No. 53

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

FINAL REPORT

MARCH 1994

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

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March 1994

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

Letter of Transmittal

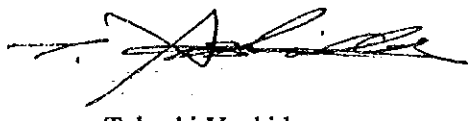
We are pleased to submit to you the report of the Feasibility Study on the Improvement of the Panama - Colon Highway in the Republic of Panama. The report includes the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as the comments made by the Ministry of Public Works and other authorities concerned in the Republic of Panama. The report consists of an Executive Summary, a Main Report and Drawings.

The report deals with the present and future transportation demand between Panama city and Colon city. There were two objectives, one of which was to formulate a master plan for arterial road development between Panama and Colon, and the other was to carry out a feasibility study on selected projects from the master plan.

From the master plan study, construction of a new highway alongside the existing Panama - Colon highway is recommended by 2010. From the results of the feasibility study on the Alcalde Diaz section and Sabanitas section, construction of these sections gives high economic returns, and the project should be commenced as soon as possible.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, the Ministry of Construction and the Japan Public Highway Corporation. We also wish to express our deep gratitude to the Ministry of Public Works and the Governmental Agencies concerned in the Republic of Panama for the close cooperation and assistance extended to us during our study. We hope this report will contribute to the development of the Republic of Panama.

Very truly yours,



Takeshi Yoshida
Team Leader
The Feasibility Study
on the Improvement of the
Panama - Colon Highway

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

Kensuke Yanagiya
President
Japan International Cooperation Agency

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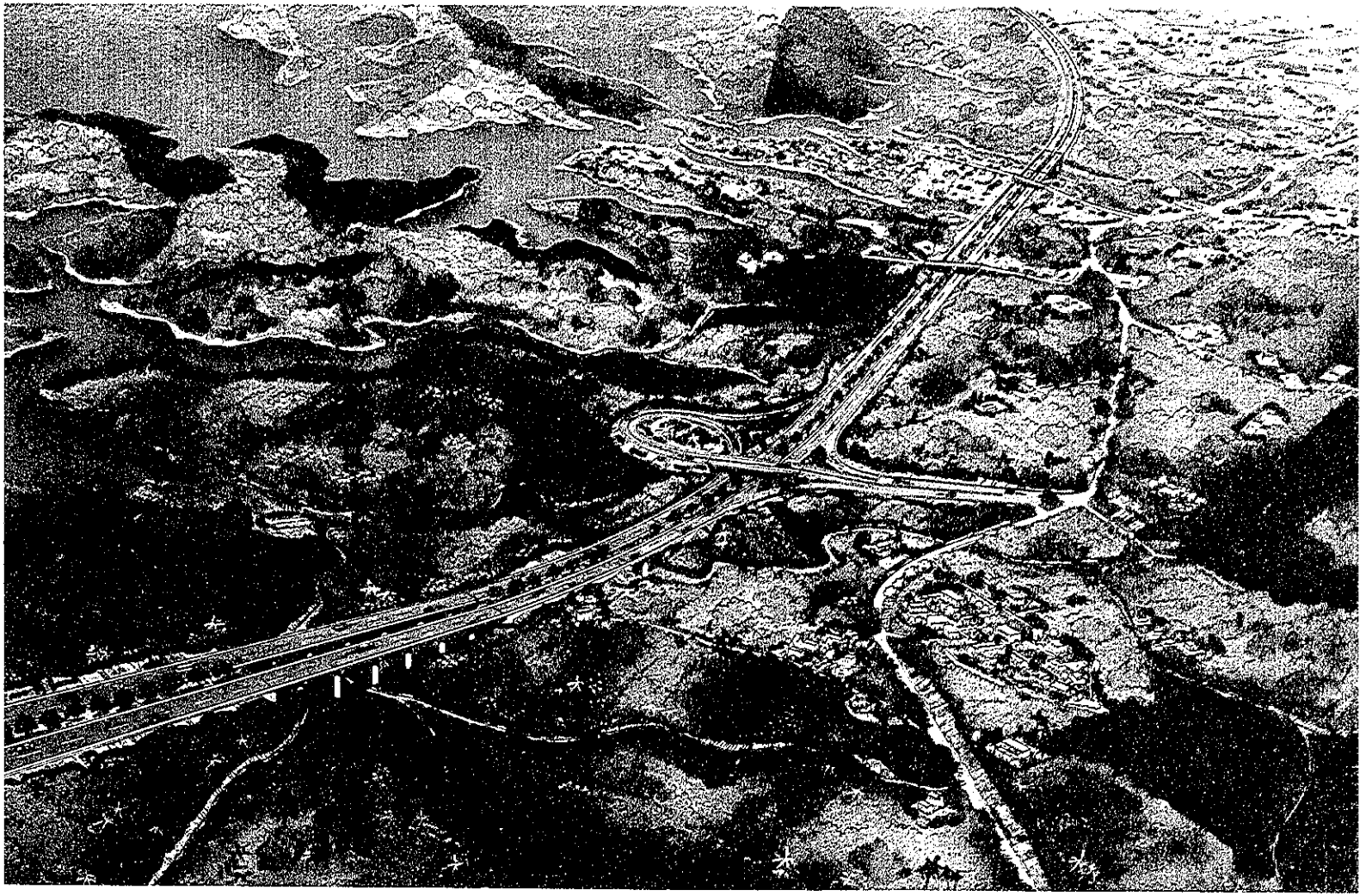


Perspective View of the Proposed New Panama-Colon Highway

INTRODUCTION

(1) Study Development

In response to the request of the Government of the Republic of Panama (hereinafter referred to as Panama) , the Government of Japan has decided to conduct the Feasibility Study on the Improvement of the Panama-Colon Highway in the Republic of Panama (hereinafter referred to as "the Study") in accordance with the relevant laws and regulation 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 continues up to March 1994.

(2) Study Purpose

The objectives of the Study are as follows;

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.

(3) Scope of the Study

1) 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 .

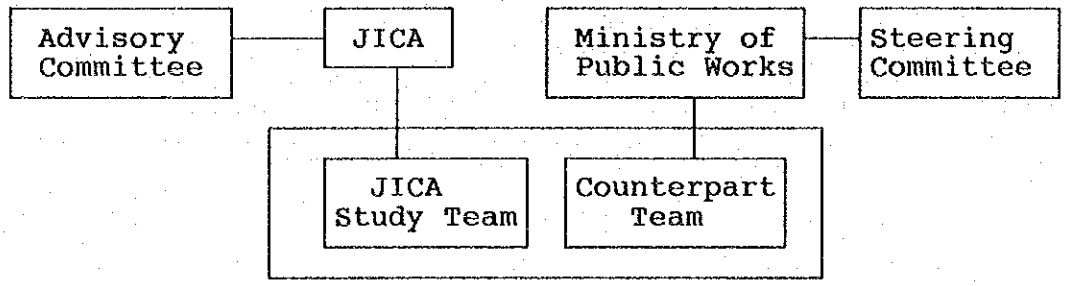
2) Study Area

The Study Area shall include the existing road of approximately 80 kilometers connecting Panama city with Colon city the alternative alignments to be considered as new road segments, and their vicinities.

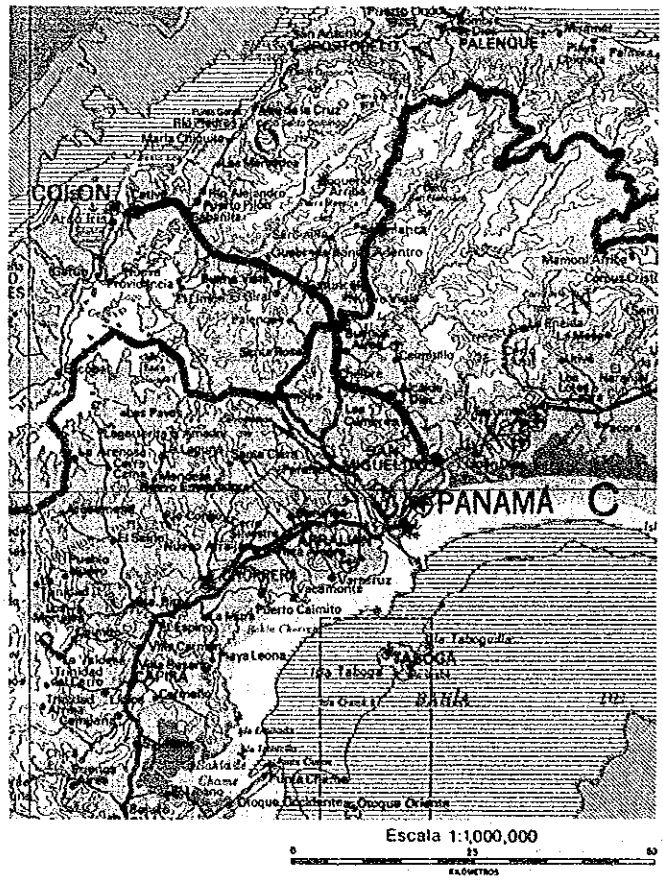
(4) Study Organization

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, to receive the advice for the Study. The government of Panama has formed the Counterpart Team, headed

by Ms. Miriam de Solis under Ministry of Public Works (MOP). MOP has organized the Steering Committee coordinator by Mr. Jose Dominguez to facilitate the progress of the Study.

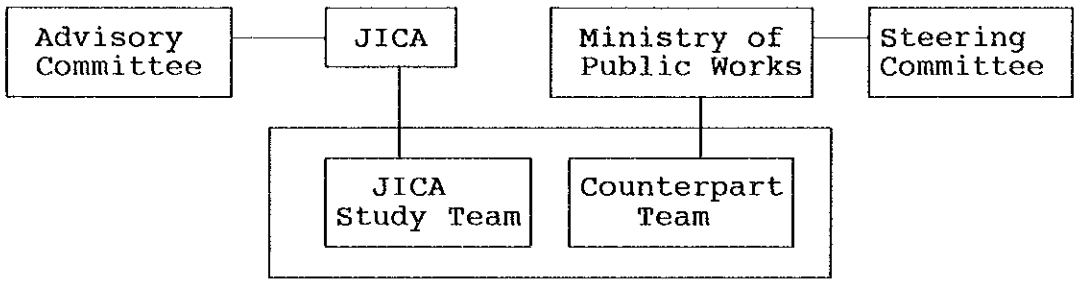


Study Organization

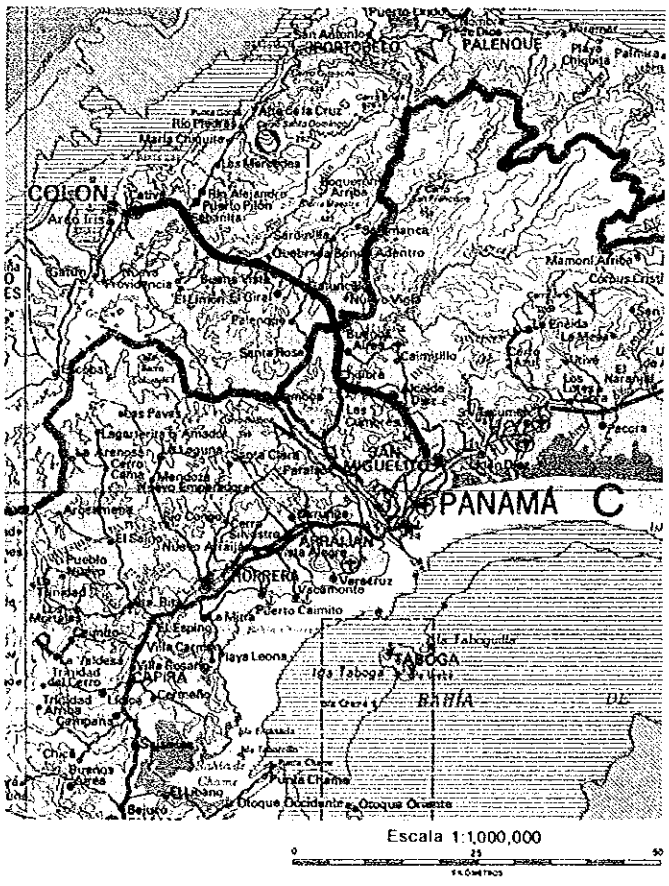


Location Map of Existing Panama Colon Highway

by Ms. Miriam de Solis under Ministry of Public Works (MOP). MOP has organized the Steering Committee coordinator by Mr. Jose Dominguez to facilitate the progress of the Study.



