EL 214.5

Diversion Tunnel

EL 145.0

EL 132.0

1:0.8

+130.0

Power House

EL 148.0

EL 145.0

+180.0

Transformer

Turbine Center

Switchyard

EL 214.5(Dam Crest)

X=305,184.05
Y=569,755.289

N55° 3'22"E

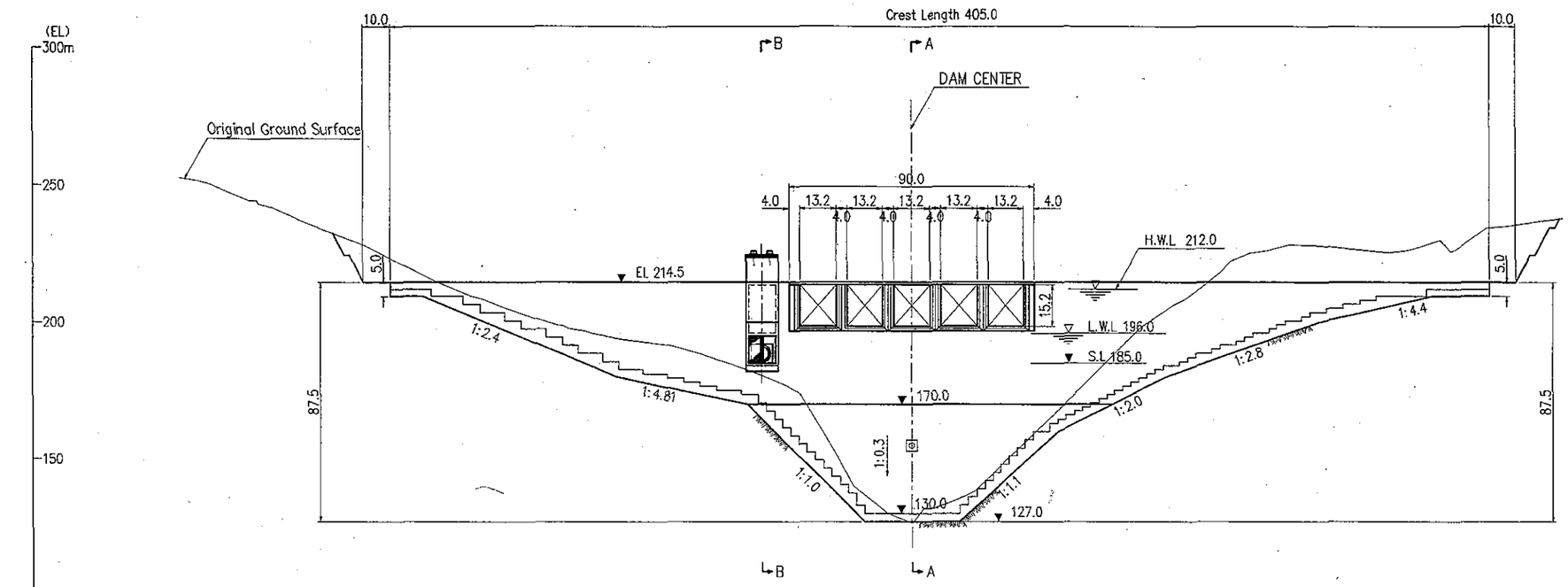
EL 214.5

0 100m

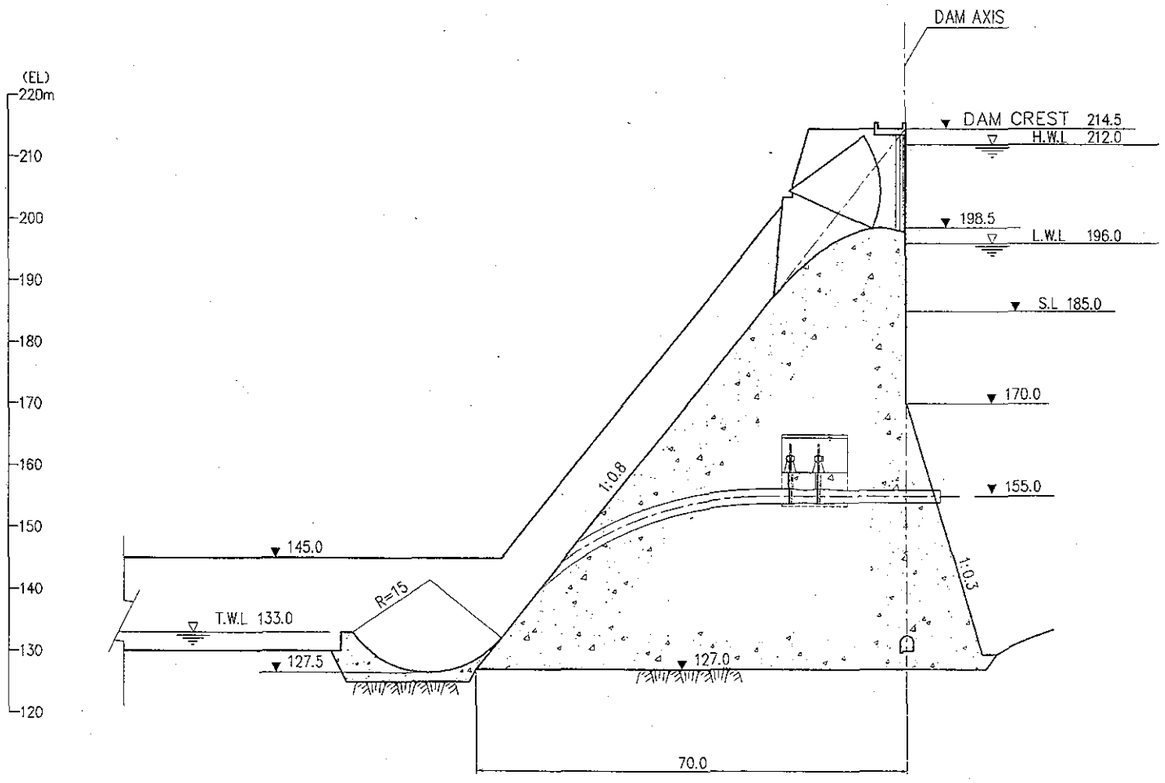
| EL CHAPARRAL HYDROPOWER PROJECT | | |
|---|---|---|
| DAM<br>DAM PLAN | | |
| **Fig. 2.1** | | DATE |

