THE REPUBLIC OF TURKEY

FEASIBILITY REPORT
ON
BESKONAK HYDROELECTRIC POWER DEVELOPMENT PROJECT

— Summary —

November 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

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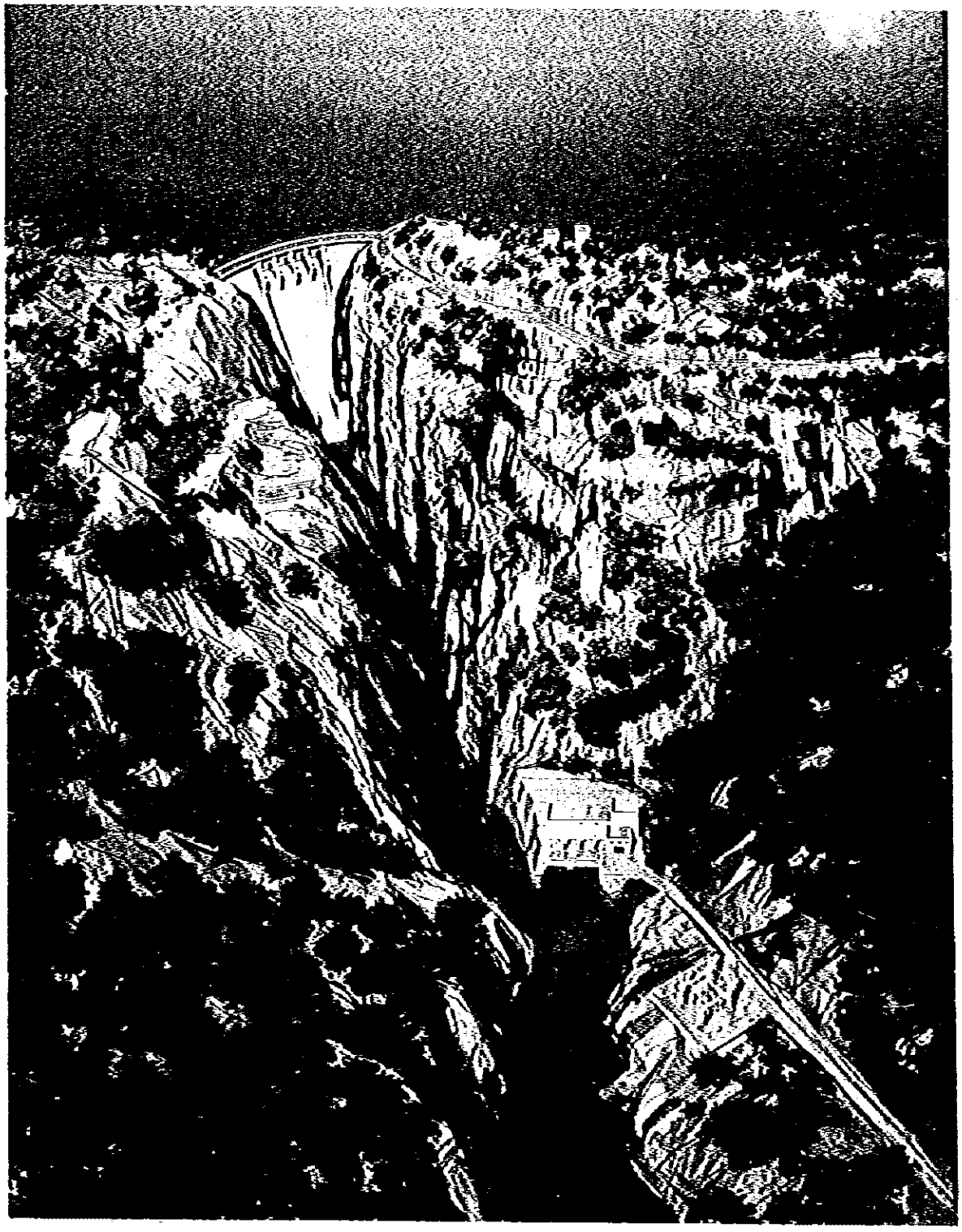
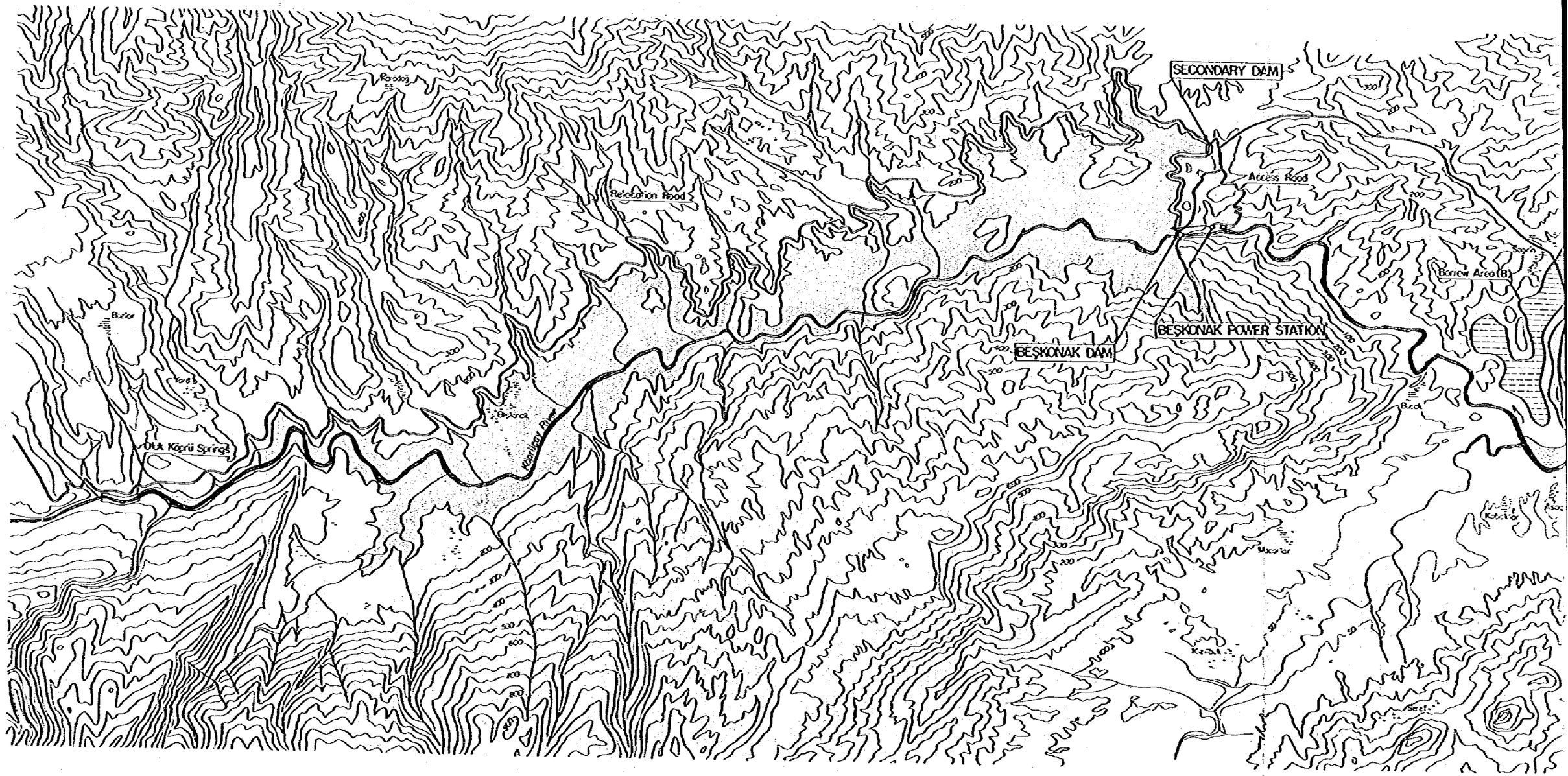
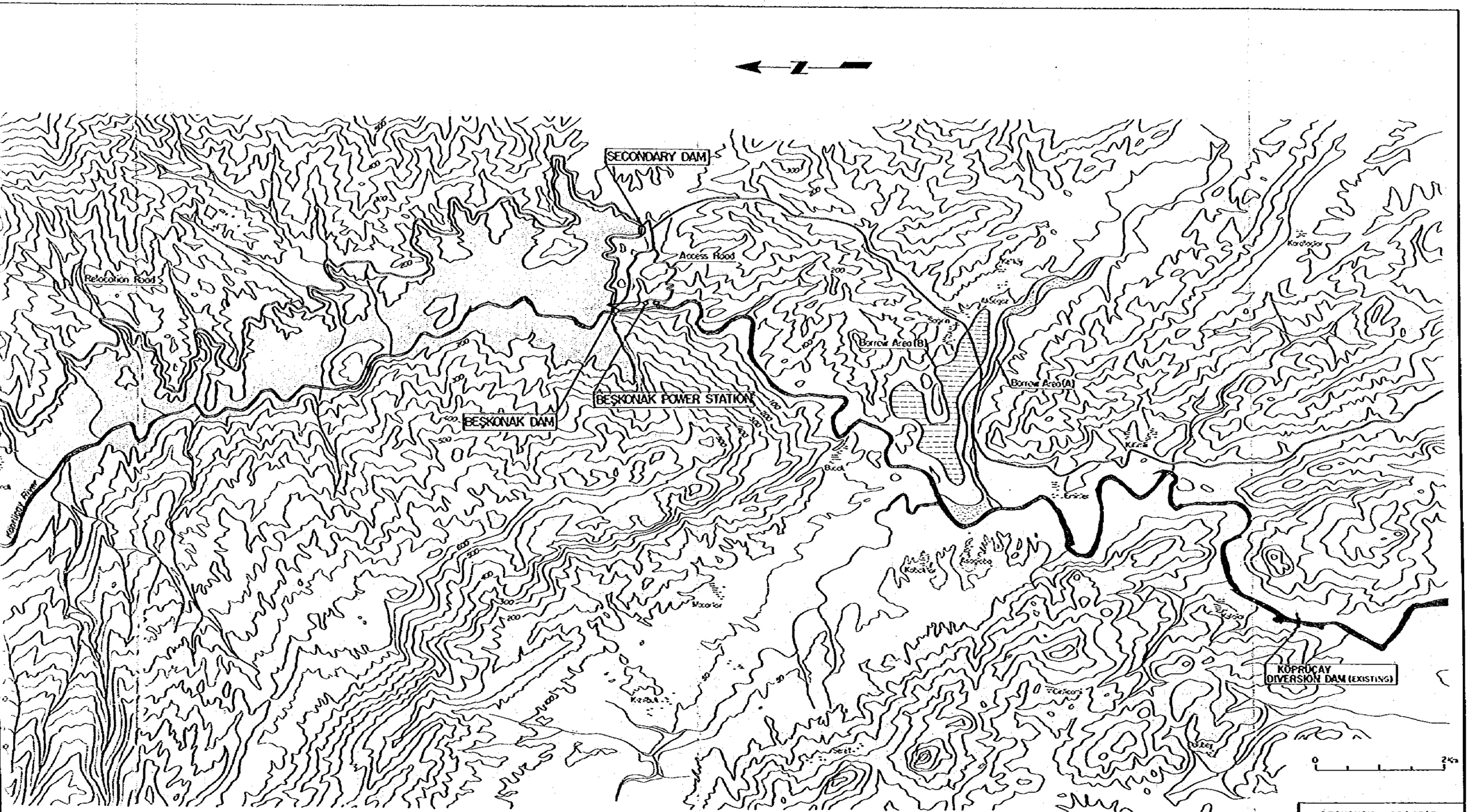



N
SECONDARY DAM
Relocation Road
Access Road
Borrow Area (B)
BEŞKONAK POWER STATION
BEŞKONAK DAM
Uluk Köprü Springs
Karasu River



BEŞKONAK PROJECT

GENERAL LAYOUT

Fig. 1 | Nov. 1983

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1. Introduction

The Beskonak Hydroelectric Power Development Project was incorporated in the long-range development plans of Turkey in 1975 as a part of the medium-scale hydroelectric power development program, for coping with the increasing power demand of the country. This Project is located at the downstream stretch of the Köprücay River in the southern part of Turkey, which flows into the Mediterranean Sea, and the installed capacity is to be 200 MW.

