REPUBLIC OF PERU

CORPORACION DEPARTAMENTAL DE DESARROLLO DE TACNA

(CORDETACNA)

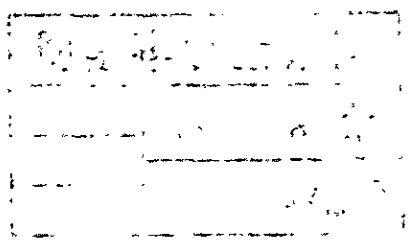
FEASIBILITY REPORT

ON

WATER SUPPLY TO THE LAKE ARICOTA

AND

ARICOTA No. 3 HYDROELECTRIC POWER DEVELOPMENT PROJECT



DECEMBER 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

国際協力事業団
受入月日 '84. 3. 26
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PREFACE

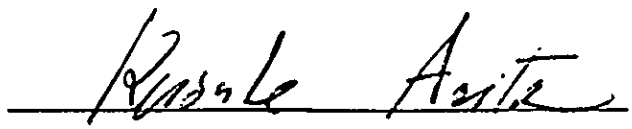
In response to the request of the Government of the Republic of Peru, the Government of Japan decided to conduct a Feasibility Study on the Water Supply for the Lake Aricota and the Aricota No.3 Hydroelectric Power Development Project and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Peru a survey team headed by Mr. Toshio Enami from October 15, 1982 to March 25, 1983.

The team exchanged views with the officials concerned of the Government of Peru and conducted a field survey in the Lake Aricota related area in the southern part of Peru. After the team returned to Japan, further studies were made and the present report has been prepared.

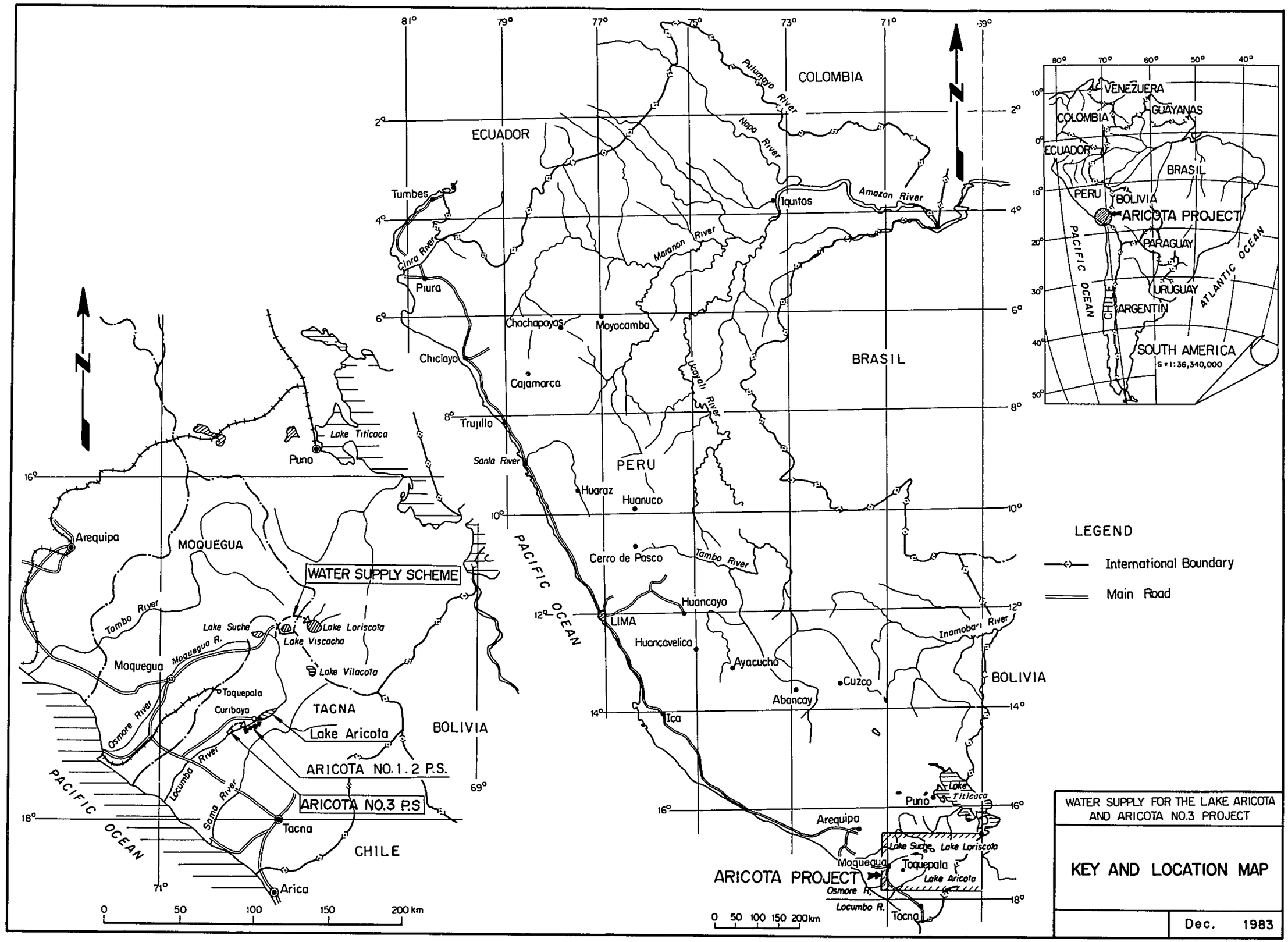
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

