CHAPTER 11
Alternative Study for Inner Ring Expressway

11. ALTERNATIVE STUDY FOR INNER RING EXPRESSWAY

11.1. OUTLINE OF INNER RING EXPRESSWAY

11.1.1. FUNCTION AND CHARACTERISTICS OF THE INNER RING EXPRESSWAY

The major purposes of construction of Inner Ring Expressway are to mitigate the traffic congestion of central area and to divert traffic flows from/to radial trunk roads in the city of Bogota. Considering those purposes of Inner Ring Expressway and the existing road network configuration of the city of Bogota, comparatively long trip traffic will use the expressway, and high running speed is required to maintain function of the expressway.

The road function and characteristics were described in the Final Report of the Master Plan Study conducted in 1996 and 1997 by JICA and are summarized in Figure 11.1-1 and Figure 11.1-2.

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

Figure 11.1-1 Function and Characteristics of a Road

Funtion of Road	Characteristics Of Road Traffic					Class of Road	Remarks
	Traffic Volume	Trip Length	Travel Speed	Mode of Trans-portation	Trip Purpose		
Mobility ↕ Land Access	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 11.1-2 Road Characteristics of Individual Road

Considering the above mentioned function and characteristics of the urban expressway, the Inner Ring Expressway (IRE) is classified as urban trunk road in the city, and the following road conditions should be required.

1) To separate from normal traffic flows
2) To maintain a high running speed

3) To establish a grade separated intersection

4) To utilize for only vehicles

11.1.2. Major Objectives of Inner Ring Expressway

As mentioned in the previous Section 10.2, traffic conditions of the city of Bogota are very heavy during the peak hours, and all the traffic flows are concentrated in the central area of Bogota City. The traffic flows of trunk radial roads which are connected between central area and sub-urban areas of Bogota also have very heavy traffic.

The land-use conditions of central area is classified as high development area which consists of commercial, institutional, and housing areas, and there are also many office and housing buildings along the existing roads. There is no room for construction of new roads, and the widening of the existing roads is very difficult.

There are two major measures to mitigate the traffic congestion in Bogota such as introduction of traffic demand management (TDM) and effective utilization of the existing roads. The TDM is temporarily decreased traffic demand by political procedure. On the other hand, the effective utilization of existing road space is to increases the road capacity with construction of new road facilities. The mitigation measure of traffic congestion in the high development area should require the introduction of both methods such as TDM and effective utilization of the existing roads at the same time. At present, the city of Bogota has been introducing one of the TDM system (regulated vehicle numberplate) from August 18, 1998. In order to achieve the most effective traffic mitigation measures in central area of Bogota, the construction of Inner Ring Expressway should be required as soon as possible.

Taking into account the above-mentioned matters, the major objectives of the Inner Ring Expressway should be to maintain the follow conditions.

1) To decrease the traffic congestion on the existing trunk roads such as Avenida Caracas, 7a, and Avenida Quito.

2) To decrease the traffic congestion on the existing sub-trunk or local roads such Carrera 11, Carrera 15, and Avenida 24.

3) To decrease the traffic accidents caused by improvement of the traffic congestion on the roads.

4) To maintain a good activity of the city of Bogota by increasing a running speed on the existing roads

5) To contribute to economic growth of the city of Bogota by improving a travel time for the citizens of the city of Bogota.

11.1.3. Routes to be Studied for Inner Ring Expressway

In the Master Plan, an Urban Expressway network which consists of 1st and 2nd ring expressways and four (4) radial expressways were recommended for the solution of traffic congestion in the city of Bogota as a short and middle term implementation plan. The 1st ring expressway of the total expressway network was recommended as a short term plan or urgent implementation plan. Based on the recommendation of the Master Plan, the feasibility study of 1st ring expressway is conducted in this study, mainly the Inner Ring Expressway

Taking into account the urban expressway network recommended by the Master Plan and the existing traffic conditions of central area, and the major objectives of the inner ring

expressway, the routes to be studied for the inner ring expressway are identified as shown in Figure 11.1-3, and routes to be studied are presented below:

1) Along the existing Avenida 7a.

2) Along the existing Calle100 to Avenida Quito.

3) Along the existing Calle 6.

Basically, the Inner Ring Expressway is formed as the ring road which is connected to the above mentioned three (3) roads.

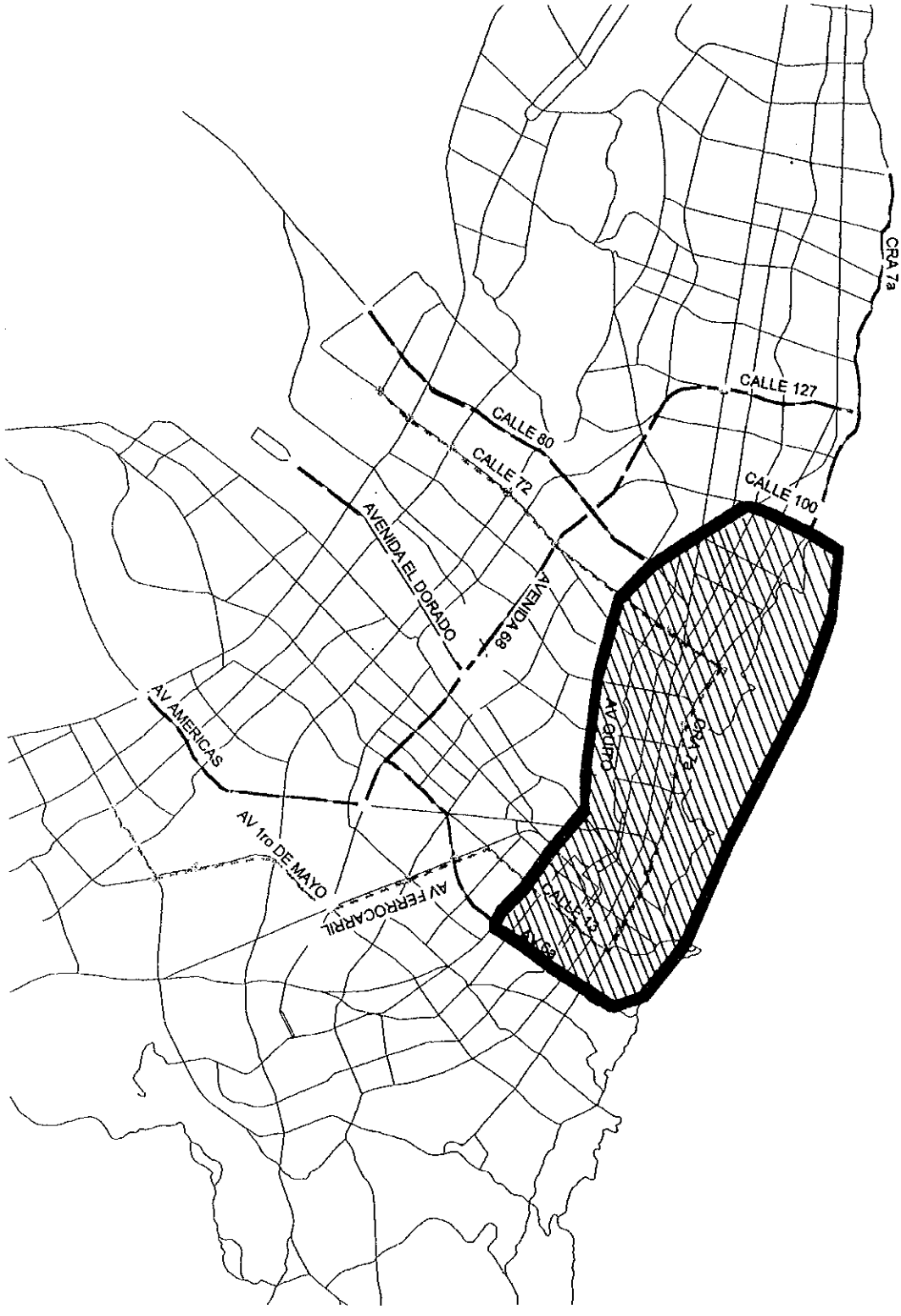

Figure 11.1-3 Route Location Area for Inner Ring Expressway

11.1.4. TYPE OF ROAD STRUCTURE

Taking into account the function and characteristics of the inner ring expressway, the major objectives of the road, as well as the conditions of existing roads, it is required a segregated road type from the existing traffic flow, as the road type for the Inner Ring Expressway. There are three (3) types of segregation method, one is to use the land on the same level of the existing road, the second is to use the area or space over the existing road (see Figure 11.1-4), and the other is to use the area or space under the existing road (see Figure 11.1-5).

As a result of reconnaissance survey of the existing roads facilities and conditions, there is no space for construction of the inner ring expressway at the same level of the existing roads. Therefore, the Inner Ring Expressway will be constructed using the space over or under existing road areas.

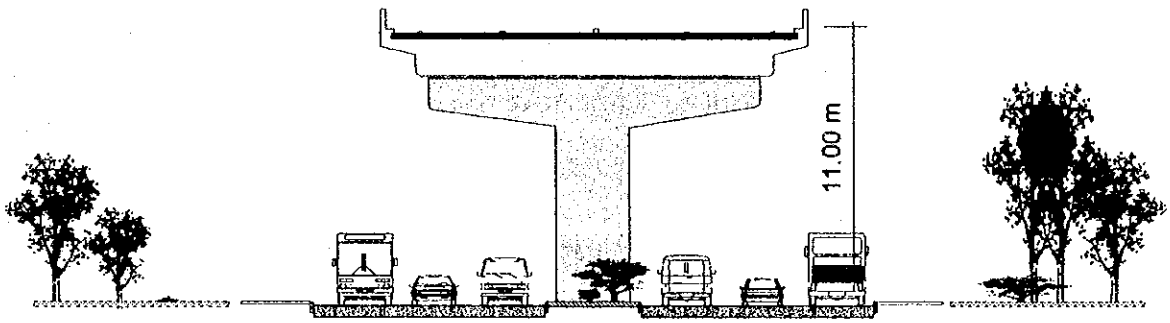

Figure 11.1-4 Typical Section for Over Pass Structure on Existing Road

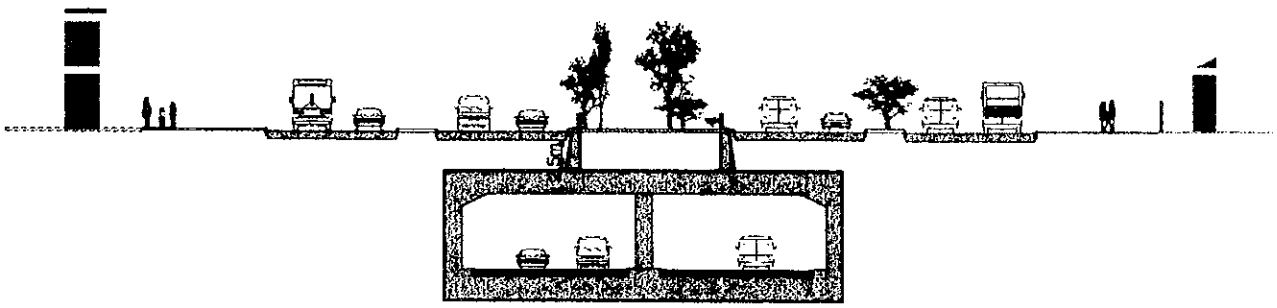

Figure 11.1-5 Typical Section of Under Pass Structure on Existing Road

11.1.5. PLANNING CRITERIA

Prior to the alternative route study and other examination of the Inner Ring Expressway, the general planning criteria should be considered based on the function of the road, and the major objectives of the Inner Ring Expressway, planning criteria are identified as follows;

(1) Traffic Control

Considering the function and characteristics of the Inner Ring Expressway, the full access control system is introduced, and bicycles and small motor cycles and pedestrians are limited to pass through the Inner Ring Expressway with due consideration of maintaining the traffic safety. The bus stops also not constructed on the Inner Ring Expressway, however, buses could pass on the road.

(2) Operation System

Generally, the construction costs of urban expressway are very costly since roads will be constructed in urban areas, and usually in a form of viaduct or tunnel structure. The urban expressways have been constructed in many cities of the world, and they are operated with a toll system due to the high construction costs, the shortage of budget of the Government, and introduction of the principle of burden share of beneficiary.

(3) Design Speed

Considering the function and characteristics of the urban expressway, and the major objectives of the Inner Ring Expressway, the design speed is identified as 60 km/h to 80 km/h.

(4) Number of Lanes

Generally, the number of lanes required on the Inner Ring Expressway will be identified according to the future traffic demand, however, in spate of low traffic, 4-lane dual carriage way will be adopted. The detailed number of lanes required is described later.

11.1.6. STRUCTURE DESIGN

(1) Design Standard

Instituto Nacional de Vias made out its own design standard (Codigo Colombiano de Puentes). In this study, the structures shall be designed based on this standard. Principal design conditions are as follows:

1) Load

a) Live Load

For the design, live load of the road structures in Colombia is indicated in Codigo Colombiano de Puentes. Also in this study, the structures shall be designed with this live load.

b) Seismic Load

In Bogota city there are a lot of earthquakes, including that of the magnitude 8 in. In the surroundings of the city, some faults were found, and so a big seismic disaster may possibly occur in the future. For the Acceleration Coefficient "A" of Bogota city in this study, shall be used A= 0.2.

2) *Strength of Principal Materials*

The strength of principal materials is shown in Table 11.1-1. The strength of concrete was set in consideration of Bogota conditions. The strength of steel shall be treated correspondingly to the ASTM.

Table 11.1-1 Strength of Materials

Material	Note	Strength
Concrete	For Superstructure	fc=280kgf/cm2
	For Substructure	fc=210kgf/cm2
	For Prestress	fc=350kgf/cm2
Reinforcing bar	(Grade 40)	fv=2800kgf/cm2
Prestressing Steel	(Grade 270)	fv=161kgf/mm2
Structural Steel	(M-183)	fu=4000kgf/cm2

Note fc: Specified compressive strength of concrete at 28 days

fv: Specified yield strength of reinforcement

fu: Minimum tension strength

(2) Structure Type

Structures which are dealt in this study are bridges, tunnels, retaining walls and box culverts. Highway bridges which will be planned in this study, are classified into large scale bridges which are constructed in mountainous area. Tunnels will be planned in mountainous area. Retaining walls and box culverts are planned in case of necessity. Selection criteria of each structure are indicated below.

1) *Superstructure of Bridge*

The superstructure of the bridge is generally classified by using materials into Reinforced Concrete (R.C.) Bridge, Prestressed Concrete (P.C.) bridge and steel bridge. In investigation of existing bridges in Bogota city, a lot of concrete bridges and a few of steel bridges were constructed. In Bogota city there are some large-scaled freshly mixed concrete factories. Therefore, cement and aggregate can be supplied domestically and also it is easy to gain freshly mixed concrete of high quality. On the contrary, there is no ironwork in Bogota city, so it is necessary to transport steel girders from Boyaca city. As a result of these constructing situations, all the bridges which were recently constructed in Bogota city are built of concrete. For the superstructure of this study concrete bridge in principle shall be adopted.

Concrete bridges are classified into R.C. bridge and P.C. bridge. The R.C. bridge is applied only to small span and P.C. bridge to medium-small and long-large span. It is possible to reduce the construction cost of bridges by using the local technology to the utmost, and so superstructure of existing bridge (P.C. Hollow Slab and P.C. Simple Composite I Girder) in Bogota city shall be adopted in principle.

In Bogota city, there is no bridge constructed in deep valley. The bridges of mountainous area will be constructed in deep valley, where the execution ability is an important factor to select a style. In this study, the P.C. box girder cantilever erection method shall be adopted, which has many experiences in the developed countries like Japan and America.

Applied span length of each style of bridges in the city and mountainous district is shown in Figure 11.2-1.

2) Substructure of Bridge

Bogota city has a large earthquake possibility, and so abutments and piers shall be the high aseismicity structure. For the substructure type of bridge, the reversed T-type abutment and the rectangular cantilever pier shall be adopted in principle. These types have many experiences in Japan and America which are developed countries in the aseismicity technology area.

3) Foundation of Bridge

In the underground soil of Bogota city, a layer at about 100 meters below surface, whose N-value is under 10, is not adequate for the bearing stratum. Judging by the soil condition, it is impossible to adopt the bearing pile. So the friction pile shall be adopted at site in the city. Regarding the kind of pile, the cast-in-place concrete pile shall be selected in principle.

In the mountainous area, the bedrock which is able to be bearing stratum, existed below surface. The spread foundation shall be adopted in principle.

4) Tunnel

In the mountainous area, the tunnels will be planned to be constructed.

