10	0	33	2	132
	2000	268	32	26	178	25	521
Duran	1982	9	0	0	2	2	13
	2000	54	7	3	26	21	111
Study Area	1982	604	91	1	134	11	842
	2000	1,272	155	50	500	100	2,077

Note) Trips are shown on the internal trip base.

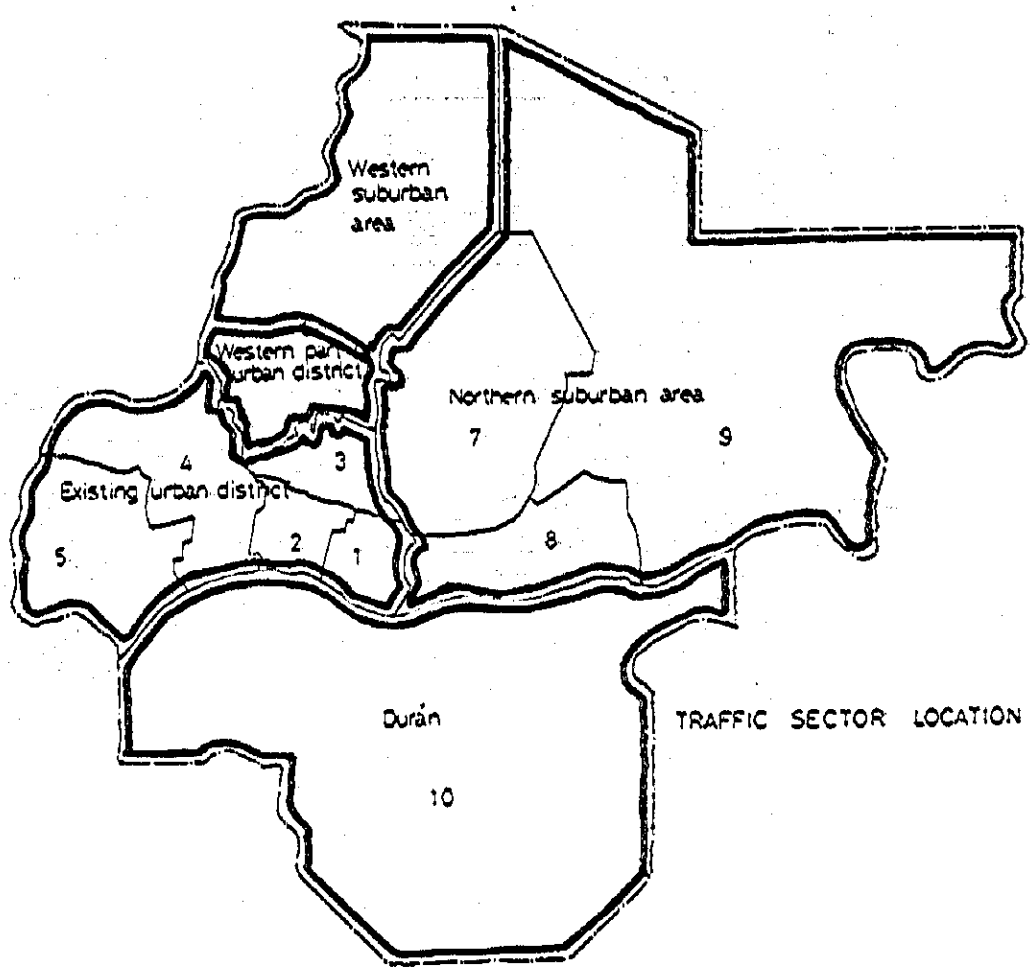
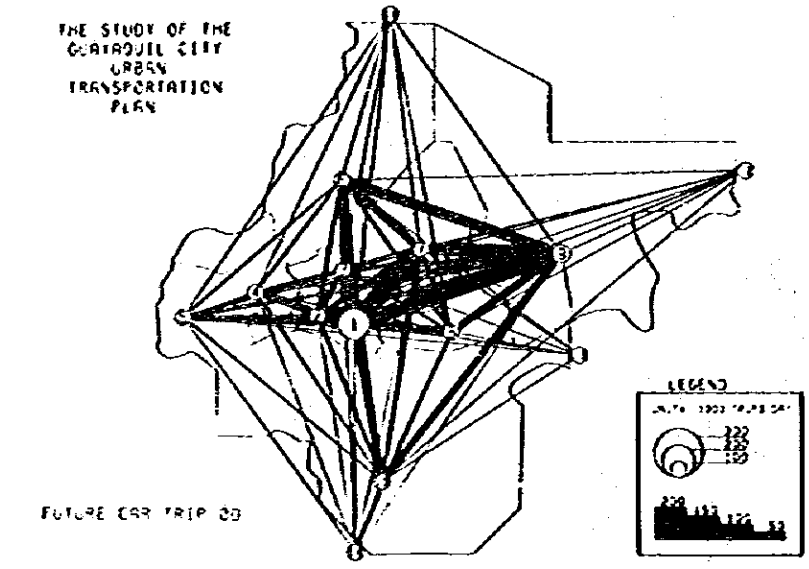
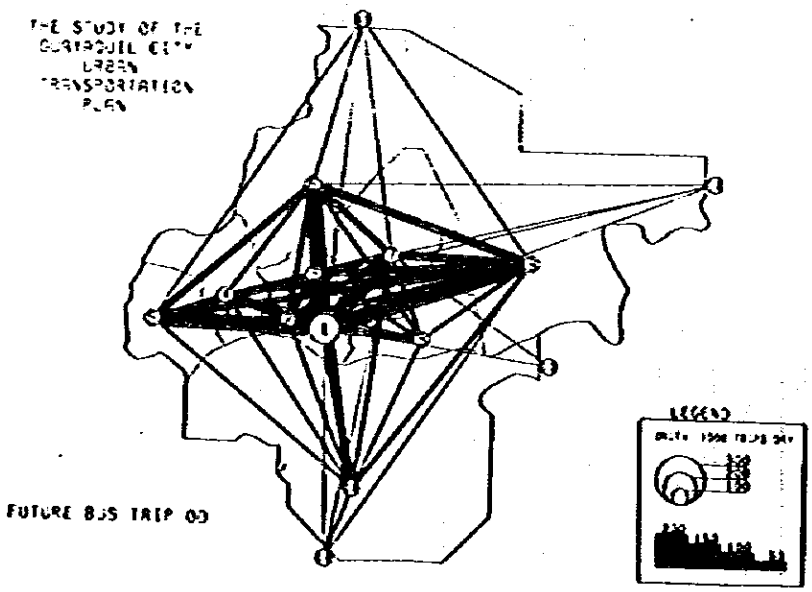
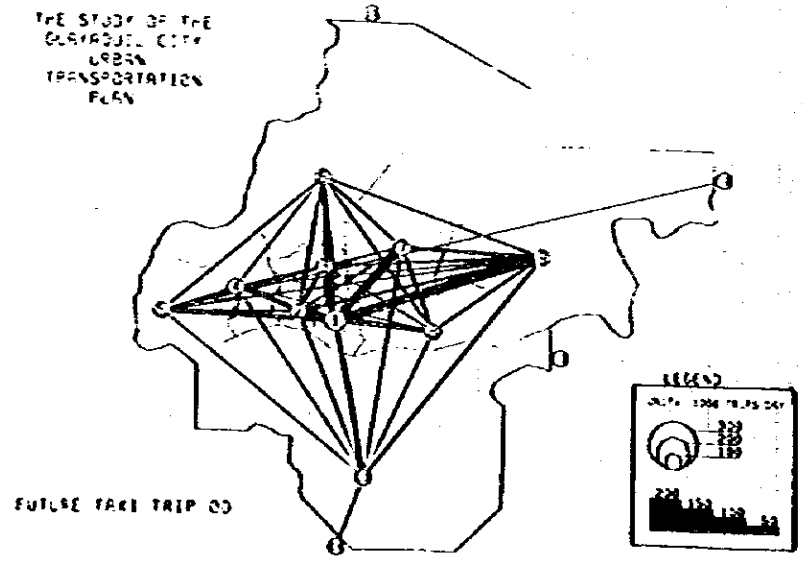


Figure 3-4.8 FUTURE DESIRED TRAFFIC LINES







3-4.6 Road Traffic Assignment

1) Outline

The final step of traffic forecasting necessitates to assign the road traffic volume to the alternative network. Road traffic assignment is the traffic simulation of vehicle trip, and its procedure is such a process that each trip interchange of vehicle is allocated to the appropriate path which is found by some criteria. Path finding process is iterative computation to search the shortest path between zone centers. There are two type of assignment. One is called the demand assignment and the other is the practical assignment. Major difference between two technics is whether the capacity constraint of road network is taken into account or not. In this Study the practical assignment is applied and the incremental assignment method is employed for it. Various traffic indicators are obtained as the result of traffic assignment to evaluate each transport plan and some of them are discussed again in the next chapter.

2) Assignment Technique

Incremental assignment method is roughly shown in Figure 3-4.9. Same assignment procedure is repeated several times until the iteration reachs the maximum and path finding is done in each stage, using the revised "Link value" which is determined by the accumulated traffic volume assigned already in the previous stage and the capacity, constraint formula.

a. Capacity Constraint Formula

Capacity constraint formula is given in a combination of link speed and link capacity, and its general form is shown in Figure 3-4.10.

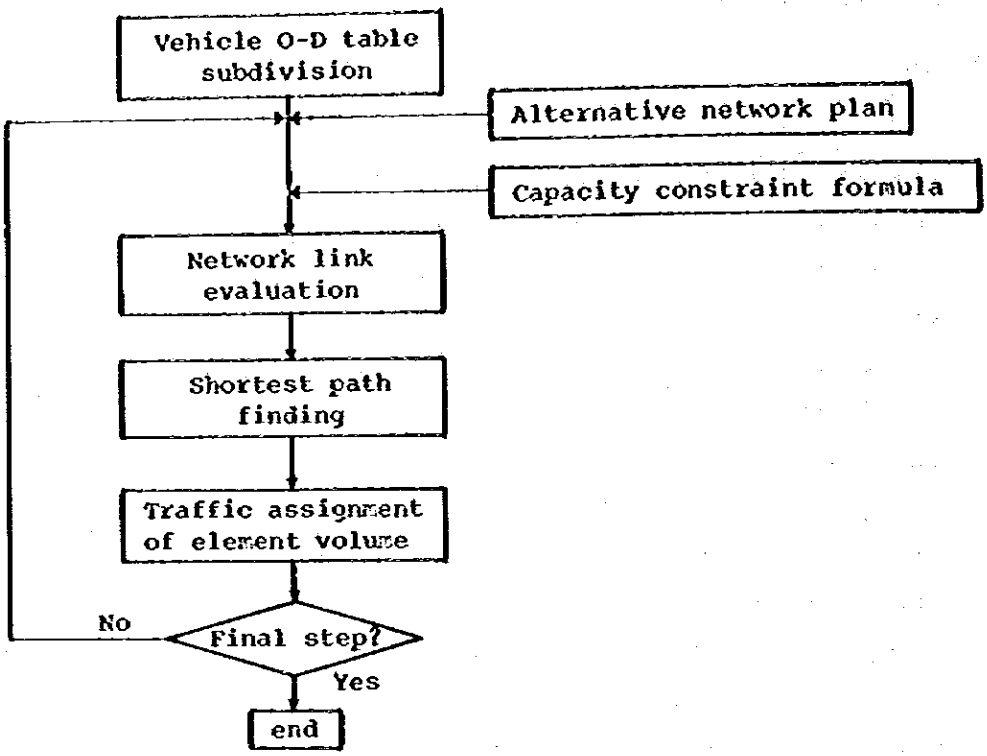


Figure 3-4.9 OUTLINE OF INCREMENTAL ASSIGNMENT

The link capacity is determined by each link, based on various factors related to its traffic capacity like the number of lanes, road width and area parameter, etc.

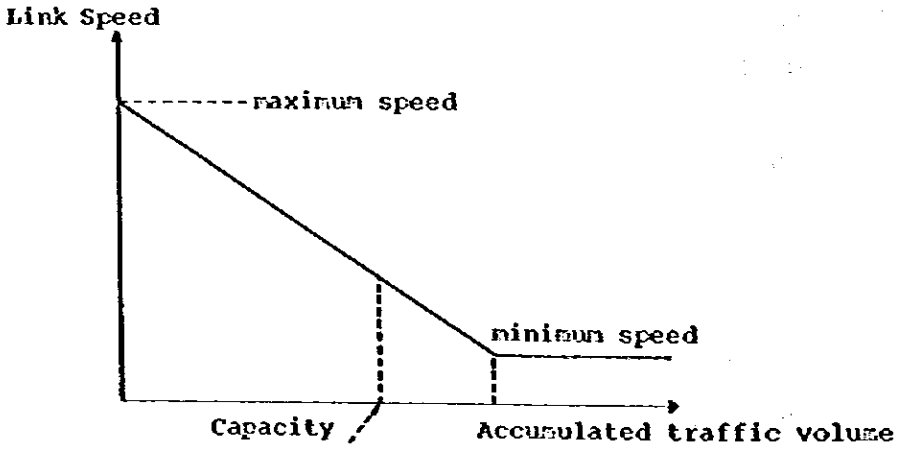


Figure 3-4.10 CONCEPT OF CAPACITY CONSTRAINT FORMULA

b. Shortest Path Finding Criteria

There are many possible indicators for the optimized iteration, i.e. actual distance, time, cost, etc. However in this Study generalized cost, which is shown by the following formula, is chosen for the criterion variable.

$$Ci = \alpha \cdot ti + \beta \cdot li$$

where Ci ; Generalized cost of link (i)
α ; Average time cost (constant)
β ; Average running cost (function of link speed)
li ; Link length
ti ; Link travel time

3) Traffic Assignment Result

Figure 3-4.11 shows the result of the future traffic assignment to the existing road. According to it, followings are pointed out.

a. General Consideration for Assigned Traffic Volume

Compared with the present traffic volume, the heavy traffic can be seen in most of road sections shown in the Figure. Especially, the traffic movement between the north and south region increases very much and the traffic concentration to CBD from the east and west direction also increases. Although this Figure shows only the traffic situation of major roads, even the minor roads might be confronted with heavy traffic as well. From this finding it can be said that future road traffic volume exceeds its capacity, the road congestion gets worse and much more road sections, suffer from it. It is inevitably considered that several transport policies and plans should be taken in future to avoid this situation.

b. Road Congestion

Table 3-4.11 shows the difference between the present and future road congestion as a whole. At present, about 90 percentage of road sections are maintained in fairly