The Köprücay River is favored with an abundant runoff throughout the year, but there is a hydrogeological problem regarding the watertightness of the reservoir since the project site is located in a calcareous rock zone. Accordingly, the Köprücay River has been undeveloped with regard to hydroelectric power generation. Since 1965, DSI has been earnestly carrying out investigation works on the project site.

The field investigation works and studies executed in connection with the Beskonak Project are shown below.

1965 - 1971	Performance of investigation works consisting of boring, test adits and preparation of geological maps by DSI.
Oct. 1981	Preliminary survey by specialists dispatched by the Japanese Government.
Feb. 1982	First Field Survey by specialists dispatched by the Japanese Government.
Jun. 1982 -	Performance of additional investigation works by DSI consisting of boring, water quality investigations, dye tests and preparation of topographical maps.

Oct. 1982	Second Field Survey by specialists dispatched by the Japanese Government.
1983	Preparation of Feasibility Study.

2. General Features of the Beskonak Project

(1)	Location	Approx. 73 km NE of Antalya city, on the Köprüçay River
(2)	Catchment Area	1,980 km^2
(3)	Annual Inflow	2,635 x $10^6 m^3$
(4)	Reservoir	
	High water level	EL.155.0 m
	Low water level	EL.134.5 m
	Available drawdown	20.5 m
	Gross storage capacity	507 x $10^6 m^3$
	Effective storage capacity	275 x $10^6 m^3$
	Reservoir area	18.4 km^2
(5)	Power Generation	
	Installed capacity	200 MW
	Annual energy production	659.9 GWh
(6)	Dam	
	Type	Concrete arch-gravity dam
	Elevation of crest	EL.160.0 m
	Height of dam	165.0 m
	Length of crest	160.9 m
	Volume of dam	488,000 m^3
	Spillway	Dam center overflow type with radial gates Capacity : 4,500 m^3/sec Gate Width x Height 12.0 m x 10.0 m @4

	Diversion tunnel	Capacity : 1,250 m^3/sec Inner dia. x Length No.1 8 m x 385 m No.2 8 m x 416 m
(7)	Power Intake	
	Type	Reinforced concrete structure
	Gate	Width x Height No.1 7.3 m x 9.0 m No.2 4.3 m x 5.0 m
(8)	Headrace Tunnel	Inner dia. x Length No.1 7.3 m x 240.5 m No.2 4.3 m x 190.2 m
(9)	Penstock	Inner dia. x Length No.1 7.3 m - 4.0 m x 357.5 m No.2 4.3 m - 2.5 m x 408.6 m
(10)	Power Station	
	Type	Semi-underground type
(11)	Secondary Dam	
	Type	Rockfill dam with impervious core
	Elevation of crest	EL.161.0 m
	Height of dam	31.0 m
	Length of crest	237.0 m
	Volume of dam	160,600 m^3
(12)	Power Generation Facilities	
	Installed Capacity	200 MW (No.1 155 MW, No.2 45 MW)
	Turbine	
	Type	Vertical-shaft Francis
	Number of units	2
	Normal effective head	105.0 m
	Maximum discharge	(No.1) 167 m^3/sec; (No.2) 50 m^3/sec
	Standard output	158 MW; 47 MW

Revolving speed	167 rpm	300 rpm
Generator		
Type	3-phase, alternating current synchronous generator	
Number of units	2	
Output	172,000 kVA (No.1) 51,000 kVA (No.2)	
Voltage	14.4 kV	
Power factor	90% (lagging)	
Frequency	50 Hz	
Revolving speed	167 rpm (No.1) 300 rpm (No.2)	
Main transformer		
Type	Outdoor, single phase, oil-immersed, forced-oil cooled with forced-air cooled	
Number of units	3	
Capacity	75,000 kVA	
Voltage	$380/\sqrt{3}/14.4$ kV	
Frequency	50 Hz	
Switchyard equipment		
Nominal voltage	380 kV	
Type of circuit breaker	Outdoor, AC, 3-phase, gas blast circuit breaker	
(13) transmission Line		
Number of circuit	1	
Nominal voltage	380 kV	

3. Watertightness of the Reservoir

The Köprücay Conglomerate is widely distributed at the right bank of the reservoir. Since this Köprücay Conglomerate is calcareous, it has been subjected to solution by groundwater and strata of high permeability has been constituted. The groundwater levels at both banks of the dam site are lower than the river water level, with a trend of quickly fluctuating with variation of the latter, indicating low watertightness on the part of the Köprücay Conglomerate. Therefore, emphasis was placed in the Feasibility Study of this Project on whether or not the watertightness of the reservoir could be secured.

With regard to the surroundings of the reservoir area and the dam site, the watertightness of the reservoir was studied by surface reconnaisance, geological structure, water quality analyses of river water and spring water, chemical analyses of rocks, distribution of karstification, etc. Further, seepage flow analyses by the finite element method were performed on the basis of the data (permeability test results, boring logs, etc.), which were obtained through investigation works carried out by DSI, while numerical studies were also made regarding leakage volume from the reservoir.

As a result of these studies, it was decided to provide a grout curtain of total length of approximately 2 km and area of approximately 380,000 m^2 in order to secure watertightness of the reservoir.

It is considered that a certain degree of leakage from the reservoir cannot be avoided even with this grout curtain, but it is judged this will not be a hindrance from the standpoints of safety of structures and function of the reservoir.

Further, regarding the reservoir watertightness, it will be absolutely necessary to have a more accurate hydrogelogical grasp of the project site. Accordingly, it is recommended for further additional investigation works to be carried out at the final

design stage and for qualitative and quantitative studies to be made regarding the range of the curtain grouting.

The geology of the project site is shown in Fig. 6 and the curtain grouting plan in Fig. 7.

4. Construction Cost

The construction cost of the Project as of March 1982 is as follows:

	Foreign Currency	Local Currency	Total
Total TL (x 10^6)	8,010	27,468	35,478
(US$ x 10^6)	(54)	(186)	(240)

The breakdown of the construction cost is shown in Table-1 and the fund requirements by year in Table-2.

5. Construction Schedule

DSI projects start-up of the Beskonak power station for 1993, and from the viewpoint of maintaining the balance of demand and supply of electric power, it is judged this timing will be reasonable.

It is thought that the construction works for the Project, including preparatory works, will require 72 months. The construction schedule is shown in Fig. 10.

6. Economic Evaluation

The results of the economic analysis of the Project are shown in the following.

Financial Internal Rate of Return (FIRR) : 9.4%

Economic Internal Rate of Return (EIRR) : 12.9%

7. Kisik Hydroelectric Power Development Project

The Kisik Project, which is located approximately 16 km downstream of the Beskonak Project, serves as a regulating pondage for the Beskonak Project, with an installed capacity of 16 MW.

Since the Kisik Project will conflict with the irrigation program for the downstream area of the Köprücay River already being carried out by DSI, it was judged that there is little possibility of development right now.

The outline of the Kisik Project is shown in Fig. 12.

Table 1 Estimated Construction Costs

(Unit: 1,000 TL)

Item	Domestic Currency	Foreign Currency	Total
Civil Works			
Care of River	1,184,100	-	1,184,100
Dams	3,894,600	-	3,894,600
Curtain Grouting	3,480,800	-	3,480,800
Water Way	1,104,000	-	1,104,000
Power Station	623,900	-	623,900
Access and Relocation Road	1,658,200	-	1,658,200
Camp Facility	100,000	-	100,000
Preparatory Works	1,204,500	-	1,204,500
Subtotal	13,250,100	-	13,250,100
Contingency (15%)	1,987,500	-	1,987,500
Total	15,237,600	-	15,237,600
Hydraulic Equipment	1,445,700	325,000	1,770,700
Electro-Mechanical Equipment	889,000	5,586,000	6,475,000
Transmission Line	187,500	102,500	290,000
Project Controlling	2,664,000	902,000	3,566,000
Land Acquisition	1,296,500	-	1,296,500
Total	21,720,300	6,915,500	28,635,800
Interest during Construction Period	5,747,700	1,094,500	6,842,200
Grand Total	27,468,000	8,010,000	35,478,000

Table 2 Fund Requirement in Each Year

(Unit: 1,000 TL)

Description	1st Year		2nd Year		3rd Year	
	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
Civil Works	864,300	-	2,482,000	-	3,568,000	-
Hydraulic Works	-	-	-	-	-	-
Electro-mechanical Equipment	-	-	-	-	-	559,000
Transmission Line	-	-	-	-	18,800	20,500
Project Controlling	129,600	-	372,300	-	538,000	85,900
Land Acquisition	1,236,500	-	-	-	-	-
Subtotal	2,290,400	-	2,854,300	-	4,124,800	665,400
Interest during Construction Period	108,800	-	353,300	-	684,800	26,700
Grand Total	2,399,200	-	3,207,600	-	4,809,600	693,100

Description	4th Year		5th Year		6th Year		Total	
	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
Civil Works	3,459,600	—	3,203,400	—	1,620,300	—	15,237,600	—
Hydraulic Works	289,100	32,500	440,500	260,000	716,200	32,500	1,445,700	325,000
Electro-mechanical Equipment	351,000	2,234,000	269,000	2,234,00	269,000	559,000	889,000	5,586,000
Transmission Line	150,000	41,000	18,700	41,00	—	—	187,500	102,500
Project Controlling	643,500	346,100	589,700	380,30	390,900	88,700	2,664,000	902,000
Land Acquisition	—	—	—	—	—	—	1,296,500	—
Subtotal	4,933,200	2,653,600	4,521,300	2,915,30	2,936,300	680,200	21,720,300	6,915,500
Interest during Construction Period	1,115,100	159,400	1,564,300	382,20	1,921,400	526,200	5,747,700	1,094,500
Grand Total	6,048,300	2,813,000	6,085,600	3,297,50	4,917,700	1,206,400	27,468,000	8,010,000