SHEET NO. OF

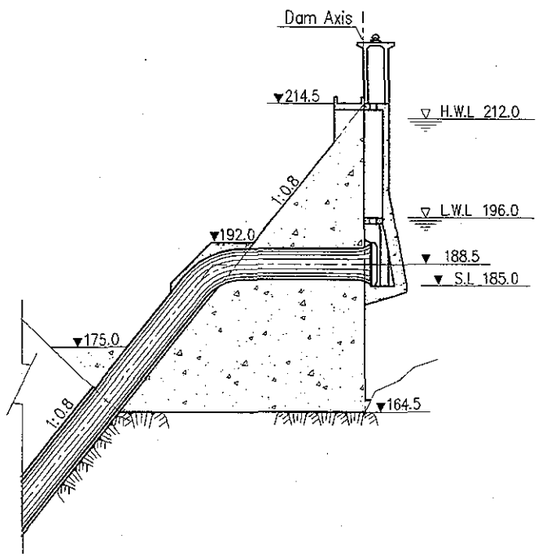
# DAM ELEVATION




## TYPICAL SECTION A




## TYPICAL SECTION B

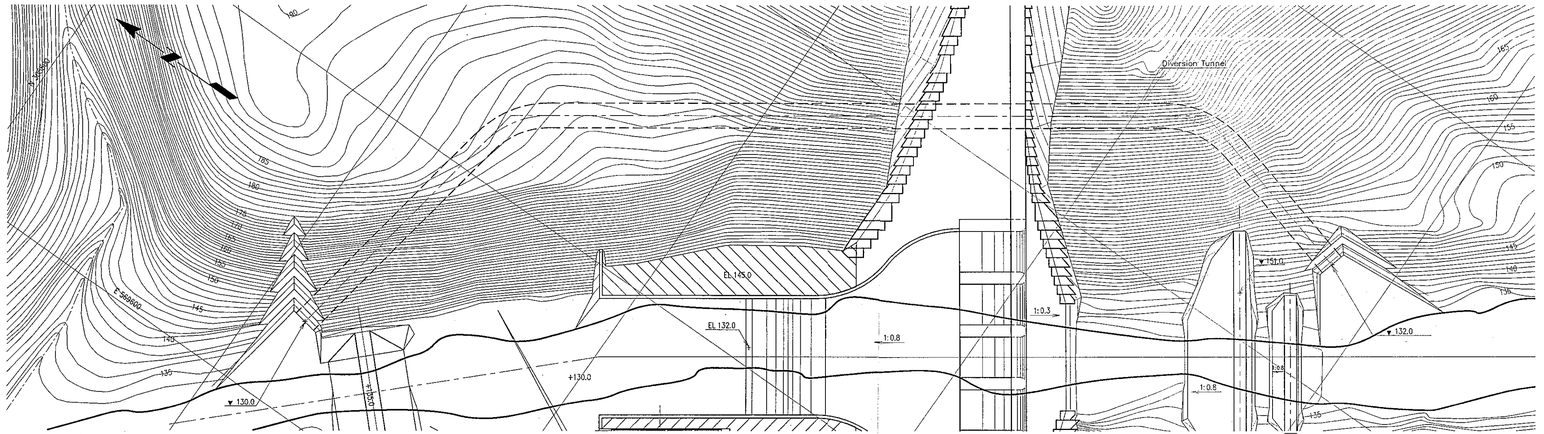



0 100m
( DAM ELEVATION )

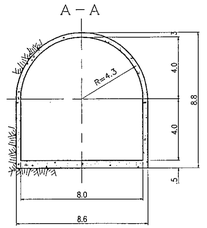
0 50m
( TYPICAL SECTION A,B )

| EL CHAPARRAL HYDROPOWER PROJECT | | |
|---|---|---|
| DAM<br>DAM ELEVATION AND TYPICALSECTION | | |
| **Fig. 2.2** | | DATE |

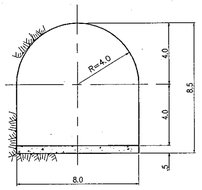
PLAN



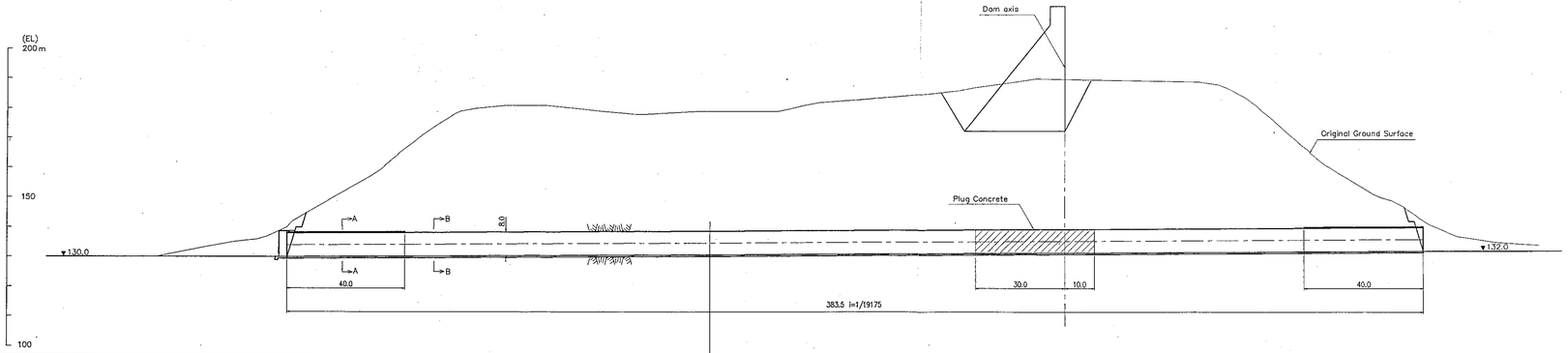

A – A




B – B




SECTION

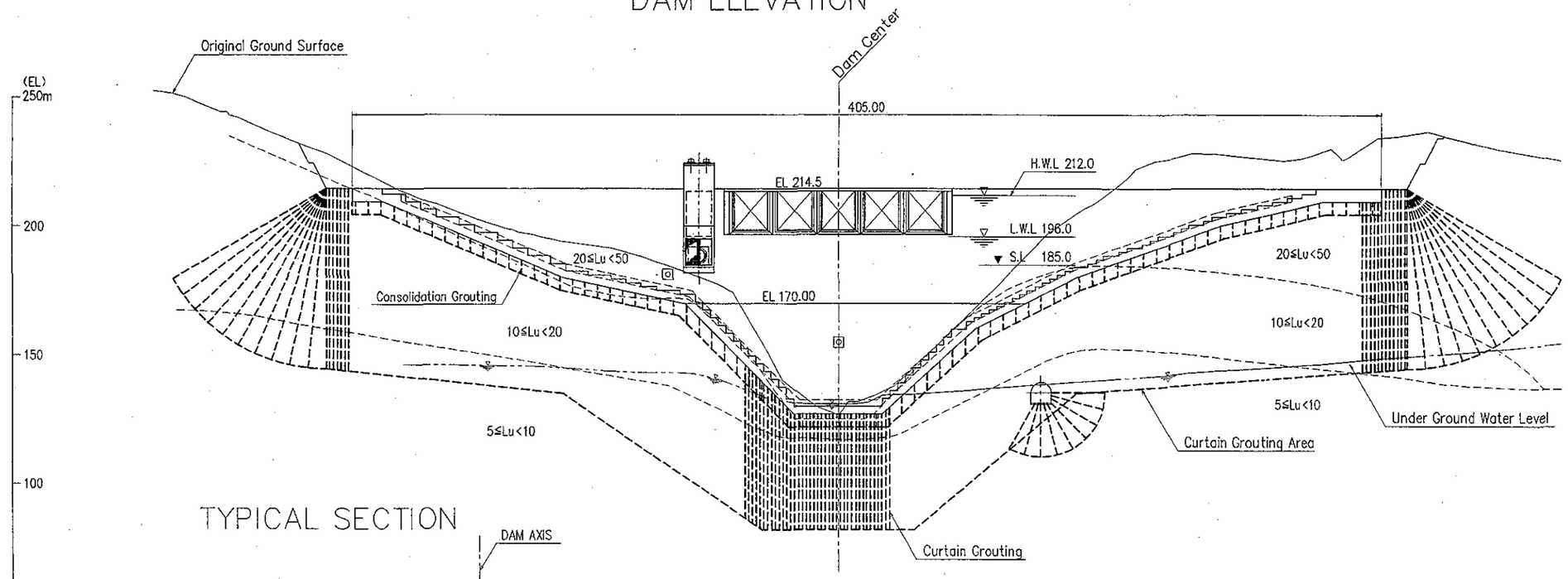



0 10m
(SECTION A–A,B–B)