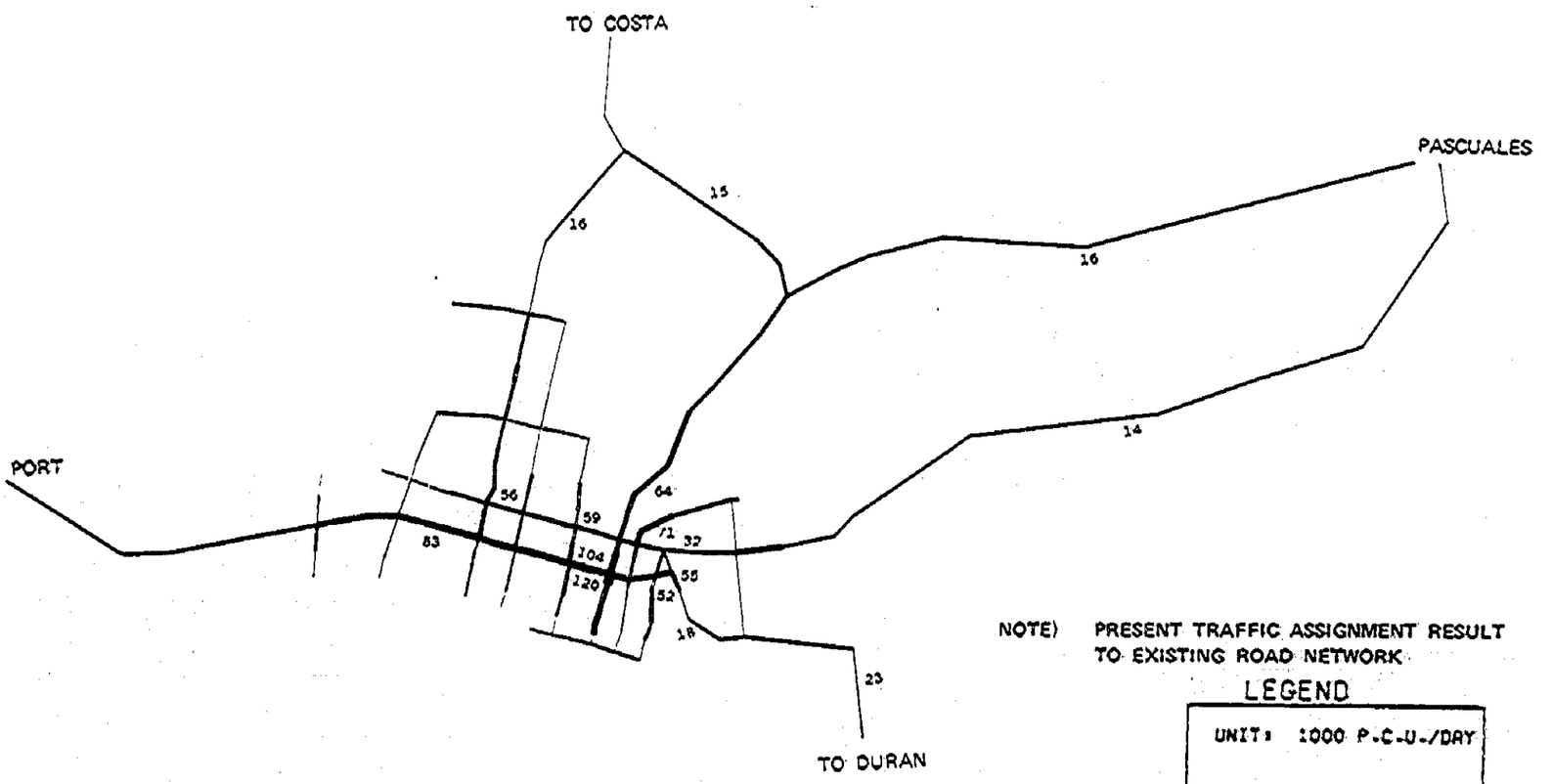
good traffic conditions, which are below 0.75 in its congestion rate, and the only small portion of road sections exceed the capacity. In future it is foreseen that about 20% of road sections face more traffic than their capacity and consequently the road sections of which congestion rate is lower than at present, decreases.

Table 3-4.11 DISTRIBUTION OF ROAD CONGESTION RATE

Unit: km

	0.75 & below	0.75~1.0	1.0~1.25	1.25 over
Present	589.6	20.0	15.9	7.5
Future	489.5	8.2	27.3	108.0

NOTE) Each figure shows the total length of links which belong to the corresponding congestion rate.



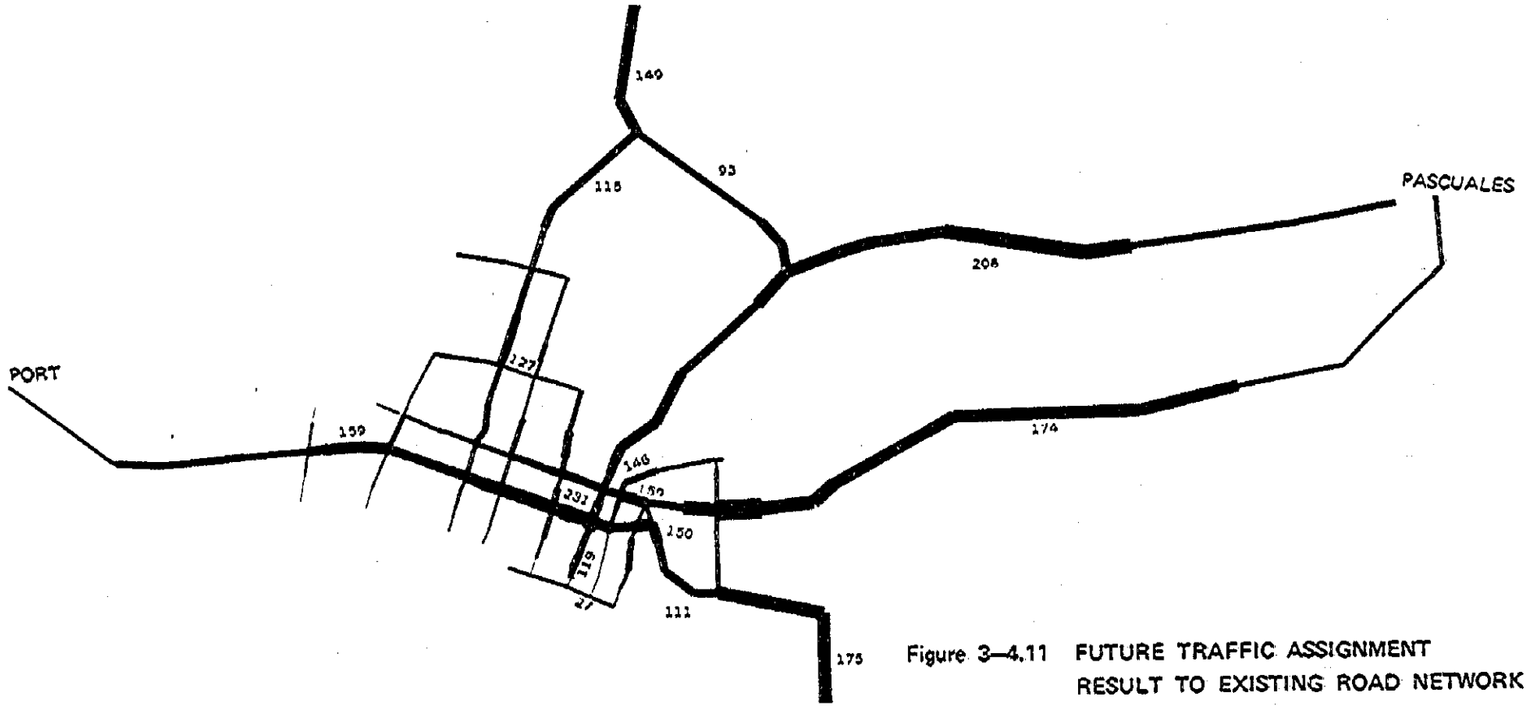
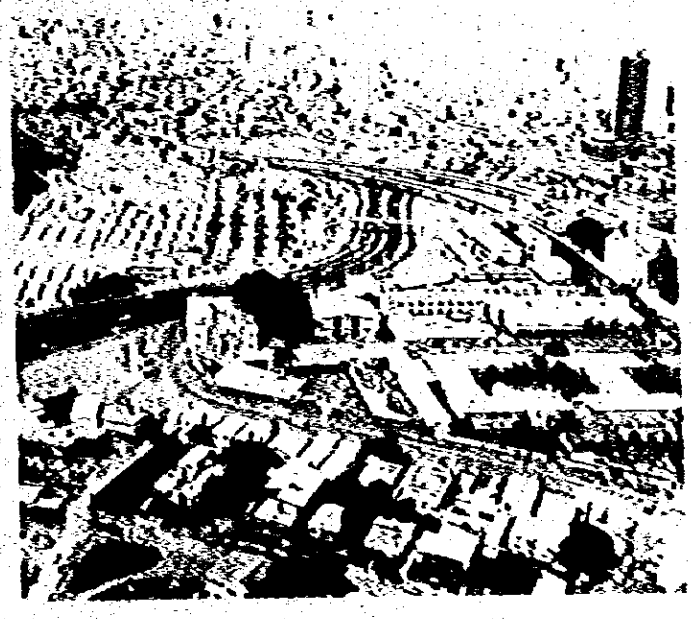


Figure 3–4.11 FUTURE TRAFFIC ASSIGNMENT RESULT TO EXISTING ROAD NETWORK

FUTURE ASSIGNMENT BASIC CASE

CHAPTER 4.

LONG TERM TRANSPORTATION PLAN FORMULATION



Chapter 4 LONG TERM TRANSPORTATION PLAN FORMULATION

In this Chapter, description is given in the first concerning the planning targets to frame a master plan of transport for 2000 year, and our proposal is made in the next concerning the plans as to the concrete network and public transport systems for the purpose of actualizing these targets. The traffic demand for the proposed master plan herein is forecast in 4-2.4.

4.1 TRANSPORTATION PLAN FORMULATION

4-1.1 Planning Policy

1) Background Situations

As forecast in the aforegoing description, it is forecast that the population and the number of cars owned in the Study Area will account for in 2000 about 2.2 times and about 4 times as many as those in the present time respectively. Unless some necessary countermeasures are taken now for the above trend, it is anticipated that the present scope of traffic congestion will expand year by year toward the peripheral area, resulting in producing a serious situation such as to constitute an obstacle not only to the normal urban activities but also to the daily life of the citizens. It is necessary, therefore, to consider some comprehensive transportation plans for easening traffic congestion in CBD as well as expediting the land use development pattern selected in Chapter 3.

2) Basic Planning Targets

The following headings are proposed as the basic planning targets for setting up the transportation plans in this Study Area:

(1) Improvement of transport capacity of the Study Area as a whole . Easening traffic congestion in CBD, particularly, resolving the bottleneck in the entrance from the northern area into CBD, improvement of accessibility to CBD and augmentation of the transport volume to match the demand.

(2) Acceleration of land development plan in the future selected (Alternative III, Linear Development Plan toward the northern area)

(3) Improvement of transport efficiency of the Study Area as a whole

. Saving resources consumption

(4) Improvement of safety

. Lessening traffic accidents

(5) Conservation of comfortable environment for urban life

3) Choice of Solutions

Bearing the planning targets as the above in mind, the alternative transport solutions are discussed as follows:

(1) Augmentation of Transport Capacity and Solution of Traffic Bottlenecks

a. New Construction and Orderly Arrangement of Road Network

What should be carried out so as to serve for the land development plan as a whole is as follows:

. New construction of the road network to match the forecast traffic volume.

. Clarification of the classified functions of the existing roads to correspond with the newly constructed road network.

. Orderly arrangement of the roads which have not been made so yet.

. Improvement of the intersections, etc.

b. Introduction of MRT (Mass Rapid Transportation System)

The road factor in and around CBD (Zone A-1, A-2, and A-3) has reached to 30%, making it quite difficult to widen the road width in these zones. In order to make use of the restricted urban space most efficiently, it is the most advantageous policy to introduce MRT with a high transportation efficiency from the viewpoint of land acquisition, economic effects, environmental conservation, as well. By adopting this policy, it can be expected for to urge diversion of car traffic and to absorb the road traffic volume. Particularly, there is a great effect on solving the traffic

bottleneck existing between Estero Salado and Cerro el Carmen and giving a topographical restriction on the traffic entering from the northern area into CBD.

c. Improvement of Bus Transport

Although buses are playing an important role as a public transport means in this Study Area, their running speed has been dropping down year by year recently to such a degree that it is difficult for them to perform their function satisfactorily. In augmenting the bus transport capacity as a whole, it is important to review the existing bus systems relating to the road network and MRT as well as to try to activate their function.

d. Corbination of Each Transport Plan

Each transport plan described in the above a - c should be selected in such a way that corbination thereof may become most effective to this Study Area. Particularly, it is desirous that, as the public systems, MRT and buses should be corbined effectively so that each system may be able to give full play to its characteristics.

(2) Alleviation of Traffic Congestion in CBD

a. Proper Layout of Urban Facilities and Promotion Thereof Selected

Traffic congestion in CBD is caused by concentration of the traffic demand in CBD resulting from concentration of the urban facilities on a partial area of the city with a large volume and high density. Our proposal of the land development plan selected in the previous Chapter recommends to attach importance to development of the northern area as well as to bring up several sub-centers in the suburbs area. In order to prevent the traffic volume from concentrating in CBD, the skeleton of the transport means in future should be planned so as to serve for accelerating development of the above area.

b. Parking Control in CBD

For the purpose of increasing the transport capacity of the roads in and around CBD as well as restricting the increase in the volume of private cars bound for CBD, it would become necessary to put parking control in CBD. At the same time, it should be considered that such countermeasures as to get the traffic demand diverted into the public transport systems smoothly.

4) Summaries

Various concrete measures to get to the abovementioned solutions are shown in Table 4-1.1. The proposed long-term transportation plan, corresponding to the master plan, comprises the followings, based on these measures and the aforementioned policy.

(1) Introduction of MRT

An optimum MRT route plan is proposed, which is basically composed of two routes: North - South and East - West, laid out then along with the main traffic routes.

(2) New Construction and Orderly Arrangement of Roads

An optimum road network is proposed, which develops on-going projects by MOP and the Municipality, and is fundamentally composed of a ring and radial system.

(3) Measures for Controlling Traffic Demand

Examination is conducted concerning control on the parking demand in CBD.

(4) Bus Transport

It is planned to augment the bus transport capacity and, in addition, various countermeasures are proposed so as to coordinate the corbinations of the abovementioned plans.

Table 4-1.1 VARIOUS COUNTERMEASURES TO COPE WITH TRAFFIC DEMAND IN URBAN AREA

- a. Increase of transport capacity by public modes
  - a-1 Introduction of mass rapid transportation
  - a-2 Improvement of bus network, frequency, fleets, etc.
- b. Improvement of public transport services
  - b-1 Accessibility to MRT stations, terminals, etc. by park & ride, pedestrians' safety facilities
  - b-2 Convenience of connecting between MRT & bus
  - b-3 Scheduled operation of bus by exclusive lanes, and so on
  - b-4 Introduction of new bus operation system such as trunk line bus, zone bus, mini-bus, etc.
- c. Smoothing of traffic flow
  - c-1 Controlling of traffic signals
  - c-2 Regulation of stop and parking, turning traffic, etc.
  - c-3 Effective usage of lanes
  - c-4 Regulation of special vehicles like heavy trucks
  - c-5 Information and guidance system to drivers
- d. Restraint of car usage
  - d-1 Restraint of car usage in special areas by traffic cell, zone system, etc.
  - d-2 Controlling of car entrance in CBD
  - d-3 Restraint of parking on roads
- e. Effective car usage
  - e-1 Riding together system in taxi
  - e-2 Preferencial passage of cars with fellow passengers like car pooling system
  - e-3 Rationalization of freight transport system
- f. Controlling of traffic generation
  - f-1 Restraint of special facilities in CBD with big traffic absorption
  - f-2 Distribution of working places near to residential area
  - f-3 Decreasing of peak traffic

4-1.2 Road Network Plan

1) Basic Planning Policy

Taking into account the functions of the road and the conditions of the environs, the general basic planning policies for the road network are summarized as follows;

(1) To provide quick and convenient services especially for long distance trips.

