JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF TURKEY
MINISTRY OF ENERGY AND NATURAL RESOURCES
GENERAL DIRECTORATE OF ELECTRICAL SURVEY
AND DEVELOPMENT ADMINISTRATION

FEASIBILITY STUDY
ON
ÇORUH-BERTA HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT

DECEMBER 1997

ELECTRIC POWER DEVELOPMENT CO., LTD.
PACIFIC CONSULTANTS INTERNATIONAL

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF TURKEY
MINISTRY OF ENERGY AND NATURAL RESOURCES
GENERAL DIRECTORATE OF ELECTRICAL SURVEY
AND DEVELOPMENT ADMINISTRATION

FEASIBILITY STUDY ON ÇORUH-BERTA HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT

DECEMBER 1997

ELECTRIC POWER DEVELOPMENT CO., LTD.
PACIFIC CONSULTANTS INTERNATIONAL

PREFACE

In response to a request from the Government of Republic of Turkey, the Government of Japan decided to conduct the Technical Cooperation for Feasibility Study on Çoruh-Berta Hydroelectric Power Development Project of Republic of Turkey and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent a study team led by Mr. Taisuke HASEGAWA of Electric Power Development Co., Ltd. to Republic of Turkey six times from November 1995 to October 1997.

The team held discussions with the officials concerned of the Government of Republic of Turkey, and conducted related field surveys. After returning to Japan, the team conducted further studies and complied the final results in this report.

I hope this report will contribute to the promotion of the plan and to enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of Republic of Turkey for their close cooperation throughout the study.

December 1997

Kimio FUJITA
President
Japan International Cooperation Agency

December 1997

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Fujita

Letter of Transmittal

We are pleased to submit to you the feasibility report on the Çoruh-Berta Hydroelectric Power Development Project of the Republic of Turkey. The report contains the advice and suggestions of authorities concerned of the Government of Japan and your Agency as well as the formulation of the above mentioned project. Also included are comments made by the Electrical Survey and Development Administration of the Republic of Turkey during technical discussions on the draft report which were held in ANKARA of the Republic of Turkey.

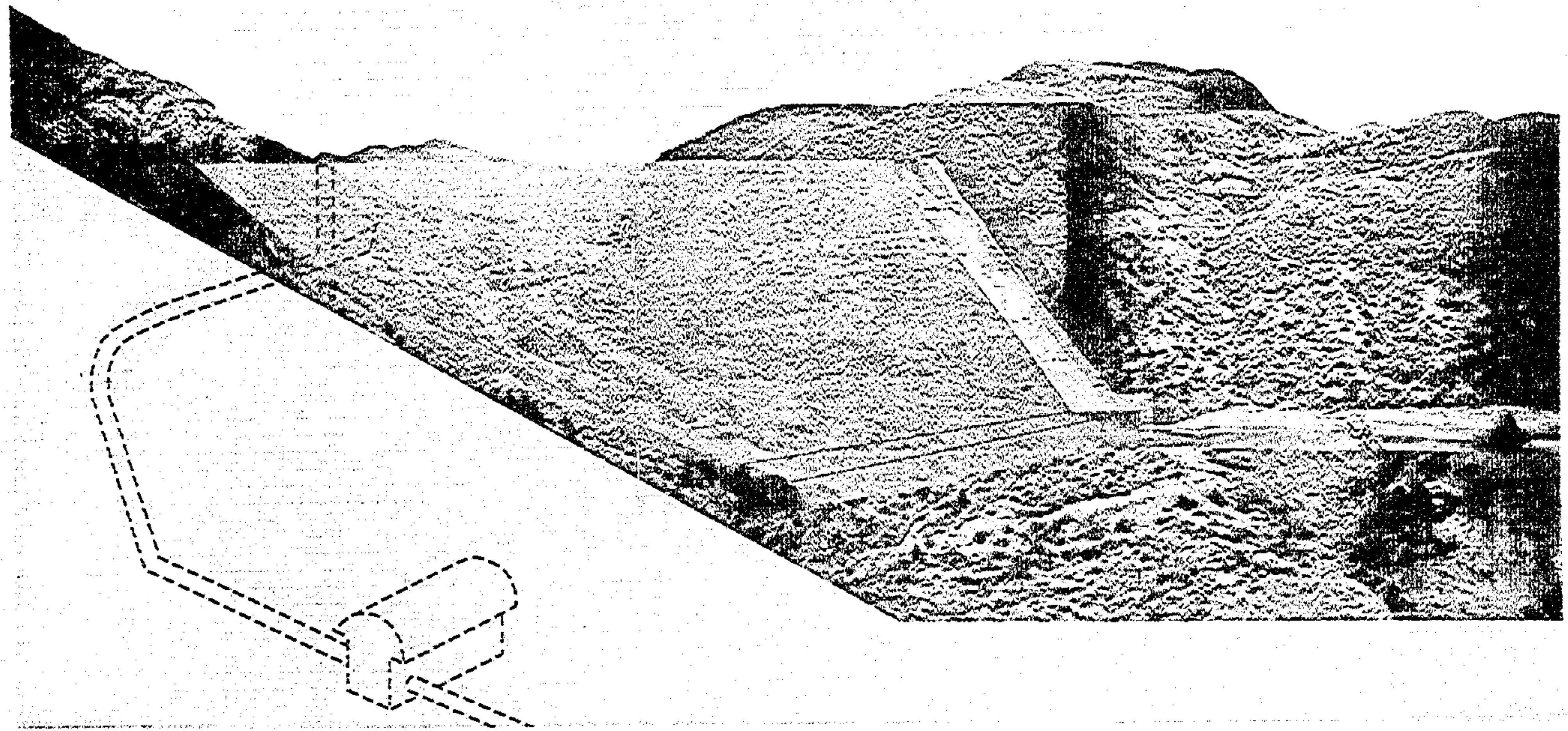
This report presents a scheme of development for Hydraulic Power Project in accordance with the demand forecast up to 2010. Upon completion of each stage of the Project, the shortage of power will be eliminated, thus greatly contributing to the improvement in stability of electric power net works is northeastern part of Turkey.

In view of the urgency of power development in the Republic of Turkey and of the need for socio-economic development of the Republic of Turkey as a whole, we recommend that the Government of Turkey implement this Project as a top priority.

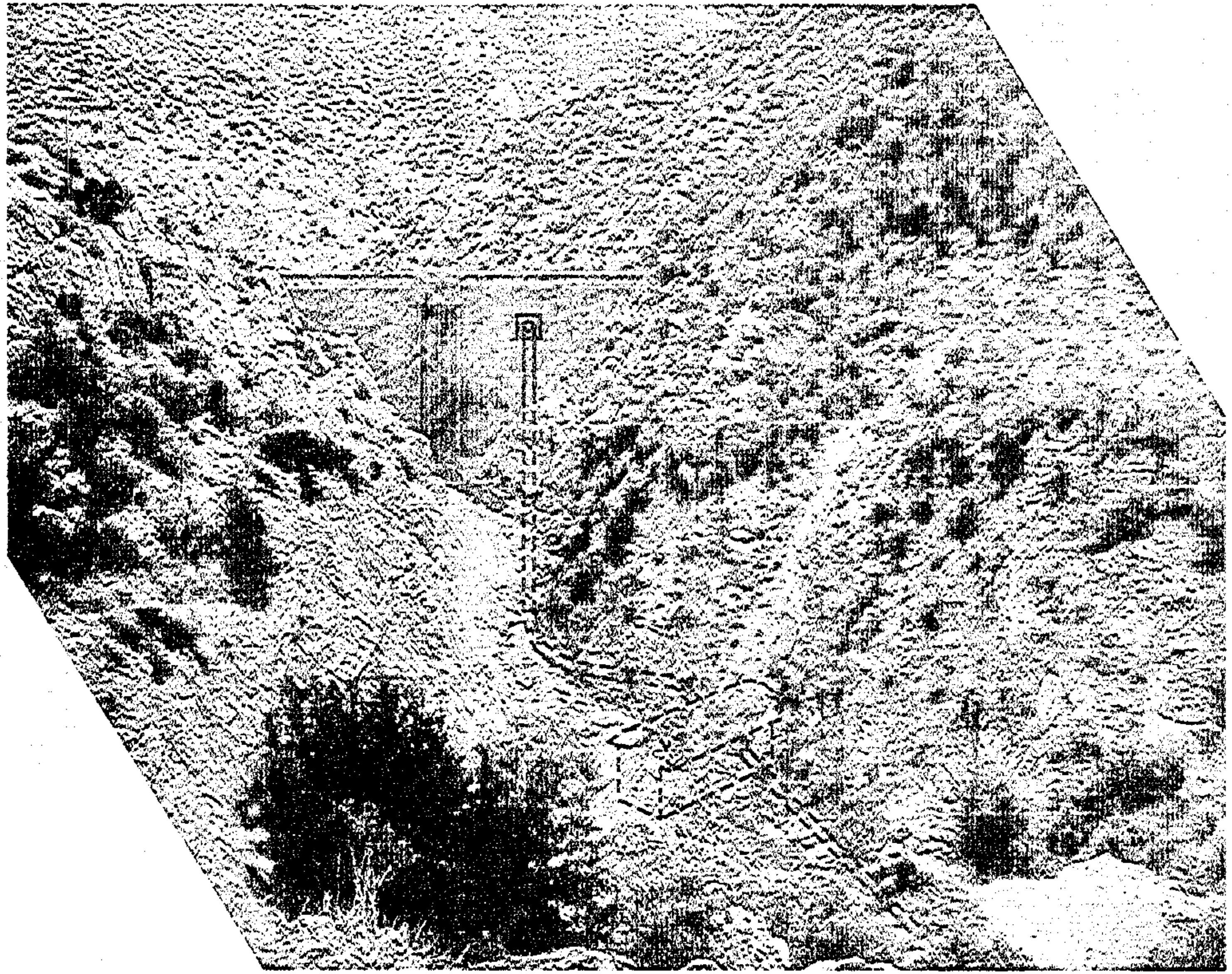
We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, and the Ministry of Energy and Natural Resources. We also wish to express our deep gratitude to the Electrical Survey and Development Administration (EİE) and other authorities' concerned of the Government of the Republic of Turkey for the close cooperation and assistance extended to us during our investigations and study.

