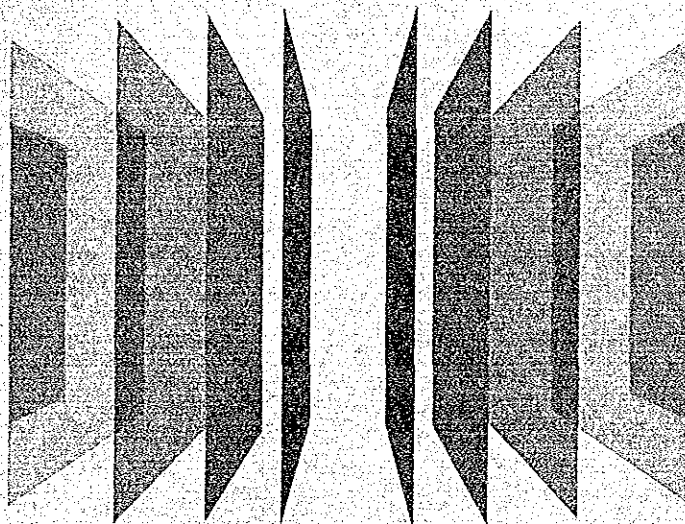


THE FEASIBILITY STUDY
ON
GUAYAQUIL CITY
URBAN TRANSPORTATION PLAN
IN
THE REPUBLIC OF ECUADOR



FINAL REPORT
MAIN VOLUME

DECEMBER 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

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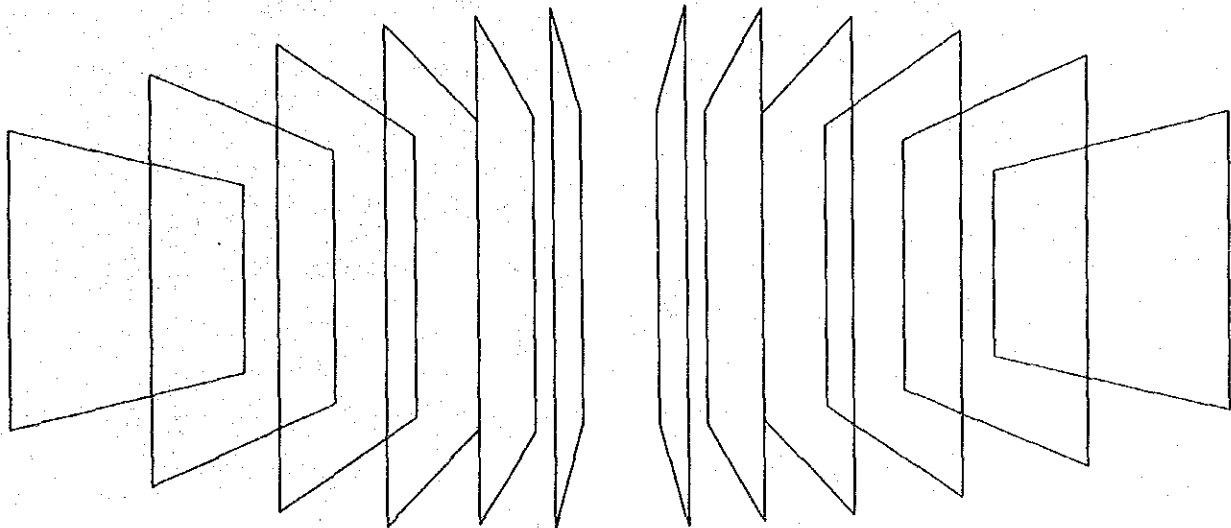
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FINAL REPORT
MAIN VOLUME

DECEMBER 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

国際協力事業団

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PREFACE


In response to the request of the Government of the Republic of Ecuador, the Japanese Government has decided to conduct a feasibility study on the Guayaquil City Urban Transportation Plan and entrusted the study to the Japan International Cooperation Agency. JICA sent to Ecuador a survey team headed by Mr. Etsutaro Iimuro, Tonichi Engineering Consultants Inc. from October to November, 1985.

The team had discussions with the officials concerned of the Government of Ecuador and conducted a field survey. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Ecuador for their close cooperation extended to the team.

December, 1986



Keisuke Arita
President

Japan International Cooperation Agency

December, 1986

Mr. Keisuke Arita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

LETTER OF TRANSMITTAL

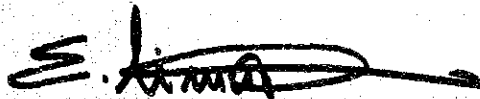
I have the honor of submitting to you herewith the Final Report of the Guayaquil City Urban Transportation Plan in the Republic of Ecuador.

The Study has been conducted by 15 Japanese experts on transportation, composed of Tonichi Engineering Consultants, Inc. and other consulting engineering companies, to examine the technical, economic and financial feasibility of the urban mass rapid transportation system (MRT) of 15 kilometers long in Guayaquil city. The Study has shown that this MRT project would be a drastic measure solving the serious traffic problems, producing considerable benefits well above the cost and promising the further development of Guayaquil, the biggest and very important city in Ecuador. I hope that the project will be carried out immediately and our study will serve as an aid to rid every citizen of the great inconvenience of commuting.

The study Team is greatly indebted to the Government of Ecuador, the Traffic Commission of Guayas, many other authorities, institutes, and persons concerned. On behalf of the Study Team, I would like to express my sincere gratitude for their cooperation and every convenience rendered to the Team.

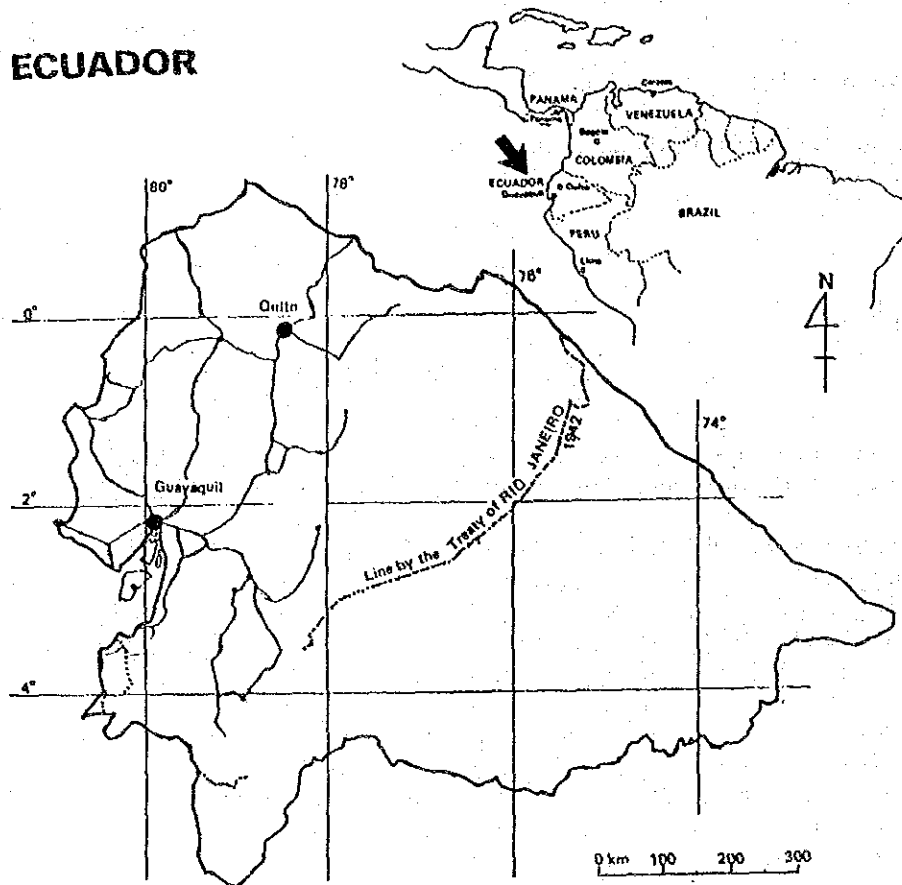
I also would like to express our deepest appreciation to the Japanese Advisory Committee, the Japan International Cooperation Agency, the Ministry of Transport, the Ministry of Construction, the Ministry of Foreign Affairs and the Japanese Embassy in Quito for giving us important suggestions and assistance throughout the Study.