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

Tokyo, December 1983



Keisuke Arita
President
Japan International Cooperation Agency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Napo River
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Ucayali River
Tumbes
Iquitos
Piura
Chachapoyas
Moyobamba
Chiclayo
Cajamarca
Trujillo
Santa River
Huaraz
Huanuco
Cerro de Pasco
Tambo River
Huancayo
LIMA
Huancavelica
Ayacucho
Cuzco
Abancay
Ica
Inamabari River
Lake Titicaca
Puno
Arequipa
MOQUEGUA
WATER SUPPLY SCHEME
Tambo River
Lake Suche
Lake Viscacha
Lake Loriscota
Lake Vilacota
Moquegua
Moquegua R.
Toquepala
Curibaya
Osmore River
TACNA
Lake Aricota
ARICOTA NO.1.2 P.S.
ARICOTA NO.3 P.S
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Sama River
Tacna
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Locumbo R.
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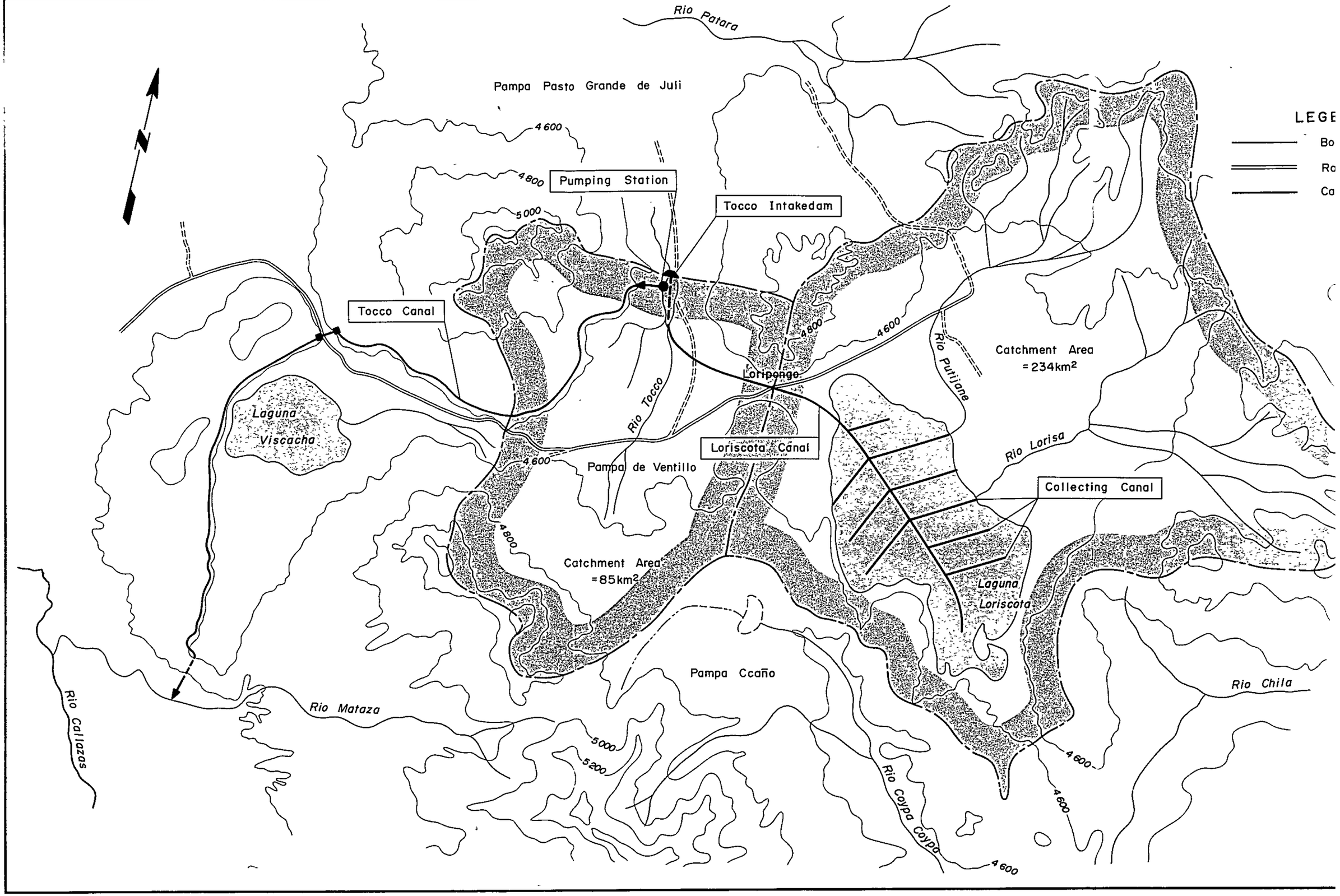
WATER SUPPLY FOR THE LAKE ARICOTA AND ARICOTA NO.3 PROJECT
KEY AND LOCATION MAP
Dec. 1983


Rio Patara
Pampa Pasto Grande de Juli
4600
4800
5000
Pumping Station
Tocco Intakedam
Tocco Canal
Laguna
Viscacha
Rio Tocco
Loriponge
4800
4600
Rio Putilane
Catchment Area
=234km²
Loriscota Canal
Pampa de Ventillo
Rio Lorisa
Collecting Canal
4600
4800
Catchment Area
=85km²
Laguna
Loriscota
Pampa Ccaño
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Rio Mataza
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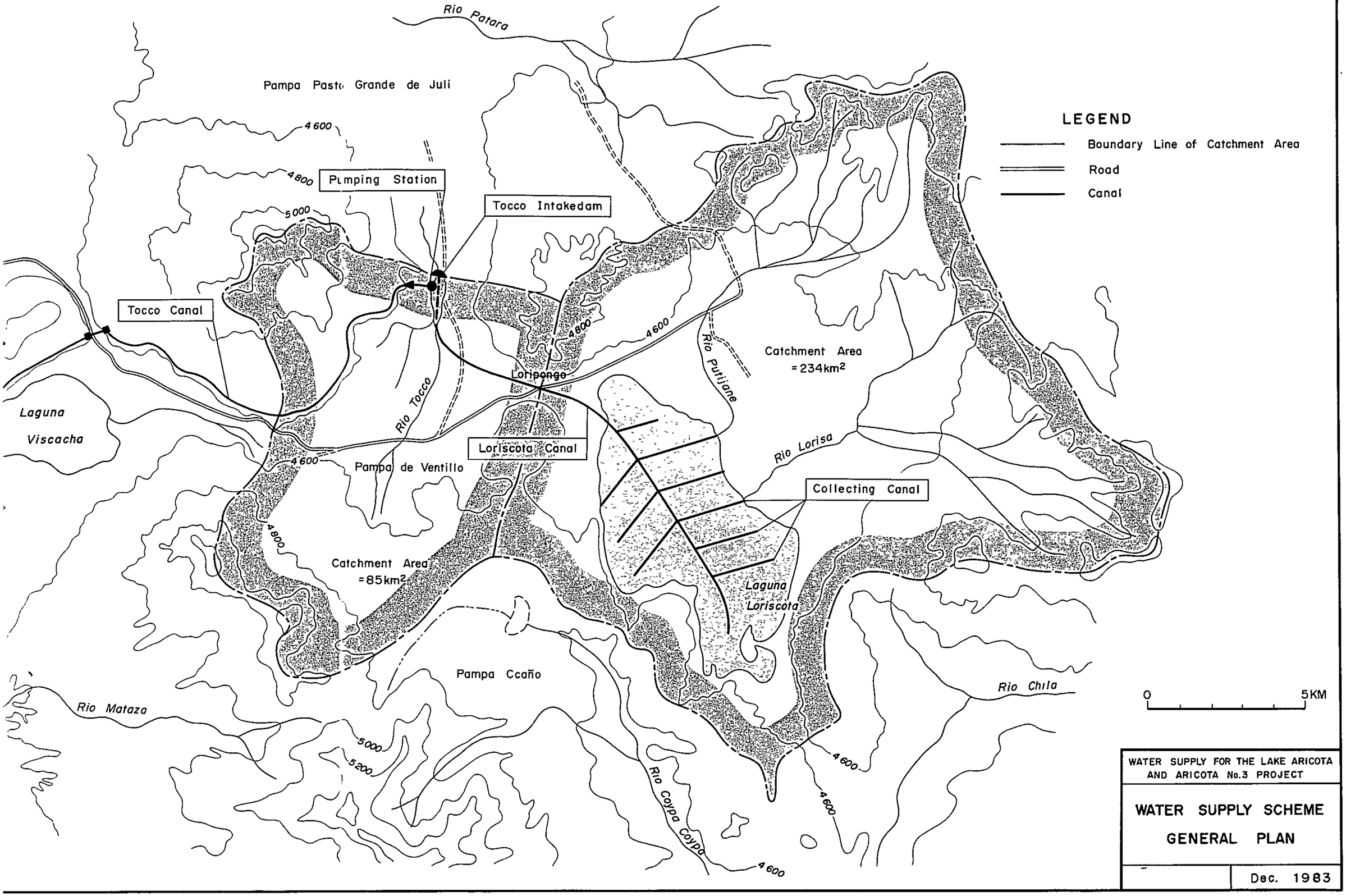

