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CORPORACION DOMINICANA DE ELECTRICIDAD

DIRECCION DE DESARROLLO HIDROELECTRICO

EL TORITO - LOS VEGANOS

HYDROELECTRIC COMPLEX DEVELOPMENT PROJECT

ON UPPER YUNA RIVER

FEASIBILITY REPORT

VOL. IV ANNEX

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JULY 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX F

ANNEX - F

ALTERNATIVE PLANS

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F. ALTERNATIVE PLANS

F.1 INTRODUCTION

F.1.1 General

The mainstream of the Yuna river flows down rapidly until it joins with the Blanco river. A head of approximately 400 m is available in the section between the confluence with Arroyo Blanco and the confluence with the Blanco river. To harness water available in the upper Yuna river basis, various alternative development plans are conceivable.

Basically, water in the Yuna mainstream is harnessed in two steps, taking into account the topographic and physiographic conditions of the mainstream and its tributaries. In the upper reach, dam and reservoir sites, as well as alternative weir sites, are found near El Torito. In the middle reach, alternative dam or weir sites are found near Los Veganos. The scheme to be developed in the upper reach is called El Torito scheme, and the scheme in the middle reach is called Los Veganos scheme.

In addition to the comparative study on alternative sites for dam or weir construction, study is to be made on water diversion from the nearby tributaries in view of the fact that water available in the mainstream at each intake site is rather limited. Such a water diversion has also an effect on the alignment of the headrace tunnel.

The result of preliminary study on the selection of alternative plans was reported in the Working Papers and discussed by CDE and JICA team in July-August 1982. The preliminary study was made by uniformly comparing the conceived alternatives to screen some alternatives worthy of further detailed studies. Such alternatives conceived in the preliminary study are introduced herein, but focuses of discussion are placed on major issues selectively in this Annex.

F.1.2 Water Use

In evaluating the alternative plans, operation of reservoir for dam-type power generation or storage for weir-type power generation is made in accordance with the operation rules as explained hereunder.

1) Dam-type Reservoir Operation:

Reservoir operation is studied in accordance with the basic rules as follows:

a) On the basis of daily mean discharge estimated at each site, relation between the available discharge and required storage capacity is analyzed by means of mass curve method. (Refer to Fig. F-01)

b) Design effective storage of each reservoir is calculated, and the firm discharge in the second worst drought year (1977) is calculated.

c) The rated water level is defined to be a mean of the full supply level (FSL) and the minimum operation level (MOL). The tail water level is assumed at a constant level, though it fluctuates actually.

d) Reservoir operation is studied in the following 3 cases: (Refer to Fig. F-02)

Case-1: In case that a reservoir water level is inbetween the high water level (HWL) and low water level (LWL), intake for power generation is the firm discharge. Power plant is operated for the peak hours to be defined (Say 6 hours a day).

Case-2a: In case that a reservoir water level is as HWL, intake for power generation is the inflow discharge. (Inflow) - (firm discharge) is used to generate secondary energy.

Case-2b: In case that a reservoir water level is at HWL, as in the Case-2a, intake rate is the plant peak discharge for 24 hours' operation.

Case-3: In case that a reservoir water level is at LWL, (to occur in the worst drought year), intake rate is the inflow discharge and rated generating capacity is not obtainable.

The program for dam-type reservoir operation is illustrated on Fig. F-03 for reference.

2) Weir-type Storage Operation:

The storage to be created by construction of weir is operated in accordance with the basic rules as follows:

a) The firm discharge is calculated at 90% dependable discharge.

b) Intake for power generation is, in principle, the daily inflow and the storage water level is daily maintained at the full supply level (FSL). The water level daily fluctuates inbetween the full supply level (FSL) and minimum operation level (MOL).

c) The rated water level is defined to be a mean of FSL and MOL. The tall water level is assumed at a constant level.

d) Operation of storage is made in the following 3 cases: (Refer to Fig. F-04)

Case-1: When daily inflow is over the plant peak discharge, power plant is operated at full scale, maintaining the full supply level (FSL). Excess water is released from spillway.

Case-2: When the inflow is less than the intake discharge, power plant is operated to the maximum extent within the daily regulating capacity of the storage.

Case-3: When the inflow is much lowered in the drought, the power plant is operated at a lower capacity, guaranteeing the operation for the peak hours to be defined (say 6 hours a day).

The program for weir-type storage operation is illustrated on Fig. F-05.

F.2 EL TORITO SCHEME

F.2.1 Conceived Alternatives

In the pre-feasibility study conducted by CDE-ENEL, construction of a dam on the Yuna mainstream at a site about 500 m upstream of the confluence with Arroyo Blanco was proposed (T-1 site). Under the ENEL plan, T-1 dam and reservoir is fed also by water diverted from Arroyo Blanco through a tunnel or canal.

An alternative plan is conceived to construct another dam on Arroyo Blanco at a site about 400 m upstream of the confluence with the Yuna mainstream (T-2 site) and combine T-1 and T-2 reservoir by excavating an open channel across the col dividing the two river basins. The scale of reservoir and dams, larger or smaller, depends on in depth technical and economic studies.

Construction of a large dam on the Yuna river in a section downstream from the confluence with Arroyo Blanco was precluded from the alternative plans, principally due to unfavorable geologic conditions affected by the fault running along the Yuna river in this section. (Refer to Annex D.2.2) However, construction of an intake weir is technically possible either in the downstream (T-4 site) or upstream (T-1 and T-2 sites) of the confluence with Arroyo Blanco.

Consequently, comparative study is made basically on 5 alternative plans as follows:

- A1 T-1 dam with diversion from A. Blanco
- A2 T-1 and T-2 dams (larger scale reservoir)
- A3 T-1 and T-2 dams (smaller scale reservoir)
- A4 Weir at T-4 site (Pino de Yuna)
- A5 Weir at T-1 and T-2 sites

These alternatives are schematically illustrated on Fig. F-06.

F.2.2 Single Dam or Combined Dams

The alternative-A1 contemplates a single dam at T-1 site while the alternative-A2 and -A3 envisage to construct combined dams at T-1 and T-2 sites. In both cases, a headrace tunnel is planned to be aligned on the left bank of the Yuna river. The alternative plans have respective characteristics as summarized hereunder:

1) A1 (Single dam at T-1):

The alternative-A1 involves construction of such structures as:

a) T-1 dam (gravity or fill-type dam)

b) Diversion weir and intake structure on Arroyo Blanco at a site about 1.8 km upstream from the confluence with the Yuna mainstream, combined with construction of access road.

c) A tunnal of about 1.4 km in length from the diversion weir to T-1 reservoir. The tunnel has to cross a fractured zone by El Torito fault (about 70 m in width), as explained in Annex D.3.2.

d) A saddle dam at T-3 site. A low fill-type dam construction is possible, but attention is to be paid to the decomposed zone as deep as 25 m from the ground surface in both abutments, as explained in Annex D.3.1.

e) An aqueduct or steel lining of a headrace tunnel (about 171 m in length) and a supporting structure (bridge of 116 m in length) to cross over Arroyo Blanco, or alternatively an inclined headrace tunnel and a steel lining (about 114 m in length) to cross beneath Arroyo Blanco. The length of headrace tunnel is longer by 430 m than the alternative -A2 and -A3.

2) A2 and A3 (Combined T-1 and T-2 dams):

The alternative-A2 and -A3 are proposed to construct a combined reservoir by dams both at T-1 and T-2 sites. These alternatives are planned in view of the geologic conditions to permit construction of a dam at T-2 site within a limited height. These alternative plans involve major structures as follows:

a) T-1 dam (gravity or fill-type dam)

b) T-2 dam (fill-type dam). The dam height is limited to be within 50-60 m to specially avoid foundation excavation of the surrounding rock of El Torito fault running along the left abutment.

c) Inlet of headrace tunnel located on the left bank of Arroyo Blanco. Crossing of the headrace tunnel through the fractured zone of El Torito fault is close to the inlet, and the treatment is much easier. (The length of headrace tunnel is shorter by 430 m than the alternative-A1.)

The maximum discharge made available from the combined reservoir under the alternative-A2 and -A3 is slightly larger than the alternative-A1, because catchment area is larger by 1.3 km^2, which extend between the diversion weir site under the alternative-A1 and T-2 damsite.

The alternatives to construct a single dam (A1) or combined dams (A2 and A3) are to be economically compared under the condition that both alternatives have the same storage capacity. As shown on Table F-01, the alternatives to construct T-1 and T-2 dams are found to be economically preferable to construct a single dam at T-1 site.

The scale of reservoir to be constructed by T-1 and T-2 dams is to be decided after making an optimization study (Refer to Annex G). It is noted, however, that the height of dam is geologically limited at T-2 site. It is further noted that the type of dam at T-1 site is selected through further comparative study as discussed in Annex G.

F.2.3 Weir Sites

Two alternative weir sites are identified and comparatively studied. They are:

A4 Weir at T-4 site (Pino de Yuna)

A5 Weir at T-1 and T-2 damsites

1) A4 (Weir at T-4 site):

Construction of a large dam at T-4 site (Pino de Yuna) is not geologically recommended due mainly to the fault running along the Yuna river. However, construction of a low gravity type weir is feasible, as explained in Annex D.3.1. The major characteristics of A4 alternative are as follows:

a) Construction of a gravity type weir at T-4 site. The storage capacity is designed to be sufficient for daily regulation of water for peak power generation.

b) Intake structure on the left abutment. A fault is running on the left abutment, but it is located close to the headrace tunnel inlet, which will require some geological treatment.

2) A5 (Weir at T-1 and T-2 sites):

This plan is an alternative to A4 plan, and is conceived to obtain a higher head in power generation. Water of the Yuna mainstream and Arroyo Blanco is taken respectively at T-1 site and T-2 site. The major characteristics of A5 alternative plan are summarized as follows:

a) Construction of a gravity type weir at T-1 site, or at a site immediately upstream of T-1 site.

b) Construction of an open channel of about 360 m in length to divert water of the Yuna mainstream to Arroyo Blanco.

c) Construction of a gravity type weir at T-2 site, or at a site immediately upstream.

d) Construction of headrace tunnel, which is longer by 960 m if compared with A4 alternative. The available head, however, is higher by 47 m than A4 plan.

The two alternatives, A4 and A5, are comparatively studied in terms of economic viability. Since the preference of one alternative to the other has not been decisive in the preliminary study, the two alternatives are designed and studied in detail as explained in Annex G and Annex I.

F.2.4 <u>Water Diversion from Arroyo Colorado</u>

As discussed in Annex C.4.2, a tributary called Arroyo Colorado has relatively larger discharge among other tributaries in the upper Yuna river basin. It also flows at higher elevation in its upper reach. Consequently, diversion of water available in the upper Arroyo Colorado to the headrace tunnel from the A2 or A3 alternatives and A4 or A5 alternative is studied. The diversion from Arroyo Colorado involves construction of facilities as follows:

a) Construction of gravity type diversion weir on Arroyo Colorado: two weirs on tributaries in case of A2 and A3 alternative and one weir on A. Colorado stream in case of A4 alternative.

b) Construction of a diversion tunnel: about 1,600 m in length in case of A2 and A3, 1,300 m in case of A4, and 1,450 m in case of A5 alternative.

c) Construction of an access road of about 2 km in length to reach diversion weir sites.

Although discharge is increased by water diversion from Arroyo Colorado, the major constraint is construction of the access road to reach the diversion weir sites, which turns out to be substantially costly. Consequently, the A2 or A3 alternative and A4 alternative are economically reviewed with or without the Arroyo Colorado water diversion.

Table F-02 indicates the results of comparative study with or without water diversion from Arroyo Colorado. It is considered recommendable to utilize water of Arroyo Colorado even though the total construction cost increases as a whole.

F.3 LOS VEGANOS SCHEME

F.3.1 Conceived Alternatives

The pre-feasibility study by CDE-ENEL proposed to construct a dam on the Yuna mainstream at a site 500 m upstream of the confluence with Arroyo Colorado. The proposed site shows V-shaped valley, sloping 30° in the left abutment and 40° in the right abutment. A dam of 72 m in height will impound 6.4 million m^3 of water. This site, called V-1 damsite, is studied as an alternative. In case of V-1 damsite, the headrace tunnel is aligned either on the left bank or on the right bank of the Yuna river.

In the section upstream of V-1 damsite, the valley is relatively narrow at some places but it is not possible to identify damsite to impound enough volume of water in the reservoir. Likewise, in the section downstream from the confluence with Arroyo Colorado, the geological conditions are not favorable to construct a large dam. (V-2 damsite in the downstream section is precluded from the comparative study on alternatives, though the site was investigated topographically and geologically.)

An alternative plan to construct a diversion weir on the Yuna mainstream is conceived at a site immediately downstream from the confluence with Arroyo Colorado. The site, called V-3 site, forms a narrow gorge, with steep cliffs of about 15 m in height in both abutments. Consequently, three alternative plans are studied in detail, as follows:

- B1 V-1 dam with left bank headrace tunnel
- B2 V-1 dam with right bank headrace tunnel
- B3 Weir at V-3 site

These alternatives are illustrated on a schematic diagram on Fig. F-06.

F.3.2 Water Diversion

In the case of V-1 dam, water diversion from the nearby tributaries is proposed, as follows:

B1 Alternative:

a) Water diversion from Arroyo Avispa to V-1 reservoir, by constructing a weir on A. Avispa (catchment area of 9.3 km^2) and a diversion tunnel of 1.4 km in length.

b) Water diversion from Arroyo Colorado (remaining river basin of 6.4 km^2 in the downstream from the weir sites for diversion to El Torito scheme) to the headrace tunnel to Los Veganos power station.

c) Water diversion from Arroyo Cana to the headrace tunnel, by constructing a weir on A. Cana (catchment area of 7.7 km^2) and a diversion tunnel of 1.0 km^2 in length.

B2 Alternative:

a) Water diversion from Arroyo Avispa

b) Water diversion from Arroyo Colorado (downstream)

Under B2 alternative, water diversion from Arroyo Caña is not contemplated, because the headrace tunnel is aligned on the right bank of the Yuna river. The right bank headrace tunnel is shorter by about 1.6 km in length than the left bank headrace tunnel under B1 alternative.

Through the comparative study on the alternative water diversion scheme, it is found that the water diversion from Arroyo Caña is not beneficial. It is more recommendable to align the headrace tunnel on the right bank of the Yuna river (B2 alternative) and to economize the construction cost. On the same reason, the headrace tunnel under B3 alternative is recommended to be aligned on the right bank of the Yuna river.

F.3.3 V-1 Dam or V-3 Weir

It has been considered at the initial stage of feasibility study that V-1 damsite offers a favorable topographic and geologic conditions for a fill-type dam construction. Through the detailed geologic survey by drilling, however, it is found that V-1 damsite involves a serious problem in geologic conditions.

As explained in Annex D.3.3, the site is composed of green rock in the right abutment and well-bedded limestone (partly muddy or tuffaceous) in the left abutment. A water table of the limestone in the left abutment is found to locate at a lower level than the river water level. This indicates the possibility of phreatic water leakage from the river to the left abutment, probably through a high permeability zone, like caves and open crack of limestone mass. Further, the water pressure tests verify that water will leak from the reservoir to a large extent. Therefore, it is considered at the ultimate stage of the field investigation that the V-1 damsite is geotechnically and economically not recommendable for a large dam construction.

Consequently, the alternative-B3 to construct a diversion weir at V-3 site is scrutinized as the only possible plan to be envisaged in Los Veganos.

F.4 EL TORITO - LOS VEGANOS COMPLEX

F.4.1 Selected Alternatives

Through the comparative study in the foregoing Chapter F.2 and F.3, alternative plans are scrutinized as follows:

El Torito	Los Veganos
A2 or A3 (Dam) +	B3 (weir)
A4 or A5 (weir) +	B3 (weir)

Since the construction of dam at V-1 site (alternative B1 and B2) is not recommended, the site of power station in El Torito scheme (A2, A3 and A4) is to be located as far downstream as possible on the left bank of the Yuna river to obtain a head as high as possible. The power house site is found on the higher portion of the left abutment of V-1 damsite.

F.4.2 Further Comparative Study

Further comparative study is to be made technically and economically on two alternative plans as selected above. A feasibility level design is to be prepared on the structures required for both alternative plans.

The study on the alternatives to construct a larger reservoir at T-1 and T-2 damsite (alternative A2) or a smaller reservoir (alternative A3) is to be made through optimization study on the dam and reservoir. (Refer to Annex G.2) In the comparative study on construction of dams or weir for El Torito scheme, effects in the downstream area, particularly effect on the Piedra Gorda dam and reservoir, are also to be reviewed.

TABLES

Table F-01 ECONOMIC COMPARISON OF ALTERNATIVES (Without water diversion from Arroyo Colorado)

(COMPARACION ECONOMICA DE LAS ALTERNATIVAS)

Description	A1		A2		A3	
	T1:Fill.	T1:Grav.	T1:Fill.	T1:Grav.	T1:Fill.	T1:Grav.
Power Generation						
Installed Capacity (kW)	7,100	7,100	9,700	9,700	8,100	8,100
Annual Energy Output (GWh)						
Primary	16.9	16.9	20.7	20.7	18.8	18.8
Secondary	11.7	11.7	14.3	14.3	13.0	13.0
Construction Cost (1000 RD$)	62,211	81,662	76,612	92,463	65,411	77,086
Annual Equivalent Benefit (B) (1000 RD$)						
Capacity Benefit	469	469	641	641	535	535
Energy Benefit						
Primary	2,748	2,748	3,366	3,366	3,057	3,057
Secondary	717	717	876	876	796	796
Total	3,934	3,934	4,883	4,883	4,388	4,388
Annual Equivalent Cost (C) (1000 RD$)						
Capital Recovery Cost	7,491	9,833	9,225	11,134	7,877	9,282
O & M Cost	311	408	383	462	327	385
Total	7,802	10,241	9,608	11,596	8,204	9,667
Benefit Cost Ratio						
(B/C)	0.50	0.39	0.51	0.42	0.54	0.45

Note:

1. Capacity Benefit = (Installed Capacity) x (Capacity Value)
   C.V. = I.C. x 66.09 RD$/KW

2. Energy Benefit = (Annual Energy Output) x (Energy Value)
   Primary E.B. = A.E.O. x 0.1626 RD$/KWh
   secondary E.B. = A.E.O. x 0.06125 RD$/KWh

3. Capital Recovery Cost = (Construction Cost) x (Capital Recovery Factor, 12% 50 yrs)
   C.R.C. = C.C. x 0.120417

4. Each of the alternatives is studied for the different types of T1 dam, that is, Fill-type and concrete-gravity-type.

Table F-02 ECONOMIC COMPARISON OF ALTERNATIVES (Without/with Water diversion from Arroyo Colorado)

(COMPARACION ECONOMICA DE LAS ALTERNATIVAS)

Description	A2 W/O	A2 W/	A3 W/O	A3 W/	A4 W/O	A4 W/
Power Generation						
Installed Capacity (kW)	9,700	12,100	8,100	10,100	4,900	6,600
Annual Energy Output (GWh)						
Primary	20.7	24.6	18.8	21.8	10.9	13.9
Secondary	14.3	16.3	13.0	15.5	12.0	15.6
Construction Cost (1000 RD$)	76,612	79,749	65,411	68,549	23,255	26,251
Annual Equivalent Benefit (B) (1000 RD$)						
Capacity Benefit	641	800	535	668	324	436
Energy Benefit						
Primary	3,366	4,000	3,057	3,545	1,772	2,260
Secondary	876	998	796	949	735	956
Total	4,883	5,798	4,388	5,162	2,831	3,652
Annual Equivalent Cost (C) (1000 RD$)						
Capital Recovery Cost	9,225	9,603	7,877	8,254	2,800	3,161
O & M Cost	383	399	327	343	116	131
Total	9,608	10,002	8,204	8,547	2,916	3,292
Benefit Cost Ratio						
(B/C)	0.51	0.58	0.54	0.60	0.98	1.11

Note:

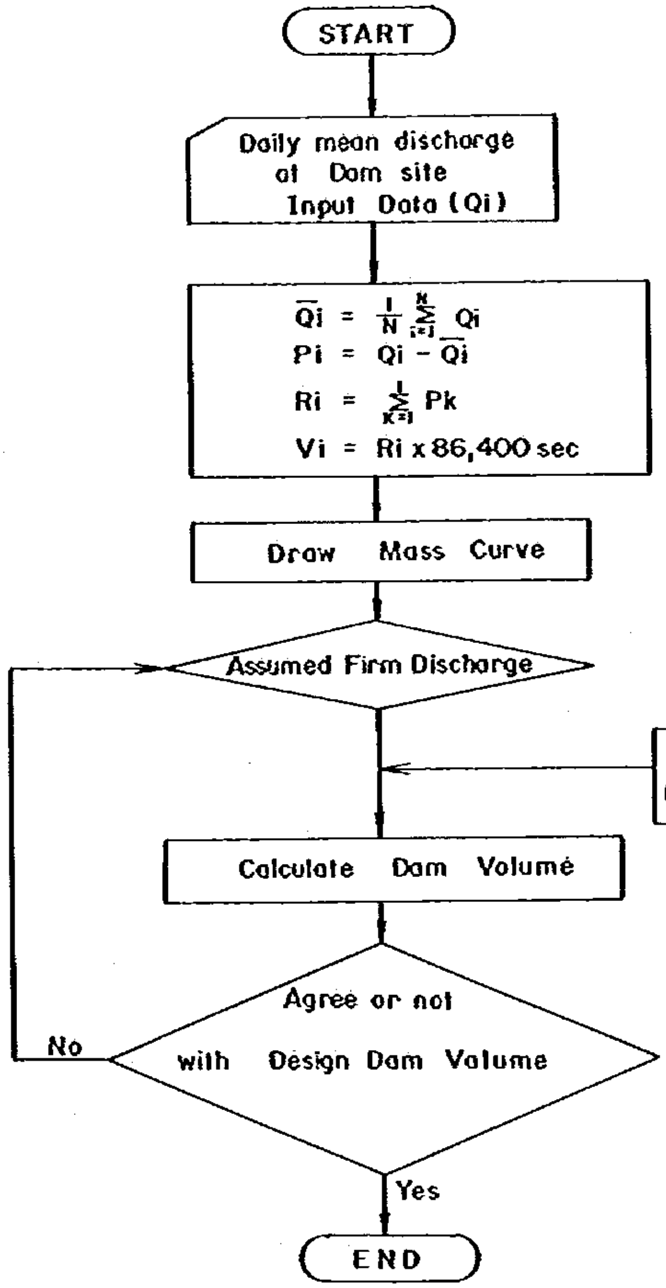
1. Capacity Benefit = (Installed Capacity) x (Capacity Value)
   C.B. = I.C. x 66.09 RD$/kW

2. Energy Benefit = (Annual Energy Output) x (Energy Value)
   Primary E.B. = A.E.O. x 0.1626 RD$/kWh
   Secondary E.B. = A.E.O. x 0.06125 RD$/kWh

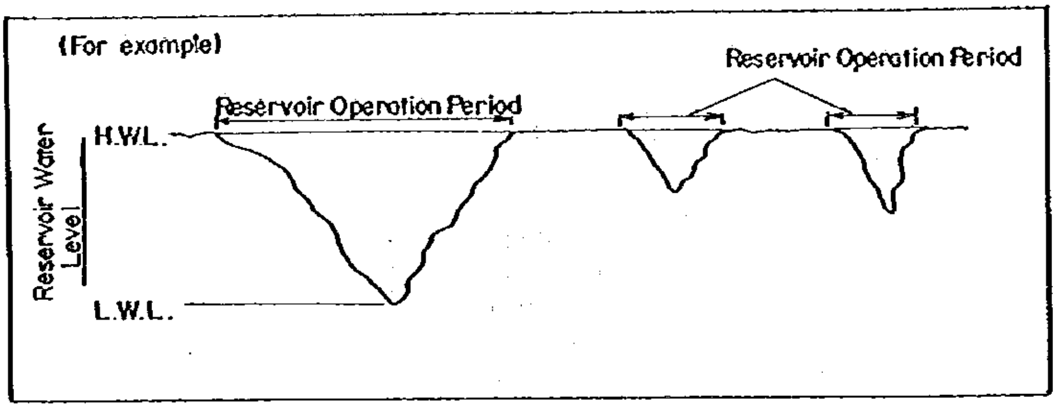
3. Capital Recovery Cost = (Construction Cost) x (Capital Recovery Factor, 12% 50 yrs)
   C.R.C. = C.C. x 0.120417

4. With regard to A2 and A3, T1 dam is fill- type.

FIGURES

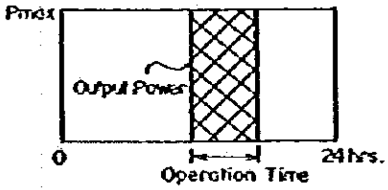


CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Flow chart for Mass Curve Method
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	F-01	*Analisis del Método de Curve de Masa*
JAPAN INTERNATIONAL COOPERATION AGENCY		



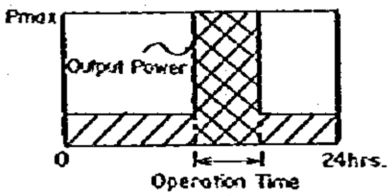
(1) CASE.1 (In case that Reservoir Water Level is between H.W.L and L.W.L)

Intake rate = Firm Discharge



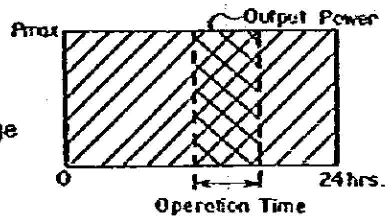
(2) CASE.2-a (In case that Reservoir Water Level is at H.W.L)

Intake rate = Inflow



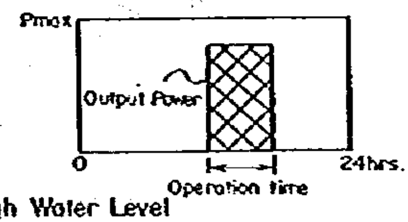
(3) CASE.2-b (In case that Reservoir Water Level is at H.W.L)

Intake rate = Plant Peak Discharge



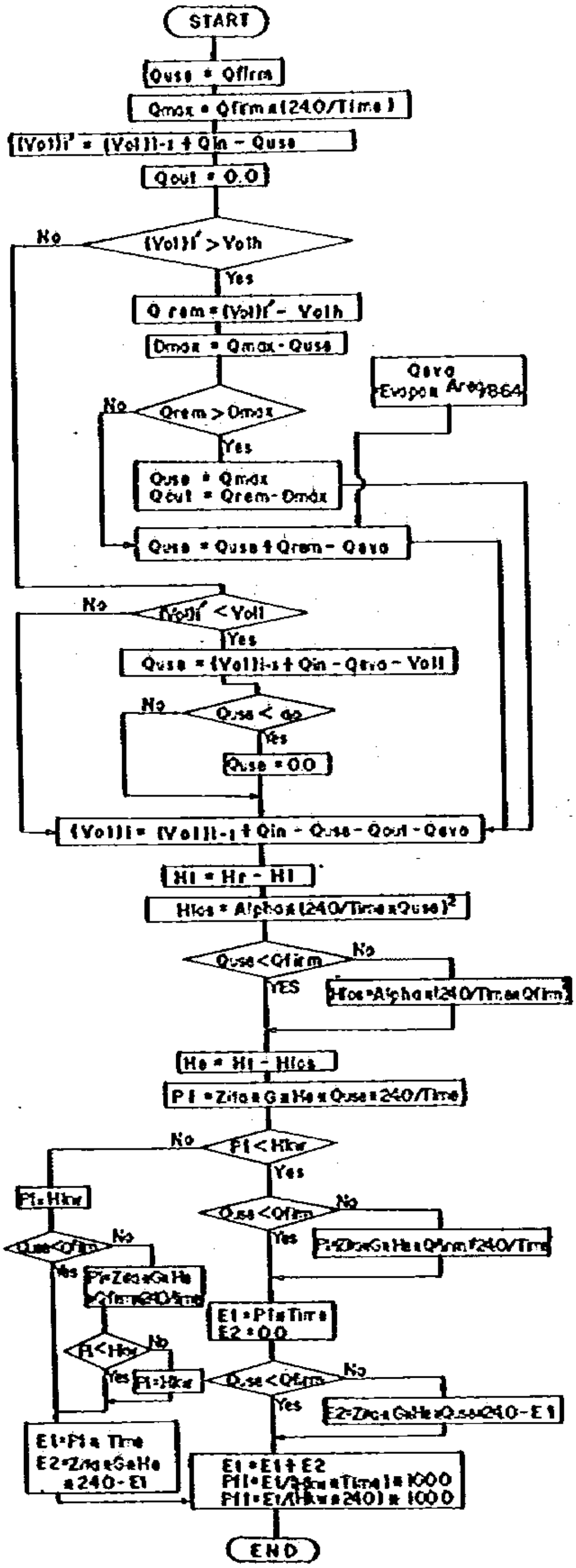
(4) CASE.3 (In case that Reservoir Water Level is at L.W.L.)

Intake rate = Inflow



Notes : H.W.L : High Water Level
L.W.L : Low Water Level
Pmax : Installed Capaty
[cross-hatched] : Primary Energy
[hatched] : Secondary Energy

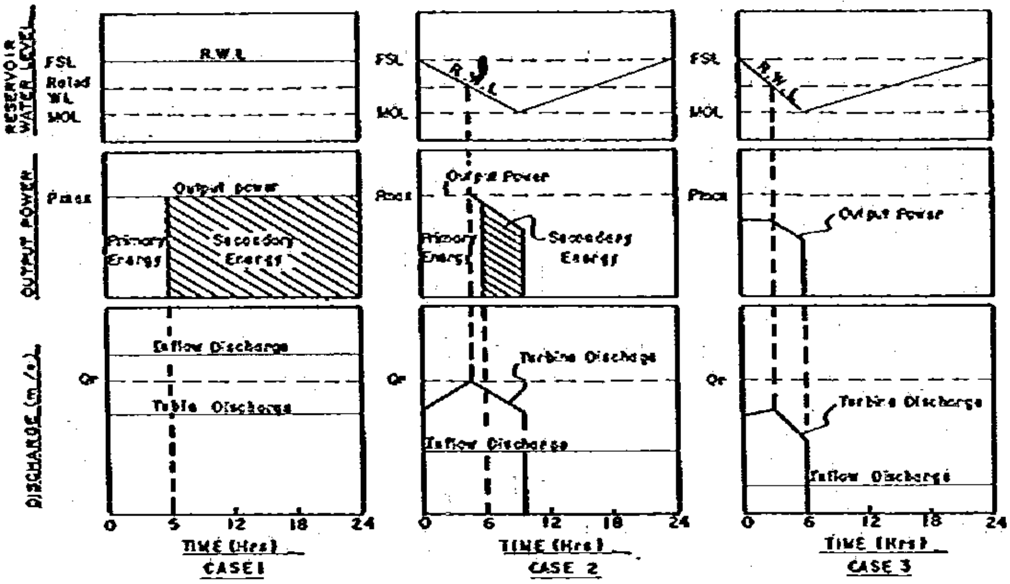
CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Schematic Description of Water Use (for Dam & Reservoir Scheme)
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	F-02	*Diagrama Esquemático del Uso de Agua (Presa de Embalse)*
JAPAN INTERNATIONAL COOPERATION AGENCY		



Abbreviations

Q firm	Design Firm Discharge	(m³/s)
Q use	Intake rate	(m³/s)
Q max	Plant Peak Discharge	(m³/s)
Time	Operation Hour	(hrs)
Q in	Inflow	(m³/s)
(Vol)i-1	Storage capacity of the day before	(m³/s)
(Vol)i	〃 the day	(m³/s)
(Vol)i'	Initial Storage Capacity of the day	(m³/s)
Qout	Spilled Volume	(m³/s)
Volh	Storage Capacity at H.W.L	(m³/s)
Voll	〃 at L.W.L	(m³/s)
Qrem	Surplus Discharge	(m³/s)
Dmax	Available Discharge	(m³/s)
Evapo	Evaporation Rate	(mm/day)
Area	Reservoir Surface Area	(km²)
Qevo	Evaporation From the Reservoir Surface	(m³/s)
Hr	Operating Level	(EL. m)
Hl	Tailwater Level	(〃)
Ht	Gross Head	(m)
Hlos	Head loss	(m)
He	Net head	(m)
Alpha	Coefficient Loss	
Quse	Utilizable Flow	(m³/s)
Zito	Overall Efficiency of Generating Equipment	(0.85)
Time	Operation Hour (hr.)	
P 1	Power output	(kw)
Hkw	Installed Capacity	(〃)
E 1	Primary Energy Output	(kwh)
E 2	Secondary Energy Output	(〃)
Et	Total Energy Output	(〃)
Qfirm	Design Firm Discharge	(m³/s)
Pf1	Plant Factor For E1	(%)
Pft	〃 For Et	(%)
G	Acceleration of Gravity	(= 9.8 m²/s)

CORPORACIÓN DOMINICANA DE ELECTRICIDAD	Fig.	Flow chart for Reservoir Operation Program (Dam type)
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELÉCTRICO EL TORITO-LOS VEGANOS	F-03	*Operación del Embalse (Presa de Embalse)*
JAPAN INTERNATIONAL COOPERATION AGENCY		



NOTE :
- R.W.L : Reservoir Water Level.
- F.S.L : Full Supply Level.
- M O L : Minimum Operation Level
- Rated WL : Rated Water Level
- Pmax : Max Output Power (Installed Capacity)
- Qr : Rated Turbine Discharge

CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Schematic Description of Water Use (for Run-of-River Scheme)
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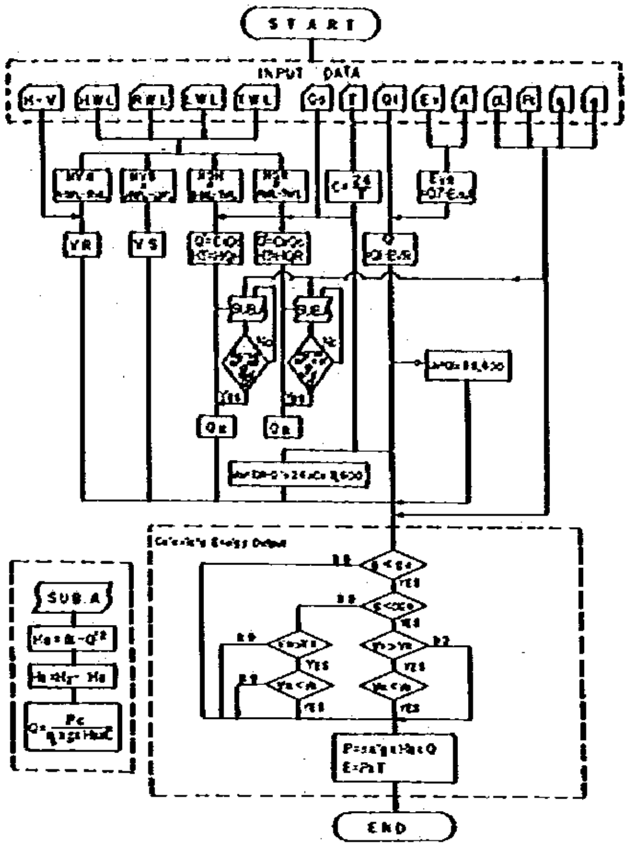
JAPAN INTERNATIONAL COOPERATION AGENCY		

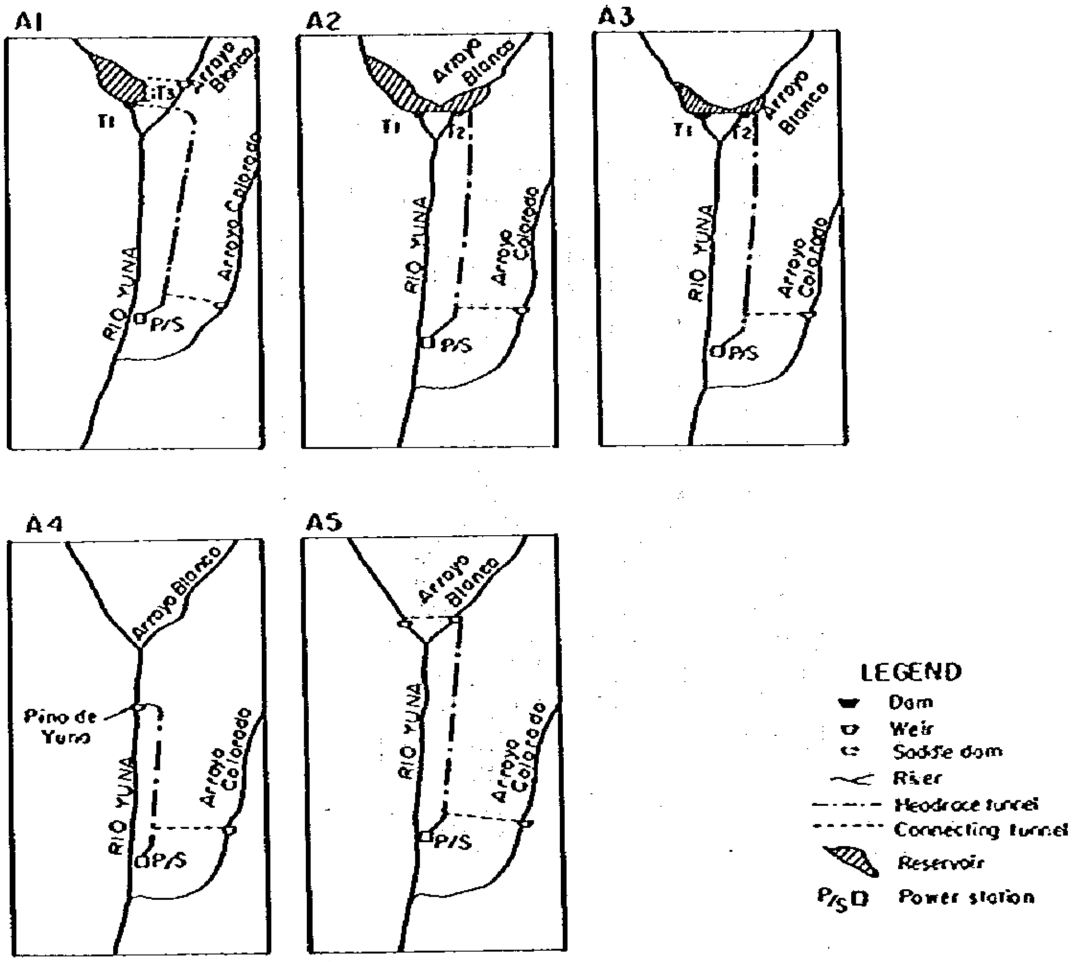


Abbreviations

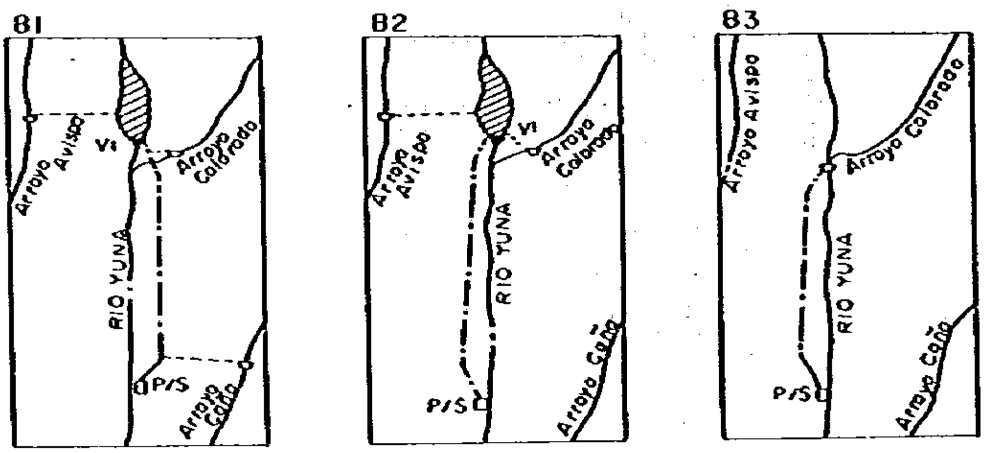
- Qi : Daily mean discharge
- Ev : Evaporation
- Evr : " of reservoir
- HWL : High water level
- R.W.L : Rated "
- L.W.L : Low "
- TWL : Tail "
- H-V : Reservoir water level (H) & reservoir storage capacity (V)
- A : Reservoir area at H.W.L
- Qa : Rated discharge
- Qc : Minimum discharge to generate P (at H.W.L)
- Vm : (Qa-Qi) x 24 x C x 3600
- Vn : Qi x 86400
- Vr : Reservoir storage capacity between H.W.L and R.W.L
- Vs : " H.W.L and L.W.L
- LQR : Reservoir level at "Qa"
- LQH : " "Qc"
- LVR : " "Vr"
- LVS : " "Vs"
- α : Formula for head loss computation $Hl=f(Qi)=\alpha Q^2$
- g : Acceleration of gravity
- η : Combined coefficient
- T : Operation time (x hours)
- Pc : Installed capacity
- Qe : Firm discharge
- C : (T/24)
- P : Power output
- E : Energy output
- Hl : Head loss
- Ht : Total head
- He : Effective head

CORPORACIÓN DOMINICANA DE ELECTRICIDAD	Fig.	Flow chart for Reservoir Operation Program (Run-of-river type)
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELÉCTRICO EL TORITO-LOS VEGANOS	F-05	*Operación del Embalse (Presa Derivadora)*
JAPAN INTERNATIONAL COOPERATION AGENCY		

POWER DEVELOPMENT SCHEMES IN EL TORITO



POWER DEVELOPMENT SCHEMES IN LOS VEGANOS



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JAPAN INTERNATIONAL COOPERATION AGENCY		

ANNEX G

ANNEX - G

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G. PRELIMINARY DESIGN

G.1 FIRM DISCHARGE

G.1.1 Firm Discharge of Dam-Reservoir Plan

The daily discharge of El Torito combined dam plan is estimated at the conversion rate of 0.08 (0.04 at T-1 damsite and 0.04 at T-2 damsite) of daily discharge recorded at Los Quemados, as a result of hydrologic analysis explained in Annex C.

