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THE REPUBLIC OF TURKEY
ELEKTRİK İŞLERİ ETÜD İDARESİ
GENEL MÜDÜRLÜĞÜ

FEASIBILITY STUDY
ON
[illegible] POWER
DEVELOPMENT PROJECT

VOLUME I
SUMMARY

DECEMBER [illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

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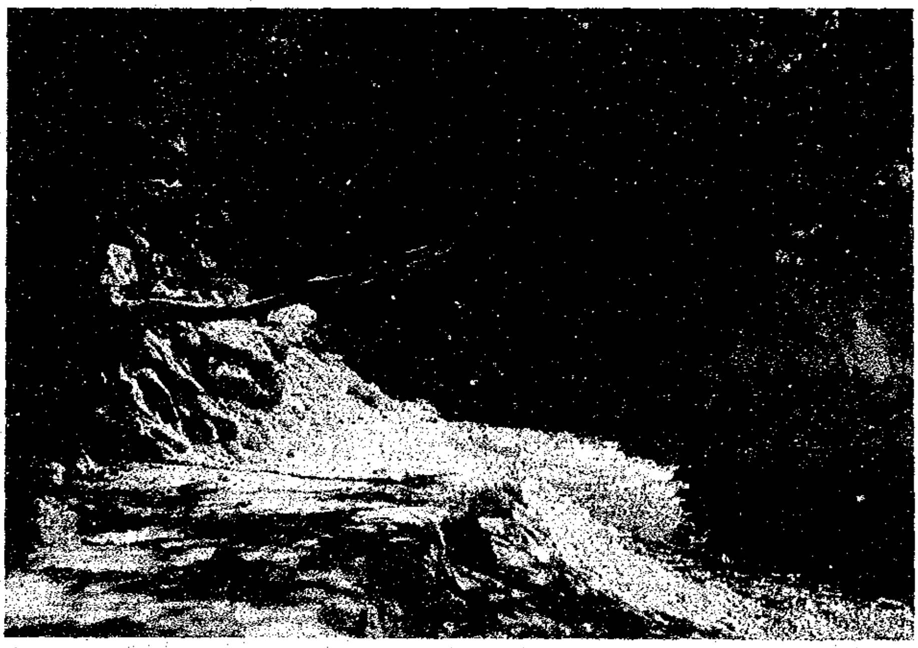
LIST OF VOLUMES

FIG. NO.

A distant view of the Görmel Gorge, in which Ermenek dam site is located, viewed from upstream (July 1989)



Erik intake weir site viewed from downstream (July 1989)

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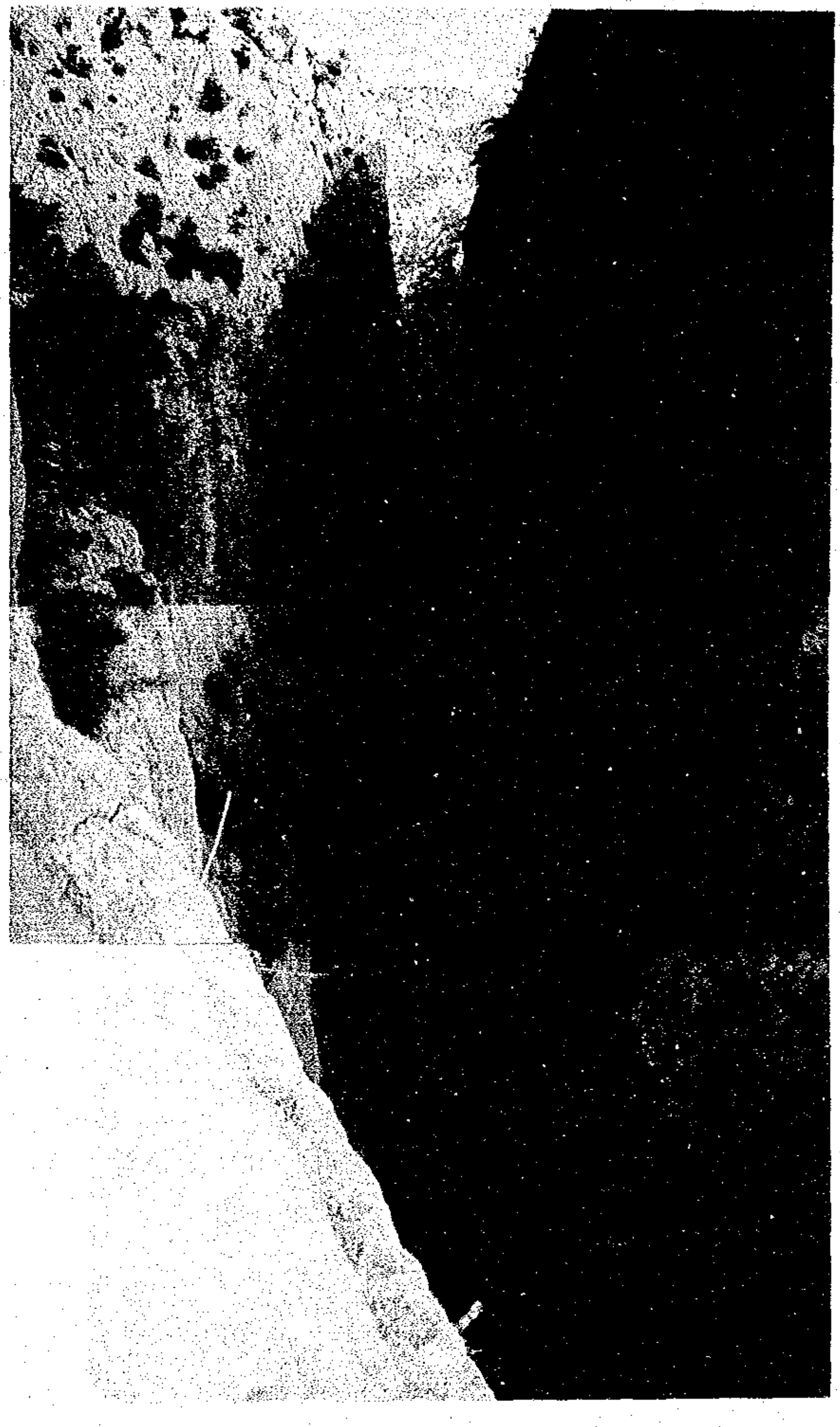
FIG. NO.



I-Cc dam site, looking downstream from the left bank (July 1989)

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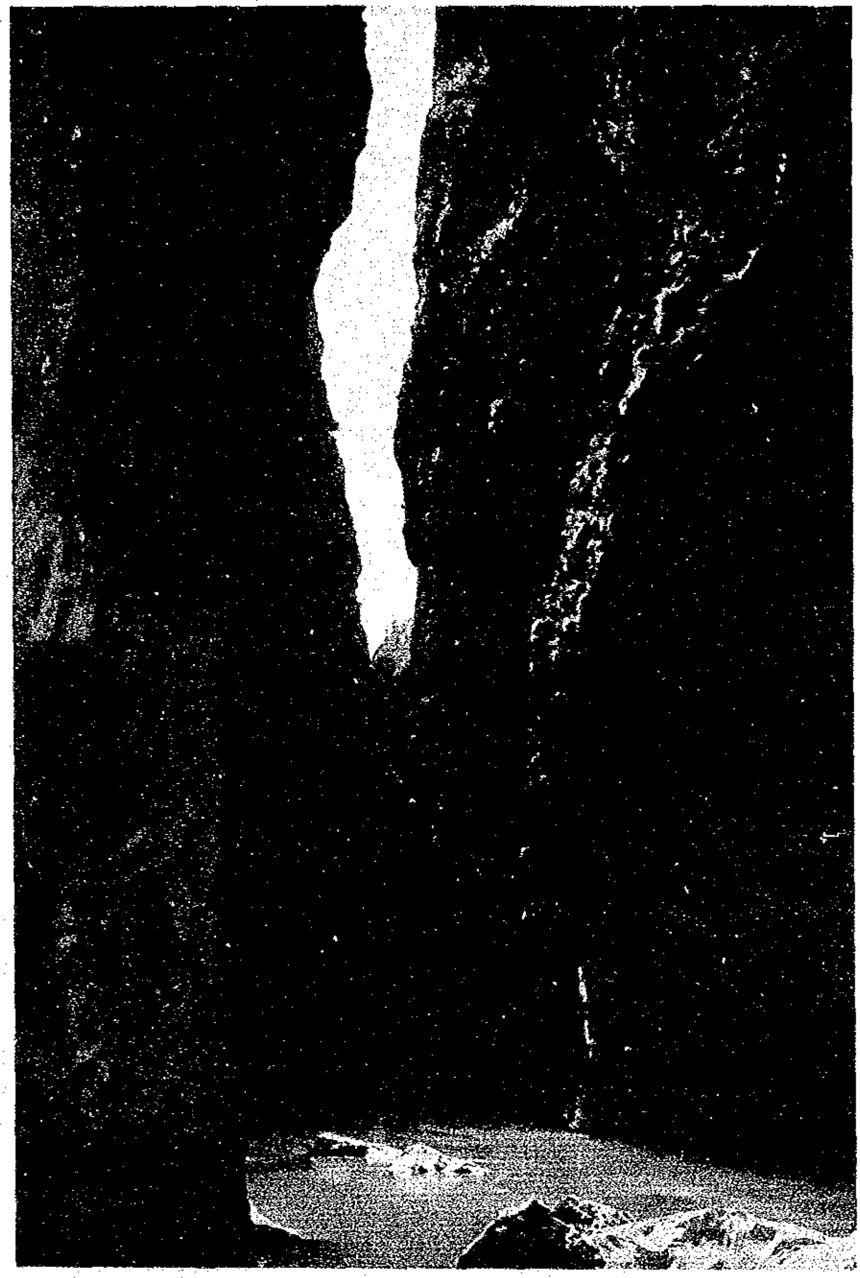
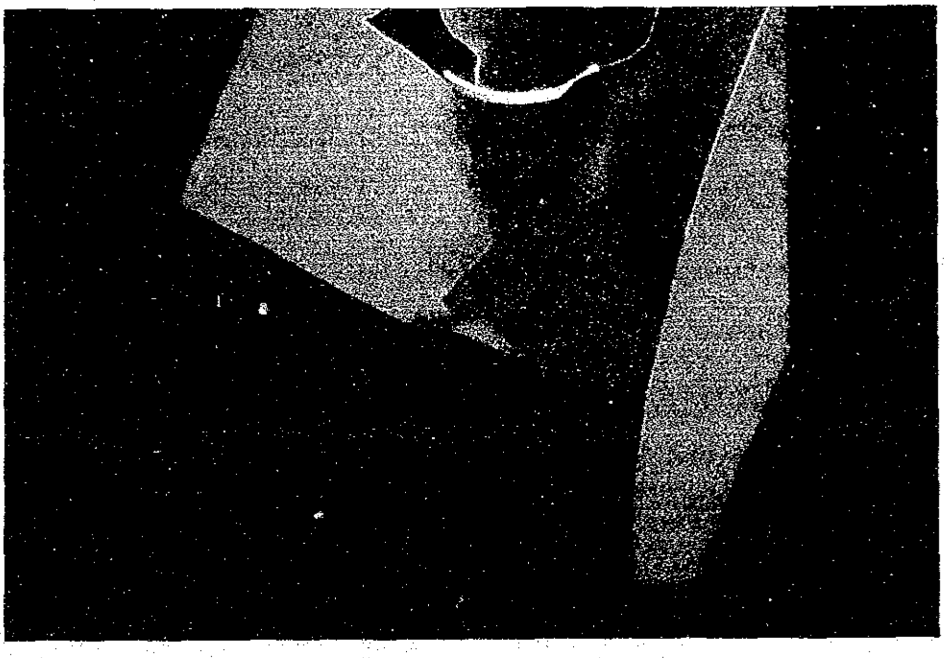
FIG. NO.



