PRELIMINARY REPORT ON THE DEVELOPMENT OF THE BAKER AND THE PASCUA RIVER IN THE REPUBLIC OF CHILE

June 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In October, 1974, the Government of the Republic of Chile requested the Government of Japan to dispatch experts to study the hydroelectric energy development in the State of Aysén.

The Japan International Cooperation Agency, in compliance with the decision of the Government of Japan sent two experts, Mr. Shigeru Ichiura and Mr. Toshio Enami, to the site from December 13, 1974 to March 12, 1975. During their sojourn in Chile they carried out technical survey, collected related information and exchanged views with the Chilean officials concerned.

This report was prepared by these experts in accordance with their own findings in Chile. I sincerely hope that this report will contribute to the advancement of electrification in Chile. On this occasion I avail myself to express my deepest appreciation to the officials concerned of the Government of Chile for their cooperation and hospitality extended to the experts.

June, 1975

Shinsaku Hogen
President
Japan International Cooperation Agency

REPORT ON THE DEVELOPMENT OF THE BAKER AND THE PASCUA RIVER

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REPORT ON THE DEVELOPMENT OF THE BAKER AND THE PASCUA RIVER IN THE PROVINCE OF AISEN

1. INTRODUCTION

In compliance with the request of the Government of Chile, the Government of Japan dispatched a mission consisting of two engineers, namely Shigeru Ichiura and Toshio Enami, who are specialized in hydro electric power engineering, in the middle of December, 1974 for three months to study power projects in the State of Aysén.

The Government of Japan has also assigned Tsuyoshi Nishimura who is now stationed in Santiago as a specialist of geology and is working as Professor at the Department of Geology, University of Chile for several years. Mr. Nishimura has travelled many times in the area of Aysén State during the past several years and is very much familiar with the topography, climate and specially the geology of the area.

2. THE PURPOSE OF THE MISSION

According to Form A.1 Application submitted by His Excellency, Mr. Roberto Kelly, Director de ODEPLAN, the Government of the Republic of Chile on 8 August, 1974 to the Government of Japan, the hydroelectric power experts are requested to prepare a report on hydroelectric potentials of the region (the State of Aysén) and possibilities of the generation of hydroelectric energy.

The mission was informed, after arrival at Santiago, that the hydroelectric power development in the State of Aysén assigned to the mission is confined to two major rivers in the area, namely the Baker and the Pascua.

3. THE WORK OF THE MISSION

The mission arrived at Santiago in the middle of December, 1974 and stayed mainly at the office of ENDESA which was kindly offered by the organization during the stay in Santiago, except during the field trip conducted in January, 1975 together with the officials of ODEPLAN and ENDESA. The trip was arranged by ENDESA, and accommodations and transportation facilities were also prepared by the organization.

a. Works in Santiago

The works in Santiago were mainly desk works, such as data collection: study of topography, hydrology, geology, existing reports, preliminary calculation and discussions with personnel of concerned specialities, etc.

The major works conducted in Santiago are as follows:

i) Scrutinizing of eleven year hydrology of the Baker and seven year record of the Pascua.

ii) Studies of the project by 1:250 000 and 1:500 000 scale topographic maps.
(1:250 000 map of the Pascua was not available).

iii) Studies of the following reports of the investigation works carried out by ENDESA
"Informe Sobre Posibilidades Hidroeléctricas en el Rio Baker (State de Aysén)" H.W./BHS 26.6.47.
"Planificación N°2. Informe. Estimación de los recursos hidroeléctricos de los ríos de la 6ª Región Geográfica" 22.3.55."
"Informe N°3/73 Recursos Hidroeléctricos del Rio Baker, Agosto, 1973"
The last report "Informe N°3/73", the latest report of planning of the Baker was especially useful for the Mission.

iv) Studies by air photographs of 1:35 000 and 1:8 000 scale which were made available quite recently.

v) Review of Cuenca del rio Baker en desagüe Lago Bertrand y en Colonia.

vi) Preparation of the preliminary report by the mission.

vii) Studies by the Pascua Report "Informe Interno de Sección Planificación Reconocimiento del rio Pascua-Enero, 1961".

b. Major places visited by the field trip group

During the field trip the mission could visit almost all places and sites which are necessary for the evaluation of the hydroelectric power potential, however some sites were impossible to perform close observation and inspection due to difficult and dangerous accessibility.
Major places visited by the field trip group are as follows:

i) Inspection of the Baker and the Pascua from the air by chartered "Sessna Skywagon 185" operated by Mr. Artidoro Leal who has flight experiences of several thousand hours in the Aysén area. (cf. Fig. I).

ii) Visits to the upper reaches of the Baker, including Chacabuco project dam site area, Bertrand gauging station, Chacabuco river basin, Tamango dam site (downstream alternative of the Chacabuco dam) by car and on foot.

iii) Visits to the Cochrane river and the Lake Cochrane.

iv) Visits to the Salton dam sites (upstream and downstream alternatives) on horseback and on foot.

v) Visit to the Las Heras dam site (the most downstream project) by boat.

c. Visits to existing hydroelectric power projects:

i) Rapel project on the Río Rapel

ii) El Toro and other 2 projects in the Río Laja basin.

4. PRESENT STATUS OF THE INVESTIGATION OF THE BAKER AND THE PASCUA RIVER

a. Topographic maps

1:500 000 scale, compiled by "Instituto Geografico Militar", primera edición 1972.
All catchment areas of both rivers are available.
1:250 000 scale

For the Baker all area is available.

For the Pascua, the main part is not available.

At the present stage, the largest scale available is only 1:250 000 maps which are not sufficient for practical planning of the hydroelectric power development, such as preliminary layout and design of the project and the estimate of the cost thereof.

