

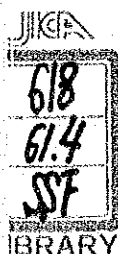
*JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)  
MINISTRY OF PUBLIC WORKS  
THE REPUBLIC OF PANAMA*

***THE FEASIBILITY STUDY  
ON  
THE IMPROVEMENT OF  
THE PANAMA-COLON HIGHWAY  
IN THE REPUBLIC OF PANAMA***

***EXECUTIVE SUMMARY***

*MARCH 1994*

***YACHIYO ENGINEERING CO., LTD.  
IN ASSOCIATION WITH  
CHODAI CO., LTD.  
ASIA AIR SURVEY CO., LTD.***



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Applied Foreign Exchange Rates in  
this report are:

US\$1.00 = Balboa 1.00

US\$1.00 = Yen 106.15

(As of July 1993)

## ***Preface***

In response to a request from the Government of the Republic of Panama, the Government of Japan decided to conduct a feasibility study on the Improvement of the Panama-Colon Highway and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent a study team to Panama three times between December 1992 and March 1994. The study team was headed by Mr. Takeshi Yoshida and composed of members of Yachiyo Engineering Co. Ltd., Chodai Co. Ltd., and Asia Air Survey Co. Ltd.

The team held discussions with the officials concerned of the Government of the Panama, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

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

March, 1994



---

Kensuke Yanagiya  
President  
Japan International Cooperation Agency







Perspective View of the Proposed New Panama-Colon Highway



## **OUTLINE OF THE STUDY**

### **1. Study Background**

Panama-colon highway is a highway which connects the metropolitan area of Panama with that of Colon, the second largest city of Panama. It is now 50 years since the road was constructed and it has suffered from insufficient maintenance. The horizontal and vertical alignment of some sections of the existing Panama-Colon highway is also sub-standard, causing traffic accidents. In addition, growth of the suburbs of Panama city has increased traffic and caused heavy traffic congestion. Therefore, improvement of the existing road or construction of new road segments is considered necessary.

In response to a request from the Government of the Republic of Panama, the preliminary study team headed by Mr. Koji Yokota was dispatched by JICA to Panama and the Scope of Work for the Study was agreed on September 1992.

### **2. Study Purpose**

- a) to formulate a Master Plan for arterial road development between Panama and Colon.
- b) to carry out a Feasibility Study on selected projects of the Master Plan.

### **3. Study Area**

The study area is the existing Panama-Colon highway, and possible alignments for a new road in the vicinity of the existing road.

### **4. Study Period**

The study period was from December 1992 until March 1993.

### **5. Study Content**

#### **Analysis**

Socio-economic conditions

Existing road conditions, traffic conditions, and environmental conditions

#### **Road Network Master Plan**

Planning policy

Socio-economic framework and future traffic demand

Road network plan alternatives

Evaluation of alternatives and selection of priority sections

#### **Mapping**

Aerial photo-mapping, ground survey, aerial mapping triangulation, topographic mapping

### Feasibility Study

- Geology, soil, and hydrology analysis
- Establishment of design standards
- Preliminary design
- Environmental impact assessment
- Preliminary project cost estimation and implementation schedule
- Economic analysis, financial analysis, and overall evaluation

## 6. Proposed Project Content

By the year 2010 the new Panama-Colon Highway (59km) will be required. The new highway will be a high standard four lane road with a 110km/hr design speed and full access control.

The road segments of the Panama-Colon highway subject to the feasibility study is 46.4km long (20.2 km of Alcalde Diaz section, 26.2 km of Sabanitas section).

## 7. Implementation Schedule

Construction of the Alcalde Diaz section should be from 1995 to 1999 and for the Sabanitas section from 1997 to 2004.

## 8. Project Cost

For the full project as identified in the Master Plan stage, the total project cost is estimated at balboa 472.95 million.

For the two project sections subject to the feasibility study, estimated costs are:

Alcalde Diaz Section:	Balboa 138.64 million	
	(Foreign portion:	Balboa 75.472 million
	Local portion:	Balboa 63.169 million)
Sabanitas Section:	Balboa 264.12 million	
	(Foreign portion:	Balboa 162.80 million
	Local portion:	Balboa 101.32 million)
Total cost for both sections:	Balboa 402.76 million	
	(Foreign portion	Balboa 238.27 million
	Local portion	Balboa 164.49 million)

## 9. Economic and Financial Evaluation

An economic analysis of the project has been carried out assuming a discount rate of 12% and analysis period up to the year 2030. The analysis is based on the premise that project benefits will be constant after the year 2010. The results are:

EIRR = 37.0%

B/C = 5.60

NPV = US\$1,123 million = Balboa 1,123 million

The financial evaluation resulted in a FIRR of 4.87% assuming a toll rate of 2 balboas per passenger car unit in each section and availability of a 6% long term loan for funding of construction. The annual deficit would disappear in the year 2014 and by 2027 the accumulated deficit would be overcome.

## **10. Environmental Impact Assessment**

During the Initial Environmental Assessment a range of possible environmental impacts were identified. These included vegetation, flora, fauna, erosion, resettlement, public facilities, splitting of communities, culture, air pollution, noise pollution and water pollution.

As a result of the environmental impact study the possibility of occurrence of water contamination in the Sabanitas section and traffic noise problems in the Alcalde Diaz section were identified as possible severe impacts, but only if countermeasures are not taken. Therefore adequate countermeasures are planned in the study so that impacts will be minimized and good environmental conditions maintained.

## **11. Project Benefits**

1. Direct benefits include passenger time savings and vehicle operating cost savings resulting from the improved Panama-Colon Highway.
2. The reduction in traffic accidents per vehicle kilometer will be significant because of vehicles will be operating on a 4-lane dual carriageway road with full access control, traffic safety devices, and so on.
3. There will also be direct benefit effect on the economy of Panama
4. Creation of development opportunities in the Colon area
5. Creation of new job opportunities (employment effect)
6. Provision of a high standard and high capacity alternative transport mode for the Panama Canal



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## **CONCLUSION AND RECOMMENDATIONS**

### ***Concept of New Highway***

In order to serve the balanced economic development of the cities of Panama and Colon as Twin Cities, it will be necessary to construct a new highway alongside the existing Panama-Colon Highway by the year 2010.

The new Panama-Colon Highway should provide high speed mobility (110 km/h design speed), secure a high standard of traffic service and safety (four lane road with full access control), and should be planned paying attention to preservation of the natural and social environment.

The new Panama-Colon Highway should have two principal functions;

To serve the direct passenger and goods movement between the cities of Panama and Colon on each ocean side.

To serve daily commuter traffic between the city centers and suburban areas such as the Alcalde Diaz area and the Sabanitas area.

### ***Project Magnitude***

The total length of the project sections of the new Panama-Colon Highway subject to the feasibility study is 46.4 km (20.2 km for Alcalde Diaz section, 26.2 km for Sabanitas section). The project sections include seven interchanges and two service areas.

The total project cost is estimated at 402.8 million balboas at 1993 prices, of which the Alcalde Diaz section costs 138.6 million balboas and Sabanitas section costs 264.1 million balboas.

### ***Implementation Schedule***

The construction of the Alcalde Diaz section should be completed by the year 1999 and the Sabanitas section should be completed by 2004.

However, as a premise of the Study, the Corredor Norte project should proceed ahead of the new Panama-Colon Highway Project.

Although the Chagres section was not studied in the feasibility study stage, it is recommended that it should be completed by 2010.

### ***Environmental Impact Assessment***

As a result of the environmental impact study the possibility of occurrence of water contamination in the Sabanitas section and traffic noise problems in the Alcalde Diaz section exists, but only if countermeasures are not taken. Therefore adequate countermeasures are planned in the study so that impacts will be minimized and good environmental conditions maintained.



### ***Economic Evaluation of the Project***

The economic internal rate of return ( EIRR ) derived from implementation of the two project sections is estimated at 37.0%, confirming a high economic return. The benefit-cost ratio at a discount rate of 12% is estimated at 5.6.

### ***Possibility of Introduction of Toll System***

According to the result of the project financial analysis with a two balboas toll for passenger cars in each section, the financial internal rate of return ( FIRR ) is estimated at 4.9%. In spite of various calculation premises, this figure is not favorably high. However the introduction of a toll system should be considered from the viewpoint of the beneficiary pays principle, even if the toll revenue would not cover the full cost of construction, maintenance and operation of the new highway.

### ***Financing of Necessary Funds***

Since implementation of the whole project will necessitate a huge investment, it is necessary to seek appropriate fund resources for the investment. Concerning the foreign currency portion of the investment, external funds under favorable conditions (less than 5% interest rate) should be obtained. Regarding the local currency portion, creation of a local fund collection system such as a motor fuel tax, a vehicle registration tax and an urban development tax are recommended.

### ***Operation and Organization of the Project***

Considering the magnitude of the project and the possibility of introduction of a toll system, the Ministry of Public Works (MOP) should establish a new department for the construction, operation, administration, and promotion of the project.

### ***Further Studies***

Since housing areas in Alcalde Diaz have been developing, the right of way of the new Panama-Colon Highway may become occupied by the sprawl of housing development. Therefore a detailed design study should be commenced as soon as possible to identify the right of way.

A feasibility study of the Chagres section should be conducted when the other two project sections advance.

## 1. INTRODUCTION

### ***Study Development***

In response to the request of the government of the Republic of Panama, the government of Japan decided to conduct the Feasibility Study on the Improvement of the Panama-Colon Highway in the Republic of Panama (hereinafter referred as "the Study") in accordance with the relevant laws and regulations in force in Japan.

Accordingly, 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 agreed to undertake the Study, in close cooperation with the authorities concerned of the Government of Panama.

The preliminary study team, headed by Mr. Koji Yokota, was dispatched by JICA to Panama and the Scope of Work for the Study was agreed on September 1992. The full-scale site study in Panama began on January 1993 and continued until February 1994.

