Vehicle Type Composition

Car	Passenger car	0.6706
	Small truck	0.2529
	Medium truck	0.0765
	Large truck	0.0000
Bus	Mini bus	0.3225
	Large bus	0.6775

Table 9.5.13 Gasoline and Diesel Consumption
(Unit: Liter/km)

km/hour	Car(P)	Car(D)	Bus
5	0.239	0.335	0.403
10	0.208	0.308	0.382
15	0.180	0.279	0.352
20	0.160	0.253	0.321
25	0.147	0.233	0.298
30	0.135	0.216	0.279
35	0.125	0.201	0.262
40	0.116	0.188	0.246
45	0.110	0.179	0.234
50	0.105	0.172	0.224
55	0.101	0.168	0.217
60	0.098	0.167	0.214
65	0.097	0.169	0.217
70	0.095	0.171	0.222
75	0.094	0.178	0.230
80	0.093	0.186	0.238

With the average travel speed listed in the above same Table 9.4.5, the energy consumption corresponding to the speed is estimated as shown in Table 9.5.14.

Table 9.5.14 Energy Consumption Corresponding to the Average Travel Speed
(Unit: Ave. Speed km/hour, Energy Liter)

	Alt. A	Alt. B	Alt. C	Alt. D	Alt. E	Alt. F	Do Nothing
Ave. Speed							
Car(P)	21.0	24.1	26.7	26.0	27.8	29.8	17.5
Car(D)	21.0	24.1	26.7	26.0	27.8	29.8	17.5
Bus	11.1	14.5	34.7	11.7	13.4	29.2	8.0
Energy							
Car(P)	0.157	0.149	0.143	0.144	0.140	0.135	0.170
Car(D)	0.249	0.236	0.227	0.229	0.224	0.217	0.266
Bus	0.375	0.355	0.263	0.372	0.361	0.282	0.390

On the other hand, total energy consumption is estimated, using the vehicle travel distance in Table 9.4.5. The vehicle travel distance of Car(P) and Car(D) is also calculated with the above vehicle composition. Consequently, Energy saving of gasoline and diesel is obtained by subtracting the energy saving in each plan from that in

"Do Nothing Case". The result is shown in Table 9.5.15. According to this Table, the energy saving is the highest in alternative C and alternative F, (both are rail system introduction plans) in accordance to the theory, followed by alternative E.

Table 9.5.15 Saving of Energy Consumption in Alternative Plans
(Unit: 1,000 Liter/year except Vehicle km)

Vehicle Type	Alt. A	Alt. B	Alt. C	Alt. D	Alt. E	Alt. F	Do Nothing
Vehicle km							
Car	13150.7	14020.8	12949.8	14415.6	13848	12875.7	16447.4
Car(P)	8818.9	9402.3	8684.1	9667.1	9286.5	8701.5	11029.6
Car(D)	4331.8	4618.5	4265.7	4748.5	4561.5	4274.2	5417.8
Bus	1712.3	1854.3	2073.3	1691.8	1775.7	1967.5	1635.8
Consumption							
Car(P)	2068.6	2088.1	1846.5	2078.7	1939.6	1757.7	2796.1
Car(D)	2194.9	2221.8	1972.3	2217.6	2075.8	1888.3	2934.5
Bus	642.6	657.9	545.5	628.8	641.8	555.4	638.4
Saving							
Car(P)	727.5	707.9	949.5	717.3	856.5	1038.4	
Total Gasoline	727.5	707.9	949.5	717.3	856.5	1038.4	
Car(D)	739.6	712.7	962.2	716.9	858.7	1046.2	
Bus	-4.3	-19.6	92.9	9.5	-3.4	83.0	
Total Diesel	735.4	693.1	1055.1	726.5	855.3	1129.1	

9.5.6 Environment Impact

Selected six alternative plans give various environment impact not only to the natural conditions but also to the daily living conditions of citizen. Since it is difficult to quantified the environment impact correctly in this Master Plan stage, the quality comparison among alternative plans was studied for the following two environment aspect; Impact to the natural conditions and Impact to the daily living conditions.

(1) Impact to the natural conditions

Environment impact to the natural conditions is more severe in alternative C, D, E and F because of introducing new road and rail transit. In these plans some areas are enforced to be cut and filled or cut down trees for the purpose of constructing roads and railways. This construction work might easily bring about debris flow, change of underground water, unfavorable ecological impact, etc. Therefore, it is needless to say that during the construction stage it is necessary for the careful device to keep these negative impact minimum as much as possible.

In addition, new constructions might deteriorate the visual aspect in the city. In some cases the construction of big infrastructure such as elevated railway or elevated expressway does not often harmonize with the existing city's visual environment. Therefore, in case of introducing the big infra-

structure, it must be carefully designed from the aesthetic aspect.

(2) Impact to the living conditions

Each alternative plan envisages different transportation conditions in the future. Therefore, the projected future traffic volume varies plan by plan. The environment impact caused by the traffic considerably depends on the volume of traffic. The following three impacts are compared among alternative plans as a negative impact;

1) Air pollution

Air pollution depends on the congestion level in the study area. According to Table 9.4.5, alternative C, E and F show the congestion rate of less than 1.0. Therefore, living in the more clean air is expected under these three alternative plans. On the other hand, the air pollution of alternative A is considered to be awful because of the congestion rate of 1.38.

2) Noise

Noise level is much influenced by the traffic volume. Since alternative C and alternative F show a relatively lower volume, the noise level is considered to low in these two plans, while alternative A, B and D will bring about a little higher noise level.

3) Traffic Safety

Traffic safety has also close relationship with the traffic volume, that is, vehicle travel distance. Therefore, generally the conclusion would be the same as that in the above "2) Noise". However, traffic safety can secure under the installation of good traffic facilities and introduction of efficient traffic management system. From this reason every alternative plan should be set up from the traffic safety aspect. Since selected six alternative plans give good traffic facilities and traffic management, the safety level is said to be the same among six alternative plans.

The above environment impact is summarizes in the following Table 9.5.16. Concluding remarks, alternative C, E and F are said to be good plans from the environment aspect.

Table 9.5.16 Comparison of Environment Impact

Factor	Alt.A	Alt.B	Alt.C	Alt.D	Alt.E	Alt. F
Natural Conditions	Fair	Fair	Average	Average	Average	Average
Aesthetic Aspect	Fair	Fair	Good	Fair	Fair	Good
Pollution	Average	Average	Excellent	Good	Excellent	Excellent
Noise	Average	Average	Fair	Average	Good	Fair
Safety	Fair	Fair	Fair	Fair	Fair	Fair
Overall Evaluation	Fair	Fair	Good	Fair	Good	Good

9.5.7 Comparison of Alternative Plans

According to the evaluation of alternative plans, a comparison study is conducted; the following comparison items are examined:

a) Total vehicle running kilometers on all the load rinks to be assigned
b) Total vehicle running hours on all the road links to be assigned
c) Average congestion degree on all the road links to be assigned
d) Average travel speed on all the road links to be assigned
e) Total benefits including time saving and operation cost saving on all the road links to be assigned
f) Economic evaluation indicators (IRR, B/C, NPV) on the initial year
g) Implementation aspects of each alternative plan
h) Socio-economic aspects of each alternative plan

The results of the above-mentioned comparison are summarized in Table 9.5.17 and Figure 9.5.1.

Table 9.5.17 Comparison of Alternative Plans

	Alternative Plans					
	A	B	C	D	E	F
1. Traffic Aspects						
1-1 Vehicle Travel Distance	14,863	14,020	12,949	14,415	13,848	12,975
1-2 Vehicle Travel Time	1,131	932	738	907	806	686
1-3 Av.Travel Speed (Km/hour)	19.0	22.0	26.6	23.0	24.8	29.6
1-4 Av. Congestion Degree	1.38	1.22	0.96	1.11	0.98	0.78
2. Economic Aspects						
2-1 Total Benefits (million)	36,228	51,341	70,098	50,974	58,502	68,672
2-2 Project Cost (million)	1,676	2,188	4,918	2,316	2,502	4,803
2-3 IRR (%)	29.0	30.9	23.1	29.8	31.0	22.4
2-4 B/C	3.183	3.537	2.230	3.315	3.540	2.131
2-5 N.P.V (million)	2,781	4,166	4,436	4,026	4,773	4,179
3. Implementation Aspects						
3-1 Difficulty	Land Problems	Land Problems	Squatter Problems	Land Problems	Land Problems	Squat Problems
3-2 No. of Houses	835	635	635	1,120	920	920
3-3 No. of Bridges	10	10	10	22	21	21
4. Social Aspects						
4-1 GDP Increment (million)	4,460	5,749	12,939	6,091	6,580	12,631
4-2 Unskilled Employment (person/year)	15,700	20,200	45,500	21,400	23,100	44,500
4-3 Fuel Saving						
Gasoline (1000 l/year)	727.5	707.9	949.5	717.3	856.5	1038.4
Diesel (1000 l/year)	735.4	683.1	1055.1	726.5	855.3	1129.1
5. Environment Aspect	Fair	Fair	Good	Fair	Good	Good
6. Evaluation Placing	4	2	5	3	1	6

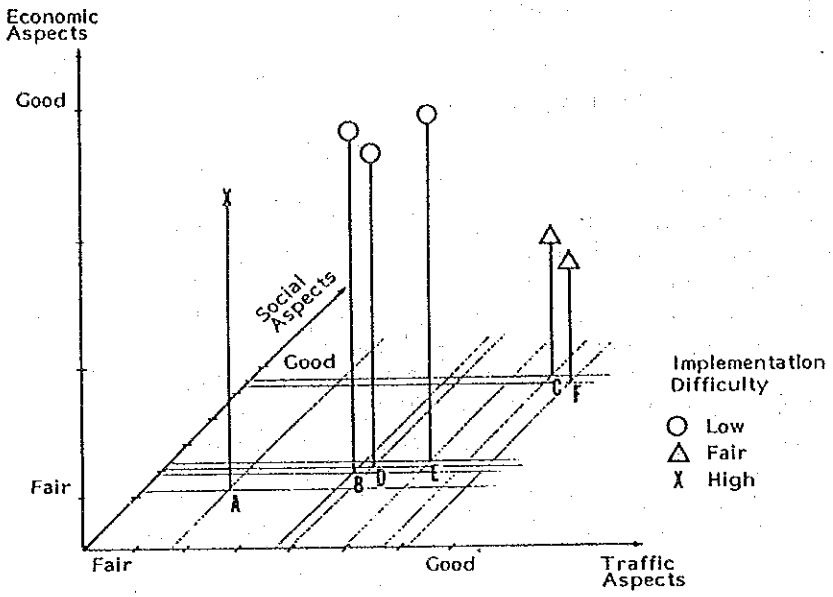


Figure 9.5.1 Sketch of Comparison of Alternative Plans

9.5.8 Selection of Optimum Alternative Plan

From the results of comparison studies for selecting an optimal transport network plan, the alternative plan E is selected. The main reasons are as follows:

a) Based on the results of economic evaluation, the Internal Rate of Return (IRR) and Cost Benefits Ratio ($^{B}/C$) of alternative plan E is indicated as the highest value among six alternative plans.

b) Based on the analysis of traffic conditions, the congestion degree of alternative plan E is indicated as the less than 1.0, however, average travel speed among six alternative plans are indicated as almost the same.

c) From the viewpoints of difficulty of implementation, the six alternative plans have almost the same conditions, due to the fact that there are problems with land acquisition and compensation, as well as the presence of many squatters in relevant areas.

d) From the social and economic point of view, alternative E is expected to produce relatively large increase in GDP, provision of employment for unskilled laborers and saving of gasoline and diesel.

e) Environment impact given by alternative E never hurts the natural conditions, living conditions and aesthetic aspect.

f) Considering the future traffic conditions, the further study on introducing a railway system would be required as a long term public transportation plan in the Metropolitan Area.

10. ROAD AND INTERSECTION PLANNING

10.1 Road Planning

10.1.1 Planning Concept

(1) General

By the year 2010 the population of Study Area will have increased to about 3.0 million and about 48,000 hectors of land will have been developed in harmonious balance with urban and suburban activities.

GDP of the Study Area has a steady growth and the future annual growth rates during 1990 to 1995 and after 1996 are expected to be 3.5 percent and 4.5 percent respectively.

At present, the population of the Study Area is about 1,800,000 and the future population in 2010 is estimated to be about 3,000,000 respectively. This economic and population growth will result in a large increase in the demand for transportation to about 2.5 times of the present.

(2) Planning Guideline

1) Road Facilities and Traffic Problems

In the Progress Report (II), the road facilities and traffic problems were discussed and identified based on problems such as traffic congestion, traffic safety, traffic environment and traffic energy saving. The problems identified are summarized below.

a) Inadequacy of the road
b) Unlinked network
c) Concentration of trunk road network
d) Imperfection of ring road network
e) Traffic congestion on road
f) Traffic bottleneck at intersection
g) Ineffective utilization of road space
h) Poor maintenance
i) Bridge structure
j) High noise level
k) Further study

2) Basic Consideration for Planning

Basically, road planning is executed for solution of the urban and suburban transportation problems and also to contribute along with national economic activities in maintaining good traffic environmental conditions. The problems to be solved in urban transportation are the following items:

a) To solve traffic congestion
b) To ensure traffic safety
c) To maintain a good traffic environment
d) To save traffic energy

In proportion to the increase in population and enlargement of economic activities in Study Area, the traffic volume also increase gradually. As traffic volume increases, the public transportation system should be reinforced in order to achieve the solutions to urban transportation problems.

In addition , Guatemala City is capital of Guatemala and the center of Central America. Considering above mentioned conditions, a road facilities plan should be implemented to maintain a good traffic situation.

3) Concepts of the Planning

Taking into account the existing traffic conditions, future development potential, socio-economic activities and basic consideration of planning, the Study Team identified the following planning goals for the future road facilities development.

a) To maintain high-quality roads
b) To maximize the benefits of transportation economy
c) To maximize resource consumption
d) To provide safety

In order to prepare a Master Plan for the solution of the urban transportation problems, the following plans are examined.

a) Long Term Plan
b) Short Term Plan

The Long Term Plan with target year 2010 is studied for road network development planning and the Short Term Plan with target year 1995 is studied mainly for traffic management planning including improvement of existing intersections and short urban roads, traffic regulation, and bus terminals.

In consideration of the sources of problems with road facilities, the following plans are examined for their solution.

a) New road construction plan
b) Existing road improvement plan
c) Existing road rehabilitation plan
d) Intersection improvement plan
e) New bridge construction plan
f) Existing bridge improvement plan

The relationship among the cause of problems, problems identified and plan to be examined is shown in Figure 10.1.1.

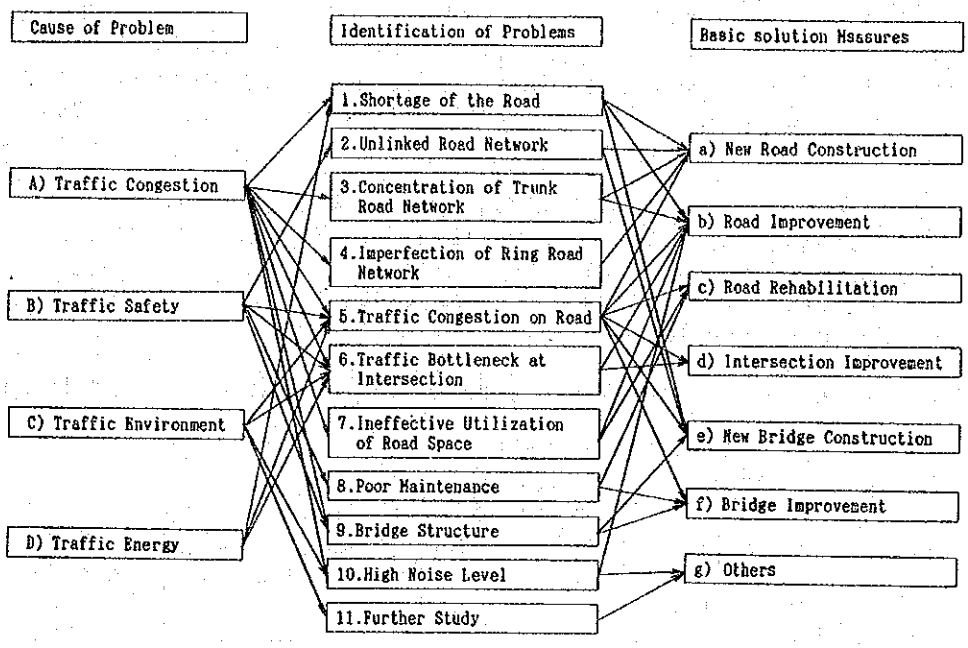


Figure 10.1.1 Relationship between Problems and Solution

10.1.2 Road Function and Characteristics

(1) Functional Road Classifications

There is no criteria for functional road classification in Guatemala Municipality and the General Direction of Roads. The road planning is conducted to adopt American Standards, that is the Policy on Geometric Design of Highways and Streets (AASHTO), 1984.

The functional road classifications of roads are adopted according to American Design Standards (AASHTO).

According to AASHTO, highways are divided into two categories: namely roads, which are located in rural areas and streets which are located in urban areas. However, definition of rural and urban areas is comparatively difficult, so, both roads and streets in the Study are called roads for the sake of convenience.

The functional road classifications can be divided into five categories based on the results of road inventory surveys and discussion with the counterparts of Guatemala Municipality and the General Direction of Roads as shown below:

a) Urban expressway (Autopista)
b) Principal arterial road
c) Minor arterial road

d) Collector road
e) Local road

(2) Road Function and Characteristics

The functions and characteristics of each classified road are examined for formulation of road network planning in the Study Area. Figure 10.1.2 summarizes road functions and characteristics. According to this figure, following matters can be described:

a) An urban expressway and arterial roads are required primarily for maintaining mobility and high road design criteria.

b) A local road and access road are required primarily for maintaining land access and low design criteria.

c) A collector road is situated between arterial roads and local roads.

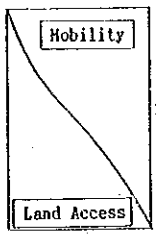
Function of Road	Characteristics of Road Traffic					Class of Road	Remarks
	Traffic Volume	Trip Length	Travel Speed	Mode of Transportation	Trip Purpose		
	Heavy ↕ Low	Long ↕ Short	High ↕ Low	↑ Motor Vehicle ↓ Motor Cycle Bicycle foot	Business to Work To School Shopping	Arterial Road Collecter Road Local Road	

Figure 10.1.2 Function and Characteristics of Road

The main and subordinate functions of a road and the characteristics of each road are summarized in Figure 10.1.3.

According to this figure, the following can be described:

a) An urban expressway and arterial roads are to serve mainly for long or comparatively long distance trip with high traffic capacity and high travel speed.

b) A local road is mainly for short distance trips with small traffic capacity and low traffic speed.

c) A collector road is situated between arterial and local road traffic characteristics.

The road network system arrangement is not only to contribute to development of urban activities but also to form the basic urban structures. In addition, the road network system arrangement is to contribute to the socio-economic development of the city.

	Network Characteristics				Traffic Characteristics								
	Link City to City	from Community	within Community	Access to Housing	Trip Length			Capacity			Travel Speed		
					Long	Middle	Short	Large	Middle	Small	High	Middle	Low
Urban Expressway		○	△		△	○		○			○		
Principal Arterial Road	○	△			○	○		○			○	△	
Minor Arterial Road		○	△			○			○			○	△
Collector Road			○	△		○	△		○	△		○	△
Local Road				○			○			○			○

○ Main Function
△ Subordinate Function

Figure 10.1.3 Relation of Road Function to Characteristics of Road Traffic

10.1.3 Road Network Planning Criteria

(1) Road Network Connection System

It is very important to consider the road network system for road network development planning in order to keep a smooth and safe traffic flow and to maintain the function and characteristics of each road.

In consideration of the function and characteristics of each road, a road network connection system is arranged as shown in Figure 10.1.4.

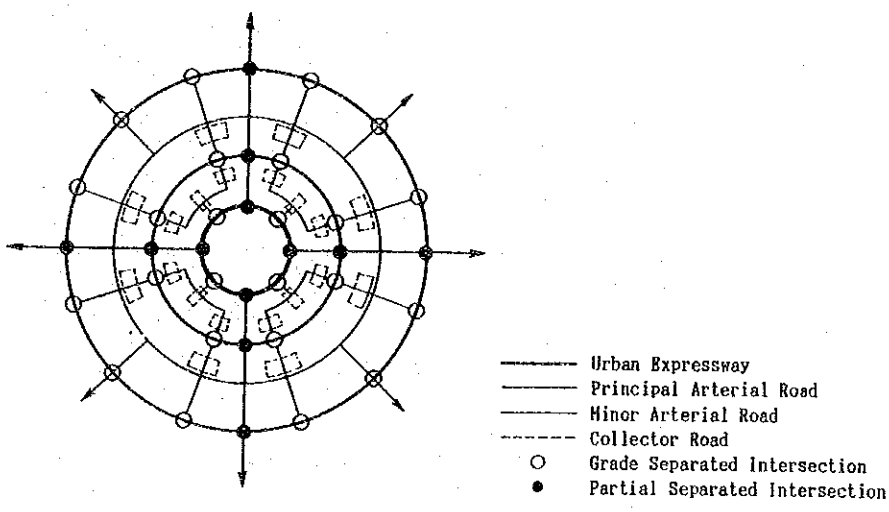


Figure 10.1.4 Road Network System Configuration

In the above-described system, arterial roads must not be connected to the local roads directly. A road should be connected to the same class road or a road classified as one class higher or lower.

(2) Road Design Criteria

Taking into account the following items, the road design criteria are examined.

a) Traffic and vehicle operating conditions
b) Road function and its characteristics
c) Planning goals
d) Natural conditions

Generally, the road design standards to be adopted in this Study follow American standards, however, some design elements are adopted as revision of the American Standard.

The road network plan is conducted to adopt the metric system, because the metric system is used for road design in Guatemala.

1) Number of Lane

Usually, the number of lanes to be required is decided depending on the results of comparative analysis of traffic capacity and planned future traffic volume on a road.

However, principal or minor arterial roads require at least 4-lanes (dual carriageway) considering function and characteristics of arterial roads.

2) Width of Lane

The width of lane is decided depending on the intended speed and a number of heavy vehicles on a road. According to the AASHTO, the width of a lane on each road is stipulated as below.

a)	Urban Expressway	= 12 ft	= 3.65 m.
b)	Arterial Road	= 12 ft	= 3.65 m.
c)	Collector Road	= 10 ft	= 3.05 m.
d)	Local Road	= 9-10 ft	= 2.74 m. - 3.05 m.

In this Study, the lane width of Urban Expressways and arterial roads is adopted as 3.5 m. in consideration of the following:

a) Land prices in urban areas are very high. The cost of road construction must be kept to a minimum.

b) The heavy vehicle percentage of total traffic volume in Study Area is comparatively low.