On the basis of the estimated daily discharge, a discharge mass curve at El Torito is prepared as illustrated on Fig. G-01. Further, the reservoir capacity for various draft value is calculated as shown on Fig. G-02. Under this study, the second worst drought year (1977) is applied in estimating the firm discharge for different alternative scale of reservoir. The firm discharge available from the reservoir means 100% guaranteed in the second worst drought year. The film discharge is thus calculated as summarized hereunder.

	Case-1	Case-2	Case-3
High water level (EL.m)	750.0	755.0	760.0
Gross storage (10^3m^3)	4,300	6,100	7,400
Effective storage (10^3m^3)	2,800	4,600	6,900
Firm discharge (m^3/s)	1.05	1.23	1.36
(Q-firm from Reservoir)	(0.74)	(0.92)	(1.05)
(Q_{90} from A. Colorado)	(0.31)	(0.31)	(0.31)

For reference, CDE estimated 90% dependable discharge (Q_{90}) from the reservoir by simulation analysis based on rainfall records, instead of estimating 100% guaranteed Q-firm on the basis of mass curve analysis. Q_{90} was estimated by CDE at 1.25 m^3/s, exclusive of discharge available from Arroyo Colorado. Since the dam-reservoir type power generation is to be planned on the basis of 100%-guaranteed Q-firm, the preliminary design will be prepared on the basis of parameters tabulated hereinabove.

G.1.2 Dependable Discharge of Weir Plan

For the weir or run-of-river type development at El Torito (T-1 plus T-2), Pino de Yuna (T-4) and at Los Veganos (V-3), the daily discharge is estimated by applying the conversion rate to the daily discharge recorded at Los Quemados, as analysed in Annex C.4.

On the basis of the estimated daily mean discharge, the discharge duration curves at El Torito (T-1 and T-2), Pino de Yuna (T-4) and Los Veganos (V-3) are estimated as illustrated on Fig. G-03 to G-05. A 90% dependable discharge (Q_{90}) is taken as a firm discharge for power generation at each site. The estimated 90% dependable discharge is as follows:

		Q_{90} (m^3/s)
El Torito	(T-1 plus T-2)	0.62
	(A. Colorado)	0.31
	(Total)	0.93
Pino de Yuna	(T-4)	0.70
	(A. Colorado)	0.31
	(Total)	1.01
Los Veganos	(V-3)	
Combined with dam plan in El Torito		1.96
Combined with weir plan in El Torito		1.72

G.2 OPTIMUM SCALE OF DAM AND WEIR

G.2.1 Optimization of Dam and Reservoir

Through the study on alternative plans in Annex F, a combination of the construction of T-1 and T-2 dams at El Torito and the construction of V-3 weir at Los Veganos has been screened as an alternative plan for further detailed studies (Refer to DWG-01). Under this plan, the scale of T-1 and T-2 combined dams is to be optimized through comparative study. The optimization of dam and reservoir is made on the basis of economic evaluation in terms of benefit/cost ratio in each scale of reservoir capacity and dam height. Further, the optimum scale of installed capacity is determined on the basis of comparative study on different hours of peak power generation.

1) Optimum Reservoir Capacity:

Three different scales of reservoir capacity are comparatively studied to determine the optimum scale. They are:

		Case-1	Case-2	Case-3
High water level	(EL.m)	750.0	755.0	760.0
Low water level	(EL.m)	740.0	740.0	740.0
Dam Crest	(EL.m)	755.0	760.0	765.0
Effective storage	($10^6 m^3$)	2.8	4.6	6.9
Firm discharge	(m^3/s)	1.05	1.23	1.36
Installed capacity	(MW)	8.7	10.3	11.4

It is noted that the highest elevation of the dam crest is limited to EL.765.0 m because the fault running along the left bank of Arroyo Blanco will not permit geotechnically the construction of a higher dam at T-2 damsite.

The result of economic comparison of three different scales of reservoir capacity is summarized on Table G-01. As a result, Case-2 to have the effective storage capacity of 4.6 million m^3 is found to be most advantageous. The dam crest is therefore set at EL.760.0 m.

2) Optimum Installed Capacity:

On the optimum reservoir capacity selected through the comparative study as explained above, the scale of installed capacity is studied for the peaking operation of different hours as follows:

	Case-1	Case-2	Case-3
Peaking operation hours a day	5	6	7
Maximum discharge (m^3/s)	5.90	4.92	4.22
Installed capacity (MW)	12.2	10.3	8.8

The result of economic comparative study is shown on Table G-02. Through the comparative study, it is found that the peaking operation of 6 hours per day with the installed capacity of 10.3 MW is economically most advantageous. The selected daily operation hours coincide with the operation hours desirable from the viewpoint of daily load curve and load duration curve as explained in Annex B.4.2.

G.2.2 Optimization of Weir Plan

The scale of weir and installed capacity is studied for El Torito (T-1 & T-2) weir and Pino de Yuna (T-4) weir for El Torito scheme, and for V-3 weir for Los Veganos scheme.

At first, a provisional storage capacity is set at 200,000 m^3 at each weir site, and the ratio between weir height and gate height is calculated to minimize the total cost of weir and gate. On the basis of calculation as shown on Table G-03 and a cost curve prepared as illustrated on Fig. G-06, a parameter to minimize the total cost of weir and gate is set as summarized hereunder.

	T1-T2 Weir	T-4 Weir	V-3 Weir	
			w/T-Weir	w/T-Dam
(Gate height)/(weir height)	0.47	0.383	0.329	0.303
(Gate height)/(sill height)	1.20	0.750	0.545	0.488

By applying the parameters calculated above, 4 cases of weir plan with different scales of storage capacity are defined as shown on Table G-04 to G-06 for respective weir construction plan. The economic comparison of each case is made as shown on Table G-07 to G-09. Consequently, the optimum scale of storage capacity of weir in El Torito and in Los Veganos is economically defined as summarized hereunder.

	Case	Storage Capacity ($10^3 m^3$)
T-1 & T-2 Weirs	(2)	110
T-4 Weir	(2)	95
V-3 Weir (w/El Torito Weir)	(2)	149
(w/El Torito Dam)	(2)	169

The optimum installed capacity and peaking operation hours is scrutinized through comparative study on the basis of storage capacity determined as explained above. The economic comparison is made on the following cases:

	Case-1	Case-2	Case-3
T-4 Weir:			
Daily operation hours	5	6	7
Maximum discharge (m^3/s)	4.85	4.04	3.46
Installed capacity (MW)	7.5	6.3	5.5
V-3 Weir (with El Torito Dam):			
Daily operation hours	5	6	7
Maximum discharge (m^3/s)	9.41	7.84	6.72
Installed capacity (MW)	10.5	8.8	7.5
V-3 Weir (with El Torito Weir):			
Daily operation hours	5	6	7
maximum discharge (m^3/s)	8.26	6.88	5.90
Installed capacity (MW)	9.0	7.7	6.7

The result of comparative study is shown on Table G-10 for T-1 & T-2 Pino de Yuna weir, G-11 for T-4 weir and G-12 for V-3 weir scheme. Consequently, 6 hours' operation a day with the installed capacity of 7.2 MW for

El Torito weir plan, 6.3 MW for Pino de Yuna scheme and 7.7 MW for V-3 Los Veganos scheme is found to be most advantageous. The selected daily operation hours coincide with the operation hours desirable from the viewpoint of daily load curve and load duration curve as explained in Annex B.4.2

The optimum scale of T-1 & T-2 weir or T-4 weir plan and V-3 weir plan is determined as summarized hereunder.

	T-1 & T-2 Weir	T-4 Weir	V-3 Weir w/T-Weir	V-3 Weir w/T-Dam
High water level (EL.m)	726.0	680.0	493.0	494.0
Low water level (EL.m)	723.4	677.5	488.5	489.5
Effective storage capacity ($10^3/m^3$)	110	95	149	169.0
Maximum discharge (m^3/s)	3.72	4.04	6.88	7.84
Installed capacity (MW)	7.2	6.3	7.7	8.8

G.3 PRELIMINARY DESIGN OF EL TORITO DAM PLAN

G.3.1 General

As explained in Annex F.2, the construction of T-1 dam on the Yuna mainstream and T-2 dam on Arroyo Blanco is contemplated. The reservoirs are combined by excavating an open channel beneath the col (T-3 site) dividing two river basins.

T-1 damsite is located at about 550 m upstream of the confluence with Arroyo Blanco. The riverbed is 15 m in width, and the river deposit is around 3 m in depth. The foundation rock is inferred to be amphibolite. On the other hand, T-2 damsite is located at about 500 m upstream of the confluence with the Yuna mainstream. The abutment at the damsite dips 35° on the left bank and 40° on the right bank. The riverbed is approximately 20 m in width and the river deposit is around 7 m in depth. The foundation rock is also inferred to be amphibolite (Refer to Annex D).

The high water level of the combined reservoir is determined at EL. 755.0 m through the optimization study explained in Chapter G.1.1.

G.3.2 El Torito Reservoir

At the high water level (EL. 755.0 m), the gross storage capacity is 6.1 million m^3, and the reservoir surface area is 40 ha. The low water level is set at EL. 740.0 m, and the effective storage capacity between the high water level and low water level is 4.6 million m^3 (Refer to Fig. G-07). At the time of design flood of 560 m^3/s, the reservoir water level rises temporarily up to EL. 757.8 m.

The dead storage is calculated for the project life period of 50 years, in accordance with the following formula:

$$Dv = V \cdot A \cdot \eta \cdot n$$

where, Dv : dead storage capacity

V : specific sediment yield (2,000 $m^3/km^2/year$) (Refer to Annex C.6)

A : catchment area (30 km^2)
η : trap efficiency (50%)
n : project life (50 years)

The dead storage capacity is estimated at around 1.5 million m^3.

G.3.3 Dam Type

From the technical point of view, construction of a concrete gravity type dam and a rock-fill type dam is possible at T-1 damsite. On the other hand, T-2 damsite permits the construction of a fill-type dam due to its geotechnical limitations.

For T-1 dam construction, a concrete gravity type dam and a rock-fill type dam are comparatively studied in terms of their economic preference (Refer to Table G-13). As a result, construction of a fill-type dam is verified to be more economical.

G.3.4 Dam Design

For the design of El Torito dams (T-1 and T-2 combined), design criteria are determined on the basis of topographic survey, geologic and geophysical survey, investigation of construction materials, etc. The major criteria are explained hereinafter (Refer to DWG-03 to DWG-05).

1) Dam Crest:

The design flood discharge is calculated at 560 m^3/s for fill-type dam construction at El Torito, which is equivalent to the probable flood for the return period of 200 years (Refer to Annex C.5.3). At the design flood, the high water level rises temporarily up to EL. 757.8 m. In view of the probable maximum flood estimated at 580 m^3/s, a free board of 2.2 m in height is designed for El Torito dams.

Consequently, the dam crest elevation is set at EL. 760.0 m. The dam height from the foundation is 55 m at T-1 damsite and 60 m at T-2 damsight.

2) Dam Axis:

The dam axis is determined on the basis of topographic and geological conditions. At T-1 damsite, the axis of rock-fill dam is designed on the straight line. At T-2 damsite, the axis is not designed to be straight to facilitate the access in the right abutment in view of the topographic conditions (Refer to DWG-03).

3) Design Earthquake Acceleration:

As explained in Annex D.4, the design earthquake acceleration at T-1 and T-2 damsite is determined at 0.15 g, including some safe measure.

4) Design Value of Embankment Materials:

On the basis of investigation on construction materials as explained in Annex E, the design value of embankment materials are determined as summarized hereunder.

	Core Materials	Filter Materials	Random Materials	Rock Materials
Wet density (t/m^3)	1.75	2.10	2.10	1.95
Saturated density (t/m^3)	1.82	2.20	2.20	2.10
Internal friction angle (°)	25	38	39	42
Cohesion (t/m^2)	3.0	0	0	0
Permeability coefficient (cm/s)	$1x10^{-6}$	$1x10^{-3}$	$1x10^{-2}$; $1x10^{-3}$	$1x10^{-1}$; $1x10^{0}$

5) Dam Zoning:

Zoning of fill-type dams at T-1 and T-2 damsite is made in accordance with the following criteria: (Refer to DWG-04)

a) Impervious core zone:

In view of the general criteria that the safety is secured if width of impervious zone is 30-50% of the water pressure head, the slope is designed at 1:0.2 on both upstream and downstream sides, with the crest width of 4.0 m. The bottom width of the impervious core zone is consequently 46% of the designed dam height.

b) Filter zone:

A single filter zone is designed on both upstream and downstream sides. The filter zone is designed to have a crest width of 3.0 m.

c) Random zone:

To minimize the embankment cost, a random zone is designed to utilize the riverbed deposit of sand and gravel to the maximum extent.

d) Rock zone:

The rock zone is designed in the light of dam stability and earthquake acceleration. It is filled up by rock materials to be excavated at the proposed quarry site.

6) Dam Stability:

On the basis of the designed dam zoning, the slope stability analysis is made by means of slip-circle method. The result of stability analysis is summarized on Table G-14 and Fig. G-08. The slopes of random zone and rock zone are determined as follows:

	Random Zone	Rock Zone
Upstream slope	1 : 1.8	1 : 2.7
Downstream slope	1 : 1.4	1 : 1.9

7) River Diversion:

River diversion is made by the cofferdams and diversion tunnels (Refer to DWG-05). The cofferdam is designed on the basis of the 20-year probable flood discharge estimated at 300 m^3/s. The diversion tunnels are aligned in the left abutment of both T-1 damsite and T-2 damsite. The tunnel of T-2 damsite is designed to be 5 m in diameter. The diversion tunnel in the left abutment of T-1 damsite is designed to function as a spillway after completion of the dam construction, and to be 9.4 m in diameter.

8) Spillway:

Spillway is designed in the left abutment of T-1 damsite, as a tunnel type spillway. It is equipped with a side channel of 60 m in crest length. The inside diameter of the tunnel spillway is designed to be 9.4 m, to allow free flow of the design flood discharge estimated at 560 m^3/s.

G.3.5 Waterway

An intake of the headrace tunnel is located on the left bank of Arroyo Blanco at around 400 m upstream of T-2 dam axis, because the section between the proposed intake site and T-2 damsite is subject to probable landslide as noted in Annex D.3.1.

The intake is equipped with a trush rack of 3.0 m in width and 2.5 m in height, and a roller gate of 2.0 m in width and 2.0 m in height. The sill crest is set at EL. 738.0 m, in view of the low water level and sedimentation in the reservoir (Refer to DWG-06).

The headrace tunnel is aligned in the left abutment of the Yuna mainstream, until it reaches at a surge tank to be located on the slope dividing the watershed of the Yuna mainstream and Arroyo Colorado. The total length of the headrace tunnel is 5,300 m. The tunnel diameter is designed to be 2.0 m, which is the minimum dimension for conventional tunnel excavation (Refer to DWG-06).

A surge tank is designed to locate at the elevation of 780 m. The surge tank is a restricted orifice type with an inside diameter of 4.0 m and a height of 46.0 m, determined on the basis of water hammer analysis.

The penstock is aligned on the ridge of a slope of the left abutment of V-1 damsite near Los Veganos. The length of penstock is about 660 m. The inside diameter is designed to gradually decrease from 2.0 m to 1.0 m (Refer to DWG-07).

G.3.6 Water Diversion from Arroyo Colorado

Diversion of water from Arroyo Colorado is planned to be incorporated into El Torito scheme. Arroyo Colorado bifurcates to Arroyo Chiquito (north side) and Arroyo Pringamosa (south side) at a point of EL. 750, about 1.5 km upstream of the confluence with the Yuna mainstream. Since the high water level of El Torito reservoir is designed at EL. 755 m, the tributary intake structures for diversion are designed on both Arroyo Chiquito and Arroyo Pringamosa. The location of weir site is selected on both Arroyo at about 100 m upstream of their confluence.

The intake weir on Arroyo Chiquito is designed to be 7.5 m in height and 60.0 m in crest length. Water is diverted through an open channel of 121 m in length up to the storage of Arroyo Pringamosa weir which is designed to be 5.5 m in height and 42.5 m in crest length. Water is led from the Pringamosa intake through a diversion tunnel of 1.6 km in length, until it joins the headrace tunnel from El Torito reservoir at a point of about 250 m from the proposed surge tank (Refer to DWG-08 and DWG-09).

G.3.7 Power Station

An open type powerhouse (Yuna No. 1 power station) is located on the left bank of the Yuna mainstream, about 400 m upstream from the confluence with Arroyo Colorado. The site is covered with talus deposit of 8-10 m in thickness. The foundation is green rock durable enough for a powerhouse construction, as explained in Annex D.3.2. (downstream powerhouse site).

The dimension of powerhouse is designed to be 22.0 m in length, 18.5 m in width and 27.5 m in height. The building accommodate a unit of turbine, generator, crane, etc. The turbine is designed to be of Francis Type, with a capacity of 10.3 MW under the rated head of 250.3 m and rated discharge of 4.92 m^3/s. The rated revolving speed is 900 rpm. The generator is rated at 12.7 MVA to deliver 10.3 MW of power at 0.85 power factor in lagging.

An outdoor switchyard is designed to have a space of 30 m in width and 40 m in length. The ground elevation is set at EL. 494.5 m. A main transformer is installed in the outdoor switchyard. The transformer is specified to be 12.7 MVA, 60 Hz, 3-phase, 6.6 kV to 69 kV in delta-star connection of natural cooled type (Refer to DWG-10).

G.3.8 Transmission Line and Substation

Power generated at the Yuna No. 1 power station is sent to a switching station to be constructed at the Rio Blanco power station, through a transmission line of 69 kV. The line is about 8 km in length. Although CDE has a plan to set up a substation at a site about 4 km downstream from the Piedra Gorda damsite to integrate a series of hydro-power plants to be developed in the upper Yuna river basin, such a location is subject to further study on the construction of the Piedra Gorda dam. The proposed connection to the Rio Blanco power station appears to be more realistic at this moment.

G.3.9 Energy Output

On the basis of firm discharge estimated at 1.23 m^3/s and the reservoir operation rule proposed in Annex F.1.2, the annual energy output of El Torito dam plan is calculated as summarized hereunder. The primary energy is the output in 6-hour peak operation, while the secondary energy is the output in off-peak hours.

Installed capacity	10.3 MW
Primary energy	22.2 GWh
Secondary energy	15.8 GWh
Total energy output	38.0 GWh

G.4 PRELIMINARY DESIGN OF EL TORITO WEIR PLAN

G.4.1 El Torito (T-1 & T-2) Intake Weirs

As an alternative to the El Torito dam and reservoir scheme, it is planned to construct intake weirs at T-1 and T-2 damsites, aiming to use higher head as possible as the topography permits. As the weir sites, riverbed width is about 10 m at T-1 site and 15 m at T-2 site. The foundation rock at T-1 and T-2 sites is composed of foliated and microcrystalline amphibolite, and the thickness of river deposit is 2 m at T-1 site and 5 m at T-2 site.

The daily mean discharge at T-1 and T-2 site is estimated at the conversion ratio of 0.04 of daily discharge record at Los Quemados. On the basis of discharge duration curve at T-1 and T-2 sites, a 90% dependable discharge (Q_{90}) is estimated at 0.62 m^3/s.

The weir at T-1 site is designed to divert water of the Yuna mainstream to Arroyo Blanco. For water diversion, an open diversion channel is to be excavated through the col dividing the Yuna mainstream and Arroyo Blanco sub-basins (called also T-3 site). The diversion channel is designed to be 360 m in total length, and the channel bottom is in EL. 722 m. (Refer to DWG-11)

T-1 weir is designed to be of free-overflow type. A non-gated concrete gravity type weir is designed, with 17.0 m in height and 50.0 m in crest length. At T-2 weir, the high water level is set at EL. 726.0 m and low water level at EL. 723.4 m to store 110,000 m^3 of water for 6-hour peak operation. The weir is designed to be a gated concrete weir with a crest length of 86 m. The gated overflow section and two ogee sections are designed to allow passage of a probable flood for the return period of 100 years, which is estimated at 420 m^3/s. Two gates of vertical lift type (12 m x 7.75 m) are installed to flush sediment in the pondage. The upstream section of the weir will be filled out by sediment in a relatively short period after the construction of weir, but the storage capacity is secured by installation of such gates. A sand flushing channel is also designed to be provided in the weir. An intake is constructed at EL. 720.5 m in the left abutment. (Refer to DWG-12)

G.4.2 Waterway

A headrace tunnel is aligned on the left bank of the Yuna river. A total length of the tunnel is approximately 5.2 km. The bedrock along the headrace tunnel route is inferred to be green schist.

The headrace tunnel is designed to be a pressure tunnel with circular cross section. The inside diameter is 2.0 m, which is the practically minimum size for excavation by the conventional tunnel work equipment. For excavation, the tunnel is divided into 3 sections: the first section of 1,700 m in length, the second section of 2,200 m and the third section of 1,400 m. Work adits are located at the intake site, near Los Veganos village, and near the proposed surge tank site (Refer to DWG-13).

A surge tank is constructed at the downstream end of the headrace tunnel. It is designed to have a concrete lined vertical shaft of 4.0 m in inside diameter and 44.0 m in height. An orifice is 0.8 m in diameter.

A penstock line is aligned on the ridge of slope near the left abutment of V-1 damsite at Los Veganos. The penstock is 615 m in length. The inside diameter is designed to decrease gradually from 2.0 m to 1.0 m. (Refer to DWG-15).

G.4.3 Water Diversion from Arroyo Colorado

Diversion of Arroyo Colorado water is planned to divert water of 0.31 m^3/s in dependable discharge. Since the intake elevation is lowered to EL. 736.5 m, if compared with El Torito dam plan, the location of the diversion weir is found immediately downstream from the confluence of Arroyo Chiquito and Arroyo Pringamosa, or about 2.2 km upstream of the confluence with the Yuna mainstream. In this case, a single intake weir is constructed.

The intake weir is designed to be concrete weir of overflow type. It is 7.5 m in height and 67 m in crest length. The weir is equipped with screen on the crest to separate water and gravels or cobbles flowing over the crest. The weir is connected to an inclined shaft to be set under the right abutment, which is in turn linked to the connecting tunnel of 2.0 m in diameter (Refer to DWG-14).

The connecting tunnel of 1,450 m in length is linked to the headrace tunnel from the intake weir, at a point of about 300 m from the surge tank (Refer to DWG-13).

G.4.4 Power Station and Transmission Line

An open type powerhouse is located at the same place as designed for El Torito dam plan (Refer to Chapter G.3.7). The dimension of powerhouse is designed to be 22.0 m in length, 18.5 m in width and 27.0 m in height.

The generating equipment is one unit of 7.2 MW. The turbine is of a vertical-shaft Francis type, with the rated capacity of 7.2 MW under the rated head of 229.2 m and the rated discharge of 3.72 m^3/s. The generator is of three-phase, and is rated 8.0 MVA to deliver 7.2 MW at 0.9 power factor in lagging.

An outdoor switchyard of 30 m in width and 40 m in length is designed beside the powerhouse. A main step-up transformer is installed in the outdoor switchyard, with the capacity of 7.2 MVA.

The plan for transmission line to the Rio Blanco power station is the same as designed for El Torito dam plan (69 kV in voltage and 8 km in length), explained in Chapter G.2.8.

G.4.5 Energy Output

On the basis of 90% dependable discharge estimated at 0.93 m^3/s and the reservoir operation rules proposed in Annex F.1.2, the annual energy output of El Torito (T-1 & T-2) weir plan is calculated as summarized hereunder. The primary energy is the output in 6-hour peak operation, while the secondary energy is the output in off-peak hours:

Installed capacity	7.2 MW
Primary energy	15.2 GWh

Secondary energy	16.9 GWh
Total energy output	32.1 GWh

G.5 PRELIMINARY DESIGN OF PINO DE YUNA WEIR PLAN

G.5.1 Pino de Yuna (T-4) Intake Weir

The proposed site for construction of intake weir is located at about 800 m downstream from the confluence with Arroyo Blanco. The riverbed is about 15 m in width, and the abutment dips 40° on the right bank and 30°-40° on the left bank. The foundation rock is composed of gneiss. The alluvial river gravel deposit is inferred to the 4.5 m in thickness.

The weir is designed to be a gated concrete weir. The gated overflow section and two ogee sections are designed to allow passage of a probable flood for the return period of 100 years, which is estimated at 440 m^3/s, as explained in Annex C.5.3. The weir is 74 m in crest length.

The storage capacity is optimized at 95,000 m^3, as explained in Chapter G.2.2. This storage is regulated by installing gates on the intake weir, for daily peak operation for 6 hours, in the range of EL. 680.0 m (high water level) and EL. 677.5 m (low water level) (Refer to Fig. G-09).

Two gates of vertical life type (12 m x 7.75 m, each) are installed to flush sediment in the storage. The upstream section of the weir will be filled out by sediment up to EL. 673.5 m in a relatively short period after the construction of weir, but the storage capacity is secured by such an installation of gates. An intake to lead water to the headrace tunnel is designed on EL. 674.5 m in the left abutment. A gate (2.0 m x 2.0 m) is set at the intake. Besides, a sand flushing channel is designed to be installed on the right side of the intake (Refer to DWG-16).

G.5.2 Waterway and Diversion from Tributary

A headrace tunnel is aligned on the left bank of the Yuna river, with a total length of 4.4 km. The rock mass along the tunnel route is inferred to be green schist. The tunnel is designed to have circular cross section with an inside diameter of 2.0 m. The excavation is planned to be made from 3 adits, each having the excavation length of 1,500 m, 1,050 m and 1,850 m. (Refer to DWG-17)

Water diversion from Arroyo Colorado is also planned to divert water (dependable discharge of 0.31 m^3/s) for this alternative plan. Arroyo Colorado water is taken at a diversion weir located at EL 695 m. The weir is 7.5 m in height and 71 m in crest length. A connecting tunnel of 1,300 m in length is connected to the headrace tunnel from the T-1 and T-2 weir at a point of about 200 m from the surge tank. (Refer to DWG-18)

The surge tank is installed at the downstream end of the headrace tunnel. It is desired to have a concrete lined vertical shaft of 4.0 m in diameter and 32.0 m in height. An orifice is 0.8 m in diameter. A penstock is designed on the same alignment as El Torito dam plan. It is 467 m in length and 2.0-1.0 m in diameter. (Refer to DWG-19)

G.5.3 Power Station

Powerhouse is located at the same place as designed for El Torito dam plan. The height of powerhouse is lowered by 0.5 m if compared with the powerhouse for the dam plan. The turbine is of a vertical-shaft Francis type, with the rated capacity of 6.3 MW under the rated head of 1,843 m and the rated discharge of 4.04 m^3/s. The generator is rated at 7.5 MVA to deliver 6.3 MW at 0.85 power factor in lagging. The transmission line is constructed in the same way as designed for El Torito dam plan and T-1 & T-2 weir plan.

G.5.4 Energy Output

In accordance with the conditions for operation of storage and power station, as explained in Chapter F.1.2, the annual energy output of the Pino de Yuna (T-4) weir plan (Yuna No. 1 power station) is calculated as summarized hereunder.

Installed capacity	6.3 MW
Primary energy	12.7 GWh
Secondary energy	13.7 GWh
Total energy output	26.4 GWh

G.6 PRELIMINARY DESIGN OF LOS VEGANOS WEIR PLAN

G.6.1 Los Veganos (V-3) Weir

The proposed weir site (V-3) is located at about 100 m downstream from the confluence with Arroyo Colorado, or about 500 m downstream from the proposed Yuna No. 1 power station. The site forms a gorge, with both abutment steeply dip for about 15 m in height. The cliff is formed of well-bedded marl and calcareous green tuff (Refer to Annex D.3.3).

Through the comparative study in Chapter G.1.2, the optimum storage capacity of Los Veganos (V-3) weir is determined at 169,000 m^3 (with EL Torito dam) or 149,000 m^3 (with El Torito weir) for daily regulation of 6 hours' peaking operation. The storage capacity is secured between the high water level at EL. 494.0 m and the lower water level at EL. 489.5 m in case of combination with El Torito dam, and between EL. 493.0 m and EL. 488.5 m in case of combination with El Torito weir. The weir is designed to have a gated overflow section, non-gated overflow section and a side channel, capable of passing a design flood discharge estimated at 820 m^3/s (Refer to Fig. G-09 and Annex C.5.3).

The gates, two in number, are designed to be of vertical lift type with a dimension of 12 m x 9.75 m, in order to flush sediment in the storage. An intake to lead water to the headrace tunnel is designed on EL. 485.5 m on the right abutment. The intake gate (2.0 m x 2.0 m) is set at the intake. Further, a sand flushing channel (3.0 m x 3.0 m) is provided in the weir beside the gates on the right abutment (Refer to DWG-20)

G.6.2 Waterway

A headrace tunnel is aligned on the right bank of the Yuna river. The tunnel alignment is proposed in due consideration of the fault that bevels twice on the alignment and runs in parallel for about a half of the tunnal route, as pointed out in Annex D.3.4. A total length of the headrace tunnel is approximately 3.3 km (Refer to DWG-21).

The headrace tunnel is a pressure tunnel with a circular cross section

The inside diameter is 2.0 m, which is the practical minimum size for excavation by conventional tunnel excavation equipment. The tunnel is divided into two sections for excavation: the first section of 1.9 km and the second section of 1.4 km. The work adits are located near V-3 intake, near El Capa and near the proposed surge tank (Refer to DWG-21).

A surge tank is constructed at the downstream end of the headrace tunnel, at EL. 510 m. The surge tank is designed to have a concrete-lined vertical type shaft of 6.0 m in inside diameter and 30.0 m in height. An orfice is 0.8 m in diameter. The minimum up-surging is about 3.3 m (with El Torito dam) or 3.0 m (with El Torito weir) above the high head water surface in case of full load rejection, and the maximum down-surging is 10.7 m (with El Torito dam) or 9.8 m (with El Torito weir) below the low head water surface in case of instantaneous load increase from a half to full load (Refer to DWG-22).

A penstock is planned to lay on the ridge of slope behind the powerhouse to be located at about 1.8 km upstream from the confluence with Rio Tireo. The penstock is 200 m in length, and 2.0 - 1.0 m in inside diameter.

G.6.3 Power Station and Transmission Line

An open type powerhouse is constructed on the old river terrace deposit developed on the right bank, at about 1.8 km upstream from the Rio Tireo confluence. The site is excavated down to about 7.0 m from the ground surface in order to obtain sound foundation. The powerhouse (Yuna No. 2) is designed to be 21.5 m in length, 19.0 m in width, and 27.0 m in height (Refer to DWG-23).

The generating equipment is one unit of 8.8 MW (with El Torito dam) or 7.7 MW (with El Torito weir). The turbine is of a vertical-shaft Francis type. The rated capacity is obtained under the rated head of 134.0 m and the rated discharge of 7.84 m^3/s(with El Torito dam) or 6.88 m^3/s (with El Torito weir). The rated revolving speed is 720 rpm (with El Torito weir). The generator is of three-phase, and is rated for 9.8 MVA (with El Torito dam) or 9 MVA (with El Torito weir) to deliver 8.8 MW or 7.7 MW of power at 0.9 power factor in lagging.

An outdoor switchyard of 30 m in width and 40 m in length is designed beside the powerhouse. A main step-up transformer with the capacity of 9.8 MVA or 9 MVA is installed in the outdoor switchyard.

The generated power is planned to be transmitted through a 69 kV line to be connected to the Rio Blanco switching station. A distance of the transmission line is approximately 4.0 km.

G.6.4 Energy Output

On the basis of 90% dependable discharge estimated at 1.96 m^3/s (with El Torito dam) or 1.72 m^3/s (with El Torito weir) at V-3 site and the reservoir operation rules proposed in Annex F.1.2, the annual energy output of Los Veganos weir plan is calculated as summarized hereunder. The primary energy is the output in 6-hour peak operation, while the secondary energy is the output in off-peak hours.

	With El Torito Dam	With El Torito Weir
Installed capacity	8.8 MW	7.7 MW
Primary energy	18.9 GWh	16.4 GWh
Secondary energy	22.8 GWh	19.0 GWh
Total energy output	41.7 GWh	35.4 GWh

Consequently, the total energy output of El Torito-Los Veganos complex is estimated as summarized hereunder.

(El Torito Dam) + (V-3 Weir)

Installed capacity	19.1 MW
Primary energy	41.1 GWh
Secondary energy	38.6 GWh
Total energy output	79.7 GWh

(T-1 & T-2 Weir) + (V-3 Weir)

Installed capacity	14.9 MW
Primary energy	31.6 GWh
Secondary energy	35.9 GWh
Total energy output	67.5 GWh

(T-4 Weir) + (V-3 Weir)

Installed capacity	14.0 MW
Primary energy	29.1 GWh
Secondary energy	32.7 GWh
Total energy output	61.8 GWh

TABLES

Table G-01 DETERMINATION OF OPTIMUM SCALE OF EL TORITO DAM AND RESERVOIR
(CAPACIDAD OPTIMA DEL EMBALSE EL TORITO)

T1 + T2 Dam

	Case 1	Case 2	Case 3
H.W.L.	750	755	760
Reservoir Storage (10^3m^3)	2,800	4,600	6,900
1. Power Generation			
Installation Capacity (kW)	8,700	10,300	11,400
Annual Energy Output (GWh)	36.1	38.0	39.4
Primary	(18.8)	(22.2)	(24.6)
Secondary	(17.3)	(15.8)	(14.8)
2. Construction Cost (10^3US$)	48,908	53,246	59,510
3. Annual Equivalent Benefit (B) (10^3US$)			
Capacity Benefit	402	476	527
Energy Benefit	2,731	3,099	3,360
Primary	(2,262)	(2,671)	(2,959)
Secondary	(469)	(428)	(401)
Total	3,133	3,575	3,887
4. Annual Equivalent Cost (C) (10^3US$)			
Capital Recovery Cost	5,889	6,412	7,166
O & M Cost	533	564	600
Total	6,422	6,976	7,766
5. Benefit Cost Ratio (B)/(C)	0.49	0.51	0.50

Table G-02 PEAK OPERATION TIME EL TORITO DAM PLAN

(OPERACION DE HORAS PICO DEL EMBALSE EL TORITO)

T1 + T2 Dam

	Case 1	Case 2	Case 3
Storage Volume (10^3m^3)	4,600	4,600	4,600
Peak Operation Time (hr)	5	6	7
1. Power Generation			
Installed Capacity (kW)	12,200	10,300	8,800
Annual Energy Output (GWh)	38.8	38.0	37.0
Primary	(21.9)	(22.2)	(22.1)
Secondary	(16.9)	(15.8)	(14.9)
2. Construction Cost (10^3US$)	55,837	53,246	53,013
3. Annual Equivalent Benefit (B) (10^3US$)			
Capacity Benefit	564	476	407
Energy Benefit	3,093	3,099	3,063
Primary	(2,635)	(2,671)	(2,659)
Secondary	(458)	(428)	(404)
Total	3,657	3,575	3,470
4. Annual Equivalent Cost (C) (10^3US$)			
Capacity Recovery Cost	6,724	6,412	6,384
O & M Cost	589	564	548
Total	7,313	6,976	6,932
5. Benefit Cost Ratio (B/C)	0.50	0.51	0.50

Table G-03(1) LEAST COST OF WEIR AND GATE
(COSTO DE LA DERIVADORA Y COMPUERTA)

T-1 & T-2 Weir

	Case 1	Case 2	Case 3
Weir height (m)	22	25	26
Gate size	12m x 11.5 m	12m x 9 m	12m x 7.7 m
Cost 10^3 US$			
Weir	993	1,358	1,825
Gate	1,428	948	744
Total	2,421	2,306	2,569

T-4 Weir

	Case 1	Case 2	Case 3
Weir height (m)	22	24.5	28.2
Gate size	12m x 11.5m	12m x 9m	12m x 7.7m
Cost 10^3 US$			
Weir	945	1,281	1,706
Gate	1,428	948	744
Total	2,373	2,229	2,450

Table G-03(2) LEAST COST OF WEIR AND GATE
(COSTO DE LA DERIVADORA Y COMPUERTA)

V-3 Weir (w/T1-T2 dams)

	Case 1	Case 2	Case 3
Weir height (m)	30.5	32.5	36.0
Gate size	12m x 13.0m	12m x 10.0m	12m x 8.5m
Cost 10^3 US$			
Weir	1,183	1,142	1,545
Gate	1,487	939	723
Total	2,670	2,081	2,268

V-3 Weir (w/T4 or T1-T2 weir)

	Case 1	Case 2	Case 3
Weir height (m)	34.4	35.9	38.2
Gate size	12m x 15.9m	12m x 13.4m	12m x 11.7m
Cost 10^3 US$			
Weir	1,448	1,657	2,097
Gate	2,596	1,886	1,477
Total	4,044	3,543	3,574

Table G-04 STORAGE VOLUME AT EL TORITO WEIR

(CAPACIDAD DEL ALMACENAJE DE LA DERIVADORA EL TORITO)

Riverbed EL: 713

		Case 1	Case 2	Case 3	Case 4
Storage Vol. (10^3m^3)		10.4	110.0	120.0	132.0
Dam Crest EL. Minus Riverbed EL. (m)	(A)	16.0	17.0	18.0	19.0
Spilway Gate Sill EL. Minus Riverbed EL. (m)	(B)	6.0	6.5	7.0	7.5
Gate Height (m)	(C)	7.5	8.0	8.5	9.0
(C)/(A)		0.47	0.47	0.47	0.47
(C)/(B)		1.20	1.20	1.20	1.20
H.W.L.		725.0	726.0	727.0	728.0
L.W.L.		722.0	723.4	724.5	725.6
Dam Crest EL.		729.0	730.0	731.0	732.0
Spilway Gate Sill EL.		719.0	719.5	720.0	720.5

Note: (A) (Dam Crest EL) - (Riverbed EL) (m)

(B) (Spilway Gate Sill EL) - (Riverbed EL) (m)

(C) Gate Height (m)

Table G-05 STORAGE VOLUME (T-4 WEIR)
(CAPACIDAD DEL ALMACENAJE (T-4))

Riverbed EL: 663

		Case 1	Case 2	Case 3	Case 4
Storage Vol. (10^3m^3)		67.4	101.1	134.8	202.2
Dam Crest EL. Minus Riverbed EL. (m)	(A)	20.0	21.0	22.0	23.5
Spillway Gate Sill EL. Minus Riverbed EL. (m)	(B)	10.0	10.5	11.5	12.0
Gate Height (m)	(C)	7.5	8.0	8.5	9.0
(C)/(A)		0.383	0.383	0.383	0.383
(C)/(B)		0.750	0.750	0.750	0.750
H.W.L.		679.0	680	681	682.5
L.W.L.		677.0	677.5	678	679.0
Dam Crest EL.		683.50	684	685	686.5
Spillway Gate Sill EL.		673.0	673.5	674	675.0

Note: (A) [Dam Crest EL] - [Riverbed EL] (m)
(B) [Spillway Gate Sill EL] - [Riverbed EL] (m)
(C) Gate Height (m)

Table G-06(1) STORAGE VOLUME (V-3 WEIR) COMBINED WITH EL TORITO DAM
(CAPACIDAD DEL ALMACENAJE (V-3) COMBINADA CON LA PRESA EL TORITO)

	Case 1	Case 2	Case 3	Case 4
S.V. (10^3m^3)	113	169	226	339
(A)	30.5	33.0	35.1	39.2
(B)	19.0	20.5	22.0	24.0
(C)	11.5	12.0	13.0	14.0
(C)/(A)	0.303	0.303	0.303	0.303
(C)/(B)	0.488	0.488	0.488	0.488
H.W.L.	491.5	494.0	496.1	499.2
L.W.L.	488.0	489.5	491.0	493.0
Dam Crest EL.	495.5	498.0	500.1	503.2
Spillway Gate Sill EL.	484.0	485.5	487.0	489.0

Note: (A) (Dam Crest EL) - (Riverbed EL) (m)

(B) (Spillway Gate Sill EL) - (Riverbed EL) (m)

(C) Gate Height (m)

Table G-06 (2) STORAGE VOLUME (V-3 WEIR) COMBINED WITH EL TORITO WEIR
(CAPACIDAD DEL ALMACENAJE (V-3) COMBINADA CON LA DERIVADORA EL TORITO)

	Case 1	Case 2	Case 3	Case 4
S.V. (10^3m^3)	99.1	148.6	198.1	297.2
(A)	29.0	32.0	33.5	36.5
(B)	17.0	19.5	20.0	22.0
(C)	9.5	10.0	11.0	12.0
(C)/(A)	0.329	0.329	0.329	0.329
(C)/(B)	0.545	0.545	0.545	0.545
H.W.L.	490.0	493.0	494.5	497.5
L.W.L.	486.0	488.5	489.0	491.0
Dam Crest EL.	494.0	497.0	498.5	501.5
Spillway Gate Sill EL.	482.0	484.5	485.0	487.0

Note: (A) [Dam Crest EL] - [Riverbed EL] (m)
(B) [Spillway Gate Sill EL] - [Riverbed EL] (m)
(C) Gate Height (m)

