THE REPUBLIC OF TURKEY
ELEKTRIK ISLERI ETUD IDARESI
GENEL MUDURLUGU

FEASIBILITY STUDY
ON
[illegible] HYDROELECTRIC POWER
[illegible]

VOLUME 4
SUPPORTING REPORT 2

ANNEX C Hydrology
ANNEX D Optimization Study
ANNEX E Compensation Survey
ANNEX F Environmental Impact Study

DECEMBER 1990

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

THE REPUBLIC OF TURKEY
ELEKTRİK İŞLERİ ETÜD İDARESİ
GENEL MÜDÜRLÜĞÜ

FEASIBILITY STUDY ON ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT

VOLUME 4

SUPPORTING REPORT 2

ANNEX-C Hydrology
ANNEX-D Optimization Study
ANNEX-E Compensation Survey
ANNEX-F Environmental Impact Study

DECEMBER 1990

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

LIST OF VOLUMES

ANNEX-C HYDROLOGY

[illegible]

ANNEX-C HYDROLOGY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

TEXT

CHAPTER 1. INTRODUCTION

1.1 Scope of Work

The hydrometeorological study for the Ermenek Hydro-electric Power Development Project consists of the 2 stages; i.e. the preliminary investigation stage and the additional detailed investigation stage. The scope of work for the preliminary investigation stage is as follows.

(1) Site reconnaissance

Siting of hydrological observation stations in and around the Project Area such as water stage gauging stations and discharge observation stations.

(2) Preliminary field survey

Field survey on the general characteristics of the Ermenek River system.

Based on the study results at the preliminary investigation stage, the following work was carried out at the additional detailed field investigation stage.

(1) Discharge observations

Actual flow measurements at the discharge observation stations and the tributaries.

1.2 The Project Area

The Ermenek River rises from the Toros Mountains at about 2,500 m in elevation and takes the streams and creeks such as Gökdere, Kücüksu, Zeyve and Erik. It flows firstly towards the south and then towards the east and finally joins with the Göksu River near Mut town at about 100 m in elevation.

The catchment area of Ermenek River is about 3,621 km² and the catchment area of Gezende Dam, which is under construction is 3,159 km². The highest elevation of the catchment area is 2,877 m. Thalweg elevation at the proposed dam site is about 500 m and the average basin elevation is 1,600 m.

About 50% of the catchment area of Ermenek River is covered mainly by juniper type of trees. There are no significant diversions of water withdrawn from the river in all the area of Ermenek River Basin. Therefore, the observed flows at stream gauging stations on the Ermenek River can be assumed as natural flows.

1.3 Previous Studies

Preceding the present feasibility study, the following hydrometeorological study was made by EİE, Department of Hydrological Survey, Division of Project Hydrology in 1985.

(1) Engineering Hydrology Report for Görmel Dam on Ermenek River in Göksu River system (in Turkish)

1.4 Hydrometeorological Stations and Available Data

(1) Rainfall Gauging Stations

Within or around the Ermenek River Basin, there are totally 26 rainfall stations of DMİ (State Meteorological Organization) including stations which had been deactivated.

Only 3 stations are located within the Ermenek River basin as follows.

(A) Göktepe
(B) Kazançi
(C) Ermenek

The locations of these stations are shown in Fig. C1.

(2) Stream Gauging Stations

The EİE and DSİ gauging stations in the Göksu River Basin, operative or discontinued, are listed in Table C1. The locations of these gauging stations are shown in Fig. C1.

(3) Other Data

The following data are also observed at Meteorological Stations of DMİ in the Göksu basin.

(a) Temperature at Ermenek
(b) Relative humidity at Ermenek
(c) Maximum wind velocity and its direction at Mut
(d) Vapour pressure at Ermenek, Hadim, Alanya and Anamur

CHAPTER 2. METEOROLOGICAL STUDY

2.1 General Climate

General climate in and around the Göksu River Basin are characterized as follows;

(1) A remarkable difference in climate can be seen between the coastal area along the Mediterranean Sea and the highland area in the central inland. The seasonal pattern of precipitation in the coastal area along the Mediterranean Sea is generally influenced by the Mediterranean climate, therefore, precipitation, either rainfall or snowfall, mainly occurs in winter and spring when the depression is activated, and the climate in summer is very dry. The climate in highland in the central part of Turkey is a continental climate, which causes a cold wind and a snowstorm in winter, and hot and dry climate in summer.

(2) The main cause of rainfall and snow in and around the Göksu River Basin is mainly due to the Western Depression, which is moving to the Middle East or Turkey from the west such as Mediterranean Sea or North Africa. There are two types of depression. One runs very fast through the southern part of mountainous area in Turkey, the other runs very slowly and is sometimes stagnant near the Cyprus Island. The former depression occurs mostly in winter, the latter occurs mostly in spring.

(3) In the Ermenek River Basin, the Mediterranean climate is dominant in lower elevations. The elevation rises rapidly towards the upstream basin and the climate is most likely to be influenced by the altitude. The mean

ground elevation (1,600 m) of the basin indicates that the basin climate falls into a transitional zone from the Mediterranean climate to the continental climate in inland area such as Karaman and Konya.

(4) heavy rainfall occurs along the coastal areas, where it records from 1,000 to 1,600 mm a year. The Ermenek River Basin is sheltered from the south- and north-west winds by the coastal mountain range. Table C2 shows that the average annual rainfalls at the meteorological stations in the Ermenek River Basin are observed between 500 and 900 mm. Precipitation increases towards the west along the river. This area variation observed in precipitation is in agreement with the prevailing wind directions from the south and north-west during storm and with the general topographical features of the area. The areal distribution of the mean annual rainfall is shown in Fig. C1.

2.2 Temperature and Relative Humidity

Temperature is observed at Ermenek Meteorological Station in the Ermenek basin. Monthly mean, maximum and minimum temperature values are shown in Table C3. Monthly patterns of mean, maximum and minimum temperatures are depicted in Fig. C2. As shown in the Fig. C2, mean temperature is 11.8°C varying in a wide range from 3.3°C in January to 22.3°C in July and August. The annual maximum and minimum temperature one 39°C in July and -15°C in January, respectively.

Mean monthly relative humidity at Ermenek Meteorological station is presented in Table C4. Monthly pattern of mean relative humidity is shown in Fig. C3. Relative humidity is high in Winter with the value of more than 60 per cent, and low in Summer less than 40 per cent.

2.3 Wind Speed

Wind speed is observed at Mut Meteorological Station. Monthly maximum wind velocity and its direction are summarized in Table C5, and monthly pattern is depicted in Fig. C4. Maximum wind velocity is generally constant throughout the year except in November with the recorded maximum value (23.2 m/s) during the past 20 years. The direction of the dominant wind is north-west.

2.4 Evaporation

There is no meteorological station which observes evaporation in the Ermenek basin. Evaporation observations are made at Silifke and Karaman Meteorological Stations.

Monthly pattern of evaporation can be generally seen in Fig. C5 which was given by the mean evaporation from reservoir at Ermenek, estimated by EİE.

CHAPTER 3. RAINFALL STUDY

3.1 Available Rainfall Data

Within or around the Ermenek River Basin, there are totally 26 rainfall stations of DMİ (State Meteorological Organization), including stations which had been deactivated.

There are 3 rainfall stations being presently operated within the basin as listed below.

(1) Göktepe
(2) Kazançi
(3) Ermenek

The locations of these stations are shown in Fig. C1. Mean monthly and annual precipitation values at the selected stations are summarized in Table C2.

3.2 Mean Annual Rainfall

Mean annual rainfall of the Ermenek River Basin at the Ermenek Dam site is 946 mm (1965-1987), based on the isohyetal map shown in Fig. C1. Table C6 shows the seasonal distribution of the mean annual rainfall in the Ermenek River Basin. It is indicated that approximately 80% of the total precipitation occurs during the winter and spring season (December-May).

3.3 Mean Monthly Rainfall Pattern

Mean monthly rainfall of the Ermenek basin is calculated as an arithmetic mean of the 3 stations (Göktepe, Kazançi and Ermenek) and its pattern is shown in Fig. C6.

3.4 Depth-Area Analysis

Depth-area relation of rainfall for the recorded maximum storm on 31st January in 1975 with a duration of 24 hours was studied. Actual storm started to rain on 30th January and continued to 1st February in and around the Ermenek basin. Duration of the storm is estimated to be 48 hours with a peak on 31st January. Since hourly rainfall data for the storm were not available, 48-hr depth-area analysis was not carried out for the Study.

By constructing the isohyets of the storm on 31st January in 1975, 24-hour depth-area curve for the Ermenek River Basin was given. 24-hr Isohyetal map during the storm in 1975 is shown in Fig. C7. The depth-area curve is shown in Fig. C8. The maximum daily rainfall depth of the 1975 storm for the Ermenek Dam site (Ca = 2,156 km^2) is estimated at 102 mm.

3.5 Depth-Duration Analysis

A depth-duration curve for Ermenek Dam site was estimated by using depth-area duration analysis performed by DMİ for the Göksu River Basin, which is shown in Fig. C9. Depth-duration less than 24 hours was estimated by the depth-duration curve within 24 hours at Antalya, which was adopted for Oymapinar Hydroelectric Power Project by DSİ.

The maximum rainfall depth of the 1975 storm for a duration greater than 24 hours was calculated with reference to the DMİ's DAD curve, and was adjusted as follows, and the results are shown in Fig. C10.

Duration (hr)	Pmax = Max Rainfall Depth by DMİ (Ca = 2,156 km^2) (mm)	$P'max = Pmax \times \frac{102}{88}$
12	65	-
24	88	102
36	121	142 *
48	138	162 *
60	144	168 *
72	160	187 *
84	189	221 *
96	216	253 *

Note: * means adjusted values.

The maximum rainfall depth with a duration less than 24 hours was estimated below:

Duration (hr)	Depth * (%)	Depth (mm)
24	100	102
18	97	99
12	88	90
6	67	68
2	36	37
1	22	22

Note: *) The value is shown as a percentage of the maximum rainfall depth for 24 hr.

The maximum rainfall depth-duration curve of the 1975 storm for the Ermenek Dam site is also shown in Fig. C10.

CHAPTER 4. RUNOFF STUDY

4.1 Available Runoff Data

The EİE and DSİ gauging stations in the Göksu River Basin, operative or discontinued, are listed in Table C1. Runoff records at those stations are presented in Tables C7 to C15. Among the EİE stations, some stations had been deactivated due to riverbed changes, and new gauging stations were installed near the respective previous sites. The difference between the catchment areas of the ex- and new stations is small. These stations replaced are as follows;

	Ex-station	New Station
(a)	1703 (Even)	1719 (Kirkyalan)
(b)	1705 (Eksiler)	1714 (Karahacili)
(c)	1704 (Selamli)	1720 (Haman)

Also, EİE installed in 1985 a gauging station, No. 1723 (Çavusköyü), on the Ermenek River near the DSİ's Station 17-14, which is located 1.75 km upstream from the Görmel Bridge. Location map of stream gauging stations (17-14 and 1723) is shown in Fig. C11. Both Stations measured the flow at the same site downstream from the Çavusköyü village. Staff gauge of 1723 (EİE) is installed at Çavusköyü, and staff gauge of 17-14 (DSİ) is located at the Görmel Bridge. Therefore the flows measured by both stations exclude the flows from the Zeyve Creek which is between Çavusköyü village and Görmel Bridge.

4.2 Reliability of the Runoff Records

The daily discharge records at the Çavusköyü village by EİE and DSİ are summarized as follows:

Station	Available Period of Records	No. of water level observation per day
17-14 (DSİ)	1965 - 1968 1972 - 1988	1 (8 a.m.)
1723 (EİE)	1985 - 1988	2 (8 a.m., 4 p.m.)

The runoff coefficient at Station 17-14 was preliminarily estimated at 0.81 based on the runoff records and estimated basin rainfall (Clause 3.1.1 of the Progress Report 1). The high value of runoff coefficient at 17-14 implied that there is a possibility of overestimating the runoff at 17-14 station. To clarify this matter, a double mass curve of monthly mean discharges at 1723 and 17-14 (1985 - 1988) was constructed as is shown in Fig. C12.

Also a review of the discharge rating curves and runoff and water measurement methods was carried out for 17-14 and 1723 stations. Some observations concerning this matter are summarized below:

(1) Both rating curves for 17-14 and 1723 were constructed originally by DSİ and EİE by plotting the runoff measurement records on log-log paper. It was observed that flood flows had been overestimated by both rating curves. But the rating curve of 1723 is more likely to have a higher reliability for the high flow range since it has more samples with high flow measurements than those at 17-14 station. Flow rating curves of both stations 1723 and 17-14 are shown in Fig. C13.

The reliability of rating curves for the low to medium flow range at Stations 1723 and 17-14 was studied using the daily gauge height records available for the 3.5 years' period from April 1985 to September 1988. The gauge heights of Station 17-14 have been read at the Görmel Bridge once a day, while those of Station 1723 at the upstream station twice a day.

The gauge heights read at 8 a.m. at the above 2 different places were plotted in Fig. C14 to see the correlation between the 2 stations. A regression curve was drawn by eye. Although the distribution range is rather wide for the medium to high flows, it is expected that the regression curve represents the correlation on the average basis.

In order to compare the rating curves of the 2 stations using the above relationship of gauge heights, the flow rating curve of Station 1723 was converted into a curve (herein referred to as the reduced H-Q of 1723) with the ordinate of gauge heights at Station 17-14 (Görmel Bridge).

Fig. C15 shows that the reduced H-Q of 1723 is almost fitting the DSİ's rating curve for the Station 17-14. This implies that both the rating curves, even though the gauge heights have been observed at the different places and the flow measurements have been made by the different organizations (17-14 by DSİ, 1723 by EİE), will give almost the same flow, on the basis of average, against the gauge heights read at 8 a.m.

It is judged that the rating curves of Stations 17-14 and 1723 have a high reliability for the low to medium flow range, as far as these are applied to the gauge heights read at 8 a.m., or probably read at the same time.

(2) Being located at the mouth of gorge, water level at Station 17-14 may be more influenced by the flow from the Zeyve Creek in the rainy seasons when compared with water level at Station 1723.

(3) Even though the diurnal variability of flows cannot be checked since hourly discharge records are not available, it was observed that during rainy season the water levels measured at 8 a.m. are relatively greater than the water levels at 4 p.m. for 1723 station. Water level changes at station 1723 between 8 a.m. and 4 p.m. are shown in Fig. C16. It suggests that there may be a periodical change of the water level with a period of one day, especially in the spring months.

Since the reason of this phenomenon is not known, it was proposed by the Study Team that EİE carry out hourly observations of gauge height for 2 or 3 consecutive days. These observations may be made several times in the spring months, depending on the river flow and weather conditions. Results of the EİE's water level observations from 26th May to 31st May, 1990 indicated clearly that the diurnal change of the flows are observed and the water levels measured in the morning (7 a.m.) and greater than the water levels in the afternoon (5 p.m.). The diurnal change of the water levels are shown in Fig. C17.

