THE REPUBLIC OF ECUADOR

FEASIBILITY STUDY
ON
CHESPI HYDROELECTRIC
DEVELOPMENT PROJECT
FEASIBILITY STUDY REPORT

(APPENDIX)

AUGUST 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

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1. REVIEW OF MASTER PLAN

1.1 General

1.1.1 Fundamental Considerations

The objectives of this study is the review of the Master Plan formulated by INECEL regarding the three project sites of Calderon, Chespi, and Palma Real at the midstream stretch of the Guayllabamba River.

The review consists of studies of the fundamental layouts of principal structures and of the optimum development scales.

The optimum development scale proposed in this Interim Report has been studied considering the subject described below. Accordingly, further detailed studies on the Chespi Project will be made at the stage of the Feasibility Study to be carried out after June.

1) The Background of the Plan

According to the Master Plan of INECEL, the future structure of electric power supply is for hydro power to be main, it being planned not to add new thermal facilities. It is understood that from the point of view of the national economy.

By around 1995, when it is expected the Chespi Project will be commissioned, the small aged thermal power generating facilities in the provinces presently numbering 210 units (approximately 580 MW) will have been successively retired to become a total of 110 MW, less than 20 percent of the present total.

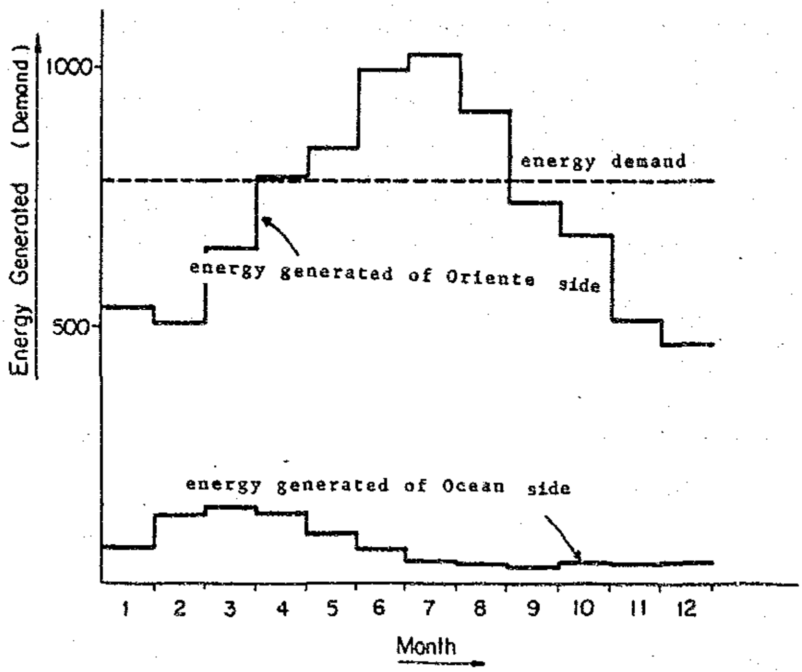
Consequently, the benefit of the hydro facilities developed up to that time will include the effect of reduced firing of these discarded thermal facilities.

However, thermal facilities beyond that point will be diverted to reserve capacity from the standpoint of power demand and supply balance and will not be included in the reduced firing effect of existing thermal in evaluating hydro power development.

Further, in case of a power supply composition of hydro power facilities being main, considering the discharge characteristics of each power plant will be an important factor. Fig. 1-1 shows the monthly energy demands and energy generation estimated in 1997.

The variation spread of the monthly energy demands are presumed constant all the year.

Fig. 1–1 Energy Generated of Hydropower and Energy Demand in 1997



The peak of the monthly energy generation is in June-August, with reductions before and after. This is because nearly all the hydro sites to be developed by the end of 1997, with the exception of the Daule Peripa Project, are in the Amazon River basin, and is due to its discharge characteristics.

On the other hand, the Daule Peripa site located in a basin on the Pacific Ocean side shows a trend which is opposite in the discharge characteristics from the project sites of the Amazon River basin. That is, through commissioning of the project at the Ocean side the electric power supply by month will be smoothed out, and not only the benefit of that project itself, but also the effectivization of surplus power of hydroelectric power stations commissioned previously, in the Amazon River basin can be looked forward to.

Consequently, the power and energy of this project site located in a Pacific Ocean side basin, when grasped on a nationwide level, almost entirely becomes effective, and moreover, is considered to contribute stabilization of electric power supply.

2) Study Technique for Optimum Development Scale
(Annual Cost Method)

This technique is for measuring the economics of the project by comparing the equalized annual cost (C) of the hydro facility during the period analyzed (50 yr) with the equalized annual cost (B) of a thermal facility having an equivalent capacity.
Therefore, since there is no process for converting the total cost to present worth, an internal rate of return cannot be calculated. However, since the level of this study is that of a Master Plan, and the objective is to make a comparison study to obtain the optimum proposal, this technique which is comparatively simple and handy is adopted.

a) Equalized Annual Cost of Hydro Power Plant

C = Depreciation + Interest + O&M Cost
Depreciation + Interest
= Total Construction Cost x Capital Recovery Factor

$$\text{Capital Recovery Factor} = \frac{i\,(1 + i)^n}{(1 + i)^n - 1}$$

Where, n : service life, 50 yr
i : interest rate, 10%

The total construction cost includes interest during construction.

Operation and maintenance (O&M) cost is to be taken as 2 percent of total construction cost.

Therefore,

C = Total Construction Cost x (0.10 + 0.02)

b) Equalized Annual Cost of Alternative Thermal Power Plant

The cost of the alternative thermal is composed of fixed costs and variable costs.

Fixed costs consist of interest on total construction cost, depreciation, and taxes and levies, and annual cost is determined equalizing these costs. Variable costs comprise fuel cost and operation and maintenance cost.

Taking fixed cost per kW as kW value, and variable cost per kWh as kWh value, the cost of the alternative thermal, or benefit of the hydro, will be according to the following equation:

$$B = P_f \times B_p + E_d \times B_E$$

Where,

P_f : firm peak output

E_d : dependable capacity

B_p : kW cost

B_E : kWh cost

① Alternative Thermal Facilities

i) Installed Capacity of Thermal Power Plant

The installed capacity of the hydro power plant has not been selected. However, it is imagined that the range of the installed capacity for each project may be from 100 to 200 MW. Here, 185 MW is adopted for the thermal power plant in order to roughly estimate the tentative master plan of each project.

The tentative installed capacity of hydro power plant: 150 MW

° kW adjustment factor

$$= \frac{(1 - 0.002) \times (1 - 0.005) \times (1 - 0.02) \times (1 - 0.03) \times (1 - 0.02)}{(1 - 0.06) \times (1 - 0.05) \times (1 - 0.12) \times (1 - 0.03)}$$

$$= \frac{0.935}{0.762} = 1.23$$

Hydro Power Plant

Service Loss	:	0.2%
Failure Loss	:	0.5%
Repair Loss	:	2.0%
Transmission Loss	:	3.0%
Flashing Loss	:	1.0%

Thermal Power Plant

Service Loss	:	6.0%
Failure Loss	:	5.0%
Repair Loss	:	12.0%
Transmission Loss	:	3.0%

° Installed capacity of thermal power plant

$$P_t = 150 \times 1.23 = 185 \text{ MW}$$

ii) Annual Energy Production

Annual plant factor (%) : 80

185 MW x 24 hr x 365 day x 0.80 = 1.296 x 10^3 MWh

iii) Investment Cost

Unit construction cost : US$1,000/kW
(including interest during construction)
= US$1,000/kW x 185,000 kW
= 185,000 x US$$10^3$

iv) Fuel Consumption Rate

$$= \frac{860 \text{ kcal/kWh}}{9{,}700 \text{ kcal} \times 0.35} = 0.25 \text{ ℓ/kWh}$$

