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

SUMMARY

DECEMBER 1997

ELECTRIC POWER DEVELOPMENT CO., LTD.
PACIFIC CONSULTANTS INTERNATIONAL

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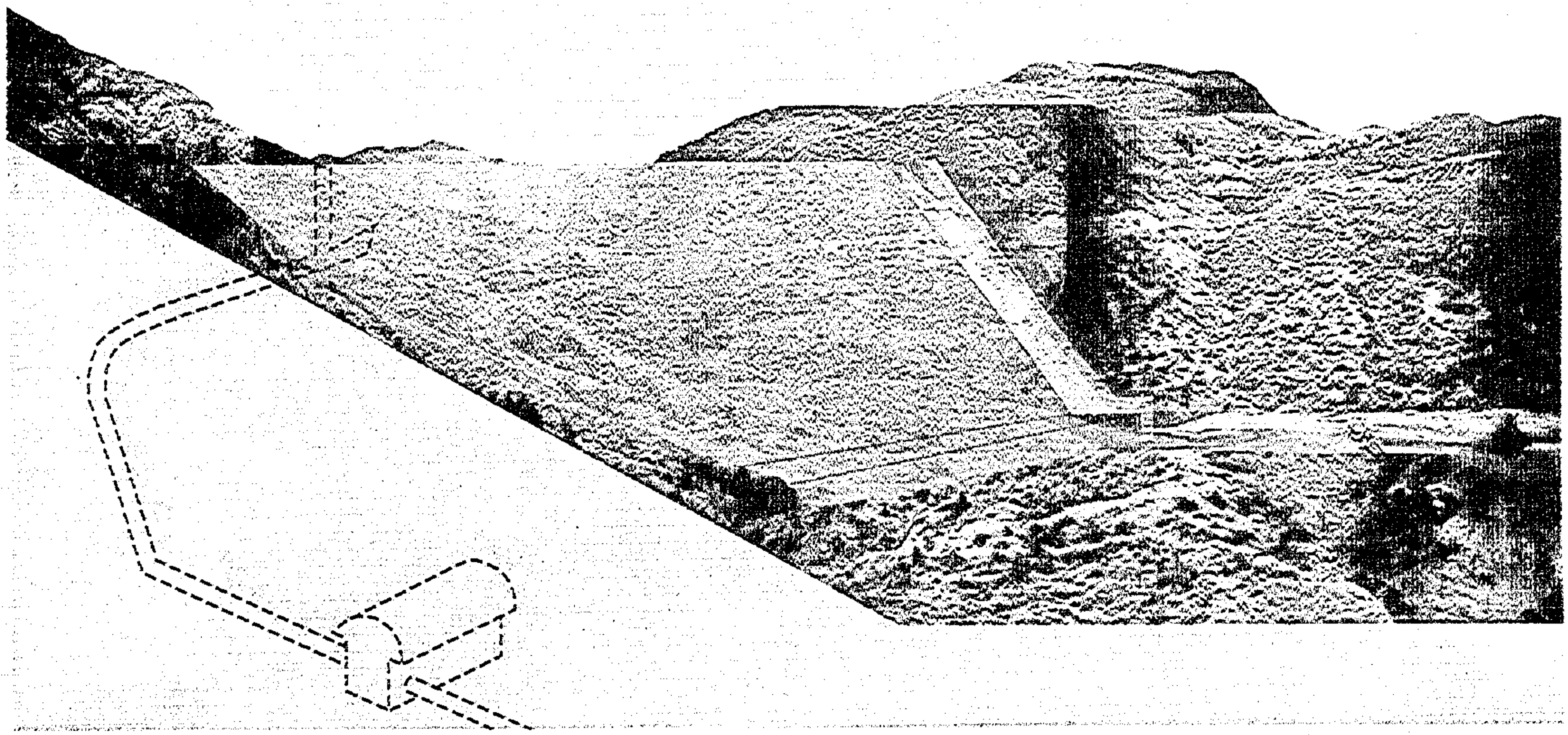
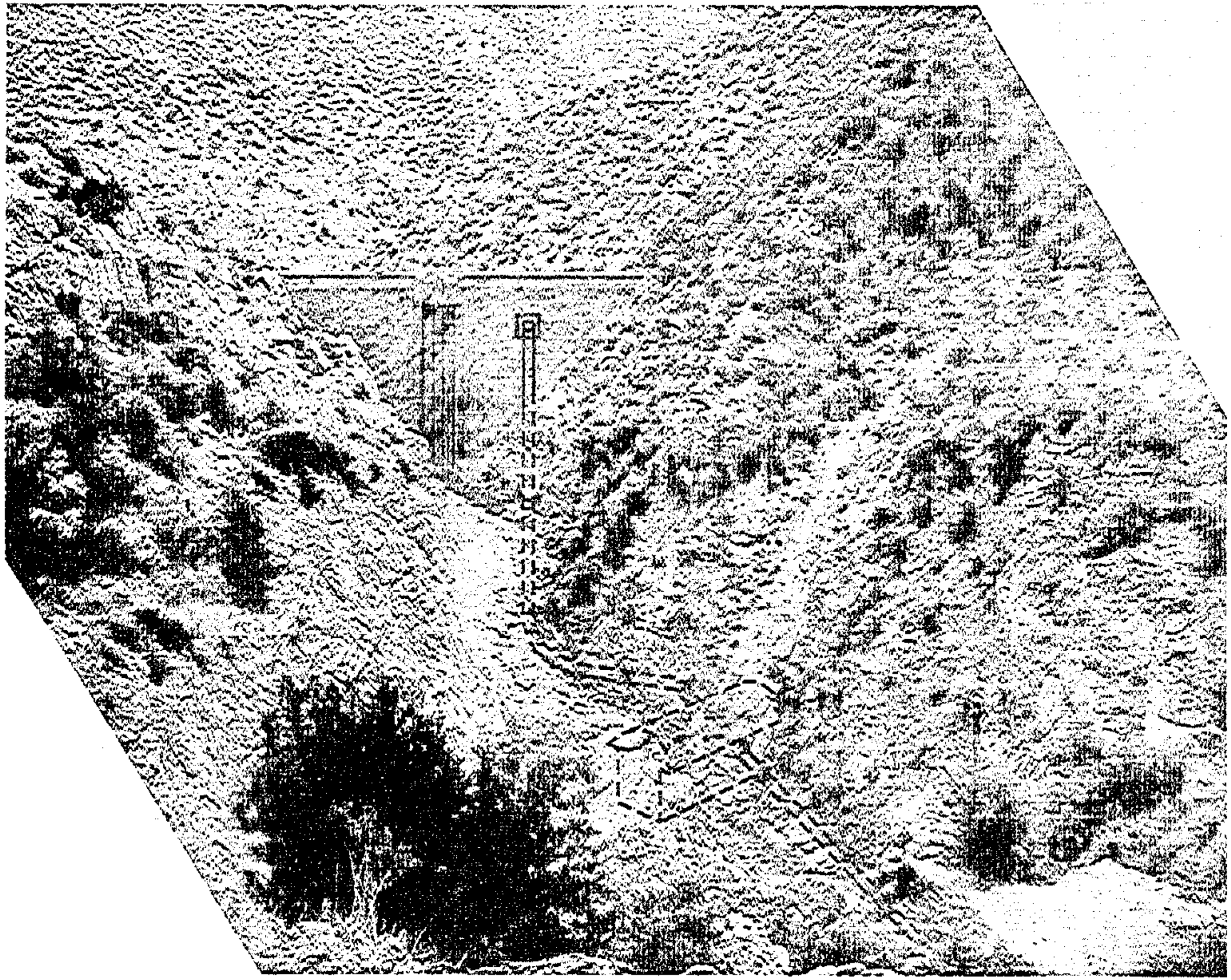
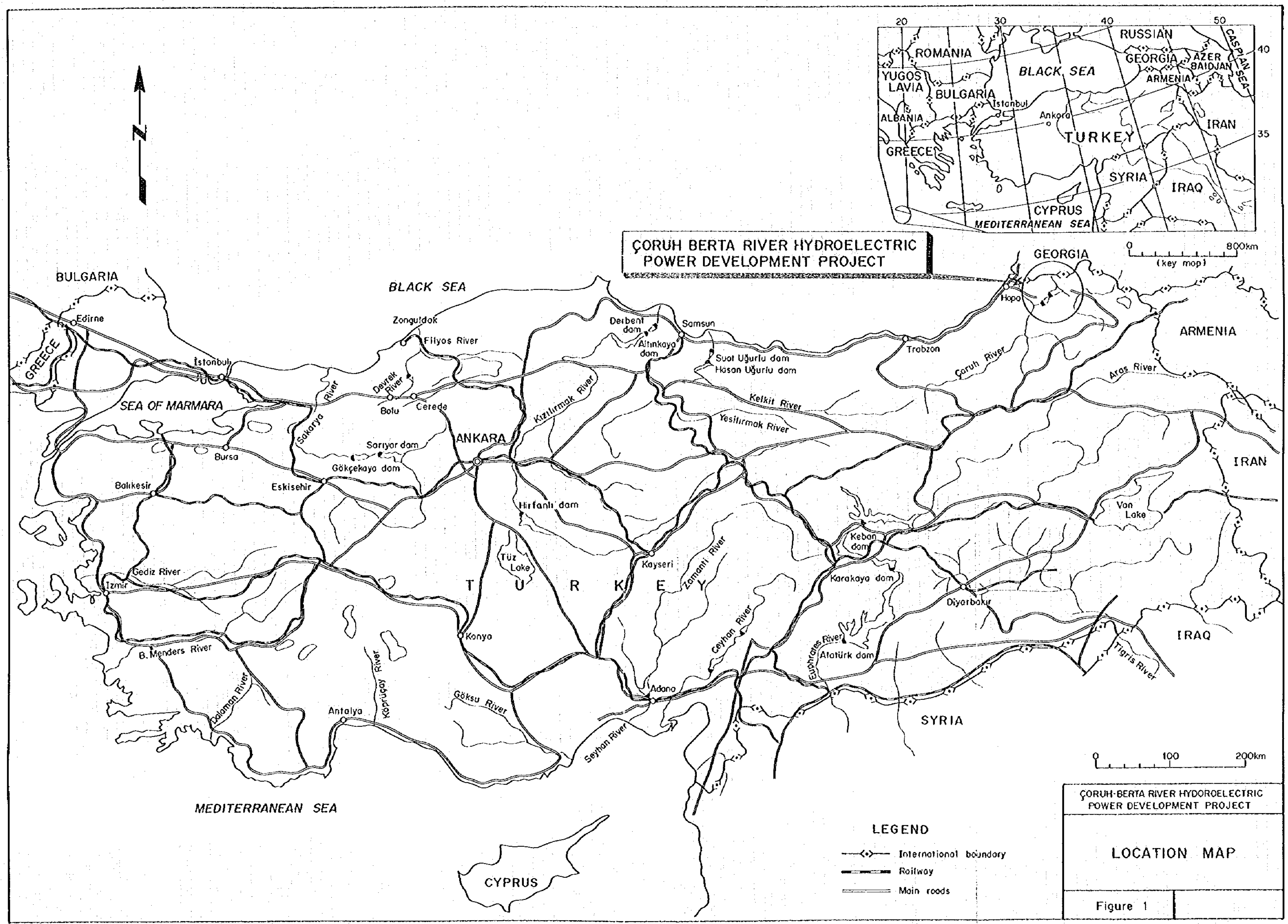


