REPUBLIC OF CHILE

PRELIMINARY REPORT ON THE BAKER AND PASCUA RIVER HYDROELECTRIC DEVELOPMENT PROJECT

Volume—I

Baker River

November 1976

JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

REPUBLIC OF CHILE

PRELIMINARY REPORT
ON
THE BAKER AND PASCUA RIVER HYDROELECTRIC DEVELOPMENT PROJECT

Volume— I

Baker River

November 1976

JAPAN INTERNATIONAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

PREFACE

The Government of Japan, in response to the request of the Government of the Republic of Chile, has decided to carry out fundamental investigation and to review the existing preliminary report for hydroelectric power project on the Baker and the Pascua Rivers in Aisen Province, Chile and has entrusted Japan International Cooperation Agency with such engineering services.

Japan International Cooperation Agency formed an investigation team consisting of seven experts with Mr. Toshio Enami of Electric Power Development Company as a leader and dispatched them to the project site for 44 days from February 10 to March 24, 1976.

The investigation team reviewed the data and/or information on the Baker and Pascua River Projects furnished by the Government of Chile, made aerial survey of the two rivers with cooperation of Empresa Nacional de Electricidad S.A. and made field investigation particularly on the Baker River.

This report is a compilation of the results of review made on the data collected in Chile, aerial survey and field investigation.

It is our earnest desire that this report will contribute towards the hydroelectric developments of Aisen Province and further the friendship between our two nations.

In closing, I wish to express my heartfelt gratitude to the investigation team members for their effort, the Government officials of the Republic of Chile, officials of the Japanese Embassy in Chile for their kind cooperation, and the Ministry of Foreign Affairs and the Ministry of International Trade and Industry for their support in dispatching the investigation team.

November, 1976

Shinsaku Hogen
President
Japan International Cooperation
Agency

LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen, President
Japan International Cooperation Agency

Dear Sir;

Submitted herewith is a report on the Baker River and Pascua River Hydroelectric Development Project in the Republic of Chile.

The investigation team conducted field investigation at a part of the project area and surveys in the project-related area between February 10 and March 24, 1976 with cooperation of Oficina de Planificación Nacional (hereinafter referred to as ODEPLAN) and Empresa Nacional de Electricidad S.A. (hereinafter referred to as ENDESA)

During this period, the investigation team was furnished with the fundamental data on hydrology, topography and geology required for the project study and with a report on the Baker River and the Pascua River hydroelectric development projects prepared by ENDESA. Exchange of views on the projects was also made several times between the technical staff of ENDESA and the investigation team.

After returning to Japan, the investigation team reviewed the hydroelectric projects and/or development programs based on the data collected in Chile and on the results of field investigation, the results of which are compiled in this report.

The Republic of Chile, with her recent vigorous economic activities, has been making a remarkable economic growth and is expected to make further advancement in economic activities.
It is believed that Aisen Province, blessed with abundant electric power resources which are contemplated by the development projects, will serve as a basis to support strongly the future economic development of the country.

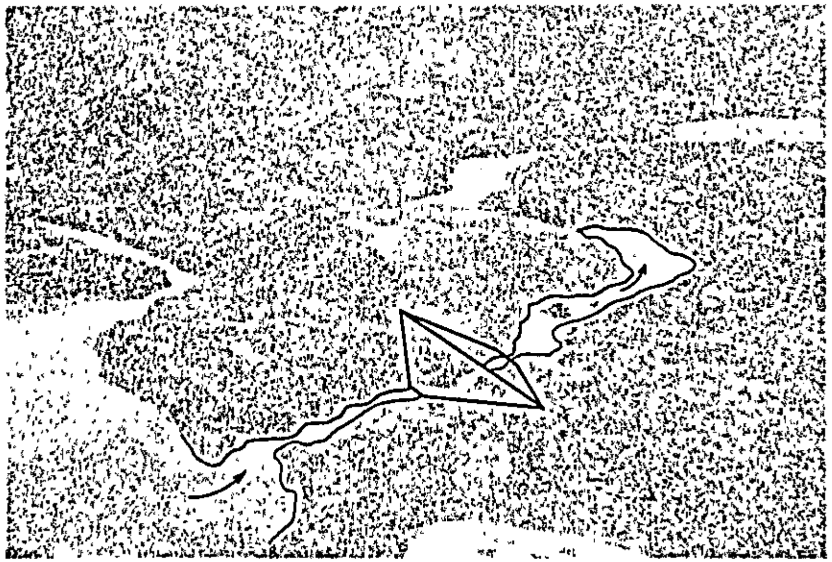
It is necessary for the implementation of the projects to make detailed investigation and studies and to work out more concrete development projects.

It is our hope that the characteristics of the projects be recognized and materialized as an effective program to contribute for the economic development of the Republic of Chile through electricity supply and various industrial development.

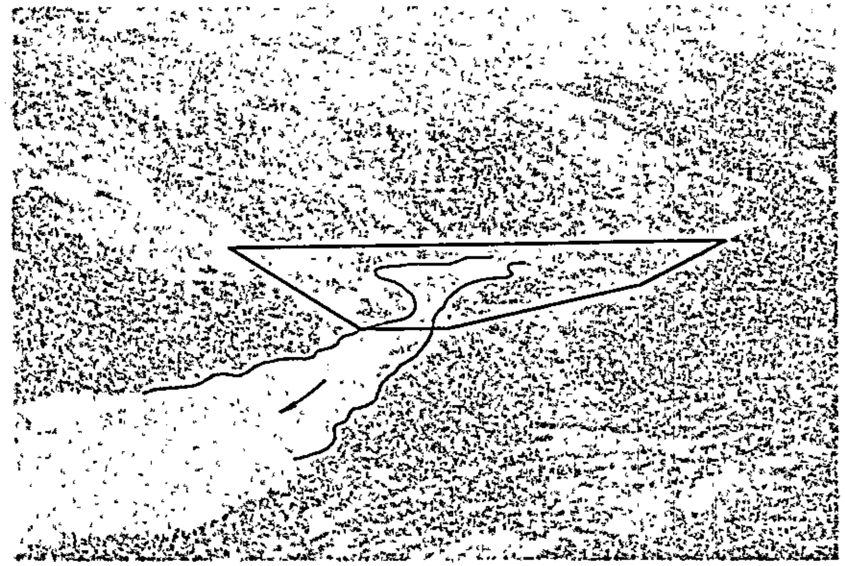
In submitting this report, we, the investigation team, wish to express out profound appreciation to those who are concerned for their kind assistance and cooperation in the field investigation and the studies involved.

November, 1976

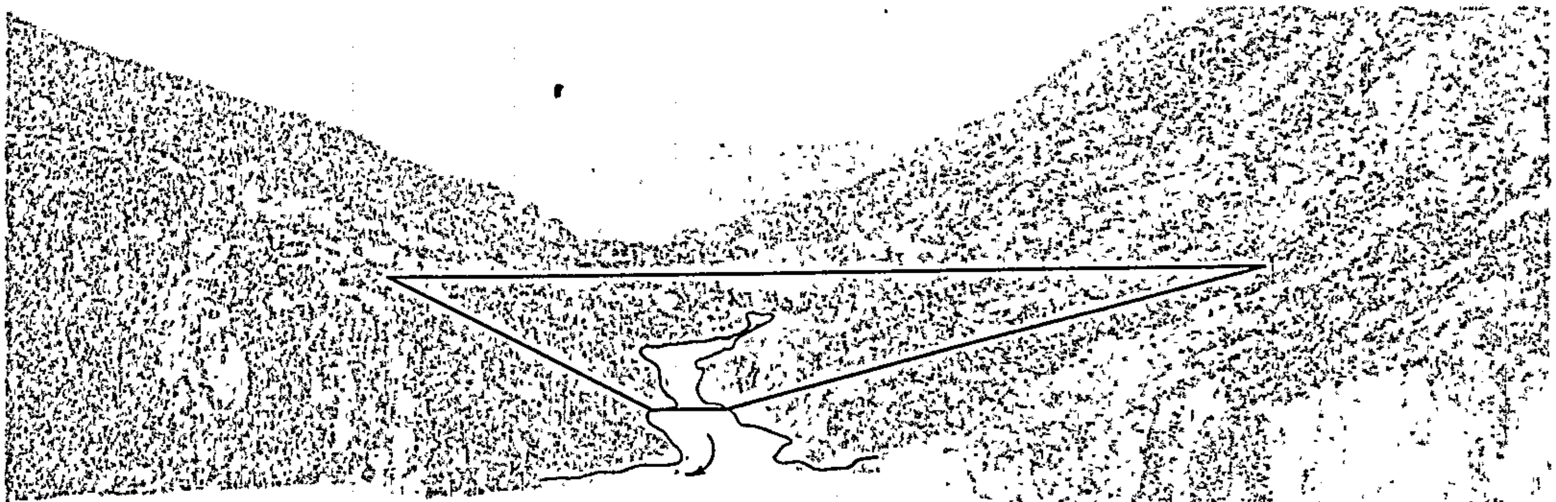
Toshio Enami
Chief
The Baker River and the Pascua River Hydroelectric Development Investigation Team for the Republic of Chile



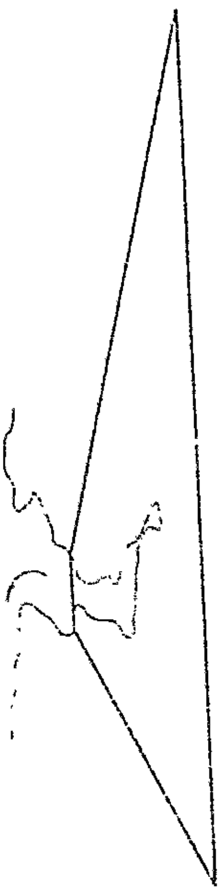
Chacabuco Dam Site

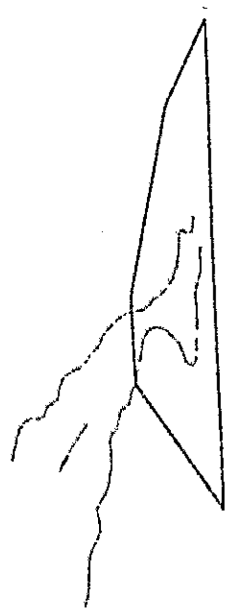


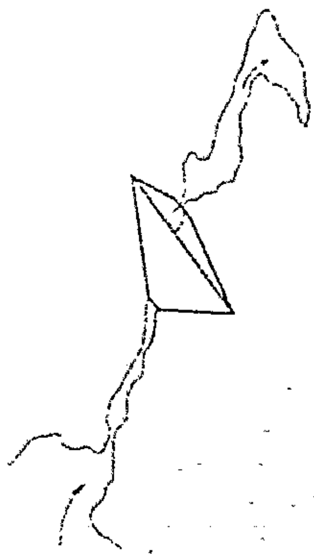
Tamango Dam Site

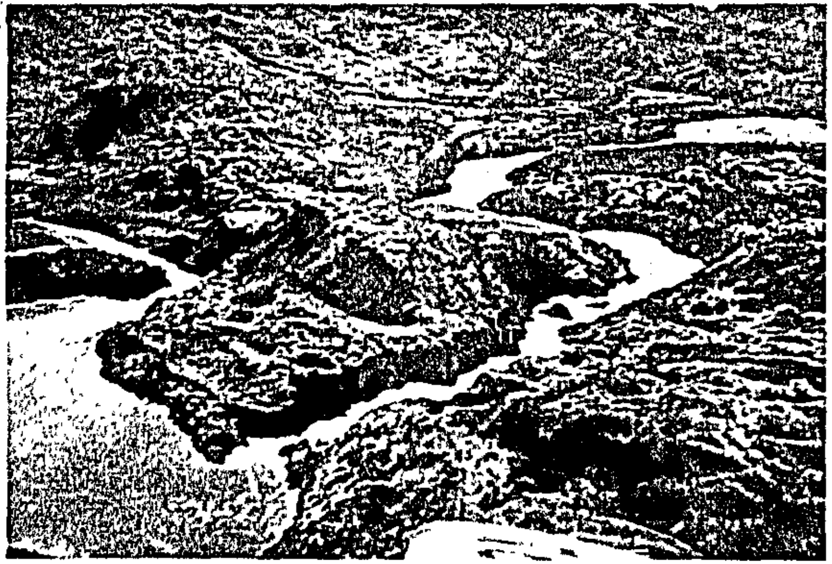


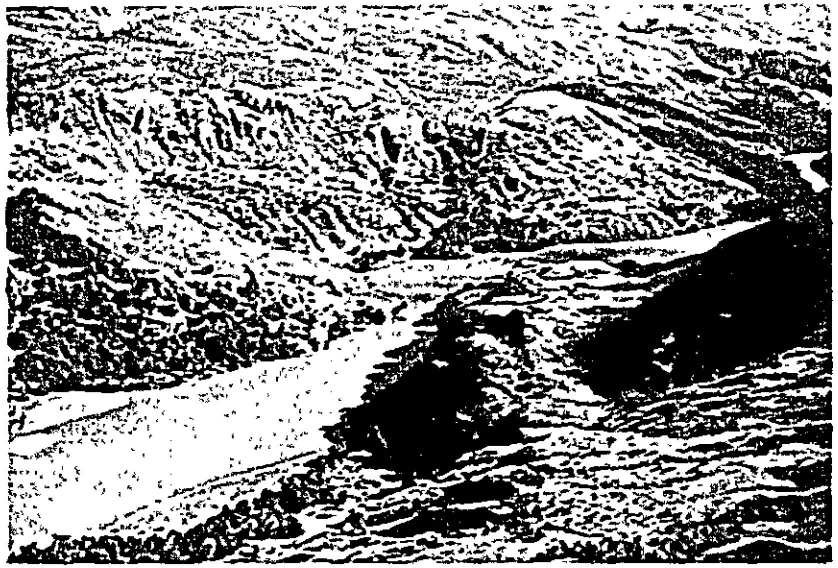
Saltón Gorge Dam Site View from downstream side



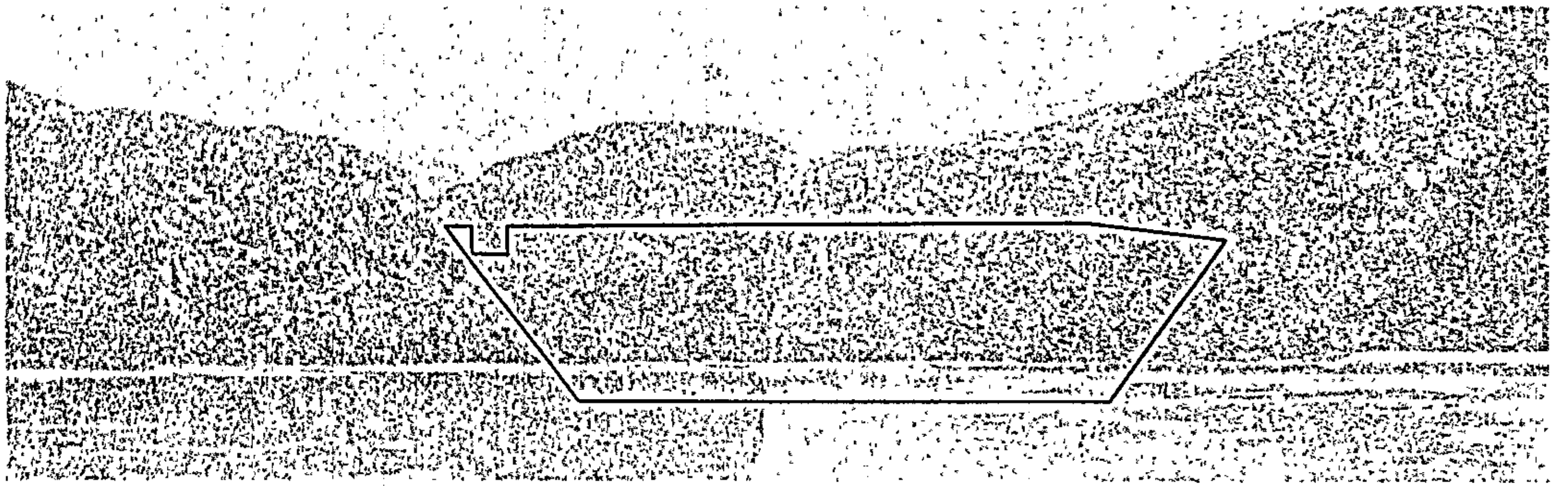




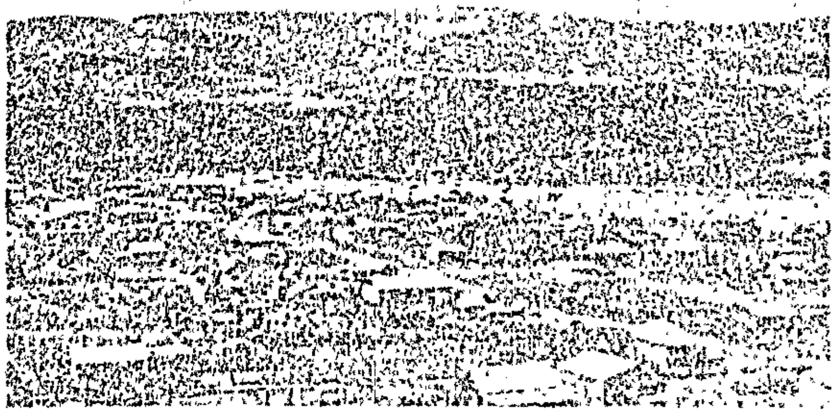

Chacabuco Dam Site


Tamango Dam Site

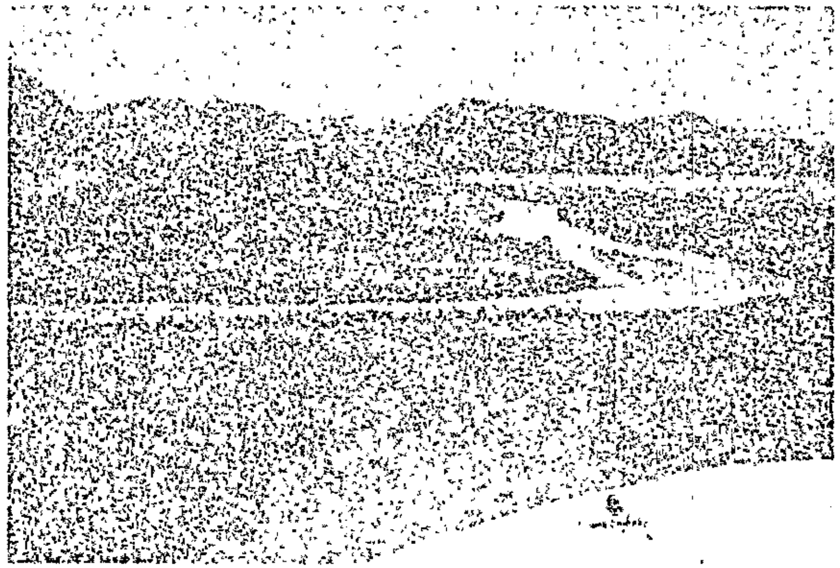

Salton Gorge Dam Site, View from downstream side



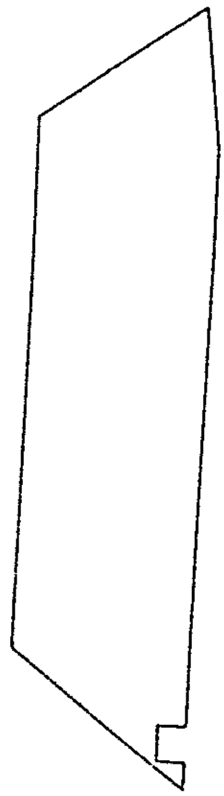
Salton San Carlos Dam Site, View from upstream side

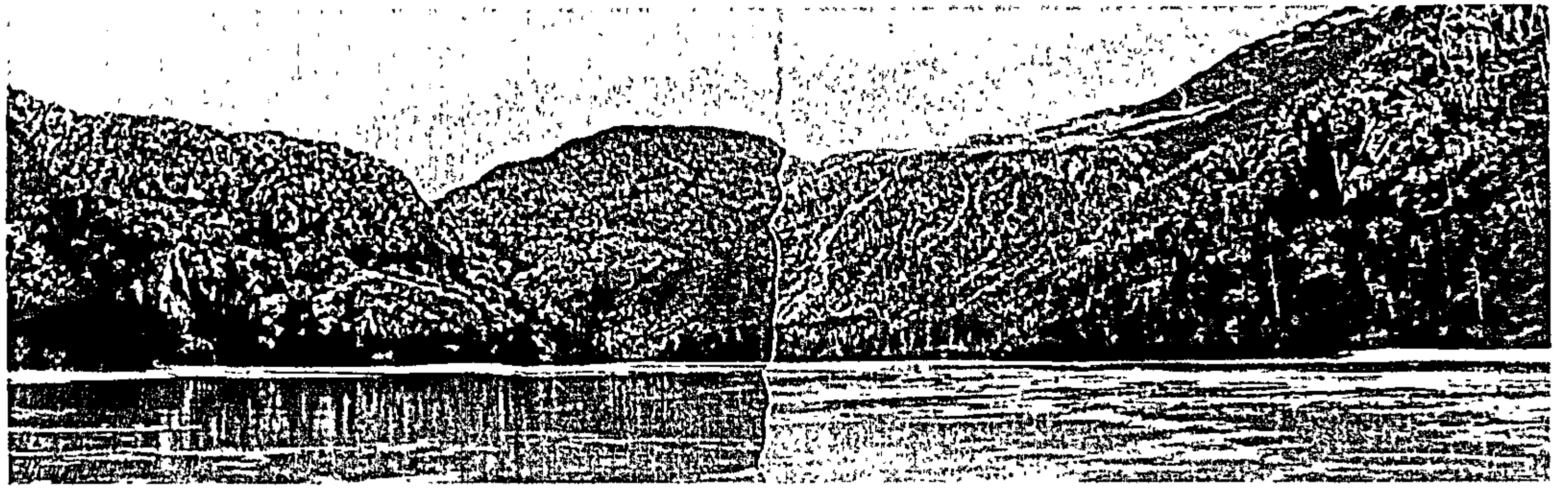


Cochrane Village living about 2,000 inhabitants
in the vicinity of Lago Cochrane



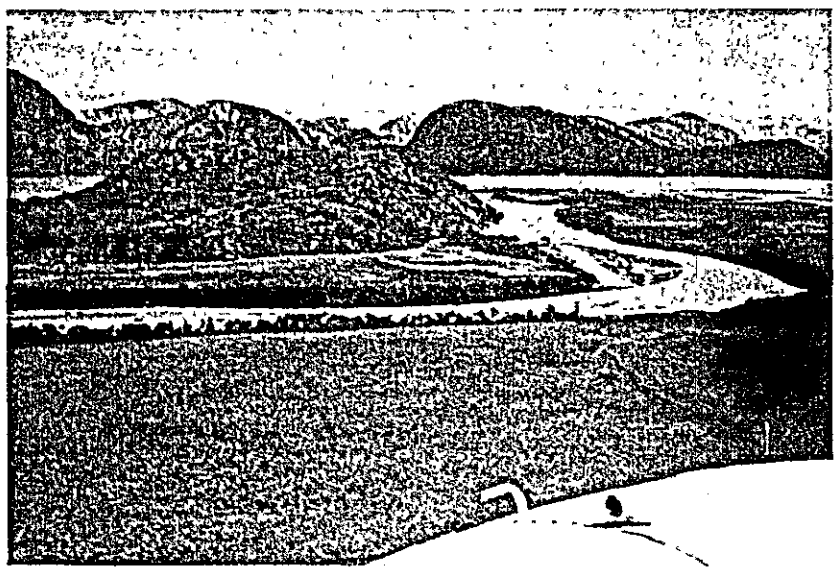
River Mouth of Baker and Tortel Airport



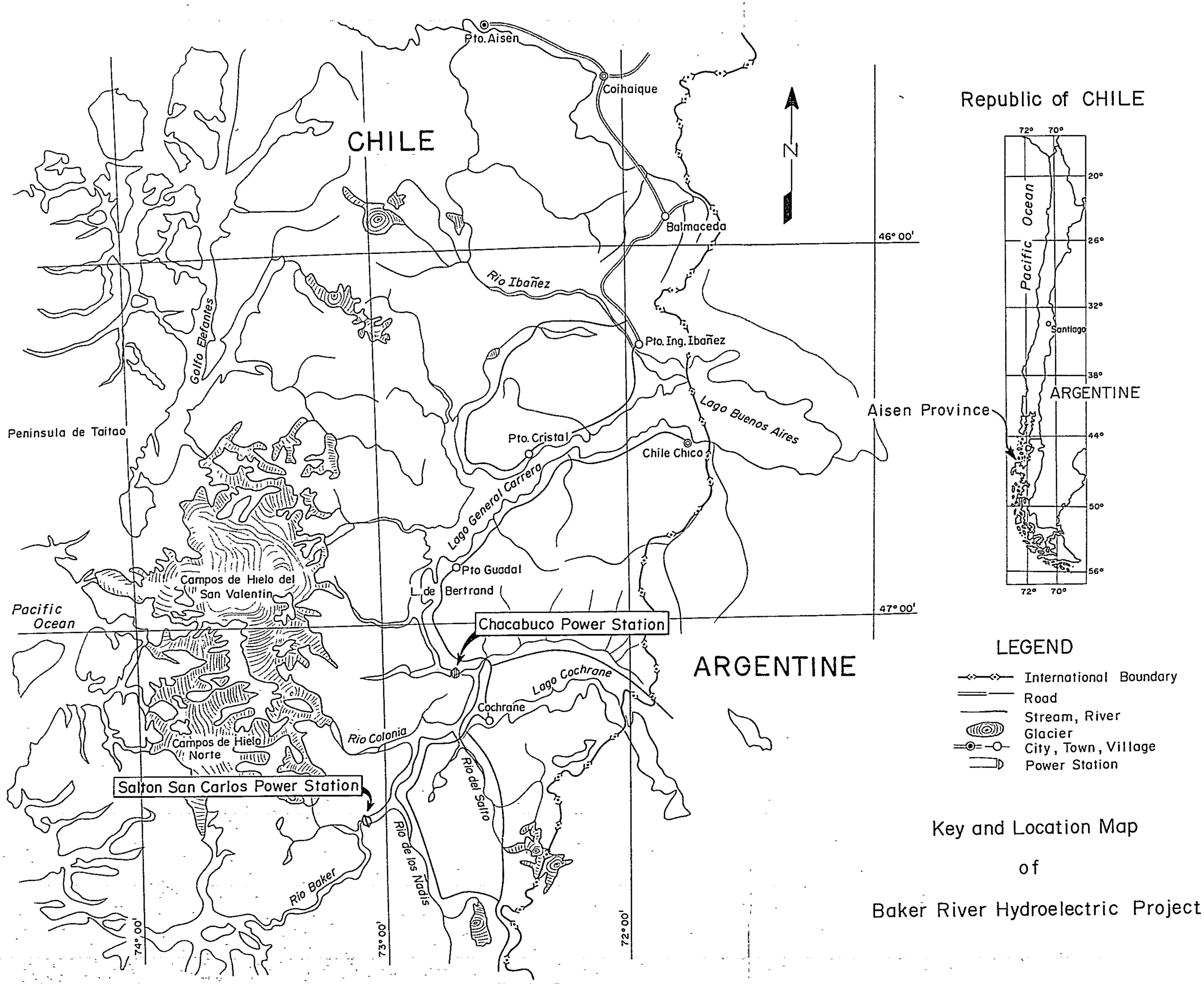


Salton San Carlos Dam Site, View from upstream side

Cochrane Village living about 2,000 inhabitants
in the vicinity of Lago Cochrane



River Mouth of Baker and Tortel Airport



Key and Location Map

of

Baker River Hydroelectric Project

CONTENTS

Figure List

Table List

Chapter 1

INTRODUCTION

Chapter 1. INTRODUCTION

1.1 Antecedent

Although the development of Aisen Province situated in southern Chile has been slow despite its abundance in water, mineral and forest resources, the Government of the Republic of Chile has started to work out a development program aiming at the regional development in Aisen Province.

With a view to promoting industrialization by inducing various industries through the development of the mineral resources by use of electricity if such is made available at low cost in this region, the Government of the Republic of Chile has since 1974 been requesting the Government of Japan for its technical cooperation for the comprehensive development program.

In reply to the request, Japan International Cooperation Agency sent two experts on hydroelectric engineering and made them participate in the field investigation of the Baker River and the Pascua River in 1974 for the purpose of investigating the possibility of hydro power generation to serve as a basis of industrial development.

Availing itself of this opportunity, the Government of the Republic of Chile directed Empresa Nacional de Electricidad S. A. (ENDESA) to prepare a preliminary program for the Baker River hydroelectric development and again at the end of 1974 requested the Government of Japan to send an investigation team of experts to promote the program as well as to conduct field investigation and to review the preliminary program prepared by ENDESA.

Japan International Cooperation Agency, in reply to the request of the Government of Chile, formed the Baker River and Pascua River Hydroelectric Development Investigation Team composed of 7 experts in the field of hydroelectric engineering, geology, materials and aseismic engineering in February, 1975 and sent them to the project site for 44 days till the end of March, 1975.

Meantime, the Government of Chile has already started its investigation for developing various industries from the viewpoint of power demand in parallel with the investigation for hydroelectric development and is now working out a comprehensive development program of Aisen Province both from power and industrial aspects.

The Government of Chile intends to start geological and other investigations with regard to the hydroelectric development as well as studying a basic program for the development of Aisen Province, referring to the report to be prepared by the Government of Japan.

1.2 Purpose and Scope of the Report

ODEPLAN is in the stage of materializing a development program of Aisen Province located in southern Chile from the viewpoints of hydroelectric and industrial development.

The report is to study the hydroelectric development projects of Aisen Province and also to aim at re-examining the preliminary report prepared by ENDESA on hydroelectric development projects of the Baker River from the aspects of planning, dam design, aseismic design, geology and construction materials, preparing an alternative program that was brought about from the result of investigation and giving recommendations on the investigation further required for the implementation of the projects.

The study involved is performed mainly from technical views, and the development scale of power generation technically feasible and the overall development program of the Baker River system is studied into taking consideration two-stage developments. The construction cost is approximately estimated only to serve as a guide. This report does not touch on industrial location program involving power demand in Aisen region and selection of the power consumed area since such program is now being made by the Government of Chile.

1.3 Formation of Investigation Team

The names and assignment of the team members, organization from which the team members are selected and the period of participation are as follows.

	Name	Assignment	Organization	Period
Chief	Toshio Enami	General Supervision	Foreign Activities Dept. Electric Power Development Co., Ltd.	From Feb. 10 to Mar. 24, 1976
Member	Jiro Shimoyama	Construction Materials	Consulting No. 2 Division, Design Section Nippon Koei Co., Ltd.	Same as above
"	Keigo Tanaka	Geology	Consulting No. 1 Division Geological Section Nippon Koei Co., Ltd.	Same as above
"	Tatsuo Omachi	Aseismics	Okukiyotsu Construction Office, Electric Power Development Co., Ltd.	From May 5 to Mar. 24, 1976
"	Kenji Kato	Planning	Foreign Activities Dept. Electric Power Development Co., Ltd.	Same as above
"	Yuichi Ebita	Coordination	Mining and Industrial Planning and Survey Department Japan International Cooperation Agency	Same as above
"	Tsuyoshi Nishimura	Geology	Chile University	From Feb. 10 to Mar. 24, 1976 Participated in Chile

1.4 Field Investigation Schedule

As shown in Appendix-2, the field investigation for the Baker River Hydroelectric Development Project was conducted for 44 days beginning on February 10 and ending on March 24, 1976.

The investigation team was based at Cochrane, Aisen Province and each expert made his investigation in each activity. Also carried out were data collection and meetings with the various organizations such as ENDESA and other agencies in Santiago.

1.5 Basic Data

The basic data and reference informations obtained during the field investigation are as follows.

(1) The hydrological data comprise of the daily mean discharge observed at the two gaging stations operated by ENDESA along the Baker River.

(2) The available topographical maps are a map to scale 1:500,000 covering the entire Aisen Province prepared by Instituto Geográfico Militar, a 1/20,000 scale aerial survey map covering the main stream of the Baker River and the reservoir area, and a 1/2,000 scale aerial survey map covering the dam site and its vicinity. Both are prepared by ENDESA.

As for Tamango and Salton Gorge sites, a topographical map to scale 1/2,000 has been prepared by the investigation team in Japan by enlarging the above-mentioned 1/20,000 scale aerial survey maps.

(3) As data for geology, construction materials and aseismic design, the investigation team has been supplied with "Proyecto de Desarrollo Hidroeléctrico de los Rios Baker y Pascua, Abril 1976" prepared by ENDESA and various other reports.

The basic data collected during the field investigation are in detail list up in Appendix-3.

Chapter 2
CONCLUSION AND RECOMMENDATION

Chapter 2. CONCLUSION AND RECOMMENDATION

2.1 Conclusion

In the Baker River Hydroelectric Development Project, the following conclusion has been reached as the results of the field investigation and the review of the preliminary report prepared by ENDESA.

(1) Basic plan

The Baker River Hydroelectric Development Project will be implemented in two-stage development. The upstream power plant will be situated immediate downstream at a rockfill dam of 71 m in height to be built at Chacabuco and will have a maximum output of 390 MW with an annual energy production of 2,840 GWh. The downstream power plant with a maximum output of 920 MW and an annual energy production of 6,800 GWh will be constructed immediate downstream at 115 m high rockfill dam to be built at Salton San Corlos. The upperstream and the lowerstream power plants will together have a maximum output of 1,310 MW and an annual energy production of 9,640 MW.

(2) Alternative plan

As the result of field investigation, Tamango in the upstream and Salton Gorge in the downstream have been found to deserve as alternative sites, in case the foundation conditions at Chacabuco and Salton San Carlos are found unsuitable for construction by geological investigation to be conducted in the future. Three combinations of these sites are possible for comparison with the basic plan. However, since seismic prospecting exploration and boring has not been conducted, it is considered that Tamango - Salton Gorge Plan shown in Chapter 9 is a most favorable alternative plan.

If one-stage development is adopted, either Salton San Carlos or Salton Gorge site is considered as a possible site for a high dam.

(3) Earthquake - resistant design

At Chacabuco damsite, since the geological composition varies largely between the left and the right banks, it is feared that different behavior of the ground at time of earthquake may give adverse effect on the stability of the dam. As for Tamango damsite, it is anticipated that a saddle on the left bank will become a weak zone for the dam structure. Therefore vibration model test will be required to confirm this problem. Thick deposit layers on the riverbed and low relative density at Salton San Carlos damsite predict existence of sand layers of uniform grain. When layers of such condition are subjected to vibrating repeated load such as seismic force, settlement and liquefaction are likely to occur. Therefore careful consideration should be made in the selection of the type of dam to be constructed.

(4) Geology

Metamorphic rock is predominant in the area where Chacabuco damsite is located. Although the metamorphic rock itself is sound and fresh, geological structure line runs in east-west direction and especially on the right bank at the damsite, a large scale fractured zone of 10 m wide is observed to have been extensively subjected to intense shear action. It is very difficult to judge whether or not the faults developed in this area is active, which fact requires sufficient geological investigation in the future.

The geology at Tamango damsite consists of andesite lava and metamorphic rock with seams running vertically and horizontally. On the left bank, thick layer of talus is distributed. Meanwhile, the right bank is composed of fairly sound andesite and lava. Although there are some problems at this damsite from the viewpoint of dam construction, technical solution is considered possible.

The formation at Salton Gorge damsite consists of sound and fresh granodiorite and outcrops of foundation rock is observed on the right bank. On the left bank, talus is distributed in thin layers. Several faults cross the gorge diagonally and are seen on the left and right banks. However, the fractured zone is narrow in width and there is no problem for constructing a dam.

The rock at Salton San Carlos damsite is composed of sound and fresh granodiorite and sound foundation rock is exposed both on the left and right banks. Several faults and seams on the both banks are considered to be treated with comparative case. Since the deposit layer of the river bed at this site is deeper than that expected and the character of the deposit will govern the success of dam construction, thorough geological investigation will be required.

(5) Construction material

Core materials are not found in the vicinity of Chacabuco damsite. However since the river terraces in this area are composed of the upper layer of sand and the lower layer of clay, whether or not the clay itself or the mixed material of clay and sand is suitable for the core material is a decisive factor. Like at Chacabuco damsite, core materials of good quality have not been found in the vicinity of the damsites at Tamango, Salton Gorge and Salton San Carlos. Therefore, whether or not the varve clay at these damsites are usable as core materials also poses an important problem.

Materials for filter zone, rock fill and aggregates for concrete seem to be available in the vicinity of respective damsite.

2.2 Recommendation

(1) Planning

Since the Baker River depends on international lakes of the General Carrera and the Cochrane for its source of water, the hydroelectric development program on this river deserves prudent consideration for these international lakes. If a two-stage development is adopted, the most favorable combination of the upstream and the downstream dams would be those at Chacabuco and Salton San Carlos. However, if either of these damsites is found unsuitable for the dam construction, an alternative program should be studies, wherein the upstream dam would be located at Tamango and the downstream dam at Salton Gorge.

(2) Hydrological observation

In order to grasp the variation of water elevation and outflow of Lake Cochrane, hydrological observatories should be built on the lakeside and at the outlet as soon as possible. As for the Baker River, two gaging stations each on the Nef River and the Ñadis River, the tributaries of the Baker River, should be constructed as soon as possible.

(3) Survey

A topographical map by aerial survey covering the entire reservoir area affected by the construction of dams should be prepared. A topographical map should also be prepared for Tamango and Salton Gorge sites. Since the elevation of each damsite is not accurate, longitudinal river servey should be performed for the sections from Lake Bertrand to the mouth of the river and from the main stream of the Baker River and Lake Cochrane.

(4) Earthquake - resistant design

In order to grasp the characteristics of seismic force, the most fundamental factor in aseismic design, earthquake survey should be conducted in this area as early as possible by installing necessary equipment. Method of survey and equipment suitable for local observation are shown in 11-3.

(5) Geology

At present Chacabuco damsite is considered to have geological problems. In order to solve the problems pointed out in this report, geological investigation should be carried out as soon as possible. Such investigation works as seismic prospecting exploration on the left and right banks, excavation of adits to accurately grasp the state of the fractured zone and rockbed test should be required. Deep erosion of riverbed is anticipated at Tamango damsite and since seams and cracks are observed on the cliff, it is necessary to conduct geological investigation by means of boring and adit excavation.
As the left and right banks at Salton San Carlos damsite are favored with good rocks, the geological investigation should be focussed at the riverbed. As for the riverbed investigation, sonic prospecting exploration from a boat is considered suitable as the first step. When the depth of water, sedimentary layer and the nature of materials forming the sedimentary layer are approximately known, suitablility of the site should be judged by conducting boring, seismic prospecting exploration and adit excavation.

(6) Construction material

Of the fill materials, those used for core pose problems. Although core materials of good quality are not seen along the Baker River, glacial deposits containing varve clay are observed. Therefore, soil test should be performed to find out whether varve clay or the mixed material of varve clay and sand is suitable for core materials. Depending upon the result of soil test, type of dam may be changed.

(7) Further investigation works

Further investigation works should be performed at the earliest possible time according to the schedule shown in Chapter 11.

Chapter 3

GENERAL CIRCUMSTANCES OF AISEN PROVINCE

Chapter 3. GENERAL CIRCUMSTANCES OF AISEN PROVINCE

3.1 Location

The Republic of Chile located in the southwestern end of South America is a country on a strip of land 4,300 km long in north-south direction and approximately 200 km wide, having a total area of 741,767 km^2. Aisen Privince, where the proposed project area is located, is one of the provinces situated in latitude from 44^o to 49^o south and in the longitude from 72^o to 75^o west in southern part of this country. With its area of 113,957 km^2, Aisen Province occupies 14 % of the entire Chile.

3.2 Climate

Strongly affected by the South Pole and Hunboldt Cold Current, the climate in southern part of the Republic of Chile is characterized by rainfall throughout the year. Aisen Province, located on a peneplain with large lakes and flanked by coastal mountain range and the Andes has varying climate from coast line to inland. Therefore, the mountains in coastal region covered by glaciers have the maximum rainfall which gradually reduces towards the inland until it becomes the minimum in the pampas region stretching into Argentina.

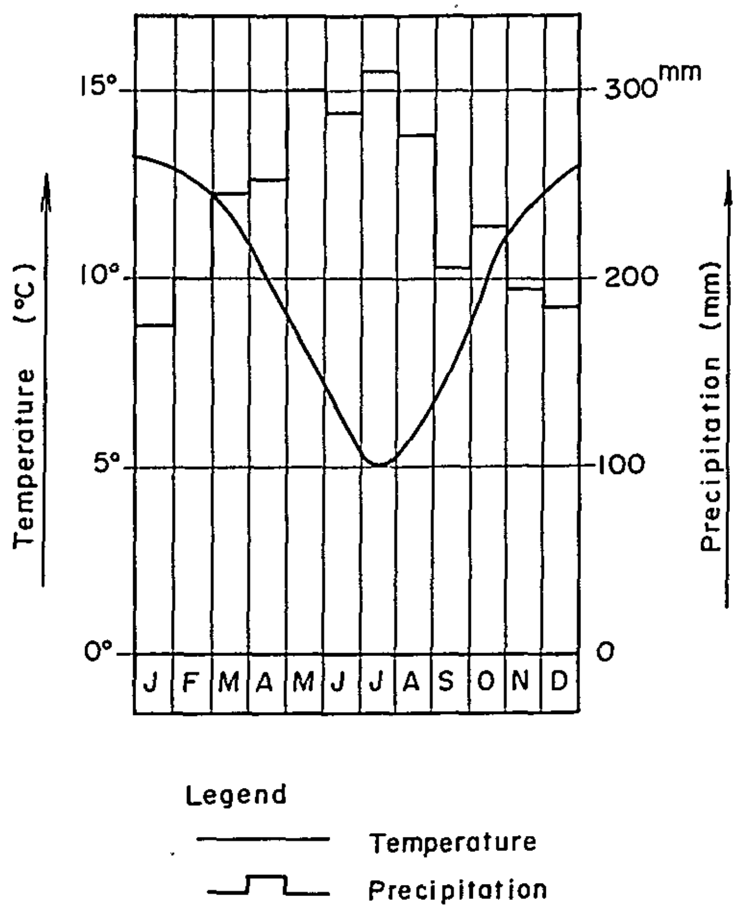
The mean annual rainfall ranges from 250 mm to 800 mm from Puerto Ibanes in the north of the reaches of the Baker River in the highland to Cochrane district, the rainfall gradually increasing towards west and reaching 900 mm in Puerto Cristal and Colonia. The rainfall exceeds 1,500 mm at Puerto Bertrand in the vicinity of eastern branch of San Valentine Range. The coastal region has a heavy rainfall varing between 3,000 mm and 3,500 mm.

In the line with amount of rainfall, the vegetation is thinly distributed in the upper stream region and it becomes accordingly thicker towards the down stream. Rain turns into snow above elevations of 500 m during winter (June to August) and above 1,000 m during summer. The snow remains unmelted and contributes to the formation of glaciers.

Humidity varies in accordance with rainfall and in the upstream region it rises to 50 - 60 % during summer (December to February) and to 60 - 70 % during autumn and spring (March to May, September to November) and to the maximum of 70 - 80 % during winter (June to August). In the coastal region, the maximum humidity is 90 % although there are some variations.

Since the Baker River basin is located in high latitudes, sunshine hours largely varies from summer to winter with a ratio of 5:1. Despite this large variation, the existence of fiords and large lakes makes the temperature difference small. The temperature in flatland is 14°C in summer and 10°C in autumn. It lowers to 4°C in winter and returns to 10°C in spring. The temperature seldom records 0°C in winter. Conversely it sometimes rises to 30°C in summer. Fig. -3. 1 shows the mean annual rainfall and temperature at Puerto Aisen.

Fig.-3・1 Monthly Average Precipitation and Temperature at Pto. Aisen



3.3 Social Conditions

With an area of 113,957 km^2, Aisen Province occupies 14 % of the entire Chile. It has a population of 58,034 and is the most undeveloped province. This region, into which immigration started in 1917, was officially recognized as a province in January 1928 and is the newest province in the Republic of Chile. The principal cities are the capital city of Coihaique, Puerto Aisen, Chile Chico, Cochrane, Puerto Cisnes with population of 20,000 for Coihaique and those ranging from few thousands to few hundreds for other cities. In the Baker River basin, where the proposed project area is located, Cochrane is situated with its population of approximately 2,000 mainly engaged in farming and cattle breeding and occasional settlers.

The roads in Aisen Province are isolated from other parts of the country and the traffic from the large cities depends either on boats or airplanes. The road starts from Puerto Chacabuco and continues to Puerto Ibañez via Coihaique and crossing Lake General Carrera, it stretches from Chile Chico to Cochrane via Puerto Bertrand. Other roads are in the form of horse trails and no road network is maintained.

3.4 Principal Industries

The principal industries of Aisen Province are fishery, mining, forestry and cattle breeding. As for fishery, sea eels, gray mullets and oysters are caught with Puerto Cisnes and Puerto Aisen as centers of activities. Part of the catch is consumed locally but most of it is tinned in Puerto Cisnes or Puerto Chacabuco and shipped to large cities. Salmon is cultured at Coihaique in the upstream of the Simpson River under the assistance of Japan International Cooperation Agency.

As for mining, copper, lead, zinc and molybdenite etc. are mined at Puerto Cristal and at Chile Chico near Lake General Carrera. Although in small quantity, gold and silver is also mined. In addition to these metal mines, marble and limestone are quarried but in small scale.

As regard to forestry, thanks to abundant forest resources, lumbering is carried out in the vicinity of Puerto Puyiguapi and Rio Tranquilo. Cattle breeding mainly of sheep is thriving and is the most important industry in this region. Products such as wool, meat and leather are the source of income. Cattle is also raised but in a small scale. Agricultural products are cultivated on self support basis and the commodities are transported from the large cities.

Glaciers represented by San Valentine, labyrinthine fiords and the Aegean Sea-like topography, a large number of such lakes in the inland area as Lake General Carrera and Lake O'Higgins and the forest surrounding these lakes make these regions as the places of scenic beauty, serving as the sight-seeing spots most typical of this country.

3.5 Present Power Situation

With a view to developing electric power required for industrialization, the Republic of Chile established ENDESA in 1944. Ever since ENDESA has implmented many power development projects and met rapidly increasing demand for electric power. The energy consumption per capita in Chile is 890 kWh and ranks in the upper level in Middle and South American countries. Recent increase of demand for electric power is largely attributable to the development of mining industry and general and commercial consumption.

The electric utilities are composed of ENDESA which owns 57. 5 % (1,478. 4 MW) of the generating facilities of the country, other electricity utilities and private energy suppliers. Of the total generating facilities of 2, 572 MW as of 1974, the electric utilities account for 1, 856 MW and the private power generation, 716 MW. The average annual increase rate in the past 4 years is 5 % for generating facilities and 6 % for energy production. (See Table - 3. 1)

Table - 3.1 Generating Facilities and Energy Production in Chile

Item \ Year	1970	1971	1972	1973	1974
Generating Facilities (MW)	2,143	*2,132	2,182	2,472	2,572
Energy Production (GWh)	7,551	8,524	8,943	8,766	9,297

Note: * The depressed figure in 1971 is due to decreasing of the private generating facilities.

The country is divided into 7 blocks from the north and each block has its own power system. Blocks No. 2, 3, 4 and 5 covering the regions from Serena City to Puerto Montt City have interconnection systems exchanging energy among these blocks. Incidentally the generating facilities of Block No. 3 which include the capital city of Santiago is 1,159 MW and occupies 45 % of the entire facilities of the country. Together with Chiloe Province, Aisen Province where the project area is located, constitutes Block No. 6. Limited to Aisen Province, the generating facilities totals to 6.1 MW with energy production of 14.8 GWh. Per capita power consumption of Block No. 6 is 155 kWh. These figures are in the lowest level in this country. There is no large scale private power generation facilities and little increase is seen in the last five years in generating facilities as well as energy production. The power generation facilities and energy production are shown in Table - 3.2.

Table - 3.2 Generating Facilities and Energy Production in Province of Aisen

Name of Plant	Company	Type	Installed Capacity	Energy Production
			KW	MWh
Puerto Sanchez	E. Minera Aisen	Diesel	862	453
Puerto Cristal	"	"	122	64
Puerto Cristal	"	Hydroelectric	206	990
Puerto Cisnes	ENDESA	Diesel	56	64
Coihaique	"	"	810	557
Chile Chico	"	"	374	621
Puerto Aisen	"	"	400	50
Puerto Ibañez	"	"	150	92
Load Cochrane	"	"	150	112
Aisen	"	Hydroelectric	3,000	11,820
Total			6,130	14,823

By connecting three power plants, namely Aisen Hydroelectric Power Plant, Aisen Thermal Power Plant and Coihaique Thermal Power Plant with 23 kv transmission lines, ENDESA forms a power system which supplies energy to Puerto Aisen, Barmaceda and Puerto Chacabuco. As seen from Table-3.2, other cities are supplied with power from small scale diesel power plant during limited hours.

Chapter 4
HYDROLOGY

Chapter 4. HYDROLOGY

4.1 Hydrological Data

Meteorological stations and hydrological stations in the basin of The Baker River and Aisen province are as shown in Fig.-4.1. The hydrological data obtained during the field investigation comprise only of discharge data recorded at Bertrand and Colonia gaging stations. The history of these two stations is short and the record of daily discharge is merely for 12 years, during which there were periods of lack of observation data. Data obtained at these two stations are shown in Table-4.1.

Table - 4.1 Characteristics of Gaging Station on Rio Baker

Name of Station	Start Year	Elevation m	Catchment Area km^2	Specific Runoff $m^3/s/1000\,km^2$	Daily Runoff Mean	Max.	Min.
Bertrand	1963. 5	190	15,700	36.3	602.5	968	371
Colonia	1963. 4	70	23,820	38.4	864.5	3,240	403

In relation with the implementation of the project, a gaging station was established at the point 2 km downstream of the confluence of the Baker River and the Ñadis River in 1975. Another station is being planned at a point immediately downstream of a gorge which is 3 km down the said station. However, these two stations are not sufficiently equipped. No observation is made on the flow from Lake Cochrane nor on those from the Colonia River and the Ñadis River. As mentioned above, data required for hydrological analysis of the Baker River Hydroelectric Development project are not sufficient.

4.2 River Flow

The river flow used by ENDESA for the study is obtained by extending to 34 year data using correlation method the actual 12 year record on the Maniguales River and the Simpson River in the Baker River basin. However, since the characteristics of basin of the Baker River is different from those of the Maniguales River and the Simpson River, these correlation can not be substantiated. It is because the Baker River basin has large lakes such as Lake General Carrera and Lake Cochrane to serve as important source of water and in addition during the dry season from November to February large glaciers running from San Valentine Glacier melt to increase the flow of the Baker River. Meantime, although there are glaciers of smalll scale in the basins of the Maniguales River and the Simpson River, they are not considered to affect largely the amount of river runoff.

Therefore, actual data observed at Bertrand and Colonia Gaging Stations are used for hydrological study. However, a series of annual data lacking monthly data are used for calculating flood discharge but not used for deciding the scale of power generation. Table-4.2 shows the periods during which observation data are obtained at the two gaging stations.

Table - 4.2 Runoff Record at Bertrand and Colonia Gaging Station

Year / Station	1963	'64	'65	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75
Bertrand	5/1									11/30	4/1	3/31 6/1	8/29
Colonia	4/1												8/31

The durations at the two gaging stations are shown in Fig. -4.2 and Table-4.3, which the discharge records of which are shown in Tables-4.4, 4.5 and Fig.-4.3. According to these data, the annual mean discharge at Bertrand Gaging Station is 603 m^3/sec and that at Colonia Gaging Station is 865 m^3/sec.

4.3 Estimation of River Runoff

The area of the entire Baker River basin is 27,150 km^2, of which the area of basin at the damsite of Salton San Carlos is 25,220 km^2. The followings are the catchment area at each damsite and gaging station.

1) Bertrand Gaging Station C.A. = 15,700 km^2
2) Chacabuco Dam Site C.A. = 16,740 km^2
3) Tamango Dam Site C.A. = 18,240 km^2
4) Colonia Gaging Station C.A. = 23,820 km^2
5) Salton Gorge Dam Site C.A. = 25,200 km^2
6) Salton San Carlos Dam Site C.A. = 25,220 km^2

For estimation of discharge at each damsite for the Baker River Hydroelectric Development Projects, since there are only two gaging stations with actual data along the river, the discharge at each site is obtained from those at the gaging stations, in proportion to the basin area taking into consideration the characteristics of catchment of each station. The discharge at each damsite will be calculated as follows.

A) Chacabuco and Tamango damsites

$$Q = Q_B + (Q_C - Q_B) \times \frac{A}{A_C - A_B}$$

where, Q :: Discharge at damsite (m^3/sec)
Q_B : Discharge at Bertrand Gaging Station (m^3/sec)
Q_C : Discharge at Colonia Gaging Station (m^3/sec)
A_B : Catchment area at Bertrand Gaging Station (km^2)
A_C : Catchment area at Colonia Gaging Station (km^2)
A : Remaining catchment area at damsite (km^2)

B) Salton Gorge and Salton San Carlos damsites

$$Q = Q_C \times \frac{A}{A_C}$$

where, Q : Discharge at damsite (m^3/sec)
Q_C : Discharge at Colonia Gaging Station (m^3/sec)
A_C : Catchment area at Colonia Gaging Station (km^2)
A : Catchment area at damsite (km^2)

Monthly mean discharge thus calculated above for Tamango and Salton Gorge is as shown in Table-4. 6 and 4. 7.

4.4 Design Flood Discharge

The flood discharge at each damsite is estimated by Gumbel Method from the record at Bertrand and Colonia Gaging Stations. The results are shown in Table-4. 8 and Fig. -4. 4.

Table - 4. 8 Probable Flood Discharge (Unit ; m^3/sec)

Return Period	Chacabuco	Tamango	Salton Gorge
2	940	1, 300	2, 370
5	1, 100	1, 540	3, 190
20	1, 320	1, 850	4, 260
100	1, 560	2, 200	5, 500
1, 000	1, 900	2, 690	7, 130

Note: Effect of flood control by constructing a dam on upstream site is not considered in estimating the above figures.

From the above figures, design flood discharge for the spillway at each damsite is calculated as shown in Table-4. 9

Table - 4. 9 Design Flood Discharge (Unit ; m^3/sec)

Dam Site	Concrete Type	Fill Type	Remarks
Chacabuco	1, 870	2, 250	Concrete Type ; $Q_D = Q_T: 100 \times 1.2$
Tamango	2, 640	3, 200	Fill Type ; $Q_D = Q_T: 100 \times 1.2 \times 1.2$
Salton Gorge	6, 600	8, 000	

Maximum flood discharge in the past is used as the capacity of diversion tunnel at each site. Then 1,600 m^3/sec is at Tamango site and 3,500 m^3/sec at Salton Gorge.

4.5 Sedimentation

As the data for estimating sedimentation at the damsites on the Baker River and the record of sedimentation at other places are not available, it is very difficult to estimate accurate sedimentation. While there are two large lakes of General Carrera/Bertrand and Cochrane in the Baker River basin, the northern and south-eastern parts of the basin are in contact with glacier ridge. Judging from severe erosion by the glaciers and steep river slope and the results of river water analysis, sedimentation is considered comparatively heavy.

Comparison between the volume of sedimentation at reservoirs in western U.S and their catchment area is shown in Fig.-4.5. According to Fig.-4.5, sedimentation at each damsite is estimated with the results as shown in Table-4.10.

Table - 4.10 Sedimentation at each site

Dam Site	Sediment - Production Rate m^3/km^2/Year	Sedimentation $10^6 m^3$
Chacabuco	760	72
Tamango	580	139
Salton Gorge	450	301

Note: Reduction effect of sedimentation by constructing on upstream dam is not considered in calculating the above figures.

4.6 Water Quality

Raw water for analysis was collected at the center of the extended wide river at a point 4 km down the Nadis River, where the velocity is comparatively slow and water is fairly turbid. Water of 700 cc was directly collected by means of wine bottle thrown from a boat. The analysis results are shown in Table-4.11.
As shown in Photo 1, the grain diameter of most of suspended particles is 10 μm.

Table-4.11 Analysis of water quality of the Baker River

Item	Unit	Sample	Reference value
Hydrogen ion concentration	PH	6.5	5.8 - 8.6
Electric conductivity	μv/cm	6.0	Below 300
Sulfuric ion (S^{2-})	ppm	6.0	-
Sulfuric acid ion (SO_4^{2-})	ppm	8.0	Below 25
Hydrochloric acid ion (cl^-)	ppm	1.7	" 10
Ammonia ion (NH_4^+)	ppm	0.4	1
Turbidity	ppm	2.0	Below 10

Note: The reference values are those of industrial water in Japan.

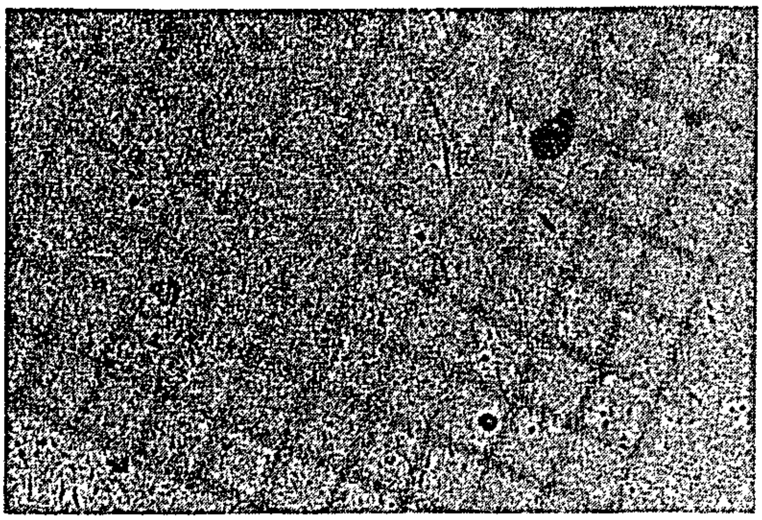


Photo-1 Microscopic photograph of filtered sediment of the Baker River (mesh: 70 m x 70 m)

Judging from the results of water analysis, except for somewhat high turbidity, the river water is fresh and contains little solubles. Most of the suspended particles seems to be fine sand. Therefore, it is presumed that there will be no large problems as to chemical effect of river water on power generation facilities. However, physical problems such as erosion of turbine blades and sedimentation in the reservoir will have to be studied in details.

Table - 4.3 Runoff Duration at Bertrand and Colonia Gaging Station

(1) Bertrand Gaging Station (Catchment Area 15,700 km^2)

(Unit: m^3/sec)

Year	Max.	95 Day	185 Day	275 Day	355 Day	Min.	Mean
1964	764	690	564	455	423	418	578
1965	901	783	660	564	451	443	667
1966	961	775	676	471	412	406	655
1967	814	617	572	479	401	397	558
1968	874	717	572	502	460	453	613
1969	966	684	596	470	422	416	602
1970	769	659	594	461	419	414	574
1971	715	600	550	435	397	385	530
Average	-	691	598	480	423	-	597

(2) Colonia Gaging Station (Catchment Area 23,820 km^2)

(Unit: m^3/sec)

Year	Max.	95 Day	185 Day	127 Day	355 Day	Min.	Mean
1964	2,529	1,079	862	697	515	480	905
1965	2,873	1,187	946	761	599	568	1,029
1966	2,390	1,115	942	700	537	515	943
1967	2,247	1,092	899	669	518	501	920
1968	2,650	1,121	850	674	591	573	925
1969	2,276	1,045	839	673	551	469	884
1970	1,560	966	754	638	520	502	817
1971	1,596	902	758	536	418	405	745
1972	1,989	1,000	777	515	427	415	804
1973	1,316	969	690	542	475	456	764
1974	1,229	905	743	544	477	467	756
Average	-	1,035	824	632	512	-	863

Table - 4.4 Monthly Average Specific Runoff at Bertrand Gaging Station

(Unit: cu. m/sec./1,000 km^2)

Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Average
1963	N	45.6	43.3	35.9	31.5	27.7	26.6	28.5	34.8	41.8	46.9	44.0	—
1964	43.6	43.9	41.6	32.7	29.5	27.4	27.7	29.1	34.5	42.5	52.9	50.8	38.0
1965	49.6	46.1	41.8	39.3	36.9	31.3	28.8	37.9	52.9	54.3	50.1	44.8	42.8
1966	43.2	43.6	55.8	50.3	38.7	31.0	26.9	27.5	30.1	33.9	39.2	38.3	38.2
1967	38.7	43.6	39.2	32.6	29.8	26.4	25.9	33.1	45.9	52.5	52.7	49.4	39.2
1968	39.2	37.5	34.0	31.9	29.7	32.4	31.4	33.4	44.5	43.3	43.4	43.3	37.0
1969	39.6	54.3	47.5	38.2	33.2	28.7	27.3	27.5	33.8	39.7	45.5	46.2	38.5
1970	41.5	40.5	41.8	35.3	31.0	28.6	27.1	28.4	33.7	38.8	37.2	37.1	35.1
1971	36.2	30.7	26.9	26.8	27.5	27.0	32.5	41.0	44.9	51.7	58.3	55.6	38.3
1972	49.2	46.9	37.3	30.0	26.0	24.1	24.5	28.0	N	N	N	N	—
1973	41.7	33.8	32.5	29.3	28.3	27.3	27.5	29.9	36.9	40.1	42.7	42.2	
1974	N	N	N	29.9	28.0	26.0	26.2	28.1	29.7	34.5	40.8	41.5	—
1975	40.4	38.0	33.2	29.7	26.4								
Average	41.5	42.5	41.1	36.0	32.0	29.1	28.4	32.2	40.0	44.6	47.4	45.7	38.4

N ; No-record

Table - 4.5 Monthly Average Specific Runoff at Colonia Gaging Station

(Unit: cu. m/sec./1,000 km^2)

Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Average
1963	46.1	43.0	41.2	29.5	24.6	21.5	25.4	28.0	42.4	58.8	51.1	44.0	38.0
1964	43.5	43.8	34.3	25.1	25.9	26.5	29.7	33.6	45.2	51.8	57.6	58.2	39.6
1965	47.2	41.3	37.0	31.7	33.3	28.3	29.6	54.7	48.6	52.8	49.4	50.5	42.0
1966	41.9	43.7	52.9	41.0	30.1	24.4	22.6	31.4	35.0	44.0	46.5	45.0	38.2
1967	41.6	48.2	31.4	28.3	26.5	22.1	25.6	48.4	56.3	59.6	53.2	45.1	40.5
1968	35.3	37.9	28.7	30.8	27.5	33.3	27.4	41.1	46.6	49.0	45.1	44.6	37.3
1969	38.2	52.3	35.8	31.6	26.4	27.3	25.4	26.7	40.9	43.3	52.8	42.7	37.0
1970	39.1	31.4	33.8	27.7	23.8	25.4	25.1	31.3	36.9	38.7	33.7	35.9	31.9
1971	29.2	24.5	20.9	23.5	24.0	26.7	34.2	42.2	39.5	52.8	46.9	40.8	33.8
1972	50.0	37.2	26.9	21.4	18.6	19.4	22.5	30.6	43.1	44.0	42.8	42.2	33.0
1973	34.8	23.4	30.7	21.0	23.7	23.6	25.4	32.4	41.9	39.3	41.7	41.1	31.6
1974	38.5	32.8	24.3	24.0	24.9	20.9	23.4	30.4	35.5	45.3	46.3	41.3	32.7
1975	40.3	29.9	23.9	22.1	21.3								—
Average	40.2	38.3	33.2	28.0	25.8	24.9	26.8	35.9	42.7	48.3	47.3	44.3	36.3

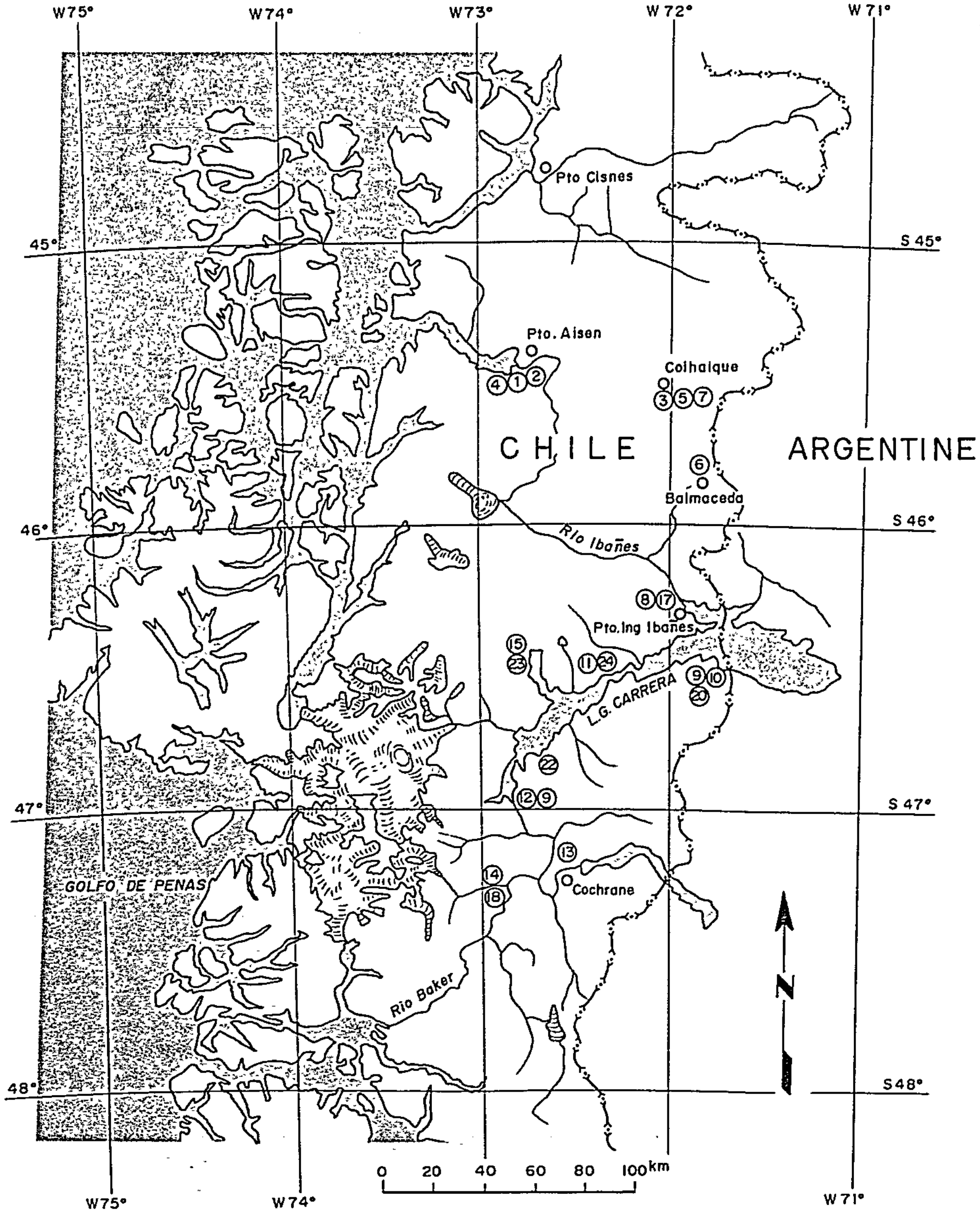
Table-4.6 Monthly Average Discharge at Tamango Dam Site Catchment Area 18,240 km^2 (Unit; m^3/sec)

Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Average
1964	794	800	704	540	511	492	520	565	709	889	887	803	685
1965	887	805	727	660	646	549	531	817	933	845	1001	982	782
1966	778	796	996	854	642	517	458	530	585	980	909	859	742
1967	728	829	657	562	519	450	470	718	915	694	769	748	672
1968	687	687	581	574	525	597	543	667	828	1011	965	870	711
1969	712	975	779	648	555	513	485	512	670	833	804	800	691
1970	739	671	703	587	511	497	479	540	638	752	884	816	651
1971	608	514	446	465	475	491	606	757	779	707	671	668	599
Average	742	760	699	611	548	513	512	638	757	839	861	818	692

Table-4.7 Monthly Average Discharge at Salton Gorge Dam Site Catchment Area 25,200 km^2 (Unit; m^3/sec)

Year	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Average
1964	1097	1104	866	632	651	668	750	848	1138	1482	1289	1110	970
1965	1189	1042	932	798	839	715	746	1380	1225	1305	1453	1468	1091
1966	1330	1246	1272	1055	1102	1334	1032	759	615	569	791	882	999
1967	1049	1213	792	713	668	557	645	1221	1420	1109	1171	1134	974
1968	889	956	722	776	694	839	690	1035	1174	1501	1340	1137	979
1969	963	1318	903	795	666	688	642	727	1031	1236	1136	1124	936
1970	985	792	852	699	600	639	632	789	930	1092	1330	1075	868
1971	736	618	526	591	604	673	862	1063	997	975	913	906	789
1972	1185	937	678	540	468	488	567	772	1686	1109	1078	1064	831
1973	877	590	774	529	597	594	643	816	1057	992	1051	1036	796
1974	866	827	612	606	627	528	716	765	896	1143	1168	1041	816
Average	1015	968	812	703	683	702	720	925	1052	1138	1156	1089	914