Table-1-1 Alternative Thermal Power Plant

Item	Unit	Value
1) Installed Capacity	kW	185,000
2) Annual Energy Production	10^6kWh	1,296
3) Annual Plant Factor	%	80
4) Fuel Consumption Rate	ℓ/kWh	0.25
5) Unit Fuel Cost	US$/kℓ	170
6) Unit Construction Cost including interest during construction	US$/kW	1,000
7) Construction Cost	10^6US$	185
8) Service Life	Year	30
9) Interest Rate (i)	%	10
10) Capital Recovery Factor	(p.u.)	$0.1(1+0.1)^{30}/ (1+0.1)^{30}-1$ $= 0.1061$
11) O & M Cost (except fuel cost)	10^3US$/ year	$185 \times 10^3 \times 0.035$ $= 6.3$

Annual Cost	Unit	Fixed	Variable
1) Depreciation & Interest	10^6US$	185x0.1061 = 19.10	
2) O & M	10^6US$	6.3x0.8 = 5.04	6.3x0.2 = 1.26
3) Fuel Cost	10^6US$	-	1,296X0.25x170 = 55.08
Total		24.14	56.34
kW Benefit	$/kW	130	-
kWh	$/kWh	-	0.0435

② Effective Power and Effective Energy

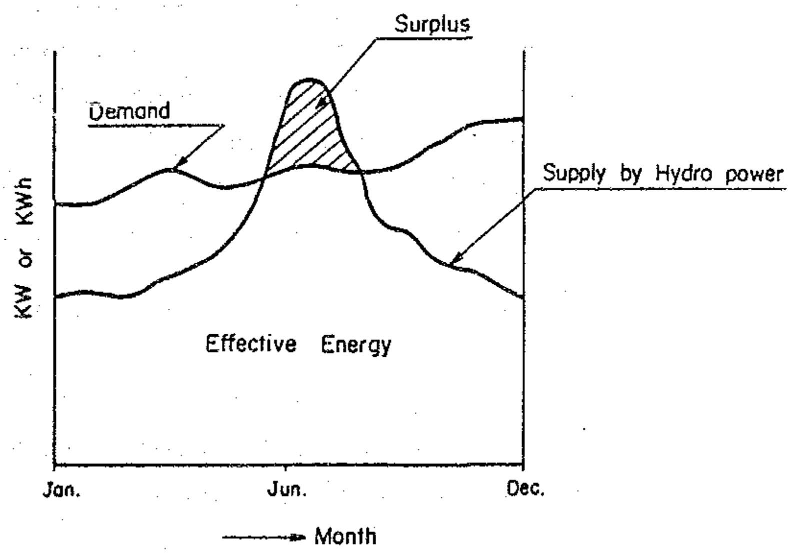
Effective power and effective energy as mentioned in this study are the electric power and electric energy that can be generated* through hydroelectric power generation from which surpluses (potentialized) in the balance of demand and supply are deducted.

* Receiving end (consequently, transmission and transformation losses, station service losses, power failure losses, etc., are deducted).

Effective power (Energy) = Generated Power (Energy) - Surplus

In carrying out the review, effective power is calculated considering the background described below.

Fig. 1-2 Conception of Effective Power (Energy)



In the study of this Report, the above is presently being investigated and has not yet been analyzed quantitatively, but in view of the abovementioned background, it is estimated that almost all of the energy produced at this project site will become effective. Therefore, it was decided to calculate the effective electric energy by the equation shown below:

Effective Electric Energy
$= \text{Available Energy Production} \times (1 - H_1)$
$\times (1 - H_2) \times (1 - H_3) \times (1 - H_4) \times (1 - H_5)$
$= \text{Available Energy Production} \times 0.935$

Where, H_1 : service loss, 0.2%
H_2 : failure loss, 0.5%
H_3 : repair loss, 2.0%
H_4 : transmission loss, 3.0%
H_5 : flashing loss, 1.0%

(3) Regulating Capacity Required

The schemes for each project site are daily regulating pond type power stations as a result of the studies described later.

The regulating capacity required for the regulating pond of a hydroelectric power station, theoretically, is determined by difference between inflow and available discharge for power generation. If it is to be attempted to effectively utilize water resources and reduce waste discharge as much as possible within the range of daily power demand and supply operation, it will be desirable for the inflow of that day to be equal to the water used for power generation.

However, operation of a power station is governed by the demand at that time and it is difficult for a fixed rate to be applied. According to the studies made up to this point, the following operation pattern will probably be adopted for the power station of this Project.

Based on the power supply by month in the previously mentioned Fig. 1-1, June through August corresponds to the rainy season in the Amazon River Basin, the group of power stations in the basin will be operated at high load throughout the day during this period. These will be applied to base supply capacity of the daily load curve. Consequently, the power station group of the Ocean side where this Project is located will be operated to meet peak demand.

On the other hand, during February through April corresponding to the rainy season at the Ocean side, the power station of this Project will conversely be operated for base supply.

Operating patterns for the following cases are considered here,

Case 1 : Application of the Form of Daily Load Curve at Nationwide Interconnection Level (24-hour Operation)

Fig. 1-3 Daily Load Curve

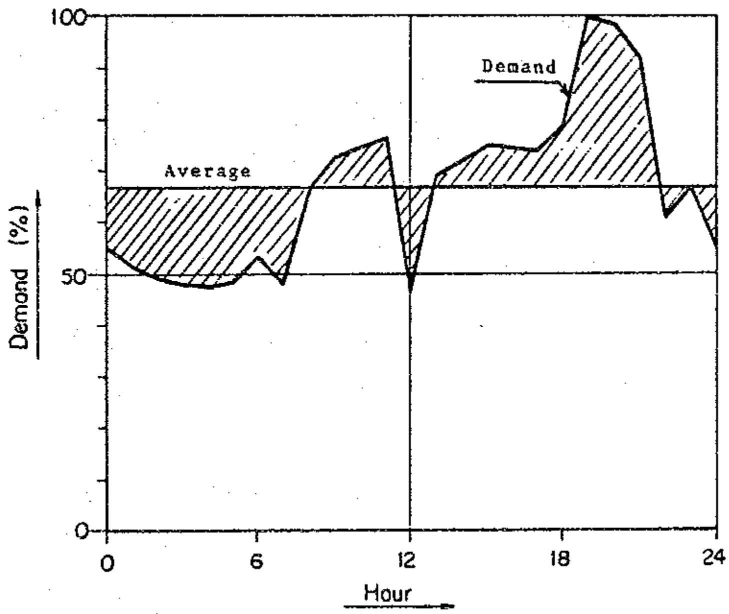


Fig. 1-3 shows the daily load curve for December 14, 1984 (Friday) in terms of percentages. With demand of 7:00 p.m. when the daily maximum load occurs as 100 percent, the electric energy of that day will be 1,600 percent. Assuming inflow to be at a constant rate, the amount of fluctuation of the regulating pond will be expressed by the equation below.

$$V_t = \sum_{i=1}^{t} P' - \sum_{i=1}^{t} P$$

Where,

P' : average daily load, 1,600/28 = 66.7
P : load
V_t : amount of fluctuation at time t

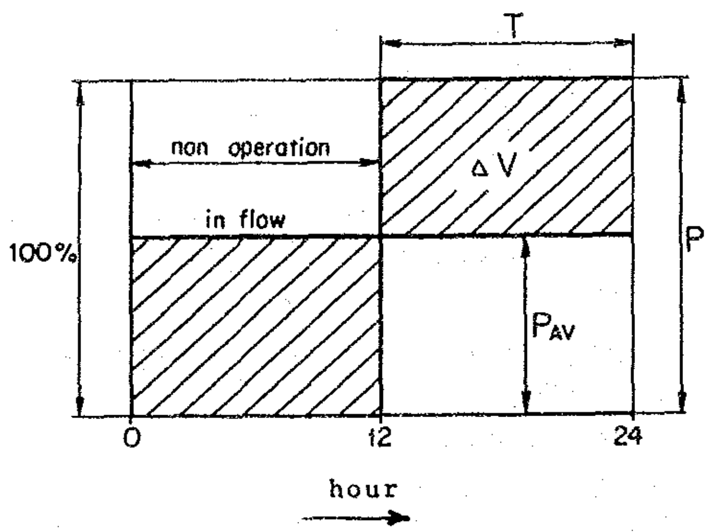
As a result of application to the above equation, the maximum V_t in the plus direction is 121 percent at 8:00 a.m., and that in the minus direction is 17 percent at 9:00 p.m., the sum of their absolute values being 138 percent. This indicates that a regulating capacity 1.4 times maximum demand will be required.