Very truly yours,

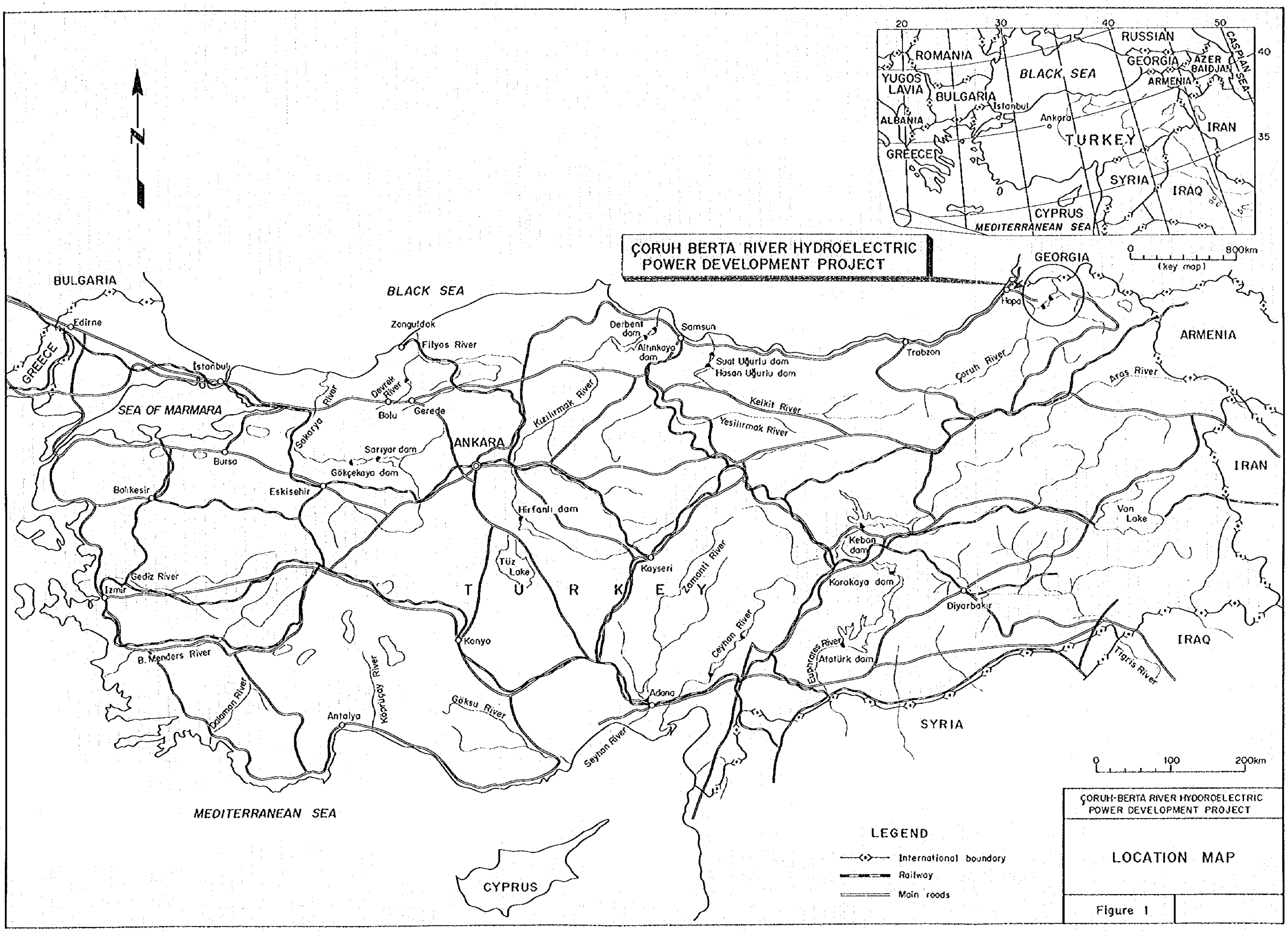
Taisuke Hasegawa
Team Leader
Çoruh-Berta Hydroelectric
Power Development Project

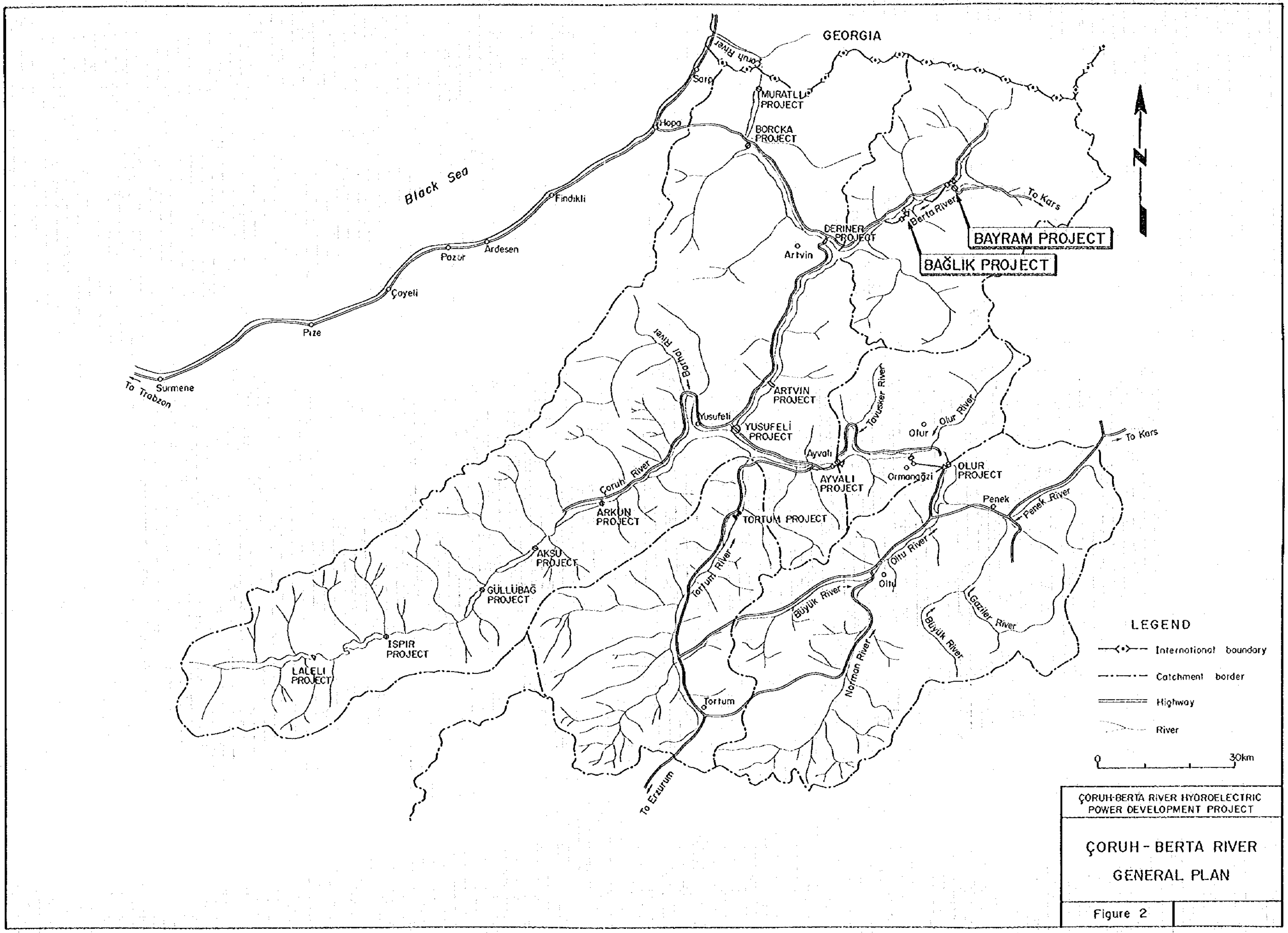


Composite Photograph of Bayram Dam, Spillway and Power Structure
View from downstream right bank