ENDESA is now making 1.20 000 scale maps for the whole river courses and 1:2 000 scale for proposed sites of dams, utilizing air photographs of 1:35 000 scale and 1:8 000 scale combined with triangulation net works which provide exact locations and the heights of the triangles, for both the Baker and the Pascua.

These maps which will become available approximately by the end of coming August, would be most useful for the preliminary study of both rivers.

b. Hydrology

ENDESA has started river gauging operation since April–May, 1963, two on the Baker and one on the Pascua, and is planning to install another gauge near Salton to clarify the discharge of the Rio Ñadis.

Eleven year record is available for the Baker and seven year record for the Pascua.

These are very valuable data for the planning of the hydroelectric power projects of the two rivers. Of course, the more records the better, seven and eleven year records will be sufficient for the preliminary study, if the data are reliable.

We visited the Bertrand gauging station during our field trip and confirmed that the station is well equipped and maintained by the people who are living close to the station. Good care is also being taken by the observer in obtaining reliable gauging data.

Generally speaking the hydrology of the two rivers are exceptionally favourable to the generation of hydroelectric power, that means the flows of the Baker and the Pascua are very constant due to the fact that sources of these two rivers contain large natural lakes, namely Lake General Carrera and O'Higgins which naturally control favourably the discharge from the outlet of these lakes. In addition, many tributaries which feed the two rivers originate from the glaciers located near the rivers, give also comparatively constant discharge by ice melting water. However, the run-off of these tributaries are less constant than the lake flow, affected by rain and release of flushy water from blocked ice.

Though the flows from the lakes are notably very clear, the tributaries which originate from the glaciers contain certain silt of fine particles, and may carry sand and gravel during flushy floods. These data concerning silting and bed load are not available at present.

Efforts were made to find some correlation between river discharge and rainfall, however the records available reveal that the annual rainfall varies considerably from place to place as follows.

Table - 1 Average Annual Rainfall in the vicinity of the Region in mm

Balmaceda	600
Coihaique	1 200
Puerto Aisén	3 000
Puerto Ibanez	800
Chile Chico	250
Puerto Cristal	900
Bertrand	1 400

It would be almost impossible to find correlation between river flow and rainfall.

Table - 2 shows the approximate catchment area and estimated average flow of each key location of the Baker and the Pascua.

TABLE - 2 Hydrology of the Baker and the Pascua

The Baker,* Average of 1963/64 ~ 1973/74

Location	Catchment Area Km^2	Average discharge m^3/sec	Specific discharge $m^3/sec/100\ Km^2$
Bertrand Gauging Station	15 700	603.8	3.8
Chacabuco dam site	16 800	630.0	3.8
Tamango dam site	18 230	685.0	3.75
Colonia Gauging Station	23 820	884.0	3.7
Salton dam site	25 176	933.0	3.7
Las Heras dam site	26 950	1 000.0	3.7
Baker river mouth	27 150		

* Based on unrevised data, difference is practically negligible
(Average of Bertrand during 1963/64 ~ 1969/70 is 631.0 m^3/sec, 4.02 $m^3/sec/100\ Km^2$)

The Pascua, average of 1963/64 ~ 1969/70

Desagüe Lago O'Higgins	13 500	613.0	4.5
Pascua river mouth	14 200		

TABLE - 3 Average monthly discharge of the Baker and The Pascua

Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Average	
The Baker, Average of 1963/64 ~ 73/74 (11 years) m^3/sec													
679	679	643	558	499	453	441	496	616	688	735	706	599	At the outlet of Lake Bertrand 15 700 Km^2
The Pascua, Average of 1963/64 ~ 69/70 (7 years)													
819	777	694	557	440	385	358	401	540	695	821	867	613	At the outlet of Lake O'Higgins 13 500 Km^2

c. Geology

Geological investigations of the Baker and the Pascua areas are still in the preliminary stage. In the "Informe N°3/73, Agosto, 1973" no description is made concerning geology of the area, except an attached geological map of the Baker basin between Bertrand and El Saltón, the most important area for the hydro electric development in the Baker.

ENDESA is now in the course of improving the geological maps of the areas by the cooperation of the University of Santiago and the Institute of Geological Investigations, Government of Chile. Two teams are now conducting field research activities in the areas and these works will be completed soon. However, geotechnical investigations such as borings, seismic explorations or pit holes have not started yet According to the view of the geologist of the mission the gorge area in which the Chacabuco project is proposed is situated in the middle of a big fault zone and the possibility of unfavorable conditions for the construction of a large dam might be discovered after detailed geotechnical survey of the area, in addition the weathering of the rock looks rather advanced.

In this connection we are of the opinion that these field investigation works by engineering geologist are very urgent before final decision of the project planning.

General geology of the area however looks rather simple. In the upstream reaches old crystalline schist and young volcanic rock (andesitis) mainly covers the area.

This geological map shows that Chacabuco and Tamango projects in the upstream reaches of the Baker are located in altered andesitic rock of probably mesozoic, while the Salton area is completely exposed by unweathered, hard granitic rock. Especially, the rock at the proposed dam site near El Saltón will have sufficient soundness from an engineering point of view.

Neither sounding works to get information of the depth of water at dam site, nor the measurement of overburden near the axes of the dam sites have not been conducted.

These works are especially important for the estimation of the construction cost of the projects.

5 PLAN FORMULATION

a. General consideration

It goes without saying that the planning of the river basin development must be based on the so-called interdisciplinary approach from the beginning of the study, as the development of the water resources belongs to one of the most important policies in exploring the natural resources of the country.

In this connection the planning should aim at maximum overall benefit of the region and the utilization of water resources for various purposes, such as irrigation, navigation, flood control, hydroelectric power, water supply, preservation of natural beauty, wild life and archeological remains as well as recreation.