3) Design Speed

Design speeds of principal and minor arterial roads are adopted to be 100 - 80 km/hr and 80 - 60 km/hr respectively considering func-

tions and characteristics of these roads.

4) Access Control

To ensure traffic safety and to maintain smooth traffic flows, full access control be required for principal roads. However, sometimes enough space cannot be found for introducing the full access control system within the urban area. In this case, a partial access control system be introduced.

5) Parking Control

A parking restriction system is introduced on principal and minor arterial roads in order to maintain traffic safety and smooth traffic flows on the roads.

6) Construction of Medians

Basically, the roads which require a high mobility function and are multi-lane roads should include a median to ensure traffic safety.

7) Construction of Sidewalks

The roads which are located in urban area should include side walks on both road sides to ensure traffic safety.

The above-mentioned seven matters are summarized in Figure 10.1.5.

	Number of Lanes (M)	Width of Lanes (M)	Design Speed (Km/h)	Access Control	Parking Restraint	Construction of Median	Construction of Sidewalk	Connected Road
Urban Expressway	≧ 4	≧ 3.5	100-80	Full	Full Restraint	Full	Non	Urban Expressway Arterial
Principal Arterial Road	≧ 4	≧ 3.5	100-80	Full & Partial	Full Restraint	Partial	Full	Expressway & Arterial
Minor Arterial Road	≧ 2	≧ 3.5	80-60	Partial	Partial Restraint	Partial	Partial	Arterial & Collector
Collector Road	≧ 2	≧ 3.0	60-40	None	Non Restraint	None	Partial	Arterial Collector Local
Local Road	≧ 1	≧ 3.0	40-20	None	Non Restraint	None	None	Collector Local
Access		≧ 2.75	—	—				Local Access

Figure 10.1.5 Criteria of Road Function

(3) Typical Cross-Section

Taking into account the function and characteristics of a road and the design criteria of road planning, the typical cross-section of the roads is identified as follows.

1) Urban Expressway

The typical cross-section of urban expressway is decided as follows.

a) 7.0 meters width of frontage roads is prepared.
b) 3.5 meters lane width is adopted for through lanes.
c) 3.0 meters lane width is adopted for frontage roads.
d) 5.0 meters width of central median is adopted in consideration of U turn traffic.
e) 2.0 meters width of right side medians are included in consideration of the traffic safety.
f) 3.5 meters width of sidewalk is included on both sides.

The above-mentioned matters, and traffic flow conditions are illustrated in Figure 10.1.6 respectively.

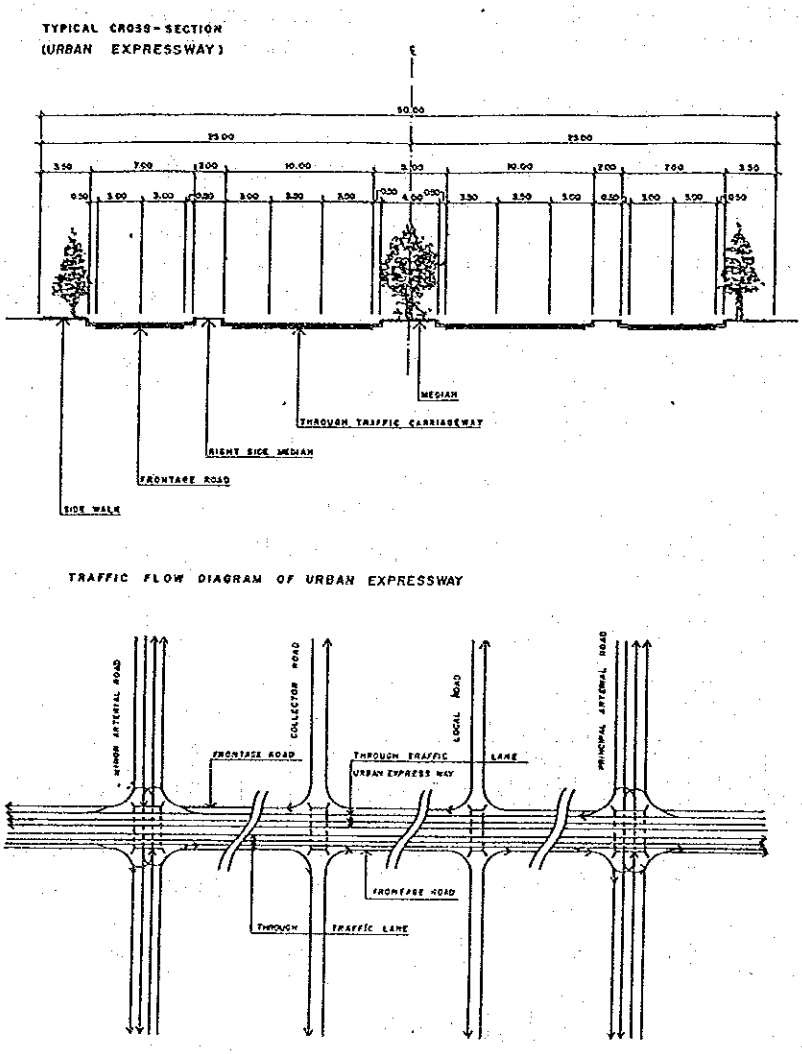


Figure 10.1.6 Cross-Section of Urban Expressway

2) Principal Arterial Road

The typical cross-section of principal arterial roads is adopted as follows.

a) 7.0 meters frontage roads are prepared on both sides.
b) 3.5 meters lane width is adopted for through lane.
c) 3.0 meters lane width is adopted for frontage roads.
d) 5.0 meters central median and 1.0 meter right side medians are included.
e) 3.5 meters sidewalks are included on both sides.

The above-mentioned matters and traffic flow conditions are illustrated in Figure 10.1.7 respectively.

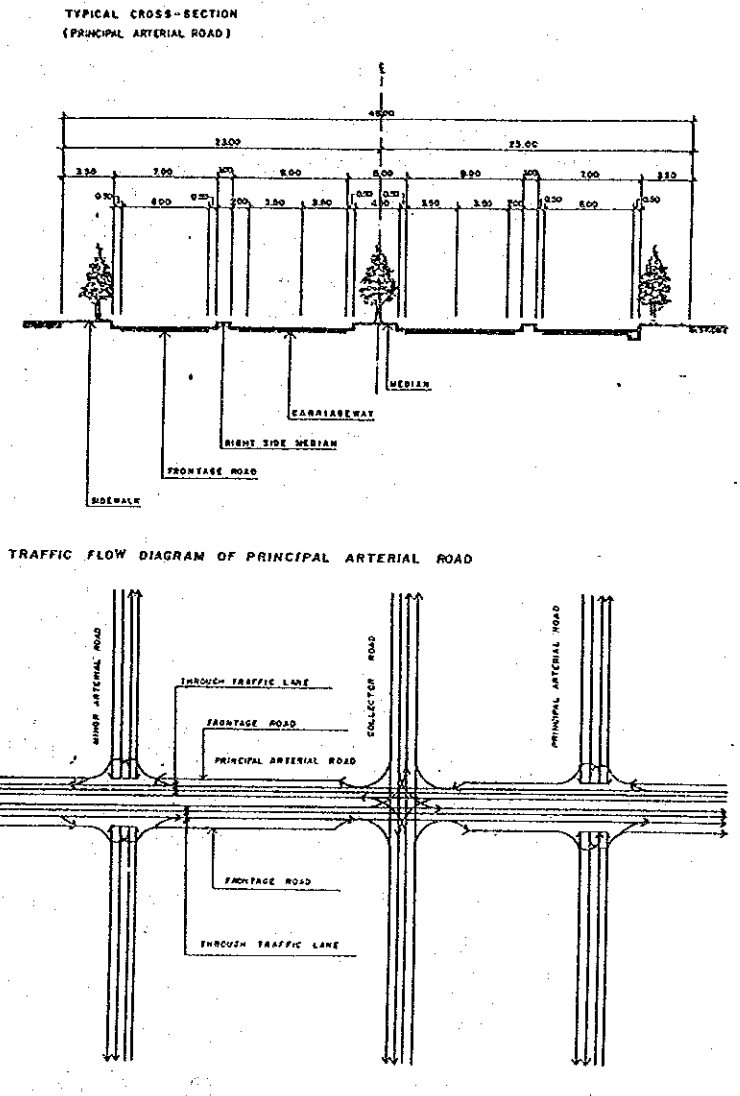


Figure 10.1.7 Cross-Section of Principal Arterial Road

3) Minor Arterial Road

The typical cross-section of minor arterial roads is adopted as follows.

a) 3.5 meters lane width is included.
b) 5.0 meters central median is included.
c) 2.0 meters shoulders are included on both sides.
d) 3.5 meters sidewalks are included on both sides.

The above-mentioned matters and traffic flow conditions are illustrated in Figure 10.1.8 respectively.

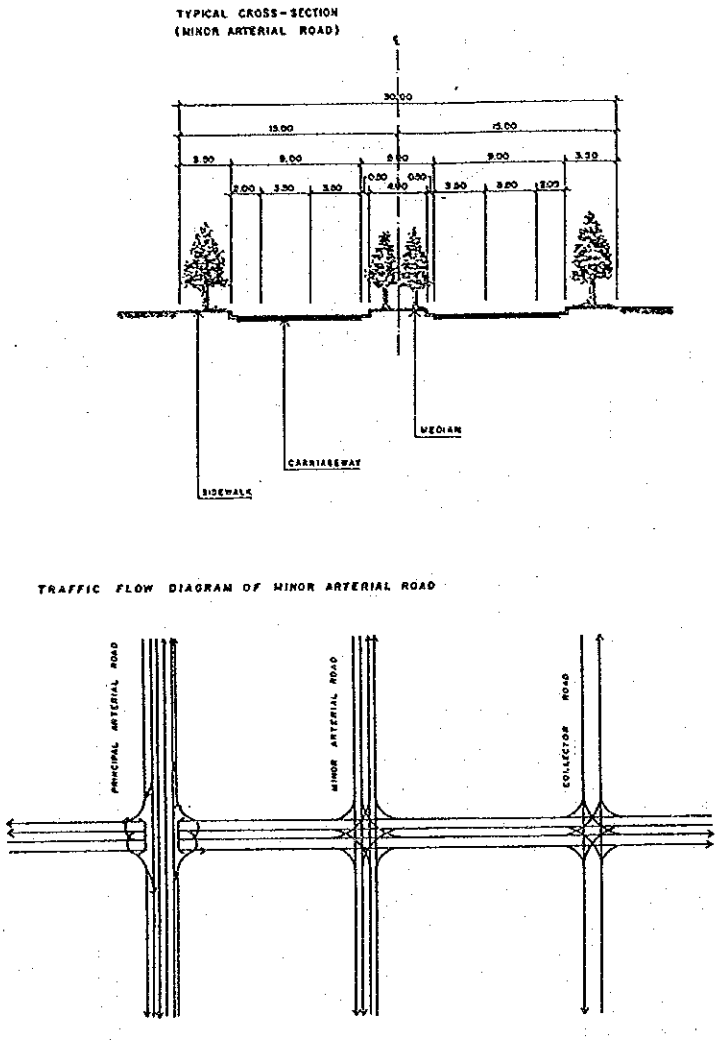


Figure 10.1.8 Cross-Section of Minor Arterial Road

10.1.4 Road Planning

(1) General

The road planning is conducted based on the transport network alternative Master Plan selected in chapter 9.

Route location is carried out considering road planning concepts, planning guidelines, and functions and characteristics of the roads.

The horizontal and vertical alignment design are also conducted to use the topographical map of scale 1:15,000, taking into account the geometric design standards of AASHTO.

(2) Future Road Network Configuration

In chapter 9, a total of 6 transportation network alternatives were prepared and evaluated to find out the optimum transport network in the Study Area. As a result of chapter 9, the Alternative Plan-E was selected.

The road network configuration of Alternative Plan-E is formed as the improvement of ring and radial road network in the Study Area.

The future road network configuration in 2010 is formed to be ring and radial road network pattern.

The function of each planned road is as described below.

1) Inner Ring Road Network

This road network is classified as minor arterial road network and consists of Calle Martí, Avenida Elena, 24 Calle zona 1 and 26, 27 calles zona 5. This road network covers Centro of Guatemala City.

2) Middle Ring Road Network

This road network is classified as an Urban Expressway Network considering future traffic characteristics and functions of roads.

The Middle Ring Road Network consists of the existing Periférico and new Periférico road. This road network covers the existing Urban Area of Guatemala City.

3) Outer Ring Road Network

This road network is classified as a minor arterial road network considering future land use and future traffic volume.

It connects surrounding areas of Guatemala City, such as Mixco, Villa Nueva, Petapa, Villa Canales, Santa Catarina Pinula and Chinautla.

4) Radial Road Network in Western Part

There are two existing radial roads in this area, namely, CA-1 and

Av. San Juan Sacatepéquez.
Taking into account future traffic demand, an additional radial road, the namely East-West Corridor is planned.

The CA-1 is classified as principal arterial road network, and Av. San Juan Sacatepéquez and the East-West Corridor are classified as minor arterial road networks.

5) Radial Road Network in Southern Part

There are three existing radial roads in this area, namely CA-9, Avenida Petapa and Avenida Hincapié.

In the future, a large traffic volume will be expected, however, the construction of new roads is very difficult due to the fact that there is no space for additional new road construction. Therefore, these roads should be improved to maintain future traffic demand.

6) Radial Road Network in Eastern Part

There is only one existing radial road in this area, namely CA-1. Due to projected demand and the difficulty of constructing new roads, additional radial roads are not planned in this area. Therefore ring road network should be reinforced.

7) Radial Road Network in Northern Part

There are two existing radial roads in this area, namely CA-1 and Av. 15 zona 6.

Taking into account the future traffic demand and the difficulty of constructing new roads, additional radial roads are not planned in this area. However, considering the effectiveness of the road network pattern, three roads, namely 13 Av. zona 7, 6a. Av. zona 2, and 15 Av. zona 6 should be connected to the Outer Ring Road (North).

The above-mentioned future road network configuration is illustrated in Figure 10.1.9.

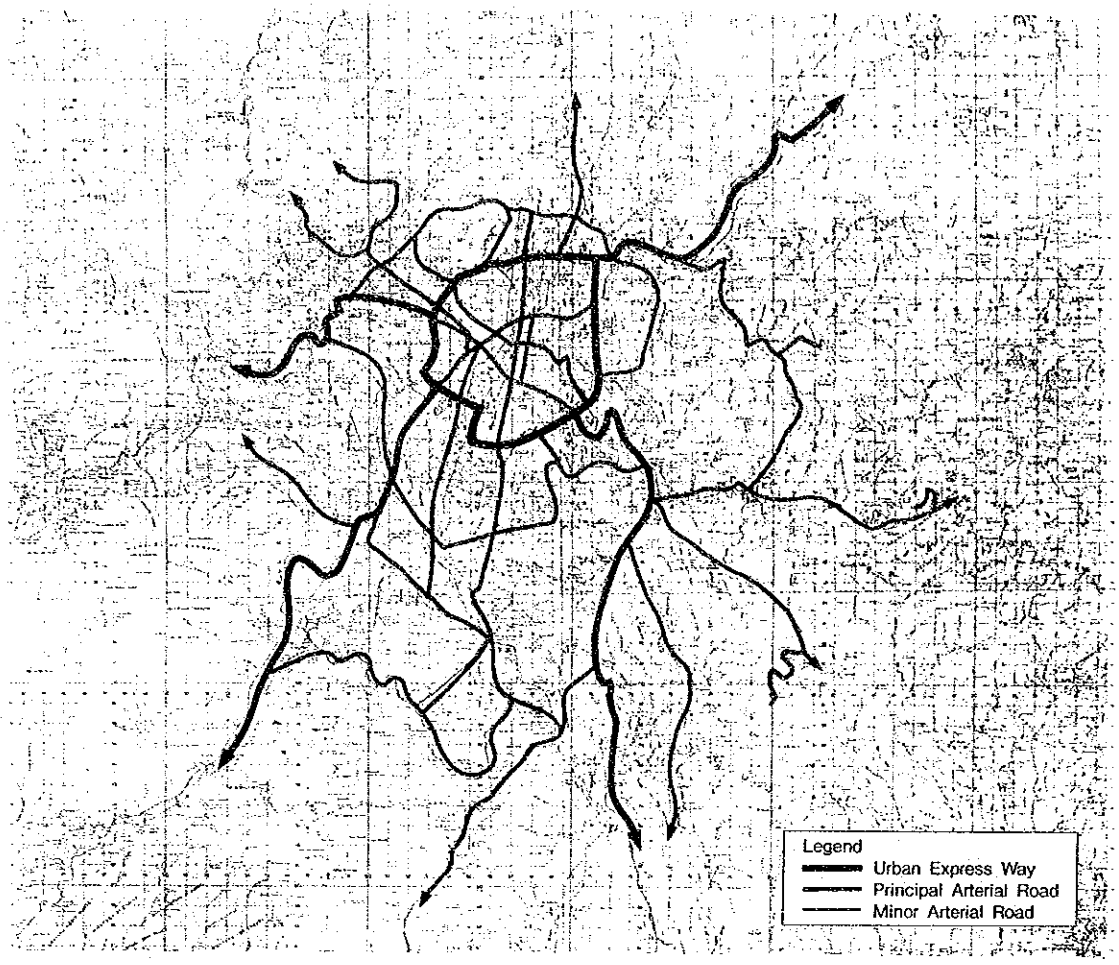


Figure 10.1.9 Future Road Network Configuration (2010)

(3) Future Traffic Volume on Major Roads

Future traffic volume in 2010 was forecasted in previous chapter 9.

The traffic volume was estimated by passenger car unit (pcu) per day for both directions, and the future traffic volume on major roads are illustrated in Figure 10.1.10.

In this figure, the following are apparent:

a) Traffic volume on the Inner Ring Road is indicated as 30,000 pcu/day - 45,000 pcu/day.
b) Traffic volume on the Middle Ring Road is indicated as 50,000 pcu/day - 90,000 pcu/day.
c) Traffic volume on the Outer Ring Road is indicated as 7,000 pcu/day - 35,000 pcu/day depending on the area.
d) Traffic volume on the Radial Road for each direction is indicated as 50,000 pcu/day - 80,000 pcu/day.

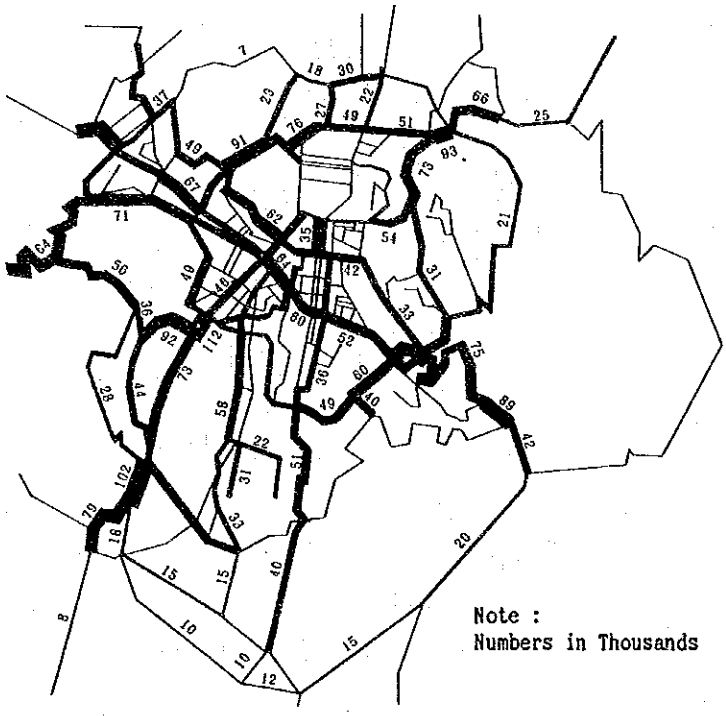


Figure 10.1.10 Future Traffic Volume on Major Road (2010)

(4) Description of Planned Roads

Based on the selected transportation network and the future traffic demand, road planning was carried out with consideration of the functions and characteristics of the roads. The road planning consists of two categories, that is, new road construction plans and the existing road improvement plan.

The road rehabilitation plan is a very important project; however, at present, it is implemented by the Guatemala Municipality. Therefore, this plan is not conducted in this Study.

The outlines of the new road construction plan and the road improvement plan are summarized in Table 10.1.1, and the location is illustrated in Figure 10.1.11. The detailed description of each planned roads are illustrated in

Figure 10.1.12 to Figure 10.1.28 respectively.

