中近東アフリカ計画に基づくトルコ国派遣
水利開発専門家総合報告書

昭和 51 年 11 月

国 際 協 力 事 業 団

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まえがき

この報告書はトルコ共和国ハルシット川開発計画に関する技術協力専門家として派遣された下記４専門家による成果を収録すると共にその概要を報告するものである。

収録する報告書の内，第１部は７月に帰国した藤田専門家による地質に関するものであり，第２部は９月に帰国した３専門家の報告書で，２，３章は牛島，４章は長谷川，５章は小谷がそれぞれ執筆し，国家水利庁（ＤＳＩ）に提出したものである。

今回の技術協力専門家の派遣に当り御協力をいただいた国際協力事業団を初め，現地大使館，外務省，通産省の関係者各位に対し深甚なる謝意を表する次第であります。

技術協力専門家

藤　田　武　俊　（地質担当　昭和５１年３月２９日～７月２８日）

長谷川　泰　資　（設計担当　昭和５１年３月２９日～９月２８日）

牛　島　照　美　（計画担当　昭和５１年３月２９日～９月２８日）

小　谷　　　敏　（電気担当　昭和５１年６月２９日～９月２８日）

あらすじ

ハルシット川はトルコ共和国の東北部に位置し，流路長150Km，流域面積3,300㎢の中級河川で，水源を標高2,500m〜3,000mのアナトリア高原に発し，北西方向に流れ黒海にそそいでいる。流域はアナトリア高原のサバンナ地帯と海岸山脈の山岳地帯に2分され，年間降雨量は前者で430mm，後者で1,400mmとその様相が著しく異っている。

ハルシット川開発計画は，前述の山岳地帯に位置し，急増する電力需要をまかなう，重要な電源地帯として着目され，開発計画の検討が行われてきたが，すでに中流部に24MWのドアンケント発電所が開発されており，現在，46MWの増設工事が，1948年の運転開始を目途に進められている。

ハルシット川開発計画については，1969年に政府調査団が派遣され，流域全体のマスタープランおよび開発計画の中枢の一部をなす，キュルチュン発電所のフイジビリティスタディが行われている。

今回の派遣目的はハルシット川開発計画の内，上流域計画地点，即ちトルー，キュルチュン，タキヨイーエの3発電所のフイジビリティスタディを行うことであったが，後述の通りトルーダム地点を変更せざるをえなくなり，地質調査資料等が不備なため，プレイジビリティスタディの内容に留らざるをえなかった。

この開発計画の基本方針は，上流に2ケ所の貯水池を設け，年間を通じて大きく変動する河川流量を貯留調整し，下流発電所群を一層有効化しようとすることにある。

トルーダムは従来上流にあるトルー町を水没させることで計画されていたが，社会経済条件の変化によって，この町を水没させることが，経済性からも困難となったため，ダム地点を6Km下流に変更し，各地点の規模も電力需要の急増およびピーク化傾向を考慮し大幅な変更を行った。

今回の検討結果は下表に示す通りであるが，上流域3発電所の出力は210MW，電力量は726×10⁶ KWH，年経費はKWH当り10円（邦貨換算）と見積った。

下流発電群およびハルシット川と略平行に流れているゲレベラ川を有効利用し，ハルシット川へ分水する計画を考慮すると，本計画の総開発量は750MWの出力と2,700×10⁶ KWHの電力量が期待され，年経費はKWH当り9円以下と予想され，これらの電力は別途建設される380KVの送電線によって東黒海地域および中央電力系統へ送電される予定である。

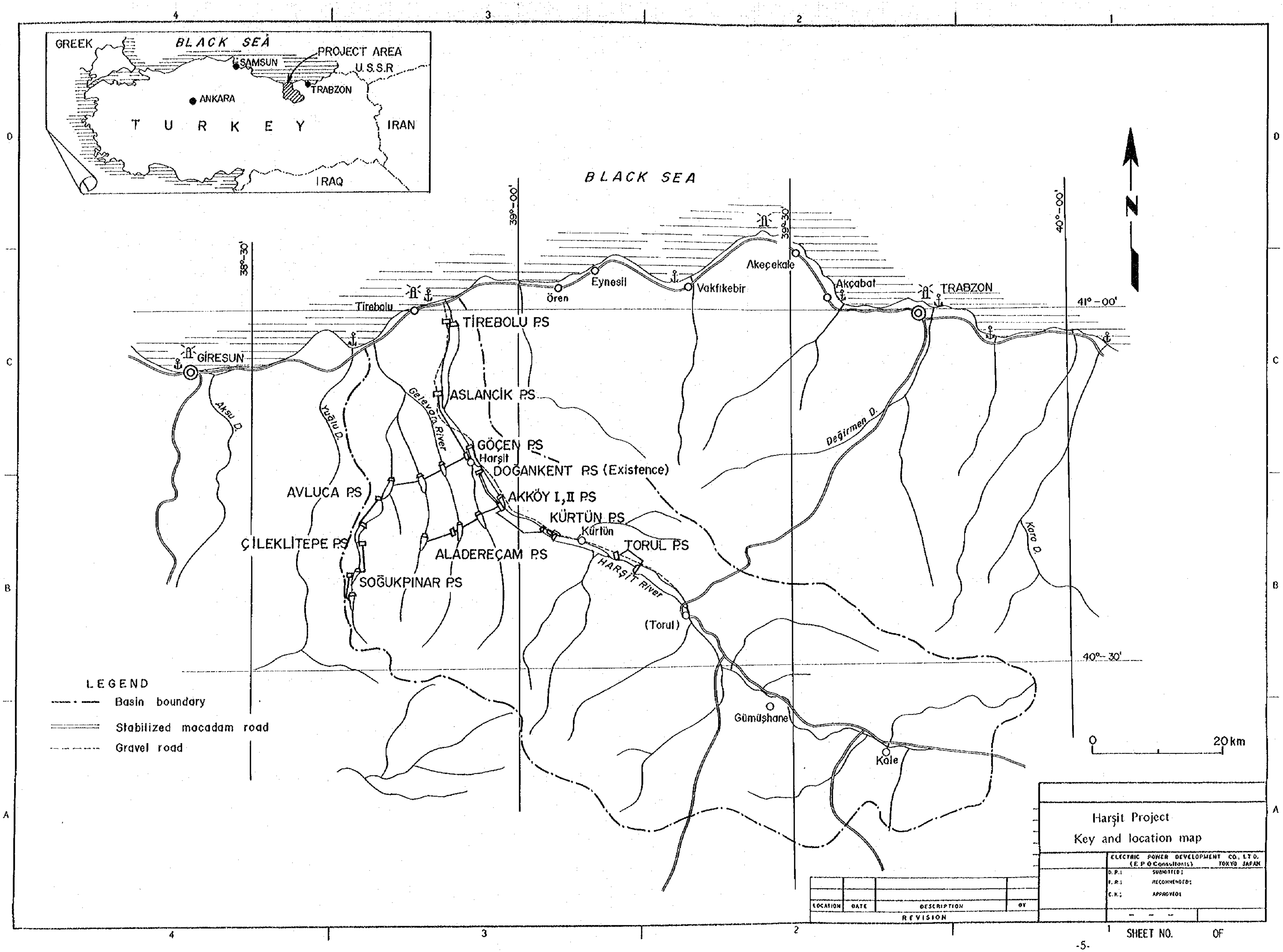
我々は最長6ケ月間にわたり，DSiのエンジニアを友好的にデスカッションを重ねながら業務を遂行してきた。トルコ共和国では1980年代になると，年間11％以上の電力需要の

伸びが想定されており，ハルシット川はトルコ共和国東北部の重要な電源地帯であることから，この電力需要に対処すべく，１９８３年より本格的開発に着手したい意向である。このため，ＤＳＩとしては，１９７７年中にハルシット川開発計画のフィジビリティレポートを作成すべく，早急に基礎調査資料を整備し，再度，日本政府に対して技術協力を要請する考えのようである。

表　ハルシット川上流域開発計画

発電所名			トルー	キュルチュン	タキヨイーエ
流量面積		㎢	2,094	2,690	2,700
年間流入量		10^6 ㎥	550	829	832
貯水池	満水位	m	917	640	540
	利用水深	m	27	30	12
	有効貯水容量	10^6 ㎥	80	63	1.9
ダム	型式	–	コンクリートアーチ	コンクリートアーチ	コンクリートセミアーチ
	高さ×ダム頂長	m×m	155 × 370	123 × 410	41 × 160
	体積	10^3 ㎥	490	380	16
導水路	内径 × 延長	m×m	3.9 × 3,600	–	425 × 13,630
発電計画	有効落差	m	264.5	98	131
	最大使用水量	㎥／S	41	86	46
	出力	mw	90	70	50
	電力量	10^6 KWH	314	195	217
工事費	工事費	億円	321	222	184
	年経費	億円	33	23	19

工事費　1TL＝２０円として邦貨換算


BLACK SEA
GREEK
SAMSUN
PROJECT AREA
U.S.S.R
TRABZON
ANKARA
TURKEY
IRAN
IRAQ
BLACK SEA
38°-30'
39°-00'
39°-30'
40°-00'
41°-00'
40°-30'
N
Tirebolu
Ören
Eynesil
Vakfıkebir
Akçekale
Akçabat
TRABZON
GİRESUN
TİREBOLU P.S
ASLANCİK P.S
GÖÇEN P.S
Harşit
DOĞANKENT P.S (Existence)
AKKÖY I, II P.S
KÜRTÜN P.S
Kürtün
TORUL P.S
AVLUCA P.S
ÇİLEKLİTEPE P.S
ALADEREÇAM P.S
SOĞUKPINAR P.S
Aksu D.
Yağlu D.
Gelevara River
HARŞİT River
(Torul)
Değirmen D.
Kara D.
Gümüşhane
Kale
0
20 km
LEGEND
Basin boundary
Stabilized macadam road
Gravel road
Harşit Project
Key and location map
ELECTRIC POWER DEVELOPMENT CO., LTD.
(E P D Consultants) TOKYO JAPAN
SUBMITTED:
RECOMMENDED:
APPROVED:
LOCATION
DATE
DESCRIPTION
BY
REVISION
SHEET NO.
OF

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DRAWING

REPUBLIC OF TURKEY GENERAL DIRECTRATE OF STATE HYDRAULIC WORKS

NOTE ON PRELIMINARY GEOLOGICAL RECONNAISSANCE

OF

COMPREHENSIVE HYDROELECTRIC DEVELOPMENT

OF

THE HARŞİT RIVER BASIN

JULY 1976

Prepared by

Taketoshi FUJITA

Consulting Geologist

Dispatched by

JAPAN INTERNATIONAL COOPERATION AGENCY

I. PREFACE

The master-plan of the hydroelectric development of the whole Harsit river basin had once been established by the Japanese mission in 1969. This time, four experts, one geologist, two civil engineers and one electrical engineer, have been dispatched by the Japanese government for the cooperation with DSI engineers on the feasibility study of the upper Harsit basin. The review of the said master-plan study based on the additional hydrological data and on the change of economical and social condition which is arisen after the former study has also been necessitated.

In the course of reviewing the master plan, Torul dam site had been relocated to 6 km. downstream from the original site where the drilling and adit excavation had been performed, in order to eliminate economic and social problems that might be occured by submergence of Torul town by the dam.

Topographic survey of new Torul dam site was completed middle of June, but the maps of other sites such as Torul power station, Akköy intake dam and Akköy power station have not become available for field work of a geologist, and 1 to 5,000 scale maps have been used for geological reconnaisance on these sites and also on the down stream projects such as Aslancik intake, Aslancik power station and Tirebolu dam.

For lack of detail topographic maps and geological investigation works, the stage of this study might be said to be Prefeasibility for Torul project and Master-plan for the other proposed projects.

This report is prepared by the geologist during his stay in Turkey, from March 30 to July 27, through the site visiting (Apr. 12 - Apr. 16, May 11 - May 18 and June 15 - June 26). The findings and understandings on the geological conditions, and also investigation program explained in this report will be fully taken into consideration in the course of feasibility study which will be continued from now on.

The present writer would like to take this opportunity to express his deepest appreciation and gratitude to many DSI engineers, especially to Regional Director Mr. Süreyya Bedestenlioglu, Project Director Mr. Zeki Demiroi and Cief Geologist Mr. Nurettin Uzuner of VII Regional Office their unlimited cooperation and warmfull hospitality extended to him.

Reviewing study of master-plan is progressing and the dimension of all projects on the Harsit has not been defined yet. Following table shows tentative plan, and figures shall be revised through the study and also depend on the result of the geological investigation works.

Table - 1 Tentative Dimension on Hydroelectric Development Plan of the Harsit River Basin

	Dam			Tunnel		Power Plant		
	Type	Height	H.W.S.	Length	Dia.	Eff. H	Max. dis.	Inst. cap.
Torul	Arch	153m	917m	3,900m	3.9m	264.5m	41.0m^3/s	90MW
Kürtün	Arch	123	640	-	-	98.0	86.0	70
Akköy	Semi Arch	41	540	13,630	4.25	131.0	46.0	50
Aslancik	Gravity	30	180	10,100	5.5	120.0	76.0	65
Tirebolu	Rock Fill	95	70	-	-	58.5	205.0	100

2. ENGINEERING GEOLOGY AND INVESTIGATION PROGRAM FOR FEASIBILITY STUDY

2.1 TORUL PROJECT

1) Dam Site Geology

New Torul dam site is located on the narrow gorge, and the hight from river bed and the width of the valley at dam crest elevation presents about the ratio of 1.4 to 3.

The limestone, sandstone, claystone, tuff and volcanic breccia belonging to upper Cretaceous period are distributed in the dam site with a strike of strata crossing the river. The strata dip 15° to 30° toward upstream in general, though there are one anticlinal axis and one synclinal axis.

Thick limestone in the upper slope and volcanic breccia in the lower portion have few beddings and expose making the cliff. The alternations of sandstone, claystone, tuff and limestone is thin bedded and crop out as the steps.

These rocks have enough bearing capacity for the foundation of proposed arch dam whose height is 155 m, and depth of deteriorated zone assumed to be around 5 m. from the surface.

Fractured zones are seen along the said folding axes. Many faults cross the river with right angle. Although most of faults have a small sheared zone or reconsolidated zone, some faults are accompanied with meterwide sheared zone. Somewhat extent of additional consolidation grouting shall be necessary along such weak zones.

Rocks crop out widely on the steep abutments, and the area covered by the slope wash is so small and its depth is estimated to be 1-3 m. in the area of arch dam foundation. Thick talus, estimated to be more than 5 m. in depth, deposit in the upstream area on both banks, where the rock embankment will be settled in case of rock fill dam. Talus deposit on the right bank is considered to be removed under the rock embankment because of its much contents of soil. On the other hand, the left bank talus consists of mainly rock blocks and fragments.

River deposits consisting of cobble and boulder are assumed to be around 10 m. in depth.

INVESTIGATION

As shown on DWG.-1,eight drill holes 570 m. in total length and 4 adits 290 m. are considered to be appropriate investigation works for the first step. According to the result of these study and dam type selection, further investigation program shall be made. Water pressure tests in the drill holes and jack tests in the adits shall be performed.

2) Construction Material

(a) River deposits; Concrete aggregate for arch dam 680.000 m^3. Filter material for rock fill dam 260.000 m^3.

Sand and gravel deposited along the river channel about. 3.5 km. long between Torul town and downstream from there, are nearest sources for aggregate or filter material. It is located around 10 km. Far from the dam site and in the upstream end of the reservoir.

The alluvial deposits in this area are neither wide no high from the river water level. However, enough amount of materials are considered to be secured by collecting and screening the deposits in this area. (100 m wide x 2.5 km. long x 4 m. deep = 1,000,000 m^3).

River deposits consist of well graded gravel and sand with maximum size of about 50 cm. Gravels are composed of andesite, volcanic brecoia, granite and a few of limestone, and are sub-rounded. It seems to be available as the aggregate for the dam concrete qualitatively, on the contrary, economical usage as the filter of rock fill dam is questionable because of much contents of big gravels.

INVESTIGATION

A series of aggregate tests with which DSI already familiar shall be carried out using the samples that will be picked in this river course.

(b) Quarry for rock fill material

Pink grantie distributed at 2 km. upstream of dam site on the right bank is considered to be best for the rock quarry, judging from the location, quantity and quality. The materials excavated at the spillway and others are also available for the rock fill.

(c) Impervious core material

A borrow area located at 6 km. downstream of dam site on the left bank had been investigated for Kürtün dam. Sufficient quality and quantity (1,800,000 m^3) had been confirmed through 10 test pits and laboratory test.* However, long transportation distance, locating opposite bank of existing road and high from river and also existing the villages are counted as demerits of this borrow area.

About 2 km. upstream of dam site, there is gentle slope on the left bank between 1.050 m. to 1.100 m. in elevation. The area is covered with clayey decomposed granite and it is considered to be available for impervious material. Quantity of material is roughly estimated to be 600.000 m^3 (300 m long x 200 m. wide x 10 m. deep).

INVESTIGATION

Test pit excavation more than five places and a series of laboratory tests shall be performed. Furthermore, if the pits do not reach the bedrock, five drill holes are recommend-

* Kürtün Projesi Kürtün Baraji, Malzeme Raporu, Nisan - 1972

ed to confirm the depth of available material.

Between the dam site and above mentioned proposed borrow area, land-slide or talus deposits are heaped on both banks. These deposits contain much amount of big blocks for core material. And also it is anticipated that the slope stability might become worse by excavation.

3) Reservoir Geology

(a) Watertightness

Rather narrow 14 km. long reservoir will be created by Torul dam. Granite, porphyry and green volcanics are predominant, and any continuous limestone strata and also other kind of permeable strata do not distribute in the reservoir area. Leakage from the reservoir may not absolutely be anticipated.

(b) Slope Stability

Centering around 1 km. upstream of the dam site, there are gentle slopes on both banks in 1.0 km. long along the river. The right bank slope is mostly located below the high water surface, but the left bank one starts from the line of 230 m. higher than proposed high water elevation, and slope stability should be studied.

The slope is composed of rock blocks and fragments with a few soil which are derived from very steep upper slope by land-slide or collapse of slope in the very old time. Bedrock can be seen along the river side here and there, and thickness of the deposits is assumed to be not so thick. The slope is cultivated and there are the hamlets. It seems to be considerably stable.

Excepting above mentioned area, the mountain slopes of both banks in the reservoir area have a steep gradient in general with scattered cliffs reflecting the character of rocks. Slope wash and talus deposits of small scale are commonly seen. After impounding the water, some of cliff collapsing and slope wash sliding may occurred but any of big land-slide may not happen.

4) Torul Power Station

So called the Karaçukur power station, which is located on the left bank at 2.5 km downstream of new Torul dam site, had been proposed as the power station in order to utilize the head between the old plan of the Torul power station (dam type) and the Kürtün dam. According to the field reconnaissance there exist very thick landslide deposits along the route of the surge tank, penstock and power station.

The new Torul power station site is selected on the left bank at 1.0 km. downstream of the Karaçukur site. There is the ridge between the Harsit river and the Kurak Dere, which presents good topography for the penstock and power station.

The gradient of the ridge at upper than 670 m. elevation is about 30°, and the lower portion becomes considerably gentle to the river side (about 630 m. El.)

The silicified green tuff accompanied with many dyks intrusions is distributed in this area. The ridge upper than 670 m elevation is naked and rugged, but the slope lower than this point is covered with thick talus deposits.

INVESTIGATION

Three drill holes on the talus deposits, which shall be drilled 5 ~ 10 m more after reaching bedrock, are recommended. One drill hole 80 m deep from El. 930 m is not essential but advisable in this stage for confirming the geological condition of the surge tank site.

5) Tunnel

The headrace tunnel, 3.95 km long with a inner diameter of 3.9 m, is planned connecting between the intake and the surge tank. One intermediate adit shall be opened for construction works on the ravine at 1.2 km from the intake.

The rocks distributed along the route are mainly green tuff and volcanic broccia interbeded with limestone and claystone. Dyke intrusions can be seen at many places and the said Upper Cretaceous members are silicified and impregnated with pyrite.

According to the geological reconnaissance along the road, the tunnel might be encountered with many faults, but the width of each sheared or brecciated zone is limited. The rocks are mostly massive and the clefts are considered to be adhered in general. Any difficulty is not anticipated in the course of tunneling works. The full section excavation with a few supporting could be expected.

INVESTIGATION

The detail field reconnaissance using I to 5.000 scale map can supply the useful information about the tunneling works.

2.2 KURTUN PROJECT

The feasibility study of the Kurtun project had been performed by the Japanese mission in 1969[1], together with the master plan study of the whole Harait river basin. In this study, the geological condition of the site is discussed in detail being based on the result of the field reconnaissance and inspection on the drillings (7 hole 1.638 m long) and adits (7 adits 183 m long). The Kurtun dam had been designed as an arch type concrete dam having the height of 133 m. The detail comparison with the fill type dam could not be made by lack of the information about the construction materials at that time.

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1. Feasibility Study of the Kurtun Project with Comprehensive Development of the Harsit River Basin; 1969, Government of Japan

The rock mechanic test[2] including the plate loading test at nine places in five adits, and the material investigations[3] had been executed by DSI after the feasibility study.

The width of the river is 60 to 70 m at the dam axis including the flood plain on the left bank and the construction of dam will be in a proportional dimention of 3 : 1 at dam crest length and dam height.

The rock is predominantly granodiorite, besides which there are andesite, diabase and crystalline limestone. The dapth of weathering is somewhat deep and rocks are cracky in some deeper portion. Many faults trending across the river are confirmed or assumed. The width of the confirmed fault zone is limited less than one meter. According to the water pressure test, watertightness of the foundation rock is poor to considerable depth on the both abutments. The result of the plate-loading test shows that the modulus of elasticity is rather small distributing 11.000 to 56.000 kg/cm^2 at the second loading cycle of the test.

Judging from the above mentioned geological candition, deep excavation, careful curtain and consolidation groutings shall be necessary in order to improve the foundation of the arch dam.

INVESTIGATION and STUDY

a) As for the quarry for concrete aggregate, the investigation shall be made at the intermediate area between the Kurtun and Akkoy dam.

b) The dam type comparison between the concrete arch and rock fill shall be studied. On the course of the study, the cost needed for foundation treatment should be estimated safety side. If the test result will show the enough quality for aggregate, cost estimation shall be made using above mentioned quarry.

c) If the arch dam will be chosen, at least three more adits on each bank shall be necessary along the dam axis in order to confirm the foundation condition for the definite designing.

2.3 AKKOY PROJECT

1) Intake Dam

The Akkoy intake damsite is selected at 2 km downstream of the Kurtun damsite, avoiding the big landslide of Ulukoy which is situated at downstream of the site on the right bank. The Harsit river, 50 m long in this stretch, runs dissecting down the green tuff with the width of the channel of 35 m and forming the steep cliffs of 40 to 50 m high on both banks. It presents good topography and geology for constructing the small dam. The dapth of the river deposits is assumed to be less

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2. Kurtun Dam Site, Rock Mechanic Test Report; 1971, Ankara DSI.
3. Kurtun Projesi, Kurtun Baraji, Malzeme Raporu; 1972, Samsun DSI

than 20 m judging from the result of the drillings at the Kurtun site.

INVESTIGATION

Four drillings 35 m deep in each, two on the left bank, two on the river bed and one on the right bank, are proposed along the dam axis. The holes on the river bed can be stopped after 10 m drilling into the bedrock.

2) Tunnel

13.7 km long pressure (H = 25 m) tunnel with an inner diameter of 4.6 m is planned on the left bank of the Harsit as the headrace of the Akkoy power station. One adit will be opened at 5.0 km far from the inlet on the Kucuk Dere where exist the road passable by motor vechicles.

Along this tunnel route the prorphiritic granite had intruded widely into the Upper Cretaceous green tuff in early stage of the Tertiary period. The rhyolite dykes and porphirite dykes intruded into both of them.

The porphiritic granite is massive and hard rock with few clefts. General speaking, tunneling works might be easier than that of the Torul headrace tunnel from the geological point of view.

INVESTIGATION

Geological mapping using 1 to 5.000 scale map might be able to supply the useful information for tunneling works.

3) Power Station

The Akkoy power station site is situated at 600 m upstream of the Dogankent intake. The width of the river channel is about 25 m and there is the flat land of 40 m wide spoil bank. The slope of about 50 m high from the river pressents steep cliff with outcrop of rock. The area higher than this is somewhat gentle as 30° and cultivated for the hezeluut. Owing to the steep topography at the river side, some portion of the power house shall be founded on the river channel. Therefore, the depth of alluvium shall be confirmed by drillings.

The rock in this area is quartz porphyry which is hard but considerably cracky on the surface. Stability of the excavated slope on the penstock line should be studied carefully. The topsoil at the higher slope is estimated thin as 1 to 3 m.