Very truly yours,

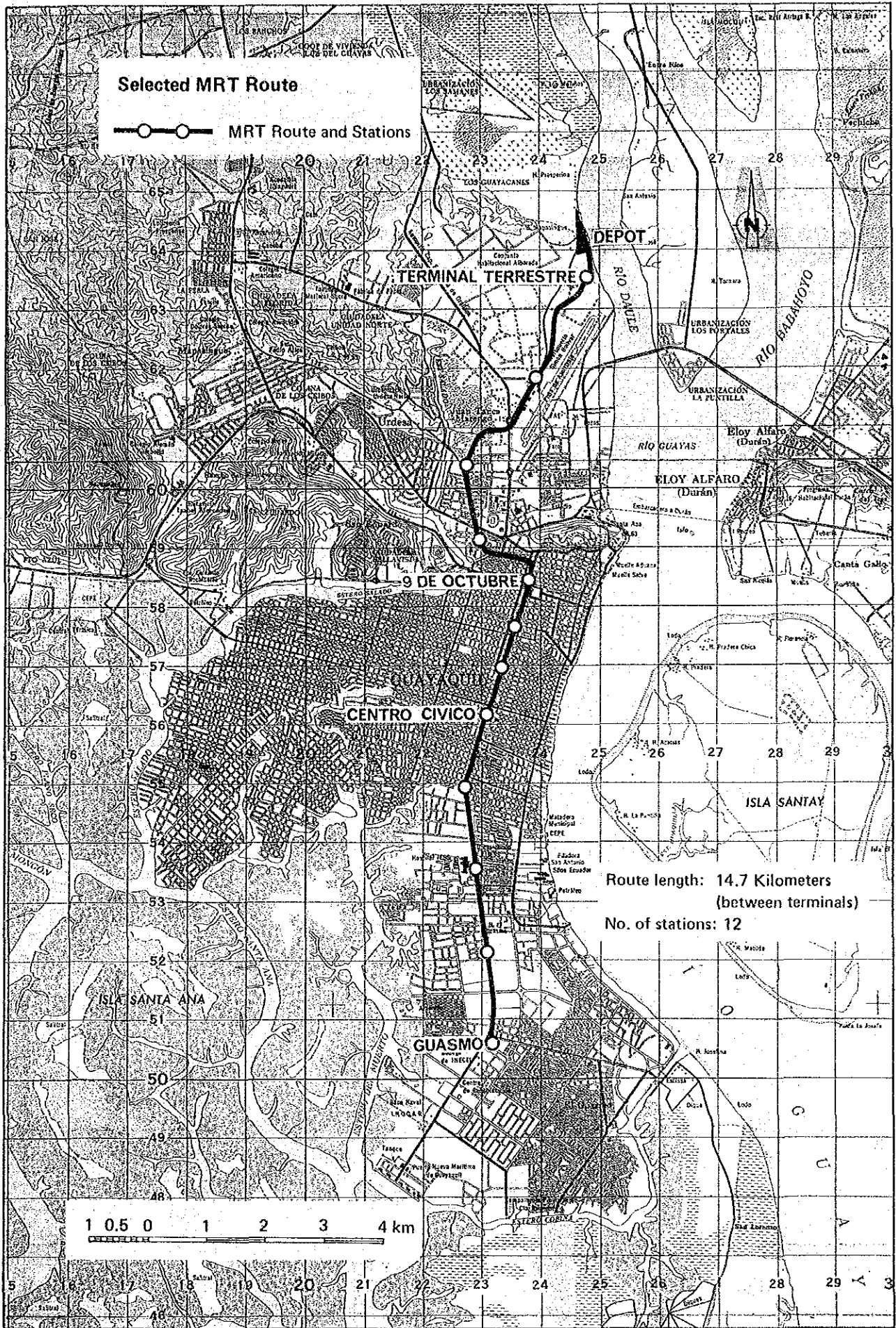


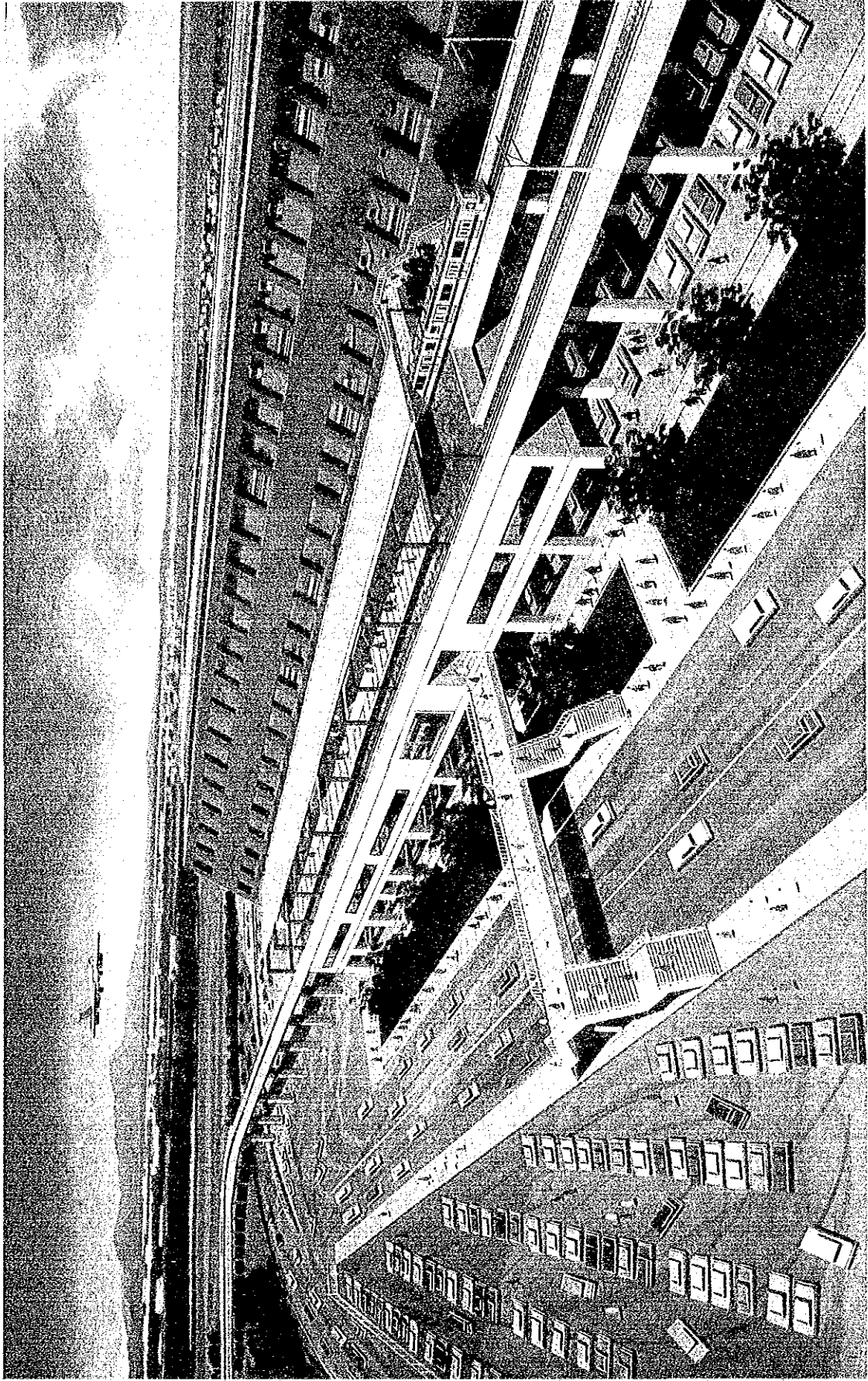
Etsutaro Iimuro
Project Manager
Japanese Study Team for
the Guayaquil Urban Transportation Plan

ECUADOR



Area	;	270,670 Km ² (after 1942)
Population & Growth Rate	;	9,378,000 (1985), 2.91%/year (80-85)
Foreign Money Exchange rate;		US 1\$ = 95 Suces in free market of the Central Bank (A) =120 Suces in free market (Nov.1985)
Gross Domestic Products	;	6,503 mil.US \$ (1983, 87 S./ \$ by (A))
GDP Per Capita	;	734 US \$ (1983, 8.857 mil. Population)
Productive Structure	;	Agriculture 13.5%, Mine & Manufacture 39.7%, Services,etc. 46.8% (1983)
International Trade	;	Export 2,583 mil. US \$/ Import 1.458 , Balance 1,125 mil. US \$ (1984)
National Budget of Govern - ment	;	953 mil.US \$ (1983, 87 S. / \$ by (A))
Index of Consumer's Prices	;	48.1%/year (1983), 30.4 (84)





