ILISU DAM AND HEPP, INVESTIGATION OF ALTERNATIVE SOLUTIONS

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ABSTRACT

ILISU DAM AND HEPP, INVESTIGATION OF ALTERNATIVE SOLUTIONS

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This study is an assessment of a hydraulic solution not only rescues Hasankeyf with countless ancient monuments from inundation but also supplies the foreseen energy production of the Ilisu Dam and HEPP Project. An alternative composed of five dams on the Tigris River and its branches was developed as a result of the conducted hydro-meteorological, water potential, flood analysis and optimization studies considering the topographical and geological characteristics of the proposed dam locations. While there is a 27 percent decrease in the overall reservoir area compared to the existing project, 4426.1 hm^3 of water can be stored in these dams with a fill volume of 14.8 hm^3. Over this storage, determined according to the maximum water levels designated by considering the upstream schemes developed by General Directorate of State Hydraulic Works (DSI), General Directorate of Electrical Power Resources Survey and Development Administration (EIE) and incorporated companies according to Law No.4628, a volume of 3634.4 hm^3 can be used as active storage. In the fully developed upstream stage, according to the conducted consecutive operation studies, while the existing project has an energy production capacity of 3094.3 GWh/year, the proposed project is capable of providing 3139.1 GWh/year with a smaller installed power although there is a slight decrease in the produced firm energy.

Keywords: Ilisu Dam, Hasankeyf, Hydropower, Tigris Basin

ÖZ

ILISU BARAJI VE HES, ALTERNATİF ÇÖZÜMLERİN ARAŞTIRILMASI

Yalçın, Emrah
Yüksek Lisans, İnşaat Mühendisliği Bölümü
Tez Yöneticisi: Yrd. Doç. Dr. Şahnaz Tiğrek

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Bu çalışma, hem sayısız tarihi eserle beraber Hasankeyf'i sular altında kalmaktan kurtaracak hem de Ilısu Barajı ve HES Projesi ile elde edilmesi öngörülen enerjiyi sağlayacak hidrolik bir çözüm araştırmasıdır. Gerçekleştirilen hidrometeoroloji, su temini, taşkın analizi ve optimizasyon çalışmaları sonucunda, Dicle Nehri ve kollarında toplam beş barajdan oluşan bir alternatif, seçilen baraj yerlerinin topografik ve jeolojik özellikleri dikkate alınarak geliştirilmiştir. Mevcut proje ile karşılaştırıldığında toplam rezervuar alanında yüzde 27 oranında bir azalma olmakla beraber, bu barajlarda toplam 14,8 hm^3'lük bir dolgu hacmi ile 4426,1 hm^3 su depolanabilecektir. Devlet Su İşleri Genel Müdürlüğü (DSİ), Elektrik İşleri Etüt İdaresi Genel Müdürlüğü (EİE) ve 4628 sayılı kanun kapsamında tüzel kişiler tarafından geliştirilen projeler dikkate alınarak tespit edilen maksimum su seviyelerine göre belirlenen bu hacmin 3634,4 hm^3'ü aktif hacim olarak kullanılabilecektir. Tam gelişmeli memba durumunda, gerçekleştirilen ardışık işletme çalışmalarına göre, mevcut proje 3094,3 GWh/yıl enerji üretim kapasitesine sahipken, sunulan proje daha düşük bir kurulu güç ile, birincil enerjide bir miktar azalma olmakla birlikte, 3139,1 GWh/yıl enerji üretimi sağlayabilecektir.

Anahtar Kelimeler: Ilısu Barajı, Hasankeyf, Hidroelektrik, Dicle Havzası

To My Family

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SYMBOLS AND ABBREVIATIONS

DAM (I) : Monthly mean inflow values in operation study of dam

DAM (O) : Monthly mean outflow values obtained by operation study of dam reservoir

Q_{DAM} : Monthly mean flow values at dam location

$Q_{STATION}$: Monthly mean flow values at station location

A_{DAM} : Drainage area of dam

$A_{STATION}$: Drainage area of station

CHAPTER 1

INTRODUCTION

1.1. General

Investigations on energy potential of the Tigris River, came into existence with reconnaissance studies resulted as use of elevations between 500 m and 370 m by Ucagac, Celikhan and Cizre Dams, were finalized in the feasibility report of Cizre Dam, offers a system composed of two dam projects, namely Ilisu and Cizre (FPGA, 1968; Ilisu Hydropower Consultants, November 1983). However, there was an item not taken into consideration throughout these studies: a submerged international heritage, Hasankeyf.

After the release of the report “*Dams and Development*” by the World Commission on Dams in 2000, large dams have been under the debate in all around the world. Ilisu Dam received immediate attraction from national and international platforms. A great effort paid by the authorities to make it possible to be supported by the international export credit agencies. However, after more than ten years of effort, the intense of debates have not been weaker than before.

Up to now, not a few number of articles and reports reviewing the project’s environmental, social and economic impacts have been presented by scientists, unions, nongovernmental organizations and professional associations (Bosshard, 1998; KHRP, 1999; Hildyard et.al., 2000; Balfour Beatty, 2001; Başgelen, 2006; Doğa Derneği, 2006; Gümüş et.al., 2006; Eberlein et.al., 2010). However, a technical solution that would minimize the effects of Ilisu has not been developed considering the continuing construction works on the dam axis. Although some arguments were being floated about a decrease in the crest elevation together with smaller dams in the upstream, no concrete proposal could have been stated expressly with tangible results (Ilisu Environment Group, 2005; Öngür, 2006).

1.2. Scope of the Study

Within the context of this assessment, an alternative formulation against to the Ilisu Dam and HEPP Project, perceived as indispensable because of flow regulation, enables Cizre Dam to supply water for the Silopi and Nusaybin-Idil-Cizre irrigations, and energy production capacities, was searched in order to rescue Hasankeyf with countless ancient monuments from inundation.

In Chapter II, Ilisu Dam and the debates on it were tried to be analyzed in a chronological manner to easily place the pieces of the development process in conjunction with international and national legislations. Then, the proposed five-dam system was presented with its topographical and geological features.

In Chapter III, the hydro-meteorological, water potential, reservoir sedimentation and optimization studies conducted step by step to calculate the hydropower potential of the proposed scheme were detailed. In addition to the energy calculations, the flood estimations of each alternative dam section were listed to be used in the economical evaluation of the system.

Chapter IV was reserved to compare the existing and proposed projects. The steps followed for the alternative scheme were applied to the existing project in order to re-evaluate its energy production capacity. Then, a preliminary economic analysis were performed through a degree estimation process based on topographical and geological studies from index maps, and not on thumb rules, but on experience of cost of previous work of the same type built was carried out in order to make an evaluation on the same base without any possibility of detailed surveys and investigations.

Finally, conclusions of the performed study were stated and recommendations for further studies were declared.

CHAPTER 2

THE ILISU DAM AND HEPP PROJECT

2.1. Ilisu Dam Debate

In this study, an alternative formulation to the Ilisu Dam and HEPP Project is proposed in order to save the historical town of Hasankeyf and archaeological sites around it from inundation. Since Hasankeyf was on the route of the Silk Road and in the Fertile Crescent, it hosted several cultures which could be traced to the foundation of both eastern and western civilizations. Although the historical ruins on the surface go back to fourth century after A.D. and the remains of Romans, Abbasids, Eyyubies, Akkoyunlus, Artuks and Ottomans can be seen while walking around in Hasankeyf, there are several tumuli waiting to be uncovered. The outcomes of the archaeological excavations are alarming that its history is dating back to the prehistoric age. Some historian claimed that it has been habituating for 10000 years without interruption (KHRP, 1999; Başgelen, 2006). Its value was actually recognized by the Turkish government, too. On April 1978, Hasankeyf was declared to be the first degree archaeological protected area by "*Gayrimenkul Eski Eserler ve Anıtlar Yüksek Kurulu*" with the Decision No.A-1105 (Gümüş et. al., 2006; KHRP, 1999). However, Ministry of Culture lifted this protection due to this dam project which was perceived as indispensable because of flow regulation and energy production capacities. Although, the administrative court of Diyarbakir ruled that there was no legal basis for this decision, the construction was initiated (Eberlein et. al., 2010). This change in the decision of the state created deep disappointment in the people of Hasankeyf. They had lived in caves within the old fort, the traditional inhabitation, until 1967. Then, they were moved down to a new settling area constructed on the side of the highway by the decision of the Governor's office. Those houses were small and not well suited to the climate of the region. However, people could not develop their assets due to this protection decision. Today, Hasankeyf people are asking for the compensation of 50 years of suffering. They are not pleased with the location of new town which will be placed right across Hasankeyf on the other side of the Tigris River. One should note that although Hasankeyf has been on the discussion table of Ilisu Dam, there are actually 200 settlements which will be inundated (Gümüş et. al., 2006).

The studies related to the Tigris River projects go back to the 1950s. After the establishment of DSI in 1954, the basin-scale surveys were initiated. The development of the Tigris Basin Plan was accomplished in 1960s. Finally, it was decided to construct Ilisu Dam in 1998. All three attempts to build the dam with an export credit policy were culminated in unsuccessful trial and in the time being the state decided to construct it with local finance credit agencies. The project was awarded to an international consortium under bilateral agreement. Thus, after 50 years, the construction was initiated. Ilisu Dam has been debated more than any other dam scheme on national and international platforms for more than 15 years since it is a project of near past values. At the beginning of 20^{th} century, dams were accepted as the backbone of the development of small, medium or mega regional projects, like South-eastern Anatolia Project (GAP).

Dams have been accepted to be the only way to supply water and prevent flood from the beginning of the civilization. In the past century, they especially the large ones were densely constructed on the various world river systems for power generation. On the other hand, some environmental damages were caused just because of them. Therefore, in the last decade, dams began to receive heavy criticisms from environmentalists. Dam opponents claim that they are blocking fish migration causing the extinction of some species. Moreover, dams are preventing sediment transport and thus the fertility of downstream plains is decreasing. The erosion problems on coast lines and cases on the wetland drainage are also the subjects under discussion. The affected population and resettlement issues have been the reasons for critics, too. The World Commission on Dams published an infamous report as "*Dams and Development*" in 2000 (WCD, 2000). The report heavily criticized the environmental and social impacts of large dams and brought new legally non-binding regulations. The impacts of dam opposition have been seen in Turkey, too. It is claimed that over the last 40 years, 1.3 million ha of wetlands have been destroyed. Cultural heritage became an issue for some other dams (Küçükdoğan, 2007). In addition, it is becoming hard and hard to convince the large number of people to resettle.