WATER SUPPLY FOR THE LAKE ARICOTA AND ARICOTA No.3 PROJECT

WATER SUPPLY SCHEME GENERAL PLAN

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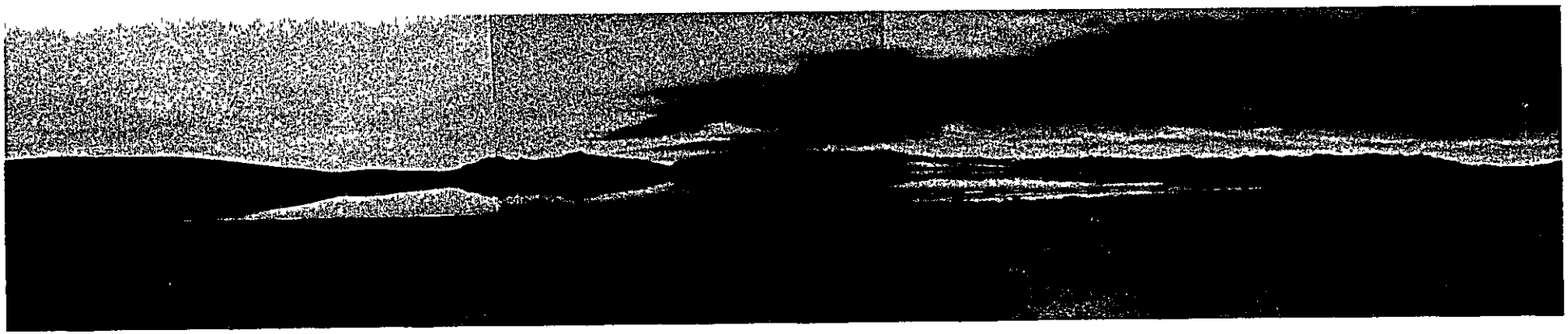
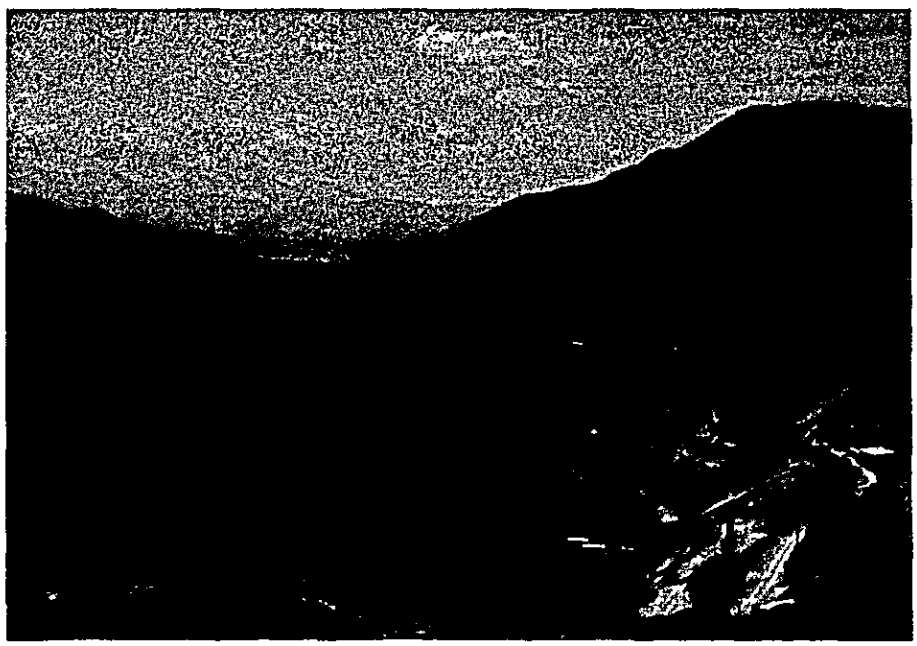
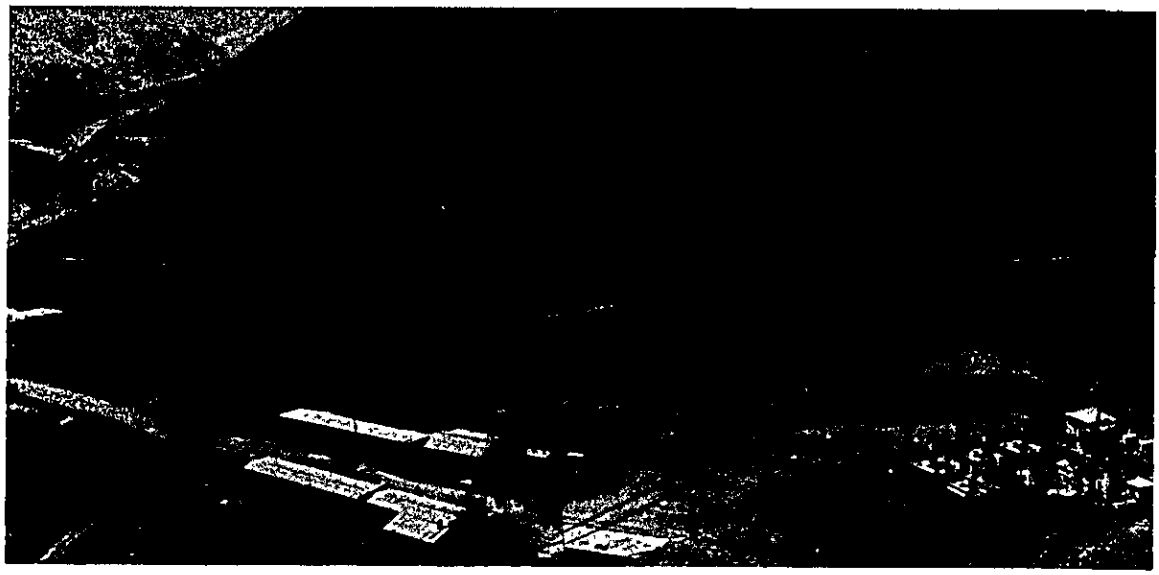


LAGUNA LORISCOTA

TOCCO DAM SITE VIEWED FROM DOWNSTREAM



LAGUNA ARICOTA AND EXISTING PUMP STATION



ARICOTA NO.3 INTAKE DAMSITE VIEWED FROM LEFT BANK

ARICOTA NO.3 POWER STATION SITE

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CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

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CHAPTER 1 INTRODUCTION

1.1 ANTECEDENTS

(1) Background and Antecedents of the Survey

The southwest region of Peru where this Project is situated has an independent electric power system and electric power demand has increased up to this time at an annual rate of approximately 12%. The supply capability of the Aricota-SPCC System in 1982 was 146.8 MW with the ratios of 24 % for hydro, and 76% for thermal. In recent years, with the situation in supply and demand regarding petroleum having become tight, it has been estimated that there will be no more surplus for export in around 1985. The Government of Peru has made it a fundamental policy of new development to restrict electric power development based on petroleum as fuel insofar as possible, giving priority to hydroelectric power development. In this region, there are Aricota No. 1 and No. 2 Power Stations which were completed from 1966 to 1967 with the cooperation of Japan, and electric power is being supplied utilizing the water of Laguna Aricota. However, because of power supply to Departamento de Tacna and use for irrigation for many years, the situation faced is that the lake water will become exhausted around 1987. Therefore, it has become necessary for water supply to Laguna Aricota to be realized as soon as possible to secure irrigation water and carry out power supply by constructing Aricota No. 3 Power Station. The Government of Peru, in view of the fact that the project area is in a remote border region where emphasis had been placed in the past on economic development for stabilization of the people's livelihood, decided to promote the Project on an urgent basis, and in March 1982 requested the Government of Japan for technical cooperation regarding a feasibility study on the Project.