Fig.-4.1 Location Map of Meteorological Observatory and Runoff Gaging Stations



A) Meteorological Observatory Station

Area	Name of Station	Elevation	Type	Start Year	Executive Organ
Aisen	1. Pto. Aisen	10m	MT	1931	DGA
	2. Pto. Aisen	10	PV	1968	ENDESA
	3. Coihaique	771	PV	1929	DGA
	4. Pto. Chacabuco	8	PV	1965	DGA
	5. Coihaique Bajo	140	PV	1920	OMC
	6. Balmaceda	520	MT	1953	OMC
	7. Coihaique	275	MT	1942	OMC
Rio Baker	8. Pto. Ibañez	—	PV	1961	DGA
	9 Chile Chico	215	MT	1963	DGA
	10 Lago en Chile Chico	212	PV	1954	OMC
	11 Pto. Cristal	25	PV	1960	OMC
	12 Pto. Bertrand	—	PV	1961	DGA
	13 Lago Cochrane	100	MT	1964	ENDESA
	14 Colonia	105	PV	1963	ENDESA
	15 Pto Murta	—	PV	1961	ENDESA
	16 Tenencia lago Carrera	—	PV	1967	DGA

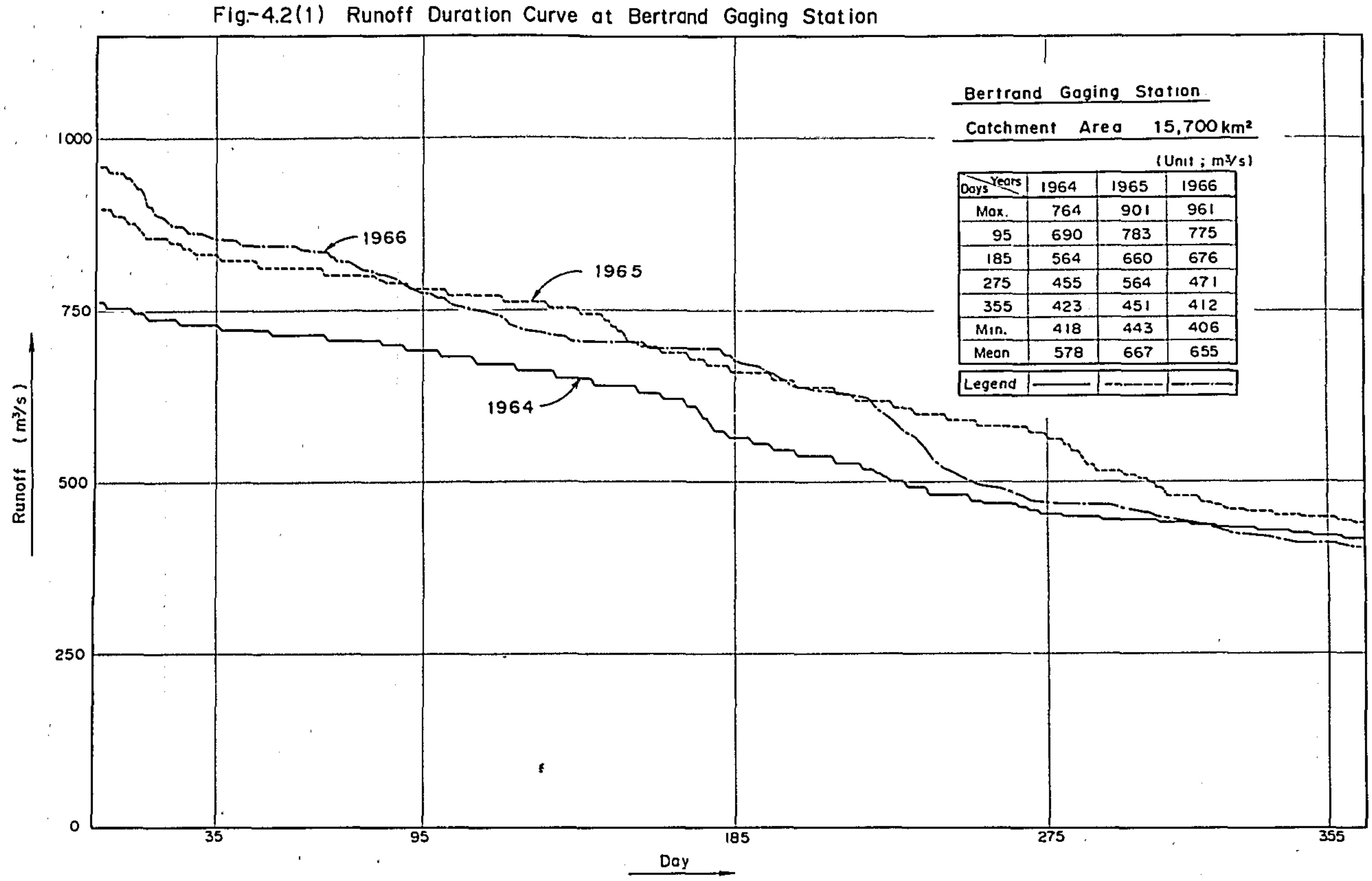
MT ; Meteorological observatory
PV ; Pluviometer

B) Runoff Gaging Station

Area	Name of Station	Elevation	Type	Start Year	Executive Organ
Rio Baker	17. Ibañes en Desembocadura	217m	Lm-LG	1963	ENDESA
	18. En Colonia	105	Lm-LG	1961	ENDESA
	19 En Desague L.Bertrand	200	Lm-LG	1963	ENDESA
	20. En Chile Chico	215	Lm	1961	ENDESA
	21 Pto. Sanchez	215	Lm	1959	ENDESA
	22 Pto. Guadal	215	Lm	1959	ENDESA
	23 Murta en Lago	219	Lm-LG	1963	ENDESA
	24 En Pto. Cristal	215	Lm	1961	ENDESA

Lm ; Staff Gage
LG ; Automatic Gage

Fig.-4.2(1) Runoff Duration Curve at Bertrand Gaging Station



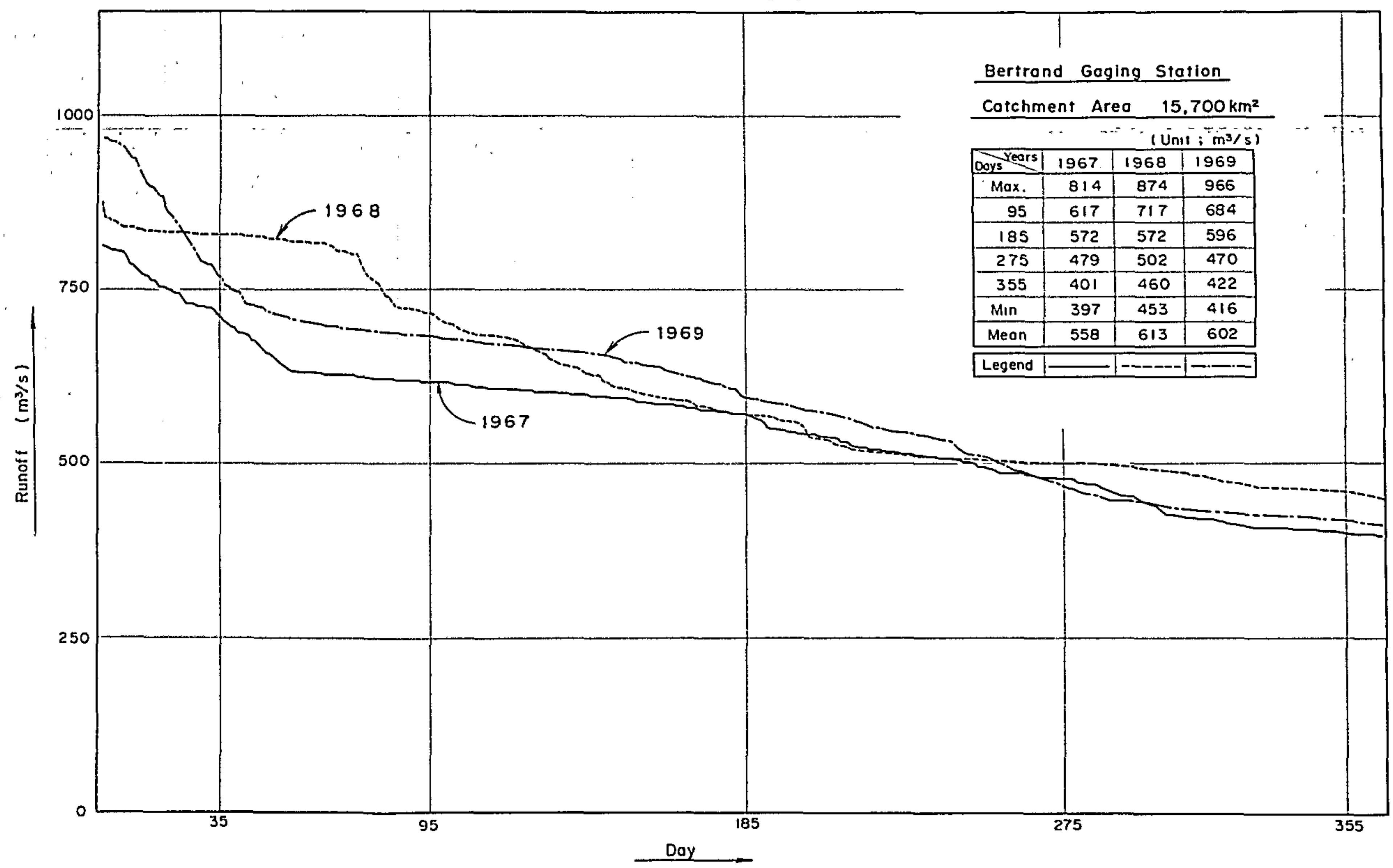
Bertrand Gaging Station

Catchment Area 15,700 km²

(Unit ; m³/s)

Days \ Years	1964	1965	1966
Max.	764	901	961
95	690	783	775
185	564	660	676
275	455	564	471
355	423	451	412
Min.	418	443	406
Mean	578	667	655
Legend	———	- - - - -	—·—·—

Fig.-4.2(2) Runoff Duration Curve at Bertrand Gaging Station



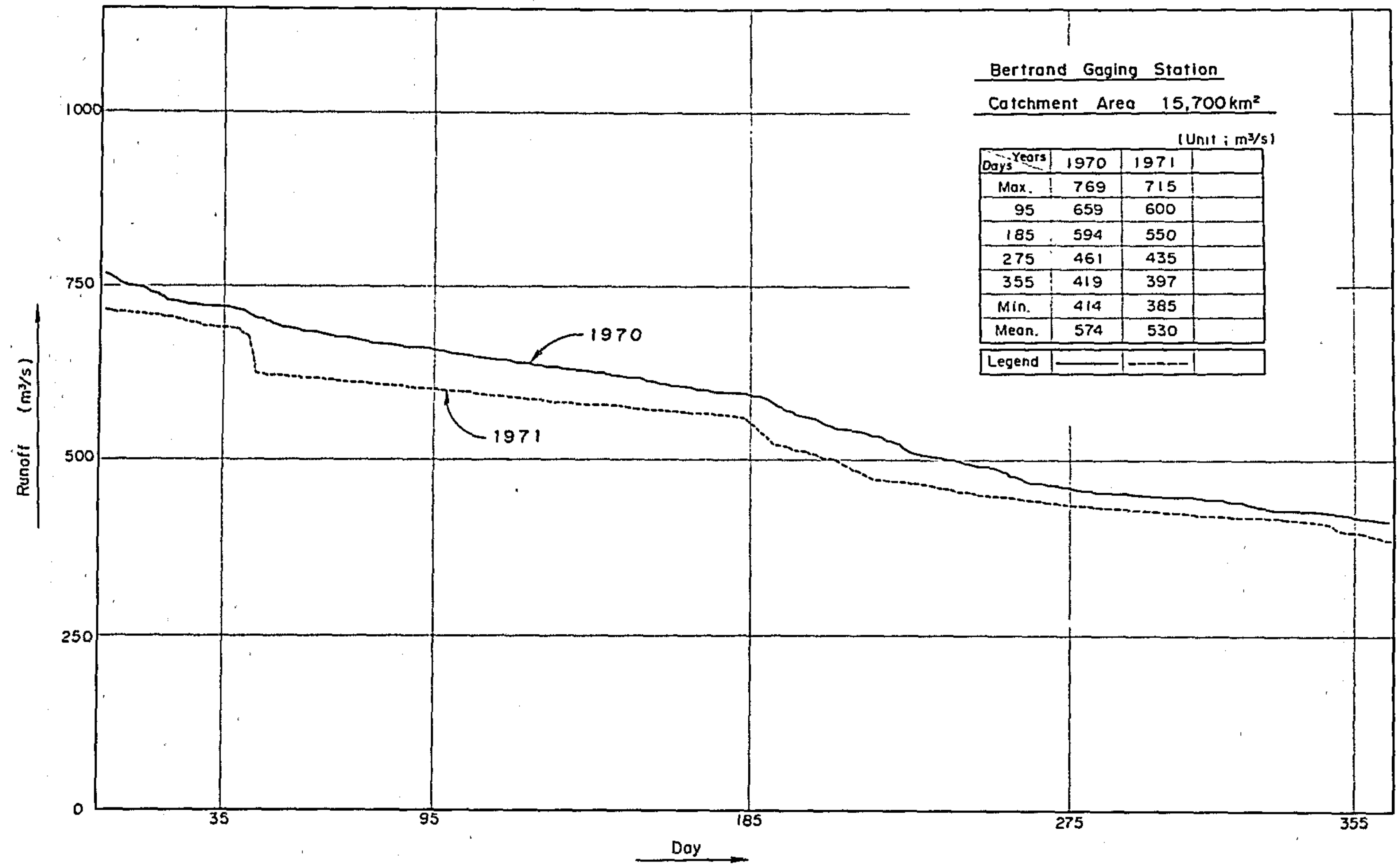
Bertrand Gaging Station

Catchment Area 15,700 km²

(Unit ; m³/s)

Days \ Years	1967	1968	1969
Max.	814	874	966
95	617	717	684
185	572	572	596
275	479	502	470
355	401	460	422
Min	397	453	416
Mean	558	613	602
Legend	———	- - - - -	—·—·—

Fig.-4.2(3) Runoff Duration Curve at Bertrand Gaging Station



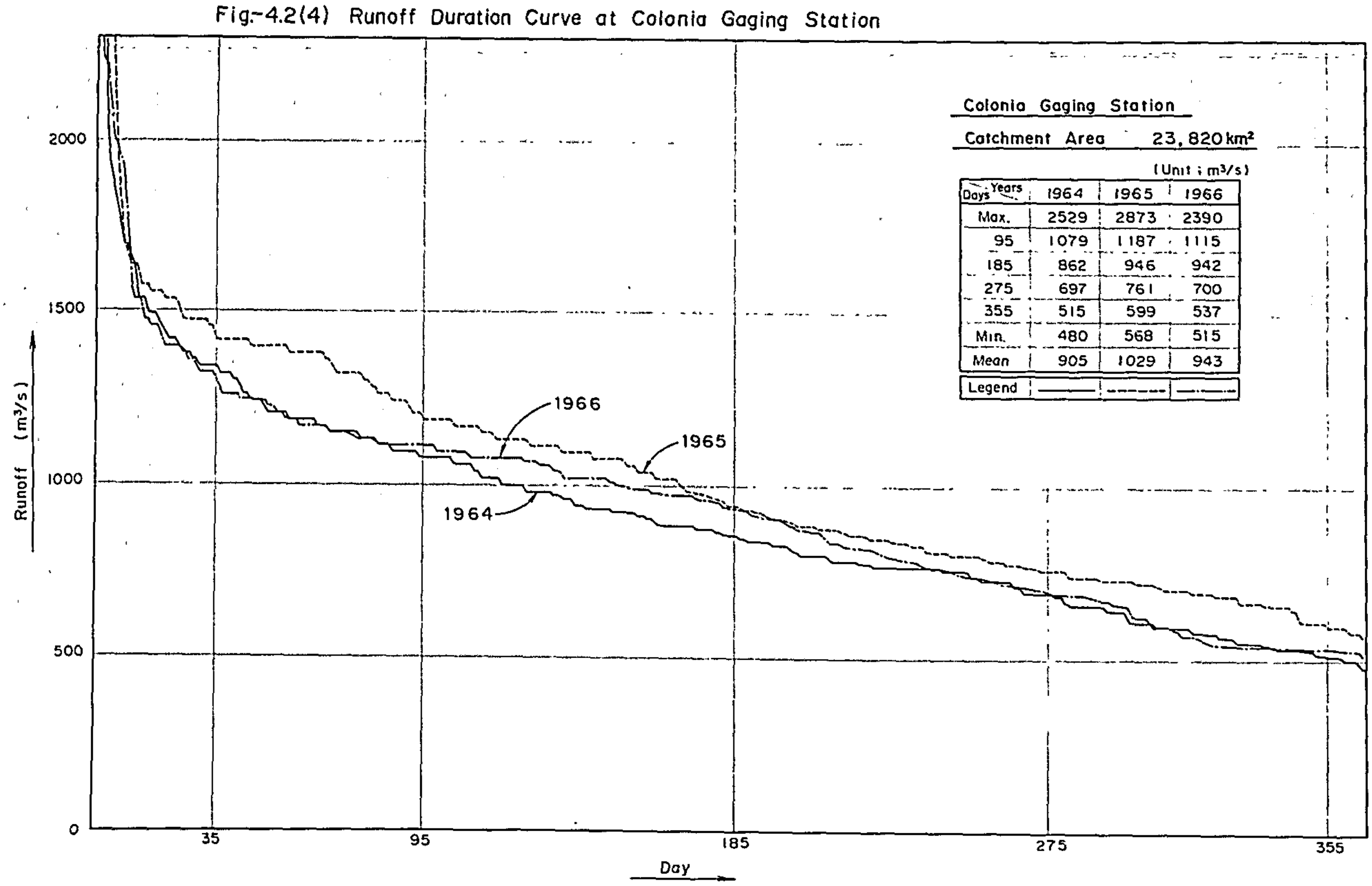
Bertrand Gaging Station

Catchment Area 15,700 km²

(Unit ; m³/s)

Days \ Years	1970	1971	
Max.	769	715	
95	659	600	
185	594	550	
275	461	435	
355	419	397	
Min.	414	385	
Mean.	574	530	
Legend	———	- - - - -	

Fig.-4.2(4) Runoff Duration Curve at Colonia Gaging Station



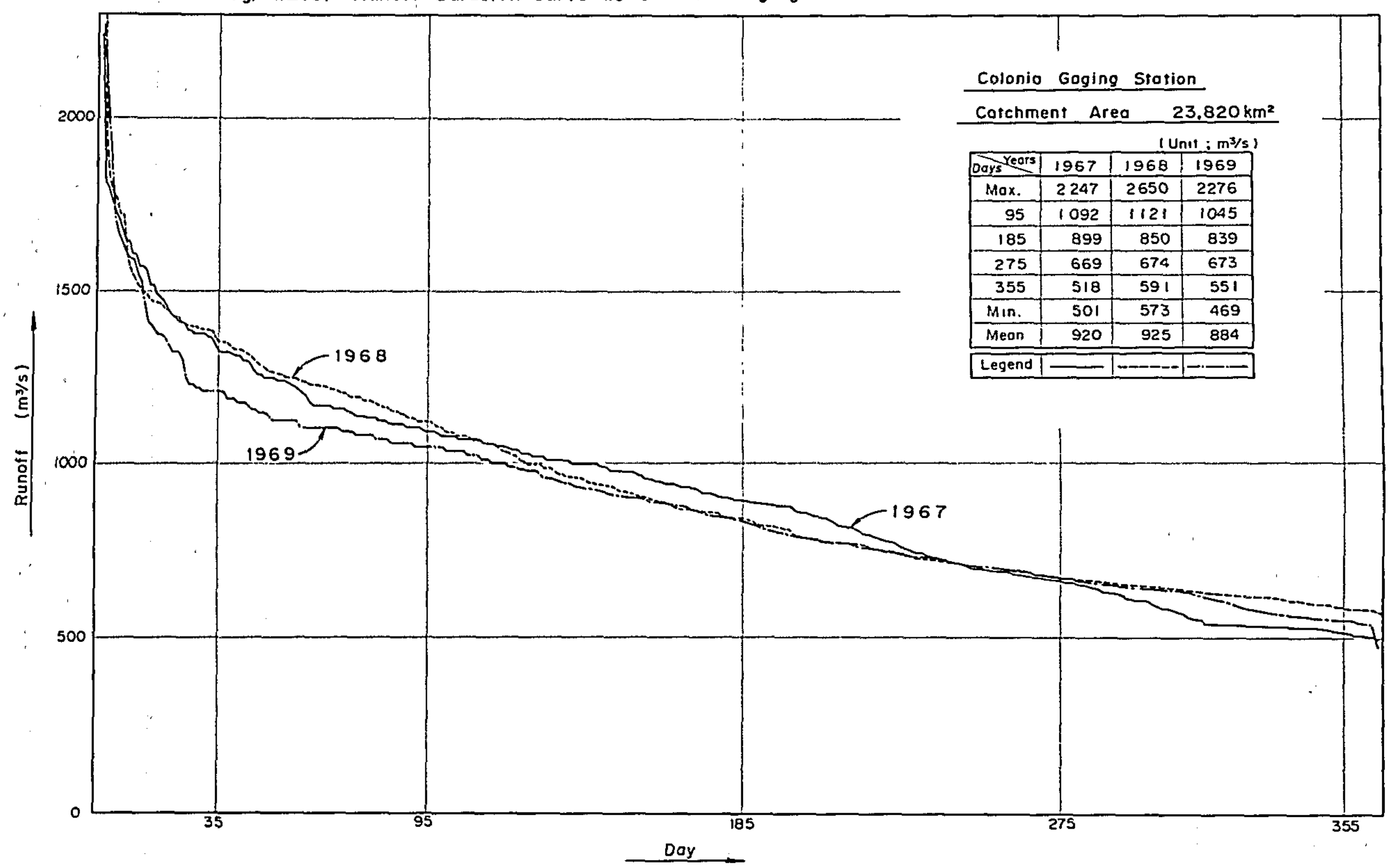
Colonia Gaging Station

Catchment Area 23,820 km²

(Unit ; m³/s)

Days \ Years	1964	1965	1966
Max.	2529	2873	2390
95	1079	1187	1115
185	862	946	942
275	697	761	700
355	515	599	537
Min.	480	568	515
Mean	905	1029	943
Legend	———	- - - - -	—·—·—

Fig.-4.2(5) Runoff Duration Curve at Colonia Gaging Station



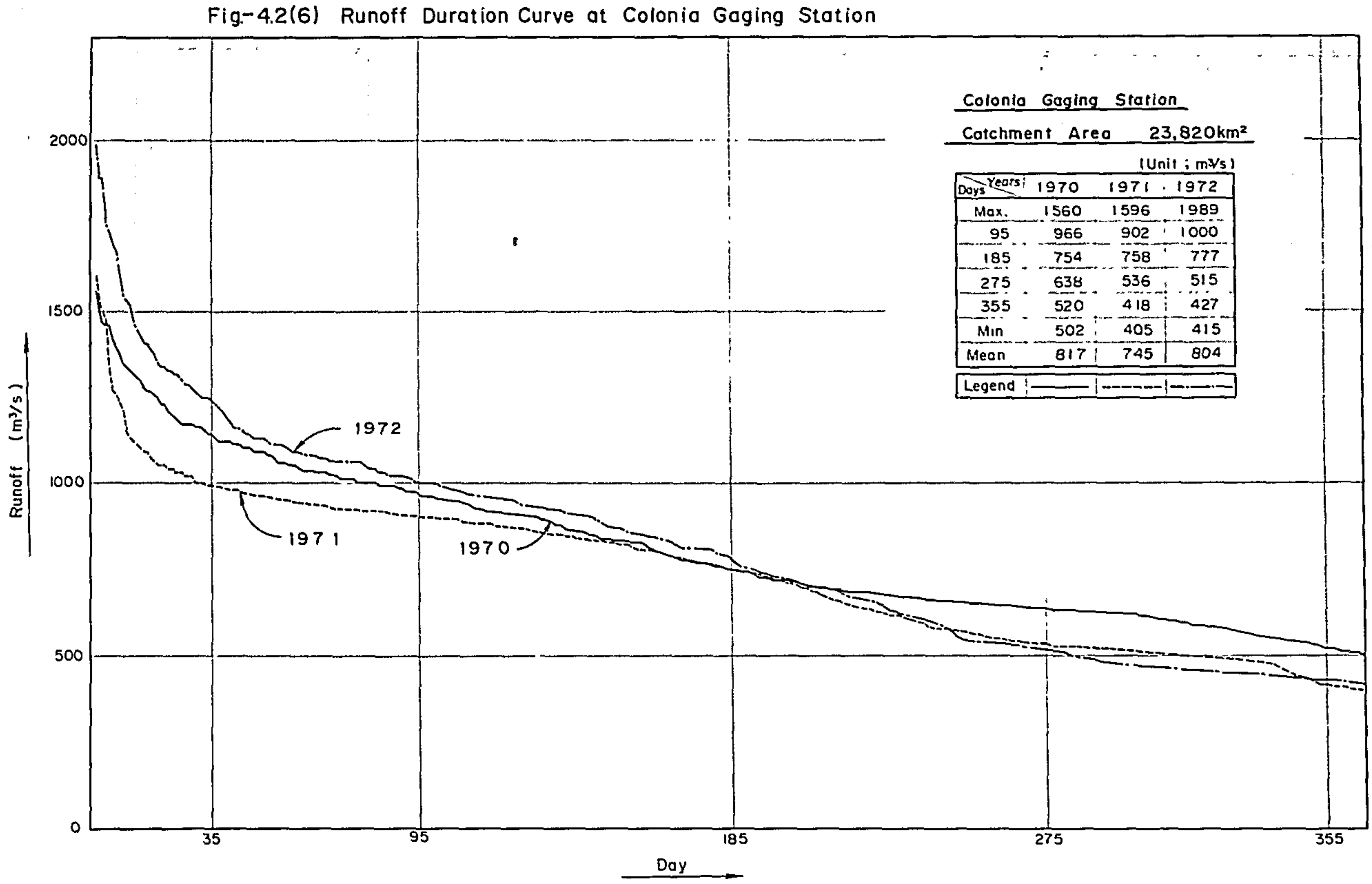
Colonia Gaging Station

Catchment Area 23,820 km²

(Unit ; m³/s)

Days \ Years	1967	1968	1969
Max.	2 247	2650	2276
95	1 092	1121	1045
185	899	850	839
275	669	674	673
355	518	591	551
Min.	501	573	469
Mean	920	925	884
Legend	———	- - - - -	-·-·-·-

Fig.-4.2(6) Runoff Duration Curve at Colonia Gaging Station



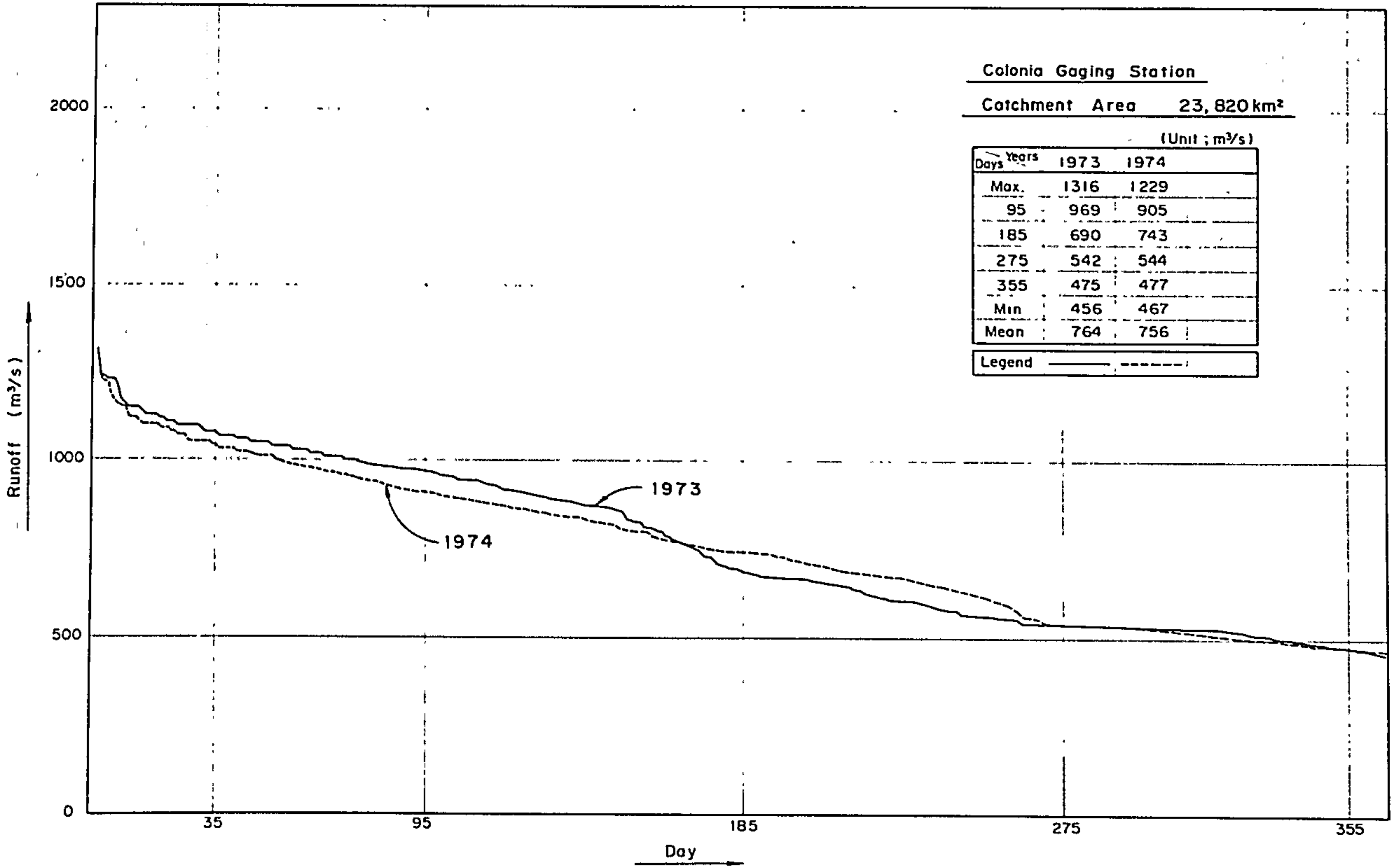
Colonia Gaging Station

Catchment Area 23,820km²

(Unit ; m³/s)

Days \ Years	1970	1971	1972
Max.	1560	1596	1989
95	966	902	1000
185	754	758	777
275	638	536	515
355	520	418	427
Min	502	405	415
Mean	817	745	804
Legend	———	- - - - -	-·-·-·-

Fig.-4.2(7) Runoff Duration Curve at Colonia Gaging Station



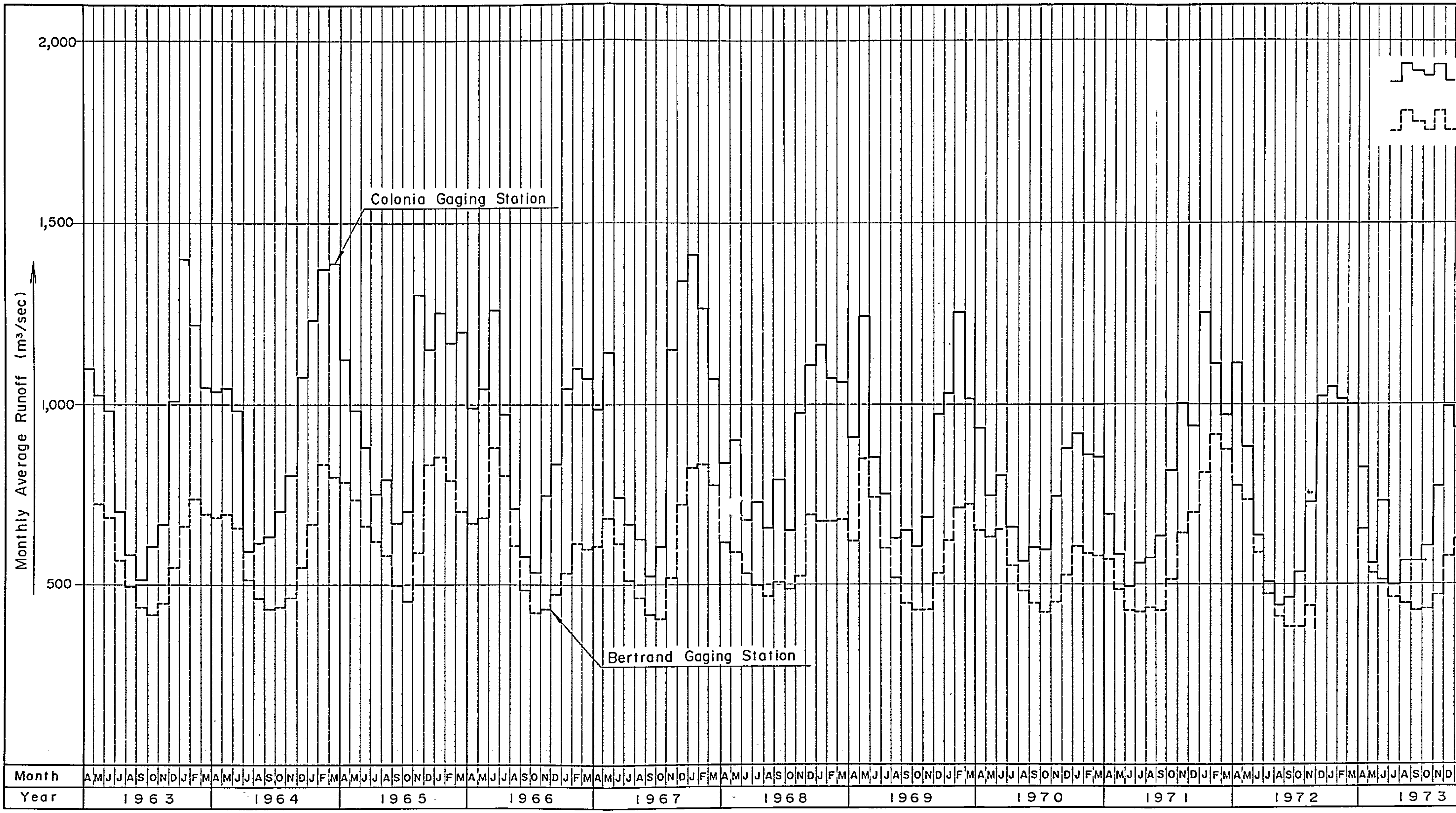
Colonia Gaging Station

Catchment Area 23, 820 km²

(Unit ; m³/s)

Days \ Years	1973	1974
Max.	1316	1229
95	969	905
185	690	743
275	542	544
355	475	477
Min	456	467
Mean	764	756

Fig.– 4.3   Monthly Average Runoff at Bertrand and Colonia Gaging Stations



erage Runoff at Bertrand and Colonia Gaging Stations

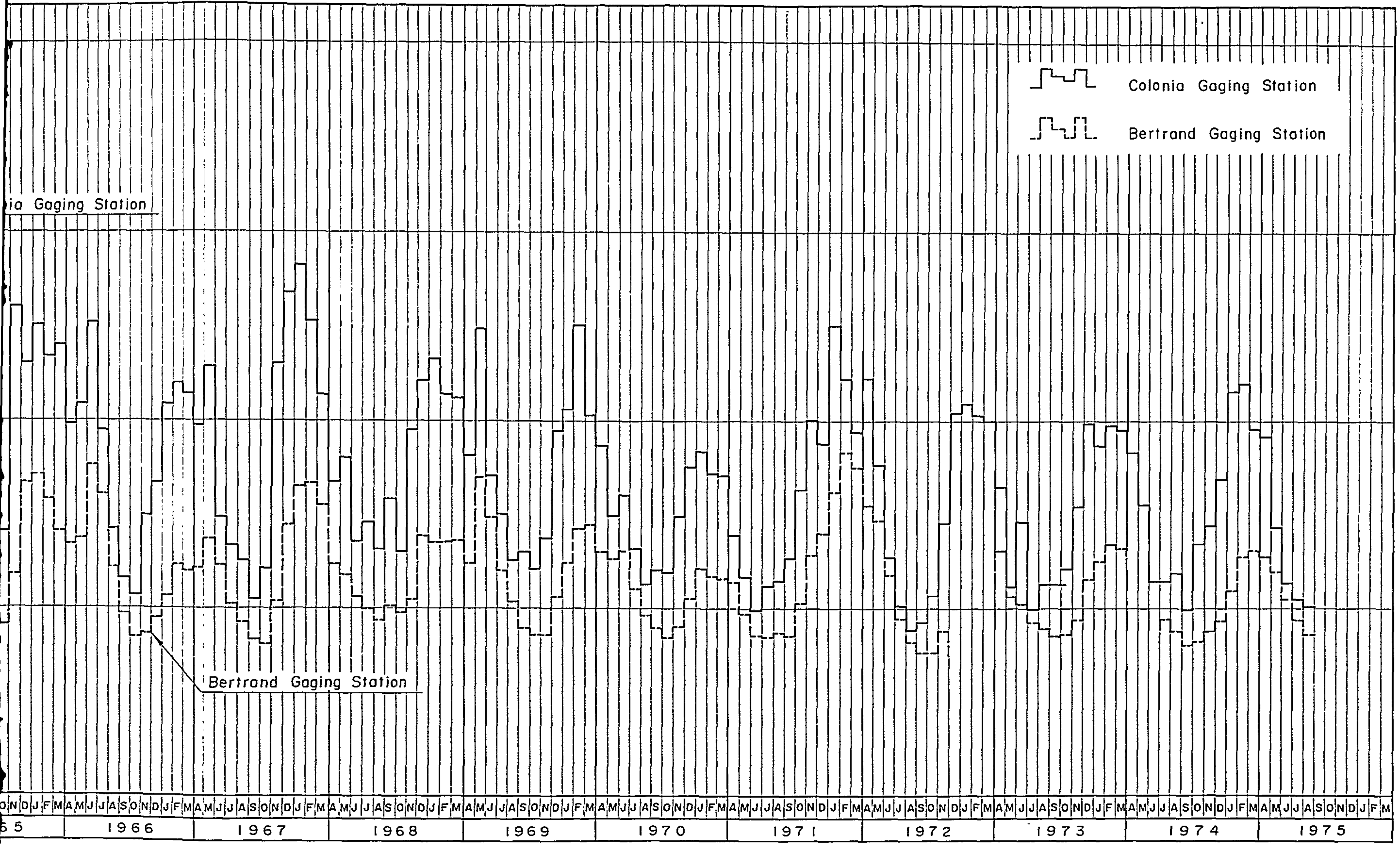


Fig.— 4.4 Probable Flood Discharge

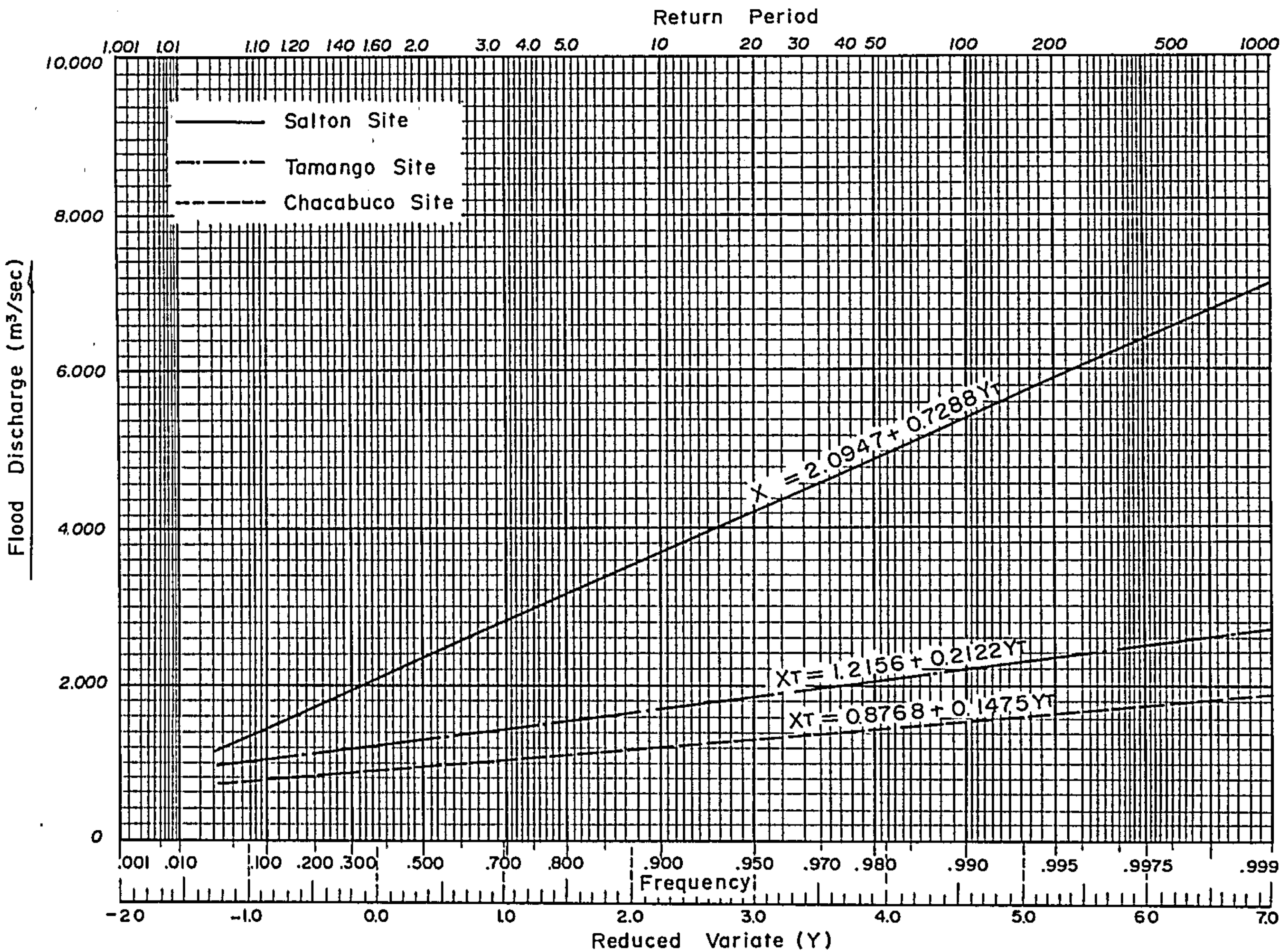
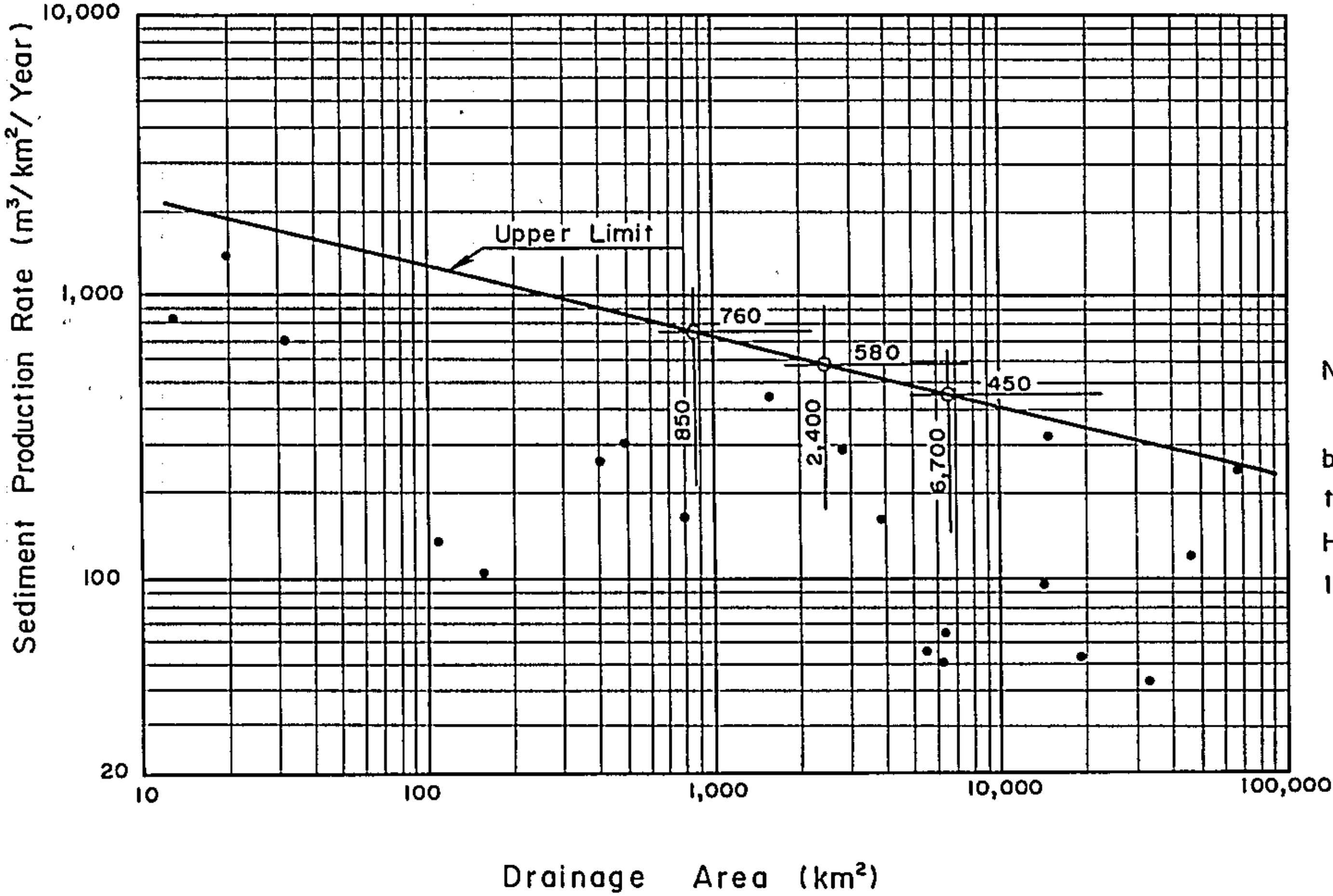


Fig.— 4.5 Rates of Sedimentation of Selected Reservoir in the Western United States



Note ;

The figure was prepared by using the data shown in the "Hand Book of Applied Hydrology. by VEN TE CHOW 1964"

Chapter 5
GEOLOGY

Chapter 5. GEOLOGY

5.1 General Geology

5.1.1 Topography

The Baker basin, in the longitude from 72° to 74° west and in the latitude from $46^{\circ}30'$ to 48° south, is located in the middle part of the Pacific Ocean coast of the Patagonia. The basin, faced to the fiord of the Pacific Ocean coast, is bounded on the north by the glacial ranges having the highest peak of the Patagonian Andes, Mt. San Valentin (EL 4,058 m) and on the southeast by the glacial mountains embracing Mt. San Lorenzo (EL 3,700 m).

In the western half of the region, the Mesozoic granitic mass are predominantly observed and the Paleozoic metamorphic complex in the eastern half of the region. In the northeastern quarter of the region, there are the Jurassic volcanic formations consisted mainly of andesitic ryolitic rocks, and the Tertiary sedimentary formation consisted of marine and continental deposits.

The topography of this region is characterized by the past glaciation and the regional geological structure.

On the eastern flank of the Patagonian Andes, the various lakes such as Lake General Carrera (about 1,893 km^2 in water surface EL 205 m), Lake Cochrane (about 380 km^2 in water surface EL 154 m), Lake O'Higgins (about 1,000 km^2 in water surface EL 285 m) etc. are scattered.

The Baker River starts at the Lake General Carrera. It is led to Caleta Tortel on the Pacific Coast after crossing the main Patagonian Andes from east to west, and joining with some large tributaries such as the Nef, Salto, Colonia, Ñadis and Ventisquero Rivers.

5.1.2 Rock Type

The metamorphic basement complex consisting of black shale, filite, quartz schist, green schist, calcareous schist and marble are widely developed in the region. The calcareous schist and marble are observed very partly in the northern part of the region, specially in the western part of the Lake General Carrera. The green calcareous schist is rarely observed in the northern half part of the region. The thickness of the metamorphic basement complex is not yet confirmed.

The metamorphic basement complex is overlain unconformably by the Jurassic volcanic rock formation, consisting of andesite lava, andesitic pyroclastic rocks and tuff accompanied with dacite and dolerite dykes, of which total thickness is estimated at 500 m approximately. These volcanic rock's are exposed;

(1) in the western part of Lake General Carrera

(2) around the confluence of the Baker and Chacabuco Rivers

(3) in both sides of the Chacabuco River

(4) in the western area of Cochrane village bounded by rivers of main Baker, Cochrane and Salto Rivers.

(5) near the confluence of the Salto River and the Tranquilo River

(6) in the proposed Tamango dam site

At the portion between the said volcanic rock and the metamorphic basement complex, some sedimentary rocks such as conglomerate and black shale having several centimeters and about 30 meters in thickness are in partly observed.

Tertiary rock formations originated of marine and continental sediments such as fine grain conglomerate, sandstone, siltstone, mudstone and limestone are also observed in the area. The thickness of these sedimentary formations are estimated by H.R. Katz (1962) more than 1,000 m. However, these formation are observed neither at the proposed dam sites nor alternative dam sites on the Baker River, but these formations are only observed at the portion between the south coast of the Lake General Carrera and the northside of the Chacabuco River.

As the Quaternary deposits, glacial deposits at the last stage of glaciation age are predominant in the valley of glacier origin (including rivers and lakes). Generally they consist of the marine deposits and lake deposits such as varve clay. The amount of varve clay in the region is considerable large and the varve clay has been deposited even in the recent age. The degree of weathering and decomposition of the foundation rock surface are comparatively light or thin in general.

The western half part of the region is consisted of the instrusive rock mass such as granite, granodiorite and small diabasic rock body.

5.1.3 Geological Structure

This region can be separated in various blocks by the geological structures or the eminent faults which are developed along the line of NNW and NEE direction. The main blocks are as follows;

(1) In the west coast of Lake General Carrera and at the north side of the Leon River, the volcanic rock formations are mainly distributed, meantime at the south side of the above area, only the metamorphic basement complex are observed.

(2) The Tertiary sedimentary formations are developed in the northern side of the Chacabuco River, but the southern side are consisted of the metamorphic basement complex and volcanic formations.

(3) Near the Tamango alternative site on the Baker River and in the western side of the river, there are the volcanic formation, and in the eastern side

there are mainly metamorphic basement complex.

(4) In the northern side of the Cochrane River there are the metamorphic basement complex, and the volcanic formation is deposited in the southern side of the river.

(5) Along the Nadis River, in the western side there are the granitic rock formation and in the eastern side the metamorphic basement complex is outcroped.

Generally, in the northern half of the region, the folding axis and schistosity in the metamorphic basement complex is mainly of the direction of NNE. In the central zone, the direction of EW is predominant, and NE direction in the southern half of the region.

The recent structural movement is registered in post Miocene, and it is characterized by the faults with NEE and NNW directions, and by the large scale foldings with the axis of EW direction.

5.2 Site Geology

5.2.1 Chacabuco Dam Site

The gorge area, in which the Chacabuco dam site is proposed is judged the most favourable site for the compact arrangement of dam, powerhouse, spillway, diversion tunnels and other main structures from the topographical conditions. However, the gorge area is situated in the middle of a big tectonic zone, and many faults or heavy sheard zones are observed in the surrounding area. Especially, at the proposed dam site, the right abutment was heavily sheared by many faults. One of these faults runs at near the dam axis and fractured zone by these faults is more than 10 meters in width. The direction of these faults is N 20°E, 80°W and NS 60°W and some of them cross over the river toward the left bank. While the right abutment of the site was sheared heavily, the condition of the left abutment side seems not to be so disturbed compared with that of the right abutment. The foundation rock in the site consist of very sound and fresh crystalline basement (cholorite-quartz-schist, N 18°E in schistosity), and no difference in the direction of schistosity is observed on both abutments.

Considering the direction of actual river flow and surrounding geological conditions, it is possible that the gorge has been formed along some big faults or fractured zones as the result of deep erosion of them.

It is very difficult to judge whether the fault is active or not. However, even though presuming that the faults and fractured zones at the site were occured by the heavy tectonic movement in the past Tertiary period, and they are not active in the recent, yet, these faults and sheared zones are unfavourable as the foundation condition of main structures such as dam, powerhouse and spillway from the geological view point.

Accordingly, the further detail geotechnical investigations and studies for the foundation treatment will be required spending considerable amount of expense and time in the future. (As shown in Fig.5-1)

However, since various conditions excepting for geological condition are favorable for implementing the project, ENDESA intends not to abandon instantaneously the proposed Chacabuco site in spite of unfavorable investigation results. ENDESA will make final decision upon confirming various pointed problems by further geological survey to be continued.

The following investigations are suggested to be performed by ENDESA.

(a) Seismic prospecting exploration on both river banks shall be conducted arranging grids of exploration lines as adequate as possible.

(b) Further surface geological survey shall be conducted in detail.

(c) Investigation adits shall be excavated and the fractured zone shall be precisely confirmed by direct observation.

(d) In-site rock mechanical tests on shear strength and deformation modulus etc. shall be performed in the adits to be excavated in fractured or weak zone.

(e) Existence of fractured zone and faults in the gorge shall be examined by core drilling and permeability tests from both river banks.

The investigation team were required by ENDESA to make further site selection in the upstream and downstream reaches of Chacabuco site, in case Chacabuco dam site be regarded unfavorable from geological view points.

Accordingly, two sites were investigated besides Chacabuco, the one is in the gorge around the confluence of the Baker River and the Nef River, and another is in the gorge about 2 km downstream of Chacabuco site.

The investigation resuts disclosed that both sites were on the tectonic zone as same as Chacabuco site and there are many faults and severely fractured and sheared zone. Main faults and fractured zone on both sites are developed in the direction from up to downstream along river flow.

Consequently, these two sites were judged not to be adequate for dam construction.

5.2.2 Tamango Dam Site

Tamango dam site is located at the narrow-gorge about 3.5 km down the confluence with Chacabuco River, where the Baker River turns its course south at right angle.

The rock foundation of the site consists of several phyroclastic andesite lavas with columnar and horizontal joints. At the area just downstream of the site, chrolite-quartz-schist basement is widely exposed. Rock formation at the right abutment is mostly exposed without weathering, but the left abutment is covered with comparatively thick talus and terrace deposits. No eminent fault and fractured zone are observed in the site. The left bank of the site forms very steep slope such as cliff or topographic overhang, and the gorge is deep more than 20 meters.

Taking into consideration the above-mentioned conditions, the following problems are pointed out for the construction of fill type dam from geotechnical views.

(a) Special treatment such as large scale trimming by the excavation or back fill concrete placement for the deep gorge and for steep slope of the abutments will be required.

(b) The impervious core zone of dam shall be laid out to evade the saddle on the left bank, or the saddle shall be flattened by excavation and embankment.

(c) Possibility of existence and the thickness of the black shale between pyroclastic lava and crystalline schist basement shall be examined at the dam site, and various physical characters of the black shale, if any such as bearing strength, permeability and shearing strength shall be examined.

(d) In view of the possibility of considerable water leakage through intensively developped joints and cracks in the foundation rock of the damsite, it will be an important part of geological investigation to execute permeability tests and grouting tests elavorately enough for the detailed design of foundation treatment.

Even though the Tamango dam site has still some problems in both geological and topographical aspects, it will appropriately be an alternative dam site for the Chacabuco site in case a large amount of expense be required for geological investigations and construction at the Chacabuco site in the future.

5.2.3 Salton San Carlos Dam Site

The dam site is located at the end of rapid area on the Baker River near San Carlos, where the river largely changes its flow direction to the left and runs toward WNW direction. The river is about 250 meter in width at the proposed dam site. The average water level of the river at the dam site is about EL 32 m and the ridge on both sides of the river are more than 170 meters above the river water level, having about $35^{o} \sim 40^{o}$ in slope. However, the depths of the water and deposits on the river bed at dam site are not yet surveyed in detail. The abutments on both sides of dam site consists of mainly granodiorite and some dikes. These rocks are completely exposed without weathering and provides very fresh and sufficient soundness.

Several faults and fractured zone filled with the acidic and basic dikes such as dacite or quartz-porphyry and dolerite, are observed on the both abutments. Many vertical joints are also developed, but most of them are closed.

Generally the Salton San Carlos dam site is regarded to be favorable for construction of high dam from the geotechnical and topographical views. In order to confirm the conditions of the river bed, water depth and sedimentary deposits etc., the sounding or investigation works should be required to conduct as soon as possible. The execution of these works are especially important for the final selection of the dam site and the estimation of the construction cost of the project.

As the seismic prospecting and core drilling are deemed not easy to execute for the investigation of the river bed, sonic prospecting exploration is suggested to be performed or a boat as a first approach.

Upon confirming by the suggested method depth of river, characteristics and depth of river deposit and upon judging the technical feasibility of the dam site, it is recommendable to proceed to the further geological investigations on both banks such as seismic prospecting exploration, core drilling, permeability tests, visible observation in adits and more precise topographical survey.

The results of the field investigation in the present stage are summarized in Fig.5-2.

5.2.4 Salton Gorge Dam Site

In case the Salton San Carlos dam site be judged unfavorable for dam construction from geological and economical views, a narrow gorge located on the main Baker about 3.5 km upstream from Salton San Carlos is recommendable as the alternative dam site even though a few meter of effective head would be sacrificed. The said gorge lying in a southwest direction is about 700 m long, and 30~40 m in width. Several meters of hydraulic head is supposedly available at the Salton Gorge site. The average elevation of the gorge is about EL 40 m and the ridges on the both sides are more than EL 200 m.

The proposed alternative dam site consists of very sound and fresh granodiorite in the whole area, and some dikes such as dacite or dolerite intruded along the fractured zones and filling up them completely. Across the gorge, in particular on the right abutment, several eminent faults EW 80°S and joints N 50° E, 90° are observed. Especially at the right abutment upstream, there is a wedge shape portion which is bounded by two eminent faults and is broken into many blocks. Other part is completely exposed without weathering and quite good for foundation. On the other hand, some talus deposits comparatively thin and narrow are observed in the vicinity of the left abutment of dam axis. In general the foundation rocks consisting of granodiorite and acidic or basic dikes are judged to be sufficient sound and fresh. Any faults or fractured zone parallel with the gorge are not found. Accordingly, it is judged that the proposed site provides the best conditions for construction large dam from such standpoints as strength, durability, permeability, structural characteristics of rock foundation and topography. The result of surface geological survey is as shown in Fig.5-3.

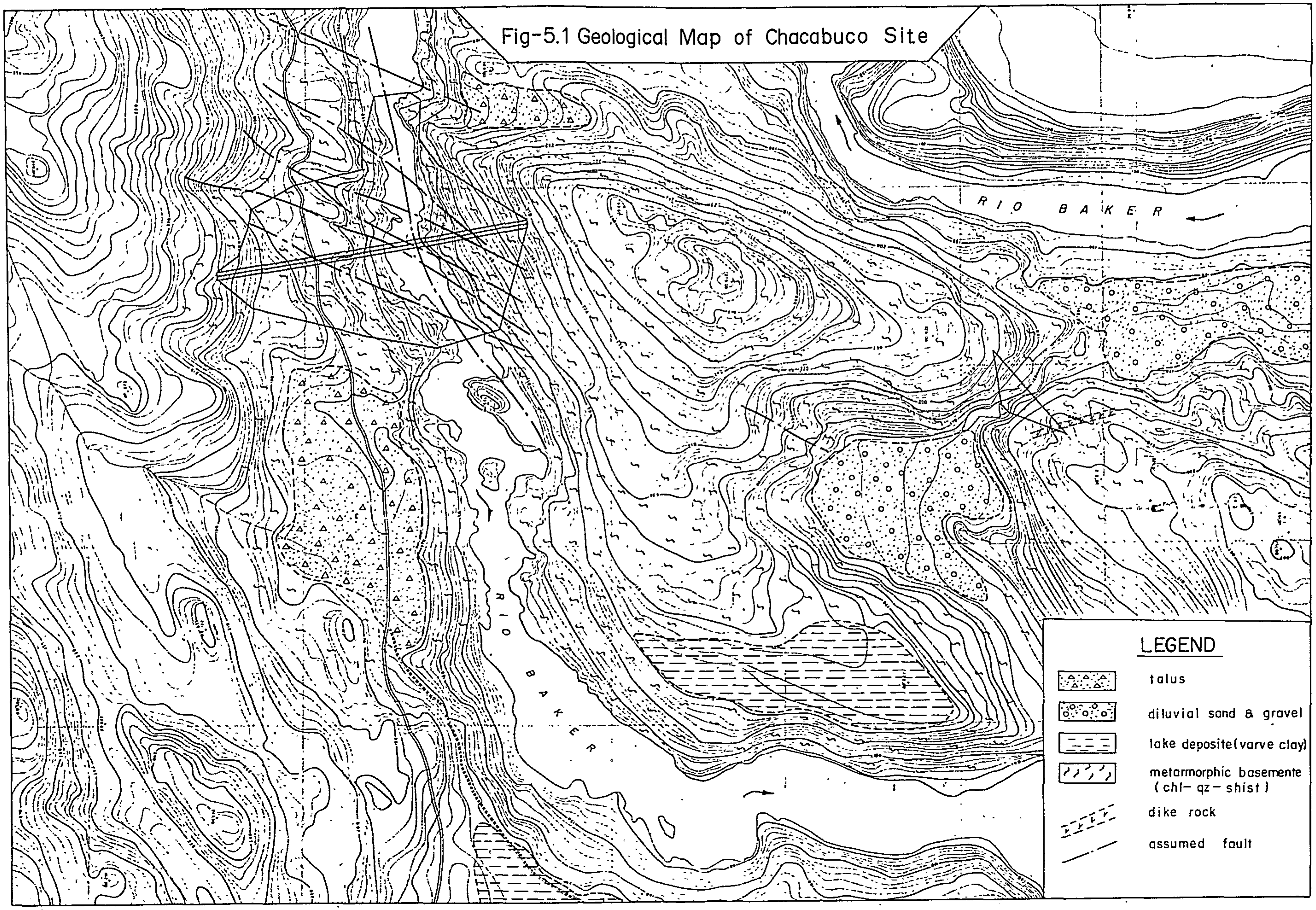
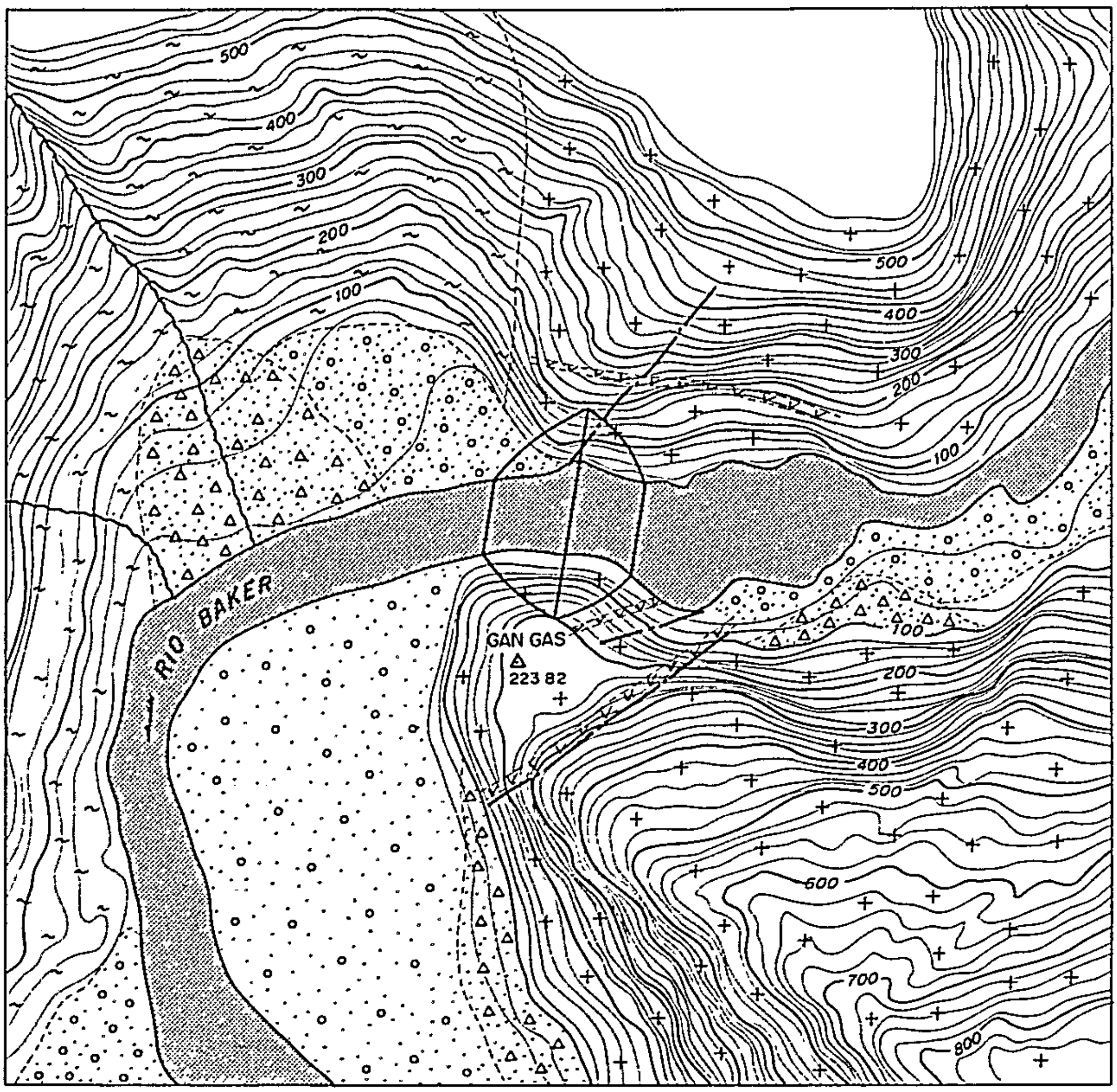


Fig-5.1 Geological Map of Chacabuco Site
RIO BAKER
RIO BAKER
LEGEND
talus
diluvial sand & gravel
lake deposite(varve clay)
metarmorphic basemente
(chl- qz- shist)
dike rock
assumed fault

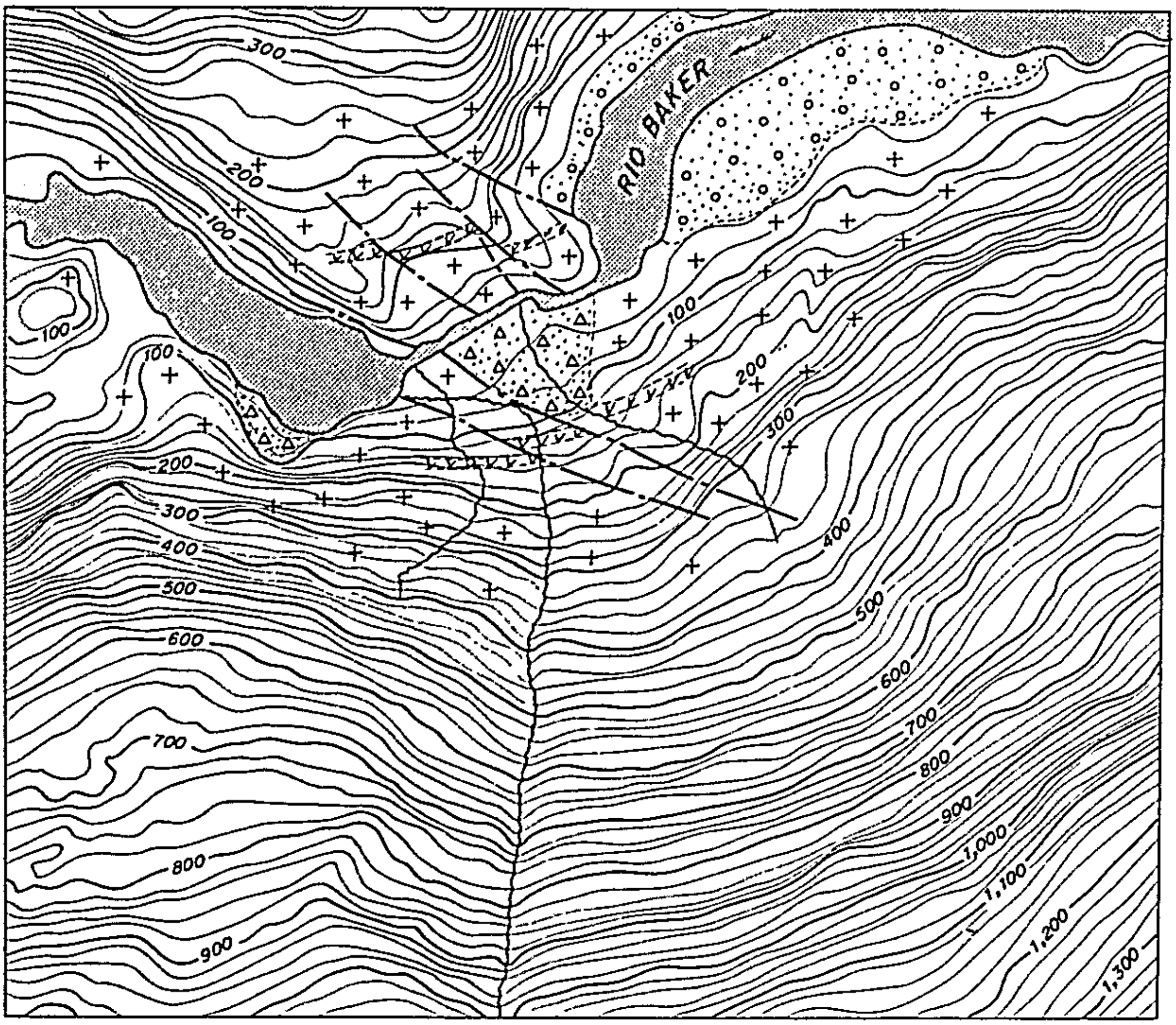
Fig-5.2 Geological Map of Salton San Carlos Site



LEGEND

- alluvial deposits
- talus
- metamorphic basement
- granite
- dike rock
- assumed fault

Fig-5.3 Geological Map of Salton Gorge Site



LEGEND

[alluvial symbol]	alluvial deposits
[talus symbol]	talus
[granite symbol]	granite
[dike symbol]	dike rock
[fault symbol]	assumed fault

Chapter 6
CONSTRUCTION MATERIALS

Chapter 6. CONSTRUCTION MATERIALS

6.1 Materials for Dam Embankment

6. 1. 1 Chacabuco dam

(a) Core material

Any adequate core material could not be found in the area nearby the Chacabuco dam site during the field investigation. Since many glacial terraces consisted of thin top soil, sandy layer with gravel in the upper portion and glacial clayey layer in the lower portion can be found on both banks of the Baker River nearby the Chacabuco damsite, check of their characteristics are required to confirm whether these materials be adequate or not for core material, taking samples from the said terraces. If the characteristics of clayey material or of the mixed material was found to be available as the core material after the laboratory test, then, the available quantity of these materials deposited in the terraces shall be confirmed by test pits or trenches.