The past flow records of Station 17-14 had been obtained by converting a gauge height read at 8 a.m. into a flow, which had been treated as the mean flow of the day. This can cause a larger daily mean flow, on those days in the spring months, than that of Station 1723, which was obtained using an average gauge height of 8 a.m. and 4 p.m. It is, therefore, judged that the gauge height reading once a day at 8 a.m. be a reason of the overestimation of the long-term average flow at

Station 17-14.

It is judged that the runoff records of Station 1723 are more reliable than those of Station 17-14.

Mean monthly runoff records of Station 17-14 for the period of 1965-1968 and 1972-1984 were reduced by the following way, to get rid of the above-mentioned overestimate:

$$\underset{\text{(up to 84)}}{Q'\ 17\text{-}14} = \underset{\text{(up to 84)}}{Q\ 17\text{-}14} \times \frac{Q\ 1723\ (85\text{-}88)}{Q\ 17\text{-}14\ (85\text{-}88)}$$

$$= 0.843\ Q\ 17\text{-}14\ \text{(up to 84)}$$

where

Q' 17-14 (up to 84) = Revised mean monthly runoff at 17-14 up to 1984

Q 17-14 (up to 84) = Observed mean monthly runoff at 17-14 up to 1984

Q 1723 (85 - 88) = Sum of mean monthly runoff at 1723 from 1985 to 1988

Q 17-14 (85 - 88) = Sum of mean monthly runoff at 17-14 from 1985 to 1988

4.3 Mean Annual Runoff

Mean annual runoff (1965-1987) at the 5 stream gauging stations in the Göksu River Basin are presented in Table C16 and summarized below:

Mean Annual Runoff of Göksu River

Station No.	Station Name	River	Drainage Area (km²)	Mean Annual Runoff (m^3/s)	(mm)	(MCM)
1719	Kirkyalan	Ermenek	3,499.6	62.4	562	1967
17-14	Görmel B.	Ermenek	2,000.0	44.6	703	1406
1712	Bucakkisla	Göksu	2,689.2	32.0	375	1008
1720	Haman	Göksu	4,304	51.1	375	1612
1714	Karahacili	Göksu	10,065.2	129	404	4067

4.4 Mean Monthly Runoff Pattern

Mean monthly runoff pattern at 17-14 (1965-1987) is shown with rainfall pattern in Fig. C6.

It clearly indicated the runoffs in March, April and May are mostly by snow-melt.

4.5 Runoff Coefficients

Mean annual runoff coefficients were calculated for the Göksu River Basin at 5 stream gauging stations so as to assess the reliability of runoff data and to clarify the basin's runoff characteristics. The results of calculations are summarized in Table C16.

As is shown in Table C17, the runoff coefficient at 17-14 station is 0.73 after the adjustment. This value of 0.73 is considered to be reasonable when compared with data of the other sub-basins.

4.6 Extension of the Mean Monthly Runoff Series

The 20 years' mean monthly runoff series derived above (1965-1987) was supplemented for the 3 missing years from 1969 to 1971, and was extended for the period from 1946 to 1964 on the basis of the runoff records at 1719 and 1703

(Kirkyalan) stations. These stations are located on the downstream reaches of the Ermenek River near the confluence of the Ermenek and Göksu Rivers. The catchment area is 3,499.6 km² at the 1719 station, and 3,584.4 km² at the 1703 station.

The monthly runoff data at the stations 17-14 (adjusted for the periods of 1965 - 1968 and 1972 - 1984) and 1723 (observed for the period of 1985 - 1988) were plotted on a full logarithmic paper against the records at 1719 and 1703 stations for the periods of 1965 - 1968 and 1972 - 1988. These records present a fair correlation of the two series of discharge data. The monthly runoff data of 17-14 (or 1723) station was then supplemented and extended using the correlation given below:

Regression equation:

$$\mathrm{Log}_{10}\, Q_{17-14} = 1.142\ \mathrm{Log}_{10}\, Q_{1719} - 0.478674$$

Correlation coefficient : $r = 0.9855$

The mean annual runoffs are calculated as follows:

$$\bar{Q}_{17-14,\ 1965-87} = 44.6\ (m^3/s)$$

$$\bar{Q}_{17-14,\ 1946-87} = 40.4\ (m^3/s)$$

The estimated long-term monthly runoff of 17-14 and its flow duration curve are shown in Figs. C18 and C19, respectively. Also, Table C18 shows the computed long-term monthly runoff series at 17-14.

4.7 Estimation of Monthly Inflow Series of the Ermenek Reservoir

The monthly inflow series of the Ermenek Reservoir were estimated for the period of 42 years (1946 - 1987), based on the monthly runoff data of 17-14 (1723) station, which is located at the Çavusköyü upstream from the Zeyve Creek. Therefore, it is necessary to estimate the runoff from the Zeyve Creek, and to finally estimate the inflow at the proposed dam site. The monthly runoff from the Zeyve Creek was calculated below:

$$Q\ Zeyve = Q\ 17\text{-}14 \times \frac{Ca,\ Zeyve}{Ca,\ 17\text{-}14} \times \frac{R,\ Zeyve}{R,\ 17\text{-}14}$$

where

Q_{Zeyve} = Estimated monthly runoff in Zeyve sub-basin

Q_{17-14} = Adjusted monthly runoff at 17-14 (1723)

Ca_{Zeyve} = Catchment area of Zeyve sub-basin

Ca_{17-14} = Catchment area at 17-14 (1723)

R_{Zeyve} = Annual mean rainfall in Zeyve sub-basin

R_{17-14} = Annual mean rainfall at 17-14

Therefore,

$$Q_{Zeyve} = Q_{17-14} \times \frac{156}{2000} \times \frac{825}{960} = 0.065\ Q_{17-14}$$

$$Q_{Ermenek} = Q_{17-14} + Q_{Zeyve} = 1.065\ Q_{17-14}$$

$$\bar{Q}_{Ermenek,\ 1965-87} = 47.5\ m^3/s$$

$$\bar{Q}_{Ermenek,\ 1946-87} = 43.0\ m^3/s$$

The above estimate of 43.0 m^3/s for the long period of 1946 - 1987 is about 91 per cent of the estimate of 47.5 m^3/s for the period of 1965 - 1987. The historical changes of estimated annual inflows are shown in Fig. C20.

Reliability of the estimated long-term average inflow was checked by the comparison of dimensionless residual mass curves of mean annual runoffs at Stations 17-14 and 1720. The Station 1720 is located near Mut on the Göksu branch stream, and has the runoff records for the 42 years from 1946 to 1987.

As is indicated in Fig. C21, both mass curves have the similar tendency in general such as the long and the most critical dry years from 1946 to 1964, and the recent recovery periods of flows. The other indices show the similarity between the 2 curves as shown below:

Index	17-14	1720
(1) The height from the top in 1946 to bottom in 1965 1/	246 %	242 %
(2) The mean annual runoff of the period 1946-1965 2/	91 %	88 %

1/: % to the mean annual flow of 1946-1987
2/: % to the mean annual flow of 1965-1987

Therefore it is judged that the long-term average flow estimated at 43.0 m^3/s for the 42 years from 1946 to 1987 should be used in the assessment of the energy outputs of the Project, instead of the average value of 47.5 m^3/s for the recorded 23 years' period from 1965 to 1987.

4.8 Estimation of Monthly Inflow Series of Nadire, II-A, II-B and Gezende Reservoirs

For the purpose of assessing the hydropower potentials of alternative schemes such as Nadire, II-A and II-B dam sites as well as reviewing the power output of the Gezende Project, the mean inflow was estimated for each dam.

The inflows of the Nadire, II-A, II-B, and Gezende Dam sites were estimated based on the inflow of the Ermenek Reservoir with adjustments by the catchment area and basin rainfall. The results of the calculation are shown in Tables C19 and C20.

4.9 Estimation of Monthly Inflow Series of the Erik Creek

For purpose of assessing the hydropower potentials of the Erik Diversion Scheme, the mean monthly inflow was estimated based on the relationship of available monthly mean runoffs at 17-14 and 1715 (Erik-Ilisu) for the 3 years of 1966, 70 and 71.

The procedure of estimation is described below:

$$Q_{Erik,\ annual} = Q_{17-14,\ annual} \frac{\bar{Q}_{1715,\ annual}}{\bar{Q}_{17-14,\ annual}}$$

$$Q_{Erik,\ monthly} = \alpha i \ Q_{Erik,\ annual}$$

where

$Q_{Erik,\ annual}$ = Annual runoff series at Erik creek

$Q_{17-14,\ annual}$ = Annual runoff at 17-14

$\bar{Q}_{1715,\ annual}$ = Mean annual runoff at 1715 in the years of 1966, 70 and 71

$\bar{Q}_{1714,\ annual}$ = Mean annual runoff at 17-14 in the years of 1966, 70 and 71

$Q_{Erik,\ monthly}$ = Monthly runoff series at Erik creek

αi = The percentage of annual runoff in a i-th month in 1970 at 1715

The monthly distribution of annual runoff in 1970 was adopted for the disaggregation into the monthly flows since the dry season in 1970 was the most critical among the three years. The resultant monthly runoff series for the Erik Creek is to yield the conservative inflows for the Erik Diversion Scheme.

Results of the estimation of Q_{Erik} and αi are as follows:

$\bar{Q}_{1715,\ annual} = 3.8\ (m^3/s)$

$\bar{Q}_{17-14,\ annual} = 44.6\ (m^3/s)$

therefore,

$$Q_{Erik,\ annual} = \frac{3.8}{44.6} * Q_{17-14,\ annual}$$

$$= 0.0852\ Q_{17-14,\ annual}$$

Values of αi (%)

J	F	M	A	M	J
11.8	9.9	10.3	8.4	7.2	6.9

J	A	S	O	N	D	Year
7.2	6.9	6.5	6.7	6.3	12.0	100

CHAPTER 5. FLOOD STUDY

In order to provide basic data for determination of design flood of the proposed Ermenek Dam, a flood study was conducted. The flood study consisted of frequency analyses on flood peak flow and flood volume, study on the development of dimensionless graph, unit graph, probable maximum precipitation and probable maximum flood. Unitgraph, probable maximum precipitation and probable maximum flood are separately described in Chapter 6.

5.1 Available Flood Data

There is no information concerning floods of the Ermenek River Basin except for the annual maximum discharge records at 17-14 and 1723 stations near the proposed dam site.

After presenting Interim Report, EİE prepared the past records of hourly water level measurements at 1714 station near the proposed Kayraktepe dam site and related hourly rainfall during flood. Those records were used to correlate rainfall and river discharge during flood in dimensionless graph study.

5.2 Frequency Analyses on Annual Maximum Flood

Frequency analyses were made on the annual maximum floods recorded for the past 18 years at Station 17-14. The flood records are listed in Table C21. The analyses were made by the Log-Pearson Type III method and the Gumbel method. Results of the frequency analyses on the annual maximum floods are presented in Table C22.

100-year probable flood in Erik creek was estimated approximately 400 m^3/s by Creager Envelop curves shown in Fig. C22. Therefore 1/100-year probable flood at the Erik Intake Weir site is estimated at 400 m^3/s.

5.3 Frequency Analyses on Annual Maximum Flood Volume

Frequency analyses were also made on the annual maximum flood volume for the past 17 years to know flood inflow volume of the proposed Ermenek Dam. The frequency analyses were made for 6 flood durations; 1-day, 2-day, 3-day, 5-day, 7-day and 10-day. These flood volume records are listed in Table C23. Probable flood volume for each flood duration was computed in accordance with the Gumbel method. Results are presented in Table C24.

The recorded maximum flood volume and 100-year probable flood volume are shown below for comparison.

Flood Volume of Ermenek River at 17-14

(Unit: 10^6 m^3)

Duration	Recorded Maximum Flood	100-year Probable Flood
1 day	81	121
2 days	110	167
3 days	137	207
5 days	165	253
7 days	192	306
10 days	235	398

The recorded maximum flood volume corresponds to a return period of about 5-10 years. The 100-year probable flood volume is about 1.5-1.7 times the recorded maximum value.

5.4 Typical Flood Hydrographs

Typical hourly flood hydrographs which were recorded at 1714 station near the proposed Kayraktepe dam site are as shown in Figs. C23 to C27.

5.5 Dimensionless Graphs

Since hourly flood hydrographs of the Ermenek River Basin were not available, dimensionless graphs were derived based on flood hydrographs observed at 1714 station in order to establish unitgraph of the Ermenek River. The dimensionless graph was derived in accordance with the procedure recommended by USBR, in which Tcv is the time from the beginning of a unitgraph to the center of its volume.

The dimensionless graphs are shown in Figs. C28 to C32 in which q denotes discharge in m^3/s; D duration hours of unit rainfall; and Lg log time between the center of unit rainfall and the time of occurrence of one-half volume of direct runoff.

Results of dimensionless graph study are summarized as follows:

Flood for Hydrograph Analysis

Date	Peak Flow (m^3/s)	Tcv (hr)
Dec 1967	814	27.70
Jan 1971	727	45.96
Dec 1971	941	41.67
Dec 1973	523	29.65
Feb 1975	1,030	44.35

CHAPTER 6. DERIVATION OF PROBABLE MAXIMUM FLOOD

A depth-duration curve of the 1975 storm for the Ermenek River Basin at the proposed dam site is discussed in 3.5. For maximizing the 1975 storm to obtain PMP (Probable Maximum Precipitation), moisture maximization factor was firstly determined. Then seasonal variation of PMP is studied in order to estimate the PMF with and without snow-melt conditions. Unitgraph is derived based on the dimensionless graph to convert PMP to PMF. After determining snow-melt runoff, base flow and rainfall loss, PMP over the Ermenek Dam site is finally converted into the PMF for the proposed Ermenek Dam.

6.1 Persisting 12-Hr Storm Dew Points

The vapour pressure records observed at the following meteorological stations were studied to estimate the representative persisting 12-hour storm dew points for the Ermenek River Basin. The locations of these 4 stations are shown in Fig. C1.

Station	Measurement Period
Ermenek	1965 - 1987
Hadim	1965 - 1987
Alanya	1960 - 1987
Anamur	1960 - 1987

The maximum persisting 12-hour dew point was estimated from the maximum persisting 12-hour vapour pressure as it was readily available on the daily observation sheets. The observations have been made 3 times a day at 7 a.m., 2 p.m. and 9 p.m. Only those persisting 12-hour vapour pressures which were recorded when a rainfall of more than 10 mm was observed during the same period were selected. An enveloping curve of the maximum vapour pressures was drawn for each of the above 4 stations and is shown in Fig. C33. In establishing those enveloping curves of the vapour pressure, the recorded 2nd and 3rd order maximum monthly values were also plotted to achieve the better representation.