Composite Photograph of Bağlık Dam and Power Structure
View from downstream right bank

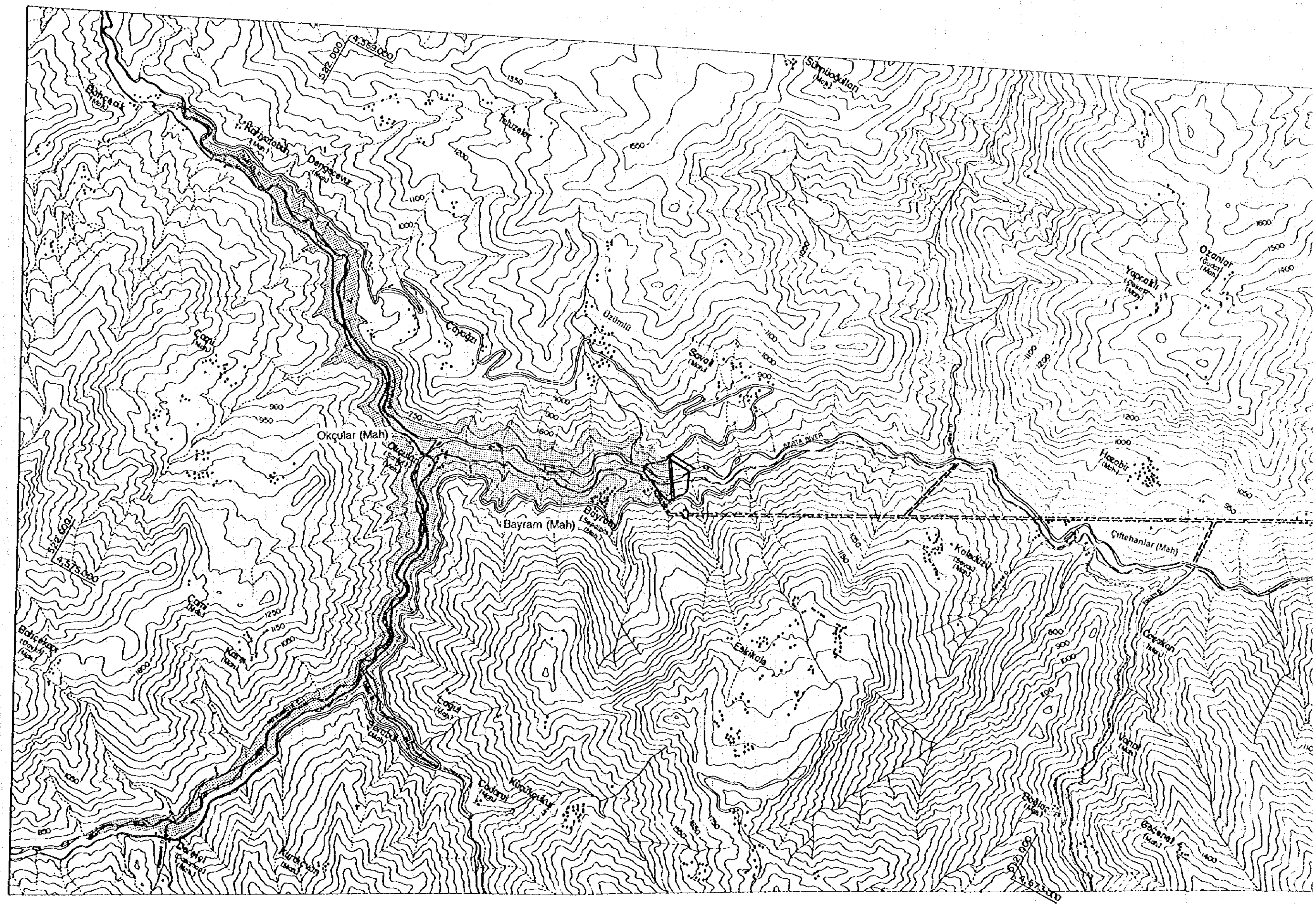

N
ROMANIA
RUSSIAN
GEORGIA
AZER BAIDJAN
CASPIAN SEA
YUGOS LAVIA
BLACK SEA
ARMENIA
BULGARIA
İstanbul
ALBANIA
Ankara
IRAN
TURKEY
GREECE
SYRIA
IRAQ
CYPRUS
MEDITERRANEAN SEA
20
30
40
50
40
35
0
800km
(key map)
ÇORUH BERTA RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT
GEORGIA
Hopa
BULGARIA
BLACK SEA
Edirne
GREECE
Zonguldak
Filyos River
Derbent dam
Samsun
Altınkaya dam
Suat Uğurlu dam
Hasan Uğurlu dam
Trabzon
Çoruh River
ARMENIA
Aras River
İstanbul
SEA OF MARMARA
Sakarya River
Devrek River
Bolu
Gerede
Kızılırmak River
Kelkit River
Yeşilırmak River
ANKARA
Bursa
Sarıyar dam
Gökçekaya dam
Balıkesir
Eskişehir
Hirfanlı dam
IRAN
Van Lake
Tüz Lake
Keban dam
Kayseri
Zamantı River
Karakaya dam
Gediz River
İzmir
T U R K E Y
Diyarbakır
Ceyhan River
Euphrates River
Atatürk dam
IRAQ
Konya
B. Menders River
Tigris River
Köprüçay River
Adana
Dalaman River
Göksu River
Antalya
Seyhan River
SYRIA
0
100
200km
MEDITERRANEAN SEA
LEGEND
International boundary
Railway
Main roads
CYPRUS
ÇORUH-BERTA RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT
LOCATION MAP
Figure 1