On the other hand, Ilisu Dam was defended by the government and governmental agencies on two bases. The first one is the increasing need for local energy sources, and the second, it is the one of the primary components of the GAP Project. Ilisu Dam will enable Cizre Dam to supply water for the Silopi and Nusaybin-Idil-Cizre irrigation schemes cover an area of 121000 ha. However, the resistance against Ilisu again takes its roots from this regional project. GAP consisted of two group projects of the Euphrates and the Tigris Rivers. It is composed of 22 dams, 19 hydroelectric power plants and the irrigation of 1.7 million ha of land. So far, the Euphrates dams, Karakaya, Ataturk, Birecik and Karkamis, were completed. On the whole, although the 75 percent of the energy projects of GAP was completed, this percentage is only 16% for the irrigation schemes (GAP, 2010).

On the same time, it is protracted project. The budget allocation has showed deviations from year to year. Whenever energy crisis occurred, it has been remembered over the last 40 years. It was in the second period of the Justice and Development Party (AKP) government that the state put special interest on GAP again and the budget allocation was increased. However, since the big dams have been already in operation and there are 300000 ha of irrigation areas in the region, environmental effects can be counted. Especially, the groundwater and soil salinity problems in the Sanliurfa-Harran plain put adverse feeling against GAP.

In brief, the Ilisu Dam and HEPP Project is not credited and receiving continues resistance:

- From environmentalist and naturalist experts on the fact that the Tigris River valley represents the last riverine and canyon ecosystem of South-eastern Anatolia. Further, there is evidence that due to the depletion of the similar ecosystems along the Euphrates River, some endangered specimen found new homes in the Tigris River banks. There will be no way for them (Doğa Derneği, 2006).

- From archaeologists, historians, anthropologists and people on the streets due to the fact that the dam will inundate important cultural assets.

- From local people who do not leave their ancestral homeland for a dam which would not increase their prosperity. The lesson has been learned from the Keban, Ataturk and Birecik Projects.

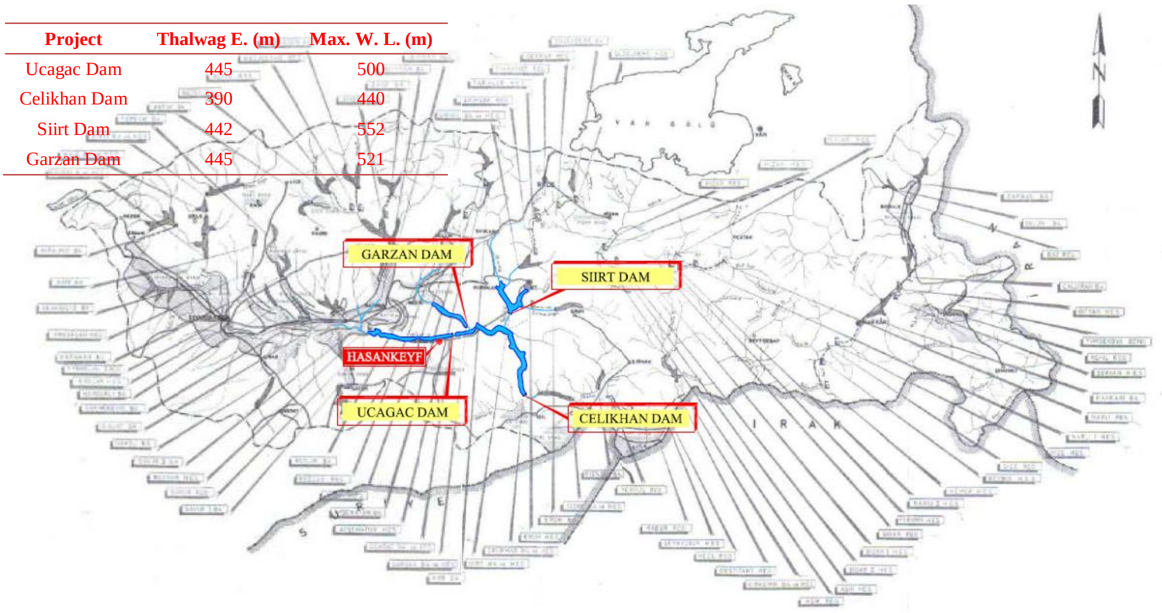
2.2. The Chronology of Ilisu Dam Debates

In this part, the main milestones of the GAP and Ilisu Dam and HEPP Projects were listed in respect of international and national legislations (Altınbilek, 2002; Erçin, 2005; Akyürek 2005; Stop Ilisu, 2010; Eberlein et al., 2010). While reading the list, each bullet shape has a meaning:

o Important national legislations related to water resources projects
• Inauguration dates of administrations related to water resources projects
▪ Major components of the GAP Project
□ Important international developments conceptual in water resources project
➢ Critical stages of the Ilisu Project development and debates on it

o **1934:** The Settlement Law No.2510 was established for newcomers from Ottoman lands and used for other businesses, too.
• **1936:** The Electricity Studies Administration was founded to investigate issues on how rivers in the country could be utilized for energy production.
▪ **1936:** This administration began its studies with the Keban Dam and HEPP Project by establishing observation stations to investigate the flow and other characteristics of the Euphrates River.
▪ **1945:** The studies on the Tigris River were initiated under the responsibility of the Electricity Survey Agency.
• **1954:** DSI was established.
▪ **1954:** The basin scale studies for 26 different basins have been started.

- **1961:** The Euphrates Planning Group Authority was established and the Euphrates Basin Development Report came out as the main document assessing the irrigation and energy potential of the Euphrates.
- **1965:** The construction of Keban Dam on the Euphrates River was initiated.
- **1966:** The Downstream Euphrates Development Report was published.
- **1968:** Investigations on energy potential of the Tigris River came into existence with "The Tigris Basin Reconnaissance Report" of the Euphrates Planning Group Authority resulted as use of elevations between 500 m and 370 m by Ucagac, Celikhan and Cizre Dams, as shown on Figure 2.1.



Project	Thalwag E. (m)	Max. W. L. (m)
Ucagac Dam	445	500
Celikhan Dam	390	440
Siirt Dam	442	552
Garzan Dam	445	521

Figure 2.1 Development Plan of the Euphrates Planning Group Authority (FPGA, 1968)

- **1970:** Additional clauses were established to the Settlement Law No. 2510 under the Law No.1306.
- **1975:** Keban Dam was inaugurated with a 1330 MW installed capacity providing one fourth of the country's electricity demand at the time. Since the operation of Keban Dam was before the concept of GAP, it is not treated as a component for it. Actually, Keban should be considered as the main structure for this project due to its control over the 70 percent of the Euphrates Basin within Turkey. It is also the first biggest dam project involving resettlement and cultural issues.
- **1976:** The construction of Karakaya Dam on the Euphrates River was initiated.
- **1977:** The first feasibility study of the Ilisu Project was conducted. As a result of analyzing ten different alternative dam axes between elevations from 370 m to 430 m on the Tigris

River after the confluence with Botan Creek, detailed on Figure 2.2, the existing dam section was designated.

- **1977:** The Tigris and Euphrates basin projects were combined in the title of South-eastern Anatolia Project.
- **1980-1982:** Preparation and acceptance of the final design for the Ilisu Project.
- **1982:** Undersecretary for Environment was established.
- **1983:** The Expropriation Law No.2942 was established.
- **1983:** The construction of Ataturk Dam on the Euphrates River was initiated.
- **1983:** The Environmental Law was declared.
- **1984:** The World Bank declined to fund GAP in general, thus rejected to be involved in the Ilisu Project, too.
- **1986:** The State Planning Organization took over the responsibilities of development activities in GAP.
- **1987:** Karakaya Dam was inaugurated with an 1800 MW installed power capacity.
- **1989:** The Southeastern Anatolia Project Regional Development Organization was established by the Government Decree No.388 in Force of Law, published in the Official Gazette dated 6 November 1989.
- **1989:** The GAP Master Plan was issued stating the general guidelines for achieving the integrated development for the region.
- **1992:** Ataturk Dam was inaugurated with a 2400 MW installed power capacity.
- **1993:** The Environmental Impact Assessment Application Guidelines were established. EIA reports have been required for storage facilities having reservoir areas of more than 15 km^2 and reservoir volumes of more than 100 hm^3 as well as power plants having installed capacities of more than 50 MW. However, this excluded the projects which had been prepared before 1993. Therefore, Ilisu Dam was not within the meaning of the law.
- **1993:** Birecik Dam on the Euphrates River was tendered under the built-operate-transfer model.
- **1994:** The Harran Irrigation Scheme was in operation.
- **1994:** The GAP Social Action Plan was launched.
- **1996:** The tender of the Ilisu Dam and HEPP Project under the built-operate-transfer model was failed to identify a binder.
- **1996:** The construction of Karkamis Dam on the Euphrates River was initiated.
- **1997:** Dicle Dam was inaugurated with a 110 MW installed power capacity.
- **1997:** Kralkizi Dam was inaugurated with a 90 MW installed power capacity.