Study Organization



Location Map of Existing Panama Colon Highway

JICA STUDY TEAM

Ing. Takeshi Yoshida	Project Manager
Ing. Koichi Tsuzuki	Road Planner (Deputy Manager)
Ing. Toshihiro Hotta	Transport Planner
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Ing. Masakazu Iwabuchi	Economist
Ing. Isao Sakai	Environment Analyst
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Member : Ing. Kihachiro Yamane (Ministry of Construction)
Member : Ing. Hiroshi Nagai (Japan Highway Public Corporation)

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Lic. Yuichi Sekiguchi

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Ing. Rigoberto Jurado	Traffic Analyst

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*Ing. Laurencio Guardia	(Coordinator of the Study - MOP)
Ing. Enrique Perez Young	(MOP)
Lic. Nelson Guardia	(MOP)
Lic. Regina Logreira	(CONAMA)
*Arq. Carlos Chacon	(MIVI)
Ing. Carlos Linares	(MIVI)
Lic. Amael Candanedo	(MIPPE)
Lic. Rene Atencio S.	(APN)

Note: * predecessor

(5) Study Report

This Final Report consists of three parts: (1) Executive Summary Report, (2) Main Report and (3) Drawings Volume.

The following Reports were submitted in the Study.

a) Inception Report	January, 1993
b) Interim Report (1)	March, 1993
c) Interim Report (2)	July, 1993
d) Draft Final Report	January, 1994
e) Final Report	April, 1994

In addition the above mentioned Reports, the following Technical Reports were submitted in the Study as to reference of the Study.

a) Road Inventory Survey Report
b) Bridge Inventory Survey Report
c) Topographic Survey and Mapping Report
d) Initial Environmental Impact Study Report
e) Road Maintenance Plan Study Report
f) Subsurface Investigation Report

1 BACKGROUND OF THE STUDY

1.1 Location and Geography

The Republic of Panama (hereinafter simply called Panama) is located on the isthmus that connects the continents of North and South America and separates the Pacific and Atlantic Oceans. The nation extends for approximately seven hundred kilometers from east to west within the boundaries of latitude 7° to 9° North and longitude 77° to 83° West. It has an area of 77,512 thousand square kilometers (slightly smaller than the area of Hokkaido). The mountain range that runs from Costa Rica to Colombia lies in the center of the nation.

The climate in Panama is principally a humid tropical climate, with an average temperature of 27°C and average humidity of 79 percent. There are two seasons in a year, namely the rainy season from April to December and the dry season from January to March. Panama is generally free from such natural disasters as hurricanes and earthquakes.

1.2 Brief History

The first visitor to Panama from the European continent was Rodrigo Galvan de Bastidas in the year 1501 AD. In the following year Christopher Columbus visited the Caribbean coast of Panama during his fourth and final voyage. In the year 1513, Balboa succeeded in crossing the isthmus and "discovered" the Pacific Ocean. Pizarro, the famous conqueror of the Inca empire, left Panama for his ambitious trip to Peru. After the conquest of the Incas, many of the treasures of Peru were carried to Spain via the "Royal Road" or "Cross Road" in the isthmus of Panama. English pirates attacked the ports of Panama several times and Morgan, the infamous pirate, destroyed Panama city. Since then, the ruins of the old city have lain in part of present day Panama city.

The republic of Panama is a relatively young country, established in 1903 to coincide with the construction of the Panama canal. The construction project of the Panama canal was commenced in 1880 as the second challenge of Ferdinand de Lesseps, the great builder of the Suez canal. His initial construction plan was a sea level canal. In spite of his effort and enthusiasm, the French canal company was eventually bankrupted due to problems such as the huge volume of rock and soil excavation, flooding of the Chagres river, the spread of yellow fever and malaria, etc..

The United States, who had been interested in the isthmus of Panama, supported the independence of Panama and then restarted the construction of the canal in 1904. After canal was opened for world wide ship transit and global trade in 1914. However,

there were conflicts between Panama and the United States over the sovereignty of the Canal Zone. After long negotiations, the new canal treaty was signed by General Omar Torrijos of Panama and U.S. President Jimmy Carter in 1977 and the Panama Canal Company was changed to the Panama Canal Commission. The Panama canal is 80 kilometers long and utilizes a system of locks to raise or lower ships between sea level and Gatun Lake. The ships have to climb or descend a total of 26.52 meters through three lock chambers. In fiscal year 1992, a total of 12,636 oceangoing vessels or 160 million tones of cargo transited the canal.

Panama has enjoyed her geographical position as a crossroads of the world. In 1948, a free trade zone was established in Colon city at the Atlantic ocean entrance of the canal and it has grown into the largest free zone in the American continent. In the 1970s, 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.

2 SOCIO-ECONOMIC SITUATION

2.1 Population

The total population of Panama in 1990 was 2,329,329 inhabitants. The annual growth rate was 2.58 percent during the 80's, 0.21 percent higher than the growth rate in the 70's as shown in Table 2.1.1.

Table 2.1.1 Population Growth in Panama

Year	Population	Annual Growth Rate (%)
1911	336,742	
1920	446,098	3.17
1930	467,459	0.47
1940	622,676	2.76
1950	805,285	2.56
1960	1,075,542	2.94
1970	1,420,002	3.06
1980	1,805,287	2.37
1990	2,329,329	2.58

Source: Panama en Cifras 1980-1990

The Transisthmian Highway (the existing Panama-Colon Highway) passes through three districts, namely Panama, San Miguelito and Colon. These districts have a total area of 4,151.20 square kilometers (km2) and a population in 1990 of 968,736 inhabitants, which is 41.6 percent of the country's total population. San Miguelito is the most densely populated district with 4,860.5 inhabitants/km2, Panama has 228.4 inhabitants/km2, and Colon has About 92 inhabitants/km2, as shown in Table 2.1.2.

The population growth rate in the Province of Panama has decreased from 3.44 percent (1970/80) to 2.85 percent (1980/90), whereas the growth rate for the Province of Colon has increased from 1.92 percent (1970/80) to 2.22 percent (1980/90).

Table 2.1.2 Population Density

District	Area (km2)	Population 1980	Population 1990	Inhabit. Density (Inh/Km2) 1980	1990
Panama	2,560.80	447,107	584,803	180	228
San Miguelito	50.00	156,611	243,025	3,132	4,861
Colon	1,540.40	113,153	140,908	75	92
Total	4,151.20	716,871	968,736	174	233

2.2 Gross Domestic Product

Panama's Gross Domestic Product (GDP) for 1990 was 4,948.7 million Balboas (1 Balboa = 1 US$), compared to 3,558.8 million Balboas in 1980. Comparing statistics at 1970 prices, the GDP was 1,868.4 million Balboas and 773 Balboas per-capita in 1990, compared to 1,745.8 millions Balboas and 892 Balboas per-capita in 1980. As shown in Table 2.2.1, Panama's economy developed rapidly during the 1970s but virtually stagnated in the 1980s.

Table 2.2.1 Gross Domestic Product 1970-1990

Year	Total at Current Price (Millions of Balboas)	Total at 1970 Prices	Per Capita 1970 Prices (Balboas)
1970	1,021.20	1,021.20	687
1980	3,558.80	1,745.80	892
1990	4,948.70	1,868.40	773

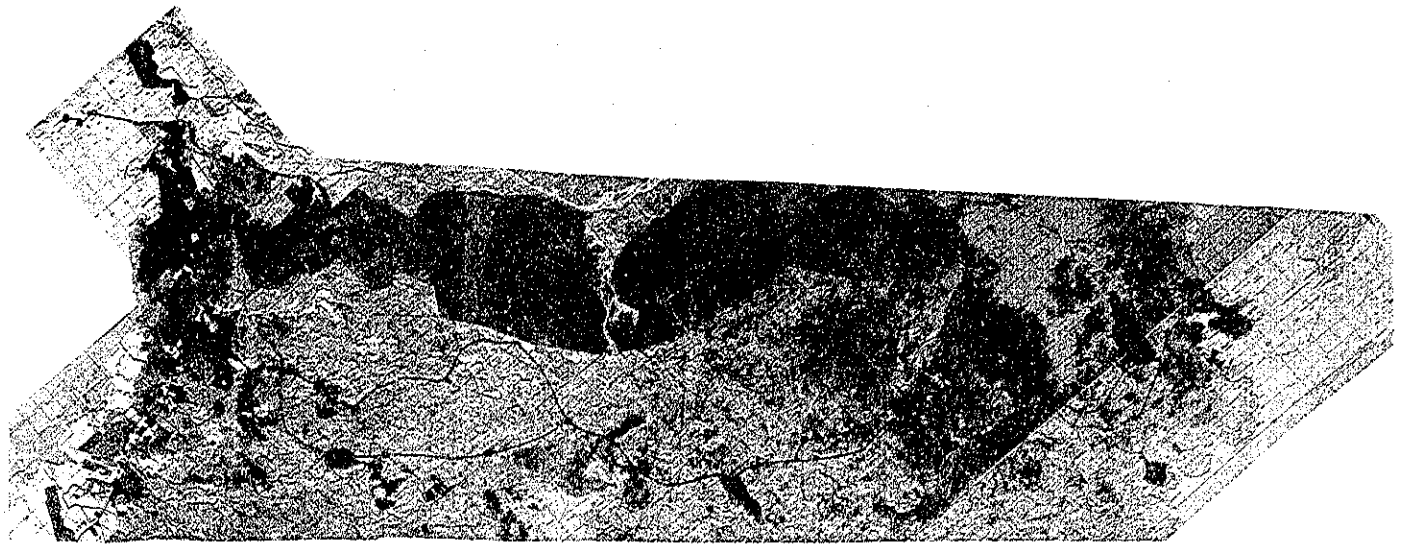
Source: Panama en Cifras 1980-1990
Panama en Cifras 1979-1983

As shown in Table 2.2.2, the GDP of Panama is mainly dependent on the Tertiary Sector which accounts for 77.08 percent of the GDP. The Primary Sector has 11.85 percent and the Secondary Sector has 11.07 percent of the total GDP. The most important activity is Transport, Storage and Communication with 25 percent of the total GDP.

Table 2.2.2 Gross Domestic Product by Sector

Sector	1970 Million of Balboas	Percent of the Total (%)
Primary(1)	221.50	11.85
Secondary (2)	206.80	11.07
Tertiary(3)	1,440.10	77.08

Source: Panama en Cifras 1980-1990
Note;
Primary Sector(1) : Agriculture, silviculture, fishing,and hunting. Mines and quarry exploitation.
Secondary Sector(2): Manufacturing industry, construction.
Tertiary Sector(3) : Electricity, gas and water supply. Wholesale and retail commerce, hotels and restaurants. Transportation, storage and communication. Financial establishments, insurance, real estate, and services to companies. Social, personal and community services. Governmental services. Domestic services.



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

EXISTING PANAMA-COLON HIGHWAY
CORREDOR NORTE
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INTERCHANGE

Present Land Use

COMMERCIAL AND BUSINESS AREA
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NATIONAL PARKS AND RESERVED AREAS
RECREATIONAL AREAS AND PARKS
INDUSTRIAL
TRANSPORTATION
CATTLE
GALLERY FOREST
LAKES
BOSQUES

The economy in Panama is heavily dependent on international and domestic services such as transport, communication, restaurants, hotels, financial establishments, etc. It can be concluded that this dependence is a result of the important role of Panama in international trade due to the Panama Canal, the Colon Free Zone and the International Banking Center.

2.3 Trade

The official currency in Panama is the Balboa which has the same value as the US Dollar. The Panamanian economy is known for having the US Dollar as a second legal currency within its money system. International trade is of great importance to the Panama economy and that is the reason why Panama has developed the Colon Free Zone and the International Banking Center to attract international trade and investment. In 1990, Panamanian exports had a value of 321,225 thousand Balboas while imports reached 1,489,087 thousand Balboas. Trade in the Free Colon Zone is measured separately from the rest of the country and in 1990, the value of reexports was 3,086,254 thousand Balboas and imports were 2,676,565 thousand Balboas as shown in Table 2.3.1.

Table 2.3.1 Panama Trade in 1990
(Unit; 1,000 Balboas)

Area	Thousand Balboas			
	Exports F.O.B.	Reexports F.O.B.	Imports C.I.F.	Differential
Whole Country	321,225		1,489,087	-1,167,862
Colon Free Zone		3,086,254		409,689

Source: Panama en Cifras 1980-1990

The most important products for export are fresh bananas 28 percent, shrimp (fresh, refrigerated or frozen) 14 percent, and sugar 11.5 percent of the total exports. For the Colon Free Zone the reexports categories vary as follows: textile materials 25 percent, electrical products 20 percent, and technical equipment (photography, medical, surgical, musical,etc.) products 17 percent as shown in Table 2.3.2.

Table 2.3.2. Panama - Main Export Products
(Unit;1,000 Balboas)

Product	Whole Country		Colon Free Zone	
	Amount	% of total	Amount	% of total
Bananas	89,444	28.00		
Shrimp	44,373	14.00		
Sugar	36,836	11.50		
Textile material			777,386	25.00
Electrical product			627,188	20.00
Technical equipment(1)			517,298	17.00

(1) Technical equipment includes instruments and equipment for photography, medicine, surgery, music, etc.
Sources: Panama en Cifras 1980-1990

2.4 Employment

Between 1985 and 1989, the percentage of the population which is economically active has increased from 56.9 percent to 58 percent, reaching 820,042 people in 1989. The unemployed population was 133,708 which is 16.3 percent of total population. The median salary for 1989 was 554.61 Balboas as shown in Table 2.4.1.