In the case of the Baker and the Pascua, however, purposes other than power generation would be much less important or negligible.

Due to the fact that only very limited population is living in the area, notably in the downstream reaches, there will be no necessity for flood control, in addition as already stressed, the flow of these two rivers are unusually uniform, therefore the variation of water level of the Baker and the Pascua is comparatively small, and will not cause harmful effects in the basin.

However, in the case of planning the location of industrial area near the river mouth, where the elevation of the terrain is very low, care must be taken in this respect.

No irrigation is conceivable at present and in the future in the basin.

There are some very small farms in the colonias irrigated by diverted river water, but most of these farms will be under water by building the proposed high dams. The rest of the above mentioned items are also of no important value and need no special attention, except the innundation of the town of Cochrane and surounding areas, because this town is a very important base for the construction and future maintenance and operation of the projects.

A good road along the Baker is under contemplation which will be very useful for the investigation, construction, maintenance and operation of the power projects in the area. This will also deny the necessity of navigation along the river course.

Concluding the above mentioned considerations, in the case of the Baker and the Pascua, it will be possible to develop these rivers exclusively for hydro electric power.

b. Planning of hydro electric power development (cf. Fig. -4)

i) The Baker River

The Baker is the largest river in the State of Aysén originating from Lake Bertrand a small beautiful lake at the outlet of lake General Carrera - Buenos Airés, which has a surface area of about 2 000 Km^2.

The approximate elevation of the lake is about 205 m above mean sea level. For the first 20 Km from its source, the Baker flows SSE, the slope of the riverbed is rather gentle,

and the water is perfectly clear, however, near the end of this flat part there is a few meters of drop, right after this drop the Rio Nef joins with the Baker. Downstream of the confluence with the Nef the flow of the Baker suddenly turns turbid.

This is the first tributary which joins the Baker on the right bank, there are two more major tributaries joining on the right bank, namely Rio de la Colonia and Rio Ventisquero, all these three rivers originate from large scale glaciers of "Cerro Calvo", about 3 000 m high located at the western part of the catchment.

On the other hand there are four major tributaries on the left bank of the Baker namely Rio Chacabuco, Rio Cochrane, Rio del Salto and Rio de las Ñadis. Rio Cochrane originates from the Lago Cochrane, discharging very clear water and there are a few beautiful water falls and cascades near the confluence with the Baker. The elevation of Lago Cochrane is approximately 154 m above sea level. On the Rio del Salto there are two falls and they have power potentials of about 15 MW.

As for the main stem, the river channel turns to the east just before the confluence with the Nef, during this course of about 15 Km the slope of the river is the steepest with an average gradient of 1:187. This portion of the river forms a deep gorge with both banks very steep and high. Its height is estimated at more than one hundred meters. By building about 60 m high dam (Chacabuco dam) in the gorge area the reservoir formed by the dam will easily reach as far as Bertrand. This is one of the proposed dam sites for upper Baker. Geologists explain that this gorge area is located on a big fault zone running from the east to the west.

After the confluence with the Chacabuco, the first left bank tributary, the main stem turns to the right nearly 90° flowing SSW until it reaches the Ocean.

For seven Km after the confluence with the Chacabuco, the river slope flattens to a gradient of 1:290, where the Tamango dam site is located, as an alternative of the Chacabuco dam. By building about a 100 m high dam, the reservoir created by the dam will reach to Bertrand.

After this point the gradient of the river becomes much flatter with an average slope of 1:1 400.

The length of the river channel for the first (steep) part is about 40 Km and the rest is about 130 Km, making about 170 Km in total.

The second dam site is located near Salton. There is another and the last rapid area on the main Baker at El Salton. Two alternatives are proposed, one in the middle of the rapid and the other at Puerto San Carlos where the Baker makes a big left turn.

As far as the head is concerned the two alternatives have only several meter difference at the most.

By building these two dams, namely Chacabuco or Tamango and Salton, nearly 80% of the total head will be utilized, as a result another project will be required in order to

use the whole head. The third and the most downstream dam site, named as Las Heras, is likely at twenty five Km upstream from the river mouth. However it will be impossible to utilize all remaining head of about 48 m, but roughly 39.5 m, about 82% of the remaining head, could be used for power generation. Total usable percentage to gross head will be about 95% if all three dams are constructed.

ii) Selection of alternative development projects

As mentioned in the previous section, there are two combined alternatives in the whole Baker, namely Chacabuco–High Salton–Las Heras series (a) and Tamango–Low Salton–Las Heras (b) series. (cf. Fig. - 2).

In order to get the maximum benefit from the power development it is indispensable to establish overall development plan or a basin plan first, not project by project basis, then select the first priority project not only from the economical point of view, but also technical, social and comsumers point of view must be taken into account.

The first work to do will be the selection of the series, however as the most downstream project Las Heras is entirely common to both series, we can lay aside the project and exclude the Las Heras in the comparison work of the series.

Unfortunately the state of investigation at present is not sufficient to compare the two series from economical point of view by estimating the cost of each project by laying out structures such as dams, waterways, surge tanks and power houses, because these structures entirely depend on the topography, geology, available construction materials and construction methods, while the electrical and mechanical machineries such as generators, turbines, transformers, control equipments, cranes, etc. are less dependent on the local conditions.

As mentioned in Section 4, topographical maps of sufficiently large scale which are indispensable to the layout and cost estimate of the project are in the process of compilation and are not available now and so are the geotechnical data.

It seems too risky to make some economical calculations based on incomplete data, because experiences show that many times economic comparison of alternatives is upset after accurate and detailed engineering data are made available.

Following are the opinions of the mission based on the available data and field inspection trip in the project area.