5) Retaining Wall and Box Culvert

Form of retaining wall depends on the wall height. Gravity type, reversed T-type, and buttressed retaining wall shall be adopted in principal at a wall height of under 3 meters, 3 to 12 meters, and over 12 meters, respectively. For the foundation of retaining wall, the cast-in place concrete pile or spread foundation shall be adopted in the same way as the foundation of bridge.

Box culvert shall be selected spread foundation after examination about balance of stresses in a ground, pile foundation in principle shall not be adopted.

11.2. PREPARATION OF ALTERNATIVE PLANS

11.2.1. BASIC CONSIDERATION FOR ALTERNATIVE ROUTE PLANS

During the period from 1995 to 1996, the Master Plan for Urban Transport of Santa Fe de Bogota was conducted by JICA. In the Master Plan, the Urban Expressway Network development projects were recommended as short and long term plans for mitigation of traffic congestion in the city of Bogota. The general concept of recommended Urban Expressway in the Master Plan was as follows,

1) Design speed; 60 to 80 km/h
2) 4-Lane dual carriageway
3) Road type; viaduct
4) Full access control system introduced
5) Toll system introduced.

Based on the results of various field surveys, policy and strategy for planning of Inner Ring Expressway as mentioned above, and the general concept plan of Urban Expressway recommended by the Master Plan, alternative examination of this study is carried out. In addition to the above, alternative plan is examined by discussion to discuss with Colombian counterpart personnel.

11.2.2. ROUTE ALTERNATIVE PLANS

(1) Preparation of Basic Alternative Routes

The major purpose or function of the Inner Ring Expressway is to mitigate the traffic congestion in the central area of Bogota, and to divert the traffic flows from / to the radial roads within the city. When preparing alternative routes, the following seven (7) items should be considered.

1) To meet a traffic characteristics and traffic volume.

As previously mentioned, the most congested traffic area of Bogota is identified as the central area covered by Avenida 7, Calle 100, Avenida Quito, and Calle 6. Considering the function and characteristics of the Inner Ring Expressway, the Inner Ring Expressway should be covered within the short term development plan. In the future, a 2nd Ring Expressway network should be constructed according to the increase in volume of future traffic. Basically, the Urban Expressway network of city of Bogota is formed as ring and radial expressway network considering the traffic characteristics of Bogota. As mentioned previous, the Inner Ring Expressway is identified as the subject route of this Feasibility Study.

From viewpoint of the traffic characteristics of Bogota for preparation of Inner Ring Expressway route, the following existing routes are selected for the Inner Ring Expressway.

1) Avenida 7
2) Calle 100
3) Avenida Quito
4) Calle 6

2) To meet the existing road network pattern.

The existing trunk road and local road network in the central area from a ring and radial pattern, as well as grid pattern. In the design, the Inner Ring Expressway will follow the existing trunk road network pattern considering easy traffic control and the function of Inner Ring Expressway.

3) To avoid the historical monuments or preserved buildings.

As a result of field survey and data collection, it was found that there are many historical monuments and buildings to be preserved along the existing trunk roads. Basically, the Inner Ring Expressway will be constructed using the existing road area (within right of way), and preserving historical monuments and buildings which are located outside of the existing roads. Therefore, the issues or problems of preservation of environment are not significant, however, location of interchange or segments of small horizontal curve of Inner Ring Expressway route would have to be carefully examined.

4) To preserve the natural and social environment along the existing roads as much as possible.

There are some wooded areas (roadside tree) on both sides of the trunk roads, and they have been kept in good natural condition. The Inner Ring Expressway will be constructed to use the area of the right of way of the existing road, therefore, the route of Inner Ring Expressway may affect the natural and social environmental aspects of the existing road. In this case, effectiveness of environment will be carefully maintained.

From the above viewpoints mentioned earlier, it is very difficult to locate the Inner Ring Expressway route on the existing Avenida 7 due to the width imitation of Avenida 7 (about 30m). In addition, there are many buildings constructed along both sides of road. On the other hand, it is comparatively difficult that the Inner Ring Expressway will be located on the existing Calle 100 because a good natural environment has to be maintained.

5) To avoid the narrow width road (less than 6-lane road).

Considering the preservation of natural and social environmental aspects, the Inner Ring Expressway should be located on the existing road which have more than 6-lane width. The roads which have more than 6-lane carriage in the central area are Avenida 7, Calle 100, Avenida Quito, Avenida Caracas, Avenida Chile, Calle 26, Calle 13, and Calle 6. The number of lane son the other roads of central area are less than 4-lane.

6) To maintain easy construction and minimum cost.

The railway lane was planned on the existing Calle 13 with viaduct type, Avenida 7 with tunnel type, and Avenida Chile with tunnel type. The stage 1 section of this railway will be completed by the year 2005 and stage 2 section will be completed by the year 2010 respectively. When the Inner Ring Expressway will be located on the same route of the railway, a construction method and cost should be examined carefully.

Based on the various field surveys, discussion with Colombian counterparts, analysis of the above mentioned matters, and policies and strategies for planning, the following three (3) Alternative Routes, namely Alternative Route-1, Alternative Route-2, and Alternative Route-3 are identified as shown in Figure 11.2-1 to Figure 11.2-3.

(2) Alternative Route-1

Alternative Route-1 is located along the existing road of Calle 100, Avenida Quito, Calle 6, and passes through an altitude of 2,800 meters above sea level in the mountain area parallel with the existing Avenida Circunvalar as shown in Figure 11.2-1. The road network configuration of Inner Ring Expressway is formed as a ring road network pattern. This mountain area is very steep, therefore, long tunnel and many long span bridges will be required for construction of the road. In addition, it is very difficult to construct approach roads (ramps or interchange) from this road to the existing Avenida Circunvalar. The construction cost of this route may be very high.

The major issues to be resolved on Alternative Route-1 are as follows:

1) To keep a good natural environment

2) To maintain a social environment (re-settlement)

3) To decrease construction cost.

4) To preserve the road side plantation as much as possible

5) To examine the type of road considering the environmental aspects

(3) Alternative Route-2

Alternative Route -2 is located on the existing road of Calle 100, Avenida Quito, Calle 6, and Avenida 7 as shown in Figure 11.2-2. Part of Alternative Route-2 is located on Avenida 7, and also a part of railway route (about 6 km) is planned at the existing Avenida 7 with tunnel. The road network configuration of Inner Ring Expressway is formed as a ring road network pattern. Careful examination for road structure should be carried out in this road segment (about 6 km) considering the layout and dimension of the structure of railway system. The stage-1 of railway will be completed by the year 2005.

The major issues to be resolved on Alternative Route-2 are as follows:

1) To maintain a urban environment (perspective of town on the Avenida 7)

2) To examine a structure type considering railway tunnel.

3) To preserve the road side plantation

4) To decrease the construction cost

5) To examine the type of road (considering the environmental aspects).

(4) Alternative Route-3

Alternative Route-3 is located on the existing road of Calle 100, Avenida Quito, and Calle 6 as shown in Figure 11.2-3. The road network configuration of Inner Ring Expressway is formed as half ring road network pattern. Alternative Route-3 passes through the comparatively wide roads with over 60 meters right of way (ROW), so, the construction method may be comparatively easy. However, many over passes are necessary at the major inter section between Avenida Quito and trunk road crossing.

The major issues to be resolved in the Alternative Route-3 are as follows,

1) To preserve the roadside trees at both sides of the existing Calle 100, Avenida Quito, and Calle 6.

2) To examine the type of road (over pass type or under pass type) considering the environmental aspects.

3) To control the traffic flow from interchange.

(5) General Description of Alternative Routes

The above-mentioned conditions of each Alternative Route are summarized in Table 11.2-1.

Table 11.2-1 Outline of Each Alternative Route

Alternative/Items	Alt. Route-1	Alt. Route-2	Alt. Route-3
Location Road	1) Av. Circunvalar 2) Calle 100 3) Av. Quito 4) Calle 6	1) Av. Ceputima(7) 2) Calle 100 3) Av. Quito 4) Calle 6	1) Calle 100 2) Av. Quito 3) Calle 6
Network Pattern	Full Ring Road Pattern	Full Ring Road Pattern	Half Ring Road Pattern
Land Use	Mountain Area Urban Area	Urban Area	Urban Area
No. of Lane	Over 4-lane	Over 4-lane	Over 4-lane
Design Speed	60-80 km/h	60-80km/h	60-80 km/h
Max. Grade	5 %	3 %	3%
Min. Curve			
Bridge Length (km)	25.89	29.42	18.82
Tunnel Length (km)	6.84	0	0
Earth Length (km)	2.14	0	0
Total Length (km)	34.87	29.42	18.82
Road Type to be Considered	1) Bridge(long span) 2) Tunnel 3) Earthwork	1) Over Bridge 2) Under Bridge	1) Over Bridge 2) Under Bridge

11.2.3. EVALUATION ITEMS OF ALTERNATIVE ROUTES

The above mentioned three Alternative Routes is evaluated based on the results of the following view points.

1) From View Point of Traffic Conditions

a) Effects of vehicle total running kilometers increased.

b) Effects of vehicle total running hours decreased.

c) Effects of average running speed increased on related roads.

d) Effects of traffic congestion degree decreased on related roads.

2) From View Point of Construction Conditions

a) Construction difficulty.

b) Traffic control during construction period.

c) Demolition of existing road facilities.

d) Safety measurement.

3) From View Point of Economical Conditions.

a) Construction cost

b) Maintenance cost.

4) From View Point of Environmental Conditions.

a) Influence or impacts of city landscape conditions.

b) Influence or impacts of city perspective conditions.

c) Preservation of natural environmental aspects.

d) Preservation of historical structures.

e) Resettlement and compensation

f) Squatters problems

g) Influence of noise and air pollution.

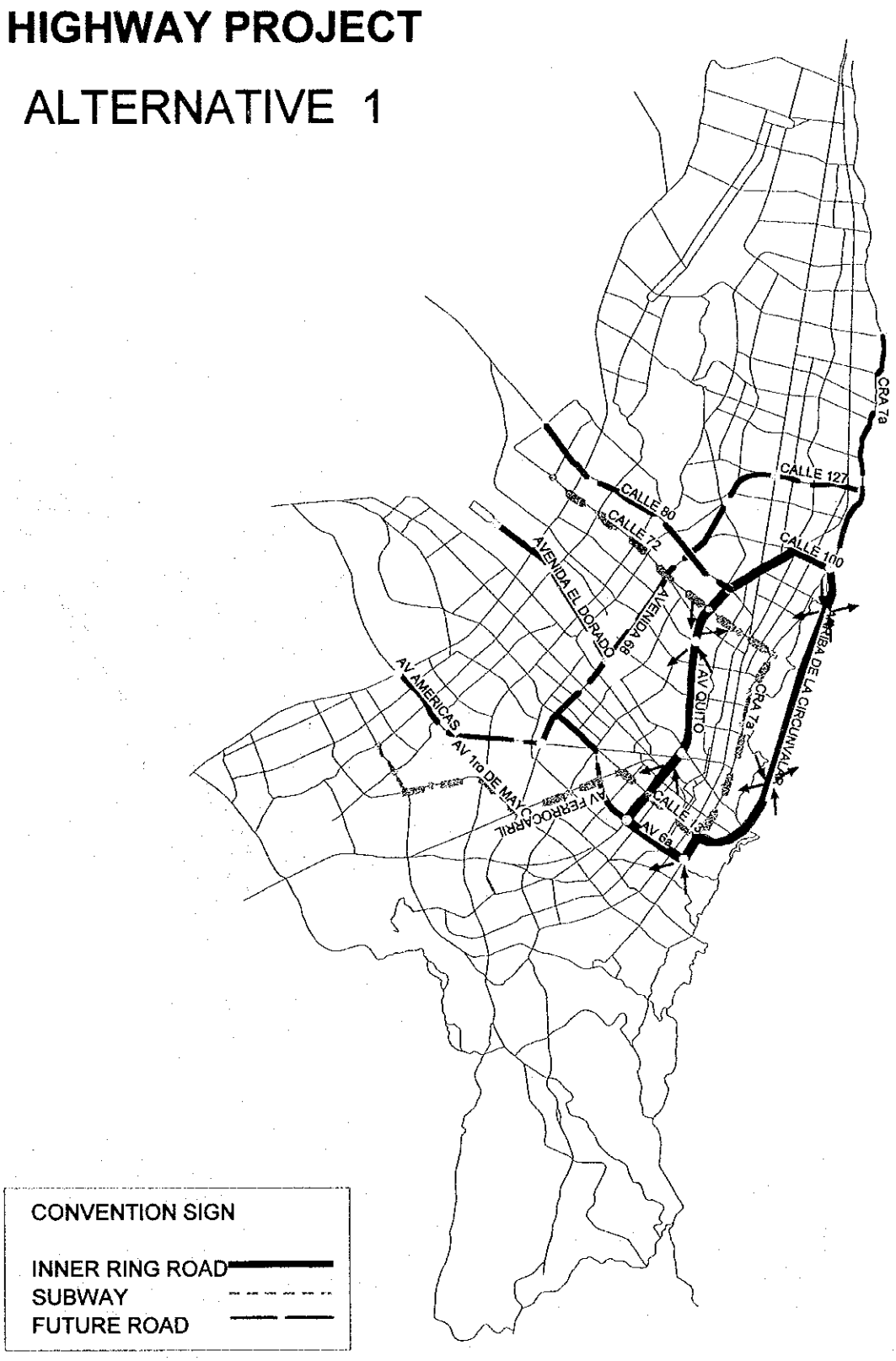

Figure 11.2-1 Location of Basic Alternative Route-1

Figure 11.2-2 Location of Basic Alternative Route-2

Figure 11.2-3 Location of Alternative Route-3

11.2.4. PREPARATION OF ALTERNATIVE CROSS-SECTION PLANS

(1) Basic Consideration for Preparation of Alternatives.

In general, the Inner Ring Expressway routes are planned considering the use of the space which is covered by right of way (ROW) of the existing roads as much as possible. However, the cross section elements of the existing roads vary depending on the classification of the road, traffic volume and characteristics of the road, and land use along the road. Therefore, it is difficult to identify a typical cross section of the Inner Ring Expressway. When the elements of cross section are examined, the following items will be considered, and based on the results of above-mentioned examination, the alternative cross sections will be prepared.

1) Regarding the Calle 100.

a) Existing road-side plantation conditions
b) Existing intersection type (at-grade or grade separated)
c) Feather of median strip and pedestrians
d) Flood control conditions
e) Construction cost

2) Regarding the Avenida Quito

a) Location of existing railway line
b) Location of existing canal
c) Location and type of intersection
d) Existing road-side plantation conditions
e) Feather of median strip and pedestrians
f) Flood control conditions
g) Perspective for environment
h) Construction cost

3) Regarding Calle 6

a) Location of existing canal
b) Existing intersection conditions
c) Feather of median strip and pedestrians
d) Flood control conditions
e) Construction cost

4) Regarding Avenida 7

a) Location of railway line
b) Structure of railway
c) Space for construction
d) Perspective for environment
e) Construction cost

5) Regarding mountain area (over Cirucunvaral)

a) Natural and social environment

b) Natural feather (topographic and geographic conditions)

c) Construction method

d) Construction cost

(2) Evaluation Items

By considering the above mentioned consideration of the alternative cross section items, environmental conditions along the existing roads and results of field reconnaissance survey, the following Alternative Cross Section plans are identified as shown in Table 11.2-2. In accordance with above mentioned matters, the concrete alternative cross sections on each route are examined in Chapter 15. The alternative cross section plans are evaluated based on the following view points.

1) From View Points of Technical Conditions.

a) Construction difficulty.

b) Traffic control during construction period.

c) Relation of exiting road facilities over the roads.

d) Relation of underground facilities.

e) Maintenance difficulty.

f) Relation of access to the existing roads.

2) From View Point of Environmental Aspects.

a) Influence or impacts of city landscape conditions.

b) Influence or impacts of city perspective conditions.

c) Preservation of road-side tree (natural conditions)

d) Preservation of historical structures conditions.

e) Resettlement

f) Squatters problems

g) Influence or impacts of noise and air pollution.

3) From View Points of Economic Conditions.

a) Construction cost.

b) Maintenance cost

Table 11.2-2 Alternative Cross section

Alternative/ Road	At-Grade Type	Viaduct Type	Tunnel Type
Calle 100	X	O	O
Avenida Quito(1)	X	O	O
Avenida Quito(2)	X	O	O
Avenida 7a	X	O	O
Calle 6	X	O	O
Cirucunvaral	O	O	O

Note ; X = Not Considered, O = Considered

11.2.5. TOLL SYSTEM ALTERNATIVE PLAN

Generally, the road type of Urban Expressway is constructed by viaduct or underground structure to utilize the existing roadway areas and river or canal areas, due to lack of space for construction of new road in the urban areas. Therefore, the construction cost is very high compared with the at-grade roads. Considering the construction cost of the Urban Expressway and recent shortage of budget of the Government as well as the introductions of burden on beneficiaries, many Urban Expressways in the world are operating to introduce the toll system. Taking into account the above-mentioned matters, the Inner Ring Expressway also will be operated through introduction of the toll road system.