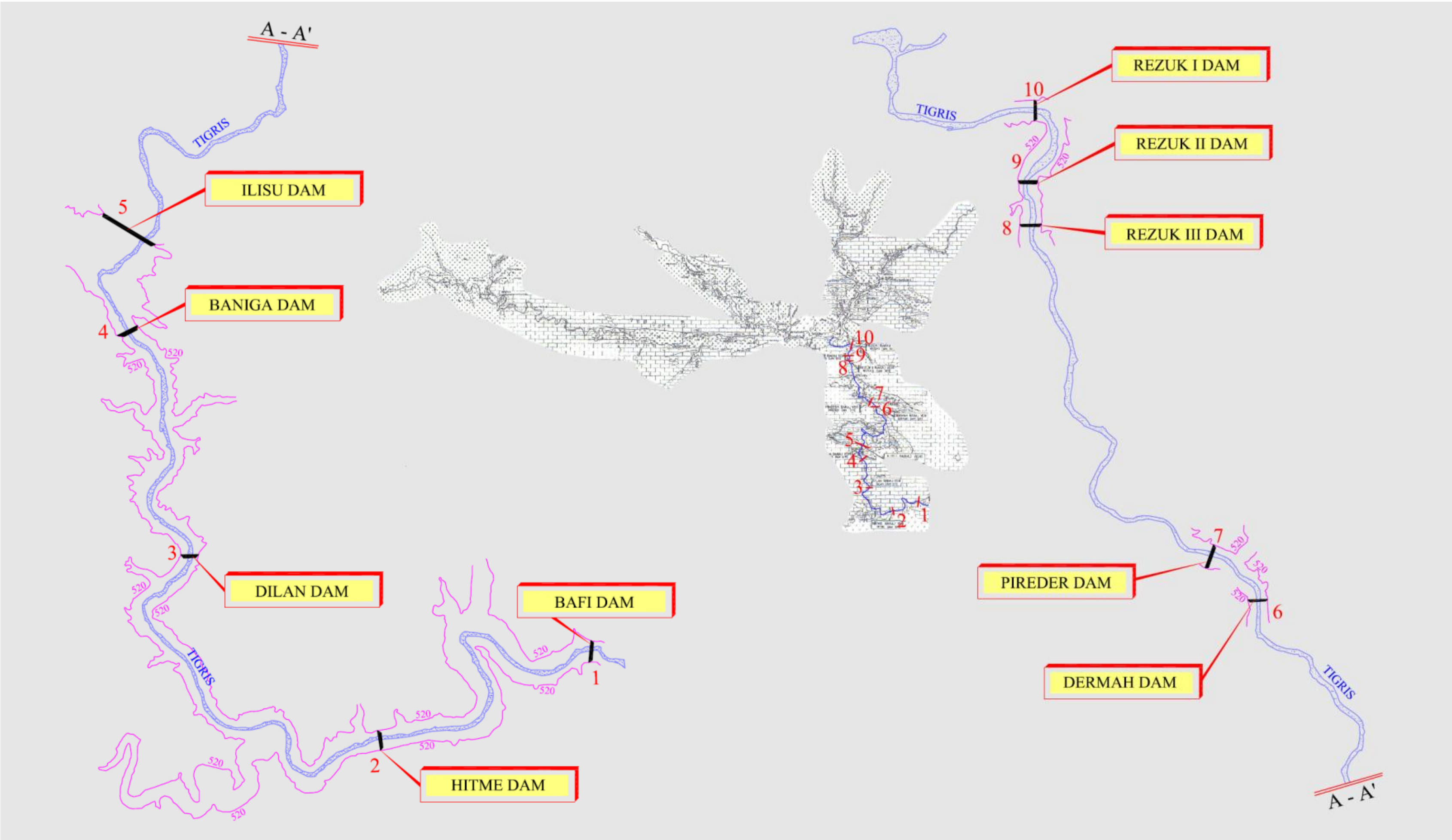


Figure 2.2 Analyzed Sections in the Designation of Ilisu Dam Axis (Temel, 1977)

- **1998:** The Ilisu Project was awarded to an international consortium of companies from Switzerland, Austria, England, Italy, and Sweden under the direction of the Swiss firm Sulzer Hydro (Sulzer Hydro was purchased by VA Tech from Austria in 1999; VA Tech Hydro was then purchased by Andritz from Austria in 2006) under a new financial model, bilateral agreement. Union Bank of Switzerland agreed to provide financing by means of application for export credit insurance in the corresponding countries.
- **1998:** The European Ilisu Campaign was created and revived in 2005. European members of this constitution are the Berne Declaration from Switzerland, ECA-Watch Austria and WEED Germany (in 2008 replaced by the network CounterCurrent (GegenStroemung)), which were supported by members of the international ECA Watch (The Corner House and Fern), BankTrack networks and the German M. Hermsen Foundation and International Rivers, USA.
- **1999:** Batman Dam was inaugurated with a 198 MW installed power capacity.
- **1998-2000:** International nongovernmental organizations took their position against the project (Bosshard, 1998; KHRP, 1999).
- **2000:** Karkamis Dam was inaugurated with a 180 MW installed power capacity.
- **2000:** Birecik Dam was inaugurated with a 672 MW installed power capacity.
- **2001:** The Expropriation Law No. 2942 was revised under the Law No. 4650.
- **2000:** The World Commission on Dams published an infamous report as "*Dams and Development*". It is the biggest victory of environmentalist nongovernmental organizations against large dams. In the report, five core values were identified and 26 guidelines were listed for the construction of large dams. Turkey and some other developing economies put strong critics to the report by claiming that they had the right to development. However, from that time onwards, the construction of large dams became difficult due to action taken from international credit agencies (WCD, 2000).
- **2000:** The GAP Master Plan was revised but there was no any major change in strategy.
- **2000:** The Swedish firm Skanska withdrew from the Ilisu Project (Hildyard et al., 2000).
- **2001:** The British construction firm Balfour Beatty and the Italian firm Impregilo withdrew from the Ilisu Project by commenting that there was not possible to solve the outstanding issues within a reasonable timescale (Balfour Beatty, 2001).
- **2002:** The Swiss bank UBS withdrew financing for the project due to the unresolved environmental and social issues.
- **2004:** The Turkish government attempted to reinitiate the Ilisu project.
- **2004-2005:** A new building consortium was formed with the Austrian firm VA Tech (now Andritz) acting as head, and the firms Züblin from Germany whose majority shareholder was in the meantime the Austrian firm STRABAG, Alstom, Stucky, Maggia, and Colenco as well as Nurol, Cengiz, Celikler, and Temelsu from Turkey. Request for insurance from German, Austrian and Swiss export credit agencies.

- **2005:** DSI stated that the Euphrates and Tigris Basins should be treated as one single basin, leaving the half century's practice of the basin identification. This action might be motivated due to the transboundary water disputes and the fact that two rivers meet at a place.
- **2005:** The GAP Master Plan was revised secondly due to accelerate the development process. By the 2005, the 75 percent of the energy projects and the 16 percent of the irrigation projects of GAP were completed.
- **May 2005:** Turkey changed its strategy from large hydro to small hydro in the country by means of the Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy Law No.5346, which has been put into force in May 2005. The private involvement in energy production was initiated. DSI listed about 500 small hydropower projects to be licensed to incorporated companies.
- **2006:** Twenty human rights and environmental organizations from the regions of Diyarbakir, Batman, Hasankeyf and Ilisu founded the Initiative to Keep Hasankeyf Alive.
- **2007:** The initiatives united seventy-three different groups including municipalities, unions, nongovernmental organizations and professional associations.
- **March 2007:** Germany, Austria and Switzerland approved the project in principle and assumed export credit liability. Guarantees were tied to 153 requirements, with a Committee of Experts monitoring compliance.
- **June 2007:** Zürcher Kantonalbank from Switzerland withdrew financing for the project due to incompatibility of Ilisu with the bank's sustainability principles.
- **August 2007:** Contracts were signed between Turkey, the building consortium and the banks Bank Austria Creditanstalt, Société Générale from France and the German bank DEKA.
- **Summer 2007:** Turkey begun on-site expropriations. The export credit agencies and the Committee of Experts are not informed, and were initially alerted to this development by nongovernmental organizations.
- **2007:** The environmental protection organization Doğa Derneği began campaigning against Ilisu Dam on the basis of environmental protection.
- **February 2008:** Turkey begun the construction in Ilisu. Roads were levelled, workers' quarters were constructed, and military camps overlooking the construction site were built.
- **March 2008:** The Committee of Experts submitted its first report. The outcome was as follows: the international standards had not been achieved; practically none of the necessary requirements had been fulfilled. A suspension of the construction for at least two years was recommended, but Turkey continued to the construction.
- **May 2008:** Doğa Derneği initiated a nation-wide "Stop Ilisu - Save Hasankeyf" campaign.
- **September 2008:** The second expert report was published. The report on resettlement left no doubt that the project is a disaster. A delay in the construction of at least three years was recommended in order for the project to meet the requirements. Consequently, the building activities in Ilisu and Hasankeyf were drastically reduced.

- **October 7th, 2008:** Germany, Austria and Switzerland sent a letter to Turkey activating the environmental failure clause. From that point on, Turkey had 60 days time to fulfil the project requirements.
- **December 23rd, 2008:** Turkey's deadline was extended, allowing another 180 days to fulfil requirements. The new deadline was set for July 6th, 2009.
- **April 17th, 2009:** A study from the University of Istanbul confirmed Hasankeyf's eligibility as a UNESCO World Heritage site, along with the Tigris Valley. The region fulfils nine out of ten possible UNESCO criteria, more than any other existing world heritage site.
- **June 2009:** More and more celebrities join the campaign, including Nobel laureate for literature Orhan Pamuk, the Turkish pop-star Tarkan, the German director Fatih Akin, and numerous German and Austrian actors and politicians.
- **July 7th, 2009:** Germany, Austria and Switzerland officially declared their withdrawal from the Ilisu Project. Never before had an existing export guarantee been cancelled due to ecological, social or cultural concerns.
- **July 8th, 2009:** The European banks also declared their withdrawal, leaving Turkey short of over 400 million Euros in funding. The European construction firms declined to make a statement.
- **Summer 2009:** Iraq suffered a devastating drought partially attributable to Turkish dams. Turkey was primarily withholding the waters of the Euphrates. Concerns increased that Ilisu Dam would worsen the situation by also reducing the outflow of the Tigris River.
- **October 2009:** The construction activity picked up again in Ilisu. Allegedly, the German company Züblin and Swiss Alstom wanted to withdraw from the project, while Austrian Andritz was favoured to remain involved.
- **November 2009:** Reports surfaced that Turkey had asked the Chinese export credit agency Sinosure to take over credit guarantees. Due to the Chinese action against Uighurs in Xinjiang (Sincan), Turkey did not further push the case and initiated searches for local funding sources.
- **January 2010:** Akbank, Garanti Bank and Halkbank agreed to fund the Ilisu Dam Project.
- **September 2010:** The building and expropriation activities are continuing together with the debates on it...