I-Cc dam site viewed from downstream (July 1989)

	THE REPUBLIC OF TURKEY ELEKTRİK İŞLERİ ETÜD İDARESİ GENEL MÜDÜRLÜĞÜ	ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Photographs (3/3)

FIG. NO.



HWL: 675 m **Dam height:** 190 m

P: 320 MW **Annual energy:** 1,054 GWh

THE REPUBLIC OF TURKEY ELEKTRİK İŞLERİ ETÜD İDARESİ GENEL MÜDÜRLÜĞÜ	ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE **Bird's-eye View of Proposed Ermenek Dam**

PRINCIPAL FEATURES

(1) Hydrology and reservoir

1.1	Catchment area at dam site	:	2,156 km^2
1.2	Mean annual inflow including 3.5 MCM of Erik water	:	1,466 MCM (= 46.5 m^3/s)
1.3	High water level (HWL)	:	675 m
1.4	Drawdown of reservoir	:	60 m
1.5	Reservoir area at HWL	:	48.4 km^2
1.6	Effective storage capacity	:	2,339 MCM

(2) Dam

2.1	Type of dam	:	Concrete arch
2.2	Maximum height	:	190 m
2.3	Length of curtain grout hole	:	386,000 m
2.4	Length of grouting tunnel	:	13,580 m

(3) Waterway

3.1	Design discharge	:	116.6 m^3/s
3.2	Headrace tunnel	:	D6.1 m x 9,042 m
3.3	Pressure shaft	:	D3.6 m x 553 m x 2 lanes
3.4	Tailrace tunnel	:	D6.1m x 1,764 m

(4) Power station

4.1	Type of power house	:	Underground
4.2	Generating equipment (main)	:	160 MW x 2 units
		=	320 MW
4.3	Erik Power Station	:	6.7 MW x 1 unit
4.4	Annual power output (Main 1,022 + Erik 32)	:	1,054 GWh

4.5 Firm-up effect on the Gezende Power Station

- Firm energy	:	118 —> 526 GWh
- Secondary energy	:	448 —> 115 GWh
Total	:	566 —> 641 GWh

(5) Transmission Lines

5.1 380 kV line to Seydişehir	:	160 km
5.2 34.5 kV line to dam site, etc.	:	16 km

(6) Investment costs (US$ million at 1989 price level)

		FC	LC	Total
6.1 Total construction costs	:	170	235	405
6.2 Tax	:	17	24	41
6.3 Interest during construction	:	29	77	106
Total investment costs	:	216	336	552

(7) Construction period

7.1 Detailed design & preparatory works	:	3 years
7.2 Main construction works	:	7
Total		10

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ABBREVIATIONS

(1) Domestic organization

DMİ : Devlet Meteoroloji İsleri
(State Meteorological Service)

DSİ : Devlet Su İsleri
(General Directorate of State Hydraulic works)

EİE : Elektrik İsleri Etüd İdaresi
(Electrical Power Resources Survey
and Development Administration)

DİE : Devlet İstatistik Enstitüsü
SIS (State Institute of Statistics)

DPT : Devlet Planlama Teskilati
SPO (State Planning Organization)

TEK : Türkiye Elektrik Kurumu
(Turkish Electricity Authority)

(2) Foreign organization

JICA : Japan International Cooperation Agency

(3) Measurement

Length

mm = millimeter
cm = centimeter
m = meter
km = kilometer

Electrical Measures

V = Volt
kW = kilowatt
MW = Megawatt
kWh = kilowatt hour
MWh = Megawatt hour
GWh = Gigawatt hour

Area

km^2 = square kilometer

Money

TL = Turkish lira
US$ = US dollar
US¢ = US cent
¥ = Japanese Yen

Volume

MCM = million cubic meter
m^3 = cubic meter

Weight			Other Measures		
kg	=	kilogram	%	=	per cent
ton	=	metric ton	°	=	degree
			'	=	minute
Time			"	=	second
sec, s	=	second	m^3/s	=	cubic meter per second
min	=	minute			
hr	=	hour			
yr	=	year			

(4) Economy and finance

EIRR	:	Economic Internal Rate of Return
FIRR	:	Financial Internal Rate of Return
FC	:	Foreign Currency
LC	:	Local Currency
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
GRDP	:	Gross Regional Domestic Product
OMR	:	Operation, Maintenance and Replacement
LS	:	Lump Sum

(5) Elevation

EL.	:	Elevation above mean sea level
FWL	:	Flood water level
HWL	:	High water level
LWL	:	Low water level

(6) Exchange rates (as of November 1989)

US$1.00 = TL2,300 = Japanese ¥143

TEXT

1. INTRODUCTION

The Feasibility Study on Ermenek Hydroelectric Power Development Project (the Study) was carried out in accordance with a Scope of Work which was agreed between the General Directorate of Electrical Power Resources Survey and Development Administration (EİE) and the Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, on September 22, 1988 in Ankara.

The Study was conducted by a Study Team of JICA in collaboration with counterpart personnel of EİE between March 1989 and December 1990, being divided into the Preliminary Investigation Stage, Additional Detailed Investigation Stage and Feasibility Grade Design Stage, with the objective of formulating an optimum plan for the Ermenek Hydroelectric Power Development Project (the Project) and to assess the technical, financial and economic feasibility of the Project.

Grateful acknowledgement is made of the assistance and cooperation provided in various forms by officials of the Republic of Turkey and other individuals to the Study Team. Heartfelt gratitude is also due to officials of the Government of Japan who supported the conduct of the Study. The Study Team is specially indebted to the counterpart personnel of EİE who efficiently performed the field works overcoming various difficulties and provided every assistance to the Study Team.

2. BACKGROUND

Turkey, 781,000 km^2 in area, occupies the Anatolian Peninsula and part of Thrace. The longest dimensions are 1,600 km east-west and 650 km north-south. The coastal regions have a continental temperate climate, while the interior plateaux have a dry and severe climate.

The population of Turkey was 50.3 million, growing at an annual rate of 2.5 per cent, in 1985. The population is concentrated in Thrace and the coastline of Anatolia. The urban population was 53 per cent in 1985.

Of the total land area of 78.1 million hectares, 36.3 million hectares (46.5 %) are agricultural land, 20.2 million hectares (25.9 %) are forest and 21.6 million hectares (27.6 %) are other lands and water surfaces.

The gross domestic product (GDP) was TL50.7 trillion (US$59.2 billion) or US$1,120 per capita at current prices in 1987. The composition of GDP was 17.4 per cent for the agriculture, forestry and fishery sector, 32.2 per cent for the industry sector, 4.1 per cent for the construction sector and 46.2 per cent for the service sector.

Reduction of state intervention in the economy, privatisation of state enterprises, encouragement of build-operate-transfer projects and foreign investment, and promotion of export oriented production were policies introduced in the 5th Five Year Development Plan (1985-1989) and these are increasingly emphasized in the 6th Five Year Plan (1990-1994).

A policy to diversify energy sources, which are heavily dependent on imports, will call for the substitution of petroleum products by pipelined gas from the U.S.S.R., and introduction of imported coal and nuclear power plants.

3. POWER STUDY

3.1 Organization

The Turkish Electricity Authority (TEK) is the corporation responsible for expansion and operation of the power supply system including rural electrification in Turkey. With regard to hydroelectric power single purpose projects, EİE undertakes master planning, survey, feasibility study and detailed design. Construction is the responsibility of the General Directorate of State Hydraulic Works (DSİ).

3.2 Existing Electricity System

The total installed capacity of power generating facilities in Turkey in 1988 was 14,518 MW comprising 6,218 MW (43 %) of hydroelectric power units and 8,300 MW (57 %) of thermal power units. The electricity demand had grown to exceed the expansion of supply capacity between 1975 and 1980, resulting in an increasing import of electricity from the U.S.S.R. and Bulgaria. The development of lignite thermal power as well as hydroelectric power thereafter relieved the demand-supply imbalance. Furthermore, the commissioning of additional units at Karakaya and Altinkaya hydroelectric plants made it possible to reduce thermal power generation from 1987.

Gross generation in 1988 was 48,049 GWh, consisting of 19,099 GWh (40 %) of thermal energy and 28,950 GWh (60 %) of hydroelectric energy. Import of energy was 381 GWh. In the same year, peak power generation was 7,613 MW corresponding to an annual load factor of 72 per cent. The average annual growth rate of the gross energy requirement was 8 per cent between 1979 and 1988.

The nationwide transmission line system comprises 7,202 km of 380 kV lines and 18,832 km of 154 kV lines.

Of the 35,167 villages in Turkey, 34,834 villages (99.1 %) had been electrified by 1988.

There are two kinds of power tariff; a two-part tariff based on kW and kWh, and a one-part tariff based on kWh only. The former is generally applied to large consumers and the latter to small consumers. The average tariff in 1989 was estimated to be TL131.23 or US¢5.7 per kWh.

3.3 Long-Term Power System Development Plan

A Long-Term Generation-Consumption Study (1994-2010) prepared by TEK in 1988 included long-term power demand forecasts and a long-term power system development plan.

The long-term power demand forecasts were prepared for high and low scenarios (see Plate 12 for the low scenario). The gross energy requirement for 1989, the base year of forecasts, was assumed at 57,925 GWh in the high scenario and 55,545 GWh in the low scenario. The forecast demand for 2000 was 166,830 GWh in the high scenario and 156,515 GWh in the low scenario, but the forecasts for 2010 were almost the same between the two scenarios; 323,850 GWh in the high scenario and 323,295 GWh in the low scenario. The low scenario forecast has been approved by the Government. The average growth rate between 1989 and 2010 was found to be 8.7 per cent for the low scenario.