There are two (2) different toll roads; the first is the distance scale rate system where the toll charge is increased in accordance with the running distance, and the second is the constant rate system which is the toll charge is constant regardless of the running distance. Generally, the distance scale rate system is adopted on the long distance route and the constant rate is adopted on the short distance route. Considering the road length and trip length, traffic control conditions of the road, the constant rate system will be adopted for the toll system of Inner Ring Expressway.

CHAPTER 12
Initial Environmental Examination

12. INITIAL ENVIRONMENTAL EXAMINATION

12.1. INTRODUCTION

12.1.1. OBJECTIVES.

The objectives of this Initial Environmental Examination (IEE) are to identify potential environmental concerns at a sufficiently early stage in the project development so that appropriate measures are incorporated into the scheme selection, planning and design to ensure that it is environmentally sound. It allows the designers to address environmental issues in a cost effective fashion after all possible scheme and design alternatives are considered.

12.1.2. OUTLINE.

In view of the current condition of the transportation network in Santa Fe de Bogota, the Government of Colombia requested the Government of Japan to undertake a study to assess the feasibility of this project. The study will make recommendations for a new expressway and the bus way which are economically viable and provide good facilities.

This report summarizes the results of the IEE which assesses the pros and cons of three alternative plans the project. Sections 12.2 and 12.3 describe the environmental baseline, and the policy, legal and administrative framework. Results of the opinion survey are discussed in Section 12.5. Based on the environmental information summarized in Section 12.2, initial environmental scoping and screening for each route are carried out in Section 12.6. In Section 12.7, the result of the initial environmental evaluation of the proposed project is summarized. The assessments of the environmental impacts, related mitigation measures, its management and monitoring plan will be scheduled to be summarized after the preferred route option will be chosen.

12.2. DESCRIPTION OF ENVIRONMENT

12.2.1. BIO-PHYSICAL ENVIRONMENT

(1) Topography

Bogota is a high land city in the Andes Mountains which were made by fold movement caused by the confrontation of the Nazca Plate (moving to the east by 7 cm/year) and the South American Plate (moving to the west by 3 cm/year). The urban area of the city is located mainly in the Bogota Plain, so-called Savanna of Bogota, except by a small hill of Suba and hills in the Simon Bolívar City. The remaining eastern part of the urban area is located at the foot of the Oriental Mountains (Cerros Orientales) of Bogota.

The Bogota Plain is a very flat high land where the average inclination is less than 1%, and an altitude of 2,600 EL-m. The plain is made up of sediments of former lakes sediments and marshes which were formed by damming up one of the synclinal valleys of Andes Mountains.

The Oriental Mountains of Bogota, an important symbolic landscape of the capital city, can be seen from the Savanna of Bogota, and its mountain structure is classified as an anticlinal range (Bogota Anticlinal Range). The average inclination of the western flank is from 12% to 50% in the northern half and 25% to 100% in the southern one. The elevation of the skyline is more or less 3,000 EL-m. The 2,800 EL-m line is defined as the eastern limit of urban area, which is the limit where public services will be provided if

development plan is authorized. The area to the east and above the 2,800 EL-m altitude is defined as a rural area of Bogota which is under control of urbanization.

The project route of the New Avenida Circunvaral lies from north to south along the Oriental Mountains going from the northern foot, then halfway up to the level of 2,800 EL-m and keeps the same elevation until it goes down to the city center area. Halfway up the Oriental Mountains it is very steep rocky slope while the foot forms less steep mountain skirt, which is made of the products of the sedimentation. The northern half of Avenida 7a is located at the foot of the Oriental Mountains. The northern part of Avenida Suba passes on the rocky hill of Suba. The rest of the roads and streets of concern such as Avenida Caracas-Autopista Norte, Avenida Quito- Autopista Sur, Avenida 68 and Calle 170, are in the Bogota Plain.

(2) Climate

The microclimate of the city varies depending on topographic conditions. In the Bogota Plain the annual precipitation is from 600 mm (in the southwest of Bogota) to 1,000 mm (in the east of the city). In the Oriental Mountains the annual precipitation is about 1,200 mm. There are two rainy seasons (March-May and October-November) and two dry seasons (December-February and June-September). The yearly-average temperature is about 14.4°C in the Bogota Plain at elevation of 2,600 EL-m. In the Oriental Mountains, the temperature goes down by 0.625 °C each 100 meters of elevation-up, that means the average temperature will be around 13.1°C at elevation of 2,800 EL-m. No significant monthly temperature variation (within only ± 0.5°C) is observed.

According to the meteorological data observed at the airport, annual evaporation is 1,066 mm, yearly. Average relative humidity is 80 %, dew temperature is 9.8 °C, duration of sunshine is 1,652 hours, and wind velocity is 2.1 m/sec.

(3) Geology and Seismology

The Bogota Plain is made of very deep and soft clay strata, originally lacustrian sediments of the Fourth Era, which has a maximum depth of 500 m. The groundwater level is relatively high, and, sometimes less than 1 meter under the ground surface. The Anticlinal Range of Bogota, which forms the Oriental Mountains, can be divided structurally into two parts: one is the inverted anticlinal range in the southern half, and the other is the normal anticlinal range in the northern half. The western flank of the inverted anticlinal range, typically observed in the height of Monserrate, is made up of the Third Era's formation of Bogota and the Chalk Era's formations like those of Guaduas, Plaeners and Arenisca Dura, presenting the erosion of anti-slope stratum and very steep rocky precipice. The northern half, the normal anticlinal range, is made up of the Chalk Era's formations like those of Labor y Tierna and Plaeners and Forth Era's sediments.

Colombia is located in the Pacific Seismological Ring. In Bogota, severe earthquakes do not occur so frequently because of the depth of the confronting plates. However, the city is located between two major faults such as the Fault of Oriental Cordillera and the Fault of Romeral. So it can be said that Bogota is a potentially dangerous, earthquake-prone city. There exist the Fault of Bogota and the Fault of El Cabo running parallel to the foot of the Oriental Mountains and eastern edge of the Bogota Plain, and some part of this fault-line is very close to Avenida 7a route. 14 earthquakes of above IX grades in MSK happened in the latest 351 years (once every 27 years) that affected the city.

Most of the Oriental Mountains area is classified as zone of geological instability and of high potentiality of erosion. There is a fear of the landslide, especially in the abandoned quarries because of inadequate management. In 1992, about 233,000 people lived in geologically high-risk zones. Table 12.2-1 summarizes major earthquakes recorded at the Bogota Plain within last 400 years.

Table 12.2-1 Major Seismic Record at Bogota Plain (period: 1600 – 1994)

Range in Richter	Occurrence			
	1600-1700	1700-1800	1800-1900	1900-
6	2	3	0	8
7	3	5	2	15
8	1	7	10	18
9	1	0	0	0

Source: EJECUTORA (Ed), Microzonification sismica de Santa Fe De Bogota, August 1997

(4) Soils

In the Bogota Plain, the origin of soils is of fluvial and lacustrian clay sediments, with erosive sand sediments in the Oriental Mountains. From the point of agricultural adequacy, the soil type is classified into eight categories (from category I to VIII). Mainly, the rural area of the Bogota Plain is categorized into Type I and III: i.e., good for cultivation with little limitation (I), and good for cultivation but under special management such as artificial drainage (III). The Oriental Mountains area can be categorized into VI and VII. This indicates there is severe (VI) or very severe (VII) limitation for agricultural cultivation but only good for pastures and forests. Soils around the New Circunvaral route is classified into VI and VII (i.e., no good for cultivation but only good for pastures and forests).

(5) Hydrology

Bogota River runs through the western boundary of the capital city, and all urban area of Bogota is situated in the Bogota River Basin. There are two branches which pass through the city from east to west and join the Bogota River in the western border of the city: Juan Amarillo River and Fucha River, both rivers originate from the Oriental Mountains.

Also, several small rivers and streams are running through the erosive valleys of the Oriental Mountains. At right angle to the Fault of Bogota, there are small faults such as Diablo Fault and San Francisco Fault, where small rivers with steep gradient such as the River of San Francisco and Streams of Arzobispo, Las Delicias, La Vieja, Los Rosales and La Chorrera are developed. These rivers are running from east to west via the urban-drainage channels, and eventually join the branches of the Bogota River at the downstream side. In the central city area, some Undergrounded channels are constructed (e.g., San Francisco River goes under the Jimenez Avenue).

In the rainy seasons, sometimes, torrential rains hit the city and cause local flood problems at the foot of the Oriental Mountains. This flood occurs so sudden and reaches the urban area within a short period due to the steep gradient of the streams. Besides, sometimes, small capacity of the urban drainage system tends to make this situation worse. There are areas of risk of flooding along the Bogota River and its branches where the longitudinal gradient is small. In 1992, about 151,000 people lived in these areas.

Several tributaries are running through Bogota, and the water quality and flow rate are measured at several points along the municipal boundary by DAMA [DAMA, personal communication, 1998]. The measurement itself was started since September, 1997 and is operated for three hours per day. Within this measurement, following nine parameters are of concern: flow rate, pH, BOD, COD, SS, temperature, Pb, Cu and Al.

(6) Air Quality

Due to the current heavy traffic condition, the air quality of entire Bogota is not good. Recently, a city-wide air quality measurement was organized in order to monitor the temporal and spatial variation of several important air quality parameters. Table 12.2-2

summarizes twelve automatic air quality and atmospheric measurement stations installed across the cityBogota [DAMA, personal communication, 1998]. All twelve stations started their measurement since December 1997, and are operated by DAMA. Station # 4 is located at the same point where other JICA Study Team installed one of measurement stations in 1991. Ten are used for the air quality and two for meteorological purposes. Also, the field measurement of the car exhaust gas, organized by DAMA, were started regularly since December, 1997 [DAMA, personal communication, 1998], and currently, measured data is stored constantly.

Table 12.2-2 Air Quality and atmospheric measurement station (Bogota)

	Name	Parameters
1	Universidad El Bosque Estacion Ambiental	Dust, SO_2, NO, NO_2, Wind velocity & direction, Rain.
2	RCN Radio-Casa Espania Estacion Ambiental DOAS	Dust, O_3, CO, SO_2, NO_2, CH_4, Wind velocity & direction, Rain, Benzene, Toluene, Formaldehyde.
3	Sony Music Estacion Ambiental	Dust, O_3, CO, SO_2, NO, NO_2, CH_4, Wind velocity & direction, Rain.
4	Hospital Olaya-Aslo MI Casa Estacion Ambiental DOAS	Dust, O_3, CO, SO_2, NO_2, Wind velocity & direction, Rain, Benzene, Toluene, Formaldehyde.
5	Universidad Nacional Estacion Ambiental	O_3, SO_2, NO, NO_2, Wind velocity & direction, Rain.
6	DAMA-Engativa Estacion Ambiental	Dust, SO_2, NO, NO_2, CH_4, Wind velocity & direction, Temperature, Rain.
7	Cazuca Estacion Ambiental	Dust, O_3, CO, SO_2, NO, NO_2, Wind velocity & direction, Rain.
8	Escuela Colombiana de Ingenieria Ambiental Meteorologica	Wind velocity & direction (2D-3D), Rain, Pressure, Humidity, Radiation.
9	Central de Mezclas Estacion Meteorologica	Wind velocity & direction (2D-3D), Rain, Pressure, Humidity, Radiation.
10	Universidad Santo Tomas Estacion Ambiental	Dust, SO_2, NO, NO_2, Wind velocity & direction, Rain.
11	Universidad Juan Corpas Estacion Ambiental	Dust, CO, SO_2, NO, NO_2, Wind velocity & direction, Temperature, Rain.
12	Empresa de Energia Estacion Ambiental.	Dust, SO_2, NO, NO_2, Wind velocity & direction, Temperature, Rain.

Note DOAS: Difference of Optical Absorption Spectrum.

(7) Water Resources

There are three main water resources for the capital city: Dam Lakes of Chingaza and San Rafael, Dam Lake of Muña, and Dam Lakes of La Regadera and Chisaca. The main water resource is from the Chingaza System in the Orinoco Basin, which is transported by Undergrounded channel to San Rafael Dam Lake. Other water resources are from upper streams of Bogota – Magdalena Basin.

Total amount of the water supply is 1,580,000 m^3/day (18.3 m^3/sec) in 1997. It is estimated that the demand will rise up to 2,780,000 m^3/day (32.2 m^3/sec) in 2015. Several water resources development plans such as Chingaza Sur-este, Chuza Norte and Sumapaz Medio sites are under consideration.

There are approximately four hundred wells across the city [DAMA, personal communication, 1998]. Daily average pumping rate is about 15,000 m^3/day. Generally, wells scattered in the northern part of the city are for the drinking purposes while wells in the metro are for the industrial-use. Water quality tests at thirty points were carried out by

requests from local residents in 1998. In thoes tests, the following three parameters of concern were pH, SS and Coli-form.

(8) Noise, Vibration

So far, no substantial noise and vibration along major road was reported organized by DAMA except from several factories and discotheque places across the city [DAMA, personal communication, 1998]. Currently, a city-wide noise measurement plan that will operate a continuous noise measurement at multiple locations of the city road network is under consideration.

(9) Vegetation

The natural vegetation in the Bogota Plain is completely destroyed because of use of urbanization and pastures except some damp vegetation remaining in a small area of the branches of the Bogota River. Also, the vegetation in the Oriental Mountains are considerably affected by human activities from the pre-columbine age, there is no natural forest left but a few secondary forests. Most of the forests are artificially planted with foreign species like eucalyptus and pines. The rest of vegetation is pasture, shrubs and areas without vegetation, resulted from recent urbanization and quarry developments. No rare flora species is reported in the study area.

After a rapid urbanization started, many foreign species were introduced to Bogota. The predominant species of grass is Kikuyo (*pennisetum clandestinum, Graminea*) which is Kenya origin. Urapán or ash (*Fraxinus chinensis, Oleaceae*), Japan origin, is the most typical tree in the streets and parks in Bogota. In 1994, tree damage caused by insect attack happened around vegetation at the airport. The damage spread out all over the city, and about 90% of Urapán suffered from the insects' attack and most were dying. This insect is identified as *Tropidosteptes chapingensis,* and no solution was found at this moment. Pino pátula (Pinus patula) and Ciprés (*Cupressus lusitanica*) are also very commonly seen in the city, and some of those tree began to die since early 1990s due to the pine warm (Pino pátula) attack and the infection of mold and bacterias after insects' attack (Ciprés). Nowadays, the utilization of native species is promoted because of the recent failure of foreign species introduction.

Table 12.2-3 Most typical trees in the streets and parks in Bogota (23 species)

Spanish Name	Scientific Name	Family
Urapán	*Fraxinus chinensis*	*Oleaceae*
Eucalipto	*Eucalyptus globulus*	*Myrtaceae*
Ciprés	*Cupressus lusitanica*	*Cupressaceae*
Sauce *	*Salix humboldtiana*	*Salicaceae*
Caucho sabanero *	*Ficus soatensis*	*Moraceae*
Guayacán de Manizales *	*Lafoensia speciosa*	*Lythraceae*
Sangregado *	*Croton funckianus*	*Euphorbiaceae*
Acacia gris	*Acacia decurrens*	*Mimosaceae*
Acacia japonesa	*Acacia melanoxylon*	*Mimosaceae*
Cerezo	*Prunus*	*Rosaceae*
Aliso *	*Alnus acuminata*	*Betulaceae*
Jazmin del Cabo	*Pittosporum undulatum*	*Pittosporaceae*
Pimiento	*Schinus molle*	*Anacardiaceae*
Pomarroso	*Syzygium jambos*	*Myrtaceae*
Pino romerón *	*Podocarpus rospigliosii*	*Podocarpaceae*
Nogal *	*Juglans neotropica*	*Juglandaceae*
Roble *	*Quercus humboldtii*	*Fagaceae*
Tibar *	Escallonia paniculata	*Escalloniaceae*
Cedro de tierra fria *	Cedrela montana	*Meliaceae*
Pino pátula	Pinus patula	*Pinaceae*
Chicalá	Tecoma stans	*Bignoniaceae*
Magnolio	Magnolia grandiflora	*Magnoliaceae*
Liquidambar	*Liquidambar styraciflua*	*Hamamelidaseae*

Note: Symbol "*" indicates native species [Kawashima, 1998].

Table 12.2-4 Most typical shrubs in the streets and parks in Bogota (17 species).