2.3. Proposed Solution to the Ilisu Dam and HEPP Project

2.3.1. A Remedy to Inundation of Hasankeyf

Evaluation of the Tigris River energy potential through a different formulation from the existing project without loss of Hasankeyf is the main objective of this study. In this evaluation, there are some constraints that could not be changed:

- There has to be a dam on the existing axis in the alternative formulation because of the continuing construction works.

- All the upstream projects such as dams and weirs which are in operation, in construction or in planning stage have to be considered while designating locations and maximum water levels of any alternative schemes (Figure 2.3).

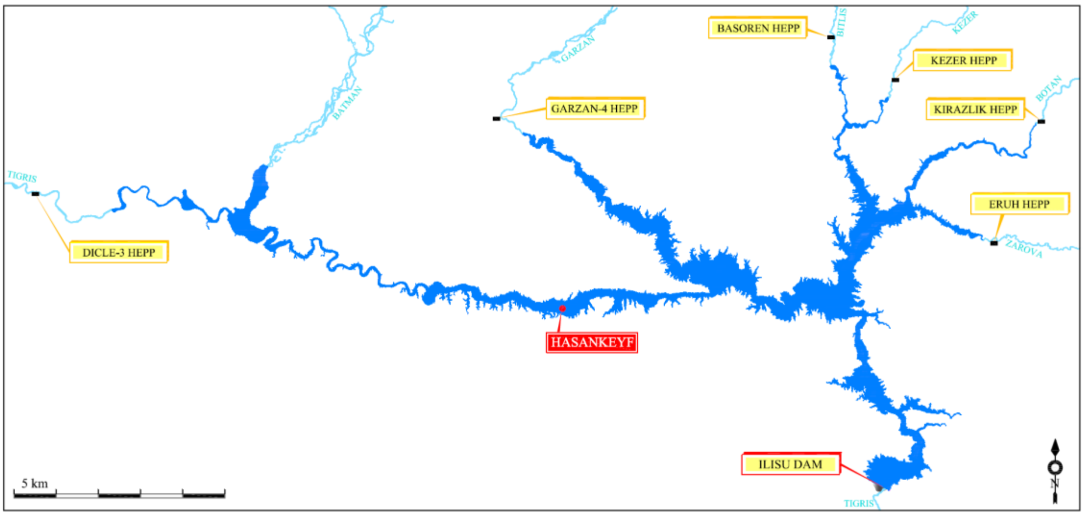


Figure 2.3 The Ilisu Dam and HEPP Project

If a choice should be made between environment and energy, one can easily prefer the protection of environment. Thus, the construction of the dam may be aborted, or the crest elevation can be lowered in order to save Hasankeyf. Nevertheless, energy options to be replaced with the production of the Ilisu project have to also be considered while taking this decision. Due to the grid system of electricity in Turkey, the type and location of alternative energy sources would not be important. However, in this assessment, the first preference is to replace the loss of energy due to lowering of the dam height by exploring new hydroelectric power plant sites in the Tigris Basin.

Within the context of the constraints listed above, the crest elevation of Ilisu Dam was lowered from 530 m to mean elevation around the historical town, 459 m (Arık, 2003). As seen from Figure 2.4, this decrease in the maximum water level of the project is ample to rescue the monuments from inundation. After that, other alternative dam locations providing the largest possible storage with the smallest possible fill volume were searched in the narrow valley sections at the upstream of Hasankeyf and the upper tributaries of the Tigris River.

Thus, a hydraulic solution composed of five dams on the Tigris River and its branches was developed as a result of the conducted hydro-meteorological, water potential, flood analysis and optimization studies together with considering the topographical and geological characteristics of the proposed dam sites, as drawn on Figure 2.4.

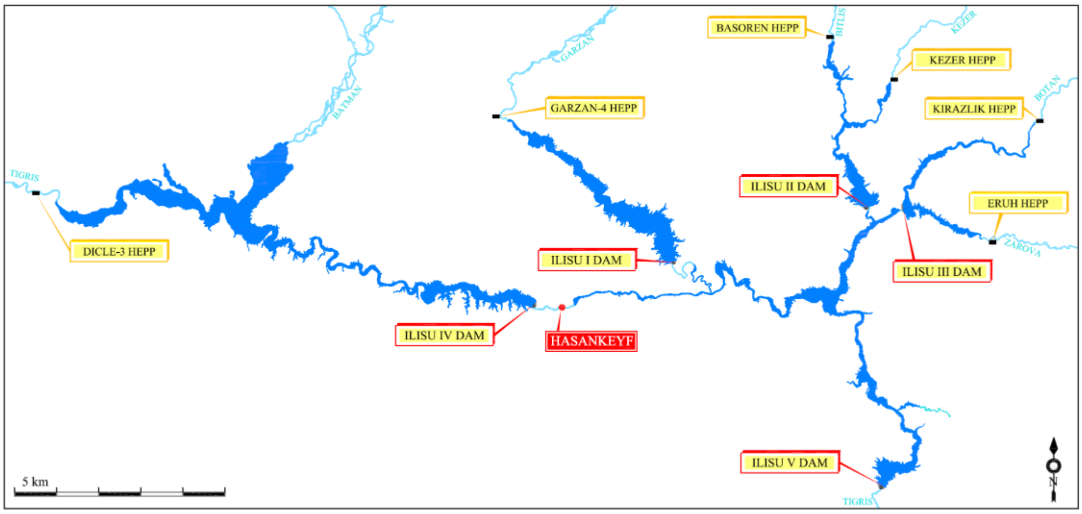


Figure 2.4 Proposed Solution

2.3.2. Searching New Dam Sites

In the determination of alternative dam sites, any technical investigations or reports could not be utilized as a guide in selecting the most appropriate places for dam construction. Instead of this, designation of possible sections by comparing the previously exploited dam locations in accordance with the 1:100000 scale geological index maps was the main process of this exploration (Figure C.2, Figure D.2, Figure E.2, Figure G.2, Figure F.2). The general geological characteristics of the proposed dam sites are listed in Table 2.1, and the positions of these formations in the stratigraphical column section of South-East Anatolia autochthonous are shown on Figure 2.5. Nonetheless, these axes have to be the object of a detailed geological surveying to better clarify the conditions with regard to watertightness and extension of grouting works.

Table 2.1 General Geologic Formations (MTA, 2007)

Project	Description
Ilisu I Dam	**The Oligocene-Eocene Germik Formation:** Gypsum, Shale, Dolomite, etc.
Ilisu II Dam	**The Middle-Upper Maastrichtian Paleocene Upper (Germav) Member:** Shale, Marl, Sandstone
Ilisu III Dam	**The Middle-Upper Miocene Selmo Formation:** Conglomerate, Sandstone, Claystone, Shale, etc., Gypsum in place.
Ilisu IV Dam	**The Middle-Upper Miocene Selmo Formation:** Conglomerate, Sandstone, Claystone, Shale, etc., Gypsum in place. **The Oligocene-Eocene Germik Formation:**
Ilisu V Dam	**The Middle-Upper Maastrichtian Paleocene Lower (Germav) Member:** Shale, Marl, Sandstone

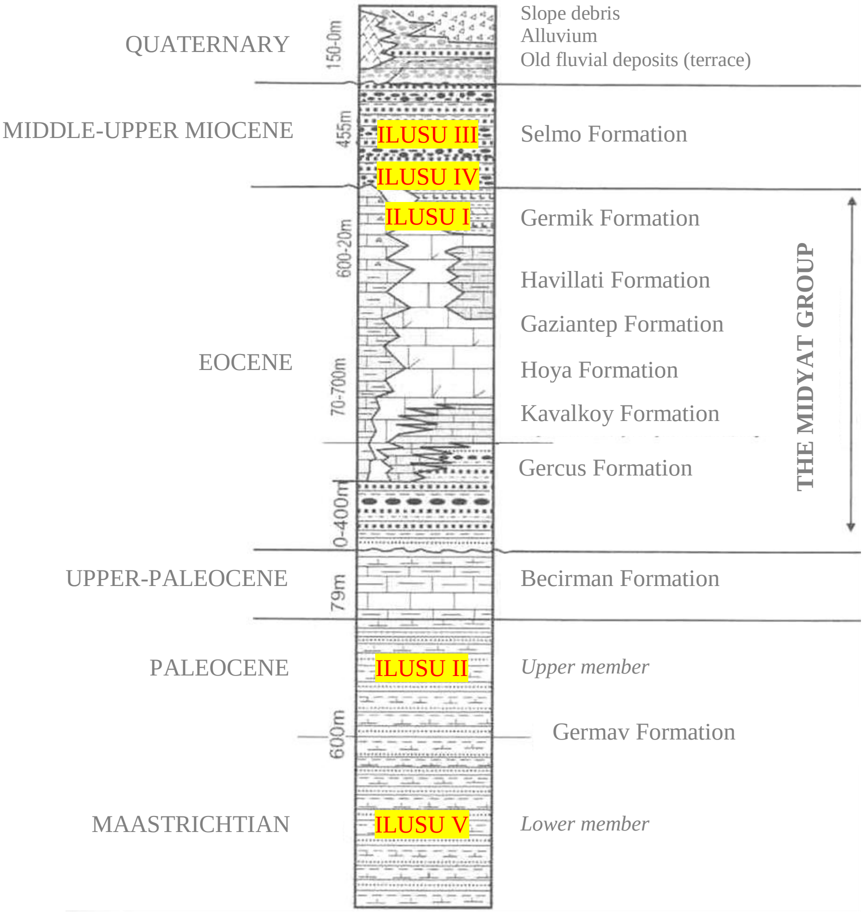


Figure 2.5 Generalized Stratigraphical Column Section of South-East Anatolia Autochthonous (MTA, 2007)

2.3.3. Topographical Properties of the Alternative Projects

According to the studies conducted on the 1:25000 scale digitized topographical maps of the proposed sites with the "*AutoCAD Civil 3D*" package program, the overall fill volume was observed as 14.8 hm^3, detailed in Table 2.2, using the same dam type and section characteristics with the dam embankment of Ilisu except the crest length, which is related to dam height (Figure C.3, Figure D.3, Figure E.3, Figure G.3, Figure F.3) (Autodesk, 2010; Kutzner, 1997; Alp, 2002).