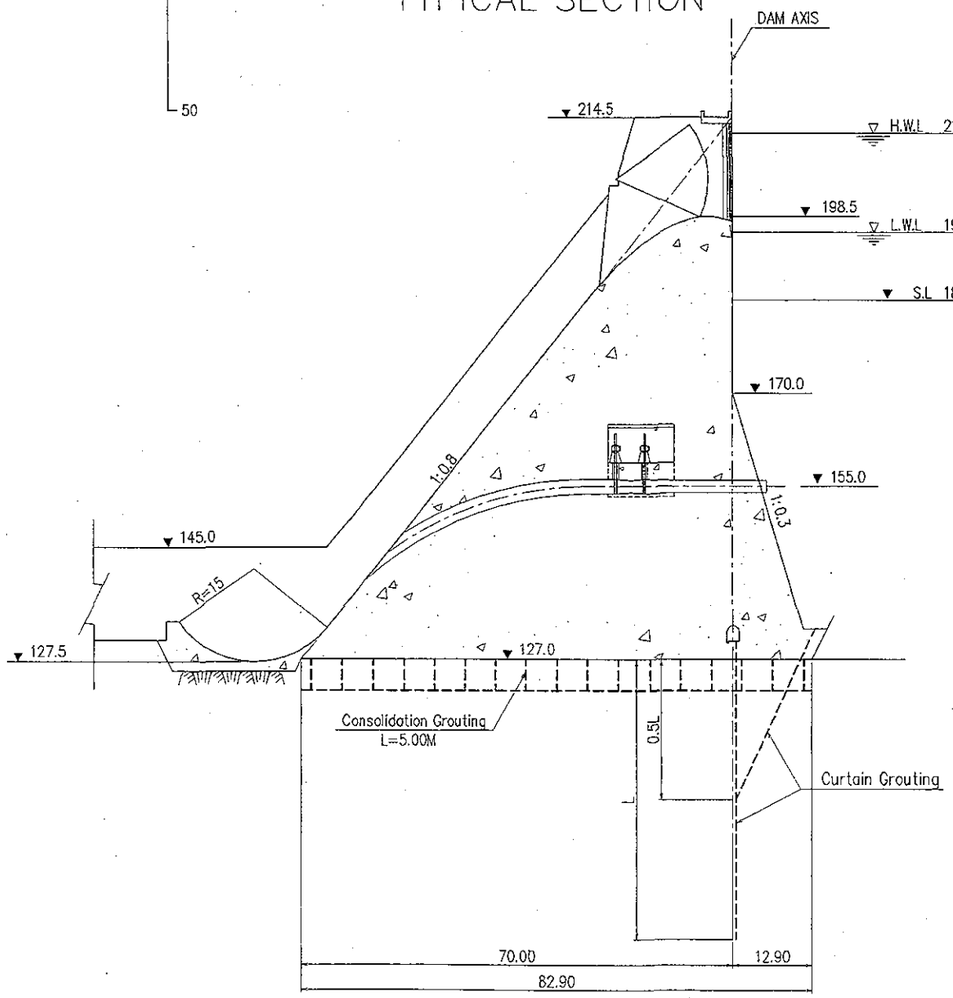
0 50m
(PLAN,SECTION)