Spanish Name	Scientific Name	Family
Sauco *	Sanbucus peruviana	*Caprifoliaceae*
Holly	*Pyracantha coccinea*	*Rosaceae*
Mermelada	*Streptosolen jamesonii*	*Solanaceae*
Alcaparro enano	*Cassia tomentosa*	*Caesalpinaceae*
Alcaparro doble	*Senna viarum*	*Caesalpinaceae*
Sietecueros nativo *	*Tibouchina lepidota*	*Melastomataceae*
Sietecueros brasilero	*Tibouchina urvilleana*	*Melastomataceae*
Amarrabollo *	*Meriania nobilis*	*Melastomataceae*
Feijoa	*Feijoa sellowiana*	*Mytaceae*
Zarcillejo	*Fuchsia boliviana*	*Onagraceae*
Abutilón	*Abutilon insigne*	*Malvaceae*
Escobo	*Malvaviscus arboleus*	*Malvaceae*
Laurel *	*Myrica parvifolia*	*Myricaceae*
Mimbre	*Salix viminalis*	*Salicaceae*
Arrayán *	*Eugenia foliosa*	*Myrtaceae*
Mortiño *	*Hesperomeles goudotiana*	*Rosaceae*
Rodamonte *	*Escallonia Myrtilloides*	*Escalloniaceae*

Note: Symbol "*" indicates native species [Kawashima, 1998].

There is a preserved forest area near the military base at Avenida 7a, so-called *Sierras del Chico*. Around that area, there are shrubs mixed with some small trees, and the vegetation itself does not have big ecological value, but it is in the process of the natural recovery.

Sometimes, forest fires occur in dry seasons in the Oriental Mountains. Because of those fires, not so many forests are remained in the area but shrubs can be seen (see Table 12.2-4). This area is declared as the area of the public utilization, and the application of the construction license of the development project that covered this area was denied by the Planning Department of Bogota in the past.

(10)Fauna

The study area is highly urbanized and no rare, domestic species of fauna is reported. However, a lot of species of domestic and migrant birds can be observed in natural swamps, the botanic garden and other green areas. It is noted that many species of bats are observed in the Savanna of Bogota. Because of the Bogota River contamination, most of native species of fish have disappeared, however, in the branches of the Bogota River, several species are reported (see Table 12.2-5).

Table 12.2-5 Principal Species of Fish reported in the Region of the Savanna of Bogota.

Spanish Name	Scientific Name
Capitán de la sabana *	Eremophilus mutissi
Guapucha *	Grundulus bogotensis
Capitán enano *	Pygidium bogotensis
Trucha arco iris	Salmo gairdneri
Carpa	Cyprinus carpi

Note: Symbol "*" indicates native species [Kawashima,1998].

12.2.2. Socio-Cultural Environment.

(1) Population and Settlements.

According to the 1993 census data, the population of Bogota is reported as 5,484,244, representing 14.7 % of total country population of 37,422,791. The estimated total 1997 country population is 5,917,430. Estimated population density in the urban area of 1997 is 140.51 person/ha. The following are fundamental statistics of Colombia of 1996.

Birth rate per 1,000 inhabitants:	22.3 persons
Death rate per 1,000 inhabitants:	4.8 persons
Average life expectancy:	Men - 68.0 years, women - 75.0 years.
Literacy rate:	96.16% (1996)

Generally, Bogota can be classified into six stratums (Table 12.2-6). Basically, lower-income people live within stratums 1 or 2 whereas higher-income people within stratums 5 or 6.

Table 12.2-6 Socio-economic strata in urban area (1997).

Strata	Estimated Inhabitants [1]	Percentage of Inhabitants	Percentage of City Blocks[2]
Stratum 1	154,000	3 %	9.3 %
Stratum 2	1,959,000	34 %	42.7 %
Stratum 3	2,353,000	41 %	30.2 %
Stratum 4	733,000	13 %	9.1 %
Stratum 5	444,000	8 %	3.7 %
Stratum 6	121,000	2 %	1.7 %
No Stratum defined	-	-	3.3 %
Total	5,764,000	100%	100 %

Source: (1) after EL MIRADOR DE BOGOTA , (2) ESTADISTICAS Santa Fé de Bogotá, D.C., 1997

Table 12.2-7 summarizes migrating situation of Bogota. From this table, almost half of people living in Bogota in 1993 migrated from outside the city.

Table 12.2-7 Birth Origin of Bogota Citizens (1993).

Birth Place	Inhabitants	Percentage
Bogota	2,715,754	55.2 %
Other Places in Colombia	1,656,647	33.7 %
Other Countries	109,152	2.2 %
No Information	441,272	9.0 %
Total	4,922,825	100 %

Source: ESTADISTICAS Santa Fé de Bogotá, D.C., 1997.

In 1996, there were 151,783 illegal lots at where 819,628 inhabitants (14.5% of total population) lived. Also in 1996, most of the illegal settlement area were legalized by the Resolution No.1126 of 1996. Within this study, some illegal squatter area are found along the New Circunvaral route.

(2) Land Use

Bogota has an administrative area of 173,170 ha with 19 wards. The urban area is 33,780 ha and the administrative, commercial and business district are located around *Centro*. Generally, the high-class residential areas are extending northward whereas lower-class south-west ward or southward.

Urbanization around the New Circunvaral route began in 1970's due to the rapid expansion of metro. New apartment complex is built around the northern half of this route while middle and lower income class housing, private schools and universities exist. Some of urban conservation areas such as *La Merced* exist near this route. Also, several illegal squatter housings are found around the upper zone of this route. There are also illegal quarry sites around there.

(3) Industry

1996 Gross Domestic Product of Bogota is 7,724,862 million Colombian Peso while that of entire country is 26,017,731 million Colombian Peso (29.7% of total national GDP). Table 12.2-8 summarizes GDP percentage of major industries of entire country and Bogota.

(4) Employment and Income

Table 12.2-9 summarizes the formal/and informal employment situation of Bogota in 1994. Unemployment rate of Bogota in 1996 is reported as 10.4%. Table 12.2-10 summarizes the economically active population with/or without occupation. Income per capita in 19 wards across Bogota in 1996 is 1,556,541Colombian Pesos. Table 12.2-11 summarizes salary income distribution.

Table 12.2-8 Industries in GDP of Bogota and Colombia (1985).

Industries	Percentage Colombia	Percentage Bogota
Agriculture and Cattle-raising	16.7	0.1
Mining	4.2	0.0
Industry	21.4	22.2
Electricity, Gas and Water	2.2	1.7
Construction, Public Work	6.9	4.6
Commerce	10.4	10.3
Transportation	6.9	9.3
Communication	1.2	2.7
Financial Services	6.1	9.2
Immovables' Services	6.2	10.4
Personal Services	8.5	13.8
Governmental Services	8.5	14.0
Domestic Services	0.4	0.3
Others	0.4	1.4
Total	100	100

Source: Information of DANE

Table 12.2-9 Formal and Informal Employment (1994).

	Formal Employment	Informal Employment	Total
Men	653,636	646,379	1,300,015
Women	454,889	468,330	923,219
Total	1,108,525	1,114,709	2,223,234

Source: ESTADISTICAS Santa Fé de Bogotá, D.C., 1997.

Table 12.2-10 Economically active population (1996).

	With occupation	Without occupation	Total
Men	1,350,132	77,937	1,428,069
Women	1,027,832	135,208	1,163,040
Total	2,377,964	213,145	2,591,109

Source: ESTADISTICAS Santa Fé de Bogotá, D.C., 1997.

Table 12.2-11 Salary incomes in Bogotá (1996).

Level of Income	Population with occupation
No Information	284,071
Not receiving salary	81,664
Less than half M. S.	103,038
1/2 - 1 M. S.	227,080
1 - 2 M. S.	945,667
2 - 5 M. S.	568,602
5 - 10 M. S.	110,029
More than 10 M. S.	57,813
Total	2,377,964

Note: M.S.: Legally Defined Minimum Salary, Source: ESTADISTICAS Santa Fé de Bogotá, D.C., 1997.

(5) Infrastructure and Services

Followings are fundamental statistics (1995) of infrastructure and public service in Bogota.

a) Water Supply: 1,032,814 customers (98.6%).

b) Sewage: 98.4%.

c) Electricity: 1,325,170 customers.

d) Gas: 241,040 customers.

e) Telephone: 1,471, 395 phone lines.

12.2.3. Relevant Development Projects.

There are several on-going development projects around the study area. The three projects which have strong influences on this new urban expressway project are shown in Table 12.2-12.

Table 12.2-12 Infrastructure Development Projects in Bogota.

Name of Project	Year	Descriptions
Metro Railway	2005	Stage 1 to be completed.
	2010	Stage 2 to be completed
Cundinamarca Toll Road	2000	4-lanes. To be completed partially.
Extension of Av. Boyaca	2000	

12.2.4. Clean Fuel Program

A number of alternative fuels have been used commercially in an effort to curtail air pollution in urban centers. Among those, compressed natural gas (CNG) and liquefied petroleum gas (LNG) reduce pollutant emissions and provide some economic benefits for certain applications and specific locations. Here, applications of those two alternative fuels in Latin America as well as Colombia are described, separately. Table 12.2-13 summarizes the comparative results of several alternative fuel costs. In Table 12.2-14, field measurement results of vehicular emissions with CNG fuel are summarized. Typical characteristics of both CNG and LPG are summarized in Table 12.2-15.

(1) Liquefied Petroleum Gas

Liquefied petroleum gas (LPG) is already widely used as a vehicle fuel in Canada, the Netherlands, and the United State. In Latin and the Caribbean, LPG is used in Venezuela (68,200 barrels per day or bbd) and Suriname (36,011 bbd). Other countries of region suing LPG include Bolivia (7,448 bbd), Costa Rica (1,250 bbd), Dominican Republic (6,850 bbd), Mexico (3,000 bbd), and Paraguay (957 bbd). In addition, LPG is used to some extent in Colombia, El Salvador, Peru and St. Kitts-Nevis. As a spark-ignition engine fuel, it has many of the same advantages as natural gas, with the additional advantage of being easier to transport. As with natural gas, nearly all LPG vehicles presently in operation are retrofitted gasoline vehicles. Due to the fuel tanks' lower cost, the costs of converting from gasoline to LPG are considerably less than those of converting to natural gas.

Use of LPG as a motor vehicle fuel is expected to bring environmental benefit to Colombia's urban centers, including Santa Fe De Bogota. This effort is being coordinated with the state petrol company, Ecopetrol, which has exclusive rights to refine and import motor vehicle fuels in Colombia. This LPG program is expected to reduce gasoline imports to some extents. It is projected that the maximum impact will be achieved in Years 2000 and 2001 when gasoline imports will be reduced by about 38 percent. At Bogota, a fuel-switching program to use LPG in public transport vehicles such as full and middle-sized buses and taxis is being initiated by the district's environmental agency, DAMA [Onursal and Gautam,1997].

(2) Compressed Natural Gas

Compressed natural gas (CNG) has many desirable qualities as a spark-ignition engine fuel. Clean-burning, cheap, and abundant in many part of the world, natural gas already plays an important role in Canada, Italy, New Zealand, Russia, and United States.

CNG's potential as a transport fuel is strongly affected by its price in the local market. Although natural gas is much cheaper to produce than gasoline, it is much more expensive to distribute. In addition, it requires costly compression process. Among Latin American and Caribbean countries, Argentina uses CNG most extensively as a motor vehicle fuel. Also, CNG-fueled vehicles circulate in Brazil, Colombia, Mexico, Peru, Trinidad and Tobago, and Venezuela to some extents [Walsh and Shah, 1997]. So far, no specific CNG program is implemented at Santa Fe De Bogota.

Table 12.2-13 Alternative Fuels Cost (1987)

Fuel	Overall Cost (1987 US$ per barrel-gasoline energy equivalent)
Crude Oil (assumed price)	18
Conventional Gasoline	27
Compressed natural gas	20 – 46
Very Heavy Oil Products	21 – 34
Methanol (from gas)	30 – 67
Synthetic Gasoline (from gas)	43 – 61
Diesel (from gas)	69
Methanol (from coal)	63 – 109
Methanol (from biomas)	64 – 126
Ethanol (from biomas)	66 – 101

Source International Energy Agency, "Substitute Fuels for road Transport: A Technology assessment", OECD, 1990.

Table 12.2-14 Exhaust Emission from CNG- and diesel-fueled buses [grams per kilowatt hour].

Bus Type	CO	HC	NOX	PM
CNG-fueled city bus	0.4	2.1	4.3	<0.05
CNG-fueled regional bus	2.5	3.1	2.9	<0.05
Diesel-fueled bus	4.0	1.2	14.0	0.55

Note: The test was performed in Netherlands on two buses equipped with DAF GKL 1160 engines. These engines were converted to lean-burn naturally-aspirated engines with an oxidation catalyst for CNG testing. Source Prensa Vehicular 70, 1994.

Table 12.2-15 General characteristics of CNG and LPG.

	CNG	LPG
Production	Fossil fuel with proven reserves estimated to be twice those of petroleum.	By-product of crude oil refining. By-product of natural gas treatment as cryogenic temperatures.
Components	Methane (95-99 percent)	Propane, Butane
Advantages	Clean-burning, cheap and abundant in many parts of the world. Lower CO, CO2, and PM emission than gasoline-fueled vehicle. No emission of lead or SO2.	Lower CO, CO2, and PM emission than gasoline-fueled vehicle. No emission of lead or SO2. Evaporative emission negligible due to the tight seal. Engine power and acceleration performance of LPG are similar to gasoline-fueled vehicle.
Disadvantage	Heavy cylinders as gas pressurized to about 3,000 psi are required. Limited traveling mileage due to the heavy equipment. Reduction in acceleration rates, need for longer braking distances, and decreases in the fuel efficiency due to the heavy equipment.	Additional cost of storing and transporting required.
Retrofitting cost	$ 1,000 - $ 1,500 for light-duty vehicle. $ 2,000 - $ 3,000 for light-duty truck and van. $ 5,000 - $ 7,000 for buses.	$ 2,000 - $ 3,000 for light-duty vehicle.

12.2.5. CULTURE AND AESTHETICS

Bogota is the quintessence of all things Colombian. It is a city of futuristic architecture, brilliant museums and all the latest in styles and gadgets, offering a vibrant and diversified culture life. Yet, it is also a city of shantytowns, street urchins, beggars, traffic jams and graffiti. It is not a handsome, pleasant or peaceful place but rather a bizarre mixture of everything from oppressive poverty to sparkling prosperity, which gives newcomers an impression of visual and mental disarray.

Over the past fifty years, Bogota has grown twenty-fold to its present population of between six and seven million. Rapid progress came only in the 1940s with industrialization and the consequent peasant migrations from the countryside into the city. In 1954, the surrounding towns of Bosa, Engativa, Fontibon, Usme, Suba and Usaquen were annexed into the city's metropolitan area, forming the so-called Distrito Especial (DE), encompassing an area of 1,587 km^2. In recent decades, the city has continued to expand rapidly to become a vast metropolis.

There are 3,474 properties of architectural conservation declared in the decree No.215 of 31st of March 1997 and decree No.201 of 21st of March 1997 (Table 12.2-16).

Table 12.2-16 Number of Properties of Architectural Conservation.

Wards	Number of Listed Property
San Cristóbal	14
Usme	7
Bosa	16
Engativá	3
Fontibón	15
Dantafé	598
Los Mártires	204
Teusaquillo	1,475
Chapinero	955
Usaquén	44
Suba	22
Barrios Unidos	121
TOTAL	3,474

Source: EL MIRADOR DE BOGOTA

Table 12.2-17 summarizes the number of major facilities or buildings along seven routes of concern within this study.

Table 12.2-17 Summary of landmark facilities.

	Commercial	Museum	Religion	Hospital	School	Misc.
Avenida 7	1	25	32	0	6	0
Caracas	0	3	27	1	4	0
Circunvalar	0	3	0	0	0	3
Quito	0	7	10	0	3	0
Suba	2	1	3	0	3	0
Cll. 170	0	0	5	0	4	0
Ave. 68	1	2	1	0	6	0
Total	4	41	78	1	26	3

12.3. ENVIRONMENTAL ORGANIZATIONS AND LAWS.

12.3.1. ENVIRONMENTAL ORGANIZATIONS

(1) SINA (National System of Environmental Organizations).

By the Law No.99 of 1993, the Ministry of Environment and National System of Environmental Organizations were established. Main objectives of SINA are as follows: (1) guaranteeing the public participation in the national environment and renewable natural resources policy, (2) insuring the right of every individual to enjoy healthy environment, and (3) protecting the natural heritage and the sovereignty of the nation.

(2) Central Government

The Ministry of Environment: The supreme organization of environmental administration mainly engaged in establishment of environmental policy on national level. The Ministry has following scientific organizations:

IDEAM (Institute of Hydrology, Meteorology and Environmental Study): One of the ministry's organizations engaged in scientific environmental studies.

INVEMAR (Institute of Marine and Coastal Investigations): One of the ministry's organizations engaged in scientific environmental studies in ecosystem of marine and coastal region.