As is indicated in "Manual for estimation of probable maximum precipitation" by WMO, dew-point records shorter than about 50 years are unlikely to yield maximum values representative of maximum atmospheric moisture. Therefore, a frequency analysis of the monthly maximum persisting 12-hour vapour pressure was made. January and February were selected for this analysis in order to maximize the maximum storm on 31st January 1975. Value for the 100-year return period was adopted for this study, but values of 50-year return period were shown for comparison. Results of this analysis are shown below;

Station	Month	Recorded Maximum	Probable V. 100-year	Pressure (mb) 50-year
Ermenek	Jan.	7.3	7.9	7.5
	Feb.	6.8	8.7	8.1
Hadim	Jan.	6.2	8.1	7.6
	Feb.	6.1	8.4	7.9
Alanya	Jan.	14.6	17.5	16.5
	Feb.	13.4	16.2	15.4
Anamur	Jan.	15.9	18.9	17.7
	Feb.	15.1	16.7	15.7

6.2 Storm Dew Point on 31st January 1975

Storm dew point is estimated for the observed maximum rainstorm on 31st January 1975 as follows;

Station	Station elev. (m)	Vapour pressure (mb)	Dew point at Station (°C)	Dew point at sea level (°C)
Ermenek	1,250	5.6	-1.2	5.5
Hadim	1,500	5.7	-1.0	7.3
Alanya	7	11.3	8.8	8.8
Anamur	5	14.1	12.1	12.1

Ermenek and Hadim stations are located leeward from the heavy rainfall area, which is mainly the southern slope of the Toros Mountain facing the Mediterranean Sea. Sea level dew points at Ermenek and Hadim stations are relatively lower than those of alanya and Anamur stations. This is because the moist air mass inflow from the sea had lost considerable amount of its moisture as the rainfall over the heavy rainfall area when it arrived at these stations. Therefore dew points at Ermenek and Hadim do not represent the dew point of the moist air mass inflow, which is the source of the typical storm over the Ermenek River Basin.

Dew point at station level was firstly reduced to sea level (1,000 mb). The representative storm dew point was calculated to be 10.5 °C as an average of 2 stations, Alanya and Anamur, both of which are located windward to the prevailing wind direction during storm.

6.3 Maximum Dew Point

Maximum dew point probable around the day of 31st January was estimated below with the same procedure as (2).

Station	Station elev. (m)	Vapour pressure (mb)		Dew point at Station (°C)		Dew point at sea level (°C)	
		100 yr	50 yr	100 yr	50 yr	100 yr	50 yr
Ermenek	1,250	8.7	8.1	5.0	4.0	11.2	10.7
Hadim	1,500	8.4	7.9	4.5	3.6	12.5	11.7
Alanya	7	17.5	16.5	15.4	14.5	15.4	14.5
Anamur	5	18.9	17.7	16.6	15.6	16.6	15.6
Average of Alanya and Anamur						16.0	15.1

6.4 Moisture Maximization Factor

Based on the storm dew point and the maximum dew point probable around 31st January, MMF was determined using the following formula.

$$MMF = h^{W}{}_{t2} \ / \ h^{W}{}_{t1}$$

where,

$h^{W}{}_{t2}$ = precipitable water in a saturated pseudoadiabatic atmosphere from the ground base of moisture column (h) to the height of 300 mb, corresponding to the maximum persisting 12-hour 1,000 mb dew point (wet-bulb potential temperature, t2).

$h^{W}{}_{t1}$ = precipitable water in a saturated pseudoadiabatic atmosphere from the ground (h) to the height of 300 mb, corresponding to the storm 1,000 mb dew point (t1).

Base elevation of the moisture column is determined at 1,700 m as the mean elevation of the mountains barrier between the moisture source in the Mediterranean sea and the Ermenek River Basin.

The moisture maximization factor is then obtained below;

- Storm dew point : t1 = 10.5 °C

- Maximum dew point : t2 = 16.0 °C

- MMF = (37.6 - 18.1) / (23.5 - 12.4)
  = 19.5 / 11.1
  = 1.76 ≑ 1.8

Fig. C34 shows the depths of precipitable water in a column of air (U.S. National Weather Service).

6.5 Probable Maximum Precipitation

The PMP for the Ermenek Dam site is then derived in accordance with the procedure as summarized below.

(1) Maximum rainfall depth-duration curve for the Ermenek Basin at the proposed dam site, which was obtained in Chapter 3.5 was used for PMP estimation (see Fig. C10).

(2) Maximum rainfall depths were multiplied by the previously obtained moisture maximization factor of 1.8.

The PMP over the Ermenek Basin thus obtained is presented in Table C25 and summarized below.

PMP over Ermenek Basin

Duration (hr)	DD over 2,156 km^2 (mm)	PMP DD x 1.8 (mm)
1	22	40
6	68	122
12	90	162
24	102	184
48	162	292
96	253	455

6.6 Seasonal Variation of PMP

In the Göksu River Basin, where the maximum flood is likely to result from a combination of snow-melt and rainfall, it is necessary to estimate the seasonal variation of PMP so that a combination of snow-melt and rainfall can be evaluated to derive a PMF for spring months.

For the purpose of constructing PMP for the entire snow-melt season, seasonal enveloping curve of PMP was drawn, based on the following procedure, as is indicated in "Manual for estimation of probable maximum precipitation" by WMO.

(1) Maximum daily basin mean rainfall in each month from January to April in each year, averaging the values of Ermenek, Göktepe and Kazançi stations in the Ermenek River Basin, was picked up. the maximum values were plotted against date of occurrence, and a smooth seasonal developing curve was then drawn. The seasonal pattern of maximum daily precipitation in the Ermenek River Basin is shown in Fig. C35.

(2) The rainfall scale was converted into terms of percentage.

6.7 Unitgraph

Three Unitgraphs were derived for unit rain of 1 mm over the three sub-basins which were divided by the with-Ermenek-dam condition for unit duration of 1 hour based on the dimensionless graph and lag time Tcv. Fig. C36 shows the 3 sub-basins in the Ermenek River Basin. Time Tcv is defined as a time from the beginning of rise of net hydrograph to center of its volume. Tcv is substituted for lag time (Lg + D/2) when the available rainfall data are limited.

Time Tcv of the Göksu River is checked for the 5 floods recorded at 1714 station as summarized below.

Time Tcv of Göksu River at 1714

Date	Tcv (hr)	Q peak (m^3/s)
Dec 1967	27.70	814
Jan 1971	45.96	727
Dec 1971	41.67	941
Dec 1973	29.65	523
Feb 1975	44.35	1,030

For each sub-basin A, B and C, two cases of lag time (Lg +D/2) were estimated based on the Snyder's coefficients Ct, tp and tp', and Q peak over the Göksu River Basin. Results of calculation of Ct, tp and tp' for 5 floods are shown as follows.

Values of Ct, tp, tp' and Q peak

Date of Flood	tr' (hr)	tp' (hr)	tp (hr)	Ct	tp' (tr'=1hr)	Qpeak (m^3/S)
Dec 1967	14	25	22.52	1.0572	21.75	814
Jan 1971	12	20	17.81	0.8361	17.25	727
Dec 1971	10	26	24.61	1.1558	23.75	941
Dec 1973	9	23.5	22.61	1.0450	21.50	523
Feb 1975	24	28	23.05	1.0821	22.25	1,030

To construct the unitgraph for the Ermenek Dam site, the following two cases were contemplated:

(1) Flood with the shortest tp
  Flood: Jan 1971
  tp : 17.81 (hr)

(2) Flood with the largest Qpeak
  Flood: Feb 1975
  Qpeak: 1,030 (m^3/s)

Results of the calculation of lag time (Lg + D/2) and Peak discharge qp ($m^3/s/mm$) for each sub-basin A, B and C based on the Snyder's coefficients Ct, tp and tp' of 2 floods selected above are shown in Tables C26 and C27. The three unitgraphs for sub-basins A, B, C and total unitgraph for the Ermenek dam site are presented in Tables C28 and C29, and depicted in Figs. C37 and C38.

Base length of the unitgraph for the Ermenek dam site by 2 cases are as follows:

Base length

Flood	Base Length (hr)
Jan 1971	67
Feb 1975	58

The basin lag tp and ($LL/s^{0.5}$) relation for each sub-basin was checked by the equation by Linsley. Results are shown in Fig. C39 and Table C30 and summarized below.

Sub-basin	$LL/S^{0.5}$	Basin Lag t'p (hr)		
		St. 1714 Feb. 1975	St. 1714 Jan. 1971	Seyhan D. Mar. 1980
A	129	10.5	8.5	5.5
B	53	6.5	5.5	3.5
C	14	5.5	4.5	2.5

The figure C39 suggested that even the lags given by the Seyhan flood is not very short. However, the lag time given by the January 1971 flood at Station 17-14 was adopted in this study to derive PMF, giving weight to the flood recorded in the basin and adopting the shorter lags between the two to be conservative in terms of flood magnitude.

6.8 Rainfall Loss

Initial rainfall loss is neglected assuming that whole the Ermenek Basin is saturated by antecedent rainfall in such an extreme storm like PMP. While the retention loss rate after the saturation is assumed to be constant at 2.0 mm/hr, which value has been commonly adopted for most of the projects such as Mut, Gezende and Kayraktepe hydropower projects around the Ermenek River Basin.

The above constant loss of 2.0 mm/hr was adopted because of the limited availability of data. This needs a future review through analysis based on the actual records of hourly rainfall and runoff to be observed in the basin.

6.9 Snow-Melt

Snow-melt runoff and its maximum rate were previously computed by EİE for the Ermenek River Basin using the degree-day method. Results are shown in Table C31. Results of this estimation were applied to this PMF analyses.

6.10 Base Flow

The mean daily discharge hydrographs of 17-14 station was analyzed. The maxim base flow discharge is assumed to be 100 m^3/s.

6.11 Probable Maximum Flood of the Proposed Ermenek Dam

The PMP for 96-hour duration is rearranged to hourly rainfalls with its peak at one fourth from the end of the duration maintaining the depth-duration relation. The results are presented in Table C25.

This hourly hydrograph of the PMP for the Ermenek Dam is converted to PMF using the unitgraph. As was explained in Chapter 6.6, two PMP were constructed. One is PMP for January without-snow-melt condition, the other is for April with-snow-melt condition. PMP for April was obtained by reducing the PMP for January based on the seasonal maximum daily precipitation curve shown in Fig. C35. PMP for April is approximately 75% of the PMP for January. Both PMP and resultant PMF for January and April are shown in Figs. C40 and C41.

Results of PMF for January and April are summarized below;

(Unit: m^3/s)

Month	By PMP	Snow-melt plus base flow	Total
January	5,800	100	5,900
April	4,100	1,300	5,400

CHAPTER 7. SEDIMENT AND WATER QUALITY STUDY

7.1 Available Sediment Data

EİE has carried out suspended sediment sampling at 1723 (Çavusköyü) since 1985. Suspended sediment sampling data are shown in Table C32.

7.2 Sediment Rating Curve

Sediment rating curve is generally approximated by a straight line on a full-log-paper as shown in Fig. C42. The line can be expressed by the following equation.

$$Qs = a \times Q^b$$

where,

Qs = suspended sediment transport in ton/day

Q = runoff in m^3/s

a, b = parameter depending on the basin characteristics

The above equation can be transformed as follows,

$$\log (Q_s) = \log (a) + b \times \log (Q)$$

The parameters a and b of the sediment rating curve are obtained as shown below.

$$\log (Q_s) = \log (0.405) + 1.65 \log (Q)$$

7.3 Sediment Inflow into the Ermenek Reservoir

Suspended sediment transport for the Ermenek River Basin is computed based on the daily runoff records at Station 1723 from 1985 to 1988 using the sediment rating curve shown in Fig. C42.

Mean daily suspended sediment transport of the Ermenek River is then obtained to be 288 ton/day.

The sediment inflow into the proposed Ermenek Reservoir is estimated as described below.

(1) Mean suspended sediment transport obtained at 1723: 288 ton/day

(2) Adjusted for runoff fluctuation within a day (assumed to be 1.2 times of the value by daily mean basis): 346 ton/day

(3) Adjusted for such probable larger floods expected during the 100 years operation than the ever occurred in the 4 years runoff records used (assumed to be 2 times of (b)): 692 ton/day

(4) Specific weight of sediments after deposited in the reservoir: 1.2 ton/m^3

(5) Specific annual suspended sediment volume:

(3) x 365 days / (4) / 2,000 km^2: 105 $m^3/km^2/year$

(6) Mean specific bed load (assumed to be 20% of (5)): 21 $m^3/km^2/year$

(7) Mean specific sediment inflow ((5) + (6)): 130 $m^3/km^2/year$

Thus the mean sediment inflow volume is estimated to be 130 $m^3/km^2/year$. It corresponds to an annual denuded depth of the land of 0.13 mm.

Assuming that a trap efficiency of sediment inflow by the Ermenek Reservoir (Ca = 2,156 km^2) is 100%, the mean annual reservoir sedimentation is calculated to be 0.28 x 10^6 m^3. After the 100 years operation of the Ermenek Reservoir, the total sediment deposit volume would be around 28 x 10^6 m^3.

7.4 Water Quality

Water sampling for chemical analyses has been carried out by EİE at Station 1723 since 1985. The results of the chemical analyses are summarized in Table C33.

Among those chemical values, a value of pH indicates that the analyzed water is either acid or alkaline. The study on the relation between the value of pH and corrosion of metal works at hydroelectric power stations in Japan indicated that the water with the pH value below 4.5 mostly causes the corrosion on the metal works at power station. the water on the Ermenek River Basin is alkaline, with the average value of 8.0.

