THE REPUBLIC OF COSTA RICA

REPORT
ON
GUAYABO AND SIQUIRRES
HYDRO-POWER PROJECTS

MARCH, 1978

JAPAN INTERNATIONAL COOPERATION AGENCY

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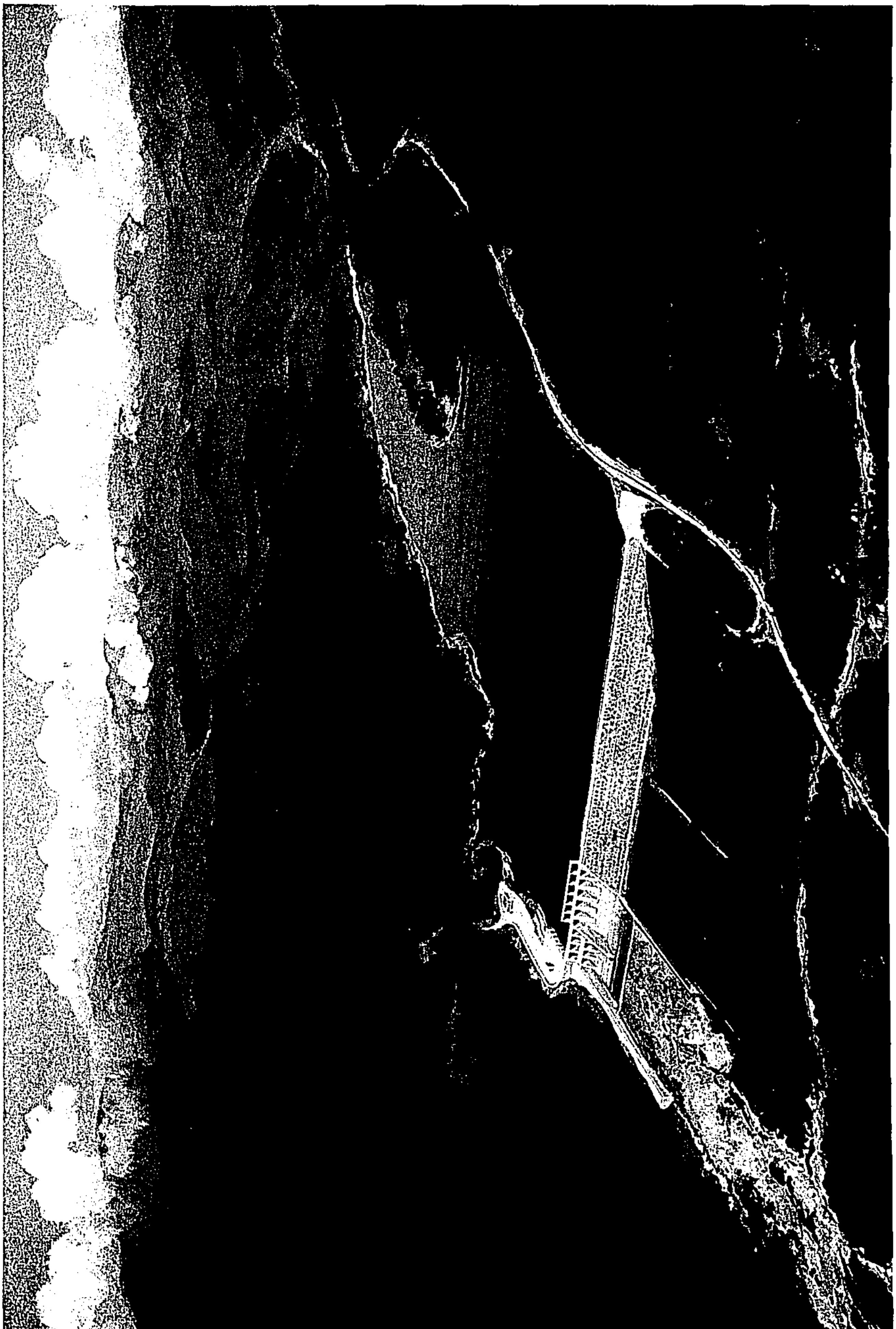


PREFACE

The Government of Japan, in response to the request of the Government of the Republic of Costa Rica, agreed to conduct a feasibility study of Guayabo Hydro-power Project and a pre-feasibility study of Siquirres Hydro-power Project which were selected from the master plan on both Reventazon river and Pacuare river. The Government of Japan entrusted this study to the Japan International Cooperation Agency (JICA).

The Agency, in consideration of the importance of the electric power situation of the Republic of Costa Rica in relation to the social and economic development of the country, dispatched a mission of six members headed by Mr. Mitsuharu Sato (Electric Power Development Co., Ltd.) to the Republic of Costa Rica for a period of forty-five (45) days from August 15, to September 28, 1977. The mission, carried out field investigations with the cooperation of government agencies of the Republic of Costa Rica and on returning to Japan, examined the data collected in the country and the results of field reconnaissance to prepare this Report.

It would be truly rewarding if this Report is to contribute to the electric power development of the Republic of Costa Rica and hence to the prosperity of the country's society and economy, to enhancing the economic relation between the Republic of Costa Rica and Japan, to further deepen the friendship and goodwill between the two countries.

In closing, I express my deep appreciation to the members of the mission for their efforts, and sincerely thanks to those persons concerned in the Government of Costa Rica and in the Instituto Costarricense de Electricidad (ICE), the agency directly concerned with accommodating the mission, the members of the Japanese Embassy in the Republic of Costa Rica, the Ministry of Foreign Affairs, and the Ministry of International Trade and Industry of the Government of Japan for their assistance in dispatching of the mission.

March, 1978

Shinsaku Hogen
President,
Japan International Cooperation Agency

Letter of Transmittal

Mr. Shinsaku Hogen
President,
Japan International Cooperation Agency

Dear Mr. Shinsaku Hogen:

We submit for your attention our report on both feasibility study of Guayabo hydro-power project along Reventazon river and pre-feasibility study of Siquirres hydro-power project along Pacuare river in the Republic of Costa Rica. A result of the study is described in detail in the Report, and an appendix is attached to it for the basic data and a technical memorandum which was made during the survey between an engineer of ICE and a leader of the survey team.

The survey team of six members made a field survey assisted by cooperation of the Instituto Costarricense de Electricidad (ICE) during their 45 days visit to the Republic of Costa Rica from 15th August 1977 to 28th September.

The team studied in Tokyo since their return to Japan and completed it in March 1978.

It is ardently hoped that the report would be useful for the electric power development in the Republic of Costa Rica in near future.

Hearty gratitude is expressed, on this occasion of submitting the Report, to everyone who kindly rendered his valuable cooperation to the surveying activities of the team.

Yours faithfully,

March, 1978

Survey Team for Guayabo
and Squirres Hydro-Power Projects

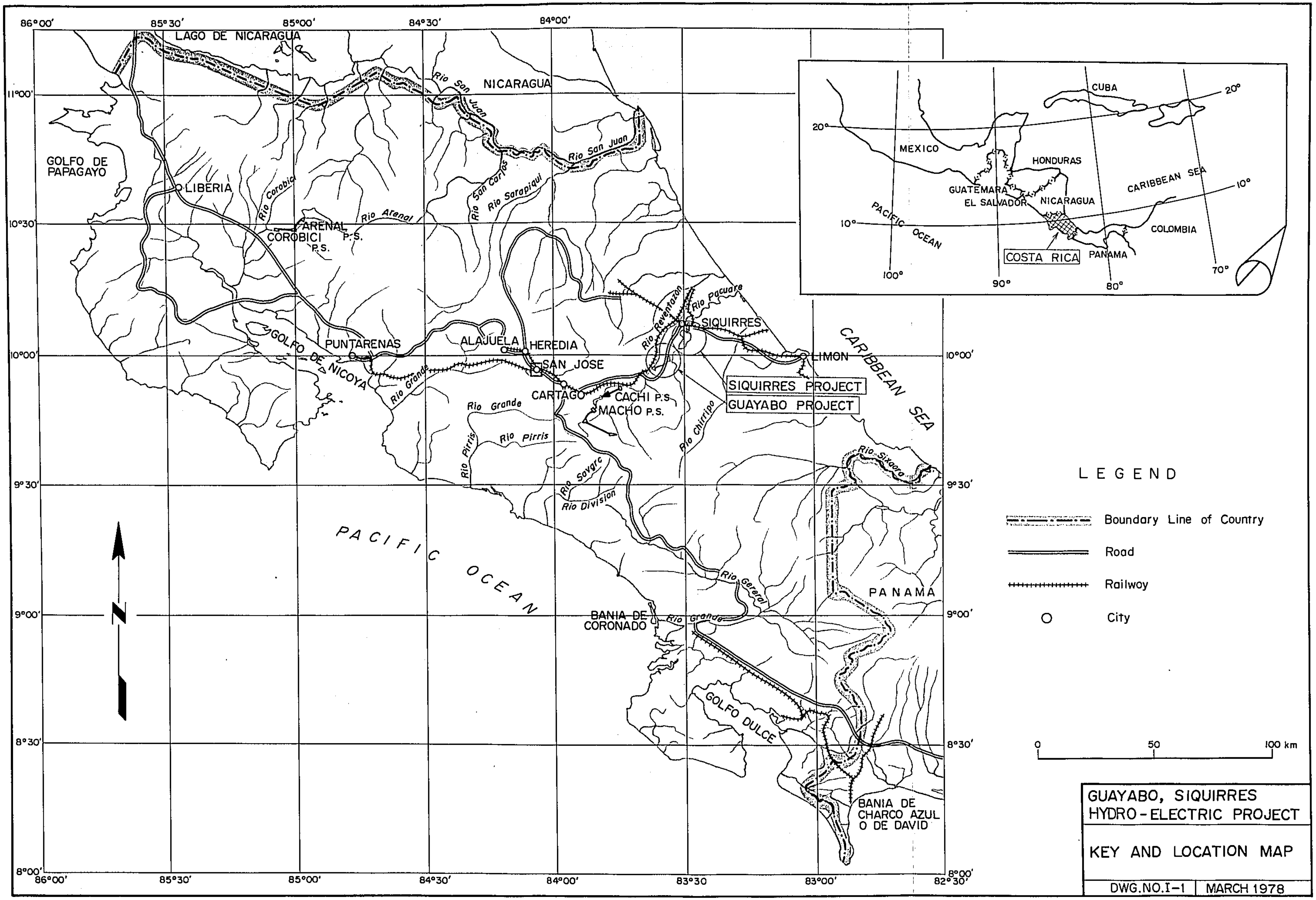
Mitsuharu Sato

Mitsuharu Sato, Team Leader

Principal Features of Guayabo and Siquirres Projects

	Guayabo Project (Feasibility Study)	Siquirres Project (Pre-feasibility Study)
Catchment Area	1,518 km^2	2,168 (1,518) km^2
Dam		
Type	Combined Dam of Gravel Fill and Concrete Gravity	Concrete Gravity Dam
Height × Crest Length	38.0 × 655.0 m	205.0 × 495.0 m
Volume	(GF) $564 \times 10^3 m^3$, (CG) $198 \times 10^3 m^3$	$2,640 \times 10^3 m^3$
Reservoir		
Annual Inflow	$4,046 \times 10^6 m^3$	$5,306 \ (3,296) \times 10^6 m^3$
Effective Storage Capacity	$3.29 \times 10^6 m^3$	$430 \times 10^6 m^3$
Drawdown	10.0m	60.0m
Headrace Tunnel	6.5 × 9,582 m × 1	6.0 × 2,780 m × 2
Power Plant		
Installed Capacity	180 MW	310 MW
Max. Power Discharge	140 m^3/sec	240 m^3/sec
Standard Effective Head	155 m	154 m
Firm Capacity	158 MW(Apr.) 180 MW(Dec.)	267 MW(Apr.) 310 MW(Dec.)
Transmission Line	230 kV, 2 cct, 60 km	230 kV, 2 cct, 65 km
Substation	78 MVA × 3 units	100 MVA × 4 units
Construction Cost		
Generating Facilities	$1,980 \times 10^6$ Colones	$3,480 \times 10^6$ Colones
Transmitting Facilities	150×10^6 Colones	260×10^6 Colones
Total	$2,130 \times 10^6$ Colones	$3,740 \times 10^6$ Colones
Economics		
Unit Energy Cost	0.21 Colones/kWh	0.24 Colones/kWh
Benefit Cost Ratio	1.18	1.25
Annual Surplus Benefit	44.3×10^6 Colones	106.0×10^6 Colones

(1 US dollar = 8.6 Colones)


LAGO DE NICARAGUA
NICARAGUA
Rio San Juan
Rio San Juan
GOLFO DE PAPAGAYO
LIBERIA
Rio Corobici
Rio San Carlos
Rio Sarapiqui
Rio Arenal
ARENAL P.S.
COROBICI P.S.
GOLFO DE NICOYA
PUNTARENAS
ALAJUELA
HEREDIA
SAN JOSE
CARTAGO
CACHI P.S.
MACHO P.S.
Rio Reventazon
Rio Pacuare
SIQUIRRES
LIMON
SIQUIRRES PROJECT
GUAYABO PROJECT
CARIBBEAN SEA
Rio Grande
Rio Grande
Rio Pirris
Rio Pirris
Rio Chirripo
Rio Savgre
Rio Division
Rio Sixaola
PACIFIC OCEAN
Rio General
Rio Grande
BANIA DE CORONADO
PANAMA
GOLFO DULCE
BANIA DE CHARCO AZUL O DE DAVID
86°00'
85°30'
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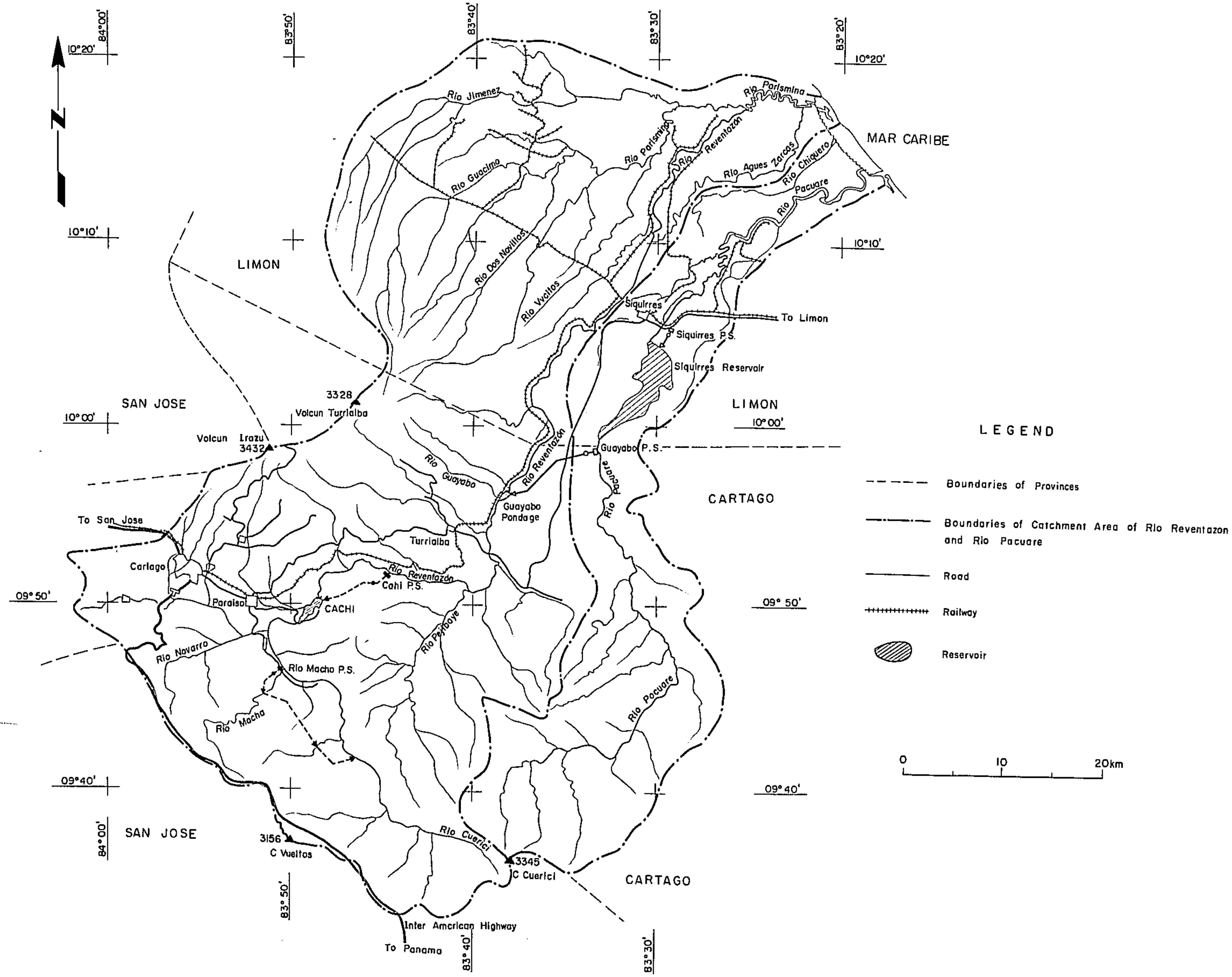
N
CUBA
MEXICO
HONDURAS
GUATEMALA
EL SALVADOR
NICARAGUA
CARIBBEAN SEA
PACIFIC OCEAN
COLOMBIA
COSTA RICA
PANAMA
20°
10°
100°
90°
80°
70°
LEGEND
Boundary Line of Country
Road
Railway
City
0
50
100 km
GUAYABO, SIQUIRRES HYDRO-ELECTRIC PROJECT
KEY AND LOCATION MAP
DWG.NO.I-1
MARCH 1978

Fig. I-I-I Map of Project Area



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PART I

INTRODUCTION, CONCLUSIONS AND RECOMMENDATIONS

PART I

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INTRODUCTION

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CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

The oil crisis of 1973 brought great changes to the world nations' energy policies. The oil price has followed a trend of gradual rise since then and the energy problem is yet an unsettled one, coupled with various evaluations of the reserves of natural resources.

Developing countries having no petroleum resources come under a heavy influence from an extreme rise of the oil price and there are immeasurable blows to their national economies.

Although the Republic of Costa Rica, a developing nation, has no petroleum resources, it is rich in rainfalls and is a volcanic land; it is therefore expected with high hopes to develop geothermal power and make more of hydraulic power.

The demand for electric power has been on the increase at an annual mean rate of 8% in the Republic of Costa Rica in recent years. To meet this demand, the country has supplied power to this date in the combination of hydroelectric and thermal powers.

The country's potential water-power resources are estimated at 40 million kW, of which 9 million kW resources are said to be feasible for power development.

However, only 4% of the feasible water-power resources have been so far developed. Further, the power system of the Republic of Costa Rica is currently forced to rely on thermal power, especially during the dry season which lasts for 5 months, because it lacks such hydro-power plants as those of sufficient storage capacity to meet the demand in the drying season. To economize on thermal power fuel, the country is promoting water-power and geo-thermal development.

The growth of power demand in future will depend upon the trend of economic development in the Republic of Costa Rica, and no abrupt change of the trend could be forecasted at present because the new economic development programme (1978-1982) is based on a policy to maintain the same rhythm of development as the past. In other words, the growth of power demand for the future is supposedly as mild as the present.

For the growth of power demand, ICE has been adding units to some existing power plants. In addition, ICE has been constructing Arenal hydro-power plant with a reservoir of big storage for which a natural lake is utilized, and an implementation of Corobici Project, immediately downstream of the plant will follow after it.

Following the completion of Corobici Power Plant, it is estimated a new electric power development will be necessary in the late 1980's.

In preparation for the demand, ICE has interested in a development of Reventazon and Pacuare rivers as a result of a study on domestic potential resources. In addition to it, ICE has been undertaking study and research programs for the development of geo-thermal power.

The Report contains studies on both Guayabo Project of Reventazon river and Siquirres Project of Pacuare river.

1.2 HISTORY

(1) The government of the Republic of Costa Rica, with the aforementioned background, asked for the Japanese Government to render technical cooperation in 1976 in order to push forward her hydro-power development in Reventazon river and Pacuare river. In acceptance of the request, the Japanese Government despatched two engineers, Kiyonori Sasahara and Toshio Enami, as the Government's experts to the site in October, 1976, to carry out a preliminary survey on the background of the technical cooperation request by the Costa Rican Government, and field survey, data-collection, and survey plan in future.

(2) On the basis of the result from the survey, the Japanese Government decided to exercise necessary technical cooperation with ICE to prepare a preliminary master plan pertaining to the hydro-power development projects in Reventazon river and Pacuare river, and despatched a Japanese Government expert, Yutaka Narita, to the Republic of Costa Rica in June, 1977.

(3) The Japanese Government decided also to execute both a feasibility study of Guayabo Project in Reventazon river and a prefeasibility study of Siquirres Project in the down-stream of Pacuare river according to the aforementioned preliminary master plan as a part of the technical cooperation, and entrusted execution of those studies to the Japan International Cooperation Agency.

1.3 EXISTING REPORTS

1.3.1 Report of Basic Study

ICE was established in 1949 by the Government. They placed Angostura run-off gauging station in 1953 for the development of Reventazon river in 1958, and Pacuare run-off gauging station for the development of Pacure river. Then, several more gauging stations were additionally placed in the drainage basins of these two rivers. In addition to compilation of the run-off data from these station, ICE prepared reports on the basis of topographical maps of the areas and the geological surveys.

The existing reports, prepared by ICE, of hydrology and geology for Guayabo Project are shown respectively in Chapter 3 and Chapter 4 of Part II in addition to Appendix.

In existing reports of hydrology and geology for Siquirres Project are shown respectively in Chapter 2 of Part III in addition to Appendix.

1.3.2 Project Report

Based on the reports aforementioned, ICE prepared the following preliminary report on Guayabo Project, which does not refer to the timing of development.

Informe Preliminar Proyecto Hidroelectrico Guayabo
Documento de Trabajo 007-77
Departamento Programas de Generacion, Ago. 1977

With respect to Siquirres Project there exists no project report referring to its very scheme such as the Guayabo Project report.

1.3.3 Master Plan

ICE conducted a nationwide inventory of potential hydro-power and compiled a report. On the basis of this report, a report for a preliminary master plan was made for the drainage basins of Reventazon and Pacuare river by Mr. Yutaka Narita, an expert despatched to ICE by the Japan International Cooperation Agency. (see Chapter 5 of Part II).

1.3.4 Other Reports

ICE prepared by himself a number of reports on load-forecast studying the development priority in addition to the existing aforementioned reports. The report on the development priority is titled as follows:

> Analisis para la Seleccion del Programa de Obras del SNI
> Periodo 1979 - 1990, Documento de Trabajo 008-77;
> Departamento de Programas de Generacion, ICE, Ago. 1977

This report recommends that Arenal Project, which is scheduled to be completed in March, 1979, be followed by Corobici Project as the next one for implementation. The report also recommends a geothermal power development as an appropriate project to come after Corobici Project.

1.4 PURPOSE AND SCOPE OF THE REPORT

ICE has conducted number of studies on both Guayabo and Siquirres Projects as mentioned in the foregoing Section 1.3. The survey team discussed with engineers of ICE in San Jose giving due considerations to them, and could define the purpose and scope of the Report as follows.

1.4.1 Guayabo Project

(1) Feasibility study on the Project will be conducted because comparatively sufficient number of basic data were found for the study of a feasibility level.

(2) In other words, the feasibility of the Project will be clarified technically and economically.

(3) The Report will give ICE an information for their judgement whether or not Guayabo Project will be adequate to follow after Corobici Project. However, it will be out of the scope of the Report to make a study on comparison of Project with alternative geothermal projects and other alternative hydro-projects.

(4) The purpose of the Project will be limited, as a result of field survey, to power, generation

1.4.2 Siquirres Project

(1) As a result of field survey, it was found that the existing basic data, especially geological data, was not sufficient yet for the study of feasibility level. Pre-feasibility study will, therefore, be conducted.

(2) In other words, it will be recommended whether or not the Project could be worthy of further study and to what extent the study could be made.

1.5 SURVEY ABROAD AND STUDY AT HOME

1.5.1 Field Survey

The field survey for the sake of feasibility study on Guayabo Project and pre-feasibility study on Siquirres Project was carried out for 45 days between August 15, 1977 and September 28.

The survey team was composed of the following six experts who took in charge of their own specialty:

Team Leader : Mr. Mitsuharu Sato
Electric Power Development Co., Ltd.
Civil Engineer,

Mr. Ryuhei Oyama
Electric Power Development Co., Ltd.
Electrical Engineer,

Mr. Kaname Hoshino
Electric Power Development Co., Ltd.
Civil Engineer,

Mr. Junnichi Tani
Electric Power Development Co., Ltd.
Civil Engineer,

Mr. Mamoru Yamada
Electric Power Development Co., Ltd.
Geological Engineer,

Mr. Masahiro Yamamoto
Japan International Cooperation Agency
Coodinator

In the activities of the survey team for data collection and field survey, their bases were San Jose, the capital city, and Limon, an important port city on the Atlantic coast.

Necessary data for the study on feasibility level concerning Guayabo Project and those on pre-feasibility level concerning Siquirres Project, respectively, were obtained.

The data obtained through the field survey, data that were under preparation by ICE, and matters of agreement are summarized in the Memorandum of Appendix A-1.

1.5.2 Counterpart

During the survey, Ing. Carlos Obregon Q. and Ing. Javier Villalobos T. of ICE were coordinators for the survey team. They visited Japan to study two Projects together with the survey team as trainees of Japan International Cooperation Agency staying for about a month in Japan from November 18, 1977. In addition to them, Ing. Oldemar Ramirez, geological engineer, cooperated with the team in the Republic of Costa Rica often visiting the sites.

1.5.3 Study at Home

The feasibility study on Guayabo Project and pre-feasibility study on Siquirres Project were conducted immediately after the survey team returned to Japan, from October 1977, to March 1978. During the report preparing period, discussions on the study were made between the survey team and two above-mentioned ICE engineers. Mr. Mitsuharu Sato, team leader, visited ICE in the Republic of Costa Rica to attain final adjustment on the study showing the draft report to them from February 24 to March 5, 1978.

1.6 BASIC DATA

Data required for the study such as demand forecast data, geological maps, topographycal maps, hydrological data and economical informations of the Republic of Costa Rica, were obtained from or through ICE. These data available are referred to in the Appendix A-1.

1.7 GENERAL AFFAIRS OF THE REPUBLIC OF COSTA RICA

(1) Geographical Features

The Republic of Costa Rica is situated in the isthmus of Central America and is continuous to the Pacific Ocean and the Caribbean Sea on its West and East sides, respectively. The country adjoins Nicaragua on its northern border and Panama on its southern border. She covers an area of 50,900 km^2, equivalent to about one seventh of area of Japan or a little smaller than the form total area of Kyushu and Shikoku. Her territory has a long and narrow and is 464 km long from north to south and 274 km long from east to west (between the Pacific Ocean and the Caribbean Sea). The coast line is about 1,100 km on the Pacific side due to a remarkable indented line, while, only 225 km on the Caribbean side nearly without indentation. There is, in the central part of the country, a valley called Valle Central formed in between the Central Mountain range and a spur of Talamanca Mountain range and its about 1,000 meters high above sea level on the average. The yearly average temperature of the highland area, in which San Jose, the capital, is situated, ranges between 15° C and 23° C, showing comfortable climate. The origin of the Central Mountain range is volcanic, and it has many volcanos such as Poas, Barva, Irazu and others which together with the volcanos of Guanacaste Mountain range justify the reason why the Republic of Costa Rica is called a volcanic country. Volcano Irazu broke out a large scale eruption in March, 1963. The Republic of Costa Rica is an earthquake country and was frequented by 20 times of high magnitude earthquake in the recent two centuries.

The topography of the Pacific coast is highly indented with a number of bays and inlets, and broad continental shelf. This will be known from the long coastline mentioned in the foregoing. The climate on the Pacific side is high both in temperature and humidity, however, the rainfall is less than one the Caribbean side. Fishing resources is rich on the Pacific coast. The Caribbean coast, on the other hand, is mostly linear in shape with a little indentation and narrow continental shelf. Its fishing resources are far from being rich. As the coast area has a good amount of rainfall, the climate is suitable for banana plantation.

(2) Climate

Annual rainfall in the central valley area, Pacific side and Caribbean side are 2,030 mm, 1,780 mm and 3,000 mm, respectively (from 1972 records). In a nationwide average, from December to April is dry season, and, from May to November is rainy season. Daily difference in temperature is comparatively small throughout the year. Yearly temperature and rainfall in San Jose are shown in the following Table (from 1974 records).

Month	1	2	3	4	5	6	7	8	9	10	11	12
Average Temperature (C)	18.0	17.8	19.2	19.3	20.0	19.7	19.4	19.8	19.3	19.2	19.2	18.2
Rainfall (mm)	2	1	0.3	48	356	450	238	305	398	249	29	61

(3) Population

The country contains a population of 1,872,000 according to the census taken in 1973. The average annual population increase in the 20 years since 1950 to 1970 amounted to as high as 3.5%. However, the increase rate decreased to 2.7% in the five years since 1968 to 1973. The average annual percentage of population increase in the ten years since 1973 to 1983 is estimated to amount to 2.4% on the basis of the census in 1973.

(4) Economy

Costarican economy in the nineteen-sixties maintained a fairly high growth rate (annual rate of 5.8%) thanks to the formation of Central America Common Market (it was put into force by 5 countries in 1963), a compratively favorable evolution in the international prices of banana and coffee, the major agricultural products of the nation, an expansion of the Government expenditures and an increase of foreign capital inflow. However, since the beginning of the nineteen-seventies the real growth rate of the gross domestic product became dull with a result of registering an average growth rate of 4.3% for the period of 1971 to 1976. This is due to the agricultural stagnation arising from the drop of production in banana and sugar, etc. in spite of the increase of production in coffee and meat.

Another feature of Costarican economy in the nineteen-seventies is the outbreak of inflation. The Republic of Costa Rica has been known in the past as the nation most stabilized in commodity prices in Latin America, and the rising rate in its consumer prices during 1965 and 1970 was as low as 2.5% per year but with the oil crisis as astart, it entered into a violint inflationary course and its rising rate reached as high as 14% in annual average during the period from 1970 to 1975, in particular marking even more than 20% after 1973.

Table I-1-1 Consumer Price Index of the Republic of Costa Rica

Year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
CPI	88	88	89	93	96	100	103	108	124	162	190

Source: United Nations statistics Year Book, 1976 Edition

This sharp rise is conseldered to have come from the increase of domestic liquidity and the price rise of imported goods. The comparison of Gross Domestic Product in the Republic of Costa Rica and that of Japan during 1960 and 1975 is given in Table I-1-2.

Table I-1-2 Percentage of Gross Domestic Product

	GDP (Nominal market price)	Agri-culture	Mining & Industries		Construc-tion	Whole-sale	Trans-portation	Others
			Total	Manufac-turing				
Costa Rica (10^6 colones)								
1960	2,860.5	26	15	(14)	4	21	4	28
1963	3,404.2	24	16	(15)	5	20	4	30
1970	6,524.5	23	20	(18)	4	21	4	28
1974	13,178.0	19	22	(20)	5	21	4	27
1975	16,507.0	20	22	(20)	5	20	5	29
Japan (10^9 yen)								
1960	15,772.0	13	37	(33)	6	17	9	19
1963	24,705.5	11	38	(34)	6	17	9	20
1970	72,279.6	6	38	(35)	7	17	7	25
1973	109,216.6	5	38	(36)	8	19	8	29
1974	129,405.1	5	37	(35)	7	18	7	31

Source: United Nations Statistics Year Book, 1976 Edition According to International Standard Classification of Industry.

(a) Agriculture

Agriculture occupies high percentage in the GDP of the Republic of Costa Rica and the contribution rate to GDP originated by agriculture is said to reach as high as 40%. 50% of the total agricultural land of the country is the cultivable land with its two-third being actually cultivated and half of the entire working population is engaged in agriculture. But the percentage which agricultural production occupies in gross production is gradually decreasing. Among agricultural products of the Republic of Costa Rica, banana, coffee, cacao and sugar are the items for export and occupy a big percentage in acquisition of foreign currencies.

Unit: 10^6 US$

	Gross amount of export	Banana	Coffee	Meat
1973	343 (100)	91 (27)	94 (27)	33 (10)
1974	431 (100)	98 (23)	125 (29)	34 (18)
1975	493 (100)	144 (29)	97 (20)	38 (8)
1976	589 (100)	145 (25)	154 (26)	40 (7)

As seen from the above list, the percentage of banana and coffee combined is 60% in 1967, 45% in 1973 and 50% in 1976. 12% of the national land is stock farming land, and the dairy farming is most popular in the high lands and the beef cattle in the lowlands near the sea.

(b) Industry

There is no heavy industry in the country and the nation's main industries are such light industries as food, chemical, cement, shoes, clothes, beverage, lumber, textile, automobile assembling, electric home appliances assembly and non-metalic,etc. The percentage which these industries occupy among the GDP is nearly the same as agriculture does and its real growth rate from 1971 to 1975 marks 6% as compared with 4.3% for agriculture, showing favorable growth. As a future course of industrialization, the promotion of so-called "new industries" like textile, metal products and machinery, etc. are expected. But those products have to seek their outlet in Central America Common Market and other market because of the domestic market being too small. Main targets and the outline of New Five Year Plan on Economic Development (1978-1982) announced by the Planning Bureau are as follows:

(i) Main targets

- To further maintain the increasing pace of each industrial field for 5 years in the past.
- To maintain the export rhythm of industrial products to the countries other than those of Central America Common Market.
- To promote alternative industries for the imported industrial products.

- To make effective use of domestic resources actively.
- To de-centralize industries in local regions.
- To pay effort toward the goal of Central America Common Market.

(ii) Outline of Industrial Policy

What attracts special attention in the industrial policy of Costa Rica is that in the future, as it was so in the past, private enterprises owe much of their activities to Governmental measures. Namely the Government of the Republic of Costa Rica will play an important role in the future such as making adequate circumstances in funds and technologies required for industrial activities, creating the necessary demand (like the purchase by Government), giving favorable treatment on taxes, promoting the export, etc. Also infrastructures indispensable for industrialization will be constructed and arranged with the responsibility of the Government. Followings are the industries in which the Government is especially paying its attention in New Five Year Plan on Economic Development.

- Expansion of agricultural production and establishment of processing industry of agricultural products.
- Promotion of small scale industries and industrial products
- Promotion of plywood industry
- Promotion of Aluminum industry

Gross domestic product by kind of economic activity of the Republic of Costa Rica is shown in Table I-1-3.

(5) Resources

(a) Mineral Resources

There are some mineral resources actually under investigation including bauxite in the southern part of Puntarenas Province.

(b) Energy Reousrces

Most part of energy supply is dependent upon hydraulic power resource and imported petroleum. In order to make the best use of geothermal resource, which is one of very few domestic energy resources of the country, ICE is earnestly trying to push forward their investigation and study. It can well be said that the Republic of Costa Rica is blessed with adundant rainfall, therefore, the country has adundant water resources. The amount of economically developable water resource is estimated, according to ICE survey, at about nine (9) million kW. In terms of electric energy that could be generated, this is equivalent to 37,000 million kWh, or 10,000 million kWh in dry season snd 27,000 million kWh in rainy season.

(c) Amount of Consumed Energy

The outline of energy consumption in the country is as mentioned below.

Table I-1-3 Gross Domestic Product by Kind of Economic Activity of the Republic of Costa Rica

Unit : 10^6 Colones

Gross Domestic Product	1971		1972		1973		1974		1975		1976		Annual growth rate (%)	
	Market price	Constant price of 1970	Market price	Constant price of 1970	Market price	Constant price of 1970	Market price	Constant price of 1970	Market price	Constant price of 1970	Market price	Constant price of 1970	Market price	Constant price of 1970
Agriculture, forestry and fishing	1443.4	1356.6	1601.6	1427.5	1962.9	1504.1	2522.4	1382.9	3417.8	1536.1	4050.1	1669.5	22.9	4.3
Manufacturing and mining	1325.0	1245.3	1507.1	1343.2	1903.3	1458.5	2677.9	1468.1	3427.3	1540.4	4047.3	1668.3	25.0	6.0
Construction	343.3	322.7	423.8	377.7	507.1	388.6	692.6	379.7	868.9	390.5	959.4	395.5	22.8	4.2
a) Sector of production	3111.7	2924.5	3532.5	3148.4	4373.3	3351.2	5892.9	3230.7	7714.0	3467.0	9056.8	3733.2	23.8	5.0
Electricity, gas and water	127.8	120.1	147.9	131.8	160.3	122.8	205.9	112.9	303.7	136.5	400.7	165.2	25.7	6.6
Transport and communications	316.0	297.0	362.0	322.6	435.6	333.8	590.7	323.8	788.6	354.4	918.1	378.4	23.8	5.0
b) Basic services	443.8	417.1	509.9	454.4	595.9	456.6	796.6	436.7	1092.3	490.9	1318.8	543.6	24.3	5.4
Commercial(wholesale, retail trade, restaurants and hotels)	1502.0	1411.7	1651.3	1471.7	2054.5	1574.3	2754.7	1510.3	3203.6	1439.8	3767.2	1552.8	20.2	1.9
Financing, insurance, etc.	321.0	301.7	404.5	360.5	508.5	389.7	635.3	348.3	816.6	367.0	975.6	402.1	24.9	5.9
Real estate	524.9	493.3	553.4	493.2	626.5	480.1	784.8	430.3	1123.8	505.1	1373.0	566.0	21.2	2.8
Government disbursements	813.6	764.7	998.0	889.5	1196.6	916.9	1576.4	864.3	2083.7	936.5	2670.4	1100.7	26.8	7.6
Other services	375.2	352.6	420.1	374.4	495.9	380.0	626.7	343.6	770.6	346.3	938.6	386.9	20.1	1.9
c) General services	3536.7	3324.0	4027.3	3589.3	4882.0	3741.0	6377.9	3496.8	7998.3	3594.7	9724.8	4008.5	22.4	3.8
d) Adjustment by change of exchange rate and others	44.8	42.1	146.1	130.2	311.2	238.5	148.3	81.3	-	-	-	-		
Total	7137.0	6707.7	8215.8	7322.3	10162.4	7787.3	13215.7	7245.5	16804.6	7552.6	20100.4	8285.3	23.0	4.3

Note: Constant prices by year were calculated from the index of whoesale price.

Source: Banco Central de Costa Rica

Year		1972	1973	1974	1975
Amount of energy consumed (equivalent to 1000 tons of oil)		612	700	639	728
Contents (%)	Petroleum	51	53	54	55
	Hydropower	26	27	27	28
	Others	23	20	19	17
	Total	100	100	100	100

As shown in the above table, hydropower occupies almost 30% of the total energy consumption, far larger than 7% of Japan. The elasticity of power demand for the period between 1971 and 1976, which shows the ratio of demand growth rate to GNP growth rate (in real terms), is 2.16. This elasticity is estimated to bebome gradually smaller in the future. According to the power demand forecast in macroeconometric method by the team and estimated GNP, the elasticity is supposed to be 1.94 for the period from 1976 to 1982 and 1.14 for the period between 1982 and 1990.

(6) Transportation and Communication

The transportation facilities within the country are relatively good. Ports of Puntarenas and Limon are open on the Pacific coast and Atlantic coast, respectively. There are Golfito and Quepos ports in addition to the abovementioned two ports. Between Puntarenas and Limon via San Jose, runs an inter-ocean railroad which handles major port of exports and imports. Annual total of the cargoes handled in all these ports is approximately 2.6 million tons. There are three more railways each connecting a comparative short distance owned by a state-operated corporation that deals in banana. The corporation offers the facilities open to general passengers. Roads are laid out including about 2,700 km of highway, of which 1,800 km is paved. The Pan-American Highway run through the largest axis of the country from Nicaragua to Panama, serving as the backbone for the entire national road system.

There exists good air transpotation service, both international and local. Juan Santamaria airport, 17 km from San Jose serves various important international air lines. A regular local air service is maintained between San Jose and some places in the interior of the country.

With reference to telecommunication system, operation of telephone network is combinedly undertaken by ICE. The number of telephone subscription totalled 112,000 in 1975. This figure is equivalent to 5.6 subscribers in every 100 people and is suggestive of the fact that telephone is far more popularized in the Republic of Costa Rica than any other Central American Countries which have the average number of the subscriber between 0.7 and 1.4 in every 100 people.

1.8 INSTITUTO COSTARRICENSE DE ELECTRICIDAD (ICE)

ICE was establisched by the government in 1949. The main purposes of ICE were to integrate, develop and operate power supply facilities and to develop the abundant hydraulic resources. Later, in 1963, ICE was additionally assigned to undertake development and operation of telecommunication systems.
Brief introduction of ICE is offered as follows from a printed copy of the outline of ICE (1974 edition):

1.8.1 Power Division

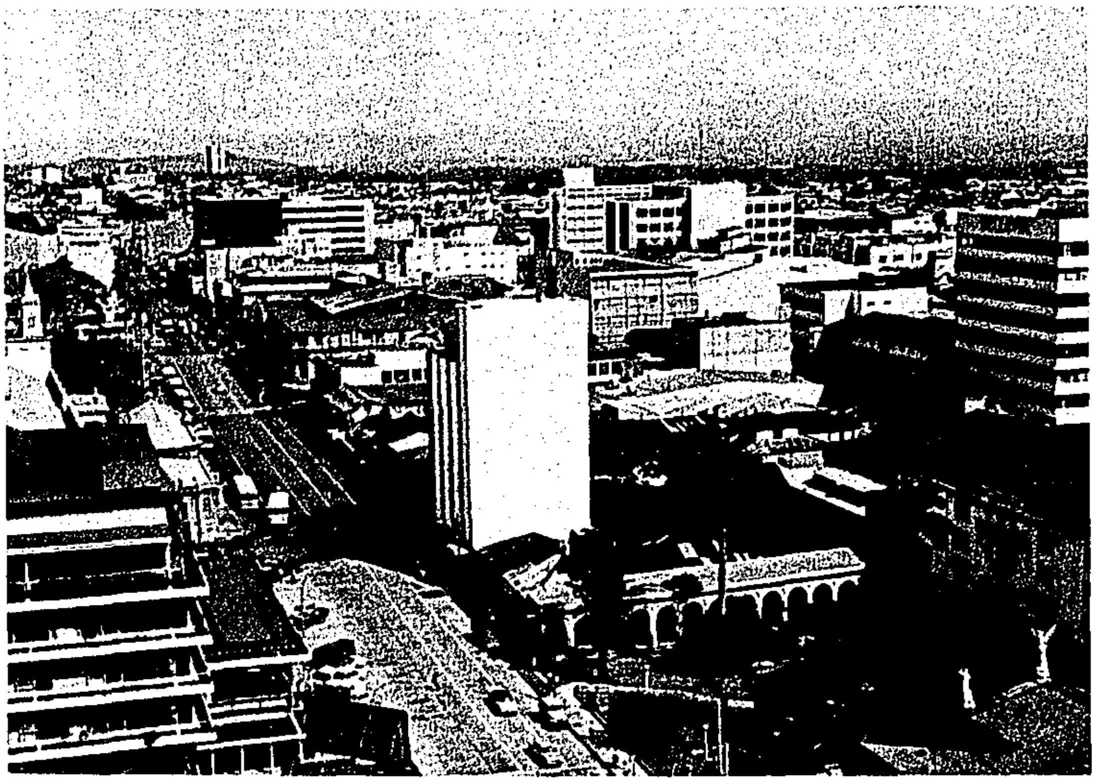
To undertake generate and transmit power was originally the purpose of the Power Division of ICE; however, the division undertakes also to distribute partially as well as to retail partially the power for itself. Most part of the power generated by ICE is wholesaled to a number of other distribution companies, for instance, to CNFL, the power distribution company in San Jose city. ICE directly distributes and directly sells its power to industrial large users of power. The users to whom ICE distributes and retails the power directly amounts to about 20% of all users in Costa Rica. The existing generating facility produces an output of 337 MW.

1.8.2 Telecommunication Division

The telecommunication Division is responsible for all the domestic telephone, telegraph and service related thereto, for instance, telex communication. Part of International service is also undertaken by the Division, while, the other part is handled by Radiografica Costarrience (RACSA), a 100% subsidiary company of ICE. This company retained 75,160 circuits as of in 1974.

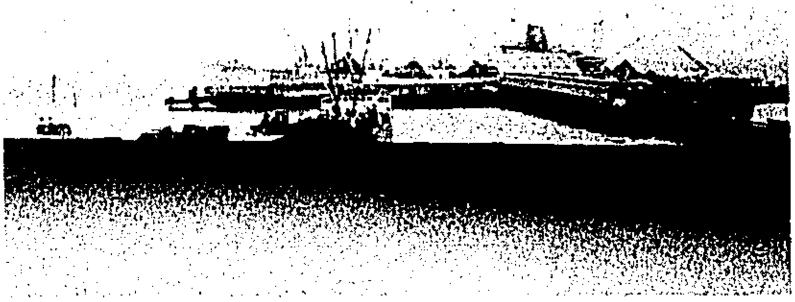
1.8.3 Financing

ICE makes it their policy to finance substantial part of necessary funds from internal sources. For instance, the amount of necessary fund in 1974 totalled US$ 230million. They obtained 41% of the fund from the internal reserve and depreciation charge, and obtained a loan covering the remaining amount. Much of the foreign currency for ICE's power development programs has been obtained from loans with the Interamerican Development Bank, World Bank, Central American Bank for Economic Integration, Commercial Banks, and in few instances, equipment suppliers. For future projects, ICE will look for financial assistance from traditional sources, or any others compatible with the Republic of Costa Rica's economic and financial programs.



Capital of Costa Rica,

— San Jose —



Port Limon

Guayabo Dam Site, Looking Downstream

– Plain of Coffee Plantation for Fill-dam on Left Bank and Hills Passed through by Tunnel on Right Bank –

Left Abutment of Guayabo Dam

– A Railroad from San Jose to Limon –

Coffee Plantation on Left Bank of Guayabo Dam Site

– Hills Over There are on Right Bank –

Site for Penstock and Power Plant of Guayabo Project
— Looking Downstream of Pacuare River from Top of Penstock Site to Power Plant Site —

Site for Guayabo Power Plant
— Looking Right Bank of Pacuare River from Plant Site, and Pacuare River Flows from Right to Left —

Siquirres Dam Site
– Looking Upstream –

Siquirres Dam Site
– Looking Upstream by Air-plane –

Downstream Area from Siquirres Dam Site

– Pacuare River Flows from Left to Right, towards Caribbean Sea –

Inter-American Highway

PART I

CHAPTER 2

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 2 CONCLUSIONS AND RECOMMENDATIONS

LIST OF FIGURE

CHAPTER 2 CONCLUSIONS AND RECOMMENDATIONS

As a result of survey and study on Guayabo and Siquirres Projects, the following conclusions and recommendations are obtained.

2.1 CONCLUSIONS AND RECOMMENDATIONS FOR GUAYABO PROJECT

Guayabo Project will be located in the middle part of Reventazon river that originates from a mountain range in the central part of the Republic of Costa Rica and flows into Parismina river which drains itself into the Atlantic Ocean. Project will provide a dam of 38 m in height in Reventazon river, and in-flows into the pondage will be diverted through a headrace tunnel of 10 km to the neighbouring Pacuare river, generating 180 MW power.

2.1.1 Conclusions

(1) The growth rates of power demand were 8.5% and 9.7%, respectively, for the average annual peak MW and energy from 1967 to 1976 in the Republic of Costa Rica. In addition to it, the above-mentioned rates will be 6.2% and 6.8% respectively from 1977 to 1990. From this forecast, it will be concluded that the demand for peak MW at the end of generation in 1977, 347 MW, will increase to 661 MW by the year 1987 and 763 MW by the year 1990. A conclusion will also be reached that the demand for energy at the end of generation, 1,737 GWh, will increase to 3,475 GWh in 1987 and 4,071 GWh in 1990.

(2) In order to cope with the increase of demand, it will be necessary for ICE to develop a new power resource in succession of Corobici Project which will be put into operation in the power system in the end of 1982.

(3) Guayabo Project has been shown to be economically and technically feasible for the new power resources.

(4) The investigations demonstrate that no unusual problems exist on the sites for the dam and power plant and on the route of headrace tunnel.

(5) The ratio of annual benefit to annual cost and surplus benefit are 1.18 and 44.3 million Colones (5.2 million U.S. dollars), respectively, in the period of analysis of 50 years.

(6) Installed capacity of 180 MW is considered to be appropriate for Guayabo Project. It will be recommended to meet the power demand in the Republic of Costa Rica that the capacity of 120 MW will be installed in 1987 and then additional 60 MW in 1989 in consideration of the growth of demand. Nevertheless, a new electric power resource will probably have to be put into operation after 1993.

(7) The annual possible energy will be 1,192 million kWh, while the investment cost will be about 2,130 million Colones (248 million US dollars). The cost of energy will be 0.211 Colones/kWh.

CAPITULO 2 CONCLUSIONES Y RECOMENDACIONES

De acuerdo a las investigaciones y estudios que se realizaron sobre los proyectos antes citados, se llegó a las conclusiones y recomendaciones que se dan a continuación.

2.1 CONCLUSIONES Y RECOMENDACIONES SOBRE EL PROYECTO HIDROELÉCTRICO GUAYABO.

El Proyecto Guayabo se ubicaría en la cuenca media del Río Reventazón, río que con cabeceras en la Cordillera Volcánica Central de Costa Rica, desemboca junto con el Río Parismina en el Océano Atlántico. El esquema proyectado consiste en la construcción, sobre el citado río, de una presa de 38 m de alto, la cual permitirá derivar las aguas de este río hacia el Río Pacuare por medio de un túnel de conducción de unos 10 Km de longitud; las aguas serán utilizadas para producir energía eléctrica. La potencia a instalar será 180 MW.

2.1.1 Conclusiones

(1) La demanda eléctrica de Costa Rica, creció durante el período 1967 - 1976, a un ritmo promedio anual de 8.5% con respecto a la potencia y 9.7% con respecto a la energía.

Por otra parte, la tasa de crecimiento promedio anual de la demanda para el período comprendido entre 1977 y 1990, se estima en 6.2% con respecto a la potencia y en 6.8% con respecto a la energía.

En base a lo anterior la demanda máxima que en 1977 fue de 347 MW, se estima que para 1987, año en que se planea que el Proyecto Guayabo entre en operación, será de 661 MW y para el año 1990 de 763 MW.

La de energía anual se incrementará de 1,737 GWH en 1977 a 3,475 GWH en 1987 y 4,071 GWH en 1990.

(2) Para poder satisfacer el crecimiento en la demanda se requiere que un nuevo proyecto entre en operación en 1987, siguiendo al Proyecto Hidroeléctrico Corobicí que entrará en línea en 1982.

(3) El Proyecto Hidroeléctrico Guayabo se juzga que es factible técnica y económicamente y por lo tanto puede ser elegido como candidato para iniciar operación en 1987.

(4) Se considera que no existe condiciones anormales en los posibles sitios de presa y casa de máquinas ni sobre la posible ruta del túnel de aducción.

(5) La razón beneficio anual entre costo anual, para un período de análisis de 50 años, es 1.18 y la diferencia entre beneficio anual y costo anual corresponde a 44.3 millones de colones (US $5.2 millones)

(6) La capacidad máxima que se considera adecuada para instalar en el Proyecto Guayabo es 180 MW; y de acuerdo a la forma de crecimiento de la demanda de Costa Rica, se pueden instalar en 1987 los primeros 120 MW y los restantes 60 MW en 1989.

A partir de 1991, se requerirá la entrada de nuevos proyectos.

2.1.2 Recommendations

In view of the above-mentioned conclusions, the following items will be recommended.

(1) In order to implement Guayabo Project, it will be recommended that necessary activities be taken with reference to the outline programme shown in Fig. I-2-1.

(2) Additional geological survey and additional investigation of construction materials should be accomplished in accordance with the recommendations shown in Chapter 4 of Part II prior to the commencement of the definite study that will be carried out in the future.

(3) It is recommended that the definite study be undertaken when the geological survey and investigation of construction materials are accomplished. The object of the definit study is to review, supplement and improve the feasibility study and it could be a basis of report for financing and of contract documents for construction.

(4) All the data, which have been used in the feasibility study, should be up-todated before the definite study will be commenced.

2.2 CONCLUSIONS AND RECOMMENDATIONS FOR SIQUIRRES PROJECT

Siquirres Project will be located on the Pacuare river about 12 km downstream from the proposed power plant of Guayabo Project. Project will be assumed to have a dam of height 200 m with a power plant of 310 MW installed capacity.

2.2.1 Conclusions

(1) Siquirres Project could be promising as one of hydraulic projects to be developed following Guayabo Project.

(2) Consequently, geological survey and investigation of construction material could be worthwile in order to make a feasibility study in the future.

(3) A possibility could exist for construction of a dam 200 m high with a normal water level of reservoir EL 250 m. In this case, appropriate location for the power plant could be probably the site immediately downstream of the dam.

(4) On an assumption that an installed capacity of the power plant could be 310 MW, the annual energy generated would be 1,850 million kWh. The investment cost for Siquirres Project could be about 3,740 million Colones (435 million US dollars). The ratio of annual benefit to annual cost will be 1.26 in the period of analysis of 50 years.

(7) La producción anual de energía eléctrica del Proyecto será de 1,192 millones de KWh, y el costo total de las obras del Proyecto será de unos 2,130 millones de colones (US $248 millones)
El costo de energía será de 0.211 colones por kWh; a precios de 1977.

2.1.2 Recomendaciones

De las conclusiones arriba mencionadas, se derivan las siguientes recomendaciones.

(1) Para llevar a cabo el Proyecto Guayabo se recomienda programar las futuras actividades a realizar, refiriéndose al cronograma general mostrado en la Figura I-1-1.

(2) Realizar investigaciones adicionales en el campo de la geología y de los materiales constructivos, previamente al inicio del estudio definitivo del proyecto y en base a las recomendaciones anotadas en el Capítulo 4 de la Parte II del presente informe.

(3) Proceder al estudio definitivo luego de concluídas las investigaciones anteriormente indicadas. El estudio definitivo tiene por objeto revisar, complementar y afinar el presente estudio de factibilidad, para así servir de base tanto para el informe de financiamiento como para los documentos de licitación.

(4) Actualizar los datos empleados en el presente estudio antes de comenzar el definifivo.

2.2 CONCLUSIONES Y RECOMENDACIONES SOBRE EL PROYECTO HIDROELÉCTRICO SIQUIRRES

En lo referente al Proyecto Siquirres el mismo estará ubicado a unos 12 Km hacia aguas abajo de la posición, en este estudio proyectada, de la Casa de Máquinas del Proyecto Guayabo, sobre el curso medio del Río Pacuare. Este esquema se analizó considerando una presa de gravedad de concreto de 200 m de alto y una capacidad a instalar de 310 MW.

2.2.1 Conclusiones

(1) El Proyecto se juzga prometedor como una posibilidad de desarrollo hidroeléctrico subsiguiente al Proyecto Guayabo.

(2) Consecuentemente, investigaciones geológicas y sobre fuentes de materiales de construcción deben ser llevadas a cabo, para realizar en el futuro, el estudio de factibilidad.

(3) Existe la posibilidad de construir una presa de 200 metros de alto, en cuyo caso el nivel máximo normal de agua, en el embalse, correspondería a la cota 250 m.s.n.m. Bajo esta condición, posiblemente, la localización más apropiada de la casa de máquinas sería al pie de la presa.

2.2.2 Recommendations

On the basis of the above-mentioned conclusions, the following will be recommended:

(1) Siquirres Project could have a possibility of development in a large scale, and it will need a long period of time for survey and investigation. It is recommended, therefore, that necessary activities be taken with reference to the outline programme shown in Fig. I-2-1.

(2) Geological survey and investigation of construction materials should be accomplished in accordance with the recommendations given in Section 2. 8 of Chapter 3 in Part III.

(3) Re-study on the height of dam and the type of dam should be accomplished when the geological survey and investigation of construction materials could be completed.

(4) In carrying out the re-study of the height of dam, an alternative study will be desirable on the development with two projects between Siquirres Dam site and Guayabo Plant site.

(5) Feasibility study will be desirable after the determination of height and type of dam which could be judged from a result of the survey and investigation described in the above-mentioned item (2).

(4) En el caso de instalar 310MW, la energía anual generada sería 1,850 millones de kWh por año. El costo total de las obras del Proyecto Siquirres sería alrededor de 3,740 millones de oolones (US $435 millones)

La razón entre el beneficio anual y el costo anual es de 1.26 para el período analizado de 50 años.

2.2.2 Recomendaciones

Teniendo como soporte las conclusiones anteriormente indicadas, se recomienda lo siguiente:

(1) El Proyecto Siquirres tiene la posibilidad de ser un desarrollo de gran magnitud, razón por la cual se requerirá un largo período de tiempo para investigaciones y estudios. Se recomienda llevar a cabo los futuros estudios siguiendo el cronograma general que se indica en la Figura II-2-1.

(2) Realizar las investigaciones relativas a la geología y a los materiales de construcción de conformidad con las recomendaciones hechas en el numeral 2.8 del Capítulo 2 de la Parte III.

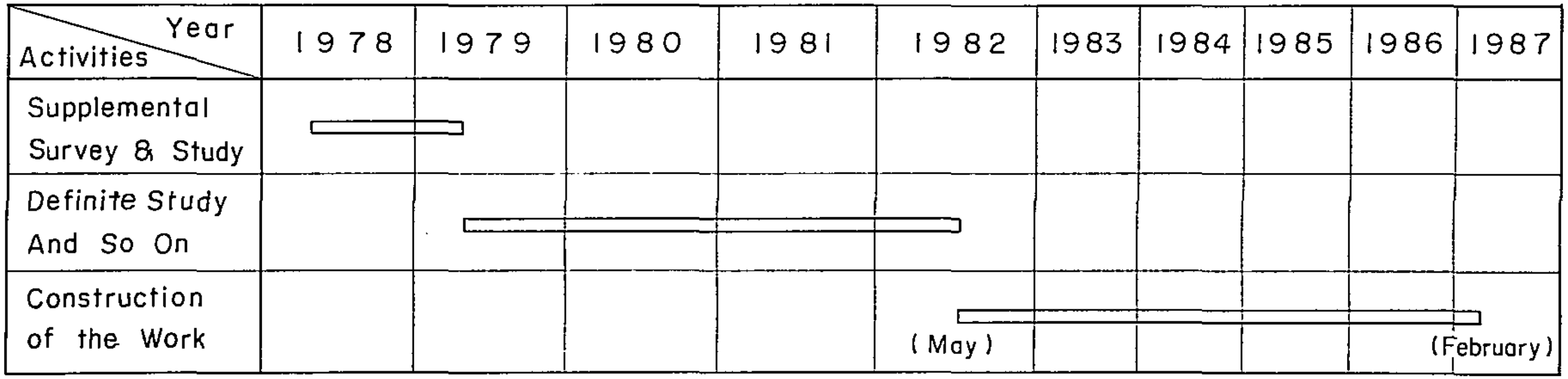
(3) Luego de concluídas las investigaciones arriba señaladas, se deberá revisar la altura de la presa y hacer un estudio para determinar el tipo de presa.

(4) Es deseable que al revisar la altura de la presa se analice también el aprovechamiento en dos caídas del potencial existente entre el sitio de casa de máquinas del Proyecto Guayabo y el sitio de presa de Siquirres.

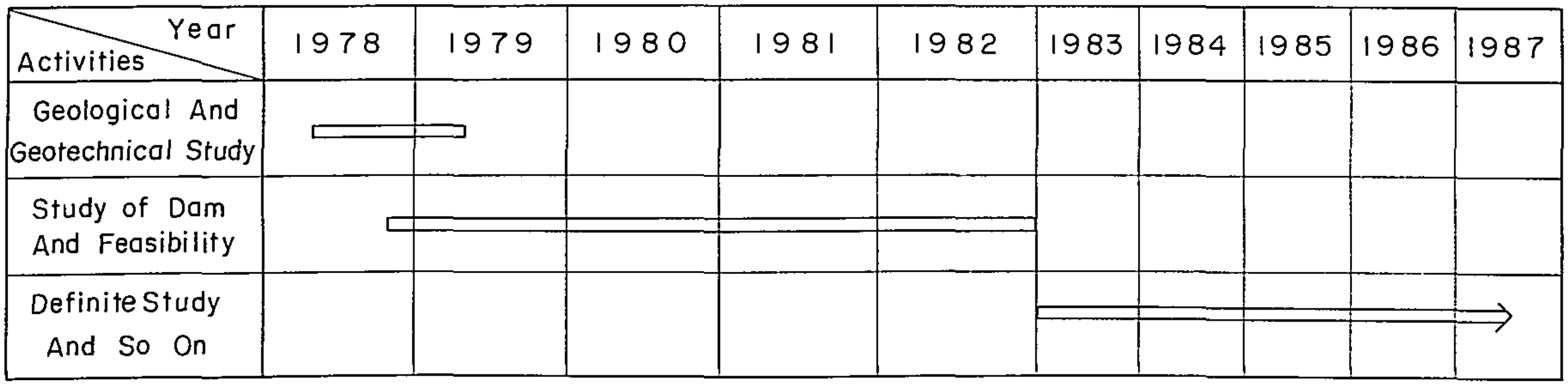
(5) Posteriormente a los trabajos de la determinación de la altura y el tipo más conveniente de presa soportados en el resultado de las investigaciones geológicas mencionadas en (2), se recomienda efectuar el estudio de factibilidad.

Fig. I - 2 - 1 Outline Programme of Activities for Implementation of Projects

Guayabo Project:



Siquirres Project:



PART II

GUAYABO HYDRO-ELECTRIC PROJECT

(FEASIBILITY STUDY)

PART II

GUAYABO HYDRO-ELECTRIC PROJECT (FEASIBILITY STUDY)

PART II

CHAPTER 1

THE POWER MARKET STUDY

CHAPTER 1 POWER MARKET STUDY

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CHAPTER 1 POWER MARKET STUDY

1.1 SERVICE AREA

Costa Rica has the highest per capita consumption of electric energy among the Central American countries. Its figure is in the higher level in Latin American countries. Its installed capacities per capita and annual generated energy per capita in 1970 were 141 watts and 593 kWh, respectively, according to statistical yearbook of the United Nations.

The figures in 1976 increased to 178 watts and 770 kWh, respectively.

The country has 7 Provinces and it is also divided into 79 Cantons.

Two areas can be distinguished in view of the present supply of electric energy into the Central zone and the non-Central zone. The Central zone extends East-West wise from Turrialba to Puntarenas, and is located in the highlands, with the elevation of 1,000 - 1,500 m above the sea level.

For the agricultural products, 86 % of coffee production, 80 % of milk and almost all of sugar cane production concentrate in this area.

On the other hand, in the non-Central zone, there are many districts of lower altitude, where temperature and humidity are higher and living conditions are not so good. Most of Guanacaste Province is affective in its agricultural production due to water shortage during the dry season.

These areas are mainly used for cattle farms. A project for irrigating some 100 thousands ha. in Guanacaste is being studied by the Government, using water from Arenal hydro-power project. Limon Province produces a large quantity of banana due to much rainfall and high temperature, but in northern district, annual rainfall exceeds 7,000 mm, there can be seen jungle areas.

The population of each province are as follows, according to the national census in 1973.

Province	Population (1,000)	Ratio (%)
San Jose	695	37
Alajuela	326	17
Cartago	205	11
Heredia	134	7
Guanacaste	179	10
Puntarenas	218	12
Limon	115	6
Total	1,872	100

1.2 ELECTRIC POWER SITUATION

The most of electric power supply facilities are connected by transmission lines of the National Interconnected System in Costa Rica. About 95 % of domestic energy demand are supplied through the interconnected system. The rest of demand scattered in the non-Central zone is supplied by independent diesel-generating systems.

1.2.1 Electric Power Enterprises

The main suppliers of electric energy in Costa Rica are as follows:

(1) Instituto Costarricense de Electricidad (ICE)

ICE is the governmental agency with administrative autonomy whose task is to study and find solutions of the power problems to the electrification on the purpose of a well-coordinated development plan. In other words, it is not only to prepare a comprehensive plan of development for a domestic supply of power, but also to make a coordination of supply system installation proposed between the enterprises. In addition to it, ICE has its purpose to supply electricity basically by developing resources in large scale and economically. ICE has main facilities of the National Interconnected System, and it owns 282 km of 138 kV transmission lines and 333 km of 34.5 kV transmission lines as of 1976. The above figures include those for Limon in Limon Province, and Liberia and Santa Cruz in Guanacaste Province. Further, it owns 273 km of the primary distribution lines of 13.8 kV and 4.1 kV, as well as 179 km of secondary lines. ICE and other Distributing companies, described below, supply energy to consumers, through the National Interconnected System.

ICE has 15 power plants as of 1976, 6 of them hydro-plants with the installed capacity of 185 MW, and 9 of them thermal plants with 162 MW.

In addition, ICE supplies energy to the consumers who have not been connected with the system. ICE mainly supplies energy for them by small diesel-generating plants.

(2) Compania Nacional de Fuerza y Luz (CNFL)

CNFL is a subsidiary company of ICE at present which was established as a branch of American and Foreign Power in 1928. It has continued the business since then in Costa Rica. Its service area covers the most of the Central zone where is densely populated. As of 1976, it supplies energy to 139,000 customers in the Central zone and surrounding area of San Jose City. CNFL has also its own generating facilities, the capacity of which amounts to total 28 MW of 7 hydro-power plants. It also owns 100 km of 34.5 kV transmission lines as well as distributing facilities. Energy sold in 1976 amount to 821 GWh.

(3) Municipal Power Distributing Companies

There are three municipal power distributing companies of Heredia (ESPH), Alajuela (JASEMA) and Cartago (JASEC). These 3 companies distribute energy to about 44,000 customers in their municipalities and surrounding areas. The generating facilities owned by these 3 companies are 11 MW of 7 hydro-plants and energy sold in 1976 was 158 GWh.

(4) Other Power Distributing Companies

Energy supply to other area than the above-mentioned districts is performed by many local public or private power distributing companies. Some of these power distributing companies near Central zone have been merged into ICE, due to the difficulty to maintain service level for increasing demand and the technical problems caused by the small scale of the enterprise. This tendency is still continuing now.

1.2.2 Present Status of Power Supply Facilities

The proportion of power supply facilities in Costa Rican System could be said that hydro-system is main and thermal-system is subordinate. Actually, capacity of facility is 224 MW for hydro and 162 MW for thermal, and the capacity of hydro is equivalent to 70 % of maximum power demand. ICE intends to develop abundant hydro-power resources in the country and hydro-plants now extending or under construction are of the capacity of 404 MW including Corobici Project.

Concerning thermal plants, ICE has a developing plan of geo-thermal plants intending to utilize domestic energy resources. No thermal plant by oil or coal is planned under the development Plan 1978-1990.

Regarding substations, ICE has plants to construct new substation and increase transformers in existing substations, anticipating the increase in demand in Central zone. Present total capacity of transformers is 794 MVA.

Regarding transmission lines, generated energy is now transmitted by 138 kV and 34.5 kV lines. ICE has, however, decided to adopt 230 kV as transmission voltage in future, and they have started the construction of transmission lines of 230 kV.

ICE has also decided to construct 230 kV international interconnected transmission line* with Nicaragua, the adjacent country. This line aims to exchange each surplus energy, thus attempting to operate economically and improve the reliability of the electric system. It is scheduled to be completed in 1980.

The outline of power supply facilities is shown in Table II-1-1.

1.2.3 Present Status of Power Demand and Supply

The records of annual energy demand and maximum power from 1967 to 1976 are shown in Table II-1-2. On the table, average increasing rate during the decade is 9.7 % (2.5 times in a decade) in energy demand and 8.5 % (2.2 times in a decade) in maximum power.

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* Contrato de Interconexion entre el Instituto Costarricense de Electricidad (ICE) y la Empresa Nacional de Luz y Fuerza (ENALUF), Jun. 1976

Table II-1-1 The Outline of Power Supply Facilities

Power Plant		Owned by	Installed Capacity (kW)		
Hydro	Cacao	(JASEMA)	672		
	Carrillos	(ESPH)	2,000		
	La Joya	(")	340		
	Birris	(JASEC)	8,240		
	Small Hydros	(CNFL)	27,660		
	Garita	(ICE)	30,000		
	Rio Macho	(")	90,000		
	Cachi	(")	64,000		
	Other Hydros	(")	799		
	Subtotal		223,711		
	Cachi	(ICE)	32,000	additional	1977
	Rio Macho	(")	30,000	"	1978
	Arenal	(")	156,000	under construction	1979
	Coro bici	(")	186,000	proposed	1982
	Total		627,711		
Thermal	Colima	(ICE)	19,540		
	San Antonio	(")	48,100		
	Barranca	(")	41,600		
	Liberia	(")	2,320		
	Santa Cruz	(")	1,000		
	San Isidro	(")	1,500		
	Siquirres	(")	1,300		
	Limon	(")	15,000		
	Moin	(")	32,000		
	Total		162,360		
	out of the interconnection		5,818		
Substation (ICE)			(MVA)		
	Colima		175		
	Rio Macho		140		
	Cachi		103		
	Barranca		90		
	La Caja		60		
	San Antonio		60		
	La Garita		58		
	Canas		20		
	Other small substations		88		
	Total		794		
Transmission Line (ICE)			(km)		
	138 kV 2 circuit		144		
	138 kV 1 circuit		139		
	34.5 kV		334		
	Total		617		

Table II-1-2 Demand Record

Year	Annual Energy Generation (GWh)	Annual Energy Sales (GWh)	Maximum Demand (MW)	System Losses (%)	Annual Load Factor (%)
1967	668	596	145	12.1	52.9
1968	738	660	155	11.8	55.6
1969	797	713	168	11.8	55.9
1970	908	801	195	13.4	53.2
1971	1,027	911	212	12.6	55.3
1972	1,134	1,017	232	11.6	55.9
1973	1,218	1,091	249	11.7	56.3
1974	1,326	1,188	271	11.7	56.0
1975	1,413	1,248	278	13.3	58.1
1976	1,549	1,356	303	14.2	58.4

Demand by types of customers is shown in Table II-1-3. According to the table, residential demand is larger, holding 50 %, though decreasing its rate year after year. Commercial demand clearly increased from 16 % to 21 % in this period. Industrial demand also increased from 21 % to 29 % through this period, showing the industrialization in this country was moderate. Maximum power demand in 1976 is 303 MW and annual load factor is 58 %. The shape of daily load curve is of the peaks at 11:00 a.m. and 19:00 p.m., due to the residential demand for cooking and lighting. The example of daily load curves is shown in Fig. II-1-1.

As for monthly maximum power, it occurs in December, but the difference from those of other months is not so large, since seasonal climatic conditions are approximately the same. According to the data on hydrology, April is the driest month in the dry season. Therefore, critical months in the balance of demand and supply of power are considered to be April and December.

Concerning transmission line, ICE supplies energy by such a system as composed of main transmission line of 138 kV and subordinate line of 34.5 kV, it has decided to put into operation 230 kV transmission line as a trunk line of the power system before the completion of Arenal project in 1979.

The main power supply capabilities are hydros, and among them, Rio Macho Plant and Cachi Plant are major. However, since the available water flow is influenced by the difference between in dry season (January - May) and in rainly season (June - December), the operation hours of thermal plants increase during the dry season in winter.

Arenal Plant under construction is a plant to regulate seasonally its capability corresponding with the reservoir of 1,185 million m^3 of effective storage capacity, and is expected to become a source of useful supply capability, together with Corobici Plant which is scheduled to be successively developed at the downstream.

1.3 LOAD FORECAST

1.3.1 Period of Analysis

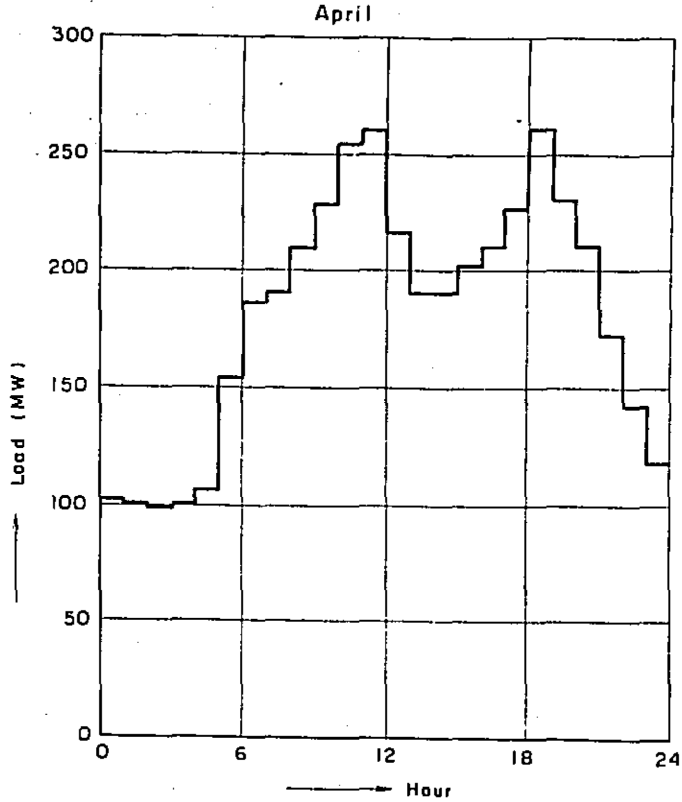
The period of analysis for load forecast is taken to be 14 years from 1977 to 1990. This period will cover those years expected for the development of Guayabo Project as well as those years when almost all the capability of the Plant will be beneficial.

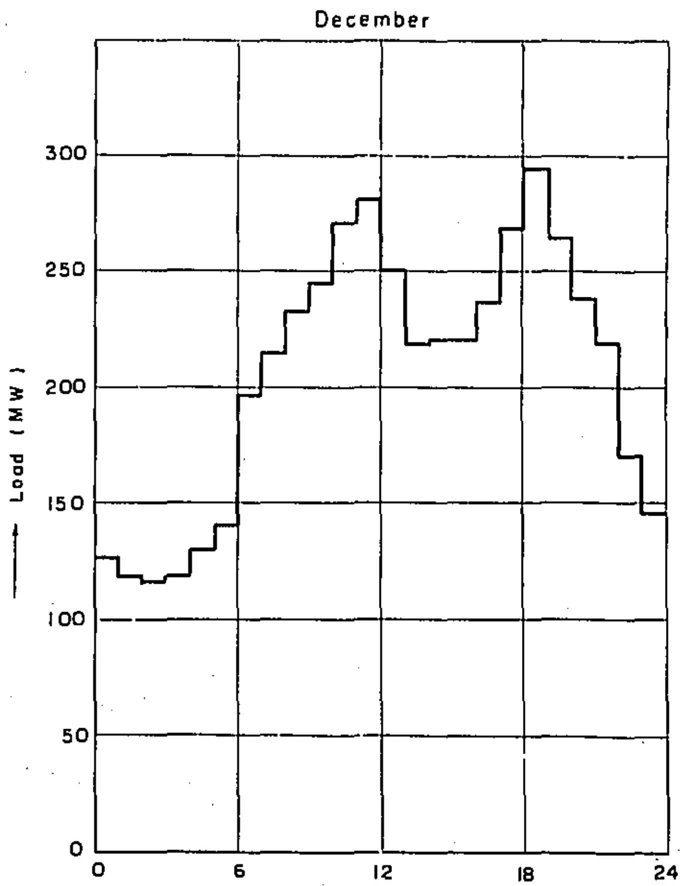
1.3.2 Load Forecast

It is necessary for the study of load forecast to understand activities of economical development in Costa Rica, which are closely connected with electric energy demand. As described in Part I, Item 1.7 (4), future economic policy in Costa Rica will be based on maintaining the rythm of economical development up to date. That means it will be reasonable to study load forecast on the basis of past records of demand.

The study of load forecast is made by the following procedure. The principal procedure is on the basis of time series tendency of energy demand by types of customers using past record of energy consumption. Then, the result will be jus-

Fig. II-1-1 Daily Load Curve in 1976





tified by two alternative methods for macro forecast; one of which will use correlation between population and energy, and the other use correlation between GNP and energy.

ICE already made a load forecast concerning its own power system until 1990, and the comparison of result is made with the result of time series tendency.

(1) Forecast Based on Time Series Tendency

On making estimation, the principal premises are as follows:

(a) Past records are the energy demand during 10 years at the demand end, as shown in Table II-1-3.
(b) To obtain a formula for the tendency curve, a quadratic equation on actual figures by ordinary least squares is adopted.
(c) Energy at generating end is calculated on an assumption of distributing line loss factor 11.5 %, and transmission line loss factor 3.5 %.
(d) Since the government has a new 5-year economic development plan, demand of proposed industries will be taken into consideration for the forecast.
(e) Maximum power is calculated from estimated demand by using annual load factor as described in Item 1.3.4.
(f) As for demand caused by popularization of home electric appliances such as television, it is supposed that the demand will rise moderately in future as shown in a below table. In the Central zone, the climate is moderately warm through the year, so air-conditioners which consume much electric energy and power are by no means necessary. For that reason, it is considered that there will not be sharp increase in future energy and power demand caused by home electric appliances.

(as of 1973)

Appliances	Popularization rate (%)	Remarks
Radio	78	
Television	37	
Cooking apparatus for kitchen	60	50 % in 1975
Refrigerator	26	
Washing machine	17	

(g) No sharp increase is assumed in energy demand due to the electrification. That is, electrification rate in 1976 was 60 %, and ICE intends to raise it up to 72 % in 1990. However, even in the past, electrification rate raised from 51% in 1970 to 60 % in 1976, so the estimation by time series tendency will presume to include any rising tendency of electrification rate in future.

The result of load forecast is shown in Table II-1-4, comparing with the one made by ICE.

Table II-1-3 Energy Demand Record

(Unit : MWh, %)

Year	Generated Energy	Energy at Demand End	Classification				
			Residential	Commercial*1	Industrial	Public Street Lighting	Others*2
1966	632,904	546,761 (100)	339,000 (62)	81,933 (15)	116,142 (21)	9,686 (2)	–
1967	668,000	596,332 (100)	364,314 (61)	(15)	131,737 (22)	10,548 (2)	–
1968	738,000	659,957 (100)	391,052 (59)	101,408 (15)	155,158 (24)	12,339 (2)	–
1969	797,000	713,496 (100)	414,894 (58)	114,756 (16)	169,580 (24)	14,257 (2)	–
1970	907,958	800,914 (100)	453,091 (57)	127,884 (16)	202,196 (25)	16,978 (2)	765 (–)
1971	1,026,610	911,497 (100)	491,386 (54)	145,435 (16)	253,917 (28)	19,671 (2)	1,088 (–)
1972	1,134,360	1,016,604 (100)	534,531 (53)	169,177 (17)	288,604 (28)	22,896 (2)	1,396 (–)
1973	1,218,500	1,090,906 (100)	566,580 (52)	182,953 (17)	313,527 (29)	26,489 (2)	1,437 (–)
1974	1,326,499	1,187,821 (100)	601,494 (51)	209,592 (18)	346,365 (29)	28,464 (2)	1,906 (–)
1975	1,413,264	1,247,623 (100)	613,131 (49)	258,393 (21)	342,624 (27)	31,303 (3)	2,172 (–)

*1. Commercial also includes hospital, school church and construction.

*2. Others are demand of small towns.

Table II-1-4 Load Forecast

		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Forecast by ICE	Energy Demand (GWh)	1,444.	1,551	1,649	1,751	1,865	1,980	2,102	2,232	2,369	2,518	2,673	2,838	3,014	3,201
	System Losses (%)	13.9	14.0	14.0	14.1	14.0	14.1	14.1	14.1	14.1	14.2	14.2	14.2	14.2	14.2
	Generated Energy (GWh)	1,677	1,803	1,918	2,039	2,170	2,304	2,447	2,599	2,759	2,934	3,114	3,309	3,514	3,732
	Energy of New Industries (GWh)	–	–	16	127	165	166	168	169	171	209	222	234	251	270
	Total Energy (GWh)	1,677	1,803	1,934	2,166	2,335	2,470	2,615	2,768	2,930	3,143	3,336	3,543	3,765	4,002
	Growth Rate of Energy (%)		7.6	7.2	12.0	7.8	5.8	5.8	5.9	5.9	7.3	6.2	6.2	6.3	6.3
	Annual Load Factor (%)	56.7	57.4	57.5	58.1	58.1	58.1	58.0	57.9	57.9	58.0	58.0	58.0	58.3	57.9
	Maximum Demand (MW)	337	359	984	425	458	486	515	545	578	619	657	698	737	789
Forecast by the Team	Energy Demand (GWh)	1,483	1,594	1,710	1,829	1,952	2,080	2,238	2,347	2,486	2,630	2,778	2,930	3,086	3,246
	System Losses (%)	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6
	Generated Energy (GWh)	1,737	1,867	2,002	2,141	2,285	2,435	2,620	2,748	2,911	3,080	3,253	3,431	3,614	3,801
	Energy of New Industries (GWh)	–	–	16	127	165	166	168	169	171	209	222	234	251	270
	Total Energy (GWh)	1,737	1,867	2,018	2,268	2,450	2,601	2,788	2,917	3,082	3,289	3,475	3,665	3,865	4,071
	Growth Rate of Energy (%)		7.5	8.1	12.4	8.0	6.2	7.2	4.6	5.7	6.7	5.6	5.5	5.5	5.3
	Annual Load Factor (%)	57.1	57.4	57.7	57.9	58.2	58.5	58.8	59.1	59.4	59.7	60.0	60.3	60.6	60.9
	Maximum Demand (MW)	347	372	400	447	480	507	541	563	592	629	661	694	728	763

Fig. II -1-2 Load Forecast: Energy

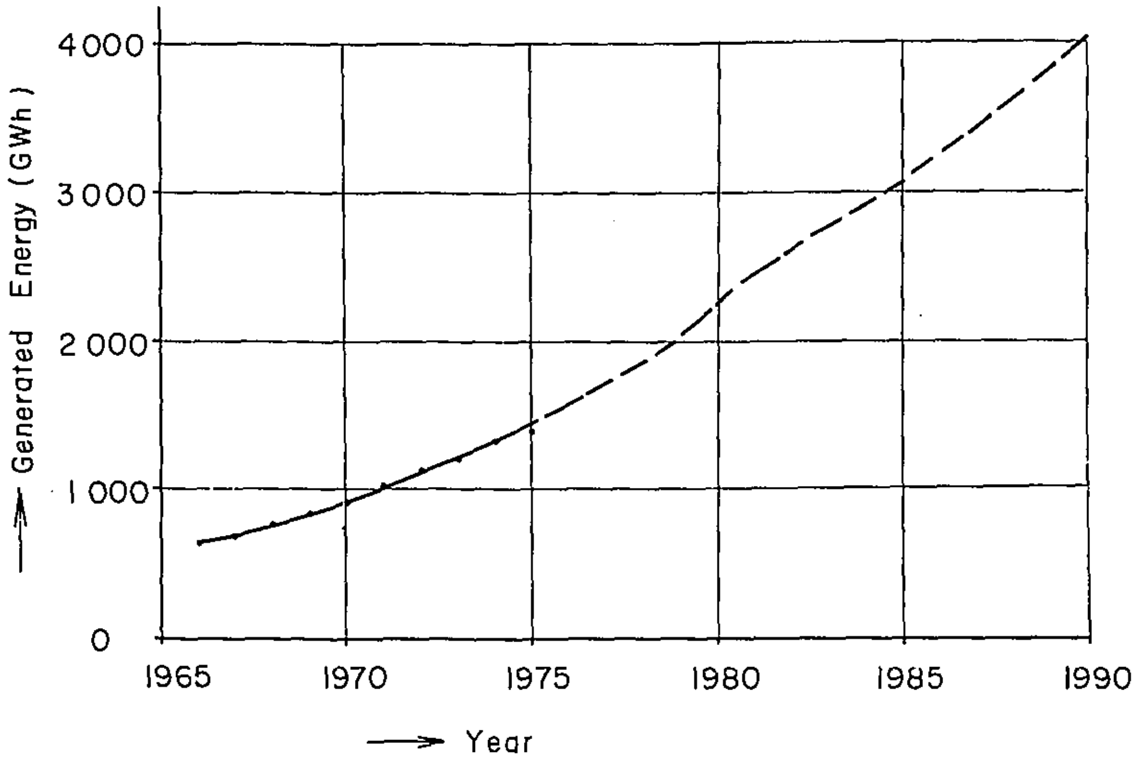


Fig. II -1-3 Load Forecast: Maximum Power

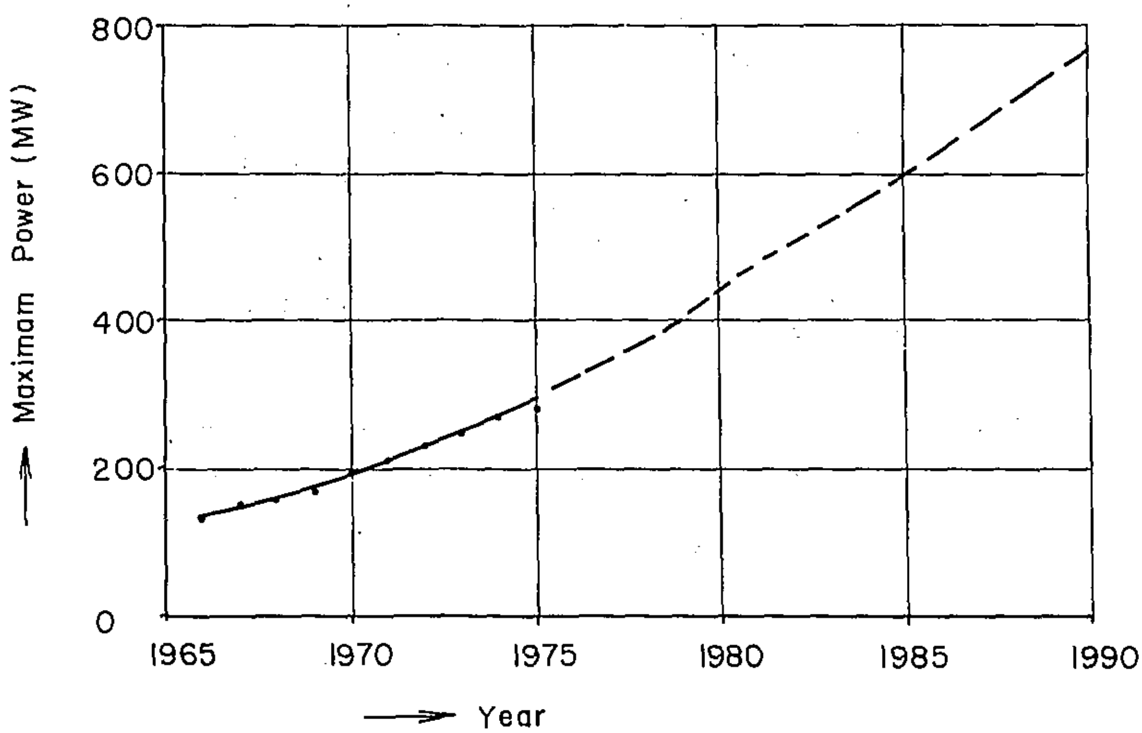
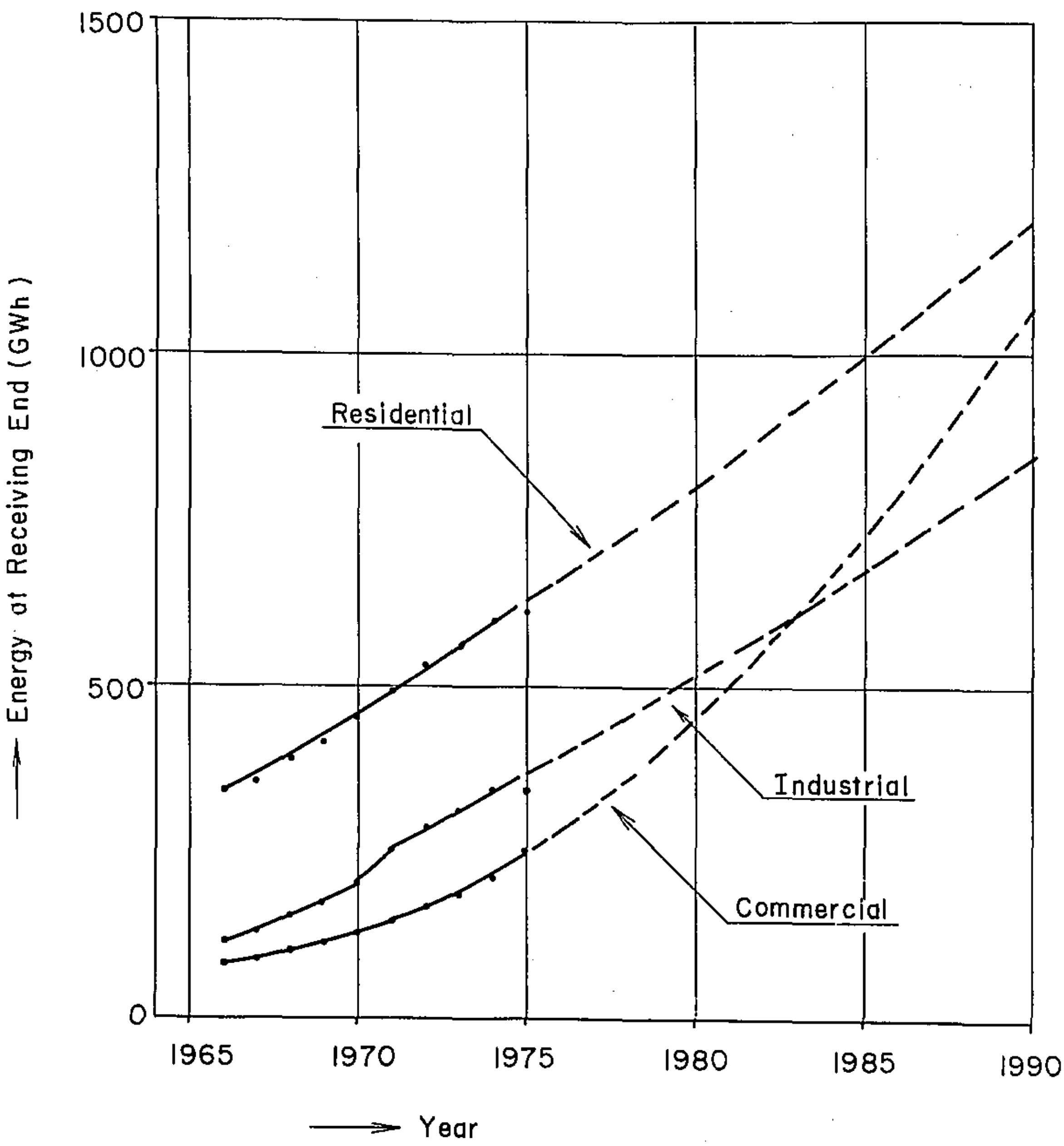


Fig. II-1-4   Tendency of Energy by Customer



Figures of tendency of energy, power and energy by type of customers are shown in Fig. II-1-2, Fig. II-1-3, Fig. II-1-4, respectively. By that table, generated energy will increase 2.34 times in 13 years from 1,737 GWh in 1977 to 4,071 GWh in 1990. It means annual increasing rate is 6.8 % in average. Maximum Power will increase 2.20 times in the same period from 347 MW in 1977 to 763 MW in 1990 showing 6.2 % of annual increasing rate in average.

(2) Load forecast based on population

Generally, there are high correlation between the population of a country and her energy consumption. Here, we shall at first try to obtain the correlation between the total population of Costa Rica and total generated energy in the National Interconnected System during the past 10 years, then make an estimation of generated energy for the anticipated population in future.

The population of Costa Rica by National census in 1973 and anticipated population therefrom in future are shown in Table II-1-5. As for generated energy, record in Table II-1-3 are used. The correlation between population and generated energy is as follows:

Multi-correlation coefficient		0.99640
Standard error		23,730
t-value	(for x)	-2.2828
t-value	(for x^2)	3.5049

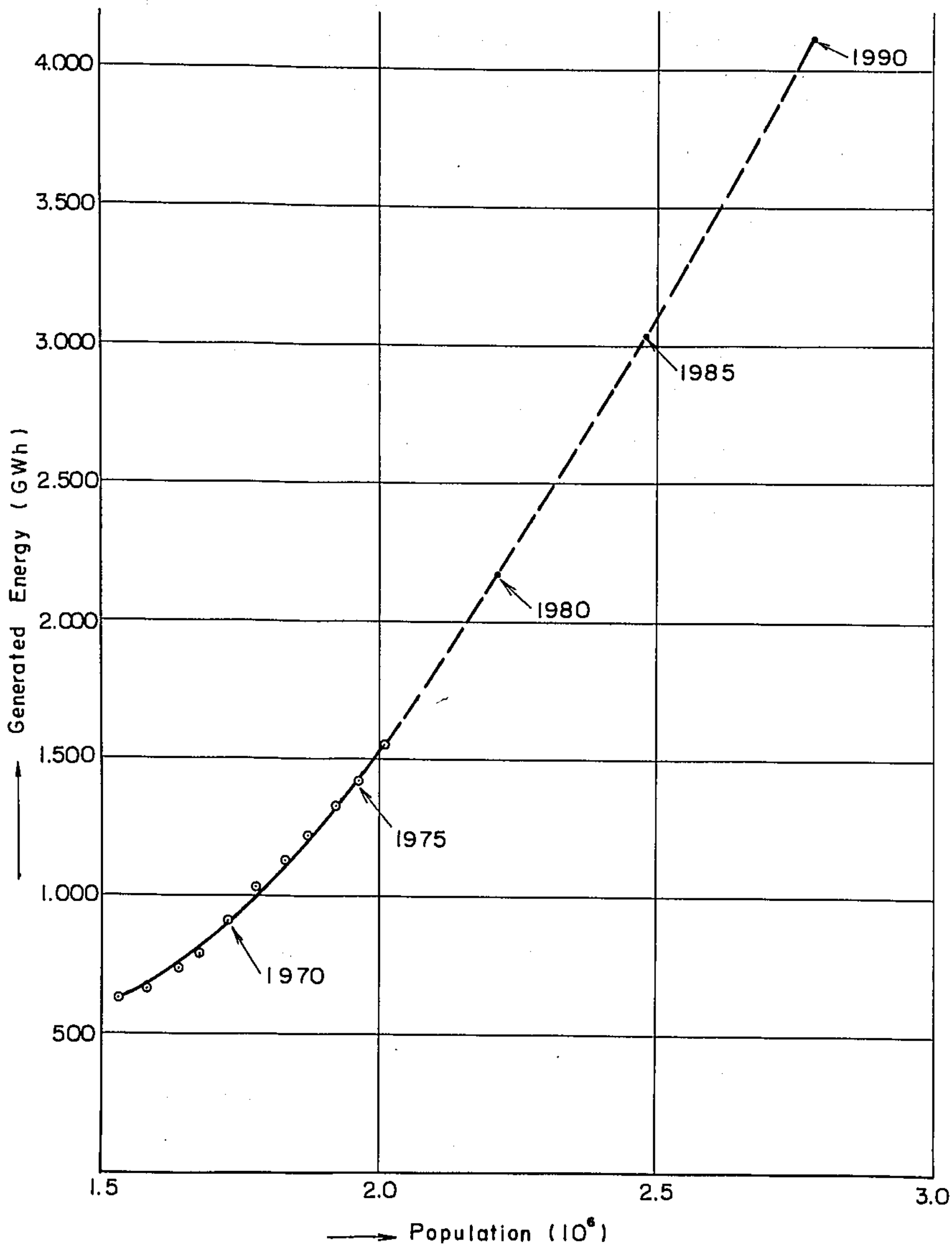
From this result, we can say that there is a high correlation between the above two factors in Costa Rica.

The estimated result, assuming such tendency will last in future, is shown in Table II-1-6 and Fig. II-1-5.

Table II-1-6 Relation between Population and Energy

Year	Population (10^3)	Generated Energy (GWh)	Year	Population (10^3)	Generated Energy (GWh)
1977	2,061	1,744	1984	2,429	2,847
78	2,111	1,878	85	2,485	3,035
79	2,162	2,021	86	2,541	3,232
80	2,213	2,171	87	2,598	3,437
81	2,266	2,328	88	2,656	3,652
82	2,320	2,494	89	2,715	3,877
83	2,374	2,667	90	2,776	4,112

Fig. II-1-5 Relation between Population and Energy Demand of the System



The comparison of the above result with the estimate by the time series tendency for the year of 1980, 1985 and 1990, is as follows:

Year	Estimate by time series (GWh)	Estimate by Population (GWh)
1980	2,268	2,171
1985	3,082	3,035
1990	4,071	4,112

That is, the load forecast by the time series tendency method is considered to be reasonable.

(3) Load Forecast Based on GNP

Macro forecast will be made from the correlation between GNP and generated energy, with which the load forecast will be checked. It is well known that generated energy is closely correlated with the economic activities of the country.

However, the correlation is different from considerably by countries, since the scale of economic structure and national income level are different by countries.

Macro tendency of generated energy per capita is observed corresponding to each of different income level per capita, according to the statistical survey* studied by EPDC and published in 1971.

The load forecast herein is conducted on the basis of the following indexes.

(a) Average growth rate of GNP/capita, presume from the actual value in the past.
(b) GNP/capita at present
(c) kWh/capita at present
(d) Extent of change in growth rate corresponding with the variation of GNP/capita.
(e) Extent of change in kWh/capita corresponding with the variation of GNP/capita.

Basic economical figures are as follows.

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* New Method of Long Range or Very Long Range Demand Forecast of Energy including Electricity Viewed from Worldwide Standpoint.

Hamaaki Aoki, EPDC, Tokyo

Year	Population (1,000)	GNP in price of 1966 (10^6 Colon)	GNP/capita (Colon)	GNP/capita in price of 1968 (US$)	Generated energy in whole country (GWh)	Energy consumption/capita (kWh)
1970	1,732	5,480	3,164	476	1,024	594
1971	1,779	5,838	3,282	494	1,148	645
1972	1,826	6,355	3,480	523	1,266	697
1973	1,872	6,844	3,656	550	1,346	719
1974	1,918	7,142	3,724	560	1,467	765
1975	1,965	7,477	3,805	572	1,526	782

In this estimate, the long term estimate will be made, starting from 1975 to the future by the actual data of GNP/capita.

The correlation between GNP/capita and its growth rate is assumed to be as in Fig. II-1-6. The correlation between GNP/capita and kWh/capita is also assumed to be as in Fig. II-1-7.

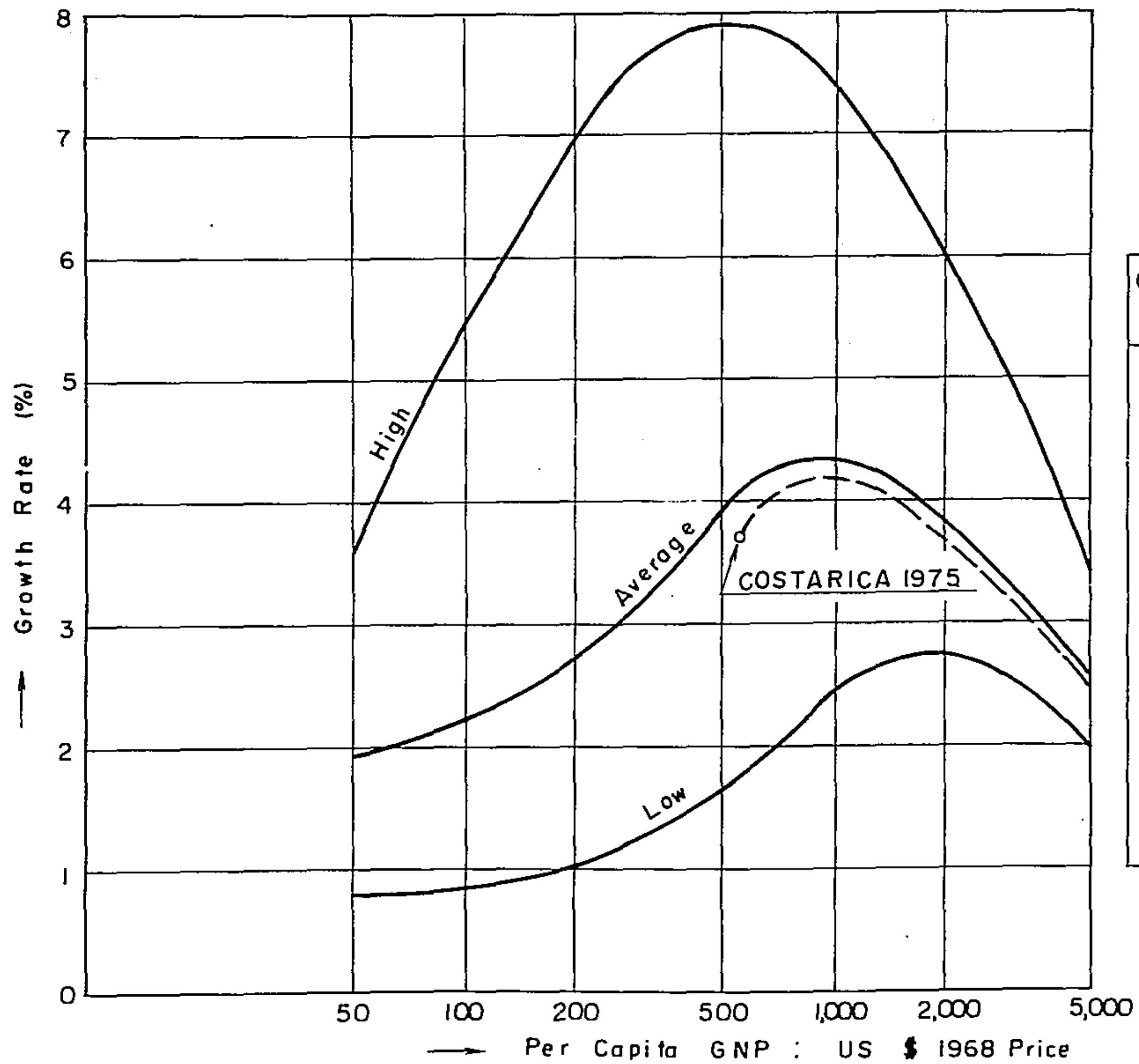
The result of estimate on total generated energy in the country, using these data and anticipated population in Table II-1-5, is shown in Table II-1-7.

Generated energy and maximum power of National Interconnected system are obtained from total generated energy in the country on the basis of the following assumptions.

(a) Energy generated by power plants, which are owned by private industrial enterprises, is assumed to be 4.5 % of total generated energy, according to the actual figures in 1974 and 1975, and it is assumed that this tendency will last in future.
(b) Generated energy in National Interconnected System is assumed to be 95 % of total generated energy by electric power companies according to ICE data.
(c) Annual load factor used to obtain maximum power is the estimated value studied in Item 1.3.4.

The result of the study is shown in Table II-1-8. The comparison of the above result with the estimate from time series tendency method, for the year of 1980, 1985 and 1990 is as follows:

Fig. II-1-6 Correlation Between per Capita GNP and Growth Rate



GNP/Capita (US $)	Growth Rate (%)	Average Growth Rate (%)
572	3.7	
		3.75
600	3.8	
		3.90
700	4.0	
		4.05
800	4.1	
		4.05
900	4.2	
		4.20
1,000	4.2	
		4.05
1,500	3.9	
		3.80
2,000	3.7	

Fig. II-1-7 Correlation Between per Capita GNP and per Capita Energy

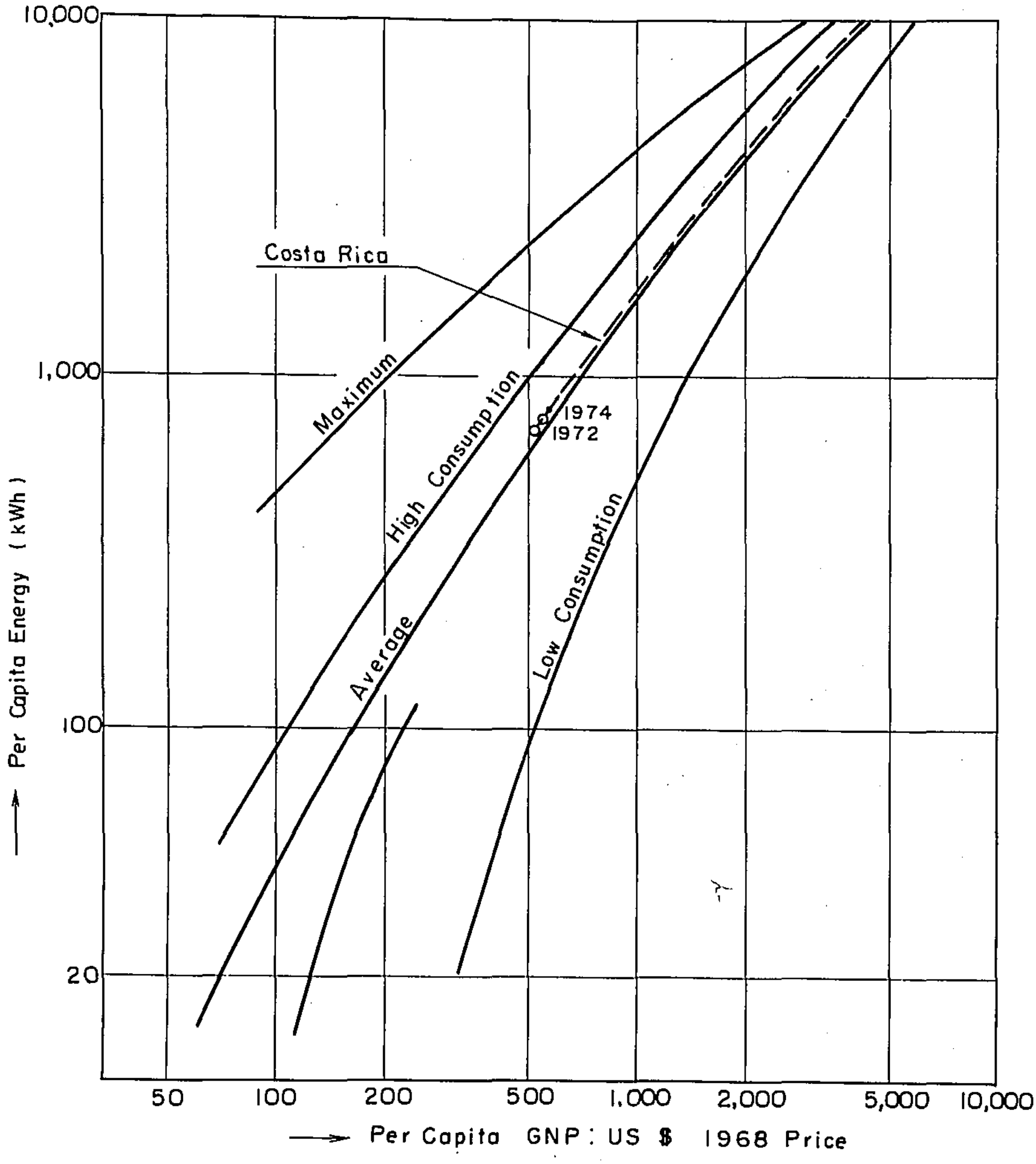


Table II-1-5 Actual and Estimated Population

Year	Population (10^3)	Year	Population (10^3)	Year	Population (10^3)
1967	1,585	1975	1,965	1983	2,374
1968	1,635	1976	2,012	1984	2,429
1969	1,684	1977	2,061	1985	2,485
1970	1,732	1978	2,111	1986	2,541
1971	1,779	1979	2,162	1987	2,598
1972	1,826	1980	2,213	1988	2,656
1973	1,872	1981	2,266	1989	2,715
1974	1,918	1982	2,320	1990	2,776

Note : Data from "Evaluacion del Censo de 1973 y Proyeccion de la Poblacion por sexo y Grupos de Edades 1950-2000".

Table II-1-7 Macro Forecast of Energy

Year	Growth rate of GNP/capita (%)	GNP/capita (Price in 1968) (US $)	kWh/capita (kWh)	Population (10^3)	Generated Energy (GWh)	Increasing rate (%)
1975	3.75	572	810	1,965	1,536	
76	3.75	593		2,012		
77	3.90	616		2,061		6.3
78	3.90	640		2,111		
79	3.90	665		2,162		
1980	4.05	692	940	2,213	2,080	
81	4.05	720		2,266		
82	4.05	749		2,320		8.3
83	4.05	779		2,374		
84	4.05	811		2,429		
85	4.05	844	1,250	2,485	3,106	
86	4.20	879		2,541		
87	4.20	916		2,598		8.7
88	4.20	955		2,656		
89	4.20	995		2,715		
1990	4.05	1,035	1,700	2,776	4,719	

Table II-1-8 Macro Forecast of Energy

Year	Total Energy (GWh)	Energy of self-industries (GWh)	Energy of Suppliers (GWh)	Energy of Interconnected System (GWh)	Annual Load Factor (%)	Maximum Power (MW)
1975	1,536	65	1,471	1,397	58.1	274
76	1,632	73	1,559	1,481	56.8	298
77	1,734	78	1,656	1,573	57.1	314
78	1,842	83	1,759	1,671	57.4	332
79	1,958	88	1,870	1,777	57.7	352
1980	2,070	94	1,986	1,887	58.0	371
81	2,252	101	2,151	2,043	58.2	401
82	2,440	110	2,330	2,214	58.5	432
83	2,642	119	2,523	2,397	58.8	465
84	2,861	129	2,732	2,595	59.1	501
85	3,106	140	2,966	2,818	59.4	542
86	3,376	152	3,224	3,063	59.7	586
87	3,670	165	3,505	3,330	60.0	634
88	3,989	180	3,809	3,619	60.3	685
89	4,336	195	4,141	3,934	60.6	741
1990	4,719	212	4,507	4,282	60.9	803

Year	Estimate by time series (GWh)	Estimate by GNP (GWh)
1980	2,268	1,887
1985	3,082	2,818
1990	4,071	4,282

That is, the load forecast by the time series tendency method is considered to be reasonable.

1.3.3 Daily Load Curve

Examining the past record of daily load curves of the electric power system, it is noted that the ratio of minimum load to the maximum tends to increase. Therefore, a daily load curve in future will be determined by estimating the ratio at each hour of a day from time series tendency curve. An example of a daily load curve in 1976 is shown in Fig. II-1-1 and the estimated daily load curve in future is shown in Fig. II-1-8. The principal figures are shown below.

Item	Year	1966	1975	1986
Min. load (%)	April	26.8	37.0	49.6
	December	28.1	39.4	50.4
Daily load factor (%)	April	61.1	69.2	74.0
	December	61.7	70.3	75.9

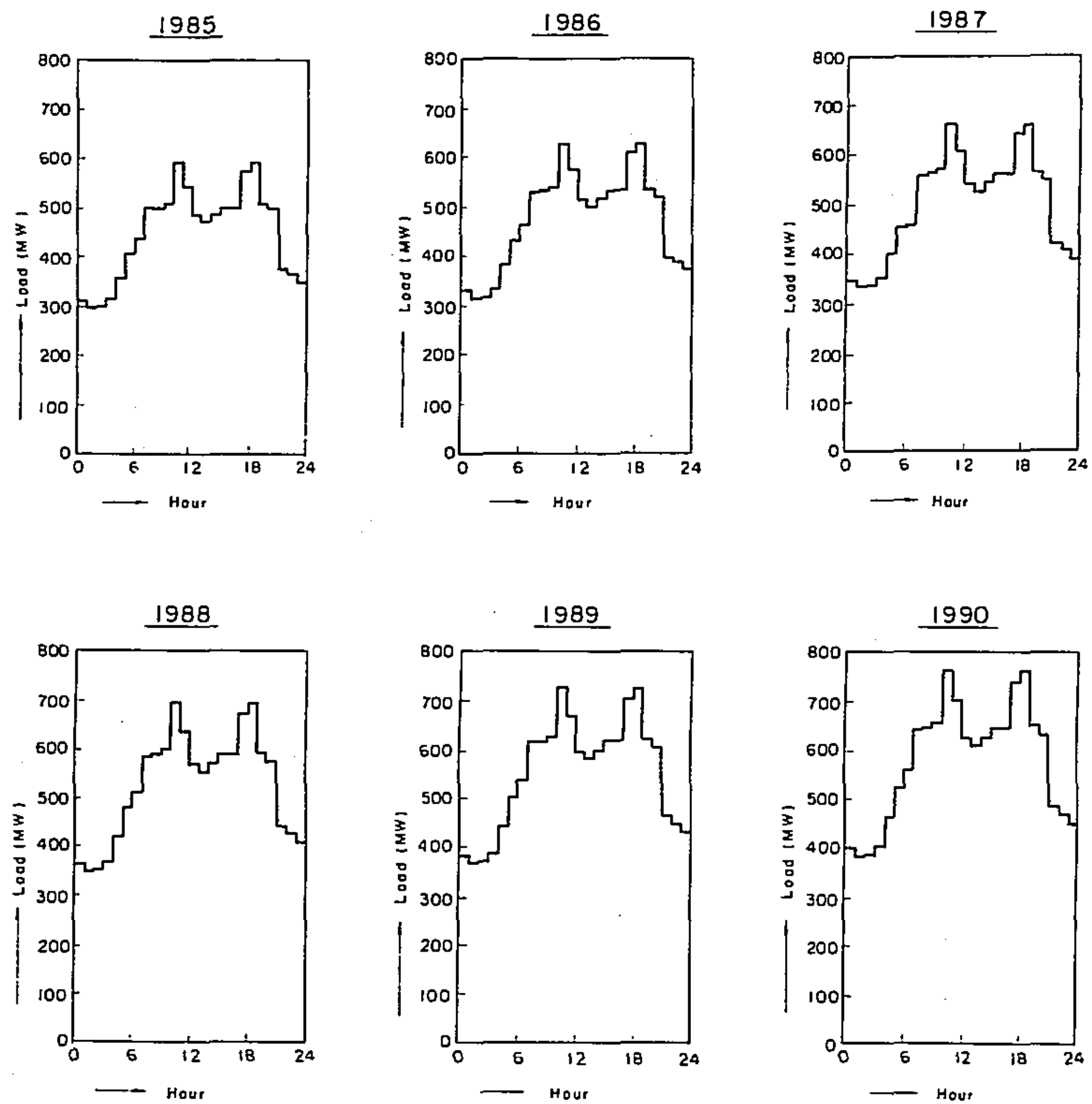
The shape of daily load curve of week-days hardly varies through the year.

Daily load factor has increased moderately up to now. It is supposed that the tendency will last in future taking into account of higher level of the figure in Japan as an example. Furthermore, the fact, that 5-year economic development plan (1975 - 1982) includes measures to discount fare for customers in off-peak hours, especially for industrial demand at midnight, will lead to increase daily load factor.

1.3.4 Annual Load Factor

Since annual load factor is also considered to show upwarding tendency every year, reflecting the improvement in daily load factor. Annual load factor in future is estimated as below on the basis of past actual data.

Fig. II-1-8 Estimated Load Curve



Past Record		Estimates	
Year	Annual load factor (%)	Year	Annual load factor (%)
1966	53.5	1977	57.1
67	52.9	78	57.4
68	55.6	79	57.7
69	55.9	1980	58.0
1970	53.2	81	58.2
71	55.3	82	58.5
72	55.9	83	58.8
73	56.3	84	59.1
74	56.0	85	59.4
75	58.1	86	59.7
		87	60.0
		88	60.3
		89	60.6
		1990	60.9

1.3.5 Monthly Maximum Power

Maximum power is estimated to occur in December on the basis of past actual data. The maximum power in April is also estimated to be 90 % of that in December on basis of actual data as described in following table. These two maximum powers are used for the study of balance of demand and supply.

Year	Maximum Demand (MW)		Ratio (%)
	April	December	April/December
1966	128	135	94.6
67	132	145	90.8
68	148	155	95.5
69	154	168	91.6
1970	177	195	90.6
71	189	212	89.2
72	210	232	90.5
73	228	249	91.4
74	239	271	88.4
75	251	278	90.3
	Average		90.8

1.4 DEMAND AND SUPPLY BALANCE

1.4.1 kW Balance

Those years applied for the study of kW balance will be 1985 - 1990, in order to determine the time when new power source will become necessary after Corobici Power Plant will commences its operation. The study is performed on December when maximum power occurs and on April which is the driest of the year.

Principal premises on the study are as follows:

(1) Generating facilities at present and in near future are shown in Table II-1-1. Among these facilities, thermal plants are regarded to go out of use by obsolecense after 1986 by 10 % equivalent to the capacity in 1985.

(2) It is assumed that when a new power source becomes necessary as demand grows, Guayabo Plant will be installed for the demand.

(3) Daily power and energy supply of hydro-plants will be calculated using average flow of the lowest five days of each month shown in Appendix. Supply capability will be determined in accordance with the shape of load curve and in consideration of above mentioned daily demand.

Supply capability of thermal plants are considered to be equal to its installed capacity.

(4) It is aimed to maintain marginal supply capability more than 10 % of maximum power demand of each month.

(5) Rio Macho Plant will be regarded as a peak load plant until 1986, the previous year when Guayabo Plant will be put into operation, and thereafter as a base-load plant, because the storage capacity of reservoir is rather small.

(6) Arenal Plant and Corobici Plant will be regarded to operate jointly, since the waterway system of these plants are connected.

The daily flow in weekdays will be corrected, since Arenal Plant is provided with a reservoir of large storage capacity, and it will be able to regulate weekly its capability (correction factor: 7/6).

(7) In the study of kW balance, it is assumed that there will be no supply capability from Nicaragua in spite of the existence of an interconnected transmission line between two countries.

The result of study is shown in Table II-1-9 and Fig. II-1-9.

1.4.2 kWh Balance

Annual generated energy will be calculated by the following procedure. As for existing hydro-plants, annual available generated energy calculated by ICE are used, while, for Guayabo Power Plant, annual available generated energy (Table II-5-3) by the team is used.