In accordance with this request, the Government of Japan decided on a policy of cooperation and commissioned the Japan International Cooperation Agency (JICA) to carry out a survey.

JICA, in June 1982, in order to study the method of implementing the survey, dispatched a preliminary survey mission consisting of six specialists to the field.

Taking into account the results of the preliminary survey, JICA dispatched to Peru a Feasibility Study Survey Mission consisting of specialists from the Electric Power Development Co, Ltd. (EPDC) from the middle of October 1982 to the end of March 1983 to carry out the necessary field investigations.

The Survey Missions based on the investigations in Peru consisting of field investigation works, field reconnaissances, data collection and discussions with the agencies involved on the Peruvian side, carried out analyses work in Japan, and for one month from the middle of July 1983, explained to the Peruvian agencies regarding selection of the basic plan for water supply to the lake from among a number of alternatives. This Study Report has been prepared based on the abovementioned field investigations, works in Japan, and coordination of opinions with persons concerned on the Peruvian side.

(2) Antecedents of Aricota No. 1 and No. 2 Hydroelectric Power Projects

In December 1959, the Government of Peru requested the Government of Japan for technical cooperation concerning the electric power development program in Peru. In response to this request, it was decided that the Overseas Electrical Industry Survey Institute, Inc. would carry out investigations on i) an electric power development project at the Pongo site on the Rio Mantaro, ii) a comprehensive development program for Departamento

de Tacna, and iii) other matters.

In August 1960, the abovementioned Survey Institute prepared a survey report mainly on the Río Mantaro Development Project, and as a result of discussions with the Peruvian Government, co-operation was requested regarding the Comprehensive Development Program for the Departamento de Tacna. In response to this request, EPDC, in March 1961, started on a preliminary survey concerning electric power development schemes for the Río Maure and Laguna Aricota systems. In succession to the above, a basic contract with the Corporación de Fomento y Desarrollo Económico del Departamento de Tacna (COFDET) was concluded in April 1962, and consulting engineering works were carried out on detailed designs, furnishing of mechanical equipment and materials, execution of construction work, loans of funds required for implementation, and supervision of works concerning power generation projects utilizing the water resources of Laguna Aricota and other sources, and irrigation projects at La Yarada and other areas. As a result, Aricota No. 2 Power Station (capacity: 11,900 kW) and Aricota No. 1 Power Station (capacity: 23,800 kW) were completed in August 1966 and January 1967, respectively, and since then, these have been operated as important power sources meeting the power demand of Tacna City and its surroundings in the southernmost part of Peru, with energy produced up to December 1982 having been 1,315 GWh.

1.2 PAST INVESTIGATIONS

Investigations and studies on plans for water supply for Laguna Aricota and Aricota No. 3 hydroelectric power development have been carried out by various agencies since 1959, but all have been of pre-feasibility study level.

The survey reports which have been prepared up to the present are the following;

(1) "Estudio de Reconocimiento para Irrigación, Mejoramiento de Riego y Aprovechamiento Hidroelectrio en Moquegua"
--Ingeniero Guillermo Banda Reyes, 1960.

Investigations and studies have been going on since 1948 to arrive at a plan to resolve the problem of water for the southern part of Peru, and this report is on one of the investigations and studies.

(2) "Estudio de Factibilidad de Irrigación del Valle de Moquegua"
--McCreary Koretsky Engineers, California, 1966.

This report describes a plan for diversion of water from the Pasto Grande site on the Río Viscachas to Departamento de Moquegua.

(3) "Report on Modified Second Stage Development of Plan Tacna"
--Electric Power Development Company (EPDC), Japan, 1972.

This survey report describes a plan for diversion of water of 2 m^3/sec from the Laguna Loriscota Basin, the Río Coypacoypa, Laguna Vilacota and the Río Yabroco in fountainhead areas in the Andes Mountain Range for supply to Laguna Aricota and construction of Aricota No. 3 (14 MW) and Aricota No. 4 power station (4.8 MW) downstream of Aricota No. 2 power station.

(4) "Investigación Desarrollo de Recursos Hídricos Subterráneas y Sistema Planificado de Producción para el Abastecimento de Agua" -- Southern Peru Copper Corporation (SPCC); 1974.

This survey report is on studies for securing water in connection with plans for new development of the Cuajone and Quellaveco mines and expansion of the Toquepala Mine all owned by SPCC.

(5) "Proyecto de la Central Hidroeléctrica de Coralaque" -- Ingeniero Tsuguo Nozaki, 1976.

This is a pre-feasibility report concerning a hydroelectric power development scheme on the Río Tambo.

(6) "Afianzamiento Hídrico de la Laguna Aricota" -Instituto Nacional de Investigaciones Energéticas (INIE), 1979.

This report is on a study of the plan to supplement the water of Laguna Aricota. There are two alternative plans with one of them having five variations.

(7) "Afianzamiento Hídrico de Aricota" -- (INIE y ORDETAM), 1980.

This report gives analyses and evaluations of the water problems of the Moquegua, Ilo and Locumba valleys, and of existing propositions.

(8) "Planeamiento del Sistema Eléctrico Interconectado, Sur-Oeste, Period 1981 - 1990" -- ELECTROPERU.

This report is on investigations and studies of electric power development in the southern part of Peru, and as a conclusion, development of Lluta hydro (210 MW) is given the highest priority, with Arequipa-Moquegua-Tacna interconnection to be hurried.

(9) "Afianzamiento Hídrico de Aricota, Estudio de Pre-Factibilidad" -- Minesterio de Agricultura, 1981.

This report describes securing of energy production at Aricota No, 1 and No. 2 power stations by conducting water

from the Loriscota Basin and the Pasto Grande site on the Río Viscachas, development of irrigation at the river systems of the Río Locumba flowing out from Laguna Aricota, and the Rio Moquegua, and the plan for supply of city water to Ilo City.

(10) "Informe sobre la Problemática y el Mejor Uso de los Ríos Tambo, Moquegua y Aricota" -- Comisión Multisectorial, 1982.

This report was prepared by a committee whose members were Peruvian Government officials, the members being from the Ministry of Agriculture, Ministry of Energy and Mines, ELECTROPERU, Ministry of Housing, and Border Area Agriculture Promotion Agency, the conclusions of the report being that taking the various past investigations into account and as a result of overall judgment, 1.78 m^3/sec should be alloted to Departamento de Moquegua and 1.44 m3/sec to Departamento de Tacna from Pasto Grande, while the Aricota No. 3 Hydroelectric Power Scheme should be promoted.

1.3 OBJECTIVES AND SCOPE OF THE SURVEY

1.3.1 OBJECTIVES

The purpose of this survey is a feasibility study of the scheme to divert water from catchment areas in the Andes Mountain Range for supply to Laguna Aricota to improve the capabilities of the existing Aricota No. 1 and No. 2 power stations to meet loads, secure irrigation water for the downstream area, and construct Aricota No. 3 power station. Accordingly, the objectives of the survey are to determine an optimum development plan, examine the possibilities for development from technical, economic and social viewpoints, and to combine the results in the form of a feasibility study report.