TABLES

Table C1 STREAM GAUGING STATIONS OF EİE AND DSİ IN THE GÖKSU RIVER BASIN

Station	EL (m)	Catchment Area Km^2	Starting Date	Deactivates in	Available Period of Records	Remarks
1703-Ermenek-Evren	126	3584.4	28.10.1945	1.10.1965	1946-1965	at the most down-stream Ermenek
1719-Ermenek-Kirkyalan	129	3499.6	1.10.1965	-	1966-1988	close to 1703
1715-Erik-Ilisu	850	241.6	10. 9.1964	15.1.1972	1966,70,71	at Erik weir site
17-14 Görmel Bridge(DSİ)	509	2000.0	1.10.1964	-	1965-1968 1972-1988	at Gormel Bridge (Flow measuring site is at Cavuskoyu.)
1723-Ermenek-Çavusköyü	-	2000.0	1.10.1985	-	1985-1988	at Cavuskoyu village
1705-Göksu-Eksiler	35	9723.6	8. 8.1952	1961	1953-1960	near Kayraktepe dam site
1714-Göksu-Karahacili	24	10065.2	1961	-	1961-1988	close to 1705
1704-Göksu-Selamli	125	4372.0	1945	1965	1946-1965	near Kayraktepe dam site
1720-Göksu-Haman	127	4304.0	1965	-	1966-1988	close to 1704
1712-Göksu-Bucakkisla	397	2689.2	1954	-	1962-1988	middle Goksu
1702-Göksu-Yerkopru	790	1412.0	1940	1959	1941-1954	upper Goksu
1722-Göksu-Aladag	725	1476.4	1974	1979	1975-1979	upper Goksu

Table C2 MEAN MONTHLY PRECIPITATION RECORDS IN AND AROUND THE ERMENEK RIVER BASIN (1/2)

Station Name	Elevation (m)	Observation Period	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Meteorological Stations Within the Catchment Area															
Göktepe	1,500	1965-1976 1979-1987	192.8	114.6	95.5	61.7	38.2	13.0	3.8	2.5	4.8	56.1	107.3	179.6	869.9
Ermenek	1,250	1953-1976 1979-1980 1982-1987	101.4	72.9	64.6	38.7	35.9	19.5	7.0	5.7	5.3	30.3	57.3	106.1	544.7
Kazançi	1,200	1965 1967-1976 1980-1981	177.3	128.7	83.2	57.9	42.2	11.1	5.1	3.7	3.7	42.9	90.9	166.1	812.8
Meteorological Stations Around the Catchment Area															
Hadim	1,500	1940 1956-1987	127.8	86.5	71.7	51.7	39.9	25.0	6.6	4.6	7.2	50.7	62.5	129.8	644.0
Taskent	1,500	1965-1981	131.0	86.8	78.8	50.1	40.2	22.6	5.2	4.7	7.0	57.7	69.6	148.2	701.9
Aladag	1,000	1965-1987	87.0	50.3	49.3	37.9	34.8	23.3	4.7	4.9	6.8	40.1	48.6	88.8	476.6
Bucakkisla	600	1958-1987	106.3	59.3	44.1	29.6	30.4	16.6	3.4	2.3	3.8	26.5	39.9	89.4	451.6
Gülnar	925	1957-1976 1978-1986	220.0	126.8	78.3	39.8	29.9	11.9	1.6	1.3	4.6	61.8	106.2	216.0	893.3

Table C2 MEAN MONTHLY PRECIPITATION RECORDS IN AND AROUND THE ERMENEK RIVER BASIN (2/2)

(mm)

Station Name	Elevation (m)	Observation Period	Months Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Aydincik(Gilindire)	10	1957-1987	181.9	110.1	71.3	34.0	12.3	1.4	0.3	0.1	5.4	58.3	94.3	183.0	752.4
Anamur	5	1944-1987	227.0	163.7	106.2	41.4	22.7	5.1	0.4	0.7	7.5	79.5	122.9	234.7	1011.7
Gazipasa	20	1956-1987	172.7	131.5	86.9	46.6	28.8	3.9	1.3	0.8	12.3	63.5	105.6	159.7	813.6
Demirtas	50	1964-1987	210.1	137.1	97.4	67.1	24.8	5.7	1.7	1.8	14.2	69.4	150.1	183.5	962.6
Alanya	7	1938-1987	249.9	165.5	93.6	51.8	32.4	5.8	3.4	0.9	18.6	78.4	151.4	230.1	1081.8
Koprulu	800	1965-1985	400.9	220.2	170.3	97.4	41.8	18.6	3.5	8.9	16.0	109.4	198.1	385.0	1670.1
Gundogmus	930	1957-1987	306.7	193.4	149.8	87.6	59.1	34.8	7.7	7.2	24.5	84.9	146.4	293.0	1395.1
Mut	275	1954-1985	84.7	56.1	40.4	23.8	21.5	13.0	4.7	1.8	4.6	30.0	44.9	88.6	414.1

Table C3 **MONTHLY MEAN, MAXIMUM, AND MINIMUM TEMPERATURE VALUES FOR ERMENEK METEOROLOGICAL STATION, °C**

Station	Observation Period	EL. (m.)		Months J	F	M	A	M	J	J	A	S	O	N	D	Annual
			Max.	17.5	18.5	20.0	26.8	33.0	34.5	39.0	37.8	37.0	32.0	23.6	19.8	39.0
Ermenek	1965 ¦ 1987	1,250	Mean	3.3	3.5	5.4	9.7	13.4	19.3	22.3	22.3	18.2	13.1	7.7	3.8	11.8
			Min.	-15.0	-13.5	-13.1	-2.0	1.2	5.0	5.5	6.5	4.5	0.3	-8.5	-9.2	-15.0

Table C4 MONTHLY MEAN RELATIVE HUMIDITY VALUES FOR ERMENEK METEOROLOGCAL STATION, % (1/2)

Year	Months												Annual
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1965	66	73	70	56	51	37	35	26	44	64	75	70	56
1966	71	66	56	53	51	42	32	37	61	53	67	67	55
1967	69	72	72	52	41	-	62	-	72	69	88	82	-
1968	84	78	59	48	61	47	60	57	56	68	72	87	65
1969	92	81	76	72	63	48	40	42	43	60	67	83	64
1970	83	79	80	58	70	42	30	38	53	49	65	82	61
1971	56	76	50	58	42	40	24	33	33	40	43	71	47
1972	78	70	54	36	40	48	40	39	42	54	59	63	52
1973	57	54	51	39	33	38	26	31	34	45	56	56	43
1974	69	55	60	53	47	48	42	34	45	38	61	78	52
1975	73	80	41	46	53	42	32	31	31	40	51	-	-
1976	62	62	59	68	48	54	41	38	-	50	61	70	-
1977	70	60	-	-	-	38	28	27	-	-	-	-	-
1978	-	57	52	47	-	30	23	34	45	42	51	60	-
1979	56	57	55	-	50	49	32	47	56	54	59	64	-

Table C4 MONTHLY MEAN RELATIVE HUMIDITY VALUES FOR ERMENEK METEOROLOGICAL STATION, % (2/2)

Year	Months												Annual
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1980	66	65	65	52	46	35	26	34	46	47	62	60	50
1981	76	65	60	50	49	48	47	-	43	43	54	65	-
1982	54	57	58	50	47	41	36	33	37	46	51	53	47
1983	58	60	55	46	46	42	39	35	35	46	66	57	49
1984	65	53	56	54	32	29	30	44	32	33	66	52	46
1985	61	58	48	40	43	33	30	36	33	48	55	56	45
1986	61	59	47	43	51	32	32	30	40	41	49	56	45
1987	59	54	60	49	37	31	29	30	32	42	50	61	44
Ave.	68	65	58	51	48	41	35	36	43	49	60	66	

Table C5 MONTHLY MAXIMUM WIND VELOCITY AND ITS DIRECTION AT MUT METEOROLOGICAL STATION, M/SEC.

	Months												Annual
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Max. Velocity	17.0	16.5	15.3	15.8	15.3	16.1	16.4	16.7	14.7	16.6	23.2	17.0	23.2
Direction	SW	NW	NW	SE	NW	NNW	NNW	NNW	NNW	NW	NW	SE	NW

Note: (1). Max velocity is measured as an instantaneous value.
(2). Direction of dominant wind is NW.
(3). Available period of the records is from 1966 to 1986.

Table C6 SEASONAL DISTRIBUTION OF THE MEAN ANNUAL PRECIPITATION IN THE ERMENEK RIVER BASIN

(mm)

Station	Mean Annual Precipitation	Spring		Summer		Autumn		Winter	
		March - May		June - August		September - November		December - February	
	mm	mm	%	mm	%	mm	%	mm	%
Göktepe	869.9	195.4	23	19.3	2	168.2	19	487.0	56
Ermenek	544.7	139.2	26	32.2	6	92.9	17	280.4	51
Kazançi	812.8	183.3	23	19.9	2	137.5	17	472.1	58

Table C7 MONTHLY RUNOFF OF ERMENEK RIVER AT 17-14

(Unit: MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1964										22.7	31.4	124	-
1965	-	238	352	466	273	98.4	35.2	22.0	19.1	25.0	46.5	145	1,720
1966	412	173	318	415	218	88.9	38.8	25.4	23.0	16.0	51.4	441	2,221
1967	252	79.7	201	500	335	114	51.1	31.5	29.4	33.9	112	171	1,911
1968	331	168	405	605	357	99.2	47.1	32.3	29.9				-
1969													-
1970													-
1971										50.4	41.5	100	-
1972	50.7	74.8	192	340	157	53.2	36.1	29.8	26.9	66.5	51.7	38.5	1,117
1973	33.2	84.0	161	205	104	33.6	24.3	20.8	19.2	25.7	35.0	121	867
1974	38.7	63.3	266	115	61.6	32.2	23.9	21.8	22.6	28.4	43.9	212	929
1975	179	133	314	559	286	92.1	43.6	31.4	26.6	40.1	85.2	82.1	1,872
1976	152	101	197	524	238	80.2	47.0	35.3	31.8	85.4	70.8	258	1,821
1977	103	183	222	340	201	66.4	40.2	30.2	29.2	34.0	33.6	56.6	1,339
1978	200	248	261	364	244	78.5	40.1	29.6	28.1	129	57.8	168	1,848
1979	343	201	203	187	121	76.4	44.0	35.6	33.7	37.6	109	172	1,563
1980	218	113	311	518	282	91.6	41.8	33.9	30.5	17.0	29.6	107	1,793
1981	169	131	361	459	274	114	55.7	20.2	16.4	23.0	161	485	2,269
1982	268	81.1	117	343	202	113	38.1	27.6	23.0	41.5	31.9	70.6	1,357
1983	61.3	76.2	191	426	222	52.4	18.8	12.7	10.9	36.8	236	248	1,592
1984	164	194	265	388	248	56.2	34.6	32.2	27.8	28.6	85.5	57.8	1,582
1985	171	129	220	301	115	45.4	29.2	23.8	23.1	81.2	-	72.9	-
1986	233	137	223	243	92.9	51.6	32.1	26.2	24.4	25.4	36.0	89.5	1,214
1987	236	143	152	421	531	207	53.3	35.4	30.1	28.1	60.9	69.4	1,967
1988	52.0	99.0	226	474	292	73.9	41.5	31.9	27.2				-

Table C8 MONTHLY RUNOFF OF GOKSU RIVER AT 1702

(Unit: MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1940											29.8	193.	
1941	112.	139.	153.	135.	59.9	47.9	44.5	42.6	38.7	40.3	35.5	45.4	894
1942	58.9	74.5	268.	342.	178.	54.5	30.1	26.9	26.7	33.4	71.9	81.8	1,247
1943	80.1	61.2	101.	270.	172.	42.3	30.5	27.2	26.1	34.5	30.7	32.1	908
1944	47.8	145.	241.	221.	149.	55.3	30.9	27.8	26.0	28.7	30.0	42.1	1,045
1945	51.9	56.3	90.6	325.	268.	88.0	33.3	28.3	26.4	27.6	31.9	94.4	1,122
1946	59.9	61.1	127.	294.	128.	55.1	32.7	29.1	27.1	31.1	29.1	70.1	944
1947	71.3	98.6	165.	119.	61.0	40.5	30.1	26.9	26.0	27.2	63.5	128.	857
1948	127.	102.	93.3	230.	163.	63.3	43.8	35.6	27.2	28.1	27.6	30.1	971
1949	30.5	33.7	111.	108.	201.	42.7	31.5	27.7	27.6	25.4	28.1	28.2	795
1950	39.6	35.9	120.	154.	74.9	34.2	26.9	25.2	24.0	25.6	24.4	26.1	611
1951	33.6	41.6	119.	97.7	61.2	36.8	26.0	24.8	23.4	33.1	28.0	42.7	568
1952	47.4	114.	147.	205.	95.3	39.7	28.5	25.2	23.6	24.1	37.7	59.9	847
1953	89.3	184.	104.	345.	184.	58.5	30.8	24.8	28.2	97.8	155.	167.	1,468
1954	91.4	106.	205.	239.	103.	37.3	35.7	31.7	23.2				

Table C9 MONTHLY RUNOFF OF GOKUSU RIVER AT 1712

(Unit: MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1961										21.5	22.7	57.3	
1962	45.9	85.7	191.	131.	85.8	35.3	22.2	20.5	19.7	27.8	25.4	166.	856
1963	148.	171.	169.	200.	129.	59.7	32.9	25.4	23.5	25.0	25.6	42.1	1,051
1964	26.5	40.1	100.	73.2	50.5	42.4	23.5	22.9	20.5	21.8	23.5	75.5	520
1965	86.5	184.	231.	238.	128.	50.3	29.3	23.8	23.0	25.3	26.3	71.9	1,117
1966	213.	130.	185.	216.	102.	44.6	27.1	23.2	22.4	23.3	28.3	127.	1,142
1967	103.	57.0	191.	342.	212.	60.6	36.2	26.9	24.7	26.6	43.4	72.7	1,196
1968	146.	154.	317.	293.	158.	50.8	30.1	25.4	25.3	28.6	78.9	195.	1,502
1969	174.	187.	307.	194.	153.	51.0	32.2	26.0	29.5	32.6	31.8	107.	1,325
1970	107.	107.	217.	173.	81.5	37.5	27.4	22.9	21.4	27.6	37.7	56.8	917
1971	89.0	55.1	168.	235.	117.	40.1	27.0	24.6	21.7	27.0	27.7	108.	940
1972	40.0	63.7	198.	244.	92.1	43.0	28.7	23.6	22.5	30.8	29.3	25.9	842
1973	24.7	36.4	96.9	102.	47.3	25.9	21.6	20.4	19.8	21.2	21.6	41.3	479
1974	25.6	43.2	173.	67.2	35.6	22.7	20.5	19.9	19.1	23.5	23.7	97.4	571
1975	101.	111.	274.	352.	174.	62.7	33.4	27.3	24.2	34.8	41.8	44.8	1,281
1976	73.5	74.7	187.	309.	134.	47.9	30.3	24.0	22.7	47.8	38.5	162.	1,151
1977	74.4	172.	186.	266.	156.	49.9	31.6	25.9	24.3	27.2	26.2	34.4	1,074
1978	115.	160.	194.	249.	126.	44.5	26.3	22.8	22.4	35.5	36.5	57.0	1,089
1979	144.	118.	108.	91.4	58.8	65.1	29.8	23.8	22.5	25.3	42.1	89.3	818
1980	114.	77.1	232.	305.	164.	52.7	27.6	25.4	21.0	24.1	25.6	50.8	1,119
1981	115.	150.	293.	235.	142.	71.6	34.3	20.1	19.5	21.2	37.1	198.	1,337
1982	112.	62.7	111.	206.	79.9	44.1	27.2	24.1	22.8	26.4	25.7	31.2	773
1983	36.6	48.0	186.	281.	119.	43.5	23.8	20.7	19.2	21.3	41.9	113.	954
1984	75.5	119.	186.	206.	127.	39.3	25.9	23.2	21.0	22.2	31.4	34.4	911
1985	60.9	68.2	127.	194.	65.2	32.3	21.4	20.3	18.9	38.4	110.	40.5	797
1986	111.	90.5	120.	105.	73.3	41.2	24.4	20.0	18.8	20.9	30.0	46.8	702
1987	140.	114.	142.	260.	217.	72.4	30.5	22.5	20.7	23.4	46.0	57.0	1,146
1988	48.2	84.1	188.	250.	113.	39.1	25.6	21.7	20.1				