Table G-07 COST COMPARISON UNDER DIFFERENT STORAGE VOLUME (T-1 & T-2 WEIR)

(COMPARACION DE LA CAPACIDAD DEL EMBALSE DERIVADORA T-1 Y T-2)

	Case 1	Case 2	Case 3	Case 4
Storage Volume (10^3m^3)	73	110	146	220
1. Power Generation				
Installed Capacity (kw)	7,000	7,200	7,200	7,300
Annual Energy Output (GWh)	31.7	32.1	32.2	32.5
Primary	14.8	15.2	15.2	15.4
Secondary	16.9	16.9	17.0	17.1
2. Construction Cost (10^3US$)	33,337	33,608	35,144	37,626
3. Annual Equivalent Benefit (B) (10^3US$)				
Capacity Benefit	464	478	478	484
Energy Benefit	3,329	3,391	3,391	3,434
Primary	(2,294)	(2,356)	(2,356)	(2,387)
Secondary	(1,035)	(1,035)	(1,035)	(1,047)
Total	3,793	3,869	3,869	3,918
4. Annual Equivalent Cost (C) (10^3US$)				
Capital Recovery Cost	4,014	4,047	4,232	4,531
O & M Cost	428	436	438	451
Total	4,442	4,483	4,670	4,982
5. Benefit Cost Ratio (B)/(C)	0.85	0.86	0.83	0.79

Table G-08 COST COMPARISON UNDER DIFFERENT STORAGE VOLUME (T-4 WEIR)
(COMPARACION DE LA CAPACIDAD DEL EMBALSE DERIVADORA T-4)

	Case 1	Case 2	Case 3	Case 4
Storage Volume (10^3m^3)	63	95	126	189
1. Power Generation				
Installed Capacity (KW)	6,100	6,300	6,300	6,400
Annual Energy Output (GWh)	26.0	26.4	26.5	26.8
Primary	12.3	12.7	12.7	12.9
Secondary	13.7	13.7	13.8	13.9
2. Construction Cost (10^3US$)	28,038	28,610	29,918	32,031
3. Annual Equivalent Benefit (B) (10^3US$)				
Capacity Benefit	405	418	418	424
Energy Benefit	2,746	2,808	2,814	2,851
Primary	(1,907)	(1,969)	(1,969)	(2,000)
Secondary	(839)	(839)	(845)	(851)
Total	3,151	3,226	3,232	3,275
4. Annual Equivalent Cost (C) (10^3US$)				
Capital Recovery Cost	3,376	3,445	3,603	3,857
O & M Cost	364	372	374	384
Total	3,740	3,817	3,977	4,241
5. Benefit Cost Ratio (B)/(C)	0.84	0.85	0.81	0.77

Table G-09(1) COST COMPARISON UNDER DIFFERENT STORAGE VOLUME:
V-3 WEIR WITH EL TORINTO DAM.
*(COMPARACION DEL COSTO (V-3)
COMBINACION CON LA PRESA EL TORITO)*

	Case 1	Case 2	Case 3	Case 4
Storage Volume (10^3m^3)	113	169	226	339
1. Power Generation				
Insta-led Capacity (kW)	8,600	8,800	8,900	9,000
Annual Energy Output (GWh)	38.4	39.7	39.8	40.1
Primary	(16.2)	(18.9)	(18.8)	(19.1)
Secondary	(22.2)	(20.8)	(21.0)	(21.0)
2. Construction Cost (10^3 US$)	24,645	25,770	26,604	27,944
3. Annual Equivalent Benefit (B) (10^3 US$)				
Capacity Benefit	568	582	588	595
Energy Benefit	3,994	4,347	4,343	4,393
Primary	(2,634)	(3,073)	(3,057)	(3,106)
Secondary	(1,360)	(1,274)	(1,286)	(1,287)
Total	4,562	4,929	4,931	4,987
4. Annual Equivalent Cost (C) (10^3 US$)				
Capital Recovery Cost	2,968	3,103	3,204	3,365
O & M Cost	123	129	133	140
Total	3,091	3,232	3,337	3,505
5. Benefit Cost Ratio (B)/(C)	1.48	1.52	1.48	1.42

Table G-09(2) COST COMPARISON UNDER DIFFERENT STORAGE VOLUME : V-3 WEIR WITH EL TORITO WEIR

(COMPARACION DEL COSTO (V-3) COMBINACION CON LA DERIVADORA EL TORITO)

	Case 1	Case 2	Case 3	Case 4
Storage Volume ($10^3 m^3$)	99	149	198	297
1. Power Generation				
Installed Capacity (kW)	7,500	7,700	7,700	7,900
Annual Energy Output (GWh)	34.8	35.4	35.7	36.5
Primary	(14.9)	(16.4)	(16.4)	(16.8)
Secondary	(19.9)	(19.0)	(19.3)	(19.7)
2. Construction Cost (10^3US$)	18,628	19,331	20,215	21,642
3. Annual Equivalent Benefit (B) (10^3US$)				
Capacity Benefit	347	356	356	365
Energy Benefit	2,331	2,488	2,496	2,555
Primary	(1,792)	(1,973)	(1,973)	(2,021)
Secondary	(539)	(515)	(523)	(534)
Total	2,678	2,844	2,852	2,920
4. Annual Equivalent Cost (C) (10^3US$)				
Capital Recovery Cost	2,243	2,328	2,434	2,606
O & M Cost	246	250	254	262
Total	2,489	2,578	2,688	2,862
5. Benefit Cost Ratio (B)/(C)	1.08	1.10	1.06	1.02

Table G-10 CASE STUDY OF PEAK OPERATION (T-1 & T-2 WEIR)
(ESTUDIO DE OPERACION PICO DERIVADORA T-1 Y T-2)

	Case 1	Case 2	Case 3
Storage Volume (10^3m^3)	110	110	110
Peak Operation Time (hr)	5	6	7
1. Power Generation			
Installed Capacity (kW)	8,600	7,200	6,200
Annual Energy Output (GWh)	33.5	32.1	30.8
Primary	(15.1)	(15.2)	(15.3)
Secondary	(18.4)	(16.9)	(15.5)
2. Construction Cost (10^3US$)	35,085	33,608	32,937
3. Annual Equivalent Benefit (B) (10^3US$)			
Capacity Benefit	570	478	411
Energy Benefit	3,468	3,391	3,321
Primary	(2,341)	(2,356)	(2,372)
Secondary	(1,127)	(1,035)	(949)
Total	4,038	3,869	3,732
4. Annual Equivalent Cost (C) (10^3US$)			
Capital Recovery Cost	4,425	4,047	3,966
O & M Cost	455	436	427
Total	4,880	4,483	4,393
5. Benefit Cost Ratio (B)/(C)	0.83	0.86	0.85

Table G-11 CASE STUDY OF PEAK OPERATION (T-4 WEIR)
(ESTUDIO DE OPERACION PICO DERIVADORA T-4)

	Case 1	Case 2	Case 3
Storage Volume (10^3m^3)	95	95	95
Peak Operation Time (hr)	5	6	7
1. Power Generation			
Installed Capacity (kW)	7,500	6,300	5,500
Annual Energy Output (GWh)	27.5	26.4	25.4
Primary	(12.6)	(12.7)	(12.8)
Secondary	(14.9)	(13.7)	(12.6)
2. Construction Cost (10^3US$)	29,867	28,610	28,038
3. Annual Equivalent Benefit (B) (10^3US$)			
Capacity Benefit	497	418	365
Energy Benefit	2,866	2,808	2,756
Primary	(1,953)	(1,969)	(1,984)
Secondary	(913)	(839)	(772)
Total	3,363	3,226	3,121
4. Annual Equivalent Cost (C) (10^3US$)			
Capital Recovery Cost	3,596	3,445	3,376
O & M Cost	387	372	361
Total	3,983	3,817	3,737
5. Benefit Cost Ratio (B)/(C)	0.84	0.85	0.84

Table G-12(1) CASE STUDY OF PEAK OPERATION
V-3 WEIR WITH EL TORITO DAM
(ESTUDIO DE OPERACION PICO (V-3)
COMBINACION CON LA PRESA EL TORITO)

	Case 1	Case 2	Case 3
Storage Voluem ($10^3 m^3$)	169	169	169
Peak Operation Time	5	6	7
1. Power Generation			
Installed Capacity (kW)	10,500	8,800	7,500
Annual Energy Output (GWh)	40.9	39.7	37.8
Primary	(18.1)	(18.9)	(18.8)
Secondary	(22.8)	(20.8)	(19.0)
2. Construction Cost (10^3 US$)	26,544	25,770	25,234
3. Annual Equivalent Benefit (B) (10^3 US$)			
Capacity Benefit	694	582	496
Energy Benefit	4,340	4,347	4,221
Primary	(2,943)	(3,073)	(3,057)
Secondary	(1,397)	(1,744)	(1,164)
Total	5,034	4,929	4,716
4. Annual Equivalent Cost (C) (10^3 US$)			
Capital Recovery Cost	3,196	3,103	3,039
O & M Cost	133	129	126
Total	3,329	3,232	3,165
5. Benefit Cost Ratio (B)/(C)	1.51	1.52	1.49

Table G-12(2) CASE STUDY OF PEAK OPERATION
V-3 WEIR WITH EL TORITO WEIR

(ESTUDIO DE OPERACION PICO (V-3)
COMBINACION CON LA DERIVADORA EL TORITO)

	Case 1	Case 2	Case 3
Storage Volume ($10^3 m^3$)	149	149	149
Peak Operation Time (hr)	5	6	7
1. Power Generation			
Installed Capacity (kW)	9,000	7,700	6,700
Annual Energy Output (GWh)	36.8	35.4	34.0
Primary	(16.0)	(16.4)	(16.6)
Secondary	(20.8)	(19.0)	(17.4)
2. Construction Cost (10^3US$)	20,832	19,331	19,082
3. Annual Equivalent Benefit (B) (10^3US$)			
Capacity Benefit	416	356	310
Energy Benefit	2,489	2,488	2,469
Primary	(1,925)	(1,973)	(1,997)
Secondary	(564)	(515)	(472)
Total	2,905	2,844	2,779
4. Annual Equivalent Cost (C) (10^3US$)			
Capital Recovery Cost	2,509	2,328	2,298
O & M Cost	261	250	243
Total	2,770	2,578	2,541
5. Benefit Cost Ratio (B)/(C)	1.05	1.10	1.09

Table G-13 COST COMPARISON OF GRAVITY DAM AND ROCKFILL DAM

(COMPARACION DEL TIPO DE LA PRESA)

Work Item	Gravity Dam		Cost 10^3US$	Fill Type Dam		Cost 10^3US$
1. Cofferdam	Ex.	350	83	Ex.	5,000	103
	Con.	830		Em.	8,000	
2. Diversion Tunnel	Ex.	11,100	660	Ex.	43,500	2,580
	Con.	2,500		Con.	9,700	
3. Foundation Treatment	L.S		4,330	L.S		3,320
4. Main Dam	Ex.	65,000	16,330	Ex.	79,000	
	Con.	133,000		Em.	369,000	5,110
5. Spillway			-	Ex.	122,100	1,930
				Con.	13,000	
Total			21,403			13,043

Note: Ex. : Excavation volume (m^3)
Em. : Embankment volume (m^3)
Con. : Concrete volume (m^3)

Spillway cost of gravity dam is included in main dam cost.

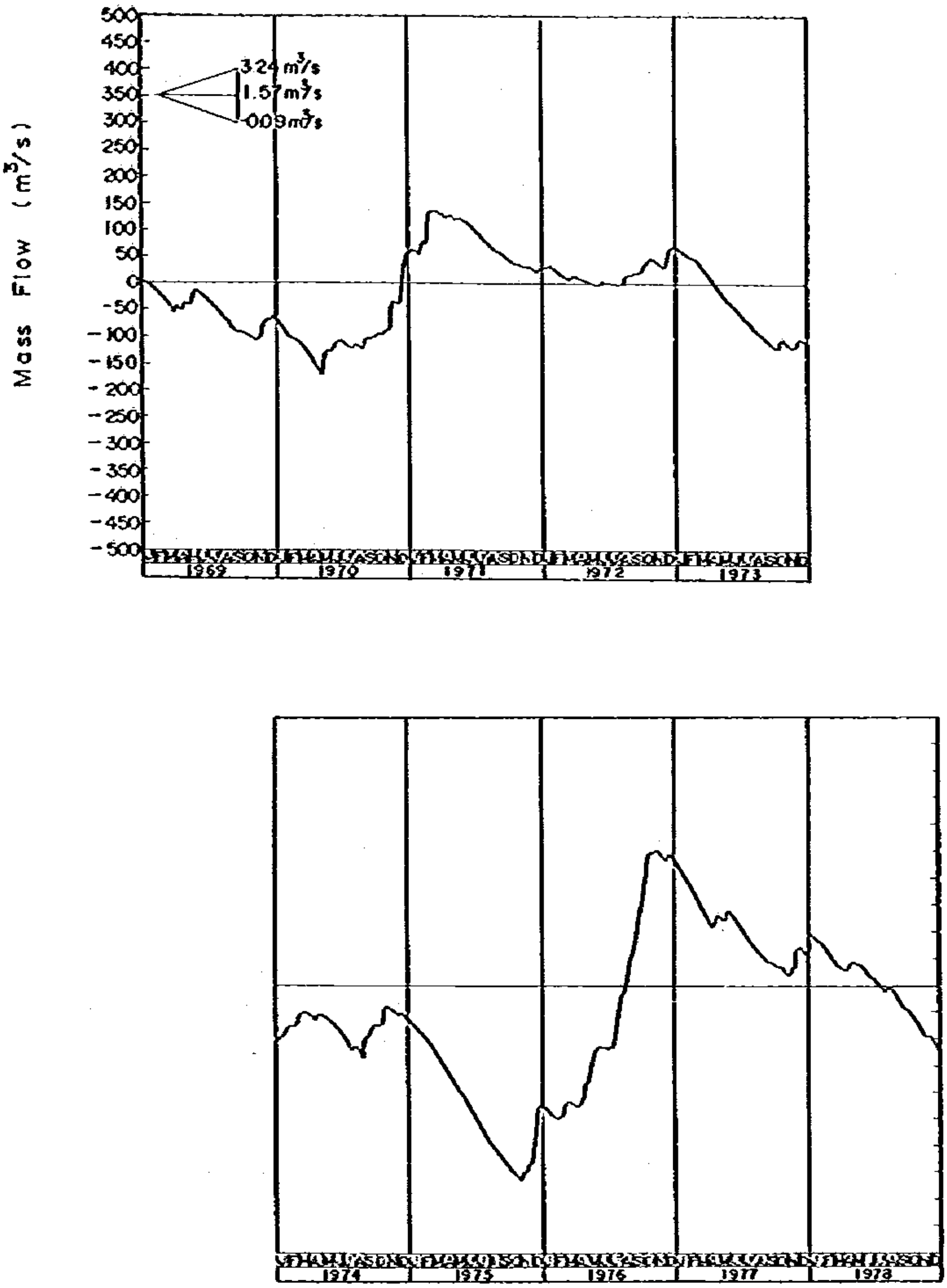
Table G-14 DETERMINATION OF SLOPE GRADIENT FOR ROCK AND RANDOM MATERIAL ZONE

(PENDIENTES DE LA PRESA DETERMINADAS POR EL ANALISIS DE ESTABILIDAD)

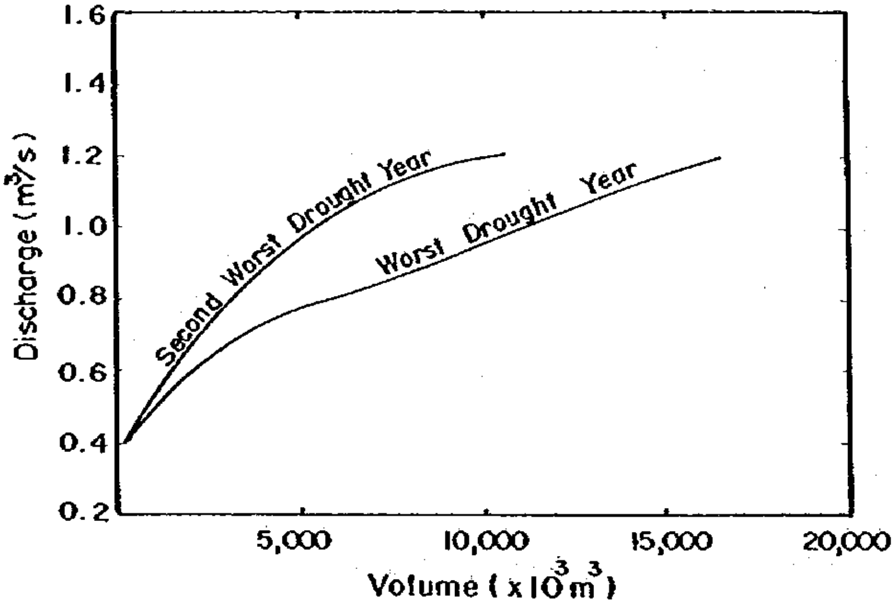
	Gradient		Safety Factor	
	Rock Zone	Random Material Zone	Normal	Seismic
Upstream Slope	1:2.7	1:2.1	2.174	1.182
		1:2.0	2.176	1.188
		1:1.9	2.179	1.194
		1:1.8*	2.183	1.200
Downstream Slope	1:1.9	1:1.5	1.670	1.194
		1:1.4*	1.688	1.206

Note: Values with asterisk are adopted to the design.

FIGURES

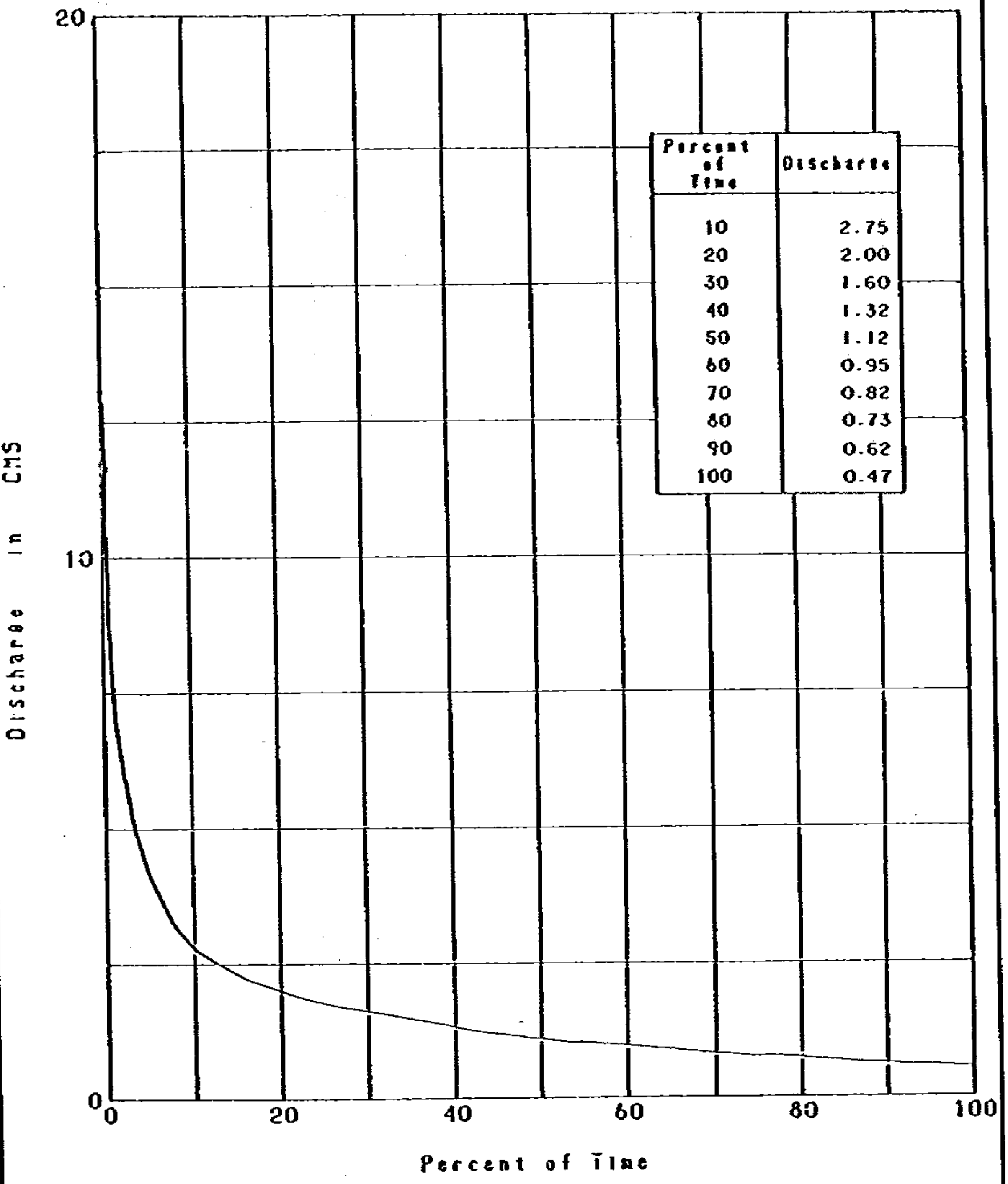


CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Discharge Mass Curve at El Torito
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	G-01	*Curva de Masa en El Torito*
JAPAN INTERNATIONAL COOPERATION AGENCY		



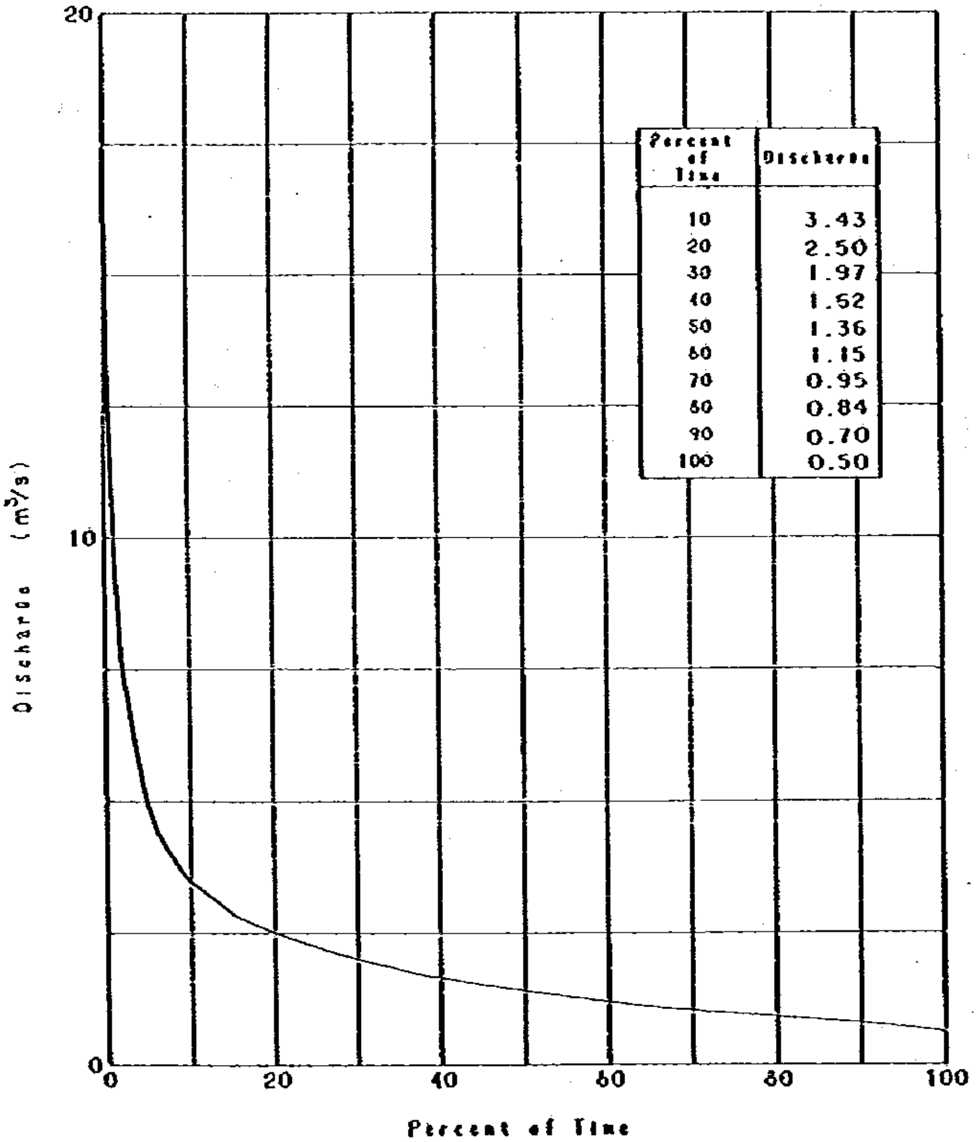
Dischoge Q (m^3/s)	For the Worst Drought Year					For the Second Worst Drought Year				
	V'max1 (m^3/s)	Vmax1 (V'max1x86,400) ($x10^3 m^3$)	Date			V'max2 (m^3/s)	Vmax2 (V'max x86,400) ($x 10^3 m^3$)	Date		
0.4	3.42	300.0	'75	AUG.	7	3.03	260.0	'77	APR.	9
0.6	22.48	1,940.0	"	"	8	17.39	1,500.0	"	"	"
0.8	67.81	5,860.0	"	OCT.	2	38.43	3,320.0	"	"	17
1.0	126.92	10,970.0	"	"	31	62.07	5,360.0	"	"	"
1.2	191.44	16,540.0	"	"	"	123.28	10,650.0	'79	MAR.	15

CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Reservoir Capacity for Various Draft Values at El Torito
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	G-02	*Capacidad del Embalse en El Torito*
JAPAN INTERNATIONAL COOPERATION AGENCY		



Percent of Time	Discharge
10	2.75
20	2.00
30	1.60
40	1.32
50	1.12
60	0.95
70	0.82
80	0.73
90	0.62
100	0.47

CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Discharge Duration Curve at El Torito (T-1 & T-2)
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	G-03	*Curva de Duración de Caudales en El Torito (T-1 y T-2)*
JAPAN INTERNATIONAL COOPERATION AGENCY		



Percent of Time	Discharge
10	3.43
20	2.50
30	1.97
40	1.52
50	1.36
60	1.15
70	0.95
80	0.84
90	0.70
100	0.50

CORPORACION DOMINICANA DE ELECTRICIDAD

EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX

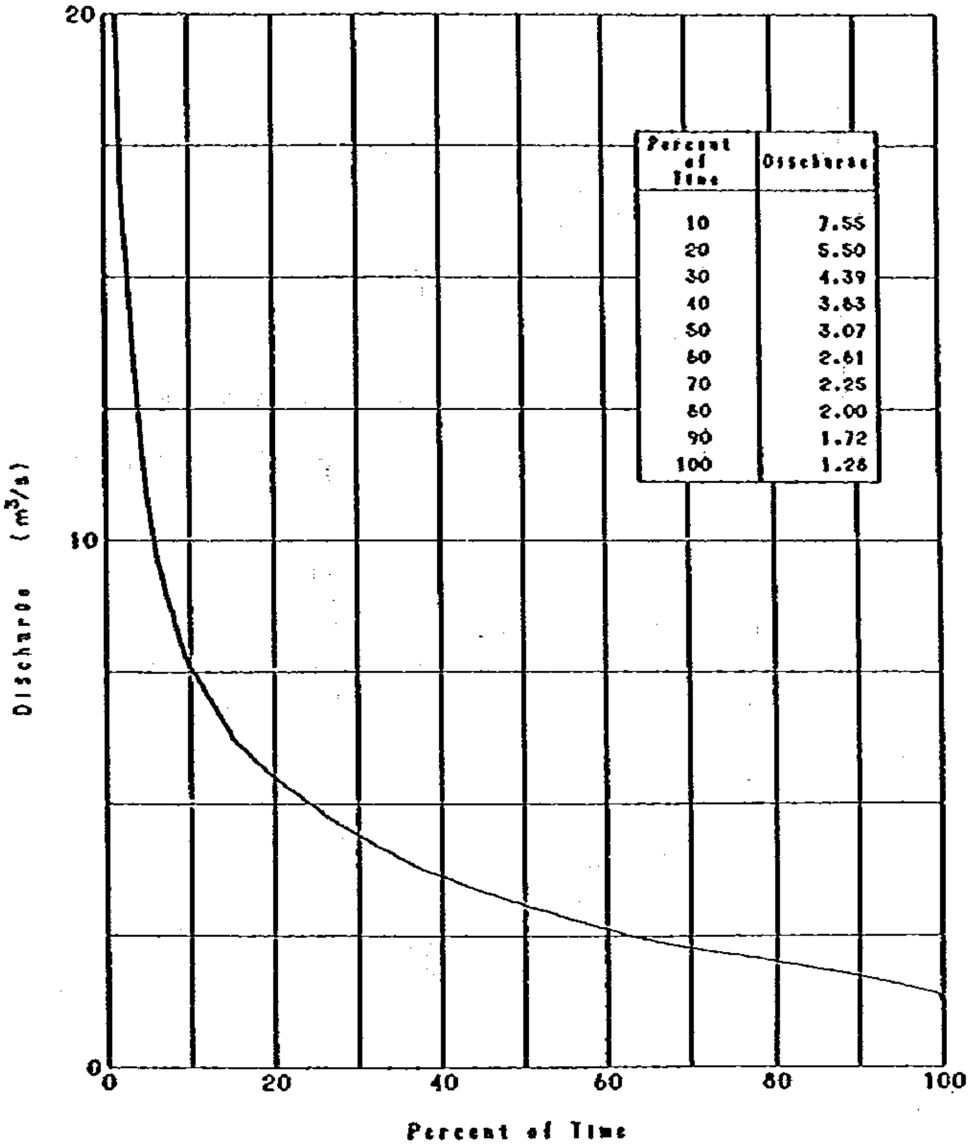
COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. G-04

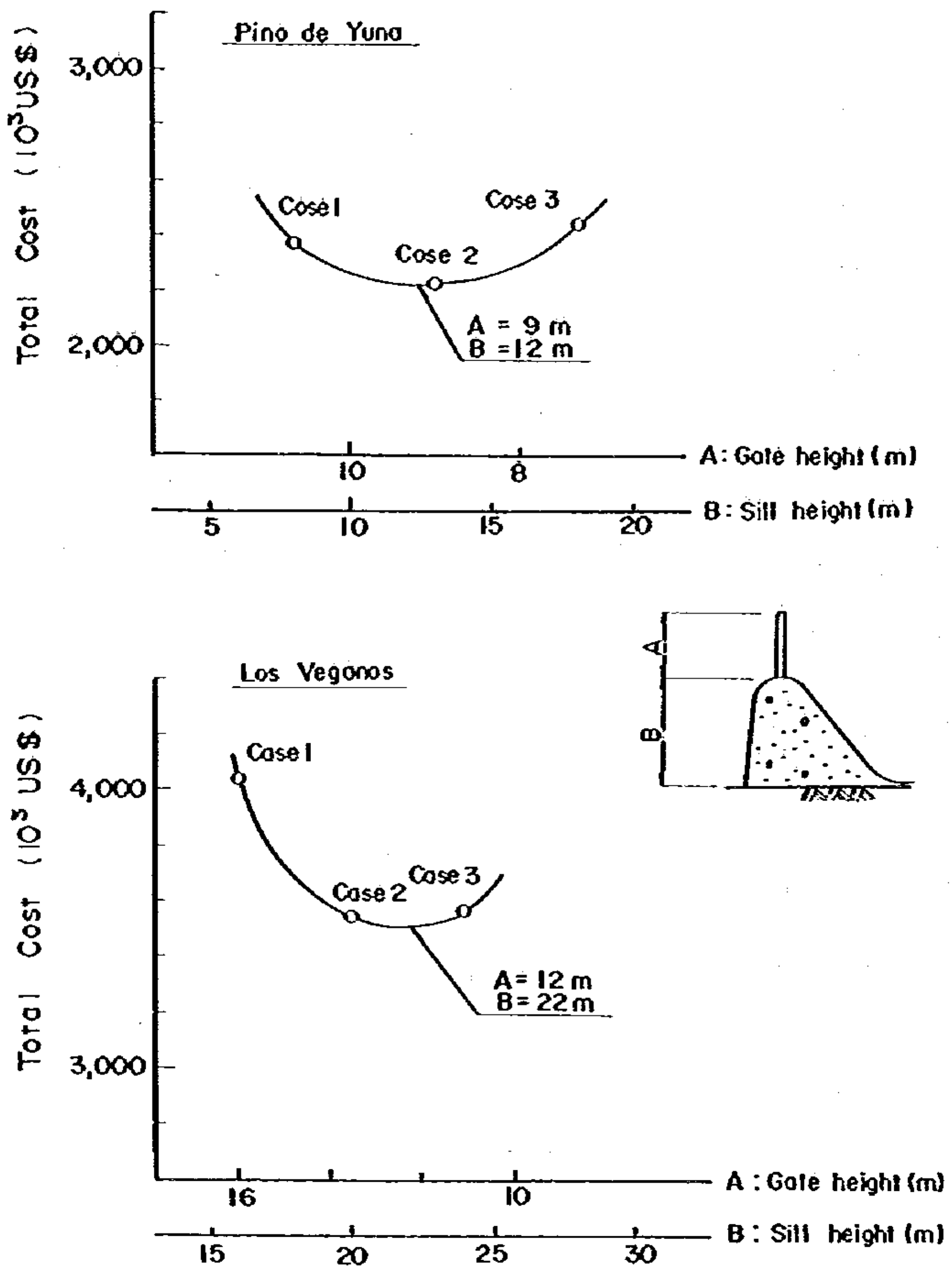
Discharge Duration Curve at Pino de Yuna

Curva de Duración de Caudales en Pino de Yuna



Percent of Time	Discharge
10	7.55
20	5.50
30	4.39
40	3.63
50	3.07
60	2.61
70	2.25
80	2.00
90	1.72
100	1.28

CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Discharge Duration Curve of V-3 Site
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELÉCTRICO EL TORITO-LOS VEGANOS	G-05	*Curva de Duración de Caudales en Los Veganos (V-3)*
JAPAN INTERNATIONAL COOPERATION AGENCY		



CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Least Cost of Weir and Gate
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	G-06	*Costo Minimo de la Derivadora y Compuerta*
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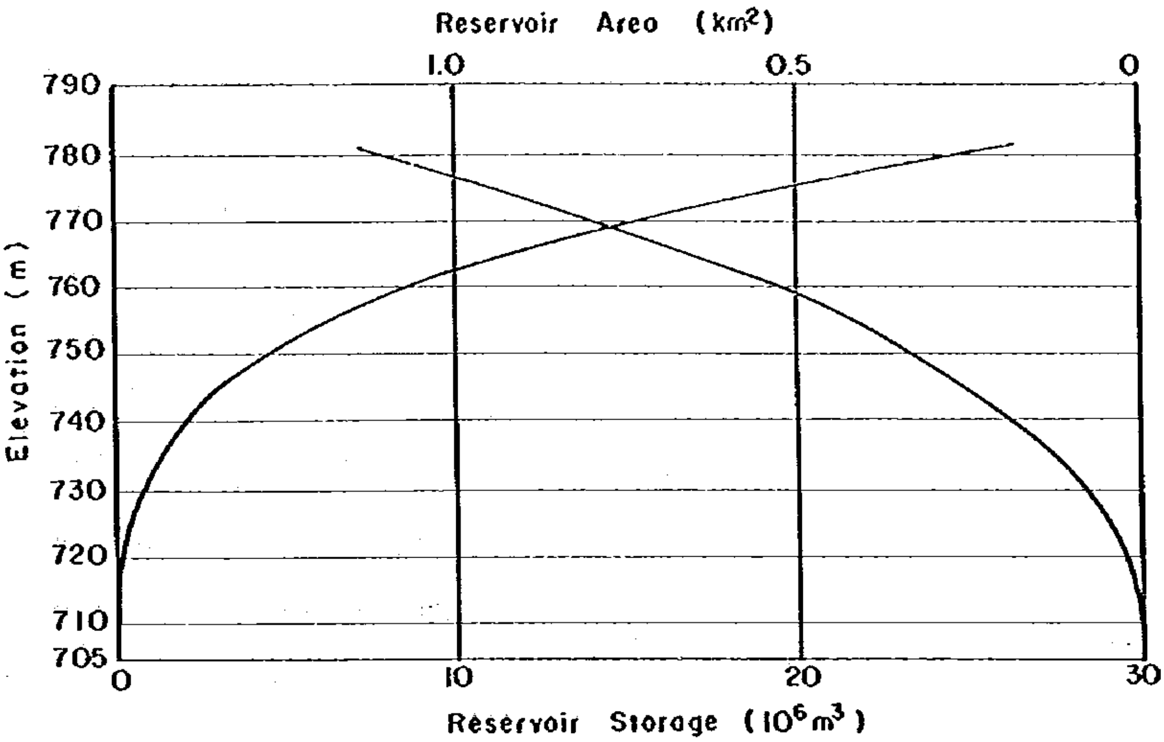

Elevation (m)	Reservoir Storage ($10^6 m^3$)	Reservoir Area (km^2)	Elevation (m)	Reservoir Storage ($10^6 m^3$)	Reservoir Area (km^2)
706	0	0	745	2.85	0.252
710	0.01	0.001	750	4.29	0.325
715	0.03	0.005	755	6.09	0.395
720	0.09	0.017	760	8.37	0.517
725	0.24	0.041	765	11.34	0.692
730	0.54	0.078	770	15.03	0.803
735	1.03	0.117	775	19.41	0.949
.740	1.77	0.180	780	24.57	1.116

CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Area - Capacity Curve at El Torito Damsite
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX / COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	G-07	*Curva de Capacidad de la Presa de Embalse El Torito*
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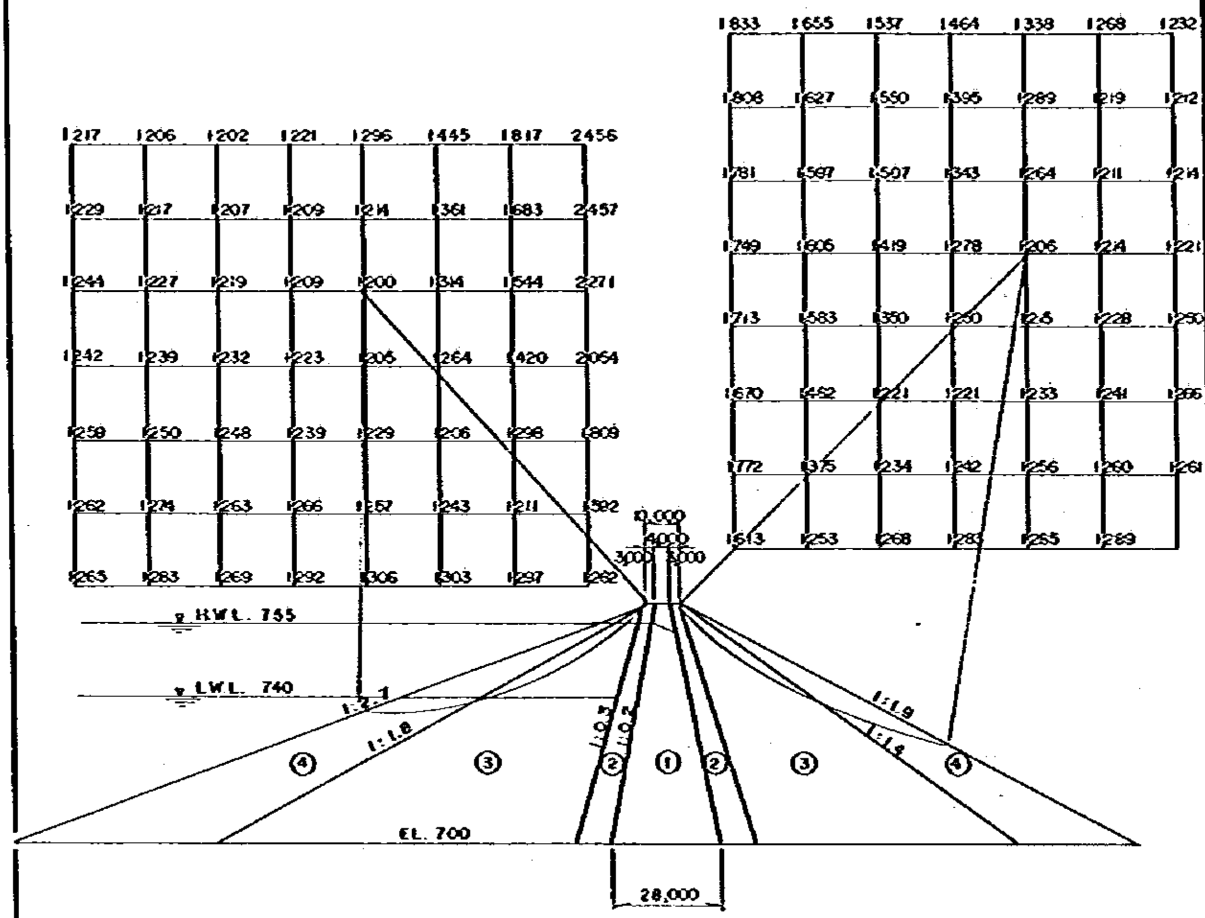
Crest EL. 760m

Seismic Kh = 0.15



	C (t/m)	φ (°)	γt (t/m³)	γsat (t/m³)
① Impervious Core	3.0	25	1.75	1.82
② Filter	0	38	2.10	2.20
③ Random Material	0	40	1.95	2.10
④ Rock	0	42	1.95	2.10

CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Stability Analysis for T2 Dam
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	G-08	*Análisis de Estabilidad de la Presa T-2*
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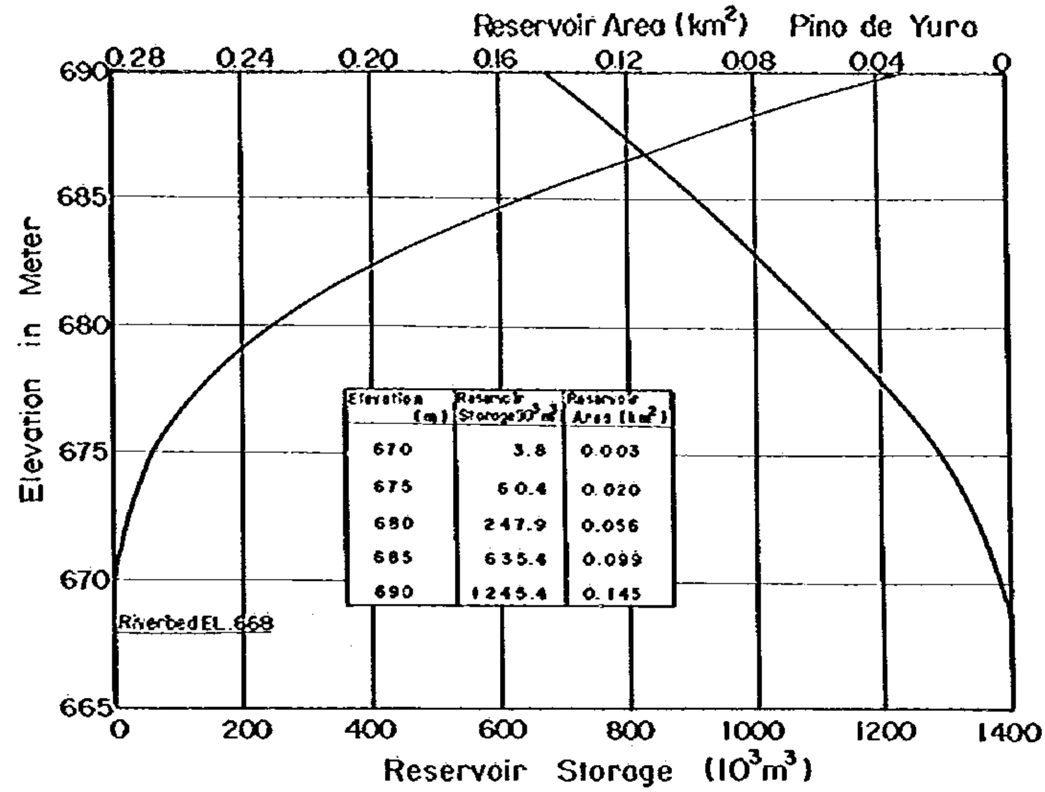
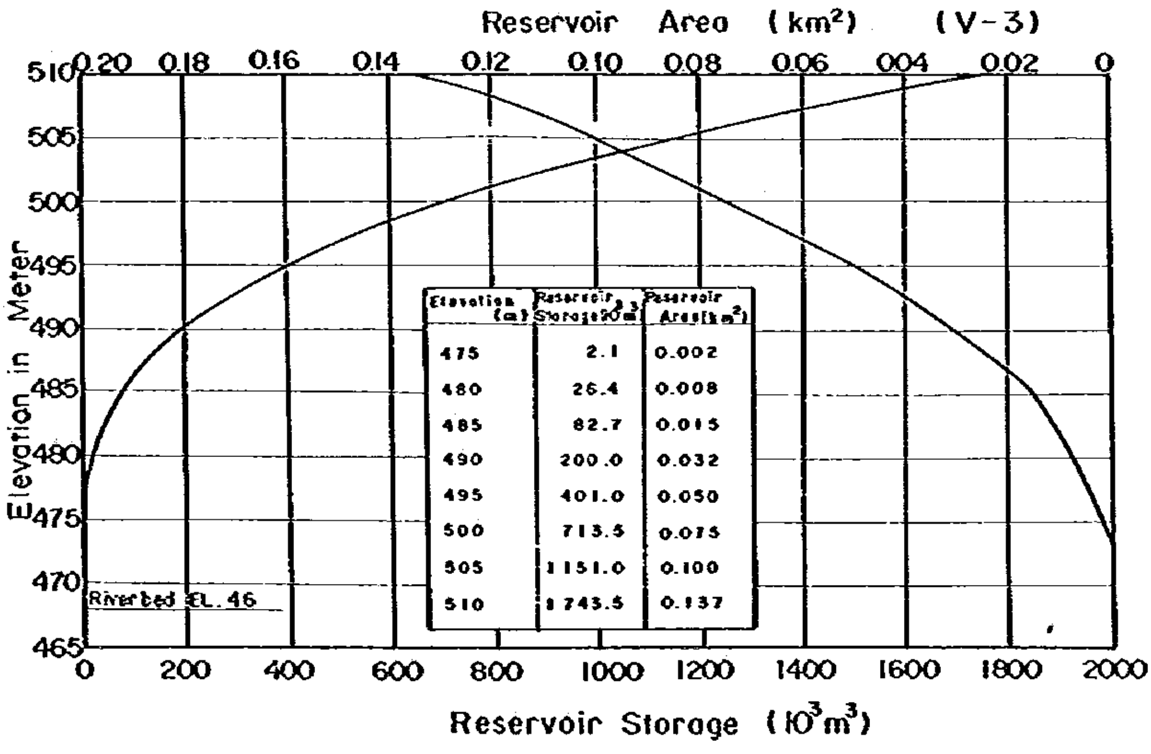


Elevation (m)	Reservoir Storage ($10^3 m^3$)	Reservoir Area (km^2)
670	3.8	0.003
675	60.4	0.020
680	247.9	0.056
685	635.4	0.099
690	1245.4	0.145



Elevation (m)	Reservoir Storage ($10^3 m^3$)	Reservoir Area (km^2)
475	2.1	0.002
480	26.4	0.008
485	82.7	0.015
490	200.0	0.032
495	401.0	0.050
500	713.5	0.075
505	1151.0	0.100
510	1743.5	0.137

CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Area-Capacity Curve at Pino de Yuno Weir Site and at V-3 Weir Site
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS	G-09	*Curva de Capacidad de la Derivadora T-4 y V-3*
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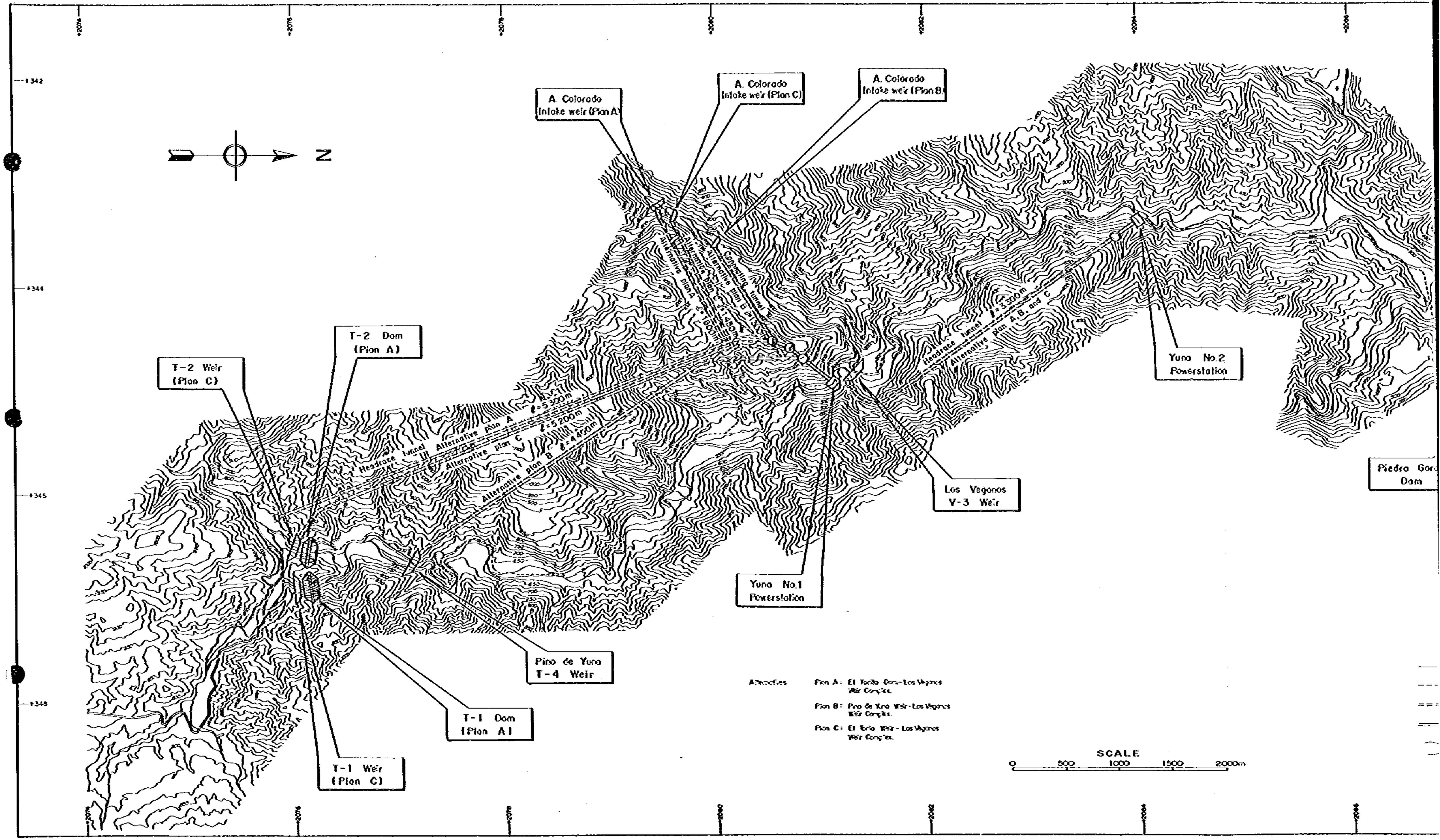
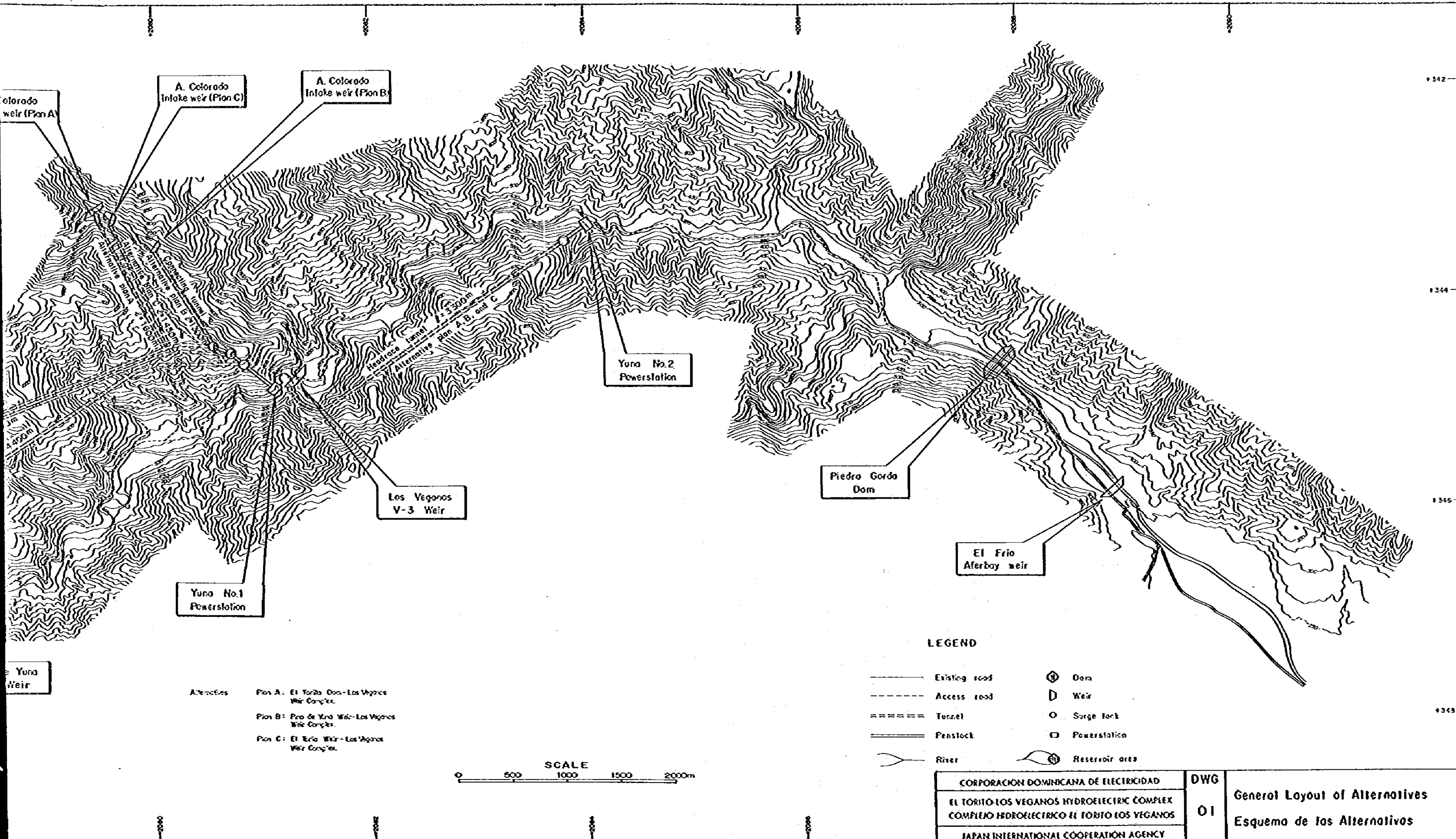
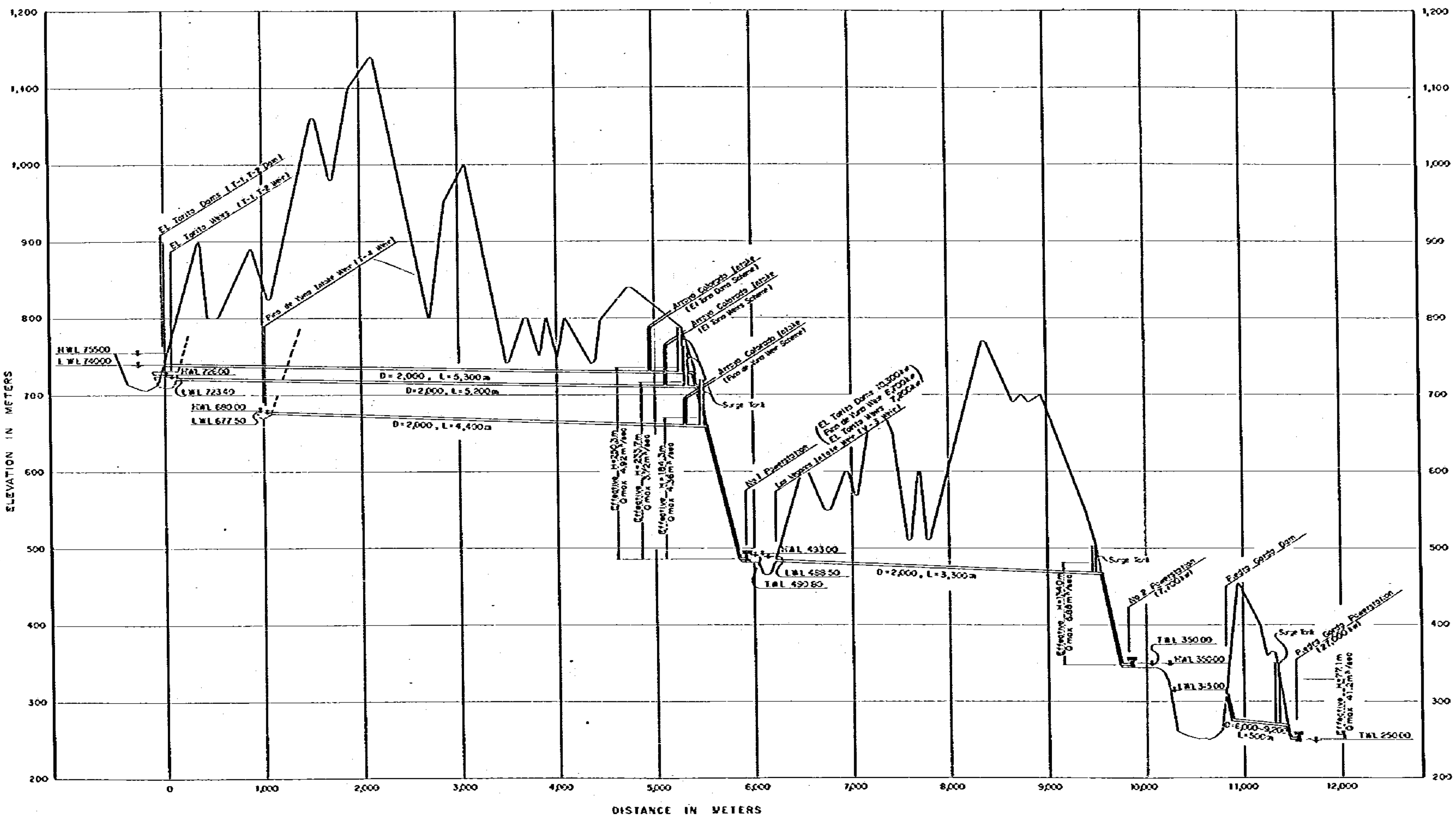
DRAWINGS


N
A. Colorado
Intake weir (Plan A)
A. Colorado
Intake weir (Plan C)
A. Colorado
Intake weir (Plan B)
T-2 Dam
(Plan A)
T-2 Weir
(Plan C)
Headrace tunnel Alternative plan A ℓ=5,300m
Alternative plan C ℓ=5,200m
Alternative plan B ℓ=4,400m
Headrace tunnel ℓ=5,300m
Alternative plan A, B, and C
Connecting tunnel
Yuna No.2
Powerstation
Piedra Gord
Dam
Los Vegonos
V-3 Weir
Yuna No.1
Powerstation
Pino de Yuna
T-4 Weir
T-1 Dam
(Plan A)
T-1 Weir
(Plan C)
SCALE
0
500
1000
1500
2000m

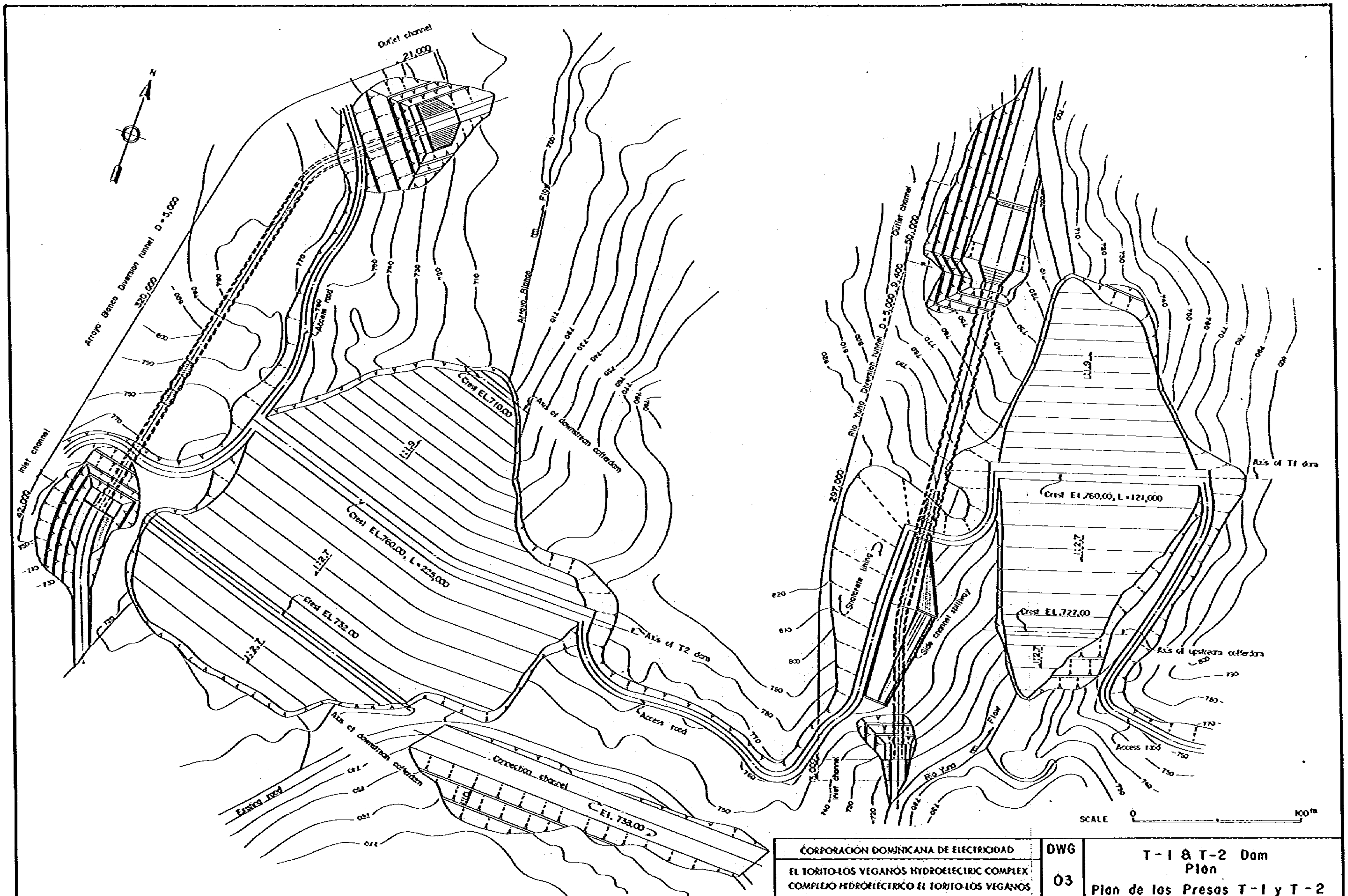


olorado
weir (Plan A)
A. Colorado
Intake weir (Plan C)
A. Colorado
Intake weir (Plan B)
Connecting tunnel
Headrace tunnel ℓ=3300m
Alternative plan A, B, and C
Yuna No.2
Powerstation
Los Veganos
V-3 Weir
Yuna No.1
Powerstation
Piedra Gorda
Dam
El Frio
Afterbay weir
Yuna
Weir
Alternatives
Plan A: El Torito Dam - Los Veganos Weir Complex
Plan B: Pino de Yuna Weir - Los Veganos Weir Complex
Plan C: El Frio Weir - Los Veganos Weir Complex
SCALE
0 500 1000 1500 2000m
LEGEND
Existing road
Access road
Tunnel
Penstock
River
Dam
Weir
Surge tank
Powerstation
Reservoir area
CORPORACION DOMINICANA DE ELECTRICIDAD
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX
COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS
JAPAN INTERNATIONAL COOPERATION AGENCY
DWG
01
General Layout of Alternatives
Esquema de las Alternativas

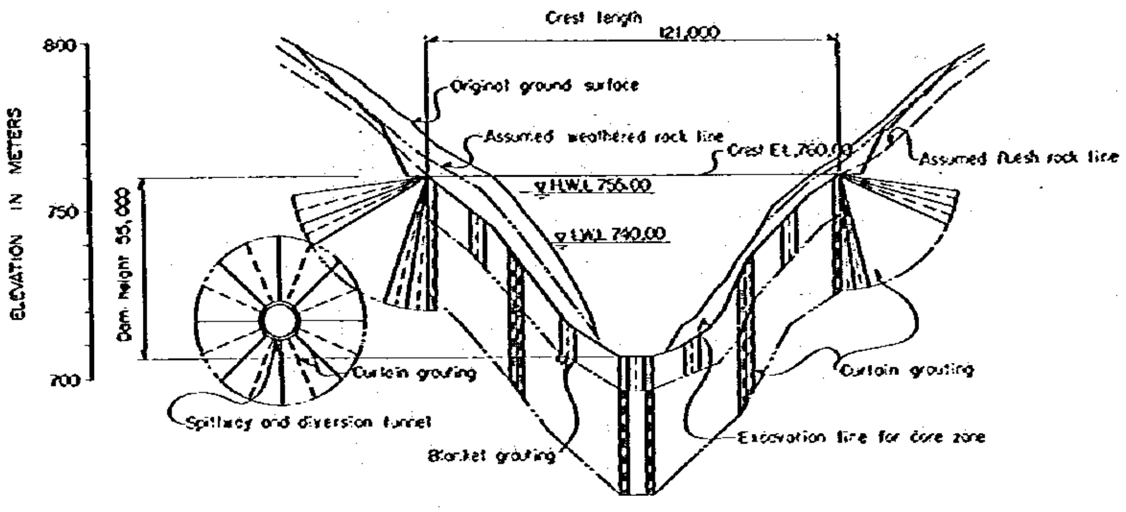


SCHEMATIC PROFILE OF EL TORITO - LOS VEGANOS COMPLEX

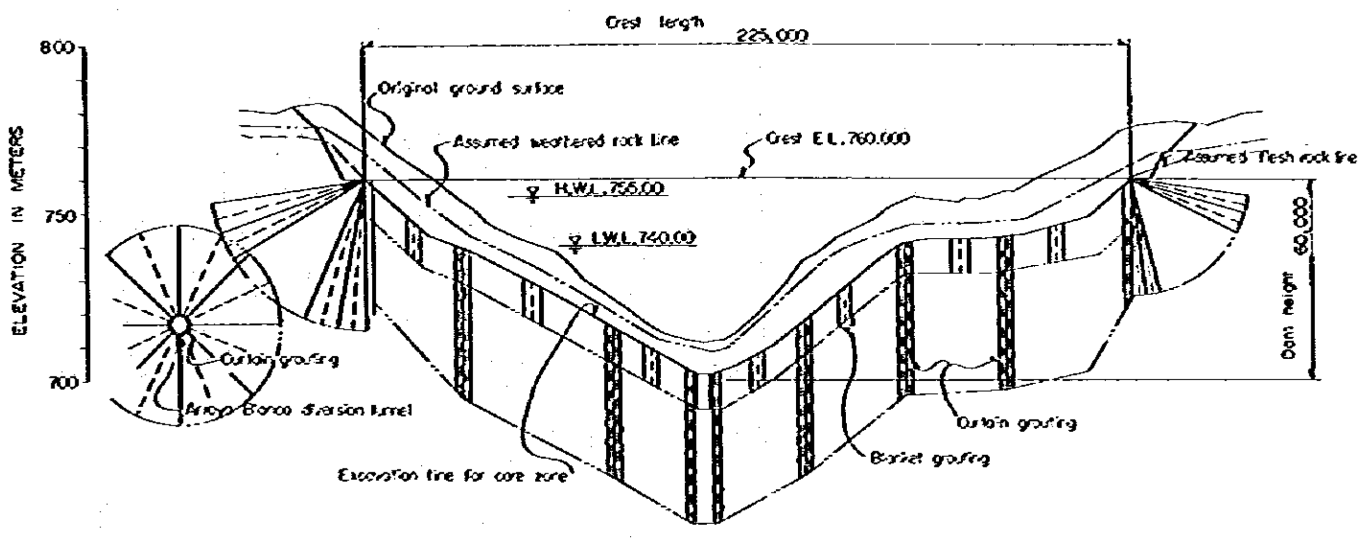
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	General Profile of El Torito - Los Veganos Complex
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	02	Perfil de las Alternativas
JAPAN INTERNATIONAL COOPERATION AGENCY		



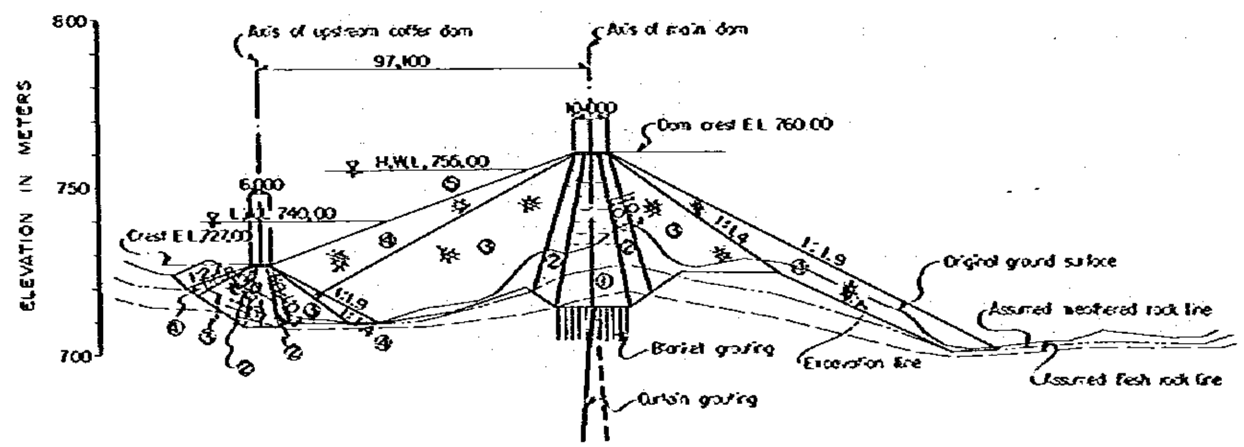
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	T - 1 & T - 2 Dam
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	03	Plan Plan de las Presas T - 1 y T - 2
JAPAN INTERNATIONAL COOPERATION AGENCY		



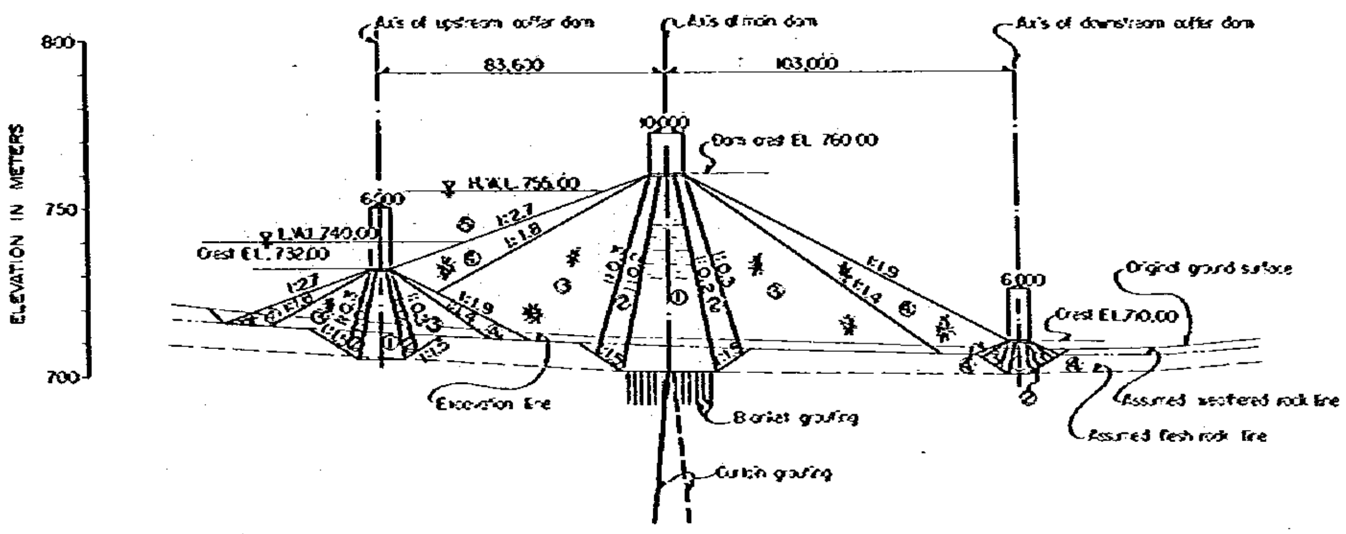
PROFILE ON AXIS OF T1 DAM



PROFILE ON AXIS OF T2 DAM



TYPICAL SECTION OF T1 DAM

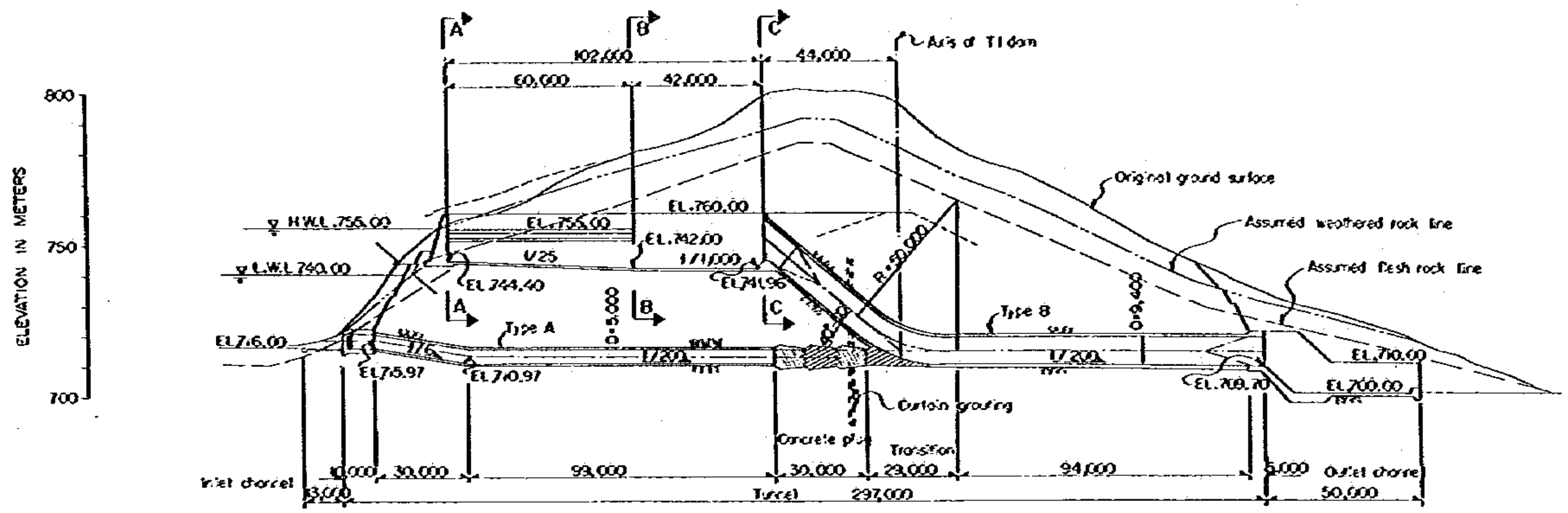


TYPICAL SECTION OF T2 DAM

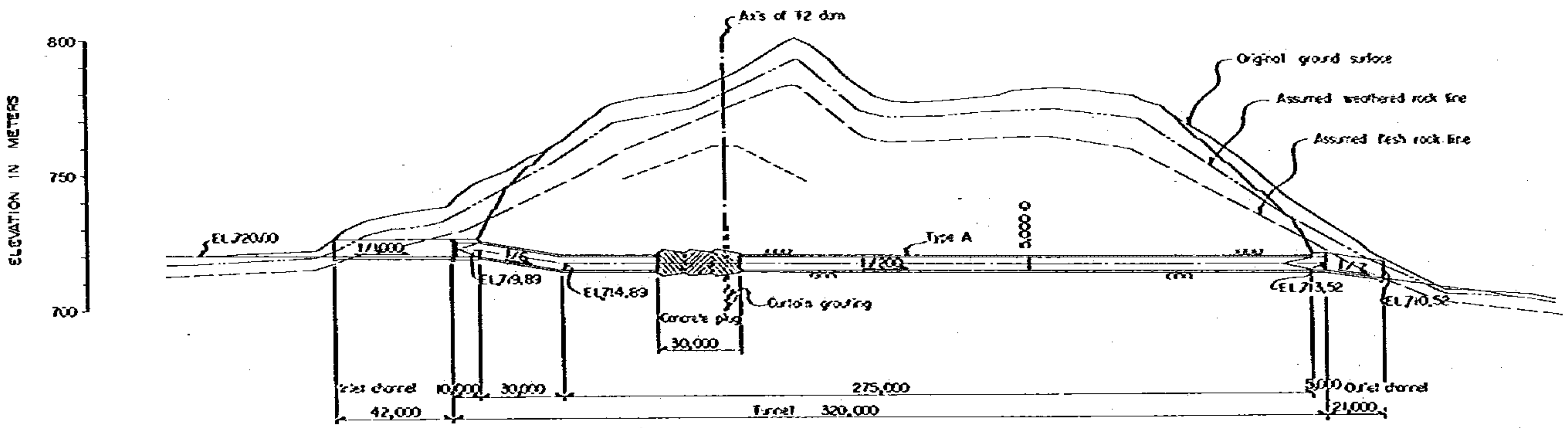
ZONE	MATERIAL
①	Impervious core
②	Filter
③	Random material
④	Rock
⑤	Rock riprap

SCALE 0 — 100m

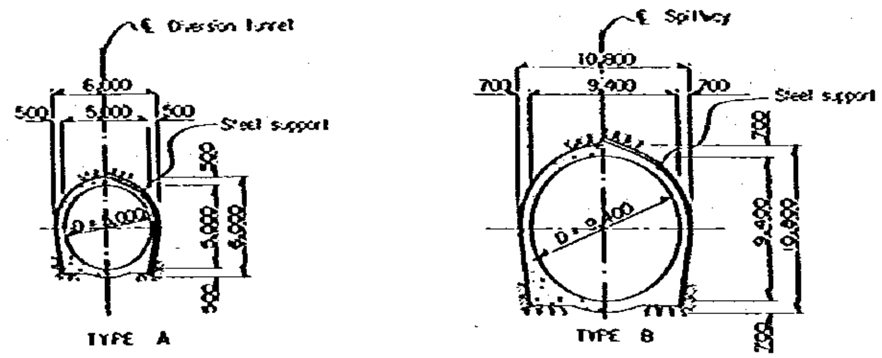
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	T-1 & T-2 Dam Profile and Typical Section of Dam Perfil y Sección Típica de las Presas T-1 y T-2
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	04	
JAPAN INTERNATIONAL COOPERATION AGENCY		



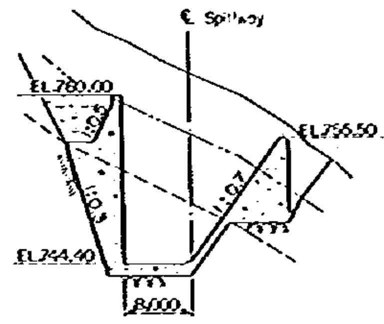
PROFILE OF RIO YUNA DIVERSION TUNNEL AND SPILLWAY SCALE A



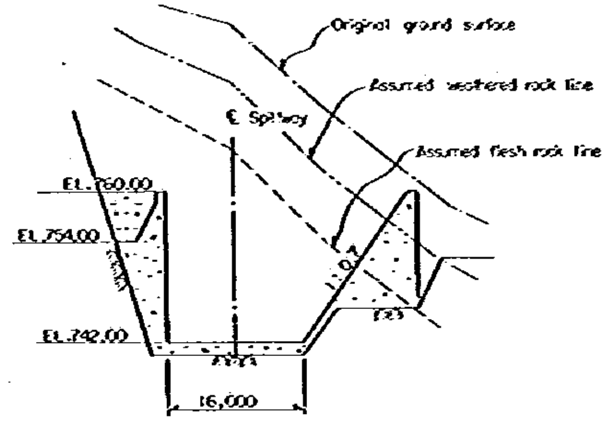
PROFILE OF ARROYO BLANCO DIVERSION TUNNEL SCALE A