### ***Study Purpose***

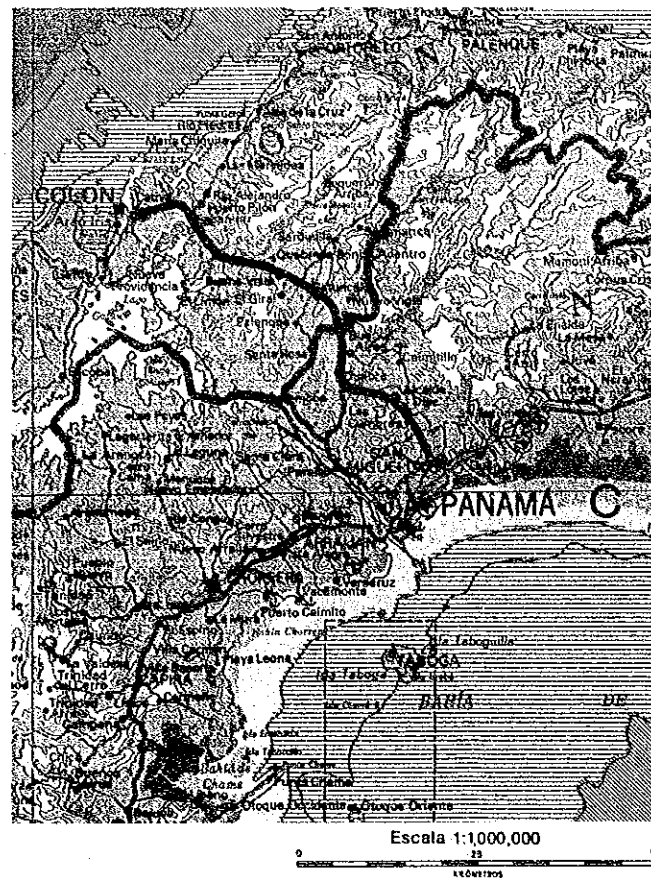
- a) to formulate a Master Plan for the arterial road development between Panama and Colon, considering improvement of the existing road and construction of a new road for certain segments.
- b) to select priority projects from the Master Plan and to carry out a Feasibility Study on the selected projects.

### ***Scope of the Study***

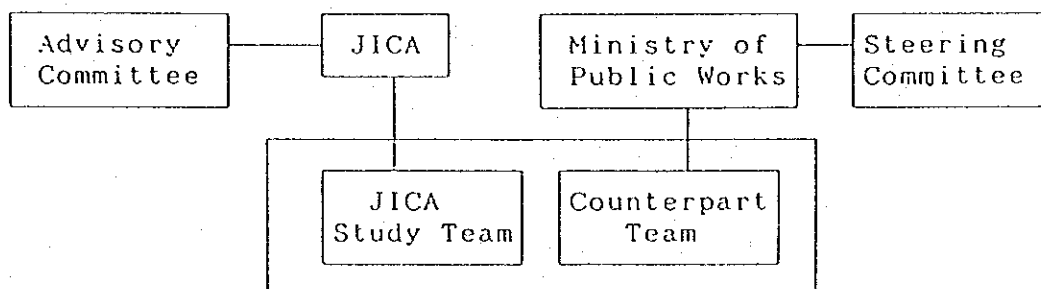
- a) Target Years: The year 2010 shall be defined as the target year for the long term plan of the Master Plan, and the year 2000 shall be defined as the target year for the mid term plan of the Master Plan.
- b) Study Area: The Study Area shall cover the existing highway connecting Panama city with Colon city, alternative alignments considered for new road segments, and their vicinities.

### ***Study Organization***

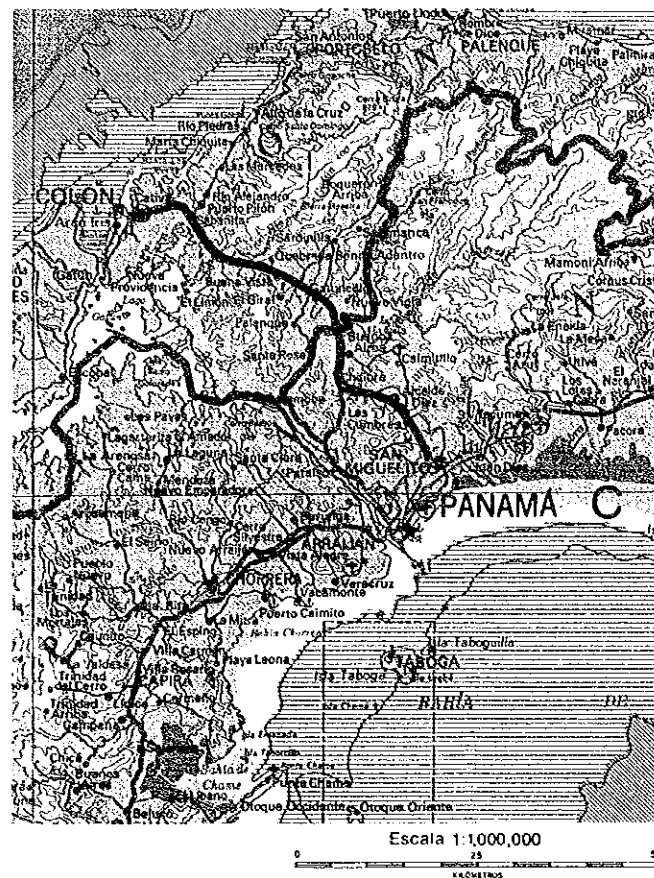
To conduct the Study, JICA has organized both the Study Team, headed by Mr. Takeshi Yoshida and the Advisory Committee, chaired by Mr. Koji Yokota. The government of Panama has formed the Counterpart Team, headed by Ms. Miriam de Solis under the Ministry of Public Works (MOP). MOP has organized the Steering Committee coordinated by Mr. Jose Domiguez (Predecessor: Mr. Laurencio Guardia) to facilitate the progress of the Study.



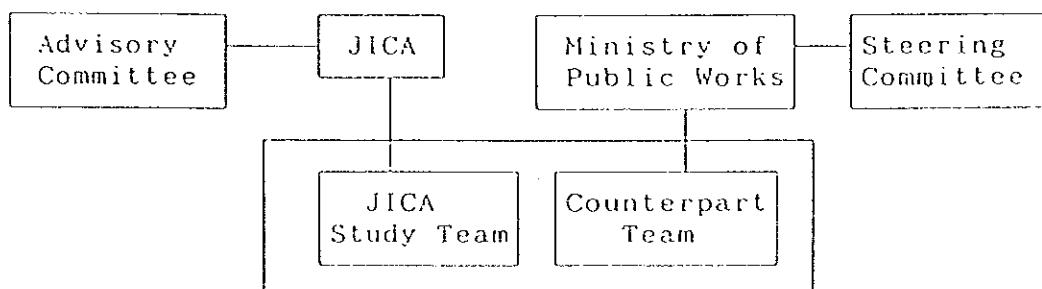
Location Map of Existing Panama Colon Highway



Study Organization



Location Map of Existing Panama Colon Highway



Study Organization

## **2. SOCIOECONOMIC CONDITIONS**

### ***Historical Background***

In the year 1513, Vasco Núñez de Balboa succeeded in the first crossing of the isthmus of Panama and "discovered" the Pacific ocean. After Pizarro's conquest of the Inca empire, a lot of bullion from Peru was carried to Spain through the "Royal Road" or "Cross Road" in the isthmus. Since that time Panama has enjoyed her geographical position as a crossroad of the world.

The republic of Panama is a relatively young country born in 1902 on the occasion of the construction of the Panama Canal. After Ferdinand de Lesseps's failure on the Canal construction, the United States supported the independence of Panama and recommenced construction of the Canal. The Canal opened for world wide ship transit and global trade in 1914.

In 1948, a free trade zone was established in Colon city and it has grown into the largest free zone in the American continent. In the 1970's Panama city commenced activities as an international banking center. At present, there are more than one hundred banks from foreign countries within the banking center.

### ***Population***

Total population of the republic in 1990 was 2.3 million and the annual population growth rate was 2.58% in the 1980s.

The proportion of the population living in urban areas was 53.7% of the total population in 1990, an increase of 3.3% from the 1980 figure of 50.4%. Panama province and Colon province represent the Metropolitan region of the Republic of Panama and have a total population of 1.3 million -- 54.7% of the total population of the Republic of Panama in 1990.

### ***Economy***

One of the unique characteristics of Panama's economy is the free use of the U.S. dollar as legal currency, although Panama has the Balboa as its own currency unit.

Panama's Gross Domestic Product (GDP) in 1991 was 5,491 million Balboa which is indicative of the recent strong economic recovery from the political and economic crisis of the end of the 1980s. GDP per capita in 1991 was 2,357 Balboa. In the 1970s Panama's economy enjoyed development, however in the 1980s growth declined because of the world wide economic recession and political problems.

The structure of Panama's economy depends principally on tertiary industries such as transport, finance and commerce, in other words, the Panama Canal, International Banking Center and Colon Free Zone.

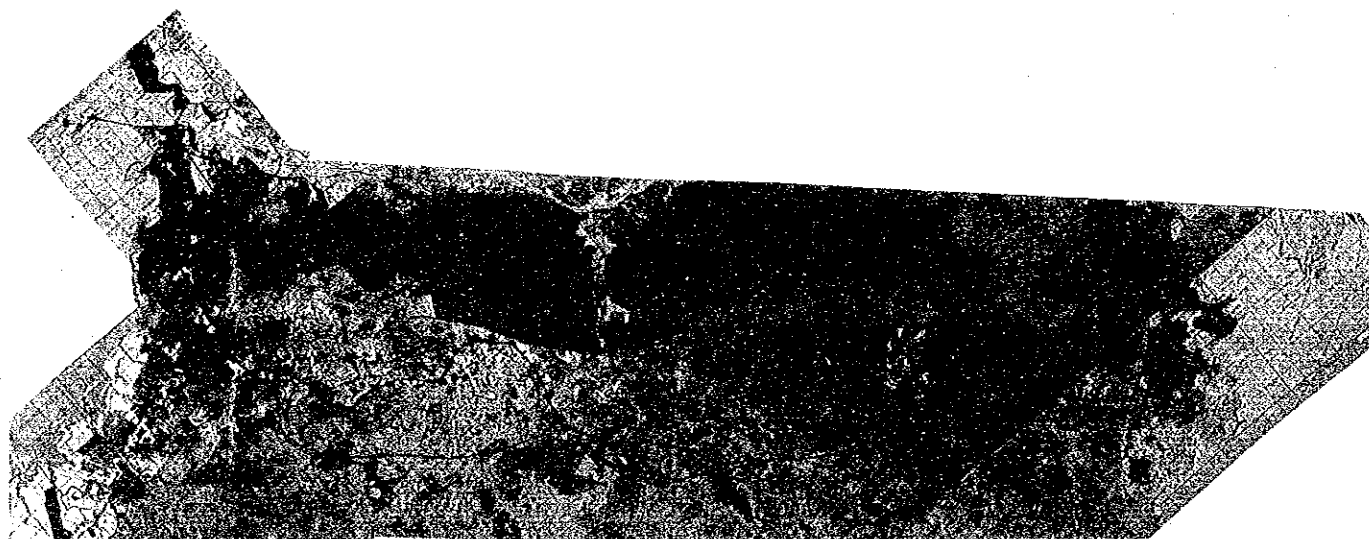
## Population Growth 1980-1990




(Unit: 1,000 Persons)