Fig. 2 Demand Forecast : Power

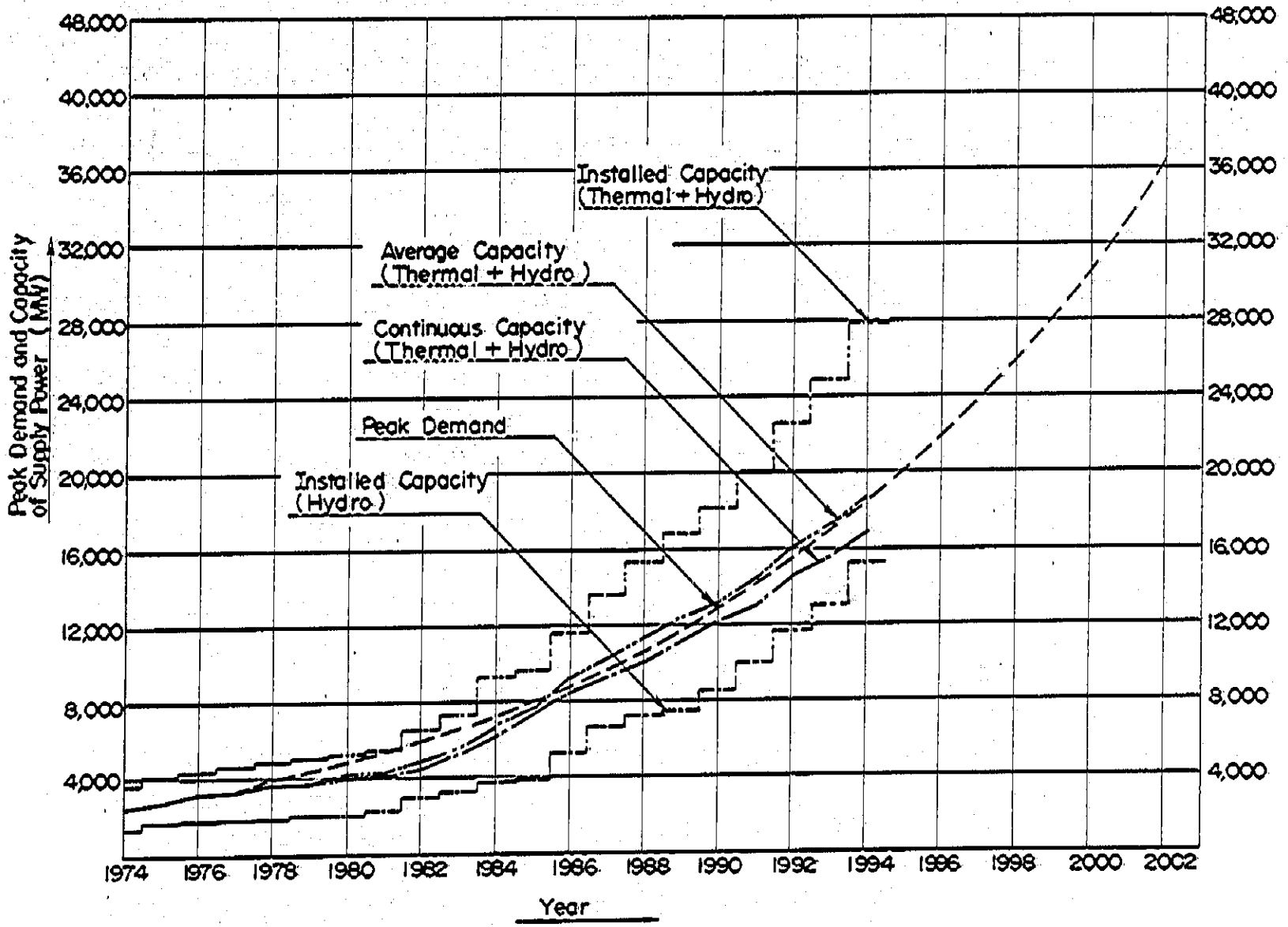


Fig. 3 Demand Forecast : Energy

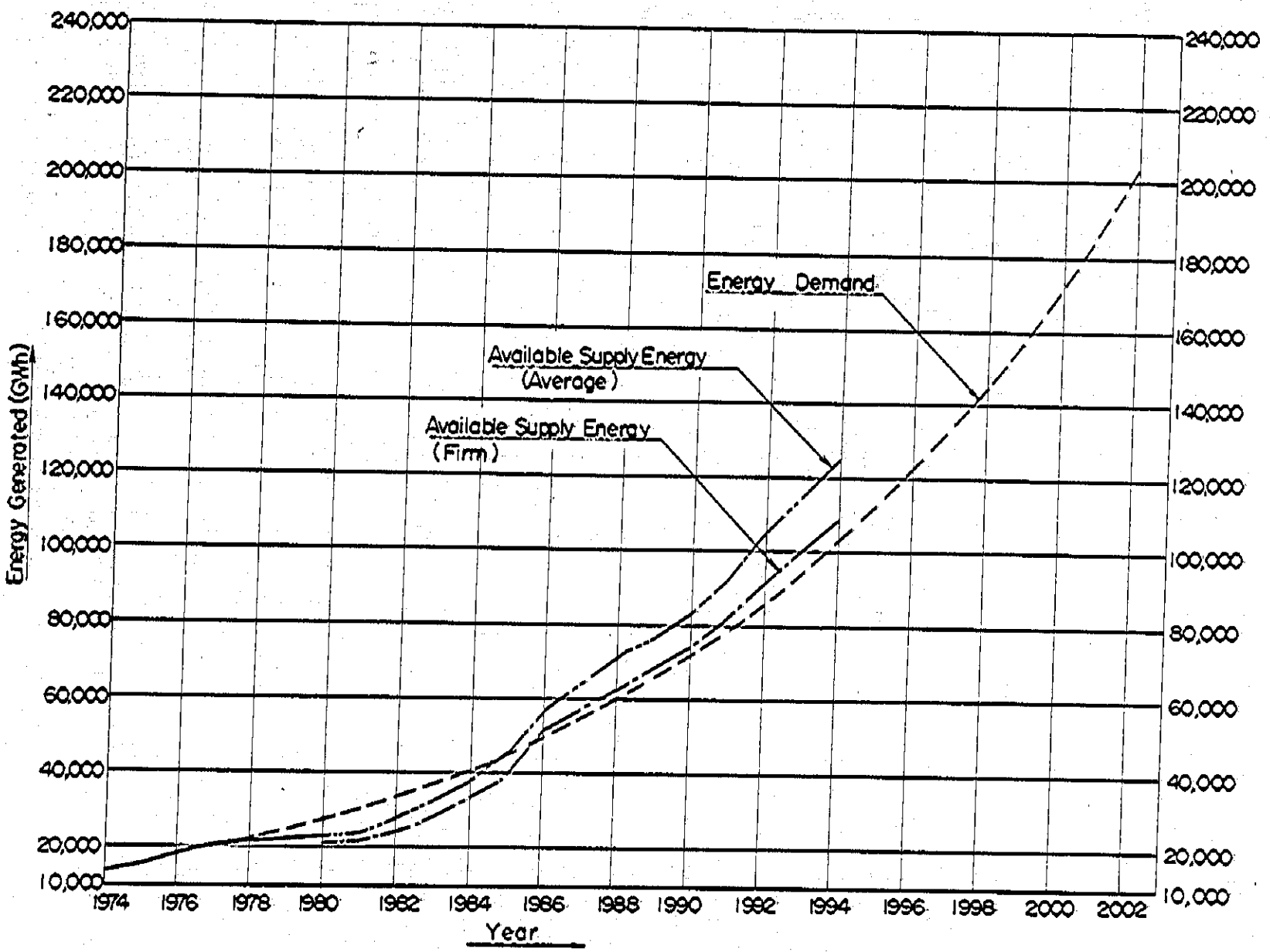


Fig. 4 Probable Maximum Flood Hydrograph

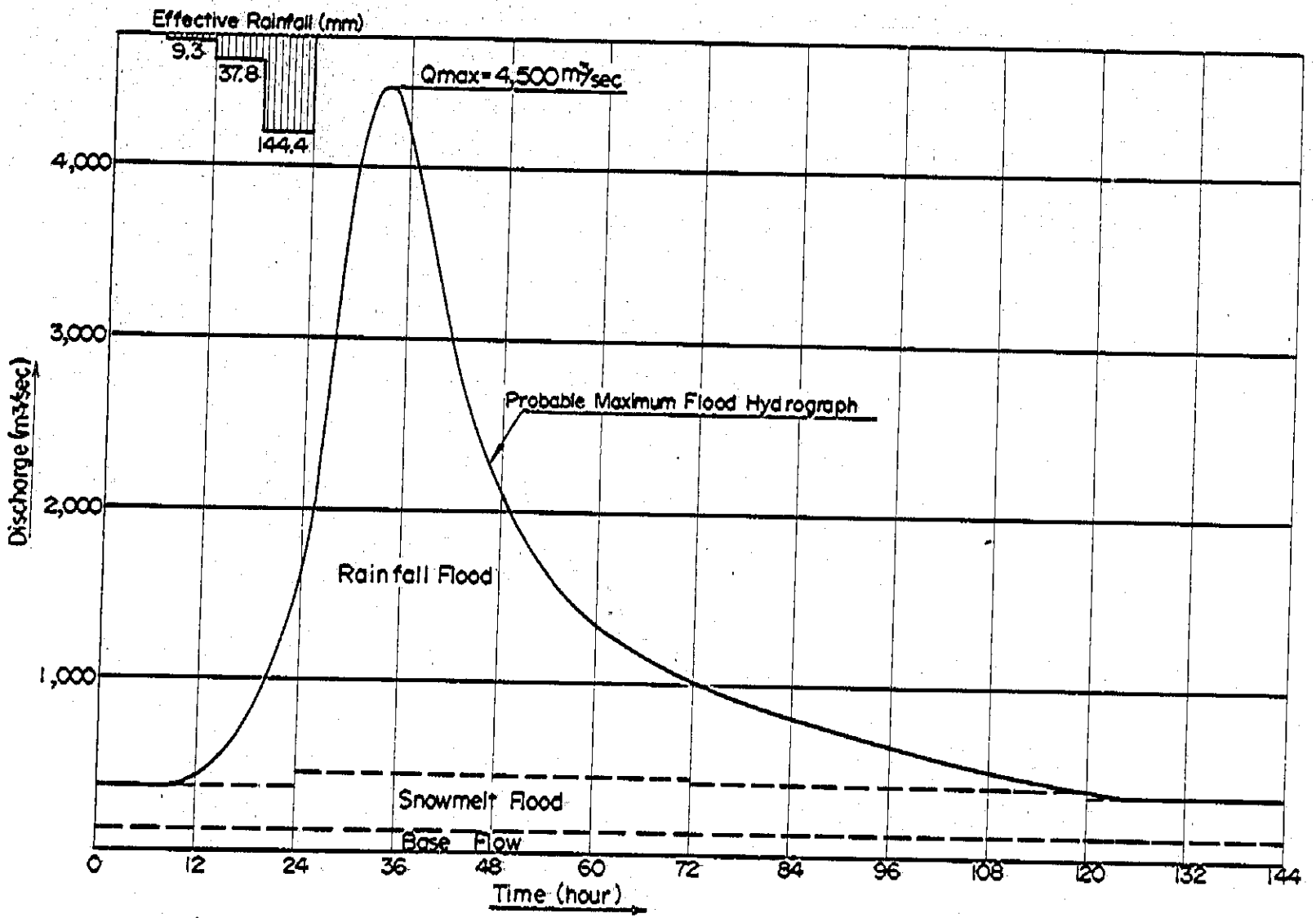


Fig. 5 Monthly Energy Production of Beşkonak P.S (1)