The long-term power system development plan involved various scenarios to supply the forecast demand up to 2010. Principal points of the plan were; (1) balanced development of hydro and thermal plants; (2) the share of hydroelectric projects was to be 46 per cent in 2000 and 36 per cent in 2010, respectively; (3) the Ermenek Project was entered into a group to be commissioned at the turn of the century; (4) fuel oil and "motorin" power plants would no longer be implemented, the present development pace of lignite power would slow down, and major thermal power plants to be implemented would be imported coal thermal plants and natural gas combined cycle power plants; and (5) the first nuclear power plant would be commissioned by 2010.

3.4 Supply Area of the Project

Large hydroelectric power stations such as Keban (1,330 MW), Karakaya (1,800 MW) and Atatürk (2,400 MW) as well as Elbistan lignite plant (1,360 MW extendable to 6,120 MW) are located in the eastern half of the country, while major load centers such as Istanbul, Ankara, Izmir and so forth are located in the western half. The main power flow in the power supply system is, therefore, from east to west. There will be no need for the Project to supply Adana or Mersin, which are located to the east. The western part of Içel province will be supplied by the Akkuyu nuclear, Kayraktepe hydro and Gezende hydro plants. Consequently, the supply area of the Project will be Konya and Karaman provinces.

The general power demand in 1988 in Konya and Karaman provinces was 671 GWh with a peak of 140 MW. Konya city consumed 57 per cent of the general demand. An aluminum smelter at Seydişehir consumed 1,114 GWh with 146 MW peak in 1989. The total demand in Konya and Karaman provinces was estimated to be 3,544 GWh with 641 MW peak for 2000, and 6,314 GWh with 1,222 MW peak for 2010, respectively.

3.5 Operation Mode of Ermenek Power Plant

The power plants to be commissioned in the vicinity of the Project site by 2010 will be Ermenek hydro (320 MW), Kayraktepe hydro (420 MW), Konya-Ilgun lignite thermal (300 MW) and Akkuyu nuclear (1,000 MW). It is presumed that the former two plants will be operated for peak power supply and the latter two for base power supply. In the TEK Long-Term Generation-Consumption Study, 1988, the capacity factor of hydroelectric projects was planned to be 40 per cent on average and 20-30 per cent for firm energy. It is recommended that a capacity factor of 33 per cent for firm energy generation, which corresponds to 8 hours full output operation a day, be applied to the Ermenek Project to supply the middle peak load, from the viewpoint of cost-effectiveness under the condition that the Project is of a dam-waterway type with a headrace tunnel of about 9 km in length, while the Kayraktepe hydro plant is of dam type having been planned with a capacity factor of 17 per cent for firm energy.

3.6 Power Values

The value of the power output from the Project was calculated at the price levels of November 1989, assuming a combination of coal thermal and natural gas combined cycle plants as the least-costly alternative facilities, referring to the TEK's long-term power system development plan. Unit construction costs were assumed to be US$820/kW for coal thermal plant and US$500/kW for gas combined cycle plant, respectively. Fuel cost was estimated for the commissioning year of the Project at a constant price of 1989 based on "Price Forecasts for Major Primary Commodities, 1988-2000, the World Bank"; US$52/ton for coal of 5,800 kcal/kg in heat value and US$130/1,000 m^3 for natural gas of 8,500 kcal/m^3 in heat value, respectively. A capacity value of US$121/kW, firm energy value of US¢2.68/kWh and secondary energy value of US¢2.33/kWh were obtained. The combined energy value of the Project was thus assessed to be US¢6.47/kWh for the capacity factor of 33 per cent.

4. REVIEW OF EXISTING PLANS

4.1 The Göksu River Basin

The Göksu river originates in the Toros mountains at EL. 2,200 m about 60 km to the north of Alanya. Its general course is to the east-southeast and, passing Mut and Silifke, drains to the Mediterranean Sea. The Ermenek river is the largest tributary of the Göksu river. It originates at EL. 2,500 m also in the Toros mountains, flows south and then eastwards, to join the Göksu river at EL. 100 m near Mut (see Plate 1 for the basin map). The Ermenek river has a catchment area of 3,621 km^2.

The Yerköprü hydroelectric power station (11 MW) has been in operation in the upstream reaches of the Göksu river since 1959 (see Plate 3 for the location). The Gezende hydroelectric power station (150 MW) is now under construction in the Ermenek river 29 km upstream of the confluence of the Göksu and Ermenek rivers. The detailed design of the Kayraktepe hydroelectric power project (420 MW) has been completed but its implementation is suspended.

A feasibility study on the Water Diversion Scheme for the Konya Closed Basin by DSİ will be completed by the end of 1990. Envisaged in this scheme is a diversion of 490 MCM/yr (15.5 m^3/s on an average) of water from the upper basin of the Göksu river to the Konya basin for the purpose of municipal and irrigation water supplies. Upon realization of this scheme, the energy outputs of Yerköprü and Kayraktepe projects will be reduced.

4.2 Hydroelectric Power Development Plans in the Göksu River Basin

According to a provisional hydroelectric power development master plan prepared by EİE, there were four potential sites, which would form a cascade between the Yerköprü power station and the confluence of the Göksu and Ermenek rivers. The total installed capacity was estimated to be 57 MW (Plate 4). For the Ermenek river, five projects were provisionally envisaged above the Ermenek Project site; the Daran, Günder (Göktepe), Dumlugöze, Berem, and Gökdere projects (Plate 5). The master plan study by EİE will be completed by the end of 1990.

4.3 Provisional Idea of the Ermenek Project

The Ermenek valley is rather flat and open in the middle reaches between the Küçük and Zeyve rivers, but below this stretch the river runs in a narrow valley with an average slope of 1/72 as far as to the Gezende reservoir. The initial idea of the Project was to regulate the river flow by creating a reservoir in the flat valley and to develop a potential between the reservoir and the confluence of the Ermenek and Erik rivers, which is located near the headwaters of the Gezende project. Major alternative ideas of the Project are illustrated in Plate 6. In the previous study by EİE, the Project was a dam and waterway type development having a concrete arch dam or fill type dam, a headrace tunnel of about 11 km in length in the right bank, a surface penstock and a surface power station. An alternative idea to construct a second dam in the upstream or downstream vicinity of the confluence of the Ermenek and Erik rivers (alternative dam site II-B or II-A) to reduce the length of waterway and to increase the regulation capacity was also presented (see Plate 6 for alternative plans). The Nadire project was conceived to develop the potential above the high water level of the Ermenek reservoir, but this was later eliminated due to the high construction costs.

For the purpose of creating the Ermenek reservoir, alternative dam sites I-A, I-B and I-C were initially conceived, but the site I-A was ruled out because of poor foundation conditions. Site I-C located in a limestone gorge downstream of the Görmel bridge appeared to be suitable for a concrete arch dam but the permeability of the rock needed further clarification. Site I-B located about 2 km upstream of Site I-C was suitable for a fill type dam but with the dam crest elevation limited to about 600 m due to landslide debris deposits on the left abutment.

With the progress of the Study, three alternative dam axes I-Ca, I-Cb and I-Cc were proposed at Site I-C, and it became clear that a higher Ermenek dam was possible. Use of the flow of Erik river for power generation at the proposed Ermenek power station also seemed to be beneficial.

Preliminary economic studies made in order to narrow down the objects of additional detailed investigation resulted in ruling out the downstream dam sites II-A and II-B; selecting an underground penstock and power station with a tailrace tunnel to be extended up to the high water level of the Gezende reservoir; and taking up the Erik river diversion scheme.

5. SITE CONDITIONS

5.1 Field Investigations Performed

EİE performed field investigations for the Project in the pre-feasibility study stage; topographic survey of the reservoir area and the alternative dam site I-B; geological investigations consisting of test drilling of 5,111 m in total depth at various sites, seismic exploration along 31 profiles in the dam sites and headrace tunnel route, a test adit, and geological mapping; hydrometeorological measurements and study; and related works.

Additional detailed field investigation works were performed by EİE's counterpart personnel, including topographic survey and mapping; test drilling of 2,328 m in total depth, seismic exploration of 9,360 m in total length, an access tunnel and a test adit in the Görmel Gorge; sampling and laboratory tests of construction materials; discharge measurements; compensation survey; environmental investigation; and related works. Location maps of the geological investigations are shown in Plates 7 and 8.

5.2 Geology

The Upper Cretaceous Ermenek Ophiolitic Melange outcrops in most of the Project region as a basement. It is composed of Carboniferous - Upper Cretaceous blocks of sedimentary rocks, mainly limestone, of different characteristics, and matrix layers. The matrix layers are formed of diabase, serpentinized peridotite, gabbro, graywacke, graywackish sandstone, schist, conglomerate and so forth.

The Cenozoic Tertiary formations, namely the Görmel Formation of Lower Miocene age and the Ermenek Formation of Middle Miocene age are dominant in the region. The Görmel Formation is composed of mainly marl, and partly claystone, sandstone, clayey to sandy limestone and conglomerate. The Ermenek Formation is composed of mainly limestone partly sandy limestone, sandstone and marl.

The Quaternary deposits, such as terrace deposits, talus deposits and so forth are seen on many slopes and along the rivers.

The alternative dam site I-C is located in the Görmel Gorge, which is formed in an upper Jurassic-Cretaceous limestone block. The block is composed of hard and massive rocks and has sufficient strength to support a high arch dam. This limestone block is bordered by the low-pervious Ophiolitic rocks of the Ermenek Ophiolitic Melange on the left bank; and by the low-pervious marl of the Görmel Formation on the right bank. Although the limestone has many solution cavities at elevations higher than about 500 m, the riverbed elevation, the limestone becomes less karstic towards the lower elevations. It is judged that water leakage could be controlled by curtain grouting.

At the alternative dam site I-B, the foundation rocks are mainly marl of the Görmel Formation and of low permeability. They are soft but strong enough to support a high fill dam. The left bank of the I-B dam site shows traces of old landslides. However, no large scale landslide would occur during and after impounding of the reservoir because of the gentle slopes and slow reservoir drawdown expected.

Most of the reservoir area is composed of sedimentary rocks of the Görmel Formation, but partly matrix layers of Melange, which are of low permeability. Limestones are seen only around the upstream end of the reservoir area. They are surrounded by matrix layers of low permeability, and the groundwater stage is judged to be close to the valley slopes. Accordingly, no leakage problems are likely to occur in the reservoir area.