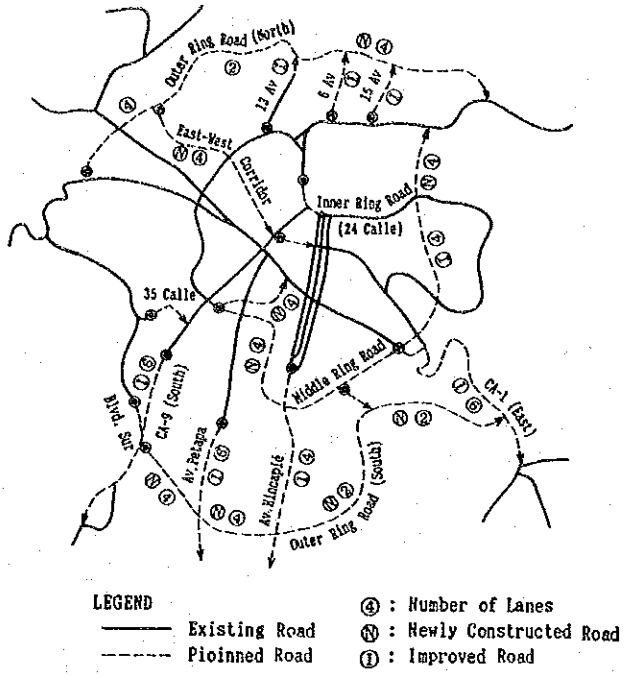


Figure 10.1.11 Location of Planned Roads

Table 10.1.1 Planned Roads and Number of Lanes

Name of Plans	Planned Length (m)	Future (2010) Traffic Volume (pcu/day)	Capacity for one lane (^{pcu}/b)	Number of lanes required
1. New Road Const. Plan	75,290	----	-----	----
1-1 Middle Ring Road Periférico)	20,400	40,000 73,000	19,000	4
1-2 Outer Ring Road (North)	16,700	10,000 35,000	(10,000) 12,500	2 or 4
1-3 Outer Ring Road (South)	23,150	10,000 20,000	(10,000) 12,500	2 or 4
1-4 East-West Corridor	11,540	30,000 45,000	12,500	4
1-5 Periférico Tramo (3a,3b)	3,500	49,000	12,500	4
2. Road Improvement Plan	43,040	----	----	----
2-1 Inner Ring Road (24 Calle)	1,580	27,000	12,000	2 to 4
2-2 Avenida Petapa	6,000	58,000	12,500	2 to 4
2-3 Avenida Hincapié	10,000	52,000	12,500	2 to 4
2-4 13 Avenida zona 7	2,050	34,000	12,000	2 to 4
2-5 6 Avenida zona 2	1,120	26,000	12,000	2 to 4
2-6 15 Avenida zona 15	2,300	27,000	12,000	2 to 4
2-7 35 Calle zona 11	1,090	91,000	12,000	2 to 6
2-8 Blvd. Sur Zona 11	1,400	44,000	12,000	2 to 4
2-9 CA-9 (South)	7,000	72,000	12,500	4 to 6
2-10 CA-1 (East)	10,500	75,000	12,500	4 to 6
Total	118,330			

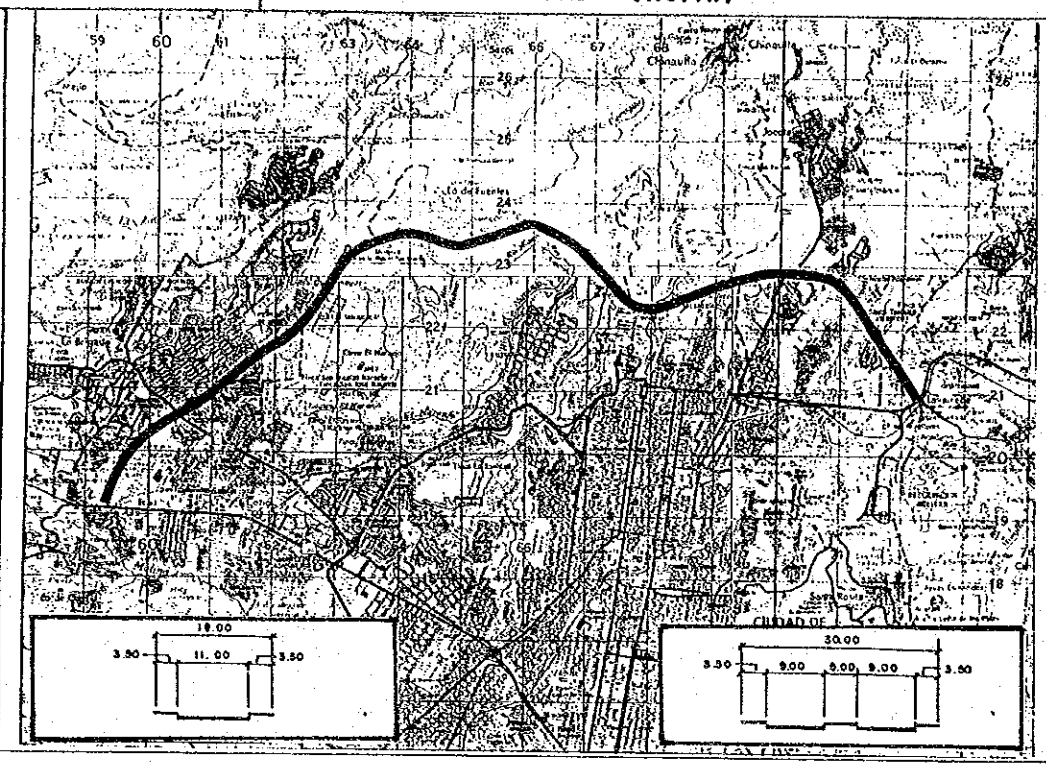
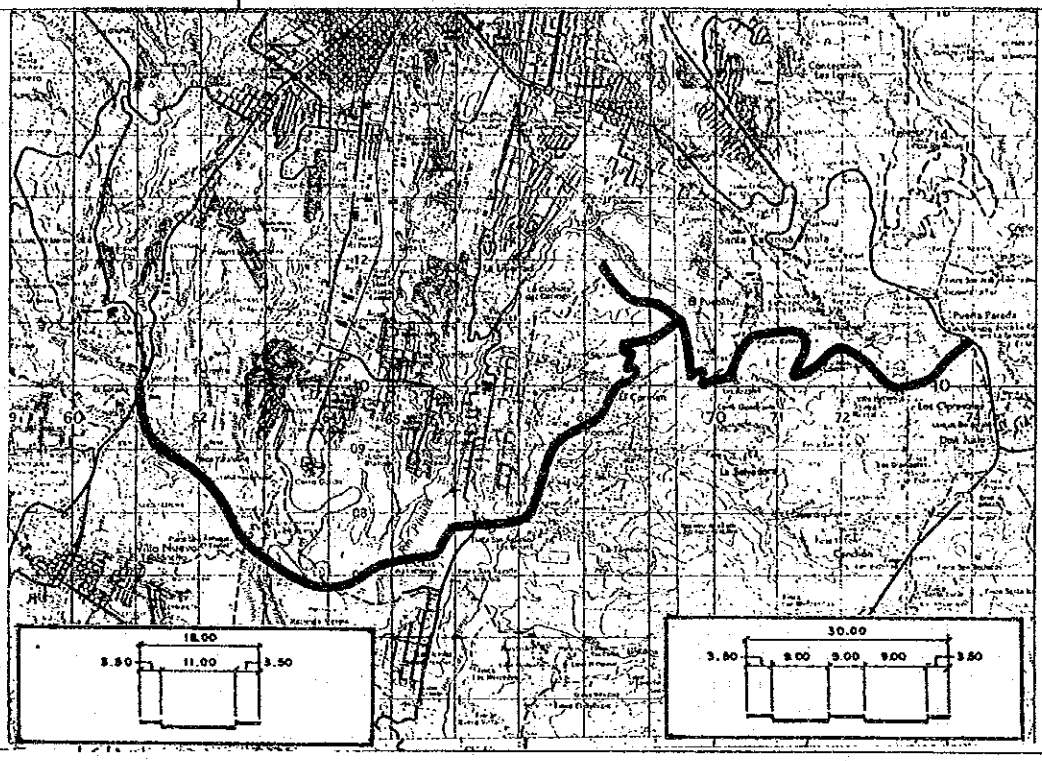
Project Name	OUTER RING ROAD (North)
Project Location Map	
Project Outline	1) Road Classification: Minor Arterial Road 2) Construction Type : New Road Construction 3) Road Length : 16,700 m. 4) Number of Lanes : 4-Lane and 2-Lane Road 5) Number of Bridges and Length: 1) 590 m. 2) 300 m. 3) 450 m. 4) 180 m. 5) 270 m. 6) Project Cost : Q287,525,000
Necessity of Project	1) This road is part of the Outer Ring Road Network configuration. 2) This road contributes to traffic distribution. 3) This road is connected to many un-linked roads. 4) This road contributes to solution of traffic congestion on CA-9 and San Juan Roads.

Figure 10.1.12 Outer Ring Road Development Project

Project Name	OUTER RING ROAD (South)

Project Location Map



Project Outline

1) Road Classification	:	Minor Arterial Road
2) Construction Type	:	New Road Construction
3) Road Length	:	23,150 m.
4) Number of Lanes	:	4-Lane and 2-Lane Road
5) Number of Bridges	:	1)80m 2)265m.
6) Project Cost	:	Q163,339,000

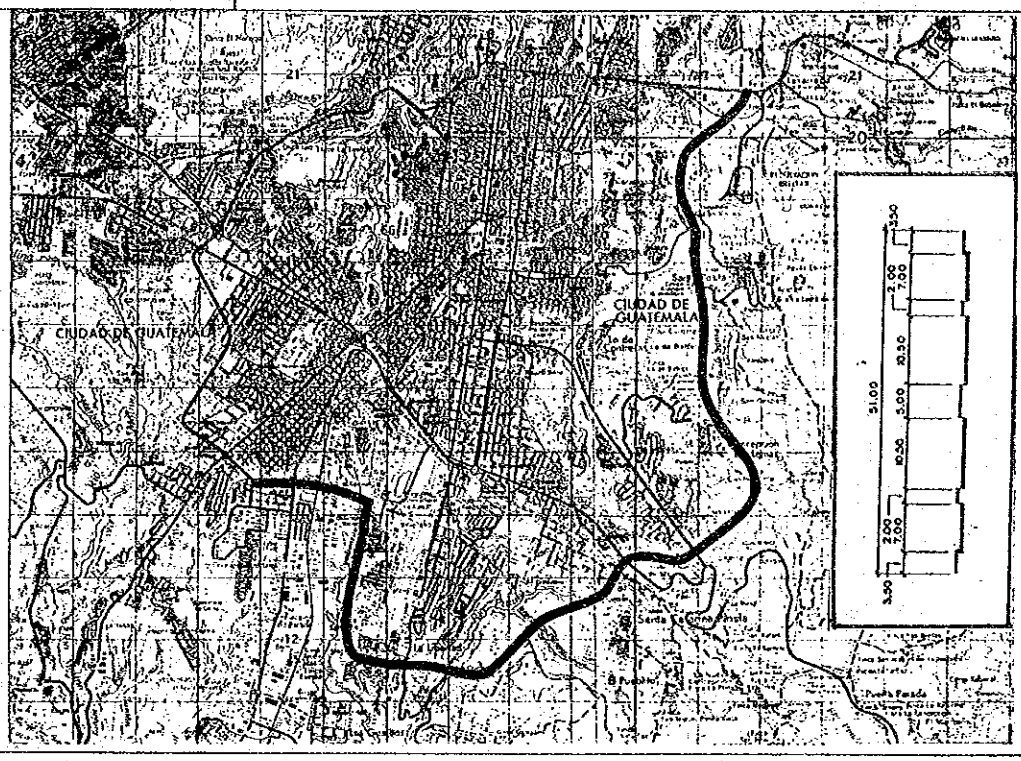
Necessity of Project

1) This road is part of the outer ring road network configuration.
2) This road contributes to traffic distribution.
3) This road contributes to urban development in Villa Nueva and Petapa.

Figure 10.1.13 Outer Ring Road Development Project

Project Name	MIDDLE RING ROAD

Project Location Map



Project Outline

1) Road Classification	:	Urban Express Way
2) Construction Type	:	New Road Construction
3) Road Length	:	20,400 m.
4) Number of Lanes	:	4 Lane Road
5) Number of Bridges and Length	:	1)350 2)200 3)100 4)400 5)300 6)200 7)100
6) Project Cost	:	Q469,999,000

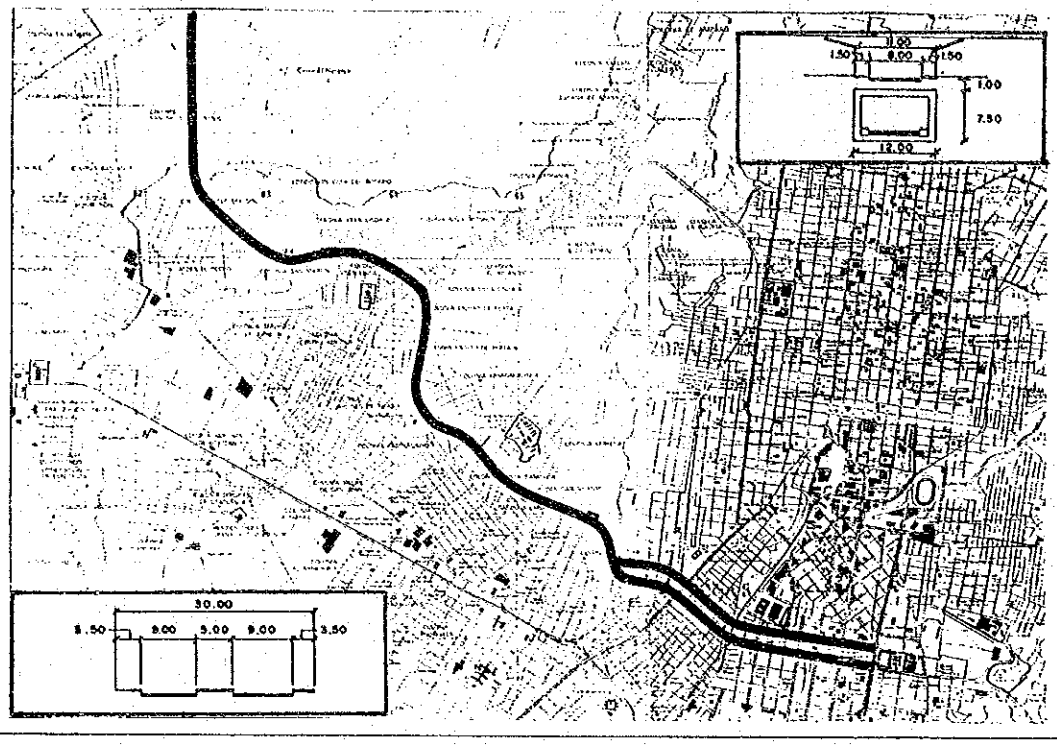
Necessity of Project

1) This road is formed on the middle ring road network configuration.
2) This road contributes to traffic distribution.
3) This road contributes to urban development.
4) This road contributes to the solution of traffic congestion on Calle Martí.

Figure 10.1.14 Middle Ring Road Development Project

Project Name	EAST-WEST CORRIDOR

Project Location Map



Project Outline

1) Road Classification	:	Minor Arterial Road
2) Construction Type	:	New Road Construction
3) Road Length	:	11,540 m.
4) Number of Lanes	:	4-Lane Road
5) Number of Bridges	:	1)140m. 2)80m.
6) Length of Concrete Box	:	1,125 m.
7) Project Cost	:	Q 170,011,000

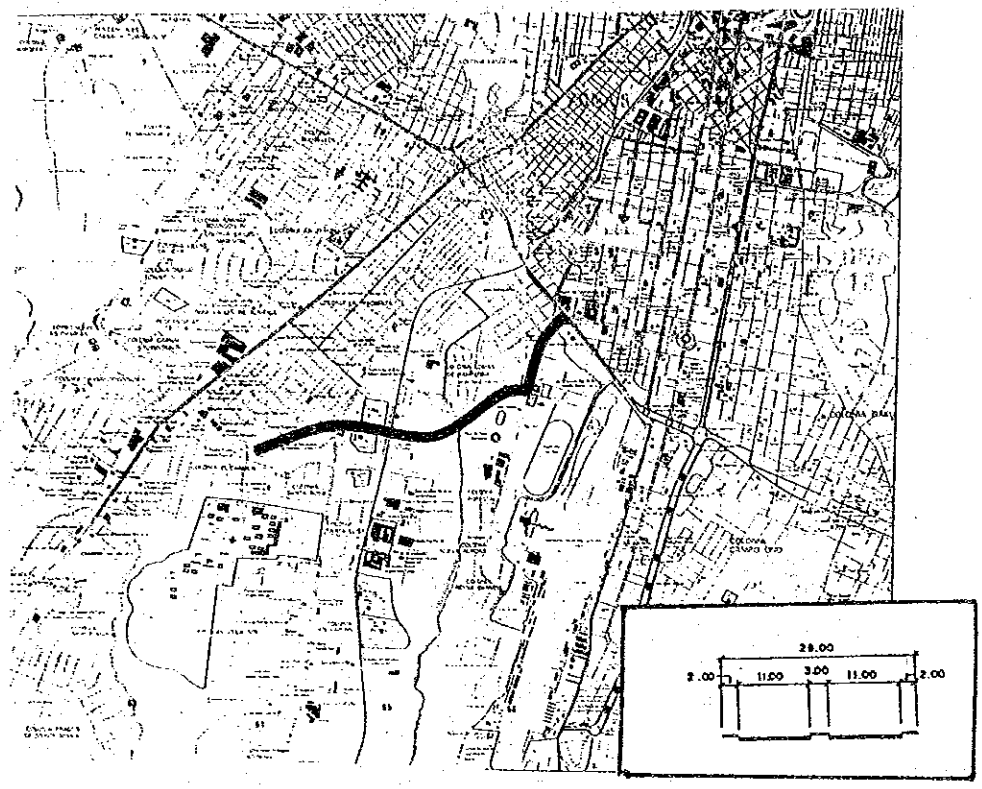
Necessity of Project

1) This project contributes to solve traffic congestion on CA-1 and San Juan Road.

Figure 10.1.15 East-West Corridor Development Project

Project Name	PERIFERICO TRAMO

Project Location Map



Project Outline

1) Road Classification	:	Minor Arterial Road
2) Construction Type	:	Newly Constructed Road and Improvement
3) Road Length	:	3,500 m.
4) Number of Lanes	:	4-Lane Road
5) Number of Bridge and length	:	1) 120 m.
6) Project Cost	:	Q 25,519,000

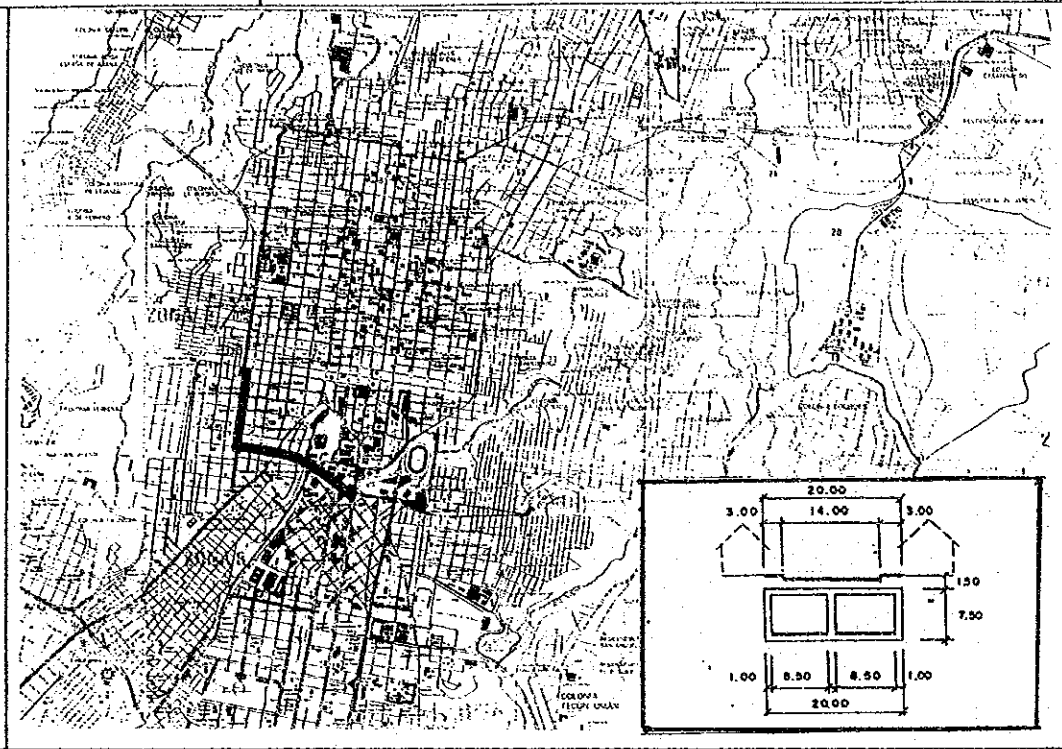
Necessity of Project

1) This road contributes to solve traffic congestion on Calzada Aguilar Batres.
2) This road contributes to solve traffic congestion on Avenida Bolivar.
3) This road contributes to solve traffic congestion on Blvd. Liberación.

Figure 10.1.16 Periferico Tramo Development Project

Project Name	INNER RING ROAD

Project Location Map



Project Outline

1) Road Classification	:	Minor Arterial Road
2) Construction Type	:	Widening of existing roads (24 st. and Av.Elena)
3) Road Length	:	1,580 m.
4) Number of Lanes	:	4-Lane Road
5) Length of Concrete Box	:	580 m.
6) Project Cost	:	Q 81,029,000

Necessity of Project

1) Present Traffic Volume exceeds the capacity of existing roads.
2) This road is formed as an Inner Ring Road Network configuration.
3) This road contributes to traffic distribution.