District	1980	1990	Annual Growth Rate (%)
Panama	447	585	2.7
San Miguelito	157	243	4.5
Colon	113	41	2.2
Total	716	986	3.3













## Gross Domestic product 1970-1990

Year	GDP at Current Prices (Mill. Balboa)	GDP at 1970 Prices (Mill. Balboa)	GDP Per Capita at 1970 Prices (Balboa)
1970	1,021.20	1,021.20	687
1980	3,558.80	1,745.80	892
1990	4,948.70	1,868.40	773



 EXISTING PANAMA-COLON HIGHWAY  
 CORREDOR NORTE  
 NEW PANAMA-COLON HIGHWAY INTERCHANGE

## Present Land Use

 COMMERCIAL AND BUSINESS AREA  
 URBAN RESIDENTIAL AREA  
 SUBURBAN RESIDENTIAL AREA  
 INSTITUTIONAL AND EDUCATIONAL  
 NATIONAL PARKS AND RESERVED AREAS  
 RECREATIONAL AREAS AND PARKS  
 INDUSTRIAL  
 TRANSPORTATION  
 CATTLE  
 GALLERY FOREST  
 LAKES  
 BOSQUES



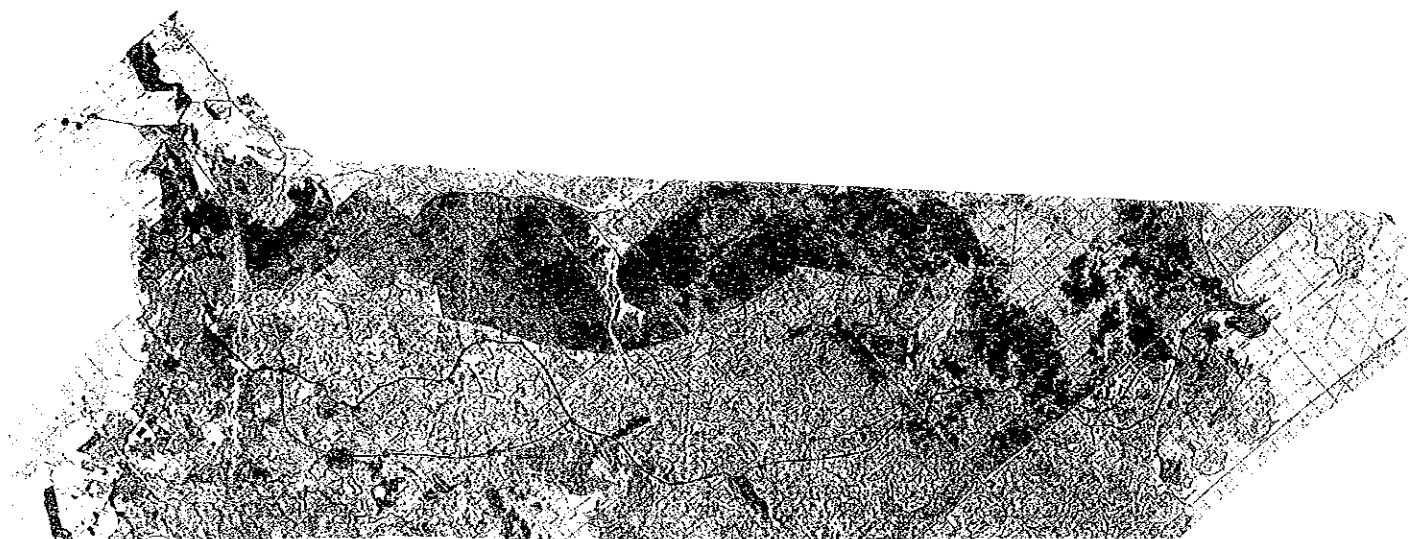
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





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 CORREDOR NORTE  
 NEW PANAMA-COLON HIGHWAY  
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## Present Land Use

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 TRANSPORTATION  
 CATTLE  
 GALLERY FOREST  
 LAKES  
 BOSQUES

### 3. EXISTING ROAD CONDITIONS

#### ***Existing Road Network***

Roads in Panama are classified into four categories; Expressways, National Primary Roads, Regional Secondary Roads and Local Roads. The cities of Panama and Colon are connected by only one road which is classified as a National Primary Road -- the Panama-Colon Highway.

The total road length in the whole country in 1992 was 10,103 km with the paved road length only 10.5% of the total. MOP's three divisions (Metropolitan, Canal Area, and Colon) which are related to the Study Area have 846 km of road network length with a paved road length of 294km (35% of total).

Historically the existing Panama-Colon Highway was constructed by the United States during 1938-1940 as a Transisthmian highway, then it was transferred to the government of Panama in 1973.

#### ***Existing Physical Features***

The existing Panama-Colon Highway is approximate 68km length between the San Miguelito intersection in Panama City and the Cuatro Altos intersection in Colon City.

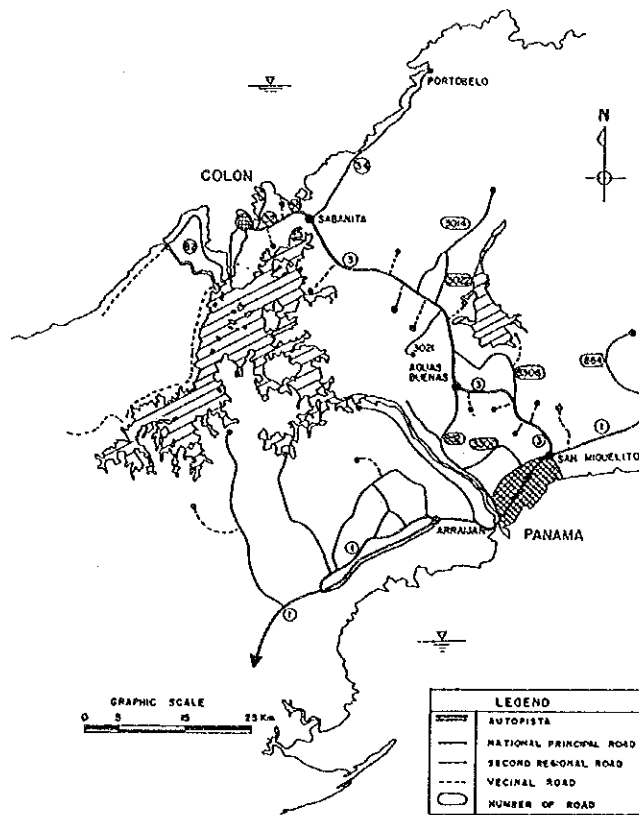
Concerning the width of the highway, the four lanes section is only 14km long and the remainder has two lanes. The highway passes some mountainous areas where horizontal and vertical alignments are not suitable for high speed travel (The minimum curvature is 180m and maximum gradient is 6%).

#### ***Existing Road Problems***

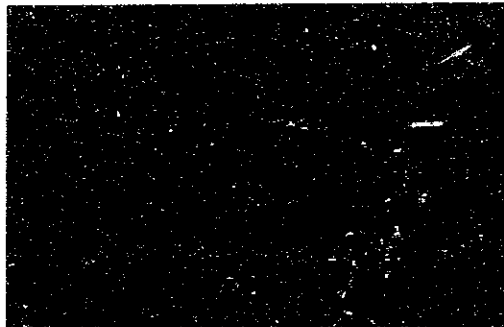
As a result of the road and bridge inventory survey, and various traffic surveys on the existing Panama-Colon Highway the following requirements are identified.

- 1) to rank the road network according to categories
- 2) to construct Corredor Norte at an early stage
- 3) to increase traffic capacity
- 4) to reduce traffic accidents
- 5) to reduce traffic congestion
- 6) to maintain pavements and drainage facilities
- 7) to maintain bridges and other structures





**Existing Road Network in the Study Area and Vicinity**



**Alignment in Mountainous Area**



**Small Radius Curves**



**Traffic Congestion**

## 4. TRAFFIC CONDITIONS

### Vehicle Ownership

The number of vehicles registered in Panama, Colon and San Miguelito Districts in 1990 was 118,000 and the number of persons per vehicle was 8.2. Since 1970 the number of vehicles has increased 2.9 times (from 41,000) and the persons per vehicle has dropped by 44% (from 14.7). The annual growth rate of registered vehicles for the last two decades was 5.4%, and the rate has been increasing rapidly in recent years.

### Traffic Volumes

The observed 24 hour traffic volume on two lane sections varied from 17,400 to 23,000 Passenger Car Units (from 8,800 to 13,700 vehicles). In the vicinity of Panama city and Colon city the general trend is that the traffic volumes are clearly increasing steadily year by year. The 24 hour traffic volume on 4 lane sections is about 40,000 Passenger Car Unit (21,000 to 25,000 vehicles).

### Modal Share and Vehicle Composition

The highest share of all vehicle types was recorded near Panama city and Colon city for passenger cars, with 54.5% and 50.7% respectively. For heavy trucks the highest share was at Rio Chagres (20.6%).