Table II-1-9 Demand and Supply Balance of Power

(MW)

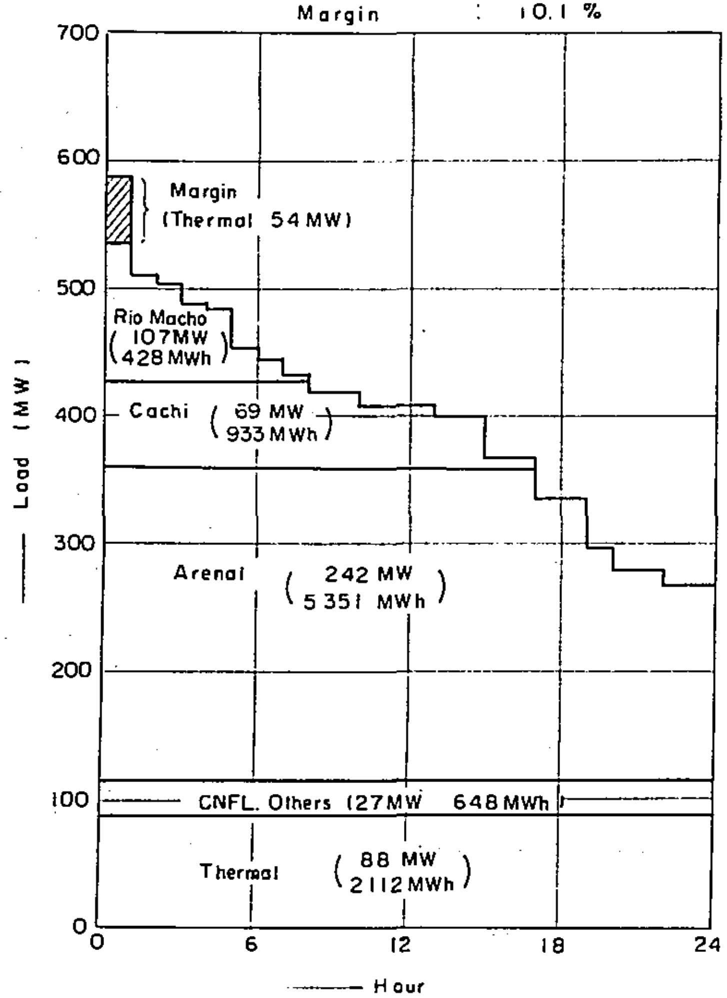
Items	Year / Month	1985 April	1985 December	1986 April	1986 December	1987 April	1987 December	1988 April	1988 December	1989 April	1989 December	1990 April	1990 December
Installed Capacity	Rio Macho	120	120	120	120	120	120	120	120	120	120	120	120
	CNFL. Others	39	39	39	39	39	39	39	39	39	39	39	39
	Cachi	96	96	96	96	96	96	96	96	96	96	96	96
	Arenal-Corobici	342	342	342	342	342	342	342	342	342	342	342	342
	Guayabo	–	–	–	–	60	120	120	120	180	180	180	180
	Siquirres	–	–	–	–	–	–	–	–	–	–	–	–
	(Sub-Total)	(597)	(597)	(597)	(597)	(657)	(717)	(717)	(717)	(777)	(777)	(777)	(777)
	Thermal	142	142	128	128	114	114	99	99	85	85	71	71
	Geo-Thermal	–	–	–	–	–	–	–	–	–	–	40	40
	Total	739	739	725	725	771	831	816	816	862	862	888	888
Supply Capability	Rio Macho	107	120	110	120	44	45	18	45	18	45	18	45
	CNFL. Others	27	63	27	63	27	63	27	63	27	63	27	63
	Cachi	69	96	72	96	96	96	96	96	96	96	96	96
	Arenal-Corobici	242	231	285	284	314	289	328	341	337	332	342	339
	Guayabo	–	–	–	–	60	120	120	120	158	180	164	180
	Siquirres	–	–	–	–	–	–	–	–	–	–	–	–
	(Sub-Total)	(445)	(510)	(494)	(563)	(541)	(613)	(589)	(665)	(636)	(716)	(647)	(723)
	Thermal	142	142	128	128	114	114	99	99	85	85	71	71
	Geo-Thermal	–	–	–	–	–	–	–	–	–	–	40	40
	Total	587	652	622	691	655	727	688	764	721	801	758	834
	Demand	533	592	565	628	595	661	625	694	655	728	687	763
	Marginal Power	54	60	57	63	60	66	63	70	66	73	71	71
	Ratio of Marginal Power (%)	10.1	10.1	10.1	10.0	10.1	10.0	10.1	10.1	10.1	10.0	10.3	9.3

Fig. II-1-9 Balance of kW - Demand

1985

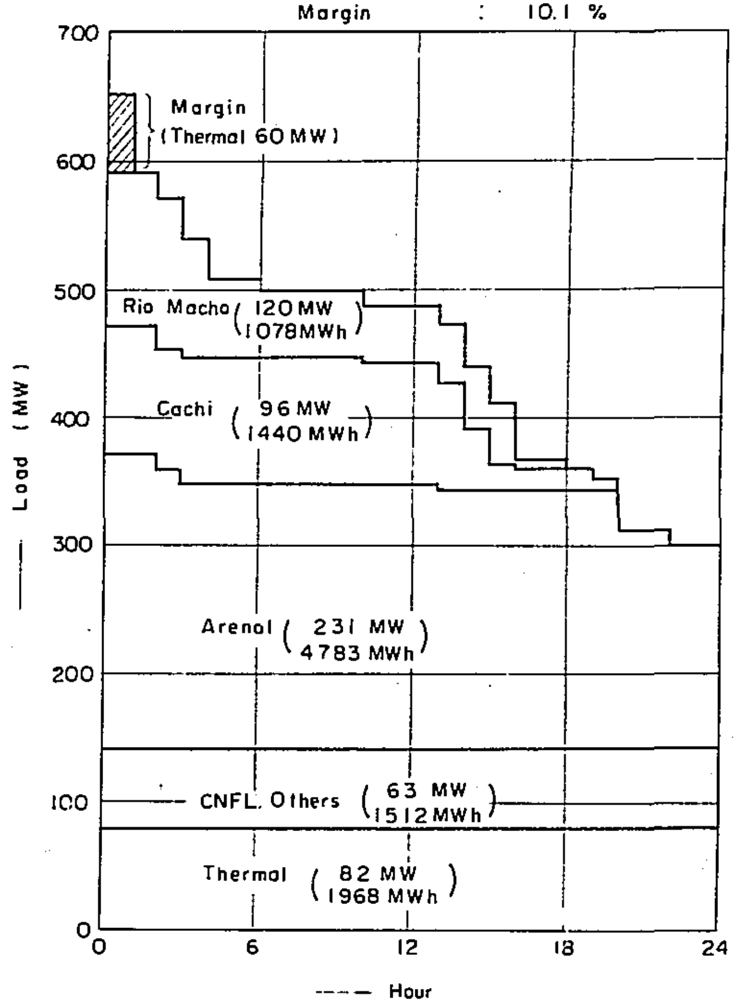
April

Max. Demand	:	533 MW
Daily Energy	:	9.472 MWh
Load Factor	:	74.0 %
Margin	:	10.1 %

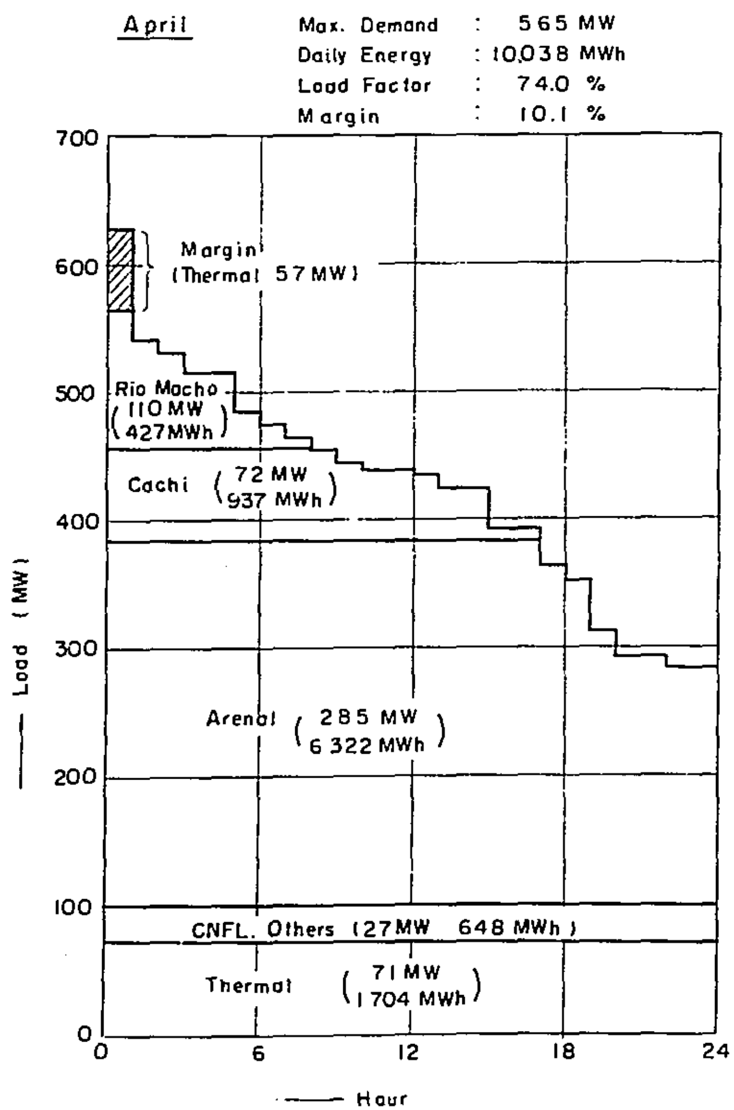


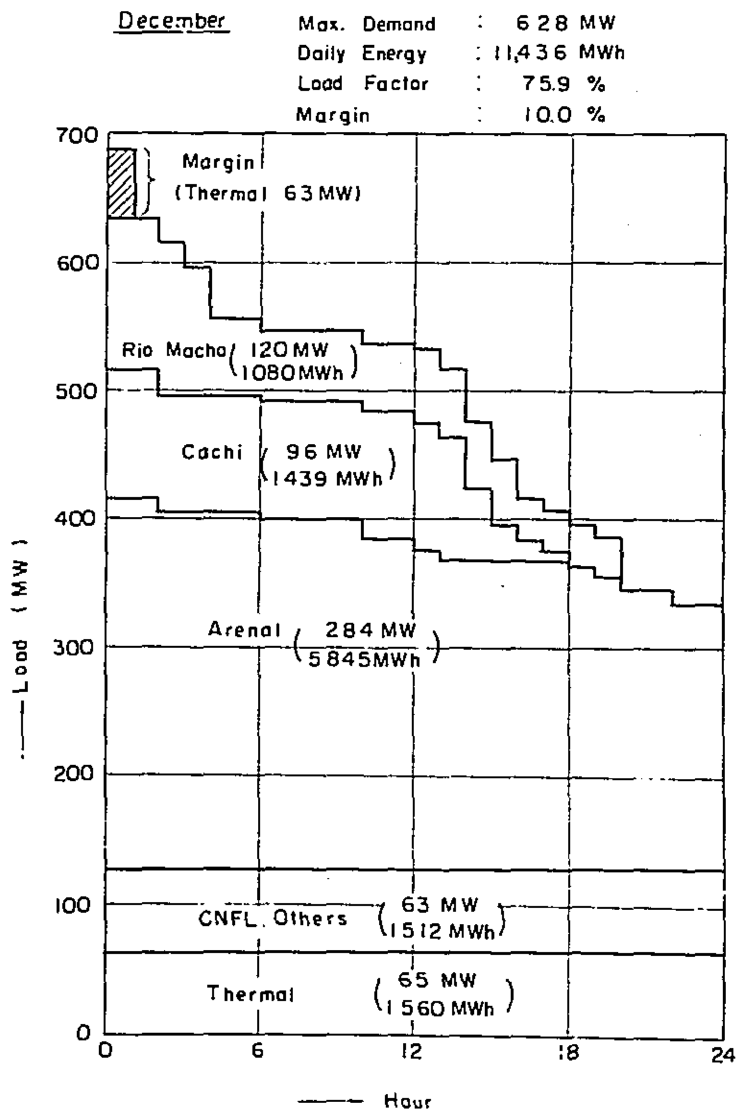
December

Max. Demand	:	592 MW
Daily Energy	:	10,781 MWh
Load Factor	:	75.9 %
Margin	:	10.1 %



1986

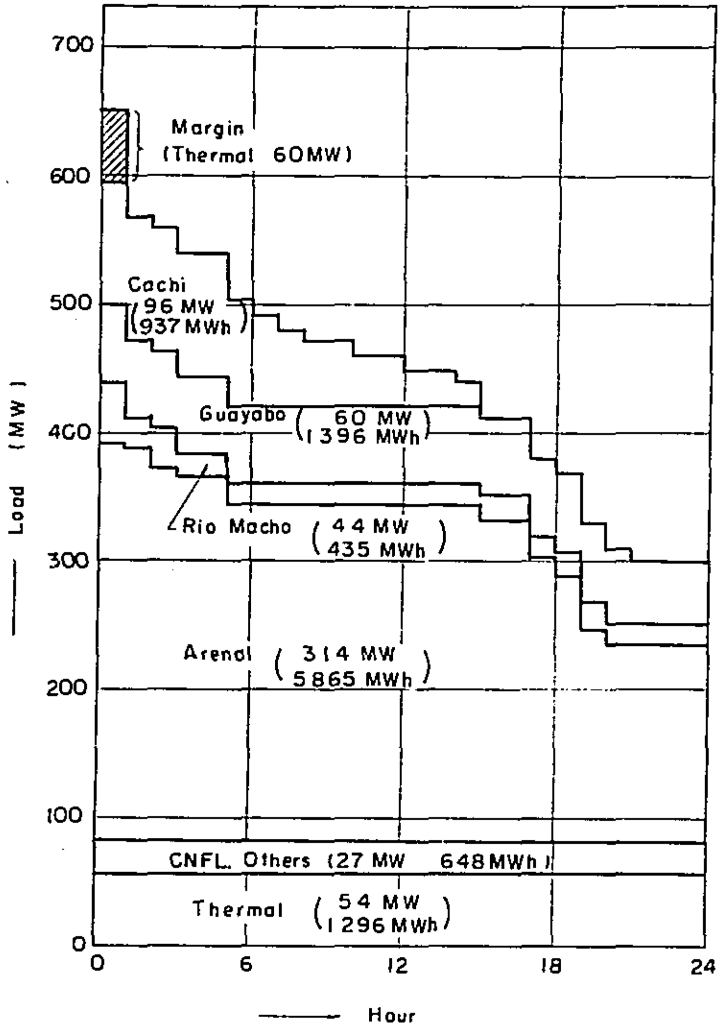

April
Max. Demand : 565 MW
Daily Energy : 10,038 MWh
Load Factor : 74.0 %
Margin : 10.1 %
Margin
(Thermal 57 MW)
Rio Macho
(110 MW
427 MWh)
Cachi (72 MW
937 MWh)
Arenal (285 MW
6 322 MWh)
CNFL. Others (27 MW 648 MWh)
Thermal (71 MW
1 704 MWh)
700
600
500
400
300
200
100
0
Load (MW)
0
6
12
18
24
Hour


December
Max. Demand : 628 MW
Daily Energy : 11,436 MWh
Load Factor : 75.9 %
Margin : 10.0 %
Margin
(Thermal 63 MW)
Rio Macho (120 MW
1080 MWh)
Cachi (96 MW
1439 MWh)
Arenal (284 MW
5 845 MWh)
CNFL. Others (63 MW
1 512 MWh)
Thermal (65 MW
1 560 MWh)
700
600
500
400
300
200
100
0
Load (MW)
0
6
12
18
24
Hour

1987

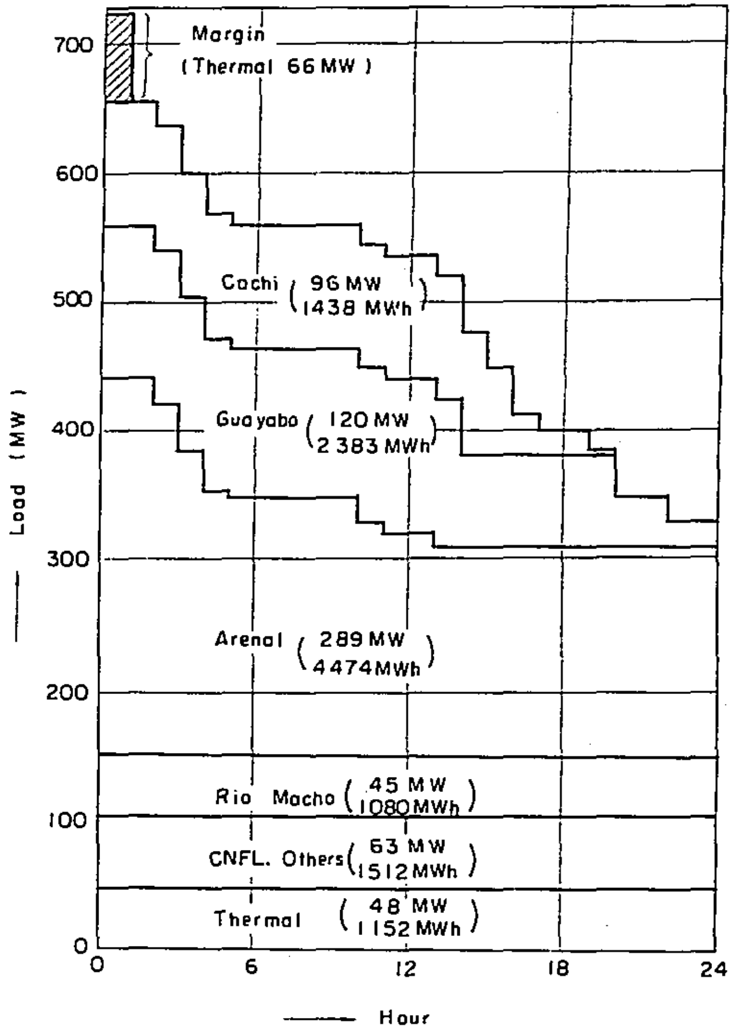
April

Max. Demand : 595 MW
Daily Energy : 10,572 MWh
Load Factor : 74.0 %
Margin : 10.0 %



December

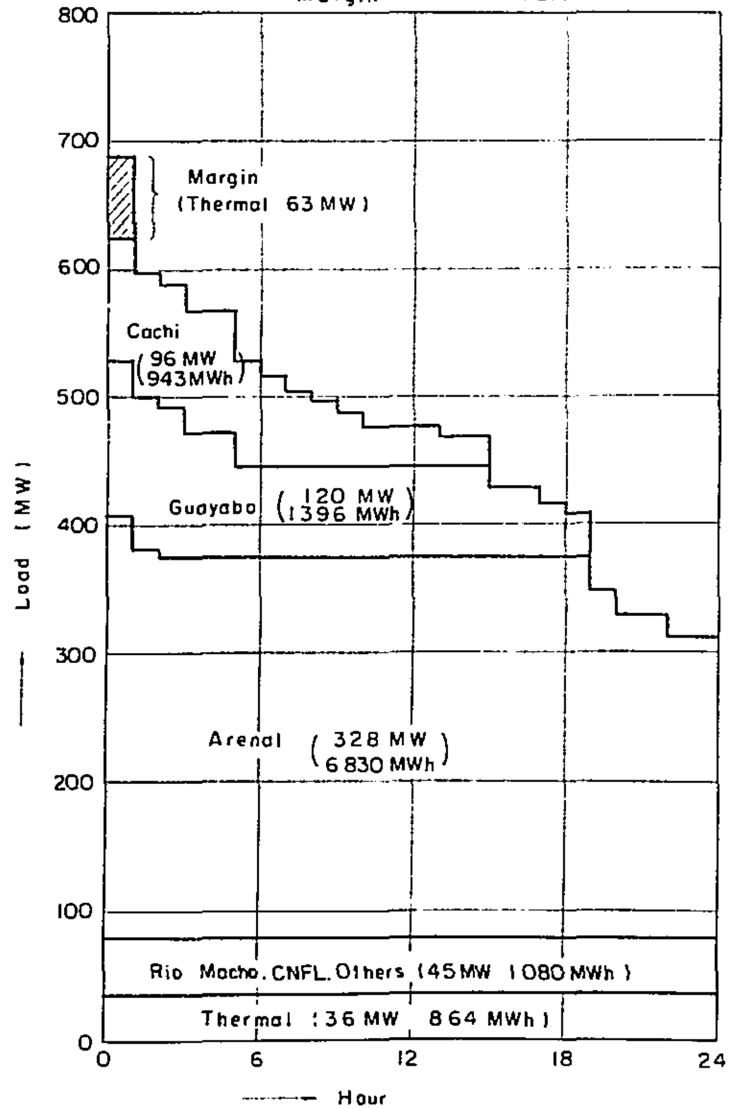
Max. Demand : 661 MW
Daily Energy : 12,039 MWh
Load Factor : 75.9 %
Margin : 10.0 %



1988

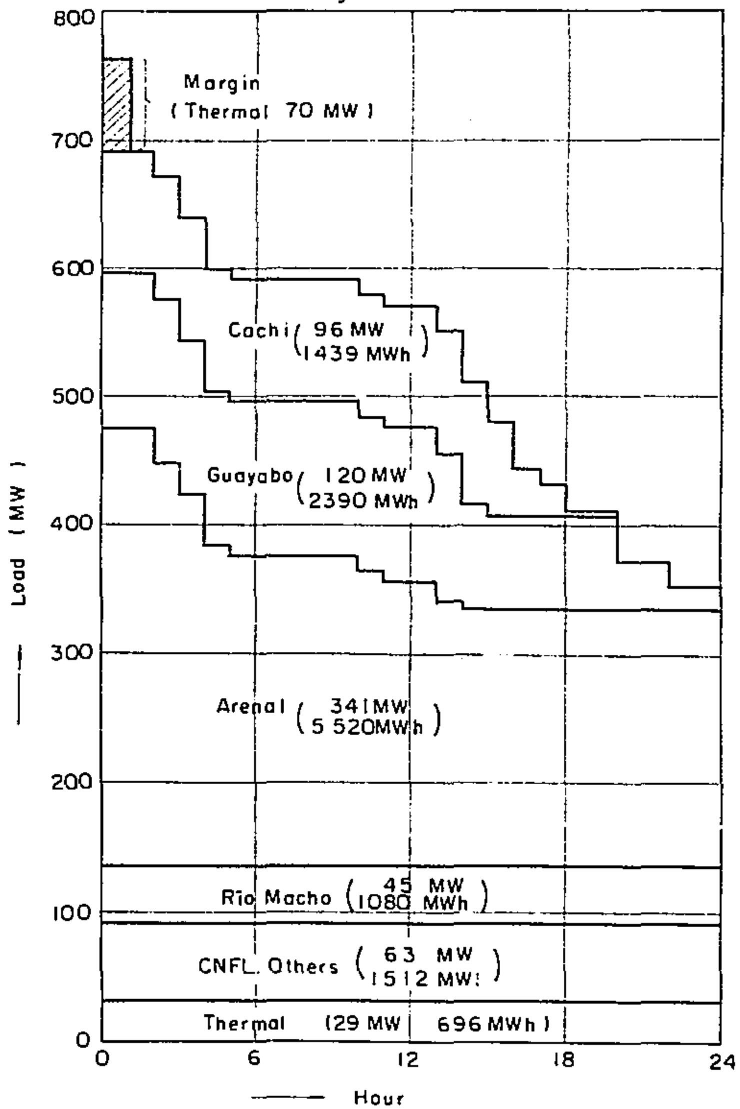
April

Max. Demand : 625 MW
Daily Energy : 11,110 MWh
Load Factor : 74.0 %
Margin : 10.1 %



December

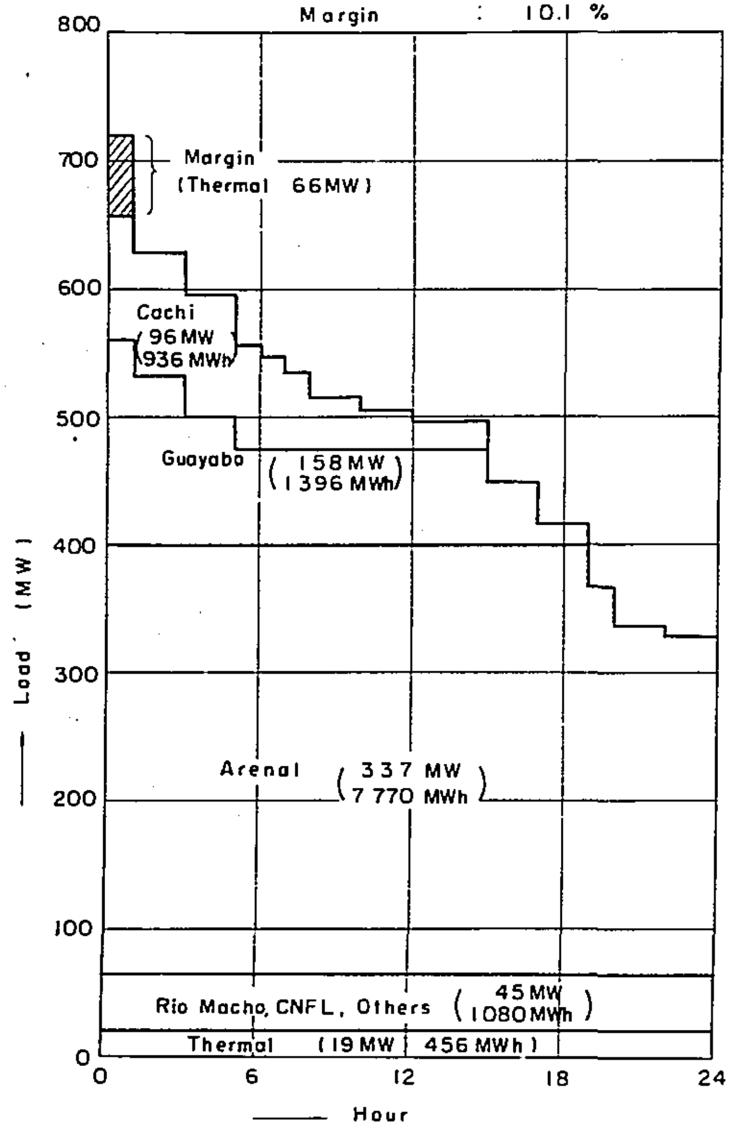
Max. Demand : 694 MW
Daily Energy : 12,637 MWh
Load Factor : 75.9 %
Margin : 10.0 %



1989

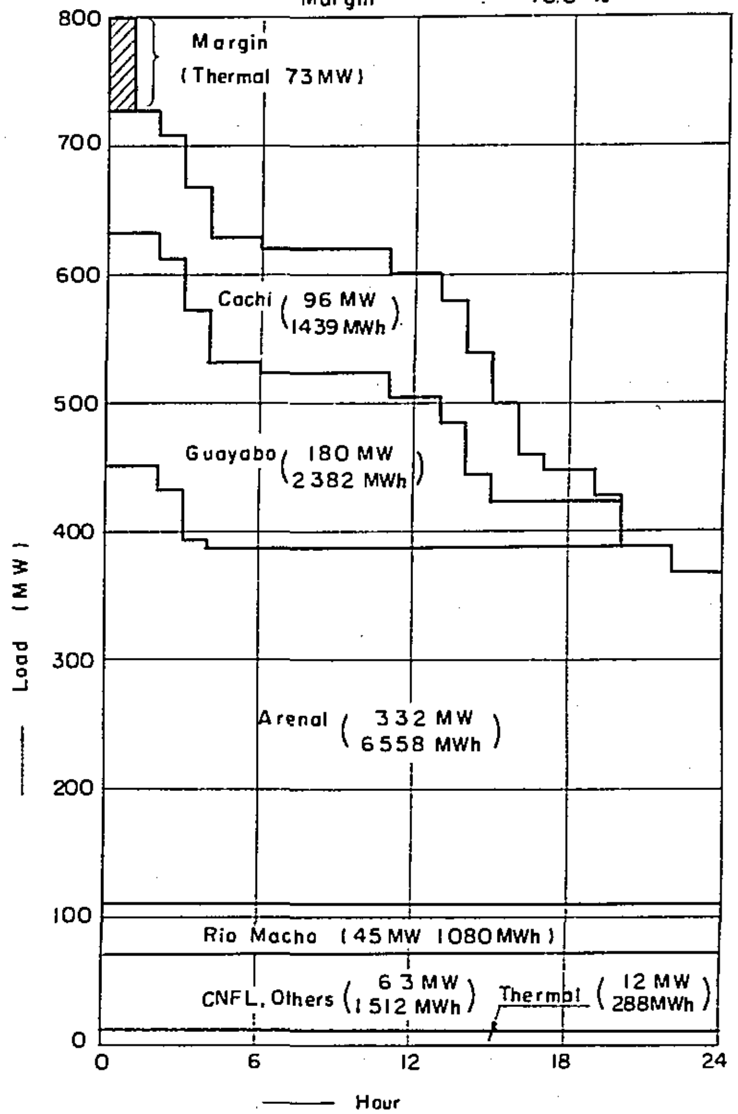
April

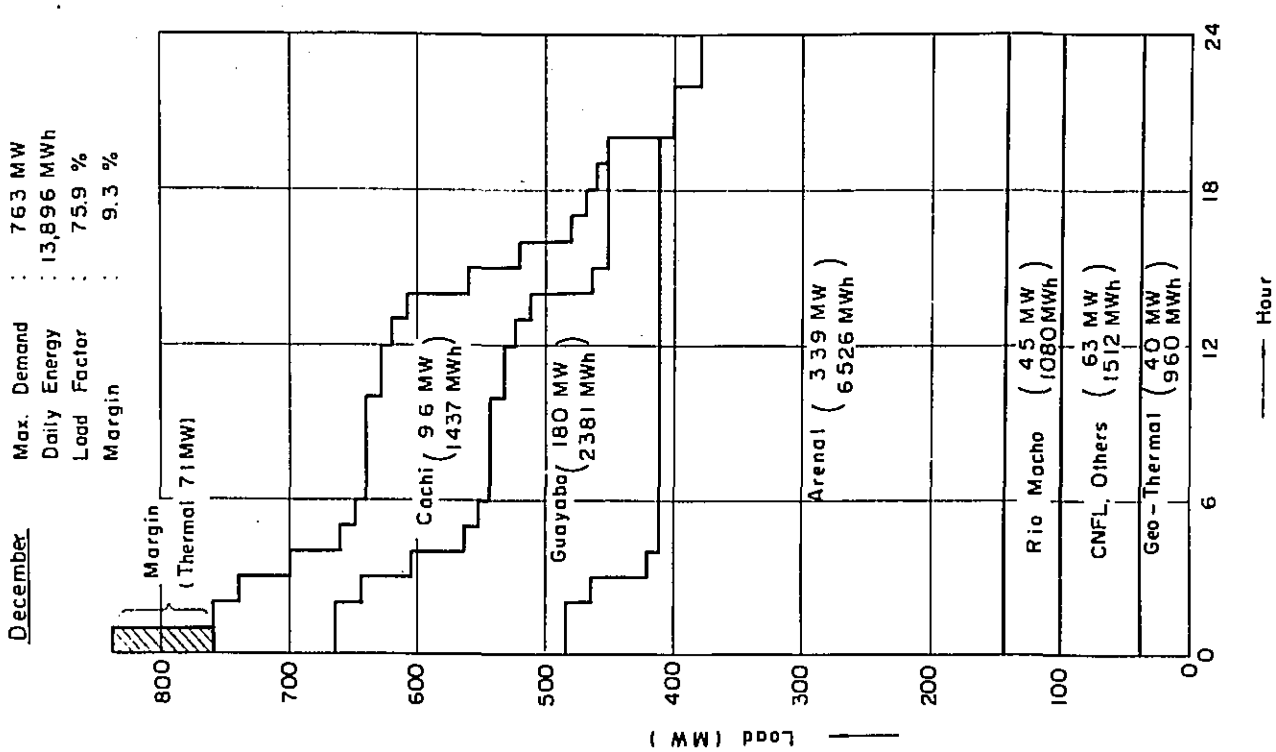
Max. Demand	:	655 MW
Daily Energy	:	11,641 MWh
Load Factor	:	74.0 %
Margin	:	10.1 %

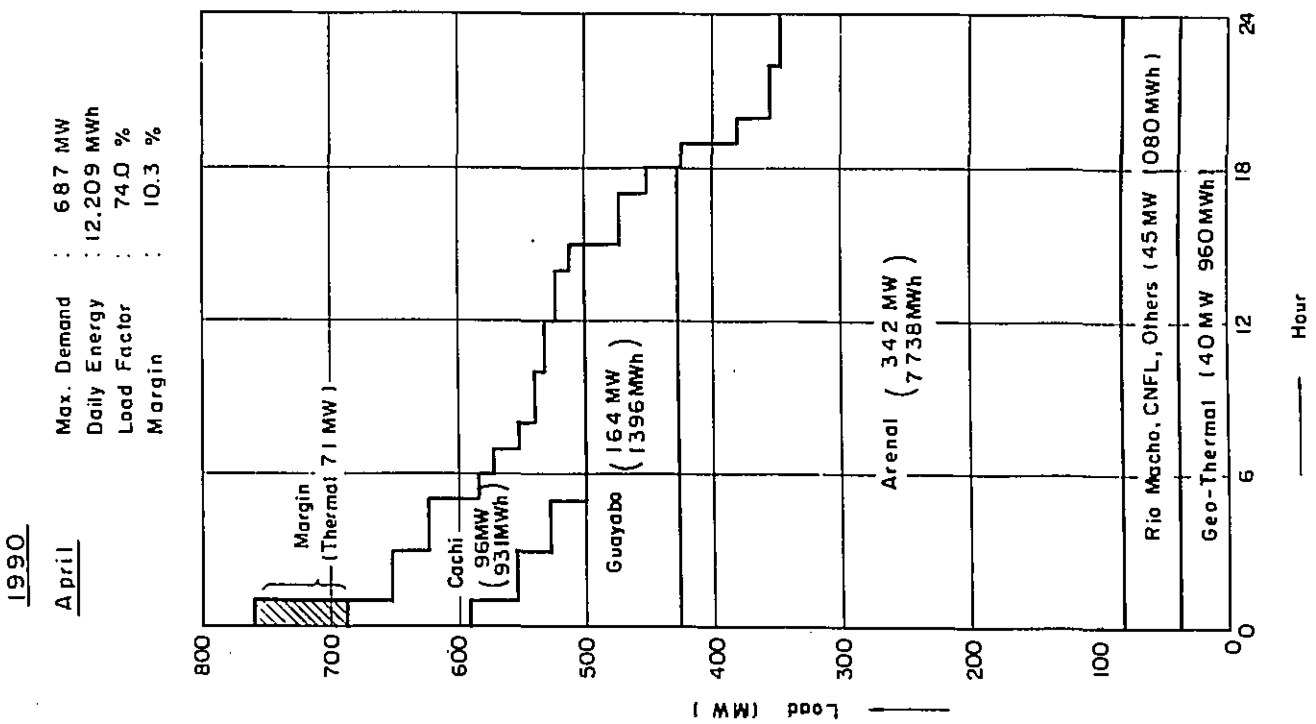


December

Max. Demand	:	728 MW
Daily Energy	:	13,259 MWh
Load Factor	:	75.9 %
Margin	:	10.0 %




December
Max. Demand : 763 MW
Daily Energy : 13,896 MWh
Load Factor : 75.9 %
Margin : 9.3 %
Margin (Thermal 71 MW)
Cachi (96 MW 1437 MWh)
Guayabo (180 MW 2381 MWh)
Arenal (339 MW 6526 MWh)
Rio Macho (45 MW 1080 MWh)
CNFL, Others (63 MW 1512 MWh)
Geo-Thermal (40 MW 960 MWh)
Load (MW)
Hour
0
100
200
300
400
500
600
700
800
6
12
18
24


1990
April
Max. Demand : 687 MW
Daily Energy : 12.209 MWh
Load Factor : 74.0 %
Margin : 10.3 %
Margin (Thermal 71 MW)
Cachi (96MW 931MWh)
Guayabo (164 MW 1396 MWh)
Arenal (342 MW 7738 MWh)
Rio Macho, CNFL, Others (45 MW 1080 MWh)
Geo-Thermal (40 MW 960 MWh)
Load (MW)
Hour
0
100
200
300
400
500
600
700
800
6
12
18
24

Thermal plants will be assumed to supplement the shortage, only after annual energy demand is supplied by generated energy of hydro-plants. In addition, thermal plants are considered to operate supplementally, equivalent to 5 % of annual utilization factor of the facilities, even when total generated energy of hydro-plants will exceed annual energy demand, i.e., even in case surplus energy by hydro-plants will be expected to occur.

The results are shown in Table II-1-10.

1.5 TIMING OF DEVELOPMENT

Judging from the results of study on kW balance shown in Table II-1-9, it will be concluded that the shortage of supply capability in the power system will occur in 1987 and a new power source should be put into operation.

In order to fulfill the shortage of capability, Guayabo Power Plant could take the place of the new power source.

As for the results of study on kWh balance, the capacity of generated energy from Guayabo Plant will be so large in comparison with annual energy demand in the year of 1987 that the commencement of operation of the 3 units will be made stepwise in accordance with the increase of power demand, to be started in February and July 1987, and February 1989.

In April 1990, kW balance will be supposedly maintained by putting a geothermal plant into the system (See Table II-1-9). It is anticipated, however, that development of a new power source will again become necessary for kW balance in 1991. On the other hand, the results of kWh balance shows Guayabo Power Plant will generate a considerable amount of surplus energy in a few years since the start of operation in 1987.

Both outline programme of electric power development and estimated maximum power demand until 1990 are shown in Fig. II-1-10.

Table II-1-10 Demand and Supply Balance of Annual Energy

(Unit. GWh)

	Year	1985	1986	1987	1988	1989	1990
Hydro	Rio Macho	658	3,245	3,245	3,245	3,245	3,245
	Garita	194					
	CNFL, Others	288					
	Cachi	701					
	Arenal-Corobici	1,404					
	Guayabo	—	—	739	931	1,182	1,192
	(Sub - total)	(3,245)	(3,245)	(3,984)	(4,176)	(4,427)	(4,437)
	Thermal	62	56	50	43	37	31
	Geo thermal	—	—				280
	Total	3,307	3,301	4,034	4,219	4,464	4,748
Annual Energy Demand		3,082	3,289	3,475	3,665	3,865	4,071
Surplus Energy		225	12	559	554	599	677

Fig. II-1-10 Maximum Power Demand and Installed Capacity

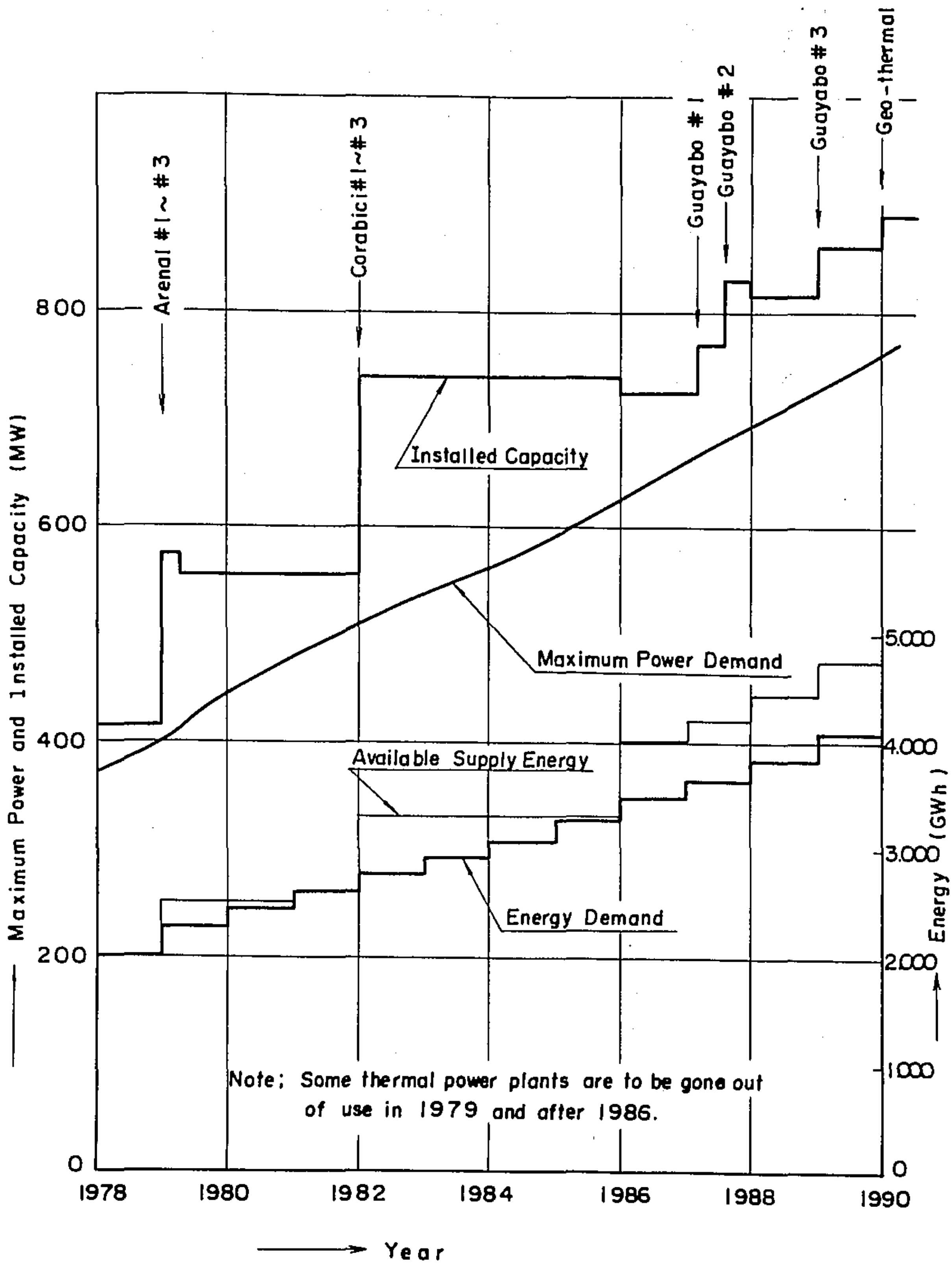


Table II-1-11 Installation Date of Thermal Power Plants

Year	Power Plant	Unit Number	Capacity (kW)
1954	San Antonio	1 , 2	10,000
1956	Colima	1 ~ 4	11,896
1962	Colima	5 , 6	7,660
1963	Liberia	2 , 3	976
1967	Liberia	1 , 4	976
1967	Limon	1 ~ 4	8,000
1968	Liberia	5	488
1969	Santa Cruz	3	300
1972	San Isidro	8	200
1972	Limon	5 ~ 7	3,000
1972	Siquirres	3	300
1973	San Antonio (G)	3 , 4	38,100
1973	Santa Cruz	6	1,000
1973	San Isidro	6	300
1973	San Isidro	8	1,000
1973	Limon	8 , 9	2,000
1974	Barranca (G)	1 , 2	41,600
1974	Siquirres	1	500
1974	Siquirres	10 , 11	2,000
1975	Siquirres	2	500
1976	San Isidro	1	300
1977	Moin		30,000

Note: the source is "SISTEMA INTERCONECTADO CARACTERISTICAS DE PLANTAS TERMOELECTRICAS EN SERVICIO"

CHAPTER 2

PLAN OF DEVELOPMENT

CHAPTER 2 PLAN OF DEVELOPMENT

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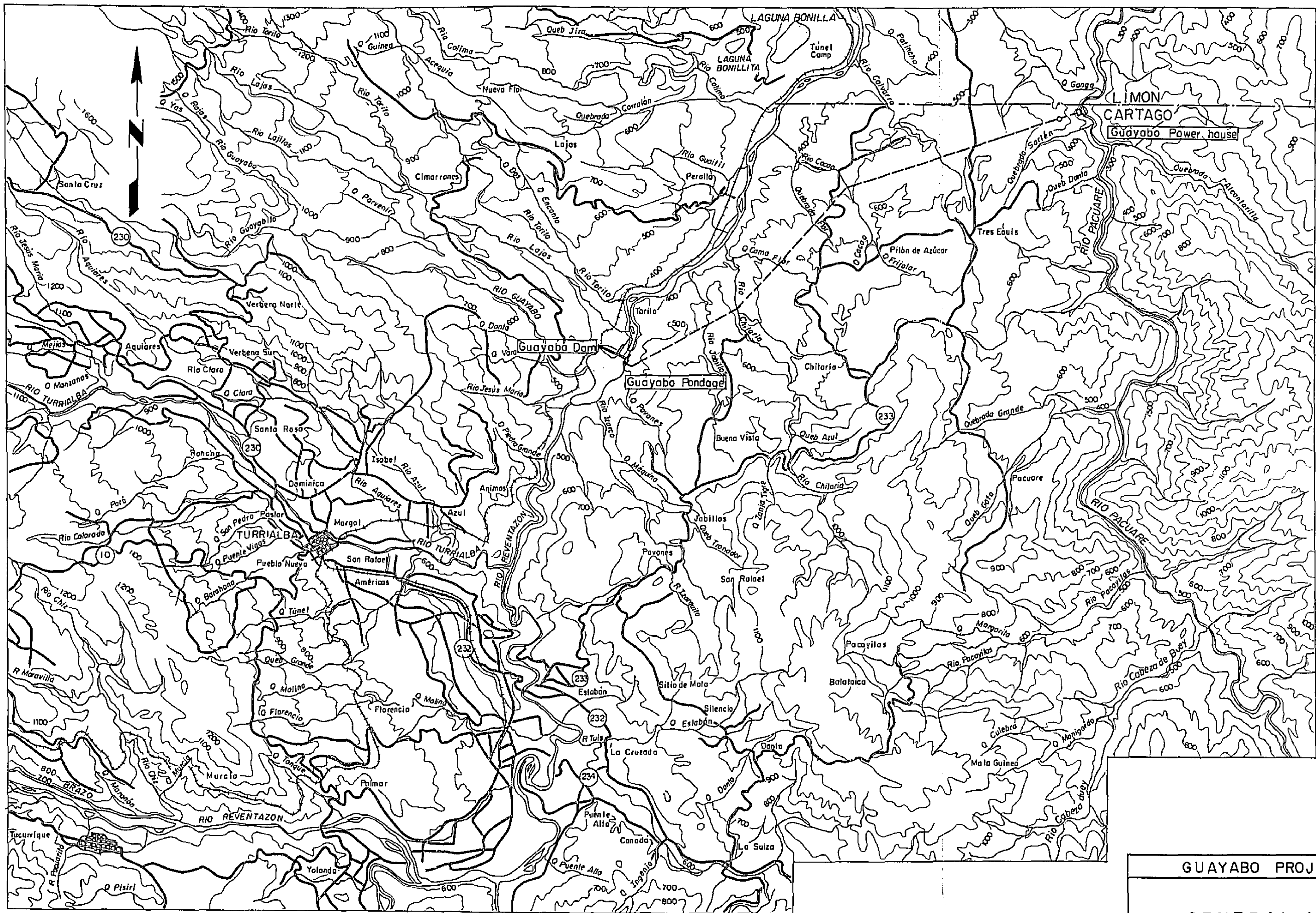
Table II-2-1 General Description of Project

Item	Units	Description	Remarks
Type of Power Generation		Diversion and On-Stream Pondage Type	
Catchment Area	km^2	1518	
Pondage and Dam			
Annual Inflow	10^6m^3	4046	$128 m^3/sec$ (Average)
Annual Power Discharge	10^6m^3	3296	$105 m^3/sec$ (Average)
Pondage			
Normal Water Level	m	430	
Water Surface Area	km^2	0.512	
Total Storage Capacity	10^6m^3	4.49	
Effective Storage Capacity	10^6m^3	3.29	
Drawdown	m	10.0	
Dam			
Type	–	Combined Dam (Gravel Fill, Concrete Gravity)	
Hight × Crest Length	m	38.0 × 655.0	
Volume	10^3m^3	564 (G.F), 198 (C.G.)	
Waterway (Tunnel)			
Headrace (Dia × Length)	m	6.5 × 9,582	
Power Production			
Standard Effective Head	m	155.0	
Standard Water Level	m	425.0	
Tailwater Level	m	246.0	
Power Discharge			
Maximum	m3/sec	140.0	
Firm	m^3/sec	45.0(Apr.) 77.3(Dec.) See Section 5.2 Chapter 5	
Output			
Installed Capacity	MW	180	
Firm Capacity	MW	158(Apr.) 180(Dec.) 59 MW Continuous	
Annual Energy Production	10^6kWh	1,192	
Transmission Line			
Section	–	Power Plant-South Substation of San Jose	
Distance	km	60	
Voltage	kV(cct)	230 (2)	
Construction Cost			
Generation Facilities	10^6 ₡	1980	₡ : Colones
Transmission Line & Others	10^6 ₡	150	
Total Construction Cost	10^6 ₡	2130	
Economic Analyses			
Cost of Energy	₡/kWh	0.211	
Benefit Cost Ratio	–	1.18	
Annual Surplus Benefit	10^6 ₡	44.3	



Scale : 1: 50,000

1000 500 0 1000 2000 3000 4000m

GUAYABO PROJECT

GENERAL MAP

DWG. NO. II - 1 | MARCH 1978

CHAPTER 2 PLAN OF DEVELOPMENT

2.1 LOCATION AND OUTLINE OF PROJECT AREA

2.1.1 Location of Project Area

Guayabo Project will have a dam with a pondage in the middle of Reventazon river. The in-flows into the pondage with a catchment area 1,518 km^2 will be led into the middle of a neighboring river, the Pacuare, by means of a headrace tunnel, and be used to generate electric power. The dam and the regulating pondage will be located at 90°56' N.L. and 83°33' W.L. about 30 km northeast of Cartago City in the Province of Cartago. The Power Plant will be located at 9°49' N.L. and 83°33' W.L. about 40 km from Cartago City.

2.1.2 Outline of Project Area

Costa Rica could be divided into the Pacific and the Atlantic coastal areas by a narrow strip of mountaineous area which runs through the central part of the country.

The mountaineous area is composed of mountain ranges such as Talamanca, Central, Tilaran. The Talmanca range has peaks with altitudes of over 3,000 meters, as represented by Mt. Chirripo (altitude 3,819 m above sea level).

The Reventazon river is one of the large rivers pouring into the Caribbean Sea. It originates in the northern part of Mt. Cuerici (altitude 3,394 m above sea level) in the Talamanca mountains which are situated on the border between the Provinces of Cartago and San Jose. It extends about 170 km from origin to rivermouth with about 2,950 km^2 of catchment area.

The uppermost tributary of Reventazon river is Grande de Orosi river, which flows north, where it joins Macho river to form Reventazon river. The river then flows into the Cachi reservoir and heads in a westerly direction in the neighborhood of the Cachi Power Station, after which it joins Pejibaye river, another major tributary of Reventazon river.

Then, the river course turns north at an angle of almost 90 degrees and rools in the wide valleys which lie along the mild-sloped foot-hills of Turrialba volcano, reaching Guayabo dam site. From this point downstream, the river expands its width steadily. It flows out of the mountains and enters into the plains at a point about 25 km downstream from the dam site. It runs farther about 45 km downstream merging with Parismina river, and pours at 5 km into the Caribbean Sea.

The slope of river bed is 1/50 in the upstream of the confluence, where Macho river is met, in the neighborhood of the Cachi Power Plant, 1/75 at Guayabo dam site in the middle of the river system and 1/2,100 in the downstream of the dam site where the river flows through the plains.

The catchment area of Reventazon river is one of areas where the heaviest rainfalls are recorded in Costa Rica. The rainfalls in the catchment area vary widely depending upon places, with some having an annual average of 8,000 mm of precipitation. In the town of Turrialba close to Guayabo Project, rainfalls reach 2,700 mm a year. With rainfalls concentrated on the May-December period, the period from January to April constitutes what is called a dry season while the rest of the year forms a rainy season.

The temperature is mild throughout the year, which average about 22°C in the town of Turrialba (altitude about 600 m above sea level).

Geological foundation of the Project area is mainly of oceanic clastic rocks consisted of mudstones and sandstones. The foundation is covered with volcanic rocks distributed in the quaternary period on the left bank of the river and with agglomerates distributed in the end of tertiary period on the right bank.

Various permanent structures of Guayabo Project will be mostly to be designed on the mudstones or sandstones which are the foundation of the area.

2.2 PRESENT SITUATION OF DEVELOPMENT IN REVENTAZON RIVER

Along Reventazon River, there are existing Rio Macho and Cachi Power Plant Rio Macho Power Plant is located in the uppermost part of the river system of the Reventazon river and takes in-flows from the main stream and Macho river, a tributary, supplying the 90 MW power produced from a head between the intake level (altitude 1,570 m above sea level) and the tailrace level (altitude 1,100 m). A power unit is being added, which is now under construction, and after the completion of the work, the power supply capacity will be increased to 120 MW. Cachi Power Plant is located downstream of Rio Macho Power Plant and makes use of the in-flow from the mainstream of the Reventazon river, supplying the capacity of 64 MW by utilizing a head between the intake level of EL 990 m and the tailrace level of EL 702 m. Cachi Power Plant is the only existing power station with a reservoir in Costa Rica. It is being expanded to increase the output capacity to 96 MW.

2.3 OUTLINE OF PROJECT

2.3.1 Plan of Power Generation

Guayabo Project will envision construction of a dam, 38 m high, in the mainstream of Reventazon, with a regulating pondage. Effective storage capacity will be about 3 million m^3, which will be subjected to regulation on a daily basis.

Water from this regulating pondage will be conduced to a power plant on the left bank of Pacuare river by way of a headrace tunnel, a distance of about 10 km, and discharged into Pacuare river after power generation.

The power plant will have an effective head of 155 m with the maximum power discharge 140 m^3/sec, which will produce a maximum power output of 180 MW and an annual available energy of 1,192 million kWh. There will be three units of turbines/generators. A general description of the Guayabo Plant is shown in Table II-2-1.

Guayabo dam will be a combined dam of a gravelfill type and a concrete gravity type. The dam will be 38.0 m high with a crest length 655.0 m.

The concrete gravity dam will have a spillway facility and a sediment control outlet.

The intake will be provided for the entrance of headrace tunnel in the right bank immediately upstream of the dam and be capable of taking in-flows in the maximum capacity of 140.0 m^3/sec.

The headrace tunnel will be 9,582 m long with 6.5 m diameter lined with concrete. A pressure tunnel of concrete lining will be designed for the maximum power discharge of 140.0 m^3/sec.

The surge tank will be of orifice type with an inner diameter 10.0 m and a height 75 m. It has an upper water chamber and a lower water chamber.

A penstock will be laid on the ground. It will have an inner diameter of 6.5 m to 5 m until it will reach a point immediately before Power Plant, where it will be branched into three pipes. The total length will be 465.0 m.

The power plant will be an on-the-ground type with (L) 62.0 m x (W) 28.0 m x (H) 32.0 m. Power plant will be equipped with three units of 66 MW turbines and 78 MVA generators.

2.3.2 Transmission Line, Substation and Communication System

The power generated by Guayabo Power Plant will be stepped up to 230 kV at an outdoor substation near Power Plant, then it will be transmitted to South Substation of San Jose by way of a 60 km transmission line with two circuits to be proposed in this study. South Substation of San Jose will be equipped with three units of step-down transformers by the time Guayabo Power Plant becomes in operation. Through those transformers the electricity will be sent with 34.5 kV transmission line to demand areas.

A set of 230 kV line maintenance facilities and equipment has been designed to be built between the Guayabo Power Plant and South Substation of San Jose. These include:

A load dispatching telephone circuit and line protection relaying system consisting of power line carrier equipment; fault locator for 230 kV transmission lines; and dam water level monitoring telemeters, which will be used for maintenance and operation of 230 kV transmission lines and Guayabo Power Plant.

A system diagram of the transmission lines is shown in Fig. II-2-1. A transmission line route diagram is shown in Fig. II-2-2.

Fig. II-2-1 OUTLINE OF TRANSMISSION LINES

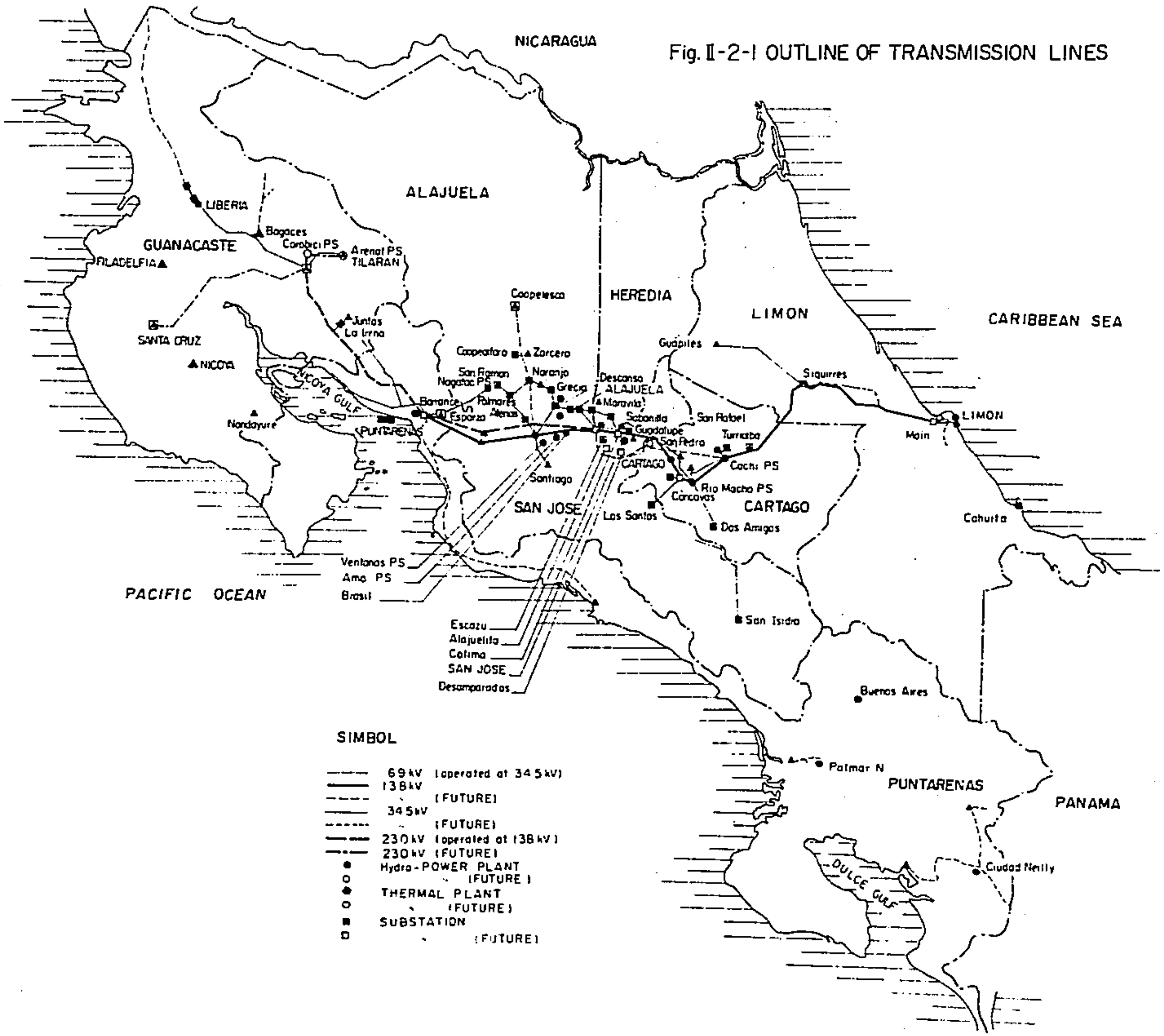
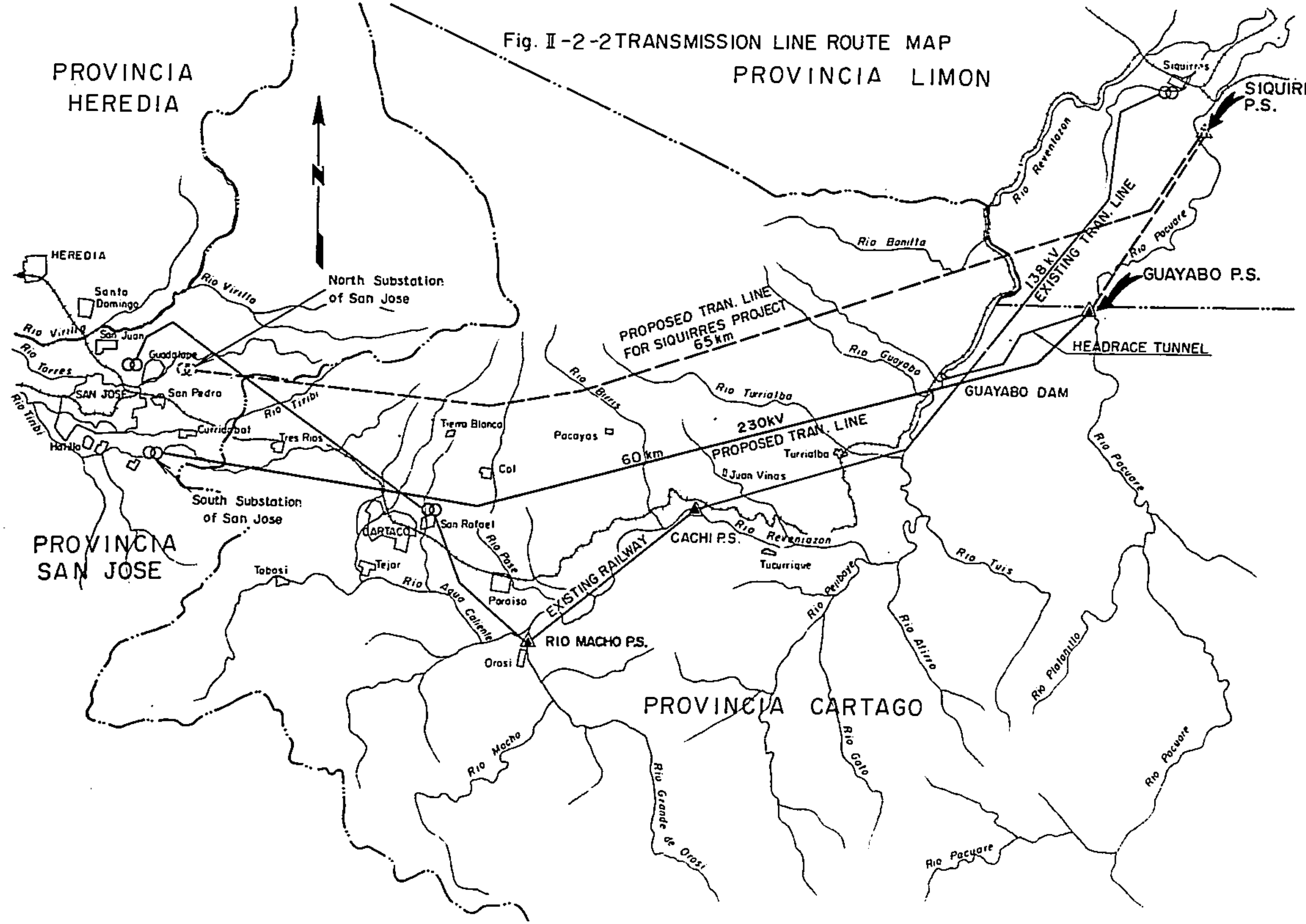


Fig. II-2-2 TRANSMISSION LINE ROUTE MAP



CHAPTER 3

HYDROLOGY

CHAPTER 3 HYDROLOGY

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CHAPTER 3 HYDROLOGY

3.1 GENERAL DESCRIPTION OF METEOROLOGY AND HYDROLOGY IN PROJECT AREA

In the area of Guayabo Project, the annual average temperature is approximately 22 degrees centigrade and the annual amount of rainfall is approximately 2,700mm. At Guayabo Dam site the annual in-flow is 4,046 million m^3 and the annual average run-off is 128 m^3/sec. The run-off decreases from January to May, and it tends to increase between June and December. The average run-off from January to May is 82 m^3/sec, and from June to December is 161 m^3/sec. The monthly average precipitation in the basin is 148mm from January to May and 277mm between June and December.

3.2 RUN-OFF GAUGING STATION AND METEOROLOGICAL GAUGING STATION

In the basin of the Guayabo Project and the sourrounding area, there are many run-off gauging stations and meteorological gauging stations.

Fig. II-3-1 shows the locations. The period of record for which the stations have recorded is indidicated in Tables II-3-1 and II-3-2. Among these the Angostura gauging station is assumed to be a representative station for Guayabo Project.

3.3 ESTIMATION OF RUN-OFF AT DAM SITE

3.3.1 Catchment Area of Dam Site

The total catchment area of the Reventazon River is approximately 2,800 km^2 and that of Guayabo site is 1,518 km^2. The numerical value is calculated from a topographical map with a scale of 1/50,000.

The catchment area of the Reventazon River is shown in Fig. II-3-2.

3.3.2 Representative Gauging Station

Angostura run-off gauging station is appropriate for the representative station for Guayabo Project, since it is situated comparatively near the point of project site and has collected the data of the daily run-off for 23 years.

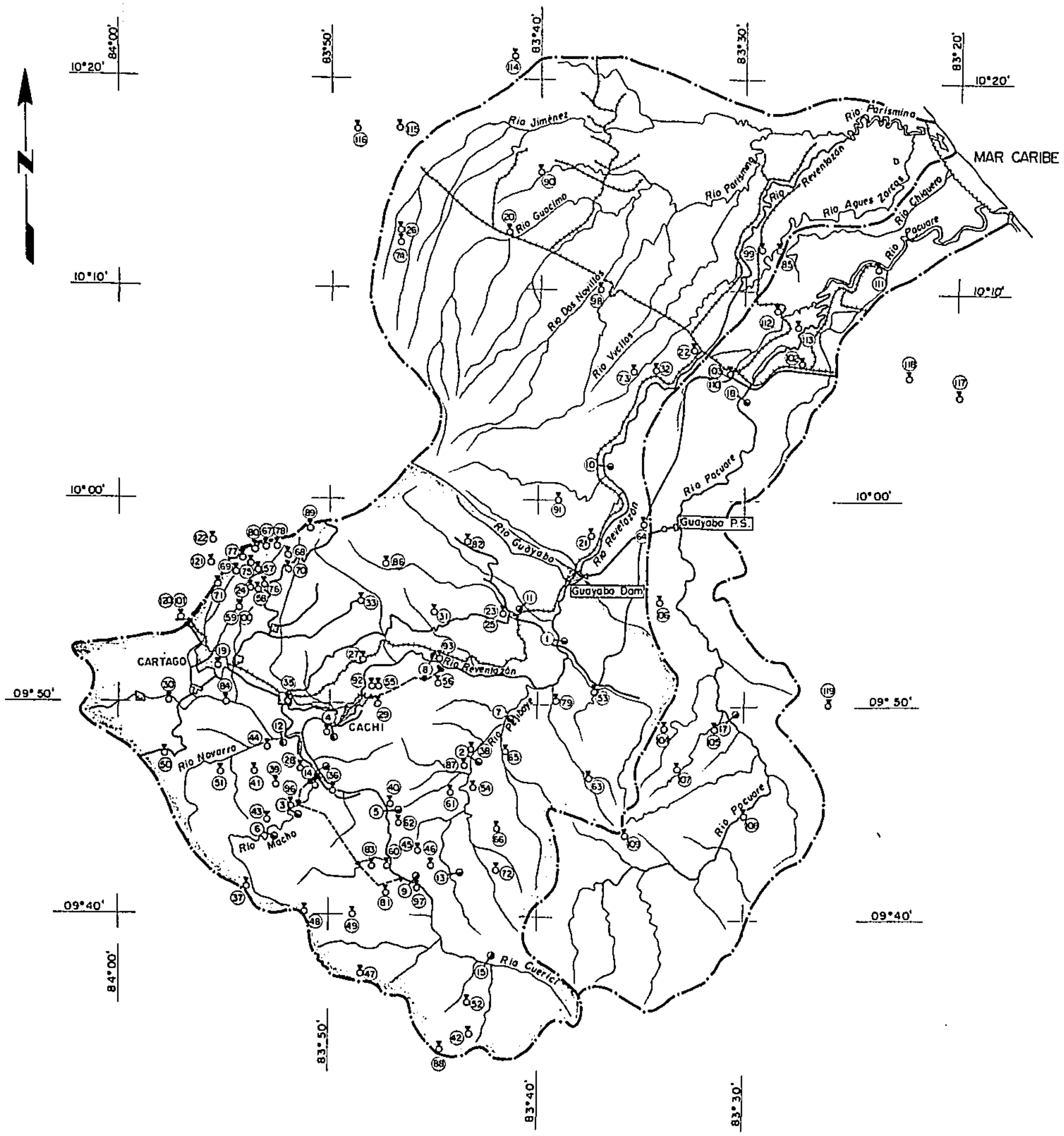
3.3.3 Period of Analysis for Run-off

The period of analysis for the run-off will be 18 years from January in 1959 to December in 1976 for the following reasons.

(1) The average run-off in 18 years is approximately as same as the average in 23 years.

(2) Angostura station has run-off records of 23 years in which the most critical year of 1959 is included. Above-mentioned 18 years include the critical year.

Fig. II-3-1 Location Map of Run-off and Meteorological Gauging Stations



Run-off Gauging Station							
No.		River	Station	Location Lat (N)	Location Long (E)	Catchment Area	Date of Installation
1	73-09-03	Reventazón	Angostura	09°53'00"	83°38'50"	1337.1	5-9-53
2	73-09-04	Pejibaye	El Humo	09°47'36"	83°43'00"	136.5	29-10-53
3	73-09-05	Macho	Montecristo	09°44'55"	83°52'00"	64.5	6-10-55
4	73-09-06	Reventazón	Cachi	09°49'03"	83°49'58"	689.7	4-5-56
5	73-09-07	Reventazón	Cordoncillal	09°45'54"	83°43'30"	253.4	5-3-58
6	73-09-08	Macho	Belén	09°45'12"	83°52'51"	47.4	22-9-60
7	73-09-09	Pejibaye	Oriente	09°49'32"	83°41'35"	226.9	6-4-62
8	73-09-10	Reventazón	El Congo	09°52'24"	83°45'21"	877.0	18-5-62
9	73-09-11	Reventazón	Tapanti	09°42'15"	83°45'00"	188.2	23-7-62
10	73-09-12	Reventazón	Pascua	10°01'33"	83°36'45"	1673.2	30-5-63
11	73-09-14	Colorado	La Bomba	09°54'21"	83°41'18"	10.2	3-1-67
12	73-09-16	Navarro	Puente Negro	09°48'36"	83°52'05"	273.3	12-3-71
13	73-09-17	Pejibaye	Las Pavas	09°41'45"	83°44'00"	18.4	27-5-71
14	73-09-19	Reventazón	Paloma	09°46'50"	83°50'12"	371.1	26-7-71
15	73-09-20	Cuerici	Cuerici	09°37'57"	83°42'36"	77.5	14-5-73
16	73-09-21	Reventazón				187.3	9-1-74
17	75-08-01	Pacuare	Pacuare	09°48'54"	83°30'50"	367.4	16-7-58
18	75-08-03	Pacuare	Dos Montañas	10°04'45"	83°30'03"	651.8	27-5-70

Meteorological Gauging Station (2)					
No		Station	Location Lat (N)	Location Long (E)	Date of Installation
*114	071-003	Curia	10°21'	83°41'	1971
115	071-005	Rio Frio	10°18'	83°47'	1969
*116	071-006	Tico Frutera	10°18'	83°49'	1973
117	077-001	Battán	10°05'	83°20'	Aug 1954
*118	077-004	La Lola	10°06'	83°22'	Aug. 1970
119	079-005	Moravia de Chirripó	09°50'	83°26'	May. 1955
120	084-040	Alto de Ochomogo	09°54'	83°57'	1949
121	084-069	Carralillo	09°57'	83°56'	1971
122	084-083	Guayabillos	09°58'	83°56'	1973

Note * Meteorological Gauging Stations
Others ; Rainfall Gauging Stations

Meteorological Gauging Station (1)					
No.		Station	Location Lat (N)	Location Long (E)	Date of Installation
19	073-003	Cartago (Comandancia)	09°52'	83°55'	May. 1941
20	073-005	Guácimo	10°13'	83°40'	Fed. 1931
21	073-007	Peralta	09°58'	83°37'	Jan. 1951
22	073-009	Cairo (Siquirres)	10°07'	83°32'	Apr. 1938
23	073-010	Turrialba (I.I.C.A.)	09°53'	83°38'	Jan. 1942
24	073-011	Sanatorio Durán	09°56'	83°53'	Jan. 1935
25	073-012	Turrialba (Northern)	09°53'	83°38'	Jan. 1951
26	073-013	Los Diamantes (Guápiles)	10°13'	83°46'	May 1938
27	073-014	El Yas	09°52'	83°49'	Jan. 1951
28	073-015	Orosi (La Maruja)	09°47'	83°51'	Aug 1949
29	073-017	Cachi (Hacienda)	09°50'	83°48'	Oct. 1951
30	073-018	El Guarco, Linda Vista	09°50'	83°58'	May. 1949
*31	073-019	Juan Viñas	09°54'	83°45'	Jun. 1948
32	073-020	La Florida (Lomas)	10°06'	83°34'	Jan. 1951
33	073-022	Pacayas	09°55'	83°49'	Dec. 1951
34	073-023	Orosi, La Guayra	09°49'	83°50'	Dec. 1960
*35	073-024	Paraiso de Cartago	09°50'	83°52'	May. 1953
36	073-026	Tapanti	09°46'	83°50'	Feb. 1939
37	073-027	El Cañón	09°41'	83°55'	Aug. 1959
38	073-028	El Humo	09°41'	83°43'	Sep. 1954
39	073-029	El Llano (Rio Macho)	09°46'	83°52'	Jul. 1957
40	073-030	Cordoncillal	09°45'	83°47'	Apr. 1959
41	073-032	Cedral (A. Jurado)	09°47'	83°53'	Jan. 1971
42	073-033	Villa Mills	09°34'	83°43'	Jan. 1942
43	073-034	Belén	09°44'	83°53'	Nov 1956-65
44	073-035	Navarro (Cartago)	09°49'	83°53'	Jan. 1969
45	073-036	T-Seis	09°43'	83°46'	Aug 1962
46	073-037	El Destierro	09°42'	83°45'	Aug 1962
47	073-038	Ojo de Agua (P. Zeledón)	09°37'	83°49'	Aug 1962
48	073-039	Tres de Junio	09°40'	83°51'	Aug 1962
49	073-040	Berma	09°40'	83°49'	Aug. 1962
50	073-041	La Cangreja	09°48'	83°58'	Aug 1962
51	073-042	Muñeco	09°47'	83°55'	Aug 1962
52	073-043	Cerro de la Muerte (Faldas)	09°36'	83°43'	Aug 1962
53	073-044	La Suiza (Turrialba)	09°51'	83°37'	Aug 1962
54	073-045	Taus	09°46'	83°43'	Aug 1962
*55	073-046	Cachi (Plantel)	09°51'	83°48'	Oct. 1962
56	073-047	Tucurrique	09°51'	83°45'	Oct. 1963
57	073-048	Puesto No. 2	09°57'	83°53'	Apr. 1964
58	073-049	Puesto No. 3	09°56'	83°53'	Apr. 1964
59	073-050	Puesto No4 Tierra Blanca	09°55'	83°54'	Apr. 1964
60	073-051	Dos Amigos	09°42'	83°47'	Apr. 1964
61	073-052	Nazaret	09°46'	83°44'	Apr. 1964
62	073-053	Valverde	09°44'	83°47'	Apr. 1964
63	073-054	La Esperanza	09°47'	83°38'	Apr. 1964
64	073-055	La Amistad	09°59'	83°35'	Apr. 1964
65	073-056	La Victoria	09°48'	83°42'	May 1964
66	073-057	Tabano	09°44'	83°42'	Jul. 1964
67	073-058	Retes 3	09°58'	83°53'	Aug 1964
68	073-059	Laguna	09°58'	83°52'	Aug 1964
69	073-060	Cañada	09°57'	83°54'	Aug 1964
70	073-061	Chicoa	09°58'	83°52'	Aug 1964
71	073-062	Llano Grande	09°57'	83°55'	Aug 1964
72	073-063	El Gato	09°42'	83°42'	Set. 1964
73	073-064	Williansburg	10°06'	83°35'	Apr. 1965
74	073-065	Santa Clara	10°17'	83°48'	Sep 1955
75	073-067	Puesto No 10	09°57'	83°53'	May. 1965
76	073-068	Pluviómetro 16	09°56'	83°53'	May. 1965
77	073-069	Casa Retes	09°58'	83°54'	May. 1965
78	073-070	Sapper	09°58'	83°52'	May. 1965
*79	073-071	Atirro	09°50'	83°39'	Aug 1964
80	073-072	Cabeza de Vaca	09°58'	83°53'	Aug. 1965
81	073-073	Ventana B, Tapanti	09°41'	83°47'	Aug 1965
82	073-074	San Antonio	09°58'	83°43'	Sep 1965
83	073-075	Cerro Los Gemelos	09°42'	83°48'	Sep 1965
*84	073-076	INCSA, Aguacaliente	09°50'	83°55'	Jan. 1966
*85	073-077	Imperio	10°12'	83°28'	May 1969
*86	073-078	Caliblanco	09°57'	83°48'	Jan. 1970
*87	073-079	Oriente	09°48'	83°43'	Jun. 1970
*88	073-080	Repetidora C. Muerte	09°33'	83°44'	Aug 1970
*89	073-081	Volcán Irazú	09°59'	83°51'	Oct. 1969
90	073-082	Cabal	10°15'	83°40'	Aug 1970
91	073-083	Finca El Sauce	10°00'	83°39'	Jan 1966
92	073-084	Presa Cachi	09°51'	83°48'	Nov. 1970
93	073-085	Casa de Máquinas Cachi	09°52'	83°45'	Nov. 1970
94	073-086	Casa Máquinas Rio Macho	09°47'	83°51'	Nov 1971
95	073-087	Hacienda Katira			Nov. 1971
96	073-088	Toma de Agua Montecristo	09°45'	83°52'	Jan. 1970
97	073-089	Sitio de Presa Tapanti	09°42'	83°46'	Jul. 1971
98	073-090	Las Mercedes (Limón)	10°10'	83°37'	Jan. 1971
*99	073-091	Hacienda El Carmen	10°12'	83°29'	Dec. 1972
100	073-092	Tierra Blanca (Coop.)	09°55'	83°54'	Jul. 1972
101	073-093	El Alto	09°54'	83°57'	Jul. 1970
102	075-001	Monte Verde	10°06'	83°27'	Oct. 1941
103	075-002	Siquirres	10°06'	83°31'	Jul. 1966
104	075-003	Platanillo	09°49'	83°34'	Sep 1954
105	075-004	Pacuare	09°49'	83°31'	Aug 1962
106	075-005	Pacuar	09°55'	83°34'	Apr. 1964
107	075-006	Beré	09°47'	83°30'	May 1964
108	075-007	Rocas Blancas	09°45'	83°30'	Jul. 1966
109	075-008	Cuencas	09°44'	83°36'	Jul. 1966
110	075-009	Siquirres	10°06'	83°31'	1931
111	075-010	La Perla	10°11'	83°23'	1970
112	075-011	San Alberto	10°09'	83°28'	Set. 1953
113	075-012	Indiana 3	10°08'	83°27'	Jan 1957

LEGEND

- Boundaries of Catchment Area of Rio Reventazon and Rio Pacuare
- Boundaries of Catchment Area of Guayabo Project
- Road
- Railway
- Runoff Gauging Station
- Meteorological Gauging Station

0 10 20 km

Sorce ; ICE

Table II-3-1 Existing Precipitation Data

Station / Year	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
San Jose	From	1885																						
(Basin : Rio Reventazon)																								
19 Cartago		(Exist in 1941 ~ 1950)																						
22 Cairo Siguirres	From	1938																						
23 Turrialba	From	1942																						
42 Villa Mills	From	1942																						
45 T−Seis																								
55 Cachi																								
(Basin : Rio Pacuare)																								
105 Pacuare																								
106 Pacuar																								
108 Rocas Blancas																								

Table II-3-2 Existing Run - off Data

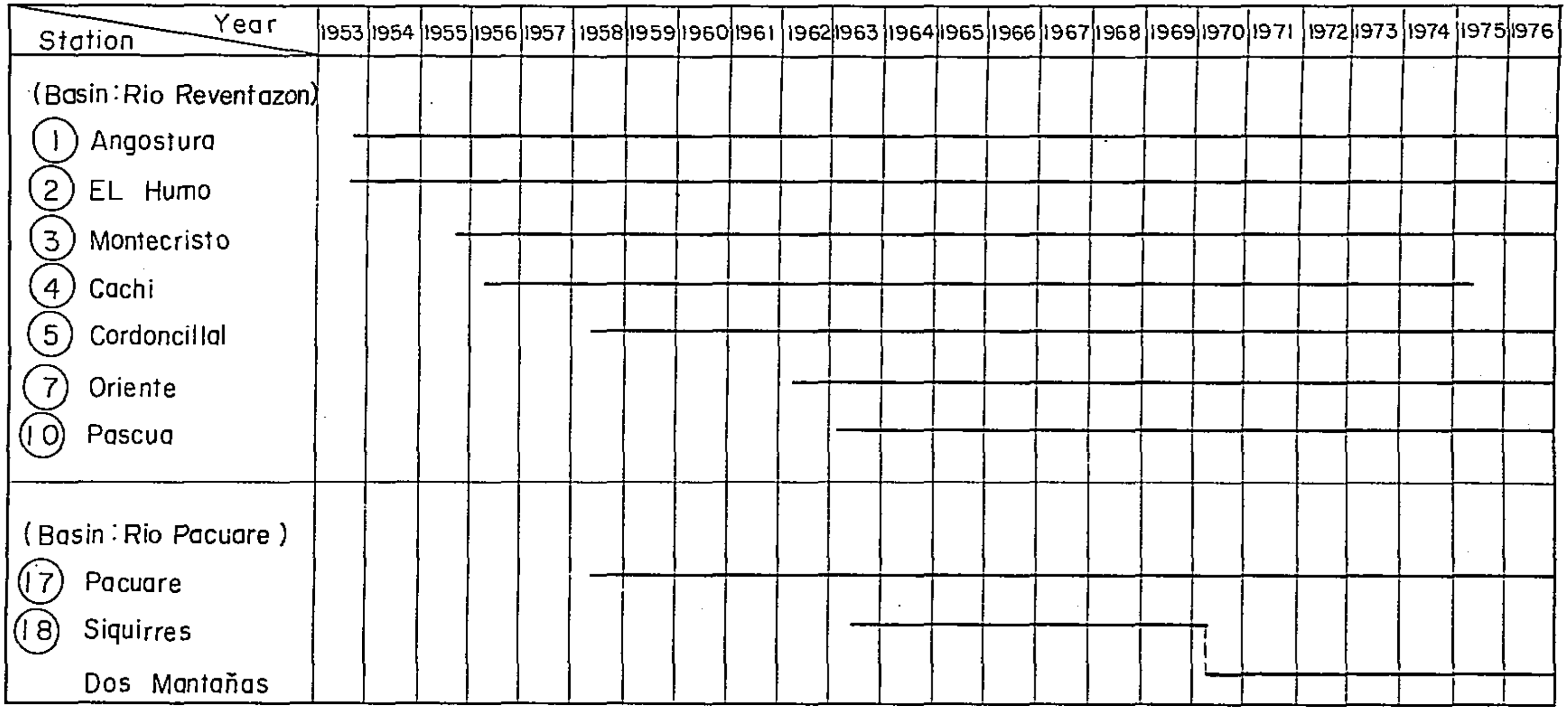
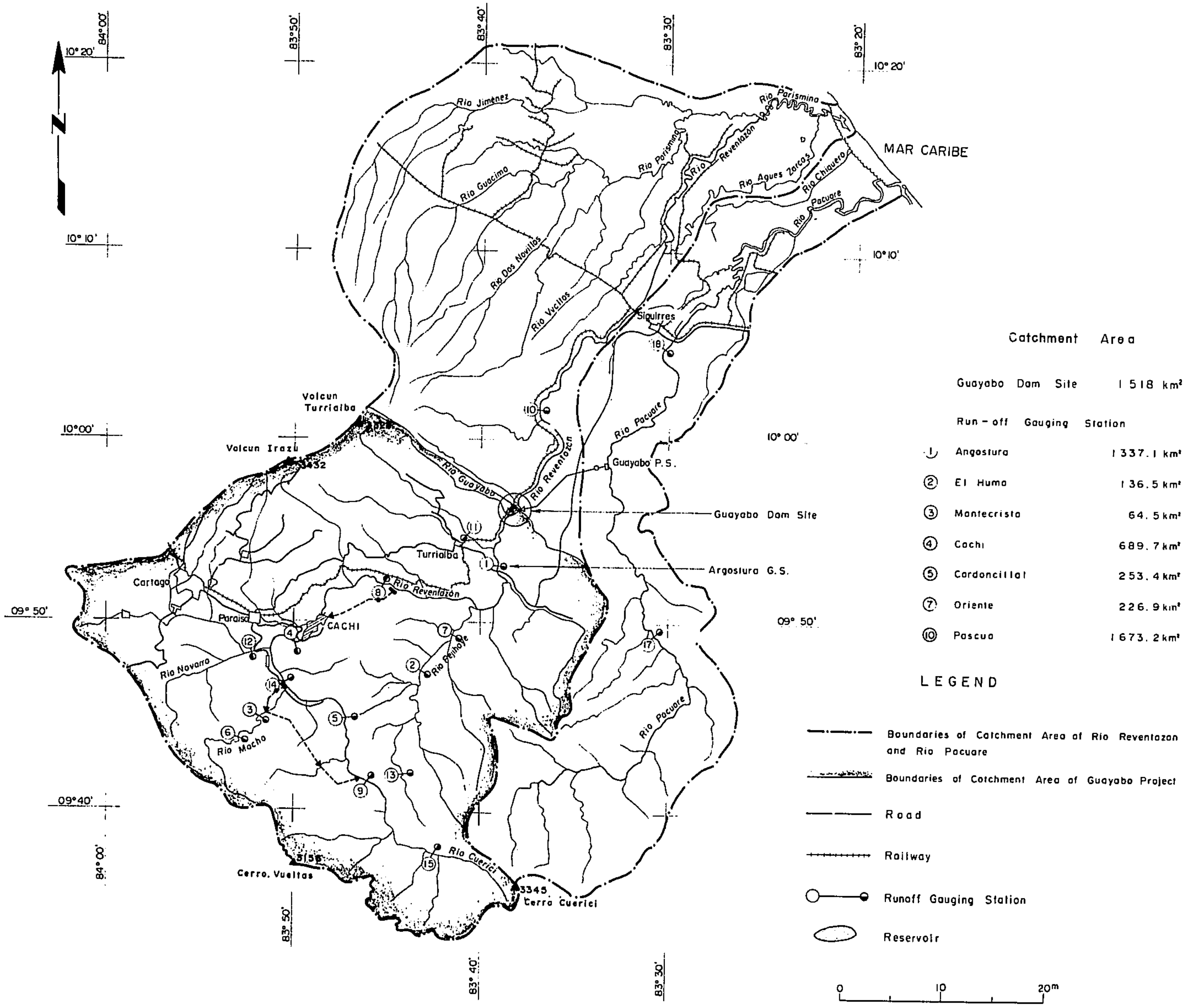


Fig. II-3-2 Catchment Area



(3) Guayabo Project will give the power discharge into the Pacuare River where Siquirres Project will be located. Study of Siquirres Project will be made in Part III of Report. So, it is better that the period of analysis for the run-off is as same as that of Siquirres Project. Fortunately, Pacuare station has run-off records since August 1958 which is one of gauging stations for Siquirres Project.

As for the reason why the period of 18 years could be adequate, see Item 3.4.2. mentioned below.

3.3.4 Supplementation of Run-off Data

Some records of run-off in 18 years are missing. ICE supplementes the missing records by determining the correlation between run-offs observed in Cachi, El Humo and Pascua gauging stations and Angostura station. The supplemented data of the run-off is considered appropriate as a result of study.

3.3.5 Run-off at Dam Site

The run-off of the river at the Guayabo Dam site is calculated, using the formula stated below.

$$Q_G = Q_A \times \frac{A_G}{A_A}$$

where Q_G: run-off at Guayabo Dam site (m^3/sec)

Q_A: run-off at Angostura station (m^3/sec)

A_G: catchment area of Guayabo Dam Site (km^2)

A_A: catchment area of Angostura station (km^2)

Table II-3-3 shows the monthly average of the run-offs at Guayabo Dam site which are computed by the formula stated above. It is quite natural that the run-off observed at the Angostura station has been influenced by the regulation of Cachi Reservoir since 1967.

However, in this study, the influence of the Cachi Reservoir control is not considered. It is thought that the run-off data should be reconstructed giving due considerations to the influence in the definite study in future.

3.4 RAINFALL

3.4.1 Precipitation

The distribution of the annual amount of precipitation in the Republic of Costa Rica is shown in Fig. II-3-3. By this isohyetal map, Costa Rica could be divided into two zones as follows.

Table II-3-3 Monthly Average Run-off at Guayabo Dam Site

Catchment Area 1518 km^2 (Unit: m^3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1959	45.5	39.5	32.6	41.4	59.6	160	122	118	141	167	122	117	97.5
1960	109.8	63.9	57.1	50.9	71.4	125	147	108	120	194	131	138	110
1961	68.2	55.7	42.1	39.6	71.1	119	131	112	168	164	160	165	108
1962	86.5	50.8	40.5	48.6	97.0	136	155	127	162	186	288	180	130
1963	78.0	72.5	63.8	87.8	121	122	132	134	176	155	192	125	122
1964	110	45.2	32.2	34.5	66.9	130	188	162	183	175	137	76.2	112
1965	146	76.4	77.1	44.6	110	153	134	170	154	174	164	109	126
1966	129	139	78.7	63.5	153	168	145	164	158	174	157	225	146
1967	126	76.2	60.5	102	99.7	193	153	178	188	197	162	111	137
1968	71.1	114	95.3	93.5	125	180	189	175	227	170	171	141	146
1969	64.3	52.4	40.6	56.9	65.2	121	93.0	178	187	186	231	175	121
1970	147	200	69.3	320	168	183	184	144	180	178	237	459	206
1971	151	76.6	85.8	102	132	138	179	173	177	210	131	72.6	136
1972	87.7	69.1	56.8	84.9	111	106	95.5	135	152	180	151	110	112
1973	85.5	71.4	52.6	34.1	73.2	193	134	168	144	172	161	225	126
1974	117	70.3	61.8	60.2	113	169	150	159	121	154	119	166	122
1975	59.2	52.5	41.0	46.3	58.7	127	158	198	225	180	188	258	133
1976	115	64.1	49.9	51.0	88.3	161	165	141	159	130	175	92.9	116
Average	99.8	77.2	57.6	75.6	99.0	149	147	153	168	175	171	164	128

LISTA DE ESTACIONES UTILIZADAS EN LA CONFECCION DEL MAPA

ESTACION	LAT N.	LONG W	PROM. ANUAL M.M.
ACOSTA	09°46'	84°08'	2.538
ARENAL, TILARAN	10°28'	84°53'	2.542
ASUNCION	09°48'	83°10'	3.766
ATENAS	09°58'	84°22'	1.806
AVANCE	09°56'	83°55'	2.703
BARRA DEL COLORADO	10°44'	83°35'	5.496
BARTOLO,QUEPOS	09°26'	84°06'	3.890
BELEN, OROSI	09°44'	83°55'	3.078
BERMA	09°42'	83°49'	3.400
BONITA	09°29'	84°12'	3.290
BUENA VISTA, ALFARO RUIZ	10°17'	84°28'	3.182
CACHI, HACIENDA	09°49'	83°48'	2.135
CAIRO, TILARAN	10°25'	84°47'	4.009
CAÑAS-GTE, LA PACIFICA	10°25'	85°07'	1.556
CAÑO NEGRO	10°27'	84°48'	4.470
CARDENAS, NICARAGUA	11°13'	85°31'	2.091
CARTAGO	09°53'	83°55'	1.202
CEDRAL, OROSI	09°49'	83°53'	3.184
CERRO DE LA MUERTE	09°35'	83°42'	2.110
CHASE, TALAMANCA	09°37'	82°51'	1.832
CIUDAD QUESADA	10°20'	84°27'	4.573
COBANO	09°43'	85°05'	2.853
COLON, NICARAGUA	11°06'	83°15'	2.104
CORDONCILLAL	09°44'	83°47'	5.376
CORONADO	09°59'	84°00'	2.254
COTE	10°35'	84°55'	3.925
COTO, UNION	08°37'	83°03'	4.247
CUENCAS	09°47'	83°33'	4.640
CURRIDABAT	09°53'	84°01'	2.418
DESAMPARADOS	09°34'	84°04'	1.941
EL ALTO	09°53'	83°57'	1.913
EL CAÑON	09°42'	83°54'	1.990
EL CASTILLO, NICARAGUA	11°01'	84°24'	3.135
EL COCO, ALAJUELA	09°59'	84°13'	1.886
EL DESTIERRO	09°37'	83°42'	5.540
EL GATO	09°42'	83°41'	6.620
EL GUARCO	09°50'	83°57'	1.554
EL HUMO	09°47'	83°43'	3.312
ESPARTA	09°59'	84°40'	2.283
ESQUINAS, GOLFITO	08°44'	83°17'	4.424
FILADELFIA	10°26'	85°35'	1.888
GOLFITO	09°39'	83°10'	4.912
GRECIA	10°03'	84°19'	3.321
HELECHALES	09°03'	83°03'	3.339
LA ARGENTINA	10°07'	84°21'	2.331
LA CANGREJA	09°47'	83°57'	1.483
LA FLORIDA	10°06'	83°04'	3.255
LAS JUNTAS, ABANGARES	10°16'	85°00'	2.308
LA LOLA	10°06'	83°22'	3.493
LA PALMA, MORAVIA	10°02'	83°59'	3.331
LA SUIZA, TURRIALBA	09°51'	83°36'	2.650
LIBERIA, GUANACASTE	10°37'	85°26'	1.624
LIMON	10°00'	83°03'	3.360
LOS DIAMANTES	10°13'	83°46'	4.475
LOS LLANOS, SAN CARLOS	10°29'	84°23'	3.302
MARGARITA, TALAMANCA	09°34'	82°43'	2.248
MONTEVERDE, GUACIMAL	10°19'	84°49'	2.283
MORAVIA, CHIRRIPO	09°51'	83°25'	2.659
MUÑECO	09°48'	83°22'	1.835
NAGATAC	10°04'	84°34'	3.476
NARANJO	10°06'	84°22'	2.497
NARANJO, LEPANTO	09°58'	85°02'	2.215
NAVARRO, CARTAGO	09°40'	83°51'	1.970
NICOYA	10°09'	85°27'	2.342
NIEVECITA, TALAMANCA	09°33'	82°43'	2.358
OJO DE AGUA, PEREZ ZELEDON	09°37'	83°49'	2.432
OJO DE AGUA, SAN RAFAEL	09°59'	84°13'	1.841
OROSI, LA GUAYRA	09°49'	83°31'	1.993
OROSI, LA MARUJA	09°48'	83°51'	2.132
OROTINA	09°53'	84°31'	2.176
PACAYAS	09°55'	83°48'	2.362
PACUARE	09°49'	83°30'	2.851
PALMARES	10°04'	84°25'	2.061
PALMAR SUR	08°57'	83°28'	3.356
PANDORA	09°43'	82°57'	3.186
PARAISO, CARTAGO	09°50'	83°52'	1.734
PERALTA	09°58'	83°37'	4.020
PLATANILLO	09°46'	83°33'	2.788
POCARES, QUEPOS	09°31'	84°10'	2.357
PUERTO HUMO, NICOYA	10°19'	85°21'	1.764
PUERTO VIEJO, SARAPIQUI	10°26'	84°00'	4.290
PUNTARENAS	09°58'	84°50'	1.401
PURISCAL	09°51'	84°19'	2.680
QUEBRADA AZUL, SAN CARLOS	10°24'	84°28'	3.512
QUEBRADA GRANDE	10°50'	85°30'	2.174
QUEPOS	09°26'	84°09'	3.862
RANCHO REDONDO	09°57'	83°56'	2.699
REPUNTA, PEREZ ZELEDON	09°18'	83°39'	2.678
RINCON DE OSA	08°42'	83°29'	3.832
RIO MACHO, EL LLANO	09°48'	83°50'	2.760
RIO NARANJO, BAGACES	10°42'	85°04'	2.083
SANATORIO DURAN	09°56'	83°52'	1.457
SAN CARLOS, NICARAGUA	11°08'	84°06'	1.836
SAN ISIDRO DEL GENERAL	09°22'	83°42'	2.925
SAN JOAQUIN DE FLORES	10°01'	84°08'	2.240
SAN JOSE	09°06'	84°05'	1.978
SAN JOSECITO, ALAJUELA	10°01'	84°16'	1.945
SAN MARCOS, TARRAZU	09°40'	84°02'	2.112
SAN MIGUEL, BARRANCA	10°00'	84°41'	1.936
SAN MIGUEL, SARAPIQUI	10°18'	84°12'	5.307

PRECIPITACION PROMEDIO ANUAL EN COSTA RICA

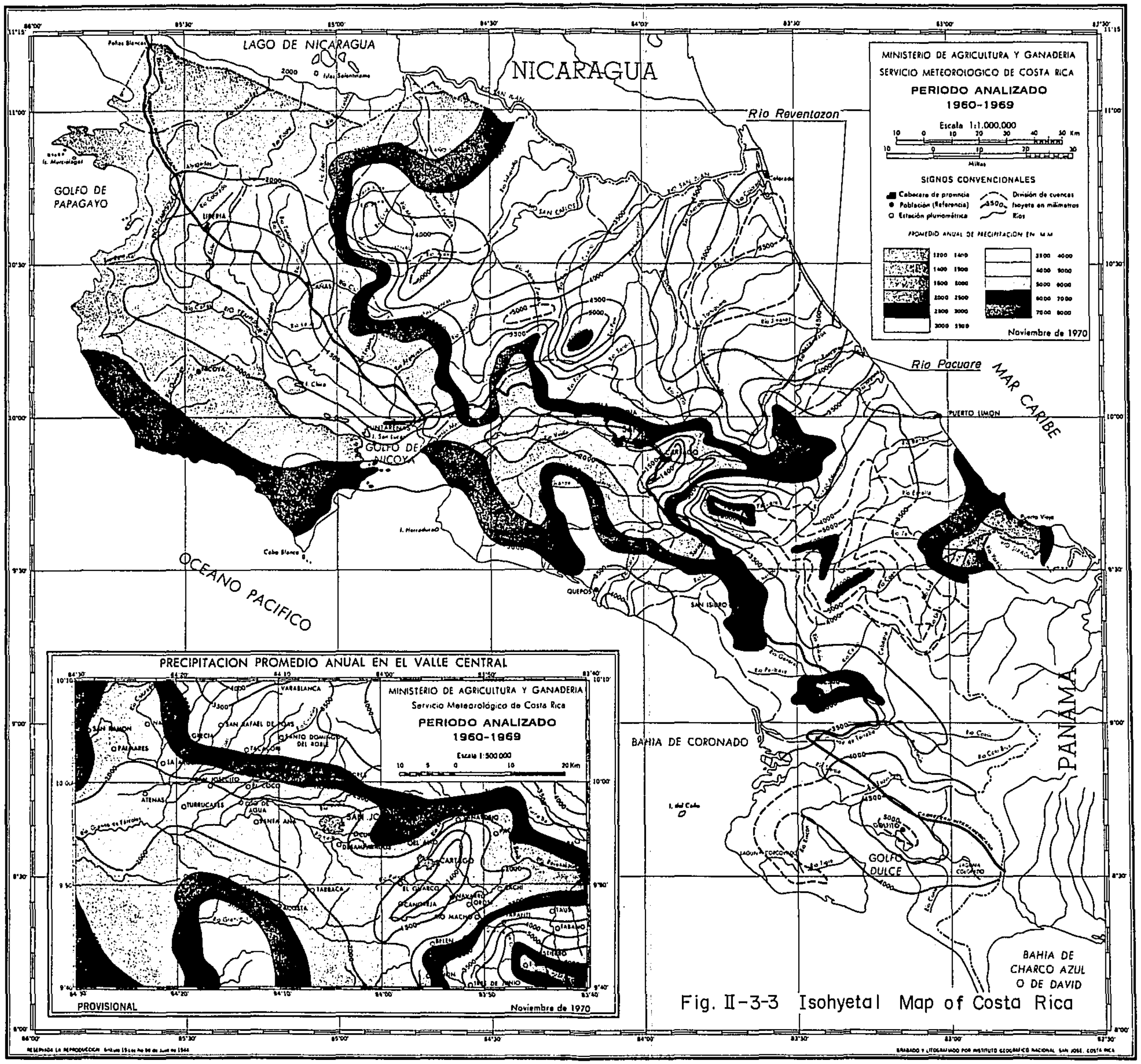


Fig. II-3-3 Isohyetal Map of Costa Rica

ESTACION	LAT. N	LONG W	PROM. ANUAL M.M.
SAN RAFAEL DE POAS	10°06'	84°14'	3.280
SAN RAMON	10°05'	84°29'	2.016
SAN VITO DE JAVA	08°50'	83°00'	4.021
SANTA ANA, SAN JOAQUIN	09°56'	84°09'	1.939
SANTA CRUZ, GUANACASTE	10°16'	85°37'	2.024
SANTO DOMINGO, EL ROBLE	10°03'	84°10'	3.076
SARAPIQUI, MAGSAGSAY	10°23'	84°02'	4.255
SIQUIRRES	10°06'	83°31'	3.719
TABANO	09°44'	83°42'	6.660
TACACORI, ALAJUELA	10°03'	84°13'	3.034
TAPANTI	09°47'	83°48'	2.609
TARBACA	09°50'	84°06'	2.091
TAUS	09°47'	83°42'	4.680
TIERRAS MORENAS	10°34'	85°02'	2.470
TILARAN	10°28'	84°59'	2.230
TRES DE JUNIO	09°40'	83°52'	2.890
TRES RIOS, HACIENDA CONCEPCION	09°53'	83°59'	2.700
T-SEIS	09°42'	83°46'	7.540
TUCURRIQUE	09°51'	83°43'	2.410
TURRIALBA I.I.C.A.	09°33'	83°31'	2.687
TURRUCARES	09°58'	84°19'	1.940
UPALA	10°54'	85°01'	2.356
VARA BLANCA	10°10'	84°10'	3.255
VILLA MILLS	09°34'	83°41'	2.580
VOLCAN, BUENOS AIRES	09°14'	83°27'	3.331
ZARCERO	10°11'	84°24'	2.000

(1) Wet zone: Atlantic Ocean side and the southern part of the Pacific Ocean side.

(2) Dry zone: The central valley and the northern part of Pacific Ocean side.

Drainage basin of Reventazon River is situated in the wet zone of Atlantic Ocean side. Fig. II-3-4 indicates the isohyetal map in the basin.

The annual precipitation in the basin is outstandingly different in places. For example, Cartago meteorological gauging station records about 1,300 mm, while T-Seis meteorological gauging station has 7,900 mm. T-seis station is situated in the basin of a tributary, of Reventazan, Pejibaye, which has much more rainfalls in the basin. Turrialba meteorological gauging station, which is comparatively close to the Guayabo Project, records the amount of rainfall 2,700 mm.

The monthly precipitations at the stations are denoted in Table II-3-4 and Fig. II-3-5.

In general, the amount of rainfall in the basin decreases from January to April and increases from May to December. The tendency is also noticed by the number of rainy days in each month in Fig. II-3-6. Hyetograph of 1-hour rainfall (mm) in an average year, which is recorded at Turrialba station, is shown in Fig. II-3-7. The precipitation happened from May to November tends to concentrate on the time between fifteen and twenty o'clock.

3.4.2 Periodicity of Precipitation

Turrialba meteorological gauging station has precipitation records for 35 years by the end of 1976 while San Jose meteorological gauging station has records for the longest term in Costa Rica, that is, 92 years by the end of 1976. The data of monthly average are plotted on a graph shown in Fig. II-3-8.

According to the figure, it could be said in general that both tendencies are similar to each other. Therefore, tendency of the annual precipitation in the basin could be estimated by the data of San Jose station which is located outside the basin.

To find out periodicity of precipitation for Turrialba station, power spectrum analysis by Fourier transformation is made by using the data of monthly precipitation at San Jose station.

The result is shown in Fig. II-3-9, and the periods of 4 years, 6 years, 9 years and 36 years are very prominent. The longest period is 36 years among them, but considering that the data is for 92 years long, the period is not reliable very well. Thus, it is appropriate that the reliable longest period or periodicity is thought to be 9 years.

In other words, it means that the period of analysis for the run-off should be at least 9 years.

The 18 years, which is mentioned in Item 3.3.3 and considered as the period of analysis for the run-off, exceeds 9 years, so it could be sufficient for the analysis.

Table II-3-4 Monthly Precipitation Data

(Unit: mm)

Station / Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
(19) Cartago	39	23	12	31	171	178	115	127	209	229	118	63	1315
(22) Cairo Siquirres	300	202	164	258	354	361	415	294	244	319	440	482	3833
(23) Turrialba	178	135	78	126	224	286	283	239	247	251	285	350	2682
(42) Villa Mills	36	23	28	97	365	339	259	315	428	483	216	98	2687
(45) T-Seis	629	402	363	521	659	729	794	885	674	738	757	751	7902

(22) Cairo Siquirres (Data exist from 1945 to 1976)
(23) Turrialba (" 1942 to 1976)
(19) Cartago (" 1941 to 1976)
(45) T-Seis (" 1963 to 1976)
(42) Villa Mills (" 1942 to 1976)

Fig. II-3-4 Isohyetal Map of Reventazon Basin

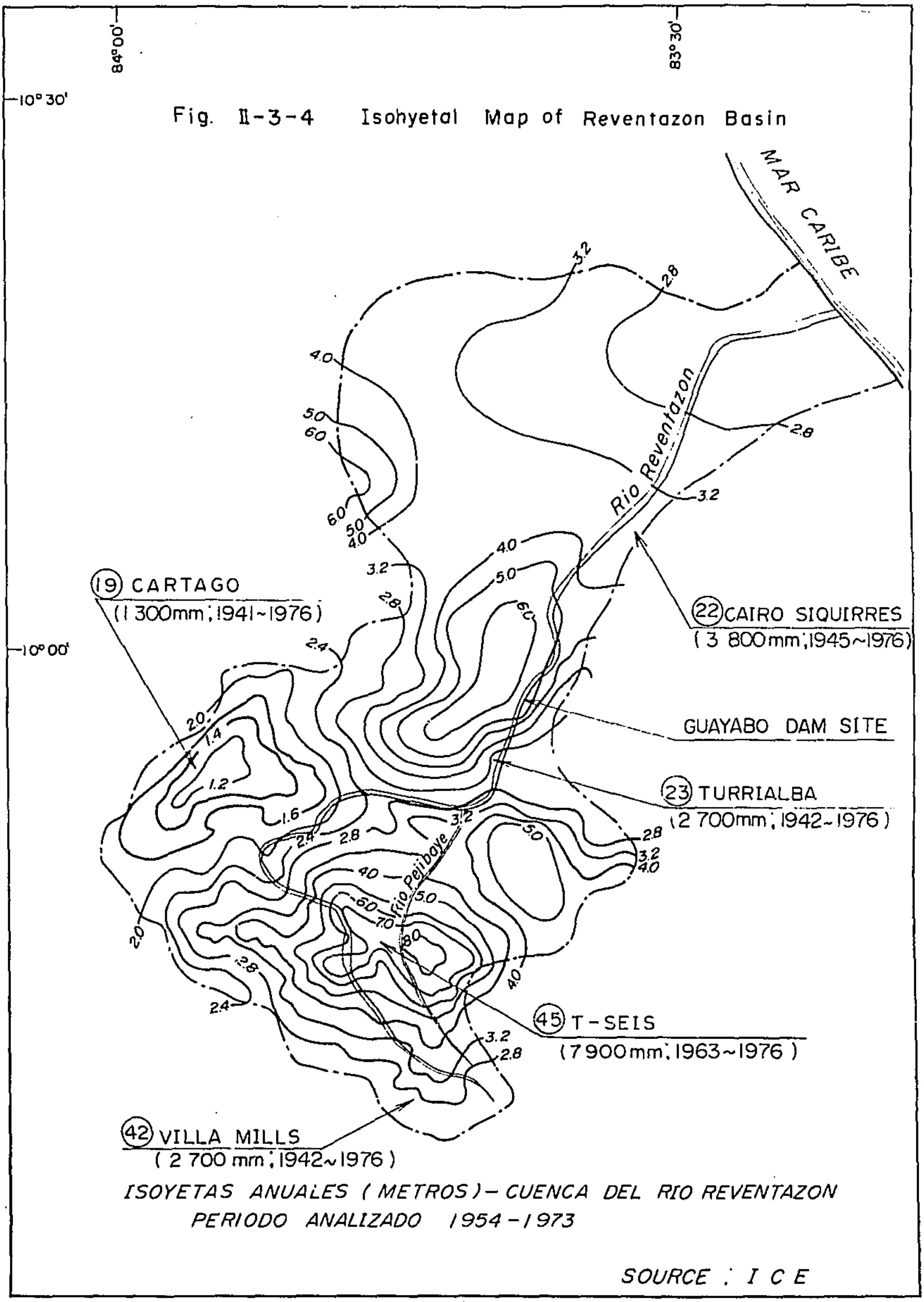


Fig. II-3-5 Monthly Precipitation

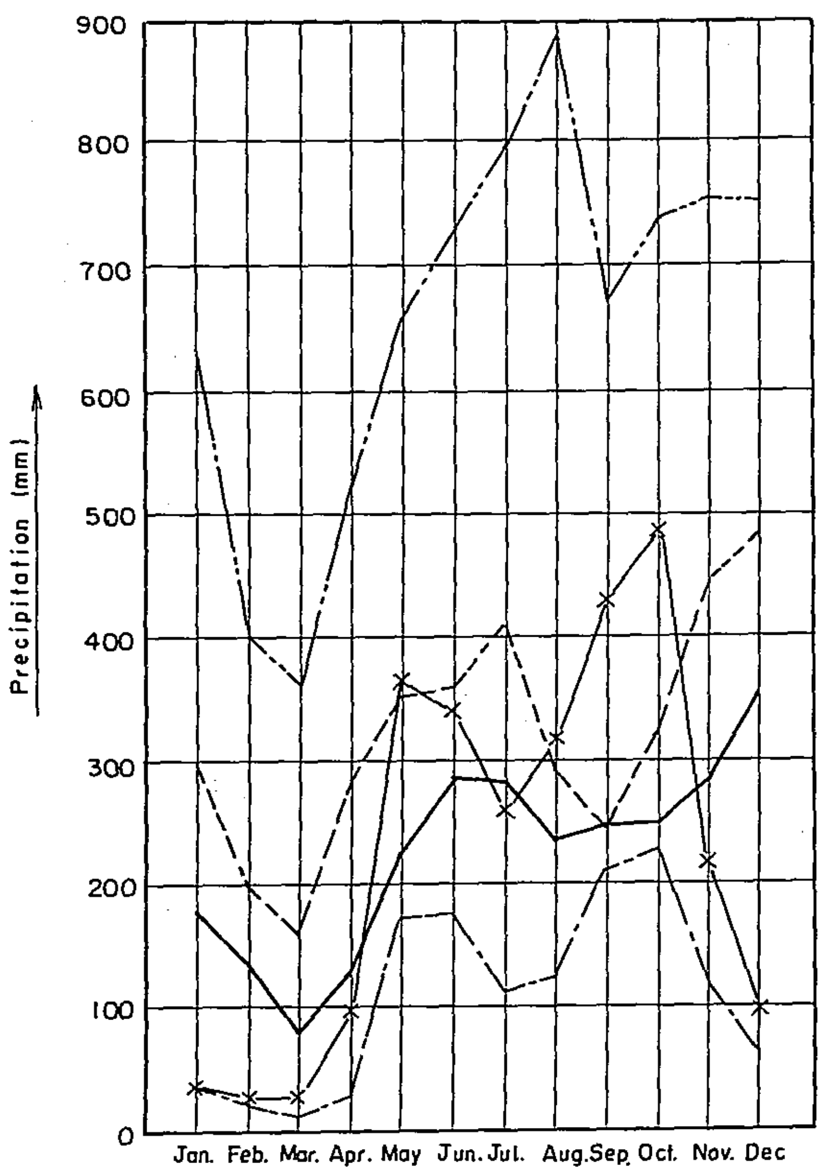


Fig. II-3-6 Monthly Rainy Days

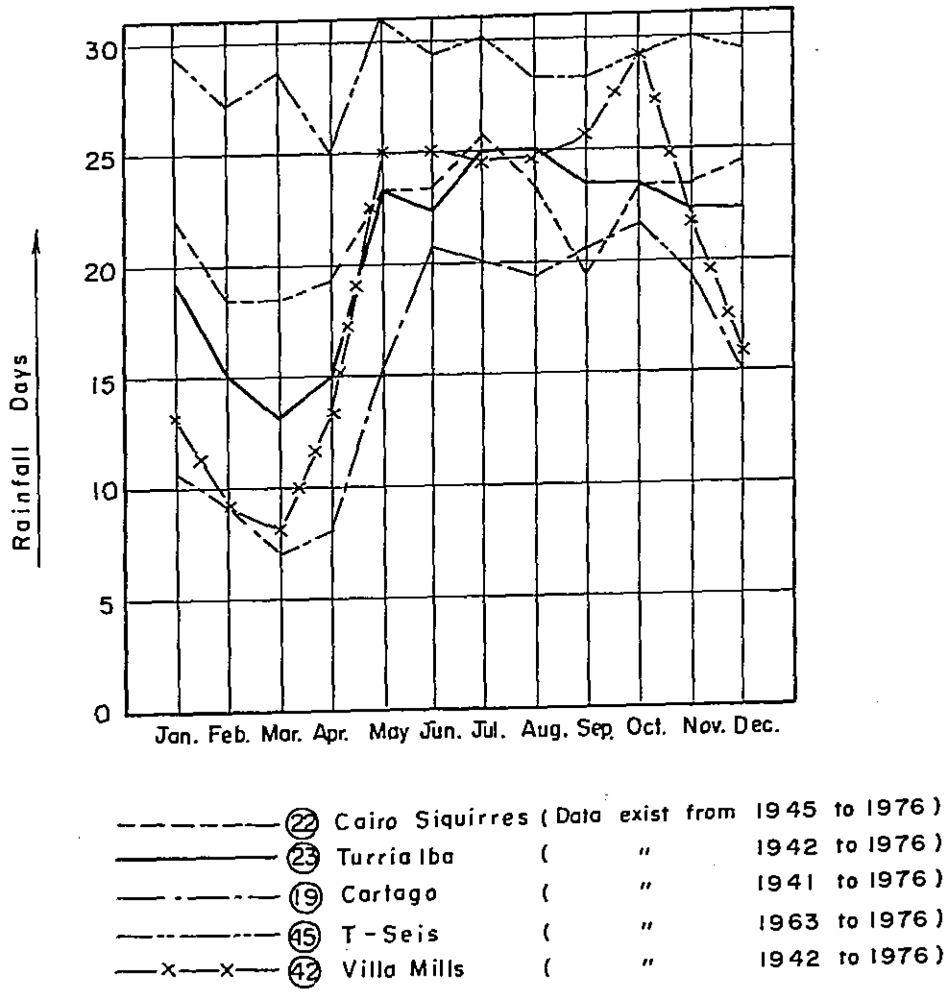


Fig. II-3-7 Hyetograph of 1-Hour Rainfall (mm) in Average Year

Data from 1974 to 1975 ㉓ Turrialba

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	3.6	2.8	3.6	3.5	7.6	6.2	4.7	7.3	2.9	5.3	3.1	6.4	6.4	7.1	6.4	2.4	7.5	5.7	10.3	4.9	3.0	6.9	6.0	4.2
Feb	6.6	3.5	4.1	3.0	2.5	1.9	1.7	1.6	2.2	1.3	0.4	0.2	1.1	0.8	2.6	2.3	2.3	2.0	2.4	3.4	6.8	2.5	2.6	0.0
Mar	1.1	0.1	0.2	0.7	0.2	0.2	0.2	0.0	0.8	0.1	0.0	0.0	0.4	0.1	0.0	1.0	0.3	1.2	4.6	2.4	1.0	3.7	1.5	0.4
Apr	1.1	0.5	0.4	0.1	0.7	1.6	1.8	0.9	0.7	0.3	0.5	0.1	0.2	1.4	2.7	1.0	3.3	7.6	8.3	4.8	7.0	4.0	6.0	0.8
May	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	5.0	0.4	5.5	1.4	3.7	2.3	1.9	22.3	20.7	8.0	2.5	0.3	0.0
Jun	0.5	0.4	0.1	0.2	0.2	0.0	0.0	0.0	0.1	0.5	0.4	0.6	5.7	13.1	12.5	13.0	27.3	8.1	13.5	11.8	7.1	7.0	3.4	3.0
Jul	1.8	4.4	3.0	6.9	8.2	4.1	6.9	11.5	14.3	8.3	5.1	2.5	3.3	7.8	7.7	13.4	35.1	9.0	6.5	2.0	2.0	1.1	0.5	0.3
Aug	8.4	10.1	4.3	0.9	3.3	2.5	3.3	6.2	6.9	13.7	3.2	3.1	1.2	1.9	8.3	7.0	11.9	15.7	10.0	10.4	3.9	3.3	3.4	2.7
Sep	0.1	0.2	0.0	0.0	0.2	0.9	0.1	0.0	0.0	0.0	0.1	0.1	3.5	13.3	5.0	17.1	23.4	14.4	8.3	4.7	0.9	0.3	0.0	0.1
Oct	0.8	0.8	0.0	0.0	0.3	0.4	0.2	0.0	3.5	0.9	4.0	1.2	0.9	2.7	9.5	14.3	12.6	14.9	25.9	7.3	3.5	1.4	0.6	0.3
Nov	2.3	1.5	1.9	1.6	2.5	3.2	5.1	4.8	1.4	1.9	2.8	3.7	2.5	2.6	3.5	8.0	18.0	9.9	4.5	3.4	4.8	3.8	2.6	2.5
Dec	12.7	13.0	12.0	6.7	19.7	14.7	9.2	6.9	2.8	10.3	7.0	4.7	2.5	1.2	3.2	1.8	8.0	6.7	11.8	9.7	11.4	13.4	9.1	11.0

HOURS

SOURCE ; I C E

Fig. II-3-8 Annual Precipitation

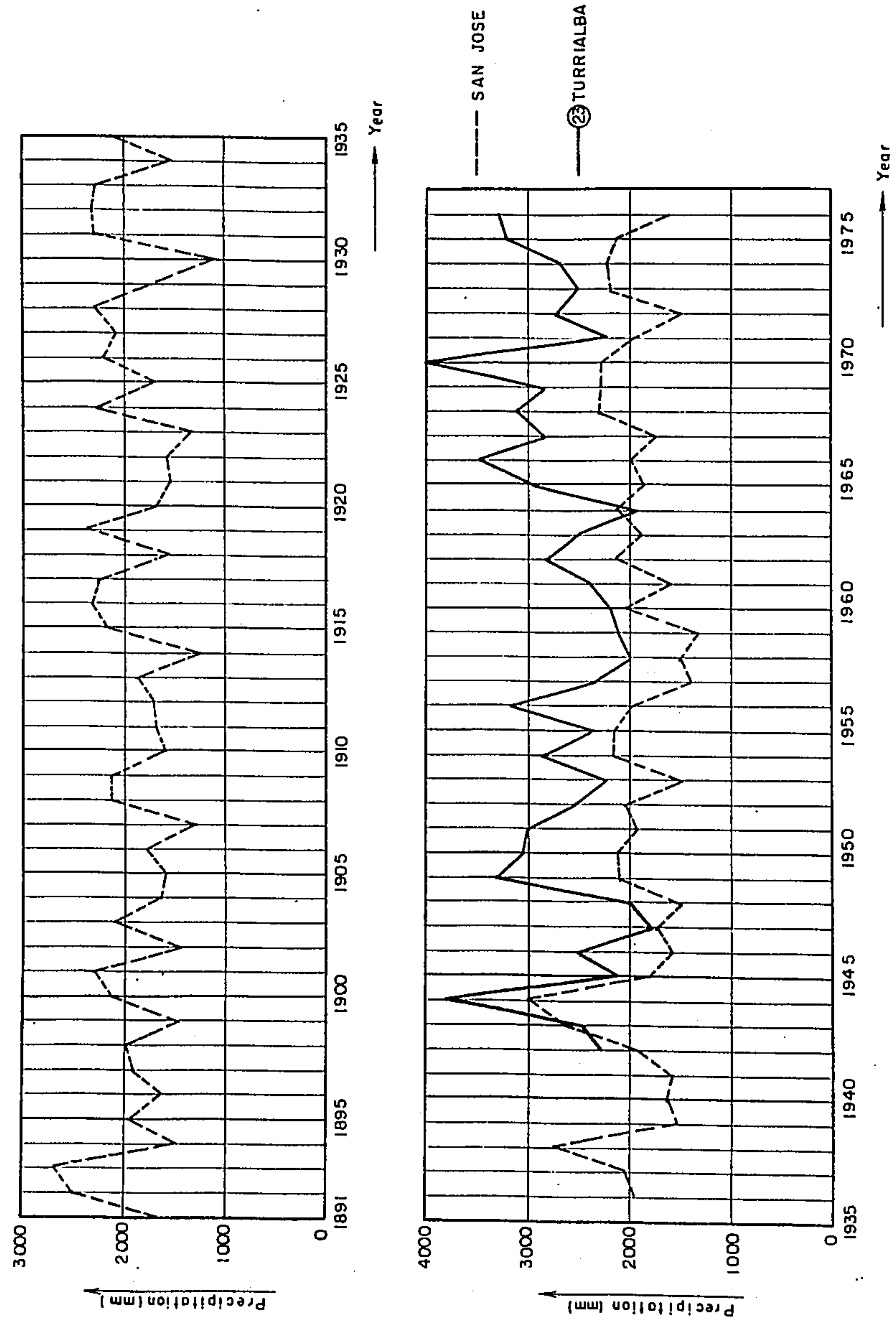
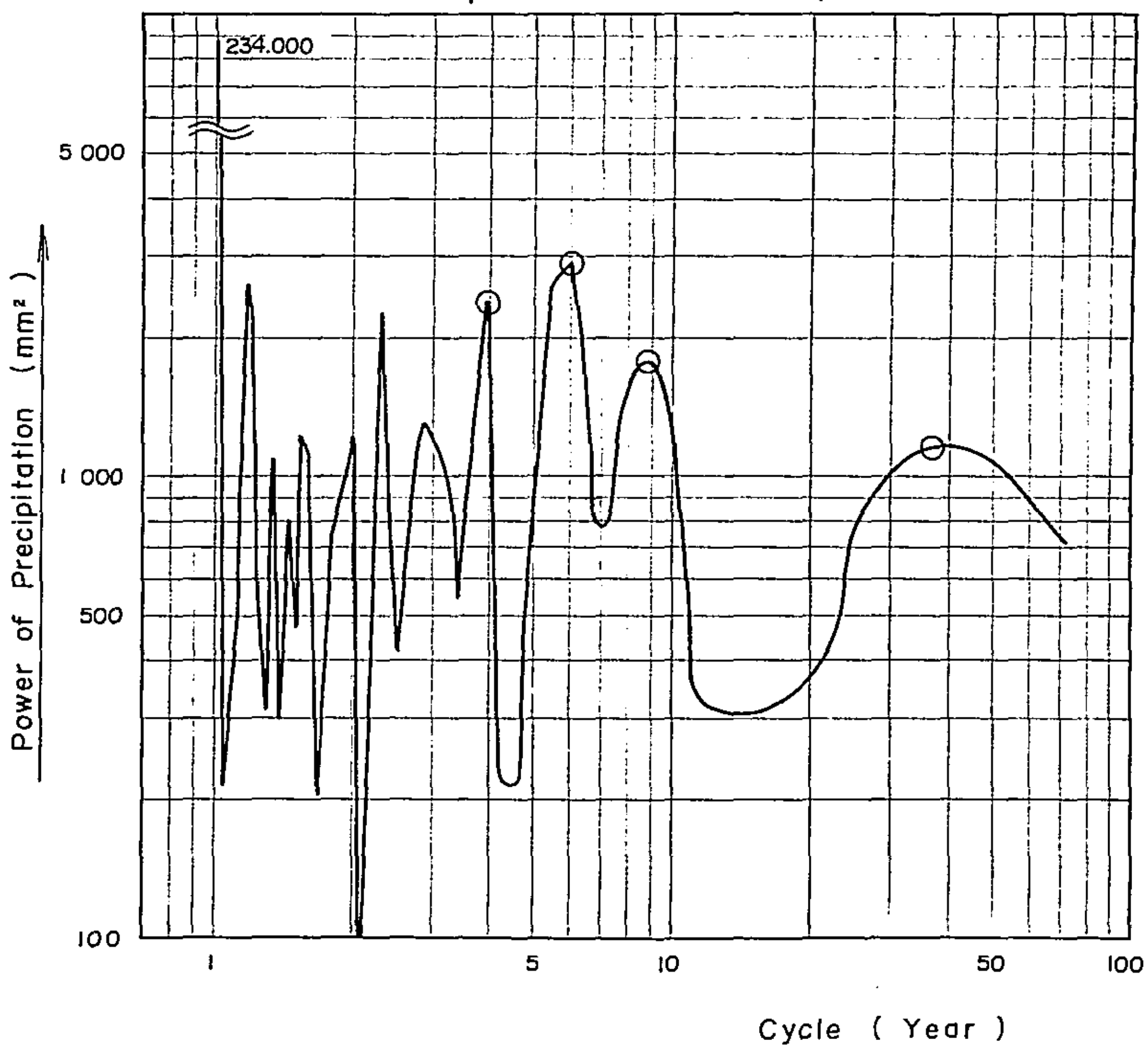


Fig. II-3-9 Power Spectrum of Precipitation at San Jose



3.5 RUN-OFF

The monthly average run-offs from 1964 to 1973 recorded by the main gauging stations are indicated in Table II-3-5.

Specific run-offs (the run-off per 100 km^2 of drainage area) are shown in Table II-3-6.

According to the Table, the specific run-off at Angostura gauging station is 9.01 m^3/sec.

A comparison made between the specific run-off and those of other gauging stations is as follows:

1) The specific run-offs at such gauging stations, along the main stream, as Cachi, Cordocillal and Pascua are from 0.86 to 1.12 times the specific run-off of Angostura, and they are nearly equal.

2) The specific run-offs at such run-off gauging stations along the tributary, Pejibaye River, as El Humo and Oriente, are between 1.79 and 1.94 times the specific run-off of Angostura. Much precipitation in the Pejibaye basin is the reason why those run-offs are exceedingly large, as stated in Item 3.4.1.
   The monthly average and the monthly maximum and minimum run-offs at Angostura station in 18 years from 1959 to 1976 are shown in Table II-3-7. According to the table, the annual average run-off in 18 years is 113 m^3/sec.
   The run-off duration for each year is shown in Table II-3-8 and Fig. II-3-10.
   An average run-off duration is shown as follows.

Duration	95 days	185 days	275 days	355 days
Run-off m^3/sec	140	101	63.7	38.1

The monthly average run-off duration curves for 18 years are shown in Fig. II-3-11.

Both the monthly average precipitation at Turrialba station and the monthly average run-off at Angostura station are indicated in Fig. II-3-12 from January 1959 to December 1968.

3.6 TEMPERATURE, HUMIDITY AND EVAPORATION

The data concerning temperature, humidity and evaporation are shown in Table II-3-9.

As for the evaporation, it is not studied because it does not influence run-off so much.

3.7 DESIGN FLOOD

The design flood at the Guayabo Dam site has been studied by ICE, and there is a report indicated below.

"Informe Hidrologico Preliminar Proyecto Hidroelectrico Amistad, Departamento de Estudios Basicos, ICE Dec. 1974".

As a result of review of the report, the design flood for spillway could be determined at 8,600 m^3/sec which would be reasonable. Actually, ICE is revising the calculation of design flood with hydro-meteorological metheds. So, the design fiood should be studied again in the definite study in future.

The design flood during construction will be different in each stage of construction. As stated in Item 6.2.2, care of the river will be made in 3 stages for which the different flood discharges could be assumed depending on the structures to be built. The design floods during construction are as follows.

During construction in the 1st stage;

Embankment of fill type dam will be carried out, and the design flood could be the existing maximum run-off 4,200 m^3/sec.

During construction in the 2nd stage;

Construction on a part of concrete gravity dam will be carried out, and the design flood could be a probable flood of 5 year's return period 1,600 m^3/sec.

During construction in the 3rd stage;

Construction of the remained part of concrete gravity dam will be carried out, and the design flood could be 800 m^3/sec.

The annual maximum run-offs in the 18 years at Angostura station are shown in Table II-3-10. The Design flood at Guayabo Power Plant site will be 4,300 m^3/sec determined by the design flood for Siquirres Dam 4,900 m^3/sec and a ratio of catchment areas.

Design flood for the Siquirres Dam will be described in Chapter 2, "Hydrology and Geology", of Part III.

3.8 SEDIMENTATION

The construction of a dam in a natural river creates a reservoir or pondage, which cannot avoid a phenomenon of sedimentation in itself. The problem of sedimentation will occur when a reservoir or pondage is going to lose its utility damaged by the sediment. At present, methods have not yet been developed to extrapolate existing results of fundamental research to broad, complex areas, such as watersheds, for prediction of the expected rate or processes of reservoir sedimentation. *

According to the data on sedimentation in many reservoirs, sedimentation will proceed in general as indicated in Figure II-3-13.

* See "Handbook of Applied Hydrology", Ven Te Chow, McGraw-Hill, 1964, p. 17-3.

Table II-3-5 Monthly Average Run-off Data at Gauging Stations

(Unit: m^3/sec)

Station	Catchment Area(km^2)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Basin: Reventazon														
(1) Angostura	1337	98.5	81.0	57.2	82.4	97.1	127.8	131.5	145.3	154.0	173.5	150.0	150.1	121
(2) El Humo	137	18.8	15.7	11.2	17.9	23.1	27.6	24.7	32.0	30.3	30.7	28.8	26.6	24.0
(3) Montecristo	64.6	4.6	3.4	2.5	3.1	3.9	6.2	6.5	8.1	8.4	8.0	6.6	7.3	5.7
(4) Cachi	690	44.4	32.1	23.1	29.3	38.2	56.2	57.1	67.6	74.4	76.7	74.7	66.7	53.4
(5) Cordocillal	253	23.0	16.6	11.4	16.4	20.7	26.8	26.5	30.8	31.5	33.1	36.1	34.2	25.6
(7) Oriente	227	26.0	21.0	15.2	26.7	34.9	44.4	36.7	48.7	47.5	50.3	45.2	41.6	36.5
(10) Pascua	1673	137.4	115.4	83.9	115.8	127.2	175.3	173.4	180.3	202.9	210.3	195.8	205.3	160
Basin: Pacuare														
(17) Pacuare	367	31.0	23.3	16.9	26.5	34.1	47.3	36.2	42.0	50.8	57.0	54.4	55.1	39.6
(18) Dos Mantanas *	652	57.9	44.0	28.8	51.0	56.6	72.5	64.7	68.2	75.6	84.0	95.3	107.0	67.1

Note: Average from 1964 to 1973

* The data contain data at Siquirres G.S. (C. A.= 657 km^2)

Table II-3-6 Specific Run-off at Gauging Stations

Station	Catchment Area(km^2)	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	Average	Ratio
		Specific Run-off (Unit: $m^3/sec/100\ km^2$)											
Basin: Reventazon													
(1) Angostura	1337	7.36	8.30	9.65	9.05	9.57	8.00	13.53	8.98	7.35	8.30	9.01	1.00
(2) El Humo	137	15.2	18.2	19.9	16.3	18.3	15.3	23.2	17.3	15.0	16.1	17.5	1.94
(3) Montecristo	64.6	6.83	8.40	8.50	8.76	8.95	7.26	12.86	10.19	7.66	9.06	8.85	0.98
(4) Cachi	690	7.30	7.49	7.91	7.14	8.30	7.46	10.87	7.64	6.09	7.06	7.73	0.86
(5) Cordocillal	253	7.35	8.10	10.20	8.66	10.67	9.60	15.77	11.02	9.33	10.08	10.1	1.12
(7) Oriente	227	13.2	13.9	17.1	15.2	16.6	14.4	22.3	16.8	14.9	16.1	16.1	1.79
(10) Pascua	1673	7.23	8.55	10.76	10.82	9.98	9.50	14.94	8.91	7.35	7.65	9.57	1.06
Basin: Pacuare													
(17) Pacuare	367	8.17	9.26	11.44	9.62	11.90	10.27	17.84	9.97	9.48	9.59	10.8	1.20
(18) Dos Montanas	652	7.02	9.14	10.70	9.57	11.19	9.77	17.58	8.96	8.97	9.59	10.2	1.13

Table II-3-7 Monthly Run-off at Angostura Gauging Station

(Unit: m^3/sec)

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Max.	580	569	230	2630	310	378	430	374	411	298	900	1660	Max. (2630)
Mean *	87.9	68.0	50.8	66.6	87.2	131	130	134	148	154	151	144	113
Min.	33.9	28.4	23.8	20.9	26.4	54.8	54.3	53.3	62.1	77.5	60.2	46.0	Min. (20.9)

Note: Mean from 1959 to 1976

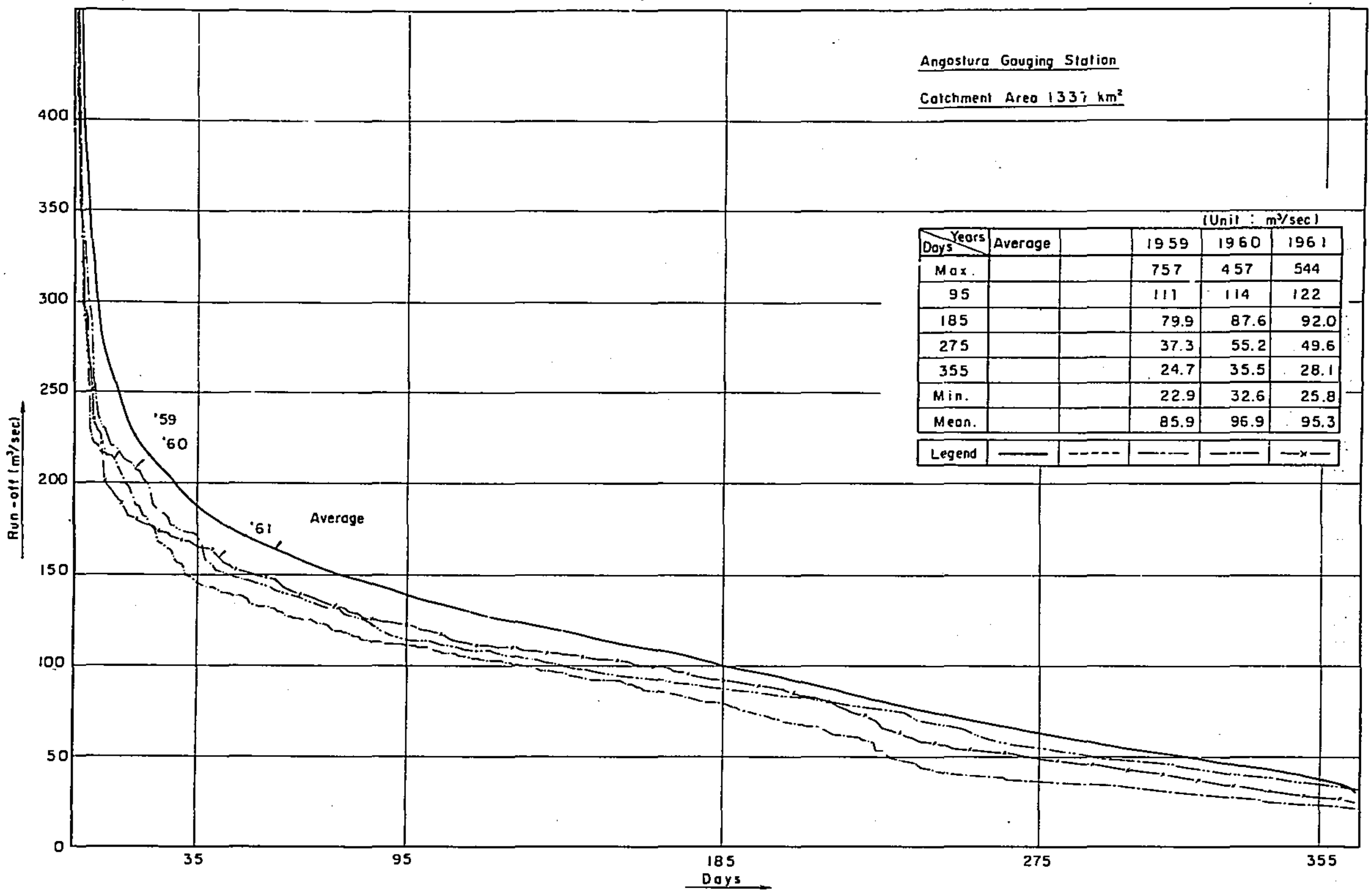
Max., Min.; Daily run-off

Table II-3-8 Run-off Duration at Angostura Gauging Station

Catchement Area 1337 km^2 (Unit: m^3/sec)

Year	Max.	95 day	185 day	275 day	355 day	Min.	Mean
1959	757	111	79.9	37.3	24.7	22.9	85.9
1960	457	114	87.6	55.2	35.5	32.6	96.9
1961	544	122	92.0	49.6	28.1	25.8	95.3
1962	900	141	98.8	52.8	32.2	29.6	115
1963	376	130	96.2	69.3	47.2	39.4	107
1964	340	137	88.8	46.0	24.6	23.4	98.5
1965	377	141	108	71.0	35.0	31.0	111
1966	593	148	119	93.0	43.0	36.0	129
1967	298	148	116	84.0	44.0	38.0	121
1968	468	161	126	82.5	48.0	33.9	128
1969	742	138	90.6	47.0	32.5	27.8	107
1970	2630	188	142	98.0	55.0	46.0	181
1971	430	154	108	73.5	54.4	47.0	120
1972	497	118	85.3	65.6	42.7	28.9	98.4
1973	523	140	96.6	51.4	26.0	20.9	111
1974	873	130	93.8	63.8	46.6	22.0	108
1975	907	168	100	43.9	32.5	24.2	117
1976	429	124	92.0	63.1	33.8	26.8	102
Average	-	140	101	63.7	38.1	-	113

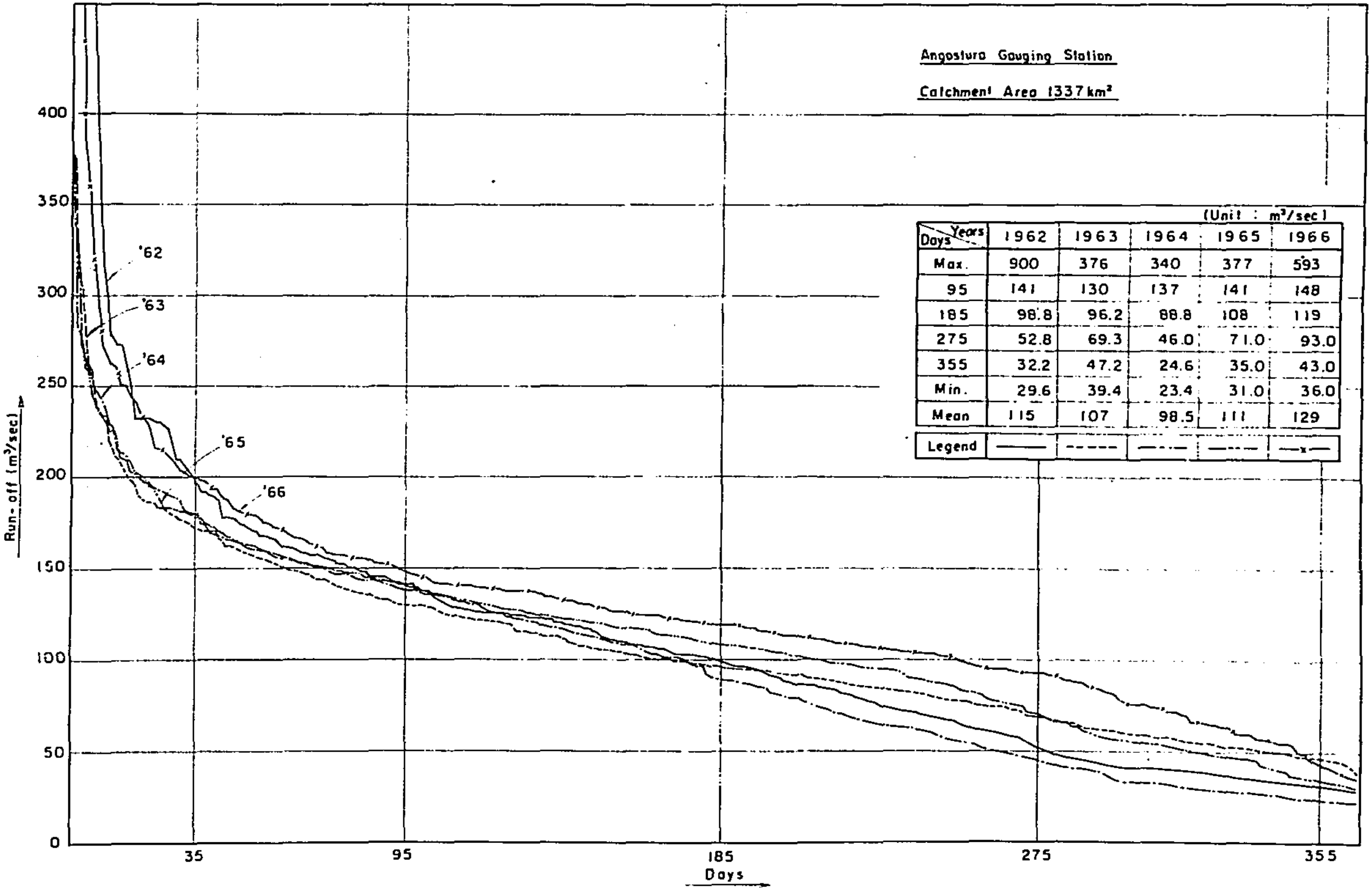
Fig. II-3-10 Run-off Duration Curve (4 - 1)



(Unit : m³/sec)

Days \ Years	Average		1959	1960	1961
Max.			757	457	544
95			111	114	122
185			79.9	87.6	92.0
275			37.3	55.2	49.6
355			24.7	35.5	28.1
Min.			22.9	32.6	25.8
Mean.			85.9	96.9	95.3
Legend	———	- - - -	—·—·—	—··—··—	—x—

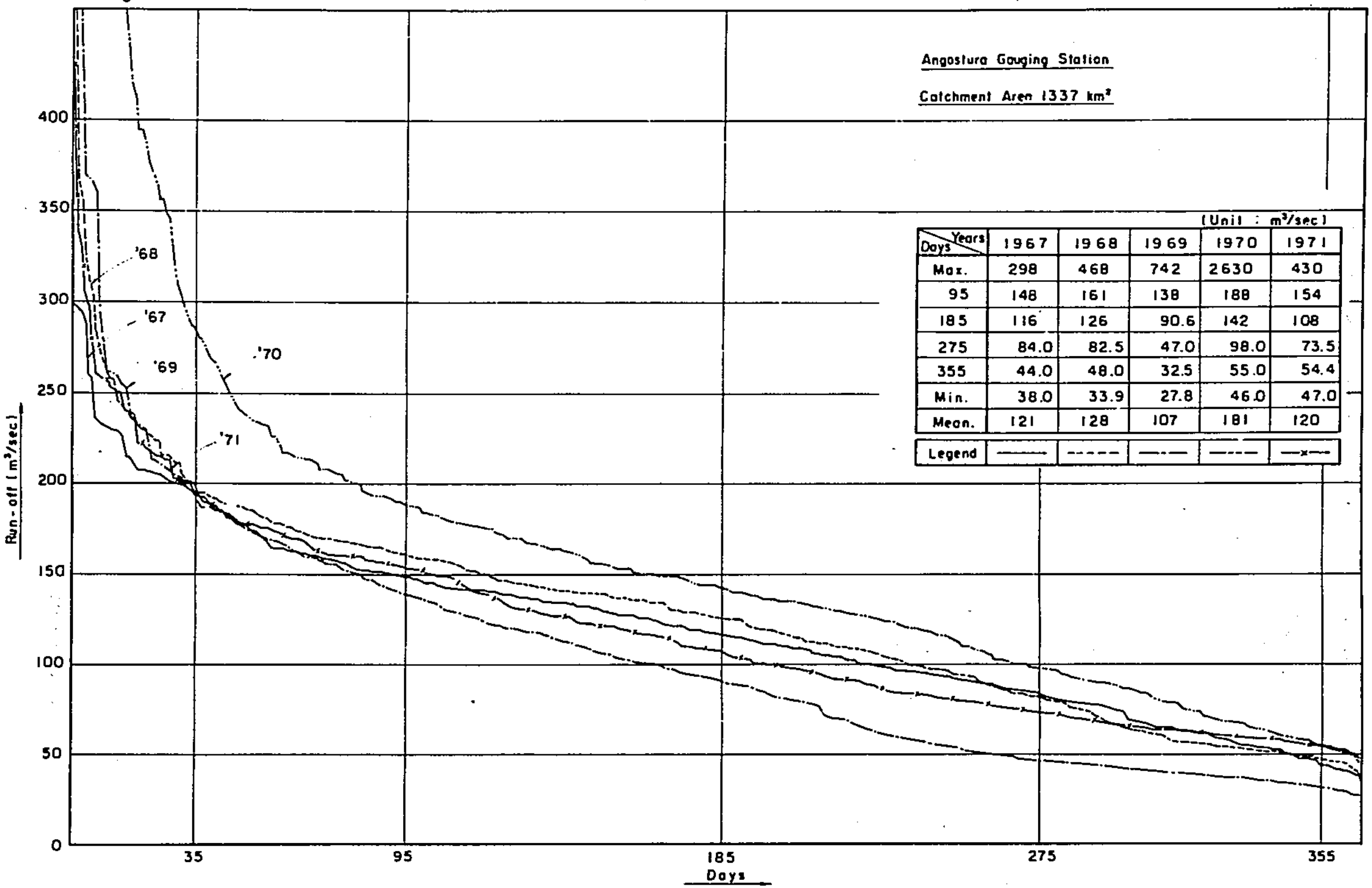
Fig. II-3-10 Run-off Duration Curve (4-2)



(Unit : m³/sec)

Days \ Years	1962	1963	1964	1965	1966
Max.	900	376	340	377	593
95	141	130	137	141	148
185	98.8	96.2	88.8	108	119
275	52.8	69.3	46.0	71.0	93.0
355	32.2	47.2	24.6	35.0	43.0
Min.	29.6	39.4	23.4	31.0	36.0
Mean	115	107	98.5	111	129
Legend	———	- - - - -	—·—·—	—··—	—x—

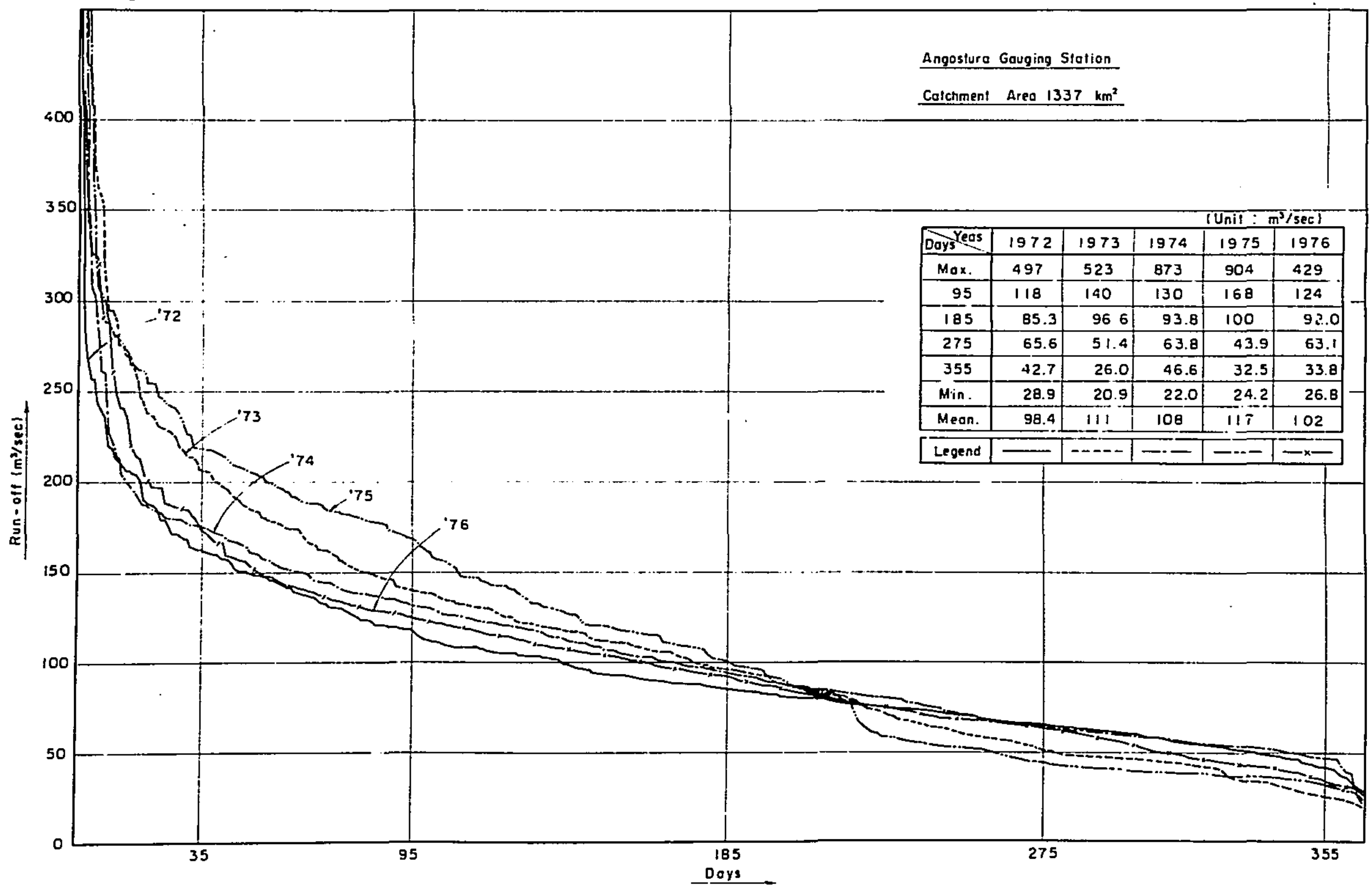
Fig. II-3-10 Run-off Duration Curve (4-3)



(Unit : m³/sec)

Days \ Years	1967	1968	1969	1970	1971
Max.	298	468	742	2630	430
95	148	161	138	188	154
185	116	126	90.6	142	108
275	84.0	82.5	47.0	98.0	73.5
355	44.0	48.0	32.5	55.0	54.4
Min.	38.0	33.9	27.8	46.0	47.0
Mean.	121	128	107	181	120
Legend	———	-----	—·—	—··—	—x—

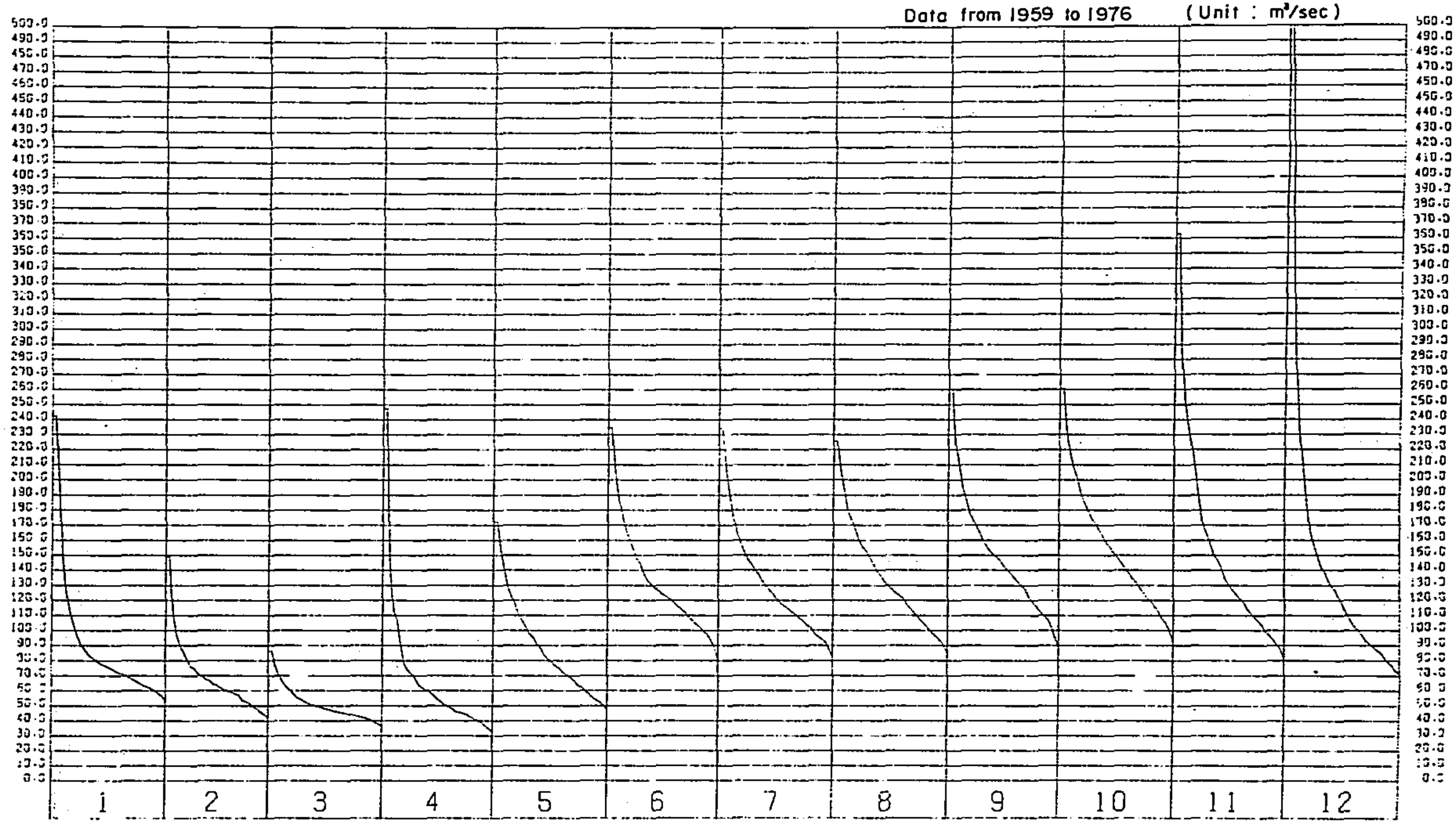
Fig. II-3-10 Run-off Duration Curve (4-4)



(Unit : m³/sec)

Days \ Yeas	1972	1973	1974	1975	1976
Max.	497	523	873	904	429
95	118	140	130	168	124
185	85.3	96 6	93.8	100	92.0
275	65.6	51.4	63.8	43.9	63.1
355	42.7	26.0	46.6	32.5	33.8
Min.	28.9	20.9	22.0	24.2	26.8
Mean.	98.4	111	108	117	102
Legend	———	- - - - -	—·—	—··—	—x—

Fig. II-3-11 Manthly Run-off Duration Curve at Angostura G.S.