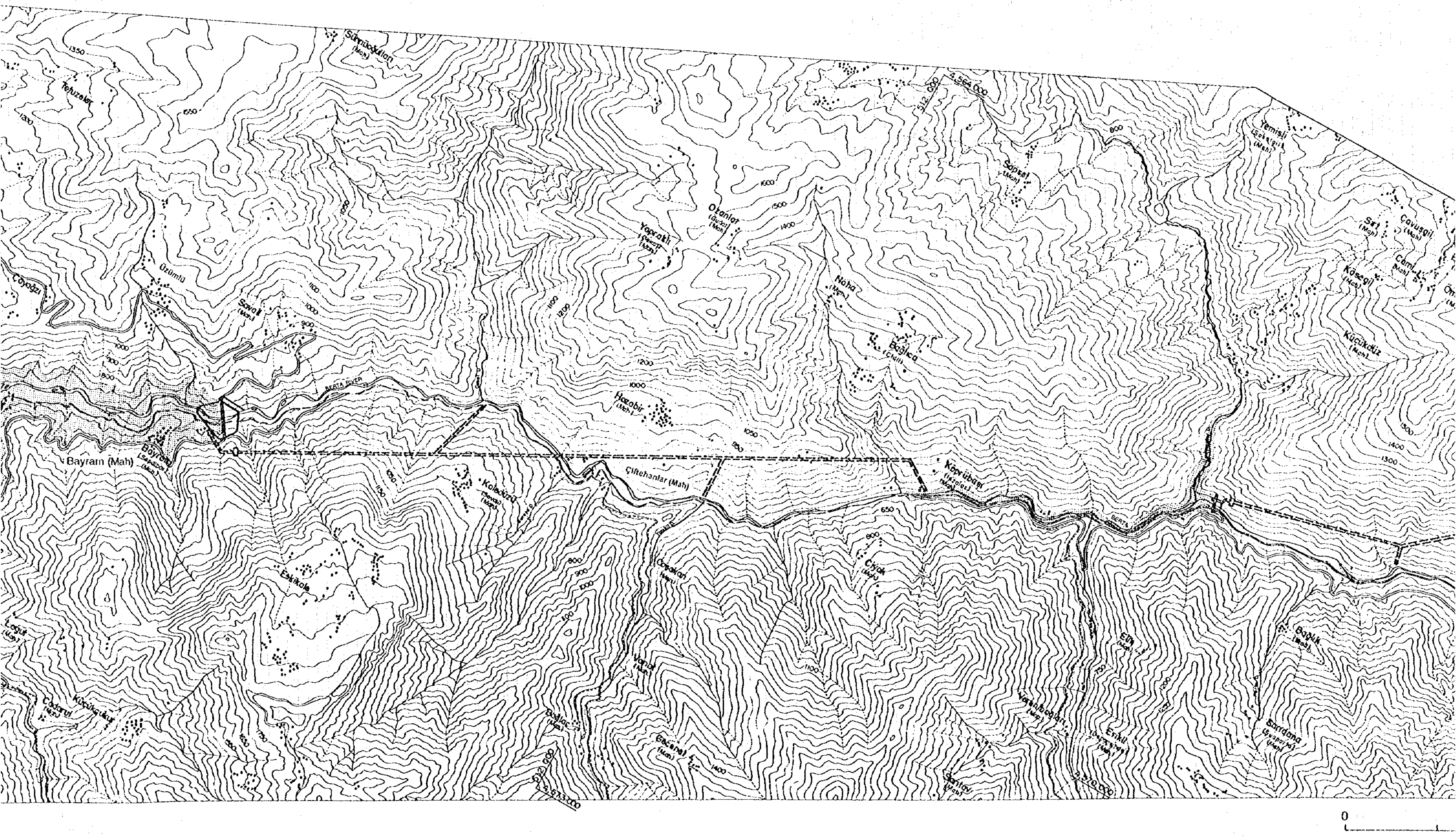


ÇORUH-BERTA RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

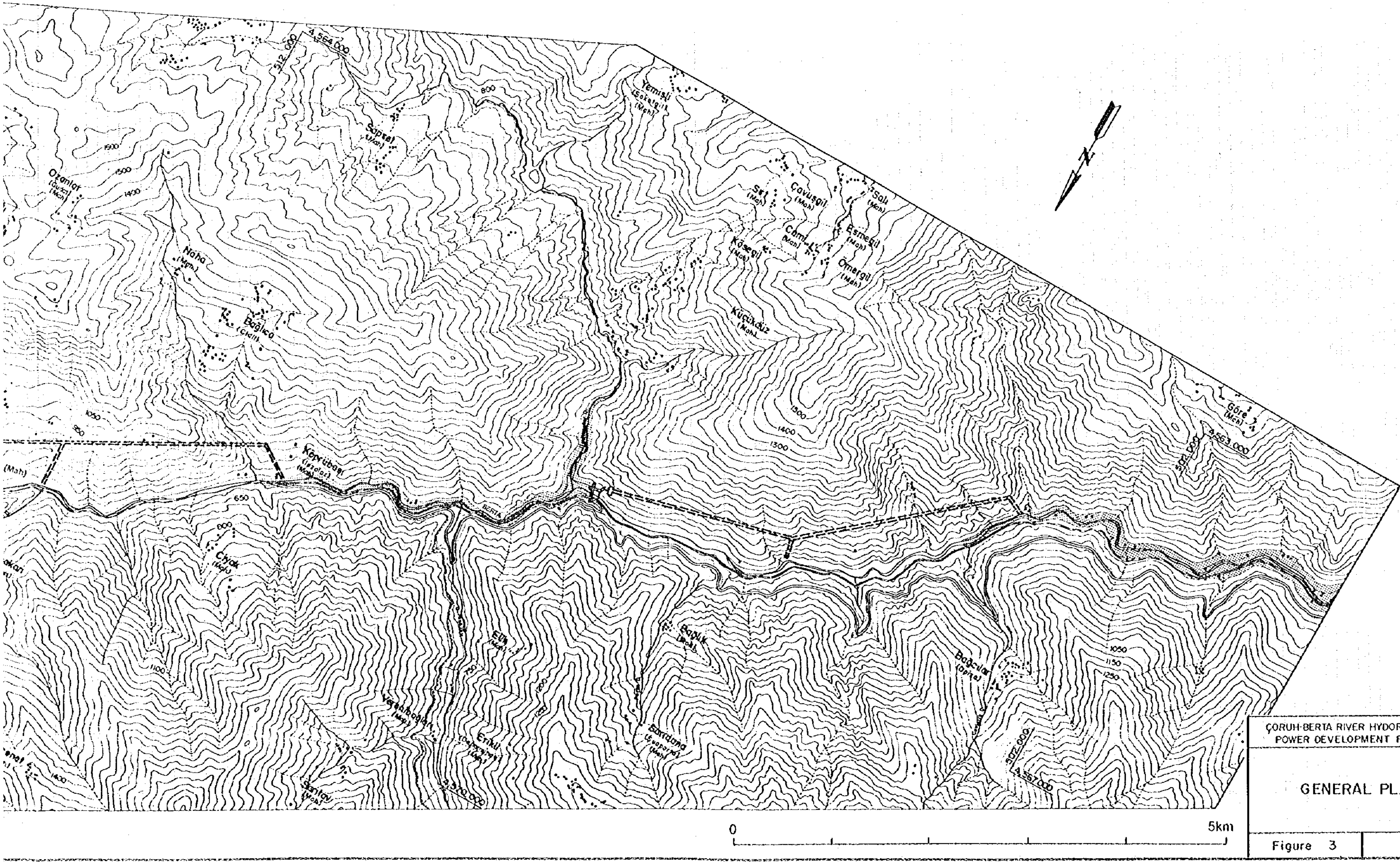
ÇORUH - BERTA RIVER GENERAL PLAN

Figure 2


Okçular (Mah)
Bayram (Mah)
Çiftehanlar (Mah)



Bayram (Mah)
Çiftehanlar (Mah)
Çayağzı
Üzümlü
Ozanlar
Yapraklı
Noha
Bağlıca
Köprübaşı
Eskikale
Yemişli
Küçükdüz
Kösegil
Çavuşgil
Erikli
4,564,000
512,000
4,573,000
0



ÇORUH-BERTA RIVER HYDROELECTRIC
POWER DEVELOPMENT PROJECT

GENERAL PLAN

Figure 3

CONTENTS

Page

CHAPTER 4 PRESENT SITUATION OF ELECTRICITY

CHAPTER 5 LOAD FORECAST AND POWER DEVELOPMENT PROGRAM

CHAPTER 6 METEOROLOGY AND HYDROLOGY

CHAPTER 14 ECONOMIC AND FINANCIAL FRAMEWORKS

CHAPTER 15 FINANCING PLAN

Chapter 16 FUTHER INVESTIGATION

SUMMARY

SUMMARY

This report concerns the feasibility study of the Çoruh-Berta Hydroelectric Power Development Project of the Republic of Turkey. The feasibility study has been conducted from 1995 to 1997 by the Japan International Cooperation Agency (JICA) under a technical cooperation program of the Government of Japan.

This report is submitted by JICA, through the Ministry of Foreign Affairs of the Japanese Government, to the General Directorate of Electric Survey and Development Administration (EİE) of the Government of Turkey.

A brief summary of the results of the feasibility study is presented in the following part of this section.

(1) Character of the Project

The river basin of Çoruh is divided into two parts, that is, Black sea climate with heavy rain in downstream area and Eastern climate as continental climate in upstream area.

Berta river area is located at the middle of Çoruh river in North East belonging to East climate area, but have an strong effect of Black sea climate and 624 mm yearly rainfall.

By above heavy rainfall, yearly discharge amount is 1.65 $m^3/s/100\ km^2$ at Bağlık damsite, which is equivalent to 1.5 times of whole average discharge of Çoruh river.

The river inclination of Berta river between Bayram dam and the tailrace outlet of Bağlık power station is more than 1/70, which is fairly steep.

The undeveloped hydropower resources in Çoruh river is equivalent to 10% of undeveloped hydropower resources in Turkey.

EİE has studied M/P of Çoruh river hydropower development scheme in 1982, and proposed total 29 schemes with 10 schemes in main river, 19 schemes in tributary including 2 schemes in Berta river.

Above schemes, 5 schemes of detailed design in main river, total installed capacity 1,957 MW have already been finished.

Additionally 5 schemes in main river and 5 schemes in tributary, total installed capacity 883 MW, those F/S have been finished.

Further more the Deriner scheme of 670 MW capacity located at the downstream of Bağlık scheme is going to start the construction by getting foreign loan as all preparatory works have been finished.

The hydraulic power schemes in Berta river have 42% of power plant factor thanks to abundant natural conditions than that of average 37% of whole Çoruh river's 29 schemes.

The total capacity in Berta river is 127 MW which is middle scale in Çoruh river schemes.