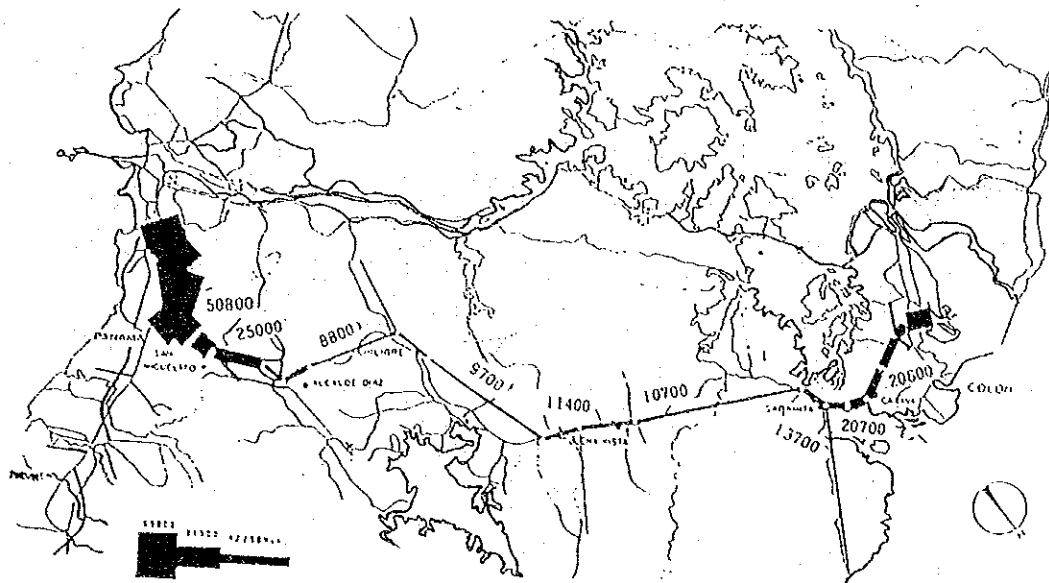
The peak hour on the existing Panama Colon Highway was observed to be from 17:00 to 18:00 and the peak hour volumes corresponded to 7.2 to 9.1% of the 24 hour volumes.

#### Existing Traffic Volume (1993)

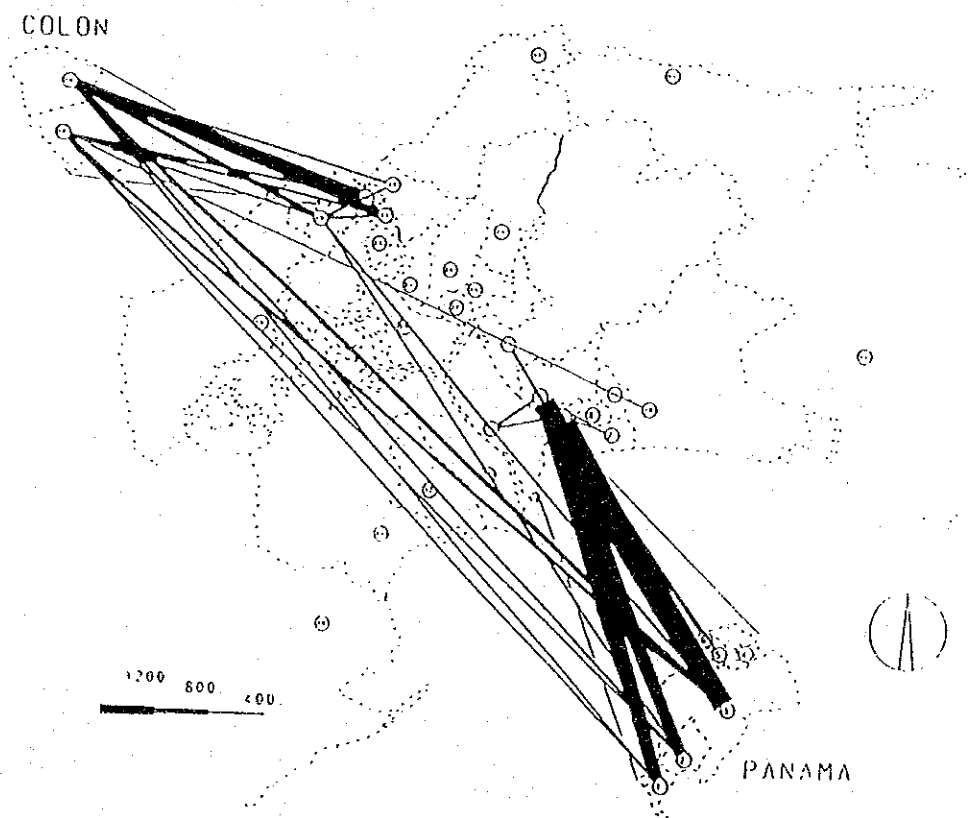
(Unit: Vehicles/day)

Location	Car & Taxi	M Bus	Bus	Pick-Up	Truck & Trailer
Los Andes*	32,800	3,400	3,600	7,100	3,900
San Isidro	19,900	1,900	2,700	5,100	3,200
Alcalde Diaz	15,600	1,800	700	4,000	3,000
Chilibre	6,000	500	500	2,100	1,900
Rio Chagres*	4,900	900	400	1,500	2,000
Buena Vista	6,300	700	400	1,800	2,000
Sabanitas	10,000	1,200	800	2,300	2,100
Cativa	11,000	1,400	800	27,00	3,500

\*: 24 hour observation    Others: based on 12 hour observation



24 Hours Vehicle Traffic Volumes



24 Hour Vehicle Movements

## 5. PLANNING POLICY

### *Objectives of the Plan*

- a) To serve balanced economic development of the Republic
- b) To create a transport axis between Panama Metropolitan Area and Colon City
- c) To secure traffic safety for users and preserve the environment for citizens

### *Targets of the Plan*

- a) To realize mobility at high speeds
- b) To secure high standard traffic services
- c) To pursue safety-oriented plan
- d) To secure preservation of natural and social environment
- e) To provide for public transport
- f) To cope with traffic demand
- g) To ensure availability of a high standard alternative to other transport modes

### *Necessary Road Functions*

- a) To serve as primary national highway in the national road network skeleton
- b) To serve as a corridor to transport passengers and goods between Panama Metropolitan Area and Colon City
- c) To be integrated with urban infrastructure development
- d) To meet daily commuter traffic demand
- e) To ensure availability of a strategic by-pass of the Canal and the railway

### *Regional Planning Concept*

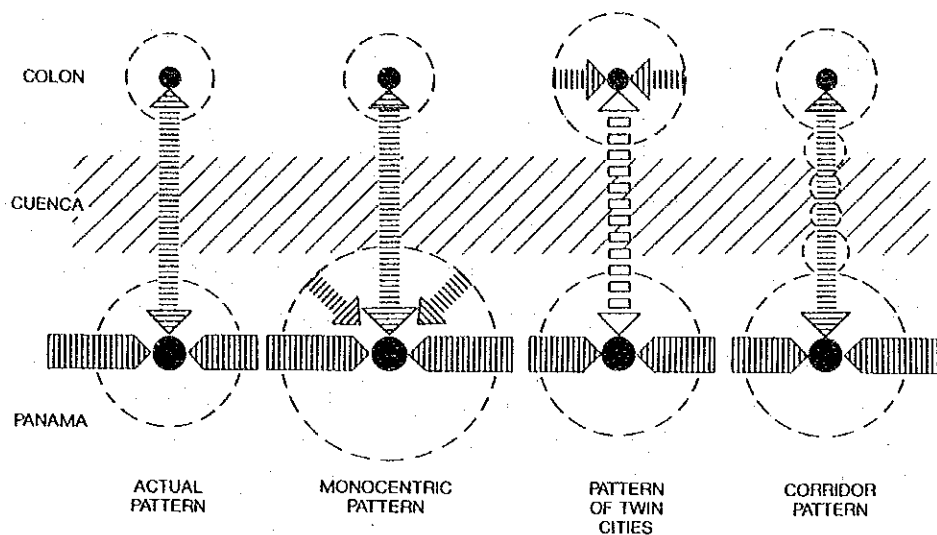
Three alternative development patterns have been considered for the Panama Metropolitan Area and Colon City.

**Mono-centric Pattern:** Only the Panama Metropolitan Area grows while Colon would be abandoned. This pattern would probably appear in the absence of a development policy.

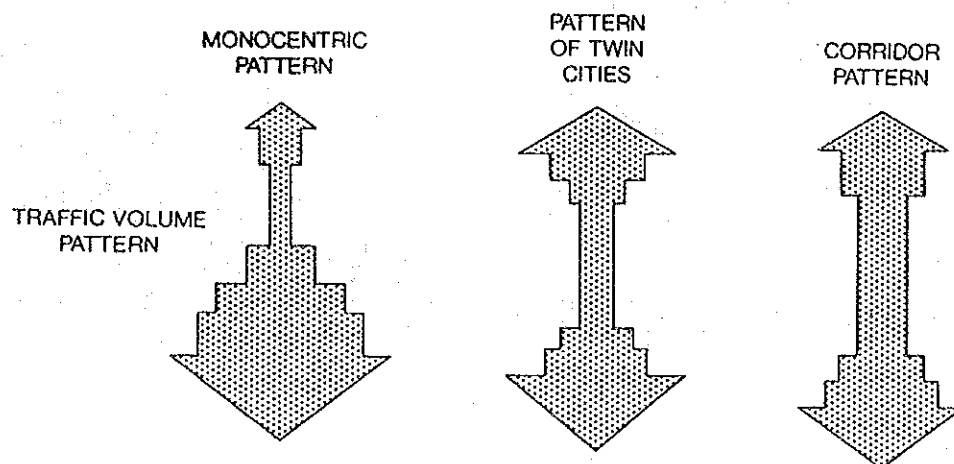
**Twin City Pattern:** The growth of Colon city is significant, while the growth of Panama Metropolitan Area is steady. Urban infrastructure development and job supply in Colon would be required.

**Corridor Pattern:** The areas between Panama and Colon city are developed along the highway. The development in the canal basin area (Cuenca) would cause environmental problems.

Considering coordination with the national development policy and environmental policy, the Twin Cities Pattern was selected.



### Development Pattern Alternatives



### Alternative Future Functions of the Panama-Colon Highway

## 6. FUTURE TRAFFIC DEMAND

### *Population Growth*

According to the estimation of the Ministry of Politics and Economic Planning (MIPPE), the total population of the Republic in 2010 was estimated between 3,180,000 and 3,476,000. The annual population growth will be 2.14% from 1980-1990, 1.80% from 1990-2000, and 1.40% from 2000-2010. The future total population of the Metropolitan Region estimated in the Study was based on the estimation of MIPPE.

The future distribution of population by district was forecast in accordance with the Twin City pattern for regional development. The future population of the four districts (Panama, San Miguelito, Colon and Chagres) in 2000 and in 2010 will be 1,245,100 and 1,493,000 respectively.

### *Trip Production*

Daily Origin-Destination (O-D) trip production in the Study Area is predicted to increase from 547,000 in 1993 to 739,000 in 2000 (1.3 times) and further to 1,049,000 (1.9 times) by 2010.