Table C10 MONTHLY RUNOFF OF GOKSU RIVER AT 1714

(Unit: MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1952										78.4	207.	428.	
1953	625.	1023.	482.	1683.	918.	346.	178.	141.	128.	131.	133.	136.	5,924
1954	266.	332.	687.	939.	550.	202.	130.	112.	105.	118.	163.	725.	4,329
1955	495.	400.	390.	413.	283.	143.	114.	106.	101.	107.	231.	269.	3,052
1956	205.	440.	421.	682.	357.	157.	110.	100.	96.5	105.	106.	128.	2,908
1957	127.	151.	382.	295.	185.	117.	95.6	84.0	83.7	115.	114.	343.	2,092
1958	638.	330.	415.	375.	195.	120.	79.0	70.7	69.9	75.7	75.7	144.	2,588
1959	576.	235.	331.	464.	239.	101.	80.2	71.5	69.8	118.	138.	183.	2,607
1960	316.	205.	392.	513.	232.	127.	106.	103.	96.3	98.6	103.	293.	2,585
1961	246.	509.	385.	654.	250.	127.	111.	99.3	99.	114.	117.	331.	3,042
1962	215.	373.	684.	463.	368.	138.	111.	101.	104.	143.	121.	893.	3,714
1963	660.	793.	624.	904.	516.	266.	173.	122.	114.	123.	124.	166.	4,585
1964	123.	184.	381.	281.	219.	148.	101.	91.0	87.9	94.9	117.	290.	2,118
1965	326.	575.	830.	842.	517.	243.	141.	115.	106.	123.	148.	353.	4,319
1966	864.	459.	622.	724.	393.	199.	123.	107.	104.	110.	169.	555.	4,429
1967	495.	245.	595.	1051.	671.	244.	158.	127.	115.	122.	233.	306.	4,362
1968	623.	456.	1020.	1047.	623.	254.	161.	128.	136.	152.	277.	695.	5,572
1969	986.	629.	1022.	675.	574.	272.	192.	166.	161.	187.	202.	547.	5,613
1970	506.	511.	713.	649.	379.	220.	165.	144.	124.	151.	183.	235.	3,980
1971	357.	258.	558.	687.	429.	192.	128.	119.	109.	134.	143.	340.	3,454
1972	166.	236.	559.	754.	417.	200.	139.	121.	106.	183.	150.	132.	3,163
1973	123.	179.	333.	366.	213.	105.	86.6	79.2	87.0	102.	106.	231.	2,011
1974	130.	168.	563.	277.	169.	96.4	73.6	71.7	71.4	102.	103.	449.	2,274
1975	395.	437.	827.	1173.	639.	289.	161.	120.	103.	134.	216.	213.	4,707
1976	376.	315.	528.	1109.	548.	231.	153.	129.	111.	214.	193.	598.	4,505
1977	328.	514.	553.	749.	516.	205.	128.	101.	99.0	120.	118.	175.	3,606
1978	501.	686.	710.	884.	539.	224.	138.	112.	108.	262.	201.	374.	4,739
1979	748.	536.	452.	395.	284.	220.	124.	101.	97.8	120.	242.	419.	3,739
1980	524.	341.	797.	1167.	658.	272.	147.	117.	115.	129.	145.	274.	4,686
1981	583.	569.	1054.	995.	608.	307.	159.	105.	93.5	130.	304.	945.	5,853
1982	658.	281.	464.	801.	415.	239.	152.	125.	114.	149.	136.	190.	3,724
1983	228.	228.	563.	974.	505.	209.	131.	113.	107.	121.	291.	606.	4,076
1984	400.	452.	555.	705.	472.	188.	128.	112.	98.1	114.	225.	186.	3,635
1985	360.	337.	476.	645.	299.	155.	108.	98.0	91.9	195.	471.	271.	3,507
1986	527.	404.	493.	444.	252.	179.	107.	93.1	89.5	98.0	134.	219.	3,040
1987	580.	406.	504.	877.	863.	391.	158.	110.	98.3	116.	214.	227.	4,544
1988	193.	322.	696.	914.	580.	216.	126.	114.	98.6				

Table C11 MONTHLY RUNOFF OF ERMENEK RIVER AT 1715

(Unit: MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1965										5.96	5.55	7.37	
1966	13.0	10.7	9.77	9.18	9.07	8.14	8.07	7.72	7.31				
1967													
1968													
1969										9.29	8.48	16.8	
1970	16.6	12.5	14.5	11.4	10.1	9.39	10.2	9.57	8.92	9.24	10.2	9.76	
1971	10.2	8.59	12.9	11.3	11.3	10.1	9.49	9.49	7.54				

Table C12 MONTHLY RUNOFF OF ERMENEK RIVER AT 1719

(Unit: MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1945											50.1	160.	
1946	94.5	103.	200.	476.	220.	63.3	33.9	29.0	27.2	41.3	31.3	121.	1,441
1947	165.	161.	315.	245.	107.	55.8	33.5	27.4	25.7	27.7	140.	263.	1,566
1948	228.	207.	158.	359.	228.	62.4	28.9	24.1	22.5	23.8	23.1	26.6	1,391
1949	45.9	65.2	162.	362.	411.	62.0	27.6	22.6	22.3	22.3	33.6	30.9	1,267
1950	90.1	53.9	195.	339.	122.	32.8	25.6	22.9	21.6	23.3	22.7	25.3	974
1951	74.5	82.6	237.	210.	91.4	35.9	26.5	23.9	23.7	53.2	37.0	88.8	985
1952	76.3	181.	176.	390.	199.	49.7	27.9	23.6	21.6	23.1	111.	175.	1,454
1953	252.	383.	207.	682.	536.	213.	81.8	55.8	48.8	61.7	62.5	63.7	2,647
1954	154.	194.	377.	536.	374.	125.	65.2	52.8	49.1	43.8	95.3	351.	2,417
1955	253.	236.	228.	255.	168.	64.3	42.6	39.1	37.2	39.1	121.	180.	1,663
1956	157.	266.	262.	502.	285.	117.	97.0	59.1	53.2	35.6	37.7	57.0	1,929
1957	51.6	63.9	212.	174.	97.4	48.5	35.7	30.8	29.7	37.6	52.3	213.	1,047
1958	243.	147.	289.	282.	151.	71.7	38.5	30.7	27.7	30.1	34.5	110.	1,455
1959	256.	104.	169.	333.	180.	71.4	50.7	43.0	39.4	53.0	75.1	120.	1,495
1960	155.	102.	226.	376.	163.	60.1	42.9	37.5	34.8	38.7	41.5	153.	1,431
1961	104.	298.	214.	381.	148.	58.8	40.2	33.5	31.2	37.1	36.3	142.	1,524
1962	90.2	167.	351.	255.	209.	63.3	42.7	34.9	36.7	60.6	44.4	441.	1,796
1963	333.	398.	340.	623.	325.	138.	69.9	48.2	45.2	45.2	45.3	78.4	2,489
1964	46.8	92.9	232.	134.	93.7	47.9	37.3	31.8	32.0	30.7	36.7	124.	940
1965	144.	261.	443.	467.	294.	113.	55.4	41.9	37.8	44.8	74.2	237.	2,213
1966	518.	205.	345.	463.	264.	112.	59.7	45.8	43.2	44.5	78.8	350.	2,529
1967	271.	109.	259.	569.	395.	135.	74.7	53.0	46.5	53.6	116.	209.	2,291
1968	330.	185.	475.	601.	385.	143.	67.7	52.4	47.8	62.6	170.	495.	3,015
1969	381.	259.	506.	372.	322.	117.	72.1	57.5	51.1	61.9	66.6	262.	2,528
1970	228.	268.	380.	385.	209.	102.	61.2	46.5	44.3	57.3	73.8	109.	1,964
1971	150.	111.	288.	338.	210.	77.6	49.9	46.6	41.9	55.0	54.6	135.	1,558
1972	70.5	105.	240.	380.	207.	82.6	56.0	48.7	44.9	91.2	71.8	54.8	1,453
1973	49.1	95.9	184.	221.	118.	46.5	35.2	31.6	30.3	35.8	44.1	121.	1,013
1974	51.0	78.9	281.	134.	80.4	38.1	32.5	31.4	29.7	42.7	47.3	251.	1,098
1975	174.	145.	326.	636.	335.	120.	61.1	41.4	37.2	53.7	96.8	93.2	2,119
1976	185.	131.	246.	604.	295.	93.1	56.3	44.6	40.8	89.7	84.2	309.	2,179
1977	129.	225.	270.	402.	237.	80.0	48.6	44.1	38.1	43.0	46.3	67.8	1,631
1978	221.	316.	334.	449.	309.	100.	55.7	47.1	44.3	143.	73.2	189.	2,281
1979	383.	261.	244.	215.	137.	89.7	50.7	47.5	39.3	48.9	115.	218.	1,849
1980	256.	144.	398.	591.	330.	114.	52.0	45.6	42.5	43.8	54.6	136.	2,208
1981	223.	196.	458.	541.	339.	143.	73.3	48.7	40.8	46.4	159.	508.	2,776
1982	295.	127.	196.	398.	224.	118.	63.3	43.6	36.5	53.1	49.7	71.3	1,676
1983	93.3	94.4	223.	454.	263.	87.1	46.6	38.6	35.0	39.9	189.	298.	1,862
1984	182.	159.	277.	388.	269.	86.5	47.3	40.1	36.3	38.1	99.2	70.5	1,693
1985	186.	156.	245.	340.	140.	61.8	40.7	36.3	33.7	91.8	255.	118.	1,704
1986	265.	171.	245.	247.	116.	68.0	44.8	38.9	36.2	39.3	47.9	94.0	1,413
1987	266.	170.	192.	455.	506.	213.	71.3	46.6	40.5	44.3	87.5	88.7	2,181
1988	70.8	126.	273.	489.	282.	90.0	50.0	40.6	35.3				

Table C13 MONTHLY RUNOFF OF GOKSU RIVER AT 1720

(Unit: MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1945											143.	316.	
1946	220.	262.	335.	419.	191.	58.9	44.1	42.8	41.4	43.8	41.9	65.5	1,765
1947	121.	184.	237.	135.	61.4	49.7	43.4	41.5	40.4	41.7	81.8	191.	1,228
1948	195.	214.	166.	294.	203.	74.4	49.7	45.9	44.1	45.5	44.1	45.8	1,422
1949	47.3	46.8	167.	328.	265.	91.9	69.5	61.3	58.8	60.1	60.6	67.6	1,324
1950	94.0	79.0	157.	188.	140.	67.6	56.2	52.6	49.3	52.1	50.4	52.2	1,038
1951	69.3	69.9	151.	120.	78.4	52.8	48.0	45.9	44.3	51.8	48.4	68.1	848
1952	79.2	159.	172.	252.	135.	69.9	56.1	53.2	49.4	50.9	67.9	132.	1,277
1953	232.	311.	214.	444.	266.	115.	69.9	59.0	55.7	56.9	55.7	60.0	1,939
1954	123.	174.	277.	299.	176.	81.1	57.3	52.6	50.1	52.3	55.6	177.	1,575
1955	159.	127.	132.	142.	93.2	47.9	45.2	44.4	42.8	44.5	74.1	94.9	1,047
1956	85.2	183.	158.	228.	110.	50.6	45.1	44.1	42.5	44.2	43.3	45.9	1,080
1957	46.1	56.5	159.	117.	67.2	51.3	48.6	44.0	42.6	48.8	46.2	120.	847
1958	204.	170.	212.	180.	120.	90.0	58.9	54.9	53.3	55.6	54.0	94.7	1,347
1959	251.	165.	236.	235.	92.6	44.2	42.2	41.2	39.7	59.2	60.8	77.7	1,345
1960	126.	90.6	183.	198.	81.4	56.6	51.6	51.0	48.9	51.0	49.7	107.	1,095
1961	110.	212.	178.	274.	111.	62.1	53.8	47.8	46.5	48.3	48.2	120.	1,312
1962	92.2	148.	343.	179.	129.	57.6	52.4	47.6	48.3	60.4	53.2	324.	1,535
1963	213.	333.	271.	311.	202.	103.	69.2	57.2	52.9	56.1	55.4	68.1	1,792
1964	53.6	67.0	144.	101.	77.8	71.1	50.0	45.0	44.9	45.5	45.5	107.	852
1965	133.	240.	327.	292.	184.	82.2	60.6	49.2	47.2	52.5	53.1	108.	1,629
1966	305.	195.	242.	256.	137.	74.9	56.5	52.5	50.4	52.7	69.8	181.	1,673
1967	166.	98.6	290.	452.	268.	102.	67.2	59.9	55.8	58.2	79.6	109.	1,806
1968	229.	225.	386.	318.	194.	101.	66.2	59.9	56.9	61.4	122.	334.	2,153
1969	379.	337.	537.	295.	248.	109.	86.4	79.4	75.7	83.3	79.8	208.	2,518
1970	187.	186.	285.	227.	130.	79.9	69.8	56.8	54.6	65.4	83.1	104.	1,529
1971	169.	101.	242.	340.	168.	77.5	60.7	57.3	53.4	61.3	61.9	160.	1,552
1972	76.6	115.	293.	329.	160.	93.9	68.9	57.8	54.7	69.7	65.1	60.0	1,444
1973	57.0	68.4	127.	125.	76.2	52.2	52.7	46.1	44.6	47.9	48.2	70.0	815
1974	56.6	76.6	211.	98.6	60.1	44.5	40.4	40.8	40.5	50.1	45.8	147.	912
1975	166.	175.	388.	466.	269.	117.	74.8	60.6	52.1	63.3	72.9	80.11	1,985
1976	122.	127.	248.	407.	191.	95.5	65.4	49.2	48.8	81.1	77.5	205.	1,718
1977	106.	258.	255.	337.	210.	80.6	59.5	54.0	50.3	54.1	57.0	74.5	1,596
1978	195.	261.	297.	360.	172.	83.7	60.2	52.7	51.7	77.1	71.4	103.	1,785
1979	249.	198.	163.	141.	98.3	104.	61.3	48.3	47.7	57.3	82.9	161.	1,412
1980	192.	130.	371.	426.	249.	94.1	64.4	57.5	52.3	54.2	59.0	105.	1,855
1981	235.	281.	476.	346.	238.	130.	67.5	44.7	37.8	59.4	82.0	332.	2,329
1982	204.	80.5	165.	272.	138.	88.4	59.9	53.5	44.2	48.7	51.4	55.8	1,261
1983	73.3	72.1	273.	407.	183.	89.3	56.5	49.7	46.1	48.7	83.7	213.	1,595
1984	133.	158.	247.	282.	174.	76.2	56.1	45.2	44.5	51.2	72.0	67.2	1,406
1985	122.	122.	184.	243.	101.	60.6	50.7	47.2	45.1	65.3	152.	85.6	1,279
1986	167.	137.	173.	140.	111.	79.9	53.9	45.8	42.6	46.8	62.1	80.8	1,140
1987	206.	165.	219.	342.	273.	108.	56.3	49.0	44.6	46.4	72.8	96.5	1,679
1988	92.2	138.	304.	368.	193.	79.1	60.2	50.4	43.3				