OVERLOOK VIEW OF TERMINAL TERRESTRE STATION

FINAL REPORT

MAIN VOLUME

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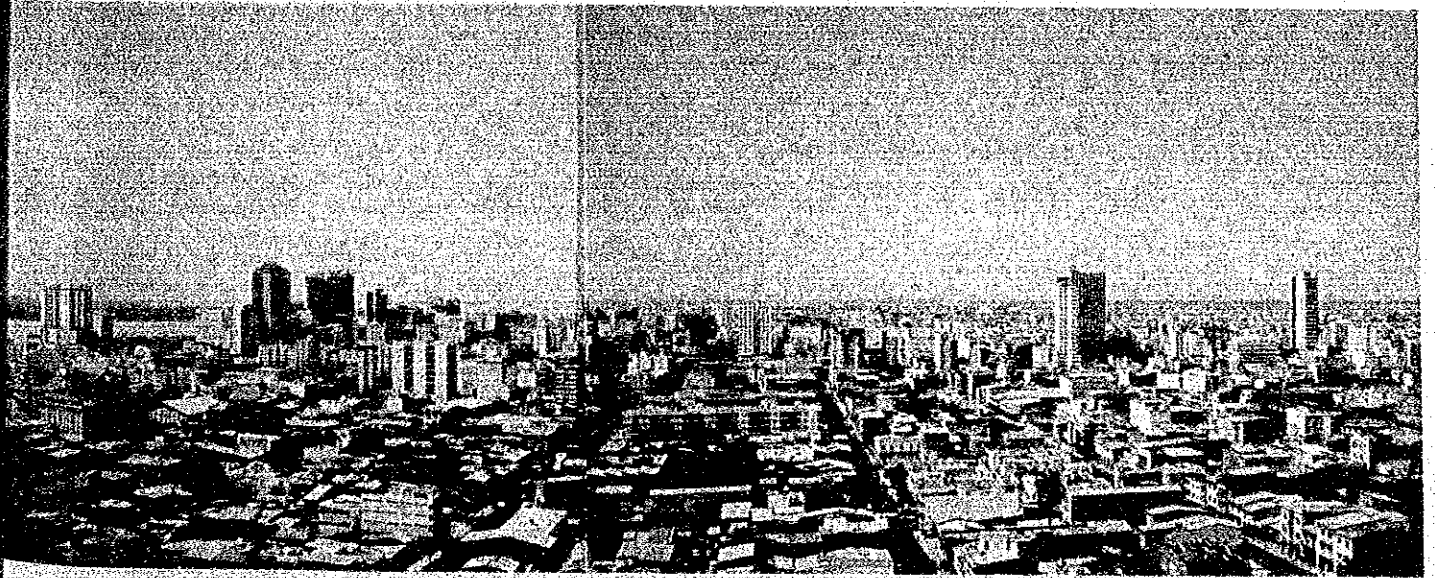
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ABBREVIATION AND DEFINITION IN THIS REPORT

CBD	-----	Central Business District (the area surrounded by Rio Guayas, Av. Quito and Av. Olmedo)
CONADE	-----	Consejo Nacional de Desarrollo
CTG	-----	Comisión de Tránsito del Guayas
EMELEC	-----	Empresa Eléctrica del Ecuador
ENFE	-----	Empresa Nacional de Ferrocarriles del Estado
FODUR	-----	Unidad Ejecutora del Fondo de Desarrollo Urbano de Guayaquil
INECEL	-----	Instituto Ecuatoriano de Electrificación
IETEL	-----	Instituto Ecuatoriano de Telecomunicaciones
INEC	-----	Instituto Nacional de Estadística y Censos
JICA	-----	Japan International Cooperation Agency
MRT	-----	Mass Rapid Transportation
the M/P Study	-----	the master plan study in 1983 by JICA
the Study, the F/S	-----	this feasibility study
the Team	-----	Japanese Study Team

MAIN VOLUME



CHAPTER 1 INTRODUCTION

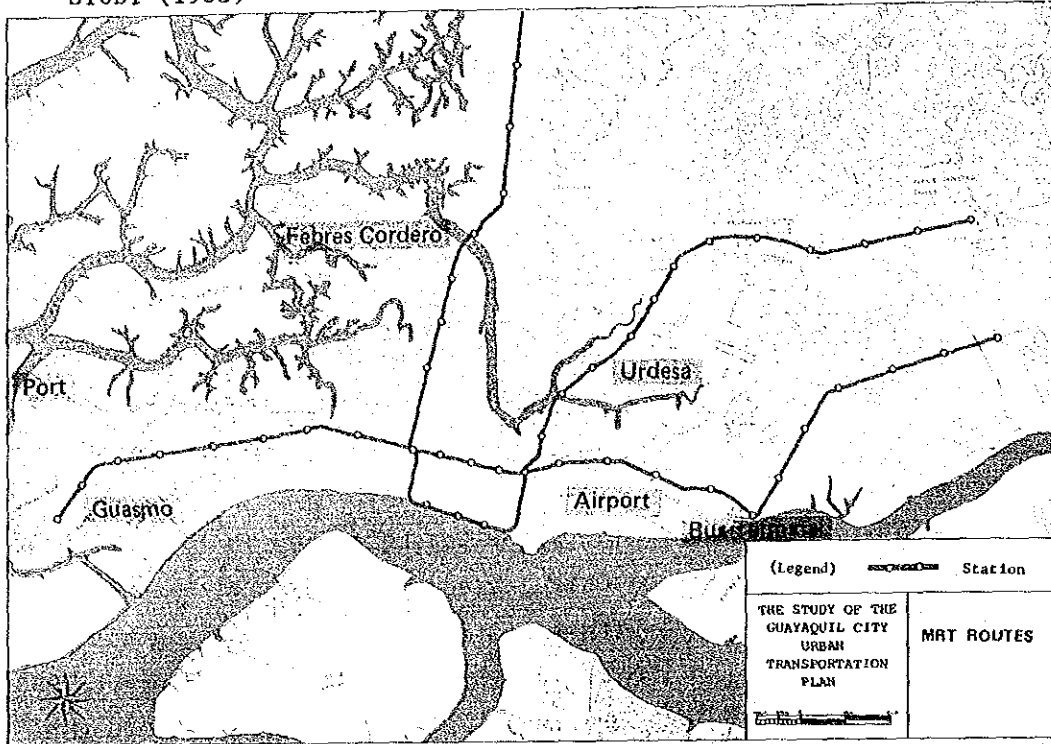
1-1 Background of Study

- 1) In response to the request of the Government of the Republic of Ecuador (hereinafter referred to as "the Government of Ecuador"), the Government of Japan decided to conduct a study on Guayaquil city urban transportation plan in 1981, and in 1982 the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, began a master plan study of urban transport for Guayaquil city which targeted the year 2000.
- 2) The above master plan study was commenced in April 1982, and its final report which recommended the two MRT (Mass Rapid Transportation) lines with total 50 kilometers long in the year 2000, was submitted to the Government of Ecuador in August 1983. Consequently, the Government of Ecuador requested to the Government of Japan technical cooperation for the feasibility study of the MRT project of which section was concluded to be most urgently implemented in its final report.
- 3) The object route of the MRT for this feasibility study (hereinafter referred to as "the Study") which started in October 1985, is the north - south line with about 15 kilometers long, originating from the Terminal Terrestre in the north and terminating at the entrance of Guasmo in the south mainly along Av. de las Americas and Av. Quito (see Figure 1-1.1 at next page).

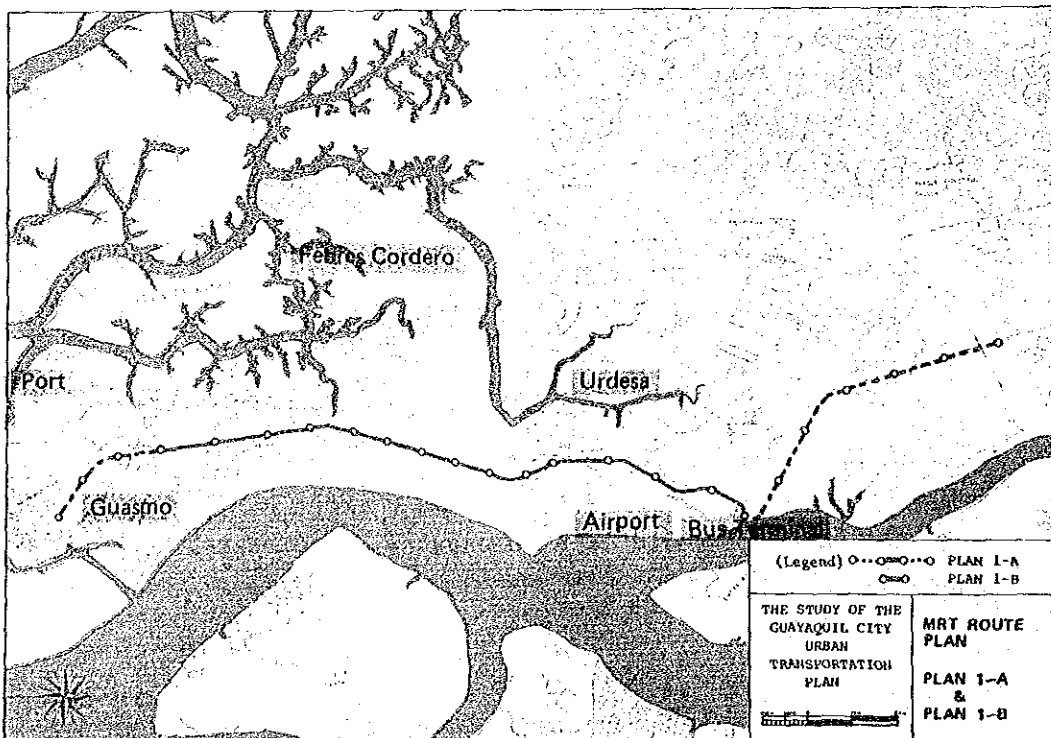
On closing the background, the Study Team is indebted to many authorities, institutes, private companies and persons concerned. The Team would like to express sincere gratitude for their cooperation.