INVESTIGATION

Three drill holes (40 m x 3) are proposed on the river bed. One hole 60 m deep is advisable at El. 555 m for the surge tank.

2.4 ASLANCIK PROJECT

1) Intake Dam

The alternative site are proposed for the Aslancik intake dam on the Harsit at upstream and downstream of confluence of the Cudul Dere. The upstream site is located at 1.3 km downstream of the Dogankent power station and the other is 0.7 km more downstream.

There is not much difference between two sites from the geological and topographical viewpoints. The width of the river is about 100 m including the flood plain on the left bank. The flood plain is about 2 m high from the river bed and consists mainly granite boulder of 50 cm to 1 m in siza. The depth of the alluvium is assumed to be around 30 m.

Bedrock is light greenish blue porphyrite. It is hard and few of cracks but some fissures are seen on the surface of slope. Bedrock crops out on both banks except the upper slope than approximately El. 183 m on the right bank of the upstream alternative, where is covered by terrace deposits.

INVESTIGATION

Three holes shall be drilled on the river bed 10 m deep to the bedrock. Total length shall be around 120 m.

2) *Tunnel*

The non-pressure headrace tunnel of 10.0 km long with 5.6 m inner diameter is planned on the left bank. Two adits shall be easily selected on the appropriate ravines.

One third section from the inlet is occupied with quartz porphyry or granite-porphyry, and middle section is limestone with intruded porphyry. Rhyolite is hydrothermaly altered into claysy in some potion and much attension shall be made in this section.

INVESTIGATION

Careful geological reconnaissance shall be necessary, especially in the section 1 km long from the surge tank the thickness of the mountain to the tunnel is this there.

3) Power Station

The power station site is selected at around 18 km upstream from the mouth of the river. There is the flat land for the power house at the foot of the slope.

Bedrock is rhyolite and sound rock crops crops out here and there on the slope. Topsoil is generally thin on the slope, but talus and river deposits might be somewhat deep at the foot of the slope where the power house will be planned to be installed.

INVESTIGATION

Two drill holes 30 m each at the power house site and one hole 130 m on the tunnel route 350 m from the head tank, at the saddle on the ridge.

2.5 TIREBOIU PROJECT

The Tirebolu damsite is located at 2.8 km upstream of the river mouth and the elevation of the river bed is 7 m. The Harsit forms a neck at the damsite with river width of 140 m and it is wider in the both of upstream and downstream. The river gradient in the reservoir area is I to 240 m and that of the downstream is I to 300 m. The slope gradient on the dam axis is 40° on the left bank and 35° on the right bank.

Rhyolite is widely distributed on both banks and top soil is very thin on the left bank but some of slope wash are seen on the right bank. The rock is very hard but columnar joints are well developed. It seems the weathering extend more deeper on the right bank. The kaolinization on the rhyolite is widely seen in the reservoir area.

River deposits consist of sand and gravel of less than 20 cm in diameter. Depth and other condition of the deposits are important factor for the study of dam design. Depth of the deposits is assumed to be around 40 m.

INVESTIGATION

One drill hole 30 m deep at El. 60 m one hole 40 m deep at the roads on both banks and 5 holes 50 to 60 m deep on the river bed along the dam axis are considered to be appropriate investigation in this stage. Three drillings total length of about 100 m are proposed at the power house site.

Table - 2 Investigation Program

ADIT

	Nos.	Length (m)
Torul dam	4	290

DRILL HOLE

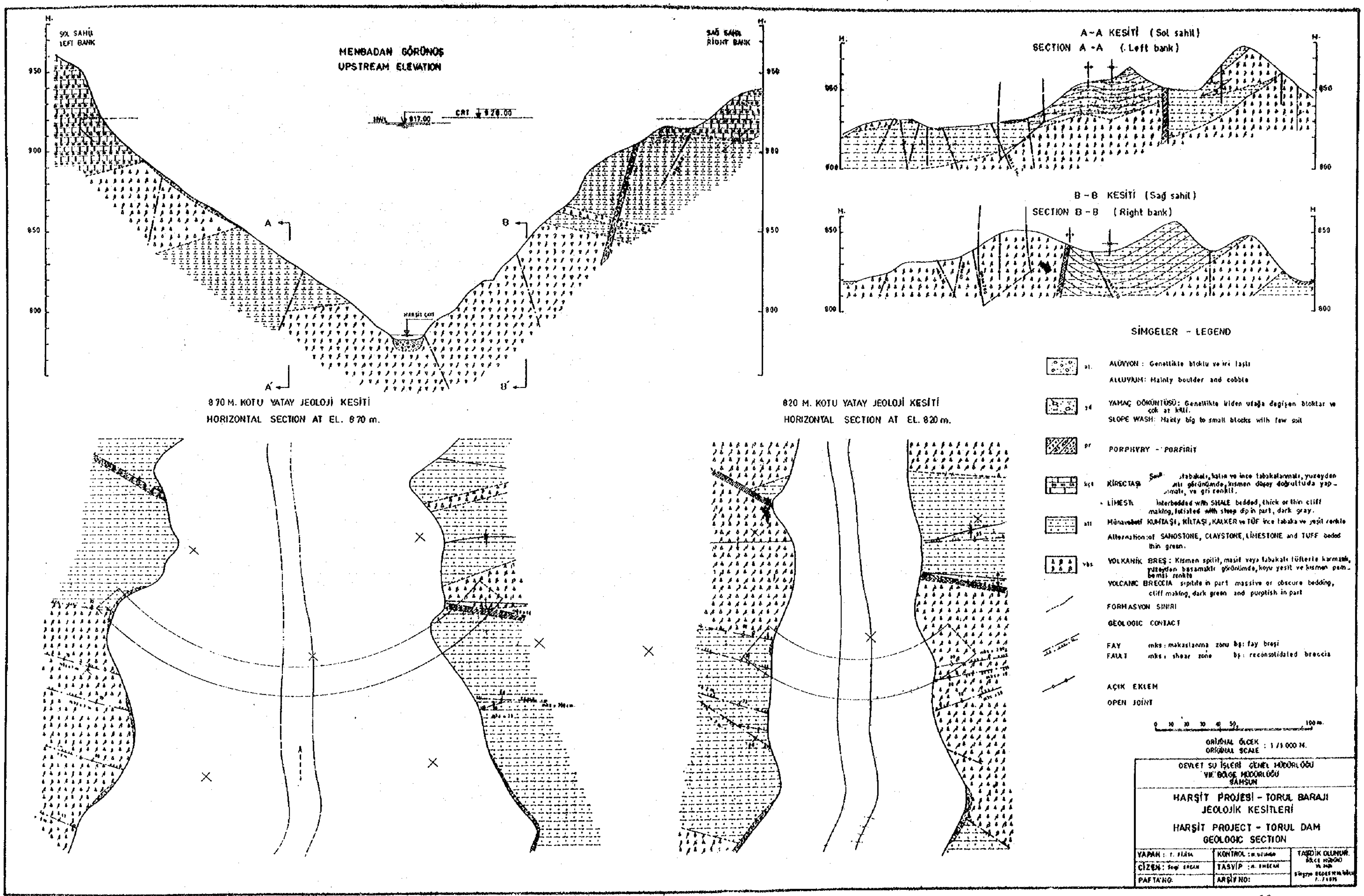
	Nos.	Length (m)	Remark
Torul dam	8	570	
Torul PS	4	160	On the talus, 5 ~ 10 m after reaching rock surface.
	(1	80)	At surge tank, second priority.
Akkoy intake	6	195	10 m after reaching bedrock at 2 hales on the river bed.
Akkoy PS	3	120	5 m after reaching bedrock.
	(1	60)	At surge tank, second priority
Aslancik intake	3	120	10 m drill into bedrock.
Aslancik PS	3	190	1 on the tunnel route 130 m.
Tirebolu dam	9	480	
Tirebolu PS	3	100	
Total	39 (2	1,935 140)	

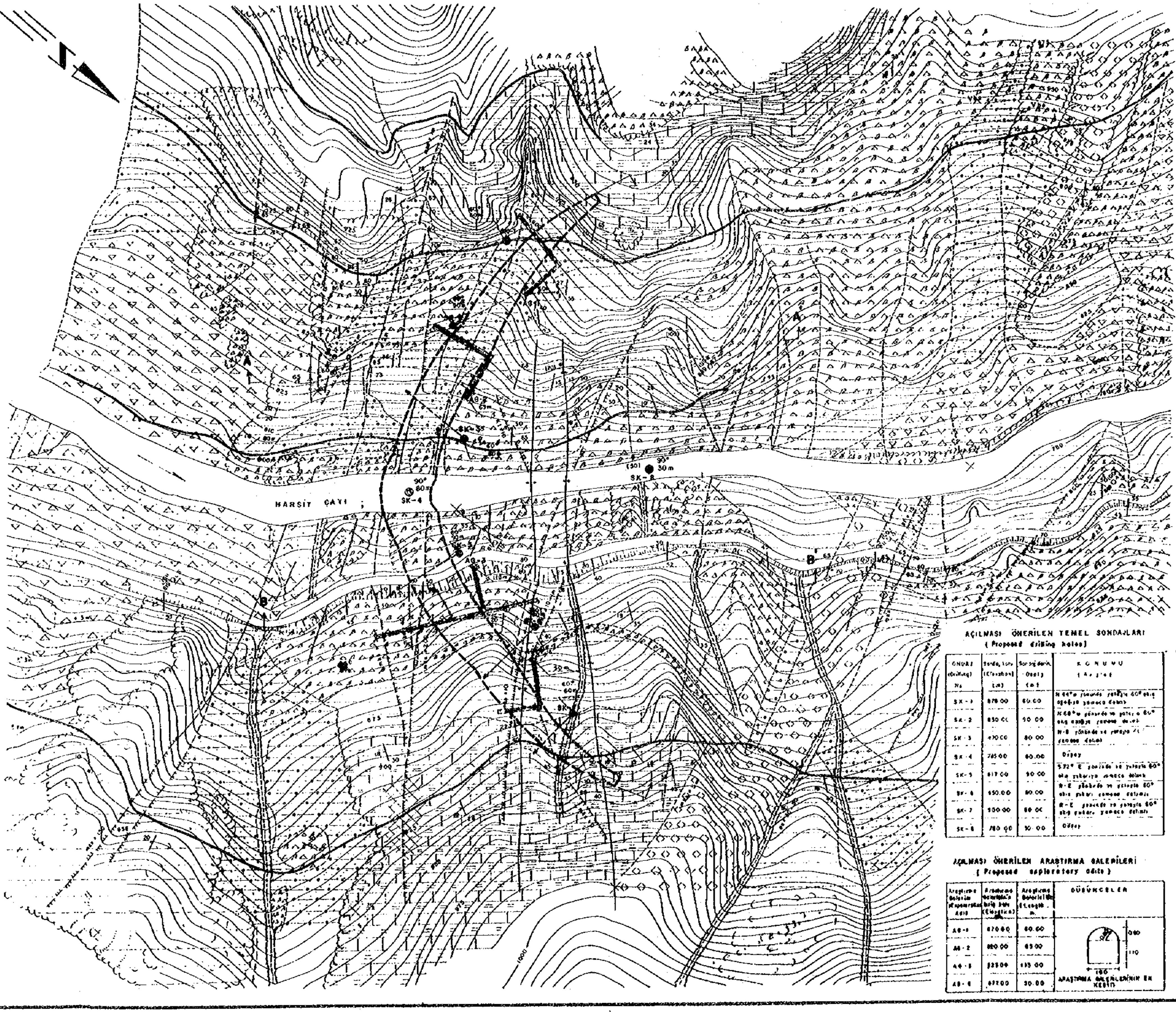
MATERIAL

Torul dam a) Aggregate investigation on river deposits.
b) Impervious core investigation.

Kurtun dam a) Cuarry investigation for aggregate.

x Water pressure test shall be performed in all drillholes on the damsite.


SOL SAHİL
LEFT BANK
MEMBADAN GÖRÜNÜŞ
UPSTREAM ELEVATION
SAĞ SAHİL
RIGHT BANK
A - A KESİTİ (Sol sahil)
SECTION A - A (Left bank)
B - B KESİTİ (Sağ sahil)
SECTION B - B (Right bank)
870 M. KOTU YATAY JEOLOJİ KESİTİ
HORIZONTAL SECTION AT EL. 870 m.
820 M. KOTU YATAY JEOLOJİ KESİTİ
HORIZONTAL SECTION AT EL. 820 m.
SİMGELER - LEGEND
PORPHYRY - PORFİRİT
FORMASYON SINIRI
GEOLOGIC CONTACT
AÇIK EKLEM
OPEN JOINT
DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
HARŞİT PROJESİ - TORUL BARAJI
JEOLOJİK KESİTLERİ
HARŞİT PROJECT - TORUL DAM
GEOLOGIC SECTION



SİMGELER
LEGEND

YAMAÇ DÖKÜNTÜSÜ : Genellikle büyükten küçüğe doğru değişen bloklar, az killi
SLOPE WASH Mainly big to small blocks with few soil

YAMAÇ MOLOZU Toprak ve kaya parça, az bloklu
TALUS Rock fragments and soil with a few blocks

PORFİRİT
PORPHYRY

KİREÇ TAŞI Şeyle aratabakalı, kalın ve ince tabakalanmalı yüzeyden basamaklı görünümde kısmen düşey doğrultuda yapraklanmalı, gri renkli
LIMESTONE Interbedded with SHALE Bedded thich or thin, cliff making, foliated with steep dip in part, dark grey

KUMTAŞI- KİLTAŞI -KİREÇTAŞI ve TÜF Münavebeli ve ince tabakalı, renk yeşil
Alternation of **SANDSTONE CLAYSTONE, LIMESTONE and TUFF** Bedded thin, green.

VOLKANİK BRES : Kısmen spilit, masif veya kalın tabakalı tüflerle karmaşık, yüzeyden basamaklı görünümde, koyu yeşil ve kısmen pempemsi renkte
VOLCANIC BRECCIA Spilitic in part. Massive or obscure bedding cliff making dark green and purplish

Çatlaklı ve kıvrımlı kısım
Cracky or folded portion

Su sızıntısı
Water seepage

Boşluk (cm olarak yatay derinliği)
Cave (lateral depth in cm.)

Formasyon sınırı
Örtülü formasyon sınırı
Geologic Contact (Concealed)

Antiklinal ve Senklinal ekseni
Axis of anticline and syncline

Açık eklem
Open joint

Fay (Örtülü veya şüpheli)
mks: makaslanma zonu, bş: breşlenme zonu, kl: kil dolgu
Fault (Concealed or assumed)
mks: shear zone, bş: reconsolidated breccia
kl: clay seam.

Doğrultu ve Eğim : 1) Tabaka 2) Eklem 3) Fay 4) İntruzif kaya kontağının
Strike and dip of 1) bed, 2) joint, 3) fault, 4) Intrusive contact

AG- Önerilen araştırma galerisi
Proposed exploratory adit

SK- Önerilen temel sondaj kuyusu
Proposed drillhole

SK- Eğimli temel sondaj kuyusu
Sloped drillhole

ÖLÇEK
Scale : 1/1000

0 10 20 30 40 50 m

AÇILMASI ÖNERİLEN TEMEL SONDAJLARI
(Proposed drilling holes)

ONDAJ (Drilling) No	Sonda, tabı (Elevation) (m)	Sondaj derin. (Depth) (m)	KONUMU (Angle)
SK-1	878.00	60.00	[illegible]
SK-2	850.00	90.00	[illegible]
SK-3	470.00	80.00	[illegible]
SK-4	765.00	60.00	Düşey
SK-5	817.00	90.00	[illegible]
SK-6	850.00	80.00	[illegible]
SK-7	900.00	80.00	[illegible]
SK-8	780.00	30.00	Düşey

AÇILMASI ÖNERİLEN ARAŞTIRMA GALERİLERİ
(Proposed exploratory adits)

Araştırma Galerisi (Exploratory Adit)	Araştırma Galerisinin Giriş kotu (Elevation) m.	Araştırma Galerisi Boyu (Length) m.	DÜŞÜNCELER
AG-1	870.00	60.00	ARAŞTIRMA GALERİLERİNİN EN KESİTİ (160, 110, 080)
AG-2	880.00	65.00	
AG-3	825.00	115.00	
AG-4	877.00	30.00	

DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
VII BÖLGE MÜDÜRLÜĞÜ
SAMSUN

HARŞİT PROJESİ
TORUL BARAJI
TEMEL SONDAJLARI ve ARAŞTIRMA GALERİLERİ PROGRAMI

YAPAN : T. Fujita, H. Uzuner	KONTROL : H. Uzuner	TASDİK OLUNUR BÖLGE MÜDÜRÜ
ÇİZEN : G. Saral	TASVİP : H. Emecan	
PAFTA NO :	ARŞİV NO :	/ /1976

REPUBLIC OF TURKEY GENERAL DIRECTORATE OF STATE HYDRAULIC WORKS

NOTE

OF

THE HARSIT RIVER PROJECT

(THE UPPER BASIN)

SEPTEMBER 1976

Prepared by

Civil Engineer, Taisuke Hasegawa

Civil Engineer, Terumi Uskijima

Electric Engineer, Hiroshi Kodani

Dispatched by

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

The comprehensive development of the entire Harsit river basin has once been studied by an OTCA mission of JAPAN in 1969.

The primary purpose of the works done by the 4 experts dispatched from JICA in 1976 was to complete the feasibility study of upper basin development, including the Torul, Akköy–I and Akköy–II dams, powerstations, co-operation with DSI engineers.

This purpose, however, could not be attained during their stay in Turkey. Since the proposed site for Torul Dam had been requested by DSI to be moved down ward so as not to submerge the town of Troul in the Troul reservoir.

The topographical survey of the new dam and Powerstation sites has commenced immediately after the new scheme was established. But, unfortunately topographical maps of Akköy–I Power Station site is not completed during their stay in Turkey.

The results of upper basin study including Torul Dam may be said to be at the prefeasibility stage on account of lack of fundamental data at the new sites.

It should be noted that the authers are much indebted to many DSI engineers and Japanese Embassy, especially VII Regional engineers, for their unlimitted co-operation and assistance extend to them during their stay in Turkey.

SYNOPSIS

As a result of the review on the former report based on the additional hydrological data and the change in economic situation, the Torul dam site was moved to a site downstream in order to save Torul town from submergence and Karacukur Project is abolished.

Torul and Kurtun Projects are of reservoir type, Akköy–I has a regulating pond and Akköy–II with an effective head of more than 1,160 m to be created by the diversion of water from the Gelevara river to the Harsit river is also with a reservoir. High water levels of Torul and Kürtün are to be lowered from 990 m to 917 m and from 650 m to 640 m respectively.

A total installed capacity and annual energy production in the upper basin amount to 400 MW and 1,400 x 10^6 KWH. When the entire Harsit basin is harnessed, they will be more than 750 MW and 2,700 x 10^6 KWH.

After a comparative study on two dam types, slender arch and rockfill, the site is considered most suited for the construction of slender arch dam if the dam foundation proves to have enough strength.

The construction cost of an arch dam may be less expensive by 20% than that of a rock-fill dam.

Torul, Kürtün and Akköy–I power stations will accommodate Francis Turbines, and Akkoy–II Pelton turbines which are suited for high heads.

CHAPTER 1. BRIEF DESCRIPTION OF PROJECT

TORUL PROJECT:

1. General

Install capacity	90,000 KW
Maximum discharge	41 m^3/S
Effective head	264.5 m
Annual inflow	550×10^6 m^3
Annual total energy production	314×10^6 KWH

2. Reservoir

Catchment area	2,094 km^2
Available water depth	27 m
Normal high water surface	917 m
Normal low water surface	890 m

3. Dam

Type	Concrete arch dam
Elevation of crest	920 m
Height	155 m
Length of crest	370 m
Volume	490,000 m^3

4. Spillway

Type	Crest overflow type
Capacity	2,326 cu.m

5. Intake

Type	Inclined type

6. Headrace Tunnel

Length	3,900 m
Inner diameter	3.9 m

7. Penstock	
Length	516 m
Diameter	3.6 ~ 1.8 m
8. Powerhouse	
Type	Out door
9. Power Generation Facilities	
Turbine	
Number of unit	2
Type	Vertical shaft Francis turbine
Out put	47,800 KW
Rated speed	429 R.P.M.
10. Generator	
Number of unit	2
Type	3–phase, AC synchronous
Rated out put	52,000 KVA
Rated voltage	13.8 KV
Rated current	2,176 A
Rated power factor	0.9
Rated frequency	5,0 HZ
Rated speed	429 R.P.M.
11. Main Transformer	
Number	1
Type	Out door, 3–phase
Rated capacity	104 MVA
Rated voltage	Primary 13.8 KV Secondary 154 KV
Rated frequency	50 HZ
12. Project Cost	$1,605.5 \times 10^6$ TL
13. Annual Cost	163.0×10^6 TL

KÜRTÜN PROJECT

1. General

Install capacity	700,000 KW
Maximum discharge	86 m^3/S
Effective head	98 m
Annual inflow	829 x 10^6 m^3
Annual total energy production	195 x 10^6 KWH

2. Reservoir

Catchment area	2,690 km^2
Available water depth	30 m
Normal high water surface	640 m
Normal low water surface	610 m

3. Dam

Type	Concrete arch
Elevation of crest	643 m
Height	123
Length of crest	410
Volume	380,000 m^3

4. Spillway

Type	Side spillway
Capacity	2,432 m^3/S

5. Intake

Type	Attached dam

6. Penstock

Length	170 m
Diameter	5.10 m

7. Powerhouse

Type	Out door

8. Power Generation Facilities

Turbine	
Number of unit	2
Type	Vertical shaft Francis turbine
Out put	37,100 KW
Rated speed	250 R.P.M.

9. Generator

Number of unit	2
Type	3-phase AC syncronous generator
Rated out put	40,400 KVA
Rated voltage	13.8 KV
Rated current	1,691 A
Rated power factor	0.9
Rated frequency	50 HZ
Rated speed	250 R.P.M.

10. Main Transformer

Number	1
Type	3-phase out door
Rated capacity	80,8 KVA
Rated voltage	Primary 13.8 KV Secondary 380 KV
Rated frequency	50 HZ

11. Project Cost	$1,134 \times 10^6$ TL
12. Annual Cost	115×10^6 TL

AKKÖY–I PROJECT

1. General

Install capacity	50 MW
Maximum discharge	46 m^3/S
Effective head	131 m
Annual inflow	832×10^6 m^3
Annual energy production	217×10^6 KWH

2. Reservoir

Catchment area	2,700 km^2
Available water depth	12 m
Normal high water surface	540 m
Normal low water surface	528 m

3. Dam

Type	Semi-arch
Elevation of crest	545.5 m
Height	41 m
Length of crest	160 m
Volume	16,000 m^3

4. Spillway

Type	Overflow
Capacity	663 m^3/S

5. Intake

Type	Inclined type

6. Headrace Tunnel

Length	13,630 m
Inner diameter	4.25 m

7. Penstock

Length	280 m
Diameter	2.60 m x 2

8. Powerhouse

Type	Outdoor

9. Power Generation Facilities

Turbine	
Number of unit	2
Type	Vertical shaft Francis turbine
Output	26,500 KW
Rated speed	375 R.P.M.

10. Generator

Number of unit	2
Type	3-phase AC syncronous generator
Rated output	28,800 KVA
Rated voltage	11 KV
Rated current	1,512 A
Rated power factor	0.9
Rated frequency	50 HZ
Rated speed	375 R.P.M.

11. Main Transformer

Number	1
Type	3-phase outdoor
Rated capacity	57.6 MVA
Rated voltage	Primary 11 KV Secondary 154 KV
Rated frequency	50 HZ

12. Project Cost — 919×10^6 TL

13. Annual Cost — 96×10^6 TL

CHAPTER 2. SCHEME OF DEVELOPMENT

2.1 GENERAL DESCRIPTION OF PROJECT AREA

2.1.1 Location and Extent

The Harsit Project Area borders on the Black Sea in northeastern Turkey, within the Latitudes 40°15′ ~ 41°00′ North and the Longitudes 38°40′ ~ 39°55′ East and includes the watershed of Gelevara River.

The project area totals some 4,173 km^2, of which 892 km^2 belongs to the watershed of Gelevara River and 3,281 km^2 to the watershed of Harsit River.

Harsit River originates in the mountain range of elevation from 2,500 m to 3,000 m running parallel to the Black Sea Coarst, and flows down roughly from the south to the north direction entering into the Black Sea at the point of 5 km east of Tirebolu Town. Gelevara River adjacent to the west of Harsit River flows in parallel with Harsit River and enters the Black Sea at the point of 13 km west of the mouth of Harsit River.

The main tributaries of Harsit River are Tezene (214 km^2), Ikisu (456 km^2), Karum (221 km^2) and Cit Creeks which join the main river upstream of the Torul Dam Site. Kurtun Creek (408 km^2) is a main tributary between the Toruland Kürtün Dam Sites. On the other hand, Kavraz Creek (129 km^2) joins with the main river at Dogankent Town.