Note: Parallel x duration curve x See Appendix A-3

Fig. II-3-12 Correlation Between Discharge and Precipitation (2-1)

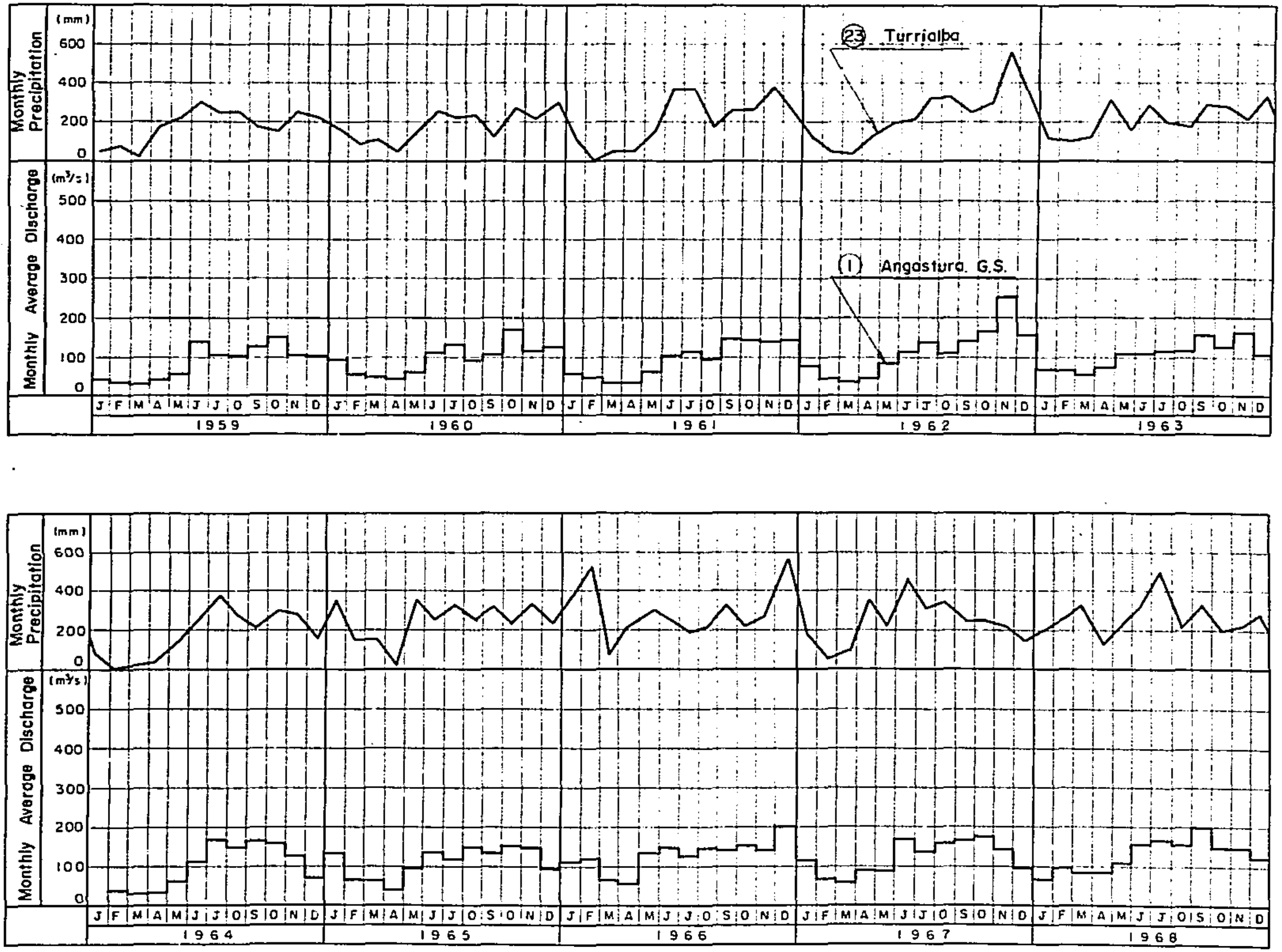


Fig. II-3-12 Correlation Between Discharge and Precipitotion (2-2)

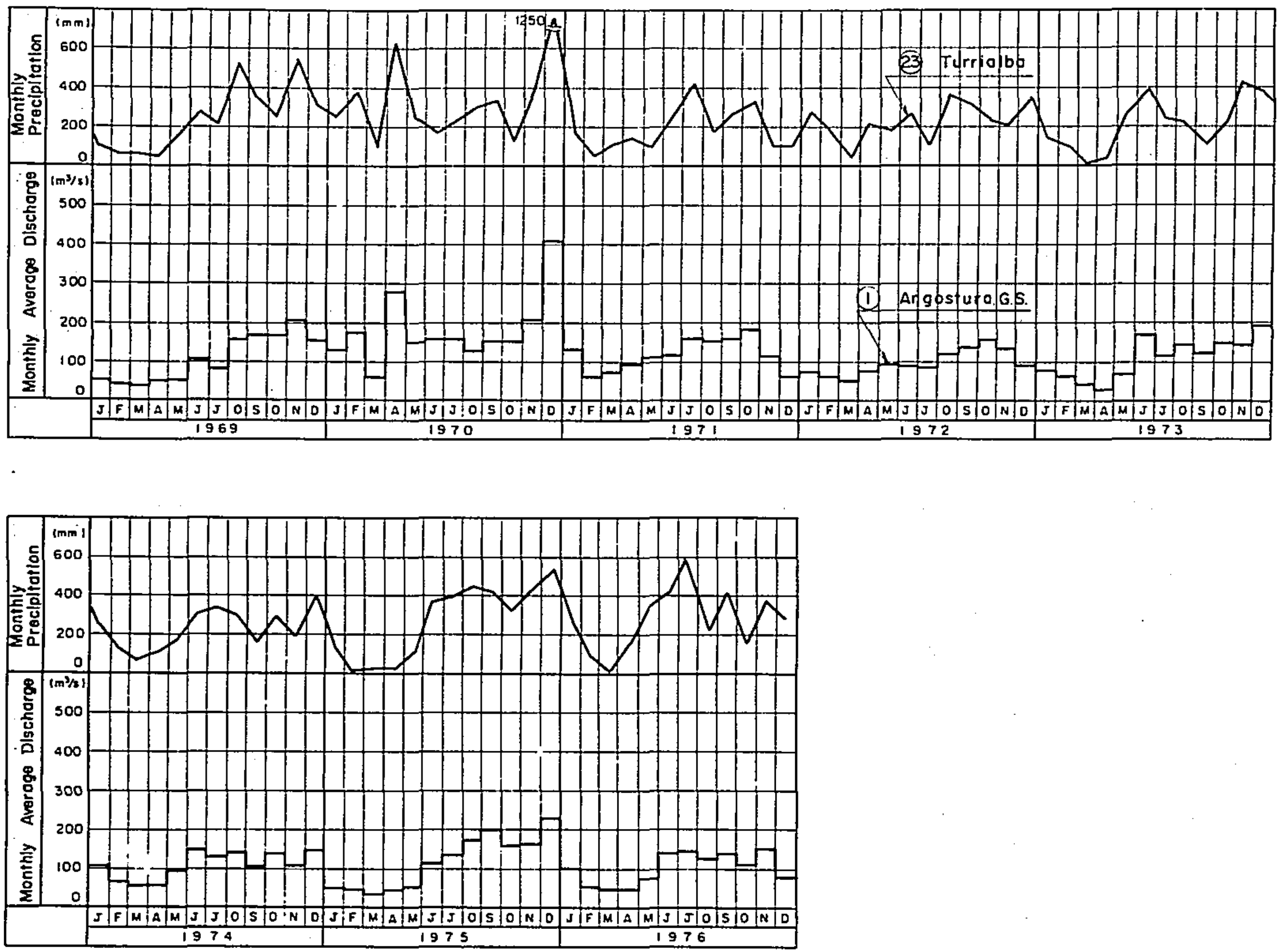


Table II-3-9 Meteorological Data at Turrialba Station

Station	TURRIALBA												
Latitud	9° 53'				Longitud		83° 38'			Altitud		602 m	
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Precipitation (mm)	175.7	137.1	73.1	129.2	222.6	260.1	288.3	239.6	220.9	246.2	277.1	366.0	2635.9
Evaporation	77.4	92.8	130.5	120.2	114.6	96.9	86.7	91.8	105.4	102.6	82.3	79.1	1180.3
Duration of Sunshine	142.0	146.7	160.1	155.0	144.4	125.8	114.9	132.4	130.8	139.0	126.2	130.4	1647.7
Solar Radiation	371.4	419.7	460.4	469.2	455.0	416.4	378.2	420.5	487.1	418.1	355.3	348.8	5000.1
(Temperature)													
Average (°C)	20.7	20.8	21.6	22.1	22.8	22.8	22.4	22.5	22.6	22.5	21.9	21.0	22.0
Aver. Max.	25.6	26.0	27.0	27.3	27.2	27.8	27.2	27.4	27.8	27.6	26.5	25.8	26.9
Aver. Min.	16.2	16.1	16.7	17.5	18.4	18.6	18.4	18.2	18.1	18.1	17.9	16.8	17.6
Absolute Max.	31.0	30.0	31.3	31.6	31.8	30.0	30.6	29.9	30.7	30.6	29.8	28.3	30.5
Absolute Min.	10.0	10.0	10.7	12.0	13.8	16.2	14.1	15.1	15.0	14.7	14.3	10.6	13.0
(Humidity)													
Aver. Daily (%)	86.8	83.9	84.1	84.4	86.7	88.5	89.9	88.7	88.0	88.5	89.2	88.8	87.3
Aver. Min.	60.2	57.1	54.4	56.2	58.4	60.3	61.9	59.9	56.2	61.0	62.6	63.1	59.3
Absolute Min.	21.0	22.0	24.0	31.0	35.0	37.0	32.0	41.0	30.0	38.0	29.0	27.0	30.6

Source: Data From ICE

Table II-3-10 Annual Maximum Discharge
Angostura gauging station
Catchment Area 1,337 km^2

No.	Year	Days		Discharge (m^3/sec)
1	1959	22	Jun.	370
2	1960	8	Oct.	511
3	1961	26	Dec.	636
4	1962	4	Nov.	1,060
5	1963	9	Dec.	671
6	1964	19	Sep.	693
7	1965	13	Jun.	599
8	1966	26	Dec.	926
9	1967	5	Jun.	569
10	1968	19	Sep.	876
11	1969	24	Nov.	1,660
12	1970	9	Apr.	3,800
13	1971	23	Sep.	683
14	1972	4	Sep.	642
15	1973	10	Dec.	1,000
16	1974	4	Dec.	1,230
17	1975	14	Dec.	1,260
18	1976	4	Jun.	598

In floods, spillway gates and sediment control gates will be open to discharge the flood. At the time, smaller particles of sediment could be brought downstream with it, but bigger sediment would deposit in the upstream. The same phenomenon is found in Cachi reservoir of Reventazon River.

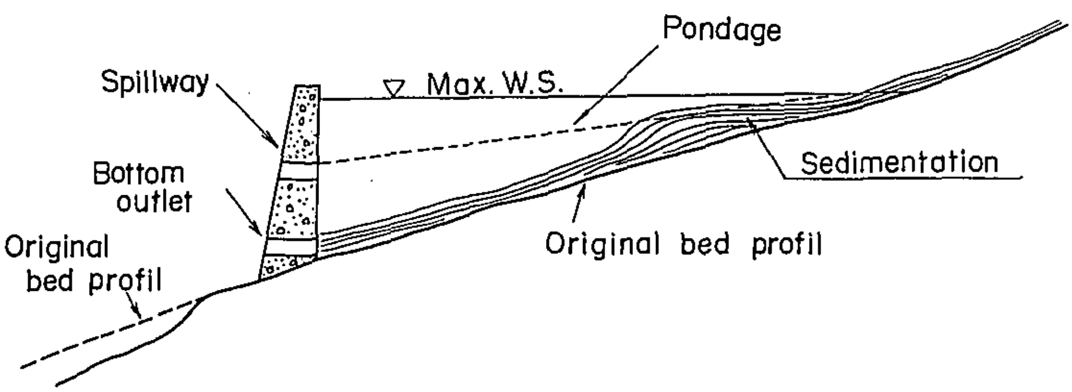
The recorded volume of sediment is approximately 900 m^3/km^2/year for Cachi reservoir.

On the other hand, in the river channel near the Guayabo Dam site, there are pretty amount of sediment. Therefore, it seems that lots of sediments would be brought into Guayabo pondage and similar phenomenon to Cachi Reservoir might be happened.

Thus, it will be necessary for the Guayabo Dam to provide sediment control out-let at the bottom of Dam. When floods will flow into the pondage, the gates of spillway and outlet will be open to evacuate the flood with sediment, and the usefulness of pondage could be preserved.

In estimation for effective storage capacity of the Guayabo Pondage, it could be assumed that sediment might deposit linearly in the pondage from the crest of spillway (EL. 415 m) to the end of pondage with a grade (1/90) which is half of grade of the river (1/45).

Fig. II-3-13 Delta Formation in Pondage



Note ------ Assumed Final Surface of Sedimentation with a Grade 1/90

CHAPTER 4

GEOLOGY AND CONSTRUCTION MATERIAL

CHAPTER 4 GEOLOGY AND CONSTRUCTION MATERIAL

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CHAPTER 4 GEOLOGY AND CONSTRUCTION MATERIAL

4.1 OUTLINE AND CONCLUSIONS

4.1.1 Purpose and Scope of Geological Survey

The purpose and scope of survey are not only to select the most favorable sites for objectives but also to offer basic data for a preliminary design. The field survey and the analysis of the result has been made, from the engineering geological point of view, regarding pondage area, such proposed structures as dam and tunnel, and construction materials for Guayabo Project. In addition, they are to prepare a plan of geological survey for the future, before a definit design, on the basis of results of the survey and analysis which will have clarified the geological problems for the sites.

The geological survey of Guayabo Project was started by ICE in 1974, and so far the exploratory works shown in the table II-4-1 have been executed. In the investigation works, the data of almost all borings have been written in the following two reports by the engineering geologist of ICE together with their comments on the results of the field reconnaissance of the project site:

Proyecto Amistad-Siquirres Sitio de Presa de Guayabo
"Informe Geologico de Reconocimient" : Junio 1975
Proyecto Amistad Linea de Tunel y Casa de Maquinas
"Informe de Reconocimient Geologico" : Mayo 1975

In our survey, we have carried out not only detailed geological survey of the proposed sites but also observations of the test pits and boring cores on the sites. In addition, microscopic inspection, X-ray diffraction of rock samples and a preliminary analysis of the result of seismic prospecting were made in Tokyo.

4.1.2 Conclusions and Recommendations

A summary of our opinions, from the engineering geological point of view, upon the Guayabo Project obtained by the survey is as follows. It is concluded that there is no unusual problem which jeopardize the implementation of the project. However, there remains some problems to be clarified in the future, and the exploratory works are necessary before carrying out definite study as shown in the Table II-4-2.

(1) Guayabo Pondage Area

In the area, there exisits no pervious stratum which could be a problem for the preservation of pondage watertightness. In addition, there is no possibility of large landsliding and collapsing of the slopes surrounding the pondage after the filling up of pondage.

(2) Guayabo Dam Site

Guayabo dam is proposed to be a combined dam. The foundation is consisted of soft clastic sedimentary rock in Tertiary Period, but they have sufficient strength

Table II-4-1 List of Geological Exploratory Works at Guayabo Dam Site

	Site		No.	Elevation(m)*	Length(m)**	Remarks
Dam site	Left bank	Drill hole	DB-3	411.67	30.0	
			DB-4	416.94	30.0	
			DB-5	421.31	30.0	
			DB-6	410.98	50.0	
			DB-7	415.06	30.0	
			DB-9	420.63	30.0	
			DB-10	410.98	163.25	Direction: S72° E, 42°
			Total: 7 holes,		343.25m	
		Test pit	DP-1	421.0	7.5	Excavating as of Oct. 1977
			DP-2	412.5	7.0	
			Total: 2 pits,		14.5m	
	Upstream	Seismic prospecting	S-1	-	360.0	Prospecting as of Oct. 1977
			S-2	-	260.0	
			S-3	-	170.0	
	River bed		S-4	-	155.0	
			S-5	-	135.0	
	Left bank		S-6	-	270.0	
			S-7	-	220.0	
			S-8	-	220.0	
			S-9	-	80.0	
			S-10	-	90.0	
			Total: 10 traverses.		1960.0m	
Headrace tunnel		Drill hole	HB-1	-	180	
Surge tank			SB-1	456.64	116.50	
Power house			PHB-1	-	25.35	

* Top elevation of drill hole and test pit.

** Length of hole and seismic traverse and depth of pit.

Table II-4-2 List of Geological Exploratory Works Suggested at Guayabo Dam Site

Site			No.	Length(m)*	Remarks
Dam site		Drill hole	DB-11	30.0	Water pressure test should be performed at drill hole. DB-11, DB-12, DB-13 and DB-14.
			DB-12	30.0	
			DB-13	40.0	
			DB-14	30.0	
			DB-15	30.0	
			DB-16	30.0	
			DB-17	30.0	
			DB-18	30.0	
			DB-19	30.0	
			Total: 9 holes	280.0 m	
		Test pit	DP-3	10.0	Plate loading test, grain size analysis and water pressure test should be performed on mud flow deposit and lower terrace deposit
			DP-4	10.0	
			Total: 2 pits	20.0 m	
Headrace tunnel			HB-2	40.0	
			HB-3	40.0	
			Total: 2 holes	80.0 m	
Penstock		Drill hole	PB-1	30.0	
			PB-2	25.0	
			PB-3	20.0	
			Total: 3 holes	75.0 m	
Borrow area	Impervious material	Drill hole	IB-1	10.0	
			IB-2	10.0	
			IB-3	10.0	
			IB-4	10.0	
			IB-5	10.0	
			IB-6	10.0	
			Total: 6 holes	60.0 m	
		Test pit	IP-1	5.0	Laboratory test should be performed on sample taken from pits.
			IP-2	5.0	
			IP-3	5.0	
			IP-4	5.0	
			Total: 4 pits	20.0 m	
	Rock fill and concret aggregate		RP-1	7.0	Grain size analysis in site and laboratory test for aggregate should be performed.
			RP-2	7.0	
			RP-3	7.0	
			RP-4	2.0	
			RP-5	7.0	
			RP-6	5.0	
			Total: 6 pits	35.0 m	

* Length of drill hole and depth of test pit.

for the foundation of both concrete dam and fill type dam proposed of about 40 meters, and they could have enough watertightness if provided with low pressure curtain grouting.

However, for the foundation of concrete dam on the right bank, in-situ test is necessary to know the physical characteristics of clastic rocks. For the base of proposed fill type dam on the left bank, it is necessary to clarify the physical characteristics of the mud-flow deposit covering the basal rock in order to get data for the treatment of the foundation in the definite study.

The axis of proposed dam is considered to be most excellent from the topographical point of view.

(3) Headrace Tunnel

In the area of the route for headrace tunnel, there is a distribution of clastic sedimentary strata in Tertiary Period composed mainly of mudstone. The mudstone is by nature poorly cemented, weak against water and easy to weather. Therefore, permanent supports will be necessary through almost all sections of the tunnel with a large diameter of 8 m. Concrete lagging might be necessary for sheared zone and the places where ground water might come out. In addition, a few of faults might cross the tunnel.

On the basal rock, there are some distributions of agglomerate strata composed of unconsolidated pyroclastics, and the strata would encounter with the tunnel near the point of IP-3. As the coverage of rock on the tunnel is small at points IP-2 and IP-3, it is necessary to investigate the geological condition by drilling.

It is confirmed by X-ray analysis made in Tokyo that the mudstone in the basal rock contains montmorillonite. Therefore, a study is necessary on the expansiveness of this mudstone.

(4) Surge Tank and Penstock Sites

They are located in the tuffaceous clastic rocks of Tertiary Period. The rocks also belong to soft rocks, but fresh rocks of them have enough bearing capacity for the base of proposed structures. At the site of the surge tank, considerable weathering down to 20 meters from the ground is seen by core boring. As for the locations of anchor blocks, an investigation is necessary by drilling on weathered layers.

(5) Power Plant Area

By changing the course of meandering Pacuare river, we will be able to provide a flat land for the power plant. The basal rock is formed by the lava which contains andesitic or basaltic massive rocks and has the same nature as pyroclastic rocks. It has enough bearing capacity for the foundation of power plant.

The thickness of river deposit is estimated at a few meters.

(6) Construction Material

As for impervious material, the weathered zone of the unconsolidated agglomerate distributing around the dam site could be used. There is no problem regarding the quantity, but further investigation and test are necessary on the characteristics of the material for the preparation of definite study.

As for filter material, gravel material and concrete aggregate, the river deposits in the up- and down-stream of the dam site could be used. The river deposits are composed of andesitic rock with enough strength of material for construction and there is no problem of quantity. The deposits contain much gravels of larger size, and screening would be necessary for obtaining filter material. For make it certain, grain size analysis and aggregate test are necessary. Filter material could be obtained not only from unweathered agglomerate in the deep portion of the area where impervious materials would be taken, but also from mud deposits excavated off the dam foundation. In conclusion, testing of materials is indispensable for the definite study on dam.

4.2 GENERAL GEOLOGY OF PROJECT AREA

4.2.1 Topography

Costa Rica, situated at the south end of Central America, has a slim territory extending northwest-southeast, and is held between the Pacific Ocean and the Caribbean Sea. Along the center line of the land runs a mountain range in the same direction of northwest-southeast. This mountain range was brought about by Continental plates movement and the consequent volcanic activity, forming a part of the Circum-Pacific volcanic belt. This mountain range has an average height over 2,500 meters in its southeastern part where stands the highest peak Mt. Chirripo, 3,819 meters. A volcanic row including Mt. Iraz, 3,432 meters, forms the mountain range extending from the middle to the northwest. The volcanic row diminishes its height gradually to the northwest and disappears near the border of Nicaragua. Most rivers flow out of the mountain ranges, forming alluvial plains toward the sea-coast and pour into the Pacific and Atlantic Oceans.

The site of Guayabo Project is situated in the mid-stream area of both Reventazon river and Pacuare river about 50 kilometers east of San Jose, the capital. The both rivers originate from the northwest of Mt. Chirripo and flow to northeast collecting water from their dendritic tributaries. They go through mountainous areas over at the points about 20 kilometers down-stream of the project site, forming alluvial plains with vast forest area along the seacoast. Finally it pours into the Caribbean Sea.

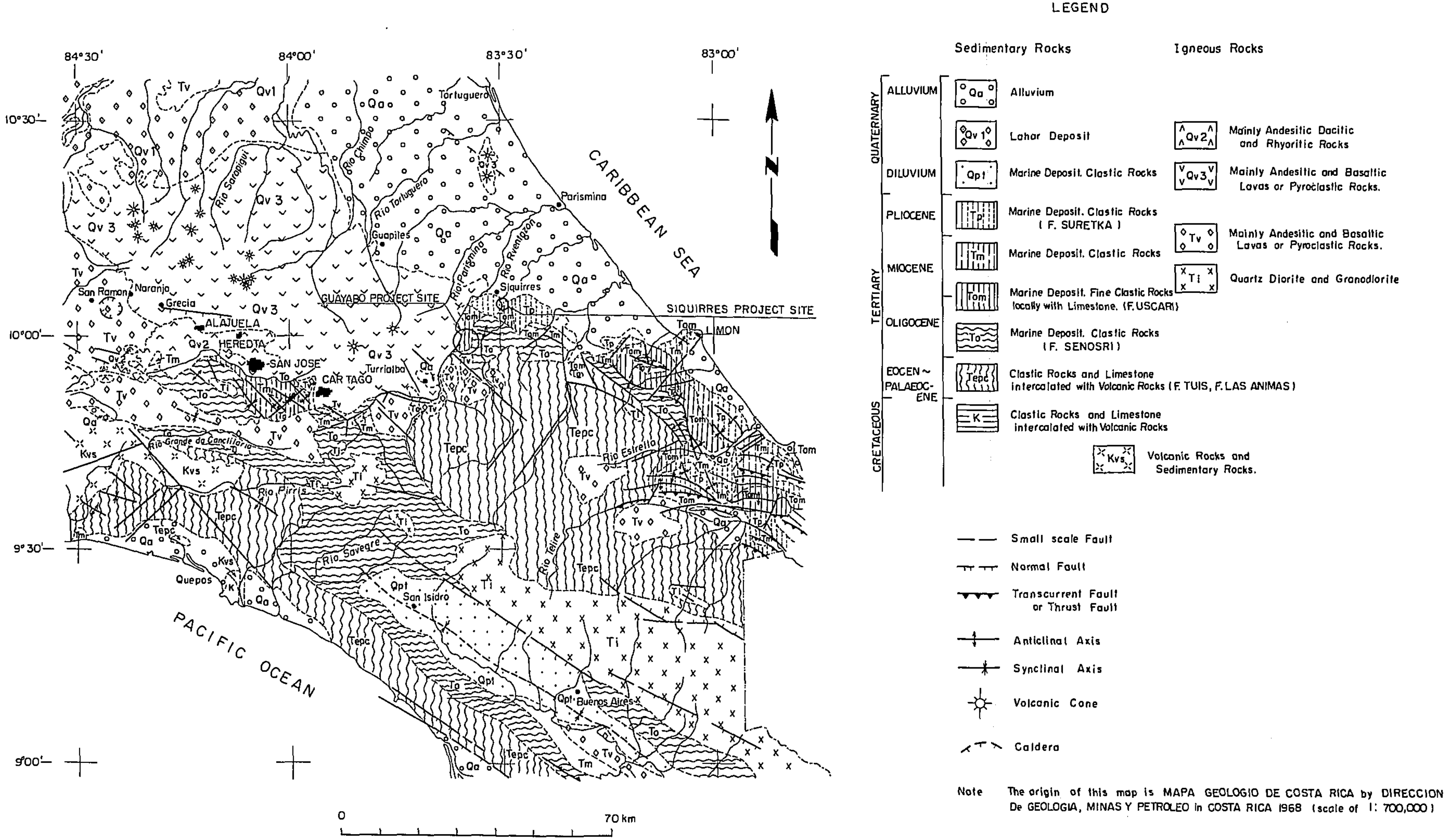
At the northwest of Project site spreads the skirt of Mt. Turrialba, a stratovolcano, with a moderate slope. To the southeast of Project site spreads a hilly area 600 to 700 meters high above sea level, formed of clastic sedimentary rocks in Tertiary Period. Reventazon river flows down along the border of these two areas with different topography, forming a valley with a wide bottom. On the contrary, Pacuare river, in which Power Plant will be located, has a narrow river bed, forming comparatively steep slope on both banks.

4.2.2 Geology (Fig. II-4-1)

(1) Stratigraphy

The geology, which forms the base of Costa Rica, is classified into two: mainly marine clastic sedimentary rock of Cretaceous Period to Tertiary Period,

Fig. II-4-1 GENERAL GEOLOGICAL MAP OF CARTAGO AND LIMON DISTRICT



and volcanic rocks of late Tertiary to Quaternary Period. The former forms a zonal distribution extending in the direction of northwest-southeast, with older sedimentary rocks along Pacific coast and newer ones along Atlantic coast. This comparatively simple geological structure was brought about by Continental plates movement.
In some parts, igneous activity including intrusion of plutnic rocks is seen. The latter was formed by the igneous activity of Circum-Pacific volcanic belt and spreads widely from the central part to the northwestern part of Costa Rica. In this volcanic belt, there are still active volcanos and Project site locates at the east of Mt. Irazu one of the active volcanos.

The geology of Project area is the clastic sedimentary rocks in Tertiary Period, volcanic rocks and alluvium of Tertiary to Quaternary Period. The clastic sedimentary rocks, which form the base of Project area, are classified into Tuis, Las Animas and Uscari formations, which are formed mainly of marine clastic sedimentary rocks deposited during Palaeocene to Miocene stages in Tertiary Period. The volcanic rocks of Pliocene to Quaternary are mainly formed of andesitic agglomerate and andesitic lava. The andesitic agglomerate covers the basal rocks with a thickness of several to about 15 meters and widely spreads over the ground. Andesitic lava is only seen in some parts covering the former, but its distribution and thickness are not identified. The alluvium is formed of river deposits, terrace deposits, mud-flow deposits, etc. distributing in a small area along the present river course.

The stratigraphy of these strata distributing in the project area is shown in the Table II-4-3.

(2) The characteristics of each formation

The relation of the proposed structures with the formation is shown in the Table II-4-4. The characteristics of each formation and rock, and the evaluation of them as foundation rock or material are as follows.

(a) Tuis formation
This formation is located in the basal strata of Guayabo Project area and widely distributes along Reventazon river and Pacuare river in the upstream of Project area. In Project area, it distributes along Pacuare river where the Power Plant is proposed and is divided into upper and lower formations.
The lower formation is composed of pyroclastic rocks including andesitic or basaltic lava and agglomerate. Each layer has sedimentary structure of 5 to 15 meters thickness. At some parts small dykes of dolerite, which are intrusive rocks, are seen. The rocks forming the lower layer, including pyroclastic rocks, generally have considerable consolidation and enough strength for foundation of Power Plant.
The upper formation distributes around Surge Tank and Penstock. It is tuffaceous and formed of siltstone, sandstone and conglomerate of gray-green color. These clastic rocks contain limy micro-fossils and bits of fossils. According to the drill hole SB-1 (length 116.5 meters in vertical) for Surge Tank, sandstone is most predominant compared with siltstone and conglomerate, and considerably tuffaceous in general. X-ray analysis was made in Tokyo on the samples of tuffaceous sandstone obtained at the depth of 46.9 meters of the boring core. The result

Table II-4-3 Generalized Geologic Sequence of Guayabo Project Area

Period	Stage	Sedimentary Rocks	Igneous Rocks
Quaternary	Holocene	Alluvial deposit	
	Pleistocene	Terrace deposit	Andesitic lava and Pyroclastic rocks
Tertiary	Pliocene		Agglomerate Unconformity
	Miocene	Uscari Formation	
	Oligocene		
	Eocene	Tuis and Las Animas Formation	Andesitic or Basaltic lava Pyroclastic rocks and Intrusive rocks
	Palaeocene		

Table II-4-4 Outline of Stratigraphic Sequence and Rock Type of Foundation Rock at Sites of Guayabo Project

Diagramatic Column	Rock Type	Thickness (m)	Distribution
	Mud-flow deposit	7 to 14	Dam site and pondage area
	Lower Terrace Deposit	3 to 5	
Uscari Formation	Mudstone and sandstone; locally interbedded with conglomerate and fossil bed		Dam site, intake headrace tunnel and pondage area
Tuis Formation	Tufferceous siltstone, sandstone and conglomerate		Surge tank and penstock
	Andesitic or basaltic lava and pyroclastic rock (Dolerite; intrusive rock)		Penstock, power plant site and its vicinity

shows that the clay mineral contained in the sample is very little in quantity and it is formed mainly of montmorillonite group.
Each rock of the upper formation belongs to poorly consolidated soft rock, but fresh rocks have enough bearing capacity for the foundation of Surge Tank and anchor blocks of Penstock.

(b) Las Animas formation
This is considered as contemporaneous heterotopic facies to Tuis formation and is formed of bedded limestone with high solidity containing many fossils. It distributes upstream of 1.6 km point from Guayabo Dam site and has no relation with the proposed structurea and pondage.

(c) Uscari formation
It forms the base of Dam site and of the route of Headrace Tunnel. This formation covers the above-mentioned Tuis formation and Las Animas formation. Judging from the harmonious geologic structure, these formations are considered to be conformable to each other. It is formed mainly of mudstone and sandstone, and partly intercalated with conglomerate and thin fossil bed. Mudstone, which is most dominant there, forms in some places alternation with sandstone in several ten centimeters to several meters thickness, and in other places massive texture of up to 10 meters thickness. Mudstone generally has dark gray color. Sandstone is classified into medium to coarse grained bed with light gray-brown color and fine grained bed with lamina and dark gray color. Mudstone, sandstone and conglomerate contain more or less limy micro fossils and fossil bits.
All Clastic rocks of Uscari formation belong to soft rocks, but the test on boring core of Dam site shows that fresh rocks have 100 to 250 kg/cm^2 compressive strength and enough strength for the foundation of the proposed dam.
X-ray analysis was made on the mudstone samples obtained at the intake site on the right bank of the Dam axis. The result showed that the mudstone sample contained clay mineral belonging to montmorillonite in considerable quantity.

(d) Agglomerate
This formation was formed by volcanic activity in Pliocene of Tertiary Period and unconformably covers the Tertiary Clastic rocks. This agglomerate shows a wide distribution in the southeastern part of the Project area with a thick layer but gradually diminishes its distribution and thickness in the northeastern part. It widely spreads in the hilly area of 600 to 700 meters in elevation where the Headrace Tunnel runs through. According to drill hole HB-1 (length 180 meters in vertical) in headrace tunnel investigation, the thickness is about 37 meters. The agglomerate is formed mainly of andesitic angular-subangular breccia of 10 cm to several cm diameter and tuffaceous matrix filling them.
Its degree of consolidation is very low. It is very much weathered in the surface layer except the areas along the present river course which are much eroded, and andesitic rocks show onion structure weathering. They could be counted as good materials for impervious materials for fill type dam, as is stated in 4.4.1. In relation to proposed structure,

the distribution might be found around the point IP-3 of Headrace Tunnel.

(e) Andesitic lava
It was formed by Quaternary volcanic activity, and consists of products of volcanos of Mt. Turrialba and Mt. Iraz in the northwest of Project area. They are seen in a brooklet on the right bank 1.4 km upstream of the dam site, but it has no relation with the proposed structures. It is called as Pavones lava and covers unconformably the agglomerate. It is considered to have several 10 meters thickness but its detail distribution is not known yet.

(f) Overburden
Reventazon river where Guayabo Dam will be located forms a valley with a wide bottom. There are seen terrace deposits spotted at 15 - 20 m above present river bed and mud-flow deposits laying almost continuously at lower levels. The mud-flow deposits cover lower terrace deposits. All these deposits are not consolidated as well as deposits on the present river bed.
The mud-flow deposits form a wide flat area at 10 to 15 m. above the present river bed, and have an important relation with Project. They were formed by massive products of present volcanos consisting of mixed deposits of boulder to clay with poor sorting. Their nature is quite different from that of terrace deposits and river bed deposits. Mud-flow deposits have 7 to 14 m thickness around the dam site and it is a problem to be studied whether they can be left in the foundation of the core zone of Fill Type Dam.
The lower terrace deposits and river bed deposits consist mainly of subrounded to round pebbles or cobbles with small quantity of granule and sand filling them. Gravels consist mostly of grey - purple colored hard andesite. Thickness of the river deposit on Reventazon river around the dam site are considered to be 3 to 5 m. The river deposits near the dam site are the best concrete aggregate and rock material for Fill Type Dam.
There are no important alluvial deposits along Pacuare river where Power Plant will be located. Only a small quantity of river deposit is seen on the narrow bed of river.

(3) Geologic Structure

The geologic structure of Costa Rica is dominated by Continental plates movement, and NW-SE direction is predominant. The Talamanca mountain range in the southeastern region and Central mountain range consisting of volcanos in the middle to northwestern regions, which form the country's back bones, follow the above structure.

As stated before, the rocks which form the basal structure of Costa Rica are mainly marine clastic sedimentary rocks deposited during Cretaceous Period in Mesozoic Era to Tertiary Period in Cenozoic Era. There, rocks with folding structure and faults along NW-SE direction develop by the influence of Continental plates movement. Generally speaking, older sedimentary rocks along Pacific coast and younger rocks along Atlantic coast distribute with zonal arrangement in NW-SE direction. The volcanic rocks of late Tertiary to Quaternary distributing middle part to northwestern part of Costa Rica were formed by Circum Pacific volcanic activity following after the Continental plates movement. These rocks unconformably cover the basal rocks composed of sedimentary rocks, but the faults and active volcanic row basically show NW-SE direction.

The Tertiary clastic rocks which mainly form the basal rocks in Project area repeat symmetrical folds with moderate slopes having fold-axis of nearly NW-SE direction. The faults in Project area are either in parallel direction to this fold structure or partly in the direction obtusely crossing the fold structure.

The Andesitic agglomerate widely distributes covering unconformably these basal rocks. The contact of these two rocks in Project area does not harmonize with the fold structure but rather, generally speaking, it is nearly flat. Further, in Project area, there exists supposedly no large scale faults or active fault which endangers implementation of Project.

4.2.3 Earthquake

Costa Rica is situated in a part of Circum Pacific Seismic Zone and active seismic activity is observed all over the country, but the frequency concentrates on the Pacific coast and it is very few on the Atlantic coast.

The records of earthquakes during 1904 to 1974 in Costa Rica are shown in Fig. II-4-2 and Table II-4-5. These records are geophisically indentified by observation in Costa Rica and data of seismic observation organizations in the world. Some earthquakes have records only of casualties without any records of scale.

In the records, most earthquakes, about 75% of the all, had hypocenters with 30 to 60 km depth. Earthqyakes of hypocenter with 0 to 30 km depth are few, and their epicenters are limited to the Pacific side of the southern part of Costa Rica to Panama. A few earthquakes of hypocenter with 60-300 km depth took places along the Pacific coast from mid Costa Rica to the border of Nicaragua.

Guayabo Project is located nearly in the central part of Costa Rica. The earthquakes which occurred near Project area concentrate in the Pacific coast to the southwest of the Project area in 40 to 100 km away.

The earthquakes of magnitude 6.5 or more, which occurred during 70 years, within the sphere of radius 100 km are shown on the Table II-4-6.

Table II-4-6 Earthquake around Guayabo Project Area

Epicenter	Magnitude (M)	Depth (km)	Date of Occurrence
*1 Within 50 km	$7.0 \leq M < 7.5$	$30.0 \leq D < 60.0$	Mar. 4, 1924
	$7.0 \leq M < 7.5$	$60.0 \leq D < 100.0$	Nov. 19, 1948
*2 Within 100 km	$7.0 \leq M < 7.5$	$30.0 \leq D < 60.0$	Aug. 16, 1909
	$6.5 \leq M < 7.0$	$60.0 \leq D < 100.0$	Jun. 18, 1939
	$6.5 \leq M < 7.0$	$30.0 \leq D < 60.0$	Dec. 22, 1939
	$6.5 \leq M < 7.0$	$30.0 \leq D < 60.0$	Oct. 27, 1940

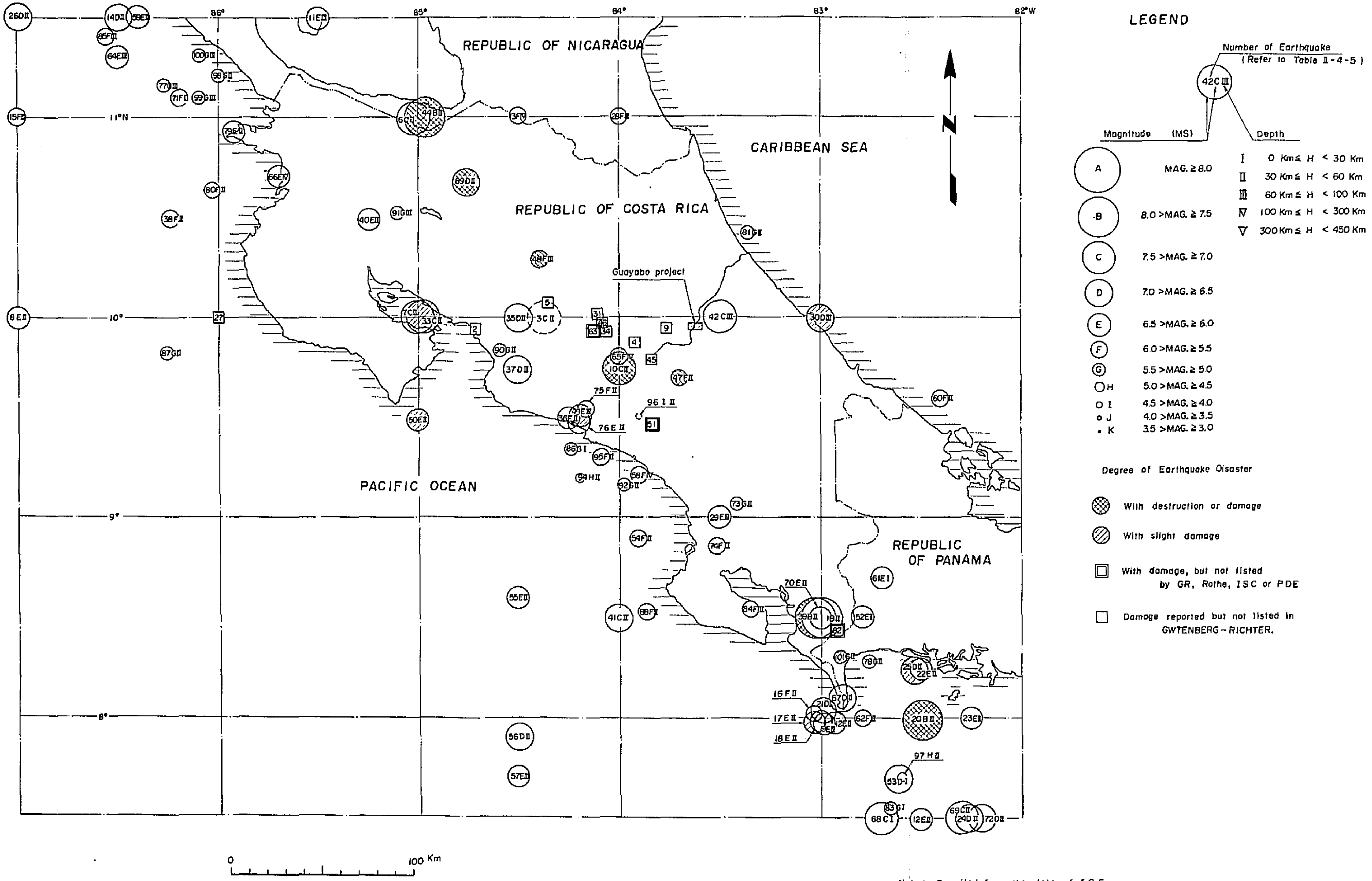
*1 : Centering around Guayabo Dam Site

*2 : Excluding *1

Table II-4-5 List of Earthquakes in Costa Rica

No.	Date	Time	Remarks	No.	Date	Time	Remarks
1	Dec. 20, 1904	-	1904 - 1952 (GUTENBERG-RICHTER, 1954)	52	Apr. 8, 1957	-	1953 - 1965 (ROTHE, 1969)
2	Jan. 20, 1905	-		53	Jul. 10, 1957	-	
3	Aug. 16, 1909	-		54	Oct. 15, 1957	-	
4	Apr. 13, 1910	-		55	Apr. 15, 1958	-	
5	Jun. 6, 1912	-		56	Jun. 6, 1958	-	
6	Apr. 24, 1916	-		57	Jun. 12, 1958	-	
7	Apr. 26, 1916	-		58	Jan. 13, 1959	-	
8	Jul. 16, 1920	-		59	Apr. 24, 1959	-	
9	Dec. 8-9, 1922	-		60	Apr. 11, 1959	-	
10	Mar. 4, 1924	-		61	Dec. 6, 1960	-	
11	Mar. 7, 1931	-		62	Feb. 5, 1961	-	
12	Oct. 12, 1931	-		63	Feb. 27, 1961	-	
13	Dec. 20, 1931	-		64	Mar. 20, 1961	-	
14	Oct. 2, 1932	-		65	May 23, 1961	-	
15	Jan. 12, 1933	-		66	Nov. 10, 1961	-	
16	May 30, 1933	-		67	Mar. 12, 1962	-	
17	Nov. 21, 1933	-		68	Jul. 26, 1962	-	
18	Nov. 23, 1933	-		69	Sep. 18, 1962	-	
19	Nov. 29, 1933	-		70	Jul. 9, 1963	-	
20	Jul. 18, 1934	01:36		71	Jul. 30, 1964	-	
21	Jul. 18, 1934	04:00		72	Dec. 15, 1965	-	
22	Jul. 18, 1934	06:35		73	Oct. 16, 1965	-	1964 - 1970 (ISC), 1971 - 1974 (PDE) MAG.≧5.0
23	Jul. 18, 1934	16:09		74	Mar. 27, 1966	-	
24	Jul. 18, 1934	16:59		75	Apr. 9, 1966	02:34	
25	Jul. 21, 1934	10:39		76	Apr. 9, 1966	02:42	
26	Dec. 22, 1934	-		77	Oct. 12, 1966	-	
27	Aug. 1, 1935	-		78	Apr. 22, 1967	-	
28	Mar. 20, 1936	-		79	Oct. 3, 1967	-	
29	Mar. 9, 1937	-		80	Oct. 4, 1967	-	
30	Jun. 18, 1939	-		81	Jul. 17, 1968	-	
31	Jun. 18, 1939	-		82	May 11, 1969	-	
32	Oct. 20, 1939	-		83	Jul. 4, 1969	-	
33	Dec. 21, 1939	-		84	Jan. 6, 1970	-	
34	Dec. 21, 1939	-		85	Jan. 20, 1970	-	
35	Dec. 22, 1939	-		86	Jun. 5, 1971	-	
36	Oct. 5, 1940	-		87	Sep. 28, 1971	-	
37	Oct. 27, 1940	-		88	Feb. 7, 1972	-	
38	Oct. 8, 1941	-		89	Apr. 14, 1973	-	
39	Dec. 5, 1941	20:		90	Aug. 4, 1973	-	
40	Dec. 6, 1941	01:		91	Oct. 2, 1973	-	
41	Dec. 6, 1941	21:		92	Oct. 18, 1973	-	
42	Nov. 19, 1948	-		93	Dec. 16, 1973	-	
43	Aug. 18, 1949	-		94	Feb. 28, 1974	20:15	
44	Oct. 5, 1950	-		95	Feb. 28, 1974	20:20	
45	Aug. 21, 1951	-		96	Feb. 28, 1974	21:35	
46	Sep. 9, 1952	-		97	May 4, 1974	-	
47	Jan. 7, 1953	-		98	May 16, 1974	-	
48	Sep. 1, 1955	-		99	Jul. 21, 1974	21:41	
49	Jul. 19, 1956	23:26		100	Jul. 21, 1974	22:33	
50	Jul. 19, 1956	23:38		101	Dec. 6, 1974	-	
51	Feb. 4, 1957	-					

Fig. II-4-2 DISTRIBUTION OF EARTHQUAKES IN COSTA RICA



Note: Compiled from the data of I C E prepared by Dr. Setsumi Miyamura in 1975.

Namely, within the sphere of radius 50 km, two times of earthquakes on magnitude 7.0 - 7.5 occurred, and within the sphere of radius 100 km occurred 3 times on the same magnitude. They had hypocenters of 30 - 100 km depth. From this history, it is assumed that an earthquake might happen of magnitude 7.0 more than once in several 10 years.

The structures should be designed so as to be safe sufficiently against such expected earthquakes. Pseudo-static analysis and dynamic analysis should be made for anti-seismic design at the time of definite study.

In this feasibility study, a simple pseudo-static analysis has been made for a preliminary design of dam and other structures, and 0.2 g is adopted for a seismic coefficient for designing. The coefficient of 0.2 g is one of aseismatic design criteria for dam in Japan.

4.3 GEOLOGY OF SITES FOR PROJECT

4.3.1 Catchment Area and Pondage

(1) Topography

Reventazon river, collecting flows from its tributaries running on the northeastern slope of the Talamanca mountain row, flows down in a rapid stream, curves surrounding the moderately sloped skirt of the Irazu volcano, turns its course to northeast and reaches Project site. On the left part of basin of Project area spreads the gently-sloping skirt of Turrialba volcano, and on the right part of basin spreads a hilly area of 600 to 700 m above sea level formed a Tertiary clastic rocks. Reventazon river has worn about 300 m deep through the moderate slopes of the both sides and forms a valley with a wide bottom.

In Dam and Pondage area, the bottom of the valley is 500 - 600 m wide and the mud-flow deposits form a flat area, with nearly the same gradient as the river. The present river-flow erodes 10 to 15 m of this flat area and meanders with the river of width 60 - 150 m. From the both sides some tributaries flow in. Along the river are observed small scale terraces about 20 m high and fan-shaped flood plains sporadically.

(2) Geology

As stated before, the basin of Reventazon river consists mainly of Tertiary clastic rocks and volcanic rocks covering them. The rock forming the base of Pondage area is Uscari formation. It consists of mudstone and sandstone interbedded with thin beds of conglomerate and fossils. In the neighbourhood of the center of Pondage area exists the Guayabo syncline crossing the river in NW-SE direction. The dip of strata on both flanks of the synclinal axis is 20° to 35° . Las Animas limy rocks distribute crossing the river under Uscari formation in the upstream end of the pondage, but it is out of Pondage limit and gives no influence upon Pondage. In Project, the height of Dam is rather low and therefore Pondage area is limited in a small valley bottom where is mainly distributed mud-flor deposit and river deposit covering basal rocks. The slopes on the river banks does not show strike slope in any places.

In the basin of Reventazon river, wide distribution of Tertiary clastic rocks

belonging to soft rocks and young pyroclastic rocks are observed. Further, the gradient of the river is steep. Therefore, the supply of much sediment materials into Pondage is considered. The basal rocks of Pondage area mainly consist of mudstone and sandstone with high watertightness. So, there is no need of concern about water leakage through pondage area.
Moreover, considering from the above-stated topography and geology, we can not think of possibility of large scale landsliding or collapsing by filling Pondage. However, on the left bank about 250 m upstream of Dam axis, the meandering river erodes the slope where is composed of sheared rock, and the slope between the railway and the river bed is as steep as 40°-45° . Therefore, the limited area has a possibility of collapsing and needs a measure of bank protection.

4.3.2 Guayabo Dam Site (DWG. No. II-3, II-4)

(1) Topography

Reventazon river forms a valley with wide bottom of about 600 m as stated above, and the valley bottom forms a flat area dipping gently downstream and consisting of mud-flow deposits. The present river course flows 10 to 15 m down the flat bottom, then meanders so much away from the left bank to the right bank. The dam axis is located there. The present river channel has about 60 m width at Dam axis. The right bank forms a steep cliff over 55° slope for about 20 m heigh above the present river bed, and in the upper part a slope of about 30° with a thick forest extends into a hilly area. Contrary to the right bank, the left bank slope has a dip of 25° - 30° and along the valley bottom there is a gently slope with talus.

The both banks form little ridges due to the brooklets pouring into the river up and down Dam site. Especially on the right bank, the contours of mountains are open to the downstream and the dam axis should be located within the limited space of several ten meters up and down the proposed Dam axis.

(2) Geology

The basal rocks forming the dam site is Uscari formation consisting of mudstone and sandstone with thin intercalations of conglomerate and fossil beds. Covering these are distributed topsoil, talus deposits, river deposits, mud-flow deposits and lower terrace deposits.

(a) Topsoil
Topsoil consists of the upper layer of black-brown colored humus and the lower layer of clayey soil of brown color. It has the thickness of several ten cm, and must be removed from the foundation of Dam.

(b) Talus deposits
These deposits are distributed around the left abutment of the dam with a moderate slope and also on the right bank downstream Dam. The talus deposits at the left abutment is not yet indentified with regard to their thickness and nature, and must be studied in the future. However, they must be removed from the foundation of the core zone of rock fill Dam.

(c) River deposits

This is widely distributed up- and down-stream of Guayabo river and also at the conjunction with Lajas river. It consists mainly of sub-round or round pebbles-cobbles and small quantity of granule and sand filling them. Mostly these gravels are formed of hard andesite but a few of mudstone or sandstone of fine grains. At the dam site, its distribution is limited and its thickness is considered 2 - 3 m judging from the exposure of the bed rock on the river bed. This deposits are distributed around the area where concrete Dam is proposed, and must be removed.

(d) Mud-flow deposits

At Dam site, the deposits are distributed widely covering the valley bottom at the left bank of Reventazon river. According to the results of survey at Dam site, its thickness is 7 - 14 m, and in some places it covers the lower terrace deposits of Reventazon river. This condition can be seen by the test pit DP-1 (length 7.5 m) and the thickness of mud-flow deposit is 7.0 m, having quite different nature from the lower terrace deposit. The mud-flow deposit is worse sorted and unconsolidated deposit consisting of subangular or subround boulders and cobbles with few of sand and silt. The gravels are mainly made of hard andesite but a few of soft mudstone or sandstone.

This deposit must be removed, from the permeability and bearing strength point of view, from the foundation of concrete Dam, but can be used at the foundation of gravel zone of fill Dam. It may have the possibility of being used even as the foundation of core zone of fill Dam, but in the preliminary design, we will remove it to be on safer side. The physical character must be identified in future by compaction test, shear test, plate loading test, water pressure test.

(e) Lower Terrace Deposit

This is the terrace deposit formed in old times covered by mud-flow deposit in Reventazon river, and confirmed in the test pit DP-1 (length 7.5 m). According to the results of DP-1 and drill hole DB-6 (50 m deep, vertical hole), the thickness of this deposit is about 3 m. The lower terrace deposit seen in the test pit is the same sand and gravel deposits as the present river deposit. It consists of subround or round cobbles/pebbles and granules and sand filling them. They are well compacted. The gravels are made mostly of hard andesite of grey purple color.

In the cores of drilling at Dam site, only hard gravels were sampled, and mud-flow deposit and lower terrace deposit could not be discriminated from each other. Therefore, at other area than the vicinity of the test pit DP-1, the distribution and thickness of lower terrace deposit are not known yet.

This deposit must be excavated and removed from the foundation of gravel zone of fill Dam. As for the foundation of core zone of fill Dam, since we are not sure about its impermeability, further survey and tests are necessary, as is the case with the mud-flow deposit covering it.

From the results of drilling executed so far at the dam site, we know that the thickness of layer of mud-flow deposit and lower terrace deposit amount to 10 - 14 m. The elevation of the contact with the basal rock is 400 m at nearby river banks and 407 m at the point of drilling DB-9 (vertical 30 m in depth). In the seismic prospecting survey performed at Dam site, we know that a low velocity zone of seismic speed 1 km/sec is distributed to the depth of 18 m, to the west of the drilling DB-9 for seismic traverse S-8. This zone shows, we guess, the existence of the deeper old river bed or a sheared zone in the basal rock.

(f) Uscari formation

This formation widely makes the base at Dam site and exposes itself widely on both banks where erosion advanced. This formation mainly consists of mudstone and sandstone with intercalations of thin conglomerate or fossil beds at some places.

At about 600 m upstream of Dam site, there is the Guayabo syncline which has an axis crossing the river. Therefore, these strata at Dam site have a strike nearly parallel to Dam axis and have a dip inclines toward upstream (E-W, 20°-25° S). There are very few joints and seams, and so far no faults running through the foundation part of the dam has been found in this formation.

According to the results of field geological survey and drilling, mudstone has the most predominant distribution at Dam site. Generally speaking, mudstone of several meters thickness and sandstone of several ten centimeters to 1 m thickness make alternation, but at some places massive mudstone stratum of over 10 m thickness can be seen.

Mudstone has dark grey color and has surface layers of several centimeters thickness decomposed. Sandstone is classified into medium to coarse grain with light grey brown color and fine grain with lamina and dark grey color. The conglomerates are granule conglomerate of various color including soft sandstone and mudstone. Mudstone, sandstone and conglomerate contain limy fossil bits and micro fossils of only a little content. Several fossil beds have been found so far by the past survey. It contains many shell fossils in the bed mostly less than several meters thick. Every rock is of soft rock, with low degree of consolidation. According to the seismic prospecting survey at Dam site, the seismic velocity of fresh rock is about 2.0 km/sec.

The results of the unconfined compression test using the drill core obtained at the dam site are shown in the Table II-4-7.

Table II-4-7 Unconfined Compressive Strength of Bedrock at Dam Site

Sample			Density	Specific gravity	Compressive strength 1/	Rock name
Drill hole	Depth (m)	No. of Sample	(g/cm³)	(g/cm³)	(kg/cm²)	
DB-3	11.8	1	-	2.75	-	mudstone
	14.9	2	-	2.68	9.4	mudstone
	18.2	3	2.09	2.73	310.0	mudstone
	24.3	4	-	2.72	105.0	mudstone
	29.3	5	2.46	2.78	722.0	mudstone
DB-4	10.0	1	-	2.65	27.9	sandstone
	15.1	2	-	2.82	114.0	mudstone
	19.9	3	-	2.64	236.0	mudstone
	24.6	4	2.00	2.73	228.0	mudstone
	29.1	5	2.04	2.68	2/	mudstone
DB-10	26.7	1	2.07	2.81	43.1	mudstone
	29.6	2	2.21		250.0	mudstone

1/ Dry state

2/ Tensile strength 12.8 kg/cm²

According to the test results, most samples have the compressive strength of 100 - 250 kg/cm². For this compressive test, the cores collected in relatively good conditions are used as samples, and are considered to be shown larger strength than average. They are considered to have enough bearing strength for the foundation of a dam of about 40 m height. The formation, however, has a bedding plain inclining 20° - 25° toward upstream and is considered to have mechanical anisotropy. Therefore, for the foundation of concrete dam, the in-situ shear test and plate loading test should be considered for definite study. Dam is situated at the bottom of the valley, so deterioration of rock by weather is generally little.

The results of water pressure tests performed in the drilling holes of Dam site are shown in Table II-4-8. They show that they have permeability as high as 20 - 40 Lugeon, down to the depth of 20 m after struck on the bedrock. However, judging from the outcrops of bedrock at Dam site, there are few seams and joints, and only minute and closed cracks are observed. We have the impression that the permeability is very little. Therefore, we must check the permeability by another water pressure test using drilling holes executed in the future. It is advisable to make low pressure tests at several stages after struck on the bedrock, and the maximum water pressure should be 7 kg/cm² even in the deepest test stage using air-packers.

Table II-4-8 Result of Water Pressure Test of Bedrock

Hole No.	Test section (m)	Water table (m)	Effective Pressure (kg/cm^2)	*Lugeon ($L/min/m$ $/10kg/cm^2$)	Rock
DB-3	18.0 ~ 21.0	3.7	10.37	29.9	Mudstone
	21.0 ~ 24.0	"	"	28.9	"
	24.0 ~ 27.0	"	"	18.6	"
	27.0 ~ 30.0	"	"	21.7	"
DB-4	7.5 ~ 10.5	4.4	8.44	55.3	Mudstone and sandstone
	10.5 ~ 13.5	"	"	51.7	" "
	13.5 ~ 16.5	"	10.44	46.3	"
	16.5 ~ 19.5	"	"	44.7	"
	19.5 ~ 22.5	"	"	41.2	Sandstone and mudstone
	22.5 ~ 25.5	"	"	35.1	Mudstone
	25.5 ~ 28.5	"	"	21.1	"
DB-7	21.0 ~ 24.0	**5.0	10.5	22.9	Mudstone
	24.0 ~ 27.0	"	"	30.2	" and conglomerate
	27.0 ~ 30.0	"	"	25.4	"
DB-9	15.0 ~ 18.0	**10.0	9.0	37.0	Conglomerate
	18.0 ~ 21.0	"	5.0	58.0	" and mudstone
	21.0 ~ 24.0	"	7.0	46.7	" and sandstone
	24.0 ~ 27.0	"	9.0	33.3	" "
DB-10	17.5 ~ 20.5	**5.0	10.5	32.6	Mudstone
	20.0 ~ 23.0	"	"	38.1	"
	23.0 ~ 26.0	"	"	27.5	" and sandstone
	26.0 ~ 29.0	"	"	32.3	"
	29.0 ~ 32.0	"	"	26.5	" and fossil bed

* Lugeon value calculated proportionally from water loss under maximum test pressure.

** Assumed ground water table bared on nearby river.

4.3.3 Headrace Tunnel (DWG. No. II-2)

(1) Topography

The headrace tunnel of 9.6 km runs through a hilly area of 600 - 700 m in elevation, situated between the rivers of Reventazon and Pacuare. This hilly area offers a complicated configuration with repeated ups and downs, being cut by brooklets flowing out from the watershed running by side of Pacuare river. Especially on the slope facing Reventazon river, where four fifths length of the tunnel runs, brooklets shaped like tree-branches with moderately developed gradiant.

The headrace tunnel, in almost all its sections, runs through deep under the ground of 100 - 200 m underneath the ground surface. At the points IP-2 and 3, the depth or coverage becomes least. We made the long adits so as to get the covering depth more than 50 m.

(2) Geology

The geology forming the tunnel route is mostly composed of Uscari formation consisting mainly of mudstone and sandstone, except a place near Surge Tank where the geology is Tuis formation consisting of tuffaceous sandstone and silt. On the ground surface, andesitic agglomerate widely is distributed with several meters to several ten meters thickness, unconformably covering these formations.

In the Uscari formation where Tunnel traverses, there exist Torito anticline and Peralta syncline. All of fold structures have an axis of NW-SE direction, and are symmetrical folds having the dip of 25° - 35° on both flanks. Tunnel crosses these fold structures with nearly right angle. Mudstone and sandstone have little seam and joint. They have little possibility of seeping ground-water, but we might occassionally encounter seeping ground-water at some faults, although we did not confirm any fault in Tunnel route. However, judging from the faults in the vicinity and photo-geologic interpretation, we expect to encounter with several faults, which are considered to cross Tunnel at obtuse angle.

At the point of Intake, the geology consists of alternation of mudstone and sandstone, and exposed rocks can be seen widely here and there. The mudstone and sandstone which form the rocks of Intake and Tunnel belong to soft rock having same nature as those at Dam site. Fresh rocks are considered to have the compressive strength 100 - 250 kg/cm^2. The clay minerals, which are contained in the mudstone samples collected at Intake site, mostly belong to montmorillonite group. Therefore, an investigation on the possibile expansibility of mudstone containing clay minerals of montmorillonite group and on distribution of montmorillonite bearing stratum are necessary in the future.

For the construction of such a big diameter Tunnel as over 8 m of excavated section under such geology, cares must be taken to line the tunnel immediately after excavation and to put permanent supports in every section. At some faults, for instance, such special works as concrete lagging may be necessary.

The sections, where agglomerate is possibly distributed along Tunnel route, are near the IP-3 where an adit is located. The agglomerate is unconsolidated clastic rock in Project area, so it must be avoided from Tunnel route.

The distribution of agglomerate must be confirmed at around IP-3 by future drilling. Further at IP-2 and 3 points where covering rock is rather thin, the weathering conditions of mudstone and sandstone must be surveyed by drilling.

4.3.4 Surge Tank and Penstock Route (DWG. No. II-5)

(1) Topography

Surge Tank is located on a small ridge where the topography changes from the hilly area to a slope on the left bank of Pacuare river. The slope, where Penstock route is located, is smooth with little ups and downs and a gradient of about 30°.

(2) Geology

The geology forming the sites for Surge Tank and Penstock route is tuffaceous siltstone, sandstone and conglomerate of Tuis formation. The strata have monoclinic structure with NW-SE, 45° SW strike and dip. Every rock has gray green color and generally contains limy fossil bit or micro fossils. According to the drilling cores at Surge Tank site (SB-1, vertical, length 116.5 m), tuffaceous sandstone is most perdominant and very little siltstone and conglomerate are found. All rocks belong to soft rock, but degree of consolidation is higher than mudstone and sandstone at Dam site.

Fresh bedrock is considered to have enough strength for supports for Surge Tank and anchor blocks of Penstock route. Surge Tank is located on a ridge and the rocks are deeply weathered and softened as deep as down to 20 m depth. In the slope where Penstock route is located, weathered bedrock can be seen at places, and topsoil and talus deposit are considered to be thin. The thickness of weathered zone is not clear and the depth of excavation for the foundation of anchor blocks will be about 10 m in the preliminary design. In the future, a drilling should be made at each site of anchor block and the thickness of weathered zone be clarified.

4.3.5 Power Plant (DWG. No. II-5)

(1) Topography

Pacuare river, where Power Plant is proposed, forms a valley of narrow bottom, flows northward with small meandering. Power Plant location will be on a curved river bed of about 20 m width in the present river course. At the inside of the curve on the right bank, there exists a flood plain of over 100 m wide. The mountain on the left bank forms a slope of about 30° gradient.

The required space for Power Plant will be obtained by changing the river route to the flood plain on the right bank.

(2) Geology

The geology of Power Plant site is the pyroclastic rocks containing andesitic or basaltic agglomerate of Tuis formation. Partly, the lava of the same nature is distributed. The rock forms a bedding structure of 5 - 15 m thickness and its strike and dip are nearly NW-SE and 40° - 60° SW. In the existing drilling PHB-1 (vertical, length 25.35 m) executed on the flood plain on the right bank of the power plant, the intrusive rock of dolerite is confirmed. Pyroclastic rocks are widely exposed along Pacuare river and are favorable bedrock for the foundation of Power Plant, being fresh and hard rock.

The river deposit in the right bank flood plain has a thickness of 5 m in the core of drilling PHB-1. The thickness of river deposit of the present river course, where Power Plant will be constructed, is estimated at several meters though not cleary indentified yet.

4.4 CONSTRUCTION MATERIAL

The quantities of impervious material, filter material, gravel material for the fill type Dam and those of concrete aggregate for the concrete Dam, Tunnel, Power Plant of Guayabo Project are as follows respectively:

Impervious material	100,000 m^3
Filter material	70,000
Rock material	394,000
Concrete aggregate	610,000

Regarding these materials, neither quantitative survey nor quality test has not yet been executed. Therefore, field investigation should be performed with pits and drillings at the points proposed in Fig. II-4-3, and a series of material tests be made using the samples collected from the pits.

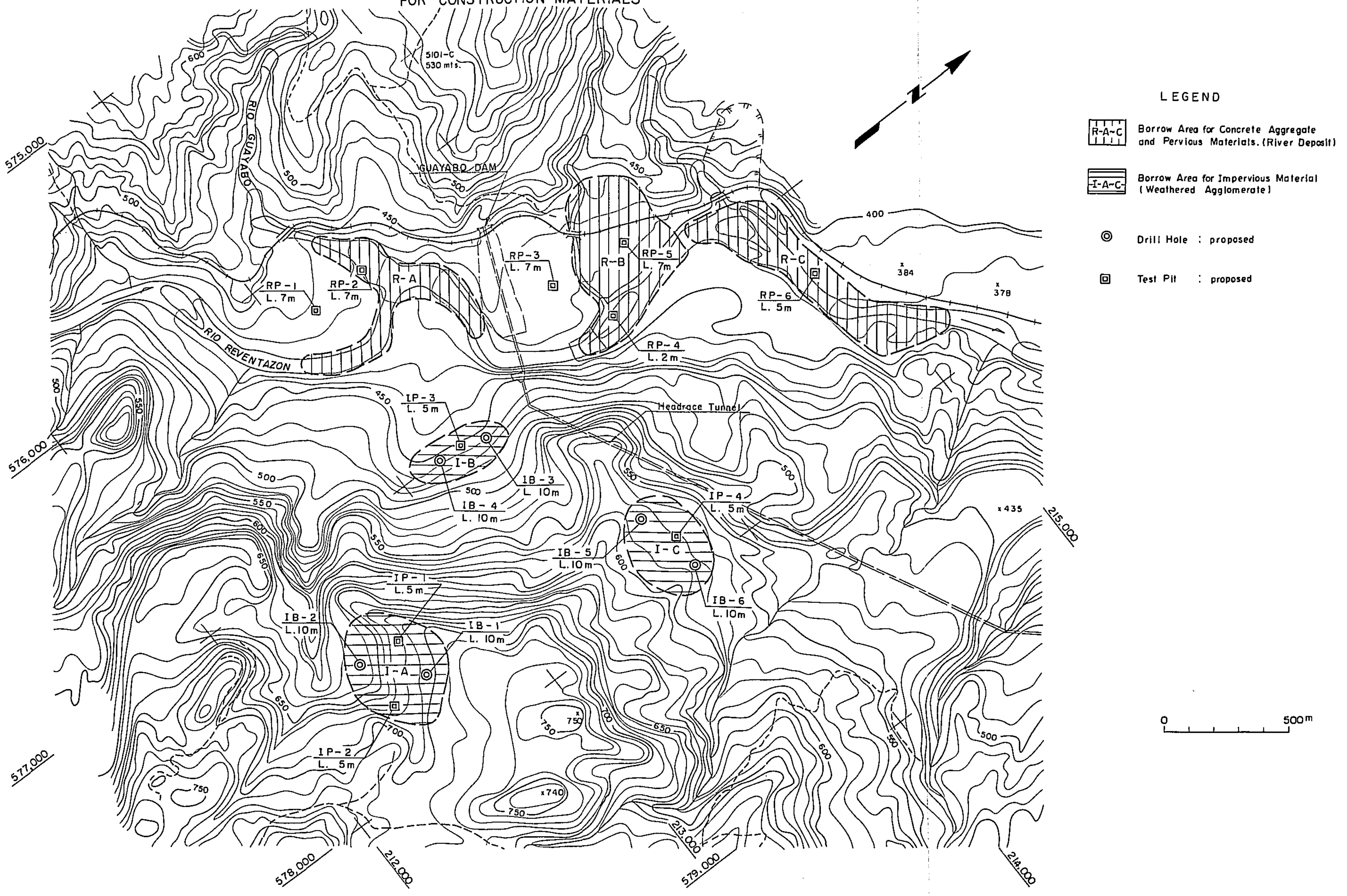
4.4.1 Impervious Material

The weathered agglomerate at places surrounding Dam site has the highest possibility of availing it for impervious material. The agglomerate is distributed in the mountain slopes and hilly areas on both banks of Reventazon river. It is an unconsolidated deposit consisting of andesitic angular-sub-angular breccia with maximum diameter about 30 cm and tuffaceous matrix filling them. Generally speaking, the agglomerate has thin layer on the left bank with thickness of less than several meters, but in some places on the right bank it has a thickness of over 10 m. The agglomerate on the left bank contains a large quantity of hard breccias, while that on the right bank, especially in the higher places, weathering has advanced even into the inside of breccia.

Based on the results of ground surface survey we have shown three favorable areas on the right bank of dam site on Fig. II-4-3. I-A area is located at the point 250 m higher than the river, and the strata is distributed widely and are well weathered, so it is the most favorable area (estimated available quantity 600,000 m^3). I-B area is inferior to I-A in the points of quantity and extent of weathering, but more favorable in a point that it is nearer to Dam site. I-C area has medium favorability between A and B from the transportation distance point of view.

Mud-flow deposit, which is widely distributed at the valley bottom near Dam site, is a worse sorted deposit containing cobble, and needs to be screened to be used for impervious material. However, it is distributed in large quantity near

Fig. II-4-3 LOCATION MAP OF PROPOSED INVESTIGATION WORKS FOR CONSTRUCTION MATERIALS



Dam site and it will be economical if it can be availed for some other material. Therefore, when this deposit is excavated in the future in pits at Dam site and in the barrow areas, at least grain size analysis should be executed.

Weathered stratum of mudstone and talus deposit, which are distributed from the both banks of the river upto the mountainsides, are mostly composed of small grains of fragment of several mm to several cm, and contains little clay, and so grade of grain size is not favorable for impervious material.

4.4.2 Filter Material

The river deposits of Reventazon river are mostly cobbles and cannot be used for filter material as they are. The above-stated mud-flor deposit excavated at the foundation of Dam can be used for filter material if it is screened. Filter material could also be collected from less weathered part in the deep portion of the weathered agglomerate area listed as favorable areas for impervious material.

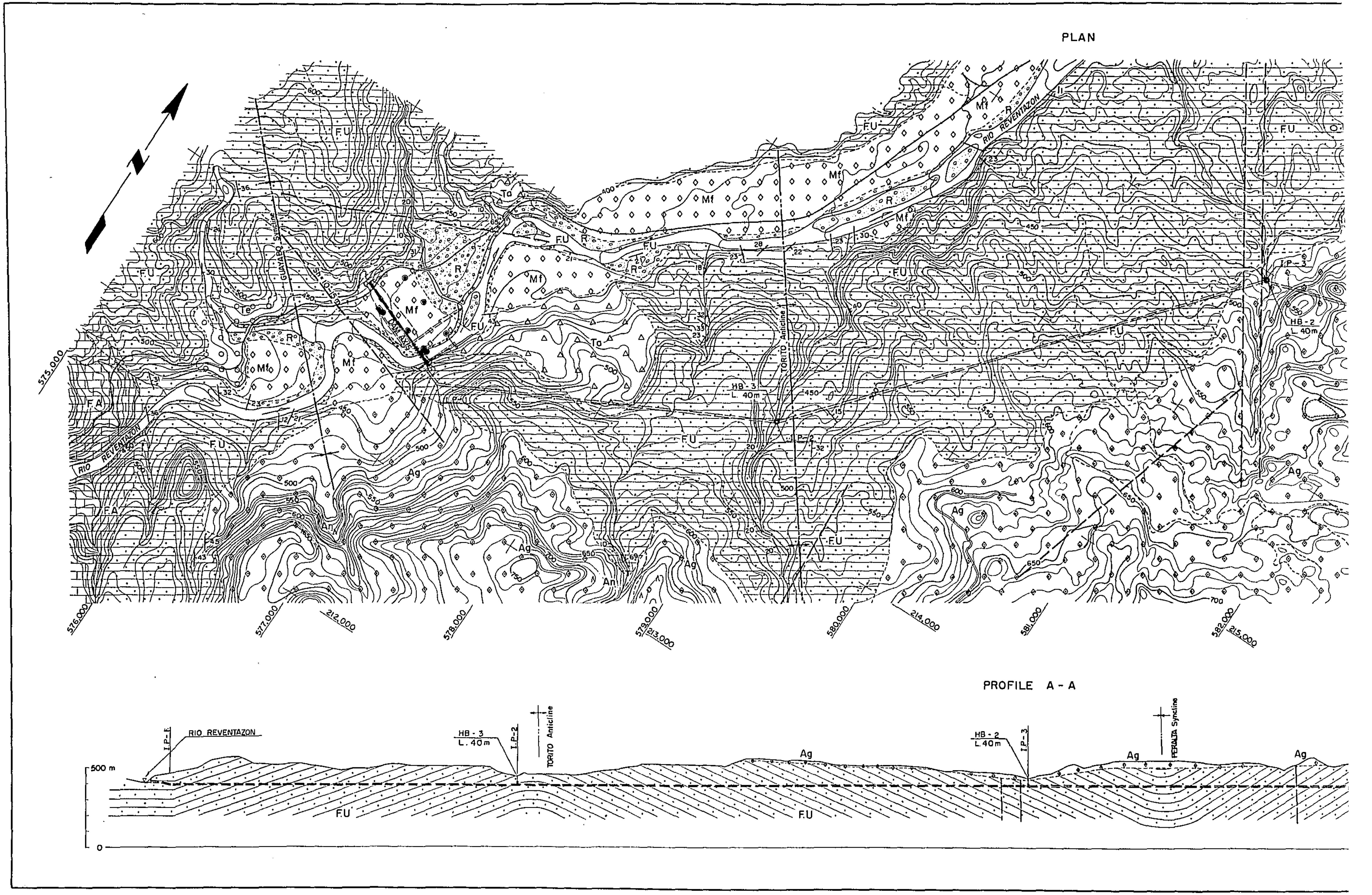
Anyhow the required quantity is little, so it can be met by any of the above-stated three strata near the dam site.

4.4.3 Gravel Material and Concrete Aggregate

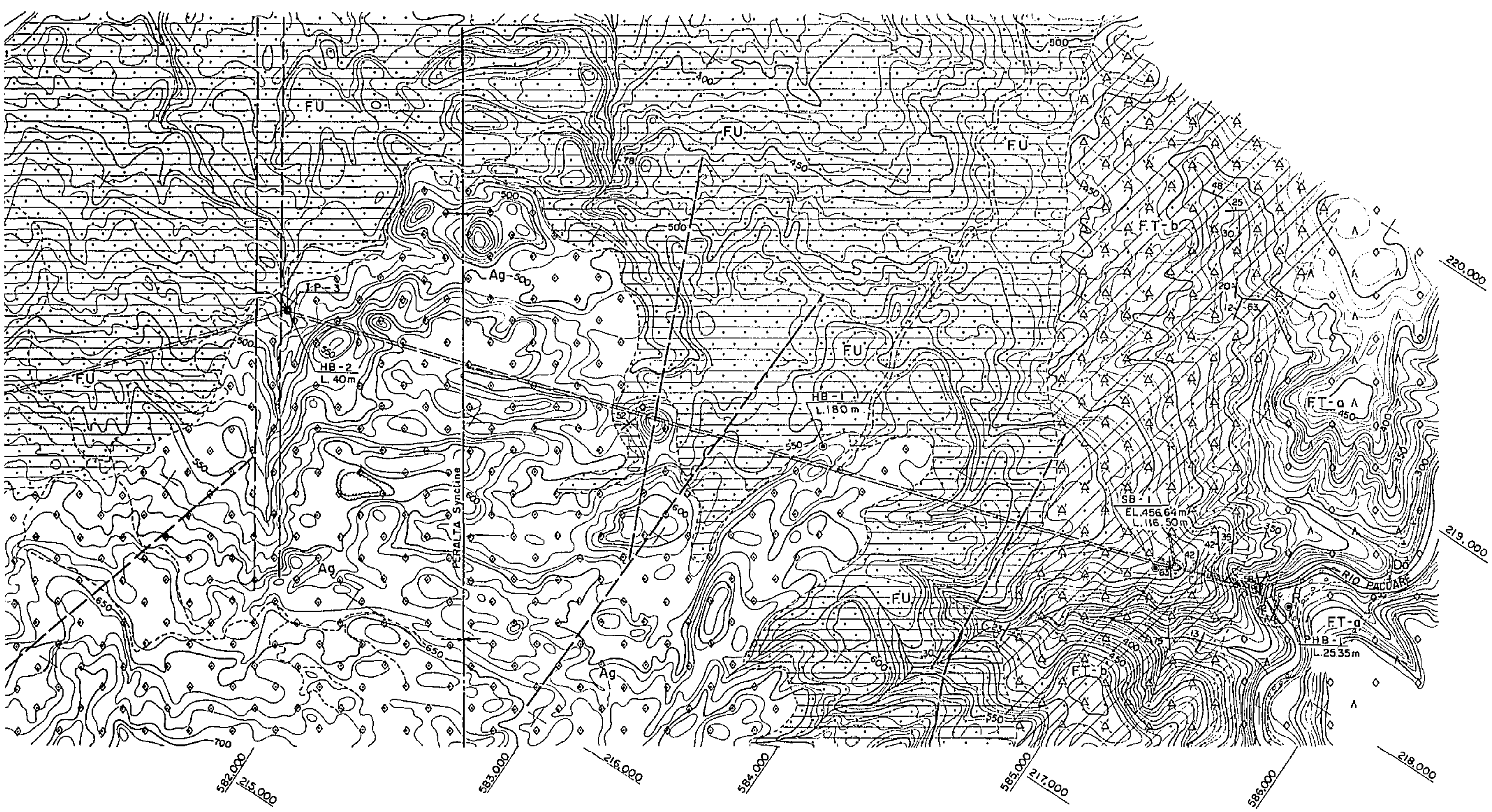
The basal rock distributing in Project area mostly consists of soft sedimentary rock of Tertiary Period. Therefore, there are few species of rock available as rock material and concrete aggregate, except the hard limestone of Las Animas formation distributing at about 1.6 km up Dam site. However, this limestone is thinly bedded from several cm to 10 cm thickness, and at the quarries where this rock is collected it will be broken into pieces of several cm diameter for aggregate only by blasting.

On the otherhand, in the upstream and downstream of Dam site, the river deposits, consisting of mostly cobble and boulder, are widely distributed, and is considered to be available for gravel material as it is for the fill type Dam, and available for concrete aggregate and filter material by screening and or blasting. These river deposits are mostly subround or round gravel by under 40 cm diameter, and contain little granule and sand. The gravels are andesite mostly, and are fresh and hard although amphibole and plagioclase have a little deterioration.

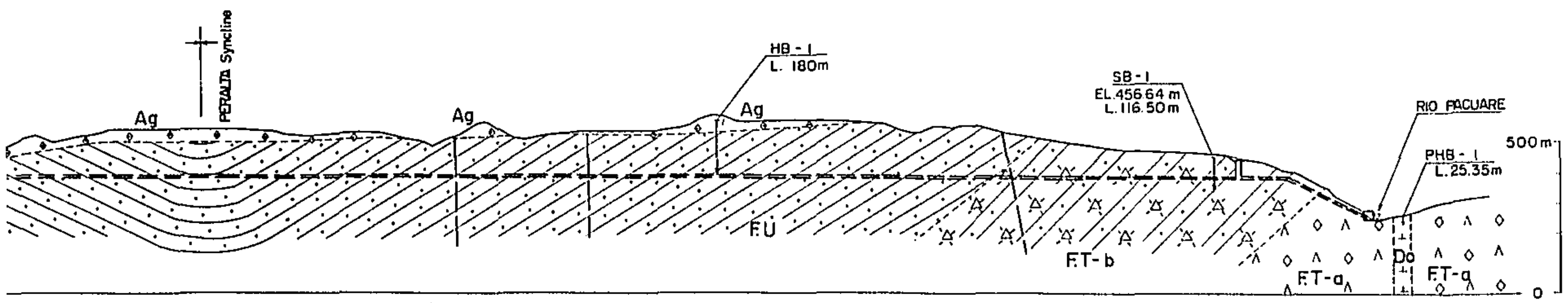
Volumes of 450,000 m^3 at A area in the upstream of Dam site, 1,300,000 m^3 at B area in the downstream of Dam site and 300,000 m^3 at C area in the downstream of Dam site could be found, and the total required quantity for filter, gravel material and concrete aggregate (totally about 1,100,000 m^3) could be available by means of the river deposits around Dam site. As for the concrete aggregate used for Power Plant and Tunnel near Power Plant, it will be more economical to use the river deposit of the same character distributed along Pacuare river, although total concrete aggregate required is about 610,000 m^3 for the project. Further survey is necessary for the aggregate in Pacuare river.


PLAN
F.U
Mf
R
Ta
Ag
An
F.A
Te
RIO REVENTAZON
GUAYABO Syncline
TORITO Anticline
HB-3
L. 40m
HB-2
L. 40m
I.P-2
I.P-3
576,000
577,000
578,000
579,000
580,000
581,000
582,000
575,000
212,000
213,000
214,000
215,000
PROFILE A-A
RIO REVENTAZON
I.P-E
HB-3
L. 40m
I.P-2
TORITO Anticline
HB-2
L. 40m
I.P-3
PERALTA Syncline
Ag
F.U
500 m
0

PLAN



- A



0 500 1000m

LEGEND

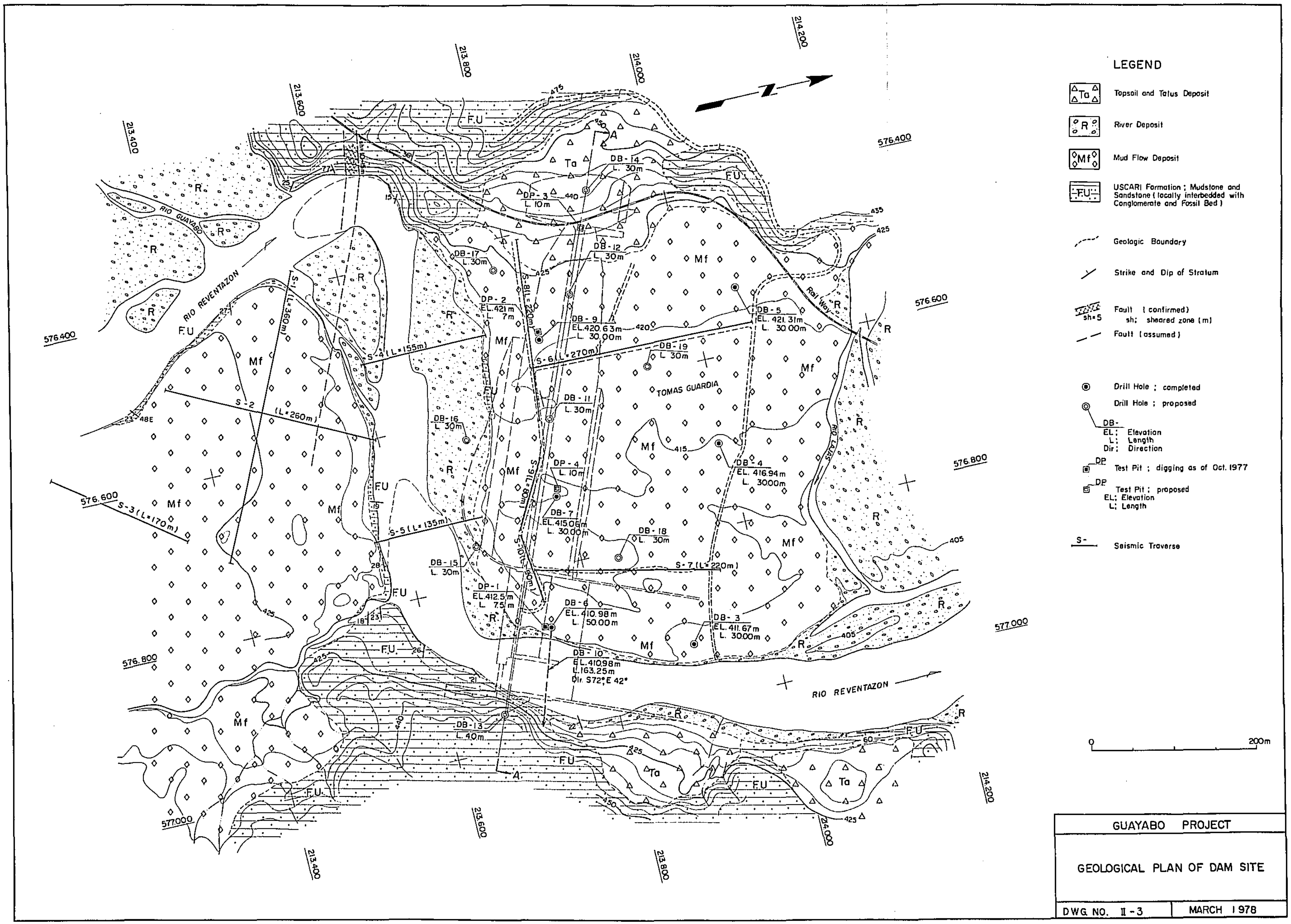
- Quaternary
  - Alluvium
    - Ta — Talus Deposit
    - R — River Deposit
    - Mf — Mud Flow Deposite
    - Te — Terrace Deposit
  - Diluvium
    - An — Andesitic Lava
- Tertiary
  - Pliocene
    - Ag — Agglomerate
  - Oligocene - Miocene
    - F.U — USCARI Formation ; Mudstone and Sandstone (locally interbedded with conglomerate and Fossil Bed)
  - Palaeocene - Eocene
    - F.T-b — TUIS Formation ; Tufferceous Siltstone Tufferceous Sandstone and Conglomerate
    - F.T-a — TUIS Formation ; Andesitic or Basaltic Lava and Pyroclastic Rock
    - F.A — LAS ANIMAS Formation ; Limestone
- Do — Dolerite (intrusive rock)

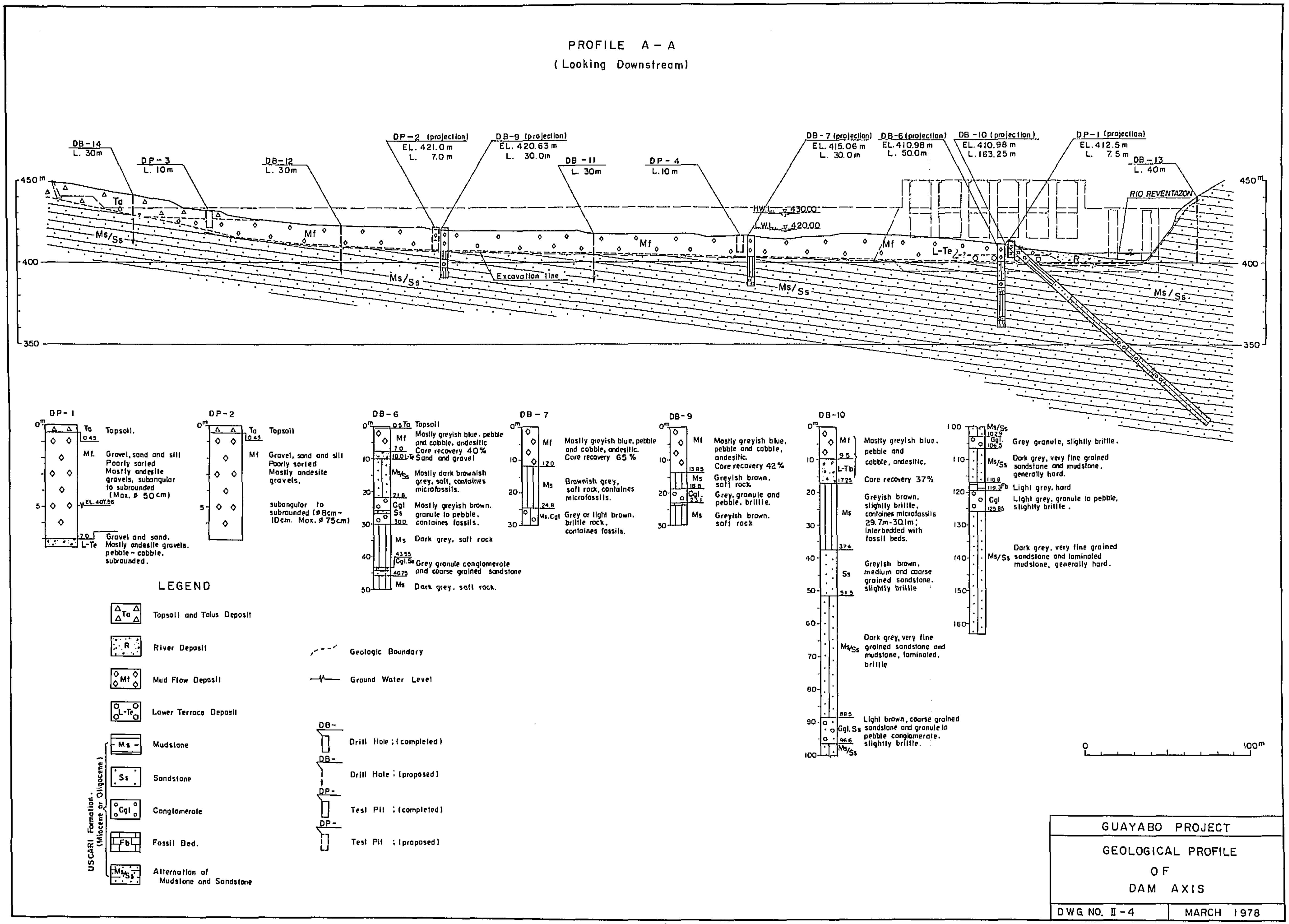
- Geologic Boundary
- Strike and Dip of Stratum
- Strike and Dip of Intrusive Contact
- Strike and Dip of Fault (confirmed) sh ; Sheared zone (m) (sh=10)
- Fault (assumed)
- Anticlinal Axis
- Synclinal Axis
- Landslide
- Test Pit ; completed (plan)
- Drill Hole ; completed (plan)
- Drill Hole ; proposed (plan)
- Drill Hole ; completed (profile)
- Drill Hole ; proposed (profile)

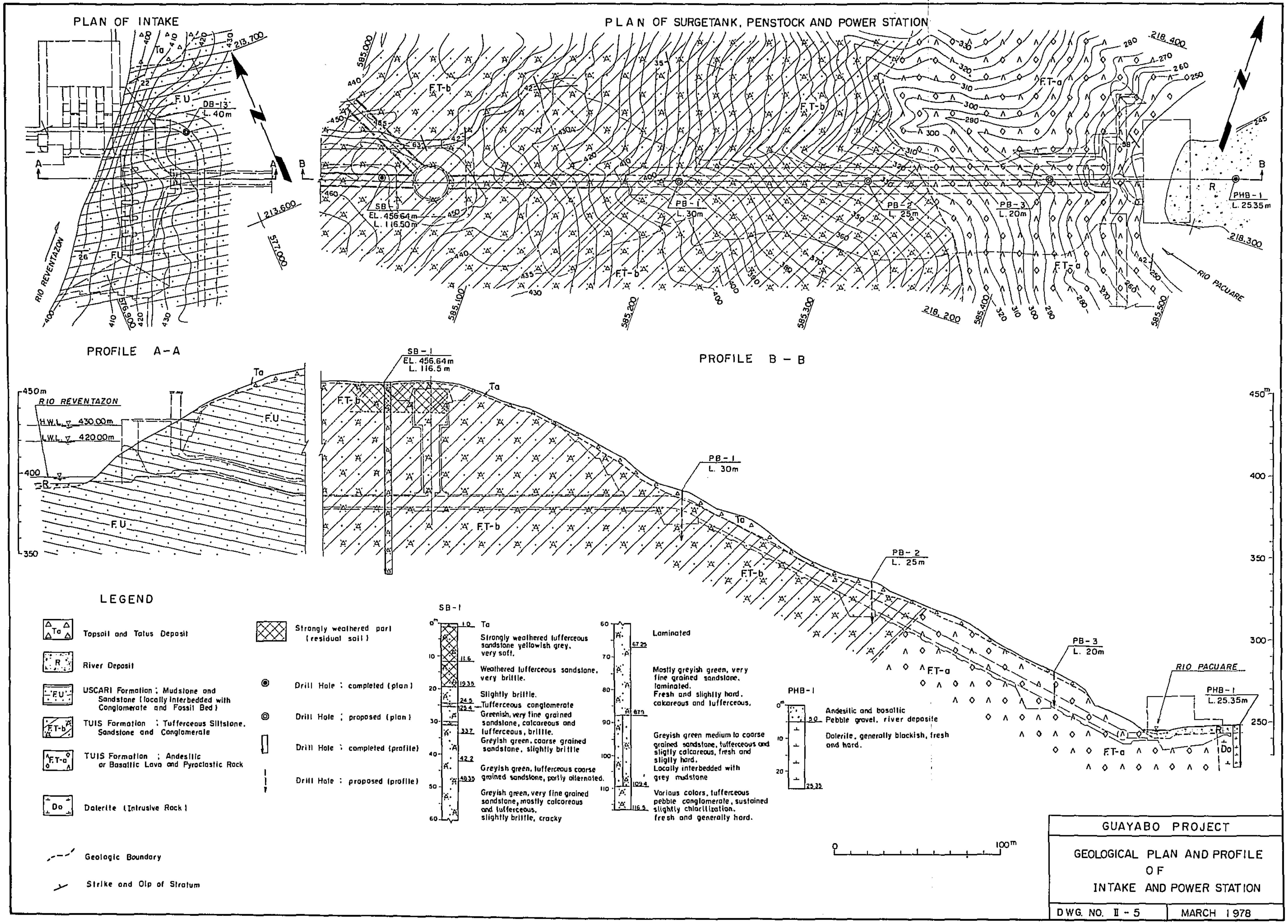
Note

Locations of proposed drill holes HB-2 and HB-3 for the headrace tunnel are shown in this drawing, but locations of proposed investigation works for another sites are shown in respective drawing.

GUAYABO PROJECT	
GEOLOGICAL PLAN OF PROJECT AREA AND PROFILE OF WATER WAY	
DWG. NO. II - 2	MARCH 1978


LEGEND
Ta Topsoil and Talus Deposit
R River Deposit
Mf Mud Flow Deposit
F.U USCARI Formation ; Mudstone and Sandstone (locally interbedded with Conglomerate and Fossil Bed)
Geologic Boundary
Strike and Dip of Stratum
Fault (confirmed) sh; sheared zone (m)
Fault (assumed)
Drill Hole ; completed
Drill Hole ; proposed
DB- EL; Elevation L; Length Dir; Direction
DP Test Pit ; digging as of Oct. 1977
DP Test Pit ; proposed EL; Elevation L; Length
S- Seismic Traverse
RIO REVENTAZON
RIO GUAYABO
TOMAS GUARDIA
Rail Way
0 200m
GUAYABO PROJECT
GEOLOGICAL PLAN OF DAM SITE
DWG. NO. II-3
MARCH 1978


PROFILE A – A
(Looking Downstream)
DB-14 L. 30m
DP-3 L. 10m
DB-12 L. 30m
DP-2 (projection) EL. 421.0m L. 7.0m
DB-9 (projection) EL. 420.63m L. 30.0m
DB-11 L. 30m
DP-4 L. 10m
DB-7 (projection) EL. 415.06m L. 30.0m
DB-6 (projection) EL. 410.98m L. 50.0m
DB-10 (projection) EL. 410.98m L. 163.25m
DP-1 (projection) EL. 412.5m L. 7.5m
DB-13 L. 40m
RIO REVENTAZON
H.W.L. 430.00
L.W.L. 420.00
Excavation line
Ta
Mf
Ms/Ss
L-Te
R
450m
400
350
DP-1
Ta Topsoil.
Mf. Gravel, sand and silt Poorly sorted Mostly andesite gravels, subangular to subrounded (Max. ø 50cm)
EL. 407.56
L-Te Gravel and sand. Mostly andesite gravels. pebble ~ cobble. subrounded.
DP-2
Ta Topsoil
Mf Gravel, sand and silt Poorly sorted Mostly andesite gravels, subangular to subrounded (ø 8cm~10cm. Max. ø 75cm)
DB-6
Ta Topsoil
Mf Mostly greyish blue, pebble and cobble, andesitic Core recovery 40%
L-Te Sand and gravel
Ms/Ss Mostly dark brownish grey, soft, containes microfossils.
Cgl Ss Mostly greyish brown. granule to pebble, containes fossils.
Ms Dark grey, soft rock
Cgl.Ss Grey granule conglomerate and coarse grained sandstone
Ms Dark grey, soft rock.
DB-7
Mf Mostly greyish blue, pebble and cobble, andesitic. Core recovery 65%
Ms Brownish grey, soft rock, containes microfossils.
Ms.Cgl Grey or light brown. brittle rock, containes fossils.
DB-9
Mf Mostly greyish blue, pebble and cobble, andesitic. Core recovery 42%
Ms Greyish brown, soft rock.
Cgl. Grey, granule and pebble, brittle.
Ms Greyish brown, soft rock
DB-10
Mf Mostly greyish blue, pebble and cobble, andesitic.
L-Tb
Core recovery 37%
Ms Greyish brown, slightly brittle, containes microfossils 29.7m-30.1m; interbedded with fossil beds.
Ss Greyish brown, medium and coarse grained sandstone, slightly brittle
Ms/Ss Dark grey, very fine grained sandstone and mudstone, laminated, brittle
Cgl. Ss Light brown, coarse grained sandstone and granule to pebble conglomerate, slightly brittle.
Ms/Ss
Cgl. Grey granule, slightly brittle.
Ms/Ss Dark grey, very fine grained sandstone and mudstone, generally hard.
Fb Light grey, hard
Cgl Light grey, granule to pebble, slightly brittle.
Ms/Ss Dark grey, very fine grained sandstone and laminated mudstone, generally hard.
LEGEND
Topsoil and Talus Deposit
River Deposit
Mud Flow Deposit
Lower Terrace Deposit
USCARI Formation (Miocene or Oligocene)
Mudstone
Sandstone
Conglomerate
Fossil Bed.
Alternation of Mudstone and Sandstone
Geologic Boundary
Ground Water Level
Drill Hole ; (completed)
Drill Hole ; (proposed)
Test Pit ; (completed)
Test Pit ; (proposed)
0 100m
GUAYABO PROJECT
GEOLOGICAL PROFILE OF DAM AXIS
DWG NO. II-4
MARCH 1978


PLAN OF INTAKE
PLAN OF SURGETANK, PENSTOCK AND POWER STATION
DB-13
L. 40m
RIO REVENTAZON
RIO PACUARE
SB
EL. 456.64m
L. 116.50m
PB-1
L. 30m
PB-2
L. 25m
PB-3
L. 20m
PHB-1
L. 25.35m
PROFILE A-A
PROFILE B - B
H.W.L. 430.00m
L.W.L. 420.00m
SB-1
EL. 456.64m
L. 116.5 m
LEGEND
Topsoil and Talus Deposit
River Deposit
USCARI Formation ; Mudstone and Sandstone (locally interbedded with Conglomerate and Fossil Bed)
TUIS Formation ; Tufferceous Siltstone, Sandstone and Conglomerate
TUIS Formation ; Andesitic or Basaltic Lava and Pyroclastic Rock
Dolerite (Intrusive Rock)
Geologic Boundary
Strike and Dip of Stratum
Strongly weathered part (residual soil)
Drill Hole ; completed (plan)
Drill Hole ; proposed (plan)
Drill Hole ; completed (profile)
Drill Hole ; proposed (profile)
Strongly weathered tufferceous sandstone yellowish grey, very soft.
Weathered tufferceous sandstone, very brittle.
Slightly brittle.
Tufferceous conglomerate
Greenish, very fine grained sandstone, calcareous and tufferceous, brittle.
Greyish green, coarse grained sandstone, slightly brittle
Greyish green, tufferceous coarse grained sandstone, partly alternated.
Greyish green, very fine grained sandstone, mostly calcareous and tufferceous, slightly brittle, cracky
Laminated
Mostly greyish green, very fine grained sandstone, laminated. Fresh and slightly hard, calcareous and tufferceous.
Greyish green medium to coarse grained sandstone, tufferceous and slightly calcareous, fresh and slightly hard. Locally interbedded with grey mudstone
Various colors, tufferceous pebble conglomerate, sustained slightly chloritization, fresh and generally hard.
Andesitic and basaltic Pebble gravel, river deposite
Dolerite, generally blackish, fresh and hard.
GUAYABO PROJECT
GEOLOGICAL PLAN AND PROFILE OF INTAKE AND POWER STATION
DWG. NO. II - 5
MARCH 1978

CHAPTER 5

PLAN OF POWER GENERATION

CHAPTER 5 PLAN OF POWER GENERATION

LIST OF FIGURES

LIST OF TABLES

CHAPTER 5 PLAN OF POWER GENERATION

5.1 BASIC CONSIDERATIONS

Guayabo Project will have a pondage in the middle part of Reventazon river, and the regulated flow there will be diverted to the neighboring river, Pacuare, through a headrace-tunnel,generating power at a plant located in Pacuare river.

At first of study for Guayabo Project, basic considerations were given to the following three points.

(1) Possibility of On-stream and Off-stream Developments
In the middle part, Reventazon river flows parallel with Pacuare river being close each other. So, there are two possibilities of development, that is, on-stream and off-stream.

For the time being, there is only a project proposed of off-stream development in the downstream of dam site, that is, a diversion type of development, Guayabo Project, according to existing reports. *

As a result of reviewing the reports, the off-stream development at the site is judged to have an advantage over the on-stream development, from the reasons as follows:

(a) The on-stream development could not obtain an economical high head in view of the topographical conditions while the off-stream development could have it considerably.

(b) There seems to be no site in the downstream of Reventazon river which could provide a reservoir, while there is Siquirres Project proposed with big reservoir in the downstream of Pacuare river. So, the off-stream development will have an advantage over the on-stream in view of economical utilization of river flow. Besides, the diversion will give no harmful influence upon the utilization of water downstream.
As a result, the Guayabo Project will lead to the off-stream development, that is, a development by diversion.

(2) Type of Reservoir

In future, main part of the power system will be occupied by hydroplants in Costa Rica, and the supply capacity could be liable to be influenced by the seasonal change of flow.

It will be necessary for the newly-built hydroplants to have reservoirs which will be able to make seasonal regulation, if the topography and economy permit.

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* (1) Documento de Trabajo 007-77
Informe Preliminar Proyecto Hidroelectrico Guayabo
(Agosto, 1977)

(2) Report on Preliminary Master Plan for Hydroelectric Projects on the Reventazon and Pacuare rivers
(Sep. , 1977).

If they will not permit it, it will be desirable for the hydro-plants to have pondages which could generate in peak hours in the dry season.

There seems to be no site for a dam with reservoir, but a site for a dam with pondage, that is, Guayabo site.

(3) Sites of Dam and Power Plant Including Tunnel Route

Economical feasibility of Guayabo Project will be dependent upon the route selection of a long head-race tunnel which will connect the two rivers. In other words, sites of dam and power plant will be selected so as to make the tunnel as short as possible.

ICE has conducted investigation and study on the sites of dam and power plant including tunnel route for Guayabo Project, and decided the dam site in the downstream from the junction of Reventazon river and its tributary, Guayabo river, and the plant site in the up-stream of Pacuare river near the boundary between Limon province and Cartago province.

Both sites are found to be the best sites for Project because of having no difficulties in view of topography and geology, availability of high head with comparatively short length of tunnel, and no harmful influence upon projects proposed for Pacuare river.

The tunnel will have the most economical route giving due considerations to geological conditions and constructional aspect, as respectively described in Chapter 4 "Geology and Construction Material" and Chapter 6"Preliminary Design".

5.2 FIRM DISCHARGE

It can be defined here that a firm discharge is a basic run-off to be used for the estimation of firm capacity of a hydro-plant which will be put into a load duration curve for kW balance analysis. The critical months for power supply will be April and December for which the balance of power in supply-demand was made as shown in Chapter 1, "Power Market Study". So, the firm discharges of the abovementioned months will be determined by an analysis of the run-off data.

As Guayabo Plant will be operated with a daily regulating pondage, monthly run-off duration curves will be studied at first for the determination of the firm discharge of every months. The monthly firm discharge will be estimated respectively from the duration curves in 18 years from 1959 to 1976 by averaging the five lowest flows in the curves for the months. These average firm discharges will be called L5 flows*, and the maximum, average and minimum values of L5 will be found respectively for every month in the period of 18 years.

The result of analysis are shown in Table II-5-1, among which L5 flows of April and December can be found as follows:

Discharge	April	December
Maximum L5	73.6(m^3/sec)	173 (m^3/sec)
Average L5	45.0	77.3
Minimum L5	33.0	57.6

* See Appendix A-3.

Table II-5-1 L5 Discharge at Guayabo Dam Site

Catchment Area 1518 km^2 (Unit; m^3/sec)

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Max.	103	81.1	68.0	73.6	113	143	132	139	153	143	124	173	Max. (173)
Mean	58.6	49.1 (46.2)	45.0 (38.3)	45.0 (36.3)	50.8	99.0	96.4	97.6	109	115	97.6	77.3	78.3 (76.8)
Min.	43.9 (39.5)	37.7 (32.7)	36.0 (27.8)	33.0 (25.4)	34.3	77.7	66.1	69.8	75.4	94.1	70.5	57.6	Min. (32.9)

Note: (1) $\text{Mean} = \frac{PL5 + SL5}{2}$

PL5 ; L5 Discharge Calculated from *Parallel Duration Curve
SL5 ; L5 Discharge Calculated from *Series Duration Curve

(2) Max. L5, Min. L5 ; Calculated from Parallel Duration Curve

Values in Parentheses are Obtained without Considering Effect of Regulation by Cachi Reservoir.

* See Appendix A-3

The minimum L5 flows means the L5 flows in the most dry year. For the firm discharges, it seems not to be appropriate to employ the minimum value of L5 discharge values on the grounds as explained as follows:

- A probability will be supposedly very small that the maximum demand for power might arise in concurrence with the minimum L5 flow. In an emergency, when it might concur, the shortage of power could be covered with a reserved power, an adequate operation of a big reservoir and/or by buying power through an international transmission line from a neighboring country. In consideration of the above, average value of L5 in 18 years will be adopted as the firm discharges at Guayabo Project, that is, 45 m^3/sec for April and 77.3 m^3/sec for December.

The L5 flow of 45 m^3/sec will include the power discharges from Cachi power station in April which is regulated by Cachi reservoir.

5.3 STUDY OF CAPACITY FOR GUAYABO PLANT

5.3.1 Basic Considerations

Guayabo Project will generate power by means of diverting Reventazon river to Pacuare river. In the downstream of Pacuare river, there is a proposed Siquirres Project which will be described in Part III. So, in the study of capacity for Guayabo Project, it will be necessary to pay due considerations to the incremental energy produced at Siquirres Project by the diverted flow. However, Siquirres Project is still in a reconnaissance stage with insufficient data for an analysis in the same level of accuracy, and the current study will be made of an isolated project.

In the definite study for Guayabo Project, therefore, it will be desirable to study with Siquirres Project, depending upon the progress of surveys in future.

Basic conditions for the analysis of capacity for Guayabo Plant is as follows.

1) Power will be generated with daily regulated flow in the pondage.
2) The effective storage of pondage will have enough capacity to be able to regulate inflows daily.
3) For the study of capacity for the plant, a yardstick will be put on the benefit cost ratio (B/C) and surplus benefit (B-C).
   The annual benefit will be obtained on the basis of cost for an alternative thermal power plant as mentioned in Chapter 8: "Economic Evaluation", while the annual cost be on the basis of investment cost roughly estimated.
4) Beneficial output and energy can be defined respectively as follows, which will be applied for determination of the benefit of Project.
   a) Beneficial output will be an average output with a daily utilization factor of plant 50% for April and December in future (1995) giving considerations to the total loss of 2.8% (2.5% loss by repairings or accidents plus 0.3% loss by plant service).

b) Beneficial energy will be annual possible energy with a reduction of the same amount of losses.
The calculation of annual possible energy will be made with an effective head between a pondage level (center of drawdown) and tailwater level. The period of calculation will be 18 years from 1959 to 1976, and the mean value will be regarded as an annual possible energy.

5) The annual cost will be calculated from the investment cost obtained by multiplying an assumed coefficient of annual expediture (11.4%) to the construction cost which could be estimated on a rough preliminary design.

5.3.2 Study on Height of Normal Water Level of Pondage

The capacity of Guayabo Plant will be determined from a result of benefit cost analysis with a combination of the pondage levels and the maximum power discharges. The pondage levels will be between EL 430 and 440 m and the maximum power discharge between 120 and 180 m^3/sec.

In this item, the maximum power discharge will be fixed at 140 m^3/sec, with such variable levels of pondage as 430 m, 435 m and 440 m, and a benefit cost analysis will be made. If the power discharge will be fixed at 140 m^3/sec, the necessary effective storage capacity will be 3.02 million m^3 from Fig. II-5-1. As for the pondage levels, EL 430 m will be a marginal lower limit of the pondage level with the effective storage 3.02 million m^3 in consideration of accuracy of the topographic maps and sedimentation.

A result of the analysis is shown in Table II-5-2, Fig. II-5-2 and a table below.

N.W.L. / Benefit and Cost	430	435	440
B/C	1.433	1.404	1.360
B-C (10^6 Colones)	97.8	97.0	92.7

As the pondage level will go up, as shown in Table II-5-2, effective head, output and energy will increase, implying that benefit will increase so much. On the other hand, annual cost will tend to increase mainly by increase of the construction cost for the dam. However, the increment of annual cost will be bigger than the increment of benefit and the economic feasibility will be deteriorated.

As a result, the most economic level of pondage will be the lowest marginal level as far as the pondage will be able to keep the effective storage. In this case it will be 430 m.

In calculating the storage curve, ICE data (Document de Trabajo 007-77) was used up to the water level of 430 m, while the part higher than this level was supplemented by the survey team. The storage curve was made on the basis of 1/10,000 maps, and it is necessary for levelling-up of accuracy for the study to prepare the maps in a scale more than 1/5,000.

Fig. II-5-1 Determination of Max. Pondage Capacity for In-Flows.

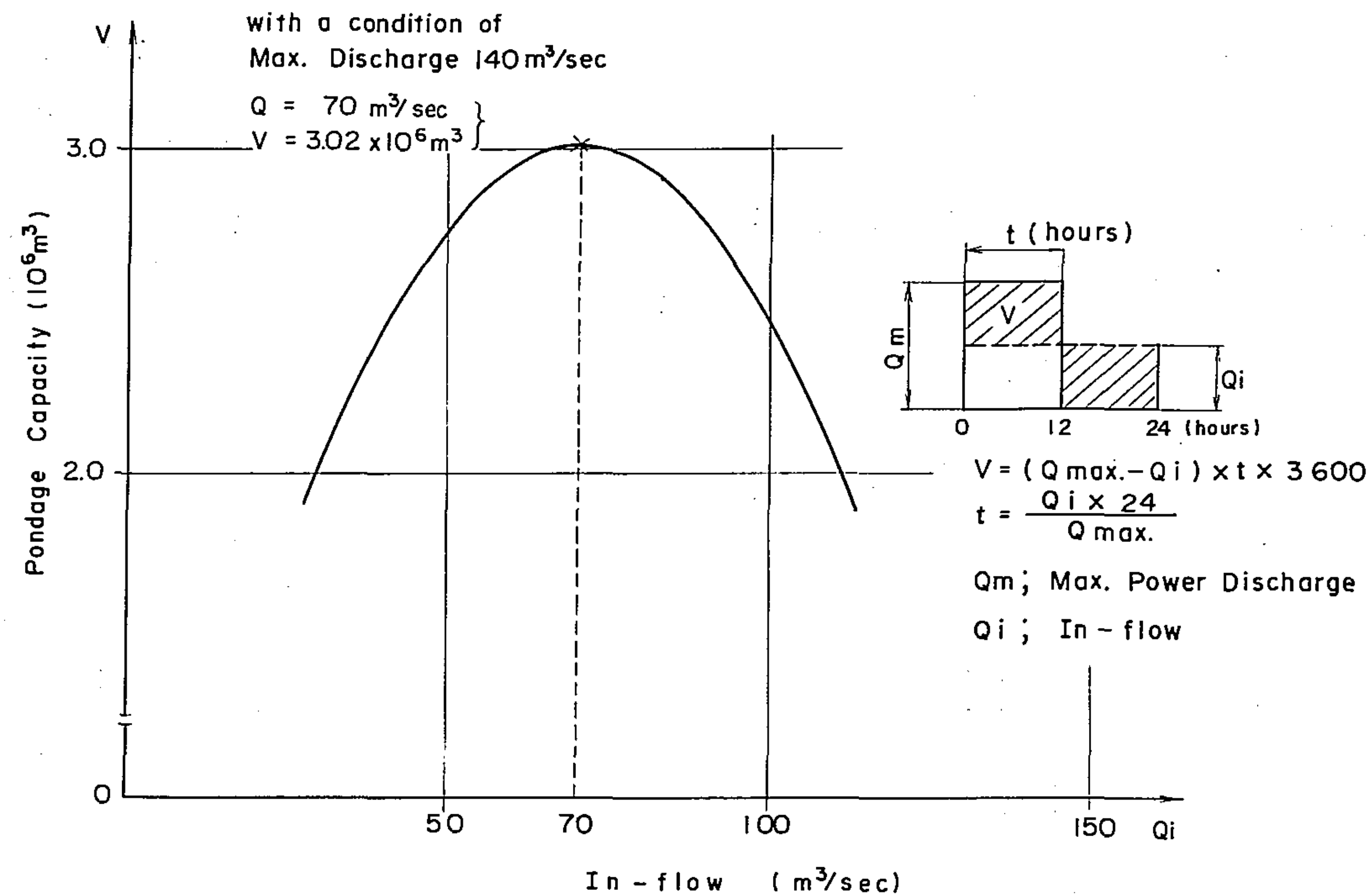
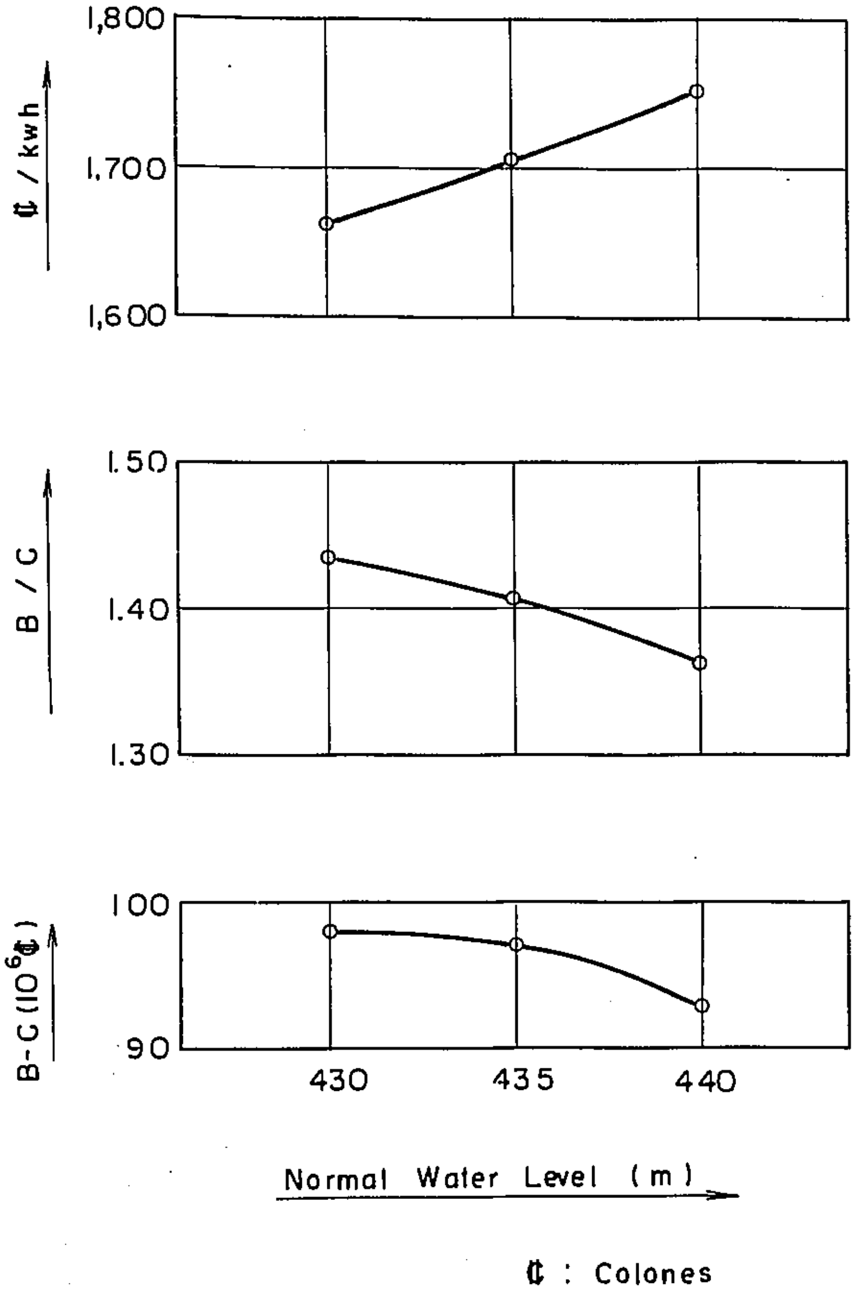


Table II-5-2 Study on Optimum Height of Normal Water Level and Max. Power Discharge

Item	Unit	Q max : 140 m^3/sec			N.W.L. : 430 m			
		N.W.L.: 430 m	N.W.L.: 435 m	N.W.L.: 440 m	Qmax: 120m^3/sec	Qmax: 140m^3/sec	Qmax: 160m^3/sec	Qmax: 180m^3/sec
Effective Head	m	155.0	162.2	167.7	154.2	155.0	155.1	153.0
Max. Power Discharge	m^3/sec	140.0	140.0	140.0	120.0	140.0	160.0	180.0
L5 Discharge (Apr.)	m^3/sec	45.0	45.0	45.0	45.0	45.0	45.0	45.0
L5 Discharge (Dec.)	m^3/sec	77.3	77.3	77.3	77.3	77.3	77.3	77.3
Installed Capacity	MW	180	191	197	155	180	208	231
Average L5 Peak Output	MW	149	157	162	136	149	159	158
Annual Energy Production	10^6kWh	1192	1248	1289	1093	1192	1262	1294
kW Benefit (B1)	10^6 Col.	103.4	109.1	111.9	94.8	103.4	110.5	109.8
kWh Benefit (B2)	10^6 Col.	220.1	230.5	238.1	201.8	220.1	233.1	239.0
Total Benefit(B=B1+B2)	10^6 Col.	323.5	339.6	350.0	296.6	323.5	343.6	348.8
Construction Cost	10^6 Col.	1980	2124	2257	1818	1980	2198	2447
Construction Cost per kWh	Col./kWh	1.661	1.702	1.750	1.663	1.661	1.742	1.891
Annual Cost (C)	10^6 Col.	225.7	242.1	257.3	207.3	225.7	250.6	279.0
Benefit Cost Ratio (B/C)	-	1.433	1.403	1.360	1.431	1.433	1.371	1.250
Annual Surplus Benefit(B-C)	10^6 Col.	97.8	97.0	92.7	89.3	97.8	93.0	69.8

Fig. II-5-2 Study on Optimum Height of Normal Water Level



5.3.3 Study on Maximum Power Discharge

Here, the optimum pondage level 430 m, which is obtained in the above item, will be fixed instead of the maximum power discharge, and the maximum power discharge will be changed into 4 cases, namely, 120, 140, 160 and 180 m^3/sec.

A result of the benefit cost analysis is shown in Table II-5-2, Fig. II-5-3 and a table below.

Benefit and Cost \ Max. Power Discharge (m^3/sec)	120	140	160	180
B/C	1.431	1.433	1.371	1.250
B-C (10^6 Colones)	89.3	97.8	93.0	69.8

On the basis of the result, the optimum maximum power discharge will be found to be 140 m^3/sec. Interpretation of Table II-5-2 and Fig. II-5-3 will be as follows.

1) Beneficial output will increase with the increase of maximum power discharge up to 160 m^3/sec, while beneficial output will not increase even if the discharge will exceed 160 m^3/sec..

2) With the increase of maximum power discharge, beneficial energy will increase, but the increment rate will tend to decrease.

3) The construction cost of headrace tunnel will give a big influence upon the investment cost, and the increment rate of investment cost will tend to increase as the construction cost of tunnel will increase involving increase of the maximum power discharge.

5.3.4 Result of Study

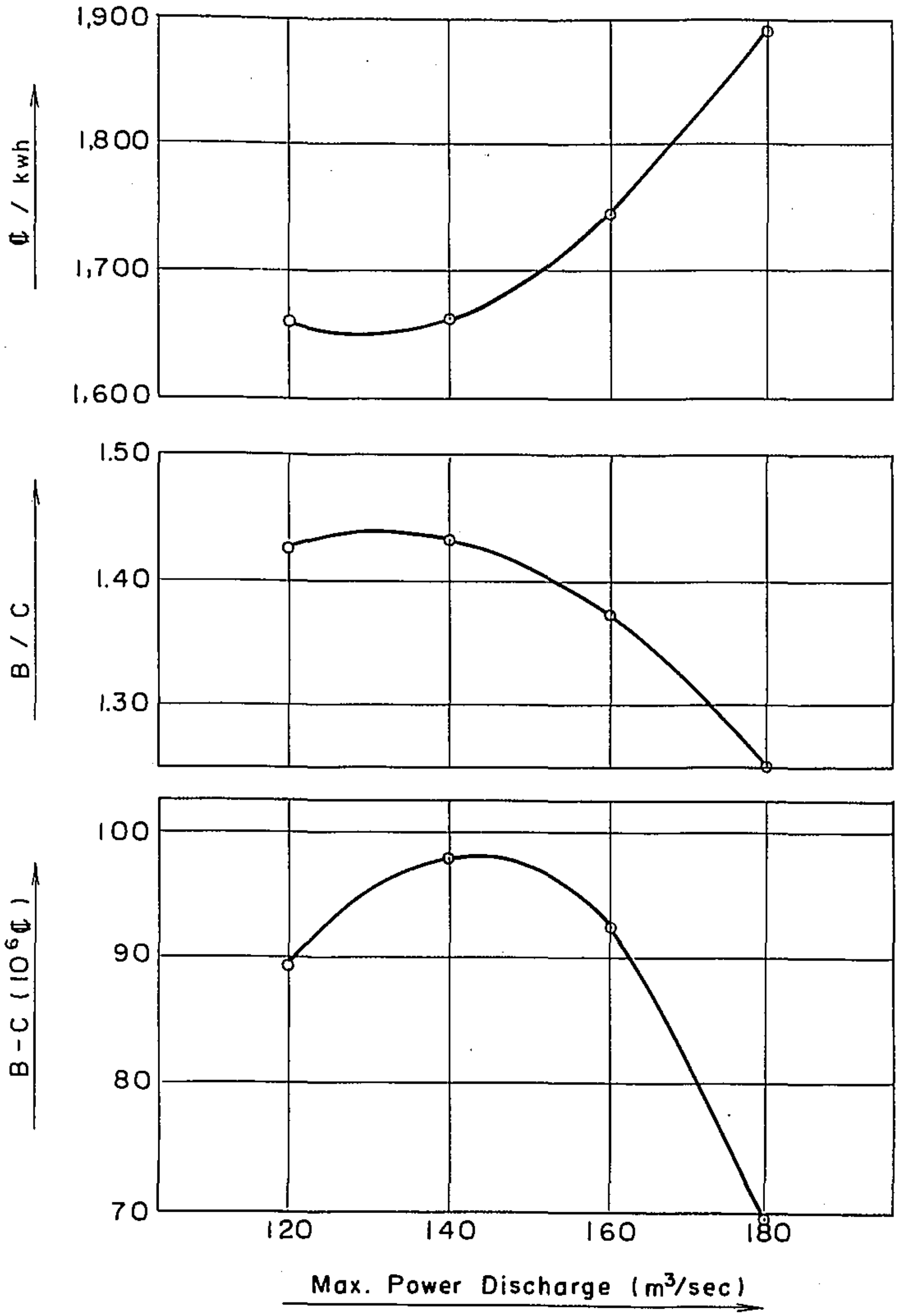
From the 5.3.2 and 5.3.3 items, it will be concluded that the optimum normal water level of the pondage and the optimum maximum power discharge will be EL 430 m and 140 m^3/sec, respectively. They will make the maximum output of the plant 180 MW.

5.4 INSTALLED CAPACITY

The installed capacity of Guayabo Plant will be 180 MW with maximum power discharge 140 m^3/sec and a standard effective head 155 m.

Standard intake level will be EL 425 m, which will be in the middle of drawdown. The tailwater level will be EL 246 m which will be an assumed water

Fig. II-5-3 Study on Optimum Max. Power Discharge



₡ : Colones

level of the tailrace when the power plant will operate with the maximum power discharge. The tailrace water level is estimated in a map of 1/10,000, and it is necessary to have a rating curve of the site in the definite study in future.

5.5 FIRM CAPACITY AND MW CONTINUOUS

The firm capacity of Guayabo Power Plant will be 158 MW and 180 MW, respectively, for April and December in 1989 when the installed capacity 180 MW will put into operation, and the MW continuous will be 59 MW which will be guaranteed through years.

5.6 ANNUAL POSSIBLE ENERGY

It will be calculated in daily operation of the pondage on the basis of daily run-offs in 18 years, the head being assumed to be a constant of 155 m. The result is shown in Table II-5-3, and the annual average possible energy in 18 years will be 1,192 million kWh.

Fig. II-5-4 also shows the monthly in-flows, power discharges and overflows.

5.7 NUMBER OF UNITS

As a result of study so far, the installed capacity of Guayabo Power Plant will be 180 MW and the number of units will be considered to be either two or three.

Less number of units, that is, two units will be favorable in view of cost economy. However, the capacity of unit 90 MW will be too large to replace the capacity in failure or outage by another power resource when considered the maximum power demand could be 700～800 MW in 1990. Therefore, three units of 60 MW will be installed at the Guayabo Plant.