Composite Photograph of Bayram Dam, Spillway and Power Structure
View from downstream right bank



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



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ÇORUH BERTA RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT
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RUSSIAN
ROMANIA
GEORGIA
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CASPIAN SEA
YUGOS LAVIA
BLACK SEA
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BULGARIA
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Derbent dam
Samsun
Altınkaya dam
Suat Uğurlu dam
Hasan Uğurlu dam
Trabzon
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ARMENIA
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GREECE
İstanbul
SEA OF MARMARA
Sakarya River
Devrek River
Bolu
Çerede
Kızılırmak River
Kelkit River
Yeşilırmak River
ANKARA
Sarıyar dam
Gökçekaya dam
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Van Lake
Keban dam
Tüz Lake
Kayseri
Zamantı River
Gediz River
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T U R K E Y
Karakaya dam
Diyarbakır
Konya
Ceyhan River
Euphrates River
Atatürk dam
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100
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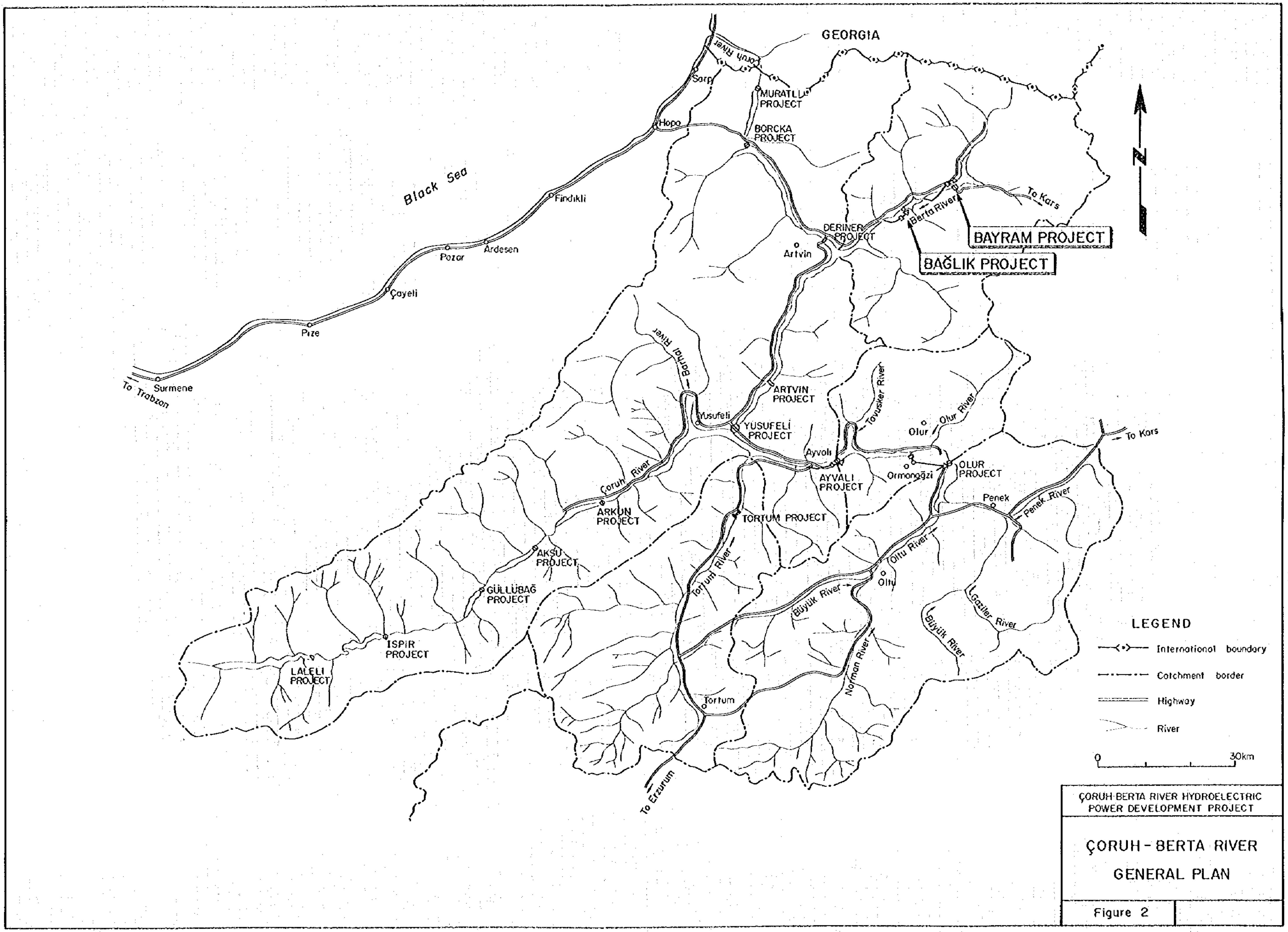
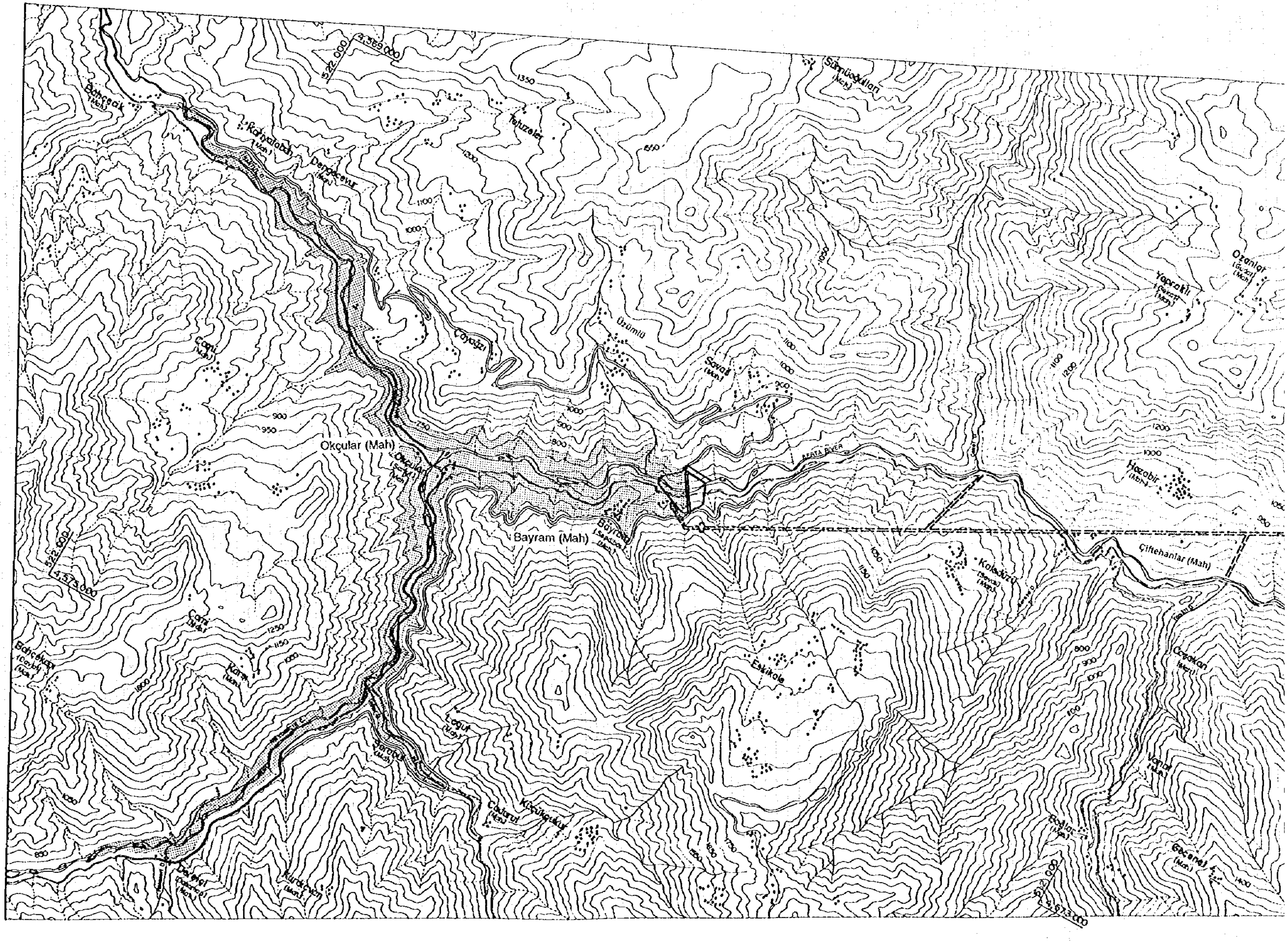
MEDITERRANEAN SEA
CYPRUS
LEGEND
International boundary
Railway
Main roads
ÇORUH-BERTA RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT
LOCATION MAP
Figure 1