(2) To ensure a smooth and safe traffic flow.

(3) To avoid dividing the community and to maintain a better urban environment.

(4) Serving as a good facility available for the people in the neighborhood.

In designing the road network in the Study Area, the following policies are taken into consideration:

(1) Limitation of passage through CBD by the through traffic.

(2) Full utilization of the existing roads, new construction plans of roads and efficient connection of these roads.

(3) Uniformity with the existing and future land use plan.

(4) Efficient utilization of the existing roads in CBD, limiting large-scale widening and improvement of the existing roads.

2) Expected Changes in Study Area

In order to develop the road network plan, the results of the landuse plan and the traffic demand estimation are reviewed. The major expected changes estimated concerning the road network plan in the Study Area from 1982 to 2000 are summarized as follows:

(1) The population in the Study Area in 2000, the target year, is expected to increase to 2.7 million and will be absorbed mainly into the northern part in the Study Area. Guayaquil will become a metropolis stretching south to north along the Rio Guayas.

(2) It is expected that the population in CBD will not increase too much from the existing population.

(3) It is estimated that the total number of vehicles will increase by 4.0 times of the existing volume.

3) Road Network

With the expansion of residential areas and urban functions in the future, trips will become longer and the pattern of commuting trips will change to that shown in the following figures.

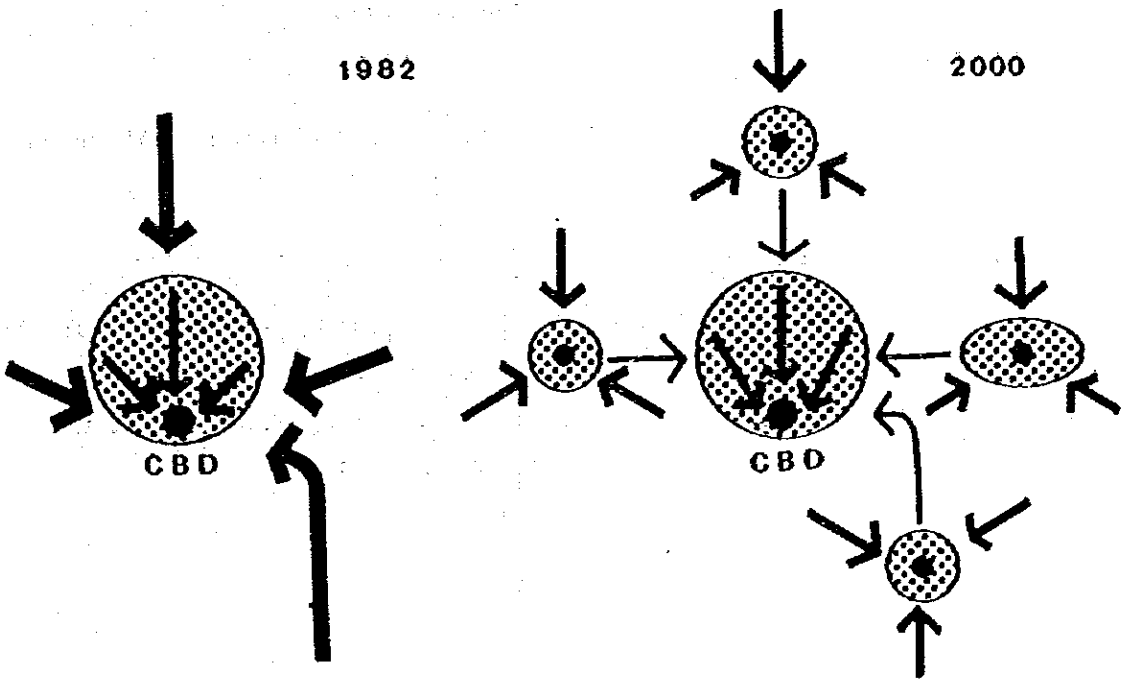


Figure 4-1.1 CHANGE OF COMMUTING TRIPS

a. Classification of Road Function

The characteristics of road function are classified into 4 types for the purpose of road network planning. They are summarized as follows:

(1) Primary Distributors (P.D.)

These roads form a skeleton for the country and connecting

cities by high level standards. They are very important in the social and economic activities over the country.

(2) District Distributors (D.D.)

These roads form a skeleton for the city and connect the main traffic generated in an area which is surrounded by the Primary Distributors.

(3) Local Distributors (L.D.)

These roads connect the District Distributors as the feeder roads for the collection and distribution of the traffic. In the residential area, the major daily use roads for the purpose of going to the adjacent areas are defined as the Local Distributors.

(4) Access Roads

These roads give direct accesses to/from buildings and houses, etc.

b. Conceptual Planning

Bearing in mind the policies, traffic demand, future land use and existing road network and characteristics, the conceptual plans for the road network were prepared through the following steps shown in Fig. 4-1.2 ∿ 4.

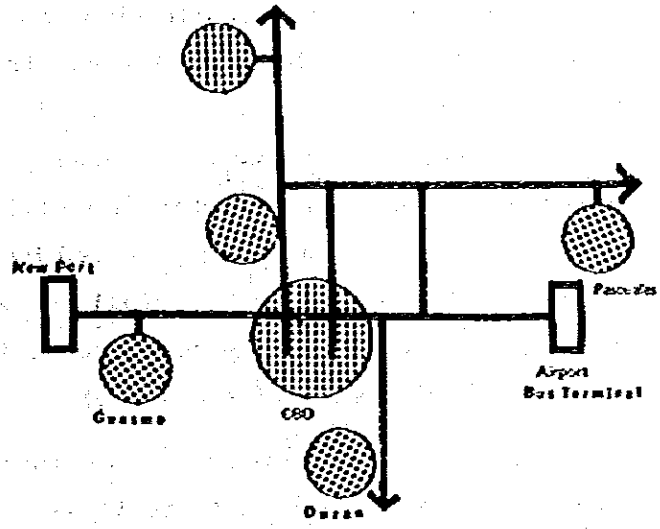


Figure 4–1.2
CONCEPTUAL URBAN
STRUCTURE

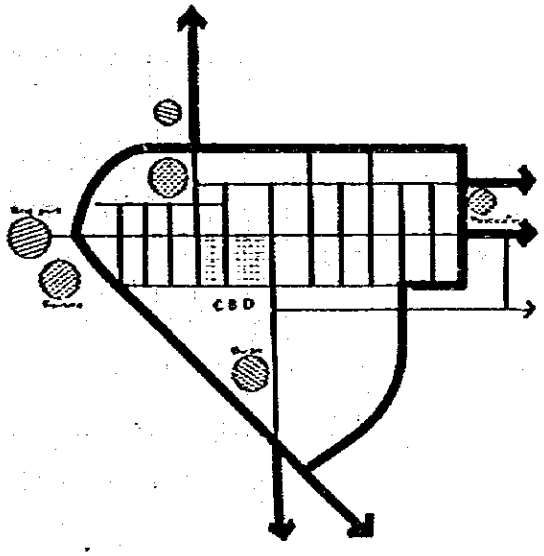


Figure 4–1.3
CONCEPTUAL ROAD NETWORK
PATTERN IN STUDY AREA

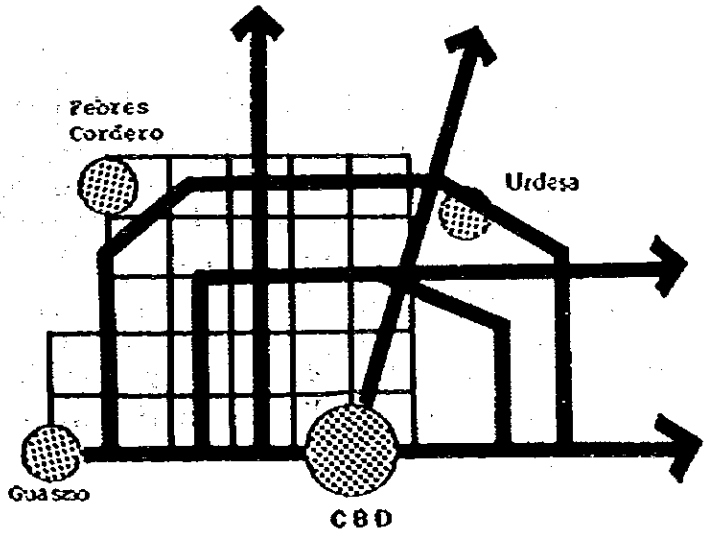


Figure 4–1.4
CONCEPTUAL ROAD NETWORK
PATTERN IN URBAN AREA

4) Proposed Road Network Plan

Based on the conceptual pattern, existing and future origin-destination traffic volume, development strategy in the landuse, etc., several road network patterns were examined on combining the considerable road links and networks. These patterns were categorized into three networks: the existing road network, the on-going project network which has been prepared by MOP (Ministerio de Obras Publicas) and the Guayaquil Municipality, and the proposed road network which could cope with the foreseeable traffic problems most effectively. (see Figure 4-1.5 and 4-1.6)

The characteristics of the proposed road network, which develops on-going projects, are summarised as follows:

a. In the Urban Center

- Establishment of two (2) circular roads for the through traffic into CBD
- Connection of Av. Malecon to the northern area by a tunnel under Cerro el Carmen to reinforce the smooth traffic flow from north to south.
- Giving function to the road along Estero Salado to link the traffic from the east and west areas.
- Improvement of function of the existing roads with limitation in the widening of the existing roads.
- Combination of the existing grid pattern network with the circular pattern.

b. In the Suburban Area

- Establishment of the road network combining the circular roads and the radial roads started from CBD.
- Utilization of the existing road plans proposed by the Guayaquil Municipality considering the land development selected.
- Planning of and completion of the Guayaquil Circular Road (Via Perimental de Guayaquil) around the urban area including Durán.