Figure 10.1.17 Inner Ring Road Development Project

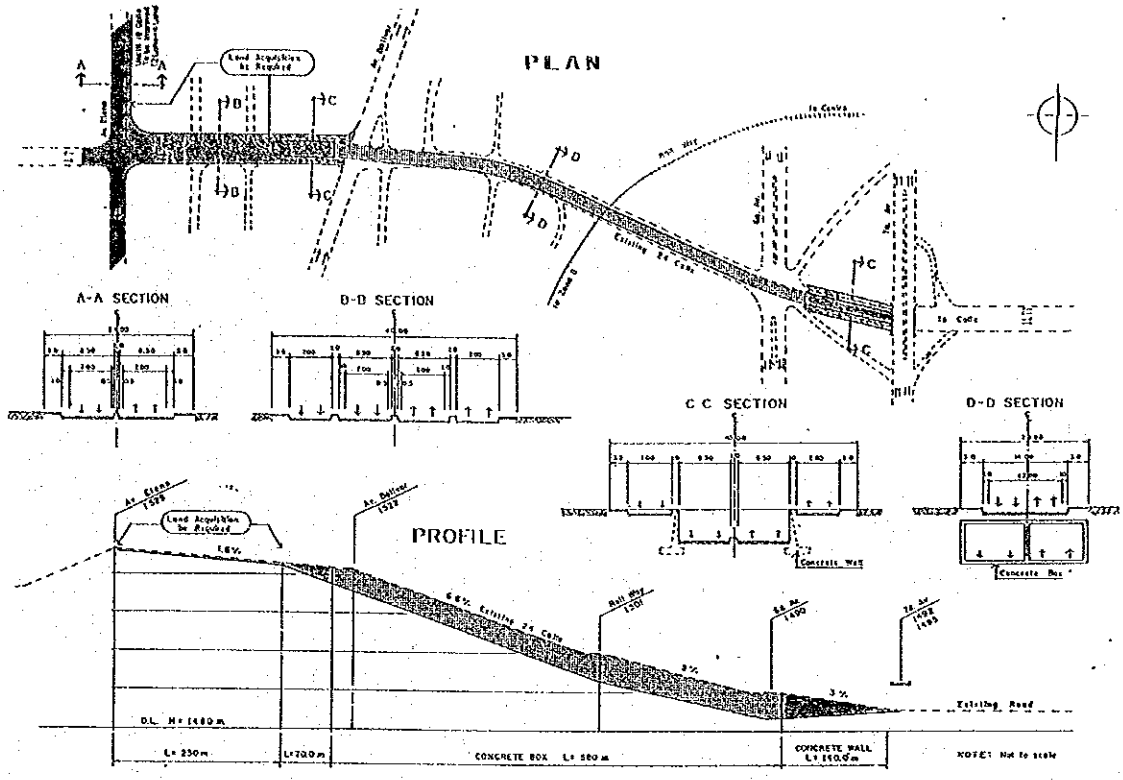


Figure 10.1.18 General Plan of Inner Ring Road

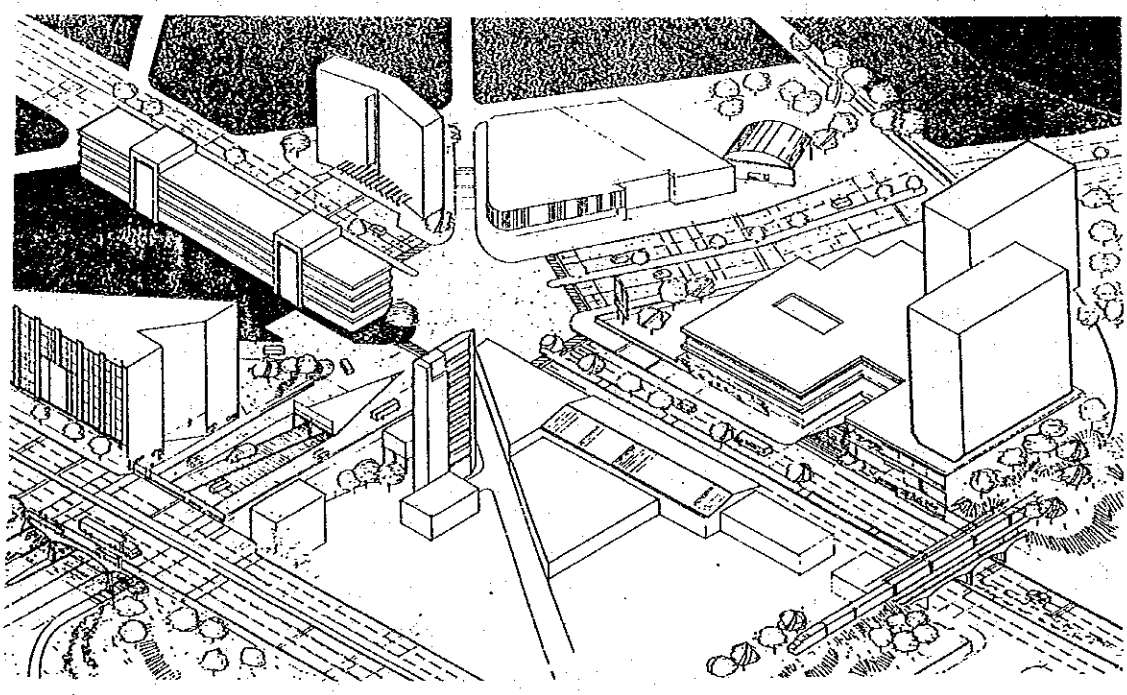
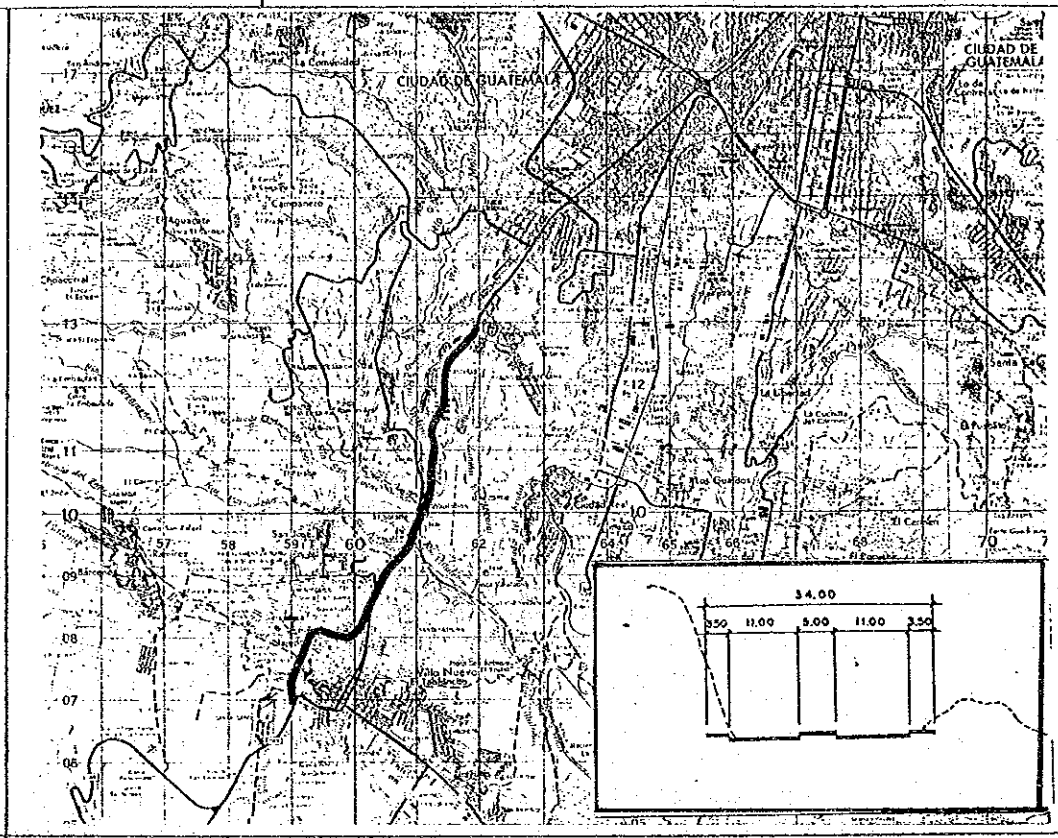


Figure 10.1.19 General View of Inner Ring Road

Project Name	IMPROVEMENT OF CA-9 (South)

Project Location Map



Project Outline

1) Road Classification	:	Principal Arterial Road
2) Construction Type	:	Widening of existing 4-lane Road
3) Road Length	:	7,000 m.
4) Number of Lanes	:	6-lane Road
5) Number of Bridges	:	1)200m. 2)200m.
6) Project Cost	:	Q 61,048,000

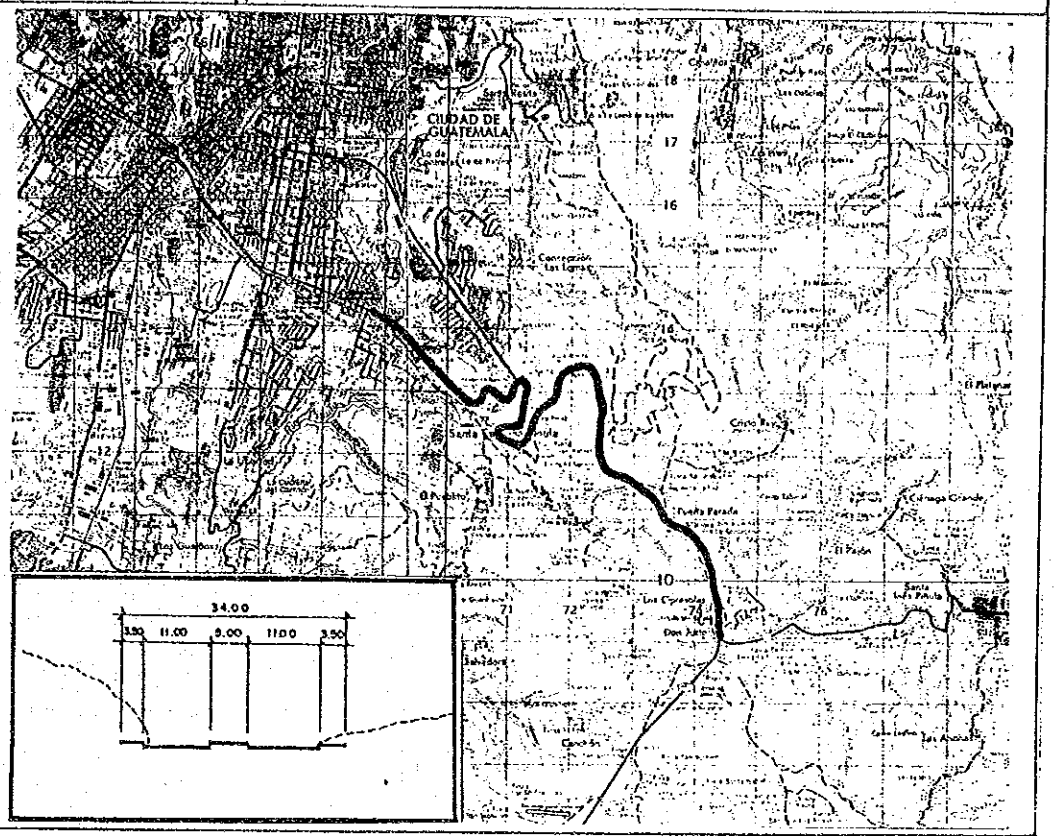
Necessity of Project

1) Future traffic volume exceeds the capacity of existing 4-lane road.

Figure 10.1.20 CA-9 (South) Widening Project

Project Name	IMPROVEMENT CA-1 (East)

Project Location Map



Project Outline

1) Road Classification	:	Principal Arterial Road
2) Construction Type	:	Widening of existing 4-Lane Road
3) Road Length	:	10,500 m.
4) Number of Lanes	:	6-Lane Road
5) Project Cost	:	Q 84,743,000

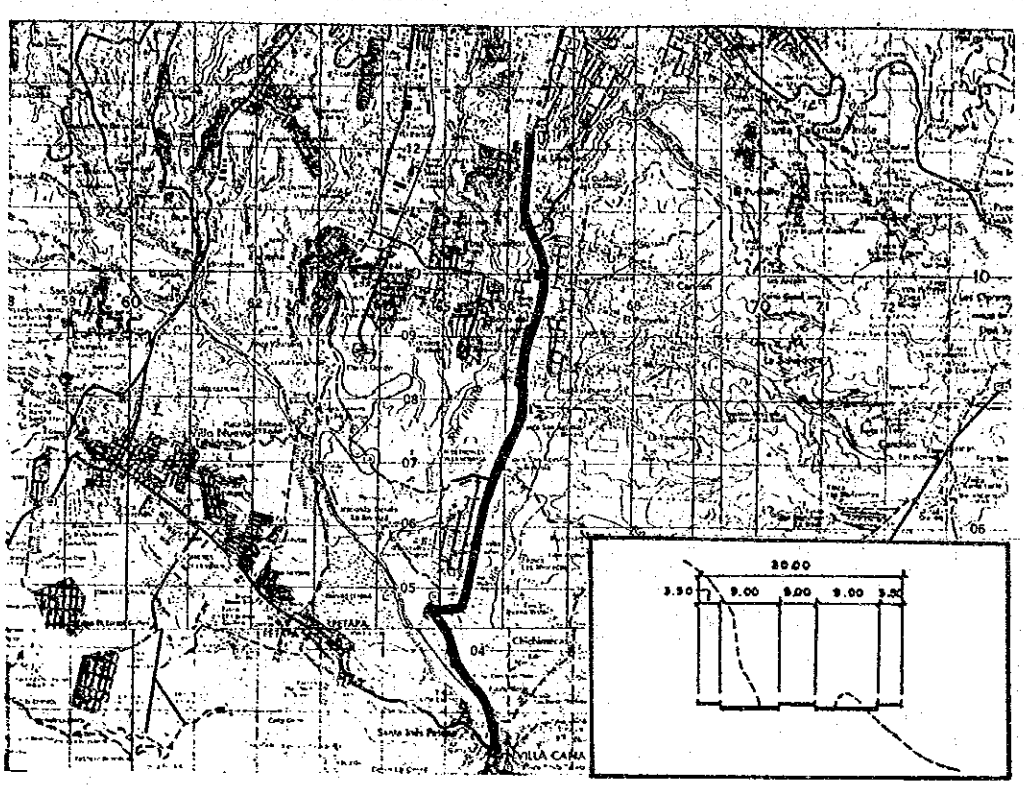
Necessity of Project

1) Future traffic volume exceeds the capacity of existing 4-lane road.

Figure 10.1.21 CA-1 (East) Widening Project

Project Name	IMPROVEMENT OF AVENIDA HINCAPIE

Project Location Map



Project Outline

1) Road Classification	:	Minor Arterial Road
2) Construction Type	:	Widening of existing 2-lane road
3) Road Length	:	10,000 m.
4) Number of Lanes	:	4-lane Road
5) Number of Bridges	:	1)600 m. 2)100 m.
6) Project Cost	:	Q124,670,000

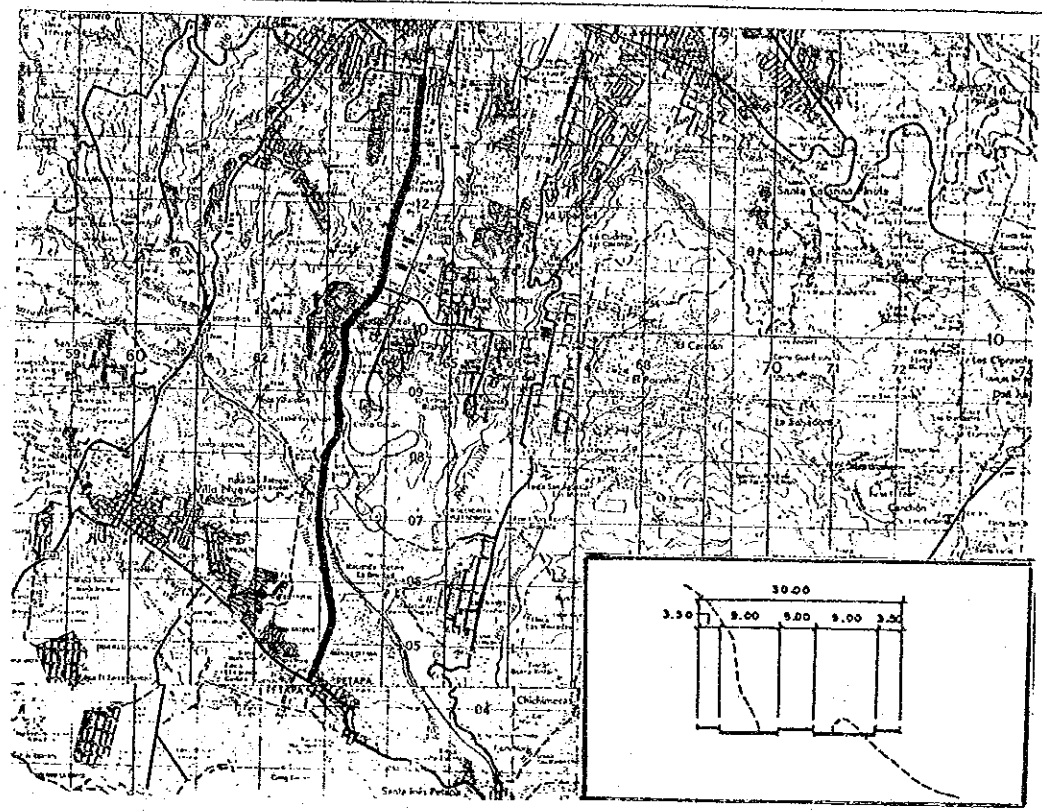
Necessity of Project

1) Future traffic volume exceeds the capacity of existing 2-lane road.

Figure 10.1.22 Avenida Hincapie Widening Project

Project Name	IMPROVEMENT AVENIDA PETAPA

Project Location Map



Project Outline

1) Road Classification	:	Minor Arterial Road
2) Construction Type	:	Widening of existing 2 or 4-lane road
3) Road Length	:	6,000 m.
4) Number of Lanes	:	4-Lane Road
5) Number of Bridges	:	1)200 m.
6) Project Cost	:	Q59,361,000

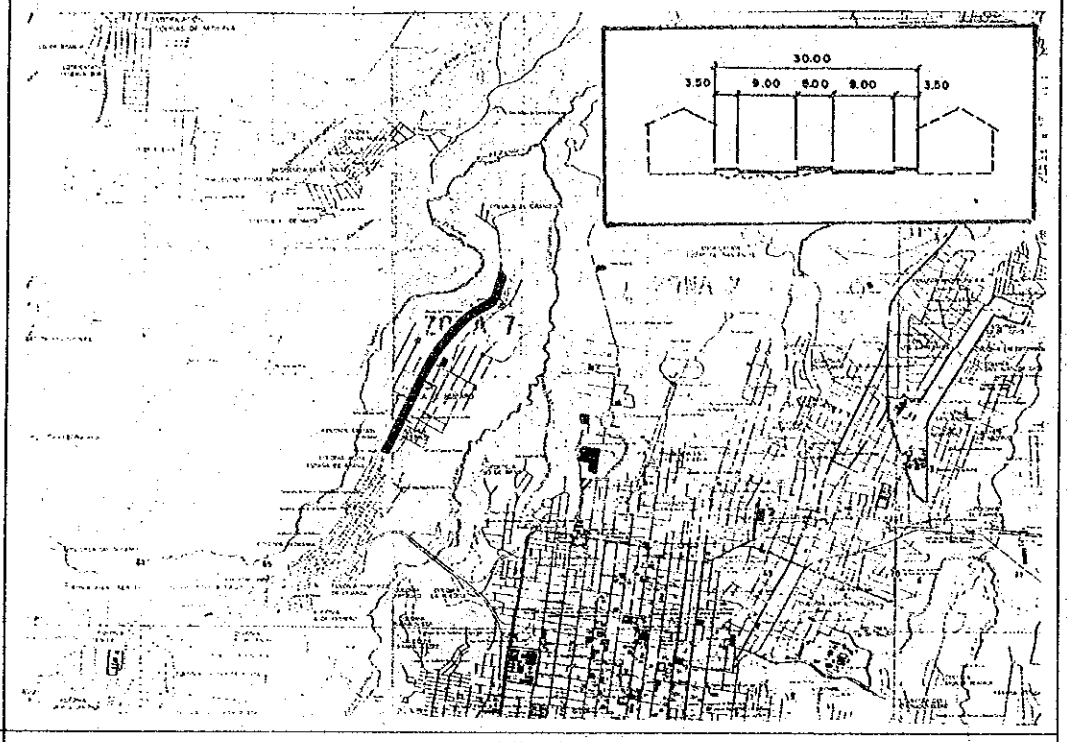
Necessity of Project

1) Future traffic volume exceeds the capacity of existing 2 or 4-lane road.

Figure 10.1.23 Avenida Petapa Widening Project

Project Name	13th. AVENUE ZONE 7

Project Location Map



Project Outline

1) Road Classification	:	Minor Arterial Road
2) Construction Type	:	Widening of existing 2-Lane Road
3) Road Length	:	2,050 m.
4) Number of Lanes	:	4-Lane Road
5) Project Cost	:	Q 2,642,000

Necessity of Project

1) Future traffic volume exceeds the capacity of existing 2-lane road
2) This road solves the problem of the un-linked road network.

Figure 10.1.24 13 AV. Widening Project

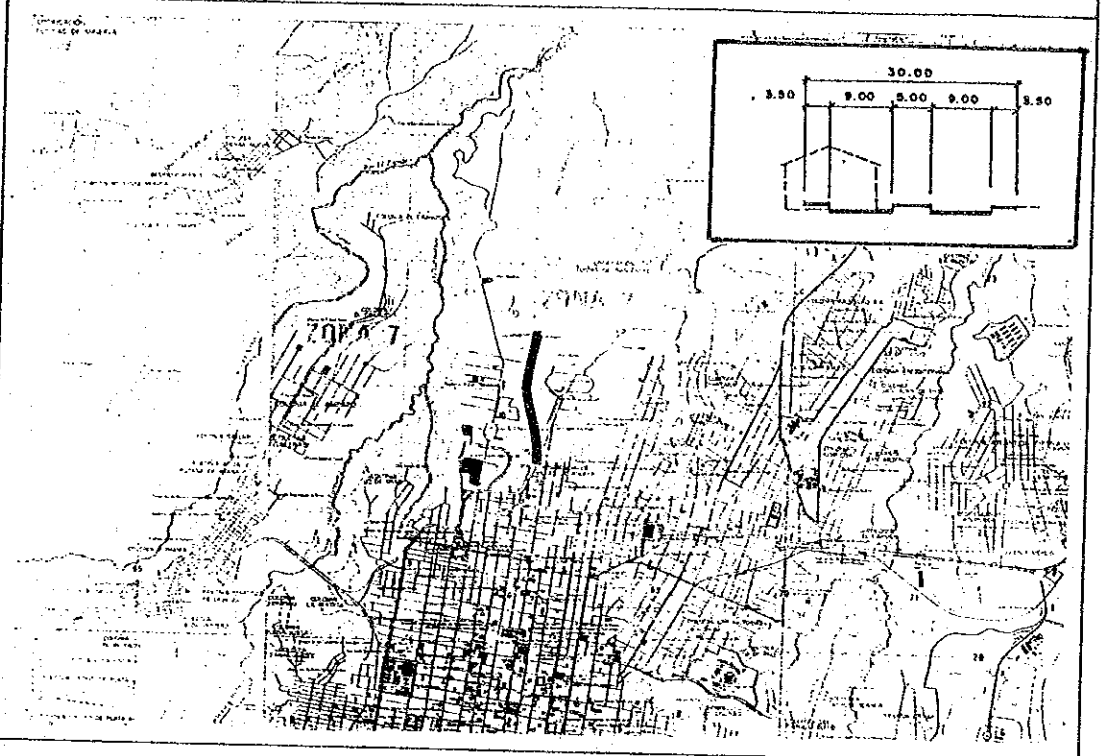
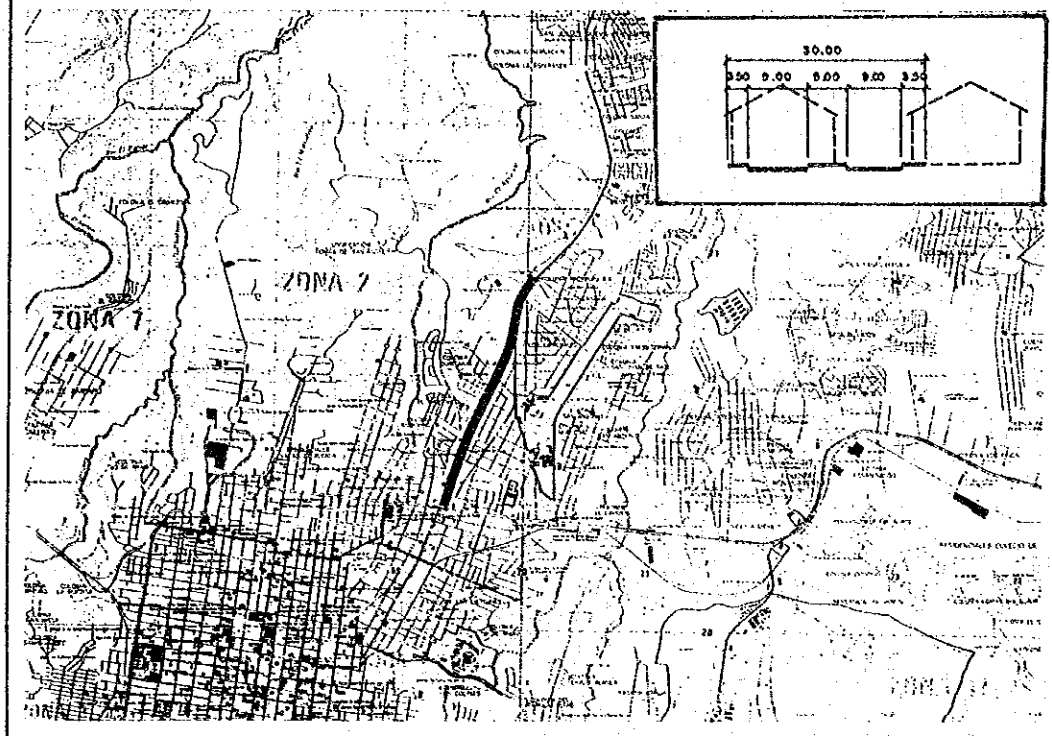
Project Name	6th. AVENUE ZONE 2
Project Location Map	
Project Outline	1) Road Classification : Minor Arterial Road 2) Construction Type : Widening and New Road Construction 3) Road Length : 1,120 m. 4) Number of Lanes : 4-Lane Road 5) Project Cost : Q17,001,000
Necessity of Project	1) This road solves the problem of the un-linked road network. 2) Future traffic volume exceeds the capacity of existing 2-lane road.