(b) Filter material

As for the filter material, the sandy gravel to be obtained from the above-mentioned terraces is expected to be available for the filter zone. In this respect, it is required to take material samples from the terraces aimed at checking their characteristics, and then, the available quantity shall be confirmed.

(c) Pervious material

Even though the explosion cost be required for the rock material to be obtained from a quarry site nearby the dam site, it is preferable to use rock material from a quarry site for the pervious zone rather than the mixed material with boulder and gravel-taking account of the hauling distance and the shearing strength of the embanked material.

In case of the pervious material is obtained from the downstream area of the Nef River, the hauling distance will be more than 5 km and further more the processing operation will be indispensable as the deposit in the Nef area abounds in fine material.

Besides, the rock materials to be obtained from the excavations of diversion tunnels, spillway and other structures are of course available for the pervious zone.

6. 1. 2 Tamango dam

(a) Core material

No borrow area available for the core material was found in the area around the Tamango damsite, however, the terrace being located on the downstream left bank of the Chacabuco River with the distance of 5 km upstream from the damsite and the terrace being located on the left bank of the Baker River with the distance of 5 km downstream from the damsite are considered to be a site proposed for the borrow area.

These terraces are consisted of sandy layer and glacial clayey layer as previously described, and it is required to take material samples from the terraces for the purpose of checking their characteristics in a laboratory.

(b) Filter material

As for the filter material, the riverside area being located on the left bank with the distance of 9 km downstream from the damsite is expected to be one of the favorable site. However, the said area is too far from the damsite and is supposed to contain silty material, accordingly it is required to take material samples from the said area and also from the glacial terrace aforementioned for the purpose of comparison.

(c) Pervious material

In case of the Tamango dam, the required quantity of pervious material will be more than 10,000,000 m^3, therefore, it is preferable to use rock material from a quarry site nearby the Tamango dam and also from the excavation of various structures considering the hauling distance and the required shearing strength.

6.1.3 Salton San Carlos dam

(a) Core material

There could not be found out during the field investigation any adequate core material around the confluence area of the Baker River and the Ventisquero River. Meanwhile the glacial terrace being located on the left bank with the distance of 10 km upstream from the damsite and the talus area being located on the left bank with the distance of 4 km downstream from the damsite are expected to be available for the borrow area. The former is being consisted of sandy layer and clayey layer, and the latter is being consisted of weathered rock, but the available material can be observed spotly in the talus area. It is requested to take soil samples from the said both areas to check their characteristics, and if the test results could meet the requirements of the core material, then, the obtainable quantity of material shall be confirmed.

Should the said materials are judged to be unsuitable in the point of characteristics and/or quantity, it is suggested that the surface core type instead of the center core type shall be adopted. In case the river deposit of the proposed Salton San Carlos damsite is considered to be too deep, Salton Gorge damsite 4 km upstream from the Salton San Carlos damsite, is recommended here with as an alternative damsite if the geological condition permits.

(b) Filter material

Sandy gravel to be obtained from the confluence area with the Ventisquero River is expected to be available for the filter zone.

It is required to take material samples from the said area to test their characteristics, and then, the obtainable quantity of material shall be confirmed.

(c) Pervious material

Since the proposed Salton San Carlos dam is considered to be one of the high and large dam, it is recommended that the rock material to be obtained from a quarry site nearby the dam shall be used for the pervious zone from both technical and economical view points. Besides, the rock material to be obtained from the excavations of diversion tunnels, spillway and other structures are of course available for the pervious zone.

6.2 Concrete Aggregate

6.2.1 Chacabuco area

Supply sources of the concrete aggregate are considered as follows:

(1) Confluence area with the Nef River

(2) Delta shaped terrace - located on the left bank of the Baker River (between left bank existing road and the Baker River) with the distance of 5 km upstream from the Chacabuco damsite.

(3) Glacial terraces - located in both banks of the Baker River.

Since the concrete aggregate shall not contain silty material and organic materials and shall be of hard and durable material, thus, it is requested to take material samples from the above areas and the laboratory tests including grain-size analysis shall be conducted, and also the obtainable quantity of deposited material shall be confirmed by test pits or trenches.

According to our experiences for the quarry area of the concrete aggregate, the required quantity in the quarry area shall be more than 1.5 times of the estimated quantity considering the operation of large scale equipment and its operation losses.

6.2.2 Tamango area

As for the supply source of the concrete aggregate, the riverside area located on the left bank of the Baker River with the distance of 10 km downstream from the Tamango damsite is expected to be one of the quarry area for the concrete aggregate.

In this connection, the laboratory tests with material samples shall be conducted.

6.2.3 Salton San Carlos area

Supply sources of the concrete aggregate are considered as follows:

(1) Confluence area with the Ventisquero River

(2) Confluence area with the Ñadis River

The deposit in the former area is expected to be rich in fine sand on one hand, and the latter is expected to abound in small size of gravel on the other. In any case, the laboratory tests with material samples shall be conducted.

Since the total required concrete volume of the Salton San Carlos power station is estimated to be more than 200, 000 m^3, it is riquired to secure sufficient quarry sites, while some grain - size control will be necessary at the crushing plant in case encountered with the undesirable grain - size proportion in the quarry sites.

Chapter 7
SUMMARY OF THE BAKER RIVER HYDROELECTRIC DEVELOPMENT PROJECT

Chapter 7. SUMMARY OF THE BAKER RIVER HYDROELECTRIC DEVELOPMENT PROJECT

7.1 Characteristics of the Baker River

The Baker River is located in the latitude from 46° to 48° south and the longitude from 71° to 73°30' west running across the Aisen Province. Rising at Lake General Carrera, the Baker River with 170 km in total length flows southwest among steep moutains forming a part of the Andes and empties into the Bay of Pena. The river basin covers an area of 27,150 km^2 including 5,560 km^2 of Argentine territory.

The river may be divided into three sections: upper reach with a gradient of 1/260 extending from Lake Bertrand to the junction with the Chacabuco River, a tributary of the Baker River; middle reach with a gradient of 1/1,300 from the Chacabuco River to the Ventisquero River; and lower reach with a gradient of 1/2,000 from the Ventisquero River to the estuary of the Baker River. The runoff of the Baker River is controlled spontaneously by glacial water and Lake General Carrera having a reservoir area of 1,893 km^2. The maximum and minimum rates of discharge measured at the Bertrand gaging station are 968 m^3/sec and 371 m^3/sec, respectively, the annual average being 603 m^3/sec. Even during the dry season from July to September, the discharge is nearly 55 % of its annual average discharge.

7.2 Relative Merits of Various Two-Stage Development Project

The relative merits of the various two-stage hydroelectric development project for the Baker River are as shown below.

(1) Basic plan proposed by ENDESA

Upstream damsite: Chacabuco

Downstream damsite: Salton San Carlos

Relative merits: The upstream and downstream damsites are most favored from the topographical standpoint. The reservoir storage capacity is high and the layout of the dam and power plant etc. is adequate. The unwatering work, the most crucial factor of the dam construction work, is expected to meet with no difficulty and ample space can be obtained for the works.

On the other hand, however, the plan has such problems as the faults and fractured zones on the right side bank of the Chacabuco damsite, and the riverbed deposits at the Salton San Carlos damsits. Rock fill type is proposed for the upstream and downstream dams. However, adequate core materials are not obtainable in areas adjacent to the damsites and it is a problem where to obtain the materials.

(2) Alternative plan

Upstream damsite: Chacabuco

Downstream damsite: Salton Gorge

Relative merits: As for the upstream dam, the damsite and conditions is the same to the Chacabuco dam as described in (1) Basic Plan. The Salton Gorge dam will be built in a gorge free from riverbed deposits and the foundation treatment will be easier than in the case of the Salton San Carlos dam

However, the layout of the power plant and other facilities is a problem. A rock fill type dam would not be appropriate, since core materials are not obtainable in the areas adjoining the proposed Salton Gorge damsite. On the other hand, if a concrete dam is planned for the site, this alternative will be a very promising plan.

(3) Alternative plan

Upstream damsite: Tamango

Downstream damsite: Salton San Carlos

Relative merits: The alternative will be proposed as a substitute in case the foundation treatment for the Chacabuco dam proves unfavorable from the technical and economical point of view. Economic considerations give the Chacabuco dam plan an advantage over the Tamango plan. But geological surface surveys indicate the Tamango damsite is free from faults which is the most crucial factor in dam construction.

The upstream and downstream dams will require higher construction costs, and the distribution of the storage capacity between the two dams is not adequate for the water utilization plan. If the rock fill type is adopted for the Tamango dam, the procurement of core materials will be a problem.

(4) Alternative plan

Upstream damsite: Tamango

Downstream damsite: Salton Gorge

Relative merits: The alternative will be proposed as a substitute if the Chacabuco plan proves unfeasible. However, the alternative is as disadvantageous as the alternative discribed in (3) above from the standpoint of effective water utilization. Foundation treatment is possible for both upstream and downstream dams. The concrete type is preferable for the Salton Gorge dam.

If further geological investigations demonstrate the feasibility of the Chacabuco dam, the combination of the upstream dam at Chacabuco (rock fill type) and the downstream dam at Salton Gorge (concrete type) will be better one. If, on the other hand, the construction of the Chacabuco dam is impracticable, better combination will be the upstream dam at Tamango (rock fill type) and the downstream dam at Salton Gorge (concrete type).

7.3 Chacabuco-Salton San Carlos Plan

This plan envisages the construction of dams at the upstream site of Chacabuco and the downstream site of Salton San Carlos in two-stage for hydroelectric development project. The total available head is 174 m having the utilization rate of 84 %. The total power plant output is 1,310 MW and the total annual energy production is 9,640 GWh (see Figs. 7-1 and 7-2 and Table 7-1).

(a) Chacabuco dam

The dam will be constructed in a gorge having U-shaped configuration located 5.5 km down the Nef River. A saddle, formed by the current of the old river and situated at the origin of the U-shaped configuration, will be very convenient for the construction of a diversion tunnel and spillway. Under this plan, a center core type rock fill dam, with a height of 71.0 m and dam volume of 1.5 million cu. m., will be constructed at Chacabuco to provide an effective storage capacity of 3,800 million cu. m. A power plant will be built immediately downstream at the dam to provide a maximum output of 390 MW and an annual energy production of 2,840 GWh utilizing a maximum head of 66.6 m and a maximum power discharge of 717 m^3/sec. (see Figs. 7-3 and 7-4)

(b) Salton San Carlos dam

The Salton San Carlos dam is located 3.5 km up the Ventisquero River, where the river flow sharply changes its direction from west to south and begins to flow into a plain after running through gorge. A center core type rock fill dam with a height of 115 m and dam volume 9.3 million cu. m will be constructed to provide an available storage capacity of 5,200 million cu. m. An underground power plant will be built on the left side bank to provide a maximum output of 920 MW and annual energy production of 6,800 GWh utilizing a maximum head of 107.5 m and the maximum power discharge of 1,075 m^3/sec (see Figs. 7-5 and 7-6).

Table - 7.1 Description of Chacabuco and Salton San Carlos Projects

Item	Chacabuco	Salton San Carlos
Location	Province of Aisen, Chile	
River	Baker River	
Catchment area	16,740 km^2	25,220 km^2
Design flood discharge	3,000 m^3/sec	3,500 m^3/sec
Gross storage capacity		17,000 x 10^6 m^3
Effective storage capacity	3,810 x 10^6 m^3	5,160 x 10^6 m^3
Reservoir area	1.900 km^2	300 km^2
High Water level	206.7m	138 m
Available drawdown	2.0 m	20.0 m
Installed capacity	390 MW	920 MW
Maximum power discharge	717 m^3/sec	1,075 m^3/sec
Effective head	64 m	104 m
Annual power production	2,840 GWh	6,800 GWh
Dam;		
Type	Rockfill with center impervious core	
Height	71 m, 54 m	115 m
Crest length	380 m, 160 m	540 m
Width of crest	8 m	8 m
Volume	1,500,000 m^3 300,000 m^3	9,300,000 m^3
Spillway		
Type	Ski jump type	Ski jump type
Gate	Tainter gate	Tainter Gate
Height x Width x Numbers	10m x 12.5m x 4	15m x 10m x 3
Length	220 m	350 m
Intake		
Structure (Height x Width)	27m x 64 m	45m x 95m
Gate	Roller	Roller
Numbers	4	4
Penstock		
Numbers	4	4
Length	86 m	144 ~ 222m
Inner diameter	5.7 m	7.0 m
Powerhouse		
Type	Semi-underground	Semi-underground
Structure (Width x Length)	35 x 125 m	30 x 177 m
Tailrace		
Type	Open channel	Tunnel

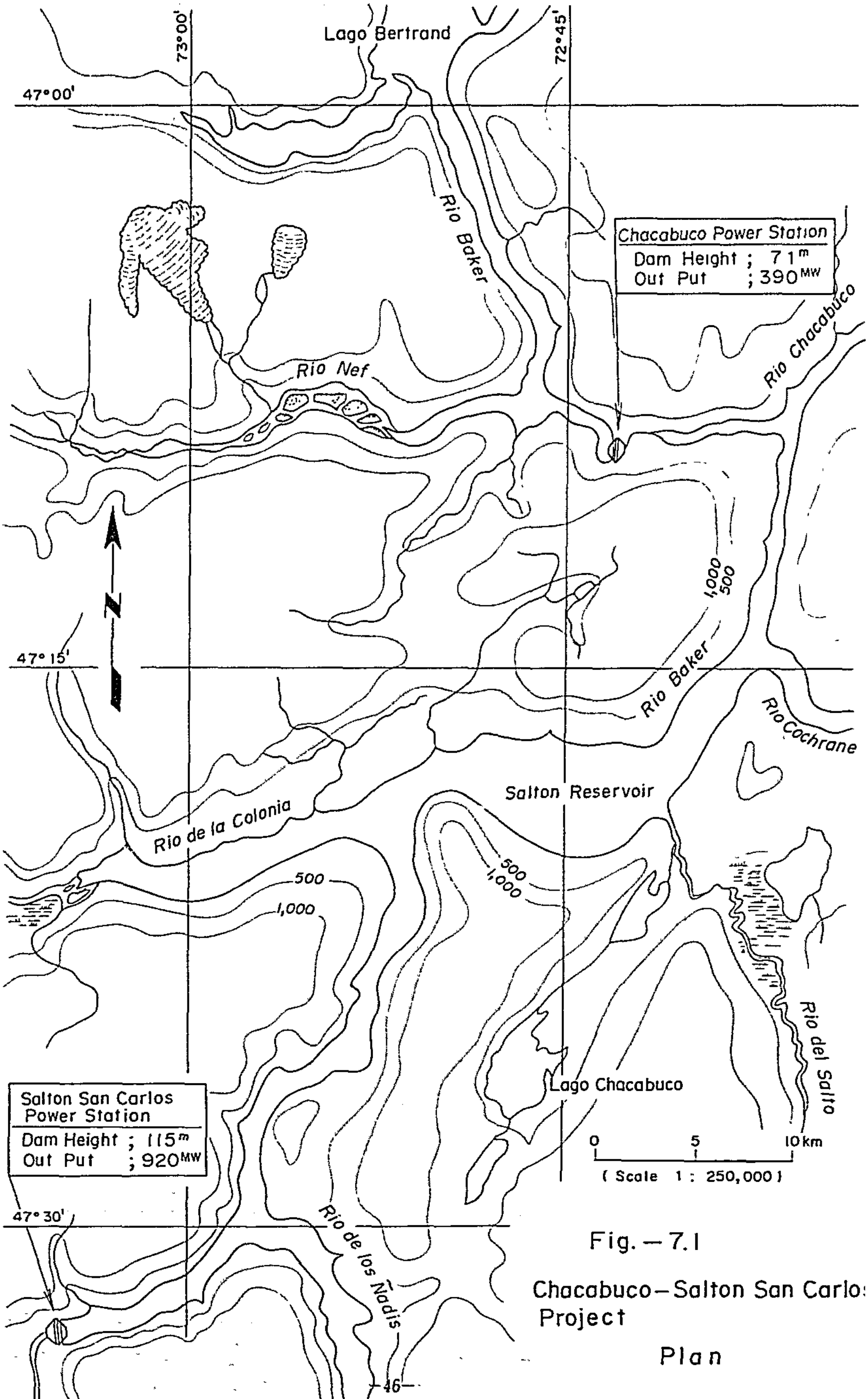


Fig. — 7.1

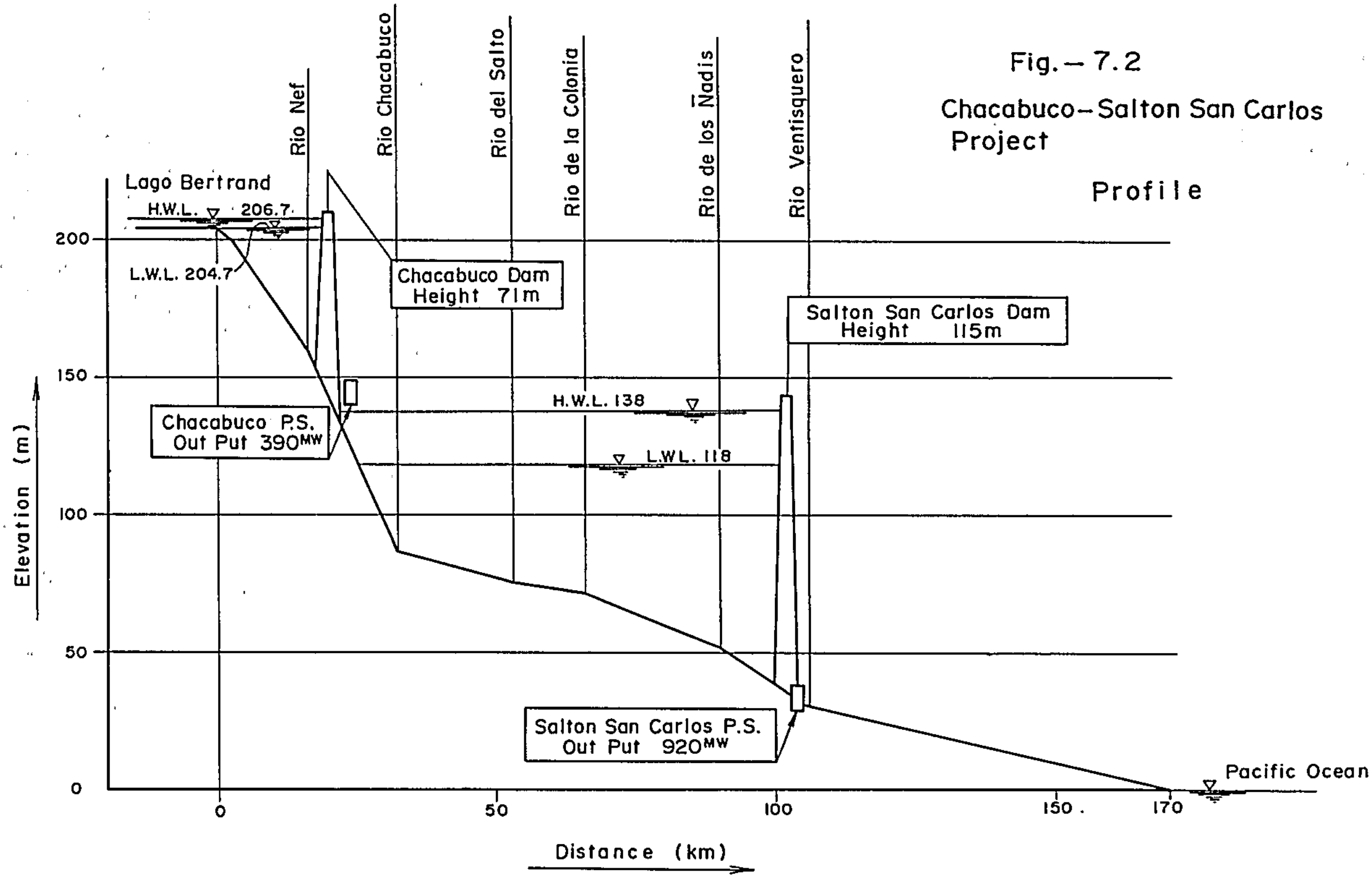
Chacabuco — Salton San Carlos Project

Plan

Fig. — 7.2

Chacabuco—Salton San Carlos Project

Profile



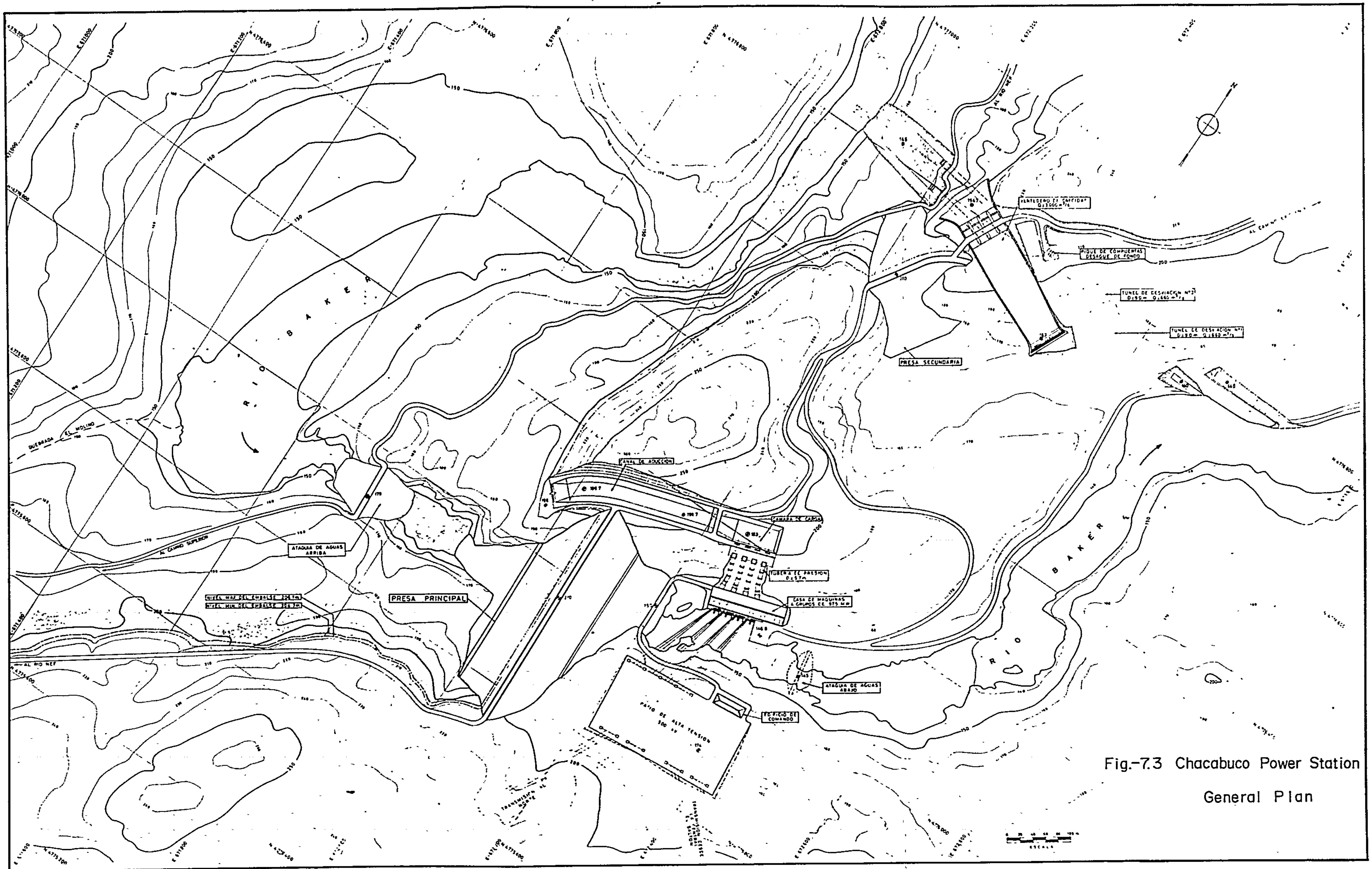
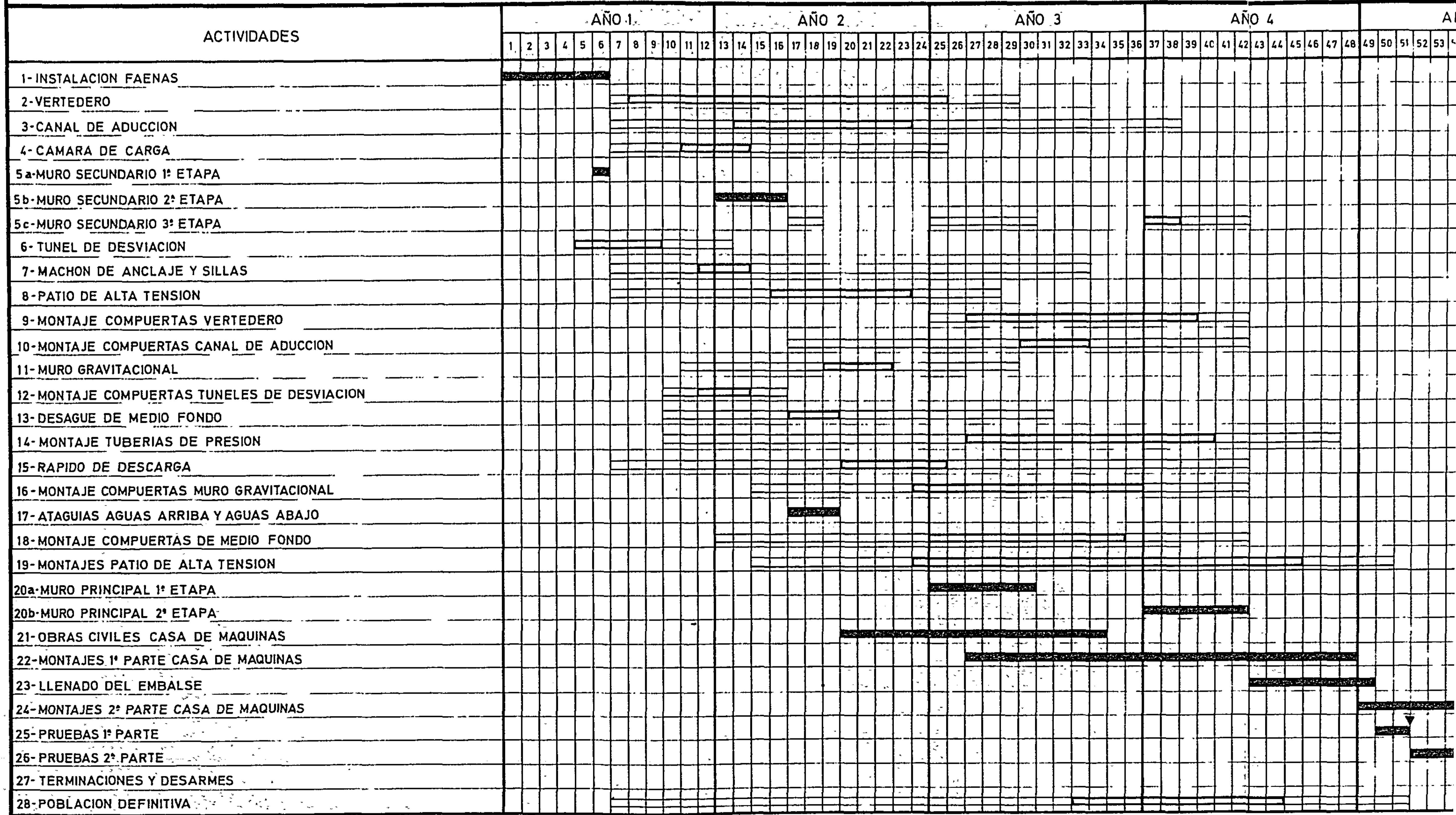


Fig.-7.3 Chacabuco Power Station

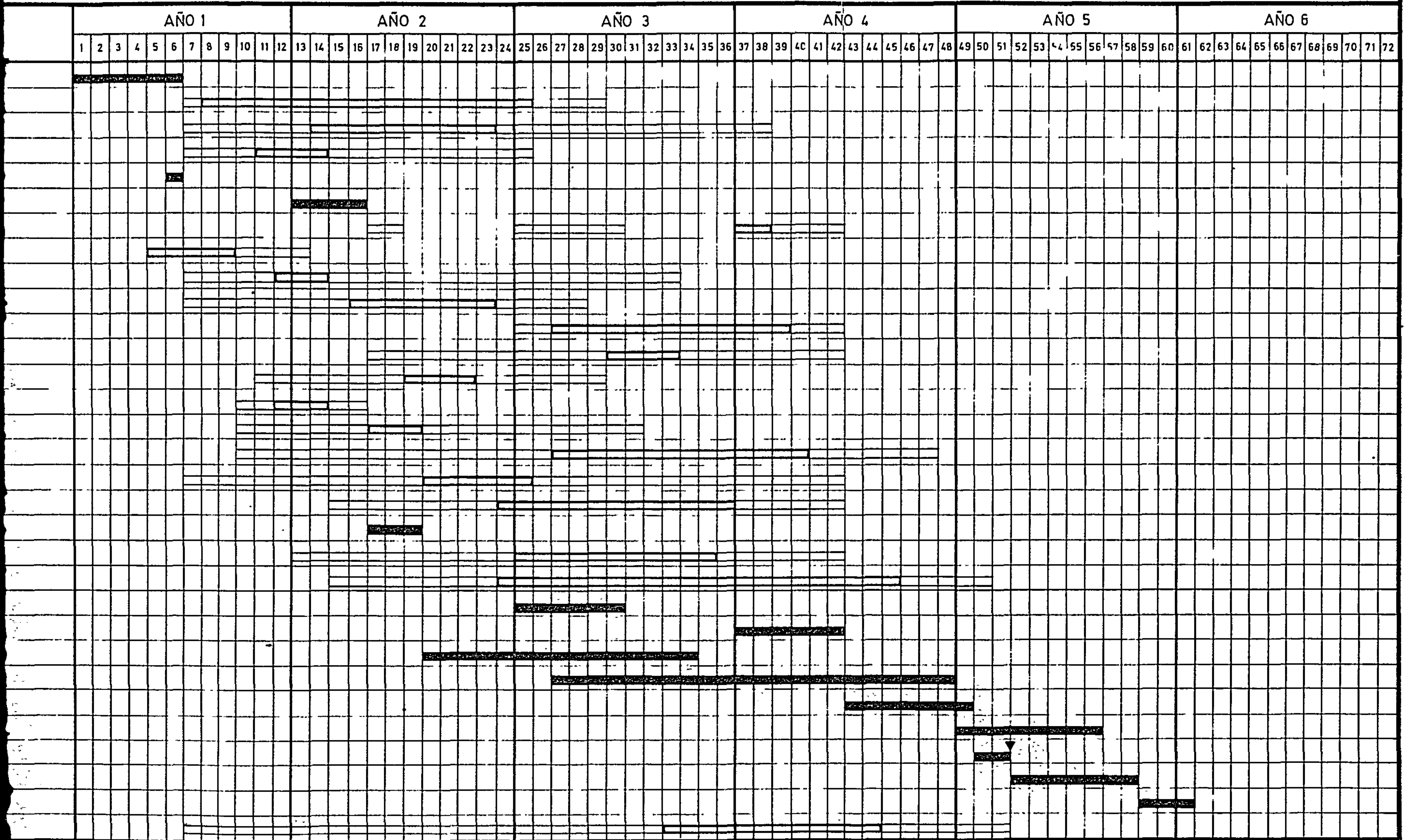
General Plan

Fig.- 7.4 Construction Schedule of Chacabuco Power Station



NOTAS: SIMBOLOGIA:
▬ ACTIVIDADES CRITICAS
▼ PUESTA EN SERVICIO 1ª UNIDAD
EL MES 1 CORRESPONDE AL MES DE OCTUBRE

Fig.-7.4 Construction Schedule of Chacabuco Power Station



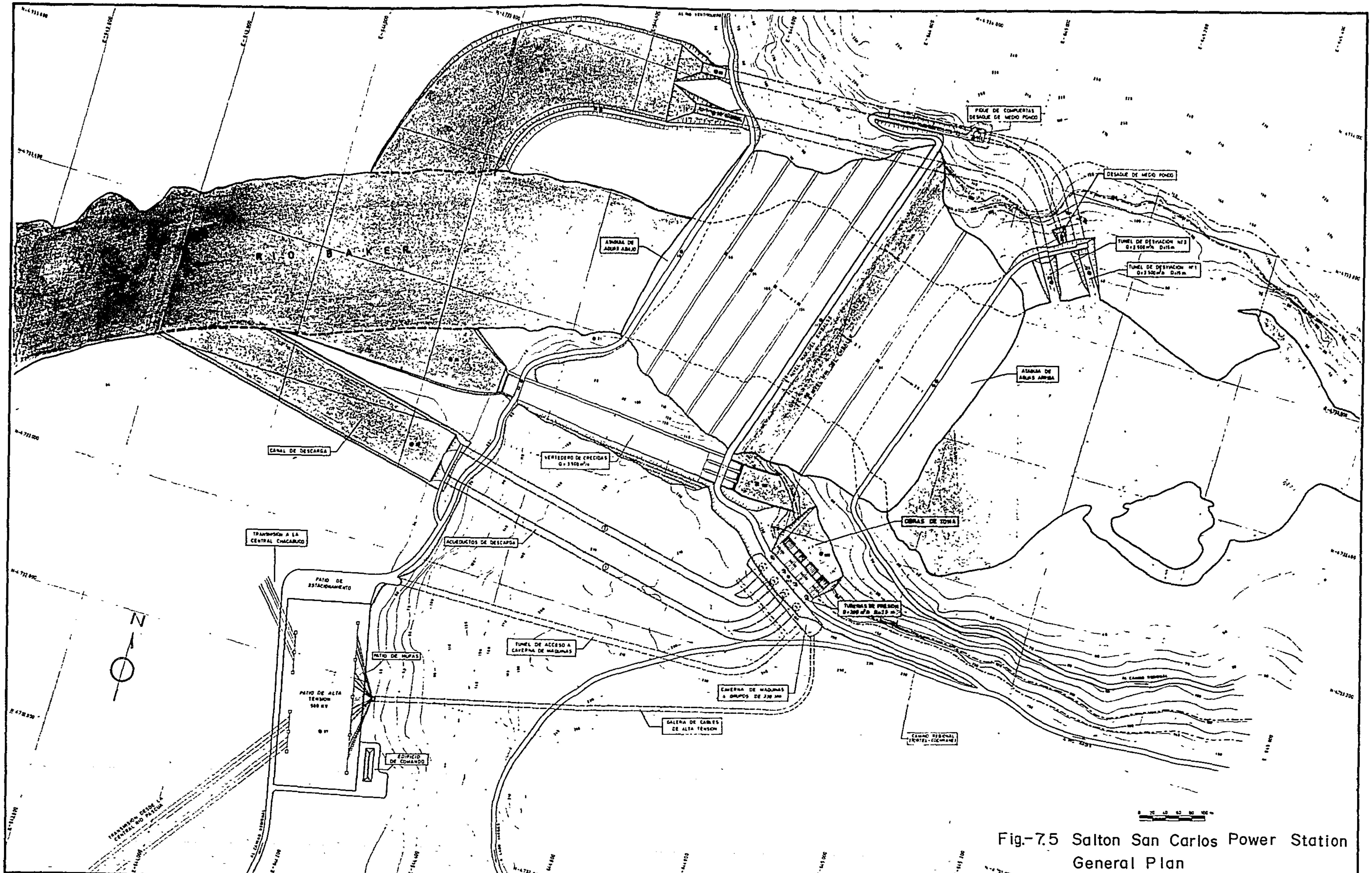
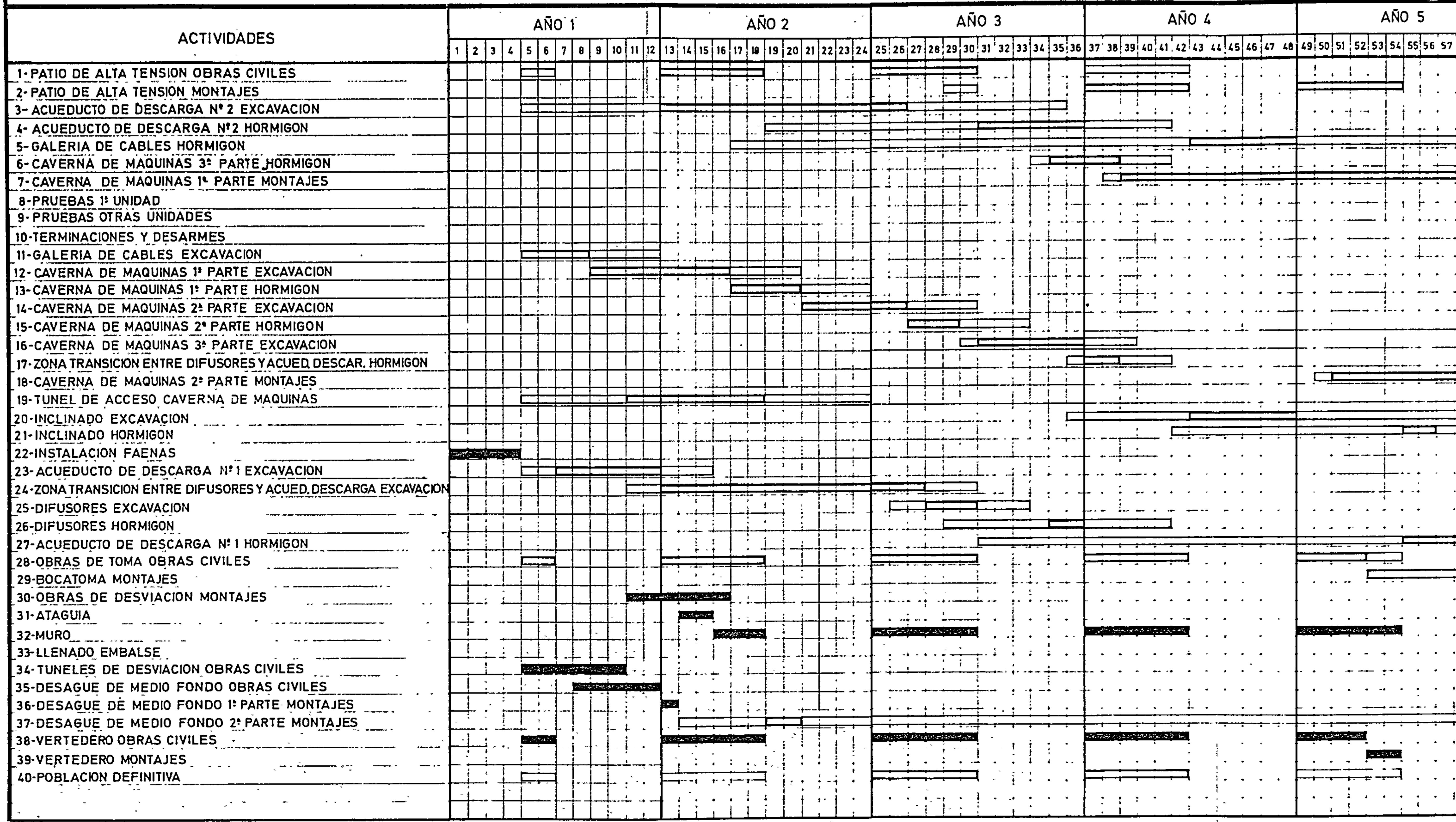


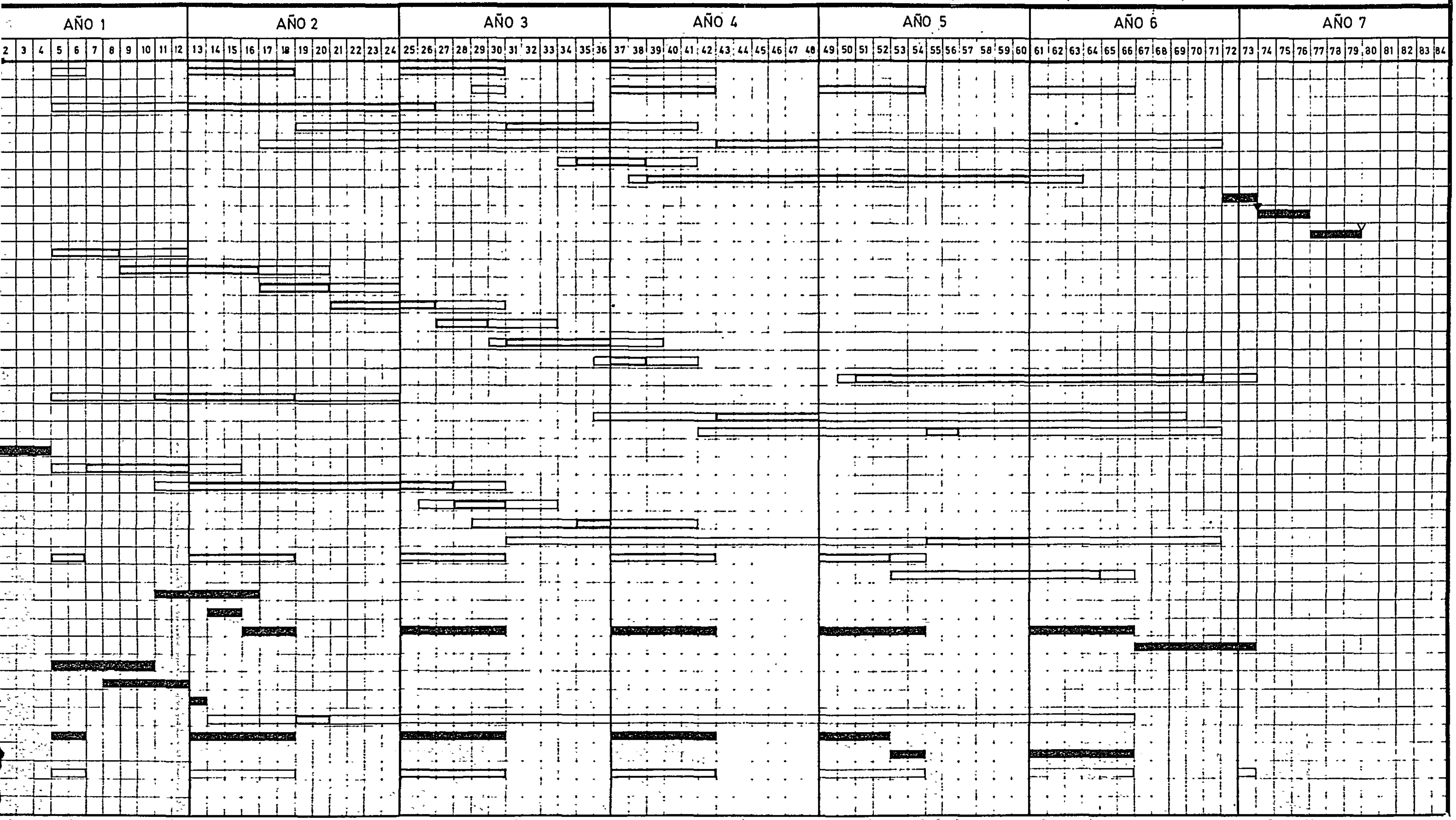
Fig.-7.5 Salton San Carlos Power Station General Plan

Fig.-7.6 Construction Schedule of Salton San Carlos Power Station



NOTAS:
SIMBOLOGIA
ACTIVIDADES CRITICAS
▼ PUESTA EN SERVICIO 1ª UNIDAD
▽ TERMINO CONSTRUCCION CENTRAL
EL MES 1 CORRESPONDE AL MES DE OCTUBRE

Fig.-7.6 Construction Schedule of Salton San Carlos Power Station



7.4 Tamango-Salton Gorge Plan

This plan envisages the construction of dams at the upstream site of Tamango and the downstream site of Salton Gorge in two stages for hydroelectric development projects. The total effective head is 171.7 m having the utilization rate of 83 %. The total power plant output is 1,160 MW and the annual energy production is 8,576 GWh (see Figs. 7-7 and 7-8 and Table 9-3).

(a) Tamango dam

The proposed Tamango damsite is located 3.7 km downstream from the point where the Baker and Chacabuco Rivers meet. The site is suitable for hydroelectric development, since it is situated in a gorge with both sides forming steep cliffs. The dam will be a center core rock fill type 170 m in height and 13.5 million cu. m in dam volume and will provide an available storage capacity of 3,800 million cu. m. An underground power plant will be built immediately downstream at the dam to provide a maximum output of 720 MW and the annual energy production of 5,541 GWh utilizing the maximum head of 114 m and the maximum power discharge 760 m^3/sec. (see Figs. 9-8 to 9-13).

(b) Salton Gorge dam

The proposed dam site is located at the fall of Salton 4 km upstream from San Carlos. At this site the Baker River, after meeting the Ñadis River, its tributary, runs through a 1 km-long gorge and forms a fall with a head of about 10 m. The dam, a center core rock-fill type 70 m in height and 1.4 million cu. m. in dam volume will be built in substantially the middle Part of the gorge to provide an available storage capacity of 1,900 million cu. m. A power plant will be constructed on the left side bank to provide the maximum output of 440 MW and the annual energy production of 3,035 GWh utilizing the maximum head of 51 m and the maximum power discharge of 1,040 m^3/sec. (see Figs. 9-16 to 9-20). If it is difficult to obtain core materials for a fill type dam, the concrete dam will be adopted for the proposed the damsite, where construction of a spillway is favored. Figs. 7-9 and 7-10 show an outline of the concrete dam plan.

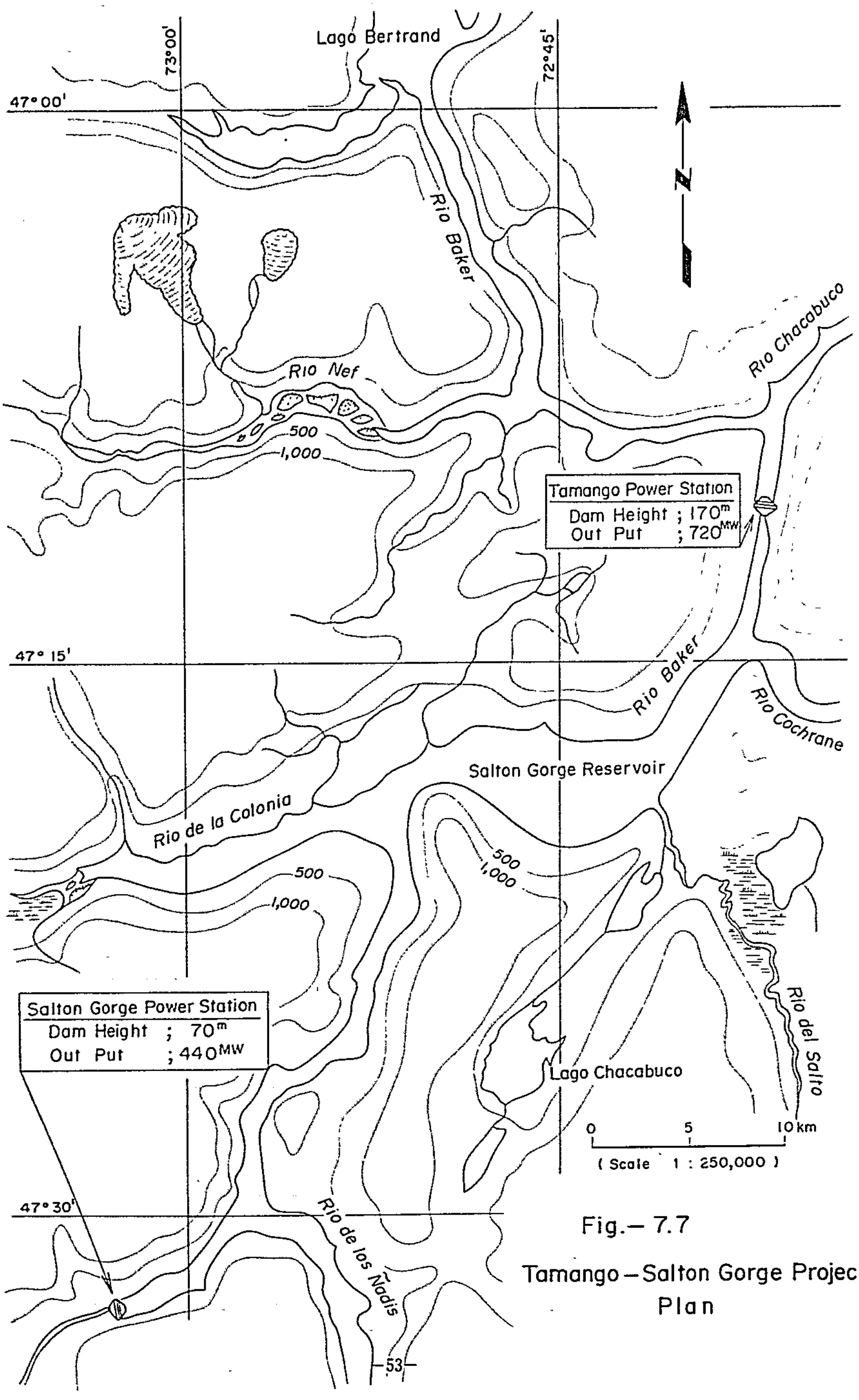
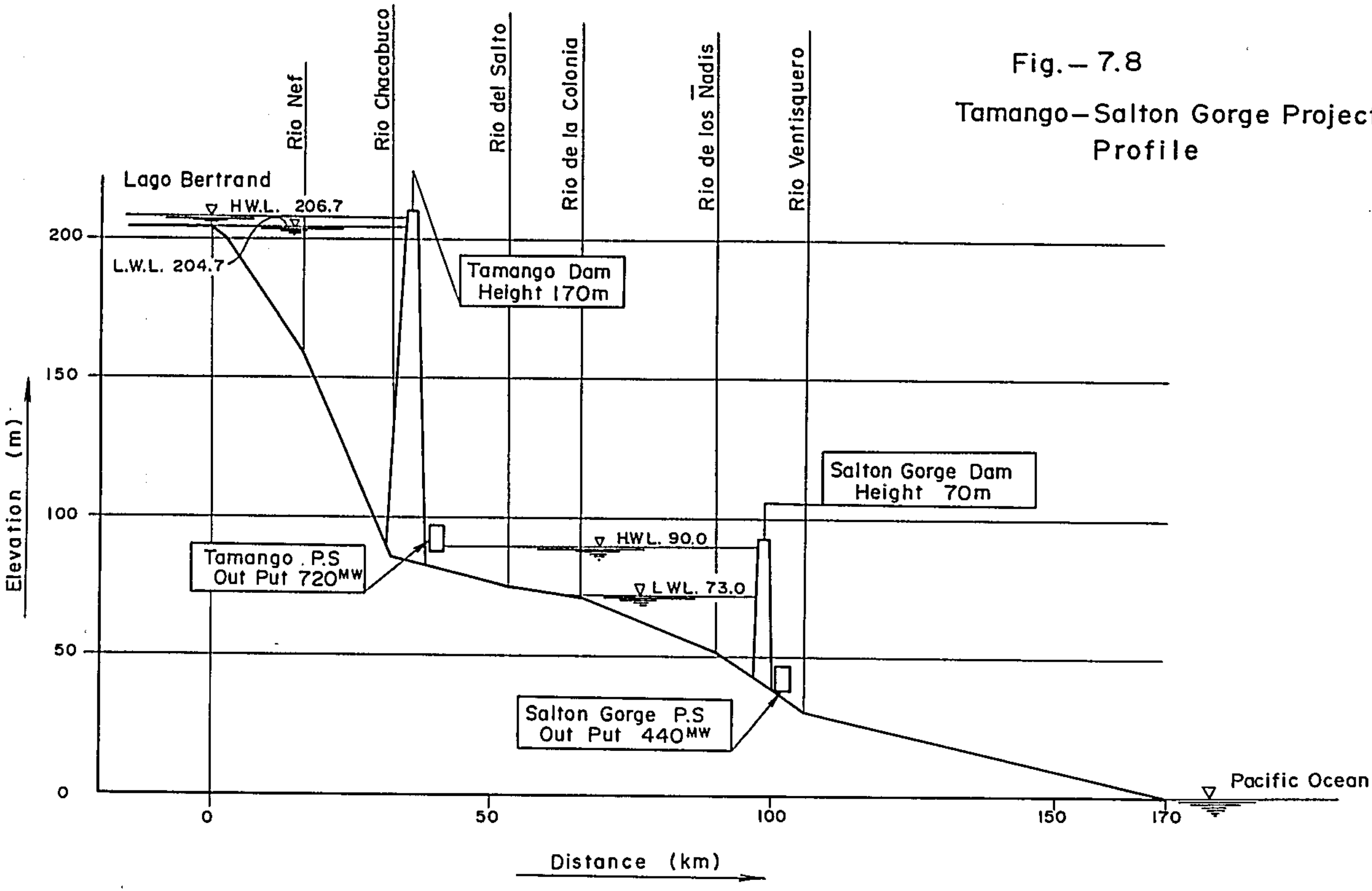


Fig.— 7.7

Tamango — Salton Gorge Projec
Plan

Fig. — 7.8

Tamango—Salton Gorge Project Profile



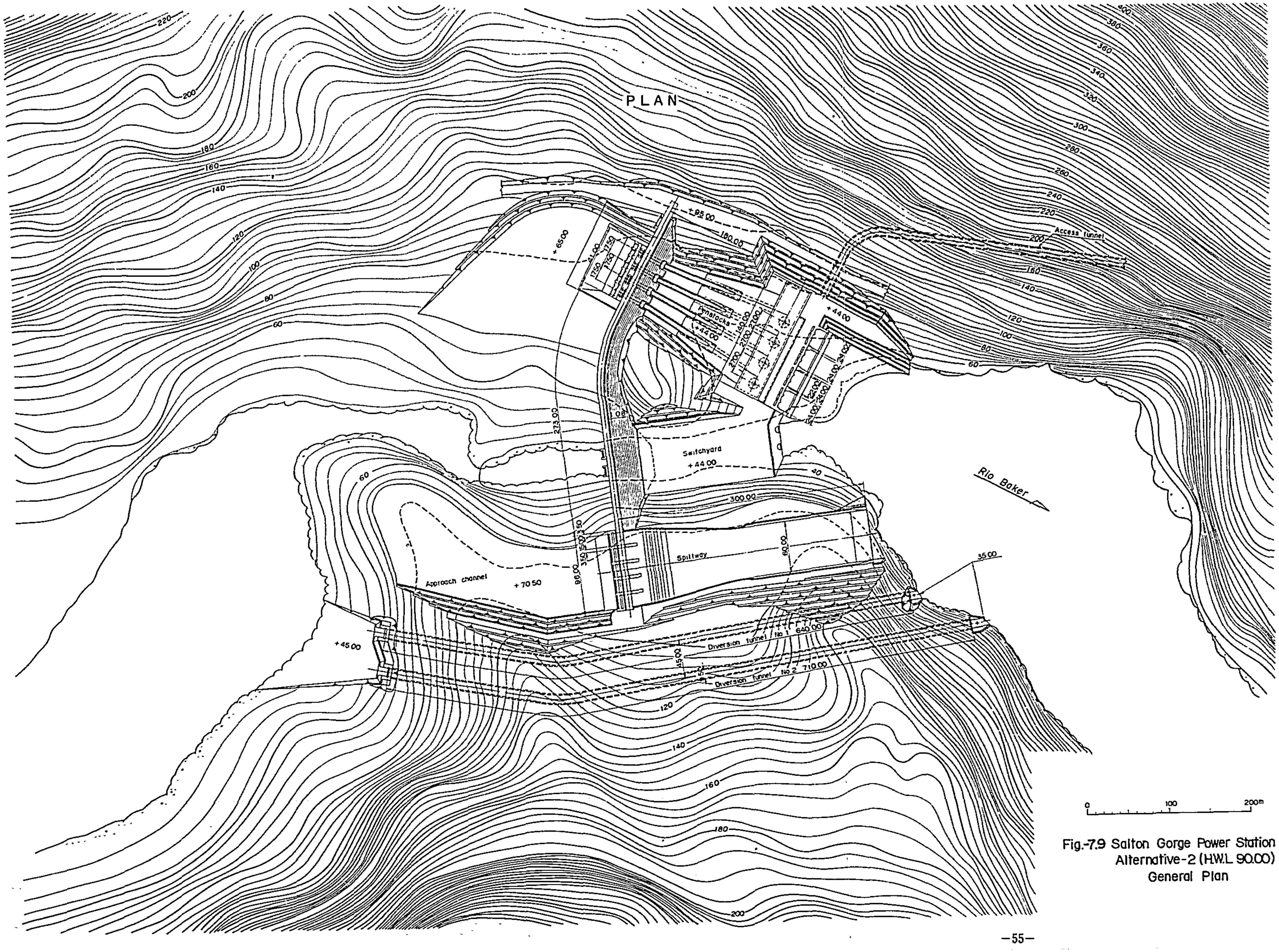
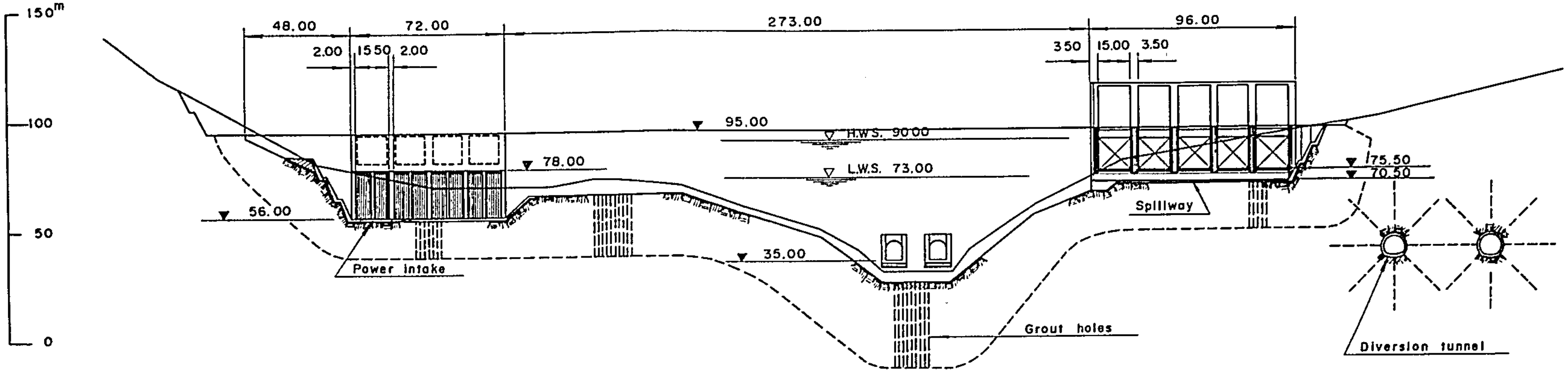


Fig.-7.9 Salton Gorge Power Station
Alternative-2 (H.W.L 90.00)
General Plan

PROFILE ALONG AXIS OF DAM



TYPICAL SECTION OF DAM

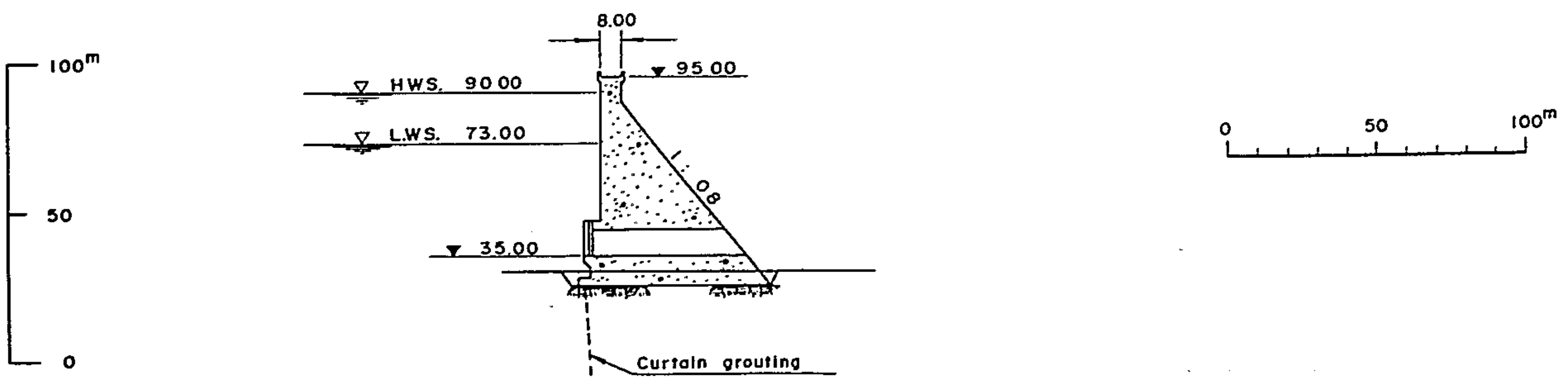


Fig.- 7.10 Salton Gorge Power Station
Alternative-2 (H.W.L.90.00)
Dam
Profile and Section

7.5 Chacabuco-Salton Gorge (HWL : 138.00) Plan

This plan envisages the construction of dams at the upstream site of Chacabuco and the downstream site of Salton Gorge in two stages for hydroelectric development. The total available head is 171.7 m having the utilization rate of 83 %. The total power plant output is 1,270 MW and the annual energy production is 9,340 GWh. (see Fig. 7-11).

(a) Chacabuco dam

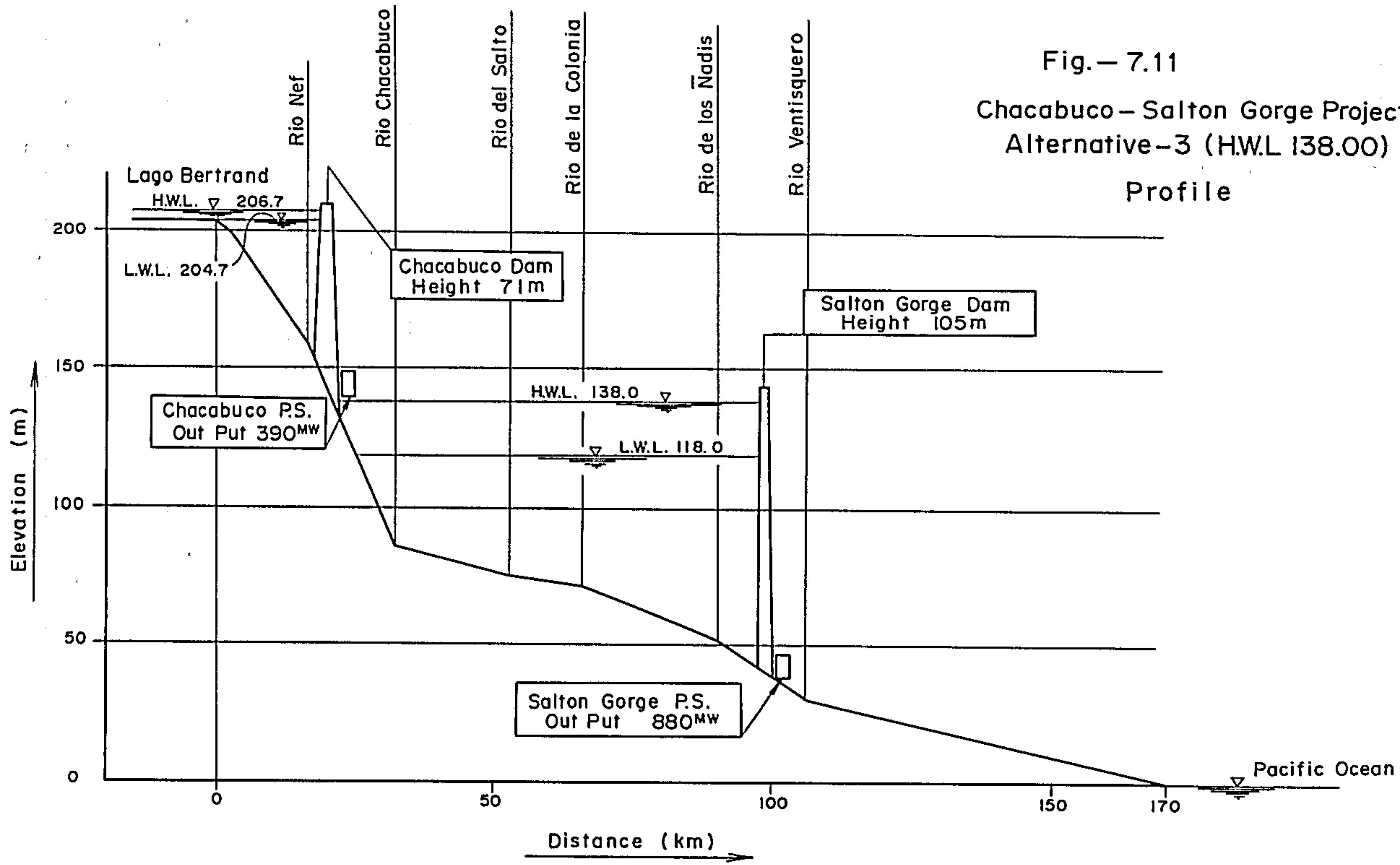
Same conditions as described in paragraph (a), 7.3, are applicable.

(b) Salton Gorge (HWL: 138.00) dam

This plan, an alternative which will be considered when the foundation treatment for the proposed dam at Salton San Carlos is found difficult, calls for the construction of a 105 m high concrete dam at the same site as mentioned in paragraph (b), 7.4, to provide an available storage capacity of nearly 5,000 million cu. m. A power plant will be built on the left hand bank to provide the maximum output of 880 MW and the annual energy production of 6,500 GWh utilizing the maximum head of 102.5 m and the maximum power discharge of 1,075 m^3/sec. Fig. 7-12 shows outline of the plan.