1.3.2 SCOPE

The scope of this investigation includes, as a water supply scheme, conduction of water from the sources in the fountainheads of the Río Chila, the Río Coypacoypa, the Loriscota Basin, the Río Tocco, and the Río Viscachas in the Andes mountain range, down Rio Mataza or the Rio De Calientes to Laguna Aricota, and as the Aricota No. 3 hydroelectric power scheme, downstream of the existing Aricota No. 2 power station, the construction intake facilities, headrace tunnel, head tank, penstock, powerhouse, tailrace, and related power transmission and transformation facilities for power generation. The survey reported here was carried out based on the Scope of Work agreed to between JICA and CORDETACNA on July 2, 1982, and the water supply plan utilizing groundwater in the upstream Andean area is not included in the survey.

1.4 FUNDAMENTAL PRINCIPLE OF THE SURVEY

(1) This survey is to be of feasibility study level with construction costs estimated for the point in time of the end of December 1982.

(2) Aricota No. 3 power station is to be connected to the Southwest System (Aricota - SPCC System) in the power system set-up of Peru, and is to serve mainly as a source of power for Tacna, Yarada, Locumba, Moquegua, Ilo, etc.

(3) Since it is expected that the water of Laguna Aricota will be exhausted several years hence, the plan for diversion of water from upstream areas is required to be completed at an early date.

(4) The terms of loans to be adopted for the financial analyses are to be based on government-to-government loans and loans from international financing institutions such as the World Bank.

1.5 ORGANIZATION OF SURVEY MISSION AND SURVEY SCHEDULE

The field investigations can be broadly divided as follows:

(1) Middle October 1982 - Early March 1983:

Determination of investigation works plan, execution of works, contracts with local contractors, and supervision of works including technical guidance

(2) Late January 1983 - Late March 1983:

Field investigations concerning feasibility study

(3) Middle July 1983 - Middle August 1983:

Interim explanations and economic survey

(4) Late November 1983 - Middle December 1983:

Explanation of draft of final report

The members of the Survey Mission and their assignments are listed below.

Name	Assignment	
Toshio Enami	Mission Chief	Electric Power Development Co, Ltd. (EPDC)
Isao Nakajima	Administrator of Field Investigation	- Ditto -
Susumu Tsunoda	Civil Engineering Design	- Ditto -
Kenji Kato	Hydrology	- Ditto -
Koji Mishima	Planning & Supervision	- Ditto -
Yoshiki Onoi	Construction Planning & Cost Estimation	- Ditto -
Tadashi Ogura	Power Transmission	- Ditto -
Fumio Wada	Electrical Engineering	- Ditto -
Hideji Kashiwagi	Geology	Kaihatsu Doboku Consultants, Inc. (KDC)
Tohru Murakami	Geology & Supervision	- Ditto -
Hirobumi Sato	Economics (General)	Electric Power Development Co., Ltd. (EPDC)
Masaru Hamada	Economics	- Ditto -

The Survey Mission prepared this report during the period from April to November 1983 based on data collected in the field

and discussions held with CORDETACNA, ELECTROPERU, INAF and other agencies concerned.

CHAPTER 2

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 2 CONCLUSIONS AND RECOMMENDATIONS

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CHAPTER 2 CONCLUSIONS AND RECOMMENDATIONS

2.1 CONCLUSION

The following conclusions were drawn as a result of investigations and studies regarding Water supply to the Laguna Aricota and the Aricota No. 3 Hydroelectric Power Development Project.

(1) Aricota No. 1 and Aricota No. 2 Power Stations which are major power sources for the South West Region of Peru were completed in January 1967 and August 1966, respectively, and since then had met the power demand of the region which has grown at a rate of approximately 12% annually, but exhaustion of the lake water has become imminent.

(2) According to the lake water utilization plan in the agreement signed between CORDETACNA, the Ministerio de Agricultura, and ELECTROPERU on November 18, 1982, the water level of the lake is scheduled to decline to EL. 2,740 m by December 1987, and the flow durations in the most recent years have been such as to indicate that this would be amply possible.

(3) Such a present situation is one constituting a crisis for securing of an electric power supply for the South West Region and of irrigation water for agriculture in the area downstream of Laguna Aricota, and as described in the Interim Report (July 1983), the Water Supply Scheme and Aricota No. 3 Hydroelectric Development scheme according to Alternative B-III must be implemented at an early date as soon as possible.

(4) It is considered there would be no difficult problems in particular in design and work execution concerning civil structures and electrical equipment in implementing the Project. With regard to the method of intake in the Laguna Loriscota Basin, according to the studies made based on data obtained up to the

present, it is considered that the plan to collect water at the lake bottom area after diluting and draining the present water would be the best method.

As for concrete methods of draining and of treating the lake bottom, it is judged that these can be adequately handled through the additional investigations and detailed designs to be made hereafter. The specifications planned for civil structures, electrical equipment, transmission lines, etc., of the Project are as given below.

a) Water Supply Scheme

i) Civil Facilities

Loriscota Canal	;	Including Collecting Canal,	L=32 km
Main Canal	;	Tocco Canal	L=30 km
Tocco Intake Dam	;	Rockfill Dam with Asphalt Concrete Facing	H=11.5 m L=135 m
Tocco Pumping Station	;	Semi-underground Type	
Pipe Line	;	Welded Steel Pipe	L=1.250 m ϕ=1.20 m

ii) Electrical Facilities

Motor	;	1,600 kW x 2, 3.3 kV
Transformer	;	4,500 kVA x 1, 69 kV/3.3 kV
Transmission Line	;	69 kV, 1 cct, 35 km

b) Aricota No. 3 Scheme

i) Civil Facilities

Intake Dam	;	Rockfill Dam with Asphalt Concrete Facing	H=5.0 m L=56 m

Waterway	;	Tunnel, Lined by Concrete or Shotcrete	L=7,245 m H=1.90 m B=1.70 m
Penstock	;	Welded Steel Pipe	L=819 m ϕ=1.40-1.20 m
Power Station	;	Semi-underground	

ii) Electrical Facilities

Turbine	;	Vertical Shaft, 4-Nozzles, Pelton Turbine 15,000 kVA x 4.60 m^3/sec
Generator	;	15,000 kVA x 1, 514 rpm, 60 Hz
Transformer	;	15,000 kVA x 1, 10.5 kV/138 kV
Transmission Line	;	138 kV, 1 cct, 8 km

(5) As seen from the condition of lake water utilization and electric power demand of Tacna City and its surroundings in the very near future, construction of the Water Supply Scheme must be completed by June 1987, and the Aricota No. 3 Hydroelectric Power Scheme by December 1987. For this purpose, the Water Supply Scheme must be started in July 1984 and the Aricota No. 3 Hydroelectric Power Scheme by July 1985.

The work schedule of the above is shown in Fig. 2-1.

(6) The total construction cost of this work is estimated to be US$67.4 million in terms of prices at the end of December 1982. Of this amount, the local and foreign currency requirements would be US$33.3 million and US$34.1 million, respectively. The funds required out of the above for the Water Suppy Scheme are US$18.5 million in foreign currency and US$19.9 million in local currency, or a total of US$38.4 million, while those for the Aricota No. 3 Hydroelectric Power Scheme are US$15.6 million in foreign currency and US$13.4 million in local currency for a total of US$29.0 million.