Table 2.4.1 Employment for 1989

Population over 15 years old	
Total Population	**1,414,180**
Economically active	820,042
Percentage of total (%)	58.00
Unemployed	133,708
Percentage of active (%)	16.30
Metropolitan area population (1)	807,428
Economically active	476,468
Percentage of total (%)	59.00
Unemployed	97,047
Percentage of active (%)	20.40

(1) The metropolitan area is the summation of the provinces of Panama and Colon
Source: Panama en Cifras 1980-1990

The distribution by sector of the economically active employed population can be seen in Table 2.4.2.

Table 2.4.2 Employment by Working Sectors for 1989

Sector	Population Employed	Percentage of Total
Total	686,334	100.00
Primary	203,497	29.65
Secondary	89,168	13.00
Tertiary	393,669	57.35

Source: Panama en Cifras 1980-1990.

In the Metropolitan Area (Panama and Colon Provinces) in 1989, the percentage of the population which is economically active was 59 percent with 476,468 people and the unemployment population was 97,047 which is 20.4 percent of total Metropolitan Area population as shown in Table 2.4.1.

2.5 Transport Sector

(1) Highway Network

The total road length of the whole country in 1990 was 10,015 kilometers with the ratio of paved road length as only 30 percent of the total. The Pan-American Highway is the most important highway of the national highway network. The Pan-American Highway traverses the Pacific side of the country from the border of Costa Rica in the west to Yavisa located in Darien province. The majority of the population of Panama is concentrated along this highway. The second major highway is the Transisthmian Highway (Panama-Colon Highway) which connects Panama city on the Pacific side with Colon city on the Atlantic side.

(2) Interregional Bus Services

Bus transport is the most common mode of transport for the people of Panama. Panama city is connected with almost all of the major cities by interregional bus services operated by private enterprise. Some of the big cities have bus terminals, however, the facilities and services available are inadequate for both passengers and bus companies.

(3) Railways

In Panama there are several railways, the most important being the Panama National Railway followed by the Chiriqui Land Company Railway. The Panama National Railway (FNP) was originally constructed by a company from the United States as the first transcontinental railway (between Panama city and Colon city) in the period of the California "Gold Rush".

During the construction of the Panama Canal, operation of the railway was transferred first to the French company and then to the US company to support the construction. After the commencement of operation of the canal, the railway was operated to serve the passenger and cargo transport needs of the Panama Canal Company. Following the Torrijos-Carter Treaty, the railway was transferred to the government of Panama in 1979. However, passenger transport stopped at the beginning of 1990 and now only two trips a day are operated for container transport between Panama and Colon cities. The Chiriqui Land Company Railway mainly serves the banana transportation requirements of the company.

(4) Aviation

Panama's international airport is located in the eastern part of Panama city and is known as Tocumen international airport. Tocumen airport is the one of the most important international airports in the Central America and Caribbean regions. The total number of passengers to pass through Tocumen airport was over one million in 1991.

The domestic airline network has been developed for passenger transport between Panama city and remote areas such as Bocas del Toro, San Blas etc. The domestic airport (Paitilla airport) is located very close to the center of Panama city.

(5) Ports

Two important ports are located at the entrances of the Panama canal, namely Cristobal port in Colon city and Balboa port in Panama city. Cristobal port, which handles almost one quarter of the total marine cargo of Panama, is the biggest port in Panama and serves for the import and export of goods, in particularly for Colon Free Zone.

(6) Number of Vehicles

In spite of the past economic recession, the number of vehicles registered in Panama has been increasing rapidly. The increased number of vehicles is causing traffic congestion on urban streets and has become a serious social problem in Panama. This phenomena is particularly severe in the Panama metropolitan area.

3 EXISTING ROAD CONDITIONS

3.1 General

3.1.1 Existing Road Network

The existing road network of the Panama-Colon area consists of only one trunk road, secondary roads and some local roads. The area between the city of Panama and Aguas Buenas is served by two roads; one trunk road and one secondary road. However, the area between Aguas Buenas and Colon city is linked by only one trunk road. There is no diversion road in the area between Aguas Buenas and the city of Colon.

There are several small villages along the existing Panama-Colon Highway. The connection between the Panama-Colon Highway and these small villages is made by only one local road. In this area also, there is no diversion road. The above mentioned existing road network is illustrated in Figure 3.1.1.

3.1.2 Road Classification

(1) Functional Road Classification

The following functional road classifications are established by the Ministry of Public Works (MOP) based on the system of road operation :

1) Expressway (Autopista)

Expressways are operated as a toll system with full or partial access control and form the primary road network in Panama.

2) National Primary Road (Carreteras Nacionales o Primarias)

National Primary Roads are roads connecting two or more provinces, or connecting cities with the most important regions. As the National Primary Roads connect two or more provinces, these define the most important areas in the Republic of Panama. They are considered as the most important component of the infrastructure for the transit of all kind of vehicles. The route numbers are from 1 to 9 in the republic. All these highways are paved with Cement Concrete or Asphalt Concrete.

3) Regional Secondary Road (Carreteras Regionales o Secundarias)

Regional Secondary Roads join regions of defined importance and cities with arterial roads, as well as roads of importance between provinces. The Regional Secondary Roads in this group join regions or the most important cities with arterial roads. Their route numeration is from 10 to 99. From these ninety

numbers, ten correspond to each province following the same rule indicated at point 2 for the assignment of the numbers.

The second group of the Regional Secondary Roads are characterized by the communication of regions or cities with arterial highways or provincial highways from the first group. This group is represented by number from 100 to 999. Each province will be assigned one hundred routes numbers following the same rule as indicated at point 2.

4) Local Road (Carreteras Vecinales)

Local Roads connect with Regional Secondary Roads and their purpose is accessibility to small villages and centers of main production set apart from other roads. These roads are designated from 1000 to 9999 and are divided into two groups according to the type of pavement (earth or coating). This excludes the Province of Panama which presents a special condition. Therefore, each province has a maximum of one thousand route numbers.

(2) Numbering of Roads

The following numeration has been assigned to these roads in order to have a control on routes:

a) Route	1 to 9	National Primary Road
b) Route	10 to 99 and 100 to 999	Regional Secondary Road
c) Route	1000 to 9999	Local Roads

All the highways have the numeration following a number sequence from west to east in each province. When a Local Road is upgraded to a Regional Secondary Road, a new numeration as Regional Secondary Road will be assigned and its previous numeration will be assigned to a new Local Road. It is important to indicate first that the number of routes will be assigned to the province whose part of the road cross from one province to another. In second place, that part of the road be larger in longitude within the province.

(3) Maintenance Classification

There are no road maintenance classifications. All roads, including Local Roads, are maintained by MOP.

3.1.3 Road Length

The total road length of Panama in 1981, 1985, and 1990 was 8,664, 9,693, and 10,015 kilometers respectively. The rate of increase of road length in the 5 year period between 1981 to 1985 was 11.9 percent; however, during the 5 year period between 1985 and 1990, it dropped to 3.3 percent. Although the total road length is still gradually increasing, the length of cement

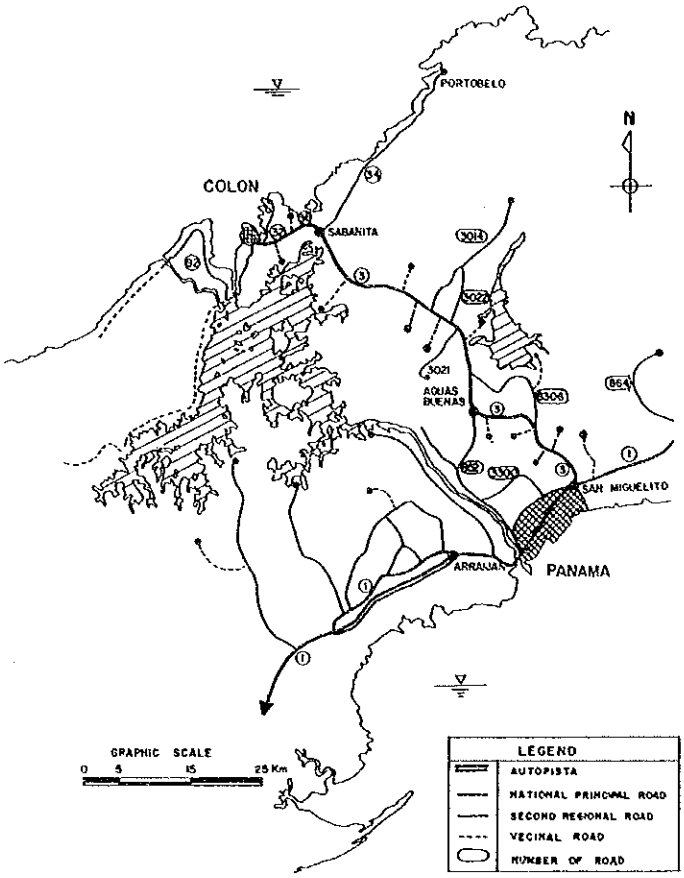
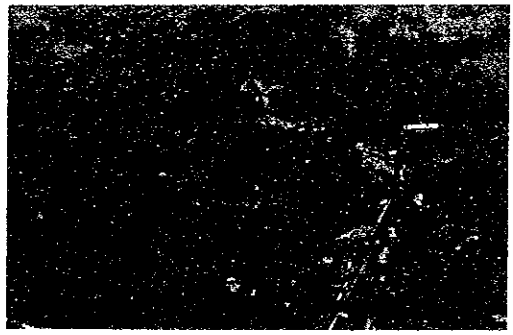
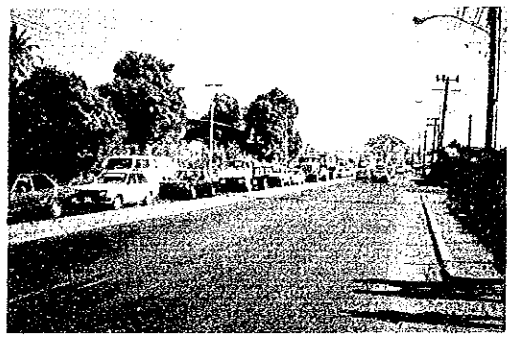


Figure 3.1.1 Present Road Network



Alignment in Mountainous Area

Small Radius Curves



Traffic Congestion

asphalt pavement roads has not increased during the period from 1985 to 1990.

3.1.4 Number of Vehicle Registrated

The number of vehicles registered in Panama in 1981, 1985 and 1990 is indicated as 147,488, 185,208 and 186,943 vehicles respectively. The growth rate during period between 1981 and 1985 was 25.6 percent, and between 1985 and 1990 the growth rate was only 1.0 percent. However, the number of vehicle registrations in 1992 rose rapidly to 210,020 vehicles, indicating a higher growth rate between 1990 to 1992 of 12.3 percent.

The number of vehicles registered in the cities of Panama and Colon in 1992 was 141,680 and 12,685 vehicles respectively. Accounting for 73.5 percent of the total in the country, this indicates the high concentration of vehicles in these two cities.

3.1.5. Traffic Accident Conditions

The number of traffic accidents in Panama increased gradually from 1980 to 1987; and decreased noticeably between 1988 and 1989, before increasing gradually again since 1989. The available data for traffic accidents on the existing Panama-Colon Highway in 1991 was obtained from the "Direccion Nacional de Transito" and is summarized as follows;

a) There were a total of 700 traffic accidents in 1991.
b) The highest traffic accidents occurred in the section between San Miguelito and Alcalde Diaz with about 330 traffic accidents.
c) The second highest traffic accidents occurred in the section between Colon and Sabanitas, with about 170 traffic accidents.
d) The third highest traffic accidents occurred in the section between Sabanitas and Quebrada Grande, with about 100 traffic accidents.
e) The majority of traffic accidents involving pedestrians occurred at San Miguelito and Colon to Sabanitas area. These areas are experiencing a rapid growth in community development and population.

3.1.6 Traffic Congestion

The traffic congestion on the existing Panama-Colon Highway can be examined from the following two points of view

a) From the viewpoint of road structure
b) From the viewpoint of traffic flow conditions

(1) From the viewpoint of Road Structure

Traffic congestion rate is calculated by comparing the actual traffic volume and traffic capacity on certain road segments, as shown below;

$$\text{Traffic Congestion (v/c)} = \frac{\text{Traffic volume (v)}}{\text{Traffic capacity (c)}}$$

Traffic capacity is calculated using the following formula:

$$C = Bc \times Cg \times Cl \times Cs \times Cu \times S$$

C : Traffic Capacity (pcu/H)
Bc: Basic traffic capacity (pcu/H)
Cg: Adjustment factor for heavy vehicles and gradient.
Cl: Adjustment factor for lane width
Cs: Adjustment factor for lateral clearance width
Cu: Adjustment factor for road side land use condition
S : Level of service for traffic operation.