Fig.— 7.11

Chacabuco – Salton Gorge Project
Alternative–3 (H.W.L 138.00)
Profile



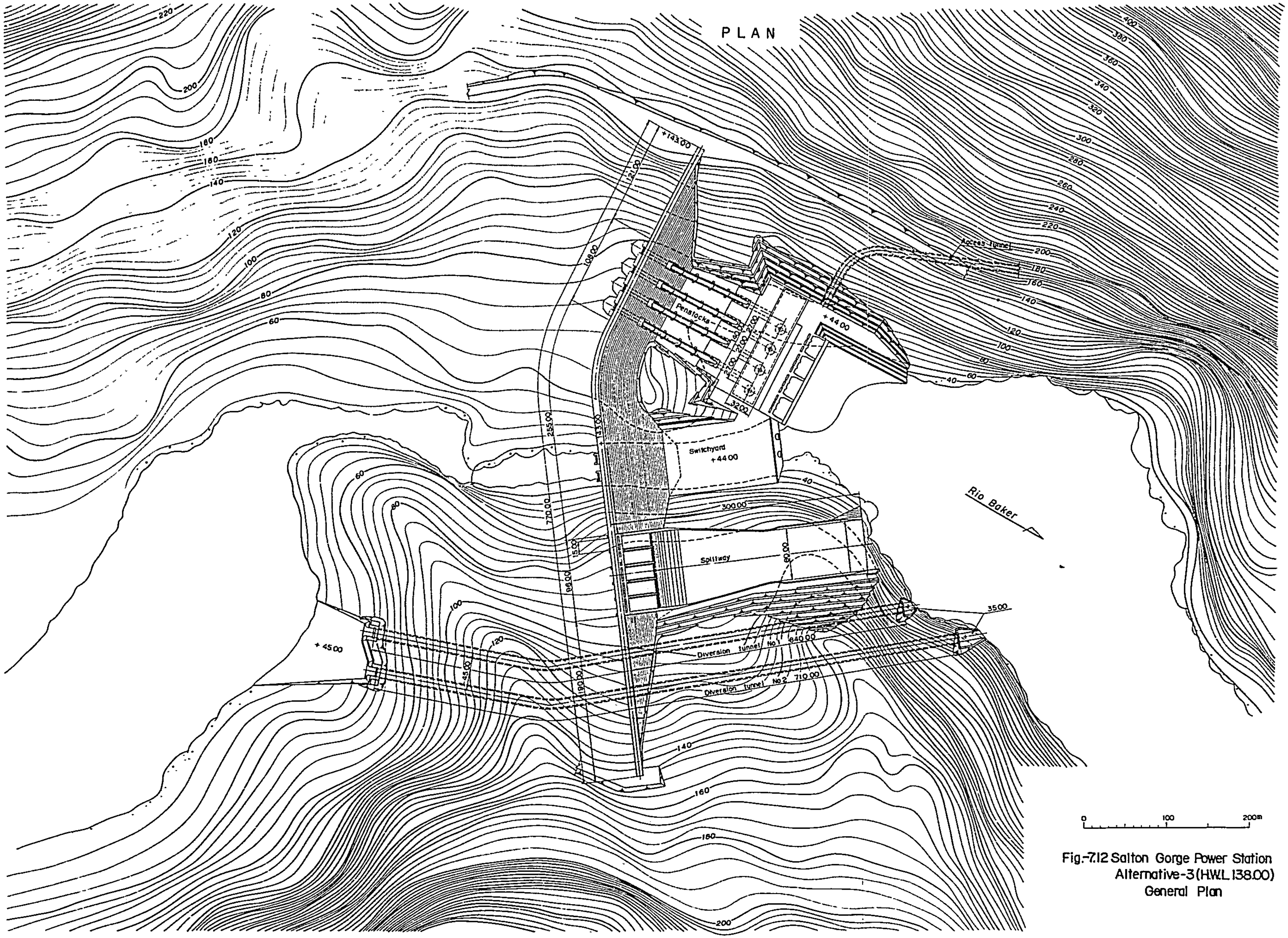


Fig.-7.12 Salton Gorge Power Station
Alternative-3 (H.W.L.138.00)
General Plan

7.6 High Salton San Carlos Plan

This plan is an alternative to the Chacabuco-Salton San Carlos plan described in 7. 3. and envisages one-stage hydroelectric development project.
Under the plan, a center core rock fill dam 180 m in height and 20 million cu. m. in dam volume will be built at Salton San Carlos to provide an available storage capacity of 19, 400 million cu. m. and an underground power plant will be constructed on the right hand bank to give the maximum output of 1, 700 MW and the annual energy production of 12, 300 GWh utilizing the maximum head of 177 m and the maximum power discharge of 1, 176 m^3/sec. (see Fig. 7-13).

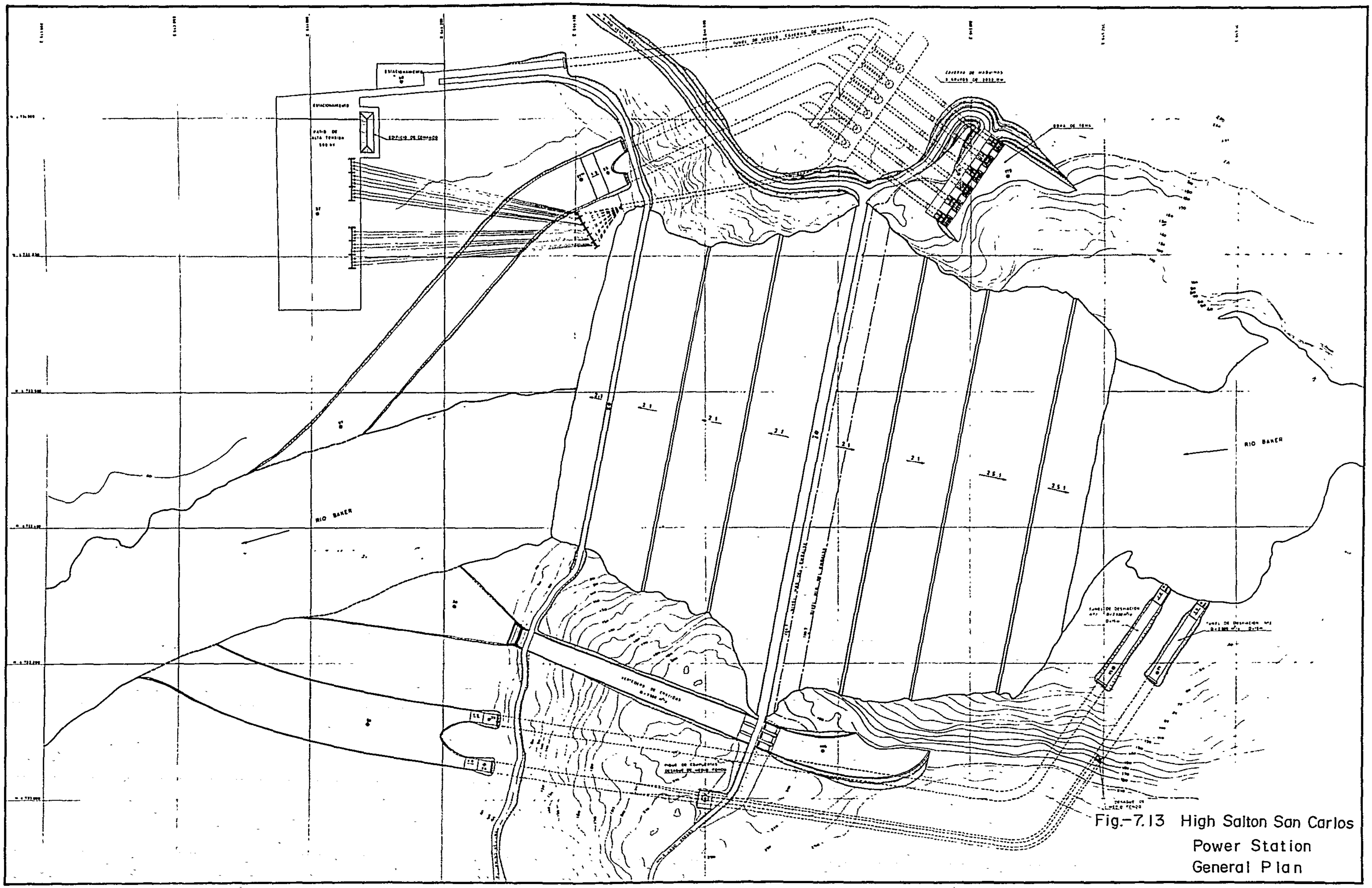


Fig.-7.13 High Salton San Carlos
Power Station
General Plan

Chapter 8
REVIEW OF CHACABUCO SALTON SAN CARLOS PLAN

Chapter 8. REVIEW OF CHACABUCO-SALTON SAN CARLOS PLAN

8.1 Hydroelectric Development Plan

The hydroelectric development plan in the Baker River system is described in Chapter 2. The one-stage development plan is considered to stand little chance of materialization for the reasons, such as the inevitable submerging of the village of Cochrane if the plan proposed by ENDESA is carried out. The multi-stage approach to hydroelectric development may be grouped into two methods: (i) Implementation of smaller power plants along the Baker River system in stages according to the annual increment of power demand, and (ii) Chacabuco-Salton San Carlos Plan which calls for the construction in two-stages of dams and power plants at the sites most favored from the topographical viewpoint. In this study, the hydroelectric development on the optimal scale is evaluated in terms of effective utilization of water resources and not from the standpoint of power demand. As already repeated, the Chacabuco-Salton San Carlos plan is the most advantageous development scheme from the topographical standpoint.

The scale of the proposed power plant at Chacabuco will be reviewed as below. Given the elevation of the Lake Bartrand and Lake General Carrera, the effective head for the power plant depends on the location of the proposed Chacabuco dam. The available water is estimated on the basis of the annually regulated discharge from the reservoir, taking the annual utilization rate into consideration. Consequently the output of 920 MW proposed in the basic plan is regarded to be adequate. As discussed in detail in Chapter 5, the available data on the geology at the proposed damsite are not sufficient to determine its appropriateness from the geological viewpoint. Accordingly, it is necessary to wait for the outcome of further geological investigations.

Unusable head will be produced between tailrace water level of the Chacabuco power plant and the high water level of the Salton San Carlos dam. An alternative would be to build a power plant in the vicinity of the end of spillway instead of immediate downstream at the dam as envisaged by the proposed plan by ENDESA and to extend the tailrace to the high water level of the downstream reservoir in order to attain the fullest utilization of the head. This alternative fully deserve to be considered if the construction of the dam at the proposed site is feasible from the geological standpoint.

Since the available head and discharge is determined in relation to the Lake Cochrane and the annual utilization rate, the scale of the Salton San Carlos power plant is considered adequate. The site will be advantageous, if the deposit of the riverbed are not very deep. The proposed layout of the underground power plant, spillway and diversion tunnel is considered appropriate. However, the design flood discharge of 3,500 m^3/sec for the Salton San Carlos power plant should be increased to include some allowance.

8.2 Design

Rock fill type dam is proposed for the Chacabuco and Salton San Carlos. However, the problem is that core materials are not obtainable in the vicinity of the damsites. Depending on the availability of varve clay, other types such as concrete or surface core fill type sould be considered. Detailed designs should be conducted taking into consideration embankment and grouting schedule and further construction of inspection gallery to facilitate maintenance. If the concrete type is adopted for the secondary dam at Chacabuco, the diversion tunnel can serve as the spillway. The tailrace construction for the Salton San Carlos power plant will be difficult, since it has a large cross section. Therefore, it is suggested to reduce the cross section of tailrace and build four tailraces. The two dams are to be equipped with outlet works, which, however, will not be effective because of its smaller capacity than that of a large reservoir.

The Baker River has a large discharge at all times, which makes it very difficult to carry out the construction of a cofferdam and diversion tunnel. It is necessary, therefore, to make a further study of the construction method.
A rapid rise in the water level is predicted when filling reserver begins. Adequate measures must be considered to cope with an eventuality arising from such a rapid rise in the water level

8.3 Construction Schedule

8. 3. 1 Chacabuco power plant

The proposed construction schedule for the Chacabuco power plant is generally appropriate. However, the 5 months period for the diversion tunnel is considered too short when taking into account the quantity of work executable per day. The reasonable construction period for the diversion tunnel and outlet works would be 9 months including some allowance. Fig. 8-1 shows the revised construction schedule indicating the quantity of work executable per day.

8. 3. 2 Salton San Carlos power plant

The proposed construction schedule for the Salton San Carlos power plant is considered generally too tight. In preparing a construction schedule, it is necessary to make a careful investigation of the quantity of work executable per day and the sequence of work. The construction period for the diversion tunnel and the outlet works should be a minimum of 15 months instead of 6 months as estimated under the basic plan. A period of at least seven years is generally required for the completion of a power plant similar in its scale to the proposed Salton San Carlos power plant. Fig 8-2 gives the revised construction schedule indicating the quantity of work executable per day.

Fig.-8.1 Construction Schedule of Chacabuco Power Station

(May ~ August : Snowy Season)

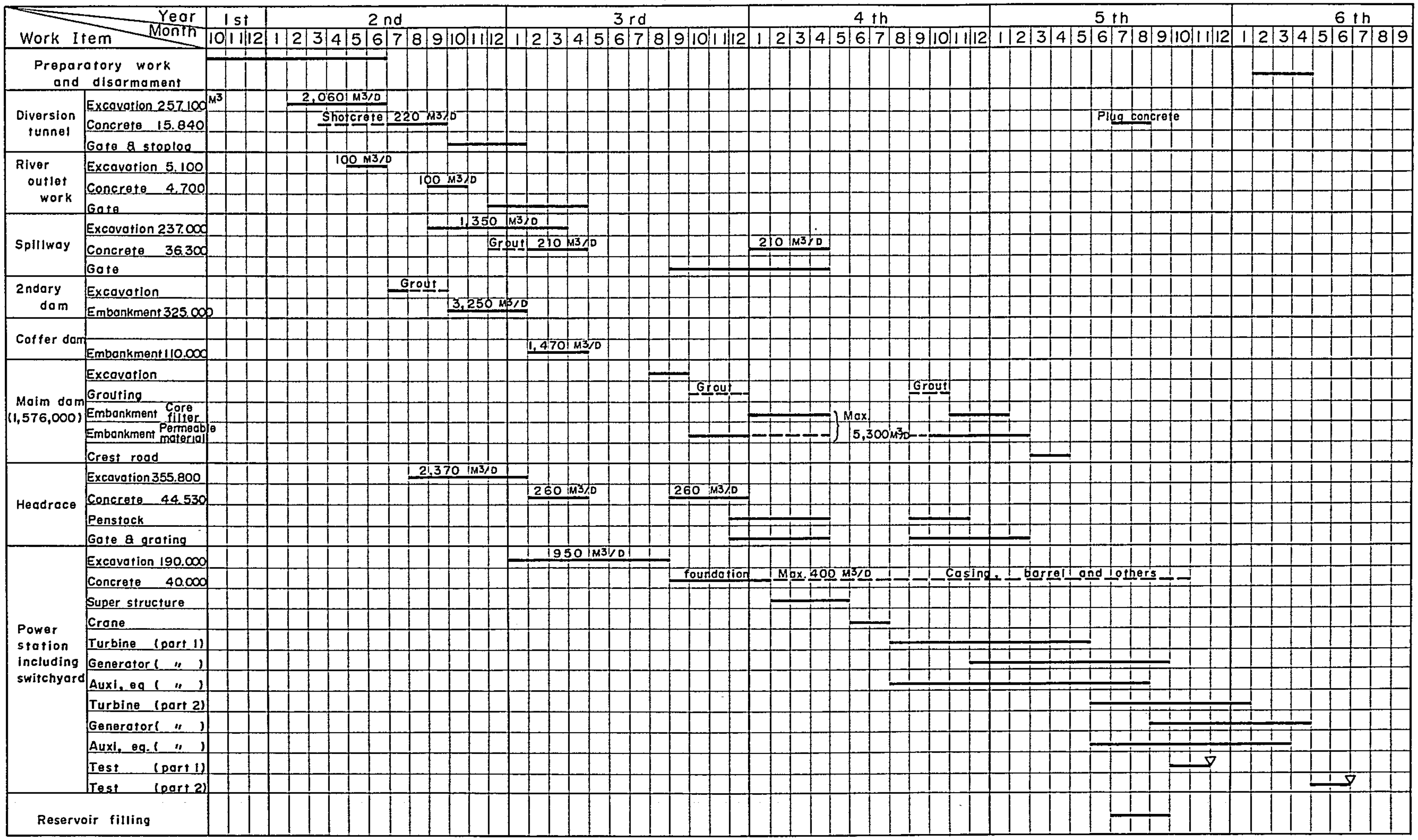
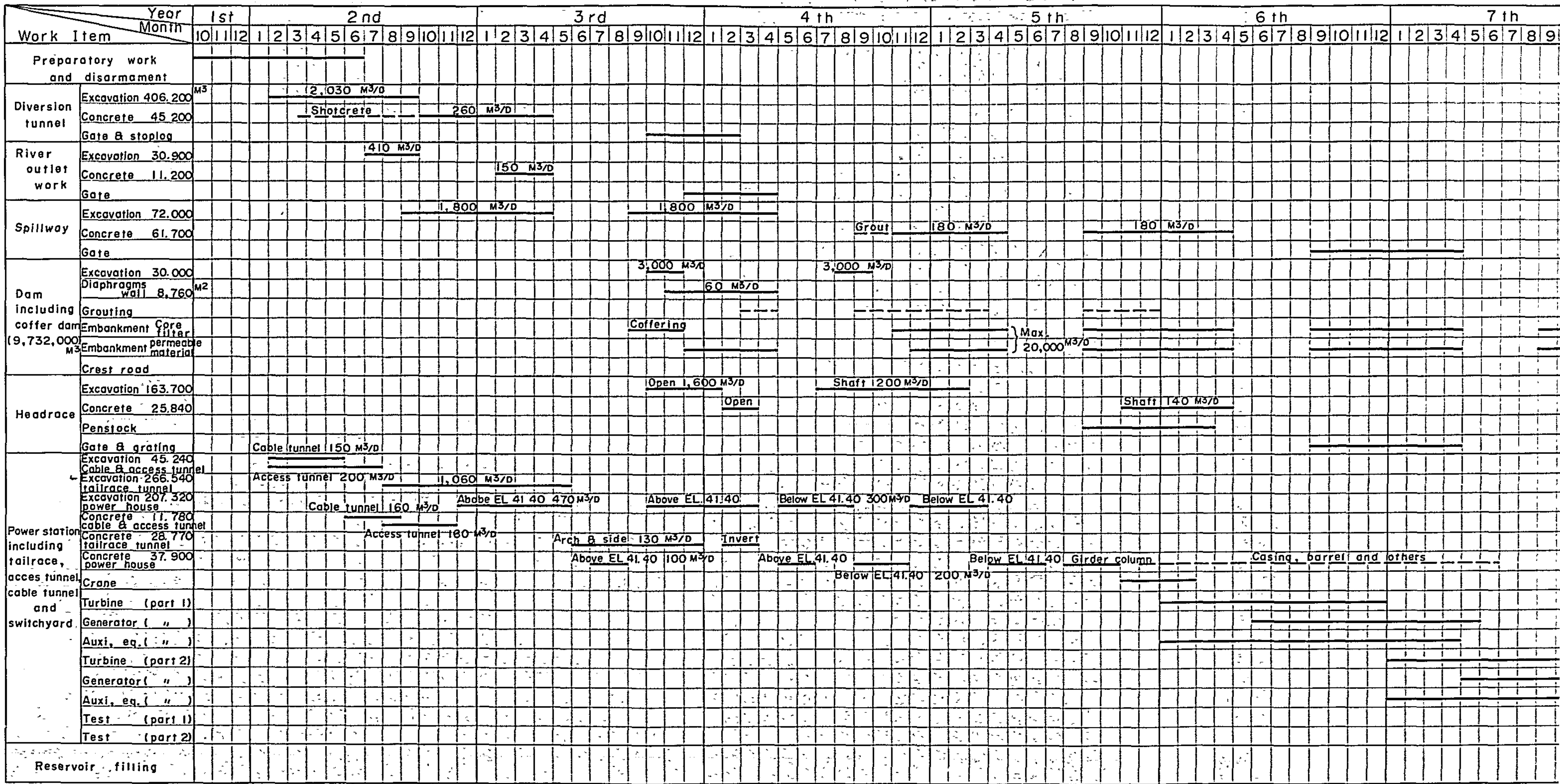


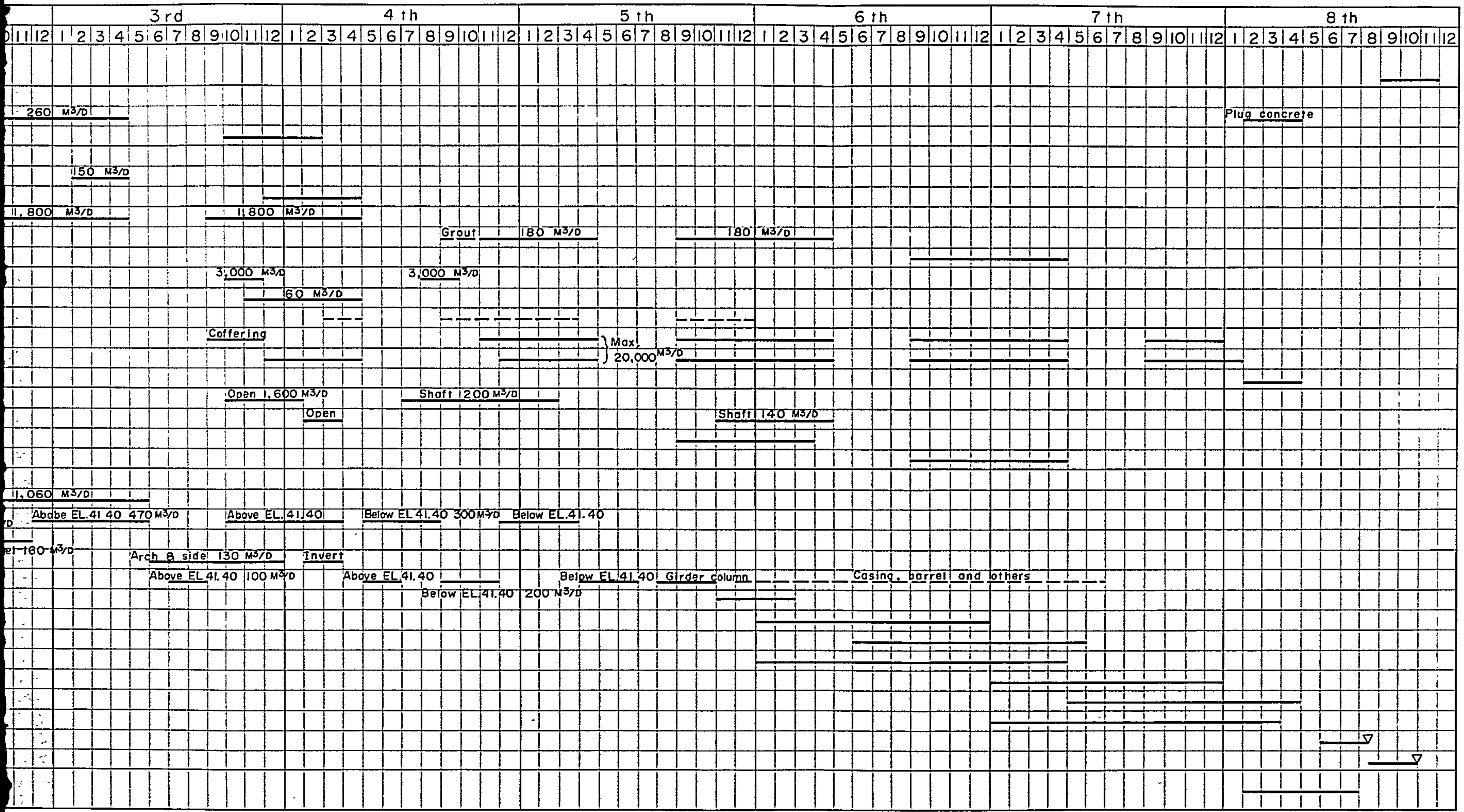
Fig.-8.2 Construction Schedule of Salton San Carlos Power Station

(May ~ August : Snowy Season)



.-8.2 Construction Schedule of Salton San Carlos Power Station

(May ~ August : Snowy Season)



8.4 Construction Cost

8 4. 1 Chacabuco power plant

The construction costs are considered generally too underestimated. Normally, electrical equipment and construction equipment account for a major portion of the total construction cost of a power plant. It is necessary, therefore, to include some allowance in the costs of the electrical equipment and construction equipment. The total construction cost excluding the infrastructure and transmission line is estimated at US$229 million. The cost will be modified more or less depending on the results of further investigations of relevant factors, such as geological conditions and the supply sources of construction materials.
Table 8-1 gives the estimated construction costs of the Chacabuco power plant by work schedule item, unit prices and other information. Table 8-2 shows the type and quantity of construction plant and equipment required for implementation of the projects.

Table - 8.1 Estimated Construction Cost (Chacabuco)

	Item	Description	Cost 10^3 U.S. $
I.	Direct Cost		
(1)	Land and Right		50
(2)	Diversion and River Outlet	Civil work	6,230
(3)	Spillway	"	5,870
(4)	Dam	"	11,140
(5)	Headrace	"	7,020
(6)	Power Station	"	8,730
(7)	Permanent Equipment		72,200
(8)	Expense for Construction Equipment		14,560
	Sub-total		125,800
II.	Indirect Cost		
(1)	Engineering and Administration	15 %	18,980
(2)	Construction Facilities		10,430
	Sub-total		29,410
III.	Contingencies		
(1)	For Direct Cost	20 %	25,300
(2)	For Indirect Cost	15 %	4,300
	Sub-total		29,600
IV.	Construction Cost	without tax	184,810
V.	Interest during Construction	8 % for F. C. 3 % for D. C.	44,290
VI.	Total Project Cost		229,100

Note: Excluding the cost of infrastructure and of the transmission line.

(A) Civil Work (Chacabuco)

Item - 1 Diversion Tunnel and River Outlet Work

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Care of water	L. S.			200.00	
Excavation open, rock	m^3	179,000	7.00	1,253.00	
Tunnel excavation, rock	m^3	78,100	30.00	2,343.00	
Shaft excavation, rock	m^3	5,100	35.00	178.50	outlet work
Concrete, diversion tunnel	m^3	15,840	65.00	1,029.60	including plug concrete
Concrete, outlet work	m^3	4,700	65.00	305.50	
Reinforcing steel	ton	470	650.00	305.50	
Grouting, backfilling	meter of tunnel	942	150.00	141.30	
Stop-log	ton	30	2,000.00	60.00	2 sets at the entrance of No. 1
Misc. work	L. S.			263.60	
Construction facilities	L. S.			150.00	
Total				6,230.00	

Note: In case of the shotcrete is required, the lining concrete for the section of shotcrete will be eliminated.

Item - 2 Spillway

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Excavation open, rock	m^3	237,000	7.00	1,659.00	
Backfilling	m^3	11,700	2.00	23.40	
Concrete, structures	m^3	36,300	65.00	2,359.50	
Reinforcing steel	ton	1,170	650.00	760.50	
Grouting, consolidation	m	1,200	25.00	30.00	including drilling
Grouting, curtain	m	2,400	45.00	108.00	"
Control room	L. S.			200.00	
Stop-log	ton	50	2,000.00	100.00	
Misc. work	L. S.			329.60	
Construction facilities	L. S.			300.00	
Total				5,870.00	

Item - 3 Dam (including 2ndary dam and coffer dams)

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Care of water	L. S.			400. 00	
Excavation open, rock	m^3	150, 000	7.00	1, 050. 00	
Embankment, core zone	m^3	298, 300	2.50	745.75	
Embankment, filter zone	m^3	214, 000	3.00	642. 00	
Embankment, pervious zone	m^3	1,253, 000	3.30	4, 134.90	material from excavation and quarry
Placing of rock material	m^3	245,700	5.50	1, 351.35	
Drilling, percussion	m	4,800	10.00	48. 00	
Drilling, Ex type	m	9, 500	30.00	285. 00	ø 59 mm
Pressure grouting	ton	358	600.00	214.80	
Concrete, dental work	m^3	500	60.00	30. 00	
Special treatment	L. S.			500. 00	at the right abutment
Observation system	L. S.			50. 00	
Stripping borrow area	m^3	50, 000	1.50	75. 00	
Crest road	m	390	300.00	117. 00	
Misc. work	L. S.			496.20	
Construction facilities	L. S.			1, 000. 00	
Total				11, 140. 00	

Item - 4 Headrace

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Excavation open, rock	m^3	355,800	7.00	2,490.60	
Concrete, structures	m^3	44,530	65.00	2,894.45	
Reinforcing steel	ton	1,350	650.00	877.50	
Cut slope protection	L. S.			100.00	
Misc. work	L. S.			257.45	
Construction facilities	L. S.			400.00	
Total				7,020.00	

Item - 5 Power Station (including switch-yard)

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Excavation open, rock	m^3	60,000	12.00	720.00	power house
Excavation open, rock	m^3	130,000	7.00	910.00	switch-yard
Banking	m^3	136,000	2.00	272.00	
Concrete, structures	m^3	40,000	65.00	2,600.00	
Reinforcing steel	ton	1,800	650.00	1,170.00	
Super structure	ton	640	1,300.00	832.00	
Architechtural work	L. S.			1,000.00	including command building
Stop-log	ton	30	2,000.00	60.00	2 sets at the tail-bay
Misc. work	L. S.			466.00	
Construction facilities	L. S.			700.00	
Total				8,730.00	

(B) Permanent Equipment (Chacabuco)

Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
(1) Diversion Tunnel and River Outlet Work					
Roller gate	ton	60	4,000	240	2 sets at the entrance of No. 2
Roller gate	ton	100	4,000	400	outlet service gate 2 sets emergency gate 2 sets
(2) Spillway					
Tainter gate	ton	360	4,000	1,440	4 sets at the weir crest
(3) Water Way					
Steel grating	ton	240	1,500	360	at the entrance of penstock 4 sets
Roller gate	ton	480	4,000	1,920	at the entrance of penstock
Penstock	ton	1,260	2,000	2,520	4 lines
Sub-total (1)+(2)+(3)				6,880	CIF Price
(4) Power Plant					
Turbine	L. S.			17,600	4 x 97.50 MW
Generator	L. S.			17,500	4 x 108 MVA
Transformer	L. S.			4,700	
Switchgear	L. S.			6,500	
Aux. equipment	L. S.			3,000	
Misc. material	L. S.			4,000	
Sub-total (4)				53,300	CIF Price
Total				60,180	CIF price

Cost of Permanent Equipment = 60,180 x 120% ≒ 72,200. 10^3 U. S. $

(including import expense, inland transportation and installation)

Table - 8.2 Construction Equipment

Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
(1) Gravel plant	L. S.			1,000.00	100 ton/hr.
(2) Batching plant	L. S.			500.00	mixer: 3 x 1.50 m^3 including cement silo
(3) Processing plant	L. S.			200.00	300 ton/hr.
(4) Compressor	L. S.			377.60	8 x 150 PS
(5) Bulldozer	L. S.			2,400.00	2 x D-9, 12 x D-8
(6) Shovel	L. S.			2,855.60	power shovel 4 x 3 m^3, 4 x 2 m^3
					tractor shovel 4 x 3 m^3, 4 x 2 m^3
(7) Dump truck	L. S.			2,728.10	24 x 20 ton, 16 x 15 ton
(8) Sheeps-foot roller	L. S.			188.80	2 x 20 ton
(9) Disk-harrow	L. S.			141.60	2 nos.
(10) Vibrating roller	L. S.			165.20	2 x 20 ton
(11) Crawler tractor	L. S.			165.20	2 x 20 ton
(12) Truck	L. S.			236.00	10 x 8 ton, 10 x 4 ton
(13) Truck crane	L. S.			470.80	3 x 30 ton
(14) Grader	L. S.			118.00	2 nos.
(15) Crawler drill	L. S.			108.60	4 x 4 ton
(16) Drill jumbo	L. S.			708.00	4 nos with drilling machine
(17) Drifter	L. S.			47.20	10 nos.
(18) Trailer	L. S.			165.20	1 x 30 ton, 1 x 40 ton
(19) Boring machine	L. S.			92.00	6 x 15 PS
(20) Grout mixer with pump	L. S.			35.40	3 x 10 PS
(21) Concrete pump	L. S.			177.00	3 x 40 m^3/hr.
(22) Truck mixer	L. S.			212.40	10 x 3 m^3
(23) Water truck	L. S.			35.40	2 x 190 PS
(24) Portable air compressor	L. S.			61.40	4 x 105 PS
(25) Road roller	L. S.			47.20	2 x 10 ton
(26) Pumps	L. S.			47.20	
(27) Fuel truck & grease car	L. S.			53.10	3 nos
(28) Other equipment	L. S.			1,334.00	
Sub-total				14,671.00	CIF price
Inland transportation	L. S.			619.00	including import expense 3 %
Total				15,290.00	

8.4.2 Salton San Carlos power plant

The construction costs are considered generally too underestimated. The total cost which does not include infrastructure and transmission line is estimated at US$526 million. The cost will be changed more or less depending on the outcome of further investigations. Table 8-3 shows the estimated construction costs of the Salton San Carlos power plant by work schedule item, unit prices and other cost data.

Table - 8.3 Estimated Construction Cost (Salton San Carlos)

		Description	Cost 10^3 U. S. $
I.	Direct Cost		
(1)	Land and Right		500
(2)	Diversion and River Outlet	Civil work	15,850
(3)	Spillway	"	11,520
(4)	Dam	"	57,020
(5)	Headrace	"	4,530
(6)	Power Station	"	26,760
(7)	Permanent Equipment		129,460
(8)	Expense for Construction Equipment		36,400
	Sub-total		282,040
II.	Indirect Cost		
(1)	Engineering and Administration	15 %	42,580
(2)	Construction Facilities		17,240
	Sub-total		59,820
III.	Contingencies		
(1)	For Direct Cost	20 %	56,770
(2)	For Indirect Cost	15 %	8,700
	Sub-total		65,470
IV.	Construction Cost	without tax	407,330
V.	Interest during Construction	8 % for F. C. 3 % for D. C.	119,400
VI.	Total Project Cost		526,730

Note: Excluding the cost of infrastructure and of the transmission line.

(A) Civil Work (Salton San Carlos)

Item - 1 Diversion Tunnel and River Outlet Work

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Care of water	L. S.			400.00	
Excavation open, common	m^3	69,100	1.50	103.65	
Excavation open, rock	m^3	71,200	7.00	498.40	
Tunnel excavation, rock	m^3	270,400	30.00	8,112.00	
Shaft and tunnel excavation, rock	m^3	26,400	35.00	924.00	outlet work
Concrete, diversion tunnel	m^3	45,200	65.00	2,938.00	
Concrete, outlet work	m^3	11,200	65.00	728.00	
Reinforcing steel	ton	800	650.00	520.00	
Grouting, backfilling	meter of tunnel	1,275	200.00	255.00	diversion tunnels
Grouting, backfilling	meter of tunnel	216	100.00	21.60	outlet work
Stop-log	ton	100	2,000.00	200.00	4 sets at the entrance of tunnels
Misc. work	L. S.			849.35	
Construction facilities	L. S.			300.00	
Total				15,850.00	

Note: In case of the shotcrete is required, the lining concrete for the section of shotcrete will be eliminated.

Item - 2 Spillway

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Excavation open, rock	m^3	720,000	7.00	5,040.00	
Backfilling	m^3	2,000	2.00	4.00	
Concrete, structures	m^3	61,700	65.00	4,010.50	
Reinforcing steel	ton	1,500	650.00	975.00	
Grouting, consolidation	m	700	25.00	17.50	including drilling
Grouting, curtain	m	1,300	45.00	58.50	" "
Control room	L. S.			200.00	
Cut slope protection	L. S.			100.00	
Stop-log	ton	50	2,000.00	100.00	1 set
Misc. work	L. S.			514.50	
Construction facilities	L. S.			500.00	
Total				11,520.00	

Item - 3 Dam (including coffer dams)

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Care of water	L. S.			1,600.00	
Excavation open, common	m^3	150,000	1.50	225.00	
Excavation open, rock	m^3	150,000	7.00	1,050.00	
Embankment, core zone	m^3	1,230,000	3.30	4,059.00	
Embankment, filter zone	m^3	690,000	3.90	2,691.00	
Embankment, pervious zone	m^3	7,350,000	4.80	35,280.00	material from excavation and quarry
Placing of rock material	m^3	462,000	7.00	3,234.00	
Diaphragms wall	m^2	8,760	150.00	1,314.00	
Drilling, percussion	m^3	5,000	10.00	50.00	
Drilling, Ex type	m	13,000	45.00	585.00	ø 59 mm
Pressure grouting	ton	450	780.00	351.00	
Observation system	L. S.			200.00	
Stripping borrow area	m^3	250,000	1.50	375.00	
Crest road	m	560	300.00	168.00	
Misc. work	L. S.			1,838.00	
Construction facilities	L. S.			4,000.00	
Total				57.020.00	

Item - 4 Headrace

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Excavation open, rock	m^3	127,000	7.00	889.00	
Tunnel excavation, rock	m^3	36,700	35.00	1,284.50	
Concrete structure & tunnel	m^3	25,840	65.00	1,679.60	
Reinforcing steel	ton	350	650.00	227.50	
Grouting, consolidation	m	6,000	30.00	180.00	
Misc. work	L. S.			119.40	
Construction facilities	L. S.			150.00	
Total				4,530.00	

Item - 5 Power Station (including tailrace, switch-yard, access, tunnel and cable tunnel)

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Excavation open, rock	m^3	22,500	7.00	157.50	
Tunnel excavation, rock	m^3	496,600	30.00	14,898.00	
Banking	m^3	122,000	2.00	244.00	switch-yard
Concrete, structure & tunnel	m^3	76,900	70.00	5,383.00	
Finishing concrete	m^3	1,550	80.00	124.00	
Reinforcing steel	ton	3,000	650.00	1,950.00	
Architechtural work	L. S.			1,500.00	including command building
Grouting, backfilling	meter of tunnel	1,900	150.00	285.00	tailrace & access tunnel
Grouting, backfilling	meter of tunnel	150	250.00	37.50	power house
Stop-log	ton	50	2,000.00	100.00	1 set at the outlet of tailrace tunnel
Misc. work	L. S.			881.00	
Construction facilities	L. S.			1,200.00	
Total				26,760.00	

(B) Permanent Equipment (Saltan San Carlos)

Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
(1) Diversion Tunnel and River Outlet Work					
Steel grating	ton	60	1,500	90	at the entrance of outlet tunnel
Roller gate	ton	100	4,000	400	outlet service gate and emergency gate 2 sets each
(2) Spillway					
Tainter gate	ton	390	4,000	1,560	3 sets at the weir crest
(3) Water Way					
Steel grating	ton	450	1,500	675	at the intake
Roller gate	ton	560	4,000	2,240	at the intake, 4 sets
Penstock	ton	1,080	2,000	2,160	4 lines
Roller gate	ton	440	4,000	1,760	4 sets at the beginning portion of tailrace tunnel
Sub-total (1)+(2)+(3)				8,885	CIF Price
(4) Power Plant					
Turbine	L. S.			32,200	4 x 230 MW
Generator	L. S.			32,200	4 x 255 MVA
Transformer	L. S.			12,900	
Switchgear	L. S.			9,700	
Aux. equipment	L. S.			5,000	
Misc. material	L. S.			7,000	
Sub-total (4)				99,000	CIF Price
Total				107,885	CIF Price

Cost of Permanent Equipment = 107,885 x 120 % ≒ 129,460 10^3 U. S. $

(including import expense, inland transportation and installation)

8.4.3 Energy cost

Table 8-4 shows the construction cost per kilowatt and energy cost per kilowatt-hour for the Chacabuco and Salton San Carlos power plants. The assumed conditions for energy cost are as follows.

A service life is 50 years and salvage value zero for generating facilities. The maintenance, personnel and overhead costs are assumed as 1.5 % of the total construction costs, and annual interest rate as 8 %. Based on these conditions, the annual expense over the service life were calculated and the ratio of the annual expense to the total construction cost was estimated 9.674 %. Assuming Puerto Chacabuco, Caleta Tortel and the estuary of the Pascua River to be the consumed areas, the annual expense and energy costs including the transmission and substation facilities were as presented in Table 8-6. The assumed conditions for calculation in respect of the transmission and substation facilities are a service life of 30 years, annual interest rate of 8 % and the percentage of the maintenance, personnel and overhead costs to the total cost of transmission and substation facilities assumed to be 2.5 %. Based on these assumptions, the percentage of annual expense for transmission and substation facilities to the total construction cost for these facilities was worked out at 11.383 %. Table 8-5 gives the construction cost of the transmission line and substations.

Table - 8.4 Energy Cost of Chacabuco and Salton San Carlos Power Stations

Power Station	Construction Cost 10^3US$	Installed Capacity MW	Annual Average Energy Production GWh	Annual Firm Energy Production GWh	Annual Cost 10^3US$	Cost per kW US$	Cost per kWh Average mills US$/kWh	Cost per kWh Firm mills US$/kWh
Chacabuco	229, 100	390	2, 850	2, 500	22, 163	587	7.9	8.9
Salton San Carlos	526, 730	920	6, 800	6, 100	50, 956	572	7.5	8.4
Total	755, 830	1, 310	9, 650	8, 600	73, 119	577	7.6	8.5

Table - 8.5 Construction Cost and Annual Cost of Transmission Line

Item		Distance km	Unit Cost US$/km	Construction Cost 10^3 US$	Annual Cost 10^3 US$
A To Southern Region					
(i) Line Chacabuco ~ Salton San Carlos 220kV, 2cct		60	140, 000	8, 400	956
(ii) Line Salton San Carlos ~ Caleta Tortel 500kV, 2cct		50	340, 000	17, 000	1, 935
(iii) Line Salton San Carlos ~ River Mouth Pascua 500kV, 2cct		90	340, 000	30, 600	3, 483
B To Northern Region					
(i) Line Salton San Carlos ~ Chacabuco 500kV, 2cct		60	340, 000	20, 400	2, 322
(ii) Line Chacabuco ~ Pto. Chacabuco 500kV, 3cct		230	510, 000	117, 300	13, 352
C Substation					
(i) In Southern Region	220kV, 300, 000kVA	-	L. S.	3, 800	432
(ii) In Northern Region	500kV, 500, 000kVA	-	L. S	16, 000	1, 821

Table - 8.6 Annual Cost at Receiving End

Item	Unit	River Mouth Pascua	Caleta Tortel	Puerto Chacabuco
Annual Cost of Power Stations	10^3US$	73,119	73,119	73,119
Annual Cost of Transmission Line	10^3US$	4,871	3,323	17,495
Total		77,990	76,442	90,614
Annual Average Energy Production	GWh	9,428	9,505	9,120
Annual Firm Energy Production	GWh	8,400	8,470	8,131
Annual Average Unit Energy Cost	mills US$/KWh	8.3	8.0	9.9
Annual Firm Unit Energy Cost	mills US$/KWh	9.3	9.0	11.1

Chapter 9

TAMANGO-SALTON GORGE ALTERNATIVE PLAN

Chapter 9. TAMANGO-SALTON GORGE ALTERNATIVE PLAN

9.1 Development Plan

This alternative plan is proposed as a substitute for the Chacabuco-Salton San Carlos Plan in case the Chacabuco dam described in Chapter 8 is not feasible or, even though feasible, requires costly foundation treatment. Under the Chacabuco-Salton San Carlos plan, the proposed damsites are restricted topographically. In addition, the high water levels of the upstream and downstream dams are limited by Lake General Carrera and Lake Cochrane, respectively. For these reasons, Tamango and Salton Gorge are selected as alternative upstream and downstream damsites. A power plant will be built at these damsites in series to attain an effective utilization of the head.

The mass curve of Fig. 9-1 was plotted using the observation records of the Bertrand gaging station covering the 1964 - 1971 period and represents the seasonal and yearly changes of the inflow into the Tamango reservoir. The mass curve shows that the reservoir inflow is limited in August, September and October but tends to increase in January, February and March. The seasonal difference is due to the discharge regulation in Lake General Carrera. The average annual inflow for the eight-years period is 694 m^3/sec, while the average monthly inflow is 525 m^3/sec for the August-October period, and 852 m^3/sec for the January-March period, which is about 1. 6 times more than in dry season.

During the eight-years period, an extreme low water level was registered in 1971. It is necessary to stabilize power plant output for a long time by regulating the reservoir inflow. Even during 1971, when the lowest droughty water level was reached, a storage capacity of about 2, 800 million cu. m. would be sufficient to regulate the reservoir inflow reasonally for power generation. A storage capacity of 3, 300 million cu. m. would be sufficient to regulate the reservoir inflow over several years. The storage capacity of 3, 800 million cu. m. impounded by the Chacabuco and Salton San Carlos dams accounts for 20 % of the annual total runoff of the Baker River and is considered adequate. The same storage capacity as the Chacabuco dam is considered for the Tamango dam. The high water level of 206. 7 m, low water level of 204. 7 m and the drow down of 2. 0 m are considered for the Tamango dam. Taking a 90 % plant utilization in respect of the power generation resulting from the average annual reservoir inflow, the power discharge is determined to be 190 m^3/sec for one unit or 760 m^3/sec for four units.

The reservoir operation rule were established in such a way as to assure a constant power output for a long time, to maximize the power generation and to minimize overflow, assuming power discharges of 760 m^3/sec at the end of May 700 m^3/sec, 640 m^3/sec and 600 m^3/sec as shown in Fig. 9-3. Fig. 9-5 shows the power discharge, reservoir inflow, reservoir level and other relevant factors involved in the reservoir operation during the 1964-1971 period in accordance with the said operation rule and Table 9-1 gives the energy generated under these conditions.

The high water level of the Salton Gorge reservoir was assumed as 90.00m in view of the restrictions imposed by the tailrace level of the Tamango power plant. The seasonal and annual changes in the reservoir inflow during the 1964 - 1971 period are represented by the mass curve of Fig. 9-2. The average annual inflow for the eight-years period is 946 m3/sec and the average monthly inflows for the August - October and January - March periods are 808 m^3/sec and 1,075 m^3/sec, respectively. As noted, the discharge during the wet season is about 1.3 times more than in the dry season.

The total storage capacity of the Salton Gorge dam at high water level is 2,900 million cu. m. The available drow down of the reservoir that assures effective storage capacity ranging between 1,700 million cu. m. and 2,100 million cu. m. is 15 m to 20 m from the topographical views. An effective storage capacity of 3,700 million cu. m. is required for seasonal regulation of the reservoir inflow. Taking into consideration water amount of overflow and the necessity for effective operation of the upstream power plant, the available drow down of the reservoir was assumed to be 17 m and the storage capacity to be 1,900 million cu. m, or about 6 % of the annual runoff. Taking a 90 % plant factor in respect of the power generated by the average annual inflow, the power discharge was assumed to be 260 m^3/sec for a unit, or 1,040 m^3/sec for four units.

Fig. 9-4 shows the reservoir operation rule and Fig. 9-6 gives the power discharge, inflow, reservoir water level and other pertinent factors involved in the reservoir operation during the 1964 - 1971 period in accordance with the operation rule. Table 9-2 shows the energy generated under the above conditions. The proposed upstream and downstream dams are rock fill type and the power plants will be semi-underground type. The maximum output is 720 MW for the upstream power plant and 440 MW for the downstream power plant. The annual energy production is 5,541 GWh for the upstream power plant and 3,035 GWh for the downstream plant.

The rock fill dam planned for the upstream site of Tamango will be 170 m in height and 13.5 million cu. m. in dam volume. The upstream power plant will be built on the left hand bank to provide a maximum output of 720 MW using the effective head of 116 m and a maximum discharge of 760 m3/sec. The rock-fill dam proposed for the downstream site of Salton Gorge will be 70 m in height and 14.3 million cu.m. in dam volume. The dam will have an effective storage capacity of 1,900 million cu. m. (see Fig. 9-7) and a design flood discharge of 8,000 m^3/sec. Four diversion tunnels of 9.5 m in diameter will be provided on the right hand bank.

The downstream power plant will be constructed on the left hand bank to provide a maximum output of 440 MW using an effective head of 51 m and a maximum discharge of 1,040 m^3/sec. Table 9-3 gives the outline of the Tamango - Salton Gorge hydroelectric development plan and the proposed major facilities. It has also been studied to construct concrete dams at the Salton Gorge site instead of rock fill type. Concrete dams are much more economical than the rock fill type, since it requires only two diversion tunnels and permit a spillway to be built inside the dam. Feasibility of the concrete dam construction should be studied after detailed geological investigations are carried out. (see Fig. 7-9)

Fig.— 9.1 Mass Curve at Tamango Site

Fig.– 9.2 Mass Curve at Salton Gorge Site

Symbols (Unit ; m^3/sec. day)

V_{t-1}	;	Storage at the end of previous day
V_t	;	Storage at the end of current day
V_{max}	;	Maximum Storage
V_{min}	;	Minimum Storage
V_H	;	Standard upper limit of storage
V_M	;	Standard middle limit of storage
V_L	;	Standard lower limit of storage
Q_o	;	Overflow in current day
Q_{max}	;	Maximum discharge for power
Q_u	;	Standard upper limit of discharge for power
Q_M	;	Standard middle limit of discharge for power
Q_L	;	Standard lower limit of discharge for power
Q_{LL}	;	Minimum discharge for power
ϑ_t	;	Inflow in current day
Q_t	;	Discharge for power in current day
Q'	;	Temporary discharge for power in current day

Basic Formulas

$$V_{max} \geqq V_{t-1} + \vartheta_t - Q_t \longrightarrow V_t = V_{t-1} + \vartheta_t - Q_t$$

$$V_{max} < V_{t-1} + \vartheta_t - Q_t \longrightarrow V_t = V_{t-1} + \vartheta_t - Q_t - Q_o$$

$$Q_o = V_{t-1} + \vartheta_t - Q_t - V_{max}$$

Operation Rulu

1. $V_t \geqq V_{max}$
   (1) $V_t - V_{max} \geqq Q_{max} \longrightarrow Q' = Q_{max}$
   (2) $Q_{max} > V_t - V_{max} \geqq Q_u \longrightarrow Q' = V_t - V_{max}$
   (3) $Q_u > V_t - V_{max} \longrightarrow Q' = Q_u$
2. $V_t < V_{max}$
   (1) $V_t \geqq V_H$
   $V_t - V_H \geqq Q_u \longrightarrow Q' = Q_u$
   $Q_u > V_t - V_H \geqq Q_M \longrightarrow Q' = V_t - V_M$
   $Q_M > V_t - V_M \longrightarrow Q' = Q_M$

(2) $V_H > V_t \geqq V_M$

$$V_t - V_M \geqq Q_M \longrightarrow Q' = Q_M$$

$$Q_M > V_t - V_M \geqq Q_L \longrightarrow Q' = V_t - V_M$$

$$Q_L > V_t - V_M \longrightarrow Q' = Q_L$$

(3) $V_M > V_t \geqq V_L$

$$V_t - V_L \geqq Q_L \longrightarrow Q' = Q_L$$

$$Q_L > V_t - V_L \geqq Q_{LL} \longrightarrow Q' = V_t - V_L$$

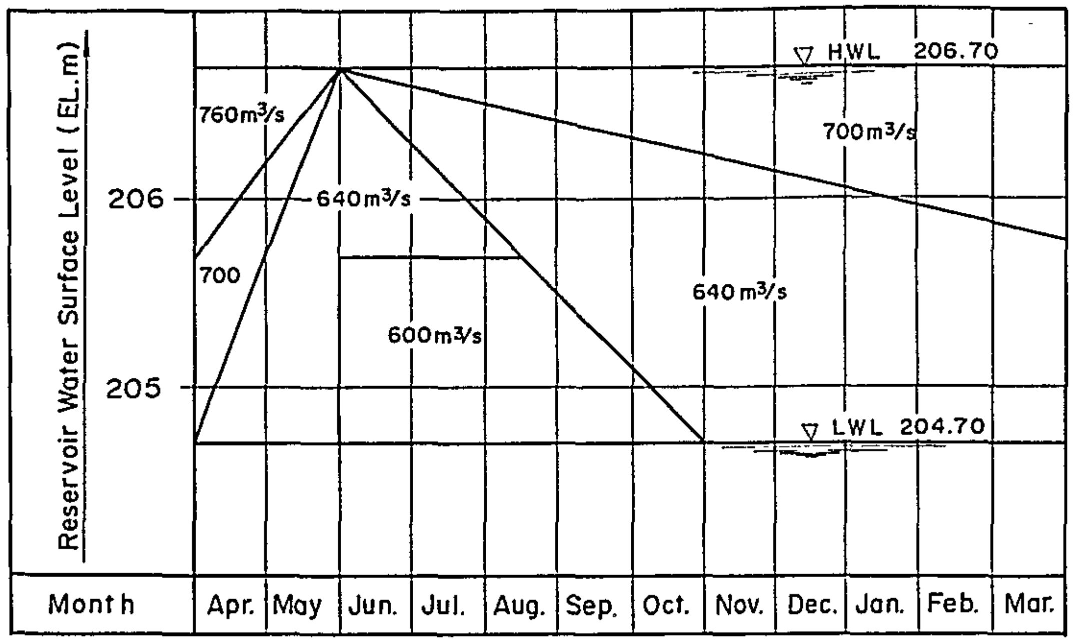
$$Q_{LL} > V_t - V_L \longrightarrow Q' = Q_{LL}$$

(4) $V_L > V_t - V_L \longrightarrow Q' = Q_{LL}$

$$V_t - Q' \geqq 0.0 \longrightarrow Q_t = Q'$$

$$V_t - Q' < 0.0 \longrightarrow Q_t = V_t$$

Fig. –9.3 Operation Rule of Tamango Reservoir



Month	V_H		V_M		V_L	
	EL. m	$10^6 m^3$	EL. m	$10^6 m^3$	EL. m	$10^6 m^3$
Apr.	205.70	1905	204.70	0	204.70	0
May	206.19	2842	205.68	1874	204.70	0
Jun.	206.70	3810	206.70	3810	205.70	1905
Jul.	206.60	3622	206.31	3063	205.70	1905
Aug.	206.50	3428	205.90	2291	205.70	1905
Aug.16	206.45	3334	205.70	1917	205.70	1905
Sep.	206.40	3233	205.50	1519	205.49	1509
Oct.	206.30	3046	205.11	772	205.11	772
Nov.	206.20	2851	204.70	0	204.70	0
Dec.	206.10	2663	204.70	0	204.70	0
Jan.	206.00	2469	204.70	0	204.70	0
Feb.	205.90	2275	204.70	0	204.70	0
Mar.	205.80	2099	204.70	0	204.70	0

Constants

Q_{max} = 760 m³/sec

Q_U = 760 m³/sec Apr. to May

= 700 m³/sec Jun. to Mar.

Q_M = 700 m³/sec Apr. to May

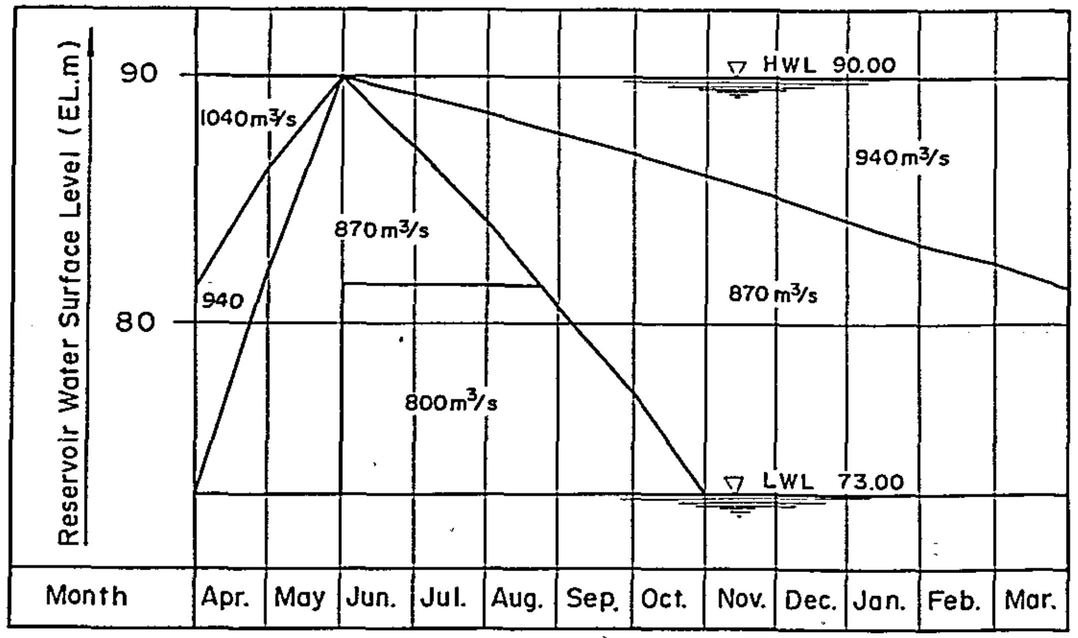
= 640 m³/sec Jun. to Mar.

Q_L = 640 m³/sec Nov. to May

= 600 m³/sec Jun. to Oct.

Q_{LL} = 600 m³/sec

Fig.– 9.4 Operation Rule of Salton Gorge Reservoir



Month	V_H		V_M		V_L	
	EL.m	$10^6 m^3$	EL.m	$10^6 m^3$	EL. m	$10^6 m^3$
Apr.	81.50	850	73.00	0	73.00	0
May	86.25	1407	82.27	934	73.00	0
Jun.	90.00	1900	90.00	1900	81.50	850
Jul.	89.25	1796	87.23	1527	81.50	850
Aug.	88.46	1689	84.10	1142	81.50	850
Aug.24	87.83	1600	81.50	840	81.50	850
Sep.	87.65	1582	80.65	758	80.65	758
Oct.	86.85	1479	77.05	385	77.05	385
Nov.	85.99	1372	73.00	0	73.00	0
Dec.	85.14	1268	73.00	0	73.00	0
Jan.	84.24	1161	73.00	0	73.00	0
Feb.	83.32	1054	73.00	0	73.00	0
Mar.	82.47	957	73.00	0	73.00	0

Constants

Q_{max} = 1040 m³/sec

Q_U = 1040 m³/sec Apr. to May

= 940 m³/sec Jun. to Mar.

Q_M = 940 m³/sec Apr. to May

= 870 m³/sec Jun. to Mar

Q_L = 870 m³/sec Nov. to May

= 800 m³/sec Jun. to Oct.

Q_{LL} = 800 m³/sec

Fig.- 9.5 In-Flow Power Discharge and Reservoir Water Surface of Tamango Power Station

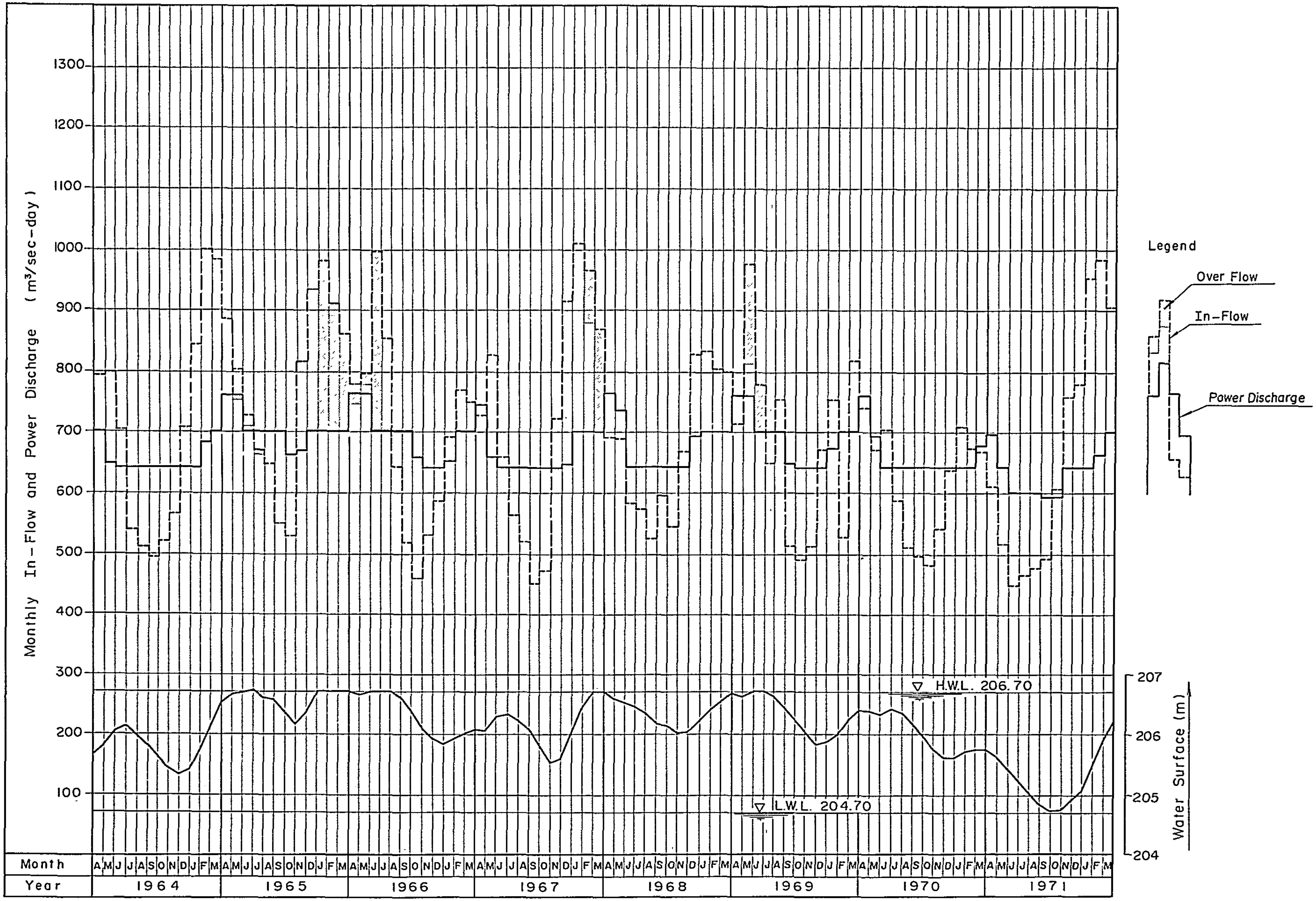


Fig.-9.6 In-Flow Power Discharge and Reservoir Water Surface of Salton Gorge Power Station

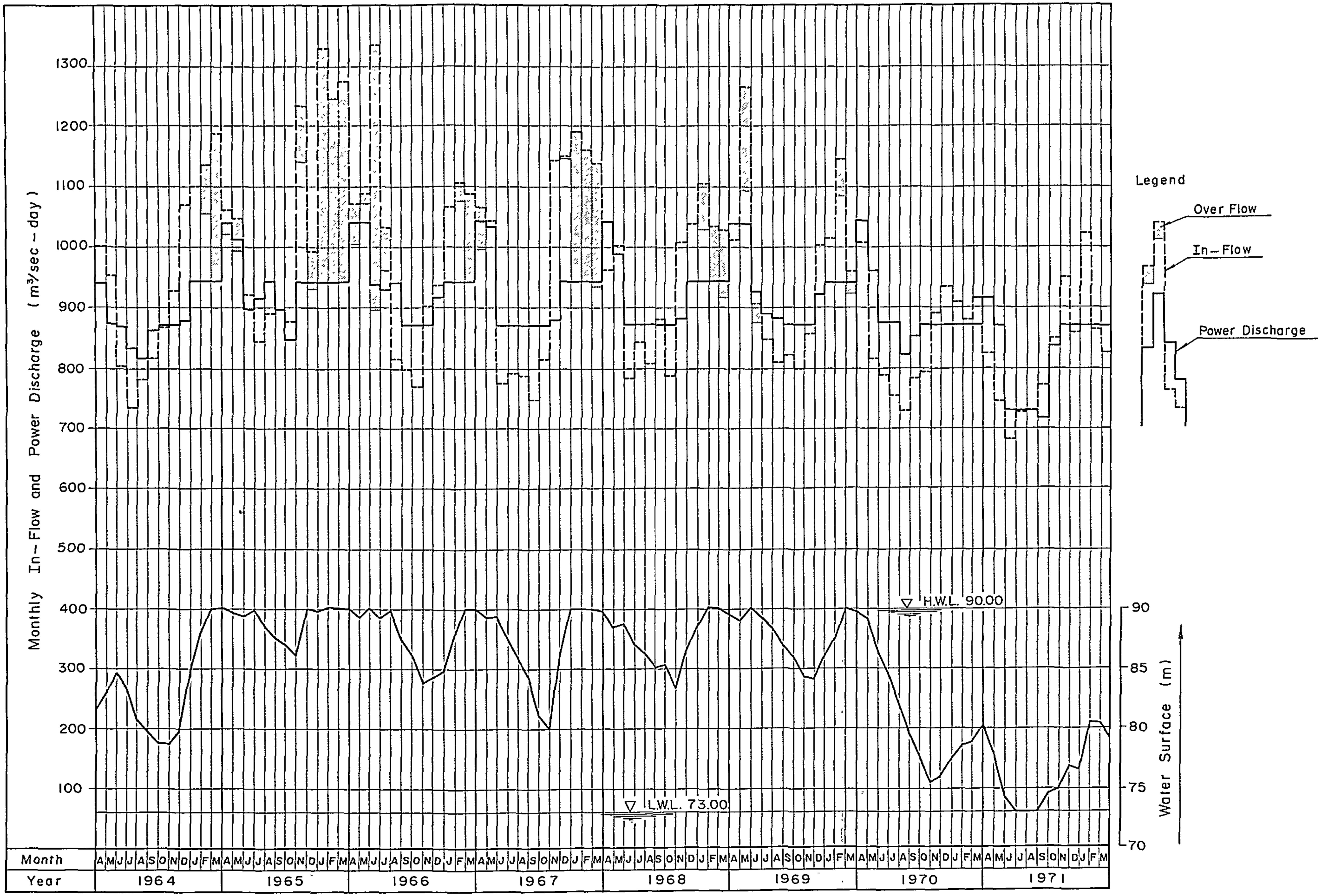


Fig.-9.7 Reservoir Storage Capacity and Area Curves of Salton Gorge

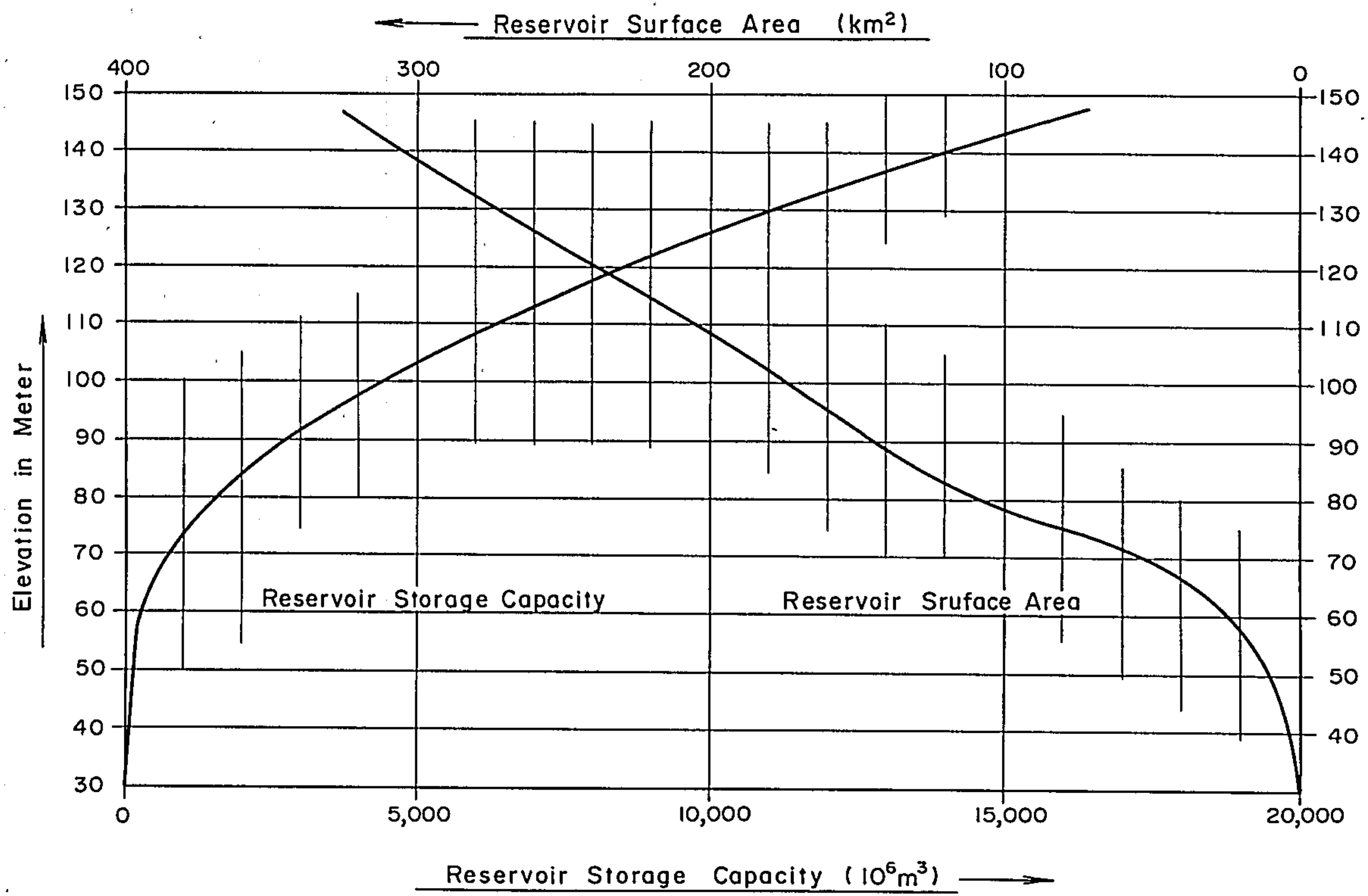


Table-9.1 Energy Production at Tamango Power Station

(Unit: GWh)

Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1964	472.9	452.8	433.8	448.1	447.4	432.2	445.9	431.0	445.2	446.0	431.3	491.3	5,377.9
1965	517.4	535.0	476.8	492.7	492.4	475.9	463.7	453.0	492.2	492.8	445.1	492.8	5,829.8
1966	517.8	534.9	476.9	492.8	492.7	476.1	461.2	433.3	447.4	454.1	442.3	489.9	5,719.4
1967	504.1	463.2	434.6	448.8	446.3	433.0	446.4	431 7	449.7	490.9	460.7	492.8	5,504.2
1968	517.6	514.8	435.3	449.4	448.9	434.0	448.1	433.2	486.4	491.1	444.3	492.6	5,595.7
1969	517.5	534.9	476.9	492.7	492.1	440.3	448.2	433.0	447.2	469.2	442.9	491.2	5,686.1
1970	516.4	487.2	434.8	449.3	448.8	433.6	447.2	432.1	446.1	446.4	403.4	471.8	5,417.1
1971	469.9	445.9	403.9	416.5	415.9	395.8	411.2	428.7	443.8	444.9	432.9	490.2	5,199.6
Average	504.2	496.1	446.6	461.3	460.8	440.1	446.5	434.5	457.2	466.9	437.9	489.1	5,541.2

Table-9.2 Energy Production at Salton Gorge Power Station

(Unit: GWh)

Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1964	242.3	239.9	235.6	220.6	210.3	205.8	210.8	208.0	230.8	273.8	264.8	296.1	2,838.8
1965	315.4	316.5	270.5	282.5	285.7	259.0	267.1	270.0	296.0	296.0	267.4	296.1	3,422.2
1966	316.1	324.8	285.7	291.2	288.0	248.5	247.0	233.4	258.0	274.6	263.5	296.0	3,326.8
1967	316.0	322.1	257.5	256.4	248.8	226.8	221.4	233.0	282.1	296.1	277.0	296.0	3,233.2
1968	311.8	304.2	254.7	255.8	249.9	242.1	243.6	235.6	282.0	291.4	267.4	295.5	3,234.0
1969	310.4	324.8	279.7	272.9	265.9	247.1	247.3	233.2	261.7	275.5	263.4	295.7	3,277.6
1970	314.1	289.7	242.2	235.8	211.4	201.1	200.0	190.1	202.4	210.8	192.1	217.0	2,706.7
1971	218.4	198.8	150.3	154.3	153.2	146.2	184.3	189.5	203.5	209.3	212.1	219.3	2,239.2
Average	293.1	290.1	247.0	246.2	239.2	222.1	227.7	224.1	252.1	265.9	250.9	276.5	3,034.9

Table - 9.3 Description of Tamango and Salton Gorge Projects

Item	Tamango	Salton Gorge
Location	Province of Aisen, Chile	
River	Baker River	
Catchment area	18,240 km^2	25,200 km^2
Design flood discharge	3,200 m^3/sec	8,000 m^3/sec
Gross storage capacity	-	2,800 x 10^6 m^3
Effective storage capacity	3,810 x 10^6 m^3	1,900 x 10^6 m^3
Reservoir area	1,900 km^2	145 km^2
High water level	206.7 m	90 m
Available drawdown	2 m	17 m
Installed capacity	720 MW	440 MW
Maximum power discharge	760 m^3/sec	1,040 m^3/sec
Effective head	116 m	51 m
Annual power production	5,541 GWh	3,035 GWh
Dam		
Type	Rockfill with center impervious core	
Height	170m (Assumed rock surface E.L 42.0)	70
Crest length	560 m	288 m
Width of crest	12 m	10 m
Volume	13,500.000 m^3	1,430,000 m^3
Spillway		
Type	Ski jump type	Ski jump type
Gate	Roller gate	Roller gate
Height x Width x Numbers	14m x 15m x 2	14.5m x 15m x 5
Length	230 m	313 m
Intake		
Structure (Height x Width)	39m x 74.5m	39m x 72m
Gate	Roller gate	Roller gate
Numbers	4	4
Penstock		
Numbers	4	4
Length (Average)	445 m	164 m
Inner diameter	7.00～6.00m	7.50 7.00m
Powerhouse		
Type	Semi-underground	Semi-underground
Structure (Width x Length)	36m x 115m	42m x 141m
Tailrace		
Type	Open channel	Open channel

9.2 Tamango Power Plant

9.2.1 Dam

The proposed Tamango dam is a center core type rock fill dam consisting of core zone, filter zone and rock zone. The slope is 1 : 2.6 for the upstream and 1 : 1.85 for the downstream. The dam is 170 m high above the bedrock, 560 m in crest length and 13.5 million cu. m. in dam volume. (see Figs. 9-8, 9-9 and 9-10)

9.2.2 Intake

The intake, to be built on the left side bank of the dam, will be of vertical concrete structure 74.5 m in width and 34 m in height. It will be provided with four gates capable of passing a power discharge of 760 m^3/sec. (see Fig. 9-11)

9.2.3 Penstock

Four penstocks will be connected with the intake installed on the left side of the dam. The penstock measures 6.0 to 7.0 m in diameter, 445 m in average length and 23 to 26 mm in thickness. (see Fig. 9-11)

9.2.4 Spillway

The spillway, to be built on the right side of the dam, will be of concrete ski-jump type. It is to be provided with two roller gates, each having height of 14 m and width of 15 m, which will be of such construction that the design flood discharge of 2,640 m^3/sec and abnormal flood discharge of 3,200 m^3/sec will be released without overflowing. (see Fig. 9-12)

9.2.5 Power station

The power station will be built adjacent to the dam on the left side bank, and will be reinforced concrete semi-underground type, 36 m in width, 46 m in height and 115 m in length. Four vertical shaft Francis turbines of 193,000 KW and four generators of 210,000 KVA, 50 Hz will be installed in the power house. (see Fig. 9-13)

9.2.6 Turbine and generator

The power station will be designed for a normal effective head of 114 m, available draw down of 2 m and maximum power discharge of 190 m^3/sec per unit. The adequate type of turbine to meet to these design conditions is vertical shaft Francis turbines. Output of the proposed Francis turbine will be 193,000 KW with revolution of 150 rpm, fitted with a butterfly valve for inlet.