Additionally those schemes have the same economic characteristics with construction cost 250 x 10^6 US$ as large scale schemes in Çoruh main river.

And there is no serious problem for transportation because the national motor ways pass through the scheme area.

As for electric transmission line, only 37 km new line would be enough to the Deriner point.

As for submerged compensation, 65 hours in Bayram reservoir and 59 houses in Bayram dam borrow area, although there are relocation of road and electric distribution net work.

Most of those submerged houses are the temporary used one which are used during winter season without farm works.

There is no industry except farm and forestry in those schemes area. So, it would be very difficult to find new industry at present.

But those scheme will employ thousands of men in the area and need a lot of construction materials. Additionally after completion of the schemes, sightseeing and leisure industry would be expected to promote the area economic activities.

(2) Demand Forecast and Power Development Plan

(a) Power Demand Forecast

As a result of comparing the estimate according to the regression formula and the forecast by TEAŞ, proximate values were obtained and the demand forecast of TEAŞ was adopted.

Parenthetically, according to the power demand forecast (as of 1994), the maximum power demand in 2010 will be 43,590 MW and the energy production 271,450 GWh, and an annual growth rate of 8.0% and annual load factor of 70% are forecast.

(b) Power Development Plan

According to the TEAŞ's power development plan
The total installed capacity in 2010 will be as much as 60,056 MW, of which the thermal and nuclear powr amounts to 36,970 MW (62%) in combination while the hydroelectric power to 23,086 MW (38%).

(3) Power System Analysis

An analysis was carried out assuming the power system around the year 2010, the year of commissioning of Bayram and Bağlık Power Stations, in order to check the characteristics of power systems in the vicinity of the power stations.

There will not be any problem with system stability and short-circuiting capacity in relation to the existing system accompanying commissioning of Berta project.

(4) Meteorology and Hydrology

(a) Dam Site Catchment Area and Runoff

		Bayram	Bağlık
Catchment area (Km^2)		1,159	1,509
Annual inflow	($10^6 m^3$)	606	786
	(m^3/s)	19.2	24.9
Specific runoff	$m^3/s/100km^2$	1.65	1.65
Design flood	m^3/s	1,660	1,830

(b) Sedimentation

The annual suspended sediment volume at the projected dam site was determined to be as follows:

Bayram dam Q_{SMD} = 253,821 tonf/year
Bağlık dam Q_{SMD} = 76,650 tonf/year

Based on the above, the sedimentation 50 years later is estimated as follows:

Bayram dam $S_{VU} = 11.76 \times 10^6 m^3$
Bağlık dam $S_{VU} = 3.55 \times 10^6 m^3$

(5) Topography, Geology, Materials, and Earthquakes

(a) Bayram Project

1) Topography

The Berta river on which the Bayram project is located is a tributary of the Çoruh river which flow into the Black Sea, and one of rivers in the Karçal and Yalnızçam mountain ranges. The mountain ranges on both sides of the Berta river have peaks from 1,000 to 3,000 m in elevation, and extend in belts from north-east to south-west. Unstable topographic features such as large-scale landslides and collapses have not been found in the results of investigations which have been carried out so far in the project area.

2) Geology

All major civil structures in the Bayram project are to be constructed in the distribution of volcanic rocks which belong to the Berta Formation of Cretaceous age in the Mesozoic. The bedrock at the dam site is composed of the Berta Formation. At the dam site alluvial deposit which consists of sand and gravel is approximately 33 m in thickness. The underground powerhouse site is emplaced in basalt of the Berta Formation. At the powerhouse site the RQD values of drilled cores are from 80% to 100% and the basalt is good condition for excavation. The tailrace tunnel route is in volcanic rocks of the Berta Formation and large faults on the route have not been found. Watertightness of the reservoir is amply assured.

3) Material

i) Core Material

Of the candidate borrow areas for soil material, C site was concluded to be suitable from the view of transportation distance, quality and volume.

The results of laboratory tests were as follows.

* Specific gravity is 2.68 ~ 2.75 and no problem.
* Maximum dry density is 1.70 ~ 1.92 tf/m^3 at optimum water content and no problem.
* In general, there is little scatter in gradation and is in the range of soil material.

ii) Filter Material

For the filter material, the alluvial deposits on the present river bed in Bayram reservoir were concluded to be suitable from the view of transportation distance, quality and volume.

(iii) Rock Material

For the rock material, the basalt and volcanic breccia at Kırmızıkaya quarry were concluded to be suitable from the view of transportation distance, quality and volume.

(iv) Concrete Aggregate

For the concrete aggregate, the alluvial deposits on the present river bed in Bayram reservoir were concluded to be suitable as the first candidate site from the view of transportation distance, quality and volume, and the basalt and volcanic breccia at Kırmızıkaya quarry as second candidate site.

The results of laboratory tests for the material at first candidate site were as follows.

Sand

* Specific gravity 2.63 ~ 2.64
* Water absorption 2.5 ~ 2.7%
* Other test results will give no problem fundamentally.

Gravel

* Specific gravity 2.50 ~ 2.61
* Water absorption 2.4 ~ 2.8%
* Other test results will give no problem fundamentally.

4) Earthquake

The project area belongs to the seismic active zone by the North Anatolian Fault. (III Seismic Risk Zone).

Maximum acceleration at the project site ground surface was estimated as 150 Gal by the results of seismic risk analysis for the earthquake data in Turkey (1880 ~ 1997).

Design horizontal seismic coefficient for Bayram dam (rockfill dam) adopted k = 0.15 as the safety side value.

(b) **Bağlık Project**

1) Topography

The Berta river on which the Bağlık project is located is a tributary of the Çoruh river which flow into the Black Sea, and one of rivers in the Karçal and Yalnızçam mountain ranges. The mountain ranges on both sides of the Berta river have peaks from 1,000 to 3,000 m in elevation, and extend in belts from north-east to south-west. Unstable topographic features such as large-scale landslides and collapses have not been found in the results of investigations which have been carried out so far in the project area.

2) Geology

All major civil structures in the Bağlık project are to be constructed in the distribution of the Yusufeli Formation of Jurassic age, the Berta Formation of Cretaceous age, and the İkizdere granitic rocks which intrude into the Yusufeli Formation and the Berta Formation. The bedrock at the dam site is composed of hard hornfels of the Yusufeli Formation. Alluvial deposit at the dam site which consists of sand and gravel is approximately 6m in thickness. The underground powerhouse site is emplaced in hornfels of the Yusufeli Formation. At the powerhouse site the RQD values of drilled cores are from 60% to 80% and the Yusufeli Formation is good condition for excavation. The tailrace tunnel route is mainly in the İkizdere granitic rocks and large faults on the route have not been found. Watertightness of the reservoir is amply assured.

3) Material

i) Concrete Aggregate

For the concrete aggregate, the alluvial deposits on the present river bed in Bayram reservoir were concluded to be suitable as the first candidate site from the view of transportation distance, quality and volume, and the basalt and volcanic breccia at Kırmızıkaya quarry as second candidate site.

The results of laboratory tests for the material at first candidate site were as follows.

(i) Sand

* Specific gravity 2.63 ~ 2.64
* Water absorption 2.5 ~ 2.7%
* Other test results will give no problem fundamentally.

(ii) Gravel

* Specific gravity 2.50 ~ 2.61
* Water absorption 2.4 ~ 2.8%
* Other test results will give no problem fundamentally.

4) Earthquake

The project area belongs to the seismic active zone by the North Analtolian Fault. (III Seismic Risk zone)

Maximum acceleration at the project site ground surface was estimated as 190 Gal by the results of seismic risk analysis for the earthquake data in Turkey (1880 - 1997).

Design horizontal seismic coefficient for Bağlık dam (concrete gravity dam) adopted k = 0.15 as the safety side value.

(6) Investigations for Environmental Aspects

(a) Both project sites lie in the barren area and low population density which has a trend on decreasing. Population to be affected by the dam-reservoirs planned is approximately 380 persons and 124 private houses.

(b) Land to be inundated is 3.38 km^2 for the Bayram project and 0.37 km^2 for the Bağlık project. There is no agriculture and dwelling area in Bağlık project site, although Bayram project site involves 243.9 da of local agriculture area on domestic consumption. In addition to the land to be inundated, 105.25 da of agricultural and dwelling area at Savail village is utilized for borrow area. These area produce no special products. Economical activity of both sites are not high by low population density and industrial activity.

(c) No forest exists in the both sites and no protected flora and animals especially found exist in the project sites. No special fish is living in the Berta River.