Figure 10.1.25 6 Av. Widening Project

Project Name	15 th. AVENUE ZONE 6

Project Location Map



Project Outline

1) Road Classification	:	Minor Arterial Road
2) Construction Type	:	Widening of existing 2-Lane Road
3) Road Length	:	2,300 m.
4) Number of Lanes	:	4-Lane Road
5) Project Cost	:	Q16,614,000

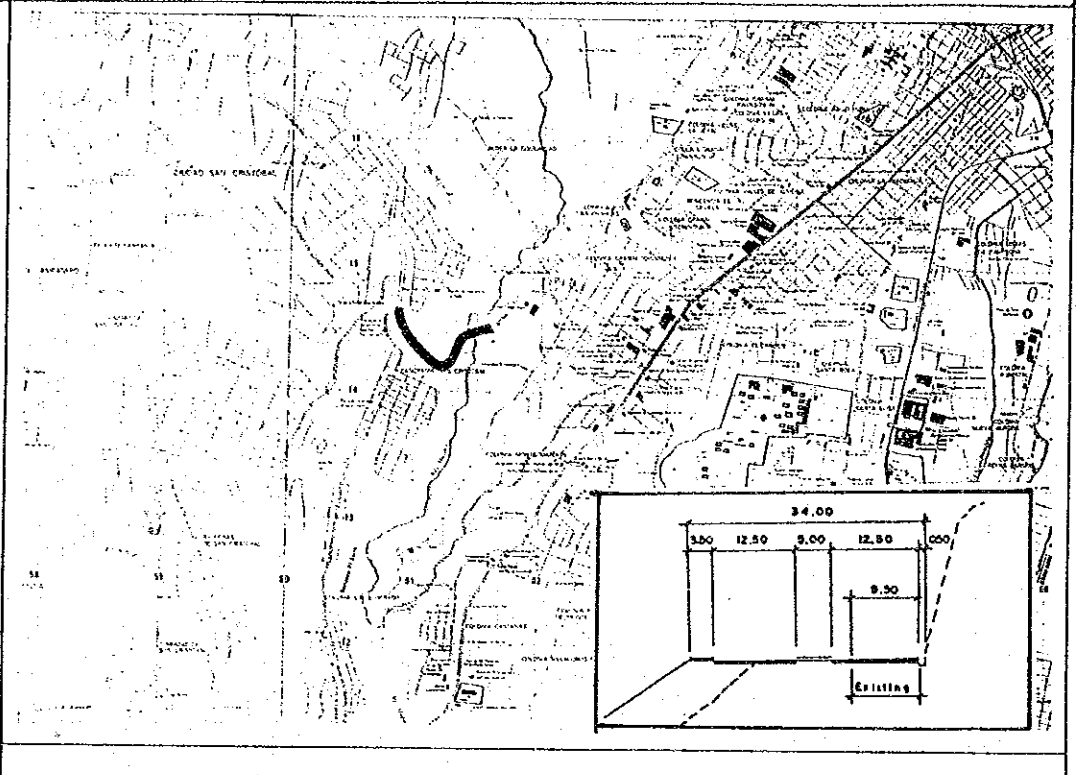
Necessity of Project

1) Future traffic volume exceeds the capacity of existing 2-lane road.

Figure 10.1.26 15 Avenida Widening Project

Project Name	35 th. STREET- CIUDAD SAN CRISTOBAL

Project Location Map



Project Outline

1) Road Classification	:	Minor Arterial Road
2) Construction Type	:	Widening of existing 2-lane road
3) Road Length	:	1,090 m.
4) Number of Lanes	:	6-Lane Road
5) Number of Bridge	:	1) 200 m.
6) Project Cost	:	Q35,784,000

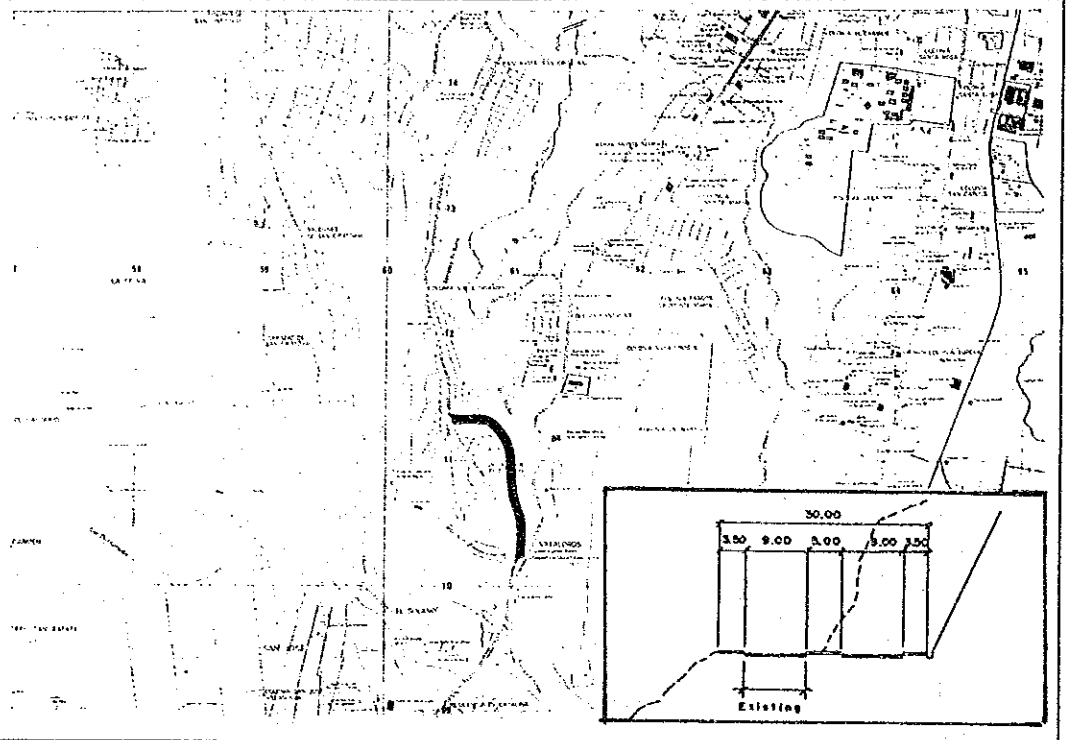
Necessity of Project

1) Future traffic volume exceeds the capacity of existing 2-lane road.

Figure 10.1.27 13 Avenida Widening Project

Project Name	BOULEVARD SUR

Project Location Map



Project Outline

1) Road Classification	:	Minor Arterial Road
2) Construction Type	:	Widening of existing 2-Lane Road
3) Road Length	:	1,400 m.
4) Number of Lanes	:	4-Lane Road.
5) Project Cost	:	Q 11,729,000

Necessity of Project

1) Future traffic volume exceeds the capacity of existing 2-lane road.

Figure 10.1.28 Boulevard Sur Widening Project

(5) Collector and Local Roads Planning

1) planning Concepts

The arterial road network planning is conducted in previous section as main study objectives in the Study. However, the collector and local road network is also very important items to control the traffic flows and to maintain efficiency road network. The collector and local road have a function to induce the housing development and to maintain the open space for human life. Therefore, these roads will be constructed according to the development of housing. When these roads will be constructed, following factors should be considered.

a) Establishment of road connection hierarchy system
b) Conformity of future traffic demand
c) Harmony of characteristics of development
d) Identification of road network pattern (See Figure 10.1.29)
e) Access to the development area

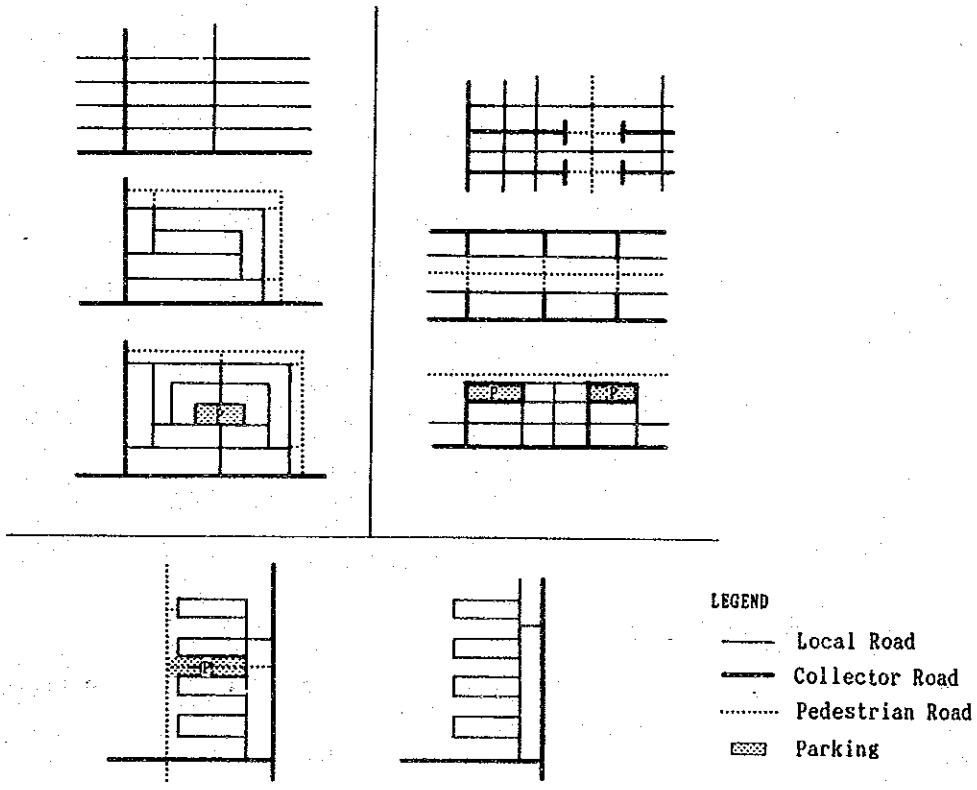


Figure 10.1.29 Concept Plan of Collector and Local Road Network

2) Necessary Road Length in 2010

The future population, space of urban area and future traffic volume on each zona in 2010 were forecasted in previous chapter. Based on these dada, the rawly construction collector and local roads are estimated. The estimated method and premises are as follows:

a) Calculation of future habitable area (HS).
b) Calculation of the existing road area (RS).
c) Calculation of the generated and attracted traffic volume (Q).
d) The average traffic capacity of these roads are adopted as 4,000 PCU/day.
e) The average cross-section width is adopted as 8.0 meters.
f) Calculation of necessary road area in 2010 (FRS) to sum following formulations.

$$FRS = \frac{Q \times \sqrt{HS} \times 8.0}{4000}$$

g) Calculation of required road length in 2010 (R.RL)

$$FRL = FRS - RS/8.0$$

The results of calculation is summarized in Table 10.1.2.

Table 10.1.2 Required Collector and Local Road Length

Zona Nunicipality	Habitable Land (Ha) (A)	Road Area (Ha) (B)	Road Ratio (C) (%) (B/A)	Gone.& Area (1000 Person)	Gene .& Attea (pcu/o)	Nesesary Road Area (Ha)	Roquired Road Area Km
1	610.0	110.2	18.1	1,025	340,000	167.9	72.1
2	311.4	24.7	7.9	257	85,000	29.6	6.1
3	238.0	73.7	31.0	187	56,000	17.3	—
4	95.0	23.3	24.5	232	77,000	15.5	—
5	435.0	87.5	20.1	325	108,000	45.0	—
6	519.7	105.4	20.3	300	100,000	45.7	—
7	927.5	120.1	12.9	723	240,000	146.2	32.6
8	118.0	33.3	28.2	93	31,000	6.9	—
9	238.0	67.1	28.2	221	73,000	23.4	—
10	470.0	89.5	19.0	289	87,000	52.3	—
11	882.0	173.4	19.7	568	189,000	114.0	—
12	948.1	100.1	10.6	566	188,000	115.8	19.6
13	508.2	51.6	10.2	208	69,000	32.5	—
14	489.0	62.4	12.8	119	40,000	17.7	—
15	511.0	109.0	21.3	141	47,000	21.7	—
16	510.3	26.2	5.1	98	33,000	16.3	—
17	949.0	43.8	4.6	319	106,000	66.5	28.4
18	1,616.5	109.5	6.8	632	210,000	170.5	76.2
19	101.0	27.4	27.1	131	43,000	8.8	—
22	365.0	32.8	9.0	294	98,000	38.2	6.8
24	417.0	27.0	6.5	108	36,000	14.7	—
25	350.0	19.2	5.5	14	5,000	3.0	—
Mixco	5,448.8	390.9	7.2	1,803	598,000	885.8	618.6
Villa Nueva	4,747.5	234.1	4.9	1,342	445,000	606.3	757.9
Petapa	1,427.5	53.8	3.8	476	158,000	120.9	83.9
Amatitilan	2,417.5	101.1	4.2	352	117,000	114.1	16.3
Villa Canales	3,360.0	145.7	4.3	724	240,000	278.2	165.6
Sta.C.Pinula	1,470.0	81.2	5.5	370	123,000	184.0	128.5
San.J.Pinula	1,190.0	113.2	9.5	141	47,000	33.1	—
Fraijanes	1,485.0	82.8	5.6	44	14,000	80.9	—
Chinauttla	257.5	35.9	13.9	129	43,000	14.1	—
Total	33,413.5	2,755.9	8.2	—	—	3,486.9	2,012.6

10.1.5 Project Cost Estimate

(1) General

The project costs of each plan are estimated based on preliminary road designs. The project cost consists of construction cost and other costs. The construction cost consists of the following items.

a) Labor cost
b) Equipment cost
c) Material cost
d) Profit of contractor
e) Taxes
f) Land acquisition cost and compensation

The project cost includes construction costs and the following items.

g) Engineering cost for further study including field survey (10% of construction costs)
h) Contingency cost (10% of construction costs)
i) Administration cost (10% of construction costs)

The project cost consists of the above-mentioned a) to i) items. It is estimated based on the following conditions.

a) The cost is indicated in Quetzales of Guatemala currency.
b) The cost is estimated in 1991 June prices.
c) The exchange rate is assumed to be 1.0 US$ = 4.90 Quetzales.

(2) Material and Labor Cost

The main construction material and labor cost data are collected from the Guatemala Chamber of Construction, Guatemala Municipality, and the General Direction of Roads.

On the basis of these data, material cost and labor costs is decided as shown in Table 10.1.3.

(3) Unit Cost of Main Working Items

The unit cost analysis of the main working items is examined considering the condition of the construction site and the construction method.

In addition, the unit costs are compared with similar construction projects which were conducted by Guatemala Municipality and CAMINOS. The unit cost of the main working items decided is shown in Table 10.1.4.

(4) Land Acquisition and Compensation

The land value data and compensation data along the planned road are collected from Guatemala Municipality. Based on this data, land acquisition cost and compensation are estimated.

(5) Project Cost

The construction cost of each plan is estimated based on the material cost, labor cost, equipment cost, and unit cost of main working items.

In addition, the construction cost is also compared to the actual similar construction project cost conducted by Guatemala Municipality and the General Direction of Roads.

The project cost is estimated by 1.3 times to the construction costs. The project costs of each plan are shown in Table 10.1.5.

Table 10.1.3 List of Construction Material Marked Price

Item	Sub-Item	Class	Unit	Unit Cost	Tax	Remarks
Soil, Stone	Soil	Common	m3	30.00	---	
	Sand	Common	m3	35.00	7	
		River Sand	m3	40.00	7	
	Gravel	> 10 mm	m3	60.00	7	Difficult
		< 10 mm	m3	60.00	7	to get
	Crushed stone	> 30 mm	m3	60.00	7	
		< 30 mm	m3	60.00	7	
Cement	Cementos Progreso	Portland Modified	42.5 Kg	13.50	7	
Concrete	In situ	T=350 Kg/cm2	m3	345.00	7	For pumping
		T=280 Kg/cm2	m3	288.00	7	service add
		T=210 Kg/cm2	m3	275.00	7	1.2/M3 by
		T=175 Kg/cm2	m3	255.00	7	each store
	Mortar	Cement 1				
		Riversand 3	m3	255.00	7	
	Concrete Block	4 x 19 x 39 cms	m2	20.00	7	
	Concrete Kerb	L-TYPE	m	MADE ON SITE ONLY		Not available on market
	Pipe Culvert (PC)	O	m			
		8" (c)	m	9.60	7	PC pipes
		12" (c)	m	18.05	7	are not
		24" (rc)	m	121.00	7	available
		42" (rc)	m	336.00	7	on market
		60" (rc)	m	655.00	7	
Steel	Steel Bar	D + = 9mm (3/8")	Ton	2580.00	7	*See Note (1)
		D + = 19mm (6/8")	Ton	2580.00	7	*See Note (1)
	Plate		Ton	2580.00	7	*See Note (1)
	Angle	L	Ton	3175.00	7	*See Note (1)
	Pipe	o 200 mm (8")	6m	---	---	Not available
		o 400 mm (16")	6m	---	---	on market
	Guard Rail	ARMCO	m	114.65	7	Difficult to get
	Electric Pole	o 100 (4")	m			Not used in Guatemala for lighting

Table 10.1.3 List of Construction Material Marked Price (Continued)

Unit: Quetzalce

Item	Sub-Item	Class	Unit	Unit Cost	Tax	Remarks
Asphalt	Asphalt	RC-250	liter	2.16	included	Imported
	Asphaltic Concrete	Hot Mixed	m3	400.00	included	Imported
Oil	Oil		liter	10.88	included	Imported
	Gasoline	Regular	liter	2.36	included	Imported
	Gasoline	Premium	liter	2.54	included	Imported
	Diesel		liter	1.57	included	Imported
	Paint		liter	25.00	included	oil paint

7%

*Note (1): -Yield point for steel bars is 40,000 #/in2 (2813 Kg/cm2)
-Steel is imported from Brasil, Mexico and processed on steel bars for construction purposes
-1 Ton = 1,000 Kg = 2,204.6 pounds

Table 10.1.4 List of Main Construction Work Unit Cost

Unit: Quetzales

Items	Unit	Labour	Equipment	Material	Profit and Others	Subtotal	Taxes	Total
Site Clearing and Demolition								
Residential	ha	3,407.90	7,001.69	----	9,540.00	19,949.72	1,050.40	21,000.00
Field	ha	846.62	1,739.12	----	2,370.04	4,956.08	260.95	5,217.00
Excavation								
Common Soil (Borrowed Fill)	m3	2.84	5.83	----	7.95	16.62	0.88	17.50
Common Soil (Waste)	m3	1.95	4.00	----	5.45	11.40	0.60	12.00
Overhauling	m3/Km	0.55	1.15	----	1.60	3.30	0.20	3.50
Embankment								
W/Borrowed Fill	m3	2.60	5.33	----	7.27	15.20	0.80	16.00
W/Selected Material	m3	3.60	7.33	25.00	8.00	43.93	2.07	46.00
Drainage								
U Concrete 0.30 x 0.30m	m	6.93	2.80	20.25	17.60	47.58	2.18	49.76
U Concrete 0.50 x 0.50m	m	17.50	5.45	27.75	23.25	73.95	3.87	77.82
U Concrete 1.00 x 1.00m	m	42.46	16.70	53.76	43.32	156.24	8.43	164.67
U Earth 1.00 x 1.00m	m	23.15	12.56	----	21.30	57.01	2.55	59.56
Pipe culvert o 12"	m	50.27	----	21.36	9.88	81.51	7.03	88.54
Pipe culvert o 42"	m	158.68	28.75	278.77	29.29	495.49	36.97	532.46
Pipe culvert o 60"	m	260.45	28.75	507.83	30.00	827.03	64.20	891.23
Box culvert 2.00 x 2.00m	m	201.55	110.40	639.95	30.05	981.95	66.97	1,048.92
Box culvert 5.00 x 2.00m	m	318.50	230.00	1,001.35	60.00	1,609.85	105.00	1,714.95
Pavement								
Carriageway								
Asphalt t=5	m2	4.25	2.75	40.85	10.75	58.60	5.40	64.00
Base course t=20	m2	1.00	1.90	5.10	1.55	9.55	0.45	10.00
Sub-base course t=20	m2	1.10	2.40	6.65	2.30	12.45	0.55	13.00
Shoulder								
Asphalt t=3	m2	2.55	1.65	29.50	9.25	42.95	5.20	48.15
Base course t=20	m2	1.00	1.90	5.10	1.55	9.55	0.45	10.00
Sub-base course t=20	m2	1.10	2.40	6.65	2.30	12.45	0.55	13.00
Sidewalk								
Concrete t=5	m2	4.25	0.50	13.57	10.00	28.32	1.45	29.77
Base course t=10	m2	0.45	0.85	2.30	0.75	4.35	0.15	4.50
Plantation	m2	2.25	0.75	2.00	3.00	8.00	0.35	8.35
Additional								
Kerb (L type) concrete	m	4.00	0.75	21.80	3.00	29.55	1.95	31.50
Facilities								
Median concrete	m	8.00	1.50	43.60	6.00	59.10	3.90	63.00
Plantation	m2	2.25	0.75	2.00	3.00	8.00	0.35	8.35
Guard Rail concrete	m	21.30	0.40	116.25	16.00	157.55	10.45	168.00
Steel	m	25.00	55.00	125.00	15.00	220.00	24.00	244.00
Lighting	Km							312,500.00
Intersection								
At-grade signalized	vol							35,700.00
At-grade non-signalized	vol							5,680.00
Grade Separated Overpass								18,075,999.00
Grade Separated Underpass								9,738,344.80
Bridge								
Concrete 5m < L < 10m	m2							1,570.00
PC 10m < L < 40m	m2							2,810.00
Steel of PC L > 40m	m2							5,555.00
Building								
Housing RC	m2	560.00	40.00	700.00	160.00	1,460.00	90.00	1,550.00
Office RC (2-4 stores)	m2	560.00	90.00	700.00	160.00	1510	90.00	1,600.00
Office RC (>6 stores)	m2	560.00	90.00	675.00	115.00	1,440.00	90.00	1,530.00
Storm Sewage								
Manholes 4 to 6m	vol	1,016.00	----	1,458.80	2,554.75	5,029.55	170.45	5,200.00
Catch basin inlet 4m	vol	770.00	----	950.00	1,000.00	2,720.00	150.00	2,870.00
Lane Marking								
(4 gal. x Km)	Km							675.00
Traffic Signs	vol							400.00

Table 10.1.5 List of Project Costs

Project Name	Segment	NO of Lane	Length (m)	Project Cost							
				Const	Land	Compe.	Sub Total	Eng.	Admi.	Contc.	Total
Outer Ring (N)	1	4	4,500	31,700	2,268	600	34,568	3,457	3,457	3,457	44,939
	2	2	5,020	21,133	1,512	400	23,045	2,305	2,305	2,305	29,960
	3	4	7,180	148,921	9,637	5,000	163,558	16,356	16,356	16,356	212,626
	Total	–	16,700	201,754	13,417	6,000	221,171	22,118	22,118	22,118	287,525
Outer Ring (S)	1	4	7,340	41,654	13,212	0	54,866	5,487	5,487	5,487	71,327
	2	2	15,810	61,150	7,128	2,500	70,778	7,078	7,078	7,078	92,012
	Total	–	23,150	102,804	20,340	2,500	125,644	12,565	12,565	12,565	163,339
Middle Ring	1	4	10,920	175,080	33,629	14,000	223,709	22,371	22,371	22,371	290,822
	2	4	9,480	100,797	34,031	3,000	137,828	13,783	13,783	13,783	179,177
	Total	–	20,400	276,877	67,660	17,000	361,537	36,154	36,154	36,154	469,999
East-West Cornidor	1	4	4,510	16,741	7,000	1,000	24,741	2,474	2,474	2,474	32,163
	2	4	3,500	16,053	8,100	5,000	29,153	2,915	2,915	2,915	37,898
	3	4	1,025	56,917	1,150	4,500	62,567	6,257	6,257	6,257	81,338
	Total	–	9,035	89,711	16,250	10,500	116,461	11,646	11,646	11,646	151,399
Periferico Trano	–	4	3,500	7,630	7,000	5,000	19,630	1,963	1,963	1,963	25,519
Inner Ring	–	4	1,580	55,554	3,776	3,000	62,330	6,233	6,233	6,233	81,029
CA-9 (South)	–	6	7,000	37,460	7,000	2,500	46,960	4,696	4,696	4,696	61,048
CA-1 (East)	–	6	10,500	39,186	21,000	5,000	65,186	6,519	6,519	6,519	84,743
Av.Hincapie	–	4	10,000	88,400	5,000	2,500	95,900	9,590	9,590	9,590	124,670
Av.Petapa	–	4	6,000	37,160	6,000	2,500	45,660	4,567	4,567	4,567	59,361
13 Av.zona 7	–	4	2,050	2,033	0	0	2,033	203	203	203	2,642
6 Av.zona 2	–	4	1,120	5,537	5,040	2,500	13,077	1,308	1,308	1,308	17,001
15 Av.zona 6	–	4	2,300	7,224	1,080	4,400	12,704	1,270	1,270	1,270	16,514
35 Av.zona 11	–	6	1,090	26,435	1,090	0	27,525	2,753	2,753	2,753	35,784
Boulevard	–	4	14,000	5,573	3,450	0	9,023	902	902	902	11,729
Total	–		115,825	983,338	178,103	83,400	1,224,841	122,487	122,487	122,487	1,592,302

10.2 Intersection Planning

10.2.1 Analysis of Intersections

During the course of the Study by March 1991, the saturation flow rates and the service level for the selected 39 intersections were analyzed and the degree of problems were identified.