The generator is an enclosed air duct circulating type with capacity of 210,000 KVA and 16.5 KV at a rated lagging power factor of 0.9. Four 210,000 KVA 3-phase forced oil-immersed air cooling transformers will be installed in an outdoor switch-yard adjacent to the power plant. The secondary voltage of the transformer will be 220 KV.

9.2.7 Related system diagram

Fig. 9-14 shows the related system diagram which has been selected. It is considered that the generators will be equipped with synchronous devices on the high-voltage circuit of 220KV and also station service transformer and a diesel generator as stand-by power source are considered.

The outdoor switchyard will be constructed on the right bank of the dam. Besides, circuit breakers, disconnecting switches and other equipment for transmission line will be installed in the outdoor switchyard.

The outgoing circuit of transmission line consists of 4 cct, 220KV lines in consideration of a distance between the power station and Puerto Aisen where power will be consumed, but 2 cct, 500KV transmission lines might be constructed instead of 4 cct, 220KV lines mentioned above provided the Pascua Hydroelectric Power Plant (1,300 MW) Project is advanced. However, as there is no definite prospect for the construction of the Pascua Hydroelectric Power Station at present, number of lines of 4 cct and transmission voltage of 220KV is regarded to be applicable for Salton Gorge and Tamango power stations.

The plan also includes the construction of facilities for outgoing lines on assumption that 2cct, 220KV lines will be laid between Salton Gorge and the power station. Single bus system with transfer bus will be installed for outdoor 220KV bus bars.

9.2.8 Construction schedule

It is estimated that the construction of Tamango power station requires about 9 years taking into account the quantity of work, arrangement of structures and specific regional factors such as topography, climate, etc. Fig. 9-15 shows relative construction schedule.

9.2.9 Construction cost

The total construction cost excluding the infrastructure and transmission line is estimated at US$580 million. However, the cost will be modified more or less depending on the results of further investigation of relevant factor, such as geological conditions and the supply sources of construction materials. Table 9-4 shows the estimated construction costs of the Tamango Power Station by costruction schedule item, unit prices and other cost data. The construction cost per kilowatt and energy cost for the Tamango power station were described in subsection 9.3.9.

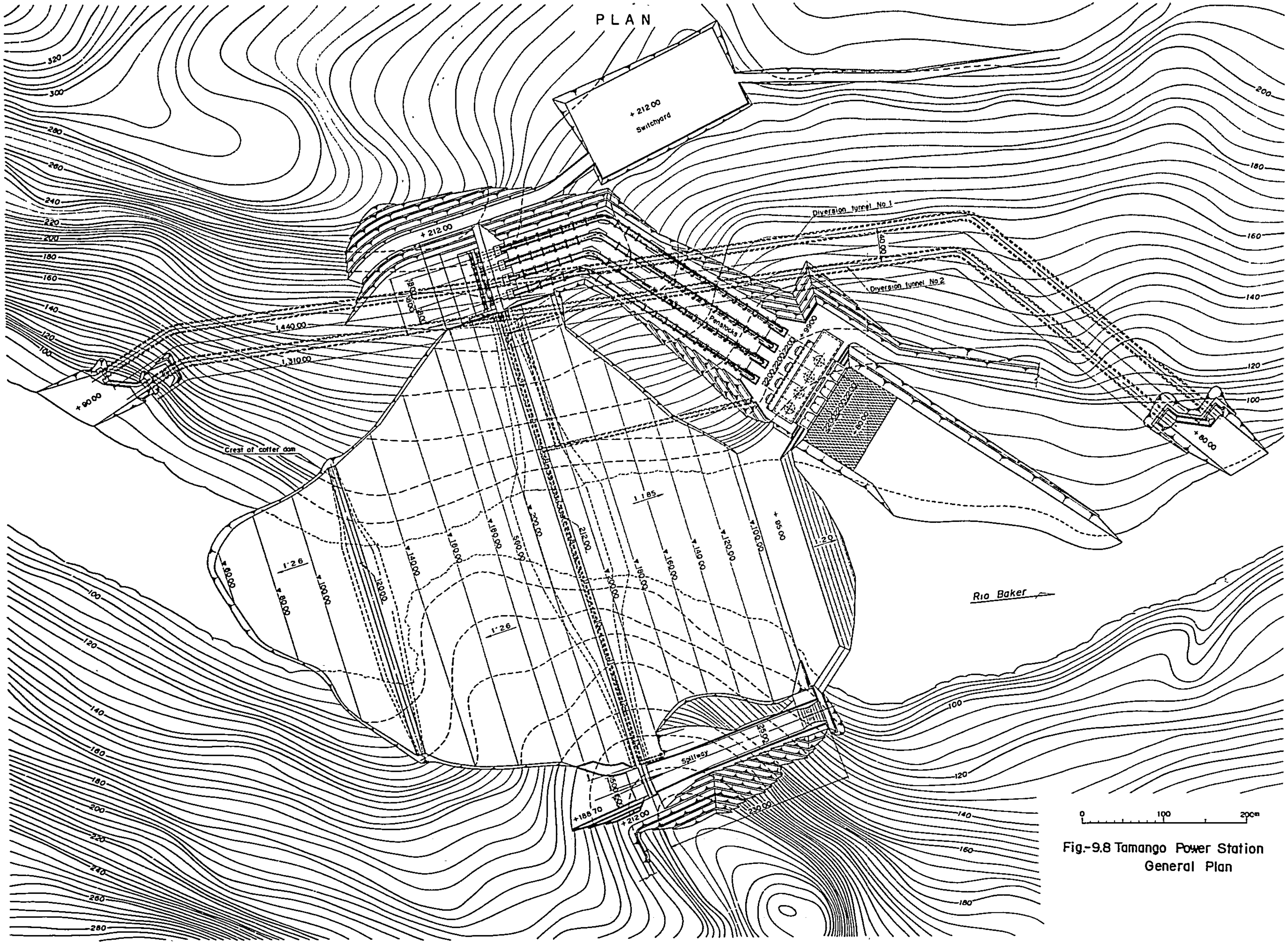
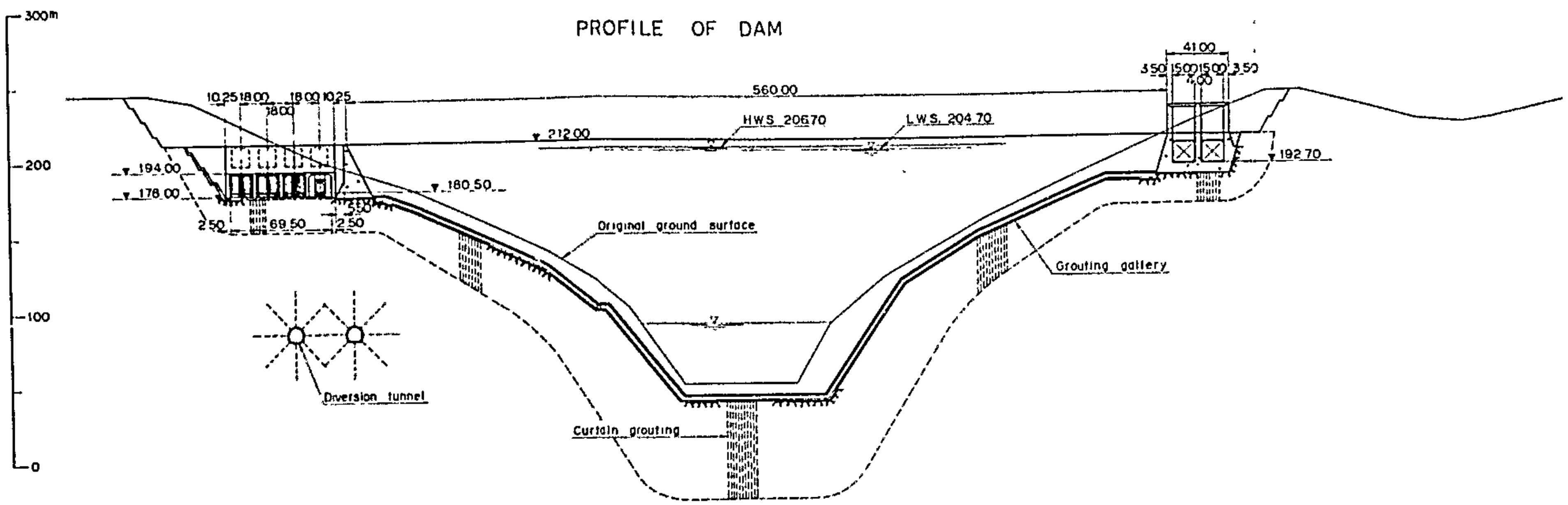


Fig.-9.8 Tamango Power Station General Plan



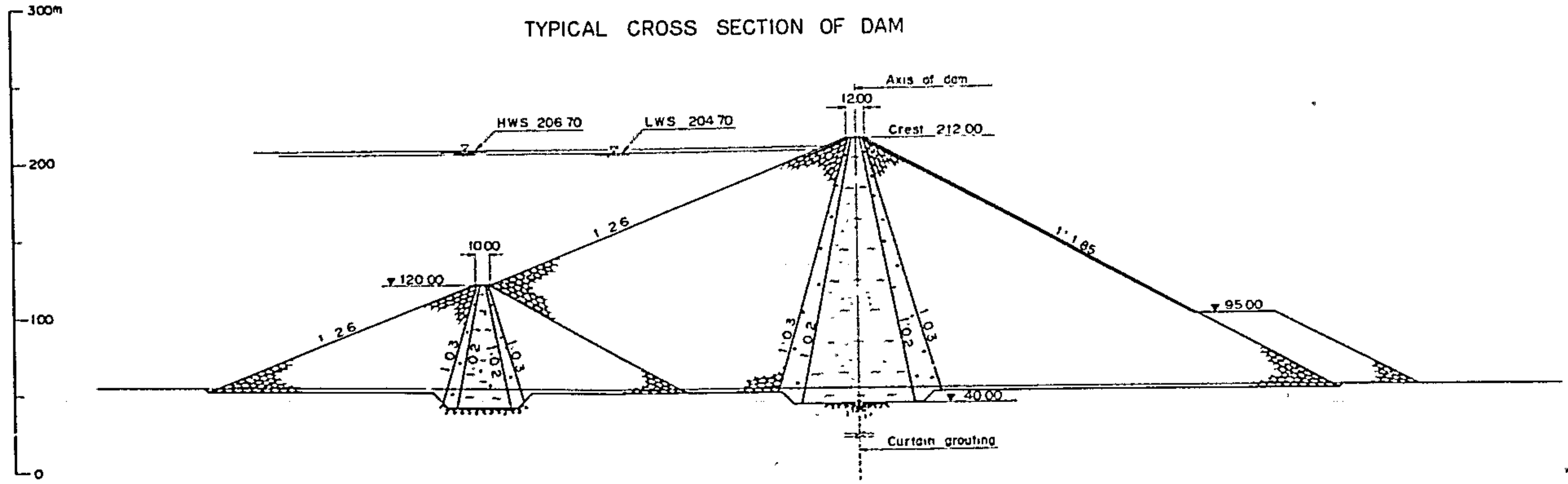


Fig.-9.9 Tamango Power Station
Dam
Profile and Section

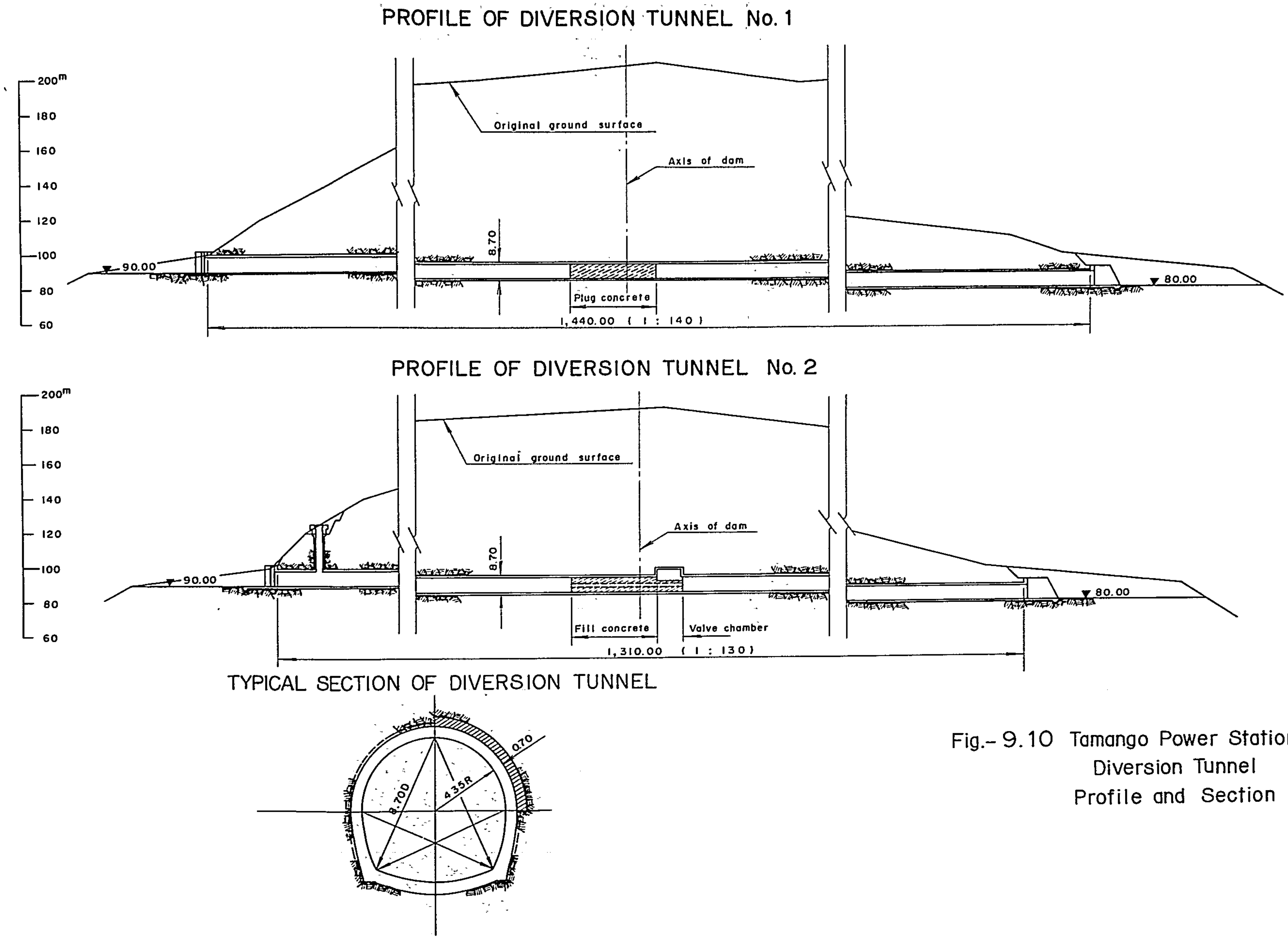


Fig.- 9.10 Tamango Power Station
Diversion Tunnel
Profile and Section

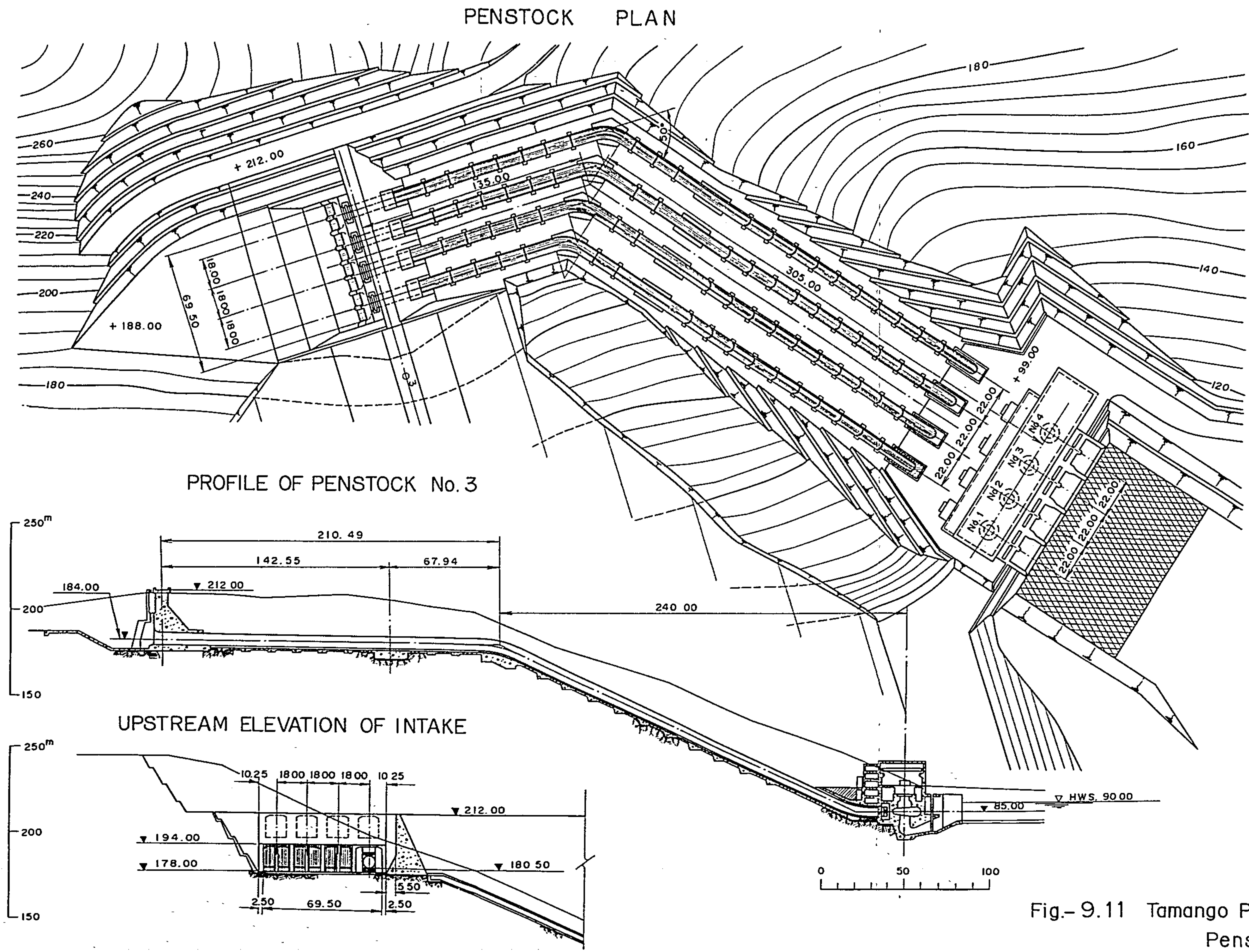
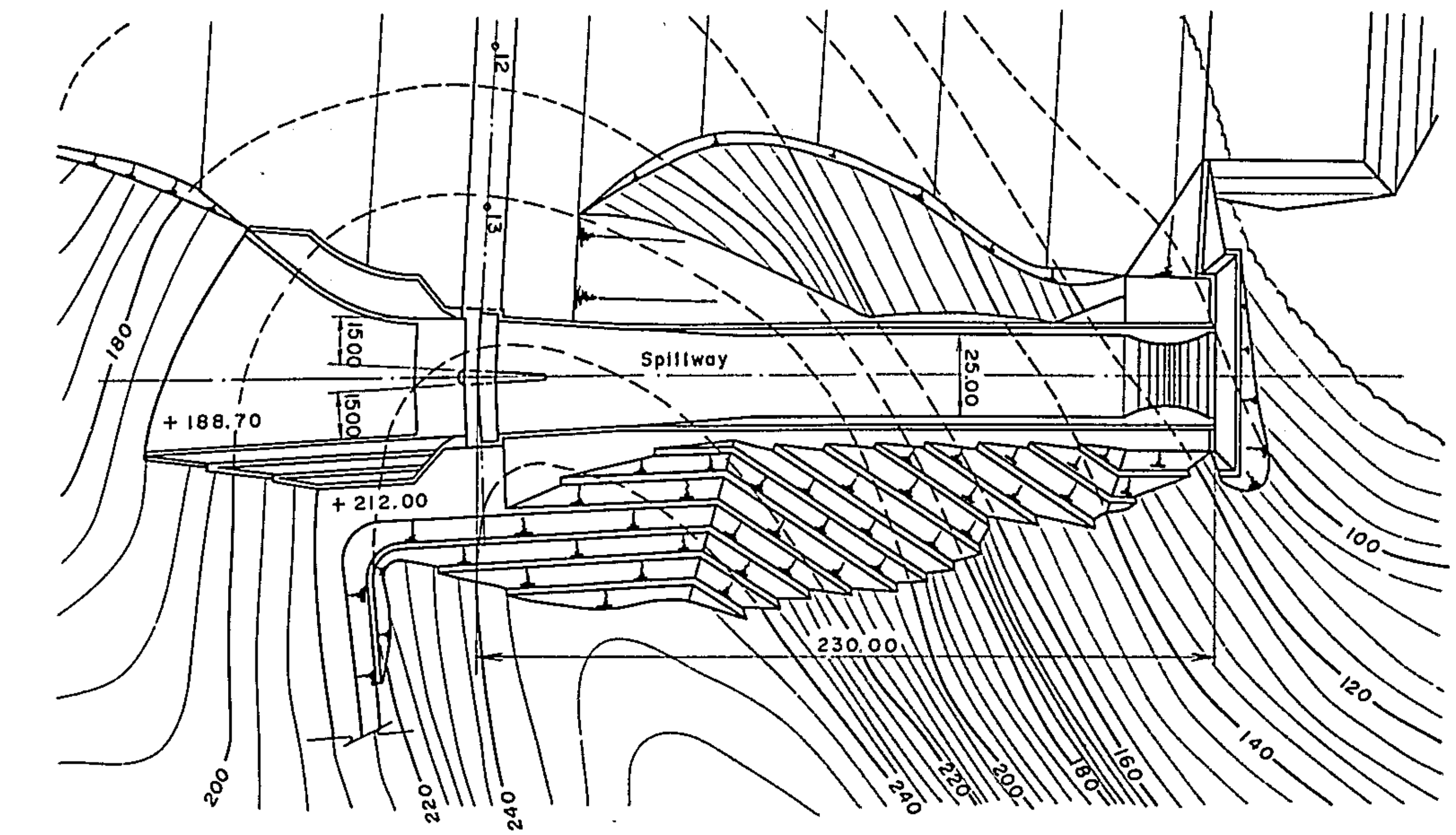
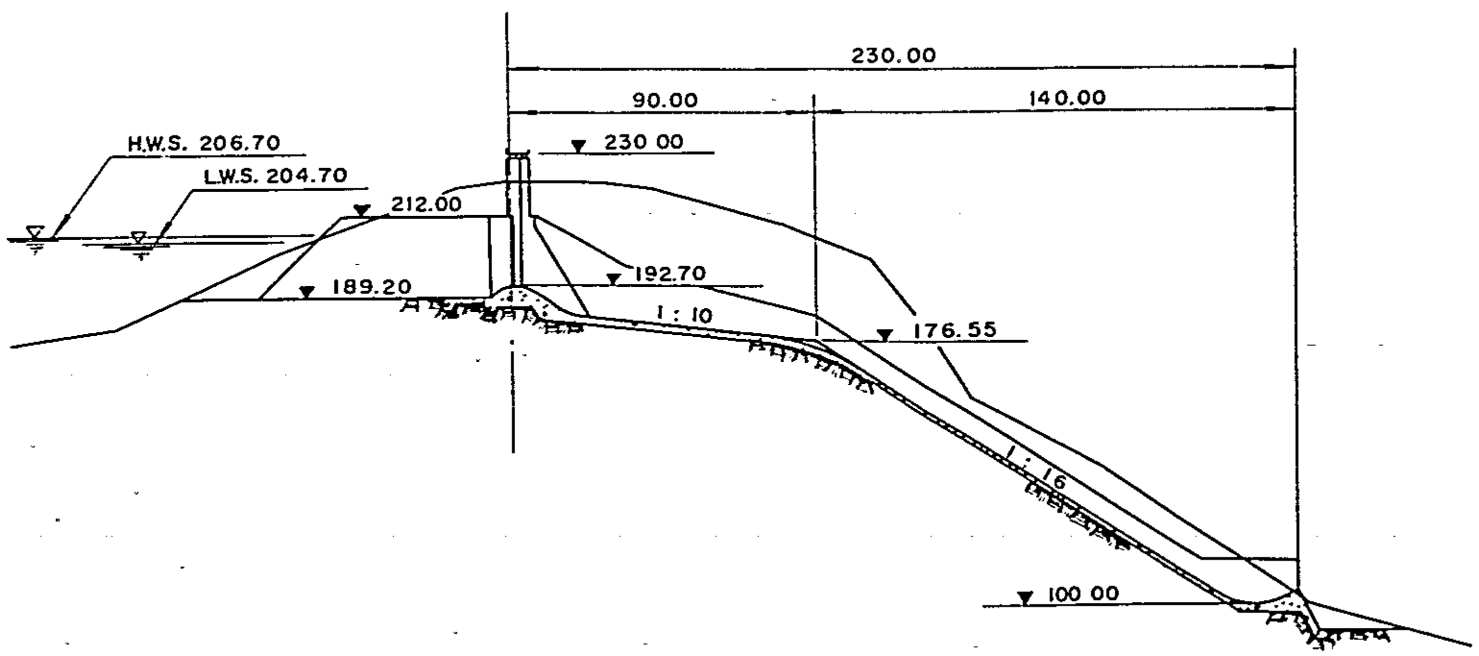


Fig.- 9.11 Tamango Power Station
Penstock
Profile and Section

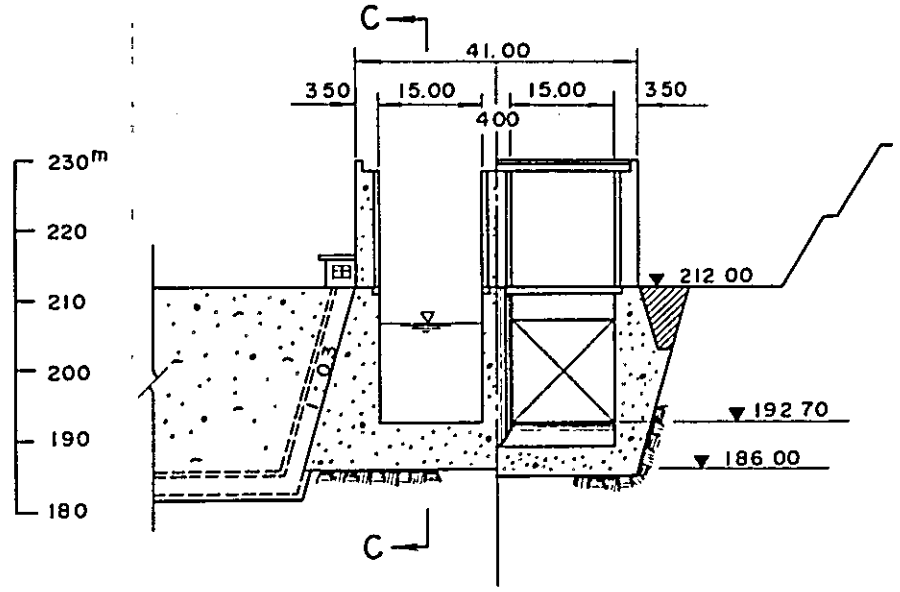
SPILLWAY PLAN



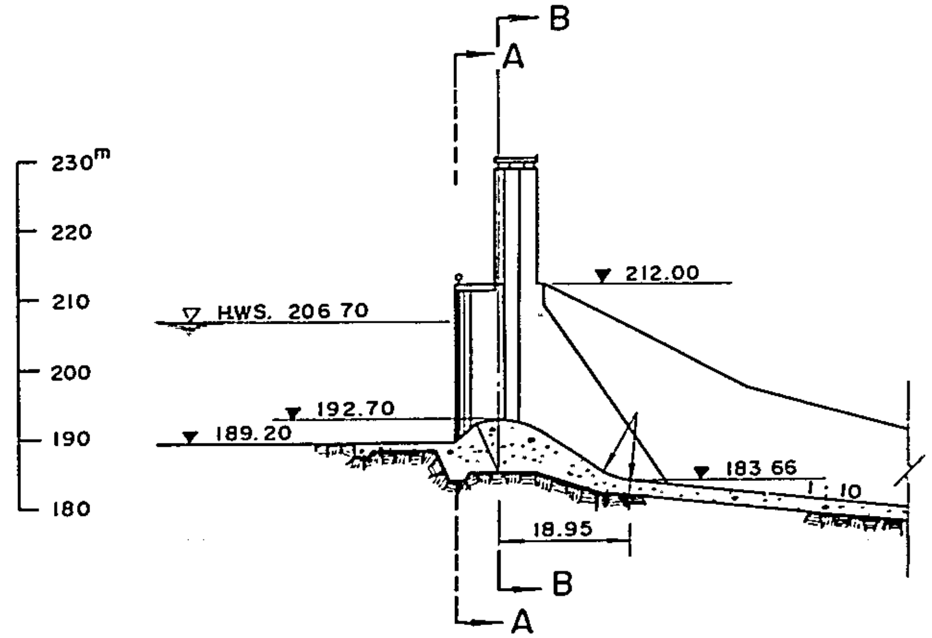
PROFILE OF SPILLWAY



SECTION A–A SECTION B–B



SECTION C–C



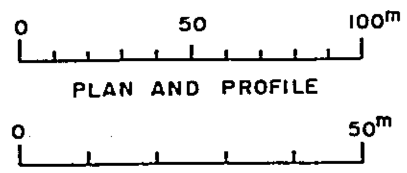
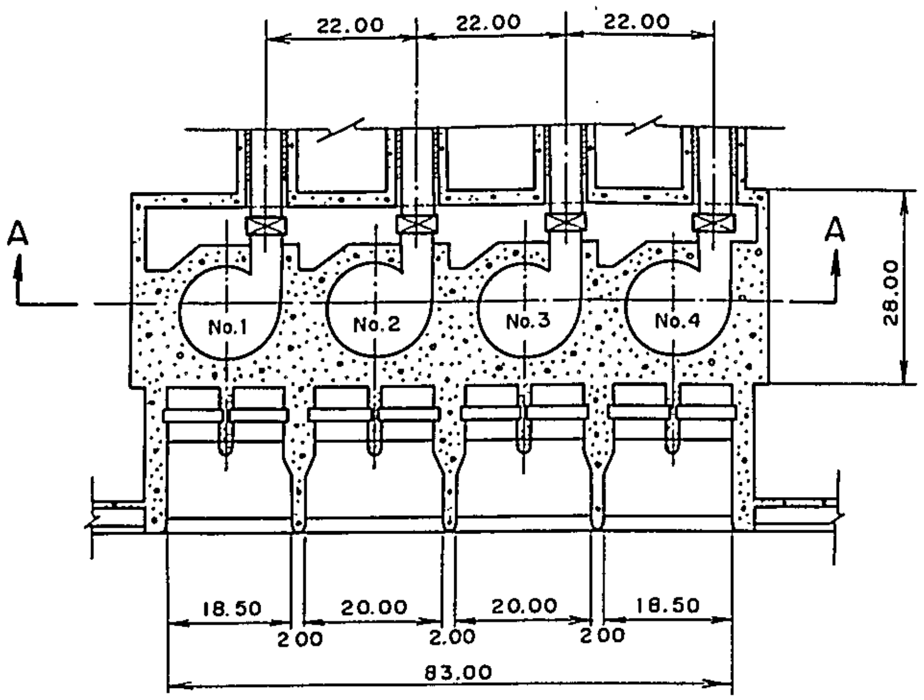
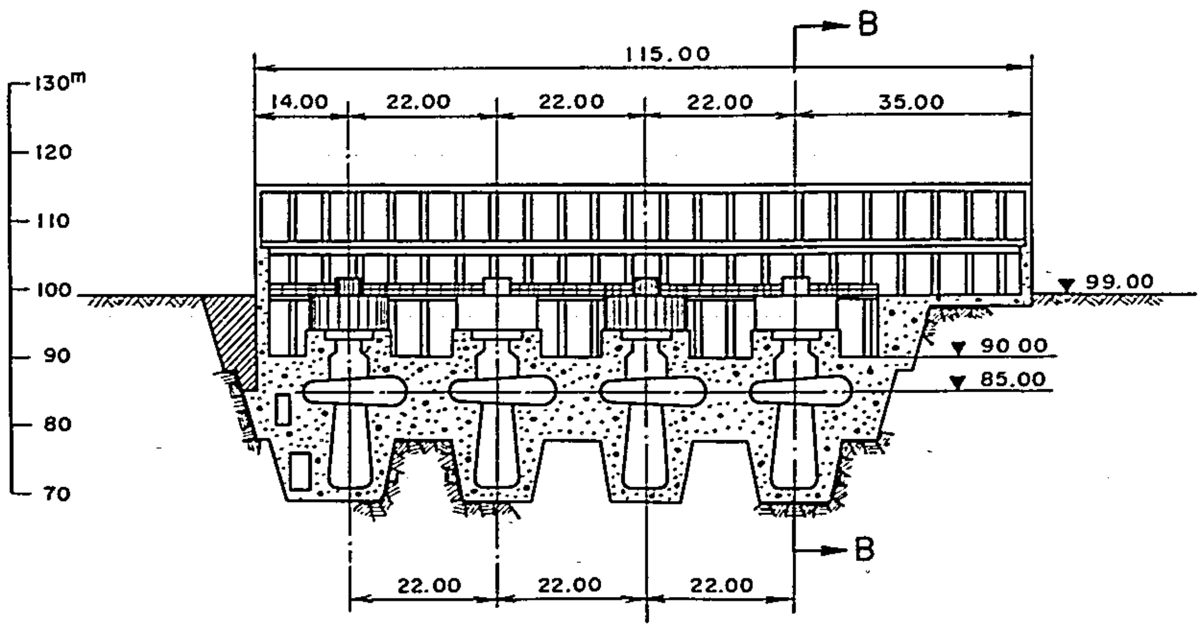


Fig.-9.12 Tamango Power Station
Spillway
Plan, Profile and Section

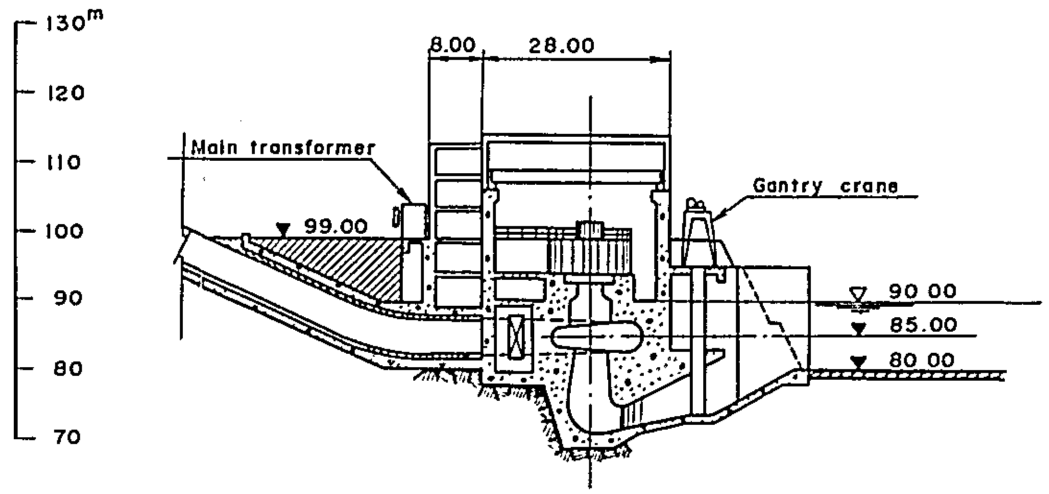
PLAN (EL 85.00)



SECTION A-A



SECTION B-B



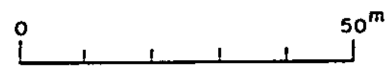


Fig.- 9.13 Tamango Power Station
Powerhouse
Plan and Section

Fig.9-14 Related System Diagram

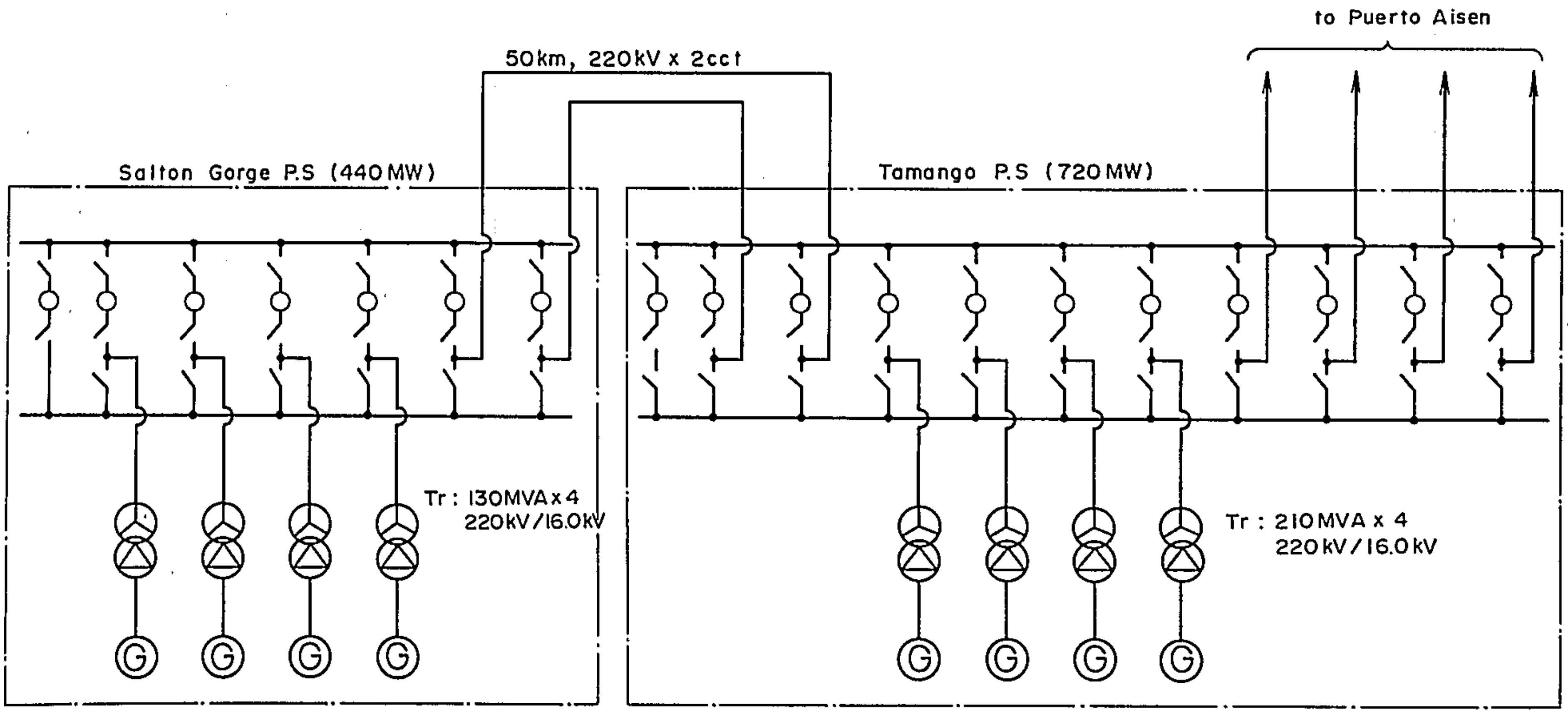
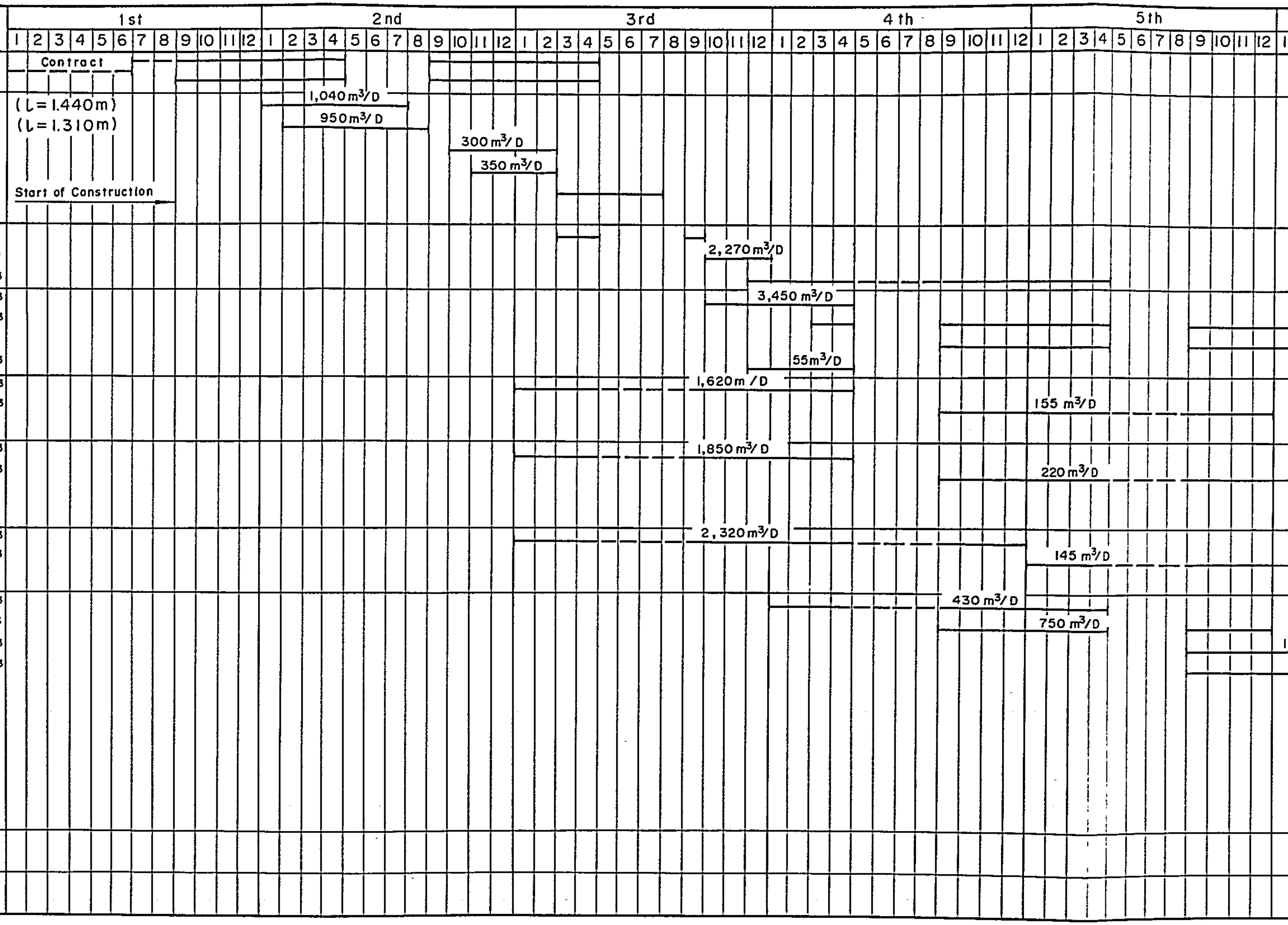


Fig.– 9.15 Construction Schedule of Tamango Power Sta

Work Item		Quantity
Preparatory Work and Disarmament		House, Road Others
Diversion Tunnel	Excavation Tunnel No. 1	189,000m³ (L=1.440m)
	〃 No. 2	173,000m³ (L=1.310m)
	Concrete No. 1	39,000m³
	〃 No. 2	36,000m³
	Grouting	
	Gate and Stoplog	
Coffer Dam	Closure Dyke	
	Excavation	177,000m³
	Embankment	1,733,000m³
Dam (Including Foundation Treatment)	Excavation	625,000m³
	Embankment	11,290,000m³
	Grouting	
	Concrete lining	7,100m³
Spillway	Excavation	504,000m³
	Concrete	47,800m³
	Gate	
Headrace – Intake	Excavation	575,000m³
	Concrete	92,500m³
	Grouting	
	Gate, Screen	
Headrace – Penstock	Excavation	964,000m³
	Concrete	45,400m³
	Penstock	
Power house (Including Tailrace)	Excavation in P.H	177,000m³
	Excavation in Tailrace	313,000m³
	Concrete in P.H	42,900m³
	Concrete in Tailrace	12,600m³
	Crane	
	Turbine (No.1, 2)	
	Turbine (No.3, 4)	
	Generator (No.1, 2)	
	Generator (No.3, 4)	
	Auxi. Equipment	
	Test	
Switchyard	Civil Work	
	Electrical Work	
Reservoir Filling		



Schedule of Tamango Power Station (May~ August ; Snowy Season)

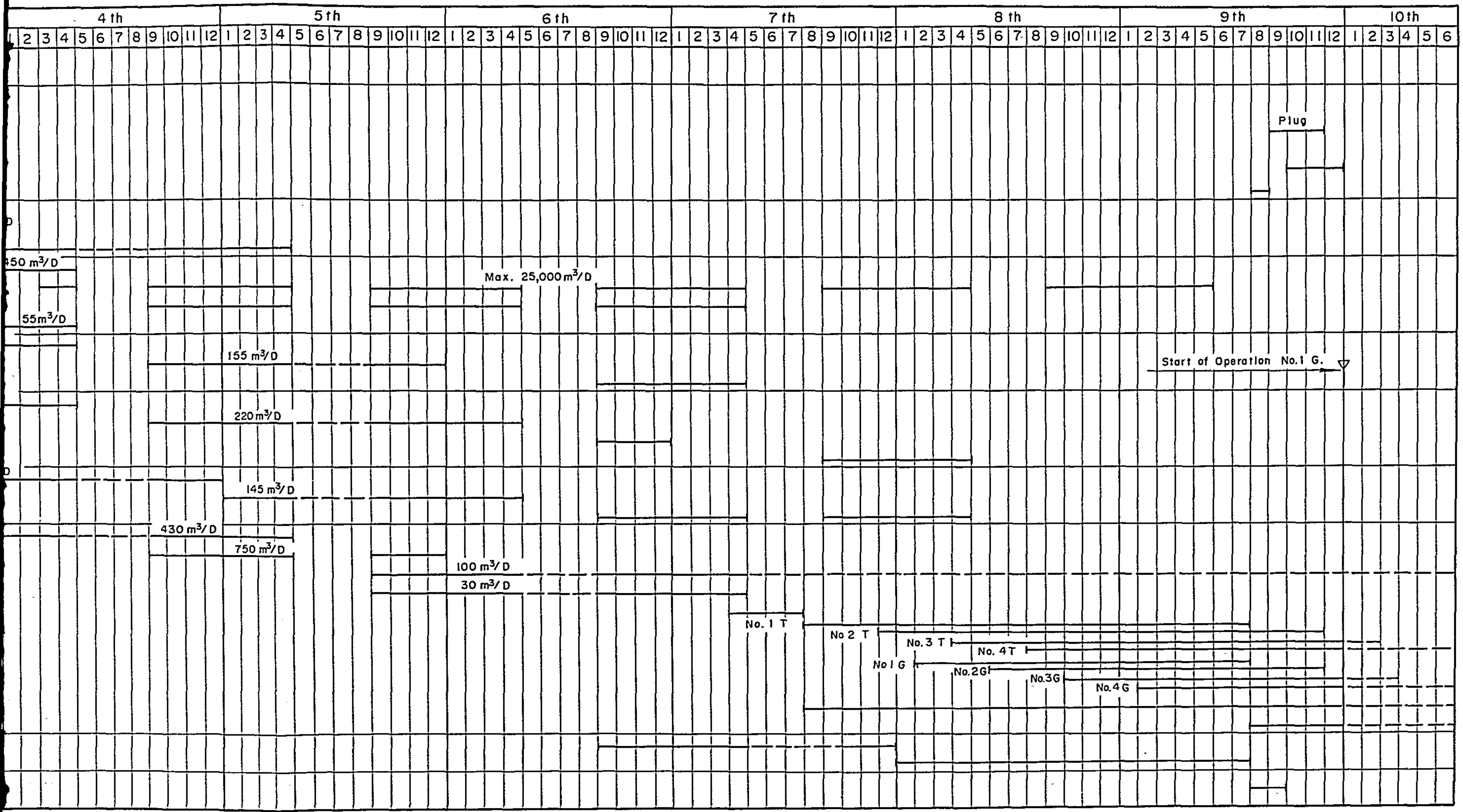


Table - 9.4 Estimated Construction Cost (Tamango)

	Item	Description	Cost 10^3 U.S.$
I.	Direct Cost		
(1)	Land and Right		200
(2)	Diversion Tunnel and Outlet Work	Civil work	15,800
(3)	Spillway	"	8,350
(4)	Dam	"	72,700
(5)	Headrace	"	21,980
(6)	Power Station	"	12,600
(7)	Permanent Equipment		132,240
(8)	Expense for Construction Equipment		43,680
	Sub-total		307,280
II.	Indirect Cost		
(1)	Engineering and Administration	15 %	46,460
(2)	Construction Facilities		17,870
	Sub-total		64,330
III.	Contingencies		
(1)	For Direct Cost	20 %	61,950
(2)	For Indirect Cost	15 %	9,280
	Sub-total		71,230
IV.	Construction Cost	without tax	442,840
V.	Interest during Construction	8% for F.C. 3 % for D.C.	137,280
VI.	Total Project Cost		580,120

Notes: Excluding the cost of infrastructure and of the transmission line.

(A) Civil Work (Tamango)

Item - 1 Diversion Tunnel

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Care of water	L. S.			300.00	
Excavation open, common	m^3	18,000	1.50	27.00	
Excavation open, rock	m^3	24,000	7.00	168.00	
Tunnel excavation, rock	m^3	255,000	30.00	7,650.00	
Shaft excavation, rock	m^3	11,000	35.00	385.00	
Concrete, structure and tunnel lining	m^3	26,000	65.00	4,940.00	including plug concrete
Reinforcing steel	ton	1,050	650.00	682.50	
Grouting, backfilling	meter of tunnel	2,750	150.00	412.50	
Stop-log	ton	60	2,000.00	120.00	2 sets, at the entrance of No. 1 tunnel
Misc. work	L. S.			815.00	
Construction facilities	L. S.			300.00	
Total				15,800.00	

Item - 2 Spillway

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Excavation open, common	m^3	110,000	1.50	165.00	
Excavation open, rock	m^3	410,000	7.00	2,870.00	
Backfilling	m^3	16,000	2.00	32.00	
Concrete, structures	m^3	50,000	65.00	3,250.00	
Reinforcing steel	ton	1,000	650.00	650.00	
Grouting, consolidation	m	900	25.00	22.50	
Grouting, curtain	m	1,600	45.00	72.00	
Control room	L. S.			200.00	
Cut-slope protection	L. S.			70.00	
Slop-log	ton	100	2,000.00	200.00	1 set, at the approach B = 15 m, H = 13 m
Misc. work	L. S.			418.50	
Construction facilities	L. S.			400.00	
Total				8,350.00	

Item - 3 Dam (including coffer dams)

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Care of water	L. S.			600.00	
Excavation open, common	m^3	180,000	1.50	270.00	
Excavation open, rock	m^3	820,000	7.00	5,740.00	
Concrete, structures	m^3	8,000	65.00	520.00	
Reinforcing steel	ton	180	650.00	117.00	
Embankment, core zone	m^3	1,770,000	3.00	5,310.00	2.50 x 120% = 3.00 (Chacabuco)
Embankment, filter zone	m^3	918,000	3.60	3,304.80	
Embankment, pervious zone	m^3	10,354,000	4.60	47,628.40	see below
Placing of rock material	m^3	131,000	7.00	917.00	
Drilling, percussion	m	13,000	10.00	130.00	
Drilling, Ex type	m	30,000	30.00	900.00	ø 59 mm
Pressure grouting	ton	3,000	600.00	1,800.00	
Observation system	L. S.			200.00	
Stripping borrow pits	m^3	350,000	1.50	525.00	
Crest road	m	560	300.00	168.00	
Misc. work	L. S.			1,569.80	
Construction facilities	L. S.			3,000.00	
Total				72,700.00	

- for reference -

Volume of pervious zone including rock placing = 10,485,000 m^3

from quarry = 8,266,000 m^3

from excavation = 3,170,000 m^3 x 70 % = 2,219,000 m^3

$$\frac{\text{material from excavation}}{\text{material from quarry}} = \frac{2,219,000}{8,266,000} = \frac{21\ \%}{79\ \%}$$

Combined unit cost = 5.50 x 0.79 + 1.00 x 0.21

= 4.35 + 0.21

= 4.56

≒ 4.60 U.S. $/$m^3$

Item - 4 Headrace

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Excavation open, common	m^3	320,000	1.50	480.00	
Excavation open, rock	m^3	1,240,000	7.00	8,680.00	
Concrete, structures	m^3	140,000	65.00	9,100.00	
Reinforcing steel	ton	4,140	650.00	2,691.00	
Cut-slope protection	L. S.			100.00	
Grouting, consolidation	m	1,500	25.00	37.50	
Grouting, curtain	m	3,000	45.00	135.00	
Misc. work	L. S.			256.50	
Construction facilities	L. S.			500.00	
Total				21,980.00	

Item - 5 Power Station (including switch-yard)

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Excavation open, common	m^3	110,000	1.50	165.00	
Excavation open, rock	m^3	440,000	10.00	4,400.00	
Banking	m^3	35,000	2.00	70.00	
Concrete, structure	m^3	56,000	65.00	3,640.00	
Reinforcing steel	ton	2,000	650.00	1,300.00	
Architectural work	L. S.			1,300.00	including command building
Stop-log	ton	60	2,000.00	120.00	2 sets, at the tail-bay B = 8 m, H = 10 m
Misc. work	L. S.			605.00	
Construction facilities	L. S.			1,000.00	
Total				12,600.00	

(B) Permanent Equipment (Tamango)

Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
(1) Diversion Tunnel and River Outlet Work					
Roller gate	ton	60	4,000	240	2 sets, at the entrance of No. 2 tunnel B = 4m, H = 9m
Ring follower gate	ton	120	4,000	480	2 sets, at the plugged portion of No. 2 tunnel
Howell-Bunger valve	ton	50	6,000	300	2 sets, " " "
(2) Spillway					
Roller gate	ton	660	4,000	2,640	2 sets, B = 15m, H = 15m
(3) Water-way					
Steel grating	ton	480	1,500	720	at the intake
Roller gate	ton	560	4,000	2,240	4 sets, at the intake B = 8m, H = 10m
Penstock	ton	7,330	2,000	14,660	4 lines, ø 7m
Sub-total (1)+(2)+(3)				21,280	CIF Price
(4) Power Plant					
Turbine	L. S.			29,600	Francis Type 4 x 185 MW = 740 MW
Generator	L. S.			29,600	
Transformer	L. S.			10,360	
Switchgear	L. S.			10,360	
Aux. equipment	L. S.			4,000	
Misc. material	L. S.			5,000	
Sub-total (4)				88,920	CIF Price
Total				110,200	CIF Price

Cost of Permanent Equipment = 110,200 x 120 % = 132,240 10^3 U. S. $

(including import expense, inland transportation and installation)

9.3 Salton Gorge Power Plant

9.3.1 Dam

The proposed Salton Gorge dam is a center core type rock fill dam consisting of core zone, filter zone and rock zone. The slope is 1 : 2.6 for the upstream and 1 : 1.85 for the downstream side. The dam is 70 m high above the bedrock, 288 m in crest length and 1.43 million cu. m in dam volume. (see Figs. 9-16, 9-17)

9.3.2 Intake

The intake, to be built on the left side bank of the dam, will be of vertical concrete structure 72 m in width and 39 m in height. It will be provided with four gates capable of passing a power discharge of 1,040 m^3/sec. (see Fig. 9-18)

9.3.3 Penstock

Four penstocks will be connected with the intake installed on the left side of the dam. The penstock measures 6.0 to 7.5 m in diameter, 164 m in average length and 20 to 21 mm in thickness. (see Fig. 9-18)

9.3.4 Spillway

The spillway, to be built on the right side of the dam, will be of concrete ski-jump type. It is to be provided with five roller gates, each having height of 14.5 m and width 15 m, which will be of such construction that the design flood discharge of 6,600 m^3/sec and abnormal flood discharge of 8,000 m^3/sec will be released without overflowing. (see Fig. 9-19)

9.3.5 Power station

The power station will be built adjacent to the dam on the left side bank and will be reinforced concrete semi-underground type 42 m in width, 54 m in height and 141 m length. Four vertical shaft Kaplan turbines of 117,000 KW and four generators of 130,000 KVA, 50 Hz will be installed in the power house. (see Fig. 9-20).

9.3.6 Trubine and generator

The power station will be designed for normal effective head of 53 m, available draw down of 17 m and maximum power discharge 260 m3/sec per unit. The adequate type of turbine to meet to these design conditions is vertical shaft Kaplan turbine. Output of the proposed Kaplan turbine will be 117,000 KW with revolution of 375 rpm fitted with a butterfly valve for inlet.

The generator is an enclosed air duct circulating type with capacity of 130,000 KVA and 16.5 KV at a rated lagging power factor of 0.9. Four 130,000 KVA 3-phase forced oil-immersed air-cooling transformers will be installed in an outdoor switchyard adjacent to the power plant. The secondary voltage of the transformer will be 220 KV.

9.3.7 Related system diagram

Fig. 9-14 shows the related system diagram which has been selected. It is considered that the generators will be equipped with synchronous devices on the high-voltage circuit of 220KV and also station service transformer and a diesel generator as stand-by power source are considered. The outdoor switchyard will be constructed about 400m down and on the left of a stream from the dam, and circuit breakers, disconnecting switches and other equipment for transmission lines will be installed in the outdoor switchyard. Single bus system with transfer bus will be installed for the Tamango power station.

9.3.8 Construction schedule

It isestimated that the construction of Salton Gorge power station requires about 7 years taking into account the quantity of work, arrangement of structures and specific regional factors, such as topography, climate, etc.
Fig. 9-21 shows the construction schedule.

9.3.9 Construction cost

Overall work outlays, exclusive of those on infrastractures and transmission lines, are estimated to reach US$408 million. This estimation, however, is likely to undergo minor amendment depending on the results of further investigations into the specific geological conditions, supply source for materials and other factors. Table 9-5 shows the estimated construction cost of Salton Gorge power station by type of work, including unit cost and other details. Table 9-6 shows construction cost per KW and power cost per KWh at the end point of transmission at Tamango and Salton Gorge power stations.

A service life is 50 years and salvage value zero for generating facilities. The maintenance, personnel and overhead costs are assumed as 1.5% of the total construction costs, and annual interest rate as 8%. Based on these conditions, the annual expense over the service life were calculated and the ratio of the annual expense to the total construction cost was estimated 9.674%.

On the other hand, Table 9-8 shows the calculation of power cost at the power reception point, inclusive of power transmission and transformation systems, on assumption that power is consumed in Puerto Chacabuco, Caleta Tortel and the estuary of the Pascua River.

The assumed conditions for calculation in respect of the transmission and substation facilities are a service life of 30 years, annual interest rate of 8% and the percentage of the maintenance, personnel and overhead costs to the total cost of transmission and substation facilities assumed to be 2.5%. Based on these assumptions, the percentage of annual expense for transmission and substation facilities to the total construction cost for these facilities was worked out at 11.383%. Table 9-7 gives the construction cost of the transmission line and substations.

