

A-4 PRELIMINARY DESIGN

A-4 Preliminary Design

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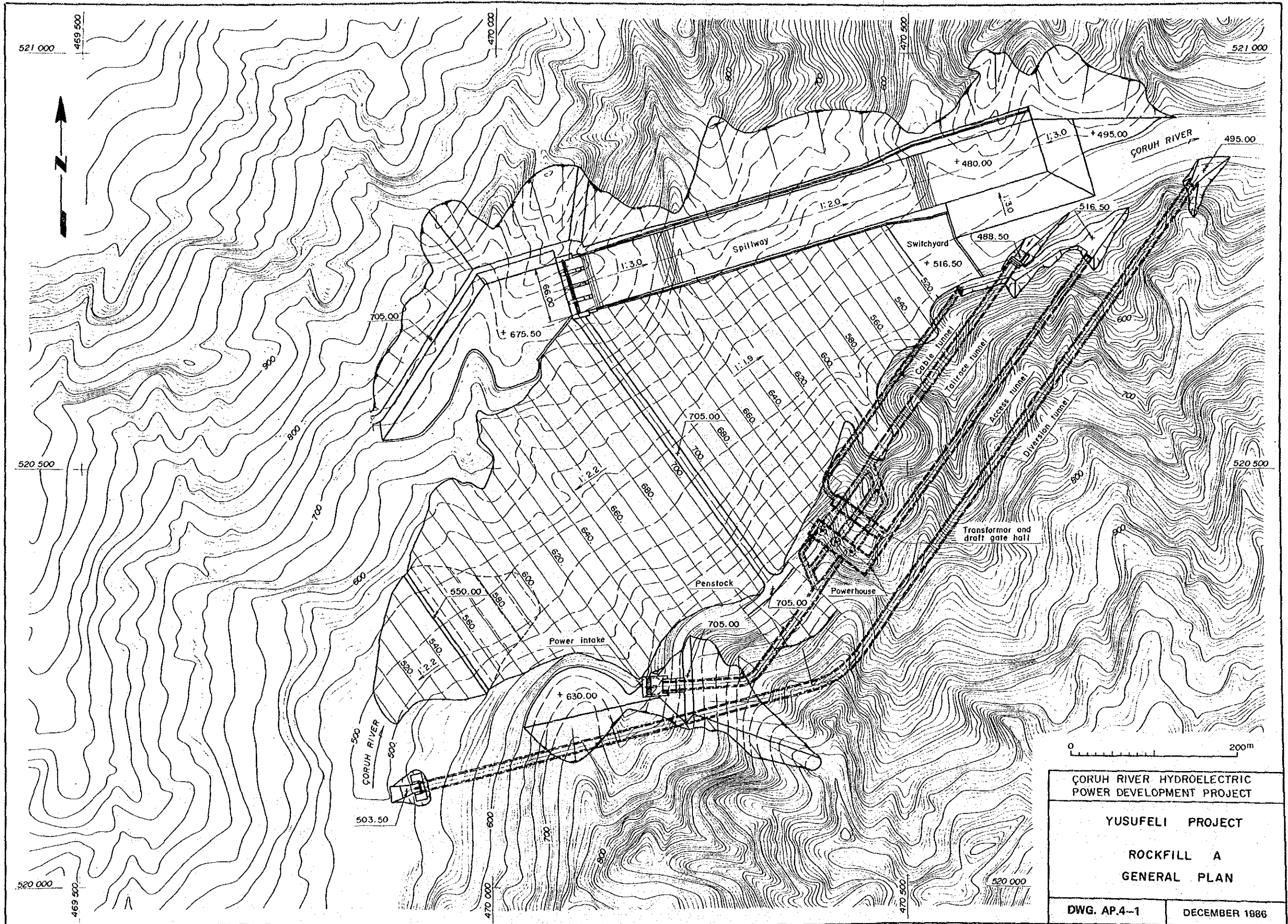
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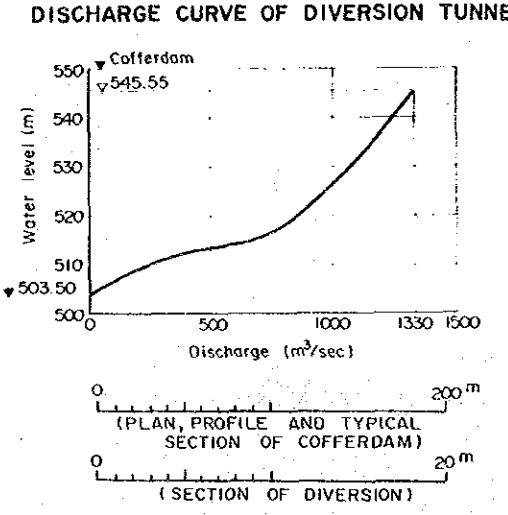
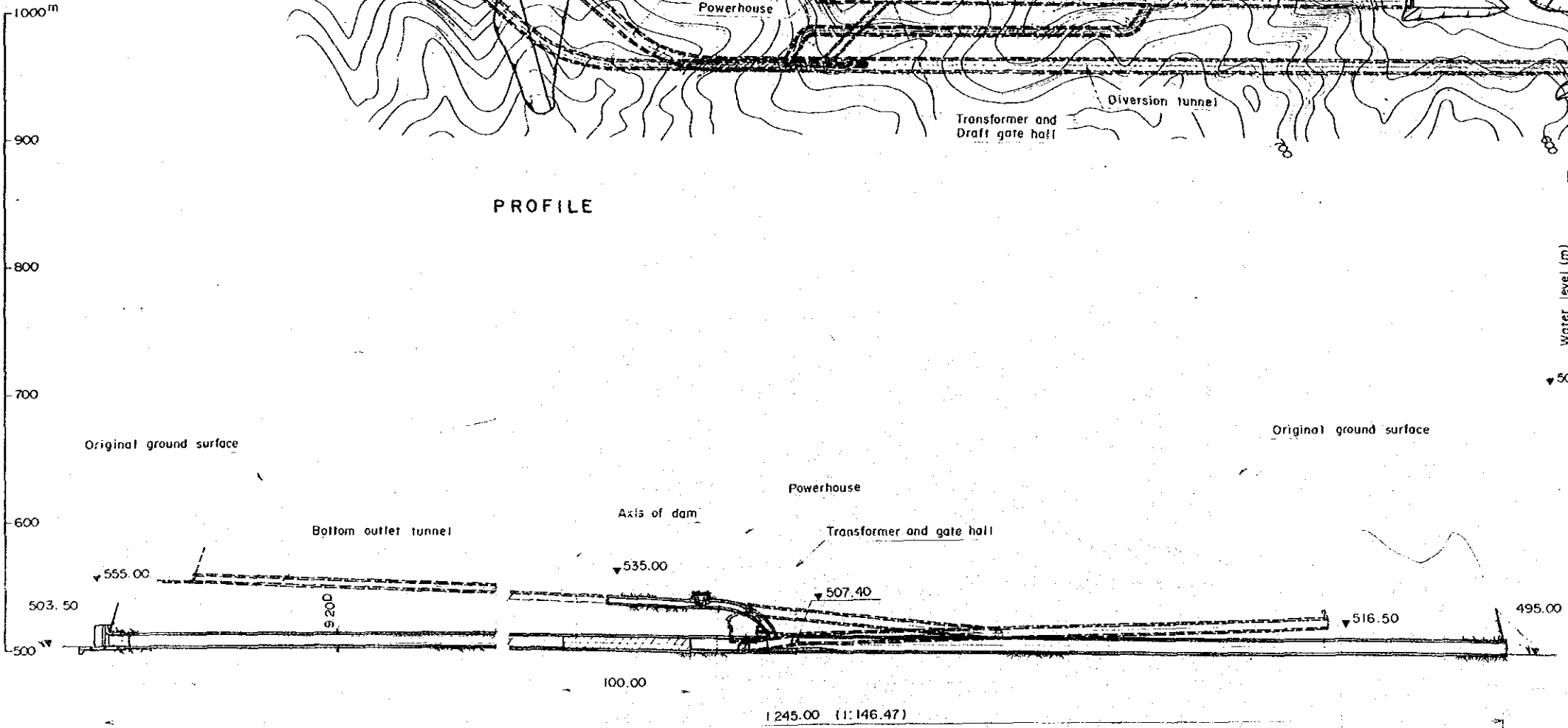
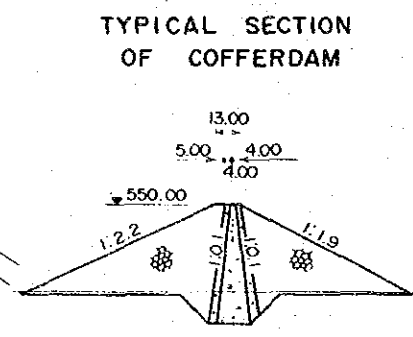
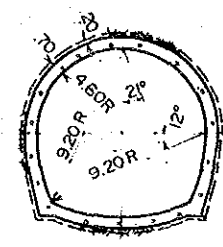
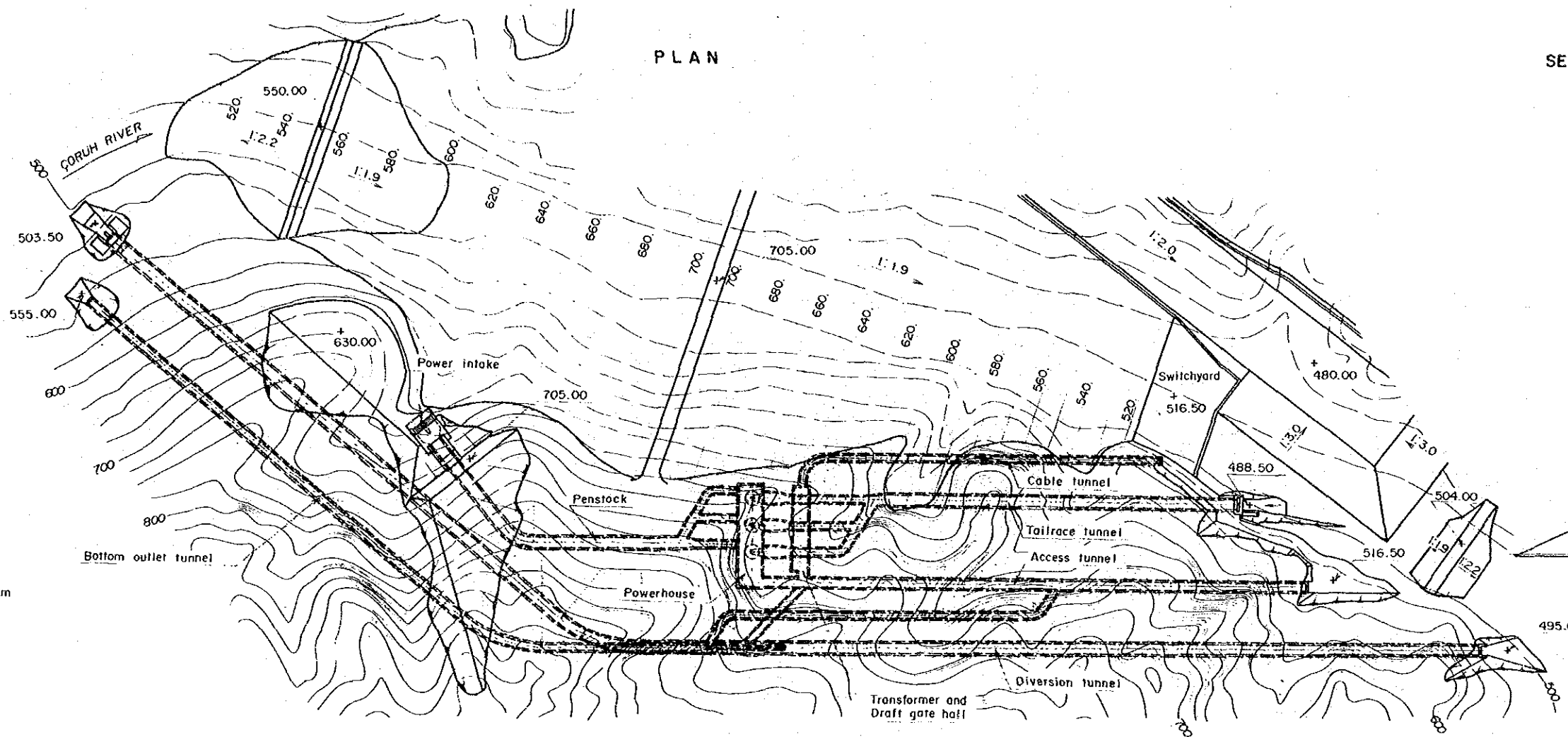
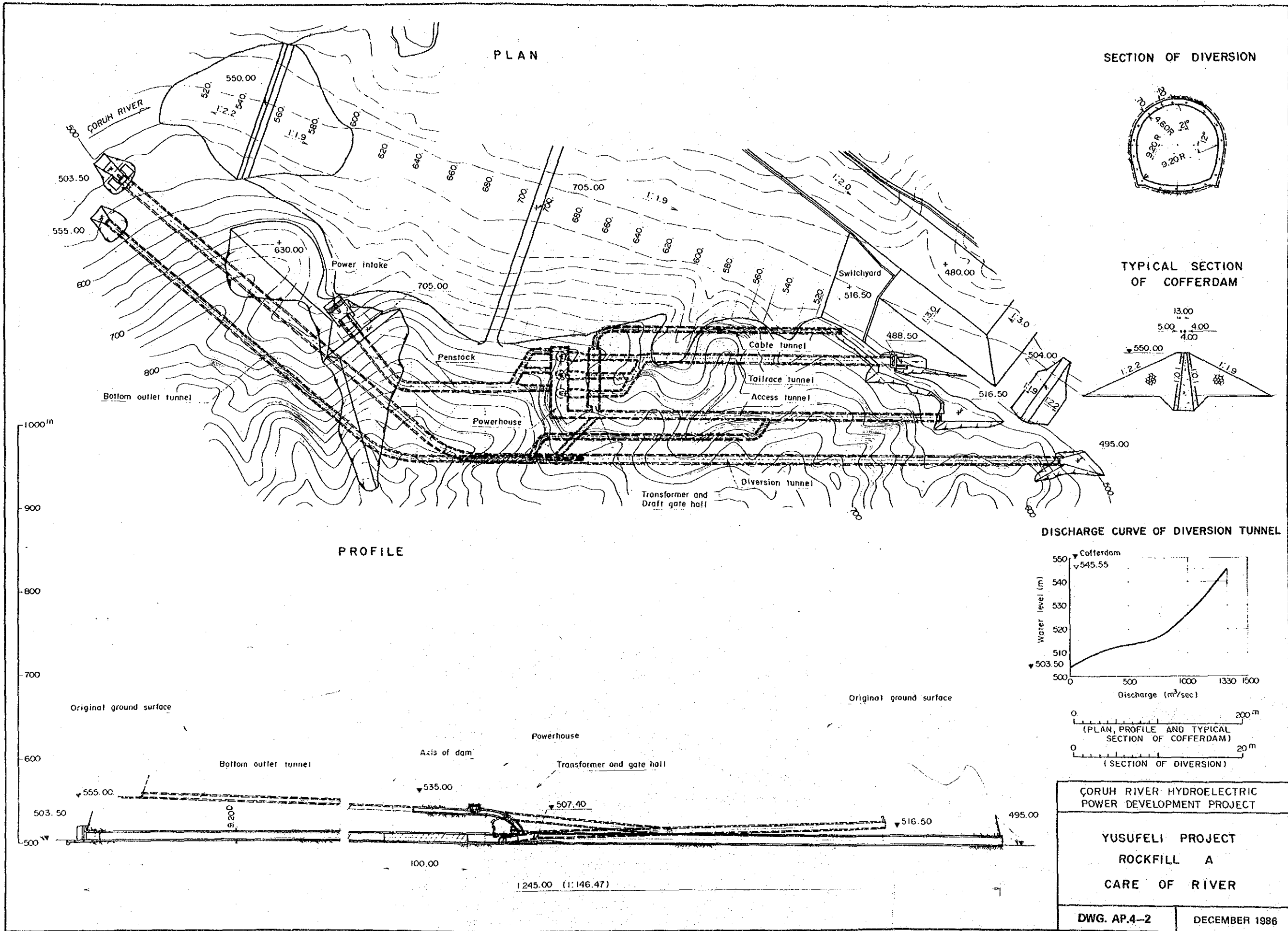
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4. 1 Drawings of Comparative Study



ÇORUH RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT	
YUSUFELI PROJECT	
ROCKFILL A GENERAL PLAN	
DWG. AP.4-1	DECEMBER 1986