The proposed headrace tunnel will pass through limestone for 6,300 m and matrix layers of the Ermenek Ophiolitic Melange for 2,700 m. The surge tank and pressure shaft will be located in limestone and matrix layers. These rocks are estimated to be in slightly weathered to fresh conditions. The tailrace tunnel will penetrate limestone for 1,050 m, matrix layers for 150 m, and marl for 550 m. A supporting system will be required for tunnel excavation especially in the matrix layers and marl.

The limestone in the power house site has similar properties to those in the I-C dam site, and is appropriate for construction of a cavern for the underground power house (see Plate 8 for the location).

The Erik intake site is located in hard and massive limestone block; the diversion tunnel will penetrate the limestone and matrix layers of the Melange; the Erik power house site is also located in the matrix layers. No geotechnical problem was found at the proposed Erik structure sites.

The study area is not in any of the seismic zones of the Anatolian Peninsula. The design seismic coefficient for the Project is evaluated at 0.05 to 0.1g.

5.3 Construction Materials

Of the 11 potential borrow areas located along the Ermenek and Zeyve rivers, 7 borrow areas are suitable for exploitation of core materials. The available volume is estimated to be more than 5 million m^3 in total. The potential borrow areas of sand for filter materials and concrete aggregates are riverbed deposits and alluvial terrace deposits along the Ermenek river. The available quantity is estimated to be 1 million m^3 in total. Quarried rocks from the left vicinity of the site I-C can be used as rockfill material, transition material, filter material for dam embankment, and as concrete aggregates. The estimated quantity is more than 10 million m^3 in total.

5.4 Hydrometeorology

The Mediterranean climate is dominant in the lower Ermenek river basin, while the upper basin belongs to a transitional climate towards the continental climate which prevails in the central plateau of Turkey. The mean annual precipitation is about 950 mm in the basin upstream of the proposed dam site. Approximately 80 per cent of the annual precipitation occurs during winter and spring; from December to May.

Mean air temperature fluctuates widely throughout the year with an annual mean at Ermenek of 11.8°C. The extreme maximum and minimum recorded were 39°C in July and -15°C in January. Maximum wind velocity ever recorded was 23 m/s at Mut with the dominant direction of northwest.

The inflow into the proposed Ermenek reservoir is estimated at 43.0 m^3/s on average for the period of 42 years from 1946 to 1987. In addition to this, an average flow of 3.5 m^3/s is available from the Erik river, which drains 239 km^2 on the right bank and joins the Ermenek river near the proposed power station site. The flow of Ermenek river has a seasonal pattern with double peaks; the highest peak in April caused by the snow-melt in spring and the second peak in January resulting from the winter rainfalls. The lowest flow takes place in September.

In the Ermenek river basin, a large flood can be caused either by heavy winter rainfall or by a combination of snow-melt and spring rainfall. The maximum flood ever observed at the proposed dam site was 1,200 m^3/s in peak discharge and 48 hours in duration. The 100-year probable flood was estimated to be 2,000 m^3/s at the Ermenek dam site and 400 m^3/s at the Erik intake weir site. Two probable maximum floods (PMF) were estimated for dam design purposes: 5,900 m^3/s in peak discharge and 440 MCM in 2-day volume as the winter season PMF in January; and 5,400 m^3/s and 510 MCM as the spring season PMF in April.

The mean sediment inflow into the proposed Ermenek reservoir was estimated at 130 $m^3/km^2/yr$. After a 100 years operation, the total sediment deposit volume would be of the order of 30 MCM, which is negligibly small compared with the dead storage capacity of 1,190 MCM.

The water of Ermenek river is slightly alkaline with an average pH value of 8.0. The hydraulic turbines and other steel structures of the Project would be free from corrosion trouble.

5.5 Access to the Project Site

A vicinity map of the Project area is shown in Plate 2. The goods imported for the Project will be unloaded at the Mersin international seaport on the Mediterranean Sea coast and will be transported either by the 234 km long Mersin-Silifke-Mut-Ermenek Power Station site road, or by the 220 km long Mersin-Silifke-Gülnar-Ermenek dam site road. The Mut-Ermenek section and the Gülnar-Ermenek section will need some improvement works, and new access roads to reach the power station and dam sites will be constructed.

6. ENVIRONMENTAL ASPECTS AND COMPENSATION COST

6.1 Existing Environmental Conditions

The population in the Göksu river basin was 250,000 in 1987, with a population density of 24/km^2. The economic structure is agricultural and lags behind the national average. There are lignite mines near the proposed Ermenek reservoir. The Coal Mine Corporation is operating a shaft reaching down to EL. 300 m. Forest covers 69.4 per cent of Ermenek district, cultivated land 13.8 per cent, and pasture/meadow occupies 13.5 per cent. Most of the streams are fed by springs. The water quality is intact.

There are a limited number of wild mammal species in the Ermenek river basin. Birds include eagles, falcons, storks and goldfinches. Poplar is the predominant hardwood in the Ermenek river basin and conifers are often observed. There are more than 22 species of fish including eel, trout, carp and mullet. Aquatic florae are very limited.

6.2 Results of Compensation Survey

The proposed Ermenek reservoir area of 4,843 ha is classified into agricultural land of 844 ha, forest of 2,086 ha, and other lands and water surfaces of 1,913 ha. The total population in the area is 500, of which 200 are living in Çavusköyü. The expropriation value excluding movable assets is estimated to be US$9.8 million.

6.3 Possible Environmental Impact

The electricity supply will greatly contribute to industrial and regional development of Konya and Karaman provinces. Most of the people removed from the reservoir area are expected to be absorbed in the labor market in urban centers nearby. The Project will provide employment opportunities especially during the construction period. Service activities in the urban areas will be benefited by the influx of people. Production forgone in the reservoir will adversely affect agriculture but only to quite a minor extent in the context of Ermenek district. The water surface will provide opportunities for aquaculture and tourism, and lake transportation would encourage trading activities. Some of the displaced farmers may prefer resettlement to monetary compensation. Health conditions will change little.

Regulation of river flow will generally be beneficial to downstream people. The groundwater levels around the Ermenek reservoir will be raised with beneficial effects on springs nearby. The existing shaft of the Coal Mine Corporation, however, might be adversely affected. The thrust to eutrophication of the reservoir water will be very weak and slow. No landslides are expected in the reservoir area. Vegetation will be affected to some extent due to construction activities and reservoir impounding.

Little impact is foreseen on terrestrial fauna and flora, except that the created water surface may alter some aspects of wildlife. Construction of the Gezende dam has already affected fish species and no further change is expected from the Ermenek dam. An increase in aquatic flora will take place very slowly.

6.4 Countermeasures

Any change in social, economic and cultural conditions today is likely to worry some members of the local community, and it is essential that they shall be consulted in advance, and their opinions taken into account.

For those in the local community who prefer resettlement rather than compensation for disturbance, it is recommended that a resettlement program be prepared to enable them to continue their agricultural life style.

In conducting detailed design of the Project, consideration should always be made to preservation of the landscape, control of air, water and soil qualities, safety, and communication with public.

In order to protect the reservoir water quality from deterioration, administrative measures should be taken to restrict discharge of unfavorable materials into the reservoir or upstream river system and integrated regional plans should be prepared to maintain human activities within desirable limits.

7. PROJECT FACILITIES

7.1 Optimization Studies

Optimization studies were performed by comparing the capitalized net benefit of various alternatives based on the net benefit maximization criteria. The evaluation period was assumed to be 60 years from the starting year of detailed design work, with a discount rate of 9.5 per cent, which was assumed to be the opportunity cost of capital (OCC) of the energy sector in Turkey.

Preceding the optimization study of the development scale of the Project, the principal components were studied and optimized in terms of their types, basic dimensions and other parameters as summarized below:

- Spillway discharge capacity :	2,600 m^3/s
- Design flood water level :	3.3 m above the HWL
- Reservoir drawdown :	60 m
- Diameter of headrace tunnel :	6.1 m
- Diameter of pressure shaft :	3.6 m x 2 lanes
- Design discharge of Erik Diversion Scheme :	6.0 m^3/s
- Type of Erik diversion tunnel:	free flow tunnel
- Tailwater level of Erik power station :	to be equal to HWL of Ermenek reservoir

A comparative study for optimization of the development scale was performed for eleven different high water levels (HWL) from EL. 645 m to EL. 695 m at intervals of 5 m.

The capitalized net benefit increased almost linearly with the increase of HWL, until HWL reached EL. 675 m, but thereafter it decreased because of delayed commissioning of power generation due to prolonged initial filling of the reservoir. Accordingly, the development scale of the

Project was determined at EL. 675 m in terms of HWL with an installed capacity of 320 MW. A general plan of the proposed Ermenek Project is shown in Plate 9, and some details are shown in Plates 10 and 11.

7.2 River Diversion Works

The river diversion works will consist of a diversion tunnel of about 365 m in length and 7 m in diameter, and upstream and downstream coffer dams. When a diversion design flood of 900 m^3/s occurs, the maximum outflow through the tunnel will be 650 m^3/s and the upstream water level will rise to EL. 534.3 m.

7.3 Dam

The Ermenek dam will be of thin concrete arch type. The dam geometry will be parabolic. The parabolic design has been developed and applied to 10 dams in Japan since 1969. It has the advantage that the thrust can be directed deep into the abutments by setting the central angle of arch as narrow as about 75 degrees. The maximum height of dam will be 190 m above foundation; the dam crest elevation will be 680.0 m with a design freeboard of 1.7 m above the flood water level; the dam crest length will be 165.8 m; and the dam volume 270,000 m^3.

7.4 Spillway

The proposed discharge system of the Ermenek dam will consist of two bottom outlets, a tunnel spillway, a normal overflow spillway, and an emergency overflow spillway. The discharge system will be capable of discharging 2,600 m^3/s with a reservoir water level at EL. 678.3 m (FWL).

The two bottom outlets will be installed in the dam body at EL. 545 m. The bottom outlets will have a gate of

4.0 m high and 2.5 m wide each, and will have a total discharge capacity of 670 m^3/s at a low water level (LWL) of 615 m to lower the reservoir water level below LWL if need arises.

The main flood discharge facility will be the tunnel spillway, which will be located in the right bank; the tunnel will be 263 m in length and 9.0 m in diameter, having two 7.0 m high and 3.0 m wide high pressure fixed wheel gates; the gates will be installed at EL. 630 m in their center elevation (45 m below HWL) and at 73 m downstream of the tunnel inlet; the maximum discharge capacity will be 1,160 m^3/s.

A normal overflow spillway will be provided at the central part of dam crest; the non-gated ogee crest will be 40 m in length and 675 m in elevation, being equal to HWL; the maximum discharge capacity will be 500 m^3/s.