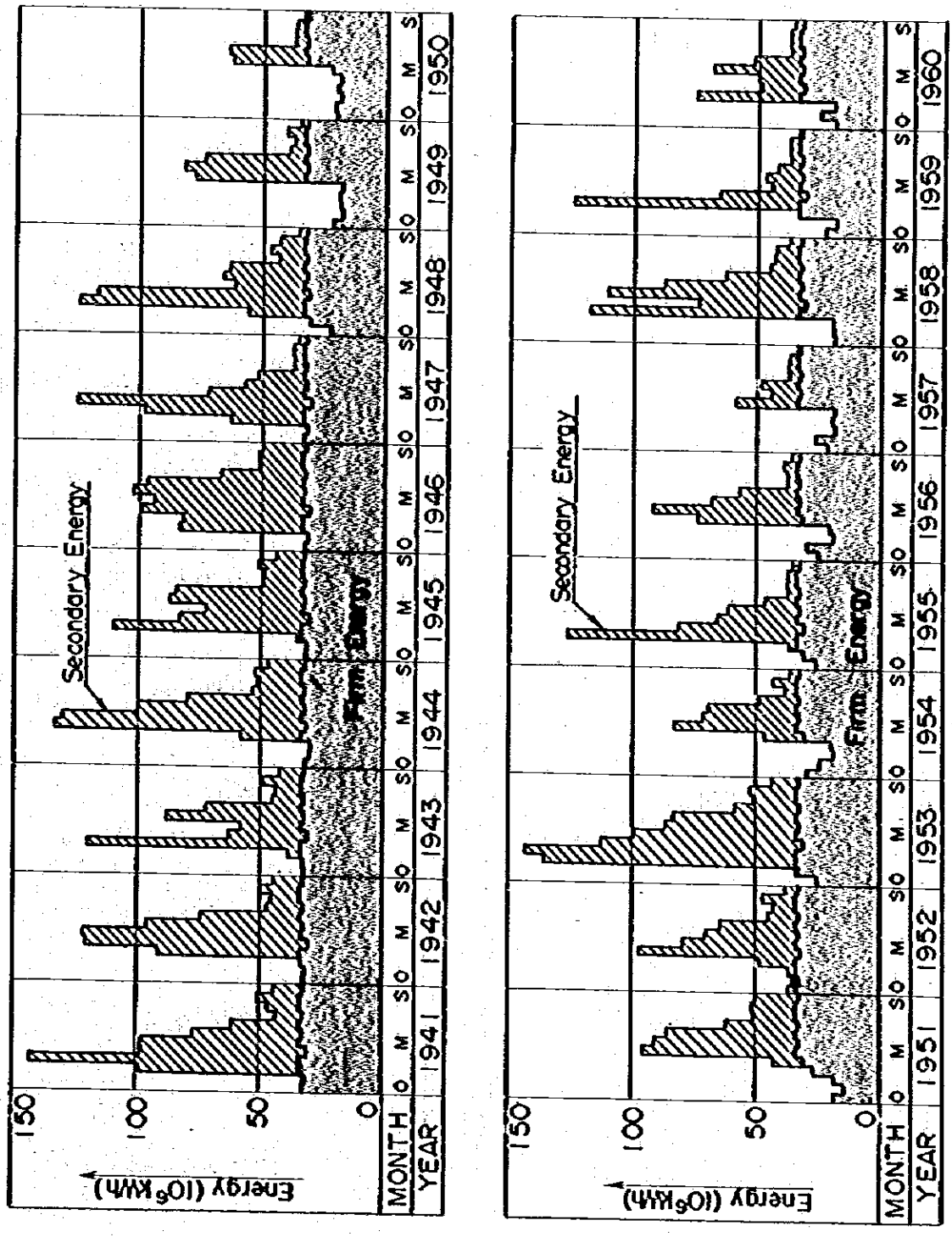
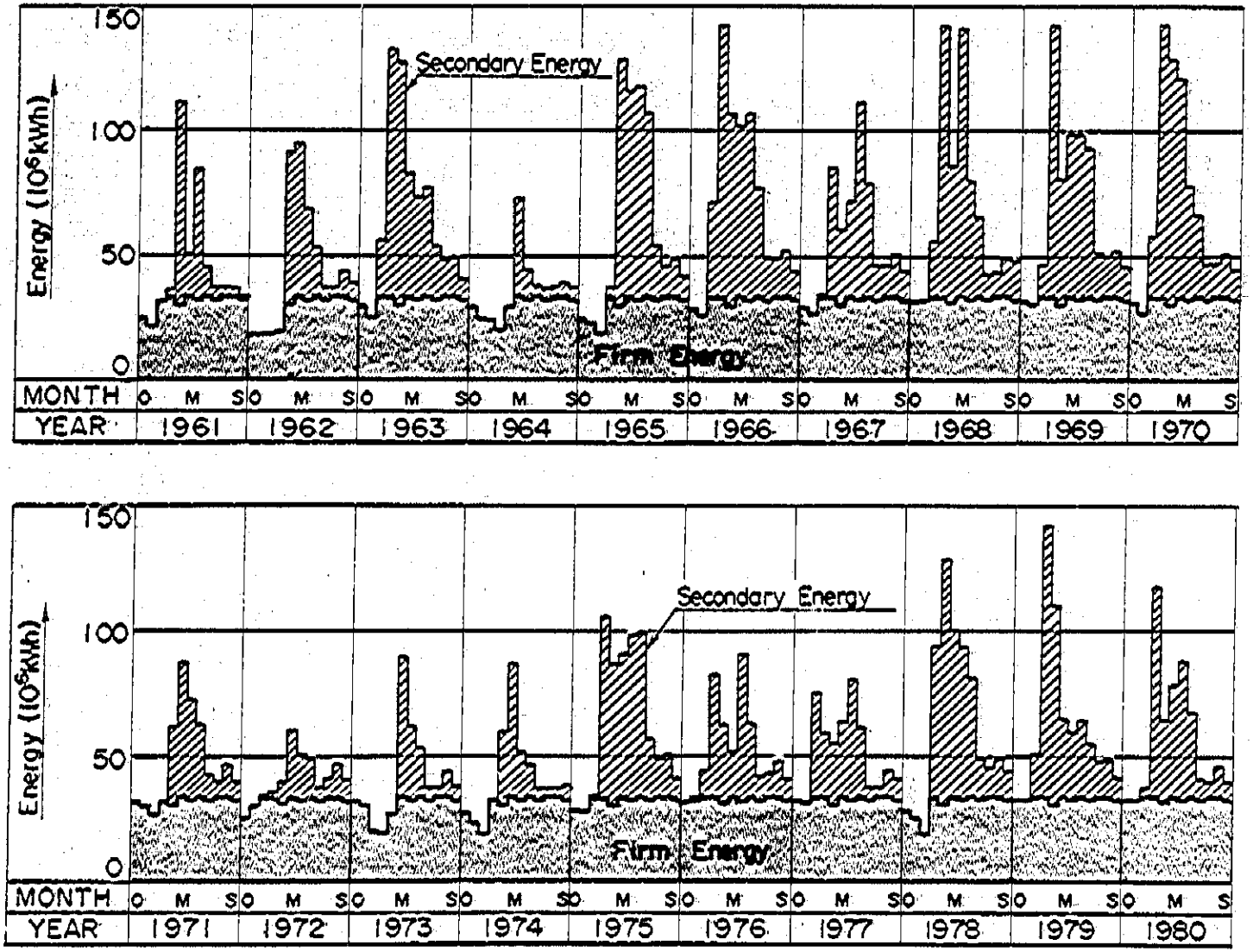
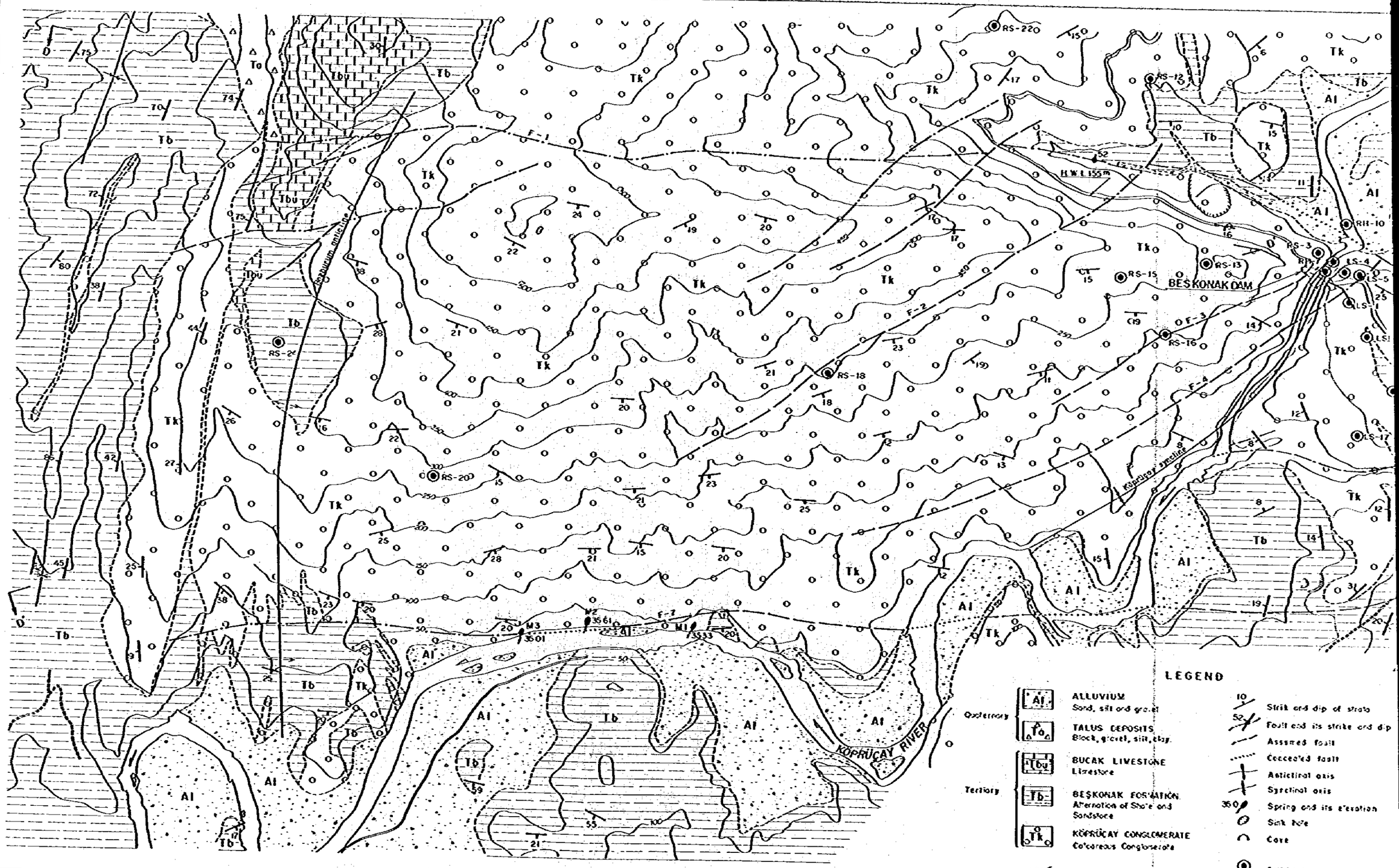
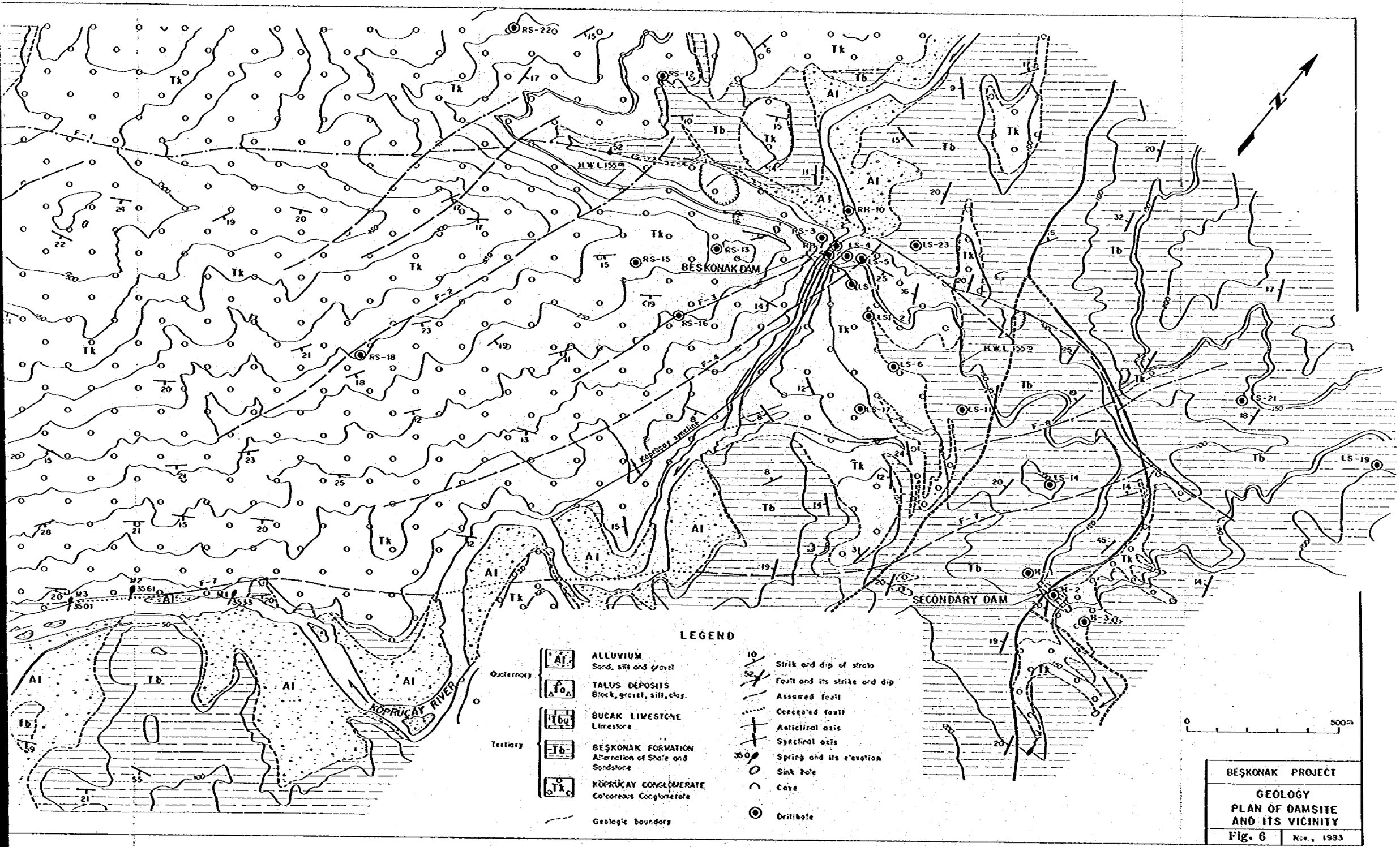