Table C14 MONTHLY RUNOFF OF GOKSU RIVER AT 1722

(Unit: MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1974										4.44	6.90	66.2	
1975	46.7	54.3	177.	255.	105.	29.4	8.83	4.62	2.76	11.6	21.0	19.0	735
1976	34.2	38.1	119.	240.	85.0	18.6	6.45	2.58	1.92	27.0	14.9	110.	698
1977	34.4	100.	136.	215.	111.	19.3	7.42	3.22	3.21	5.10	4.03	11.3	650
1978	67.8	102.	137.	205.	99.0	17.7	4.38	2.90	3.39	15.4	18.0	47.6	720
1979	95.2	90.1	85.2	74.8	43.5	52.0	9.80	3.64	3.03				

Table C15 MONTHLY RUNOFF OF ERMENEK RIVER AT 1723

(Unit: MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1985				275.	114.	28.4	19.1	16.7	15.6	49.5	179.	66.9	
1986	173.	119.	185.	201.	88.8	47.3	22.1	18.0	17.4	18.9	21.6	61.4	974
1987	199.	127.	148.	349.	407.	178.	52.9	26.6	23.8	29.0	59.9	65.6	1,666
1988	49.5	95.2	216.	421.	226.	63.9	31.3	27.1	20.2				

Table C16 MEAN ANNUAL RUNOFF AND BASIN PRECIPITATION IN THE GÖKSU RIVER BASIN (1965-1987)

Station No.	Station Name	River	Altitude (m)	Drainage Area (km^2)	Operating Agency	Mean (m^3/s)	Annual (MCM)	Runoff (mm)	Mean Annual Rainfall (mm)	Runoff Ratio	Loss (mm)
1719	Kirkyalan	Ermenek	129	3499.6	EİE	62.4	1967	562	835	0.67	273
17-14	Görmel B.	Ermenek	509	2000.0	DSİ	44.6	1406	703	960	0.73	257
1712	Bucakkisla	Göksu	397	2689.2	EİE	32.0	1008	375	620	0.60	245
1720	Haman	Göksu	127	4304	EİE	51.1	1612	375	636	0.59	261
1714	Karahacili	Göksu (downstream)	24	10065.2	EİE	129.0	4067	404	708	0.57	304

N.B. * Mean annual runoff and rainfall at stream gauging stations were estimated by runoff and rainfall records between 1965-1987 (23 years).

Table C17 MEAN ANNUAL RUNOFF COEFFICIENTS AND PRECIPITATION LOSSES IN THE GÖKSU RIVER BASIN (1965-1987)

Sub-basin	River	Drainage Area (km^2)	Mean Annual Runoff (m^3/s)	Mean Annual Runoff (MCM)	Mean Annual Runoff (mm)	Mean Annual Rainfall (mm)	Runoff Ratio	Loss (mm)
>17-14 1/	Ermenek	2000.0	44.6	1406	703	960	0.73	257
17-14 - 1719 2/	Ermenek	1499.6	17.8	561	374	635	0.59	261
>1712	Göksu	2689.2	32.0	1008	375	620	0.62	245
1712 - 1720	Göksu	1614.8	19.1	604	374	675	0.55	301
1720 - 1714 1719	Göksu downstream	2261.6	15.5	488	216	647	0.33	431

1/: the sub-basin upstream from the station 17-14

2/: the sub-basin between the stations 17-14 and 1719

Table C18 COMPUTED LONG-TERM MONTHLY RUNOFF SERIES AT 17-14

(Unit: MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1945											29.0*	109.3*	-
1946	59.9*	66.1*	141.0*	379.0*	157.0*	37.9*	18.6*	15.5*	14.5*	23.3*	17.0*	79.4*	1,009
1947	113.0*	110.0*	237.0*	178.0*	69.0*	32.8*	18.3*	14.6*	13.5*	14.8*	93.8*	193.0*	1,088
1948	164.0*	147.0*	108.0*	275.0*	164.0*	37.3*	15.5*	12.6*	11.6*	12.4*	12.0*	14.1*	974
1949	26.3*	39.2*	111.0*	278.0*	321.0*	37.0*	14.7*	11.7*	11.5*	11.5*	18.4*	16.7*	897
1950	56.7*	31.5*	137.0*	258.0*	80.2*	17.9*	13.5*	11.9*	11.1*	12.1*	11.8*	13.3*	655
1951	45.7*	51.4*	171.0*	149.0*	57.7*	19.8*	14.0*	12.5*	12.3*	31.1*	20.5*	55.8*	641
1952	46.9*	126.0*	122.0*	302.0*	140.0*	28.8*	14.9*	12.3*	11.1*	12.0*	72.0*	121.0*	1,009
1953	184.0*	296.0*	147.0*	572.0*	434.0*	151.0*	50.8*	32.8*	28.2*	36.8*	37.4*	38.2*	2,008
1954	105.0*	136.0*	291.0*	434.0*	288.0*	82.4*	39.2*	30.8*	28.4*	24.9*	60.5*	268.0*	1,788
1955	184.0*	170.0*	164.0*	186.0*	116.0*	38.6*	24.1*	21.9*	20.7*	21.9*	79.4*	125.0*	1,152
1956	107.0*	195.0*	192.0*	403.0*	211.0*	76.4*	61.7*	35.0*	31.1*	19.6*	21.0*	33.6*	1,386
1957	30.0*	38.3*	151.0*	120.0*	62.0*	28.0*	19.7*	16.7*	16.0*	20.9*	30.5*	151.0*	684
1958	176.0*	99.2*	215.0*	209.0*	102.0*	43.7*	21.5*	16.6*	14.8*	16.2*	19.0*	71.2*	1,004
1959	187.0*	66.8*	116.0*	252.0*	125.0*	43.5*	29.4*	24.4*	22.1*	30.9*	46.1*	78.7*	1,022
1960	105.0*	65.3*	162.0*	290.0*	112.0*	35.7*	24.3*	20.9*	19.1*	21.6*	23.4*	104.0*	983
1961	66.8*	222.0*	152.0*	294.0*	100.0*	34.8*	22.6*	18.3*	16.9*	20.6*	20.1*	95.3*	1,063
1962	56.8*	115.0*	268.0*	186.0*	148.0*	37.9*	24.2*	19.2*	20.3*	36.1*	25.3*	348.0*	1,285
1963	252.0*	309.0*	258.0*	516.0*	245.0*	92.3*	42.4*	27.8*	25.8*	25.8*	25.9*	48.4*	1,868
1964	26.9*	58.7*	167.0*	89.2*	59.3*	27.6*	20.7*	17.3*	17.4*	19.1	26.5	104.0	634
1965	96.9**	201.0	297.0	393.0	230.0	82.9	29.7	18.5	16.1	21.1	39.2	122.0	1,547
1966	347.0	146.0	268.0	350.0	184.0	74.9	32.7	21.4	19.4	13.5	43.3	372.0	1,872
1967	212.0	67.2	169.0	421.0	282.0	96.1	43.1	26.5	24.8	28.6	94.4	144.0	1,609
1968	279.0	142.0	341.0	510.0	301.0	83.6	39.7	27.2	25.2	37.4*	117.0*	397.0*	2,300
1969	294.0*	189.0*	407.0*	286.0*	243.0*	76.4*	44.0*	34.0*	29.7*	36.9*	40.2*	192.0*	1,872
1970	164.0*	197.0*	293.0*	298.0*	148.0*	65.3*	36.5*	26.7*	25.2*	33.8*	45.2*	70.5*	1,403
1971	102.0*	72.0*	214.0*	257.0*	149.0*	47.8*	28.9*	26.7*	23.7*	42.5	35.0	84.3	1,083
1972	42.7	63.0	162.0	287.0	132.0	44.8	30.4	25.1	22.7	56.0	43.6	32.4	942
1973	28.0	70.8	136.0	173.0	87.6	28.3	20.5	17.5	16.2	21.7	29.5	102.0	731
1974	32.6	53.3	224.0	96.9	51.9	27.1	20.1	18.4	19.0	23.9	37.0	179.0	783
1975	151.0	112.0	265.0	471.0	241.0	77.6	36.7	26.5	22.4	33.8	71.8	69.2	1,578
1976	128.0	85.1	166.0	442.0	201.0	67.6	39.6	29.7	26.8	72.0	59.7	217.0	1,535
1977	86.8	154.0	187.0	287.0	169.0	56.0	33.9	25.4	24.6	28.7	28.3	47.7	1,128
1978	169.0	209.0	220.0	307.0	206.0	66.2	33.8	24.9	23.7	109.0	48.7	142.0	1,559
1979	289.0	169.0	171.0	158.0	102.0	64.4	37.1	30.0	28.4	31.7	91.9	145.0	1,318
1980	184.0	95.2	262.0	437.0	238.0	77.2	35.2	28.6	25.7	14.3	24.9	90.2	1,512
1981	142.0	110.0	304.0	387.0	231.0	96.1	46.9	17.0	13.8	19.4	136.0	409.0	1,912
1982	226.0	68.3	98.6	289.0	170.0	95.2	32.1	23.3	19.4	35.0	26.9	59.5	1,143
1983	51.7	64.2	161.0	359.0	187.0	44.2	15.8	10.7	9.20	31.0	199.0	209.0	1,342
1984	138.0	163.0	223.0	327.0	209.0	47.4	29.2	27.1	23.4	24.1	72.1	48.7	1,332
1985	144.0	109.0	185.0	275.0	114.0	28.5	19.0	16.6	15.6	49.6	180.0	67.0	1,203
1986	173.0	119.0	185.0	201.0	88.9	47.2	22.0	17.9	17.4	19.0	21.5	61.3	973
1987	199.0	127.0	148.0	349.0	407.0	178.0	52.8	26.5	23.8	28.9	59.9	65.6	1,666
1988	49.6	95.2	216.0	421.0	226.0	63.8	31.3	27.1	20.2				-

Note: (1) The values with * were extended by the corelation with 1719.
(2) The value with ** was estimated by the corelation with 1719.
(3) The values with underlines are original monthly values at 1723 station.

Table C19 ESTIMATED MEAN ANNUAL RUNOFF BY SUB-BASIN FOR THE PERIOD OF 1965-1987

Sub-basin	Drainage Area	Mean Annual Runoff			Mean Annual Rainfall	Runoff Ratio	Loss
	(km^2)	(m^3/s)	(MCM)	(mm)	(mm)		(mm)
>Nadire	1318.8	33.4	1053	799	1090	0.73	291
Nadire - 17-14	681.2	11.2/44.6	353	519	721	0.72	202
17-14 - Görmel B. (Zeyve Creek)	156.0	2.9	91.4	586	825	0.71	239
17-14 - II-B	428.4	4.0	126	294	520	0.57	226
II-B - II-A (Erik R.)	238.8	3.8	120	502	830	0.61	328
II-A - Gezende	326.8	3.3/58.6	104	318	600	0.53	282
Gezende - 1719	341.1	3.8/62.4	120	351	650	0.54	299

Table C20 ESTIMATED MEAN ANNUAL RUNOFF BY SUB-BASIN FOR THE PERIOD OF 1946-1987

Sub-basin	Drainage Area (km^2)	Mean Annual Runoff (m^3/s)	Mean Annual Runoff (MCM)	Mean Annual Runoff (mm)	Mean Annual Rainfall (mm)	Runoff Ratio	Loss (mm)
>Nadire	1318.8	30.3	956	725	-	-	-
Nadire - 17-14	681.2	10.1/40.4	319	468	-	-	-
17-14 - Görmel B.	156.0	2.6/43.0	82	526	-	-	-
Görmel B.- II-B	428.4	3.7	117	272	-	-	-
II-B - II-A (Erik)	238.8	3.5	110	462	-	-	-
II-A - Gezende	326.8	3.0/53.2	95	289	-	-	-
Gezende - 1719	341.1	3.5/56.7	110	324	-	-	-

Table C21 ANNUAL PEAK FLOW OBSERVED AT STATION 17-14

Year	Date day, month		Peak Discharge m^3/s
1965	21	JAN	480
1966	25	JAN	730 *
1967	12	JAN	540
1968	13	MAR	680
1969	-		-
1970	-		-
1971	-		-
1972	10	APR	240
1973	26	FEB	160
1974	15	MAR	870
1975	20	DEC	560
1976	12	APR	880
1977	3	DEC	820
1978	20	JAN	700 *
1979	3	JAN	880
1980	14	DEC	1,200
1981	6	JAN	630
1982	16	NOV	855 *
1983	27	DEC	410
1984	1	DEC	750
1985	1	APR	280

Note: * indicates that the value was revised after rechecking daily water level and discharge data and rating curves at 17-14 (DSİ)

Table C22 PROBABLE FLOOD AT STATION 17-14

(Unit : m^3/s)

Return Period (Yr)	Probable Flood: Third Type of Log-Pearson	Probable Flood: Gumbel
1.01	173	143
1.5	465	497
2	582	610
5	904	889
10	1137	1074
25	1452	1308
50	1701	1481
100	1960	1653
200	2233	1824

Table C23 MAXIMUM FLOOD VOLUME RECORDED AT STATION 17-14

(Unit : 10^6 m)

Year	Duration (day)					
	1	2	3	5	7	10
1966	56	77	96	122	149	184
1967	39	67	102	143	181	136
1968	52	77	94	137	187	259
1969	-	-	-	-	-	-
1970	-	-	-	-	-	-
1971	-	-	-	-	-	-
1972	-	-	-	-	-	-
1973	13	26	35	55	65	71
1974	47	65	82	108	131	155
1975	37	50	72	116	162	225
1976	52	78	98	135	181	234
1977	27	50	69	92	113	145
1978	43	65	76	92	111	156
1979	70	105	119	146	169	189
1980	65	92	119	153	194	272
1981	29	55	81	126	162	216
1982	81	110	137	165	192	235
1983	20	36	54	87	118	159
1984	64	105	146	184	205	226
1985	19	36	52	79	107	142