An emergency overflow spillway will be added to the discharge system to provide for such an incident as malfunctioning of one of the four gates of the discharge system; it will consist of two non-gated ogee crests, one to the right and the other to the left of the normal overflow spillway; the ogee crest will be 30 m each in crest length and 678 m in crest elevation being 3 m above HWL or the normal ogee crest elevation.

7.5 Grout Curtain

Grout curtains will be provided in the limestone block down to an elevation of 400 m in general. On the left bank, the grout curtain will be connected with the Ophiolitic rocks of the Ermenek Ophiolitic Melange and on the right bank with the marl of the Görmel Formation (see Plate 11 for the grout curtain system).

The grout curtain system will consist of grout tunnels of 13,580 m in total length, and grout holes of 386,000 m in total depth. The grouting will require about 39,000 tons of cement. The objectives of the grout curtain works will be not only to perform the grouting but also to investigate and search the limestone for all the karstic cavities and potential water leakage paths.

Grouting tunnels, 3.5 m in internal diameter, will be excavated at six different elevations in the left bank at standard vertical intervals of 40 m. The lowest tunnel will be at 465 m in invert elevation. On the right bank, the tunnels will be placed at seven elevations, of which the lowest will be excavated at an elevation of 425 m to facilitate the grouting works planned for the right end of the block.

In order to facilitate access to the grouting tunnel, ten access tunnels will be excavated mostly from the downstream side of the gorge. These will be for railway transportation. In addition, 3 vertical elevator shafts will be provided: No. 1 in the left abutment of the dam; No. 2 at 180 m to the south from the right abutment; No. 3 at 1,160 m further to the south from the second shaft. Shaft Nos. 1 and 2 will be used for the movement of workers, transportation of light materials, and to provide space for air ducts and other pipes. Shaft No. 3 will be mainly for excavation, lining, drilling and grouting works in the lowest grout tunnel in the right bank. After completion of the construction works, these shafts will be used for inspection and maintenance works.

7.6 Waterway

The waterway will consist of an intake, a headrace tunnel, a headrace surge tank, underground pressure shafts of double lanes, a tailrace surge tank, a tailrace tunnel, and a tailrace outlet.

The power intake will be of shaft type, 10 m in excavation diameter and 80 m in height. The headrace will be a pressure tunnel of 6.1 m in internal diameter and 9,042 m in length. The headrace surge tank will be of chamber type with a riser shaft of 11 m in diameter. The pressure shaft will branch into 2 lanes at 60 m downstream of the surge tank; inclined at 45 degrees; 368 m in the length of inclined portion; 4.9 m in internal diameter in the single lane part; and 3.6 m in the double lane part. An inlet valve will be provided at the downstream end of each pressure shaft. A tailrace surge tank of port type will be provided 80 m downstream of the turbines. The tailrace tunnel will be 6.1 m in internal diameter, 1,764 m in length and 325 m in invert elevation at the outlet.

7.7 Power House

The power house will be of underground type with a cavern, 38.5 m high, 27.0 m wide and 98.0 m long, and will be constructed by NATM (the New Austrian Tunnelling Method) in the limestone block without concrete lining. The turbine center will be set at an elevation of 320 m, being 13 m lower than the normal tailwater level of 333 m. The lowest elevation of excavation below the draft tube will be 310.5 m, allowing 6.5 m above the bottom surface of the limestone block. A draft tube gate chamber will be constructed between the power house and the tailrace chamber.

7.8 Erik Diversion Scheme

The Erik Diversion Scheme will consist of an intake weir, a desilting basin, an Erik diversion tunnel, a head tank with excess water spillway, a penstock, an Erik power house, an inlet shaft with air-trap chamber, and a connecting tunnel.

The intake weir will be of concrete gravity type, having a crest elevation at 820 m. The design flood will be 400 m^3/s, which is a 100-year probable flood. A desilting basin will be provided to trap suspended sediment during floods and snow-melting season. Because of site topography, the basin is located underground. The Erik diversion tunnel will be of free flow type; 2.2 m in width; 2.3 m in height; and 3,580 m in length. A headtank will be provided at the connection point of the diversion tunnel and the penstock. The penstock will be of surface type, 240 m in length and 1.2 m in internal diameter. An excess water spillway will be provided in parallel with this penstock.

The Erik power house will be of surface type, 18.5 m wide, 18.2 m long, and 24.5 m high. It will accommodate one set of generating equipment. The tailrace chamber will be 25 m in height above foundation and 8 m in internal diameter. The turbine center elevation will be 674.4 m. The top elevation of the tailrace chamber wall will be 695.5 with a freeboard of 1.57 m above the maximum surge water level. The inlet shaft to guide the turbine discharge towards the Ermenek headrace tunnel will be inclined at 45 degrees with a section 3.5 m high, 3.5 m wide, and 90 m in shaft height. An air trap chamber will be provided in a horizontal tunnel, which will connect the inlet shaft with the Ermenek headrace tunnel. At the downstream end of the connecting tunnel, a throttle device will be provided to reduce the reverse flow into the shaft during surging.

7.9 Hydromechanical Works

The principal hydromechanical works will consist of gates, stoplogs, trashracks, steel liners and penstock. The thickness of steel shell plate for the pressure shaft will range between 18 and 38 mm depending on the acting pressure. The total steel weight of hydromechanical facilities will be about 3,600 tons.

7.10 Generation Equipment

Two sets of turbine, generator and transformer with auxiliary equipment will be installed in the underground power house. One set of 380 kV switchgear will be placed in an outdoor switchyard, being connected with 380 kV power cables to the transformers. Two sets of overhead travelling crane of 135 tons in capacity each will be provided in the power house.

The hydraulic turbines will be of vertical shaft Francis type, 308 m in rated net head, 116.6 m^3/s in maximum discharge, 163.5 MW in rated output, 333 rpm in rotation speed. The generators will be vertical shaft alternators to be directly coupled with the turbines, 180 MVA in rated output and 14.4 kV in rated voltage. The main transformers will be single phase two winding; 3 transformers will form one bank; 60 MVA x 3 units x 2 banks. The outdoor switchyard will have a double bus system with a transfer bus.

A one-man-control system will be adopted for controlling the generating equipment. Both the generation equipment and 380 kV switchgear will be controlled from one control room, which will be located in the underground power house.

7.11 Transmission Line

A 380 kV transmission line, 160 km in length, will be constructed between the Ermenek power station and the Seydişehir substation. The conductor will be 3-bundled 954 MCM ACSR, which is the standard size for 380 kV main lines in Turkey. A power line carrier (PLC) system will be provided.

7.12 Generation Equipment of Erik Power Station

One set of generating equipment will be placed in an surface type power house, which will be provided with a small overhead travelling crane. A step-up transformer and a 34.5 kV switchgear will be placed adjacent to the power house. The turbine will be of vertical shaft Francis type, 133 m in net head, 6.0 m^3/s in maximum discharge, 6,950 kW in rated output, 750 rpm in rotation speed. The generator will be directly coupled with the turbine, 3 phase, 8,375 kVA in rated output, 0.8 in rated power factor, 6.6 kV in terminal voltage. The transformer will be 6.6/34.5 kV, 8,375 kVA. The Erik power station will be connected to a 34.5 kV line, which will be constructed between the Ermenek power station and the dam site. This line will further be connected to the existing 34.5 kV line between Ermenek and Kazançi.

The Erik power station will be operated by remote supervision and control from the control room of the Ermenek power station.

8. CONSTRUCTION SCHEDULE AND COSTS

8.1 Construction Schedule

The construction schedule of the Project was prepared with the base year at the commencement of the detailed design, assuming a local tender for the preparatory works, and international tenders for the main construction works.

As shown in Plate 13, the detailed investigation and design works including the preparation of tender documents will be continued for 3.5 years. Local contractors will construct access roads and tunnels to the proposed dam site in the 2nd and 3rd years, while contractors for the main works will be selected within the 3rd year counted from the base year. Construction works of the main civil works will be started from the 4th year with excavation works of the diversion tunnel and the access tunnels towards grouting tunnels. The river diversion will be performed at the beginning of the 5th year. Supply and erection works of hydromechanical facilities, electromechanical equipment and power transmission lines will be started in the 8th year. All the construction works will be completed at the middle of the 10th year upon completion of the critical path works of curtain grouting in the limestone block, and the commissioning tests will follow.

When the dam is constructed up to the elevation of 615 m (LWL) in the later part of the 8th year, the river diversion tunnel will be closed to start initial filling of the reservoir. Construction works of the dam body will be completed in the late 9th year. In the later part of the 10th year, the reservoir would be filled for half the effective storage capacity, and the generation equipment will be commissioned.

8.2 Construction Costs

Construction costs were estimated at the price level of November 1989; US$1.00 = TL2,300 = J¥143. The costs included land acquisition cost, direct construction cost, administration and engineering costs, physical contingency, value added tax (VAT) of 10 per cent, and interest during construction (IDC), but excluded price contingency and customs. IDC was estimated assuming implementation by a public organization with an international soft loan combined with a commercial loan. Repayment conditions assumed were;

Loan-1: an international loan at an interest rate of 2.9 per cent per annum, applicable to 75 per cent of the eligible costs, which include interests for Loan-1 during a grace period of 10 years, repayable in 30 years including the grace period;

Loan-2: a commercial loan at an interest rate of 8.0 per cent per annum, applicable to the remaining investment costs, which include interests for Loan-2 during 10 years of grace period, repayable in 20 years including the grace period.

The investment costs were estimated as summarized below:

(US$ million at Nov. 1989 price levels)

Work Items	Foreign Portion	Local Portion	Total
1. Land acquisition	0.21	11.52	11.73
2. Direct construction cost	139.73	176.51	316.24
3. Administration & engineering	15.45	21.41	36.86
4. Physical contingency	14.59	26.00	40.59
5. Total construction cost	169.98	235.44	405.42
6. VAT (10 %)	17.00	23.54	40.54
7. IDC	28.90	77.20	106.10
8. Total investment costs	215.88	336.18	552.06

9. PROJECT FEASIBILITY

9.1 Electricity Output

The annual output of the Ermenek power station was estimated to be 925 GWh of firm energy and 97 GWh of secondary energy, based on the 42-year hydrological record between 1946 and 1987. The maximum output will be 320 MW (100 % of installed capacity) most of the time, but less when the reservoir water surface falls below the rated water level. The dependable maximum output for 90 per cent of the time will be 294 MW (92 % of the installed capacity).

The annual output of the Erik power station will be 19 GWh of firm energy and 13 GWh of secondary energy. The dependable maximum output will be 3 MW, being operated at a capacity factor of 55 per cent on an average.