Gelevara River has two large tributaries called the Karadona and the Karaoracix which join with the main river 10 ~ 13 km upstream from the mouth of Gelevara River.

Average gradient of Harsit and Gelevara Rivers are 1/100 and 1/30 respectively.

Main settlements in the project area are Tirebolu Town the Black Sea Coarst, and Dogankent and Kürtün Villages, Torul Town and Gumushane City along the river from the mouth to the upstream.

The upstream reach of Harsit River flows through the typical area of the inland of Turkey, but the downstream from Torul Town changes the condition of land and them the river passes through the Eastern Black Sea Coarst Area. The basin of Gelevara River is covered with the large trees and seems as if it were in Japan except for a small part of the upper basin.

2.1.2 Climate and Hydrology

The climate of the project area is different in places from the sea side to the upper part of Harsit River. The downstream part is a typical sub-humid region characterized by warm, semi-dry springs and summers and wet autumns and winters. The climate from Torul to the upper part of watershed is rather cool and dry with wet springs and dry summers.

Within the project area, the precipitation is not uniform depending on its climate, it decreases going from the North to the South, that is, from the Black Sea to the upper part of the basin. Annual average precipitations are 1,763 mm at Tirebolu, 1,374 mm at Dogankent and 428 mm at Gumushane.

Consequently, the discharge conditions of the rivers are considerably different along the rivers. For the Harsit Project, comparing the annual average runoffs at the Torul, Kürtün, Kavrazan Gelevara Gauging Stations, their differences are as follows:

	Annual average flow per km^2 (10^6 m^3)	Annual average discharge per 100 km^2 (m^3/sec.)
Torul Gauging station	0.26	0.83
Kürtün Gauging station	0.31	0.98
Between Torul and Kurtun G.S.	0.43	1.35
Kavraz Gauging station	0.60	1.89
Celevara Gauging station	0.79	2.50

Distribution of annual rainfall is quite regular. From autumn to early spring, the precipitation is 10% higher than the annual average. Monthly average precipitations of the Harsit Meteorological station are given below:

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Precipitation (mm)	109	124	122	98	84	134	80	110	111	149	123	129	1,313

The monthly average temperatures which are recorded at the Gumughane Meteorological station are given below:

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Temperature (°C)	-2.0	-3.0	4.1	9.5	14.2	17.3	20.2	19.9	16.5	11.4	5.5	0.1	9.5

However, the climate tends to become milder to the North.

In general, the climate condition of the project is moderate for all kind of construction.

2.2 SCHEME OF COMPREHENSIVE DEVELOPMENT

The Harsit Project has been studied by the DSI as an important electric power development program from as early as 1950 in order to meet the rapidly growing power demand.

Based on the above investigation, the first-stage work of the Dogankent Power station was completed in 1968 and the second-stage work started in 1972 will be completed in 1978.

The Torul and Kürtün Dams are the main projects of the basin and the regulated water in their reservoirs is expected to largely increase the energy at the downstream power stations.

As for Gelevara River, the result of studies and field investigations shows that it is very economical and technically feasible to provide the reservoirs on the upstream stretches and to divert the stored water to Harsit River immediately upstream of the Dogankent Dam. And on the downstream of Gelevara River, some power stations will be able to be planned from the point of view of the effective utilization of the national resources and the stored water will be diverted to Aslancik Dam to also increase the power and energy at the downstream power stations.

Therefore, the study of the comprehensive development should be considered at the same time both Harsit River and Gelevara River.

In order to regulate the runoff of the rivers which fluctuates sharply by seasons, the high dams should be constructed at the upper part of basin. The DSI and the Japanese Mission in 1969 selected the Torul and Kürtün Dam Sites, as for the Kürtün Dam Site, our team found the selection appropriate through the studies and the field investigations, but the Torul Dam Site is found to be moved as far as 6 km downstream on the reasons below:

(1) Torul Town should not be made submerged, because it is an important base of the traffic connecting the inland regions and the Black Sea Coarst from the ancient time, and is a center of the social and economical activities of the near by peoples.

(2) The fertile orchards spread on the upstream of the reservoir especially around the town, and the submergence of the orchards means to deprive them of their living rights.

(3) The compensation cost has been rapidly increasing with the levelling up of the standard of living in this country comparing with that of 8 year ago when the study was made, and the new compensation cost is estimated 650 x 10^6 TL which nearly corresponds to 90% of the construction cost of this dam.

(4) The high water level of the reservoir should be reduced from 990 m to 920 m to save the town and the orchards from the submergence, and the effective capacity of the reservoir will become extremely insufficient.

In regard to the Kürtün Dam Site, the geological investigation and the topographical map have been already prepared, and as for the new Torul Dam Site, the topographical map was urgently made, but the geological investigation might be said to be at the stage of the surface reconnaissance.

The following conditions are taken in consideration for the study of the development scheme:

(1) The study of the development of this basin should be taken up to the whole power demand in Turkey. Because the power generated in this basin will be connected with the existing Keban – Ankara – Istanbul Transmission Line of 380 KV and with the Tirebolu – Carsamba Transmission Line of the same voltages which is scheduled along the Black Sea Coarst, and the power also will be supplied for the rapidly increasing demand of the Eastern Part of the Black Sea Coarst Area.

(2) The development is scheduled to be started in 1983 in consideration of the power demand and other scheduled sites. The power demand of all systems in Turkey is expected to be 5,130 MW in 1980 and the annual demand is expected to increase at the rate of more than 10% in the 1980's, and the peak demand as well as the base one will rapidly increase.

Accordingly, the power potential in this basin should be developed to meet these two kinds of demand which will be supplied by the peak power stations and the base load ones.

(3) The development plan should be paid consideration to the established capacity of the Dogankent Power station.

The major structure of the project are two arch dams, one at Torul and the other at Kürtün with the heights of 153 m and 133 m above bedrock to form the reservoirs with total storage capacities of 165×10^6 m^3 and 110×10^6 m^3 respectively.

The annual fluctuations of flow are regulated through the reservoirs and the water will be effectively utilized at the Torul and Kurtun Power Stations and the downstream power stations named Akköy–I, Dogankent, Aslancik and Tirebalu. Further, the runoffs of Gelevara River and Kavraz Creek are diverted to Harsit River to produce 180 mm of power at the Akköy–II Power station and the runoffs downstream of Gelevara River are also utilized at some power stations and diverted to the Aslancik Dam.

The supposed power and annual energy production in the basin will reach more than 750 MW and $2{,}700 \times 10^6$ KWH respectively.

The summarized data and explanations of the various projects within the upper river basin are as follows:

2.3 SCHEME OF DEVELOPMENT FOR EACH PROJECT

The Torul and Kürtün Projects have close relationship with the various downstream projects. Therefore, the whole projects should be considered at the same level, but it is more important how to effectively utilize their potential energy and how to largely develop them as much as economic permit to effectively develop the downstream various projects.

2.3.1 Torul Power Station

The Torul Dam Site is oblized to be moved as far as 6 km downstream because of the already mentioned reasons. The new dam site consists of the steep slopes with the exposed rock at the both sides and is the best site for the arch dam not being found out on the upper and downstream.

The houses and the farms are scarcely found around the reservoir except for the immediate upstream of the dam site and Torul Town and the orchards are saved from the submergence setting the high water level 917 m.

The Torul Project located on the most upstream of the basin, is developed as the peak power station. The dam with the height of 155 m and the crest length of 370 m is the dome-type arch dam.

The drawdown of the reservoir is 27 m, while the normal outlet water level is 630 m which corresponds to 10 m lower than the high water level of the Kurtun Reservoir in order to effectively utilize the potential energy.

The power station is located at the right bank 4 km downstream of the dam, and the water supplied through the tunnel of the diameter and the length of 3.9 m and 3,900 m respectively.

The design head, the maximum discharge and the installed capacity are 264.5 m, 41 m^3/S and 90 MW respectively and the annual energy production is 314×10^6 KWH.

2.3.2 Kürtün Power Station

The Kürtün Dam Site located on the middle of the basin, consists of a little gentler slopes than the Torul Dam Site with the exposed rock at the both sides, and is the best site not being found out nearby.

The houses concentrate only at Kürtün Village and the farms are scarcely existing around the reservoir.

The Kürtün Reservoir is to mainly regulate the inflow from Kürtün Creek. The Kürtün Project is the dam type peak power station and the dam with the height of 123 m and the crest length of 410 m is the dome-type arch dam.

The high water level is 640 m and the drawdown is 30 m, while the normal outlet water level is 530 m.

The power station is provided at the sight bank 100 m downstream of the dam.

The design head, the maximum discharge and the installed capacity are 98 m, 86 m^3/S

and 70 MW and the annual energy production is 195 x 10^6 KWH.

2.3.3 Akköy–I Power Station

The Akköy Dam Site is selected considering the effective regulating capacity and the topographical and geological conditions through the study and the field investigation. The dam site consisting of the narrow stream pushing out the exposed rock at the both sides, is located at 2 km downstream of the Kürtün Dam.

The Akköy Pond is to regulate the outflow from the Kürtün Power station. The dam is the semi-arch type with the height of 41 m and the crest length of 160 m and the high water level is 540 m.

The Akköy Power station is located at the left bank 1 km upstream of the Dogankent Dam and the water is conducted through the tunnel of 13,620 m. The outlet water level is 383 m which corresponds to the high water level of the Dogankent Dam.

The design head, the maximum discharge and the installed capacity are 131 m, 46 m^3/S and 50 MW respectively and the annual energy production is 217 x 10^6 KWH.

2.3.4 Akköy–II Power Station

The Akköy–II Power station consists of the effective head of 1,163 m and three dams named Aladerecam, Gokcebel and Yasmakli.

The Aladerecam Dam Site is located at the upstream reach of Karaovacik Creek and the dam with the height of 70 m and the crest length of 260 m is planned as the rock-fill type.

The stored water in the reservoir is diverted to the Gokcebel Reservoir through the tunnel of 4.6 km and the Aladerecam Power station of 6.5 MW is installed.

The Gokcebel Dam with the height of 113 m and the crest length of 270 m is situated at Gelevara River and is planned as the rock-fill type. The stored water is diverted to the Yasmakli Reservoir through the tunnel of 5.6 km.

The Yasmakli Dam of the semi-arch type is located at the upstream stretch of Kavraz Creel and its height and crest length are 63 m and 220 m respectively.

The high water level and the drawdown of the reservoir are 1,620 m and 40 m respectively and the stored water which is joinly operated with the Gokcebel Reservoir is diverted to Harsit River through the tunnel of 3,800 m and the penstock of 2,700 m.

The Akköy–II Power station is constructed in parallel with the Akköy–I Power station.

The maximum discharge is 19.5 m^3/S and the installed capacity and the annual energy production are largely 180 MW and 607 x 10^6 KWH respectively.

2.3.5 Summary of Optimum Development Scales

The summary of the optimum development scales of the various projects within the upper basin is given on the table 2.1, but the best solutions should be determined by the economical comparisons with other alternative plans which are now being prepared by the DSI.

Table – 2.1 Comprehensive Development Plan within the Upper River Basin

Description	Unit	Torul	Kürtün	Akköy–I	Akköy–II	Total
Drainage area	km^2	2.094	2.684	2.694	328	
High water level	km^2	917	640	540	1.620	
Low water level	km^2	890	610	528	1.580	
Effective storage capacity	10^6 m^3	80	63	1,85	65,7	
Design head	m	264,5	98	131	1.163	
Maximum discharge	m^3/S	41	86	46	19,5	
Dam height	m	155	123	41	63	
Length of headrace	m	3.900	–	13.630	3.800	
Installed capacity	MW	90	70	50	186,5	396,5
Project construction cost	10^6 N	1.606	1.134	919	2.284	5.943
Annual cost	10^6 TL	163	115	96	235	609
Annual energy production	10^6 KWH	317	195	217	625	1.351
Unit price per KWH	Kr/KWH	52	59	44	37	45

Note: Aladereçam power station is included in Akköy–II.

CHAPTER 3. DETERMINATION OF DEVELOPMENT SCALES

3.1 COMPREHENSIVE DEVELOPMENT PLAN BY THE JAPANESE MISSION

The comprehensive development plan of Harsit River by the Japanese Mission in 1969 consist of total eight power stations of seven power stations on Harsit River and one power station diverted from the upstream of Gelevara River. The total installed capacity and the annual energy production are expected 499 MW and 2,147 x 10^6 KWH respectively.

The summarized data of the various projects are listed on the table 3.1.

Table – 3.1 Harsit River Comprehensive Development Plan

Description	Unit	Torul	Kara-cukur	Kurtun	Akkoy	Gun-yazu	Dogan-kent	Aslancik	Tirebolu	Total
Drainage area	km^2	2.026	2.026	2.753	2.753	299	2.912	2.995	3.266	
High water level	m	990	850	650	545	1.630	383	180	70	
Low water level	m	946	840	620	535	1.586	-	-	48	
Effective storage capacity	10^6 m^3	207.8	-	73.3	-	74.8	-	-	34.5	
Design head	m	115	183	92	137	1.215	183	100	58	
Maximum discharge	m^3/S	48	48	78	34	11	45	45	114	
Dam height	m	155	-	133	-	-	-	-	95	
Length of water way	m	-	6.500	-	12.700	7.400	7.127	8.320	-	
Installed capacity	MW	47	74	61	40	113	70	38	56	499
Annual energy production	10^6KWH	143.4	214.4	200.1	229.4	529.6	411.3	228.1	191.1	2,147.4

3.2 BASIC CONSIDERATION FOR PROJECT

The basic data for study, such as the data of the water gauging station, the design flood and soon have been prepared by the DSI and these data and some explanations are as follows:

3.2.1 Inflow of Respective Sites

The data of the four water gauging stations named Torul, Kürtün, Kavraz and Gelevara are prepared and the periods of their observation are from 1943 to 1975. The data of each unobserved periods are calculated using the logarithmic correlation with other water gauging stations.

The inflows at each project site are converted by the catchment area ratio between each project site and the water gauging station. The monthly average inflows at the water gauging stations are as follows:

Table 3-2. Inflow Data of the Water Gauging Stations

(1943 ~ 1975)

Name of W.G.S.	Catchment Area (km^2)	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Average
Torul	1,935	10^6 m^3	16.9	19.8	51.2	117.3	123.7	68.3	26.1	15.4	14.0	16.7	18.3	20.0	507.7	42.3
		m^3/s	6.3	8.2	19.2	45.3	46.2	26.4	9.7	5.7	5.4	6.2	7.1	7.5	193.1	16.1
Kürtün	2,686	10^6 m^3	26.9	32.4	84.2	191.3	202.6	108.3	44.2	26.0	22.7	27.6	30.1	32.7	829.0	69.1
		m^3/s	10.0	13.4	31.4	73.8	75.6	41.8	16.5	9.7	8.8	10.3	11.6	12.2	315.1	26.3
Kavraz	118	10^6 m^3	2.6	3.1	6.2	12.9	15.7	8.7	4.3	2.9	3.3	3.8	3.5	3.3	70.3	5.9
		m^3/s	1.0	1.3	2.3	5.0	5.9	3.4	1.6	1.1	1.3	1.4	1.4	1.2	26.9	2.2
Celevela	141	10^6 m^3	2.8	4.0	9.7	23.5	32.5	15.8	6.0	3.6	3.2	3.5	3.5	3.4	111.5	9.3
		m^3/s	1.0	1.7	3.6	9.1	12.1	6.1	2.2	1.3	1.2	1.3	1.4	1.3	42.3	3.5

3.2.2 Catchment Area of Respective Sites

The catchment areas of the respective sites are estimated on the basis of the topographical map of the scale 1 : 100,000.

The cathment areas of the proposed dam sites are as follows:

Table 3-3. Catchment Areas of Respective Dam Sites

Name of Dam Site	Unit	Catchment Area	
		Total Area	Incremental Area
Torul	km^2	2,094	2,094
Kürtün	km^2	2,686	592
Akköy - I	km^2	2,696	10
Akköy - II	km^2	328	328
Aladereçam	km^2	47	47
Gokçebel	km^2	185	185
Yasmakli	km^2	96	96

3.2.3 Storge Capacities of Respective Reservoirs

The storage capacities of the respective reservoirs are estimated on the basis of the reservoir capacity curves which are measured with the topographical map of the scale 1 : 25,000.

3.2.4 Flood Flows of Respective Sites

Two kinds of flood flow, that is, the statistical method and the physical method are studied. The statistical solutions of 10.50 and 100 years frequencies are employed for designs of cofferdam for concrete dam, cofferdam for rock fill dam and spillway for runoff type concrete dam respectively. The physical solutions are studied for design of spillway for the reservoir type dam.

3.2.4.1 Statistical Method

The statistical probability calculation is based on the past flood records of the four water gauging stations according to the Gumbel's Method, and the flood flows at each dam site are converted by 2/3 power of the catchment area ratios between the dam sites and the water gouging stations.

The statistical solutions at each dam site are given below;

Q500 Torul

Table 3-4. Flood Analysis by Statistical Method

Sign	Torul	Kürtün	Akköy	Aladereçam	Gokçebel	Yasmakli	Remark
CA	2.094	2.686	2.696	47	185	96	Catchment Area
Q_2	208	246	246	35	89	23	Q_{i_1}: Return
Q_5	288	340	340	60	150	33	period
Q_{10}	355	419	419	80	201	41	
Q_{15}	440	520	520	105	263	51	
Q_{50}	500	590	590	124	311	58	
Q_{100}	562	663	663	143	359	66	
Q_{500}	704	831	831	186	467	83	

3.2.4.2 Physical Method

The physical method gives the probable maximum precipitation that may happen, if all factors contributing to the generation of precipitation are to reach their most critical condition simultaneously from which the probable maximum flood can be obtained.

In this study, the probable maximum precipitation is estimated by the Herchfield Method and from which the probable maximum flood including the snow melting flood is estimated using the Systhenetic Unit Hydrograph Method by Snyder.

The physical solutions at each dam site are as follows;

Table 3-5. Flood Analysis by Physical Method

Name of Dam	Torul	Kürtün	Akköy	Aladereçam	Gökçebel	Yaşmakli
Flood Flow	2.326	2.432	2.432	389	941	522

3.2.5 Sedimentation of Respective Reservoirs

The respectable amounts of the suspended materials are included in the runoff of Harsit River as well as other Turkish rivers especially in the wet seasons, so that the periodical measurement of the suspended material content is curried out at the Kürtün Gauging Station.

As the amounts of the suspended material are found to correlate monthly well to the amounts of runoff similarly to other same kind of rivers by the result of analisis, the annual amount of suspended material is estimated by these correlation factors.

The annual amount of the bed material is estimated using the data of other countries and the formula of the Civil Engineering Institute of Japanese Ministry of Construction.

The amount of the bed material of Kavraz Creek and Gelevara River is estimated using the above mentioned Japanese formula, because these rivers are covered with green and steep and always clean similarly to Japanese rivers. The amount of suspended material of these rivers is assumed to be 30% of the amount of the bed material.

The economic life of dam is assumed to be 50 years.

The results of studies at each dam site are shown on the Table 3-6.

Table 3-6. Amount of Sedimentation

Description	Unit	Torul	Kürtün	Akköy	Aladereçam	Gokçebel	Yasmakli
Catchment Area	m km^2	2,094	592	10	47	185	96
Bed Material	m^3/km^2, year	34	31	38	502	192	200
Suspended Material	m^3/km^2, year	207	207	207	151	58	60
Total	10^6 m^3/50 year	25.7	7.10	0.12	1.53	2.31	1.25

3.2.6 Euaporation of Respective Reservoirs

The evaporation data from 1965 to 1974 at the Demirciler, Gumushane and Soguteli Meteorological Stations are studied and the monthly average evaporation data are used as the loss water volumes from the water surfaces of the respective reservoirs.

The result of study is shown on the Table 3-7.

Table 3-7 Evaporation Data

Unit: mm

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
28.5	32.5	41.8	62.3	83.1	100.0	113.6	104.7	86.7	47.2	32.8	25.6	758.8

3.2.7 Reservoir Operation and Energy Production

Inflows into the respective reservoirs fluctuate by months, but the fluctuation is not considerable extent on yearly basis. Therefore the operation rules of the respective reservoirs are established so as to regulate such fluctuation of the monthly inflows to obtain the maximum firm energy and to minimize the spillage, and the calculation of energy production is monthly carried out to the periods of 33 years (1943 ~ 1975) for which runoff data are available.

The calculation method of the Akböy Regulating Pond is theoretically established in order to obtain the maximum energy production.

It is defined that the annual firm energy is an amount of energy 12 times of minimum monthly energy in all years and the annual secondary energy is the annual total energy less the annual firm energy.

3.2.8 Project Construction Cost and Annual Cost

As for the planning stage, the construction costs of each item are estimated using the unit costs which will be described latter and the project construction costs and its annual costs are calculated using the following rules.

The project construction cost is calculated as follow:

(1) Miscellaneous work factor of 5% is adopted to only civil work cost and contingency factors of 15%, 5% and 0% are adopted to civilwork, electric equipment and general steel work costs respectively. Summation of construction, miscellaneous and contingency costs is called "Foundamental Cost" in which land acquisition cost is not included.

(2) Project controlling cost is 15% of foundamental cost.

(3) Summation of foundamental cost and project controlling cost is called "Substantial Cost" in which land acquisition cost is included.

(4) Interest ratio of 9.5% is adopted to the substantial cost considering construction periods of each item.

(5) Summation of substantial cost and interest expence is called "Project Construction Cost".

The calculation method of annual cost is as follow:

(1) Total facters of amotization, interest and replacement of each item are shown on the Table 3-8.

(2) Maintenance and operation cost of 0.3% and 1.0% for foundamental cost of dam and camp facility, and other foundamental cost respectively are used, but maintenance and operation cost for power station and tailrace is graphically shown on the Fig. 3-1.

(3) Summation of above mentioned items is called "Annual Cost".

3.3 OPTIMUM SCALE DETERMINATION OF EACH PROJECT

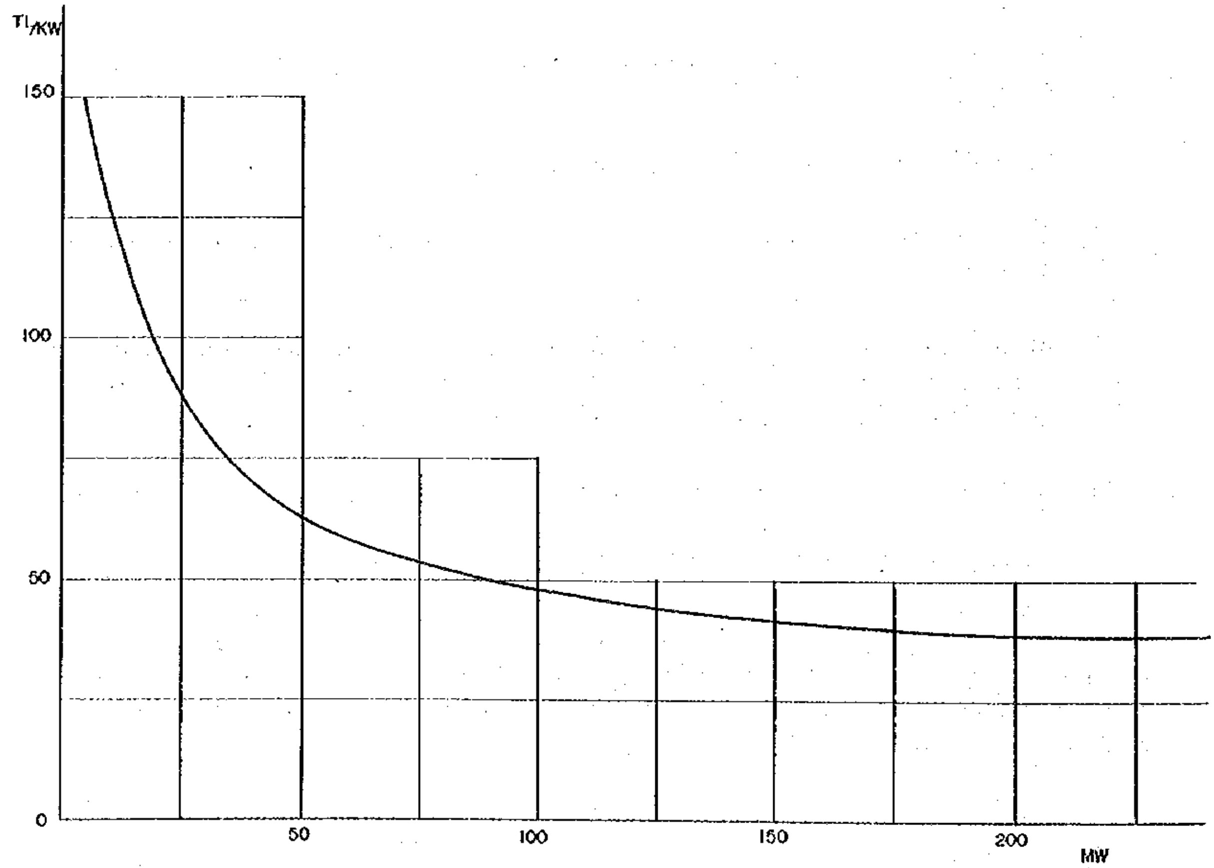
The optimum scales of each project are determined considering topography, geology, sedimentation, storage capacity, available depth of reservoir, effective head and so on. As these optimum scales might be said to be in the sphere of the prefeasibility study, the further study should be continued.