The maximum water levels were designated by considering the upstream schemes developed by DSI, EIE and incorporated companies according to Law No.4628, as shown on Figure 2.6. In order to use the possible maximum storage between the mean elevation around Hasankeyf and the tail water levels of the upstream plants, the maximum water levels of the three alternative projects on Garzan Creek, Bitlis Creek and the Tigris River were selected higher than the existing one, as presented in Table 2.2.

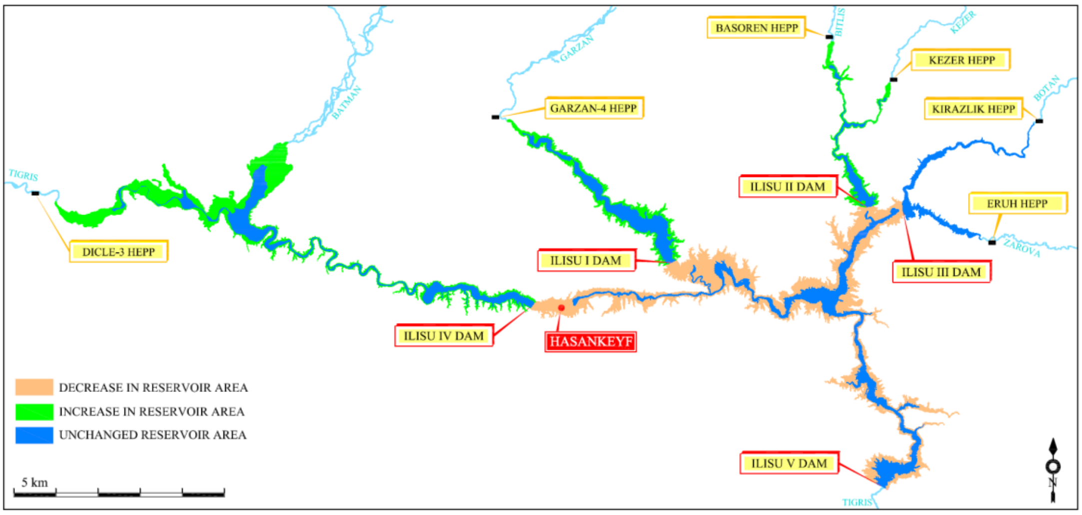


Figure 2.6 State of Reservoir Area as Compared with the Existing Project

Moreover, the reservoir area and storage capacity determinations were applied through the 1:25000 scale digitized topographic maps of the region using the "*AutoCAD*" package program (Autodesk, 2010). At the designated maximum water levels, the total reservoir area declines to 235.3 km^2 which connotes a notable reduction in the expropriation and resettlement process having a budget of 0.75 billion €, a higher value from the costs for the Ilisu scheme civil works, and a fertile land area of 86.1 km^2 rescued from inundation including the monuments in historical town (Ilisu Environment Group, 2005). Although there is a 10014.6 hm^3 reduction in the storage due to a 71 m decrease in the crest elevation of the existing project, the reservoirs volume becomes 4426.1 hm^3 together with other four dams, as detailed in Table 2.2.

2.3.4. Adversities that Would be Encountered in Application

The basin management policy of DSI as commissioning of downstream reservoirs firstly shows itself in this project as sediment control structures or waiting for construction of the upstream schemes, namely Garzan, Basoren, Sirvan, Alkumru, Eruh and Silvan Plain Dams. In this study, the minimum water levels of the proposed dams were determined for the fully developed upstream stage according to the sediment amount that would be deposited in the reservoirs as dead volume during the economic life of the projects, as listed in Table 2.2 (Table C.10, Table D.9, Table E.12, Table F.14, Table G.3).

In this assessment, the locations were designated with the priority of observing maximum storage as mentioned above. If the administration considers this project as an alternative to Ilisu Dam, of course a detailed geological surveying would be conducted at the proposed dam sites. As a result of these explorations, if some modifications are needed due to negative geological conditions, the energy loss owing to these can be tolerated by changing the sediment management policy from allocation of dead volume to sediment release downstream as use of dead storage in energy production. Indeed, moderate changes in the placement of dam axes do not affect the total storage considerably due to the narrow valley type of the Tigris River and its tributaries (Figure 2.6).

Table 2.2 Salient Features of the Existing and Proposed Projects (Ilisu Environment Group, 2005)

Item	Unit	The Existing Project	The Proposed Project					
			Ilisu I	Ilisu II	Ilisu III	Ilisu IV	Ilisu V	Total
General								
Location	-	Sirnak/Dargecit	Batman/Besiri	Siirt/Merkez	Siirt/Merkez	Batman/Hasankeyf	Sirnak/Dargecit	-
River/Creek	-	Tigris	Garzan	Bitlis	Botan	Tigris	Tigris	-
Reservoir								
Maximum Water Level during Re-regulation	m	525.0	530.0	530.0	525.0	530.0	457.0	-
Minimum Water Level	m	485.0	485.0	475.0	480.0	515.0	425.0	-
Total Volume at Max. W. L.	hm^3	**10926.3**	1005.1	462.7	420.7	1625.9	911.7	**4426.1**
Active Storage	hm^3	**7847.6**	964.6	444.2	397.0	1006.9	821.7	**3634.4**
Dead Storage	hm^3	3078.7	40.5	18.5	23.7	619.0	90.0	-
Reservoir Area at Max. W. L.	km^2	**321.4**	41.9	19.8	16.2	109.2	48.2	**235.3**
Reservoir Area at Min. W. L.	km^2	111.4	5.1	2.0	2.2	39.3	8.3	-
Dam Embankment								
Type	-	Concrete Faced Rock-Fill	Concrete Faced Rock-Fill	Concrete Faced Rock-Fill	Concrete Faced Rock-Fill	Concrete Faced Rock-Fill	Concrete Faced Rock-Fill	-
Side Slopes	-	1/1.4 - 1/1.4	1/1.4 - 1/1.4	1/1.4 - 1/1.4	1/1.4 - 1/1.4	1/1.4 - 1/1.4	1/1.4 - 1/1.4	-
Thalwag Elevation	m	400.0	469.0	459.0	459.0	461.0	400.0	-
Crest Elevation	m	530.0	532.0	532.0	527.0	532.0	459.0	-
Crest Lenght	m	1820.0	942.8	1499.4	1674.6	1036.5	978.7	-
Crest Width	m	8	5	5	5	5	5	-
Height of Dam above Thalwag	m	130.0	63.0	73.0	68.0	71.0	59.0	-
Fill Volume (exc. foundation)	hm^3	**23.3**	2.9	3.3	4.7	1.9	2.0	**14.8**

CHAPTER 3

HYDROPOWER POTENTIAL OF THE ALTERNATIVE PROJECT

Investigations on energy potential of the five-dam system were started with the analysis of the flow records at a large number of hydrometric stations operated by DSI and EIE, shown on Figure 3.1. These records, corrected according to the existing irrigation abstractions, listed in Table 3.1, and correlations were used to produce a reasonably representative record of flows at dam sites for the period 1971-2000. In the correlation studies, upstream-downstream relationships along each of the Tigris River branch systems were evaluated with the quantities of corresponding months, and inappropriate data sets were not taken into account. Although flows in the Tigris River and its tributaries within the catchment are monitored by a comprehensive network of stations, these correlations remained insufficient to constitute a longer data set for some branches.

Table 3.1 Irrigation Projects in Operation (DSI, 2010)

Irrigation Projects	**Com. Date**	**Irrigation Area**	
		Gross (ha)	**Net (ha)**
Ortaviran	1963	550	516
Kahlara	1965	380	380
Serifbaba	1971	130	120
Devegecidi	1972	10600	5800
Silvan	1972	8790	7590
Gozegol	1974	650	550
Kunres	1979	19	19
Kabakli	1980	182	87
Bespinar	1980	140	121
Kirkat (Gercus)	1985	350	348
Goksu	1996	4234	3582
Kozluk	1996	3973	3362
Kralkizi - Dicle	2002	4758	4758
Total		**34756**	**27233**

An evaluation conducted at the existing upstream conditions can engender excess capacity allocations in the design of reservoir systems. That would mean unoptimized installations and more initial outlay. Thus, instead of using directly catchment area ratio to bring these runoff values to the dam locations, a joint operating policy was formulated at each branch for the stage corresponds to full development of the irrigation and domestic water supply schemes in the Tigris Basin as listed in Table 3.2 and Table 3.3. It includes not only the existing reservoirs but also the proposed projects developed by DSI, EIE and incorporated companies according to Law No.4628 in order to compensate the effects of the presence of upstream schemes and abstractions as shown on Figure 3.1 and Figure 3.2.

Table 3.2 Irrigation Projects in Planning Stage (DSI, 2010)

	Irrigation Projects	**Irrigation Area**	
		Gross (ha)	**Net (ha)**
	Silvan	202306	176613
	Kralkizi - Dicle	130159	110115
	Nusaybin-Idil-Cizre	89000	89000
	Garzan	60000	60000
	Silopi	32000	32000
Silvan Plain Dams	Anbar	13498	11784
Silvan Plain Dams	Kurucay	6013	5249
Silvan Plain Dams	Pamukcay	5134	4482
Silvan Plain Dams	Baslar	4309	3762
Silvan Plain Dams	Bulaklidere	5890	5142
Silvan Plain Dams	Kibris	3124	2727
Silvan Plain Dams	Karacalar	5099	4451
	Batman	37744	32951
	Ergani	1861	1861
	Total	**596137**	**540137**

Table 3.3 Domestic Water Supply Projects in Planning Stage (DSI, 2010)

Abstraction from	**Demand (m^3/s)**
Guzeldere Reservoir	0.35
Bitlis Creek	0.60
Dicle Reservoir	4.53

The consecutive operations of the schemes were simulated on a monthly basis throughout the 30-year historical record with the topographical and technical features of the projects as taking into account net evaporation from the reservoir water surfaces estimated from precipitation, temperature and evaporation records at the meteorological stations operated by DMI, as drawn on Figure 3.1. From this were determined changes in storage, flows through turbines and spillway releases.