Calculations are similarly made for December 16, 1984 (Sunday), July 16, 1984 (Monday), and July 18, 1984 (Wednesday). The values for these days are 1.34, 1.11, and 1.51, respectively.

Case 2 : Peaking Operation at 100 Percent Load Factor

Fig. 1-4 and 1-5 shows a case of operating the power station during peak hours only.

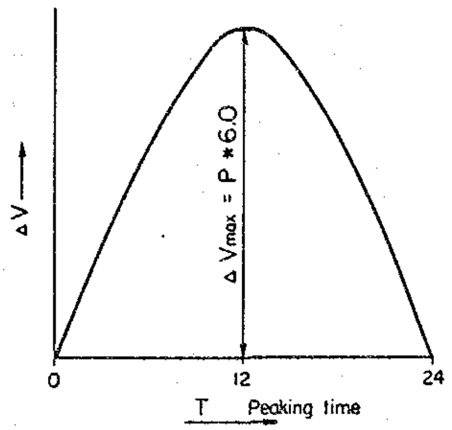
Fig. 1-4 Capacity of Regulating Pondage



$$P \times T = P_{AV} \times 24 \qquad P_{AV} = \frac{1}{24} \cdot P \times T$$

$$V = (P - P_{AV}) \times T$$
$$= (P - \frac{1}{24} \cdot P \times T) \times T$$

Fig. 1–5 The Relation between Regulated Capacity and Peaking Time



As a result, the maximum regulating capacity required occurs when peaking time continues for 12 hours, and the capacity corresponds to 6 times load factor of 100 percent.

Based on the cases above, a volume corresponding to 6 hours of maximum available discharge is adopted as the capacity required of the regulating pond.

3) Principles of Master Plan Review

(a) Plan

Regarding the principles for reviewing the Master Plan, it is the normal way to carry out the review from the standpoint of integrated development of the three project sites. Further, since the Calderon project site is located at the upstream-most part of the area of the present study, to plan this project site for a reservoir-type power station as large as practicable will be the best method as it will increase the effective output and energy of the downstream power station group, and consequently make possible the economical development of these power stations.

However, as a result of field investigations, it was learned that at the Calderon project site, although the Pisque River forms a favorable topographic structure for good water storage at the vicinity of the confluence with the mainstream, there is a problem from a geological standpoint for a reservoir to be planned. Further, debris collapses are in progress almost everywhere along the river downstream of the damsite, and a necessity arises for the powerhouse site to be planned avoiding this debris collapse area.

Also, as a result of investigations of sediment records among the data collected, it was learned that the amount of sediment was excessive for a reservoir to be planned.

Consequently, it became unavoidable for the Calderon site to plan as a daily regulating pond type in consideration of debris collapse at the surroundings of the reservoir and inflow of large quantities of sediment. Because of this, when the economics are considered,it is thought the timing of development of the Calderon site will be considerably delayed, and the study was carried out under the principle that it would not be interlocked with the study of the Chespi project site.

The Chespi project site had been estimated to be a site of good economics from the beginning and emphasis was placed on this site in the previous field investigations. From a topographical standpoint, it is not possible for the layout of the Chespi project site to be changed greatly, and when the topographical and geological conditions are considered, there is a limit to the storage capacity that can be secured, and it is judged that a daily regulating type will be optimum as the system of power generation. As a result of carrying out field investigations with the above as the basis, it was learned that there can be no alternative for the damsite when considering the geological conditions, the necessary capacity for regulation and sedimentation, the layout of principal structures, etc. Further, for the powerhouse site, judging by the topographical and geological conditions in the vicinity of this Project area, an adequate site can not be found other than the vicinity of the location chosen this time.

Hence, the basic layout is determined as a natural conclusion, and the study of the optimum developmnt scale is remained as the main topic.

As described later, two alternatives came up as damsites for the Palma Real project site. Regarding the upstream damsite alternative, investigations have not been made because of the difficulty of approach, but the dam height is not large, and judging by the geological condition at the Chespi powerhouse site it is considered that there will be no problem and planning is done on that basis. The downstream damsite was selected according to the topographical conditions of the vicinity, and it is considered to be optimum as a site for planning a rockfill dam, but there is a slight drawback that the dam height will become large.

Topographically, there is no powerhouse site other than that selected this time; no suitable site can be seen elsewhere.

Taking into account the above consideration, and based on the results of hydrologic data studies, at least four cases each of maximum available discharges were selected for studying the development scale of each project site, preliminary designs have been made, work quantities are calculated, and construction costs are estimated. Meanwhile, effective power and energy are computed, economic comparisons are made by the annual cost method, and studies are made of the optimum development scales for the individual project sites.

(b) Hydrology and Meteorology

The hydrological and meteorological investigations at this stage mainly had their objectives in low-water analyses. The reason for this is that the low-water discharge has a direct relation with economics, especially benefit.

A number of values have been trial-calculated up to the present on the runoffs at the project sites. The bases for calculating those values are thought to have been suitable at their respective times of calculation.

In the present study, the data collected in the first survey are included in addition to the abovementioned data to again calculate the runoffs at the individual project sites.

On the other hand, regarding high-water analyses and sedimentation analyses concerned with design of principal structures, data already studied are analyzed but held to the extent of preliminary studies for the full-fledged feasibility study to be carried out at the next stage.

However, if at the stage of analysis an extreme problem shall exist in the results of the studies already made and it is judged that the effect on the Project will be great, a study stressing this point is to be made.

(c) Preliminary Design

The conceptual layouts for the review of the Master Plan on the project sites of Calderon, Chespi, and Palma Real are as described in (a), "Plan." Based on these concepts, the topographical and geological conditions of the principal structure sites were investigated in the field, together with which the layout plans for the various structures were studied. The maximum available discharges and regulating capacities assumed to be optimum, and the sediment load quantities of the individual project sites were kept in mind and the design concepts for the individual sites were studied beforehand, the appropriatenesses of the various structures were verified in field investigations, and further, alternatives were given positive consideration.

A feature of the Guayllabamba River is that handling of sediment load is the greatest problem in design. Since it is estimated that a power station with a daily regulating pond is the optimum development mode for each of the project sites, the basic principle of design is to aim for alleviation of sediment flow to the intake by positive flushing out of this sediment load.

At the damsite of the Calderon project site, the Pisque River which has relatively little sediment load is to be utilized to the maximum to reduce sediment inflow at the intake, and this is taken to be the best design technique.

In other words, a dam is to be built on the mainstream which has a large amount of sediment load, and this dam is utilized to remove sediment, while an intake is provided at the Pisque River to draw clean water.