Institute of Humboldt (Institute of Investigations of Biological Resources): One of the ministry's organizations engaged in basic and applicable studies in conservation of genetic resources of flora and fauna

Institute of Amazons (Amazon Institute of Scientific Investigations): One of the ministry's organizations engaged in biological, social and ecological investigations in the Amazon Region.

INGEOMINAS (Institute of Investigations on Geological Science, Mines and Chemistry): One of the organizations of the Ministry of Mines and Energy engaged in investigations in geological science, mines and chemistry.

IGAC (Geographic Institute of "Agustín Codazzi"): One of the organizations of the Ministry of Finance and Public Credit engaged in geographical investigations, land surveys and Cartography.

National Direction for the Prevention and Attention of Disasters: Organization of the Ministry of Government engaged in prevention and attention of disasters.

(3) Regional and Local Government.

CAR (Regional Autonomous Corporation of Cundinamarca): One of the regional autonomous corporations of the Ministry of Environment whose jurisdiction is the rural area of Bogota.

DAMA (Technical Administrative Department of Environment of the Capital District of Bogota): Environmental organization of the capital city whose jurisdiction is the urban area of Bogota. DAMA is one of the 4 major cities' organizations, with more than one million of population, whose level of administrative jurisdiction is same as that of the Regional Autonomous Corporations.

Secretariat of Health of the Capital District of Bogota: Organization of health of Bogota engaged in administration of environment in workplaces and homes concerning health control.

EAAB - Water and Sewage Enterprise of the Capital District of Bogota: Public enterprise of water supply and sewage. Many environmental studies about water resources were conducted by EAAB.

UPES (Office of Prevention and Attention of Emergencies of Bogota): Organization of Bogota engaged in prevention and attention of disasters. Geological and seismological studies have been done for disaster control.

12.3.2. Environmental Laws

(1) Constitution.

The Constitution of the Republic of Colombia was extensively revised in 1991 after 95 years since 1886. It provides the basic burdens of the state and people's right on environment and natural resources. Within this constitution, basically, the following four Articles are related to environmental concern.

Article 49: The Burden of the State in Health and Environmental Sanitation

Article 79: People's Right for Enjoyment of Sound Environment and the Duty of the State

Article 80: The Burden of the State in Management and Utilization of Natual Resources

Article 82: The Duty of the State in Watching of the Integrity of Public Space

(2) Law of the Ministry of Environment and the National Environment System (Law 99 of 1993)

The law consists of following eight titles:

Title 1: Fundamentals of Colombian Policy of Environment

Title 2: Concerning the Ministry and SINA

Article 2: Creation of Ministry of Environment and its Objectives.

Article 4: Function of National Environment System (SINA)

Article 5: Function of the Ministry of Environment

Title 3: Structure of the Ministry

Title 4:National Council of Environment

Title 5: Technical and scientific support of the Ministry

Title 6: Regional Autonomous Corporations

Title 8: Environmental License

Title 9: Functions of Territorial Entities and Environmental Planning

(3) Environmental Criteria

Within this study, any environmrntal standard related with the stench and vibration are not found. The principal criteria of noise, air and visual contamination are listed as follows.

1) Noise

Decree 948 of 1995 is concerned with the noise restriction to the environment as follows,

Article 15, Decree 948 of 1995. For the difinition of norms of Environmental Noise, the Ministry of Environment set the following Classifications

Section A. (Tranquility and silence): Urban areas where hospitals, kindergardens, liblaries, sanatoriums and homes of geriatrics are located.

Section B. (Tranquility and Medium Noise): Residential zones or zones exclusively designated for habitational development, parks in urban area, schools, universities and colleges.

Section C. (Medium Noise Restricted): Zones with permissive use of industries and commerce, offices, institutional use and other related use.

Section D. (Suburban or Rural Zone of Tranquility and Medium Noise): Rural inhabited areas destinated to agricultural activities, or suburban residential zones and recreational zones.

Within this Decree, the following description can be found for the noise generation.

Article 53: Zones of Cushioning of Noise of Road with High Circulation of Vehicles: The design and construction of new roads of high circulation of vehicles in the urban areas or in the surroundings of inhabited areas should be considered to have zones of cushoning of noise which minimize the impact on the surrounding inhabited areas, or with elements of mitigation of environmental noise.

Tables 12.3-1 and 12.3-2 summarize the envitonmental standards for noise.

Table 12.3-1 Permitted Noise Level for City Zone.

	Sound Pressurre Level (dBA)	
	Day time (7:00-21:00)	Night time (21:00-7:00)
Residential	65	45
Commercial	70	60
Industrial	75	75
Places required to be quiet	45	45

Table 12.3-2 Permissible Maximum Level for Vehicles.

Type of Vehicles	Sound Pressure Level (dBA)
Less than 2 tons	83
2 – 5 tons	85
More than 5 tons	92
Motorcycles	86

2) Air

Tables 12.3-3 and 12.3-4 summarize the environmental standard for national level and for Bogota, respectively.

Table 12.3-3 Environmental Standard (Air Quality, National-level).

	Dust	SO_2		CO		O_3		NOX	
	$\mu g/m^3$	$\mu g/m^3$	ppb	$\mu g/m^3$	ppm	$\mu g/m^3$	ppb	$\mu g/m^3$	ppb
Annual	100	100	<38	*	*	*	*	100	<32
Day	400	400	<150	*	*	*	*	*	*
8 hrs	*	*	*	15000	<13	*	*	*	*
3 hrs	*	1500	<566	*	*	*	*	*	*
1 hr	*	*	*	15000	<13	170	<85	*	*

Table 12.3-4 Environmental Standard (Air Quality, Bogota City).

	Dust	SO_2		CO		O_3		NOX	
	$\mu g/m^3$	$\mu g/m^3$	ppb	$\mu g/m^3$	ppm	$\mu g/m^3$	ppb	$\mu g/m^3$	ppb
Annual	76.8	76.8	<29	*	*	*	*	76.8	<24
Day	307.2	307.2	<116	*	*	*	*	*	*
8 hrs	*	*	*	11520	<10	*	*	*	*
3 hrs	*	1152	<434	*	*	*	*	*	*
1 hr	*	*	*	11520	<10	130.56	<65	*	*

3) Visual Contamination.

The legislation for the control of visual contamination has started only recently in Colombia. Law 140 of 1994, controls advertising in the national territory as follows,

Article 3, Law 140 of 1994: Within the national territory, any advertising activities are prohibited in the following places:

a) Private advertising in the area of public space regulated by municipalities or districts based on the Law 9 of 1989.

b) In places within a distance of 200 meters from national monuments.

c) In places where they are prohibited by regulations established by Councils of municipalities or districts based on No.7 and No.9 of the article 313 of the National Constitution.

d) In the private property without consent of proprietor or possessor.

e) On the infrastructure installations such as supporting posts of electricity and telephone, bridges, tower of electricity, and other structures or properties of the state.

12.3.3. ENVIRONMENTAL LICENSE

(1) Environmental License

1) Law 99 of 1993

Article 49. – Obligation of Environmental License: Execution of constructions, establishment of industries or development of any activity, which could produce grave deterioration to the renovable natural resources or environment or introduce considerable or notorius modifications to landscape, require Environmental License.

Article 50. -About Environmental License: It is understood that the authorization, which is granted by competent environmental authority for the execution of construction or activity, grasps by environmental license the observance of the beneficent of the license that establishes in the relation with prevention, mitigation, correction, compensation and management of the environmental effects of the authorized construction or activity.

2) Decree 1753 of 1994

Article 2. Concept: The Environmental License is the authorization which competent authority grants, by means of administrative act, to a person for the execution of a project, construction or activity which might produce grave deterioration to the renovable natural resources or environment or introduce considerable or notorious modifications to landscape, and in which are established requirements, obligations, and conditions that the benefit of the environmental license should accomplish to forestall, mitigate, correct, compensate and manage the environmental effects of the authorized project, construction or activity.

Article 5. Modality: There are following three modalities in the environmental license:

a) Ordinal Environmental License: In which are established requirements, obligations, and conditions that the benefit of the environmental license should accomplish to forestall, mitigate, correct, compensate and manage the environmental effects of the authorized project, construction or activity, without disposing about the authorization of permission, authorization or concession for the use, utilization or mobilization of the renewable natural resources.

b) Single Environmental License: License in which include permission, authorization or concession necessary for the development of project, construction or activity. The effectiveness of these types of permissions is the same as the Environmental License.

c) Global Environmental License: This license is of exclusive competence of the Ministry of Environment, and in virtue of the ministry all the constructions and activities related with exploitation of petroleum and natural gas are authorized

Article 9: No project, construction or activity requires more than one Environmental License.

(2) Competent Authorities

1) Law 99 of 1993

Article 51: The environmental license will be granted by the Ministry of Environment, Regional Autonomous Corporations and certain Cities and Districts according to the provisions in this law.

Article 61: The Savanna of Bogota and its páramos, waters, valleys, surrounding heights and mountain system are declarable as national ecological interest. The Ministry of Environment will determine that in the zones where exists compatibility with exploitation of mines, with the base of this determination, the Regional Autonomous Corporation of Cundinamarca (CAR) will authorize or negate the correspondent environmental licenses. The Cities and the Capital District will expedite the regulations of land use in consideration of the dispositions, which treat this article, and those of national level expedited by the ministry of environment.

Article 65.- Functiones of Cities, Districts and Capital District of Santafé de Bogotá.

Article 66.- Competence of Large Urban Centers: The cities, districts or metropolitan areas which urban population are iqual to or more than one million of inhabitants perform, within the urban limit, the same functiones attributed as the Regional Autonomous Corporations, which are applicable to urban environment.

2) Decree 1753 of 1994

Article 6. Competent Environmental Authorities of Environmental License

a) Ministry of Environment

b) Regional Autonomous Corporations

c) The cities, districts or metropolitan areas which urban population are equal to or more than one million inhabitants

d) The territorial entities delegated by Regional Autonomous Corporations.

Article 8. Competence of Regional Autonomous Corporations: Clause 8. Regional Autonomous Corporations are competent in their respective jurisdictions to authorize Environmental License in the execution of public works of road network which is out of national system.

Article 12. Competencia de las grandes ciudades: The cities, districts or metropolitan areas which urban population are iqual to or more than one million of inhabitants are cometent within the respctive urban perimeter to authorize environmental license as the same as the cases defined to Regional Autonomous Corporations

3) Decree of the District 673 of 1995

Article 1:The Adminstrative Technical Department of Environment (DAMA) is the authority of environment within the urban perimeter of the Capital District.

(3) Environmental Diagnosis of Alternatives

1) Law 99 of 1993

Article 56.- Environmental Diagnosis of Alternatives

Within the project which requires environmental license, the person of interest should apply in the step of feasibility study to refer to ask to the competent environmental authority whether the environmental diagnosis of alternatives is necessary or not. On the

basis of the information provided the environmental authority will decide the necessity and will define the terms of reference within the period of thirty (30) work days.

2) Decree 1753 of 1994

Article 17. The environmental diagnosis of alternatives can be required to evaluate alternatives of design of projects like the construction of roads that do not belong to the national system.

Article 18. Objective: The environmental diagnosis of alternatives will have the objective to supply the information to evaluate and compare the different options, under which the present petitioner would be able to develop a project, construction or activity, with the purpose of rationalizing the utilization of environmental resources and avoiding or minimizing the risks, negative effects and impacts that will be produced.

Article 19. Contents of the Environmental Diagnosis of Alternatives: The environmental diagnosis of alternatives will contain the following items:

a) Objective of the project, construction or activity.

b) Description of different alternatives of project, construction or activity in technical, socio-economical and geographical terms.

c) Identification, estimation and comparative analysis of possible impact, risks and effects derived by the project, construction or activity concerning environment and their different alternatives.

d) Description of possible strategies of prevention and environmental control for each alternative.

e) Article 21. Selection of Alternatives: The competent authority of environment disposes of the environmental diagnosis of alternatives until sixty (60) days counted from the presentation, so as to pronounce about the diagnosis.

(4) Environmental Impact Study

1) Law 99 of 1993

Article 57.-Concerning the Environmental Impact Study: It is understood that by way of the Environmental Impact Study the petitioner of environmental license should present the whole information to the competent environmental authority.

2) Decree 1753 of 1994

Article 22. –Concept: The environmental impact study is an instrument of making decisions and environmental planning demanded by environmental authority to definite the correspondent measures of prevention, correction, compensation and impact mitigation and negative effects of project, construction or activity.

Article 23. The environmental impact study is demanded in all the cases that are required environmental license according to the law and regulations. The environmental impact study should correspond to the characteristics of the project, construction or activity in its content and profundity.

Article 24. -Objective and Scope

Article 25. –Contents: The environmental impact study has to contain at least the following items:

a) Summary of the Environmental Impact Study

b) Description of the project, construction or activity including the location, steps dimensions, costs and timetable of execution.

c) Description of the process and operation; identification and estimation of consumption, products, by-products, rubbish, residue, emissions, wastewater and technical risks, their sources and system of control while the project, construction or activity.

d) Delineation, characterization and diagnosis of the area of direct and indirect influence, as well as range and grades of impacts of the project, construction or activity on the basis of the affectation that could occur in the various components of environment.

e) Estimation of the impacts and effects of environment: on the basis of the information of the anterior clauses, sensitive, critical and environmentally and socially important ecosystems will be identified. At the same time, the environmental impacts and effects, its relation of causality will be identified, characterized and estimated, and the analysis of risk will be elaborated.

f) Plan of Environmental Management: The plan will be elaborated so as to forewarn, mitigate, correct and compensate the possible impacts and effects of the project, construction or activity concerning environment. The plan of pursuit, monitoring and continuation should be included.

(5) Procedure

The EIA evaluation process of Colombia are described in Article 58 (Concernig the Procedure of authorization of Environmental Licenses), Law 99 of 1993 and in Article 30, Decree 1753 of 1994. Figures 12.3-1 to 12.3-5 show the flow chart of EIA process.

(6) Public Audience

1) Law 99 of 1993

Article 69. -Concerning the Right to Intervene in the Procedure of Environmental administration.

Article 70. -Concerning the Procedure of Intervention.

Article 71. -Concerning the Publication of the Decision about Environment.

Article 72. -Concerning the Public Audience of Administration about Environmental Decision in Procedure: When a construction or activity that is going to be developed or attempted to develop, that could cause impact to environment or to removable natural resources, and for the development require permission or environmental license conformed to the law or the regulations, the National General Procurator or its delegate for environmental affairs, the Defender of Populace, the Ministry of Environment, other environmental authorities, Governors, Mayors, or at least One Hundred (100) Persons or Three (3) nonprofit Entities will be able to apply for realization of Public Audience which will be celebrated in the presence of the competent authority for the authorization of permission or environmental license in question.

(7) Sanctions

Article 84, Law 99 of 1993.- Sanctions y Denunciation: When the violation of the norms about the environmental protection or about management of renovable natural resources occur, the environmental authority will impose the sanctions and preventive measures which *Article 85 (Types of Sanctions)* of the present Law treats. Also, in *Article 33 of Decree 1753 of 1994*, suspention or revocation of the environmental license is specified.