The applied methodology in the consecutive operations can be stated as follows:

- Characteristics of the planning projects were founded from the feasibility, pre-feasibility and reconnaissance study reports, and if the projects are in operation, the environmental impact assessment report of Ilisu Dam was utilized.

- Net evaporation rates of reservoirs were based on the evaporation records of meteorological stations operated by DMI. Assuming a 0.5^{o}C decrease in temperature for per 100 m increase in altitude, the temperature data observed at the base-stations were transformed to the maximum water levels during re-regulation of reservoirs (Limak, October 2006). Then, the monthly total evaporation quantities corresponding to these transformed temperatures were determined by means of the correlations between monthly mean temperature and monthly total evaporation records of the base-stations. Afterwards, the calculated evaporation values were multiplied with the pan coefficient (0.7) to convert the pan evaporations to the actual evaporation that would occur from the lake surfaces (Usul, 2009). Lastly, the net evaporation rates to be used in the operation studies were obtained by subtracting the precipitation records of the appropriate stations, that thought as it would represent the reservoir area, from these values.

- In calculation of the inflow values, net abstractions were used for the upstream irrigations as that the 20 percent of the demand would return to the river bed again (Ilisu Hydropower Consultants, November 1983). However, this rate of return is 15 percent for the Batman-Silvan Projects (Suiş and Sial, December 2001).

- The 10 percent of monthly mean flow values of the last 10 years (1991-2000) at dam locations was left to river bed for the maintenance of natural life as environmental water for the projects with energy tunnels (DSI, 2010).

- Five type of program written in VBA (Visual Basic for Application) on Excel software was utilized to conduct the reservoir operations:

  (**1**) Operation of an Irrigation Project (Appendix I.1)
  (**2**) Operation of an Irrigation Project Reinforced by Upstream Reservoir (Appendix I.2)
  (**3**) Operation of a Multi-Purpose Project (Appendix I.3)
  (**4**) Operation of a Multi-Purpose Project Reinforces Downstream Irrigation (Appendix I.4)
  (**5**) Operation of the Dicle-Kralkizi Project (Appendix I.5)

For the Ilisu I, II, III and IV Power Plants, the operation studies were conducted in accordance with a rule that guarantees the maximum firm power in 95 percent of the entire period, determined by trial and error in the series of runs, and also maximizes the generation of secondary power unrestricted up to the installed capacity together with a preliminary economic analysis to obtain optimum design discharges. In the optimization, runs were carried out, by means of a new Visual Basic program combining the "*Operation of a Multi-Purpose Project*" and optimization methodologies together, with a range of design discharges plus varying penstock and energy tunnel characteristics in number and diameter for each trial (Appendix I.3, Appendix J.3). The discharge values coming in between 5 and 25 percent of the time were analyzed in 5 m^3/s intervals. Due to lack of possibility to make a preliminary design of penstocks and energy tunnels, if any, with 1:25000 scale topographic maps of the proposed sites, the lengths of these units were selected as 200 m and 400 m, respectively. For each discharge rate, at least three different combinations of penstocks were attempted to rest assure that the variant selected is the optimum one. The diameters of the penstocks in these combinations were designated as that the flow velocity in them is 5 m/s (Yıldız, 1992). Only one energy tunnel was envisaged in the proposed systems. In each trial, the tunnel diameter was selected as that the rate of flow is 4 m/s (Yıldız, 1992). However, this diameter has to be larger than the value required for the availability of construction, 3.2 m (Pro-sem, 2008).

The inflow values of Ilisu V Dam were obtained by adding the intermediate basin flows to ones through the turbines and spillway releases of other four dams, and the same optimization procedure was applied for this plant in the "*Operation of a Multi-Purpose Project Reinforces Downstream Reservoir*" algorithm with considering the Silopi and Nusaybin-Idil-Cizre projects irrigated from Cizre Reservoir (Appendix I.4, Appendix J.3).

In addition to the energy calculations, the recurrence floods and the probable maximum flood of Ilisu I, Ilisu II, Ilisu III and Ilisu IV catchment areas were estimated to be used in the economical evaluation of the proposed system. As the flood values at Ilisu V Dam, the results of an analysis conducted for Ilisu Dam in 2008 were used. In these estimations, the effects of the presence of upstream reservoirs were not taken into consideration, as a similar approach to the analysis done for the Ilisu Project, because there is not a notable allocation of storage for flood control in these schemes (Ilisu Dam and HEPP Engineering and Consultancy Services Consortium, 2008).

The recurrence floods of catchment areas were on one hand calculated based on the available flow data, via point and regional flood frequency analysis, and on the other hand by using Snyder's synthetic unit hydrograph method. In these calculations, the procedures described in the "Applied Flood Hydrology" book were followed (Özdemir, 1978). The other synthetic methods, namely DSI, superposed Mockus and non-superposed Mockus, were not performed since the drainage areas are all bigger than 1000 km^2 (Özdemir, 1978). As a result, after comparison of the flood discharges observed in these processes, the quantities to be used in the design of these schemes were determined.