The results of the comparison studies within the upper basin are summarized as follows.

Table 3-8 Factor of Amotization Instrerest and Replacement

		Life of Structure (year)	Preiod of Replacement (year)	Rate of Replacement (year)	Factor (Interest Ratio 9.5%)
Dam Body		150	45	2	0.09503
Spillway		150	45	2	0.09503
Tunnel		150	45	2	0.09503
Penstock Line		75	45	50	0.09587
Valve and Gate		75	45	50	0.09587
Power Station	Building and other Structure	75	20	10	0.09694
	Turbine Generator et'c.	35	35	100	0.09914
	Total	–	–	–	0.09870
Transformer and Switchyard Structure		40	28	90	0.10257
Transmission Line		45	45	100	0.09662
Telephone System		25	25	100	0.10596
Road		100	–	–	0.09501
Bridge	Concrete	100	45	2	0.09504
	Steel	100	45	50	0.09582
Permanent Camp		65	20	10	0.09708
Engineering, planning, Investigation Project Control, Management, Temporary Camps, Coffer Dam, Grouting, Land Acquisition.		50	–	–	0.09603

Fig. 3-1 Maintenance and Operation Cost of Power Station from the Data of D.SI 1976



3.3.1 Torul and Kürtün Projects

The torul and Kürtün Projects are studied at the same time because it is more effective to be simultaneously operated.

The alternative plans of them are selected as follows.

The high water levels of the Torul Reservoir is fixed to 917 m to pursue the maximum scale merit and the low water levels and the installed capacities are selected 870 m, 880 m and 890 m, and 60 MW 75 MW and 90 MW respectively.

As for the Kürtün Project, the high water levels and the low water levels of the reservoir and the installed capacities are selected 650 m and 620 m, 620 m and 610 m, and 50 MW, 60 MW and 70 MW respectively.

The alternative plans come amount to 27 cases, and the better solution is judged as follow: that is, the high water levels, the low water levels and the installed capacities of the Torul and Kürtün Power Stations are 917 m and 640 m, 890 m and 610 m, and 90 MW and 70 MW respectively. But the larger installed capacity is concluded to be more effective and economical by the the discussion of the future power demand character with the D.SI.

Therefore, the following cases are studied in more detail and the results of studies are shown on the same table.

The best solution is determined to be the alternative plan - I.

3.3.2 Akköy - I Project

The installed capacities of 40 MW, 50 MW, 60 MW and 70 MW are selected as the alternative plans, and the results of studies are shown on the Table 3-10.

The alternative - II is judged to be the best solution.

3.3.3 Akköy - II Project

This project is very unique one, but should be carefully studied because of involving some engineering problems.

The installed capacity of the Aladereçam Power Station is selected only one case of 6.5 MW, and the installed capacities of 180 MW, 210 MW and 240 MW are selected as the alternative plans for the Akköy - II Project. The studing results of these alternative plans are shown on the Table 3-11.

The best solution is judged to be the alternative - I, but other alternative plans having smaller installed capacities will have to be further studied from now on.

Table 3-9. Alternative Plan fo Torul and Kürtün Power Stations

		Alternative Plan-I			Alternative Plan-II			Alternative Plan-III		
		Torul	Kürtün	Total	Torul	Kürtün	Total	Torul	Kürtün	Total
Drainage Area	km^2	2,094	2,686		2,094	2,686		2,094	2,686	
Annual Inflow	$10^6\ m^3$	550	829		550	829		550	829	
Design Flood	m^3/s	2,325	2,435		2,325	2,435		2,325	2,435	
Reservoir										
High Water Level	m	917	640		917	640		917	640	
Low Water Level	m	890	610		890	610		890	610	
Total Storage Capacity	$10^6\ m^3$	165	110		165	110		165	110	
Effective Storage Capacity	$10^6\ m^3$	80	63		80	63		80	63	
Dam (Arch Type)										
Elevation of Crest	m	920	643		920	643		920	643	
Height	m	155	123		155	123		155	123	
Length of Crest	m	370	410	370	370	410		370	410	
Headrace Tunnel										
Length	m	3,900	–		3,900	–		3,900	–	
Diameter	m	3.9	–		4.1	–		4.45	–	
Generating Plan										
Grass Head	m	278	100		278	100		278	100	
Effective Head	m	264.5	98		265.5	98		266.5	98.5	
Maximum Discharge	m^3/s	41	86		45.5	98		54	110	
Installed Capacity	MW	90	70		100	80		120	90	
Number of Unit	N	2	2		2	2		2	2	
Annual Energy										
Firm Energy	10^6 KWH	141	78	219	141	78	219	141	78	219
Secondary Energy	10^6 KWH	173	117	290	178	120	298	183	121	304.
Total Energy	10^6 KWH	314	195	509	319	198	517	324	199	523
Project Cost										
Construction Cost	10^6 TL.	1,606	1,134	2,740	1,650	1,158	2,808	1,718	1,179	2,897
Annual Cost	10^6 TL.	163	115	278	167	117	284	175	120	295
Annual Cost per KWH	KV/KWH	51.9	59.0	54.7	52.4	59.1	54.9	54.0	60.3	56.4

Table 3-10. Alternative Plan of Akköy-I Power Station

	Unit	Alt.-I	Alt.-II	Alt.-III	Alt.-IV
Drainage Area	km^2	2,700	2,700	2,700	2,700
Annual Inflow	10^6 m^3	832	832	832	832
Design Flood	m^3/s	665	665	665	665
Regulating Reservoir					
High Water Level	m	544	544	544	544
Normal Water Level	m	540	540	540	540
Low Water Level	m	528	528	528	528
Total Reservoir Capacity	10^6 m^3	2.4	2.4	2.4	2.4
Effective Reservoir Capacity	10^6 m^3	1.84	1.84	1.85	1.85
Dam (Semi Arch Dam)					
Crest Elevation	m	545.5	545.5	545.5	545.5
Crest Length	m	160	160	160	160
Height	m	41	41	41	41
Headrace Tunnel					
Length	m	13.630	13.630	13.630	13.630
Diameter	m	3.85	4.25	4.60	4.95
Generating Plan					
Gross Head	m	157	157	157	157
Effective Head	m	128	131	133.5	135.5
Maximum Discharge	m^3/s	37.5	46	54	62
Installed Capacity	MW	40	50	60	70
Number of Unit	N	2	2	2	2
Annual Energy					
Firm Energy	10^6 KWH	72	73	74	76
Secondary Energy	10^6 KWH	125	144	160	173
Total Energy	10^6 KWH	197	217	234	248
Project Cost					
Construction Cost	10^6 KWH	833	919	994	1,058
Annual Cost	10^6 KWH	87.3	95.7	103.7	110.4
Annual Cost per KWH	10^6 KWH	44.3	44.1	44.3	44.5

Table 3-11. Alternative Plan fo Akköy-II Power Station including Aladereçam Power Station

	Description	Unit	Alt.-I	Alt.-II	Alt.-III
Aladereçam	Drainage Area	km^2	47	47	47
	Annual Inflow	$10^6\ m^3$	37.1	37.1	37.1
	Design Flood	m^3/s	245	245	245
	Reservoir				
	High Water Level	m	1,842.4	1,842.5	1,842.5
	Low Water Level	m	1,822.5	1,822.5	1,822.5
	Total Storage Capacity	$10^6\ m^3$	14.8	14.8	14.8
	Effective Storage Capacity	$10^6\ m^3$	13.5	13.5	13.5
	Dam (Rock Fill Type)				
	Crest Elevation	m	1,845	1,845	1,845
	Crest Length	m	260	260	260
	Height	m	70	70	70
	Headrace Tunnel				
	Diameter x Length	m x m	2.0 x 4,600	2.0 x 4,600	2.0 x 4,600
	Generating Plan				
	Grass Lead	m	226	226	226
	Bffective Head	m	210	210	210
	Maximum Discharge	m^3/s	3.75	3.75	3.75
	Installed Capacity	MW	6.5	6.5	6.5
	Number of Unit	N	1	1	1
Cökçebel	Drainage Area	km^2	185	185	185
	Annual Inflow	$10^6\ m^3$	146.1	146.1	146.1
	Design Flood	m^3/s	610	610	610
	Reservoir				
	High Water Level	m	1,620	1,620	1,620
	Low Water Level	m	1,580	1,580	1,580
	Total Storage Capacity	$10^6\ m^3$	48.9	48.9	48.9
	Bffective Storage Capacity	$10^6\ m^3$	40.4	40.4	40.4
	Dam (Rock Fill Type)				
	Crest Elevation	m	1,623	1,623	1,623
	Crest Length	m	270	270	270
	Height	m	113	113	113
	Waterway Tunnel				
	Diameter x Length	m x m	3.3 x 5,600	3.3 x 5,600	3.3 x 5,600

(Table 3-11. con't)

	Description	Unit	Alt.-I	Alt.-II	Alt.-III
Yasmakli	Drainage Area	km²	96	96	96
	Annual Inflow	10^6 m³	52.8	52.8	52.8
	Design Flood	m³/s	395	395	395
	Reservoir				
	High Water Level	m	1,620	1,620	1,620
	Low Water Level	m	1,580	1,580	1,580
	Total Storage Capacity	10^6 m³	12.6	12.6	12.6
	Effective Storage Capacity	10^6 m³	11.8	11.8	11.8
	Dam (Semi-Arch Type)				
	Crest Elevation	m	1,623	1,623	1,623
	Crest Length	m	218	218	218
	Height	m	63	63	63
	Headrace Tunnel				
	Diameter x Length	m x m	2.65 x 3.800	2.90 x 3,800	3.05 x 3,800
	Penstock Line				
	Average Diameter x Length	m x m	2.15 x 3,700	2.30 x 3,700	2.45 x 3,700
	Generating Plan				
	Gross Head	m	1,224	1,224	1,224
	Effective Head	m	1,163	1,166	1,169
	Maximum Discharge	m³	19.5	22.7	25.9
	Installed Capacity	MW	180	210	240
	Number of Unit	N	3	3	3
Summary	Drainage Area	km²	328	328	328
	Aladereçam	km²	47	47	47
	Gökçebel	km²	185	185	185
	Yaşmakli	km²	96	96	96
	Annual Inflow	10^6 m³	236.0	236.0	236.0
	Aladereçam	10^6 m³	37.1	37.1	37.1
	Gökçebel	10^6 m³	146.1	146.1	146.1
	Yaşmakli	10^6 m³	52.8	52.8	52.8
	Construction Cost	10^6 TL	2,283.8	2,372.9	2,479.8
	Aladereçam	10^6 TL	344.0	344.0	344.0
	Gökçebel	10^6 TL	645.2	645.2	645.2
	Yaşmakli	10^6 TL	1,294.6	1,383.7	1,490.6
	Annual Cost	10^6 TL	235.4	245.4	257.4
	Aladereçam	10^6 TL	35.0	35.0	35.0
	Gökçebel	10^6 TL	63.6	63.0	63.6
	Yaşmakli	10^6 TL	136.8	146.8	158.8

(Table 3-11. con't)

	Description	Unit	Alt.-I	Alt.-II	Alt.-III
Summary	Installed Capacity	MW	186.5	216.5	246.5
	Aladereçam	MW	6.5	6.5	6.5
	Akköy-II	MW	180	210	240
	Energy Production	10^6 KWH			
	Ferm Energy	10^6 KWH	405.9	405.9	405.9
	Aladereçam	10^6 KWH	11.4	11.4	11.4
	Akköy-II	10^6 KWH	394.5	394.5	394.5
	Secondary Energy	10^6 KWH	219.1	238.8	254.0
	Aladereçam	10^6 KWH	6.5	6.5	6.5
	Akköy-II	10^6 KWH	212.6	232.3	247.5
	Total Energy	10^6 KWH	625.0	644.7	659.9
	Aladereçam	10^6 KWH	17.9	17.9	17.9
	Akköy-II	10^6 KWH	607.1	626.8	642.0
	Annual Cost per KWH	Kr/KWH	37.7	38.1	39.0
	Aladereçam	Kr/KWH	196	196	196
	Akköy-II	Kr/KWH	37.4	37.8	38.8
	Aditional Annual Cost per KWH of Aladereçam	Kr/KWH	47.6	47.6	47.6

CHAPTER 4. LAYOUT FOR DAM AND POWERPLANT OF HARSIT PROJECT (TORUL DAM)

4.1. GENERAL

It is concluded that any type of dam can be constructed from the topographic and geologic points of view, although there is no so, wide land as easily constructed a rock fill type dam.

4.2 CHARACTRISTICS OF SITE

The valley-width to height ratio is about 2. and canyon shape is just a flat V. Therefore, a slender arch dam and rockfill dam can be considered for the layout of project at the site. Although V shape valley is said to be not suitabe for rockfill dam but for arch dam. Nevertheless there are lately some examples constructed such a site in Japan, named YANASE Dam, width to height ratio is 1.8, and have concluded that rock fill type dam can be constructed at V shaped valley on condition that this type will be economical.

Trees and bushes are found very few in the neighbourhood of the proposed dam location because most of the rocks are exposed nearly to the ground surface.

Geological charactristics is discribed at the report "Geology of Torul Dam Site".

As for the climate conditions the average temperature is around 9.7°C. The average max. 20.2°C, the average min. -2.0°C.

Then the temperature doesn't affect the construction of any type of dam.

The average annual amount of rainfall is 750 mm and the frequency of precipitation more than 1 mm is 70 days/year, while that of more than 10 mm is 20 days/year.

Then, the frequency of precipitation might not affect so much the construction of any type of dam, especially rockfill type.

The accessibility to the site is fairly easy, but it may be necessary to improve some part of access road at the time of dam construction. The distance between the site and TRABZON is about 100 km on the roads.

Construction materials for rockfill dam is available with in a range of 10 km upstream and concrete aggregates with in a range of 3.5 km down or upstream.

Ample supplies of cement are expected available from TRABZON.

4.3 THE FAETORS WHICH AFFECTS THE LAYOUT

4.3.1 Design Flood

The Torul Dam site is not expected sommuch flood that any type of dam will be possible to be constructed from the flood discharge point of view.

4.3.2 Alluvial Deposits

The depth of alluvial deposits at Torul dam site will be not expected so much as 10 m.

4.3.3 Earthquak Effects

The project area is located in the third grade earth quake region in Turkey. And it is recommended that 0.12 ~ 0.15 G. can be taken as the horizontal acceleration of seismic intensity in the design analysis of the dam.

4.4 ALTERNATIVE SOLUTIONS OF TORUL DAM

Two kind of dam type are considered for the layout of the project, that is, slender arch dam, rockfill dam, taking the characteristics of site and the factors above described into consideration.

4.4.1 Arch Dam

4.4.1.1 Dam

This arch dam has a height of 155 m and a crest length of 370 m. The volume of mass concrete of dam is 490,000 m^3. The crest of the dam is located at elevation of 920 m providing 3 m of free-board from the normal high water level of El. 917 m.

Symmetrical arch dam is possible to be constructed at this site, although economical comparison is necessary for deciding symmetry or not. And slender arch dam may be possible to be designed judging from the external appearance exposed rocks at the site.

Final arch dam shape should be decided not only by the result of stress analysis but also model test including dynamic test.

In this stage the preliminary arch dam is showed the drawing (7), (8).

4.4.1.2 Arch Dam Spillway

a) Overflow type

Slender arch dam may be designed for the layout as a most economic type like Oymapinar arch dam and also the crest of dam can be utilized as a spillway with a depth of nappe 8 m without endangering the safety of dam because the amount of design flood is not so much as 2,325 m^3/sec.

of However, it remains to be solved by the model studies whether it is necessary for the toe of dam to have a protection works with a plunging pool even if this type of dam might be selected with this mappe over the crest.

In anyway arch dam with a crest spillway is said to be most economical on condition that the site is suitable for constructing this type of dam.

b) Tunnel orifice type

As a alternative for arch dam, reference can be made to an arch dam in Japan named the Nagawado arch dam which is to discharge the design flood 1,800 m^3 /sec.

In Torul dam comparison with crest overflow type and tunnel orifice one may be done from economical point of view.

c) Side spillway type

Instead of these two types of spillway an arch dam with side spillway attached to the dam in the right and left bank is usually considered as an alternative.

But in this case side spillway type with arch dam is not suitable for this site. Because much amount of rock excavation will be expected to cut the steep valley at the both right or left bank.

4.4.2 Rockfill Dam

4.4.2.1 Dam

The dam has a height of 156 m and a crest length of 306 m.

The volume of embankment is 5,440,000 m^3. The crest of the dam is located at elevation of 921 m providing 4 m of freeboard from the normal high water level of El. 917 m.

The shape of the cross section is selected of shown in the Drawing (2) by taking the seismic condition into consideration as a same seismic intensity of HASAN UGURLU Dam.

However, the final cross section should be decided by the result of sliding circle method applies the result of materials tests and geological investigations.

4.4.2.2 Diversion Work

The upstream cofferdam is located about 300 m upstream from the dam axis.

Diversion after performing this duty, in the left bank, will be utilized a part of it later on as an outlet work.

As there is only one diversion, outlet tunnel may be constructed for the exclusive use although it's inner diameter is 3.00 m.

The discharge capacity of the diverson tunnel is 440 m^3/sec. at a upstream water level of 801.50 m, corresponds to the flood discharge of 25 years period by Gumbel Method.

The diversion tunnel have an inner diameter of 6.50 m, the length of 822.83 m and the crest elevation of the cofferdam is 803,50 m.

4.4.2.3 Spillway

a) Side spillway

Location of spillway

At this dam site spillway will be considered to construct at the both right and left bank.

Judging from economical end technical standpoints the right bank spillway is suitable fo for the site.

The chute-type spillway on the right bank has a capacity to release a maximum probable flood discharge of 3,364 m^3/sec by a surcharge of 2.00 m higher than normal high water level.

The controlling system of the spillway consist of 2 roller gate with effective width of 12.00 m and height 15.50 m.

The model tests should be performed in anyway as to the dissipating effect of stilling basin.

Due considerations should be paid for the erosion of the river bed which will influence the stability of downstream valley.

The result of economical comparison of right and left bank spillway is shown as follows.

COMPARISON OF SPILLWAY (ROCKFILL DAM)

	Right Bank Spillway	Unit Price/m^3	Price
Common excavation	90,000 m^3	38 TL.	3,420 x 10^3 TL.
Rock excavation	810,000 m^3	78 TL.	63,180 x 10^3 TL.
Concrete wall and invert	62,000 m^3	700 TL.	43,400 x 10^3 TL.
		Total	110,000,000 TL.

	Left Bank Spillway	Unit Prion/m³	Price
Common excavation	113,000	38 TL.	4,294 x 10^3 TL.
Rock excavation	1,019,000	78 TL.	79,482 x 10^3 TL.
Concrete wall and invert	57,000	700 TL.	39,900 x 10^3 TL.
		Total	123,676,000 TL.

Then 123,676,000 - 110,000,000 = 13,676,000 TL.

Above result is shown that right bank spillway is cheaper than left one.

4.5 WATER WAY

4.5.1 Intake

The type of intake is selected the inclined intake type because of the economical and easy construction.

4.5.2 Headrace Tunnel

The length of headrace tunnel is about 3,900 m and the diameter is 3.90 m.

4.5.3 Surge Tank

The type of surge tank is chamber type with upper and lower chamber.

To eliminate the height of upper chamber, it had better to put the orifice at the upper chamber on the difinit design stage.

4.5.4 Penstock

This penstock line has a vertical shaft more than 100 m length.

To avoid the vertical shaft much amount of excavation will be expected to construct the powerhouse of the same site.

The design head of penstock is the maximum 371.42 m including waterhammer 30% of total static head and a maximum thickness of steel penstock is 2.8 cm (SM41)

The total weight of steel penstock is about 1,160 ton.

4.6 POWERSTATION

The site of powerstation is at the right bank and 4 km down stream from Torul dam.

The width of stream at the tailrace is not so wide that a little down stream site seems to be better for powerstation but not so preferable for penstock.

4.7 SWITCHYARD

Electric current from the transformers will be carried by cables in a duct buried in a underground from the powerstation to the switchyard.

The swichyard has an area 33 m x 20 m

The detail is shown in drawing (14).

4.8 TAILRACE

The riverbed must be excavated because the center of generator is El. 626.00 and the original river bed is El. 635.00.

The amount of excavation volume is about 224,000 cu. m.

From the tailrace point of view a little down stream power house site is preferable, in near future economical comparison combenated with penstock, power house, tail race must be proceede after after investigating each ground conditions.

4.9 CALCULATION OF UNIT PRICE

The unit prices for civilworks are calculated by referring the labour costs, transportation fees construction materials such as cement reinforcing bar.

These basic data obtained form DSI are as follows.

4.9.1 Basic Data from DSI

Labor Cost	Harsit PR 1976	Altinkaya 1974	Government Standard 1976
Foreman	225 TL.	168 TL.	150 TL.
Carpenter	195	130	130
Labour	96	75	64
Mason	180	130	120
Mechanics	180	130	120
Equipment operation (A)	180	140	120
Equipment operation (B)	150	125	100
Steel worker	195	130	130
Blacksmith	195	130	130
Electrician	195	130	130
Tunnel workman	120	75	80
Wilder	195	130	130
Plumber	195	130	130
Repairman	225	140	150

Average increased ratio + 43%

Machines		1976	1974	Ratio
Bulldozer	(100 H.P)	1.5 x 10^6 TL.	1.1 x 10^6 TL.	1.36
Bulldozer	(345 H.P)	4.4 x 10^6	2.8 x 10^6	1.57
Truck	(10 ton)	0.5 x 10^6	0.35 x 10^6	1.43
Light oil	(1 ℓ)	2.44 x 10^6	2.44 x 10^6	1.0
Gasoline	(1 ℓ)	2.74 x 10^6	2.74 x 10^6	1.0

Average increased ratio + 45%

Materials	1976	1974	Ratio
Cement	580 TL.	399 TL.	1.45
Reinforcing bar	11,000	8,000	1.38

Average increased ratio + 28%

Each unit price can be divided under four head, that is, labour fee, material cost, machine fee and overhead.

And new unit prices are calculated by employing abovementioned ratio.

4.9.2 The Results of Unit Price

Item	Unit Price
Common excavation (m^3)	
Diversion	46 TL.
Dam	46
Spillway	38
Intake	52
Powerhouse	52
Switchyard	52
Rock Excavation (m^3)	93
Diversion	93
Intake	93
Dam	112
Spillway	78
Surge Tank	93
Power House	93
Switchyard	93

Item	Unit Price
Tunnel Excavation (m^3)	
Diversion	350 TL.
Headrace (Horizontal)	350
Headrace (Inclined)	490
Drainage	378
Penstock (Vertical)	490
Intake (Vertical)	490
Surge Tank (Vertical)	490
Concrete Price (m^3)	
Diversion	
Structure	722
Wall	700
Lining	666
Plug	588
Spillway	
Pier and Bridge	832
Wall	700
Crest	700
Invert	700
Outlet	
Structure	722
Valve Chamber	722
Around Pipe	611
Waterway	
Intake Structure	722
Wall	700
Shaft	666
Headrace Lining	777
Surge Tank Lining	777
Surge Tank Wall	700
Penstock Around Pipe	611
Power House	
Tailrace	722
Slub Column	810
Sub Structure	722
Draft Tube	722

Item	Unit Price
Barrel Casing	810 TL.
Wall	700
Switch Yard	
Wall	700
Base	700
Dam	
Arch Concrete	430
Dam Embankment Price (m^3)	
Rockfill Dam	
Rock	48
Filter	173
Core	98
Metal Price (t)	
Gate	60,000
Penstock	40,000
Transhrack	30,000
Reinforcing Bar	11,000
Steel Support	20,000
Anchor Bar	22,000 (Including drilling)
Cement Price (t)	
Cement (including transfortation fee 90 TL.)	670

4.10 COST OF DAMS

The type of dams are finally decided by those costs after investgating of technical point of view.

Cost estimations were made by using the following precedures.