Table II-5-3 Energy Production

(Unit: 10^6 kWh)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1959	44.1	34.6	31.6	38.9	57.8	121.6	113.1	112.2	109.3	127.9	109.3	86.8	987.0
1960	82.8	58.0	54.6	47.8	69.1	111.6	124.0	102.2	107.9	133.7	106.1	108.9	1106.6
1961	65.5	48.9	40.8	37.2	68.7	106.3	117.8	107.6	127.6	130.9	124.0	119.2	1094.2
1962	82.5	44.5	39.2	45.6	86.4	115.7	124.6	119.6	124.3	135.1	121.1	115.9	1154.4
1963	75.5	63.4	61.7	81.2	106.6	107.9	122.8	116.8	125.1	126.1	125.5	106.6	1219.3
1964	88.1	41.0	31.2	32.4	64.7	116.2	132.8	131.2	129.5	133.0	116.1	73.8	1090.1
1965	109.1	65.5	71.9	41.8	93.8	124.0	121.7	134.7	127.0	133.1	124.8	102.4	1249.9
1966	106.4	98.3	75.9	59.5	129.9	127.4	121.5	127.5	128.1	133.8	117.1	132.3	1357.8
1967	116.1	66.6	58.6	91.1	96.5	129.7	131.2	133.8	131.2	134.9	127.3	103.2	1320.4
1968	66.3	86.6	83.6	85.7	113.4	130.7	134.3	134.9	128.9	132.0	126.9	109.8	1333.1
1969	62.2	45.9	39.3	53.3	62.5	109.8	89.1	134.5	125.4	131.9	127.1	124.4	1105.5
1970	99.9	110.6	67.1	109.6	127.7	130.9	134.0	115.4	127.6	131.4	128.7	135.6	1418.6
1971	124.7	67.0	83.0	83.7	105.8	110.0	124.8	134.6	126.5	134.4	113.5	70.3	1278.3
1972	84.9	61.1	55.1	78.7	97.1	99.2	92.5	108.8	123.6	130.9	115.8	91.2	1138.8
1973	72.8	62.4	51.0	32.0	70.1	126.8	113.7	114.0	121.2	128.5	122.2	124.9	1139.8
1974	105.0	61.5	59.8	56.5	101.7	127.2	129.3	125.5	108.3	124.8	96.3	93.6	1189.7
1975	57.4	46.0	39.7	43.4	57.0	105.3	125.5	134.4	130.3	126.2	127.7	132.6	1125.3
1976	91.2	58.2	48.4	47.8	84.7	120.3	127.0	118.0	124.6	121.8	118.9	86.9	1147.5
Average	85.2	62.2	55.2	59.2	88.5	117.8	121.1	122.5	123.7	130.6	119.4	106.6	1192.0

Fig.II-5-4 In-Flow, Power Discharge and Energy Production

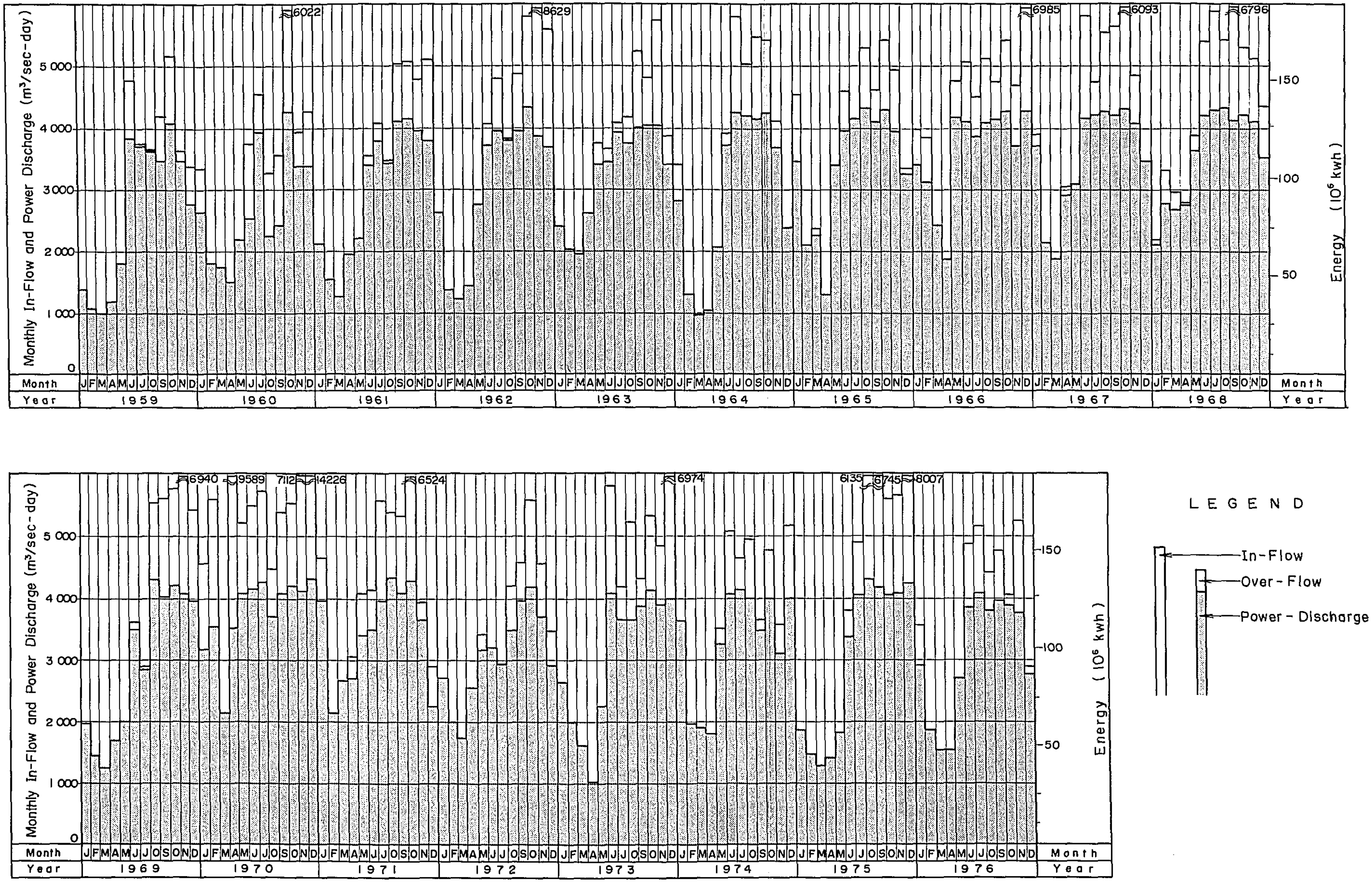
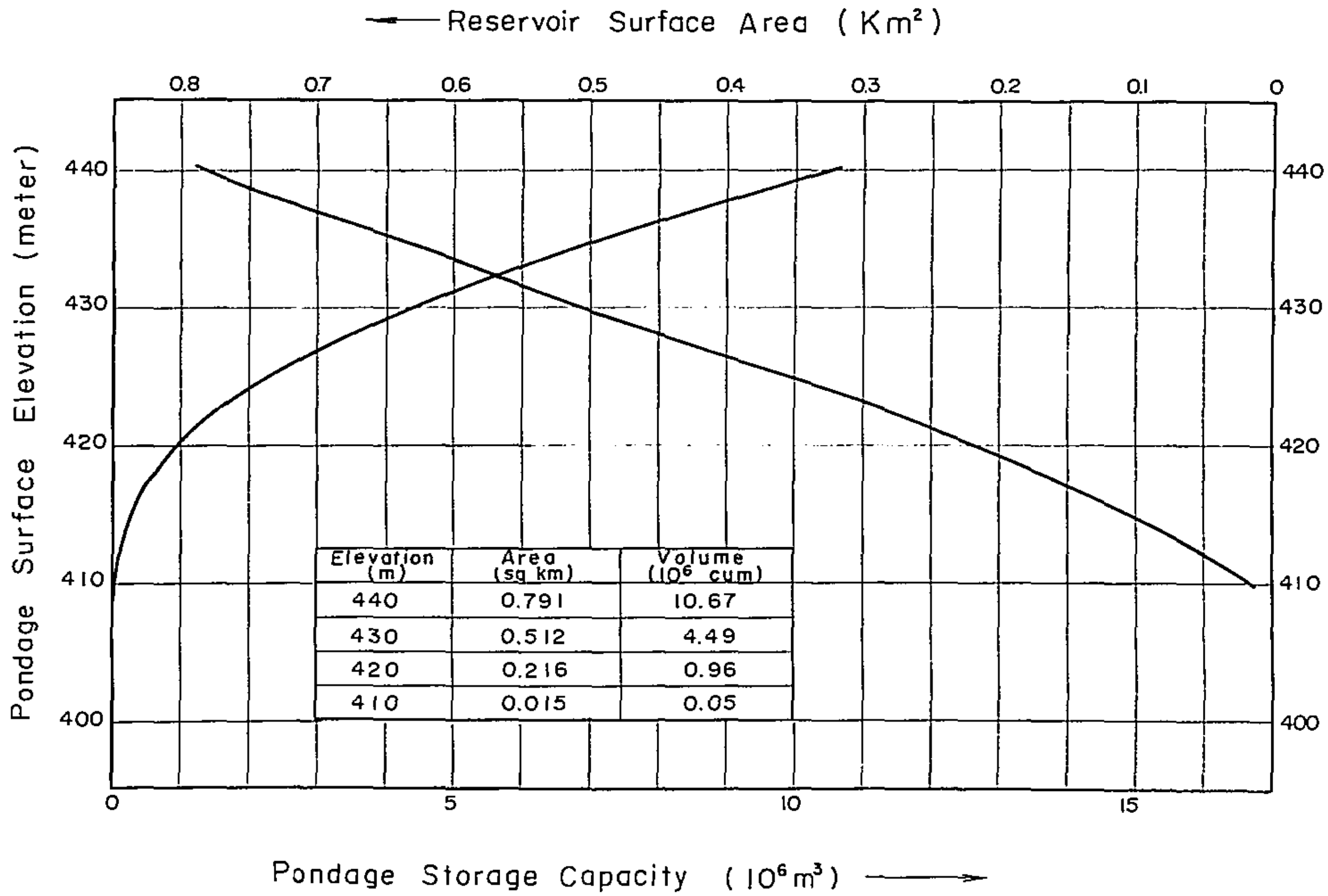


Fig. II-5-5 Pondage Surface Area and Storage Capacity Curve

Guayabo Pondage



Elevation (m)	Area (sq km)	Volume (10^6 cum)
440	0.791	10.67
430	0.512	4.49
420	0.216	0.96
410	0.015	0.05

PART II

CHAPTER 6

PRELIMINARY DESIGN

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LIST OF FIGURES

LIST OF DRAWINGS

CHAPTER 6 PRELIMINARY DESIGN

6.1 PRELIMINARY DESIGN

6.1.1 Civil Structures

As a result of study in Chapter 5; "Plan of Power Generation," Guayabo Project will propose a dam in Reventazon river with a pondage which will store about 3 million m^3 of water at a normal water level 430.0 m.

The regulated flow will be led through a headrace tunnel to Pacuare river where a power plant will be located. The Plant will generate the maximum output 180 MW by three units of turbine-generator with a head 155 m and maximum power discharge of 140 m^3/sec.

(1) Dam

Type of the dam will be a combined dam of a fill-dam and a gravity dam giving due considerations to the factors described below.

(a) The dam should be provided a big spillway for the design flood 8,600 m^3/sec.
(b) The crest length of dam will be very long, 655 m, with the normal water level 430.0 m.
(c) As for the topography of the dam site, there is a plain of river-deposit which covers the foundation rock on the left bank and an existing river on the right bank.
(d) Mudstone and sandstone at the dam site consist of the foundation rock on which either concrete or fill-dam could be built without considerable geological problems.

The combined dam will have a fill-dam (33.0 m high and 480.0 m long), which will be constructed on the left plain, and a gravity dam (38.0 m high and 175.0 m long) will a spillway and a sediment control outlet on the river-bed of right bank.

Gravels and cobbles will be used for the construction of the fill-type dam, inasmuch as it could be readily collected from spots close to the proposed construction site. It was assumed that the weathered layers of the rock formation found in the vicinity of the dam about 700 m above sea level on the right bank could be used as an impermeable material and that the river bed pebbles found near the dam as materials for transition and shell zones.

As for the slope of dam, in consideration of geological conditions explained in Chapter 4 "Geology and materials," the slope of the upstream was assumed at 1:3.50 and that of the downstream, 1:3.00. Detailed investigations should further be conducted both on the dam foundation and the construction materials for the dam, so that the definit design of the dam can be drafted on the basis of the findings of those investigations.

(2) Spillway

As has been explained in Chapter 3 "Hydrology," the design flood of the Guayabo Dam is estimated at 8,600 m^3/sec. The spillway will be of an overflow type, and will be able to discharge safely the flood of 8,600 m^3/sec with the high water level 430.0 m. It will provide six roller gate (15.0 m high and 13.0 m long) given due considerations to the big flood discharge, and maintenance factors.

However, longitudinal as well as sectional surveys of the Reventazon river should be conducted so that the definite design of the spillway could be devised by a hydraulic experiment defined on the basis of the findings of those surveys.

(3) Sediment control outlet

As has been stated in Chapter 3 "Hydrology," it is assumed that a considerable amount of sediment will flow into the Guayabo pondage. Although it is conceivable that a considerable amount of these sediment could be flushed away by operating the spillway gates during floods, sedimentation below the overflow crest would be unavoidable. Thus, there is a need to install a sediment control facility in addition to the spillway gates for eliminating the sediment below the crest so that the dam could provide active storage for the operation of pondage.

Two sediment control outlets (5.0 m wide and 5.0 m high) will be constructed at the bottom of dam which will be effective as a sediment control facility. The volume of water which pass through the outlets will be 1,000 m^3/sec at EL. 430.0 m where the regulating pondage is full.

The sediment control outlets will also be used as a kind of diversion channel during the dam construction.

(4) Intake

Because of the terrain, the intake will be constructed on the right bank and directly upstream of the dam. The capacity of the intake will be 140.0 m^3/sec and the maximum velocity of flow in front of the intake screen will be 1.0 m/sec. The elevation of the intake sill will be 417.0 m in consideration both of the pondage water-level and the crest of spillway.

A screen with a 1:0.30 slope will be installed in front of the intake. Behind the intake, a roller gate (6.5 m wide and 8.0 m high) will be installed at the entrance of the headrace tunnel for the maintenance and operation of the tunnel.

(5) Headrace tunnel

The headrace tunnel will be a pressure tunnel with the maximum capacity of flow 140.0 m^3/sec. The tunnel will be circular in shape. The inside diameter of the tunnel was decided in such a manner that the sum of the annual cost based on the construction cost of the headrace tunnel and the annual loss of benefit due to head loss could be the minimum. The result of the study is shown in Fig. II-6-1. Thus, the inside diameter of the tunnel was determined at 6.5 m.

As has been explained in Chapter 4 "Geology and Material", the ground of the area where the headrace tunnel will be built is mainly made up of mudstone and sandstone. The route of the headrace tunnel was selected after considering the geological conditions, rock coverage of the tunnel, and the temporary adits for tunnel excavation. The headrace tunnel will be 9,582 m long.

Reinforced concrete lining will be applied to approximately the entire length of the headrace tunnel. However, the parts of tunnel will be reinforced by means of steel lining at places of weak rocks and in the vicinity of the penstock and the surge tank. Mortar and high-pressure grouting will be made for the entire length of the tunnel.

(6) Surge tank

The length of tunnel from the Guayabo pondage to the power plant is very long, that is, about 10 km. So, the tunnel needs a large surge tank. The tank will be underground and of round shape because of the surrounding topography and the geological condition. It will be 75.0 m high and will have an inside diameter of 10.0 m with upper and lower chambers.

Steel lining will be applied for the section where the headrace tunnel is connected to the shaft of the surge tank for protecting it from cavitation. It also gives easiness for construction of the interconnecting point. Except for this interconnecting point, concrete lining will be applied to all parts of the surge tank.

(7) Penstock

A penstock will be laid on the ground because of the topographical and geological conditions of the site. The penstock will have an inside diameter of 6.5 - 5.0 m and it will be branched out in three pipes in front of the power plant. The length is 465.0 m from the top to the power plant. As for the manner of branching, a ball-shaped branch will be employed. The penstock will be of high-tension steel.

The inside diameter of the penstock, as has been the same case with the study on the inside diameter of the headrace tunnel, was decided in such a manner that the sum of the annual cost of constructing the penstock and the annual loss of benefit due to head loss could be the minimum.

The result of this study is shown in Fig. II-6-2.

(8) Power Plant and switchyard

The power plant, equipped with three turbines and three generators, will have the installed capacity of 180 MW. In consideration of the topographical and geological conditions, the power plant and the switchyard will be on-the-ground type and outdoor type respectively. The draft tube will be elbow-type and three draft gates will be provided at the outlet. Since the Pacuare river bends abruptly near the power plant, it will be better to face the draft tube down-stream in consideration of a smooth flow of the power discharge and preventing the sediment from flowing into the tube when the power plant is not operating.

The elevation of center of the turbine will be 242.5 m in consideration of the draft head based on the tailrace water level 245.5 m at the time of the operation of one turbine.

Fig. II-6-1 Study on Headrace Tunnel Diameter

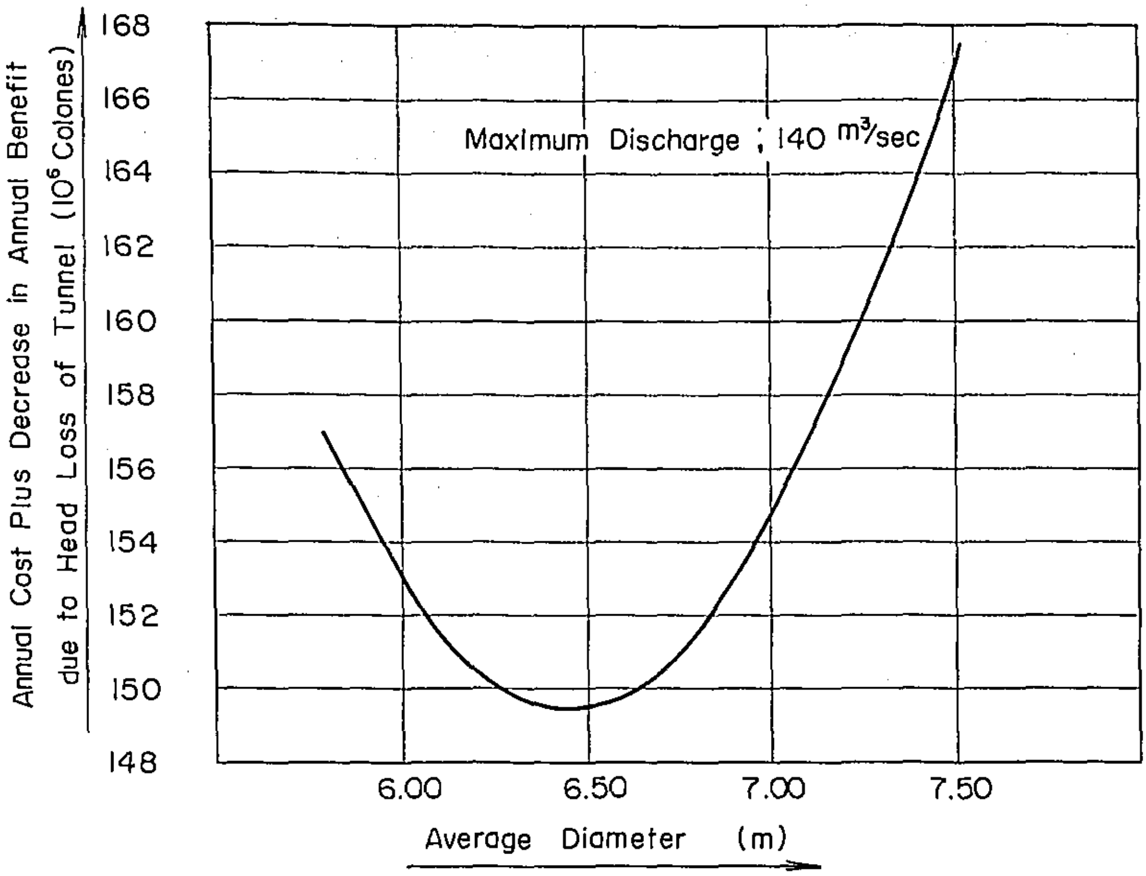
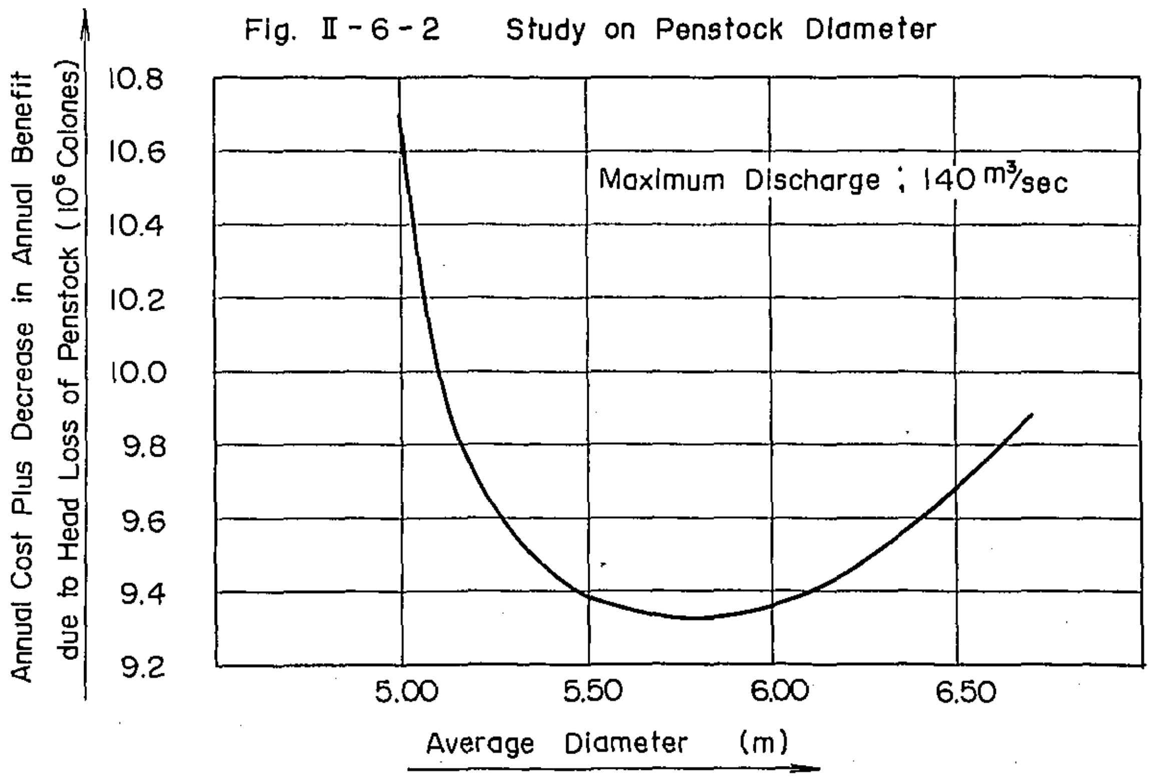


Fig. II-6-2 Study on Penstock Diameter



The elevation of the access road to the power plant and the switchyard will be 251.5 m in consideration of the design flood of 4,300 m^3/sec at the point of the power plant.

However, prior to proceed to the definite study, the more accurate water level of the tailrace should be determined by conducting longitudinal and sectional surveys of the Pacuare river at the site of the power house.

6.1.2 Turbine and Generator

The power plant will have a normal effective head 155 m. The drawdown of the regulating reservoir will be 10 m, and the available power discharge for a unit of turbine will be 47 m^3/sec. Under these conditions, it would be most appropriate to adopt a vertical-shaft Francis type turbine. Number of units will be three for the power plant.

The output of unit is 66,000 kW with a rotating speed 300 rpm. Buttefly valve will be used as a main valve for the unit.

As for the generators, capacity of unit is 78,000 kVA with a voltage of 13.8 kV and the power factor of 0.8 (lag.).

Unit system is adopted for the auxiliary equipments of the turbines and generators.

Three units of 78,000 kVA 3-phase oil immersed air-cooled transformers will be installed in the outdoor switchyard adjoining the power house. The secondary voltage of the main transformer will be 230 kV as is explained later (see Item 6.1.3).

A transmission line of 230 kV could be put from the power plant to South Substation of San Jose and the number of circuits will be two in consideration of the output of Guayabo Power Plant. The bus system in the switchyard at Guayabo Power Plant will be single, but it could be converted to double when the Siquirres Project is to be operated in the future.

One-man control system will be adopted for the operation on the turbines, generators and the outdoor switchyard, and the entire control and operation will be made from a control room. The single line diagram is shown as an example in Fig. II-6-3, and the layout of the outdoor switchyard, in Fig. II-6-4.

6.1.3 Transmission Lines

(1) Transmission line

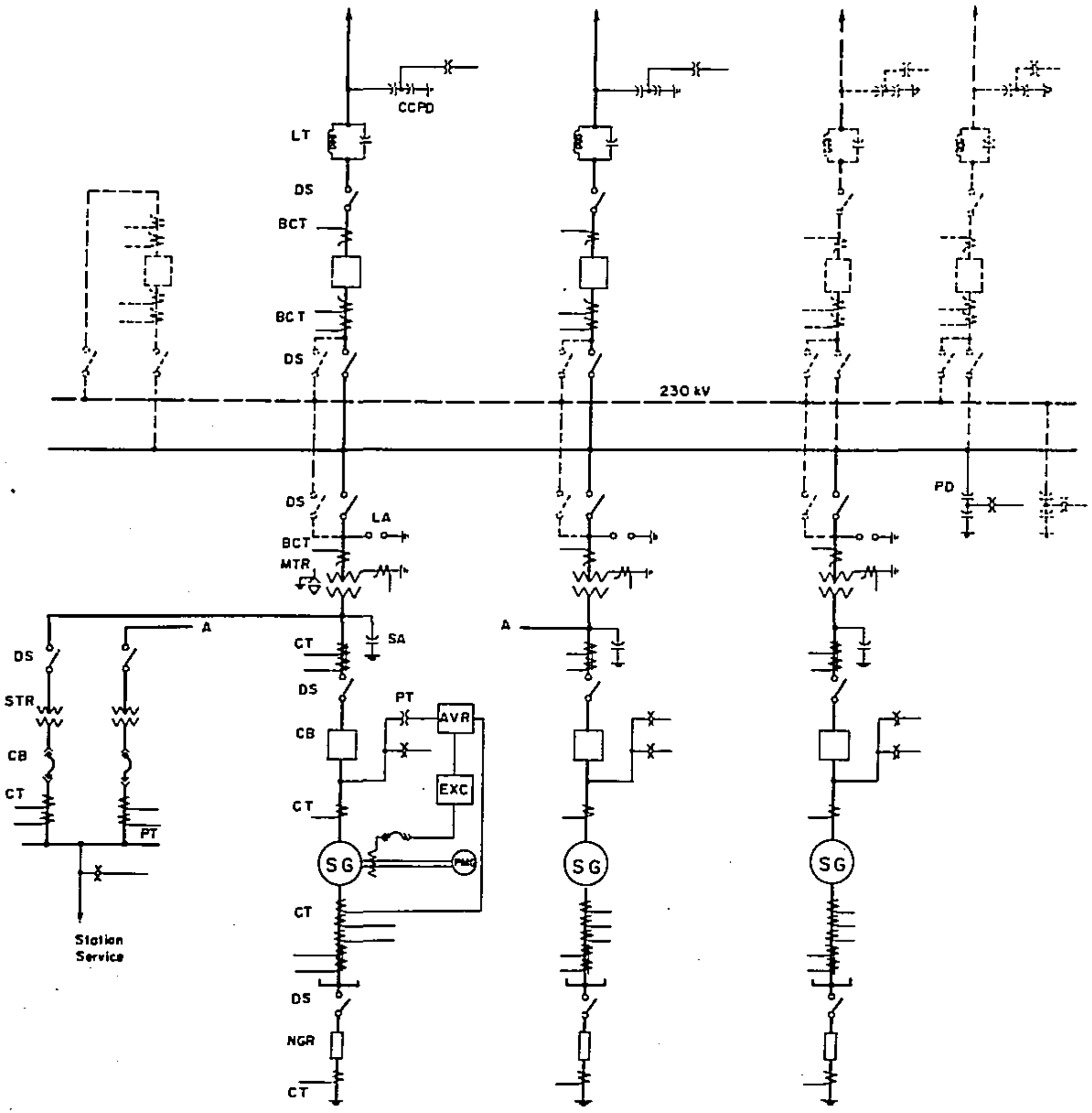
To transmit the power generated by Guayabo Power Plant to demand areas close to metropolitan region, a transmission line will be installed between Guayabo Power Plant and South Substation of San Jose.

The capacity of the transmission line will be 230 kV of two circuits in consideration of Guayabo Power Plant's maximum output of 180 MW as well as the forthcoming Siquirres Project.

The projected transmission line will start from Guayabo Power Plant crossing over the existing 138 kV transmission line and Reventazon River, then extend over the hills along National Highway No. 230 and No. 10. At a point north of Cartago City, it will cross National Highway No. 8 and No. 2. It will then head westward along Tiribi River to South Substation of San Jose.

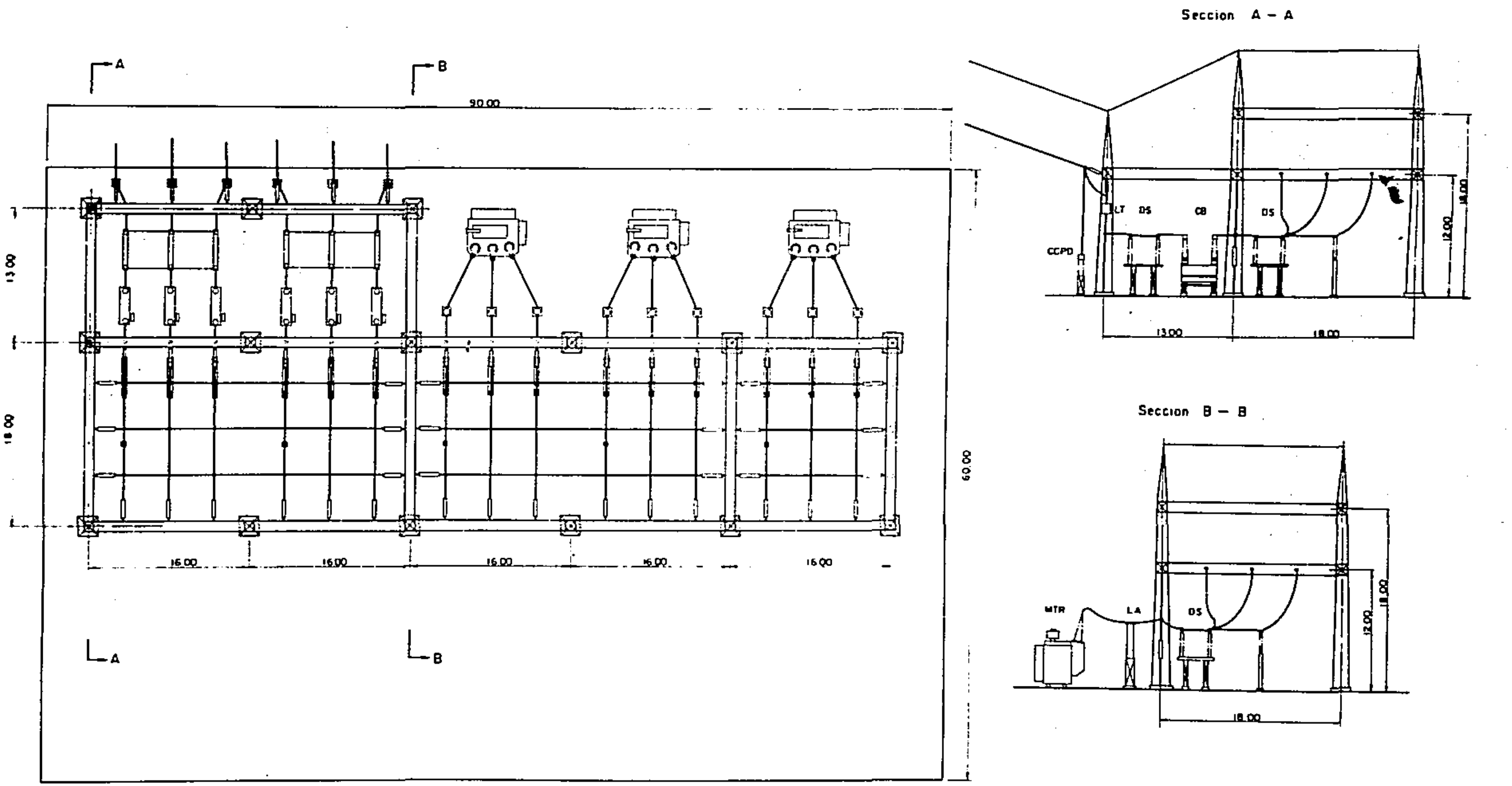
Fig. II-6-3 Single-Line Diagram of GUAYABO Power Plant

for South of San Jose S.S



SG	Synchronous generator
MTR	Main transformer
STR	Station service transformer
CB	Circuit breaker
DS	Disconnecting switch
PT	Potential transformer
CT	Current transformer
PD	Potential device
CCPD	Coupling capacitor potential device
LA	Lightning arrester
SA	Surge absorber
NGR	Neutral grounding resister
EXC	Excitation system
AVR	Automatic voltage regulator
PMG	Permanent magnet generator
LT	Line trap
GB	Grounding blade
BCT	Bushing type current transformer

Fig. II-6-4 Swichyard -Plan of GUAYABO Power Plant



The highest elevation in the route is about 1,600 m and in most part, it will pass through pasture lands. It will also aim to avoid sharp angles and road crossing as much as possible to facilitate construction and maintenance. The route map is shown in Fig. II-2-1.

Two aerial ground wires will be provided for the line because lightning occurs frequently in these areas. There will be 13 insulators.

For the output of 180 MW, a transmission line with sectional area of 410 mm^2 in a single circuit would be most appropriate taking into consideration the possible power losses in a useful life of the transmission line. However, the size of the transmission line should be determined by jointly considering various factors, such as the developing time and capacity of Siquirres Project and its effect on the existing system. At this point, it is not clear when the Siquirres Plant would be put into operation. The capacity of the plant is also not determined yet. In addition, Guayabo Power Plant will be capable of generating power more than 20 per cent of the total demand. So, it will be assumed to use the 410 mm^2 equivalent transmissiln line with two circuits, enhancing its supply reliability.

An example of steel tower for the transmissiln line is shown in Fig. II-6-5. For the protection of the transmission line, a power line carrier relaying system will be adopted.

(2) Substation

The transmission line from Guayabo Power Plant will be connected to the 230 kV bus at South Substation of San Jose where the voltage will be reduced to 34.5 kV. In response to the development of Guayabo Project, 78 MVA transformers will be installed at the substation to supply power to customers. The outline of the transformer is shown in chapter 6.1.5 "Principal Features".

The single-line diagram of the substation is shown in Fig. II-6-6.

6.1.4 Telecommunication System

Tele-communication system between Guayabo Power Plant and South Substation of San Jose will be provided for the operation and maintenance of the plant.

(1) Telephone circuit for load-dispatching

A power line carrier circuit with two channels will be provided between Guayabo Power Plant and South Substation of San Jose for telephone and telemeter circuits for the exclusive use of load dispatching.

The telemeter circuit will be also used for transmitting signal and information on Guayabo Power Plant to a load dispatching office.

(2) Power line carrier device for transmission line protection

For the protection of the 230 kV transmission line, a power line carrier device will be provided between Guayabo Power Plant and South Substation of San Jose by using the power line carrier relaying system.

Fig. II-6.-5 Transmission Line Tower Configuration

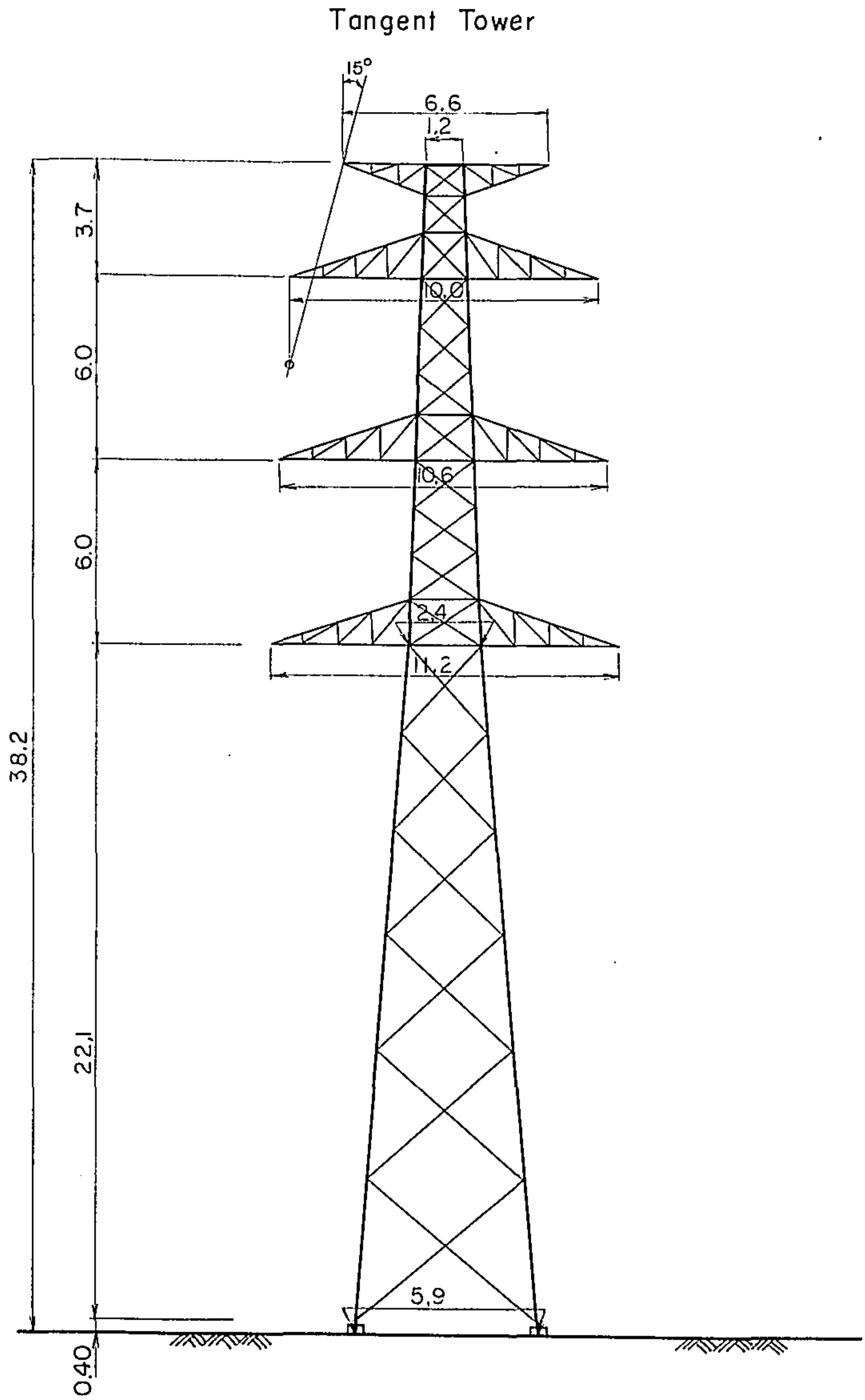
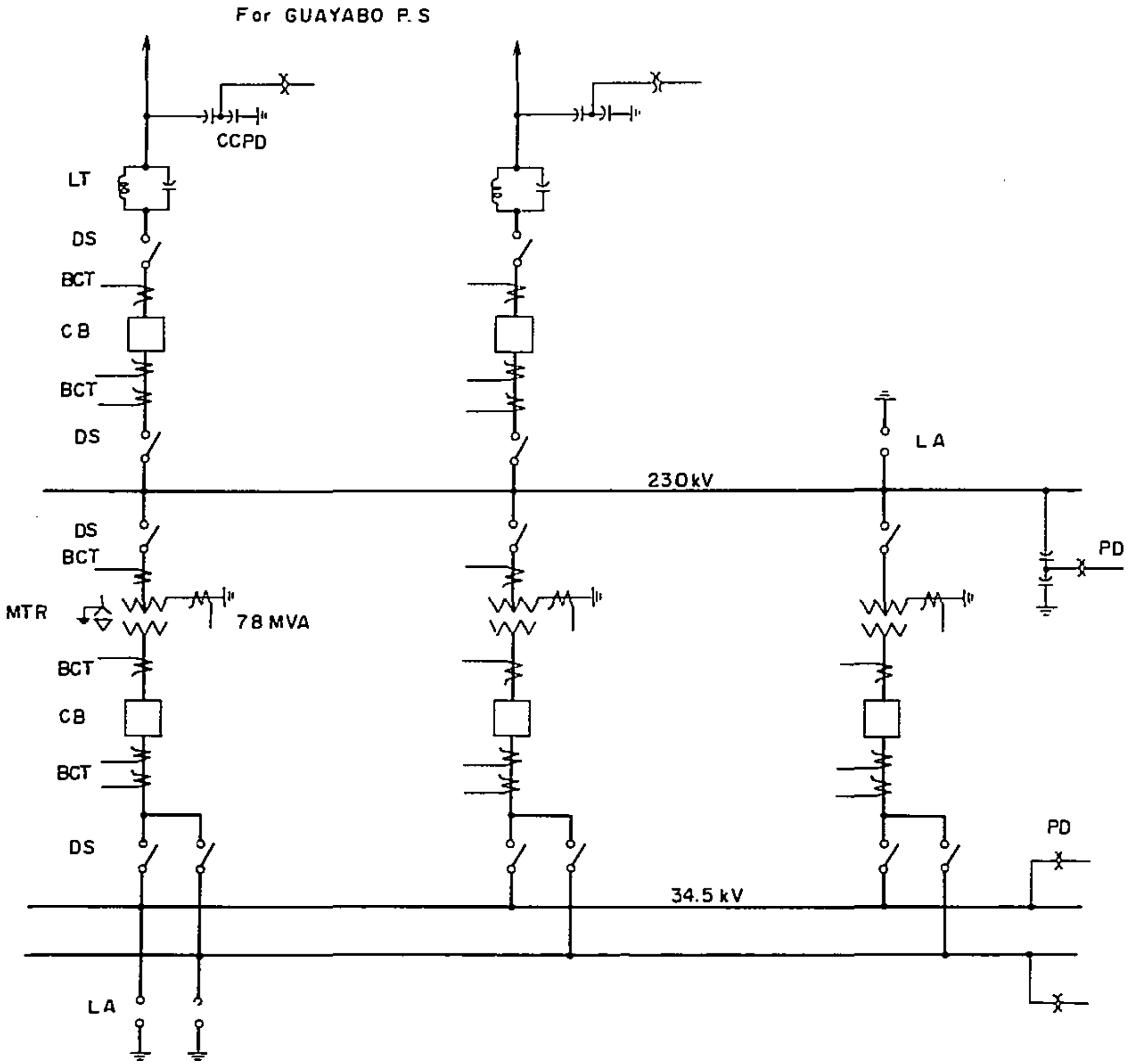


Fig. II-6-6 Singl-Line Diagram of South of San Jose Substation



MTR : Main transformer

L A : Lightning arrester

D S : Disconnecting switch

C B : Circuit breaker

L T : Line trap

CCPD : Coupling capacity potential device

P D : Potential device

(3) Maintenance system for transmission line

South Substation of San Jose will have a set of fault locator required for maintenance of the 230 kV transmission line covering the 60 km distance between Guayabo Power Plant and South Substation of San Jose. In addition, a VHF movable station with another relay station will be provided for the maintenance base of Guayabo Power Plant.

(4) Inspection system of Dam

Guayabo Substation will be equipped with a water-level telemeter for observing the water-level of Guayabo pondage. Moreover, a tone-ringer circuit will be installed between Guayabo Power Plant and Guaybo Dam as a telephone for maintenance.

The outline of the tele-communication system of Guayabo Project is shown in Fig. II-6-7 and Fig. II-6-8.

6.1.5 System Analysis

A digital simulation study was made on the power flows, voltage, short-circuit capacity and stability in the power system at the time of partial and full operation of Guayabo Project. The details of the study are shown in the Appendix. The outline of the result is as follows.

(1) Under normal conditions, the power flow will not pose any problem as it is, until 1990.

However, it could be predicted that this transmission line would become over-loaded when the line of the La Caja-Colima 138 kV double circuits might operate in a single circuit.

As has already been planned by ICE, therefore, it would be desirable from the standpoint of reliability to newly construct a 230 kV transmission line (single-line for the time being) between Corobici and North Substation of San Jose.

Moreover, in accordance with power increases, it would become necessary to increase the capacity of the substations which would be La Caja, Canas and Colima. The capacity required and time of construction are shown in the Appendix.

(2) As a voltage regulating measure, it would become necessary to place static condensers as voltage regulation in order to maintain the voltage close to 100 per cent at peak load, since the substations located close to such cities as Heredia, Colima and Sabanllla are situated far from the main power sources, such as Arenal, Corobici and Guayabo.

The aforementioned installation of a new 230 kV transmission line between Corobici and North Substation of San Jose will also be effective in reducing the capacity of the static condensers required for voltage regulation of the power system.

The Garita and Concavas substations will also need static condensers for voltage regulation to cope with the increasing demand for power. Judging from the length of line and the type of line used, voltage rise in the line at night will not pose any problem.

Fig. II-6-7 TELECOMMUNICATION SYSTEM DIAGRAM

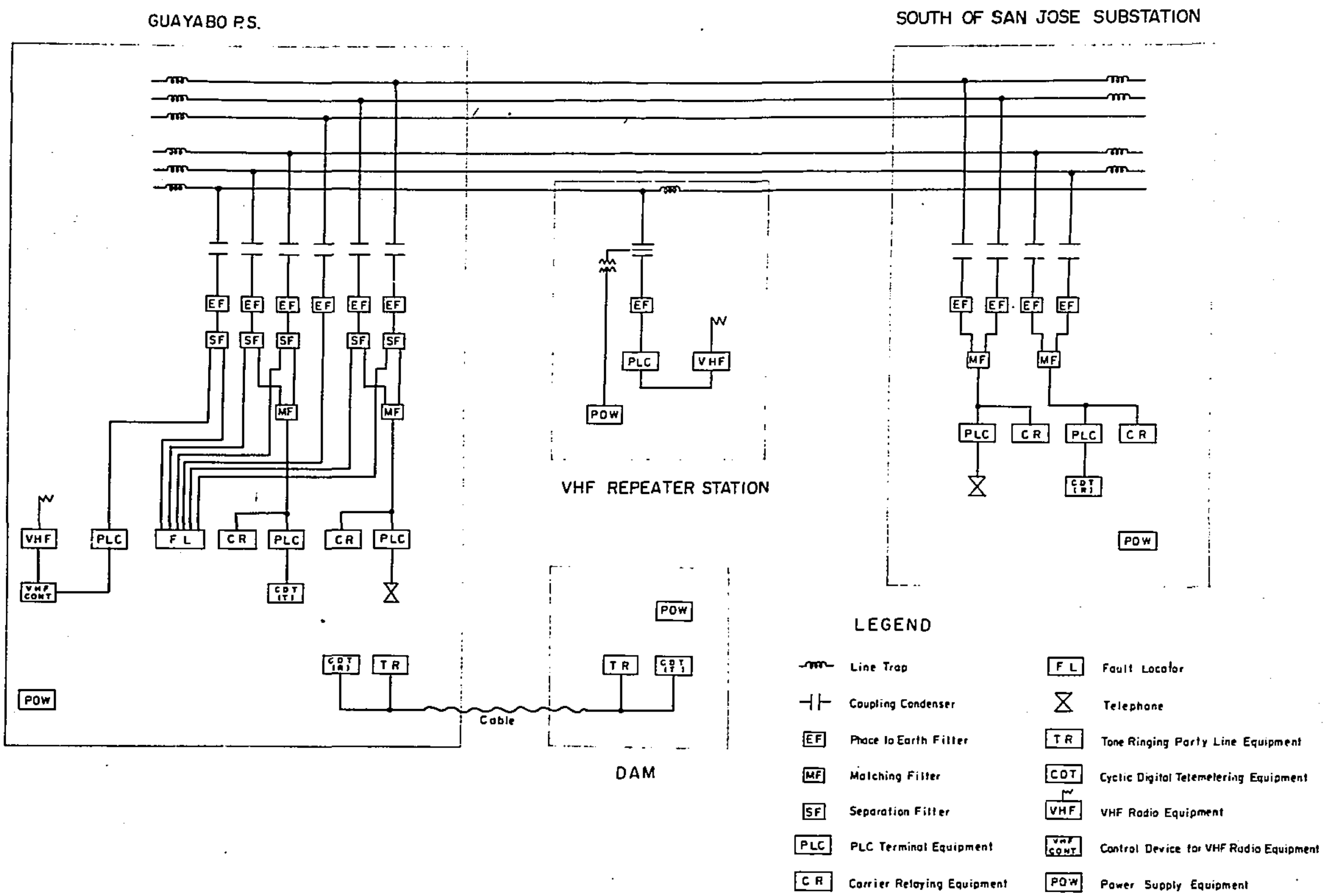
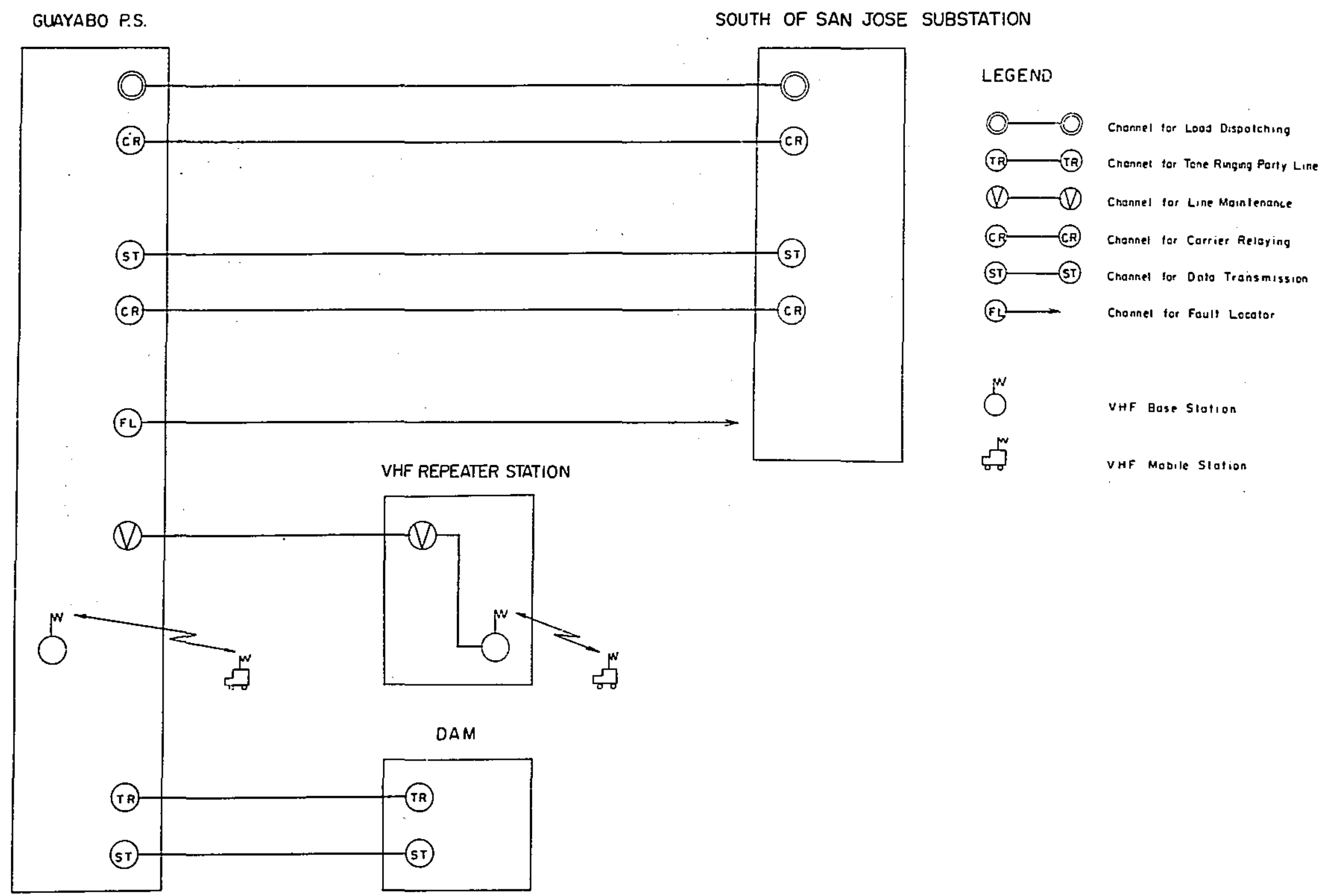


Fig. II-6-8 TELECOMMUNICATION CIRCUIT DIAGRM



(3) The results of the study on the short-circuit capacity are shown in the following table.

Voltage (kV)	Substation	Short-Circuit Capacity	
		(MVA)	(kA)
230	Arenal	1,912	4.8
138	La Caja	1,903	8.0
34.5	La Caja, Secondary side	832	13.9
13.8	Colima, Loading End	505	21.1
13.8	Arenal, Generating End	1,663	69.6

Note : A reactance of the generator is assumed to be X'd.

(4) As for power stability, a study was made on static stability and transient stability.

The result of the calculation of power flow at peak load in December 1990 shows that there are a 25 degrees difference in phase as the maximum between one of the generators and the bus of Colima Substation which covers the main district for power demand. Therefore, there is no problem from the standpoint of static stability.

A study on transient stability was made on an assumption that a 3-phase short-circuit had occurred near the bus of Guayabo Power Plant at peak load in December 1987 and in December 1990. The results are stable, too.

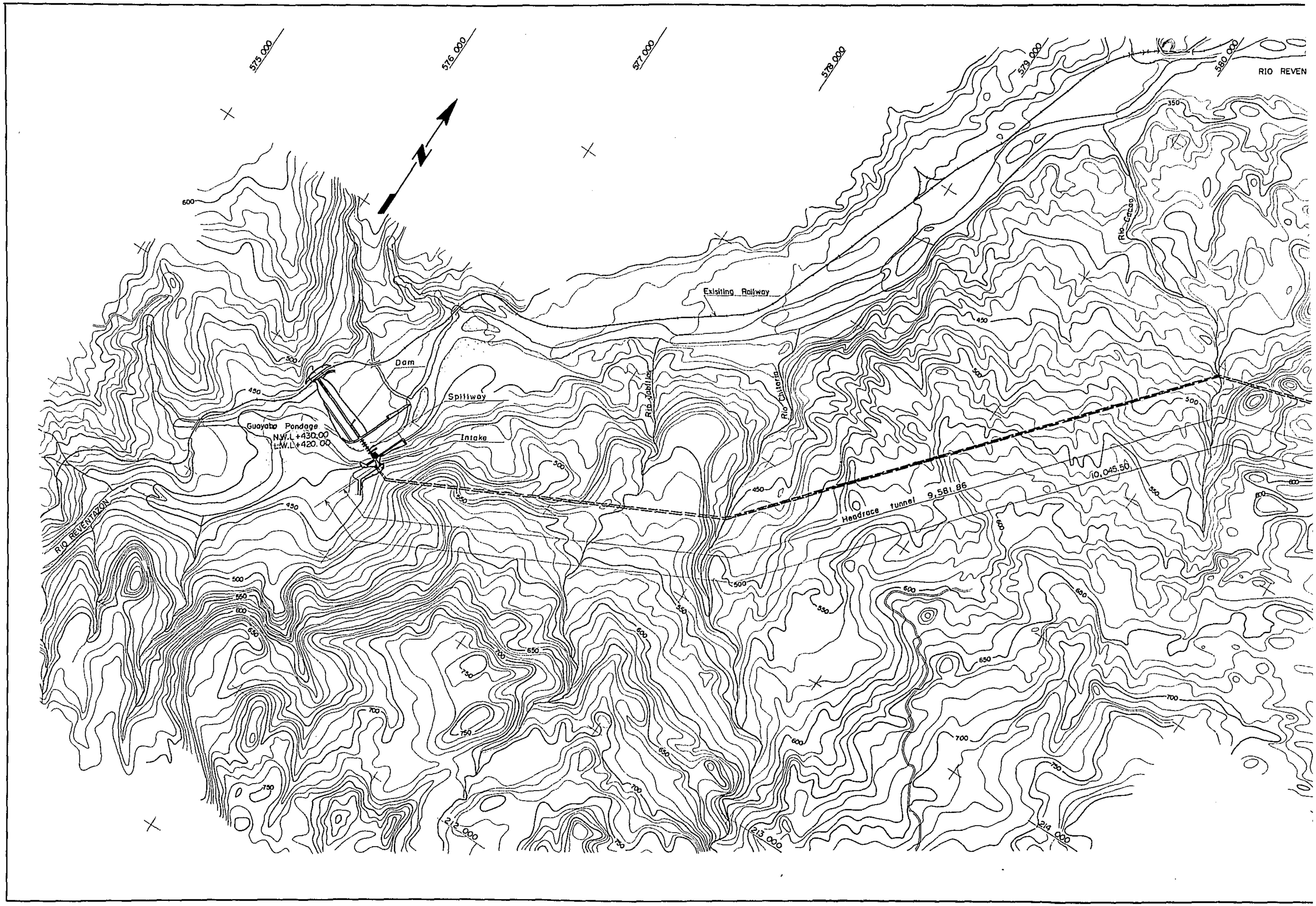
6.1.6 Principal Features

The principal features for Guayabo Project is as follows.

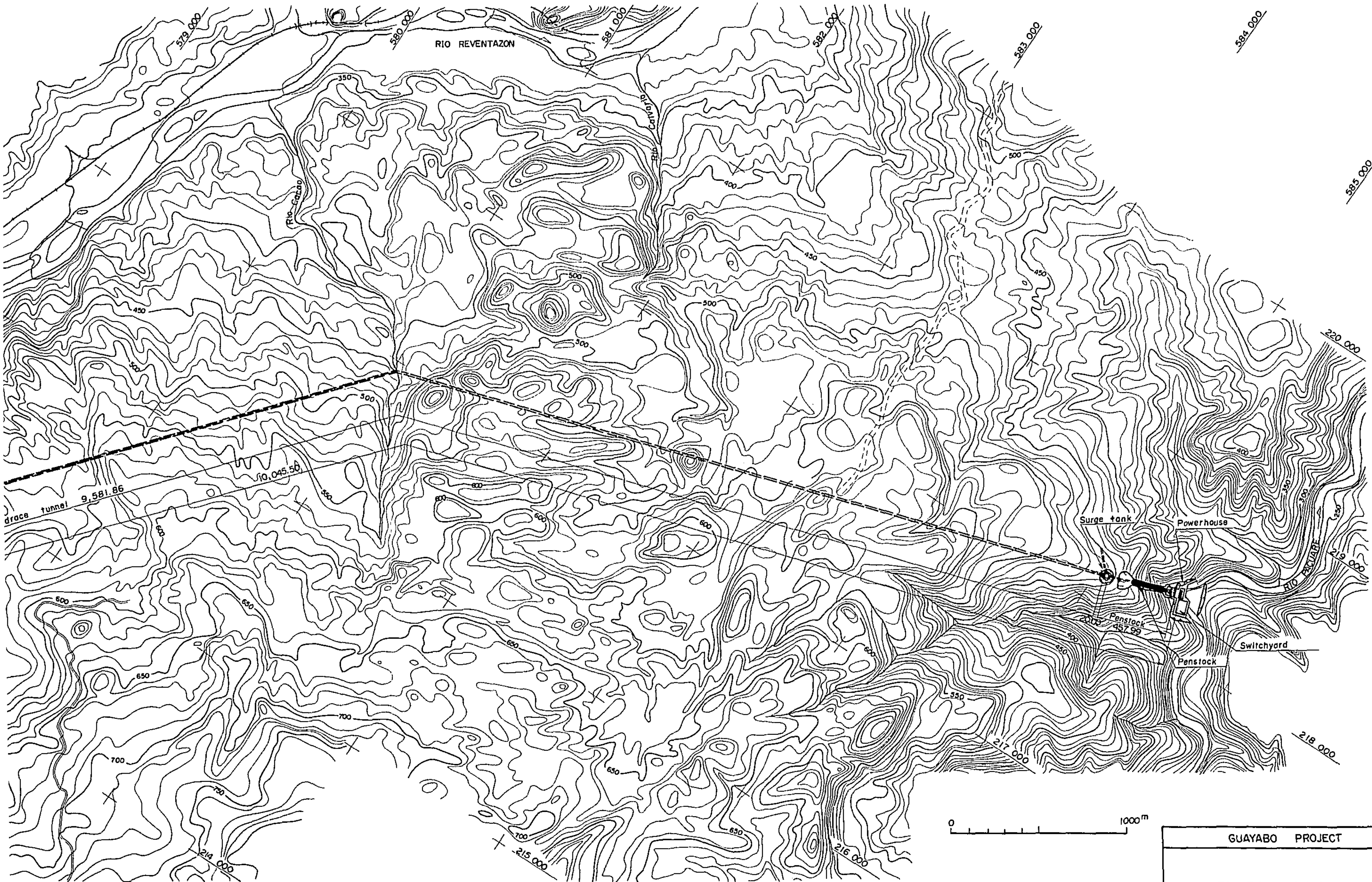
Designation	Item	Specification	
Civil Works			
Dam	Type	Combined dam	
		Concrete gravity;	Gravel-fill
	Height	38m	33m
	Length, crest	175m	480m
	Width, crest	9m	9m
	Volume	198,000m^3	564,000m^3
	Slope, Upstream	Vertical	1 : 3.50
	Slope, Downstream	1 : 0.90	1 : 3.00

Designation	Item	Specification
Spillway	Type	Overflow
	Capacity	8,600 m^3/sec (design flood)
	Overflow crest	Elevation 415.0 m
	Gate, type	Roller gate
	Dimension	13.0 x 15.0 m
	Number of gates	6
Outlet	Type	Sediment Control Outlet
	Type of gate	Tainter gate, Roller gate
	Number of gates	2 , 2
	Sill	Elevation 402.5 m
Intake	Type	Reinforced concrete
	Sill	Elevation 417 m
	Type of gate	Roller gate
	Dimension	6.0 x 8.0 m
	Number of gates	1
Headrace tunnel	Type	Circular-shaped pressure tunnel
	Number of tunnel	1
	Dimension	Inside diameter 6.5 m Length 9,581.86 m
Surge Tank	Type	Orifice
	Number	1
	Dimension	Shaft: Inside diameter 10 m Height 40.0 m Upper chamber: Inside diameter 20.0 m Height 22.0 m Lower chamber: Inside diameter 6.5 m Length 50.0 m
Penstock	Type	On-the-ground
	Number of pipes	1 (Branched to 3 pipes near the power plant)
	Dimension	Main: Inside diameter 6.5 - 5.0 m Length 432 m No. 2 branched pipe: Inside diameter 2.7 m Length 26.0 m No. 1 and 3 branched pipe: Insidediameger 2.7 m Length 33.0 m

Designation	Item	Specification
Draft gate	Type	Reinforced
	Gate	Sluice
Power House	Type	On-the-ground
	Dimension	Length 62 m
		Width 28 m
		Height 32 m
	Base	Elevation 251.50 m
<u>Electrical Equipment</u>		
Turbine	Type	Vertical Francis
	Output	66,000 kw
	Standard effective head	155 m
	Revolving speed	300 rpm
	Number of units	3
Generator	Type	Vertical shaft
		3-phase
		Synchronous
	Capacity	78,000 kVA
	Voltage	13.8 kV
	Frequency	60 Hz
	Number of units	3
Main transformer	Type	3-phase
		Oil-immersed
		Air-cooled
	Capacity	78,000 kVA
	Voltage	13.8/230 kV
	Number of units	3
Transmission line	Total length	60 km
	Voltage	230 kV
	Number of circuits	2
	Size of conductors	Equivalent to 410 mm^2
	Support	Steel tower
Substation	Name	South Substation of San Jose
	Transformer	78,000 kVA
	Voltage	3 transformers
		230/34.5 kV
Telecommunication equipment	Telephone	2 ch.
	Carrier relay	2 ch.
	Fault locator	One system
	Level telemeter	One system



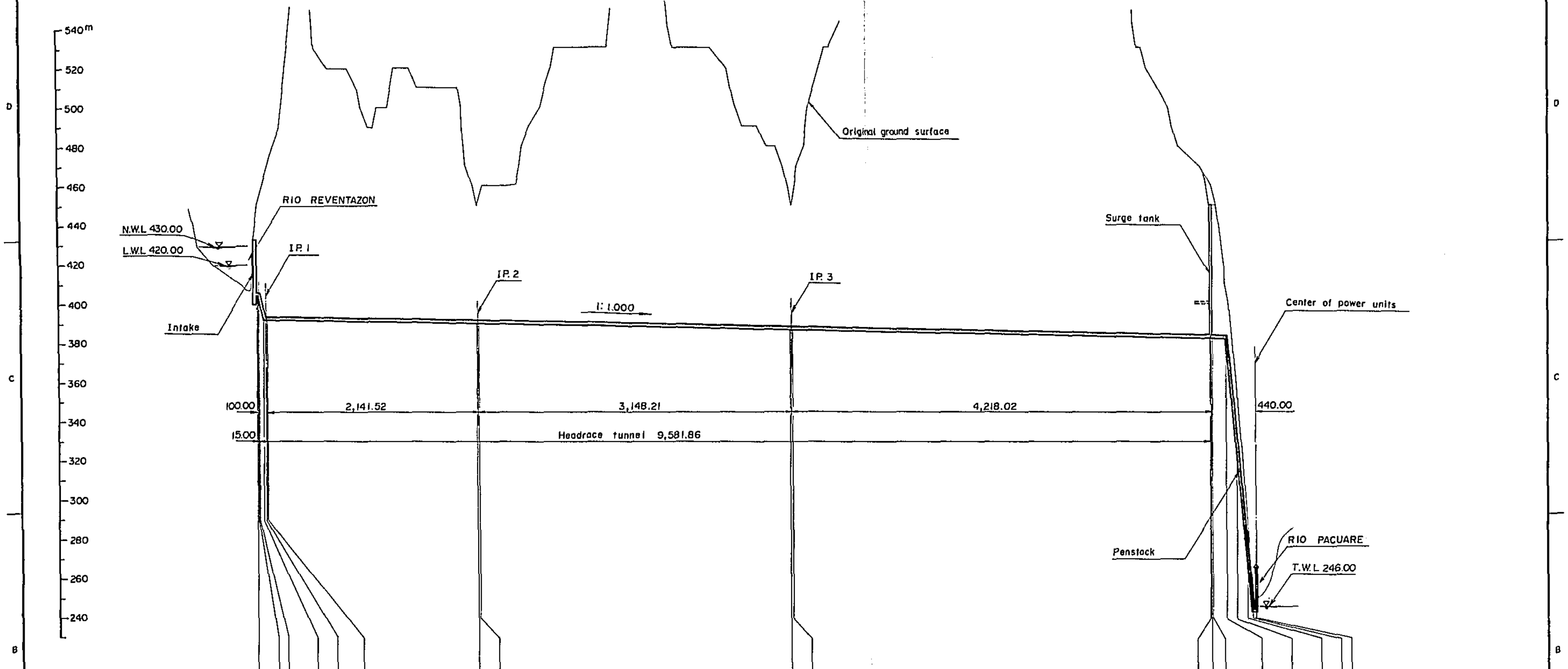
575 000
576 000
577 000
578 000
579 000
580 000
RIO REVEN
Existing Railway
Dam
Spillway
Intake
Guayabo Pondage
N.W.L+430.00
L.W.L+420.00
RIO REVENTAZON
Rio Jabillos
Rio Chitaria
Rio Gacso
Headrace tunnel 9,581.86
10,045.50
212 000
213 000
214 000



GUAYABO PROJECT

GENERAL PLAN

DWG. NO. II-6 | MARCH 1978



Station	Section Distance	Accumulative Distance	Original ground Lev.	Formation Level
0	0	0	441.00	405.25
1	15.00	15.00	452.00	405.25
I.P.A	5.00	20.00	455.00	405.25
I.P.B	50.00	70.00	464.00	393.18
BC.1	16.49	86.49	467.00	393.17
EC.1	25.38	111.87	470.00	393.14
BC2	2,122.01	2,233.88	450.00	391.02
EC2	11.85	2,245.73	450.00	391.01
BC3	3,133.52	5,379.25	450.00	387.88
EC3	16.92	5,396.17	450.00	387.86
2	4,199.33	9,595.50	455.00	383.66
3	10.00	9,605.50	455.00	383.65
4	10.00	9,615.50	455.00	383.64
I.P.C	140.00	9,755.50	390.00	383.50
5	105.85	9,861.35	338.00	326.97
6	105.85	9,967.20	284.00	270.44
I.P.D	52.30	10,019.50	252.00	242.50
7	26.00	10,045.50	244.00	242.50

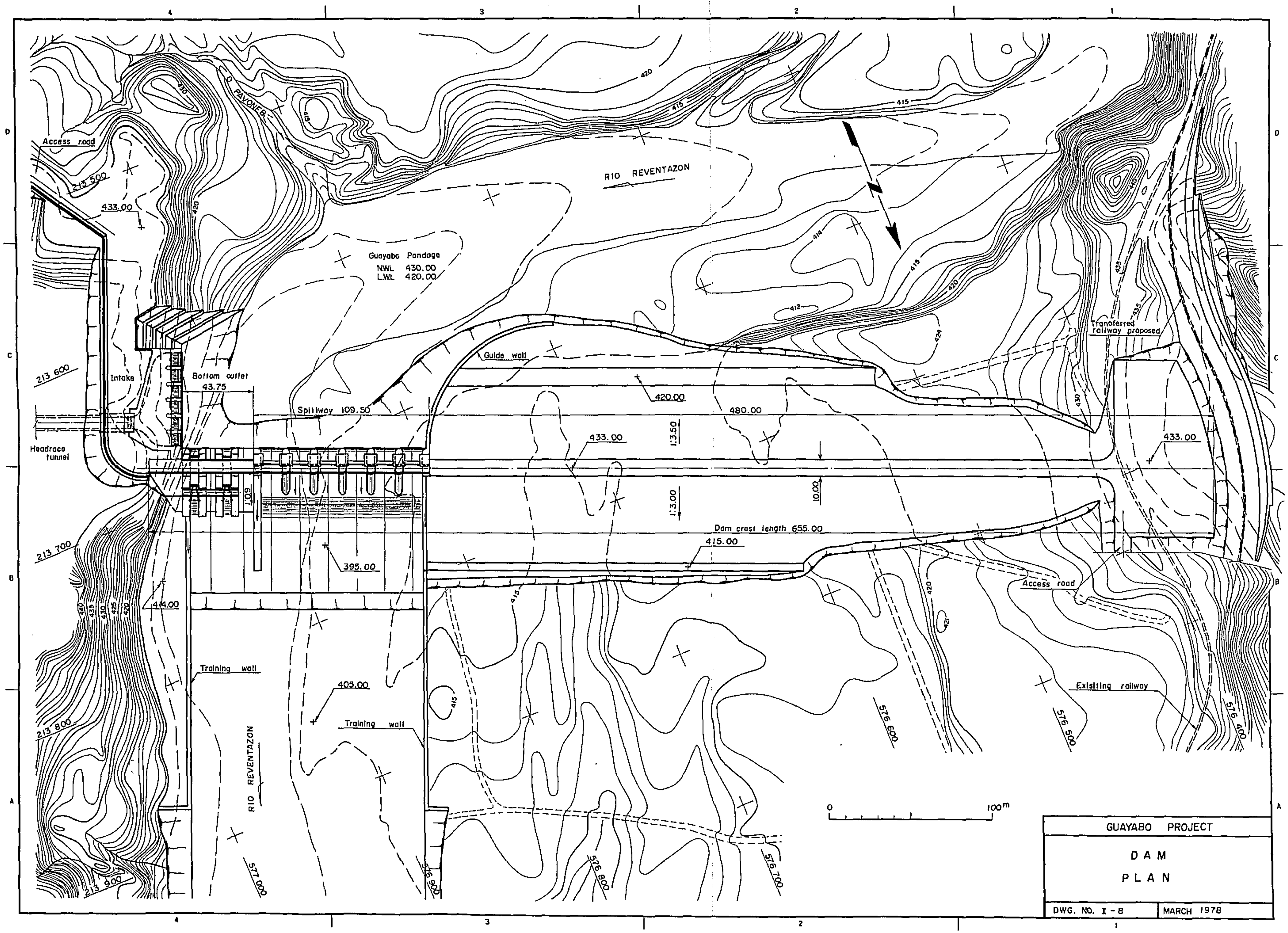
0 — 2,000m (Horizontal)

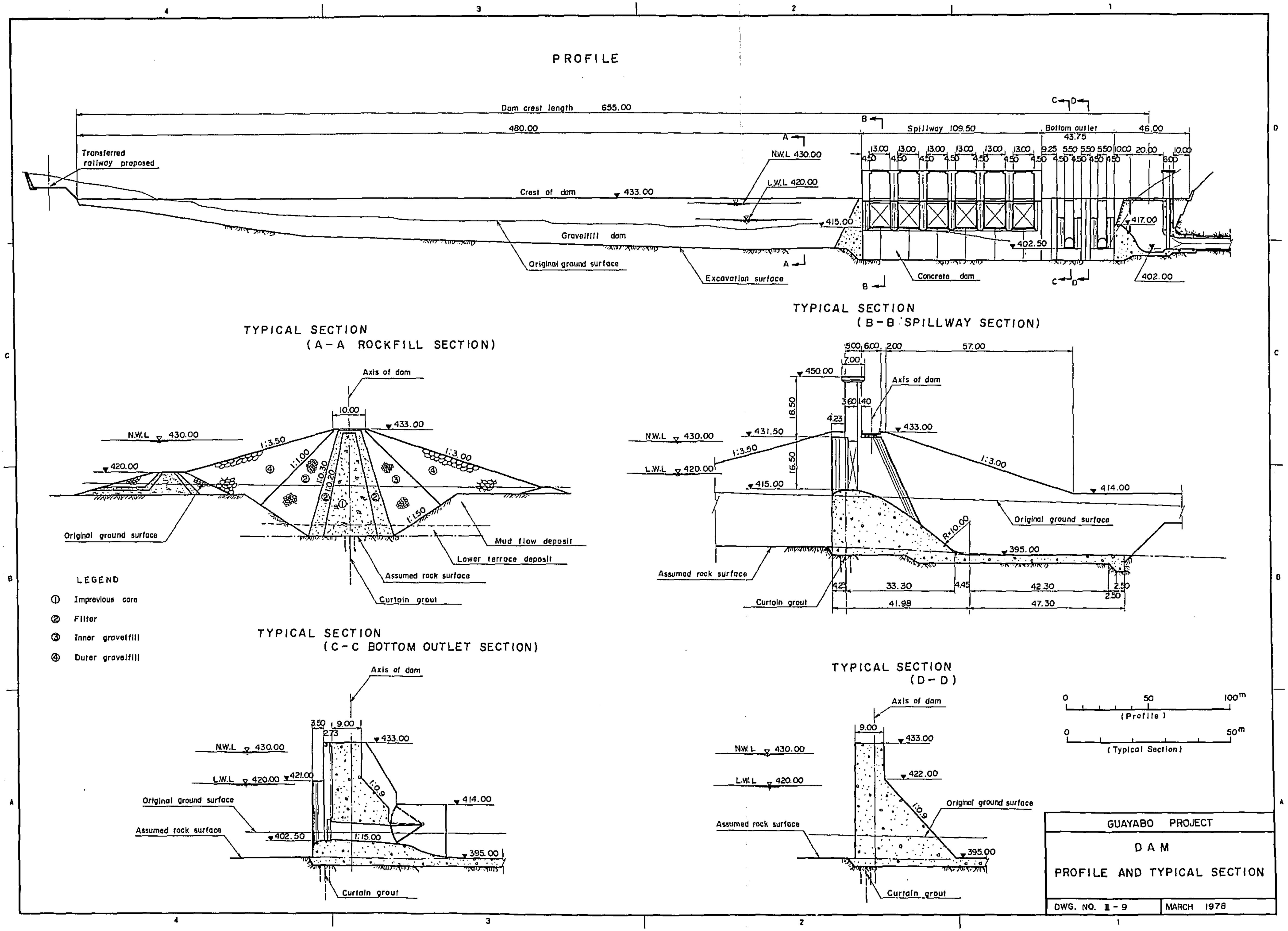
GUAYABO PROJECT

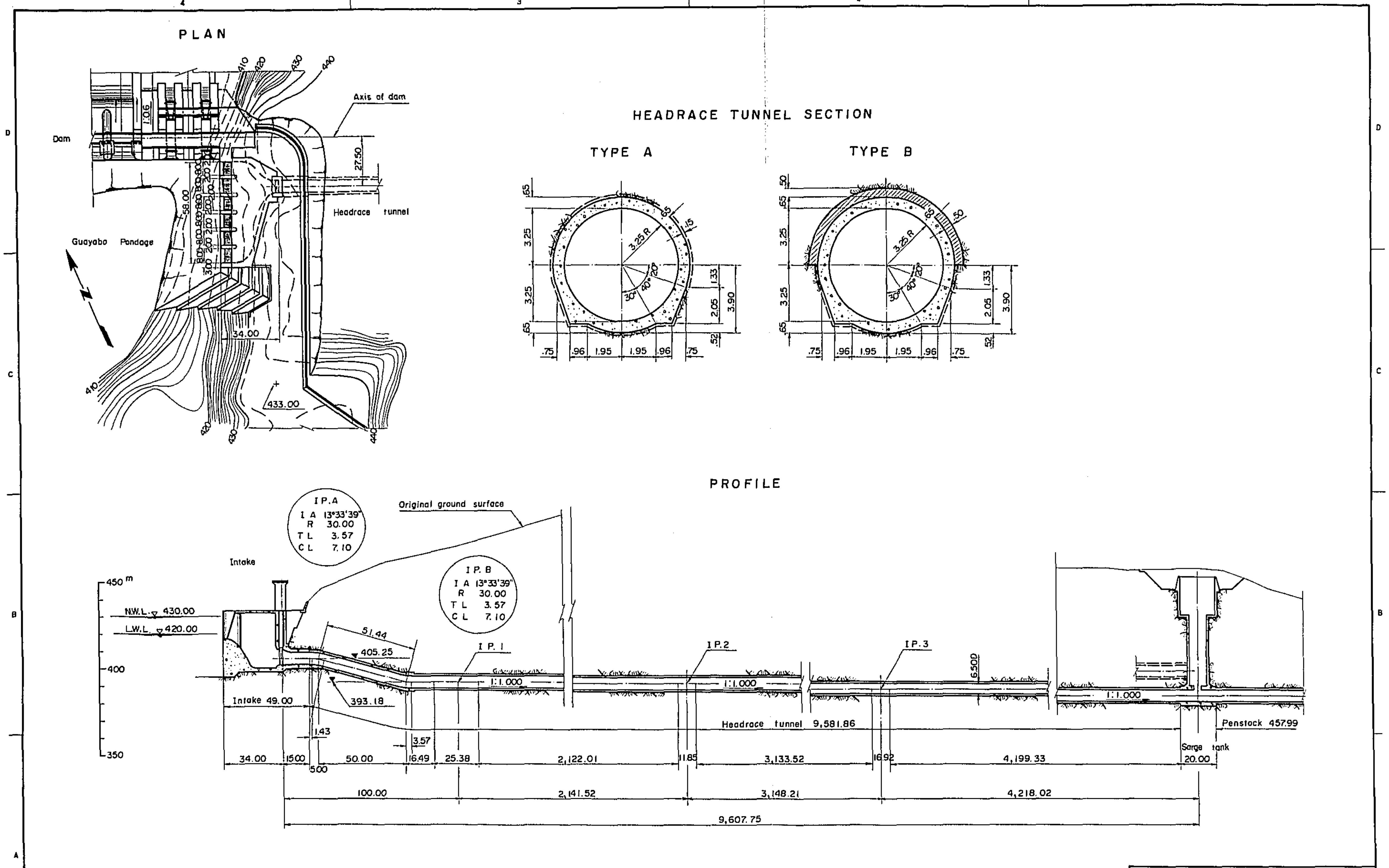
WATER CONDUCTOR

LONGITUDINAL PROFILE

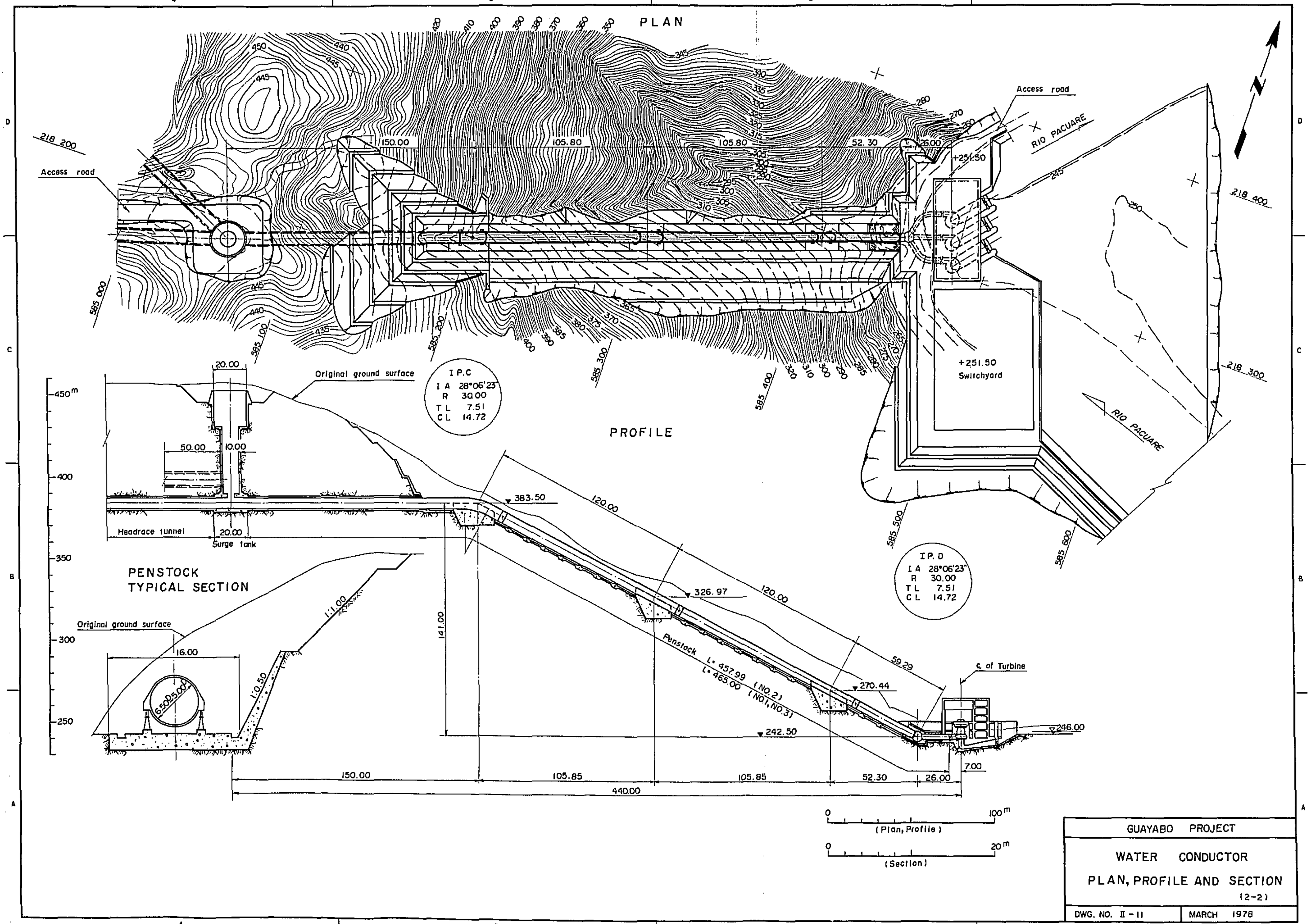
DWG. NO. II - 7 | MARCH 1978

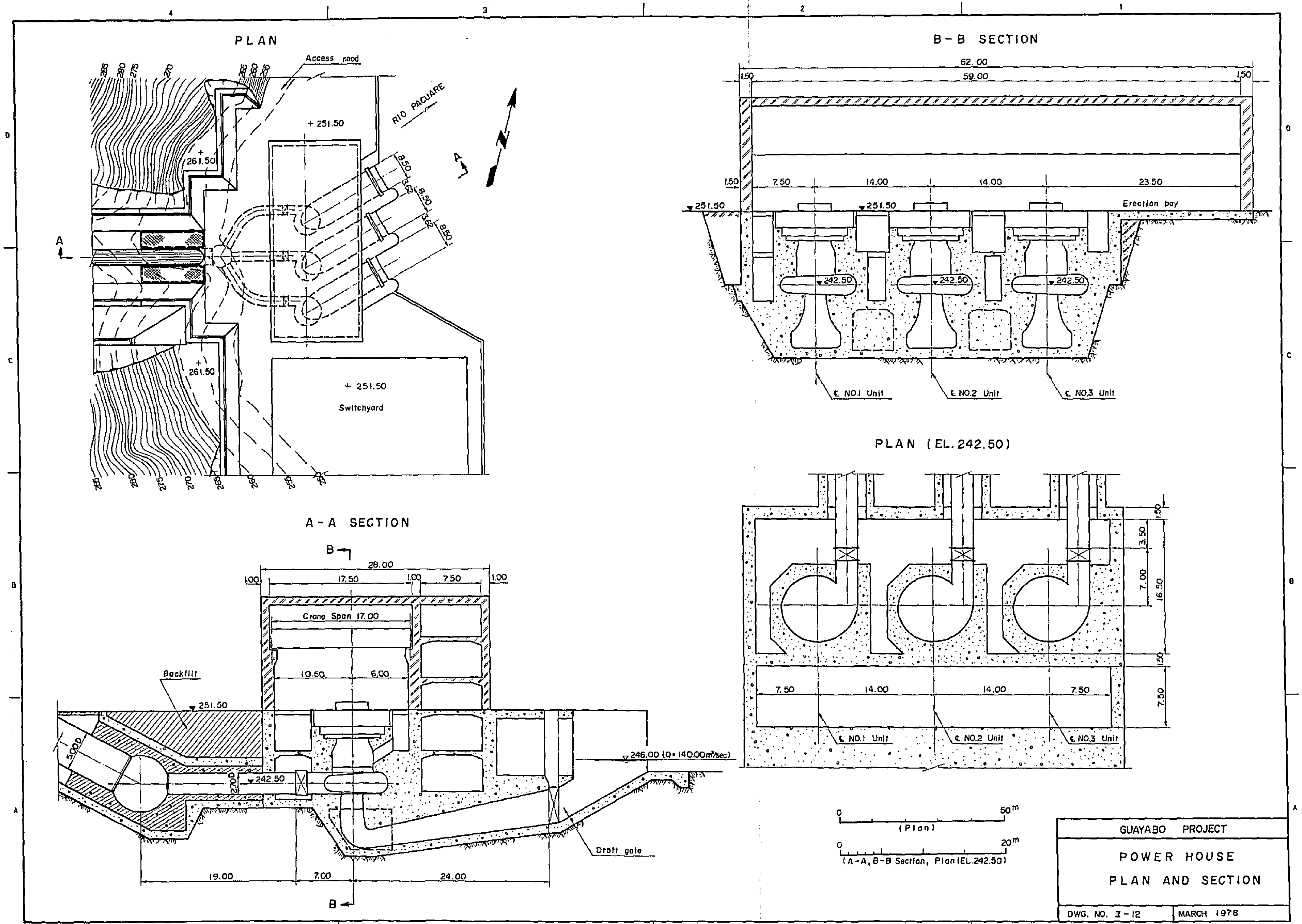

Access road
213 500
433.00
RIO REVENTAZON
Guayabo Pondage
NWL 430.00
LWL 420.00
Guide wall
Intake
Bottom outlet
43.75
Spillway 109.50
420.00
480.00
433.00
1:3.50
Headrace tunnel
1:3.00
10.00
Dam crest length 655.00
415.00
395.00
Access road
Transferred railway proposed
213 600
213 700
213 800
213 900
414.00
Training wall
405.00
Training wall
RIO REVENTAZON
Existing railway
576 600
576 500
576 400
577 000
576 900
576 800
576 700
0
100m
GUAYABO PROJECT
DAM
PLAN
DWG. NO. II - 8
MARCH 1978


PROFILE
Dam crest length 655.00
480.00
Spillway 109.50
Bottom outlet 43.75
46.00
Transferred railway proposed
N.W.L 430.00
L.W.L 420.00
Crest of dam ▼433.00
Gravelfill dam
Original ground surface
Excavation surface
Concrete dam
▼415.00
▼402.50
▼417.00
402.00
TYPICAL SECTION (A-A ROCKFILL SECTION)
Axis of dam
10.00
▼433.00
N.W.L ▼430.00
▼420.00
1:3.50
1:3.00
1:1.00
1:0.30
1:0.20
1:1.50
Original ground surface
Mud flow deposit
Lower terrace deposit
Assumed rock surface
Curtain grout
LEGEND
① Impervious core
② Filter
③ Inner gravelfill
④ Outer gravelfill
TYPICAL SECTION (B-B SPILLWAY SECTION)
57.00
▼450.00
Axis of dam
18.50
16.50
4.23
▼433.00
N.W.L ▼430.00
▼431.50
L.W.L ▼420.00
▼415.00
1:3.50
1:3.00
▼414.00
Original ground surface
R=10.00
▼395.00
Assumed rock surface
Curtain grout
33.30
42.30
41.98
47.30
TYPICAL SECTION (C-C BOTTOM OUTLET SECTION)
Axis of dam
9.00
▼433.00
N.W.L ▼430.00
L.W.L ▼420.00
▼421.00
▼414.00
1:0.9
Original ground surface
Assumed rock surface
▼402.50
1:15.00
▼395.00
Curtain grout
TYPICAL SECTION (D-D)
Axis of dam
9.00
▼433.00
N.W.L ▼430.00
▼422.00
L.W.L ▼420.00
1:0.9
Original ground surface
Assumed rock surface
▼395.00
Curtain grout
0 50 100m (Profile)
0 50m (Typical Section)
GUAYABO PROJECT
DAM
PROFILE AND TYPICAL SECTION
DWG. NO. II-9
MARCH 1978



GUAYABO PROJECT	
WATER CONDUCTOR PLAN, PROFILE AND SECTION (2-1)	
DWG. NO. II-10	MARCH 1978


PLAN
PROFILE
PENSTOCK TYPICAL SECTION
Access road
Access road
RIO PACUARE
RIO PACUARE
+251.50
+251.50 Switchyard
Original ground surface
Original ground surface
Headrace tunnel
Surge tank
Penstock L = 457.99 (NO.2)
L = 465.00 (NO1, NO.3)
℄ of Turbine
I P.C
I A 28°06'23"
R 30.00
T L 7.51
C L 14.72
I P. D
I A 28°06'23"
R 30.00
T L 7.51
C L 14.72
383.50
326.97
270.44
242.50
246.00
150.00
105.85
105.85
52.30
26.00
440.00
(Plan, Profile)
(Section)
GUAYABO PROJECT
WATER CONDUCTOR
PLAN, PROFILE AND SECTION
(2-2)
DWG. NO. II - 11
MARCH 1978



PLAN
Access road
RIO PACUARE
+ 251.50
+ 261.50
+ 251.50
Switchyard
A
B-B SECTION
62.00
59.00
1.50
7.50
14.00
14.00
23.50
251.50
Erection bay
242.50
℄ NO.1 Unit
℄ NO.2 Unit
℄ NO.3 Unit
PLAN (EL. 242.50)
7.50
14.00
14.00
7.50
3.50
7.00
16.50
7.50
A-A SECTION
28.00
17.50
7.50
1.00
Crane Span 17.00
10.50
6.00
Backfill
251.50
5.00
2.70
242.50
246.00 (Q = 140.00m³/sec)
Draft gate
19.00
7.00
24.00
B
0
50m
(Plan)
20m
(A-A, B-B Section, Plan (EL.242.50))
GUAYABO PROJECT
POWER HOUSE
PLAN AND SECTION
DWG. NO. II - 12
MARCH 1978

6.2 PROGRAMME AND PLAN OF CONSTRUCTION

6.2.1 Programme of Construction

A construction period of 57 months will be required to complete the Guayabo Project in view of the scale of the work layout of the structures to be built, local conditions and other factors.

The operation of Guayabo Power Plant should be commenced by February 1987 because of the electric power supply and demand situation. In view of the required construction period, the work should be started by May 1982. The construction programme is shown in Fig. II-6-9. Its outline is as follows.

(1) First year (1982)

Various preparatory works will be started necessary for starting the construction and excavation of the headrace tunnel.

(2) Second year (1983)

Excavation for widening the width of the existing river bed will be started as the first stage for care of river necessary for the fill dam construction. The training wall for the spillway on the left will be placed. Excavation for the dam foundation, grouting for the foundation and embankment dam will also be carried out to complete.

Excavation for the headrace tunnel will be continued. Concrete lining of tunnel and excavation of the surge tank will be started.

(3) Third year (1984)

For the second stage of care of river needed for construction of the concrete gravity dam, a coffering of the sediment control outlet and intake sections will be carried out, followed by excavation of river-bed within the cofferdam. The foundation grouting, concrete placing for the dam, and installation of the sediment control gates and the intake gate will be made to complete.

As for tunnel and power plant works, excavation and concrete placing will be commenced on rocks for the penstock, power plant, tailrace and the outdoor switchyard.

(4) Fourth year (1985)

For the third stage of care of river for construction of the remained part of concrete gravity dam, coffering of the spillway section will be carried out, followed by excavation of river-bed within the cofferdam. The foundation grouting, and concrete placing for the dam will be made to finish.

The excavation and concrete lining of the headrace tunnel, which will have been progressing in the previous years, will be completed, followed by placing of the invert concrete. Also, mortar and cement grouting for the headrace tunnel will be carried out at the same time. On the other hand, the work will start for installation of the penstock and electrical equipments.

(5) Fifth year (1986)

The remaining engineering work and installation of hydraulic equipments will be completed. All other works will be completed such as the installation of electrical equipments, transmission lines, substations which are necessary for starting the operation of the power plant.

(6) Sixth year (1978)

Operational tests will be conducted from December of the preceding year, and the power plant will be ready to operate commercially in February.

6.2.2 Plan of Construction

(1) Local conditions

(a) The site of the Guayabo Project is located at a point about 60 km east northeast of the capital city of San Jose and is convenient for carrying out construction work. Moreover, 80 km to the east of the construction site is the port of Limon, facing the Atlantic, and 180 km to its west is the port of Puntarenas on the Pacific. The two ports are expected to serve as the ports for unloading imported supplies, machinery and equipment for the Guayabo Project.
The ports are equipped with facilities capable of unloading heavy supplies. Roads leading to the construction site are maintained adequately.

(b) Electric power for construction
Power required for carrying out the Guayabo Project is estimated at about 6,000 kw. To satisfy this requirement, a substation will be constructed in an area close to the headrace tunnel located about 20 km from existing Siquirres Substation. These two substations will be connected by a 34.5 kV transmission line. From the new substation, power will be supplied by means of 34.5/6.6 kV transmission lines to the scattered construction sites, such as dam, adits for headrace tunnel, and power plant. The total length of the line is estimated at 12 km.

(c) Water Supply
Water from the Reventazon river and the Pacuare river will be used for construction and drinking purposes.

(2) Procurement of construction materials

It is estimated that 145,000 tons of cement, 14,500 tons of reinforcing bar, 4,800 tons of steel materials, 600 tons of explosives and about 2,100 kl of oil, including light oil, gasoline and heavy oil, will be needed as the principal supplies for the construction. All these supplies, except cement, will be imported from foreign countries.

Aggregates for manufacturing concrete will be obtained from construction sites near the rivers of Reventazon and Pacuare. Transition materials and shell materials for the fill dam will be collected from points close to the dam on the

Reventazon river. Impermeable materials could be obtained from a point about 700 m above sea-level on the right bank of the dam. Further detailed study is needed on the concrete aggregate and fill-dam materials.

(3) Construction of Main Structures

(a) Care of River:

As for the flood discharge at the Guayabo Dam site, the largest recorded flow is 4,200 m^3/sec and the probable five-year flood, 1,600 m^3/sec. The following three methods can be considered for care of the river at Guayabo Dam site.

(i) A conventional diversion tunnel
(ii) A diversion channel made by excavating through the hill of coffee plantation where the fill-dam will be built.
(iii) Cofferring half of the river

The first method (i), which calls for a diversion tunnel is obviously disadvantageous from the economic standpoint, inasmuch as the design flood of 4,200 m^3/sec for the fill dam is extremely high. The second method, calling for providing a channel, will greatly restrict the work schedule for the following reasons:

- The channel would require a large amount of excavation into the hill.
- The work to fill up the dam on the channel would be carried out at a time of the final stage of the project, and this would restrict the construction programme.

Consequently, method (ii) is not only economical but also restrictive compared to method (iii). On the other hand, method (iii) affords the execution of stream diversion quite freely for constructing the various structures and has economic advantage over (i) and (ii).
Thus, the Guayabo Dam Construction will be carried out in three stages.

(b) Construction of Dam

(i) 1st stage

As for the first stage of care of the river, the width of the river-bed will be expanded by excavating the nearest land to the river on the left bank. The main work entails excavation and concrete placing for the construction of a training wall of the spillway on the left bank. In parallel with the training wall construction a coffer dam will be built in the upstream foot of fill-dam.
After completion of embankment of the coffer dam, the excavation of the fill-dam will be continually carried out, followed by its foundation grouting and embankment works. The elevation of top of coffer dam will be 420.0 m by considering the highest recorded flood discharge of the past.

(ii) 2nd stage

As the second stage of care of the river, the river flow will be diverted by building a coffer dam between the intake and the sediment control outlet. This will cause the stream to flow down through the spillway which will be constructed next year. After completion of the coffer dam, excavations, foundation groutings and concrete placing will be carried out on the intake structures and the sediment control outlet.

After completion of the concrete works, gates will be installed to the intake and the sediment control outlet.

A probable flood of 5-year 1,600 m^3/sec could be adopted as a reference for planning the work in this stage.

(iii) 3rd stage

As the third stage of care of the river, the river flow will be diverted from the spillway section to the sediment control outlet section by building a cofferdam surrounding the spillway section. Excavation, foundation grouting, and concrete placing for the spillway section will follow.

After the completion of the concrete work, installation of the dam bridges, spillway gates, hoisting bridges, etc. will be carried out.

The capacity of the sediment control outlet will be 800 m^3/sec when the water level is 420.0 above sea-level.

In carrying out the dam construction, it will be necessary to relocate beforehand the railway on the left bank of Guayabo Dam site towards the hill.

Following are the required dam volumes for the project.

Fill-dam 564,000 m^3

(Impermeable soil material 93,000 m^3)
(Filter material 67,000 m^3)
(Shell material 404,000 m^3)

Gravity dam 198,000 m^3

(c) Construction of headrace tunnel

The headrace tunnel will be a pressure tunnel with an inside diameter of 6.5 m and total length of about 9,600 m. The construction will be carried out by dividing the tunnel into four sections with adits for works, that four adits are shown in Fig. II-6-11.

Adit No.3 and No.4 will be used for the longest section of tunnel, which covers a distance of about 4.5 km.

The sections of headrace tunnel will have two types of shape, Type A and Type B, shown in DWG. No. II-10. Type A will cover 70 per cent of the tunnel and, Type B the remaining 30 per cent. Either an excavation of full or upper-half sectional area could be adopted for the excavation of the tunnel, but it would depend on the actual geological conditions found during excavation.

Supports for protection will be placed in the entire length of the tunnel. Concrete lining of the headrace tunnel will be carried out in parallel with the progress of tunnel excavation.
After the concrete lining, concrete placing for invert, mortar and high-pressure grouting, etc. will be carried out successively.

(d) Construction of Other structures

(i) Surge tank
After excavating the pilot shaft, it will be successively enlarged downward to the prescribed sectional area. After the excavation for enlargement, concrete lining will be carried out.

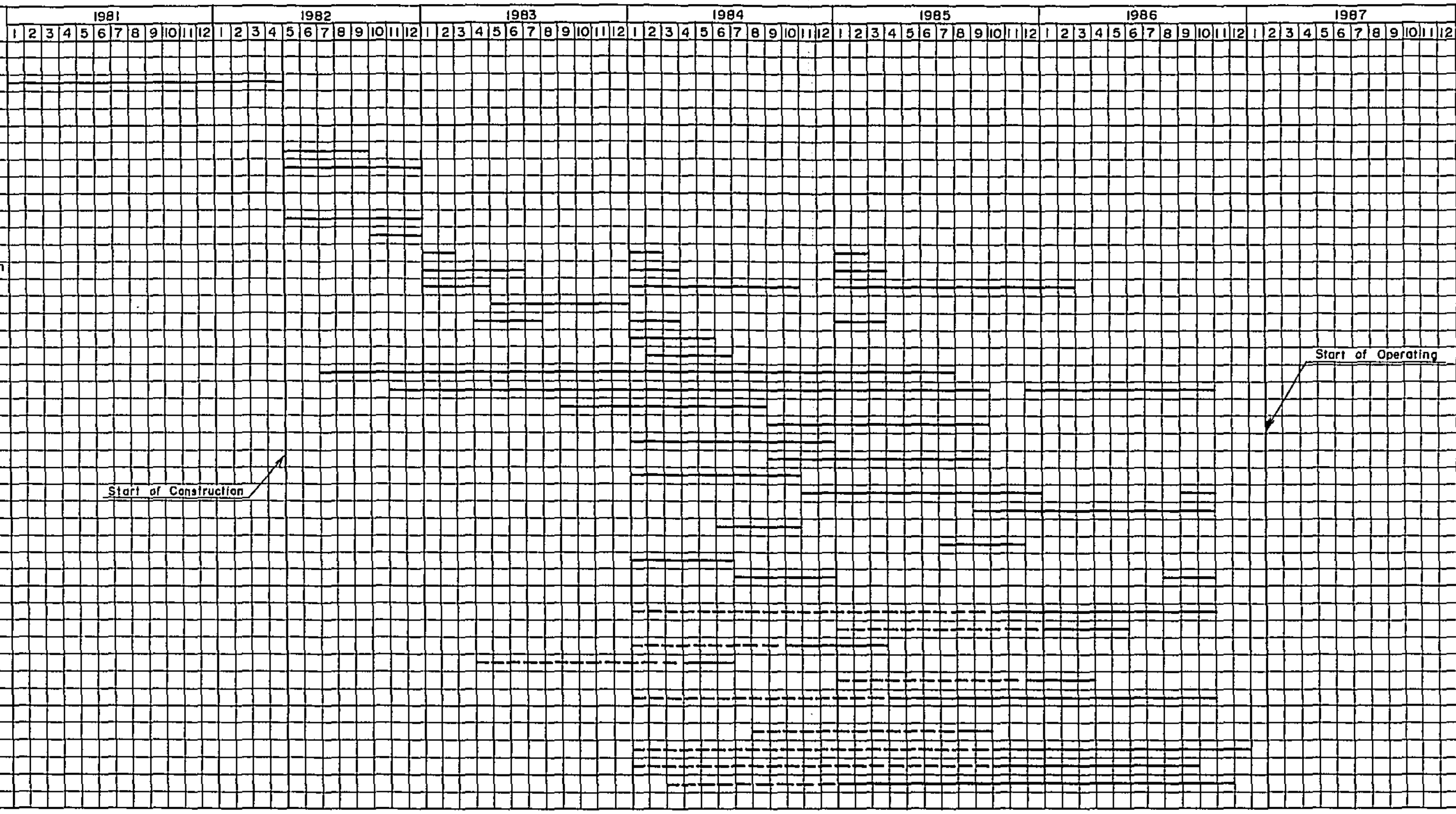
(ii) Penstock
Penstock will be put in place after excavating the foundation, placing concrete and anchor blocks.

(iii) Power station
Protruding land will be excavated for diversion of the river, followed by reclamation of a foundation for the power plant in the river bed. Concrete placing for the foundation will be carried out to construct the power plant.

(iv) Outdoor switchyard
It will be constructed next to the power station. Same as the case of the power station, the site required for the switchyard will be prepared by excavating a portion of the hill-side after the river flow will have been altered.
Since the slope of excavated hill will be steep, consideration will be given to the retaining wall and mortar spray with grass seeds to protect it from sliding.

Fig. II-6-9 Construction Schedule

Works	Quantity	Remarks
(I) Preparation of contract document and Letting contract		
Civil works		
(II) Preparation works		
Camp facility		
Access road	5 km	
(III) Civil works		
Construction facilities		
Clearing		
River diversion		
Dam (Excavation)	554 000m	
(Concrete)	198 000	
(Embankment)	564 000	
(Grouting)		
Intake (Excavation)	191 000	
(Concrete)	25 900	
Headrace tunnel (Excavation)	518 000	
(Concrete)	197 000	
Surgetank (Excavation)	39 100	
(Concrete)	7 100	
Penstock (Excavation)	80 000	
(Concrete)	35 500	
Powerhouse (Excavation)	25 000	
(Concrete)	22 500	
(Superstructure)		
Tailrace (Excavation)	68 000	
(Concrete)	2 800	
Switchyard (Excavation)	62 000	
(Concrete)	10 000	
(IV) Hydraulic equipment		
Spillway gate	6	
Road bridge	6	
Bottom outlet gate	4	
Intake gate	1	
Draft gate	3	
Penstock		
(V) Electrical equipment		
Crane		
Turbine & Generator		
Other equipment		
(VI) Transmission line		

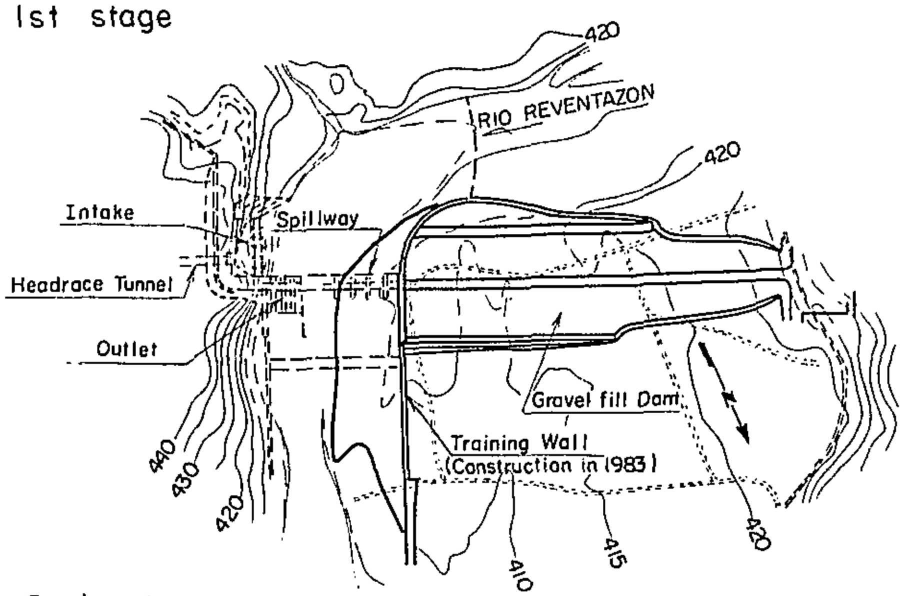


Note ——— Construction and installation works

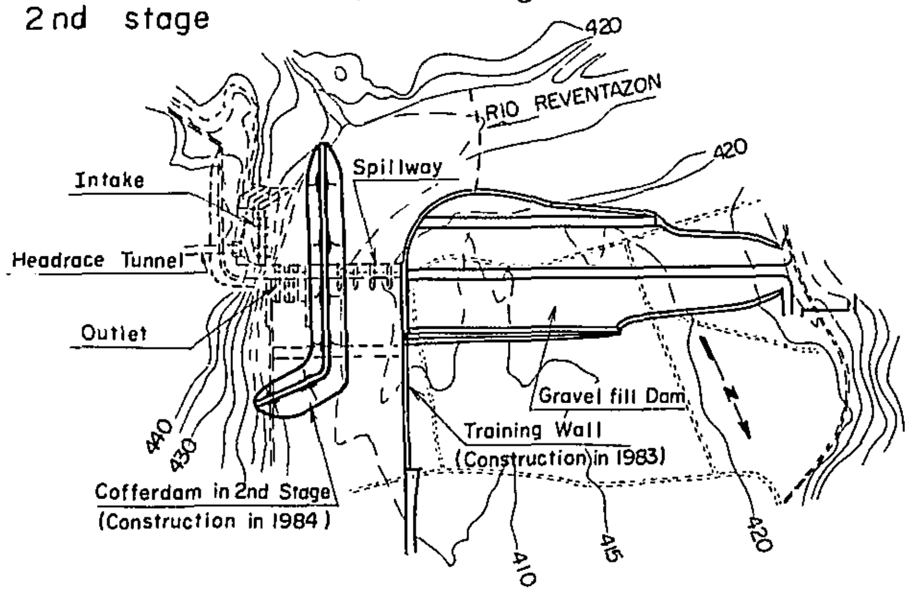
– – – – Manufacturing , ocean freight and inland transportation

Fig. II-6-10 Diversion Scheme

(1) In 1st stage



(2) In 2nd stage



(3) In 3rd stage

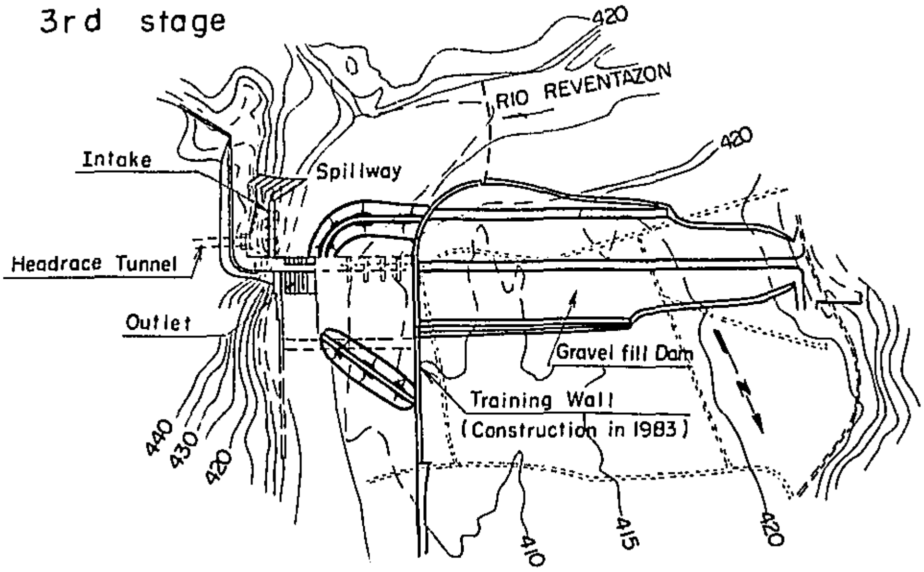


Fig. II-6-11 Location of Adits for Headrace Tunnel

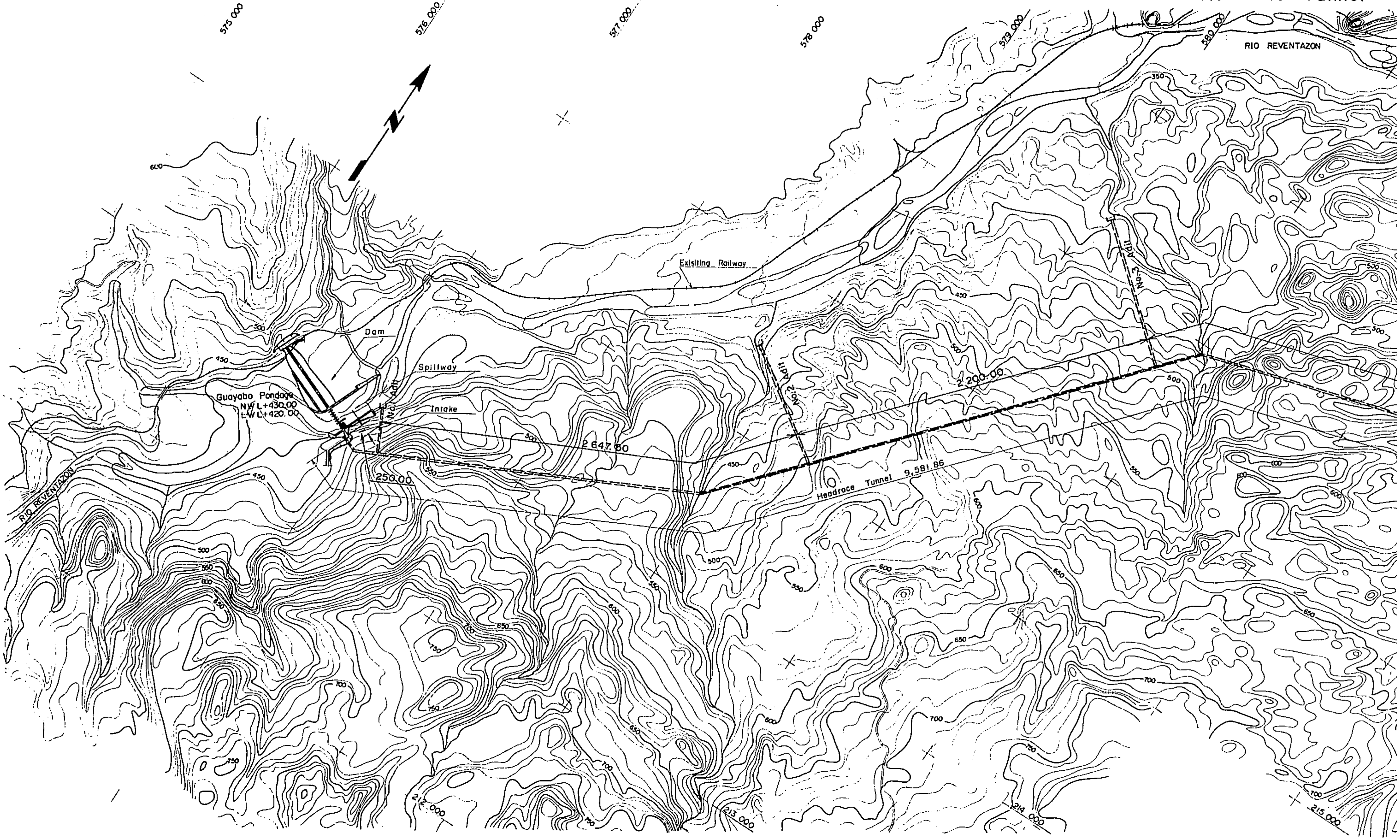
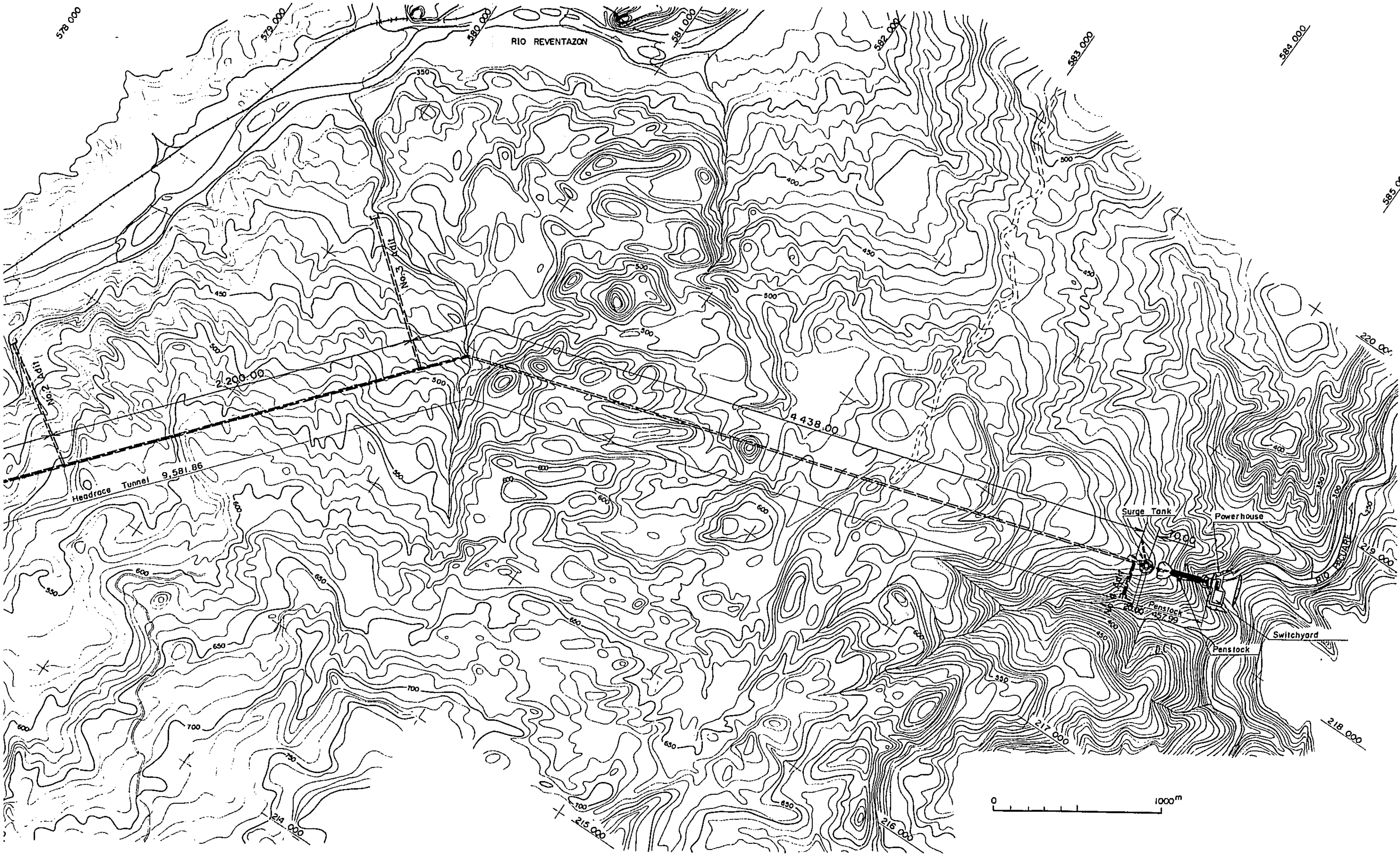


Fig. II-6-11 Location of Adits for Headrace Tunnel



CHAPTER 7

CONSTRUCTION COST

CHAPTER 7 CONSTRUCTION COST

LIST OF TABLES

CHAPTER 7 CONSTRUCTION COST

7.1 BASIC CONDITIONS

In estimating the construction cost of Guayabo Project, consideration will be given to the natural conditions, local conditions, construction-scale, and technological levels expected at present on the project site. Commodity-prices will be based on those of 1977.

(1) Scope of construction cost estimate

The scope of construction cost estimate covers the dam, head-race tunnel, power plant and transmission lines and substations from the power plant to South Substation of San Jose.

The construction cost also includes the costs of preparatory works, engineering, administration, compensation and interest during construction.

(2) Cost of civil works

a) Quantities of works are estimated on the basis of designs in Chapter 6 "Preliminary Design".
b) Unit-price for work will be estimated in consideration of recent real cost in the works constructed or under construction in Costa Rica in addition to the local conditions of Project site.

(3) Cost of equipment

Cost estimates will be made on all the hydraulic and electrical equipments, transmission lines, and substation facilities as well as communication-instruments which will be supplied by foreign manufacturers. The cost includes transportation charge by sea, insurance, unloading and inland-transportation costs, as well as installation cost at the site.

(4) Contingencies

Contingency allowance of 15% will be included as a separate item in each project facility except head-race tunnel work for which it will be 20%.

(5) Engineering fee

It will be 5% of direct construction cost of Project as a result of discussion with ICE.

(6) Administration Cost

It will be 5% of direct construction cost of Project as a result of discussion with ICE.

(7) Compensation cost

The cost includes land-aguisition cost, and replacing cost for a part of the railway etc.

(8) Interest during construction

It will be 8% annualy for foreign currency and 12% annualy for domestic currency required for Project.

(9) Division of cost into Domestic and Foreign Currencies
Construction cost will be divided into domestic and foreign currencies.

Domestic currency includes labourer's wages, parts of salaries for foreign labourers, such materials as cement which will be purchased in Costa Rica, and transportation charges of imported equipments and local materials to be obtainable in Costa Rica. Remainder of cost minus domestic currency will mean foreign currencies. Conversion rate adopted for the division purpose is as follows: 8.6 Colones=1US dollar

7.2 SUMMARY OF CONSTRUCTION COST

The total construction cost for executing Guayabo Project will be 2,130 million Colones, in which foreign currencies are 1,200 million and domestic or local currencies are 870 million Colones.

In the total construction cost, the cost for generating facilities is 1,980 million Colones, in which foreign currency is 1,157 million Colones and domestic or local currency is 823 million Colones. The cost for transmission line and substation are 150 million Colones in which foreign currency is 103 million and local currency is 47 million Colones.

Table II-7-1 shows the summary of estimated construction cost. Table II-7-2 shows the necessary funds during construction classified by each year.

Table II-7-1 Summary of Estimated Construction Cost

(Unit: 10^3 Colones)

Item	Total Cost	Foreign Currency	Local Currency
1. Generating Facility			
1.1 Civil Works	(1027,000)	(541,200)	(485,800)
(1) Care of River & Diversion	14,500	5,800	8,700
(2) Dam	187,000	121,500	65,500
(3) Intake	28,000	11,200	16,800
(4) Headrace Tunnel	518,800	259,400	259,400
(5) Surge Tank	23,900	12,000	11,900
(6) Penstock Foundation	29,300	11,700	17,600
(7) Powerhouse Building	38,800	21,300	17,500
(8) Switch Yard	12,800	7,000	5,800
(9) Miscellaneous	17,100	9,400	7,700
(10) Contingencies	156,800	81,900	74,900
1.2 Hydraulic Equipment	(146,100)	(131,300)	(14,800)
(1) Gate	41,400	41,400	0
(2) Penstock	39,700	39,700	0
(3) Miscellaneous	14,000	14,000	0
(4) Installation Cost	32,000	19,200	12,800
(5) Contingencies	19,000	17,000	2,000
1.3 Electrical Equipment	(264,000)	(222,100)	(41,900)
(1) Turbine	73,500	73,500	0
(2) Generator	67,700	67,700	0

Item	Total Cost	Foreign Currency	Local Currency
(3) Transformer	17,400	17,400	0
(4) Miscellaneous	34,500	34,500	0
(5) Installation Cost	36,500	0	36,500
(6) Contingencies	34,400	29,000	5,400
2. Preparation Work	(69,000)	(27,900)	(41,100)
2.1 Access Road	25,000	7,500	17,500
2.2 Electrical Equipment for Construction	20,000	18,000	2,000
2.3 Surveying	24,000	2,400	21,600
3. Engineering Fee (Foreign Expert's Fee)	(75,000)	(75,000)	(0)
4. Administration Cost	(75,000)	(0)	(75,000)
5. Compensation	(6,000)	(0)	(6,000)
6. Interest during Construction	(317,900)	(159,500)	(158,400)
Total	1980,000	1157,000	823,000
7. Transmission Line			
(1) Transmission Line	67,100	43,700	23,400
(2) Substation	33,500	29,300	4,200
(3) Communication System	6,000	4,700	1,300
(4) Contingencies	16,000	11,600	4,400
(5) Engineering Fee (Foreign Expert's Fee)	6,100	6,100	0
(6) Administration Cost	6,100	0	6,100
(7) Compensation	3,000	0	3,000
(8) Interest during Construction	12,200	7,600	4,600
Total	150,000	103,000	47,000
Grand Total	2130,000	1260,000	870,000

Table II-7-2 Fund Requirement in Each Year

(Unit: 10^6 Colones)

	Total Fund Requirement			1982			1983			1984			1985			1986			1987		
	Total	F.C.	L.C	Total	F.C	L.C	Total	F.C	L.C	Total	F.C.	L.C	Total	F.C	L.C	Total	F.C	L.C	Total	F.C	L.C
(1) Generating Facilities																					
Preparation Works	69.0	27.9	41.1	62.0	25.0	37.0	7.0	2.9	4.1	-	-	-	-	-	-	-	-	-	-	-	-
Civil Works	1027.0	541.2	485.8	127.6	65.0	62.6	142.7	77.6	65.3	211.5	112.0	99.5	220.8	121.0	99.8	147.3	73.3	74.0	176.9	92.3	84.6
Hydraulic Equipment	146.1	131.3	14.8	-	-	-	1.6	1.6	-	16.2	14.6	1.6	52.7	47.4	5.3	61.0	54.6	6.4	14.6	13.1	1.5
Electrical Equipment	264.0	222.1	41.8	-	-	-	22.2	22.2	-	-	-	-	177.7	177.7	-	37.7	-	37.7	26.4	22.2	4.2
Compensation	6.0	0	6.0	4.5	-	4.5	0.5	-	0.5	0.5	-	0.5	0.3	-	0.3	0.2	-	0.2	-	-	-
Sub-Total	1512.1	922.5	589.6	194.1	90.0	104.1	174.2	104.3	69.9	228.2	126.6	101.6	451.5	346.1	105.4	246.2	127.9	118.3	217.9	127.6	90.3
Engineering Fee (Foreign Expert's Fee)	75.0	75.0	0	37.5	37.5	-	7.5	7.5	-	7.5	7.5	-	7.5	7.5	-	7.5	7.5	-	7.5	7.5	-
Administration Cost	75.0	0	75.0	7.5	-	7.5	7.5	-	7.5	19.5	-	17.5	17.5	-	17.5	17.5	-	17.5	7.5	-	7.5
Interest During Construction	317.9	159.5	158.4	9.5	4.8	4.7	16.0	8.0	8.0	22.2	11.2	11.0	47.7	23.9	23.8	95.4	47.9	47.5	127.1	63.7	63.4
Total	1980.0	1157.0	823.0	248.6	132.3	116.3	205.2	119.8	85.4	275.4	145.3	130.1	524.2	377.5	146.7	366.6	183.3	183.3	360.0	198.8	161.2
(2) Transmission Line																					
Transmission Line	122.6	89.3	33.3							8.9	8.9	-	71.5	71.5	-	30.0	-	30.0	12.2	8.9	3.3
Compensation	3.0	0	3.0							-	-	-	3.0	-	3.0	-	-	-	-	-	-
Sub-Total	125.6	89.3	36.3							8.9	8.9	-	74.5	71.5	3.0	30.0	-	30.0	12.2	8.9	3.3
Engineering Fee (Foreign Experts Fee)	6.1	6.1	0							3.0	3.0	-	1.5	1.5	-	1.5	1.5	-	0.1	0.1	-
Administration Cost	6.1	0	6.1							-	-	-	2.0	-	2.0	3.0	-	3.0	1.1	-	1.1
Interest During Construction	12.2	7.6	4.6							1.3	0.8	0.5	2.1	1.2	0.9	3.8	2.5	1.3	5.0	3.1	1.9
Total	150.0	103.0	47.0							13.2	12.7	0.5	80.1	74.2	5.9	38.3	4.0	34.3	18.4	12.1	6.3
Grand Total	2130.0	1260.0	870.0	248.6	132.3	116.3	205.2	119.8	85.4	288.6	158.0	130.6	604.3	451.7	152.6	404.9	187.3	217.6	378.4	210.9	167.5

Note: L.C : Local Currency
F.C : Foreign Currency

CHAPTER 8

ECONOMIC EVALUATION

CHAPTER 8 ECONOMIC EVALUATION

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CHAPTER 8 ECONOMIC EVALUATION

8.1 MEANS OF ECONOMIC EVALUATION

The economic evaluation of an electric power project will be accomplished by a comparison of the subject project with an alternative power project that provides equivalent service of the subject project. The alternatives, which could be approved world-wide for a hydro-power project, would be such thermal power projects as oil, coal, nuclear power plants or geo-thermal plant among which a representative alternative could be selected. As a result of a preliminary study on the alternatives, an oil thermal power plant will be selected as the alternative project which could be operated at the lowest cost among them.

Consequently, the economic evaluation will be made by substituting the cost of the alternative thermal power plant into the benefit of Guayabo hydro plant, and the benefit cost ratio and surplus benefit will be determined as a judgement criterion of the economic evaluation for Guayabo Project.

8.2 ANNUAL COST

The investment cost of Guayabo Project will amount to 2,130 million Colones as described in "Construction Cost" in Chapter 7. The construction cost for items of the work are shown in Table II-8-1 with useful lives of facilities and equipments.

The annual cost will be calculated for a period of analysis 50 years, in an agreement with ICE, in the following conditions:

(1) Rate of interest: Foreign currency 8.0%, Domestic currency 12.0%

(2) Depreciation method: Sinking fund

(3) Maintenance and operation cost
Dam and pondage: 0.1% of the investment cost
Hydraulic Equipments: 1.5% of the investment cost
Other Facilities: 1.0% of the investment cost

(4) Administration expenses and others: 0.6% of the investment cost

The annual cost calculated on the basis of the above-mentioned conditions will be 242.3 million Colones as shown in Table II-8-2. This annual cost is estimated for convenience on an assumption that the three generators start their operation altogether at the same time, because time differences between the starting times among 3 units will be less than one and a half years and the annual costs could be nearly the same.

Table II-8-1 Construction Cost and Useful Life (Yrs.) of Facility

(Unit: 10^3 Colones)

Item	Useful Life Years	Total Cost	Foreign Currency	Local Currency
1. Generating Facilities				
Civil Works	50	1027,000	541,200	485,800
Hydraulic Equipment	50	146,100	131,300	14,800
Electric Equipment	35	264,000	222,100	41,900
Engineering Fee		75,000	75,000	0
Administration Cost		75,000	0	75,000
Others		75,000	27,900	47,100
Interest during Construction		317,900	159,500	158,400
Total		1980,000	1157,000	823,000
2. Transmission Line and Other Facilities				
Transmission Line and Others	30	125,600	89,300	36,300
Engineering Fee		6,100	6,100	0
Administration Cost		6,100	0	6,100
Interest during Construction		12,200	7,600	4,600
Total		150,000	103,000	47,000
3. Total Construction Cost		2130,000	1260,000	870,000

Table II-8-2 Annual Cost

(Unit: 10^3 Colones)

Item	Investment Cost	Annual Cost
1. Interest and Depreciation	2130,000	210,000
1.1 Civil Works	(1437,000)	(146,000)
1.2 Hydraulic Equipment	(191,000)	(16,500)
1.3 Electric Equipment	(352,000)	(32,500)
1.4 Transmission Line Sub-station and Communication System	(150,000)	(15,000)
2. Maintenance and Operation	2130,000	19,500
2.1 Generating Facilities	(1980,000)	(18,000)
2.2 Transmission Line, Sub-station and Communication System	(150,000)	(1,500)
3. Administration Expense	2130,000	10,700
4. Other Expense	2130,000	2,100
Total Annual Cost (C)		242,300

8.3 ANNUAL BENEFIT

8.3.1 Annual Cost of Alternative Thermal Power Plant

(1) Outline of the Alternative Thermal Power Plant

In the study of the economic feasibility of Guayabo Project, the following thermal power plant will be supposed to be the alternative.

(a) The alternative will have an approximately equal capacity to Guayabo power plant and consume exclusively heavy oil as the fuel.
(b) The alternative will be located at Moin near by Port Limon.
(c) The price of machines and equipments will be estimated on the basis of international market prices.

The basic data for the alternative with the above-mentioned conditions are shown in Table II-8-3.

Table II-8-3 Alternative Thermal Power Plant

Installed Capacity	(MW)	198
Unit Capacity	(MW x Unit)	66 x 3
Annual Plant Factor	(%)	70
Thermal Efficiency at Generating End	(%)	34
Annual Energy Production	(10^6kwh)	1214
Percent of Powerhouse Service Use	(%)	5
Annual Avaialble Energy	(10^6kwh)	1153
Annual Energy Consumption	(10^3 kl)	315.6
Construction Cost	(10^6Colones)	1005

(2) Annual Cost of the Alternative Thermal Power Plant

The alternative will be equipped with 3 units of generator with 66 MW capacity per unit totalling 198 MW. The annual cost will be divided into fixed cost and variable cost as shown in Table II-8-4. An interest rate of 8.8% will be employed as a investment weighted average of two interest rates, assuming 8% for foreign 80% of investment cost and 12% for domestic currency (20% of investment cost).

The annual cost per kW is taken to be the annual fixed cost per kW multiplied by a kW adjustment factor.

The reason for multiplying by a kW adjustment factor is described below.

A thermal power plant compared with a hydropower plant has higher rates of outage from faults and due to periodical repairs. Therefore, for the same reliability as in the case of a hydroelectric power plant being added to the system, a thermal power plant requires an installed capacity which is larger by as extent corresponding to the outage rate. This additional installation required should be considered as a benefit of the hydroelectric power plant, and the coefficient for taking this into consideration is the kW adjustment factor.

In addition, the kW adjustment factor could be modified in consideration of additional losses of the plant and transmission line between Moin and South Substation of San Jose. The modified factor will be 1.154, and kWh adjustment factor be 1.060.

As a result, the fixed cost and variable cost of the alternative, in other words, benefit per kW and benefit per kWh of Guayabo hydro-power plant, respectively, will be as follows:

Benefit per kW	:	713 Colones
Benefit per kWh	:	0.190 Colones

The process of calculation is shown in Table II-8-4.

Table II-8-4 Estimated Annual Cost of Alternative Thermal Plant

Col. : Colones

Item	Unit	Fixed Cost	Vaviable Cost	Notes
Interest and Depreciation	10^3 Col.	96,088	-	Serviceable Years: 30 (*1) C.R.F. = 0.09561
Operation, Maintenance and Administration Cost	10^3 Col.	20,100	5,025	Construction Cost x 0.025 Fixed Cost 80% Variable Cost 20%
Tax and Insurance	10^3 Col.	6,102	-	Tax: 5.44 Col./kW/year Insurance: Construction Cost x 0.005
Fuel Cost	10^3 Col.	-	212,904	$3156\text{x}10^3$ (kl) x 0.6746 (Col./l)
Total	10^3 Col.	122,290	217,929	
Annual Cost at Sending End				
Cost per kW	Col.	713	-	$\frac{122,290 \text{ x } 10^3}{198,000}$ x 1,154(*2)
Cost per kWh	Col.	-	0.190	$\frac{217,929 \text{ x } 10^3}{1214 \text{ x } 106}$ x 1.06(*3)

(Note)

*1 Capital Recovery Factor (i = 8.8%)

*2, *3 kW, kWH, Adjustment Factor

Item			Hydro	Steam
Transmission	Loss	(%)	1.0*4	2.0*5
Station Service	Loss	(%)	0.3	5.0
Failure	Loss	(%)	0.5	0.5~5.0*6
Repair	Loss	(%)	2.0	10.0

kW Adjustment Factor = $\frac{(1-0.01)\text{x}(1-0.003)\text{x}(1-0.005)\text{x}(1-0.02)}{(1-0.02)\text{x}(1-0.05)\text{x}(1-0.005)\text{x}(1-0.10)} = 1.154$

kWh " " = $\frac{(1-0.01) \text{ x } (1-0.003)}{(1-0.02) \text{ x } (1-0.05)} = 1.060$

*4 Guayabo -- South Substation of San Jose

*5 Moin -- South Substation of San Jose

*6
In this study, the failure loss of alternative steam thermal is estimated at 0.5%.

8.3.2 Salable Energy

The possible annual energy of Guayabo power plant will be, as explained in the Chapter 5, "Plan of Power Generation", 1,192 million kWh. Not all the possible energy generated by Guayabo Power Plant could be salable for a few years immediately after the start of operation in 1987. Energy generated at existing plants could be assumed to have priorities of sales for consumers to Guayabo Plant.

If the growth rate of energy demand will be 5.7% annually after 1991, all the energy generated is not completely salable until 1992.

The total energy loss to be incurred from Power Plant to South Substation of San Jose will be estimated at 3.8% taking into account of transmission loss, loss due to accident in the plant or repairing work, and loss by service for own-plant. The salable energy in each year at South Substation of San Jose is shown in Table II-8-5.

Table II-8-5 Salable Energy in Each Year

(At South Substation of San Jose)

Year	Salable Energy (10^6 kWh)
1987	173
1988	363
1989	561
1990	765
1991	988
1992	1147
1993	1147
.	.
.	.
.	.
.	.
.	.
.	.
2036	1147

8.3.3 Annual Benefit of Guayabo Power Plant

The annual benefit of Guayabo Power Plant will be estimated by means of the benefit per kW and the benefit per kWh that are given in Item 8.3.1.

In the estimation of benefits, beneficial output (kW) will be an average of L_5 outputs in April and December, and beneficial energy (kWh) will be salable energy in each year. The output and energy will be those of the end of South Substation of San Jose, and take into account of loss 3.8 % between the end and the Plant.

The output of Guayabo Plant in December will become entirely beneficial in the third year (1989) from 1987 when the plant will start the operation. On the other hand, the output in April will become entirely beneficial in the seventh year (1993).

With respect to electric energy, the energy will not become entirely beneficial until a few years (1992) since the plant operation, as explained in the preceding Item. In other words, the output and energy consumed will be increased after the start of the operation in correspondent with the increase in demand for power in future.

Therefore, the beneficial output and electric energy could be obtained from making them into uniform equivalence in the period of analysis 50 years.

The equivalent output at South Substation of San Jose in April and December will be 154 MW and 164 MW, respectively, and average of them be 159 MW. As the energy will be 912 million kWh, the annual benefit will be 286.6 million Colones calculated from the beneficial output and beneficial energy. Further the equivalent output and energy are calculated with a discount rate 10 %.