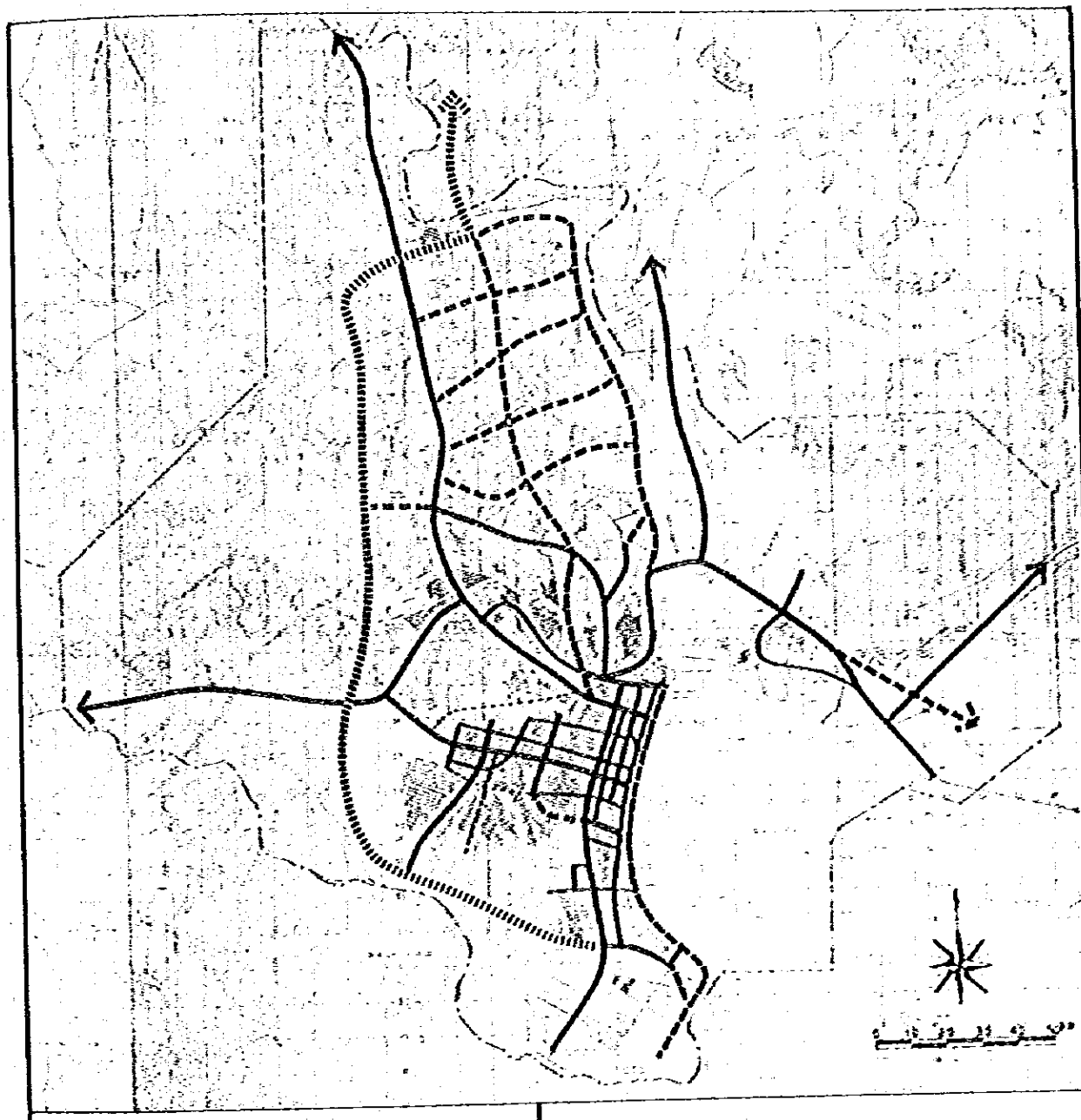


Figure 4–1.5 ON-GOING PROJECT NETWORK

ON-GOING PROJECT

PRIMARY DISTRIBUTOR

DISTRICT DISTRIBUTOR

LOCAL DISTRIBUTOR

THE STUDY OF THE GUAYAQUIL CITY URBAN TRANSPORTATION PLAN

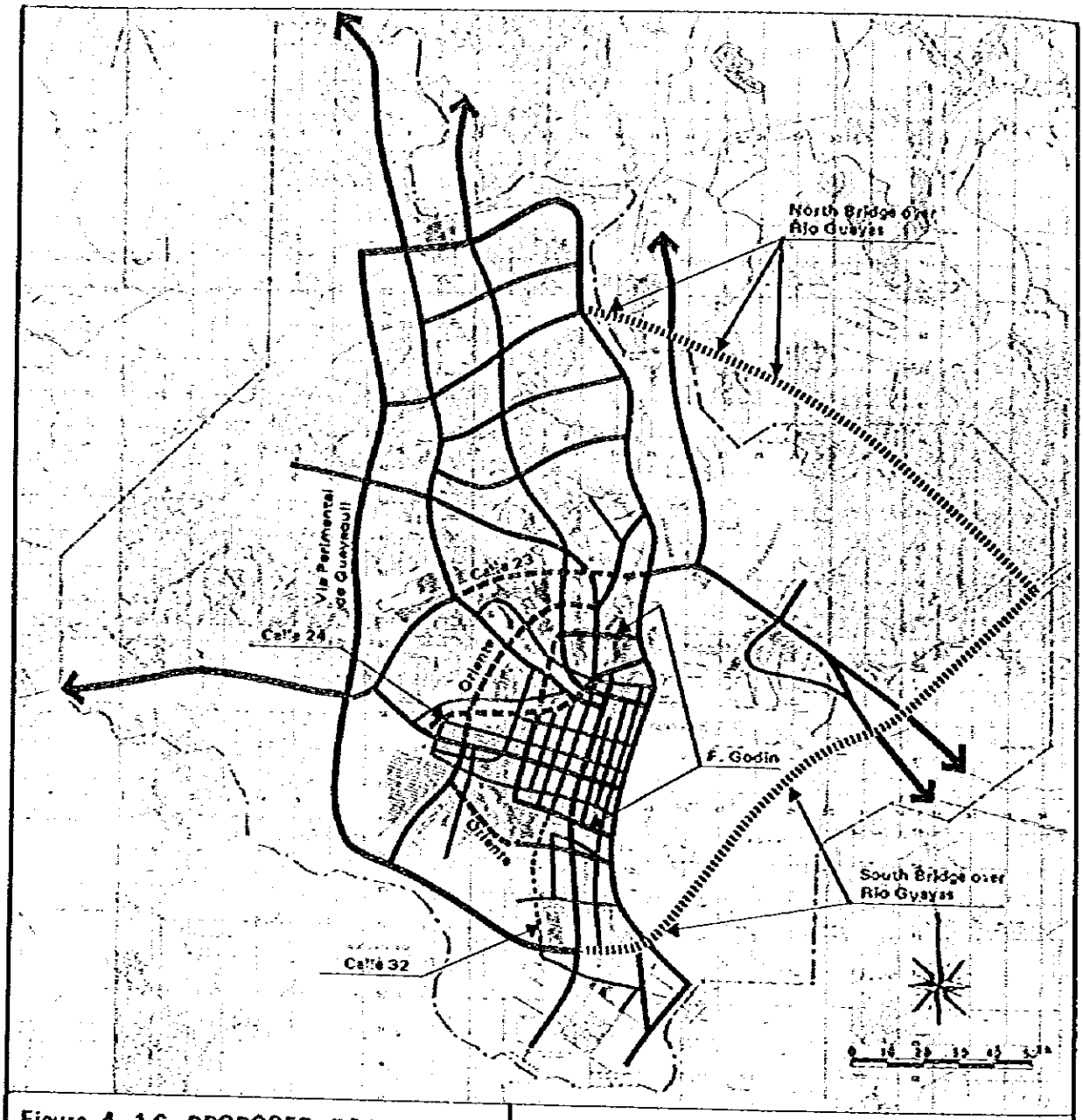


Figure 4-1.6 PROPOSED ROAD NETWORK

PROPOSED ROAD

PRIMARY DISTRIBUTOR

DISTRICT DISTRIBUTOR

LOCAL DISTRIBUTOR

THE STUDY OF THE GUAYAQUIL CITY URBAN TRANSPORTATION PLAN

Dimensions of the proposed road network:

a. Total length of proposed projects by each function

Primary distributors	40.2 km	71.8 km
District distributors	30.3 km	
Local distributors	1.3 km	

b. Large scale re-structure of intersections

Diamond intersection	12 points	17 points (See Figure 4-1.9, 10)
Full service intersection		
• Trumpet type	2 points	
• Clover leaf type	3 points	

5) Design Criteria

a. Design Standards

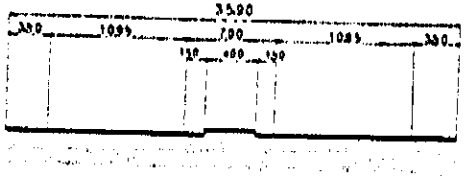
In Ecuador, two standards are applied for road designing: namely "Road Design Manual (Manual de Diseño de Carreteras)" and "Geometric Roads Design Standards (Normas de Diseño Geométrico de Carreteras)". These design standards and manual are usually adopted for the high level road. However, it is considered appropriate here to apply these standards and manual for designing the road width. In the above standards and manual, the road width is quoted as 3.65 m per lane. However, the Guayaquil Municipality adopts 3.5 m per lane for the road width and this is considered appropriate in applying to the urban area. Therefore a road width of 3.5 m is adopted for the road design in the urban area in this Study. Typical cross sections in each type are shown in Fig. 4-1.7.

Table 4-1.2 COMPARISON OF STANDARD DESIGN

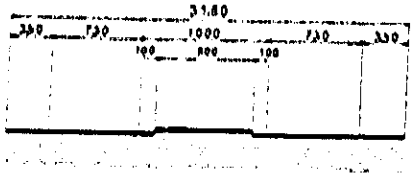
Item	Unit	Ecuador	Japan	Australia
Design Speed	km/h	50		
Clearance	m	4.5	4.5	4.5
Minimum Curve Radius	m	80	80	90
Maximum Superelevation	%	10	12	8
Transition Curve	m	57	60	63
Sight Distance	m	65	55	63
Maximum Grade	%	9	9	8
Minimum Vertical Curve Length	m	30	60	70
Minimum Radius of Vertical Curve (Crest)	-	11	8	12
Minimum Radius of Vertical Curve (Sag)	-	8	7	8

Figure 4–1.7 CROSS-SECTION OF ROAD

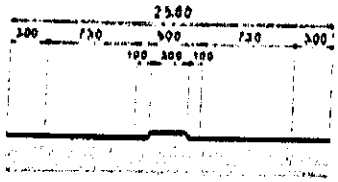
Type A



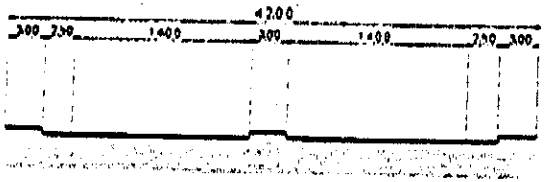
Type B



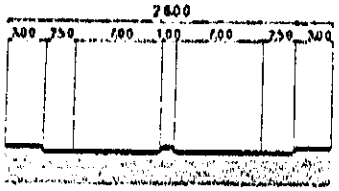
Type C



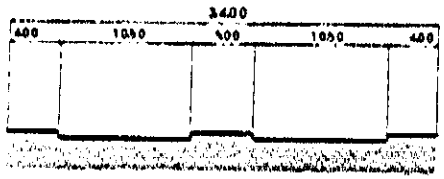
Type D



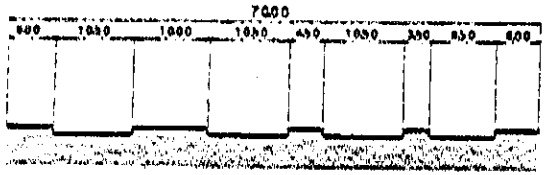
Type E



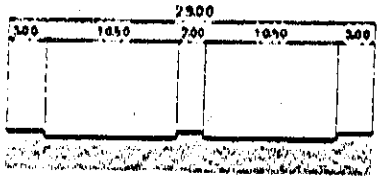
Type F



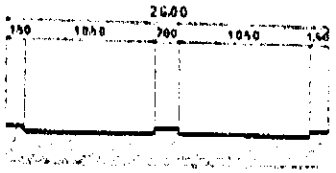
Type G



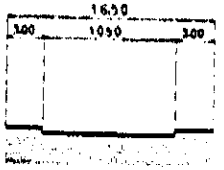
Type H



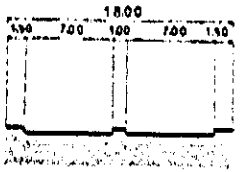
Type I



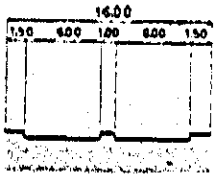
Type J



Type K



Type L



b. Type of Roads in Each Classification

Twelve (12) types of cross-sections are prepared for the proposed road network based on the standards and manual and local conditions. These cross sections shown in the above figures are classified by road function as under:

FUNCTIONAL CLASSIFICATIONS BY TYPE OF ROADS

Road Function	Type of Cross Section
Primary Distributors	A, B
District Distributors	C,D,E,F,G,H,I,J,K
Local Distributors	L

Table 4-1.3 LIST OF ROAD STANDARD

Name	Class	Design Speed (km/h)	Typical Cross Section
1 Vía Panamericana Occidental	Primary Distributors	100	A, B
2 Vía Panamericana Occidental	Primary Distributors	100	B
3 Vía la Costa	District Distributors	80	C
4 Vía Puerto	District Distributors	80	C
5 Vía Puente Bolívar	Primary Distributors	100	C
6 Vía Simón Bolívar	District Distributors	80	C
7 Vía al Tablazo	District Distributors	80	C
8 Francisco de Orellana	District Distributors	60	D
9 No.9	District Distributors	60	C
10 No.10	District Distributors	60	E
11 No.11	District Distributors	60	F
12 No.12	District Distributors	60	E
13 No.13	District Distributors	60	E
14 Juan Tama Marango	District Distributors	60	C
15 25 de Julio	District Distributors	60	G
16 de los Arrayanes	District Distributors	60	F
17 Carlos Luis Arrayanes Julio	District Distributors	60	H
18 Pedro Menendez Gilbert	District Distributors	60	H
19 Revolución	District Distributors	60	K
20 Octubre	District Distributors	60	K
21 4 de Noviembre	District Distributors	60	K
22 Mahuad Santos Bolívar	District Distributors	60	HK
23 No.23	District Distributors	60	H
24 No.24	District Distributors	60	K
25 No.25	District Distributors	60	E
26 Puente	District Distributors	60	G
27 Pedro Godoy	District Distributors	60	K
28 No.28	Local Distributors	40	L
29 No.29	Local Distributors	40	L
30 No.30	Local Distributors	40	L
31 No.31	Local Distributors	40	L
32 No.32	Local Distributors	40	L
33 No.33	Local Distributors	40	L

Note) As for the road number, see Fig. 4-1.8.

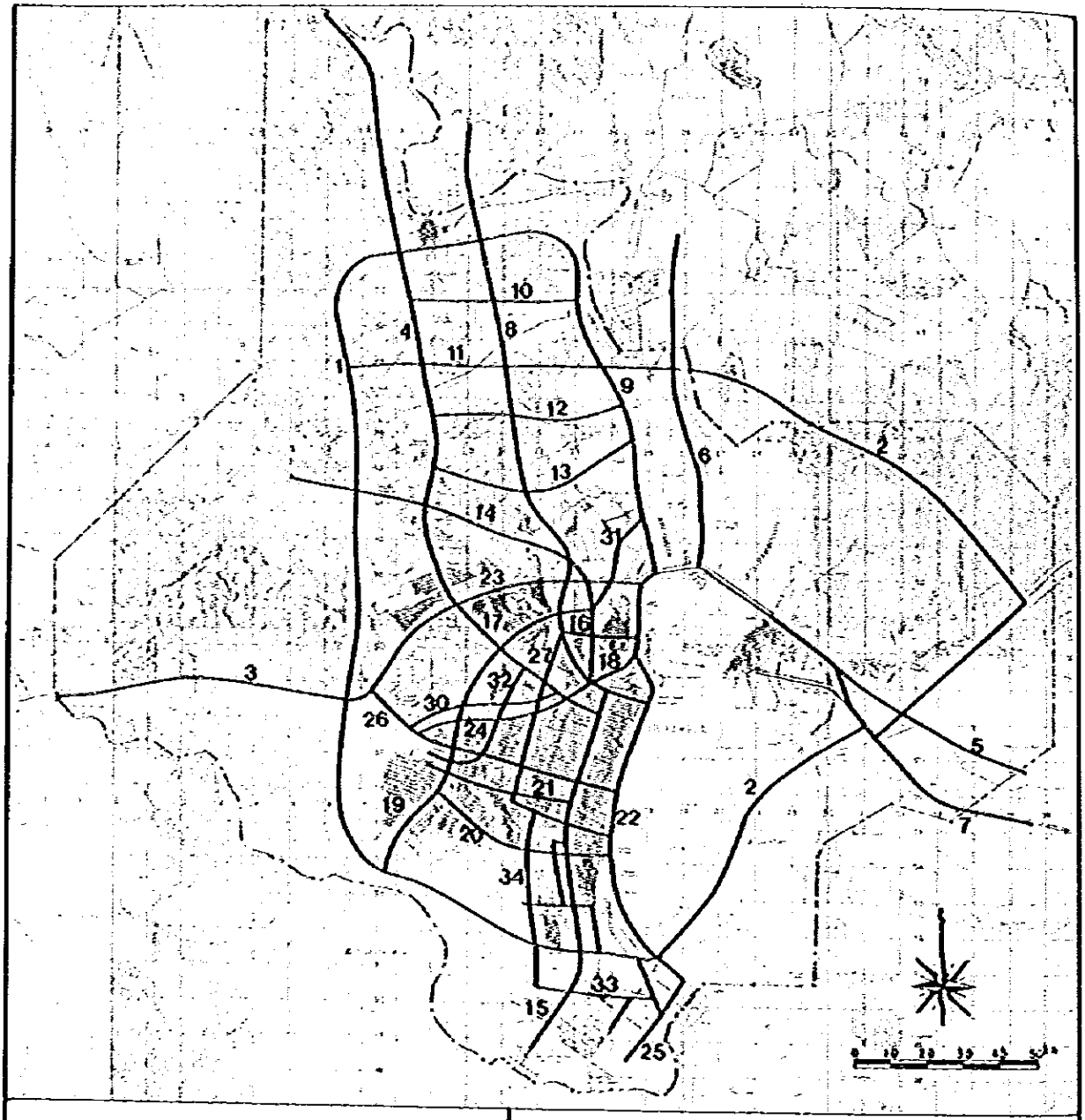


Figure 4-1.8 ROAD NUMBER

Note: Numbers correspond to Table 4-1.3 respectively

THE STUDY OF THE GUAYAQUIL CITY URBAN TRANSPORTATION PLAN

6) Intersection Planning

Taking into account the traffic volume and the characteristics of each confluent roads, three (3) types of intersections are adopted as follows:

(1) At-grade intersection
(2) Diamond intersection (At-grade intersection in the urban area)
(3) Full service intersection (Diamond intersection in the urban area)

Table 4-1.4 TYPE OF INTERSECTIONS BY ROAD FUNCTIONAL CLASSIFICATION

	Primary Distributors	District Distributors	Local Distributors	Access Roads
Primary Distributors	(3)	(3)	-	-
District Distributors	(3)	(2)	(1)	-
Local Distributors	-	(1)	(1)	(1)
Access Roads	-	-	(1)	(1)

a. Grade separation of intersections

The improvement plan for the existing intersections has both aspects of the long term solutions and short term counter-measures and the later is discussed in Chapter 6, "Short-term Improvement Plan". The former mainly consists of grade separation plan and as a result grade separation is applied to 23 intersections. Some of them are included in the on-going projects and mainly consist of connecting the existing roads with Via Perimental de Guayaquil.

In the proposed project, several elevated intersections are introduced to support Via Perimental de Guayaquil and in addition the intersections around CBD are improved by grade separation, particularly in the crossing points between the ring roads and arterial roads connecting CBD with northern area.

This plan protects the radial roads between CBD and northern area from reduction of their traffic capacity and connects the radial roads with the ring roads.

The types and locations of planned intersections are shown in Table 4-1.5 and Figure 4-1.9, 10.

b. Relationship with MRT plan

Several grade separations are located close to MRT routes such as the intersection between Av. 25 de Julio, Av. Quito and Av. de las Americas. They needs adjustment with MRT plan.

In case of the Eloy Alfalo intersection it is very important to improve not only the intersection itself but also the wider area including Circulo Guaya y Quil, using the existing grade separation of Calle Julian Coronel. Figure 4-1.11 shows an improvement plan for the Eloy Alfalo intersection.