1. Escalation of prices of Altinkaya dam.

2. Reffering the unit price of Oymapinar project.

At the end of the estimations for civil works, following values were obtained (See Page 55)

Rockfill dam	786,362,000 TL.
Concrete arch dam	650,170,000 TL.

As it is seen concrete arch type is more economical by 20% compared with rockfill type.

The reason for such a difference is the high cost of spillway compare with that of arch type.

However, in the light of past experience, it will be difficult to determine economical superiority of inferiarity without detailed investigations of geology and materials.

After these investigations, acurate unit price will be calculated and correct judgements could be taken to these porpose.

4.11 BREAKDOWN OF ROCKFILL, ARCH DAM

Item	Arch Dam	Fill Dam	Difference (Arch-Rock)
Diversion	12,900 x 10^3 TL.	22,130 x 10^3 TL	- 9,230 x 10^3 TL
Coffer Dam	3,440	900	2,540
Dam	303,600	401,700	- 98,100
Spillway	37,700	144,000	- 106,300
Outlet Works	1,040	8,042	- 7,002
Intake	5,350	5,350	0
Head Race Tunnel	68,880	68,880	0
Surge Tank	3,812	3,812	0
Penstock	5,670	5,670	0
Power House	14,733	14,733	0
Switch Yard	3,652	3,652	0
Tailrace	7,563	7,563	0
Material Supply, Transportation	97,820	23,300	74,520
Hydraulic Equipment	84,010	76,630	7,380
Total	650,170,000 TL.	786,362,000 TL.	- 136,192,000 TL.

(+ 20%)

4.12 PROJECT COST OF TORUL DAM AND POWER STATION

Description	Civil Works	Machine	Metal	Note
Dam				
Diversion	x 10^3 TL.	x 10^3 TL.	x 10^3 TL	
and Cofferdam	18,017	-	2,940	
Dam	385,854	-	1,370	(outlet Valve and screen, pipe)
Spillway	42,749	-	27,000	
Intake	5,882	-	5,100	(screen, gate, pipe)
Headrace Tunnel	74,040	-	-	Civil works are included cement price.
Surge Tank	4,158	-	-	
Penstock	6,516	-	46,400	
Powerhouse				
Machine Room	16,086	-		
Turbine	-	46,000		
Generator	-	49,500		
Transformer	-	7,800		
Accesories	-	38,500		
Transportations And Installation	-	37,500		
Others	-	8,160		
Tailrace	7,649	-	1,200	
Switchyard	3,806	-		
Contingencies	113,233	9,540	0	Civil Works 20% Machine 5%
Relocation of Road	89,700	-		
Camp Facility	22,500			
Subtotal	790,190	197,000	84,010	(Construction Cost) 1,071,200
Project Controlling Expense				161,600
Land and Compensation				86,100
Intrest During Construction (9.51)				281,100
Project Cost				1,600,000 x 10^3 TL.

CHAPTER 5. POWER PLANT

5.1 ELECTRIC FACILITIES

Torul Project

Kürtün and Akköy - I project were designed under same thinking as Torul Power Plant explained hereinafter.

The type of the Turbine would be a vertical-shaft, single-wheel, single-stream Francis turbine. The rated head at this power station would be 264.5 m with the turbine out put 47,800 kW x 2 units, and Francis turbine most suited to these conditions was selected.

The revolving speed of the turbine was selected to be as high as possible without exceeding the limits of specific speed for Francis type turbine, and takeing into account the standard number of poles of the generator, it was set at 429 rpm.

The generator would be a vertical-shaft, revolving field, fully enclosed, internally cooled, ordimary type in consideration of out put and rotating speed.

Since the out put of the generators is relatively small at 52,000 KVA x 2 with the 154 KV step-up substation.

The transmission line of 154 KV is connected to Kürtün substation.

5.2 POWER TRANSMISSION METHOD

The power transmission system of Harşit Project has been proposed in a way which would preclude duplication of investment in transmission facilities which might etherwise be coused if all of the power stations projected on the Harsit River are put into operation independently of each other.

The transmission of the power obtainable at the Harşit would be best effectuated by the 380 KV transmission line which is proposed for new scheme frome Keban power station through the vicinity of Kürtün power station to the Black sea cost.

In such case, if the 4 power station (Torul, Kürtün, Akköy-I, Akköy-II) are put on the 380 KV transmission line individually and directly, any trouble or failure at any of the power stations would effect the entire system of 380 KV line.

In order to avoid such adverse affect, it has been proposed to the step-up substation.

The power will be put into the 380 KV transmission line after having been stepped up at the substation.

The above transmission system is illustrated in Fig. 15.

This interconnecting network is now being studied by TEK.

5.3 BRIEF DISCRIPTION OF ELECTRICAL FACILITIES.

5.3.1 Torul Project

1. Hydraulic Turbine

Number of Unit	2
Type	Vertical shaft. single runner single discharge francis turbine
Normal Effective Head	264.5 m
Discharge	20.5 m^3/s.
Out Put	(at normal effective head)
Rated Speed	429 rpm.
Specific Speed	88 m kW
Draft Head	- 4 m
$\frac{kW}{\sqrt{H}}$	2,939

2. Generator

Number of Unit	2
Type	3-Phase, AC synchronous generator, vertical shaft, rotating field, enclosed hood air circulation type with air coolers
Out Put	52,000 KVA (continuous)
Rated Voltage	13.8 KV
Rated Current	2,176 A
Power Factor	0.9 (lagging)
Frequency	50 Hz
Rated Speed	429 rpm.
Number of Pole	14
$\frac{KVA}{N}$	121

3. Main Transformer

Number of Unit	1
Type	Out door 3-phase oil immersed forced oil cooled with forced air cooler
Rated Capacity	104 MVA (continuous)
Rated Voltage	Primary 13.8 KV Secondary 154 KV
Rated Frequency	50 Hz
Connection	Delta (P)/Star (S)

4. Machine Hall Crane

Type	Over head travelling crane
Number of Unit	1
Capacity	140 ton
Span	14 m

5.3.2 Kürtün Project

1. Hydraulic Turbine

Number of unit	2
Type	Vertical shaft. single runner single discharge francis turbine
Discharge	43 m^3/s.
Out Put	37,100 kW (at normal effective head)
Rated Speed	250 rpm.
Specific Speed	156 m - kW
Draft Head	- 3 m
$\frac{KWH}{\sqrt{H}}$	3,748

2. Generator

Number of Unit	2
Type	3-phase, AC synchronous generator vertical shaft, rotating field, enclosed hood air circulation type with air coolers
Out Put	40,400 KVA (continuous)

Rated Voltage	13.8 KV
Rated Current	1,691 A
Power Factor	0.9 (lagging)
Frequency	50 Hz
Rated Speed	250 rpm.
Number of Pole	24
$\frac{KVA}{N}$	162

3. Main Transformer

Number of Unit	1
Type	Out door 3-phase oil immersed forced oil cooled with forced air cooler
Rated Capacity	80.8 MVA (continuous)
Rated Voltage	Primary13.8 KV Secondary 380 KV
Rated Frequency	50 Hz
Connection	Delta (P)/Star (S)

4. Machine Hall Crane

Type	Over head travelling crane
Number of Unit	1
Capacity	160 ton
Span	14.5 m

5.3.3 Akköy-I Project

1. Hyraulic Turbine

Number of Unit	2
Type	Vertical shaft single runner single discharge francis turbine
Normal Effective Head	131.0 m
Discharge	23 m^3/s
Out Put	26,500 kW (at normal effective head)
Rated Speed	375 rpm.
Specific Speed	137 m - kW

Draft Head	- 3 m
$\frac{kW}{\sqrt{H}}$	2,753

2. Generator

Number of Unit	2
Type	3-phase AC symchronous generator vertical shaft, rotaling field, enclosed hood air circulation type with air coolers
Out Put	28,800 KVA (Continuous)
Rated Voltage	11.0 kV
Rated Current	1,512 A
Power Factor	0.9 (logging)
Frequency	50 Hz
Rated Speed	375 rpm.
Number of Pole	16
$\frac{KVA}{N}$	76.8

3. Main Transformer

Number of Unit	1
Type	Out door 3-phase oil immersed forced oil cooled with forced air cooler
Rated Capacity	57.6 MVA (Continuous)
Rated Voltage	Primary 11 KV Secondary 154 KV
Rated Frequency	50 Hz
Connection	Delta (P)/Star (S)

4. Machine Hall Crane

Type	Over head travelling crane
Number of Unit	1
Capacity	120 ton
Span	13 m

5.3.4 Akköy-II Project

1. Hydraulic Turbine

Number of Unit	3
Type	Vertical shaft VP-1R2N Pelton turbine
Normal Effective Head	1,163 m
Discharge	19.5 m^3/s
Out Put	64,800 kW (at normal effective head)
Rated Speed	429 rpm.
Specific Speed	12 m - kW
Draft Head.	2 m
$\frac{kW}{\sqrt{H}}$	1,900

2. Generator

Number of Unit	3
Type	3-phase, AC symchronous generator verticalshaft, rotating field, enclosed hood air circulation type with air coolers
Out Put	70,500 KVA (continuous)
Rated Voltage	13.8 KV
Rated Current	2,950 A
Power Factor	0.9 (largging)
Frequency	50 Hz
Rated Speed	429 rpm.
Number of Pole	14
$\frac{KVA}{N}$	164

3. Main Transformer

Number of Unit	3
Type	Out door, 3-phase oil immersed forced oil cooled with forced air cooler.
Rated Capacity:	70.5 MVA (continuous)

Rated Voltage	Primary 13.8 KV Secondary 154 KV
Rated Frequency	50 Hz
Conection	Delta (P)/Star (S)

4. Machine Hall Crane

Type	Over head travelling crane
Number of Unit	1
Capacity	135 ton
Span	13 m

5.4 LOAD FORECAST

The tends of power demand from the year 1960 are indicated in Table 1.

In 1950, 94% of the supply capacity depended on thermal power generation, but as a result of the remarkable development of hydro power against total capacity has enlarged so that in 1975, 65.4% was thermal while hydro counted for 34.6%.

It is thought that hydro power capacity will even larger in another 10 years.

Turkey's total load and energy position expected to be as Table 2.

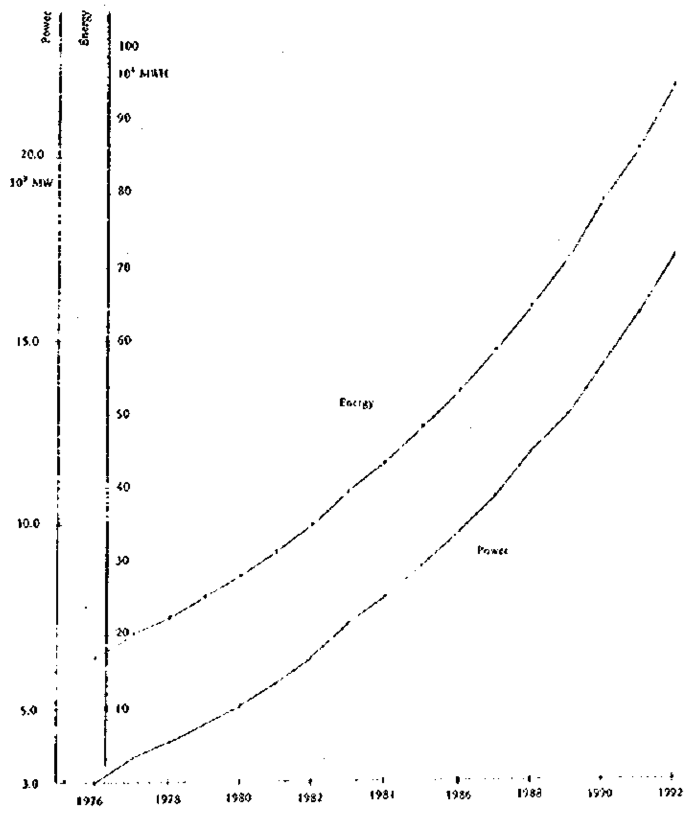
Table 1. Energy and Power Demand — Turkey

Year	Energy 10^6 KWH	Inc. %	Power MW	Inc. %	Hydro 10^6 KWH	%	Thermal 10^6 KWH	%
1960	2,800	12.2	617	11.0	1,000	35.7	1,800	64.3
1961	3,000	7.1	687	11.3	1,250	41.7	1,750	58.3
1962	3,600	20.0	762	10.9	1,150	31.9	1,850	68.1
1963	4,000	11.0	863	13.3	2,100	52.0	3,900	48.0
1964	4,500	12.5	926	7.3	1,650	36.5	2,850	63.5
1965	4,900	8.8	1,026	10.7	3,200	44.9	2,700	55.1
1966	5,500	12.2	1,180	15.0	2,350	42.7	3,150	57.3
1967	6,200	12.7	1,330	12.7	2,400	38.7	3,800	61.3
1968	6,900	11.2	1,450	9.0	3,200	46.4	3,700	53.6
1969	7,800	13.0	1,678	15.7	3,500	44.9	4,500	55.1
1970	8,600	10.2	1,813	8.0	3,000	34.9	5,600	65.1
1971	9,800	13.9	2,016	11.2	2,600	26.5	7,200	73.5
1972	11,200	14.2	2,050	1.6	3,200	28.6	8,000	71.4
1973	12,400	10.7	2,106	2.7	2,700	21.8	9,700	78.2
1974	13,500	8.8	2,733	29.7	3,700	27.4	9,800	72.6
1975	15,600	15.5	2,782	1.7	5,400	34.6	10,200	65.4
Average		10.2		10.7				

Table 2. Load Forecast Turkey

Year	Energy 10^6 KWH	Inc. %	Power MW	Inc. %	Hydro 10^6 KWH	%	Thermal 10^6 KWH	%
1976	17,900	13.3	3,240	16.4	8,000	44.7	9,900	55.3
1977	20,200	12.9	3,650	12.7	8,000	39.6	12,200	60.4
1978	22,700	12.4	4,110	12.6	8,000	35.3	14,700	64.7
1979	25,400	11.9	4,600	11.9	9,800	38.6	15,600	61.4
1980	28,300	11.4	5,130	11.5	10,500	37.1	17,800	62.9
1981	31,500	11.3	5,710	11.3	10,800	34.3	20,700	65.7
1982	35,100	11.4	6,370	11.6	15,000	42.7	20.100	67.3
1983	39,600	12.8	7,250	13.8	22,000	55.6	17,600	44.4
1984	43,700	10.4	8,010	10.5	24,000	54.9	19,700	45.1
1985	48,300	10.5	8,850	10.5	27,000	55.9	21,300	44.1
1986	53,400	10.3	9,785	10.6	28,000	52.4	25,400	47.6
1987	59,000	10.5	10,810	10.5	31,000	52.5	28,000	47.5
1988	64,900	10.0	11,900	10.1	33,000	50.8	31,900	49.2
1989	71,400	10.0	13,100	10.1	35,000	49.0	36.400	51.0
1990	78,500	10.0	14,400	9.9	37,000	47.1	41,500	52.9
1991	86,300	9.9	15,800	9.7	39,000	45.2	47,300	54.8
1992	95,000	10.1	17,400	10.1	42,000	44.2	53,000	55.8
1993	104,000	9.5	19,000	9.2	44,000	42.3	60,000	57.7
1994	114,000	9.6	21,000	10.5	46,000	40.4	68,000	59.6
1995	125,000	9.7	23,000	9.5	48,000	38.9	77,000	61.1
Average		10.9				11.2		

Total Power and Energy Demand Estimate Curve Turkey 1976



5.5 COST OF THE ELECTRICAL EQUIPMENT

5.5.1 Torul Powerpalant

1 $ = 15 TL. = 300 Yen

Description	Unit	Weight	Cost 10^3 Yen	Cost 10^3 TL.
1. Machine		1,849 ton	2,836,000	141,800
(1) Turbine	2	540	920,000	46,000
(2) Cenerator	2	620	990,000	49,500
(3) Main Transformer	1 L.S.	220	156,000	7,800
(4) Control Boad	1 L.S.	9	103,500	5,175
(5) Cubicles etc.	1 L.S.	84	251,000	12,550
(6) Switchyard Equip	1 L.S.	196	85,500	4,275
(7) Crane, M-G etc.	1 L.S.	117	180,000	9,000
(8) Others	1 L.S.	30	50,000	2,500
(9) Telecom. Set	1 Set	30	100,000	5,000
2. Transportation Charge	1 L.S.		184,600	9,230
3. Installation	1 L.S.		567,200	28,360
4. Insurance	1 L.S.		21,200	1,060
5. Others	1 L.S.		142,000	7,100
Total			3,751,000	187,550

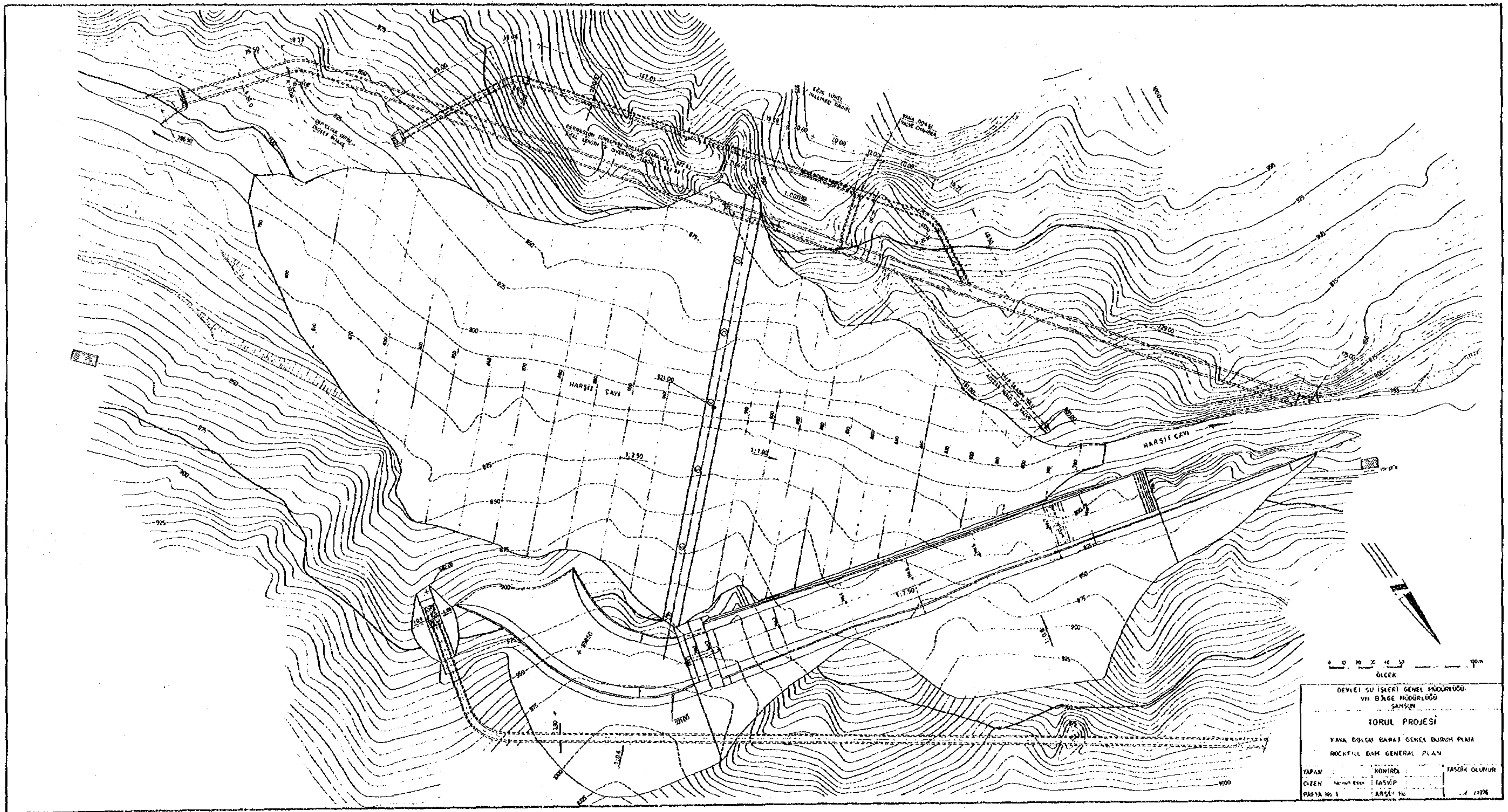
5.5.2 Kürtün Powerplant

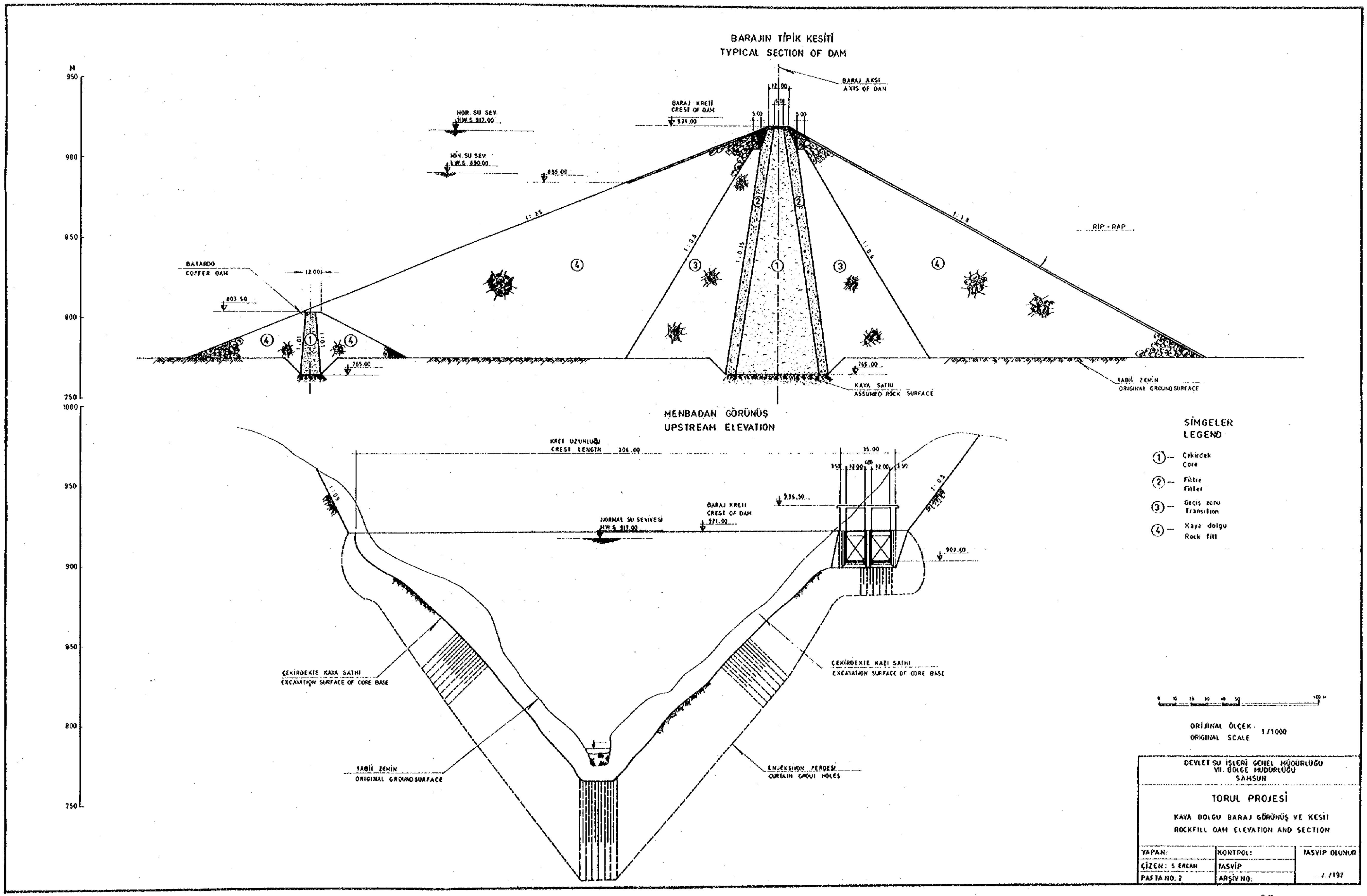
Description	Number	Weight	Cost 10^3 Yen	Cost 10^3 TL.
1. Machine		2,800 ton	4,310,700	215,535
(1) Turbine	2	680	1,056,000	52,800
(2) Generater	2	780	1,078,000	53,900
(3) Main Transformer	1	190	121,000	6,050
(4) Control Boad	1 L.S.	13	118,000	5,900
(5) Cubicles Etc.	1 L.S.	117	241,200	12,060
(6) Switchyard	1 L.S.	830	1,390,500	69,525
(7) Crane, M-G Etc.	1 L.S.	100	126,000	6,300
(8) Others	1 L.S.	40	60,000	6,000
(9) Telecom. Set	1 L.S.	50	120,000	9,000
2. Transportation Charge	1 L.S.		280,000	14,000
3. Installation	1 L.S.		862,200	43,110
4. Insurance	1 L.S.		37,000	1,850
5. Others	1 L.S.		215,100	10,755
Total			5,705,000	285,250