ÇORUH RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

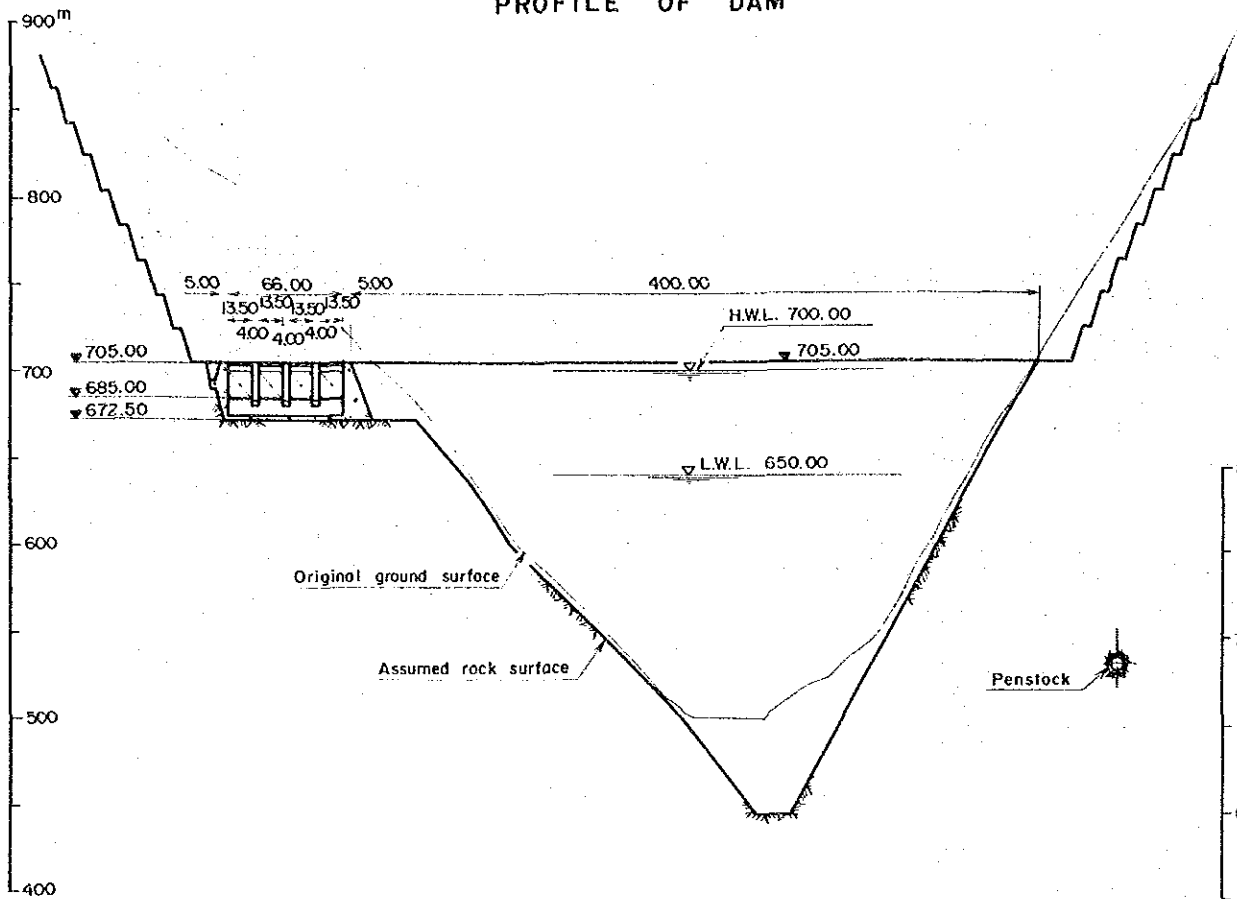
YUSUFELI PROJECT

ROCKFILL A

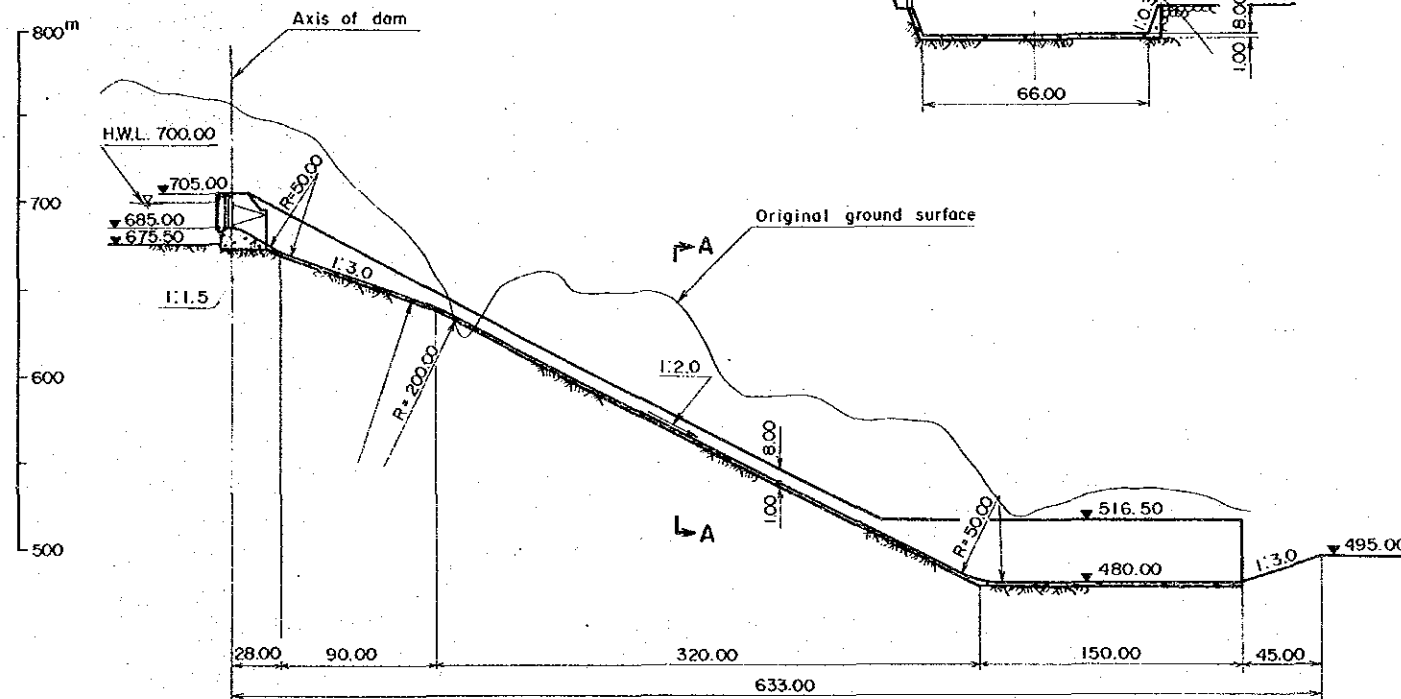
CARE OF RIVER

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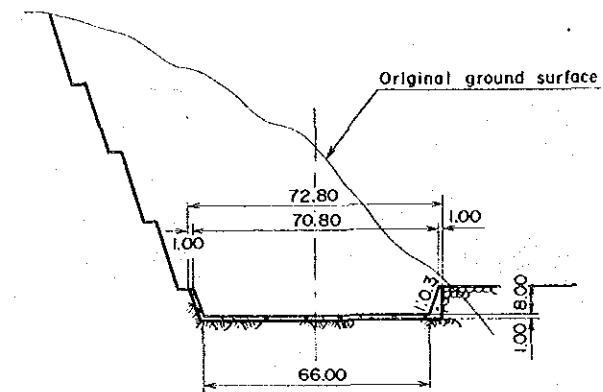
PROFILE OF DAM



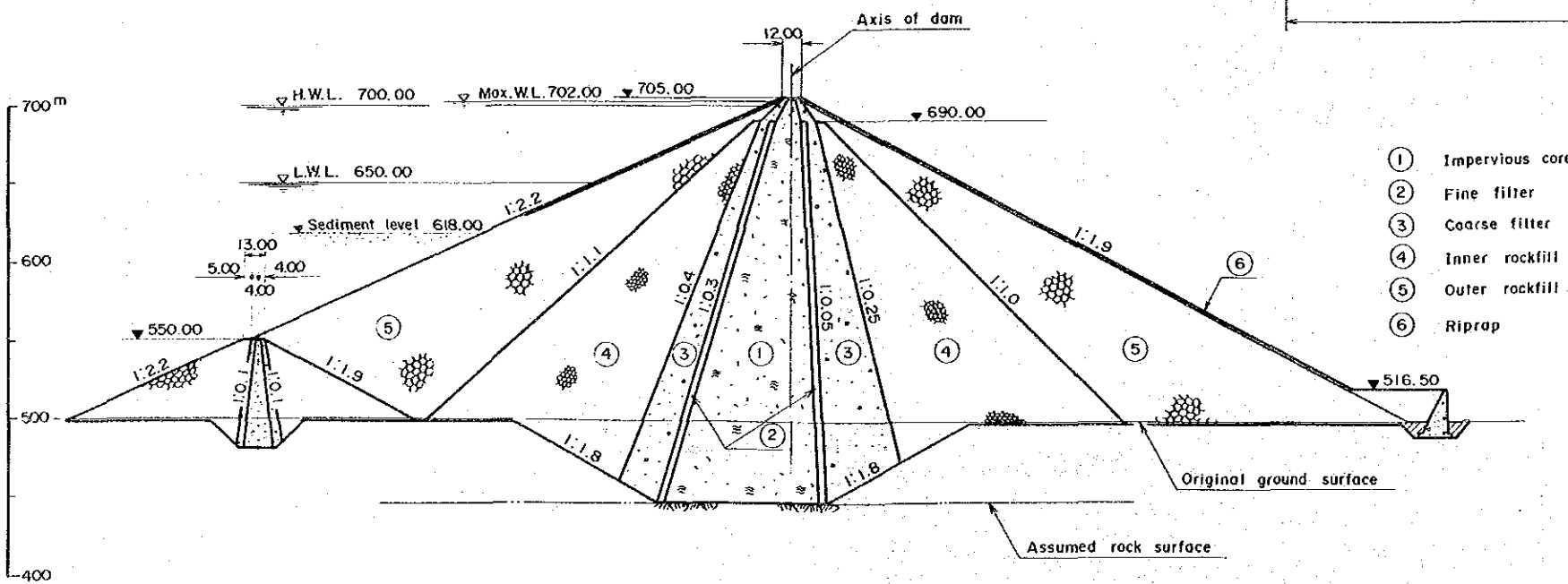
PROFILE OF SPILLWAY



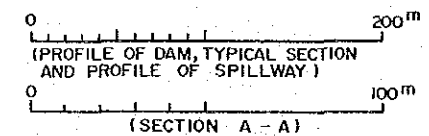
SECTION A - A



TYPICAL SECTION OF DAM

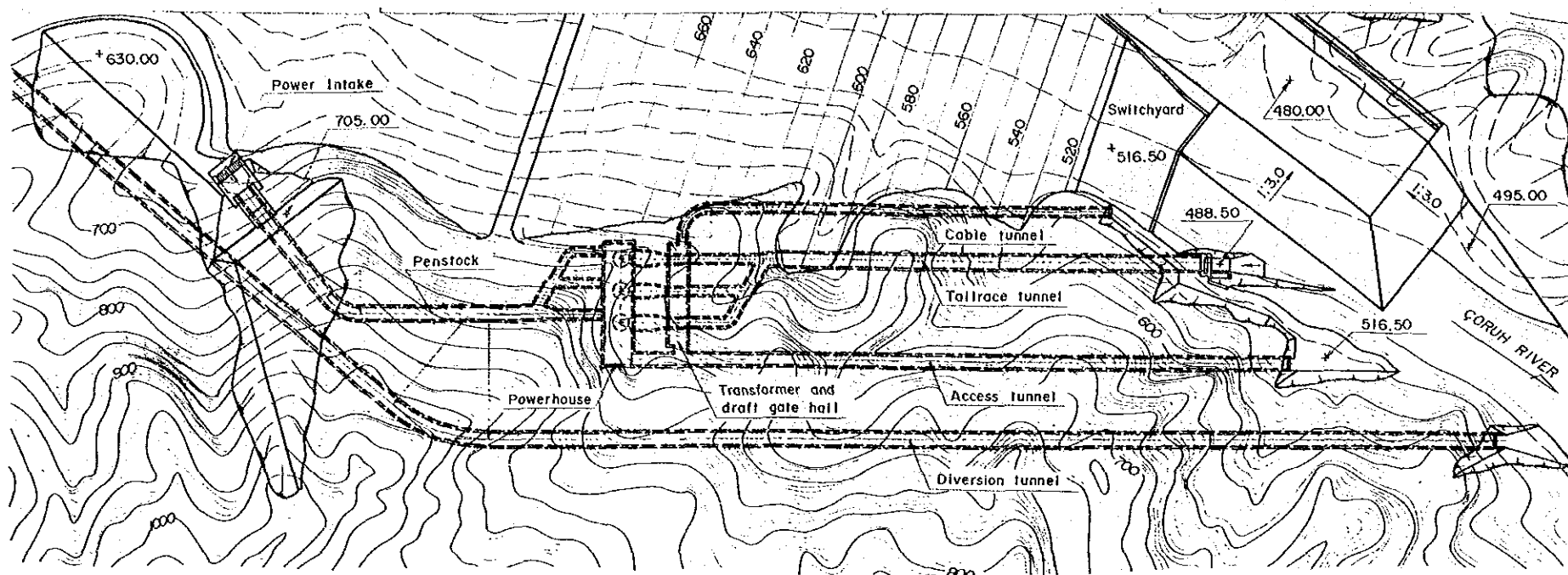


- ① Impervious core
- ② Fine filter
- ③ Coarse filter
- ④ Inner rockfill
- ⑤ Outer rockfill
- ⑥ Riprap

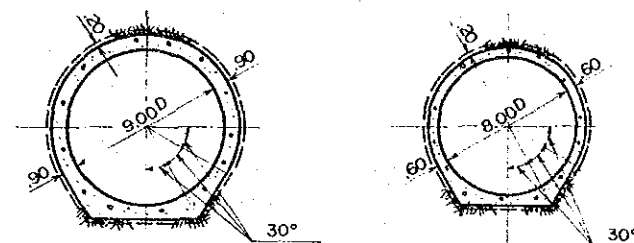


ÇORUH RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT	
YUSUFELI PROJECT	
ROCKFILL A	
DAM AND SPILLWAY	
DWG. AP.4-3	DECEMBER 1986

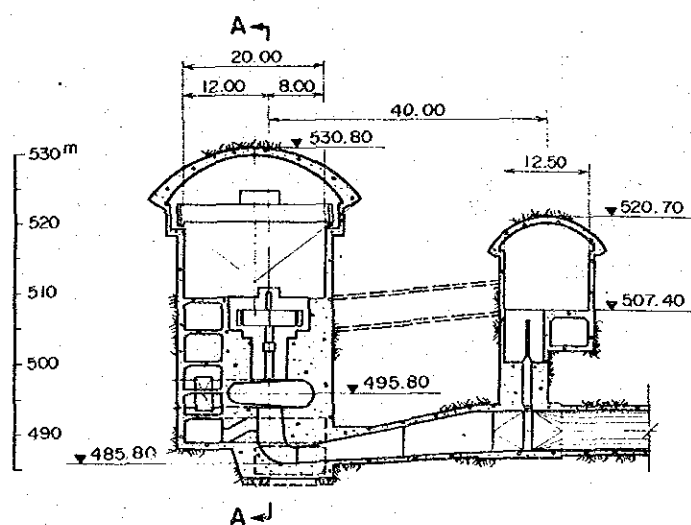
PLAN



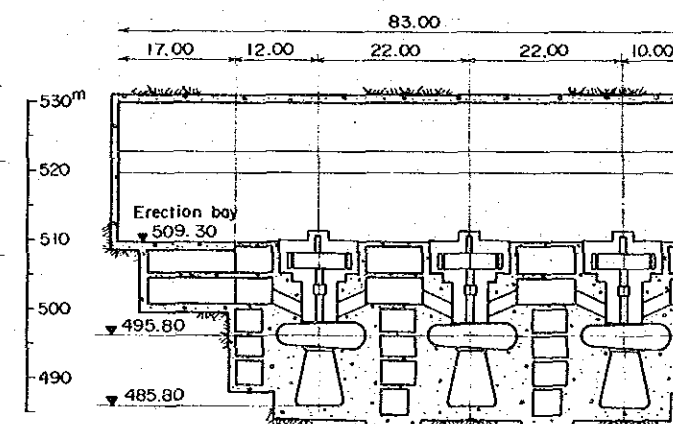
SECTION OF PENSTOCK



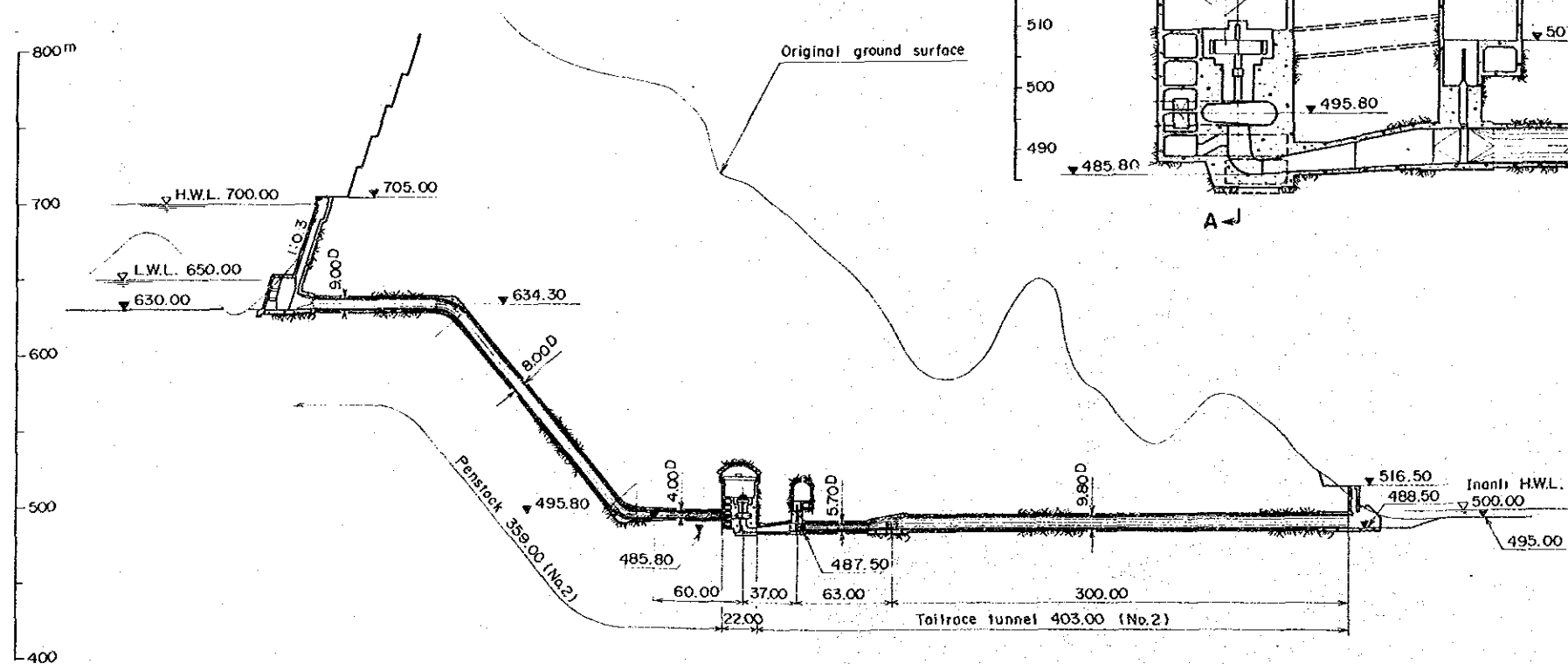
SECTION OF POWERHOUSE



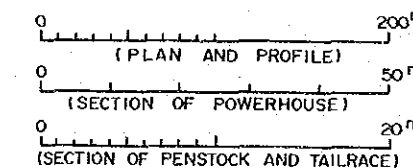
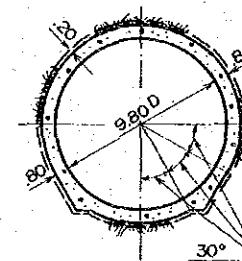
SECTION A - A