In addition, the elevated road plan over the Av. Quito and Av. Machala has been studied recently. As an idea of adjusting the relationship between the elevated roads and the MRT route, it is conceivable that the elevated road over Av. Quito will be changed and annexed to the one over Av. Machala and the MRT will pass through Av. Quito.

Judging from the existing road conditions, the elevated road will limited in the section between Calle Julian Coronel and Calle Gomez Rendon. Since this elevated road plan has many problems in its execution such as structure of ramps, improvement of the existing intersections etc., further detailed study including land acquisition will be required.

Table 4-1.5 LIST OF INTERSECTIONS TO BE IMPROVED

No.	Location of Intersection	Type
(1)	Via Perimental de Guayaquil and Av. 25 de Jul.	Cloverleaf
2	Via Perimental de Guayaquil and Trinitaria Island	Diamond
(3)	Via Perimental de Guayaquil and Revolacion	Trumpet
(4)	Via Perimental de Guayaquil and Via la Costa	Cloverleaf
(5)	Via Perimental de Guayaquil and Av. J. T. Marengo	Cloverleaf
6	Via Perimental de Guayaquil and No. 11	Trumpet
(7)	Via Perimental de Guayaquil and Via Daule	Cloverleaf
(8)	Via Perimental of Guayaquil and Francisco de Orellana	Cloverleaf
9	Via Perimental de Guayaquil and No. 9	Cloverleaf
10	Via Perimental de Guayaquil and Via Sarbolondon	Diamond
11	Via Perimental de Guayaquil and Via al Trunfo	Trumpet
12	Via Perimental de Guayaquil and Via Duran Boliche	Cloverleaf
13	Via Perimental de Guayaquil and Santay Island	Diamond
14	Av. Quito and Av. Portete	Diamond
15	Via Daule and No. 23	Diamond
16	Av. C. Jul. Arosemana T. and No. 27	Diamond
17	Av. Francisco de Orellana and No. 27	Diamond
18	Av. Francisco de Orellana and No. 23	Diamond
19	Av. Francisco de Orellana and Av. J. T. Marengo	Cloverleaf
20	Eloy Alfalo Intersection	Diamond
21	Circulo Guayas y Quil	Diamond
22	Av. de las Americas and Av. J. T. Marengo	Diamond
23	Av. P. Menendez Gilbert and No. 9	Diamond

( ) is on-going project.

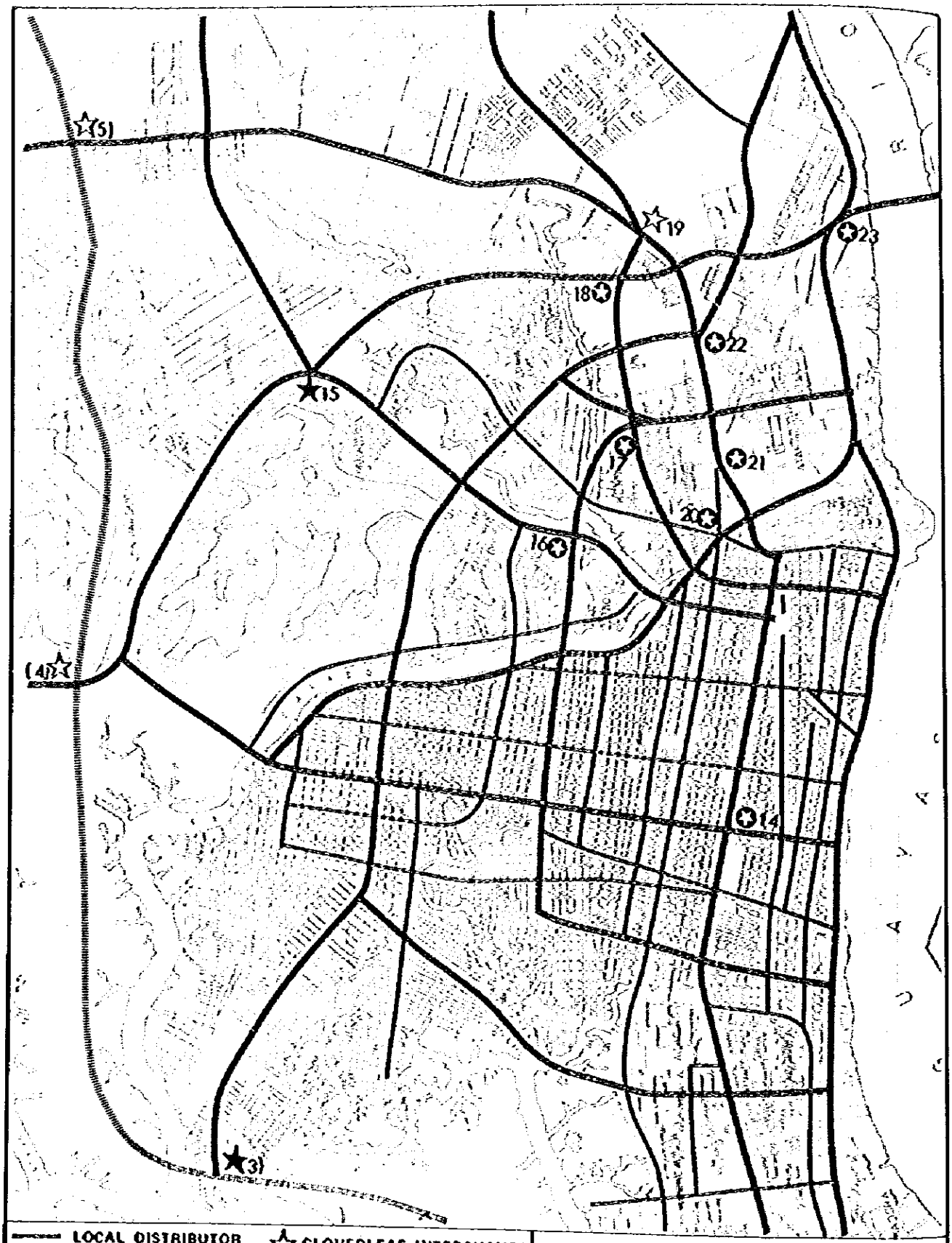
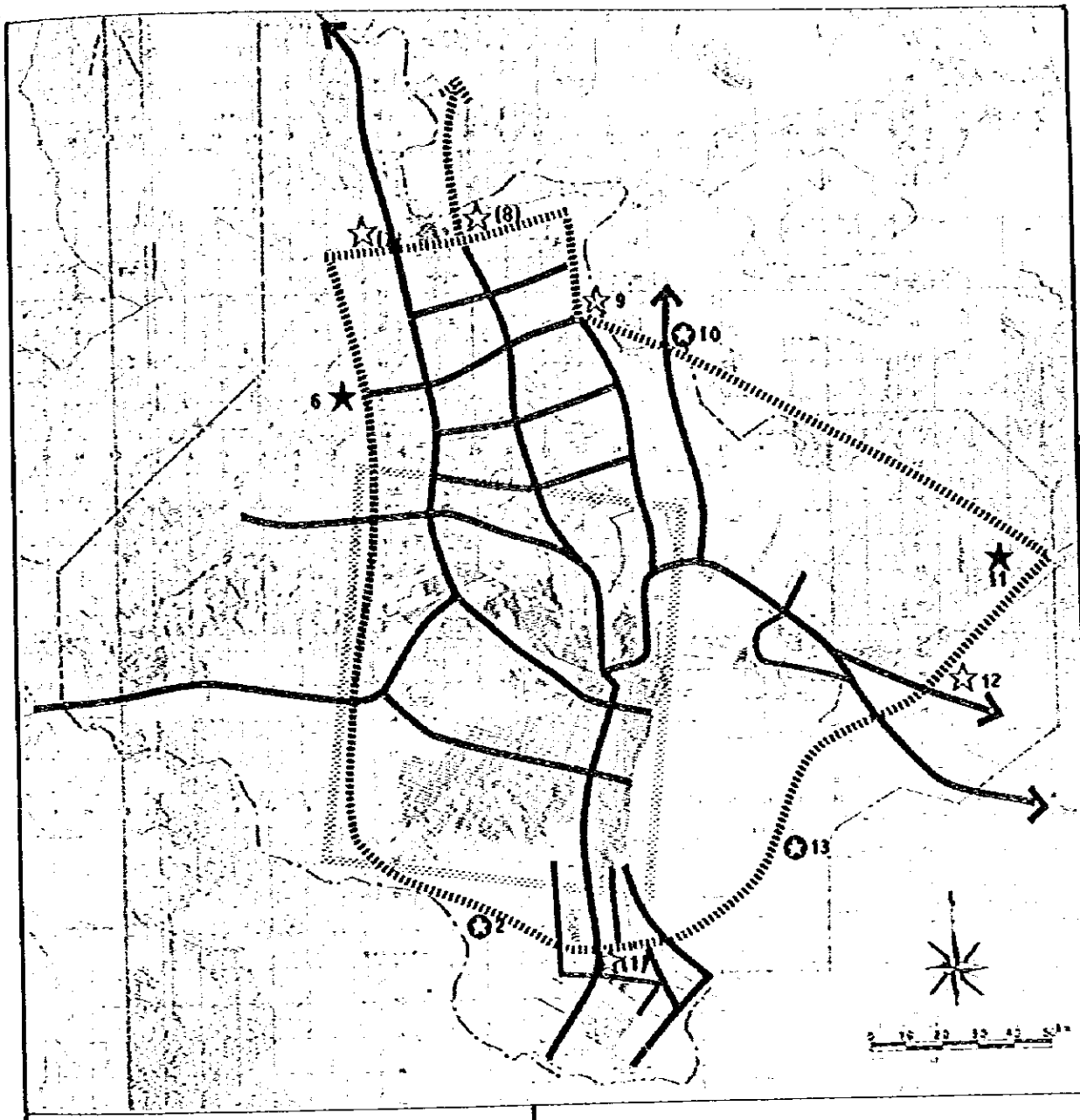


Figure 4-1.9 LOCATION & TYPE OF INTERSECTIONS TO BE IMPROVED (1)

THE STUDY OF THE GUAYAQUIL CITY URBAN TRANSPORTATION PLAN



(Note)
( ) is on-going project

Figure 4-1.10 LOCATION & TYPE OF INTERSECTIONS TO BE IMPROVED (2)

THE STUDY OF THE GUAYAQUIL CITY URBAN TRANSPORTATION PLAN

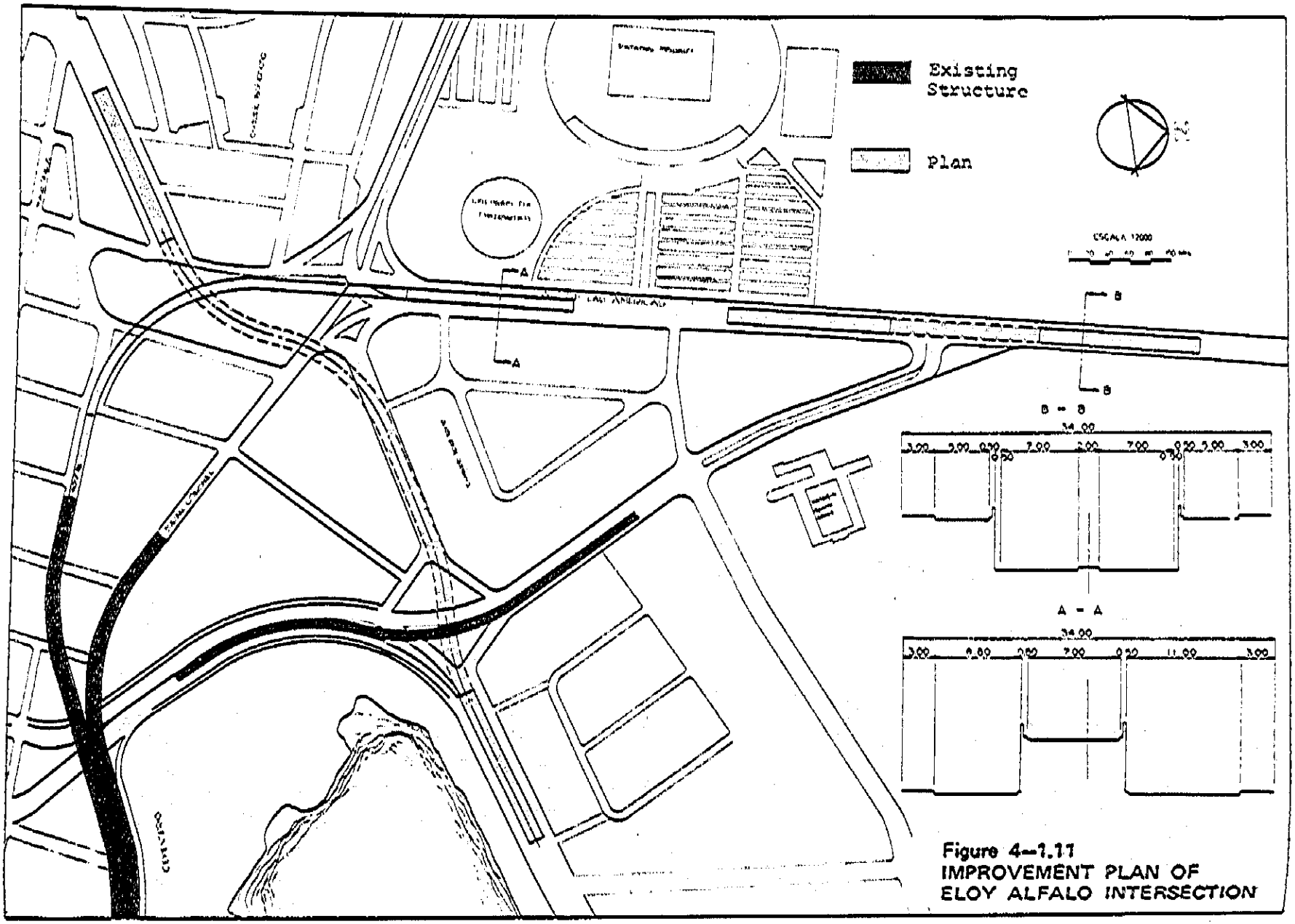
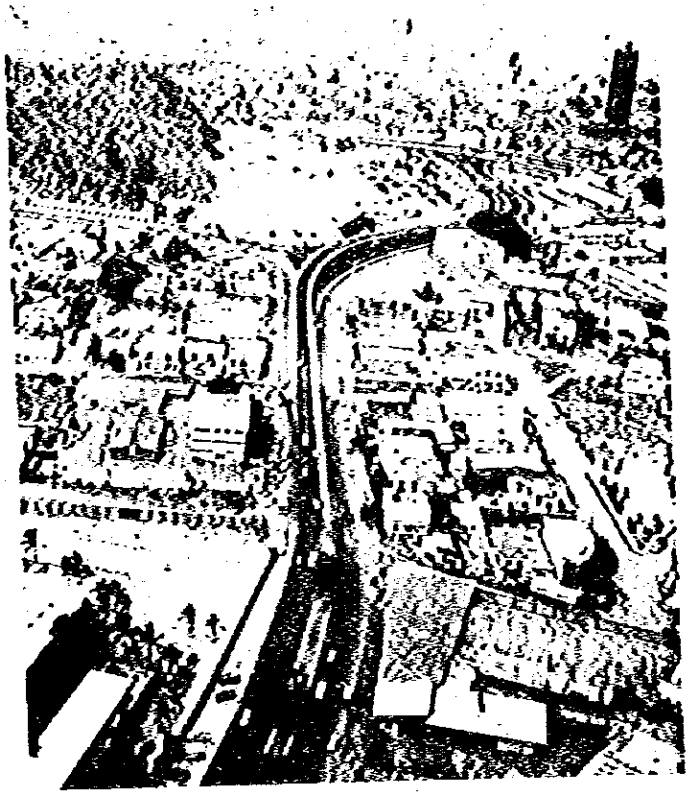


Figure 4--1.11
IMPROVEMENT PLAN OF
ELOY ALFALO INTERSECTION

General view of
Figure 4-1.7



Av. de Las Americas in front of Lica University

7) Project Cost

a. Unit Cost

The road construction cost of the projects is estimated using the unit cost collected from the M.O.P, C.P.G, Municipality and private contractors. Some examples of the unit cost are shown in Table 4-1.7.

b. Project Cost Estimate Procedure

Construction cost is estimated by:

Unit cost in each cross-section x its length by each type of road.

c. Estimation Result

The total construction cost is summarized in Table 4-1.6.