Figure 1-1.1 WHOLE MRT LINE IN 2000 AND OBJECT ROUTE IN THIS STUDY

1) THE WHOLE MRT ROUTE IN 2000 YEAR RECOMMENDED IN THE MASTER PLAN STUDY (1983)

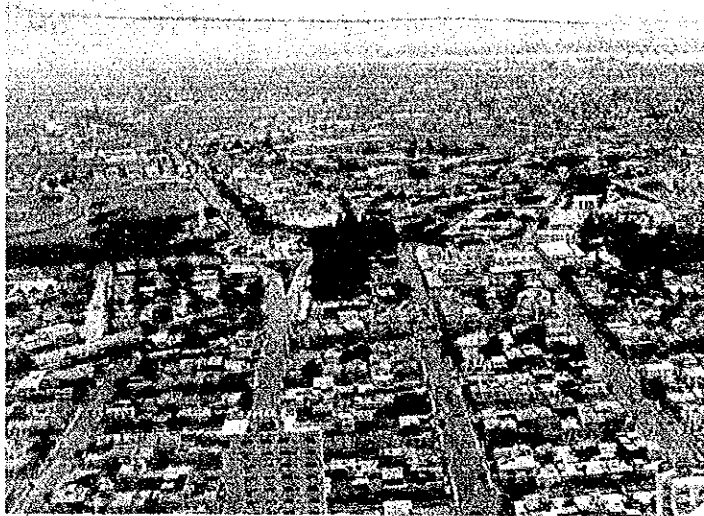


2) THE OBJECT ROUTE OF THIS FEASIBILITY STUDY (PLAN 1-B IN THE MASTER PLAN STUDY)



Present Outlook of the area along the MRT route

Northern part



Central Part

Southern Part



1-2 Study Objectives and its Organization

1-2.1 Objectives of Study

The objectives of the Study are;

- (1) to examine the technical, economic and financial feasibility of the north-south line of the MRT with about 15 kilometers long, starting from the Terminal Terrestre in the north and passing Av. de las Americas and Av. Quito toward the southern part of the city, Guasmo.
- (2) to pursue technology transfer to Ecuadorian counterpart personnel in the course of the Study.

On proceeding with MRT project study, the basic concept to improve the public transport system in the city is also worked out.

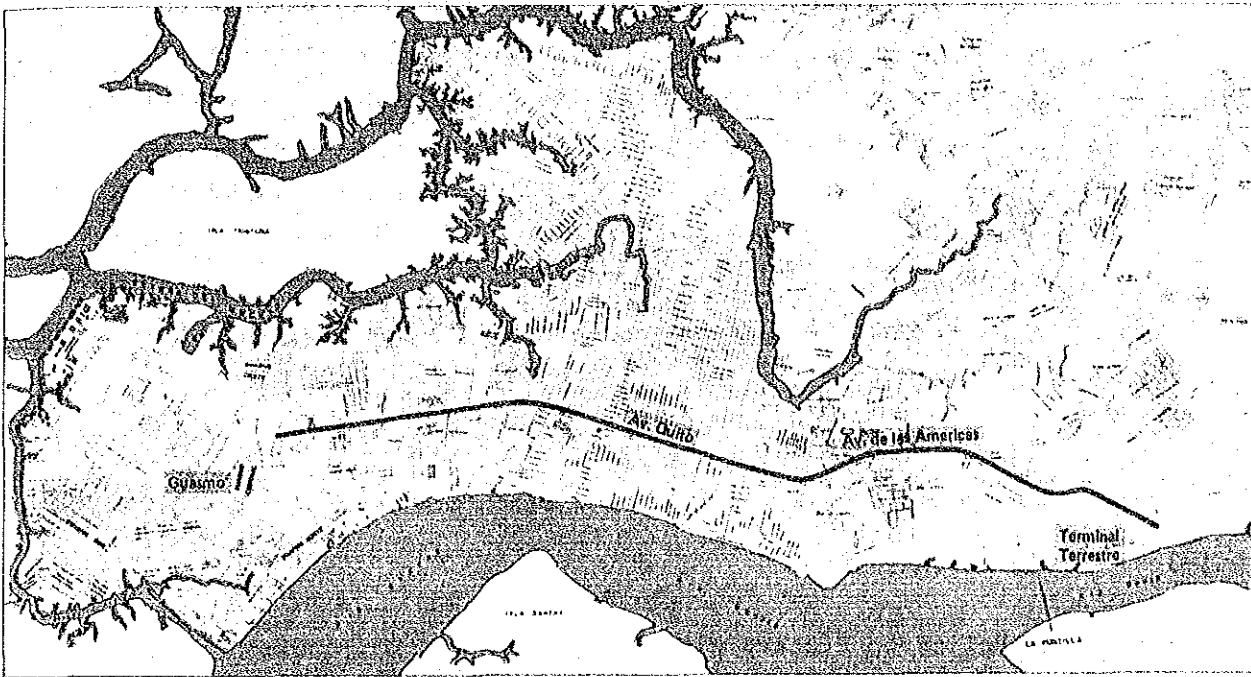
They are;

- Basic idea for bus route reorganization and coordination plan between bus and the MRT in main stations
- Improvement plan of accessibility from Av. Quito to the Guayas river side
- Improvement concept on streets used for the MRT passage, and land use development around the main stations and along the wayside of the MRT

1-2.2 Object Route of MRT to be Examined

Figure 1-2.1 shows the basic object route of the MRT to be examined in this study, which was recommended to be most urgently implemented of the whole MRT lines with 50 kilometers long targetted 2000 year in the master plan studied by JICA in August 1983.

Figure 1-2.1 BASIC OBJECT ROUTE OF MRT



Main Street of the City, Av. Quito

1-2.3 Study Organization

JICA organized the Japanese Study Team of 15 experts to carry out the Study in close coordination with Ecuadorian counterparts provided by Comision de Transito de la Provincia del Guayas (Traffic Commission of the Province of Guayas, hereinafter referred to as "CTG"). JICA also established the Japanese Advisory Committee of 4 members to review the findings by the Study Team.

All members and persons concerned with the Study are listed on Appendix A-1.

1-3 Study Approach

1-3.1 Basic Policy to Proceed with Study

1) Recommendation of Mater Plan (M/P) Study

As mentioned in 1-1. BACKGROUND OF STUDY, this F/S purposes to examine the feasibility of the North-South route with about 15 kilometers long which had been recommended to be most urgently implemented of all 50 kilometers in the year 2000 in the Final Report of the M/P Study submitted by JICA in August 1983.

Of these 50 kilometers of the MRT, the M/P Study proposed the priority of execution in each section in every 5 year to 2000 in coordination with the road improvement and other related plans.

As for the MRT system, it selected 5 alternative systems applicable (Urban Railway, Light Rail Transit (LRT), Monorail, Rubber Tyre Type Railway and Subway), and concluded that any of the four systems except the subway would produce benefits over its cost to the whole 50 kilometers in 2000 (see Table 1-3.1).

2) Basic Policy to Proceed with Study and its Method

The object route being examined in this F/S composes of the whole MRT network in 2000 which is involved in the Long Term Transportation plan drawn in the master plan. The Study is, therefore, basically executed subject to the conclusions of the M/P, and consistent with extension of the MRT route in future and other plans involved in it. The major subjects of the Study are as follows:

a. Review and Update of Data, and Demand Forecast

Various data of the transport condition and socio-economic frameworks that form the basis for the demand forecast are reviewed and updated, and based on their changes after the M/P Study, the MRT demand forecast is carried out.

b. Selection of MRT Route Alternatives

There would be very few possibility of big changes in the route, but some alternatives including small modifications of the alignment are picked up both in the northern and in the southern part and are examined in detail. They are compared with each other from various aspects: passenger demand, construction cost, alignment, type of trackway structures, necessity of land acquisition, difficulty and/or easiness for construction work etc., and the optimum one is selected among them.

c. Selection of MRT System Alternatives

In spite of prospects of the M/P Study, three of five systems in Table 1-3.1; Urban Railway, Light Rail Transit (LRT), Monorail are examined again more in detail to verify which one would be the most feasible to the object route (about 15 kilometers) selected in the above 'b'. They are evaluated from the viewpoints of transport capacity, investment cost, operation and maintenance cost, facility of maintenance, availability to the route requisites

Table 1-3.1 COMPARISON OF ALTERNATIVE SYSTEMS TO 50 KILOMETERS IN 2000

(Results of the M/P Study in 1983)

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

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

2. ○ means good and Δ means common.

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

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

3. 1 US dollar = 50 Sucres (free market average in 1982)

4. Construction cost is estimated in 1982 prices.

5. Source: Final Report (Summary) p. S-28, August 1983

selected and route extension in future, etc., and the most suitable system is selected.

In this report, the LRT used in the M/P is renamed Light Urban Railway because although the both systems have same characteristics or performances and are generally classified into a same category, the LRT sometimes means a street railway on roads with car traffic while the MRTs in this Study are operated only on the exclusive right-of-way through the whole object route of 15 km (as for the definition of the LRT, refer to the supplementary volume 1, PART 4 2-3).

d. Formulation of Construction and Management Plan

Based on the optimum route and system selected in their alternatives, a complete construction and management plan, including transport plan and estimation of project cost and operation and maintenance cost, is formulated for the 'Basic Case' that opens the whole route of 15 km in 1990 at a time (see the latter item 'f').

e. Other Improvement Plans Related to the MRT

For improving the public transportation system in the Guayaquil city, conceptional plans are worked out for several items related to the MRT. They are: bus route reorganization, improvement of accessibility from Av. Quito to the Guayas river, development of the areas around stations and the wayside, etc.

f. Economic and Financial Analysis and Overall Evaluation

The final purpose of the Study is to decide the most economically and financially effective opening year, its section and extension among various staged construction cases which have different process for completing the whole route of 15 km.