Comparison of the two series is listed as follows;

TABLE - 4

		a Chacabuco-High Salton Series		b Tamango-Low Salton Series	
		Chacabuco	High Salton	Tamango	Low Salton
Head water elevation	m	205.0	145.0	205.0	106.0
Tail water elevation	m	145.0	50.0	106.0	48.0
Gross head	m	60.0	95.0	99.0	58.0
Approximate loss head	m	2.0	8.0	2.0	4.6
Net head	m	58.0	87.0	97.0	53.4
Max. plant discharge	m^3/sec	820.0	1 180.0	860.0	1 170.0
Installed capacity (Out put)	MW	400.0	850.0	690.0	520.0
Average annual energy	GWh	2 660	6 000	4 830	3 620
Mean usable discharge	m^3/sec	655.0	950.0	685.0	933
Annual energy for 95% duration	GWh	2 360	5 500	4 130	3 320

		a Chacabuco-High Salton Series		b Tamango-Low Salton Series	
		Chacabuco	High Salton	Tamango	Low Salton
Height of dam	m	70.0	105.0	109.0	68.0
Total annual energy	GWh	8 660		8 450	
Total energy for 95% duration	GWh	7 860		7 450	
Total installed capacity	MW	1 250		1 210	
Total complete series					
Total installed capacity	MW	1 650		1 570	
Total annual energy	GWh	11 110		10 990	

GENERAL COMPARISON TABLE OF a AND b SERIES

TABLE - 5-1

Item of upper project	a Series, Chacabuco	b Series, Tamango
1) Geology of the dam site	Generally less favourable, due to the fault zone and weathering at Chacabuco.	Tamango is less weathered than Chacabuco.
2) Proposed type of upper dam	Concrete (due to narrowness of the channel and the rapid)	At Tamango rockfill dam may be preferable.
3) Materials for dam	Cement must be transported from Concepcion, concrete aggregate will be available in the area.	Materials for the Tamango rockfill dam will be obtainable in the vicinity.
4) Method of construction	Some difficulty may arise because of steep gorge, diversion will not be easy.	Less difficult, enough space for construction equipment and camp.
5) Accessibility	favourable	favourable
6) Spillway	Overflow type may be preferable.	Saddle portion on the left bank will be suitable for spillway
7) Power house	No favourable location near the dam, may be necessary to locate after confluence with Chacabuco.	Available near the toe of the proposed dam.
8) Reservoir	Area of the reservoir will be small.	Area will be much larger than Chacabuco because of the topography. Regulation of natural discharge and operation of the power plant will be easier.

TABLE - 5-2

Item of Lower Project	a Series, High Salton	b Series, Low Salton
1) Geology	Exactly same	Exactly same
2) Type of dam	Rockfill will be likely.	Rockfill will be likely.
3) Material for dam	Likely available.	Likely available.
4) Height of dam	About 105 m	About 68 m
5) Reservoir	Larger and easier for regulation and operation.	Smaller but no special problems.
6) Innundation	Elevation of the reservoir will be very close to Cochrane, possibly innundate part of it.	No innundation problem

According to the above study no decisive conclusion will be available, unless cost estimate based on more detailed data of topography and geology are made available. As far as the production of power is concerned "a" series will be superior because it utilizes more head at the down stream project, where more discharge of river is available. Of course this is one favourable factor to "a" series, but other items such as economical, technical and social factors should be taken into account for the final selection.

Concerning the installed capacity and annual power generation, it is pointed out that these figures are calculated by the average value of available discharge, therefore, for fifty percent of the years power production will be less than this value while for the rest of the years production will be more than that unless the river discharge is regulated by big, carry over reservoir.

In this connection annual flow duration curves and mass flow curves study based on daily flow and effective reservoir capacity is very useful.

The third or the most downstream project is the Las Heras. This project is located at the only likely dam site available between Salton and the river mouth.

The salient features of the project is as follows.

Head water elevation	EL 48.0 m.
Tail water elevation	EL 8.5 m (estimate)
Gross head	39.5 m
Approximate loss of head	4.5 m
Net head	35.0 m
Average discharge	1 000 m^3/sec
Plant discharge	1 250 m^3/sec
Installed capacity	360 MW
Annual energy generation	2 540 GWh

The economy of the project would be less than the two upstream projects due to the fact that during our field trip it was roughly estimated that the crest length of the Las Heras dam will be at least 1 000 m measured by eye-sight, and the overburden on the bed rock looks considerably deep.

As a result the main stem of the Baker river would have a total potential of approximately 1 600 MW of installed capacity and 11 000 GWh of average annual energy generation.

iii) The Pascua River

The Pascua is the second largest river in the province of Aisén located near the southern end of the province. The river originates from Lake O'Higgins–San Martin situated around the Chile–Argentine border with a surface area of about 1 000 Km^2. Inflow into the lake is also supplemented by many small lakes located between Lake O'Higgins and Cochrane of the Baker basin. Although the area of catchment and the main lake is smaller

than that of the General Carrera, the annual discharge of the Pascua is a little more than the Baker at the outlet of the lake, which is fed by the flow from many glaciers spread from "Campo de Hielo Sur" of 2 600 m high located on the western side of the lake. The total catchment area of the Pascua is approximately 14 200 Km^2, nearly half of that of the whole Baker and 13 500 Km^2 at the outlet of the Lake O'Higgins where a sole gauging station is located. (cf. Table - 2) Due to the poor accessbility to the river the investigation of the Pascua is far behind in that of the Baker, however quite recently a foot path has been completed along the left bank of the river, together with an air strip for small plane in the middle reaches.

The foot path was rather easy to build by enlarging or improving the old trail constructed by the first expedition party which had visited the area at the begining of the twentieth century.