The 150 MW Gezende power station can generate 566 GWh of annual energy, but firm energy will be only 118 GWh, the remaining 448 GWh being secondary energy, and the dependable maximum power will be only 41 MW at a capacity factor of 33 per cent because of its small reservoir capacity. The regulated flow from the Ermenek reservoir will significantly improve the operating conditions of the Gezende power station. It is estimated that the annual output of the Gezende power station will be 641 GWh including 526 GWh of firm energy and 115 GWh of secondary energy with a dependable maximum output of 150 MW, when the Ermenek Project is realized.

The initial filling of the Ermenek reservoir will temporarily reduce the discharge available at the Gezende power station. It was assumed that the discharge necessary for the Gezende to generate its firm energy (118 GWh) would be sustained during the initial filling. The loss of Gezende secondary energy will continue for two years, under the average hydrological conditions, before commissioning of the Ermenek power station.

9.2 Economic Evaluation

The financial costs were adjusted to economic costs by eliminating land compensation costs, tax and interest during construction.

Benefits attributable to the Project are the power benefit generated by both the Ermenek and Erik power stations and the increased power benefit at the Gezende power station. The loss of Gezende secondary energy during the initial filling of Ermenek reservoir was accounted as a negative benefit. Production forgone from the farmland submerged by the Ermenek reservoir was also accounted as a negative benefit.

The economic internal rate of return (EIRR) of the Project will be 14.9 per cent, well exceeding the opportunity cost of capital of 9.5 per cent, and B/C ratio would be 1.76 for the discount rate of 9.5 per cent.

The results of a sensitivity test are as follows;

		EIRR(%)
Base case:		14.9
Case-1:	Investment cost increase by 10 %	13.9
Case-2:	Investment cost increase by 20 %	13.0
Case-3:	Coal US$52/ton -----------> US$48/ton	
	Natural gas US$130/$10^3m^3$ -> US$120/$10^3m^3$	14.5
Case-4:	Case-1 + Case-3	13.6
Case-5:	Case-2 + Case-3	12.7

The values of EIRR are much higher than the opportunity cost of capital of 9.5 per cent in all the cases tested.

9.3 Financial Evaluation

The operation revenue was estimated by applying the latest average tariff of TL131.23/kWh (US¢5.7/kWh) to the energy output of the Project less 12 per cent for station use and losses. The influence on the output at the Gezende power station was not taken into account.

The financial IRR was calculated to be 8.7 per cent, which was slightly lower than the economic opportunity cost of capital, indicating the need for some financial arrangement like provision of a soft loan.

A calculation showed that all the loan could be paid back out of the operation net income and upon completion of the repayment of Loan-1, the accumulated surplus would amount to US$270 million, if the Project is implemented by a public organization with two loans as assumed in Section 8.2.

10. FURTHER STUDY

The mode of financing and implementation should be determined at an early stage by the Government, so that making of financial arrangements can be started.

A time consuming further investigation will be required in order to clarify the geological conditions of the Project in sufficient detail for the design, under such condition that limestone is prevailing. A detailed schedule for the geological investigation should be prepared and the ongoing investigation by EİE should be continued accordingly.

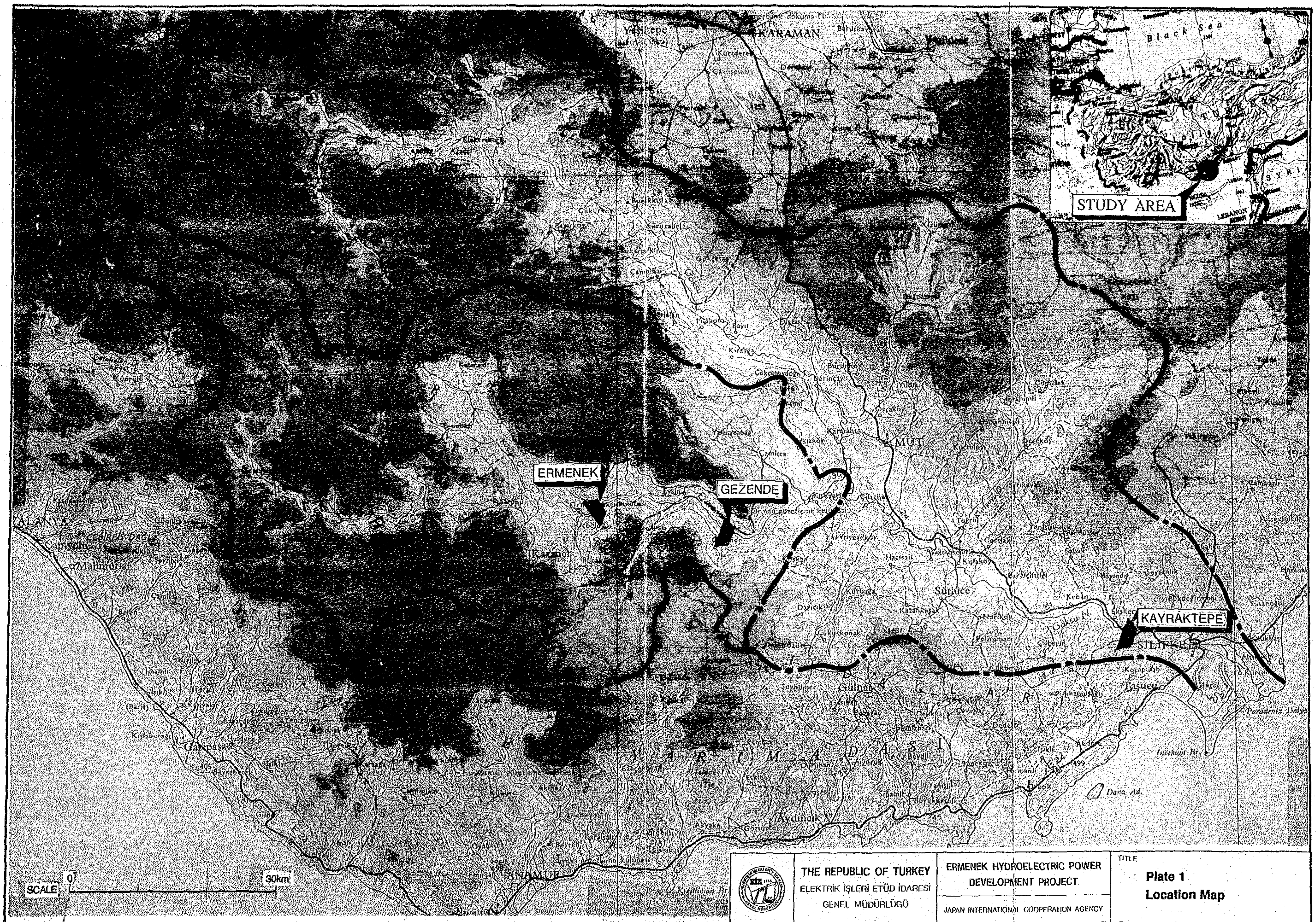
An automatic water level recorder was installed by EİE in July 1990 near the Ermenek dam site. It will be important to continue water stage observation using this recorder to clarify actual conditions of the daily water level changes due to snow-melt, as well as to collect and analyze information on the shape of the flood hydrograph. It is recommended that automatic raingauges be installed in the Ermenek river basin for clarification of the rainfall characteristics of short duration and the basin lag. Suspended load measurements should be started at the proposed Erik intake weir site.

The design of the Erik Diversion Scheme will have to be elaborated, because the plan still remains at a pre-feasibility level.

The detailed design of the Project should be started, so that construction of access roads and temporary facilities required as preliminary works can be commenced in good time.

The main environmental issues were identified and countermeasures to them were proposed based on investigations to date. As in any reservoir project, it is important to have detailed social and environmental studies made so that future problems can be avoided by timely mitigation or avoidance. These studies should include a biological inventory study, fishery and tourism potential studies, and consultations, including questionnaire studies, with local people.