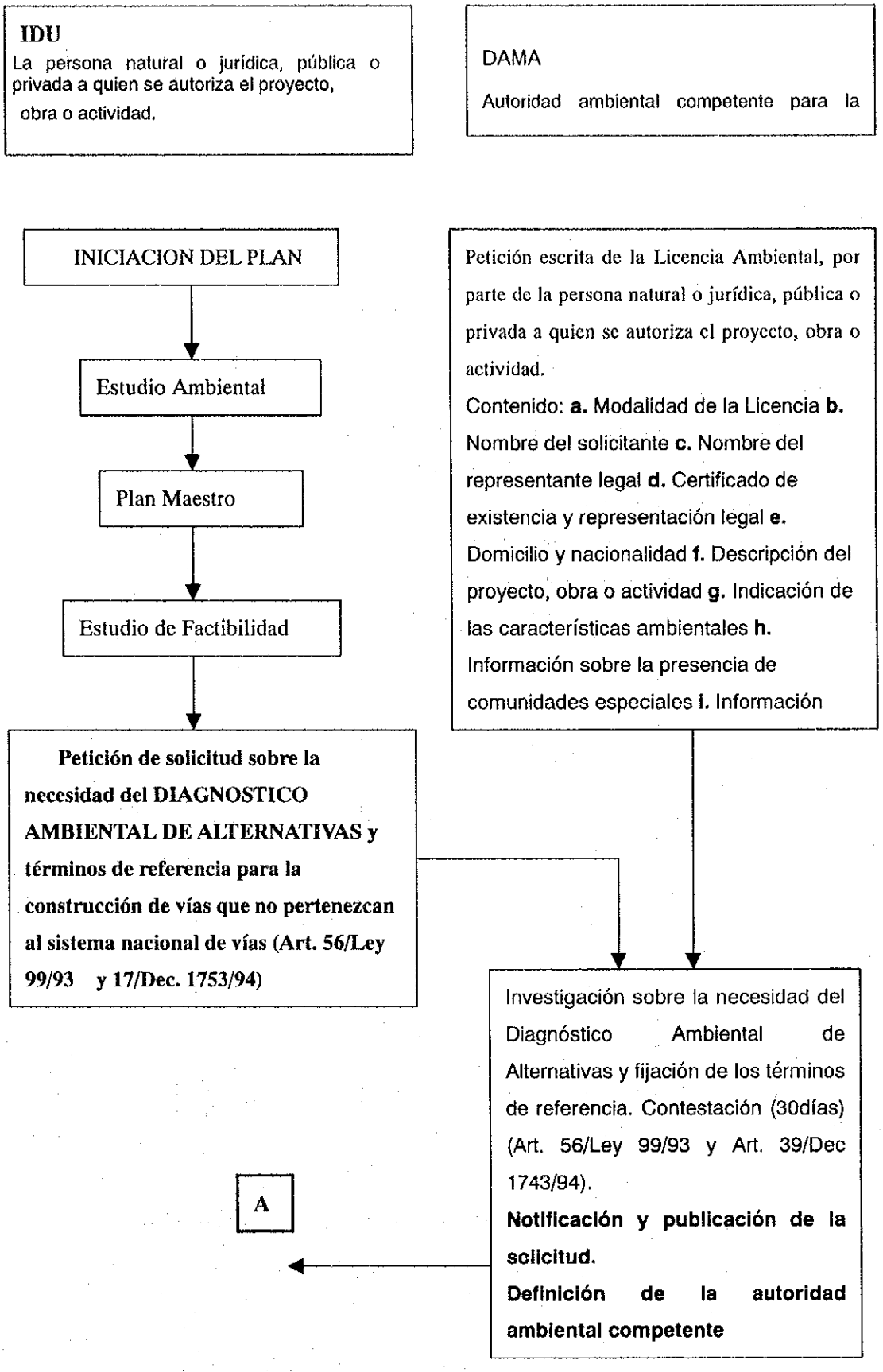

Figure 12.3-1 Procedimiento Para El Otorgamiento De La Licencia Ambiental

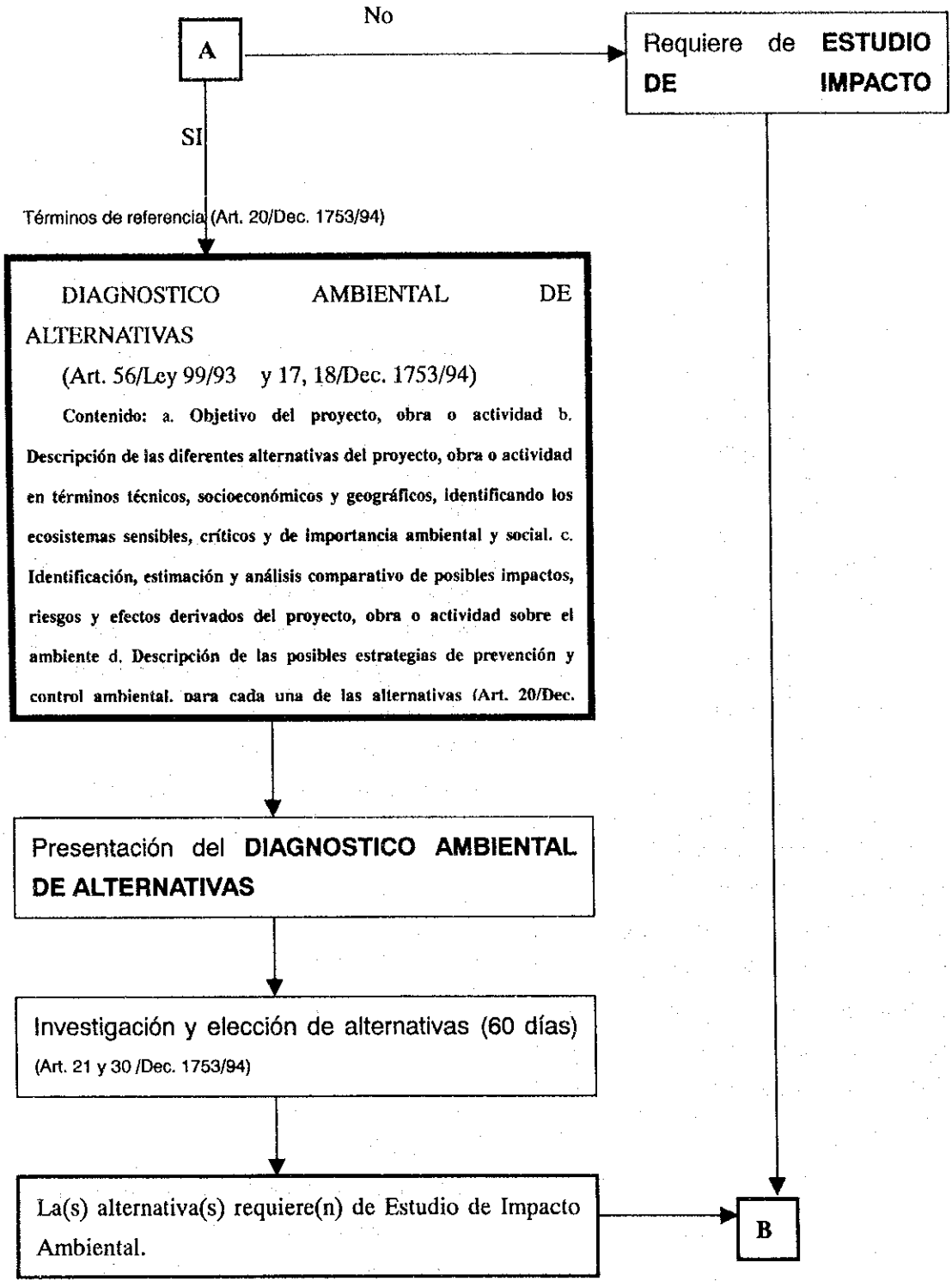

Figure 12.3-2 Procedimiento Para El Otorgamiento De La Licencia Ambiental

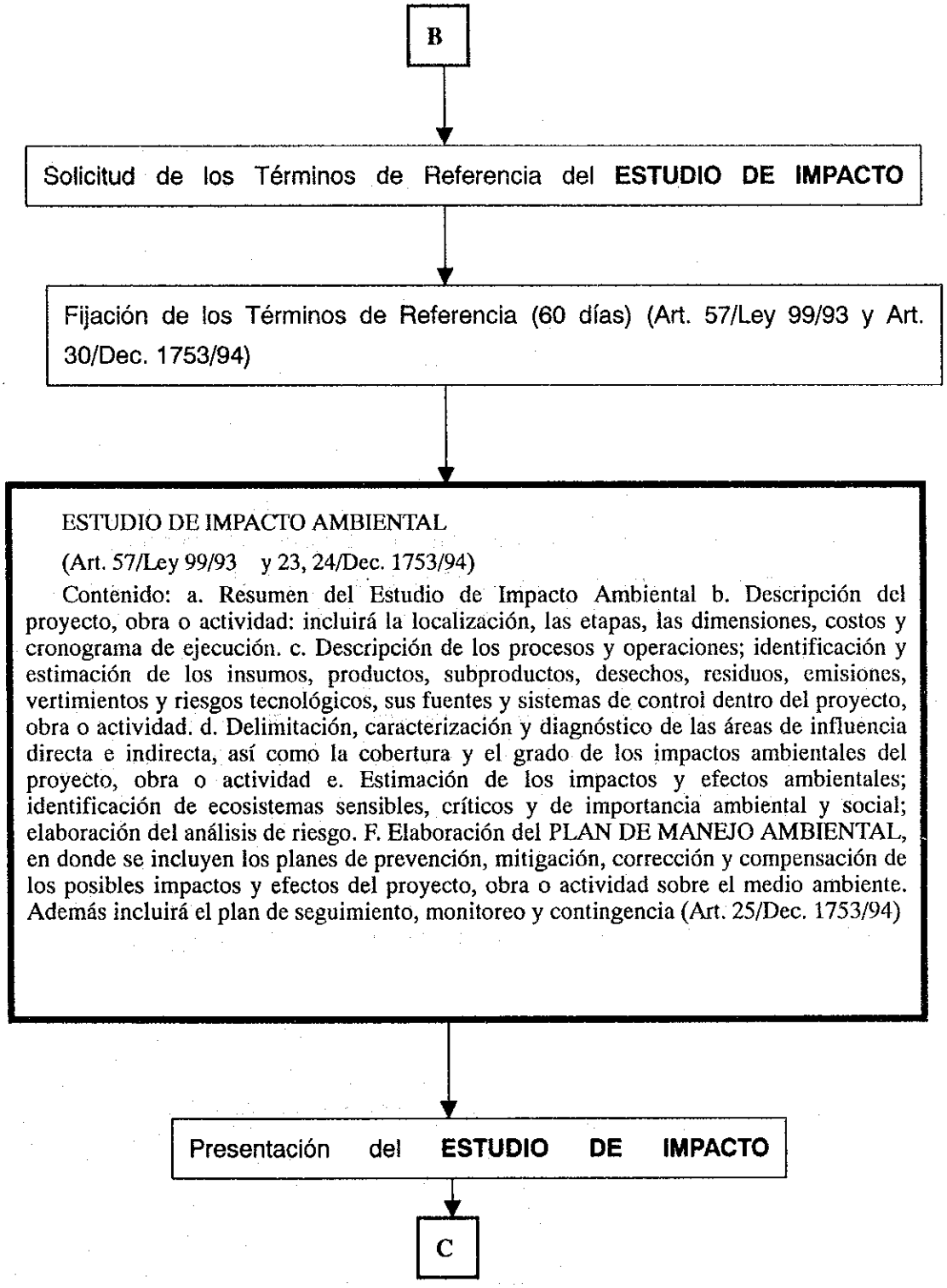

Figure 12.3-3 Procedimiento Para El Otorgamiento De La Licencia Ambiental

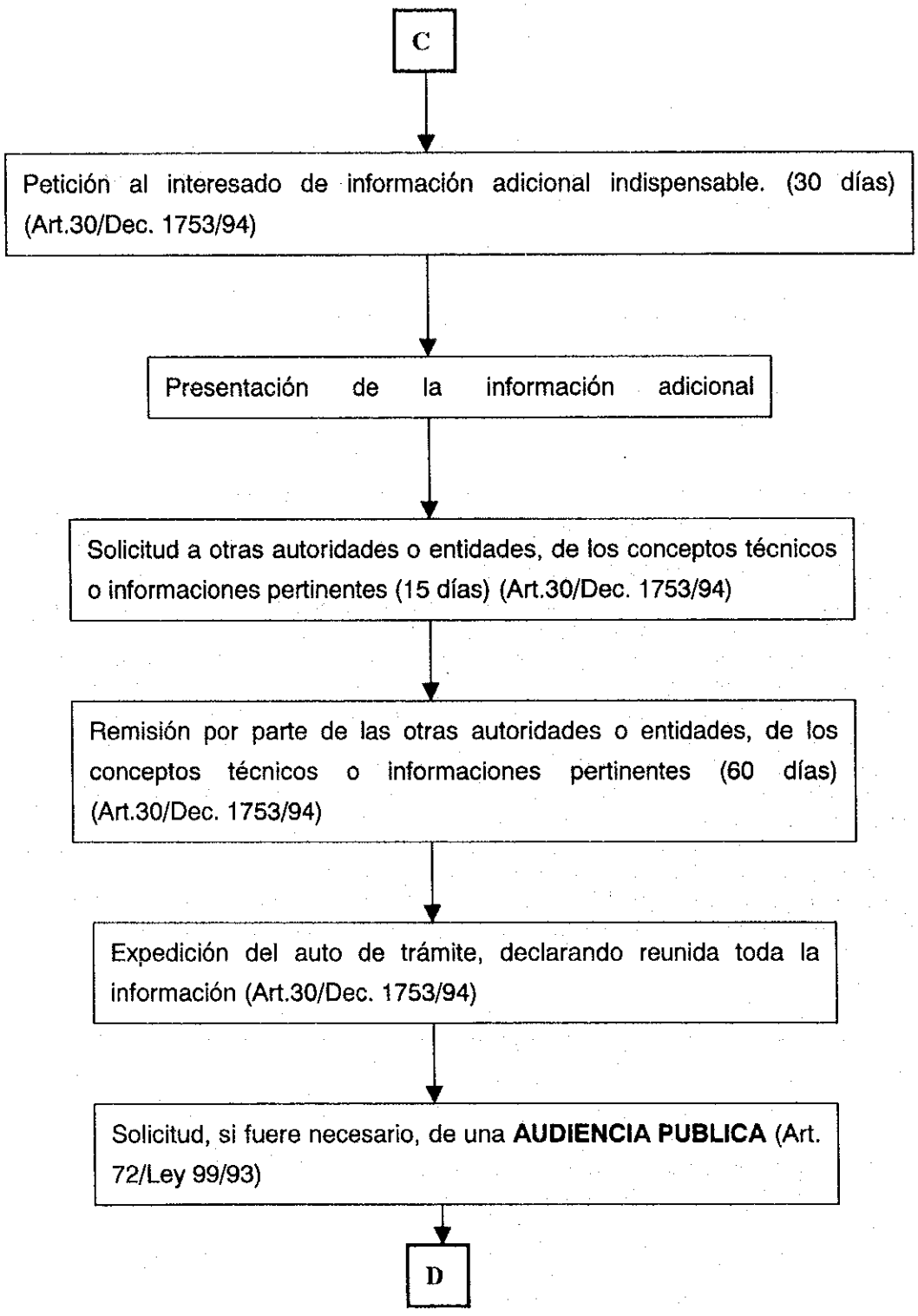

Figure 12.3-4 Procedimiento Para El Otorgamiento De La Licencia Ambiental

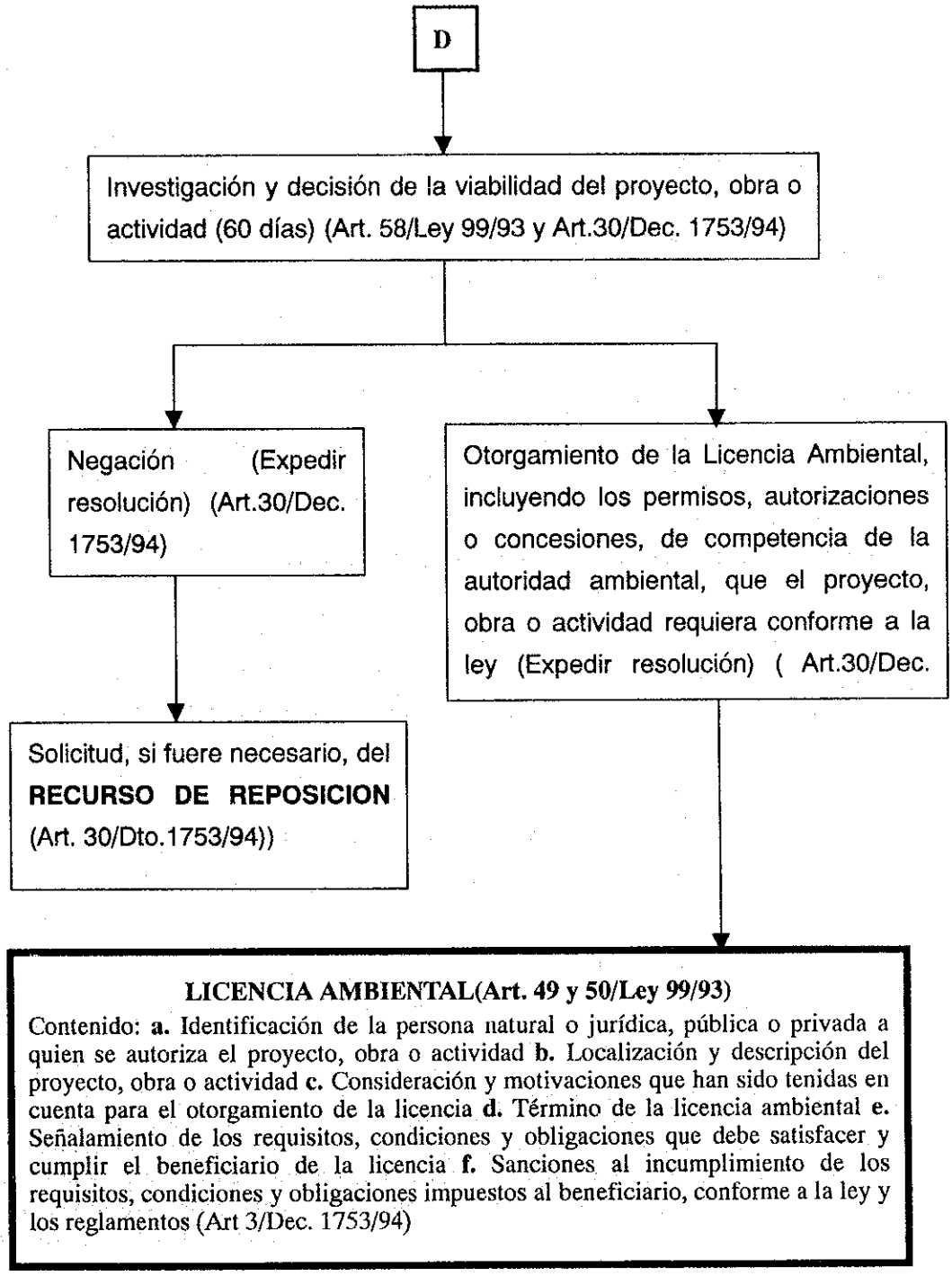

Figure 12.3-5 Procedimiento Para El Otorgamiento De La Licencia Ambiental

12.4. VISUAL RESOURCES

12.4.1. INTRODUCTION OF TOWNSCAPE SCHEMA

(1) General

It is important to consider the following viewpoints, when the townscape planning is carried out.