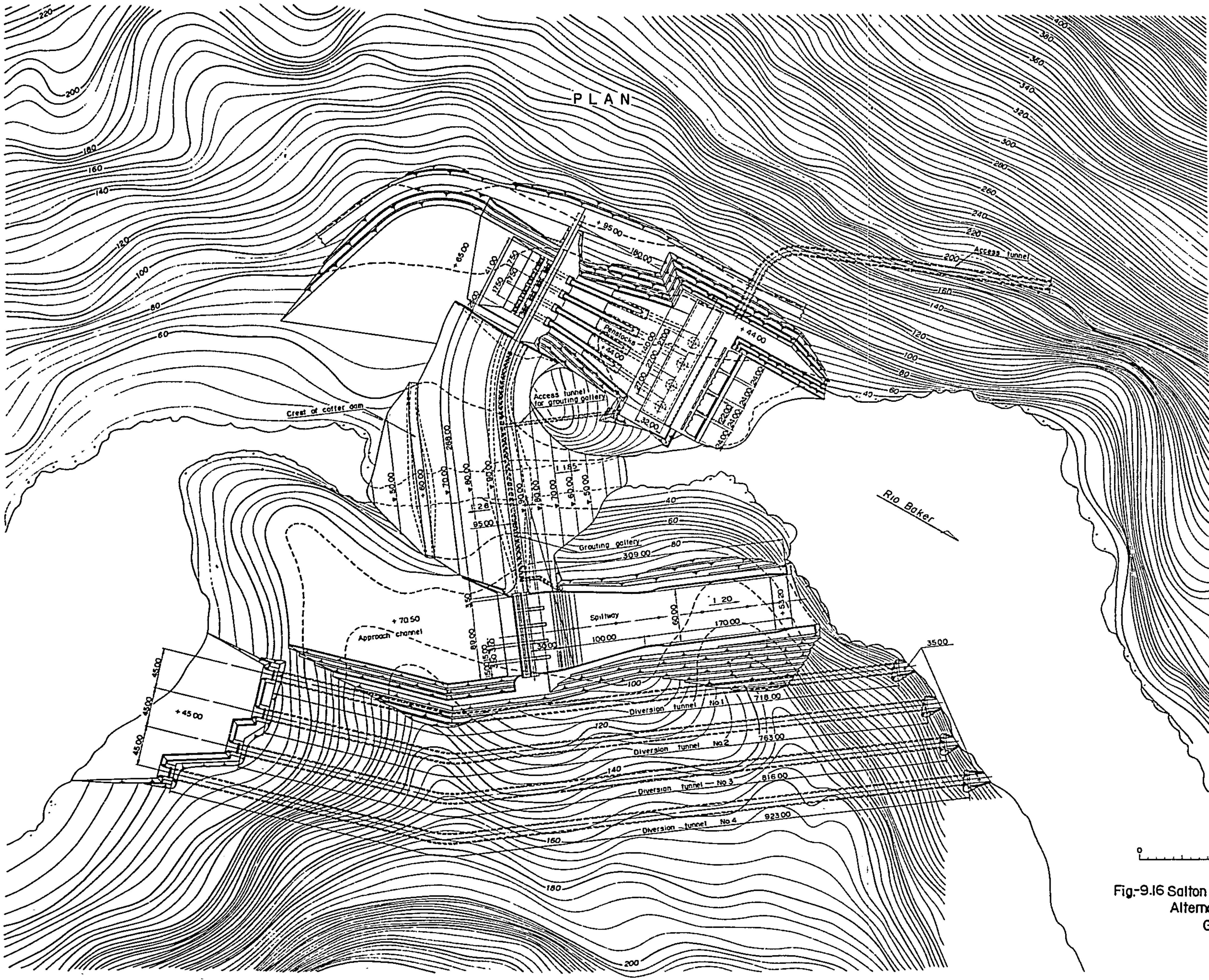
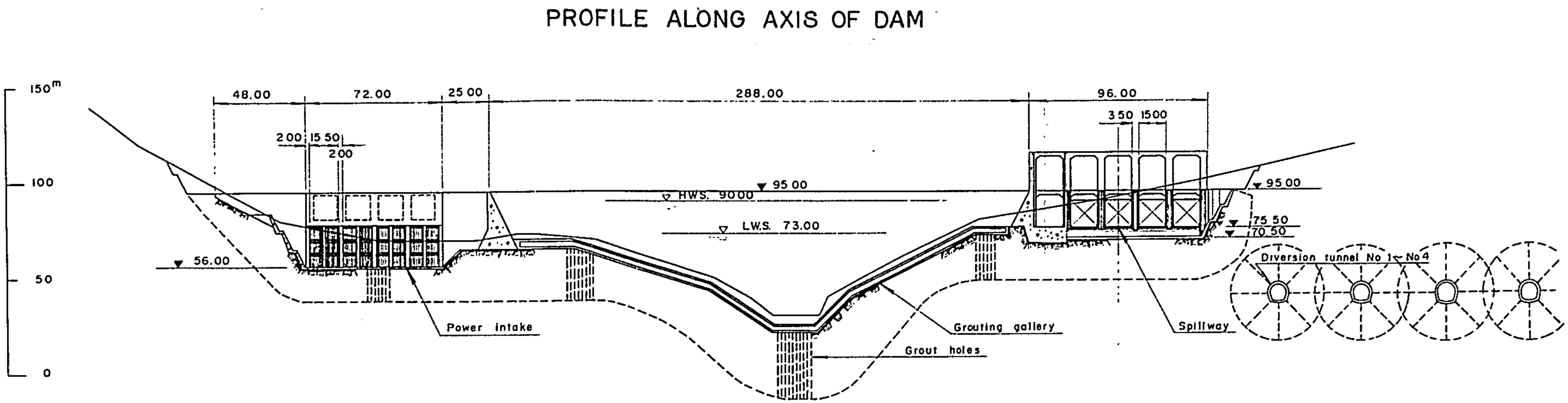


Fig.-9.16 Salton Gorge Power Station
Alternative-1 (H.W.L 90.00)
General Plan



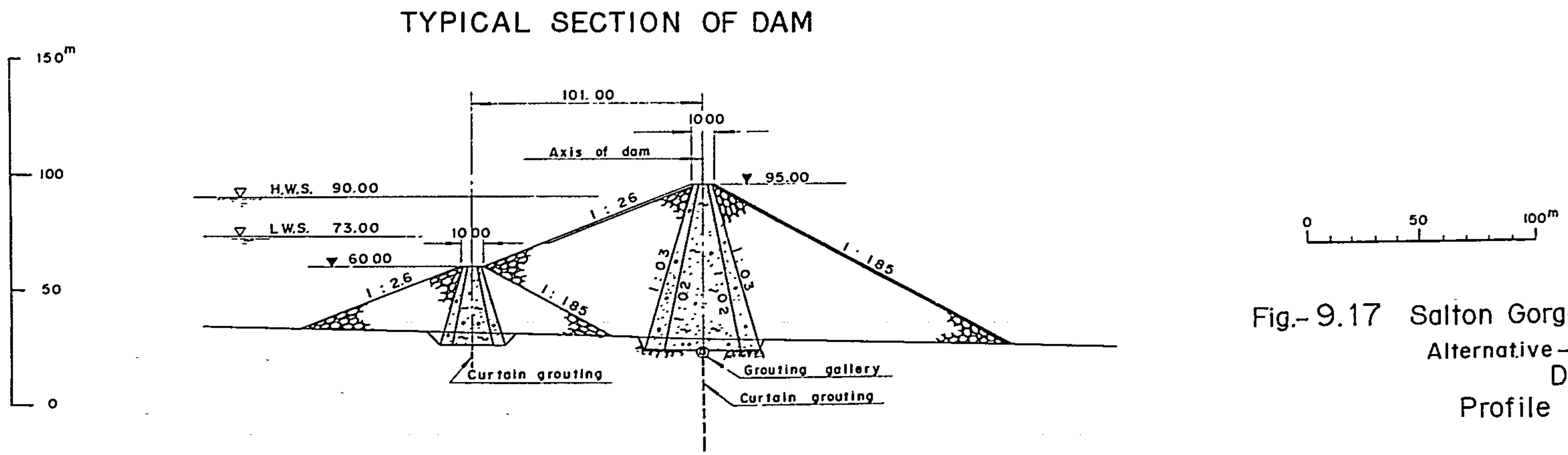


Fig.- 9.17 Salton Gorge Power Station
Alternative - 1 (H.W.L. 90.00)
Dam
Profile and Section

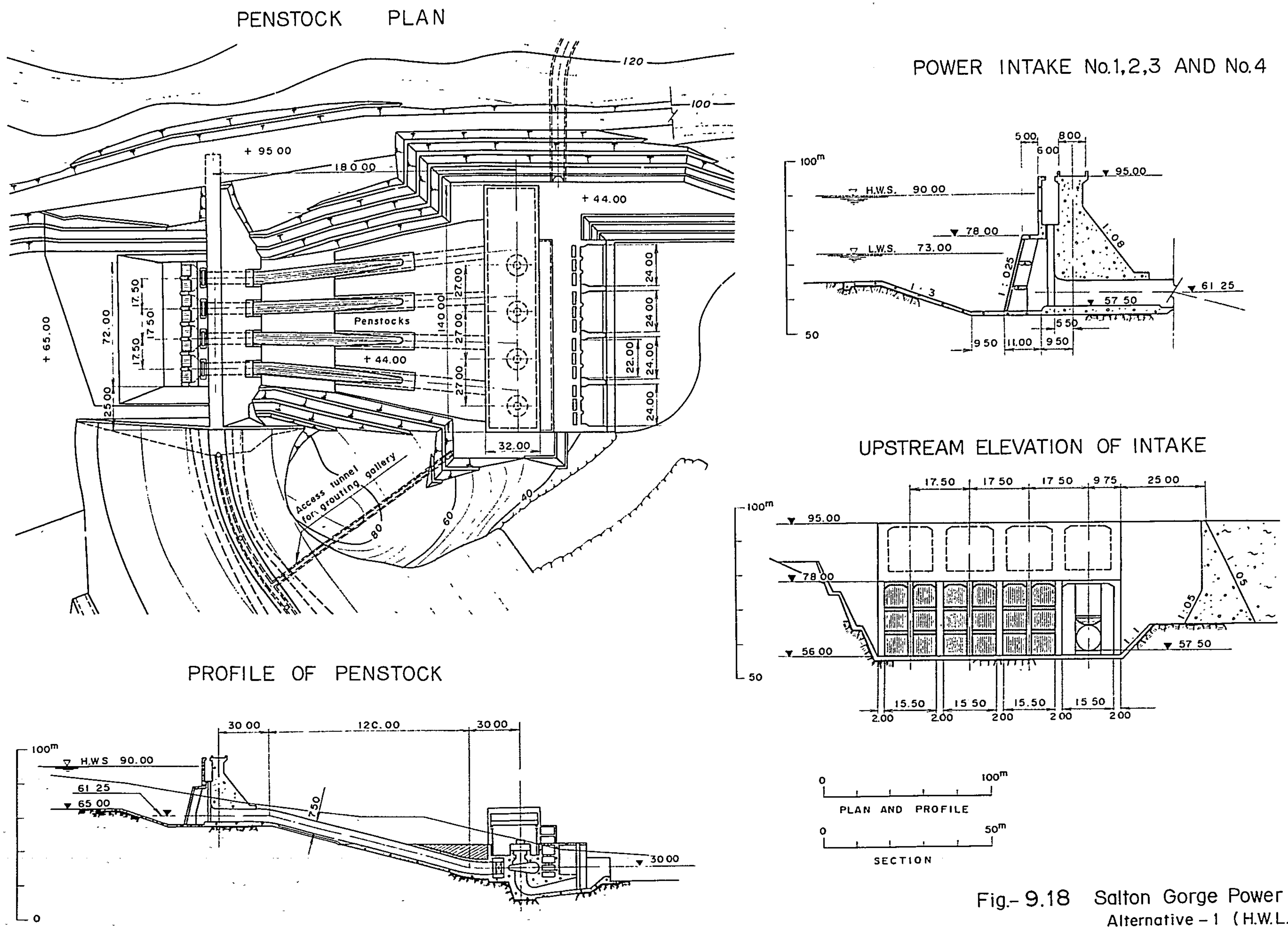


Fig.- 9.18 Salton Gorge Power Station
Alternative - 1 (H.W.L. 90.00)
Intake and Penstock
Profile and Section

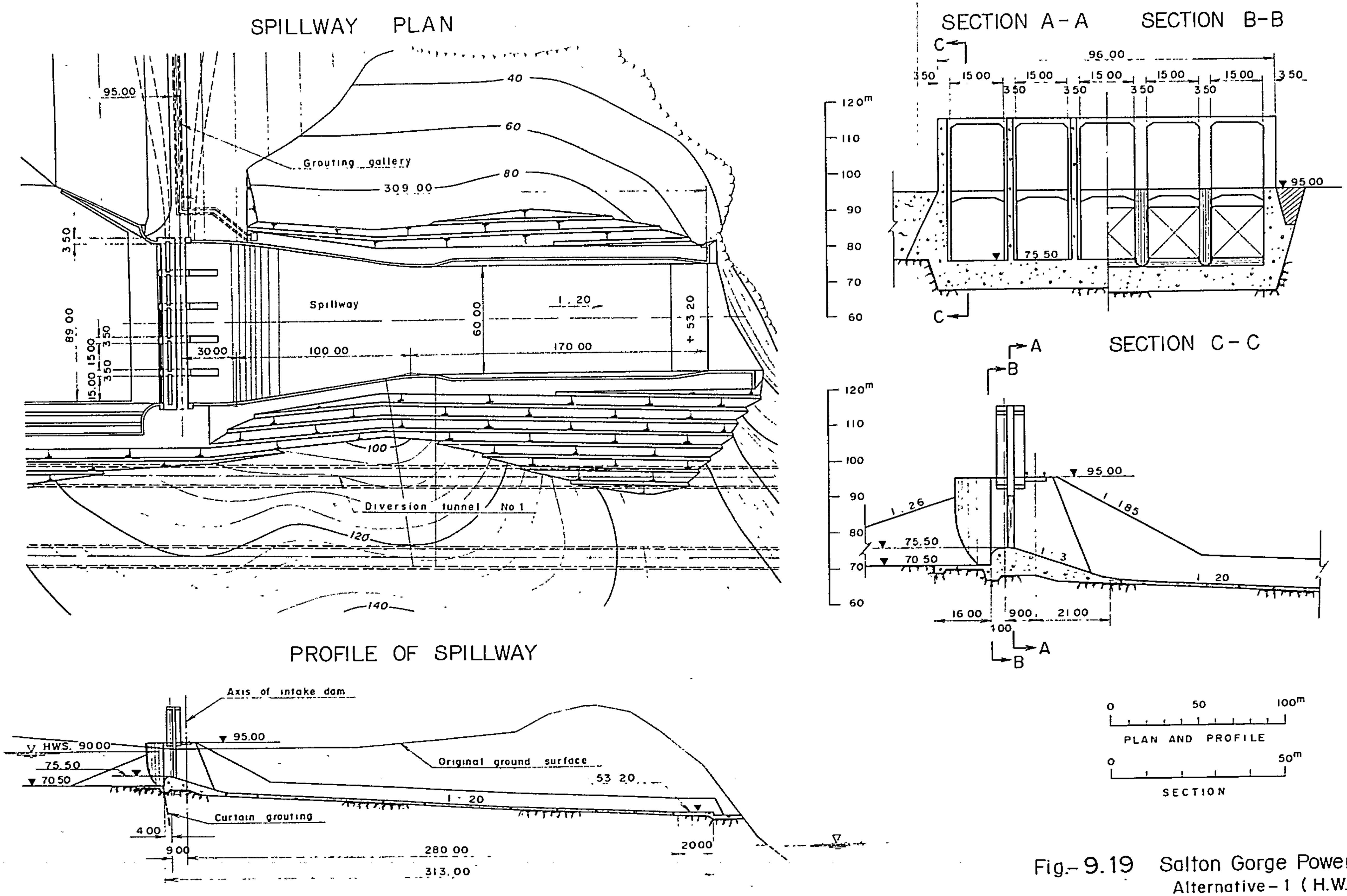
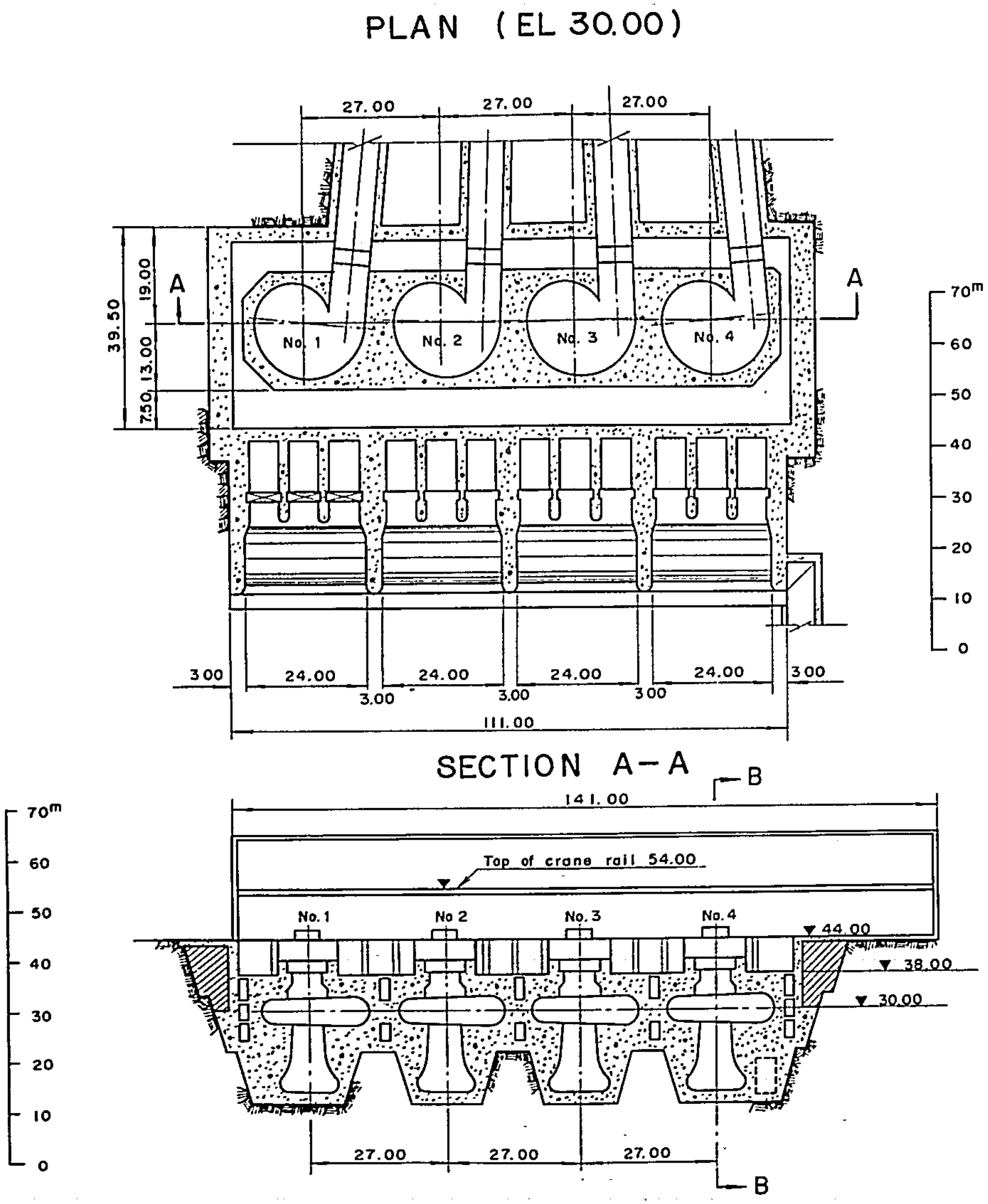


Fig.- 9.19 Salton Gorge Power Station
Alternative-1 (H.W.L. 90.00)
Spillway
Plan, Profile and Section



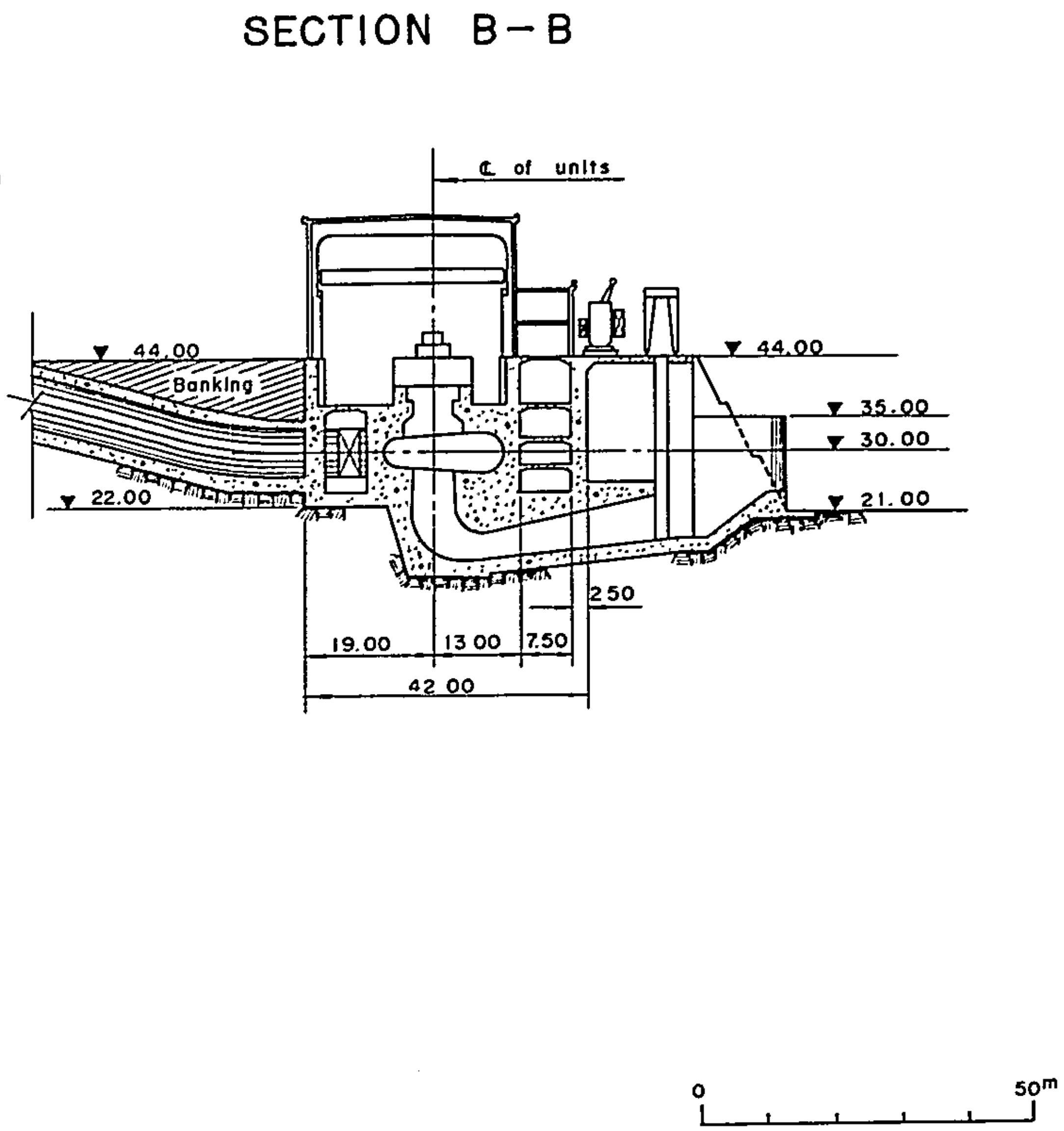


Fig.- 9.20 Salton Gorge Power Station
Alternative - 1 (H.W.L.90.00)
Powerhouse
Plan and Section

Fig.-9.21 Construction Schedule of Salton Gorge Power Station

Work	Item	Quantity	Schedule (1st – 5th year, months 1–12)
Prepatory Work and Disarmament		House, Road Others	Contract
Diversion Tunnel	Excavation Tunnel No. 1	(l=718m) 102,000m³	870m³/D
	〃 No. 2	(l=763m) 109,000m³	1,040 m³/D
	〃 No. 3	(l=816m) 116,000m³	810 m³/D
	〃 No. 4	(l≈923m) 131,000m³	920m³/D
	Concrete Tunnel No. 1	24,200m³	Start of Construction; 370 m³/D
	〃 No. 2	25,700m³	400 m³/D
	〃 No. 3	27,500m³	210m³/D
	〃 No. 4	31,000m³	240m³/D
	Grouting		
	Gate and Stoplog		
Coffer Dam	Closure Dyke		
	Excavation	11,000m³	
	Embankment	187,160 m³	
Dam (Including Foundation Treatment)	Excavation	115,000m³	
	Embankment	1,311,000m³	Max. 15,000m³/D
	Concrete	3,100m³	16m³/D
	Grouting		
Spillway	Excavation	1,398,000m³	7,170m³/D
	Concrete	85,900m³	275m³/D
	Gate		
Headrace – Intake	Excavation	566,000m³	3,630m³/D
	Concrete	118,500m³	325m³/D
	Grouting		
	Gate, Screen		
Headrace – Penstock	Excavation	417,000m³	
	Concrete	26,400 m³	
	Penstock		
Power house (Including Tailrace and Access Tunnel)	Excavation in P.H.	216,000m³	1,040m³/D
	Excavation in Tailrace	337,000 m³	810 m³/D
	Concrete in P.H.	85,000m³	290 m³/D
	Concrete in Tailrace	24,800 m³	165 m³/
	Crane		
	Turbine (No.1, 2)		
	Turbine (No.3, 4)		
	Generator (No. 1, 2)		
	Generator (No.3, 4)		
	Auxi, Equipment		
	Test		
Switch yard	Civil Work		
	Electrical Work		
Reservoir Filling			

ction Schedule of Salton Gorge Power Station (May～August ; Snowy Season)

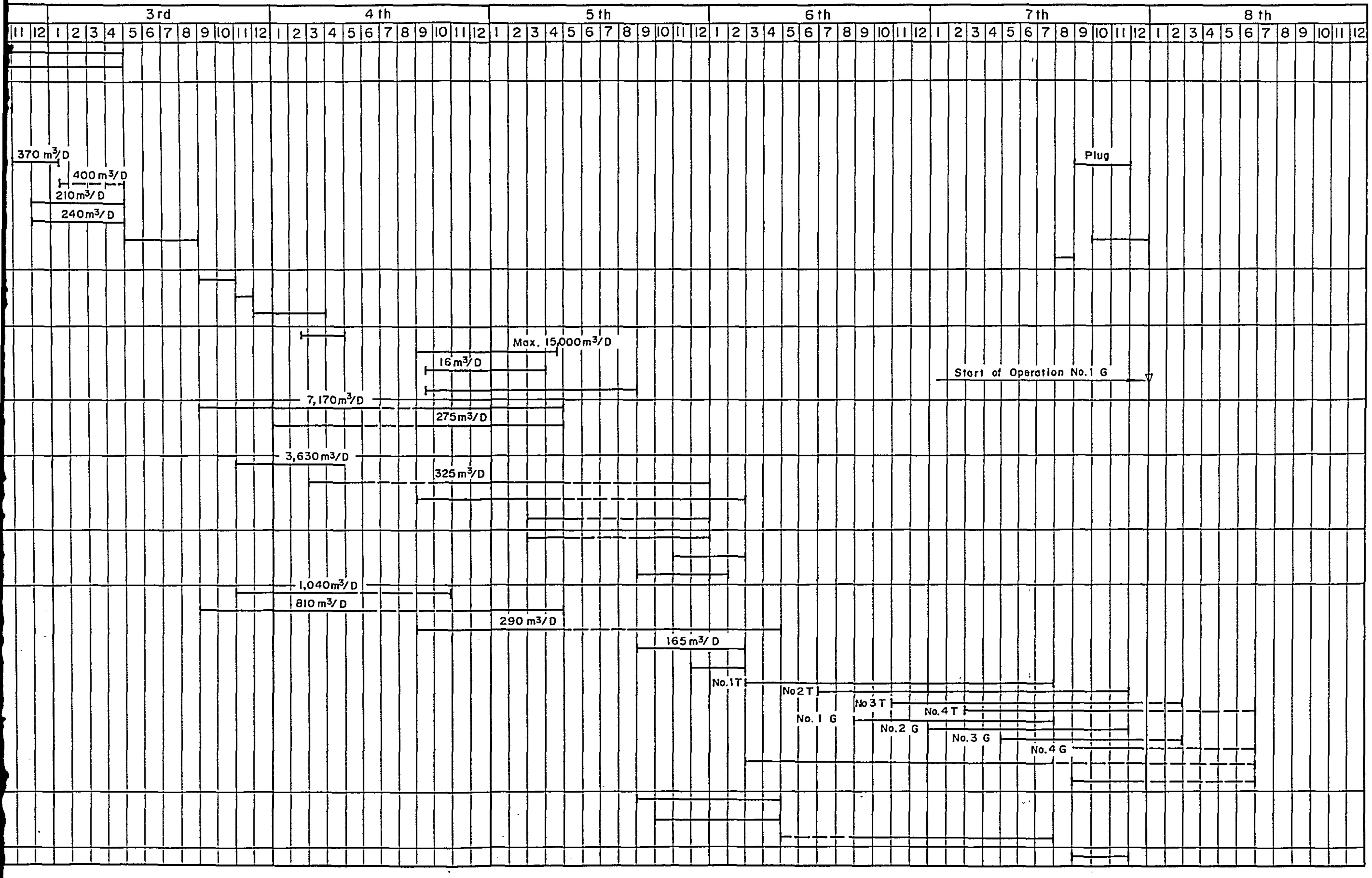


Table-9.5 Estimated Construction Cost (Salton Gorge)

	Item	Description	Cost 10^3 U.S. $
I.	Direct Cost		
(1)	Land and Right		350
(2)	Diversion Tunnel	Civil work	21,800
(3)	Spillway	"	17,300
(4)	Dam	"	7,790
(5)	Headrace	"	19,190
(6)	Power Station	"	18,190
(7)	Permanent Equipment		110,520
(8)	Expense for Construction Equipment		29,120
	Sub-total		224,260
II.	Indirect Cost		
(1)	Engineering and Administration	15 %	33,860
(2)	Construction Facilities		13,790
	Sub-total		47,650
III.	Contingencies		
(1)	For Direct Cost	20 %	45,140
(2)	For Indirect Cost	15 %	6,930
	Sub-total		52,070
IV.	Construction Cost	without tax	323,980
V.	Interest during Construction	8 % for F. C. 3 % for D. C.	84,230
VI.	Total Project Cost		408,210

Notes: Excluding the cost of infrastructure and of the transmission line.

(A) Civil Work (Salton Gorge)

Item - 1 Diversion Tunnel

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Care of water	L. S.			400	
Excavation open, common	m^3	10,000	1.50	15	
Excavation open, rock	m^3	120,000	7.00	840	
Tunnel excavation, rock	m^3	344,000	30.00	10,320	
Concrete, structure and tunnel lining	m^3	110,000	65.00	7,150	
Reinforcing steel	ton	1,520	650.00	988	
Grouting, backfilling	meter of tunnel	3,220	150.00	483	
Stop-log	ton	120	2,000.00	240	6 sets for three tunnel
Misc. work	L. S.			964	
Construction facilities	L. S.			400	
Total				21,800	

Item - 2 Spillway

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Excavation open, common	m^3	300,000	1.50	450	
Excavation open, rock	m^3	1,140,000	7.00	7,980	
Backfilling	m^3	2,500	2.00	5	
Concrete, structures	m^3	88,000	65.00	5,720	
Reinforcing steel	ton	1,800	650.00	1,170	
Grouting, consolidation	m	600	25.00	15	
Grouting, curtain	m	1,200	45.00	54	
Control room	L. S.			200	
Cut-slope protection	L. S.			100	
Stop-log	ton	100	2,000.00	200	1 set, B = 15m, H = 13m
Misc. work	L. S.			706	
Construction facilities	L. S.			700	
Total				17,300	

Item - 3 Dam (including coffer dams)

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Care of water	L. S.			400.00	
Excavation open, common	m^3	32,000	1.50	48.00	
Excavation open, rock	m^3	90,000	7.00	630.00	
Concrete, structures	m^3	3,300	65.00	214.50	
Reinforcing steel	ton	70	650.00	45.50	
Embankment, core zone	m^3	195,000	3.30	643.50	3.30; as same as Salton San Carlos
Embankment, filter zone	m^3	132,000	3.90	514.80	
Embankment, pervious zone	m^3	1,000,000	3.00	3,000.00	3.30 x 90 % = 3.00 (Chacabuco)
Placing of rock material	m^3	45,000	5.00	225.00	
Drilling, percussion	m	3,000	10.00	30.00	
Drilling, Ex type	m	7,500	30.00	225.00	ø 59 mm
Pressure grouting	ton	700	600.00	420.00	
Observation system	L. S.			50.00	
Stripping borrow pits	m^3	30,000	1.50	45.00	
Crest road	m	290	300.00	87.00	
Misc. work	L. S.			411.70	
Construction facilities	L. S.			800.00	
Total				7,790.00	

Item - 4 Headrace

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Excavation open, common	m^3	220,000	1.50	330.00	
Excavation open, rock	m^3	800,000	7.00	5,600.00	
Concrete, structures	m^3	147,000	65.00	9,555.00	
Reinforcing steel	ton	4,350	650.00	2,827.50	
Cut-slope protection	L. S.			50.00	
Grouting, consolidation	m	900	25.00	22.50	
Grouting, curtain	m	1,800	45.00	81.00	
Backfilling	m^3	55,000	2.00	110.00	
Misc. work	L. S.			214.00	
Construction facilities	L. S.			400.00	
Total				19,190.00	

Item - 5 Power Station (including switch-yard)

Work Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
Excavation open, common	m^3	126,000	1.50	189	
Excavation open, rock	m^3	500,000	10.00	5,000	
Banking	m^3	35,000	2.00	70	
Concrete, structures	m^3	113,000	65.00	7,345	
Reinforcing steel	ton	3,900	650.00	2,535	
Cut-slope protection	L. S.			50	
Architechtural work	L. S.			1,000	including command building
Stop-log	ton	75	2,000.00	150	3 sets, at the tail-bay B = 7m, H = 9m
Misc. work	L. S.			851	
Construction facilities	L. S.			1,000	
Total				18,190	

(B) Permanent Equipment (Salton Gorge)

Item	Unit	Quantity	Unit Cost U.S.$	Cost 10^3 U.S.$	Remarks
(1) Diversion Tunnel and River Outlet Work					
Roller gate	ton	60	4,000	240	2 sets, at the entrance of one of the tunnels B = 4m, H = 9m
Ring follower gate	ton	120	4,000	480	2 sets
Howell-Bunger valve	ton	50	6,000	300	2 sets
(2) Spillway					
Roller gate	ton	1,650	4,000	6,600	5 sets, B = 15m, H = 15m
(3) Water-way					
Steel grating	ton	700	1,500	1,050	at the intake
Roller gate	ton	700	4,000	2,800	4 sets, at the intake B = 8m, H = 10m
Penstock	ton	2,660	2,000	5,320	4 lines, ø 7.50m
Sub-total (1)+(2)+(3)				16,790	CIF Price
(4) Power Plant					
Turbine	L. S.			28,200	Kaplan Type 4 x 140 MW = 560 MW
Generator	L. S.			23,520	
Transformer	L. S.			7,060	
Switchgear	L. S.			8,230	
Aux. equipment	L. S.			3,500	
Misc. material	L. S.			4,800	
Sub-total (4)				75,310	CIF Price
Total				92,100	CIF Price

Cost of Permanent Equipment = 92,100 x 120 % = 110,520 10^3 U. S. $

(including import expense, inland transportation and installation)

Table -9.6 Energy Cost of Tamango and Salton Gorge Power Stations

Power Station	Construction Cost 10^3US$	Installed Capacity MW	Annual Average Energy Production GWh	Annual Firm Energy Production GWh	Annual Cost 10^3US$	Cost per kW US$	Cost per kWh Average mills US$/kWh	Cost per kWh Firm mills US$/kWh
Tamango	580, 120	720	5, 541	4, 886	56, 121	805	10. 1	11. 5
Salton Gorge	408, 210	440	3, 035	2, 094	39, 490	927	13. 0	18. 9
Total	988, 330	1, 160	8, 576	6, 980	95, 611	852	11. 2	13. 7

Table -9.7 Construction Cost and Annual Cost of Transmission Line

Item	Distance km	Unit Cost US$/km	Construction Cost 10^3US$	Annual Cost 10^3US$
A To Southern Region				
(i) Line Tamango ~ Salton Gorge 220kV, 2cct	60	140, 000	8, 400	956
(ii) Line Salton Gorge ~ Caleta Tortel 500kV, 2cct	50	340, 000	17, 000	1, 935
(iii) Line Salton Gorge ~ River Mouth Pascua 500kV, 2cct	90	340, 000	30, 600	3, 483
B To Northern Region				
(i) Line Salton Gorge ~ Tamango 500kV, 2cct	60	340, 000	20, 400	2, 322
(ii) Line Tamango ~ Pto. Chacabuco 500kV, 3cct	230	510, 000	117, 300	13, 352
C Substation				
(i) In Southern Region 220kV, 300, 000kVA	-	L.S	3, 800	432
(ii) In Northern Region 500kV, 500, 000kVA	-	L.S	16, 000	1, 821

Table -9.8 Annual Cost at Receiving End

Item	Unit	River Mouth Pascua	Caleta Tortel	Puerto Chacabuco
Annual Cost of Power Stations	10^3US$	95,611	95,611	95,611
Annual Cost of Transmission Line	10^3US$	4,871	3,323	17,495
Total		100,482	98,934	113,106
Annual Average Energy Production	GWh	8,380	8,447	8,104
Annual Firm Energy Production	GWh	6,820	6,876	6,597
Annual Average Unit Energy Cost	mills US$/KWh	12.0	11.7	14.0
Annual Firm Unit Energy Cost	mills US$/KWh	14.7	14.4	17.2

Chapter 10
EARTHQUAKE-RESISTANT DESIGN

Chapter 10. EARTHQUAKE-RESISTANT DESIGN

10.1 Seismicity in Areas along the Baker River

In southern Chile between 46° and 50°S in which the Baker Basin is located seismic activities are low, and it has been judged that there is little possibility that powerful earthquake may occur in the future.

Table 10-1 shows the records of major earthquakes that occured from 1535 through 1955, whereof epicenters were always limited to the northern or central part of Chile, namely north of Valdivia, or to the southern tip of the country near the Strait of Magellan. In any case, there is no record that earthquake occured in areas, about 1,000 km north and south of the Baker. This fact provides the ground for discounting the possibility against the occurrence of large earthquakes in these region. In view of a fact, however, that these areas are covered with vast stretches of unexplored fields and mountains and sparsely populated and that seismic observation system has not been established and the available records only data back to several hundred years ago, the past occurrence of earthquakes might have been overlooked. Also, in relation to large earthquakes, potential influence of distant earthquake should be taken into consideration.

In the event the vibrations of powerful earthquake occurring in a distant area are propagated to the districts along the Baker, the seismic waves may contain long period components and may cause greater vibrations of large structures which have long natural period. As the vibratory characteristics of such seismic waves vary with the path of propagation and geology of an area hit by earthquake, these problems should be explicate them by means of continued seismic observations. In view of the fact that no seismic observation has been conducted in the area concerned, it is conclude that no helpful data or information are available to resolve this problem.

The great earthquake which hit southern Chile May, 1960 spread its aftershock region deep into the southern part of Patagonia. Table 10-2 shows records of earthquakes occurring in a region between 45° to 56°S, which present evidence to the presence of the aftershock in southern Patagonia as readily so assumed from frequent records of earthquakes in late May, 1960. Even in the region selected as the site of the Project, it is possible that remote earthquakes may incite another in the close vicinity of such region, according to this table. Any earthquakes which may occur in the projected region concerned, though small or localized, cannot be ignored or belittled inasmuch as it is possible that the safety of reservoirs and structures may be threatened.

In connection therewith, interest in earthquakes caused by reservoirs is mounting, mainly on the recognition of potential hazards that minor shallow earthquakes may be easily incited by changes in stress condition and water content of the ground due to the presence of reservoir. Though actual situation has not been thoroughly clarified yet, thorough heed should be given to the potential impact of reservoirs on the earthquake.

10.2 Earthquake-resistant Design of Structures

As a new approach to earthquake-resistant design of structures, a need has been stressed in recent years to make integrated evaluation of earthquake-resistance by means of elucidating the vibratory characteristics and strength of structures and dynamic properties of component materials. This basic policy is applicable, without modification, to the Baker River Hydroelectric Development Project, but as necessary data and information have not been made available to data, forthcoming surveys are expected to serve these purposes. Especially, on-site seismic observation should be conducted as soon as possible.

In assessment of dynamic stability of a dam during earthquakes, investigations should not be made only into the stability of the dam itself but into that of its foundation and slopes around the reservoir. As foundation stress condition of ground, ground-water level, pore water pressure, etc. vary with the construction of a dam and the depth of the impounding water at the bottom of a reservoir and its peripheral area, thorough investigations should be made to ascertain whether or not new adverse factors may emerge, such as ground liquefaction, land slide or sloughing of mountain sides.

This report does not make reference to tidal waves though it seems necessary to conduct studies on the stability of structures against tidal waves as well as against earthquakes when selecting coastal area as the site of the project.

10.3 Results of Earthquake Observation

In view of the situation mentioned above, the survey team carried with it complete set of seismometric apparatuses to Cochrane village where earthquake observation was made throughout the team of survey.

The field observation was not only designed to acquire knowledge on the optimum means of observation and the most suitable type of seismometer to be used at site, but to present Japanese popular seismometric method and analytical method of seismogram.

The seismometric apparatuses were installed in Cochrane village for a period of 24 days, during which, first 21 days allowed the first survey team only 6 hours' observation during the night daily due to limited power supply in the village. During the last three days, however, uninterrupted observation was available with the aid of batteries and DC-AC transformers carried by the second survey team from Japan to the village.

The seismographic apparatuses used were of the type that could be energized upon detection of any vibrations in excess of the predetermined level. The apparatuses were also provided with a function of recording vibrations while making automatic adjustment of amplitude thereof so that wave form may not be put out of recording papers.

The seismographic instruments were installed in a shed (1.5 x 1.5 m) made of timber and corrugated iron sheets and built on exposed bedrocks. The seismographs were activated 16 times during the term of observation, recording minor vibration waves. These recorded wave forms did not include those considered to represent earthquake vibrations.

Fig. 10-1 shows the records of oscillations and exemplary analysis of wave forms. The "observed waves" in the top column of Fig. 10-1 represent accelerations of horizontal ground motion for 2 - 3 seconds in terms of wave form, with the maximum amplitude reaching 1.56 gal. Those in second and lower columns show the results of Fourier spectral analysis, auto-correlation analysis and power's spectral analysis, in each of which, pertinent smoothing functions were employed. Obviously, these analytical results show dominant presence of 35 Hz components, but it is not certain whether it represents natural frequency of ground at the point of observation. It is attributable to a number of factors; first, there stands a power station near the observation house and it is possible that the seismographs may have recorded vibrations produced by machinery and equipment installed in the power plant and, secondary, it is considered that the recorded wave forms contain the pulsatory motion of wind and that seismographs may have been energized by gale and/or gust.

Cochrane village, with 2,000 population and located in the central part of the region selected as the site of the Baker River Hydroelectric Development Project, is considered most suitable for earthquake observation. Therefore, we should like to recommend the following system for future earthquake observations to be conducted in this village.

10.4 Vibration Characteristics of Structures and Dynamic Properties of Construction Materials

ENDESA is experienced in detailed studies on the stability of a dam during earthquakes employing the method of dynamic finite element analysis, as in the case of designing Colbun dam 126 m high rock fill type dam to be constructed on the Maule River.

For the purpose of providing aseismic design of structures to be constructed under the Baker River Hydroelectric Development Project, such dynamic analytical method will be introduced in addition to the static analysis in the future. Needless to say, as the reliability of such numerical analysis depends on the rationality such input data as material constants of ground and structures and seismic wave forms, it is necessary that rigid dynamic tests are performed at site or in laboratories prior to analysis so as to determine the accurate value of dynamic properties.

The dynamic deformation characteristics of component of ground and rock fill type dam, such as clay sand and gravels, etc. tend to vary substantially and in a complicated manner with a difference in water content, grain size, relative density, stress history, loading velocity, loading intensity, etc. of these materials. Therefore, in the case of performing dynamic tests on such materials, it is essential to select pertinent test methods in proper recognition of the purpose and limit of the test concerned.

In Salton San Carlos Dam, it has been assumed that there is a thick layer of sediments on the riverbed. The recent field survey has confirmed the presence of several sand bars on the riverbed. It is estimated that new subaqueous sand deposits feature low relative density and uniform grain size to a certain degree, but, if sand deposits are subjected to repeated vibratory load under such conditions, it is possible that considerable settlement or liquefaction of such deposits may occur. These factors should be taken into consideration on the occasion of designing a dam at this site.

Bedrocks on the right abutment of Chacabuco Dam have large fractured zones subjected to strong shearing action and there is a considerable difference in the geology of bedrocks on the left and right abutments of the dam, as discovered by the recent geological survey. In the case of such geological structures, ground at each side of a dam show different motion when hit by earthquake and the stability of structures to be constructed in this area may in some case be threatened.

It is preferable that seismographs are installed on each side of the dam to allow simultaneous observation of bedrock vibrations and that measurement of micro tremors and seismic prospecting are conducted to determine the vibration characteristics of the ground.

As Tamango Dam is flanked with steep abutments and has a complex topography around it, facing saddles on the left bank, it is difficult to determine the vibration characteristics of large structures to be constructed in this area. Therefore, model vibration test is considered effective for the purpose. The rock fill type dam should show especially earthquake-resistance in the region where large deformation occurs to soil and gravels which show considerably nonlinear behaviors.

In the present situation where dynamic, failure mechanism of a dam has not been sufficiently explicated and the principle of similarity has not been introduced, it appears that there is no alternative but to determine the final strength of a dam by means of vibration failure tests on a model dam, on which occasion, it is preferable to use as large models as practically available.

Fig.-10.1 Earthquake Record at Cochrane in Chile

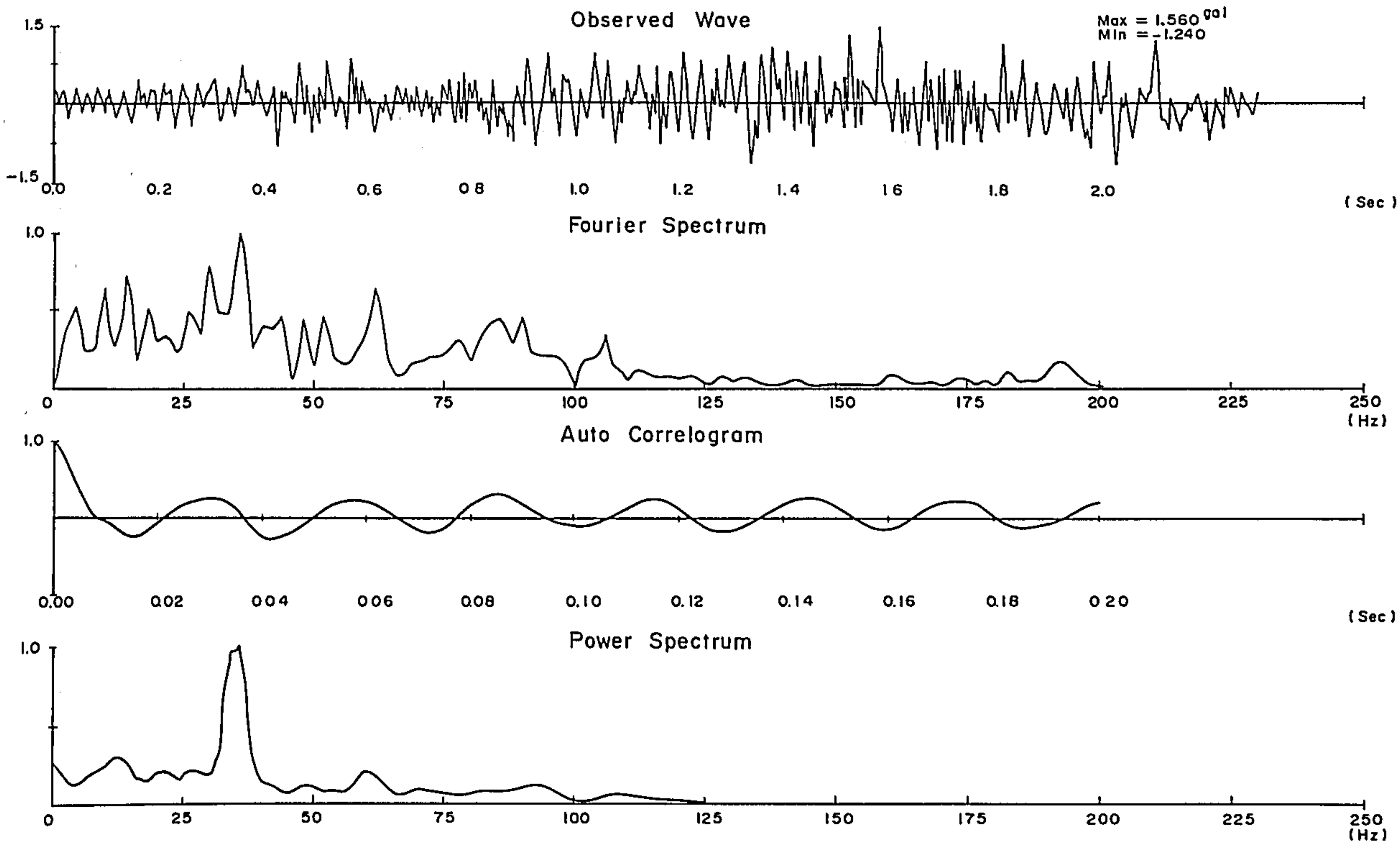


Table -10.1 Epicentral Regions of Major Historical Earthquakes in Chile, 1535 - 1955

(From Lamnitz, 1970)

Date		Epicentral region	Origin	Magnitude	Remarks
1562	October 28	So. Chile			Apocryphal
1570	February 8	Concepcion	Offshore	8 - $8\frac{1}{2}$	Destructive tsunami
1575	March 17	Santiago	Coast Range	7 - $7\frac{1}{2}$	More than 100 km from Santiago
1575	December 16	Valdivia	Offshore	$8\frac{1}{2}$	As in 1960
1604	November 24	Arica	Offshore	$8\frac{1}{4}$ - $8\frac{1}{2}$	Major tsunami
1615	September 16	Arica	Offshore	$7\frac{1}{2}$	Small tsunami
1647	May 13	Santiago	Range Fault	$8\frac{1}{2}$	Epicenter between Santiago - Valparaiso
1657	March 15	Concepcion	Offshore	8	Major tsunami
1681	March 10	Arica	Offshore	7 - $7\frac{1}{2}$	No tsunami damage
1687	July 12	San Felipe	Aconcagua Valley	7 - $7\frac{1}{2}$	Few data
1715	August 22	So. Peru	Coastal	$7\frac{1}{2}$	Damage in Arica
1730	July 8	Valparaiso	Offshore	$8\frac{3}{4}$	Major tsunami
1737	December 24	Valdivia	Offshore, Valdivia - Chiloe	$7\frac{1}{2}$ - 8	Prob. tsunami
1751	May 25	Concepcion	Offshore	$8\frac{1}{2}$	Major tsunami
1796	March 30	Capiapo	Inland or near-coastal	$7\frac{1}{2}$ - 8	No tsunami
1819	April 3, 4, 11	Capiapo	Coastal	$8\frac{1}{4}$ - $8\frac{1}{2}$	Large tsunami
1822	November 19	Valparaiso	Coastal	$8\frac{1}{2}$	Moderate tsunami geodetic charges
1829	September 26	Valparaiso	Coastal	7	No tsunami
1835	February 20	Concepcion	Offshore	8 - $8\frac{1}{4}$	Major tsunami
1837	November 7	Valdivia	Offshore	8	Tsunami
1847	October 8	Illapel	Near-coastal	7 - $7\frac{1}{2}$	No tsunami
1849	November 17	Coquimbo	Offshore	$7\frac{1}{2}$	Moderate tsunami
1850	December 6	Maipo Valley	Andean	7 - $7\frac{1}{2}$	As in 1958
1851	April 2	Casablanca	Range Fault	7 - $7\frac{1}{2}$	No tsunami
1859	October 5	Capiapo	Coastal	$7\frac{1}{2}$ - $7\frac{3}{4}$	Moderate tsunami

(to be continued)

Date	Epicentral region	Origin	Magnitude	Remarks
1868 August 13	Arica	Offshore	$8\frac{1}{2}$	Major tsunami
1869 August 24	Pisagua	Offshore	$7 - 7\frac{3}{4}$	Aftershock Moderate tsunami
1871 October 5	Iquique	Coastal	$7 - 7\frac{1}{2}$	Few data
1877 May 9	Pisagua	Offshore	$8 - 8\frac{1}{2}$	Major tsunami
1879 February 2	Magellan	Near-coastal	$7 - 7\frac{1}{2}$	As in 1949
1880 August 15	Illapel	Coastal	$7\frac{1}{2} - 8$	No tsunami report
1906 August 16	Valparaiso	Coastal	8. 6	Small tsunami; geodetic displacements
1918 December 18	Capiapo	Coastal	$7\frac{1}{2}$	Moderate tsunami
1922 November 10	Huasco	Coastal	8. 4	Destructive tsunami
1928 December 1	Talca	Near-coastal	8. 4	Small tsunami; some geodetic displacements
1939 January 24	Chillan	Coast Range Fault	8. 3	No tsunami
1943 April 6	Illapel	Coastal	8. 3	Minor tsunami
1949 December 17	Punta Arenas	Near-coastal	$7\frac{1}{2}$	Minor tsunami
1953 May 6	Chillan	Coast Range Fault	$7\frac{1}{2}$	As in 1939

Table - 10.2 Earthquakes in Southernmost Area of Chile, 45^oS - 56^oS

Epicenter		Date	Depth (km)	Magnitude	Comments
Latitude	Longitude				
45 0 S	73.0 W	1960 May 27	0	0	
45.0 S	73.0 W	1960 June 25	0	0	
45.0 S	74.0 W	1960 June 2	60	0	
45.0 S	74.5 W	1963 January 31	33	0	
45.0 S	75.0 W	1960 May 24	0	0	
45.0 S	75.0 W	1960 December 29	17	0	
45.0 S	75.1 W	1963 August 22	33	4.5	
45.0 S	75.5 W	1960 May 26	60	0	
45.0 S	76.0 W	1960 May 25	0	0	
45.0 S	76.0 W	1960 May 25	0	0	
45.0 S	76.5 W	1960 June 15	0	0	
45.0 S	77.0 W	1960 May 27	0	0	
45.1 S	76.7 W	1963 May 15	33	4.8	
45.5 S	73.0 W	1960 June 12	0	0	
45.5 S	73.5 W	1960 June 6	60	0	
45.5 S	73.8 W	1965 February 4	33	5.1	
45.5 S	74.0 W	1960 May 26	0	0	
45.5 S	75.0 W	1960 July 2	0	0	
45.5 S	76.0 W	1960 August 1	0	0	
45.5 S	77.0 W	1960 May 23	0	0	
45.6 S	76.1 W	1969 April 13	33	4.6	
45.6 S	73.4 W	1962 December 6	33	0	
45.7 S	72.6 W	1965 November 28	33	5.8	
45.8 S	75.2 W	1964 January 22	33	4.7	
45.8 S	76.1 W	1965 December 4	33	4.8	
45.9 S	75.3 W	1963 August 27	33	5.3	
45.9 S	76.0 W	1965 February 15	33	4.9	
46.0 S	73.5 W	1960 June 6	0	0	

(to be continued)

Epicenter		Date	Depth (km)	Magnitude	Comments
Latitude	Longitude				
46.0 S	74.0 W	1960 June 7	60	0	
46.0 S	74.0 W	1960 June 12	0	0	
46.0 S	74.5 W	1960 May 28	60	0	
46.0 S	75.5 W	1950 January 3	0	0	
46.0 S	76.1 W	1965 February 14	33	4.8	
46.3 S	74.8 W	1963 May 19	48	6.3	
46.5 S	74.0 W	1960 June 2	0	0	
46.5 S	77.0 W	1960 May 23	0	0	
47.0 S	75.0 W	1959 September 4	0	0	
47.0 S	75.0 W	1960 May 25	0	0	
48.0 S	77.0 W	1960 May 23	0	0	
48.5 S	76.1 W	1962 March 23	33	0	
50.5 S	72.4 W	1966 September 29	52	4.7	
50.5 S	73.0 W	1959 April 8	0	0	
50.5 S	74.0 W	1960 May 24	0	0	
50.9 S	73.6 W	1961 December 13	50	0	
52.5 S	72.0 W	1973 April 13	11	5.1	
53.5 S	71.5 W	1950 January 30	0	0	
54.0 S	71.0 W	1949 December 17	0	0	
54.0 S	71.0 W	1949 December 17	0	0	
54.5 S	70.0 W	1949 December 17	0	0	
56.0 S	67.0 W	1930 July 13	0	0	

Chapter 11

FURTHER INVESTIGATION AND SURVEYS

Chapter 11. FURTHER INVESTIGATION AND SURVEYS

Fig. 11-1 and Appendix-1 show the schedule and detail works of the further investigations and surveys to be conducted in the future.

11.1 Hydro-meteorology

Meteorological stations are concentrated in the upper reach of the Baker River to facilitate their maintenance and control. However, it is necessary to establish at least two additional meteorological stations, one in the middle reach and the other in the lower reach, to cover the entire project site. Meteorological observations should preferably be performed in the vicinity of the proposed damsites for the purpose of preparing construction schedule of work plans such as temporary works, cooling and curing of concrete, and construction schedule of main works. It is recommended, therefore, to establish one of the two additional meteorological station at Salton San Carlos and the other at Caleta Tortel.

ENDESA has operated four gaging stations at Bertrand, Colonia and two more points, one upstream from the Salton Gorge and the other downstream from it. These gaging stations will cover the main stream of the Baker. However, an additional gaging station should be set up each on the Ñadis River, Nef River and Lake Cochrane. Evaporation gages should preferably be installed in Lake Cochrane and Lake General Carrera. It is important to investigate the quality of water, since it is a factor of vital importance in selecting hydraulic equipment, turbines and temporary construction plants.

Field reconnaissances have been carried out in recent years to shed light on the glaciation which characterizes the Baker River system. However, further investigations should preferably be undertaken to obtain more information on the glaciation of the river.

11.2 Topography

Two topographical maps covering the Baker River basin are presently available: one to scale 1/500,000 and the other 1/250,000. Last year ENDESA prepared an aerial survey map to 1/20,000 scale covering the main stream of the Baker. A map to scale 1/2,000 has been prepared to embrace the proposed damsites of Chacabuco and Salton San Carlos. It is necessary to prepare an aerial survey map to scale 1/20,000 covering the reservoir area of the proposed dams and a topographical map to scale 1/2,000 covering additional damsites, Tamango, Salton Gorge. When the final selection of the damsite is made, it is necessary to make a 1/1,000 scale topographical map of the selected damsite. A consistent system of leveling survey has not been adopted in the past to survey the Baker River basin. It is essential, therefore, to carry out levelings, such as those linking Lake Bertrand with the Pacific coast, Lake Cochrane with the Baker, and the Baker with the international bench mark at Rodolfo.

11.3 Earthquake Observation

As pointed out in Subsection 2.2 Earthquake-Resistant Design, it is essential to perform earthquake observations in the project area at an early date. The recommended method for earthquake observation and the specifications of the equipment suitable for the purpose are described below in detail.

11.3.1 Site-selection for seismic observations

It is recommendable to carry out earthquake observations at the village of Cochrane. The site for installation of seismographs must meet the following requirements:

(1) The site must not be located on a steep cliff, in areas adjacent to the summit, on thick layers of poor subsoil, or in other places which are likely to show special vibratory behaviors.

(2) The site must not be susceptible to the effects of vibratory equipment such as motors and compressors.

(3) The site must be distant from busy roadways or airports.

(4) The site must be free from excessibely high or low temperature, high humidity, inundation and strong winds.

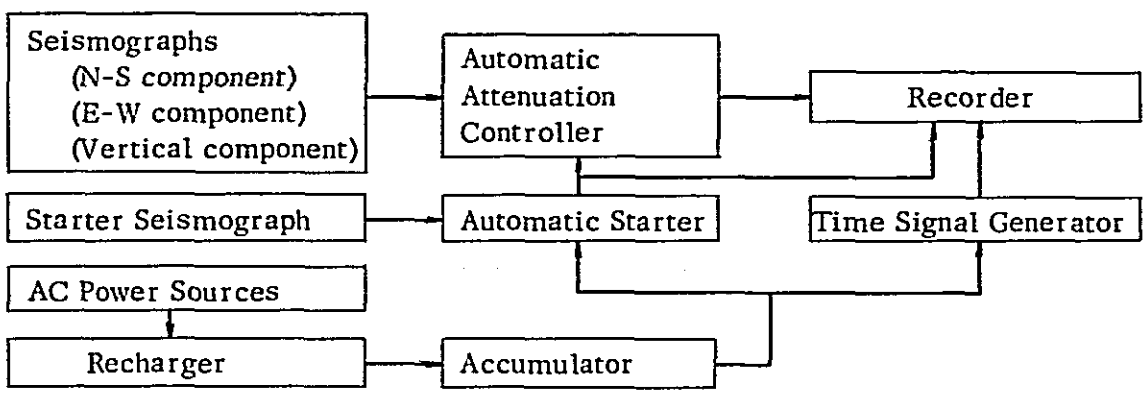
(5) The site must be easy of access for inspection and maintenance purpose and easy of obtaining AC power sources.

(6) The site must be distant from high voltage transmission lines or transformers or objects easy to be caught by lightning.

11.3.2 Method of measurement and measuring system

Fig. 11-2 is a block diagram showing the observation procedure suited to the local condition.

Fig. 11-2 Block Diagram for Observation Procedure



The observation method is outlined below.

As already stated, AC 220 V is supplied in the village of Cochrane during six night hours. The accumulator is recharged from the AC power source and the observation equipment are driven by DC 12 V supplied to the accumulator. From the standpoint of stable and economical operation of the observation equipment, this system has advantages over the system of using AC power during the nighttime to directly drive the equipment. Electromagnetic seismographs are to be installed in the east-west, south-north and vertical directions to detect seismic motion in the two different horizontal directions and vertical direction. The output of each seismograph is fed to the automatic attenuation controller, in which amplitudes are automatically controlled to prevent oscillatory wave forms from overrunning the recording paper and are put out. Electric signals denoting the attenuation values are also put out and recorded on the paper simultaneously.

The starting seismograph is of the same mechanism as the other three seismographs, but when it detects any vibrations in excess of the predetermined level, the automatic starter makes the recorder start and makes it stop after the lapse of a given time. Time indicating electric signals sent to the recorder from the time signal generator are recorded on the same paper as seismic wave forms, thereby making it possible to determine the exact time when the earthquake is detected.

Table 11-1 is a list of the equipment required for seismic observations under the procedure described above.

The equipment listed above must meet the specifications set forth in Table 11-2.

Table 11-1 Seismic Observation Equipment

Equipment	Specification	Unit	Q'ty	Remarks
(a) Electromagnetic Seismograph				
Horizontal accelerometer	For measurement	pc.	2	
Horizontal accelerometer	For starting	pc.	1	
Vertical accelerometer	For measurement	pc.	1	
(b) Automatic starter		pc.	1	
(c) Automatic attenuation controller	For measuring 3-component acceleration	pc.	1	
(d) Recording equipment				
Recorder (Visigraph)			1	W/Paper spool
Galvanometer	Accesary to recorder		10	6 for measurement 2 for time indication 2 for recording sensitivity
Time indicating signal generator		pc.	1	
Recording paper		roll.	5	
(e) Power supply unit				
Recharger		pc.	1	With shielded cover for induction voltage
Accumulator		pc.	1	
(f) Container	Anti-corrosive cabinet	pc.	1	Anti-freezing and anti-frosting heater contained
(g)				
Shielded vinyl cable	0.75mm^2; 2 cores	m	10	For use with seismograph

Table 11-2 Specification of Seismic Observation Equipment

Equipment	Item	Specification
(a) Electro magnetic Seismograph	Frequency range	0.3 30 Hz
	Max. measurable acceleration	500 gal
	Damping	Electromagnetic
	Working temperature range	- 10°C ~ +40°C
	Working humidity range	10 - 80 %
(b) Automatic starter	Type	Accelerometer type
	Max. sensitivity	1 gal
	Sensitivity control	Variable
	Working temperature range	-10°C ~ +40°C
	Working voltage	DC 12 V
(c) Automatic Attenuation Controller	Sensitivity control	x 1, x 1/4, x 1/16
	Switching response time	Within 10 m/sec
	Components	3
	Permissible error	Within ±2.5%
	Working voltage	DC 12 V
	Working temperature range	- 10°C ~ +40°C
(d) Recording equipment		
Recorder	Components	6
	Recording speed	5 cm/sec and 10 cm/sec
	Timing	1/10 sec
	Permissible error on speed	Within ±5 %
	Working voltage	DC 12 V
	Ray Source	Tungsten lamp
	Working temperature range	- 10°C ~ +40°C
Time signal generator	Time signal	Date, hour, minute and second
	Working voltage	DC 12 V
	Working temperature range	- 10°C ~ +40°C
Galvanometer	Frequency range	0 ~ 50 Hz

Equipment	Item	Specification
(e) Power supply unit		
Recharger	Input voltage	AC 220 V
	Output voltage	DC 14 V
	Output current	4 A
Accumulator	Output voltage	DC 12 V
	Capacity	120 AH
	Working temperature range	- 10^{o}C ~ +40^{o}C
(f) Container	Interior finish	Lined with adiabatic materials
	Containing	Automatic starter, automatic attenuation controller, recording equipment, power supply unit and heater
	Mechanism	Steel self-standing type
(g) Cable	Standard	To JIS 3312

11.4 Geological Investigation

No field geological surveys have been undertaken so far from views of geological engineering in the project sites, although studies and/or reviews only based upon aerial photographs and existing reports have been performed. Therefore, the investigation team held series of discussions with ENDESA on the geological surveys to be carried out in the future, and made some advice on them. The investigation team emphasized the necessity of performing at an early date a riverbed survey by echo-sounding method at the proposed Salton San Carlos damsite and seismic prospecting explorations and borings at the proposed Chacabuco damsite. ENDESA disclosed geological surveys at both damsites would start in October, 1976. ENDESA and Chilean Local consulting firms lack practical experiences in geological surveys for large-scale dam projects. If the Government of Chile desires to obtain continued technical cooperation from the Government of Japan for the Baker River hydroelectric development projects, it is advisable for the Government of Japan to send a geologist and a expert on seismic prospecting exploration concurrently a specialized in echo-sounding to Chile later 1976 or early 1977 taking into consideration the progress of geological survey made by ENDESA.

11.5 Testing for Construction Material

Tests as shown in Table 11-3 below must be conducted to determine the appropriateness of construction materials such as dam embankment materials and concrete aggregates.

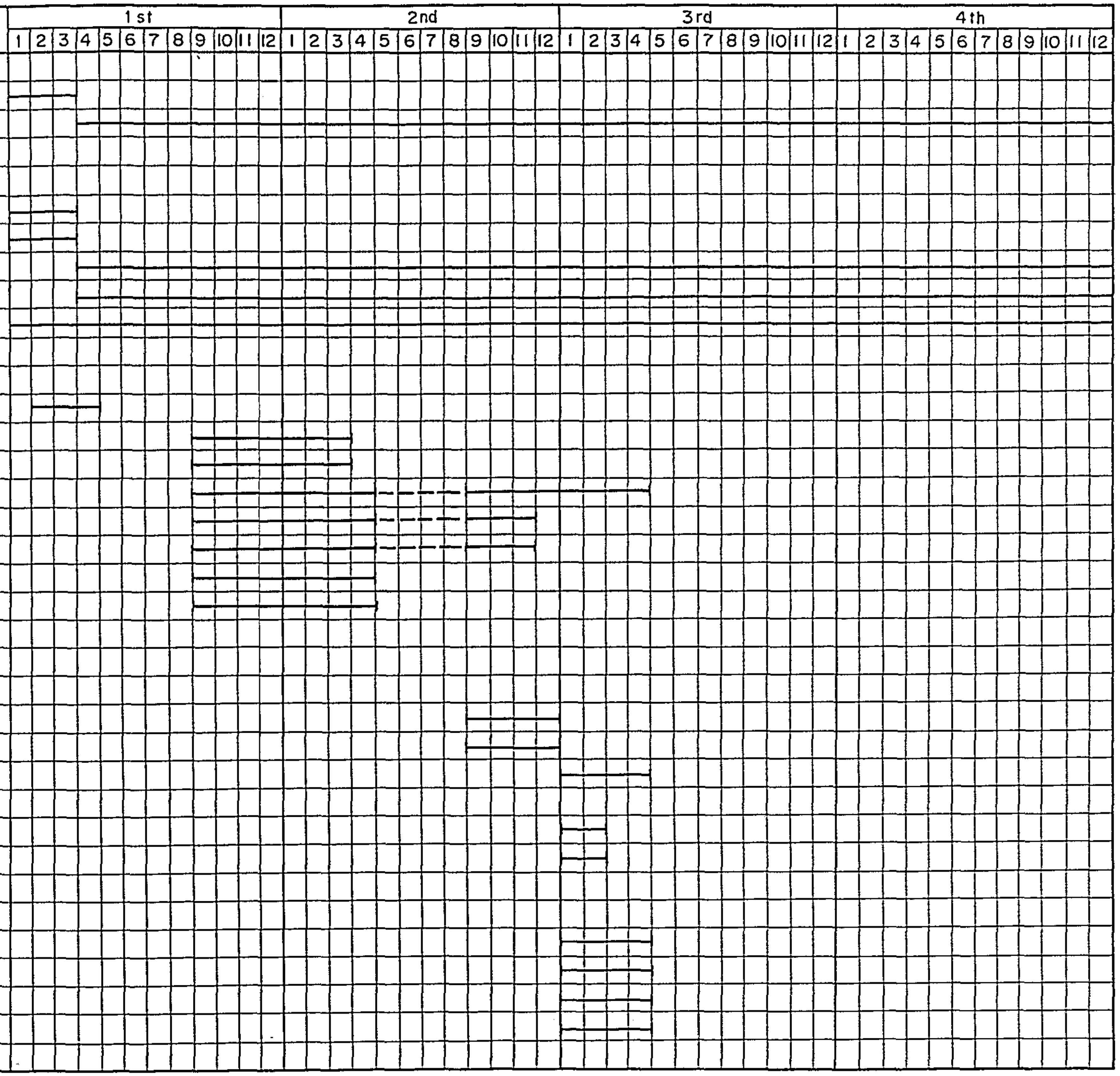
Table 11-3 Tests of Construction Materials

Core Materials	Filter Materials	Impermeable Materials	Concrete Aggregates
Mechanical tests	Specific gravity test	Specific gravity test	Sieve test
Compaction test	Sieve test	Water absorption test	Specific weight test
Triaxial compression test	Water absorption test	Durability test	Water absorption and surface water absorption test
Unconfined compression test	Compression or consolidation test	Compression test	Specific gravity test
Permeability test	Permeability test	Shearing test	Void ratio test
Consolidation test			Fineness modulus test
			Impurity test

These tests should preferably be conducted after various investigations at the proposed sites have been thoroughly carried out and the layout of the project has been studied. Fig. 11-1 shows the schedule of testing for construction materials.