ÇORUH-BERTA RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

ÇORUH - BERTA RIVER GENERAL PLAN

Figure 2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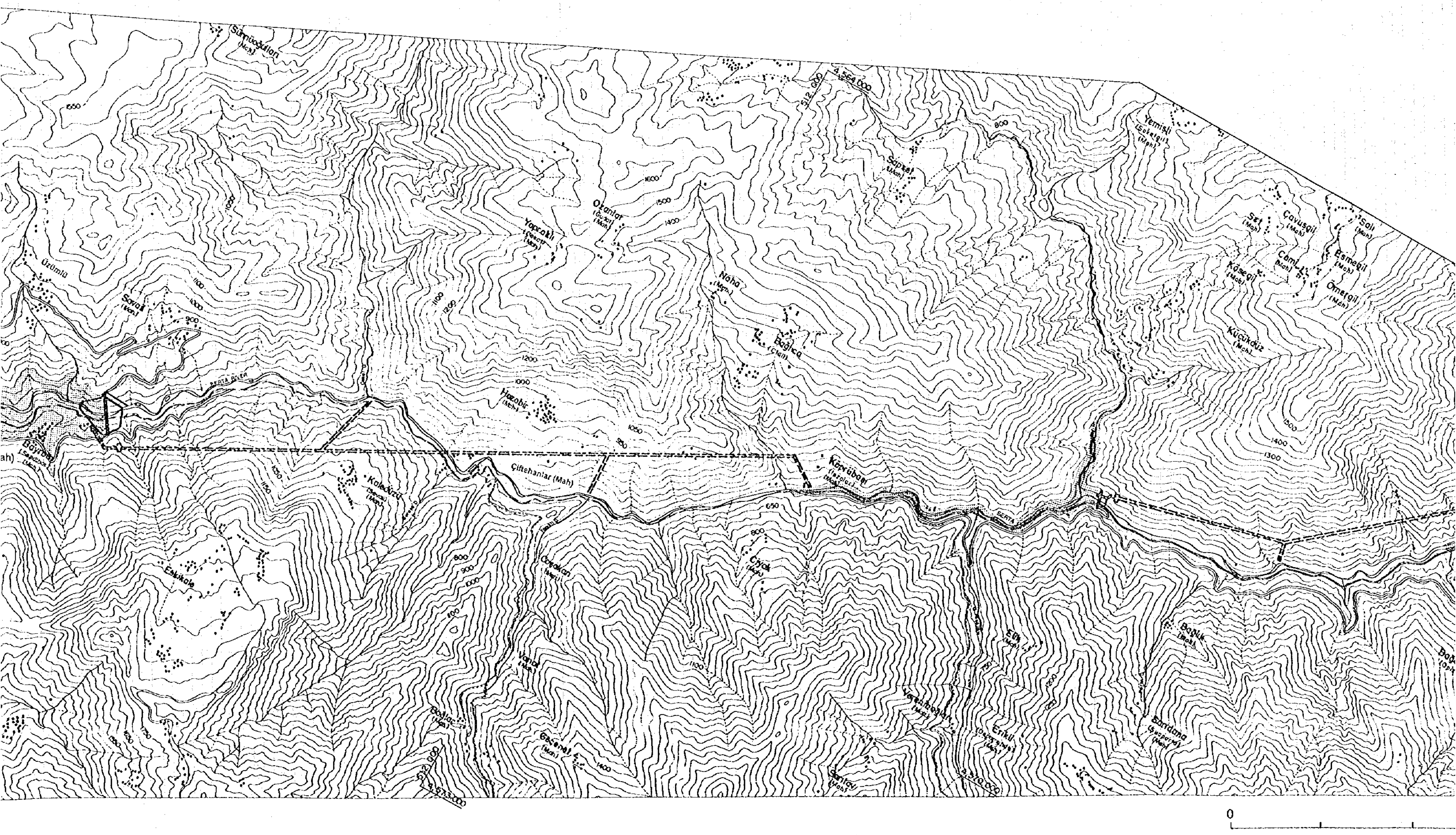