The traffic capacity (C) on the road sections of the existing Panama-Colon Highway are calculated based on the above formula. The actual existing traffic volume (V) on the various points of the existing Panama-Colon Highway were observed by the JICA Study Team in February 1993. The traffic congestion rates are shown in Table 3.1.1 as a results of calculation.

(2) From the viewpoints of Traffic Flow Conditions

The existing Panama-Colon Highway is the road connecting the cities of Panama and Colon and is classified as a National Primary Road. Therefore, many heavy vehicles with full load are travelled on this road. The running speed of these heavy vehicles on longitudinal gradients steeper than 3 percent is less than 20 km/h and these heavy vehicles cause traffic congestion on such road sections.

Table 3.1.1 Traffic Congestion Rate

(Unit; PCU/D)

Road Section	Traffic Volume (V)	Capacity (C)	V/C
San Miguelito-San Isidro	33,000-50,700	64,000	0.51-0.79
San Isidro-Alcalde Diaz	25,000-11,000	16,000	1.56-0.69
Alcalde Diaz-Don Bosco	10,200- 8,900	18,000	0.56-0.49
Don Bosco-Rio Chagres	11,000-10,000	18,000	0.61-0.55
Rio Chagres-Buena Vista	11,300	18,000	0.63
Buena Vista-Sabanita	10,700-13,700	18,000	0.59-0.76
Sabanitas-Cativa	20,700	16,000	1.29
Cativa-4 Altos	19,800-35,900	64,000	0.31-0.56

3.2 Road Structure Conditions

3.2.1 Road Inventory Survey

The Road Inventory Survey was conducted on the existing Panama-Colon Highway by the JICA Study Team with close collaboration from the Panamanian Counterparts in February 1993. The starting point of the survey is the grade separated intersection at San Miguelito in Panama city, namely Station (STA.) No. 0+000, and the end point of the survey is Cuatro Altos at grade intersection in Colon city, namely STA. No. 68+000.

The distance between stations (STA.) is set at 1,000 meters and the total survey length calculated to be 68,000 meters. The road structure condition of the existing Panama-Colon Highway was inspected at about 500 meters intervals. The main inspection and measurement items for the road inventory survey are as follows;

a) Measurement of road cross-section elements
b) Inspection of pavement condition
c) Inspection of slope protection condition
d) Inspection of drainage condition
e) Inspection of underground facilities condition
f) Inspection of related facilities condition

3.2.2 Road Condition and its problems

Based on the results of road inventory survey, the existing road condition and its problems are described below;

The existing road was constructed by U.S. Government from 1938 to 1940, and about 30 years later in 1973, full scale rehabilitation works were implemented by the U.S. Government. Since 1973, no full scale rehabilitation works have been done; however, small scale maintenance works have been executed by MOP.

Considering the existing road conditions described above, MOP commenced a study for a full scale rehabilitation works of the existing Panama-Colon Highway in March 1993. The major existing road conditions and problems are described below;

(1) Horizontal Curvature

The minimum horizontal curvature is adopted 180 meters at the road segment between Gatun Bridge and Sabanitas which is classified as mountainous area. In other segments, a comparatively large horizontal curvature of 250 or 300 meters are used for flat and hilly terrains. Based on these dimensions, the design speed for mountainous and flat or hilly terrain will be approximately 60 km/h and 80 km/h according to the topographic conditions.

(2) Vertical Curvature

The existing Panama-Colon Highway starts at San Miguelito grade separated intersection (STA. No. 0+000) which is located about 20 meters above sea level and rises to its highest point at Las Cumbres (STA. No. 12) which is about 200 meters above sea level. From there, it passes through hilly or mountainous terrain at about 100 to 150 meters above the sea level before finally descending to Colon city.

The maximum longitudinal gradient adopted was about 6.0 percent in Las Cumbres area and a gradient of about 4.0 percet to 5.0 percent was also used on many other road segments. The running speed of fully loaded heavy vehicles is decreased when negotiating these steep gradient segments. The running speed decreases to 15 to 20 km/h and traffic congestion frequently occurs.

Considering the above traffic conditions, a climbing lane or road widening should be constructed to maintain a smooth traffic flow and to ensure traffic safety.

(3) Cross-Section

4-Lane dual carriageways are maintained at two road segments; one is from San Miguelito at grade separated intersection to San Isidro in Panama City of length about 4.0 kilometers, and the other is from Cativa to Cuatro Altos intersection in Colon City of length about 6.0 kilometers. The other parts of the existing road are maintained as 2-Lane road.

The lane width of both 4-Lane dual carriageway and 2-Lane roads is adopted as 3.65 meters (12'). The minimum shoulder width is adopted as 1.8 meters. The basic design standards such as width of cross-section elements were determined by AASHTO.

3.3 Bridge Structure Conditions

3.3.1 Bridge Inventory Survey

The bridge inventory survey was conducted by the JICA Study Team in close collaboration with the Panamanian Counterparts in February 1993.

There are eighteen bridges on the existing Panama-Colon Highway between the grade separated intersection at San Miguelito in Panama and the at grade intersection at Cuatro Altos in the city of Colon. The bridge inventory survey was carried out on the above mentioned eighteen bridges. The surveys consist of visual surveys and measurement of some parts of the bridge structure. The main visual survey items are as follows:

a) Surface of concrete slab condition
b) Underside of concrete slab condition
c) Expansion joint condition
d) Concrete slab condition
e) Steel beam condition
f) Concrete beam condition
g) Lateral beam condition
h) Abutment condition
i) Pile condition
j) Related facilities condition

3.3.2 Bridge Conditions and its Problems

The general condition of each bridge is summarized in Table 3.3.1. The detailed bridge conditions are described in the Technical Report (Bridge Inventory Survey). The eighteen bridges were constructed in 1940. In 1973, a rehabilitation project was implemented by the U.S. Government. In 1982, three bridges (Bridge No.15, 16 and 17) were constructed when the widening of the existing road from 2-Lane to 4-Lane road was constructed.

Since 1940, these bridges have been in continuous operation for more than 50 years. Considering this period, the maintenance of these bridges is in comparatively good condition. However, the following three maintenance problems were noticed on almost all of the bridges.

(1) Alligator Cracks on the Surface of Concrete Slab

There are many alligator cracks on the surface of the slab of almost all the bridges. In particular, the reinforcing steel bars in the concrete slab can be seen by visual inspection. Therefore, maintenance works should be conducted as soon as possible.

(2) Destruction of Expansion Joint

The expansion joint structures of almost all the bridges have already been destroyed by both the impact of heavy vehicles and other causes. Therefore, the vehicles receive large shocks when passing onto the bridge. It is required that the expansion joints should be improved as soon as possible.

(3) Corrosion of Steel Member Structure

Corrosion of steel members of the bridge structure has occurred on almost all the bridges. The corrosion can be observed mainly on the following members,

a) Main girder
b) Lateral girder
c) Shoe
d) Bracket
e) Guard rail
f) Drainage pipe

Table 3.3.1 Outline of Bridges

No.	Cross-Section Width (m)	Total Length (m)	Angle (degree)	No. of Traffic Lanes	Type	Span Arrengment (m)
1	8.585	15.240	90°	2	1-H	14.986
2	8.585	30.785	90°	2	1-H,1-H,1-H	7.531,15.164, 7.531
3	8.585	21.946	90°	2	1-H	21.488
4	15.291	35.357	75°	4	3-H	9.754+12.192+ 9.754
5	15.291	48.768	90°	4	3-H	13.716+21.336+13.716
6	5.291	49.378	90°	4	3-H	13.716+21.336+13.716
7	17.122	184.099	90°	4	3-Hv,2-Tv,	16.95+18.3+17.18, 61.0+61.05,9.45
8	8.585	43.586	90°	2	2-Hv	21.336+21.336
9	8.585	41.148	90°	2	3-H	12.192+15.240+12.192
10	8.520	40.234	65°	2	3-H	12.150+15.250+12.700
11	8.585	32.004	90°	2	3-H	9.754+12.192+ 9.754
12	8.585	40.234	60°	2	3-H	12.192+15.240+12.192
13	8.585	101.803	90°	2	1-H,3-Iv	8.288,22.860+36.576 +22.860
14	8.585	40.234	90°	2	3-H	12.192+15.240+12.192
15	8.585	12.192	90°	2	1-H	11.887
	8.584	15.640	90°	2	1-PCI	15.240
16	8.858	39.929	90°	2	3-H	12.192+15.240+12.192
	8.584	40.824	90°	2	1-PCI,I-PCI, 1-PCI	12.192,15.240,12.192
17	8.585	40.234	90°	2	3-H	12.192+15.240+12.192
	8.584	40.234	90°	2	1-PCI,1-PCI, 1-PCI	12.192,15.240,12.192
18	14.681	12.497	90°	4	1-H	11.887

3.4 Other Facilities Conditions

(1) Electrical Power Line

An electrical power line runs from Electric Plant Bahia Las Minas in Colon city to Panama city. The power line is located on the eastern side of the Panama-Colon Highway about 1.0km from the road. The power line crosses the road at Quebrada Grande and from here to Panama City it is located on the western side of the existing road. In addition there is another electrical power line from the Madden dam to the city of Panama and to the Panama Canal.

(2) Water Supply Pipe Line

The water supply pipe line connects Represa Madden Dam to Panama city with a 1.2 meter diameter concrete pipe. The water pipe line is located on the eastern side of the existing Panama-Colon Highway.

(3) Pedestrian Crossing Bridge

The pedestrian bridge crosses the four-lane dual carriageway at San Miguelito. There is no pedestrian bridge on the section of 4-Lane dual carriageway in Colon city.

4 EXISTING TRAFFIC CONDITIONS

4.1 Traffic Survey

The following surveys were carried out to understand the existing traffic conditions and to obtain basic data for future forecasting of the traffic on the Panama-Colon Highway.

a) Origin destination survey
b) Traffic volume count
c) Interview survey on Pan-American highway
d) Travel speed survey

4.1.1 Origin Destination (O/D) Survey

This survey was conducted to obtain origin and destination (O/D) of traffic data and other important travel related information for vehicles on the existing Panama - Colon - Highway. The results of this survey will be reflected in future O/D tables. The O/D survey was conducted by means of roadside interviews. It was carried out continuously for 12 hours at 8 stations located at major points along the Panama-Colon Highway. The sampling ratio of each survey point as more than 20 percent of the traffic volume. In consideration of the road plans, thirty five (35) survey zones were set up for the origin and destination survey as shown in Figure 4.1.1. Twelve(12) of the survey zones were on the existing Panama-Colon Highway and the other twenty three (23) the survey zones located away from it.

4.1.2 Traffic Count Surveys

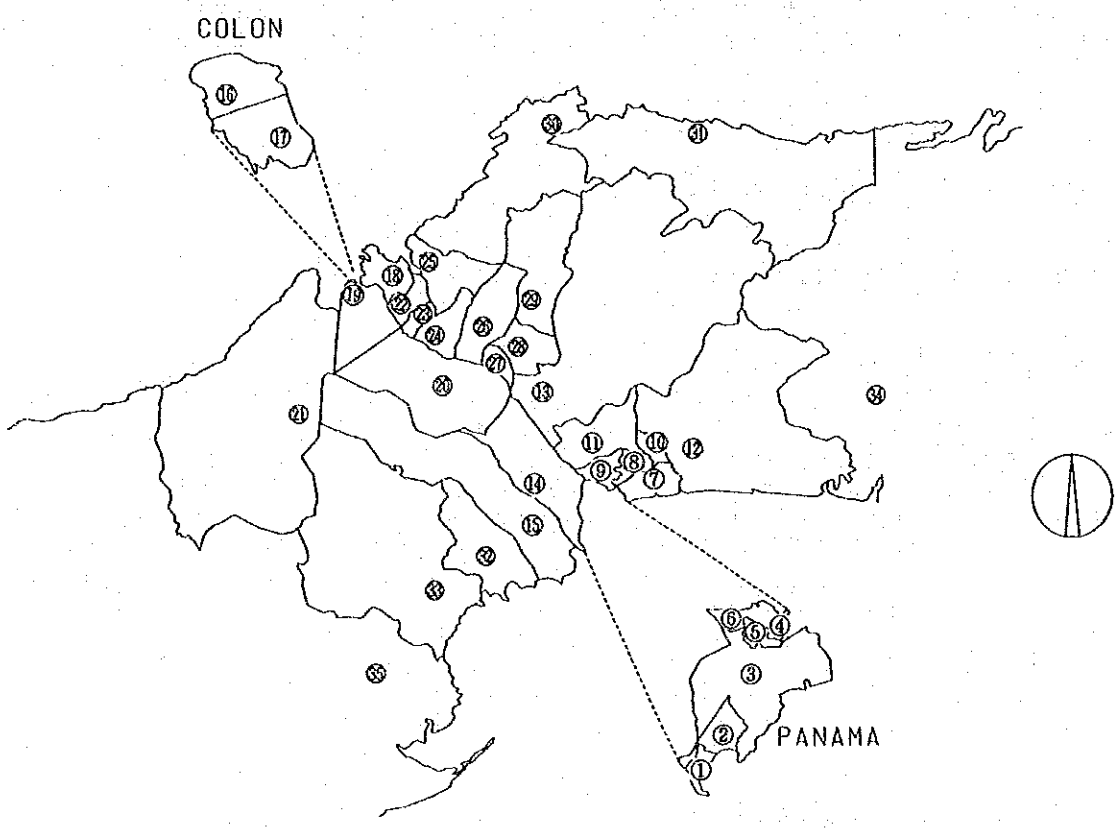
A traffic count survey was conducted to obtain the current vehicle volume on the Panama-Colon highway. The data collected were traffic volumes by direction, by vehicle type and by hour. A 24 hour traffic volume survey was conducted at five points in Panama city and on Chagres bridge. A 12 hour traffic volume survey was carried out at Twenty nine(29) points. Twenty(20) of the survey points were on the existing Panama-Colon Highway.