10.2.2 Selection of Improvement Measure for Problem Intersections

Based on the results of analysis as well as the existing site condition at each intersection, a suitable measure to solve the present problem is examined for each intersection mainly from the traffic capacity point of view.

For the selection of a suitable measure, the possibility of application of various measures is examined using the following steps. The target service level for the intersection improvement is set as at least "D".

STEP 1: Modification of the present signal phasing and timing, including replacement of existing traffic signal with overhang signal displays with 30mm diameter lenses.

STEP 2: Installation of traffic signal for an unsignalized intersection.

STEP 3: Provision of an additional lane/channelization without land acquisition and modification of the signal phasing.

STEP 4: Provision of an additional lane/channelization with land acquisition and modification of the present signal phasing.

STEP 5: Construction of a grade separation.

10.2.3 Intersection Improvement Plans

At this stage, an improvement measure is proposed for each individual intersection under the present traffic condition, since most of improvement measures are considered to be urgent solutions for problem intersections.

The major problems and the solution for each intersection are listed in Table 10.2.1. In addition, location of improvement sites are shown in Figure 10.2.1, while a perspective view and a conceptual plan of a continuous underpass at Obelisco and Blvd. Liberación is presented in Figures 10.2.2 and 10.2.3, respectively.

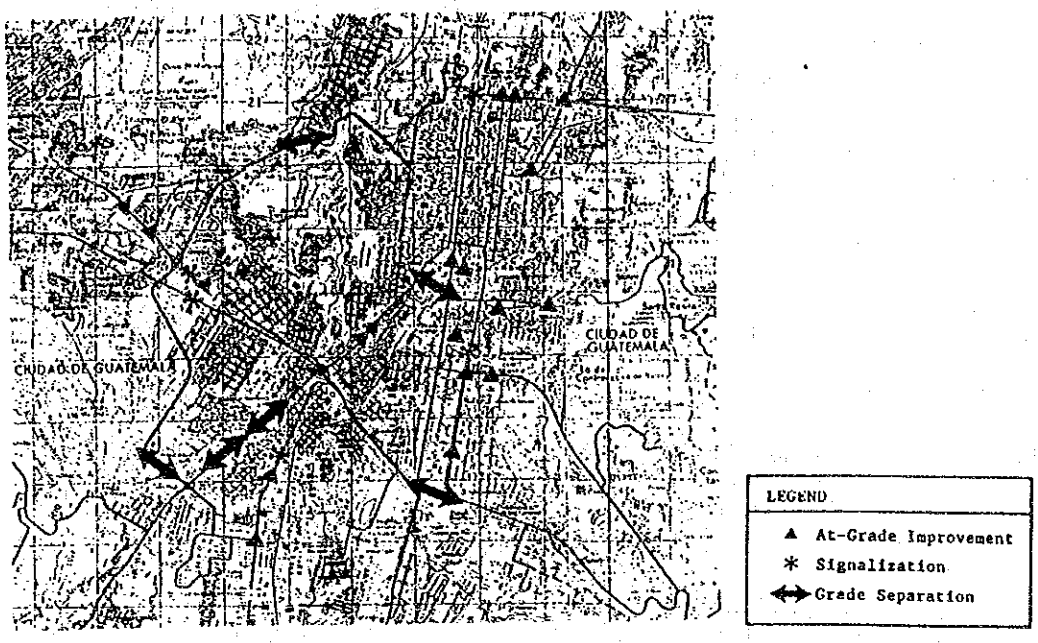


Figure 10.2.1 Location of Intersection Improvement Sites

Table 10.2.1 Improvement Plan of Intersections (1)

No.	Intersection Location	Major Problems	Improvement Measures
I-1	7a Ave./18 Calle, Z1	-Critical flow rate of 18 Calle west bound traffic. -Many illegal loading/unloading of passengers by buses. -High heavy vehicle ratio.	-No improvement measure is proposed because of conversion of 18 Calle to a pedestrian mall by Municipality
I-2	6a Ave./18 Calle, Z1	-Critical flow rate of 6a Ave. south bound traffic. -High heavy vehicle ratio.	- Same as above -
I-3	6a Ave./Diag.2, Z1	-Critical flow rate of all approach traffic. -High heavy vehicle ratio.	-Demolition of a median on northern approach of 6a Ave. and provision of an additional right-turn lane. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
I-4	7a Ave./21 Calle/Diag. 2, Z1	-Conflicts between traffic on west side lanes and left turn traffic on east side lanes of 7a Ave. -Long traffic delays for left-turn traffic on east side lanes of 7a Ave. -High heavy vehicle ratio.	-Closure of median opening. -Clear pavement markings -Relocation of present bus stop in front of Banco de Guatemala
I-5	Ave. Bolívar/24 Calle, Z1	-Over-saturated traffic flows on Ave. Bolívar and 24 Calle east bound traffic. -High heavy vehicle ratio. -Illegal parking on Ave. Bolívar.	-Provision of additional right-turn lane on Ave. Bolívar. -Provision of additional left-turn lane on western approach of 24 Calle. -Modification of signal phasing and timing under multi pattern control. -Strict enforcement of illegal parking. -Clear pavement markings. -Replacement of traffic signal
			-Grade separation (future).
I-6	15 Ave./7a Calle, Z1	-Over-saturated traffic flows on 15 Ave. and 7a Calle west-bound traffic. -High heavy vehicle ratio.	-Provision of additional left-turn lane on 15 Ave. -Regulation of western approach of 7a Calle as west-bound one-way street. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
I-7	Calle Martí/6a Ave./6a Calle, Z2	-Long delays for traffic on Diag. 2. -Many traffic accidents.	-Installation of traffic signal. -Clear pavement markings.
I-8	Calle Martí/10a Ave., Z2	-Over-saturated traffic flows on Calle Martí. -High heavy vehicle ratio.	-Provision of additional left-turn lane for eastern approach of Calle Martí. -Provision of additional right-turn lane on western approach of Calle Martí. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
I-9	Calle Martí/11 Ave., Z2	-Over-saturated traffic flows on Calle Martí. -High heavy vehicle ratio.	-Provision of additional left-turn lane for western approach of Calle Martí. -Segregation of right-turn traffic on 11 Ave. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal

Table 10.2.1 Improvement Plan of Intersections (2)

No.	Intersection Location	Major Problems	Improvement Measures
I-10	6a Ave./Ruta 2/Via 1, Z4	-Over-saturated traffic flows on every approach. -High heavy vehicle ratio.	-Provision of additional left-turn lane on eastern approach of Ruta 2. -Provision of additional right-turn lane on eastern approach of Ruta 2. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
			-Grade separation (future).
I-11	7a Ave./Ruta 6/Via 7, Z4	-Over-saturated traffic flows on every approach. -High heavy vehicle ratio.	-Demolition of medians on both sides of 7a Ave. -Segregation of six lanes on southern approach of 7a Ave. -Provision of additional through lane on eastern approach of Ruta 6. -Prohibition of left turns from both approaches of Ruta 2. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
I-12	Ave. Reforma/10a Ave./Ruta 6, Z4	-Long delays of traffic on 10a Ave. and left-turn traffic on Ave. Reforma. -Many traffic accidents.	-Installation of traffic signal. -Provision of additional left-turn lane and through lane on Ave. Reforma. -Provision of additional through/right-turn lane on 10a Ave. -Clear pavement markings. -Replacement of traffic signal
I-13	12 Ave./27 Calle, Z5	-Critical flow rates of traffic on every approach. -High heavy vehicle ratio.	-Provision of additional left-turn lane on 12 Ave. -Segregation of left-turn lane and right turn lane on 27 Calle. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
I-14	27 Calle/Diag. 14/29 Ave., Z5	-Over-saturated through traffic flow on Diag. 14. -Critical flow rates of traffic on 27 Calle. -High heavy vehicle ratio.	-Provision of additional left-turn lane on Diag. 14. -Segregation of left-turn lane on western approach of 27 Calle. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
I-15	Calle Martí/15 Ave., Z6	-Critical flow rates of all approaches. -High heavy vehicle ratio.	-Provision of additional left-turn lane on northern approach of 15 Ave. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
I-18	C. Roosevelt/23 Ave., Z7	-Long delay of traffic on most movements from 23 Ave. and left-turn movement from western approach of Calzada Roosevelt. -Many traffic accidents.	-Installation of traffic signal with vehicle actuated signal system. -Segregation of left-turn lane and right-turn lane on Calzada Roosevelt. -Clear pavement markings.

Table 10.2.1 Improvement Plan of Intersections (3)

No.	Intersection Location	Major Problems	Improvement Measures
I-19	C.San Juan Sacatepéquez/ 23 Ave., Z7	-Over-saturated traffic flows on eastern approach of C. San Juan Sacatepéquez and 23 Ave. -High heavy vehicle ratio.	-Provision of additional right-turn lanes on both sides of C. San Juan Sacatepéquez. -Provision of left-turn lanes on both sides of 23 Ave. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
I-20	C. San Juan Sacatepéquez/ 30 Ave., Z7	-Long traffic delay of left-turn movement from 30 Ave. -Many traffic accidents.	-Installation of traffic signal under vehicle actuated control system. -Provision of left-turn lane on western approach of C. San Juan Sacetepéquez. -Segregation of left-turn lane and two right-turn lanes on 30 Ave. -Clear pavement markings.
I-21	C.San Juan Sacatepéquez/ 33 Ave., Z7	-Over-saturated traffic flows on western approach of C. San Juan Sacatepéquez. -High heavy vehicle ratio. -Different carriageway surface level on C. San Juan Sacatepéquez	-Provision of additional left-turn lane on western approach of C. San Juan Sacatepéquez. -Provision of two left-turn lanes on 33 Ave. -Modification of signal phasing and timing. -Clear pavement markings. -Leveling both carriageways of C. San Juan Sacatepéquez. -Replacement of traffic signal
I-22	C.San Juan Sacatepéquez/ 37 Ave., Z7	-Over-saturated traffic flows on C. San Juan Sacatepéquez. -Critical flow rate of left-turn traffic on 37 Ave. -High heavy vehicle ratio.	-Provision of additional left-turn lane on eastern approach of C. San Juan Sacatepéquez. -Provision of additional through/right-turn lane on western approach of C. San Juan Sacatepéquez. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
I-23	A. Periférico/13 Ave., Z7	-Long delay of left-turn traffic from 13 Ave. -Many traffic accidents.	-Grade separation
I-24	Ave. Bolívar/32 Calle, Z8	-Over-saturated left-turn traffic flow on Ave. Bolívar. -High heavy vehicle ratio.	-Provision of additional left-turn lane on southern approach of Ave. Bolívar. -Modification of signal phasing and timing under coordinated control system with I-25 intersection. -Clear pavement markings. -Replacement of traffic signal
I-25	Ave. Bolívar/33 Calle, Z8	-Critical flow rate of traffic on southern approach of Ave. Bolívar -High heavy vehicle ratio.	-Modification of signal phasing and timing under coordinated control system with I-24 intersection. -Clear pavement markings. -Replacement of traffic signal

Table 10.2.1 Improvement Plan of Intersections (4)

No.	Intersection Location	Major Problems	Improvement Measures
I-26	Ave. Reforma/2a Calle, Z9	-Over-saturated traffic flows on every approach. -A monument is an obstruction for traffic flows.	-Provision of additional through/right-turn lane on southern approach of Ave. Reforma. -Segregation of left-turn lane and right-turn lane on 2a Ave. -Prohibition of parking along 2 Calle and side roads of Ave. Reforma. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
I-27	Ave. Reforma/12 Calle, Z9	-Over-saturated traffic flows on northern approach of Ave. Reforma and western approach of 12 Calle. -Critical flow rate on other approaches.	-Prohibition of left turns from western approach of 12 Calle and southern approach of Ave. Reforma. -Provision of additional right-turn lane on northern approach of Ave. Reforma by utilizing side road. -Segregation of left-turn lane and right-turn lane on eastern approach of 12 Calle. -Modification of signal phasing and timing. -Prohibition of parking along western side road of Ave. Reforma. -Clear pavement markings. -Replacement of traffic signal
I-28	Obelisco, Z9	-Over-saturated traffic flows on every approach. -High heavy vehicle ratio. -Damaged pavement surface.	-Provision of additional right-turn lane on 18 Calle. -Modification of signal phasing and timing. -Rehabilitation of pavement. -Clear pavement markings. -Replacement of traffic signal
			-Continuous underpass (future).
I-29	Blvd. Liberación/6a Ave., Z9	-Over-saturated traffic flow on eastern approach of Blvd. Liberación. -Critical flow rate of traffic on western approach of Blvd. Liberación.	-Segregation of traffic lanes to four lanes on Blvd. Liberación. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
			-Continuous underpass (future).
I-30	Blvd. Liberación/12 Calle/7a Ave., Z9	-Over-saturated traffic flows on every approach.	-Grade separation (by Municipality).
I-31	Blvd. Liberación/Ave. Castellana, Z9	-Over-saturated traffic flows on eastern approach of Blvd. Liberación. -Critical flow rate of traffic on other two approaches. -High heavy vehicle ratio.	-Grade separation (by Municipality).
I-32	6a Ave./2a Calle, Z10	-Critical flow rates of traffic on every approach.	-Provision of additional lane on northern approach of 6a Ave. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal

Table 10.2.1 Improvement Plan of Intersections (5)

No.	Intersection Location	Major Problems	Improvement Measures
I-34	Blvd. Aguilar Batres/ 13 Calle, Z11	-Over-saturated traffic flows on every approach. -High heavy vehicle ratio.	-Provision of additional right-turn lane on northern approach of Blvd. Aguilar Batres. -Provision of two left-turn lanes on southern approach of Blvd. Aguilar Batres. -Segregation of right-turn lane on western approach of 13 Calle. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
			-Grade separation (future).
I-35	Blvd. Aguilar Batres/ 19 Calle, Z11	-Over-saturated traffic flows on southern approach of Blvd. Aguilar Batres and 19 Calle. -Critical flow ratio of traffic on northern approach of Blvd. Aguilar Batres. -High heavy vehicle ratio.	-Provision of additional through lane on northern approach of Blvd. Aguilar Batres. -Provision of additional right-turn lane on southern approach of Blvd. Aguilar Batres. -Provision of additional left-turn lane on 19 Calle. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal
			-Grade separation (future).
I-36	A. Periférico/9a Ave., Z11	-Long delays of through and left-turn traffic on 10a Ave. -Complicated traffic flows due to irregular shape intersection. -Many traffic accidents.	-Grade separation.
I-37	Ave. Petapa/14 Ave., Z12	-Long traffic delay on 14 Ave. -Many traffic accidents. -Too-large size of intersection. -Insufficient sight distance from vehicles from 14 Ave. due to acute crossing angle.	-Installation of traffic signal. -Extension of medians. -Prohibition of left turn from 15 Calle and 16 Calle. -Clear pavement markings. -Replacement of traffic signal.
I-38	Ave. Petapa/19 Calle, Z12	-Critical flow ratio of through traffic on Ave. Petapa and left-turn traffic on 19 Calle. -High heavy vehicle ratio. -Staggered shape intersection.	-Extension of median at southern part of Ave. Petapa. -Provision of additional through lane on southern approach of Ave. Petapa. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal.
I-39	Ave. Petapa/USAC, Z12	-Over-saturated traffic flow of left-turn movement on southern approach of Ave. Petapa. -High heavy vehicle ratio.	-Provision of additional through lane on southern approach of Ave. Petapa. -Modification of signal phasing and timing. -Clear pavement markings. -Replacement of traffic signal.

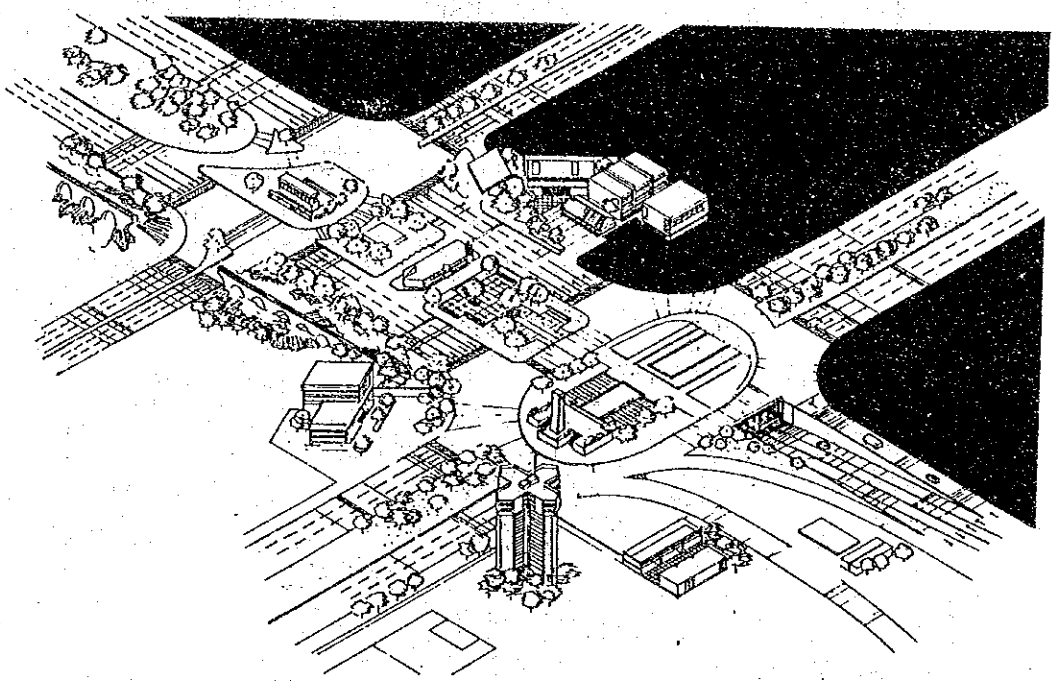


Figure 10.2.2 Perspective View of Continuous Underpass at Obelisco and Blvd. Liberación

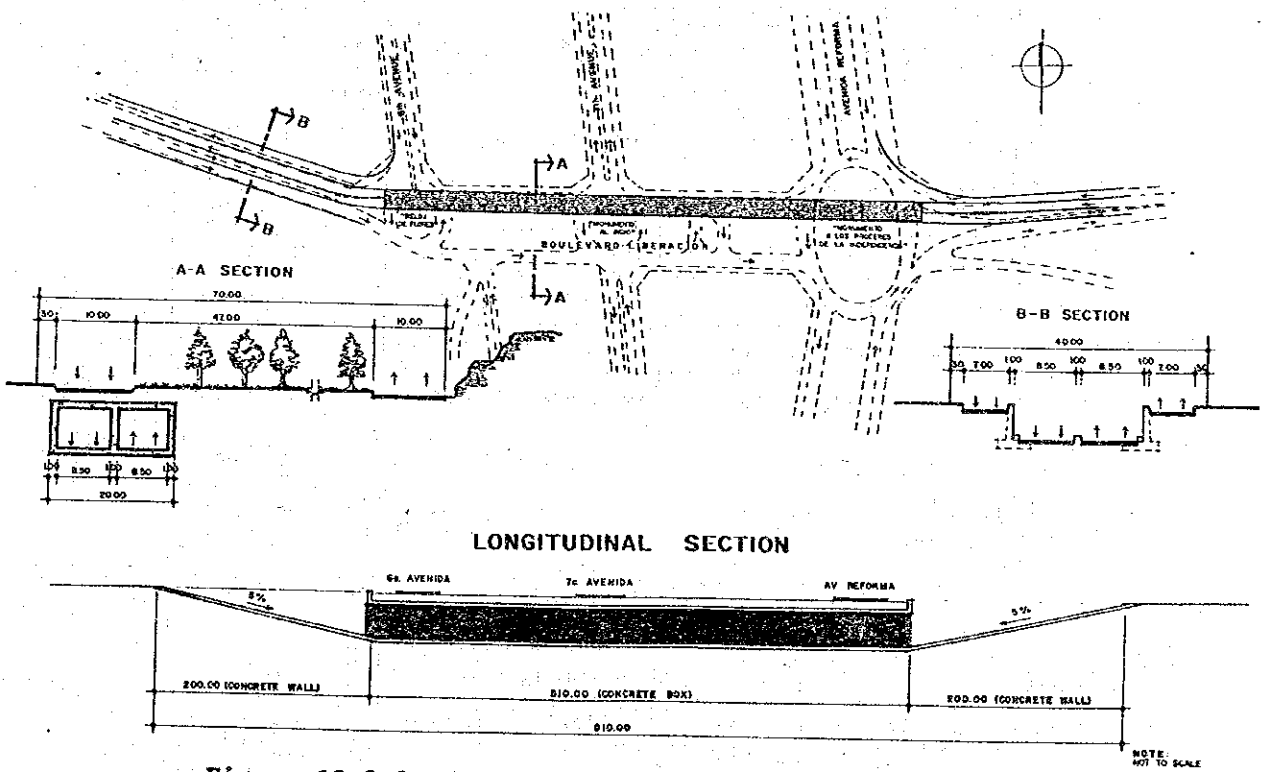


Figure 10.2.3 Conceptual Plan of Continuous Underpass at Obelisco and Blvd. Liberación

10.2.4 Rough Estimation of Improvement Costs

According to above mentioned improvement plans, improvement costs are roughly estimated and summarized in Table 10.2.2 below.