| EL CHAPARRAL HYDROPOWER PROJECT | | |
|---|---|---|
| DIVERSION TUNNEL PLAN AND SECTION | | |
| Fig. 2.3 | | DATE |

# DAM ELEVATION

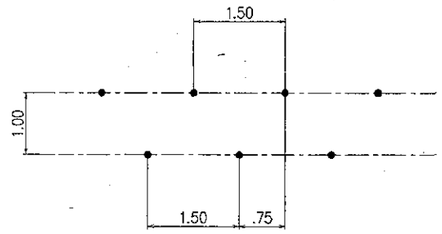



# TYPICAL SECTION

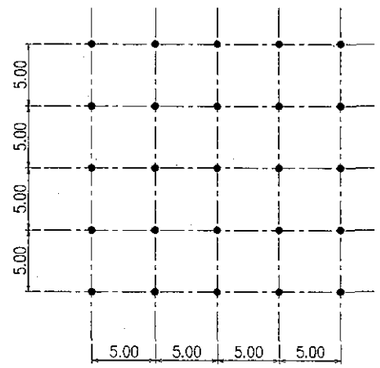


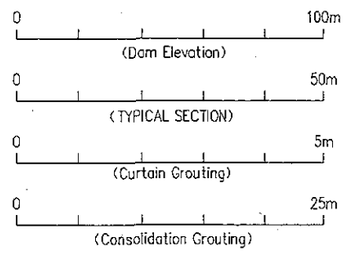

# PATTERN

## Curtain Grouting




## Consolidation Grouting




**EL CHAPARRAL HYDROPOWER PROJECT**

**DAM**

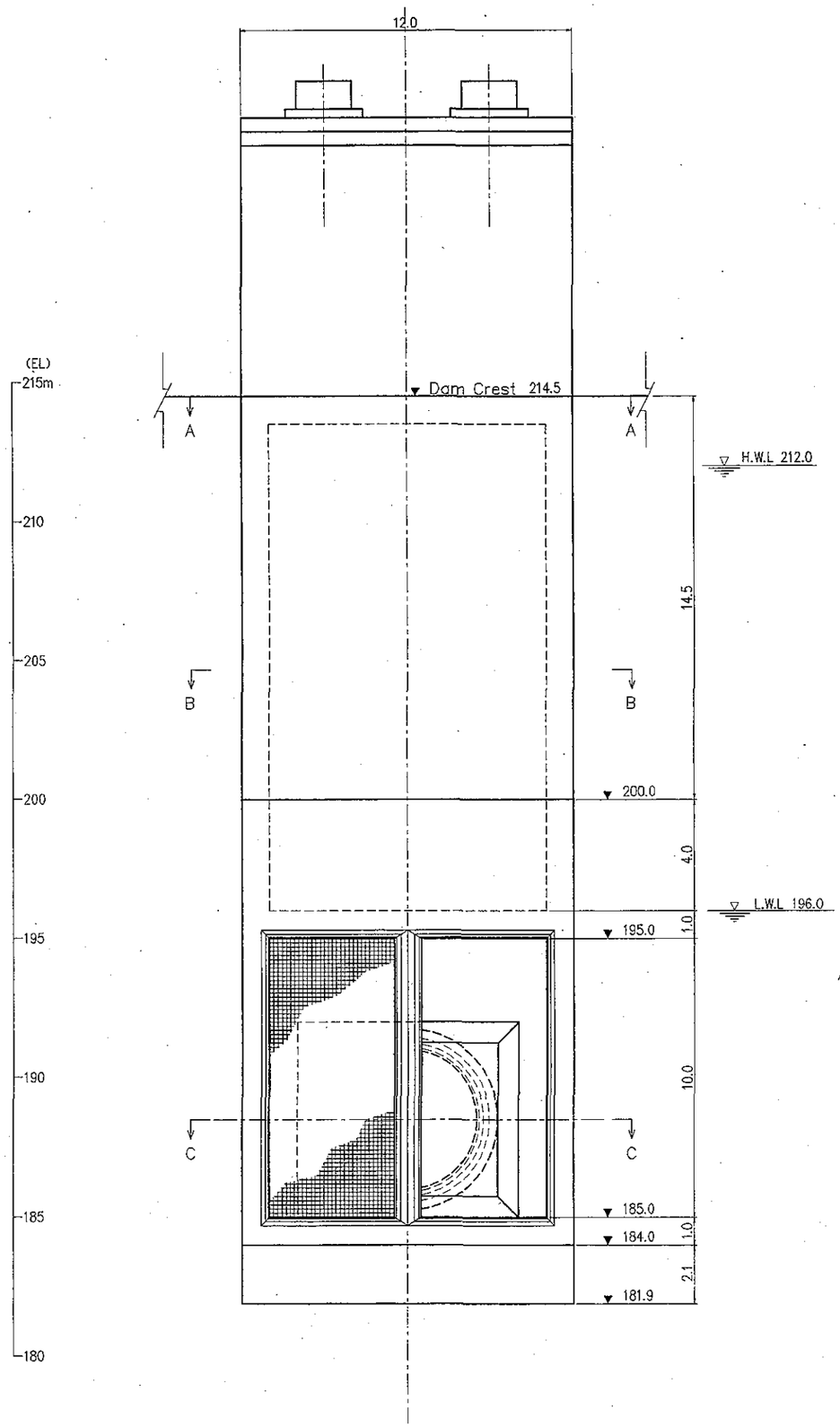
**DAM GROUTING PLAN**

**Fig. 2.4**

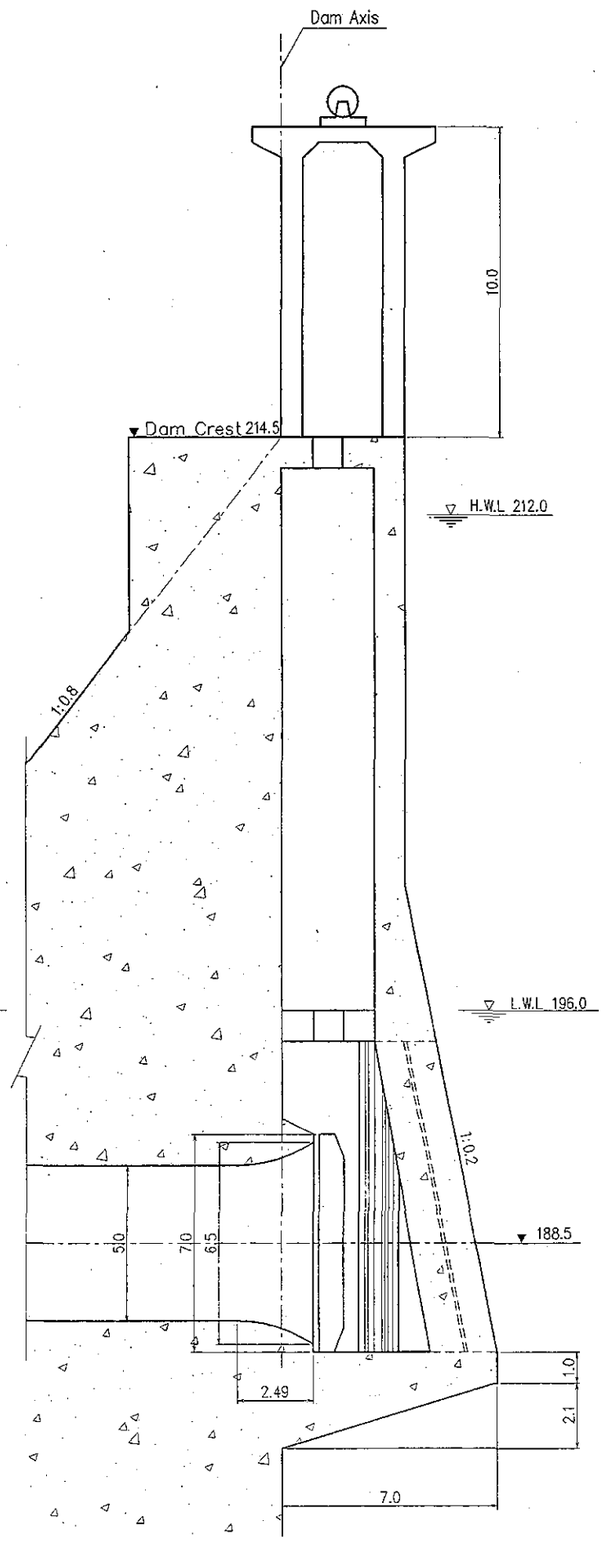
DATE