Table C24 PROBABLE FLOOD VOLUME AT STATION 17-14

(Unit : 10^6 m)

Return Period (yr)	Duration (day)					
	1	2	3	5	7	10
1.01	6	19	30	55	75	92
1.50	33	54	72	102	129	164
2	42	65	85	117	146	187
5	63	92	118	153	189	243
10	77	110	140	178	217	281
25	95	133	167	208	253	328
50	108	150	187	231	279	363
100	121	167	207	253	306	398
200	134	184	228	276	332	433

Table C25 DEPTH-DURATION OF PROBABLE MAXIMUM PRECIPITATION (1/4)

Time (hr)	Area Depth-Duration (mm)	Max. Depth-Duration (mm)	P (mm)	PMP (mm) JAN.	APR.
0	0	0	0	0	0
1	22.4	40.3	40.3	4.9	3.7
2	36.7	66.1	25.8	4.9	3.7
3	44.6	80.3	14.2	4.6	3.5
4	52.5	94.5	14.2	4.9	3.7
5	60.4	108.7	14.2	4.9	3.7
6	68.3	122.9	14.2	4.6	3.5
7	71.9	129.4	6.5	4.9	3.7
8	75.5	135.9	6.5	4.9	3.7
9	79.1	142.4	6.5	4.9	3.7
10	82.6	148.7	6.3	4.9	3.7
11	86.2	155.2	6.5	5.0	3.8
12	89.8	161.6	6.4	5.3	4.0
13	91.3	164.3	2.7	5.0	3.8
14	92.8	167.0	2.7	5.0	3.8
15	94.4	169.9	2.9	5.3	4.0
16	95.9	172.6	2.7	5.0	3.8
17	97.4	175.3	2.7	5.0	3.8
18	98.9	178.0	2.7	5.3	4.0
19	99.4	178.9	0.9	5.0	3.8
20	99.9	179.8	0.9	2.9	2.2
21	100.5	180.9	1.1	2.9	2.2
22	101.0	181.8	0.9	2.9	2.2
23	101.5	182.7	0.9	2.9	2.2
24	102.0	183.6	0.9	2.9	2.2

Table C25 DEPTH-DURATION OF PROBABLE MAXIMUM PRECIPITATION (2/4)

Time (hr)	Area Depth-Duration (mm)	Max. Depth-Duration (mm)	P (mm)	PMP (mm) JAN.	APR.
25	105.3	189.5	5.9	2.7	2.0
26	108.7	195.7	6.2	2.9	2.2
27	112.0	201.6	5.9	2.9	2.2
28	115.3	207.5	5.9	2.9	2.2
29	118.7	213.7	6.2	0.9	0.7
30	122.0	219.6	5.9	0.9	0.7
31	125.3	225.5	5.9	0.9	0.7
32	128.7	213.7	6.2	0.9	0.7
33	132.0	237.6	5.9	0.9	0.7
34	135.3	243.5	5.9	0.9	0.7
35	138.7	249.7	6.2	0.9	0.7
36	142.0	255.6	5.9	0.9	0.7
37	143.7	258.7	3.1	0.9	0.7
38	145.3	261.5	2.8	3.1	2.3
39	147.0	264.6	3.1	2.8	2.1
40	148.7	267.7	3.1	3.1	2.3
41	150.3	270.5	2.8	3.1	2.3
42	152.0	273.6	3.1	2.8	2.1
43	153.7	276.7	3.1	3.1	2.3
44	155.3	279.5	2.8	3.1	2.3
45	157.0	282.6	3.1	2.8	2.1
46	158.7	285.7	3.1	3.1	2.3
47	160.3	288.5	2.8	5.9	4.4
48	162.0	291.6	3.1	6.2	4.7

Table C25 DEPTH-DURATION OF PROBABLE MAXIMUM PRECIPITATION (3/4)

Time (hr)	Area Depth-Duration (mm)	Max. Depth-Duration (mm)	P (mm)	PMP (mm) JAN.	APR.
49	162.5	292.5	0.9	5.9	4.4
50	163.0	293.4	0.9	5.9	4.4
51	163.5	294.3	0.9	6.2	4.7
52	164.0	295.2	0.9	5.9	4.4
53	164.5	296.1	0.9	5.9	4.4
54	165.0	297.0	0.9	6.2	4.7
55	165.5	297.9	0.9	5.9	4.4
56	166.0	298.8	0.9	0.9	0.7
57	166.5	299.7	0.9	2.7	2.0
58	167.0	300.6	0.9	2.7	2.0
59	167.5	301.5	0.9	2.7	2.0
60	168.0	302.4	0.9	2.9	2.2
61	169.6	305.3	2.9	2.7	2.0
62	171.2	308.2	2.9	2.7	2.0
63	172.8	311.0	2.8	6.5	4.9
64	174.3	313.7	2.7	6.5	4.9
65	175.9	316.6	2.9	6.3	4.7
66	177.5	319.5	2.9	6.5	4.9
67	179.1	322.4	2.9	6.5	4.9
68	180.7	325.3	2.9	6.5	4.9
69	182.3	328.1	2.8	14.2	10.7
70	183.8	330.8	2.7	14.2	10.7
71	185.4	333.7	2.9	14.2	10.7
72	187.0	336.6	2.9	25.8	19.4

Table C25 DEPTH-DURATION OF PROBABLE MAXIMUM PRECIPITATION (4/4)

Time (hr)	Area Depth-Duration (mm)	Max. Depth-Duration (mm)	P (mm)	PMP (mm) JAN.	PMP (mm) APR.
73	189.8	341.6	5.0	40.3	30.3
74	192.7	346.9	5.3	14.2	10.7
75	195.5	351.9	5.0	0.9	0.7
76	198.3	356.9	5.0	1.1	0.8
77	201.2	362.2	5.3	0.9	0.7
78	204.0	367.2	5.0	0.9	0.7
79	206.8	372.2	5.0	0.9	0.7
80	209.7	377.5	5.3	5.9	4.4
81	212.5	382.5	5.0	6.2	4.7
82	215.3	387.5	5.0	5.9	4.4
83	218.2	392.8	5.3	3.1	2.3
84	221.0	397.8	5.0	2.8	2.1
85	223.7	402.7	4.9	3.1	2.3
86	226.3	407.3	4.6	0.9	0.7
87	229.0	412.2	4.9	0.9	0.7
88	231.7	417.1	4.9	0.9	0.7
89	234.3	421.7	4.6	2.7	2.0
90	237.0	426.6	4.9	2.9	2.2
91	239.7	431.5	4.9	2.9	2.2
92	242.3	436.1	4.6	5.0	3.8
93	245.0	441.0	4.9	5.3	4.0
94	247.7	445.9	4.9	5.0	3.8
95	250.3	450.5	4.6	4.6	3.5
96	253.0	455.4	4.9	4.9	3.7

Table C26 ESTIMATION OF FLOOD LAG TIME BY JAN. 1971 FLOOD

River Basin	L (km)	$\bar{L}$ (km)	t'p (t'r=12hr)	tp	Ct	t'p (t'r=1hr)	Ca (km²)	(Lg+D/2)	t'p+D/2	q_p(m^3/s/mm)
			hr							
Göksu (1714)	231	116	20	17.81	0.8361	17.25	10,065	45.96	-	-
Ermenek										
Basin A	79	27	-	8.34	0.8361	8.21	1,319	14.77	9 hr	29.77
Basin B	32	16	-	5.43	0.8361	5.43	563	9.85	6 hr	19.06
Basin C	20	10	-	4.10	0.8361	4.16	283	8.21	5 hr	11.51
Total Basin	-	-	-	-	-	-	2,156	-	8 hr	46.56

Table C27 ESTIMATION OF FLOOD LAG TIME BY FEB. 1975 FLOOD

River Basin	L (km)	$\bar{L}$ (km)	t'p (t'r=24hr)	tp	Ct	t'p (t'r=1hr)	Ca (km²)	(Lg+D/2)	t'p+D/2	q_p (m^3/s/mm)
			hr							
Göksu (1714)	231	116	28	23.05	1.0821	22.25	10,065	44.35	-	-
Ermenek										
Basin A	79	27	-		1.0821	10.55	1,319	13.94	11 hr	44.47
Basin B	32	16	-		1.0821	6.96	563	8.87	7 hr	29.84
Basin C	20	10	-		1.0821	5.31	283	7.60	6 hr	17.52
Total Basin	-	-	-		-	-	2,156	-	11 hr	55.93

Table C28 UNITGRAPH FOR ERMENEK DAM ESTIMATED BY JAN. 1971 FLOOD (1/3)

Time(hr)	q_A(m^3/S)	q_B(m^3/S)	q_C(m^3/S)	Total(m^3/S)
0	0	0	0	0
1	0.25	0.26	0.22	0.73
2	0.70	1.09	1.12	2.91
3	1.70	3.57	4.00	9.27
4	3.83	9.27	9.19	22.29
5	8.27	16.55	11.51	36.33
6	14.47	19.06	9.59	43.12
7	22.74	16.55	7.19	46.48
8	27.91	12.58	6.07	46.56
9	29.77	10.99	5.11	45.87
10	27.91	9.53	4.31	41.75
11	23.47	8.27	3.60	35.34
12	19.85	7.08	3.04	29.97
13	17.99	6.16	2.56	26.71
14	16.33	5.30	2.16	23.79
15	14.89	4.63	1.84	21.36
16	13.44	3.97	1.52	18.93
17	12.41	3.44	1.28	17.13
18	11.06	2.98	1.08	15.12
19	10.13	2.58	0.90	13.61
20	9.20	2.25	0.76	12.21
21	8.27	1.95	0.64	10.86
22	7.55	1.67	0.54	9.78
23	6.93	1.47	0.45	8.85

Table C28 UNITGRAPH FOR ERMENEK DAM ESTIMATED BY JAN. 1971 FLOOD (2/3)

Time(hr)	$q_A(m^3/S)$	$q_B(m^3/S)$	$q_C(m^3/S)$	Total(m^3/S)
24	6.20	1.26	0.38	7.84
25	5.69	1.07	0.32	7.08
26	5.17	0.94	0.27	6.38
27	4.65	0.81	0.22	5.68
28	4.24	0.70	0.19	5.13
29	3.88	0.61	0.16	4.65
30	3.52	0.53	0.13	4.18
31	3.20	0.46	0.11	3.77
32	2.89	0.40	0.10	3.39
33	2.71	0.34	0.08	3.13
34	2.38	0.30	0.07	2.75
35	2.17	0.25	0.06	2.48
36	1.96	0.22	0.05	2.23
37	1.78	0.19	0.04	2.01
38	1.61	0.17		1.78
39	1.47	0.14		1.61
40	1.34	0.13		1.47
41	1.20	0.11		1.31
42	1.08	0.09		1.17
43	0.99	0.08		1.07
44	0.91	0.07		0.98
45	0.82	0.06		0.88
46	0.74			0.74

Table C28 UNITGRAPH FOR ERMENEK DAM ESTIMATED BY JAN. 1971 FLOOD (3/3)

Time(hr)	$q_A(m^3/S)$	$q_B(m^3/S)$	$q_C(m^3/S)$	Total(m^3/S)
47	0.68			0.68
48	0.62			0.62
49	0.56			0.56
50	0.51			0.51
51	0.45			0.45
52	0.41			0.41
53	0.38			0.38
54	0.35			0.35
55	0.31			0.31
56	0.28			0.28
57	0.26			0.26
58	0.24			0.24
59	0.21			0.21
60	0.20			0.20
61	0.18			0.18
62	0.16			0.16
63	0.14			0.14
64	0.13			0.13
65	0.12			0.12
66	0.11			0.11
67	0.10			0.10

Table C29 UNITGRAPH FOR ERMENEK DAM ESTIMATED BY FEB. 1975 FLOOD (1/3)

Time(hr)	$q_A(m^3/S)$	$q_B(m^3/S)$	$q_C(m^3/S)$	Total(m^3/S)
0	0	0	0	0
1	1.04	1.32	0.95	3.31
2	2.68	2.87	1.99	7.54
3	4.05	4.56	3.37	11.98
4	5.59	7.13	5.48	18.20
5	7.45	10.58	8.63	26.66
6	9.86	15.66	17.52	43.04
7	12.60	29.84	11.44	53.88
8	16.21	21.54	6.26	44.01
9	18.62	12.06	5.18	35.86
10	29.58	9.19	4.14	42.91
11	44.47	8.09	3.37	55.93
12	37.24	6.69	2.72	46.65
13	27.39	5.59	2.20	35.18
14	19.17	4.63	1.77	25.57
15	14.79	3.82	1.42	20.03
16	13.47	3.20	1.15	17.82
17	12.27	2.68	0.92	15.87
18	10.95	2.21	0.74	13.90
19	9.75	1.84	0.60	12.19
20	8.76	1.54	0.49	10.79
21	8.11	1.26	0.39	9.76
22	6.90	1.06	0.32	8.28

Table C29 UNITGRAPH FOR ERMENEK DAM ESTIMATED BY FEB. 1975 FLOOD (2/3)

Time(hr)	$q_A(m^3/S)$	$q_B(m^3/S)$	$q_C(m^3/S)$	Total(m^3/S)
23	6.13	0.88	0.26	7.27
24	5.48	0.74	0.21	6.43
25	4.93	0.61	0.17	5.71
26	4.33	0.51	0.13	4.97
27	3.86	0.43	0.11	4.40
28	3.40	0.35	0.09	3.84
29	3.07	0.29	0.07	3.43
30	2.74	0.24	0.06	3.04
31	2.41	0.20	0.04	2.65
32	2.14	0.17	0.04	2.35
33	1.88	0.14		2.02
34	1.69	0.12		1.81
35	1.48	0.10		1.58
36	1.34	0.08		1.42
37	1.17	0.07		1.24
38	1.06			1.06
39	0.94			0.94
40	0.83			0.83
41	0.74			0.74
42	0.66			0.66
43	0.59			0.59
44	0.53			0.53
45	0.47			0.47
46	0.42			0.42

Table C29 UNITGRAPH FOR ERMENEK DAM ESTIMATED BY FEB. 1975 FLOOD (3/3)

Time(hr)	$q_A(m^3/S)$	$q_B(m^3/S)$	$q_C(m^3/S)$	$Total(m^3/S)$
47	0.37			0.37
48	0.33			0.33
49	0.30			0.30
50	0.26			0.26
51	0.23			0.23
52	0.21			0.21
53	0.19			0.19
54	0.16			0.16
55	0.14			0.14
56	0.13			0.13
57	0.11			0.11
58	0.11			0.11

Table C30 BASIN LAG TIME IN ERMENEK RIVER BASIN

River Besin	$L\bar{L}/\sqrt{s}$	Basin lag t'p	
		Feb. 1975	Jan. 1971
Basin A	129	10.5 hr	8.5 hr
Basin B	53	6.5	5.5
Basin C	14	5.5	4.5

Table C31 CALCULATION OF PROBABLE MAXIMUM SNOW MELT HYDROGRAPH AT GÖRMEL BRIDGE

Day	Maximum Cumulative Temperature °C	Maximum Temperature Difference °C	Temperature Design Pattern °C	Temperature at average elevation of snow-melt area °C	Multiplication of temperature by maximum snow-melt rate 0.388 °C	Daily Snow-melt (1700 km^2) 10^6 m^3	Daily snow-melt discharge m^3/sec
1	19.7	19.7	16.6	13.2	5.122	87.074	1008.
2	38.4	18.7	17.2	13.8	5.354	91.018	1053.
3	56.8	18.4	18.3	14.9	5.781	98.277	1137.
4	75.1	18.3	18.7	15.3	5.936	100.912	1168.
5	92.3	17.2	19.7	16.3	6.324	107.508	1244.
6	109.1	16.8	19.6	16.2	6.286	106.862	1237.
7	128.7	19.6	18.4	15.0	5.820	98.940	1145.
8	146.4	17.7	17.7	14.3	5.548	94.316	1092.
9	163.0	16.6	16.8	13.4	5.199	88.383	1023.
10	179.5	16.5	16.5	13.1	5.083	86.411	1000.