4.1.3 Interview Survey on the Pan-American Highway

The interview survey was carried out to understand current vehicle movement between origin and destination in accord to established zones, and shares of usage for the Autopista (toll section) and the non-toll section of the Pan-American Highway between Arraijan and Chorrera. A 12 hour survey consisting of driver interviews was carried out at 2 stations, one on the toll section and one on the non-toll section.

4.1.4 Speed Survey

This survey was conducted to find out the existing traffic conditions on the Panama-Colon Highway. The floating car method was used for the survey: assume an average speed and measure the amount of time needed to pass through each road section.



ZONE No	PI ZONE No	ORIENT.	PI ZONE
1	116		San Felipe
	115		El Chorrillo
	114		Santa Ana
	113		La Exposition o Calidonia
2	109		Bella Vista
3	118		Curundu
	119		Betania
	121		Pueblo Nuevo
	122		San Francisco
	123		Parque Lefevre
	124		Rio Abajo
4	125		Mateo Iturralde
5	126		Victoriano Lorenzo
6	132		Angelia Pando De Ycaza
7	135		Juan Diaz
8	134		Pose Domingo Espinar
9	133		Bellavista Porras
10	108		Federal
11	107		Las Cumbres
12	110		Pacora
	111		San Martin
	112		Tocumen
13	105		Chilibre
14	102	S-Eastern	Arnon
15	103	S-Western	Arnon
16	51		Barrio Norte
17	52		Barrio Sur
18	58		Cativa
19	60	E-Eastern	Cristobal
20	60	S-Eastern	Cristobal
21	59		Christo
	60	Western	Cristobal
	61		Escobal
	69		Nuevo Chagres (Cabecera)
	70		Achiote
	71		El Guabo
	72		La Encantada
	73		Palmas Bellas
	74		Piña
	75		Salud
22	63		Sabanitas
23	64		Nueva Providencia
24	65		Limon

ZONE No	PI ZONE No	ORIENT.	PI ZONE
25	66		Puerto Pilon
26	57		Buena Vista
27	56		Santa Rosa
28	67		San Juan
29	55		Salamanca
30	82		Portobelo (Cabecera)
	83		Cacique
	84		Puerto Lindo o Garrote
	85		Isla Grande
	86		Maria Chiquita
31	87		Palenque (Cabecera)
	88		Cuango
	89		Mirasol
	90		Nombre de Dios
	91		Palmira
	92		Playa Chiquita
	93		Santa Isabel
	94		Nuevo Frio
32	332		Arraijan (Cabecera)
	333		Juan D. Arosemena
	334		Nuevo Emperador
	335		Santa Clara
	336		Veracruz
	337		Vista Alegre
33	376		Barrio Balboa
	377		Barrio Colon
	378		Amador
	379		Arosemena
	380		El Arado
	381		El Coco
	382		Feuillet
	383		Guadalupe
	384		Herrera
	385		Bartedo
	386		Iturralde
	387		La Represa
	388		Los Diaz
	389		Mendoza
	390		Obaldia
	391		Playa Leona
	392		Puerto Caimito
	393		Santa Rita
34	-		Outside of East
35	-		Outside of West

Figure 4.1.1 Location of Survey Zone

4.2 Traffic Condition

4.2.1 Traffic Volume on the Panama-Colon Highway

(1) Traffic Volume Fluctuation

The annual fluctuation in 24 hour traffic volume for 1972 to 1993, between San Miguelito and Colon is shown in Figure 4.2.1, and the hourly fluctuations of the established road sections are shown in Figure 4.2.2

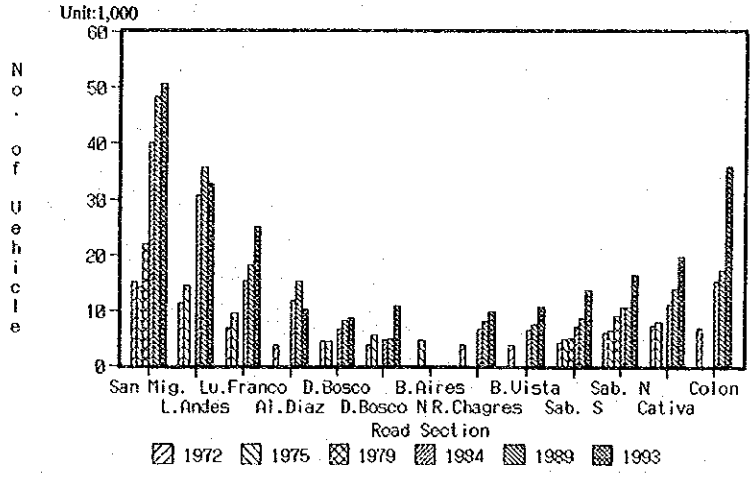


Figure 4.2.1 Traffic Volume Annual Fluctuation

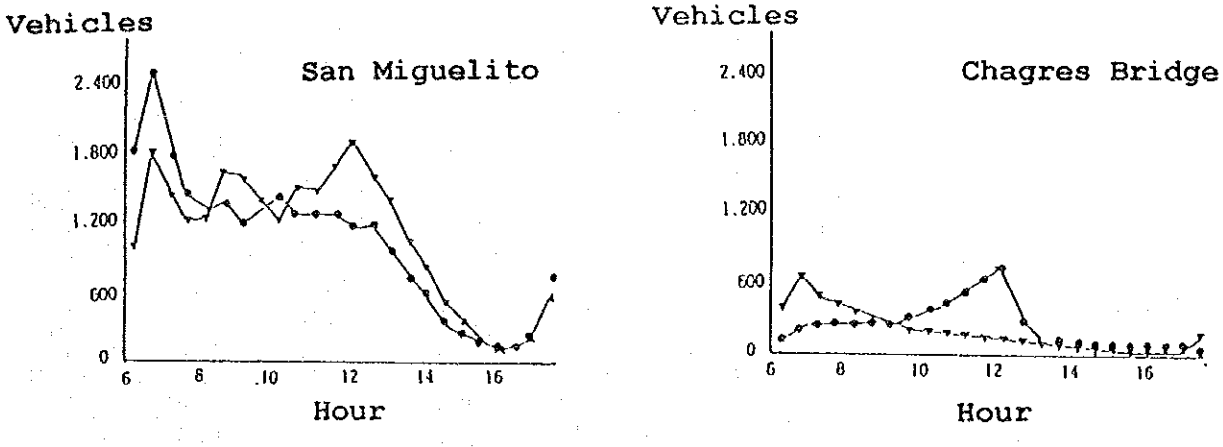


Figure 4.2.2 Traffic Volume Hourly Fluctuation

(2) Traffic Flow

The vehicle volume at each survey point is shown in Table 4.2.1 and Figure 4.2.3 shows the survey points. Figure 4.2.4 is a traffic flow diagram based on the traffic flow on the existing Panama-Colon highway from the traffic volume survey in which the Cuatro de Altos section, in the Panama vicinity and Colon City had high traffic volumes of 33,000 vehicles and 36,000 vehicles, respectively. There was less traffic on the chagres Bridge section which only registered 10,000 vehicles.

Table 4.2.1 24 hours Vehicle Traffic Volume

Road Section Number	Vehicle Type							Total
	P.Car	Taxi	M.Bus	Bus	Pick-up	Truck	Trailer	
1*	36,741	16,258	2,325	5,282	4,995	2,276	668	68,524
2*	31,605	12,372	2,081	2,481	4,832	1,818	449	55,638
3	16,370	5,775	2,026	3,409	4,979	1,741	710	35,010
4	25,080	7,653	3,366	3,593	7,124	2,644	1,292	50,752
5*	17,401	2,435	1,926	2,718	5,096	2,161	1,060	32,799
6*	14,413	1,168	1,756	660	3,987	1,933	1,042	24,958
7*	5,099	397	1,089	456	1,993	1,147	833	11,014
8*	4,656	337	1,049	382	1,812	1,113	834	10,182
9*	4,332	232	508	345	1,610	977	832	8,836
10*	5,777	242	481	453	2,078	1,040	846	10,919
11	4,730	157	891	435	1,503	1,116	903	9,735
12*	6,083	257	736	400	1,819	1,105	881	11,282
13*	6,092	257	740	400	1,845	1,112	881	11,327
14*	5,644	227	1,091	319	1,623	1,095	686	10,685
15*	7,018	1,202	936	555	2,156	1,099	721	13,687
16*	8,693	1,163	1,152	782	2,318	1,358	741	16,206
17*	10,361	1,316	1,491	855	2,783	2,750	1,099	20,654
18*	9,995	1,269	1,446	845	2,656	2,711	825	19,745
19*	10,664	1,575	1,271	908	2,466	2,783	920	20,588
20*	8,744	1,325	601	202	2,041	1,278	1,013	15,204
21	18,583	4,594	2,529	2,679	4,014	2,036	1,446	35,881
22*	36,799	7,353	1,987	166	3,286	913	16	50,520
23*	40,039	9,856	857	2,198	5,849	1,545	358	60,702
24	32,080	9,113	2,654	2,531	6,466	2,886	822	56,552
25	33,546	7,635	2,544	2,287	6,191	2,335	626	55,164
26*	4,174	1,644	201	2,113	1,720	376	33	10,261
27*	694	77	72	78	250	60	10	1,242
28*	2,405	101	113	271	808	159	31	3,889
29*	108	3	37	0	76	52	2	279
30*	3,487	1,230	376	334	828	492	50	6,798
31*	890	118	101	21	295	156	485	2,065
32*	3,517	586	495	297	1,117	2,260	919	9,190
33*	4,581	752	1,098	976	920	596	260	9,183
34*	5,899	808	560	874	1,938	828	148	11,055
35*	3,221	176	547	185	562	432	159	5,282

Note : * is data for 12 hours with the volumes for 24 hours estimated based on the 12 hours result.