1) In order to maintain a good townscape, the following three (3) conditions must be met. These conditions should also be harmonized with each other.

a) The 1st, perspective beauty of artificial institution such as a building and a road.

b) The 2nd, natural environment such as greenery, water, and topography.

c) The 3rd , atmosphere of reflected civil life, culture, history and so on

In addition to the above, in order to keep a good townscape, the infrastructure in the city should maintain a sufficient open spaces.

2) The townscape is mainly formed by a public open space, a road space, a rivers space, a park space, architectural structures, and private lands. The townscape should harmonizedbetween public open space and private open space.

12.4.2. PROCEDURE AND BASIC CONDITIONS FOR TOWNSCAPE PLANNING

(1) Planning Procedure

The townscape planning is conducted along the following procedures.

a) To understand the characteristics of the existing townscape conditions in the study area.

b) To identify the targets of townscape improvement

c) To identify the design-theme of future townscape conditions.

d) To select the methodology for mitigation measures of the townscape.

e) Execution

f) Maintenance and supervision

g) To conserve and develop townscape resources

(2) Understanding of the Existing Townscape

The view of the townscape will be changed from the individual viewpoints such as the angle of view points, height of viewpoint, and areas, therefore, the viewpoint from the opens space are very important for understanding of the townscape conditions. In this study, the understanding of townscape condition is examined from the following viewpoints.

1) From Viewpoints of Open Space

a) Street — Carriageway
Pedestrian
Roadside Plantation
Road Facilities

b) Building Areas — Fence
Garden
Building

2) From Viewpoints of Building Facilities

3) From Viewpoints of Structure Type, Structure Color

(3) Laws of Visual Contamination in Colombia

The laws of visual contamination in Colombia were recently formulated in 1994 as Laws 140. The principal contents of this law are as follows,

a) Private advertising in the area of public spaces administered by municipal or districts will be based on the Laws 9 of 1989.
b) In places within the districts, 200 meters from national monuments.
c) At places prohibited by regulations established by Councils of municipalities or districts are based on the No.7 and No.9 of the article 313 of the National Constitution.
d) At private property without consent of projector or possessor.
e) On the infrastructure installations such as supporting posts of electricity and telephone, bridges, tower of electricity, and other structures which are properties of the state.

12.4.3. EXISTING TOWNSCAPE CONDITIONS IN BOGOTA

The city of Bogota is located on about 2,500 to 2,700 meters above sea-level, and the mountain area is located on the east side of the city of Bogota. The mountain rises to an altitude of 2,600 to over 3,000 meters above sea-level.

Avenida Cirucunvaral is running at about 2,700 meters above sea-level, and Avenida 7a and Avenida Caracas are passing through at about 2,600 meters above sea-level. The high buildings with over 15 stories are located along the existing Avenida Cirucunvaral, 7a and Avenida Caracas because the soil condition of the mountain side is comparatively good. There are no high buildings on the western side of the existing Avenida Caracas because the soil condition of these areas are poor.

The area below the 2,800 meters altitude is classified as urban area in the city of Bogota and the areas above 2,800 meters altitude is classified as unbiult-up area., therefore housing estates have developed below 2,800 meters altitude. The land-use of more than 2,800 meters altitude is forest area, however, some place are occupied by the illegal houses.

As mentioned above, the townscape of Bogota, is keeping a good balance between mountain area and buildings, however, this good perspective is obstructed by some high buildings. Especially, when the urban expressway with viaduct type will be constructed on the Avenida 7a, the balance between the perspective of city and type of road should be considered because the right of way (ROW) on the Avenida 7a is very narrow (28 to 33 meters) .

The town perspective of viewpoint from the city is shown in Figures 12.4-1 to 12.4-3.

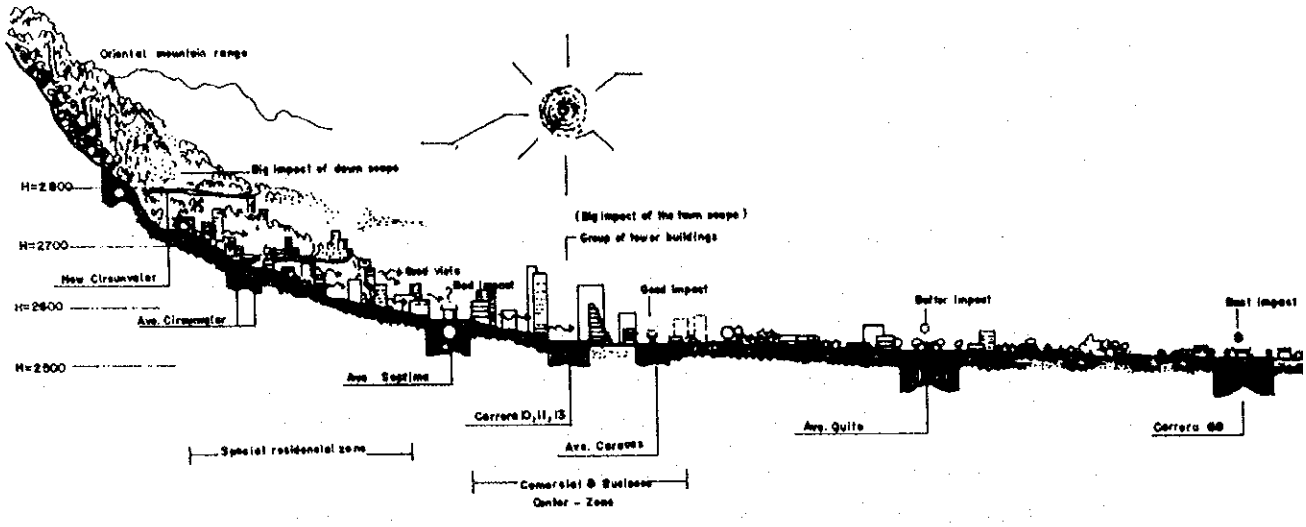

Figure 12.4-1Perspective of Bogota city

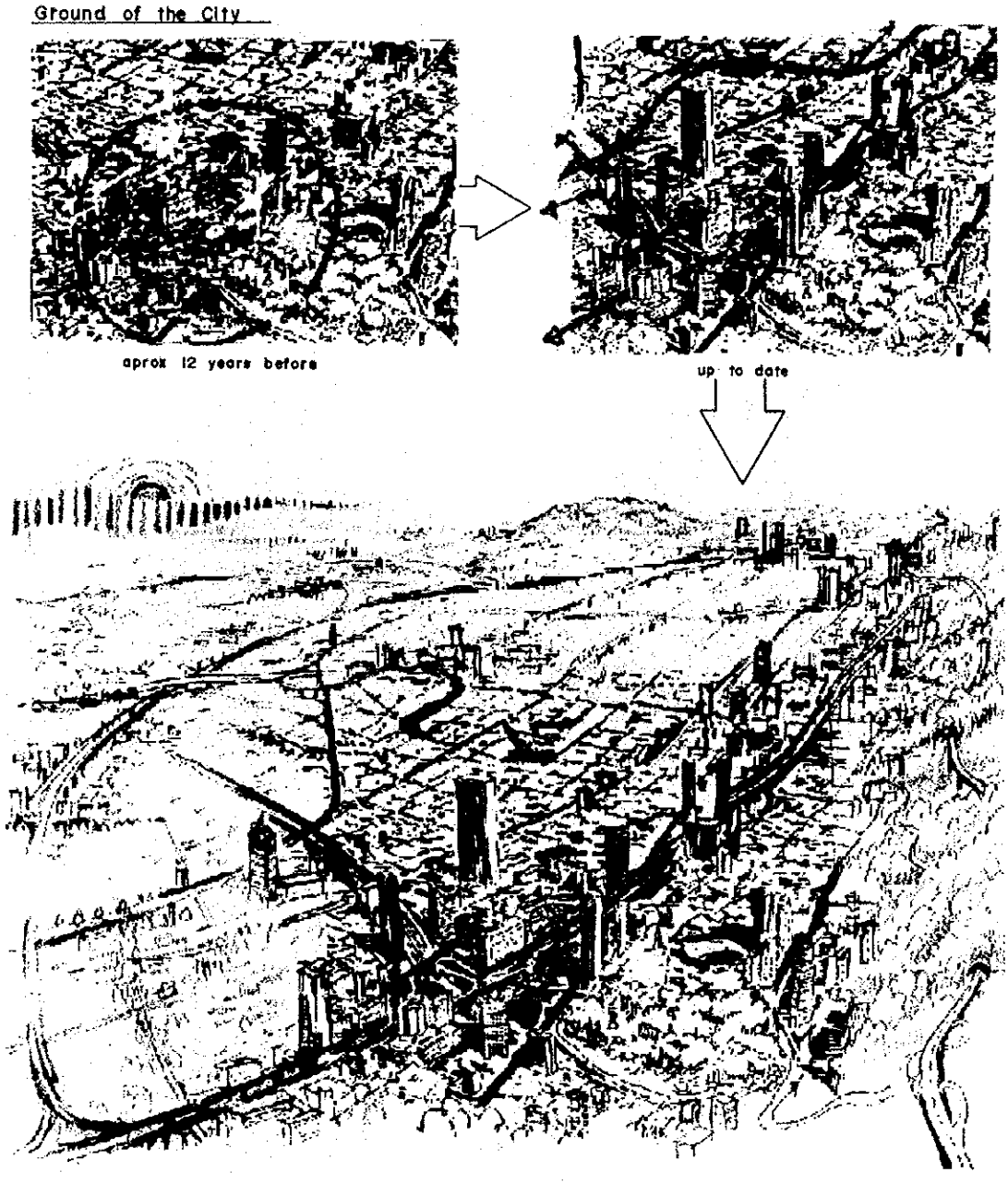

Figure 12.4-2 Perspective of Building Conditions in Bogota

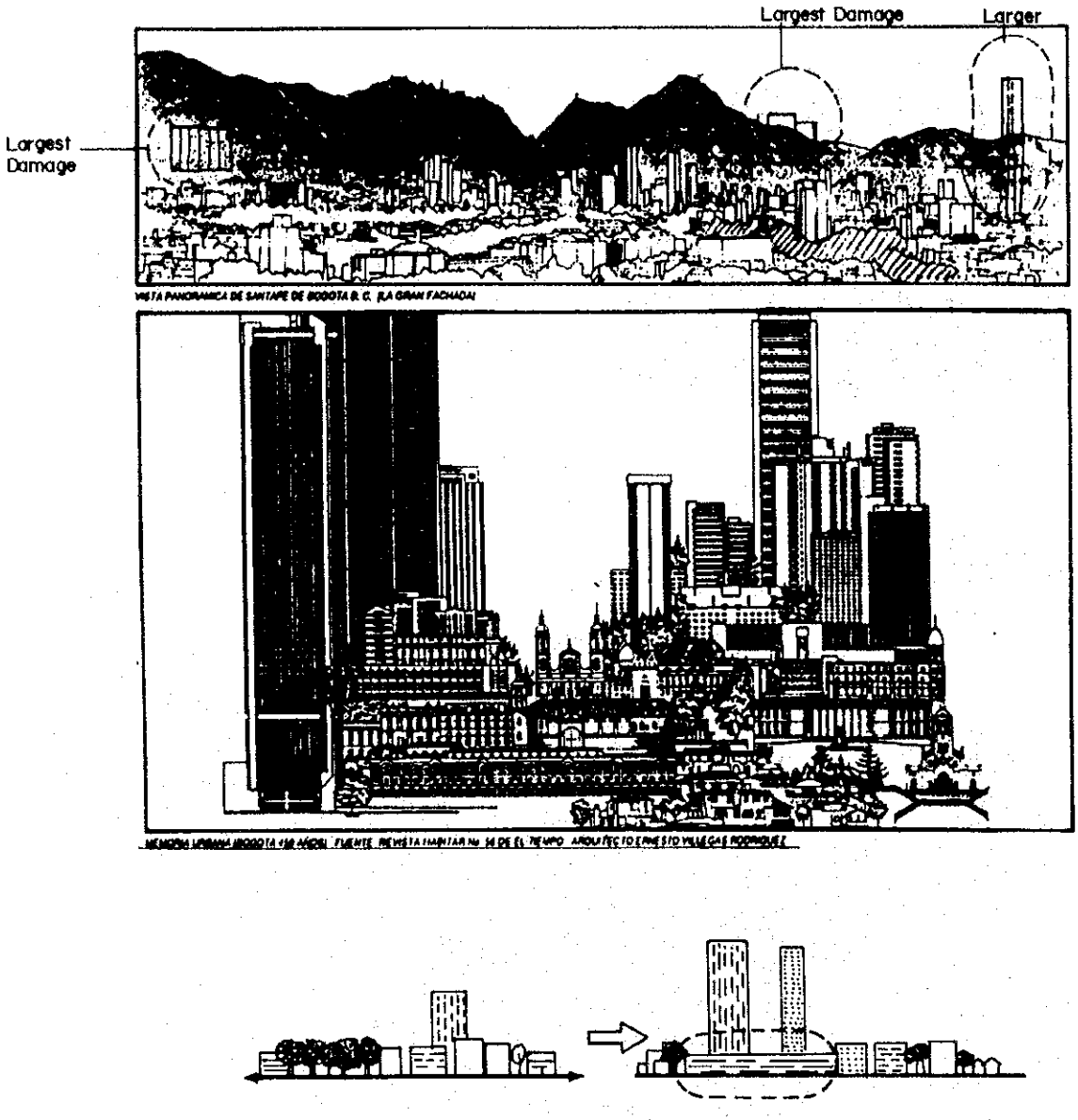

Figure 12.4-3 Perspective of Mountain Area as Viewed from Town Area

12.4.4. Basic Consideration of Perspective Planning

(1) Planning of Road Perspective

The planning or design of road perspective is conducted based on the road structure design. The roads are classified as urban expressway, arterial road, district road, and local road, in accordance with the function and characteristics of the roads. Therefore, the planning or design of road perspective should be carried out considering the function and characteristics of the road to be examined, and items to be considered for the design of road perspective are as follows,

1) To design in accordance with the function and characteristics of a road.

2) To consider the inhabitants along the road and road user.

3) To maintain a good balance of the project.

The road perspective design should be carried out to show which are urban and sub-urban areas, to identify the environmental conditions along the road, the customs of the area, and natural feature of the area. Therefore, the road perspective design should be conducted to examine the above mentioned matters.

(2) Characteristics or Factor of Road Perspective

The characteristics or factor of road perspective design is conducted based on the three (3) viewpoints such as the factor of road itself, factor of road side environmental conditions, and factor of a long distance view. The factor of road is identified to consider the road structure itself, and road facilities. The factors of road side environmental conditions are identified to consider the land use such as residential, commercial, and industrial areas. The factor of long distance view is identified according to the natural conditions along the road to be designed.

(3) Perspective of Road Structure

The elements to be considered for design of road structure perspective are as follows,

a) Road structure itself

b) Type and width of median strip

c) Width of shoulder

d) Type and width of frontage roads

e) Type and location of bus stops

f) Roadside plantation

g) Road related facilities

h) Type and location of bicycle roads.

The road perspective design should be conducted to consider the above mentioned matters.

(4) Green Planning

The function of green planning for road construction is to increase the function of perspective, to maintain a green space conservation, to maintain the function of traffic safety, and to keep a good natural environmental condition along the roads. The major construction methods associated with green planning are as follows,

a) Planting of roadside tree

b) Planting of median strip

c) Planting of under the viaduct

d) Planting of grass for noise protection.