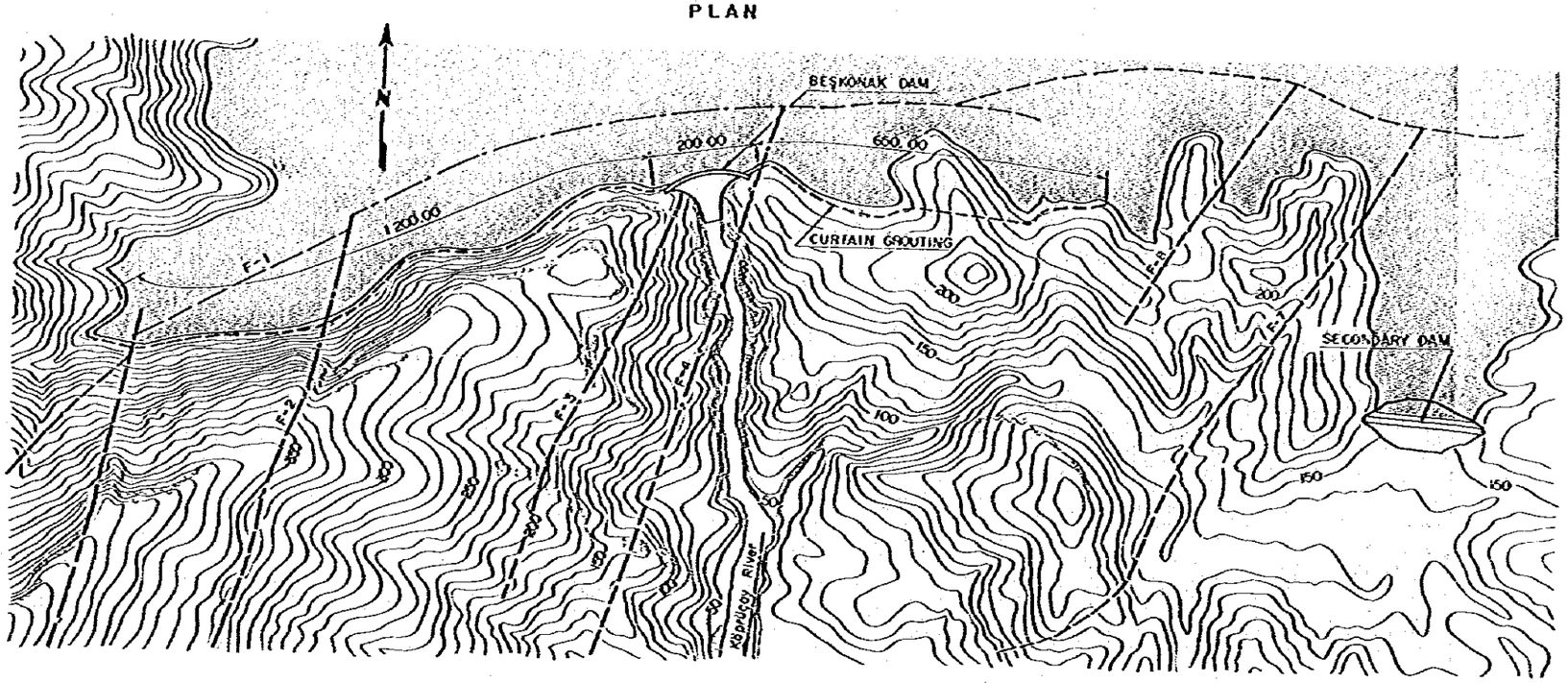
Fig. 5 Monthly Energy Production of Beşkonak P.S (2)




RS-22
RS-12
RS-3
RS-13
RS-15
RS-16
RS-18
RS-20
RS-17
RH-10
LS-4
LS-5
LS
BESKONAK DAM
H.W.L 155m
F-1
F-2
F-3
F-4
Köprüçay syncline
Beşkonak anticline
KÖPRÜÇAY RIVER
M1
M2
M3
3533
3561
3601
Tb
Tbu
Tk
To
Al
LEGEND
Quaternary
ALLUVIUM
Sand, silt and gravel
TALUS DEPOSITS
Block, gravel, silt, clay
Tertiary
BUCAK LIMESTONE
Limestone
BEŞKONAK FORMATION
Alternation of Shale and Sandstone
KÖPRÜÇAY CONGLOMERATE
Calcareous Conglomerate
Geologic boundary
Strik and dip of strata
Fault and its strike and dip
Assumed fault
Concealed fault
Anticlinal axis
Synclinal axis
Spring and its elevation
Sink hole
Cave
Drillhole

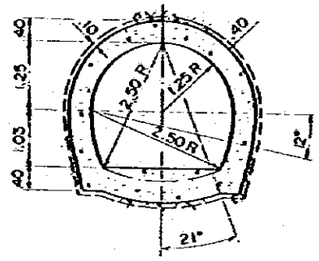

RS-220
RS-12
RS-3
RS-13
RS-15
RS-16
RS-18
RH-10
RH-7
LS-4
LS-5
LS-23
LS-6
LS-11
LS-17
LS-14
LS-21
LS-19
H-1
H-2
H-3
BEŞKONAK DAM
SECONDARY DAM
H.W.L 155m
H.W.L 155m
Köprüçay syncline
KÖPRÜÇAY RIVER
F-1
F-2
F-3
F-7
F-8
Tk
Tb
Al
LEGEND
Quaternary
Tertiary
ALLUVIUM
Sand, silt and gravel
TALUS DEPOSITS
Block, gravel, silt, clay.
BUCAK LIMESTONE
Limestone
BEŞKONAK FORMATION
Alternation of Shale and Sandstone
KÖPRÜÇAY CONGLOMERATE
Calcareous Conglomerate
Geologic boundary
Strik and dip of strata
Fault and its strike and dip
Assumed fault
Concealed fault
Anticlinal axis
Synclinal axis
Spring and its elevation
Sink hole
Cave
Drillhole
0
500m
BEŞKONAK PROJECT
GEOLOGY
PLAN OF DAMSITE
AND ITS VICINITY
Fig. 6
Nov., 1983