Considering the results of the M/P Study, cases tested in economic and financial analysis are selected as shown in Figure 1-3.1.

The characteristics of selected cases are outlined as below.

- | | |
|------------------|--|
| Basic Case | Whole route of 14.7 km is opened in 1990 at a time. |
| Case A, B | Construction starts from the northern end, Terminal Terrestre, and goes southward. |
| Case C, D | Construction starts from the southern end, Guasmo, and goes northward. |
| Case E,F,G | Construction ends at the first stage and no extension of the route. |

As for the opening year of the MRT system, according to the implementation program of the M/P Study, the initial section of each case is to be opened in 1990. Extension of the route to the final 14.7 Km is proposed by cases in one or two stage process as shown in Figure 1-3.1.

In making the above section cases, two sectioning points have been picked up. They are 9 de Octubre and Centro Civico. The former is near CBD, while the latter is in the most suitable place to reach the western and southern part of the city by buses. The both places, it is thought, might be the busiest points along the would-be MRT

route where the majority of passengers would take or alight MRT trains.

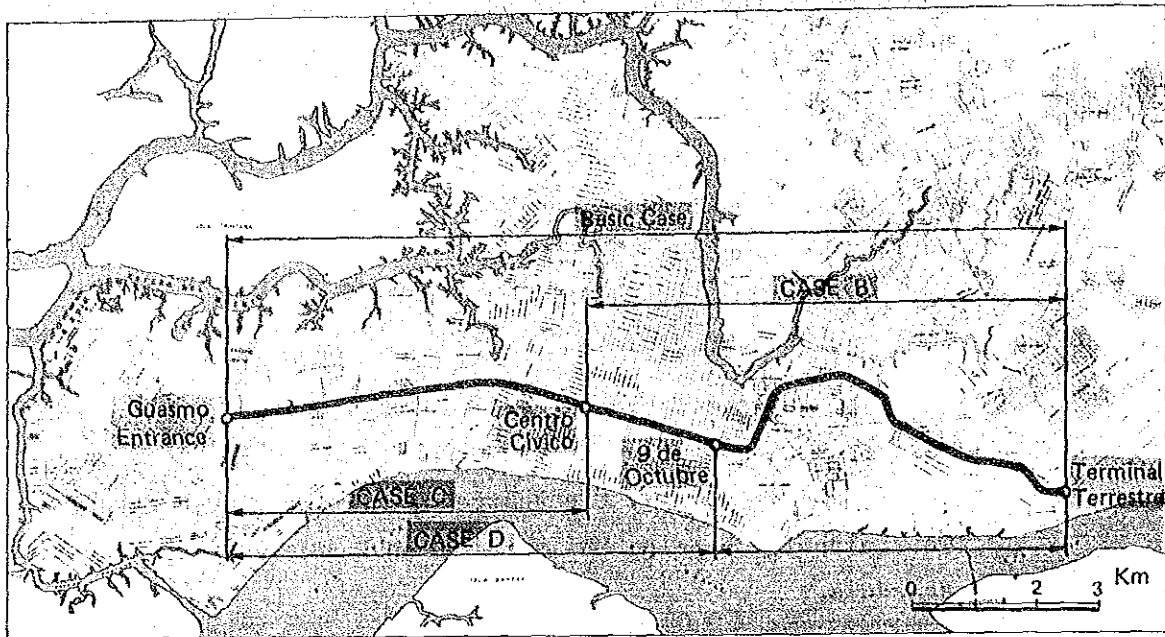
Another reason is in their proper distance from the terminals of the proposed MRT route. If the MRT route is too short, people won't use it nor the construction of MRT be required.

g. Implementation Program

The implementation program for the most feasible case selected in the above 'f' is worked out. It consists of the financing plan by the source of the fund, preparatory work plan for opening MRT services and construction schedule.

Figure 1-3.1 CASES TESTED IN ECONOMIC AND FINANCIAL ANALYSIS

(SECTION CASES)

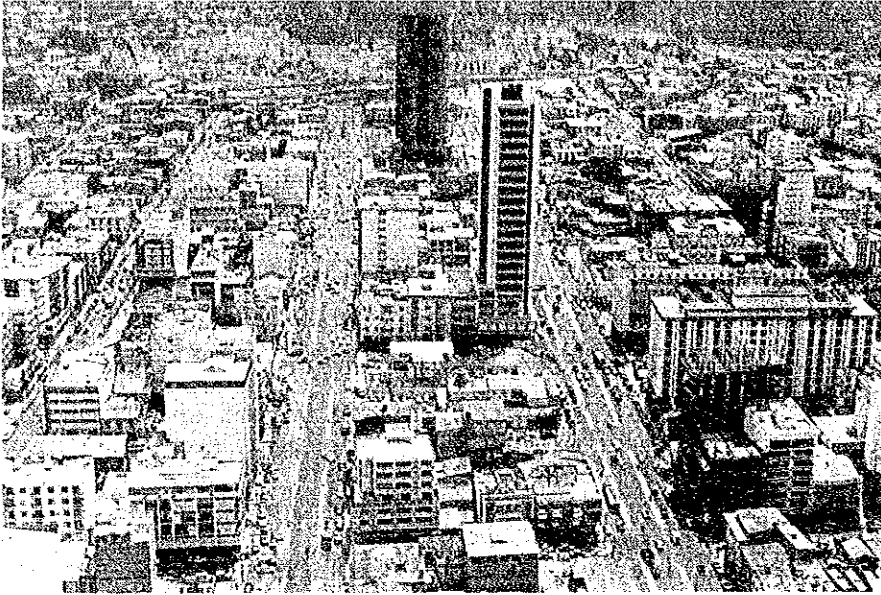


TEST CASE

Test Case	Opening Year and its Section
Basic Case	1990 (14.7 km)
Case A-1	1993 (8.0 km) 1990 (6.7 km)
Case A-2	1996 (5.6 km) 1993 (2.4 km) 1990 (6.7 km)
Case B-1	1993 (5.6 km) 1990 (9.1 km)
Case C-1	1990 (5.6 km) 1993 (9.1 km)
Case C-2	1990 (5.6 km) 1993 (2.4 km) 1996 (6.7 km)
Case D-1	1990 (8.0 km) 1993 (6.7 km)
Case E	(No further construction) 1990 (6.7 km)
Case F	(No further construction) 1990 (9.1 km)
Case G	1990 (8.0 km) (No further construction)

Selected Sectioning Points for Test Cases

9 de Octubre

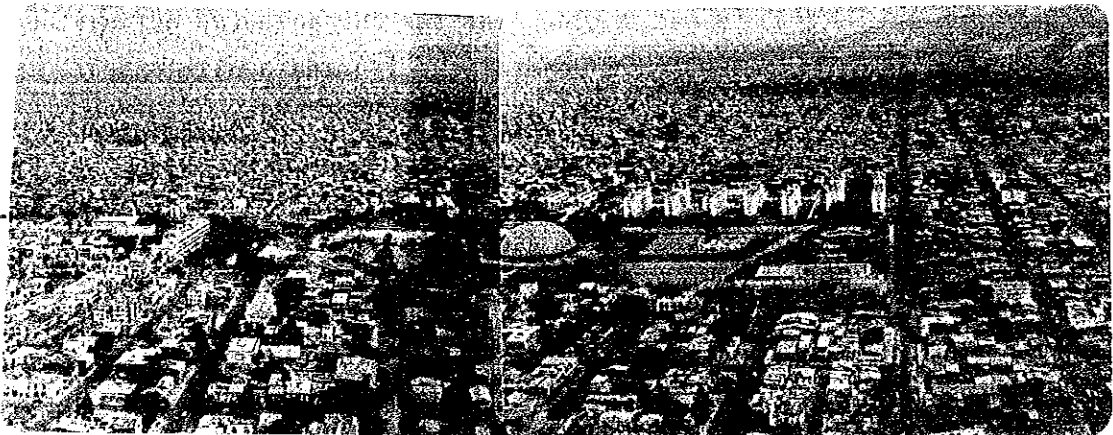


← Av. 9 de Octubre

↑ Av. Quito (MRT Route)