Maximum Snow-melt Rate	=	0.388 cm/°C-day
Ermenek Elevation	=	1250 m
Snow-melt Starting Elevation	=	1250 m
Avg. elevation of the area above 1250 m	=	1740 m
Area above 1250 m	=	1700 km^2
Temperature Decrease Rate	=	0.7 °C/100 m.

Table C32 SUSPENDED SEDIMENT VALUES FOR 1723 STATION (1/2)

Date	Runoff (m^3/s)	Concentration (ppm)	Sediment (ton/day)
14/12/1985	20.140	7.8	14.
14/03/1986	95.962	74.0	614.
17/04/1986	109.600	148.8	1,409.
23/05/1986	44.027	87.2	332.
05/06/1986	22.779	38.5	76.
10/07/1986	8.384	26.3	19.
08/08/1986	8.567	37.2	28.
11/09/1986	6.373	5.6	3.
23/10/1986	8.411	5.8	4.
21/11/1986	8.645	13.0	10.
17/12/1986	8.810	15.1	12.
09/01/1987	254.291	300.3	6,598.
18/02/1987	86.968	95.8	720.
20/03/1987	38.430	82.7	275.
15/05/1987	167.956	138.7	2,013.
13/06/1987	101.955	71.0	625.
23/07/1987	14.854	3.3	4.
25/08/1987	8.488	7.9	6.
11/09/1987	9.376	11.2	9.
25/10/1987	10.794	28.4	27.
27/11/1987	21.749	17.2	32.
25/12/1987	26.853	57.1	133.
13/01/1988	18.514	19.1	31.
26/02/1988	29.246	36.4	92.
28/03/1988	99.481	107.1	921.
22/04/1988	108.659	87.4	821.
26/05/1988	54.028	25.6	120.
23/06/1988	19.339	34.5	58.

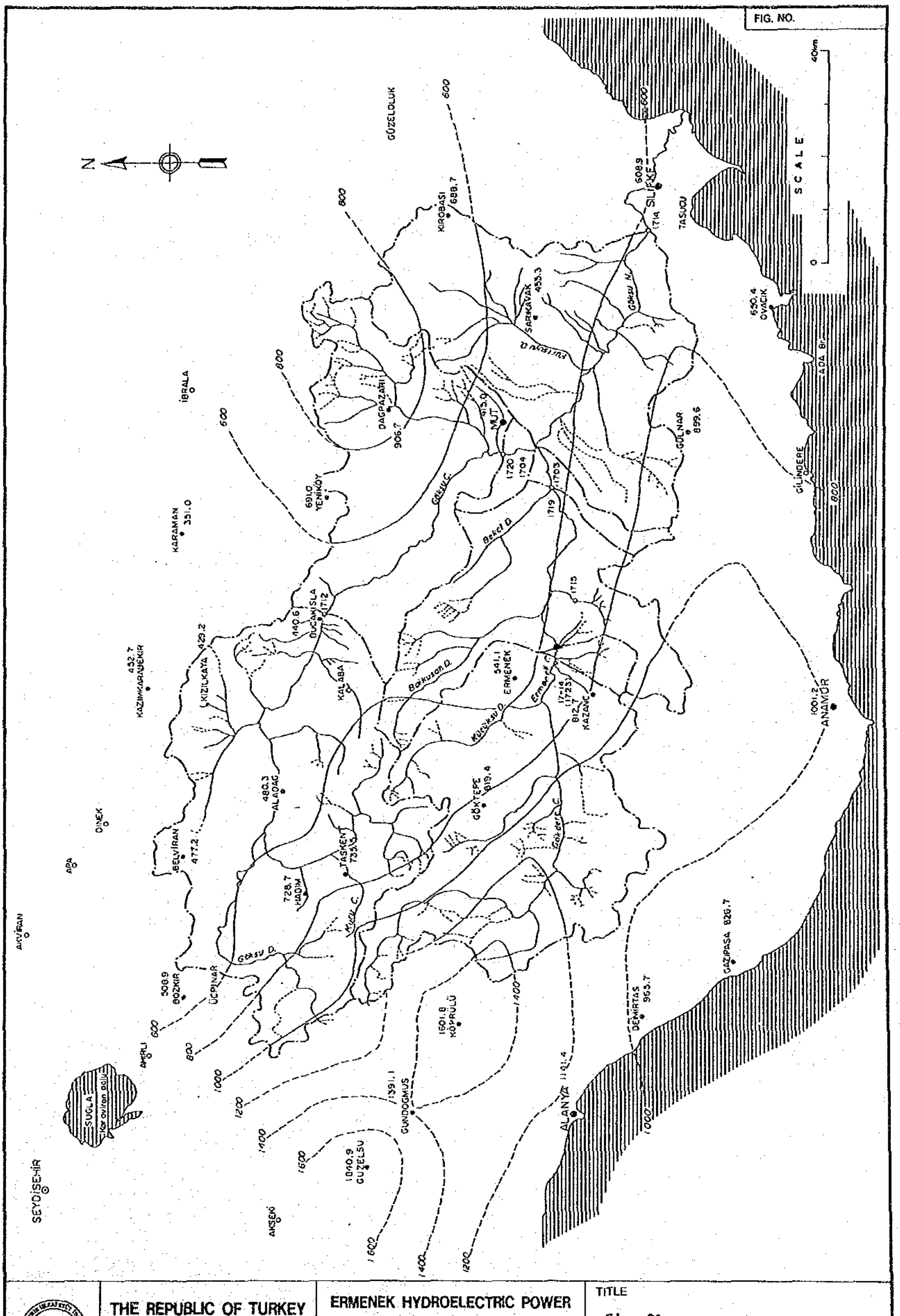
Table C32 SUSPENDED SEDIMENT VALUES FOR 1723 STATION (2/2)

Date	Runoff (m^3/s)	Concentration (ppm)	Sediment (ton/day)
19/07/1988	10.367	20.6	19.
10/08/1988	10.283	163.7	146.
18/09/1988	7.470	80.3	52.
24/10/1988	8.614	283.5	211.

Table C33 RESULTS OF CHEMICAL ANALYSES OF THE WATER SAMPLES COLLECTED AT 1723 ÇAVUSKÖYÜ GAUGING STATION

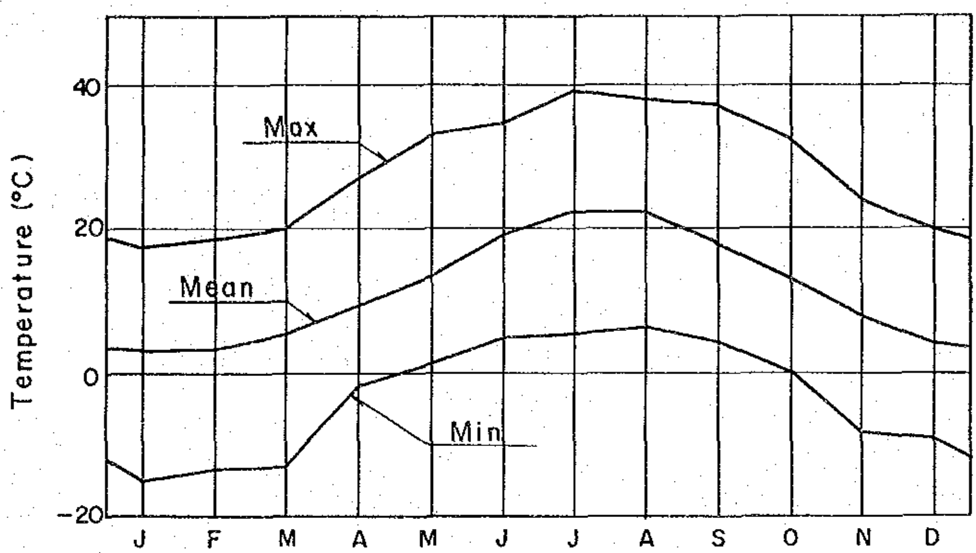
Date of Sampling	EC ($x 10^6$)	PH	Cations (mg/Liter)			Anions (mg/Liter)			
			Na	K	Ca + Mg	Co_3	HCO_3	Cl	SO_4
14 Dec 1985	219	7.8	0.15	0.02	2.10	0.00	1.80	0.15	0.32
14 Mar 1986	212	8.1	0.09	0.02	2.10	0.20	1.70	0.22	0.09
17 Apr 1986	218	8.1	0.07	0.02	2.00	0.30	1.50	0.18	0.11
23 May 1986	181	8.0	0.09	0.03	1.80	0.10	1.45	0.18	0.19
5 Jun 1986	197	7.8	0.09	0.02	2.00	0.00	1.60	0.15	0.36
10 Jul 1986	307	8.2	0.15	0.03	3.40	0.30	2.65	0.19	0.44
8 Aug 1986	251	7.8	0.13	0.02	2.60	0.00	2.25	0.14	0.36
21 Nov 1986	280	8.1	0.13	0.02	2.90	0.20	2.35	0.17	0.33
17 Dec 1986	340	8.2	0.18	0.04	3.60	0.40	2.65	0.23	0.54

FIGURES



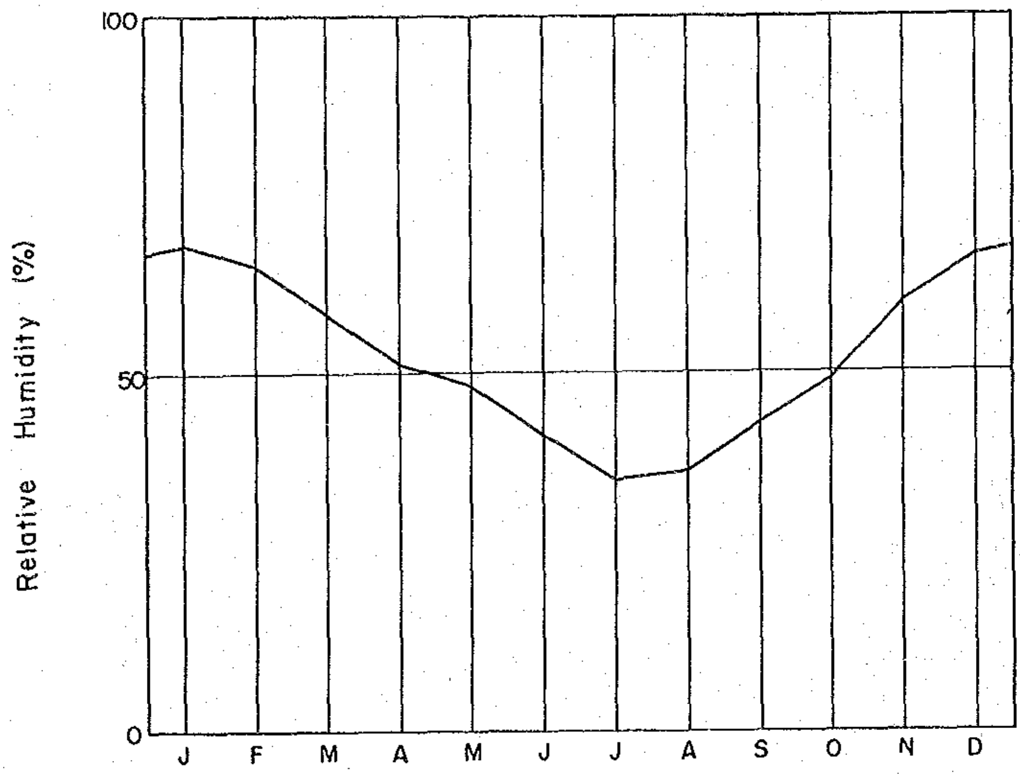
THE REPUBLIC OF TURKEY ELEKTRİK İŞLERİ ETÜD İDARESİ GENEL MÜDÜRLÜĞÜ	ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Fig. C1 The Göksu Basin and Isohyet of Annual Precipitation

FIG. NO.



Max., Mean and Min. Temperature at Ermenek

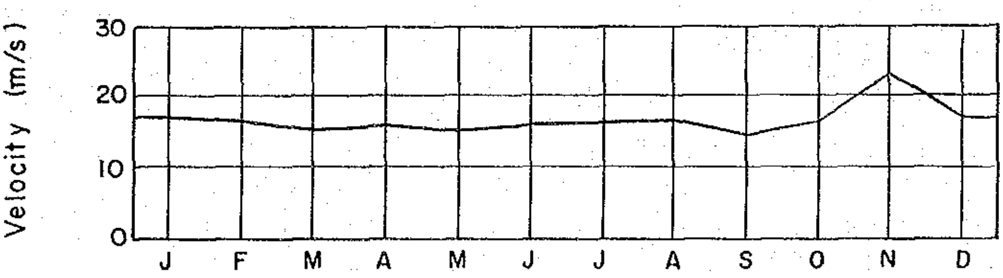
THE REPUBLIC OF TURKEY ELEKTRİK İŞLERİ ETÜD İDARESİ GENEL MÜDÜRLÜĞÜ	ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Fig. C2 Maximum, Mean and Minimum Temperature at Ermenek



Monthly Meam Relative Humidity in Ermenek

THE REPUBLIC OF TURKEY ELEKTRİK İŞLERİ ETÜD İDARESİ GENEL MÜDÜRLÜGÜ	ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Fig. C3 Monthly Mean Relative Humidity in Ermenek

FIG. NO.



Monthly Maximum Wind Velocity

THE REPUBLIC OF TURKEY ELEKTRİK İŞLERİ ETÜD İDARESİ GENEL MÜDÜRLÜGÜ	ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Fig. C4 Monthly Maximum Wind Velocity	