Table 10.2.2 Rough Intersection Improvement Costs (1)

No.	Intersection Location	Improvement Type	Improvement Cost
I-3	6a Ave./Diag.2, Z1	-At-grade improvement	Q48,000.-
I-4	7a Ave./21 Calle/Diag. 2, Z1	-At-grade improvement	Q397,000.-
I-5	Ave. Bolívar/24 Calle, Z1	-At-grade improvement	Q54,000.-
		-Grade separation	See 24 Calle improvement plan in Sec. 10.1
I-6	15 Ave./7a Calle, Z1	-At-grade improvement	Q53,000.-
I-7	Calle Martí/6a Ave./6a Calle, Z2	-Signalization	Q68,000.-
I-8	Calle Martí/10a Ave., Z2	-At-grade improvement	Q68,000.-
I-9	Calle Martí/11 Ave., Z2	-At-grade improvement	Q66,000.-
I-10	6a Ave./Ruta 2/Vía 1, Z4	-At-grade improvement	Included in 6a Ave. improvement in Sec. 12.2
		-Grade separation	See 24 Calle improvement plan in Sec. 10.1
I-11	7a Ave./Ruta 6/Vía 7, Z4	-At-grade improvement	Included in 7a Ave. improvement in Sec. 12.2
I-12	Ave. Reforma/10a Ave./Ruta 6, Z4	-Signalization	Q68,000.-
I-13	12 Ave./27 Calle, Z5	-At-grade improvement	Q51,000.-
I-14	27 Calle/Diag. 14/29 Ave., Z5	-At-grade improvement	Q71,000.-
I-15	Calle Martí/15 Ave., Z6	-At-grade improvement	Q55,000.-
I-18	C. Roosevelt/23 Ave., Z7	-Signalization	Q107,000.-
I-19	C.San Juan Sacatepéquez/ 23 Ave., Z7	-At-grade improvement	Q84,000.-
I-20	C. San Juan Sacatepéquez/ 30 Ave., Z7	-Signalization	Q93,000.-
I-21	C.San Juan Sacatepéquez/ 33 Ave., Z7	-At-grade improvement	Q231,000.-
I-22	C.San Juan Sacatepéquez/ 37 Ave., Z7	-At-grade improvement	Q72,000.-
I-23	A. Periférico/13 Ave., Z7	-Grade separation	Q8,473,000.-
I-24	Ave. Bolívar/32 Calle, Z8	-At-grade improvement	Q84,000.-

Table 10.2.2 Rough Intersection Improvement Costs (2)

No.	Intersection Location	Improvement Type	Improvement Cost
I-25	Ave. Bolívar/33 Calle, Z8	-At-grade improvement	Q54,000.-
I-26	Ave. Reforma/2a Calle, Z9	-At-grade improvement	Q65,000.-
I-27	Ave. Reforma/12 Calle, Z9	-At-grade improvement	Q58,000.-
I-28	Obelisco, Z9	-At-grade improvement	Q1,325,000.-
		-Grade separation	Q63,923,000.-
I-29	Blvd. Liberación/6a Ave., Z9	-At-grade improvement	Included in 6a Ave. improvement in Sec. 12.2
		-Grade separation	See I-28 improvement plan
I-32	6a Ave./2a Calle, Z10	-At-grade improvement	Q51,000.-
I-34	Blvd. Aguilar Batres/ 13 Calle, Z11	-At-grade improvement	Q71,000.-
		-Grade separation	Q10,278,000.-
I-35	Blvd. Aguilar Batres/ 19 Calle, Z11	-At-grade improvement	Q71,000.-
		-Grade separation	Q10,278,000.-
I-36	A. Periférico/9a Ave., Z11	-Grade separation	Q11,319,000.-
I-37	Ave. Petapa/14 Ave., Z12	-Signalization	Q73,000.-
I-38	Ave. Petapa/19 Calle, Z12	-At-grade improvement	Q54,000.-
I-39	Ave. Petapa/USAC, Z12	-At-grade improvement	Q54,000.-
Total Intersection Improvement Cost			Q105,817,000.-

11. PUBLIC TRANSPORT PLAN

11.1 Basic Conditions for Planning

11.1.1 Public Transport Passengers

Based on the selected network pattern E, the number of person trips between pairs of person trip zones is estimated. The total number of person trips by public modes is estimated at 3321 thousand. This is 85% more than the 1990 level of 1793 thousand. Here the 67 person trip zones are integrated into 34 zones considering major corridors (See Figure 11.1.1). Out of the total of 595 pairs, 42 pairs account for 50%. Among them, the highest demand is seen along the major radial corridors such as the west corridors, the north-east corridors and the south corridors, followed by the Middle Ring Road (Periferico) to and from the zone of the University of San Carlos (USAC).

Table 11.1.1 Major OD Pairs of Public Transport Person Trip Zones in 2010

Serial No	O/D	O/D	No.of PT	%	Accum.%
1	14	14	144,240	4.3	4.3
2	14	1	103,067	3.1	7.4
3	16	14	79,683	2.4	9.8
4	32	32	76,174	2.3	12.1
5	16	16	70,695	2.1	14.3
6	14	2	65,554	2.0	16.2
7	25	25	62,980	1.9	18.1
8	32	1	58,765	1.8	19.9
9	25	14	41,609	1.3	21.2
10	26	22	40,954	1.2	22.4
11	22	20	40,368	1.2	23.6
12	28	26	37,885	1.1	24.7
13	32	30	36,704	1.1	25.9
14	28	28	34,808	1.0	26.9
15	20	20	33,430	1.0	27.9
16	32	28	33,324	1.0	28.9
17	12	1	32,190	1.0	29.9
18	25	16	31,075	0.9	30.8
19	30	28	30,922	0.9	31.7
20	28	25	30,875	0.9	32.7
21	23	20	30,589	0.9	33.6
22	32	14	29,498	0.9	34.5
23	32	2	28,860	0.9	35.4
24	28	14	28,601	0.9	36.2
25	25	1	28,592	0.9	37.1
26	16	1	28,395	0.9	37.9
27	25	20	27,488	0.8	38.8
28	22	22	27,453	0.8	39.6
29	32	3	27,191	0.8	40.4
30	7	1	26,907	0.8	41.2
31	23	23	26,682	0.8	42.0
32	16	2	26,255	0.8	42.8
33	20	14	26,016	0.8	43.6
34	25	2	25,943	0.8	44.4
35	32	12	25,354	0.8	45.1
36	30	30	24,055	0.7	45.9
37	30	14	23,464	0.7	46.6
38	3	1	23,377	0.7	47.3
39	28	22	23,293	0.7	48.0
40	28	20	23,228	0.7	48.7
41	4	1	23,075	0.7	49.4
42	20	16	22,067	0.7	50.0
Others			1,659,538	50.0	100.0
Total			3,321,223	100.0	

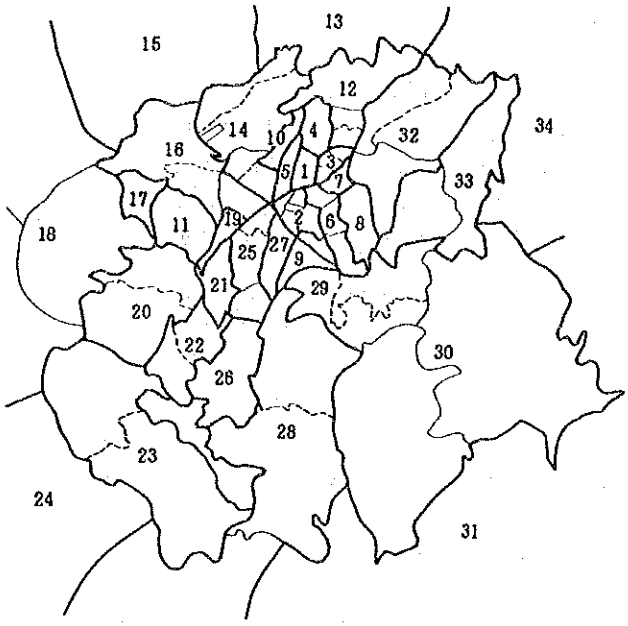


Figure 11.1.1 Integrated Zones of Public Transport Person Trips

11.1.2 Public Transport Planning Guidelines

(1) Public Transport Dominance

In general, the share of public transport trips tends to decrease according to increase of car ownership. However, the majority of the citizens use public transport and public transport has advantages over private transport from an urban and regional development point of view such as space requirement, economy, energy and environment. Therefore, priority should be placed on public transport development to maintain good service and attract passengers.

(2) Public Transport Network Structure

Improvement of the public transport system includes full coverage of public transport routes, frequent operation, enough capacity and maintenance of sufficient speeds. For the improvement without causing traffic congestion, a hierarchical structure should be introduced. This consists of a high-capacity high-speed system along major routes and feeder services along branch routes. At the same time, in order to reduce the number of transfers, the transport of the major routes should operate along the middle corridors of the north-south direction in CBD, which is roughly a rectangle longer in the north-south direction and shorter in the east-west direction.

(3) Priority Measures for Public Transport

To support and promote efforts for service improvement by the bus operators, the government should give priority to the public transport by means of busways, bus lanes, terminals, stops and other non-physical measures. These measures can be more effective than subsidies.

11.2 Future Public Transport System

11.2.1 Hierarchy of Public Transport

As new categories of buses, 1) extra-urban buses, 2) key route buses, 3) ordinary buses and 4) feeder buses are proposed.

(1) Extra-urban Buses

1) Concept of Extra-urban Buses

Extra-urban buses can be classified into two major types. The first type is mainly for commuting purposes in the Metropolitan Area. The second type is for non-commuting purposes. This type roughly corresponds to extra-urban buses to and from outside the Metropolitan Area.

The commuter extra-urban buses should be integrated into the urban bus network.

2) Alternative Concepts regarding Penetration of Non-Commuter Extra-urban Buses into the City and Location of Extra-urban Bus Terminals

a) Existing Pattern

Penetration of extra-urban buses into CBD such as Zone 4 Terminal, scattered terminals in Zone 1 and Zone 6 Terminal currently causes the following problems:

- Traffic congestion
- No integration of extra-urban buses and urban buses
- Problems of the communities such as uncleanliness, environmental pollution, lack of security and lack of safety

b) Centralized Pattern

Reorganization and relocation of existing terminals to new integrated terminals at city centers have the following characteristics:

- Convenience for passengers
- Integration of extra-urban and urban transport
- Traffic will be concentrated but congestion can be alleviated by utilization of FEGUA's right of way and a viaduct on 18th street of Zone 1.
- Redevelopment or renewal of the terminal areas should be accompanied by construction of multi-functional buildings.

c) Semi-Decentralized Pattern

Reorganization and relocation of existing terminals to new terminals at CBD boundaries have the following characteristics:

- Most extra-urban bus passengers need urban transport to reach inside of CBD.

- Difficulty to reserve sufficient area
- Traffic congestion may worsen at such areas as Trebol and Calle Marti.

d) Decentralized Pattern

Reorganization and relocation of existing terminals to new terminals at intersections between inter-regional arterial routes and the Periferico have the following characteristics:

- Most extra-urban bus passengers need urban transport to reach inside of CBD.
- Traffic congestion in CBD will be alleviated.
- The Periferico can be fully utilized.
- It is comparatively easy to obtain sufficient areas for the terminals, because the locations are away from CBD and the required area for each terminal is relatively small.

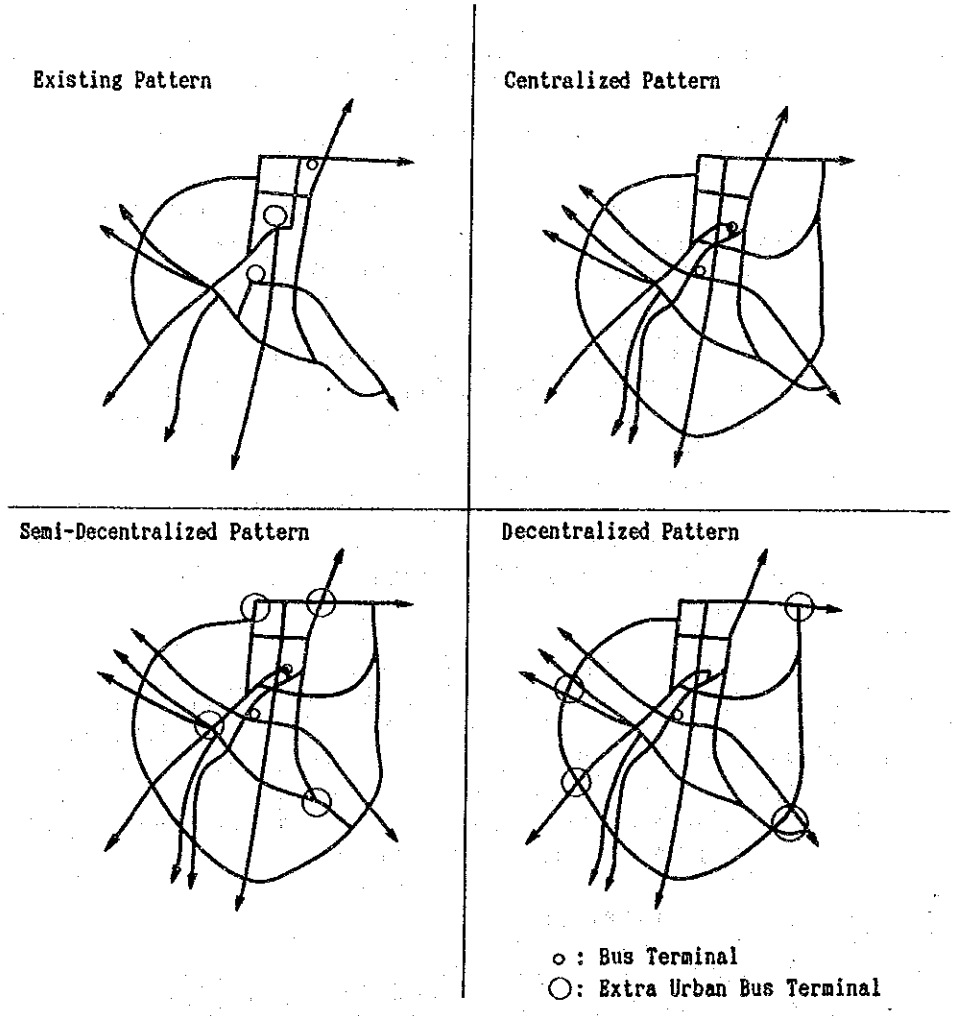


Figure 11.2.1 Alternative Location Patterns of Extra-urban Bus Terminals

e) Recommended Pattern

The decentralized pattern is recommended both for passengers' convenience and traffic reasons. The terminals for non-commuter extra-urban buses are connected with CBD by urban key route buses.

Non-commuter extra-urban bus routes with insufficient passengers such as CA1 East (CA1E), Department Road 1 (DR1) and Department Road 15 (DR15) are not equipped with such terminals as of 2010. Non-commuter extra-urban buses along CA1E and DR1 use the Zona 4 Bus Center. Those along DR15 use the Zona 1 Bus Center. These centers are also covered by urban buses.

Special extra-urban buses start at the centers or each company's off-road terminal. These special buses include international buses and tourist buses.

(2) Key Route Buses

1) Concept of Key Route Buses

Routes along arterial roads connecting major OD pairs are served by key route buses. The basic idea of the key route bus is to increase capacity and to raise the service level while maintaining efficiency and alleviating traffic congestion along major routes. Some of the present extra-urban bus services mainly for commuting should be upgraded to this category.

The key route buses should have such characteristics as:

- Large capacity (approximately 80 passengers including standing passengers)
- Fixed bus stops (approximately 600 m - 800 m between bus stops)
- Connection with feeder services without extra fares
- Improvement of interchange functions
- No parking in CBD
- Priority measures such as bus priority or bus exclusive lanes or bus ways, well equipped bus stop and terminal spaces

2) Alternative Concepts regarding Penetration of Key Route Buses into CBD and Location of Transfer Functions (Figure 11.2.2)

a) Existing Pattern

- No hierarchy of the network without clear sharing of roles between buses and microbuses
- No clear pattern of the network
- Penetration of outer routes into CBD

b) Separation of Inside and Outside CBD Routes

- Outside routes do not enter into CBD. CBD has a separate system.
- Congestion in CBD can be alleviated by effective operation of the CBD system.

- Most passengers need transfers to reach their destinations in CBD
- Transfer functions are necessary on the CBD boundary, which tend to cause congestion around the locations.

c) Penetration into Selected Roads in CBD

- The key route buses operate all through selected north-south roads in the middle of CBD.
- East-west routes in CBD are mainly served by feeder buses.
- Ordinary buses operate on the CBD boundaries.
- The majority of passengers do not need transfers in CBD.

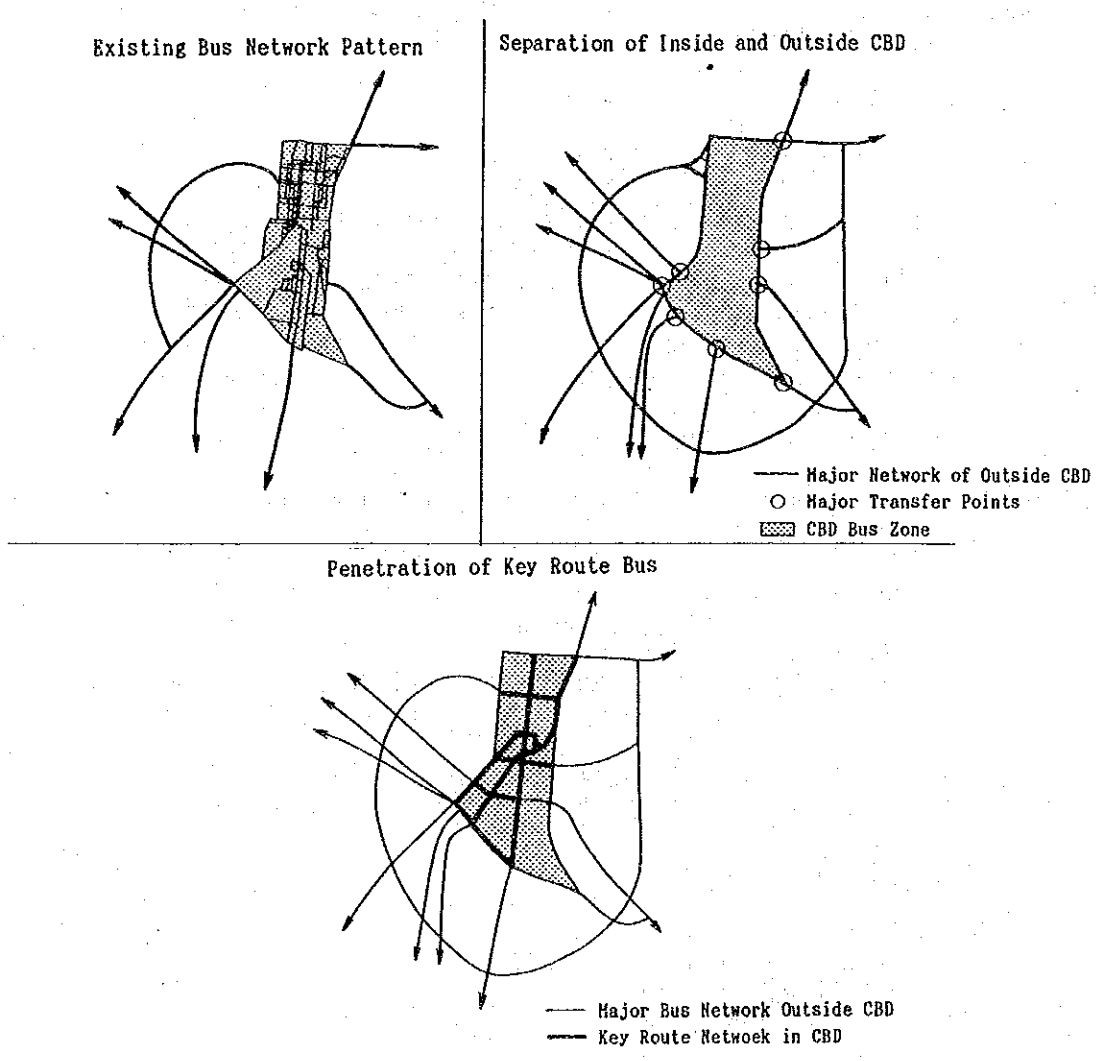


Figure 11.2.2 Alternative Patterns of Key Route Bus Network in CBD

d) Recommended Pattern

The alternative c) is recommended both for passengers' convenience and for traffic reasons.

Table 11.2.1 Comparison of Key Route Network Patterns in CBD

Item	Existing pattern	Separation of inside & outside CBD routes	Penetration into selected roads in middle of CBD
No.of roads for key routes	More	0 or Few on boundaries	Few on middle north-south roads
Frequency of key route buses on each road	Less	N.A. or between the other cases	More
No.of transfers	Less	More	Less
Road congestion	More	Less	Less
Travel speed	Less	More	More
Travel time	More	More	Less

(3) Ordinary Buses

1) Concept of Ordinary Buses

Routes connecting minor OD pairs are served by ordinary buses. Some of the present extra-urban buses mainly for commuting, which connect minor OD pairs and do not become key route buses, should be in this category.

Most ordinary buses should have capacity of not less than 40 passengers. They should have fixed bus stops with 400 m to 600 m intervals. They can share bus priority measures with key route buses along their routes, such as bus priority or bus exclusive lanes or bus ways, well equipped bus stop and terminal spaces.