PROFILE



SECTION OF TAILRACE

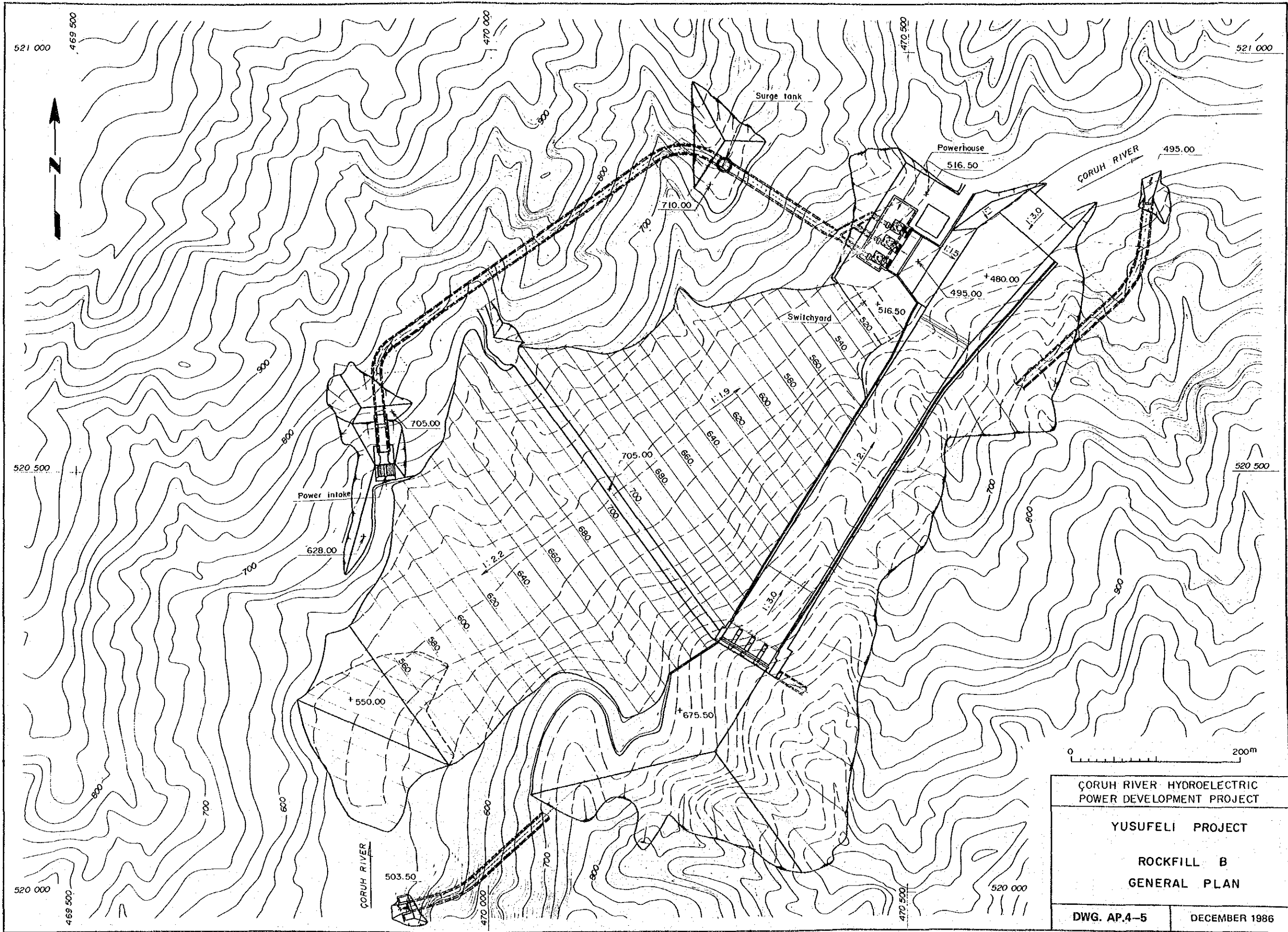


ÇORUH RIVER HYDROELECTRIC
POWER DEVELOPMENT PROJECT

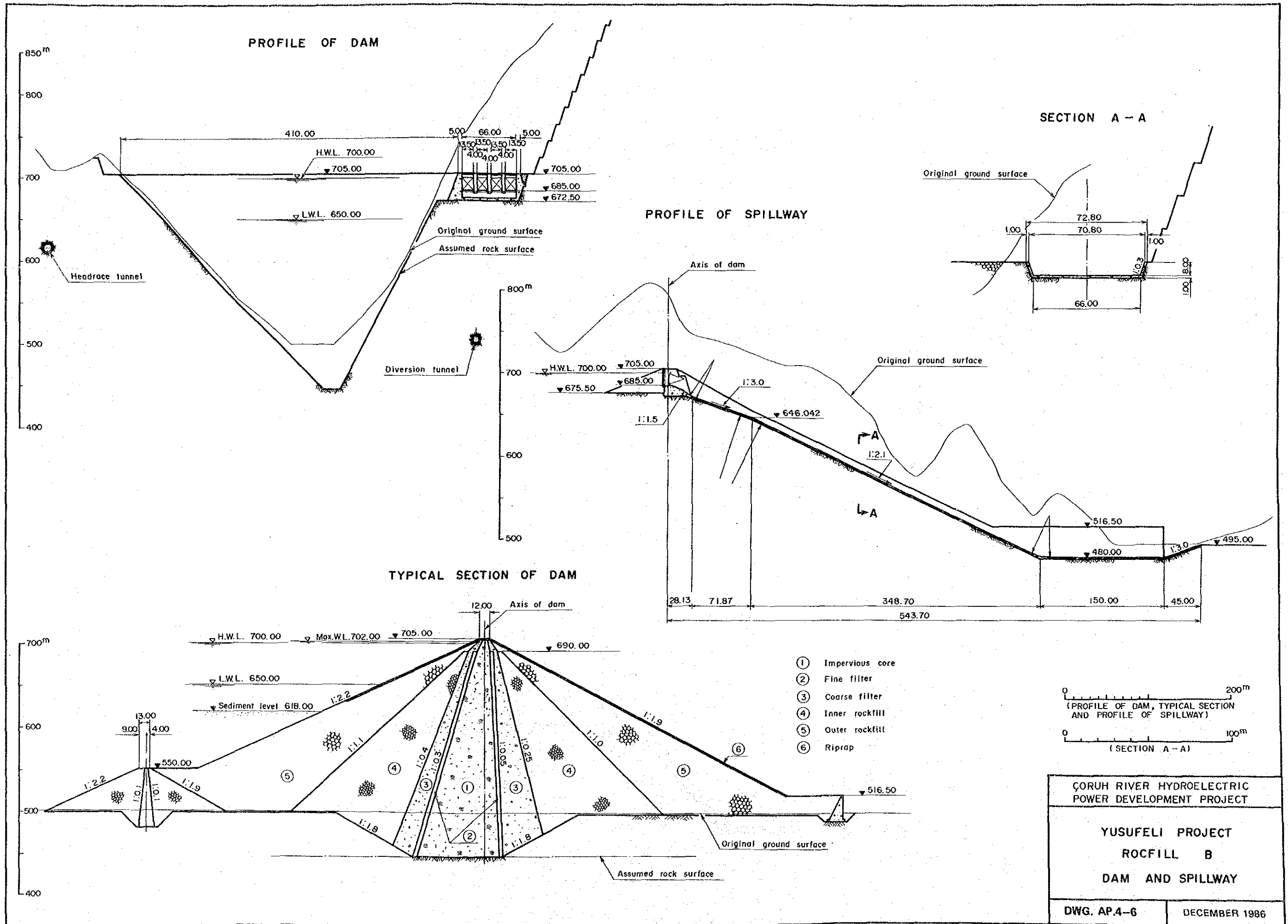
YUSUFELI PROJECT
ROCKFILL A
WATERWAY

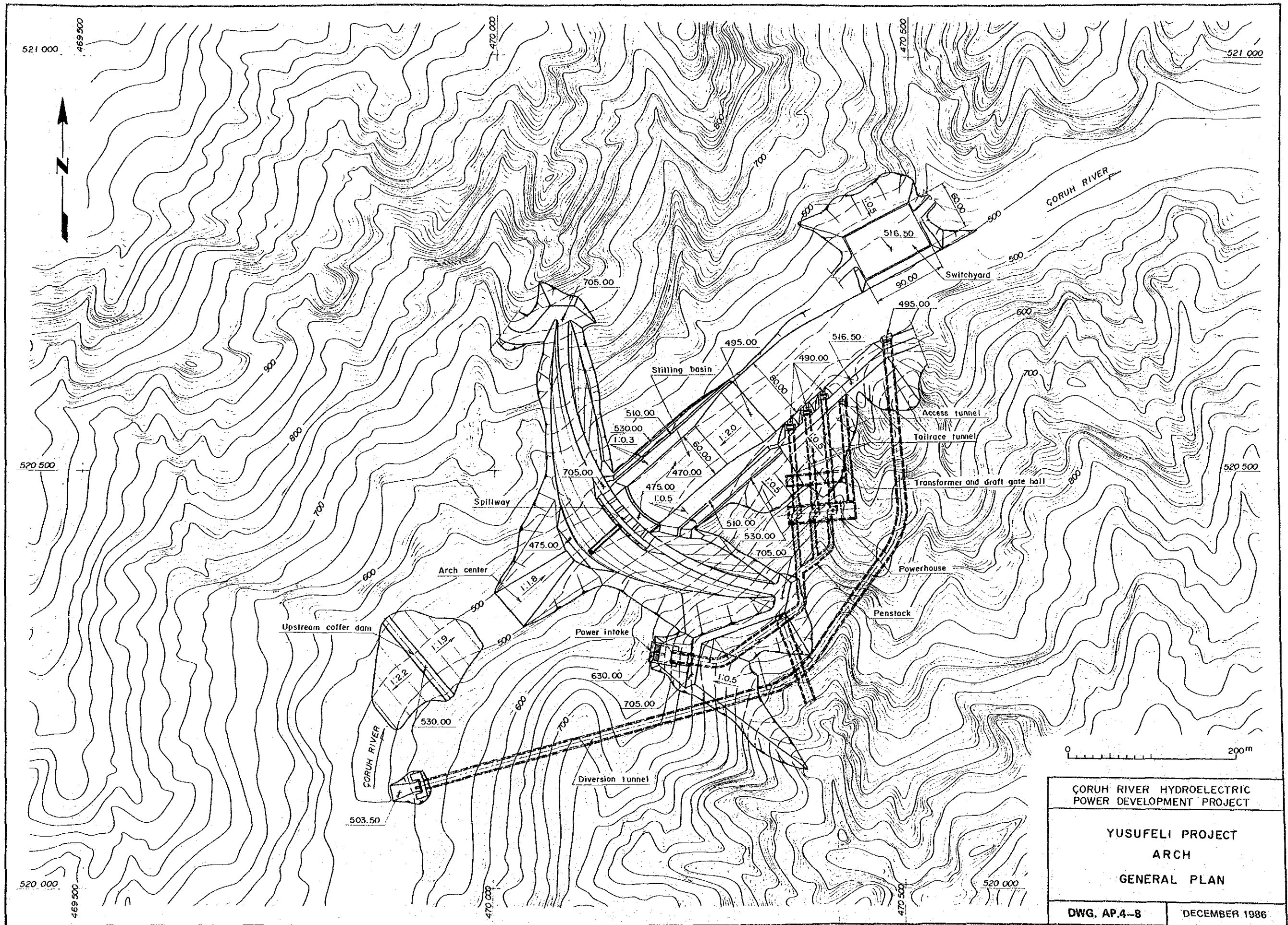
DWG. AP.4-4

DECEMBER 1986



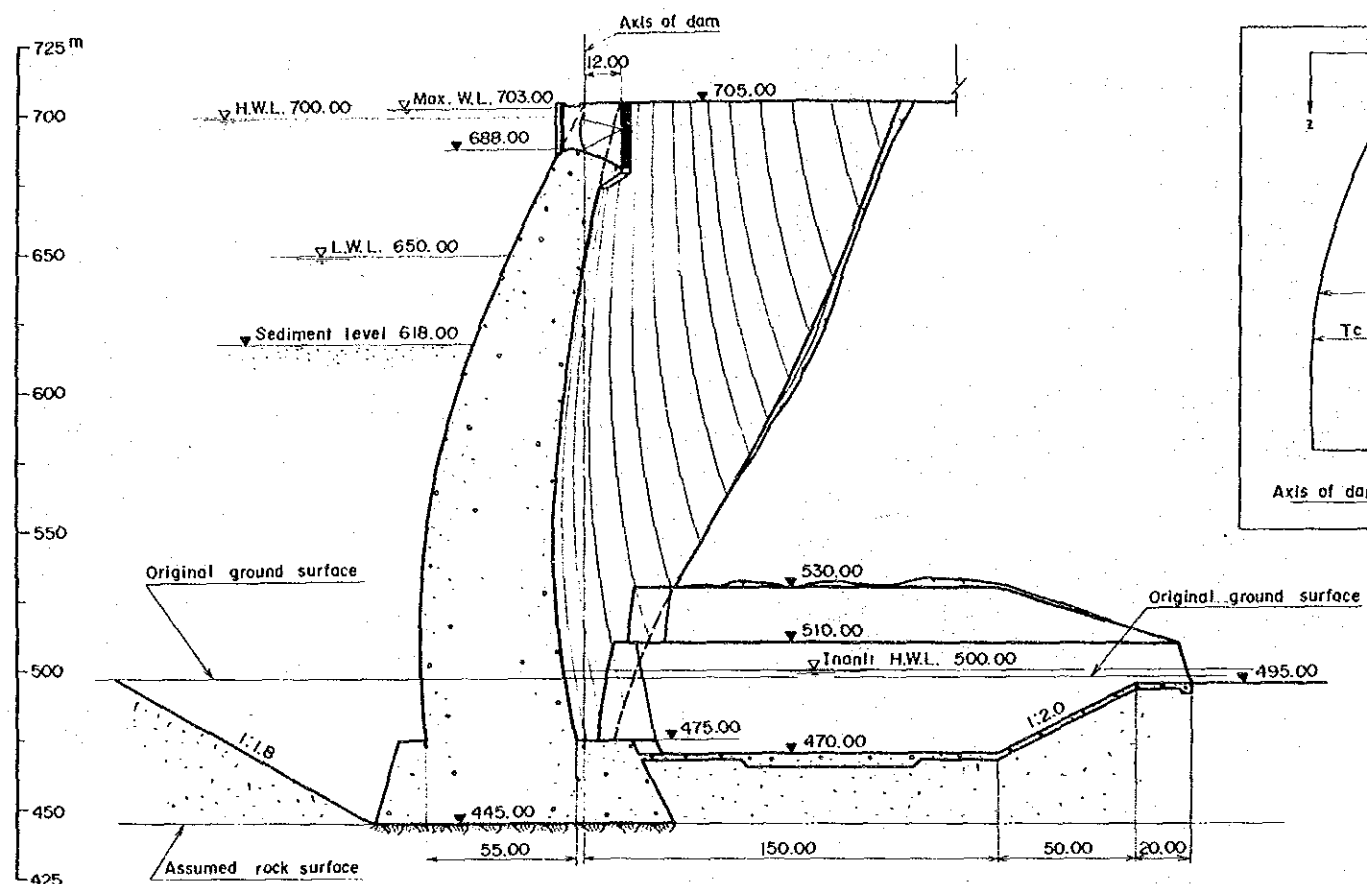
ÇORUH RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT	
YUSUFELI PROJECT	
ROCKFILL B GENERAL PLAN	
DWG. AP.4-5	DECEMBER 1986