The green planning should be implemented on the inner ring expressway and trunk bus-way to keep good natural and social environment conditions in the city of Bogota.

12.5. FIELD SURVEY: AIR QUALITY

12.5.1. STUDY DESIGN

In order to grasp the current air quality condition across Bogota, the field measurement of the air quality along major roads were carried out by JICA Study Team. Within this measurement, following five parameters are of concern: Dust (PM-10), CO, NO, NO_2 and SO_2. Based on the result of the traffic survey, conducted by JICA Study Team (June, 1998), fifty six points were selected initially. After several field observations and interviews with local residents, fifty two points are chosen for this measurement. Among these, forty nine points are used for the road environment measurement and three for the background. Tables 12.5-1 and 12.5-2 summarize the outline of this air quality measurement work.

Table 12.5-1 Air Quality Measurement.

Total number of sampling points = 52. Measuring period: July/23 – July/31/98		
	Parameter	Instrument
1	Dust (PM-10)	Model P5H2, Shibata-Kagaku Kikai Co.
2	CO	Model COM4, Kohmei-Rikagaku Co.
3	NO_x & SO_2	Diffusion-Type Sampler, Kanapori

Table 12.5-2 Location of Measurement Points

	Localitacion aprox – Castado		Localitacion aprox – Castado
1	Av 100 Cll 163A-20 Columna Casa Occ. P. amarillo	31	Av. Quito, Cll 15 Occ.
2	Av 100 Cll 144 Muro Or	32	Av. Quito, Cll 8-35 Occ.
3	Av 100 Cll 131 Col Or	33	Cll 6 – Cra 19A-49-s
4	Av 100 Cll 118 Or	34	Av Caracas No.9-03S-Occ
5	Av 7 Seminario Or	35	Av. Quito, Cll 2-15S Occ.
6	Cra 7, Cll 82 Occ.	36	Autopista Sur Cll 38-23S Occ
7	Cra 7, Cll. 60 – Cll 61 Occ.	37	Cll 44S- Av27Occ.
8	Cra 7, No. 34 – 70 Occ.	38	Autopista Sur, Trv. 54A-06 Occ.
9	Cancelled.	39	Cancelled
10	Cancelled	40	Autopista Sur, Cra70 Occ
11	Cancelled	41	Autopista sur Cra80 Occ
12	Av. Caracas – Cll 36-32 Or	42	Calle 170 Transversal 58
13	Av Caracas - Cll 59-Cll 59A-Or	43	Trv. 52 Cll 128A-Or
14	Av Caracas – Cll 63 –80 – Or	44	Av Suba Cll 118 Or
15	Av Caracas Cll 84 – 02 – Op	45	Av Suba Peatonal 106
16	Av. Quito,Cll 93 Bis Occ.	46	Av Suba Cll 92-85 Occ P
17	Av 100 Cra 11 – S	47	Av 68 Cafam La Floresta
18	Av. Quito, Trv. 10, Cll 116-30 Occ.	48	Av 68 Metropolis-Or (Cll 75)
19	Av Los-Libertadores-Cll 166-38 – P – Or	49	Av. 68 Cll 62A-Or
20	Av Los-Libertadores-Dg 147 – GH- Or	50	Av 68 Cll 23 – Or
21	Av Los-Libertadores-Cll 131 – Frente a Sentry – Or	51	Av 68 Cll 10-28-Or-Poste
22	Av Los-Libertadores-Cll 106-28 P. Hotel-Or	52	Cll 1 Sur – Or Caseta
23	Av Los-Libertadores-Cll 95 – 08 P.Or	53	Cll 38A-40 Sur Or-P
24	Av. Quito, Dg. 86 A Occ.	54	Parque Sta Barbara Cll 119-Cra20
25	Av. Quito, Cll 75A-51 Occ.	55	U. Nacional de Col
26	Av. Quito, Cll 65 Occ.	56	Parque Ciudad Montes
27	Av. Quito, Campin Occ.		
28	Av. Quito, Cll 47 Occ.		
29	Av. Quito, Cll 39A-14 Occ.		
30	Av. Quito, Cll 22-20 Occ.		

Note P: Poste, Or: Orental, S: Sur, Col: Colegio, Trv: Transversal, Occ: Occidente, Av:Avenida, Cra: Carrera, Cll: Calle, GH: Conjunto Residencial Granada Hills.

12.5.2. DISCUSSIONS

Figures 12.5-1 to 12.5-5 show the spatial variation of Dust (PM10), CO, NO, NO_2 and SO_2 measured within this study, respectively. The obtained data for each parameters are varied within following ranges, respectively.

PM10: 0.001 – 0.062 mg/m^3

CO: 1 - 32.5 ppm

NO: 0.03 – 0.448 ppm

NO_2: 0.008 – 0.044 ppm

SO_2: 0.005 - 0.075 ppm

Comparing with another air quality data measured at DAMA's 12 stations (see Table 12.2-1, DAMA's results are attached in Appendix), good agreements between both results are found, so it can be said measurements carried out within this study reflect the current situation well, and those results is valid.

Figures 12.5-6 to 12.5-10 summarize the measured data of the current roadside NOX and SO_2 conditions along major streets, respectively. Throughout this field study, the ratio of NO to NO_2 is relatively large. This indicates the oxidation process of NO (mainly, a photochemical reaction) is not so significant along each roadsides. In Bogota, only one environmental criteria for NOX is established (76.8 ug/m^3 for annual NOX) whereas WHO guideline specifies more strict environmental criteria for NOX (400 ug/m^3 (or 195 ppb) for 1-hour NO_2). Note the field data of NOX and SO_2 measured throughout this study is daily-averaged one, so it would be hard to compare the current air quality condition directly with this environmental criteria but be good enough to obtain rough estimates that might be used for future relevant monitoring work. Based on these facts, it can be said most of obtained NOX data are above the city-environmental criteria, so that the current air quality conditions of metropolitan Bogota, in particular, the area along 7a, Quito and several points such as #13(Caracas), #14(Caracas), #46 (Suba) and #50 (Avenida 68) are severely deteriorated.

All measured SO_2 values are less than city-environmental criteria (116 ppb for 24-hours SO_2). Figures 12.5-11 to 12.5-15 show the measured data of current roadside PM10 and CO conditions for each major streets, respectively. All measured PM10 values are less than city-environmental criteria (307.2 ug/m^3 for 24-hours PM10). Note PM10 measuring time throughout this study is only five-minutes, so it would be meaningless to judge the current roadside dust condition directly by comparing with this environmental criteria. Also, it is not wise to carry out a simple straightforward extrapolation work using those data obtained within short measurement periods in order to estimate a daily based one. However, based on data summarized here, it is likely that 24-hour PM10 values at several points would exceed the city environmental criteria, so further work is necessary to increase the reliability of this measurement work.

In Bogota, 1-hour environmental criteria for CO is set as 10 ppm, and most of roadside air quality conditions except Avenida Suba is not good, in particular, some values exceed more than 20 ppm. Similar local distribution pattern (#6, 7 and 8) can be recognized in that of NOX data. Note CO measurement was done when the instrument reading became stable (actual CO measuring time throughout this study was less than five-minutes), so it would not be appropriate to evaluate the current roadside CO condition directly with this environmental criteria.

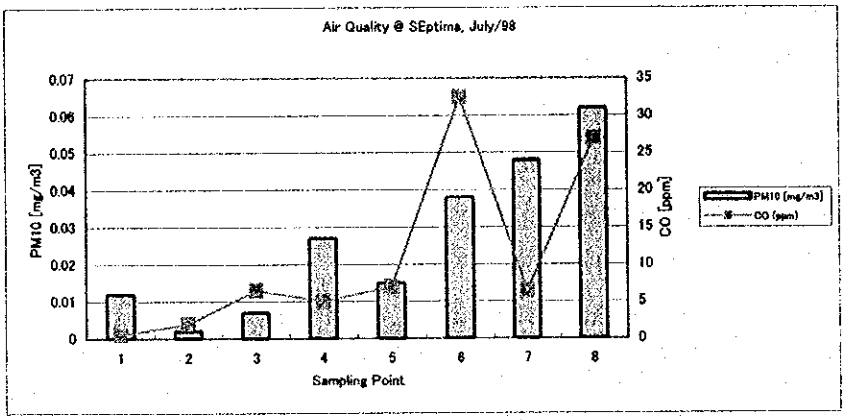

Figure 12.5-1 Field Measurement @ 7a (PM10, CO, July 98)

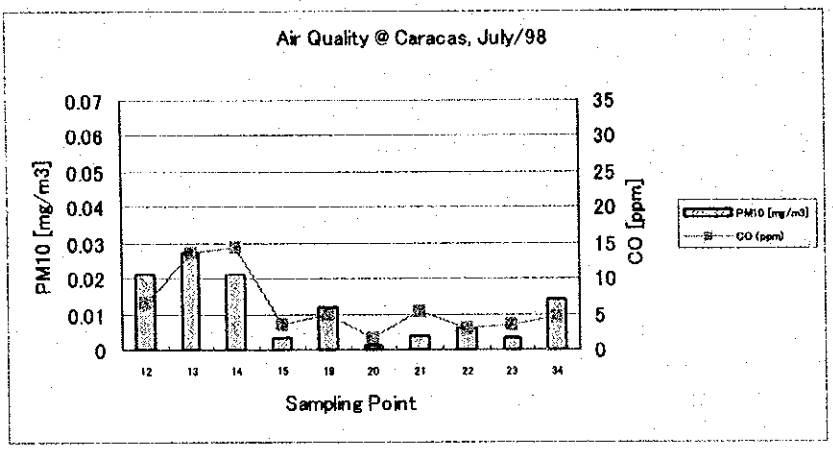

Figure 12.5-2 Field Measurement @ Caracas (PM10, CO, July 98)

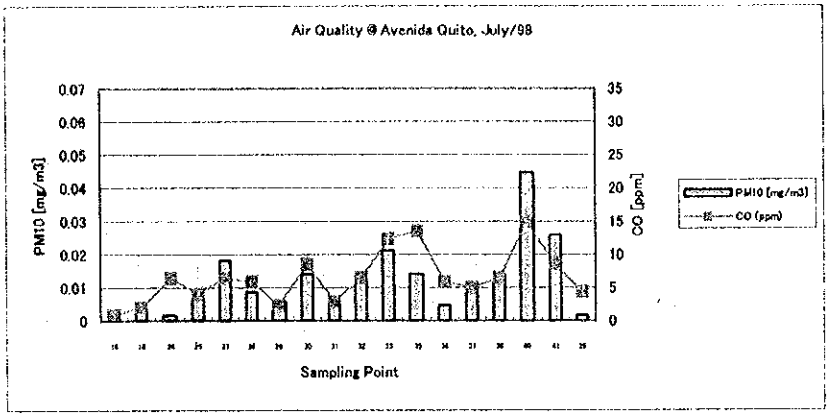

Figure 12.5-3 Field Measurement @ Quito (PM10, CO, July 98)

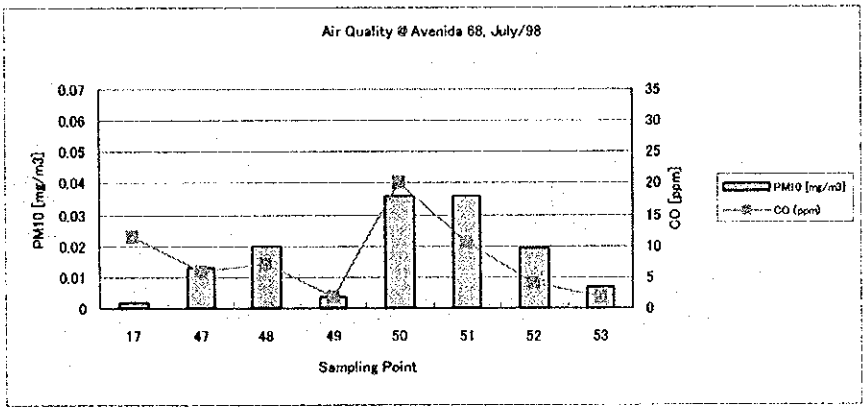

Figure 12.5-4 Field Measurement @ 68 (PM10, CO, July 98)

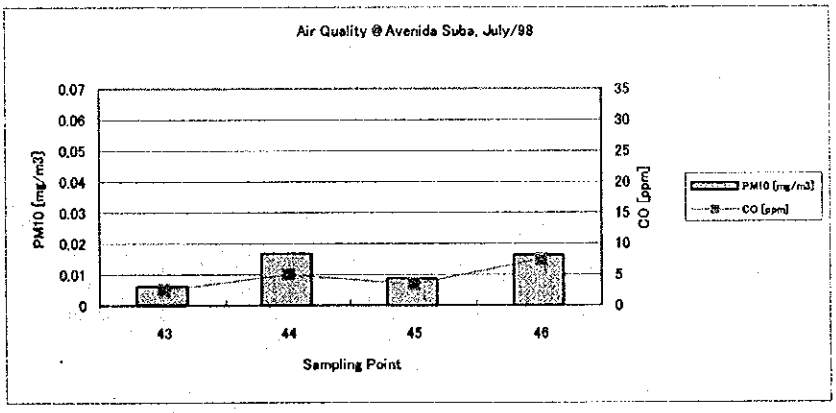

Figure 12.5-5 Field Measurement @ Suba (PM10, CO, July 98)

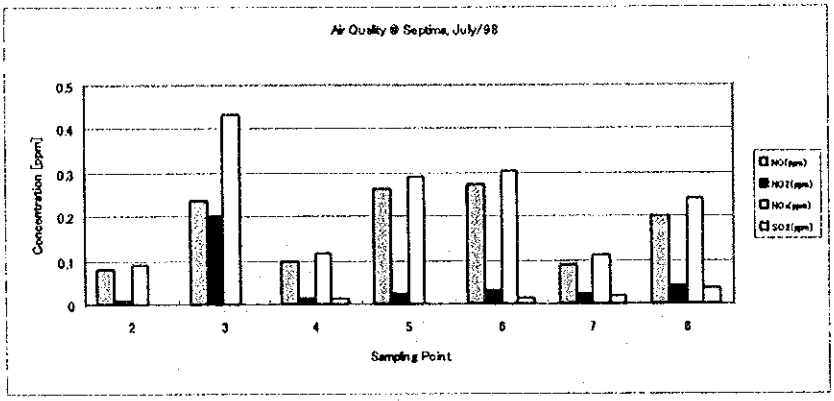

Figure 12.5-6 Field Measurement @ 7a (NOX and SO_2, July 98)

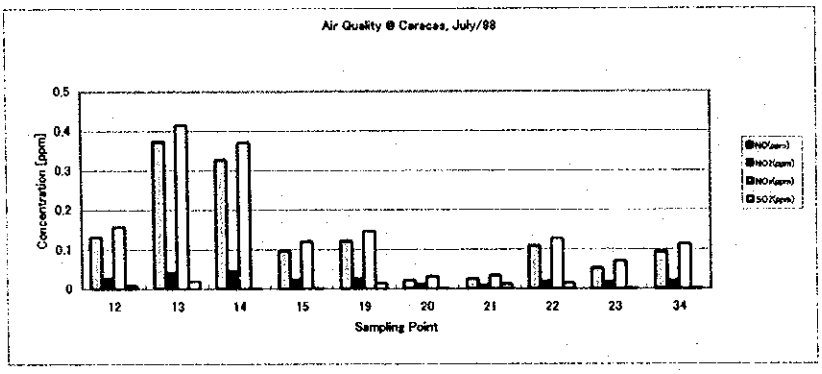

Figure 12.5-7 Field Measurement @ Caracas (NOX and SO_2, July 98)

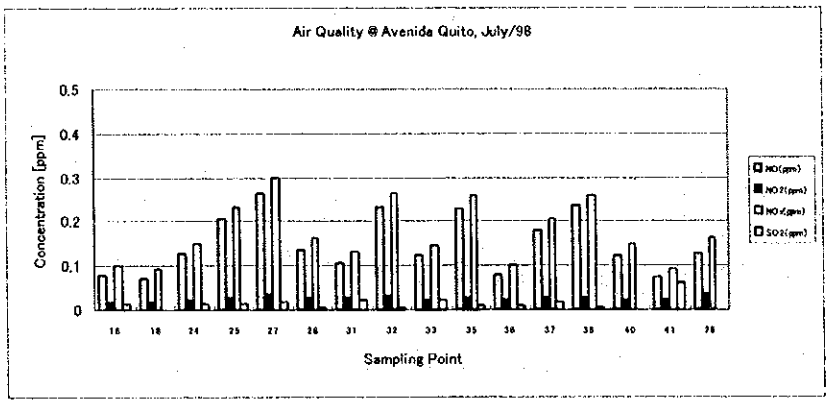

Figure 12.5-8 Field Measurement @ Quito (NOX and SO_2, July 98)