Smaller buses such as the present microbuses can serve even minor OD pairs or connect specific places such as market places. Their service can be more flexible than larger buses. For example, their stops can have flexibility. On the other hand, they should avoid arterial roads.

2) CBD Network

In CBD, ordinary buses should operate along the boundary. Schematic minimum routes are as follows.

- Buses from north-west go along the western boundary area of CBD to south and return along the same area
- Buses from south-west go along the western boundary area of CBD to north and return along the same area
- Buses from north-east go along the eastern boundary area of CBD to south and return along the same area
- Buses from south-east go along the eastern boundary area of CBD to north and return along the same area

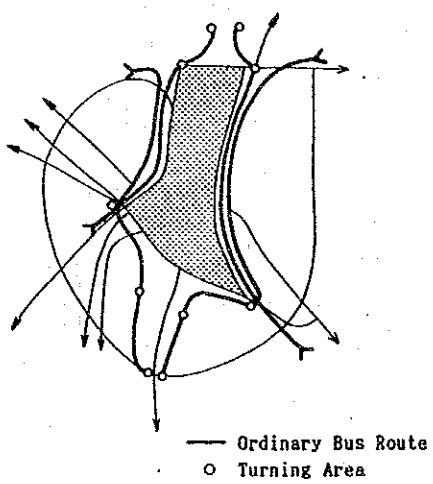


Figure 11.2.3 Ordinary Bus Network Pattern at CBD

(4) Feeder Buses

1) Concept of Feeder Buses

The feeder service is a frequent service by small buses (with capacity of approximately 20 - 30 passengers) to feed passengers to key route buses. The distance between bus stops is generally shorter than that of ordinary buses. The service is for short trips. The fares are low. If passengers ride key route buses connected with the feeder buses, there is no need to pay for the feeder buses. They can share priority measures with connected key route buses.

2) Operation Areas

The operation areas are basically along branch roads within at most 3 km to 4 km from a key route. The operation areas or routes are limited so as not to disturb traffic of arterial roads. Outside CBD, feeder buses may stop flexibly according to the demand where there is no congestion. In CBD, feeder buses circulate mainly along the

east-west direction connected with the key route buses at middle north-south roads and with ordinary buses at the north-south boundaries of CBD.

11.2.2 Public Transport Network

(1) Major Network of Public Transport

The selected alternative for the major network of public transport introduces busways and bus lanes.

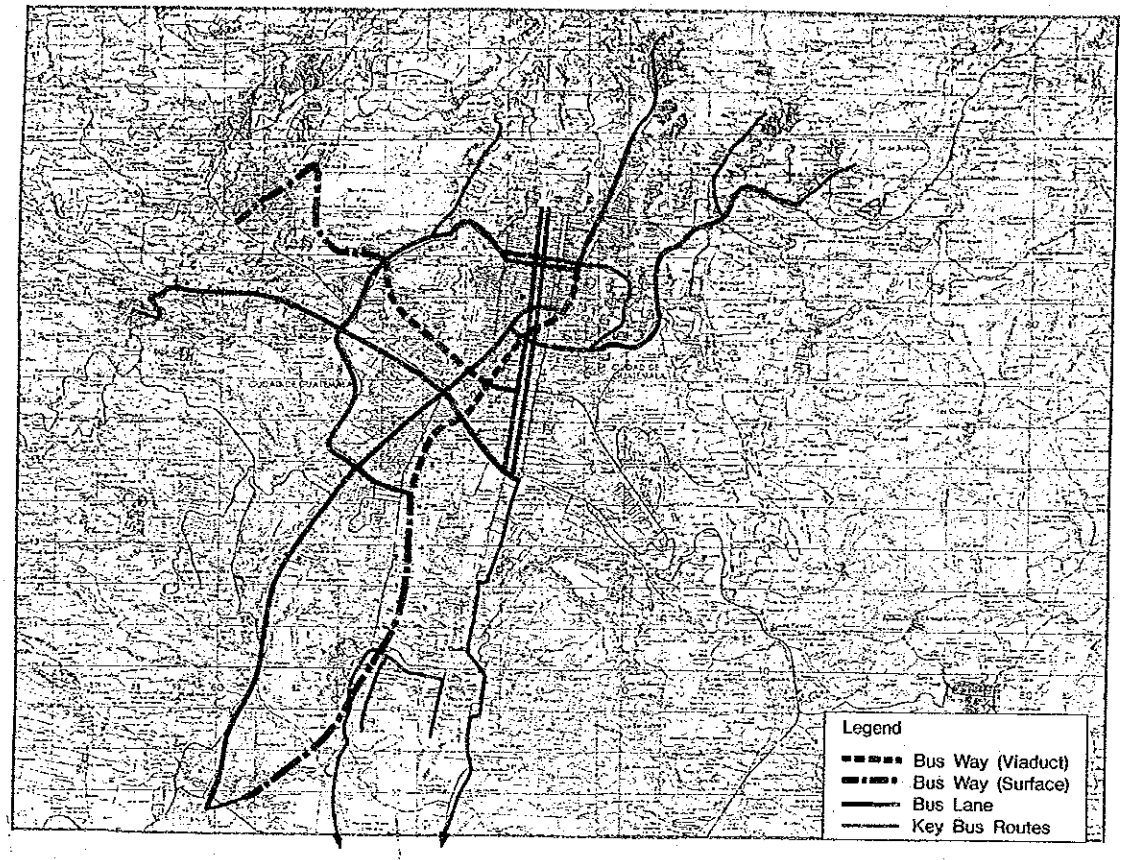


Figure 11.2.4 Busway and Bus Lane Network

1) Busways

Busways are roads exclusively for bus operation to make the most use of buses (See Figure 11.2.5). The busways can improve capacity and speed of bus transport maintaining the flexible nature of buses and the services. An average commercial speed of 25 km/h can be expected.

To maintain smooth flow of the buses, the busways should be on viaducts within Periferico. Outside Periferico, major intersecting

roads should underpass the bus ways on the surface level.

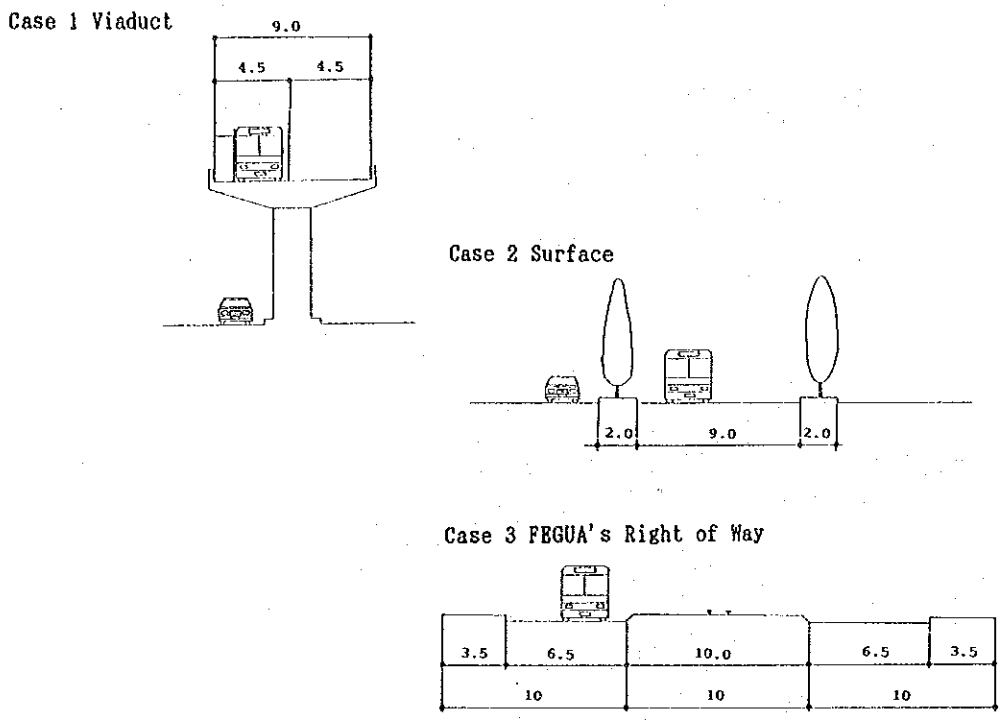


Figure 11.2.5 Examples of Busways

The busway routes are along the east-west corridor and the FEGUA's right of way. It is anticipated that the busways can be converted to rail transit routes when it is feasible and possible.

The western end of the bus way is Zona 19 (Florida), where the bus passengers gather from surrounding communities by feeder buses. Large demand from Milagro and San Francisco should be served by comparatively large capacity feeder services through National Road 5 and across Rio Salaya.

The southern end of the bus way is Villa Nueva, which is a development center of the southern suburbs and also on the way further south to Amatitlan onwards. The route diverts from FEGUA at Ciudad Real.

The feeder services cover neighboring areas within 3 km to 4 km, that is, not including Amatitlan.

Since the inner ring road will connect the north-eastern areas such as Zona 18 and Zona 17 with CBD, the northern end of the busway extends only to Calle 8 or 9 to distribute passengers to the northern Centro.

For utilization of the FEGUA's right of way, relocation of squatters

in certain areas such as Zona 4 is necessary in addition to civil engineering work. Provision of housing for the estimated 1550 families of squatters along the route is required, therefore, the transport system should be developed in coordination with Banvi's housing projects.

2) Bus Lanes

Bus lanes are used exclusively by buses during designated hours. An average commercial speed of 20 km/h can be expected. During other hours, buses have priority over cars in the lanes. An example of bus exclusive hours is 2 or 3 hours in the morning peak (6 - 9 o'clock) and 2 or 3 hours in the evening peak (16 - 19 o'clock). Another example which can be introduced to the Centro is bus exclusive lanes during the whole day except late at night and early in the morning.

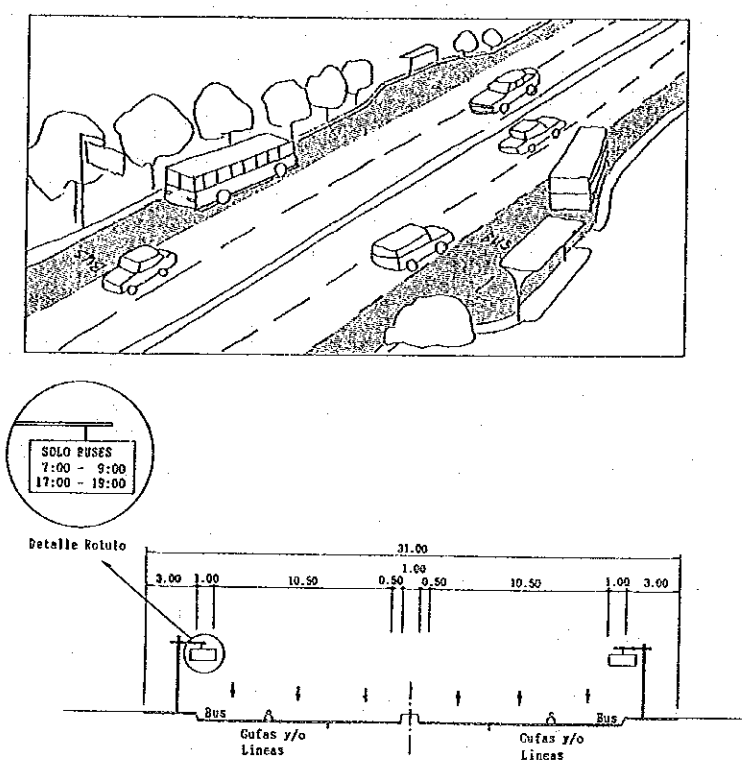


Figure 11.2.6 Examples of Bus Lanes

Bus lanes are basically introduced for key route buses on arterial roads with 3 lanes each way except in the Centro.

Bus lanes are not introduced where there is not enough estimated demand for buses because introduction of bus lanes may cause congestion of cars, the disadvantages of which may be greater than advantages for buses.

(2) Bus Routes

Bus routes in 2010 are planned based on estimation of the future demand for public transport. These should be regarded as basic routes integrating similar routes. In reality, there should be variations of these routes. (See Figure 11.2.7, Table 11.2.2 and Table 11.2.3)

The total number of bus passengers is 4518 thousand. The simulation neglected intra-zonal trips, which account for 6.7 % of the total, resulting in the total trip figure of 4217 thousand. This consists of 4092 thousand urban bus passengers and 125 thousand extra-urban bus passengers. 896 thousand passengers accounting for 27.0 % of the total trips transfer once for a trip and 164 thousand passengers accounting for 4.9 % transfer more than once. In 1990, about 33 % of person trips have a transfer or more. One of the major causes for transfers in future are changes between key route buses and feeder buses. Another major cause is traffic generation and attraction in remote areas such as Los Ocotes, Lodecoy, Barcenos, the south coast of the Amatitlan lake and outside the Metropolitan area. However, owing to the rerouting, the rate of transfers will remain at the present level.

To avoid traffic congestion, key route buses and major ordinary buses should have larger capacity than most existing buses. Assuming the capacity according to the types of buses, the necessary bus fleet for urban service is estimated at 3870 buses in 2010. It is therefore necessary to add approximately 770 buses to the existing 3100 buses (urban buses and extra-urban buses to be incorporated in the urban network) and to renew the existing fleet.

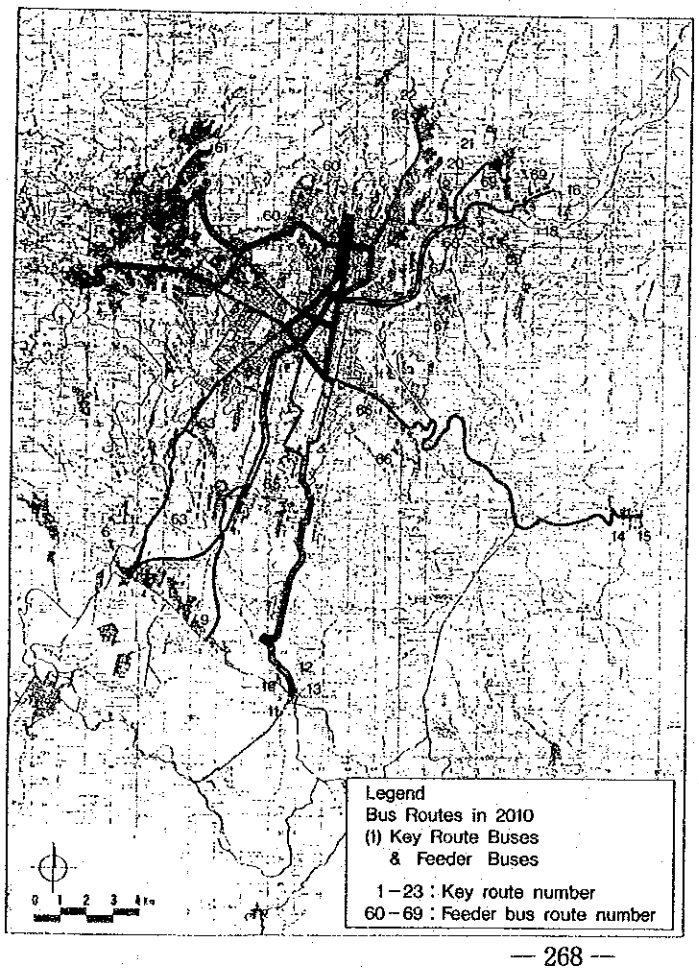


Figure 11.2.7

Bus Routes in 2010

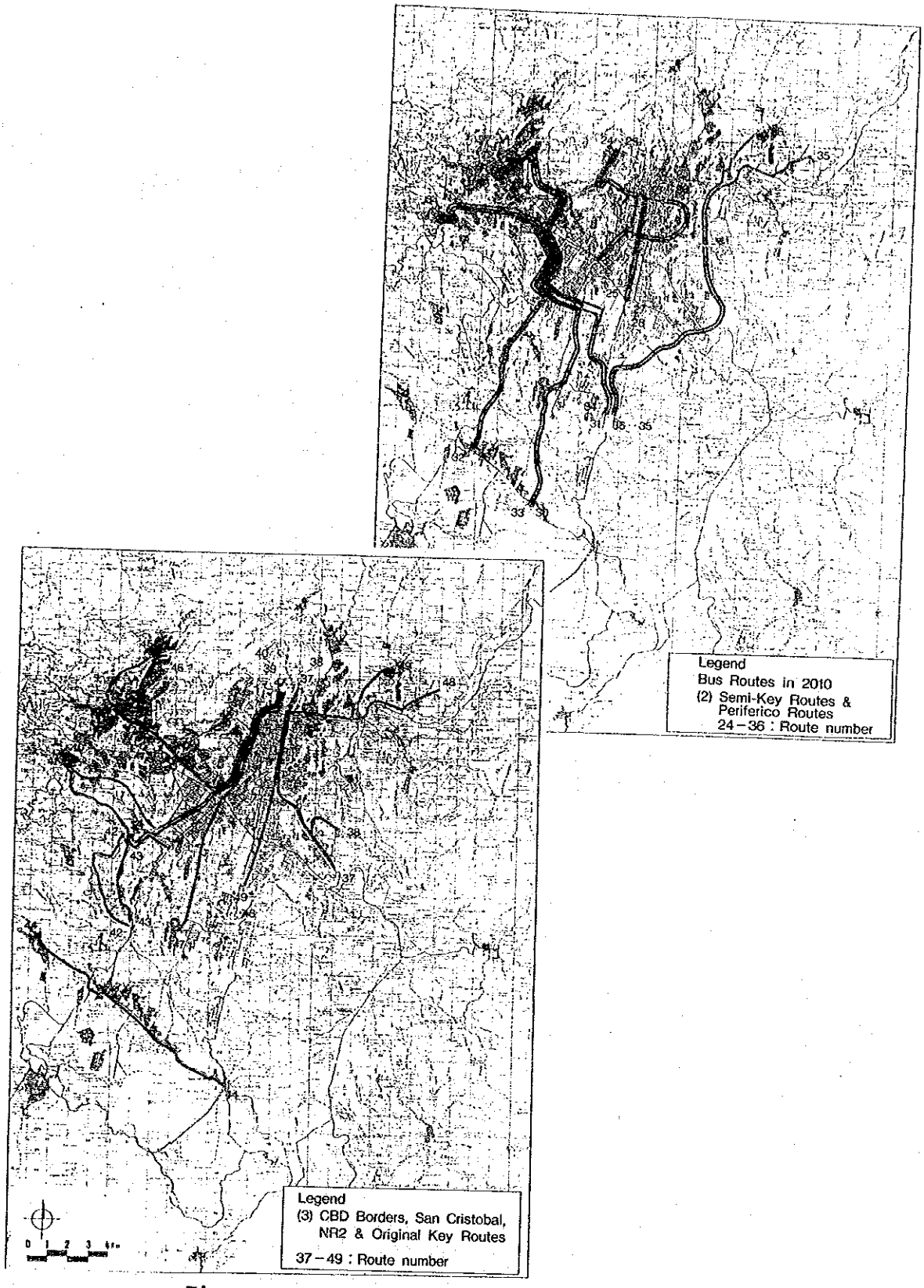


Figure 11.2.7 Bus Routes in 2010 (continued)

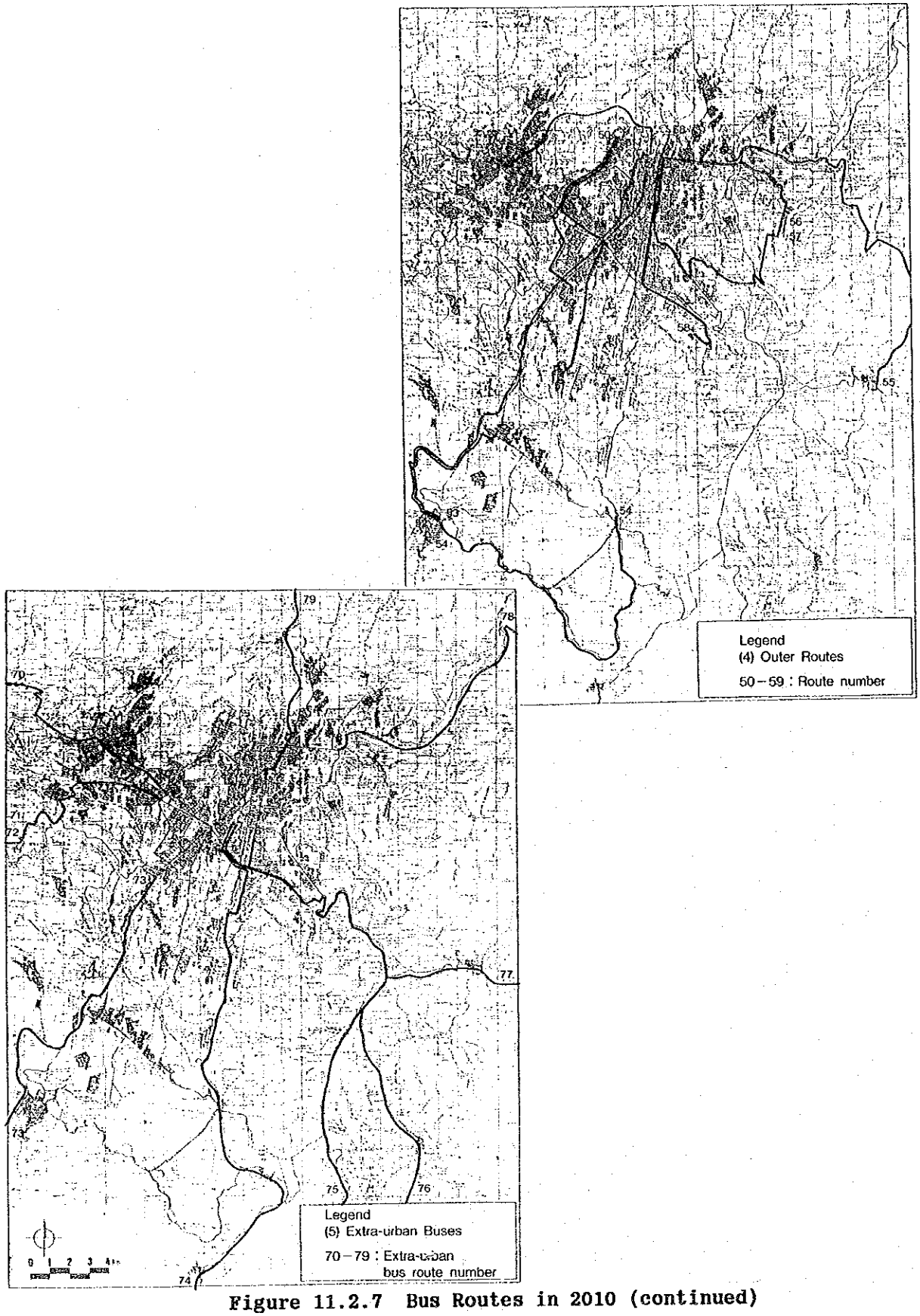


Figure 11.2.7 Bus Routes in 2010 (continued)