The Pascua has about 40% more head than the Baker.

The elevation of Lake O'Higgins is at EL 285 m while the river course is only 60 Km long measured by the 1:500 000 scale map. (cf. Fig. - 3) This makes the average gradient of the river about four times steeper than the Baker. Average gradient of the Pascua is roughly 1:210, in addition the river makes a big turn to the left at Quetru where a base camp of ENDESA investigation team for the Pascua is located. The direct distance between Lake O'Higgins outlet and the ocean is only 30 Km.

Another different feature from the Baker is the vegetation of the basin. In the Pascua the area was not burnt during colonial development era, though it makes access and visibility more difficult, it works favourably to the hydrology of the river. In case of the Baker basin almost all flat lands as well as mountain slopes which were once thick jungle consisting of big trees were burnt by the colonialists. This could be verified by burnt remains of trees in that region.

The formulation of plan of the Pascua is less advanced compared to that of the Baker, due to more difficult accessibility and lack of basic data, however those necessary materials will be made available in a couple of months then the work must progress to a more advanced stage. Fig. 3 shows the profile of a tentative development plan of the Pascua which appeared in the ENDESA report.

No definite development plan is available at present, however, it would be quite in order to say that the Pascua is also a very good river having nearly the same order of hydroelectric power potential of the Baker, which is more concentrated in a confined area than the Baker. The potential is estimated to be at least 1 200 MW. As the topographical feature of the Pascua is quite different from that of the Baker the method and type of development will not be same with each other. However, even without sufficient engineering data it would not be an over-statement to say that the Pascua possesses abundant and cheap hydro power, if no special problem is disclosed later on.

6. CONCLUSIONS AND RECOMMENDATIONS

As previously mentioned, the present stage of the investigation of both rivers does not permit to conclude anything definitely. Our conclusions are as follows, subject to the condition that some parts of this section may be revised when more technical and other information are made available.

i) Conclusions

a. The Baker and the Pascua river located in the State of Aysén have hydro electric power potentials of roughly 1 600 MW and 1 200 MW of good quality having approximately 80 percent plant factor respectively. The annual energy generation would be about 11 000 and 8 400 GWh respectively.

b. The hydrology of two rivers is very favourable for generation of hydro electric power because the discharge of both rivers is regulated automatically by large natural lakes.

c. Both rivers could be developed exclusively for hydro electric power generation without taking into account other purposes.

d. Present stage of investigation does not permit to make economical comparison between two series of development plan of the Baker, and it is urgently needed to prepare necessary data to complete this work.

e. As the power projects of the two rivers look very promising, it is strongly advised to expedite the formulation of basin plans of each river and feasibility study of individual power project to make the best utilization of the water resources of both rivers.

f. Minimum single power installation of the Baker will be in the order of 200 MW, if the power plant is smaller than this size the unit cost of power will increase appreciably.

ii) Recommendations

a. To promote the above mentioned conclusions the following works should be done as soon as possible for the power projects.

To complete 1:20 000 scale topographic maps which cover all main stems as well as necessary parts of tributaries, tributary projects and proposed reservoir areas, as well as profiles of rivers.

To complete 1:2 000 scale maps of all proposed project sites and alternatives.

To complete geotechnical investigation for proposed dam sites, waterway routes, penstock and power plant, etc., by borings, seismic explorations, adits and tunnels if necessary.

The survey of cross sections, profiles of the proposed dam sites and their alternatives are urgently needed to lay out and to estimate the cost of the projects, together with the soundings of river channel and the measurement of the depth of overburden.

To make more detailed study of hydrology, concerning regulation of new reservoirs created by the dams, by way of mass curves.

b. In parallel with the above power engineering studies, survey for the posibility or suitability of the location of industrial plants should also be carried out.

In Aysén power development case, the power generated here will be utilized by some industrial plants only.

If the Aysén power is not interlinked with the other power net work, this is likely the case, the power generation is entirely connected with the industrial plants.

In this connection the power plants cannot be built without taking into account the industrial power load. On the other hand industrial plants cannot be planned without calculating the amount of generation and the cost of electric power, which are closely interrelated to each other.

As supplementary thermal power will be practically not available during dry periods, primary power of the projects should be studied carefully.

In other words the power supplier has to study the nature of the industrial power consumption whereas the industrial enterpriser has to check the nature and cost of power generation to make best utilization of available power.

c. More hydrological data must be collected together with measurement of suspended material in the river as well as the bed load of the river.

d. Measurement of seismic force should be started as soon as possible by installing seismographs at Cochrane. These data will be most valuable for the design of hydro electric power structures in this area.

e. There are still many basic investigations, design works and industrial planning works, before actual construction will be started, which cost a lot of money and will takes at least several years before the construction.

As the size of the power projects is considerably large and so is the investment, basic research works should be carried out sufficiently to clarify all problems concerning the development of power project, such espenses will pay in the long run.