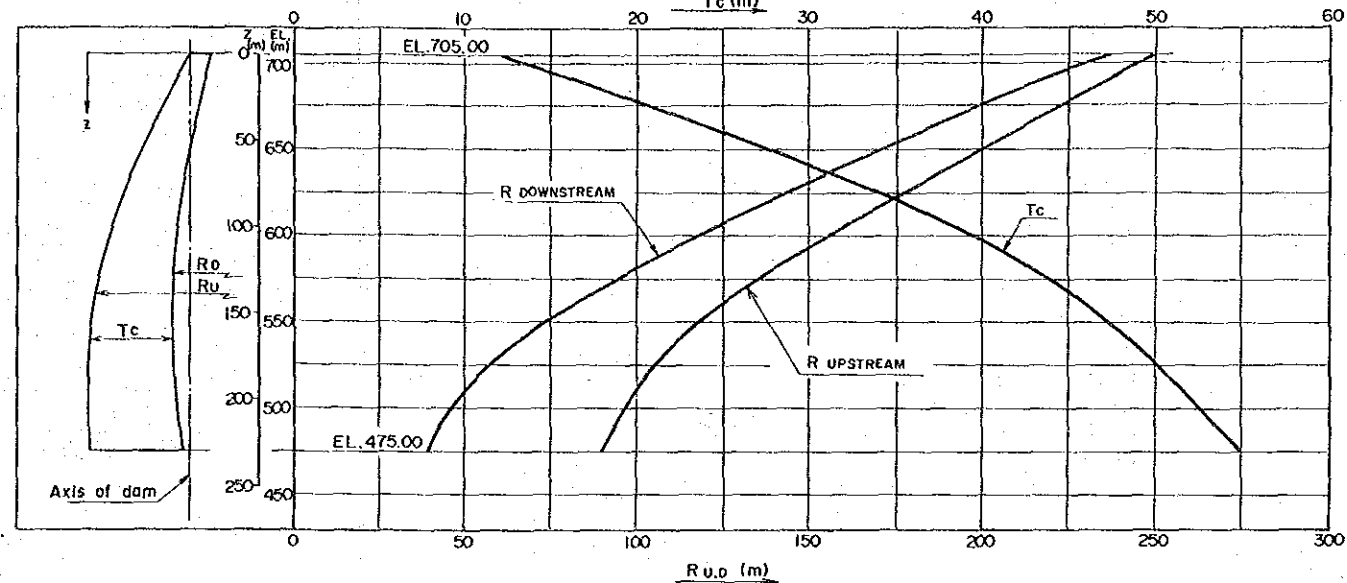


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YUSUFELI PROJECT ARCH GENERAL PLAN	
DWG. AP.4-8	DECEMBER 1986

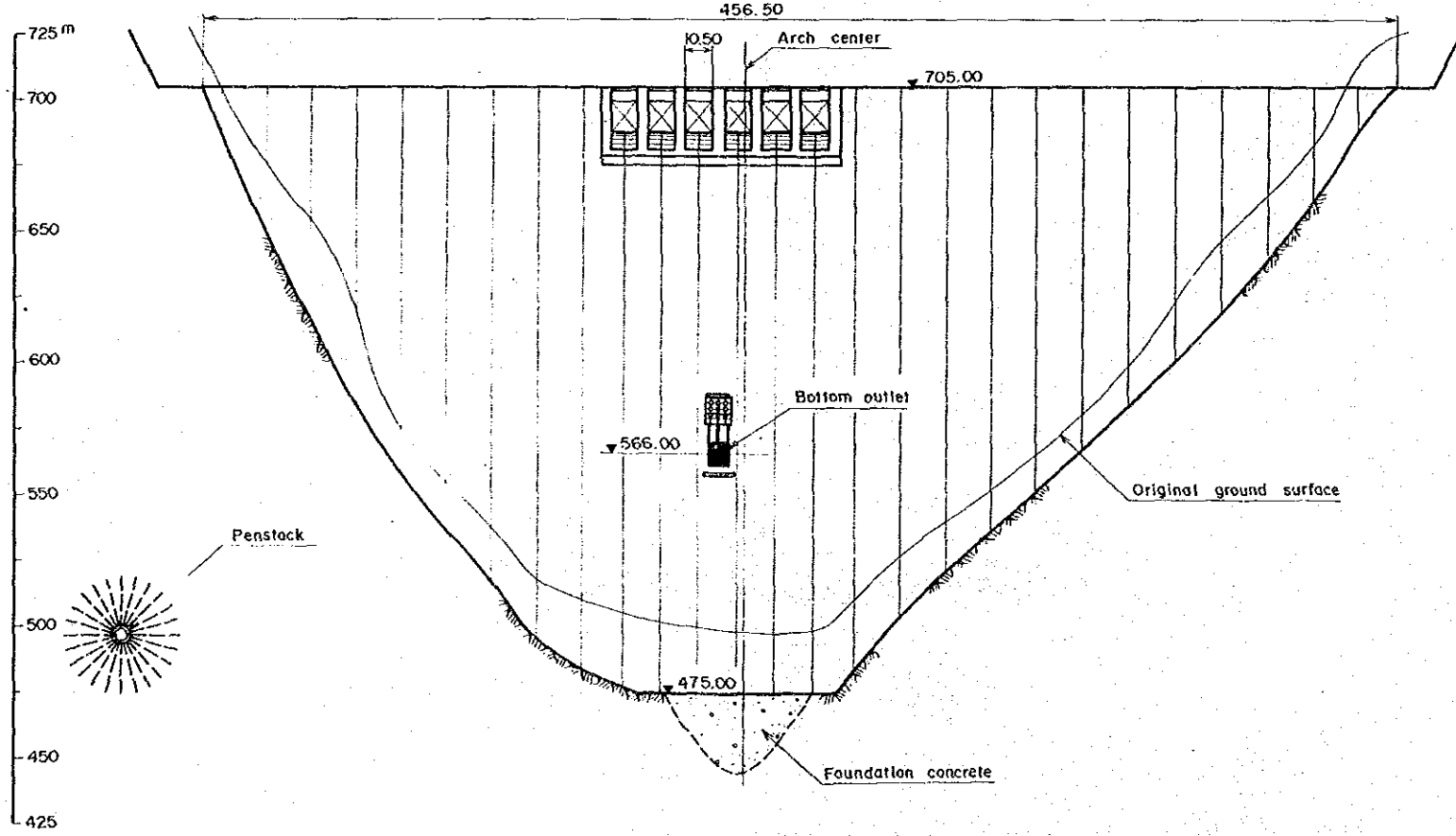
SECTION OF ARCH CROWN



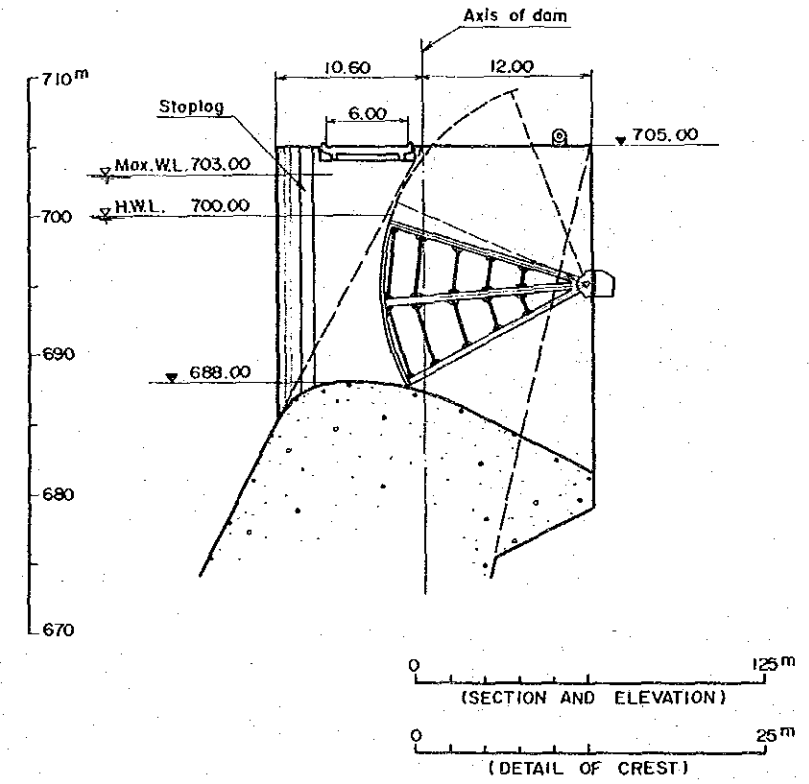
ARCH GEOMETRY



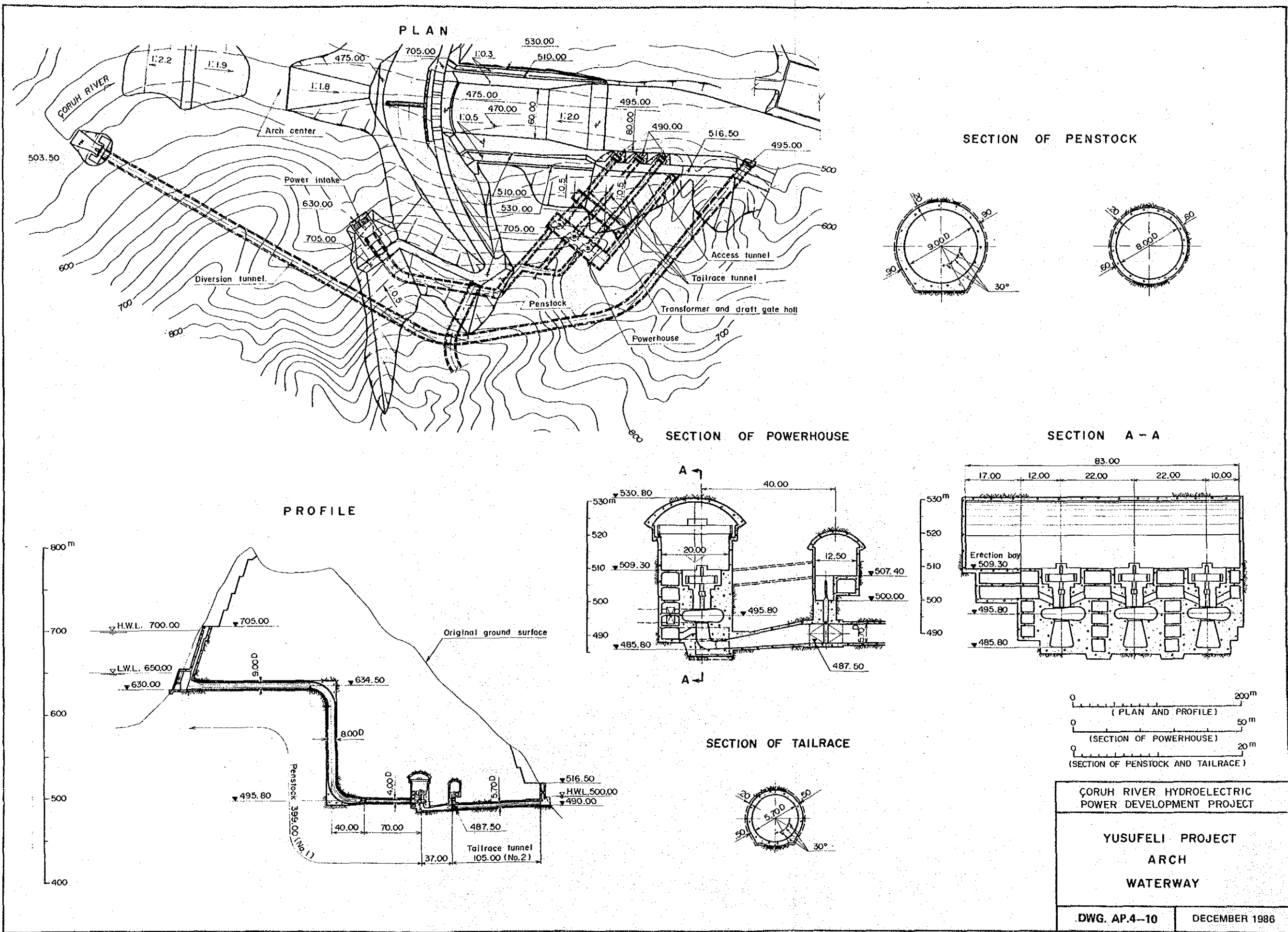
DOWSTREAM ELEVATION

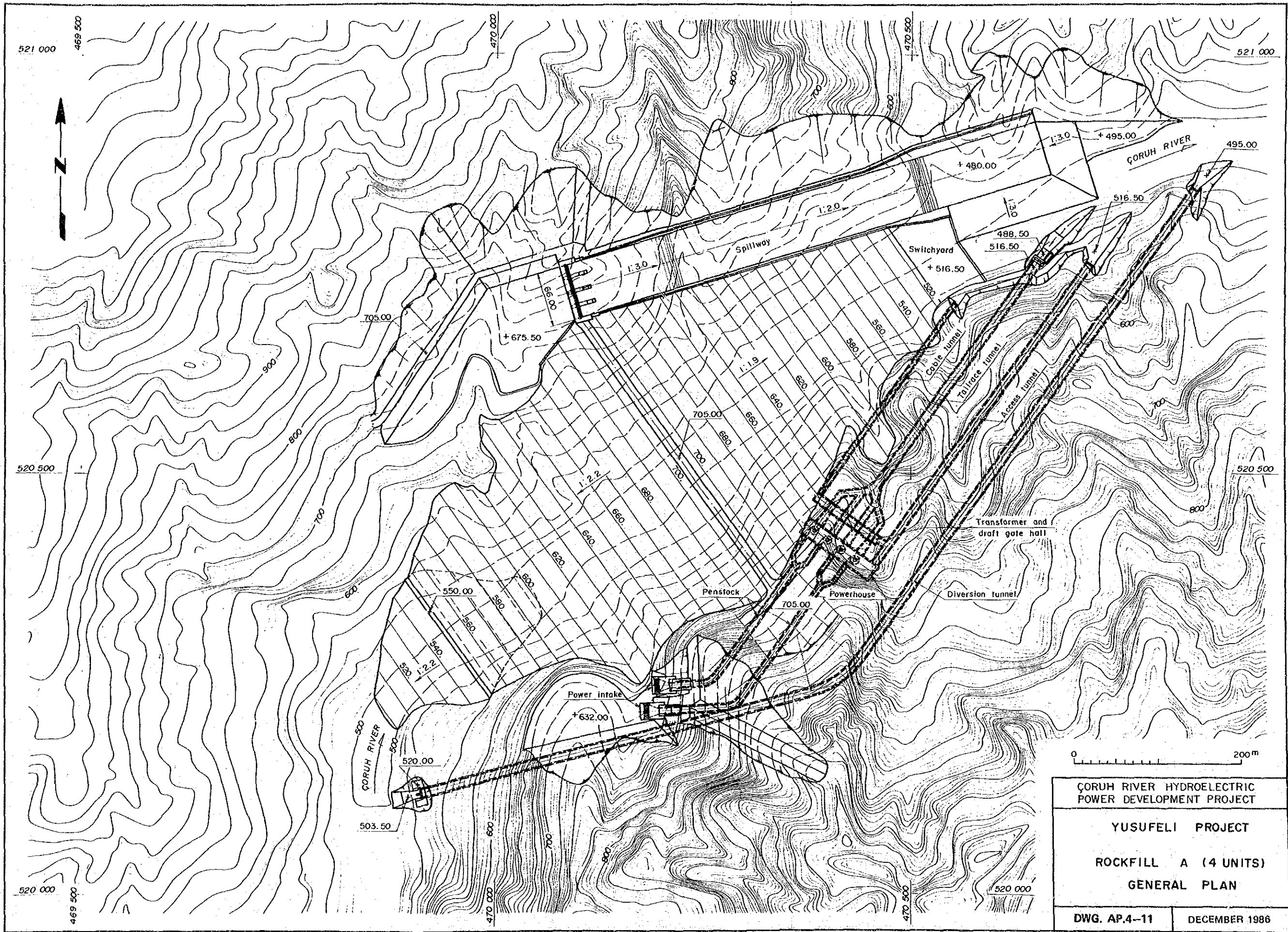


DETAIL OF SPILLWAY CREST

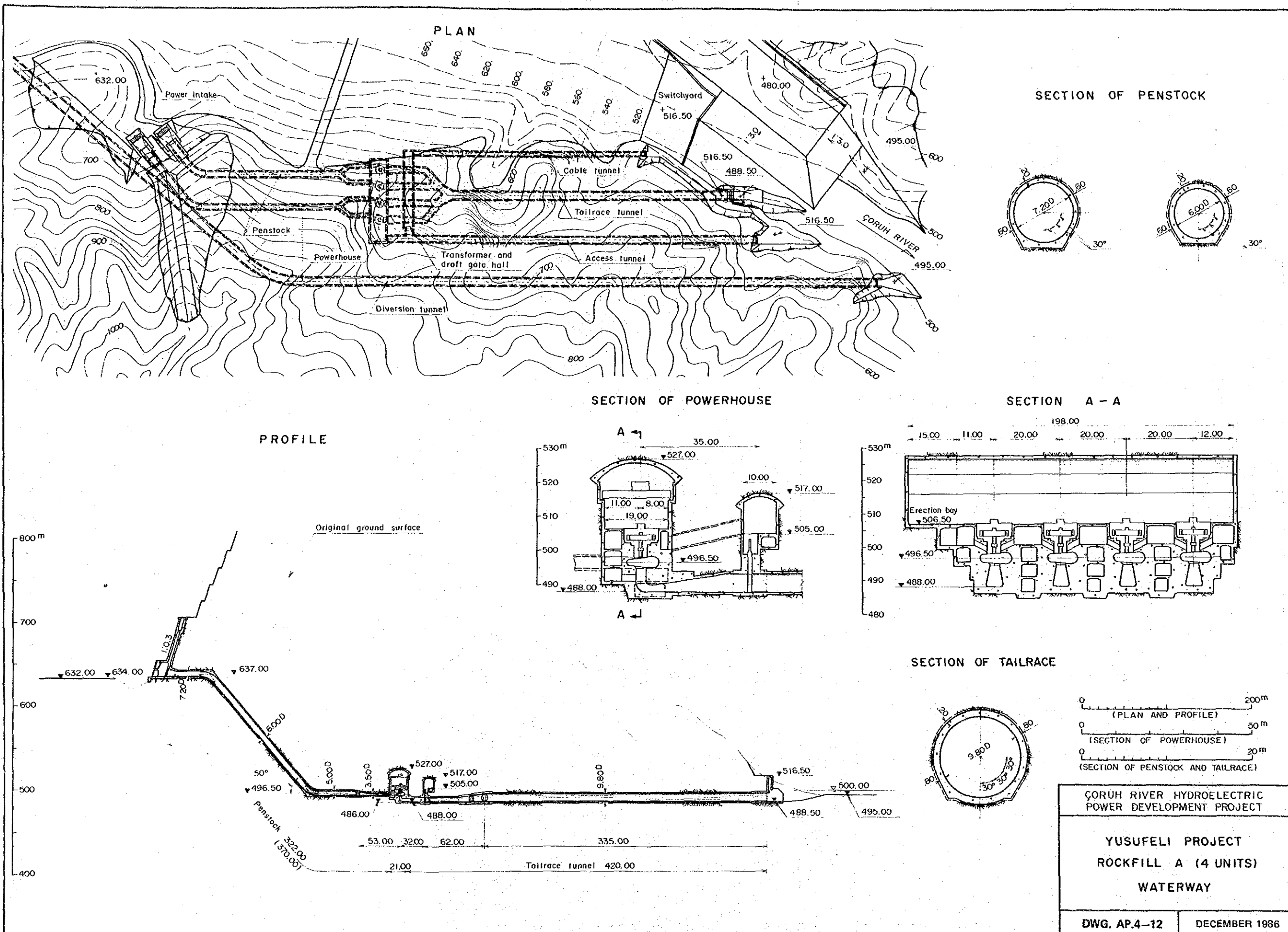


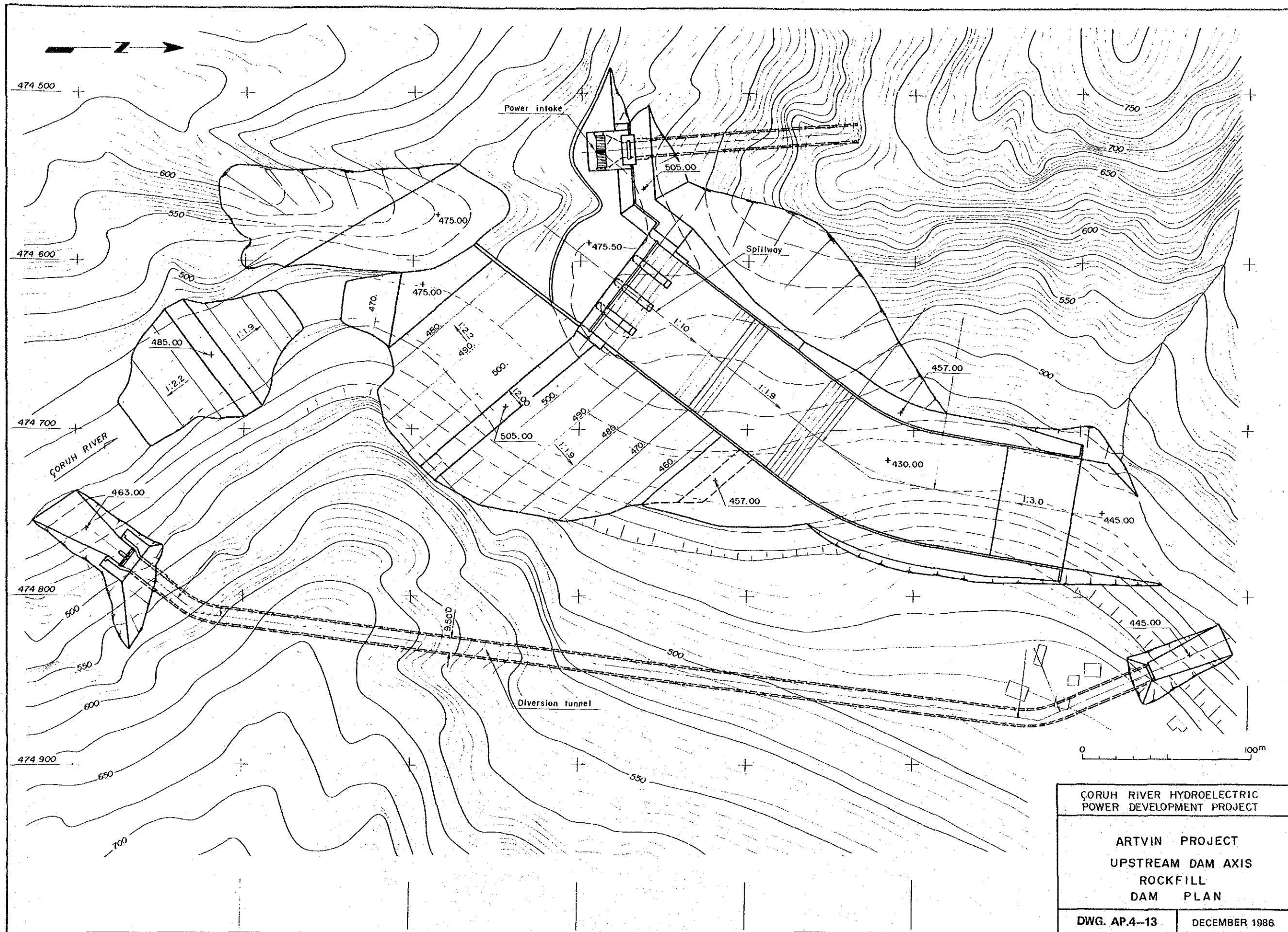
ÇORUH RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT	
YUSUFELI PROJECT ARCH DAM AND SPILLWAY	
DWG. AP.4-9	DECEMBER 1986