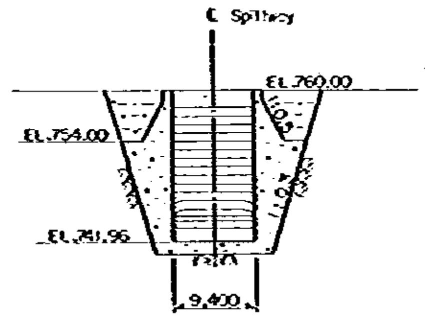
TYPICAL SECTIONS OF TUNNEL SCALE B



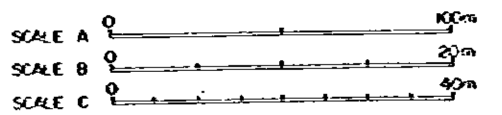
SECTION A-A SCALE C



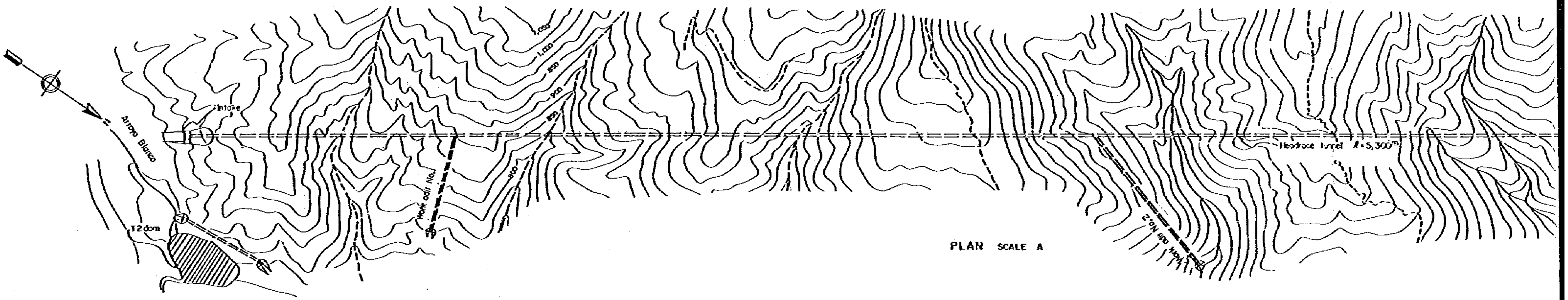
SECTION B-B SCALE C



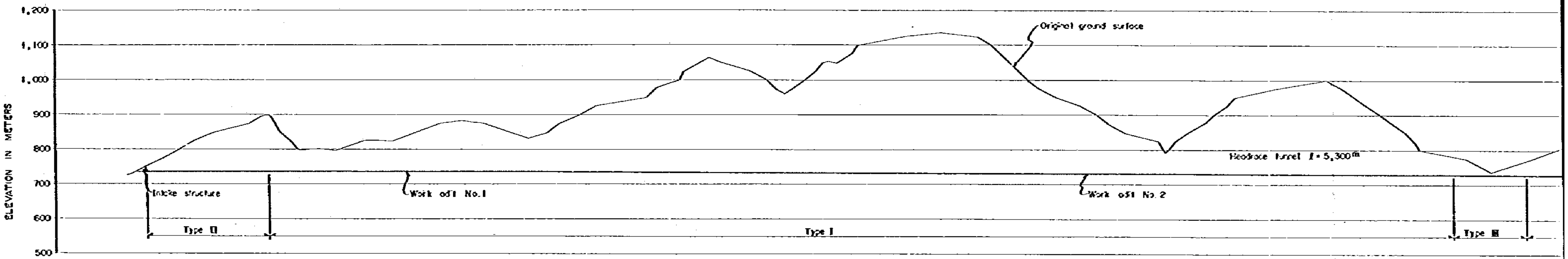
SECTION C-C SCALE C



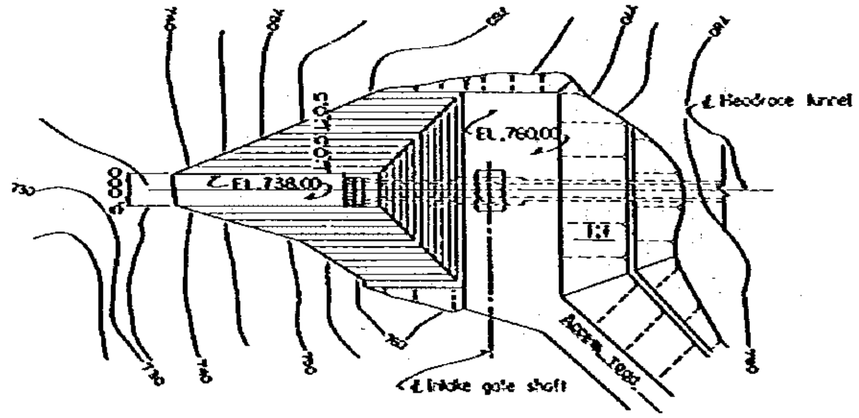
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	T-1 & T-2 Dam Diversion Tunnel and Spillway Túnel de Derivación y Vertedero de las Presas T-1 y T-2
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS	05	
JAPAN INTERNATIONAL COOPERATION AGENCY		



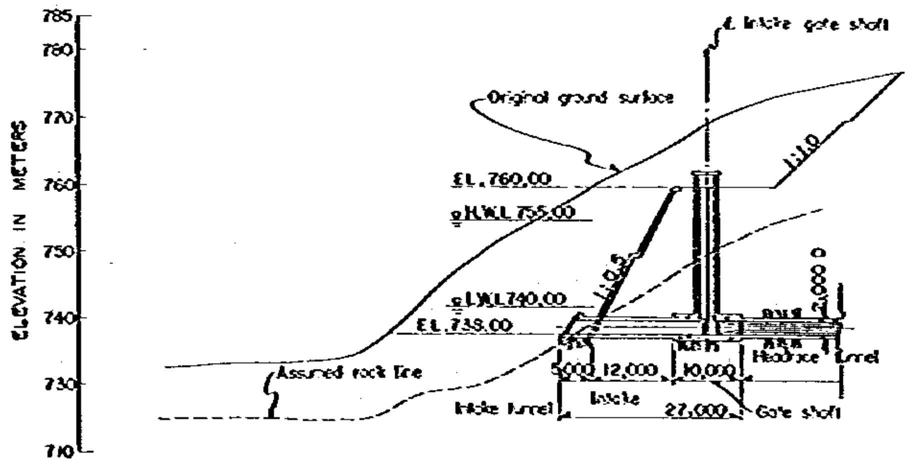
PLAN SCALE A



PROFILE SCALE A

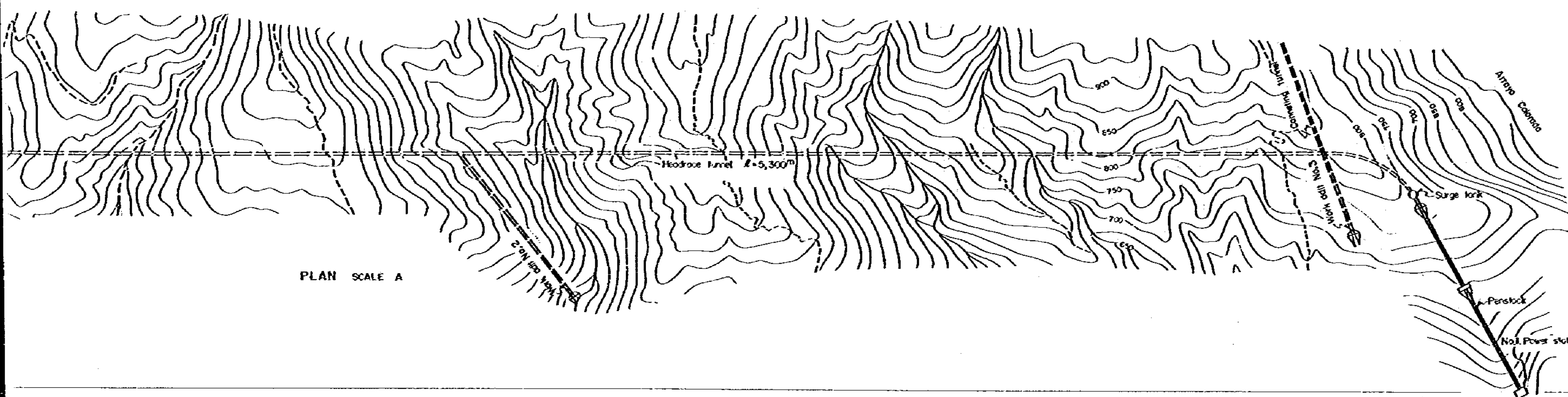


PLAN

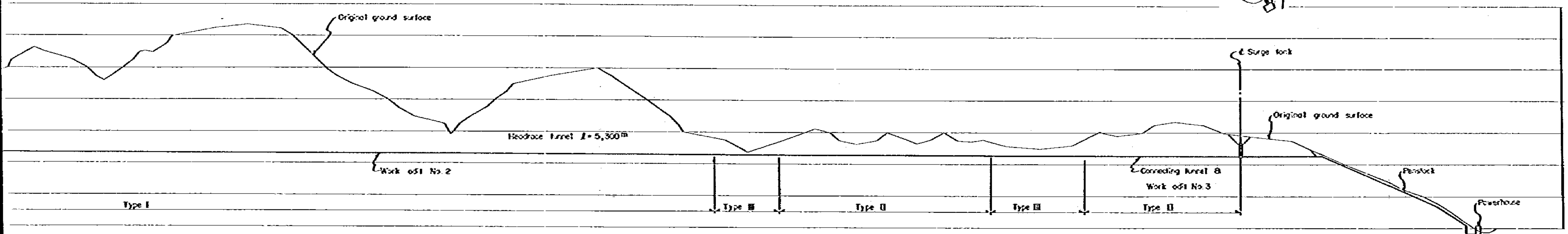


PROFILE

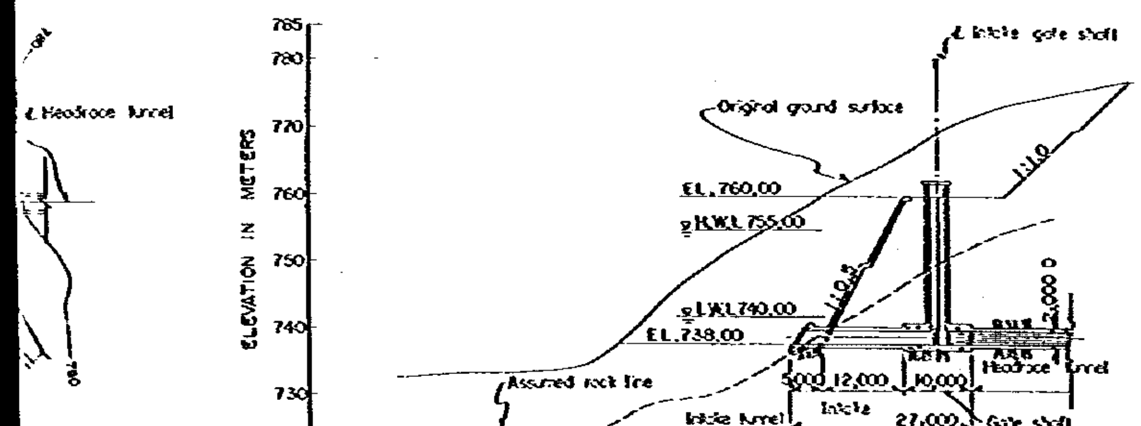
INTAKE STRUCTURE SCALE B



PLAN SCALE A

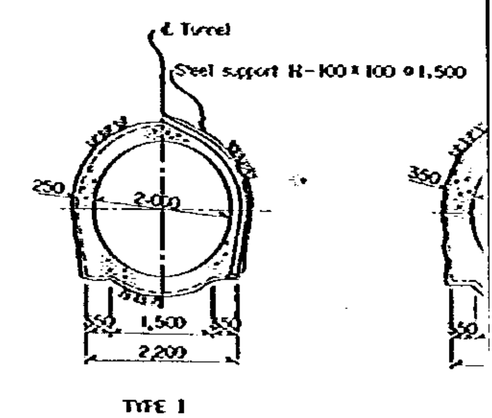


PROFILE SCALE A

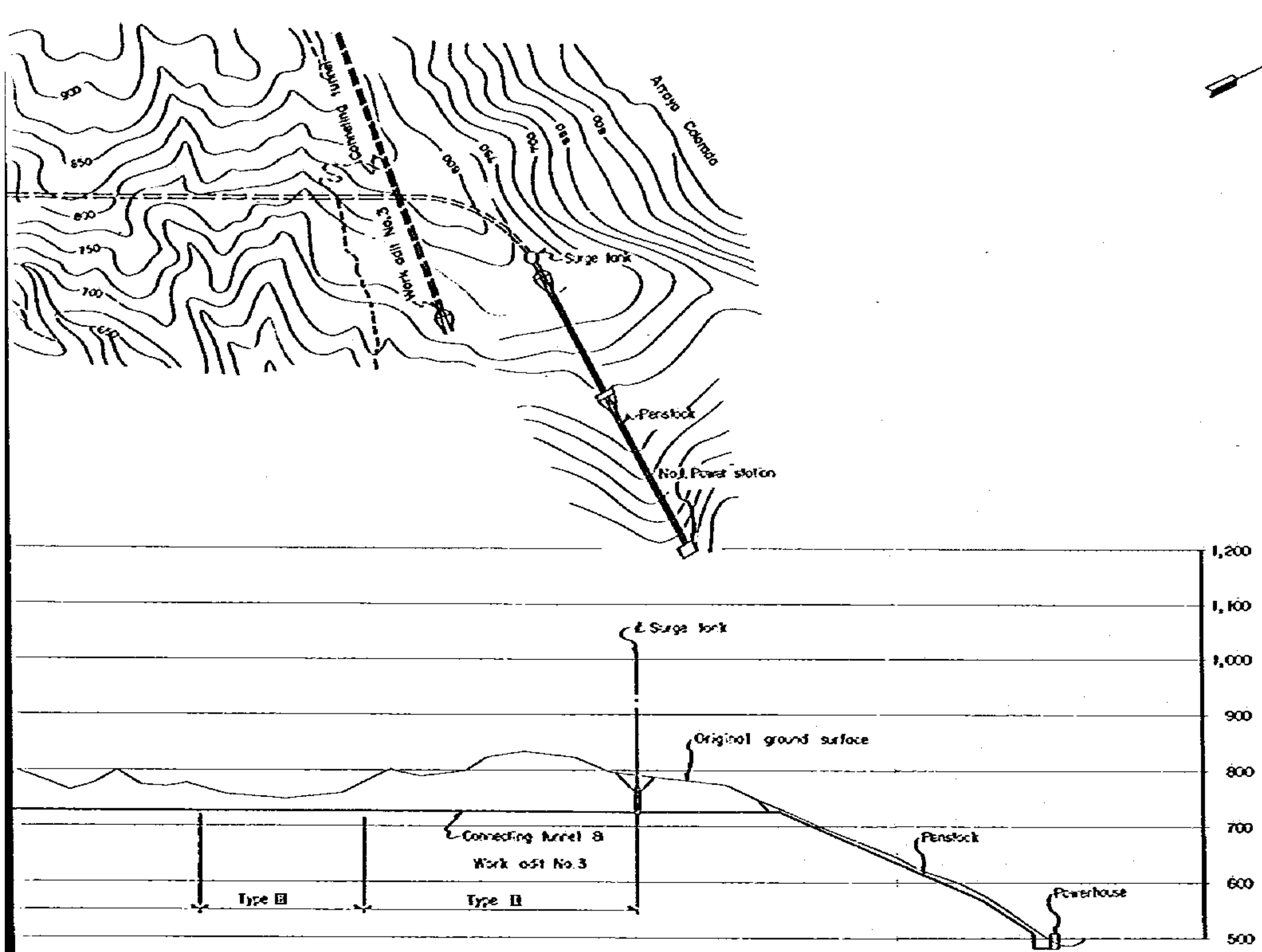


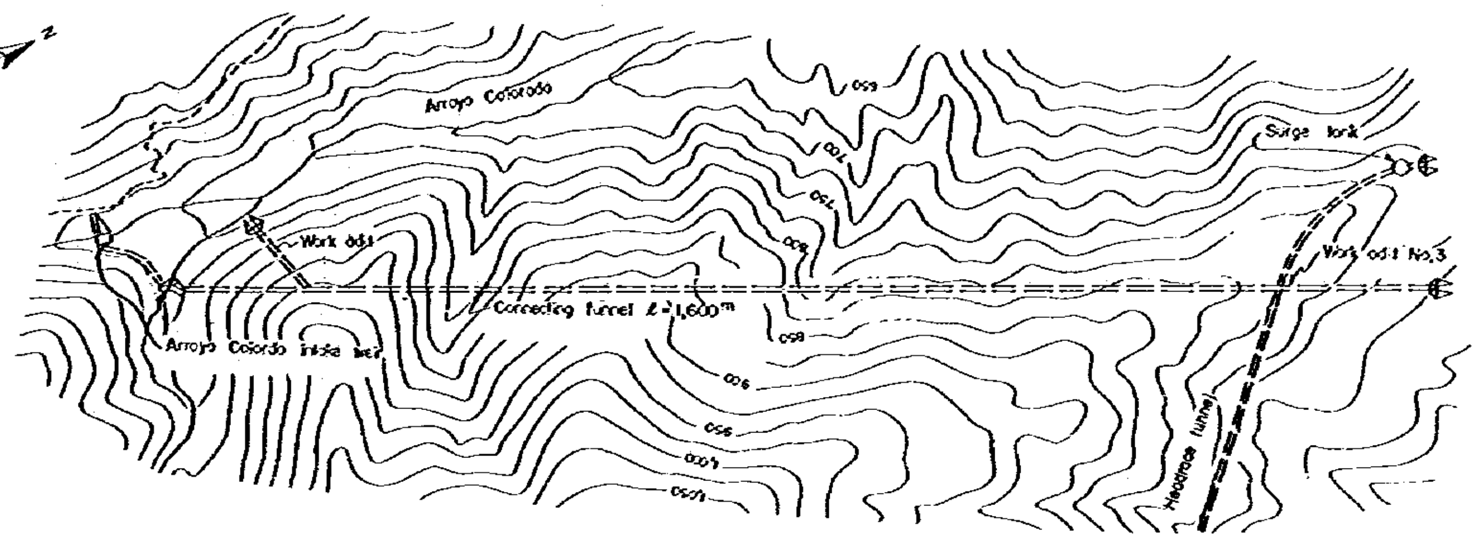
PROFILE

INTAKE STRUCTURE SCALE B

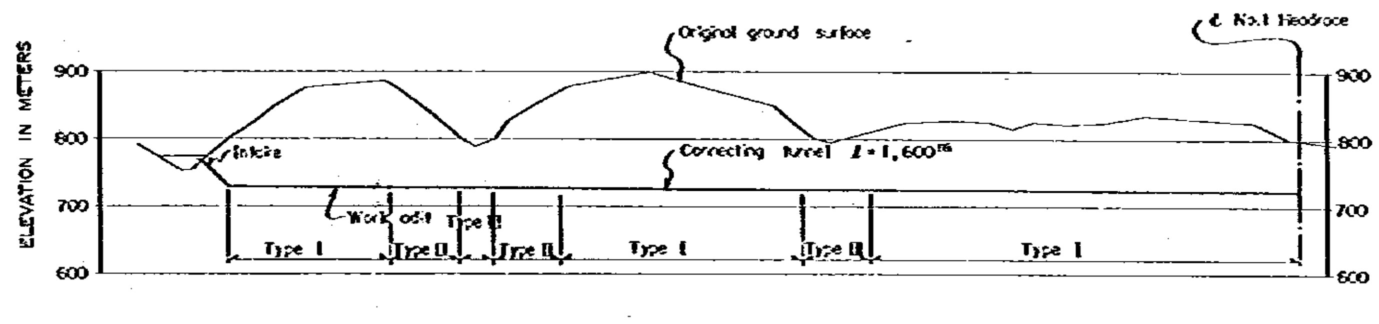


TYPICAL CROSS SECTIONS C

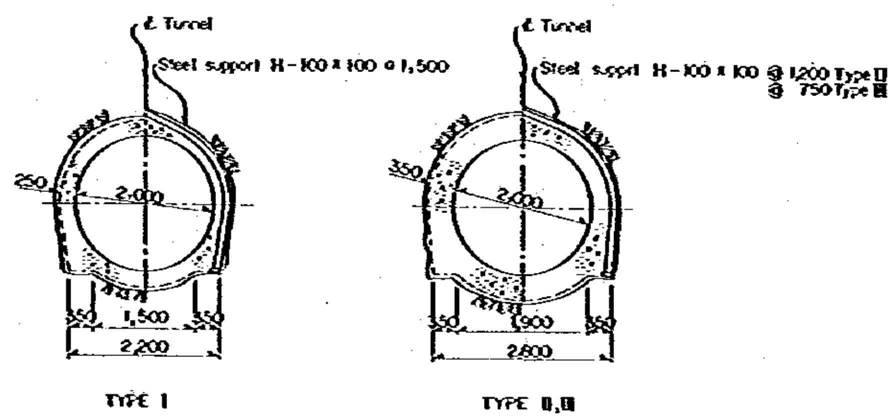




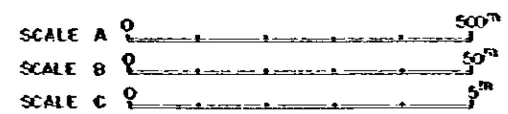
PLAN SCALE A



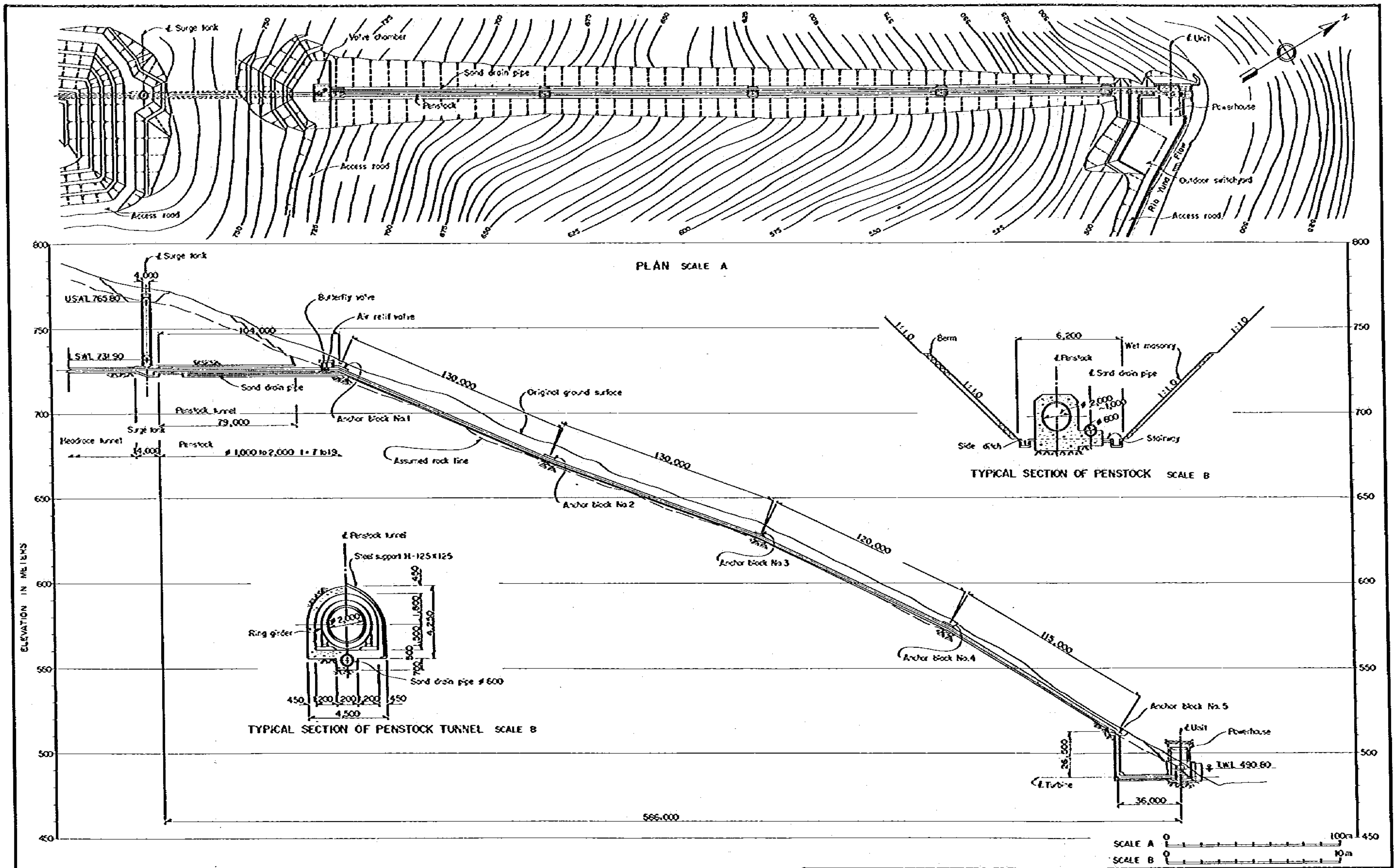
PROFILE OF CONNECTING TUNNEL SCALE A



TYPICAL CROSS SECTIONS OF TUNNEL SCALE B

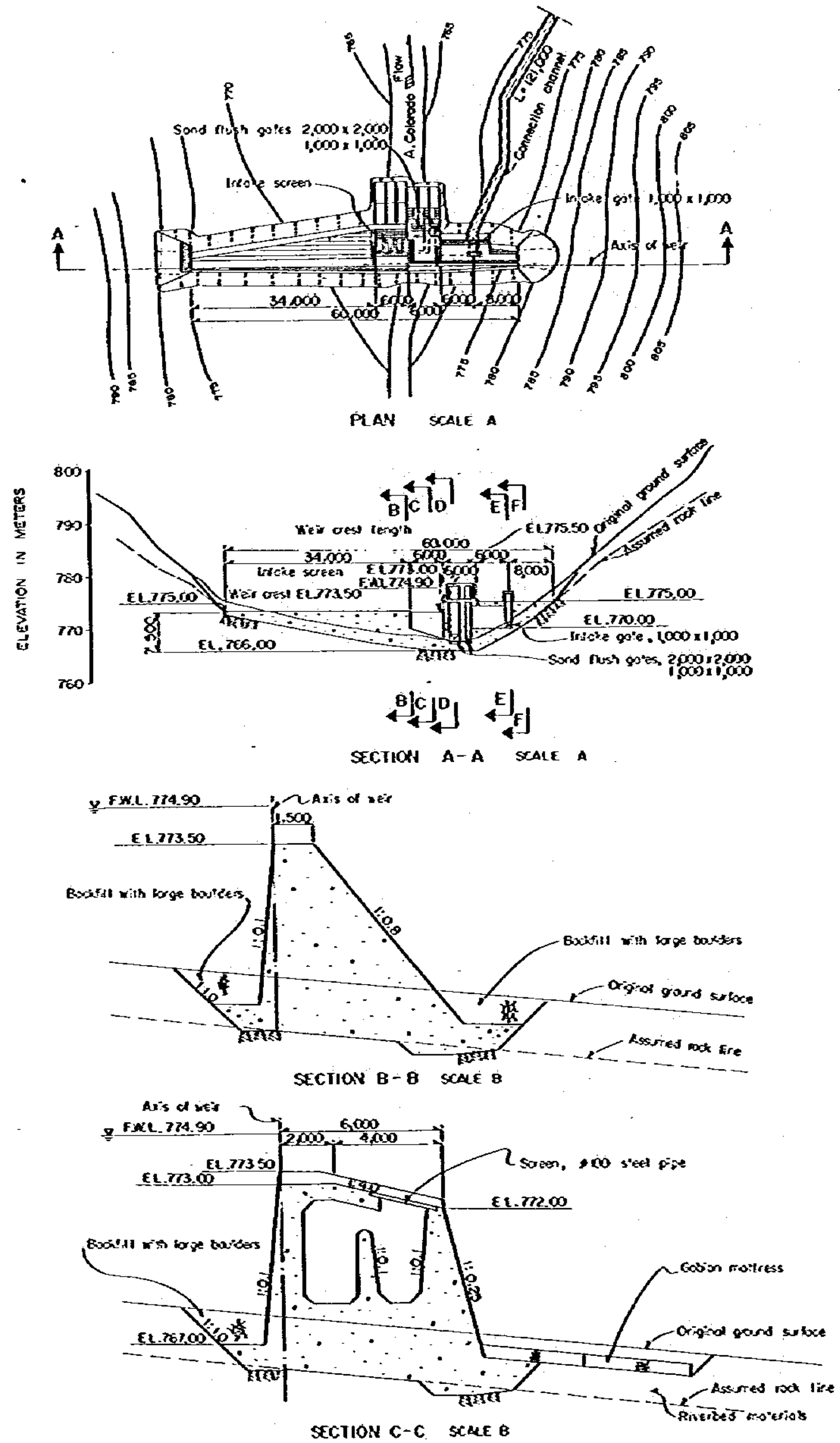


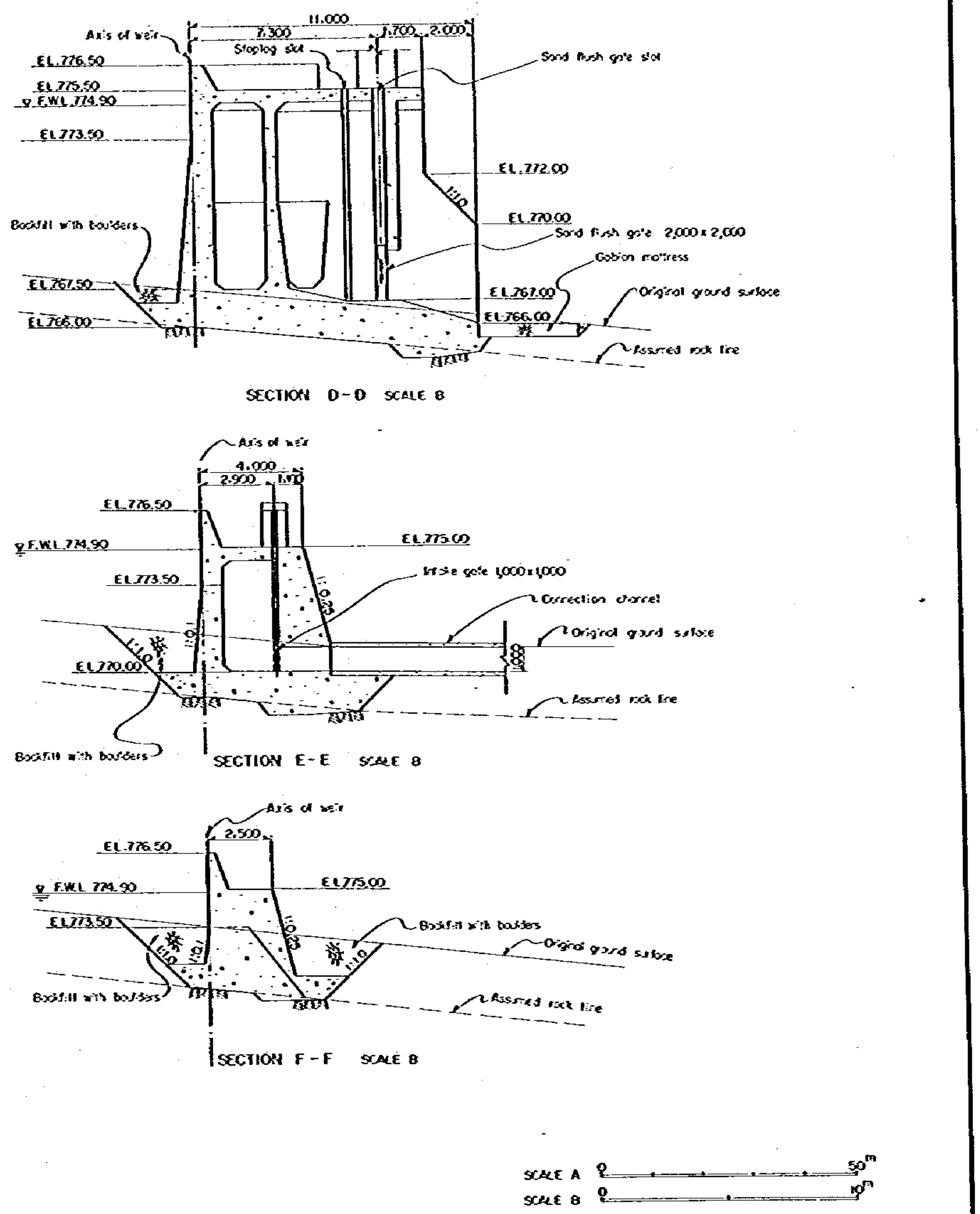
CORPORACIÓN DOMINICANA DE ELECTRICIDAD	DWG	T-1 & T-2 Dam Waterway
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS	06	Conduccion de Agua Presas T-1 y T-2
JAPAN INTERNATIONAL COOPERATION AGENCY		



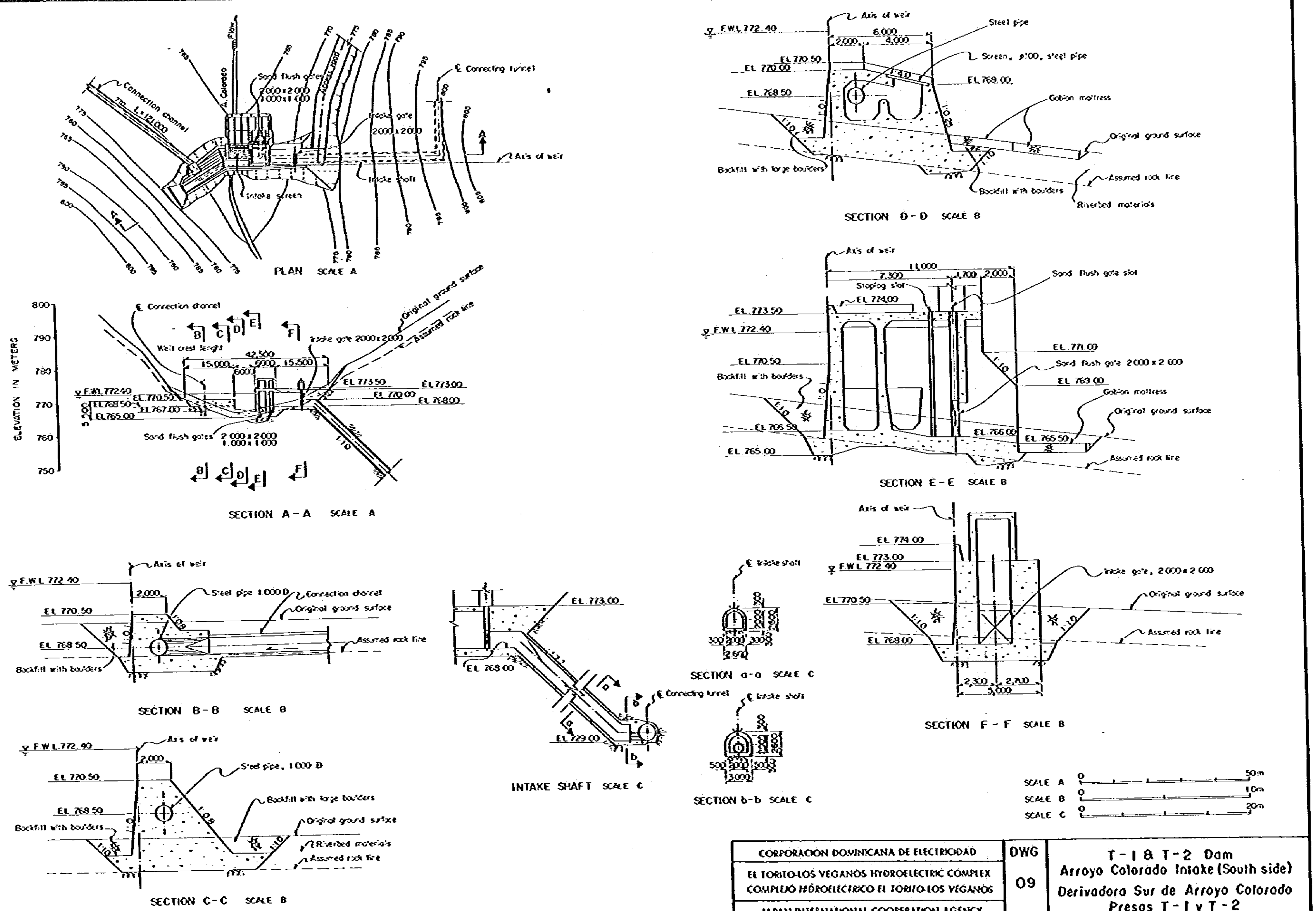
PROFILE SCALE A

CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	T-1 & T-2 Dam Surge Tank and Penstock
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	07	Chimenea de Equilibrio y Tuberia de Presion para las Presas T-1 y T-2
JAPAN INTERNATIONAL COOPERATION AGENCY		

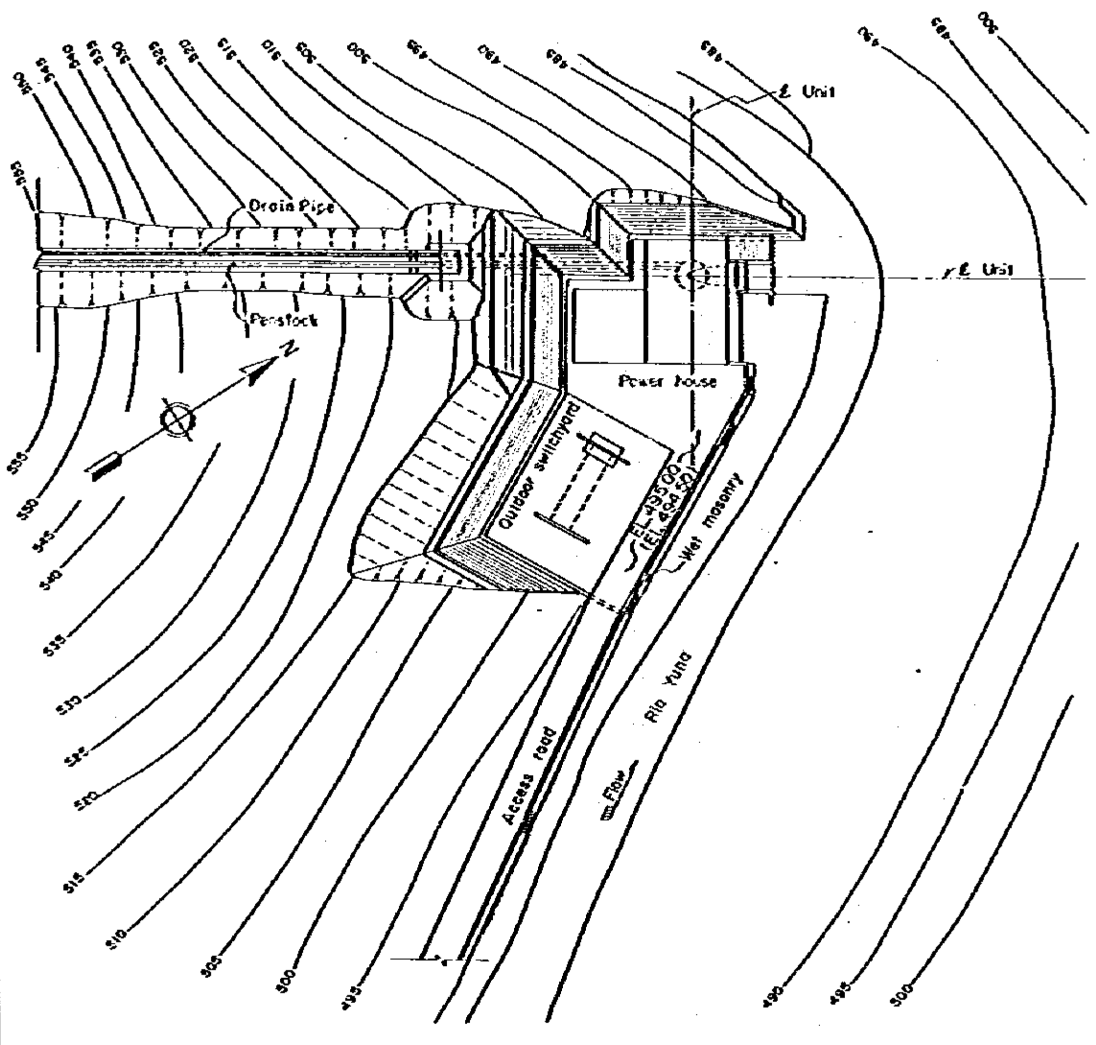




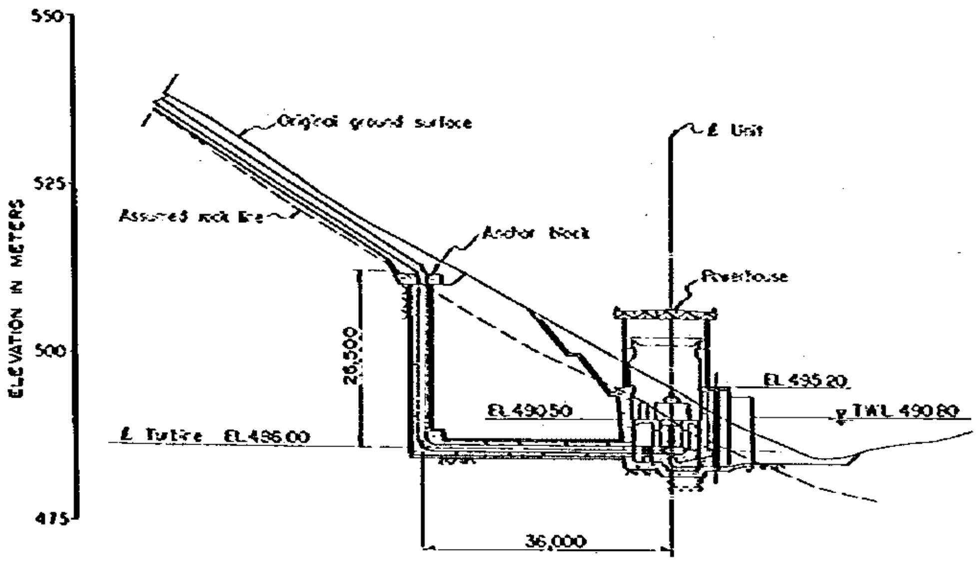
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	T-1 & T-2 Dam Arroyo Colorado Intake (North side)
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS	08	Derivadora Norte de Arroyo Colorado Presas T-1 y T-2
JAPAN INTERNATIONAL COOPERATION AGENCY		