SHEET NO. OF

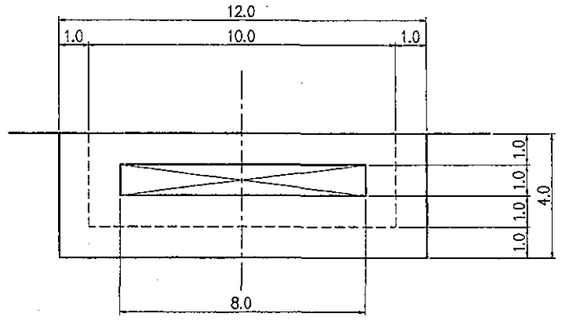
## PROFILE



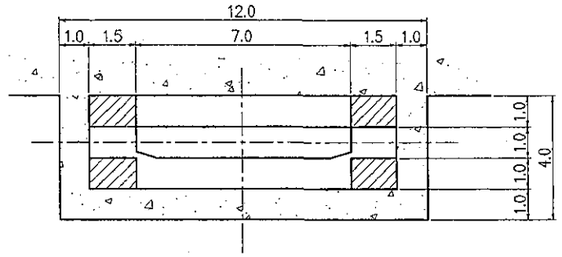

## SECTION



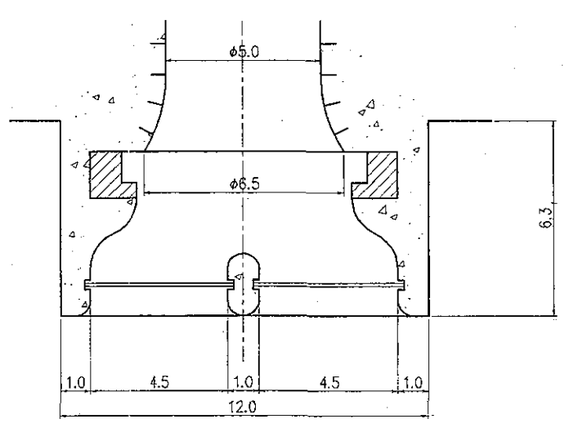

## SECTION A–A




## SECTION B–B




## SECTION C–C

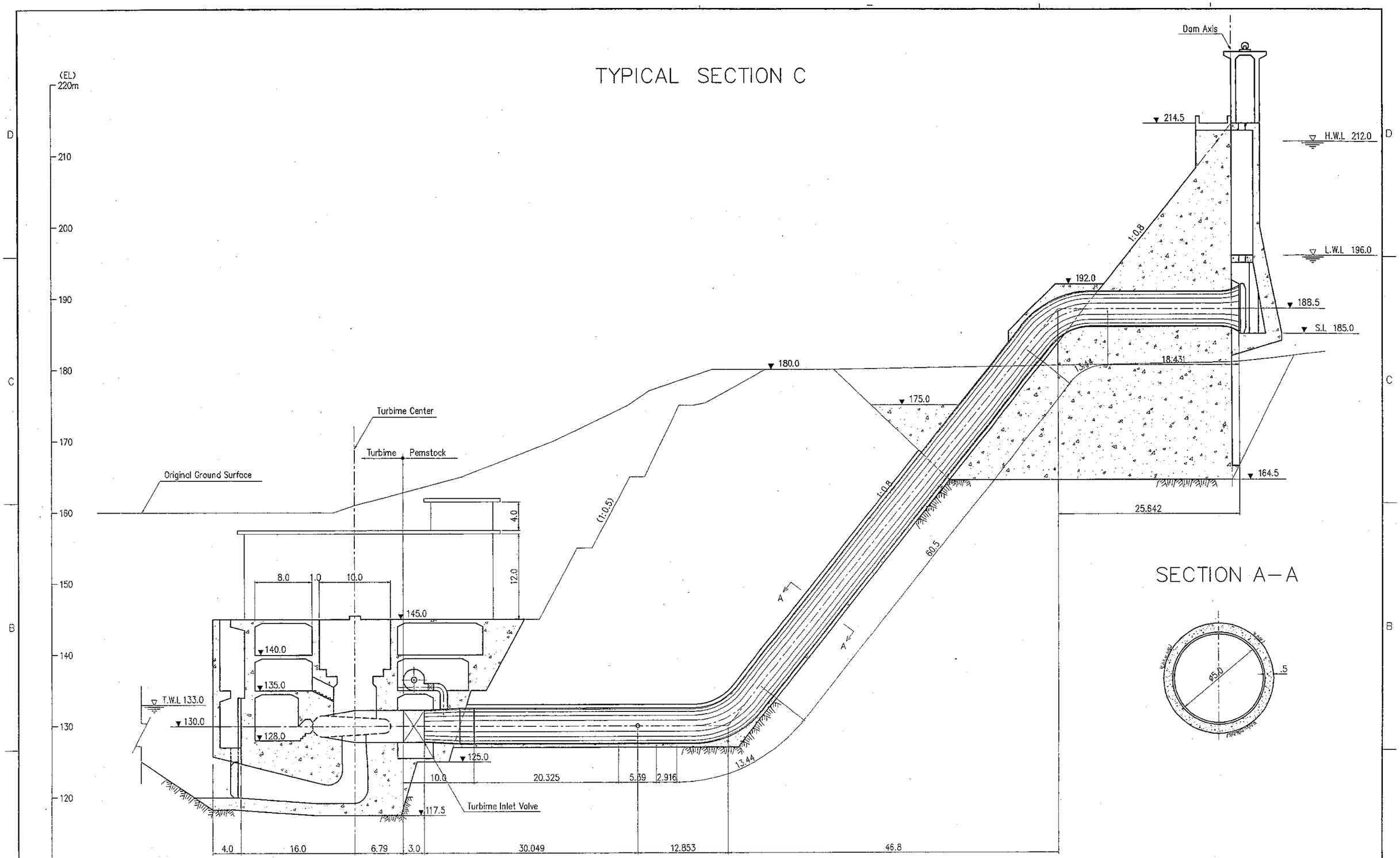



0 10m

| | | |
|---|---|---|
| EL CHAPARRAL HYDROPOWER PROJECT | | |
| INTAKE<br>PROFILE AND SECTION | | |
| **Fig. 2.5** | | DATE |

SHEET NO. OF

# TYPICAL SECTION C




## SECTION A–A

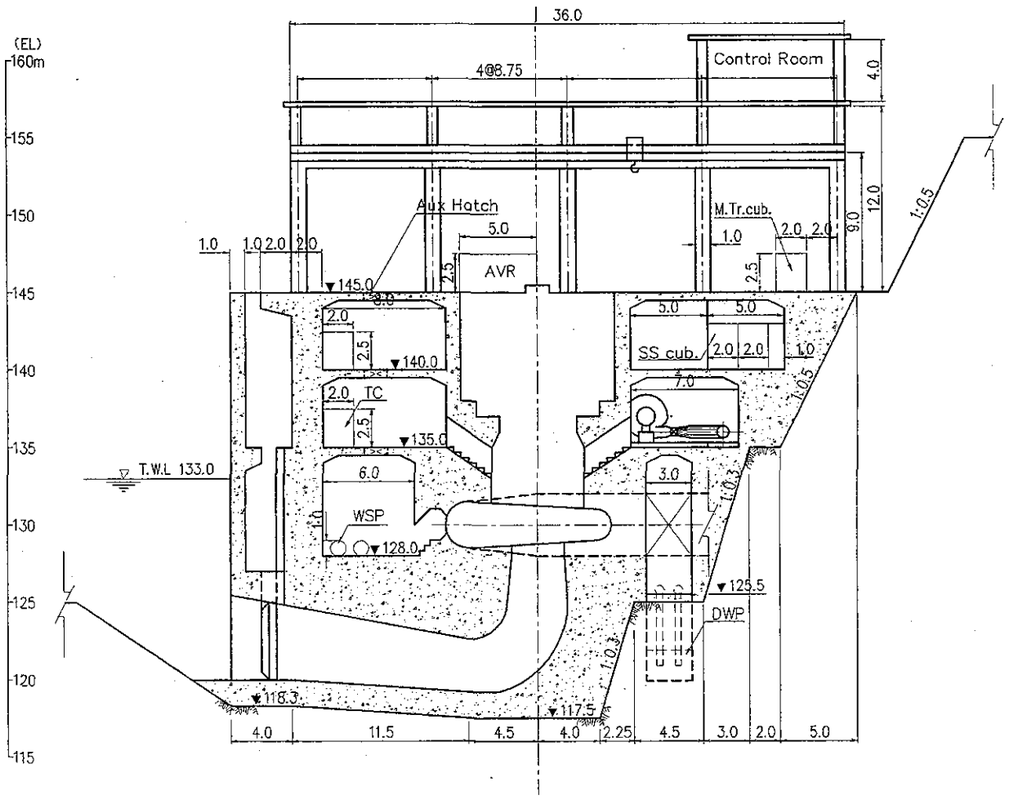



0 25m
(TYPICAL SECTION C)