PLATES



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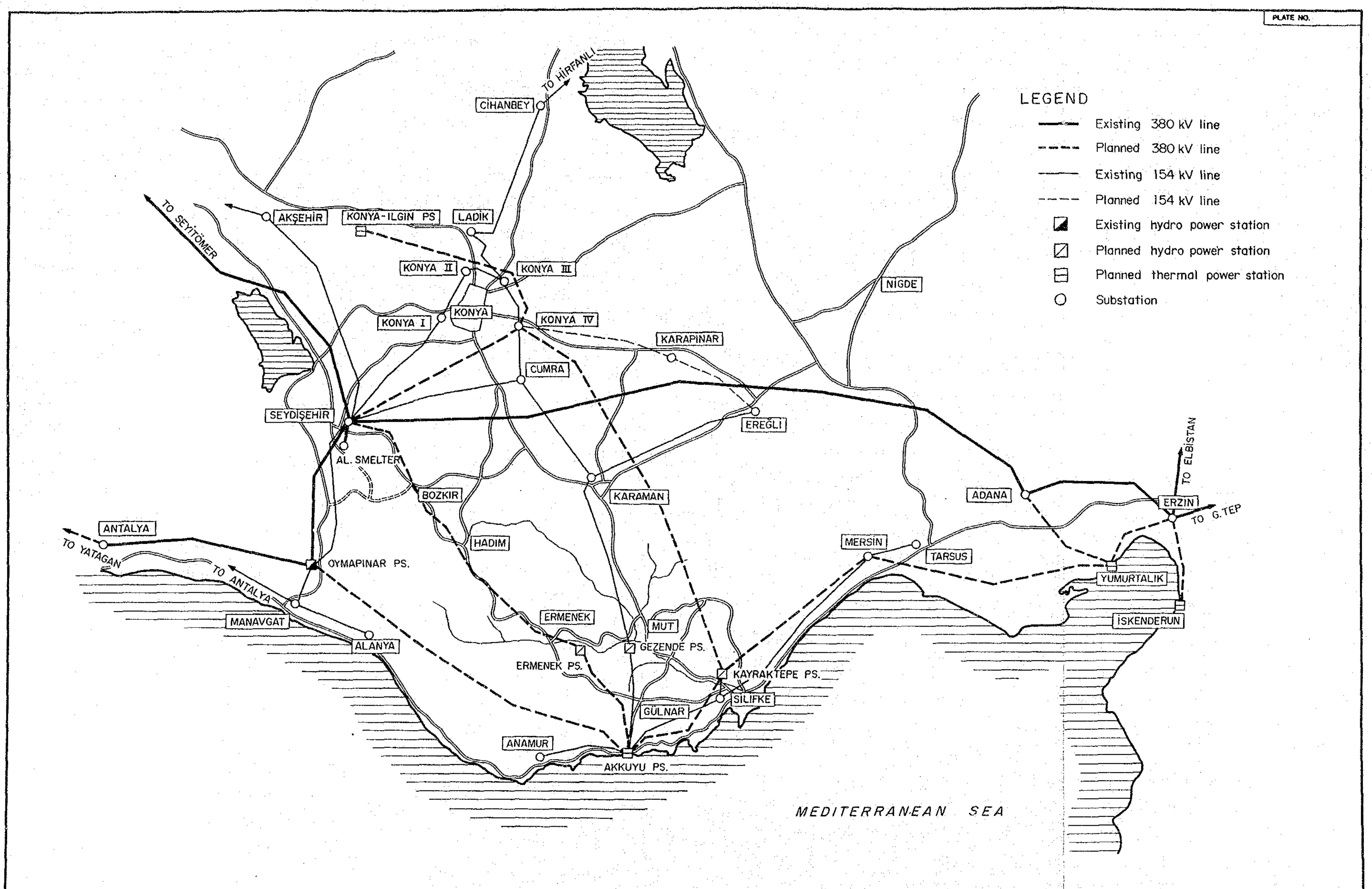
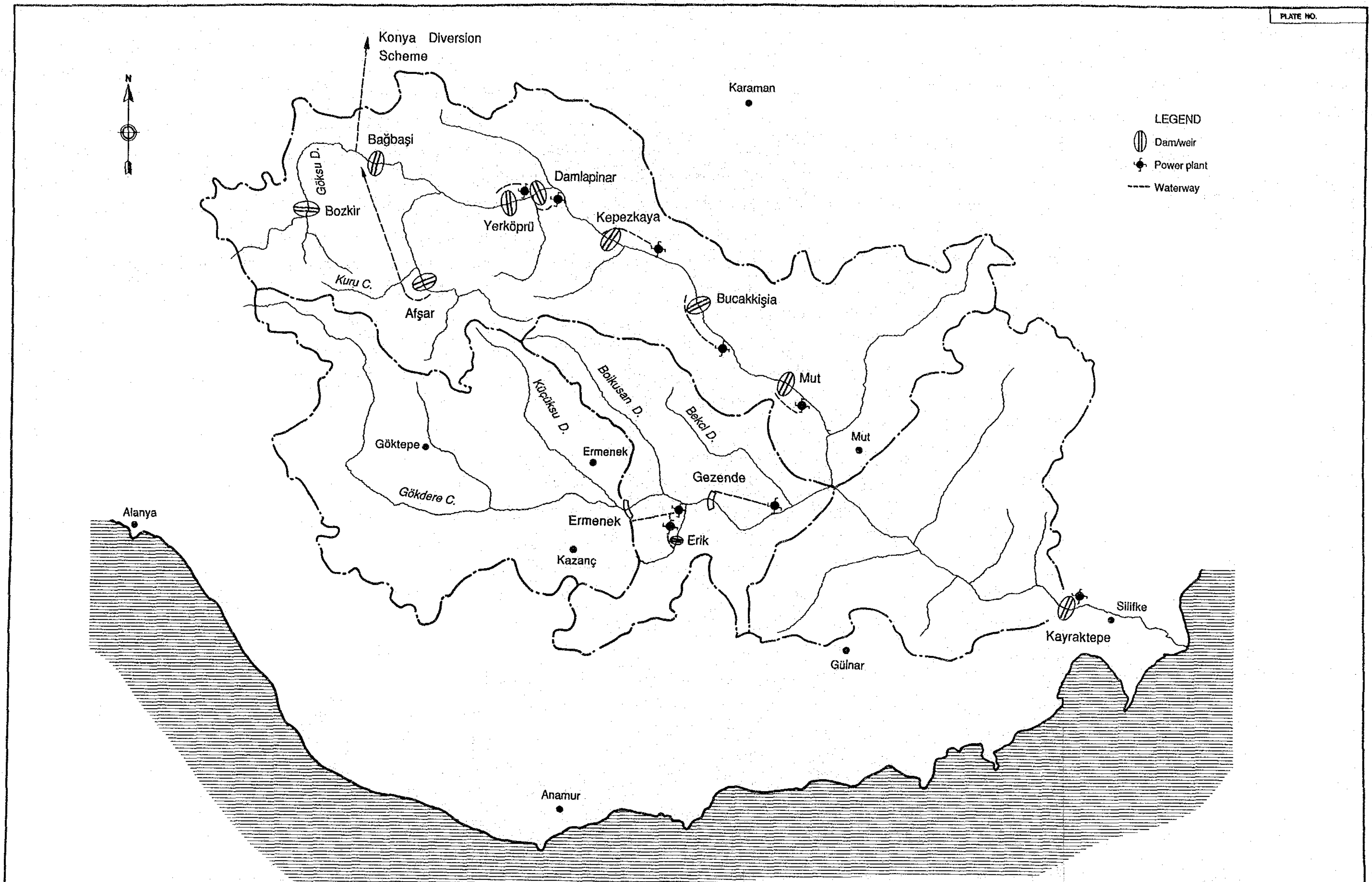
ELEKTRİK İŞLERİ ETÜD İDARESİ
GENEL MÜDÜRLÜĞÜ

ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE
Plate 1
Location Map



THE REPUBLIC OF TURKEY ELEKTRİK İŞLERİ ETÜD İDARESİ GENEL MÜDÜRLÜĞÜ	ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE	**Plate 2** **Vicinity Map of the Project Area**



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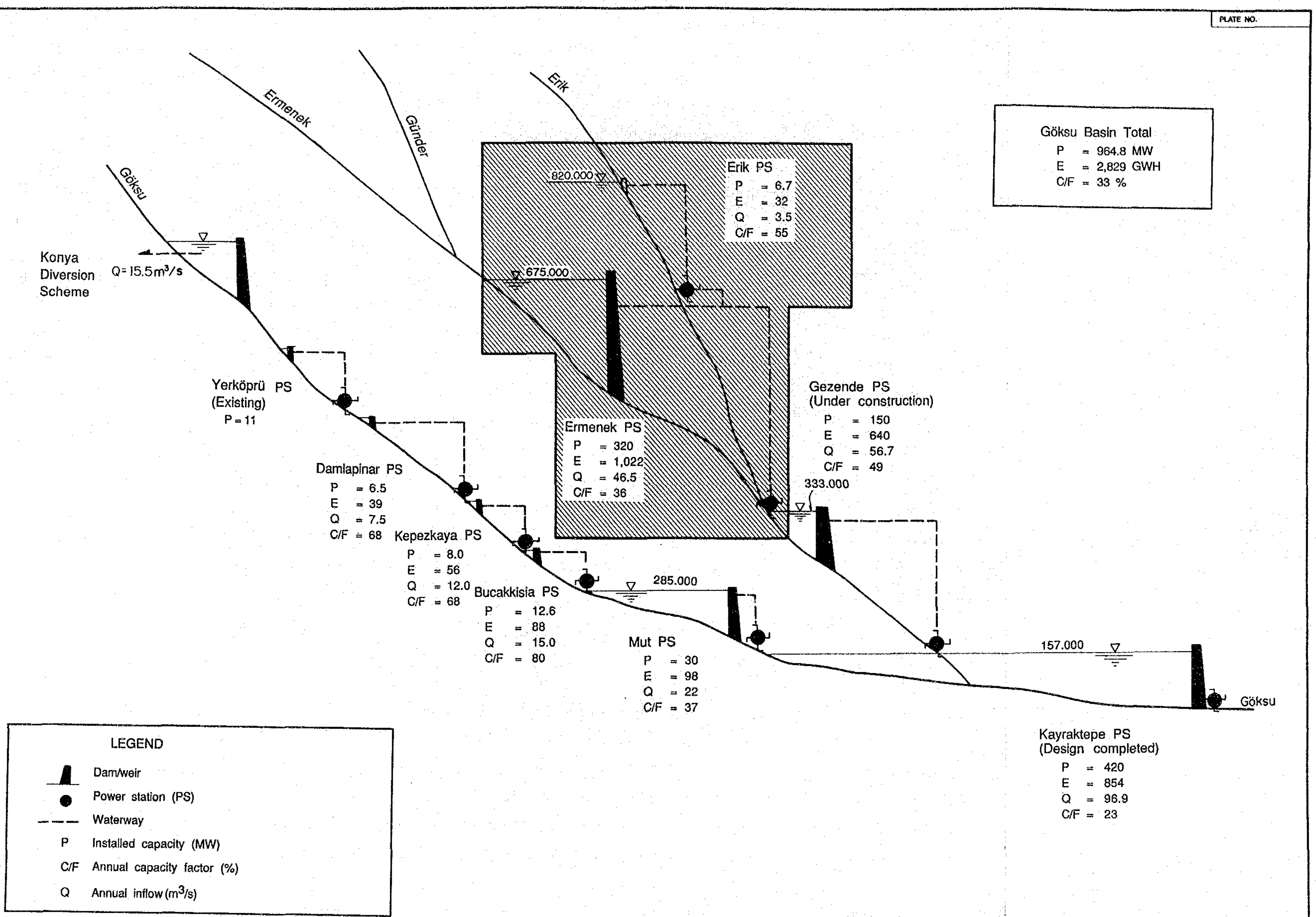
TITLE **Plate 3**
Overall Development Plan of Göksu River Basin, Plan