Further, an alternative plan to provide an intake dam on the mainstream and the main dam on the Pisque River is made the object of a comparison study.

The headrace tunnel is planned at the right-bank side in consideration of the location of the powerhouse, collapses along the river, and the ease of headrace tunnel construction.

It is conceivable for the powerhouse to be a semiunderground type, but an underground type is selected considering the topographical conditions and the economics. In this regards, it is looked forward to that a geological investigation be made at the feasibility study stage and the matter be restudied.

The damsite for the Chespi Project is selected in consideration of topographical and geological conditions, the structure of the settling basin in front of the intake, and the regulating pond capacity required.

Further, run-off type power generation is also conceivable, and giving consideration to space for a settling basin, the damsite is selected at a location slightly downstream from the abovementioned damsite and a comparison study is made. Needless to say, it is more economical for the headrace tunnel to be on the right-bank side. For the powerhouse, the location selected this time is the best from a topographical pointof view, and there is no other candidate site to be seen. For the layout of the powerhouse, both semi-underground and underground types are conceivable, but judging by the economics, the former is more advantageous. In case of a semi-underground powerhouse, two alternative routes are conceivable for the penstock line, but it is judged that the route selected here will be economical. Further, in case of this project site, it is recommended that debris farriers be planned in the upstream reach to reduce the sediment inflow to the regulating pond in view of the topographical and geological conditions, the limitations concerning space for the settling basin and sedimentation capacity, and of maintenance and operation after commissioning.

Upstream and downstream alternatives are conceivable for the damsite of the Palma Real Project. In the case of the upstream alternative the headrace tunnel will be long, and the aggregate construction cost of the extra length of the tunnel and the regulating pond dam will be the main subject of economical comparison study with the downstream alternative. In case of the downstream alternative, the damsite is optimum for a rockfill dam, but in such case the dam volume will be large. It may be judged that the upstream alternative will be better in economics, but both alternatives are made the objects of study.

For the headrace tunnel, the right-bank side is recommendable considering the location of the powerhouse, configurations of the river, and the topographical conditions.

The geological conditions of the penstock line route is not favorable at the powerhouse site, but it is judged that the site selected here is the optimum.

It is judged that a semi-underground type will be the most economical for the powerhouse type in view of the topography.

Based on the fundamental considerations, preliminary designing is done considering the topographical and geological characteristics of the various project sites, and work quantities of each work item are estimated.

(d) Estimation of Approximate Construction Costs

Unit prices for calculation of construction costs shall be built up considering the scales of the work quantities, construction period and method, materials, construction equipment, prevailing costs of labor, and international prices of materials and machinery which cannot be procured locally. However, since the present study is a review of the Master Plan, unit prices are set referring to prevailing unit prices, and prices of materials, machinery and labor obtained in previous surveys in Ecuador, and considering international standard prices, work quantities, construction periods and so on.

Estimation of work quantities, as previously stated, is done on an approximate basis in view of the purpose of reviewing the Master Plan. However, regarding the work quantities of the principal structures, 1/5,000 topographic maps are used and preliminary designs are made, and estimating is done for individual work items.

The percent each of direct construction costs are allowed for engineering costs and administrative costs.

Contingency costs estimated are 10 percent for civil works and 5 percent for equipment purchase and installation.

Interest during construction is 10 percent as average interest for local and foreign currency requirements, and is estimated by the approximate equation of 0.4 x (interest) x (construction period) with the construction period being estimated.

(e) Basic Conditions in Electrical Design

The comparisons of hydroelectric power generation schemes of Calderon, Chespi, and Palma Real in the Guayllabamba River Basin and determination of scales are done considering the conditions below.

i) Regarding types and numbers of turbines and generators, when selected empirically from the effective heads and maximum available discharges, two vertical-shaft Francis turbines are optimum.
The examination of turbine type considering sedimentation, water quality, etc. will be left to the feasibility sutdy stage, and in the present review of the Master Plan the three projects will be compared under identical conditions.

ii) The transmission lines for transmitting the electric power generated at the three hydro power stations to SNI (National Interconnected System) are to be 138 kV, 2 cct, with conductors 636 MCM ACSR, for INECEL Standard Zoon II Type transmission lines, and the sections are to be from the individual power stations to San Antonio Substation (SNI).

iii) The San Antonio Substation site is located approximately 3 km northeast of the equatorial monument 16 km north of Quito. This substation was planned by INECEL for connection with SNI when the Coca Codo Sinclair Project (3,000 MW) in the Amazon River Basin and the projects in the Guayllabamba River planned by INECEL have been developed. Consequently, the transmission lines from the three power stations of this Project will be connected with 138-kV buses of San Antonio Substation. Since standard 138-kV buses of INECEL are of transfer bus type, this type is to be adopted for this Project also, and only the construction costs of incoming facilities for the 2-cct transmission lines from the three projects of Calderon, Chespi, and Palma Real, and of bus extensions are considered. Further, this San Antonio Substation site and the site of Calderon Substation on which Empresa Electrica Quito (EEQ) will start work in 1985 are extremely close to each other and it is desirable for discussions and studies of technical and economic aspects to be carried out by the two parties, INECEL and EEQ.

iv) The telecommunications facilities between the individual power stations and San Antonio Substation, and between the power stations and dams are to be as follows:

Power Station - San Antonio: Power line carrier system (4 Ch)
Power Station - Dam: Radio (UHF, 4 Ch)

v) Electric power supply for construction work is to be achieved by constructing the 138-kV transmission lines and dam distribution lines in advance and combining these with construction site substations.

1.1.2 Considerations on Study Results

The review of the Master Plan on the Calderon, Chespi, and Palma Real sites described in 2.1.1 in the Interim Report has been carried out based on the preconditions and study techniques indicated.
On comparisons of the three sites taking into account items such as development scale, timing of commissioning, accessibility, and the scale of investment funds required for construction, it is judged that the Chespi site is superior from the standpoints of economy, topography,, and geology, and at the present time, it is judged that the optimum development scheme will be a daily regulation type as development system with available discharge of 70 m^3/s and output of 167 MW. Therefore, it is desirable for detailed studies to be made in a feasibility study and development of the project promoted aggresively.

The features of the results of economic analyses performed on the individual project sites are as described below.

1) Calderon Project

The powerhouse site for this project has to be selected to avoid slope failure areas along the river as previously mentioned, while moreover, the headrace tunnel is long. Since the tunnel is to be provided roughly parallel to the river, the effective head-tunnel length efficiency is inferior compared with the other two project sites, while the specific runoff is small, and these are the economic demerits compared with the other two project sites. There is geologically a limit to raising the high water level of the regulating pond, and the only possibility for economically developing this project site, because the construction cost of the headrace tunnel makes up such large portion of the entire construction cost, is to be restudied measures for economizing on the construction cost of the tunnel based on results of further geological investigations.

2) Chespi Project

This project site, as previously stated, is superior in economics, and especially, the effective head-tunnel legnth efficiency is favorable to an extent seldom seen, and consequently, it can be recommended as a promising site for development.

Furthermore, the discharge ratio of the remaining catchment area from the Calderon project site is good, and the specific runoff sites abruptly. This is one of the factors making the economics of this project site favorable.

It is judged amply worthwhile to improve the accuracy of the contents of the scheme through the Feasibility Study to follow.

3) Palma Real Project

This project site is located at a point where the specific runoff is slightly better than for the Chespi Project, but because the headrace tunnel route runs roughly parallel to the river the effective head-tunnel length efficiency is slightly poor, and this is the greatest factor impairing the economics of this project.