5.5.3 Akköy - I Powerplant

1 $ = 15 TL. = 300 Yen

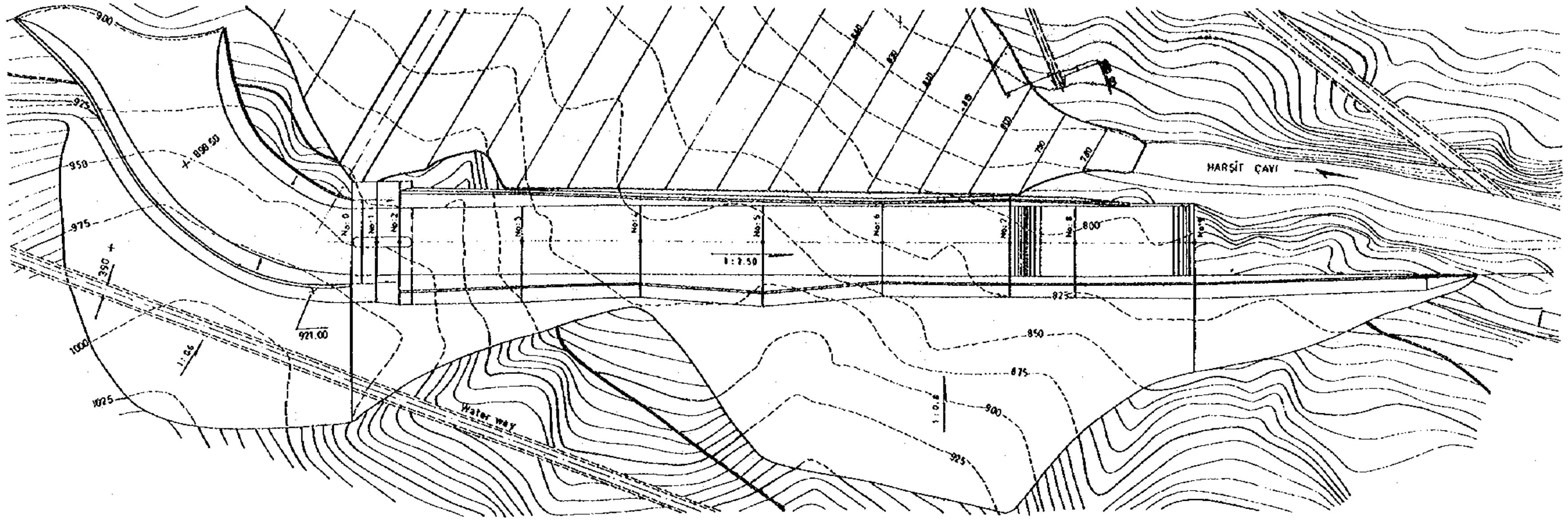
Description	Number	Weight	Cost 10^3 Yen	Cost 10^3 TL.
1. Machine		1,690 ton	2,771,000	138,550
(1) Turbine	2	500	880	44,000
(2) Generator	2	540	924,000	46,200
(3) Main Transformer	1	160	103,800	5,190
(4) Control Boad	1 L.S.	10	156,000	7,800
(5) Cubicles Etc.	1 L.S.	103	299,000	14,950
(6) Switchyard	1 L.S.	196	85,500	4,275
(7) Crane, M-G Etc	1 L.S.	121	172,000	8,600
(8) Others	1 L.S.	30	50,700	2,535
(9) Telecom. Set	1 L.S.	30	100,000	5,000
2. Transportation Charge	1 L.S.		169,000	8,450
3. Installation	1 L.S.		554,000	27,700
4. Insurance	1 L.S.		20,500	1,025
5. Others	1 L.S.		138,500	6,925
Total			3,653,000	182,650


HARŞİT ÇAYI
ÖLÇEK
DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
VII. BÖLGE MÜDÜRLÜĞÜ
SAMSUN
TORUL PROJESİ
KAYA DOLGU BARAJ GENEL DURUM PLANI
ROCKFILL DAM GENERAL PLAN
YAPAN
KONTROL
TASDİK OLUNUR
ÇİZEN
TASVİP
PAFTA No 1
ARŞİV No

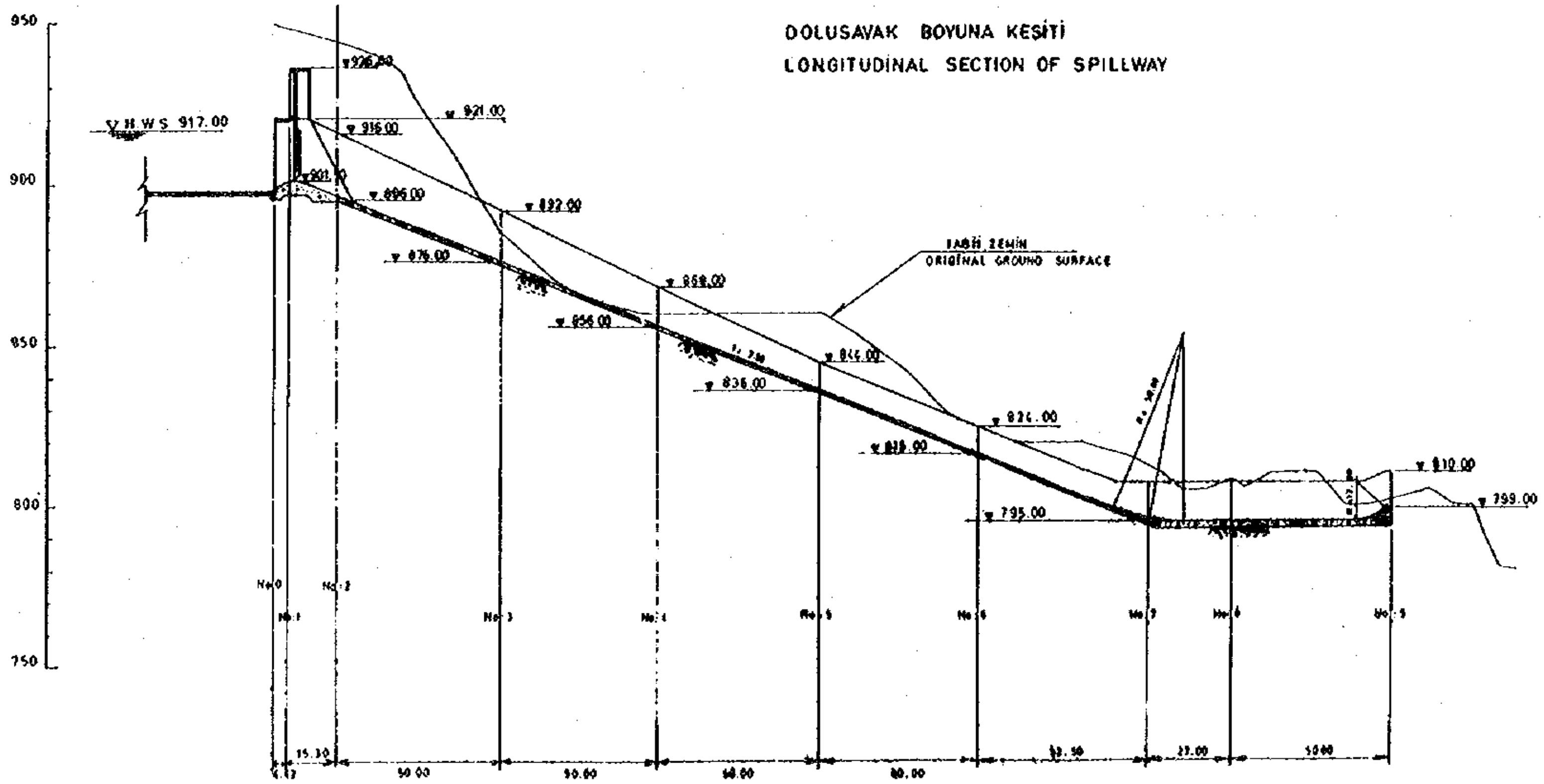


BARAJIN TİPİK KESİTİ
TYPICAL SECTION OF DAM
BARAJ AKSI
AXIS OF DAM
BARAJ KRETİ
CREST OF DAM
921.00
HOR. SU SEV.
H.W.S. 917.00
MİN. SU SEV.
L.W.S. 890.00
885.00
BATARDO
COFFER DAM
12.00
803.50
765.00
RİP - RAP
KAYA SATHI
ASSUMED ROCK SURFACE
TABİİ ZEMİN
ORIGINAL GROUNDSURFACE
MENBADAN GÖRÜNÜŞ
UPSTREAM ELEVATION
KRET UZUNLUĞU
CREST LENGTH 306.00
35.00
936.50
NORMAL SU SEVİYESİ
H.W.S. 917.00
902.00
ÇEKİRDEKTE KAYA SATHI
EXCAVATION SURFACE OF CORE BASE
ÇEKİRDEKTE KAZI SATHI
EXCAVATION SURFACE OF CORE BASE
TABİİ ZEMİN
ORIGINAL GROUNDSURFACE
ENJEKSİYON PERDESİ
CURTAIN GROUT HOLES
SİMGELER
LEGEND
1 — Çekirdek Core
2 — Filtre Filter
3 — Geçiş zonu Transition
4 — Kaya dolgu Rock fill
ORİJİNAL ÖLÇEK
ORIGINAL SCALE 1/1000
DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
VII. BÖLGE MÜDÜRLÜĞÜ
SAMSUN
TORUL PROJESİ
KAYA DOLGU BARAJ GÖRÜNÜŞ VE KESİT
ROCKFILL DAM ELEVATION AND SECTION
YAPAN:
KONTROL:
TASVİP OLUNUR
ÇİZEN: S. ERCAN
TASVİP
PAFTA NO: 2
ARŞİV NO:
/ /197

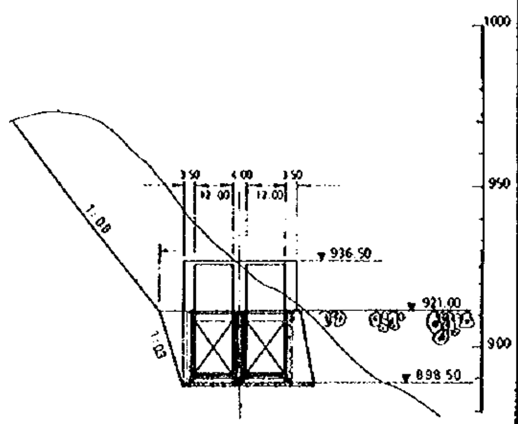
DOLUSAVAK PLÂNI
PLAN OF SPILLWAY



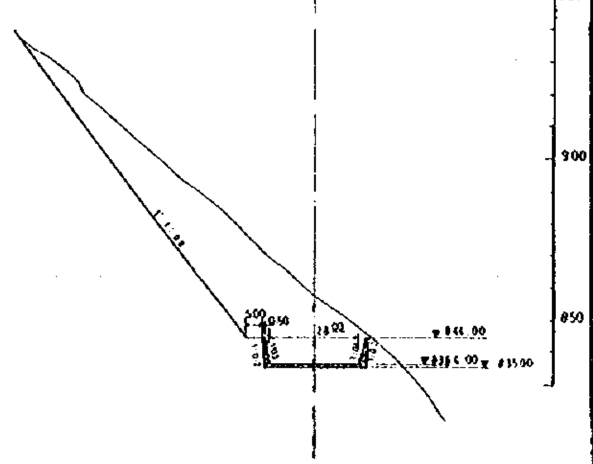
DOLUSAVAK BOYUNA KESİTİ
LONGITUDINAL SECTION OF SPILLWAY

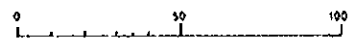


SECTION No: 0



SECTION No: 5



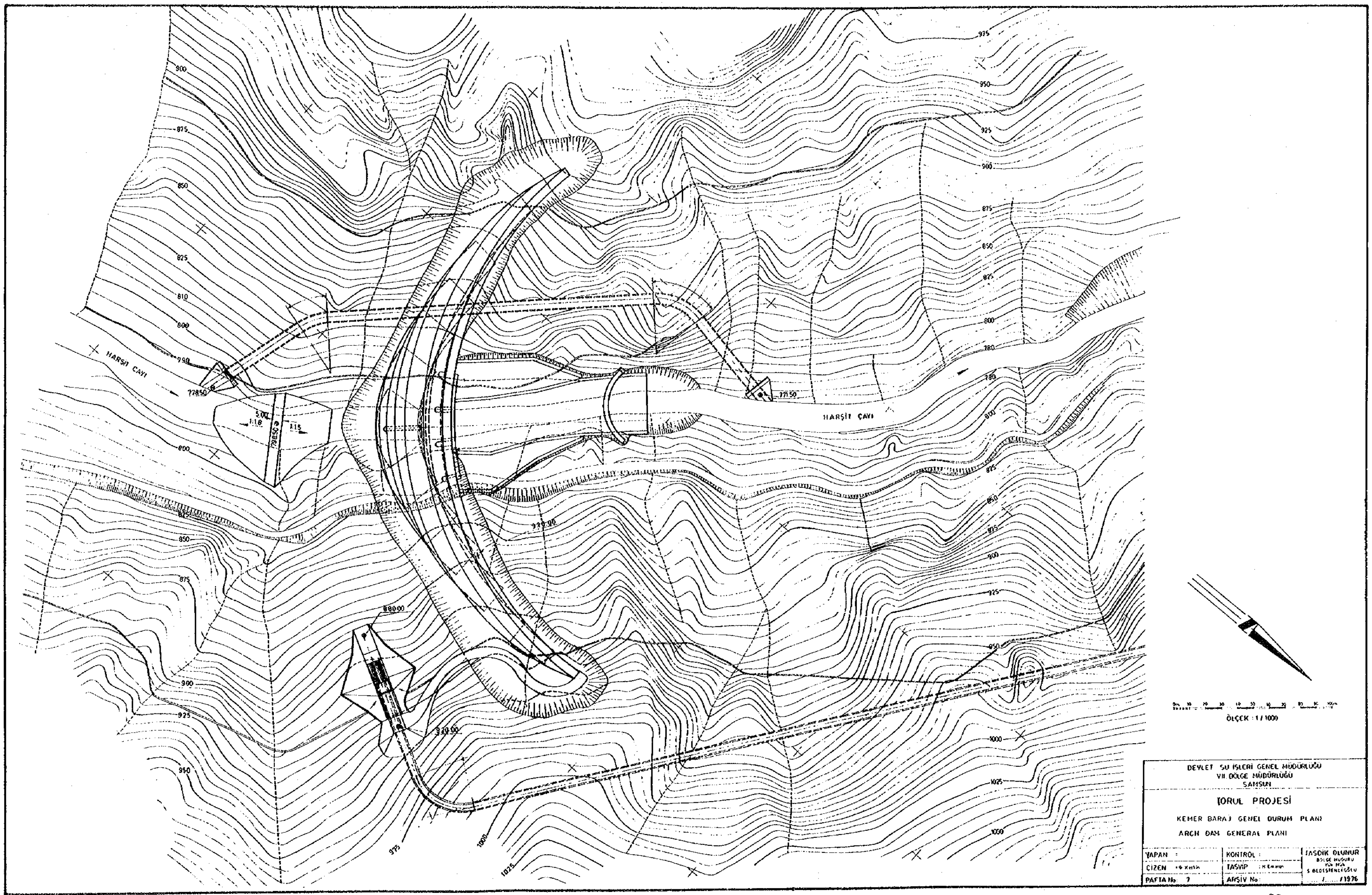


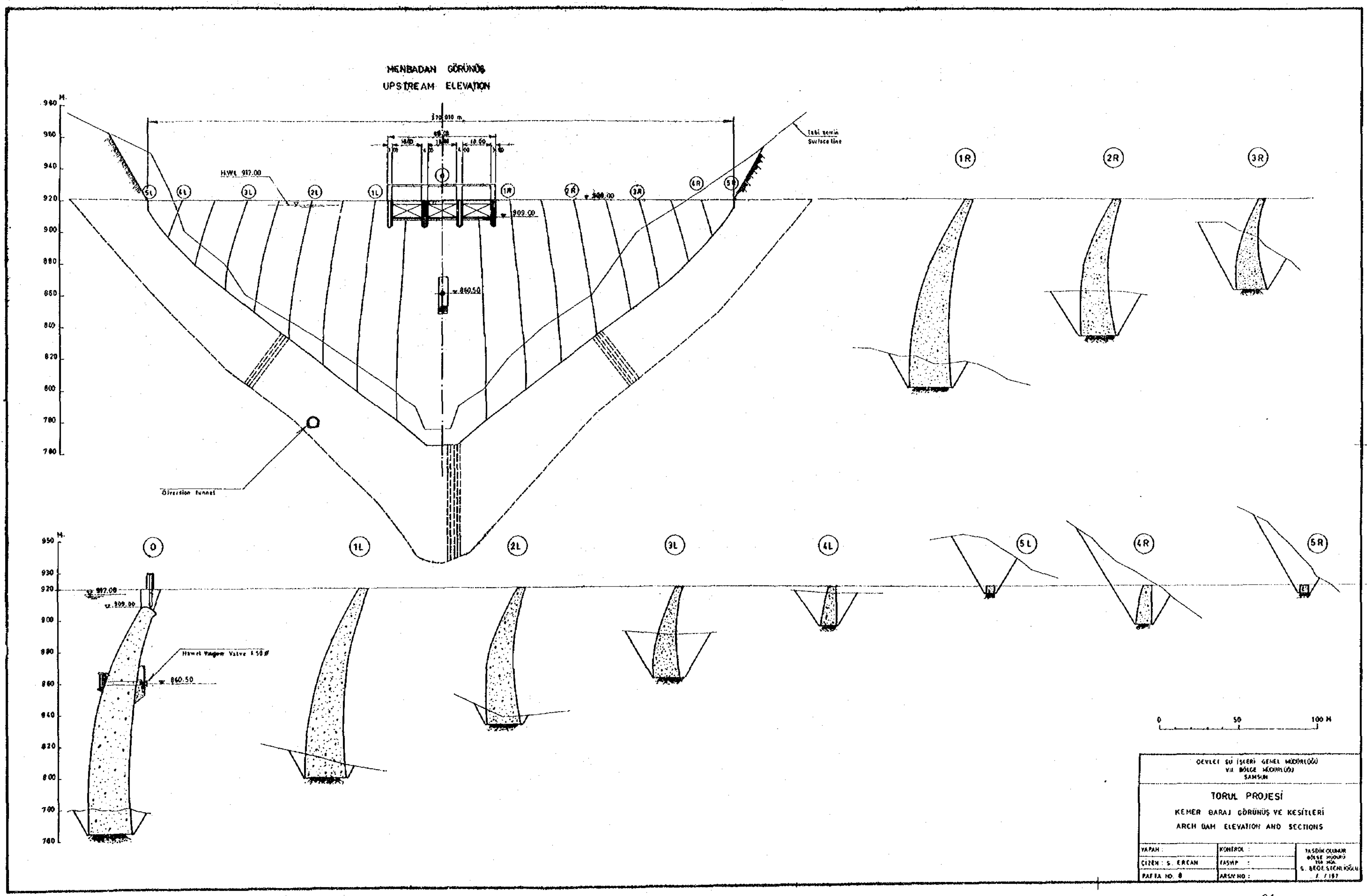
DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
VII. BÖLGE MÜDÜRLÜĞÜ
SAMSUN

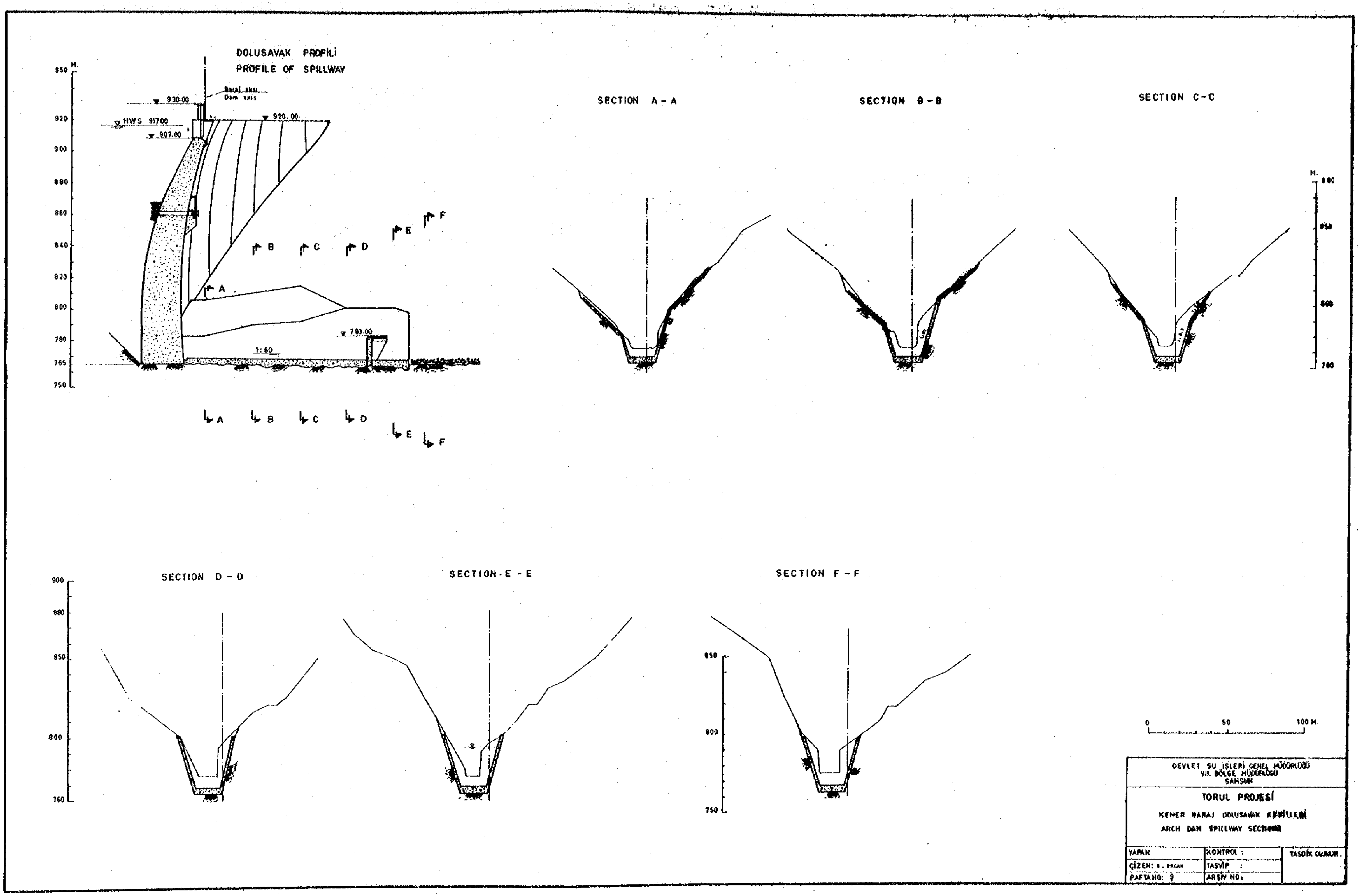
TORUL PROJESİ

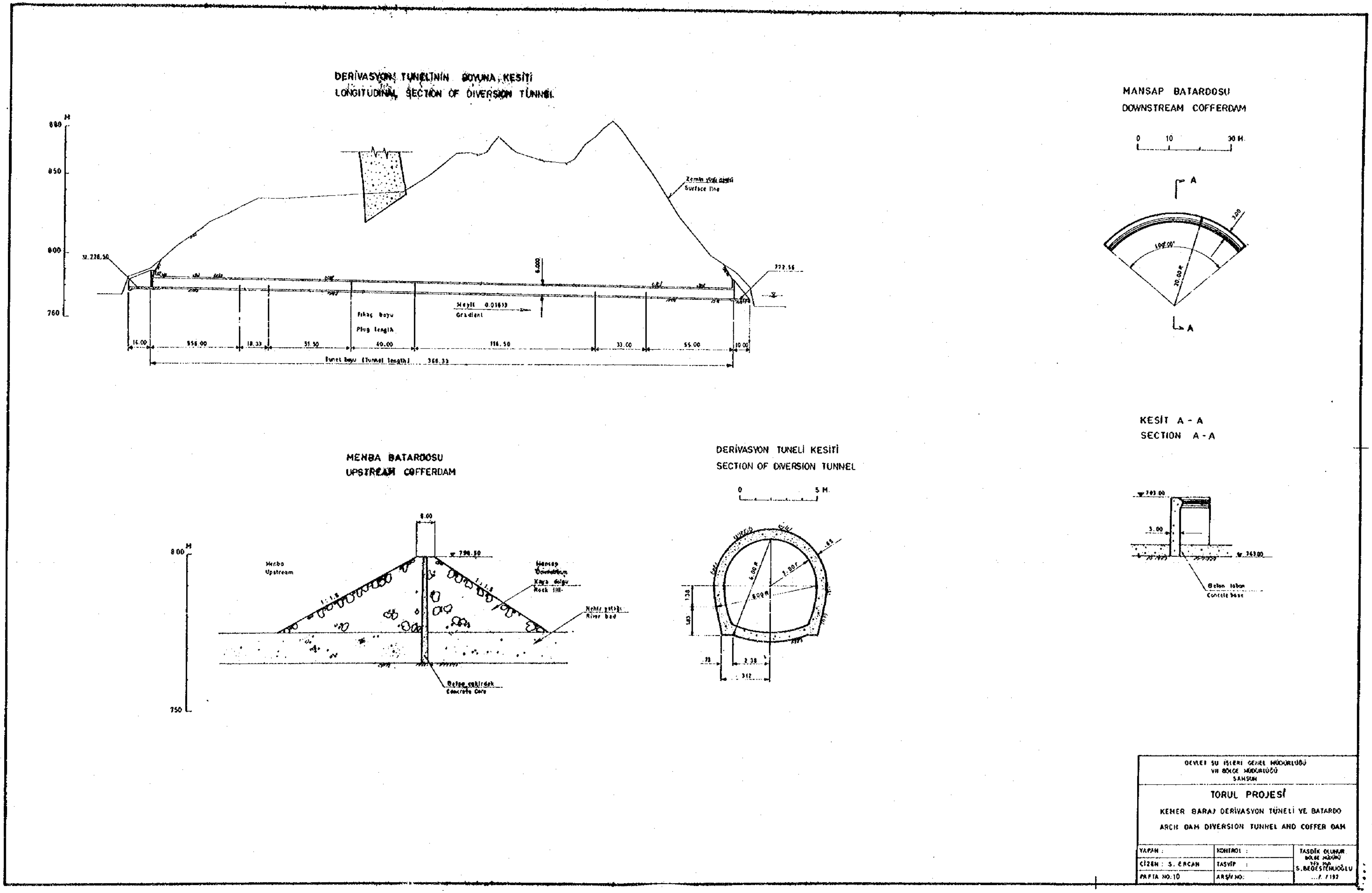
KAYA DOLGU BARAJ DOLUSAVAK PLAN VE KESİTLERİ
ROCKFILL DAM SPILLWAY PLAN AND SECTION