Table 4-1.6 PROJECT COST

(Unit: Million Sucres in 1982 prices)

Project	Item	Engineering Cost	R-O-W * Acquisition Cost	Construction Cost	Total
On-Going	Road	222	2,152	3,943	6,317
	Intersection	24	351	295	670
	Total	246	2,503	4,238	6,987
Proposed Road	Road	397	1,724	16,771	18,892
	Intersection	104	600	1,307	2,011
	Total	501	2,324	18,078	20,903

* R-O-W: Right of way

Table 4-1.7 LIST OF UNIT COST

Work Item	Description	Unit	Unit Cost (Sucre)	Remarks
1 Site Clearing		Ha	4,000	t = 30 cm*1
2 Excavation	Common	m^3	120	
3 Embankment	Common	m^3	130	
4 Pavement	Carriage-way	m^2	400	
	Pedestrian	m^2	120	
	Shoulder	m^2	150	
5 Drain	V-Shaped	m	1,500	
6 Culvert Pipe	Rc ø 400	m	1,900	
	Rc ø 500	m	2,600	
	Rc ø1000	m	5,100	
	Rc ø1700	m	11,200	
	Rc ø2500	m	12,500	
7 Reinforced Concrete	280 kg/cm^2	m^3	4,300	Bridge
	240 kg/cm^2	m^3	3,000	Wall
	210 kg/cm^2	m^3	3,500	Wall
	160 kg/cm^2	m^3	1,800	Foundation
8 Form	Wood	m^2	185	
9 Reinforcement	SD 30*2	t	16,700	
10 Steel		t	19,000	
11 Sand		m^3	180	Transport*3 L=5 km
12 Gravel		m^3	360	Transport L=5 km
13 Crushed Stone		m^3	320	Transport L=5 km
14 Concrete Pile	ø 400	m^2	1,900	
15 Block	Concrete	m	175	
16 Guard-Rail		m	5,000	
17 Curb		m	210	
18 Traffic sign		set	5,000	
19 Lane marking		m	200	

*1 Thickness of stripping
*2 SD: Deformed Steel Bar
*3 Including transport cost (L=5.0 km)

4-1.3 Mass Rapid Transportation (MRT) Plan and Alternative MRT Systems

1) Aim of MRT Introduction

The purposes of MRT introduction consist of the following three points:

- Alleviation of the road traffic volume (Diversion of car traffic into MRT).
- Activation of the existing bus systems and improvement of public transport service thereof by effective combination with MRT.
- To promote better land development in the suburbs in future.

2) MRT Routes

a. Main Traffic Routes

In order to maximize MRT characteristics such as mass transport capacity and effective utilization of the urban space, it is necessary to layout its routes along with the main traffic routes which have a great traffic demand. Judging from the current flow and the future land use plan, the future main traffic routes are anticipated to be as shown in Figure 4-1.12. These routes will be extended from CBD toward the following four directions:

(1) Route to connect the present airport and the Bus Terminal under construction, being anticipated to extend toward the northern area.

(2) Route to extend toward the industrial area located along Via Daule in the north-westward passing through Kennedy and Urdesa.

(3) Route to extend to Febres Cordero and further to the western area to be developed in future.

(4) Route to extend toward the port located in the south end and the Guasmo area around the port in southward.

Among the above four routes, the north-south direction extending northward to connect the airport and the Bus Terminal as well as southward to connect the port and Guasro is extremely important to compose the urban axis in future.

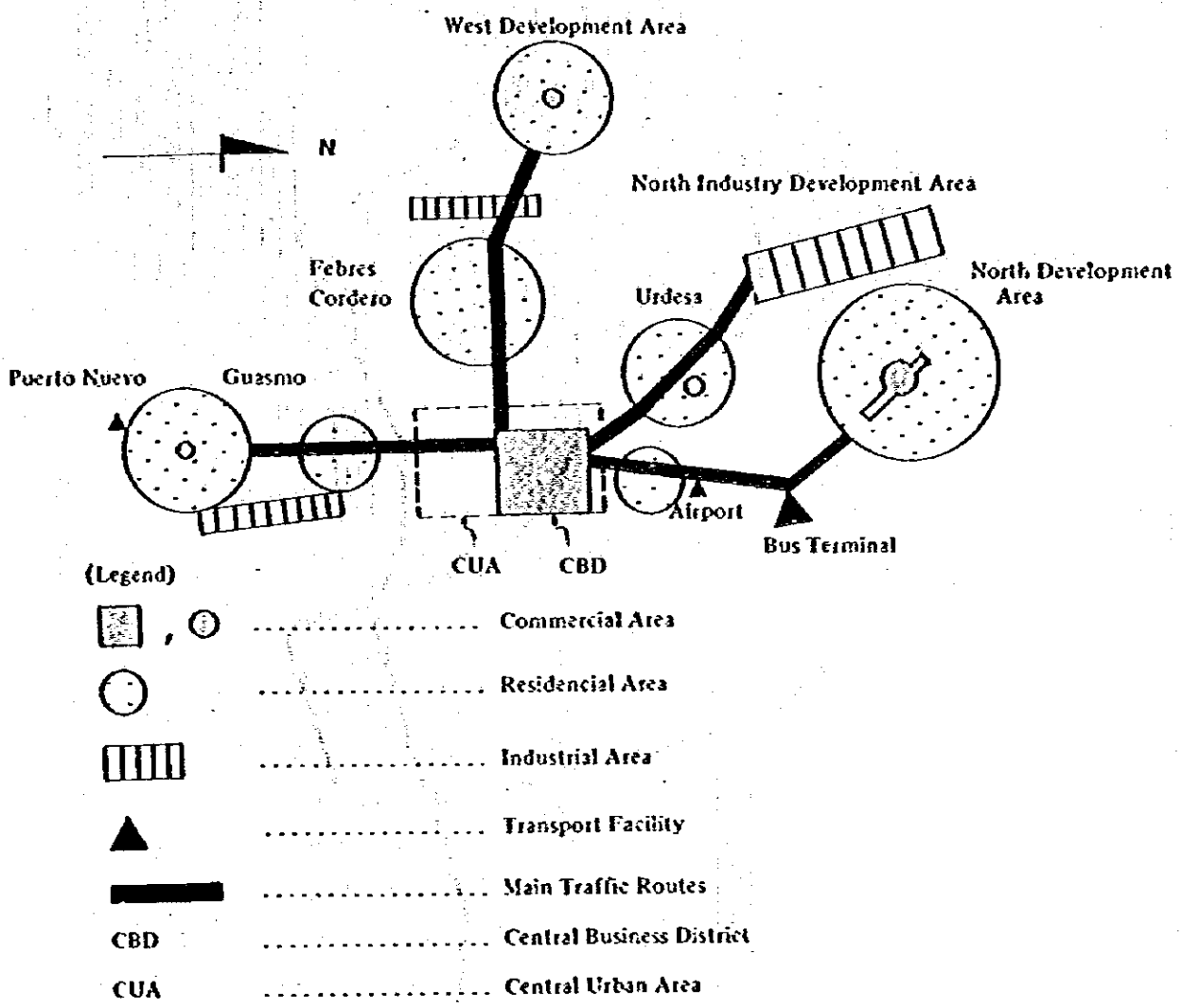


Figure 4-1.12 MAIN TRAFFIC ROUTES

b. MRT Routes

The MRT routes shown in Figure 4-1.13 were selected so as to cover the entire main traffic routes taking account of the route patterns shown in Table 4-1.8.

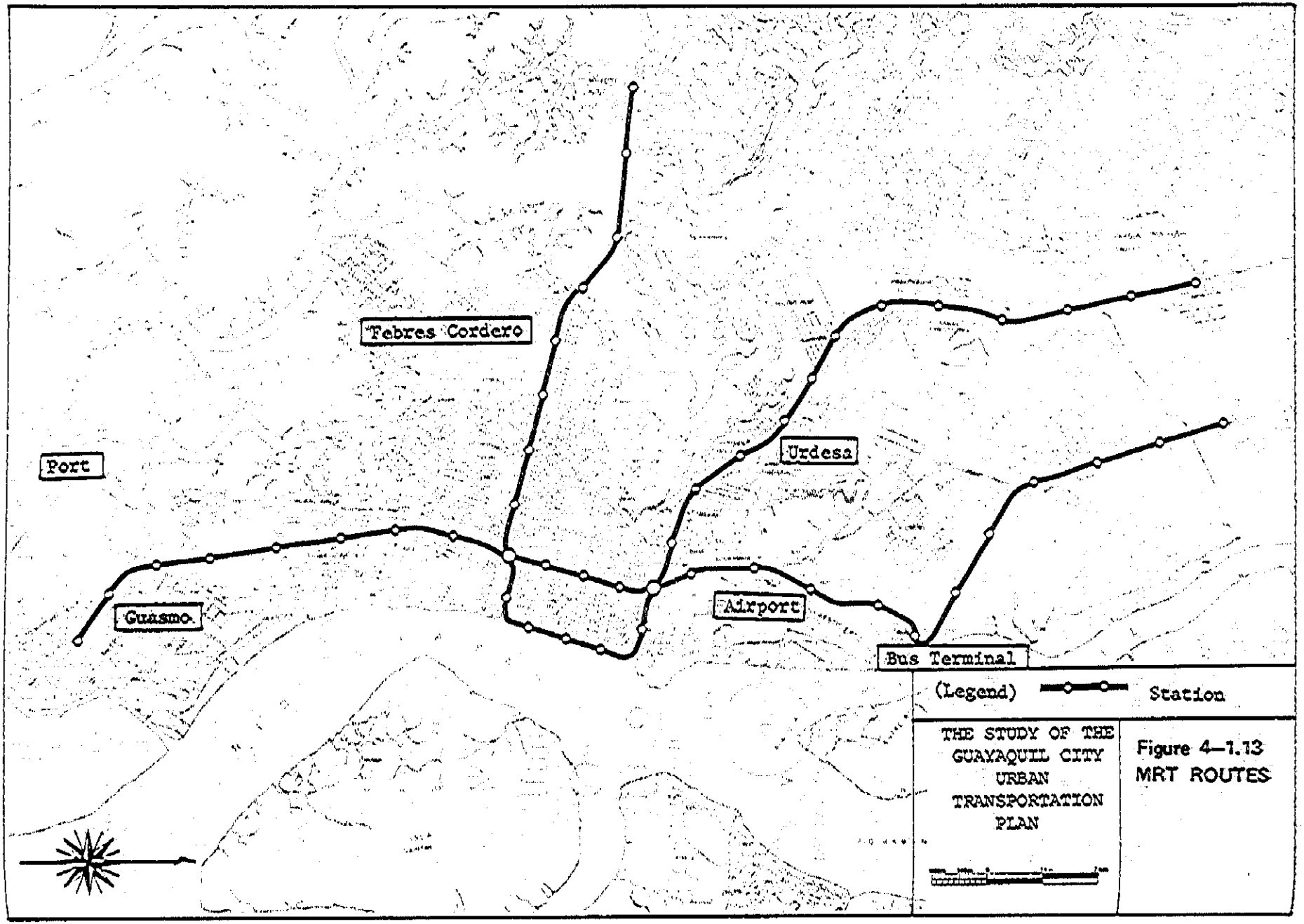
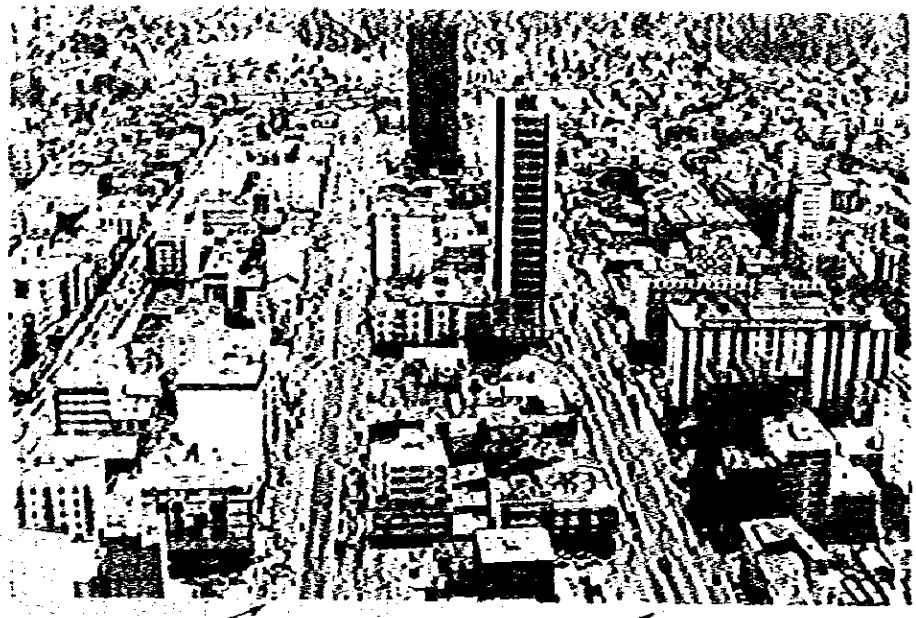


Figure 4-7.13
MRT ROUTES



The standard width of the streets related to the MRT routes is as follows:

Av. 25 de Julio	:	70 m
Av. Quito	:	29 m
Av. de las Americas	:	34 m
Av. Portete	:	26 m
Calle Portete	:	16.5 m
Malecon Simon Bolivar	:	45 m
Calle Padre Aguire	:	15 m
Av. Jhon F. Kennedy	:	32 m
Av. Victor Emilia Estrada	:	26 m
Av. Francisco Huerta Rendon	:	37 m

c. Assumed Location of Stations, Depot and Maintenance Shop

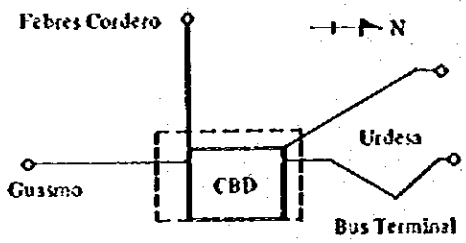
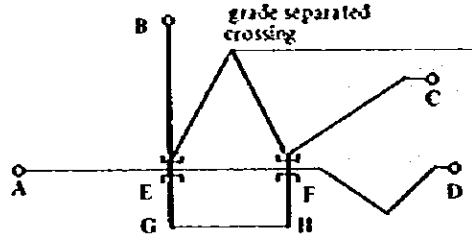
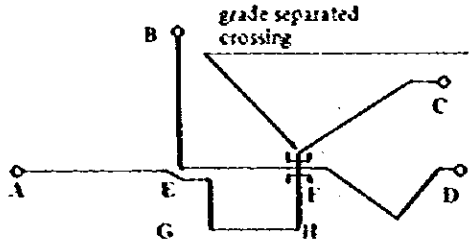
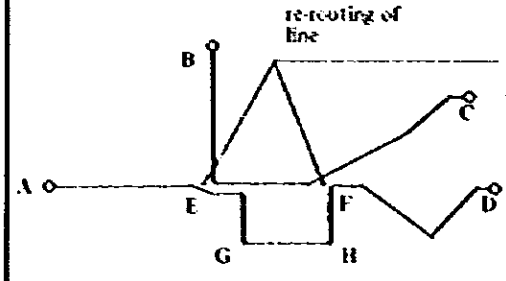
c-1. Location of Stations

Location of stations was selected based on the following concept:

(1) Distance between Stations

The standard distance between each two stations is 700 - 800 m within CUA (Central Urban Area) and

Table 4-1.8 MRT ROUTE PATTERN

Route pattern	Explanation
(Basic pattern)  	
(Pattern 1)  	1. This pattern is suitable to the case of preferential execution of the North-South Route (A-E-F-D). 2. Grade separated crossing of the MRT routes generates at Point E and Point F.
(Pattern 2)  	1. This pattern is suitable to the case of preferential execution of the East-West Route (B-E-F-D). 2. Grade separated crossing of the MRT routes generates at Point F.
(Pattern 3: Recommended)  	1. This pattern is suitable to the case of preferential execution of either route (A-E-F-D, B-E-F-D). However, for the completion of the whole plan it is necessary to re-route the lines operated at the first stage at point E and/or F. 2. No grade separated crossing of the MRT routes generates.