#### **Future Daily Trip Production in the Study Area**

(Unit:PCU)

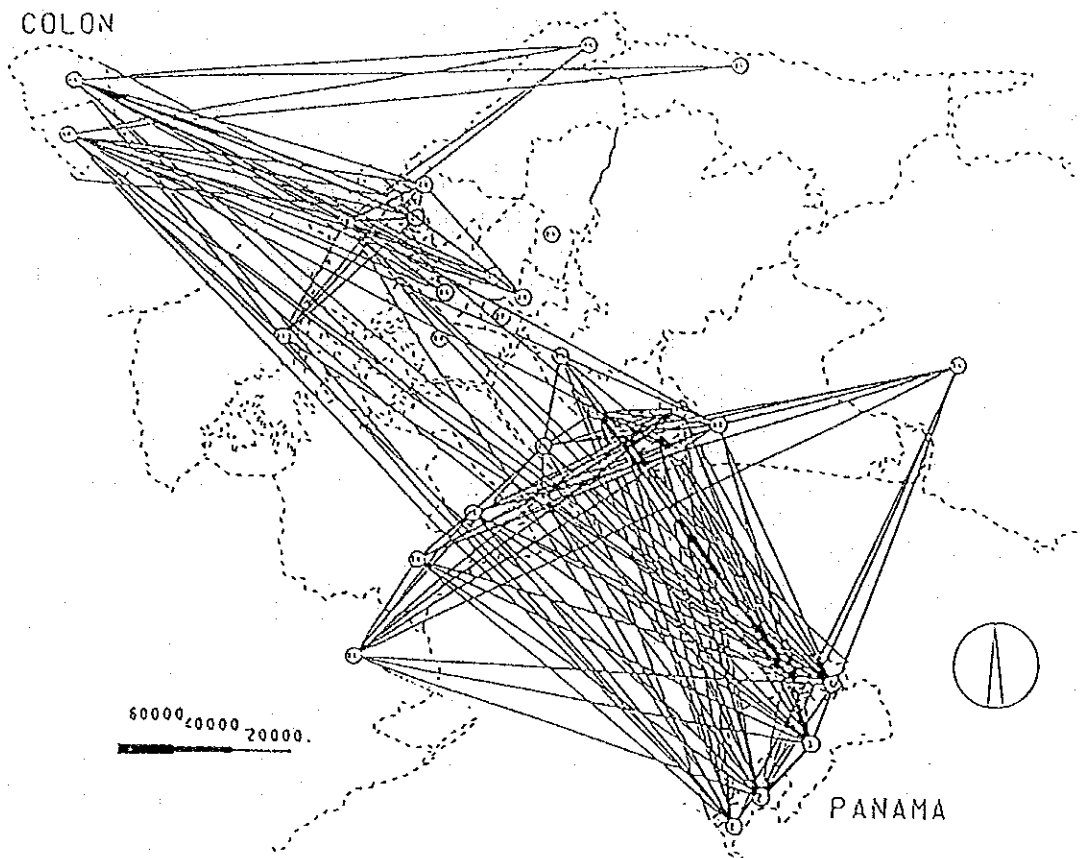
Year	P.Car	Taxi	Bus	Truck	Total
1993	326,887	44,739	61,259	114,497	547,382
2000	433,191	72,083	82,432	151,098	738,804
2010	649,363	76,090	107,175	216,399	1,049,027

### *Future Traffic Demand*

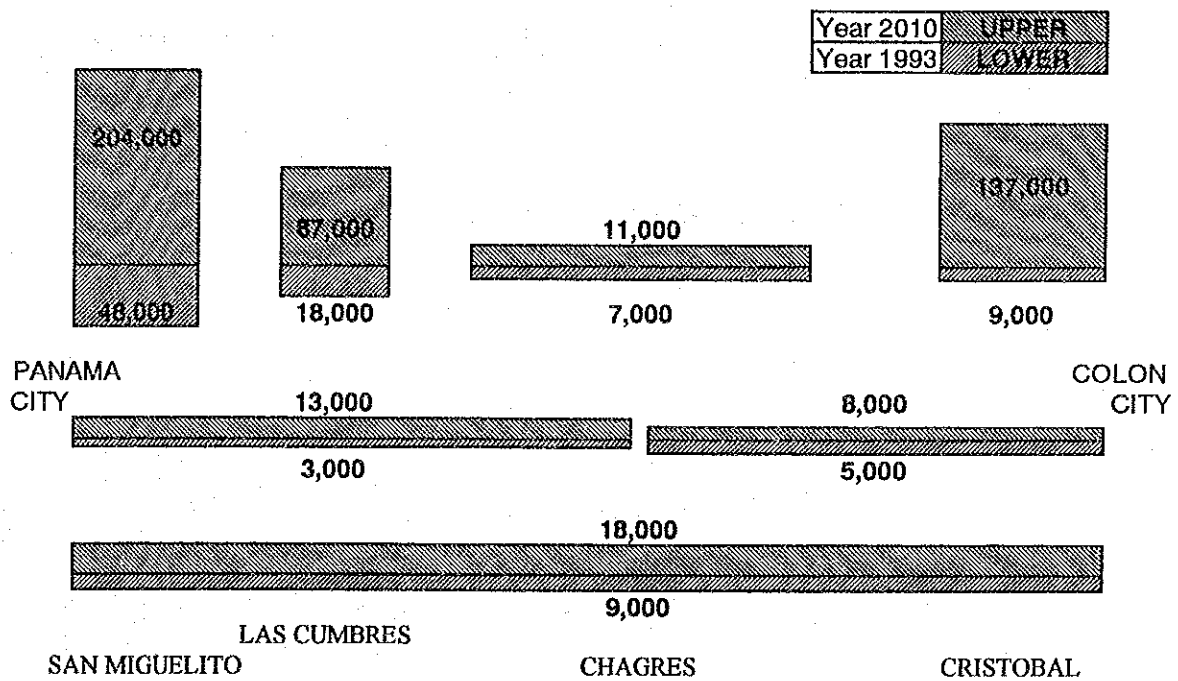
Daily traffic running directly between Panama and Colon, which is about 9,000 PCU in 1993, will double to about 18,000 PCU in 2010.

Daily commuter traffic from the outskirts of Colon to Colon city, which is about 9000 PCU in 1993, will increase over 15 times to 137,000 PCU in 2010.

Medium-distance trips per day along the Panama to Colon route will grow to 13,000 and 8,000 PCU. Trips in the section between Chagres and Cristobal will grow by a factor of 1.6.



Traffic Demand (2010)



Traffic Volume by Trip Length (PCU)

## 7. ROAD NETWORK PLAN ALTERNATIVES

### *Road Network Planning Conditions*

- 1) to formulate a long term master plan for development of the primary road network between the cities of Panama and Colon with 2010 as the target year.
- 2) to conduct a route location study within the area between Corredor Norte in Panama city and Cuatro Altos intersection in Colon city.

### *Proposed Alternative Plans*

The following three Alternative Plans for the Master Plan of the road network in 2010 between the cities of Panama and Colon have been proposed and evaluated.

#### 1) Alternative Plan A

This is a plan for widening of the existing Panama-Colon Highway from 2-Lane to 4-Lane or from 4-Lane to 6-Lane including improvement of intersections.

#### 2) Alternative Plan B

This is a plan for new road construction. The alignment passes near the Soberania national park on the west side of the existing Panama-Colon Highway.

#### 3) Alternative Plan C

This is also a plan for new road construction. The alignment passes though the Alcalde Diaz area.

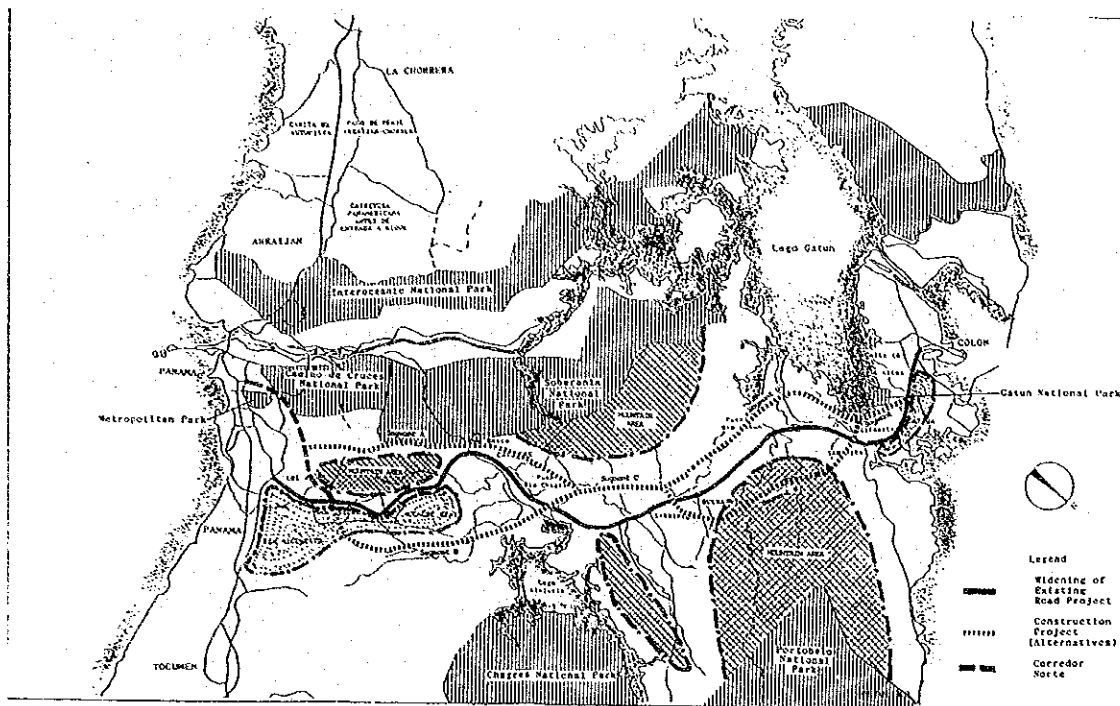
Alternative Plan C is divided into three variations;

Plan C-1; 80 Km/h design speed is adopted

Plan C-2; 110 Km/h design speed is adopted

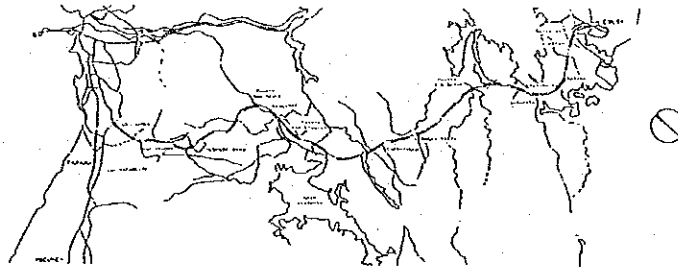
Plan C-3; 110 Km/h design speed is adopted and access control is introduced.