Sürmüoğulları (Mah)
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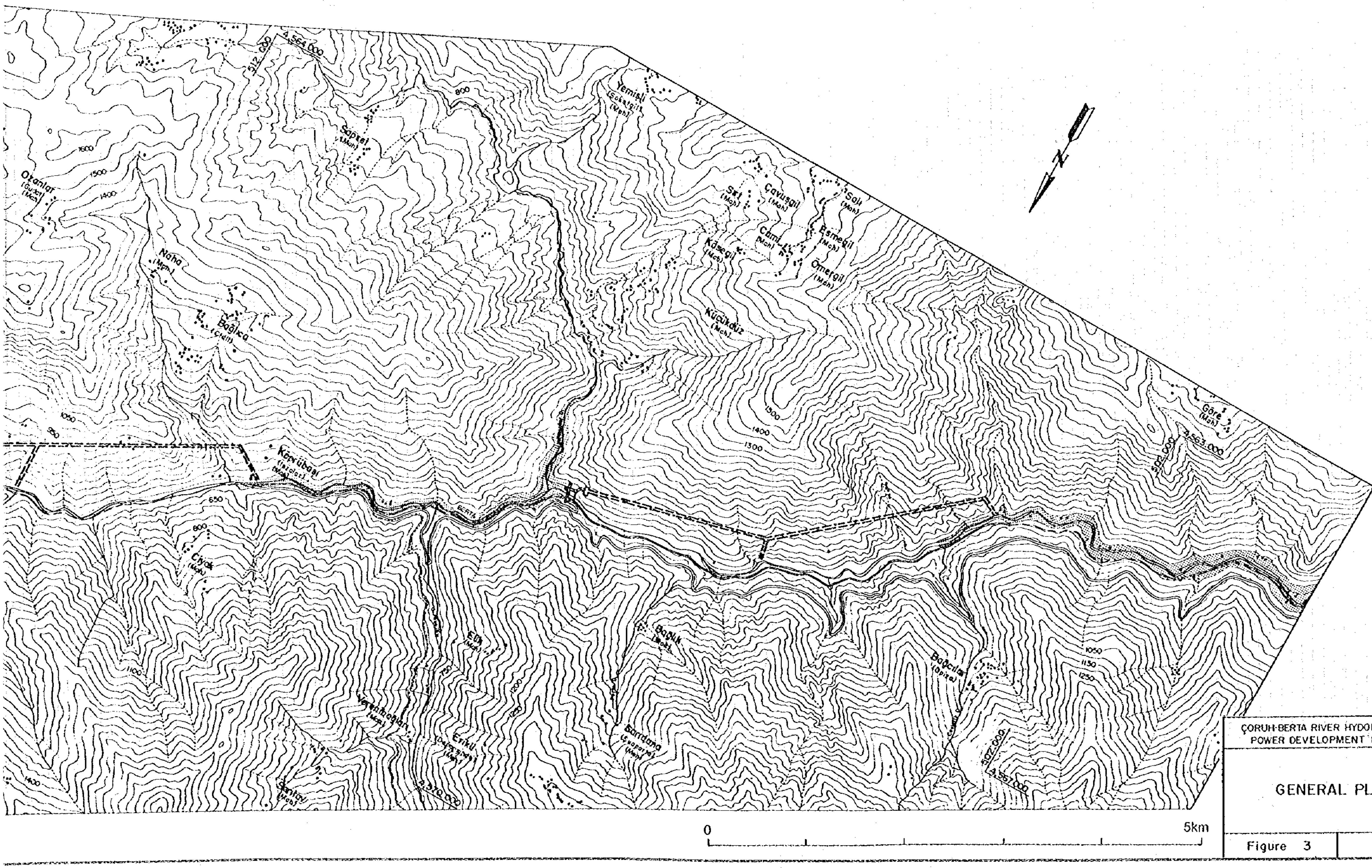

ÇORUH-BERTA RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

GENERAL PLAN

Figure 3

CONTENTS

1. Introduction

This Report summarizes the results of the Feasibility Study on Çoruh-Berta Hydroelectric Power Development Project at Berta river, Çoruh river basin in Republic of Turkey.

The Feasibility study was carried out in response to the request of the Government of Republic of Turkey to the Japan Government.

In 1994, power demand forecast (from 1995 to 2010) was prepared by TEAŞ (former TEK). In 2010, maximum power demand is estimated at 43,590 MW. Power generation is estimated at 271,450 GWh and annual average growth rate is approximately 8.0%.

The total installed capacity of generating facilities in Turkey at the end of 1995 is 20,952 MW, of which the thermal power amounts to 11,089 MW (53%) and hydroelectric to 9,863 MW (47%). According to the power development plan by TEAŞ, it is anticipated that the total installed capacity in 2010 will be as much as 60,056 MW, of which the thermal and nuclear power amounts to 36,970 MW (62%) in combination while the hydroelectric power to 23,086 MW (38%).

Turkish Government performed the M/P of hydropower development schemes in Çoruh main and tributary river each in 1982 and in 1992.

As above results 10 schemes in main river and 19 schemes in tributary, total installed capacity 3,157 MW, are now under planning.

The Turkish Government appreciate that the Çoruh Berta hydropower scheme is one of the highest priority to develop urgently and has already carried out the basic geological investigation to that site.

And in January, 1994, the Turkish Government requested the Japanese Government to make the feasibility study for this project regularly.

The Scope of works for the study was agreed upon between the General Directorate of Electrical Survey and Development Administration (EIE) on behalf of the Government of

Republic of Turkey and the Japan International Cooperation Agency (JICA) on August 31, 1995.

JICA entrusted the Electric Power Development Co., Ltd. (EPDC), Japan, to perform the study on the basis of the Scope of Works.

The JICA Study Team, headed by Mr. T. Hasegawa (EPDC), Team Leader, started the works for the study in November 1995. First, the Inception Report was prepared, The Report contained the policy of the study, method of the study, diversion of the technical undertakings between the EİE and the JICA. In the Report, the Study Team divided the study period into three stages on the basis of the Scope of Works, namely Preliminary Investigation Stage, Detailed Investigation Stage and Feasibility Design Stage. Second, the site reconnaissances and studies were carried out to select the optimum layout for the project and prepared the Progress Report in March 1996. Third, the detailed investigation works were carried out at the selected layout and prepared the Interim Report in March 1997. Finally, the determination of development scheme and feasibility design were carried out. All study works were completed in October 1997.