7. ACKNOWLEDGEMENT

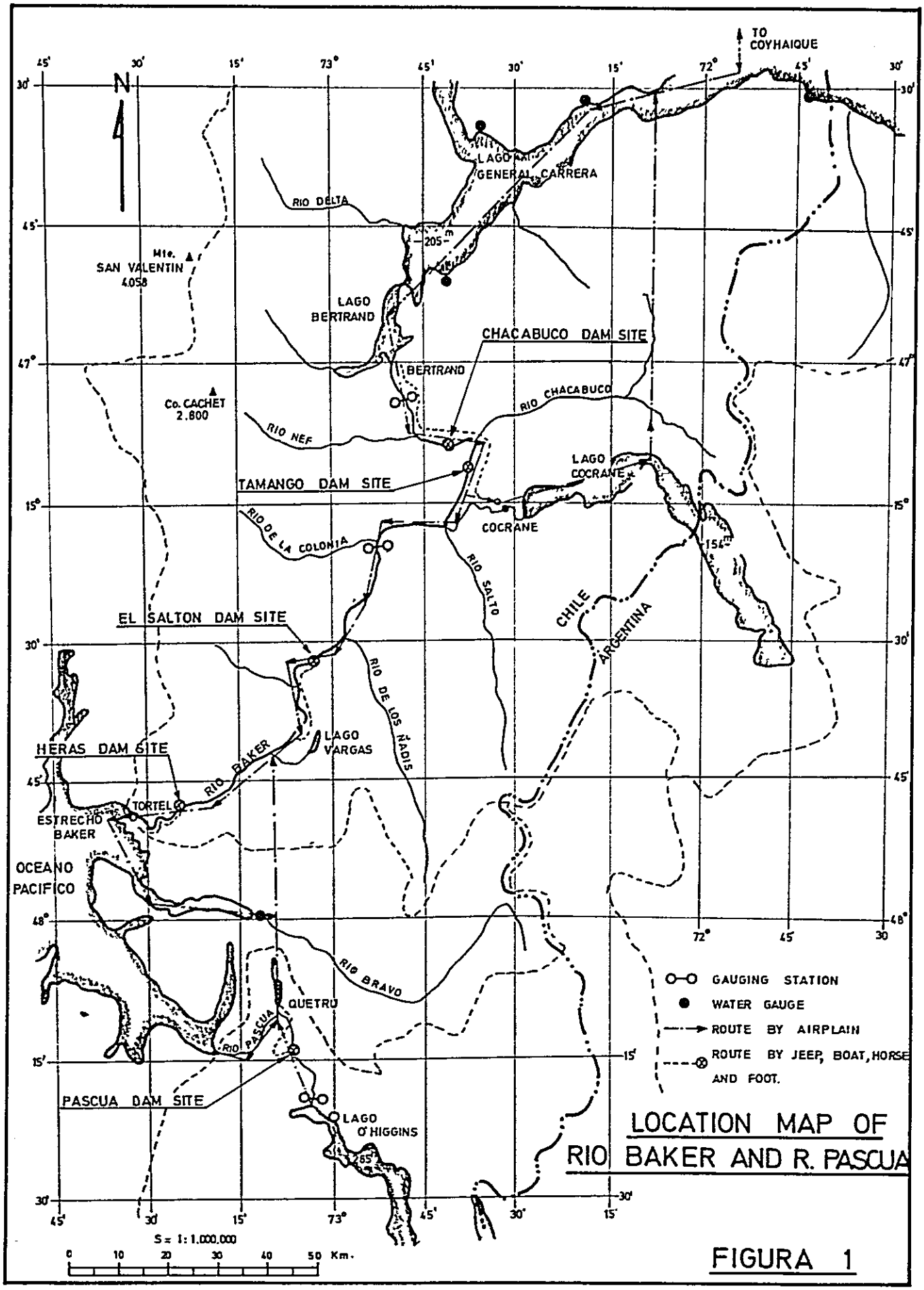
The mission would like to express its sincere thanks to the Government of Chile for the cooperation, hospitality and assistance extended to the mission. Especially to ODEPLAN for its general arrangement and custom clearance, and to ENDESA for providing office space equipped with a telephone extension, power plug and locker to keep stationaries and calculating machines, etc. All maps, hydrological data, engineering reports concerning the Baker and the Pascua rivers, and other reference materials were kindly prepared by ENDESA.

In addition a field trip to visit all key accessible parts of the Baker and the Pascua river projects including inspection flight to obtain a general picture of both rivers was carefully arranged by ENDESA. Although the project area is generally difficult to access, the trip was completed safely and successfully according to schedule, thanks to the unusually good weather.

The mission also acknowledge with thanks for the arranged visit to some of typical ENDESA hydro power plants such as the Rapel, El Toro, Abanico and Antuco projects which show