PLAN

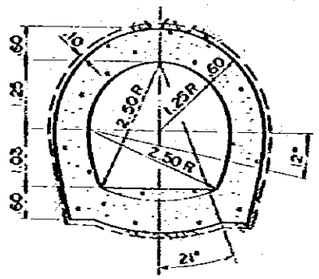


SECTION OF GROUTING GALLERY

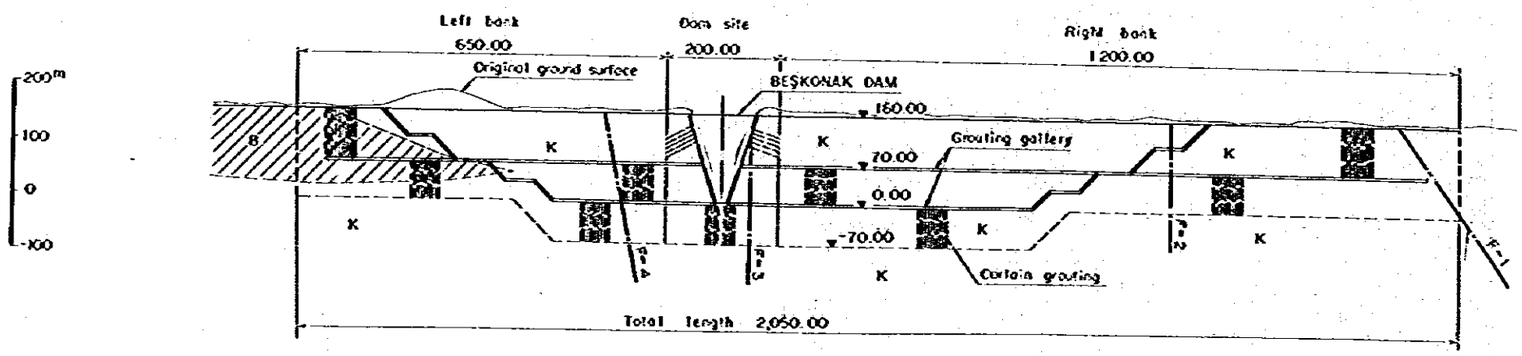
TYPE I
(Upper stage)



TYPE II
(Lower stage)



PROFILE



0 5m
(Section of grouting gallery)

0 500m
(Plan, Profile)