Although a definite statement cannot be made until the results of further geological investigations become available, it is expected that the geological conditions along the downstream part of the headrace tunnel route and the penstock route are slightly adverse, and it is thought improvement in the economics may not be looked forward to very much. However, if a feasibility study is to be carried out with thorough geological investigations after development of the Chespi Project, and design and construction are planned based on new technology, it is thought there will be sufficient chance of the economics being improved.

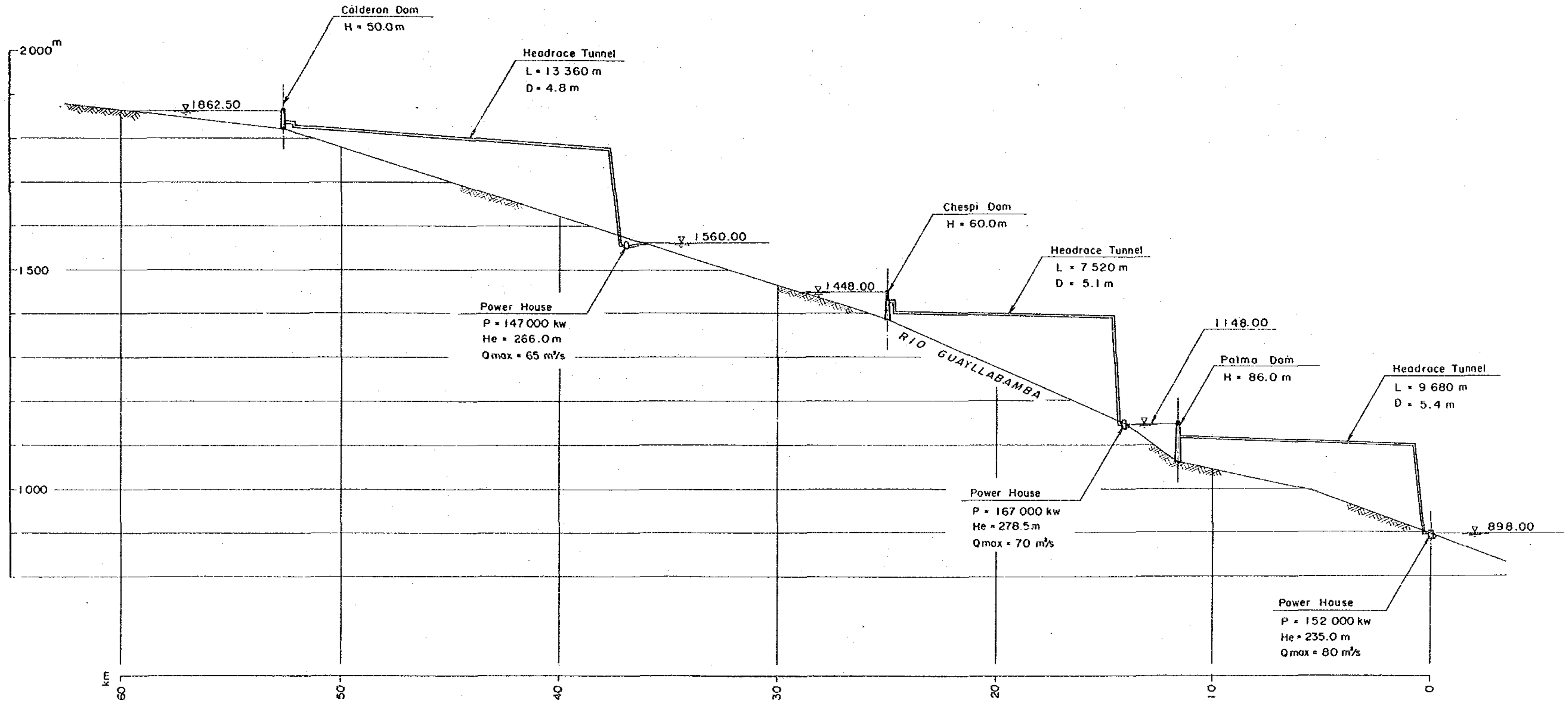
1.1.3 Outline of Project

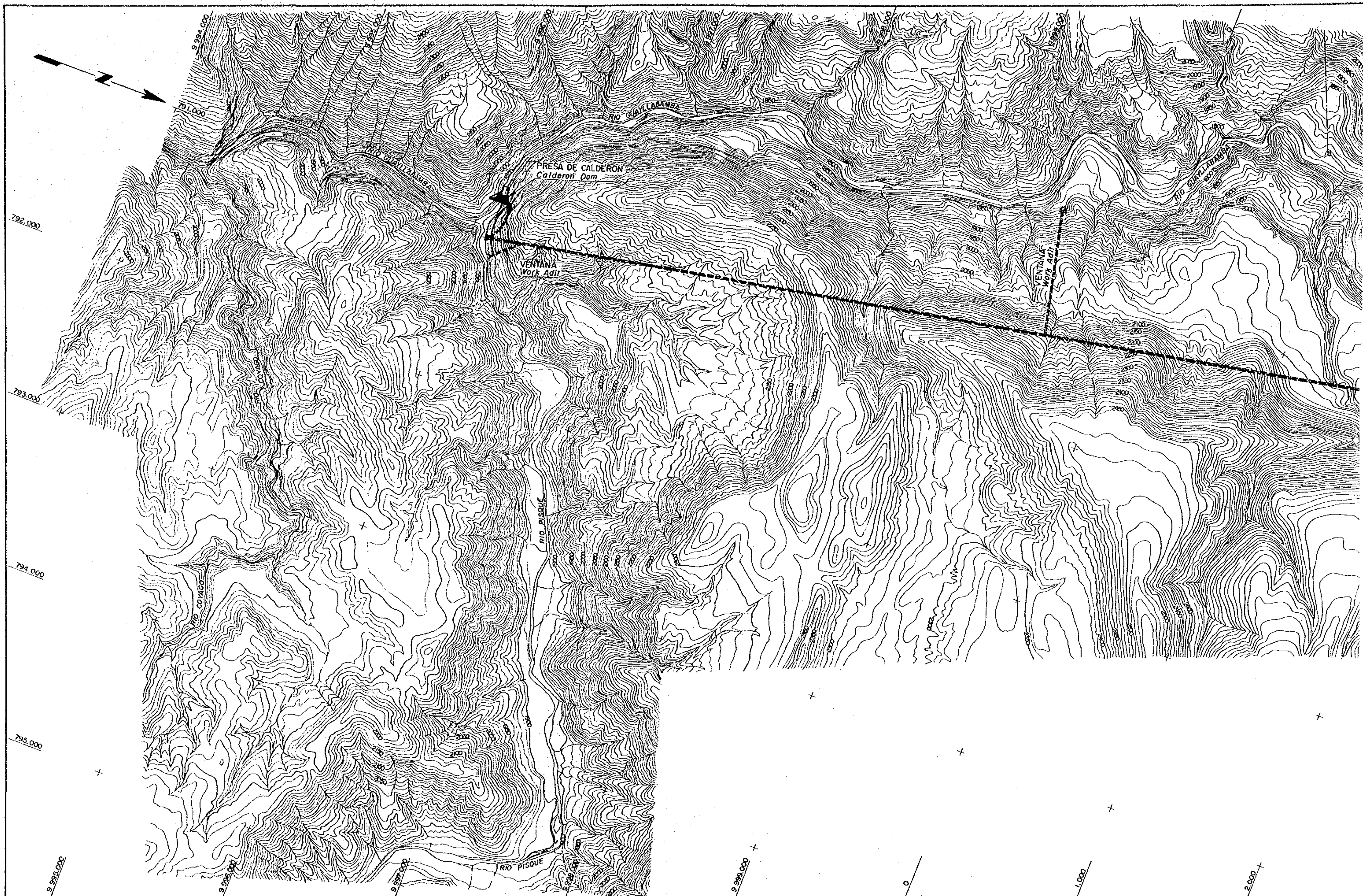
The optimum development schemes for the respective sites are described in detail in 2.2, 2.3, and 2.4 in the Interim Report. The description below is an outline.