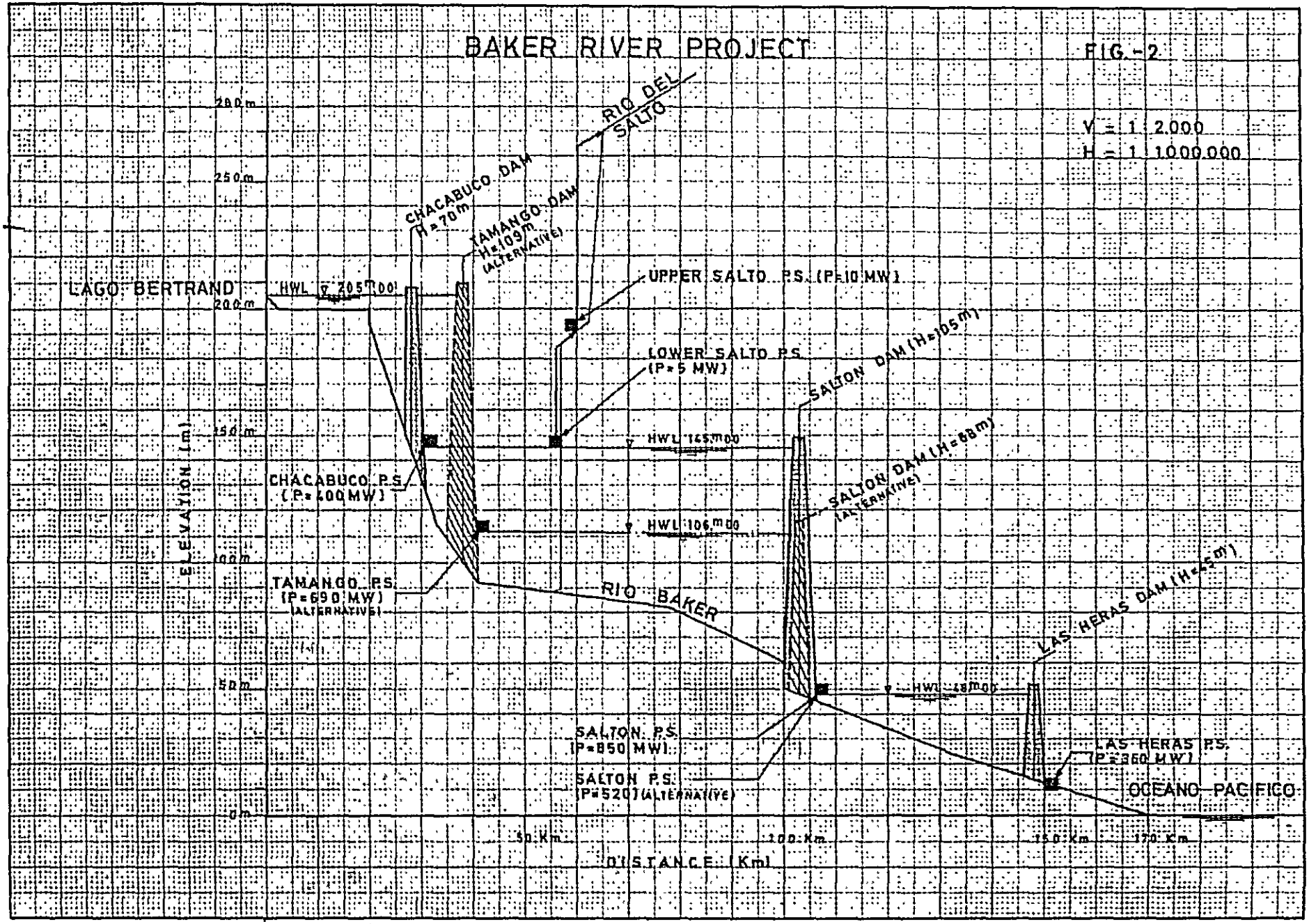
high level of standard in engineering achievements.

The mission is very much grateful to all arrangements which have made the three month stay of the mission in Chile pleasant and successful.