8.3.4 Benefit Cost Ratio and Surplus Benefit

(1) The annual cost and annual benefit from the Power Plant will be 242.3 million and 286.6 million Colones respectively. The benefit cost ratio (B/C) and the surplus benefit (B-C) will be as follows:

B/C : 1.18
B - C : 44.3 million Colones

It means that it will be better to implement the Guayabo Project and to supply the power than development of an alternative thermal power plant.

In conclusion, the Guayabo Project will be economically feasible.

(2) Not all the possible energy of the Guayabo Plant could be salable for a few years immediately after the start of operation as mentioned in Item 8.3.2.

However, as a reference, benefit cost ratio (B/C) and surplus benefit (B - C) will be estimated on an assumption that 50% and 100% of the equivalent surplus energy 174 million kWh incurred from 1987 to 1991 could be salable to such a neighboring country as Nicaragua. In the estimation, the unit price for the salable energy of the surplus could be determined to be 0.135 Colones per kWh according to ICE document*. The result is as follows:

Surplus energy salable (%)	The benefit cost ratio (B/C)	Surplus benefit (B - C) (Unit: Colones)
50	1.23	56.0 million
100	1.28	67.8 million

* Contrato de Interconexion Entre el Instituto Costarricense de Electricidad y la Empresa Nacional de Luz y Fuerza.

(3) The result of Item (1), above-mentioned, does not include any influence of inflation. Here as a reference, an economic analysis will be made on an assumption that the inflation with an annual rate of 6 % will continue on after the operation of Guayabo Power Plant. The benefit cost ratio and surplus benefit will be calculated in the period of analysis 50 years in order to see the influence of inflation upon the benefits and costs.

(a) Cost Items Influenced by Inflation
The items are assumed to be influenced by an inflation rate of 6%.

(i) Hydro-power plant:
Replacement costs for turbines/generators, transmission lines and substations, operation of maintenance cost, administration cost and others.

(ii) Thermal power plant:
Replacement cost for all facilities, operation & maintenance cost, insurance cost and fuel cost.

(b) Annual Benefit and Annual Cost
The annual benefit and annual cost are calculated on the basis of above-mentioned assumptions in the period of analysis 50 years with a discount rate 10%. The result is as follows.

Annual Benefit per kW	991 Colones/kW
Annual Benefit per kWh	0.429 Colones/kWh
Annual Benefit	548.8 million Colones
Annual Cost	292.2 million Colones

(c) Benefit Cost Ratio and Surplus Benefit
From the above, the benefit cost ratio and surplus benefit are calculated as follows.

Benefit Cost Ratio (B/C)	1.88
Surplus Benefit (B - C)	256.7 million Colones

It could be concluded that Guayabo hydro-power plant would have much more advantage over the alternative thermal power, because the former has a longer useful life than the latter and the variable cost (mainly fuel cost) gives a big influence of inflation upon the annual cost.

8.4 COST OF ENERGY

The cost of energy per KWh, which will be supplied by Guayabo power plant for delivery at South Substation of San Jose, will be obtained from the relation between the salable energy given in Item 8.5.2 and the annual cost geven in the section 8.2.

Table II-8-6 shows the cost of energy in each year depending on the salability. The cost of energy will be 0.211 Colones per kWh from 1992 on when total energy generated could be salable.

Table II-8-6 Energy Cost

Year	Salable Annual Energy (10^6kWh)	Annual Cost (10^6Colones)	Energy Cost (Colones/kWh)
1987	173	242.3	1.401
1988	363	242.3	0.667
1989	561	242.3	0.432
1990	765	242.3	0.317
1991	988	242.3	0.245
1992	1147	242.3	0.211
1993	1147	242.3	0.211
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
2036	1147	242.3	0.211

PART III

SIQUIRRES HYDRO-ELECTRIC POWER PROJECT

(PRE - FEASIBILITY STUDY)

PART III

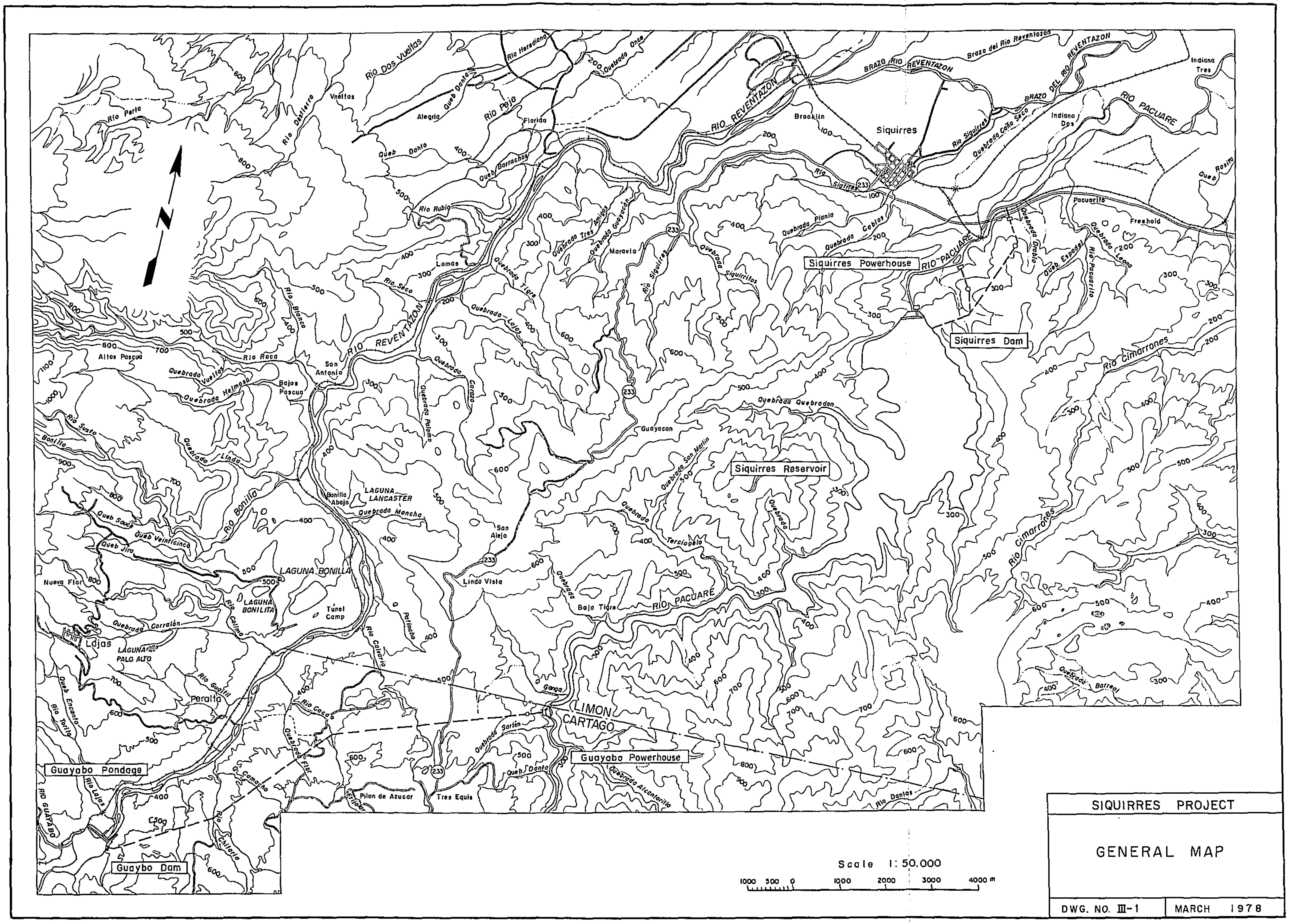
SIQUIRRES HYDRO-POWER PROJECT (PRE-FEASIBILITY STUDY)

CHAPTER 1

PLAN OF DEVELOPMENT

CHAPTER 1 PLAN OF DEVELOPMENT

LIST OF DRAWING


SIQUIRRES PROJECT
GENERAL MAP
DWG. NO. III-1
MARCH 1978
Scale 1: 50.000
1000 500 0 1000 2000 3000 4000 m
Siquirres
Siquirres Powerhouse
Siquirres Dam
Siquirres Reservoir
Guayabo Powerhouse
Guayabo Pondage
Guaybo Dam
RIO REVENTAZON
RIO PACUARE
Rio Cimarrones
Rio Dos Vueltas
Rio Siquirres
Rio Bonilla
LAGUNA BONILLA
LAGUNA LANCASTER
LAGUNA BONILITA
LAGUNA PALO ALTO
Lajas
Peralta
Tunel Camp
Linda Vista
Guayacan
Moravia
San Antonio
Bajos Pascua
Altos Pascua
Bonilla Abajo
San Alejo
Baja Tigre
Tres Equis
Pilon de Azucar
Nueva Flor
Brooklin
Florida
Alegria
Lomas
Indiana Dos
Indiana Tres
Freehold
Pacuarito
LIMON
CARTAGO
RIO GUAYABO
Rio Lajas

CHAPTER 1 PLAN OF DEVELOPMENT

1.1 LOCATION AND OUTLINE OF PROJECT AREA

The project will be located on the downstream of Pacuare river. Around 3 km downstream of the dam site, there are a railway and a road which lead up to Limon City along the skirts of mountains.

The Pacuare river is adjacent to Reventazon river and it flows into the Caribbean Sea. The river originates its source in the northern part of Cuerici range (3,394 m above sea level). Its extension is approx. 130 km and its catchment area is approx. 880 km^2.

Since Pacuare river has no big tributaries, its catchment area is comparatively small for its extension. The stream flows in the rainy area of its upper reaches at 1/60 inclination down to arrive at Guayabo Power Plant site mentioned in Part II.

Downstream from Guayabo Power Plant site, the inclination becomes mild and it flows in the wide valleys down to enter a V-shaped gorge where is the site of Siquirres Dam.

Then, it passes through the mountain area of approx. 3 km and flows into the Caribbean Sea, meandering in jungle plains at a river grade of 1/2000.

The Pacuare basin will be classified into an area having much rainfall in Costa Rica. The rainfall in the upstream amounts to as much as 6,000 mm, while in the town of Siquirres near the dam site 4,000 mm annually. The rainfall at the town of Siquirres throughout the year indicates less in February and March, while relatively much in other months.

The nature of the rock in the basin of the said river is mainly composed of the marine clastic sedimentary rock belonging to Miocene Period. Siquirres reservoir area has the same geology. On the other hand, the rock at Siquirres Dam site consists of basalt lava and sandstone.

1.2 OUTLINE OF PROJECT

As mentioned in Item 2.1, there is a V-shaped valley in the downstream of Pacuare river. Said site seems to be the best for the construction of dam, which could have a big storage with high head. The site will also provide a good site for Power Plant.

Siquirres Project could provide a dam, 200 m high, at the site with a reservoir which effective storage will be 430 million m^3. The reservoir will regulate seasonally annual in-flows 5,306 million m^3, including power discharge from Guayabo Power Plant, in the catchment area 650 km^2. The regulated flows will be used for generation of power at Power Plant located immediately downstream of the dam.

On an assumption that Guayabo Plant were in operation, a study has been made on three different locations of Power Plant when the dam site is fixed at a place. As a result, the most economical location could be immediately downstream of the dam, in which effective head will be 154 m. The plant will have the maximum output of 310 MW and annual energy of 1,850 million kWh with power discharge of 240 m^3/sec.

1.3 HEIGHT AND TYPE OF DAM

1.3.1 Height of Dam

The dam site has a narrow V-shaped valley. Near the highest part of the valley, at an elevation of more than 250 m, it is almost flat on both right and left banks. The nature of the rock at the dam site consists of hard and compact basalt lava, but there are marls and sandstones under the lava. The rock at the highest part of the valley is rather weathered. Therefore, the dam height will be limited to an elevation of approx. 250 m.

As for the geological data on the site, there is a geological survey report based on two boring cores (Refer to Chapter 3, Hydrology and Geology). As a result of study of the report and on actual field investigation, a judgement was made that it could construct a high dam with a dam height of about 200 m and reservoir level of EL 250 m.

1.3.2 Type of Dam

As a type of dam at the site, a rock-fill dam or a concrete dam could be considered. As for a concrete dam, such types of dam could be considered as gravity dam, arch gravity and arch dam.

However, it will be conservative to design the dam as a gravity dam at the moment giving due considerations to the available informations limited on geology and construction material. Alternative types of dam should be studies only after conducting a thorough survey on geology and construction material. In designing the gravity dam, the followings were considered as design criteria and conditions.

(1) Allowable compressive stress on concrete and foundation rock
.... 50 kg/cm^2

(2) Shearing resistance strength of concrete and foundation rock
.... 33.0 kg/cm^2

(3) Coefficient of earthquake 0.2

(4) Spillway design flood .... 4,900 m^3/sec
Design flood during construction .... 1,000 m^3/sec

CHAPTER 2

HYDROLOGY AND GEOLOGY

CHAPTER 2 HYDROLOGY AND GEOLOGY

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CHAPTER 2 HYDROLOGY AND GEOLOGY

2.1 GENERAL DESCRIPTION OF METEOROLOGY AND HYDROLOGY IN PROJECT AREA

In the area of Siquirres Project, the annual average temperature is approximately 26 degreees centigrade and the annual amount of rainfall is approximately 4,000 mm. At Siquirres Dam site the annual in-flow is 2,010 million m^3 and the annual average run-off is 63.7 m^3/sec not including power discharge from Guayabo Power Plant. The run-off decreases from January to May, and it tends to increase between June and December.

2.2 RUN-OFF GAUGING STATION AND METEOROLOGICAL GAUGING STATION

In the basin of Siquirres Project and the surrounding area, there are many run-off gauging stations and meteorological gauging stations. Fig. II-3-1 in Chapter 3, Part II shows the locations. The period of record for which the stations have recorded are indicated in Table II-3-1 and II-3-2. Among these, the Angostura gauging station, Dos Montanas gauging station and Pacuare gauging station are assumed to be representative stations for Siquirres Project.

2.3 ESTIMATION OF RUN-OFF AT DAM SITE

2.3.1 Catchment Area of Dam Site

The total catchment area of Pacuare river is approximately 880 km^2 and that of Siquirres site is 650 km^2. Further, it amounts to 2,168 km^2 where a catchment area 1,518 km^2 of Guayabo Project is included. The numerical value is calculated from a topographic map with a scale of 1/50,000. Fig. III-2-1 shows the catchment area of the Project.

2.3.2 Representative Gauging Station

Angostura, Dos Montanas and Pacuare run-off gauging station are the representative stations for Siquirres Project.

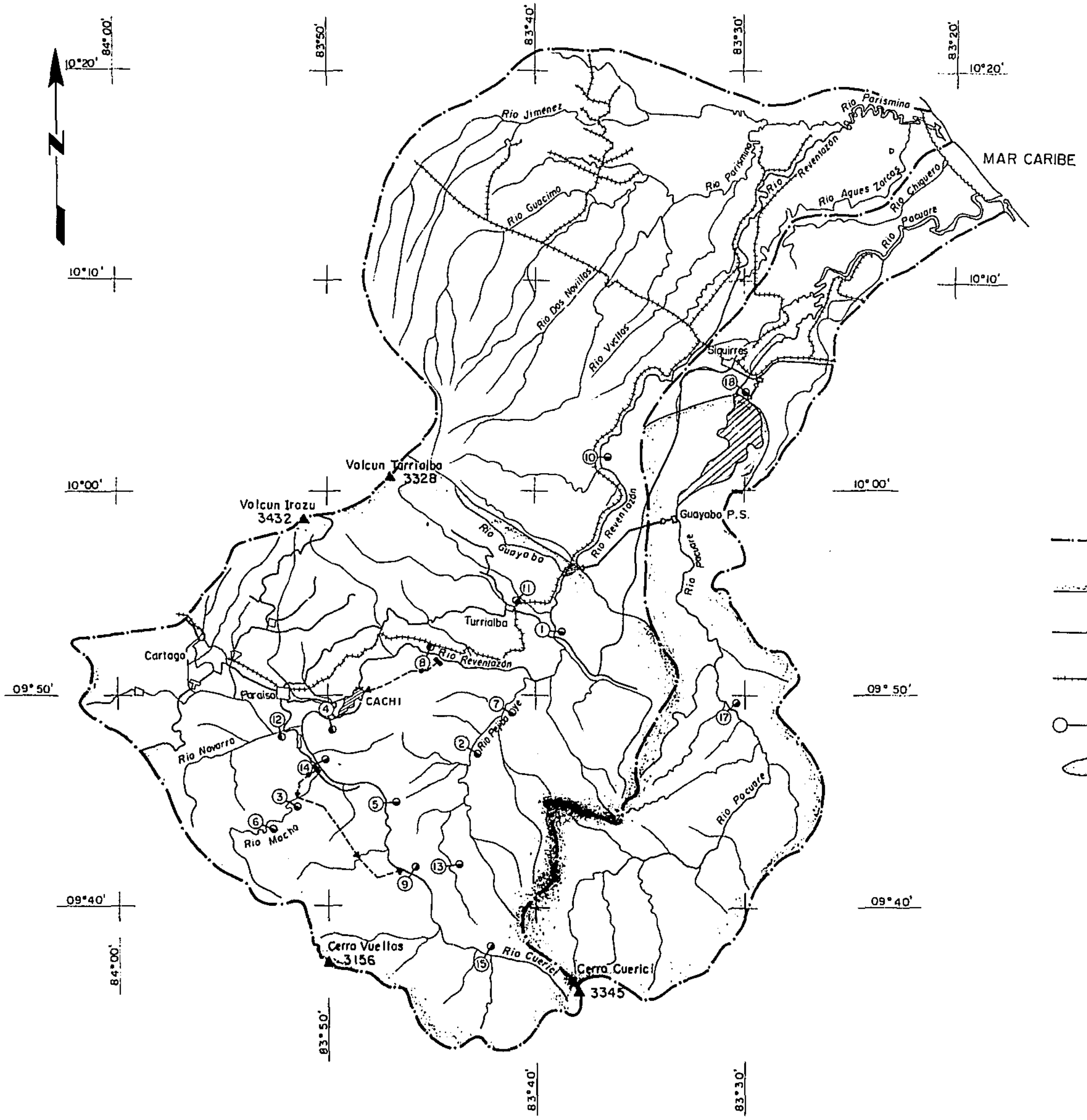
2.3.3 Period of Analysis for Run-off

The period of analysis for the run-off will be 18 years from January in 1959 to December in 1976. The period is the same as of Guayabo Project.

2.3.4 Supplementation of Run-off Data

The run-off record of Dos Montanas station started from May in 1964 with little lack of information of run-off data. In order to supplement the missing data, as a result of checking the correlation between Dos Montanas station and Pacuare station, it could be judged that there would exist high correlationship between the two stations.

Fig. III-2-1 Catchment Area



Catchment Area

(1)	Guayabo Dam Site	1 518 km²
(2)	Siquirres Dam Site	650 km²
	(1 518 + 650 = 2 168 km²)	

Run-off Gauging Station

(1)	Angostura	1 337.1 km²
(18)	Dos Montañas	651.8 km²

LEGEND

- Boundaries of Catchment Area of Rio Reventazon and Rio Pacuare
- Boundaries of Catchment Area of Guayabo Project and Siquirres Project
- Road
- Railway
- Runoff Gauging Station
- Reservoir

Therefore, a supplemental estimate could be made on the missing records from the monthly data of Pacuare station, employing regression analysis method.

The conditions for computation by regression analysis are follows:

(1) The period of analysis will be from July in 1963 to April in 1974.

(2) Monthly run-off will be used for the analysis.

(3) The run-off data will be divided into 3 groups, that is, January - April, May - August, and September - December.

(4) The coefficient of regression has been obtained from the least squares method.

The result of this computation is as follows:

Regression-formula $Y = AX + B$

X : Run-off at Pacuare gauging station
Y : Run-off at Dos Montanas gauging station

Group Period		Coefficient of regression A	Coefficient of regression B	Coefficient of correlation
1	Jan. - Apr.	1.9673	-2.7873	0.974
2	May - Aug.	1.2426	16.052	0.854
3	Sep. - Dec.	1.7425	-5.299	0.888

The run-offs obtained from the formula are shown in Appendix A-2.

2.3.5 Run-off at Dam Site

The run-off at Siquirres dam site is calculated using the formula stated below.

$$Qs = Qd \times \frac{As}{Ad} + Qg$$

where, Qs : Run-off at Siquirres dam site (m^3/sec)
Qd : Run-off at Dos Montanas station (m^3/sec)
Qg : Power discharge at Guayabo power plant (m^3/sec)
As : Catchment area of Siquirres dam site (650 km^2)
Ad : Catchment area of Dos Montanas station (652 km^2)

Table III-2-1 shows the monthly average run-offs at Siquirres dam site which are computed by the formula stated above.

2.4 RAINFALL

The distribution of rainfall in Costa Rica is described in Chapter 3, Part II. Pacuare basin also belongs to the region of Atlantic Ocean side having much rail-falls same as Reventazon basin.
The isohyetal map in Pacuare basin is shown in Fig. III-2-2, and the monthly precipitation at Siquirres meteorological station is shown in Table III-2-2. The annual precipitation is 4,000 mm.
Further, the data on temperature, humidity and evaporation at Siquirres station are gathered, altogether, in Table III-2-2.

2.5 RUN-OFF

The monthly average run-offs from 1964 to 1973 recorded by the main gauging stations in Reventazon and Pacuare basins are indicated in Table II-3-5 in Chapter 3, Part II. Specific run-offs (the run-off per 100 km^2 of catchment area) are shown in Table II-3-6.
According to the Table, the specific run-off of Pacuare river is approximately 10 m^3/sec, which is greater than that of Reventazon river by 10 - 20%.

The monthly average and the monthly maximum and minimum run-offs at Dos Montanas station in 13 years from 1964 to 1976 are shown in Table III-2-3. According to the table, the annual average run-off in 13 years is 66.1 m^3/sec. The run-off duration for each year is shown in Table III-2-4 and Fig. III-2-3.

2.6 DESIGN FLOOD

The design flood at Siquirres Dam site has been studied by ICE. The report of these studies and the estimated design flood with various methods are shown as follows:

(1) "Avenida Máxima Probable, Rio Pacuare Sitio de Presa, Proyecto Hidroelectrico Siquirres" Jul., 1976.

Estimated design flood (m^3/sec)	Method
3,927	Unit Hydrograph Method
4,000	Isochronous Method
4,878	Simulation Model Method

(2) "Informe Hidrologico Preliminar, Proyecto Hidroelectrico Siquirres" Jul., 1976

Estimated design flood (m^3/sec)	Method
5,390	Creager Method
4,960	Sautic Method
4,460	Myer Method
4,720	Cherardell Method

As a result of review of the report and discussions with engineers of ICE, the design flood for spillway could be determined at 4,900 m^3 which would be reasonable. The design flood during construction could be determined at 1,000 m^3/sec by making study based on the above-mentioned report (2).

This design flood during construction, according to the records in Dos Montanas gauging station, is the second biggest value, while the first-place value is 2,920 m^3/sec. When considered in the return period, they are approximately 3 years and approximately 100 years, respectively.

2.7 SEDIMENTATION

The sedimentation in Siquirres reservoir is estimated from the formula of empirical formula considering several elements and actual records of Cachi reservoir.

(1) Calculation based on Capacity of the Reservoir and Catchment Area (Empirical-formula of "Witzig"):

$$qs = K_1 \ (V/A) \ 0.83$$

where, qs : Specific sedimentation (Acre. feet/100 sq. miles/year)
V : Capacity of reservoir (Accre. feet)
A : Catchment area (sq. miles)
K1 : Regional Index 0.10

From this formula the specific sedimentation is 255 $m^3/km^2/year$.

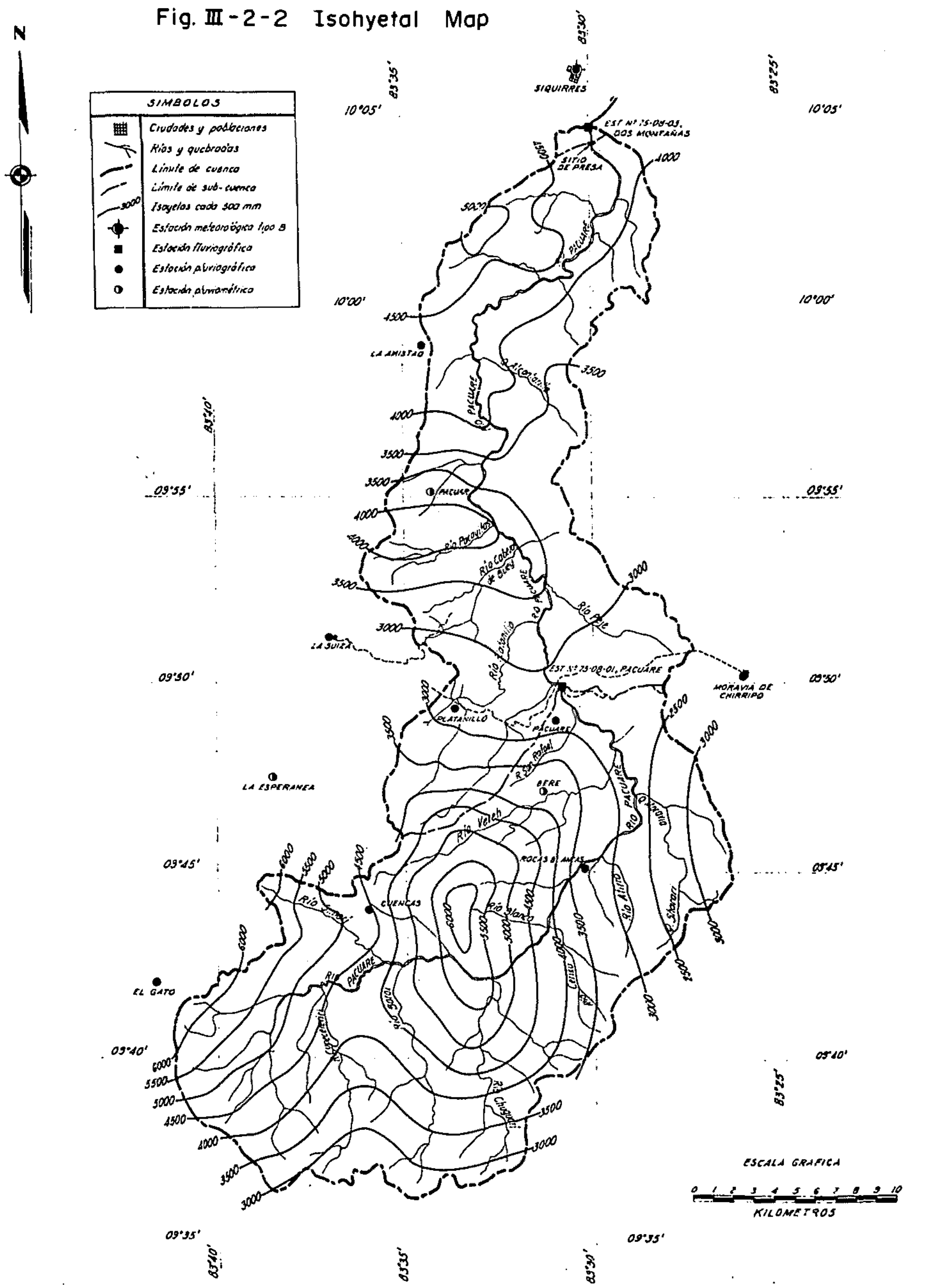
(2) Calculation based on Actual Results of Cachi Reservoir

According to ICE data, the actual sedimentation in Cachi reservoir is as follows:

1.05 million ton/year/785 km^2 (900 $m^3/km^2/year$)

The result shows the estimated specific sedimentation of (2) than that of (1), and the specific sediment 900 $m^3/km^2/year$ could be adopted for the Siquirres reservoir. As a result, 60 million m^3 is assumed for the sedimentation in Siquirres reservoir in 100 years. The assumed elevation of sediment corresponding to this value will be 160 m.

Fig. III-2-2 Isohyetal Map



ESTACIONES METEOROLOGICAS UTILIZADAS					
(DENTRO DE LA CUENCA)					
Nº	ESTACION	PRECIPIT. PROMEDIO (mm)	AÑOS DE REGISTRO	TIPO APARATO	OPERADA POR
073-002	Siquirres	3834	1964-73	B	ICE
073-003	Platanillo	2930	1964-73	C	ICE
073-004	Pacuare	2948	1964-73	C	ICE
073-005	Pacuar	3937	1964-73	C	ICE
073-006	Bere	3642	1964-73	C	ICE
073-007	Rocas Blancas	3166	1964-73	C	ICE
073-008	Cuencas	4954	1964-73	C	ICE
(VECINAS A LA CUENCA)					
073-003	Moravia de Chirripó	2665	1964-73	C	ICE
073-044	La Suiza	2816	1964-73	C	ICE
073-054	La Esperanza	4399	1964-73	C	ICE
073-055	La Amistad	4100	1964-73	C	ICE
073-063	El Gato	6646	1964-73	C	ICE

PRECIPITACION Y ESCORRENTIA PROMEDIO						
Nº	RIO	ESTACION	AREA DE DRENAJE Km²	PRECIPITACION EN mm	ESCORRENTIA PROMEDIO ANUAL EN mm	COEFICIENTE ESCORR.
75-08-01	Pacuare	Pacuare	367.4	4094	3332	0.81
75-08-03	Dos Montañas	Pacuare	631.8	3330	3.57	0.83

LOCALIZACION DE LA CUENCA Nº 75-08, RIO PACUARE HASTA LA ESTACION Nº 75-08-03, DOS MONTAÑAS EN COSTA RICA

Notas

1- Este mapa fue confeccionado con base en información obtenida del Instituto Geográfico de Costa Rica escala 1:50000.
2- La precipitación promedio en la cuenca hasta la estación Nº 75-08-03, Dos Montañas, es de 3330 mm
3- La precipitación promedio en la cuenca hasta el Sitio de Presa del Proyecto Siquirres, es de 3330 mm
4- Area de la cuenca hasta el Sitio de Presa = 630.8 Km²

REV.	FECHA	DESCRIPCION	POR	APROB.

Dibujó: I.G. de C.R. Br. S. Laporte M.	Presentó: Ing. C.M. Obregón Q.	OFICINA DE ESTUDIOS BASICOS SECCION DE HIDROMETEOROLOGIA PROYECTO SIQUIRRES ISOYETAS DE PRECIPITACION MEDIA, PARA EL PERIODO 1964-1973, EN LA CUENCA DEL RIO PACUARE HASTA LA ESTACION FLUVIOGRAFICA Nº 75-08-03, DOS MONTAÑAS
Calcó: Dib. J.A. Pérez R.	Recomendó: Ing. E. Evans R.	
Verificó: Ing. R.A. Feoli M.	Aprobó: Dir. Electrificación	

Instituto Costarricense de Electricidad
SAN JOSE, COSTA RICA

Fecha: 13 enero 1975
Escala: 1:100000
Número: 100-14-6

Table III-2-1 Monthly Average Run off at Siquirres Dam Site

Catchment Area 2168 km^2 (Unit: m^3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1959	52.1	50.3	43.1	53.1	101	189	168	166	161	232	176	138	129
1960	133	102	83.7	76.7	121	187	193	168	178	239	183	209	156
1961	96.8	74.3	57.4	51.0	109	175	180	157	216	232	225	213	149
1962	136	75.0	55.9	75.2	155	197	201	181	183	267	332	209	173
1963	116	108	90.2	132	170	182	194	182	222	231	256	181	172
1964	157	69.1	48.1	48.3	93.1	172	202	194	201	220	181	105	141
1965	193	110	118	63.1	146	194	191	202	215	226	211	157	169
1966	173	187	113	100	219	223	184	189	188	203	219	264	187
1967	170	103	82.1	147	149	232	205	221	219	230	215	163	178
1968	108	163	144	143	185	230	221	222	241	214	220	184	190
1969	96.2	74.4	56.7	78.2	90.9	184	140	211	225	227	295	247	161
1970	205	230	94.2	326	214	200	219	197	210	197	298	470	238
1971	176	103	115	142	182	185	205	198	200	239	189	108	171
1972	132	102	81.4	124	170	181	130	170	210	237	202	159	158
1973	128	103	68.4	47.5	105	204	179	183	196	207	217	308	163
1974	169	99.9	82.8	82.9	160	215	208	216	169	201	188	207	167
1975	85.1	73.0	55.0	58.6	80.8	158	194	219	237	219	270	269	161
1976	145	102	68.0	68.8	148	222	229	214	211	191	227	149	165
Average	137	107	81.0	101	144	196	191	194	205	223	228	208	168

Note: Includes Guayabo power discharge

Table III-2-2 Meteorological Data at Siquirres Station

Station	SIQUIRRES												
Latitud	10° 06'				Longitud		83° 31'			Altitud		70 m	
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Precipitation (mm)	340.5	201.4	136.8	325.9	274.6	351.2	424.4	315.7	290.6	312.3	494.7	531.4	3999.5
Evaporation	99.4	102.8	114.7	113.5	108.2	103.6	91.2	96.7	94.1	98.0	81.0	92.8	1196.0
(Temperature)													
Average (C°)	24.3	24.9	25.9	26.4	26.5	26.4	25.9	26.0	26.0	26.4	25.6	24.9	25.8
Aver. Max.	29.2	29.5	29.8	30.5	30.6	30.7	30.4	31.4	31.2	31.4	30.1	29.5	30.4
Aver. Min	19.3	19.0	20.1	20.6	21.3	21.2	20.9	20.5	20.4	20.3	20.6	19.9	20.3
Absolute Max.	35.2	34.0	34.5	34.0	33.2	35.0	32.2	34.4	45.0	34.2	33.0	33.2	34.0
Absolute Min.	13.0	15.0	16.0	16.0	17.0	19.0	18.2	16.2	16.0	17.0	16.0	16.0	16.3
(Humidity)													
Aver. Daily	80	74	74	77	78	79	81	77	78	79	80	79	78
Aver. Min.	63	55	56	60	61	63	67	60	62	63	63	63	61
Absolute Min.	45	44	45	43	47	46	52	43	48	46	45	44	46

Source: Data From ICE

Table III-2-3 Monthly Run-off at Dos Montanas Gauging Station

(Unit: m^3/sec)

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Max.	103	105	44.6	211	86.1	94.2	98.4	92.2	104.8	103	162	331	Max. (331)
Mean*	55.1	40.3	26.2	43.3	54.1	72.7	68.0	72.5	75.9	82.0	97.9	106	66.1
Min.	26.0	20.5	14.0	12.3	22.1	48.8	34.6	57.8	51.6	61.3	58.0	29.6	Min. (14.0)

Note: Not Includes Guayabo power discharge

(Note) * Mean from 1964 to 1976

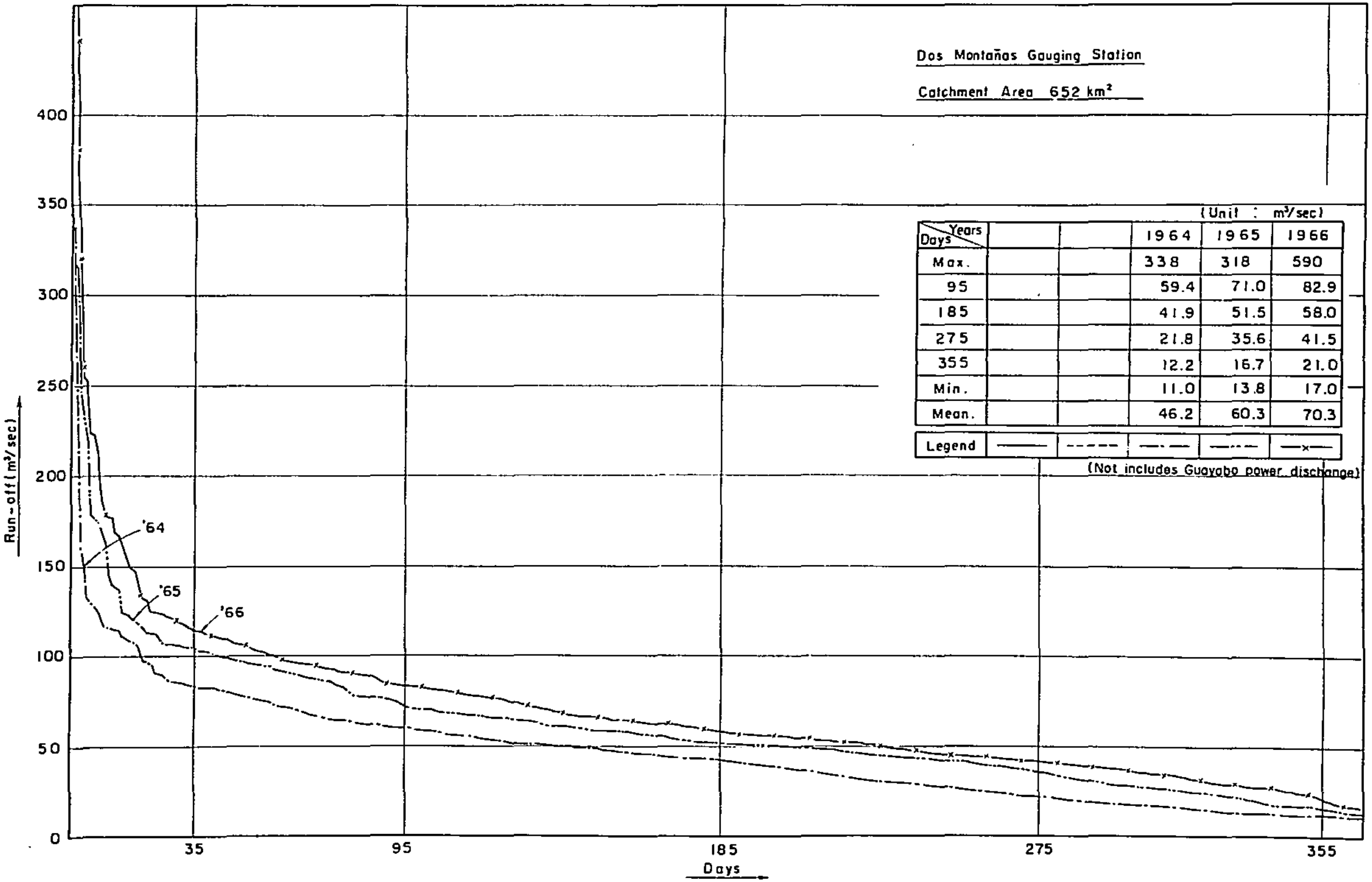
Table III-2-4 Run-off Duration of Dos Montanas Gauging Station

Catchment Area 652 km (Unit: m^3/sec)

Year	Max.	95 day	185 day	275 day	355 days	Min.	Mean
1964	338	59.4	41.9	21.8	12.2	11.0	46.2
1965	318	71.1	51.5	35.6	16.7	13.8	60.3
1966	590	82.9	58.0	41.5	21.0	17.0	70.3
1967	247	75.3	59.0	38.5	18.1	15.2	63.0
1968	324	89.2	68.0	45.5	27.0	25.5	73.5
1969	567	78.0	54.2	22.6	14.3	12.8	64.3
1970	1620	103	62.2	45.5	22.1	15.0	115
1971	194	74.0	52.2	35.0	20.0	17.3	58.6
1972	312	77.4	48.0	31.0	20.5	19.3	58.6
1973	512	74.8	51.0	25.6	11.5	10.9	62.8
1974	549	73.0	53.7	34.3	16.3	15.7	62.9
1975	587	87.9	51.0	18.3	11.7	11.4	62.1
1976	528	77.7	51.0	33.7	14.5	12.1	64.3
Average	-	78.7	54.0	33.0	17.4	-	66.1

Note: Not includes Guayabo power discharge

Fig. Ⅲ-2-3 Run-off Duration Curve (3 – 1)

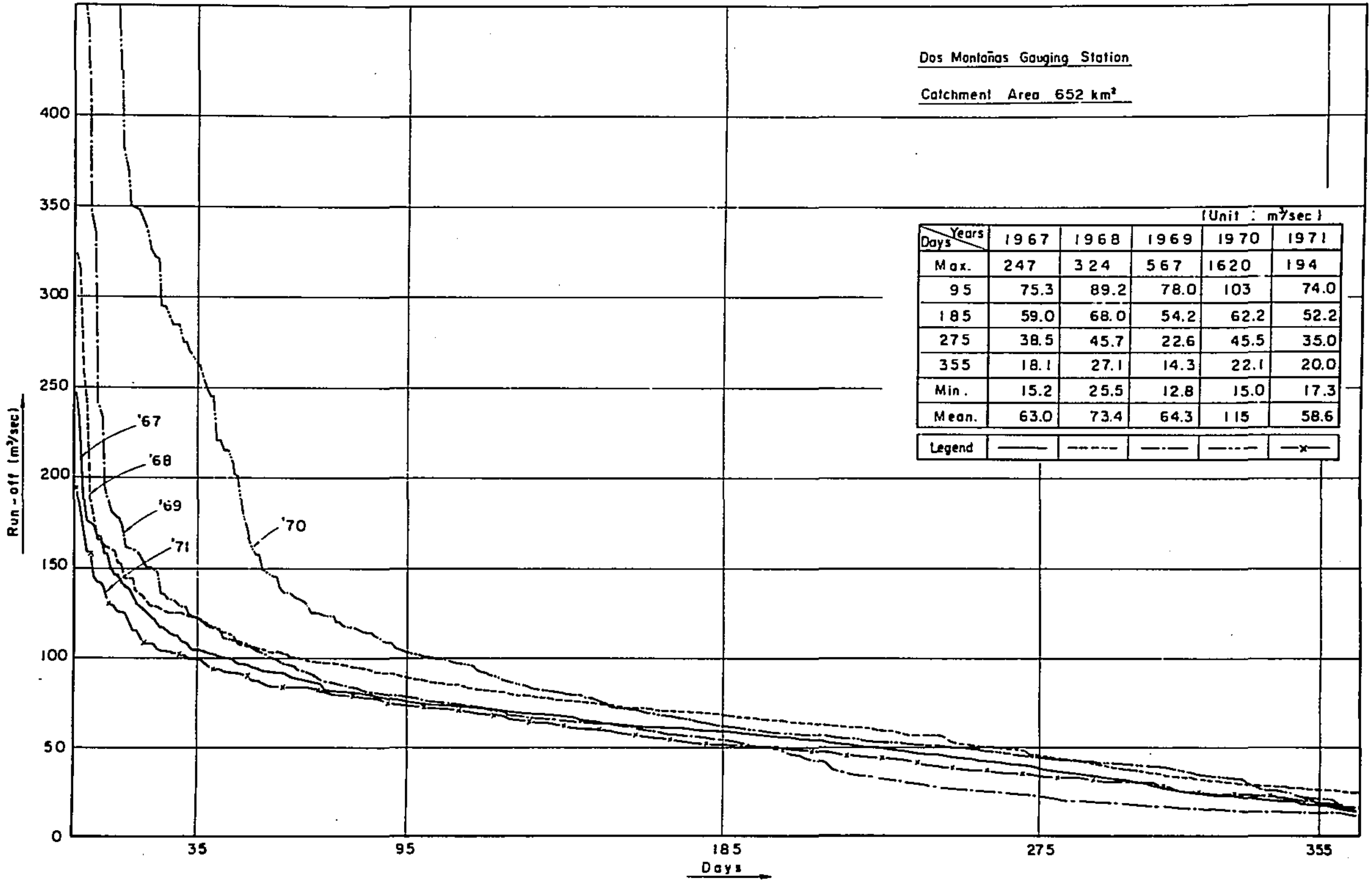


(Unit : m³/sec)

Days \ Years			1964	1965	1966
Max.			338	318	590
95			59.4	71.0	82.9
185			41.9	51.5	58.0
275			21.8	35.6	41.5
355			12.2	16.7	21.0
Min.			11.0	13.8	17.0
Mean.			46.2	60.3	70.3
Legend	———	- - - - -	—·—	—··—	—×—

(Not includes Guayabo power discharge)

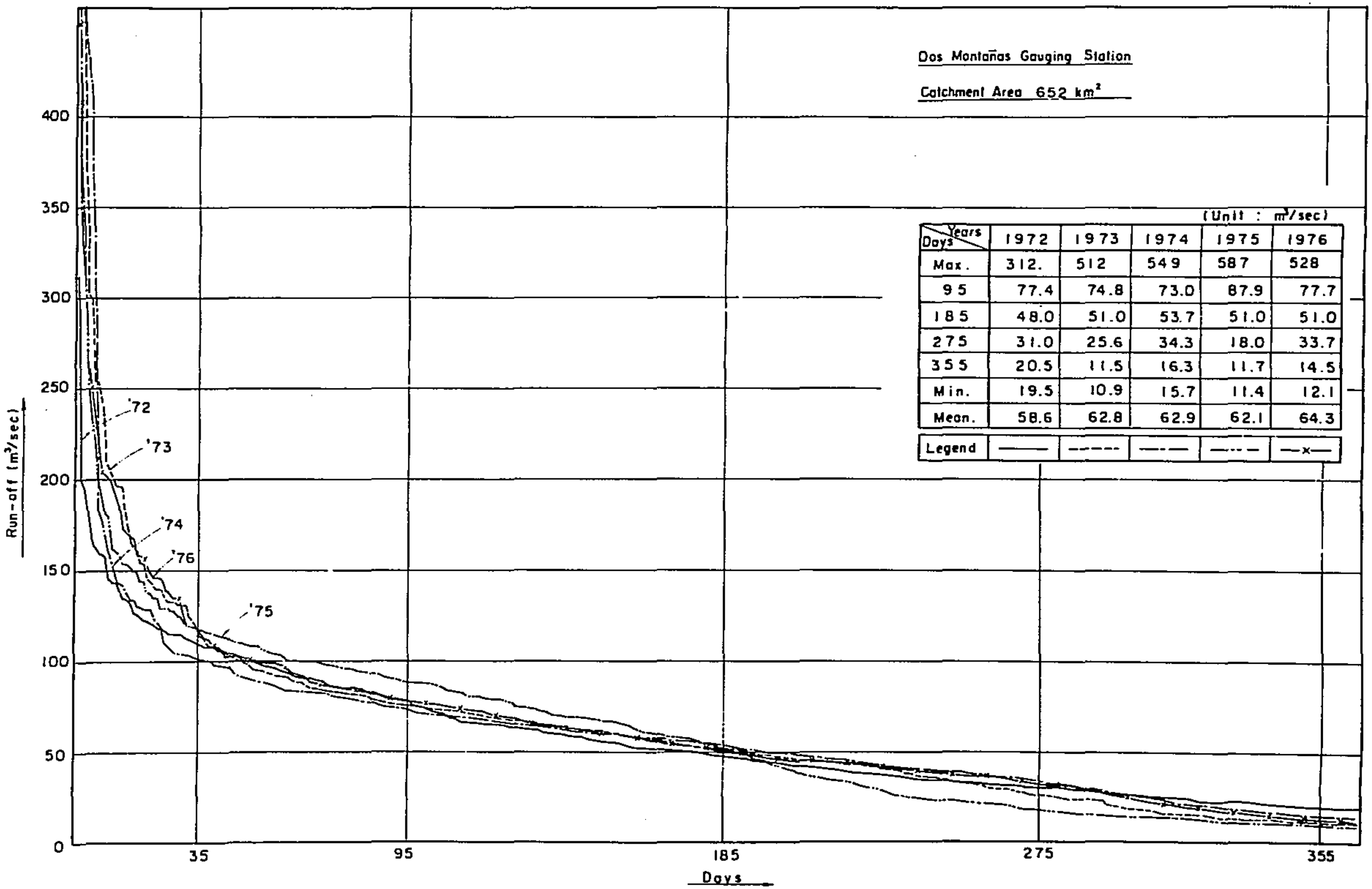
Fig. III-2-3 Run-off Duration Curve (3-2)



(Unit : m³/sec)

Days \ Years	1967	1968	1969	1970	1971
Max.	247	324	567	1620	194
95	75.3	89.2	78.0	103	74.0
185	59.0	68.0	54.2	62.2	52.2
275	38.5	45.7	22.6	45.5	35.0
355	18.1	27.1	14.3	22.1	20.0
Min.	15.2	25.5	12.8	15.0	17.3
Mean.	63.0	73.4	64.3	115	58.6
Legend	———	- - - - -	—·—·—	—··—··—	—x—

Fig. Ⅲ-2-3 Run-off Duration Curve(3-3)



(Unit : m³/sec)

Days \ Years	1972	1973	1974	1975	1976
Max.	312.	512	549	587	528
95	77.4	74.8	73.0	87.9	77.7
185	48.0	51.0	53.7	51.0	51.0
275	31.0	25.6	34.3	18.0	33.7
355	20.5	11.5	16.3	11.7	14.5
Min.	19.5	10.9	15.7	11.4	12.1
Mean.	58.6	62.8	62.9	62.1	64.3
Legend	———	------	—·—·—	—··—··—	—x—

2.8 GEOLOGY

2.8.1 Introduction

The geological investigations for Siquirres Project have been started since 1974 by ICE, and mainly the surface geological survey has been performed so far. The result was summarized in the following reports.

(1) ICE : Proyecto Siquirres Sitio de Presa
"Informe de Reconocimiento Geologico" Ene. 1975

(2) ICE : Proyecto Siquirres Linea de Tunel
"Informe de Reconocimiento Geologico" Oct. 1975

For geological investigation, 2 drillings have been executed at Dam site (Table III-2-5).

Table III-2-5 List of Drill Holes at Siquirres Dam Site

Hole No.	Location	Top Elevation	Length of Hole(m)	Remarks
DB-1	Left Bank	256	265.15	
DB-2	Right Bank	207.5	231.16	

In our investigation, surface geological survey was performed on Dam site and 3 alternative sites proposed for Power Plant. In addition to it, the cores of 2 drilling-holes were inspected.
In the Report, our findings are reported, and a recommendation is made on the geological investigation in future.

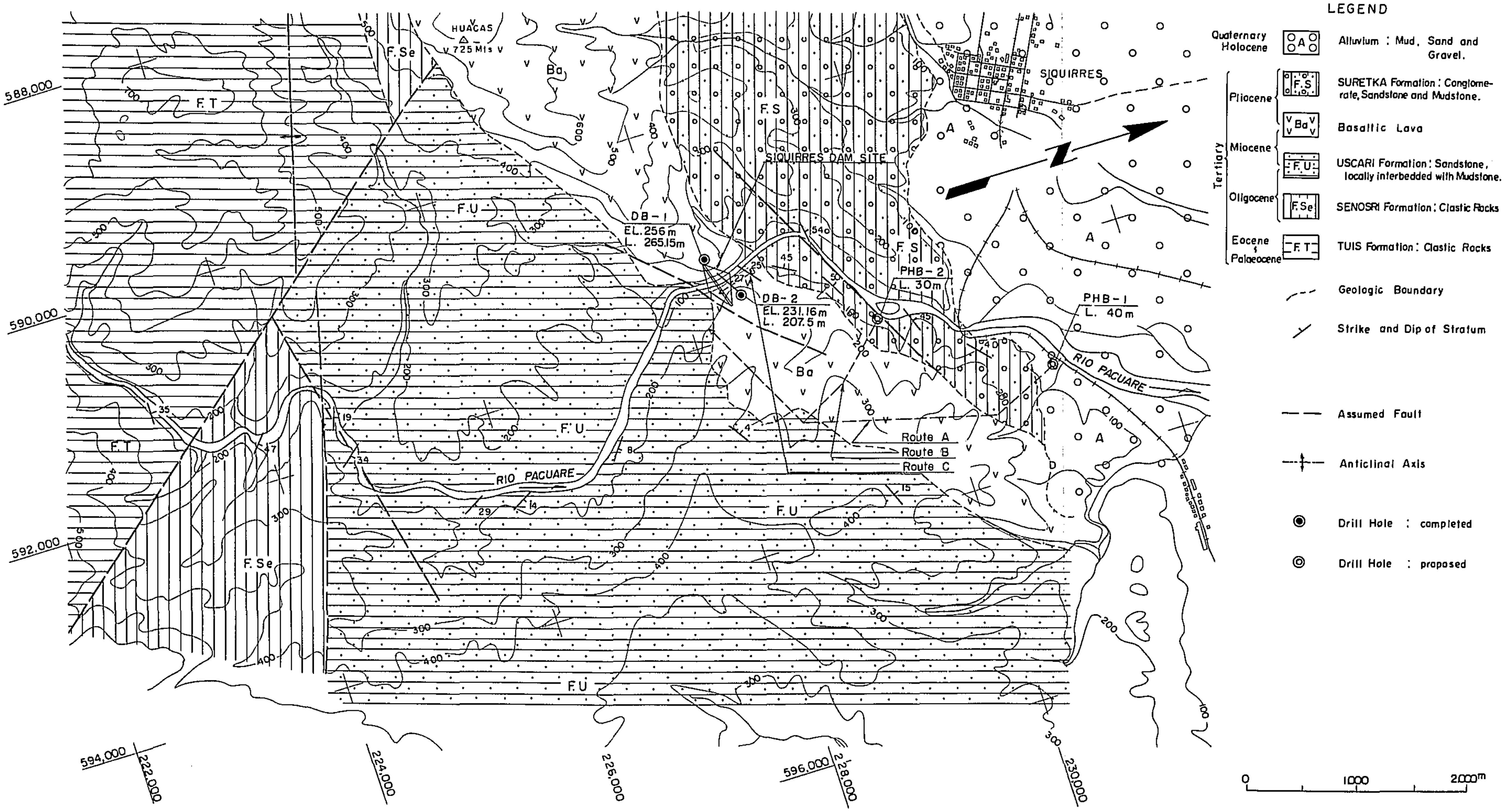
2.8.2 General Topography and Geology of Project Area

(1) Topography (Fig. III-2-4)

Siquirres Project area is located in the downstream of Pacuare river and 12 km downstream of proposed Guayabo Power Plant. Pacuare river passes through the mountain-area at about 3 km of the downstream from Dam site and meanders along a wide alluvial plain consisting of a dense forest. It flows down towards north east, then flows into the Caribbean Sea in a distance of 45 km from Dam site. The mountain on both banks of Pacuare river in Project Area shows hilly topography eroded with many ravines, and the elevation of the mountain is gradually lowered towards the alluvial plain at the downstream of the river.

The proposed Dam site is located on the ridges which protrude out towards the river from hilly highland in the elevation of about 700 m at the left bank and about 450 m at the right bank of the river. The river is narrowed with these ridges on the valley forming a V-shaped gorge. In the upstream of Dam site, in about 4 km, there is on the left bank a fan-shaped land of gentle slope, although its geographic origin is unknown yet.

Fig.III-2-4 GEOLOGICAL PLAN OF SIQUIRRES PROJECT AREA



Note 1) This geological plan is mainly based on the reports "Informe de Reconocimiento Geologico, Sitio de Presa. Projecto Siquirres", 1974 by I.C.E. and "Informe de Reconocimiento Geologico, Linea de Tunel" 1975 by I.C.E.,

2) The locations of proposed drill holes at the dam site are shown in DWG. No. III-2 and DWG. No. III-3

Siquirres Dam site, having the above topography, is suitable for constructing a high dam with big reservoir capacity in the basin of Pacuare river.

(2) Geology

The basin of Pacuare river consists mainly of marine clastic sedimentary rocks of Tertiary Period, and it is generally made of poorly cemented sandstone and mudstone. The same marine clastic sedimentary rocks in Tertiary Period are distributed in the reservoir area, however the details of geological structure or rock-facies are still unknown yet. Table III-2-6 shows the stratigraphy of formations in Project area.

The rock composing the ridge of both sides of the river at Dam site is basalt lava. The upstream-area embosoming the basalt lava consists of Uscari formation composed mainly of sandstone, while the downstream-area is distributed with Suretka formation composed of conglomerate, sandstone and mudstone. These are distributed with the strike and dip of nearly NE-SW, and 25°-50° NW, thus the sandstone of Uscari formation is distributed in the lower part of the basalt lava which will become a foundation of Dam. The basalt lava is generally very hard and dense rock, whereas sandstone, conglomerate and mudstone, namely, clastic sedimentary rocks belong to poorly cemented soft rocks.

Table III-2-6 Generalized geologic sequence around Siquirres Dam Site

Period	Stage	Name of formation and rock type
Tertiary	Pliocene	SURETKA formation Conglomerate, sandstone and mudstone
	Miocene	Basalt lava
	Oligoceme	USUCARI formation Mainly sandstone, locally interbedded with mudstone

2.8.3 Damsite

(1) Topography (DWG. No. III-2, III-3)

Pacuare river at the proposed Dam axis has a channel in its width of about 15 m at the river bed of about 60 m in elevation. The slope of both sides of the river shows the steep cliff of 70° up to an elevation of 160 m, and the precipitous cliff of 40°-50° continues even more than 160 m, however, the slope higher than about 250 m in elevation leads to the gradually elevated ridge.

The abutments of Dam site are composed of a lean ridge jutting out to Pacuare river, being interposed with the slope of upstream-side of 50°-70° and that of downstream side of 20°-30° . Dam axis is topographically limited to around the current proposed Dam axis.

(2) Geology

The bedrock is composed of basalt lava, and sandstone and mudstone of Uscari formation are distributed underneath the lava. The conditions have been already confirmed with the boring DB-1 (vertical, length 265.15 m). Distributed overburden deposits are topsoil and river-deposit.

(a) Toposoil and talus deposit
Their thickness was proved to be about 3 m at the points of the boring DB-1 and DB-2. The distribution is unknown yet, however, it seems to be thin in view of the topography, in general.

(b) River deposits
It is rather widely distributed in the upstream and downstream of Dam site, but it is narrowly distributed at around Dam axis. The thickness of the deposits is unknown yet.

(c) Basalt lava
The thickness of basalt lava which exists in Dam site is estimated at about 250 m. This lava seems to be composed of about 15 lava-layers in view of the distribution of autobrecciated lava by means of the investigation boring DB-1 and DB-2. The strike and dip of the lava-layer is nearly NE-SW and 25° NW, and it shows a gentle slope towards the downstream.
Basalt lava is mostly a dense and hard rock with bluish black color. Brownish gray black autobrecciated lava is also well cemented and hard rock. The lava shows generally developed amygdaloidal texture with gas-cavity. The steep slope along the river-side is widely distributed with fresh rock of less crevices. The weathering conditions between the hillside and the ridge is unknown yet, however, severely weathered bedrock was observed to the depth of about 26 m from the ground-surface by the boring DB-1, also, comparatively severe weathering is expected generally at the site along the mountain-ridge.

(d) Uscari formation
It is widely distributed at the upstream of Dam site, and is composed mainly of gray sandstone. At Dam site, the rock is distributed at deeper than 258.0 m in drilling hole DB-1 covering with basalt lava. Mudstone observed in this drilling core shows grayish green, and contact zone with the lava shows red brown color in the development of slickenside. The detailed distribution of sandstone and mudstone at the deep part of dam-foundation is unknown yet. However, both rocks belong to less cemented soft rock.
In view of the above topographic and geological conditions, it could be concluded as follows.
Dam foundation is made up of hard basalt lava, and also topographically it is a favorable site. Whereas, in order to decide the height and type of Dam, the following geological conditions should be clarified, namely, the mountains on both banks at Dam site shows a lean ridge at the higher elevation, thus the thicker weathering and lower permeability against water seepage can be prospected. This means that there may be a possibility of leakage from the ridge other than the part of Dam

site, thus it is necessary to investigate the thickness of weathered zone and permeability in a wider area along the ridge including Dam site. The mountain slopes of both banks show the steep slope, thus there is a possibility that the bedrock has clefts due to creeping, and water pressure test should be performed with the exploratory boring.
Also, there is a contact zone of the lava and sedimentary rock under the river bed at the Dam site. Sandstone and mudstone are less cemented soft rocks, thus it is necessary to investigate and grasp the position and condition of the contact zone and also, permeability and strength of the rocks should be clarified.
There may be no fault with greater sheared zone at Dam site, but the details are unknown yet.

2.8.4 Headrace Tunnel and Powerhouse (Fig. III-2-4)

As a result of the geological mapping up-to-date, three alternative sites of Power Plant are topographically considered, and these sites are all on the right side of Pacuare river. The reasons are that there is topographically no proper place for Intake site on the left bank and Headrace Tunnels are located in the part of hard basalt lava on the right bank.

The lst alternative (route-A) is located at the foot of hill facing to the alluvial plain in about 3 km downstream of Dam site. The 2nd alternative (route-B) is located at about 1.5 km downstream, and the 3rd alternative (route-C) is located at immediately downstream of Dam site.

The geology of Headrace Tunnel and Power Plant of the 3rd alternative are consisted of hard basalt lava, thus there may be no geological problems. Geological details on the 1st and 2nd alternatives are unknown yet, however, there is a study of geological investigation performed by ICE on the 2nd alternative. As for both the 1st and 2nd alternatives, Tunnel-routes are considered to be consisted of the same basalt lava as that of Dam site, but partially, there is a possibility of soft rock distribution of sandstone of Uscari formation. Conglomerate, mudstone and sandstone of Suretka formation are assumed to be distributed around Power-Plants and Penstock lines. The fresh rock of sedimentary rocks of those Suretka formation seems to have the bearing strength in the foundations for Power Plants and anchor blocks of Penstock lines. The slopes of Penstock lines in the 1st and 2nd alternatives are parallel with the beddings of the strata, thus care should be taken for the stability of excavated slope.

In the 1st alternative, the problem is the thickness of alluvial deposit distributed at the site of Power Plant.

In future, it seems necessary to perform the geological survey on the basis of a topographic map with a scale of about 1/2000 for the clarification of topography and geology, and if necessary, seismic prospecting and exploratory boring should be performed for the comparison and review of each route.

2.8.5 Construction Material

In about 3 km of the downstream from the proposed Dam site, there is an extended alluvial plain formed with Pacuare river and tributaries. There are wide flood plains on both river-sides, and is distributed with the river deposits composed mainly of bigger gravels of hard andesite. Thus, there may be no problem of the concrete-aggregate for concrete Dam on both quality and quantity.

In planning a rockfil Dam, rock material will be taken from the south east slope at the elevation of 500-600 m above the sea-level at about 1.5 km distant from the river of left bank of Dam site, because there is distributed with hard basalt and no effect on watertightness of reservoir even if quarried there. As for the impervious material, it was impossible yet to indicate a highly recommended site by the current reconnaissance study. Investigations are necessary on the gentle slope of fan-shaped area observed on the left bank in about 4 km of the upstream from the dam site or hilly area surrounding Dam site.

2.8.6 Summary

Siquirres Project seems to be favorably bestowed with better topographical and geological conditions by nature for a hydro-power Project with a large scale reservoir. However, in order to decide the height and type of Dam, it is necessary to grasp the weathering conditions and permeability in wider area along the mountain-ridge at Dam site, and also, it may be needed to clarify the strength and permeability of mudstone or sandstone, as well as to grasp the conditions of the contact zone between the basalt lava and sedimentary rocks.

Table III-2-7 shows a list of geological exploratory works suggested at Siquirres Dam site, and DWG. No. III-2 and III-3 show the locations suggested for drillings and test adits in future.

Table III-2-7 List of Geological Exploratory Works Suggested at Siquirres Dam Site

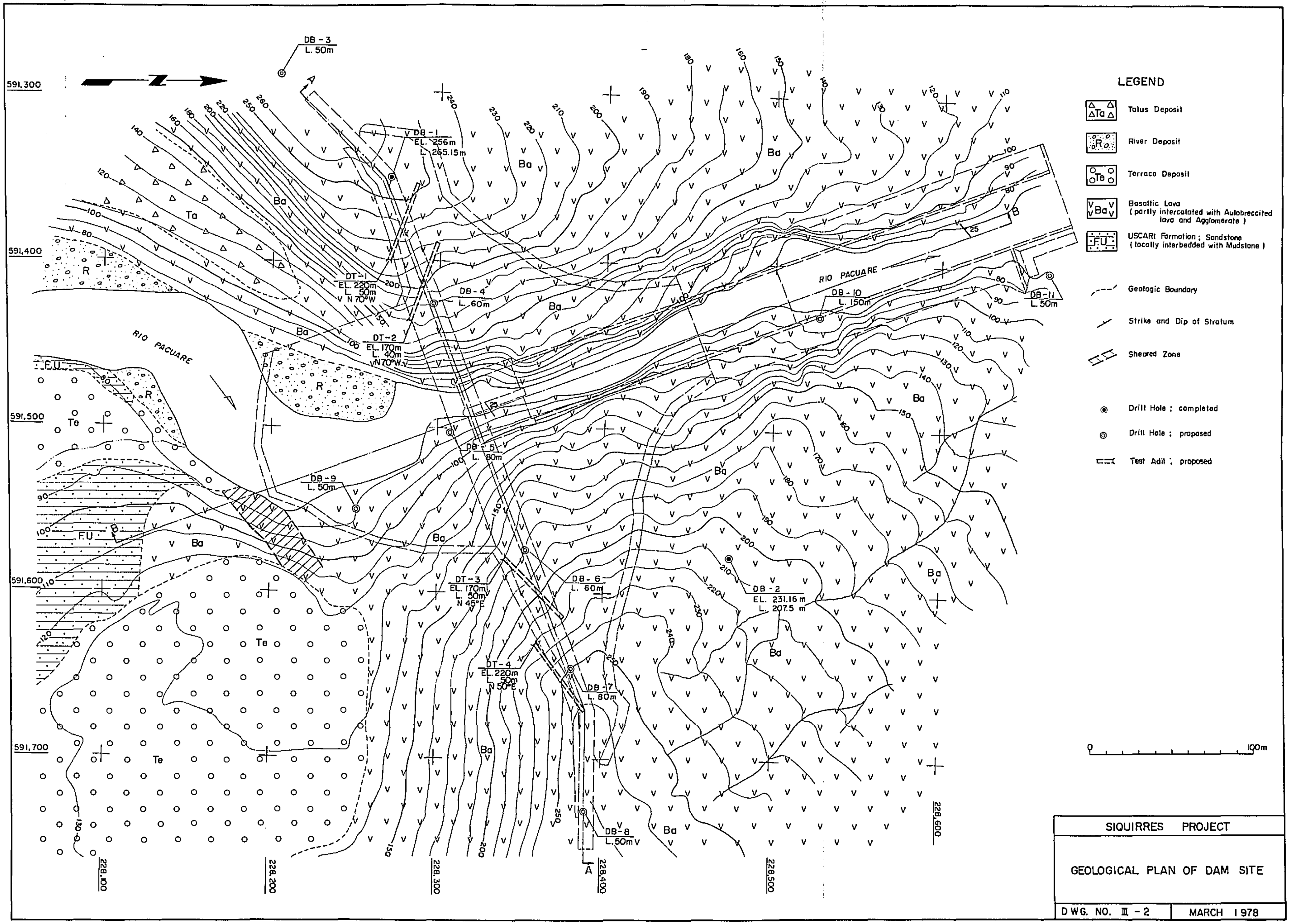
Drill hole	No.	Site	Length (m)	Remarks
Drill hole	DB-3	Left bank	50	Water pressure test should be performed at all drill holes.
	DB-4	" bank	60	
	DB-5	Right bank	80	
	DB-6	" bank	60	
	DB-7	" bank	80	
	DB-8	" bank	50	
	DB-9	" bank	50	
	DB-10	" bank	150	
	DB-11	" bank	50	
Test adit	DT-1	Left bank	50	
	DT-2	" bank	40	
	DT-3	Right bank	50	
	DT-4	" bank	50	

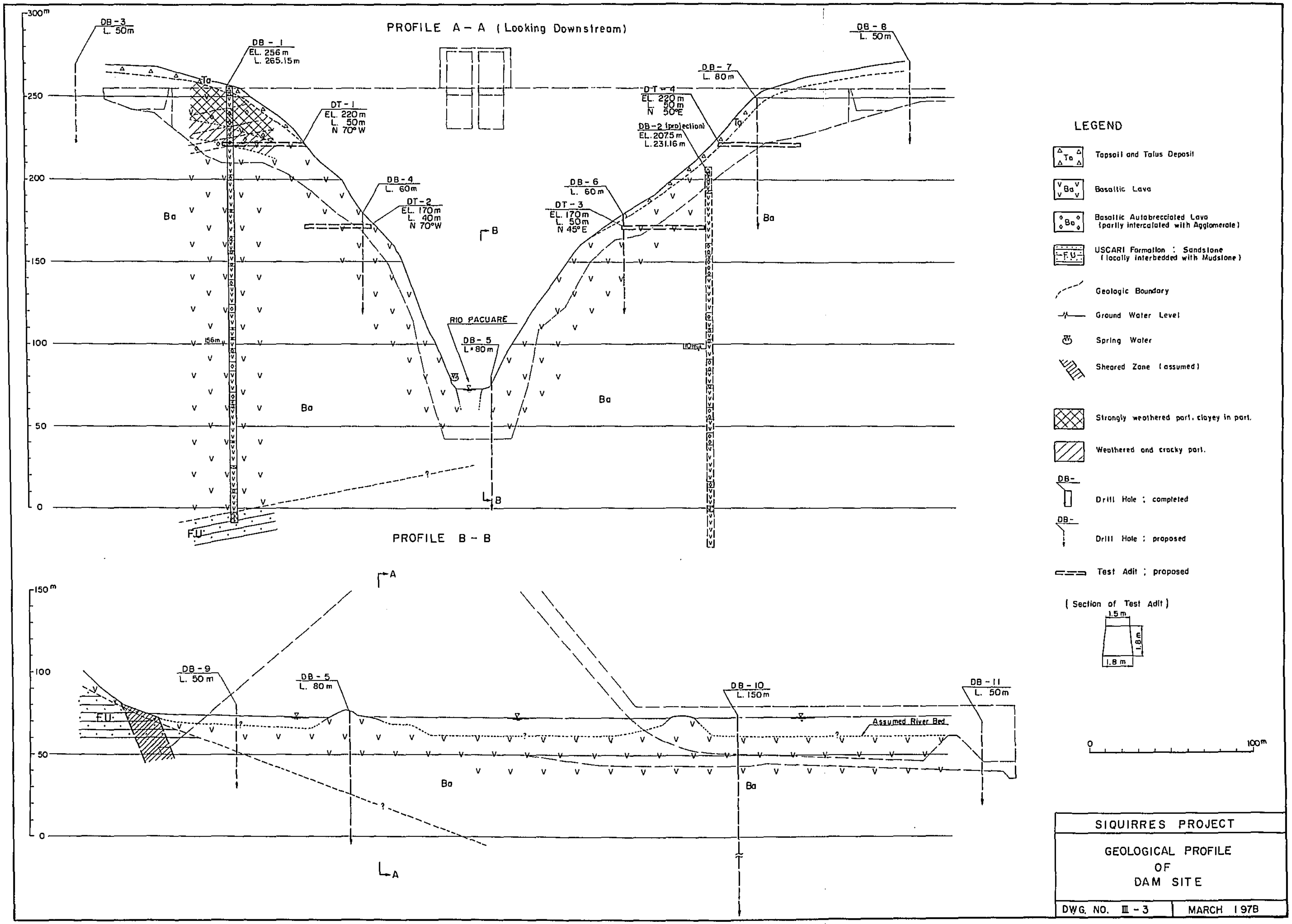
At first, the drilling of holes could be made to obtain a basic geological data based on which proposed Dam axis and Dam height could be determined, then test adits could be excavated to obtain additional geological data based on which more detailed design of Dam could be prepared. Dam height could possibly be very high, and it is necessary to clear the characteristics of soft Uscari formation of sandstone and mudstone on which the basalt is founded. Especially, a block shearing test and plate loading test should be made on exposed rocks of Uscari formation in the upstream of Dam site before the definit study on height and type of Dam.

In reservoir-area, an extensive geological survey should be performed using a map of more than 1/5000 in scale for the clarification of geological structure. Especially, possibility of the land-slide accompanied by filled water in the reservoir should be studies. As far as checking on a map in scale of 1/ 25,000 is made, there seems no sites of saddle, topographically, around the reservoir area in the case of normal water level of 250 m.

For Headrace Tunnel route and Power Plant, it needs to grasp the topographic and geological conditions by preparing a topographic map of 1/2000, and seismic prospecting survey and exploratory drilling should be performed on the 1st and 2nd alternative, if they are found to be competitive, for the clarification of geological conditions.

Concrete aggregate can be obtained from places nearby Dam site. In planning a rockfil Dam, it is afraid whether impervious materials could be obtained or not in the area.


LEGEND
Talus Deposit
River Deposit
Terrace Deposit
Basaltic Lava (partly intercalated with Autobrecciated lava and Agglomerate)
USCARI Formation ; Sandstone (locally interbedded with Mudstone)
Geologic Boundary
Strike and Dip of Stratum
Sheared Zone
Drill Hole ; completed
Drill Hole ; proposed
Test Adit ; proposed
RIO PACUARE
SIQUIRRES PROJECT
GEOLOGICAL PLAN OF DAM SITE
DWG. NO. III - 2
MARCH 1978



SIQUIRRES PROJECT

GEOLOGICAL PROFILE OF DAM SITE

DWG. NO. III - 3 | MARCH 1978

CHAPTER 3

PLAN OF POWER GENERATION

CHAPTER 3 PLAN OF POWER GENERATION

LIST OF FIGURES

LIST OF TABLES

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CHAPTER 3 PLAN OF POWER GENERATION

3.1 BASIC CONSIDERATIONS

Basic considerations has been paid for the study of Siquirres Project as follows.

(1) Guayabo Power Plant is porposed in the upstream of Siquirres Dam site, and it could be assumed that Guayabo Plant were in operation with the maximum power discharge 140 m^3/sec which has been determined in Part II.

(2) According to an existing report*, there are two plans of development in Pacuare river for the downstream of Guayabo Power Plant, that is, a plan of development with a dam and that of development with two dams. In this study, the former plan of development will be adopted for a reason described below.

Main part of power system in Costa Rica will be occupied by hydro-power plants in future, and it will be necessary for the system to have new power plants with reservoirs which will be able to regulate flows seasonally. For the seasonal regulation in Siquirres reservoir, it will be necessary to have such a big capacity as a few hundreds million cubic meters judging from the much increment of flow in Pacuare river by the power discharge from Guayabo Plant. The plan of development with a dam could store about 430 million m^3, while that of development with two dams store about 130 million m^3. In view of seasonal regulation capability, the former could be advantageous over the latter.

* Report on Preliminary Master Plan for Hydro-electric Projects on the Reventazon and Pacuare rivers. Sept. 1977

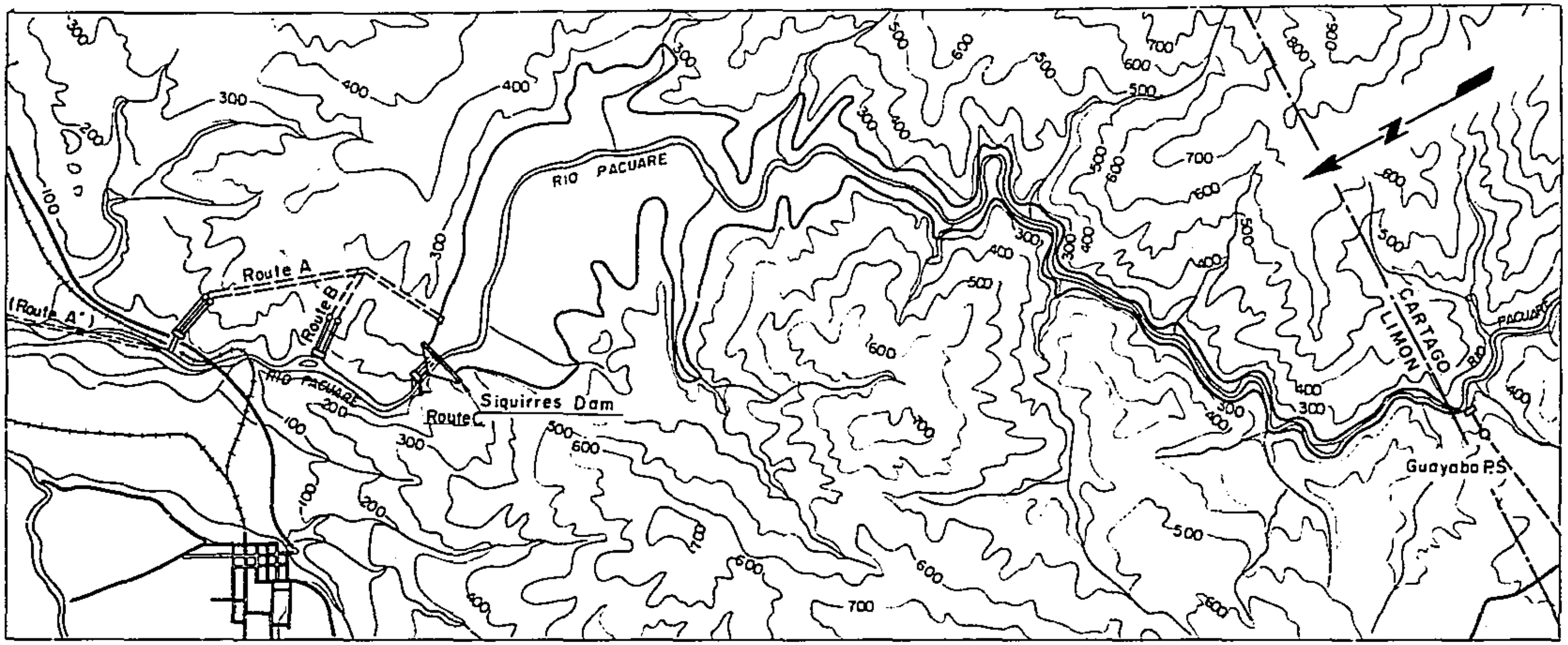
(3) Siquirres Dam site will be located at about 2.5 km upstream of a rail-way bridge on Pacuare river. The site have been surveyed and studied by ICE, and it will be the best site for a dam from a topographical point of view in addition to a good efficiency of storage, high head and a good location of power plant. The dam site is shown in Fig. III-3-1.

(4) The normal water level of Siquirres Dam will be EL 250 m which could be a marginal altitude for dam in view of topography, as mentioned in Section 1.3 of Chapter 1.

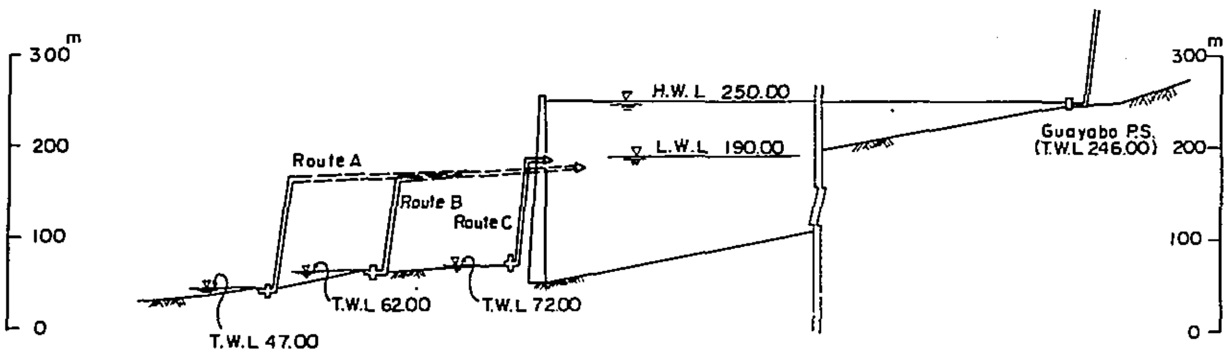
(5) The storage capacity of reservoir will be as large as possible in order to make seasonal regulation as explained in the item (2). The effective storage will be 430 million m^3 with a draw-down of 60 m.

Fig. III-3-1 Illustration of Alternative Plans

PLAN



PROFILE



3.2 FIRM DISCHARGE

Firm discharge of Siquirres Power Plant will be considered for April and December for a reason described in Chapter 5, "Plan of Power Generation", in Part II.

A mass-curve has been prepared by run-off data in 18 years from 1959 to 1976. Fig. III-3-2 shows the mass curve.

In the curve, the lowest discharges for April and December are 90 m^3/sec in 1959 and 100 m^3/sec in 1971 respectively. The second lowest discharges will be employed as the firm discharges.

Firm discharge for April : 102 m^3/sec (in 1964)

Firm discharge for December : 148 m^3/sec (in 1964)

3.3 MAXIMUM POWER DISCHARGE

For a study of maximum power discharge, it will be necessary to estimate the utilization factor of plant proposed in future giving due considerations to the shortage of power supply in the load duration curve. In this case, the factor could be estimated at 50%.

The maximum power discharge will be estimated at 240 m^3/sec from the firm discharge 102 m^3/sec for April with the utilization factor 50% multiplied by an adjustment factor 7/6 which implies the effect of week end.

3.4 RESERVOIR OPERATION

Fig. III-3-3 shows the operation rule of Siquirres reservoir which is prepared with reference to the mass-curve. The reservoir operation in 18 years are shown in Fig. III-3-4 on the basis of the operation rule.

The annual power discharge of Siquirres Power Plant will be 5,201 million m^3 if operated according to the operation rule, and the volume of discharges will amount to 98% of annual in-flows 5,306 million m^3.

The storage capacity factor, regulated discharge factor and capable duration of regulated discharge are as follows.

$$\text{Storage Capacity Factor} = \frac{\text{Effective Storage Capacity } (m^3/\text{sec.day})}{\text{Annual In-flow } (m^3/\text{sec.day})} \times 100$$

$$= 8\%$$

$$\text{Regulated Discharge Factor} = \frac{\text{Maximum Power Discharge } (m^3/\text{sec})}{\text{Annual In-flow } (m^3/\text{sec.day}/365 \text{ days})} \times 100$$

$$= 143\%$$

$$\text{Capable Duration of Regulated Discharge} = \frac{\text{Effective Storage Capacity } (m^3/\text{sec.day})}{\text{Maximum Power Discharge } (m^3/\text{sec})}$$

$$= 21 \text{ days}$$

Fig. Ⅲ-3-2 Mass Curve of Siquirres Reservoir (2-1)

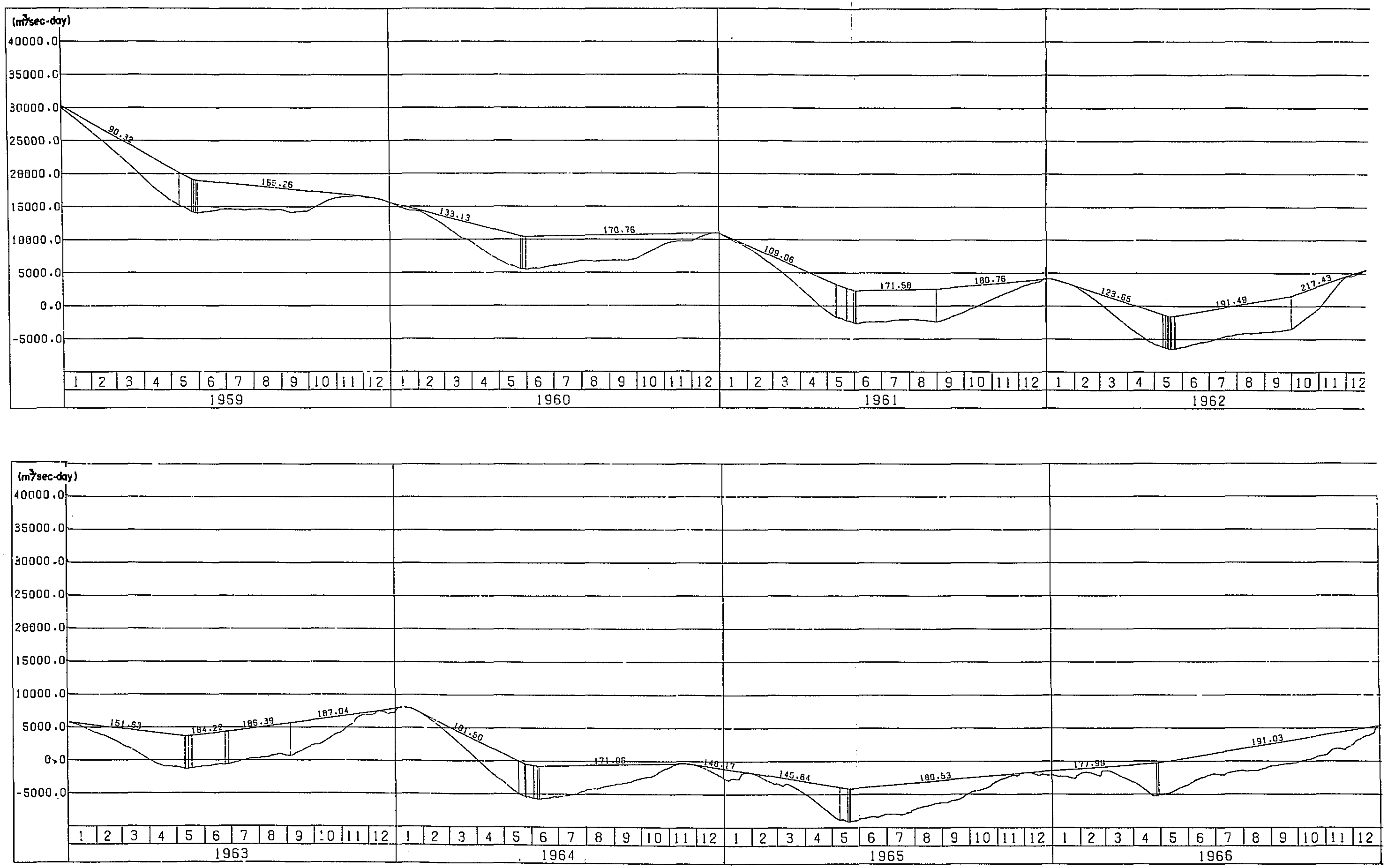


Fig. III-3-2 Mass Curve of Siquirres Reservoir (2-2)

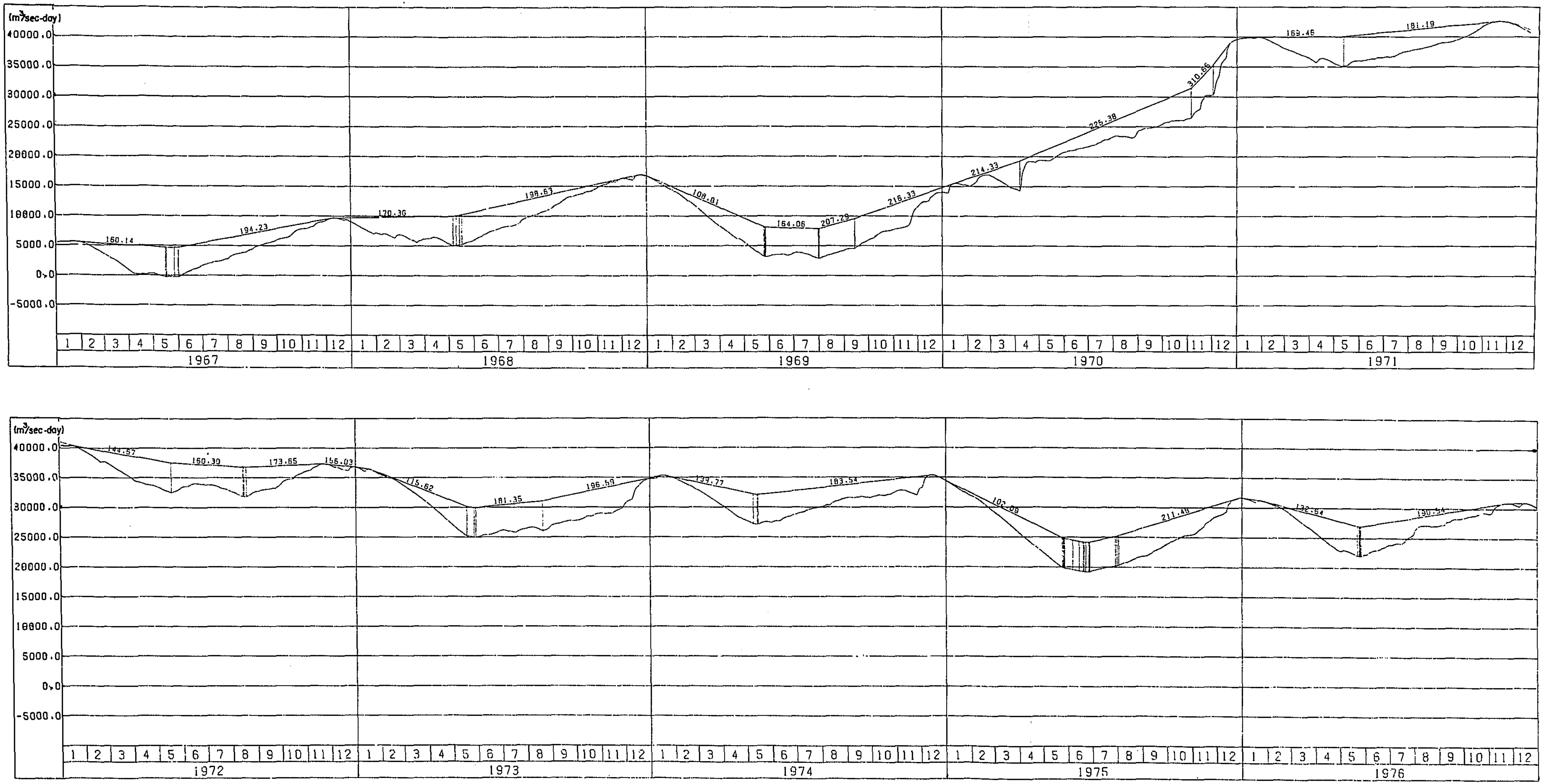
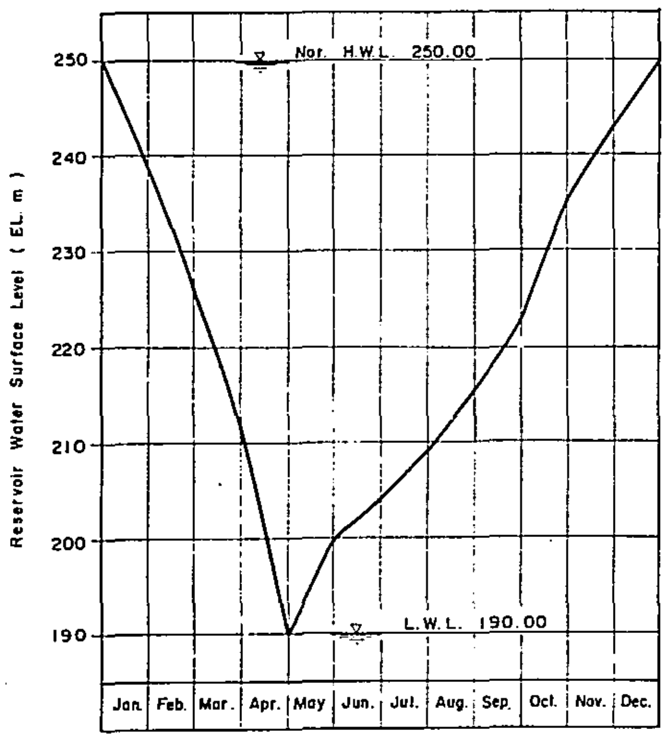


Fig III-3-3 Operation Rule of Reservoir

Month	Vs (m)	Vs ($10^6 m^3$)	Vs (m^3/sec-day)
Jan.	239	318.9	3691
Feb.	226	218.6	2530
Mar.	211	107.5	1244
Apr.	190	0	0
May	198	34.8	403
Jun.	204	68.6	794
Jul.	209	103.4	1197
Aug.	215	138.2	1600
Sept.	226	210.0	2430
Oct.	235	284.1	3288
Nov.	243	355.9	4119
Dec.	250	430.0	4977



Symbols (Unit ; m^3/sec-month)

V_{n-1}	:	Storage at the end of previous month
V_n	:	Storage at the end of current month
V_s	:	Standard middle limit at storage
V_{max}	:	Maximum storage
V_{min}	:	Minimum storage
f_n	:	Overflow in current month
Q_u	:	Standard Upper limit of discharge for power
Q_L	:	Standard lower limit of discharge for power
q_n	:	Inflow in current month
Q_n	:	Discharge for power in current month

Constants (Unit ; m^3/sec-month)

$Q_u = 200.0$ m^3/sec

$Q_L = 90.0$ m^3/sec

Basic Formulas

$V_{max} \geq V_{n-1} + q_n - Q_n \longrightarrow V_n = V_{n-1} + q_n - Q_n$

$V_{max} < V_{n-1} + q_n - Q_n \longrightarrow \begin{cases} V_n = V_{n-1} + q_n - Q_n - f_n \\ f_n = V_{n-1} + q_n - Q_n - V_{max} \end{cases}$

Operation rule

1. $V_{n-1} + q_n > V_s$

   (1) $Q_u \leq V_{n-1} + q_n - V_s \longrightarrow Q_n = Q_u$

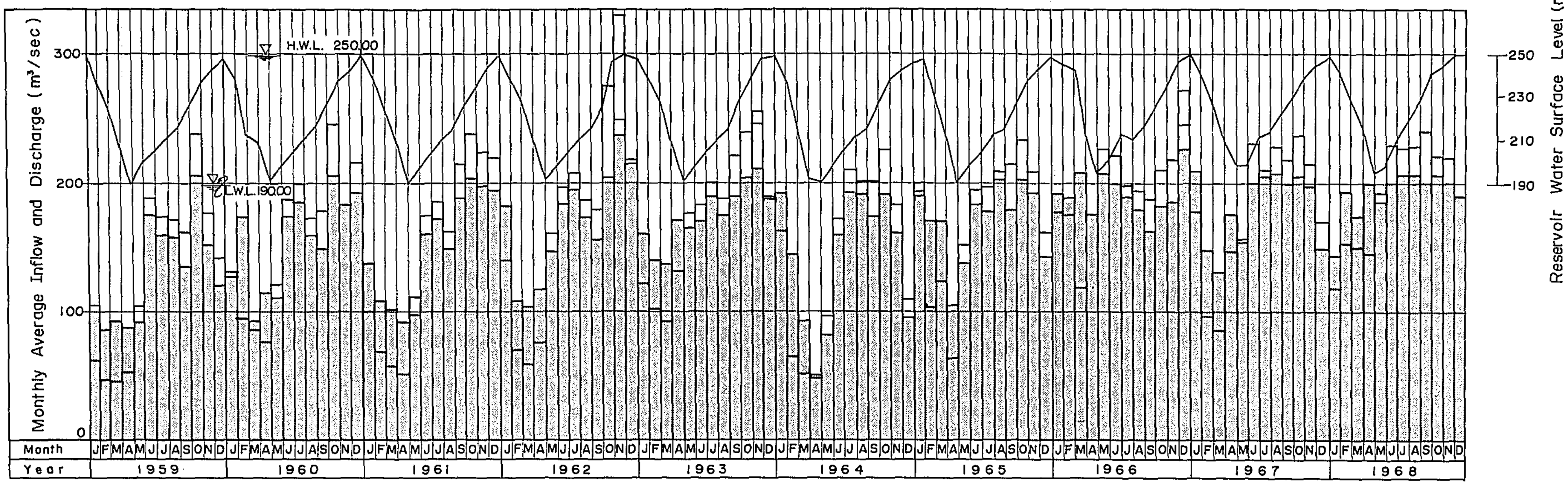
   (2) $Q_u > V_{n-1} + q_n - V_s \longrightarrow Q_n = V_{n-1} + q_n - V_s$

2. $V_{n-1} + q_n < V_s$

   (1) $Q_L \leq V_{n-1} + q_n - V_{min} \longrightarrow Q_n = Q_L$

   (2) $Q_L > V_{n-1} + q_n - V_{min} \longrightarrow Q_n = V_{n-1} + q_n - V_{min}$

Fig.Ⅲ-3-4 In-Flow, Power Discharge and Water Surface of Siquirres Reservoir



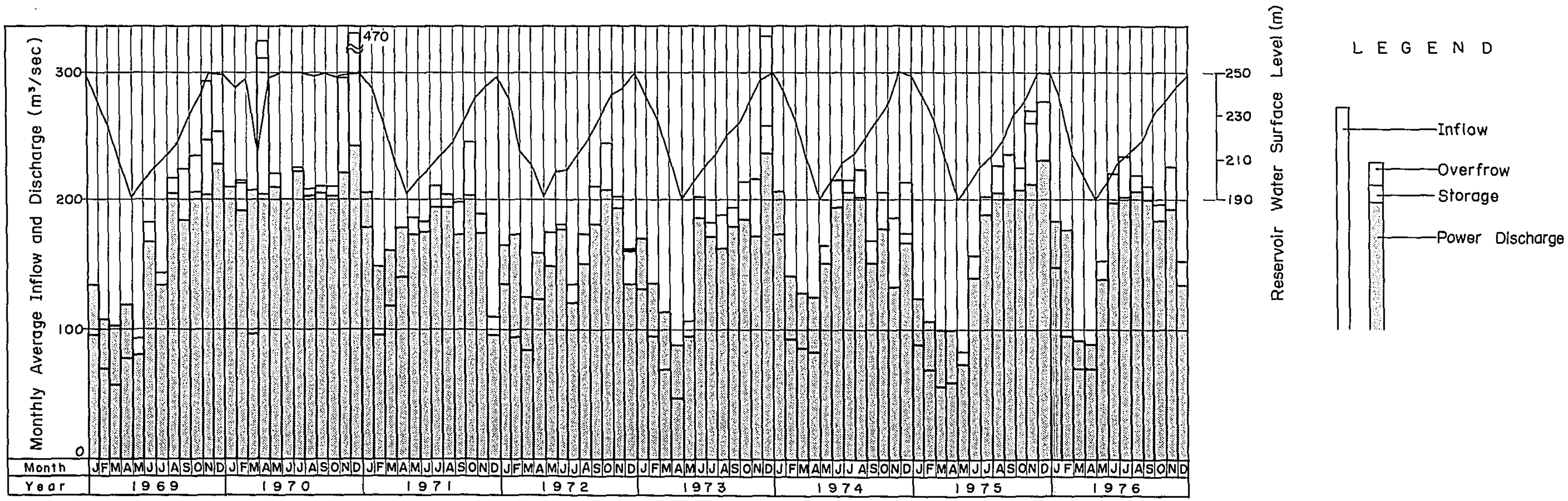
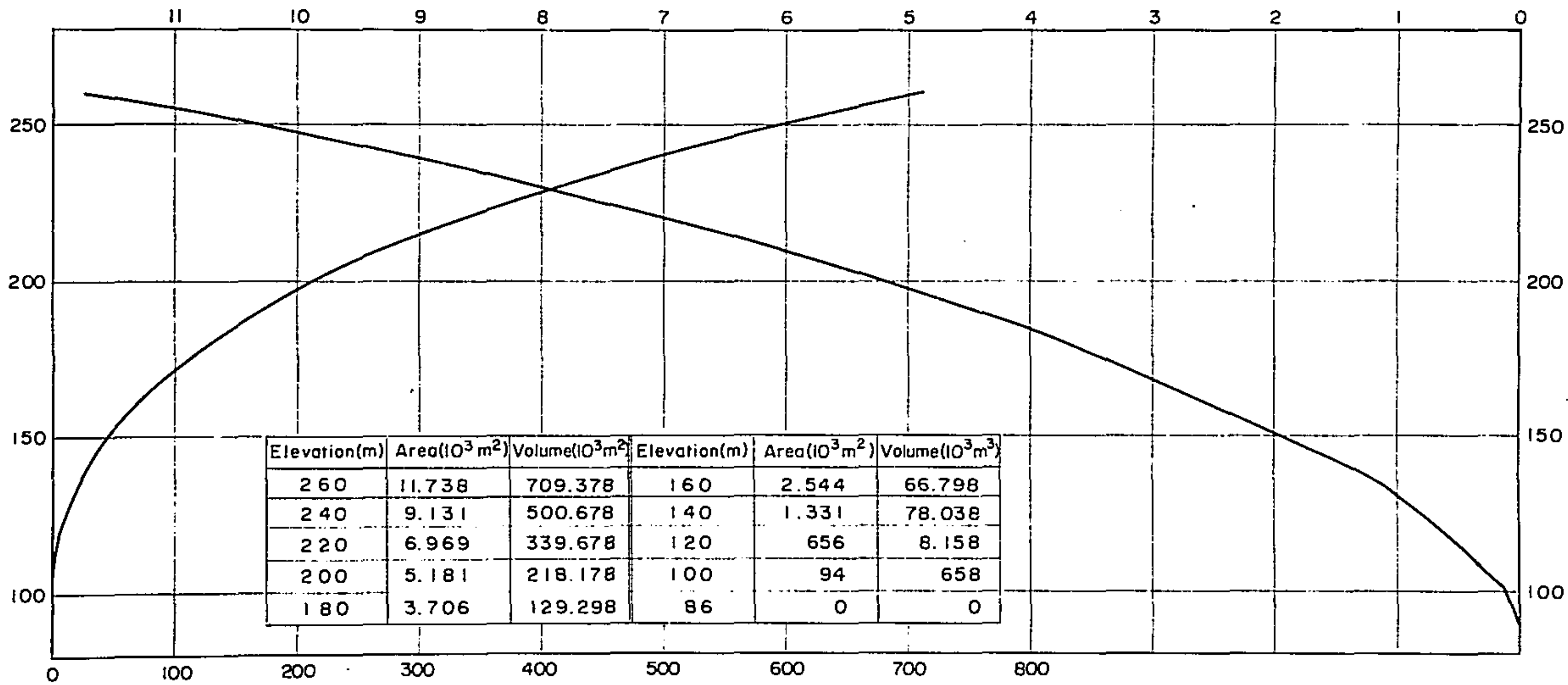


Fig.III-3-5 Reservoir Surface Area and Storage Capacity Curve (Siquirres Site)

← Reservoir Surface Area (x $10^6 m^2$)



Elevation(m)	Area($10^3 m^2$)	Volume($10^3 m^2$)	Elevation(m)	Area($10^3 m^2$)	Volume($10^3 m^3$)
260	11.738	709.378	160	2.544	66.798
240	9.131	500.678	140	1.331	78.038
220	6.969	339.678	120	656	8.158
200	5.181	218.178	100	94	658
180	3.706	129.298	86	0	0

Reservoir Storage Capacity (x $10^6 m^3$) →

map scale ; 1/25 000, 1/50 000

3.5 WAY OF POWER GENERATION

3.5.1. Alternative Ways of Power Generation

Three alternative ways of routes are proposed for the power generation, and a benefit cost comparison is made on the alternatives below (see Fig. III-3-1).

Route A: The length of headrace tunnel will be the longest among them, about 2.8 km, and the head increment from the dam site about 25 m.

Route B: The length of tunnel will be the second among them, about 1.8 km, and the head increment about 15 m.

Route C: The plant will be located immediately downstream of the dam.

Table III-3-1 shows such statistical figures as heads, installed capacities, annual possible energy.

3.5.2. Pre-requisite for Comparison

Following pre-requisites are assumed for the comparison of alternatives.

(1) An economic comparison will be made on the basis of benefit cost ratio (B/C) and surplus benefit (B - C), and the values of benefit for power could be taken from the values of annual cost for the alternative thermal power plant described in Chapter 8, "Economic Evaluation", of Part II.

(2) The beneficial peak output and energy will be estimated for the determination of the benefit as follows.

  (a) The beneficial peak output will be the average of peak outputs for April and December, which could be estimated from the firm discharges of the months, deducted the total loss 2.8% (2.5% loss by accidents or repairs and 0.3% loss for plant service.) The utilization factor will be estimated more than 50%, (that means more than 12 hours operation), for the shortage of power in the load duration curve in future.

  (b) The beneficial energy will be the annual possible energy deducted the same loss 2.8%. The annual possible energy will be calculated on the basis of a reservoir operation rule, and be annual average energy in 18 years from 1959 to 1976 which is a period of analysis.

(3) The annual cost will be determined by multiplying simply an annual cost factor (11.4%) to the total construction cost.

3.5.3 Construction Cost

The construction cost will be estimated on the basis of the preliminary designs which are shown in DWG. No. III-4 ~ 9. The costs for items of the work are shown in Table III-3-2. The total construction cost for each alternative route is shown below, without including the costs of transmission line and sub-station.

Alternative	Construction Cost (Colones)
Route A	4,280 million
Route B	3,900 million
Route C	3,480 million

3.5.4 Result of Study

A result of economic comparison is shown in a table below, and the details are shown in Table III-3-3. In the table, the alternative Route-C could be the best as far as the benefit cost comparison is concerned.

Alternative	Cost per kWh (Colones/kWh)	Benefit Cost Ratio (B/C)	Surplus Benefit (B - C) (million Colones)
Route A	2.07 (2.05) *	1.24 (1.26) *	118 (142) *
Route B	2.03	1.27	119
Route C	1.88	1.36	144

* Sub-alternative of A, designated A'

The sub-alternative, Route A', could give an increment of head, about 27 m, to the power plant of Route A if it could provide a tailrace channel of 2.8 km. The tailrace channel could be found on the alluvium which would have much uncertainties for the construction.

A result of rough benefit cost analysis is shown in parenthesis in the table above, and seems more or less beneficial. However, the sub-alternative has much uncertainties for the foundation of tailrace channel, and it could be concluded herewith that the alternative, Route C, could be the best.

The study is made on the basis of maps with a scale of 1/25,000, and it will be necessary for the improvement of accuracy of the study to execute the following surveys until the study in future.

(1) Surveying of Longitudinal Profil of River:

The range of surveying will be limited from the dam site (EL 70 m) to the end of tailrace for the sub-alternative, Route A' (EL 20 m)

(2) Surveying for Topography:

The range covers an area between the end of tailrace for the alternative, Route A', and the power plant areas for the alternative, Route C, with an scale more than 1/10,000.

Table III-3-1 Outline of Alternatives

	Item	Unit	Alternatives Route A	Route B	Route C
Catchment Area	Siquirres Site	Km^2	650	(Same As Left)	(Same As Left)
	Guayabo Site	Km^2	1,518		
	Total	Km^2	2,168		
Annual Inflow	Siquirres Site	$10^6 m^3$	2,010	(Same As Left)	(Same As Left)
	Guayabo Site	$10^6 m^3$	3,296		
	Total	$10^6 m^3$	5,306		
Reservoir	Normal Water Level	m	250		
	Low Water Level	m	190		
	Surface Area	Km^2	10.3	(Same As Left)	(Same As Left)
	Gross Capacity	$10^6 m^3$	600		
	Effective Capacity	$10^6 m^3$	430		
	Drowdown	m	60		
Dam	Type		Concrete Gravity	(Same As Left)	(Same As Left)
	Height x Crest Length	m	205 x 495		
	Volume	$10^3 m^3$	2,640		
Waterway	Headrace Tunnel (Dia x Length)	m	$60^m x 2780^m x 2$	60 x 1750 x 2	-
Power Generation	Standard Reservoir Level	m	230	230	230
	Tailwater Level	m	47	62	72
	Standard Effective Head	m	172	160	154
	Max. Power Discharge	m^3/sec	240	240	240
	Installed Capacity	MW	350	325	310
	Annual Energy Possible	$10^6 kWh$	2,070	1,920	1,850
Construction Cost	Total Cost	10^6 Colones	4,280	3,900	3,480
	Cost Per kW	10^3 Colones	12.2	11.8	11.2
	Cost Per kWh	Colones	2.07	2.03	1.88

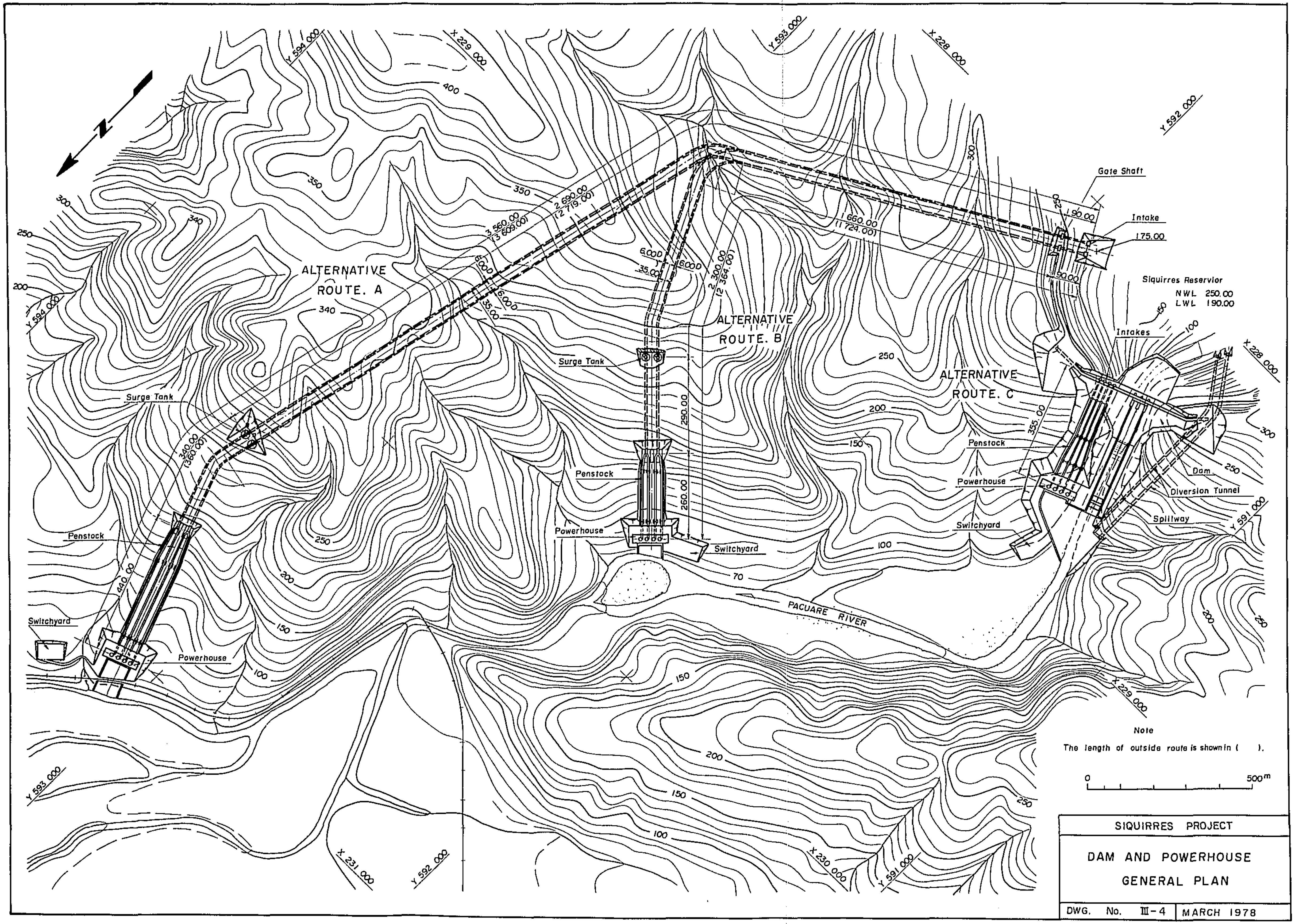
Table III-3-2 Summary of Estimated Construction Cost

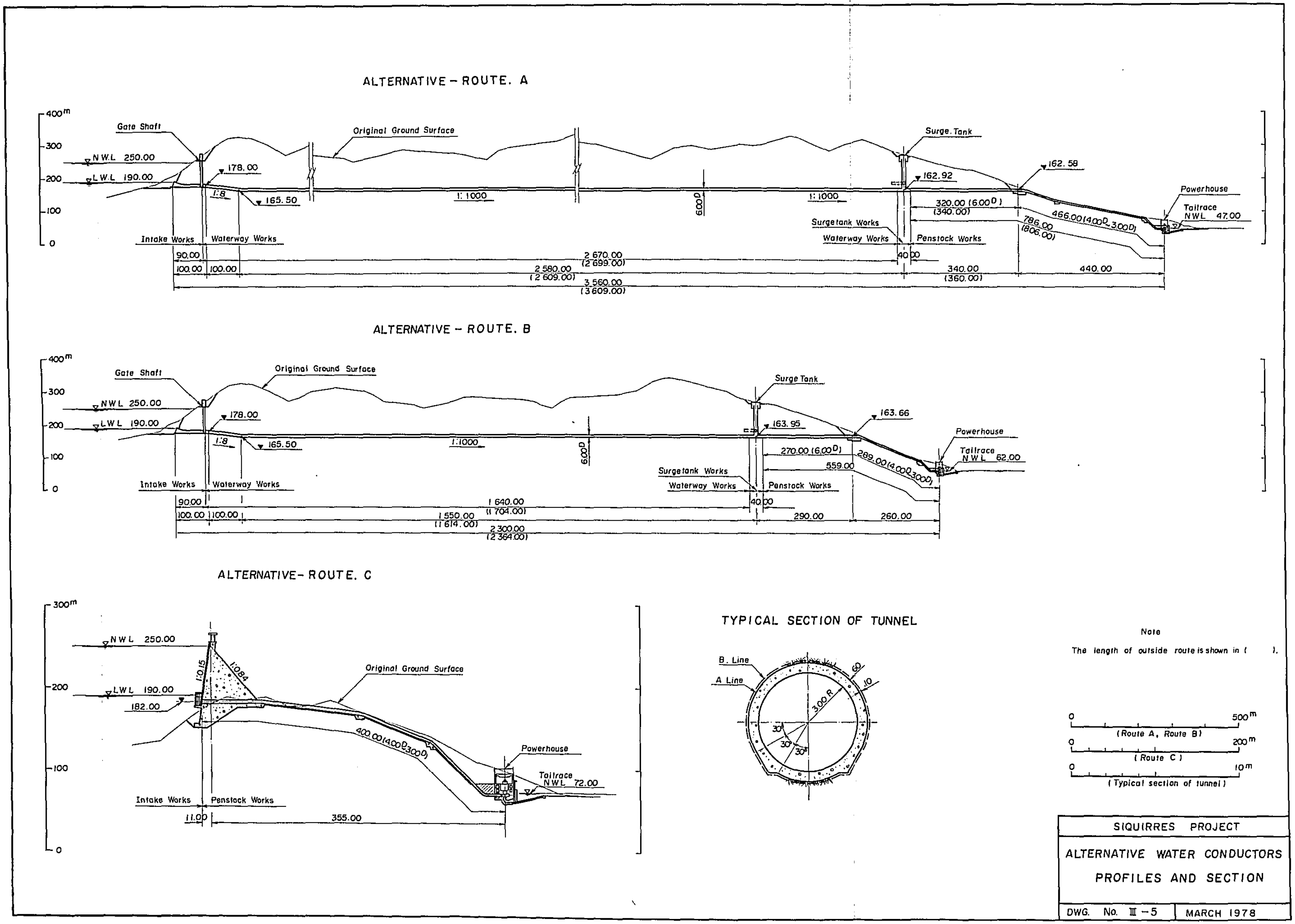
(Unit: 10^3 Colones)

Alternatives / Item of cost	Route A	Route B	Route C
1. Generating Facility			
1.1 Civil Works	2,266,000	2,121,000	1,888,000
(1) Diversion and Care of River	99,200	99,200	99,200
(2) Dam	1,320,000	1,320,000	1,320,000
(3) Intake	47,200	47,200	6,200
(4) Headrace Tunnel	245,000	152,600	0
(5) Surge Tank	38,100	37,900	0
(6) Penstock Foundation	73,300	55,500	64,600
(7) Powerhouse and Tailrace	62,200	49,800	76,900
(8) Switchyard	3,200	5,400	6,400
(9) Contingencies	377,800	353,400	314,700
1.2 Hydraulic Equipment	334,000	237,000	182,000
(1) Gates	51,100	51,100	49,200
(2) Penstocks	180,600	113,520	77,400
(3) Installation Cost	46,300	32,900	25,300
(4) Contingencies	56,000	39,480	30,100
1.3 Electric Equipment	500,000	465,000	447,000
2. Preparation Work	136,000	127,000	113,000
3. Engineering	162,000	147,000	132,000
4. Administration Cost	162,000	147,000	132,000
5. Compensation	10,000	6,000	6,000
6. Interest During Construction	710,000	650,000	580,000
Total	4,280,000	3,900,000	3,480,000

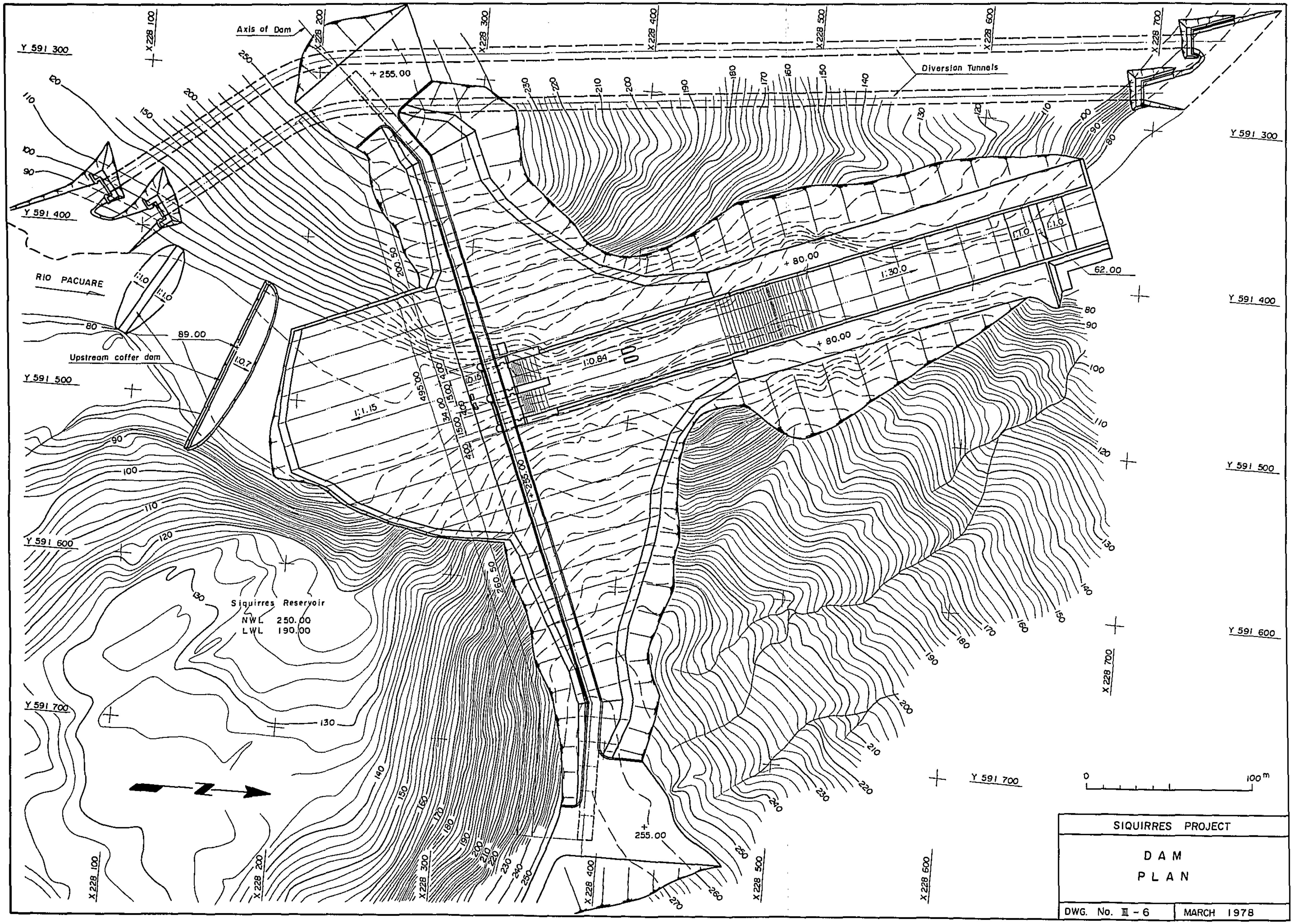
Table III-3-3 Benefit-Cost Comparison Between Alternatives

Item	Unit	Alternative -Route A-	Alternative -Route B-	Alternative -Route C-
Effectiv Head	m	172	160	154
Max. Power Discharge	m^3/sec	240	240	240
Installed Capacity	MW	350	325	312
Beneficial Peak Output	MW	315	293	281
Beneficial Energy	10^6kWh	2,012	1,866	1,978
kW Benefit (B1)	10^6 Colones	224	209	200
kWh Benefit (B2)	10^6 Colones	382	355	341
Total Benefit (B=B1 + B2)	10^6 Colones	606	564	541
Construction Cost	10^6 Colones	4,280	3,900	3,480
Construction Cost per kWh	C/kWh	2.07	2.03	1.88
Annual Cost (C)	10^6 Colones	488	445	397
Benefit Cost Ratio (B/C)	-	1.24	1.27	1.36
Annual Surplus Benefit (B - C)	10^6 Colones	118	119	144


N
ALTERNATIVE ROUTE. A
ALTERNATIVE ROUTE. B
ALTERNATIVE ROUTE. C
Surge Tank
Penstock
Powerhouse
Switchyard
Gate Shaft
Intake
175.00
Siquirres Reservior
NWL 250.00
LWL 190.00
Intakes
Dam
Diversion Tunnel
Spillway
PACUARE RIVER
3 560.00 (3 609.00)
2 690.00 (2 719.00)
1 660.00 (1 724.00)
2 300.00 (2 364.00)
Note
The length of outside route is shown in ( ).
0
500m
SIQUIRRES PROJECT
DAM AND POWERHOUSE GENERAL PLAN
DWG. No. III-4
MARCH 1978

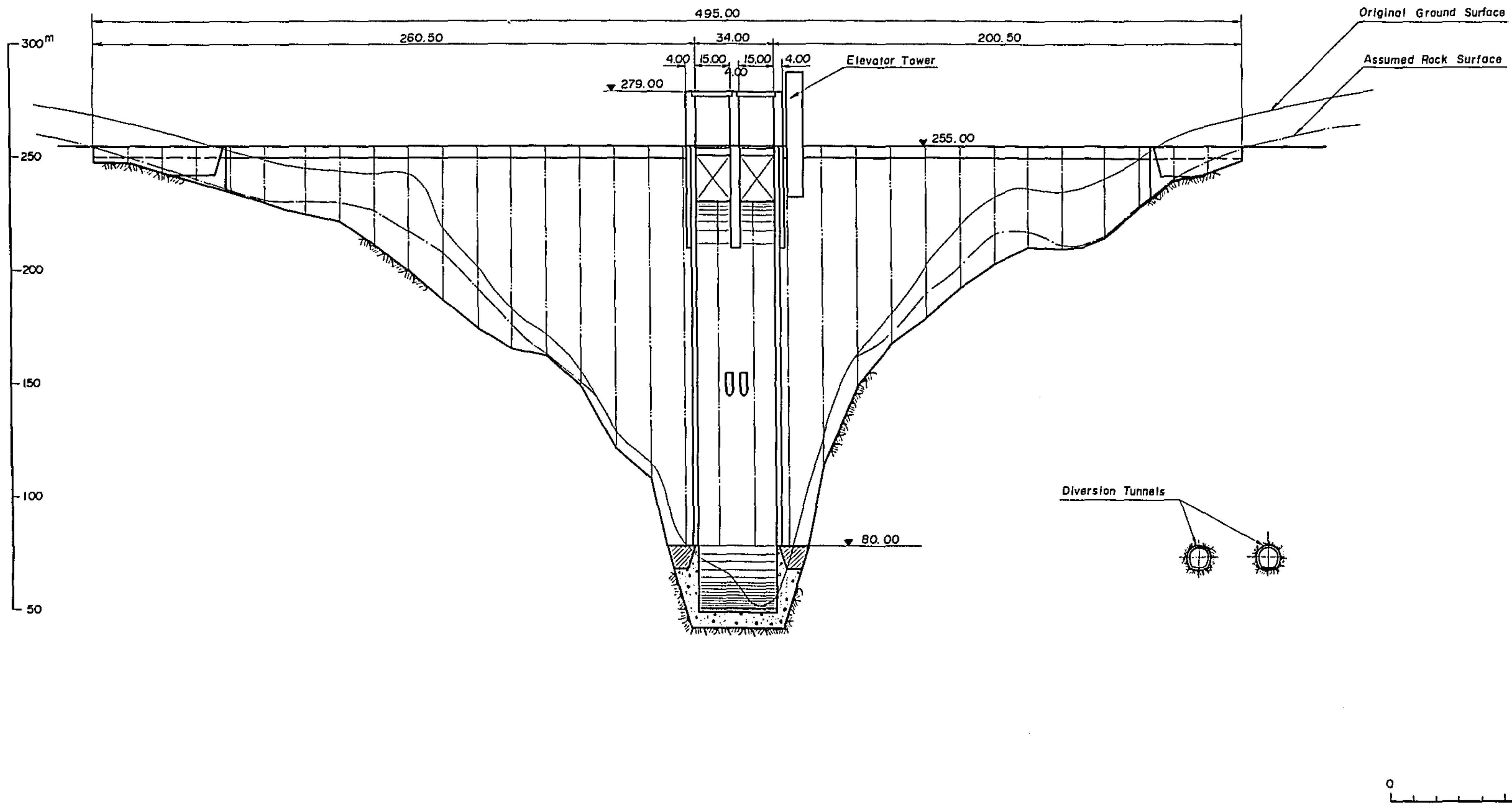


ALTERNATIVE - ROUTE. A
Gate Shaft
Original Ground Surface
Surge. Tank
NWL 250.00
LWL 190.00
178.00
165.50
1:8
1:1000
6.00D
162.92
162.58
Powerhouse
Tailrace NWL 47.00
320.00 (6.00D) (340.00)
466.00(4.00D 3.00D)
786.00 (806.00)
Intake Works
Waterway Works
Surgetank Works
Penstock Works
90.00
100.00
2 670.00 (2 699.00)
2 580.00 (2 609.00)
3 560.00 (3 609.00)
40.00
340.00 (360.00)
440.00
ALTERNATIVE - ROUTE. B
Gate Shaft
Original Ground Surface
Surge Tank
NWL 250.00
LWL 190.00
178.00
165.50
1:8
1:1000
6.00D
163.95
163.66
Powerhouse
Tailrace NWL 62.00
270.00 (6.00D)
559.00
289.00(4.00D 3.00D)
Intake Works
Waterway Works
Surgetank Works
Penstock Works
90.00
100.00
1 640.00 (1 704.00)
1 550.00 (1 614.00)
2 300.00 (2 364.00)
40.00
290.00
260.00
ALTERNATIVE- ROUTE. C
NWL 250.00
LWL 190.00
182.00
1:0.15
1:0.84
Original Ground Surface
400.00(4.00D 3.00D)
Powerhouse
Tailrace NWL 72.00
Intake Works
Penstock Works
11.00
355.00
TYPICAL SECTION OF TUNNEL
B. Line
A Line
3.00 R
.60
.10
30°
Note
The length of outside route is shown in ( ).
0 500m (Route A, Route B)
0 200m (Route C)
0 10m (Typical section of tunnel)
SIQUIRRES PROJECT
ALTERNATIVE WATER CONDUCTORS
PROFILES AND SECTION
DWG. No. III-5
MARCH 1978



Axis of Dam
Diversion Tunnels
RIO PACUARE
Upstream coffer dam
89.00
Siquirres Reservoir
NWL 250.00
LWL 190.00
+ 255.00
+ 80.00
62.00
1:30.0
1:0.84
1:1.15
1:0.7
1:1.0
Y 591 300
Y 591 400
Y 591 500
Y 591 600
Y 591 700
X 228 100
X 228 200
X 228 300
X 228 400
X 228 500
X 228 600
X 228 700
0
100 m
SIQUIRRES PROJECT
DAM
PLAN
DWG. No. III - 6
MARCH 1978

DOWNSTREAM ELEVATION

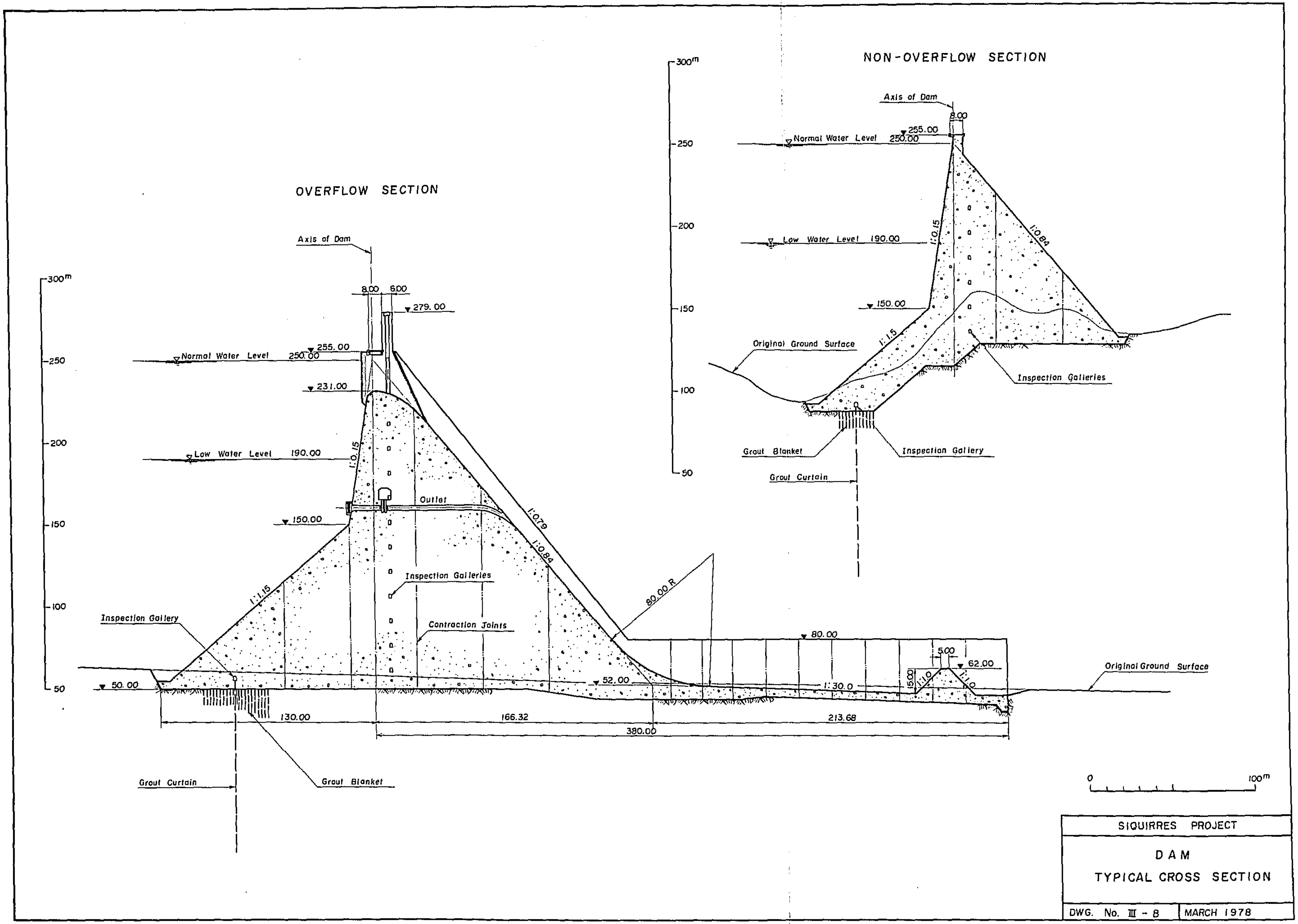


SIQUIRRES PROJECT

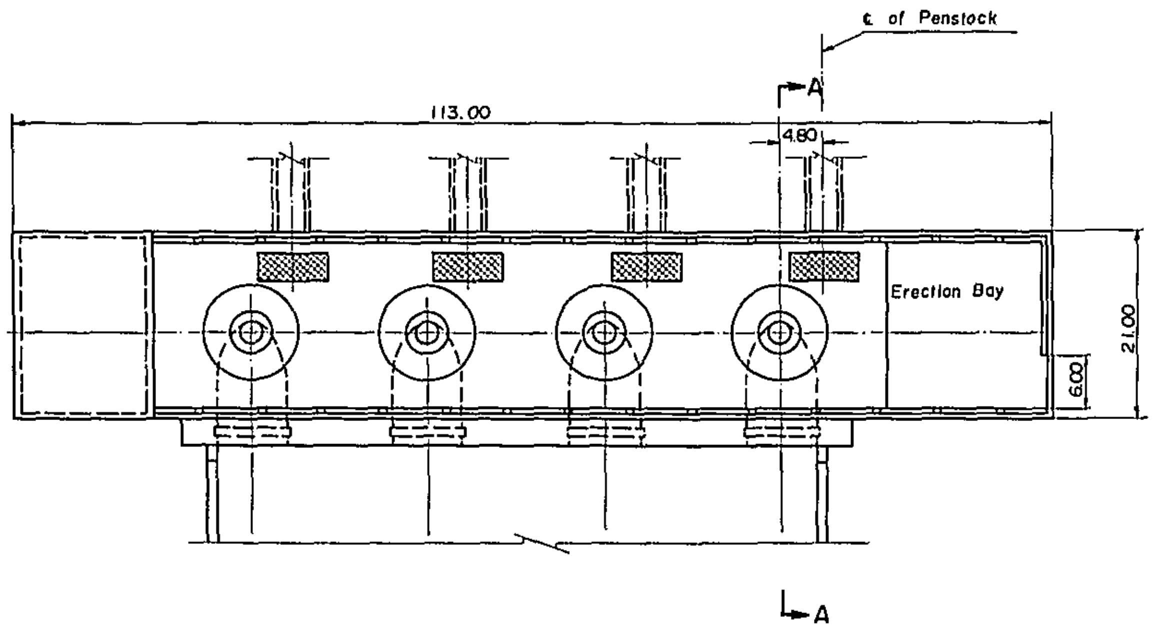
DAM

DOWNSTREAM ELEVATION

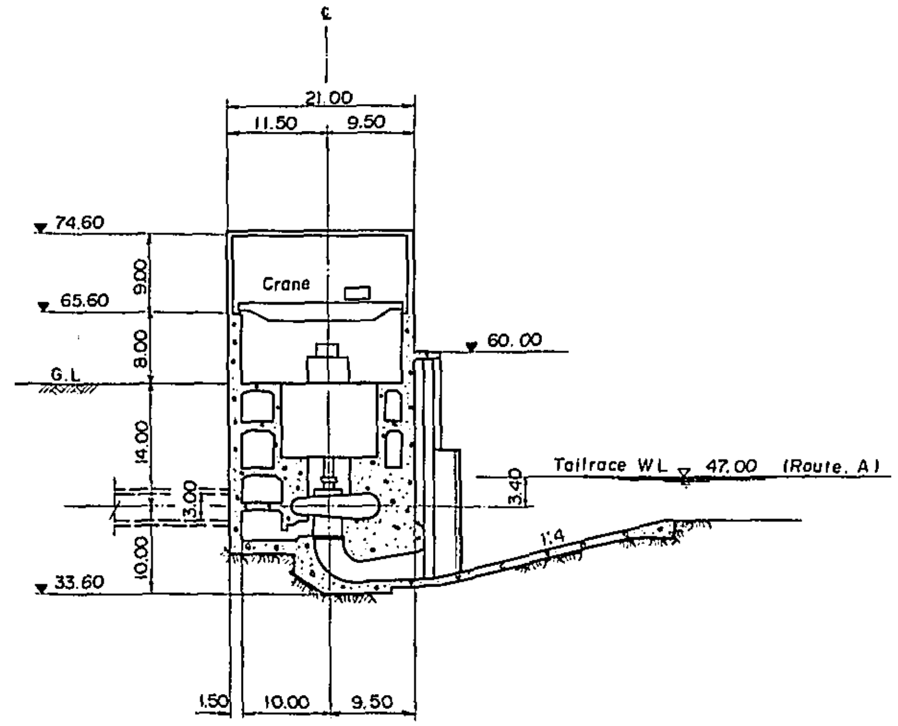
DWG. No. III - 7 | MARCH 1978


OVERFLOW SECTION
NON-OVERFLOW SECTION
Axis of Dam
Normal Water Level 250.00
Low Water Level 190.00
255.00
279.00
231.00
150.00
8.00
6.00
Outlet
1:0.15
1:0.79
1:0.84
1:1.15
1:1.5
Inspection Galleries
Inspection Gallery
Contraction Joints
80.00 R
80.00
52.00
50.00
62.00
5.00
15.00
1:1.0
1:30.0
130.00
166.32
380.00
213.68
Grout Curtain
Grout Blanket
Original Ground Surface
300m
250
200
150
100
50
0
100m
SIQUIRRES PROJECT
DAM
TYPICAL CROSS SECTION
DWG. No. III - 8
MARCH 1978

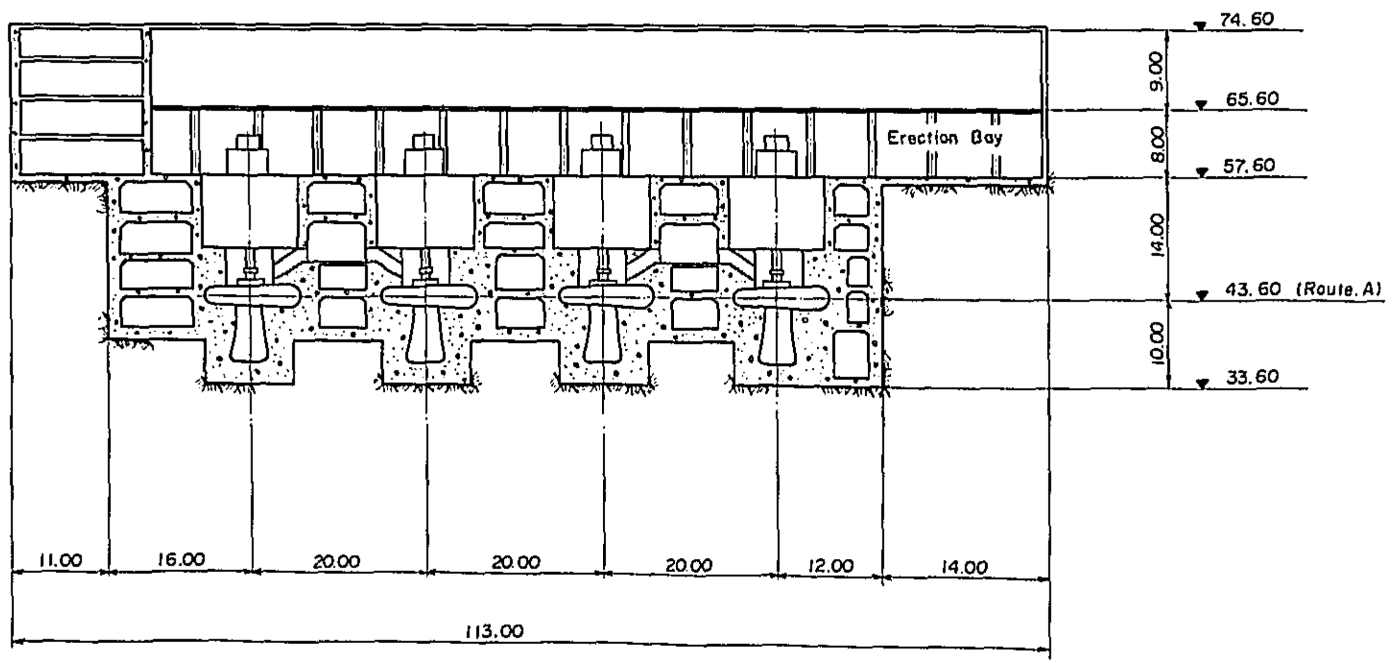
PLAN



A–A SECTION



LONGITUDINAL SECTION



Note

1) This drawing shows the plan and sections of powerhouse in an alternative conductor (Route A).