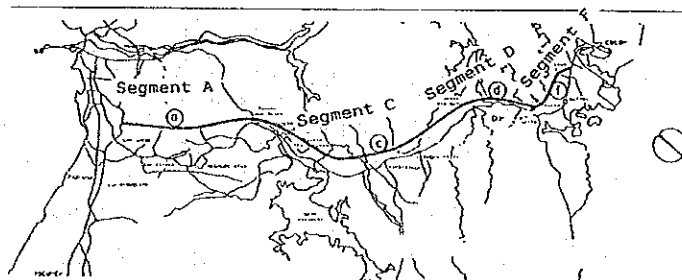


Route Location Conditions

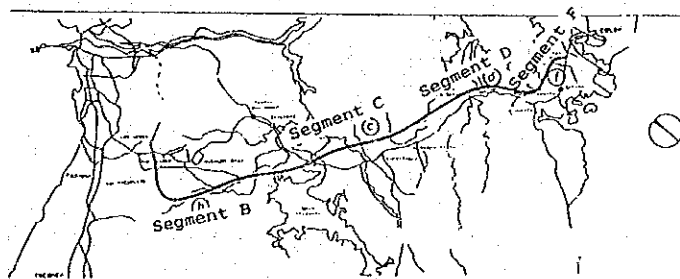
Alternative Plan A



Alternative Plan B



Alternative Plan C



## 8. ALTERNATIVE EVALUATION AND PRIORITY ROAD SECTIONS

### *Evaluation of Alternatives*

Alternative Plans are evaluated based on the economic and technical evaluations as well as the initial environmental examination.

From the economic evaluation, all of the five Alternative Plans are economically feasible, however, Plan C-3 has the highest Benefit and Cost (B/C) ratio and Economic Internal Rate of Return (EIRR) as well as the largest Net Present Value (NPV). Therefore Plan C-3 is the most efficient investment plan.

Alternative	B/C Ratio	EIRR (%)	NPV (mill. balboa)
Plan A	2.15	17.32	203.1
Plan B	2.36	18.54	422.4
Plan C-1	2.86	21.21	378.6
Plan C-2	2.40	18.76	380.3
Plan C-3	2.96	21.68	531.8

From the initial environmental examination, no significant environmental damage is expected from any of the five Alternative Plans.

From these results Alternative Plan C-3 is recommended for the Master Plan of the road network between the cities of Panama and Colon in 2010.

### *Priority Road Sections*

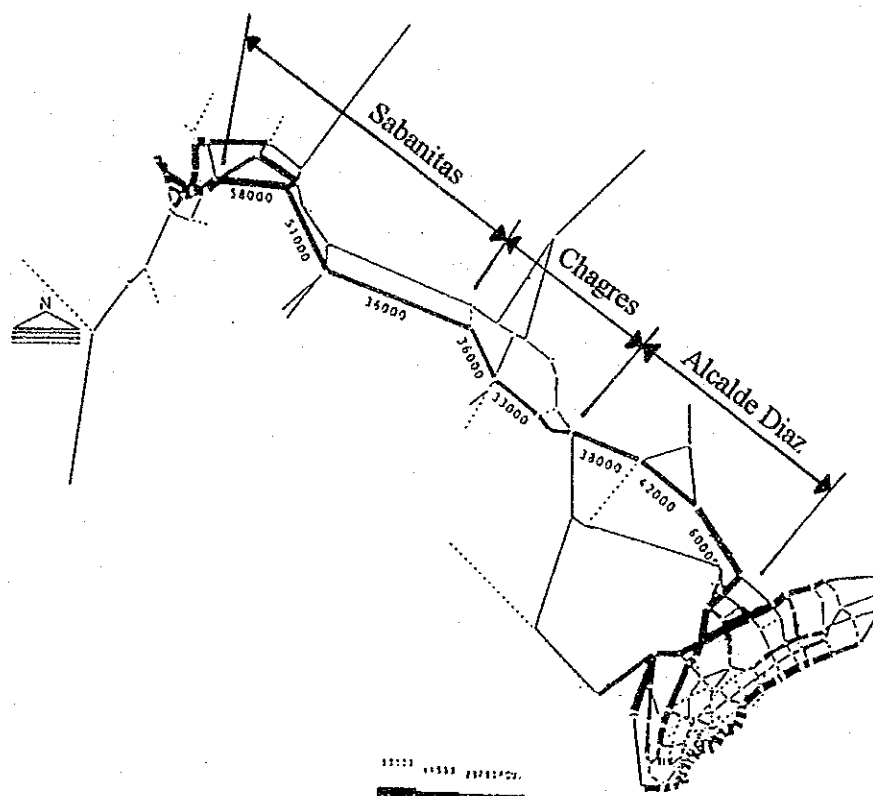
The route of Alternative Plan C is divided into three sections; Alcalde Diaz, Chagres and Sabanitas Section.

As a result of the comparison study on the three Sections, Alcalde Diaz and Sabanitas Sections were selected for the feasibility study to be conducted. The main reasons for the selection are as follows;

- Heavy traffic congestion has been occurring on Alcalde Diaz and Sabanitas Sections, and improvements should be implemented as soon as possible.
- Future traffic demand in the year 2000 is such that the Chagres Section will still have spare traffic capacity in 2000.
- The economic evaluation shows that the Alcalde Diaz and Sabanitas Sections have higher economic indicators than the Chagres Section.
- Many traffic accidents have occurred on the Alcalde Diaz and Sabanitas Sections, and the existing road alignment on the Sabanitas Section is very steep and dangerous.

## Comparison of Proposed Road Sections

Items /Section	Alcalde Diaz	Chagres	Sabanitas
Section Length (Km)	22	12	26
Construction Cost(B 1000)	83,205	43,076	132,327
Traffic Accidents(in 1991) ( per Km.)	14.4	4.3	9.0
Traffic Volume (in 2010) PCU/D/Km	60,000	33,000	58,000
Traffic Volume (in 2000) PCU/D/Km	31,000	19,000	25,000
Vehicle * Km (in 2000)	682,000	55,000	546,000
Vehicle * Hr (in 2000)	12,000	3,400	12,000
Traffic Congestion(V/C) on Existing Road(in 1993)	$0.7 < V/C < 1.5$	$V/C < 0.8$	$0.7 < V/C < 1.3$
Traffic Congestion(V/C) on Existing Road(in 2000)	$1.0 < V/C < 2.0$	$V/C < 1.0$	$1.0 < V/C < 1.5$
Vehicle * Km / Const. Cost (V/B 1000)	8.19	1.27	4.13
Time Cost Saving (Hr/D)	65,100	19,500	52,400



Assigned Traffic Volume in 2010 - Alternative Plan C-3 with Access Control

## 9. DESIGN CONDITIONS AND TYPICAL CROSS-SECTION

### *Design Conditions*

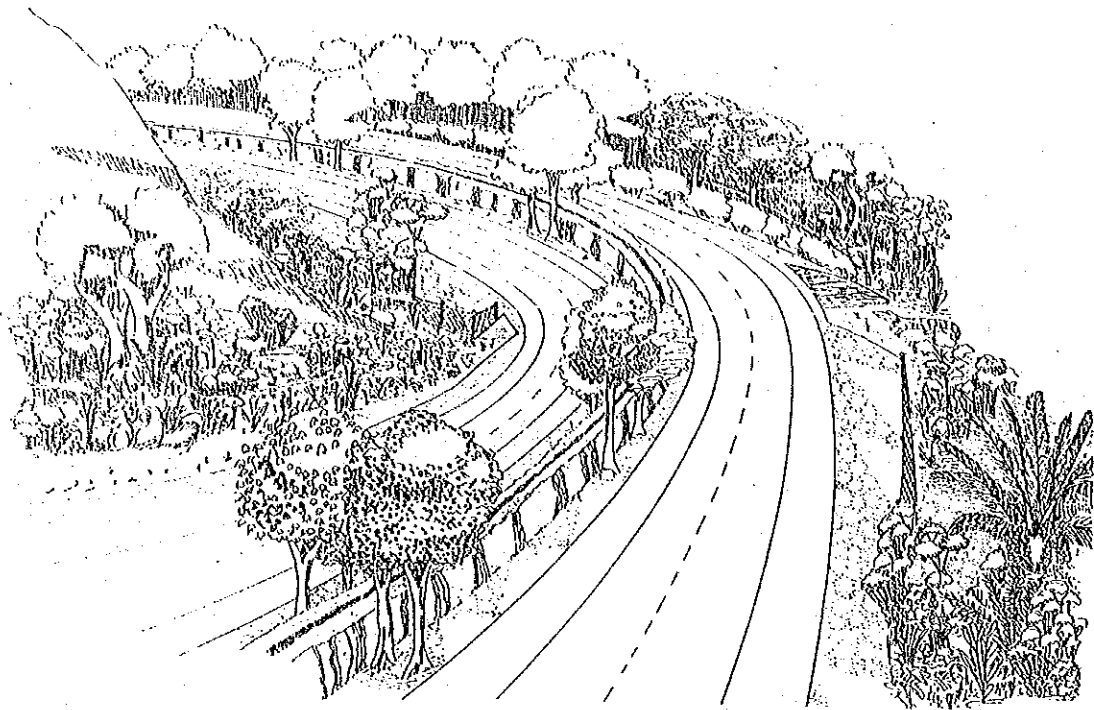
The Feasibility Study is conducted based on the following design conditions.

- 1) The Feasibility Study is implemented at the route of Alcalde Diaz and Sabanitas Sections using topographic maps of scale 1:5,000.
- 2) The Feasibility Study is conducted based on the detailed design of Corredor Norte as a premise of the Study.
- 3) As a result of the comparison study and considering the function of the road, a 110 Km/h design speed is adopted for the proposed new highway.
- 4) A Policy on Geometric Design of Highways and Streets (AASHTO) is adopted for the design standards of the Study.
- 5) Taking into account the road functions and characteristics, full access control is introduced for the proposed road and the introduction of a toll system is also considered.