1000 - 1300 m out of CUA respectively.

(2) Accessibility to main establishments such as hospital, school, studium, etc. where passengers gather to (Figure 4-1.13).

(3) Dimensions in Each Route

Table 4-1.9 DIMENSIONS IN EACH ROUTE

	Route length (km)	No. of stations	Average distance between stations (km)
North-South route	26.3	26	1.05
East-West route	24.7	25	1.03
Total	51.0	51	1.04

c-2. Location of Depot and Maintenance Shop

It is recommendable that both the depot and maintenance shop are located in such a site as easy to acquire land and near the terminal of the route. From the above point of view, location thereof is selected as follows:

- Site adjacent to the northern terminal for the North-South route
- Site westward Portete Bridge or adjacent to the northern terminal for the East-West route

3) Alternative MRT Systems

In this section, the five systems are selected out of a number of MRT systems which are considered very promising judging from the forecast transport demand and the characteristics of the Study Area (the structure, particularly, the width of roads, geological features, topography, precipitation, etc. of the town area), and comparison of these five systems is conducted based on the following design criteria.

a. General Design Criteria

a-1 Assumed Routes and Location of Stations

These are shown in Figure 4-1.13.

a-2 Transport Volume

The transport volume estimated from 4-2 in Chapter 4 is as shown in Table 4-1.10.

Table 4-1.10 TRANSPORT VOLUME

Transport Volume / Route	No. of passengers per day (A)	Maximum passenger flow per day in one direction (B)	Maximum passenger flow per hour in one direction (C)
North-South route	629,000	283,000	34,000
East-West route	543,000	222,000	26,600
Total	1,172,000	-	-

(Note): Taking for that the concentration ratio is 12% per one peak hour, the value was figured out from the expression (C) = (B) x 0.12.

a-3 Geological Conditions

The depth of the stratum supporting the MRT's structures is approximately as follows:

For the north-south direction: 15 - 30 m deep
For the east-west direction : 30 - 40 m deep

The stratum above the supporting layer comprises a soft clay layer mixed with sand, and the N-value thereof is 5 or under. The ground water level is about 1.0 m under the surface of the earth.

a-4 Conditions of Sewer Pipes, Drainpipes, etc.

In the ground under the central separator of Av. 25 de Julio, a sewer pipe is laid for the extension of about 2 km commencing from the boundary point between this

avenue and Av. Quito. For the rest part of it, only sewer pipes and drainpipes of small sizes are laid and there seems to be no obstacles to constructing the MRT structures.

a-5 Standards for Operation and Construction

(1)	Design Speed	:	Maximum speed = 80 km/h Scheduled speed = 30 km/h
(2)	Horizontal Curves:		Minimum radius of 300 m as desirable one (If it is unavoidable to be shorter than 300 m, the minimum radius allowed by each system to be applied)
(3)	Maximum Grade	:	3.5 percent on tangent track, 1 percent through stations
(4)	System Operation	:	Minimum peak period = 150 sec. Station stopping time = 15 - 25 sec.
(5)	Structure	:	Minimum vertical clearance over the roads = 4.8 m.
(6)	Vehicle	:	Electrically-propelled car with air-conditioner
(7)	Control system	:	Automatic Train Stop (ATS)
(8)	Power Supply	:	13.2 KV, 60 cycle, three phase electric power supplied by the electric company (Empresa Electrica de Ecuador)

b. Description of Alternative Systems

Judging from the transportation demand in the Study Area, several types of transport systems would be applied including an urban railway (elevated style, partially on the ground style), light rail transit, monorail, rubber tyre type railway, subway, etc.

General characteristics of these transport systems are described hereunder.

b-1 General Characteristics of Each Transport System

(1) Urban Railway

For a huge city with a large population of, for instance, two or three millions or more, it would be suitable to adopt Urban Railway as MRT's trunk line having the transportation capacity of 50,000 person/hour/one way and more.

Since level crossing of MRT with roads is possible, construction cost of MRT can be lowered by combination of the elevated style in the urban area with on the ground style in the suburban area.

As the construction cost per meter of Urban Railway is about 1/3 - 1/4 of the sare of Subway in general, profitability of this project is much better than that of Subway.

(2) Light Rail Transit (LRT)

Although LRT is generally classified into the category of Street Railway utilizing roads in joint with car traffic, this means in this Chapter a transport system to operate light vehicles in an exclusive lane with right of way. So to speak, LRT is a miniaturized urban railway.

The characteristics of LRT are that its construction cost is low (about 80% of Urban Railway, if the traffic demand is within a rather small region), small occupying space of operating site is enough, and it can be operated on a sharply curved track. The transportation capacity (with an assumed train length of 90 m or under) is 8,000 - 25,000 P/h/way.

(3) Monorail

A monorail system was originally developed for the purpose of solving as much as possible the problems on securing the right of way and decreasing noise. Also, it can utilize central separator in the streets of a city.

The characteristics of Monorail are that the track structures are light occupying much smaller space, and it is available for steep gradient and sharp curve. However, since it is necessary to adopt an elevated style for the entire track route on account of level crossing with roads being impossible, its construction cost is higher to a certain extent than that of Urban Railway. The transportation capacity (with an assumed train length of 90 m) is 11,000 - 32,000 P/h/way.

(4) Rubber Tyre Type Railway

In this system, the vehicles are equipped with rubber tyres for the purpose of decreasing noise produced by steel wheels but, basically, this system is same as Urban Railway. The vehicles of this type have been used by the subways in Sapporo (Japan), Paris and Mexico City.

Same as Monorail, since level crossing with roads is impossible for this system, an elevated style is adopted for the entire track route.

(5) Subway

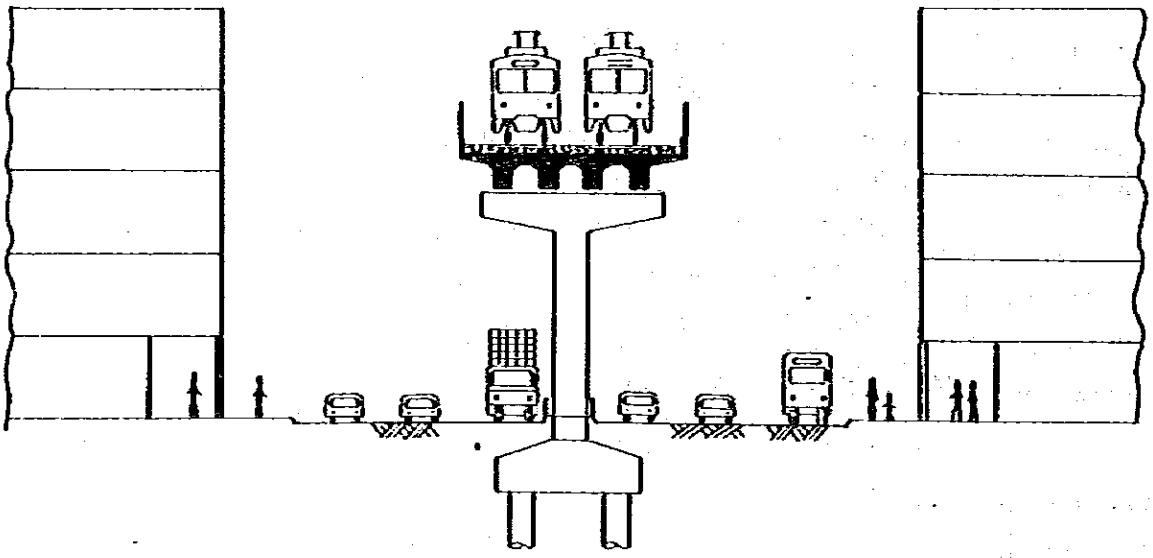
Subway is the most ideal transport means in a city because of no interference with the things on the ground and of its large transportation capacity and has been adopted in big cities in the world. It would be difficult, however, to provide this system in every city due to its trerendous construction cost.

Moreover, the profitability of Subway as a project might be worsened by the decrease in its traffic volume to be converted from other competing transport means in case of its users being directly charged with all of the construction cost as fares in order to compensate the investment cost.

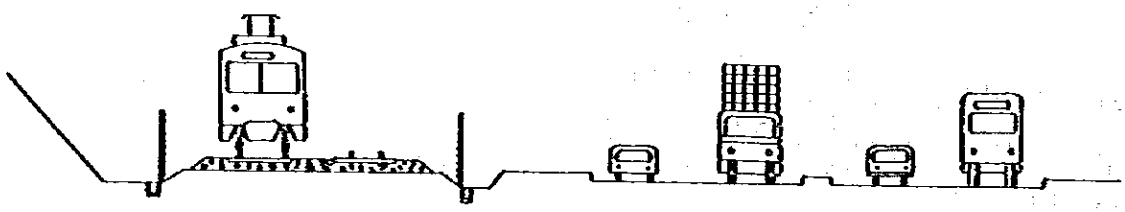
b-2 Typical Cross Section

The typical cross section of each system is shown in Figure 4-1.14 - Figure 4-1.17.

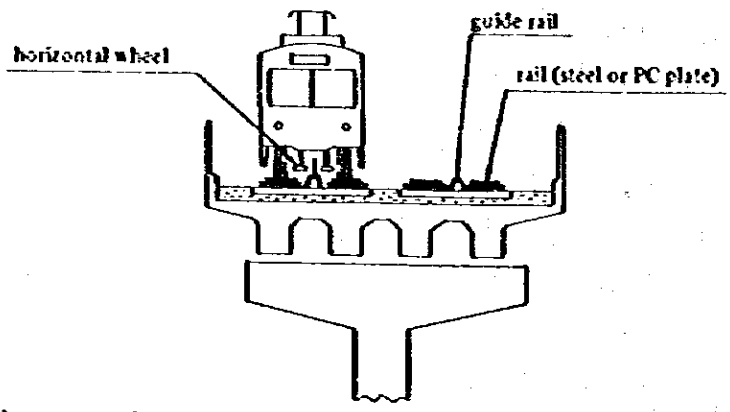
Elevated track



On the ground track



Track structure of rubber tyre type railway

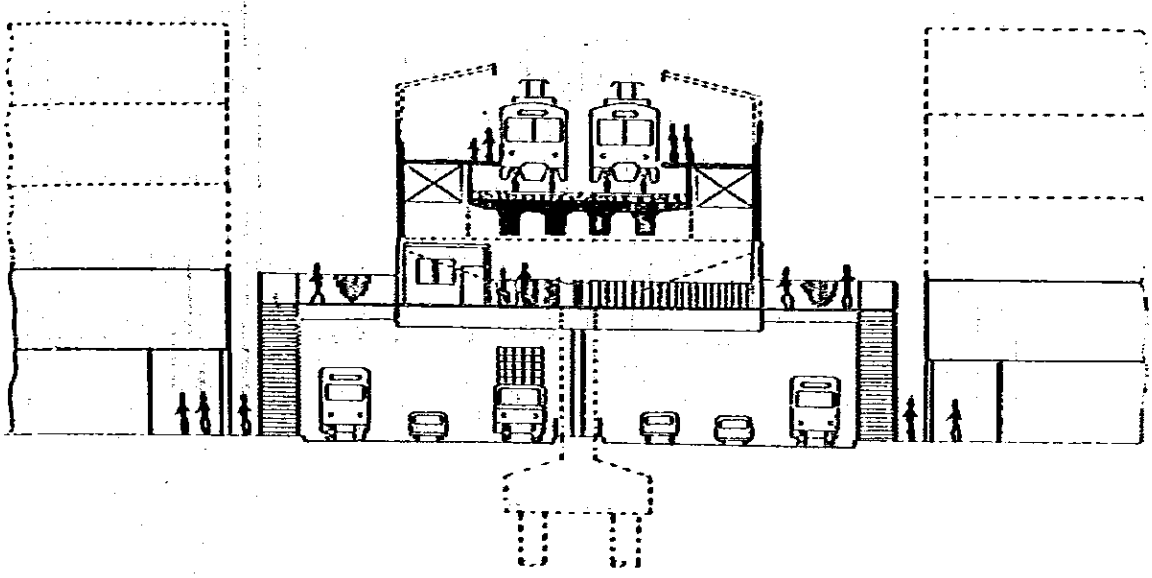


(Note): Applicable for LRT and Rubber Tyre Type Railway

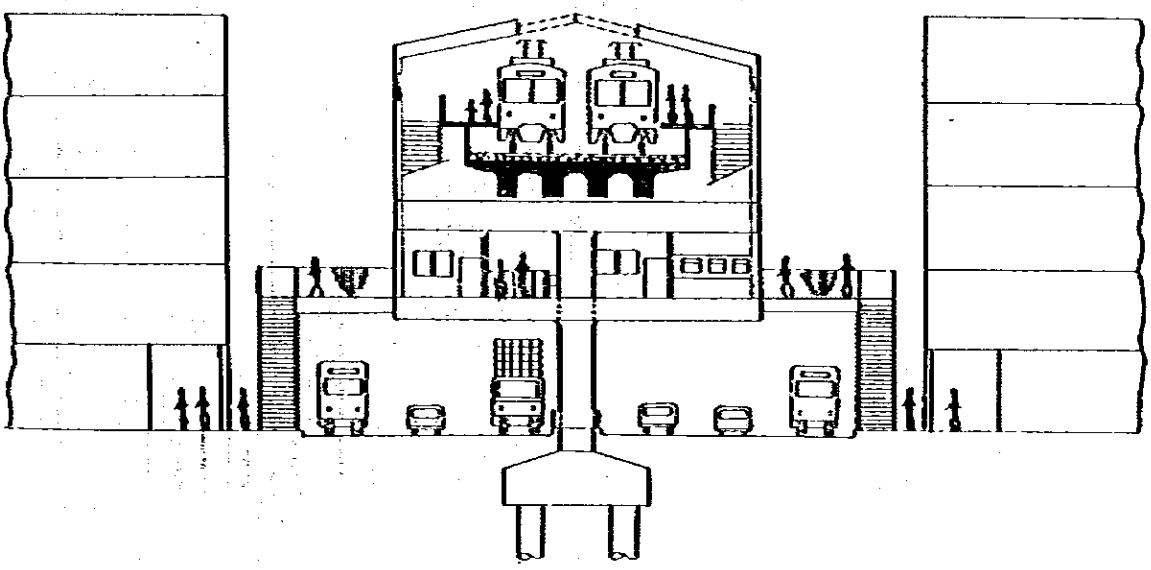
Figure 4-1.14 TYPICAL CROSS SECTION (Urban railway)