ÇORUH RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT	
YUSUFELI PROJECT	
ROCKFILL A (4 UNITS)	
GENERAL PLAN	
DWG. AP.4-11	DECEMBER 1986



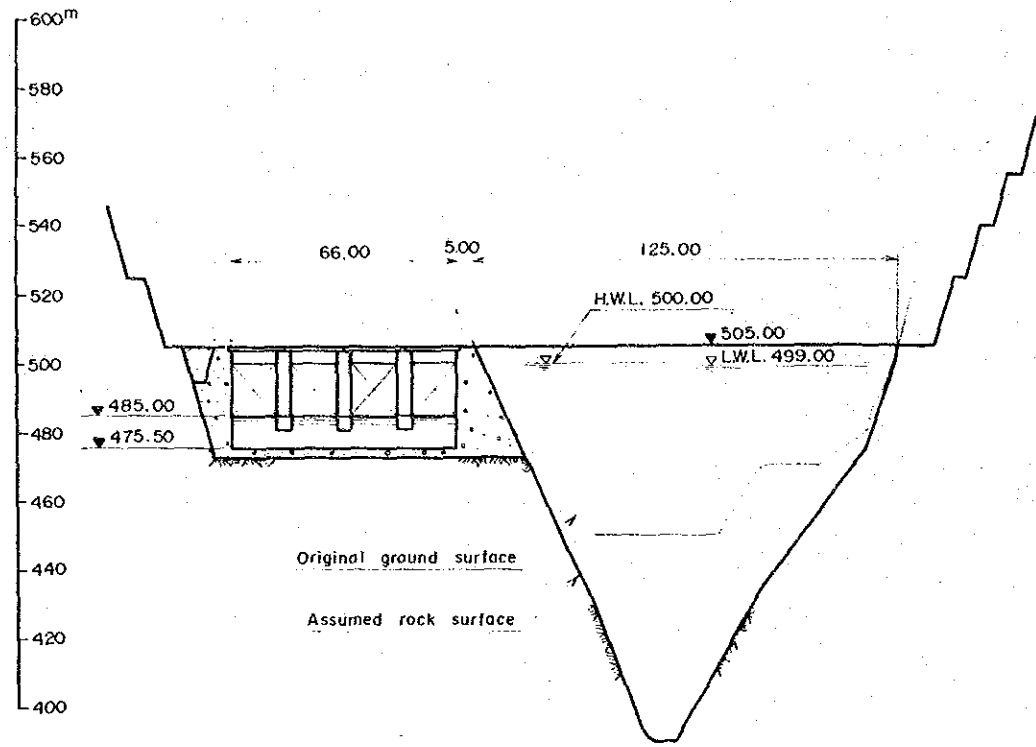


ÇORUH RIVER HYDROELECTRIC
 POWER DEVELOPMENT PROJECT

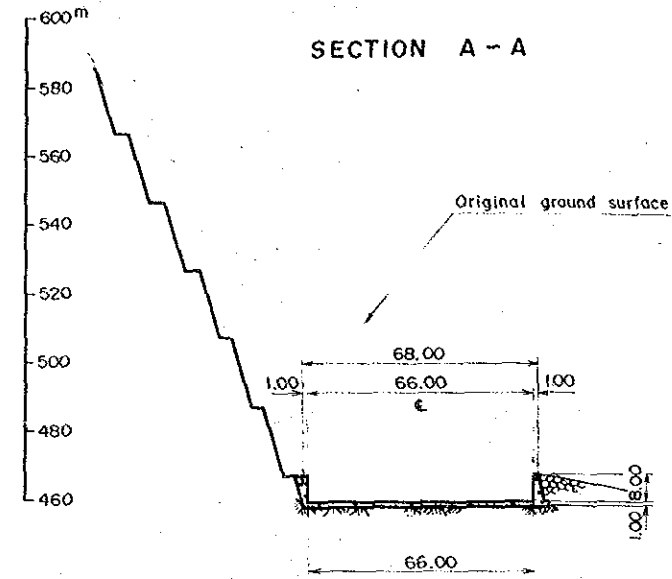
 ARTVIN PROJECT
 UPSTREAM DAM AXIS
 ROCKFILL
 DAM PLAN

 DWG. AP.4-13 DECEMBER 1986

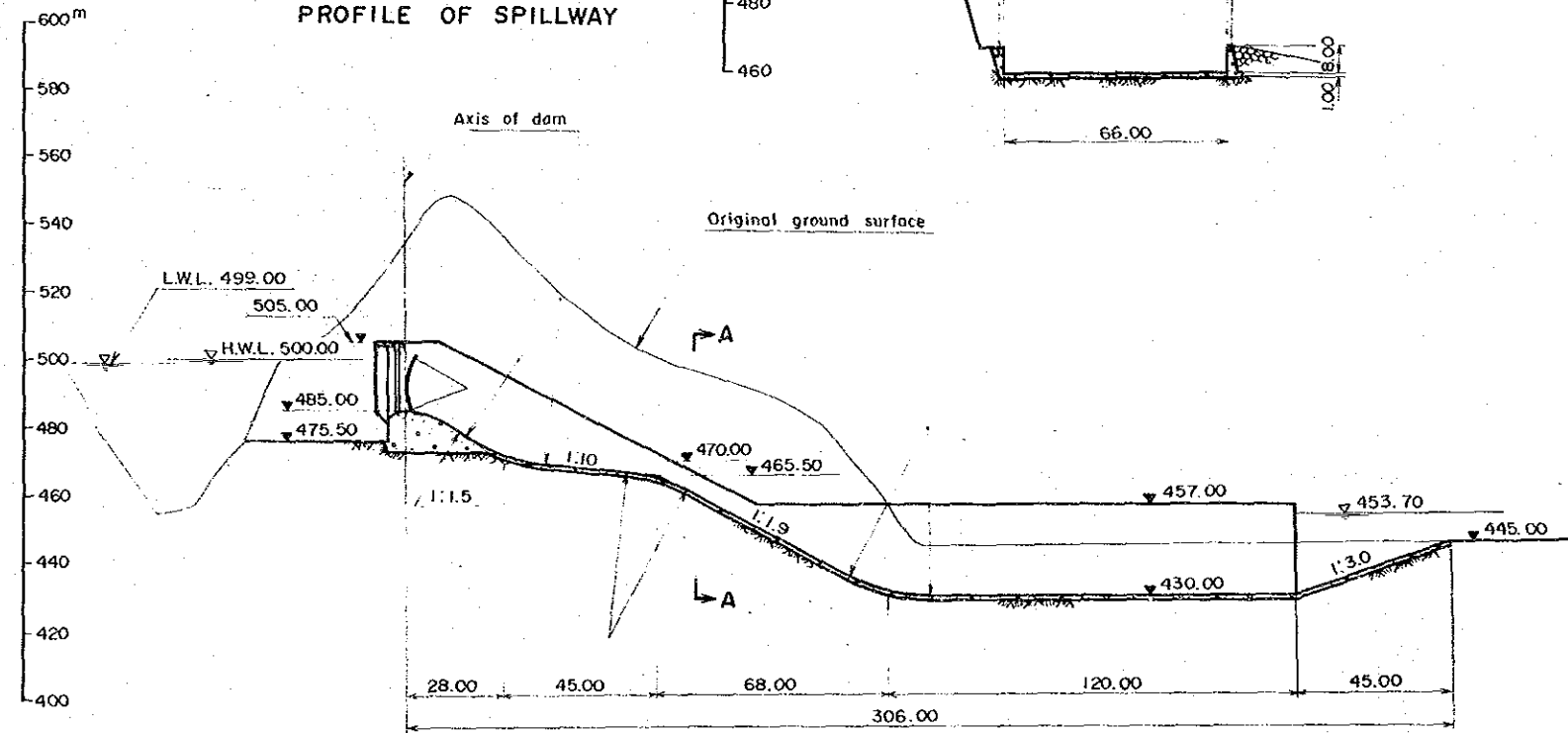
PROFILE OF DAM



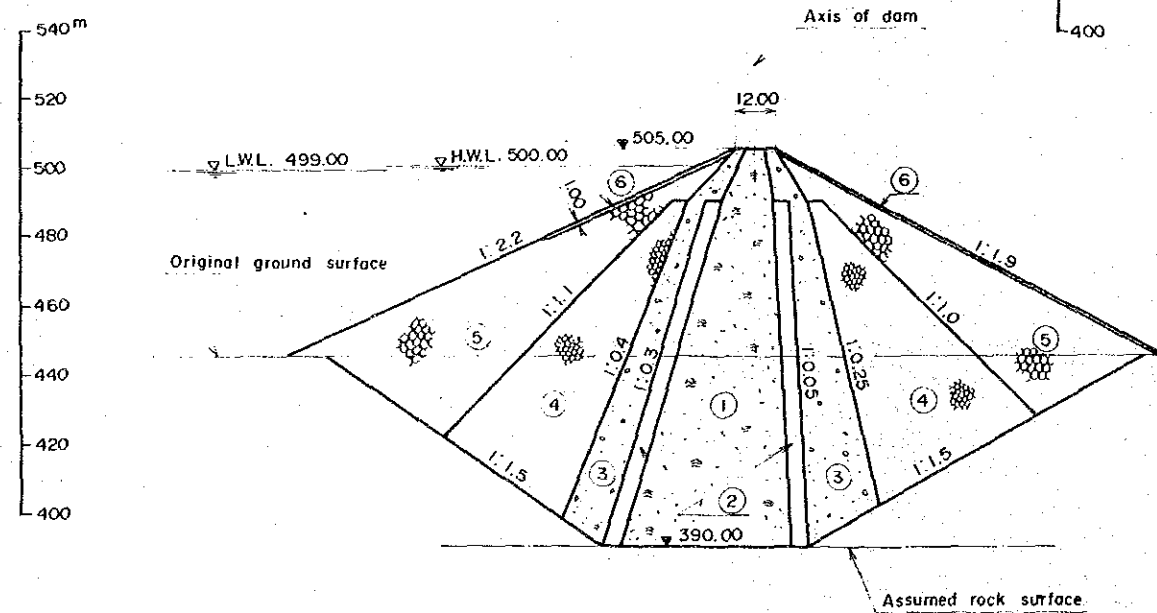
SECTION A - A



PROFILE OF SPILLWAY



TYPICAL SECTION OF DAM

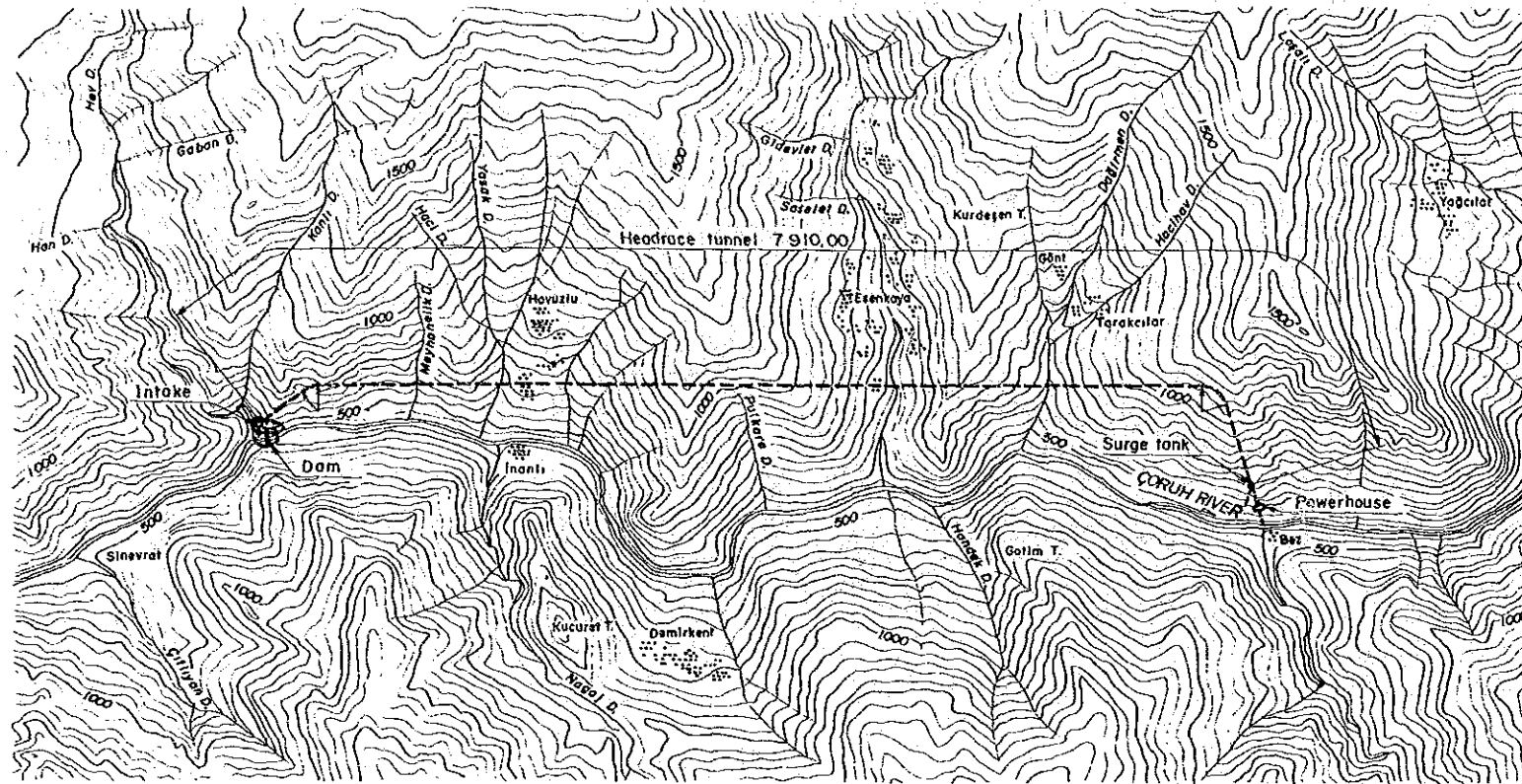


- ① Impervious core
- ② Fine filter
- ③ Coarse filter
- ④ Inner rockfill
- ⑤ Outer rockfill
- ⑥ Riprap