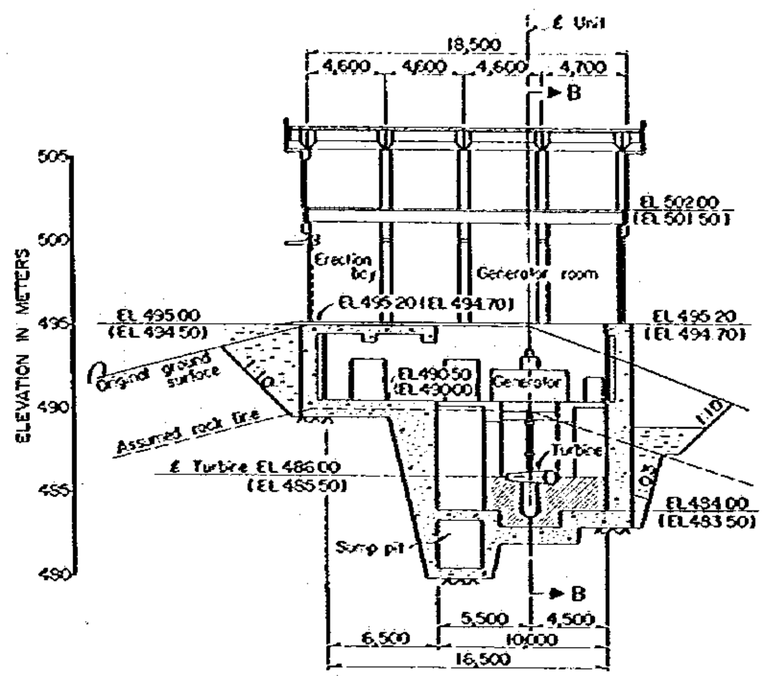
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	T - 1 & T - 2 Dam Arroyo Colorado Intake (South side)
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	09	Derivadora Sur de Arroyo Colorado Presas T - 1 y T - 2
JAPAN INTERNATIONAL COOPERATION AGENCY		



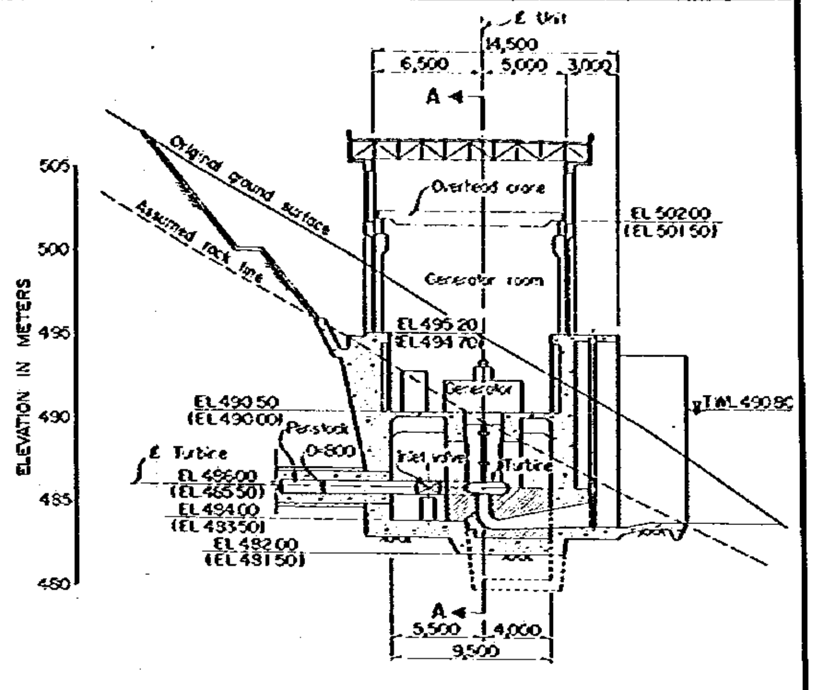
PLAN SCALE A



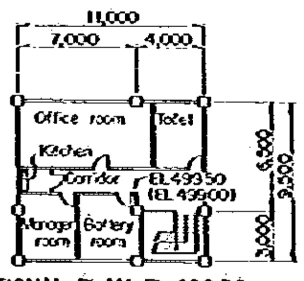
PROFILE SCALE A



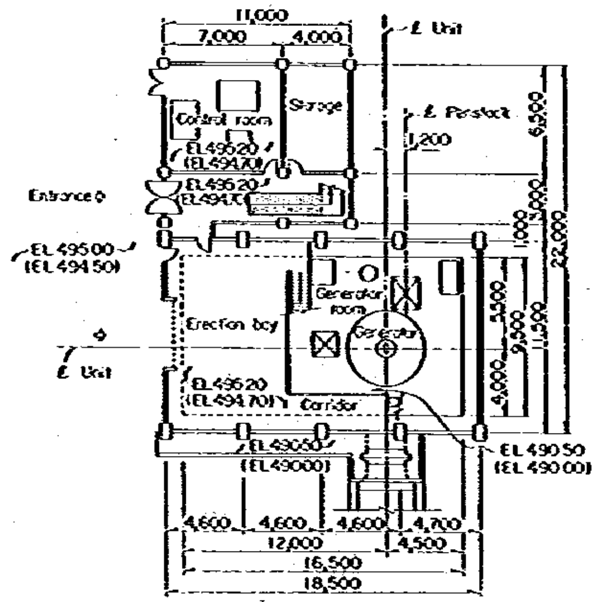
SECTION A-A SCALE B



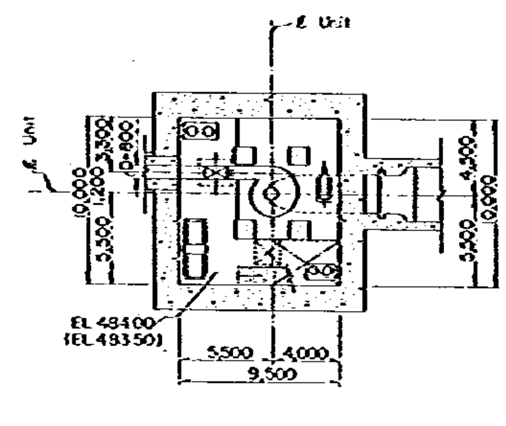
SECTION B-B SCALE B



SECTIONAL PLAN EL 499.50 SCALE B
(EL 499.00)

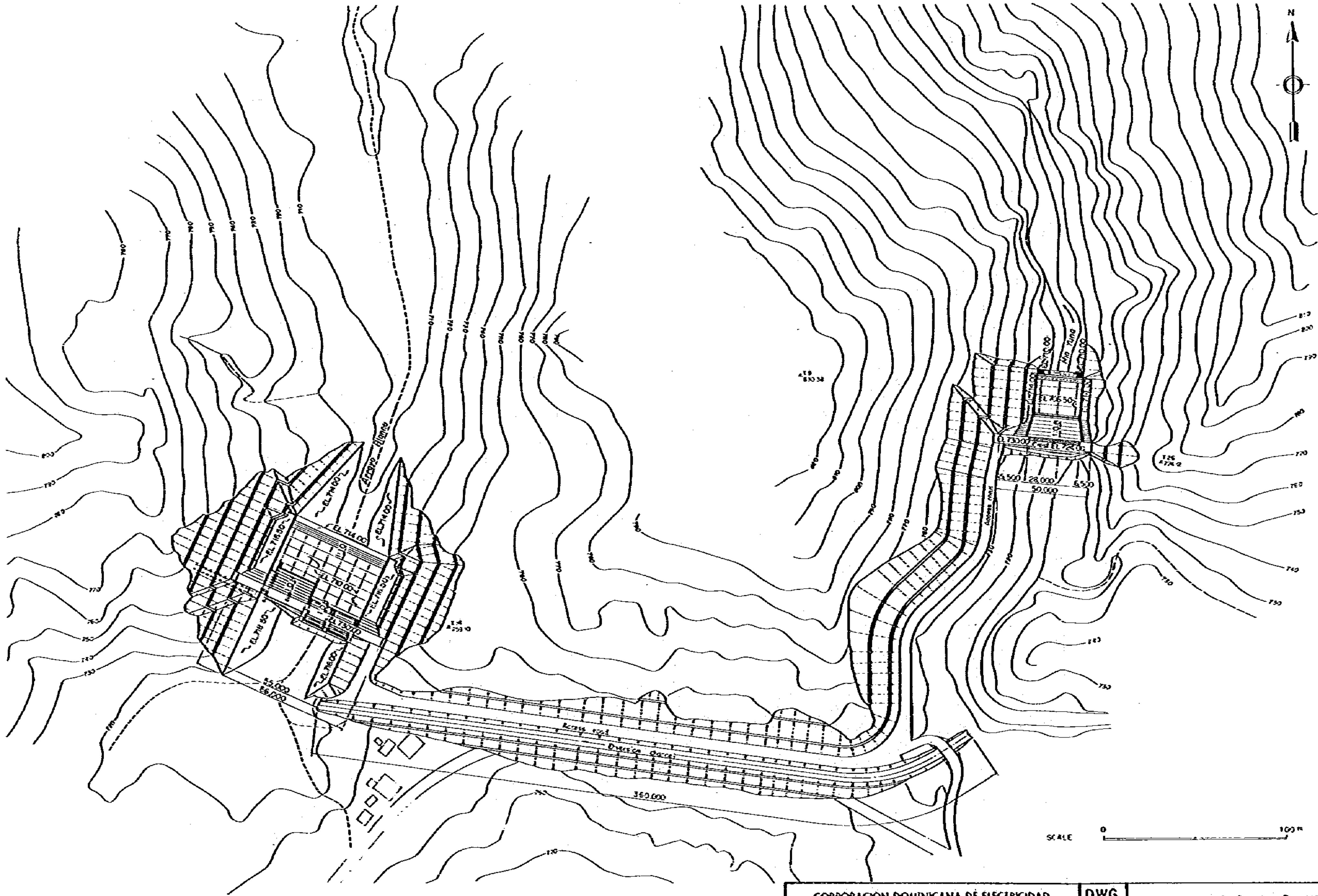


SECTIONAL PLAN EL 495.20 SCALE B
(EL 494.70)

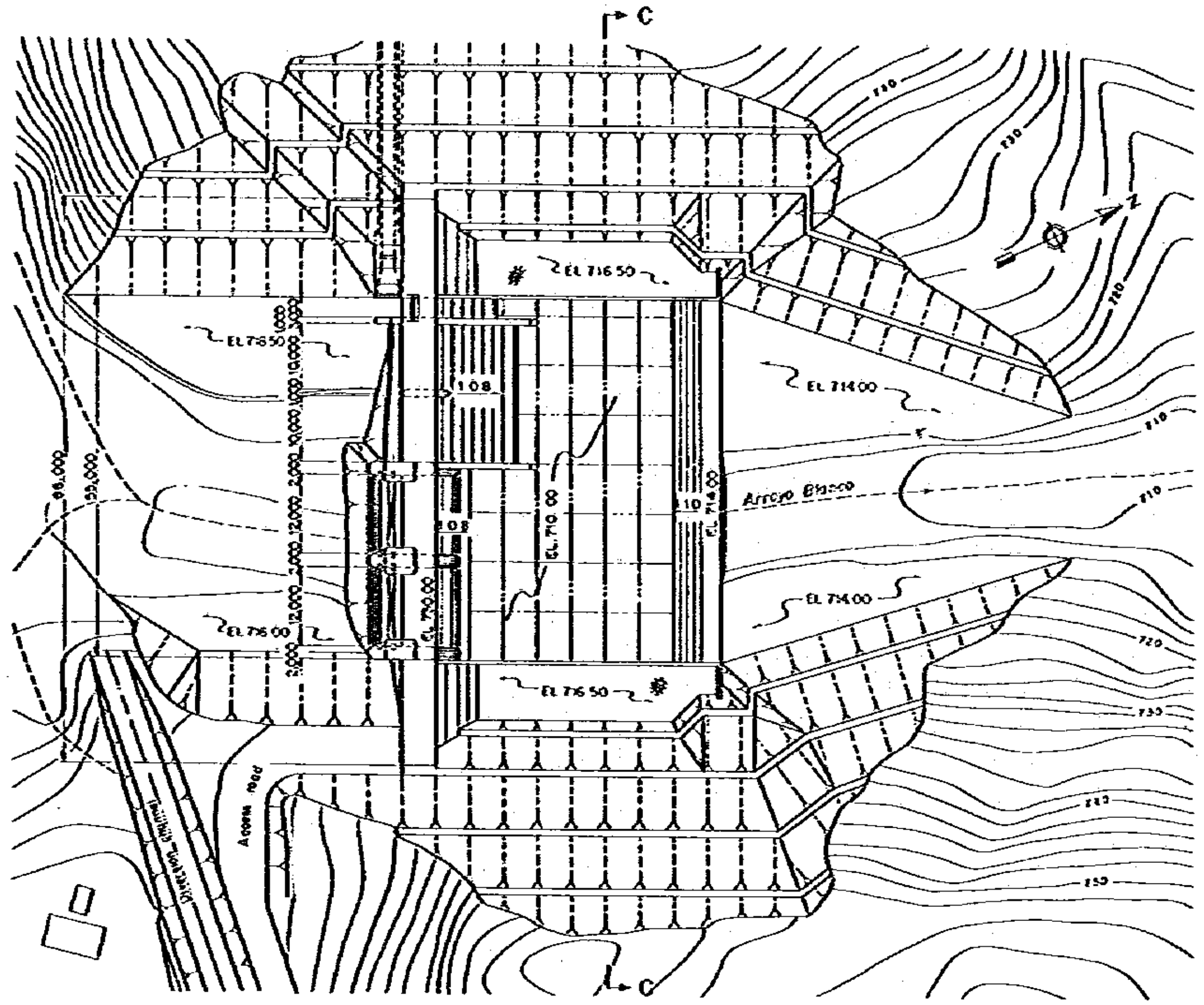


SECTIONAL PLAN EL 484.00 SCALE B
(EL 483.50)

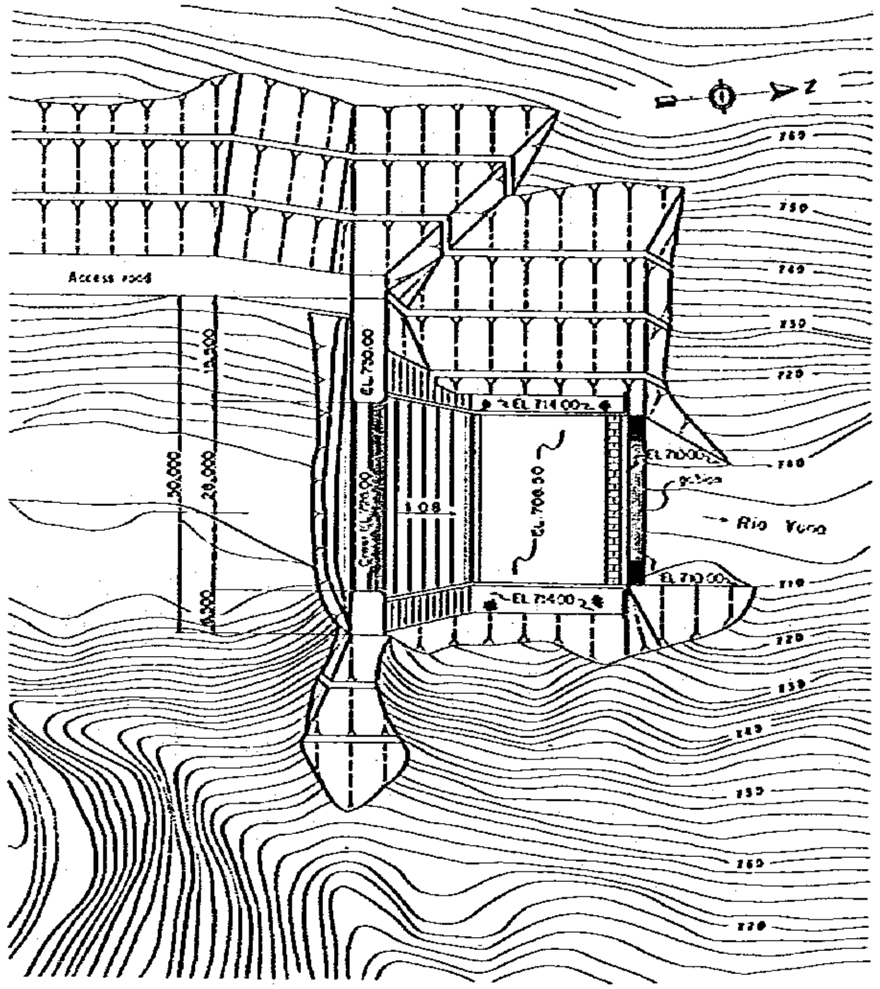
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	El Torito Scheme No. 1 Powerstation
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	10	Central Yuna No. 1 para Esquema El Torito
JAPAN INTERNATIONAL COOPERATION AGENCY		



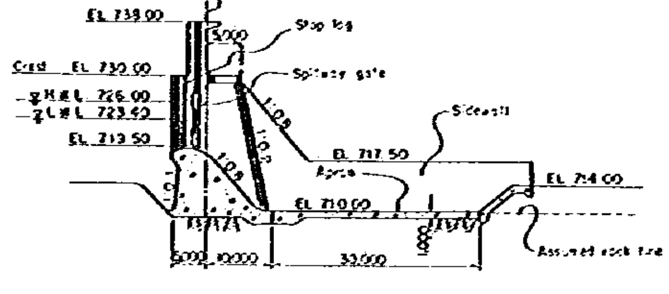
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	T-1 & T-2 Weir General Layout Plan General de las Derivadoras El Torito
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS	11	
JAPAN INTERNATIONAL COOPERATION AGENCY		



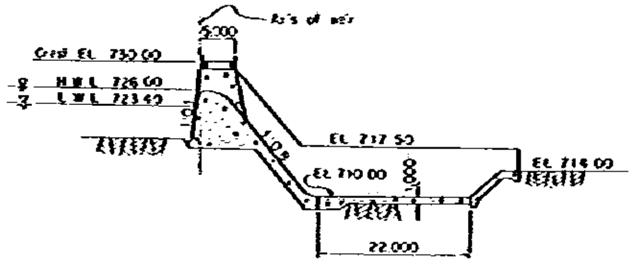
PLAN



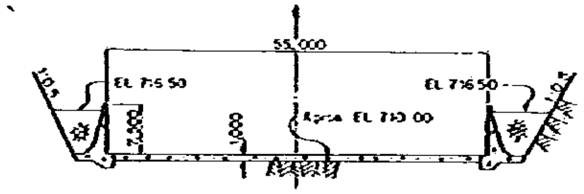
PLAN



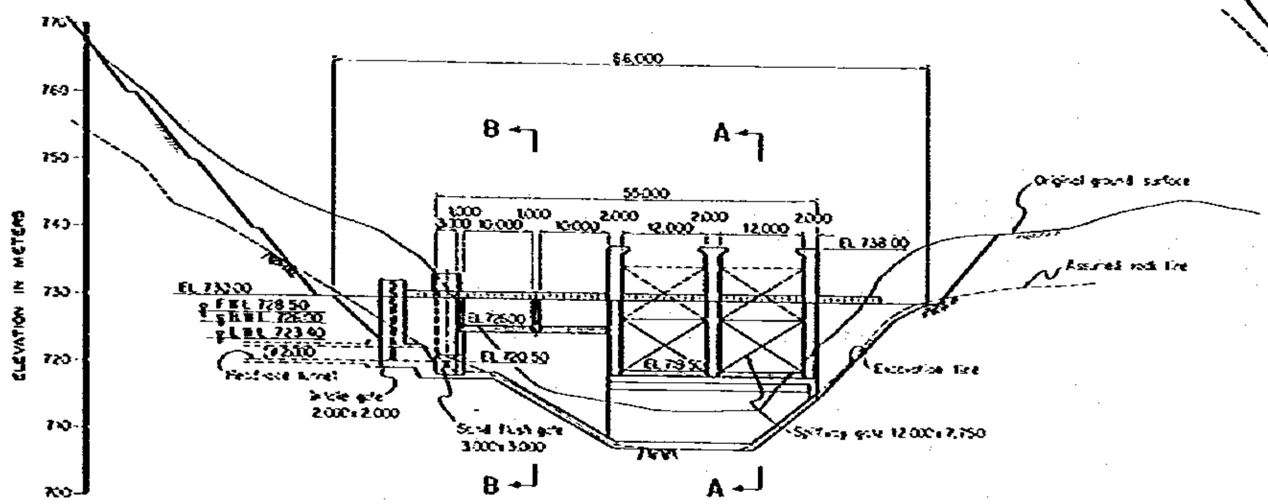
SECTION A – A



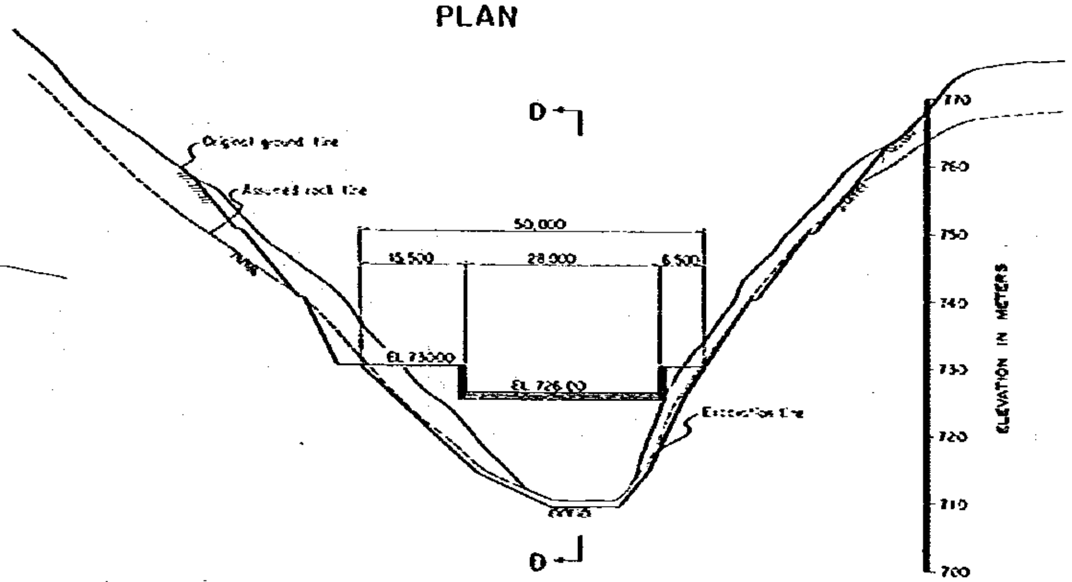
SECTION B – B



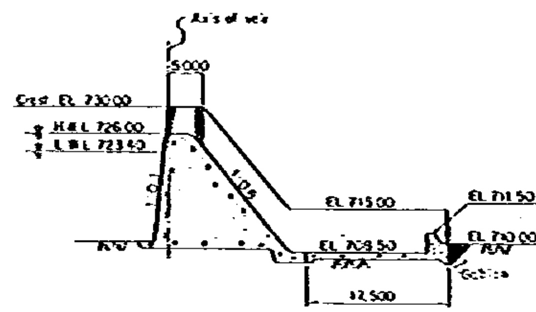
SECTION C-C



UPSTREAM ELEVATION



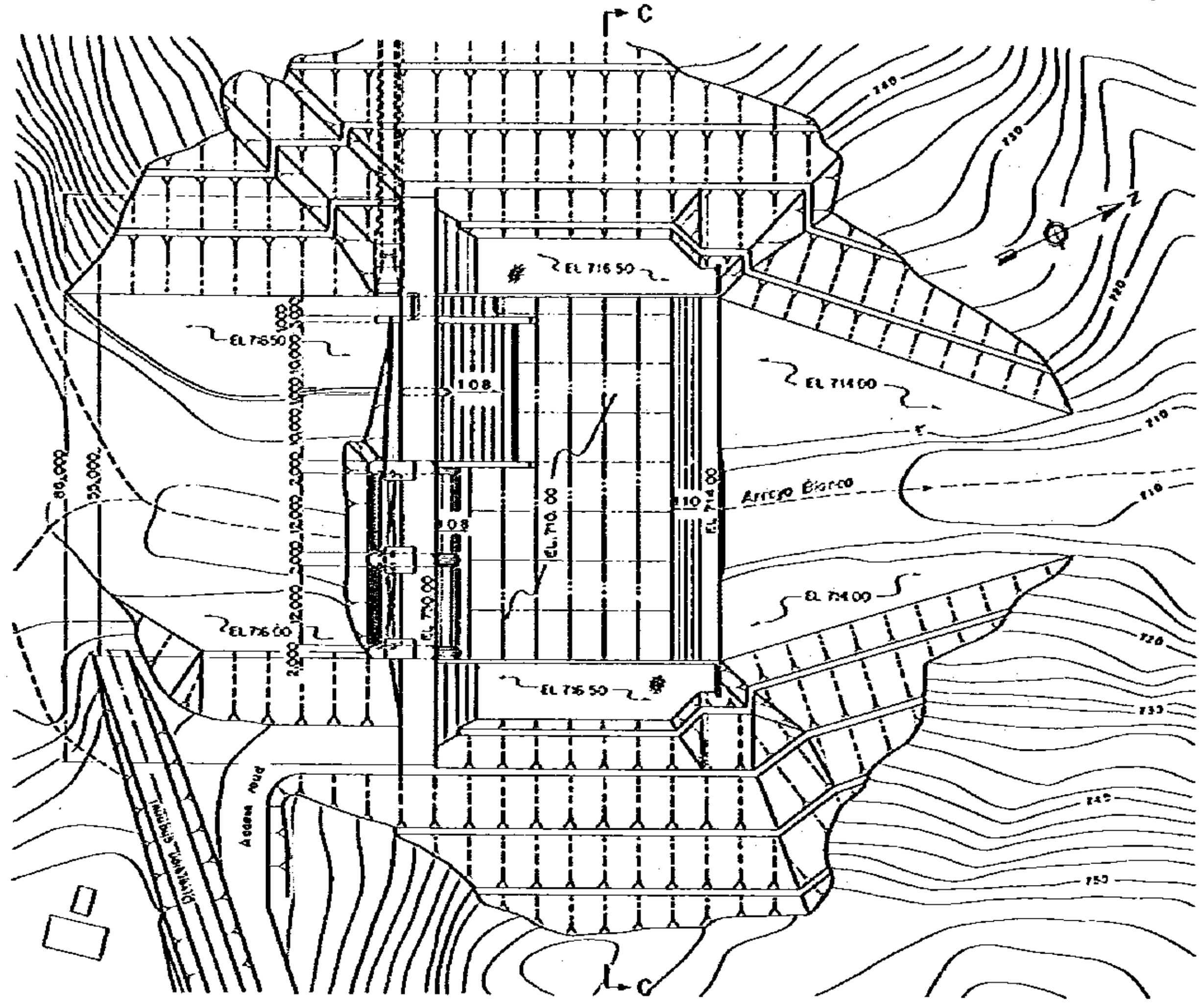
UPSTREAM ELEVATION



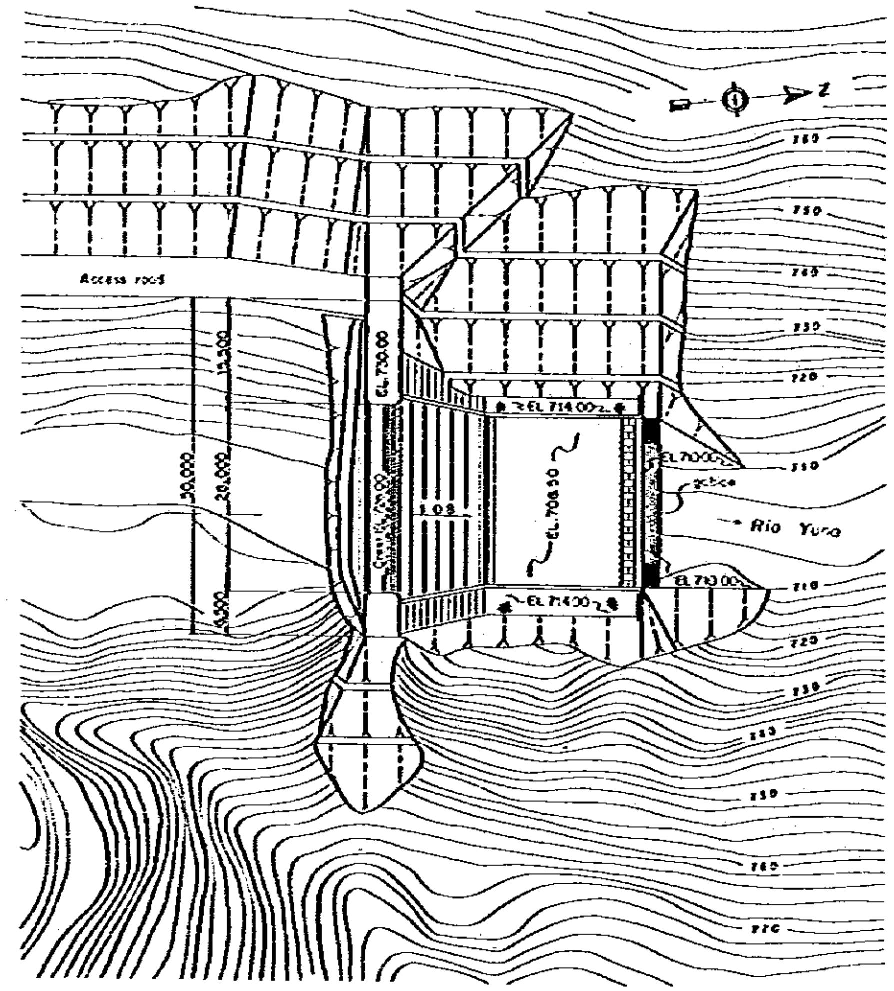
SECTION D-D

SCALE 0 — 50 m

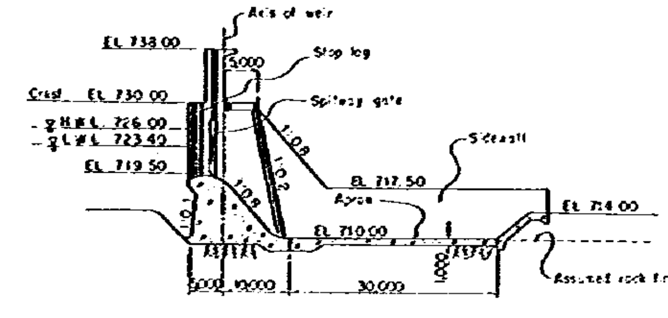
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	T - 1 & T - 2 Weir Plan and Profile of W
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS	12	Plan y Sección de los Derivadoras T-1 y T-2
JAPAN INTERNATIONAL COOPERATION AGENCY		



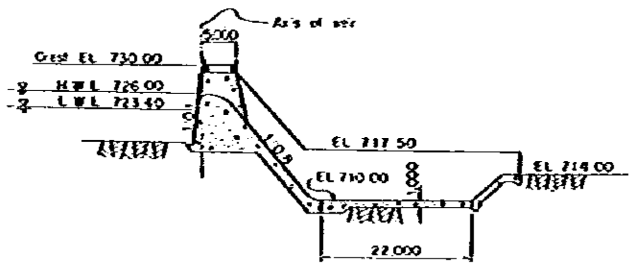
PLAN



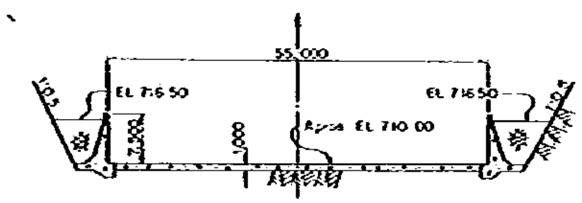
PLAN



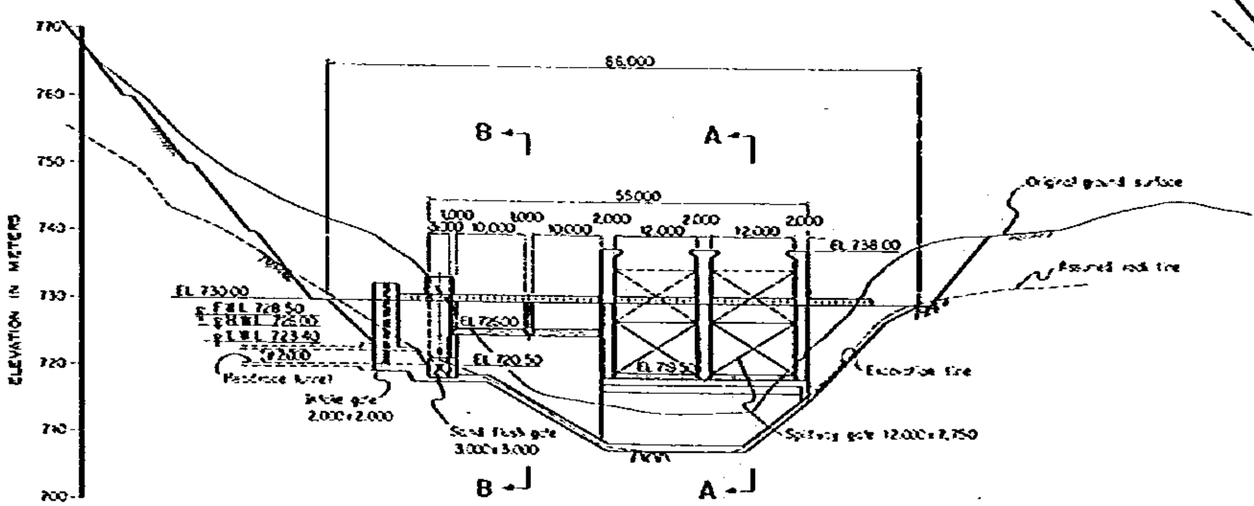
SECTION A – A



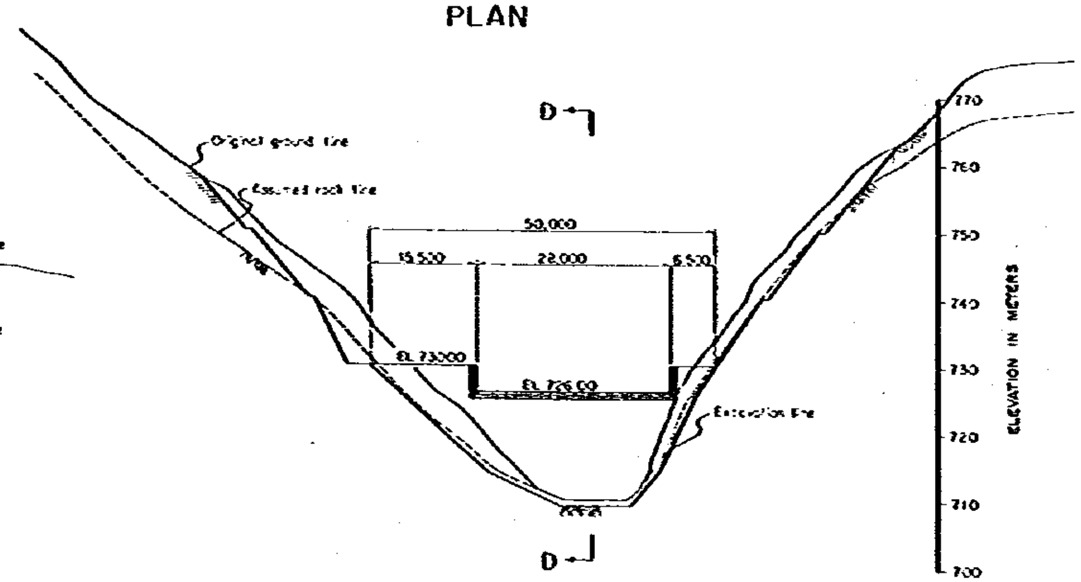
SECTION B – B



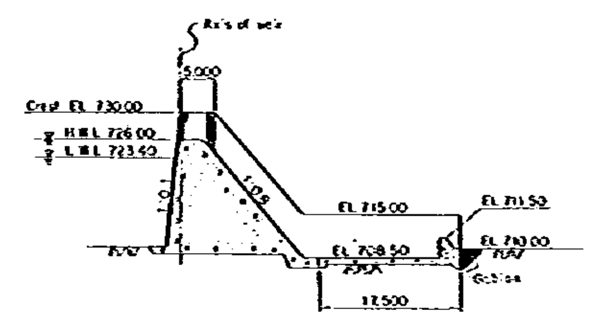
SECTION C–C



UPSTREAM ELEVATION



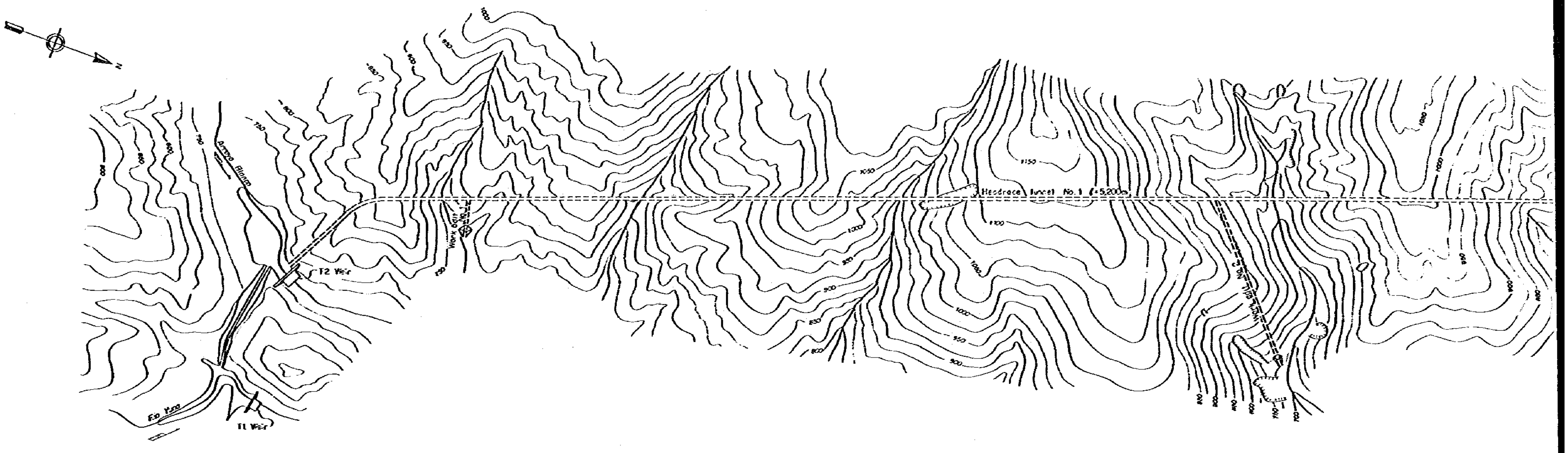
UPSTREAM ELEVATION



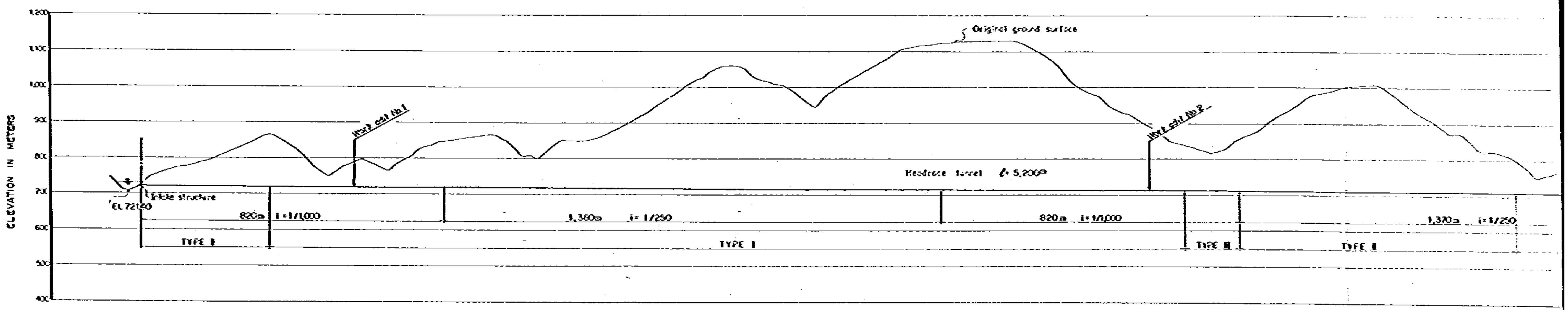
SECTION D–D

SCALE 0 — 50 m

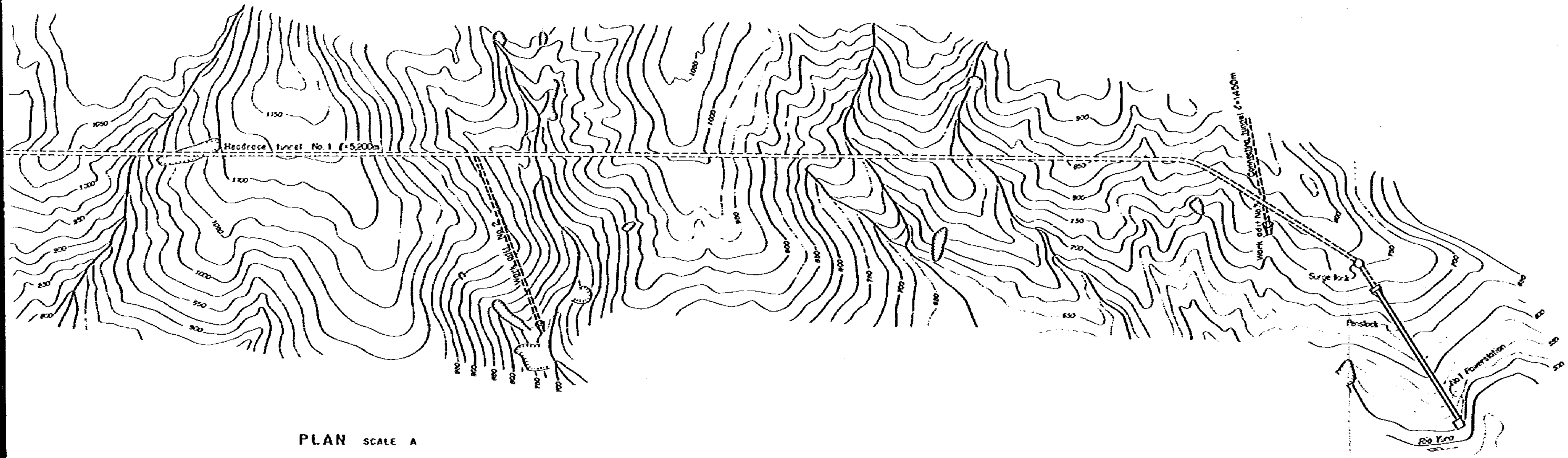
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	T - 1 & T - 2 Weir Plan and Profile of Weir
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	12	Plan y Sección de los Derivadoras T-1 y T-2
JAPAN INTERNATIONAL COOPERATION AGENCY		