Fig.–11.1 Schedule of Investigation Work (May~ August ; Snowy Season)

Item	Unit	Quantity
1) Seismic Observation Survey		
Seismograph Facilities	Place	3
Seismic Observation Survey	L.S	1
2) Hydrological Investigation		
Meteorological Observation Facilities	Place	2
River Runoff Observation Facilities	Place	3
Meteorological Observation	L.S	1
River Runoff Observation	L.S	1
Water Quality Test	L.S	1
3) Geological Investigation		
Aerial Geological Survey	L.S	1
Surface Geological Survey	km^2	8.9
Sonic Prospecting Exploration	km	5.5
Seismic Prospecting Exploration	km	42.5
Core Drilling Exploration	m	5,230
Permeability Test	Time	503
Adit Exploration	m	680
Bearing Test	Time	23
4) Topographical Survey		
Mapping from Aerial Photos (Additional)		
Catchment (Additional) 1/20,000	km^2	100
Site 1/2,000	km^2	5.7
Leveling Survey	km	334
Profile Leveling of River		
(From Bertrand to Sea)	km	223
(From Rio Baker to Lago Cochrane)	km	19.5
5) Material Test		
Core Material	L.S	1
Filter Material	L.S	1
Permeability Material	L.S	1
Concrete Aggregate Material	L.S	1



Note : Breakdown of quantities for each scheme is summarized in Appendix– 1

Appendix

Appendix-1 Quantity of Investigation Works

Table-A.1 Summary of Investigation Works

Item	Unit	Quantity				
		Chaca-buco	Taman-go	Salton San Carlos	Salton Gorge	Total
1) Seismic Observation Survey						
Seismograph Facilities	place	2	-	1	-	3
Seismic Observation Survey	L. S.	1	-	1	-	1
2) Hydrological Investigation						
Meteorological Observation Facilities	place	1	-	1	-	2
Meteorological Observation	L. S.	1	-	1	-	1
River Runoff Observation Facilities	place	-	1	2	-	3
River Runoff Observation	L. S.	-	1	1	-	1
Water Quality Test	L. S.	1	-	1	-	1
3) Geological Investigation						
Aerial Geological Survey	L. S.	1	1	1	1	1
Surface Geological Survey S = 1/500	km^2	0.5	1.5	0.7	0.8	3.5
" " S = 2,000	km^2	1.0	2.0	1.2	1.2	5.4
Sonic Prospecting Exploration	km	-	-	5.5	-	5.5
Seismic Prospecting Exploration	km	7.1	13.1	12.8	9.6	42.6
Core Drilling Exploration	m	1,330	1,610	2,040	730	5,710
Permeability Test	time	228	186	35	54	503
Adit Exploration	m	430	250	-	-	680
Bearing Test	time	11	12	-	-	33
4) Topographical Survey						
Mapping from Aerial Photos (Catchment) (S=1/20,000)	km^2	20	-	80	-	100
" " (Site) (S=1/2,000)	km^2	-	2.8	-	2.9	5.7
Leveling Survey	km	144	-	190	-	334
Profile Leveling of River						
(from Bertrand to Sea)	km	223	-	-	-	223
(from Rio Baker to Lake Cochrane)	km	19.5	-	-	-	19.5
5) Material Test						
Core Material	L. S.	1	1	1	1	1
Filter Material	L. S.	1	1	1	1	1
Permeability Material	L. S.	1	1	1	1	1
Concrete Aggregate Material	L. S.	1	1	1	1	1

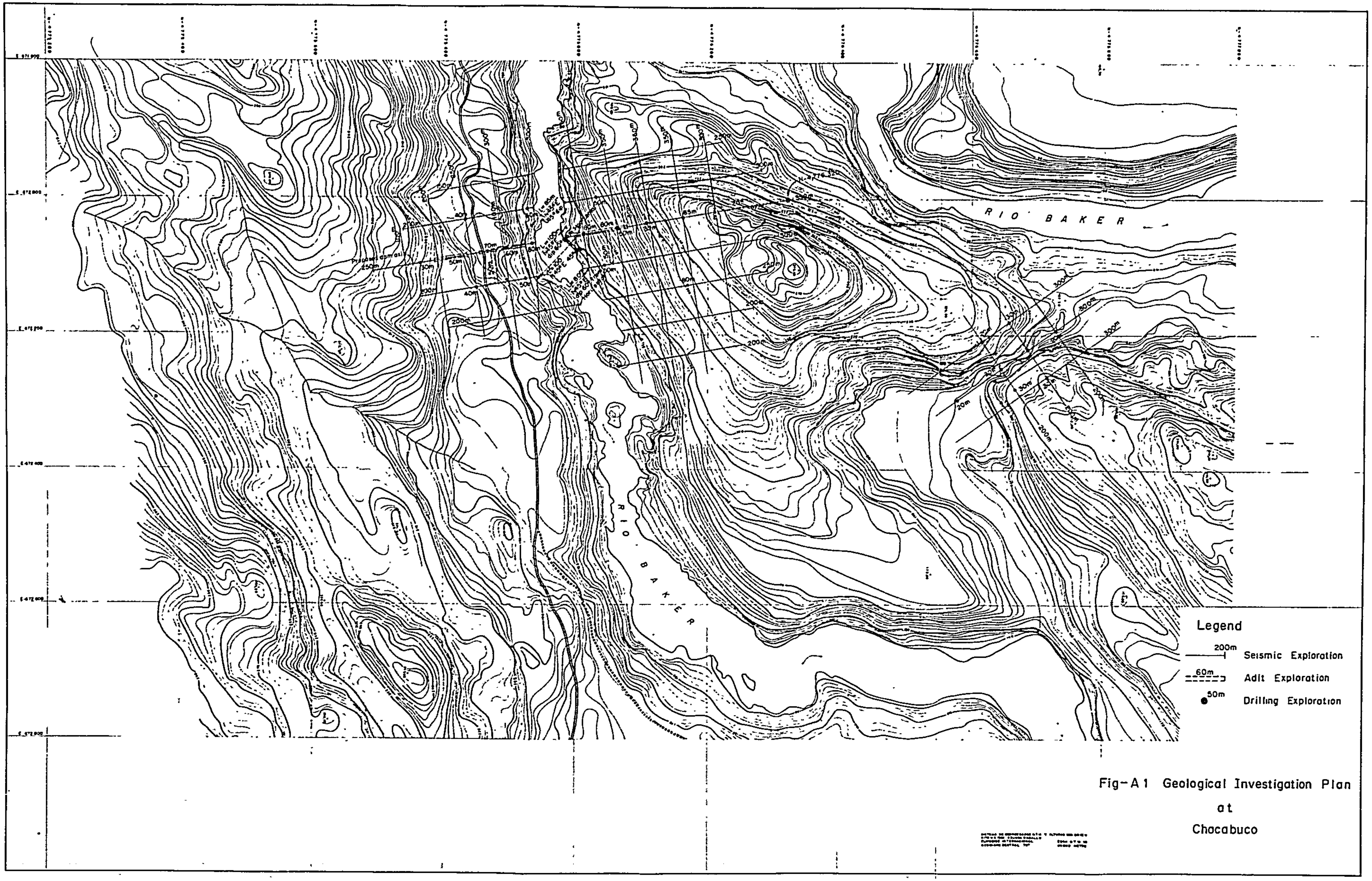


Fig-A1 Geological Investigation Plan
at
Chacabuco

Table-A.2 Quantity of Investigation Works for Chacabuco Site

Item			Description		Unit	Quantity
1) Seismic Observation Survey						
Seismograph Observation			Chacabuco Site		place	2
Seismic Observation Survey					L. S.	1
2) Hydrological Investigation						
Meteorological Observation Facilities			Chacabuco Site		place	1
Meteorological Observation					L. S.	1
Water Quality Test					L. S.	1
3) Geological Investigation						
Aerial Geological Survey					L. S.	1
Surface Geological Survey			S = 1/500		km^2	0.5
(Dam and Spillway Area)			S = 1/2,000			1.0
Seismic Prospecting Exploration			Dam			5.6
" "			Spillway			1.5
Core Drilling Exploration (in Dam)						
Location	N-4,775,933 E- 672,043	EL 147m	direction	N 45° E 45° dip	m	85
"	N-4,775,987 E- 672,045	EL 147m	"	N 45° E 60° dip	"	100
"	N-4,775,946 E- 672,120	EL 147m	"	N 45° E 45° dip	"	100
"	N-4,776,022 E- 672,108	EL 146m	"	N 45° E 60° dip	"	80
"	N-4,775,768 E- 672,095	EL 200m	"	Vertical	"	30
"	N-4,775,833 E- 672,035	EL 176m	"	do.	"	40
"	N-4,775,850 E- 672,133	EL 182m	"	"	"	40
"	N-4,775,895 E- 672,075	EL 170m	"	"	"	60
"	N-4,775,917 E- 672,017	EL 148m	"	"	"	50
"	N-4,775,925 E- 672,120	EL 162m	"	"	"	50
"	N-4,775,935 E- 672,068	EL 142m	"	"	"	80
"	N-4,776,015 E- 672,055	EL 167m	"	"	"	80
"	N-4,776,032 E- 672,000	EL 186m	"	"	"	50
"	N-4,776,047 E- 672,100	EL 172m	"	"	"	50
"	N-4,776,065 E- 672,045	EL 189m	"	"	"	50

Item			Description	Unit	Quantity
Location	N-4,776,110 E- 672,038	EL 210m	direction Vertical	m	30
"	N-4,776,162 E- 672,027	EL 252m	" "	"	65
"	N-4,770,172 E- 672,128	EL 223m	" "	"	80
Core Drilling Exploration (in Spillway)					
Location	N-4,776,612 E- 672,203	EL 212m	direction Vertical	m	20
"	N-4,776,658 E- 672,180	EL 194m	" "	"	30
"	N-4,776,727 E- 672,193	EL 161m	" "	"	20
"	N-4,776,680 E- 672,222	EL 157m	" "	"	30
"	N-4,776,645 E- 672,250	EL 156m	" "	"	30
"	N-4,776,580 E- 672,296	EL 155m	" "	"	20
"	N-4,776,667 E- 672,280	EL 191m	" "	"	30
"	N-4,776,715 E- 672,262	EL 203m	" "	"	30
Total					1,330
Permeability Test				times	228
Adit Exploration (Right bank)			Portal: N-4,775,924 E- 672,070 EL 150m	m	220
			Portal: N-4,775,837 E- 672,085 EL 178m	"	50
" (Left bank)			Portal: N-4,776,003 E- 672,056 EL 160m	"	160
Total				"	430
Bearing Test (in the adit)				times	11
4) Topographical Survey					
Mapping from Aerial Photos					
(Catchment 1/20,000)			Additional	km^2	20
Leveling Survey					
(from Tamango to Chacabuco)				km	20
(from Chacabuco to Bertrand)				"	33
(from Tamango to International Bench mark)				"	91
Profile Leveling of River					
(from Bertland to Sea)				km	223
(from Rio Baker to Lake Cochrane)				"	19.5
5) Material Test					
Core Material				L. S.	1
Filter Material				"	1
Permeability Material				"	1
Concrete Aggregate Material				"	1

Fig-A2 Geological Investigation Plan
at
Tamango

Table-A.3 Quantity of Investigation Works for Tamango Site

Item	Description	Unit	Quantity
1) Hydrological Investigation			
River Runoff Observation Facilities	Tamango Site	times	1
River Runoff Observation		L. S.	1
2) Geological Investigation			
Aerial Geological Survey		L. S.	1
Surface Geological Survey (Dam, Spillway, Power Station Area)	S = 1/500	km^2	1.5
	S = 1/2,000	"	2.0
Seismic Prospecting Exploration (Dam, Spillway, Power Station Area)	Right bank	km	5.0
	Left bank	"	8.1
Core Drilling Exploration (Dam Spill-way, Power Station)	Core drilling with permeability test	m	930
	Core drilling	"	680
Permeability Test	5m staging	times	186
Adit Exploration (Dam Site)		m	140
"		"	110
Bearing Test (in the adit)		times	12
3) Topographic Survey			
Mapping from Aerial Photos	Site S = 1/2,000	km^2	2.8
4) Material Test			
Core Material		L. S.	1
Filter Material		"	1
Permeability Material		"	1
Concrete Aggregate Material		"	1

Note: Grouting Test

The practicable plan and method of grouting test will be recommended after reviewing the results of permeability test of core drilling holes.

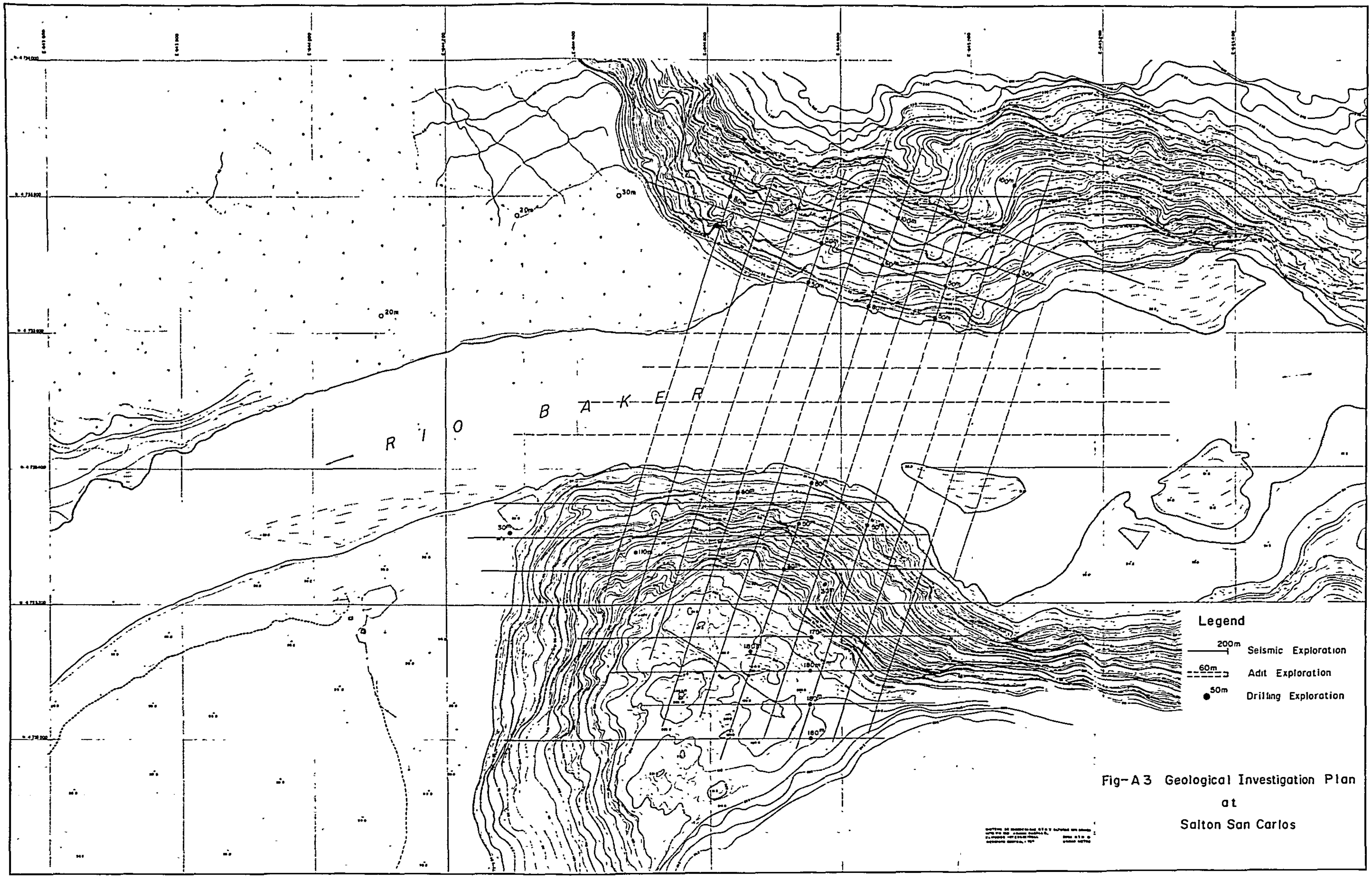


Fig-A 3 Geological Investigation Plan
at
Salton San Carlos

Table-A.4 Quantity of Investigation Works for Salton San Carlos Site

Item	Direction	Unit	Quantity
1) Seismic Observation Survey			
Seismograph Facilities	Cochrane	place	1
Seismic Observation Survey		L. S.	1
2) Hydrological Investigation			
Meteorological Observation Facilities		place	1
·River Runoff Observation Facilities	Mouth Lago Cochrane and Nadis	"	2
Meteorological Observation		L. S.	1
River Runoff Observation		"	1
Water Quality Test		"	1
3) Geological Investigation			
Aerial Geological Survey		L. S.	1
Surface Geological Survey (Dam, Spill-	Scale = 1/500	km^2	0.7
way, Power Station)	Scale = 1/2,000	"	1.2
Sonic Prospecting Exploration (on the	River flow direction	km	2.4
River)	River cross direction	"	3.1
Seismic prospecting Exploration (Dam	Right bank	"	4.4
Spillway, Power Station)	Left bank	"	8.4
Core Drilling Exploration	Core drilling with permeability test	m	400
(Dam, Spillway, Power Station)	Core drilling	m	1,160
Permeability Test	5m staging	times	35
4) Topographical Survey			
Mapping from Aerial Photos			
(Catchment 1/20,000)	Additional	km^2	80
Leveling Survey			
(from Sea to Salton San Carlos)		km	85
(from Salton San Carlos to Tamango)		"	85
(from Rio Baker to Lago Cochrane)		"	20
5) Material Test			
Core Material		L. S.	1
Filter Material		"	1
Permeability Material		"	1
Concrete Aggregate Material		"	1

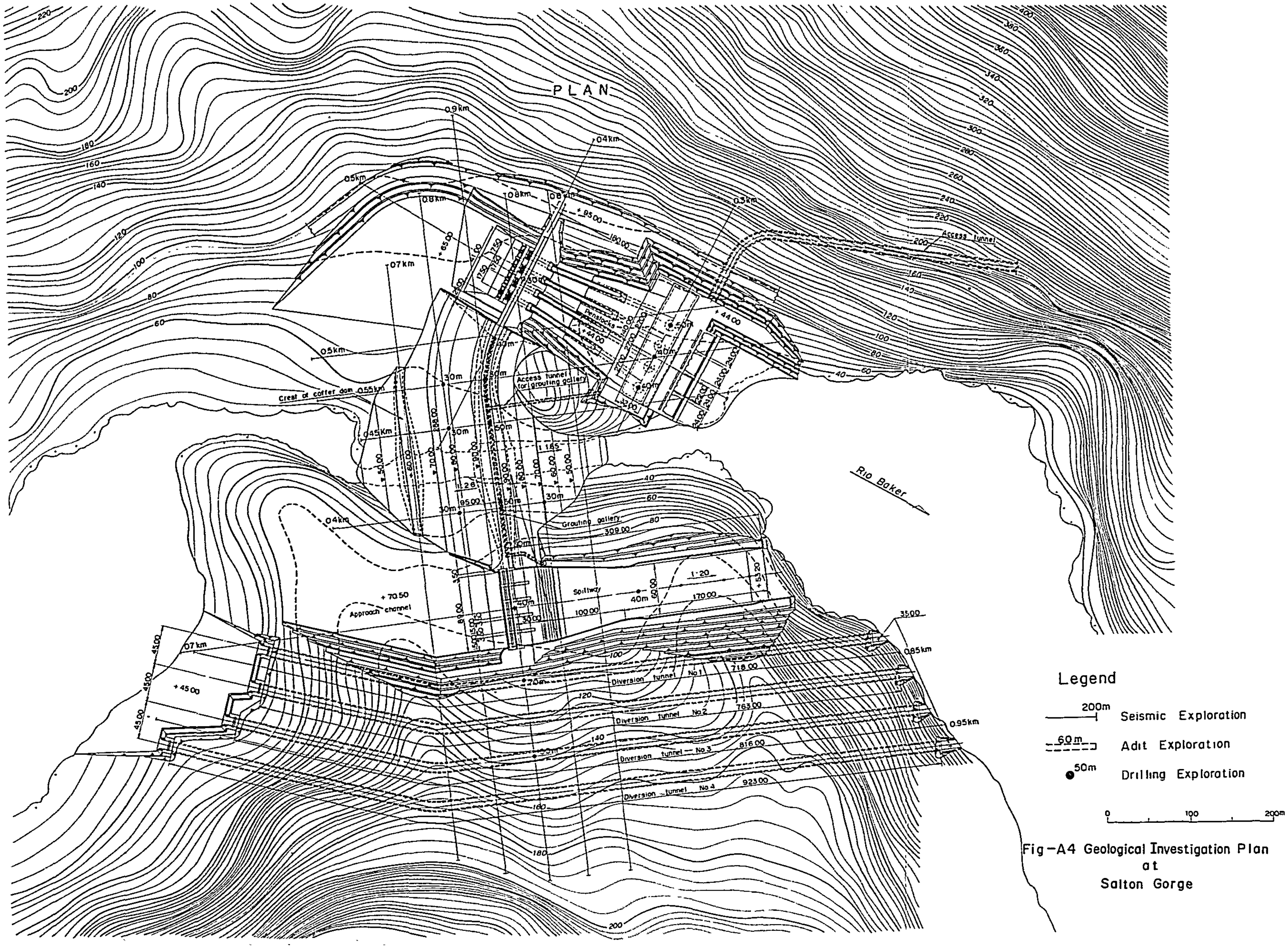


Fig-A4 Geological Investigation Plan at Salton Gorge

Table-A.5 Quantity of Investigation Works for Salton Gorge Site

Item	Description	Unit	Quantity
1) Geological Investigation			
Aerial Geological Survey		L. S.	1
Surface Geological Survey	Scale = 1/500	km^2	0.8
(Dam, Spillway, Power Station)	Scale = 1/2,000	"	1.2
Seismic Prospecting Exploration	(Dam, spillway, power station traverse line)	km	9.6
Core Drilling Exploration (Dam, Spillway, Power Station)	Core drilling with permeability test	m	270
	Core drilling	"	460
Permeability Test	5m staging	times	54
2) Topographical Survey			
Mapping from Aerial Phots	(Site S = 1/2,000)	km^2	2.9
3) Material Test			
Core Material		L. S.	1
Filter Material		"	1
Permeability Material		"	1
Concrete Aggregate Material		"	1

Appendix-2 Field Investigation Schedule for Baker and Pascua River Hydroelectric Development Project

No.	Date	No. 1 Group	Staying	No. 2 Group	Staying
1	Feb. 10	Leave Tokyo at 20:00 (AF-100)			
2	11	Arrive Santiago at 19:30 (AV-83) 3)	Santiago		
3	12	Visit to ODEPLAN, ENDESA and Japanese Embassy in Chile. Meeting in the afternoon	"		
4	13	Meeting at ENDESA	"		
5	14	Preparation of investigation	"		
6	15	"	"		
7	16	Meeting at ENDESA	"		
8	17	" "	"		
9	18	Trip from Santiago to Coihaique by airplane (LAN-CHILE)	Coihaique		
10	19	Visit to the Headquaters of Army in Coihaique	"		
11	20	Trip from Coihaique to Cochrane by airplane Investigation at Chacabuco and Tamango damsites by vehicle	Cochrane "		
12	21	Aerial survey, Cochrane - Pascua - Ñadis - San Carlos - Cochrane	San Carlos		
13	22	Trip, Cochrane - Ñadis - San Carlos by airplane and boat	"		
14	23	Trip for investigation, San Carlos - Ventisquero - San Carlos by boat	"		
15	24	Investigation at Salton Gorge and Salton San Carlos damsites	"		
16	25	"	"		
17	26	"	"		
18	27	"	"		
19	28	"	"		
20	29	Trip from San Carlos to Cochrane by boat and airplane	Cochrane		
21	Mar. 1	Investigation at Chacabuco and Tamango damsites by vehicle	"		
22	2	"	"		
23	3	Trip from Cochrane to Coihaique by airplane	Coihaique		
24	4	Investigation into Chacabuco Port	"		
25	5	Trip, Coihaique - Puerto Montt - Santiago by airplane (LAN-CHILE)	Santiago	Leave Tokyo at 20:00 (AF-100)	
26	6	Joint meeting with No. 1 and No. 2 group of investigation team	"	Arrive Santiago at 13:40 (BN-979)	Santiago
27	7	"	"	Meeting with No. 1 and No. 2 group	"
28	8	Meeting at ENDESA and study on the result of field investigation	"	Trip from Santiago to Coihaique by airplane (LAN-CHILE)	Coihaique
29	9	"	"	Investigation into Chacabuco Port and visit to Aisen Power Station	"
30	10	"	"	"	"
31	11	"	"	Trip, Coihaique - Caleta Tortel - Cochrane by airplane	Cochrane
32	12	"	"	Trip, Cochrane - Pascua - Cochrane by airplane	"
33	13	"	"	Investigation at Chacabuco and Tamango damsites	"
34	14	"	"	Trip, Cochrane - Ñadis - San Carlos - Cochrane - Coihaique	Coihaique
35	15	"	"	Meeting on result of field investigation	"
36	16	"	"	Trip, Coihaique - Balmaceda - Santiago by airplane (LAN-CHILE)	Santiago
37	17	Meeting with Japanese Embassy and ENDESA	"	Meeting with Japanese Embassy and ENDESA	"
38	18	"	"	"	"
39	19	Visit to ODEPLAN, ENDESA and Japanese Embassy	"	Visit to ODEPLAN, ENDESA and Japanese Embassy	"
40	20	Collection of data	"	Collection of data	"
41	21	"	"	"	"
42	22	Trip from Santiago to New York by airplane (LH-495)	New York	Trip from Santiagot to New York by airplane (LH-495)	New York
43	23	Leave New York at 12:15 (JL-005)		Leave New York at 12:15 (JL-005)	
44	24	Arrive Tokyo at 18:40		Arrive Tokyo at 18:40	

Remarks:

Engineers of ENDESA

No. 1 Group
- R. Bennewitz (Civil Engineer)
- L. Barozzi (Geologist)
- J. Espinoza (Civil Engineer)
- A. Goldsack (Geologist)
- C. Meier

No. 2 Group
- J. Espinosa (Civil Engineer)
- L. Aylwin (Civil Engineer)
- C. Meier

Appendix 3. Basic Data

The basic data obtained during the field investigations are as shown below.

(1) Hydrological data

ESTACION : BAKER EN DES.L.BERTRAND LATITUD : 47 4 0 S LONGITUD : 72 48 0 W (YEAR 1963)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	0.	729.	733.	609.	537.	464.	408.	439.	447.	609.	721.	721.
2	0.	721.	745.	609.	537.	454.	408.	443.	447.	609.	721.	721.
3	0.	713.	745.	600.	527.	464.	409.	447.	447.	609.	721.	721.
4	0.	713.	746.	600.	527.	460.	414.	451.	455.	619.	721.	713.
5	0.	713.	729.	600.	518.	460.	414.	451.	507.	619.	729.	705.
6	0.	721.	721.	591.	518.	455.	414.	447.	518.	619.	738.	698.
7	0.	745.	721.	582.	518.	455.	414.	447.	518.	619.	729.	690.
8	0.	746.	721.	582.	512.	451.	414.	447.	512.	619.	729.	698.
9	0.	774.	713.	582.	512.	447.	414.	451.	512.	628.	738.	705.
10	0.	744.	713.	582.	512.	447.	414.	451.	512.	628.	738.	705.
11	0.	745.	698.	582.	507.	443.	414.	451.	518.	628.	755.	705.
12	0.	745.	698.	573.	507.	443.	414.	451.	518.	628.	755.	705.
13	0.	746.	690.	564.	507.	443.	414.	451.	527.	639.	755.	705.
14	0.	729.	680.	555.	501.	439.	414.	451.	546.	639.	764.	698.
15	0.	721.	680.	546.	501.	431.	414.	447.	555.	628.	755.	698.
16	0.	721.	670.	555.	501.	427.	411.	447.	555.	639.	755.	690.
17	0.	713.	670.	545.	492.	427.	411.	447.	555.	639.	746.	680.
18	0.	713.	660.	546.	482.	427.	414.	443.	555.	649.	729.	680.
19	0.	713.	649.	545.	482.	427.	418.	443.	555.	649.	729.	630.
20	0.	713.	639.	537.	482.	423.	418.	447.	555.	649.	738.	670.
21	0.	713.	639.	527.	473.	423.	418.	447.	573.	660.	738.	670.
22	0.	694.	639.	545.	473.	423.	418.	447.	591.	690.	738.	670.
23	0.	690.	649.	545.	473.	423.	418.	443.	600.	713.	738.	660.
24	0.	690.	649.	545.	473.	418.	418.	443.	600.	713.	729.	650.
25	0.	690.	649.	546.	469.	418.	423.	439.	600.	721.	729.	680.
26	0.	690.	649.	546.	469.	414.	423.	439.	609.	713.	729.	705.
27	0.	690.	639.	545.	454.	414.	423.	443.	609.	713.	729.	690.
28	0.	690.	628.	544.	469.	414.	423.	447.	609.	713.	729.	680.
29	0.	670.	619.	545.	459.	411.	427.	451.	609.	713.	738.	670.
30	0.	680.	609.	545.	464.	409.	431.	447.	609.	713.		670.
31		705.		537.	454.		439.		609.	721.		670.
TOTAL	0.	22147.	20397.	17455.	15340.	13053.	12925.	13398.	16932.	20348.	21363.	21413.
AVERAGE	0.	715.	690.	563.	495.	435.	417.	447.	546.	656.	737.	691.

ANNUAL TOTAL 194831.
ANNUAL AVERAGE 532.

ESTACION : BAKER EN DES.L.BERTRAND LATITUD : 47 4 0 S LONGITUD : 72 48 0 W (YEAR 1964)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	670.	670.	755.	555.	464.	435.	423.	439.	492.	582.	796.	834.
2	670.	670.	745.	545.	459.	431.	423.	447.	492.	582.	803.	826.
3	660.	660.	738.	545.	469.	431.	423.	447.	501.	582.	803.	826.
4	660.	660.	729.	545.	459.	431.	418.	447.	501.	600.	796.	815.
5	649.	650.	721.	537.	469.	431.	418.	451.	512.	600.	803.	815.
6	649.	650.	713.	537.	469.	427.	418.	451.	518.	600.	815.	834.
7	649.	649.	713.	527.	459.	423.	418.	451.	537.	600.	815.	826.
8	649.	639.	705.	527.	469.	423.	418.	451.	537.	600.	815.	826.
9	639.	639.	698.	527.	464.	418.	423.	451.	546.	628.	815.	826.
10	639.	639.	690.	527.	482.	418.	427.	455.	546.	639.	826.	826.
11	639.	639.	690.	527.	482.	423.	431.	455.	537.	639.	826.	826.
12	639.	649.	670.	527.	492.	427.	431.	455.	537.	639.	815.	815.
13	649.	705.	670.	527.	482.	431.	435.	455.	537.	639.	803.	815.
14	755.	713.	650.	527.	482.	435.	439.	451.	537.	639.	815.	815.
15	746.	705.	660.	518.	473.	435.	439.	451.	537.	649.	835.	804.
16	713.	705.	649.	518.	473.	435.	439.	447.	537.	649.	835.	804.
17	713.	698.	639.	518.	459.	435.	443.	447.	537.	649.	835.	793.
18	713.	690.	628.	512.	464.	435.	443.	447.	546.	660.	843.	783.
19	705.	690.	628.	507.	450.	435.	443.	447.	546.	670.	859.	783.
20	705.	680.	619.	507.	450.	431.	443.	447.	555.	670.	859.	774.
21	713.	680.	619.	501.	455.	431.	443.	447.	555.	660.	872.	774.
22	721.	680.	609.	501.	455.	439.	443.	447.	555.	660.	880.	774.
23	713.	705.	600.	501.	455.	439.	447.	460.	555.	680.	859.	774.
24	705.	729.	591.	492.	451.	435.	451.	469.	564.	746.	852.	764.
25	705.	721.	591.	482.	451.	431.	451.	473.	564.	755.	859.	764.
26	698.	721.	582.	482.	447.	427.	447.	482.	564.	755.	859.	764.
27	690.	721.	573.	482.	447.	427.	443.	492.	564.	774.	843.	764.
28	690.	721.	573.	482.	443.	427.	443.	482.	564.	783.	836.	764.
29	680.	745.	554.	482.	447.	423.	439.	492.	564.	783.		774.
30	680.	764.	555.	473.	447.	423.	435.	492.	573.	783.		764.
31		755.		459.	439.		435.		573.	793.		755.
TOTAL	20506.	21363.	19578.	15910.	14357.	12892.	13472.	13718.	16783.	20688.	23272.	24701.
AVERAGE	684.	689.	653.	513.	463.	430.	435.	457.	541.	667.	831.	797.

ANNUAL TOTAL 217250.
ANNUAL AVERAGE 595.

ESTACION : BAKER EN DES.L.BERTRAND   LATITUD : 47 4 0 S   LONGITUD : 72 48 0 W   (YEAR 1965)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	746.	764.	649.	690.	591.	518.	455.	464.	890.	847.	856.	720.
2	746.	774.	639.	690.	582.	518.	451.	454.	901.	847.	846.	720.
3	755.	764.	628.	680.	582.	518.	460.	469.	901.	847.	856.	712.
4	804.	755.	628.	670.	573.	518.	460.	464.	901.	855.	846.	703.
5	804.	755.	628.	670.	582.	518.	460.	464.	901.	847.	846.	703.
6	815.	746.	619.	650.	591.	518.	460.	469.	890.	847.	839.	703.
7	815.	738.	519.	550.	530.	518.	455.	473.	890.	838.	829.	703.
8	815.	774.	619.	705.	509.	512.	451.	482.	869.	838.	822.	703.
9	815.	743.	519.	537.	519.	512.	451.	482.	851.	838.	811.	703.
10	804.	774.	619.	639.	519.	507.	451.	482.	851.	838.	811.	703.
11	793.	764.	639.	539.	519.	507.	451.	482.	843.	847.	803.	703.
12	783.	764.	549.	623.	509.	507.	443.	482.	834.	855.	803.	703.
13	783.	755.	539.	619.	509.	501.	443.	501.	826.	864.	792.	712.
14	764.	745.	639.	519.	509.	492.	443.	512.	815.	875.	781.	712.
15	755.	738.	649.	509.	500.	492.	447.	512.	804.	885.	781.	703.
16	755.	729.	649.	600.	591.	492.	447.	518.	804.	875.	775.	703.
17	746.	721.	650.	591.	532.	482.	451.	546.	793.	864.	775.	694.
18	729.	713.	660.	591.	582.	482.	451.	564.	793.	875.	775.	694.
19	721.	705.	650.	591.	592.	482.	451.	573.	783.	875.	768.	703.
20	815.	698.	650.	591.	582.	482.	447.	591.	783.	864.	758.	712.
21	826.	690.	670.	582.	582.	482.	447.	619.	774.	855.	758.	703.
22	804.	690.	680.	582.	573.	473.	447.	509.	774.	847.	748.	703.
23	793.	690.	690.	582.	564.	469.	451.	660.	783.	847.	738.	694.
24	774.	690.	698.	573.	555.	464.	455.	746.	793.	838.	728.	694.
25	774.	690.	698.	573.	555.	460.	455.	859.	804.	838.	721.	694.
26	774.	680.	705.	564.	546.	460.	455.	851.	804.	847.	728.	694.
27	764.	680.	698.	564.	546.	473.	451.	859.	804.	847.	721.	694.
28	764.	670.	698.	564.	537.	469.	455.	880.	804.	847.	721.	694.
29	774.	670.	698.	582.	527.	464.	455.	890.	815.	847.		703.
30	774.	650.	690.	600.	527.	455.	460.	890.	815.	855.		703.
31		650.		591.	527.		460.		834.	864.		694.
TOTAL	23384.	22430.	19696.	19133.	17952.	14745.	14019.	17847.	25727.	26453.	22036.	21732.
AVERAGE	779.	724.	657.	617.	579.	492.	452.	595.	830.	853.	787.	703.

ANNUAL TOTAL 245209.
ANNUAL AVERAGE 672.

ESTACION : BAKER EN DES.L.BERTRAND LATITUD : 47 4 0 S LONGITUD : 72 48 0 W (YEAR 1966)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	694.	622.	929.	742.	593.	526.	449.	411.	469.	495.	603.	603.
2	694.	625.	951.	755.	584.	521.	447.	412.	471.	493.	595.	610.
3	694.	623.	952.	799.	572.	517.	443.	414.	468.	495.	589.	611.
4	694.	625.	952.	859.	572.	515.	441.	414.	467.	501.	595.	613.
5	703.	625.	952.	838.	568.	517.	438.	413.	469.	503.	597.	616.
6	694.	632.	952.	890.	564.	511.	438.	414.	467.	505.	600.	625.
7	694.	632.	951.	880.	554.	505.	435.	415.	467.	508.	597.	624.
8	703.	639.	952.	853.	549.	503.	430.	418.	467.	508.	603.	614.
9	694.	635.	943.	851.	547.	504.	431.	419.	467.	510.	622.	607.
10	694.	643.	943.	852.	539.	503.	430.	421.	467.	517.	628.	603.
11	694.	627.	934.	841.	532.	501.	427.	423.	462.	524.	631.	600.
12	694.	625.	929.	829.	522.	498.	425.	424.	458.	524.	631.	602.
13	694.	624.	920.	822.	514.	493.	426.	425.	462.	524.	634.	600.
14	703.	633.	951.	820.	506.	490.	423.	426.	456.	526.	634.	602.
15	703.	635.	901.	814.	503.	487.	419.	424.	469.	532.	628.	600.
16	694.	642.	838.	822.	502.	487.	418.	425.	471.	536.	625.	597.
17	685.	639.	857.	813.	597.	494.	415.	427.	469.	539.	622.	595.
18	695.	653.	855.	810.	594.	491.	414.	432.	469.	543.	617.	592.
19	676.	699.	847.	803.	589.	478.	414.	435.	469.	546.	617.	589.
20	676.	713.	839.	801.	584.	473.	414.	438.	464.	543.	617.	586.
21	667.	715.	822.	787.	576.	471.	413.	443.	467.	539.	625.	584.
22	667.	715.	810.	775.	573.	469.	412.	442.	471.	538.	625.	578.
23	658.	725.	807.	759.	570.	467.	412.	445.	471.	540.	620.	576.
24	658.	744.	799.	753.	568.	464.	412.	447.	473.	543.	617.	573.
25	658.	733.	791.	755.	568.	462.	412.	446.	480.	546.	611.	572.
26	648.	732.	780.	745.	560.	459.	409.	445.	487.	550.	611.	581.
27	638.	743.	758.	735.	554.	456.	409.	449.	492.	549.	608.	608.
28	638.	744.	755.	723.	549.	459.	406.	451.	493.	549.	608.	622.
29	628.	771.	752.	713.	543.	455.	406.	450.	490.	564.		617.
30	628.	845.	743.	705.	535.	451.	406.	457.	492.	606.		608.
31		911.		713.	529.		409.		494.	608.		614.
TOTAL	20350.	21214.	26271.	24735.	15710.	14905.	13084.	12927.	14638.	16506.	17210.	18622.
AVERAGE	678.	684.	875.	798.	507.	497.	422.	431.	472.	532.	615.	601.

ANNUAL TOTAL 218984.
ANNUAL AVERAGE 600.

ESTACION : BAKER EN DES. L. BERTRAND LATITUD : 47 4 0 S LONGITUD : 72 48 0 W (YEAR 1967)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	613.	575.	713.	543.	487.	437.	397.	418.	628.	818.	828.	852.
2	608.	584.	706.	540.	484.	431.	400.	421.	622.	816.	830.	846.
3	603.	589.	697.	532.	473.	427.	403.	427.	620.	822.	834.	851.
4	606.	595.	687.	521.	471.	424.	400.	443.	622.	826.	833.	847.
5	614.	578.	679.	519.	471.	423.	403.	455.	628.	828.	839.	834.
6	620.	591.	673.	519.	487.	421.	403.	465.	632.	828.	833.	829.
7	617.	598.	652.	517.	484.	423.	400.	471.	632.	828.	839.	828.
8	620.	597.	660.	515.	479.	423.	400.	478.	633.	832.	843.	828.
9	617.	602.	655.	512.	473.	425.	400.	483.	639.	834.	833.	828.
10	621.	603.	645.	511.	479.	427.	400.	480.	651.	832.	826.	816.
11	628.	620.	642.	510.	487.	424.	400.	480.	667.	832.	823.	805.
12	628.	690.	632.	513.	490.	421.	401.	481.	699.	832.	815.	803.
13	628.	689.	620.	515.	487.	421.	402.	486.	716.	832.	813.	805.
14	632.	679.	606.	521.	479.	421.	405.	497.	726.	826.	805.	800.
15	628.	690.	600.	521.	491.	420.	409.	493.	728.	818.	800.	788.
16	622.	703.	595.	521.	479.	414.	409.	508.	728.	822.	801.	776.
17	611.	745.	595.	519.	473.	413.	409.	525.	732.	816.	826.	770.
18	617.	732.	596.	515.	469.	411.	409.	532.	739.	811.	829.	767.
19	608.	726.	597.	513.	464.	410.	409.	543.	757.	822.	836.	753.
20	606.	764.	591.	503.	462.	406.	409.	551.	755.	828.	839.	760.
21	607.	795.	574.	505.	460.	406.	408.	572.	750.	822.	836.	752.
22	600.	790.	576.	510.	458.	406.	409.	578.	764.	818.	823.	741.
23	594.	774.	570.	513.	454.	406.	406.	575.	787.	826.	816.	742.
24	586.	771.	563.	503.	454.	406.	409.	573.	799.	828.	818.	733.
25	584.	771.	565.	503.	454.	404.	409.	573.	812.	826.	829.	715.
26	586.	755.	560.	503.	454.	403.	409.	588.	807.	828.	831.	707.
27	586.	752.	554.	495.	451.	403.	412.	603.	805.	832.	826.	704.
28	586.	746.	551.	487.	447.	402.	412.	619.	805.	830.	839.	702.
29	581.	732.	546.	487.	445.	399.	414.	628.	807.	819.	874.	696.
30	578.	729.	543.	481.	441.	397.	414.	632.	814.	818.		698.
31		723.		479.	441.		415.		810.	819.		696.
TOTAL	18235.	21241.	18454.	15357.	14518.	12450.	12595.	15558.	22314.	25571.	24017.	24062.
AVERAGE	608.	685.	615.	512.	468.	415.	406.	519.	720.	825.	828.	776.

ANNUAL TOTAL 224882.
ANNUAL AVERAGE 614.

ESTACION : BAKER EN DES. L. BERTRAND   LATITUD : 47 4 0 S   LONGITUD : 72 48 0 W   (YEAR 1968)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	677.	571.	570.	510.	484.	451.	509.	465.	660.	686.	687.	702.
2	670.	608.	584.	515.	480.	450.	508.	463.	671.	681.	690.	714.
3	668.	600.	581.	512.	477.	453.	508.	462.	679.	678.	690.	730.
4	664.	590.	577.	511.	472.	471.	507.	459.	681.	675.	693.	725.
5	663.	584.	570.	505.	470.	509.	507.	458.	687.	674.	690.	727.
6	659.	591.	564.	503.	463.	527.	505.	460.	689.	673.	693.	730.
7	650.	609.	550.	512.	462.	537.	504.	462.	684.	665.	699.	729.
8	646.	612.	559.	500.	461.	535.	502.	464.	693.	666.	696.	720.
9	643.	596.	554.	500.	455.	537.	499.	457.	718.	660.	702.	713.
10	640.	591.	552.	498.	456.	530.	499.	455.	717.	656.	699.	713.
11	634.	609.	539.	503.	456.	525.	502.	473.	724.	656.	690.	708.
12	631.	631.	538.	501.	454.	520.	502.	475.	724.	663.	681.	704.
13	628.	619.	535.	497.	455.	517.	505.	489.	725.	674.	687.	703.
14	628.	610.	539.	497.	454.	519.	502.	493.	722.	675.	687.	695.
15	620.	603.	529.	493.	453.	517.	498.	502.	721.	679.	684.	687.
16	617.	597.	520.	498.	465.	517.	491.	503.	723.	683.	678.	686.
17	610.	595.	518.	503.	462.	516.	490.	502.	724.	679.	672.	677.
18	604.	593.	514.	504.	464.	513.	484.	505.	727.	675.	663.	667.
19	601.	592.	514.	502.	455.	511.	491.	509.	717.	672.	666.	652.
20	595.	582.	525.	501.	450.	508.	488.	515.	711.	674.	666.	663.
21	591.	577.	521.	497.	458.	511.	494.	522.	702.	679.	666.	661.
22	586.	572.	517.	494.	474.	503.	489.	594.	700.	694.	675.	659.
23	583.	573.	513.	493.	483.	511.	488.	599.	692.	693.	669.	653.
24	580.	568.	509.	498.	471.	510.	484.	511.	688.	691.	669.	648.
25	577.	571.	508.	504.	465.	505.	484.	628.	687.	701.	666.	647.
26	577.	575.	506.	500.	453.	503.	479.	539.	685.	709.	663.	642.
27	573.	572.	503.	501.	450.	504.	480.	539.	682.	706.	666.	635.
28	568.	570.	502.	506.	456.	502.	475.	542.	684.	699.	681.	628.
29	562.	569.	503.	502.	456.	504.	473.	542.	686.	694.		621.
30	562.	562.	503.	493.	454.	510.	469.	551.	687.	692.		616.
31		552.		491.	453.		465.		687.	689.		609.
TOTAL	18507.	18245.	16033.	15527.	14432.	15233.	15283.	15758.	21675.	21091.	19064.	21074.
AVERAGE	617.	589.	534.	501.	466.	508.	493.	525.	699.	680.	681.	680.

ANNUAL TOTAL 211926.
ANNUAL AVERAGE 581.

ESTACION : BAKER EN DES.L.BERTRAND LATITUD : 47 4 0 S LONGITUD : 72 43 0 W (YEAR 1969)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	602.	691.	857.	633.	555.	477.	431.	424.	467.	597.	669.	749.
2	598.	672.	853.	633.	551.	473.	433.	422.	470.	598.	678.	755.
3	595.	665.	845.	639.	554.	469.	433.	423.	476.	597.	688.	753.
4	588.	694.	837.	633.	547.	457.	433.	422.	481.	605.	686.	752.
5	580.	716.	832.	644.	545.	463.	431.	420.	484.	606.	679.	754.
6	575.	730.	823.	638.	547.	455.	427.	419.	484.	607.	675.	765.
7	572.	748.	810.	632.	544.	458.	426.	416.	489.	607.	689.	752.
8	569.	754.	800.	628.	539.	450.	424.	416.	497.	602.	704.	768.
9	577.	767.	791.	625.	537.	452.	423.	417.	511.	601.	717.	759.
10	577.	785.	789.	620.	537.	451.	427.	417.	513.	608.	720.	758.
11	580.	796.	778.	615.	539.	450.	435.	418.	515.	610.	729.	752.
12	611.	817.	759.	600.	554.	450.	434.	420.	514.	615.	724.	746.
13	627.	936.	755.	595.	543.	450.	430.	423.	514.	610.	722.	741.
14	630.	961.	748.	593.	535.	448.	429.	427.	518.	607.	724.	740.
15	641.	955.	739.	590.	533.	448.	427.	426.	537.	620.	723.	736.
16	648.	951.	724.	591.	525.	444.	424.	430.	547.	624.	722.	730.
17	647.	965.	719.	595.	521.	440.	421.	431.	547.	629.	720.	723.
18	642.	965.	715.	590.	515.	439.	423.	429.	547.	641.	726.	721.
19	634.	962.	708.	588.	511.	440.	424.	428.	543.	648.	730.	721.
20	625.	953.	705.	585.	508.	440.	428.	428.	541.	645.	727.	721.
21	612.	944.	699.	584.	505.	447.	429.	433.	544.	648.	723.	715.
22	617.	935.	694.	574.	504.	451.	429.	437.	548.	650.	718.	708.
23	618.	923.	693.	574.	502.	451.	432.	442.	549.	645.	729.	704.
24	625.	912.	686.	564.	498.	450.	437.	444.	558.	645.	742.	696.
25	643.	902.	680.	554.	492.	447.	435.	446.	565.	646.	750.	691.
26	665.	894.	675.	553.	491.	443.	434.	449.	579.	642.	736.	685.
27	674.	881.	657.	571.	492.	439.	435.	455.	581.	637.	724.	678.
28	690.	849.	651.	575.	490.	439.	430.	458.	583.	635.	724.	672.
29	695.	835.	648.	559.	485.	438.	429.	450.	586.	635.		655.
30	687.	832.	641.	551.	479.	434.	426.	451.	588.	638.		666.
31		854.		554.	477.		426.		595.	641.		674.
TOTAL	18644.	26410.	22349.	18511.	16157.	13514.	13305.	12940.	16471.	19339.	19998.	22470.
AVERAGE	621.	852.	745.	597.	521.	450.	429.	431.	531.	624.	714.	725.

ANNUAL TOTAL 220208.
ANNUAL AVERAGE 603.

ESTACION : BAKER EN DES.L.BERTRAND LATITUD : 47 4 0 S LONGITUD : 72 43 0 W (YEAR 1970)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	676.	635.	681.	593.	535.	448.	441.	425.	467.	605.	600.	590.
2	669.	652.	670.	590.	528.	449.	441.	424.	474.	601.	601.	600.
3	664.	640.	667.	584.	525.	447.	437.	428.	477.	603.	601.	602.
4	659.	627.	663.	575.	525.	444.	433.	430.	477.	602.	594.	604.
5	653.	619.	662.	570.	518.	441.	433.	429.	483.	618.	598.	605.
6	652.	613.	701.	553.	512.	439.	435.	430.	491.	616.	597.	593.
7	677.	622.	705.	559.	510.	445.	431.	429.	499.	613.	590.	590.
8	678.	635.	712.	572.	506.	452.	428.	427.	504.	611.	582.	580.
9	668.	631.	701.	571.	508.	451.	425.	428.	501.	610.	578.	578.
10	678.	627.	685.	554.	505.	449.	422.	428.	497.	602.	577.	576.
11	668.	618.	681.	550.	502.	449.	419.	432.	493.	599.	577.	576.
12	662.	614.	672.	559.	495.	445.	417.	436.	491.	606.	571.	577.
13	655.	605.	663.	555.	495.	445.	417.	441.	492.	607.	571.	564.
14	645.	597.	653.	550.	490.	452.	416.	450.	501.	617.	569.	564.
15	635.	593.	670.	542.	489.	455.	417.	449.	505.	612.	569.	572.
16	650.	599.	653.	545.	491.	455.	415.	445.	508.	609.	585.	579.
17	654.	593.	659.	542.	487.	453.	414.	448.	509.	608.	589.	572.
18	661.	581.	659.	535.	484.	453.	414.	448.	507.	606.	590.	571.
19	663.	577.	653.	524.	479.	454.	415.	454.	501.	609.	586.	568.
20	656.	619.	649.	530.	472.	455.	417.	457.	515.	617.	579.	577.
21	647.	633.	637.	534.	459.	453.	419.	458.	561.	614.	579.	572.
22	644.	622.	632.	552.	457.	449.	423.	461.	565.	609.	574.	569.
23	641.	619.	632.	549.	462.	448.	426.	462.	588.	607.	578.	566.
24	637.	644.	630.	545.	459.	448.	425.	463.	596.	623.	577.	568.
25	631.	643.	630.	544.	455.	454.	422.	465.	602.	622.	582.	591.
26	628.	692.	631.	545.	454.	448.	424.	467.	602.	619.	585.	597.
27	621.	697.	622.	543.	453.	447.	428.	469.	599.	614.	585.	597.
28	616.	694.	611.	540.	451.	447.	430.	464.	599.	610.	586.	591.
29	627.	692.	613.	535.	453.	445.	429.	464.	592.	604.		589.
30	624.	690.	595.	545.	450.	442.	428.	463.	594.	596.		582.
31		635.		539.	449.		428.		597.	600.		581.
TOTAL	19539.	19708.	19709.	17157.	15078.	13454.	13159.	13376.	16387.	18889.	16350.	18041.
AVERAGE	651.	635.	657.	554.	486.	449.	425.	446.	529.	609.	584.	582.

ANNUAL TOTAL 200877.
ANNUAL AVERAGE 550.

ESTACION : BAKER EN DES.L.BERTRAND LATITUD : 47 4 0 S LONGITUD : 72 48 0 W (YEAR 1971)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	580.	520.	441.	394.	438.	420.	470.	599.	715.	705.	898.	971.
2	572.	523.	438.	397.	434.	419.	470.	606.	712.	708.	910.	966.
3	567.	519.	435.	395.	431.	418.	469.	610.	710.	710.	910.	952.
4	565.	512.	433.	393.	427.	419.	468.	621.	712.	710.	923.	944.
5	566.	513.	432.	395.	430.	417.	469.	618.	708.	707.	940.	942.
6	566.	512.	432.	397.	429.	417.	471.	623.	703.	713.	917.	936.
7	561.	507.	431.	394.	454.	417.	468.	621.	689.	727.	917.	937.
8	566.	507.	430.	393.	458.	418.	466.	621.	690.	733.	917.	917.
9	565.	502.	429.	390.	449.	418.	465.	618.	697.	736.	912.	921.
10	561.	498.	430.	390.	441.	419.	463.	617.	702.	747.	925.	896.
11	565.	495.	423.	336.	437.	419.	465.	620.	705.	754.	921.	892.
12	563.	493.	428.	335.	435.	421.	471.	617.	710.	783.	917.	886.
13	583.	490.	428.	336.	434.	425.	484.	614.	712.	801.	914.	878.
14	610.	487.	427.	392.	432.	422.	505.	612.	715.	810.	920.	867.
15	598.	484.	426.	454.	435.	421.	501.	621.	714.	818.	925.	871.
16	594.	481.	425.	451.	435.	417.	501.	620.	710.	813.	921.	869.
17	587.	479.	425.	449.	434.	417.	502.	616.	712.	819.	917.	861.
18	585.	475.	424.	445.	431.	418.	511.	616.	712.	841.	914.	863.
19	581.	473.	419.	447.	428.	415.	512.	652.	705.	840.	912.	869.
20	577.	470.	417.	443.	426.	414.	517.	683.	695.	856.	915.	861.
21	573.	466.	415.	443.	424.	414.	519.	698.	692.	871.	910.	858.
22	570.	464.	413.	453.	421.	414.	520.	696.	692.	906.	902.	852.
23	564.	462.	411.	446.	421.	412.	534.	689.	690.	910.	896.	839.
24	560.	459.	411.	443.	419.	411.	559.	689.	697.	906.	898.	830.
25	555.	454.	409.	443.	422.	415.	562.	692.	702.	912.	894.	827.
26	549.	454.	403.	443.	423.	448.	568.	691.	705.	894.	902.	818.
27	550.	452.	408.	441.	425.	459.	573.	689.	708.	877.	915.	807.
28	541.	449.	405.	441.	425.	457.	582.	688.	708.	869.	921.	796.
29	537.	447.	401.	433.	421.	451.	588.	690.	710.	871.	940.	786.
30	529.	445.	399.	437.	420.	469.	592.	678.	707.	894.		784.
31		443.		435.	418.		595.		707.	900.		777.
TOTAL	17040.	14940.	12658.	13055.	13357.	12730.	15840.	19315.	21846.	25141.	26523.	27073.
AVERAGE	568.	482.	422.	421.	431.	424.	511.	644.	705.	811.	915.	873.

ANNUAL TOTAL 219528.
ANNUAL AVERAGE 600.

ESTACION : BAKER EN DES.L.BERTRAND LATITUD : 47 4 0 S LONGITUD : 72 43 0 W (YEAR 1972)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	752.	752.	663.	524.	422.	384.	372.	393.	0.	0.	0.	0.
2	748.	773.	654.	520.	422.	384.	372.	393.	0.	0.	0.	0.
3	747.	782.	633.	523.	416.	384.	372.	396.	0.	0.	0.	0.
4	759.	772.	632.	515.	418.	382.	372.	398.	0.	0.	0.	0.
5	759.	768.	623.	510.	418.	381.	372.	400.	0.	0.	0.	0.
6	765.	768.	620.	505.	416.	381.	372.	402.	0.	0.	0.	0.
7	761.	750.	613.	499.	420.	381.	371.	406.	0.	0.	0.	0.
8	754.	739.	603.	493.	422.	379.	371.	412.	0.	0.	0.	0.
9	743.	732.	602.	493.	418.	384.	372.	416.	0.	0.	0.	0.
10	741.	719.	594.	488.	418.	382.	371.	419.	0.	0.	0.	0.
11	739.	711.	595.	435.	420.	382.	372.	422.	0.	0.	0.	0.
12	736.	705.	590.	435.	422.	382.	371.	425.	0.	0.	0.	0.
13	734.	708.	584.	433.	418.	382.	371.	432.	0.	0.	0.	0.
14	732.	722.	578.	475.	416.	382.	372.	437.	0.	0.	0.	0.
15	727.	757.	578.	459.	414.	381.	372.	437.	0.	0.	0.	0.
16	719.	772.	572.	470.	412.	381.	378.	437.	0.	0.	0.	0.
17	714.	763.	567.	473.	410.	379.	381.	439.	0.	0.	0.	0.
18	747.	772.	567.	465.	408.	378.	393.	439.	0.	0.	0.	0.
19	773.	765.	554.	457.	405.	376.	396.	442.	0.	0.	0.	0.
20	819.	750.	564.	452.	404.	375.	396.	444.	0.	0.	0.	0.
21	850.	743.	567.	453.	402.	375.	398.	454.	0.	0.	0.	0.
22	852.	739.	572.	450.	402.	375.	396.	460.	0.	0.	0.	0.
23	852.	732.	572.	444.	400.	375.	402.	467.	0.	0.	0.	0.
24	843.	729.	554.	439.	395.	375.	402.	478.	0.	0.	0.	0.
25	825.	722.	558.	437.	395.	372.	398.	488.	0.	0.	0.	0.
26	839.	718.	550.	439.	393.	372.	400.	493.	0.	0.	0.	0.
27	800.	713.	545.	432.	393.	371.	398.	492.	0.	0.	0.	0.
28	793.	703.	539.	430.	393.	378.	402.	496.	0.	0.	0.	0.
29	787.	690.	534.	430.	391.	379.	400.	493.	0.	0.		0.
30	786.	683.	528.	427.	386.	375.	396.	493.	0.	0.		0.
31		677.		427.	384.		393.		0.	0.		0.
TOTAL	23166.	22833.	17537.	14513.	12556.	11367.	11904.	13202.	0.	0.	0.	0.
AVERAGE	772.	737.	585.	471.	408.	379.	384.	440.	0.	0.	0.	0.

ANNUAL TOTAL 127278.
ANNUAL AVERAGE 349.

ESTACION : BAKER EN DES.L.BERTRAND LATITUD : 47 4 0 S LONGITUD : 72 43 0 W (YEAR 1973)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	698.	593.	522.	499.	421.	442.	428.	436.	529.	627.	665.	671.
2	690.	581.	514.	501.	459.	448.	431.	437.	546.	626.	662.	663.
3	682.	575.	509.	495.	479.	444.	431.	433.	558.	624.	672.	667.
4	675.	574.	503.	493.	469.	444.	430.	441.	555.	621.	670.	669.
5	667.	571.	494.	490.	465.	440.	430.	439.	553.	621.	671.	672.
6	658.	540.	489.	492.	462.	435.	433.	439.	550.	620.	672.	672.
7	651.	554.	487.	491.	466.	432.	433.	436.	546.	616.	673.	677.
8	638.	552.	488.	485.	452.	431.	435.	435.	552.	612.	670.	680.
9	652.	547.	492.	484.	453.	438.	433.	440.	554.	610.	672.	676.
10	697.	541.	495.	480.	447.	439.	432.	443.	553.	605.	674.	670.
11	692.	541.	490.	474.	445.	434.	427.	452.	561.	605.	670.	669.
12	685.	539.	491.	472.	444.	432.	424.	459.	576.	611.	665.	669.
13	678.	539.	503.	454.	442.	427.	422.	466.	576.	632.	664.	675.
14	677.	535.	522.	450.	442.	422.	424.	467.	570.	625.	665.	668.
15	673.	532.	519.	460.	441.	419.	425.	470.	571.	629.	670.	657.
16	662.	534.	513.	453.	445.	419.	426.	470.	573.	634.	671.	650.
17	658.	532.	503.	453.	449.	417.	430.	454.	571.	637.	677.	654.
18	649.	524.	502.	444.	443.	415.	433.	454.	573.	639.	677.	663.
19	646.	520.	537.	444.	435.	413.	433.	471.	579.	639.	673.	669.
20	646.	517.	538.	444.	435.	412.	433.	477.	596.	636.	675.	668.
21	642.	509.	533.	440.	435.	413.	435.	487.	608.	633.	676.	665.
22	639.	509.	529.	440.	433.	413.	434.	497.	604.	630.	677.	665.
23	636.	503.	529.	435.	432.	424.	432.	498.	601.	626.	674.	667.
24	634.	502.	527.	431.	430.	438.	432.	498.	599.	624.	670.	652.
25	629.	507.	523.	430.	425.	433.	433.	502.	600.	629.	666.	661.
26	624.	504.	513.	429.	422.	427.	438.	500.	599.	640.	667.	657.
27	620.	499.	511.	432.	433.	425.	439.	503.	604.	641.	672.	649.
28	613.	500.	517.	433.	438.	425.	434.	514.	619.	641.	674.	644.
29	605.	495.	511.	431.	435.	427.	435.	531.	620.	648.		640.
30	602.	491.	503.	431.	433.	427.	435.	529.	618.	654.		636.
31		495.		427.	438.		435.		626.	660.		631.
TOTAL	19618.	16475.	15312.	14247.	13760.	12859.	13375.	14097.	17938.	19495.	18734.	20536.
AVERAGE	654.	531.	510.	460.	444.	429.	431.	470.	579.	629.	671.	662.

ANNUAL TOTAL 196496.
ANNUAL AVERAGE 538.

ESTACION : BAKER EN DES.L.BERTRAND LATITUD : 47 4 0 S LONGITUD : 72 48 0 W (YEAR 1974)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	0.	0.	0.	435.	434.	427.	390.	427.	432.	488.	624.	641.
2	0.	0.	0.	433.	428.	423.	390.	436.	430.	494.	627.	658.
3	0.	0.	0.	493.	426.	420.	391.	432.	426.	497.	625.	674.
4	0.	0.	0.	493.	426.	420.	391.	428.	428.	503.	627.	665.
5	0.	0.	0.	494.	425.	417.	388.	426.	432.	510.	632.	661.
6	0.	0.	0.	495.	419.	417.	386.	428.	437.	512.	632.	661.
7	0.	0.	0.	497.	417.	417.	394.	432.	437.	517.	633.	663.
8	0.	0.	0.	495.	417.	414.	402.	433.	440.	524.	638.	669.
9	0.	0.	0.	495.	421.	415.	409.	436.	446.	520.	646.	669.
10	0.	0.	0.	497.	432.	419.	408.	438.	449.	523.	645.	667.
11	0.	0.	0.	493.	435.	418.	410.	442.	452.	529.	642.	671.
12	0.	0.	0.	497.	451.	410.	408.	442.	460.	529.	650.	672.
13	0.	0.	0.	481.	445.	407.	409.	445.	467.	528.	650.	669.
14	0.	0.	549.	473.	441.	407.	416.	446.	470.	530.	648.	669.
15	0.	0.	544.	477.	440.	406.	419.	447.	467.	537.	640.	667.
16	0.	0.	539.	473.	443.	404.	423.	449.	469.	538.	639.	667.
17	0.	0.	534.	470.	441.	405.	428.	462.	482.	533.	639.	653.
18	0.	0.	532.	455.	438.	405.	429.	456.	486.	533.	642.	660.
19	0.	0.	526.	452.	445.	403.	427.	450.	481.	534.	640.	655.
20	0.	0.	525.	453.	450.	401.	424.	445.	479.	544.	640.	653.
21	0.	0.	519.	454.	458.	405.	426.	444.	479.	559.	658.	652.
22	0.	0.	518.	451.	459.	401.	427.	445.	481.	567.	659.	645.
23	0.	0.	505.	449.	456.	399.	426.	448.	486.	565.	650.	637.
24	0.	0.	503.	447.	455.	398.	421.	447.	490.	555.	640.	636.
25	0.	0.	500.	445.	450.	399.	418.	445.	496.	569.	637.	636.
26	0.	0.	504.	443.	450.	402.	416.	440.	497.	571.	637.	627.
27	0.	0.	502.	439.	453.	400.	415.	442.	496.	574.	641.	622.
28	0.	0.	493.	433.	446.	395.	412.	439.	495.	593.	642.	624.
29	0.	0.	492.	434.	446.	391.	413.	437.	493.	611.		622.
30	0.	0.	489.	435.	437.	389.	417.	435.	489.	609.		619.
31		0.		432.	432.		424.		488.	616.		615.
TOTAL	0.	0.	8754.	14553.	13519.	12235.	12757.	13224.	14460.	16812.	17923.	20209.
AVERAGE	0.	0.	292.	470.	439.	408.	412.	441.	466.	542.	640.	652.

ANNUAL TOTAL 144571.
ANNUAL AVERAGE 396.

ESTACION : BAKER EN DES. L. BERTRAND LATITUD : 47 4 0 S LONGITUD : 72 48 0 W (YEAR 1975)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	614.	641.	545.	506.	428.	0.	0.	0.	0.	0.	0.	0.
2	614.	632.	540.	513.	428.	0.	0.	0.	0.	0.	0.	0.
3	621.	624.	530.	515.	422.	0.	0.	0.	0.	0.	0.	0.
4	631.	618.	527.	500.	415.	0.	0.	0.	0.	0.	0.	0.
5	633.	619.	530.	503.	416.	0.	0.	0.	0.	0.	0.	0.
6	631.	624.	524.	504.	415.	0.	0.	0.	0.	0.	0.	0.
7	624.	634.	528.	502.	411.	0.	0.	0.	0.	0.	0.	0.
8	628.	629.	539.	495.	409.	0.	0.	0.	0.	0.	0.	0.
9	635.	625.	533.	492.	405.	0.	0.	0.	0.	0.	0.	0.
10	630.	620.	531.	485.	414.	0.	0.	0.	0.	0.	0.	0.
11	627.	617.	531.	480.	424.	0.	0.	0.	0.	0.	0.	0.
12	627.	613.	528.	480.	420.	0.	0.	0.	0.	0.	0.	0.
13	623.	609.	527.	478.	417.	0.	0.	0.	0.	0.	0.	0.
14	615.	603.	525.	471.	416.	0.	0.	0.	0.	0.	0.	0.
15	621.	597.	524.	466.	415.	0.	0.	0.	0.	0.	0.	0.
16	618.	591.	522.	460.	415.	0.	0.	0.	0.	0.	0.	0.
17	617.	587.	520.	453.	413.	0.	0.	0.	0.	0.	0.	0.
18	624.	582.	523.	455.	414.	0.	0.	0.	0.	0.	0.	0.
19	633.	580.	520.	452.	410.	0.	0.	0.	0.	0.	0.	0.
20	642.	578.	516.	449.	420.	0.	0.	0.	0.	0.	0.	0.
21	645.	575.	513.	443.	420.	0.	0.	0.	0.	0.	0.	0.
22	644.	575.	513.	443.	417.	0.	0.	0.	0.	0.	0.	0.
23	635.	576.	512.	442.	412.	0.	0.	0.	0.	0.	0.	0.
24	656.	584.	510.	441.	408.	0.	0.	0.	0.	0.	0.	0.
25	664.	581.	505.	439.	404.	0.	0.	0.	0.	0.	0.	0.
26	663.	581.	503.	433.	404.	0.	0.	0.	0.	0.	0.	0.
27	663.	569.	499.	433.	414.	0.	0.	0.	0.	0.	0.	0.
28	659.	564.	502.	439.	414.	0.	0.	0.	0.	0.	0.	0.
29	653.	567.	498.	435.	413.	0.	0.	0.	0.	0.	0.	0.
30	647.	559.	495.	427.	0.	0.	0.	0.	0.	0.		0.
31		549.		427.	0.		0.		0.	0.		0.
TOTAL	19037.	18507.	15615.	14491.	12034.	0.	0.	0.	0.	0.	0.	0.
AVERAGE	635.	597.	521.	467.	388.	0.	0.	0.	0.	0.	0.	0.

ANNUAL TOTAL 79685.
ANNUAL AVERAGE 218.