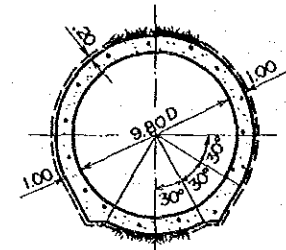
0 100m
 (PROFILE OF DAM, PROFILE OF SPILLWAY,
 TYPICAL SECTION OF DAM, SECTION A-A)

ÇORUH RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT	
ARTVIN PROJECT UPSTREAM DAM AXIS ROCKFILL DAM AND SPILLWAY	
DWG. AP.4-14	DECEMBER 1986

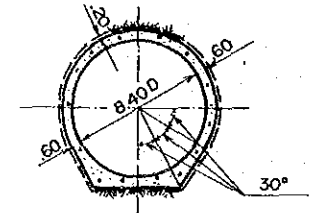
PLAN



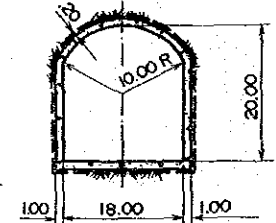
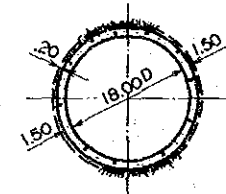
SECTION OF HEADRACE



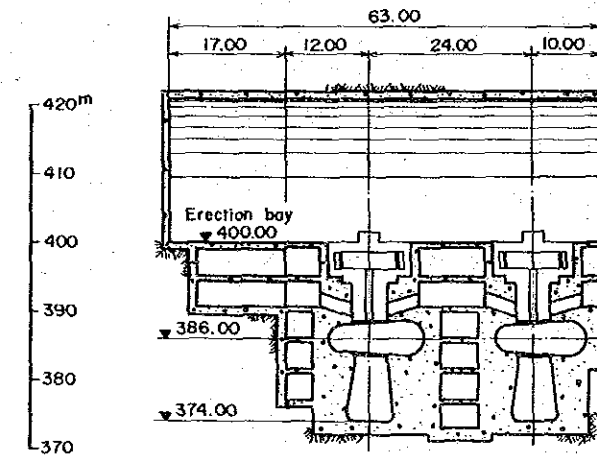
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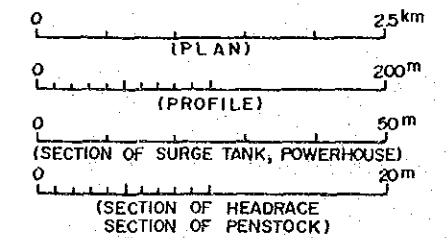
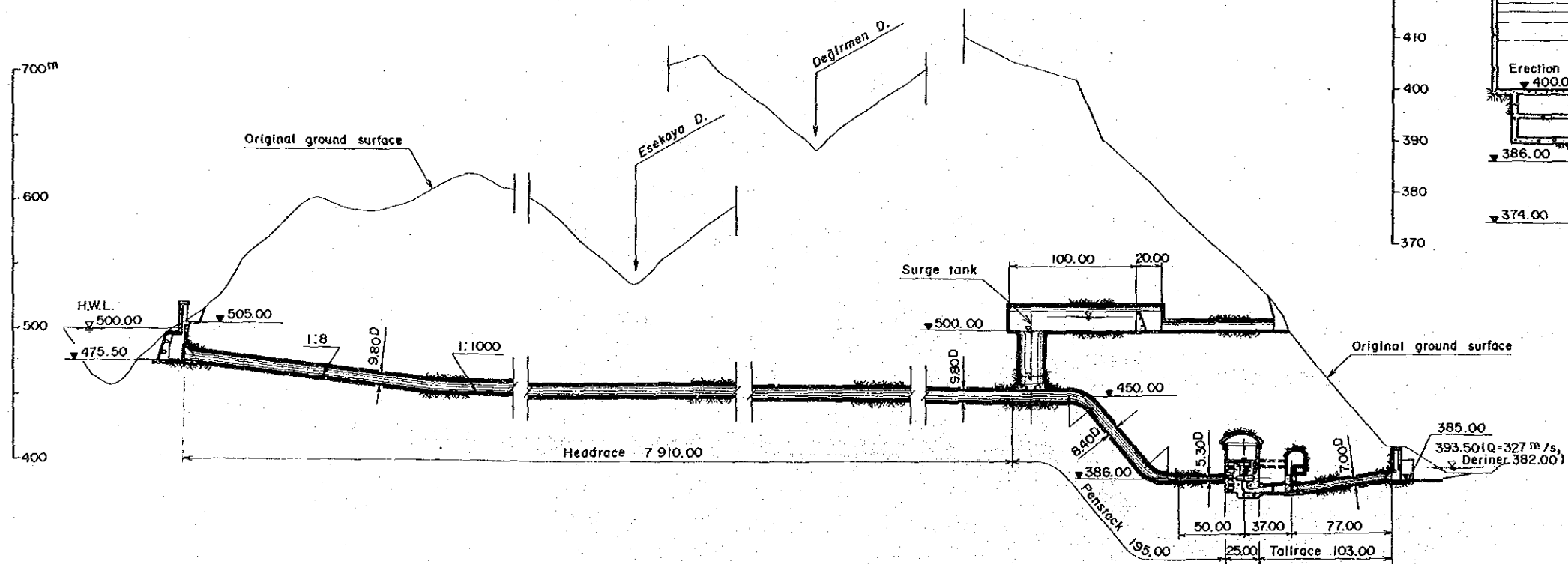
SECTION OF SURGE TANK



SECTION OF POWERHOUSE



PROFILE



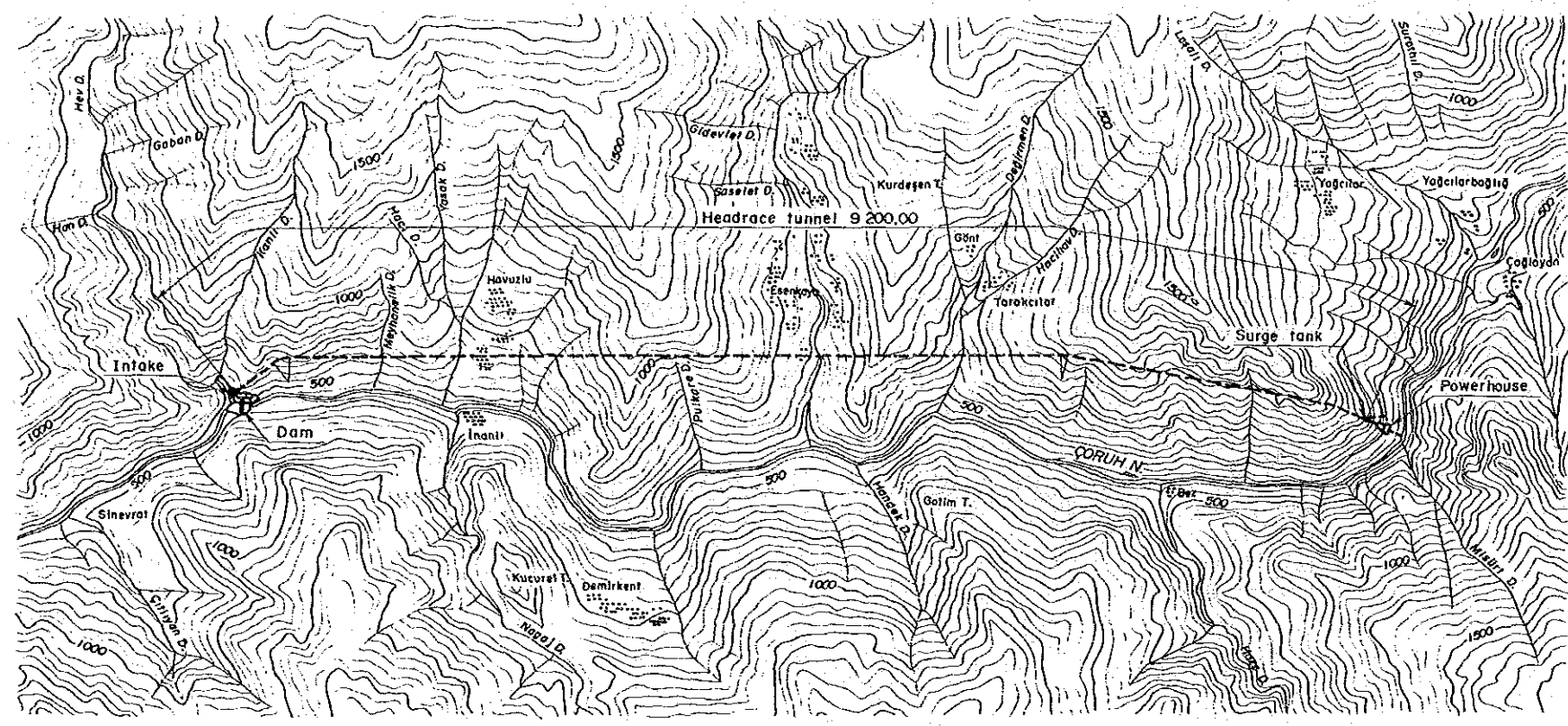
CORUH RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

ARTVIN PROJECT
UPSTREAM DAM AXIS
ROCKFILL WATERWAY A

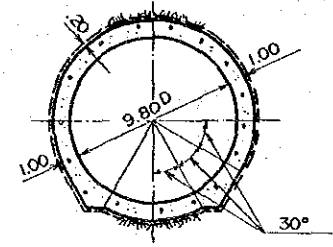
DWG. AP.4-15

DECEMBER 1986

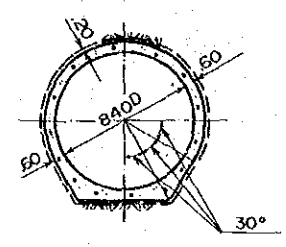
PLAN



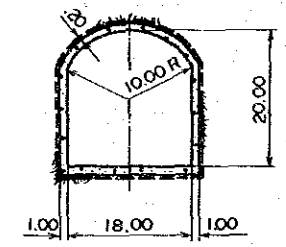
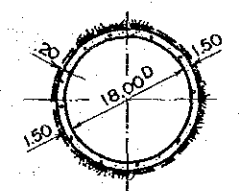
SECTION OF HEADRACE



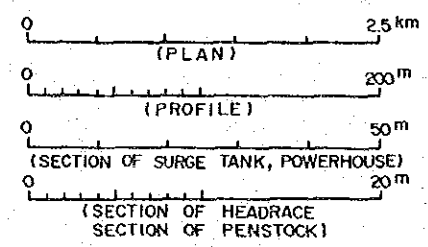
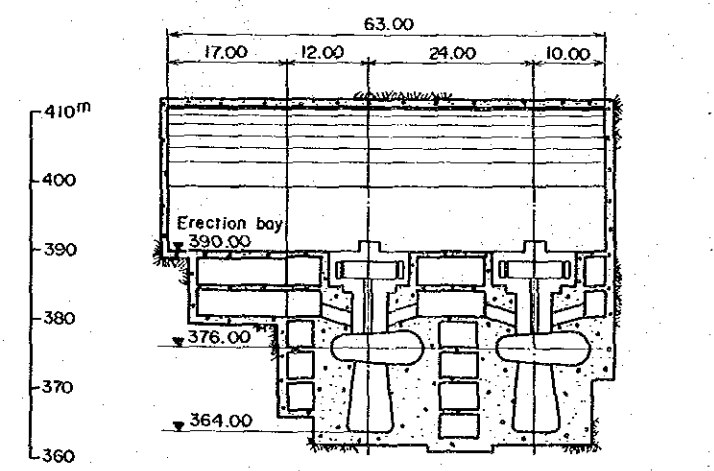
SECTION OF PENSTOCK