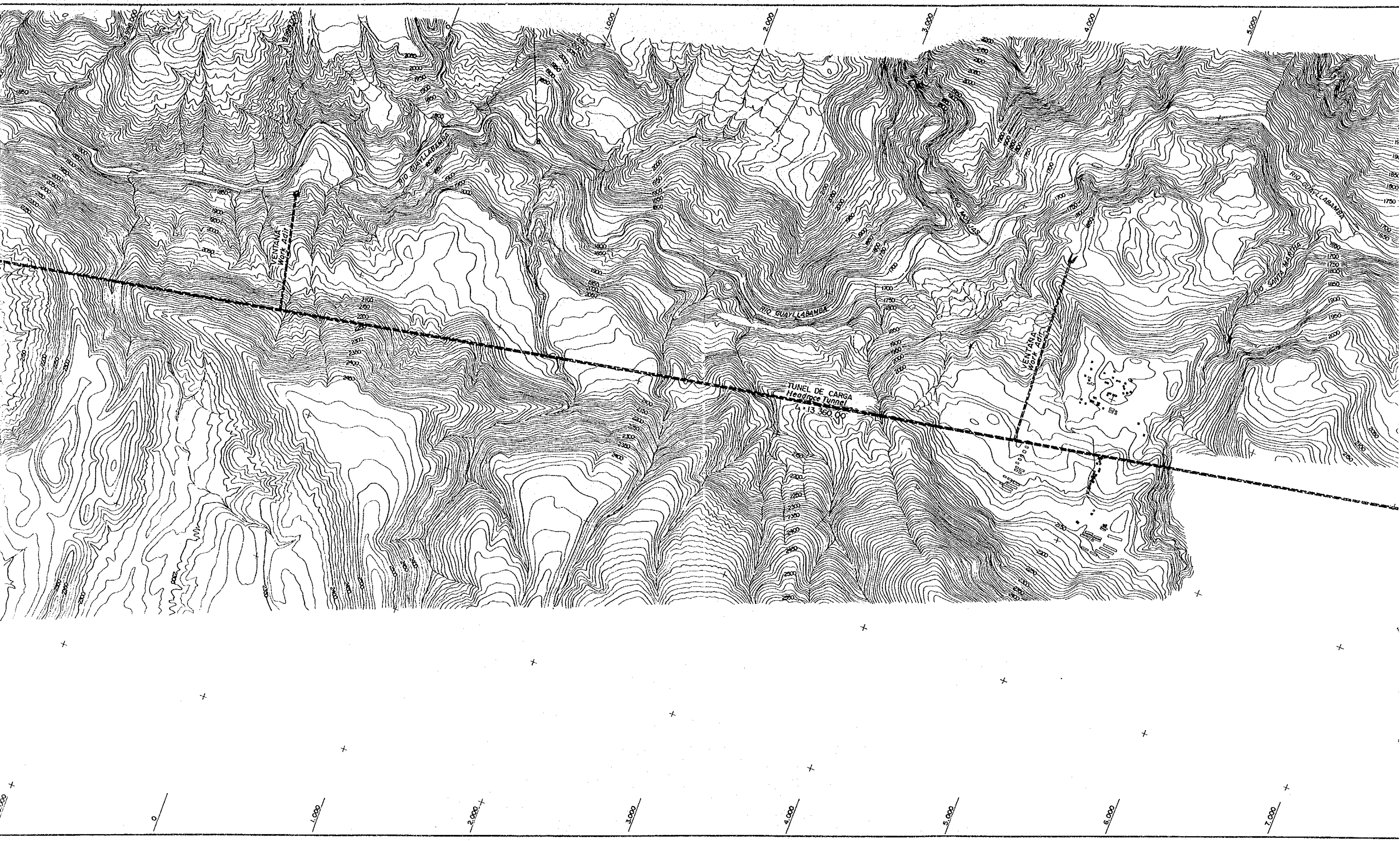
Table-1-2 Optimum Development Scale

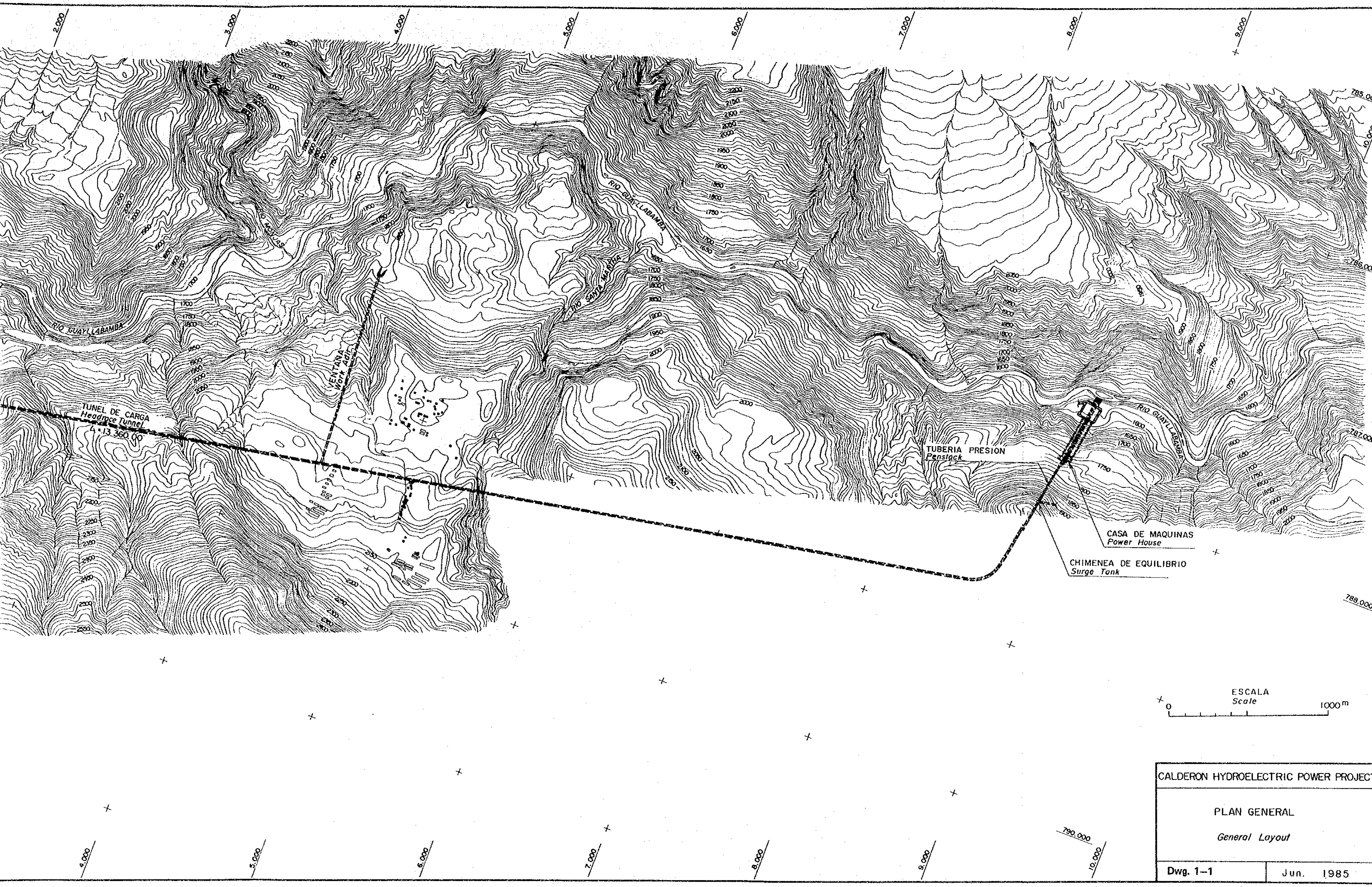
Project	Unit	Calderon	Chespi	Palma Real
Development System		Daily Regulation	Daily Regulation	Daily Regulation
Catchment Area	km^2	4,033	4,606	4,754
Average of Annual Runoff	m^3/s	46.3	60.1	65.2
Available Discharge	"	40.9	49.9	55.4
High Water Level	m	1,862.5	1,448.0	1,148.0
Low Water Level	m	1,847.0	1,436.0	1,130.0
Available Drawdown	m	15.5	12.0	18.0
Total Storage Capacity	10^3m^3	4,259	3,367	4,500
Effective Storage Capacity	"	1,404	1,512	1,728
Type		Concrete Gravity	Concrete Gravity	Concrete Gravity
High x Length	mxm	51.0 x 136.0	60 x 120	86 x 124
Volume	m^3		116,000	272,000
Tunnel (D x L x n)		4.8x13,360x1	5.1x7,520x1	5.4x9,680x1
Intake Water Level	m	1,855.5	1,442.0	1,139.0
Tailrace Water Level	"	1,560.0	1,148.0	898.0
Effective Head	m	266.0	278.5	223.0
Maximum Discharge	m^3/s	65	70	80
Installed Capacity	MW	147	167	152
Annual Energy Production	10^6 kWh	780.9	998.6	882.8
Construction Cost	10^3 US$	322,100	297,080	321,000
Unit Construction Cost (kW)	US$	2,191	1,779	2,112
Unit Construction Cost (kWh)	mill	412	297	364
Annual Benefit	10^3 US$	42,600	54,474	48,151
Annual Cost	"	38,650	35,650	38,520
B/C	-	1.102	1.528	1.250
B-C	10^3 US$	3,950	18,824	9,631