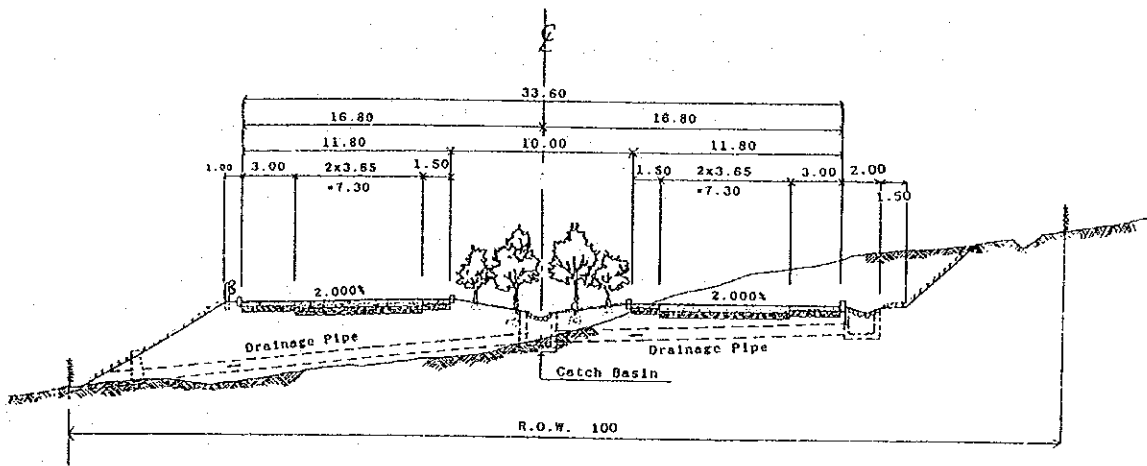
### *Typical Cross-Section*

The typical cross-section is designed considering the past experience of road construction in Panama, functions of the proposed road and geometric design standards.

- 1) In accordance with AASHTO, a 3.65-m (12-feet) lane width is adopted.
- 2) The right and left shoulder widths are 3.00m and 1.50m respectively. However, on longer span bridges exceeding 50m in length, 1.80m and 1.20m shoulders are used for economic reasons.
- 3) A 10.00m median width is used considering future widening.
- 4) A cement concrete pavement of 25cm-thickness and a cement stabilized base course are used for the carriage way.
- 5) A 100m wide right of way is adopted.



Typical Perspective View



Typical Cross-Section

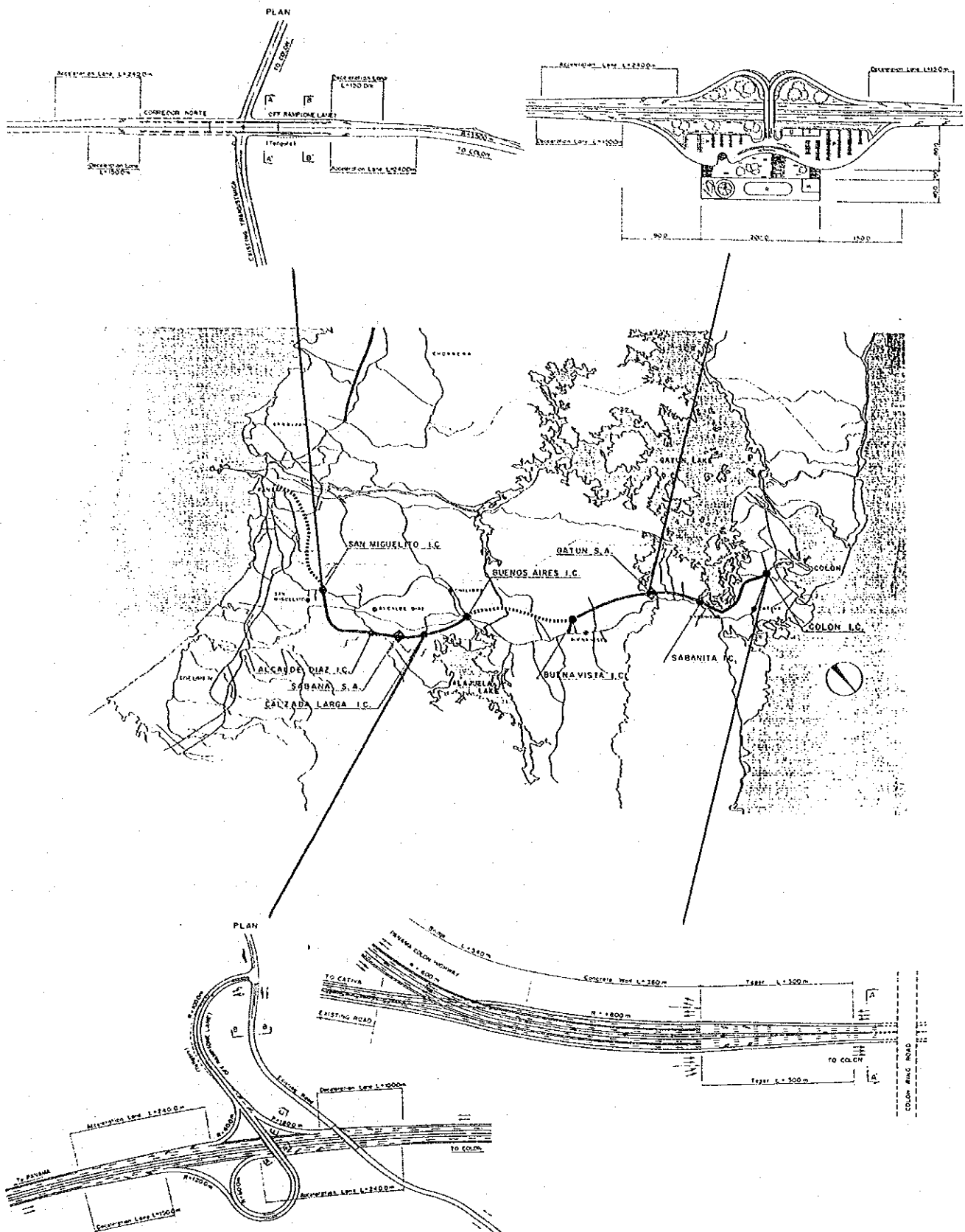
## 10. PRELIMINARY DESIGN FOR ALCALDE DIAZ SECTION

The major design items are as follows;

- 1) The road length of Alcalde Diaz Section is 20.2km.
- 2) The minimum horizontal curvature is 800m and the maximum vertical gradient is 3.00 % .
- 3) The total of twelve bridges comprises two bridges of 100 m, six of 60 m and four of less than 40 m.
- 4) Four interchanges and four bus stops are designed for the traffic demand and access control.
- 5) The total excavation and embankment volumes are calculated as 2,190,000m<sup>3</sup> and 1,620,000 m<sup>3</sup>.

In addition to the above, the following facilities are designed to preserve the environment.

- a) Noise barriers are used on both road sides to mitigate noise pollution for 1 km in the Alcalde Diaz housing area.
- b) Plantations are designed along median strip of the proposed road to improve the environment and safety.
- c) Slope protection is proposed at cuttings and embankments to avoid soil erosion.
- d) One service area is proposed for users. It is located and designed with consideration of scenic value and the environment.
- e) Security fences are proposed on both sides of the right of way for traffic safety.



Road Layout and Interchanges

## 11. PRELIMINARY DESIGN FOR SABANITAS SECTION

The major design items are described as follows;

- 1) The road length of Sabanitas Section is 26.2 km.
- 2) The minimum horizontal curvature is 600 m and the maximum vertical gradient is 3.00 %.
- 3) The total of fifteen bridges comprises eight bridges exceeding 100m, three of 90m and four of 60 m.
- 4) Three interchanges and three bus stops are designed for the traffic demand and access control.
- 5) The total excavation and embankment volumes are calculated as 4,260,000 m<sup>3</sup> and 3,270,000 m<sup>3</sup>.

In addition to the above, the following facilities are designed to preserve the environment.

- a) Three long span bridges (L=115 m, 300 m, and 90 m ) are designed to prevent water contamination of Gatun lake
- b) Plantations are designed along the median strip of the proposed road to improve the environment and safety.
- c) Slope protection is proposed at cuttings and embankments to avoid soil erosion.
- d) One service area is proposed for users. It is located with consideration of scenic value and the environment.
- e) Security fences are proposed on both sides of the right of way for traffic safety.



Summary Table for Alcalde Diaz and Sabanitas Sections

Road Section / Items	Unit	Alcalde Diaz (20.2km)	Sabanitas (26.2km)	TOTAL (46.4km)
<b>1. Design Considerations</b>				
Design Traffic Volumes	Veh/day	60,000	58,000	----
Design Speed	km/hr	110	110	----
Levels of Service	-	C	C	----
Access Control	-	Full	Full	----
Number of Lanes	Num.	4	4	----
Width of Lane	m	3.65	3.65	----
Median Width	m	10.0	10.0	----
Shoulder Width (Right)	m	3.0	3.0	----
Shoulder Width (Left)	m	1.5	1.5	----
Right of Way Width	m	100	100	----
Pavement Type (t=25cm)		Concrete	Concrete	----
<b>Horizontal Alignment</b>				
Minimum Radius	m	800	600	----
<b>Vertical Alignment</b>				
Maximum Grade	%	3.0	3.0	----
<b>2. Road Facilities</b>				
Number of Interchanges	Num.	4	3	7
Average Separation	km	6.7	13.0	----
Number of Service Areas	Num.	1	1	2
Number of Bus Stops	Num.	4	3	7
<b>3. Quantities</b>				
Road Length	km	20.2	26.2	46.4
Excavation Volume	m <sup>3</sup> x1000	2,200	4,260	6,460
Embankment Volume	m <sup>3</sup> x1000	1,600	3,270	4,870
Spoil to Waste	m <sup>3</sup> x1000	600	990	1,590
Pavement (t=25cm)	m <sup>2</sup>	309,900	382,040	691,940
Pavement Shoulder(t=15cm)	m <sup>2</sup>	158,900	135,700	294,900
<b>Bridges</b>				
20m<L<50m	m	130	50	180
50m<L	m	245	2,145	2,390
Over Bridges	Num.	5	6	11
<b>Land Acquisition</b>				
Residential Areas	km	2.0	1.2	3.2
<b>Compensation</b>				
Houses	Num.	78	60	138
Factories	Num.	2	----	2

## 12. PROJECT COST ESTIMATE AND IMPLEMENTATION SCHEDULE

### ***Project Cost Estimate***

The project cost is estimated based on the construction quantities estimated from the preliminary road and bridge design, considering construction methods, construction materials required and discussions with Panamanian counterparts.