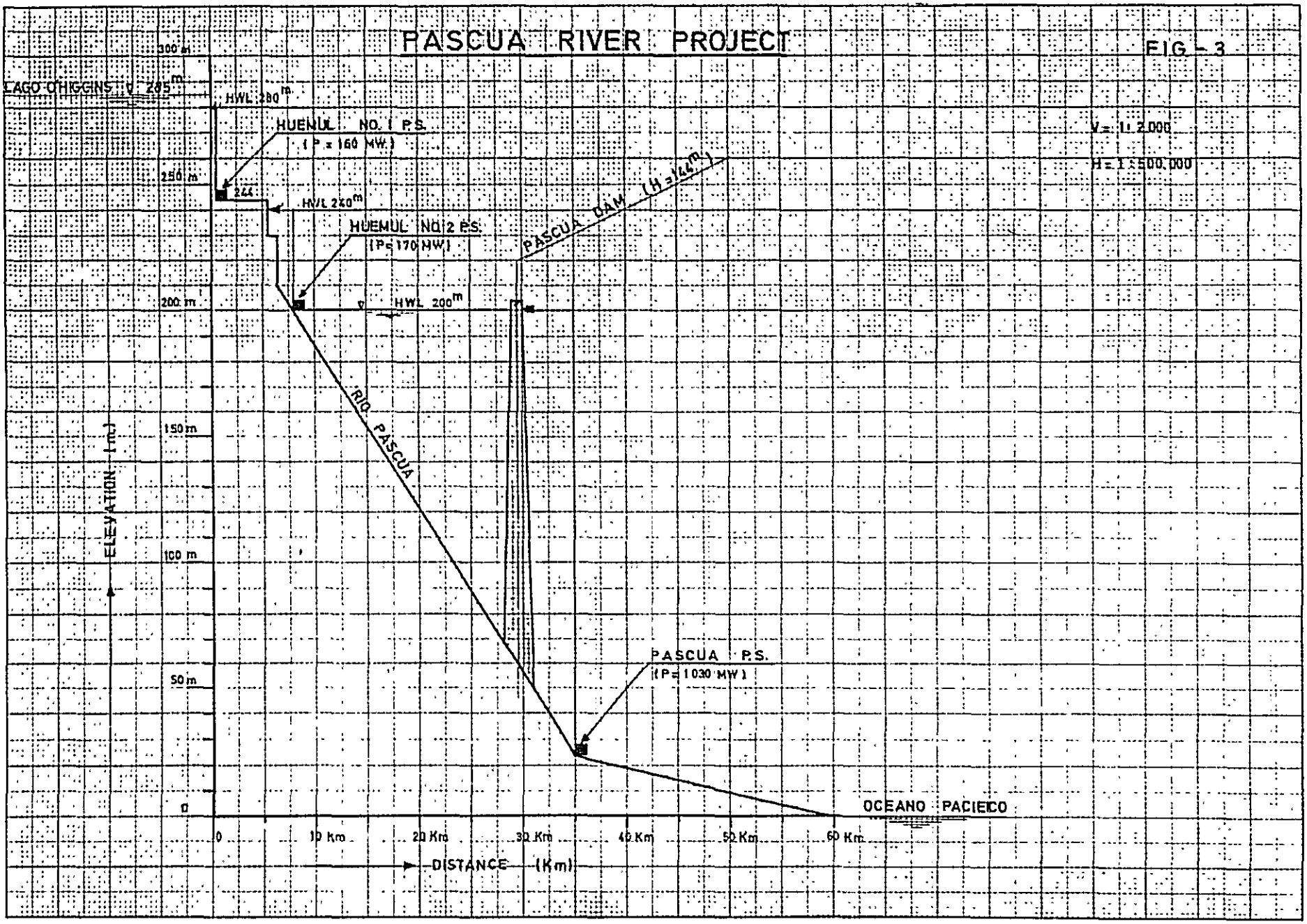
LOCATION MAP OF RIO BAKER AND R. PASCUA

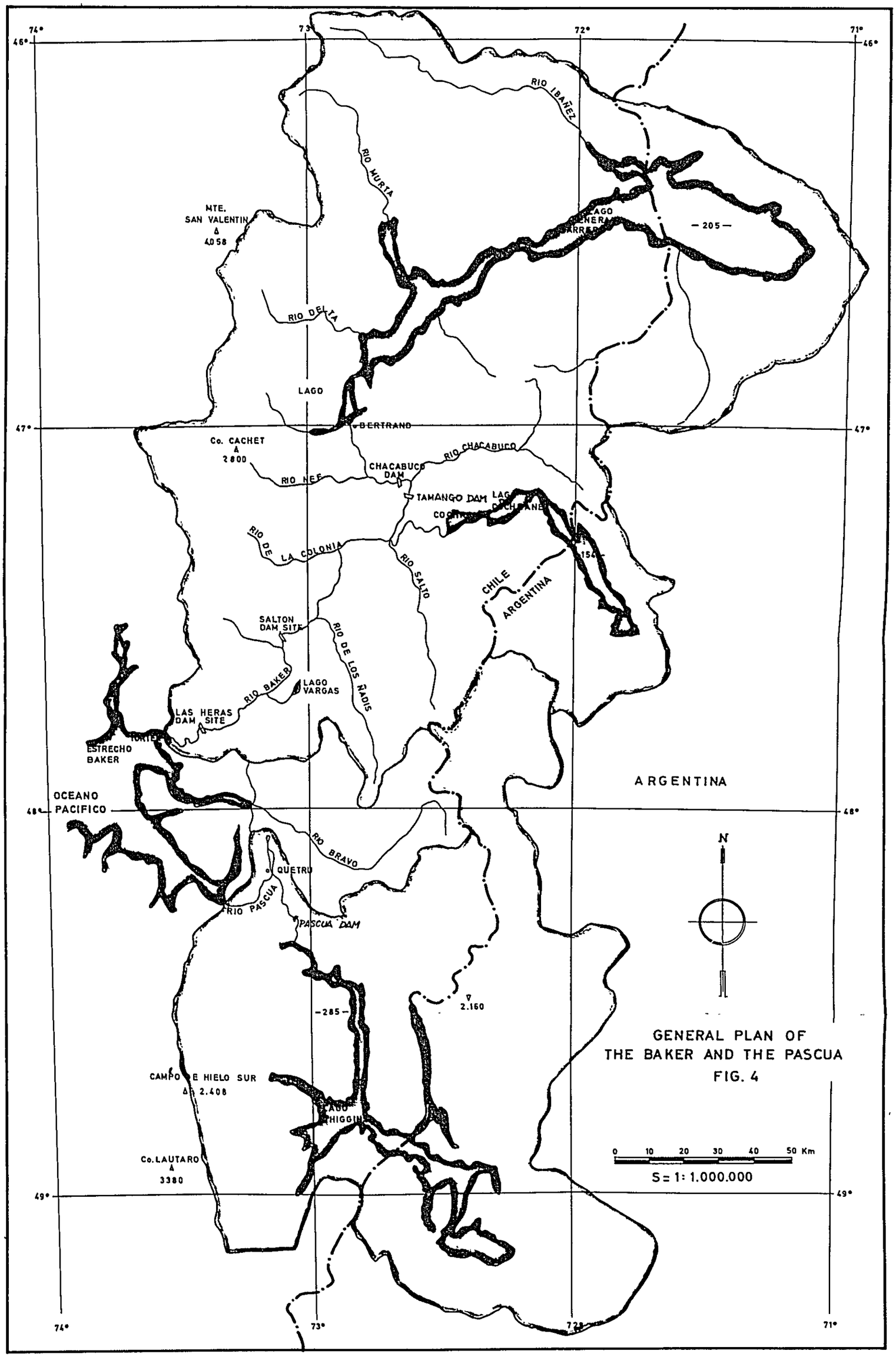
FIGURA 1


BAKER RIVER PROJECT
FIG.-2
V = 1 2.000
H = 1 1.000.000
RIO DEL SALTO
CHACABUCO DAM H=70m
TAMANGO DAM H=109m (ALTERNATIVE)
LAGO BERTRAND
HWL 205m00
UPPER SALTO P.S. (P=10 MW)
LOWER SALTO P.S. (P=5 MW)
SALTON DAM (H=105m)
HWL 165m00
SALTON DAM (H=88m) (ALTERNATIVE)
CHACABUCO P.S. (P=400 MW)
HWL 106m00
TAMANGO P.S. (P=690 MW) (ALTERNATIVE)
RIO BAKER
LAS HERAS DAM (H=45m)
HWL 48m00
SALTON P.S. (P=850 MW)
SALTON P.S. (P=520) (ALTERNATIVE)
LAS HERAS P.S. (P=360 MW)
OCEANO PACIFICO
ELEVATION (m)
200m
250m
150m
100m
50m
0m
50 Km
100 Km
150 Km
170 Km
DISTANCE (Km)

PASCUA RIVER PROJECT

FIG - 3





GENERAL PLAN OF
THE BAKER AND THE PASCUA
FIG. 4