Centro Civico

Av. Quito

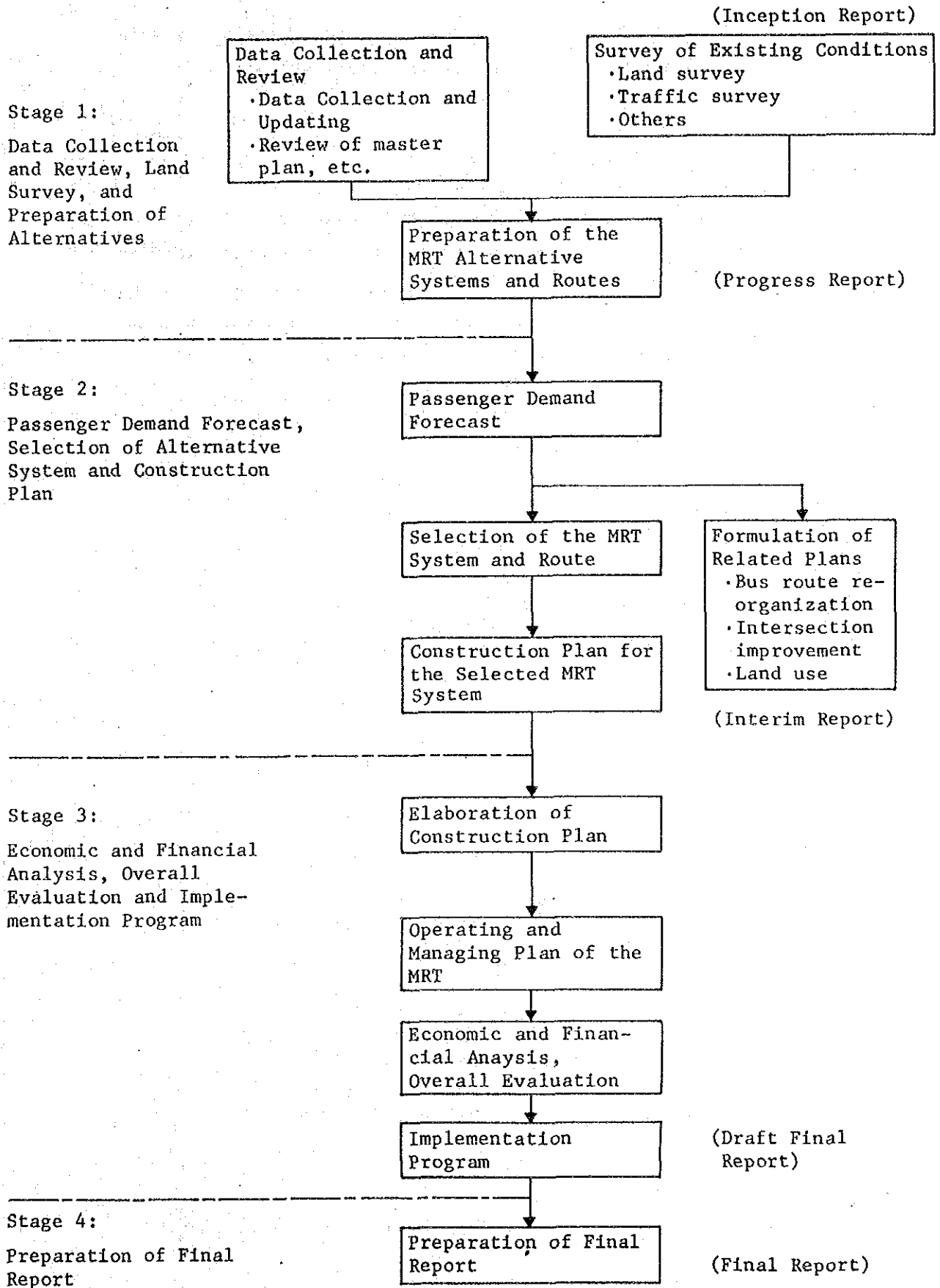


1-3.2 Schedule and Staging of Study

The study started in October 1985 and finished in December 1986, executed by the following stages and items shown in Figure 1-3.2

- Stage 1:
- Data collection, review and updating of the master plan, national and regional development plans, etc.
 - Land survey, supplementary traffic survey and other surveys on existing condition such as bus routes, land use, traffic volume and configuration of intersections, underground and aerial obstacles, etc., along the MRT route
 - Preparation of the MRT alternative systems and route alignments to be examined
- Stage 2:
- Passenger demand forecast
 - Selection of the MRT system and route location
 - Formulation of the related plans to the MRT such as recognition of bus routes, improvement of big intersection, land use and impact on the wayside
 - Construction plan for the selected MRT system including operation plan and preliminary engineering design
- Stage 3:
- Elaboration of the construction plan
 - Operating and managing plan of the MRT
 - Economic and financial analysis, and overall evaluation of the project
 - Implementation program
- Stage 4:
- Preparation of the Final Report

Figure 1-3.2 STAGING OF THE STUDY



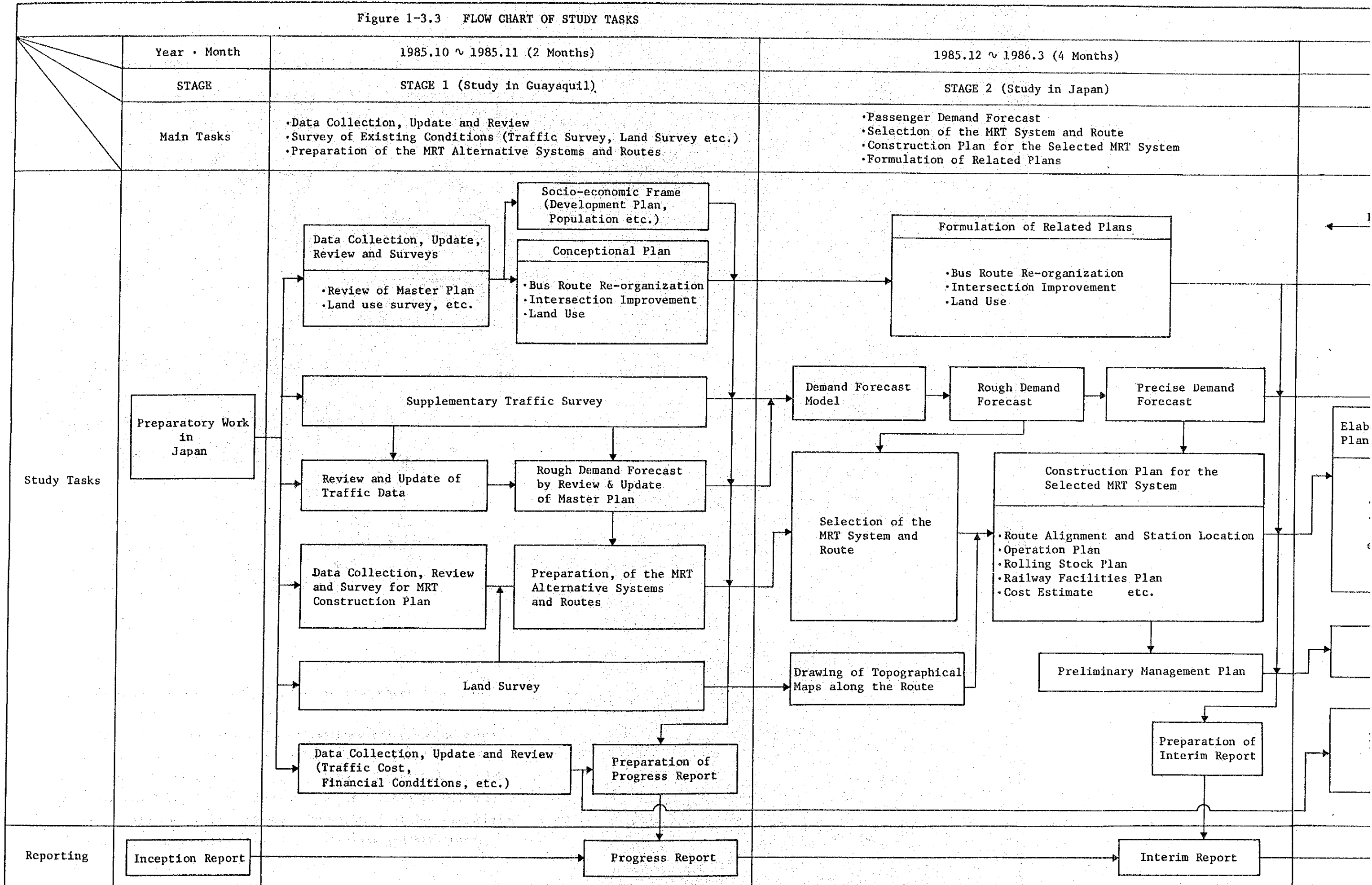
1-3.3 General Flow Chart of Study

Figure 1-3.3 shows the general flow of the Study which clarifies between each task by the above stages.

1-3.4 Study Area

The Study covers the Guayaquil urban area and her surroundings for the traffic demand forecast which exactly corresponds to that of the M/P Study in 1983, while the area along the MRT route is studied in detail to ensure the accuracy of the project. Figure 1-3.4 shows the whole study area.