2) In the other alternative conductors (Routes B, C), the dimensions are as same as that of Route A, but only the elevations are to be changed.

0 40m

SIQUIRRES PROJECT	
POWERHOUSE PLAN, SECTIONS	
DWG. No. III – 9	MARCH 1978

CHAPTER 4

ECONOMIC EVALUATION

CHAPTER 4 ECONOMIC EVALUATION

LIST OF TABLES

CHAPTER 4 ECONOMIC EVALUATION

4.1 MEANS OF ECONOMIC EVALUATION

The alternative Route C could be adopted for the development of Siquirres Project, since the Route C is the best plan among the 3 alternatives studied in Section 3.5, Chapter 3.

The economic evaluation of Siquirres Project, the alternative Route C, will be made on the basis of a comparison of the project with an alternative power project.

An oil thermal power plant will be selected as the alternative power plant.

The judgement of economic evaluation will be made on the benefit cost ratio and annual surplus benefit.

4.2 ANNUAL COST

The capital cost of Siquirres Project will amount to 3,740 million Colones, as shown in Table III-4-1.

This investment cost includes the contruction costs of substations, transmission lines and other facilities. (Fig. II-2-2 in Chapter 2, Part II shows the route of transmission line). The construction costs for items of the work are shown in Table III-4-1 with useful lives of facilities and equipments.

The rate of interest 10% will be employed with a reference to a result of study for Guayabo Project.

The annual cost calculated on the basis of the above-mentioned conditions will be 421 million Colones as shown in Table III-4-2 for a period of analysis 50 years.

4.3 ANNUAL BENEFIT

4.3.1 Salable Energy

As stated in Chapter 3 "Plan of Power Generation", the annual average possible energy in 18 years of Siquirres project (Route C) is 1,850 million kWh. An assumption has been made that its whole energy may be effectively consumed after the start of operation.

The total energy loss to be incurred from Plant to North Substation of San Jose will be estimated at 3.8% taking into account of transmission loss, loss due to accident in the plant or repairing work and loss by service for own-plant.

The annual salable energy calculated on the basis of the above-mentioned conditions will be 1,780 million kWh.

4.3.2 Annual Benefit

The annual benefit of Siquirres Project will be estimated by means of the benefit per kW and the benefit per kWh as stated in Chapter 8, Part II "Economic Evaluation".

The values are as follows:

Benefit per kW	713 Colones
Benefit per kWh	0.190 Colones

In the estimation of benefits, beneficial output (kW) will be an average of L_5 outputs in April and December, and beneficial energy (kWh) be salable energy in each year. The output and energy will be those of end of North Substation of San Jose, and take into account of loss 3.8% between the end and the Plant.

The beneficial output and beneficial energy of Power Plant are 265 MW and 1,780 million kWh respectively at the substation, and the annual benefit obtained from these values has become 527 million Colones.

4.4 RESULTS OF ECONOMIC EVALUATION

From the study made hitherto, the benefit cost ratio (B/C) and annual surplus benefit (B-C) will be computed as follows:

Annual Cost (C)	421 million Colones
Annual Benefit (B)	527 million Colones
Benefit Cost ratio (B/C)	1.25
Annual Surplus Benefit (B-C)	106 million Colones

The cost per kWh of delivery on arrival at North Substation of San Jose will be 0.24 colones.

Table III-4-1 Construction Cost and Useful Life (Yrs) of Facility

(Unit: 10^3 Colones)

Item	Useful Life Years	Total Cost
1. Generating Facilities		
Civil Works	50	1888,000
Hydraulic Equipment	50	182,000
Electric Equipment	35	447,000
Engineering Fee		132,000
Administration Cost		132,000
Others		119,000
Interest during Construction		580,000
Total		3480,000
2. Transmission Line and Other Facilities		
Transmission Line and Others	30	214,000
Engineering Fee		11,000
Administration Cost		11,000
Interest during Construction		24,000
Total		260,000
3. Total Construction Cost		3740,000

Table III-4-2 Annual Cost

(Unit: 10^3 Colones)

Item	Investment Cost	Annual Cost
1. Interest and Depreciation	3740,000	380,000
1.1 Civil Works	(2610,000)	(263,000)
1.2 Hydraulic Equipment	(252,000)	(25,000)
1.3 Electric Equipment	(618,000)	(64,000)
1.4 Transmission Line, Substation and Communication System	(260,000)	(28,000)
2. Maintenance and Operation	3740,000	18,000
2.1 Generating Facilities	(3480,000)	(15,000)
2.2 Transmission Line, Substation and Communication System	(260,000)	(3,000)
3. Administration Expense	3740,000	19,000
4. Other Expense	3740,000	4,000
Total Annual Cost (C)	-	421,000

APPENDIX

APPENDIX

A-1 TECHNICAL MEMORANDUM

September 23, 1977

MEMORANDUM

OF

NECESSARY DATA OR DOCUMENTS

FOR

GUAYABO PROJECT AND SIQUIRRES PROJECT

1. REQUIRED LEVEL OF STUDY

Guayabo Project .... Feasibility Level
Siquirres Project .... Pre-feasibility Level

2. HYDROLOGICAL AND METEOROLOGICAL DATA

Description of Items	Data or Documents	Note
2.1 River Flows	Guayabo:	
	Informe Hidrólogico Preliminar Proyecto Hidroélectrico Amistad, ICE 1974	Obtained
	Siquirres:	
	Informe Hidrólogico Preliminar Proyecto Hidroeléctrico Siquirres, ICE 1975	Obtained
2.2 Supplemental		
River Flow Data up-to-date Since May 1973	Guayabo Siquirres	Obtained
2.3 Flood Hydrograph and flood damages	Data for Design Flood and for Calculation of Benefit by flood control Avenida Maxima probable Río Pacuare Sitio de Presa Proyecto Hidroélectrico Siquirres. U.C. 1976	Guayabo site not obtained yet Siquirres site Obtained

Description of Items	Data or Documents	Note
2.4 Sedimentation	Data for Assumed Amount of Deposit in Reservoir and for Design of Diversion Works	Obtained
2.5 Other Items		
2.5.1 Histogram of Typical Daily Rainfall in wet and dry Seasons	Data for construction Method and Period	
2.5.2 Precipitation Evaporation Humidity Temperature Duration of Sunshine Hours Solar Radiation		Under Preparation
2.5.3 Descripcion System of Gaging Stations		

3. MAPS

Description of Items	Data or Documents	Note
3.1 Guayabo Project		
. Dam Site	1/1,000, 1/10,000, 1/25,000 (UN Standard 1/5,000)	
. Reservoir	1/10,000, 1/25,000 (UN Standard 1/10,000)	
. Tunnel	1/10,000 (UN Standard 1/10,000)	
. Penstock . Surge Tank . Power House	1/10,000 (UN Standard 1/2,000)	1/1,000 Under Preparation
3.2 Siquirres Project		
. Dam Site	1/500, 1/1,000, 1/10,000 1/25,000 *UN Standard is 1/50,000 but you had better to prepare more detailed maps)	Need for Maps of 1/1,000 and 1/2,000 Which Cover

(Continued)

Description of Items	Data or Documents	Note
		Extended Area, Under Preparation
• Reservoir	1/25,000 (UN Standard is 1/50,000 ditto)	1/10,000 Under Preparation
• Tunnel	1/10,000 (UN Standard is 1/50,000 ditto)	
• Penstock • Surge Tank • Power House	1/10,000 (UN Standard is 1/50,000 ditto)	1/2,000 Under Preparation

4. GEOLOGY AND EXPLORATION

Description of Items	Data or Documents	Note
4.1 Guayabo	• Proyecto Amistad - Siquirres Sitio de Presa de Guayabo	Obtained
	"Informe Geológico de Recono cimiento" Junio 1975 I.C.E.	Obtained
	• Proyecto Amistad Línea de Túnel y Casa de Máquinas "Informe de Reconocimiento-Geológico" Mayo 1975 I. C. E.	Obtained
	• Plans Originally Prepared by Dr. Setsumi Miyamura for I. C. E. July 1975	Obtained
	• Aerial Photograph	Obtained
4.2 Siquirres	• Proyector Siquirres Sitio de Presa "Informe de Reconocimiento Geológico" Enero 1975 I. C. E.	Obtained
	• Proyecto Siquirres Línea de Túnel "Informe de Reconocimiento Geológico" Octubre 1975 I. C. E.	Obtained
	• Aerial Photograph	Obtained

Description of Items	Data or Documents	Note
4.3 Additional Investigation Required for Guayabo Project:	(Time limit ----- Beginning of November in this year)	
a) At Dam Site		
. Core Boring (PAM - 11)	. Data for Permeability Coefficient of Alluvium and Mudrock foundation Safety Analysis	Method As Indicated
. Test Pit (DP-1 -2)	. Data for gradation or quantity of Aggregates in Alluvium (Rock-fill material + Concrete aggregate)	Method of USBR
	. Data for Density of Alluvium in Layers (Safety Analysis)	Method of USBR
. Seismic Survey for foundation Rock (SP-1, -2, -3)	. Data for Rock qualities and finding - out of Faults (Safety Analysis)	As indicated
. Test Pit (CP-1 -2)	. Data for quantity and quality of impervious core such as gradation and content of water in soils (Alternative--Concrete Core) (Safety Analysis)	Method of USBR
b) Tunnel		
. Core Boring (PA-4)	. Data for sound Coverage of rock	As indicated

5. OTHER ENGINEERING DATA OR DOCUMENTS

Description of Items	Data or Documents	Note
5.1 References		
Published on Earthquake or Volcanic Activities in Costa Rica		

Description of Items		Data or Documents	Note
5.2	Design Criteria of structures against earthquake	. Codigo Sismico de Costa Rica C.F.C. 1974	Obtained
5.3	Ecological Map, Isohyetal map, soil classification map		Obtained
5.4	Reports on Project Implemented	. Data for local conditions including construction cost	
		. Arenal	Obtained
		. Informe del Estudio de Estabilidad de la Presa de Arenal I.C.E. 1977	
		. Design Report for Arenal Dam N° 1,2 W.A 1975	
		. Board of Consultants - Arenal N° 1,2 I.C.E. 1976/1977	
5.5	Construction Cost Estimates	(Agreement)	
5.5.1	Form of Cost Estimates	. Follows as International Standard such as UN's with Minor changes	
5.5.2	Pay Items		

. Contingencies

Land	10%
Civil works	15%
Tunnel works	20%
Penstocks, gates	15%
Turbines, Enerators Switchyard equipment	15%

Description of Items	Data or Documents	Note
• Others		
Investigation	As given by I.C.E.	
Engineering	5% of total C. Cost	
Administration	5% of total C. Cost	
Other costs	5% of total C. Cost	
5.5.3 Unit Price	• Determined with reference to I.C.E. price and Arenal of Cachi Projects's price	
	• Indice de Costos de la Direccion Construccion Energia en el año ICE 1977	Obtained
5.5.4 Partition of Unit Price for domestic and foreign currencies	Followed as ICE Standard	

6. ECONOMIC EVALUATION

Description of Items	Data or Documents	Note
6.1 Principle	Benefit-Cost Comparison (B/C, B - C)	
6.2 Period of Analysis	Determined from useful life of facilities, e.g. Dam 50 years Transmission Line 30 years Steam Plant 30 years Gas Turbine Plant 20 years Diesel Plant 25 years Geothermal Plant 30 years	
6.3 Interest Rate	Domestic 12% Foreign 8% (For Sensibility Analysis 6%, 4%, if possible) (Interest during construction is the same above) (Discount Rate determined by Survey Team) (Internal Rate of Return will be calculated)	

Description of Items		Data or Documents	Note
		(Effect of Inflation will be calculated, if possible)	
6.4	Conversion Rate	1 U.S.$ = 8.6 ₡	
6.5	Alternative Thermal (steam) Plant for Calculation of Benefit	Location : Moin Installed Capacity same as Hydro-power Unit capacity Less than or equal to 10% of Max. Power Demand Annual Plant Factor same as Hydro-Power Percent of Power House Service ; 5% Construction cost Determined by Survey Team Operation & Maintenance Ditto Administration ; Ditto Tax ; 5,44/kw-year Insurance ; 0.5% of Initial Investment cost Fuel ; 0.6746 (heavy oil at Moin in 1976) KW Adjustment factor Determined by Survey Team Route of Transmission Line ; Ditto	
6.6	Annual operation and Maintenance costs	From "Multiple Purpose River Basin Development", UN	
	Dam and reservoirs	0.1% of Capital cost	
	Intake and outlet works	1.0% of Capital cost	
	Hydro plants	1.0% of Capital cost	
	Steam plants (excluding fuel)	2.5% of Capital cost	
	Transmission lines	1.0% of Capital cost	

Description of Items	Data or Documents	Note
Penstocks	1.5% of Capital cost	
Gates, hoists, miscellaneous Metal work	1.5% of Capital cost	
Bridges, concrete and steel	3.0% where, i) (Capital cost)= (Direct Items) + (Indirect Items) ii) (Indirect Items)= (Contingencies) + (Engineering Fee) + (Interest During Construction)	
6.7 Annual Cost	= (Interest) + (O & M Cost) + (Depreciation)	
6.8 Depreciation	By Sinking Fund Depreciation	

7. LOAD FORECAST

7.1 Existing demand forecast	. Capítulo de mercado eléctrico 1976 - 1990 SNI	
Basic data	. Mercado eléctrico 1976-1990 SNI . Proyección del mercado eléctrico . Zonas de distribución las (Planos) principales empresas eléctricas de Costa Rica 1985 . Costos de operación y balances de situación de varias empresas eléctricas año 1986	

Description of Items	Data or Documents	Note
	. Informe de operación de las principales empresas productoras y distribuidoras de energía electrica año 1976	
	. Poblacion: Total, urbana y rural	
	. Grado de electrificacion	
7.2 Reference	. Plan Nacional de desarrollo 1978-1982 (OFIPLAN)	
7.3 Demand and supply balance	. Reunión annual #20 1976	
	. Total length of distribution lines	Not obtained yet
	. O.C.P. Sepias cuadro #4	
	. Commissioning dates of new power plants	
	. Document de trabajo 008-77 "Appendice"	Flow data
	. Loss rates of the power system	
	. Programa preliminar de obras (Plans) generación del SNI 1978-2000	
7.4 Interconnection	. Interconexión Costa Rica-Nicaragua-Línea de 230 KV	
	. Contrato de interconexion entre el ICE.y la ENALUF	
	. Sistema Nacional Interconectado	
7.5 Others	. Tarifas y reglamento para suministro de energia electrica	

8. OTHER DOCUMENTS RECEIVED

8.1 Proyecto Pacuare	. Informe Geológico de Reconocimiento-Sitios de Presa	

Description of Items	Data or Documents	Note
8.2 ICE	• Universidad de Costa Rica Facultad de Ingeniería Escuela de Ingeniería Civil • Definición Preliminar del Proyecto Hidroeléctrico de Siquirres - 1975	
8.3 ICE	• Informe Geológico Preliminar del Proyecto Hidroeléctrico de Angostura en el rio Reventazón 1969	
8.4 ICE	Informe de Reconocimiento Geologico a los Sitios de Presa #1 y #2 de la Alternative de Murcia en la Cuenca Media del Río Reventazón Julio 1972	
8.5 ICE	• Boletín Hidrológico #9 - Diciembre 1974	
8.6 ICE	Oficina de Proyectos -Seccion Geología -Ampliacion No. 1 - Rio Macho	
8.7 ICE	Sección de Geología -Informe Geólogico Final al Proyecto Hidroeléctrico de Cachí - 1963	
8.8 ICE	Desarrollo Hidroelectrico del Rio Arenal	
8.9 ICE	Proyecto Nacional de Servicio Meteorológico e Hidrológico OMM/PNUD/Gobierno de Costa Rica -Boletín Hidrológico - Junio 1975	

Description of Items	Data or Documents		Note
8.10 ICE:	Documento de trabajo	002-77	
ICE:	Ditto	003-77	
ICE:	Ditto	004-77	
ICE:	Ditto	004-77 (Apendix)	
ICE:	Ditto	005-77	
ICE:	Ditto	006-77	
ICE:	Ditto	00 -77	
8.11 CEPAL:	Naciones Unidas Consejo Económico y Social 1976		

Above-mentioned data, document, and agreements are obtained and reached between the persons below.

Mitsuharu Sato
LEADER OF JAPANESE MISSION

Carlos Ml. Obregón Q.
JEFE SECCION PROYECTOS HIDRO-ELECTRICOS, I.C.E.

A-2 RUN-OFF DATA OF ANGOSTURA AND DOS-MONTANAS GAUGING STATIONS

A-2-1 Angostura G.S.

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEC.
RIO REVENTAZON EN ANGOSTURA 73-03-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532 MSNM

ANO HIDROLOGICO 1953 - 1954 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1						77.2	103	64.5	37.9	50.1	43.0	43.5
2						83.7	88.6	62.7	101	48.3	44.4	45.3
3						93.4	74.2	60.5	92.4	49.4	42.3	45.1
4						96.3	69.3	59.9	93.3	48.1	57.5	49.2
5						112	65.1	58.9	90.8	45.8	50.5	48.3
6					90.1	124	61.3	56.0	87.1	47.7	47.4	49.5
7					83.7	109	76.6	54.6	77.1	51.6	46.7	48.3
8					84.5	112	141	59.2	72.3	54.9	51.4	57.2
9					78.5	84.4	97.9	67.3	66.0	74.5	44.7	69.1
10					90.0	78.1	86.0	59.2	62.3	73.4	45.2	55.0
11					101	95.9	90.7	55.2	91.8	58.8	42.2	58.4
12					91.1	82.2	74.2	51.9	87.1	53.7	43.1	62.9
13					90.9	82.3	137	49.8	78.8	75.5	67.0	62.5
14					105	124	144	92.3	68.6	62.0	53.0	63.4
15					99.4	94.7	97.3	94.4	69.9	54.6	46.6	57.6
16					87.5	103	103	77.3	63.3	54.7	43.8	50.5
17					75.5	126	103	72.1	62.8	54.4	53.0	79.7
18					71.4	125	93.7	67.9	60.6	64.3	51.2	58.8
19					74.4	103	85.2	119	59.7	54.4	46.9	119
20					75.1	88.5	79.0	210	62.6	55.0	44.8	83.5
21					74.0	85.8	79.3	147	61.1	58.7	42.8	93.5
22					87.0	86.8	70.2	95.6	61.3	56.9	40.5	81.5
23					88.6	76.8	66.9	86.7	56.7	51.2	39.0	76.9
24					99.9	75.8	66.1	79.2	54.1	62.6	38.5	65.8
25					107	94.3	103	71.5	52.5	49.8	38.0	72.8
26					108	80.9	84.2	109	50.7	46.8	37.7	96.5
27					144	76.1	82.1	81.9	73.3	45.3	37.7	79.3
28					178	74.8	74.5	71.8	80.7	43.7	38.2	70.2
29					105	73.1	72.5	67.1	57.9		40.0	66.7
30					85.1	72.9	67.0	65.8	53.9		40.9	63.3
31						87.1		111	50.9		41.2	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE ANO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
OCT	18	2.46	257	30	0.91	72.9	92.9	69	92.9	69	248.75	186
NOV	13	2.58	276	6	0.76	61.3	87.5	65	87.5	65	226.68	170
DIC	20	3.35	435	13	0.61	49.8	80.0	60	80.0	60	214.21	160
ENE	23	1.74	158	26	0.62	50.7	70.9	53	70.9	53	189.95	142
FEB	10	1.39	116	29	0.51	43.7	55.2	41	55.2	41	133.42	100
MAR	13	1.14	92.0	27	0.42	37.7	45.2	34	45.2	34	120.96	90
APR	19	2.16	214	1	0.51	43.5	66.6	50	66.6	50	172.65	129
TOT												

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
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REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEC.
RIO REVENTAZON EN ANGOSTURA 73-03-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532 MSNM

ANO HIDROLOGICO 1954 - 1955 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	104	83.3	102	148	125	115	192	133	104	85.3	53.0	57.1
2	111	78.9	154	102	140	141	150	118	99.3	75.5	49.4	64.2
3	122	114	118	93.5	173	129	130	111	92.7	96.4	46.1	51.3
4	129	90.2	97.8	98.3	103	107	118	110	98.9	61.8	43.8	42.3
5	155	132	92.0	125	109	101	126	108	91.9	61.8	42.2	39.1
6	130	182	142	179	115	143	115	98.1	87.6	59.9	41.4	37.3
7	103	89.3	103	135	114	94.5	106	103	84.9	55.3	40.4	36.4
8	115	81.1	190	178	86.0	192	101	95.2	82.1	67.4	46.9	38.2
9	115	96.3	223	130	84.8	164	100	89.2	79.6	68.1	45.4	37.7
10	123	95.6	228	107	74.3	358	98.7	124	78.6	91.8	43.1	45.0
11	98.2	100	183	99.9	77.2	179	94.2	104	79.6	58.7	67.9	62.0
12	115	102	149	99.4	88.7	144	90.2	98.4	77.9	146	72.4	65.6
13	109	214	188	122	80.2	135	90.4	99.6	76.5	90.1	41.6	58.7
14	97.8	186	153	105	97.4	115	82.8	95.8	80.0	69.3	43.3	54.4
15	114	132	104	92.5	94.8	112	79.6	93.1	80.0	61.6	38.5	52.1
16	101	126	103	85.6	106	93.7	81.3	107	76.8	59.0	36.3	49.1
17	91.4	115	120	87.2	106	156	99.1	321	84.2	56.3	37.2	45.4
18	94.0	125	117	91.3	117	147	99.9	284	87.5	52.8	38.2	43.9
19	96.1	118	140	99.4	134	450	116	184	80.7	124	36.4	52.4
20	158	109	117	86.7	110	531	341	399	74.4	61.1	35.5	53.6
21	136	219	99.1	141	100	267	163	507	71.0	54.2	35.2	53.8
22	97.8	121	101	107	141	167	191	472	69.0	50.3	36.0	47.1
23	119	105	100	95.7	127	154	304	399	67.4	65.3	38.3	42.4
24	109	99.6	96.2	175	190	605	378	342	68.1	59.4	38.3	38.6
25	109	92.4	100	153	147	386	204	233	73.2	57.0	45.8	40.4
26	104	141	98.0	134	129	303	172	166	84.0	52.9	54.6	47.1
27	112	167	121	103	228	194	145	164	74.2	53.0	89.9	37.7
28	158	131	112	134	176	226	145	126	69.7	56.9	55.5	32.6
29	111	110	169	112	154	149	130	178	74.5		53.4	30.6
30	96.8	96.8	121	131	129	168	176	118	79.4		46.1	28.4
31	87.5		137	135		225		112	91.2		46.6	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEC	CAUDAL PROMEDIO MENSUAL DE ESTE ANO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY	20	2.79	311	31	1.09	87.5	114	85	114	85	304.27	228
JUN	13	3.97	609	2	0.99	78.9	122	91	122	91	315.58	236
JUL	18	2.98	348	5	1.14	92.0	132	98	132	96	352.35	264
AGO	25	2.89	330	16	1.07	85.6	119	89	119	89	318.34	238
SET	27	3.54	487	10	0.93	74.3	122	91	122	91	315.91	236
OCT	25	5.00	948	16	1.15	93.7	208	156	151	113	557.38	417
NOV	24	4.74	855	15	1.00	79.6	147	110	117	88	381.82	286
DIC	20	4.06	636	9	1.10	89.2	184	137	132	99	491.82	368
ENE	1	1.67	149	23	0.85	67.4	81.3	61	76.1	57	217.63	163
FEB	12	2.14	211	22	0.61	50.3	69.7	52	62.4	47	168.58	126
MAR	1	0.94	75.0	21	0.39	35.2	46.4	35	45.8	34	124.30	93
ABR	14	0.58	49.0	30	0.28	28.4	46.2	35	56.4	42	119.62	89
TOT	25	5.00	948	30	0.28	28.4	116	87	104	78	3667.57	2743

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REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM.

ANO HIDROLOGICO 1955 - 1956 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	27.0	109	95.2	150	125	92.3	154	103	272	60.4	61.8	55.0
2	26.6	127	107	113	154	94.2	170	99.0	176	91.8	73.1	51.1
3	26.4	175	130	104	145	81.7	160	104	264	106	73.2	50.9
4	43.8	187	114	117	125	101	172	93.4	437	87.9	71.4	50.7
5	25.7	82.2	99.0	107	138	121	142	89.2	105	69.5	71.7	50.4
6	26.8	77.5	152	104	155	90.4	161	96.2	111	61.8	76.8	50.3
7	24.9	85.6	235	110	209	103	166	237	97.8	60.8	68.0	50.1
8	24.5	97.0	152	113	132	92.6	130	256	88.1	66.0	82.1	50.0
9	31.1	139	110	92.0	102	155	138	198	98.2	68.2	66.3	50.0
10	36.6	126	108	127	175	235	123	200	88.7	59.3	89.9	100
11	35.3	106	109	179	234	99.9	112	164	80.8	52.9	71.8	77.9
12	31.3	96.1	106	109	89.4	92.8	112	111	83.8	46.7	66.8	72.6
13	36.2	92.0	94.3	106	150	414	105	126	78.2	45.5	62.7	64.5
14	30.3	95.0	92.8	114	141	1200	92.6	117	65.4	43.0	59.2	55.2
15	27.8	95.0	91.3	104	96.1	752	127	146	61.2	42.1	57.9	48.8
16	33.1	76.5	89.4	82.0	89.0	591	127	118	59.5	51.6	62.5	55.7
17	57.3	72.7	124	94.0	178	528	122	109	73.5	57.3	61.4	91.4
18	71.0	62.7	204	84.0	166	394	119	123	95.3	53.0	57.9	138
19	95.1	66.0	185	113	136	244	94.5	251	89.3	103	56.2	93.2
20	120	64.7	132	91.1	100	180	102	164	78.4	106	61.5	91.6
21	52.2	76.0	122	78.5	91.1	193	103	144	71.0	97.1	55.7	78.0
22	40.3	84.3	107	84.7	87.2	171	93.7	140	65.2	94.0	74.0	79.0
23	56.8	74.2	113	74.1	104	176	92.2	127	61.4	88.1	72.9	63.0
24	79.3	62.6	107	74.7	132	257	84.2	123	61.3	76.5	62.8	66.8
25	68.4	59.6	119	77.1	124	243	90.9	127	60.3	69.2	58.6	102
26	46.5	83.5	109	71.0	88.1	259	108	132	60.4	66.1	147	124
27	75.5	106	104	70.2	96.0	238	134	123	58.7	68.0	68.6	78.1
28	260	74.6	102	60.3	83.9	225	130	125	68.8	72.5	62.0	68.6
29	234	69.6	88.4	102	111	196	110	146	82.8	67.7	59.9	67.8
30	157	91.9	94.5	65.7	86.7	180	102	233	69.4		61.1	56.5
31	106		116	86.5		224		327	61.1		58.9	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE ANO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY	28	3.38	415	8	0.21	24.5	64.7	48	89.4	67	173.39	130
JUN	9	2.32	204	25	0.74	59.6	93.8	70	108	81	243.16	182
JUL	7	3.59	457	14	1.04	82.8	119	89	126	94	319.93	239
AGO	1	2.82	308	28	0.75	60.3	98.6	74	109	81	264.20	198
SET	7	3.11	365	28	1.05	83.9	128	96	125	94	332.08	248
OCT	14	6.78	1670	3	1.02	81.7	259	193	187	140	692.40	518
NOV	7	2.76	304	24	1.05	84.2	123	92	119	89	317.70	238
DIC	31	3.80	499	5	1.11	89.2	150	112	138	103	401.05	300
ENE	4	3.90	519	27	0.73	58.7	104	78	85.4	64	278.52	208
FEB	12	1.57	136	15	0.49	42.1	71.4	53	65.4	49	179.02	134
MAR	26	1.60	140	21	0.69	55.7	68.2	51	53.1	40	182.62	137
APR	18	2.16	214	15	0.59	48.8	71.0	53	61.3	46	184.11	138
TOT	14	6.78	1670	8	0.21	24.5	113	84	105	79	3568.13	2669

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RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1956 - 1957 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	37.2	113	169	212	118	195	165	81.0	200	64.8	34.6	216
2	55.1	173	247	169	117	139	187	83.6	155	62.2	33.7	86.3
3	32.4	173	225	160	111	129	140	91.5	125	59.9	33.1	51.0
4	49.3	104	208	149	207	155	122	113	113	58.4	32.0	38.1
5	101	533	187	136	157	185	110	138	101	57.2	31.7	31.6
6	123	159	193	132	149	210	100	116	95.2	54.9	31.2	29.1
7	130	124	160	123	147	211	99.6	314	90.3	55.3	30.5	30.6
8	423	130	154	116	146	240	105	200	84.6	58.0	30.5	30.2
9	152	109	190	112	140	240	113	157	120	61.9	30.2	31.5
10	126	114	184	111	120	172	110	165	96.6	56.4	29.6	46.7
11	136	135	201	107	120	161	98.1	116	89.3	54.2	31.0	48.3
12	108	185	242	106	138	146	95.2	118	79.6	64.1	32.8	58.3
13	110	116	198	109	170	176	96.0	102	90.1	67.7	29.3	42.5
14	236	132	201	113	180	336	95.2	93.9	79.8	64.8	28.8	37.9
15	212	104	322	122	145	313	92.4	207	75.5	64.8	28.8	35.3
16	133	98.2	242	133	151	234	99.2	188	72.6	63.5	28.5	39.7
17	292	106	208	170	192	218	115	180	75.7	58.9	28.1	46.9
18	336	152	193	146	151	175	113	134	90.2	58.7	28.4	49.8
19	232	169	189	135	197	140	105	131	88.9	55.6	27.9	67.4
20	179	118	173	115	205	140	140	124	80.5	53.1	27.5	45.6
21	244	143	167	110	196	162	137	158	77.6	51.4	27.0	38.2
22	411	114	169	109	138	141	107	134	76.2	51.9	26.7	33.0
23	297	118	162	119	143	125	100	116	69.8	54.8	33.7	29.7
24	297	143	172	126	170	125	90.5	103	66.6	43.3	52.4	28.8
25	262	110	192	145	150	114	92.9	97.4	64.4	37.2	54.6	27.5
26	150	138	172	159	140	118	84.0	99.6	70.9	36.1	66.6	29.3
27	216	132	178	162	128	118	84.0	96.2	99.1	35.3	87.1	30.3
28	211	147	173	170	133	135	112	99.1	82.5	37.5	55.8	27.5
29	142	123	147	163	142	118	92.4	96.1	77.2		39.1	26.7
30	130	140	171	169	187	154	94.0	178	72.5		34.7	27.3
31	107		224	142		132		398	68.1		223	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEC	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE ANO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY				3	0.34	32.4	183	137	121	90	489.89	366
JUN				16	1.20	98.2	145	109	120	90	376.29	281
JUL	2	3.51	479	29	1.65	147	194	145	149	111	519.52	389
AGO	17	3.30	422	12	1.28	106	137	103	118	89	367.20	275
SET	30	3.05	363	3	1.34	111	153	114	134	100	396.32	296
OCT	14	5.03	958	25	1.37	114	172	129	183	137	461.98	346
NOV	1	2.77	306	26	1.05	84.0	110	82	117	87	284.66	213
DIC	31	3.96	606	1	1.01	81.0	143	107	139	104	383.61	286
ENE	1	2.48	260	25	0.80	64.4	91.1	68	86.8	65	243.98	182
FEB	12	0.91	72.5	27	0.39	35.3	55.1	41	62.8	47	133.25	100
MAR				22	0.25	26.7	42.2	32	50.5	38	113.09	85
ABR				29	0.25	26.7	44.7	33	57.2	63	115.87	87
TOT				22	0.25	26.7	123	92	112	83	3884.60	2905

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RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1957 - 1958 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	76.3	102	63.4	116	108	239	99.6	124	68.6	64.3	52.1	34.1
2	48.9	120	128	81.9	109	265	104	120	69.1	71.8	48.1	33.1
3	34.1	129	158	76.0	128	263	93.3	152	72.5	151	47.7	32.9
4	29.7	188	114	223	89.4	206	79.0	127	147	200	46.5	32.6
5	29.3	199	82.4	169	324	127	92.6	111	91.1	133	46.8	31.9
6	37.0	146	84.7	173	107	134	120	103	76.6	67.7	51.2	31.1
7	39.4	111	83.3	554	97.0	149	127	86.6	71.7	70.8	52.0	30.5
8	41.6	107	115	155	132	160	98.9	79.6	90.9	70.8	60.7	31.5
9	41.9	90.1	177	121	101	171	160	152	129	79.4	48.0	52.3
10	36.4	99.0	258	95.9	120	182	289	209	114	80.5	45.1	73.5
11	42.6	88.1	168	96.5	90.1	219	168	252	90.9	70.5	41.0	52.8
12	55.9	103	150	86.3	78.2	295	259	649	91.5	60.0	43.3	45.7
13	47.9	120	171	126	155	462	155	395	85.6	57.3	41.4	44.3
14	77.6	96.2	144	92.0	118	209	115	193	82.4	56.6	38.1	41.4
15	88.2	148	115	106	233	239	143	145	76.5	59.5	37.3	39.7
16	94.8	92.1	105	88.9	107	179	251	146	72.8	61.6	38.8	38.1
17	97.6	93.1	126	128	146	182	243	137	98.6	69.7	40.2	40.5
18	76.6	92.1	108	91.7	103	134	126	142	148	101	37.0	36.7
19	90.1	83.9	97.5	120	133	147	104	157	145	129	35.5	39.5
20	100	74.7	93.6	315	173	145	107	125	111	126	39.3	37.3
21	103	83.6	91.7	103	214	117	88.7	110	87.0	162	46.6	38.9
22	124	73.2	97.9	95.0	243	143	84.7	96.5	68.9	126	63.2	37.4
23	94.9	86.4	96.1	81.5	315	209	136	98.2	63.7	105	53.2	43.9
24	113	150	82.7	122	462	139	249	120	61.0	82.1	42.0	39.0
25	103	408	81.3	75.7	358	377	140	95.8	59.5	70.0	40.2	40.5
26	114	163	115	82.3	292	188	122	78.7	58.4	62.9	88.9	34.6
27	133	110	122	103	222	152	118	75.4	56.1	56.9	43.3	39.4
28	121	85.3	177	94.4	244	123	95.4	73.5	58.6	55.0	38.5	38.7
29	96.7	76.3	140	88.7	124	112	137	71.5	73.1		37.0	40.5
30	123	68.4	101	83.1	139	102	105	70.9	108		36.1	38.5
31	121		124	94.1		93.3		69.4	65.5		36.1	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	21	2.16	214	5	0.30	29.3	78.5	59	110	83	210.17	157
JUN				30	0.86	68.4	120	89	120	90	309.87	232
JUL				1	0.79	63.4	122	91	142	106	325.78	244
AGO				3	0.95	75.7	130	97	121	91	348.88	261
SET				4	0.98	78.2	175	131	144	108	454.87	340
OCT				31	1.15	93.3	189	141	184	138	506.42	379
NOV				4	0.99	79.0	140	105	122	91	363.76	272
DIC				31	0.87	69.4	147	110	141	105	393.56	294
ENE				27	0.70	56.1	86.9	65	86.8	65	232.64	174
FEB				28	0.68	55.0	90.0	67	68.2	51	217.78	163
MAR				19	0.39	35.5	45.7	34	49.5	37	122.27	91
ABR	10	1.57	136	7	0.32	30.5	39.7	30	53.7	40	102.89	77
TOT				5	0.30	29.3	114	85	112	84	3588.86	2684

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RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1958 - 1959 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	30.6	70.9	134	84.7	77.9	106	101	81.6	48.9	39.4	27.7	24.9
2	28.0	94.4	117	83.0	72.3	80.8	105	102	45.9	41.0	40.6	24.5
3	35.9	176	153	79.4	82.4	85.4	83.6	65.6	44.0	37.3	49.4	24.7
4	34.8	228	146	114	71.4	91.3	76.5	58.8	42.1	34.7	35.5	24.9
5	36.7	162	120	108	67.7	102	71.0	55.5	40.1	32.8	31.6	24.0
6	52.4	118	118	88.2	84.7	75.1	68.0	52.1	40.0	33.9	30.3	24.5
7	82.9	129	104	87.9	111	81.2	75.7	50.1	40.7	65.1	28.9	23.4
8	242	94.5	125	94.4	110	79.1	87.7	46.6	42.2	44.3	29.5	23.4
9	97.9	81.4	147	83.2	77.8	89.4	99.4	45.3	37.3	40.4	30.0	24.1
10	84.5	116	146	76.9	80.9	77.0	125	43.4	35.4	35.9	31.1	23.4
11	57.3	89.7	102	135	80.9	84.2	146	45.9	47.2	35.4	30.5	22.9
12	109	102	86.7	140	109	81.2	127	72.5	61.5	33.5	27.8	27.8
13	174	78.8	129	156	176	89.5	88.7	71.6	48.1	31.3	26.8	35.3
14	194	71.9	122	134	156	90.1	78.1	55.8	42.1	34.8	26.4	50.3
15	272	100	91.8	99.3	148	100	74.6	53.1	39.4	35.7	26.2	43.7
16	113	77.8	80.6	84.6	285	110	71.3	59.0	36.7	31.5	25.6	36.9
17	129	67.8	137	112	177	113	67.9	52.8	37.4	30.6	25.9	41.4
18	153	257	145	545	351	107	66.3	56.1	37.3	29.4	26.3	59.0
19	168	101	139	202	100	133	72.0	85.1	40.5	28.4	27.9	68.6
20	114	96.7	118	102	85.6	141	69.5	80.1	39.2	37.3	26.7	50.6
21	316	72.7	108	84.5	77.0	101	71.6	70.6	36.7	33.2	25.4	40.6
22	121	116	95.2	113	86.7	102	68.5	65.6	35.6	29.7	24.5	36.6
23	108	139	87.2	111	73.3	115	85.8	63.7	39.6	30.5	29.5	33.6
24	177	160	97.8	108	99.1	88.1	73.5	53.1	35.7	32.3	27.7	73.1
25	119	114	122	93.1	113	103	89.8	49.3	34.1	29.0	25.8	53.9
26	101	102	136	107	85.6	84.7	80.2	51.7	33.9	29.7	25.1	36.4
27	231	92.4	110	85.6	94.2	76.2	74.1	52.1	37.4	29.0	24.9	33.5
28	139	141	98.2	94.2	111	92.7	85.4	70.6	36.9	28.4	24.5	34.3
29	128	134	92.3	99.7	106	130	63.3	70.9	36.1		24.9	38.3
30	178	156	91.1	85.1	99.5	121	58.1	55.1	36.1		26.7	36.4
31	110		89.1	98.2		120		51.2	35.2		25.5	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY				2	0.27	28.0	127	95	113	85	340.16	254
JUN				17	0.85	67.8	118	88	120	89	305.86	229
JUL	4	2.57	274	16	1.01	80.6	116	87	137	102	310.00	232
AGO				10	0.96	76.9	119	89	121	90	318.73	238
SET				5	0.95	67.7	115	86	138	103	298.08	223
OCT	29	2.37	243	6	0.94	75.1	98.4	74	170	127	263.52	197
NOV	11	2.93	337	30	0.72	58.1	83.5	62	116	86	216.40	162
DIC	2	1.55	133	10	0.51	43.4	60.9	46	128	95	163.03	122
ENE	12	0.83	66.2	26	0.37	33.9	40.1	30	79.0	59	107.42	80
FEB	7	0.98	78.2	19	0.28	28.4	34.8	26	62.6	47	84.21	63
MAR	2	0.84	67.0	28	0.21	24.5	28.7	21	46.0	34	76.83	57
ABR	19	1.36	113	11	0.18	22.9	36.5	27	50.8	38	94.61	71
TOT				11	0.18	22.9	81.5	61	107	80	2578.79	1929

C.SOLIDO= 4.09268E-06 *C.LIQUIDO^ 4.04759 PARA 0 <= C <= 407
C.SOLIDO= 368.23 *C.LIQUIDO^ 1 PARA 407 <= C <= 4000

~~INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION~~
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1959 - 1960 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	29.4	132	114	112	93.9	163	89.8	65.5	68.8	101	36.7	46.3
2	53.5	111	96.5	103	80.1	137	111	62.6	65.8	107	35.8	42.4
3	53.9	118	92.3	103	80.1	126	124	59.6	74.6	90.1	34.4	40.0
4	41.4	187	109	95.7	93.0	123	132	59.4	75.6	77.4	35.2	38.7
5	37.6	215	119	94.1	68.9	97.3	102	68.4	57.0	66.0	35.5	38.7
6	38.3	217	112	145	67.0	182	119	86.5	52.3	58.9	33.8	39.7
7	37.2	114	90.0	166	67.1	188	140	148	60.0	55.5	32.8	44.0
8	40.4	105	83.1	127	62.1	123	118	757	60.1	53.2	33.7	40.5
9	35.5	92.8	82.3	98.6	67.0	155	103	217	53.8	55.4	34.6	36.7
10	32.1	99.8	78.6	84.1	77.7	146	107	131	51.4	48.8	36.9	36.0
11	37.9	298	90.0	83.3	70.6	200	104	106	52.3	49.1	34.4	39.4
12	52.0	138	97.6	92.2	96.7	204	93.2	86.7	48.1	46.3	32.6	40.7
13	47.9	102	125	92.1	177	133	94.6	77.7	52.0	42.9	37.3	54.5
14	74.1	103	129	101	149	292	55.0	74.6	75.1	42.6	39.1	58.8
15	111	215	112	86.3	142	230	85.8	80.8	57.5	49.5	36.7	47.1
16	62.8	131	97.3	79.9	125	175	84.1	75.9	52.9	55.2	34.8	47.3
17	48.8	141	84.7	88.6	198	193	104	71.4	65.2	47.7	33.7	43.8
18	42.8	110	92.0	80.6	127	221	133	69.8	67.2	50.4	35.0	47.4
19	36.1	116	88.9	80.2	222	156	99.4	102	71.7	56.9	37.1	40.5
20	33.9	110	72.7	112	110	143	144	85.9	94.2	56.0	35.5	40.9
21	43.6	112	76.0	122	120	143	167	75.2	85.2	58.4	37.9	42.9
22	36.0	208	92.3	126	411	117	158	71.5	62.7	55.7	121	45.0
23	32.6	212	132	92.5	138	113	126	66.6	74.0	49.2	145	44.4
24	31.0	150	136	97.2	129	103	107	61.2	148	52.3	86.1	49.6
25	39.6	114	100	105	139	103	100	58.4	337	47.8	82.9	48.2
26	86.8	110	138	132	125	112	93.1	62.3	457	41.6	80.5	46.5
27	69.0	104	181	123	97.8	86.3	79.9	61.5	187	39.6	88.3	46.5
28	82.2	90.8	143	92.1	107	111	75.7	69.1	113	39.7	62.1	54.6
29	79.0	113	140	108	119	93.8	73.3	70.1	90.1	38.7	55.1	52.8
30	101	164	105	113	169	96.6	67.0	63.8	85.2		48.6	51.2
31	81.4		116	108		107		62.3	77.3		46.8	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE ANO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY	16	2.21	220	1	0.30	29.4	52.5	39	103	77	140.72	105
JUN	22	3.08	370	28	1.13	90.8	141	106	144	92	365.76	274
JUL	29	2.44	253	20	0.91	72.7	107	80	132	99	287.30	215
AGO	7	2.97	340	16	1.00	79.9	105	78	118	88	280.24	210
SET				8	0.77	62.1	124	93	136	102	322.19	241
OCT				27	1.08	86.3	148	110	167	125	395.11	295
NOV	20	2.69	292	30	0.84	67.0	107	80	115	86	278.20	208
DIC				25	0.72	58.4	103	77	124	93	277.15	207
ENE				12	0.58	48.1	95.9	72	81.4	61	256.79	192
FEB	1	1.36	113	29	0.44	38.7	56.3	42	61.8	46	141.08	106
MAR	22	2.37	243	12	0.35	32.6	50.3	38	46.6	35	134.78	101
ABR	29	1.21	99.2	10	0.40	36.0	44.8	34	49.9	37	116.23	87
TOT				1	0.30	29.4	94.6	71	105	78	2995.50	2240

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 533MSNM

ANO HIDROLOGICO 1960 - 1961 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	49.8	103	93.6	95.7	101	230	206	113	55.0	70.8	38.1	37.5
2	45.6	88.1	110	84.8	119	172	185	135	53.5	80.8	36.3	31.5
3	44.9	97.0	85.7	79.8	109	133	202	207	52.1	65.3	50.9	29.9
4	52.8	126	150	86.6	106	172	255	183	52.8	64.6	49.3	30.2
5	48.5	132	136	77.2	89.6	176	181	349	56.2	60.0	44.6	28.4
6	42.1	124	138	78.3	85.7	146	165	303	56.2	53.5	42.8	27.2
7	41.1	99.2	111	69.6	81.0	151	138	212	56.4	51.0	41.4	26.3
8	40.3	83.1	105	67.4	83.1	231	124	156	53.9	52.2	40.0	26.3
9	37.2	83.3	111	96.5	82.9	200	113	143	52.1	52.8	43.7	44.9
10	37.5	96.8	131	108	110	225	103	126	60.2	47.2	54.0	54.1
11	39.1	98.0	87.3	89.4	93.3	221	102	109	62.6	48.9	48.0	34.3
12	48.7	82.8	97.6	85.4	107	218	94.1	99.0	56.5	47.2	41.4	33.1
13	107	68.8	95.2	73.1	95.1	173	94.4	114	54.1	44.0	38.7	30.3
14	69.6	80.4	144	74.8	85.9	140	92.4	115	51.4	43.1	36.7	28.1
15	92.5	108	220	95.6	75.1	116	93.1	106	53.4	42.1	39.2	27.7
16	78.3	112	148	97.7	82.5	104	87.6	104	63.1	40.8	36.0	28.2
17	67.5	134	146	131	108	183	76.6	92.4	58.7	41.0	34.8	29.7
18	64.7	104	105	89.7	98.5	171	76.4	90.0	53.2	43.5	34.0	27.7
19	68.4	115	93.9	76.5	76.1	119	79.7	116	53.3	40.0	32.8	27.7
20	56.3	143	102	97.6	89.2	101	105	131	50.4	39.5	31.5	27.2
21	49.0	111	108	139	157	137	113	92.3	140	38.5	30.8	25.8
22	45.0	85.0	129	137	144	173	90.8	82.0	120	42.3	30.2	32.9
23	46.7	113	214	151	147	134	78.6	77.7	73.2	46.5	34.8	36.6
24	55.5	169	127	103	139	150	87.7	76.7	62.9	44.5	36.2	44.6
25	66.9	149	114	90.5	140	142	84.6	74.2	58.7	46.4	30.8	47.0
26	90.3	176	114	80.1	94.2	131	83.7	69.6	58.4	46.0	29.6	52.1
27	82.1	121	127	78.4	83.9	147	94.8	66.2	52.8	39.4	29.0	49.6
28	108	110	237	113	133	211	86.1	63.3	50.0	40.0	28.4	42.7
29	100	108	154	88.4	125	293	88.1	60.7	49.2		27.7	42.8
30	94.0	91.7	174	111	125	195	81.8	58.5	46.6		29.0	42.5
31	80.5		112	100		210		56.5	47.2		27.7	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE ANO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY	28	1.51	129	9	0.41	37.2	62.9	47	97.3	73	168.47	126
JUN	26	2.59	277	13	0.86	68.8	110	83	122	91	286.17	214
JUL	28	3.60	503	3	1.07	85.7	130	97	132	98	347.35	260
AGO	23	2.32	235	8	0.85	67.4	95.0	71	115	86	254.54	190
SET	21	2.67	289	15	0.94	75.1	106	79	132	98	273.55	205
OCT	8	3.63	511	20	1.23	101	171	128	168	125	458.35	343
NOV	4	3.12	378	18	0.96	76.4	115	86	115	86	299.16	224
DIC	5	3.62	508	31	0.70	56.5	122	91	124	93	326.75	244
ENE	21	2.04	197	30	0.56	46.6	60.1	45	78.7	59	161.06	120
FEB	3	1.70	153	21	0.44	38.5	49.1	37	60.2	45	118.77	89
MAR	10	0.84	67.0	31	0.27	27.7	37.0	28	45.4	34	99.22	74
ABR	10	1.20	98.2	21	0.24	25.8	34.9	26	48.0	36	90.45	68
TOT	8	3.63	511	21	0.24	25.8	91.1	68	103	77	2883.81	2157

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIPECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOF BASICOS - OFICINA DE HIDPOLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1961 - 1962 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	45.8	73.8	85.5	112	96.0	152	180	301	84.9	55.0	40.0	31.5
2	42.1	64.6	80.9	138	111	123	191	197	81.7	52.8	38.7	32.5
3	36.4	70.1	92.0	106	113	173	178	168	157	51.4	40.8	34.4
4	34.0	110	88.7	101	90.0	135	188	147	124	49.2	39.4	34.0
5	34.0	107	99.2	103	179	129	122	131	103	48.6	38.1	31.5
6	34.0	110	131	106	273	122	110	117	90.5	48.0	37.4	30.2
7	34.4	117	148	99.3	193	129	107	111	87.0	46.6	36.7	30.2
8	37.4	119	228	106	123	125	151	107	79.0	46.6	39.4	31.5
9	34.5	160	163	98.5	119	105	226	99.2	75.7	46.0	38.1	36.0
10	43.8	185	163	94.3	164	99.0	201	93.2	71.6	44.6	36.7	35.4
11	51.5	168	123	100	172	96.0	137	91.9	68.5	44.6	35.4	32.2
12	80.6	102	121	87.4	148	91.0	149	106	69.6	42.8	34.8	65.4
13	72.8	85.9	111	78.4	137	199	148	131	71.7	42.8	34.0	49.2
14	113	103	108	80.4	116	164	.125	125	72.1	43.1	34.8	40.8
15	99.6	99.2	110	113	158	176	111	103	67.7	44.7	35.4	38.1
16	94.4	82.7	122	121	168	173	111	91.3	67.0	45.6	33.4	36.7
17	74.3	124	118	129	177	169	108	84.9	62.6	46.0	34.0	37.9
18	58.8	102	103	91.0	142	154	99.6	82.6	64.0	44.0	41.4	40.3
19	53.3	87.6	97.8	83.1	134	150	99.8	94.0	61.8	42.1	40.0	42.0
20	49.5	77.1	106	75.9	123	170	133	103	62.8	42.1	36.7	34.1
21	47.6	103	108	96.1	109	165	145	107	73.5	42.1	33.4	30.8
22	61.0	104	114	90.3	125	181	111	94.2	70.5	41.4	32.2	41.9
23	68.3	85.1	92.5	89.6	151	177	91.3	92.7	70.1	41.4	32.8	50.7
24	107	107	93.8	90.1	151	155	118	110	80.3	40.0	33.1	61.6
25	128	112	87.3	110	170	133	139	369	74.5	40.0	34.0	58.6
26	82.5	124	110	89.0	164	123	133	544	61.0	39.4	34.8	72.2
27	73.4	88.8	88.5	96.0	140	116	108	233	58.8	40.8	35.4	74.6
28	71.1	76.8	78.7	102	139	103	102	148	62.1	42.1	33.4	61.1
29	65.0	88.3	138	79.7	173	142	152	119	67.6		30.8	47.0
30	59.1	105	150	81.0	156	181	265	104	61.8		29.6	42.1
31	55.7		111	108		166		92.3	60.3		30.2	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE ANO MC/SEC	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY	25	2.13	210	4	0.37	34.0	62.7	47	93.0	70	167.87	126
JUN	10	2.67	289	2	0.81	64.6	105	78	120	90	271.47	203
JUL	8	3.15	385	28	0.99	78.7	115	86	130	97	309.22	231
AGO	15	2.55	271	20	0.95	75.9	98.6	74	113	84	263.96	197
SET	6	3.09	372	4	1.12	90.0	148	111	134	100	383.10	287
OCT	13	3.21	400	12	1.13	91.0	144	108	165	124	386.73	289
NOV	30	3.09	372	23	1.13	91.3	141	106	118	88	366.31	274
DIC	26	4.06	636	18	1.03	82.6	145	108	126	94	388.57	291
ENE	3	1.89	178	27	0.73	58.8	76.2	57	78.4	59	204.14	153
FEB	14	0.83	66.2	26	0.45	39.4	44.8	33	58.5	44	108.33	81
MAR	3	0.50	42.8	30	0.30	29.6	35.6	27	44.3	33	95.46	71
ABR	27	1.49	127	6	0.31	30.2	42.8	32	47.4	35	110.98	83
TOT	26	4.06	636	30	0.30	29.6	96.6	72	102	77	3056.06	2286

INSTITUTO CUSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1962 - 1963 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	40.0	102	177	117	119	125	108	77.0	74.0	93.6	45.2	48.6
2	51.9	84.7	202	103	112	161	152	69.0	75.0	80.4	46.6	46.0
3	63.6	86.3	162	110	96.2	174	190	72.0	85.0	70.0	46.6	44.0
4	58.7	131	178	111	98.8	278	626	70.0	82.0	61.8	58.5	43.4
5	47.2	143	210	96.0	103	246	900	67.8	83.0	58.5	75.6	54.9
6	42.1	113	227	110	91.6	192	766	100	85.1	62.2	74.9	47.3
7	47.2	152	161	107	120	226	600	86.7	98.3	75.6	69.6	42.1
8	42.8	138	141	136	150	190	315	97.0	80.1	95.4	58.3	39.4
9	40.0	230	118	137	126	148	232	272	75.7	95.1	78.0	47.5
10	39.4	170	106	106	108	138	231	150	73.2	78.3	63.4	66.2
11	56.7	125	96.2	105	103	125	189	165	71.0	67.0	62.6	62.5
12	54.2	112	117	100	129	152	177	125	68.5	69.3	60.3	88.2
13	52.3	101	145	86.4	106	170	232	301	65.5	66.7	61.0	73.2
14	59.6	93.9	167	73.0	104	167	416	360	63.4	58.7	56.5	60.3
15	56.0	88.2	115	73.2	159	156	478	490	63.3	56.5	55.7	51.4
16	60.3	123	154	119	229	174	232	272	62.2	53.5	57.4	54.7
17	68.9	148	123	107	219	142	157	205	62.2	54.2	58.1	67.0
18	65.2	141	103	118	171	126	127	172	60.9	51.4	53.5	101
19	86.7	122	95.2	155	141	123	255	230	55.5	60.7	51.4	130
20	130	120	88.4	124	145	128	232	195	53.4	52.9	50.7	95.2
21	108	94.6	84.1	115	127	123	148	207	56.4	62.5	52.1	136
22	84.8	84.0	96.3	103	167	264	117	150	55.7	58.8	48.6	134
23	102	81.4	88.5	93.1	275	176	107	137	58.9	60.3	52.0	107
24	122	78.2	86.4	107	192	155	91.0	158	69.2	53.5	60.4	96.0
25	145	162	145	124	178	232	110	144	70.1	50.7	48.6	80.7
26	210	134	90.3	98.0	158	166	86.3	118	59.2	49.2	47.2	85.4
27	187	102	132	109	123	128	81.5	96.0	55.5	47.2	50.0	89.7
28	125	101	200	122	150	127	77.0	84.0	52.7	46.0	50.7	90.3
29	129	95.1	124	120	166	141	78.0	82.0	55.3		49.2	123
30	133	125	157	154	125	124	91.6	79.0	52.8		50.7	116
31	141		145	126		111		74.0	106		48.6	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE ANO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY	26	2.79	309	10	0.45	39.4	85.5	46	92.2	69	228.93	171
JUN	9	3.21	400	24	0.98	78.2	119	89	120	90	309.43	231
JUL	5	3.10	374	21	1.05	84.1	137	102	131	98	366.54	274
AGO	19	2.38	244	14	0.92	73.0	112	84	113	84	299.35	224
SET	22	3.95	602	6	1.13	91.6	143	107	135	101	370.79	277
OCT	3	3.68	524	31	1.34	111	164	123	165	123	439.60	329
NOV	4	5.31	1060	28	0.97	77.0	253	190	132	98	656.85	491
DIC	13	3.44	460	5	0.85	67.8	159	119	129	97	424.70	318
ENE	31	1.76	161	28	0.55	52.7	68.7	51	77.4	58	183.95	138
FEB	1	1.54	132	28	0.55	46.0	63.9	48	59.0	44	154.66	116
MAR	4	1.16	942	1	0.54	45.2	56.2	42	45.5	34	150.51	113
ABR	21	2.10	205	8	0.45	39.4	77.4	58	50.4	38	200.53	150
TOT	4	5.31	1060	8	0.45	39.4	120	90	104	78	3785.79	2831

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1963 - 1964 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	93.0	94.0	139	106	98.9	107	154	95.3	259	51.5	32.0	23.9
2	82.8	78.0	138	129	82.6	97.2	153	108	246	47.5	31.0	23.7
3	73.2	84.0	124	124	85.3	95.0	133	101	155	46.0	30.0	23.9
4	62.0	160	115	112	94.8	101	258	95.5	122	48.8	31.0	23.8
5	57.0	152	113	105	106	106	280	89.0	111	47.0	30.5	23.4
6	53.0	93.0	110	88.2	131	96.2	197	137	107	46.5	29.5	23.4
7	78.0	86.3	110	87.4	238	123	241	129	99.0	44.0	28.6	23.9
8	65.0	123	105	171	190	173	200	100	88.0	43.5	29.6	24.6
9	56.0	142	148	105	177	156	184	167	340	42.0	31.0	24.4
10	53.0	103	145	101	220	208	213	376	81.0	41.0	28.6	25.0
11	83.0	136	128	181	234	187	157	186	85.0	40.6	28.6	24.4
12	121	130	109	157	234	163	136	127	75.0	40.6	28.4	26.2
13	86.2	113	140	187	163	149	141	104	73.0	40.0	29.0	26.6
14	100	101	120	183	162	184	199	97.0	71.0	40.6	28.6	27.6
15	130	95.7	112	121	188	171	305	78.0	99.0	42.0	29.7	25.0
16	120	100	102	100	211	149	263	84.0	85.5	41.0	34.0	26.8
17	98.0	86.2	130	153	147	131	204	79.0	77.0	40.6	29.0	29.7
18	82.4	84.0	124	122	126	166	187	75.0	74.0	40.0	28.6	28.0
19	120	81.5	144	113	151	159	177	76.0	65.3	36.0	28.0	27.6
20	310	89.2	125	147	171	161	171	75.0	68.3	34.2	29.5	25.5
21	175	85.8	113	159	155	171	148	69.1	63.0	33.5	27.6	25.8
22	144	72.5	130	144	122	121	130	67.8	62.9	33.0	27.6	29.6
23	122	93.2	119	115	133	116	133	67.0	61.0	32.8	28.0	33.0
24	103	102	108	94.5	158	176	129	67.9	61.7	33.5	26.6	47.1
25	90.0	121	95.0	85.5	180	135	113	138	58.0	33.0	25.8	60.0
26	125	101	85.5	80.0	179	114	101	140	54.0	34.5	25.8	55.2
27	143	92.5	78.5	78.2	149	97.0	93.4	108	54.2	35.5	25.0	43.3
28	137	99.0	116	76.5	132	95.7	89.5	98.5	48.3	33.2	25.0	41.5
29	130	151	90.5	74.9	116	95.2	89.0	82.0	50.4	32.5	25.0	34.2
30	105	172	87.9	83.0	107	96.0	92.5	104	48.8		23.9	33.1
31	115		92.3	89.3		122		98.5	49.5		23.8	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	20	2.85	322	10	0.65	53.0	107	80	93.7	70	286.21	214
JUN	4	3.08	369	22	0.91	72.5	107	80	119	89	278.37	208
JUL	19	2.91	333	27	0.98	78.5	116	87	130	97	310.75	232
AGO	11	4.02	624	29	0.94	74.9	118	89	114	85	317.30	237
SET	15	3.42	454	2	1.03	82.6	155	116	137	102	401.03	300
OCT	10	3.70	529	3	1.17	95.0	136	102	162	121	364.72	273
NOV	4	3.78	551	29	1.02	89.0	169	126	135	101	438.17	328
DIC	9	4.18	671	23	0.78	67.0	110	82	127	95	295.45	221
ENE	1	3.06	379	28	0.55	48.3	96.5	72	79.1	59	258.59	193
FEB	1	0.68	58.5	29	0.31	32.5	39.8	30	57.3	43	99.70	75
MAR	2	0.39	37.2	31	0.11	23.8	28.4	21	43.9	33	75.97	57
ABR	25	1.10	97.3	5	0.10	23.4	30.4	23	48.6	36	78.81	59
TOT	9	4.18	671	5	0.10	23.4	101	76	104	78	3205.12	2397

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RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1964 - 1965 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	38.4	80.8	189	209	136	153	159	87.0	48.6	71.4	77.0	49.3
2	39.5	96.5	157	168	138	143	157	79.0	47.0	67.9	63.6	48.6
3	37.4	81.8	145	153	143	148	226	74.0	55.4	77.9	61.0	47.2
4	33.7	122	130	138	137	171	196	70.0	66.2	74.6	58.5	53.0
5	30.3	106	114	133	108	125	142	75.0	81.0	66.4	53.9	45.5
6	34.7	77.0	99.6	120	97.0	131	136	86.6	209	63.6	50.4	62.2
7	33.6	89.2	103	111	117	113	130	81.1	258	60.0	79.0	42.1
8	39.1	113	144	109	126	108	130	88.4	197	63.0	174	41.0
9	46.1	88.4	114	112	133	101	159	73.2	133	58.5	151	40.5
10	53.4	121	127	123	162	108	145	67.0	116	56.0	120	36.2
11	51.9	150	112	200	146	114	116	64.5	107	55.9	89.5	34.0
12	43.5	125	131	103	143	181	120	66.1	94.3	54.4	77.0	33.5
13	44.3	103	192	137	162	188	113	63.6	87.4	51.4	71.0	40.0
14	49.5	88.8	190	134	182	156	118	68.5	82.7	49.6	65.0	35.1
15	50.4	134	134	200	234	132	122	78.8	90.4	48.6	61.0	32.0
16	57.8	121	174	165	208	193	125	62.8	98.3	48.0	57.0	31.8
17	62.1	110	179	189	192	199	104	55.3	119	47.0	56.4	31.0
18	71.5	142	150	212	160	147	105	56.0	277	48.0	56.0	33.1
19	76.0	139	118	194	250	152	101	59.6	377	55.4	54.4	33.0
20	71.0	135	131	163	202	228	96.3	61.0	247	88.4	51.2	36.9
21	57.0	118	162	167	163	212	92.0	79.3	175	71.4	68.1	40.2
22	47.0	143	239	164	243	174	88.0	63.6	143	61.4	54.4	51.0
23	62.3	258	317	125	187	180	101	64.1	123	58.0	51.9	46.0
24	61.2	120	213	128	149	165	111	63.0	106	52.8	52.4	41.5
25	68.0	117	168	135	152	179	102	56.0	101	55.7	53.4	37.3
26	109	137	166	130	151	146	91.0	45.0	94.0	143	49.8	35.9
27	117	108	146	143	152	141	85.0	63.0	109	141	47.5	35.8
28	84.3	96.3	140	123	140	135	87.0	55.4	95.0	96.3	46.0	34.2
29	89.5	86.4	201	114	165	150	79.0	54.4	87.0		47.0	36.8
30	66.1	137	264	101	160	144	85.0	51.2	83.4		50.4	35.4
31	80.5		272	114		154		49.6	75.8		58.0	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	26	2.48	279	5	0.27	30.2	58.9	44	90.5	68	157.77	118
JUN	30	2.51	284	6	0.89	77.0	115	86	119	89	297.58	223
JUL	22	3.77	549	6	1.12	99.6	165	124	133	100	442.50	331
AGO	17	2.81	333	11	1.13	100	143	107	117	87	381.80	286
SET	19	4.25	693	6	1.10	97.0	161	121	139	104	418.00	313
OCT	16	3.51	479	9	1.14	101	154	115	141	121	412.39	308
NOV	3	2.81	333	29	0.91	79.0	121	90	136	100	312.71	234
DIC	8	1.17	105	31	0.57	49.6	67.2	50	122	91	179.88	135
ENE	19	3.67	521	2	0.53	47.0	129	96	83.2	62	344.17	257
FEB	26	1.91	198	17	0.53	47.0	67.4	50	58.1	43	162.93	122
MAR	8	1.91	198	28	0.52	46.0	67.9	51	45.9	34	181.94	136
ABR	22	0.75	64.5	17	0.78	31.0	39.3	29	47.8	36	101.77	76
TOT	19	4.25	693	5	0.27	30.2	107	80	104	78	3393.41	2538

C.SOLIDO= 4.09268E-06 *C.LIQUIDO* 4.04759 PARA 0 <= C <= 407
C.SOLIDO= 368.23 *C.LIQUIDO* 1 PARA 407 <= C <= 4000

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
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REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1965 - 1966 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	36.0	161	112	159	114	127	177	106	106	171	95.0	66.0
2	33.2	127	94.5	183	108	147	240	104	96.0	144	97.0	64.0
3	35.0	121	95.3	181	97.3	160	233	99.0	93.0	121	133	56.0
4	37.8	122	120	160	109	141	194	99.5	89.0	119	100	51.0
5	42.5	102	114	183	117	156	152	95.3	82.0	107	91.0	50.0
6	56.8	112	113	167	121	123	132	95.0	76.0	106	66.0	49.0
7	54.5	130	107	135	137	124	129	98.0	76.0	124	64.0	48.0
8	55.2	181	98.0	128	188	120	127	105	93.0	103	60.0	40.0
9	53.5	179	105	182	146	106	147	85.0	124	93.0	57.0	45.0
10	110	163	100	155	144	101	144	78.0	137	87.0	55.0	42.0
11	172	127	107	150	134	112	142	75.0	97.0	104	64.0	42.0
12	116	125	104	118	108	202	130	75.0	93.0	99.0	66.0	41.0
13	81.0	220	90.0	117	113	210	180	71.3	109	92.0	60.0	40.0
14	66.5	117	87.5	118	127	147	159	69.0	102	84.0	58.0	39.0
15	77.9	104	100	151	131	148	152	69.2	117	77.0	57.0	38.0
16	91.5	94.0	108	134	132	139	139	76.0	91.0	72.0	57.0	37.0
17	76.0	82.0	95.0	120	121	117	124	83.0	81.0	72.0	55.0	38.0
18	66.5	89.4	142	150	122	132	111	97.0	88.0	76.0	54.0	36.0
19	82.8	97.3	129	178	117	113	106	98.0	87.8	72.0	62.0	36.0
20	95.0	123	103	181	114	164	99.5	203	74.0	88.0	56.0	43.0
21	109	124	121	152	126	165	102	98.0	71.0	83.0	75.0	57.0
22	155	135	134	167	137	169	99.5	89.0	74.0	74.0	92.0	55.0
23	155	197	108	150	160	191	93.0	86.0	93.0	67.0	76.0	44.0
24	104	184	117	140	153	235	113	87.0	99.0	139	65.0	66.0
25	117	183	125	154	137	283	260	87.0	76.0	569	65.0	102
26	106	155	157	159	122	199	201	89.0	72.0	225	65.0	66.0
27	86.0	135	148	172	147	153	131	95.0	262	140	60.0	70.0
28	117	129	148	142	225	142	111	127	323	113	60.0	165
29	149	124	131	122	211	144	108	102	166		55.0	95.0
30	225	113	166	119	144	147	110	108	146		60.0	111
31	230		170	125		139		132	230		70.0	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	30	3.36	443	2	0.32	33.0	96.5	72	91.0	66	258.57	193
JUN	13	3.94	599	17	0.95	82.0	135	101	120	90	350.41	262
JUL	30	2.80	331	14	1.00	87.0	118	88	132	99	315.30	236
AGO	19	2.80	331	13	1.28	117	150	112	120	90	401.93	301
SET	28	3.22	412	3	1.10	97.0	135	101	139	104	350.98	262
OCT	23	3.62	508	10	1.13	101	153	115	160	120	410.92	307
NOV	2	3.22	412	23	1.06	93.0	145	108	135	101	375.49	281
DIC	20	3.50	476	14	0.80	69.0	96.2	72	120	90	257.58	193
ENE	28	3.70	529	21	0.83	71.0	114	85	85.5	64	304.45	228
FEB	25	4.66	827	23	0.79	67.0	122	91	63.0	47	295.57	221
MAR	3	1.54	150	18	0.62	54.0	69.4	52	47.7	36	185.76	139
ABR	28	2.06	217	18	0.37	36.0	55.9	42	48.4	36	144.98	108
TOT	25	4.66	827	2	0.32	33.0	116	87	105	79	3651.91	2731

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
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REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1966 - 1967 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	102	169	95.0	104	124	232	119	137	174	84.3	51.0	41.0
2	128	378	93.0	95.0	112	182	107	263	164	78.4	54.0	40.0
3	121	245	93.2	95.0	120	138	181	361	142	73.3	53.8	43.0
4	121	175	93.0	86.0	113	119	216	251	114	94.0	63.0	41.0
5	105.	139	96.0	94.0	140	139	239	179	117	89.6	58.0	42.0
6	84.8	154	93.0	151	155	148	211	155	125	84.0	57.0	51.0
7	103	200	89.0	209	122	129	204	137	117	74.0	56.0	67.5
8	115	172	107	172	128	140	178	124	96.0	67.1	59.0	63.1
9	156	133	139	124	161	112	165	113	96.5	65.5	63.1	98.0
10	117	118	94.0	122	200	115	137	124	105	63.3	48.0	102
11	121	108	85.0	102	189	126	119	294	134	62.0	87.0	78.0
12	187	124	142	109	152	140	112	214	104	62.0	65.1	102
13	181	141	263	141	138	130	117	179	104	63.0	74.0	77.0
14	136	193	242	130	119	167	105	154	95.0	59.0	65.0	67.0
15	163	122	150	106	145	183	96.0	163	89.2	61.0	59.0	82.0
16	166	107	121	95.0	166	170	103	132	91.4	62.0	53.0	111
17	137	98.0	110	152	157	149	89.0	115	99.0	54.0	50.0	109
18	145	119	108	207	126	250	85.0	108	86.3	62.0	50.0	85.5
19	203	123	102	250	111	199	82.0	104	93.0	65.0	48.0	68.3
20	145	137	157	193	112	177	78.0	103	162	65.0	47.0	69.3
21	155	141	196	158	108	158	74.0	124	142	79.0	47.0	117
22	141	138	194	155	127	215	78.0	123	115	65.0	48.0	139
23	137	136	132	131	106	187	152	138	108	69.1	44.0	187
24	111	118	114	120	134	161	314	105	108	55.0	53.0	110
25	124	146	132	128	130	157	150	268	100	59.6	48.0	148
26	147	140	119	174	130	137	119	593	99.5	54.0	44.0	132
27	132	137	115	198	126	134	104	512	93.0	55.0	44.0	96.0
28	126	121	141	202	138	126	134	272	95.0	54.2	44.0	104
29	115	113	126	175	161	117	157	233	100		42.0	115
30	103	103	109	159	215	113	111	200	92.0		39.0	98.0
31	140		110	152		114		179	94.0		38.0	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	2	3.16	399	6	0.97	85.0	134	101	94.3	71	360.10	269
JUN	2	4.58	799	17	1.11	98.0	148	111	122	91	384.31	287
JUL	13	3.62	508	11	0.98	85.0	128	96	132	98	342.16	256
AGO	19	3.54	487	4	0.99	86.0	145	108	122	91	387.50	290
SET	30	4.22	683	23	1.18	106	139	104	139	104	359.86	269
OCT	18	3.44	462	30	1.24	113	154	115	160	119	411.52	308
NOV	24	3.54	487	21	0.86	74.0	138	103	135	101	357.35	267
DIC	26	4.94	926	20	1.15	103	199	148	126	94	531.71	398
ENE	2	2.50	283	18	0.99	86.0	111	83	87.4	65	298.50	223
FEB	5	1.90	197	17	0.62	54.0	67.1	50	63.3	47	162.38	121
MAR	9	1.78	181	31	0.40	38.0	53.3	40	48.1	36	142.73	107
ABR	21	2.66	308	2	0.43	40.0	89.5	67	51.3	38	231.87	173
TOT	26	4.94	926	31	0.40	38.0	125	94	107	80	3969.95	2969

C.SOLIDO= 4.09268E-06 *C.LIQUIDO^ 4.04759 PARA 0 <= C <= 407
C.SOLIDO= 368.21 *C.LIQUIDO^ 1 PARA 407 <= C <= 4000

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1967 - 1968 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	94.3	91.0	201	137	185	223	105	168	93.7	100	97.3	112
2	89.5	157	150	120	230	196	109	148	51.5	84.4	84.1	113
3	76.0	260	129	225	199	199	127	150	54.6	71.6	82.1	101
4	81.0	190	132	229	214	178	148	138	57.3	62.6	76.6	91.5
5	68.4	298	136	173	158	158	127	120	54.0	56.8	71.8	102
6	64.3	192	118	151	198	137	125	110	51.9	63.8	69.1	94.1
7	77.8	147	119	160	153	115	133	105	48.0	57.6	63.9	93.3
8	90.4	142	122	162	151	131	111	112	50.4	90.0	53.0	126
9	78.2	157	135	185	159	122	152	111	52.9	179	52.0	161
10	75.3	205	141	146	177	134	138	96.0	53.8	141	42.0	137
11	97.9	205	121	145	204	129	133	80.0	55.4	106	45.0	105
12	93.0	137	106	130	160	115	124	100	53.3	79.8	49.1	97.4
13	80.7	116	192	128	141	132	119	95.5	53.3	76.6	49.0	88.1
14	78.3	121	127	113	134	121	113	89.0	50.0	87.6	55.4	82.7
15	85.5	139	123	109	127	207	119	83.0	61.6	74.0	83.0	96.5
16	96.8	164	143	127	142	202	132	85.4	67.1	62.6	46.4	84.0
17	90.7	173	116	141	138	140	296	79.5	64.1	57.9	47.4	65.5
18	114	193	99.0	151	141	184	206	79.0	59.4	75.4	57.5	57.5
19	124	164	100	125	145	192	163	93.4	64.2	67.9	59.0	66.0
20	106	155	111	102	149	200	160	80.0	61.9	52.3	50.4	61.3
21	85.0	136	110	131	151	257	161	90.9	65.0	47.5	47.0	55.4
22	81.6	141	149	118	145	288	134	84.6	52.8	55.0	47.4	57.4
23	76.0	156	178	137	154	294	141	79.8	50.1	86.4	137	56.8
24	85.1	143	126	195	164	228	134	121	52.9	70.0	230	56.3
25	95.2	147	132	206	156	180	109	106	57.3	326	152	54.5
26	77.8	149	140	236	136	165	96.0	92.1	55.3	240	110	53.1
27	77.4	231	207	211	152	161	119	96.5	50.5	168	86.6	52.6
28	116	234	125	178	171	152	232	55.2	33.9	146	161	42.8
29	103	200	110	158	207	140	162	55.2	47.0	116	181	50.0
30	85.0	170	134	152	215	141	145	57.5	141		120	57.3
31	88.0		134	184		141		53.0	177		96.1	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	11	2.40	266	6	0.75	54.3	87.8	66	93.8	70	235.19	176
JUN	5	3.84	569	1	1.03	90.8	170	127	125	94	440.90	330
JUL	26	2.84	338	18	1.11	99.0	134	101	132	99	359.94	269
AGO	3	3.58	499	20	1.15	102	157	116	125	93	421.03	315
SET	30	3.22	412	15	1.37	127	165	124	141	105	428.20	320
OCT	18	3.60	503	12	1.26	115	173	130	161	120	463.79	347
NOV	17	3.30	430	26	1.09	96.0	142	107	135	101	369.19	276
DIC	19	2.40	266	31	0.61	53.0	97.5	73	124	93	261.07	195
ENE	31	2.44	273	28	0.33	33.9	62.6	47	85.7	64	167.77	125
FEB	25	3.80	557	21	0.54	47.5	100	75	65.9	49	250.89	188
MAR	24	2.86	342	10	0.46	42.0	83.7	63	50.5	38	224.90	168
ABR	9	2.40	266	28	0.47	42.0	82.4	62	53.4	40	213.52	160
TOT	5	3.84	569	28	0.33	34.0	121	91	108	81	3836.23	2869

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
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REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1968 - 1969 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	54.6	139	176	153	137	94.0	185	109	81.4	55.5	38.0	60.0
2	58.7	150	178	142	143	141	170	100	63.0	50.9	30.6	50.5
3	40.0	159	224	178	145	167	168	97.0	58.0	51.5	34.3	43.5
4	68.0	157	244	171	139	136	146	110	53.3	49.3	39.0	34.8
5	75.8	195	178	142	166	146	162	109	64.2	101	38.0	37.6
6	62.3	158	165	144	213	129	140	103	57.5	67.0	36.6	32.7
7	113	168	159	127	259	117	128	93.3	66.3	55.0	34.1	44.0
8	90.1	145	158	140	236	170	158	75.0	51.0	52.6	31.0	45.4
9	74.7	134	136	170	211	141	139	81.0	48.0	44.2	34.7	47.7
10	84.0	157	126	204	201	115	112	79.0	46.2	52.0	32.0	52.0
11	118	174	161	216	232	129	107	80.5	43.7	44.0	28.5	47.0
12	121	159	125	162	224	189	112	80.7	45.3	47.0	28.0	44.5
13	119	163	139	137	187	143	230	80.0	51.0	43.4	27.8	40.1
14	107	183	123	126	165	111	172	78.0	40.7	40.5	36.4	42.0
15	121	151	110	136	170	129	134	141	41.8	39.0	32.0	41.6
16	104	125	99.3	130	267	158	140	468	47.2	32.4	30.3	40.0
17	94.7	187	135	115	211	145	148	358	57.4	36.3	30.7	38.0
18	108	188	165	164	306	152	152	236	59.2	38.3	33.7	38.2
19	163	192	185	226	367	150	125	155	59.8	40.3	34.2	42.7
20	128	155	193	227	275	110	129	127	58.5	42.2	35.0	34.4
21	120	176	201	169	215	98.0	109	115	63.0	41.4	40.1	46.6
22	136	146	189	166	182	125	99.2	106	54.6	40.0	45.4	80.4
23	125	150	157	144	246	116	97.2	117	51.6	39.0	32.5	82.2
24	112	142	167	136	257	125	134	94.6	56.0	38.3	35.4	104
25	140	132	174	143	192	285	262	103	55.3	39.0	36.2	92.3
26	134	109	160	130	200	195	313	104	48.0	39.0	39.4	59.2
27	119	171	189	113	140	181	169	97.0	61.7	38.3	40.0	42.3
28	130	188	160	134	120	241	139	82.5	69.2	35.0	41.7	46.3
29	137	129	216	144	100	195	119	84.7	62.0		41.0	47.0
30	167	169	191	148	82.9	165	108	89.6	70.3		37.1	46.2
31	186		173	138		156		87.0	68.0		55.1	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	31	2.76	324	3	0.43	40.0	110	82	94.9	71	294.70	220
JUN	18	3.26	421	26	1.21	109	158	118	127	95	410.48	307
JUL	3	3.72	535	16	1.12	99.4	166	124	134	100	445.50	333
AGO	19	3.54	487	27	1.25	113	154	115	127	95	412.56	309
SET	19	4.80	876	30	0.95	82.9	200	149	145	108	517.35	387
OCT	25	3.48	472	1	1.07	94.0	150	112	160	120	402.11	301
NOV	26	4.05	633	23	1.10	97.2	150	112	136	102	389.35	291
DIC	16	3.72	535	28	0.95	82.5	124	93	124	93	331.85	248
ENE	7	1.74	176	14	0.44	40.7	56.6	42	83.9	63	151.65	113
FEB	5	1.85	190	16	0.31	32.4	46.2	35	64.6	48	111.66	84
MAR	22	0.94	82.0	13	0.22	27.8	35.8	27	49.6	37	95.80	72
ABR	25	2.16	232	6	0.31	32.7	50.1	37	53.2	40	129.88	97
TOT	19	4.80	876	13	0.22	27.8	117	87	108	81	3692.85	2762

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
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RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1969 - 1970 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	37.6	106	138	76.0	163	185	128	260	97.0	64.0	69.0	100
2	45.0	137	136	120	155	135	106	213	90.0	62.0	55.0	93.7
3	41.6	122	116	126	166	165	115	210	87.0	60.0	67.6	67.0
4	33.5	129	101	205	171	147	87.4	201	81.3	100	63.0	59.0
5	39.4	102	94.2	236	151	124	138	168	80.3	211	60.0	55.9
6	42.7	82.3	89.0	169	113	145	118	139	79.0	232	58.2	68.0
7	45.1	86.4	100	143	109	187	102	159	90.0	209	55.0	553
8	45.1	108	90.0	167	114	251	142	118	240	296	53.6	443
9	50.5	100	94.5	187	95.0	253	114	98.3	580	234	53.0	2630
10	47.0	93.3	78.0	185	101	206	122	99.6	538	217	55.0	1110
11	35.0	92.7	85.0	162	104	261	136	97.6	258	287	53.5	625
12	40.6	98.0	70.2	137	126	279	129	95.7	178	235	63.3	250
13	45.4	90.6	64.4	128	93.4	208	107	101	153	230	55.1	195
14	46.0	118	81.7	138	93.3	189	127	111	127	376	60.3	233
15	50.2	119	79.6	144	199	211	131	111	112	237	70.0	213
16	55.6	101	78.0	149	178	231	155	367	103	193	59.1	175
17	49.6	97.2	86.0	173	159	172	159	427	94.5	170	59.7	155
18	36.3	94.1	72.5	141	201	144	123	187	91.0	167	55.0	148
19	45.2	88.6	61.0	152	213	152	181	161	94.0	147	58.5	133
20	50.0	71.0	77.0	135	159	88.0	230	147	81.0	153	58.5	106
21	50.7	79.0	60.0	170	233	117	176	150	75.0	144	53.0	38.0
22	46.2	85.0	59.1	187	255	117	364	169	64.0	151	49.0	90.0
23	44.3	99.0	56.4	168	195	120	498	147	61.8	149	46.0	91.0
24	41.3	110	54.3	175	180	110	742	135	70.4	145	52.1	75.0
25	63.6	113	80.0	157	157	120	359	115	70.0	102	49.8	93.0
26	90.5	120	70.4	151	162	118	363	106	65.0	98.0	56.5	74.0
27	83.0	103	70.0	130	178	112	294	98.0	68.0	86.5	85.9	79.0
28	103	130	79.0	174	203	107	224	90.0	87.0	79.0	84.5	113
29	125	163	71.6	142	259	122	204	38.0	74.0		88.6	110
30	134	155	66.0	155	261	133	234	119	71.0		63.9	120
31	127		81.0	153		122		105	68.0		71.4	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	[illegible]
MAY	29	2.58	295	4	0.32	33.5	57.4	43	92.6	69	153.79	115
JUN	29	3.06	379	20	0.83	71.0	106	80	126	94	275.89	206
JUL	1	2.40	266	24	0.62	54.2	81.9	61	131	98	219.45	164
AGO	4	3.44	462	1	1.03	95.5	157	118	129	96	421.20	315
SET	28	3.50	476	14	1.06	93.4	165	123	146	109	427.39	320
OCT	11	4.04	630	20	1.00	87.7	164	123	160	120	439.00	328
NOV	24	6.76	1660	4	1.00	87.4	204	152	140	105	528.28	395
DIC	17	4.92	919	29	1.02	88.0	154	115	126	94	412.42	308
ENE	9	4.30	708	23	0.76	61.8	130	97	86.6	65	348.04	260
FEB	14	3.66	519	3	0.70	60.0	176	132	71.2	53	426.60	319
MAR	29	2.62	301	22	0.52	46.0	61.1	46	50.3	38	163.36	122
ABR	9	10.60	3800	5	0.64	55.9	282	211	66.6	50	729.87	546
TOT	9	10.60	3800	4	0.32	33.5	145	108	110	83	4545.46	3399

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
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RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1970 - 1971 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	128	188	139	181	183	242	177	133	172	62.4	83.2	53.1
2	132	160	136	125	150	214	143	135	174	60.7	93.0	54.4
3	103	187	131	129	162	156	149	758	163	79.6	72.2	51.7
4	93.1	164	132	129	190	164	135	1660	145	79.6	73.4	56.5
5	98.0	142	128	71.0	192	156	128	959	127	73.1	67.4	54.6
6	109	150	125	103	156	194	326	462	156	68.3	98.0	54.4
7	150	131	135	90.0	164	144	397	394	160	76.5	69.0	50.6
8	91.3	126	135	68.5	132	107	310	344	132	68.6	84.0	56.7
9	102	120	196	84.3	136	139	217	419	164	65.5	98.4	123
10	97.1	116	170	124	110	182	214	764	120	65.6	83.6	154
11	121	164	213	119	114	183	131	624	94.4	67.1	73.5	180
12	97.3	208	232	101	91.6	123	128	366	127	59.2	75.6	331
13	98.3	159	192	138	136	117	121	303	127	55.4	73.0	137
14	134	135	154	100	118	178	146	268	148	49.1	73.0	135
15	216	137	149	98.6	170	138	167	279	121	62.6	57.4	117
16	223	153	153	116	120	144	464	226	153	65.4	76.3	128
17	217	144	188	89.5	126	144	734	239	108	65.7	106	75.4
18	148	182	190	94.0	179	140	356	371	81.0	63.0	74.0	66.1
19	155	177	161	78.6	168	119	348	918	83.6	107	71.0	76.9
20	149	214	172	76.0	145	97.4	170	356	103	60.1	66.0	75.4
21	193	187	179	90.5	85.2	140	177	393	97.0	69.4	59.2	69.2
22	190	141	118	87.1	162	110	153	413	171	47.0	79.3	89.3
23	175	150	100	74.4	179	124	150	253	306	57.3	84.5	76.1
24	149	158	134	108	167	136	130	212	146	59.6	81.2	64.1
25	147	202	108	127	176	116	115	200	131	64.0	96.2	59.2
26	188	164	130	130	206	79.9	122	193	112	66.0	73.6	62.3
27	176	207	271	208	205	140	82.3	208	110	81.1	63.0	62.4
28	202	173	266	263	205	166	106	193	91.6	72.1	60.5	60.6
29	172	156	180	201	232	226	124	163	91.0		64.5	57.0
30	151	140	170	276	184	285	156	165	117		61.3	55.4
31	175		142	246		234		163	90.0		61.3	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	15	3.08	370	8	1.30	91.3	148	110	95.8	72	395.72	296
JUN	27	4.00	618	10	1.49	116	161	121	128	96	417.74	312
JUL	27	3.84	569	23	1.37	100	162	121	133	99	434.50	325
AGO	27	3.84	569	8	1.05	68.5	127	95	129	96	339.25	254
SET	4	3.36	438	21	1.24	85.2	158	118	147	110	409.86	307
OCT	29	5.00	948	26	1.18	79.8	157	117	160	120	420.61	315
NOV	16	6.20	1410	27	1.07	82.3	209	156	144	108	541.41	405
DIC	4	8.10	2280	1	1.53	133	404	302	141	106	1082.93	810
ENE	23	3.44	460	18	1.05	81.0	133	99	89.2	67	356.10	266
FEB	19	2.32	252	22	0.63	47.0	67.5	51	71.0	53	163.38	122
MAR	17	2.27	244	15	0.77	57.4	75.6	57	51.7	39	202.40	151
ABR	12	3.12	378	7	0.67	50.6	89.5	67	67.9	51	232.10	174
TOT	4	8.10	2280	22	0.63	47.0	158	118	113	85	4995.98	3736

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1971 - 1972 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	59.5	84.0	340	127	130	172	161	113	59.7	54.1	60.9	28.9
2	60.9	81.3	261	142	131	153	150	79.1	71.0	51.6	55.7	31.4
3	63.9	92.7	190	158	122	197	157	70.6	105	48.8	50.0	42.9
4	63.8	223	176	174	178	189	189	75.3	86.0	53.7	47.8	86.1
5	63.5	96.9	87.0	184	170	160	157	65.4	93.0	47.7	49.3	70.6
6	63.2	92.0	100	170	251	186	139	69.6	80.0	59.2	50.0	72.9
7	69.9	78.0	83.0	156	203	160	137	78.8	109	64.4	51.3	66.7
8	74.5	75.0	118	149	161	120	130	67.9	116	61.2	52.4	66.1
9	83.2	109	109	151	158	91.2	149	70.9	87.8	52.2	55.0	73.2
10	94.7	258	150	129	140	131	131	66.0	82.6	50.9	54.4	73.8
11	89.1	101	92.0	153	143	176	128	62.6	79.9	49.8	54.1	74.7
12	101	99.8	118	154	117	179	119	60.2	89.6	42.9	42.7	77.9
13	161	99.5	89.0	124	70.6	219	100	51.6	111	34.6	58.9	80.5
14	110	140	121	121	77.3	136	108	58.8	109	47.3	62.5	78.4
15	161	213	185	100	104	153	109	62.3	106	45.0	62.6	80.2
16	115	84.2	275	123	117	198	91.8	54.6	93.1	45.0	57.2	80.7
17	123	95.4	260	121	123	213	105	59.5	80.8	43.1	56.3	148
18	239	82.1	170	132	128	191	127	62.0	76.5	41.9	51.3	92.7
19	254	149	430	182	156	258	104	58.5	68.0	37.9	36.9	87.8
20	178	176	115	166	159	241	110	65.5	65.7	37.9	48.2	84.0
21	204	201	109	122	177	153	91.0	59.0	63.2	132	55.1	88.7
22	98.5	115	202	169	125	178	95.3	59.2	61.6	157	56.1	89.2
23	218	110	215	139	178	239	96.1	58.7	54.7	113	52.6	83.5
24	133	108	113	161	251	298	82.2	64.0	56.6	79.8	49.7	79.6
25	121	101	120	155	253	223	101	58.9	58.1	70.9	47.5	77.4
26	98.9	104	108	215	161	164	88.4	57.1	55.3	66.3	42.0	71.0
27	85.2	93.0	96.6	162	216	157	79.8	53.2	59.1	55.4	44.5	66.9
28	80.0	99.0	103	160	195	184	83.2	51.7	55.2	62.3	44.8	64.9
29	175	140	127	195	144	168	83.8	53.2	59.2	60.9	39.8	67.2
30	78.0	160	116	189	151	221	73.4	56.0	52.6		32.1	57.5
31	76.0		119	149		240		60.0	49.2		30.4	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	20	3.03	372	1	0.80	59.5	116	87	96.9	72	310.67	232
JUN	30	4.00	618	8	0.99	75.0	122	91	128	95	315.44	236
JUL				7	1.08	83.0	158	118	134	101	423.15	316
AGO	25	2.98	363	15	1.25	100	153	114	130	97	408.84	306
SET	23	4.22	683	13	0.82	70.6	156	117	148	110	405.12	303
OCT	23	4.00	618	9	1.17	91.2	185	139	151	121	496.64	371
NOV	4	2.32	254	30	0.85	73.4	116	87	143	107	300.24	225
DIC	1	2.16	231	13	0.59	51.6	64.0	48	137	102	171.31	128
ENE	12	2.08	220	31	0.57	49.2	77.2	58	88.6	66	206.88	155
FEB	21	2.07	219	13	0.36	34.6	60.9	46	70.5	53	152.56	114
MAR	1	0.90	77.9	31	0.27	30.4	50.1	37	51.6	39	134.10	100
ABR	17	1.84	189	1	0.24	28.9	74.8	56	68.3	51	193.85	145
TOT	23	4.22	683	1	0.24	28.9	111	83	113	85	3518.75	2632

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
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REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1972 - 1973 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	61.4	112	83.5	85.2	107	148	137	67.8	53.2	57.7	50.7	42.8
2	68.5	93.6	88.1	75.8	130	168	144	66.6	55.5	56.3	54.9	43.3
3	62.4	97.9	102	108	156	204	136	63.2	49.7	63.4	48.2	46.3
4	66.7	86.3	89.4	83.4	287	162	137	63.8	57.8	89.0	43.0	45.1
5	64.8	97.0	108	72.2	238	142	114	64.4	49.3	65.6	49.4	36.0
6	61.2	108	79.8	60.7	175	135	102	67.8	44.6	63.8	51.3	33.9
7	62.3	110	86.6	63.8	138	119	120	147	45.6	66.4	51.4	34.2
8	64.5	108	84.8	67.9	125	120	267	94.0	42.9	66.0	52.6	32.9
9	63.8	108	76.8	98.8	118	105	206	80.7	45.1	62.1	50.4	31.3
10	71.1	129	96.8	75.0	127	103	162	80.0	45.5	64.5	47.0	28.8
11	77.4	123	87.6	74.0	119	118	150	72.0	43.8	75.3	35.4	24.6
12	76.2	105	75.4	61.9	103	92.1	151	63.0	44.7	104	45.1	20.9
13	85.3	112	73.6	53.3	103	89.3	147	65.6	122	87.8	47.6	25.3
14	65.8	96.1	70.3	80.0	103	108	208	70.9	295	74.4	48.6	27.2
15	69.5	85.4	66.5	95.9	118	184	203	74.1	227	67.9	48.0	32.1
16	66.5	77.1	55.6	107	130	257	206	72.7	130	64.3	48.2	24.5
17	80.4	75.9	70.5	105	105	234	186	68.4	108	64.1	45.4	26.0
18	91.4	82.4	78.6	103	149	242	133	84.8	92.3	54.5	34.7	24.7
19	91.1	98.6	82.3	168	120	256	119	83.8	81.0	58.2	39.6	26.7
20	95.5	83.4	111	220	108	213	108	74.1	67.8	58.1	46.5	22.8
21	101	74.8	105	179	93.0	164	105	89.7	59.0	57.3	47.0	21.6
22	87.6	73.9	93.6	160	90.3	159	82.2	111	58.3	56.4	42.9	23.7
23	141	72.2	97.8	170	101	150	87.4	150	59.9	54.5	46.9	27.8
24	130	93.3	92.0	171	149	154	89.9	497	58.9	46.3	44.8	27.2
25	118	103	85.6	211	161	130	80.8	145	57.4	37.7	36.5	30.5
26	159	87.6	75.1	218	143	132	88.3	103	57.3	48.4	43.7	30.4
27	188	66.4	65.2	179	141	163	93.1	79.9	55.4	47.7	48.0	29.7
28	187	54.8	68.1	157	138	171	75.2	102	49.4	48.4	49.0	25.6
29	190	92.4	75.7	136	123	200	75.8	82.1	51.4		46.9	23.2
30	145	106	73.9	122	123	160	73.2	73.5	64.5		47.4	32.3
31	128		89.6	120		126		61.8	62.8		45.6	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	28	3.12	389	6	0.82	61.2	97.4	73	96.9	72	260.96	195
JUN	10	2.62	301	28	0.63	54.8	93.4	70	126	94	242.19	181
JUL	20	2.63	302	16	0.64	55.6	84.2	63	131	98	225.40	169
AGO	20	3.28	424	13	0.71	53.3	119	89	129	97	318.11	238
SET	4	4.08	642	22	1.15	90.2	134	100	147	110	347.44	260
OCT	16	3.96	605	23	1.14	89.3	158	118	161	120	424.06	317
NOV	14	3.60	500	30	0.85	73.2	133	99	142	107	344.47	258
DIC	24	4.96	934	31	0.95	61.8	97.3	73	135	101	260.73	195
ENE	14	3.24	419	8	0.68	42.9	75.3	56	87.9	66	201.75	151
FEB	12	2.00	200	25	0.40	37.7	62.9	47	70.1	52	152.07	114
MAR	7	0.90	66.4	18	0.41	34.7	46.3	35	51.3	38	124.13	93
ABR	9	0.87	66.2	12	0.11	20.9	30.1	22	66.4	50	77.92	58
TOT	24	4.96	934	12	0.11	20.9	94.2	70	112	84	2979.22	2228

C.SOLIDO= 4.09268E-06 *C.LIQUIDO^ 4.04759 PARA 0 <= C <= 407
C.SOLIDO= 368.23 *C.LIQUIDO^ 1 PARA 407 <= C <= 4000

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1973 - 1974 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	27.6	174	119	145	183	165	111	146	91.1	67.3	59.1	47.8
2	34.7	225	110	133	185	139	94.8	128	91.9	66.5	58.0	41.8
3	35.6	195	99.0	117	207	112	92.2	112	106	59.8	58.5	40.8
4	35.6	177	94.0	130	175	125	92.8	96.0	95.9	61.2	57.6	48.8
5	34.4	160	84.4	118	137	162	116	86.0	88.6	67.1	56.2	51.2
6	34.6	152	73.8	120	131	156	102	79.6	83.5	76.3	56.9	58.1
7	41.2	148	67.4	98.5	117	159	85.2	81.1	95.0	69.1	59.7	55.2
8	47.1	117	69.8	109	126	125	187	83.5	92.0	64.6	56.0	51.9
9	59.1	114	97.0	86.2	105	197	151	89.4	186	61.3	50.8	49.3
10	42.5	113	106	86.1	120	206	116	426	184	59.4	46.6	38.4
11	46.5	94.8	84.4	93.0	125	166	96.6	523	143	61.3	53.3	25.0
12	48.6	83.8	84.3	73.0	122	141	106	509	113	60.6	54.5	22.0
13	26.4	103	70.5	66.4	154	138	99.5	432	197	70.9	53.2	29.0
14	28.7	142	67.3	63.1	146	118	119	270	149	68.3	53.9	38.5
15	33.9	117	72.6	60.8	141	111	169	214	122	65.0	52.4	47.0
16	42.0	120	86.5	61.1	106	101	218	178	113	62.0	52.7	48.3
17	48.0	156	94.5	70.4	96.8	88.3	177	220	102	58.4	52.9	46.2
18	60.1	162	124	71.9	109	83.6	162	361	93.2	64.6	57.8	47.1
19	106	257	132	74.4	99.3	81.7	192	313	91.1	63.8	61.1	58.8
20	97.4	289	132	119	121	104	165	212	88.0	62.5	53.4	58.6
21	79.1	231	238	178	112	149	129	184	81.6	60.3	51.6	57.2
22	86.3	180	171	191	96.2	140	121	230	87.4	58.1	55.1	89.5
23	78.0	214	174	200	103	295	122	193	79.5	50.9	54.5	66.5
24	86.2	247	139	229	106	275	130	150	94.3	46.6	47.4	66.8
25	92.7	269	138	184	107	236	122	130	83.2	46.8	49.3	60.0
26	76.5	205	161	243	95.1	198	147	127	74.6	51.7	54.8	65.9
27	81.7	201	188	355	88.3	174	150	142	71.7	66.1	53.1	81.4
28	113	180	175	229	111	148	206	111	78.0	63.8	54.1	63.2
29	109	153	140	374	136	150	264	107	69.9		54.9	62.9
30	135	134	134	276	138	133	215	113	76.2		55.5	74.8
31	132		131	237		111		97.8	75.5		53.0	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	19	2.54	286	13	0.41	26.4	64.5	48	95.3	71	172.74	129
JUN	20	3.76	547	12	1.14	83.8	170	127	128	96	441.82	330
JUL	20	2.84	341	14	0.95	67.3	118	88	130	97	315.96	236
AGO	27	4.52	779	15	0.87	60.8	148	111	130	97	396.76	297
SET	1	3.16	404	27	1.18	88.3	127	95	146	109	328.30	246
OCT	23	4.00	616	19	1.11	81.7	151	113	161	120	404.97	303
NOV	8	2.96	364	2	0.92	65.6	142	106	142	106	367.81	275
DIC	10	5.16	1000	6	1.10	79.6	198	148	138	103	530.81	397
ENE	9	2.68	320	29	0.92	69.9	103	77	88.6	66	276.67	207
FEB	6	1.19	94.8	24	0.61	46.6	61.9	46	69.7	52	149.82	112
MAR				10	0.61	46.6	54.5	41	51.5	38	145.87	109
ABR	10	4.00	616	12	0.14	22.0	53.1	40	65.8	49	137.57	103
TOT	10	5.16	1000	12	0.14	22.0	116	87	112	84	3669.04	2744

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REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1974 - 1975 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	71.8	214	156	118	164	132	156	110	53.5	99.6	42.0	39.9
2	67.1	155	178	137	125	129	173	103	53.7	77.1	39.5	39.7
3	65.1	110	128	133	106	117	95.3	258	44.6	67.8	37.9	37.0
4	65.7	137	111	110	98.0	114	143	873	49.6	63.8	37.6	38.5
5	59.0	113	120	106	101	115	76.4	722	50.5	62.5	41.0	39.1
6	57.7	100	108	102	86.2	120	124	339	52.4	57.9	36.6	40.8
7	56.5	87.4	105	98.7	79.7	124	72.6	220	55.7	57.1	36.8	40.5
8	64.9	94.1	121	82.5	102	129	81.6	172	48.4	55.5	38.3	45.0
9	86.5	135	92.6	87.8	138	126	124	150	52.8	44.2	36.7	43.9
10	78.9	168	160	93.8	112	78.8	66.3	138	54.3	46.9	37.4	42.6
11	83.5	178	135	119	125	80.3	111	108	51.8	44.2	38.2	42.3
12	74.2	307	182	170	166	104	63.8	101	48.0	43.0	40.4	41.0
13	82.9	276	199	174	109	102	61.5	104	49.5	40.9	41.7	38.6
14	99.8	151	141	170	97.3	92.8	60.2	89.7	52.6	39.8	38.6	38.1
15	118	125	153	171	103	92.8	62.3	86.9	52.2	38.0	33.9	32.6
16	151	129	159	131	100	82.4	62.7	82.4	52.6	38.8	38.6	34.7
17	159	153	116	165	108	121	74.8	76.6	56.6	35.4	38.4	35.0
18	174	148	121	97.5	102	149	83.5	71.6	55.3	36.6	39.1	38.6
19	178	130	134	83.6	80.9	212	83.2	65.8	38.7	35.0	36.7	37.2
20	149	136	143	96.4	97.1	186	79.0	60.9	53.6	35.6	40.1	36.4
21	120	130	117	188	86.4	132	69.1	56.8	54.6	34.3	38.0	47.2
22	122	125	106	165	74.1	130	70.6	57.4	57.9	30.8	34.7	52.7
23	123	137	113	175	83.5	80.1	79.6	59.6	51.2	29.2	36.3	53.5
24	119	144	118	226	80.5	147	69.7	52.7	60.5	33.5	36.7	50.7
25	93.8	123	140	173	143	179	85.8	55.5	51.8	37.3	31.8	40.0
26	87.2	183	136	166	91.6	260	98.0	55.8	43.9	32.5	29.4	36.7
27	85.8	179	110	184	69.9	192	176	55.7	49.1	37.6	24.2	41.0
28	85.6	136	145	158	98.9	175	302	46.0	52.3	41.4	26.0	41.9
29	81.9	121	119	178	125	163	203	54.1	52.9		28.4	39.5
30	78.8	134	102	138	139	150	128	51.1	51.8		28.9	39.1
31	134		116	144		194		50.1	65.4		35.9	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	31	3.69	527	7	0.76	56.5	99.2	74	95.5	71	265.57	199
JUN	12	4.81	876	7	1.12	87.4	149	111	129	96	385.21	288
JUL	12	3.36	468	9	1.17	92.6	132	99	130	97	352.91	264
AGO	17	3.44	487	8	1.04	82.5	140	105	130	98	375.09	281
SET	12	4.40	740	22	0.98	74.1	106	80	144	108	275.80	206
OCT	18	3.77	550	10	1.03	78.8	136	102	160	120	363.67	272
NOV	28	3.03	394	14	0.81	60.2	105	78	140	105	270.95	203
DIC	4	5.77	1230	28	0.61	46.0	146	109	138	103	391.11	293
ENE	7	1.20	95.9	26	0.57	43.9	52.2	39	86.9	65	139.77	105
FEB	1	1.80	172	23	0.31	29.2	46.3	35	68.6	51	112.00	84
MAR	2	0.66	49.7	27	0.19	24.2	36.1	27	50.8	38	96.75	72
ABR	22	0.86	64.5	15	0.38	32.6	40.8	31	64.7	48	105.74	79
TOT	4	5.77	1230	27	0.19	24.2	99.0	74	112	83	3134.50	2344

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO REVENTAZON EN ANGOSTURA 73-09-03

AREA DE DRENAJE: 1337KM2 ELEVACION: 532MSNM

ANO HIDROLOGICO 1975 - 1976 DATOS DESDE:SET.6,1953

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	40.5	91.8	214	121	116	188	97.7	246	93.4	61.9	40.4	44.5
2	46.5	81.3	277	147	108	196	88.1	177	81.5	68.0	49.1	45.0
3	46.1	85.6	264	188	119	242	95.0	139	78.1	68.4	45.6	37.0
4	38.3	82.3	271	261	136	208	142	132	83.5	68.4	41.6	31.2
5	46.3	76.6	178	240	133	194	219	142	72.7	64.9	48.3	28.2
6	36.9	81.4	135	176	204	202	215	171	75.5	63.7	48.6	36.5
7	37.3	106	182	176	198	181	199	218	75.6	66.0	43.2	34.2
8	30.5	107	142	121	162	186	156	264	74.4	42.4	41.8	31.5
9	35.3	96.1	176	157	142	218	129	254	80.9	56.1	40.8	36.2
10	31.1	72.9	120	117	171	196	120	187	75.6	63.0	46.9	51.5
11	38.7	79.5	83.3	115	168	156	146	217	75.3	69.6	43.0	46.6
12	37.0	95.5	120	118	280	168	179	421	69.4	71.3	39.6	39.3
13	39.9	81.2	115	132	307	127	217	599	68.2	65.5	42.2	33.1
14	41.3	83.1	115	146	207	144	163	907	64.7	64.5	31.6	40.1
15	42.8	100	118	166	177	154	237	494	59.6	60.8	45.5	33.8
16	34.3	102	140	199	155	225	299	322	64.0	72.2	46.5	33.0
17	39.7	108	116	178	180	241	202	261	86.4	57.7	47.0	36.3
18	42.8	95.7	114	211	183	191	190	216	334	60.9	47.0	37.9
19	42.5	81.2	97.2	189	187	183	144	187	405	60.1	44.0	50.0
20	45.1	109	97.2	226	204	165	142	161	188	62.1	44.2	67.9
21	54.9	117	101	287	191	152	146	146	128	58.2	43.0	53.6
22	57.9	90.8	104	180	281	140	128	128	109	45.8	49.6	50.6
23	58.1	130	124	188	302	126	247	131	102	48.9	55.8	46.5
24	60.5	194	110	255	274	81.9	208	129	89.0	49.8	52.5	39.8
25	56.3	110	115	184	232	86.7	170	120	67.7	43.1	52.0	39.8
26	59.8	101	153	137	243	109	182	130	74.7	38.1	46.0	50.2
27	80.9	117	91.2	172	254	107	146	143	75.1	31.8	42.0	55.1
28	97.4	209	126	150	206	78.4	126	117	72.5	30.5	26.8	67.3
29	90.4	260	101	183	205	84.8	120	109	75.0	24.9	33.0	67.6
30	86.4	213	110	170	218	88.9	119	96.4	67.8		42.0	92.6
31	111		108	115		86.1		90.6	66.9		44.5	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	M.M.C	MM
MAY	28	2.59	303	8	0.32	30.5	51.8	39	93.5	70	138.70	104
JUN	28	3.74	541	10	0.96	72.9	112	84	128	96	290.16	217
JUL	26	3.56	492	11	1.20	83.3	139	104	130	98	373.03	279
AGO	20	3.08	405	11	1.48	115	174	130	132	99	466.99	349
SET	22	3.98	610	2	1.35	108	198	148	146	110	513.48	384
OCT	16	3.66	519	28	1.15	78.4	158	118	160	120	421.66	317
NOV	16	3.57	494	2	1.25	88.1	165	124	141	106	428.70	321
DIC	14	5.84	1260	31	1.27	90.6	228	170	142	106	609.55	456
ENE	18	4.17	667	15	0.94	59.6	101	76	87.5	65	270.65	202
FEB	15	1.52	120	29	0.42	24.9	56.5	42	68.1	51	141.54	106
MAR				28	0.76	26.9	44.0	33	50.5	38	117.38	88
ABR				5	0.80	28.2	44.9	34	63.8	48	116.37	87
TOT	14	5.84	1260	29	0.42	24.9	123	92	112	84	3890.67	2910

A-2 Monthly Run-off at Dos Montanas Gauging Station

C.A = 652 km^2

(Unit : m^3/sec)

Year	Jan.	Fed.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1959	16.4	10.8	10.5	11.7	41.9	59.4	51.5	50.2	44.9	100.	59.8	48.2
1960	39.5	34.2	27.5	25.9	50.1	68.4	65.3	62.4	62.8	101.	69.7	96.7
1961	29.3	18.7	15.4	11.4	37.9	61.8	58.6	45.8	79.9	97.0	93.3	90.4
1962	50.3	24.3	15.5	26.7	66.1	74.2	72.7	57.3	50.6	128.	203.	89.1
1963	38.5	35.3	26.5	45.3	60.0	67.2						

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
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REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO PACUARE EN SIQUIRRES 75-09-02

AREA DE DRENAJE: 657KM2 ELEVACION: 53[illegible]

ANO HIDROLOGICO 1963 - 1964 DATOS DESDE: JUNIO 6,1963

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1			65.0	53.2	39.8	65.3	134	67.3	338	24.0	17.5	12.5
2			65.3	80.9	55.6	60.8	128	30.4	233	27.7	17.5	12.4
3			66.5	106	46.2	59.4	118	61.5	132	26.5	17.5	12.4
4			66.5	68.0	59.4	64.8	163	54.0	96.7	25.9	16.3	12.3
5			108	59.4	55.6	67.4	188	52.2	82.4	25.1	16.5	12.2
6			75.7	55.6	58.0	65.3	150	73.0	75.8	24.9	16.5	12.2
7			68.0	50.8	110	70.2	134	64.7	66.5	24.0	17.1	12.3
8			60.8	58.0	108	95.3	121	54.0	61.5	23.7	16.4	12.3
9		94.8	63.6	60.8	68.0	93.2	104	176	56.1	22.0	16.7	12.3
10		78.8	98.6	56.9	144	100	102	223	52.7	22.7	16.1	12.4
11		92.8	96.7	52.0	119	126	96.5	111	49.3	22.6	15.3	12.3
12		120	75.7	75.7	106	131	85.6	72.6	47.5	21.9	14.9	12.3
13		119	66.5	66.7	80.4	103	104	61.1	45.4	21.8	15.3	12.3
14		92.8	63.6	132	77.3	131	153	54.4	47.5	21.1	16.0	12.3
15		78.8	66.5	69.6	75.7	117	239	50.3	82.2	21.4	21.6	12.1
16		72.6	59.0	59.4	108	118	265	47.5	60.8	21.1	21.3	13.2
17		74.2	63.6	54.4	78.9	92.6	201	45.3	51.0	20.5	17.0	13.1
18		65.0	66.5	57.1	89.4	150	163	43.4	46.2	20.3	15.4	12.5
19		60.8	68.0	55.6	111	116	134	42.6	43.0	20.1	15.1	12.5
20		60.0	63.6	63.1	102	120	115	40.9	40.8	19.8	15.3	11.7
21		59.0	63.2	74.1	125	132	102	39.9	38.9	19.4	14.6	11.7
22		55.6	68.0	79.1	98.7	100	92.8	38.1	37.3	19.3	20.5	11.5
23		66.5	69.6	59.7	91.2	102	88.2	37.0	36.1	18.7	17.2	17.2
24		103	63.6	57.1	92.5	167	80.4	48.6	35.4	18.7	16.1	16.7
25		81.1	71.0	54.2	108	109	73.1	116	33.6	18.5	14.5	23.3
26		166	60.8	49.3	102	90.9	68.5	92.9	32.6	18.6	13.8	17.4
27		143	54.4	46.1	95.0	87.9	63.7	82.1	31.4	18.3	13.4	17.8
28		65.0	69.0	43.6	120	86.6	61.0	65.0	30.7	17.9	14.2	19.3
29		64.8	60.9	41.9	83.8	79.0	57.3	55.0	23.8	17.6	13.1	19.5
30		89.0	54.4	37.7	72.8	127	65.0	99.2	24.5		13.0	13.0
31			54.3	41.0		138		81.8	28.0		12.9	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE AÑO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
JUL	10	1.42	198	31	0.67	54.3	68.3	104	68.3	104	182.81	278
AGO	13	1.82	313	30	0.52	37.7	62.0	94	62.0	94	165.97	252
SET	19	1.86	325	1	0.54	39.8	89.4	136	89.3	136	231.66	352
OCT	30	1.90	338	3	0.71	59.4	102	155	102	155	273.52	415
NOV	15	2.16	426	29	0.70	57.3	123	188	123	187	313.69	476
DIC	9	2.87	724	23	0.51	37.0	72.1	110	72.1	110	193.23	294
ENE	1	2.35	500	31	0.42	28.0	66.8	102	66.8	102	179.02	272
FEB	1	0.46	31.4	29	0.30	17.6	21.7	33	21.7	33	54.41	83
MAR	15	0.49	34.6	31	0.24	12.9	16.1	25	16.1	24	43.14	66
ABR	25	0.50	35.6	22	0.22	11.5	13.9	21	14.0	21	36.14	55
TOT	9	2.87	724	22	0.22	11.5						

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO PACUARE EN SIQUIRRES 75-08-02

AREA DE DRENAJE: 657KM2 ELEVACION: 53[illegible]

ANO HIDROLOGICO 1964 - 1965 DATOS DESDE: JUNIO 6,1963

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	12.5	35.5	89.5	74.0	80.8	59.4	94.9	44.0	21.0	41.7	37.6	24.5
2	12.7	37.1	71.5	59.5	77.3	54.1	106	36.7	20.8	39.6	32.2	24.3
3	12.4	31.9	57.4	62.0	68.4	53.1	124	32.5	20.6	44.8	29.0	28.6
4	13.0	48.6	48.5	61.0	57.2	65.0	114	30.7	22.2	37.8	35.1	24.7
5	11.6	44.0	41.4	55.6	50.4	50.9	83.2	31.1	33.6	33.9	28.0	22.2
6	11.0	33.4	63.8	50.9	46.2	48.5	71.6	45.1	124	32.7	45.1	21.0
7	12.0	30.4	47.2	48.6	44.1	57.7	75.7	37.8	137	31.4	176	20.2
8	11.4	42.5	70.6	43.0	45.4	49.8	66.9	34.1	89.0	31.1	163	19.4
9	11.5	41.9	56.8	50.0	58.0	46.4	59.4	30.3	63.6	28.8	102	18.9
10	13.1	39.6	58.7	41.0	62.2	46.6	55.6	28.5	52.6	27.9	66.5	16.6
11	12.9	76.7	52.6	39.7	55.5	64.2	54.1	27.8	50.8	27.1	52.0	18.2
12	13.3	58.0	43.8	38.7	50.9	77.6	55.1	27.6	42.3	26.2	44.8	18.3
13	13.0	42.9	51.6	45.1	48.6	111	52.3	28.0	38.6	25.4	40.0	18.4
14	18.3	35.0	71.0	82.1	50.5	85.0	55.4	29.7	38.7	24.5	37.2	17.6
15	24.6	82.2	50.0	87.3	60.5	84.8	52.1	30.0	53.6	23.9	35.1	17.8
16	22.8	48.5	63.3	75.0	57.8	114	49.8	26.8	61.1	23.4	35.6	17.8
17	22.6	43.0	46.3	83.7	44.2	110	45.1	25.6	79.8	22.8	31.4	17.9
18	26.3	39.3	47.3	78.7	38.7	82.1	42.0	25.1	220	22.9	30.0	17.8
19	32.4	59.6	43.0	61.0	83.8	163	40.3	24.4	318	36.0	28.7	17.9
20	31.4	58.1	42.9	63.5	127	149	39.9	29.5	248	49.7	28.5	17.6
21	28.8	55.1	65.4	58.5	85.8	119	43.4	29.5	136	31.4	32.2	17.6
22	32.4	63.5	116	63.7	68.6	90.7	39.3	30.0	108	26.8	28.8	17.6
23	38.3	74.5	129	48.7	89.8	115	45.1	27.6	83.8	25.2	27.0	16.5
24	27.9	85.8	107	50.8	62.2	96.8	50.7	26.8	71.1	23.9	26.2	16.0
25	38.0	50.8	80.4	59.4	65.0	116	40.8	25.0	63.6	25.2	26.2	15.5
26	72.8	42.0	62.3	48.6	63.5	100	37.0	24.7	59.3	82.5	25.0	14.9
27	76.8	42.6	61.5	82.2	59.4	80.4	35.1	34.7	61.0	90.8	25.0	14.5
28	41.9	45.3	51.0	53.0	55.4	69.7	33.4	25.9	55.9	48.5	27.5	14.5
29	49.7	34.7	53.2	51.0	86.3	66.1	37.4	23.3	50.1		26.5	16.7
30	39.0	42.1	71.4	49.7	74.6	69.4	40.6	22.5	47.0		32.4	16.1
31	36.1		108	80.0		79.2		21.7	44.0		27.3	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE AÑO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY	27	1.25	162	6	0.21	11.0	26.5	40	26.5	40	70.89	108
JUN	15	1.43	200	7	0.45	30.4	48.8	74	48.8	74	126.54	193
JUL	22	1.56	235	5	0.56	41.4	65.2	99	66.8	102	174.76	266
AGO	31	1.52	224	12	0.53	38.7	59.5	91	60.8	92	159.49	243
SET	20	1.55	232	18	0.53	38.7	63.9	97	76.6	117	165.74	252
OCT	19	2.05	387	9	0.60	46.4	83.0	126	92.5	141	222.44	338
NOV	2	1.41	195	28	0.48	33.4	58.0	88	90.5	138	150.40	229
DIC	6	0.71	59.6	31	0.35	21.7	29.6	45	50.8	77	79.23	121
ENE	19	2.26	457	3	0.34	20.6	81.1	123	74.0	113	217.30	331
FEB	26	1.27	166	17	0.36	22.8	35.2	54	28.5	43	85.18	130
MAR	7	1.59	243	26	0.39	25.0	44.6	68	30.4	46	119.57	182
ABR	3	0.67	32.5	28	0.26	14.5	18.7	28	16.4	25	48.52	74
TOT	19	2.24	457	6	0.21	11.0	51.2	78	55.2	84	1620.02	2465

RIO PACUARE EN SIQUIRRES 75-08-02

AREA DE DRENAJE: 657KM2 ELEVACION: 53MSNM

ANO HIDROLOGICO 1965 - 1966 DATOS DESDE:

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	13.8	89.1	55.3	68.2	44.0	94.0	93.5	60.8	46.0	109	41.5	37.2
2	13.8	60.8	47.0	106	42.0	95.0	102	56.9	38.7	85.0	40.0	28.8
3	13.8	52.0	42.9	104	58.0	97.0	104	58.0	35.4	81.4	53.2	25.0
4	16.8	48.5	45.1	65.0	38.0	77.0	91.0	52.0	33.5	77.0	63.8	26.0
5	16.8	46.2	49.0	60.6	42.0	70.0	76.0	55.3	30.4	62.2	54.4	23.5
6	55.9	46.2	53.2	55.6	51.0	65.0	56.5	52.0	29.5	57.2	48.5	24.3
7	26.9	75.0	49.5	50.8	88.0	58.0	63.1	50.5	27.8	62.0	45.0	32.5
8	26.9	49.7	44.0	52.2	99.0	58.0	66.4	58.0	28.6	50.8	41.9	24.3
9	39.0	50.7	40.2	111	67.0	56.0	82.1	48.5	63.7	44.5	39.0	21.6
10	82.1	106	40.3	51.0	70.0	54.5	75.7	45.0	62.2	41.8	37.8	21.0
11	86.9	65.0	43.1	51.5	65.5	51.5	66.5	42.6	42.9	42.5	35.6	20.3
12	60.5	67.9	46.0	50.6	53.5	86.0	59.0	41.5	43.2	38.2	34.6	20.0
13	33.0	77.4	42.9	48.5	48.5	94.0	96.0	39.2	63.8	37.5	32.5	18.6
14	28.6	52.0	42.2	65.5	51.5	70.0	99.0	35.8	55.6	53.5	31.5	18.0
15	24.3	46.2	43.4	70.1	58.0	87.0	78.9	33.8	60.8	31.4	41.2	17.6
16	30.0	43.0	56.4	86.3	65.0	85.0	69.6	31.4	45.1	30.0	29.3	17.6
17	30.4	38.7	48.5	50.0	63.0	67.5	58.0	47.8	39.5	30.5	28.1	18.3
18	27.8	38.7	59.9	51.0	64.5	68.0	52.5	93.5	43.0	27.8	28.2	17.5
19	66.9	38.7	89.6	50.8	77.0	51.0	30.6	98.4	40.7	27.2	31.5	17.0
20	50.8	37.7	46.8	94.3	101	101	50.2	103	34.5	37.7	27.8	18.4
21	44.0	58.9	102	74.0	104	112	43.5	58.5	33.5	33.8	34.6	37.5
22	59.4	60.8	144	68.0	96.5	91.4	48.5	45.0	34.5	29.5	34.6	27.8
23	106	74.0	71.0	70.0	117	90.5	44.0	42.2	67.7	28.2	29.5	22.6
24	85.0	105	55.6	64.0	122	115	68.5	41.5	53.0	222	27.8	99.4
25	68.3	85.0	50.0	58.0	175	232	168	37.0	38.5	590	26.6	105
26	58.0	86.4	43.0	53.0	123	139	173	34.7	34.5	82.0	29.5	52.0
27	62.0	72.8	76.4	50.0	105	120	96.6	37.5	160	53.0	29.5	51.0
28	60.8	75.1	315	49.0	99.0	112	75.7	50.2	300	45.5	26.0	92.4
29	104	70.7	76.0	46.0	118	112	65.0	42.9	113		24.6	62.2
30	63.6	58.0	65.0	49.0	95.0	94.7	63.2	55.5	94.4		24.0	109
31	68.5		58.0	49.0		77.5		66.8	177		26.2	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE AÑO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY	23	1.37	187	1	0.25	13.8	49.8	76	38.2	58	133.45	203
JUN	25	1.38	189	20	0.52	37.7	62.5	95	55.7	85	162.10	247
JUL	28	3.00	790	9	0.54	40.2	65.8	100	66.5	101	176.37	268
AGO	15	1.52	224	29	0.60	46.0	63.6	97	61.7	94	170.47	259
SET	7	1.95	355	3	0.52	38.0	80.0	122	77.7	118	207.45	316
OCT	25	2.23	453	19	0.64	51.0	89.7	137	91.6	139	240.33	366
NOV	25	1.85	322	21	0.57	43.5	78.2	119	86.4	131	202.75	308
DIC	19	1.37	187	16	0.46	31.4	52.1	79	51.2	78	139.60	212
ENE	28	2.51	564	7	0.42	27.8	63.6	97	70.5	107	170.29	259
FEB	25	3.98	1290	19	0.41	27.2	75.4	115	44.1	67	182.41	278
MAR	3	0.80	72.6	30	0.38	24.0	35.4	54	32.1	49	94.89	144
ABR	24	1.49	215	19	0.29	17.0	36.9	56	23.1	35	95.61	145
TOT	25	3.98	1290	1	0.25	13.8	62.8	95	58.2	89	1975.69	3006

RIO PACUARE EN SIQUIRRES 75-08-02

AREA DE DRENAJE: 657KM2 ELEVACION: 53MSNM

ANO HIDROLOGICO 1966 - 1967 DATOS DESDE:JUNIO 9,1963

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	87.2	117	48.5	44.0	56.2	92.6	61.0	106	74.3	35.1	21.3	15.3
2	90.3	131	47.0	39.7	55.5	97.6	60.8	178	68.5	32.3	20.8	15.8
3	104	123	44.0	38.2	54.6	79.0	149	214	62.5	32.0	21.0	15.4
4	89.0	102	41.5	35.7	47.5	63.6	155	188	57.8	44.0	26.1	15.2
5	94.6	82.3	40.2	36.6	44.0	56.5	176	134	55.1	36.4	23.7	16.1
6	62.2	107	39.2	34.5	50.8	56.7	165	109	67.3	32.3	23.5	16.7
7	58.0	146	38.0	56.7	49.6	71.4	168	96.2	51.5	30.2	22.8	20.5
8	61.0	118	46.9	59.8	42.7	58.5	121	88.8	47.5	28.8	22.9	39.0
9	80.6	92.8	62.0	45.0	48.5	65.2	94.8	89.8	46.8	27.8	21.5	75.0
10	62.5	75.7	41.5	40.1	65.7	55.6	80.0	96.4	49.0	26.8	20.5	63.2
11	52.0	66.6	38.7	36.6	77.7	55.5	70.5	111	50.7	26.2	42.2	37.1
12	76.0	63.3	82.2	44.6	52.0	56.0	63.9	120	48.0	26.3	28.8	32.5
13	90.5	118	124	41.5	45.5	54.4	66.4	105	46.0	27.4	31.4	34.6
14	74.1	101	124	54.5	44.0	47.4	57.5	95.5	44.0	25.5	25.5	51.1
15	106	88.8	83.8	32.0	52.2	45.1	54.1	94.1	42.6	24.4	22.7	96.8
16	125	66.7	65.2	35.6	52.4	71.5	55.6	78.2	41.5	23.7	21.0	121
17	113	58.5	66.5	43.2	82.2	65.0	48.5	70.3	40.5	23.6	20.4	70.0
18	90.3	71.4	63.2	69.7	45.0	87.8	45.1	76.0	59.7	24.7	21.2	62.5
19	121	74.0	80.3	66.0	53.0	80.5	42.5	76.5	65.5	24.4	20.2	43.8
20	84.4	76.4	63.8	101	40.8	95.1	40.8	108	87.0	23.6	18.9	36.2
21	100	113	63.1	91.4	40.8	68.4	43.0	102	61.0	22.9	18.5	44.8
22	96.8	89.0	55.6	66.3	42.2	80.2	58.0	82.5	53.9	23.6	18.8	67.5
23	100	80.5	49.6	62.0	46.1	70.0	115	76.9	46.2	23.5	18.1	86.5
24	83.8	78.8	46.0	49.7	68.5	56.8	223	83.2	41.7	22.1	18.3	44.5
25	83.9	75.6	63.5	44.0	54.4	56.9	110	255	37.9	25.2	20.4	68.5
26	82.9	72.5	55.5	73.5	52.0	52.0	94.3	471	35.1	24.8	18.1	67.6
27	90.6	77.7	49.3	110	40.3	56.5	77.5	251	34.0	23.5	16.8	48.5
28	82.9	68.0	66.9	112	48.4	80.3	123	148	33.5	21.6	18.2	54.5
29	74.2	59.4	55.6	82.1	50.5	58.0	132	114	58.7		18.1	61.0
30	72.2	53.3	52.0	66.1	66.3	59.4	93.2	95.6	42.6		17.0	52.0
31	77.9		47.0	79.3		55.6		82.5	40.0		15.3	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE AÑO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY	19	1.53	226	11	0.65	52.0	86.1	131	54.2	82	230.59	351
JUN	13	2.11	408	30	0.66	53.3	88.2	134	66.5	101	228.73	348
JUL	11	1.59	243	7	0.52	38.0	59.5	91	64.8	95	159.37	242
AGO	27	1.60	246	6	0.49	34.5	57.8	88	60.7	92	154.78	235
SET	24	1.11	130	20	0.55	40.8	51.6	79	71.2	108	133.87	204
OCT	1	1.51	221	15	0.59	45.1	65.5	100	85.1	129	175.31	267
NOV	24	2.43	532	20	0.55	40.8	94.8	144	88.5	135	245.76	374
DIC	26	2.96	770	17	0.69	70.3	129	196	70.6	107	345.30	525
ENE	20	1.05	130	28	0.37	33.5	50.7	77	65.5	100	135.68	206
FEB	4	0.56	53.9	28	0.23	21.6	27.3	41	39.9	61	65.97	100
MAR	11	0.67	67.5	31	0.15	15.3	21.8	33	28.5	45	58.41	89
ABR	15	1.77	298	4	0.15	15.2	49.8	76	29.8	45	129.01	196
TOT	12	2.96	770	4	0.15	15.2	65.2	99	60.5	92	2062.74	3138