(d) Water reduction sections, approximately 8 km for the Bayram project and 4.5 km for the Bağlık project will be formed by the implementation of both projects. 0.3 ~ 0.7 m^3/sec of artificial discharge from both dams is planned for 3 months of dry season considering of natural inflow volume for 2 sections in order to maintain a natural river water stream, although precious organisms can not be found in these sections. Appropriate amount of water on discharge to water reduction sections is to be decided by the detailed design study.

(e) Serious water pollution and eutrophication phenomena are not predicted, since nutrition level of Berta River is low and by rapid exchange of reservoir water.

(f) Serious losses of sediment matters to be carried to the Çoruh river mouth and expansion of saltification at river mouth region are not expected.

(g) On the construction works, pollution prevention measures will be introduced in accordance with the related Turkish regulation. Land slope protection measures will be adapted for disposal and borrow area.
Locations of treatment facilities on waste water to be originated from workers and concrete preparation work are to be decided by the detailed design study.

(h) Serious issues on environmental side is not found. Relocation of private and public properties will be planned. Total cost on land acquisition and relocation of properties is accounted as 21.3 x 10^6 US$.

(7) Optimum Development Plan

Based on results of studies of development plans made up to this point, the Çoruh-Berta Hydroelectric Development Project is to be 2-step development scheme consisting of the Bayram project and the Bağlık project.

The Bayram project would consist of constructing dam 145 m in height on the Berta river at the Bayram village site approximately 2.5 km downstream from the confluence of the Meydancık river and the Şavaşat river to provide reservoir of high water level at EL. 740 m, effective storage capacity 113 x $10^6 m^3$, drawing water of maximum 43 m^3/s from an intake at the right bank of the dam, generating power of maximum output of 68 MW and with effective head of 182.9 m at underground powerhouse immediately downstream of the intake, and the water after power generation would be discharged into the Berta river at the Köprübaşı village 2 km upstream from the confluence with the Karçal river by tailrace tunnel of length of approximately 8 km, this development plan being the optimum development plan.

For the Bağlık project, the optimum development plan would consist of constructing dam 74 m in height on the Berta river at the Arktaşı village site approximately 250 m downstream of the confluence with the Sungu river to provide reservoir of high water level EL. 530 m, effective storage capacity 1 x $10^6 m^3$, drawing water of maximum 52 m^3/s from intake that is attached to the dam, generating power of maximum output of 59 MW with effective head of 130.9 m at underground powerhouse immediately downstream of the intake, and the water after power generation would be discharged into the Berta river at the Arktaşı village site by tailrace tunnel of length of approximately 4.5 km.

(8) Construction Program and the Cost

(a) Construction Program

The main structures in the Bayram project area are rockfill dam of height 145 m, intake, penstock, underground powerhouse, and tailrace tunnel of approximately 8 km.

The main structures in the Bağlık project area are concrete gravity dam of height 74 m, intake, penstock, underground powerhouse, and a tailrace tunnel of approximately 4.5 km.

With start of operation of Bayram project and Bağlık project in 2007, it will be necessary for preparations for start of construction to be made according to the schedule below.

Nov. 1995 - Dec. 1997	Feasibility Study
Jan. 1998 - Jun. 1998	Provision and Award of Final Design (6 months)
Jul. 1998 - Dec. 1999	Final Design (1.5 years)
Jan. 2000 - Dec. 2000	Financial Formulation (1 year)
Jan. 2001 - Dec. 2001	Bidding and Award of Contract for Construction (1 year)
Jan. 2002 - Dec. 2006	Construction (5 years)

The critical path of the Bayram project is dam construction, and it is necessary for a proper schedule to be set up centered on this construction.

The critical path of the Bağlık project is powerhouse construction, and it is necessary for a proper schedule to be set up centered on this construction.

(b) Construction Cost

The time of estimation is to be the initial part of Jan. 1996 with 1US$ at TL61,000.

The total construction cost of Bayram project is to be TL10,495,634 million (US$172,060 thousand, L.C=TL6,681,044 million, F.C=TL3,814,590 million).

The total construction cost of Bağlık project is to be TL4,847,268 million (US$79,463 thousand, L.C=TL3,319,751 million, F.C=TL1,527,517 million).

(9) Economic and Financial Analysis

(a) Economic Internal Rate of Return (EIRR)

With due recognition of the economic viability of the Project to be analyzed from a broader national perspective, the quantitative impact represented by EIRR worked out 15.4%. Given the estimated real weighted average cost of capital for TEAŞ standing at around 10-12%, the EIRRs well outnumber the cut-off rate[1] ,thereby making it possible to accept that the Project with those sub-projects altogether be substantially feasible. Benefit-Cost ratio also surpassed the crucial cut-off rate of unit 1.0, with the estimated 1.65.

---

[1] Reference: ADB, *Ibid.*

(b) Financial Internal Rate of Return (FIRR)

The FIRR of the investment plan with the accruable costs (base cost plus physical contingency) and benefits expressed as per 1997 price level, worked out 11.9%. With the current opportunity cost of capital standing at around 9 percent, the FIRRs for the Project, by and large, outnumbers the real cost of capital in view, thereby making it possible to accept the Project as financially viable. Yet, there remains somewhat the vulnerability of the project to real price-hyke. Benefit-Costs ratio is estimated at1.22%, with the implication that the project benefit is higher than the value of investment.

(c) Sensitivity Analysis

The major financial risks associated with power project include lower growth in demand for power and front end implementation delays. Given the strong demand growth experienced in the Project area, the former risk will be considered low. In the meantime, sensitivity analysis is to be carried out for the following three cases to assess the magnitude of the possible risks therein. (i) lower tariff by 10%, (ii) capital cost overrun by 10%, and (iii) one year delay in implementation.

The results of the analysis are summarized as follows.

	Base Case	Benefits, -10%	Capital C, +10%	Implementation one- year delay
EIRR	15.4%	12.8%	14.2%	14.8%
E B-C Ratio	1.65	1.38	1.41	1.50
FIRR	11.9%	9.5%	10.8%	11.3%
F B-C Ratio	1.22	1.20	1.11	1.18

(10) Financing Plan

(a) Financing Plan

Of the total "financial costs" for the project of US$311.9 million, the initial investment for the foreign and local cost portions, exclusive of replacement cost in the 41-43rd years in the investment outlay worked out respective of US$95.5 million and US$150.9 million, thereby leading to US$246.5 million in aggregate. Replacement cost accrued in the far later years during the project period is being excluded due to very low probability of credit extended by international or bi-lateral financing institutions. With the highly hypothetical assumption that 100 percent of these foreign and local cost (base cost plus physical contingencies) are presumably covered by multi, and bi-lateral aid agencies, notably, the World Bank and the Overseas Economic Cooperation Fund, Japan, differences in financial terms and conditions between the two agencies are reiterated herewith in a bid to articulate the basic assumptions.

	Foreign Cost Portion		Local Cost Portion	
	Multi-Lateral	Bi-Lateral	Multi-Lateral	Bi-Lateral
Financing Coverage (%)	100	100	100	100
Loan Period (years)	20	30	20	30
Grace Period (years)	5	10	5	10
Loan Repayment Period (yrs)	15	20	15	20
Interest Rate (%)	3.5	3.5	9.5	9.5

(b) Repayment Plan

In compliance with the hypothetical parameters associated with the two financing sources as above, annuity payments are calculated as follows.

	Foreign Cost Portion		Local Cost Portion	
	Multi-Lateral	Bi-Lateral	Multi-Lateral	Bi-Lateral
Disbursement (US$million)	95.5	95.5	150.9	150.9
Principal (US$million)	101.5	95.5	184.5	150.9
Cumulative Repayment (US$million)	132.2	157.0	353.5	445.1
Annual Payment (US$million)	8.8	6.7	23.6	17.1
Present value of Repayments (S$milion)	85.5	85.5	117.2	116.8

In a bid to simplify the model, annuity payments are assumed to be made once a year, at the end of the fourth quarter. Commitment charge of 0.75% which is payable to the agreed amount of loan is not included either in discussion for the same reason. Amortization is on a levelized basis, and interest which is payable all over the project duration will be on the diminishing balance of the outstanding principal, as such interest costs will decrease proportionately as principal is amortized.