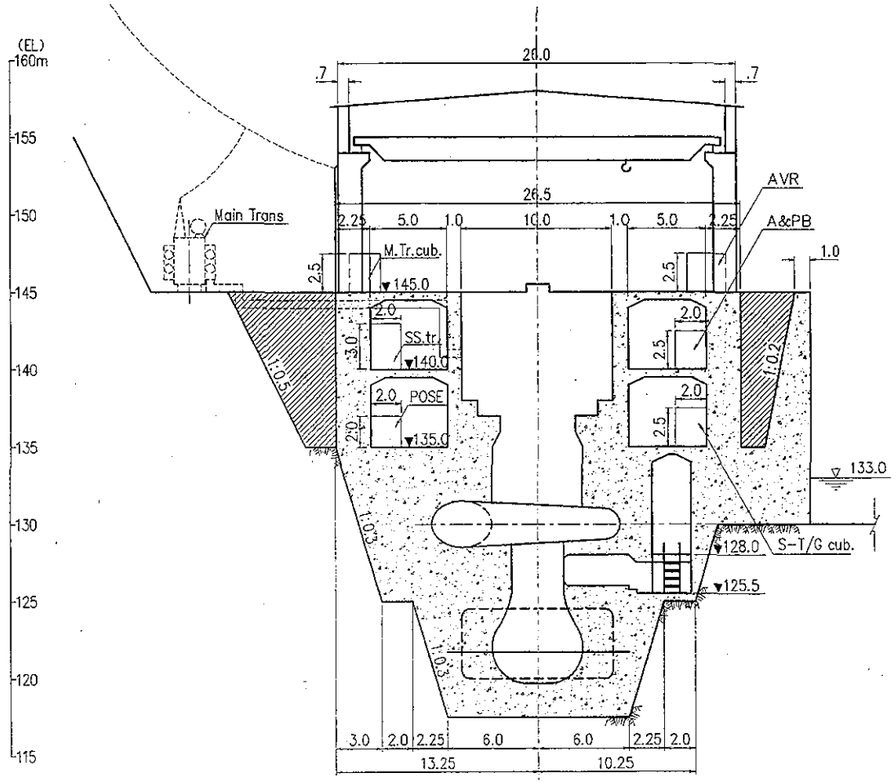
0 10m
( SECTION A–A)

| | | |
|---|---|---|
| EL CHAPARRAL HYDROPOWER PROJECT | | |
| PENSTOCK TYPICAL SECTION | | |
| Fig. 2.6 | | DATE |

## TYPICAL SECTION D




## TYPICAL SECTION E




Legend :

(Typical section D)
M.Tr.cub. : Main Transformer Control Cubicle
AVR : Exciter regulation (with AVR) Cubicle
SS cub. : Station Service Cubicle
TC : Turbine Control Board
WSP : Water Supply Pump
DWP : Drainage Water Pit

(Typical Section E)
M.Tr.cub. : Main Transformer Control Cubicle
AVR : Exciter Regulation (with AVR) Cubicle
SS.Tr. : Station Service transformer
A&PB : Automatic Control & Protection Relay Board
POSE : Pressure Oil Supply Equipment
S-T/G cub. : Sub-Turbine/Generator Control Cubicle