AREA DE DRENAJE: 657KM2 RIO PACUARE EN SIQUIRRES 75-08-02 ELEVACION: 53MSNM

ANO HIDROLOGICO 1967 - 1968 DATOS DESDE:JUNIO 9,1963

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	43.2	64.1	116	59.6	123	77.4	61.0	130	29.7	72.2	61.7	69.4
2	40.0	87.8	82.3	58.8	174	69.3	56.7	98.7	29.5	51.2	54.6	79.2
3	35.3	167	71.5	233	125	76.6	52.0	91.5	35.6	43.5	51.2	67.5
4	34.2	103	72.5	173	96.4	74.2	49.6	104	52.8	39.2	45.5	79.2
5	31.3	139	71.2	92.2	80.8	79.4	49.7	80.7	34.4	35.7	42.2	67.0
6	30.4	103	59.5	104	72.2	63.5	46.7	73.4	30.7	33.8	39.0	59.1
7	28.7	101	53.8	112	68.0	56.2	55.6	79.5	28.9	32.2	36.6	57.0
8	27.4	86.0	62.8	87.2	81.1	61.7	53.2	72.1	27.9	71.7	34.7	75.2
9	30.6	93.9	50.4	72.8	92.3	61.0	94.6	73.5	27.5	115	33.2	96.7
10	40.3	89.3	51.0	81.6	72.2	69.4	85.3	60.4	27.0	88.9	31.6	114
11	63.4	157	47.2	79.4	68.3	65.5	62.9	55.6	26.5	61.8	30.5	85.2
12	44.7	93.9	52.5	74.8	68.1	50.7	56.9	58.0	25.8	49.7	29.4	65.4
13	41.0	72.8	176	63.5	66.8	48.8	54.4	54.4	25.6	41.4	28.8	56.9
14	36.8	62.3	68.8	58.6	61.8	46.8	55.5	52.0	26.0	36.4	41.1	50.7
15	32.4	73.6	61.0	54.5	95.9	91.2	75.3	47.6	34.7	33.2	81.9	45.7
16	40.0	91.7	59.1	52.3	73.7	102	107	43.8	45.3	33.1	38.5	42.5
17	59.3	112	60.7	56.3	69.9	81.4	247	42.3	35.7	31.1	33.0	40.2
18	91.7	113	57.6	55.1	61.7	145	148	40.5	29.2	29.2	31.3	37.8
19	96.5	80.5	51.5	50.4	59.4	128	108	38.5	27.0	28.9	29.8	37.6
20	68.2	76.8	61.0	46.8	61.3	138	109	37.4	25.8	27.3	28.1	35.6
21	49.3	72.4	60.5	45.8	65.1	158	100	36.6	25.5	26.8	27.2	33.8
22	41.7	62.2	59.3	44.2	61.8	187	81.5	35.2	29.0	28.1	27.1	32.3
23	41.5	62.4	73.2	52.5	54.5	167	74.8	37.5	25.5	50.1	153	31.3
24	57.6	73.3	59.8	102	77.0	141	64.3	58.0	90.0	37.8	160	30.4
25	48.1	70.2	73.7	145	76.2	114	59.0	50.7	50.7	239	97.8	30.2
26	73.6	70.7	67.2	126	68.5	99.8	55.7	39.4	42.0	186	68.0	28.6
27	57.4	91.2	116	104	62.9	91.5	71.3	35.7	38.4	125	60.9	27.9
28	70.9	135	78.2	88.8	64.9	80.7	87.9	34.2	34.2	100	144	27.3
29	80.5	119	68.7	71.5	100	70.6	77.8	33.0	32.1	73.5	128	26.6
30	59.0	99.5	81.0	64.3	80.2	67.0	86.0	31.5	128		85.1	27.2
31	49.3		56.1	76.6		69.3		31.0	125		62.2	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE AÑO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY	18	1.24	169	8	0.30	27.4	49.8	76	53.1	81	133.43	203
JUN	3	2.27	468	22	0.63	62.2	94.1	143	73.4	112	243.96	371
JUL	13	2.04	384	11	0.50	47.2	70.3	107	65.9	100	188.36	287
AGO	3	3.02	799	22	0.47	44.2	83.4	127	65.2	99	223.48	340
SET	1	2.15	423	23	0.52	54.5	79.4	121	72.8	111	205.89	313
OCT	22	1.68	269	14	0.45	46.8	91.4	139	86.4	131	244.68	372
NOV	17	2.19	437	6	0.45	46.7	79.6	121	85.7	132	206.21	314
DIC	1	1.35	199	31	0.29	31.0	56.7	86	67.8	103	151.78	231
ENE	30	1.75	293	21	0.22	25.5	40.2	61	60.4	92	107.65	164
FEB	25	1.97	362	21	0.24	26.8	62.8	96	44.5	68	157.40	239
MAR	23	1.74	290	22	0.24	27.1	58.6	89	35.3	54	156.90	239
ABR	10	1.20	168	29	0.23	26.6	51.9	79	34.2	52	134.59	205
TOT	3	3.02	799	21	0.22	25.5	68.2	104	62.2	95	2154.31	3278

AREA DE DRENAJE: 657KM2 RIO PACUARE EN SIQUIRRES 75-08-02 ELEVACION: 53MSNM

ANO HIDROLOGICO 1968 - 1969 DATOS DESDE:JUNIO 9,1963

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	36.7	106	72.1	97.7	88.6	63.7	126	59.2	36.0	26.5	16.5	34.1
2	34.3	124	75.8	86.2	78.1	67.8	123	56.8	35.2	23.7	15.9	23.4
3	33.8	107	93.9	111	79.9	80.9	127	53.0	34.1	22.2	15.9	19.0
4	30.4	108	106	105	65.5	83.9	97.0	49.8	33.0	23.7	15.7	18.7
5	52.0	125	87.7	85.1	64.9	98.4	86.2	49.6	31.5	47.8	15.3	17.2
6	69.0	114	73.9	74.9	113	76.1	76.1	46.1	30.8	32.7	15.0	16.6
7	103	88.1	67.3	70.7	176	65.4	71.1	44.4	30.3	25.6	16.5	16.6
8	92.9	72.9	66.7	72.1	162	77.6	70.5	43.5	29.2	23.4	15.8	15.3
9	72.1	72.2	62.5	79.2	117	67.6	73.5	44.5	28.3	22.6	15.3	14.6
10	77.4	72.3	56.8	91.9	95.2	64.2	63.7	44.2	27.5	22.0	15.0	14.3
11	67.9	79.2	52.1	74.6	91.4	62.1	72.1	48.5	27.1	21.6	15.0	15.0
12	60.3	89.2	50.2	80.6	103	77.8	70.0	49.7	26.7	20.9	14.9	15.6
13	58.6	116	61.5	70.0	96.6	68.2	166	43.4	25.9	20.0	14.2	14.3
14	49.2	99.9	51.4	65.3	82.8	63.9	104	40.4	25.6	19.2	15.9	14.3
15	68.9	78.9	46.6	63.7	82.3	69.2	80.5	84.4	27.3	19.0	14.6	14.3
16	70.2	66.7	45.5	56.9	128	96.1	69.3	324	33.0	19.6	15.7	14.0
17	84.9	94.5	48.5	59.2	123	81.7	62.9	259	28.3	20.4	14.2	15.3
18	91.0	122	62.3	85.5	131	74.1	59.4	151	27.2	19.4	14.2	16.9
19	81.4	137	79.0	91.0	144	64.2	56.8	99.7	25.7	20.1	14.0	18.8
20	69.5	94.6	70.8	106	136	61.0	58.8	82.3	26.1	23.0	11.8	14.9
21	102	92.3	66.5	85.8	119	58.1	57.5	70.6	31.6	21.7	15.0	14.9
22	91.9	86.5	88.1	107	125	56.1	51.1	61.9	25.5	20.2	23.6	34.3
23	75.9	72.6	75.3	96.9	144	63.2	51.9	56.8	25.0	19.4	18.8	65.4
24	62.7	65.5	75.1	74.9	125	69.1	59.4	53.5	24.7	18.3	14.9	53.6
25	70.4	64.3	70.8	73.4	105	103	162	49.2	24.2	17.9	13.2	32.1
26	63.8	56.8	57.5	65.4	89.8	120	164	46.7	23.8	17.5	15.0	27.1
27	57.2	61.7	134	83.9	77.8	93.7	103	44.0	27.1	17.2	17.9	22.4
28	69.1	91.9	102	81.9	73.3	100	82.6	42.2	25.2	17.7	18.7	19.7
29	75.9	96.3	316	99.1	35.8	122	70.6	40.4	24.3		18.0	18.6
30	76.9	76.4	159	95.4	61.1	97.4	63.2	38.7	46.8		20.1	17.4
31	93.7		117	86.6		97.0		37.2	32.1		26.0	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE AÑO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY	21	1.52	235	4	0.28	30.4	69.1	105	56.3	86	185.16	282
JUN	18	2.20	441	26	0.54	56.8	91.1	139	76.9	117	236.03	359
JUL	29	3.03	804	16	0.44	45.5	83.6	127	68.9	105	223.94	341
AGO	10	1.40	211	16	0.54	56.9	83.1	126	68.2	104	222.64	339
SET	7	1.94	352	30	0.58	61.1	105	159	78.1	119	271.64	413
OCT	25	1.44	219	22	0.53	56.1	78.8	120	85.1	130	211.04	321
NOV	25	1.93	348	22	0.49	51.1	86.0	131	86.6	132	222.84	339
DIC	16	2.12	412	31	0.36	37.2	71.4	109	68.4	104	191.35	291
ENE	30	0.90	110	26	0.20	23.8	29.0	44	55.2	84	77.68	118
FEB	5	0.58	61.7	27	0.11	17.2	22.3	34	40.8	62	53.85	82
MAR	31	0.28	30.5	25	0.06	13.2	16.3	25	32.1	49	43.60	66
ABR	23	1.14	156	16	0.07	14.0	21.6	33	32.1	49	56.05	85
TOT	29	3.03	804	25	0.06	13.2	63.1	96	62.4	95	1995.78	3036

RIO PACUARE EN SIQUIRRES 75-08-02

AREA DE DRENAJE: 657KM2 ELEVACION: 53MSNM

ANO HIDROLOGICO 1969 - 1970 DATOS DESDE:JUNIO 9,1963

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	16.5	75.5	83.4	55.9	91.3	107	70.3	171	58.0	54.0	33.0	75.0
2	18.0	86.0	85.0	81.1	80.4	101	80.7	157	54.4	48.2	31.3	43.0
3	16.5	77.5	66.2	66.9	95.4	90.0	61.5	181	49.7	43.0	29.6	34.0
4	15.0	92.2	62.2	105	86.7	72.0	54.9	177	47.6	67.0	28.8	25.3
5	14.9	70.6	54.4	122	72.8	66.6	63.5	136	45.6	136	27.1	23.5
6	14.3	53.1	50.6	86.9	61.7	75.6	64.9	117	43.5	139	27.1	25.3
7	14.3	78.9	56.6	64.7	56.4	100	54.4	103	45.6	86.0	26.3	39.5
8	12.8	102	49.9	57.8	72.4	159	67.3	93.0	123	128	23.2	685
9	12.8	92.8	56.7	73.0	64.4	149	63.0	85.2	565	146	22.5	1620
10	18.5	60.7	48.7	63.9	56.1	128	61.9	77.8	558	136	21.7	880
11	15.6	59.2	45.1	89.3	52.0	118	64.3	72.0	221	183	21.7	430
12	15.0	63.0	42.7	58.7	65.2	123	74.9	76.0	145	200	21.0	345
13	15.0	54.2	40.4	50.4	59.8	117	59.2	86.5	117	349	23.0	275
14	15.0	52.6	50.2	63.2	58.6	111	60.4	104	96.5	263	24.3	340
15	14.6	54.1	45.6	65.9	98.0	120	66.5	80.6	82.2	133	25.5	262
16	26.3	64.0	42.1	64.2	179	132	87.6	336	72.0	99.3	21.7	255
17	30.0	64.0	73.3	79.0	108	104	97.4	196	65.5	134	22.5	92.0
18	27.4	56.2	49.6	79.6	116	96.6	78.0	150	60.5	92.9	22.1	71.0
19	18.7	45.8	42.4	67.9	129	80.8	147	128	56.8	72.1	26.3	62.0
20	23.2	43.4	36.5	63.3	96.5	70.6	150	109	53.2	64.2	23.2	50.2
21	18.7	37.5	33.9	76.2	132	68.0	241	161	49.7	58.0	19.5	43.0
22	19.7	36.5	33.5	83.9	131	63.0	465	153	47.6	52.3	18.0	40.3
23	19.1	56.0	31.3	86.2	110	58.6	567	135	44.5	48.7	17.2	35.5
24	34.6	66.9	29.6	78.3	97.1	57.0	500	110	37.0	45.6	16.5	34.0
25	30.0	63.7	29.8	79.3	84.4	55.2	450	93.2	56.0	42.4	15.7	43.0
26	43.9	77.5	45.6	74.4	75.7	56.6	345	83.7	58.0	40.4	15.0	27.0
27	52.4	56.4	42.4	67.9	74.6	55.6	235	74.0	57.0	38.5	40.8	99.0
28	50.1	74.6	41.9	70.1	110	51.5	187	68.0	86.5	35.6	35.4	202
29	64.3	115	53.4	71.2	124	100	160	75.3	67.0		41.6	99.0
30	73.6	109	36.8	65.4	122	80.9	161	73.0	56.0		25.7	83.0
31	65.2		49.5	77.4		79.8		64.2	58.0		33.7	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE ANO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY	28	1.26	181	8	0.05	12.8	26.6	41	51.4	78	71.37	109
JUN	8	1.46	223	22	0.35	36.5	68.0	103	75.4	115	176.18	268
JUL	17	1.09	145	24	0.27	30.0	48.7	74	66.0	200	130.40	198
AGO	5	1.31	191	13	0.49	50.4	73.2	111	68.9	105	195.94	296
SET	16	1.84	319	11	0.50	52.0	92.0	140	80.1	122	238.51	363
OCT	7	1.49	229	28	0.50	51.5	91.9	140	86.1	131	246.02	374
NOV	24	5.70	2340	7	0.52	54.4	161	245	97.2	148	416.85	634
DIC	16	2.40	520	31	0.60	64.2	120	183	75.8	115	321.97	490
ENE	10	3.12	846	6	0.42	43.5	103	157	62.0	94	276.25	420
FEB	13	3.78	1180	28	0.34	35.6	105	159	49.9	76	253.57	386
MAR	27	0.91	112	26	0.08	15.0	25.2	38	31.1	47	67.46	103
ABR	9	6.50	2920	5	0.19	23.5	211	321	57.7	88	547.65	833
TOT	9	6.50	2920	8	0.05	12.8	93.8	143	66.8	102	2942.14	4476

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO PACUARE EN DOS MONTANAS 75-08-03

AREA DE DRENAJE: 652KM2 ELEVACION: 75MSNM

ANO HIDROLOGICO 1970 - 1971 DATOS DESDE:JUNIO 9,1963

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	63.4	64.2	50.1	77.8	157	131	61.5	58.0	40.0	38.4	39.2	17.3
2	64.2	78.0	89.9	68.0	71.2	111	47.7	60.5	56.0	38.4	43.4	17.3
3	50.1	59.8	75.8	96.7	62.1	101	41.8	328	54.0	36.1	37.3	17.3
4	46.5	62.2	69.6	61.6	55.2	72.8	34.8	615	53.0	29.2	30.9	31.3
5	48.1	58.5	66.5	51.1	87.8	59.8	76.2	761	51.5	29.2	26.1	18.2
6	43.3	82.5	53.7	45.5	125	53.7	284	518	51.0	29.2	25.1	17.3
7	41.0	52.2	52.2	52.1	103	60.4	294	348	50.0	24.0	22.0	17.3
8	41.2	46.2	53.7	51.2	58.3	43.4	267	265	48.9	25.0	28.5	21.1
9	41.2	41.3	70.3	50.3	55.8	66.8	177	380	48.0	27.5	41.1	145
10	41.0	39.0	95.7	37.4	58.9	81.3	157	990	46.0	25.0	26.1	183
11	41.4	47.1	102	55.0	60.4	67.8	145	720	44.5	25.1	24.0	170
12	41.2	86.4	124	32.9	46.2	58.4	117	322	43.9	25.1	21.0	194
13	41.7	55.7	102	33.8	51.5	41.8	102	270	42.5	25.1	23.0	100
14	63.2	50.7	79.4	59.1	53.0	40.4	98.0	210	42.0	25.1	20.0	72.8
15	82.0	58.5	69.5	27.6	44.9	42.0	99.9	220	38.0	25.1	30.0	61.6
16	109	108	66.3	34.3	55.2	54.4	321	180	36.5	32.2	24.0	52.2
17	136	85.0	81.6	44.9	51.6	47.7	930	149	37.0	26.1	52.8	44.7
18	125	62.6	114	43.9	61.5	34.8	389	335	38.0	25.1	29.5	39.0
19	81.5	50.7	95.9	40.0	57.1	29.2	285	1350	36.5	22.0	25.1	34.8
20	100	56.3	79.8	37.0	68.7	38.3	85.0	295	38.0	21.0	25.1	33.4
21	116	71.1	90.6	40.0	52.3	58.3	275	350	33.5	20.0	22.0	44.2
22	148	43.3	64.7	37.0	73.1	36.7	245	370	66.0	26.0	31.4	34.8
23	132	43.3	53.7	77.0	87.3	40.5	69.0	165	70.0	32.9	48.9	34.1
24	123	54.3	52.2	48.0	79.3	45.9	57.0	117	72.8	22.0	37.6	28.1
25	103	77.9	44.8	68.0	68.5	37.7	50.0	114	59.8	25.1	36.2	25.1
26	114	72.0	86.3	112	101	34.7	52.0	105	52.2	24.0	36.1	25.1
27	125	53.7	120	115	97.3	72.1	36.5	118	46.2	20.0	26.1	25.1
28	123	57.4	120	215	93.8	90.7	44.5	105	44.7	24.1	24.0	25.1
29	109	55.3	100	250	96.6	110	54.0	79.9	40.4		23.0	22.0
30	81.2	57.8	104	215	92.5	72.7	53.0	80.0	40.4		23.0	21.0
31	66.3		88.2	245		82.6		79.9	38.9		20.0	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE ANO MC/SEC	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY				7	1.00	41.0	82.0	126	55.8	86	219.59	337
JUN	12	2.32	152	10	1.67	39.0	61.0	94	73.3	113	158.20	243
JUL	12	2.56	206	25	1.71	44.8	81.1	124	67.9	109	217.24	333
AGO				15	1.58	27.6	78.1	120	70.0	107	209.12	321
SET	6	2.56	206	15	1.71	46.9	74.2	114	79.4	122	192.37	295
OCT	1	2.64	224	19	1.60	29.2	61.3	94	83.0	127	164.15	252
NOV	16	5.52	1080	27	1.63	34.5	162	248	105	161	418.69	642
DIC	6	5.48	1070	1	1.80	58.0	331	508	108	165	887.70	1362
ENE	23	2.60	215	21	1.63	33.5	47.1	72	60.1	92	126.16	194
FEB	23	1.76	52.2	21	1.51	20.0	26.7	41	67.0	72	64.63	99
MAR	17	1.90	74.4	14	1.51	20.0	29.1	45	30.9	47	78.06	120
ABR	12	2.90	286	1	1.46	17.3	52.4	80	57.0	88	135.82	208
TOT	16	5.52	1080	1	1.48	17.3	90.5	139	69.8	107	2871.69	4406

RIO PACUARE EN DOS MONTANAS 75-08-03

AREA DE DRENAJE: 652KM2 ELEVACION: 75MSNM

ANO HIDROLOGICO 1971 - 1972 DATOS DESDE:JUNIO 9,1963

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	45.0	57.3	74.5	55.7	56.1	92.0	108	61.0	51.0	31.0	27.4	20.2
2	39.0	49.3	64.0	61.3	56.2	84.0	104	43.0	34.0	31.0	25.5	21.0
3	37.3	61.2	54.0	50.8	78.0	83.9	99.0	40.5	37.0	31.0	23.6	37.3
4	35.0	84.0	52.5	50.8	91.9	95.0	105	38.2	37.5	31.0	23.6	81.1
5	34.0	83.5	47.0	54.8	71.3	92.0	91.0	35.6	40.0	28.5	23.6	46.5
6	33.5	78.0	46.2	68.3	79.7	83.0	79.0	35.8	38.9	25.2	23.6	37.1
7	33.5	79.9	43.8	52.2	74.0	94.0	75.9	35.8	74.0	25.2	22.3	30.5
8	34.0	116	46.0	48.1	68.2	84.0	73.0	35.8	73.9	23.4	21.4	28.5
9	36.5	88.0	43.9	50.2	60.4	71.9	72.0	35.8	60.0	23.4	21.0	25.5
10	83.0	80.0	108	46.8	64.6	74.0	78.0	35.0	56.3	23.4	21.9	59.6
11	52.0	72.0	74.1	54.4	62.3	94.0	81.0	33.7	52.0	22.5	26.0	43.6
12	44.3	69.0	69.1	59.7	53.2	113	68.5	33.7	62.0	21.6	25.5	28.9
13	65.0	84.0	64.2	49.7	47.8	103	65.0	33.7	60.0	21.6	32.1	25.2
14	64.0	68.0	75.5	45.5	47.8	84.0	64.2	31.5	58.0	20.8	29.4	29.0
15	70.3	67.9	126	49.5	50.6	104	62.5	31.5	61.0	19.9	34.2	33.8
16	81.0	58.0	105	65.7	52.0	100	61.0	31.5	55.1	19.9	29.4	31.6
17	94.0	58.0	104	62.0	49.1	109	71.0	31.5	48.0	19.9	25.5	30.5
18	120	57.5	84.4	70.5	47.8	100	78.0	31.5	45.0	19.9	23.6	44.6
19	158	58.0	139	65.7	51.4	102	69.9	31.5	41.0	19.9	23.6	45.7
20	130	71.9	81.9	65.7	62.0	125	55.9	31.5	37.5	31.7	23.6	43.9
21	142	88.0	79.7	53.6	59.9	103	54.0	31.5	35.5	103	25.5	40.3
22	116	64.0	73.4	57.4	50.4	102	51.0	31.5	34.3	90.2	27.4	52.2
23	97.0	55.5	129	64.5	55.2	108	53.0	31.5	33.0	48.0	25.5	40.7
24	92.0	52.5	84.2	52.2	84.0	130	51.0	39.2	33.5	35.6	23.6	57.0
25	84.0	50.0	78.4	56.0	88.0	100	51.0	38.2	32.0	30.1	23.6	50.0
26	71.5	46.0	76.8	72.5	84.0	92.0	48.3	33.7	32.0	29.1	23.6	49.9
27	63.5	44.5	68.4	60.8	72.0	94.5	45.5	31.5	32.0	29.1	22.8	44.3
28	61.0	51.9	70.3	62.4	74.0	80.0	45.5	31.5	32.0	27.1	21.9	38.0
29	93.1	69.0	79.6	79.8	72.2	125	45.5	31.5	31.2	27.1	21.9	36.5
30	90.8	58.9	56.4	86.3	86.0	160	48.4	36.5	31.0		21.0	35.0
31	75.7		53.6	73.0		142		40.5	31.0		19.3	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE ANO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY				6	1.63	33.5	73.4	113	58.0	89	196.55	302
JUN				27	1.71	44.5	67.4	103	72.6	111	174.60	266
JUL	19	2.76	253	7	1.70	43.8	76.1	117	68.8	106	203.72	313
AGO	29	2.56	195	14	1.85	45.5	59.5	91	68.8	106	159.49	245
SET	3	2.48	173	14	1.86	47.8	65.0	100	77.8	119	168.49	258
OCT				9	1.96	71.9	100	154	84.9	130	269.07	413
NOV	30	2.12	100	29	1.79	45.5	68.5	105	101	155	177.65	273
DIC	24	2.06	77.2	17	1.73	31.5	35.4	54	99.9	153	94.71	145
ENE	1	2.08	80.6	30	1.72	31.0	44.5	68	58.4	90	119.25	183
FEB	22	2.32	129	18	1.60	19.9	31.3	48	45.3	69	73.55	121
MAR	15	1.84	44.8	31	1.59	19.3	24.6	38	30.2	46	65.91	101
ABR	4	2.36	140	1	1.61	20.2	40.4	62	55.2	85	104.75	161
TOT				31	1.59	19.3	57.2	88	68.4	105	1812.38	2781

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO PACUARE EN DOS MONTANAS 75-08-03

AREA DE DRENAJE: 652KM2 ELEVACION: 75MSNM

ANO HIDROLOGICO 1972 - 1973 DATOS DESDE:JUNIO 9,1963

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	43.0	81.5	45.0	20.1	44.2	182	68.5	38.9	68.5	27.6	23.5	10.9
2	48.0	74.5	51.9	21.5	64.7	199	65.4	36.8	65.4	25.6	20.0	10.9
3	35.2	78.0	51.0	26.0	79.1	157	59.3	34.9	59.3	45.0	19.3	10.9
4	33.3	78.0	51.0	24.0	91.6	103	66.0	34.3	56.4	60.6	18.1	11.2
5	32.5	71.0	60.0	20.5	93.0	90.5	63.5	35.0	56.4	37.3	17.8	12.1
6	27.1	72.0	51.5	21.0	58.4	88.9	60.0	34.9	50.9	25.5	17.2	11.2
7	26.9	85.0	45.0	20.5	52.3	88.9	115	63.0	43.0	27.5	20.6	11.5
8	39.5	103	41.0	20.1	52.3	78.5	195	50.3	40.5	25.6	20.6	11.5
9	42.0	115	38.5	20.1	52.3	77.9	121	38.5	36.0	23.7	19.9	11.2
10	36.8	122	43.0	20.5	59.7	65.4	97.0	37.2	29.4	23.7	18.4	11.7
11	42.1	108	39.0	22.5	55.7	62.2	91.0	36.0	27.4	47.2	17.7	12.1
12	42.6	84.0	35.0	31.1	49.5	63.8	79.9	32.7	82.4	74.6	15.6	11.7
13	42.0	101	32.0	30.0	49.5	63.8	85.0	32.9	140	51.2	15.6	11.7
14	47.4	94.0	32.0	38.0	46.7	62.2	106	39.3	166	38.3	15.6	13.1
15	41.6	76.5	30.5	53.6	74.6	96.4	103	34.9	107	33.8	15.6	17.0
16	43.8	66.0	28.1	52.1	77.4	162	132	30.8	70.2	31.6	15.6	15.8
17	47.0	66.0	26.3	41.5	69.9	159	108	30.8	56.5	29.5	15.6	13.8
18	85.0	65.0	25.2	45.2	66.4	127	83.0	41.1	48.1	25.6	15.6	12.6
19	90.0	65.0	25.8	90.0	64.8	124	73.0	48.2	43.0	23.7	15.6	13.0
20	87.0	58.5	35.5	108	56.7	113	64.5	42.1	40.5	26.0	15.5	14.0
21	111	53.0	31.1	110	52.1	109	65.0	47.2	38.2	25.5	15.0	14.6
22	115	50.5	26.8	95.0	56.5	100	63.0	52.5	35.8	24.4	12.6	18.5
23	112	45.0	29.5	86.0	71.4	89.1	58.3	117	35.8	23.0	12.6	15.3
24	85.0	62.0	28.8	145	118	81.8	54.0	312	33.7	23.0	12.6	13.1
25	99.0	85.0	27.0	143	106	85.9	51.0	134	29.4	23.0	12.6	13.1
26	115	65.5	27.8	118	90.2	85.5	51.0	115	28.4	23.0	12.6	13.1
27	126	55.0	24.1	92.0	120	99.9	55.5	100	29.4	23.7	12.1	19.9
28	143	55.0	23.5	84.0	168	94.4	47.0	106	26.5	23.9	12.0	15.7
29	135	59.5	23.0	68.0	159	122	43.0	98.5	23.6		11.8	13.1
30	103	55.0	22.1	65.0	139	78.7	40.5	82.0	34.7		11.5	18.2
31	98.0		20.6	50.8		68.5		71.7	35.9		11.2	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEG	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEG	CAUDAL PROMEDIO MENSUAL DE ESTE ANO MC/SEG	L/S/K	DE TODO EL REGISTRO MC/SEG	L/S/K	VOLUMEN EN M.M.C	MM
MAY				7	1.73	26.9	70.2	108	59.4	91	187.90	288
JUN				23	1.90	45.0	75.0	115	72.9	112	194.36	298
JUL				31	1.65	20.6	34.6	53	65.4	100	92.59	142
AGO				8	1.64	20.1	57.8	89	67.7	104	154.75	237
SET	27	2.78	257	1	1.90	44.2	78.0	120	77.8	119	202.19	310
OCT	16	3.12	341	11	1.97	62.2	103	157	86.7	133	274.69	421
NOV				30	1.86	40.5	78.8	121	98.8	152	204.28	313
DIC	24	3.50	441	16	1.77	30.8	64.7	99	96.4	148	173.36	266
ENE	13	2.68	227	29	1.64	23.6	52.8	81	57.8	89	141.55	217
FEB	12	2.08	80.6	24	1.60	23.0	32.0	49	44.0	67	77.51	119
MAR				31	1.42	11.2	15.8	24	28.8	44	42.34	65
ABR				1	1.41	10.9	13.4	21	51.0	78	34.78	53
TOT				1	1.41	10.9	56.3	86	67.2	103	1780.25	2731

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEC.
RIO PACUARE EN DOS MONTANAS 75-08-03

AREA DE DRENAJE: 652KM2 ELEVACION: 695MSNM

ANO HIDROLOGICO 1973 - 1974 DATOS DESDE: JUNIO 9,1963

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	17.9	58.8	61.6	97.2	81.8	54.7	45.8	196	69.7	33.1	36.9	16.5
2	12.1	53.7	56.4	54.9	74.7	55.2	42.6	174	73.5	31.4	31.7	16.4
3	11.3	63.9	50.9	53.8	74.0	49.6	41.7	160	68.2	30.3	27.5	19.7
4	11.5	57.3	45.5	57.4	75.0	50.6	39.9	153	56.3	30.3	26.5	17.7
5	11.8	63.2	44.3	64.6	67.1	63.1	47.3	143	53.1	30.3	24.7	17.0
6	11.6	70.0	39.4	51.0	70.4	90.7	43.5	139	51.7	33.1	22.5	17.7
7	12.6	67.5	41.9	46.7	65.5	66.8	38.2	132	48.7	30.3	22.1	17.0
8	12.6	50.9	46.8	42.9	59.3	66.1	71.7	130	51.8	28.4	21.3	16.0
9	12.6	54.9	71.8	44.4	54.1	75.9	66.1	139	151	26.5	24.6	16.3
10	35.4	60.4	61.3	37.0	52.2	106	48.1	253	137	28.4	22.1	16.2
11	29.8	43.7	46.8	36.4	63.7	91.6	45.6	514	85.5	27.5	21.3	16.1
12	15.7	40.5	43.0	34.8	67.3	84.1	50.9	478	73.3	28.3	22.7	16.1
13	14.4	58.1	45.3	33.2	76.3	112	48.1	434	128	42.3	20.7	16.0
14	12.6	76.9	48.3	32.7	82.0	91.1	51.7	299	88.2	34.1	19.4	15.9
15	24.7	61.8	51.7	31.7	83.2	88.7	100	200	66.2	29.4	19.8	15.9
16	39.5	60.1	53.8	30.3	69.4	72.6	134	107	61.1	26.1	19.6	15.8
17	25.0	64.6	45.6	29.3	72.6	71.0	113	130	56.3	23.7	18.8	15.7
18	24.3	75.3	71.8	32.6	80.2	67.6	91.2	254	51.7	25.4	20.1	15.7
19	66.4	77.0	82.7	32.3	84.6	67.1	121	206	46.0	26.2	19.6	28.0
20	52.5	79.7	80.7	30.9	87.9	65.5	101	152	41.9	26.6	19.1	22.9
21	51.3	77.7	145	61.4	80.9	74.8	88.1	124	39.9	23.7	18.9	40.2
22	41.9	67.8	98.1	64.4	67.6	94.7	75.4	194	39.9	22.9	18.8	50.1
23	33.4	64.0	85.6	62.0	61.4	107	77.4	132	37.9	22.1	20.4	25.9
24	32.3	73.6	81.3	72.0	59.9	104	61.1	102	37.9	21.7	17.9	20.8
25	42.0	109	68.2	85.0	48.1	94.1	71.9	93.3	37.9	21.3	17.7	18.5
26	26.5	93.5	61.6	103	45.4	75.5	60.6	85.0	37.9	21.1	17.5	30.4
27	43.2	94.3	57.6	130	45.4	69.9	60.3	118	36.9	42.9	16.5	50.1
28	51.8	88.1	53.0	162	41.2	58.4	210	91.4	36.0	63.3	16.4	28.7
29	44.7	82.1	49.5	196	52.7	52.3	301	83.0	36.9		16.9	25.2
30	74.5	71.1	46.8	132	53.0	50.9	242	81.1	36.9		16.8	44.1
31	62.4		72.5	100		46.7		71.5	35.0		16.6	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEC	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEC	CAUDAL PROMEDIO MENSUAL DE ESTE AÑO MC/SEC	L/S/K	DE TODO EL REGISTRO MC/SEC	L/S/K	VOLUMEN EN M.M.C	MM
MAY	30	2.46	168	3	1.42	11.3	32.2	49	56.7	87	86.17	132
JUN	25	2.48	173	12	1.80	40.5	68.7	105	72.5	111	177.94	273
JUL	21	2.68	227	6	1.79	39.4	61.6	94	65.1	100	164.90	253
AGO	1	2.31	127	17	1.75	29.3	65.9	101	67.5	104	176.42	271
SET				28	1.87	41.2	66.6	102	76.8	118	172.53	265
OCT	10	2.52	194	31	1.92	46.7	74.8	115	85.6	131	200.30	307
NOV	28	3.43	422	7	1.84	38.2	87.0	133	97.7	150	225.43	346
DIC	14	3.64	480	31	2.32	71.5	180	276	104	160	481.10	738
ENE	9	2.81	201	31	2.05	35.0	60.4	93	58.0	89	161.77	248
FEB	28	2.43	97.6	25	2.01	21.3	29.7	46	42.7	66	71.69	110
MAR	1	2.08	37.9	29	1.91	16.4	21.1	32	28.1	43	56.45	87
ABR	21	2.62	148	17	1.93	15.7	22.8	35	48.4	74	58.98	90
TOT	14	3.64	480	3	1.42	11.3	64.2	98	66.9	103	2033.85	3120

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEC.
RIO PACUARE EN DOS MONTANAS 75-08-03

AREA DE DRENAJE: 652KM2 ELEVACION: 695MSNM

ANO HIDROLOGICO 1974 - 1975 DATOS DESDE:

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	39.2	142	83.0	62.8	57.4	84.6	90.0	103	33.3	30.8	14.9	12.6
2	27.5	100	100	85.7	64.9	83.7	83.0	100	30.5	27.5	14.8	12.6
3	30.3	69.4	64.5	68.3	56.4	92.0	79.0	428	25.4	25.5	16.2	12.5
4	41.2	59.6	67.6	67.0	46.4	69.8	73.0	549	23.9	29.0	15.6	12.5
5	32.2	64.0	79.7	141	48.0	55.1	68.0	445	23.9	31.0	14.8	12.4
6	30.3	50.2	65.4	75.9	57.7	49.2	63.0	266	23.9	25.0	14.8	12.4
7	43.5	45.9	68.8	54.4	47.0	63.0	52.7	176	23.1	23.6	16.6	12.3
8	45.2	44.3	102	59.1	41.6	104	55.2	130	23.9	22.0	15.4	12.3
9	57.2	56.2	69.7	58.6	41.4	74.2	56.1	108	23.9	21.8	14.6	11.8
10	47.5	81.5	97.6	60.5	41.3	57.7	51.0	92.6	23.9	21.8	14.8	11.7
11	49.0	127	77.4	134	41.5	51.8	46.4	82.1	22.4	20.8	15.4	11.6
12	50.0	123	104	134	74.8	50.0	40.6	76.8	22.4	20.4	15.4	11.5
13	46.5	164	110	158	67.1	60.0	39.3	70.2	22.0	19.2	14.8	11.4
14	59.0	119	79.1	144	55.2	46.4	38.0	65.4	22.0	19.2	14.8	11.4
15	96.0	83.1	77.7	101	65.3	46.2	36.7	66.0	22.2	18.5	14.3	11.4
16	98.0	87.6	83.5	80.6	83.3	63.2	35.5	55.2	22.0	17.9	13.8	11.4
17	104	83.5	67.1	97.6	59.2	71.6	34.3	54.5	24.0	17.9	12.8	11.4
18	102	83.5	67.8	96.9	51.2	68.6	39.3	53.2	26.0	19.0	12.7	11.8
19	82.0	65.4	70.4	78.2	50.0	70.3	36.8	47.5	25.0	18.3	12.6	11.8
20	68.0	60.2	59.4	88.9	53.7	70.5	35.5	45.0	25.0	17.7	12.5	11.8
21	56.0	60.2	62.4	88.2	59.4	57.5	33.1	42.7	27.6	17.1	12.4	12.3
22	48.0	69.9	67.9	87.4	43.7	57.4	32.0	41.8	30.5	16.5	12.4	13.8
23	51.0	71.1	59.4	68.9	41.0	55.3	37.1	40.5	29.5	16.5	12.3	16.2
24	49.0	77.0	57.8	101	57.5	83.5	33.1	39.4	36.0	15.9	12.2	14.1
25	42.0	71.4	57.8	106	54.1	90.4	46.1	39.4	33.0	15.4	12.1	12.0
26	42.0	74.6	82.1	74.0	45.3	130	131	38.3	26.0	15.3	12.1	11.4
27	48.0	74.0	60.2	65.4	44.3	97.0	499	36.3	23.5	15.2	14.4	13.2
28	49.3	66.2	88.9	64.9	40.7	80.0	396	36.3	22.0	15.0	15.4	13.6
29	43.2	57.8	61.2	82.3	61.0	77.0	182	35.2	24.2		13.8	12.0
30	44.5	59.6	64.9	56.1	61.0	80.0	128	34.3	23.9		12.8	11.4
31	73.7		56.2	58.8		91.0		33.3	42.2		12.7	

MES	CAUDALES EXTREMOS MAXIMO INSTANTANEO DIA	ESC.	MC/SEC	MINIMO PROMEDIO DIARIO DIA	ESC.	MC/SEC	CAUDAL PROMEDIO MENSUAL DE ESTE AÑO MC/SEC	L/S/K	DE TODO EL REGISTRO MC/SEC	L/S/K	VOLUMEN EN M.M.C	MM
MAY				2	1.97	27.5	54.7	84	56.5	87	146.57	225
JUN	1	3.04	276	8	2.14	44.3	79.7	122	73.2	112	206.60	317
JUL	1	2.74	181	31	2.22	56.2	74.6	114	65.9	101	199.89	307
AGO	5	2.95	247	30	2.27	56.1	87.1	134	69.1	106	233.24	358
SET	24	2.78	192	28	2.17	40.7	53.7	82	74.9	115	139.22	214
OCT				15	2.21	46.2	72.0	110	84.5	130	192.81	296
NOV	27	4.23	654	22	2.10	32.0	85.4	131	96.7	148	221.27	339
DIC	4	4.50	739	31	1.97	33.3	111	170	105	160	296.42	455
ENE				13	1.84	22.4	26.0	40	55.3	85	69.73	107
FEB				28	1.72	15.0	20.5	31	40.9	63	49.58	76
MAR	27	1.79	19.0	25	1.67	12.1	14.0	21	26.9	41	37.53	58
ABR	23	1.76	17.1	13	1.65	11.4	12.3	19	45.4	70	31.90	49
TOT				13	1.65	11.4	57.6	88	66.1	101	1824.72	2800

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO PACUARE EN DOS MONTANAS 75-08-03

AREA DE DRENAJE: 652KM2 ELEVACION: 8G0SNM

ANO HIDROLOGICO 1975 - 1976 DATOS DESDE:

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	11.4	50.0	58.0	73.6	53.9	99.5	95.5	93.3	48.5	44.3	22.9	14.0
2	16.4	43.4	48.1	70.2	48.7	93.8	93.6	77.5	47.2	46.0	22.1	13.8
3	17.9	35.2	56.6	89.2	54.1	105	110	67.9	46.0	44.8	22.1	13.6
4	16.0	40.8	80.3	108	62.4	87.7	137	66.4	44.8	40.1	19.8	13.3
5	21.8	38.3	68.5	89.6	58.5	88.3	127	74.2	43.6	37.9	19.3	16.7
6	17.1	36.3	65.4	92.9	86.4	87.7	144	89.7	42.4	37.6	21.3	17.0
7	16.5	34.3	63.9	90.8	99.5	82.1	182	95.2	39.0	37.4	20.9	17.3
8	14.8	46.1	58.0	80.3	97.5	71.8	138	115	37.9	37.1	20.6	17.7
9	12.8	46.2	68.5	67.0	109	103	144	119	39.0	36.9	20.3	17.9
10	12.3	36.3	68.7	56.6	110	117	134	111	42.4	39.0	20.0	21.3
11	12.3	49.1	50.2	50.0	114	108	120	119	40.1	77.5	19.7	17.0
12	15.5	31.4	56.1	69.0	153	89.6	129	192	36.9	53.6	19.4	15.7
13	17.8	43.6	54.0	98.3	153	73.4	134	372	32.8	43.6	19.1	15.5
14	18.3	46.2	54.9	82.3	115	70.2	149	587	32.8	37.9	18.8	15.3
15	13.8	47.5	65.2	96.2	99.5	85.6	223	322	32.8	33.8	18.5	15.1
16	18.9	36.3	87.4	103	84.3	102	237	200	34.8	31.8	18.2	15.0
17	22.0	51.7	68.7	80.3	92.6	117	161	162	30.0	29.9	17.8	14.8
18	17.1	36.3	60.1	106	99.4	108	129	261	111	27.1	17.5	14.6
19	14.3	34.3	57.7	98.2	87.8	106	113	112	139	27.1	17.2	14.5
20	13.8	34.3	61.4	104	92.9	85.8	99.5	99.0	66.4	27.5	16.9	23.6
21	18.3	42.7	65.9	99.5	87.2	78.6	129	91.5	75.9	26.7	16.6	19.0
22	24.6	42.7	74.2	80.3	100	68.5	93.5	87.9	67.9	26.0	16.3	24.5
23	20.3	35.2	70.2	67.2	124	67.0	179	79.2	59.1	25.2	16.0	14.5
24	26.4	40.5	67.0	79.0	127	70.2	149	82.6	55.0	24.4	15.7	12.7
25	46.1	40.5	62.4	82.1	119	76.8	159	74.2	50.4	23.6	15.4	12.4
26	50.0	36.3	60.2	68.5	98.1	87.5	152	71.1	47.2	22.8	15.1	12.1
27	35.2	57.0	78.9	60.9	124	79.0	115	67.8	46.0	22.1	14.9	15.3
28	38.3	59.6	71.8	57.7	95.6	72.8	95.2	64.9	45.8	22.9	14.7	22.1
29	38.9	113	58.0	67.9	110	82.8	87.9	59.1	45.5	23.7	14.5	33.3
30	31.6	99.5	80.4	78.6	108	96.8	74.2	53.6	45.3		14.3	46.0
31	34.1		77.4	59.5		100		51.0	45.1		14.2	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	H.M.C	MM
MAY	25	2.44	104	1	1.65	11.4	22.1	34	53.6	82	59.15	91
JUN	29	2.89	231	12	1.95	31.4	46.1	71	70.9	109	119.61	184
JUL				2	2.11	48.1	65.1	100	65.8	101	174.36	268
AGO	18	2.75	186	11	2.12	50.0	80.8	124	70.0	107	216.53	332
SET	11	2.84	215	2	2.11	48.7	98.9	152	76.7	118	256.24	393
OCT	10	2.72	176	23	2.24	67.0	89.1	137	84.9	130	238.57	366
NOV	15	3.12	306	30	2.36	74.2	134	206	99.6	153	348.56	535
DIC	14	4.09	736	31	2.20	51.0	133	204	107	164	355.80	546
ENE				13	2.04	32.8	50.7	78	54.9	84	135.70	208
FEB	11	2.40	80.9	25	1.92	22.1	34.8	53	40.4	62	87.16	134
MAR	1	1.94	23.7	25	1.84	16.4	18.1	28	26.2	40	48.44	74
ABR	29	2.48	95.2	25	1.77	12.1	17.9	27	43.3	66	46.34	71
TOT	14	4.09	736	1	1.65	11.4	65.9	101	66.1	101	2086.44	3201

INSTITUTO COSTARRICENSE DE ELECTRICIDAD - DIRECCION DE ELECTRIFICACION
DEPARTAMENTO DE ESTUDIOS BASICOS - OFICINA DE HIDROLOGIA
REGISTRO DE CAUDALES MEDIOS DIARIOS EN MC./SEG.
RIO PACUARE EN DOS MONTANAS [illegible]

AREA DE DRENAJE: 652KM2 ELEVACION: [illegible]

ANO HIDROLOGICO 1976 - 1977 DATOS DESDE: JUNIO 9,1975

DIA	MAY	JUN	JUL	AGO	SET	OCT	NOV	DIC	ENE	FEB	MAR	ABR
1	42.2	69.4	64.5	529	56.7	53.5	39.6	35.5	26.3	(17.4)	[illegible]	[illegible]
2	93.3	75.6	53.5	249	67.9	74.6	82.9	36.2	25.6	(17.3)	22.6	12.7
3	87.6	145	51.0	200	65.4	85.1	58.4	32.6	24.5	(17.2)	[illegible]	12.1
4	119	156	76.5	173	51.0	65.4	135	29.6	23.3	(17.1)	21.3	12.7
5	74.4	112	104	135	72.8	92.9	231	(26.3)	22.2	[illegible]	[illegible]	[illegible]
6	43.1	104	93.9	117	57.9	79.9	215	(33.1)	[illegible]	[illegible]	21.3	[illegible]
7	92.4	98.5	77.1	101	60.2	72.5	214	(32.2)	(20.8)	(16.8)	[illegible]	[illegible]
8	33.7	92.0	63.6	85.2	170	59.7	204	(31.8)	(20.5)	(16.7)	31.4	12.5
9	54.1	80.9	52.7	64.1	192	55.6	198	(41.9)	(20.2)	(16.6)	34.3	12.6
10	41.3	84.4	57.7	59.7	102	75.2	135	259	(19.9)	(16.6)	26.4	12.5
11	39.8	93.5	51.0	66.7	75.0	90.2	109	122	(19.7)	(16.4)	24.4	12.5
12	37.9	72.4	49.4	60.8	62.5	61.6	102	150	(19.3)	(16.4)	20.6	12.5
13	35.0	68.8	40.5	71.2	62.7	69.2	105	151	(19.1)	(16.3)	20.6	12.5
14	34.8	54.9	38.0	73.7	83.0	56.2	86.1	99.0	(20.8)	(15.2)	19.8	12.5
15	46.2	60.8	35.6	61.6	158	64.2	79.6	79.2	(19.1)	(16.1)	19.8	12.4
16	51.2	86.5	59.5	54.4	126	87.4	75.7	65.4	(19.0)	(15.0)	15.1	12.4
17	37.9	97.5	167	54.5	95.4	101	80.5	77.7	(18.4)	(15.5)	15.7	14.3
18	44.3	85.8	148	59.7	69.9	91.3	73.7	64.7	(19.8)	(15.6)	13.5	[illegible]
19	34.8	106	101	51.0	69.5	73.7	68.8	44.2	(19.8)	(15.7)	13.5	12.7
20	32.4	138	186	44.9	51.0	75.8	64.0	40.1	(28.8)	(17.7)	13.4	12.7
21	44.2	107	329	44.1	52.6	69.9	59.1	35.3	(25.7)	17.4	13.4	13.3
22	46.8	83.9	117	44.9	59.2	59.7	54.3	38.7	(30.6)	15.8	13.4	21.3
23	49.3	73.4	83.9	64.6	43.4	56.2	47.4	37.0	(39.9)	16.6	13.3	19.5
24	57.7	71.9	99.1	61.6	47.6	52.6	53.2	35.9	(37.7)	16.4	13.3	16.6
25	61.1	99.0	146	46.6	58.2	49.1	85.2	34.7	(29.0)	16.3	13.2	15.7
26	76.9	146	99.4	47.9	60.3	45.5	56.1	33.6	(25.0)	16.6	13.2	15.4
27	108	119	97.2	38.0	46.0	42.0	52.8	32.5	(22.2)	17.0	13.1	17.0
28	78.3	78.2	76.2	36.7	80.1	41.2	49.5	31.3	(19.8)	19.1	13.1	16.4
29	118	84.4	85.1	42.0	100	40.4	46.2	30.2	(18.4)		13.0	[illegible]
30	86.2	81.6	158	72.9	61.6	39.6	42.8	29.0	(17.6)		13.0	[illegible]
31	87.5		202	47.9		39.8		27.9	(17.5)		12.9	

	CAUDALES EXTREMOS						CAUDAL PROMEDIO MENSUAL				VOLUMEN EN	
	MAXIMO INSTANTANEO			MINIMO PROMEDIO DIARIO			DE ESTE ANO		DE TODO EL REGISTRO			
MES	DIA	ESC.	MC/SEG	DIA	ESC.	MC/SEG	MC/SEG	L/S/K	MC/SEG	L/S/K	H.M.C	MM
MAY	29	2.97	215	20	2.04	32.4	61.0	94	52.8	81	163.32	251
JUN	26	3.41	347	15	2.27	60.8	94.2	145	72.9	112	244.23	375
JUL	21	3.96	538	15	2.13	35.6	98.4	151	68.0	104	263.44	404
AGO	1	4.54	805	28	2.14	35.7	92.2	141	71.6	110	[illegible]	[illegible]
SET	6	4.14	606	23	2.19	43.4	78.7	121	76.9	118	203.97	313
OCT	11	2.85	180	31	2.16	39.8	65.6	101	83.8	129	175.61	[illegible]
NOV	8	3.46	383	1	2.19	38.0	100	154	101	155	259.45	398
DIC	10	3.65	427	31	2.06	27.9	59.4	91	107	164	159.03	244
ENE	ND	ND	ND	31	1.86	17.5	23.0	35	51.0	78	61.66	95
FEB	28	1.86	23.9	19	1.83	15.7	16.7	26	38.6	59	40.48	[illegible]
MAR	8	2.10	39.0	17	1.83	15.7	18.4	28	25.6	39	[illegible]	[illegible]
ABR	1	2.04	32.8	19	1.78	8.97	13.9	21	41.2	63	[illegible]	[illegible]
TOT	1	[illegible]	[illegible]	17	[illegible]	15.7	60.1	92	65.9	101	[illegible]	[illegible]

( ): Valores estimados, mediante correlación de caudales promedio diarios con la estación [illegible] Pacuare en [illegible]

A-3 DESCRIPTION OF L_5 FLOW

Description of L5 Flow

(1) The L5 flow is defined to be an average of the lowest five (5) flows in a month.

(2) There are 2 methods for the determination of the average L5 flow of N-year which is called, in detail, Series L5 flow (SL5) or Parallel L5 flow (PL5) depending upon the method adopted.

(3) Determination of SL5

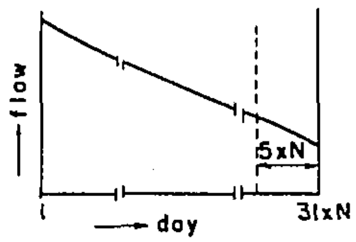
If there are records of flows in the month of N-year, put the records in descending order of magnitude independent upon the year and day. Averaging each N records in descending order, a monthly flow duration curve of "series" will be obtained for the month. The average of the lowest five (5) is SL5 flow of the month.

(4) Determination of PL5

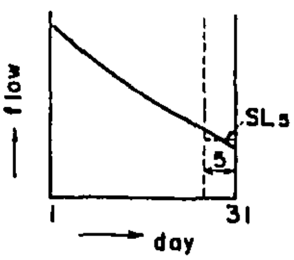
If there are records of flows in the month of N-year, put the monthly flow duration curve in each year on a same paper. Averaging and making it into a monthly flow duration curve, the lowest five (5) flows will be found. The average of them is PL5 flow of the month.

(5) The average L5 flow of N-year is generally determined to be an average of SL5 and PL5 flows in this report.

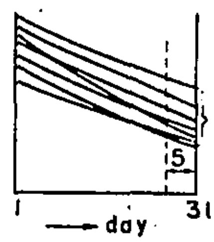
Monthly Flow Duration Curve of "Series"



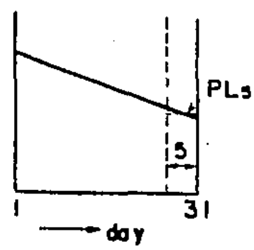
31 x N records be reduced into 31 records



Monthly Flow Duration Curve of "Parallel"



Average and make it into a monthly flow duration curve



L_5 Discharge at Angostura Gauging Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1959	34.8	28.8	24.8	23.4	31.8	97.7	78.5	81.6	66.4	95.4	76.0	60.0
1960	51.2	40.4	33.3	37.9	39.0	79.7	91.1	72.3	79.5	114.2	78.6	61.0
1961	48.7	39.5	28.4	26.6	34.2	72.5	85.7	79.1	103.8	98.8	99.9	88.6
1962	60.7	40.3	31.1	30.8	40.9	82.9	88.5	84.3	98.5	121.2	82.8	70.6
1963	53.9	48.9	46.8	43.0	56.2	80.0	86.9	78.5	93.5	95.6	93.1	69.4
1964	50.2	32.9	24.5	23.6	33.9	82.9	108.5	104.8	116.2	108.2	84.8	53.2
1965	58.6	48.2	48.1	32.2	36.9	92.9	92.5	118.4	107.1	109.8	100.0	71.9
1966	73.4	71.4	55.0	37.0	99.6	105.8	90.6	93.0	109.8	114.2	79.4	106.6
1967	90.4	54.4	41.4	41.4	72.0	120.2	105.0	113.4	135.2	120.4	106.0	60.2
1968	45.8	53.8	45.6	50.6	56.7	125.8	116.7	122.2	115.8	105.6	104.1	78.5
1969	43.7	36.1	29.0	35.5	36.4	80.7	58.2	120.0	97.3	106.8	103.3	90.3
1970	65.4	70.3	50.0	64.8	95.4	125.6	115.8	73.7	103.8	102.0	109.3	151.8
1971	87.4	53.6	59.9	52.8	62.2	80.1	89.5	117.4	97.2	126.2	80.5	52.9
1972	53.4	39.0	36.2	45.1	62.2	68.4	65.1	61.5	98.1	99.5	77.4	63.2
1973	44.2	45.7	37.8	22.4	30.2	101.7	69.5	64.4	95.1	91.7	92.3	83.9
1974	73.6	50.8	49.1	30.6	60.6	100.9	102.7	88.8	77.0	82.9	62.1	50.8
1975	44.7	32.1	27.4	35.1	33.6	78.3	94.0	117.2	122.4	83.6	104.0	106.6
1976	64.6	33.5	34.3	31.4	53.9	85.4	91.8	77.3	100.6	87.7	86.7	58.8
① Average (parallel)	58.0	45.5	39.0	36.9	52.0	92.3	90.6	92.7	101.0	103.6	90.0	76.6
② Average (Series)	45.1	35.8	28.4	27.1	37.4	82.1	79.2	79.2	90.7	98.6	82.0	59.5
Average ($\frac{1}{2}$ ① + ②)	51.6	40.7	33.7	32.0	44.7	87.2	84.9	86.0	95.9	101.1	86.0	68.1

A-4 MONTHLY DISCHARGE AND L_5 DISCHARGE OF POWER STATIONS

Monthly Discharge and L_5 Discharge of Power Stations

(Unit : m^3/sec)

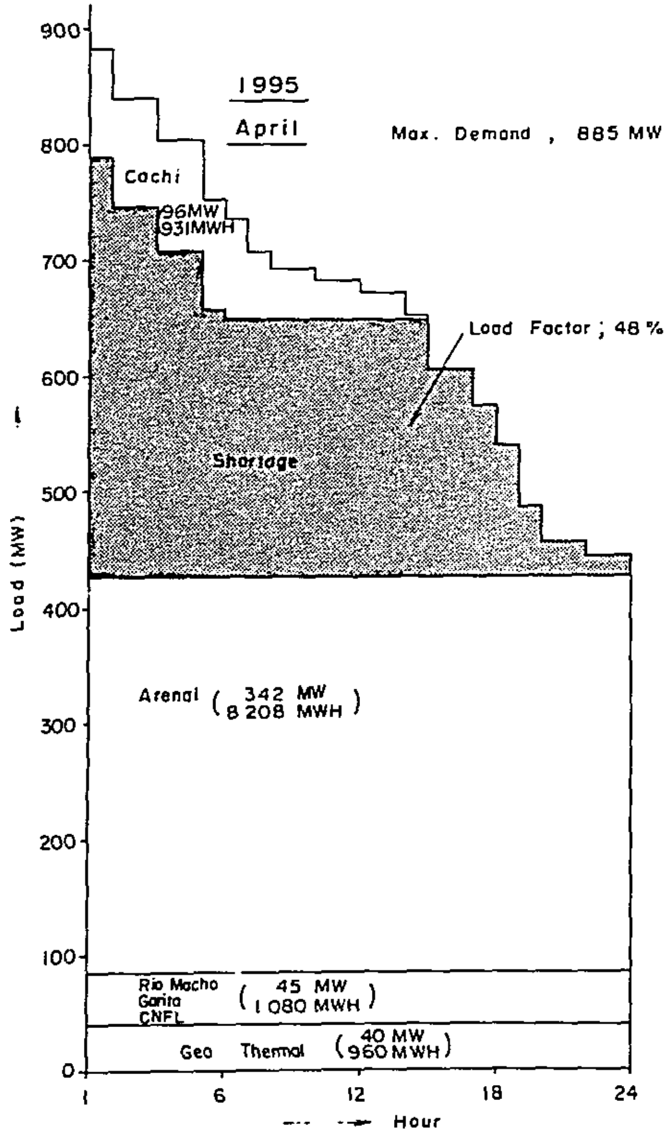
	Item / Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Remarks
Monthly Average	(Angostura G.S. C.A.=1337 km2)													
	① Monthly Average Discharge	87.9	68.0	50.8	66.6	87.2	131	130	134	148	154	151	144	From Jan. 1959 to Dec. 1976
	② L_5 Average Discharge	51.6	40.7	33.7	32.0	44.7	87.2	84.9	86.0	95.9	101	86.0	68.1	
	③ = ② ÷ ①	0.59	0.60	0.66	0.48	0.51	0.67	0.65	0.64	0.65	0.66	0.57	0.47	
	④ Cachi G.S. (C.A.=692km^2)	39.2	28.1	20.9	24.6	38.2	53.4	59.4	60.9	71.6	76.8	72.0	63.2	From May 1955 to Apr. 1974
	⑤ Garita P.S. (C.A.=739km^2)	17.5	16.5	15.3	14.7	16.1	17.7	17.7	17.9	17.9	17.9	18.0	18.0	From Jan. 1957 to Dec. 1973
	⑥ San Miguel G.S. (C.A.=832km^2)	22.4	17.5	15.3	16.1	22.9	37.8	34.8	39.1	66.5	81.6	56.7	34.8	From May 1956 to Apr. 1973
Monthly Average Discharge of Power Station	⑦ Rio Macho and Macho No. 1 P.S. (C.A.=283km^2)	18.0	11.5	8.55	10.1	15.6	21.8	24.3	24.9	29.3	31.4	29.4	25.8	④ × $\frac{283}{692}$: Run-off (*2) Qmax. : 34m^3/sec
	⑧ Cachi P.S. (C.A.=735km^2)	44.5	31.9	23.7	27.9	43.3	60.6	67.4	69.1	81.2	87.1	81.7	71.7	④ × $\frac{785}{692}$: Run-off Qmax. : 54m^3/sec
	⑨ Garita P.S. (C.A.=639km^2)	17.5	16.5	15.3	14.7	16.1	17.7	17.7	17.9	17.9	17.9	18.0	18.0	Power Discharge
	⑩ CNFL and Others P.S.	20.2	17.1	13.8	14.5	20.6	34.0	31.3	35.2	59.9	73.4	51.0	31.3	⑥ × 90% : Run-off Qmax. : 17m^2/sec
	⑪ Arenal and Corobici P.S.	38.7	56.1	56.1	56.1	56.1	56.1	38.7	38.7	38.7	38.7	38.7	38.7	
	⑫ Guayabo P.S. (C.A.=1518km^2)	99.8	77.2	57.7	75.6	99.0	149.	148	152	168	175	171	163	① × $\frac{1518}{1337}$: Run-off Qmax. : 140m^3/sec
L_5 Discharge of Power Station	⑬ Rio Macho and Macho No. 1 P.S.	9.44	6.90	5.64	4.85	7.96	14.6	15.8	15.9	19.0	20.7	16.8	12.1	③ × ⑦
	⑭ Cachi P.S.	26.3	22.0 (19.1)	22.3 (15.6)	22.1 (13.4)	22.1	40.6	43.8	44.2	52.8	57.5	46.6	33.7	③ × ⑧ ( ) : Before Regulation of Cachi Reservoir
	⑮ Garita P.S.	14.9	(*1) 9.90	(*1) 10.1	(*1) 7.06	(*1) 8.21	16.2	16.1	17.4	17.4	17.4	18.0	18.0	(*1) ③ × ⑨
	⑯ CNFL and Others P.S.	11.9	9.66	9.11	6.96	10.5	22.8	20.3	22.5	38.9	48.4	29.1	14.7	③ × ⑩
	⑰ Arenal and Corobici P.S.	38.7	56.1	56.1	56.1	56.1	56.1	38.7	38.7	38.7	38.7	38.7	38.7	
	⑱ Guayabo. P.S.	58.6	49.1 (46.2)	45.0 (38.3)	45.0 (36.3)	50.8	99.0	96.4	95.6	109.	115.	97.6	77.3	② × $\frac{1518}{1337}$

(Note) Monthly Average Run-off are quoted from "Boletin Hidrologico 1975" and "Document de Trabajo 003-77"

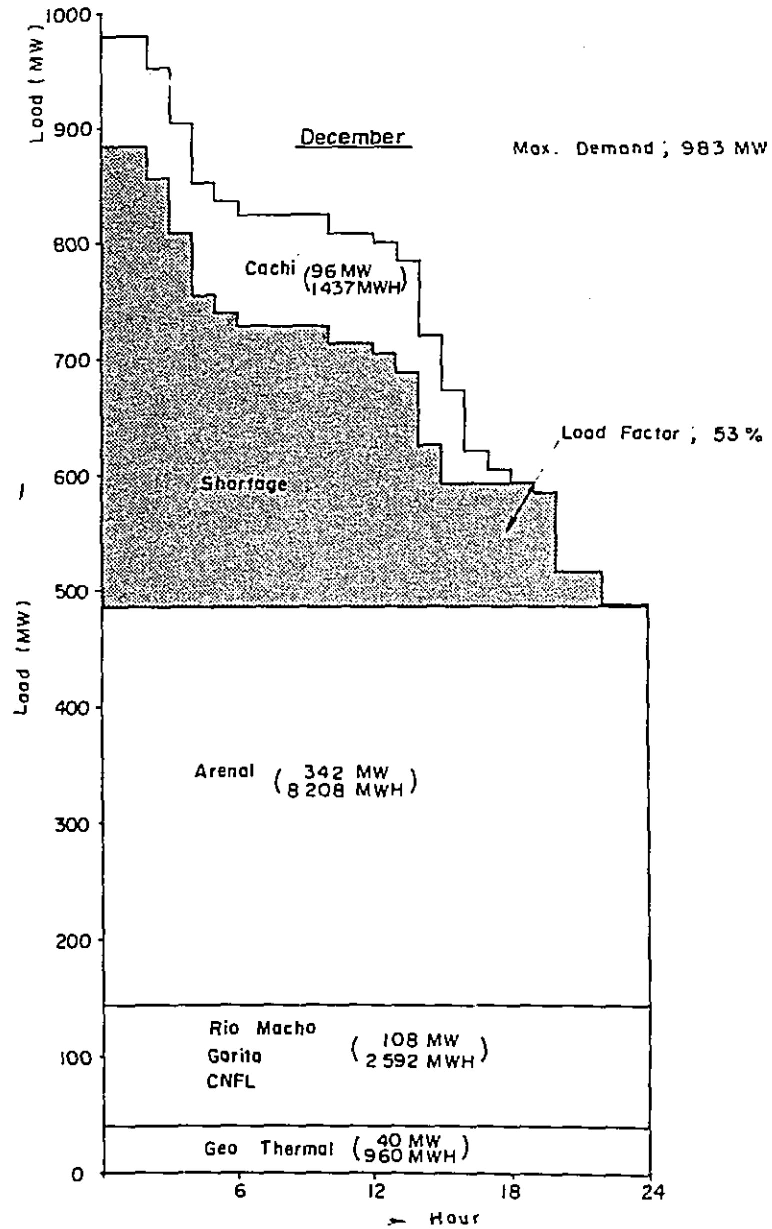
(*2) Qmax.; Max. Power discharge

A-5 DAILY LOAD DURATION CURVE IN 1995

Appendix A－5



1995
April
Max. Demand , 885 MW
Cachi
96MW
931MWH
Load Factor ; 48 %
Shortage
Arenal (342 MW 8 208 MWH)
Rio Macho
Gorita
CNFL
(45 MW 1 080 MWH)
Geo Thermal (40 MW 960 MWH)
Load (MW)
Hour



December
Max. Demand ; 983 MW
Cachi (96 MW 1437 MWH)
Load Factor ; 53 %
Shortage
Arenal (342 MW 8 208 MWH)
Rio Macho
Gorita
CNFL
(108 MW 2 592 MWH)
Geo Thermal (40 MW 960 MWH)
Load (MW)
Hour

A-6 POWER SYSTEM ANALYSIS

6.1 Premises

Some premises assumed in the studies are described below.

(1) Siquirres Power Plant will not be developed before 1990.
(2) The interconnected transmission line with Nicaragua will be excluded in spite of the existence.
(3) A rate of expansion in power demand for each of the substations is 6% annually on the basis of an expected value* in December, 1981.
*(this value is got from ICE data, August 1977, Data 36-6-281.)
(4) Years intended for the study are April/December of 1987 and 1990, respectively, and that the power demand in the same year will show higher in December than in April by about 10%.
(5) Thermal power plants will be used supplementally as supply capability and a newly installed thermal power plant will be PAILAS P.P., geothermal power plant in 1990.
(6) Tap ratio for the existing transformer is 1.0 since existing phase adjustment facilities and their installation sites are not clear, the calculation is made in assumption that they are not provided.

6.2 Power Flow and Voltage Regulation

Five cases of calculation for voltage and flow are performed. Four of them are for the time of April and December in 1987 and 1990, respectively. One of them is for December in 1990, in assumption that a 230 kV transmission line with 1 circuit will be installed between Corobici and Colima. In calculation, the following conditions are set.

(1) Power factor of load is 0.85 and no change will be made through a year.
(2) A voltage at higher bus section in the major substations are about 98%.
(3) Each of the transformers has a tap of 100 $\pm$ 5% (fixed, LRT)

6.2.1 Extension Plan of Transmission Line and Substation

(1) Transmission Line

No problem will be expected by 1990 under existing conditions. However, an overload by 130%*1 or so will be expected at a peak in December, 1990, as shown in Table A-6-1. If 138 kV transmission line with two circuits between La Caja and Colima supplying power to major substations in northern part of San Jose will be operated in one circuit due to certain reason. For reference, if Corobici and Colima are connected by a single circuit of 230 kV, 410° , ACSR in December of 1990, the overload will decrease to 85% (Fig. A-6-6).

In view of elimination of such problems as overload and countermeasure for voltage regulation in the northern substations to be described later, it is preferable to have a new installation of 230 kV transmission line (a single circuit for a while) between Corobici and North Substation of San Jose*2 by 1989 or so as already planned in ICE.

Table A-6-1 Estimated Power Flow between LA CAJA and COLIMA

Date	Number of Circuits	Effective Flow per One Circuit	Overflow Factor
April in 1987	2 cct	88 MW	54 % (88/162 × 100)
	1	158	98
December in 1987	2	97	60
	1	173	107
December in 1990	4	62	38
	2	117	72
	1	210	130
Dec. in 1990 Connection of 23 kV between COROBICI and COLIMA	2	79	49
	1	137	85

Note) In consideration of a reactive power, the overload factor will be slightly increased.

Table A-6-2 Substations Required to Increase Their Capacity

Substation	Initial planned capacity (MVA)	Estimated flow of peak (MW)	Required capacity (MVA)
LA CAJA 230/138 kV	3 × 60	195 (Apr. '87) 244 (Dec. '90)	4 × 60 Apr. '87
CANAS 230/138 kV	30	33 (Dec. '87) 39 (Dec. '90)	40 (or 2 × 30) Apr. '88
COLIMA 138/34.5	4 × 30	121 (Apr. '90) 134 (Dec. '90)	5 × 30 Dec. '90

Note) *1 For one line of 138 kV, ACSR 330 mm^2 continuous heat capacity rating of 162 MW is set to be 100%.

*2 The planned site of North Substation of San Jose is in the northern part of Colima Substation.

And as another countermeasure for overload, values of flow flowing between La Caja and Colima of 138 KV, 8.7 km, 2 circuits, when they are changed to four circuits, are also showed in Fig. A-6-5. However, in view of an existence of interconnected transmission line with Nicaragua in future and anticipated extension of geothermal power plant, it is further effective in reliability to have a newly installed transmission line between Corobici and North Substation of San Jose of 230 kV irrespective of its economy.

(2) Transformer

(a) Transformer at the Demand end.
It is preferable to increase its capacity in accordance with demand.

(b) Transformer for interconnection
According to the initial plan of installation of the facilities, it is expected to have an overload condition in the transformers in three substations shown in Table A-6-2. It will become necessary to increase those capacity.

6.2.2 Voltage Regulation

As a result of the study, it was found that it was required to have a phase modifier such as static condenser in order to keep a voltage of substation up to 100% or so in case of peak load. It is due to the fact that the substations located in northern part of San Jose such as Heredia, Colima and Sabanilla are far away from the major power supply sources such as Corobici, Arenal and Guayabo (see Table A-6-3). In calculation, the required capacity of phase modifier is large*, due to installation of the static condenser at a primary side of the substations.

If there is a 230 kV transmission line with 1 cct between Corobici and Colima in December of 1990 (see Figs. A-6-6 and A-6-7), it is possible to decrease the capacity of about ten percent by having a comparison at the same period, as shown in Table A-6-3.

Further, if it is possible to adjust a tap ratio by adopting LRT for transformers, it will become more effective to control the voltage.

In calculation, an adjusting width of this LRT tap is set for 5%. In a actual operation in the system, it is preferable to set this value to 100 ± 10% or so in consideration of dropping of power capability or one circuit operation for the transmission line with two circuits.

Note) * For reference only, an installation of a static condenser at the secondary side of the transformer will make a secondary voltage by only 1/4 of the primary voltage in calculation. However, this will in turn cause a decrease in primary voltage, so it will be required to have a proper adjustment.

Table A-6-3 Required Values of Static Condenser (Example)

Date		HEREDIA (Primary)	COLIMA (Secondary)	SABANILLA (Primary)	ESTE Primary
1987	Apr.	84 MVA	0	77	5
	Dec.	94	0	93	32
1990	Apr.	82	50	82	24
	Dec.	91	60	90	21
December of 1990 Connection of 230 kV between COROBICI and COLIMA		LRT Tap 1.0 79 (88)*	Tap 1.0 58 (60)	Tap 1.0 80 (87)	Tap 1.0 18 (20)
		LRT Tap 0.95 74 (81)	Tap 0.95 57 (58)	Tap 0.95 75 (80)	Tap 0.95 17 (18)

Note) * The value in the ( ) shows one when 138 kV transmission line between Colima and La Caja is made to be one circuit.

Furhter, it will be required to install the static condenser in consideration of the voltage regulation, in the substations of Garita and Concavas, since power demand will exceed over a generated power in the area. Due to vague data of the daily load curve, the calculation of voltage and power flow in the midnight is not made, and it is, however, supposed that no probiem is expected for an increase in voltage at midnight in view of a length of line and size of the conductors.

6.3 Short Circuit Capacity

Short circuit capacities of the power system in 1990 are as shown in Figs. A-6-8 and A-6-9. In performing calculations, it is assumed that a reactance of the generator is X_d'' and all the generators are in operation in the system. A current flow from the load is neglected.

Table A-6-4
Maximum Short Circuit Capacities

Voltage (kV)	Power Plant or Substation	Short Circuit Capacity MVA	KA
230	ARENAL	1,912	4.8
138	LA CAJA	1,903	8.0
34.5	LA CAJA Secondary	832	13.9
13.8	COLIMA Load end Secondary	505	21.1
	ARENAL* Generator terminal	1,663	69.6*

Note: *) The generated voltage in ARENAL P.P. is assumed to be 13.8 kV.

Table A-6-5
Standard of Circuit Breaker
(JEC 1970)

Voltage (kV)	Interrupting Ratings (Maximum) MVA	KA
240	16,600	40
120	8,310	40
36	1,560	25
12	1,660	80

Maximum short circuit capacity in each class of the voltages in indicated in Table A-6-4. Each of the values is in the range of interrupting ratings for the circuit breaker specified in the standard of JEC.

6.4 Stability

6.4.1 Static Stability

According to the result of calculation of flow at a peak load in December of 1990 shown in Fig. A-6-5, a difference in voltage phase angle between a bus is Colima and each of the generators is 25 degrees at maximum, so there is no problem in a static stability.

6.4.2 Transient Stability

It is assumed that an accident of three phase ground fault is occurred near Guayabo Power Plant's bus at peak load of December, 1987 and December, 1990 (as to pre-flow, refer to Figs. A-6-3 and A-6-5) and the following relay sequence is employed to open and close the breakers at both ends of the line.

3 LG	One circuit power transmission	Failure of re-closing	One circuit power transmission
7 ~	0 30 ~	C 7 ~	0

Occurrance of accident

Sequence of 0-C-0 (7-30-7~)

The result is stable, as shown in Figs. A-6-10 and A-6-11. In this case, a study was made without AVR of the generator. But in the actual system AVR is considered as a margin for the transient stability.

6.5 Conclusion of the Study

As described above, studies on a power flow, voltage regulation, short circuit capacity and stability have been performed, and no problem has been found for the short circuit capacity and stability. On the other hand, as to the power flow and voltage regulation, there may be expected no substantial problem in a normal operational mode. But, in order to improve a realibility of the system, it is recommended to follow after the suggestions described below.

(1) It is preferable to install North Substation of San Jose

(230/138 kV, 100 MVA LRT ± 10%) by 1988 to 1989 and to install a 230 kV, transmission line with 1 cct. between North Substation of San Jose and Corobici.

(2) Increase in capacity of La Caja 230/138 kV transformer:

3 x 60 MVA (at present) --- 4 x 60 MVA (1987)

Increase in capacity of Colima 138/34.5 kV transformer:

4 x 30 MVA (at present) --- 5 x 30 MVA (1990)

(3) In substations such as Heredia, Colima and Sabanilla, it may be expected to have an installation of a facility for modifying the phase such as a static condenser for countermeasure against a voltage fluctuation at peak load. In this study, a calculation was made in such condition as the static condenser was installed at a primary side of the transformer. But in the actual system, it should be determined in reference to the existing phase adjusting device, influence from LRT tap, and installation place (primary and secondary sides of the transformer).

North Substation of San Jose of Section 6.1 and as additional installation of 230 kV transmission line are effective in view of a countermeasure against the voltage in these northern substations.

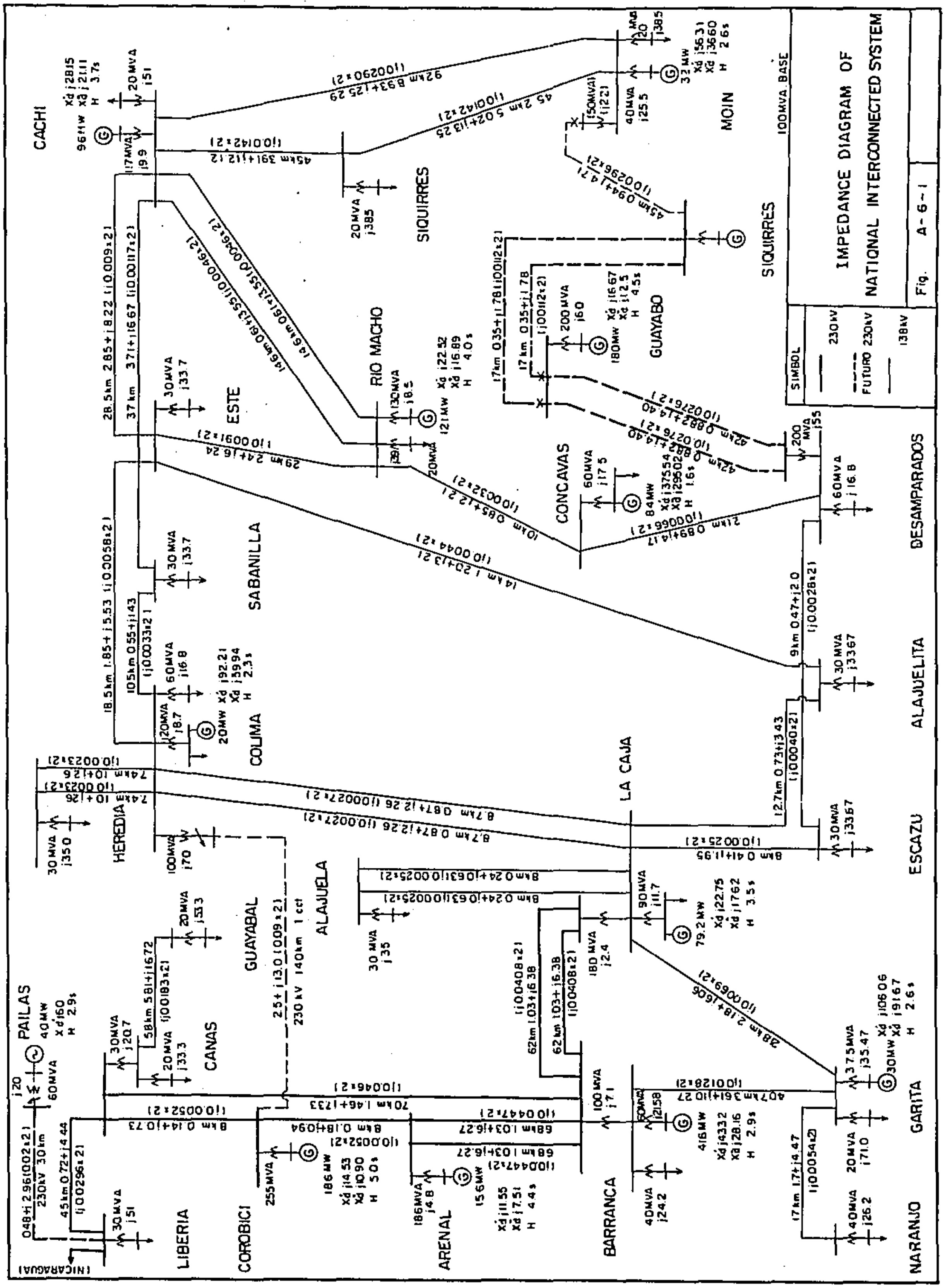
The extension of the facilities described above and a proper selection for a transformer taps at the demand side (0.95 to 1.05) will enable a stable and reliable operation in the system until a year of 1990.

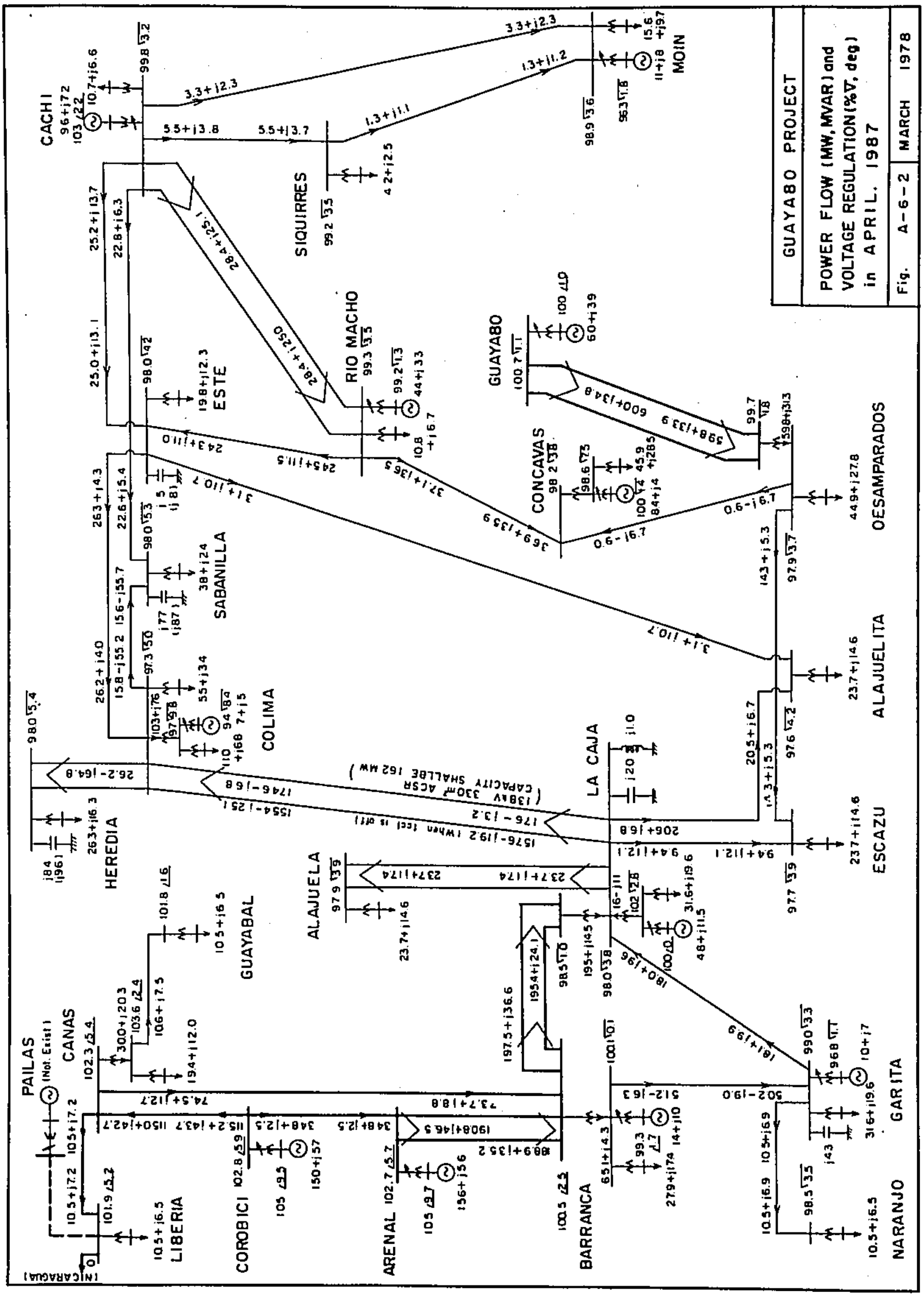
Table A-6-6 Constants of Generator

Power Plant	(Type)	Rated output (MW)	Power factor (%)	X'd Machine base (%)	Inertia constant H(general value, sec)
GUAYABO	(H)	180	80	30.1	4.5
CONCAVAS	(T)	8.4	80	31.5	1.6
RIO MACHO	(H)	121	80	22.7	4.0
MOIN	(T)	32	80	18.0	2.0
CACHI	(H)	96	80	27.1	3.7
LA CAJA*	(T, H)	79.2	80	18.0	3.5
GARITA	(H)	30	80	31.8	2.6
BARRANCA	(T)	41.6	80	18.0	2.9
ARENAL	(H)	156	90	18.0	4.4
COROBICI	(H)	186	80	27.0	5.0
COLIMA	(T)	20	80	18.4	2.3
PAILAS	(E)	40	80	24.0	2.0

Note: H: Hydroelectric power plant
T: Thermal power plant
E: Geothermal power plant

* In LA CAJA, a hydroelectric power plant and several thermal power plants are arranged as one unit. An inertia constant of generator H is a general value in reference to a type and a ratio of capacity.

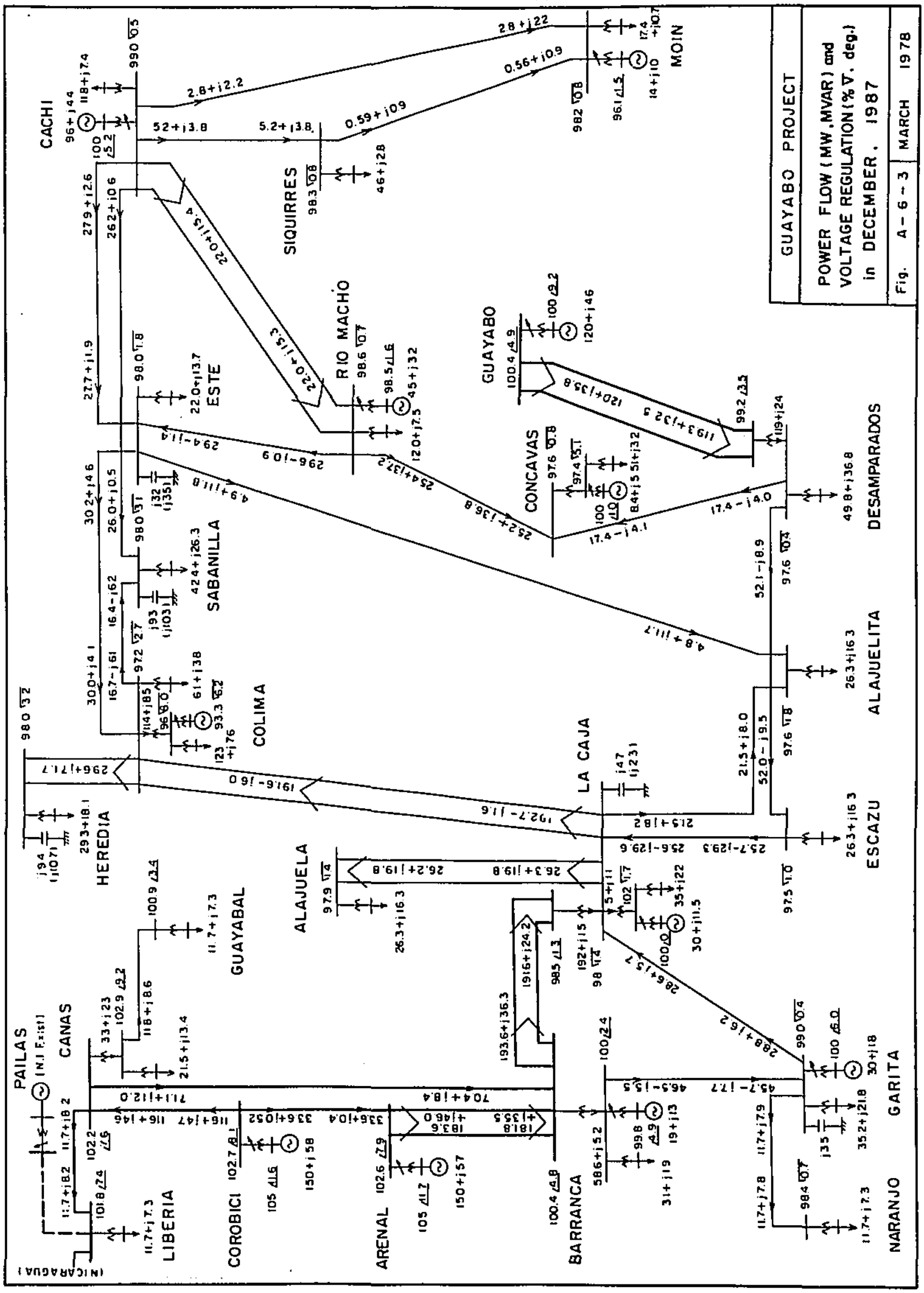

IMPEDANCE DIAGRAM OF
NATIONAL INTERCONNECTED SYSTEM
Fig. A-6-1
100MVA BASE
SIMBOL
230kV
FUTURO 230kV
138kV
CACHI
SIQUIRRES
MOIN
RIO MACHO
ESTE
GUAYABO
CONCAVAS
SABANILLA
COLIMA
DESAMPARADOS
ALAJUELITA
LA CAJA
HEREDIA
ESCAZU
ALAJUELA
GUAYABAL
PAILAS
CANAS
GARITA
LIBERIA
COROBICI
ARENAL
BARRANCA
NARANJO
NICARAGUA

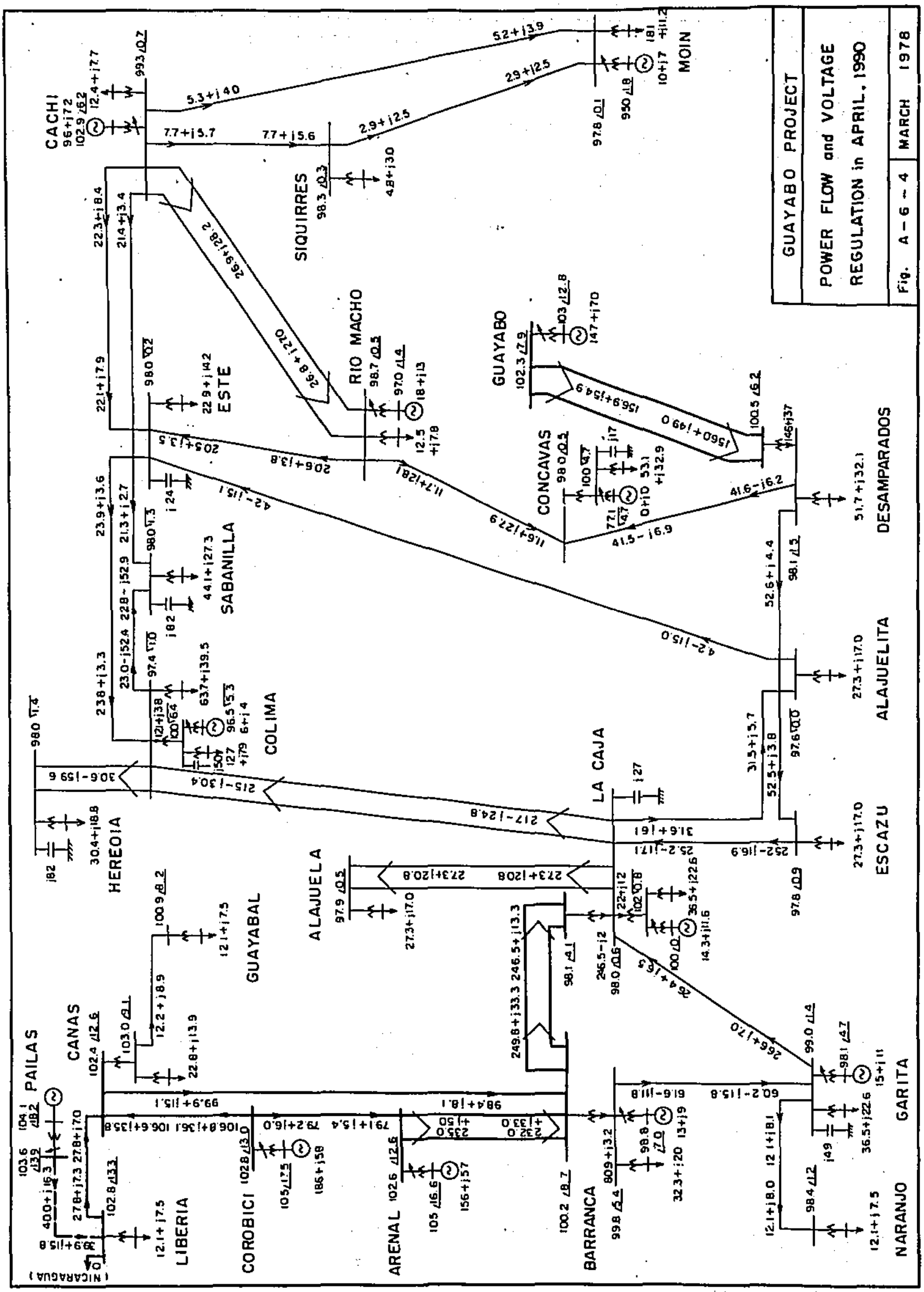


GUAYABO PROJECT

POWER FLOW (MW, MVAR) and VOLTAGE REGULATION (%V, deg) in APRIL, 1987

Fig. A-6-2 MARCH 1978

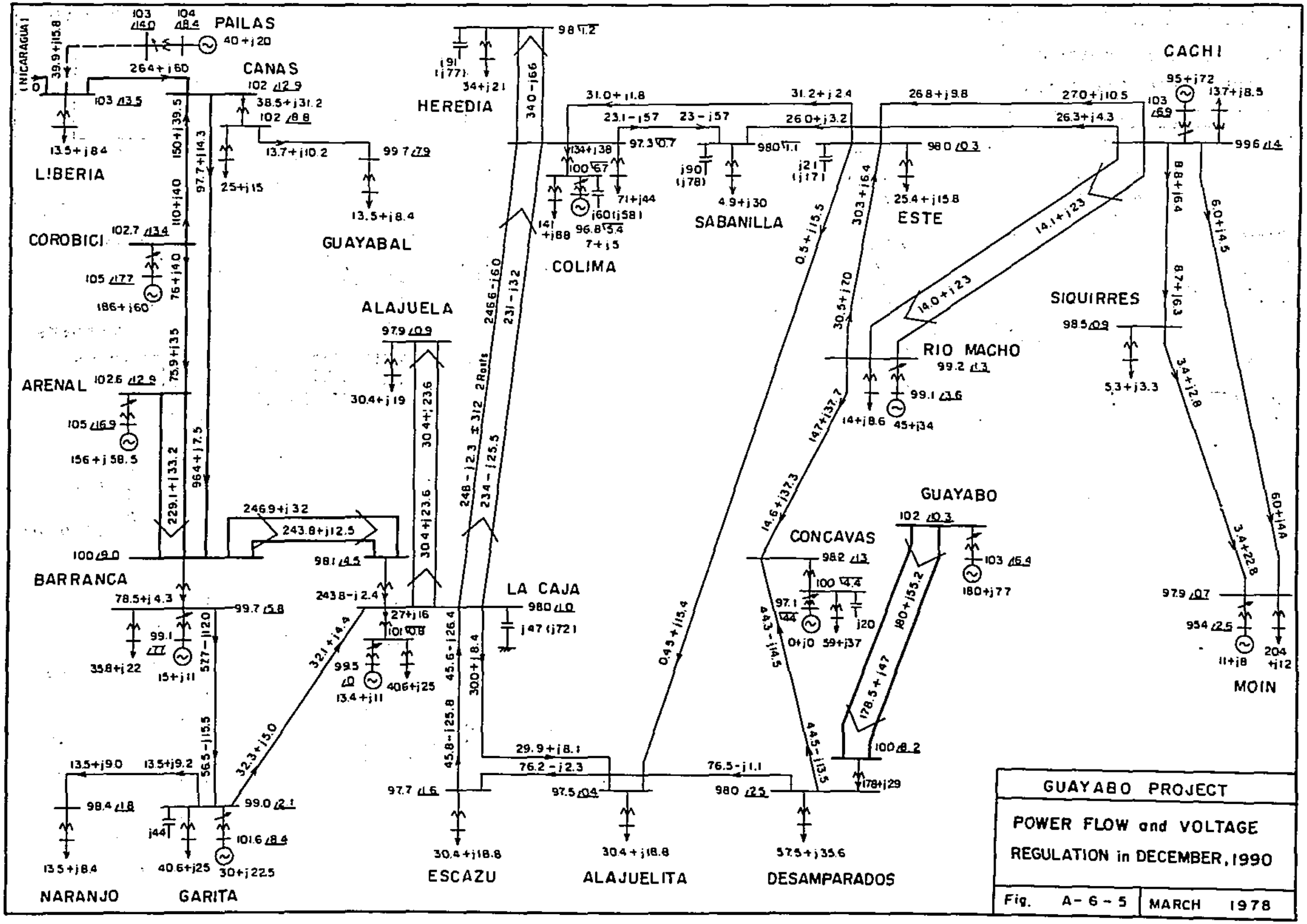

GUAYABO PROJECT
POWER FLOW (MW, MVAR) and VOLTAGE REGULATION (% V. deg.) in DECEMBER, 1987
Fig. A - 6 - 3
MARCH 1978
CACHI
MOIN
SIQUIRRES
RIO MACHO
ESTE
GUAYABO
CONCAVAS
DESAMPARADOS
SABANILLA
ALAJUELITA
COLIMA
LA CAJA
HEREDIA
ESCAZU
ALAJUELA
GUAYABAL
PAILAS (N.I. Exist)
CANAS
GARITA
LIBERIA
COROBICI
ARENAL
BARRANCA
NARANJO
(NICARAGUA)



GUAYABO PROJECT

POWER FLOW and VOLTAGE REGULATION in APRIL, 1990

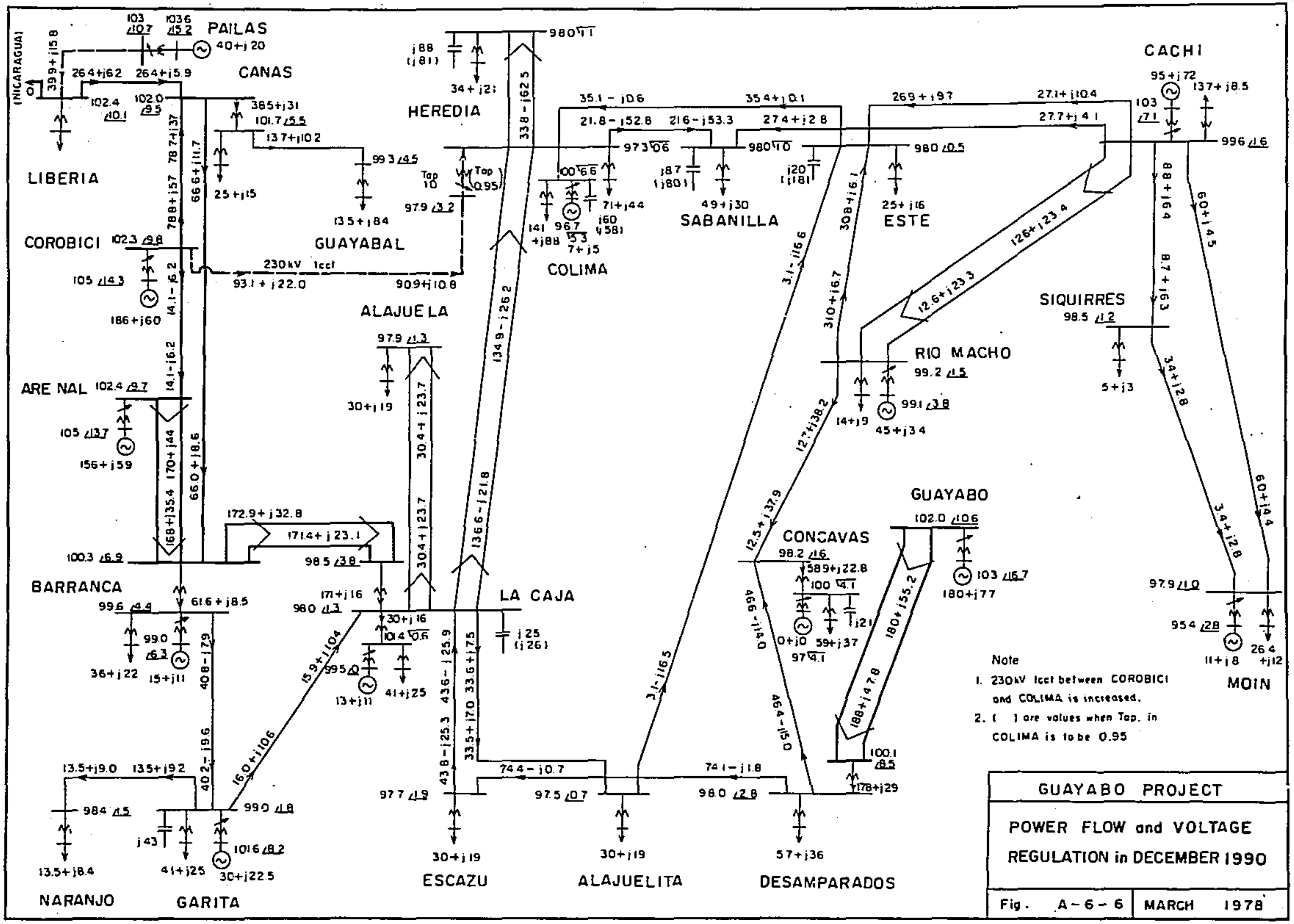
Fig. A - 6 - 4 MARCH 1978



GUAYABO PROJECT

POWER FLOW and VOLTAGE REGULATION in DECEMBER, 1990

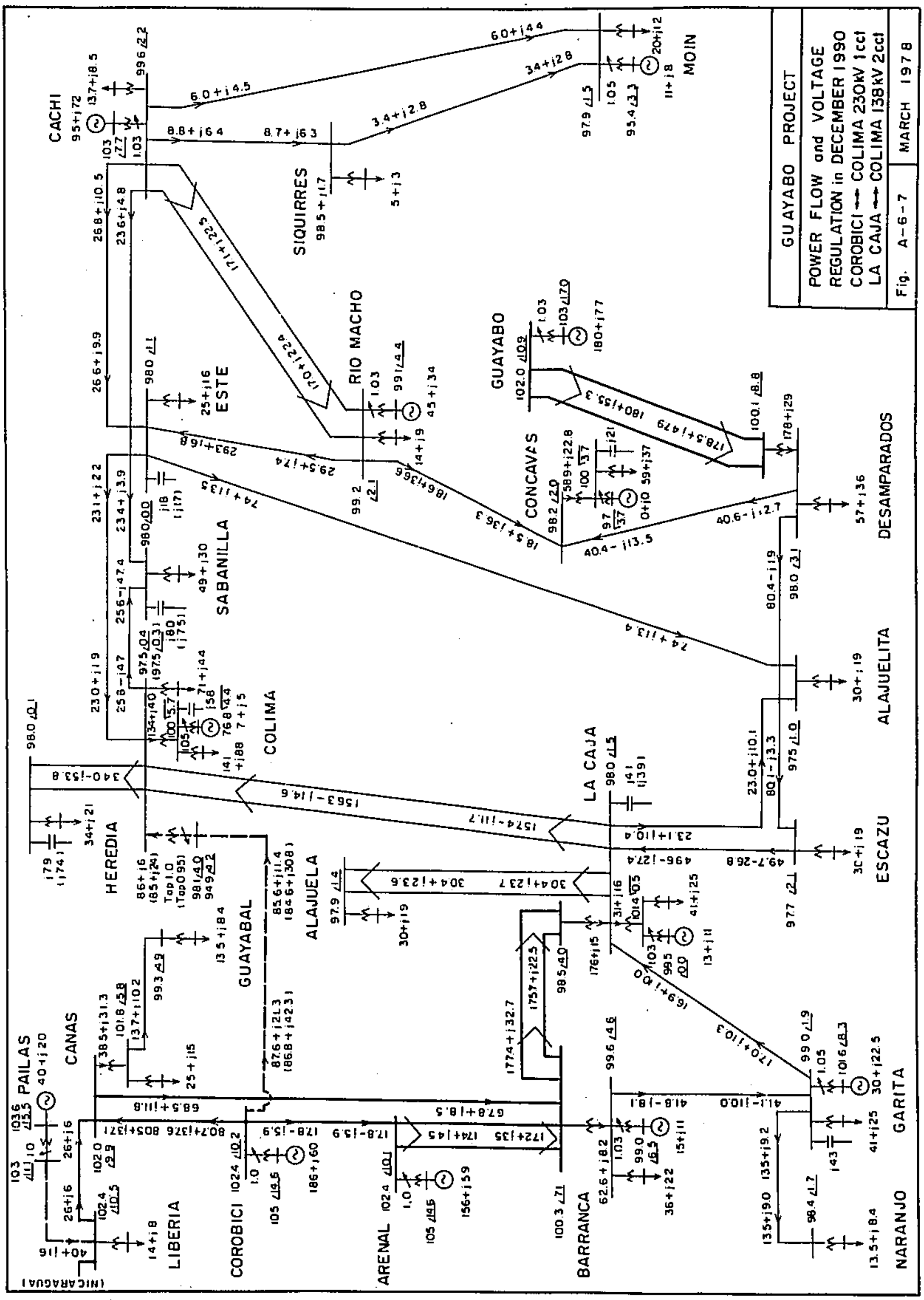
Fig. A-6-5 | MARCH 1978

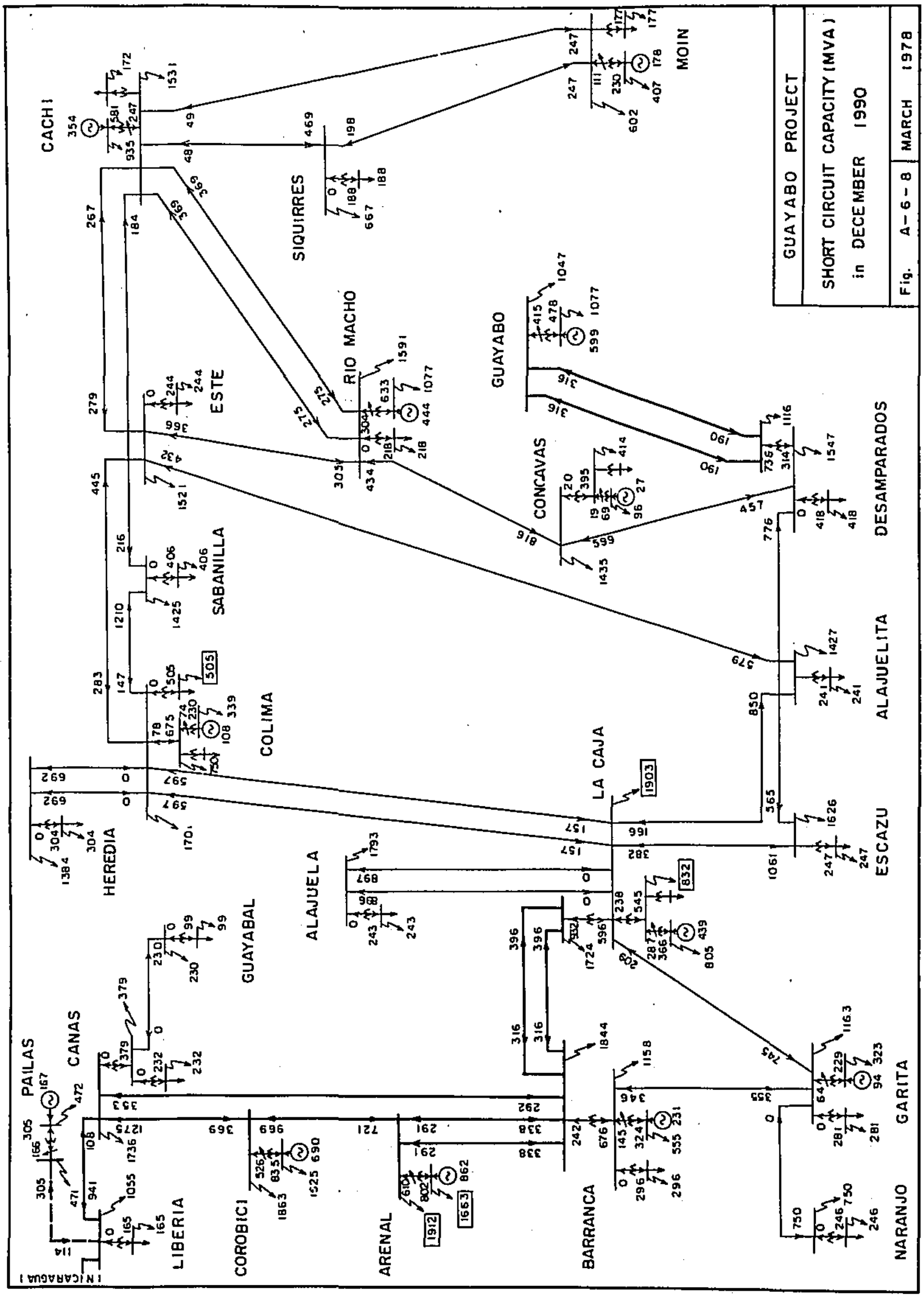


GUAYABO PROJECT

POWER FLOW and VOLTAGE REGULATION in DECEMBER 1990

Fig. A-6-6 MARCH 1978


GUAYABO PROJECT
POWER FLOW and VOLTAGE REGULATION in DECEMBER 1990
COROBICI —— COLIMA 230kV 1cct
LA CAJA —— COLIMA 138kV 2cct
Fig. A-6-7
MARCH 1978
CACHI
MOIN
SIQUIRRES
RIO MACHO
ESTE
GUAYABO
CONCAVAS
DESAMPARADOS
SABANILLA
ALAJUELITA
COLIMA
HEREDIA
LA CAJA
ESCAZU
ALAJUELA
GUAYABAL
CANAS
PAILAS
LIBERIA
(NICARAGUA)
COROBICI
ARENAL
BARRANCA
GARITA
NARANJO


GUAYABO PROJECT
SHORT CIRCUIT CAPACITY (MVA)
in DECEMBER 1990
Fig. A-6-8
MARCH 1978
CACHI
MOIN
SIQUIRRES
RIO MACHO
ESTE
GUAYABO
CONCAVAS
DESAMPARADOS
SABANILLA
COLIMA
ALAJUELITA
LA CAJA
HEREDIA
ESCAZU
ALAJUELA
GUAYABAL
CANAS
PAILAS
LIBERIA
NICARAGUA
COROBICI
ARENAL
BARRANCA
GARITA
NARANJO

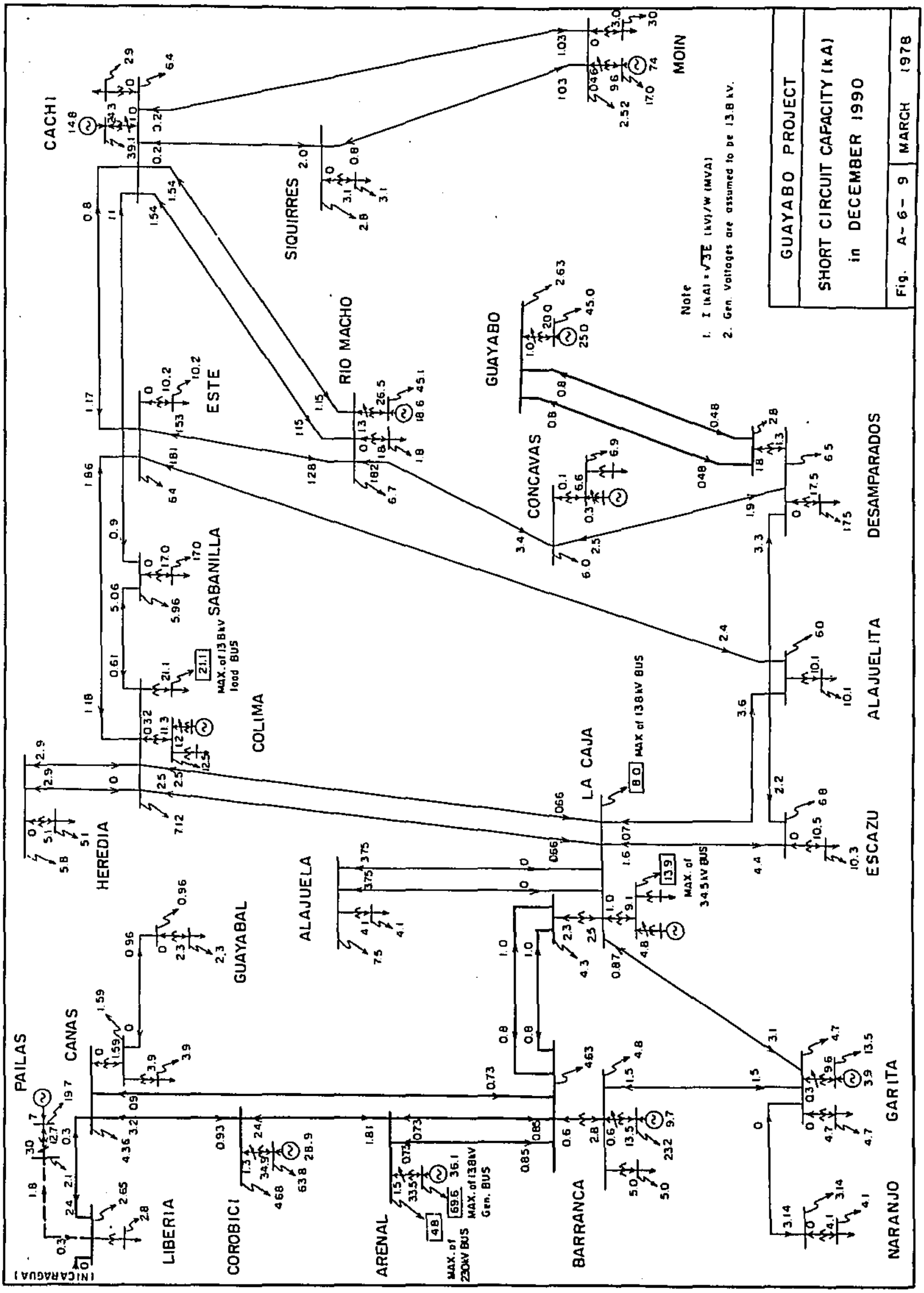
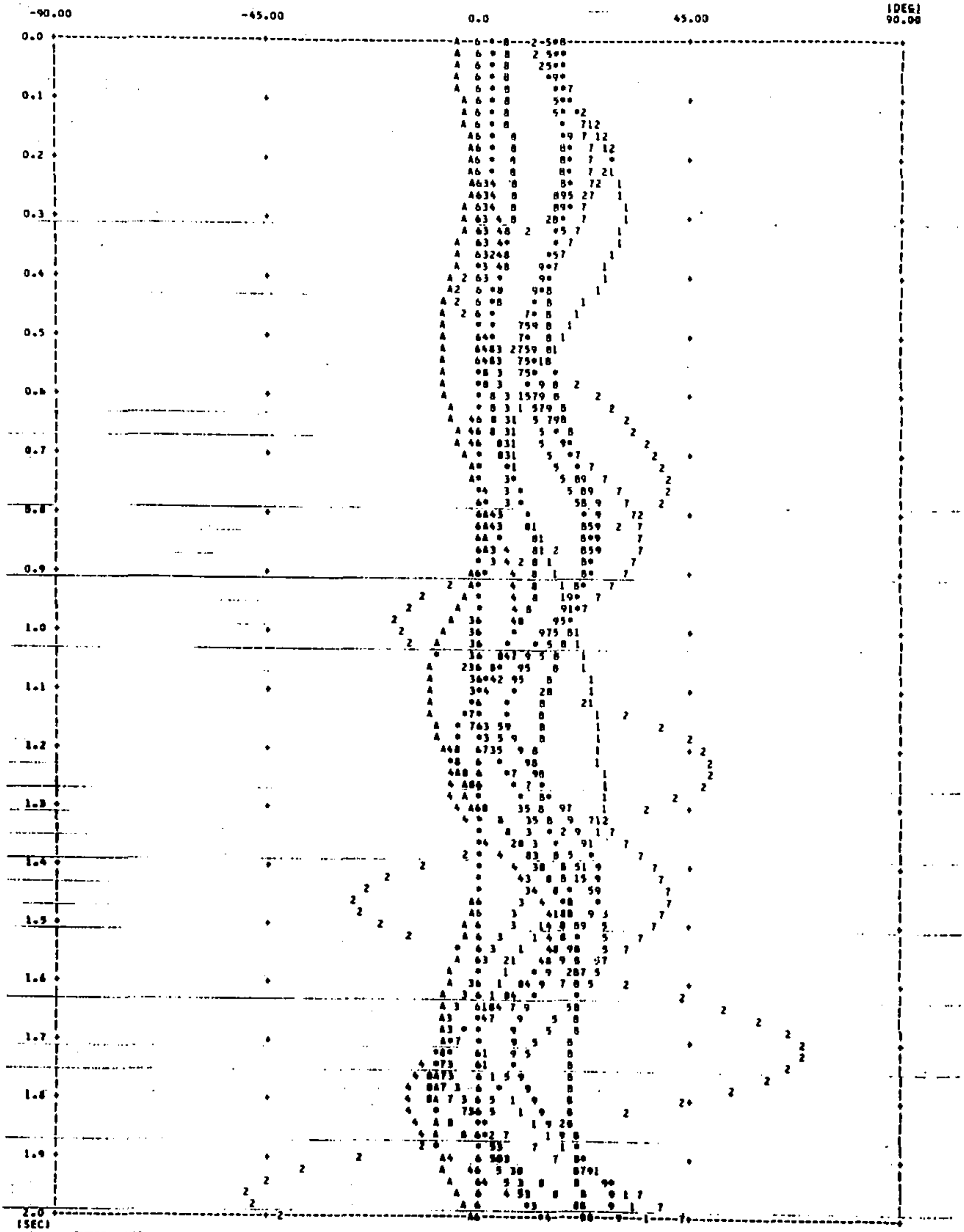

GUAYABO PROJECT
SHORT CIRCUIT CAPACITY (kA)
in DECEMBER 1990
Fig. A-6-9
MARCH 1978
Note
1. I (kA) = √3E (kV)/W (MVA)
2. Gen. Voltages are assumed to be 13.8 kV.
CACHI
MOIN
SIQUIRRES
RIO MACHO
ESTE
GUAYABO
CONCAVAS
DESAMPARADOS
SABANILLA
COLIMA
ALAJUELITA
LA CAJA
ESCAZU
HEREDIA
ALAJUELA
GUAYABAL
PAILAS
CANAS
LIBERIA
(NICARAGUA)
COROBICI
ARENAL
BARRANCA
GARITA
NARANJO

Fig. A-6-10

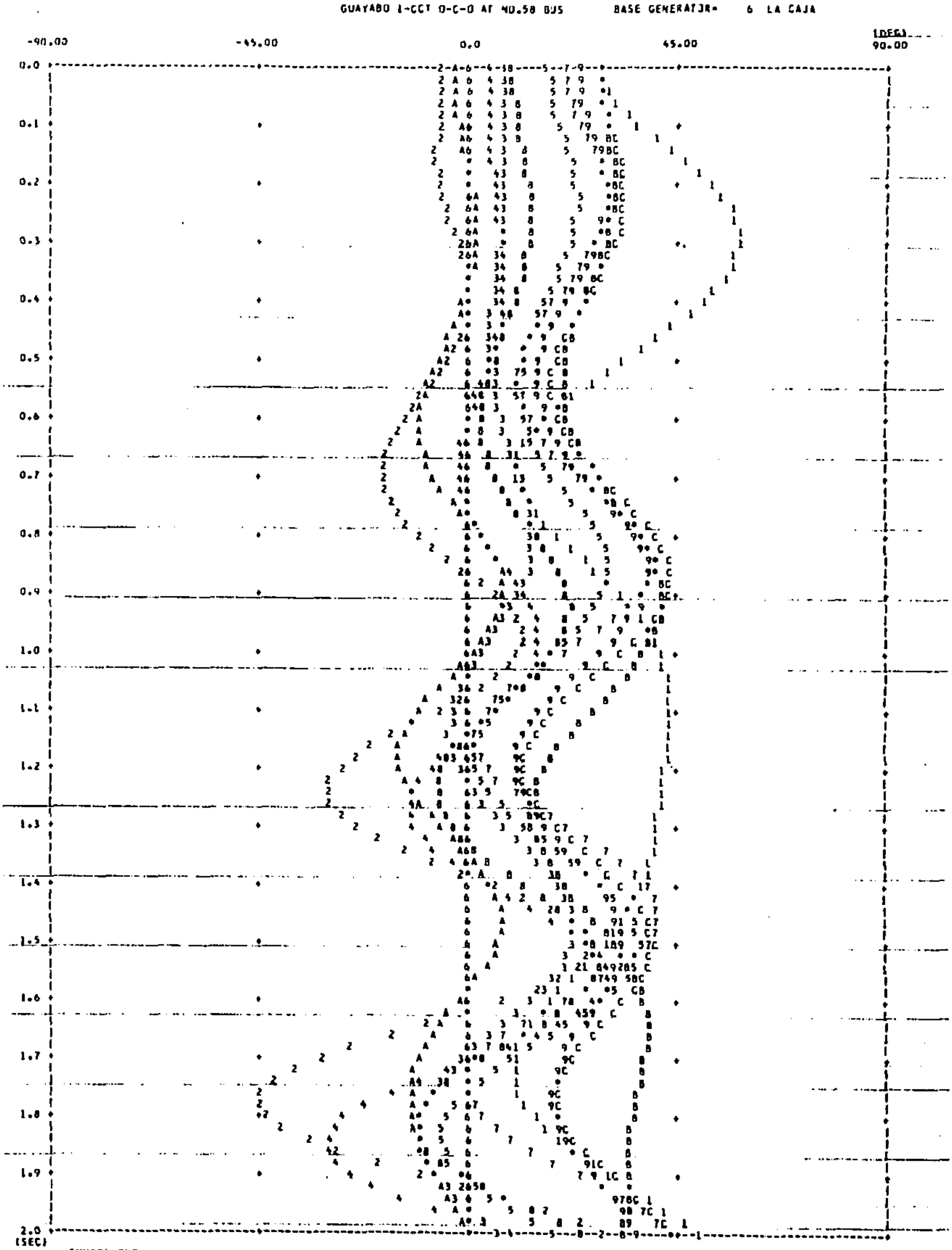
DECEMBER 1987.

GUAYABO 1-CCT O-C-O AT 93.58 BUS BASE GENERATOR: 6 LA CAJA



SYMBOL	GNO	SYMBOL	GNO	SYMBOL	GNO	SYMBOL	GNO
1=	1 GUAYABO PS	2=	2 CONCAVAS	3=	3 RIO MACHO	4=	4 MOIN PS
5=	5 CACHI	6=	6 LA CAJA	7=	7 GARITA	8=	8 BARRANCA
9=	9 ARENAL	A=	10 COLIMA	6=	11 COROBICI		

Fig. A-6-11 DECEMBER 1990.



SYMBOL	GNO	SYMBOL	GNO	SYMBOL	GNO	SYMBOL	GNO
1=	1 GUAYABO PS	2=	2 CONCAVAS	3=	3 RIO MACHO	4=	4 MOIN PS
5=	5 CACHI	6=	6 LA CAJA	7=	7 GARITA	8=	8 BARRANCA
9=	9 ARENAL	A=	10 COLIMA	B=	11 COROBICI	C=	61 PATLAS

A-7 GEOLOGIC LOG OF DRILL HOLE

Geologic Log of Drill Hole

	Name of Hole	Location	Length of Hole (m)	Sheet	Remarks
Guayabo project	DB-3	Dam, Left bank	30.0	1-2	Water Pressure Test
	DB-4	Dam, Left bank	30.0	3-4	Water Pressure Test
	DB-5	Dam, Left bank	30.0	5-6	
	DB-6	Dam, Left bank	50.0	7-9	
	DB-7	Dam, Left bank	30.0	10-11	Water Pressure Test
	DB-9	Dam, Left bank	30.0	12-13	Water Pressure Test
	DB-10	Dam, Left bank	163.25	14-22	Water Pressure Test
	HB-1	Headrace tunnel	180.0	23-31	
	SB-1	Surge tank	116.5	32-37	
	PHB-1	Power House	25.35	38-39	
Siquirres Project	DB-1	Dam, Left bank	265.15	40-53	
	DB-2	Dam, Right bank	231.16	54-65	

Classification of Core Character in Drill Hole

WEATHERING		HARDNESS		CRACK INTERVAL	
5	The rock forming minerals and grains are completely deteriorated and discolored, and rock is remarkably weathered and loosened	E	The rock can be easily excavated with a hammer tip and easily broken with fingers and can be scratched by fingernail.	V	Cracks and joints are spaced less than 1 cm apart
4	Almost rock forming minerals and grains excluding quartz are slightly softend and altered. Somewhere, unweathered parts are remained as block or gravel in weathered parts	D	The rock is easily broken by blow of hammer. Sometimes snapped off by hands or can be whitled with a knife.	IV	Cracks and joints are spaced 1 to 5 cm apart
3	The rock forming minerals and grains are slightly softend and altered. Most of cracks, sometimes rock itself are stained by limonites etc. and some cracks are filled by clay materials.	C	The rock is broken by blow of hammer into small pieces to fragment with some amount of rock dust and powder.	III	Cracks and joints are spaced 5 to 10 cm apart
2	The rock forming minerals and grains are partially sustained with slight weathering and deterioration. Some of cracks are slightly stained but lacked clayey materials.	B	The rock is broken by strong blow of hammer into pieces to fragments with some amount of rock powder.	II	Cracks and joints are spaced 10 to 30 cm apart
1	The rock is very fresh, and the rock forming minerals and graines are neither weathered nor deteriorated.	A	The rock is broken by strong blow of hammer into sharp edged pieces or fragments with sharp fractures.	I	Cracks and joints spaced more than 30 cm apart

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 1

GUAYABO PROJECT — HOLE No. DB-3 (SHEET 1 OF 2)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	30.00 m	COMMENCED	8 Mar. '75
ELEVATION	411.67 m	DEPTH OF OVERBURDEN	8.90 m	COMPLETED	1 Apr. '75
COORDINATE		LENGTH OF ROCK DRILLING	21.10 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40)	DEPTH	ELEVATION
0m–8.9	Mud flow deposit	◇		N.C.P.					Mainly andesitic fragments (Ø max. 33cm) partially sandy cores. cores 4.3m long in total — 8.9	3.7 Ground water level	0m	411.67 m; 407.97
8.9–11.6	Mudstone			NB	brownish gray		4	5 – 4	Brittle and very cracky, generally bearing fossil fragments. — 11.6		9	402.77
11.6–13.9						3	3	4 – 3	Brittle. Dip of bedding plane is about 20 degree. — 13.9			
13.9–14.07							4	5-4	14.07			
14.07–15.85							3 – 4	4	15.85			
15.85–19.6						3 – 2	3	4 – 3	Low grade of solidificacion, but generally sound. — 19.6	Lu = 29.9 (Max. P = 10.0 kg/cm²) Maximum pressure at top of hole		
19.6–20								3-4			20	391.67

Legend: core loss; RQD; weathering 1 (fresh) ~ 5 (decomposed); hardness 1 (hard) ~ 5 (soft); core cutting 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; driller's note

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 2

GUAYABO PROJECT — HOLE No. DB-3 (SHEET 2 OF 2)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	30.00 m	COMMENCED	8 - Mar. - '75
ELEVATION	411.67 m	DEPTH OF OVERBURDEN	8.90 m	COMPLETED	1 - Apr. - '75
COORDINATE		LENGTH OF ROCK DRILLING	21.10 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

Columns: DEPTH | ROCK NAME | LOG | CORE RECOVERY (0 → 100 %) | CEMENTATION, KIND OF BIT, CASING | OBSERVATION OF CORE: COLOR, WEATHERING, HARDNESS, CORE CUTTING, DESCRIPTION | WATER TABLE, WATER PRESSURE TEST, LEAKAGE OF DRILLING WATER (LUGEON 0, 10, 20, 30, 40) | DEPTH | ELEVATION

Depth 20 m, elevation 391.67 m

Depth (m)	Rock name	Bit / casing	Color	Weathering	Hardness	Core cutting	Description	Water pressure test
20.0 – 22.0	Mudstone	NB, BST	brownish gray	3 - 2	3	4 - 3	Generally bearing fossil fragments.	Lu = 28.9 (Max.P = 10.0 kg/cm²) (21.0 – 24.0)
22.0 – 22.5						3		
22.5 – 25.17							Dip of bed is 18° 20.5m - 25.17m Soft and brittle	Lu = 18.6 (Max.P = 10.0 kg/cm²) (24.0 – 27.0)
25.17 – 29.0			light brownish gray	3	4 - 3	4	Mostly cracky cores, partially granular cores. 25.32 - 25.37m clayey. Dip of bed is 20°	Lu = 21.7 (Max.P = 10.0 kg/cm²) (27.0 – 30.0)
29.0 – 30.0					3	4 - 3		

Bottom of hole 30.00

Depth 30 m, elevation 381.67

Legend: core loss; RQD; ▶ driller's note 4; 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; 1 (hard) ~ 5 (soft); 1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 3

GUAYABO PROJECT — HOLE No. DB-4 (SHEET 1 OF 2)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	30.00 m	COMMENCED	6 -Apr.- '75
ELEVATION	416.94 m	DEPTH OF OVERBURDEN	6.10 m	COMPLETED	25 -Apr.- '75
COORDINATE		LENGTH OF ROCK DRILLING	23.90 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

Depth (m)	Rock name	Color	Weathering	Hardness	Core cutting	Description	Water pressure test / Lugeon	Elevation
0 – 6.1	Mud flow deposit					Mainly consists of hard andesitic fragments (ø 2 ~ 45cm), matrix loss, partially sandy cores. Cores 4.0m long	3.7 Ground water level	416.94 / 413.24 / 410.84
6.1 – 9.47	Mudstone	greyish brown	3	3; 3-4	3; 3-4; 4-5	Soft and brittle, generally bearing minute fossil fragments. 8.2 Dip of bed is 16°. Fragmental cores (ø 1-2cm) 9.47	Lu = 55.3 (Max. P=8.0kg/cm²)	407.47
9.47 – 11.0	Sandstone	light gray	4	4	5	Granular cores. Soft rock but generally sound. 11.0		405.94
11.0 – 20	Mudstone	light greyish brown	3-2; 3; 3-2	3; 3-4; 4; 3	3-4; 4-5; 5; 3	Low grade of solidification, but generally sound. 14.3 Granular cores. 15.45 16.15 Bearing minute fossil fragments.	Lu = 51.7 (Max.P=10.0kg/cm²); Lu = 46.3 (Max.P=10.0kg/cm²); Lu = 44.7 (Max.P=10.0 kg/cm²)	396.94

Column headings: DEPTH, ROCK NAME, LOG, CORE RECOVERY (0 → 100%), CEMENTATION, KIND OF BIT, CASING (N, C.P, NB), OBSERVATION OF CORE: COLOR, WEATHERING, HARDNESS, CORE CUTTING, DESCRIPTION; WATER TABLE, WATER PRESSURE TEST, LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40); DEPTH; ELEVATION

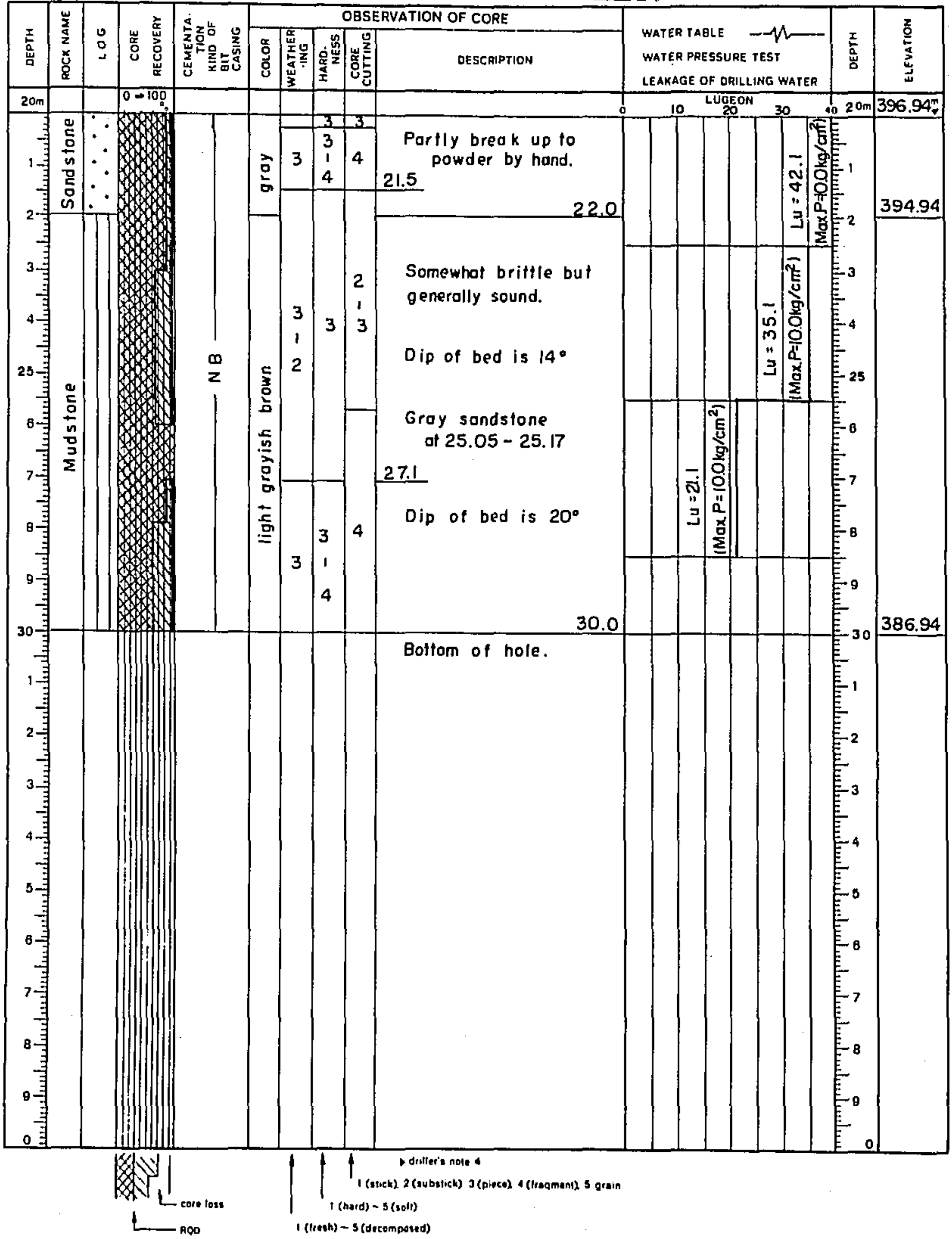
Legend: core loss; RQD; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; ▸ driller's note ◂

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 4

GUAYABO PROJECT — HOLE No. DB-4 (SHEET 2 OF 2)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	30.00 m	COMMENCED	6 -Apr.- '75
ELEVATION	416.94 m	DEPTH OF OVERBURDEN	6.10 m	COMPLETED	25 -Apr.- '75
COORDINATE		LENGTH OF ROCK DRILLING	23.90 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

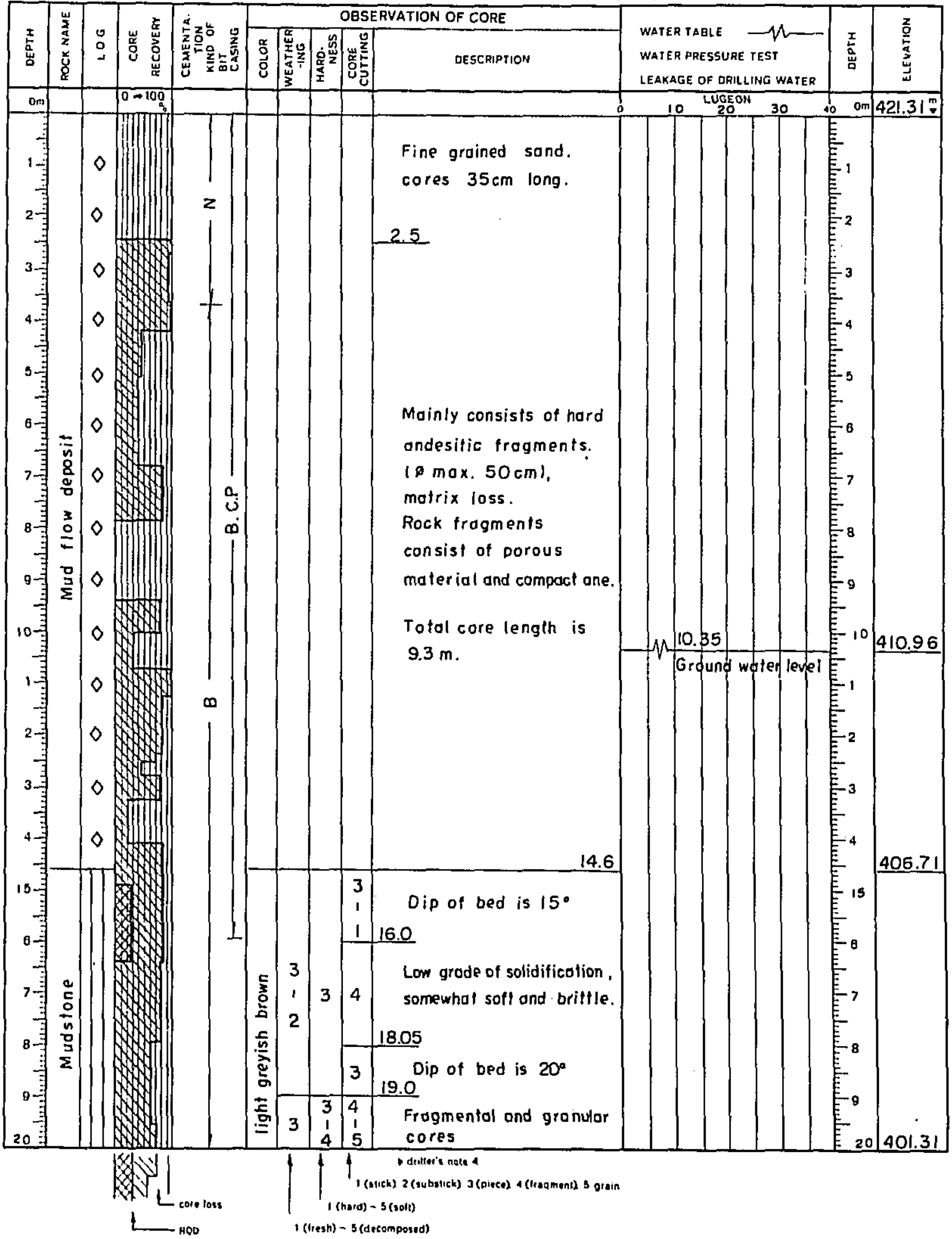


GEOLOGIC LOG OF DRILL HOLE

Sheet No. 5

GUAYABO PROJECT — HOLE No. DB-5 (SHEET 1 OF 2)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	30.00 m	COMMENCED	10 Apr. '75
ELEVATION	421.31 m	DEPTH OF OVERBURDEN	14.60 m	COMPLETED	24 -Apr.- '75
COORDINATE		LENGTH OF ROCK DRILLING	15.40 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		



GEOLOGIC LOG OF DRILL HOLE

Sheet No. 6

GUAYABO PROJECT — HOLE No. DB-5 (SHEET 2 OF 2)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	30.00 m	COMMENCED	10 -Apr.-'75
ELEVATION	421.31 m	DEPTH OF OVERBURDEN	14.60 m	COMPLETED	24 -Apr.-'75
COORDINATE		LENGTH OF ROCK DRILLING	15.40 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION, KIND OF BIT, CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40)	DEPTH	ELEVATION
20m											20m	401.31 m
20–22.45	Mudstone			B	light brownish gray	3	3 - 4	4 - 5	Fragmental and granular cores, brittle. 22.45			
22.45–22.75	Ss								Gray sandstone, brittle. 22.75			406.71
22.75–24.75	Mudstone				dark gray		4	5	24.1 Soft, slickenside. 24.75			396.35
24.75–30.0	Sandstone				dark brownish gray	3 - 2	3	3 - 4	Light gray, fine grained sandstone 24.96. Somewhat brittle but generally sound. Interbedded with dark brownish gray mudstone at 25.24 - 25.84m. 30.0		30	381.38
30									Bottom of hole			

core loss — RQD

1 (fresh) ~ 5 (decomposed)

1 (hard) ~ 5 (soft)

1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain

▸ driller's note ◂

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 7

GUAYABO PROJECT — HOLE No. DB-6 (SHEET 1 OF 3)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	50.00 m	COMMENCED	26 -Apr.- '75
ELEVATION	410.98 m	DEPTH OF OVERBURDEN	10.00 m	COMPLETED	28 -May.- '75
COORDINATE		LENGTH OF ROCK DRILLING	40.00 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

Column headings: DEPTH, ROCK NAME, LOG, CORE RECOVERY (0 → 100 %), CEMENTATION, KIND OF BIT, CASING; OBSERVATION OF CORE: COLOR, WEATHERING, HARDNESS, CORE CUTTING, DESCRIPTION; WATER TABLE, WATER PRESSURE TEST, LEAKAGE OF DRILLING WATER (LUGEON 0, 10, 20, 30, 40); DEPTH; ELEVATION.