The study was mainly performed together with counterparts in EİE. During the study, technical transfer including seminar (by EİE and the Study Team) was given to EİE's engineers.

2. Character of the Project

The river basin of Çoruh is divided to 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 houses 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.

3. Result of the Study

3.1 Power Demand Forecast and Power Development Plan

(1) 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.

According to the power demand forecast of TEAŞ (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.

(2) 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 power amounts to 36,970 MW (62%) in combination while the hydroelectric power to 23,086 MW (38%).

3.2 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.

3.3 Meteorology and Hydrology

(1) 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

(2) Sedimentation

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

Bayram dam Q_{SMD} = 253,821 tf/year
Bağlık dam Q_{SMD} = 76,650 tf/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 $S_{VU} = 3.55 \times 10^6 m^3$

3.4 Topography, Geology, Materials, and Earthquakes

3.4.1 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

(a) 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.

(b) 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.

(c) 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.

(d) 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 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.

3.4.2 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 6 m 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

(a) 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.

3.5 Investigations for Environmental Aspects

(1) 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.

(2) 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.

(3) 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.

(4) 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.

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

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

(7) 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.

(8) 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 21.3×10^6 US$.

3.6 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 $113 \times 10^6 m^3$, drawing water of maximum 43 m^3/s from 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 $1 \times 10^6 m^3$, 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 Arktası village site by tailrace tunnel of length of approximately 4.5 km.

3.7 Construction Program and the Cost

(1) 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 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.

(2) Construction Cost

The time of estimation is to be the initial part of Jan. 1996 with US$1 at TL 61,000.

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$79,463thousand, L.C=TL3,319,751 million, F.C=1,527,517 million).

3.8 Economic and Financial Analysis

(1) 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.

(2) 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.

(3) 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.

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[1] Reference: ADB, *Ibid.*

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

3.9 Financing Plan

(1) 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

(2) 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.

3.10 Outline of the Project

3.10.1 Bayram Project

<u>River</u>

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

<u>Reservoir</u>

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

<u>Dam</u>

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

<u>Diversion Tunnel</u>

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

3.10.2 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

<u>Penstock</u>

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

<u>Powerhouse</u>

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

<u>Access Tunnel</u>

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

<u>Cable Tunnel</u>

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

<u>Drainage Tunnel</u>

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

<u>Tailrace Chamber</u>

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

4. 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 million, F.C.=TL1,527,517million).

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. 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.

5. 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 will 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.