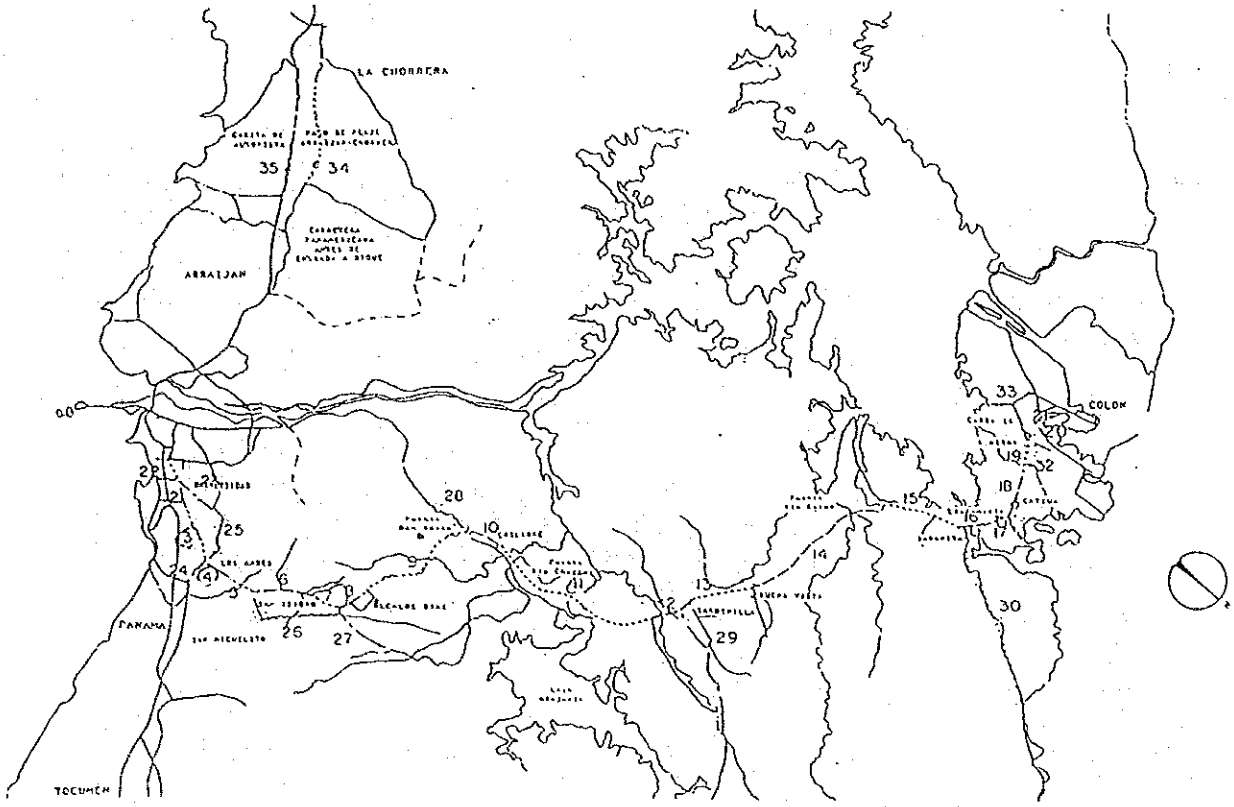


Figure 4.2.3 Location of Traffic Volume Road Section

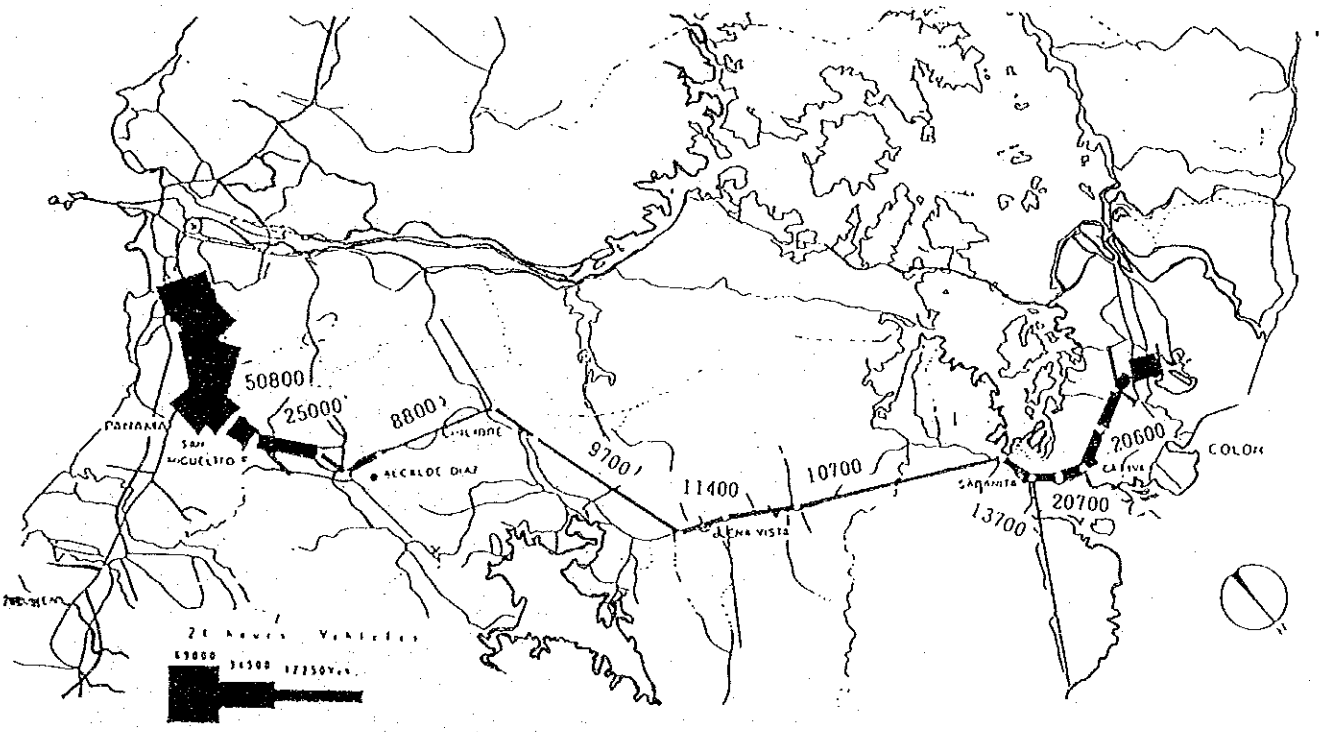


Figure 4.2.4 Traffic Volume on Panama-Colon Highway(1993)

(3) Peak Percentages

1) San Isidro (Section 5)

From the traffic volume survey, the peak percentage of 9.8 percent in the Panama City direction on the San Isidro Section was recorded between 7:00 and 8:00. In the Colon City direction , the peak percentage of 7.4 percent was recorded between 16:00 and 17:00 and the peak for both directions of 8.2 percent was recorded between 7:00 and 8:00.

2) Chagres Bridge (Section 11)

The highest hourly percentage in the Colon City direction on the Chagres Bridge of 12.3 percent was recorded between 6:00 and 7:00 while that for the Panama City direction of 13.4 percent was recorded between 17:00 and 18:00. The peak hourly percentage for both directions was 8.2 percent between 6:00 and 7:00.

3) Cuatro Altos (Section 9)

The highest hourly percentage in the Colon City direction of 9.2 percent was recorded between 7:00 and 8:00 while that for the Panama City direction was 12.2 percent between 15:00 and 16:00. The peak hourly percentage for both direction was 9.0 percent between 15:00 and 16:00.

(4) Ratio of 24-Hour Traffic Volume to 12-Hour Traffic Volume

On the existing Panama-Colon highway, a 24-hour traffic volume survey was conducted at Los Andes and Chagres. Table 4.2.2 shows the average the ratios of 24-hour traffic to 12-hour traffic at survey locations by vehicle type.

Table 4.2.2 24 Hours / 12 Hours Traffic Volume Ratio

Vehicle Type	24 hours / 12 hours ratio
Passenger Car	1.464
Taxi	1.683
Micro bus	1.378
Bus	1.374
Pick-up and small van	1.240
Truck	1.137
Semi and full trailer	1.209

(5) Vehicle Composition

The highest vehicle shares recorded at San Isidro (Section 6), Sardinilla (Section 12) and Cativa (Section 18) were for passenger cars with 54.5, 50.1 and 47.2 percent, respectively. The percentage of trucks between San Isidro (Section 6) and Sabanitas (Section 14) on the existing Panama Colon highway were high

at 19.5 to 23.6 percent. There was also a high percentage of trucks (20.2 to 22.2 percent) near Cativa (Section 17 and Section 18).

(6) Major Intersection Traffic Flow in 1993

The traffic flow at a major intersection (San Miguelito) related well with past traffic records on the Panama-Colon Highway as shown in Figure 4.2.5

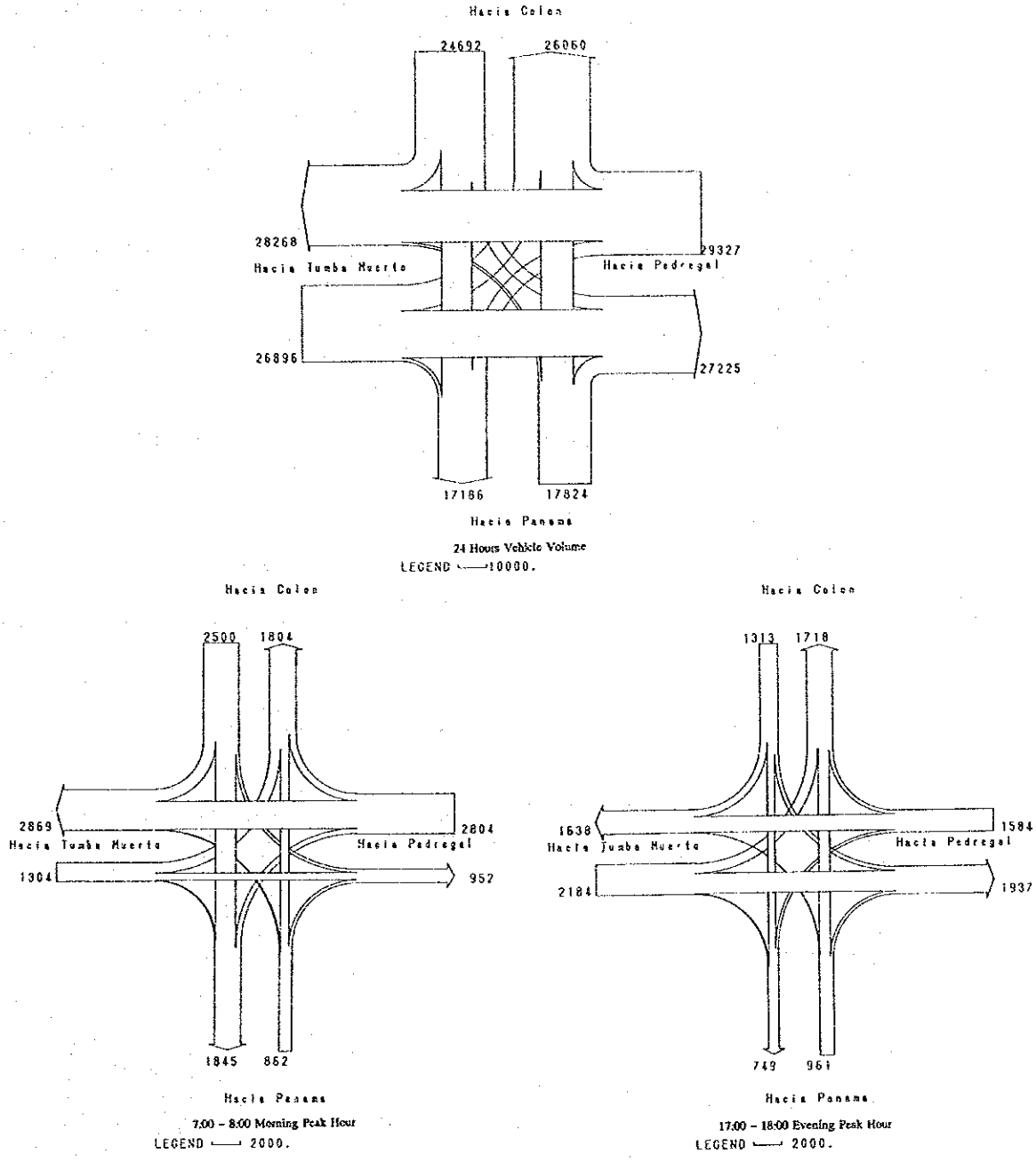


Figure 4.2.5 Traffic Flow in San Miguelito Intersection

4.2.2 Vehicle Movement on the Panama-Colon Highway in 1993

(1) 24 hour Vehicle Movement on the Panama-Colon Highway in 1993

Vehicle movement on the Panama-Colon Highway is shown in Figure 4.2.6 as 24 hour movement. The movement volume was expanded by the following factors.

a) Expansion factor of 12 hour traffic volume divided by the number of origin-destination samples for each vehicle classification
b) Ratio obtained from 24 hour traffic volume divided by 12 hour traffic volume for each vehicle classification

Vehicle movement is categorized into the following 3 types as shown in Figure 4.2.6

a) Type 1; The largest volume of vehicle movement between Panama (Zone 1-6) and Belisario Porras (Zone 9) or Las Cumbres (Zone 11)
b) Type 2; The second largest volume of vehicle movement between Colon (Zone 16-17) and Cativa (Zone 18), Cristobal (Zone 19), Sabanitas (Zone 22) or Puerto Pilon (Zone 25)
c) Type 3; Volume of vehicle movement between Panama (Zone 1-6) and Colon (Zone 16-17)

Type 1 is intrazonal movement within the metropolis of Panama and is mostly commuted. Type 2 is also intrazonal movement within the Colon urban area. Type 3 is inter-city movement between the cities of Panama and Colon and includes the Free Zone; the trip distance for this type is longer than all other types.

4.2.3 Vehicle Speed on the Panama-Colon Highway in 1993

Table 4.2.3 shows average vehicle speed and average trip time of whole section between San Miguelito and Cualto Altos intersection on the Panama-Colon Highway.