(11) Outline of the Project

1) Bayram Project

River

Name of River	Berta
Catchment Area	1,159 km^2
Annual Inflow	606 x 10^6 m^3 (19.20 m^3/s)

Reservoir

High Water Level	740.00 m
Low Water Level	686.00 m
Available Drawdown Depth	54.00 m
Sedimentation Level	676.00 m
Gross Storage Capacity	133.0 x 10^6 m^3
Effective Storage Capacity	113.0 x 10^6 m^3
Reservoir Area	3.38 km^2

Dam

Type	Rockfill Dam with Center Core
Elevation of Dam Crest	745.00 m
Thalweg Elevation	635.00 m
Height of Dam (from foundation)	145.00 m
Length of Dam Crest	415 m
Volume of Dam (including coffer dam)	6,144 x 10^3 m^3

Diversion Tunnel

Design Flood	320 m^3/s
Type	Standard Horse Shoe, Pressure, Concrete Lining
Number	One
Inner Diameter	5.70 m
Length	795 m

Outlet Equipment

Type	Main valve	Jet Flow Gate
	Sub valve	High Pressure Slide Gate

Spillway

Design Flood	1,660 m^3/s
Type	Shute with Gates
Overflow Crest Elevation	727.50 m
Width of Overflow Crest	23.00 m (Including pier width 3.00 m)
Energy Dissipator	Hydraulic Jump Basin
Type of Gate	Radial
Number of Gate	Two
Size of Gate	Width 10.00 m x Height 12.50 m

Intake

Type	Horizontal
Number	One
Inlet Elevation	676.00 m

Size	Width 8.00 m x Height 6.00 m
Type of Gate	Roller Gate
Number of Gate	One
Size of Gate	Width 3.30 m x Height 3.30 m

Intake Tunnel

Type	Circular, Pressure, Concrete Lining
Number	One
Discharge Capacity	43.00 m^3/s
Inner Diameter	3.30 m
Length	65.00 m

Penstock

Type	Steel Embedded
Number	One Line
Inner Diameter x Length	3.30~2.50 m x 320.24 m

Powerhouse

Type	Underground, Concrete Lining
Size	Width 19.00 m x Height 41.00 m x Length 44.50 m

Access Tunnel

Type	Half Circle Half Rectangular, Concrete Lining
Size	Width 5.00 m x Height 5.00 m x Length 901 m Inclination 1:10.00 Elevation of Tunnel Exit 635.00 m

Cable Tunnel

Type	Half Circle Half Rectangular, Concrete Lining
Size	Width 4.00 m x Height 4.00 m x Length 369 m Inclination 1:4.02 Elevation of Tunnel Exit 650.00 m

Drainage Tunnel

Type	Half Circle Half Rectangular, Concrete Lining
Size	Width 3.50 m x Height 3.50 m x Length 154 m Inclination Level

Tailrace Chamber

Type	Chamber, Concrete Lining
Size	Width 4.60 m x Height 16.20 m x Length 30.00 m

Tailrace

Type	Standard Horse Shoe, Non Pressure, Concrete Lining • Shotcrete
Max. Discharge	43.00 m^3/s
Inner Diameter	4.60 m
Length	7,930 m

Development Plan

Normal Intake Water Level	722.00 m
Normal Tail Water Level	530.00 m
Gross Head	192.00 m
Effective Head	182.90 m
Maximum Discharge	43.00 m^3/s
Number of Unit	One
Installed Capacity	68 MW
Firm Peak Power	57.6 MW

Turbine

Type	Vertical Shaft, Francis Turbine
Number	One
Max. Discharge	43.00 m^3/s
Turbine Output	69,500 kW
Revolving Speed	300 rpm

Generator

Type	Three phases Alternating Current Synchronous
Number	One
Rated Output	75,400 kVA
Revolving Speed	300 rpm
Frequency	50 Hz
Voltage	13.2 kV
Power Factor	0.9 lag

Main Transformer

Type	Outdoor Three phases, Forced-oil-forced-air cooled type
Number	One
Capacity	75,400 kVA
Voltage	(Primary) 13.2 kV (Secondary) 154 kV

Switchyard

Bus System	Single Bus + Transformer Bus
Bus	Aluminum Pipe
Number of Lines Connected	1 cct
Voltage	154 kV
Conductor Type	ACSR

Annual Energy Production

Average Energy	250.4 GWh
Firm Energy	144.9 GWh

Construction Period: 5 years

Project Cost: $10,495,634 \times 10^6$TL
($172,060 \times 10^3$US$)

Unit Construction Cost at Sending End

Per kW	154×10^6 TL/kW (2,525 US$/kW)
Per kWh	4,331 TL/kWh (0.071 US$/kWh)

Economic Evaluation (Total value of Bayram project and Bağlık project)

EIRR	15.4%
FIRR	11.9%
Benefit-Cost Ratio (Financial)	1.22

2) Bağlık Project

River

Name of River	Berta
Catchment Area	1,509 km^2
Annual Inflow	786×10^6 m^3 (24.90 m^3/s)

Reservoir

High Water Level	530.00 m
Low Water Level	527.00 m
Available Drawdown Depth	3.00 m
Sedimentation Level	517.00 m
Gross Storage Capacity	7.3×10^6 m^3
Effective Storage Capacity	1.0×10^6 m^3
Reservoir Area	0.37 km^2

Dam

Type	Concrete Gravity Dam
Elevation of Dam Crest	533.00 m
Thalweg Elevation	465.00 m
Height of Dam (from foundation)	74.00 m
Length of Dam Crest	190 m
Volume of Dam	195×10^3 m^3

Outlet Equipment

Main Valve	Jet Flow Gate
Sub Valve	High Pressure Slide Gate

Spillway

Design Flood	1,830 m^3/s
Type	Center Overflow with Gates
Overflow Crest Elevation	519.00 m
Width of Overflow Crest	31.00 m (Including pier width 3.00 m)
Energy Dissipator	Bucket Basin
Type of Gate	Radial
Number of Gate	Two
Size of Gate	Width 14.00 m x Height 11.00 m

Intake

Type	Attached to Dam body
Number	One
Inlet Elevation	517.00 m
Size	Width 3.60 m x Height 3.60 m
Type of Gate	Roller Gate
Number of Gate	One
Size of Gate	Width 3.60 m x Height 3.60 m

Penstock

Type	Steel Embedded
Number	One Line
Inner Diameter x Length	3.60~3.00 m x 212.28 m

Powerhouse

Type	Underground, Concrete Lining
Size	Width 21.00 m x Height 41.50 m x Length 50.00 m

Access Tunnel

Type	Half Circle Half Rectangular, Concrete Lining
Size	Width 5.00 m x Height 5.00 m x Length 560 m
	Inclination 1:10.00
	Elevation of Tunnel Exit 462.00 m

Cable Tunnel

Type	Half Circle Half Rectangular, Concrete Lining
Size	Width 4.00 m x Height 4.00 m x Length 264 m
	Inclination 1:5.73
	Elevation of Tunnel Exit 465.00 m

Drainage Tunnel

Type	Half Circle Half Rectangular, Concrete Lining
Size	Width 3.50 m x Height 3.50 m x Length 164 m
	Inclination Level

Tailrace Chamber

Type	Chamber, Concrete Lining
Size	Width 4.60 m x Height 15.10 m x Length 30.00 m

Tailrace

Type	Standard Horse Shoe,
	Non Pressure, Concrete Lining • Shotcrete
Max. Discharge	52.00 m^3/s
Inner Diameter	4.90 m
Length	4,454 m

Development Plan

Normal Intake Water Level	528.50 m
Normal Tail Water Level	392.00 m
Gross Head	136.50 m
Effective Head	130.90 m
Maximum Discharge	52.00 m^3/s
Number of Unit	One

Installed Capacity	59 MW
Firm Peak Power	56.2 MW

Turbine

Type	Vertical Shaft, Francis Turbine
Number	One
Max. Discharge	52.00 m^3/s
Turbine Output	60,500 kW
Revolving Speed	250 rpm

Generator

Type	Three phases Alternating Current Synchronous
Number	One
Rated Output	65,600 kVA
Revolving Speed	250 rpm
Frequency	50 Hz
Voltage	13.2 kV
Power Factor	0.9 lag

Main Transformer

Type	Indoor, Three phases, Forced-oil-forced-air cooled type
Number	One
Capacity	65,600 kVA
Voltage	(Primary) 13.2 kV (Secondary) 154 kV

Switchyard

GIS

Annual Energy Production

Average Energy	225.8 GWh
Firm Energy	128.4 GWh

Construction Period — 5 years

Project Cost — $4,847,268 \times 10^6$ TL ($79,463 \times 10^3$ US$)

Unit Construction Cost at Sending End

Per kW	82×10^6 TL/kW (1,347 US$/kW)
Per kWh	2,318 TL/kWh (0.038 US$/kW)

Economic Evaluation (Total value of Bayram project and Bağlık project)

EIRR	15.4%
FIRR	11.9%
Benefit-Cost Ratio (Financial)	1.22

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

(1) Çoruh-Berta Hydroelectric Power Development Project should be developed as soon as possible because the project is feasible technically, economically and financially. It is possible to commission the project in 2007 when lead time for final design, financial arrangement and construction period are taken into account.