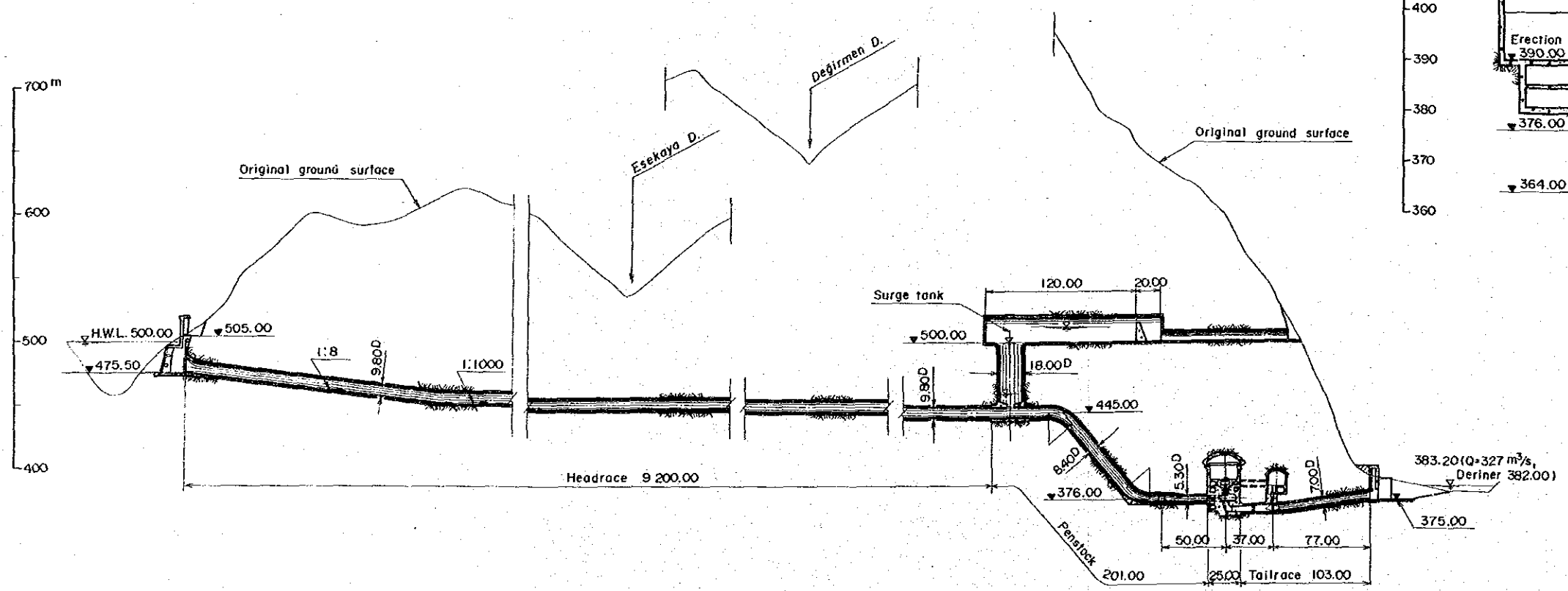
SECTION OF SURGE TANK



SECTION OF POWERHOUSE



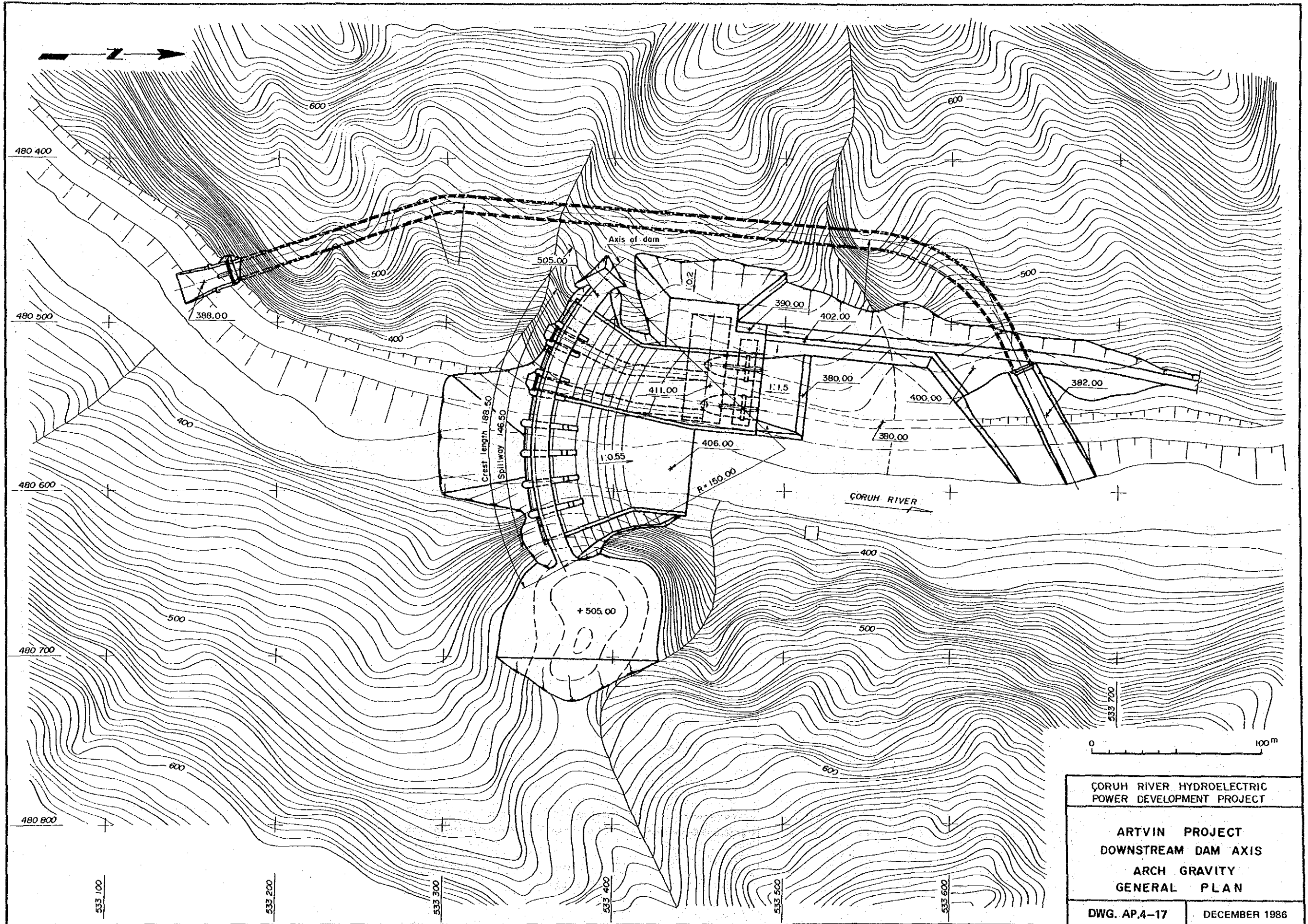
PROFILE



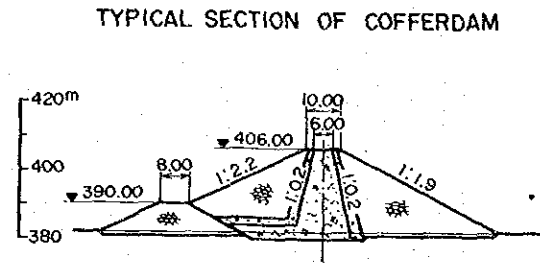
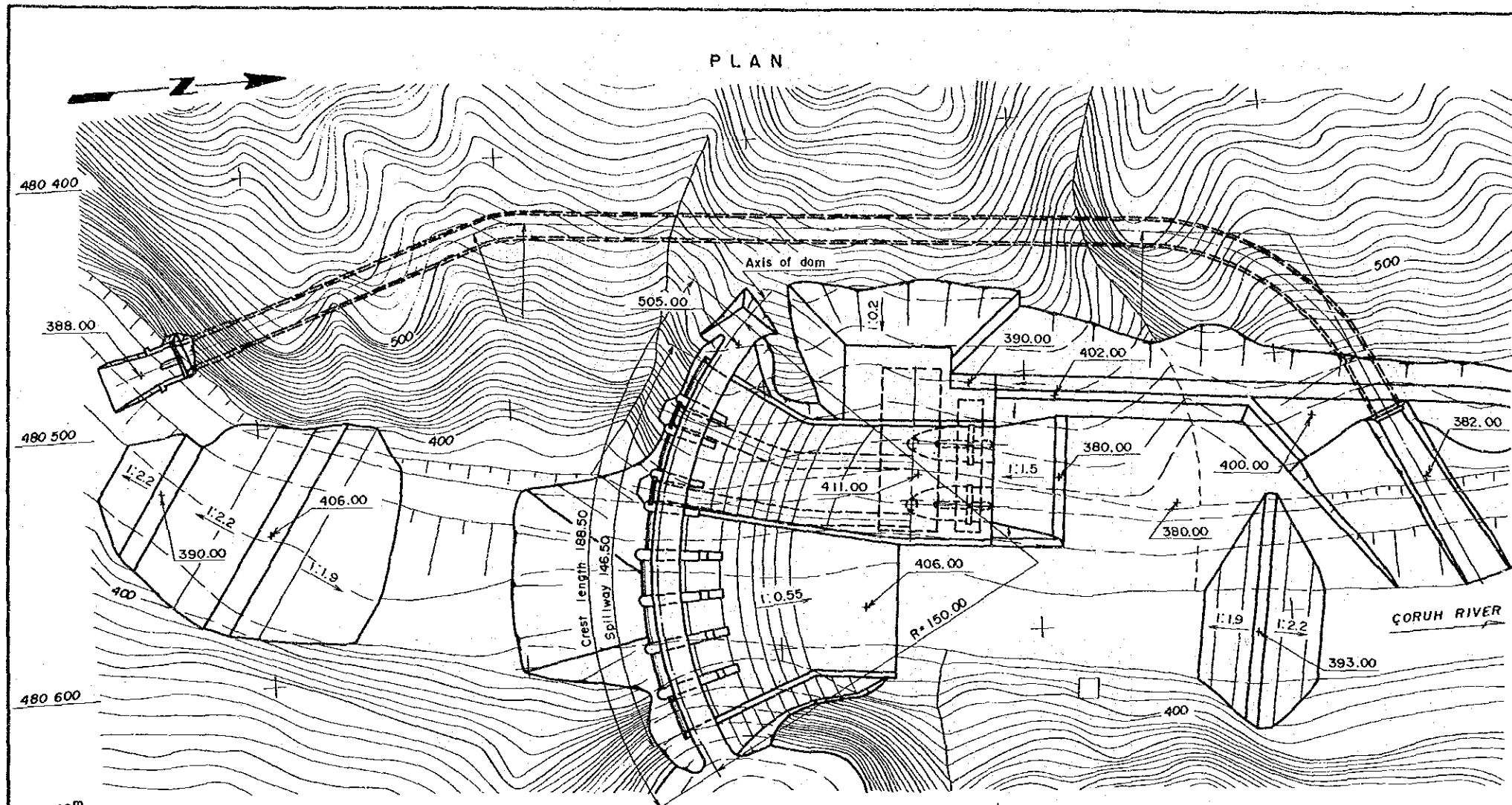
ÇORUH RIVER HYDROELECTRIC
POWER DEVELOPMENT PROJECT

ARTVIN PROJECT
UPSTREAM DAM AXIS
ROCKFILL WATERWAY B

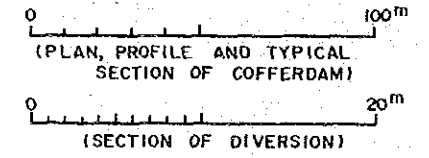
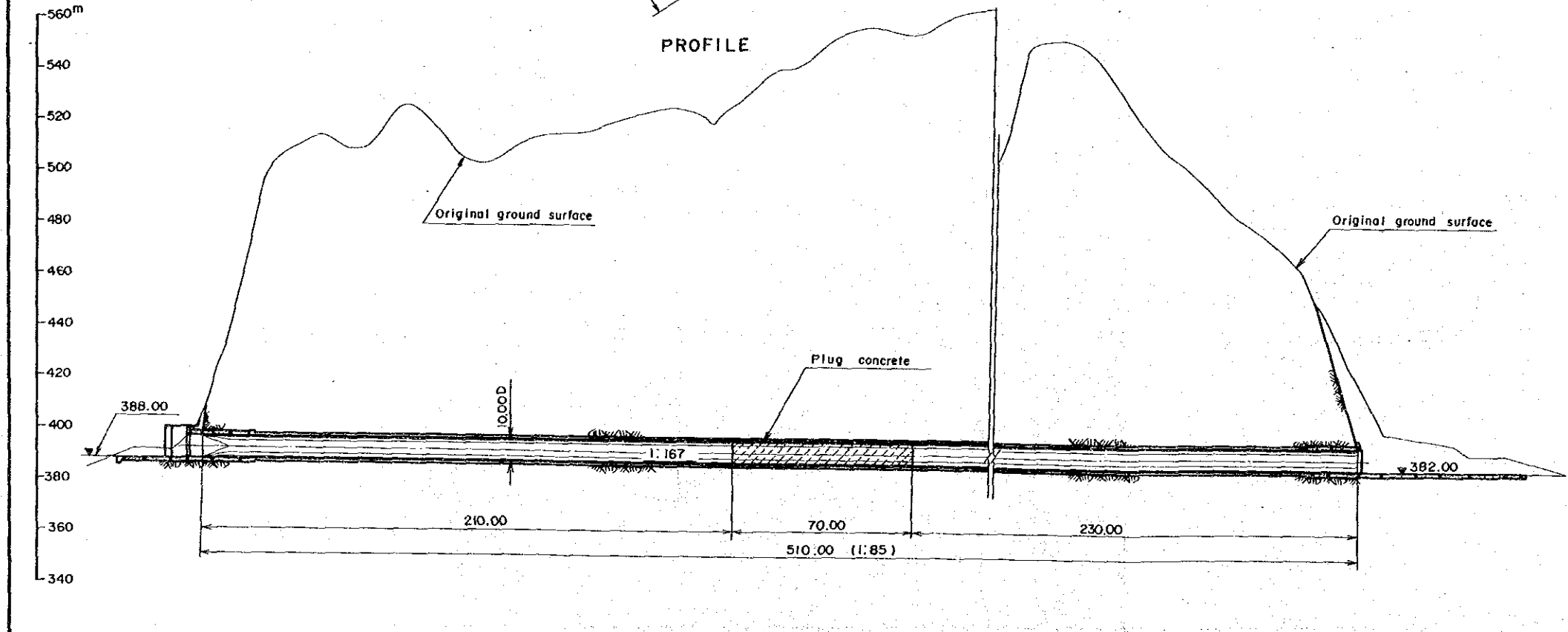
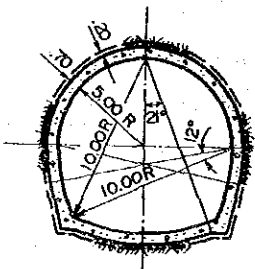
DWG. AP.4-16 DECEMBER 1986



ÇORUH RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT	
ARTVIN PROJECT DOWNSTREAM DAM AXIS ARCH GRAVITY GENERAL PLAN	
DWG. AP.4-17	DECEMBER 1986

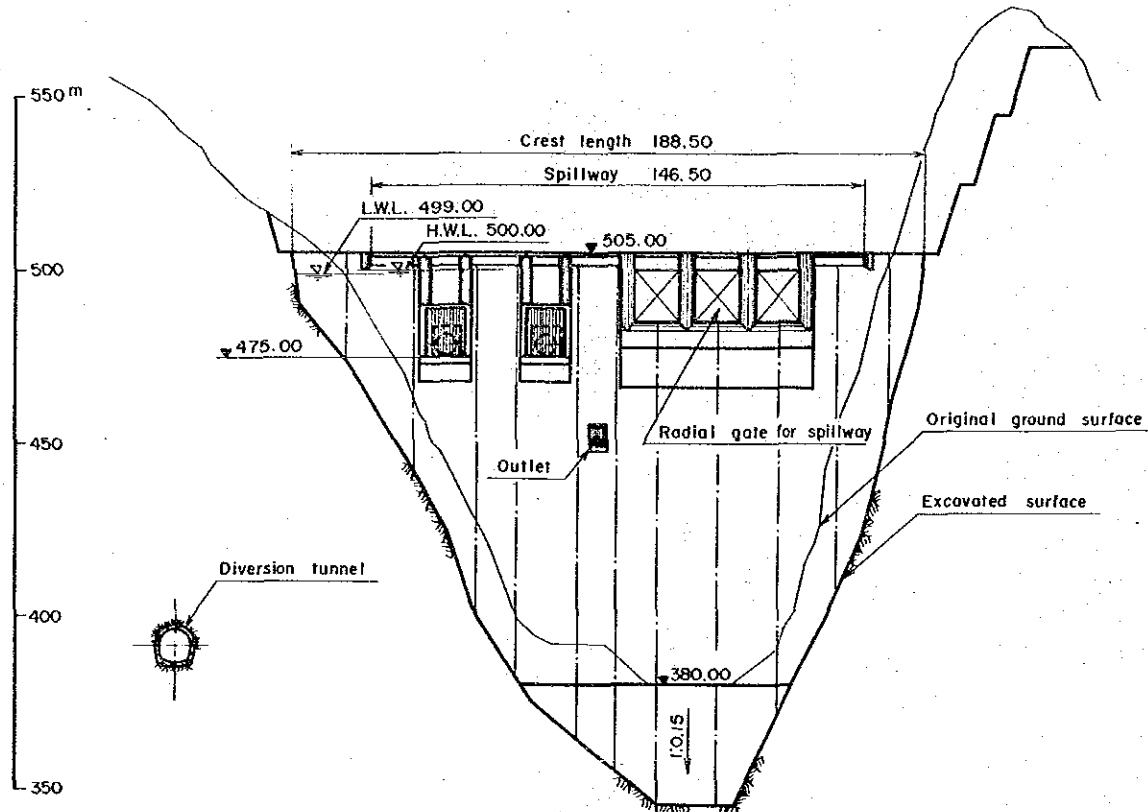


SECTION OF DIVERSION

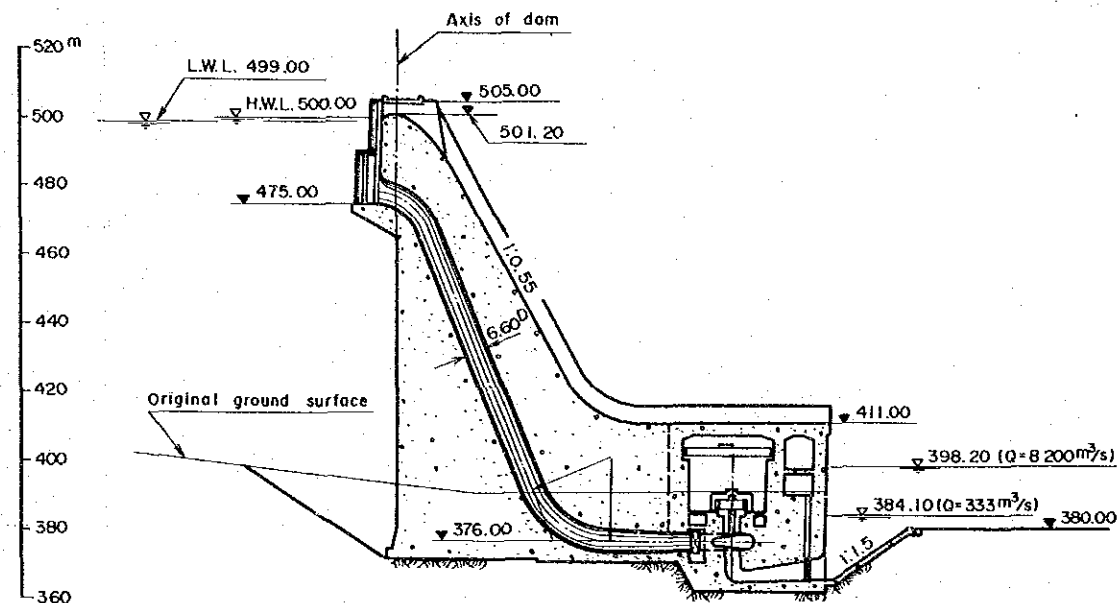


CORUH RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT	
ARTVIN PROJECT DOWNSTREAM DAM AXIS ARCH GRAVITY CARE OF RIVER	
DWG. AP.4-18	DECEMBER 1986

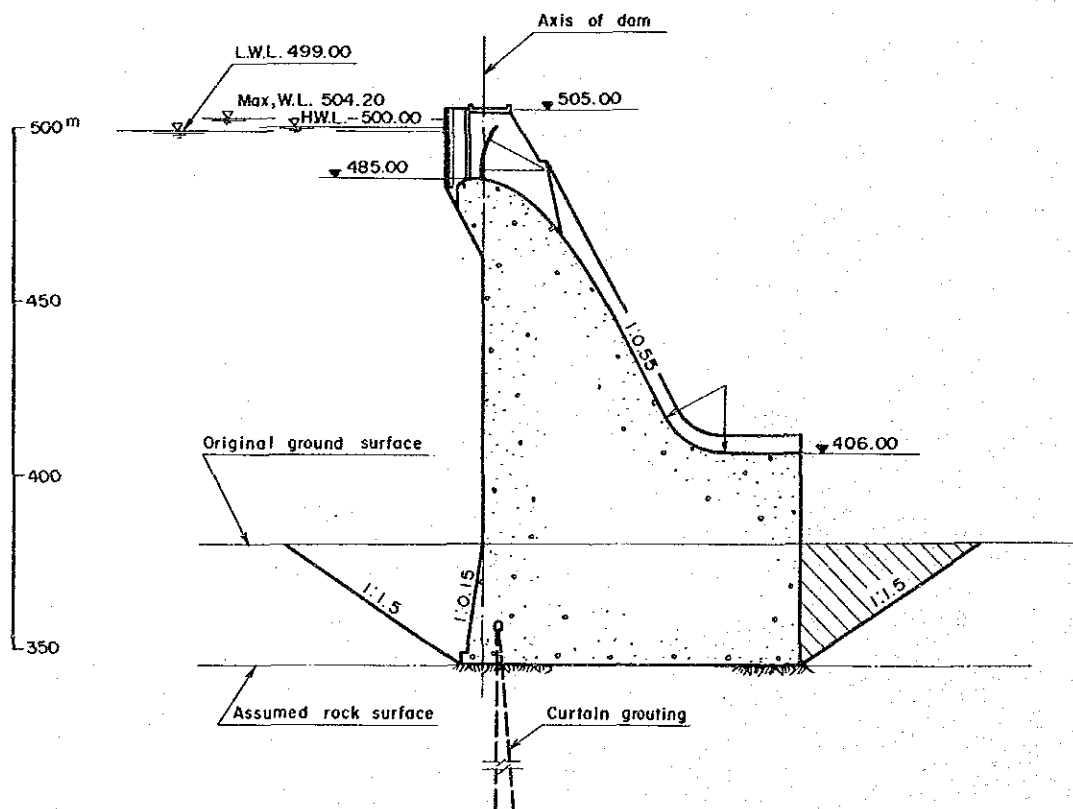
UPSTREAM ELEVATION



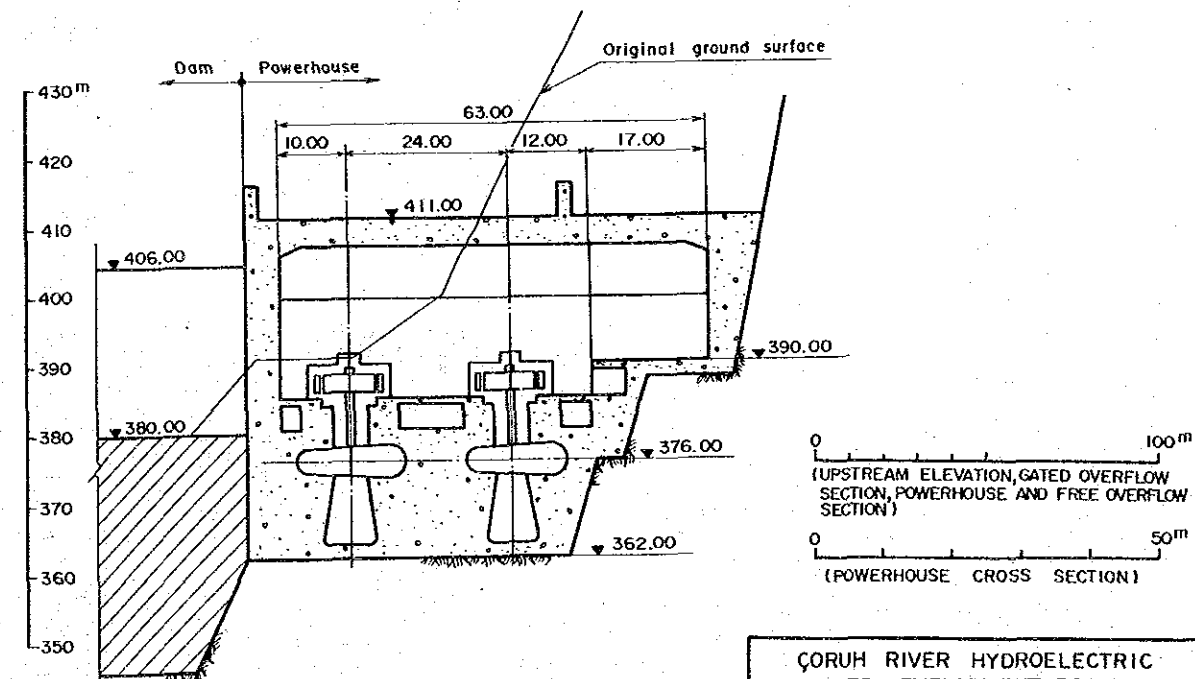
POWERHOUSE AND FREE OVERFLOW SECTION



GATED OVERFLOW SECTION



POWERHOUSE CROSS SECTION



ÇORUH RIVER HYDROELECTRIC
POWER DEVELOPMENT PROJECT

ARTVIN PROJECT
DOWNSTREAM DAM AXIS
ARCH GRAVITY
ELEVATION AND SECTION

DWG. AP.4-19

DECEMBER 1986

4. 2 Stability Analysis of Yusufeli Dam

4.2 Stability Analysis of Yusufeli Dam

4.2.1 General

Stability has been examined for the rockfill dam at Yusufeli site by calculating safety factors along slip circles and infinite slope at shallow zone.