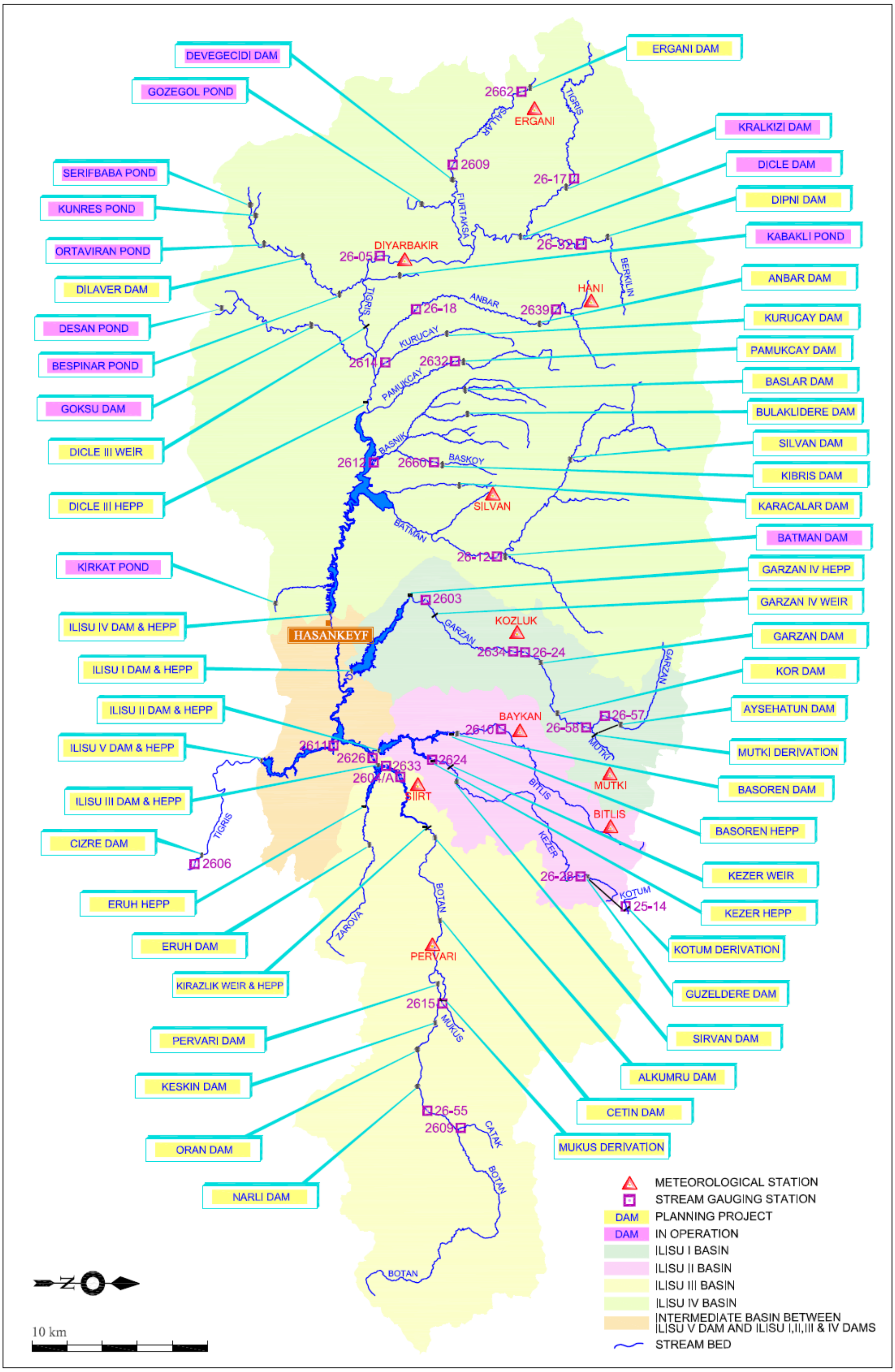


Figure 3.1 Project Area and Hydro-Meteorological Stations

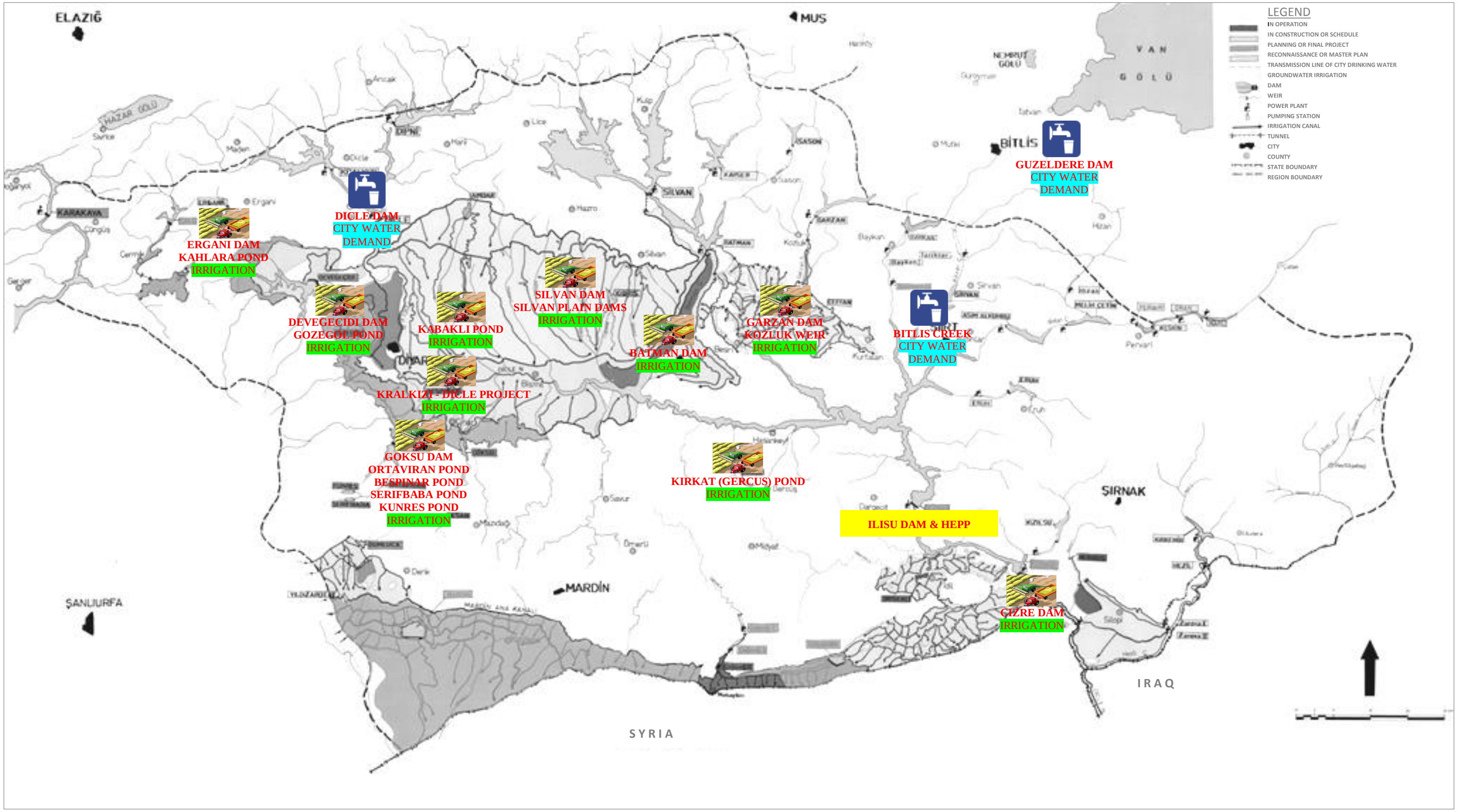


Figure 3.2 Development Plan of Xth Regional Directorate of State Hydraulic Works (DSI, 2010)

3.1. The Garzan Projects and Ilisu I Dam and HEPP

There are the Aysehatun Dam and HEPP Project with Mutki Derivation, the Kor Dam and HEPP Project, the Garzan Dam and HEPP Project and the Garzan irrigation scheme covers 60000 ha in the upstream of the Ilisu I Dam and HEPP Project (Figure C.1) (DSI, 2010).

3.1.1. Estimated Evaporation Rates

The evaporation rates for Aysehatun and Kor Reservoirs were based on the measurements at Bitlis meteorological station (Table A.11, Table A.14, Figure C.1). By means of the monthly mean temperature and monthly total evaporation correlation of this station, the monthly total evaporation quantities corresponding to the transformed temperatures were calculated as pan evaporations (Figure A.1). The net evaporation quantities to be used in the operation studies were obtained by subtracting the precipitation records of Mutki station from the converted actual evaporation values (Table A.1, Figure C.1, Table C.2, Table C.3).

For Garzan and Ilisu I Reservoirs, the records of Siirt meteorological station were used (Table A.12, Table A.15, Figure C.1). The pan evaporations were obtained along with the correlation between monthly mean temperature and monthly total evaporation observations made at the station (Figure A.2). Then, the net evaporations from these lakes are equal to the difference between the actual evaporation rates and the monthly total precipitation values of Kozluk and Siirt stations, respectively (Table A.2, Table A.3, Figure C.1, Table C.4, Table C.5).

3.1.2. Water Resources

3.1.2.1. Stream Gauging Stations

The flow records observed at Bogazonu (DSI 26-57), Meydanonu (DSI 26-58), Kozluk (DSI 26-24), Kozluk (EIE 2634) and Besiri (EIE 2603) gauging stations were utilized to calculate the monthly mean flow values at dam locations, as listed in Table 3.4 (Table B.1, Table B.2, Table B.3, Table B.4, Table B.5, Figure C.1, Figure C.8, Figure C.9, Figure C.10, Figure C.11, Figure C.12). The measurements at Besiri station were corrected due to the upstream irrigation abstraction in operation since 1996 according to the Garzan-Kozluk irrigation module for the net irrigation area of 3362 ha (Table C.6, Figure C.13) (Enersu, December 2008).

Table 3.4 Characteristics of Stream Gauging Stations (DSI, 2007-b; EIE, 2005)

Station Id	Station Name	Opening Date	Closing Date	Drainage Area (km^2)	Elevation (m)	Mean Discharge (m^3/s)	Valuable Years
DSI 26-57	Keyburan Brook-Bogazonu	24.10.1981	-	425.0	1200	8.6	5
DSI 26-58	Garzan Creek-Meydanonu	29.11.1981	08.01.1999	783.2	909	15.8	3
DSI 26-24	Pisyar Creek-Kozluk	01.08.1970	-	1359.3	620	26.0	14
EIE 2634	Garzan Creek-Kozluk	19.10.1999	30.09.2000	1407.7	630	23.0	1
EIE 2603	Garzan Creek-Besiri	01.11.1945	30.09.2000	2450.4	545	49.0	54

3.1.2.2. Correlation Studies

In order to produce a representative data between the years 1971 and 2000, the discontinuities in the records of Bogazonu and Meydanonu stations were fulfilled by the correlations with Besiri gauging station (Figure C.14, Figure C.15, Figure C.17, Figure C.18). In the extension of the flow values measured at Kozluk (DSI 26-24) station, the correlation equation observed with the corrected rates of Besiri station was utilized for the period 1985-1999. For the year 2000, the quantities were transformed from the observations at Kozluk (EIE 2634) station according to the catchment area ratio between these stations (Figure C.16, Figure C.19).

3.1.2.3. Monthly Mean Flow Calculations

In order to calculate the monthly mean inflow values for the operation study of the Ilisu I Dam and HEPP Project, a joint operating policy from upstream to downstream was formulated, as summarized in Figure 3.3:

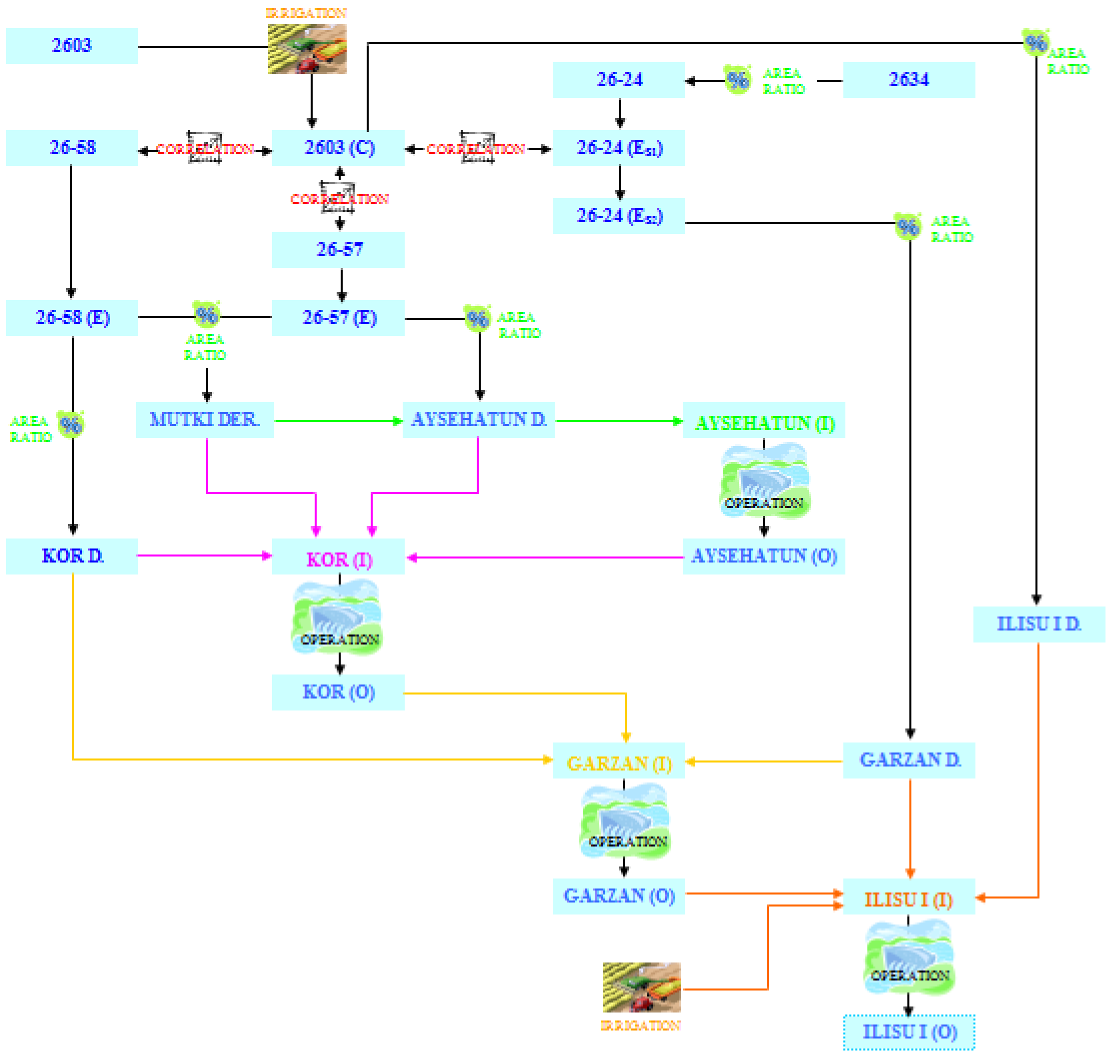


Figure 3.3 Scheme for Monthly Mean Flow Calculations of the Garzan Project

- **The Aysehatun Dam and HEPP Project with Mutki Derivation:** In the estimation of the monthly mean flow rates at the Mutki Weir location, the drainage area ratio among the weir and the intermediate catchment between Meydanonu and Bogazonu gauging stations was utilized (Equation 3.1) (Figure C.1, Figure C.20). The amounts diverted from Mutki Creek to Aysehatun Dam were determined from these values according to the capacity of the transmission channel, 25.74 m^3/s (Figure C.21) (DSI, 1987).