Table 4.2.3 Average Travel Speed and Trip Time

Direction	Time Period	Average Speed(km/h)	Average Trip Time
Panama->Colon	Morning Peak	54.6	1 h 13 m 16 s
	Evening Peak	58.2	1 h 8 m 40 s
	Off Peak	59.9	1 h 6 m 48 s
Colon->Panama	Morning Peak	51.0	1 h 18 m 28 s
	Evening Peak	55.0	1 h 12 m 41 s
	Off Peak	53.1	1 h 15 m 15 s

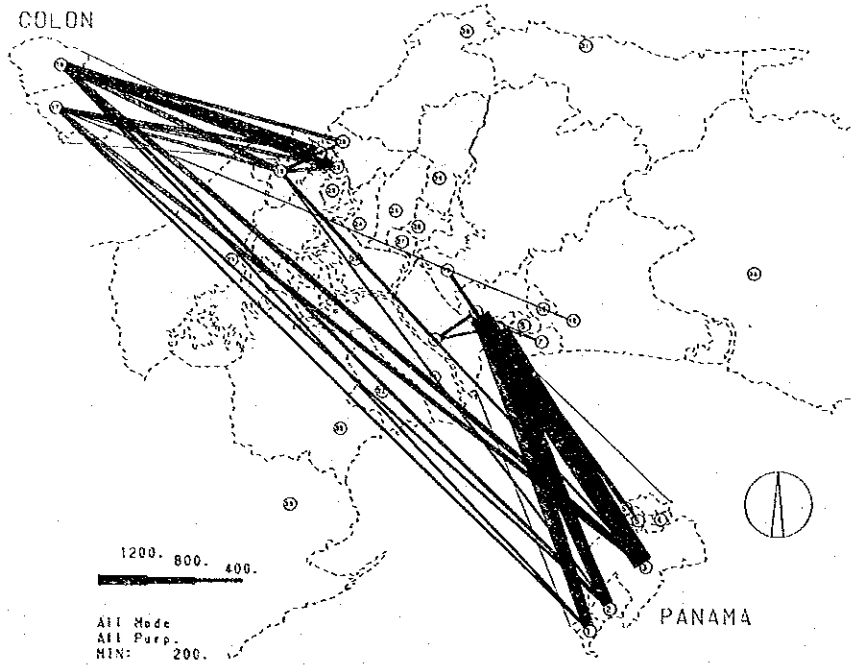


Figure 4.2.6 24 Hours Vehicle Movement

4.2.4 Results of Interview Survey on the Pan-American Highway

Figure 4.2.7 shows the results of the origin-destination survey for vehicles (16,337 veh/day) using the non-toll road, old Pan-American Highway and toll road (Autopista). The number of vehicles using the toll road was 5,282 which accounted for 32.3 percent of the total traffic on the Arraijan Chorrera section. The volumes of traffic by vehicle type using the toll and non-toll road are shown in Table 4.2.4.

Table 4.2.4 Traffic Volumes (Arraijan Chorrera section)
(Unit: Vehicles/day)

Description	Car	Bus	Truck	Total
Toll Road	3,397	732	1,153	5,282
Non Toll Road	6,707	1,434	2,914	11,055
Total	10,104	2,166	4,067	16,337

From the responses of the interview survey for traffic on the Arraijan Chorrera Section, the major reasons for section selection are as follows.

1) Non-toll section

a) for money saving	13%
b) by fixed route	34%

2) Toll section

a) for time saving	80%
b) for passenger safety	10%

3) Both of non-toll section and toll section

a) for time saving	27%
b) for money saving	11%
c) by short distance route	8%
d) for passenger safety	7%
e) by fixed route	22%

4.2.5 Goods Transport Situation on the Panama-Colon Highway

The road side interview survey obtained the commodities transport goods, loading weight and type of loading vehicles. Results of analysis the characteristics of present goods transportation on the existing Panama-Colon Highway are as follows.

a) 59.2 percent of goods vehicles are empty.
b) Petroleum products, other construction materials and pulp/paper are heavy loads with average load weights of more than 10 tons.
c) Average loaded weight of actually loaded goods vehicles is 6.9 tons.
d) Major forms of loading are as follows;
   - as number of vehicles of more than 1,000 vehicle/day
   - Boxes (5 percent Total goods vehicles)
   -Others determined as mixed loading (15 percent Total goods vehicles)
   - as weights of more than 5,000 ton/day
   - Bulk (880 Veh./Day)
   - Liquids (580 Veh./Day)
   - Containers (335 Veh./Day)
   - Others (3,935 Veh./Day)
e) The total weight of commodities transportation on the Panama-Colon Highway are estimated approximately 60,000 ton/day.

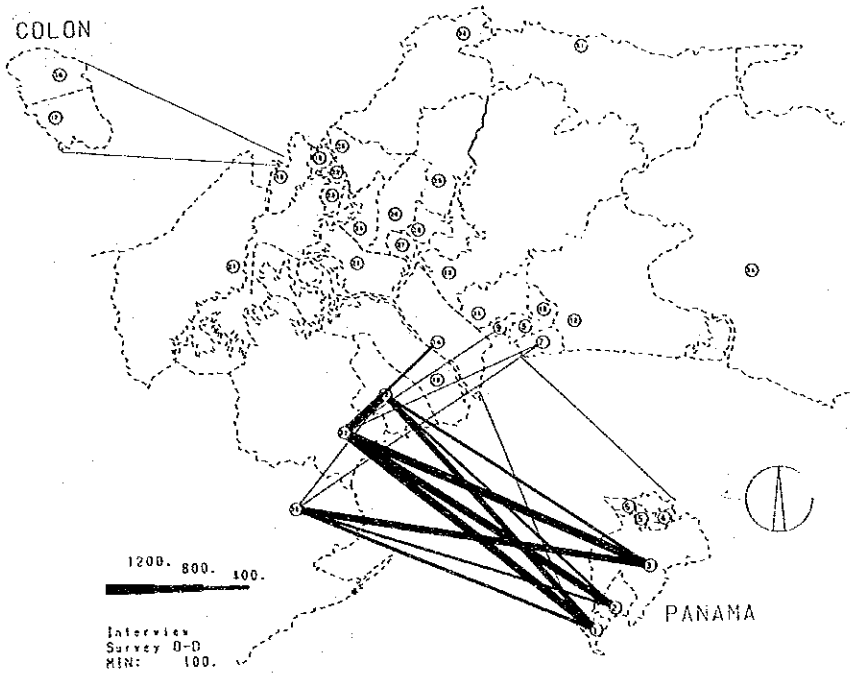


Figure 4.2.7 Vehicle Movement on 24 Hours Expanded Volume

5. ENVIRONMENTAL CONDITIONS

5.1 Back Ground and Procedure of Environmental Study

Today, the environment is of great interest to many people all over the world. And the idea that any development project cannot succeed without environmental considerations gaining ground internationally. In this study, the necessity of an environmental study is pointed out at the stage of the preliminary study.

As the first step of an initial environmental study, the present environmental conditions in this study area are examined. The results are used for evaluating each alternative route plan from the viewpoint of environmental impact. That evaluation is also used for judging if an environmental impact assessment (E.I.A.) is required at the feasibility study stage, for selecting some important environmental items if an E.I.A. is required. The Study Area is located on the east of the Panama Canal including the existing Panama-Colon Highway and all the alternatives.

The items for the environmental study, as shown below, are chosen after discussions with MOP and the local consultant, in consideration of the characteristics of the Study and the conditions in the Study Area. The content of the present study are decided after the items are chosen. This study mainly consisted of collecting existing data and their analysis with only a brief field study. As a results of fields reconnaissance survey and data collection and its analysis, a items for the environmental study are identified as follow;

1) Natural environment

   a) Topography and geology
   b) Vegetation
   c) Fauna
   d) Soil erosion
   e) Hydrological situation
   f) Landscape

2) Social environment

   a) Resettlement
   b) Economic activities
   c) Public facilities
   d) Safety and split of communities
   e) Cultural property

3) Pollution

   a) Air pollution
   b) Water pollution
   c) Noise and Vibration

5.2 General Condition of the Study Area

Panama is a narrow strip of tropical land that is both a bridge between the continental masses of the Americas and an isthmus dividing two oceans. The Panama-Colon Highway runs parallel to the most accessible tropical forests in the world.

Geologically, Panama is very young. It is estimated that 10 million years ago, North and South America were separated by a sea channel 1,500 kilometers wide. Gradually the strait narrowed and barely 2.5 million years ago it closed forming the land bridge between the two continents. The last point where the two oceans remained in contact was the Chagres River Basin, where the Panama Canal is located.

The closing of the marine strait and the consolidation of the Panama land bridge constitutes a major event in the geological evolution of our planet. An important result is that it permitted the "Great American Biological Exchange". The isthmus land bridge permitted species of flora and fauna from the south to migrate to the north and vice versa.

Most of the land crossed by the Panama-Colon Highway is within the Panama Canal watershed, which in essence is the basin of the Chagres River. This watershed has a total surface area of 3,260 km2, and is Panama's most important watershed.The functioning of the interoceanic canal and the water supply for the cities of Panama and Colon where half of the country's population lives depend on the water storage capacity of the artificial Lakes Gatun and Alhajuela.

Lake Gatun was formed in 1913, when a dam was built near the mouth of the Chagres River on the Atlantic side, whereas Lake Alhajuela was formed in 1934 when Madden Dam was built on the upper reaches of the Chagres.

The forests along the Panama Canal, particularly those in protected areas such as Barro Colorado Natural Monument and Soberania National Park are perhaps some of the most studied tropical forests in the world. Nonetheless new species of flora and fauna are being identified by ongoing studies, while new species await identification in the future.

5.3 Natural Environment

5.3.1 Topography and Geology

There have been no active volcanoes in the canal watershed since the Pliocene. The western Gatun Lake basin has the lowest elevation while the eastern sector at Alhajuela the highest. The highest point is Cerro Pelado with an altitude of 1,180 meters above sea level and in the east sector, the highest point is Cerro Jefe with a altitude of 1,007 meters.

The mountains of the area are round-topped, and steep sided, formed not by folding under lateral pressure but by volcanic intrusion. The southern rim of the watershed, where the headwaiters are located, lies on the continental divide. The divide is located three times as far away from the Atlantic as it is from the Pacific. Given the short distance from the divide to the Pacific Ocean only small rivers and creeks are found on the Pacific side. The basin itself curves north and westward into the Atlantic.

The Study Area corridor has been classified morphologically as a region of low hills. The coastal plains at both ends of the area consist of sedimentary material from the tertiary period.

5.3.2 Vegetation

According to the classification system of Lesslie Holdridge the vegetation of the Study Area can be divided into four distinctive zones: wet tropical forests, very wet tropical forests and wet and very wet premonitory tropical forests. Within the Study Area the first three zones are found about 90 percent of the vegetation is wet tropical forests, about 4 percent is very wet premontane forests and the remainder 6 percent wet premontane forests. The biotemperature of the wet tropical forests is 25 degrees centigrade at elevations below 400 meters above sea level.

In general the road crosses an area of very high precipitation ranging from 1,500 millimeters to 4,000 millimeters yearly. There is less rainfall on the Pacific side of the road but it gets higher as it moves towards the Caribbean side. Most of this rain falls during the nine months long "wet" or monsoon season. This rainy season stretches from May to December. Most precipitation occurs in a three month period August to October, when rain is particularly heavy.

There are thousands of species of flora that have been identified, however hundreds, if not thousands, remain to be identified. According to the most complete study, the Missouri Botanical Garden's Flora of Panama, there are 1,500 known species of tree identified for Panama. Of this number, about

500 species are found within the Panama Canal watershed. In Barro Colorado Island, 250 tree species have been identified. But it should be stressed that there are still unknown, unseen tree species. The estimated percentage of unknown tree species ranges anywhere from 10 to 20 percent.

As will be shown in Chapter 5.4.1, the primary tropical vegetation of these three different zones found in the Study Area is substantially altered by de-forestation due to slash and burn agriculture,extensive cattle ranching, urbanization and industry. Today natural forests in the Study Area are almost confined to the conservation areas. In addition to the conservation areas, there are some pockets of forest in the Study Area, the largest of which is located around the city of Colon. There is still a considerable amount of mangrove forest at the Caribbean end of the highway in and around Colon. Part of these mangroves are affected by the oil spill that took place at the Texaco refinery a few years back.

Another problem is the uncontrolled expansion of a very aggressive exotic and fire resistant grass, Saccharum spontaneum. Originally introduced to protect the banks of the canal from erosion, it is spreading to all kinds of open or cleared terrain in the watershed and outside it. It is now found all around Panama City. Its control is expensive and demanding. It will not, however, grow in the shadow of trees. There are no reliable statistics on the amount of open land now covered by this grass. Some estimates put is as high as 50,000 hectors. Every year, in the dry season, vast expanses of the grass are burnt, by accident or on purpose, creating huge fires that, driven by the trade winds, burn uncontrolled for days.

5.3.3 Fauna

The forests in the conservation areas parallel to the axis of the Panama-Colon Highway are the natural habitat for over 150 species of vertebrates. Among the main mammals found in them are: the jaguar (Felis onca), ocelot (Felis pardalis), tigrillo congo (Felis yagovaroundi), the American lion (Felis concolor), the howling monkey (Alovatta palliata), the red spider monkey (Atelesgeoffrovi panamensis), the tapir (Tapirus bardu) and the white tail deer (Odocoileus virginianus). Of the vertebrate species 15 are included in the CITES international list of endangered species.

In an area of barely 77,000 square kilometers Panama has more species of birds than the combined territories of the United States,Canada and Mexico. There are over 600 species of birds. This extraordinary diversity includes two species of birds of prey threatened by extinction: the harpy eagle (Harpia haepyja) and the peregrine Falcon (Falcon peregrinus). Three of the five main migration routes used by the birds of America converge over Panama and particularly along the

In Soberania National Park, 150 species of amphibians and reptiles are identified. The distribution of the endangered species is not clear for individual species but most of the endangered species are forest dwellers. Forest vegetation seems to be essential for the fauna in the Study Area.