Cases examined are as follows.

- 1 Case of Normal High Water Level
 - . Upstream and Downstream slopes
 - . Normal and Earthquake cases
- 2 Case of work completion
 - . Upstream and Downstream slopes
 - . Normal and Earthquake cases

4.2.2 Basic Equations

1) Slip circle method

$$\text{Normal condition: } S.F.(N) = \frac{(\sum N - \sum U) \tan \phi + \sum C.L}{\sum T}$$

$$\text{Earthquake condition: } S.F.(E) = \frac{(\sum N - \sum N_e - \sum U) \tan \phi + \sum C.L}{\sum T + \sum T_e}$$

, where

S.F. : Safety Factor, N and E indicate Normal and Earthquake condition respectively.

$\sum N$: Summation of normal force acting on slip surface of slices, due to weight of embankment material and hydrostatic pressure of reservoir water.

$\sum T$: Summation of tangential force acting on slip surface of slices, due to weight of embankment material and hydrostatic pressure of reservoir water.

$\sum N_e$: Summation of normal force acting on slip surface of slices, due to earthquake.

$\sum T_e$: Summation of tangential force acting on slip surface of

slices, due to earthquake

$\sum U$: Summation of pore water pressure acting on slip surface of slices

ϕ : Internal friction angle of embankment material

C : Cohesion force of embankment material

L : Length of slip circle

2) Infinite slop method

Upstream face (Submerged slope)

Normal condition : S.F.(N) = $n \cdot \tan \phi$

$$\text{Earthquake condition: S.F.(E)} = \frac{\left\{ n - k \left(1 + \frac{1}{\gamma_{\text{sub}}} \right) \right\} \tan \phi}{1 + n \cdot K \left(1 + \frac{1}{\gamma_{\text{sub}}} \right)}$$

,where

n : Slope gradient (1:n)

sub : Unit weight of rock material in water

$\tan \phi$: Internal friction coefficient of rock material

k : Seismic coefficient

Downstream face (Slope in open air)

Normal condition : S.F.(N) = $n \cdot \tan \phi$

$$\text{Earthquake condition: S.F.(E)} = \frac{(n - k) \tan \phi}{1 + n \cdot k}$$

4.2.3 Calculation Condition

1) Properties of embankment material

Zone	Material	Specific gravity	Unit weight (t/m ³)			Coeff. of internal friction	Cohesion
			Dry	Wet	Saturated		
1	Impervious core	2.75	1.70	2.05	2.08	0.40	0
2	Fine filter	2.70	2.00	2.10	2.26	0.70	0
3	Coarse filter	2.70	2.05	2.15	2.29	0.70	0
4	Inner rockfill	2.60	1.90	1.95	2.13	0.90	0
5	Outer rockfill	2.60	1.85	1.90	2.14	1.00	0
6	Alluvial deposit	2.65	1.90	-	2.18	0.70	0

These design values were adopted from Altinkaya project, since no detail material test has been conducted over the present project.

2) Load condition

Considered loads are dead weight, hydrostatic pressure, pore water pressure and seismic force.

① Hydrostatic pressure (Design water level)

. In the case of Normal High Water level

Upstream Water Level : El.710.00 m

Downstream Water Level: El.500.00 m

. In the case of work completion

Upstream Water Level : 500.00 m

Downstream Water Level: 500.00 m

② Pore water pressure

In the case of Normal High Water Level, pore water pressure was obtained from flow net, while it is assumed, in the case of work completion, that the max. pore water pressure is fifty (50) percent of the overlying load. These distributions are shown in Fig. AP.4-3.

③ Seismic coefficient

. In the case of Normal High Water Level

$$K = 0.15$$

. In the case of work completion

$$K = 0.10$$

4.2.4 Result

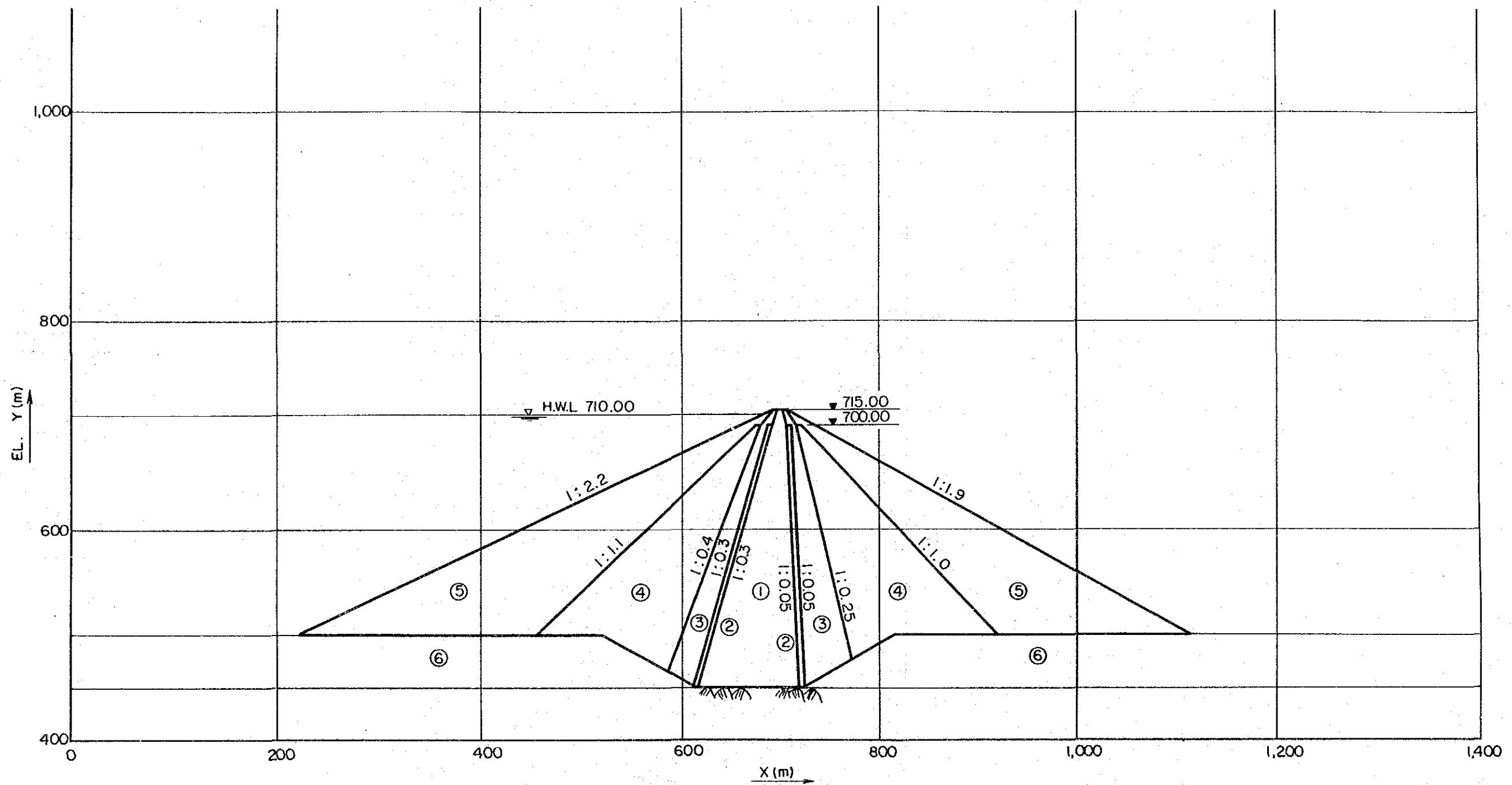
The calculation has been conducted by a computer. The result is shown in the following table and figures.

Table Minimum Safety Factor

Condition		Slip Circle	Infinite Slope	
Normal High Water Level	Normal	Upstream	2.03	2.20
		Downstream	1.53	1.90
	Earthquake	Upstream	1.04	1.18
		Downstream	1.02	1.36
Work Completion	Normal	Upstream	1.71	2.20
		Downstream	1.59	1.90
	Earthquake	Upstream	1.28	1.72
		Downstream	1.21	1.51

From the result, the dam body is generally safe in any cases of the examination for the given design values. Though there are a few cases that safety factor slightly exceeds one (1.0), improvement is expected if detail material test will be conducted and actual design values will be detected over the project. In present stage, as mentioned in section 2.3, those design values are for the time being adopted from Altinkaya project.

It is, thus, desirable to carry out in detail the analyses in definite study stage where detail material data will be available.



Properties of embankment materials

	Specific gravity	Unit weight t/m ³			Coefficient of internal friction	Cohesion
		Dry	Wet	Saturated		
Impervious core ①	2.75	1.70	2.05	2.08	0.40	0
Fine filter ②	2.70	2.00	2.10	2.26	0.70	—
Coarse filter ③	2.70	2.05	2.15	2.29	0.70	—
Inner rockfill ④	2.60	1.90	1.95	2.13	0.90	—
Outer rockfill ⑤	2.60	1.85	1.90	2.14	1.00	—
Alluvial deposit ⑥	2.65	1.90	—	2.18	0.70	—

Fig. AP.4-1 Typical Section and Zoning of Dam

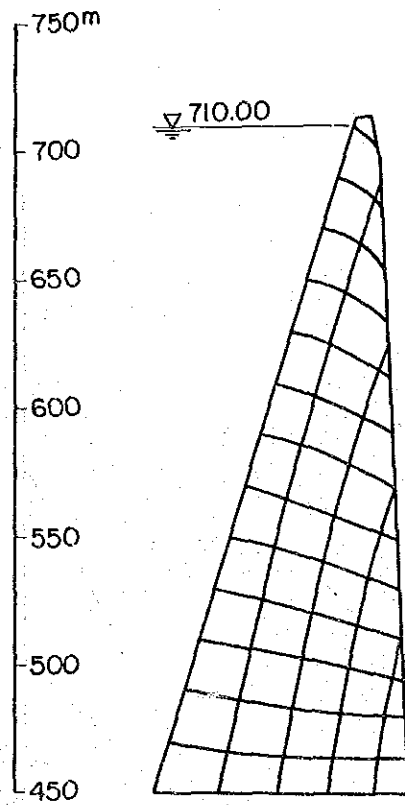
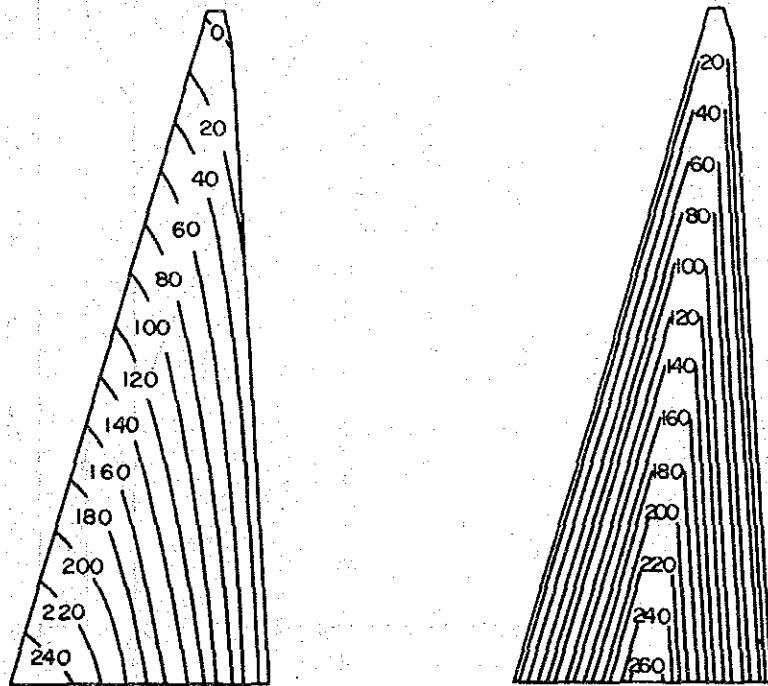


Fig. AP.4-2 Flow Net in Normal High Water Level



(a) Normal High Water Level

(b) Work Completion

Fig. AP.4-3 Pore Water Pressure Distribution

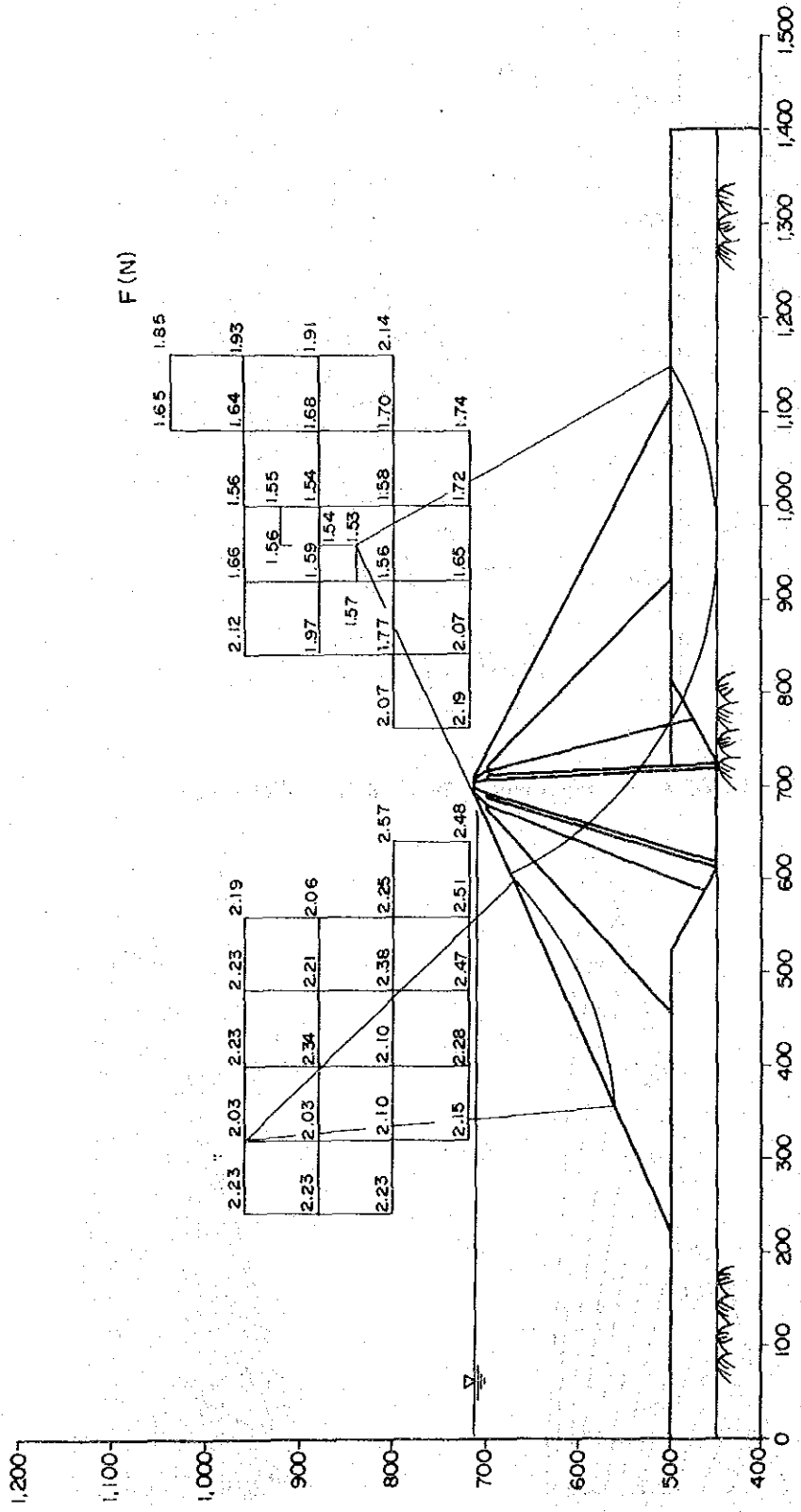


Fig. AP.4-4 Normal High Water Level, Normal Condition