(7) The sum total of increased energy production obtained at the existing power station group through water supply to Laguna Aricota (annual average 1.66 m^3/sec) and the energy production obtained from the new power station as a result of implementation of the Project will be 155.0 GWh/yr. Furthermore, through this water supply and power generation discharge, irrigation water for approximately 3,000 ha spread out in the Locumba Valley and at Ite Norte, and a source of 0.5 m^3/sec for city water supply to Ilo City will be secured.

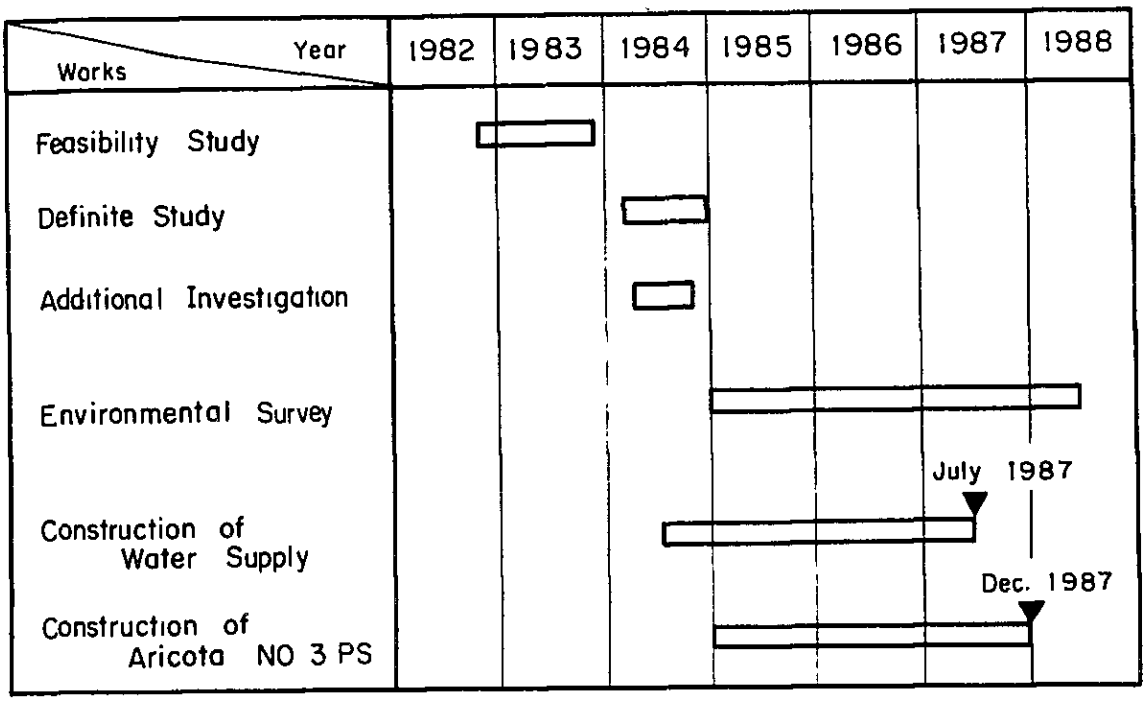
(8) On making an economic evaluation combining the increased energy production at the existing power station group, the energy production from the newly constructed power station, and irrigated farming in the downstream area utilizing power generation discharge, the economic internal rate of return of the Project will be 13.1%.

(9) A diesel power generating facility in the vicinity of Ilo City was assumed as an alternative facility to provide service equal to the electric power to be obtained from the Project. Combining the benefits of this and agriculture, the benefit-cost ratio (B/C) will be 1.53. The equalizing discount rate in this case would be 17.1%.

Consequently, the Project is amply feasible.

(10) Of the fund requirements, assuming that the foreign currency portion and the local currency portion would be respectively covered by government-to-government aid and loans from international financing institutions, on formulating a repayment plan based on electricity charge revenues only, the cumulative cash flow will show a surplus in 2004, the seventeenth year after actual start of operation, and the plan is reasonable from a financial point of view also.

Fig. 2-1 **Whole Schedule of the Project**



Note : ▼ Commencement of Operation

2.2 RECOMMENDATIONS

Based on the "Conclusions" of the preceding section, the following are recommended.

(1) Concerning the Construction Schedule

a) In view of the present state of water utilization at Laguna ARicota, the Water Supply Scheme must be implemented at an early date as soon as possible, with water delivered by July 1987 at the latest.

b) The Aricota No. 3 Hydroelectric Power Scheme, in order to meet the growth in power demand at Tacna City and its surroundings, must have construction completed and operation started in December 1987 at the latest.

c) In order to achieve the above goals, work must be started on the Water Supply Scheme in July 1984, and on the Aricota No. 3 Hydroelectric Power Scheme including preparatory works by January 1985.

d) For implementation of the plan, further investigations required, and detail designing including preparation of tender documents must be completed by the end of 1984. Meanwhile, since the construction period for the Loriscota waterway including the time required for dilution and drainage of Laguna Loriscota is 3 years, the fundamental study regarding Laguna Loriscota development, including additional investigations, should be carried out in as short a period as possible, with a part of contract work to be started in advance.

(2) Concerning Additional Investigations and Detail Designing

a) With regard to additional investigations required in order to be able to carry out detail designing, topographical surveying, geological explorations by pits and boring in the Loriscota and Tocco basins, and investigations of lake bottom materials of Laguna Loriscota should be considered as main.

b) In particular, it will be necessary to continue hereafter with studies on the outflow pattern of the Loriscota basin after drainage, the corresponding water collection facilities, and lake bottom treatment. Accordingly, the analyses of groundwater investigations, and supplemental investigations presently being carried out by CORDETACNA in upstream areas should be concentrated on the Loriscota and Tocco basins.

c) The construction method to be adopted for the waterway at Loripongo, based on additional investigations data, must be such that construction can be done economically in the shortest possible time.

d) Prior to dilution and drainage of Laguna Loriscota, investigations should be carried out for a year or two on water quality and runoff of the Rio Tambo, and irrigation water intake at the downstreammost part, as well as the states of agriculture and fishing. The drainage schedule must be studied in detail based on these investigations.

e) The present condition of the river channel of the Rio Callazas downstream of the Rio Mataza which will be adopted as the water conduction route must be studied in detail. Particularly, thorough adjustments must be made, including methods of control, with regard to the irrigation water presently being diverted to Coranchay and Cairani.