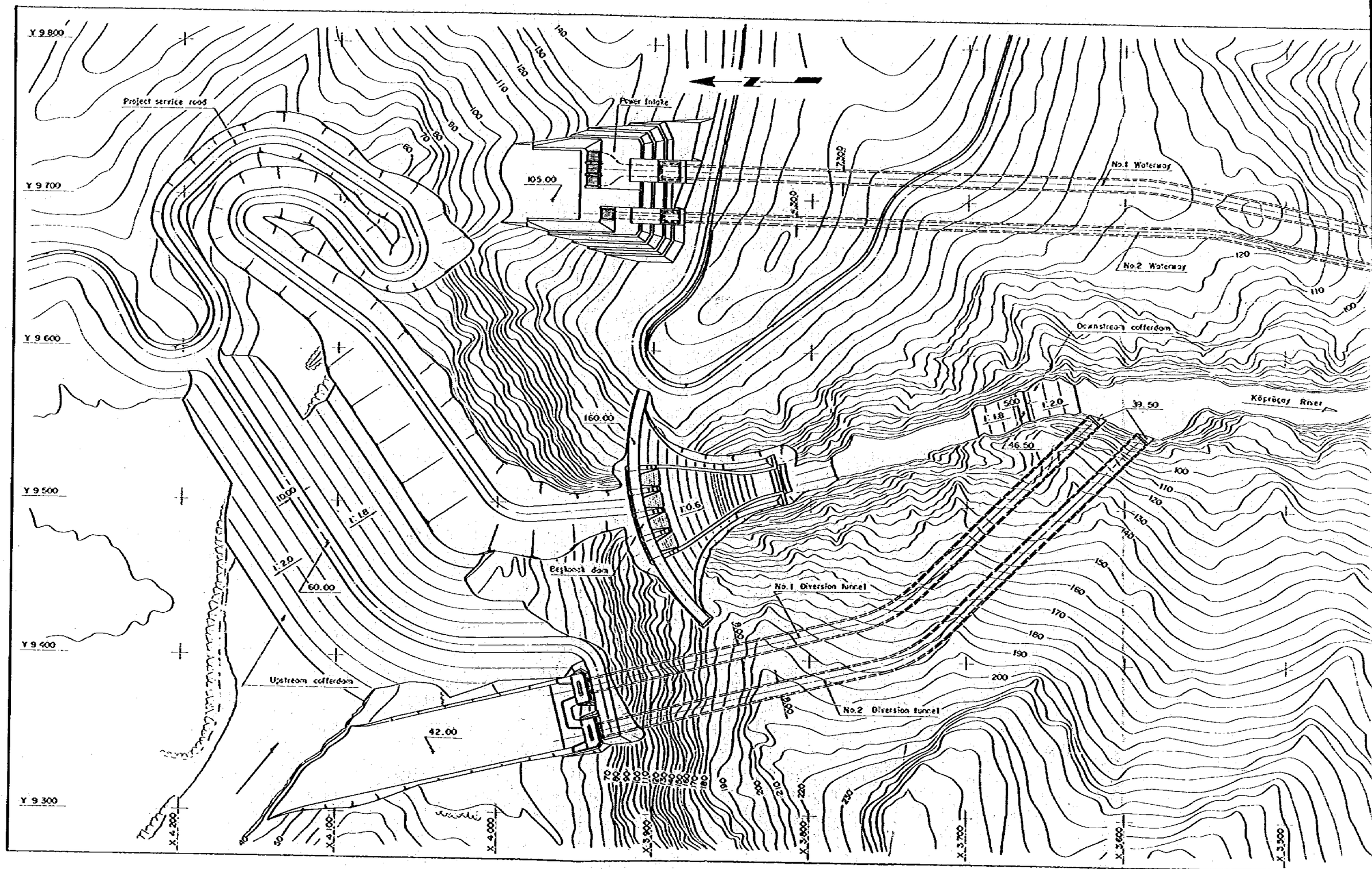
Legend

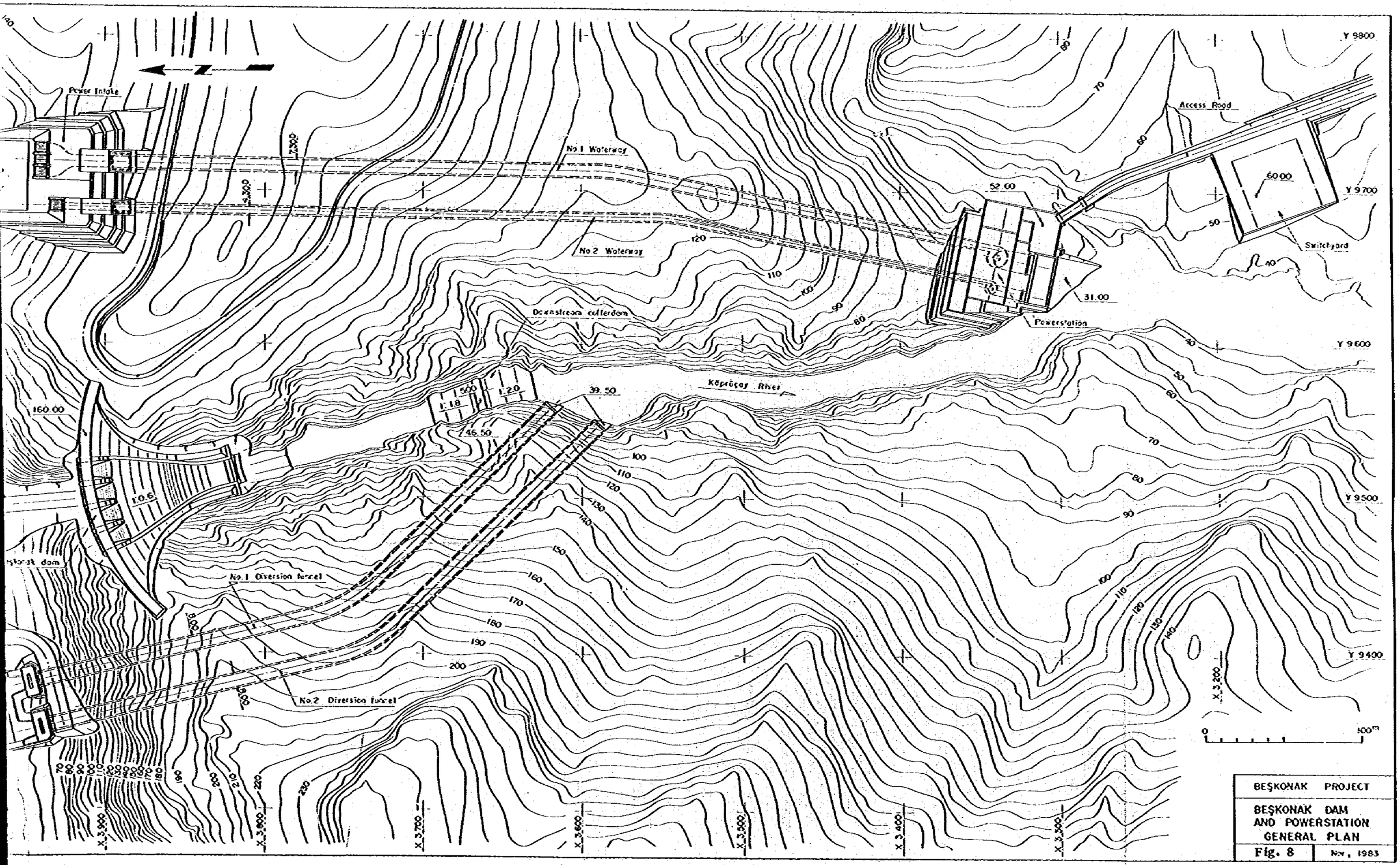
K: Conglomerate

B: Beşkonak formation

F: Fault zone

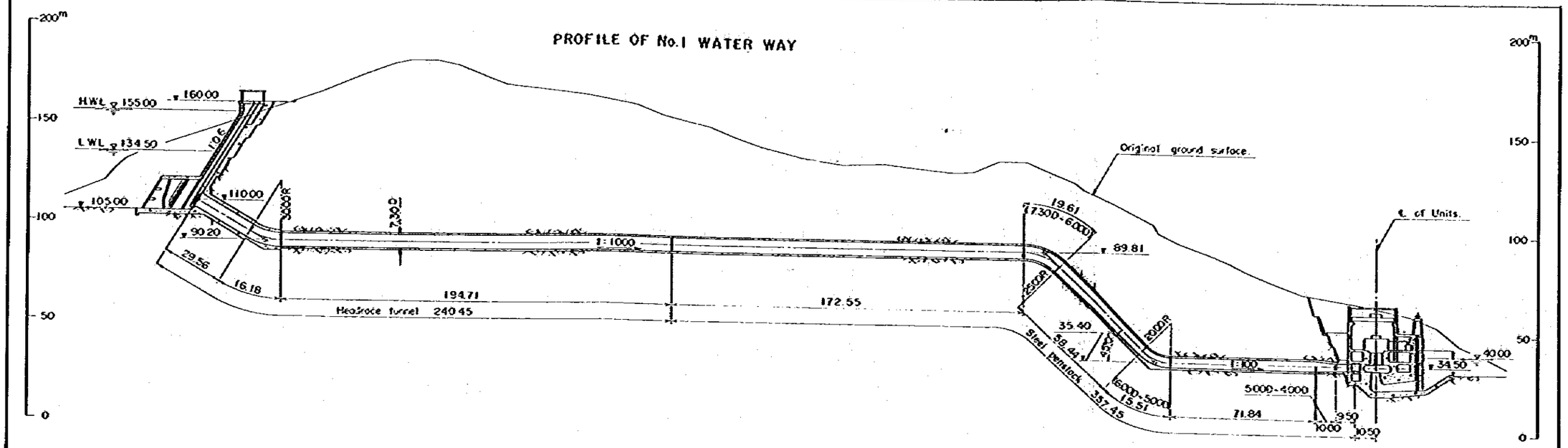
BEŞKONAK PROJECT	
BEŞKONAK RESERVOIR GROUT CURTAIN COARSES GENERAL	
Fig. 7	Nov., 1983


Y 9 800
Y 9 700
Y 9 600
Y 9 500
Y 9 400
Y 9 300
Project service road
Power intake
105.00
No.1 Waterway
No.2 Waterway
Downstream cofferdam
Köprüçay River
39.50
46.50
160.00
1:0.6
1:1.8
1:2.0
60.00
100.00
Reservoir dam
No.1 Diversion tunnel
No.2 Diversion tunnel
Upstream cofferdam
42.00
X 4 200
X 4 100
X 4 000
X 3 900
X 3 800
X 3 700
X 3 600
X 3 500

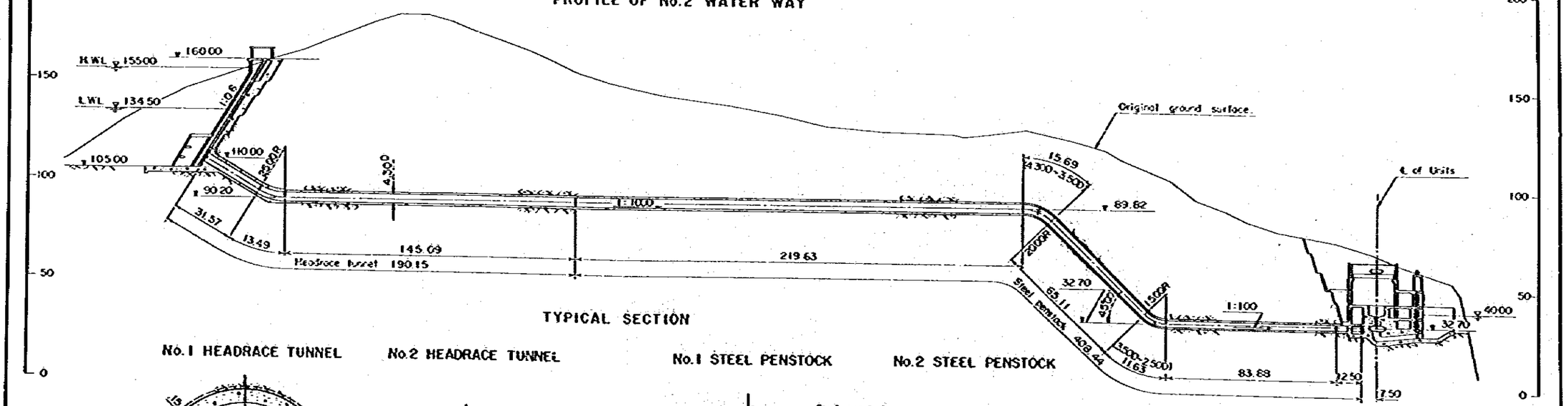


BEŞKONAK PROJECT	
BEŞKONAK DAM AND POWERSTATION GENERAL PLAN	
Fig. 8	Nov., 1983

PROFILE OF No.1 WATER WAY

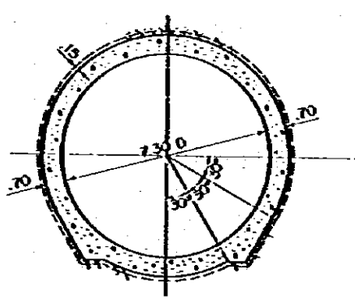


PROFILE OF No.2 WATER WAY

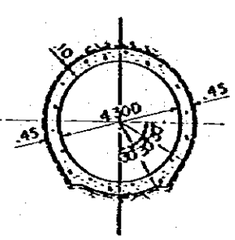


TYPICAL SECTION

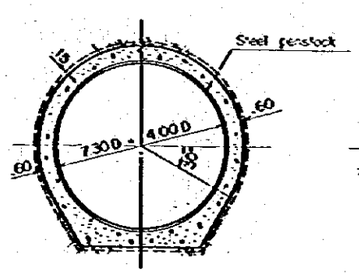
No.1 HEADRACE TUNNEL



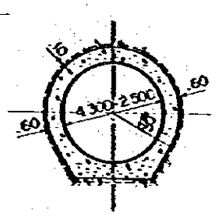
No.2 HEADRACE TUNNEL



No.1 STEEL PENSTOCK



No.2 STEEL PENSTOCK



0 10m (Typical section)

0 100m (Profile)

BEŞKONAK PROJECT	
WATER WAY PROFILE AND SECTIONS	
Fig. 9	Nov, 1983

Fig. 10 Transmission System of Antalya Region (in 1982)