Depth (m)	Rock name	Color	Weathering	Hardness	Core cutting	Description	Elevation
0 – 0.5						Topsoil 0.5	410.98 / 410.48
0.5 – 10.0	Mud flow deposit					Mainly consists of hard andesitic fragments, matrix no core. Total core length is 4.1m. 10.0	400.98
10.0 – 10.5	Mudstone	light brownish gray	4	4-3	4-3	Strongly weathered, clayey. 10.5	400.48
10.5 – 13.5	Mudstone	light brownish gray	3	4 - 3	4	Brittle, mostly 1-3cm fragments, generally bearing minute fossil fragments. 13.5	397.48
13.5 – 13.8	Ss			3		Light gray fine grained sandstone 13.8	397.18
13.8 – 16.18	Mudstone	brownish gray		3 - 4	4 - 3	Fault breccia at 13.95 ~ 14.13m. 16.18	394.80
16.18 – 16.5	Ss			3-2	2	Light brownish gray, fine grained sandstone 16.5	394.48
16.5 – 19.16	Mudstone	brownish gray	3 - 2	3 / 3-4	3 - 4 / 4-5	Somewhat brittle but generally sound. Dip of bed is 15° 19.16	391.82
19.16 – 19.5	Ss			3	3 - 4	Gray sandstone 19.5	391.48
19.5 – 20	Ms		3	3-4	4-5	Brownish gray mudstone	390.98

Casing: NX.C.P; Kind of bit: N

Legend:
- core loss
- RQD
- 1 (fresh) ~ 5 (decomposed)
- 1 (hard) ~ 5 (soft)
- 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain
- ▸ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 8

GUAYABO PROJECT — HOLE No. DB-6 (SHEET 2 OF 3)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	50.00 m
ELEVATION	410.98 m	DEPTH OF OVERBURDEN	10.00 m
COORDINATE		LENGTH OF ROCK DRILLING	40.00 m
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m
BEARING OF ANGLE HOLE		CORE RECOVERY	%
COMMENCED	26 - Apr. - '75	COMPLETED	28 - May - '75
DRILLED BY		LOGGED BY	

DEPTH	ROCK NAME	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	ELEVATION
20m							390.98 m
20–21.8	Mudstone	brownish gray	3	3-4	4-5	Brittle, mostly cracky cores. partially interbedded with thin sandstone 21.6 / 21.8	389.18
21.8–25.96	Conglomerate	gray	3	4-3	5-3	22.4 Brittle 23.1	
		light brownish gray	2-3	2-3	3-2	Generally hard, bearing fossil fragments (ø 0.2 ~ 2.5cm) 25.35	
				4-3	4-5	Brittle 25.96	385.02
25.96–27.02	Sandstone			3	3-4	Light brownish gray, fine grained sandstone 26.7 / 27.02	383.96
				4			
27.02–28.5	Mudstone	light brownish gray		4-3	4-5	Brittle, fragments and grains. 28.5	382.48
28.5–30.0	Conglomerate					30.0	380.98
30.0–40	Mudstone	dark gray	3	4	5	Very brittle, mostly granular to fragmental cores. 35.0	
				3-4	4	Fragment ø 0.5 ~ 2cm, brittle.	
40							370.98

CEMENTATION / KIND OF BIT / CASING: N

WATER TABLE; WATER PRESSURE TEST; LEAKAGE OF DRILLING WATER; LUGEON 0 – 40

CORE RECOVERY 0 → 100 %

Legend: core loss; RQD; driller's note; 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; 1 (hard) ~ 5 (soft); 1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 9

GUAYABO PROJECT — HOLE No. DB-6 (SHEET 3 OF 3)

LOCATION: Left Bank, Damsite
ELEVATION: 410.98 m
COORDINATE:
ANGLE FROM HOLIZONTAL: 90°
BEARING OF ANGLE HOLE:

DEPTH OF HOLE: 50.00 m
DEPTH OF OVERBURDEN: 10.00 m
LENGTH OF ROCK DRILLING: 40.00 m
TOTAL LENGTH OF CORE: m
CORE RECOVERY: %

COMMENCED: 26 Apr. '75
COMPLETED: 28 May. '75
DRILLED BY:
LOGGED BY:

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION / KIND OF BIT / CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
40m											40m	470.98 m
40.00–43.35	Mudstone			N	dark gray	3	3 - 4	4	Dip of bed is 17° 43.35		43.35	367.63
43.35–44.45	Cgl	o o o		N	light gray	3	3	3	Somewhat hard, bearing fossil fragments. 44.45		44.45	366.53
44.45–45.75	Ss	· · ·		N		3			Light brownish gray sandstone. 45.75		45.75	365.23
45.75–50.0	Mudstone			N	dark gray	3	3 - 4	4	Fragments ∅0.5 ~ 1.5 cm as a result of mudcrack which is produced after coring 50.0		50	360.98
50									Bottom of hole			

Legend:
- core loss
- RQD
- driller's note 4
- 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain
- 1 (hard) ~ 5 (soft)
- 1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 10

GUAYABO PROJECT — HOLE No. DB-7 (SHEET 1 OF 2)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	30.00 m	COMMENCED	20 -May.- '75
ELEVATION	415.06 m	DEPTH OF OVERBURDEN	12.00 m	COMPLETED	7 -Jun.- '75
COORDINATE		LENGTH OF ROCK DRILLING	18.00 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
0m – 12.0	Mud flow deposit	◇		N, C.P, BQ					Mainly consists of hard andesitic fragments (ø max. 36cm), matrix no core. Cores 7.7m long in total. 12.0		0m – 12	415.06m – 403.06
12.0 – 20	Mudstone			BQ	light brownish gray	3 - 4	4	5 - 4	Low grade of solidification. very brittle, break up to powder, generally bearing minute fossil fragments.		12 – 20	403.06 – 395.06

Legend: core loss; RQD; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; ▸ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 11

GUAYABO PROJECT — HOLE No. DB-7 (SHEET 2 OF 2)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	30.00 m
ELEVATION	415.06 m	DEPTH OF OVERBURDEN	12.00 m
COORDINATE		LENGTH OF ROCK DRILLING	18.00 m
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m
BEARING OF ANGLE HOLE		CORE RECOVERY	%
COMMENCED	20 May '75	COMPLETED	7 Jun. '75
DRILLED BY	I.C.E	LOGGED BY	

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER PRESSURE TEST (LUGEON 0–40)	DEPTH	ELEVATION
20m											20m	395.06 m
20–21.6	Mudstone			BQ	light brownish gray	3 - 4	4	5 - 4	Dip of bed is 18° 21.6			
21.6–24.8	Mudstone			BQ	light brownish gray	3	3 - 4	4 - 5	Generally brittle, granular to fragmental cores. 24.8	Lu = 22.9 (Max. P = 10.0 kg/cm²)		390.26
24.8–25.7	Cgl.	o o		BQ	gray	3	4		Conglomerate, bearing fossil fragment 25.7	Lu = 30.2 (Max. P = 10.0 kg/cm²)	25	389.36
25.7–27.95	Mudstone			BQ	whitish brown	3	3 - 4	4	Fragment ø 0.5 ~ 3 cm Dip of bed is 15°. 27.95			387.11
27.95–29.2	Cgl.	o o o		BQ	gray	3	3 - 4	3 - 5	Conglomerate, bearing fossil fragment 29.2	Lu = 25.4 (Max. P = 10.0 kg/cm²)		385.86
29.2–30.0	Ms.			BQ	gray	3	3	4	Mudstone 30.0		30	385.06
30									Bottom of hole			

WATER TABLE; WATER PRESSURE TEST; LEAKAGE OF DRILLING WATER

▸ driller's note 4
1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain
1 (hard) ~ 5 (soft)
1 (fresh) ~ 5 (decomposed)
core loss
RQD

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 12

GUAYABO PROJECT — HOLE No. DB-9 (SHEET 1 OF 2)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	30.00 m
ELEVATION	420.63 m	DEPTH OF OVERBURDEN	13.85 m
COORDINATE		LENGTH OF ROCK DRILLING	16.15 m
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m
BEARING OF ANGLE HOLE		CORE RECOVERY	%
COMMENCED	18-Jun.-'75	COMPLETED	27-Jun.-'75
DRILLED BY	I.C.E	LOGGED BY	

DEPTH (m)	ROCK NAME	CEMENTATION / KIND OF BIT / CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER PRESSURE TEST (LUGEON 0–40)	ELEVATION
0 – 13.85	Mud flow deposit	BQ, C.P					Mainly consists of hard andesitic fragments. φ max. 22cm, partially gravels of sandstone. core 5.8m long in total. 13.0 Fine to medium grained sand 13.85		420.63
13.85 – 18.8	Mudstone		light greyish brown	3	3 - 4	5 - 4	Generally brittle, bearing minute fossil fragments	Lu=37.0 (Max.P=8.0kg/cm²)	406.78
17.8 – 18.8				3 - 4	4	5	17.8 Very brittle. 18.8	Lu=58.0 (Max.P=4.0kg/cm²)	401.83
18.8 – 20	Cgl		Light gray	3	3	3	Conglomerate, generally sound.		400.63

Legend: core loss; RQD; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; ▸ driller's note 4

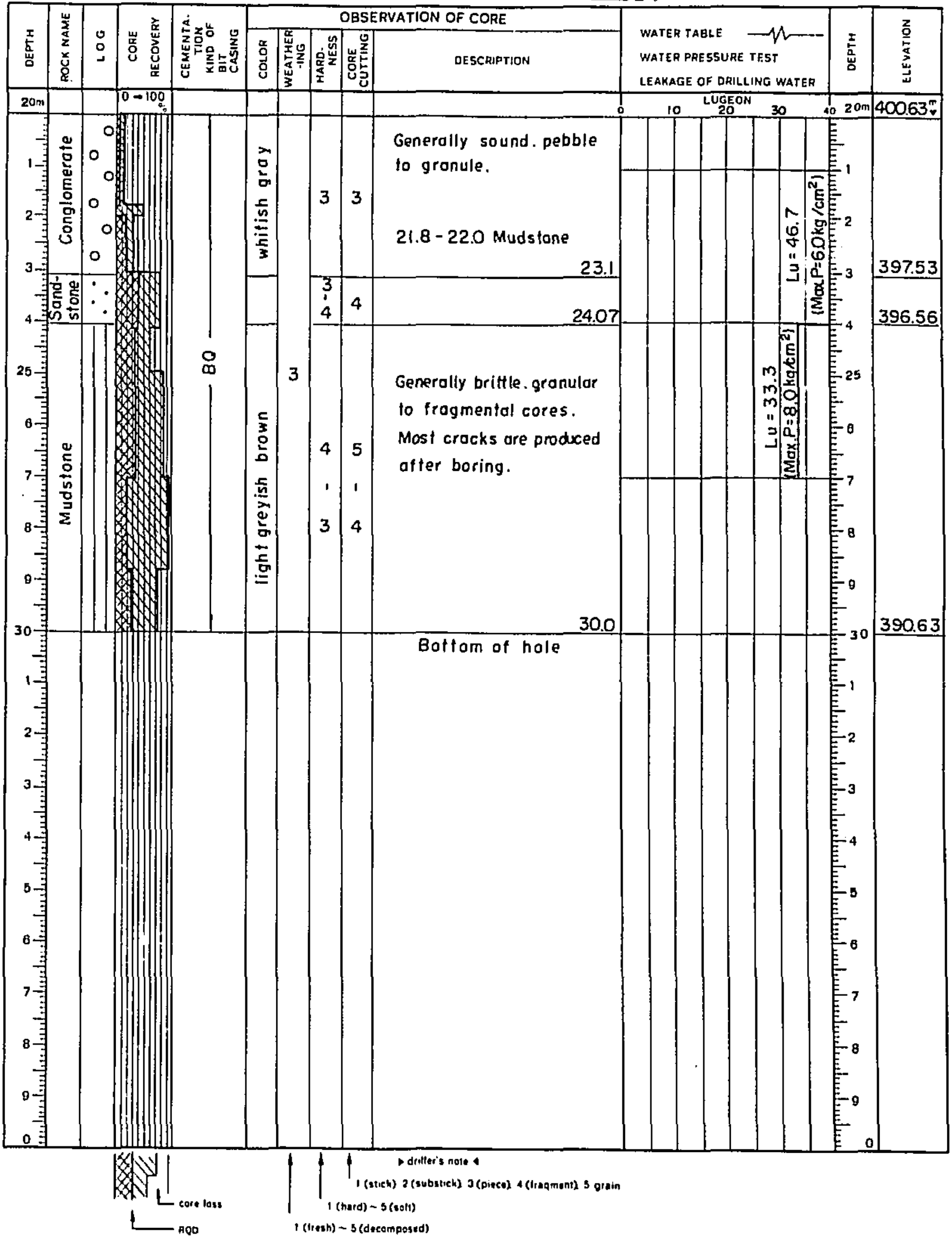
WATER TABLE; WATER PRESSURE TEST; LEAKAGE OF DRILLING WATER

GEOLOGIC LOG OF DRILL HOLE

Sheet. No. 13

GUAYABO PROJECT — HOLE No. DB-9 (SHEET 2 OF 2)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	30.00 m	COMMENCED	18 -Jun.- '75
ELEVATION	420.63 m	DEPTH OF OVERBURDEN	13.85 m	COMPLETED	27 -Jun.- '75
COORDINATE		LENGTH OF ROCK DRILLING	16.15 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		



GEOLOGIC LOG OF DRILL HOLE

Sheet No. 14

GUAYABO PROJECT — HOLE No. DB-10 (SHEET 1 OF 9)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	163.25 m	COMMENCED	19 - Jun.- '75
ELEVATION	410.98 m	DEPTH OF OVERBURDEN	17.25 m	COMPLETED	10 - Sep.- '75
COORDINATE		LENGTH OF ROCK DRILLING	146.00 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	42°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE	S72°E	CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40)	DEPTH	ELEVATION
0m – 15.0	Mud flow deposit.	◇		NX, NX.C.P (to 10); NB					Mainly consists of hard andesitic fragments ø 10-20cm, matrix no-core.		0m	410.98 m
15.0 – 17.25	Mud flow deposit.	◇		NB					15.0 No core			
17.25 – 20	Mudstone				light brownish gray	3 - 2	3	4 / 3	17.25 18.0 Low grade of solidification, but somewhat good condition.	Lu = 32.6 (Max.P=10.0kg/cm²)	17 / 20	399.44 / 397.60

▸ driller's note 4

1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

1 (hard) ~ 5 (soft)

1 (fresh) ~ 5 (decomposed)

core loss

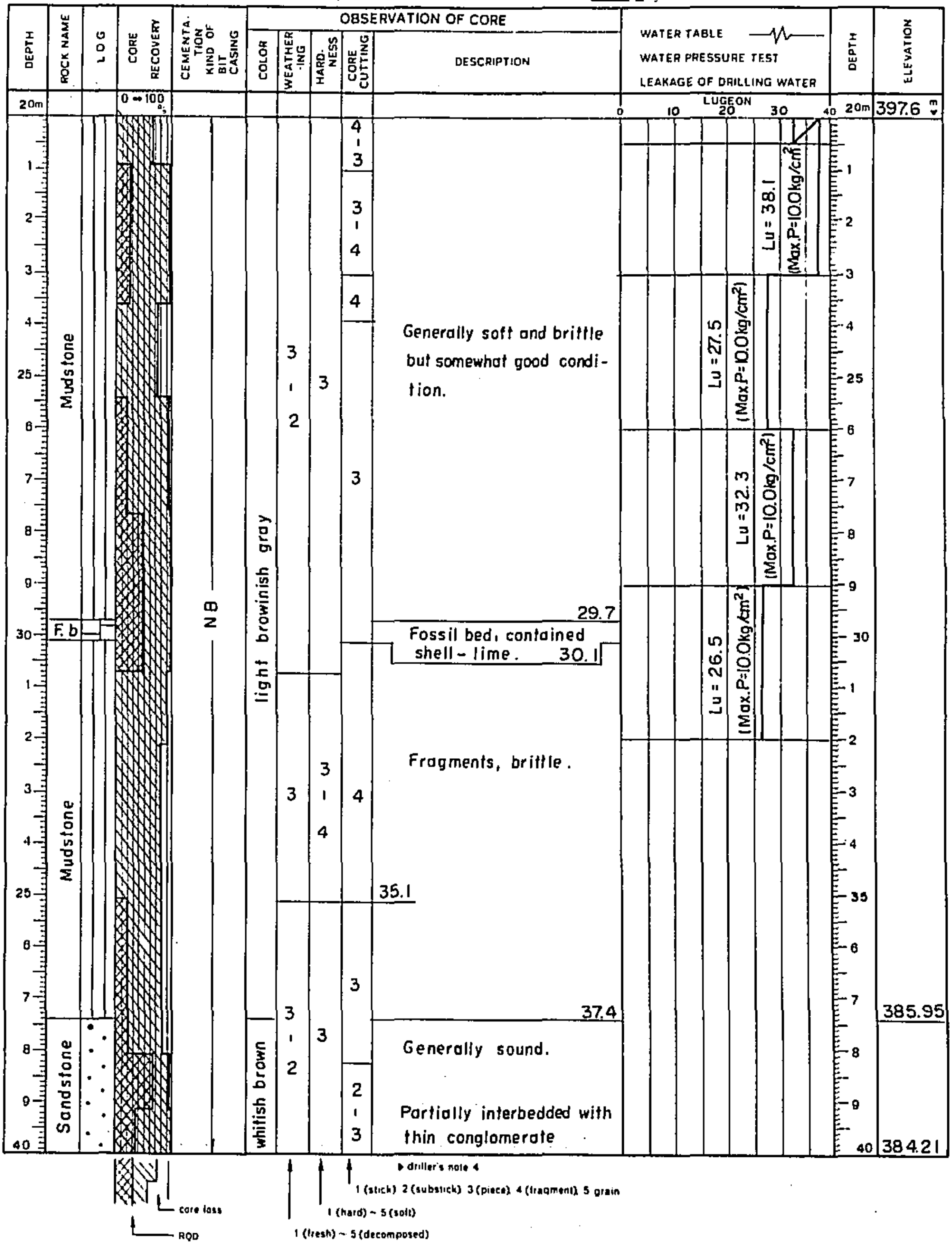
RQD

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 15

GUAYABO PROJECT — HOLE No. DB-10 (SHEET 2 OF 9)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	163.25 m	COMMENCED	19 Jun. '75
ELEVATION	410.98 m	DEPTH OF OVERBURDEN	17.25 m	COMPLETED	10 Sep. '75
COORDINATE		LENGTH OF ROCK DRILLING	146.00 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	42°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE	S 72°E	CORE RECOVERY	%		

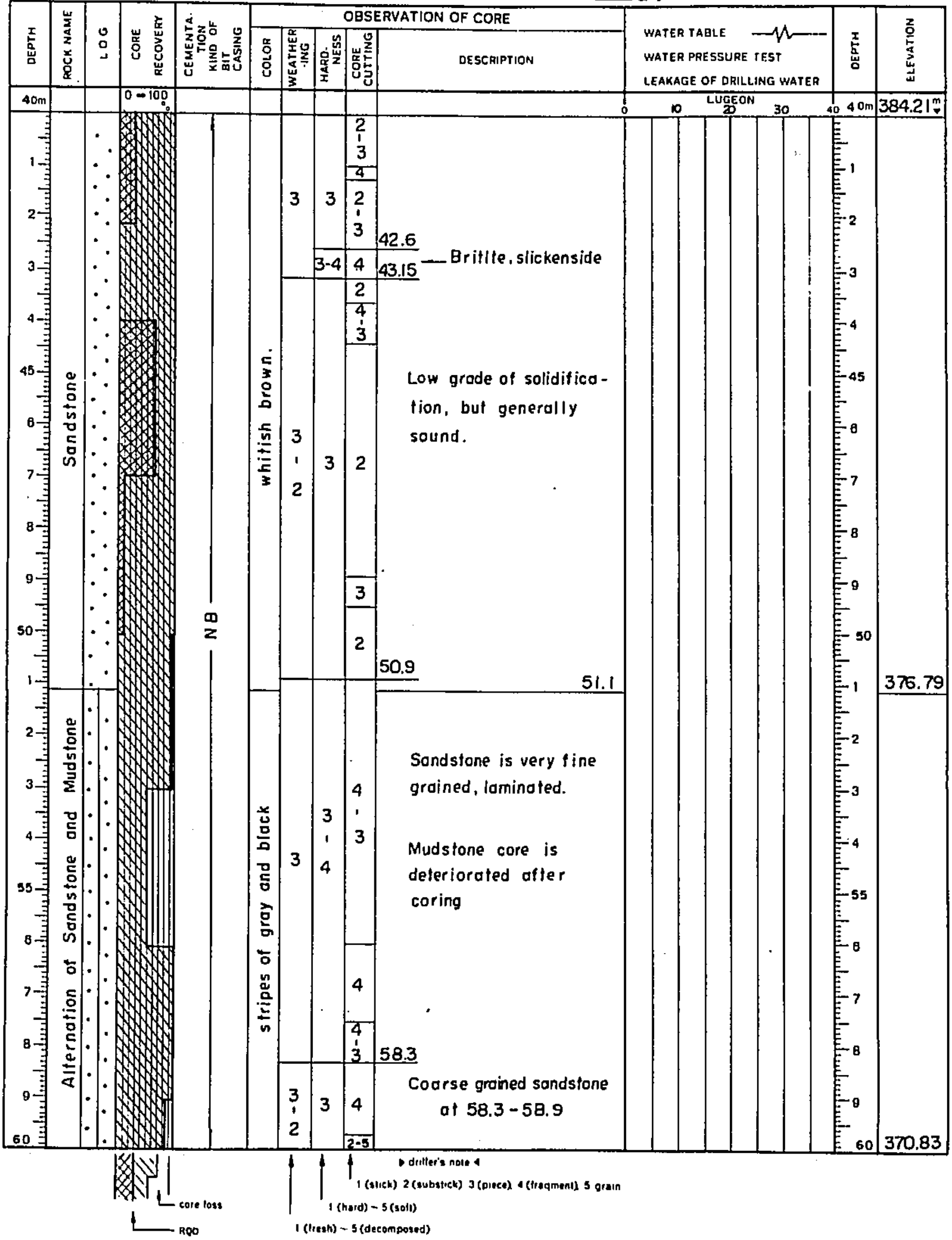


GEOLOGIC LOG OF DRILL HOLE

Sheet No. 16

GUAYABO PROJECT — HOLE No. DB-10 (SHEET 3 OF 9)

LOCATION	Left. Bank, Damsite	DEPTH OF HOLE	163.25 m	COMMENCED	19 Jun. '75
ELEVATION	410.98 m	DEPTH OF OVERBURDEN	17.25 m	COMPLETED	10 Sep. '75
COORDINATE		LENGTH OF ROCK DRILLING	146.00 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	42°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE	S72°E	CORE RECOVERY	%		

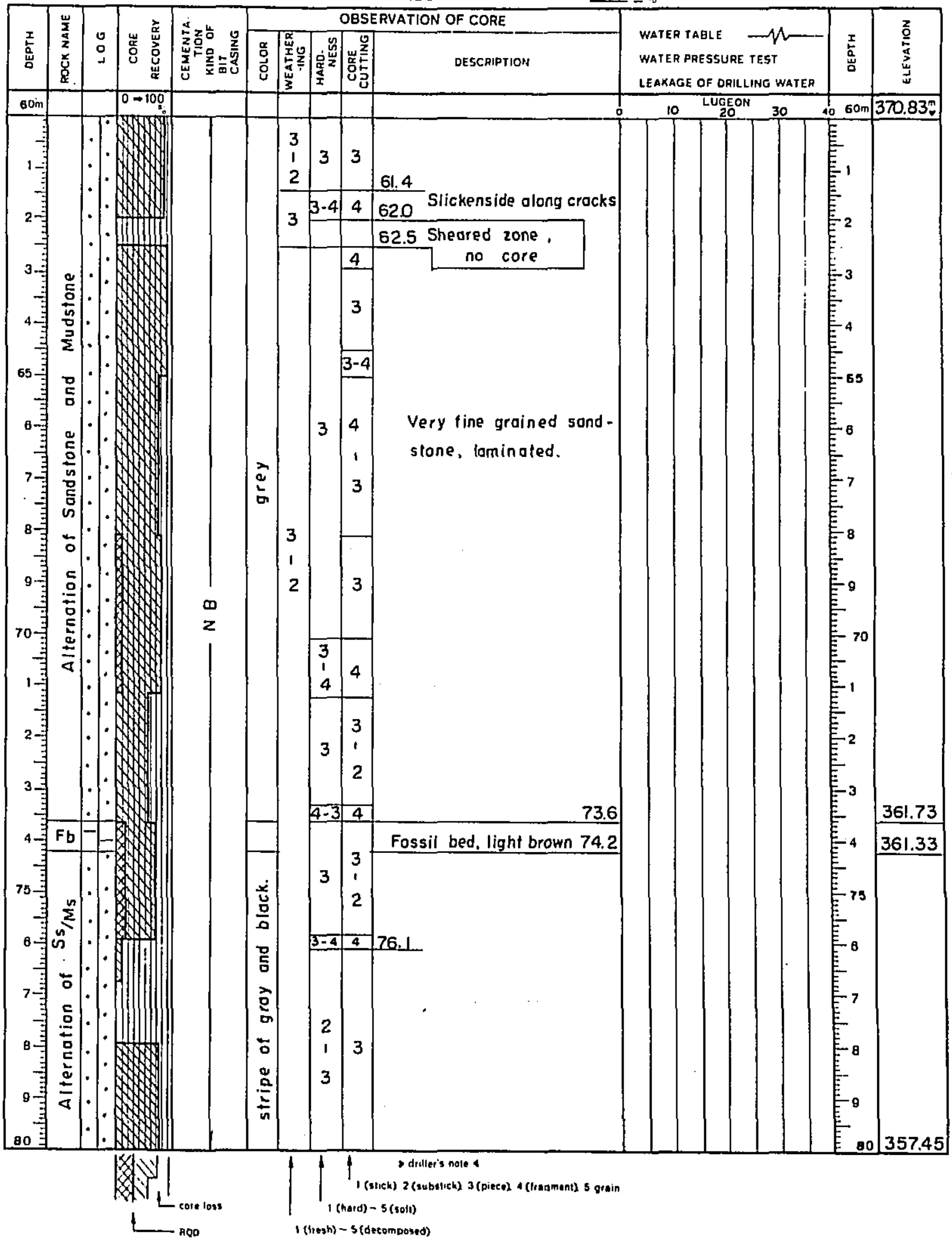


GEOLOGIC LOG OF DRILL HOLE

Sheet No. 17

GUAYABO PROJECT — HOLE No. DB-10 (SHEET 4 OF 9)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	163.25 m	COMMENCED	19 -Jun.- '75
ELEVATION	410.98 m	DEPTH OF OVERBURDEN	17.25 m	COMPLETED	10 -Sep.- '75
COORDINATE		LENGTH OF ROCK DRILLING	146.00 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	42°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE	S72°E	CORE RECOVERY	%		

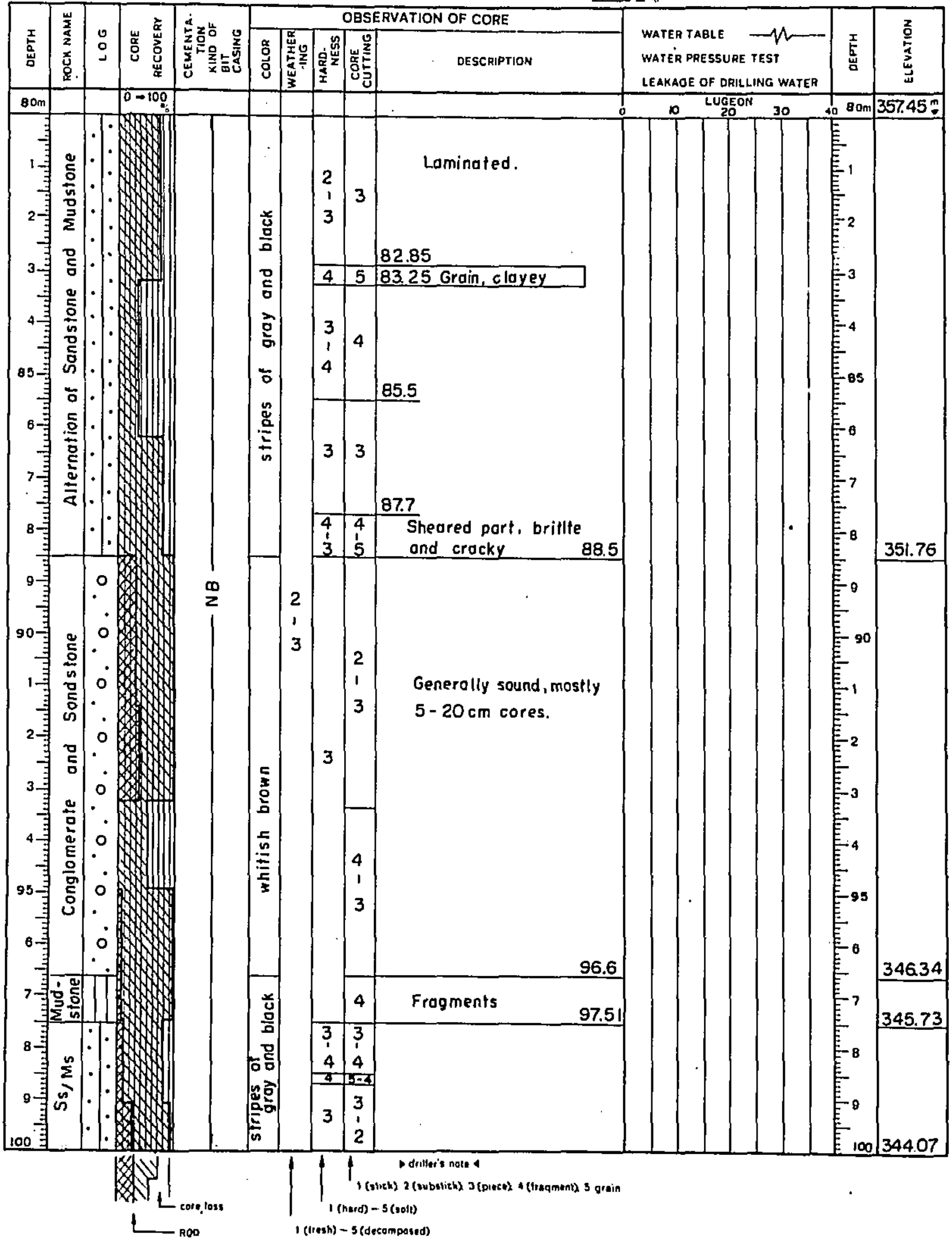


GEOLOGIC LOG OF DRILL HOLE

Sheet No. 18

GUAYABO PROJECT — HOLE No. DB-10 (SHEET 5 OF 9)

LOCATION	Left Bank Damsite	DEPTH OF HOLE	163.25 m	COMMENCED	19 - Jun. - '75
ELEVATION	410.95 m	DEPTH OF OVERBURDEN	17.25 m	COMPLETED	10 - Sep. - '75
COORDINATE		LENGTH OF ROCK DRILLING	146.00 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	42°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE	S72°E	CORE RECOVERY	%		



GEOLOGIC LOG OF DRILL HOLE

Sheet No. 19

GUAYABO PROJECT — HOLE No. DB-10 (SHEET 6 OF 9)

LOCATION: Left Bank, Damsite	DEPTH OF HOLE: 163.25 m	COMMENCED: 19 - Jun. - '75	
ELEVATION: 410.98 m	DEPTH OF OVERBURDEN: 17.25 m	COMPLETED: 10 - Sep. - '75	
COORDINATE:	LENGTH OF ROCK DRILLING: 146.00 m	DRILLED BY: I. C. E	
ANGLE FROM HOLIZONTAL: 42°	TOTAL LENGTH OF CORE: m	LOGGED BY:	
BEARING OF ANGLE HOLE: S 72° E	CORE RECOVERY: %		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40)	DEPTH	ELEVATION
100 m – 102.9	Alternation Ss/Ms			NB	stripes of gray and black	2	3	3-2; 3-4	Very fine grained sandstone, laminated. 102.9		0 m	344.07 / 342.13
102.9 – 106.5	Conglomerate			NB	gray	1-3; 3	3-4; 3	4; 3-2	Pebble conglomerate. 106.5			339.72
106.5 – 116.8	Alternation of Sandstone and Mudstone			NB	stripes of gray and black	2	3-1-2	2-1; 3-4; 2-1; 4; 2-1	Generally sound, somewhat hard, mostly 15 - 40cm cores. 116.8			332.83
116.8 – 119.3	Fossil bed			NB	light gray		4; 3-2	2-3; 5-4; 2-3	Containing shell-lime. 118.1; 118.7 Sheared zone. 119.3			331.5
119.3 – 120	Cgl			NB	light gray	3	4-5	4-5	Sheared zone, granular or fragmental cores.		120	330.68

▸ driller's note 4

Core cutting: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

Hardness: 1 (hard) ~ 5 (soft)

Weathering: 1 (fresh) ~ 5 (decomposed)

Core recovery: core loss; RQD

GEOLOGIC LOG OF DRILL HOLE

Sheet. No. 20

GUAYABO PROJECT — HOLE No. DB-10 (SHEET 7 OF 9)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	163.25 m	COMMENCED	19 - Jun. - '75
ELEVATION	410.98 m	DEPTH OF OVERBURDEN	17.25 m	COMPLETED	10 - Sep. - '75
COORDINATE		LENGTH OF ROCK DRILLING	146.00 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	42°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE	S72°E	CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
120m											120m	330.68 m
120.4						3	4-5	4-5	Sheared zone 120.4			330.42
120.4–125.85	Conglomerate			NB	light gray		3		Somewhat brittle, Gravel consist of mudstone, sandstone and a little shell-lime 125.85			326.77
125.85–140	Alternation of Sandstone and Mudstone			NB	stripes of gray and black	2	3 - 2	2 - 3	Generally sound. Sandstone is very fine grain, laminated.			
~133.4–135							3	4 - 3				
~135–137.6							3 - 2	2 - 3				
~137.6–137.9							3	4				
~137.9–138.8							3 - 2	2 - 3				
~138.8–139.2							3	4-3				
~139.2–140							3-2	2-3				
140											140	317.30

▸ driller's note 4

Core cutting: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

Hardness: 1 (hard) ~ 5 (soft)

Weathering: 1 (fresh) ~ 5 (decomposed)

core loss

RQD

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 21

GUAYABO PROJECT HOLE No. DB-10 (SHEET 8 OF 9)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	163.25 m	COMMENCED	19 -Jun.-'75
ELEVATION	410.98 m	DEPTH OF OVERBURDEN	17.25 m	COMPLETED	10 -Sep.-'75
COORDINATE		LENGTH OF ROCK DRILLING	146.00 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	42 °	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE	S72°E	CORE RECOVERY	%		

Columns: DEPTH | ROCK NAME | LOG | CORE RECOVERY (0 → 100 %) | CEMENTATION KIND OF BIT CASING | OBSERVATION OF CORE: COLOR, WEATHERING, HARDNESS, CORE CUTTING, DESCRIPTION | WATER TABLE, WATER PRESSURE TEST, LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40) | DEPTH | ELEVATION

Depth: 140 m – 160 m; Elevation: 317.3 – 303.92

Rock name: Alternation of Sandstone and Mudstone

Kind of bit: NB

Color: stripes of grey and black.

Weathering: 2

Depth (m)	Hardness	Core cutting	Description
140.5–141.85	3–2	2–3	141.85
141.85–142.1	2–3	3	142.1
~142.1–142.6	3-2	2-3	
~142.6–143.2	3	4	
~143.2–145.2	2–3	3	Somewhat hard, generally sound.
~145.2–147.0		2	Sandstone is very fine grain, laminated
~147.0–150.6	2–3	1–3	
~150.6	3-4	4	Partially clayey
~150.7–151.2	3	3-4	
~151.2–152.6	2–3	1–3	
~152.6	3-4	4	
~152.7–153.0	2-3	1-3	
~153.0–153.5	3	3	
~153.5–154.0		4-3	
~154.0–160	3	3–2	

Legend: Core recovery: core loss; RQD. Weathering: 1 (fresh) ~ 5 (decomposed). Hardness: 1 (hard) ~ 5 (soft). Core cutting: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; ▶ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 22

GUAYABO PROJECT — HOLE No. DB-10 (SHEET 9 OF 9)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	163.25 m	COMMENCED	19 -Jun.- '75
ELEVATION	410.98 m	DEPTH OF OVERBURDEN	17.25 m	COMPLETED	10 -Sep.- '75
COORDINATE		LENGTH OF ROCK DRILLING	146.00 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	42°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE	S72°E	CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 ~ 100 %)	CEMENTATION, KIND OF BIT, CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
160m											160m	303.92 m
160–163.25	Alternation Ms/Ss			NB	stripes of grey and black	2	3	3 – 1 – 2	Somewhat brittle, but generally sound.			
163.25									163.25 Bottom of hole		3	301.74

core loss; RQD

1 (fresh) ~ 5 (decomposed)

1 (hard) ~ 5 (soft)

1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

▶ driller's note ◀

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 23

GUAYABO PROJECT — HOLE No. HB-1 (SHEET 1 OF 9)

LOCATION: Headrace Tunnel	DEPTH OF HOLE: 180 m	COMMENCED: - -	
ELEVATION: ____ m	DEPTH OF OVERBURDEN: 37.65 m	COMPLETED: - -	
COORDINATE: ____	LENGTH OF ROCK DRILLING: 142.35 m	DRILLED BY: I. C. E	
ANGLE FROM HOLIZONTAL: 90°	TOTAL LENGTH OF CORE: ____ m	LOGGED BY: ____	
BEARING OF ANGLE HOLE: ____	CORE RECOVERY: ____ %		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION (OBSERVATION OF CORE)	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40)	DEPTH	ELEVATION
0m – 5.0									No core		0m – 5	
5.0 – 20	Agglomerate								Low grade of solidification, mainly andesitic fragments(Ø 1 - 3 cm), matrix no core.		5 – 20	
15.85 – 17.05									15.85 Greyish brown, silt and clay. 17.05			

core loss

RQD

1 (fresh) ~ 5 (decomposed)

1 (hard) ~ 5 (soft)

1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

▸ driller's note ◂

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 24

GUAYABO PROJECT — HOLE No. HB-1 (SHEET 2 OF 9)

LOCATION	Headrace Tunnel	DEPTH OF HOLE	180 m	COMMENCED	- -
ELEVATION	m	DEPTH OF OVERBURDEN	37.65 m	COMPLETED	- -
COORDINATE		LENGTH OF ROCK DRILLING	142.35 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (m)	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION (m)
20 – 37.65	Agglomerate								23.0 Low grade of solidification, mainly andesitic fragments (ø 5 - 10cm), matrix no core. 37.65			
37.65 – 40	Mudstone				light brownish gray	4 - 3	4	3	Mostly soft and brittle. Core is decomposed after lifted.			

Legend: RQD; core loss; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain; • driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 25

GUAYABO PROJECT — HOLE No. HB-1 (SHEET 3 OF 9)

LOCATION	Head race Tunnel	DEPTH OF HOLE	180 m	COMMENCED	- -
ELEVATION	m	DEPTH OF OVERBURDEN	37.65 m	COMPLETED	- -
COORDINATE		LENGTH OF ROCK DRILLING	142.35 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION, KIND OF BIT, CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40)	DEPTH	ELEVATION (m)
40m – 56.45	Mudstone				light brownish gray	4-3 / 3	4 / 3 ' 4	3 / 3	40.3 Poorly solidified, generally soft and brittle, bearing minute fossil fragments. Core is decomposed after drilling. 56.45		40m	
56.45 – 59.45									No core 59.45			
59.45 – 60	Ms					3	3-4	4	Light brownish gray mudstone		60	

▶ driller's note ◀

Core cutting: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

Hardness: 1 (hard) ~ 5 (soft)

Weathering: 1 (fresh) ~ 5 (decomposed)

core loss

RQD

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 26

GUAYABO PROJECT — HOLE No. HB-1 (SHEET 4 OF 9)

LOCATION	Headrace Tunnel	DEPTH OF HOLE	180 m	COMMENCED	- -
ELEVATION	m	DEPTH OF OVERBURDEN	37.65 m	COMPLETED	- -
COORDINATE		LENGTH OF ROCK DRILLING	142.35 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
60m–62.3	Mudstone				light brownish gray			4	Fragments, poorly recovered.		60m	43
62.3–80					gray	3	3 ~ 4	3	Poorly solidified, generally soft and brittle. Core is decomposed after drilling.		80	

Legend: core loss; RQD; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; a driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 27

GUAYABO PROJECT — HOLE No. HB-1 (SHEET 5 OF 9)

LOCATION: Headrace Tunnel	DEPTH OF HOLE: 180 m	COMMENCED: - -
ELEVATION: m	DEPTH OF OVERBURDEN: 37.65 m	COMPLETED: - -
COORDINATE:	LENGTH OF ROCK DRILLING: 142.35 m	DRILLED BY: I. C. E
ANGLE FROM HOLIZONTAL: 90°	TOTAL LENGTH OF CORE: m	LOGGED BY:
BEARING OF ANGLE HOLE:	CORE RECOVERY: %	

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION, KIND OF BIT, CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40)	DEPTH	ELEVATION (m)
80m–80.7	Mudstone				gray	3	3-4	3	80.7		80m	
80.7–98.5	Mudstone				gray	3-2	3	3-2	Poorly solidified, generally brittle, easily breakable to fragment. Mostly bearing minute fossil fragments.			
98.5–100	Mudstone				gray	3-2	3-4	4	98.5		100	

core loss

RQD

1 (fresh) ~ 5 (decomposed)

1 (hard) ~ 5 (soft)

1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 28

GUAYABO PROJECT — HOLE No. HB-1 (SHEET 6 OF 9)

LOCATION: Headrace Tunnel	DEPTH OF HOLE: 180 m	COMMENCED: - -	
ELEVATION: m	DEPTH OF OVERBURDEN: 37.65 m	COMPLETED: - -	
COORDINATE:	LENGTH OF ROCK DRILLING: 142.35 m	DRILLED BY: I.C.E	
ANGLE FROM HOLIZONTAL: 90°	TOTAL LENGTH OF CORE: m	LOGGED BY:	
BEARING OF ANGLE HOLE:	CORE RECOVERY: %		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION, KIND OF BIT, CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40)	DEPTH	ELEVATION
100m – 114.4	Mudstone				gray	3 | 2	3 | 4	4	Poorly solidified. brittle, Mostly flaky cores. Surface of core is decomposed after boring.		100m	m
114.4 – 120	Mudstone				gray		3	2	Poorly solidified, but generally sound. Surface of core is decomposed after boring.		120	

Legend:
- core loss
- RQD
- 1 (fresh) ~ 5 (decomposed)
- 1 (hard) ~ 5 (soft)
- 1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain
- ▶ driller's note ◀

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 29

GUAYABO PROJECT — HOLE No. HB-1 (SHEET 7 OF 9)

LOCATION	Headrace Tunnel	DEPTH OF HOLE	180 m	COMMENCED	- -
ELEVATION	m	DEPTH OF OVERBURDEN	37.65 m	COMPLETED	- -
COORDINATE		LENGTH OF ROCK DRILLING	142.35 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (m)	ROCK NAME	LOG	CORE RECOVERY (0→100%)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION (m)
120–127.9	Mudstone				gray	3 ~ 2	3	2	Poorly solidified, generally brittle, mostly 15 cm cores. Surface of core is decomposed.			
127.9–132.85	Mudstone				gray	3 ~ 2	3 ~ 4	4	Soft and brittle, flaky cores.			
132.85–137.85	Mudstone				gray		3	4	Brittle, flaky cores.			
137.85–140	Mudstone				gray		4	4	Unconsolided, soft, easily breakable to grain by hand.			

core loss; RQD

▶ driller's note 4

1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain

1 (hard) ~ 5 (soft)

1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 30

GUAYABO PROJECT — HOLE No. HB-1 (SHEET 8 OF 9)

LOCATION	Headrace Tunnel	DEPTH OF HOLE	180 m	COMMENCED	- -
ELEVATION	m	DEPTH OF OVERBURDEN	37.65 m	COMPLETED	- -
COORDINATE		LENGTH OF ROCK DRILLING	142.35 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (m)	ROCK NAME	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION
140 – 141.1	Mudstone	gray	3 - 2	4	4	141.1
141.1 – 142.85	Sandstone	whitish brown	3	4	4 - 5	Very brittle, granular or fragmental cores. 142.85
142.85 – 160	Mudstone	gray	3 - 2	3	3	Poorly solidified, mostly 1-10cm cores. Surface of core is decomposed.

Column headings: DEPTH; ROCK NAME; LOG; CORE RECOVERY (0 → 100 %); CEMENTATION, KIND OF BIT, CASING; OBSERVATION OF CORE: COLOR, WEATHERING, HARDNESS, CORE CUTTING, DESCRIPTION; WATER TABLE; WATER PRESSURE TEST; LEAKAGE OF DRILLING WATER (LUGEON 0, 10, 20, 30, 40); DEPTH; ELEVATION (m)

Legend:
- core loss
- RQD
- WEATHERING: 1 (fresh) ~ 5 (decomposed)
- HARDNESS: 1 (hard) ~ 5 (soft)
- CORE CUTTING: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain
- ▶ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 31

GUAYABO PROJECT — HOLE No. HB-1 (SHEET 9 OF 9)

LOCATION	Headrace Tunnel	DEPTH OF HOLE	180 m	COMMENCED	- -
ELEVATION	m	DEPTH OF OVERBURDEN	37.65 m	COMPLETED	- -
COORDINATE		LENGTH OF ROCK DRILLING	142.35 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40)	DEPTH	ELEVATION
160m – 169.9	Mudstone				gray	3 / 1	3	2 / 1	Poorly solidified, brittle, mosty 5-25cm cores, generally bearing minute fossil fragments. Surface of core is decomposed. 169.9		160m	43
169.9 – 170.8	Cg l	o o				2		3	Whitish brown, granule conglomerate 170.8		170	
170.8 – 180	Mudstone				gray				Same condition as 160 - 169.0 m.		180	

Legend: core loss; RQD; WEATHERING: 1 (fresh) ~ 5 (decomposed); HARDNESS: 1 (hard) ~ 5 (soft); CORE CUTTING: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; ▶ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 32

GUAYABO PROJECT — HOLE No. SB-I (SHEET I OF 6)

LOCATION	Surge Tank	DEPTH OF HOLE	116.50 m
ELEVATION	456.64 m	DEPTH OF OVERBURDEN	11.60 m
COORDINATE		LENGTH OF ROCK DRILLING	104.90 m
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m
BEARING OF ANGLE HOLE		CORE RECOVERY	%
COMMENCED	14-Dec.-'74	COMPLETED	16-Jan.-'75
DRILLED BY	I.C.E	LOGGED BY	

DEPTH (m)	ROCK NAME	LOG	CORE RECOVERY (0→100%)	CEMENTATION / KIND OF BIT / CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION (m)
0											0m	456.64
0–1.0	Topsoil	△		NB, C.P					Reddish brown. 1.0		1	455.64
1.0–11.6	Residual soil	△		NB, C.P	yellowish gray	4	5-3	5-3	Strongly weathered, very soft, granular or fragmental cores. 11.6			445.04
11.6–17.6	Sandstone			NB, C.P	yellowish gray	3-4	3-4	3-4	Poorly solidified, fine grained tuffaceous sandstone, mostly bearing minute fossil fragments, strongly weathered, very brittle.			
17.6								4	17.6			
17.6–18.5						3	3	3	18.5			
18.5–19.35						4-3	4-3	4	19.35			
19.35–20						3	3				20	436.64

▸ driller's note 4

1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

1 (hard) ~ 5 (soft)

1 (fresh) ~ 5 (decomposed)

core loss

RQD

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 33

GUAYABO PROJECT — HOLE No. SB-1 (SHEET 2 OF 6)

LOCATION	Surge Tank	DEPTH OF HOLE	116.50 m	COMMENCED	14 Dec. '74
ELEVATION	456.64 m	DEPTH OF OVERBURDEN	11.60 m	COMPLETED	16 Jan. '75
COORDINATE		LENGTH OF ROCK DRILLING	104.90 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (m)	ROCK NAME	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	ELEVATION (m)
20 – 24.5	Sandstone	greenish gray			3; 4; 2-3	Brittle, stained cracks. 24.5	20.45 Ground water level	436.64; 436.19; 432.14
24.5 – 25.4	Cgl	gray			4	Granule conglomerate 25.4		431.24
25.4 – 30.0	Sandstone	greenish gray	3	3	2; 4; 2	Somewhat brittle, mostly 15cm cores. 30.0		426.64
30.0 – 30.85	Cgl	gray				Granule conglomerate. 30.85		425.74
30.85 – 40	Sandstone	whitish green.	3-4; 3; 3-4; 3; 4-3	3-4; 3; 3-4; 3; 4-3	3; 4; 3-4; 4; 3-4; 4	31.5 Very fine grained sandstone. 32.9 / 33.7 Poorly solidified, generally tuffaceous, contained of microfossils and minute fossil fragments. — Clayey — Partially clayey.		422.94; 416.64

Kind of bit / casing: NB

Core recovery 0 → 100 %; core loss; RQD

Weathering: 1 (fresh) ~ 5 (decomposed)

Hardness: 1 (hard) ~ 5 (soft)

Core cutting: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; ▸ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 34

GUAYABO PROJECT — HOLE No. SB-1 (SHEET 3 OF 6)

LOCATION	Surge Tank	DEPTH OF HOLE	116.50 m	COMMENCED	14-Dec.-'74
ELEVATION	456.64 m	DEPTH OF OVERBURDEN	11.60 m	COMPLETED	16-Jan.-'75
COORDINATE		LENGTH OF ROCK DRILLING	104.90 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

Depth: 40m – 60m; Elevation: 416.64 m (40m), 411.64 (45), 408.74, 396.64 (60)

Rock name: Sandstone; Core recovery: 0 → 100 %; Kind of bit: NB; Color: greenish gray

Water table / Water pressure test / Leakage of drilling water: Lugeon 0 – 10 – 20 – 30 – 40

OBSERVATION OF CORE

WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION
4-3	4-3	4	40.2
3	3	4-3	Slightly fractured zone at 30.4 - 48.35, mostly brittle. 42.2
3-4	3-4		45.0
4	4-5	5	Fault breccia clayey. 45.15
3-4	3-4	4-3	Soft and brittle. 47.9
4	4	4-5	48.35 Altered, clayey
3	3	3	
	3-4	4	
	3	2-3	
	3-4	4-3	Poorly solidified, brittle and cracky
	3	2-3	
		3-4	
		4	53.7 - 54.0m Very soft
3-4	3-4	4	
3	3	3-4	
		3-2	

Legend: core loss; RQD; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain; ▸ driller's note ◂

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 35

GUAYABO PROJECT — HOLE No. SB-I (SHEET 4 OF 6)

LOCATION: Surge Tank	DEPTH OF HOLE: 116.50 m	COMMENCED: 14 -Dec.- '74	
ELEVATION: 456.64 m	DEPTH OF OVERBURDEN: 11.60 m	COMPLETED: 16 -Jan.- '75	
COORDINATE:	LENGTH OF ROCK DRILLING: 104.90 m	DRILLED BY: I. C. E	
ANGLE FROM HOLIZONTAL: 90°	TOTAL LENGTH OF CORE: m	LOGGED BY:	
BEARING OF ANGLE HOLE:	CORE RECOVERY: %		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0→100%)	CEMENTATION, KIND OF BIT, CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
60m–63.5	Sandstone			NB	greenish gray	3	3	3-2	Very fine grained, and partially silty, laminated, tuffaceous. 63.5		60m	396.64 m
63.5–66.4								4; 3-2	Generally containing microfossils and minute fossl fragments. 66.4			
66.4–67.25						4	4	4-5	Altered zone, clayey. 67.25			
67.25–69.1						3-2	3-2	3-2	69.1			
69.1–69.35									Altered part, clayey. 69.35			
69.35–78.5				BST		3-2	3-2	3-4	Slightly well solidified, generally sound. Fine grained, laminated, tuffaceous and generally bearing minute fossil fragments. 78.2–78.43 m altered, clayey. 78.5			
78.5–80								3-2			80	376.64

Core recovery: RQD; core loss

Core cutting: driller's note: 1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain

Hardness: 1 (hard) ~ 5 (soft)

Weathering: 1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 36

GUAYABO PROJECT — HOLE No. SB-1 (SHEET 5 OF 6)

LOCATION	Surge Tank	DEPTH OF HOLE	116.50 m	COMMENCED	14 - Dec. - '74
ELEVATION	456.64 m	DEPTH OF OVERBURDEN	11.60 m	COMPLETED	16 - Jan. - '75
COORDINATE		LENGTH OF ROCK DRILLING	104.90 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (m)	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
80 – 86.2	Sandstone			BST	greenish gray	3 - 2	3 - 2	3 - 2	Generally sound. mostly 10-15cm cores. 86.2		80m	376.64 m
86.2 – 86.9	Ms								Gray mudstone 86.9			370.44
86.9 – 87.9	Sand-stone				greenish gray				87.9			368.74
87.9 – 88.35	Ms					3	3-4	4	Gray mudstone 88.35			
88.35 – 100	Sandstone				greenish gray	3 - 2	3 - 2	3 - 2	Medium to coarse grained, tuffaceous and generally contained minute fossil fragments. Cracks are stained with limonite. partially interbedded with thin mudstone. 98.9 - 99.1m Altered, clayey		100	356.64

Legend: RQD; core loss; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; ▸ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 37

GUAYABO PROJECT — HOLE No. SB - I (SHEET 6 OF 6)

LOCATION: Surge Tank	DEPTH OF HOLE: 116.50 m	COMMENCED: 14 -Dec.- '74
ELEVATION: 456.64 m	DEPTH OF OVERBURDEN: 11.60 m	COMPLETED: 16 -Jan.- '75
COORDINATE:	LENGTH OF ROCK DRILLING: 104.90 m	DRILLED BY: I. C. E
ANGLE FROM HOLIZONTAL: 90°	TOTAL LENGTH OF CORE: m	LOGGED BY:
BEARING OF ANGLE HOLE:	CORE RECOVERY: %	

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40)	DEPTH	ELEVATION
100m – 109.5	Sandstone			BST	greenish. gray	3 - 2	3 - 2	2 - 3 / 3 - 4 / 2 - 3	Same condition as 88.35 - 100.0 m 102.7 ~ 102.8 clayey 109.5		100m	356.64 m / 347.14
109.5 – 116.5	Conglomerate			BST	various colores	2 - 3	2 - 3	2	Generally sound, well cemented, hard. 113.0 Tuffaceous granule conglomerate, bearing fossil fragments. 116.5			340.14
116.5 – 120									Bottom of hole		120	

Legend: core loss; RQD; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; ▸ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 38

GUAYABO PROJECT — HOLE No. PHB-1 (SHEET 1 OF 2)

LOCATION	Powerhouse	DEPTH OF HOLE	25.35 m	COMMENCED	6 -Feb.- '75
ELEVATION	m	DEPTH OF OVERBURDEN	5.00 m	COMPLETED	13 -Feb.- '75
COORDINATE		LENGTH OF ROCK DRILLING	20.35 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION / KIND OF BIT / CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40)	DEPTH	ELEVATION
0m – 5.0	River deposit			C.P					Mainly andesitic and basaltic gravel (ø 5-20cm, max. 30cm) 5.0	3.9 Ground water level.	0m	
5.0 – 7.85	Dolerite	⊥		NB	dark gray	3 - 2	3 - 2	3; 4 - 3	Weatherd, slightly brittle, mainly fragmental cores. 7.85			
7.85 – 20	Dolerite	⊥		NB	dark gray	2	2 - 3	3 - 2; 3; 4; 3 - 2; 4 - 3; 3 - 2	Generally fresh and hard, mostly 5-15cm cores.		20	

Legend: core loss; RQD; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain; ▸ driller's note ◂

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 39

GUAYABO PROJECT — HOLE No. PHB-1 (SHEET 2 OF 2)

LOCATION	Powerhouse	DEPTH OF HOLE	25.35 m	COMMENCED	6 -Feb.- '75
ELEVATION	m	DEPTH OF OVERBURDEN	5.00 m	COMPLETED	13 -Feb.- '75
COORDINATE		LENGTH OF ROCK DRILLING	20.35 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90 °	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0 10 20 30 40)	DEPTH	ELEVATION (m)
20m – 25.35	Dolerite			NB	dark gray.	2	2 - 3	3 - 2	Intergranular texture, fresh and hard.		20m – 25	
25.35									25.35 Bottom of hole.			
25.35 – 30 – 40											25.35 – 30 – 40	

core loss
RQD

1 (fresh) ~ 5 (decomposed)
1 (hard) ~ 5 (soft)
1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain
▸ driller's note ◂

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 40

SIQUIRRES. PROJECT — HOLE No. DB-I (SHEET I OF 14)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 -Nov.- '74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 -Feb.- '75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (m)	ROCK NAME	LOG	CORE RECOVERY (0→100%)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	ELEVATION (m)
0 – 1.5	Topsoil	△		NB	brown				light brown.		256
1.5 – 3.0	Topsoil	△		NB	brown				1.5 greyish brown		
3.0 – 5.5	Residual soil	△		NB		4 – 5	4	5 – 4	3.0 Basalt, completly weathered, clayey		253.0
5.5 – 6.4	Basalt	V		NB	dark greyish brown	3 – 2	2	3 – 4	5.5		250.5
6.4 – 7.9	Basalt	V		NB	dark greyish brown	3 – 2	3 – 2	4 – 3	6.4		
7.9 – 13.0	Basalt	V		NB	dark greyish brown	2 – 3	2	3	7.9 Wheatherd basalt lava.		
13.0 – 20	Weathered basalt	◇ V		NB	light greynish brown	4	4	4 – 5	13.0 Autobrecciated lava, strongly weathered, very soft, clayey		243.0
20											236

core loss

RQD

▶ driller's note 4

1 (stick), 2 (substick) 3 (piece), 4 (fragment), 5 grain

1 (hard) ~ 5 (soft)

1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 41

SIQUIRRES. PROJECT — HOLE No. DB - I (SHEET 2 OF 14)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 - Nov. - '74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 - Feb. - '75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (m)	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION, KIND OF BIT, CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	ELEVATION (m)
20 – 24.0	Weathered basalt	◇ V ◇ V		NB	light greyish brown	4	4	5	Autobrecciated lava, strongly weathered, very soft. 24.0		236
24.0 – 25.3	Weathered basalt	V		NB	dark gray	2–3	2	3–1–2	Lava, amygdaloidal, generally hard. 25.3		
25.3 – 25.65	Weathered basalt	V		NB		4	4		25.65		230.35
25.65 – 28.32	Basalt	V V		NB	dark gray	3–4	3	4	Weathered lava, slightly brittle. Many small gas cavities. 28.32		
28.32 – 30.8	Basalt	V V V		NB	dark gray	2	2	3	Fresh, hard. 30.8		
30.8 – 31.65	Basalt	◇		NB	dark gray	3	3–2	4	Autobrecciated lava, fragmental cores. 31.65		
31.65 – 32.55	Basalt	V		NB	dark gray	2	2	2–3	32.55		
32.55 – 35.9	Basalt	◇ V ◇		NB	dark gray	3 / 2–3	3 / 2–3	4 / 2–3	Autobrecciated lava, many small gas cavities, slightly brittle. 35.9		220.1
35.9 – 40	Basalt	V V V V		NB	dark gray	2	2	2–1–1	Lava, fresh, hard and compact, mostly 10- 30 cm cores (max. 35 cm)		216

Legend:
- core loss
- RQD
- ▸ driller's note 4
- Core cutting: 1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain
- Hardness: 1 (hard) ~ 5 (soft)
- Weathering: 1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 42

SIQUIRRES. PROJECT — HOLE No. DB-1 (SHEET 3 OF 14)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 -Nov.- '74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 -Feb.- '75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (40m)	ROCK NAME	LOG	CORE RECOVERY (0→100 %)	CEMENTATION / KIND OF BIT / CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH (40m)	ELEVATION
40–43.7	Basalt	V		NB	dark gray	2	2	2-3 / 3-2 / 4-3	43.7			212.3
43.7–45.67		V			purplish gray	2-3	3-2	4-3	Many small gas cavities partially amygdaloidal, slightly brittle. 45.67			
45.67–47.3		V						3-4	47.3			208.7
47.3–53.2		V			dark gray	2	2	1-2 / 3	Massive lava, fresh and hard. Dip of flow structure is 32 degree. 53.2			202.8
53.2–54.55		◇ / V			purplish gray	2-3	2-3	4-3	Autobrecciated lava, generally sound. 54.55			
54.55–56.45		◇						2	56.45			199.55
56.45–60		V			bluelsh black	2	2	3	Fresh and hard, mostly 5-10cm cores.		60	196

Legend: core loss; RQD; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; * driller's note *

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 43

SIQUIRRES PROJECT — HOLE No. DB - I (SHEET 4 OF 14)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 -Nov.- '74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 -Feb.-'75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (m)	ROCK NAME	LOG	CORE RECOVERY (0→100 %)	CEMENTATION / KIND OF BIT / CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	ELEVATION (m)
60 – 61.0	basalt	V		NB		2		3		196 – 195.0
61.0 – 68.1	basalt	◇ V		NB	purplish gray	2	2	2, 1, 1	Autobrecciated lava, fresh and hard, Mostly small gas cavities (Ø1 - 3mm)	195.0 – 187.9
68.1 – 74.55	basalt	V		NB	dark gray	2	2, 1, 3	3, 1, 4	Massive lava, many gas cavities (Ø1-7mm) generally sound.	187.9 – 181.55
74.55 – 75.9	basalt	◇ V		NB	dark gray	2		2, 1, 1	Autobrecciated lava, fresh and hard.	181.55 – 180.1
75.9 – 80	basalt	V		NB	dark gray	2	2	2, 4, 2	Massive lava.	180.1 – 176

OBSERVATION OF CORE

WATER TABLE; WATER PRESSURE TEST; LEAKAGE OF DRILLING WATER — LUGEON 0 – 40

Legend: core loss; RQD; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; ▸ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

SIQUIRRES. PROJECT — Sheet No. 44

HOLE No. DB - I (SHEET 5 OF 14)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 -Nov.- '74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 -Feb.- '75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0→100%)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION (m)
80m											80m	176
80 – 81.75	Basalt	V		NB	dark gray	2	2	2 / 4	Massive lava, fresh and hard			
81.75 – 85.9	Basalt	V		NB	dark gray	2	2-3	3-2 / 4-3	Mostly many little gas cavities and a few amygdales			
85.9 – 87.8	Basalt	V		NB	dark gray	2	2	3	Massive lava, mostly 5 - 10cm cores.			
87.8 – 89.3	Basalt	V		NB	dark gray	2	2	3-2				
89.3 – 90.6	Basalt	V		NB	dark gray	2	2	3			90.6	165.4
90.6 – 93.4	Basalt	◇ V ◇		NB	dark gray	2	2 / 2-3	3 / 4	Autobrecciated lava, quartz veins produced along cracks.		93.4	162.6
93.4 – 99.5	Basalt	V		NB	purplish grey	2	2	2-3	Massive lava, fresh, hard and compact. slightly weathered along cracks.		99.5	156.5
99.5 – 100	Basalt	◇		NB		2-3	3	4-3	Autobrecciated lava.		100	156

▸ driller's note ◂

Core cutting: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

Hardness: 1 (hard) ~ 5 (soft)

Weathering: 1 (fresh) ~ 5 (decomposed)

Core recovery: core loss; RQD

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 45

SIQUIRRES. PROJECT — HOLE No. DB - I (SHEET 6 OF 14)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 -Nov.-'74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 -Fev.-'75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

Column headings: DEPTH (100m) · ROCK NAME · LOG · CORE RECOVERY (0 → 100 %) · CEMENTATION, KIND OF BIT, CASING · OBSERVATION OF CORE: COLOR, WEATHERING, HARDNESS, CORE CUTTING, DESCRIPTION · WATER TABLE, WATER PRESSURE TEST, LEAKAGE OF DRILLING WATER (LUGEON 0–40) · DEPTH · ELEVATION (m)

Rock name: Basalt (100–120 m). Kind of bit: NB. Elevation at 100 m: 156.

Depth (m)	Color	Weathering	Hardness	Core cutting	Description	Elevation (m)
100–101.2	purplish gray	2-3	3	4-3	Autobrecciated lava, slightly brittle	154.8
101.2–107.0	purplish gray	2	2; 2-3; 2; 2-3; 2	2; 4; 2; 4; 2	Lava, mostly hard, generally produced many small gas cavities. Partially cracky. ← Slickenside	149.0
107.0–109.0	purplish gray	2-3	3-2	4; 2	Autobrecciated lava, slightly brittle.	147.0
109.0–116.8	dark gray	2	2-1; 2; 2-1; 2	1; 2-3; 2-1; 3-4	Lava, fresh, hard and compact. 111.1 - 114.0 m, Mostly produced many small gas cavities (Ø 2-10mm) and a few amygdales.	139.2
116.8–119.1	purplish gray	2	2-1	2; 4	Slightly autobrecciated lava, hard.	
119.1–120		2-1	2	2	Autobrecciated lava.	136

Legend: core loss; RQD; ▸ driller's note ◂; Core cutting: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; Hardness: 1 (hard) ~ 5 (soft); Weathering: 1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

SIQUIRRES. PROJECT HOLE No. DB-1 (SHEET 7 OF 14) Sheet No. 46

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 -Nov.- '74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 -Feb.- '75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION (m)
120m											120m	136
120.0–120.4	Basalt	◇		NB			2	2	120.4			135.6
120.4–132.2	Basalt	V		NB	dark gray	2–1	2–1	2–1, 3	Massive lava, fresh, compact and hard, mostly 10-40 cm cores. A few gas cavities produced at 121.5-123.8 m			
132.2									132.2			123.8
132.2–137.1	Basalt	◇, V		NB	purplish gray	2	2	2, 3, 2	Autobrecciated lava, fresh and hard. Generally produced many small gas cavities(Ø2~4mm) and a few amygdales.			
137.1									137.1			118.9
137.1–140	Basalt	V		NB	bluish black	2–1	2–1	2	Massive lava.			
140											140	116

Legend:
- core loss
- RQD
- 1 (fresh) ~ 5 (decomposed)
- 1 (hard) ~ 5 (soft)
- 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain
- ▶ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 47

SIQUIRRES . PROJECT HOLE No. DB - I (SHEET 8 OF 14)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 -Nov.-'74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 -Feb.-'75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I. C.E
ANGLE FROM HOLIZONTAL	90 °	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
140m – 146.25	Basalt	V		NB	bluish black	2–1	2–1	2	Massive lava, fresh, hard and compact. Fragmental cores at 144.2 - 144.32m		140m	116
146.25 – 147.15	Basalt	◇		NB	bluish black			2–1	Purplish autobrecciated lava, amygdaloidal		146.25	109.75
147.15 – 152.2	Basalt	V		NB	bluish black	2	2	1, 3-4, 2-1, 4	Lava, fresh and hard. Partially produced small gas cavities (Ø max. 2 cm)		147.15	108.85
152.2 – 153.6	Basalt	◇, V		NB	bluish black			2–1	Purplish autobrecciated lava.		152.2	103.8
153.6 – 155.25	Basalt	V		NB	bluish black						153.6	102.4
155.25 – 159.0	Basalt	V		NB	bluish black	2–1	2–1	2	Massive lava, fresh and hard,	156.0 (water table)	155.25 / 156	100.0
159.0 – 160	Basalt	◇		NB	bluish black				Autobrecciated lava.		159.0	97.0
160											160	96

driller's note 4

Core cutting: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

Hardness: 1 (hard) ~ 5 (soft)

Weathering: 1 (fresh) ~ 5 (decomposed)

Core recovery: core loss; RQD

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 48

SIQUIRRES. PROJECT — HOLE No. DB - 1 (SHEET 9 OF 14)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 - Nov. - '74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 - Feb. - '75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
160m – 161.4	Basalt	◇ V		N B	bluish black	2-1 / 2	2-1 / 2	2 / 4-3	Autobrecciated lava.		160m – 161.4	96 – 94.6
161.4 – 165.8		V V V V V					2-1	2-1	Massive lava, fresh, hard and compact. Partially produced a few small gas cavities.		161.4 – 165.8	
165.8 – 166.9		V					2	2			165.8 – 166.9	89.1
166.9 – 172.7		◇ V ◇ V ◇ V				2-1	2	1	Autobrecciated lava, fresh and hard.		166.9 – 172.7	83.3
172.7 – 180		V V V V V V V V					2-1	1-2	Massive lava, fresh, hard and compact		172.7 – 180	76

Legend: core loss; RQD; ▸ driller's note ◂; Core cutting: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; Hardness: 1 (hard) ~ 5 (soft); Weathering: 1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 49

SIQUIRRES. PROJECT HOLE No. DB - I (SHEET 10 OF 14)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 - Nov. - '74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 - Feb. - '75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION (m)
180 m – 185.6	Basalt	V		NB	bluish black	2 – 1 – 1	2 – 1 – 1	2	Massive lava.		180 m	76
185.6 – 186.4		◇					2	2	Autobrecciated lava			70.4
186.4 – 187.7		V							← Many little gas cavities (Ø 1 - 2mm)			
187.7 – 190.65		◇ V ◇					2 – 1 – 1		Autobrecciated lava			
190.65 – 193.0		V					2	2 – 1 – 1	Lava, generally produced many gas cavities (Ø 1 - 10mm)			65.35
193.0 – 194.7		◇ V					2	2	Autobrecciated lava, hard.			63.0
194.7 – 196.7		V			greyish black		1 – 1	1 – 3	Lava, hard			61.3
196.7 – 196.93		V				2	4 - 3	4	Soft, clayey.			59.3
196.93 – 200		V			bluish black	2 – 1 – 1	2 – 1 – 1	2 – 1 – 1	Lava, fresh, hard and compact.		200	56

core loss

RQD

1 (fresh) ~ 5 (decomposed)

1 (hard) ~ 5 (soft)

1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

▸ driller's note ◂

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 50

SIQUIRRES. PROJECT HOLE No. DB - I (SHEET 11 OF 14)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 - Nov. - '74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 - Feb. - '75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
200m			0 → 100 %								200m	56
200–204.5	Basalt	V		NB	bluish black			2 – 1 – 1	Massive lava, fresh hard and compact, mostly 15-40 cm cores.			
204.5		V						4	Slickensides along cracks.			
204.5–215.3		V				2 – 1 – 1	2 – 1 – 1	2 – 1 – 1				
215.3									215.3		215	40.7
215.3–216.1		◇				2			Autobrecciated lava.			
216.1									216.1			39.9
216.1–217.9		V				2 – 1 – 1	2	2 – 1 – 3	Generally produced many gas cavities (Ø 2-10mm).			
217.9									217.9			
217.9–220		V					2 – 1 – 1	2	Massive lava.		220	36

core loss

RQD

1 (fresh) ~ 5 (decomposed)

1 (hard) ~ 5 (soft)

1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain

▸ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 51

SIQUIRRES PROJECT HOLE No. DB - I (SHEET 12 OF 14)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 - Nov. - '74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	17 - Feb. - '75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
220m – 230.16	Basalt	V		NB	bluish. black	2-1-1	2-1-1	2 (to 221.9); 3 (221.9–229.16); 2 (229.16–230.16)	221.9 / 229.16 — Massive lava, generally sound. 230.16		220m – 230	36 / 25.84
230.16 – 231.85	Mudstone				reddish brown	2	4-1-3	4	Soft and brittle, looks like fine grained tuff. 231.85			24.15
231.85 – 233.2		◇ V					3-1-2	2-1-3	Autobrecciated lava, slightly brittle. 233.2			22.8
233.2 – 240	Basalt	V			bluish brown	2-1-1	2-1-1	3-1-2; 2-1	Massive lava, hard and compact.		240	16

core loss

RQD

driller's note

1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

1 (hard) ~ 5 (soft)

1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

SIQUIRRES. PROJECT HOLE No. DB - I (SHEET 13 OF 14) Sheet No. 52

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 - Nov. - '74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 - Fev. - '75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
240m – 244.5	Basalt	V		NB	bluish black	2 - 1	2 - 1	3 - 2	Massive lava; 244.5		240m	16 m – 11.5
244.5 – 246.8	Basalt	◇ V		NB	reddish brown	3	3 - 2	2 - 3	Autobrecciated lava, generally slickenside produced, brittle; 246.8		245	9.2
246.8 – 253.8	Basalt	V		NB	bluish black	2 - 1	2 - 1	2 - 1	fresh and hard; 253.8		250	2.2
253.8 – 254.7	Basalt	◇		NB	dark gray	2	3 - 2		— Autobrecciated lava; 254.7			
254.7 – 256.6	Basalt	V		NB	dark gray	2	3 - 2	3	Lava, slightly brittle; 256.6		255	
256.6 – 258.0	Basalt	V		NB	dark gray	2	3 - 2	4 - 3	Slightly sheared, slickenside; 258.0			-2.0
258.0 – 260	Mudstone			NB	reddish brown		3 - 4	3	Poorly solidified, generally soft and brittle, slickenside		260	-4.0

core loss

RQD

1 (fresh) ~ 5 (decomposed)

1 (hard) ~ 5 (soft)

1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

▶ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 53

SIQUIRRES. PROJECT — HOLE No. DB - I (SHEET 14 OF 14)

LOCATION	Left Bank, Damsite	DEPTH OF HOLE	265.15 m	COMMENCED	11 - Nov. - '74
ELEVATION	256 m	DEPTH OF OVERBURDEN	25.65 m	COMPLETED	27 - Feb. - '75
COORDINATE		LENGTH OF ROCK DRILLING	239.50 m	DRILLED BY	
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 – 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
260m											260m	- 4.0
260 – 262.0	Mudstone			NB	reddish brown				262.0			
262.0 – 265.15	Mudstone			NB	greenish gray	2	3 / 1 / 4	3	Generally soft and brittle, no calcareous. 265.15		265	- 9.5
									Bottom of hole			

core loss

RQD

▸ driller's note ◂

1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

1 (hard) ~ 5 (soft)

1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No.54

SIQUIRRES PROJECT — HOLE No. DB-2 (SHEET 1 OF 12)

LOCATION	Right Bank, Damsite	DEPTH OF HOLE	231.16 m	COMMENCED	23 May. '75
ELEVATION	207.5 m	DEPTH OF OVERBURDEN	3.10 m	COMPLETED	26 -Jul.- '75
COORDINATE		LENGTH OF ROCK DRILLING	228.06 m	DRILLED BY	I. C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (m)	ROCK NAME	LOG	CEMENTATION, KIND OF BIT, CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	ELEVATION
0–3.1	Topsoil	△	NB	reddish brown				Including rock fragment	204.4
3.1–5.25	Basalt	V	NB	bluish black	2	2	2	Lava, compact and hard	202.55
5.25–7.88	Basalt	◇ V	NB	reddish purpl	3	2–3	4	Autobrecciated lava, fragmental cores.	199.62
7.88–14.5	Basalt	V	NB	dark gray	2	2	2–3	Lava, compact and hard, partially gas cavities	
14.5–16.23	Basalt	V	NB	brownish gray	2–3	3–2	4	Many gas cavities, slightly brittle.	
16.23–20	Basalt	V	NB	dark gray	2	2	2–3	Compact and hard, a few gas cavities.	187.5

WATER TABLE; WATER PRESSURE TEST; LEAKAGE OF DRILLING WATER — LUGEON 0–40

Core recovery 0 → 100 %; core loss; RQD

▶ driller's note 4

1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

1 (hard) ~ 5 (soft)

1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 55

SIQUIRRES. PROJECT

HOLE No. DB-2 (SHEET 2 OF 12)

LOCATION	Right Bank, Damsite	DEPTH OF HOLE	231.16 m	COMMENCED	23 May '75
ELEVATION	207.5 m	DEPTH OF OVERBURDEN	3.10 m	COMPLETED	26 Jul. '75
COORDINATE		LENGTH OF ROCK DRILLING	228.06 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH | ROCK NAME | LOG | CORE RECOVERY (0 → 100 %) | CEMENTATION KIND OF BIT CASING | OBSERVATION OF CORE: COLOR, WEATHERING, HARDNESS, CORE CUTTING, DESCRIPTION | WATER TABLE, WATER PRESSURE TEST, LEAKAGE OF DRILLING WATER (LUGEON 0–40) | DEPTH | ELEVATION

Depth 20m – 40m; Elevation 187.5 (at 20m) – 167.5 (at 40m)

Rock name: Basalt. Log: V. Kind of bit: NB.

Depth (m)	Color	Weathering	Hardness	Core cutting	Description
20 – 23.6	dark gray	2	2	4, 2–3	Lava, compact and hard, cracks weathered to brown.
23.6 – 26.4	dark gray			3	
26.4 – 27.5	dark gray	2–3	2–3	4–3	Many gas cavities, slightly brittle.
27.5 – 33.55	dark gray	2	2	2–1–3, 2	Lava, fresh and hard generally many gas cavities filled with zeolite.
33.55 – 35.7	purplish black	2–3	3–2	4	Many gas cavities, slightly brittle.
35.7 – 40	dark gray	2	2	2–1–3	Lava, generally sound.

▶ driller's note 4

1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

1 (hard) ~ 5 (soft)

1 (fresh) ~ 5 (decomposed)

core loss

RQD

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 56

SIQUIRRES. PROJECT HOLE No. DB-2 (SHEET 3 OF 12)

LOCATION	Right Bank, Damsite	DEPTH OF HOLE	231.16 m	COMMENCED	23 - May - '75
ELEVATION	207.5 m	DEPTH OF OVERBURDEN	3.10 m	COMPLETED	26 - Jul. - '75
COORDINATE		LENGTH OF ROCK DRILLING	228.06 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

OBSERVATION OF CORE

DEPTH (m)	ROCK NAME	CEMENTATION / KIND OF BIT / CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	ELEVATION (m)
40 – 41.38	Basalt	NB	dark gray	2	2	2 - 3		167.5
41.38 – 43.4	Basalt	NB	dark gray	2 - 3	2 - 3	4; 3 - 2	Lava, slightly brittle, generally many gas cavities (Ø max 4 cm)	
43.4 – 46.2	Basalt	NB	dark gray	2	2	2 - 3	Fragmental cores and many gas cavities at 45.5 - 46.0 m.	161.3
46.2 – 52.4	Basalt	NB	bluish black	2 - 3	3 - 2	1 - 3	Autobrecciated lava, a few amygdales. slightly brittle.	155.1
52.4 – 55.6	Basalt	NB	dark gray	2	2	3-4; 2; 3 - 4	Lava, fresh and hard, somewhat cracky cores.	151.9
55.6 – 60	Basalt	NB	bluish black	2	2 - 3	2 - 1	Autobrecciated lava, fresh and hard, mostly 15 - 40 cm cores.	147.5

CORE RECOVERY: 0 → 100 %

WATER TABLE; WATER PRESSURE TEST; LEAKAGE OF DRILLING WATER; LUGEON 0 – 40

core loss

RQD

1 (fresh) ~ 5 (decomposed)

1 (hard) ~ 5 (soft)

1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain

▶ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 57

SIQUIRRES. PROJECT HOLE No. (SHEET 4 OF 12)

LOCATION	Right Bank, Damsite	DEPTH OF HOLE	231.16 m	COMMENCED	23 - May - '75
ELEVATION	207.5 m	DEPTH OF OVERBURDEN	3.10 m	COMPLETED	26 - Jul. - '75
COORDINATE		LENGTH OF ROCK DRILLING	228.06 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0→100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
60m											60m	147.5 m
60–66.0	Basalt	◇ V		NB	bluish black	2	2–3	2–1	Autobrecciated lava, fresh and generally hard. 66.0		66.0	141.5
66.0–73.7		V					2	3–1–2	Massive lava, generally produced amygdales. 73.7			
73.7–80		V						2–1–1	Massive lava, fresh, compact and hard, mostly 15-40 cm cores. Amygdales produced in general.		80	127.5

Legend: core loss; RQD; driller's note 4; 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; 1 (hard) ~ 5 (soft); 1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 58

SIQUIRRES. PROJECT HOLE No. DB - 2 (SHEET 5 OF 12)

LOCATION	Right Bank, Damsite	DEPTH OF HOLE	231.16 m	COMMENCED	23 - May - '75
ELEVATION	207.5 m	DEPTH OF OVERBURDEN	3.10 m	COMPLETED	26 - Jul. - '75
COORDINATE		LENGTH OF ROCK DRILLING	228.06 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
80m	Basalt	V		NB	blueish black	2	2	2-1	81.23		80m	127.5 m
81.23–88.48		V			blueish black		2-3	3-4	Lava, generally fresh and hard, somewhat cracky cores. Mostly containing amygdoles			
88.48		◊ V			purplish black				Autobrecciated lava,			119.02
90.35		◊ V			purplish black				Mostly 15-40cm cores.			
92.9		V			blueish black		2	2-1-1	Massive lava, fresh compact and hard,			114.6
98.0		◊ V			purplish black				Autobrecciated lava.			109.5
100											100	107.5

Legend: core loss; RQD; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain; ▸ driller's note ◂

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 59

SIQUIRRES. PROJECT HOLE No. DB - 2 (SHEET 6 OF 12)

LOCATION	Right Bank, Damsite	DEPTH OF HOLE	231.16 m	COMMENCED	23 - May - '75
ELEVATION	207.5 m	DEPTH OF OVERBURDEN	3.10 m	COMPLETED	26 - Jul. - '75
COORDINATE		LENGTH OF ROCK DRILLING	228.06 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (m)	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION (m)
100 – 104.4	Basalt	V		NB	dark gray	2	2		Massive lava, fresh. hard and compact.		100	107.5 – 103.1
104.4 – 106.48	Basalt	◇ V ◇		NB	brownish dark gray	2	2	2 1 1	Autobrecciated lava,			103.1 – 101.02
106.48 – 113.7	Basalt	V		NB	dark gray	2	2	2 1 1	Lava, slightly altered but hard and compact. Many Amygdales	110.0	110	101.02 – 97.5
113.7 – 116.6	Basalt	V		NB	dark gray	2	2 1 1	1 1 2	Massive lava, hard and compact.			90.9
116.6 – 120	Basalt	◇ V ◇		NB	brownish dark gray	2	2	2 1 1	Autobrecciated lava, Many amygdales		120	90.9 – 87.5

Core recovery legend: core loss; RQD

▶ driller's note ◀

Core cutting: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

Hardness: 1 (hard) ~ 5 (soft)

Weathering: 1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 60

SIQUIRRES. PROJECT — HOLE No. DB-2 (SHEET 7 OF 12)

LOCATION	Right Bank, Damsite	DEPTH OF HOLE	231.16 m	COMMENCED	23 - May - '75
ELEVATION	207.5 m	DEPTH OF OVERBURDEN	3.10 m	COMPLETED	26 - Jul. - '75
COORDINATE		LENGTH OF ROCK DRILLING	228.06 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90 °	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (m)	ROCK NAME	LOG	CORE RECOVERY (0→100 %)	CEMENTATION / KIND OF BIT / CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
120 – 123.55	Basalt	◇ V ◇ V		NB	brownish dark gray	2	2	2 – 1	Same condition as 116.6 - 120.0 m — 123.55		120m	87.5 – 83.95
123.55 – 130.9	Basalt	V		NB	dark gray	2 – 1	2 – 1	1 – 2	Massive lava, fresh, hard and compact, Gracks are not weathered.			
130.9 – 132.35	Basalt	V		NB	dark gray	2 – 1	2	1 – 2	130.9 Many amygdales (Ø max. 20mm) — 132.35			75.15
132.35 – 134.3	Basalt	◇ V		NB	dark gray		2		Autobrecciated lava. — 134.3			73.2
134.3 – 136.4	Basalt	V		NB	dark gray		2		Many amygdales (Ø 0.5 - max. 20mm)			
136.4 – 138.55	Basalt	V		NB	dark gray		2 – 1		136.4			
138.55 – 140	Basalt	V		NB	dark gray		2	2 – 1	138.55		140	67.5

Legend: core loss; RQD; f (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; ▶ driller's note 4

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 61

SIQUIRRES. PROJECT — HOLE No. DB-2 (SHEET 8 OF 12)

LOCATION	Right Bank, Damsite	DEPTH OF HOLE	231.16 m	COMMENCED	23 - May - '75
ELEVATION	207.5 m	DEPTH OF OVERBURDEN	3.10 m	COMPLETED	26 - Jul. - '75
COORDINATE		LENGTH OF ROCK DRILLING	228.06 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH (m)	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION, KIND OF BIT, CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION (m)
140 – 141.7	Basalt	V		NB				2 – 1			140	67.5
141.7 – 146	Basalt	V		NB	dark gray		2 – 1	2	141.7 Massive Lava, fresh, hard and compact, mostly 10 - 30cm cores.		146	61.5
146 – 153	Basalt	V, ◇		NB	brownish black	2 – 1	2	2 – 1	Autobrecciated lava,		153	54.5
153 – 160	Basalt	V		NB	dark-gray		2 – 1		Massive lava,		160	47.5

Legend: ▸ driller's note ◂; core loss; RQD; Core cutting: 1 (stick), 2 (substick), 3 (piece), 4 (fragment), 5 grain; Hardness: 1 (hard) ~ 5 (soft); Weathering: 1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 62

SIQUIRRES. PROJECT — HOLE No. DB-2 (SHEET 9 OF 12)

LOCATION	Right Bank, Damsite	DEPTH OF HOLE	231.16 m	COMMENCED	23 - May. - '75
ELEVATION	207.5 m	DEPTH OF OVERBURDEN	3.10 m	COMPLETED	26 - Jul. - '75
COORDINATE		LENGTH OF ROCK DRILLING	228.06 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
160m–161.3	Basalt	V		NB	dark gray		2–1	2–1	Massive lava		160m–161.3	47.5 m – 46.2
161.3–168.7	Basalt	V, ◇		NB	brownish black		2	1–2	Autobrecciated lava, fresh and hard, mostly 15 - 50 cm cores.		161.3–168.7	46.2 – 38.8
168.7–180	Basalt	V		NB	dark gray	2–1	2–1	1	Massive lava, fresh hard and compact.		168.7–180	38.8 – 27.5

Legend:

- core loss
- RQD
- ▸ driller's note ◂
- Core cutting: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain
- Hardness: 1 (hard) ~ 5 (soft)
- Weathering: 1 (fresh) ~ 5 (decomposed)

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 63

SIQUIRRES. PROJECT HOLE No. DB-2 (SHEET 10 OF 12)

LOCATION	Right Bank, Damsite	DEPTH OF HOLE	231.16 m	COMMENCED	23 - May - '75
ELEVATION	207.5 m	DEPTH OF OVERBURDEN	3.10 m	COMPLETED	26 - Jul. - '75
COORDINATE		LENGTH OF ROCK DRILLING	228.06 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0 → 100 %)	CEMENTATION, KIND OF BIT, CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
180m – 194.4	basalt	V		NB	dark gray	2 – 1	2 – 1	1	Massive lava, Sound. 194.4		180m – 194.4	13.1
194.4 – 196.85	basalt	◇ V ◇		NB	brown		2 – 3		Autobrecciated lava, generally containing many gas cavities and Amygdales 196.85		194.4 – 196.85	10.65
196.85 – 200	basalt	V		NB	dark gray	2	2	2	Massive lava, fresh and hard.		196.85 – 200	7.5

▸ driller's note 4

1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain

1 (hard) ~ 5 (soft)

1 (fresh) ~ 5 (decomposed)

core loss

RQD

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 64

SIQUIRRES PROJECT — HOLE No. DB-2 (SHEET 11 OF 12)

LOCATION	Right Bank, Damsite	DEPTH OF HOLE	231.16 m	COMMENCED	23 - May - '75
ELEVATION	207.5 m	DEPTH OF OVERBURDEN	3.10 m	COMPLETED	26 - Jul. - '75
COORDINATE		LENGTH OF ROCK DRILLING	228.06 m	DRILLED BY	I.C.E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

Columns: DEPTH | ROCK NAME | LOG | CORE RECOVERY (0 → 100 %) | CEMENTATION, KIND OF BIT, CASING | OBSERVATION OF CORE: COLOR, WEATHERING, HARDNESS, CORE CUTTING, DESCRIPTION | WATER TABLE, WATER PRESSURE TEST, LEAKAGE OF DRILLING WATER (LUGEON 0–40) | DEPTH | ELEVATION

Depth 200 m – 220 m; elevation at 200 m: 7.5 m; bit: N B

Depth (m)	Rock name	Color	Weathering	Hardness	Core cutting	Description	Elevation
200 – 201.5	Basalt	dark gray	2	2	2		7.5
201.5 – 205.78	Basalt	dark gray	2	3 – 2	2 – 3	Slightly britlle due to many gas cavities.	1.72
205.78 – 209.4	Mudstone	light brownish gray	3	3 – 4	4 – 5	Looks like fine grained tuff. Poorly solidified, generally soft, slightly sheared, slickenside	-1.9
209.4 – 214.08	Basalt	dark gray	2	2	3 – 4	Lava, fresh and hard, somewhat cracky.	
214.08 – 216.65	Basalt	dark gray	2	2	2		
216.65 – 217.6	Basalt	dark gray	2	2	3 – 4		
217.6 – 220	Basalt	dark gray	2	2	2		-12.5

Legend:

- driller's note 4
- Core cutting: 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain
- Hardness: 1 (hard) ~ 5 (soft)
- Weathering: 1 (fresh) ~ 5 (decomposed)
- core loss
- RQD

GEOLOGIC LOG OF DRILL HOLE

Sheet No. 65

SIQUIRRES. PROJECT — HOLE No. DB-2 (SHEET 12 OF 12)

LOCATION	Right Bank, Damsite	DEPTH OF HOLE	231.16 m	COMMENCED	23 -May- '75
ELEVATION	207.5 m	DEPTH OF OVERBURDEN	3.10 m	COMPLETED	26 -Jul.- '75
COORDINATE		LENGTH OF ROCK DRILLING	228.06 m	DRILLED BY	I. C. E
ANGLE FROM HOLIZONTAL	90°	TOTAL LENGTH OF CORE	m	LOGGED BY	
BEARING OF ANGLE HOLE		CORE RECOVERY	%		

DEPTH	ROCK NAME	LOG	CORE RECOVERY (0→100%)	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION	WATER TABLE / WATER PRESSURE TEST / LEAKAGE OF DRILLING WATER (LUGEON 0–40)	DEPTH	ELEVATION
220m											220m	-12.5
220.55	Basalt	V		NB	dark gray	2	2	4	220.55			
222.8		V						2-3	222.8			
		V						3-4				
229.2		V						2-3	Lava, fresh and hard. 229.2			
231.16		V						3	231.16		231	-23.66
									Bottom of hole			
240											240	

Legend: core loss; RQD; 1 (fresh) ~ 5 (decomposed); 1 (hard) ~ 5 (soft); 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain; ▸ driller's note 4

A-8 PHOTOMICROGRAPHIC AND PETROGRAPHIC DESCRIPTION OF ROCK

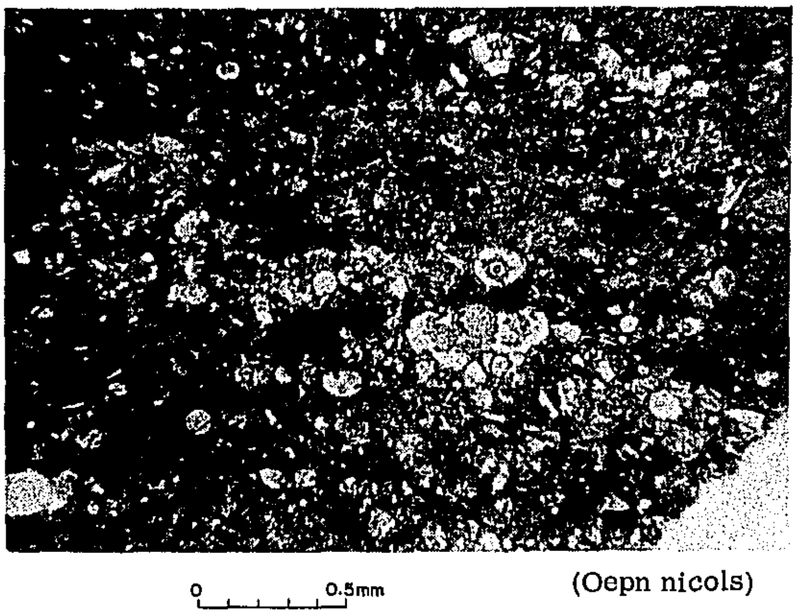
Photomicrograph and Petrographic Description of Rock (Plate 1 of 9)

Locality:

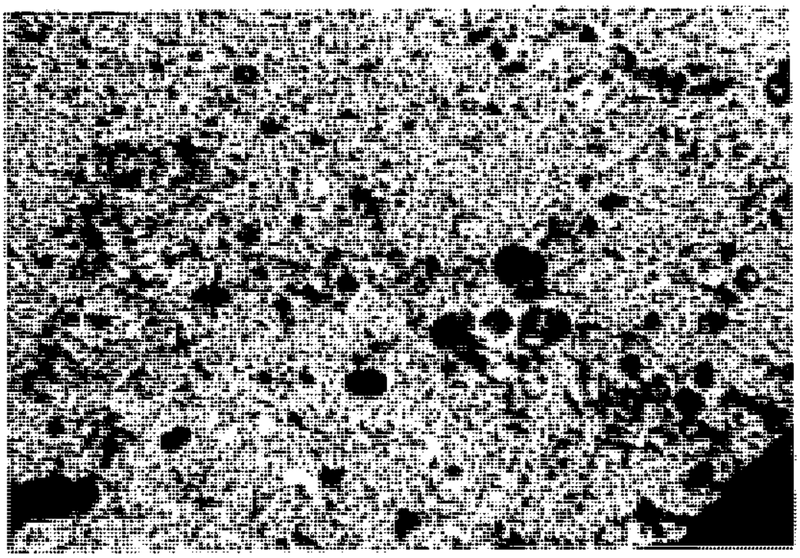
Guayabo Project
Drill hole SB-1
at 20.3 m deep
(Surge tank)

Rock name:

Tuffercous
sandstone



(Oepn nicols)



(crossed nicols)

Petrographic
description:

Granular texture.

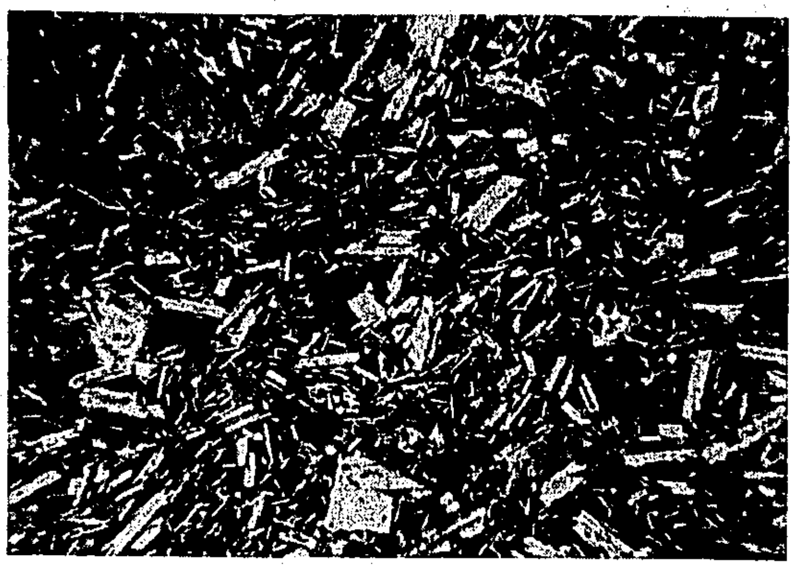
Bearing micro-fossil fragments. Dotted with xenomorphic amphibole and minute magnetite.

Locality:

Guayabo Project
Drill hole PHB-1
at 15.0 m deep
(Powerhouse)

Rock name:

Dolerite



0 0.5mm (open nicols)

(crossed nicols)

Petrographic description:

Intergranular texture.

Consisting of plagioclase and amphibole phenocrysts. Plagioclase presents idiomorphic and albite twin, fresh. Amphibole presents hypidiomorphic and light green color, somewhat altered into chlorite.

Groundmass shows flow structure, and include many plagioclases and minute pyroxenes, dotted with magnetites (small than 0.1 mm). Gas cavities are filled with nepheline.

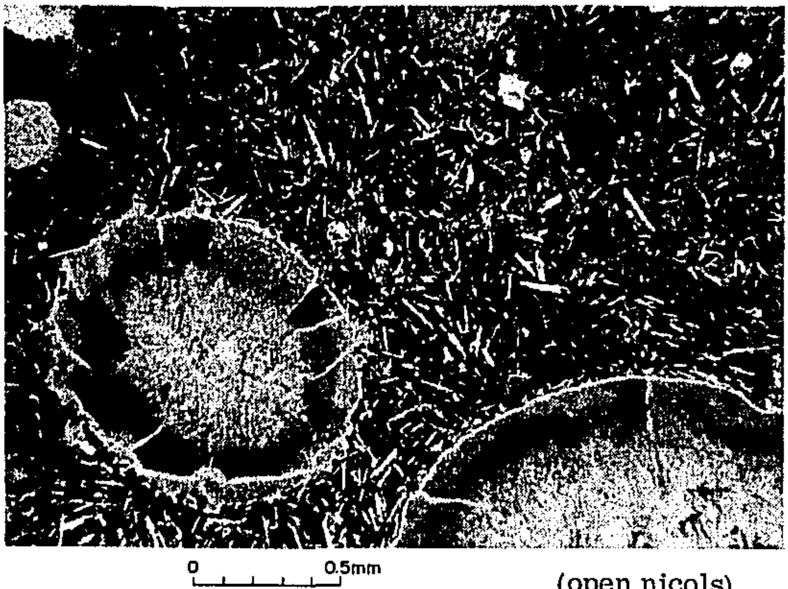
Photomicrograph and Petrographic Description of Rock (Plate 3 of 9)

Locality:

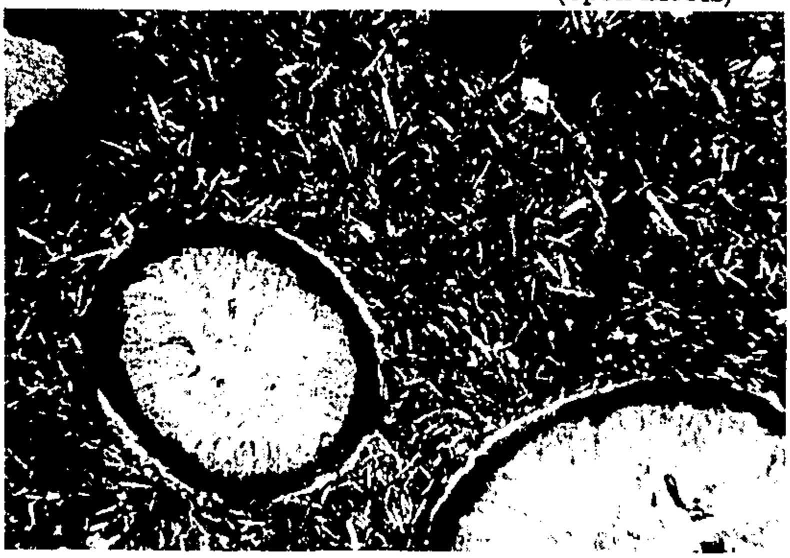
Guayabo Project
80 m up stream from
powerhouse, left bank

Rock name:

Basalt



(open nicols)



(crossed nicols)

Petrographic
description:

Intergranuler texture.

Consisting of phenocrysts of plagioclase and amphibole. Plagioclase presents idiomorphic (0.5 - 2.7 mm) and is somewhat altered. Amphibole presents light green color and hypidiomorphic shape (0.5 - 1.0 mm), it is altered into chlorite.

Groundmass shows flow structure, including phagioclase and minute pyroxene, dotted with magnetite (smaller than 0.2 mm). Glass of groundmass is altered into chlorite and presents light green. Dotted gas cavities (2 - 4 mm) are filled with chlorite and zeolite.

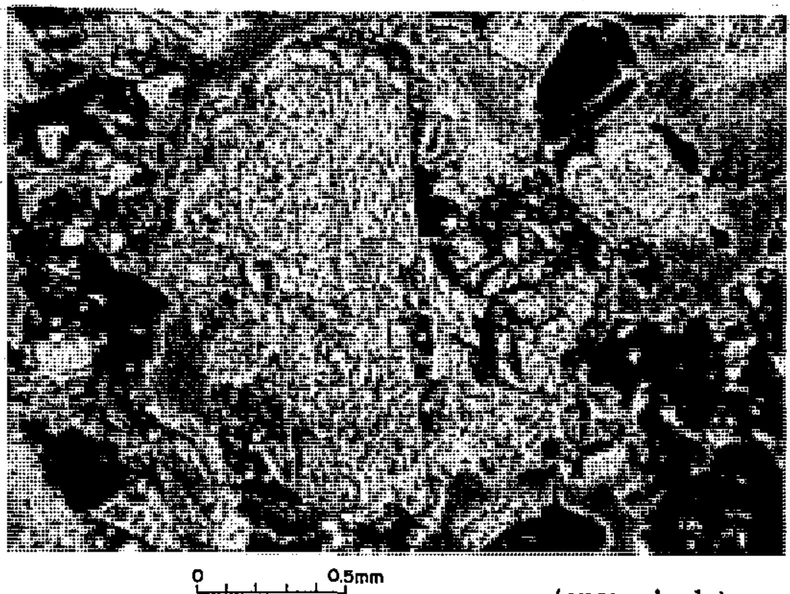
Photomicrograph and Petrographic Description of Rock (Plate 4 of 9)

Locality:

Guayabo Project
Powerhouse
Left bank of R.
Pacuare

Rock name:

Andesitic lapilli tuff
(Matrix of agglomerate)



(open nicols)

(crossed nicols)

Petrographic
description:

Andestic and basaltic grains of smaller than 2 mm in size are filled with glass. Phroxene and plagioclase are altered into chlorite.

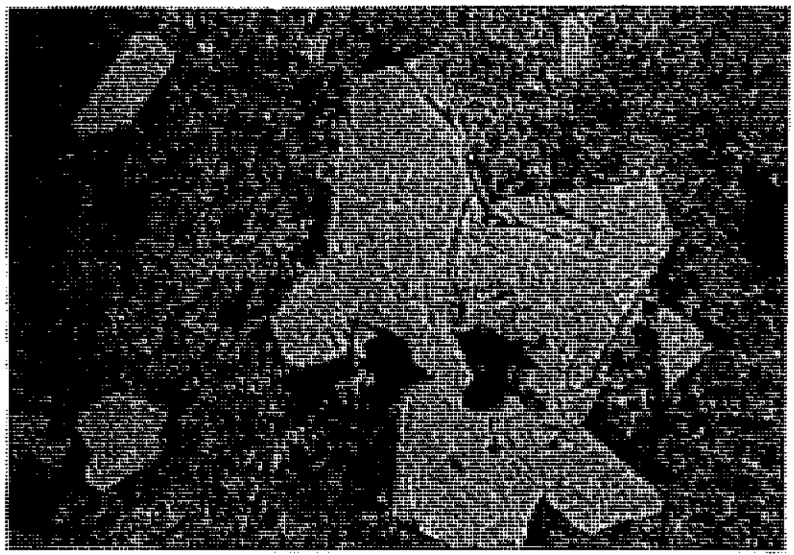
Photomicrograph and Petrographic Description of Rock (Plate 5 of 9)

Locality:

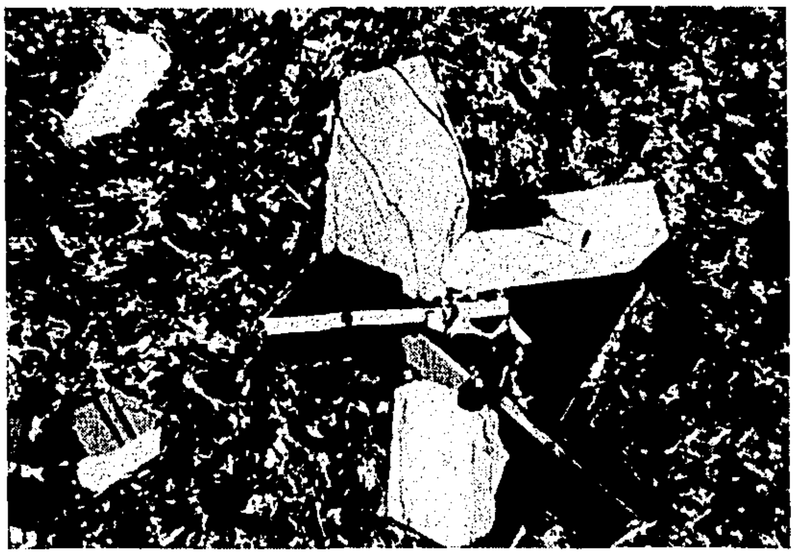
Guayabo Project
Powerhouse
Left bank of R.
Paucuare

Rock name:

Andesite (Breccia
of agglomerate)



(open nicols)



(crossed nicols)

Petrographic
description:

Porphyritic texture with flow structure of intersertal groundmass.

Consisting of phenacryst of phagioclase, pyroxene, amphibole and small amount of quartz. Plagioclase shows idiomorphic and albite twin in part, fresh. Pyroxene and amphibole are somewhat altered.

Groundmass is somplosed of plagioclase and dotted magnetite.

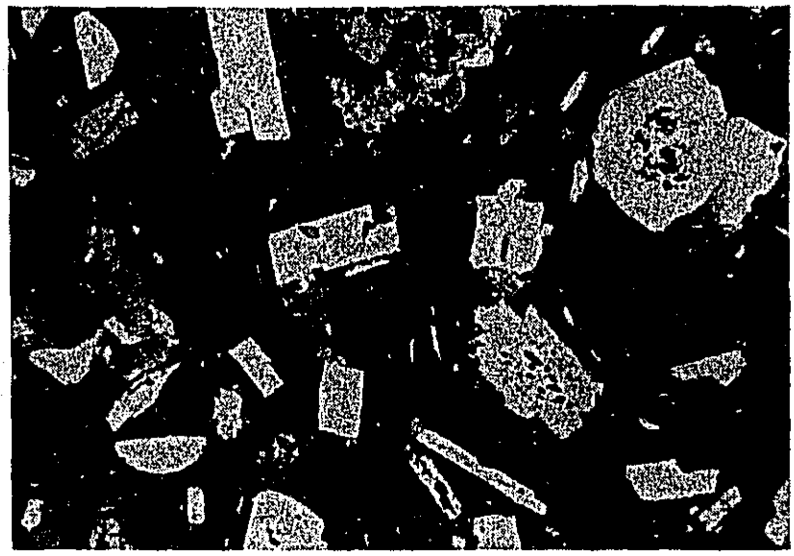
Photomicrograph and Petrographic Description of Rock (Plate 6 of 9)

Locality:

Guayabo Project
Test pit DB-1
at 1.3 m deep

Rock name:

Pyroxene andesite
(Breccia of mud
flow deposit)



0 0.5mm

(open nicols)

(crossed nicols)

Petrographic
description:

Prophyritic texture with intersertal groundmass.

Phenocryst consists of plagioclase, amphibole and pyroxene. Plagioclase presents idiomorphic or hypidiomorphic, and has albite twin and zonal texture, fresh. Amphibole and pyroxene present idiomorphic or hypidiomorphic. They are almost fresh and present light yellow.

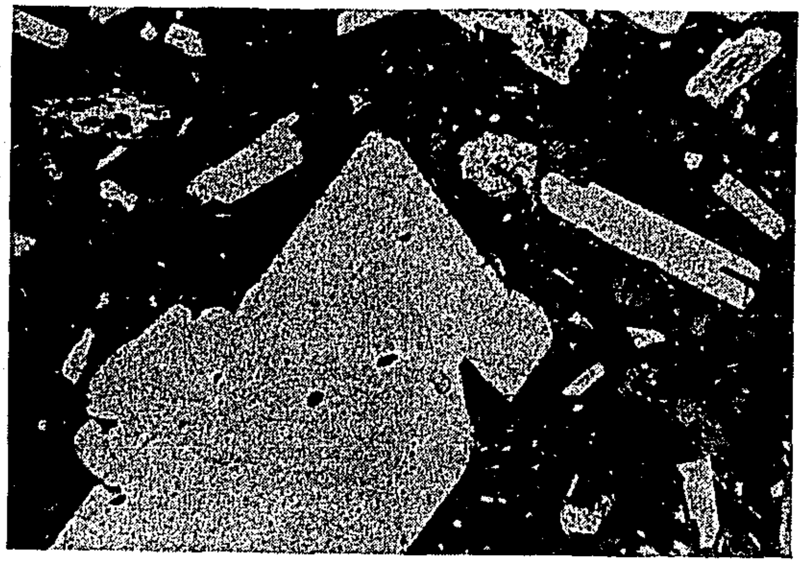
Groundmass has flow-structure consisting of microphenocryst of plagioclase and pyroxene, and slightly altered into chlorite. Small amount of magnetite and quartz (0.1 - 0.2 mm) are contained.

Locality:

Guayabo Project
River bed of
Damsite

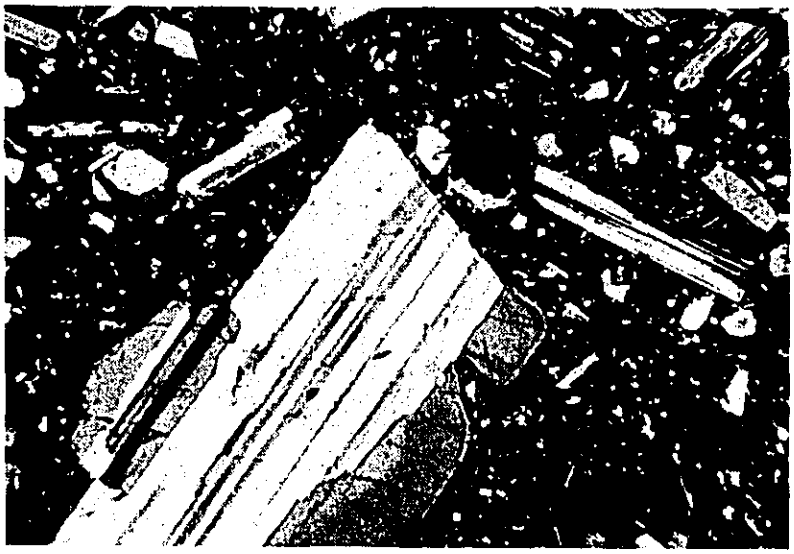
Rock name:

Tow-pyroxene
andesite
(Gravel of river
deposit)



0 0.5mm

(open nicols)



(crossed nicols)

Petrographic
description:

Porphyritic texture with intersertal groundmass.

Phenocryst consists of plagioclase, amphibole, orthopyroxene and angite. Plagioclase, 0.2 - 5.5 mm in size, shows albite twin and it is slightly altered in part. Pyroxene presents idiomorphic or hypidiomorphic, and is fresh. Amphibole presents hypidiomophic and is somewhat altered.

Groundmass is glassy including microphenocryst of plagioclase and pyroxene, and slightly chloritizated. Tiny magnetite and zircon are spotted. Fresh as a whole.

Photomicrograph and Petrographic Description of Rock (Plate 8 of 9)

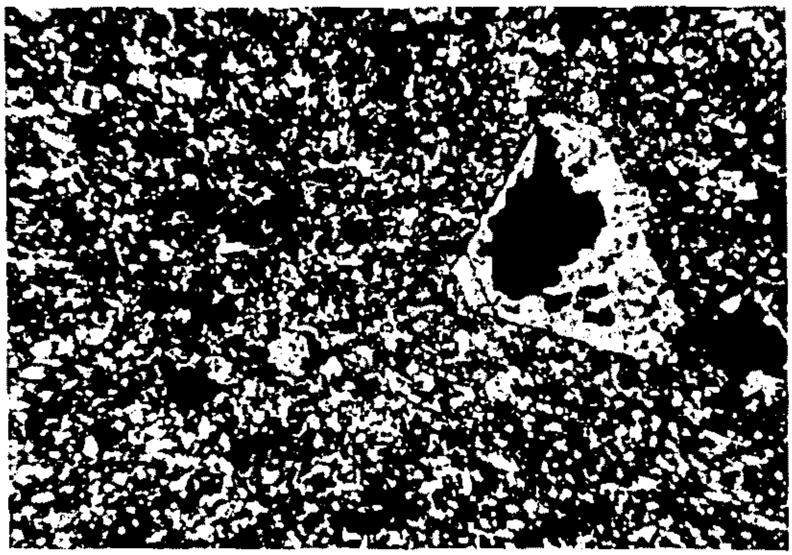
Locality:

Siquirres Project
Drill hole DB-2
at 107.34 m deep

Rock name:

Olivine basalt

0.5 mm (open nicols)



(crossed nicols)

Petrographic
description:

Intergranular texture.

Phenocryst consists of olivine which has 0.2 - 1.2 mm in size and presents idiomorphic or hypidiomorphic with light brown color, and is strongly altered.

Groundmass consists of columnar plagioclase and granular pyroxene spotting with few of magnetite and amygdaloidal minerals.

Considerably altered in general.

Photomicrograph and Petrographic Description of Rock (Plate 9 of 9)

Locality:

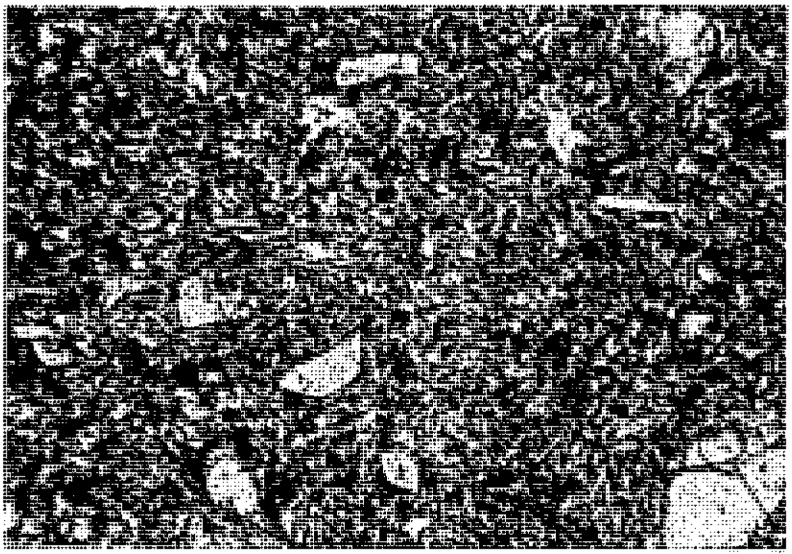
Siquirres Project

Drill hole DB-2

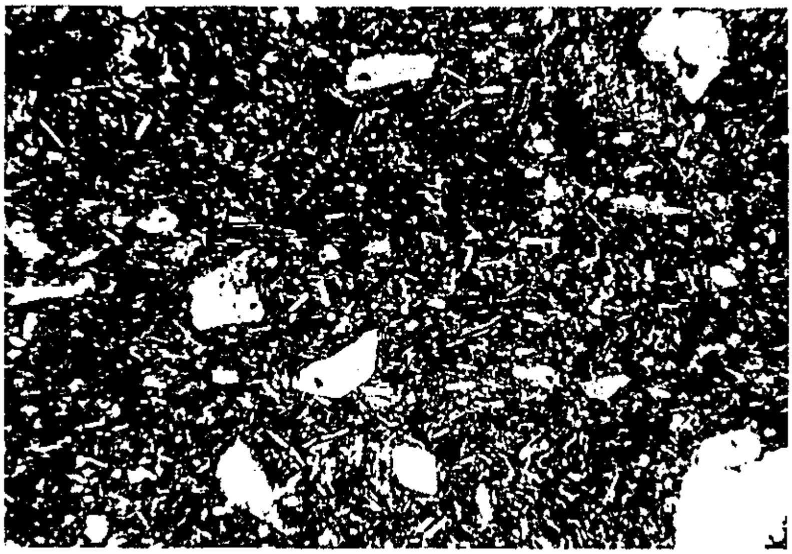
at 154.9 m deep

Rock name:

Olivine basalt



0 0.5mm (open nicols)



(crossed nicols)

Petrographic description:

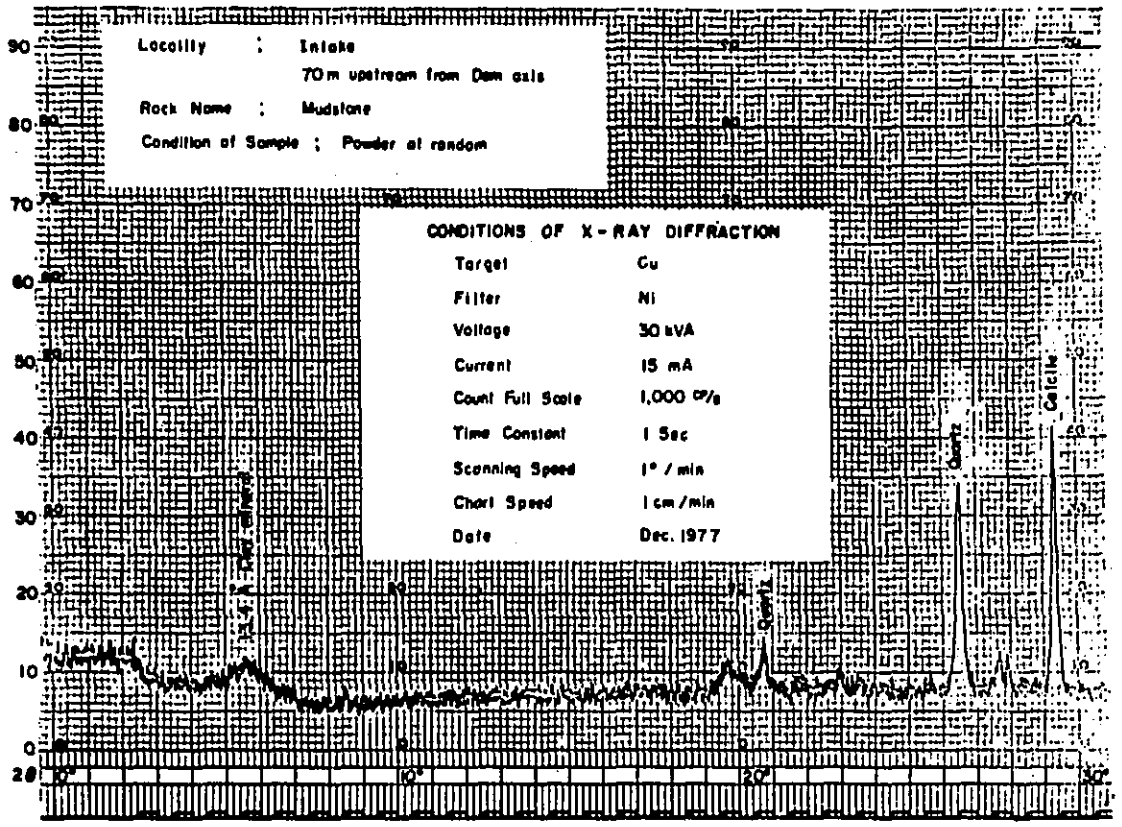
Intergranular texture.

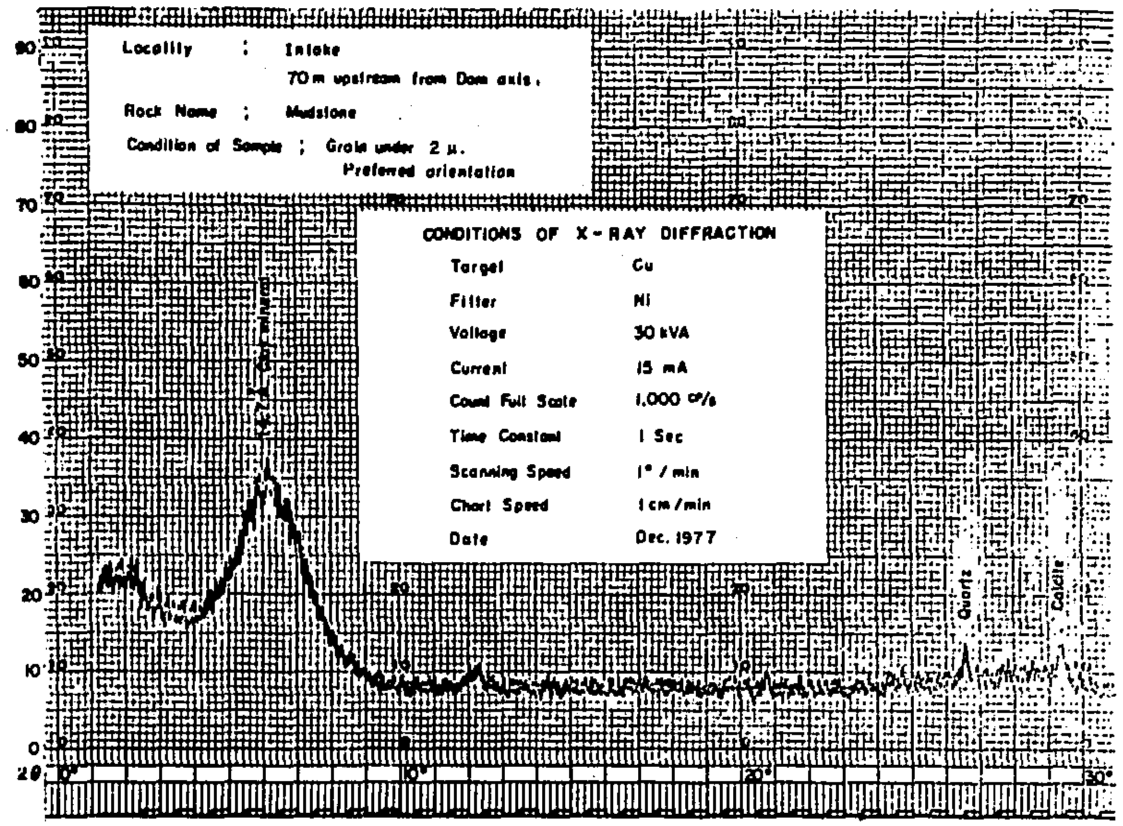
Phenocryst consists of idiomorphic or hypidiomorphic olivine showing yellowish brown color.

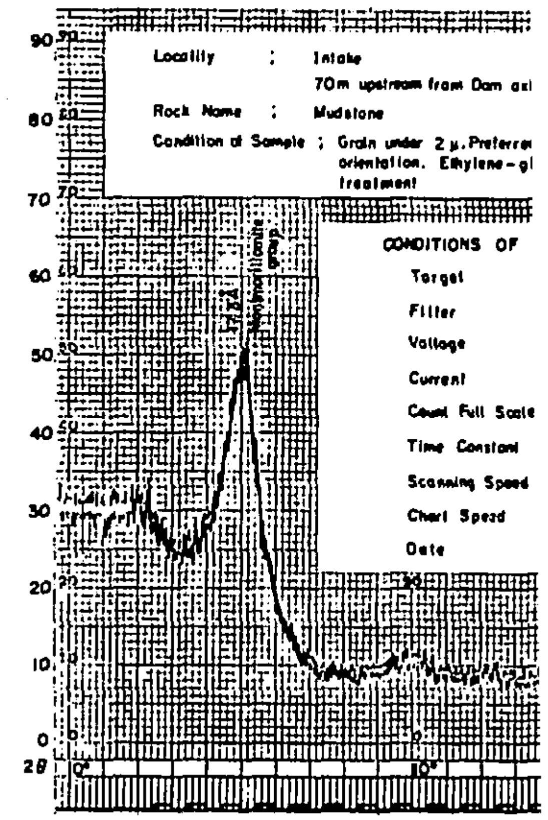
Columar plagioclase and granular pyroxene are predominantly seen in groundmass presenting flow structure. Chloritization has been progressed.

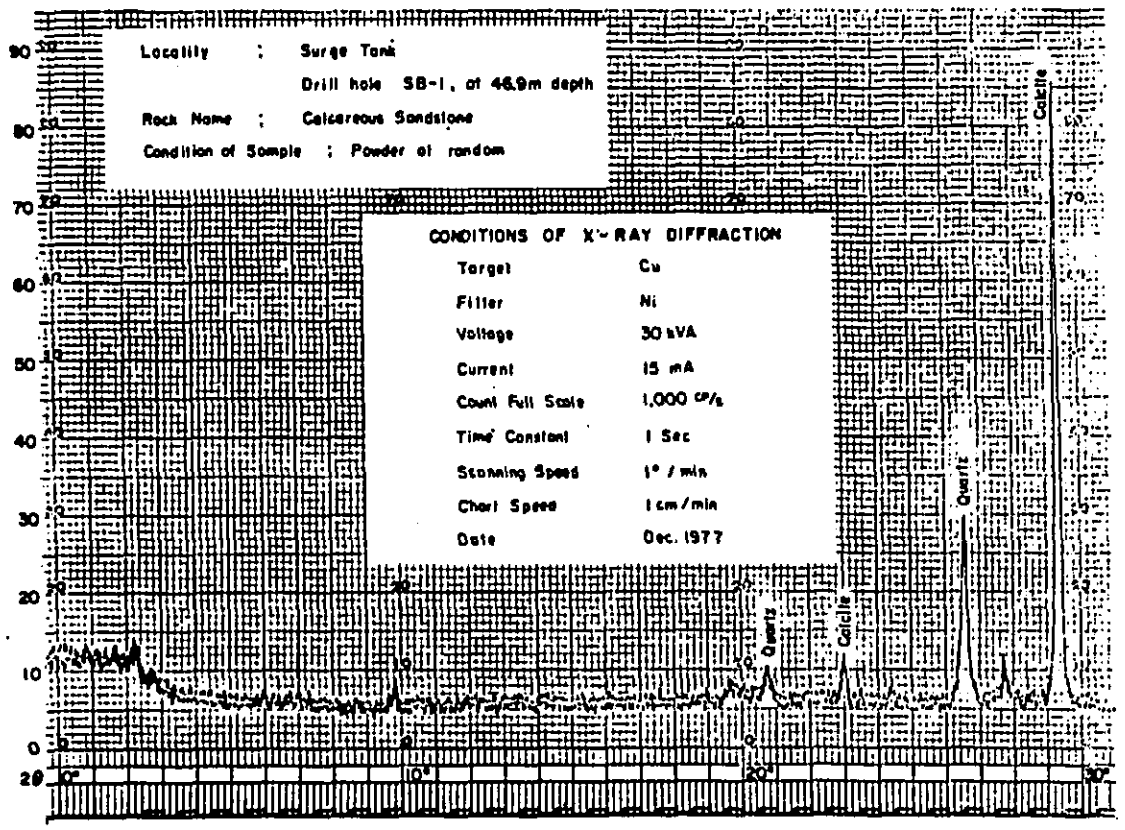
A-9 X-RAY DIFFRACTION

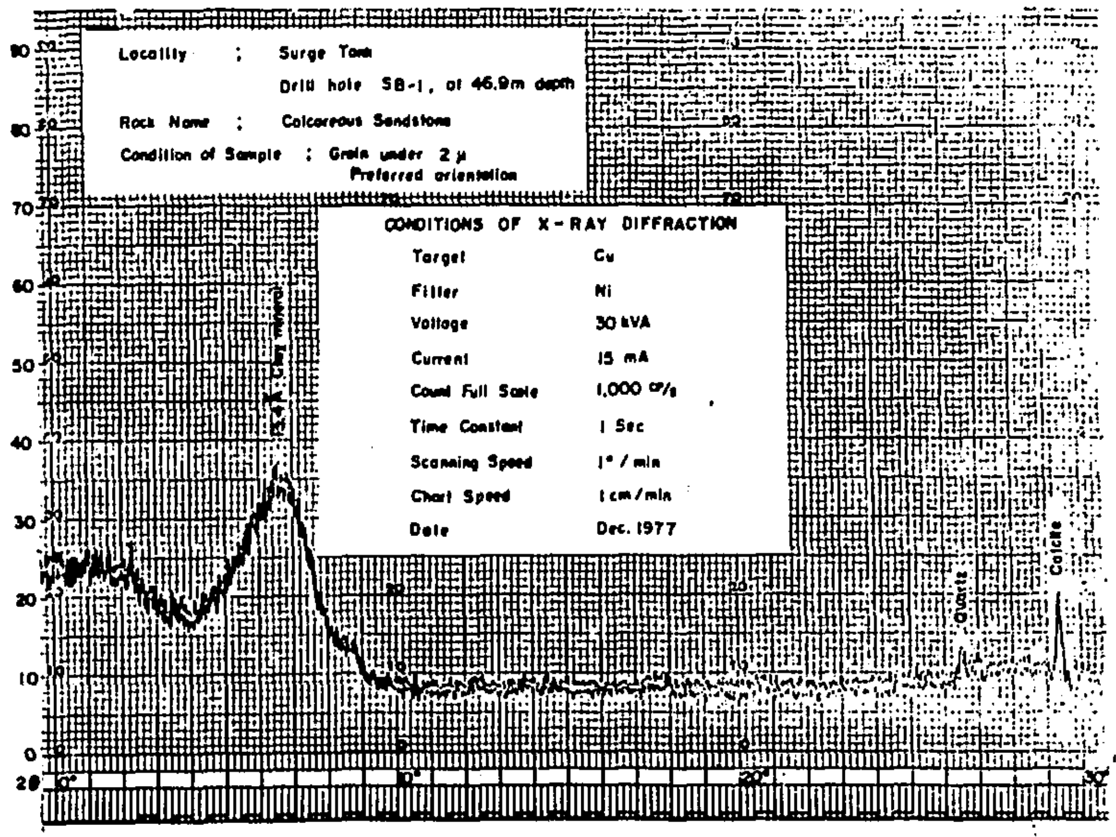
X-RAY DIFFRACTION ANALYSIS (GUAYABO Project)

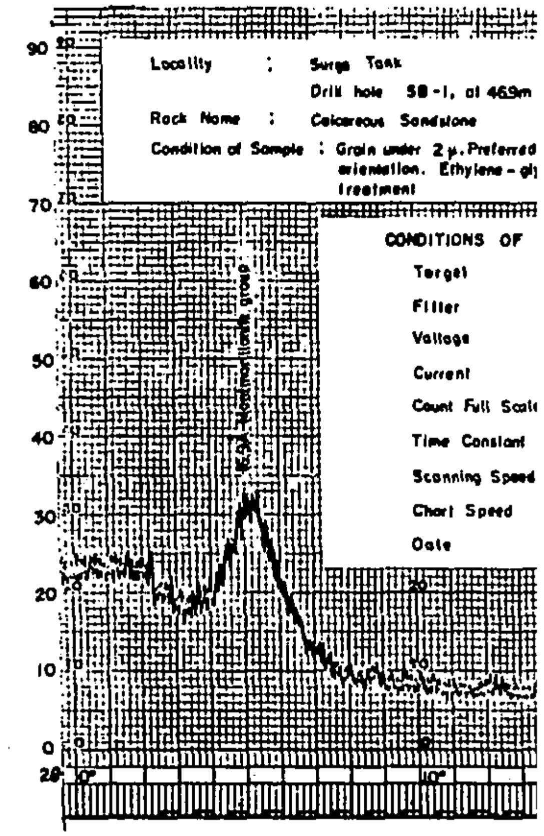












X - RAY DIFFRACTION ANALYSIS (GUAYABO Project)