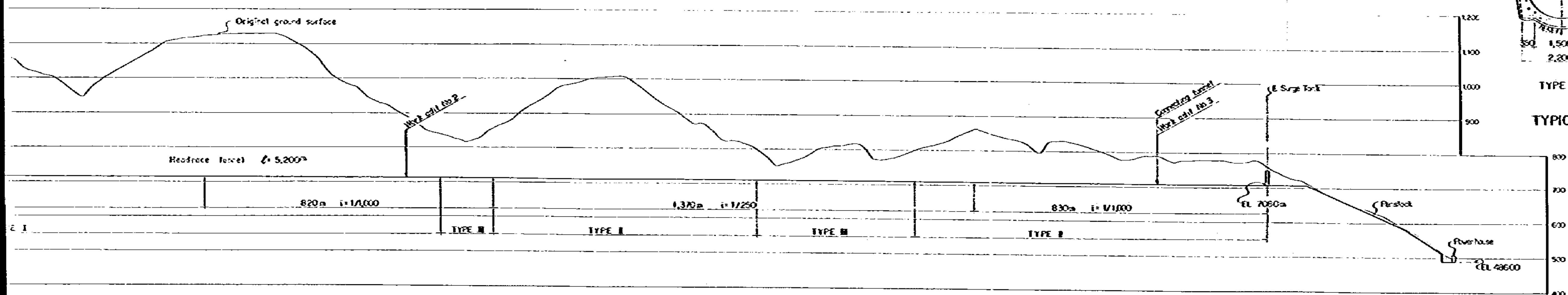
PLAN SCALE A



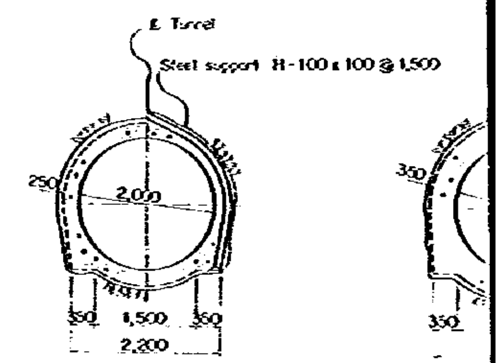
PROFILE SCALE A



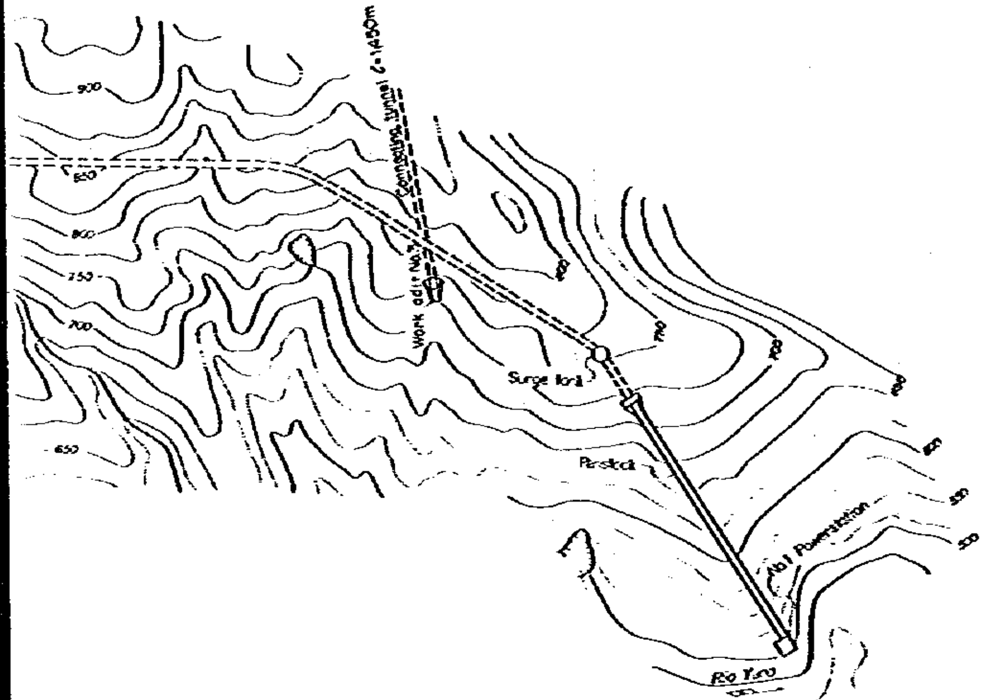
PLAN SCALE A

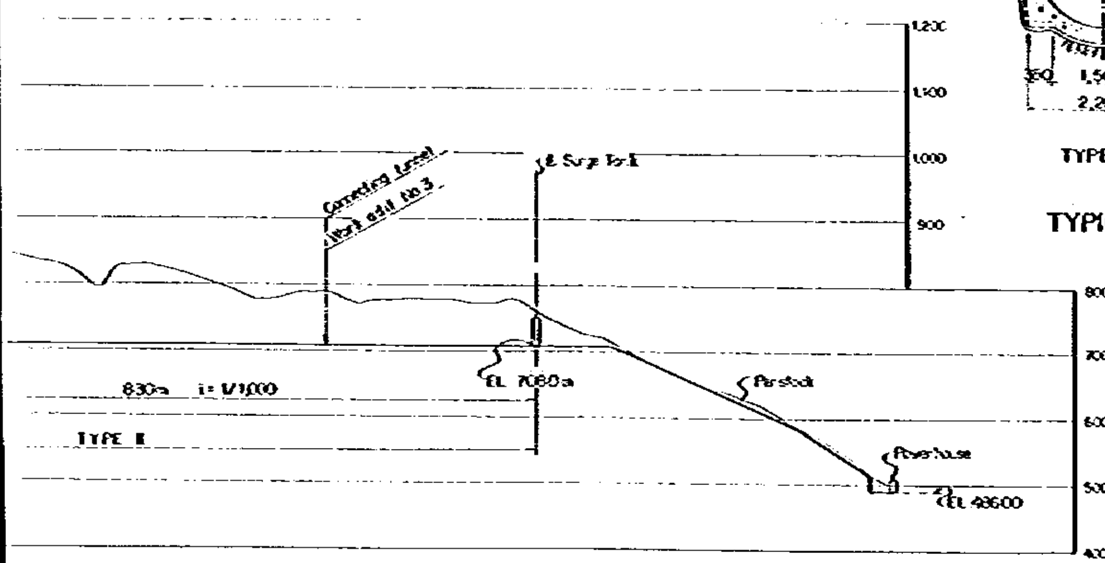


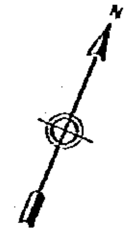
PROFILE SCALE A

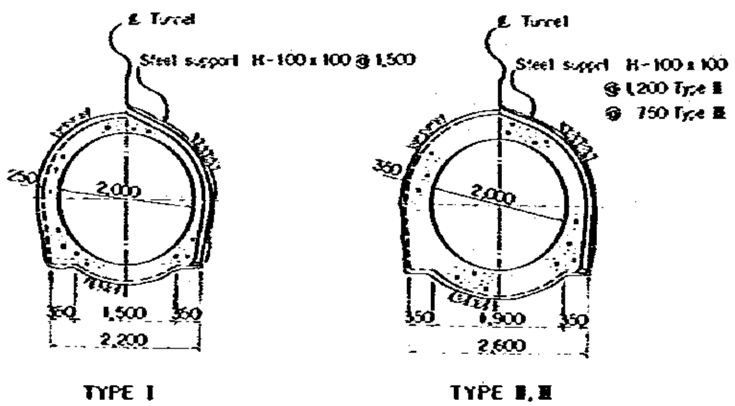


TYPICAL CROSS SECTIONS OF T

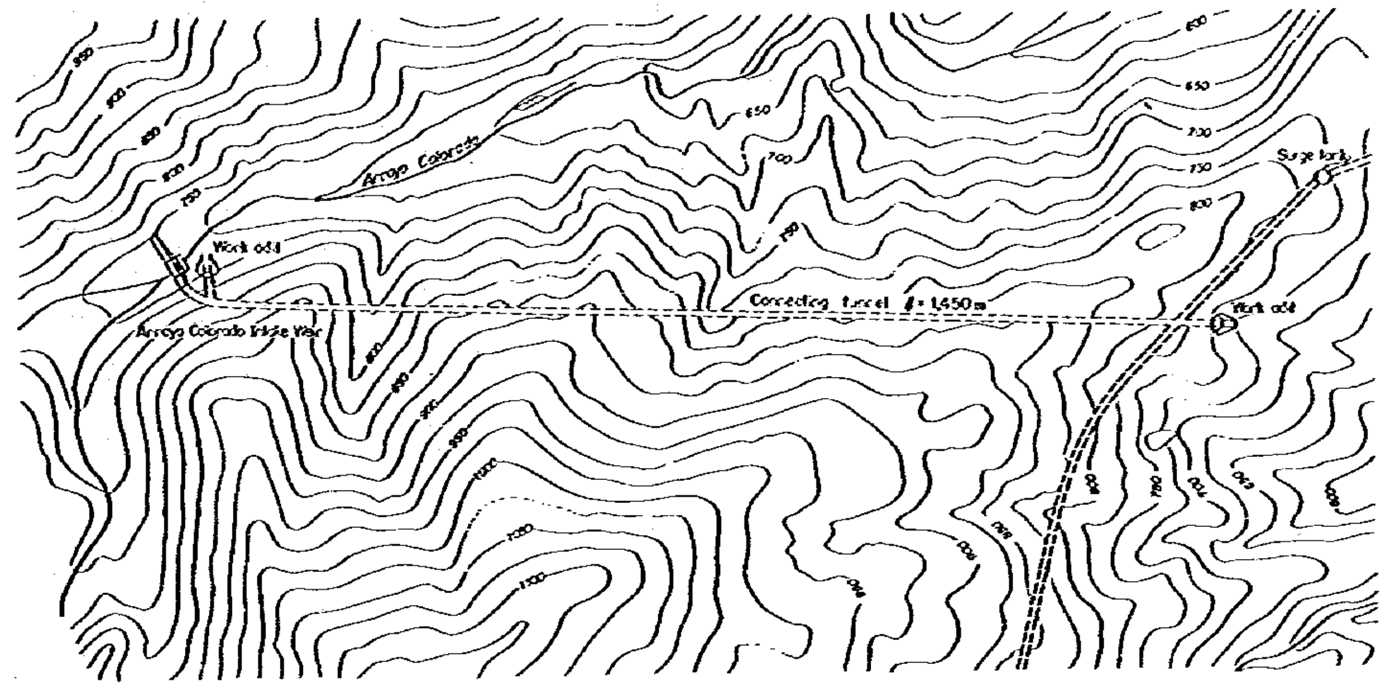




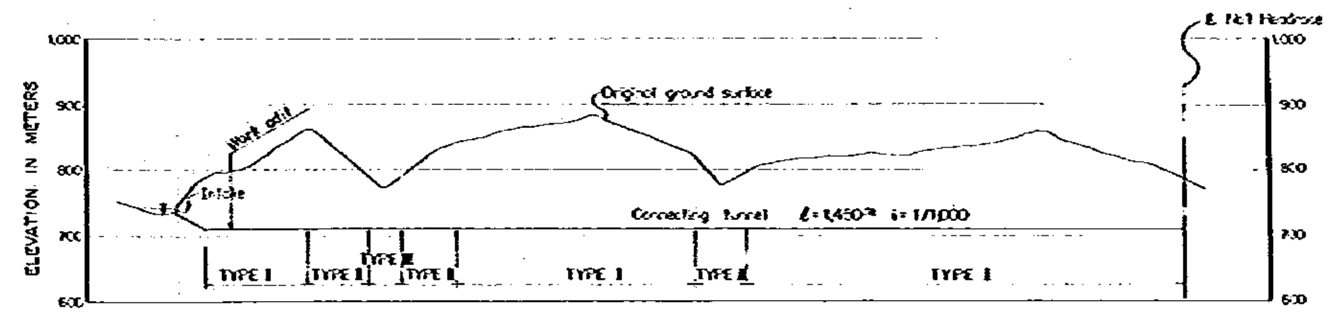




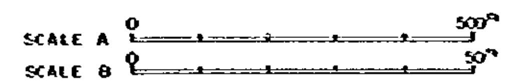
TYPICAL CROSS SECTIONS OF TUNNEL SCALE B



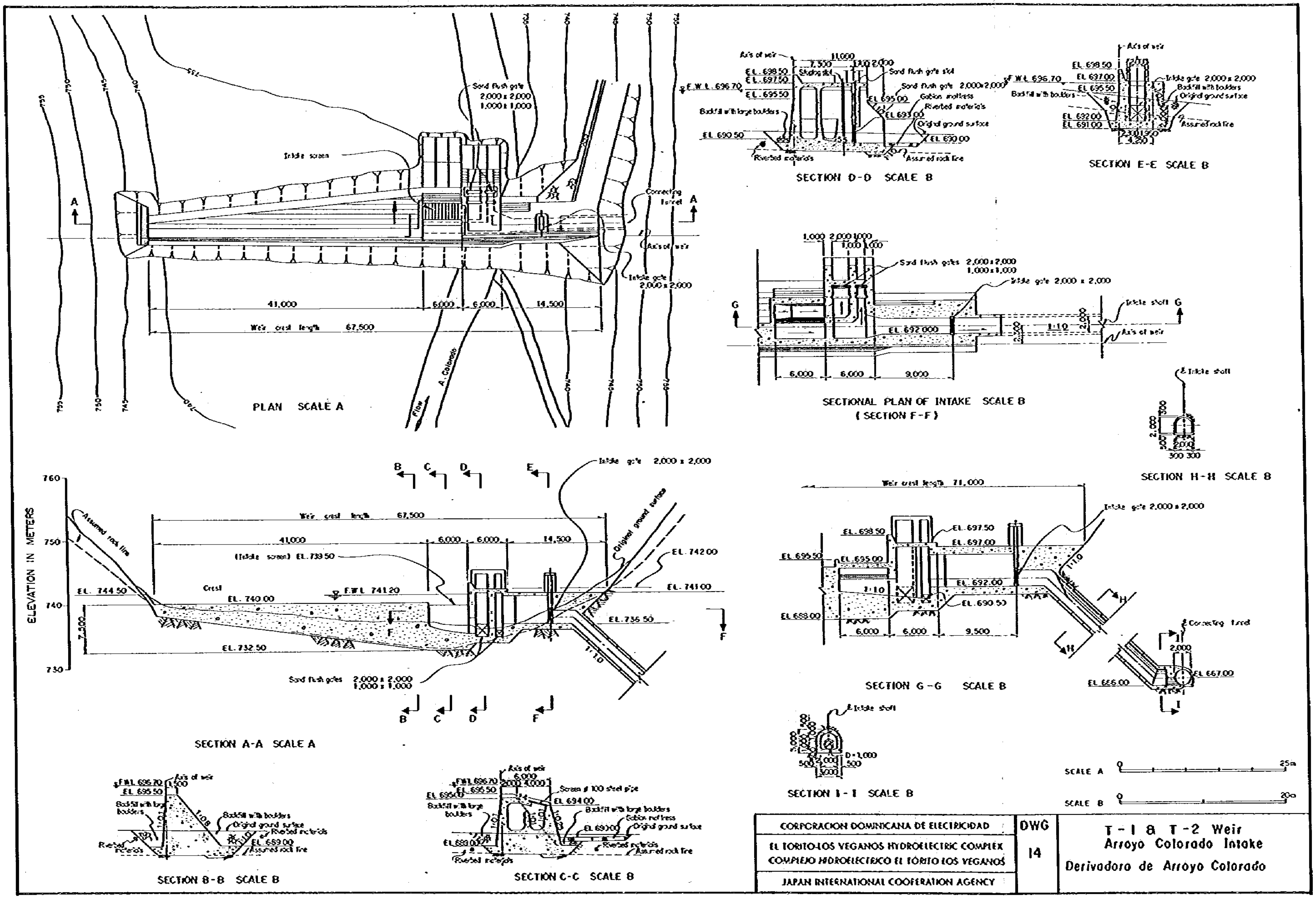
PLAN SCALE A



PROFILE OF CONNECTING TUNNEL SCALE A



CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	T-1 & T-2 Weir Waterway
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	13	Conduccion de Agua Derivadora T-1 y T-2
JAPAN INTERNATIONAL COOPERATION AGENCY		



CORPORACION DOMINICANA DE ELECTRICIDAD

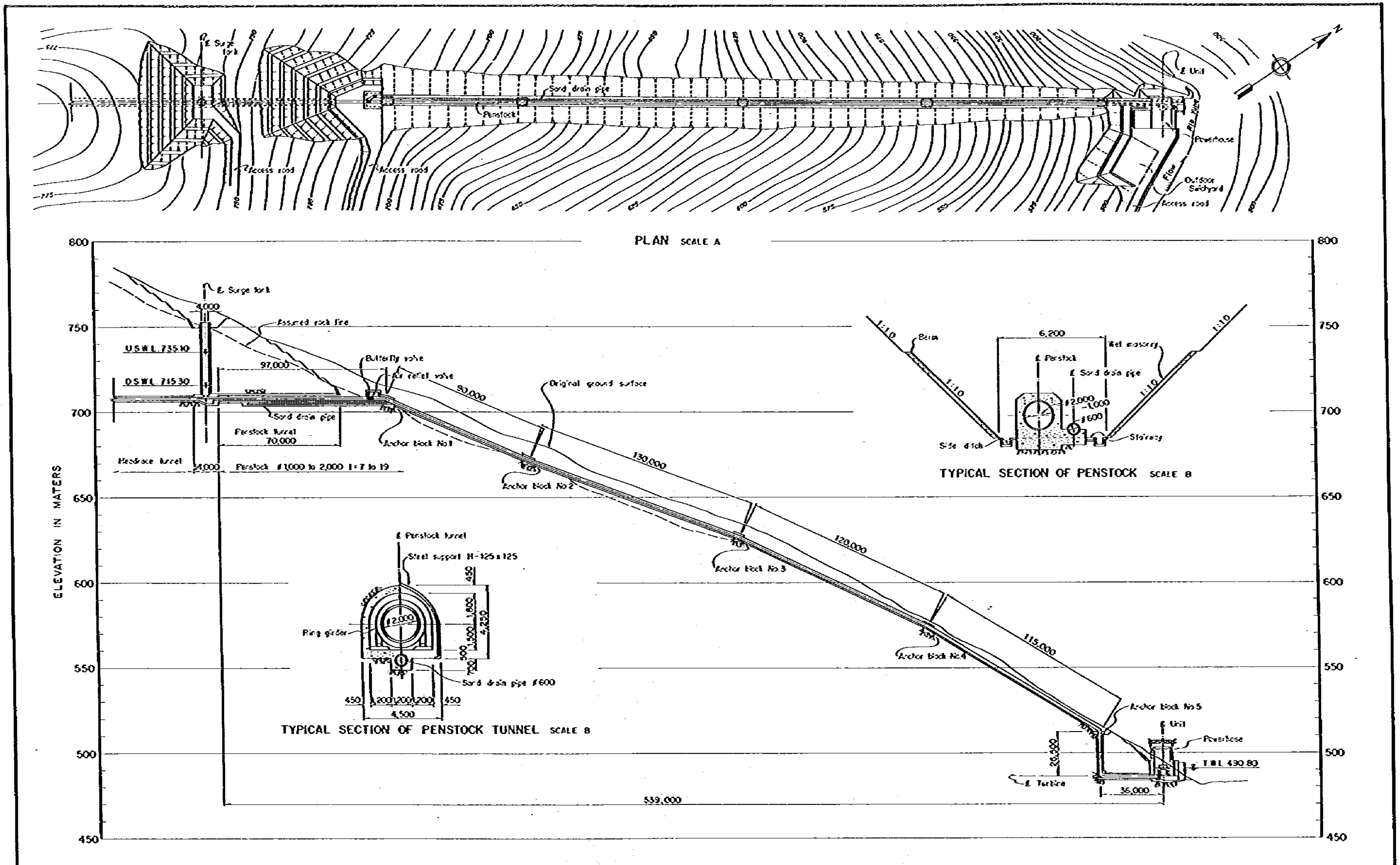
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX

COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS

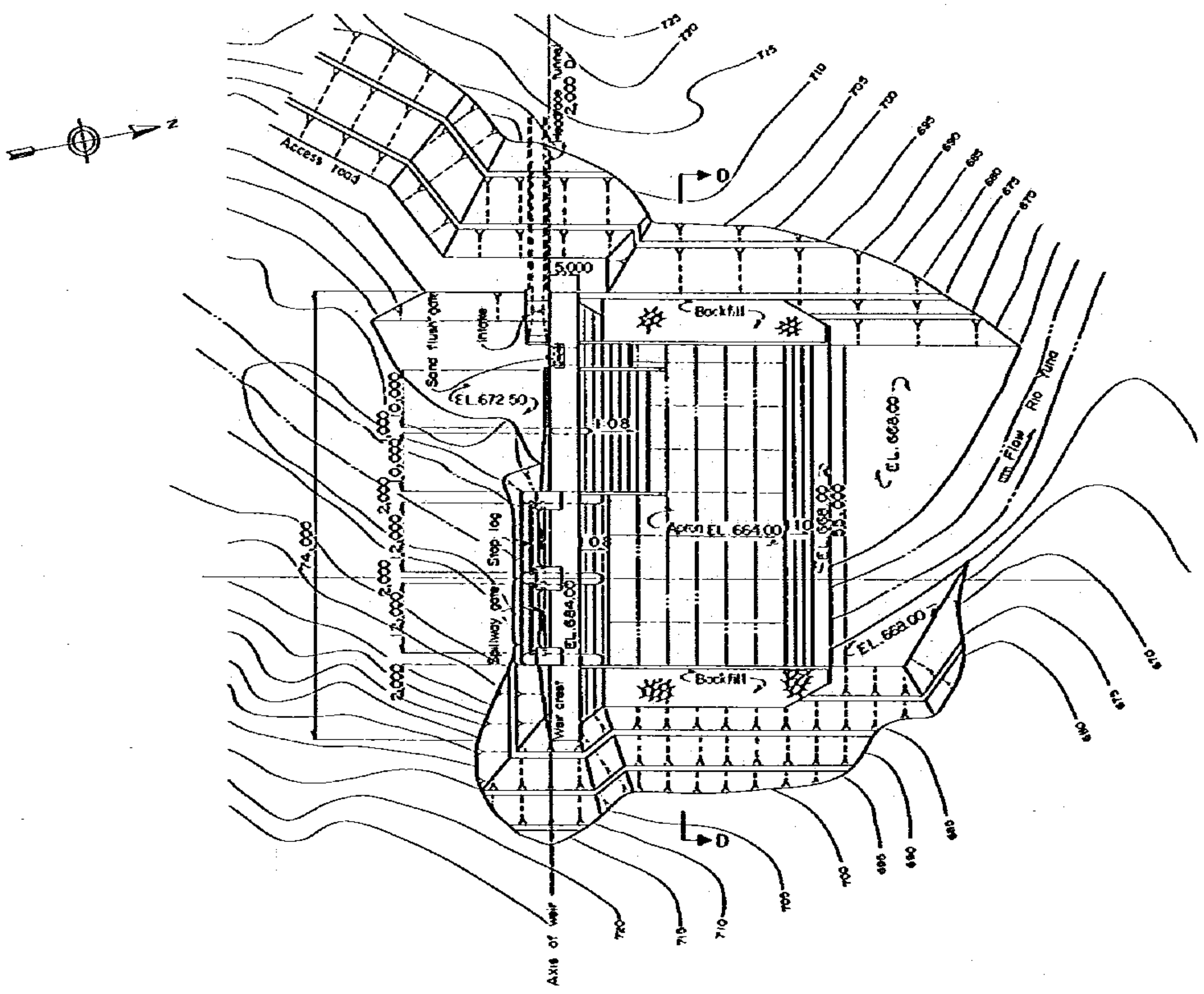
JAPAN INTERNATIONAL COOPERATION AGENCY

DWG 14

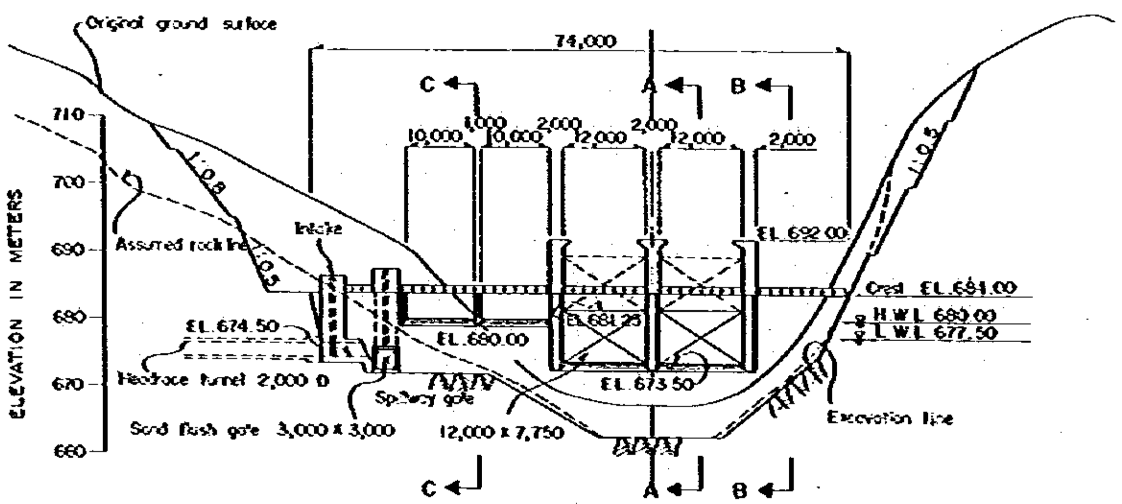
T-1 & T-2 Weir
Arroyo Colorado Intake
Derivadora de Arroyo Colorado



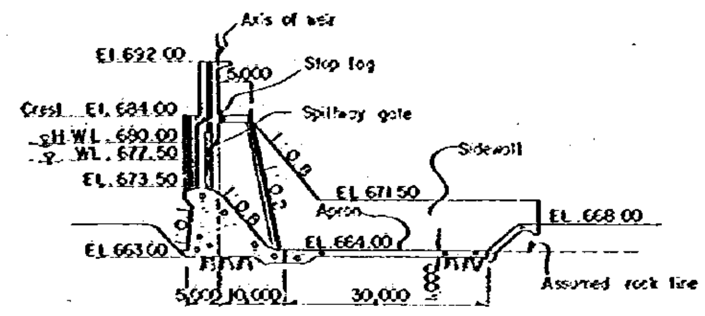
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	T-1 & T-2 Weir Surge Tank and Penstock, Chimenea de Equilibrio y Tuberia de Presion para los Derivadoras T-1 y T-2
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS	15	
JAPAN INTERNATIONAL COOPERATION AGENCY		



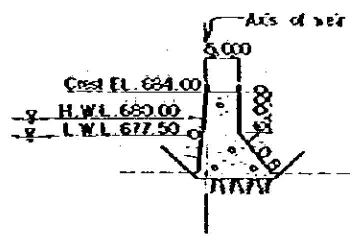
PLAN



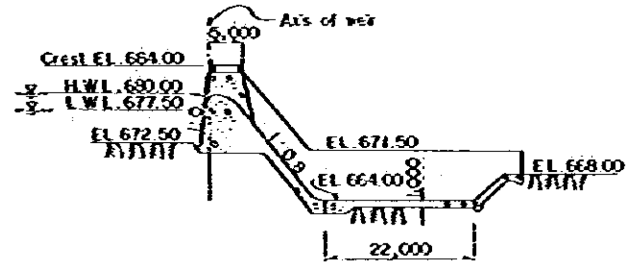
UPSTREAM ELEVATION



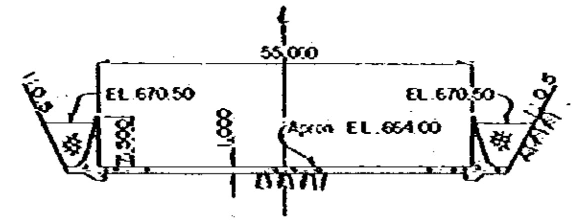
SECTION A - A



SECTION B - B



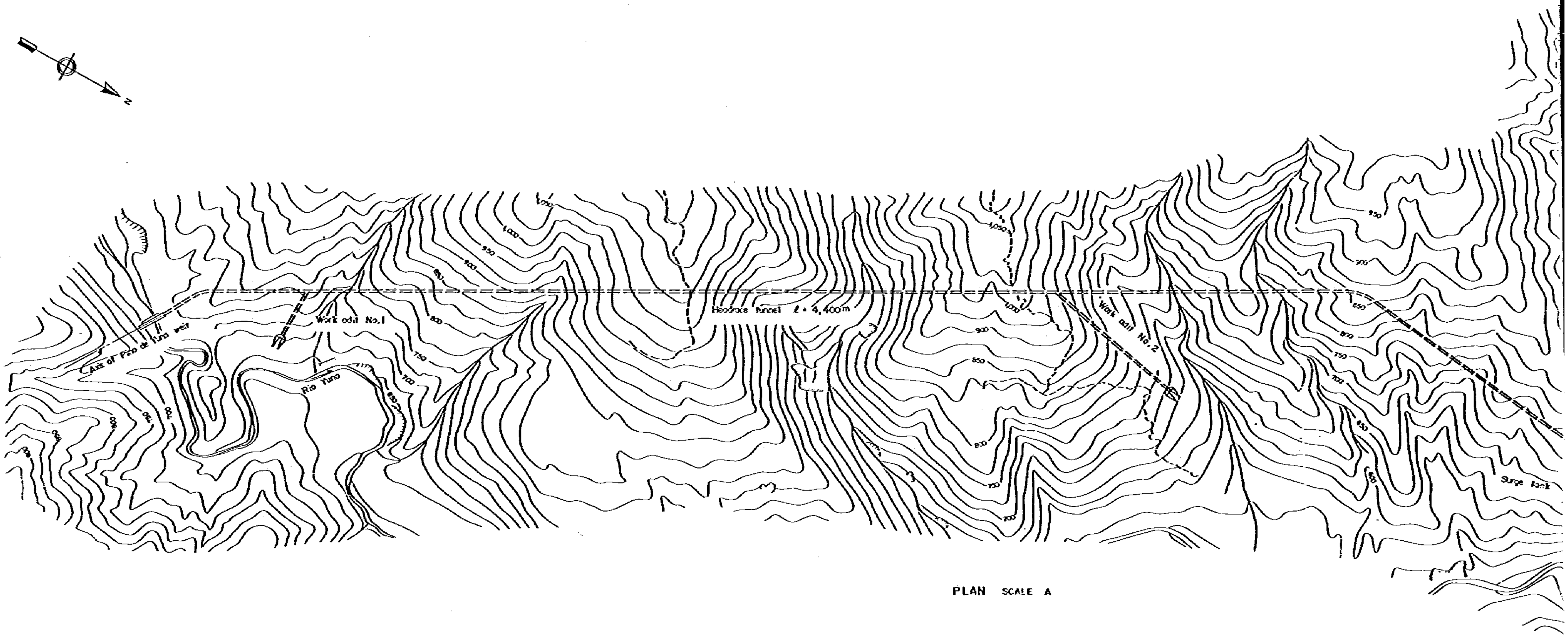
SECTION C - C



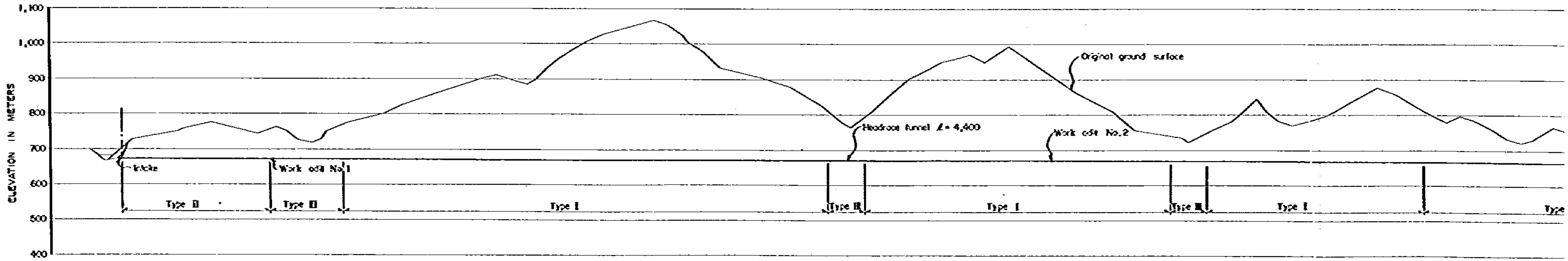
SECTION D - D

SCALE 0 — 50m

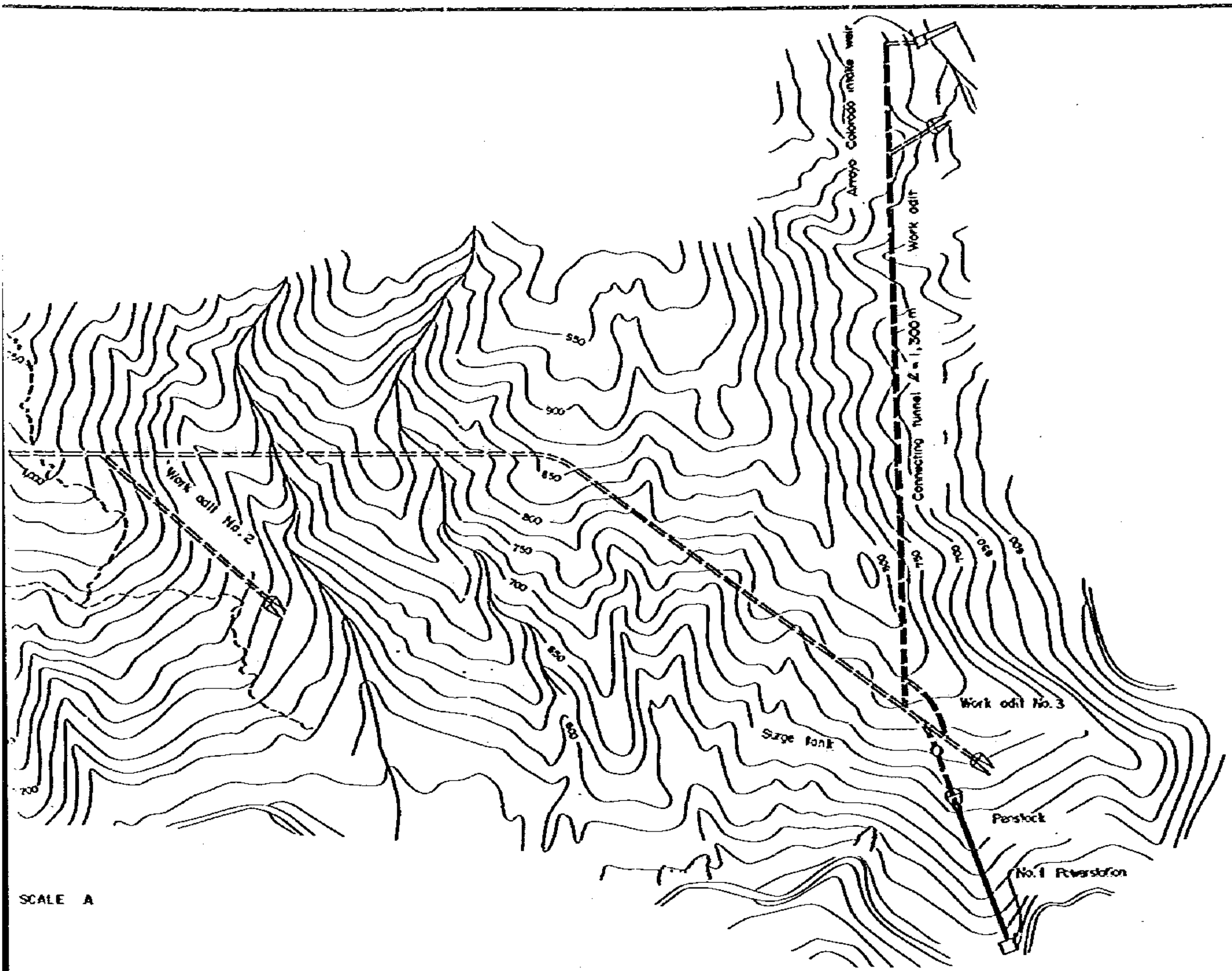
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	Pino de Yuna Weir Plan
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS	16	Plan de Derivadora T - 4 en Pino de Yuna
JAPAN INTERNATIONAL COOPERATION AGENCY		