Figure 1-3.3 FLOW CHART OF STUDY TASKS



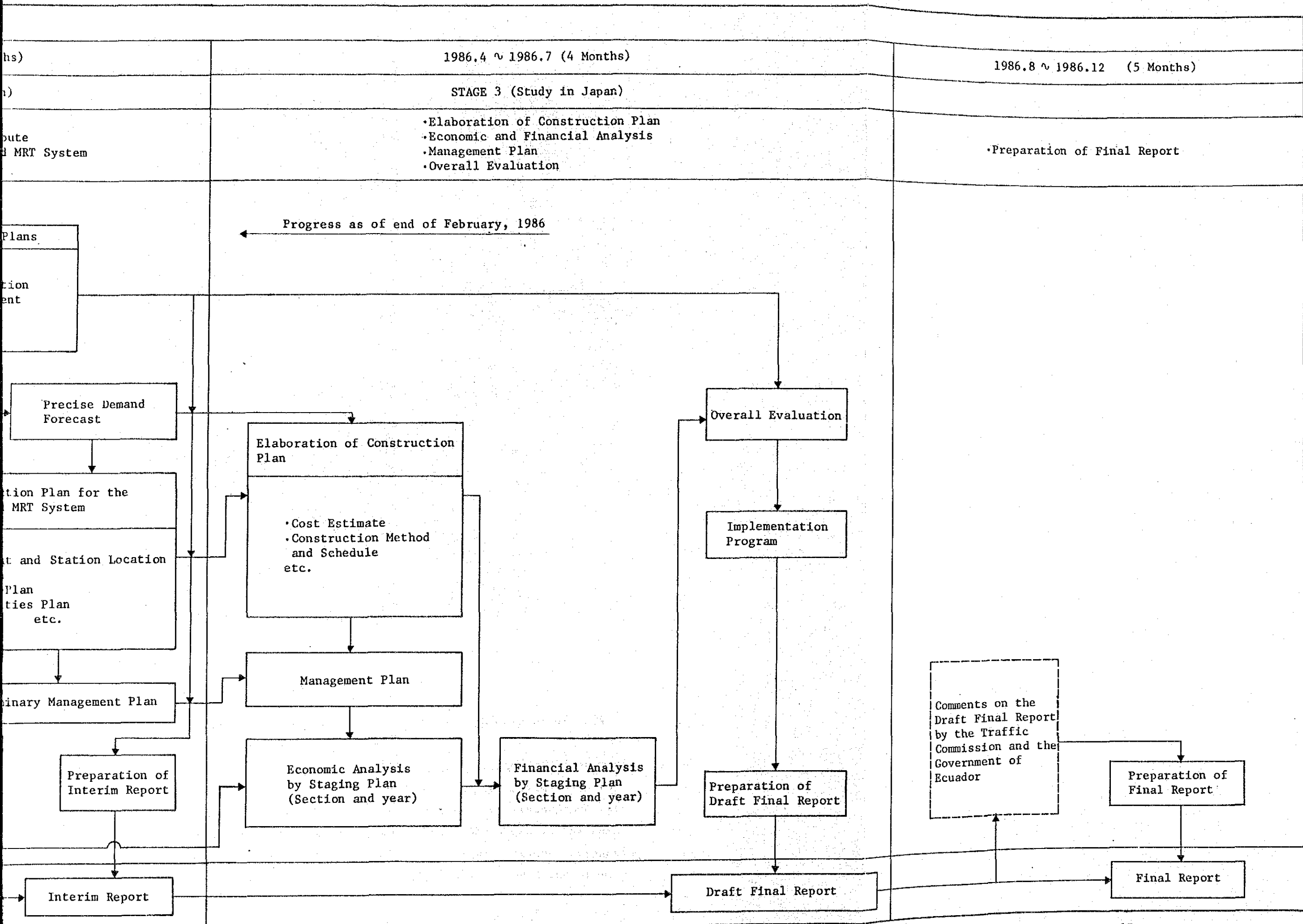
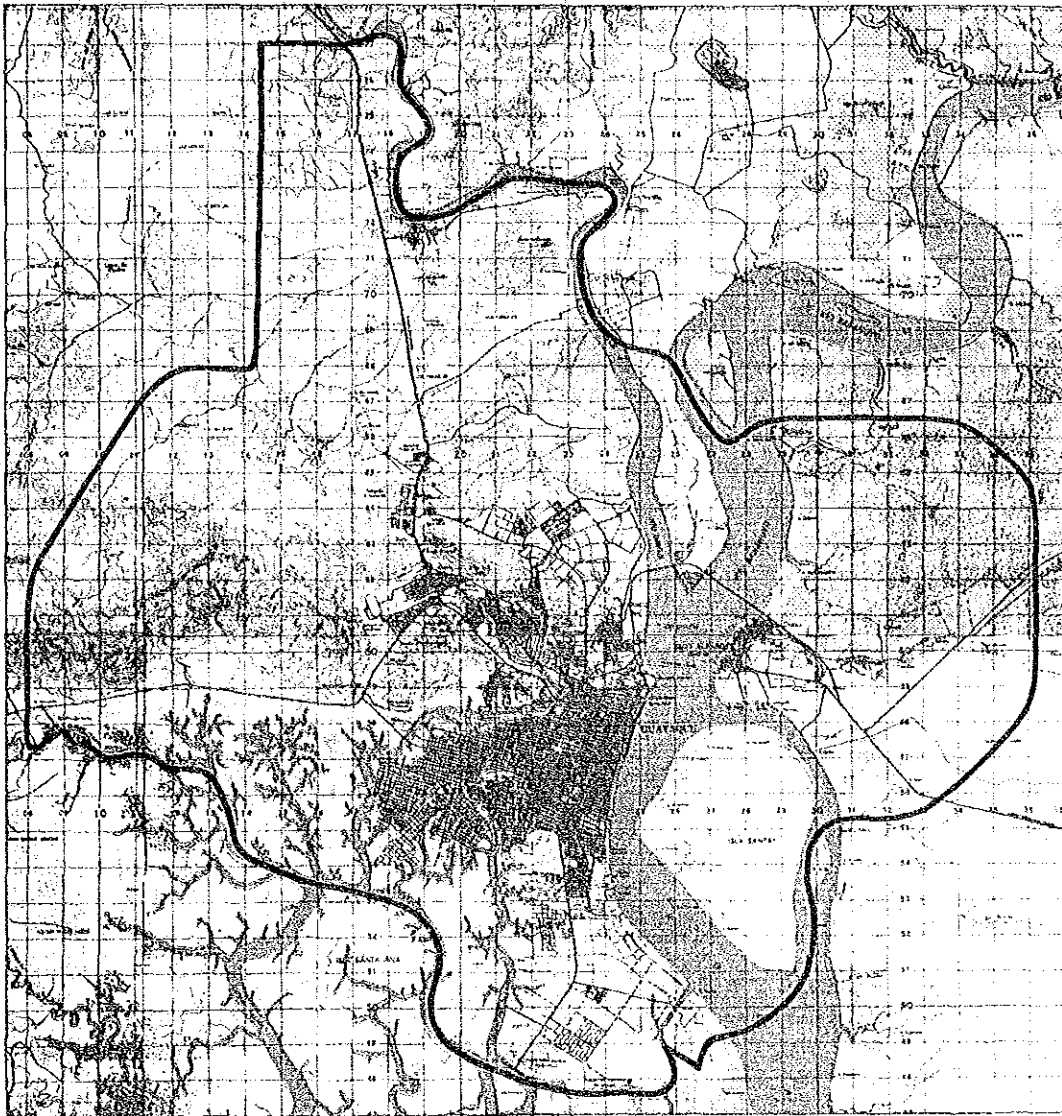