5.3.4 Soil Erosion

Most soils of the watershed are suitable for forests. They are broken-steep terrain with a high erodability potential given the nature of the soils, the steep topography and high rainfall pattern. There are studies on soil erosion in the watershed but only in the areas of the main rivers supplying water for the canal. There are few studies, if any, on soil erosion problems along the Panama-Colon Highway.

Based on studies carried out elsewhere in the watershed, the estimated risk of erosion for the highway sector is estimated to be as high as about 100 tons per hector per year. However in the critical areas, in the northernmost and mountainous parts, the isoerodability potential, given the steepness of the terrain and very high rainfall, are estimated as high as about 2000 tons of soil yearly per acre. These particularly sensitive areas are those located toward the northern sector of the Study Area where the terrain is steeper and rainfall greater. Some of the critical areas are located in the vicinity of the foothills of Sierra Llorona.

5.3.5 Hydrological Situation

The Panama Canal watershed is a hydrological system formed by three sub watersheds: Gatun Lake with an area of 223,075 hectors, Alhajuela Lake an area of 103,150 hectors and tiny Miraflores Lake, a micro basin of 17,450 hectors on the Pacific side of the isthmus. As can be expected in an area of high precipitation and steep hills and narrow valleys, the Panama-Colon Highway runs between the thick network of rivers and streams flowing directly into Gatun and Miraflores Lakes, and the downstream sector of Madden Dam and Alhajuela Lake.

The existing highway crosses some 75 streams, most of which have slow rates of flow. There are two exceptions: the Chagres River, with an average flow of 30.3 m3/second and the Gatun River with 6.75 m3/second.

The general orientation of the flow in these multiple streams and rivers is east to west towards Gatun Lake. Deforestation has severely altered the hydrological regime of the watersheds of these rivers and streams. They therefore have intense floods in the rainy season and severe water shortages in the dry season.

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5.3.6 Landscape

The Panama-Colon Highway runs first in the flat lowlands on the Pacific Coast around Panama City, then it climbs into the continental divide at Las Cumbres barely 15 kilometers from the city. It then approaches the Panama Canal watershed, zigzagging, climbing and in between small round-topped hills, crossing many small streams and two larger rivers, the Chagres and the Gatun. To the east can be seen the distant steep forested highlands of the Chagres National Park and headwaters of the Chagres River. To the west lies the tropical forests of the Cruces Trail and Soberania National Park. After skirting in between Gatun Lake and the hillsides of the Sierra Llorona the road comes into the flat terrain of the coastal Caribbean plains.

The Study Area has several places for tourism and recreation. People visit the Chagres, Gatun Gatuncillo and other rivers along the Panam-Colon Highway. Also visited are the Gatun and Alhajuela Lakes, the canal and increasingly the protected natural areas, which have, on account of their accessibility, enormous potential for tourism. Summit Botanical Garden and Zoo, located 26 kilometers from Panama City, received 500,000 weekend visitors in 1992. Several spots along the road offer lovely views of the artificial lakes and the mountains.

5.4 Social Environment

5.4.1 Land Use

At the start of this century, 95 percent of the Panama Canal watershed was covered by primary tropical forests. Then, during the construction of the canal 15 percent of its total surface was inundated by the formation of Lakes Gatun (42,000 hectors), Alhajuela (3,300 hectors) and Miraflores.

As late as 1950, about 80 percent of watershed was still covered with forest. However, major environmental changes followed in the wake of the construction of the Panama-Colon Highway in 1940. From the highway, secondary roads were later pushed deeper into the Gatun and Alhajuela basins.

It is estimated that between 1952 and 1976 over 174,000 hectors of tropical forest were cut and burned in the Panama Canal watershed. About 90 percent of the areas that are deforested now covered by pastures for the extensive raising of beef cattle. Presently only 30 percent of the watershed remains forested. Most of these surviving forests are within the protected areas established by the government since the 1970's.

The Panama-Colon Highway has become a focal point for urban and industrial development within the canal water-shed and facilitated a massive forest colonization by peasants from other regions of Panama. During the 1960's and 1970's peasant settlement intensified. Many parts of Gatun basin were deforested as was the western area of Lake Alhajuela. Most of the land in the Study Area consists of degraded pasture for extensive cattle ranching. Forested areas are mainly confined to the conservation areas. It is difficult to estimate the percentages of agriculture, housing and industry.

5.4.2 Settlement and Population

The estimated population for the Panama Canal watershed is 197,000 inhabitants. However 70 percent of this figure is concentrated along the Panama-Colon Highway, that is about 127,000 people. Most of them live in the semi-urban towns that have grown up along it or at places no more than a kilometer from it. Besides them, there are many tiny rural settlements, or "caserios", in the Study Area.

Among the most important populated areas, from south to north, are San Miguelito, Las Cumbres, La Cabima, Alcalde Diaz, Chilibre, Villa Unida, El Veinte, Gatuncillo, Paraiso, Nuevo San Juan, Buena Vista and Sabanitas. Population density varies substantially in the Study Area. The areas of greater densities lie at both ends: in Panama-San Miguelito on the Pacific side and on the Atlantic side, where densities surpass

1000 pers/km2. The overall population density figure for the eastern side of the Panama Canal watershed is 38 pers/km2.

Forty years ago, there were hardly any towns along the Panama-Colon Highway. Now there are many and new ones are springing up. During the last 10 years, the population along the highway increased from 90,000 people in 1980 to 127,000 in 1990, that is an increase of over 30,000 people or 33 percent in a decade. In all probability, all of these towns will continue to grow in the years to come. Their inhabitants will demand more services from the state and these facilities will in turn draw more people.

5.4.3 Economic Activity

A rough estimate is that as much as 75 percent of the labor force commutes daily, by car and buses,to work in Panama City, Colon, the Free Zone, the Canal Commission or the military bases of the United States along the canal. The remainder consists of public employees, such as school teachers and medical personnel, those employed by the factories and industrial establishments along the highway and finally those employed in their own small businesses: stores, bars, restaurants, garages and fuel stations.

There is a small percentage (no more than 5 percent), engaged full time in subsistence agriculture, cattle ranching or fishing. There is another group or category of people who are part-time farmers and city laborers. When they cannot find employment in the towns or cities they fall back on subsistence agricultural activities or fishing to feed their families on a day to day basis.

Some thirty years ago, only one factory, a cement plant, existed in the canal watershed. Today, there are many industries; plastics, glass, paper, lubricants, soap, pesticides, pharmaceuticals, smelting and saw milling. In addition to manufacturing plants, there are some large scale poultry and pork breeding and processing plants and there is even an alligator farm. It needs to be pointed out that most of the Panama-Colon Highway towns can be classified as dormitory towns for they have little economic activity of their own and most of their residents work in Panama city or Colon. This is the case for the towns of Las Cumbres, Villa Caceres, Alcalde Diaz and Chilibre.

5.4.4 Public Facilities

Public transportation carries most of the populations of the highway towns to their workplaces in Panama City and Colon. That means most working people depend on a very erratic, congested and sub-standard bus service. The amount of time

spent by people on the highway going to and from work is substantial. They mostly leave before sunrise and return late at night.

Public facilities in the towns and villages along the highway are either deficient or non-existent. This is particularly so in the case of health, education and recreational facilities. There are not many good public health facilities. People prefer to come to Panama City for medical treatment or hospitalization. The same can be said about public high school education. Although towns and villages have increased considerably, the number and quality of recreational facilities has not. There is not a single movie theater along the road, or public swimming pool. The same applies to theaters and sports centers. There are few public libraries and those in existence are not well furnished. In short, people along the highway towns need to come to the big terminal cities for social and cultural services.

Towns and villages along the highway have very poor garbage collection and waste disposal systems. This has created a serious problem in the dumping of garbage illegally. A typical case is Chilibre, where there are illegal dumps on the outskirts of the town and very close to Madden Dam, where Panama City gets its water supply from. In general, all rivers and streams along the existing highway are also used as dump sites for garbage causing greatly reducing the quality of water supplies and contributing to more frequent flooding.

5.4.5 Cultural Properties

Most of the significant historic and cultural sites within the Study Area are those linked to the three great stages of the history of interoceanic communications across the isthmus of Panama. The old colonial or Spanish system using a combination of river travel, via the Chagres, and overland mule trails; then the railway, the first interoceanic railway in the Americas built in 1850-1855 during the California Gold Rush years; and thirdly the canal period, divided into a French and an American period. Each of the three great periods of interoceanic communications generated different patterns of immigration, settlement, land use, defense and commerce. The remnants of the old Spanish "royal road" across the isthmus can still be seen in the cobbled stones of the Cruces and Nombre de Dios trails. The old system also survives in the form of stone bridges, custom houses and fortifications.

Since the Study Area coincides with the historic transit route across the isthmus during the pre-hispanic and colonial periods, further analysis of the archaeological and historical data is required in the final study.

5.5 Pollution

5.5.1 Air Pollution

There is no studies of air pollution in the Study Area. The main visible source of air contamination is the Cemento Panama Factory located in the vicinity of San Juan and Gatuncillo Rivers. The factory has no air cleaners so its smokestacks belch out thick smoke reeking of sulfur that the strong winds of the dry season push downwind for several kilometers, covering enormous expanses of land, vegetation and housing with a ugly ash-like dust.

5.5.2 Water Pollution

The slowly increasing pollution in the streams, rivers and lakes of the Study Area is a major environmental problem facing local population and all water users in the Panama Canal watershed.

Ongoing development constitutes a major cause of destruction of watersheds threatening the amount and quality of the water supply. The causes are varied. There is a rise in the amount of sediments carried by the flowing water due to rising erosion brought about by deforestation and unplanned urban development. The serious limitations of the waste and sewage disposal systems in the towns and cities, pouring chemicals and diverse organic matter into rivers and streams are all contributing factors in the gradual but overall deterioration of water resources.

The Canal Commission carried out a study in the middle sector of the Chagres river and at the Culebra or Gaillard Cut. The study revealed the following:

a) Coliform bacteria concentrations of up to 1,100/100 ml in the water of the Chilibre River at the point it flows into the Chagres. There were also high rates of coliform in the Gatuncillo, Limon and other tributaries of the Chagres.
b) Temperatures of up to 27.5 degrees centigrade in the Chagres and up to 29 degrees centigrade near Lake Gatun.
c) Dissolved concentrations of oxygen less than 4.0 p.p.m. in the water of the Chagres River.
d) Nitrates combined with phosphorus in the Chilibre River and Alhajuela Lake provide propitious conditions for the proliferation of a variety of species of aquatic plants and grasses. The phosphorus currently originates from the sewage going into the Chilibre River due to rapid urbanization.
e) The PH of Chagres river at times is under 6. This

acidity, together with the low hardness and prevailing alkalinity make the water corrosive to a certain extent.

5.5.3 Noise and Vibration

No study has been done on noise and vibration caused by traffic in Panama.

5.6 Others

5.6.1 Conservation Areas

The Panama-Colon Highway runs between two forested areas of extraordinary hydrological and biological importance protected by special legislation. East of the highway lies the Chagres National Park protecting the vital forests of the headwaters of the Chagres River. West of the highway lies the "ecological corridor" of Panama's metropolitan region, a belt of 32,000 hectors of natural forests stretching from Colon to Panama City. These forests were once part of the former Canal Zone, which have gradually become protected areas. The names, surface areas and dates of creation of these protected areas are as follows:

a) Chagres National Park (129,000 ha, in 1984)
b) Gatun Recreation Park (348 ha, in 1985)
c) Barro Colorado Natural Monument (5,400 ha)
d) Soberania National Park (22,000 ha, in 1980)
e) Cruces Trail National Park (4000 ha, in 1992)
f) Metropolitan Natural Park (265 ha, in 1983)
g) Summit Botanical Garden and Zoo (250 ha)

It is feasible for the government to create a new national park on the west bank of the canal in the near future, an area of 65,000 hectors that extending from the Pacific to the Atlantic. It will be called Interoceanic Park of the Americas.

5.6.2 Laws

There are several studies carried out in the last decade to list and catalog environmental regulations in Panama. Among these studies are those carried out by PNUMA, CONAMA, the National University of Panama, INRENARE and IDIAP. Laws and regulations relating to the environmental Iimpact of road building are rather recent.

In recent years, the Ministry of Public Works has been incorporating some environmental considerations into its activities. Much remains however to be done. The World Bank, in its operational directives on environ- mental evaluation when considering the construction of roads in category A, states: Projects with major and diverse environmental repercussions normally require environmental evaluation.

A new law as of December 30, 1992, which created the latest protected area in the Study Area; the Cruces Trail National Park, should be noted when referring to the construction of highways. It stipulates: Projects to build roads such as the North Corridor and the continuation of the Panama-Arraijan Highway need to consider the evaluation and mitigation of

environmental impact. Their design needs to take into account and permit the free access of wild-life species to the forest area of the Cruces Trail National Park.