0 20m

**EL CHAPARRAL HYDROPOWER PROJECT**

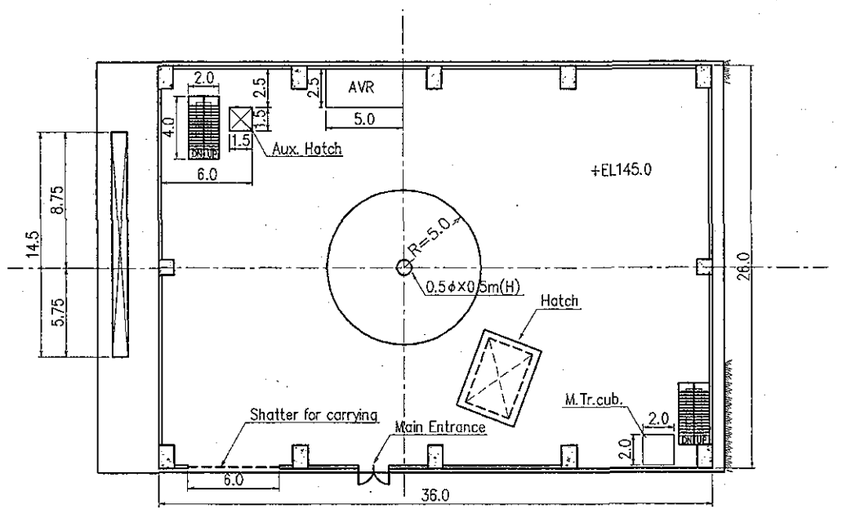
**POWER HOUSE**
**TYPICAL SECTION**

**Fig. 2.7**

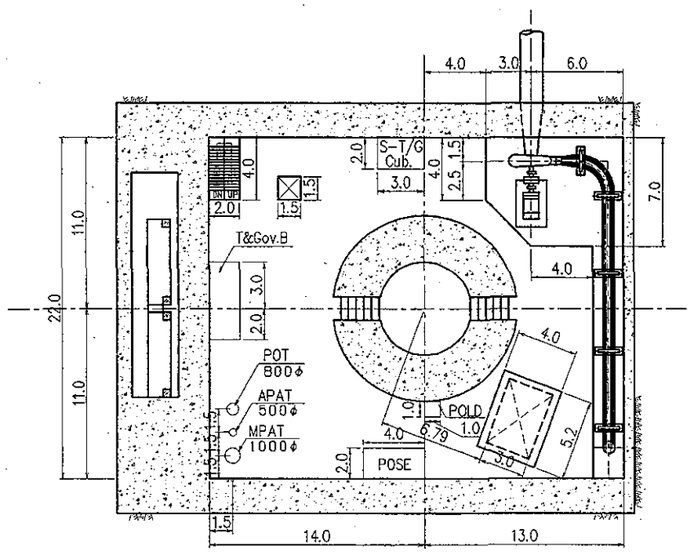
DATE

SHEET NO. OF

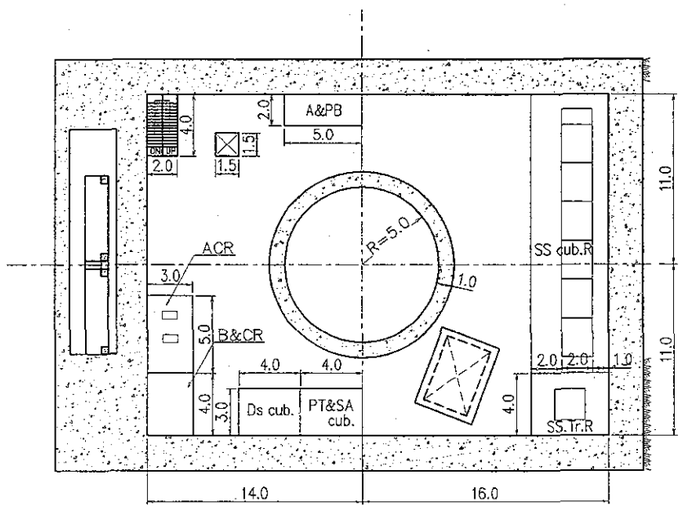
## EL145.0



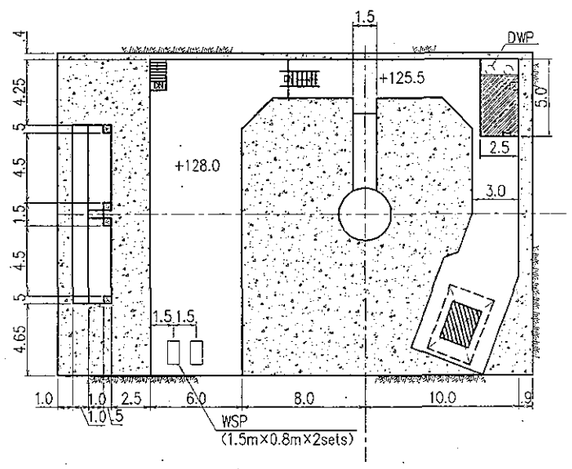

## EL135.0




## EL140.0




## EL125.5




Legend :

(EL145.0)
M.Tr.cub. : Main Transformer Control Cubicle
AVR : Exciter Regulation (with AVR) Cubicle

(EL140.0)
SS.Tr.R : Station Service Transformer Room
A&PB : Automatic Control & Protection Relay Board
SS cub.R : Station Service Cubicle Room
ACR : Air Compressor Room
B&CR : Battery & Charger Room
DS cub. : Disconecting switch Cubicle
PT&SA cub. : Potential Transformer & Serge Absorber Cubicle

(EL135.0)
S-T/G cub. : Sub-Turbine/Generator Control Cubicle
T&Gov.B : Turbine & Governor Control Board
POT : Pressure Oil Tank
APAT : Auxiliary Pressure Air Tank
MPAT : Main Pressure Air Tank
POSE : Pressure Oil Supply Equipment
POLD : Pressure Oil Lifting Device