YAPAN :	KONTROL :	TASDİK OLUNUR
ÇİZEN : S. ERCAN	TASVİP :	../../19?
PAFTA NO. 3	ARŞİV NO:	

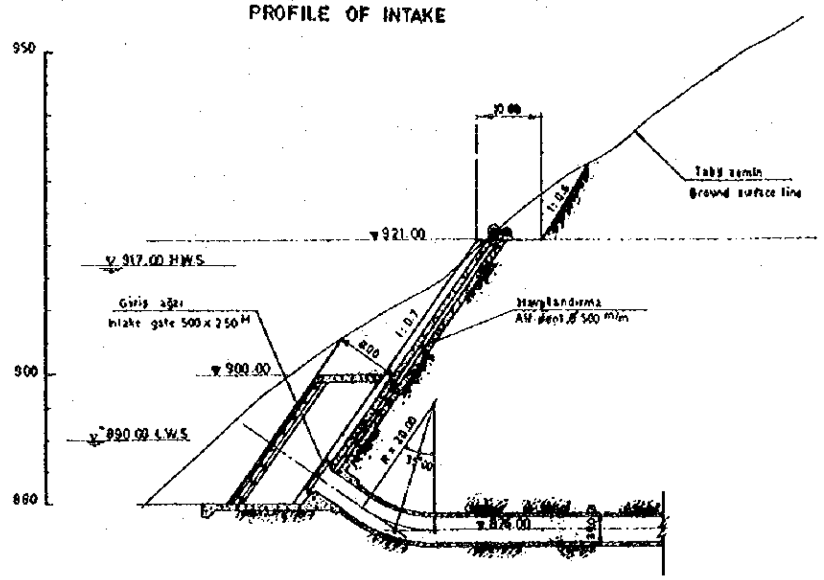

HARŞİT ÇAYI
HARŞİT ÇAYI
ÖLÇEK : 1/1000
DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
VII. BÖLGE MÜDÜRLÜĞÜ
SAMSUN
TORUL PROJESİ
KEMER BARAJ GENEL DURUM PLANI
ARCH DAM GENERAL PLANI
YAPAN :
KONTROL :
TASDİK OLUNUR
ÇİZEN
TASVİP
PAFTA No: 7
ARŞİV No:
....../....../1976


MENBADAN GÖRÜNÜŞ
UPSTREAM ELEVATION
H.W.L. 917.00
909.00
860.50
Tabi zemin
Surface line
Diversion tunnel
Howel Bunger Valve
DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
VII. BÖLGE MÜDÜRLÜĞÜ
SAMSUN
TORUL PROJESİ
KEMER BARAJ GÖRÜNÜŞ VE KESİTLERİ
ARCH DAM ELEVATION AND SECTIONS
YAPAN :
ÇİZEN : S. ERCAN
KONTROL :
TASVİP :
ARŞİV NO :
TASDİK OLUNUR
BÖLGE MÜDÜRÜ
0
50
100 M

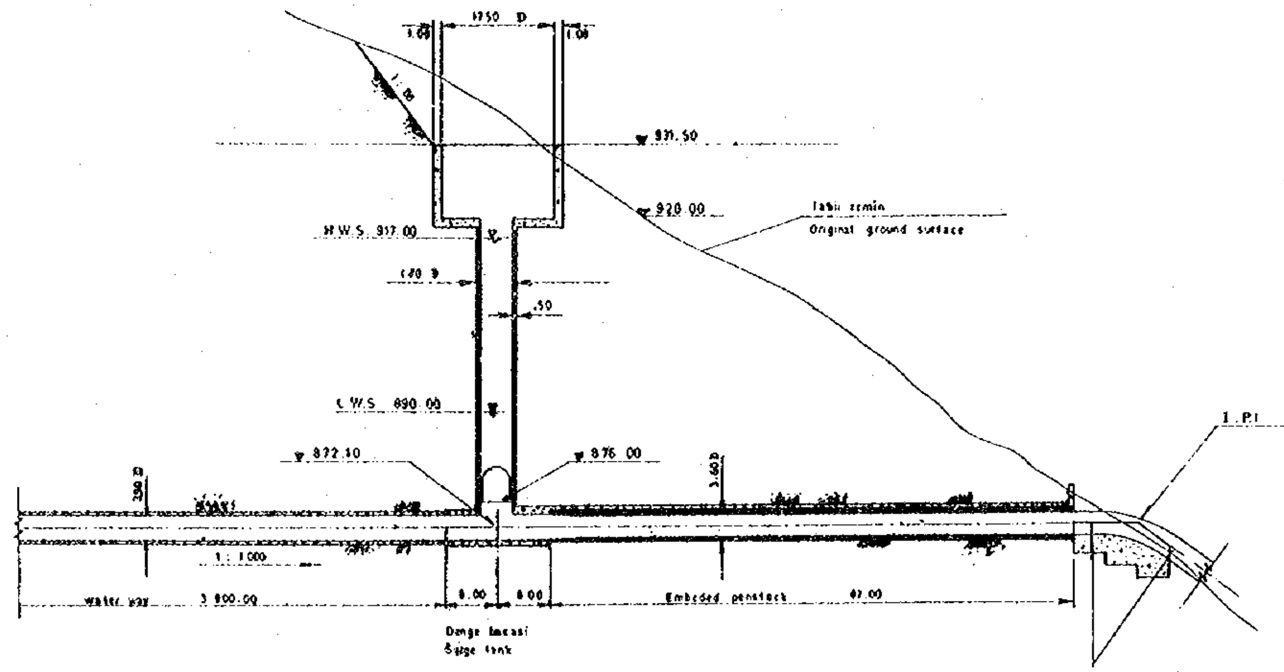

DOLUSAVAK PROFİLİ
PROFILE OF SPILLWAY
Baraj aksı
Dam axis
930.00
920.00
HWS 917.00
907.00
793.00
1:60
SECTION A - A
SECTION B - B
SECTION C - C
SECTION D - D
SECTION E - E
SECTION F - F
0
50
100 M.
DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
VII. BÖLGE MÜDÜRLÜĞÜ
SAMSUN
TORUL PROJESİ
KEMER BARAJ DOLUSAVAK KESİTLERİ
ARCH DAM SPILLWAY SECTIONS
YAPAN
ÇİZEN:
PAFTANO: 9
KONTROL :
TASVİP :
ARŞİV NO:
TASDİK OLUNUR.


DERİVASYON TÜNELİNİN BOYUNA KESİTİ
LONGITUDINAL SECTION OF DIVERSION TUNNEL
Zemin yüzü çizgisi
Surface line
Meyil 0.01613
Gradient
Tıkaç boyu
Plug length
16.00
18.33
51.50
40.00
116.50
33.00
55.00
10.00
Tünel boyu (Tunnel length) 368.33
MANSAP BATARDOSU
DOWNSTREAM COFFERDAM
0
10
30 M.
A
20.00 R
KESİT A - A
SECTION A - A
3.00
Beton taban
Concrete base
MENBA BATARDOSU
UPSTREAM COFFERDAM
8.00
▽ 790.50
Menba
Upstream
Mansap
Downstream
Kaya dolgu
Rock fill
Nehir yatağı
River bed
Beton çekirdek
Concrete Core
DERİVASYON TÜNELİ KESİTİ
SECTION OF DIVERSION TUNNEL
0
5 M.
2.38
3.12
DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
VII BÖLGE MÜDÜRLÜĞÜ
SAMSUN
TORUL PROJESİ
KEMER BARAJ DERİVASYON TÜNELİ VE BATARDO
ARCH DAM DIVERSION TUNNEL AND COFFER DAM
YAPAN :
KONTROL :
ÇİZEN : S. ERCAN
TASVİP :
PAFTA NO:10
ARŞİV NO:
TASDİK OLUNUR
BÖLGE MÜDÜRÜ
S.BEDESTENCİOĞLU

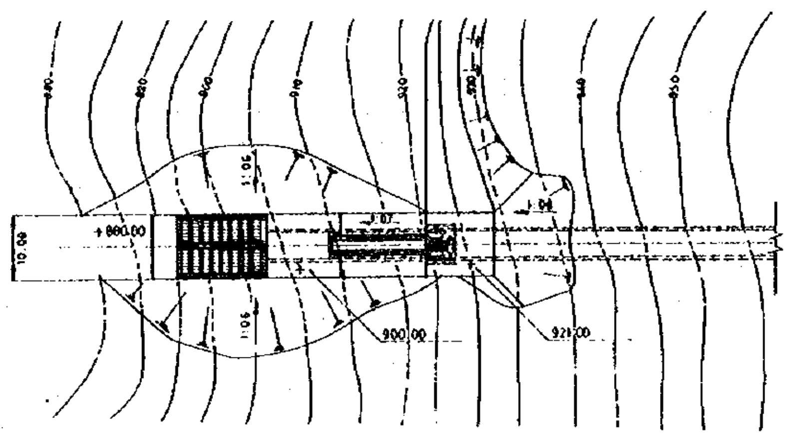
SU ALMA AĞZI PROFİLİ
PROFILE OF INTAKE



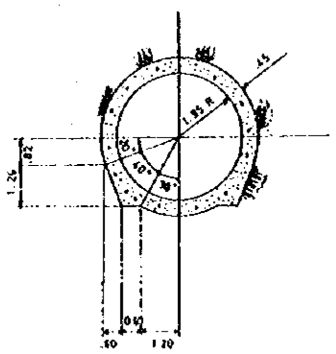
DENGE BACASI PROFİLİ
PROFILE OF SURGE TANK



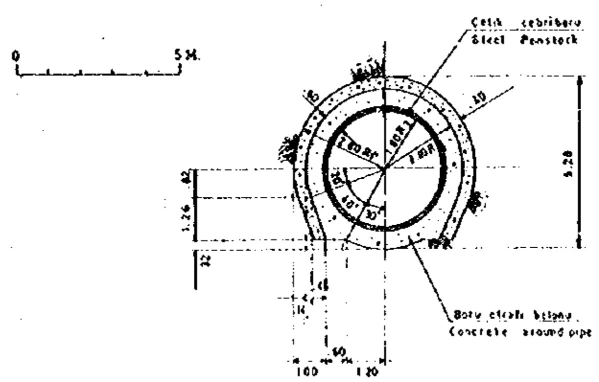
SU ALMA AĞZI PLANI
PLAN OF İNTAKE



SECTION OF WATERWAY

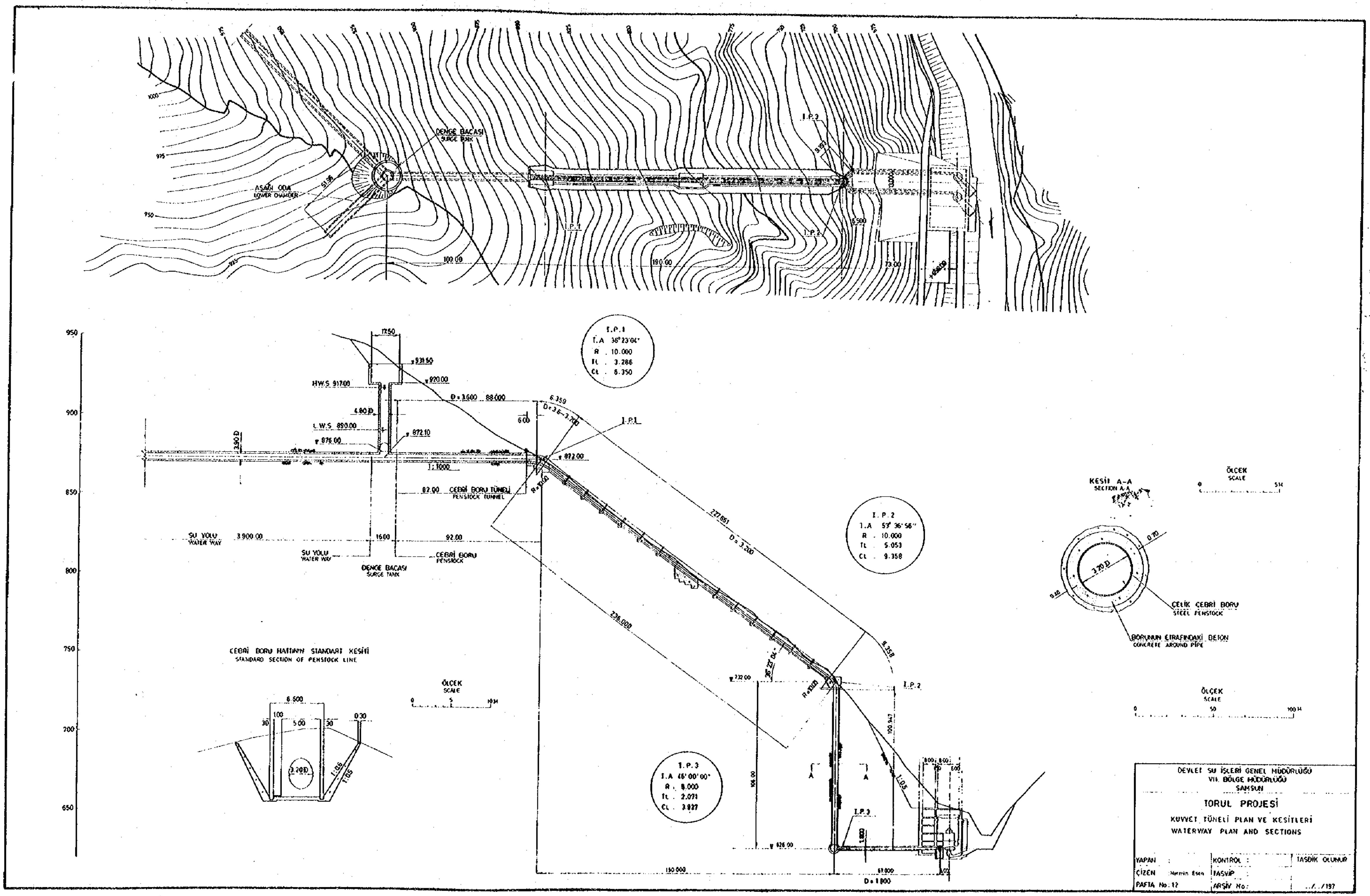


SECTION OF EMBEDED PENSTOCK



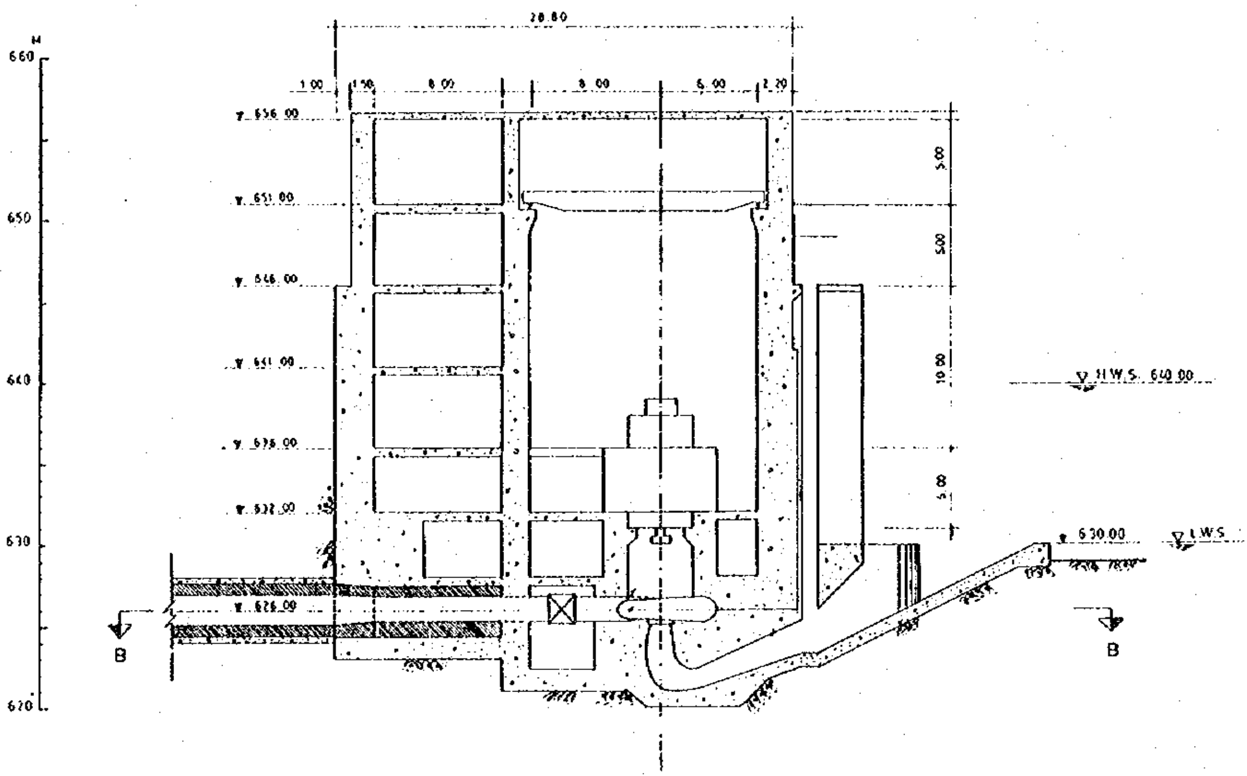
ÖLÇEK: 1/500

DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ VII. BÖLGE MÜDÜRLÜĞÜ SAMSUN		
TORUL PROJESİ		
SUALMA YAPISI, DENGE BACASI PLAN VE KESİTLERİ INTAKE, SURGE TANK PLAN AND SECTIONS		
YAPAN:	KONTROL:	TASDİK OLUNUR.
ÇİZEN: S. ERCAN	TASVİP:	../../197
PAFTA NO: 11	ARŞİV NO:	


DENGE BACASI
SURGE TANK
AŞAĞI ODA
LOWER CHAMBER
I.P.1
I.P.2
I.P.3
HWS 917.00
LWS 890.00
CEBRİ BORU TÜNELİ
PENSTOCK TUNNEL
SU YOLU
WATER WAY
CEBRİ BORU
PENSTOCK
I.P.1
I.A 36°23'04"
R . 10.000
TL . 3.286
CL . 6.350
I.P.2
I.A 53°36'56"
R . 10.000
TL . 5.053
CL . 9.358
I.P.3
I.A 46°00'00"
R . 8.000
TL . 2.071
CL . 3.827
KESİT A-A
SECTION A-A
ÇELİK CEBRİ BORU
STEEL PENSTOCK
BORUNUN ETRAFINDAKİ BETON
CONCRETE AROUND PIPE
CEBRİ BORU HATTININ STANDART KESİTİ
STANDARD SECTION OF PENSTOCK LINE
ÖLÇEK
SCALE
DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
VII. BÖLGE MÜDÜRLÜĞÜ
SAMSUN
TORUL PROJESİ
KUVVET TÜNELİ PLAN VE KESİTLERİ
WATERWAY PLAN AND SECTIONS
YAPAN :
KONTROL :
TASDİK OLUNUR
ÇİZEN : Nermin Esen
TASVİP :
PAFTA No: 12
ARŞİV No:
../../197