Elevated station

Standard station



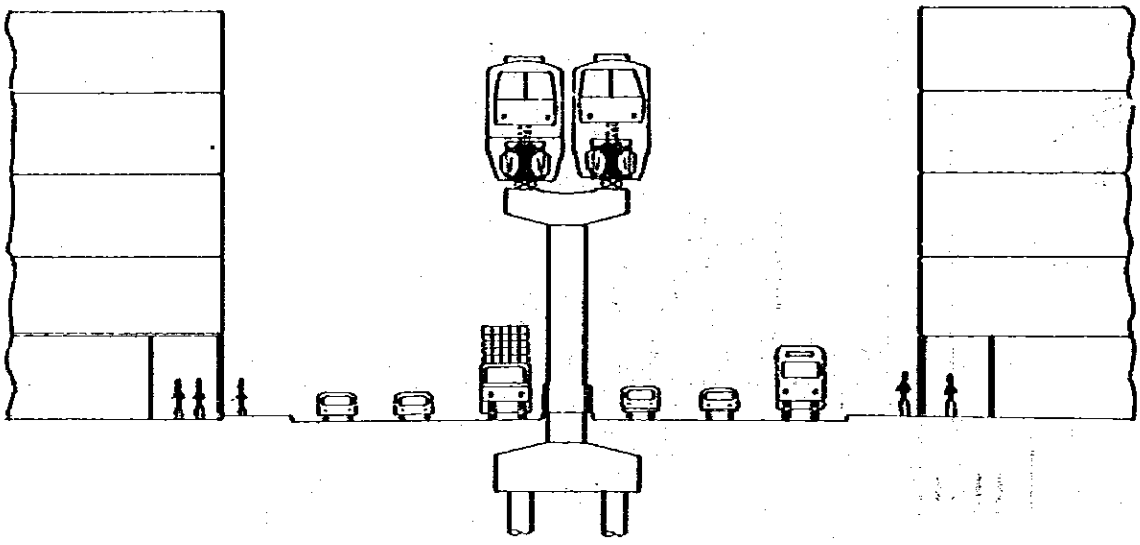
Main station



(Note): Applicable for LRT and Rubber Tyre Type Railway

Figure 4-1.15 TYPICAL CROSS SECTION (Urban railway station)

Elevated track



Elevated station

(Main station)

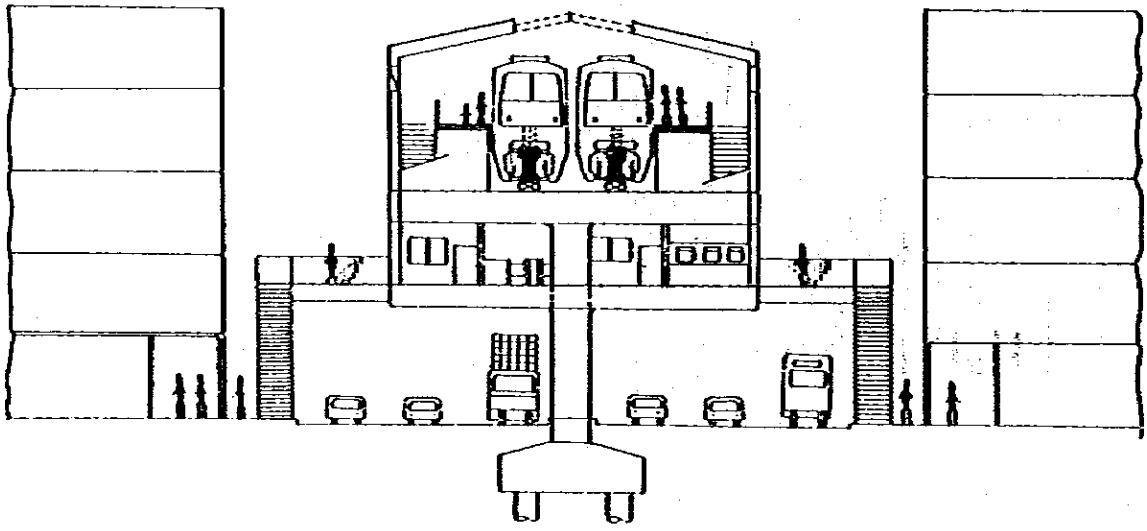
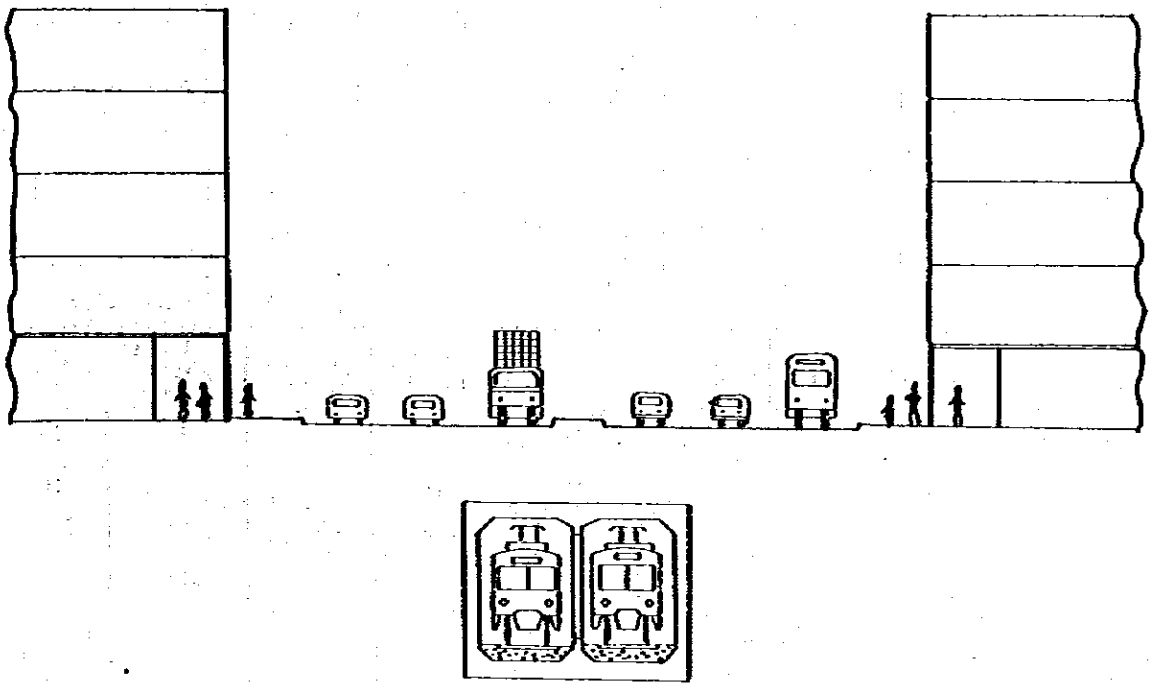


Figure 4-1.16 TYPICAL CROSS SECTION (Monorail)

Underground track



Underground station

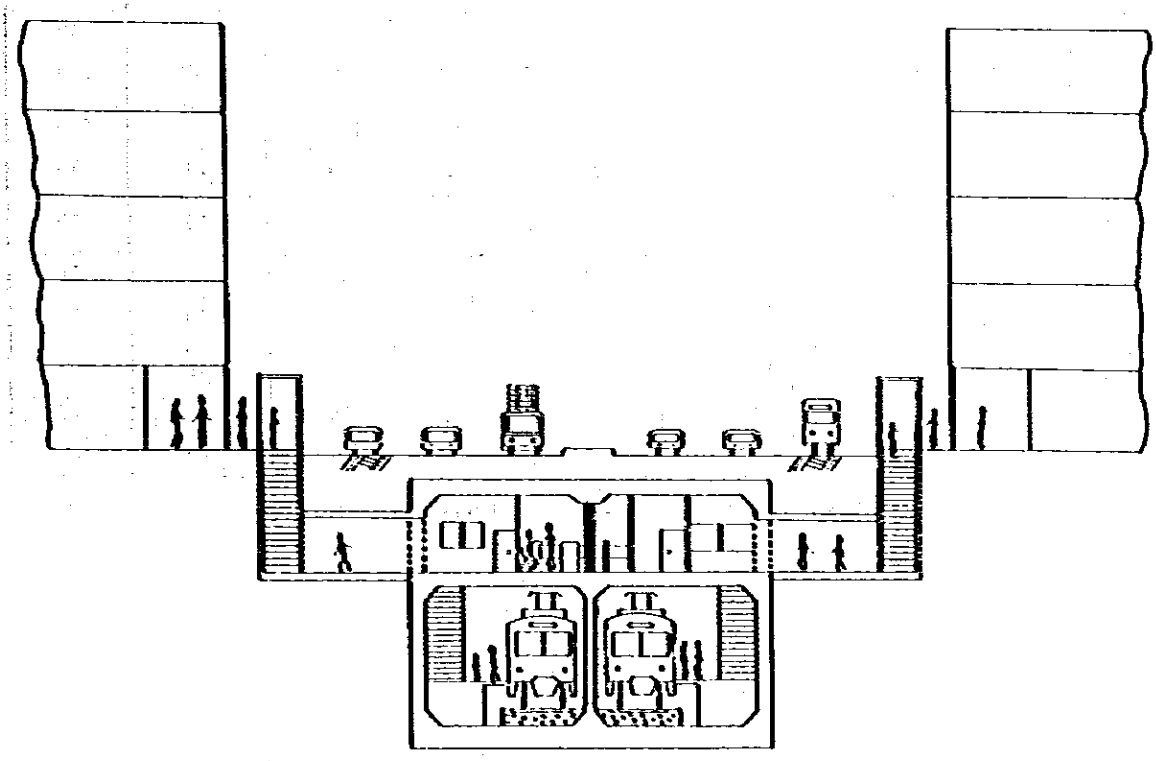


Figure 4-1.17 TYPICAL CROSS SECTION (Subway)

c. Approximate Construction Cost

For the purpose of comparing each system with others, an approximate construction cost of each system is figured out based on Table 4-1.11 and its result is shown in Table 4-1.12.

d. Comparison of Alternative Systems

Shown in Table 4-1.13.

Table 4-1.11 UNIT CONSTRUCTION COST

(Unit: Million sucres in 1982 prices)

Construction Item			Unit	Urban Railway	Light Rail Transit	Monorail	Rubber Tyre Type Railway	Subway
Civil Work	Track		double track/km	36	30	–	70	36
	Structure of Way	On the ground	ditto	16	14	–	–	16
		Elevated (Standard)	ditto	260	210	200	260	260
		Elevated (Special)	ditto	390	315	300	390	–
		Underground	ditto	–	–	–	–	1,200
	Station	On the ground	station	18	16	–	–	18
		Elevated (Standard)	ditto	64	54	70	64	64
		Elevated (Special)	ditto	96	81	105	96	–
		Underground	ditto	–	–	–	–	250
	Depot and Maintenance Shop		lot	260	220	600	500	260
Electric Work	Substation		station	160	50	110	110	160
	Power Distribution		double track/km	20	16	44	20	30
	Signal and Telecommunication		ditto	10	9	30	30	10
Rolling Stock			car or unit	24	40	28	36	24
Engineering (Survey, Design, Supervision)			double track/km	20	20	20	20	20
Land	Suburban Area		1,000 m²	1	1	1	1	1
	Urbanized Area		1,000 m²	10	10	10	10	10
Contingency			%	10	10	10	10	10

(Note) Exchange rate: 1 U.S. Dollar = 50 sucres (Average in 1982)

Table 4-1.12 TOTAL INVESTMENT IN EACH MRT SYSTEM

(Unit: million sucress in 1982 prices)

Item \ System	Urban Railway	Light Rail Transit (LRT)	Monorail	Rubber Tyre Type Railway	Subway	Remarks
Civil Work	14,960	12,290	16,620	22,820	45,820	including stations & depot and maintenance shop
Electric Work	2,810	2,280	5,420	4,200	3,320	
Rolling Stock	6,530	10,880	12,100	11,230	6,530	
Engineering & Contingency	3,950	4,070	4,790	5,160	7,090	including land acquisition cost
Total	28,250	29,520	38,930	43,410	62,760	
Investment per km	554	579	763	851	1,231	

(Note): Track type

Urban Railway & LRT: elevated style for 32.6 km in the urban area and on the ground style for 18.4 km in the suburbs.

Monorail & Rubber Tyre Type Railway: elevated style for the whole 51 km.

Subway : underground style for 28 km in the urban area, elevated style for 4.6 km and on the ground style for 18.4 km in the suburbs.

Table 4-1.13 COMPARISON OF ALTERNATIVE SYSTEMS

		Urban Railway	Light Rail * Transit	Monorail	Rubber Tyre Type Railway	Subway
Transport Capacity (person/hour/one way) {headway = 150 seconds}		1 train = 4 cars 80 m 35,000	1 train = 3 units 87 m 25,000	1 train = 6 cars 84 m 32,000	1 train = 4 cars 72 m 29,000	1 train = 4 cars 80 m 35,000
Rolling Stock	Length/width (m)	20/2.9	29/2.5	14/3.0	18/3.1	20/2.9
	Maximum capacity (person/car)	360	350	220	300	360
	Maximum speed (km/h)	120	80	80	70	120
	Electric power	1,500 V.DC	750 V.DC	1,500 V.DC	1,500 V.DC	1,500 V.DC
Width of structure (m)		9.4	8.5	4.5 (from beam to beam)	9.8	9.0
Minimum curve radius (m)		160(120)	100(25)	100(50)	200(120)	160(120)
Maximum grades (%)		3.5	4.0	6.0	6.0	3.5
Level crossing with roads		Possible	Possible	Impossible	Impossible	Possible
Environment impact	Noise	Δ	Δ	O	O	O
	Vibration	Δ	Δ	O	O	Δ
	Air pollution	O	O	O	O	O
	View	Δ	Δ	O	Δ	O
Safety		O	O	Δ	O	Δ
Comfortability		O	O	O	O	Δ
Operation		O	O	O	O	O
Maintenance		O	O	Δ	Δ	Δ
Required train length for the maximum transport volume (34,000 person/hour/one way) in this plan		80 m	116 m	98 m	90 m	80 m
Construction cost (million sucres) [( ) means the cost per km]		28,250 (554)	29,520 (579)	38,930 (763)	43,410 (851)	62,760 (1,231)

(Note): 1. The values in the above Table show standard ones.
The values in parenthesis show those allowable in special cases.

2. O means good and Δ means common.

* Light Rail Transit system has its own right-of-way independent of other transport modes, and its performance is almost equivalent to that of Urban Railway although the vehicle size is small.

** Less than about 100 meters would be desirable in the station length over the roads to minimize influences to the waysides of the MRT route or road traffic.