(2) Optimization study by comparison of various alternatives concerning storage capacity, development layout and etc. was carried out. As a result, it is determined that this project is to be two stage development project by Bayram project and Bağlık project.

Bayram project consists of 145 m high and approximately 6,200 x 10^3m^3 volume of center core rockfill dam to provide 113 x 10^6m^3 effective storage capacity of reservoir, approximately 321 m long penstock, underground powerhouse immediate downstream of dam to generate 68 MW of power and 7,930 m of tailrace tunnel.

Bağlık project consists of 74 m high and approximately 195 x 10^3m^3 volume of concrete gravity dam approximately 213 m long penstock, underground powerhouse immediate downstream of dam to generate 59 MW of power and 4,454 m of tailrace tunnel.

(3) The electric power generated at Bayram and Bağlık project plant is to be transmitted to Deriner project substation by 37 km of transmission line (Bayram project-Bağlık project 12 km 1 circuit, Bağlık project-Deviner project 25 km 2 circuit).

(4) The total construction cost of Bayram project is to be TL10,495,634 million (US$172,060 thousand, L.C=TL6,681,044 million, F.C=TL3,814,590 million).

The total construction cost of Bağlık is to be TL4,847,268 million (US$79,463 thousand, L.C=TL3,319,751 x million, F.C.=TL1,527,517 million).

EIRR and FIRR for Bayram and Bağlık project is 15.4% and 11.9% respectively.

(5) The result of environmental impact assessment shows no problem on natural and social environment of the project area.

To keep river environment, continuous water of 0.5 m^3/s will be released from Bayram dam and Bağlık dam to downstream.

In order to maintain a natural river water stream 0.3 ~ 0.7 m^3/s of artificial discharge from both dams is planned for 3 months of dry season for their each water reduction sections between dam and tailrace outlet.

Recommendation

(1) Çoruh-Berta hydroelectric power development project is feasible technically, economically and financially. The project is recommended to be put in service in the beginning of 2007.

(2) Detailed design is needed for the project because this report shows feasibility design.

(3) The following geological investigations are required for the detailed design.

(Bayram project)

- Drilling investigation at the dam site
- Drilling investigation at the underground powerhouse site
- Drilling investigation at the tailrace tunnel route

(Bağlık project)

- Drilling investigation at the dam site
- Exploratory adits at the dam site
- Drilling investigation at the tailrace tunnel route

(4) On the detailed design stage, detailed study on discharge to be needed to water reduction sections swill be carried out in order to get appropriate amount of discharge considering a natural inflow to these sections.

Location of treatment system of wastewater to be orignated from workers and concrete preparation work will be also decided on the detailed design stage.

CHAPTER 1 INTRODUCTION

CONTENTS

List of Tables

CHAPTER 1 INTRODUCTION

The Republic of Turkey was primarily an agricultural country, but emphasis has been placed on industrialization in recent years. It may be considered that economic exchanges with neighboring countries have increased with the collapse of the former Soviet Union, and the rising demand due to this has spurred acceleration of industrialization.

In step with this, securing of electric energy has become of importance, and the Turkish Government, giving priority to development of domestic energy resources, has been endeavoring to develop lignite thermal and hydroelectric power which are domestic resources. Lignite thermal has met strong opposition because of problems of pollution, and new development has become difficult. Accordingly, the situation in society has become one where installation of pollution prevention facilities cannot be avoided and the increase in construction cost for this has caused priority for development to be lowered, while on the other hand, the superiority of hydroelectric power generation has recently come to be favorably rerecognized.

In general, growth of GDP and growth of electric power become more or less proportionate as industrialization progresses. The growths in GDP and electric power supplied from 1984 to 1994 are shown in Table 1-1.

Table 1-1 GDP Growth and Electric Energy Supply Growth

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
GDP Growth (%)	6.7	4.2	7.0	7.5	2.1	0.3	9.3	0.9	6.0	7.5	-5.4
Energy Generating Growth (%)	12.7	13.4	17.3	11.8	8.5	10.3	11.4	4.9	10.9	9.0	7.2

Annual Report (from Central Bank)

1.1 Background of the Project

Turkey has 35,241 MW of hydroelectric potential from both economic and technical views point, 9% of which belongs to the Çoruh river.

On the Berta River, which is one of the biggest tributary of the Çoruh river including Oltu, Berta and Barhal rivers, 476 million kWh and 127 MW installed capacity are learned to be developed.

Berta river Hydropower Development Project was started by EİE in 1987 and resulted in master plan report on Çoruh-Berta river basin in 1992.

The Çoruh river is located in the northeast of Turkey and selected as a important river for large scale hydroelectric power development.

The studies have been performing by EİE as a whole.

The Government of Turkey requested the Government of japan in January 1994 to make a feasibility study concerning the Berta Hydroelectric Power Development Project in Berta river which is one of tributary in Çoruh river.

The Government of Japan in response to this request, commissioned JICA in 1995 to dispatch a preliminary survey team to Turkey for exchange of opinion with the related agencies and to make a general reconnaissance of the project site.

Based on the results of the above, an agreement was reached in August 1995 between EİE and JICA, under the title of Scope of Works for the feasibility study on the Berta Hydroelectric Power Development Project in the Republic of Turkey.

1.2 Objective of Study

Objective of the study is to decide optimum hydroelectric power development project technically, economically and financially, to prepare feasibility study report and to realize technical transfer through study of the project.

1.3 Field Investigation during the Study

Field investigations carried out by EIE during the study are as shown in Table 1-2.

1.4 The Record of Dispatched Team and List of Engineers

In November 1995, JICA began the work based on the before-mentioned "Scope of Works". JICA next dispatched the following survey teams for field investigations concerning the Project.

First survey mission	(except Environment)	Nov. 27, 1995 ~ Dec. 13, 1995
First survey mission	(Environment)	Jan. 4, 1996 ~ Jan. 16, 1996
Second survey mission		Feb. 11, 1996 ~ Feb. 17, 1996
Third survey mission	(Phase 1)	May 22, 1996 ~ Jul. 31, 1996
Third survey mission	(Phase 2)	Sep. 16 1996 ~ Nov. 14, 1996
Fourth survey mission		Feb. 19, 1997 ~ Mar. 17, 1997
Fifth survey mission		Oct. 1, 1997 ~ Oct. 15, 1997

During this period survey team submitted the following reports to EIE. Engineers participated the Study are as shown in the following list.

Inception Report	November 1995
Progress Report	March 1996
Interim Report	March 1997
Draft Final Report	October, 1997

List of Engagements

EİE

Mr. Tuncay DERMAN	Head of Project Design Department
Mr. Şukrü KARABİBER	Chief of Dams and Hydroelectric Power Plants Section
Mr. Nejat GÜRCAN	Design Engineer, Civil, Dams and Hydroelectric Power Plants Section
Mrs. Şule AKÇAY	Design Engineer, Civil, Dams and Hydroelectric Power Plants Section
Mrs. Gülgün GÜRCAN	Design Engineer, Civil, Dams and Hydroelectric Power Plants Section
Mrs. Özlem YILMAZ	Design Engineer, Environmental, Dams and Hydroelectric Power Plants Section
Mr. Orhan YAGCI	Chief of Geotechnical Services Section
Mr. Sükrü BAY	Geological Engineer, Geotechnical Services Section
Mr. Mehmet TANRIKULU	Chief of Project Hydrology Section
Mrs. Nazlı BAYKARA	Hydrology Engineer, Civil, Project Hydrology Section
Mr. Rıdran Seref ENERCU	Laboratory Technician
Mr. Mehmet GÜNGÖR	Chief of Electrical and Mechanical Division

JICA Team

Mr. Taisuke HASEGAWA	Team Leader
Mr. Masayuki SEINO	Planning
Mr. Nobuo HASHIMOTO	Design
Mr. Mitsuru MIYASHITA	Hydrology
Mr. Youzou FUKUTAKE	Geology
Mr. Teruyoshi HATANO	Geology
Mr. Takaya NOMURA	Electrical
Mr. Kiyoshi KIKUCHI	Environmental
Mr. Takao OZAKI	Economy

Table 1-2 Field Investigation during the Study

Item	Quantity	Remarks
Topographical Map (1/1,000)		
Bayram dam	0.5 km^2	
Bayram outlet	0.1 km^2	
Bağlık dam	0.2 km^2	
Bağlık outlet	0.1 km^2	
Geological Investigation		
Drilling Core		
Bayram project	12 holes 929.65 m	
Bağlık project	5 holes 510 m	
Test Pit		
Bayram project	9 pit 28.35 m	
Seismic prospecting		
Bayram project	6 lines 5,000 m	
Hydroelectrical Survey		
Observation of sediment	3 gaging stations from July 1996	Must be operated after the Feasibility Study