(EL125.0)
WSP : Water Supply Pump
DWP : Drainage Water Pit

0 20m

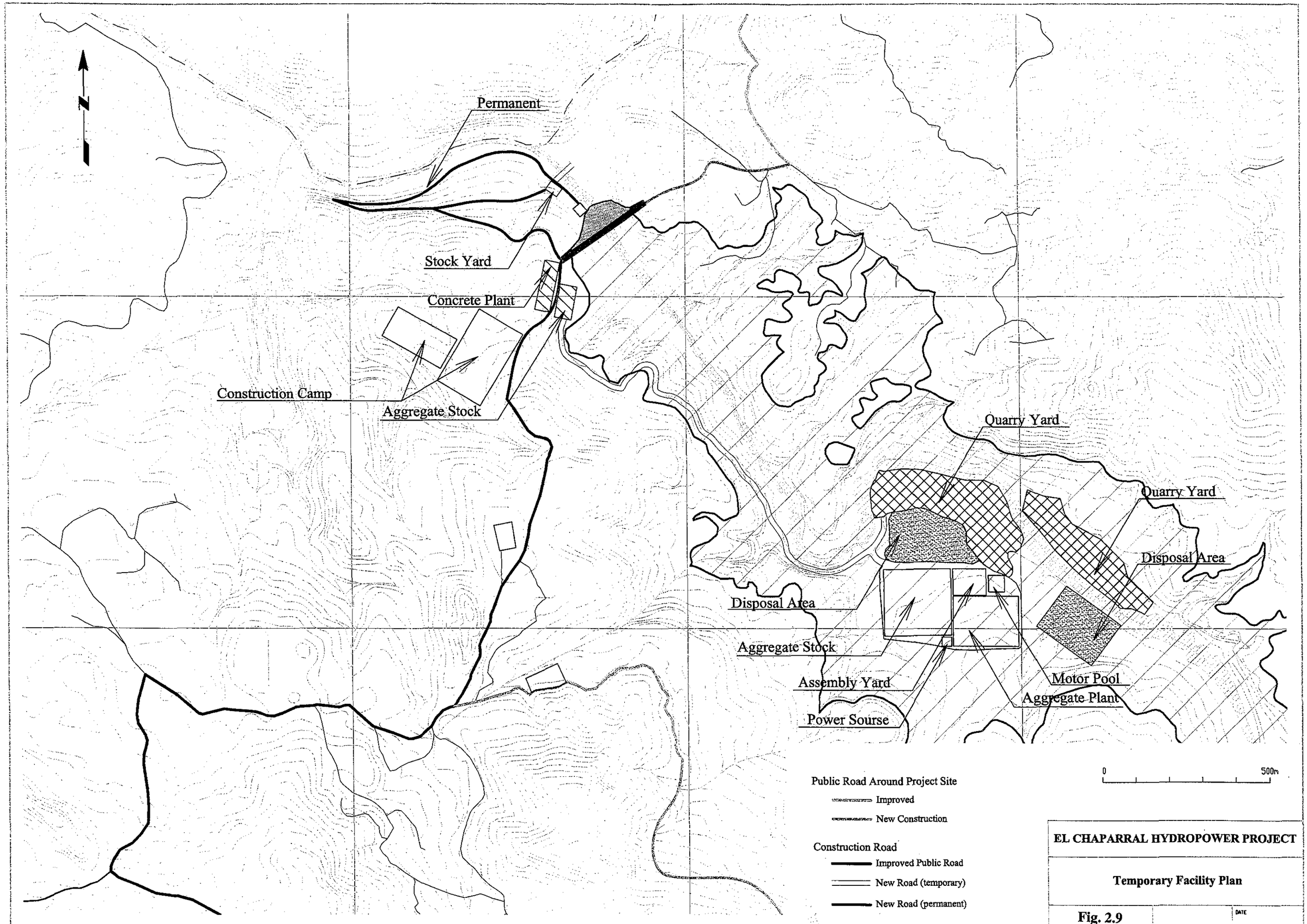
**EL CHAPARRAL HYDROPOWER PROJECT**

**POWER HOUSE PLAN**

**Fig. 2.8**

DATE

SHEET NO. OF




**EL CHAPARRAL HYDROPOWER PROJECT**

**Temporary Facility Plan**

**Fig. 2.9**

DATE

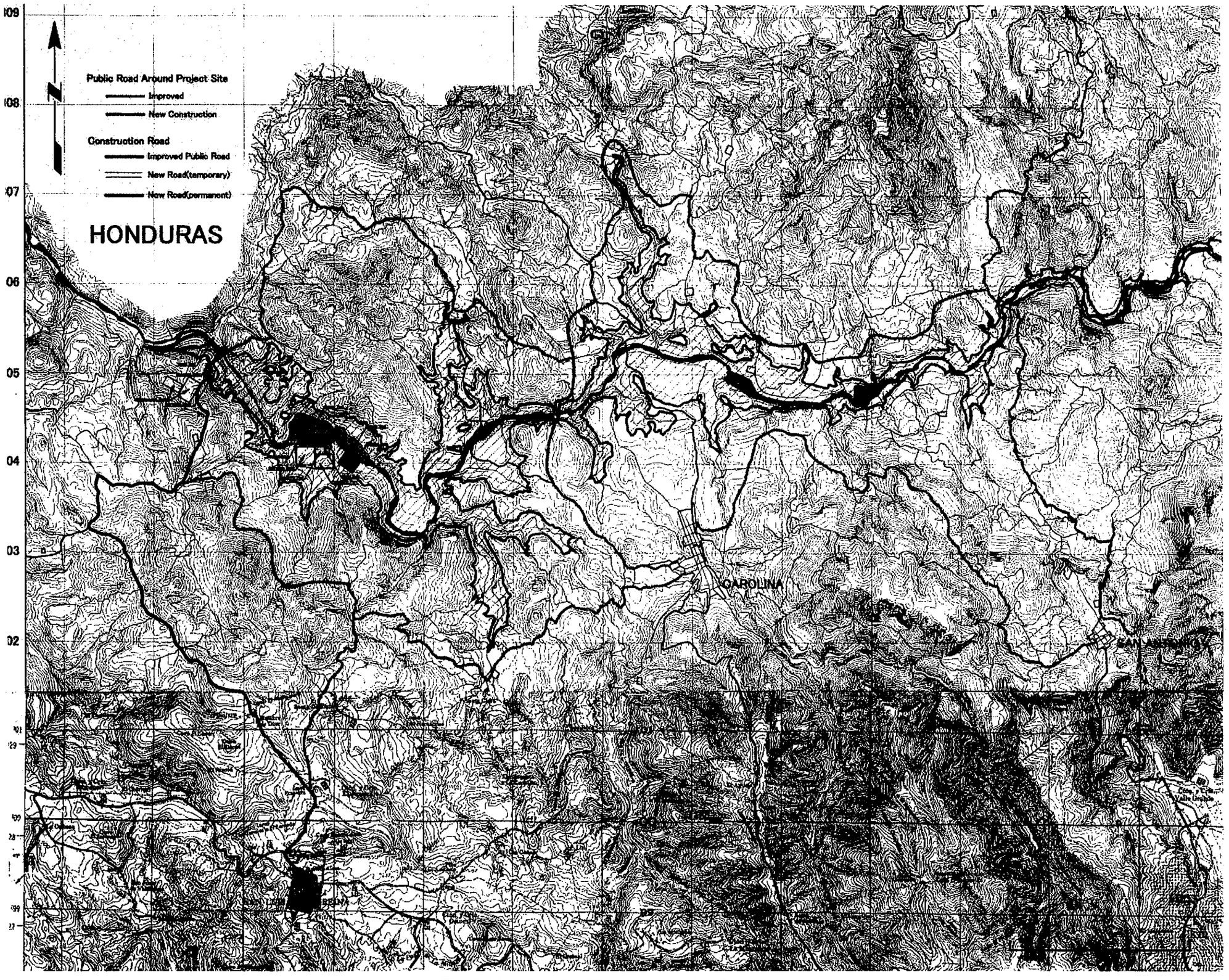



**Fig.2.10 Road Plan around Reservoir**

# CHAPTER 3
# ECONOMIC AND FINANCIAL EVALUATION

# CHAPTER 3 ECONOMIC AND FINANCIAL EVALUATION

## 3.1 Economic Evaluation

### 3.1.1 Methodology

Economic evaluation aims at measuring the "economic" impact brought about to a country by implementing a project from a viewpoint of national economy. Here, a comparison of costs and benefits expressed in terms of economic prices will be made by applying the Discount Cash Flow Method, which is widely adopted for such purposes.

### 3.1.2 Economic Cost of the Project

Construction cost and Operation & Maintenance cost will be included in the cost stream.

### 3.1.3 Economic Benefit of the Project

For the purpose of this study, the following two categories of benefits were adopted: one is the saved cost of alternative thermal power project, and the other is income from electricity sale derived from average unit cost of energy for the last five years of US$67.65/MWh and the annual available energy of 233.21GWh. In addition, benefits derived from $CO_2$ emission trading (Certificate of Emission Rights) were estimated.

### 3.1.4 Economic Evaluation

Evaluation indices like the Net Present Value (B-C) and Benefit Cost Ratio (B/C) at various discount rates, as well as EIRR are summarized below:

| | Benefit | | Criteria | Discount rate |
|---|---|---|---|---|
| | Alternative thermal | Power sales | | |
| NPV | 72,822 | 74,637 | > 0 | 6 % |
| | 34,388 | 29,323 | > 0 | 8 % |
| | 10,680 | 1,623 | > 0 | 10 % |
| B/C | 1.57 | 1.59 | > 1 | 6 % |
| | 1.29 | 1.25 | > 1 | 8 % |
| | 1.10 | 1.01 | > 1 | 10 % |
| EIRR | 11.3% | 10.2% | > costo de oportunidad de capital | |

It was found out that the evaluation indices using the power sale revenue as benefit became lower as compared to those with the alternative thermal. Notwithstanding, any evaluation index, including those lower values, exceeds the evaluation criteria, and the Project can be judged as sound from economic point of view.

The result of calculation considering the emission trading of CDM is as follows:

| | Benefit | | Criteria | Unit price |
|---|---|---|---|---|
| | Alternative thermal | Power sales | | |
| NPV (i = 10%) | 12,713 | 3,656 | > 0 | US$3 |
| | 14,069 | 5,011 | > 0 | US$5 |
| | 17,457 | 8,399 | > 0 | US$10 |
| B/C (i = 10%) | 1.12 | 1.03 | > 1 | US$3 |
| | 1.13 | 1.05 | > 1 | US$5 |
| | 1.16 | 1.08 | > 1 | US$10 |
| EIRR | 11.6% | 10.3% | > OCC | US$3 |
| | 11.7% | 10.5% | > OCC | US$5 |
| | 12.1% | 10.8% | > OCC | US$10 |

## 3.2 Financial Evaluation

### 3.2.1 Methodology

Financial analysis aims at measuring the expected return on investment from a viewpoint of implementing body. Here Discounted Cash Flow method was adopted. Evaluation index to be

obtained will be Financial Internal Rate of Return (FIRR) on investment. FIRR on investment will not be affected by financing conditions, therefore, it is appropriate to evaluate the profitability of the project itself.

### 3.2.2 Financial Cost and Benefit of the Project

(1) Financial Cost

Financial cost of the Project include the initial investment cost, cost for replacement of equipment, and Operation and Maintenance cost expressed at the market price.

(2) Financial Benefit

Financial benefit of the Project is the revenue to be earned by the electricity sale. Commercialization Unit and Study Department of CEL elaborated a report "Proyecciones de Generación e Ingresos Corrientes de la Central Hidroeléctrica El Chaparral, Período 2009-2024", using the optimization model of SDDP. According to this report, annual salable energy is calculated as 180.2GWh, and the average sale price is US$58.08/MWh. Here the annual revenue was calculated as US$10,466 thousand based on these values.

### 3.2.3 Financial Evaluation

Financial Internal Rate of Return (FIRR) on investment was calculated based on the financial revenue. The result is shown below. It was found that the softer loan condition is required to implement the project.

| Item | Result | Criteria |
|---|---|---|
| FIRR | 6.4% | > interest rate |

As a result, it was found out that the soft loan with better conditions is required for implementing the project.