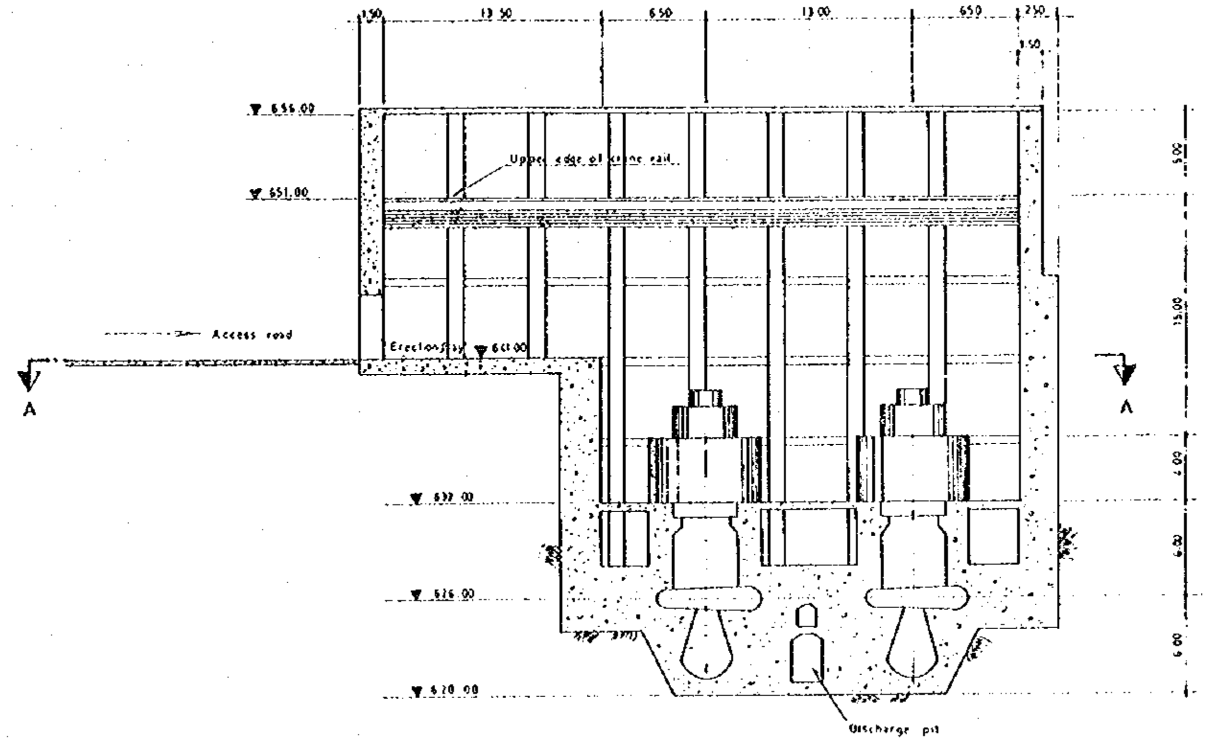
SANTRAL ENİNE KESİTİ

TRANSVERSE SECTION OF MACHINE HALL

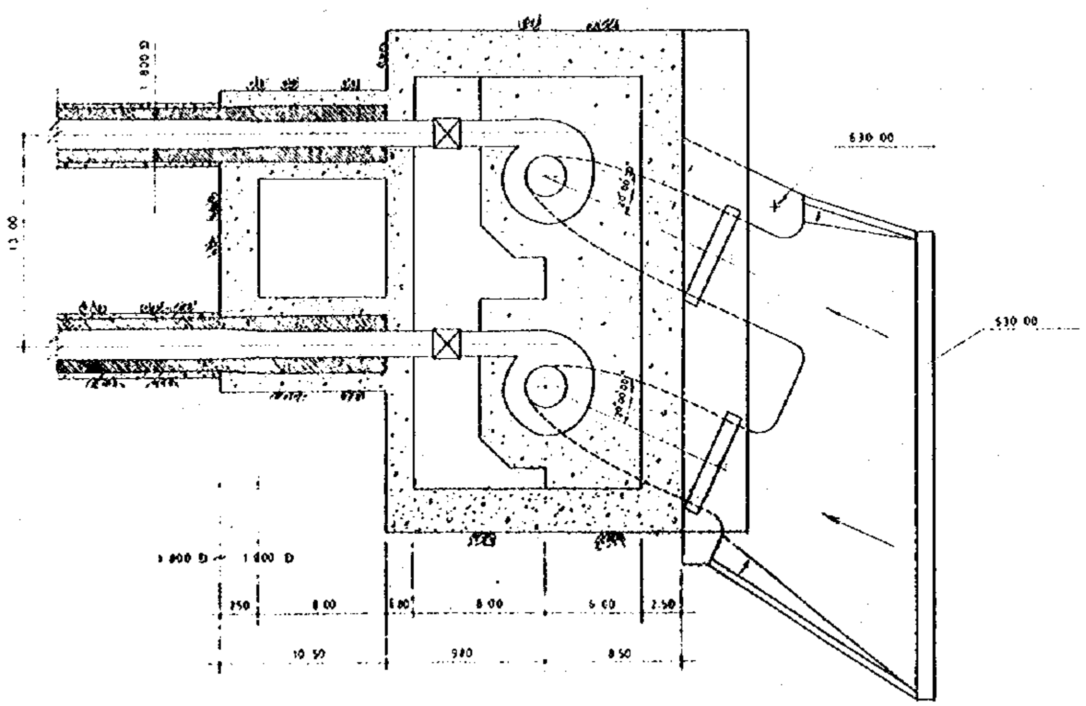


SANTRAL BOYUNA KESİTİ

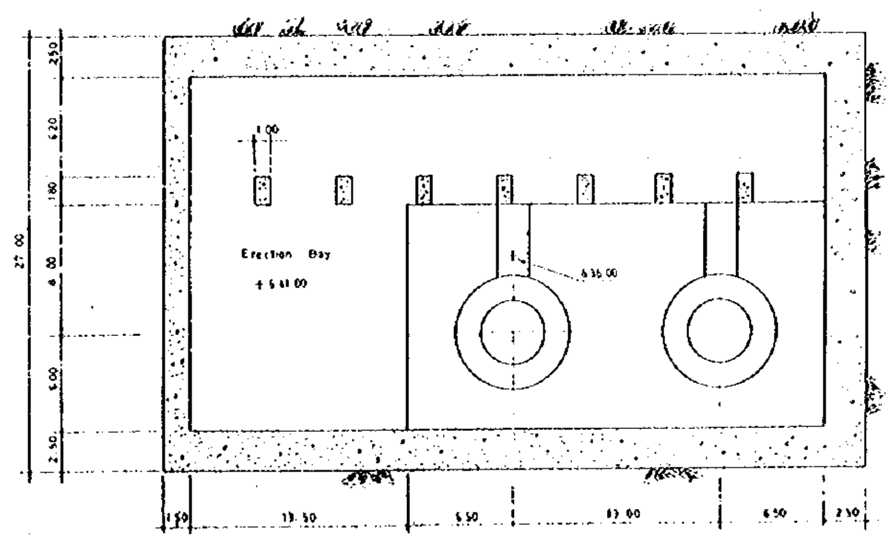
LONGITUDINAL SECTION OF MACHINE HALL



SECTION B – B (EL. 626.00)



SECTION A – A (EL. 641.00)



0 10 20 M

ÖLÇEK : 1/200

DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
VII. BÖLGE MÜDÜRLÜĞÜ
SAMSUN

TORUL PROJESİ

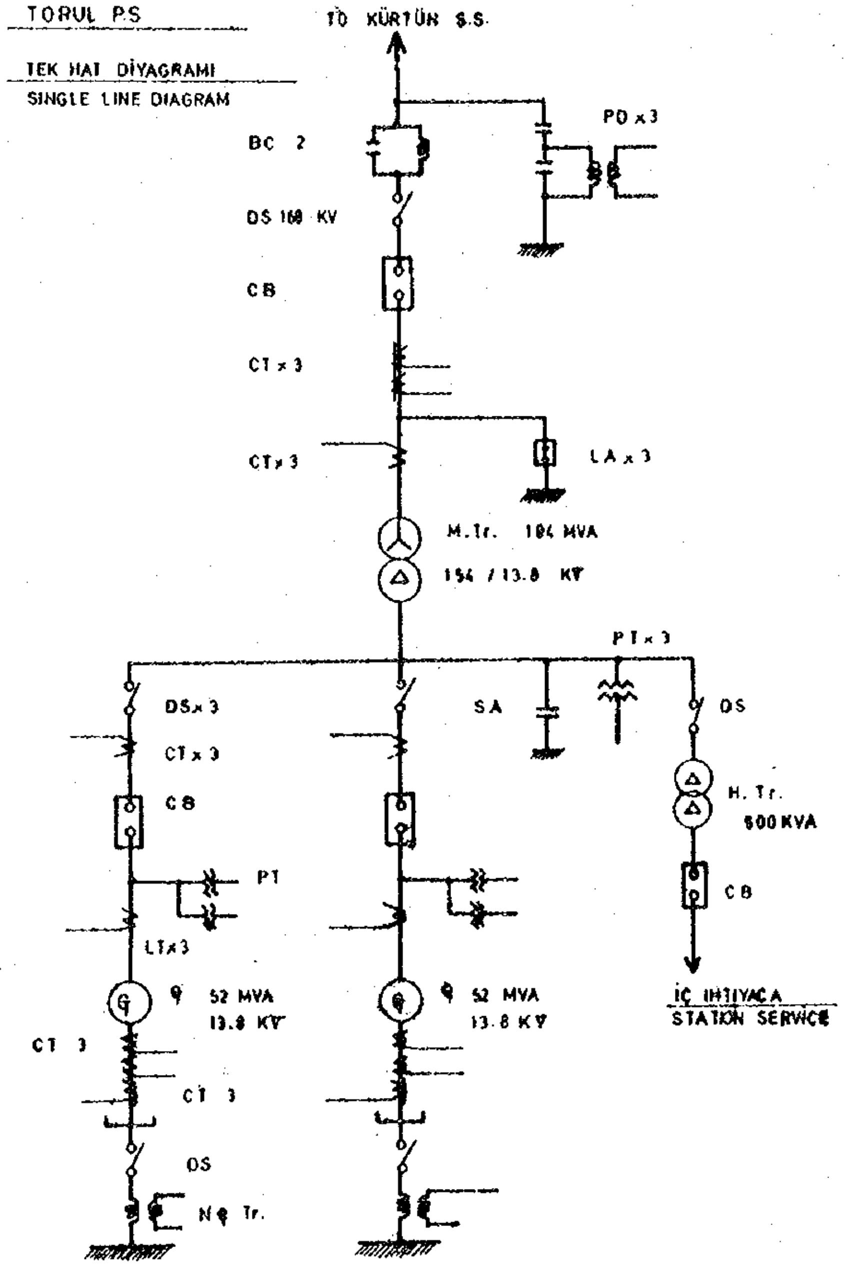
SANTRAL PLAN VE KESİTLERİ

POWER PLANT SECTIONS

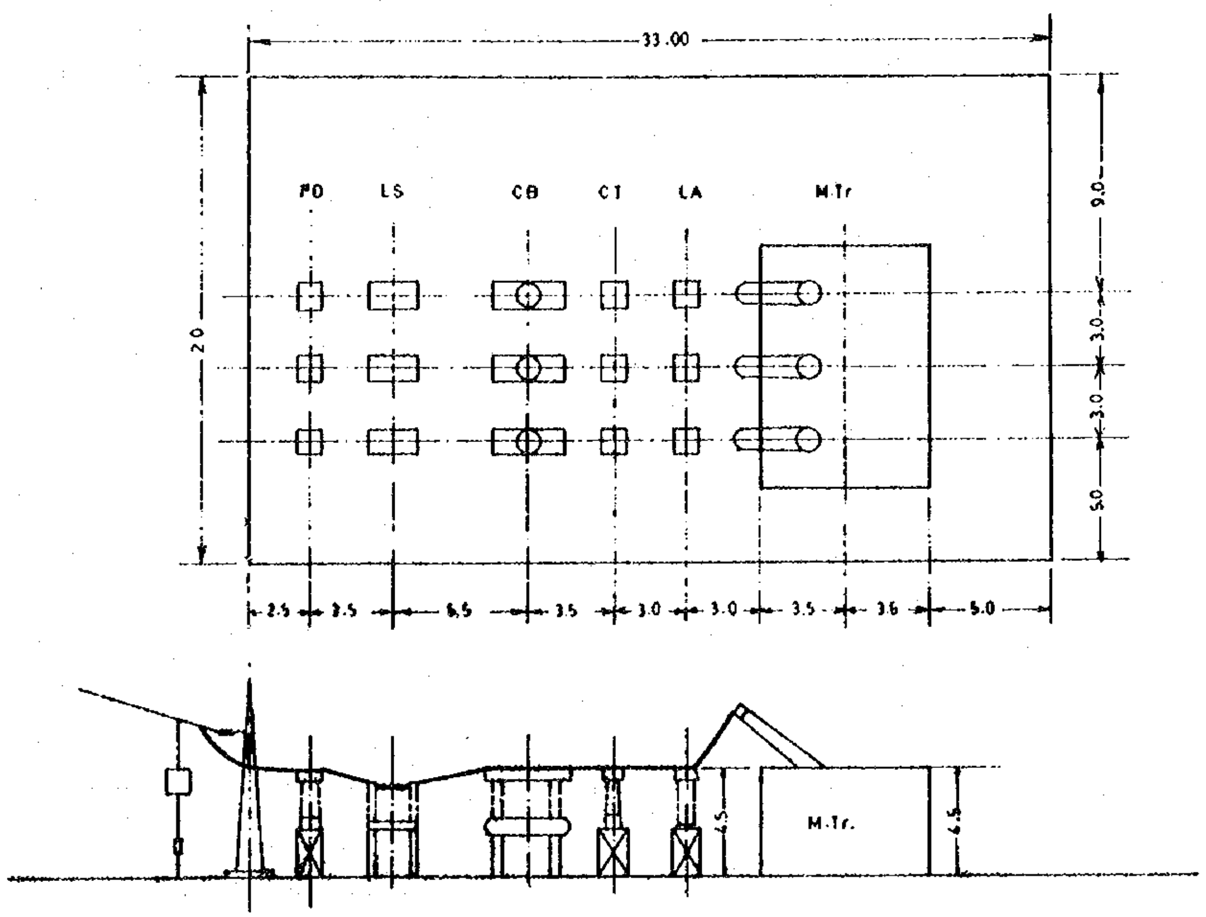
YAPAN:	KONTROL:	TASDİK OLUNUR.
ÇİZEN : S. ERCAN	TASVİP	
PAFTA NO: 13	ARŞİV NO:	... / ../197

TORUL P.S

TEK HAT DİYAGRAMI
SINGLE LINE DIAGRAM



TORUL P.S SWICHYARD EGUİP



İŞARETLER
LEGEND

Ge : JENERATÖR
GENERATOR

MTr : ANA TRANSFORMATÖRÜ
MAIN TRANSFORMER

CB : KESİCİ
CIRCUIT BREAKER

DS : AYIRICI
DISCONNESTING SWITCH

CT : AKIM TRASFORMATÖRÜ
CURRENT TRANSFORMER

PD : GERİLİM CİHAZI
POTENTIAL DEVICE

PT : GERİLİM TRANSFORMATORU
POTENTIAL TRANSFORMER

LA : PARAFUDR
LIGHTNIN ARRESTER

LT : TIKAÇ BOBİNİ
LINE TRAP

NGT : NÖTR TOPRAKLAMA TRASFORMATÖRÜ
NEUTRAL GROUNDING TRANSFORMER

SA : DARBE YUTUCU
SURGE ABSORBER

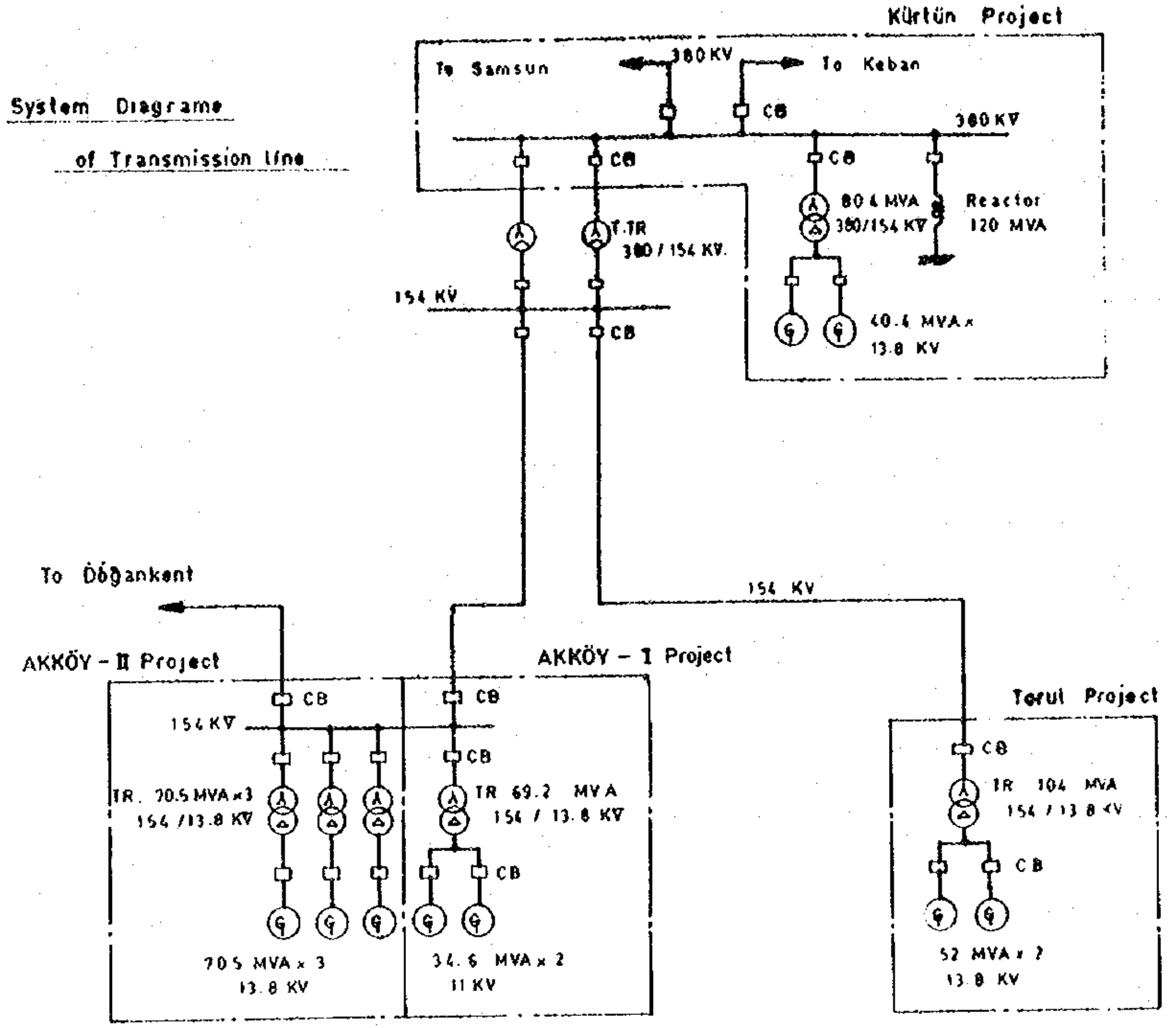
DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
VII. BÖLGE MÜDÜRLÜĞÜ
SAMSUN

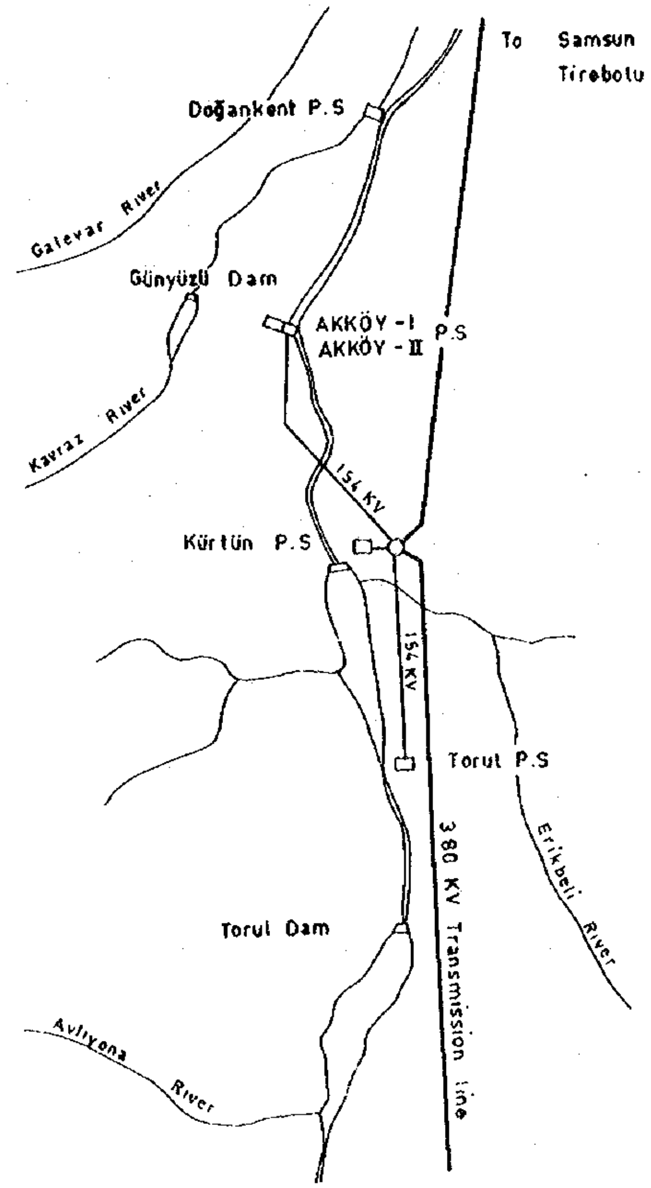
TORUL PROJECT

TORUL ŞALT SAHASI TEK HAT DİYAGRAMI
TORUL SWITCH YARD SİNGLE LİNE DIAGRAM

YAPAN.	KONTROL:	TASDIK OLUNUR
ÇİZEN: S. ERCAN	TASVİP :	
KOD /4	ARSIV NO:	/ / 197

System Diagrame of Transmission line





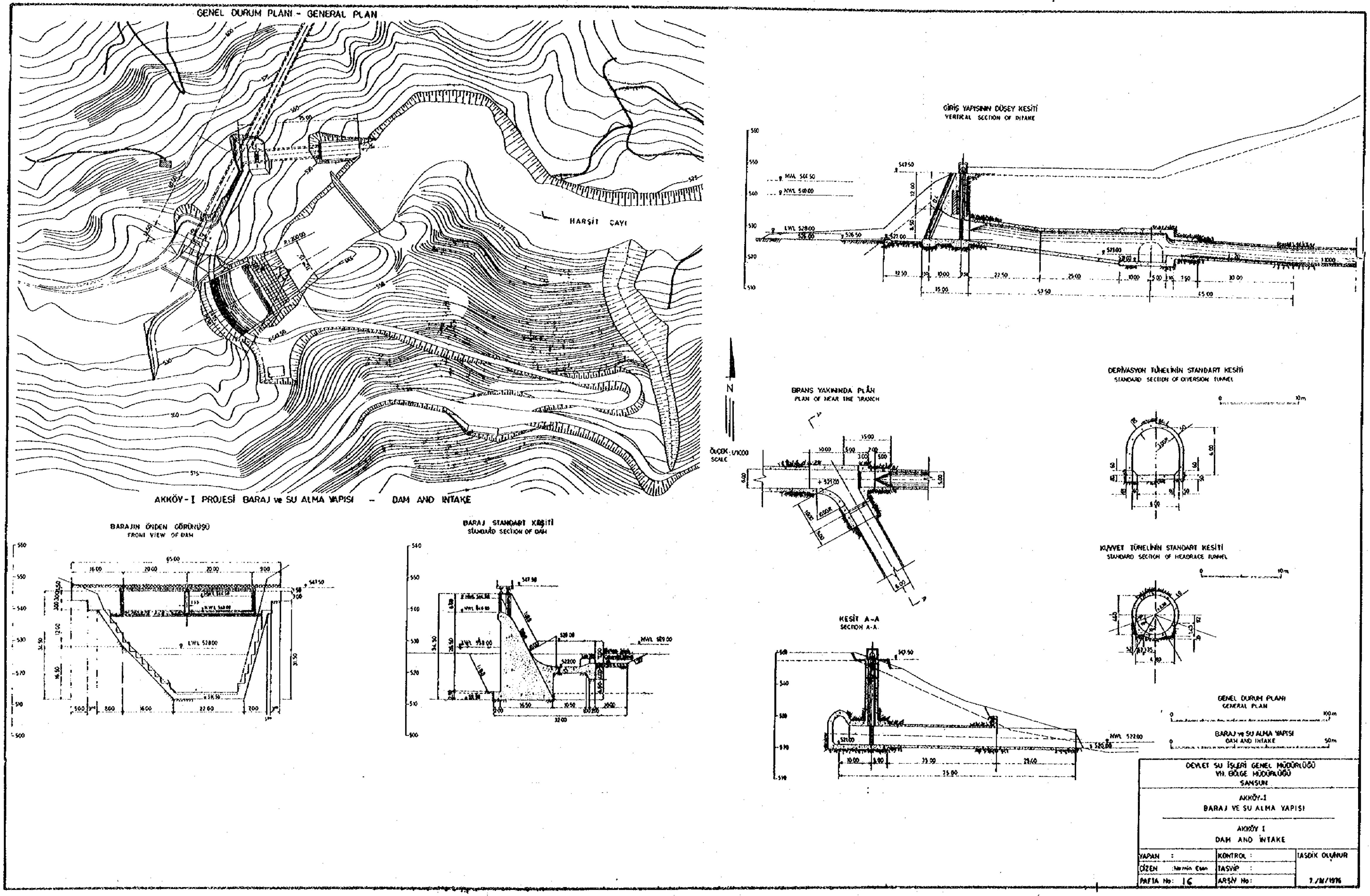
DEVLET SU IŞLERİ GENEL MÜDÜRLÜĞÜ
VII BÖLGE MÜDÜRLÜĞÜ
SAMSUN

TORUL PROJESİ

NAKİL HATTI

TRANSMİSSON ROUTE

YAPAN:	KONTROL	TASDİK OLUNUR
ÇİZEN: S. ERCAN	TASVIP	
KOD NO: 15	ARSIVNO	/../197


GENEL DURUM PLANI - GENERAL PLAN
HARŞİT ÇAYI
AKKÖY - I PROJESİ BARAJ ve SU ALMA YAPISI - DAM AND INTAKE
GİRİŞ YAPISININ DÜSEY KESİTİ
VERTICAL SECTION OF INTAKE
BRANŞ YAKININDA PLAN
PLAN OF NEAR THE BRANCH
DERİVASYON TÜNELİNİN STANDART KESİTİ
STANDARD SECTION OF DIVERSION TUNNEL
KUVVET TÜNELİNİN STANDART KESİTİ
STANDARD SECTION OF HEADRACE TUNNEL
BARAJIN ÖNDEN GÖRÜNÜŞÜ
FRONT VIEW OF DAM
BARAJ STANDART KESİTİ
STANDARD SECTION OF DAM
KESİT A-A
SECTION A-A
ÖLÇEK: 1/1000
SCALE
GENEL DURUM PLANI
GENERAL PLAN
BARAJ ve SU ALMA YAPISI
DAM AND INTAKE
DEVLET SU İŞLERİ GENEL MÜDÜRLÜĞÜ
VII. BÖLGE MÜDÜRLÜĞÜ
SAMSUN
AKKÖY-I
BARAJ VE SU ALMA YAPISI
AKKÖY I
DAM AND İNTAKE
YAPAN :
ÇİZEN : Nermin Esen
PAFTA No: 16
KONTROL :
TASVİP :
ARŞİV No:
TASDİK OLUNUR