CHAPTER 3

DEVELOPMENT PLAN

CHAPTER 3 DEVELOPMENT PLAN

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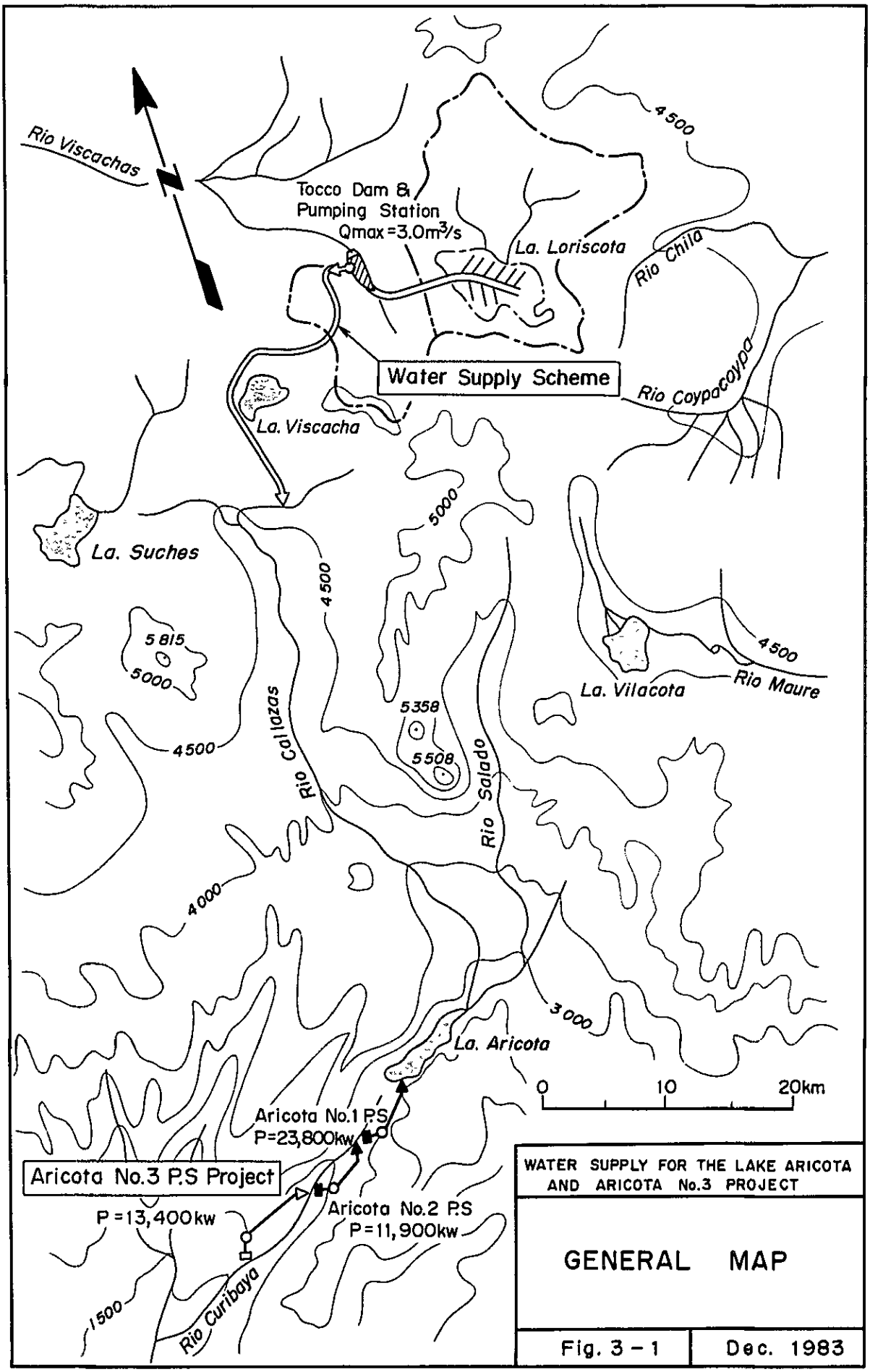
FIGURE LIST



WATER SUPPLY FOR THE LAKE ARICOTA AND ARICOTA No.3 PROJECT

GENERAL MAP

Fig. 3 – 1 | Dec. 1983

CHAPTER 3 DEVELOPMENT PLAN

3.1 LOCATION AND OUTLINE OF PROJECT AREA

3.1.1 LOCATION OF PROJECT AREA

The Laguna Aricota Water Supply Scheme and Aricota No. 3 Hydroelectric Power Scheme consists of supplying an annual average 1.66 m^3/sec of water from the Loriscota Basin and the Río Tocco in the Andes Mountain Range plateau area in Southern Peru to Laguna Aricota approximately 60 km south, and to construct Aricota No. 3 Power Station approximately 7 km downstream of Aricota No. 2 Power Station which was completed in August 1966 to obtain an output of 13,400 kW.

The project straddles Departamento de Puno and Departamento de Tacna in the southern part of the Republic of Peru, and Laguna Aricota, the focal point of the Project, is a natural lake in the vicinity of 17°21'south latitude, and 70°17' west longitude. This region is bounded on the southwest and east by the Republic of Chile and the Republic of Bolivia, respectively, and the distance from the project site to the closest point on the Chilean border is approximately 60 km in the southeast direction.

3.1.2 OUTLINE OF PROJECT

(1) The geographical features of the Republic of Peru are that the Cordillera Occidental, Cordillera Central, and Cordillera Oriental which make up the Andes Mountain Range run north-south roughly parallel to the coast line, by which the topography is divided into the Costa, Sierra, and Selva.

The project area is spread from a plateau area of elevation 4,500 m which is the western slope of the Sierra down through a transition area to an elevation of 1,300 m.

(2) The plateau area where the Water Supply Scheme is located is a plain (arid land) of elevations from about 4,000 m to 4,500 m, where lakes and swamps such as Laguna Loriscota (EL. 4,549 m), Laguna Viscacha (EL. 4,575 m), and Laguna Suches (EL. 4,450 m) exist. Tall mountains of EL. 5,000 to 6,000 m rise up around this plateau area. This area has an annual precipitation of 400 - 600 mm, and comprises the fountainheads of the Río Tambo, Laguna Aricota (Río Locumba), the Río Ilave, etc. In this region, the Loriscota Basin of catchment area of 234 km^2 is a closed basin with no outflowing river, and it is thought the water balance is maintained by evaporation from the surface of Laguna Loriscota which holds slightly saline water. The Rio Callazas and Río Salado flow from the fountainhead area toward Laguna Aricota, and are sources of the Río Locumba.

(3) The Río Locumba, which is comprised of Laguna Aricota, the Río Curibaya, the Río Ilavaya and the Río Cinto, generally forms deep gorges in the transition area. On the Río Curibaya, there are indications of landslides and dammed lakes estimated to have been caused by earthquakes and volcanic activity in this area of rugged topography in geologic times. The present Laguna Aricota is seen to be one of these dammed lakes and the volume of water stored at a water level of 2,800.04 m in December 1982 is 430 x 10^6 m^3.

Aricota No. 1 and No. 2 Power Stations completed in January 1967 and August 1966, respectively, and which have been in operation since then, take advantage of the heads provided by the topography and the water resources of the natural lake. The Río Curibaya, whose runoff consists mostly of the power generation discharge of the two power stations, merges with the Río Ilavaya and the Río Cinto in the vicinities of Locumba to become the Río Locumba, which feeds the Pacific Ocean. There is practically no rainfall in the Costa. For example, it is less than 10 mm annually at La Yarada, The Río Locumba, including the Río

Callazas, flows down approximately 150 km from its fountainhead area, and including tributary basins, has a catchment area of about 5,700 km^2.

3.2 OUTLINE OF DEVELOPMENT PLAN

3.2.1 ANTECEDENTS

(1) The results of study of basic plans concerning the Water Supply Scheme have been given in the interim report (July 1983). In effect, studies were made up of Alternative A in which a reservoir would be built at Pasto Grande and water distributed by the Moquegua Gorge and the Laguna Aricota Water Supply Scheme, Alternative B in which the Loriscota Basin is made the principal water source and water is conducted to Laguna Aricota via the Rio Callazas, and Alternative C in which the route of water conduction in Alternative B is changed to the Río Salado. As a result of discussions based on the three basic plans, it was decided to adopt B-III which would use the Loriscota Basin and the Río Tocco as the sources for water intake.