The project cost includes the following items:

- a) construction cost
- b) land acquisition cost
- c) compensation cost
- d) engineering cost
- f) contingency

The project cost is estimated at 1993 base prices in the Panama currency, Balboas (equivalent in value to the US Dollar). The total project cost is 402.8 million Balboas, of which the Alcalde Diaz section costs 138.6 million Balboas and the Sabanitas section costs 264.1 million Balboas.

### ***Implementation Schedule***

The implementation schedule is arranged based on consideration of the following basic items;

- a) To balance future traffic demand and capacity on each section
- b) To meet urban development schedules
- c) To take account of the financial capacity for investment in each year
- d) To coordinate the road network configuration
- e) To consider the traffic safety conditions on the existing Panama-Colon Highway

## Summary of Road Project Cost

(Unit: Balboa 1,000's)

Road	Length (km)	Construction Cost		Land Cost	Total Cost	Cost per km	Foreign (%)	Local (%)
		Foreign	Local					
Alcalde Diaz	20.2	75,472	36,635	24,337	138,641	6,858	54.40	45.60
A-1 (Panama)	9.2	34,308	18,624	15,956	68,888	7,488	49.80	50.20
A-2 (Cement Fact.)	6.3	24,039	11,772	4,373	40,184	6,379	59.80	40.20
A-3 (Chagres)	4.7	17,125	8,236	4,208	29,569	6,271	57.90	42.10
Sabanitas	26.2	162,796	85,472	15,852	264,120	10,081	61.60	38.40
S-1 (Buena Vista)	16.5	107,457	55,396	9,169	172,022	10,426	62.50	37.50
S-2 (Colon)	9.7	55,339	30,076	6,683	92,098	9,495	60.10	39.90
Grand Total	46.4	238,268	124,104	40,389	402,761	8,680	59.16	40.84

Source: Team Estimate

## Implementation Schedule

Road Section	Year									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Alcalde Diaz Section)										
A-1	*****	=====								
A-2	*****		=====							
A-3	*****			=====						
Sabanitas Section										
S-1			*****	=====						
S-2						*****	=====			
Annual Investment Cost (Balboa millions)	34.0	20.9	48.8	56.0	68.7	51.1	60.5	19.6	19.6	23.5

Note: \*\*\*\*\* Land acquisition and engineering design period

===== Construction period

### 13. ENVIRONMENTAL IMPACT AND EVALUATION

#### *Environmental Impact and evaluation*

From the environmental impact study, the impact of each item was predicted, then those are examined using standards for evaluation. Main impacts are categorized from grade I (possible severe impact) to grade III (negligible impact).

In this project two possible grade I impacts are predicted. One is water contamination at the Sabanitas water supply intake, and the other is noise affecting residents along the Alcalde Diaz Section. The route passes along the shore of Gatun Lake near the Sabanitas water supply intake and soil from excavations could affect water quality at the intake. In the Alcalde Diaz Section, the route passes through some populated areas on embankment fill. So, in such areas, residents will be affected by traffic noise.

Other items were classified as having either a small impact (grade II), or a negligible impact (grade III).

#### *Countermeasures*

The water contamination at the Sabanitas water intake and the noise problem at Alcalde Diaz residential areas have been evaluated as major environmental problems. Therefore strict countermeasures should be taken to maintain good environmental conditions.

Countermeasures are planned to avoid water contamination at the Sabanitas water inlet. Three bridges are planned in the Sabanitas Section to avoid water contamination and soil erosion which might be caused by the project if reclamation is chosen as the means for construction in this section. Measures such as sheet piling are also proposed to prevent soil from washing into the lake during construction. The slopes of cuttings and embankments will be replanted using fast growing grass.

A noise prevention barrier is proposed along each side of the road for 1km in the Alcalde Diaz Section to maintain good living conditions for residents.

For other items, the impacts are not critical but some countermeasures and compensation have been suggested in addition to normal good practice so that the present environmental conditions are maintained or improved.

### Environmental Impact, Evaluation and Countermeasures

Item	Main Impact	Evaluation	Main Countermeasure
<b>Vegetation</b>	felling secondary forest for 12.0km in Sabanitas Section	III	minimizing felling trees, planting for surface recovery
<b>Fauna</b>	division and destruction of forest habitat (Not of endangered species)	III	minimizing destruction of habitat, 3 underpasses for wildlife
<b>Soil Erosion</b>	severe for 24 km (category 4)	II	gentle slopes, replanting
<b>Resettlement</b>	132 households	II	compensation
<b>Economic Activities</b>	2 factories, 1 warehouse, 1 drug store, 1 furniture shop for removal	II	compensation
<b>Public Facilities</b>	1 church, 1 seminary, 1 schools, 1 kindergarten for removal	II	compensation
<b>Safety &amp; Splitting of Communities</b>	31 cross roads and 16 settlements along the project route	II	13 over bridges
<b>Cultural Property</b>	nil	III	monitoring
<b>Air Pollution, Noise, Vibration</b>	noise for residents in Alcalde Diaz Section	I	establishment of noise barriers
<b>Water Contamination</b>	Sabanitas Water Intake	I	3 bridges, sheetpile method, replanting of slopes

Note:

I : large impact predicted if no countermeasures taken

II : slight impact predicted, some countermeasures or compensation is required

III: nil or negligible impact, general considerations can avoid or mitigate the impact

## **14. PROJECT EVALUATION**

### ***Economic Analysis***

An economic analysis of the project has been carried out considering the project economic cost, vehicle operating cost and passenger time cost savings, and an analysis period up to the year 2030. A discount rate of 12% has been assumed for the B/C and NPV calculations.

The economic value of the project is quite high and the estimated Economic Internal Rate of Return (EIRR) is 37%. The good results are mainly because of the benefit accrued from passenger time savings on the new Panama-Colon highway. This project will improve the Panamanian economy substantially and the economic investors who have been behind the development of Panama City will become active on the Caribbean side as well. This suggests substantial activation of the Panamanian economy after completion of the Project.

However, the project requires a great deal of monetary investment equivalent to nearly one tenth of the external debt of the Republic. Despite the substantial recovery of the Panamanian economy since the crisis, the amount of future debt may impede upward Panamanian economic growth.

### ***Financial Analysis***

From the macroeconomic view, the financial credibility of the Project is not well shaped. The Financial Internal Rate of Return (FIRR) is 4.9%, and a cash surplus will only be observed in the very last years of the project analysis period. Thus, a well organized financial scheme will be required.

In this analysis, a toll scheme is introduced. The toll charge is assumed to be 2.00 Balboas per passenger car, an amount which approximates the value of passenger time cost savings. The results demonstrate that the project cost will be covered by the toll revenues over the life of the project. If Panamanian equity is introduced with this toll scheme, the financial credibility may be substantially improved.

### ***Funding Scheme***

There is no question that this project needs a very soft loan to relieve the financial burden on the Panamanian Government of implementing the Project. Long-term interest rates for financial arrangements must never exceed 5 percent.

Further efforts of the Panamanian Government to relieve the financial burden of the project are necessary for implementation of this project. Introduction of a toll scheme, institutionalization of road funds, and procurement of a very soft loan are examples of financial measures that the Panamanian Government should try to achieve.

## Results of Economic Benefit-Cost Analysis

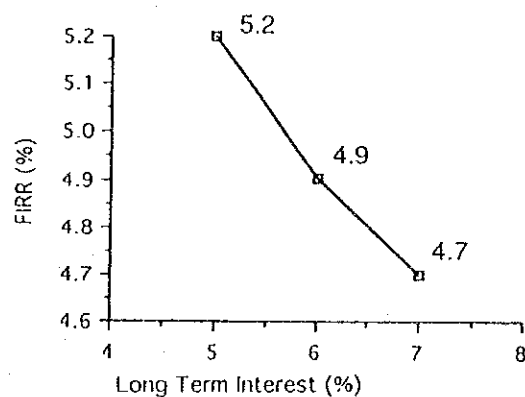
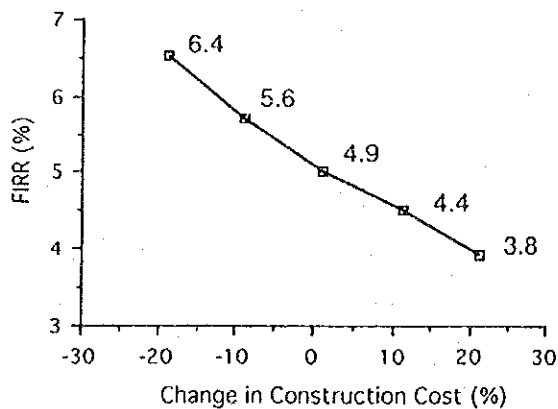
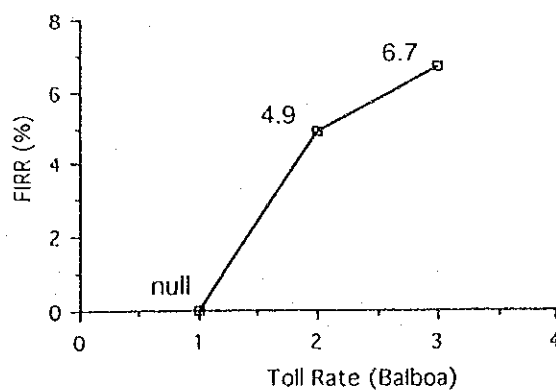
	Alcalde Díaz (A-1,2,3)	Sabanitas (S-1,2)	Total
<b>EIRR(%)</b>	41.0	31.1	37.0
<b>B/C*</b>	6.6	4.7	5.6
<b>NPV*(million Balboas)</b>	597	523	1,120

\* B/C ratio and NPV are calculated at 12% discount rate

## Results of Financial Benefit-Cost Analysis

	Alcalde Díaz (A-1,2,3)	Sabanitas (S-1,2)	Total
<b>FIRR(%)</b>	7.8	null	4.86
<b>B/C*</b>	0.6	0.2	0.40
<b>NPV*(million Balboas)</b>	-60	-139	-199

\* B/C ratio and NPV are calculated at 12% discount rate.



## Sensitivity Analysis of FIRR

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