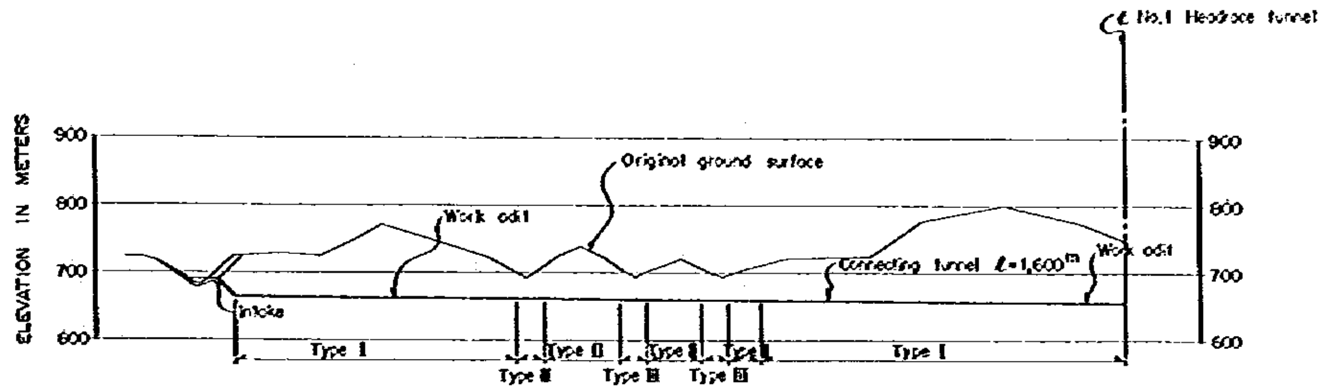


PLAN SCALE A

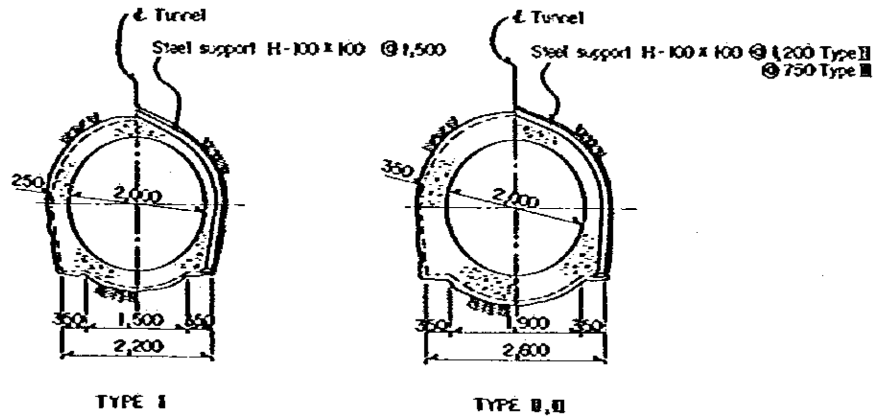


PROFILE SCALE A

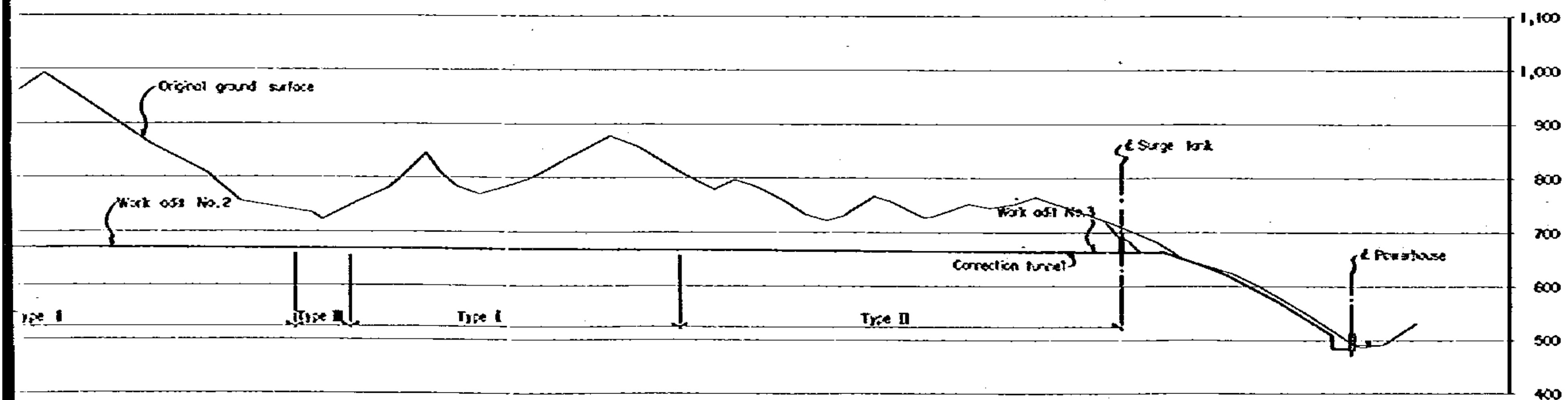




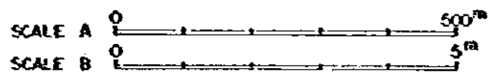
PROFILE OF CONNECTING TUNNEL SCALE A



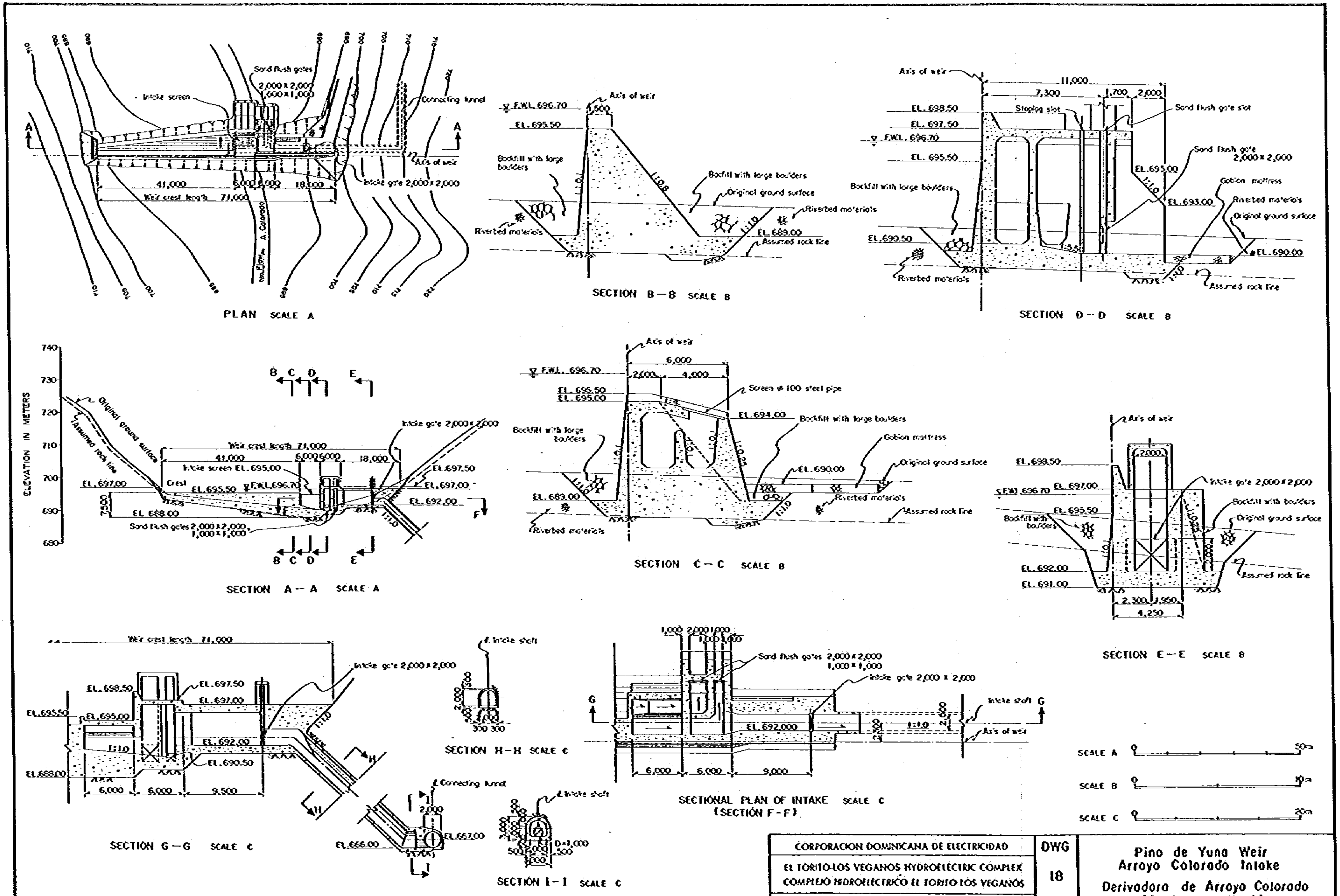
TYPICAL CROSS SECTIONS OF TUNNEL SCALE B



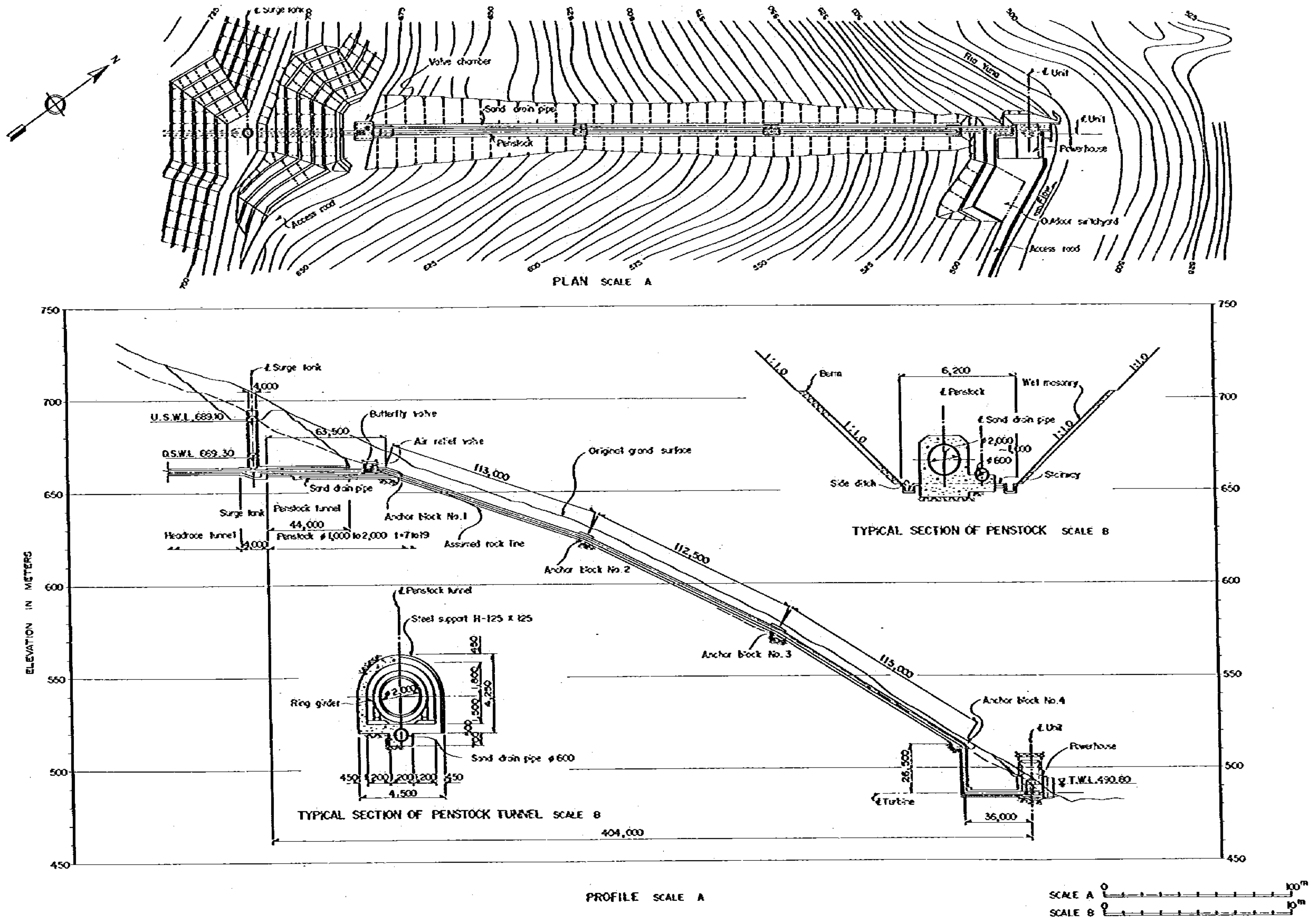
E SCALE A



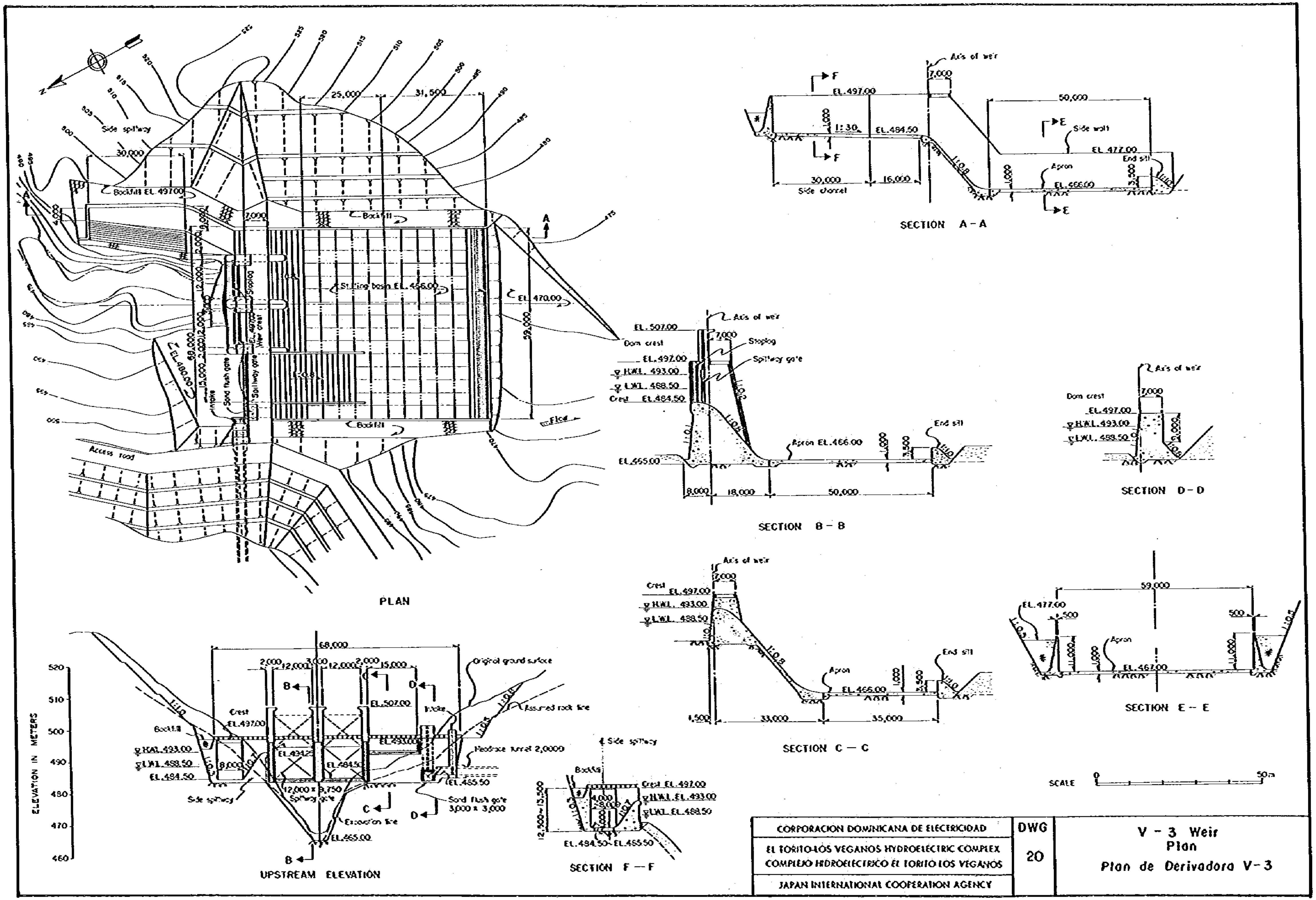
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	Pino de Yuna Weir Waterway
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	17	Conducción de Agua Derivadora T - 4
JAPAN INTERNATIONAL COOPERATION AGENCY		



CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	Pino de Yuna Weir
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELÉCTRICO EL TORITO-LOS VEGANOS	18	Arroyo Colorado Intake
JAPAN INTERNATIONAL COOPERATION AGENCY		Derivadora de Arroyo Colorado (Derivadora T-4)



CORPORACIÓN DOMINICANA DE ELECTRICIDAD	DWG	Pino de Yuna Weir Surge Tank and Penstock
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	19	Chimenea de Equilibrio y Tubería de Presion para la Derivadora T-4
JAPAN INTERNATIONAL COOPERATION AGENCY		



CORPORACION DOMINICANA DE ELECTRICIDAD

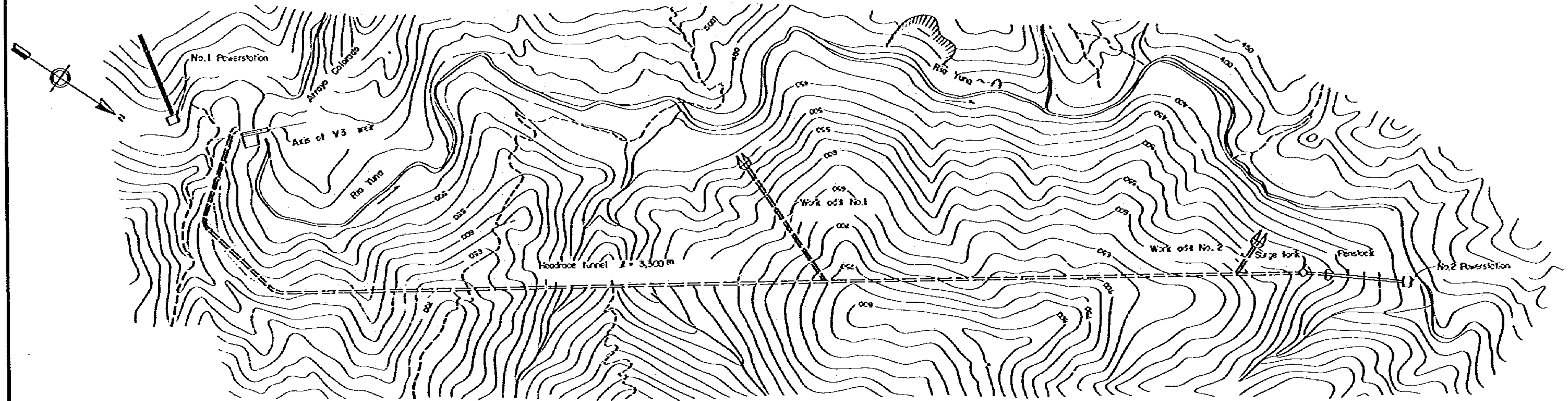
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX

COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS

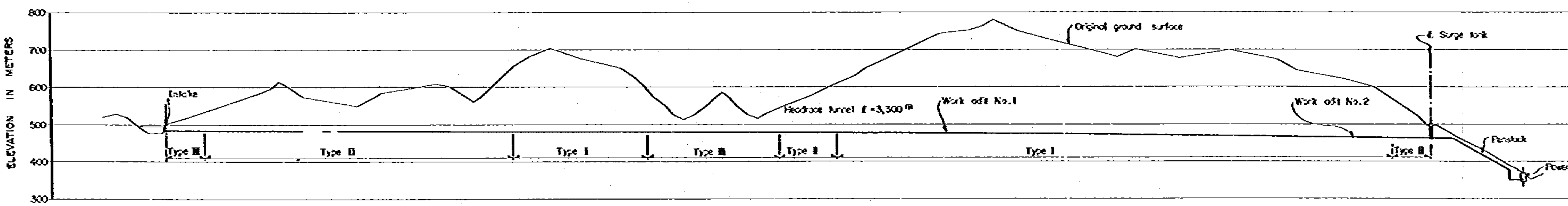
JAPAN INTERNATIONAL COOPERATION AGENCY

DWG 20

V - 3 Weir
Plan
Plan de Derivadora V-3

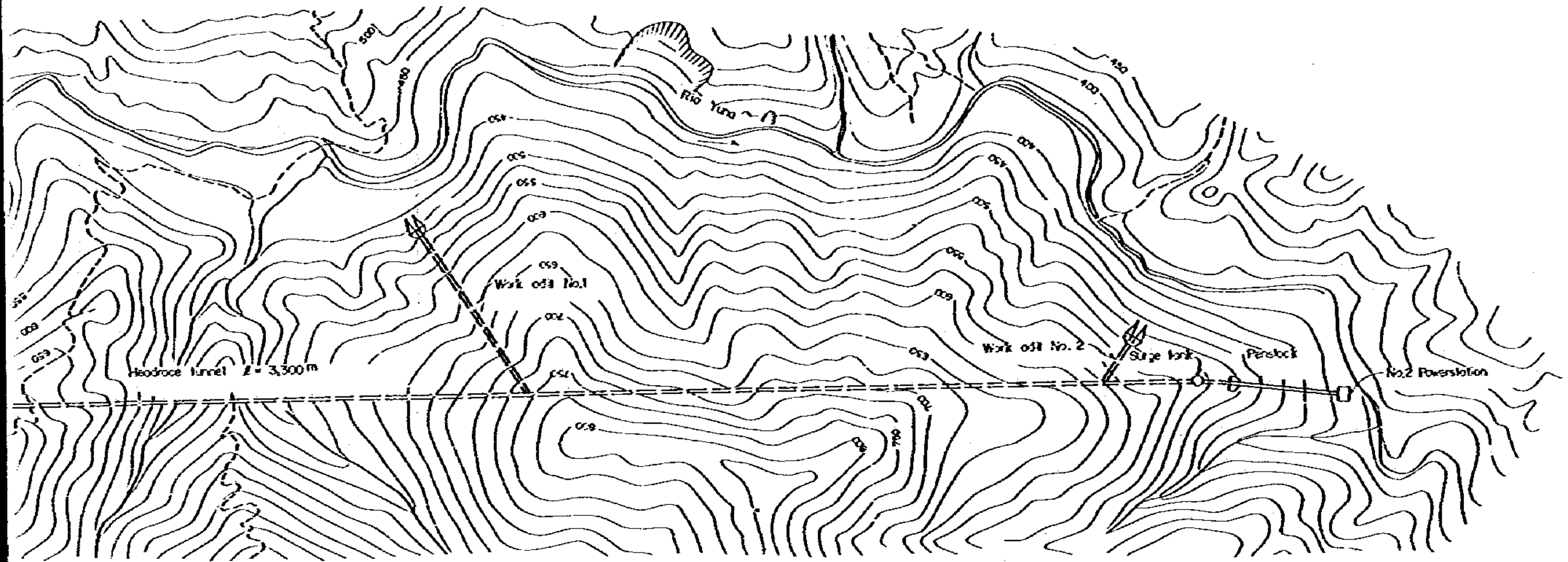


PLAN SCALE A

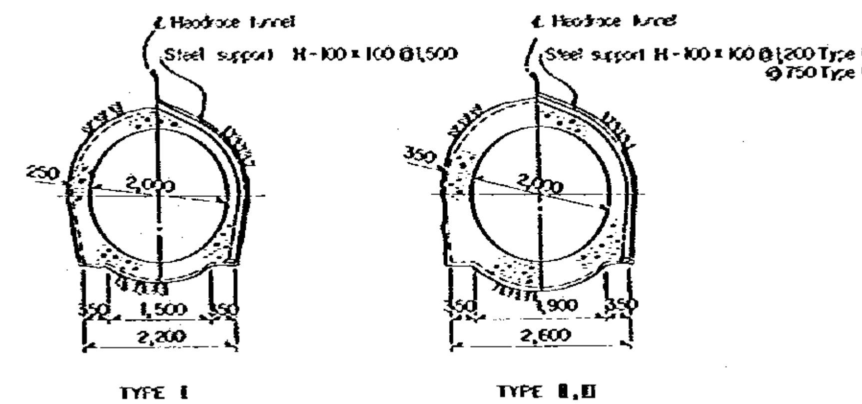


PROFILE SCALE A

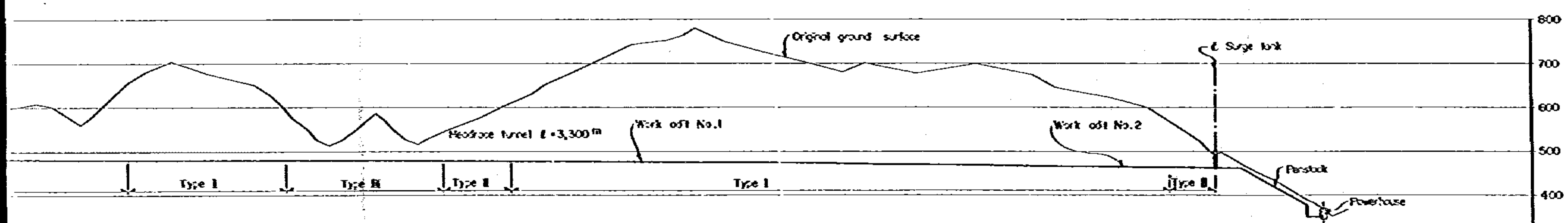
CORPORACION DO
EL TORITO-LOS VEGA COMPLEJO HIDROELEC
JAPAN INTERNATIO



PLAN SCALE A



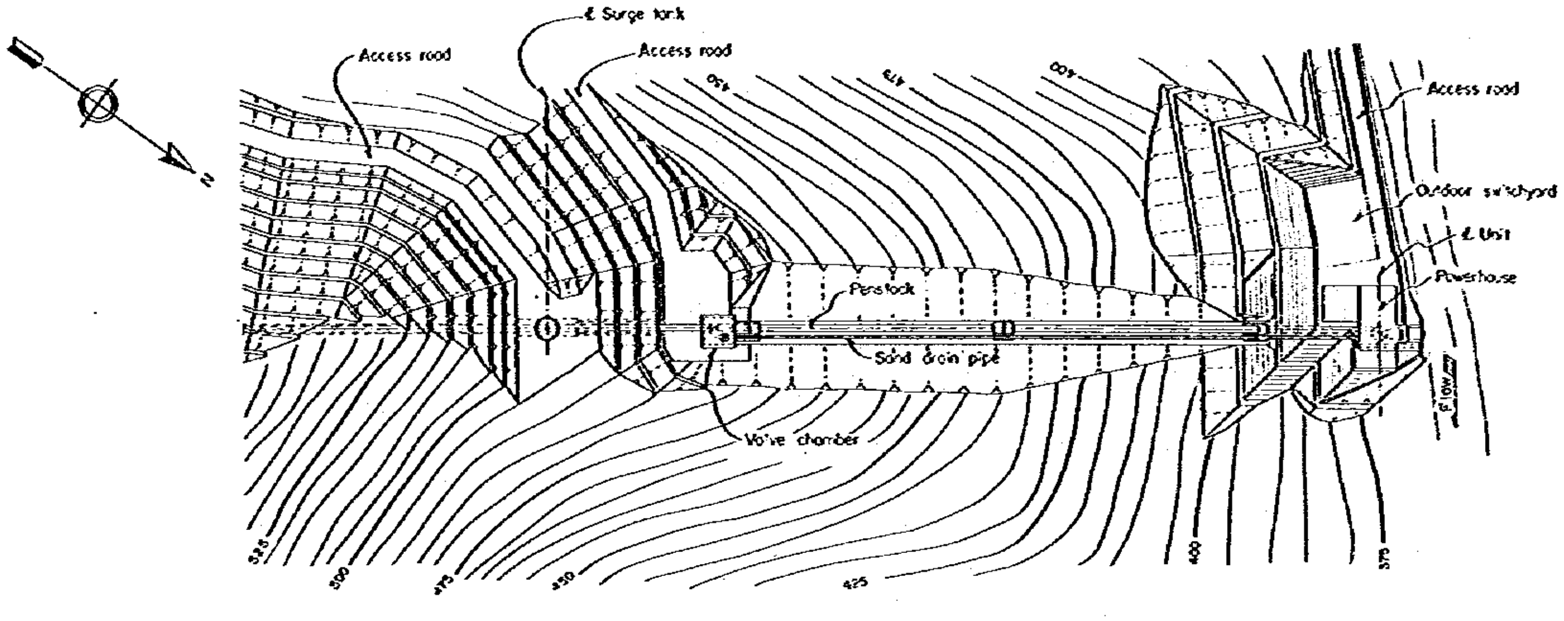
TYPICAL CROSS SECTIONS OF HEADRACE TUNNEL SCALE B



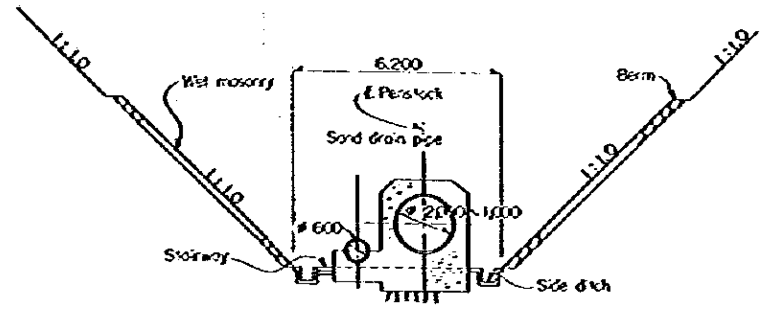
PROFILE SCALE A

SCALE A 0 — 500 m
SCALE B 0 — 5 m

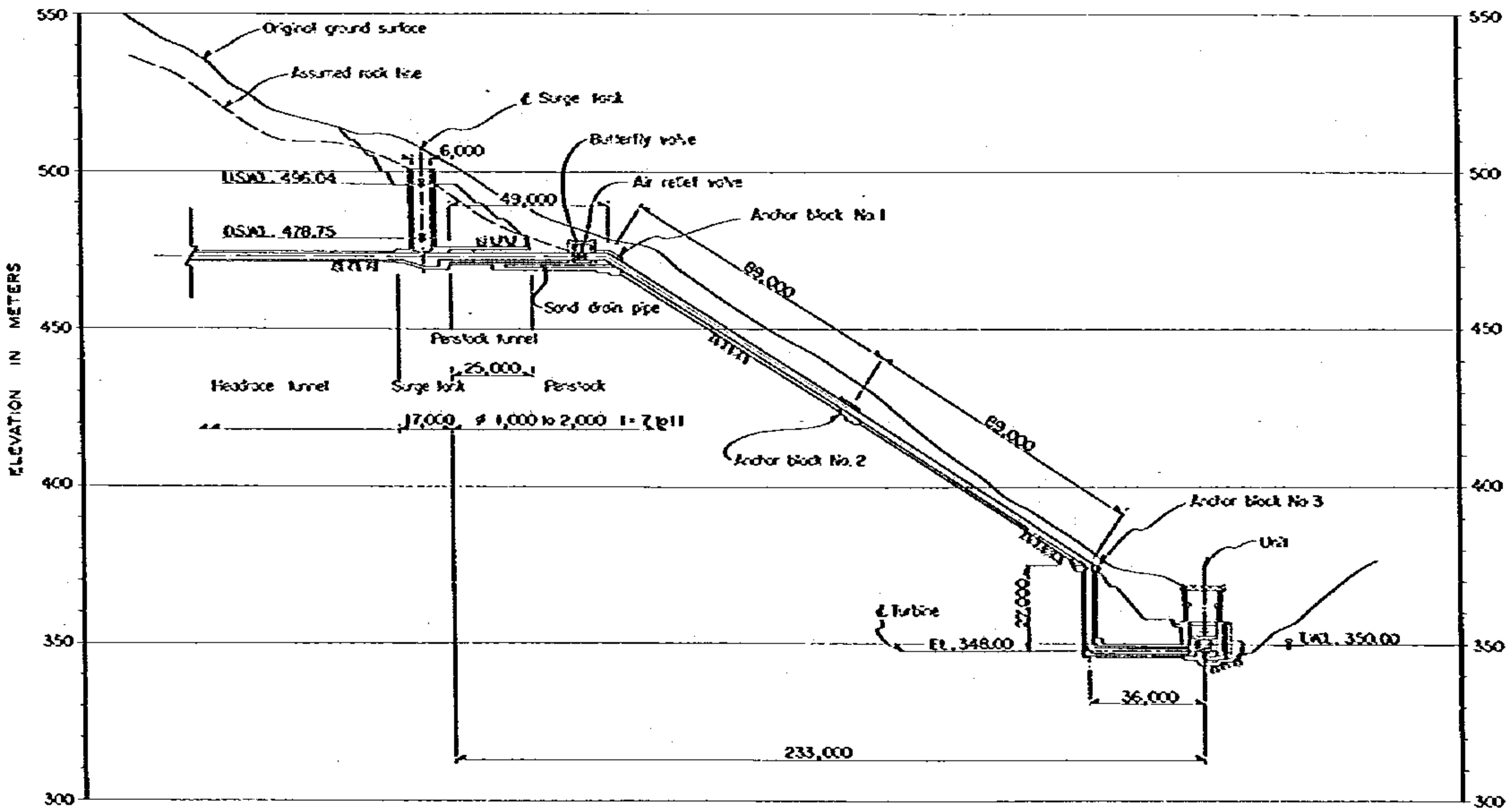
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	V-3 Weir
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS	21	Waterway Conduccion de Agua Derivadora V-3
JAPAN INTERNATIONAL COOPERATION AGENCY		



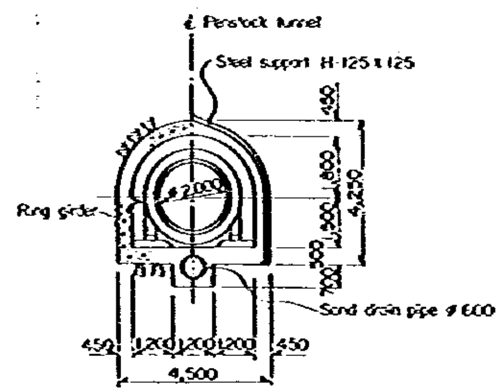
PLAN SCALE A



TYPICAL SECTION OF PENSTOCK SCALE B



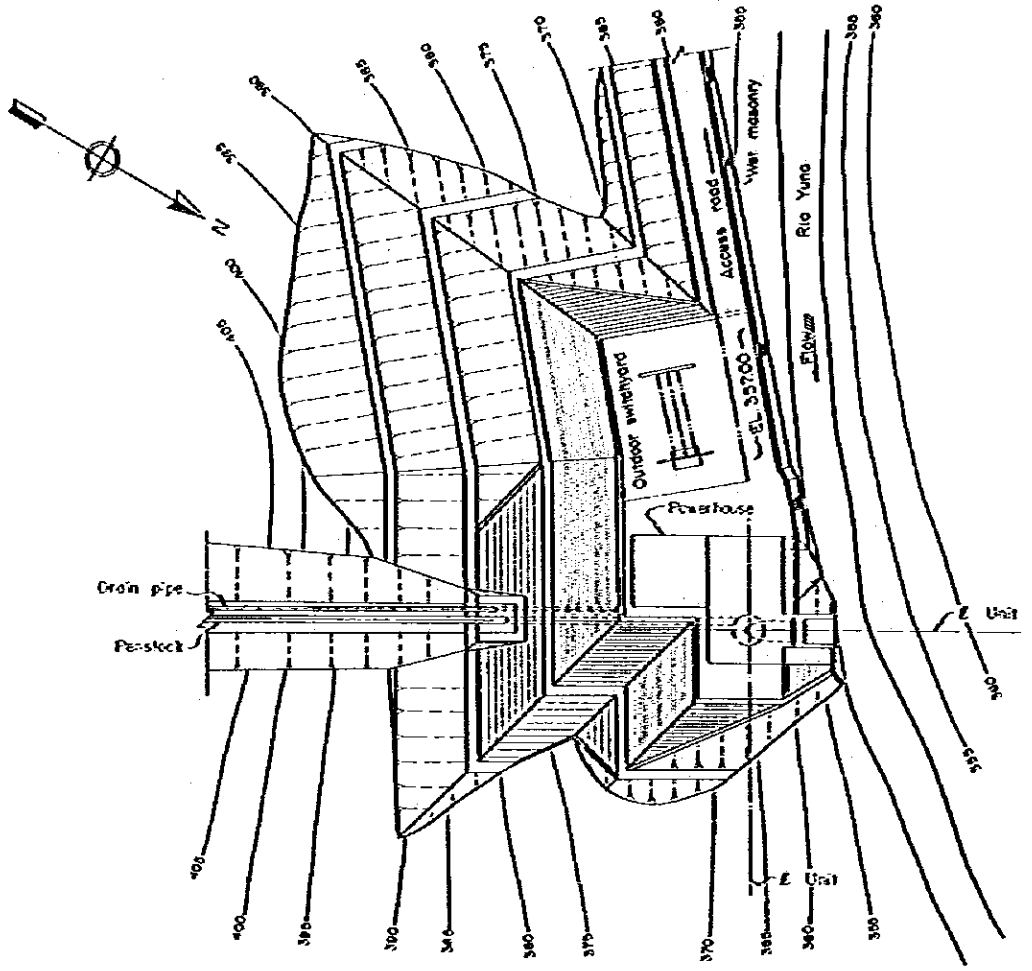
PROFILE SCALE A



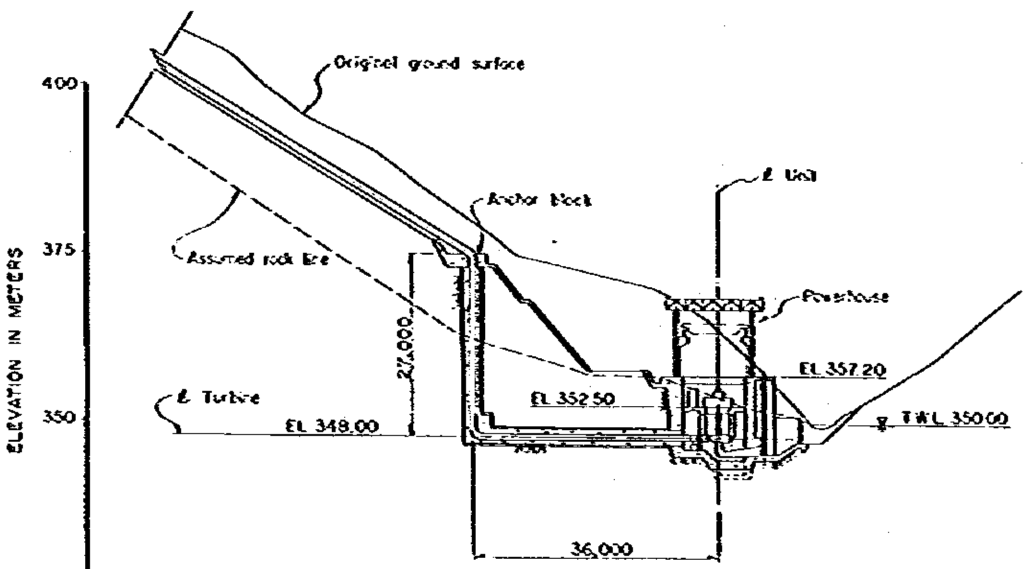
TYPICAL SECTON OF PENSTOCK TUNNEL SCALE B

SCALE A 0 — 100 m
SCALE B 0 — 10 m

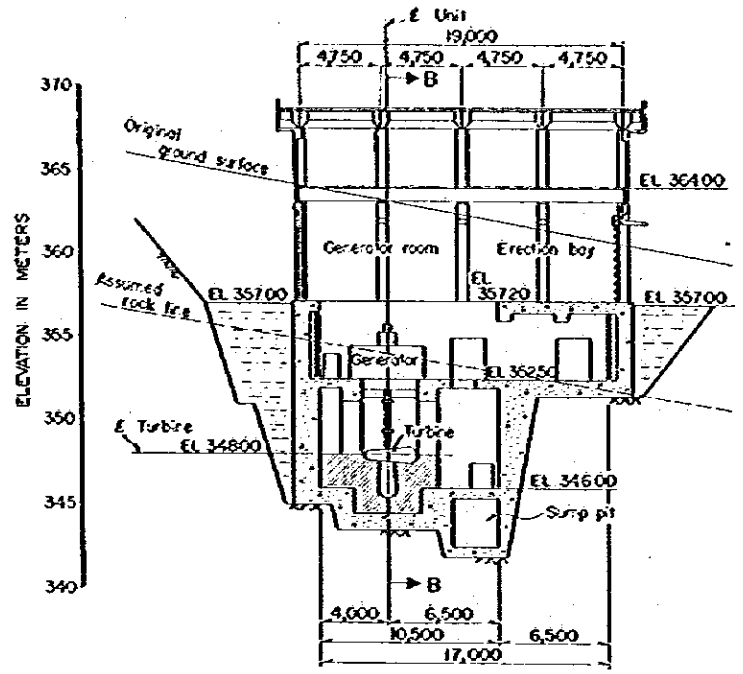
CORPORACION DOMINICANA DE ELECTRICIDAD	DWG	V - 3 Weir Surge Tank and Penstock
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS	22	Chimeneo de Equilibrio y Tuberia de Presion para Derivadora V-3
JAPAN INTERNATIONAL COOPERATION AGENCY		



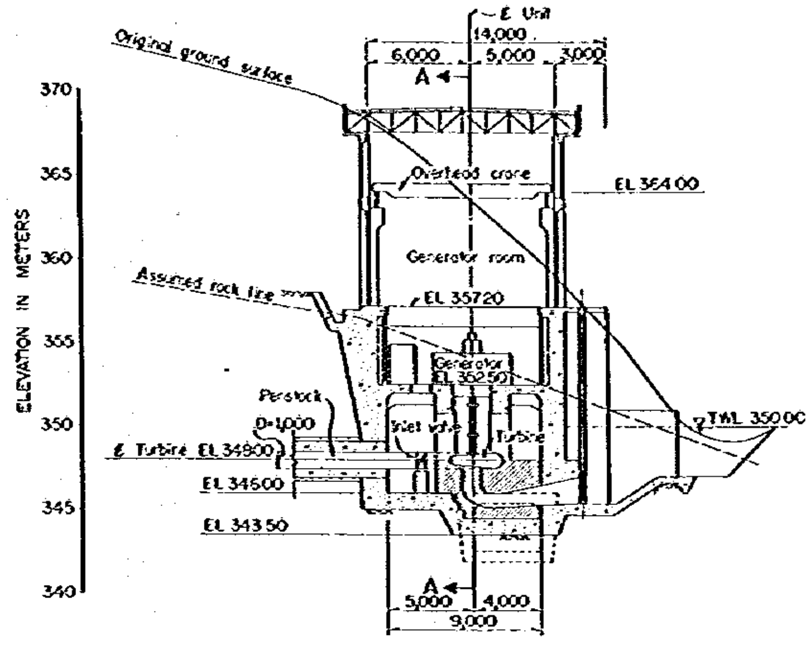
PLAN SCALE A



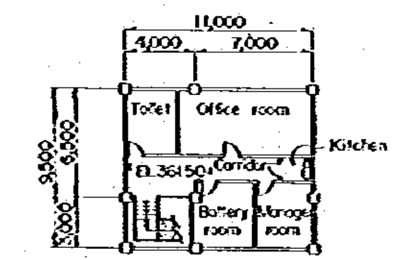
PROFILE SCALE A



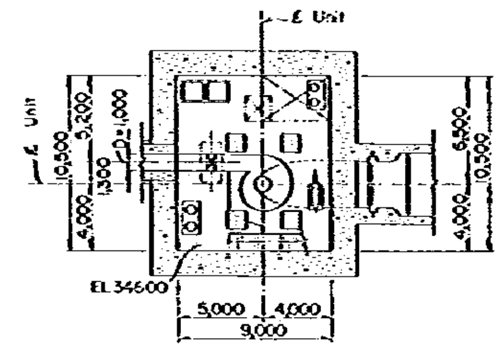
SECTION A-A SCALE B



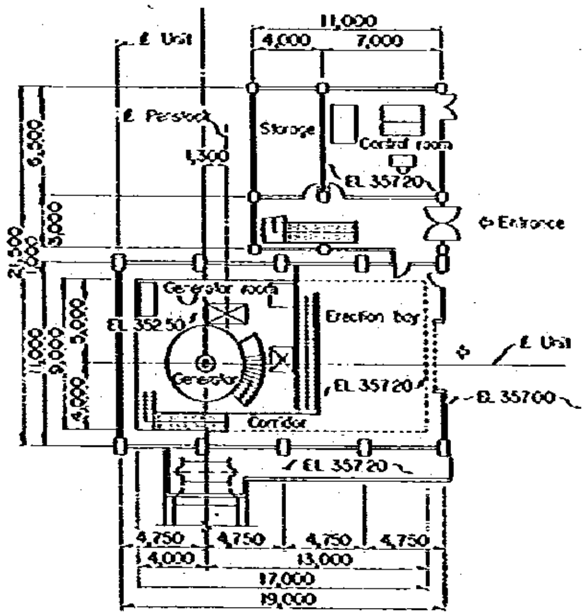
SECTION B-B SCALE B



SECTIONAL PLAN EL 361.50 SCALE B



SECTIONAL PLAN EL 346.00 SCALE B



SECTIONAL PLAN EL 357.00 SCALE B

SCALE A 0 — 50m

SCALE B 0 — 20m

CORPORACIÓN DOMINICANA DE ELECTRICIDAD	DWG	Los Veganos Scheme No. 2 Powerstation
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELÉCTRICO EL TORITO LOS VEGANOS	23	*Central Yuna No. 2 Esquema Los Veganos*
JAPAN INTERNATIONAL COOPERATION AGENCY		