Fig. 1–6 Profile of the RIO GUAYLLABAMBA

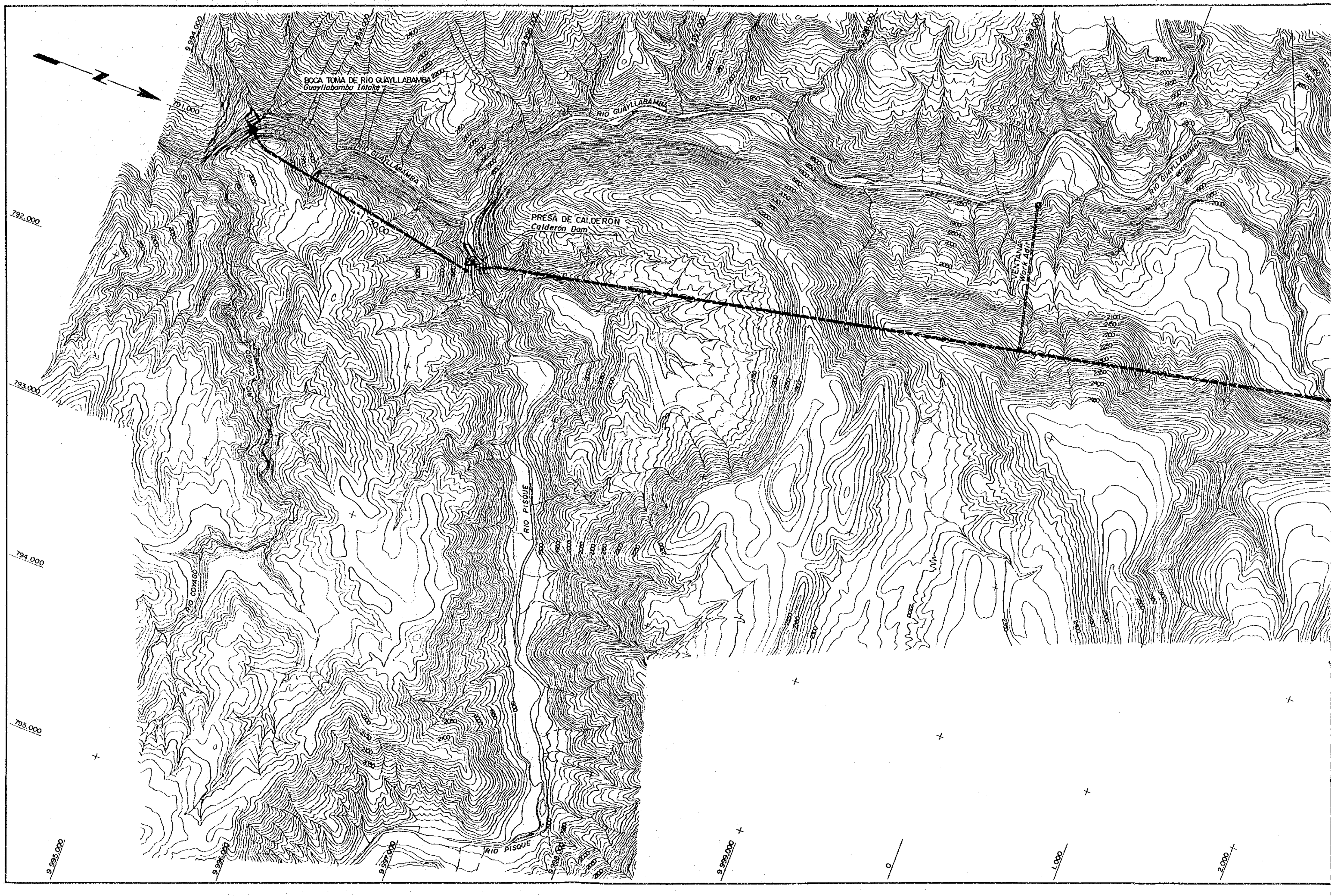


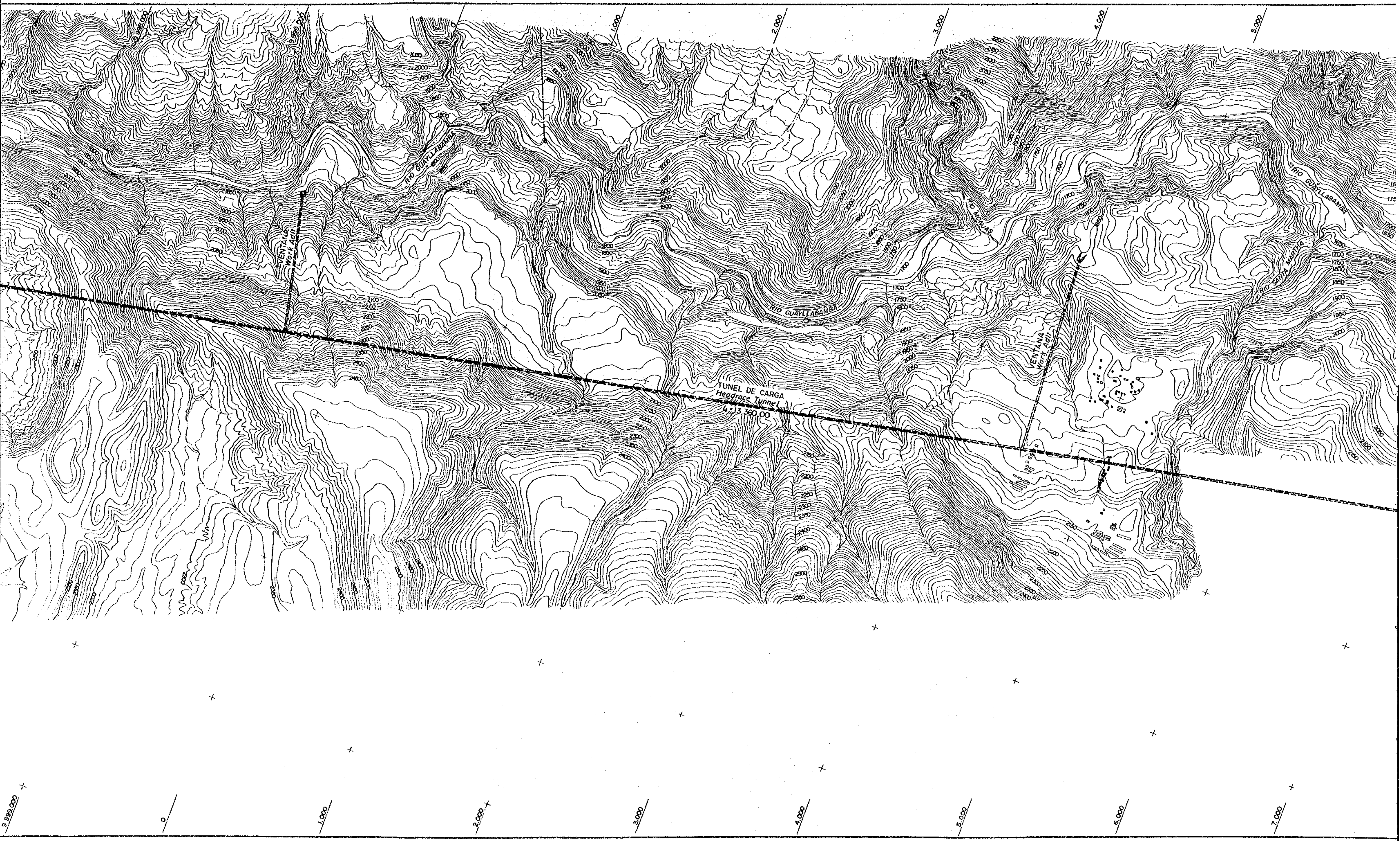

N
PRESA DE CALDERON
Calderon Dam
VENTANA
Work Adit
VENTANA
Work Adit
RIO GUAYLLABAMBA
RIO PISQUE
RIO COYAGO
792,000
793,000
794,000
795,000
9,995,000
9,996,000
9,997,000
9,998,000
9,999,000
0
1,000
2,000

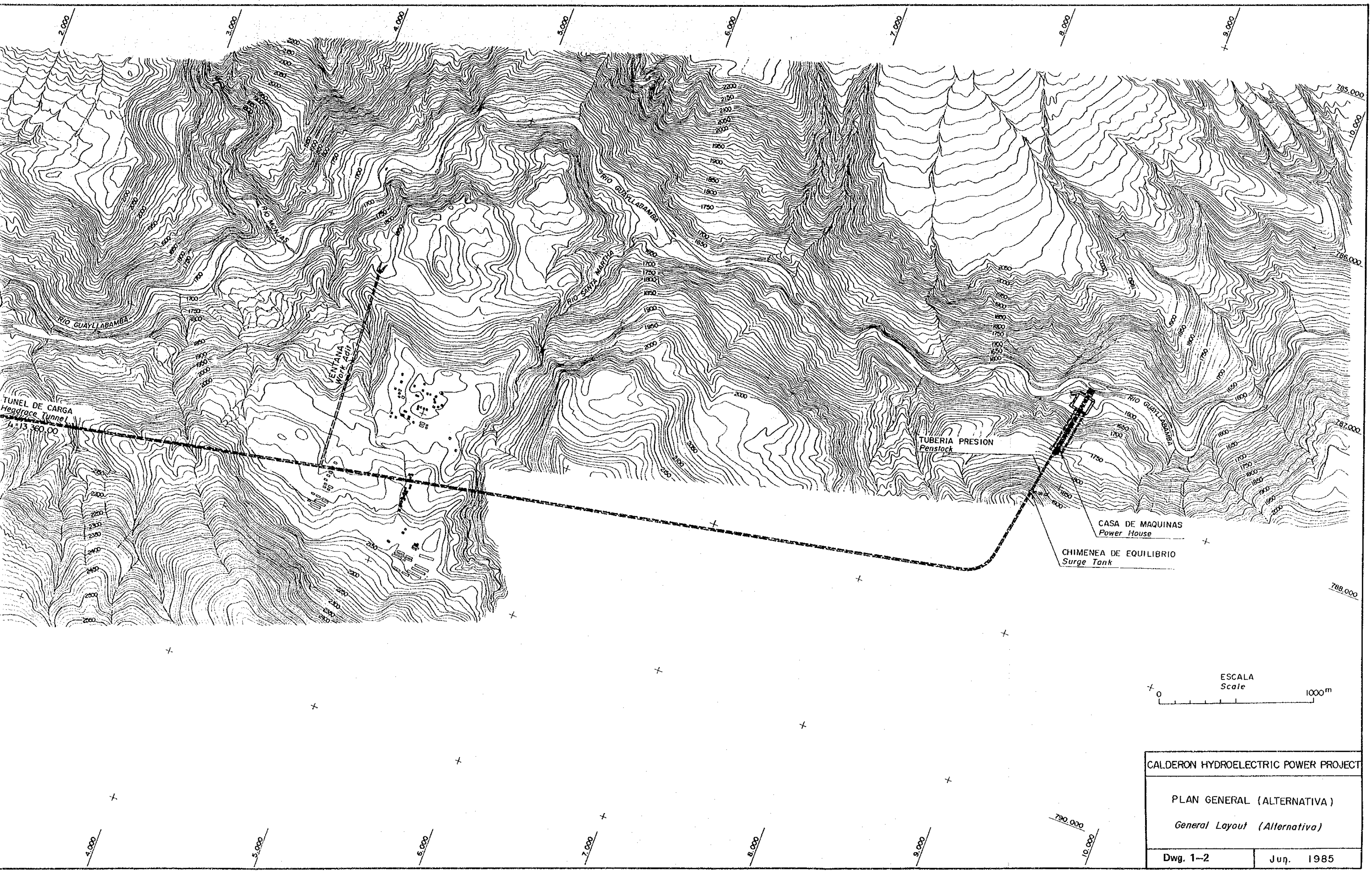

RIO GUAYLLABAMBA
VENTANA
Work Adit
TUNEL DE CARGA
Headrace Tunnel
L=13 360.00
RIO SANTA MARTA
1,000
2,000
3,000
4,000
5,000
6,000
7,000



CALDERON HYDROELECTRIC POWER PROJECT	
PLAN GENERAL *General Layout*	
Dwg. 1–1	Jun. 1985


N
BOCA TOMA DE RIO GUAYLLABAMBA
Guayllabamba Intake
RIO GUAYLLABAMBA
PRESA DE CALDERON
Calderon Dam
RIO PISQUE
RIO COYAGO
791.000
792.000
793.000
794.000
795.000
9.995.000
9.996.000
9.997.000
9.998.000
9.999.000
0
1.000
2.000


RIO GUAYLLABAMBA
RIO GUAYLLABAMBA
RIO GUAYLLABAMBA
RIO MONJAS
RIO SANTA MARTHA
VENTANA
Work Adit
VENTANA
Work Adit
TUNEL DE CARGA
Headrace Tunnel
L: 13 360.00
9 999 000
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000



CALDERON HYDROELECTRIC POWER PROJECT	
PLAN GENERAL (ALTERNATIVA)	
General Layout (Alternativa)	
Dwg. 1–2	Jun. 1985