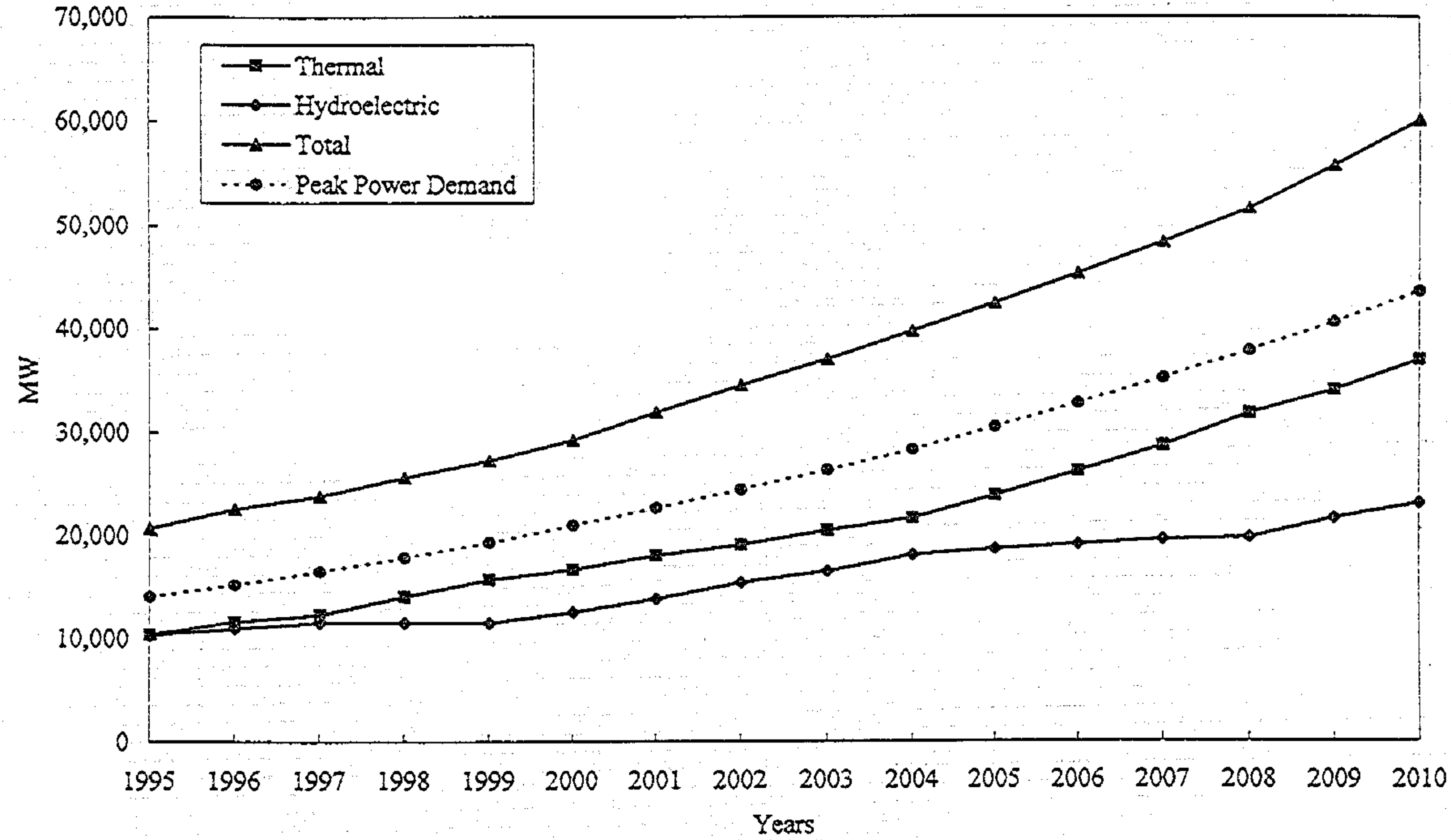

Figure 4 Trend of Power Development Plan

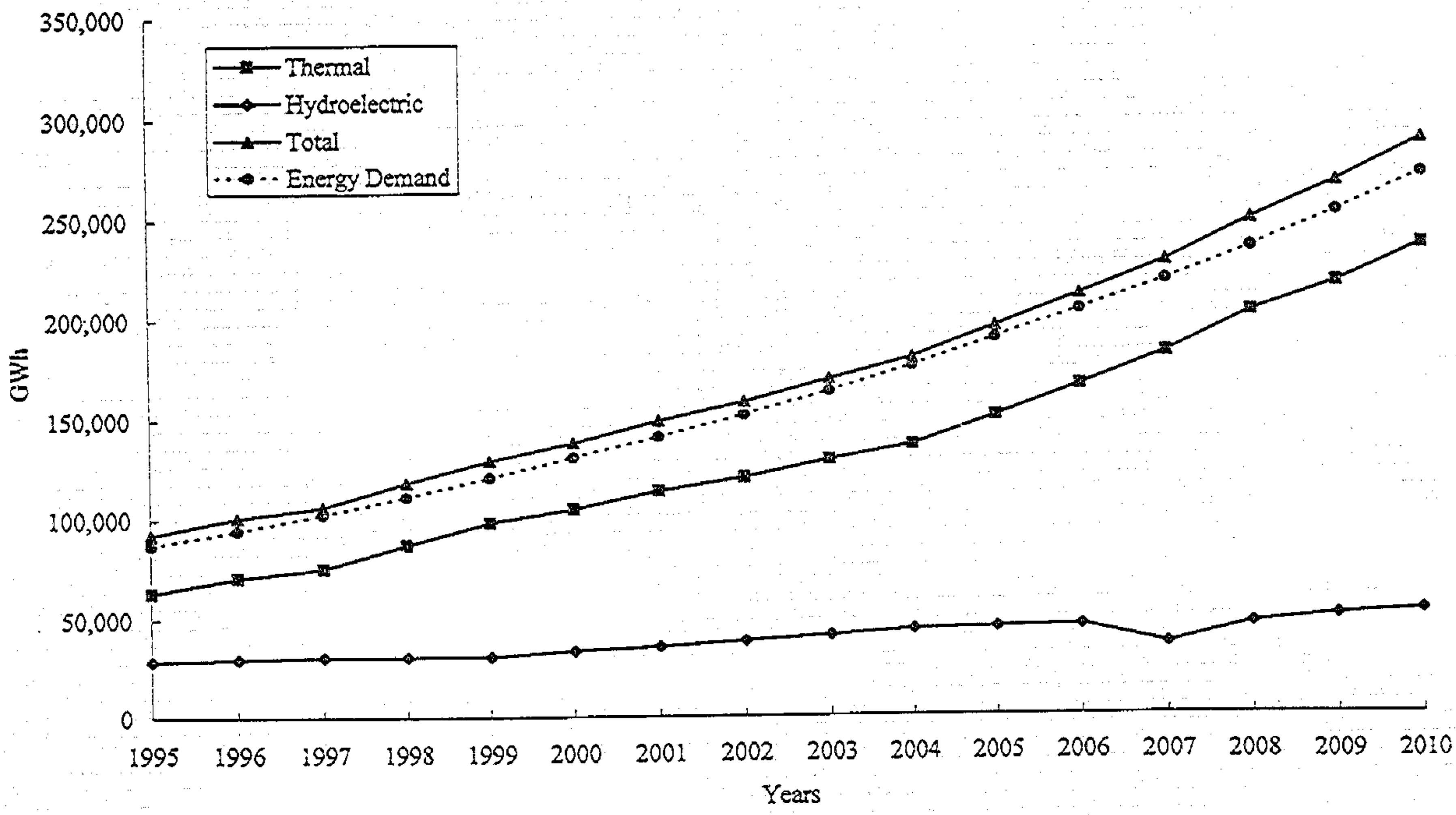

Figure 5 Trend of Demand and Supply Forecast