(2) Regarding the Aricota No. 3 Hydroelectric Power Scheme, in "Report on Modified Second Stage Development of Plan Tacna, 1972," basic studies were made on five cases concerning waterway route, power station location, output, etc. Here, a study will be made based on Alternative III-C which was considered most advantageous in the abovementioned report. This is a plan for performing intake from the tailrace of Aricota No. 2 Power Station, conducting the water for approximately 7 km along the right bank of the Rio Curibaya and providing a power station at Chulibaya.

3.2.2 LAGUNA ARICOTA WATER SUPPLY SCHEME

(1) This project consists of a plan to draw the water resources of the Andes plateau area and conduct the water to Laguna Aricota

approximately 60 km distant utilizing an intake dam, pumping station, waterways and natural rivers. The objective of this is to supply water to Laguna Aricota which is beginning to rapidly dry up, thereby securing water for power generation at Aricota No. 1 and No. 2 Power Stations presently in operation and for irrigated farmland spread out along Locumba Valley.

(2) An annual average volume of 1.66 m^3/sec would be collected from the Loriscota Basin (catchment area: 234 km^2) after draining Laguna Loriscota (approximately 70 x 10^6 m^3) which holds water unsuitable for irrigation, and the Río Tocco (catchment area: 85 km^2) which is one of the rivers upstream of Pampa de Pasto Grande. These two basins which are separated by the low hills at Loripongo must be connected by an excavated waterway or other suitable means. The open canals for water collection at the lake bottom area, the excavated waterway at Loripongo, and the waterway to the intake dam site on the Río Tocco are to have gradients of 1/3,000, and the volume of earthwork is estimated to be a maximum of 1.4 x 10^6 m^3.

The Maure and Capillune Formation formed in the Late Tertiary, and comprised of lacustrine-deposited conglomerate-siltstone covering the area of water collection are extremely good aquifers, but since investigations concerning safety yield, and the relation with surface water, etc., are not adequate, they will not be considered as sources this time.

(3) An intake dam is to be constructed on the Río Tocco approximately 4 km northwest from the Loripongo site (northwest shore of Laguna Loriscota). The dam considered would have a height of 11.5 m and a crest length of 135.0 m and be of a scale that there will be practically no regulating capacity. The reasons for this are i) the backwater from a high dam would go back as far as Laguna Loriscota, and this may affect water collection at the old lake bottom, and ii) in accordance with the runoff duration, a

pumping facility for pump-up approximately 80 m to the headrace will be amply possible from an economic standpoint.

The capacity of the pumping station would be a maximum head of 85 m, maximum pump-up volume of 3.0 m^3/sec, and output of 3,200 kW.

(4) On gaining height through the pumping station and the pump-up pipeline of approximately 1,250 m, the water will pass the western shore of Laguna Viscacha by open channel to reach the Río Mataza. This waterway will require one inverted siphon and one tunnel each to be provided along the way. From the end of the waterway at the Río Mataza, the water will flow down approximately 60 km to Laguna Aricota by natural streams (Río Mataza - Río Callazas).

(5) Irrigated farming has been carried out for a long time at the Locumba Valley depending on seepage flow from Laguna Aricota and recharge flows from the Río Ilavaya and the Río Cinto.

This farmland was expanded further with the completion of Aricota No. 1 Power Station in January 1967, and the construction in succession of the irrigation facilities of Ite Norte.

At present, irrigation is being carried out on approximately 4,300 ha of farmland in the Locumba Valley and the Ite Norte district, and alfalfa, beans, capsicum, and potato are being cultivated. The implementation of the Water Supply Scheme will mean a stable supply of water to the irrigated farmland in the Locumba Valley, and assurance of a source in case of increasing the city water supply to Ilo of 230 ℓ/sec at present to 500 ℓ/sec.

3.2.3 ARICOTA NO.3 HYDROELECTRIC POWER SCHEME

An output of 13,400 kW would be obtained at Aricota No. 3 Power Station with the available head of approximately 400 m remaining downstream of Aricota No. 2 Power Station (Chintari) on the Río Curibaya (Río Locumba System) rising from Laguna Aricota.

Firstly, a regulating pond having approximately 6,000 m^3 as capacity is to be provided near the end of the tailrace of the No. 2 power station. Based on the results of investigations of the topography and geology it was judged advantageous to construct a pool-type regulating pond having an asphalt facing.

From here, the water would go through an intake to be conducted to Chulibaya by a headrace tunnel to be provided at the right-bank side of the Río Curibaya. The scale of the tunnel would be a length of 7.2 km, height of 1.90 m, and width of 1.70 m, with the cross section a top-round, bottom-rectangular shape, and the maximum passage capacity would be 4.6 m^3/sec. According to surface reconnaissances and the records of construction of the No. 1 and No. 2 power stations, it should be possible for a simple method to be substituted for the tunnel lining where the geology is favorable.

The headrace tunnel would go to an open-type head tank and a exposed-type penstock of length of about 820 m to connect to a powerhouse of installed capacity of 13,400 kW. The powerhouse would be a surface type provided with one 15,000 kVA generator and a gantry crane, the principal specifications being height of 18.50 m, length of 16.00 m, and width of 13.00 m.

The power generated would be supplied through a newly constructed transmission line of approximately 8 km and voltage of 138 kV to an expanded switchyard to be provided a the No. 2 power station. From here the power is to be transmitted through

a 138 kV transmission line to the city of Ilo and 66 kV transmission line to the city of Tacna, respectively, to the loads of ELECTROPERU.

Table 3-1 Project Feature

Item	Unit	Feature
A. Water Supply Scheme		
1. River		Rio Putijane (Loriscota Basin) Rio Lorisa (") Rio Tocco
2. Catchment Area		
Laguna Loriscota	km^2	234
Rio Tocco	km^2	85
3. Collecting Canal		
Collecting Canal	km	20
Loriscota Canal	km	12
Slope		1 : 3,000
4. Tocco Intake Dam		
Type		Rockfill Dam with Asphalt Concrete Facing
Height	m	11.5
Crest Length	m	135
Water Level	E.L m	4,542
5. Pumping Station		
Type	m	Semi-underground
Pumping Head (Max.)	m	85
Output	kW	3,200
6. Pipe Line		
Type		All-welded Steel Pipe, Exposed
Length	m	1,250
Diameter	m	1.20
7. Tocco Canal		
Type		Open Canal
Capacity	m^3/sec	3.0
* Length	km	30
Slope		1 : 1,500
8. Increased Energy Production	GWh	84.19

* Length of Tocco Canal is including Inverted Syphon of 500 m and Mataza tunnel of 600 m

Item	Unit	Feature
B. Aricota No. 3 Scheme		
1. River		Rio Curibaya of Rio Locumba System
2. Pound		
Water Level	E.L m	1,749.50
Storage Capacity	m^3	6,000
3. Intake dam		
Type		Rockfill Dam with Asphalt Concrete Facing
Height	m	5
Crest Length	m	56
4. Headrace Tunnel		
Type		Top-round, bottom-rectangular Concrete or Shotcrete Lining
Length	m	7.245.35
Height x Width	m	1.90 x 1.70
Slope		1 : 800
5. Penstock		
Type		All-welded Steel Pipe, Exposed
Length	m	819.11
Diameter	m	1.40 - 1.20
6. Powerhouse		
Type		Semi-underground
Effective Head	m	357.00
Maximum Discharge	m^3/sec	4.6
Installed Capacity	kW	13,400
Energy Production	GWh	70.82

CHAPTER 4

POWER DEMAND FORECAST

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