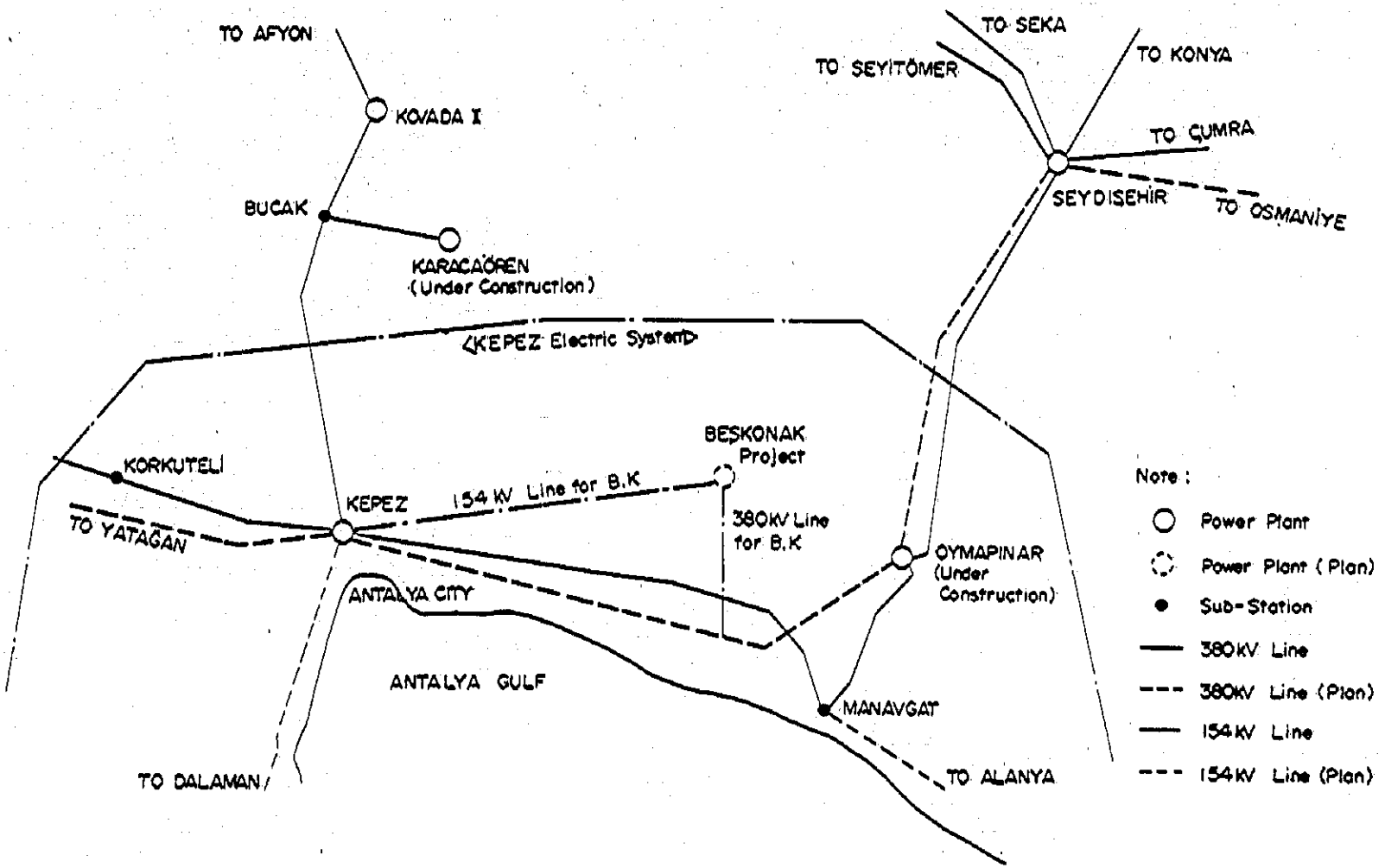
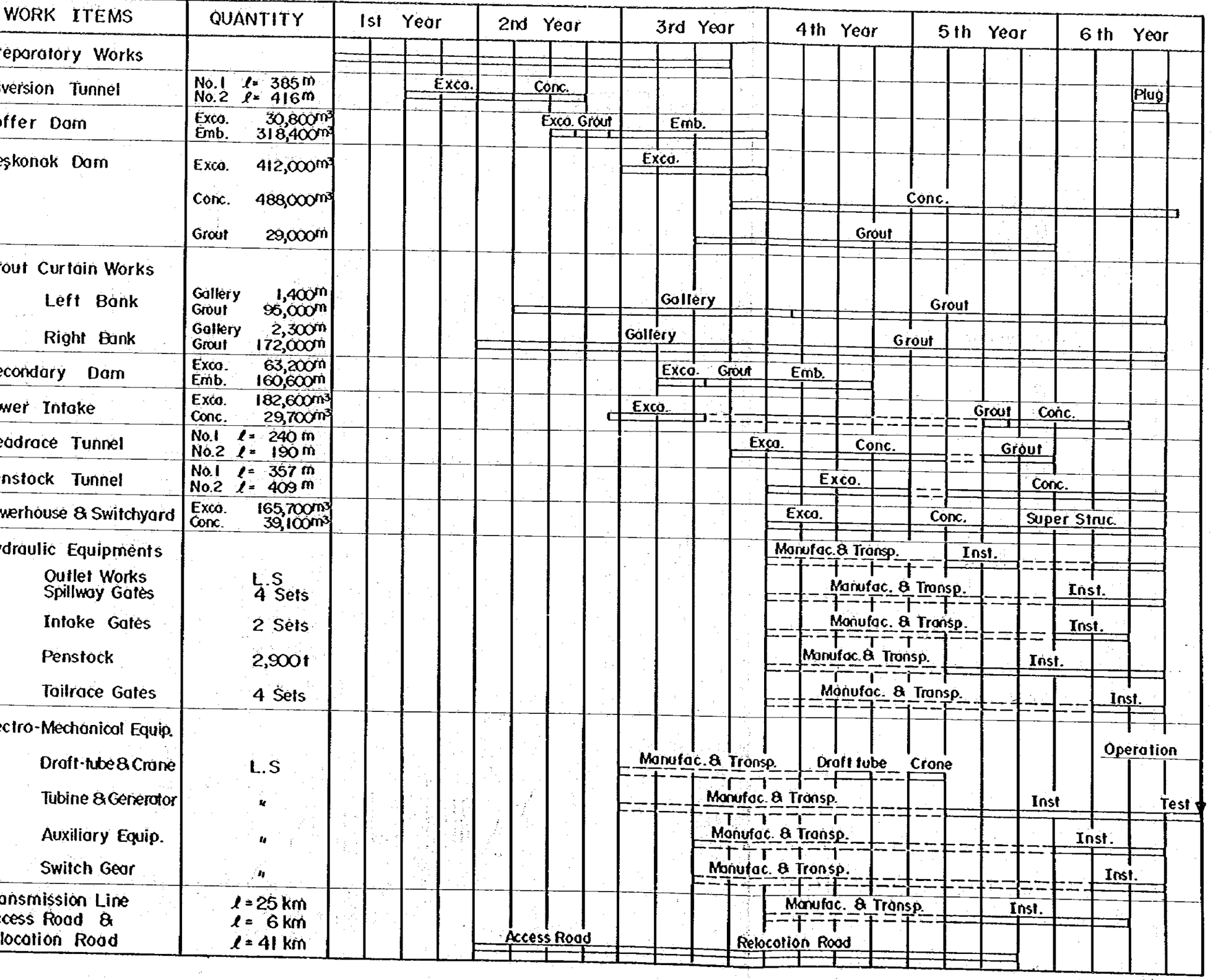
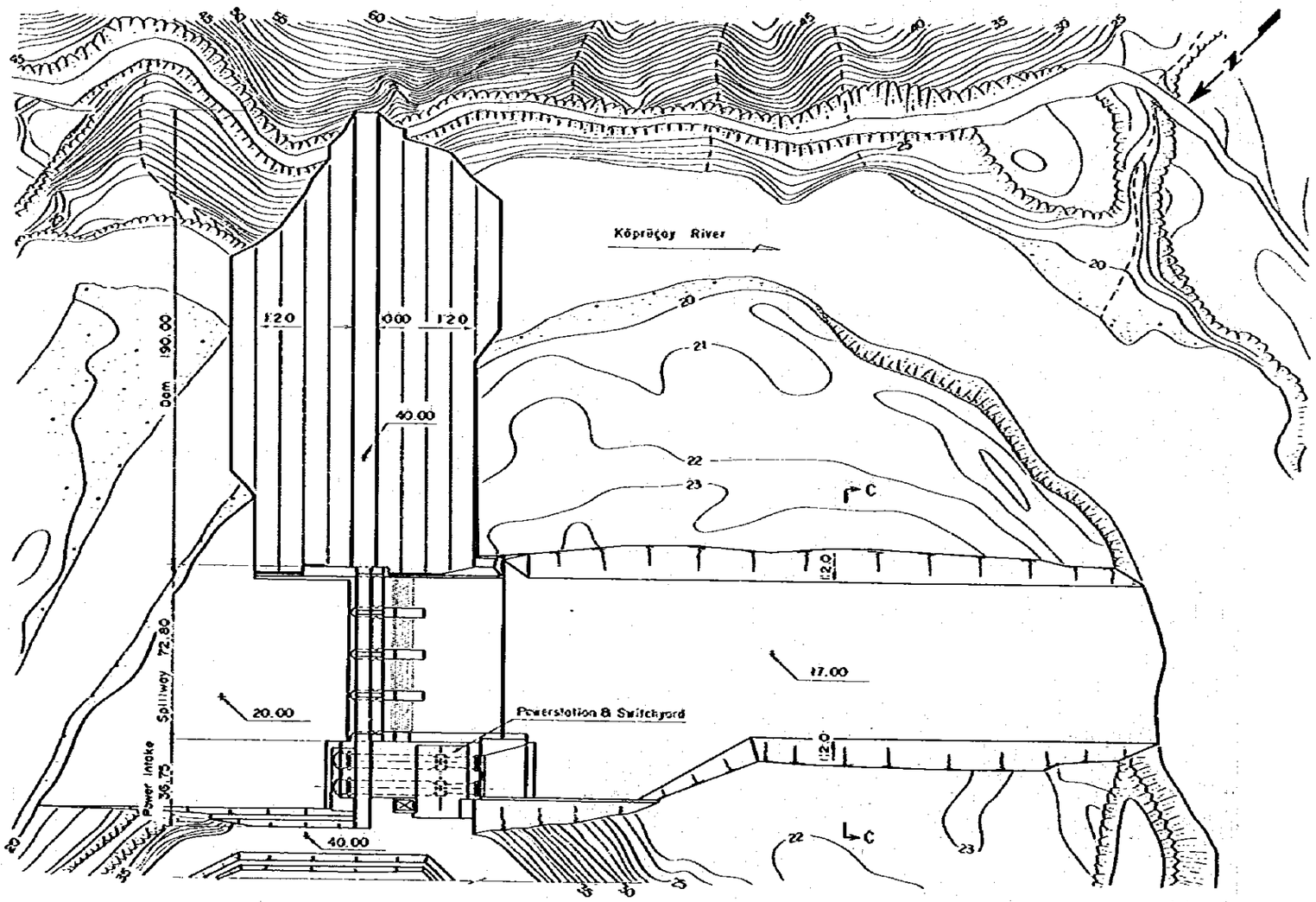


Fig. 11 Construction Schedule

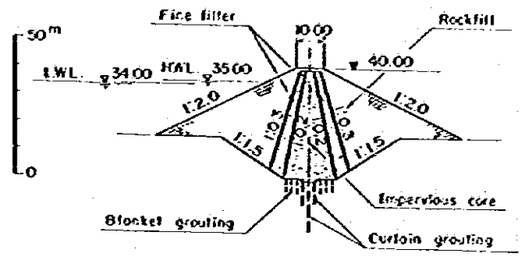
WORK ITEMS	QUANTITY
Preparatory Works	
Diversion Tunnel	No.1 ℓ= 385 m No.2 ℓ= 416 m
Coffer Dam	Exca. 30,800 m³ Emb. 318,400 m³
Beşkonak Dam	Exca. 412,000 m³ Conc. 488,000 m³ Grout 29,000 m
Grout Curtain Works	
Left Bank	Gallery 1,400 m Grout 95,000 m
Right Bank	Gallery 2,300 m Grout 172,000 m
Secondary Dam	Exca. 63,200 m³ Emb. 160,600 m³
Power Intake	Exca. 182,600 m³ Conc. 29,700 m³
Headrace Tunnel	No.1 ℓ= 240 m No.2 ℓ= 190 m
Penstock Tunnel	No.1 ℓ= 357 m No.2 ℓ= 409 m
Powerhouse & Switchyard	Exca. 165,700 m³ Conc. 39,100 m³
Hydraulic Equipments	
Outlet Works Spillway Gates	L.S 4 Sets
Intake Gates	2 Sets
Penstock	2,900 t
Tailrace Gates	4 Sets
Electro-Mechanical Equip.	
Draft-tube & Crane	L.S
Tubine & Generator	"
Auxiliary Equip.	"
Switch Gear	"
Transmission Line Access Road & Relocation Road	ℓ = 25 km ℓ = 6 km ℓ = 41 km



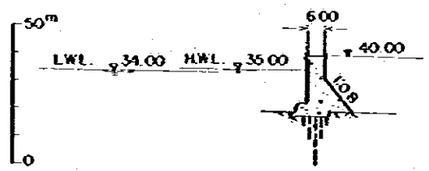
PLAN



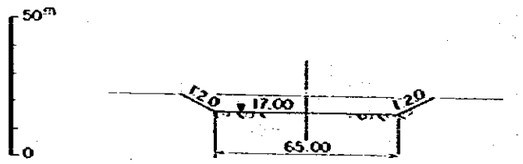
SECTION A - A



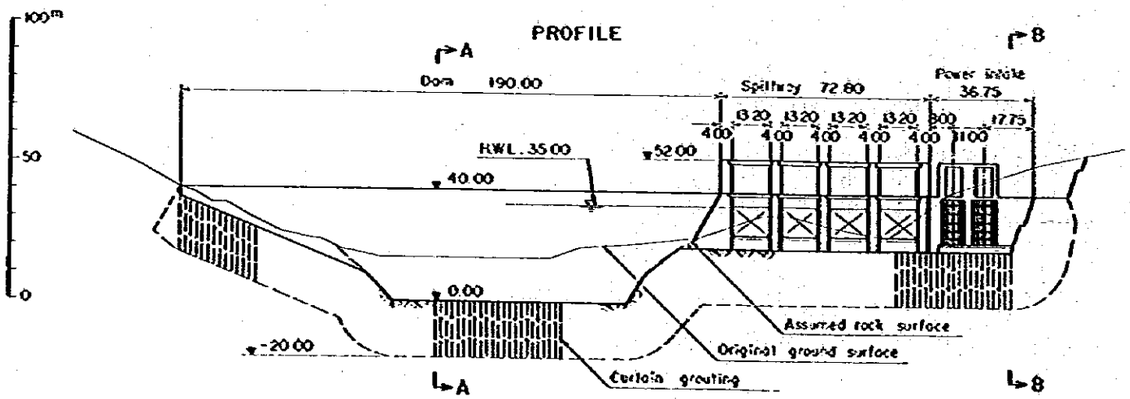
SECTION B - B



SECTION C - C



PROFILE



BEŞKONAK PROJECT	
KISIK DAM AND POWERSTATION GENERAL (ALTERNATIVE)	
Fig. 12	Nov., 1983