Figure 1-3.4 STUDY AREA

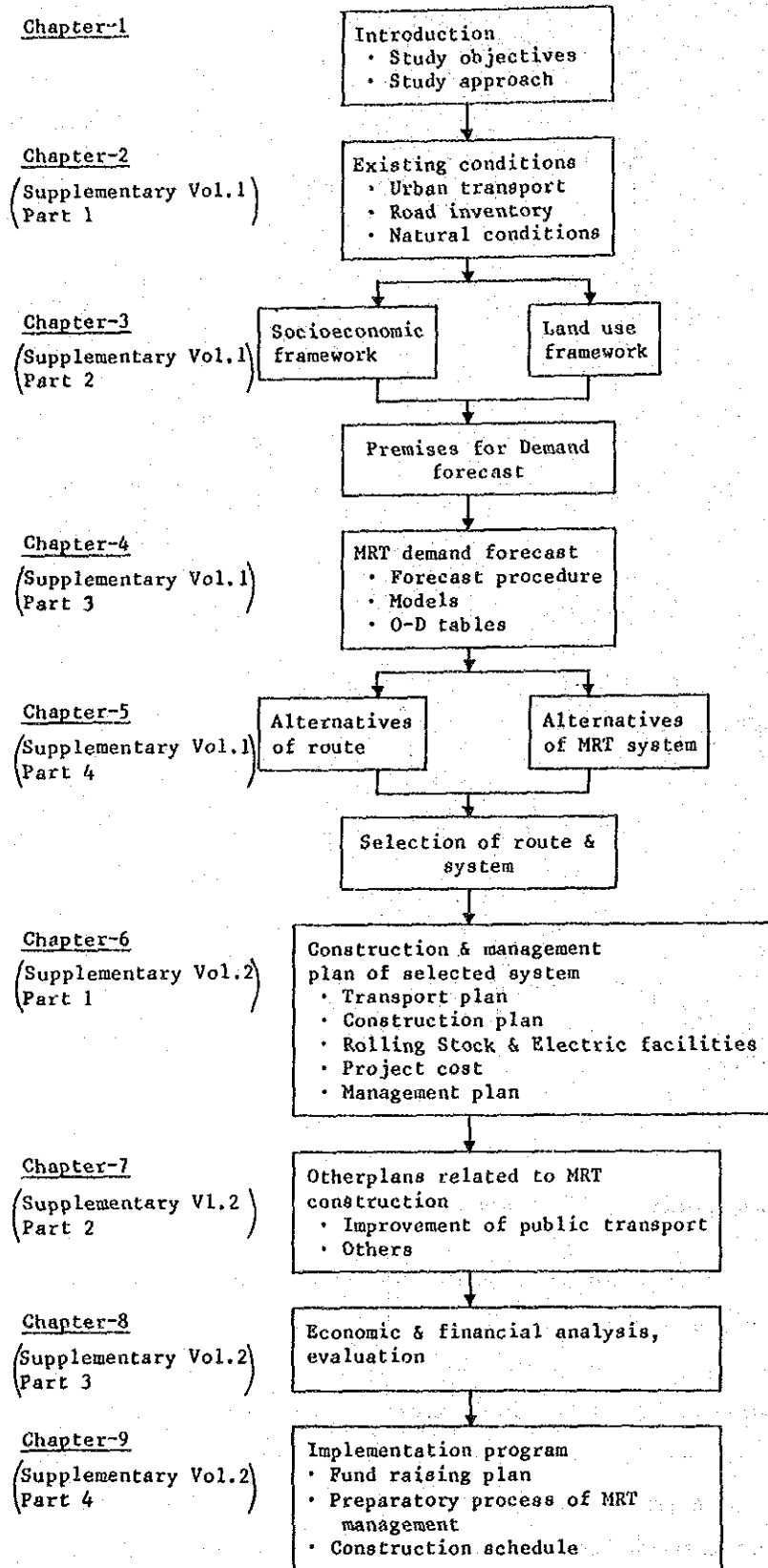


1-4 Arrangement of this Report

Arrangement and principal items in each chapter of this report are shown in Figure 1-4.1.

In order to describe technical methodologies and data more in detail, 2 of 3 supplementary volumes are prepared so as to correspond to each chapter of this volume. Correspondence with the main and 2 supplementary volumes is also shown in the same figure, while the third supplementary volume includes engineering drawings such as profiles, sections, stations and structures, etc.

Figure 1-4.1 ARRANGEMENT AND CONTENTS OF THIS REPORT



CHAPTER 2 EXISTING CONDITIONS IN STUDY AREA

2-1 Existing Condition of Urban Transport

Overall urban traffic demand in Guayaquil is mainly catered by such road transport as private vehicles, taxis and public buses. These transport systems had well functioned previously because the Guayaquil city was not large and its road system has developed in relatively sufficient level. Now, however, they seem to be confronted with heavier load than their transport capacity while the city is being urbanized extensively and its urban population is growing rapidly.

The traffic demand for typical transport modes are shown in Table 2-1.1.

Table 2-1.1 PRESENT URBAN TRAFFIC DEMAND IN GUAYAQUIL BY MODE

Unit: Trips/day in 1982

MODE	TRIP VOLUME
Private Vehicles	1,051,000
Bus	842,000
Taxi	420,000
Total	2,313,000

Source) M/P Study

The trips of private vehicles will increase with the car ownership growth in future, resulting in making the road traffic congestion worse.

The public urban bus system plays an important role in urban transport and it provides mobility to the people who lack self-movable means.

Though a bus can afford to carry more peoples than a small private vehicles and thus utilize roadway more efficiently, traffic congestion on the road is disturbing the transportability of urban bus system.

1) Traffic Volume on Arterial roads in Guayaquil.

The Guayaquil city has such an urban development pattern that the suburban areas have been extended to surroundings from the single core of the city and the major roads connect them each other. Such major roads consist of wide multi-carriageways and have high capacity but the concentration of traffic on these roads leads to congestion.

Figure 2-1.1 shows traffic flow of major arterial road sections situated at entry points toward the CBD.

In comparison with the data at year 1982 when Master Plan was studied, a greater change can be seen mainly at northern suburban sections while minor changes occur at the innermost sections near the CBD.

2) Variation by time

The traffic flow have a peak between 8 and 9 a.m., remain fairly constant throughout the day time and fall gradually after 6 p.m. (see Figure 2-1.3)

3) Vehicle Composition

The vehicular composition varies fairly depending on the road sections because each road has particular route characteristics from the viewpoint of the roadside land use. (see Figure 2-1.2).

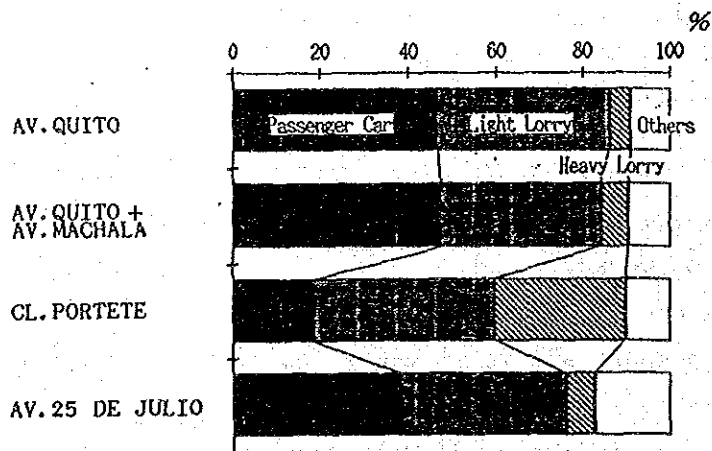
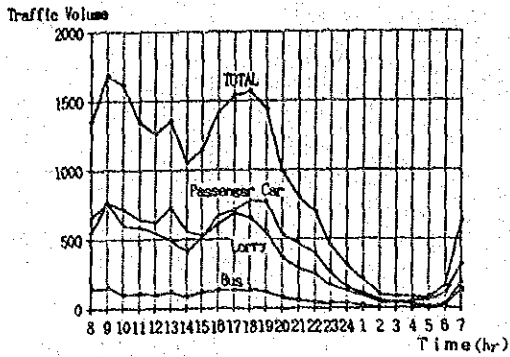


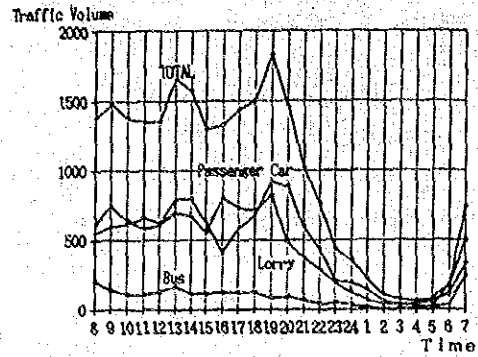
Figure 2-1.2 TRAFFIC COMPOSITION BY ROADS

Source) The supplementary traffic survey by the Study Team in 1985

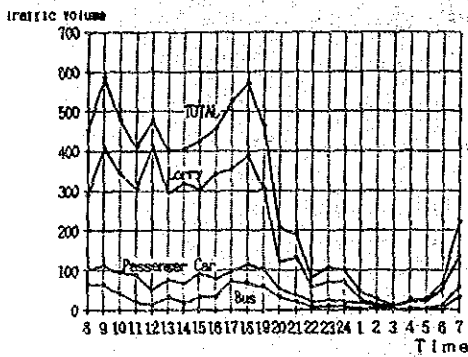
Road section (9 de Octubre (Entry))



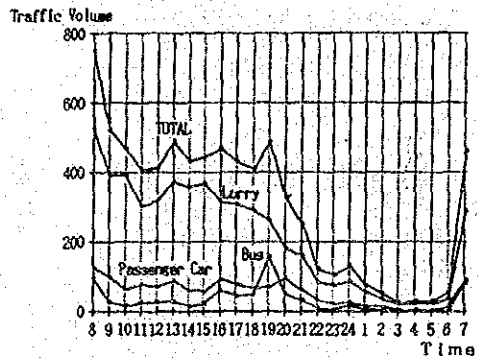
Road section (9 de Octubre (Exit))



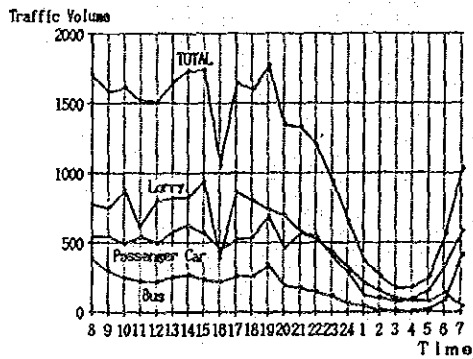
Road section (Cl. Portete (Entry), Puente Portete)



Road section (Cl. Portete (Exit), Puente Portete)



Road section (Av. 25 de Julio (Entry))



Road section (Av. 25 de Julio (Exit))

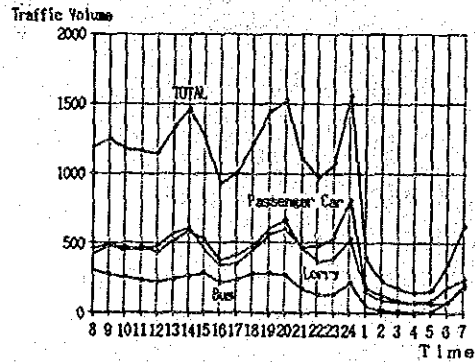


Figure 2-1.3 TRAFFIC VARIATION BY TIME

Source) The supplementary traffic survey by the Study Team