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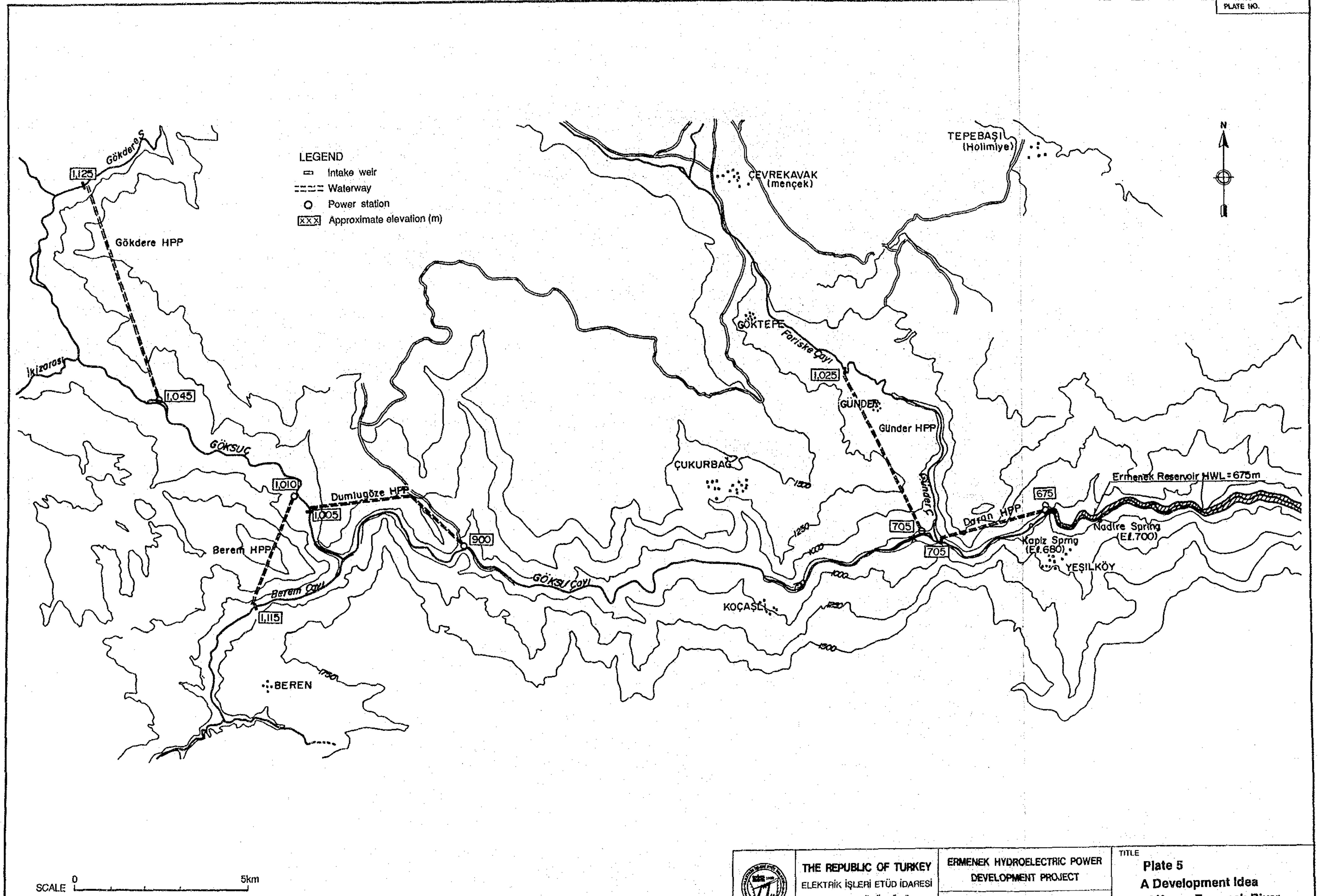
JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE **Plate 4**
Overall Development Plan of Göksu River Basin, Profile



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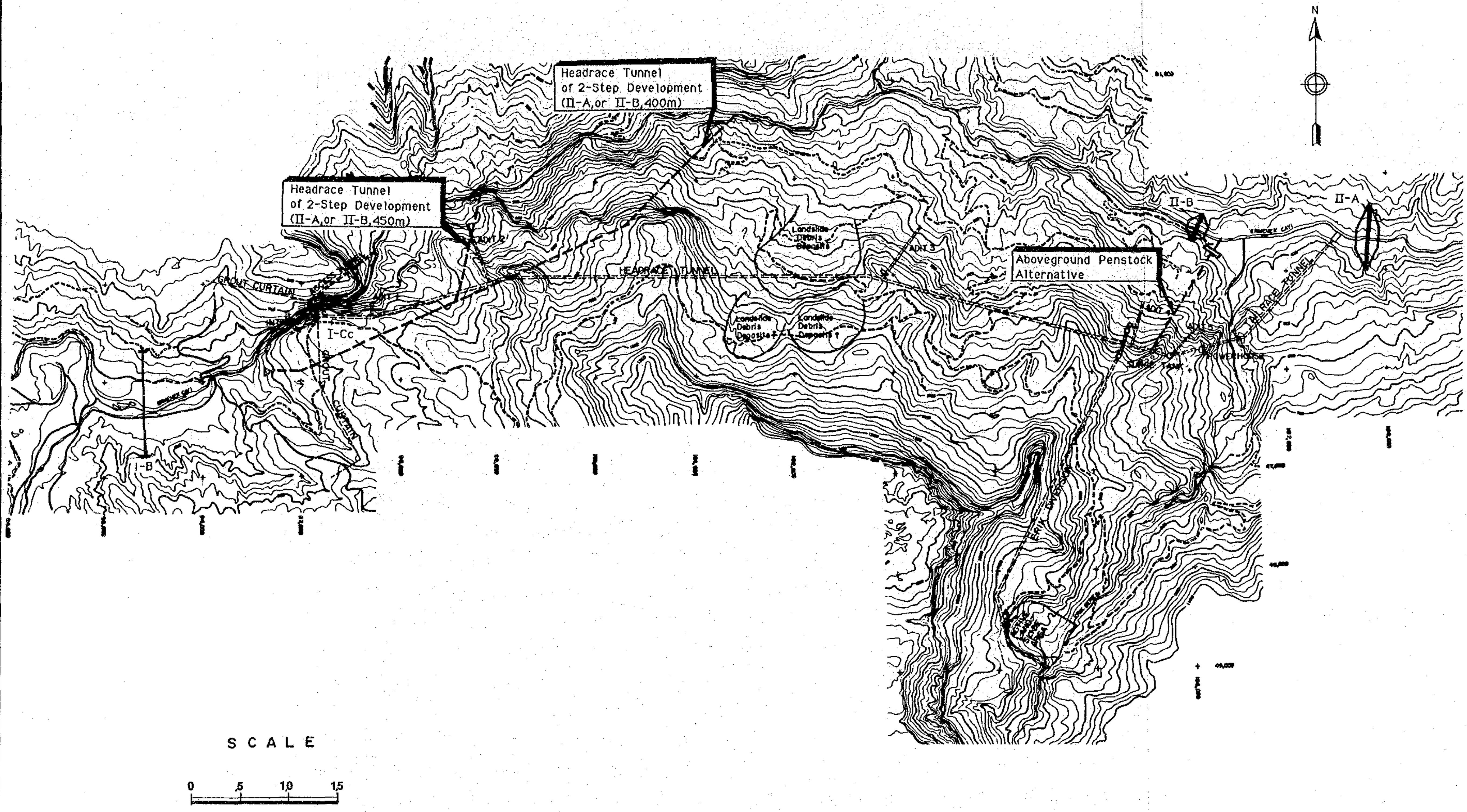
TITLE

Plate 5
A Development Idea of Upper Ermenek River

PLATE NO.



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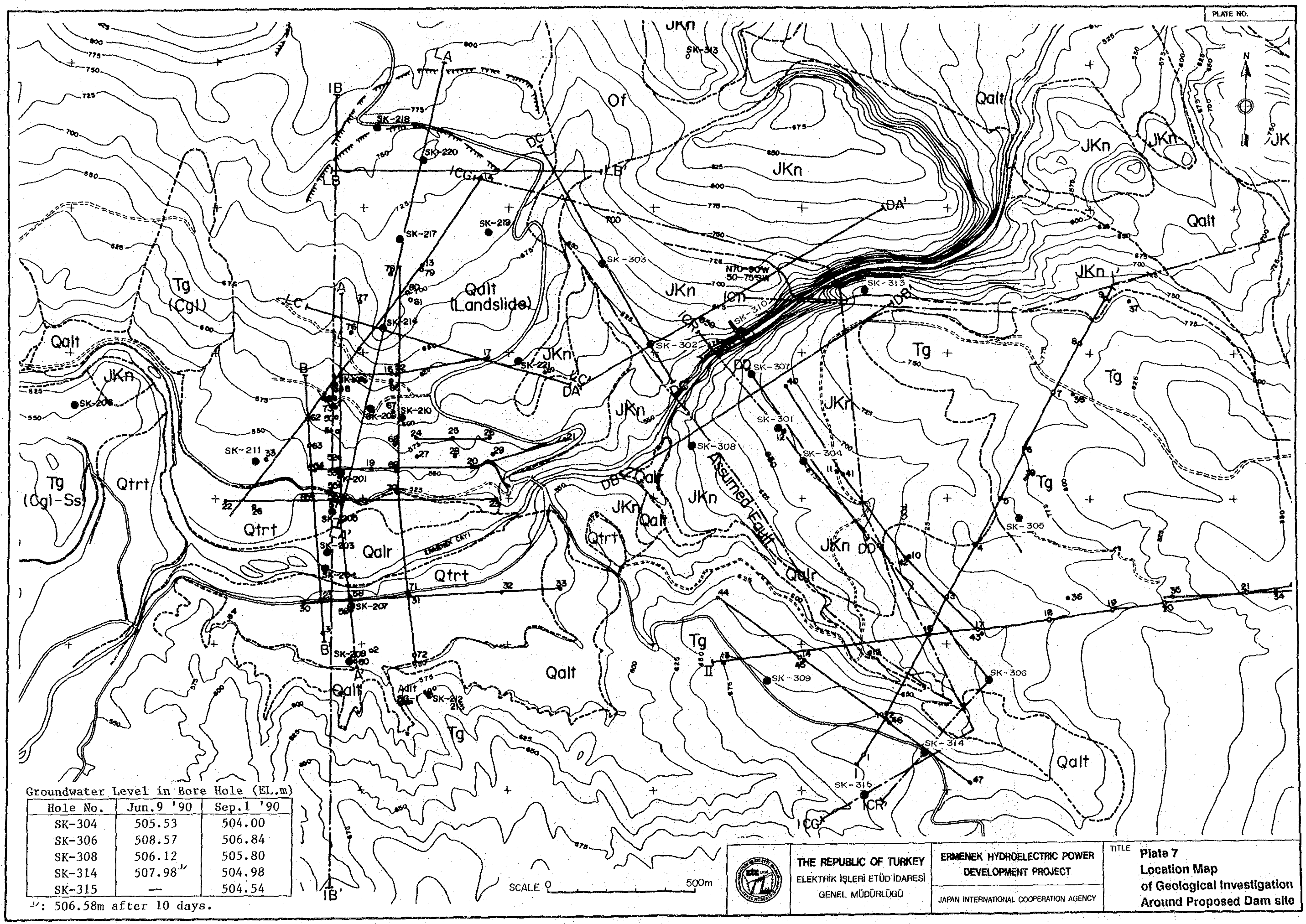

Groundwater Level in Bore Hole (EL.m)

Hole No.	Jun.9 '90	Sep.1 '90
SK-304	505.53	504.00
SK-306	508.57	506.84
SK-308	506.12	505.80
SK-314	507.98[1/]	504.98
SK-315	—	504.54

1/: 506.58m after 10 days.

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TITLE

Plate 7
Location Map of Geological Investigation Around Proposed Dam site