ESTACION : BAKER EN COLONIA   LATITUD : 47 21 0 S   LONGITUD : 72 51 0 W   (YEAR 1963)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	981.	983.	1548.	725.	697.	530.	495.	734.	697.	1418.	1655.	1079.
2	918.	973.	1784.	725.	734.	530.	495.	734.	697.	1456.	1495.	1079.
3	973.	946.	1535.	716.	697.	530.	495.	734.	697.	1437.	1320.	1060.
4	1340.	936.	1515.	725.	669.	530.	568.	770.	814.	1399.	1260.	1060.
5	1151.	936.	1242.	725.	669.	530.	697.	734.	1169.	1340.	1242.	1242.
6	1097.	1002.	1097.	716.	645.	535.	599.	716.	1380.	1340.	1205.	1079.
7	1041.	1224.	1060.	707.	660.	530.	553.	697.	1360.	1340.	1151.	1002.
8	946.	1205.	1022.	697.	645.	530.	537.	697.	1079.	1320.	1097.	1041.
9	918.	1380.	1002.	697.	614.	530.	539.	688.	936.	1300.	1205.	1097.
10	918.	1360.	964.	697.	599.	520.	535.	697.	843.	1425.	1205.	1133.
11	927.	1187.	936.	688.	599.	520.	530.	697.	918.	2482.	1418.	1133.
12	899.	1133.	927.	669.	599.	520.	530.	660.	899.	1280.	1340.	1151.
13	881.	1079.	919.	660.	599.	530.	535.	645.	890.	1205.	1320.	1079.
14	862.	1097.	890.	660.	583.	520.	553.	645.	1002.	1187.	1260.	1060.
15	852.	973.	871.	645.	568.	520.	539.	614.	1079.	1097.	1169.	1002.
16	862.	936.	852.	614.	553.	505.	553.	614.	1133.	1079.	1115.	983.
17	890.	936.	843.	716.	544.	505.	770.	614.	936.	1133.	1079.	973.
18	890.	936.	833.	669.	544.	495.	599.	599.	871.	1169.	1060.	946.
19	1022.	936.	814.	660.	544.	480.	716.	599.	862.	1187.	1097.	936.
20	1399.	936.	805.	660.	544.	480.	734.	599.	936.	1169.	1115.	927.
21	1865.	964.	796.	660.	539.	495.	660.	660.	1041.	1242.	1115.	918.
22	1843.	946.	805.	660.	539.	495.	660.	697.	1151.	1535.	1151.	890.
23	1615.	927.	833.	805.	537.	505.	599.	660.	1183.	1806.	1187.	890.
24	1399.	936.	843.	770.	539.	505.	614.	583.	1151.	1695.	1187.	946.
25	1242.	955.	843.	770.	537.	505.	599.	599.	1155.	1758.	1151.	1097.
26	1151.	973.	843.	761.	530.	495.	645.	645.	1133.	1635.	1151.	1242.
27	1097.	946.	796.	734.	535.	495.	645.	660.	1163.	1380.	1169.	1187.
28	1041.	936.	770.	734.	535.	495.	645.	583.	1131.	1340.	1205.	1079.
29	1002.	936.	743.	734.	530.	495.	697.	734.	1070.	1340.	1205.	1002.
30	983.	973.	734.	697.	535.	495.	734.	697.	995.	1380.		1115.
31		1151.		697.	535.		725.		973.	1535.		1097.
TOTAL	32905.	31757.	29464.	21793.	18197.	15350.	18795.	20005.	31344.	43409.	35329.	32525.
AVERAGE	1097.	1024.	982.	703.	587.	512.	606.	667.	1011.	1400.	1218.	1049.

ANNUAL TOTAL 330873.
ANNUAL AVERAGE 904.

ESTACION : BAKER EN COLONIA LATITUD : 47 21 0 S LONGITUD : 72 51 0 W (YEAR 1964)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	983.	852.	1151.	614.	553.	520.	535.	761.	936.	1115.	1475.	1475.
2	936.	843.	1079.	614.	583.	515.	544.	770.	890.	1242.	1475.	1399.
3	890.	833.	1022.	599.	599.	520.	532.	779.	881.	1380.	1380.	1418.
4	890.	833.	1002.	599.	645.	515.	532.	779.	890.	936.	1399.	2575.
5	862.	881.	973.	599.	645.	515.	532.	779.	927.	1133.	1475.	1399.
6	862.	881.	936.	599.	688.	505.	553.	770.	927.	1133.	1575.	1418.
7	899.	852.	918.	583.	660.	505.	599.	770.	936.	1079.	1535.	1418.
8	881.	833.	909.	583.	645.	495.	553.	761.	936.	1060.	1535.	1515.
9	843.	805.	881.	614.	645.	480.	697.	761.	927.	1022.	1575.	1555.
10	814.	805.	871.	614.	697.	480.	734.	787.	927.	1022.	1635.	1635.
11	824.	787.	862.	614.	770.	505.	770.	805.	918.	1380.	1418.	1535.
12	871.	862.	833.	614.	843.	697.	770.	805.	843.	1169.	1133.	1399.
13	964.	1495.	805.	669.	787.	716.	787.	734.	787.	1079.	833.	1320.
14	1931.	1495.	796.	660.	743.	734.	805.	734.	833.	1115.	843.	1242.
15	1690.	1360.	717.	614.	716.	743.	787.	697.	843.	1130.	1041.	1169.
16	1300.	1187.	770.	599.	660.	770.	734.	660.	890.	1320.	1187.	1133.
17	1187.	1041.	761.	660.	660.	787.	734.	660.	890.	1320.	1380.	1133.
18	1151.	1022.	761.	645.	599.	805.	770.	660.	890.	1320.	1475.	1260.
19	1079.	983.	743.	599.	583.	814.	761.	645.	927.	1320.	1475.	1399.
20	1133.	964.	734.	599.	553.	843.	761.	881.	946.	1475.	1380.	1535.
21	1097.	983.	734.	583.	544.	843.	770.	688.	983.	1380.	1320.	1695.
22	1224.	973.	734.	568.	537.	770.	770.	697.	1022.	1260.	1360.	1575.
23	1151.	1060.	716.	568.	537.	770.	779.	805.	1887.	1260.	1380.	1418.
24	1079.	1535.	697.	568.	537.	697.	770.	890.	1380.	1320.	1418.	1280.
25	1002.	1360.	697.	553.	537.	614.	770.	936.	1475.	1300.	1456.	1133.
26	964.	1151.	697.	568.	537.	583.	770.	1022.	2070.	1260.	1475.	1133.
27	927.	1060.	688.	583.	532.	568.	770.	1022.	2529.	1242.	1418.	1151.
28	909.	1002.	669.	583.	520.	553.	770.	1022.	1133.	1300.	1399.	1187.
29	890.	1097.	660.	553.	505.	544.	761.	983.	1002.	1340.		1187.
30	862.	1320.	660.	544.	515.	537.	770.	983.	936.	1399.		1169.
31		1187.		553.	515.		770.		983.	1418.		1151.
TOTAL	31095.	32342.	24546.	18515.	19090.	18943.	21960.	24046.	33344.	38229.	38450.	43011.
AVERAGE	1037.	1043.	818.	597.	616.	631.	708.	802.	1076.	1233.	1373.	1387.

ANNUAL TOTAL 343571.
ANNUAL AVERAGE 941.

ESTACION : BAKER EN COLONIA LATITUD : 47 21 O S LONGITUD : 72 51 O W (YEAR 1965)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	1115.	1187.	796.	936.	843.	796.	669.	852.	1418.	983.	1390.	1097.
2	1115.	1205.	770.	918.	814.	890.	660.	805.	1399.	1002.	1320.	1151.
3	1169.	1187.	761.	881.	787.	805.	660.	787.	1456.	1022.	1360.	1922.
4	1555.	1097.	743.	843.	779.	779.	743.	770.	1399.	1022.	1320.	2016.
5	1399.	1079.	734.	814.	787.	743.	761.	770.	1320.	964.	1260.	1169.
6	1399.	1022.	734.	805.	862.	734.	725.	779.	1242.	890.	1242.	1079.
7	1380.	973.	725.	787.	909.	725.	697.	814.	1205.	918.	1187.	1115.
8	1242.	1097.	734.	770.	927.	716.	697.	862.	1187.	1022.	1133.	1151.
9	1187.	1418.	743.	761.	946.	707.	660.	890.	1169.	1133.	1115.	1205.
10	1115.	1283.	743.	743.	946.	697.	645.	909.	1169.	1133.	1115.	1242.
11	1041.	1107.	947.	761.	927.	688.	614.	843.	1169.	1041.	1115.	1242.
12	1002.	1133.	1077.	743.	890.	660.	614.	805.	1151.	1399.	1115.	1300.
13	964.	1079.	977.	734.	852.	660.	599.	805.	1133.	1456.	1115.	1260.
14	936.	1002.	909.	725.	833.	645.	614.	881.	1097.	1535.	1151.	1242.
15	918.	940.	890.	707.	814.	614.	614.	1097.	1097.	1575.	1169.	1242.
16	899.	899.	904.	697.	805.	599.	697.	1115.	1079.	1535.	1169.	1137.
17	881.	881.	881.	688.	779.	599.	734.	1060.	1079.	1399.	1169.	1115.
18	871.	862.	852.	688.	761.	583.	734.	1079.	1079.	1456.	1169.	1115.
19	862.	843.	839.	669.	743.	583.	734.	1360.	1079.	1456.	1187.	1115.
20	862.	814.	852.	669.	779.	599.	725.	1380.	1097.	1380.	1187.	1097.
21	1022.	805.	940.	669.	770.	614.	697.	1380.	1115.	1320.	1169.	1169.
22	1555.	805.	970.	688.	761.	614.	660.	1675.	1151.	1242.	1151.	1224.
23	1380.	833.	961.	707.	743.	614.	568.	1635.	1187.	1224.	1151.	1187.
24	1224.	881.	964.	707.	725.	599.	716.	2545.	1115.	1242.	1115.	1115.
25	1169.	890.	983.	688.	707.	583.	833.	1970.	1022.	1260.	1079.	1060.
26	1097.	890.	1022.	669.	697.	583.	761.	2780.	1041.	1320.	1079.	1041.
27	1041.	881.	1041.	669.	688.	599.	734.	2873.	1097.	1360.	1115.	1060.
28	1022.	871.	983.	688.	669.	787.	761.	2265.	1115.	1399.	1115.	1079.
29	1097.	852.	983.	707.	660.	734.	814.	1789.	1060.	1399.		1133.
30	1205.	814.	973.	909.	660.	707.	852.	1555.	983.	1399.		1115.
31		805.		927.	707.		862.		983.	1475.		1079.
TOTAL	33724.	30518.	26431.	23367.	24570.	20256.	21854.	39130.	35893.	38961.	32962.	37274.
AVERAGE	1124.	984.	881.	754.	793.	675.	705.	1304.	1158.	1257.	1177.	1202.

ANNUAL TOTAL 364940.
ANNUAL AVERAGE 1000.

ESTACION : BAKER EN COLONIA LATITUD : 47 21 0 S LONGITUD : 72 51 0 W (YEAR 1966)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	1079.	909.	1950.	545.	599.	629.	543.	664.	895.	895.	1320.	1022.
2	1079.	936.	2226.	545.	786.	611.	542.	667.	828.	918.	1160.	1041.
3	1079.	964.	2150.	573.	765.	629.	539.	668.	769.	911.	1070.	1079.
4	1097.	903.	1980.	1022.	786.	599.	538.	682.	741.	938.	1051.	1070.
5	1097.	1022.	2390.	1022.	765.	629.	537.	688.	726.	970.	1106.	1079.
6	1115.	1079.	2237.	1475.	765.	660.	538.	693.	723.	1251.	1124.	1133.
7	1097.	1079.	1535.	1260.	786.	599.	541.	686.	726.	2247.	1106.	1124.
8	1097.	1169.	1427.	1215.	765.	599.	538.	689.	789.	1205.	1124.	1012.
9	1151.	1022.	1350.	1097.	748.	629.	540.	700.	913.	1060.	1300.	936.
10	1133.	1060.	1022.	1070.	741.	677.	542.	708.	983.	973.	1380.	890.
11	1079.	1060.	1260.	1022.	730.	629.	540.	711.	843.	1002.	1260.	885.
12	1079.	938.	1205.	993.	730.	599.	539.	719.	751.	982.	1169.	871.
13	1079.	942.	1142.	978.	711.	599.	539.	723.	728.	978.	1160.	857.
14	1079.	942.	1115.	993.	693.	545.	539.	732.	744.	953.	1169.	866.
15	1115.	942.	1079.	978.	693.	545.	535.	715.	847.	921.	1142.	888.
16	1079.	942.	1088.	978.	693.	545.	515.	704.	857.	948.	1060.	866.
17	1022.	932.	1097.	1097.	786.	573.	533.	744.	813.	948.	1012.	961.
18	964.	904.	1022.	1160.	741.	548.	531.	801.	773.	934.	993.	1260.
19	918.	1002.	1022.	1070.	693.	542.	531.	791.	755.	909.	983.	1800.
20	890.	1022.	993.	1070.	711.	538.	533.	770.	742.	899.	1002.	1115.
21	871.	983.	993.	978.	677.	540.	536.	813.	746.	895.	1088.	961.
22	824.	957.	978.	978.	695.	542.	537.	820.	786.	909.	1115.	907.
23	824.	961.	1320.	978.	712.	542.	536.	797.	824.	948.	1079.	885.
24	833.	993.	993.	978.	730.	574.	539.	801.	874.	1002.	1022.	885.
25	843.	1242.	993.	936.	693.	566.	540.	820.	911.	1017.	980.	904.
26	871.	1124.	588.	913.	693.	550.	538.	793.	970.	1012.	982.	980.
27	881.	1070.	545.	913.	677.	553.	537.	765.	1002.	1012.	1002.	1242.
28	881.	1041.	588.	913.	693.	559.	538.	773.	1012.	1002.	1031.	1485.
29	871.	1012.	973.	843.	677.	559.	540.	828.	961.	1051.		1575.
30	881.	1280.	573.	828.	660.	544.	543.	963.	918.	1389.		1380.
31		1779.		828.	660.		573.		881.	1418.		1270.
TOTAL	29908.	32291.	37825.	30249.	22254.	17453.	16690.	22428.	25831.	32492.	30990.	33229.
AVERAGE	997.	1042.	1261.	976.	718.	582.	538.	748.	833.	1048.	1107.	1072.

ANNUAL TOTAL 331640.
ANNUAL AVERAGE 909.

ESTACION : BAKER EN COLONIA LATITUD : 47 21 0 S LONGITUD : 72 51 0 W (YEAR 1967)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	1242.	928.	881.	680.	612.	526.	542.	1042.	998.	1250.	1355.	1401.
2	1133.	922.	854.	669.	652.	538.	544.	1137.	939.	1230.	1447.	1392.
3	1051.	1002.	845.	647.	869.	541.	537.	1160.	939.	1282.	1511.	1410.
4	1070.	983.	827.	655.	803.	541.	534.	1137.	1022.	1326.	1474.	1333.
5	1169.	940.	812.	635.	750.	539.	533.	1058.	1081.	1391.	1392.	1237.
6	1224.	893.	804.	634.	718.	543.	532.	1023.	1092.	1401.	1216.	1195.
7	1196.	945.	737.	663.	764.	543.	534.	1315.	1104.	1466.	1258.	1184.
8	1133.	993.	819.	642.	782.	539.	538.	1521.	1137.	1937.	1216.	1195.
9	1070.	980.	806.	632.	763.	537.	543.	1686.	1160.	2650.	1132.	1237.
10	1031.	955.	785.	677.	725.	539.	609.	1039.	1170.	1780.	1079.	1205.
11	1115.	1002.	773.	737.	698.	537.	644.	901.	1326.	1820.	1067.	1132.
12	1106.	1495.	750.	791.	699.	535.	625.	904.	1612.	1520.	1079.	1153.
13	1097.	1565.	736.	829.	685.	530.	588.	925.	1714.	1320.	1067.	1195.
14	1115.	1300.	741.	751.	662.	523.	576.	1030.	1814.	1250.	1090.	1174.
15	1070.	1215.	754.	721.	630.	516.	596.	1180.	1649.	1230.	1153.	1079.
16	1012.	1237.	742.	700.	612.	509.	612.	1092.	1457.	1250.	1248.	1034.
17	955.	1520.	728.	676.	586.	509.	616.	1058.	1370.	1230.	1355.	1011.
18	893.	1413.	719.	662.	573.	507.	583.	1070.	1326.	1180.	1355.	1000.
19	852.	1242.	708.	655.	565.	507.	579.	1149.	1380.	1260.	1428.	1000.
20	839.	1437.	703.	712.	545.	509.	556.	1348.	1293.	1400.	1428.	1011.
21	857.	1737.	691.	759.	543.	517.	561.	1170.	1230.	1310.	1333.	973.
22	852.	1427.	702.	701.	541.	518.	558.	1047.	1250.	1220.	1195.	929.
23	824.	1251.	721.	664.	540.	519.	629.	1004.	1576.	1290.	1111.	907.
24	795.	1151.	695.	635.	538.	509.	696.	1092.	1649.	1470.	1121.	893.
25	779.	1115.	685.	611.	536.	502.	682.	1250.	1761.	1430.	1226.	874.
26	797.	1106.	679.	591.	535.	501.	670.	1326.	1612.	1450.	1300.	868.
27	824.	1079.	673.	589.	534.	521.	677.	1412.	1475.	1540.	1268.	865.
28	885.	1012.	673.	601.	535.	538.	690.	1315.	1391.	1470.	1344.	874.
29	888.	961.	669.	616.	532.	556.	694.	1170.	1370.	1240.	1492.	865.
30	862.	922.	686.	693.	528.	542.	729.	1070.	1380.	1170.		853.
31		899.		658.	524.		890.		1326.	1210.		838.
TOTAL	29736.	35527.	22448.	20886.	19579.	15791.	18897.	34631.	41603.	43973.	36740.	33317.
AVERAGE	991.	1146.	748.	674.	632.	526.	610.	1154.	1342.	1418.	1267.	1075.

ANNUAL TOTAL 353128.
ANNUAL AVERAGE 965.

ESTACION : BAKER EN COLONIA LATITUD : 47 21 0 S LONGITUD : 72 51 0 W (YEAR 1968)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	825.	783.	868.	779.	676.	592.	680.	585.	1122.	1090.	1100.	1456.
2	826.	1143.	963.	876.	651.	582.	694.	583.	1183.	1045.	1100.	1600.
3	828.	1184.	898.	785.	632.	573.	674.	585.	1389.	1090.	1121.	1680.
4	833.	1056.	829.	733.	618.	680.	674.	591.	1768.	1045.	1163.	1650.
5	853.	982.	775.	695.	599.	1121.	661.	605.	1362.	1045.	1184.	1590.
6	887.	990.	730.	666.	586.	1333.	658.	622.	1151.	1056.	1121.	1530.
7	912.	1163.	697.	642.	577.	1268.	655.	669.	1080.	1045.	1153.	1373.
8	920.	1121.	684.	628.	586.	1143.	638.	722.	1059.	1000.	1100.	1184.
9	926.	1045.	673.	626.	611.	1000.	630.	726.	1263.	979.	1205.	1121.
10	941.	943.	662.	681.	694.	926.	624.	695.	1277.	959.	1100.	1056.
11	896.	990.	648.	721.	647.	878.	635.	754.	1205.	979.	1056.	1011.
12	871.	1226.	652.	749.	592.	852.	674.	754.	1107.	1034.	984.	1000.
13	885.	1090.	656.	754.	602.	909.	705.	908.	1057.	1174.	979.	1045.
14	874.	973.	641.	829.	599.	938.	701.	945.	1025.	1205.	1011.	1034.
15	855.	900.	631.	760.	624.	818.	671.	950.	1024.	1205.	1000.	967.
16	845.	848.	619.	693.	618.	758.	645.	961.	1034.	1216.	988.	930.
17	898.	852.	610.	801.	634.	732.	624.	868.	1066.	1226.	930.	905.
18	917.	827.	603.	919.	641.	599.	613.	850.	1074.	1100.	909.	892.
19	874.	793.	617.	773.	698.	704.	635.	855.	1056.	1079.	918.	887.
20	822.	774.	699.	721.	664.	698.	671.	965.	1000.	1067.	988.	892.
21	787.	748.	664.	698.	660.	690.	730.	950.	966.	1153.	1034.	883.
22	772.	724.	647.	672.	658.	711.	698.	1385.	942.	1364.	1100.	905.
23	762.	715.	633.	657.	990.	694.	671.	1560.	943.	1383.	1143.	914.
24	768.	710.	622.	667.	818.	684.	645.	1499.	954.	1550.	1100.	874.
25	778.	723.	610.	719.	743.	673.	630.	1608.	965.	1737.	1079.	843.
26	775.	804.	600.	709.	738.	654.	621.	1724.	970.	1630.	1045.	786.
27	758.	795.	584.	729.	732.	654.	621.	1723.	1003.	1373.	1132.	810.
28	792.	780.	588.	870.	582.	647.	621.	1407.	1039.	1174.	1322.	802.
29	785.	798.	598.	783.	651.	638.	621.	1163.	1092.	1090.		790.
30	746.	778.	782.	722.	628.	645.	610.	1130.	1118.	1056.		778.
31		749.		690.	608.		594.		1105.	1067.		754.
TOTAL	25211.	28007.	20483.	22747.	20347.	23794.	20224.	29342.	34398.	36216.	30065.	32942.
AVERAGE	840.	903.	683.	734.	656.	793.	652.	978.	1110.	1168.	1074.	1063.

ANNUAL TOTAL 323776.
ANNUAL AVERAGE 887.

ESTACION : BAKER EN COLONIA LATITUD : 47 21 0 S LONGITUD : 72 51 0 W (YEAR 1969)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	736.	930.	1067.	733.	665.	637.	564.	707.	848.	1079.	1170.	1090.
2	732.	874.	1045.	932.	675.	637.	573.	610.	860.	1022.	1320.	1120.
3	718.	839.	1022.	924.	676.	606.	562.	566.	904.	990.	1420.	1120.
4	711.	1000.	979.	838.	675.	643.	565.	558.	899.	972.	1300.	1110.
5	704.	1045.	959.	798.	659.	619.	561.	561.	921.	990.	1140.	1120.
6	698.	1410.	947.	775.	644.	623.	542.	555.	977.	1011.	1100.	1230.
7	698.	1205.	926.	760.	649.	735.	540.	544.	870.	1000.	1150.	1310.
8	732.	1100.	914.	746.	640.	703.	550.	541.	936.	973.	1350.	1260.
9	740.	1079.	905.	736.	639.	586.	544.	551.	1022.	949.	1510.	1180.
10	808.	1205.	896.	726.	645.	635.	574.	579.	1045.	953.	1460.	1090.
11	852.	1205.	892.	714.	650.	678.	690.	605.	1000.	1000.	1460.	1030.
12	1121.	1143.	865.	702.	742.	639.	649.	647.	952.	1022.	1470.	984.
13	1322.	2111.	852.	699.	794.	642.	610.	704.	937.	1011.	1340.	960.
14	1143.	2276.	848.	702.	707.	645.	586.	719.	956.	1011.	1280.	946.
15	1121.	1931.	830.	729.	679.	623.	570.	729.	1079.	1034.	1270.	953.
16	1100.	1590.	830.	817.	660.	949.	554.	746.	1121.	1090.	1210.	972.
17	1011.	1401.	806.	882.	644.	650.	555.	746.	1022.	1111.	1200.	990.
18	947.	1300.	806.	892.	631.	654.	567.	695.	959.	1163.	1130.	1000.
19	887.	1248.	794.	856.	615.	653.	589.	657.	904.	1163.	974.	1030.
20	826.	1205.	786.	782.	600.	656.	633.	692.	884.	1056.	944.	1050.
21	786.	1174.	778.	728.	596.	551.	667.	710.	885.	1034.	994.	1050.
22	766.	1121.	778.	697.	587.	736.	654.	763.	916.	1056.	1030.	990.
23	794.	1067.	774.	688.	582.	656.	642.	789.	943.	1034.	1330.	932.
24	818.	1056.	778.	673.	575.	499.	716.	761.	990.	1011.	1380.	916.
25	909.	1034.	774.	666.	566.	570.	672.	757.	1022.	1000.	1560.	910.
26	1216.	1034.	762.	664.	556.	579.	642.	777.	1100.	1000.	1400.	888.
27	1090.	1079.	762.	678.	556.	856.	642.	808.	1121.	1000.	1190.	860.
28	1226.	1344.	754.	698.	554.	616.	620.	855.	1056.	1034.	1120.	833.
29	1100.	1322.	740.	705.	553.	754.	615.	852.	1034.	1056.		831.
30	984.	1184.	732.	687.	553.	469.	639.	845.	1056.	1090.		829.
31		1100.		673.	551.		713.		1079.	1079.		915.
TOTAL	27296.	38612.	25601.	23300.	19518.	19509.	18800.	20619.	30198.	31994.	35202.	31499.
AVERAGE	910.	1246.	853.	752.	630.	650.	606.	687.	974.	1032.	1257.	1016.

ANNUAL TOTAL 322148.
ANNUAL AVERAGE 883.

ESTACION : BAKER EN COLONIA LATITUD : 47 21 O S LONGITUD : 72 51 O W (YEAR 1970)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	991.	1100.	900.	647.	673.	520.	586.	621.	701.	865.	818.	918.
2	983.	1170.	902.	654.	647.	537.	579.	638.	746.	943.	834.	918.
3	924.	1040.	903.	654.	631.	553.	550.	631.	834.	988.	905.	979.
4	891.	951.	904.	634.	621.	556.	560.	657.	861.	967.	861.	959.
5	848.	852.	906.	634.	608.	550.	542.	722.	830.	959.	848.	951.
6	840.	790.	907.	628.	599.	546.	532.	687.	861.	951.	778.	934.
7	923.	856.	908.	621.	582.	542.	532.	641.	947.	922.	754.	909.
8	1110.	685.	910.	631.	586.	664.	520.	628.	918.	905.	758.	852.
9	1100.	678.	911.	687.	582.	704.	510.	634.	963.	887.	736.	798.
10	1160.	665.	912.	660.	602.	654.	510.	641.	830.	896.	774.	750.
11	1170.	657.	914.	644.	589.	634.	512.	677.	778.	930.	806.	770.
12	1070.	652.	878.	647.	582.	631.	527.	701.	704.	922.	848.	782.
13	942.	652.	834.	684.	566.	634.	542.	770.	687.	883.	822.	810.
14	878.	669.	798.	657.	568.	608.	589.	1010.	670.	955.	810.	750.
15	823.	703.	839.	638.	569.	618.	612.	1270.	762.	1000.	798.	732.
16	864.	717.	810.	625.	573.	615.	625.	914.	767.	1040.	883.	830.
17	939.	713.	794.	625.	573.	634.	625.	782.	788.	996.	1050.	926.
18	961.	717.	766.	625.	563.	621.	608.	754.	813.	922.	1070.	918.
19	1030.	710.	754.	618.	556.	638.	592.	746.	839.	856.	967.	874.
20	1020.	696.	736.	599.	553.	628.	641.	722.	839.	870.	883.	852.
21	949.	689.	722.	660.	547.	647.	644.	729.	802.	883.	900.	852.
22	879.	685.	701.	729.	540.	628.	647.	750.	1250.	887.	943.	883.
23	851.	678.	694.	778.	537.	599.	722.	770.	1170.	870.	926.	839.
24	829.	675.	694.	729.	502.	586.	680.	778.	1230.	839.	883.	810.
25	803.	669.	680.	694.	520.	602.	654.	778.	1140.	905.	830.	770.
26	772.	664.	740.	687.	517.	647.	618.	762.	1050.	1050.	852.	967.
27	773.	659.	722.	673.	512.	602.	639.	750.	963.	1000.	896.	900.
28	786.	649.	690.	670.	510.	553.	660.	758.	922.	963.	918.	874.
29	867.	636.	673.	660.	508.	589.	687.	746.	893.	896.		839.
30	966.	630.	651.	664.	522.	589.	651.	715.	864.	826.		810.
31		892.		726.	537.		634.		834.	806.		790.
TOTAL	27942.	23199.	24153.	20482.	17575.	18129.	18530.	22382.	27251.	28582.	24151.	26546.
AVERAGE	931.	743.	805.	661.	567.	604.	598.	746.	879.	922.	863.	856.

ANNUAL TOTAL 278922.
ANNUAL AVERAGE 764.

ESTACION : BAKER EN COLONIA   LATITUD : 47 21 0 S   LONGITUD : 72 51 0 W   (YEAR 1971)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	770.	599.	582.	412.	515.	498.	1090.	905.	1150.	918.	1470.	751.
2	743.	582.	577.	412.	523.	495.	935.	934.	1090.	932.	1340.	855.
3	715.	566.	571.	407.	505.	485.	815.	917.	983.	954.	1350.	951.
4	701.	556.	565.	418.	497.	483.	722.	907.	942.	962.	1380.	1000.
5	724.	550.	559.	440.	509.	482.	681.	923.	912.	978.	1410.	1000.
6	747.	540.	553.	444.	558.	490.	655.	881.	901.	1000.	1320.	1020.
7	770.	530.	547.	436.	607.	499.	642.	889.	894.	1090.	1210.	1080.
8	770.	525.	541.	418.	651.	493.	622.	859.	926.	1180.	1260.	1100.
9	790.	530.	536.	414.	715.	491.	599.	826.	937.	1160.	1270.	1110.
10	758.	530.	530.	412.	670.	495.	577.	848.	964.	1130.	1330.	1110.
11	743.	537.	524.	405.	666.	514.	573.	856.	992.	1150.	1280.	1080.
12	734.	530.	518.	403.	691.	517.	584.	840.	974.	1190.	1220.	1040.
13	726.	530.	512.	407.	807.	539.	711.	838.	915.	1450.	1130.	1020.
14	717.	525.	506.	405.	739.	571.	954.	869.	864.	1290.	1060.	1030.
15	703.	520.	500.	938.	661.	538.	835.	836.	906.	1140.	951.	1060.
16	700.	525.	495.	1530.	621.	525.	773.	900.	897.	1070.	958.	1040.
17	691.	979.	489.	951.	588.	519.	750.	875.	923.	1090.	961.	1000.
18	682.	918.	483.	830.	553.	531.	760.	926.	946.	1320.	1010.	1000.
19	674.	910.	477.	701.	527.	540.	790.	1020.	897.	1290.	1020.	1060.
20	665.	874.	471.	641.	511.	552.	787.	1270.	871.	1240.	988.	1090.
21	656.	545.	465.	602.	501.	583.	767.	1470.	853.	1390.	987.	1030.
22	648.	530.	459.	576.	498.	609.	760.	1600.	842.	1730.	1020.	965.
23	639.	525.	454.	566.	486.	628.	789.	1500.	894.	1890.	1040.	965.
24	630.	512.	448.	545.	486.	611.	990.	1260.	948.	1750.	1020.	904.
25	621.	496.	442.	545.	495.	629.	1100.	1110.	988.	1530.	980.	889.
26	615.	492.	436.	525.	519.	873.	1030.	1020.	1030.	1340.	924.	862.
27	631.	484.	430.	515.	536.	1320.	992.	1020.	1030.	1250.	871.	849.
28	641.	480.	424.	510.	529.	1210.	963.	1050.	979.	1230.	813.	832.
29	647.	500.	418.	506.	520.	1130.	1120.	1040.	937.	1250.	771.	817.
30	621.	502.	412.	508.	505.	1230.	984.	1060.	923.	1430.		814.
31		582.		502.	504.		910.		902.	1670.		809.
TOTAL	20877.	18092.	14924.	17324.	17693.	19080.	25260.	30149.	29210.	38994.	32344.	30133.
AVERAGE	696.	584.	497.	559.	571.	636.	815.	1005.	942.	1258.	1115.	972.

ANNUAL TOTAL 294080.
ANNUAL AVERAGE 803.

ESTACION : BAKER EN COLONIA LATITUD : 47 21 0 S LONGITUD : 72 51 0 W (YEAR 1972)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	808.	1110.	728.	541.	466.	419.	475.	670.	744.	1100.	1100.	863.
2	813.	1130.	724.	538.	458.	416.	460.	551.	757.	1070.	1080.	866.
3	822.	1060.	710.	537.	450.	415.	448.	542.	792.	1150.	1100.	896.
4	902.	972.	693.	538.	447.	428.	439.	575.	826.	1160.	1040.	907.
5	923.	951.	681.	536.	449.	420.	431.	633.	910.	1050.	1020.	910.
6	973.	905.	669.	534.	448.	423.	428.	648.	1060.	969.	1050.	943.
7	975.	891.	660.	532.	448.	434.	428.	663.	1130.	932.	1110.	956.
8	931.	857.	646.	527.	445.	449.	432.	690.	991.	886.	1120.	973.
9	926.	843.	635.	522.	454.	465.	442.	728.	903.	900.	1110.	985.
10	954.	812.	615.	532.	458.	492.	444.	759.	910.	952.	1080.	975.
11	1015.	802.	604.	532.	459.	486.	445.	724.	991.	1050.	1040.	957.
12	1157.	796.	615.	523.	455.	470.	450.	734.	1030.	1070.	1060.	1070.
13	1048.	792.	608.	523.	459.	465.	464.	715.	958.	1010.	1110.	1060.
14	953.	836.	597.	525.	460.	466.	461.	706.	943.	975.	1060.	1000.
15	899.	1000.	607.	519.	456.	464.	461.	688.	922.	1030.	1010.	931.
16	883.	964.	650.	508.	450.	463.	512.	701.	931.	1130.	1050.	877.
17	868.	953.	620.	502.	445.	461.	713.	706.	926.	1230.	1050.	887.
18	1016.	934.	602.	516.	441.	456.	708.	740.	930.	1240.	1050.	902.
19	1303.	937.	633.	510.	436.	451.	720.	731.	1120.	1130.	1020.	916.
20	1617.	906.	623.	493.	436.	442.	677.	696.	1520.	1140.	1000.	944.
21	1891.	875.	663.	514.	438.	441.	590.	729.	1540.	1150.	1000.	993.
22	1989.	853.	668.	510.	432.	480.	587.	765.	1330.	1100.	942.	1130.
23	1688.	844.	695.	495.	431.	515.	543.	812.	1140.	1040.	895.	1320.
24	1408.	837.	698.	490.	427.	490.	612.	843.	1060.	976.	871.	1240.
25	1250.	852.	672.	478.	424.	477.	659.	867.	1070.	944.	885.	1150.
26	1160.	834.	621.	473.	422.	473.	561.	920.	1080.	984.	906.	1030.
27	1106.	811.	596.	480.	423.	469.	542.	909.	1060.	1010.	898.	1020.
28	1081.	794.	579.	479.	428.	489.	539.	857.	1060.	981.	885.	1070.
29	1084.	777.	547.	470.	427.	515.	537.	808.	1060.	1010.		1210.
30	1111.	759.	543.	470.	423.	495.	540.	752.	1060.	1070.		1170.
31		743.		470.	419.		874.		1070.	1080.		1040.
TOTAL	33554.	27430.	19202.	15817.	13714.	13829.	16622.	21862.	31824.	32519.	28542.	31191.
AVERAGE	1118.	885.	640.	510.	442.	461.	536.	729.	1027.	1049.	1019.	1006.

ANNUAL TOTAL 286106.
ANNUAL AVERAGE 784.

ESTACION : BAKER EN COLONIA LATITUD : 47 21 0 S LONGITUD : 72 51 0 W (YEAR 1973)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	975.	657.	778.	539.	475.	659.	626.	622.	872.	984.	1230.	991.
2	921.	631.	764.	567.	765.	677.	669.	611.	970.	957.	1080.	966.
3	874.	608.	696.	542.	945.	609.	676.	650.	1120.	901.	1070.	982.
4	827.	609.	673.	532.	774.	584.	671.	664.	1030.	861.	1050.	1050.
5	800.	602.	604.	533.	699.	546.	672.	642.	1010.	856.	1040.	1100.
6	853.	581.	567.	534.	649.	539.	666.	561.	989.	841.	950.	1100.
7	832.	566.	541.	535.	625.	535.	617.	545.	928.	838.	919.	1150.
8	833.	559.	545.	531.	590.	534.	564.	559.	916.	826.	888.	1050.
9	881.	556.	653.	532.	541.	540.	545.	596.	915.	828.	874.	1050.
10	1230.	543.	684.	528.	532.	536.	538.	673.	891.	819.	874.	984.
11	1130.	542.	662.	523.	532.	532.	537.	755.	889.	822.	862.	904.
12	1030.	543.	672.	512.	527.	525.	534.	869.	1030.	853.	886.	945.
13	974.	541.	941.	502.	518.	512.	534.	857.	1010.	968.	904.	909.
14	943.	543.	1230.	495.	511.	514.	566.	807.	966.	953.	949.	972.
15	871.	544.	1040.	492.	513.	498.	609.	771.	953.	1010.	983.	894.
16	826.	543.	869.	487.	522.	488.	608.	743.	1000.	1020.	1010.	845.
17	810.	542.	811.	479.	537.	479.	674.	708.	965.	1030.	1090.	908.
18	786.	542.	732.	472.	539.	480.	686.	690.	913.	989.	1100.	1010.
19	759.	538.	1020.	471.	535.	475.	674.	812.	938.	975.	1070.	1080.
20	751.	538.	978.	471.	515.	488.	640.	865.	1100.	936.	1030.	1120.
21	732.	532.	827.	470.	508.	504.	583.	881.	1150.	892.	993.	1090.
22	719.	532.	731.	467.	501.	528.	560.	988.	1100.	821.	1020.	1040.
23	711.	533.	706.	464.	501.	651.	545.	984.	1100.	800.	1050.	1010.
24	700.	530.	677.	461.	495.	800.	557.	955.	1060.	803.	1010.	1000.
25	699.	537.	657.	456.	488.	673.	610.	927.	980.	839.	962.	938.
26	690.	540.	619.	460.	482.	618.	639.	860.	962.	957.	930.	911.
27	682.	534.	569.	478.	524.	570.	655.	787.	971.	1070.	962.	889.
28	676.	535.	581.	489.	541.	561.	612.	868.	1080.	1100.	1020.	861.
29	671.	536.	565.	503.	531.	568.	580.	980.	1090.	1090.		852.
30	663.	531.	543.	495.	533.	601.	569.	910.	1040.	1180.		851.
31		586.		480.	542.		593.		992.	1220.		879.
TOTAL	24849.	17254.	21935.	15500.	17490.	16824.	18809.	23140.	30930.	29039.	27806.	30331.
AVERAGE	828.	557.	731.	500.	564.	561.	607.	771.	998.	937.	993.	978.

ANNUAL TOTAL 273907.
ANNUAL AVERAGE 750.

ESTACION : BAKER EN COLONIA   LATITUD : 47 21 0 S   LONGITUD : 72 51 0 W   (YEAR 1974)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	860.	896.	738.	510.	492.	509.	476.	777.	544.	783.	1420.	1110.
2	874.	841.	702.	502.	476.	500.	482.	838.	540.	826.	1380.	1190.
3	956.	905.	683.	516.	471.	494.	506.	897.	540.	872.	1220.	1400.
4	1020.	940.	677.	541.	477.	487.	498.	907.	548.	911.	1160.	1200.
5	1030.	1050.	666.	537.	476.	483.	489.	820.	652.	982.	1100.	1050.
6	576.	1050.	649.	653.	467.	482.	535.	742.	706.	1020.	1100.	963.
7	941.	916.	652.	766.	470.	480.	694.	732.	798.	1080.	1130.	1000.
8	1100.	865.	641.	775.	489.	479.	773.	723.	977.	1090.	1110.	1070.
9	1120.	833.	622.	739.	496.	561.	773.	723.	1119.	1020.	1110.	1100.
10	1150.	798.	589.	676.	537.	557.	713.	747.	1162.	1020.	1120.	1070.
11	1110.	768.	564.	654.	636.	536.	655.	721.	1013.	1090.	1090.	1020.
12	1320.	741.	549.	741.	860.	524.	609.	732.	976.	1080.	1120.	1020.
13	1220.	729.	544.	688.	733.	508.	679.	741.	963.	1030.	1060.	1010.
14	1030.	701.	545.	626.	673.	504.	743.	741.	1016.	1020.	1060.	995.
15	940.	686.	540.	583.	610.	505.	756.	749.	913.	1110.	969.	966.
16	924.	711.	537.	546.	629.	501.	713.	706.	871.	1110.	951.	972.
17	909.	706.	533.	542.	631.	501.	765.	748.	879.	972.	993.	972.
18	850.	684.	535.	542.	562.	499.	871.	806.	914.	881.	1010.	977.
19	798.	678.	534.	539.	674.	502.	842.	744.	853.	910.	1050.	956.
20	778.	677.	536.	535.	689.	509.	770.	689.	804.	1000.	1080.	941.
21	762.	659.	531.	533.	785.	493.	719.	662.	838.	1130.	1140.	940.
22	744.	643.	531.	525.	717.	481.	695.	662.	827.	1210.	1200.	895.
23	745.	621.	533.	522.	688.	473.	822.	686.	838.	1400.	1120.	844.
24	743.	603.	529.	511.	668.	471.	1154.	693.	869.	1230.	1020.	844.
25	740.	602.	527.	500.	627.	520.	758.	687.	930.	1160.	982.	821.
26	751.	615.	529.	499.	606.	516.	636.	670.	925.	1180.	1020.	816.
27	763.	1030.	523.	492.	564.	491.	542.	641.	893.	1130.	1070.	819.
28	755.	895.	519.	487.	543.	477.	536.	593.	882.	1210.	1110.	828.
29	746.	316.	518.	482.	537.	470.	532.	570.	837.	1320.		890.
30	886.	798.	511.	478.	530.	469.	530.	545.	800.	1380.		897.
31		754.		483.	524.		678.		786.	1360.		884.
TOTAL	27541.	24201.	17292.	17723.	18337.	14982.	20944.	21692.	26213.	33517.	30895.	30460.
AVERAGE	918.	781.	576.	572.	592.	499.	676.	723.	846.	1081.	1103.	983.

ANNUAL TOTAL 283797.
ANNUAL AVERAGE 778.

ESTACION : BAKER EN COLONIA LATITUD : 47 21 0 S LONGITUD : 72 51 0 W (YEAR 1975)

DAY	4	5	6	7	8	9	10	11	12	1	2	3
1	895.	790.	564.	567.	476.	0.	0.	0.	0.	0.	0.	0.
2	919.	806.	554.	595.	471.	0.	0.	0.	0.	0.	0.	0.
3	976.	782.	542.	632.	476.	0.	0.	0.	0.	0.	0.	0.
4	1070.	751.	542.	623.	464.	0.	0.	0.	0.	0.	0.	0.
5	1220.	753.	545.	588.	458.	0.	0.	0.	0.	0.	0.	0.
6	1220.	748.	544.	602.	452.	0.	0.	0.	0.	0.	0.	0.
7	1080.	775.	541.	577.	445.	0.	0.	0.	0.	0.	0.	0.
8	970.	839.	641.	556.	442.	0.	0.	0.	0.	0.	0.	0.
9	1120.	822.	648.	542.	447.	0.	0.	0.	0.	0.	0.	0.
10	1080.	794.	606.	538.	503.	0.	0.	0.	0.	0.	0.	0.
11	925.	758.	603.	537.	554.	0.	0.	0.	0.	0.	0.	0.
12	885.	732.	591.	532.	532.	0.	0.	0.	0.	0.	0.	0.
13	885.	710.	655.	532.	507.	0.	0.	0.	0.	0.	0.	0.
14	832.	695.	648.	533.	512.	0.	0.	0.	0.	0.	0.	0.
15	804.	682.	622.	513.	513.	0.	0.	0.	0.	0.	0.	0.
16	857.	670.	603.	493.	508.	0.	0.	0.	0.	0.	0.	0.
17	854.	655.	576.	503.	520.	0.	0.	0.	0.	0.	0.	0.
18	948.	638.	565.	503.	523.	0.	0.	0.	0.	0.	0.	0.
19	927.	626.	554.	502.	512.	0.	0.	0.	0.	0.	0.	0.
20	968.	632.	542.	498.	552.	0.	0.	0.	0.	0.	0.	0.
21	938.	645.	542.	492.	545.	0.	0.	0.	0.	0.	0.	0.
22	930.	700.	560.	487.	540.	0.	0.	0.	0.	0.	0.	0.
23	902.	692.	560.	499.	528.	0.	0.	0.	0.	0.	0.	0.
24	963.	711.	542.	438.	525.	0.	0.	0.	0.	0.	0.	0.
25	1010.	721.	538.	480.	506.	0.	0.	0.	0.	0.	0.	0.
26	981.	724.	538.	488.	511.	0.	0.	0.	0.	0.	0.	0.
27	984.	711.	537.	487.	548.	0.	0.	0.	0.	0.	0.	0.
28	950.	681.	535.	492.	539.	0.	0.	0.	0.	0.	0.	0.
29	895.	657.	533.	490.	539.	0.	0.	0.	0.	0.	0.	0.
30	826.	622.	535.	483.	533.	0.	0.	0.	0.	0.		0.
31		575.		476.	532.		0.		0.	0.		0.
TOTAL	28814.	22098.	17106.	16334.	15713.	0.	0.	0.	0.	0.	0.	0.
AVERAGE	960.	713.	570.	527.	507.	0.	0.	0.	0.	0.	0.	0.

ANNUAL TOTAL 100065.
ANNUAL AVERAGE 273.

Precipitation STATION Pto. Aisen. ENDESA CATCHMENT AREA ______ sq km

RIVER IN THE BASIN OF ______ ELEVATION 10 m UNIT mm S 45° 24' W 72° 42'

YEAR	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	ANNUAL
1931	206.0	269.0	99.0	179.0	235.0	277.0	244.0	171.0	135.0	398.0	127.0	203.0	2543.0
1932	241.0	209.0	393.0	556.0	302.0	326.0	376.0	164.0	241.0	285 0	215.0	252.0	3560.0
1933	313.0	390.0	313.0	287.0	471.0	387.0	294.0	462.0	244.0	252.0	167.0	70.0	3650.0
1934	205.0	170.0	212.0	145.0	242.0	111.0	481.0	281.0	97.0	138.0	28.0	32.0	2142.0
1935	216.0	202.0	250.0	161.0	366.0	352.0	192.0	276.0	166.0	175.0	416.0	395.0	3197.0
1936	238.0	89.0	262.0	242.0	183.0	278.0	423.0	210.0	223.0	79.0	48.0	331.0	2606.0
1937	25.0	331.0	331.0	254.0	367.0	544.0	358.0	285.0	152.0	149.0	311.0	184.0	3291.0
1938	281.0	107.0	363.0	182.0	385.0	352.0	333.0	324.0	213.0	257.0	462.0	226.0	3485.0
1939	269.0	255.0	179.0	191.0	260.0	317.0	350.0	397.0	105.0	223.0	84.0	96.0	2726.0
1940	283.0	212.0	256.0	347.0	350.0	342.0	317.0	160.0	172.0	61.0	220 0	205.0	2925.0
1941	44.0	130.0	107.0	221.0	217.0	251.0	222.0	308.0	231.0	172.0	255.0	329.0	2487.0
1942	219.0	231.0	257.0	326.0	214.0	165.0	270.0	303.0	208.0	124.0	132.0	223.0	2672.0
1943	88.0	180.0	247.0	104.0	364.0	179.0	194.0	69.0	283.0	387.0	127.0	69.0	2291.0
1944	14.0	160.0	102.0	114.0	226.4	188.0	182.0	313.0	406.0	368.0	142.0	100.0	2261.4
1945	80.9	112.7	304.8	426.5	353.9	222.2	372.0	363.5	183.9	343.2	233.3	172.0	3168.9
1946	193.1	211.6	48.3	264.6	350.1	107.8	232.3	237.8	163.0	238.0	372.0	196 4	2615.0
1947	345.2	251.7	129.4	123.6	316.0	198.9	165.0	312.8	253.9	175.1	112.6	179.8	2564.0
1948	158.2	150.7	209.9	184.9	376.8	506.1	165.9	177.0	119 8	157.5	58.0	316.0	2580.8
1949	185.3	286.0	409.0	258.5	362.4	328.7	253.9	182.4	186.0	42.1	142.8	189.3	2826.4
1950	86.5	262.9	521.2	244.0	328.8	472.1	329.5	308.2	90.0	110.1	144.2	357.5	3255.0
1951	194.2	78.9	178.9	146.3	487.9	331.4	183.8	430.2	269.2	246.0	392.0	61.7	3000.5
1952	227.9	135.5	419.6	211.6	348.9	55.0	217.4	214.1	241.7	194.7	136.0	21.7	2424.1
1953	405.0	229.1	379.4	126.8	435.5	337.7	337.0	356.3	242.9	123.4	97.5	89.2	3164.8
1954	116.9	180.0	94.6	164.5	162.4	113.6	426.9	396.2	198.0	175.9	168.7	234.0	2431.7
1955	117.3	240.6	109.4	330.1	89.9	205.2	202.3	215.6	127.0	47.9	98.5	448.6	2232.4
1956	229.1	121.7	194.7	113.5	151.3	271.7	247.1	263.7	230.1	213.9	105.9	152.2	2294 9
1957	278.8	164.0	403.2	87.0	443.6	179.1	533.4	707.8	308.8	315.9	243.2	412.1	4076.9
1958	342.8	174.0	128.0	387.7	611.7	283.8	1069.0	659.8	201.8	214.3	378.9	213.9	4666.5
1959	289.8	457.2	499.3	288.1	453.2	268.6	254.6	535.3	311.1	416.2	166.2	142.3	4081.9
1960	212.6	293.3	132.6	281.8	436.9	360.7	500 0	360.9	348.9	415.2	345.8	291.5	3980.2

Precipitation STATION Pto. Aisen. ENDESA CATCHMENT AREA ______ sq km

RIVER IN THE BASIN OF ______ ELEVATION 10 m UNIT mm S 45° 24' W 72° 42'

YEAR	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	ANNUAL
1961	347.3	167.3	289.5	145.6	228.9	301.0	169.9	241.3	202.2	224.4	185.3	120.7	2623.4
1962	114.7	35.1	158.1	289.9	176.4	461.8	233.9	342.2	184.2	81.8	141.1	200.3	2419.5
1963	181.0	73.6	268.4	557.5	325.4	369.7	398.9	178.4	200.1	67.8	219.1	321.4	3161.3
1964	192.0	262.0	271.0	259.0	403.0	121.0	252.0	318.0	213.0	139.0	24.0	269.0	2723.0
1965	232.0	281.0	44.0	313.0	316.0	447.0	261.0	354.0	156.0	266.0	443.0	181.0	3294.0
1966	99.0	53.0	223.0	134.0	755.0	286.0	366.0	198.0	168.0	152.0	303.0	300.0	3037.0
1967	219.0	158.0	123.0	164.0	512.0	200.0	388.0	417.0	175.0	156.0	276.0	277.0	3065.0
1968	115.4	353.2	148.5	113.4	202.0	179.1	379.7	266.8	346.9	183.5	242.2	301.0	2831.7
1969	88.8	182.1	84.4	452.2	455.2	259.5	323.3	291.8	317.5	243.2	59.8	125.4	2882.2
1970	158.6	186 6	189.9	275.1	410.8	349.3	451.5	259.2	302.2	104.6	93.9	462.8	
1971	286.2	157.9	149.6	256.2	185.2	138.6	445.9	358.4	327.0	127.4	248.8	327.4	3008.6
1972	273.1	325.1	185.4	257.4	375.5	193.4	383.8	146.5	207.8	243.3	21.6	142.2	2755.1
1973	244.7	54.0	D	D	D	D	D	D	D	D	D	119.5	
1974	328.5	137.5	171.4	226.5	222.7	154.1	261.6	307.1	95.2	67.4	177.4	129.3	2278.6
1975	56.6	181.2	86.1	288.5	249.2	317.3	346.6	340.5	283.9	172.5	181.6		
1976	269.1	99.6	128.4	163.0	247.7	33.0	50.0						

D: No record

Precipitation STATION Pto. Chacabuco, DGA CATCHMENT AREA sq km

RIVER IN THE BASIN OF ELEVATION 8 m UNIT mm S 45° 29' W 72° 50'

YEAR	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	ANNUAL
1965	D	D	D	D	D	D	253.8	427.9	220.3	251.9	459.2	106.8	
1966	106.2	D	D	D	D	D	D	D	216.5	184.0	75.7	309.2	
1967	D	D	126.0	100.0	458.2	268.4	371.5	399.9	199.7	D	D	D	
1968	218.2	382.1	123.3	134.6	246.2	169.5	429.9	275.6	383.2	158.9	294.8	318.3	3134.6
1969	129.5	201.1	100.1	442.6	458.0	314.0	322.5	294.5	360.0	289.7	77.9	153.3	3142.9
1970	177.2	209.5	185.2	350.2	462.1	D	D	D	135.8	107.1	62.2	348.6	
1971	283.6	186.4	185.5	234.0	212.3	193.4	578.5	394.5	319.8	163.3	310.0	347.1	3405.7
1972	352.1	339.6	189.2	284.8	326.6	237.5	464.4	198.5	248.0	264.3	29.4	121.9	3056.3
1973	210.0	68.8	147.3	198.0	225.7	327.5	128.5	329.3	35.0	167.9	169.9	34.9	2195.3
1974	346.5	168.5	197.2	265.2	308.0	246.0	311.5	385.5	139.5	100.8	197.4	207.9	2819.7
1975	69.4	211.5	65.0	319.0	233.0	298.5	390.0	475.0	370.0	219.9	223.9	314.6	3135.1
1976	291.7	119.4	145.5	242.4	305.0								

D: No record

Precipitation STATION Coihaique Alto, OMC CATCHMENT AREA sq km

RIVER IN THE BASIN OF ELEVATION mm m UNIT mm S 45° 29' W 71° 36'

YEAR	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	ANNUAL
1969	8.2	27.7	21.6	54.9	57.7	32.1	97.0	26.6	67.5	18.6	D	6.5	
1970	22.2	18.6	15.7	28.1	46.2	22.6	66.9	22.3	33.4	D	14.0	D	
1971	D	D	D	D	D	D	8.8	72.9	33.8	12.0	3.0	24.0	
1972	27.7	21.0	17.5	14.0	71.2	11.9	14.6	14.7	22.0	13.3	15.4	9.8	263.1
1973	8.9	7.9	20.0	25.7	51.2	65.1	53.9	42.3	18.9	22.3	D	D	
1974	18.0	D	D	56.0	79.0	25.5	24.0	72.5	19.2	17.5	19.0	1.0	
1975	11.5	12.0	40.0	41.0	16.3	30.5	45.5	32.7	20.3	15.0	59.8	47.1	371.7
1976	37.0	26.7	29.5	29.7	35.0	D	D						

D: No record

Precipitation STATION Coihaique Bajo, OMC CATCHMENT AREA ______ sq km ______

RIVER, IN THE BASIN OF ______ ELEVATION 140 m UNIT mm S 45°32' W 71°40'

YEAR	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	ANNUAL
1920	D	D	D	D	D	D	67.2	132.2	64.6	91.8	57.1	70.4	D
1921	95.7	51.2	29.8	136.6	194.0	192.8	93.6	292.3	62.1	5.5	42.7	173.9	1370.2
1922	6.9	52.8	69.4	25.2	27.4	107.7	101.1	173.0	91.3	4 8	21.3	20.6	1711.5
1923	45.1	126.5	249.9	121.8	72.9	88.0	80.6	68.3	38.4	36.5	78 8	44 6	1051.4
1924	3.8	44.6	94.4	97.0	184.9	248.1	105.6	169.7	33.3	23.7	26.3	79.3	1110.7
1925	64.7	78.1	67.5	206.4	21.7	278.3	50.0	256.5	217.4	29.4	55.3	41.7	1417.0
1926	105 8	44.5	111.0	75.3	136.5	56.8	107.0	38.1	28.1	48.1	204.0	128.5	1075.7
1927	75.5	38.2	69.3	240.3	131.2	87.2	54.1	135.0	50 8	6.3	36.2	24 0	948.1
1928	54.8	33.6	91.8	117.3	53.2	241.3	113.2	219.7	29.6	7.2	63 3	230.0	1255.0
1929	45.6	31.6	25.9	190.0	91.7	121.7	D	D	D	D	D	D	D
1968	D	90.5	53.5	15.0	68.0	33.1	139.7	80.7	170.8	24.9	22.9	67.6	766.7

D: No record

Precipitation STATION Coihaique, OMC CATCHMENT AREA ______ sq km ______

RIVER, IN THE BASIN OF ______ ELEVATION 275 m UNIT mm S 45° 34' W 71° 33'

YEAR	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	ANNUAL
1942	D	D	D	D	D	D	D	D	47.0	19.0	7.0	24.0	
1943	23.0	6.0	44.0	28.0	124.0	50.0	75.0	20.0	103.0	45.0	0.0	8.0	526.0
1944	8.0	19.0	41.8	81.8	63.6	171.7	80.8	72.5	112.2	99.2	21.8	12.1	783.6
1945	7.6	60.9	126.5	121.7	249.9	115.8	88.6	130.0	54.4	123.9	39.3	28.1	1146.7
1946	19.1	62.2	17.2	75.0	210.1	43.8	156.3	92.2	48.3	81.8	157.7	26.3	987.7
1947	38.2	93.0	40.7	14.5	96.1	74.0	42.7	42.9	39.2	52.9	20.2	44.9	599.3
1948	20.2	32.1	48.3	48.7	165.6	159.2	71.5	D	D	D	D	D	
1950	21.1	75.0	194.1	30.8	134.3	70.2	D	D	D	D	D	D	
1961	162.4	77.7	77.0	44.4	150.8	206.0	119.6	125.0	83.3	56.0	47.8	47.0	1197.0
1962	51.4	1.8	111.0	162.0	147.4	358.7	169.3	257.4	71.0	0.0	32.0	154.3	1516.3
1963	58.1	6.2	178.8	475.0	181.0	366.0	88.2	121.1	145.0	53.0	53.6	231.4	1914.9
1964	73.1	130.4	20.5	125.3	423.0	81.4	217.5	268.0	95.5	99.3	0.0	132.7	1691.7
1965	113.0	270.8	22.5	280.7	305.5	347.6	148.7	260.0	75.0	110.2	197.2	85.0	2216.2
1966	20.0	48.0	135.5	55.0	914.0	239.0	684.0	61.8	76.6	74.3	47.0	126.3	2481.0
1967	131.0	40.0	60.0	81.0	388.0	124.0	171.0	216.0	97.0	55.0	159.0	96.0	1618.0
1968	88.0	184.0	50.8	39.6	143.8	63.1	241.7	172.1	322.3	73.4	87.7	135.8	1602.3
1969	12.9	25.6	24.0	114.3	162.1	84.4	213.0	70.2	138.0	55.9	4.6	16.3	921.3
1970	55.9	47.3	51.7	69.6	177.1	87.5	206.9	65.3	103.9	11.4	15.7	108.7	
1971	53.8	13.9	55.7	29.6	79.0	66.8	226.5	107.3	82.8	40.5	65.5	64.7	886.1
1972	103.1	67.0	41.0	73.6	156.6	52.8	110.9	42.1	31.8	60.0	12.9	28.6	280.4
1973	42.8	15.7	27.1	88.6	100.2	108.6	89.2	109.5	91.1	53.9	18.4		
1974	72.6	67.3	37.4	77.0	162.0	58.2	76.8	106.7	33.5	15.8	38.9	11.2	757.4
1975	8.3	51.8	40.9	68.6	75.6	50.9	72.2	129.6	94.6	52.1	133.7	119.1	897.4
1976	88.9	36.7	74.7	63.6	119.9	77.8	185.0						

Precipitation STATION Chile Chico, DGA CATCHMENT AREA ______ sq km ______

RIVER, IN THE BASIN OF ______ ELEVATION 215 m UNIT mm S 46• 32' W 71• 44'

YEAR	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	ANNUAL
1963	D	D	D	D	D	D	D	D	D	26.5	8.9	17.7	D
1964	6.0	12.0	20.0	22.0	40.0	0.0	24.0	15.0	18.2	D	D	D	D
1965	5.0	0.0	D	80.4	43.1	63.7	62.4	D	8.5	8.3	41.3	D	D
1966	1.0	6.8	35.7	18.5	148.3	51.7	67.0	34.0	2.5	8.0	14.5	0 0	388.0
1967	16.0	0.0	8.3	12.5	55.7	19.7	44.2	51.4	7.1	87.8	4.6	D	D
1968	0.0	0.0	2.4	0.0	1.5	2.7	43.2	24.3	54.0	1.0	2.0	5.0	136.1
1969	0.0	0.0	10.0	63.8	59.8	24.6	59.0	42.0	39.6	1.0	D	D	299.8
1970	9.8	0.0	10.0	15.0	41.3	25.6	56.9	8.1	17.1	D	D	8.3	192.1
1971	5.4	0.0	30.0	1.2	19.0	8.2	196.7	62.2	21.2	6.3	16 3	2.6	369.1
1972	79.0	38.4	14.1	18.4	98.2	21.9	41.8	D	D	D	D	D	D
1973	D	D	D	D	D	D	D	D	D	D	D	D	D
1974	14.3	17.7	13.6	20.7	91.9	12.6	18.5	21.4	5.8	0.4	6.1	19.8	242.8
1975	4.6	18.6	19.9	14.2	17.6	39.5	25.4	D	23 3	2.2	19.5	5.8	D
1976	16.1	13.0	37.5	20.3									

D: No record

Lago General Carrera

Precipitation STATION En Chile Chico, ENDESA CATCHMENT AREA ______ sq km ______

RIVER, IN THE BASIN OF ______ ELEVATION 215 m UNIT mm S 46• 36' W 71• 43'

YEAR	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	ANNUAL
1954	0.0	0.0	11.0	7.8	18.0	0.7	17.3	18.6	19.0	4.0	0.0	4.0	110.4
1955	23.0	0.0	2.0	21.0	35.8	20.6	61.4	0.0	6.0	0.0	0.0	1.0	170.8
1956	0.0	0.0	0.0	9.9	1.0	10.0	8.2	7.0	21.0	1.0	0.0	0.0	58.1
1957	0.0	0.0	6.0	3.0	21.0	23.0	38.0	25.0	12.0	6.0	5.0	0.0	139.0
1958	0.0	0.0	0.0	4.0	47.0	7.5	43.1	29.2	7.7	6.9	24.4	25 6	195.4
1959	9.1	18.0	36.2	13.7	13.3	5.0	20.5	67.3	21.6	31.0	0.0	0.0	235.7
1960	0.0	16.0	4.9	0.0	71.4	29.9	25.1	7.1	10.4	0.6	4.0	3.5	172.9
1961	7.3	10.6	3.1	4.1	15.2	55.8	80.6	31.5	13.5	5.1	0.0	1.0	227.8
1962	0.0	8.1	5.5	9.4	10.5	88.6	20.6	42.9	16.1	0.0	6.6	3.7	212.0
1963	10.7	2.2	22.4	85.2	24.9	28.0	92.1	85.8	70.3	30.9	13.9	10.8	526.3
1964	0.0	8.5	28.5	10.0	43.3	2.2	15.5	31.2	14.6	4.4	0.0	13.5	143.2
1965	7.9	7.0	0.0	68.9	46.6	54.0	60.3	63.4	6.6	4.4	47.4	4.1	370.6
1966	0.0	2.2	10.0	22.2	181.9	83.8	80.8	23.7	5.0	6.1	6.2	0.0	421.9
1967	4.4	0.0	5.3	3.4	48.0	25.0	57.0	62.0	6.5	66.0	1.0	1.3	279.9
1968	3.5	5.5	0.5	D	11.5	12.6	38.6	25.0	63.4	5.0	10.6	11.7	192.9
1969	Abolished												

D: No record

Precipitation STATION En Pto. Cristal, ENDESA CATCHMENT AREA ____ sq km ____

RIVER, IN THE BASIN OF ____ ELEVATION 215 m UNIT mm S 46° 38' W 72° 22'

YEAR	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct	Nov.	Dec.	ANNUAL
1960	26.0	92.0	21.0	8.0	125.0	100.0	79.0	116.0	60.0	149 0	52.0	125.0	953 0
1961	113.0	40.0	92.0	26.0	84.0	170.0	90.0	87.0	50.0	96.0	42 0	42.0	932.0
1962	33.0	0.4	58.0	69.0	92.0	232.0	41.0	107.0	67.0	0 0	62.0	66.0	827.4
1963	33.0	10.0	79.0	167.0	97.0	D	155.0	76.0	60.0	24.0	8.0	107.0	D
1964	27.0	56.0	77.0	121.0	245.0	20.0	88.0	115.0	80.0	34.0	2.0	73.0	938.0
1965	58.0	85.0	34.0	155.0	116.0	182.0	D	100 0	66.0	41.0	245.0	D	D
1966	D	D	D	D	D	D	D	D	D	D	D	D	D
1967	61.0	35.0	32.0	28.0	255.0	22.0	119.0	51.0	14.0	D	D	61.0	D
1968	27.9	68.5	18.2	46.9	34.0	64.8	83.8	81.2	217.4	44.3	91.7	55.2	843.9
1969	4 9	51.7	34.2	298.8	227.6	78.0	110 4	59.6	126.7	47.6	3.0	50.0	1092 5
1970	9.0	18.5	63.1	12.8	157.3	57.4	43.8	30.8	35.7	7.7	7.5	81.6	525.2
1971	48.1	24.5	26.2	11.9	62.7	9.9	163.0	192.5	104.3	73.0	42.0	107.8	865.9
1972	107.8												
1973		Abolished											

D: No record

Precipitation STATION Puerto Bertrand, DGA CATCHMENT AREA ____ sq km ____

RIVER, IN THE BASIN OF ____ ELEVATION ____ m UNIT mm S 47° 00' W 72° 50'

YEAR	Jan	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	ANNUAL
1961	D	D	D	D	D	D	D	D	D	D	129.2	80.0	D
1962	36.6	D	D	28.8	75.9	63.1	67.5	165.0	75.6	D	D	46.9	D
1963	167.5	D	D	241.2	241.6	82.7	42.0	59.9	63.8	9.3	52.8	166.0	D
1964	67.0	126.8	D	189.9	202.0	89.7	189.6	122.3	25.3	12.2	7.0	77.0	D
1965	101.0	121.2	47.0	170.5	182.4	205.8	176.9	130.4	213.5	91.7	227.7	24.8	1692.9
1966	47.3	48.3	237.0	64.5	177.6	28.3	106.9	94.8	54.8	34.3	34.5	82.1	1110.6
1967	124.1	D	D	69.1	366.3	161.1	217.8	293.5	54.4	84.6	147.5	165.9	D
1968	31.4	141.5	39.0	38.5	D	68.2	242.3	147.7	194.6	75.4	157.3	126.6	D
1969	31.4	65.7	23.3	356.2	233.4	113.0	132.8	161.1	210.8	135.4	22.0	52.4	1543.5
1970	44.2	100.2	135.9	120.6	D	194.7	61.4	82.4	144.6	15.9	2.6	172.4	D
1971	132.9	36.5	153.9	25.5	56.3	117.8	323.2	292.1	241.3	92.4	182.7	80.1	1734.7
1972	219.5	175.3	107.7	128.6	46.4	124.3	14.0	22.2	145.5	7.1	1.0	172.4	1164.3
1973	132.9	36.5	23.9	104.1	156.0	173.4	84.9	326.9	103.0	12.4	95.4	66.6	1316.0
1974	158.8	70.2	98.9	157.9	82.4	135.2	217.7	275.8	89.6	66.3	100.1	51.7	1506.1
1975	27.3	77.1	39.7	115.7	52.1	147.5	75.7	256.7	137.9	66.8	114.7	69.4	1180.6
1976	142.5	102.1	87.3										

D: No record

(2) Topographical map

(i) Scale : 1/500,000
Prepared by : Instituto Geografico Militar in 1972
Coverage : Entire area of the Aisen Province

(ii) Scale : 1/250,000
Prepared by : Instituto Geografico Militar during 1950/1953 period
Coverage : Entire area of the Aisen Province

(iii) Scale : 1/20,000
Prepared by : ENDESA in 1975
Coverage : Baker and Pascua River basin (except a part of the tributaries)

(iv) Scale : 1/2,000
Prepared by : ENDESA in 1975
Coverage : Proposed sites of dams and power plants

(3) Aerial photographs

(i) Scale : 1/60,000
Prepared by : USAF in 1974/1975
Coverage : Baker River basin

(ii) Scale : 1/14,000
Prepared by : SAF in 1974
Coverage : Baker River basin

(4) Reports and other materials

(i) "Proyecto de Desarrollo Hidroelectrico de Los Rios Baker y Pascua", prepared by ENDESA.

(ii) "Produccion y Consumo de ENDESA en Chile", prepared by ENDESA in 1974.

(iii) "Atlas Escolar de Chile con la Microregionalizacion del Pais", prepared by Instituto Geografico Militar in 1976.

(iv) "Atlas de la Republica de Chile", prepared by Instituto Geografico Militar in 1970.