$$Q_{MUTKI} = (Q_{26\text{-}58} - Q_{26\text{-}57})\left(\frac{A_{MUTKI}}{A_{26\text{-}58} - A_{26\text{-}57}}\right) \tag{3.1}$$

The flow rates at the Aysehatun Dam location were transformed from the extended data set of Bogazonu station according to the catchment area ratio between them (Equation 3.2)

(Figure C.1, Figure C.22). The sum of these values with the diverted flows from Mutki Creek was utilized as the monthly mean inflow values of Aysehatun Dam and HEPP (Figure C.23).

$$Q_{AYSEHATUN} = Q_{26\text{-}57}\left(\frac{A_{AYSEHATUN}}{A_{26\text{-}57}}\right) \tag{3.2}$$

The operation study of Aysehatun Reservoir was conducted by the "*Operation of a Multi-Purpose Project*" program considering the environmental water needs (Table C.1, Figure C.4, Table C.2, Table C.7, Figure C.24, Appendix I.3) (DSI, 1987). The outflows are equal to the sum of spillway releases and flows through turbines (Figure C.25).

- **The Kor Dam and HEPP Project:** The extended flows of Meydanonu station were transposed to the dam site in proportion to the drainage areas (Equation 3.3) (Figure C.1, Figure C.26). Then, the monthly mean inflow values of Kor Dam and HEPP were determined as subtracting the flow rates at the Aysehatun Dam and Mutki Weir locations from the sum of these values with the outflows of Aysehatun Dam and HEPP (Figure C.27).

$$Q_{KOR} = Q_{26\text{-}58}\left(\frac{A_{KOR}}{A_{26\text{-}58}}\right) \tag{3.3}$$

The reservoir operation was applied in the "*Operation of a Multi-Purpose Project*" algorithm as taking into account the requirements for environmental water (Table C.1, Figure C.5, Table C.3, Table C.8, Figure C.28, Appendix I.3) (Aksa, December 2004). The outflow rates were thus determined from spillway releases and flows through turbines (Figure C.29).

- **The Garzan Dam and HEPP Project:** The catchment area ratio was used to bring the extended runoff values at Kozluk (DSI 26-24) gauging station to the dam axis (Equation 3.4) (Figure C.1, Figure C.30). The difference between the sum of these estimated values with the outflow rates of the Kor scheme and the flow amounts at the Kor Dam site was evaluated as the monthly mean inflow values of Garzan Dam and HEPP (Figure C.31).

$$Q_{GARZAN} = Q_{26\text{-}24}\left(\frac{A_{GARZAN}}{A_{26\text{-}24}}\right) \tag{3.4}$$

The Garzan irrigation scheme, covers an area of 60000 ha, will be largely irrigated from the outflows of Garzan Reservoir. Therefore, the operation was conducted by the "*Operation of a Multi-Purpose Project Reinforces Downstream Irrigation"* program according to the fact that the outflow rates are equal or greater than the irrigation water demands of the corresponding months, determined according to the Garzan irrigation module (Table C.1, Figure C.6, Table C.4, Table C.9, Figure C.32, Figure C.33, Appendix I.4) (Enersu, December 2008).

- **The Ilisu I Dam and HEPP Project:** A transposition was carried out through the drainage areas to estimate the flow rates at the Ilisu I Dam location by using the corrected data set of Besiri station (Equation 3.5) (Figure C.1, Figure C.34). In order to determine the monthly mean inflow values of Ilisu I Dam and HEPP, the flow amounts at the Garzan Dam site and net irrigation abstractions were subtracted from the sum of the runoff values of Ilisu I Dam with the outflow rates of Garzan Dam and HEPP (Figure C.35).

$$Q_{ILISU-I} = Q_{2603}\left(\frac{A_{ILISU-I}}{A_{2603}}\right) \quad (3.5)$$

3.1.3. Sediment Transport

The sedimentation volume was calculated using the suspended load concentration data at Besiri gauging station, collected for a total of 285 days during the period 1975-1999 (EIE, 2000). After performing sediment analysis, annual specific suspended load was found to be 208 m^3/year/km^2. By adding a 50% more to this value for bed load, a total of 312 m^3/year/km^2 was obtained (EIE, 2010). The volume of sediment that would be deposited in the reservoir as dead volume for 50 years was calculated according to the area contributing the sediment transport between the Garzan and Ilisu I schemes. Then, the elevation of the power intake sill, or the minimum operating level, was designated in line with this storage by using the area-volume curve as 485 m (Figure C.7, Table C.10).

3.1.4. Operation Studies

A total of 72 runs were conducted for three different combinations of penstocks with the design discharges determined from the drawn discharge-duration curve of the project site (Figure C.36). As a result of this analysis, the optimum design discharge for this plant was observed as 35 m^3/s through a system composed of one penstock and one energy tunnel with 4.1 m and 4.5 m inlet diameters, respectively (Figure C.37). The energy production capacity of this combination is 143.3 GWh/year, composing of 135.1 GWh/year firm energy and 8.2 GWh/year secondary energy, with an installed power of 33.4 MW.

3.1.5. Flood Analysis

3.1.5.1. Calculation of Design Floods from Observed Runoff

The characteristics and corresponding observation periods of the used stream gauging stations in this approach are given in Table 3.5. The flood discharges for different return periods were calculated with the annual maximum instantaneous flow records of each station by means of the most appropriate probability distribution function using Kolmogorov-Smirnov test (Table C.11).

Table 3.5 Characteristics of Stream Gauging Stations Used in Flood Frequency Analyses (EIE, 2005)

Station Id	Station Name	Drainage Area (km^2)	Elevation (m)	Observation Period
EIE 2603	Garzan Creek-Besiri	2540.4	545.0	1946-2002 (57)
EIE 2624	Kezer Creek-Pinarca	1169.6	530.0	1972-2006 (35)
EIE 2616	Bitlis Creek-Karinca	346.4	1145.0	1965-1970 (6)
EIE 2610	Bitlis Creek-Baykan	640.4	910.0	1955-2006 (52)

3.1.5.1.1. Point Flood Frequency Analysis

The flood peaks calculated for Besiri station were transposed to the dam site in proportion with the drainage areas by applying Equation 3.6 (Table C.12):

$$Q_{ILISU-I} = Q_{2603}\left(\frac{A_{ILISU-I}}{A_{2603}}\right)^{0.667} \qquad \mathbf{(}3.6\mathbf{)}$$

3.1.5.1.2. Regional Flood Frequency Analysis

In this approach, initially, a homogeneity test was done for the determined base periods concerning the observation periods of the stream gauges (Table C.13, Figure C.40, Table C.14, Table C.15). As a result of this test conducted for each period, none of these stations were eliminated (Figure C.41). Then, the recurrence flood peaks of all the stations given in Table 3.5 were divided by the corresponding $Q_{2.33}$ recurrence values and thus the non-dimensional recurrence flood peak values were found (Table C.16). After that, the $Q_{2.33}$ recurrence discharge versus drainage area curve was plotted on a logarithmic paper using the data obtained for each station (Figure C.42). From this curve, the 2.33 years return period flood discharge for the Ilisu I catchment can be read as 634.4 m^3/s. Eventually, this value was multiplied by the average non-dimensional recurrence flood values and thus the regional recurrence flood peaks for the project were obtained (Table C.17).

3.1.5.2. Flood Recurrences Calculated Using Snyder Synthetic Unit Hydrograph Method

Finally, the recurrence and probable flood calculations were carried out using Snyder's unit hydrograph method together with considering the drainage area characteristics.

- **Precipitation Analysis:** The meteorological stations of Mutki, Haskoy, Kozluk, Baykan, Sason, Kurtalan, Sarikonak and Batman are located inside or near the Ilisu I drainage area (Figure C.43). From the maximum 24-hour precipitation rates of these stations, the 24-hour precipitations for different return periods were calculated using the appropriate distribution functions (Table C.18, Table C.20). In order to obtain the mean areal precipitation over the watershed, Thiessen polygons were used to assess the weight of each station (Figure C.43, Table C.21). The corresponding precipitations were calculated for different durations by multiplying the basin precipitations with the pluviograph rates, the area reduction factor and the maximization factor, 1.13 (Table C.22, Table C.23, Table C.24, Figure K.1).

  In the probable maximum flood calculations, the 24-hour probable maximum precipitation values of these meteorological stations were calculated using the Hershfield statistical method with the formula "$PMP_{24} = X + KM \, x \, S$", where KM is the frequency factor, X is the corrected average and S is the corrected standard deviation of the annual maximum rainfall records (Table C.19, Figure K.4, Figure K.5, Figure K.6, Figure K.7). The values for the frequency factor were evaluated according to the X-KM envelopes prepared by DSI Hydrology Branch Office for East Anatolia and South-East Anatolia. The probable maximum precipitation amounts for different periods were again obtained by multiplying the station values by the Thiessen weights, the pluviograph rates, the areal reduction factors and the maximization factor (Table C.20, Table C.21, Table C.22, Table C.23, Table C.24).

- **Baseflow:** The base flow of Garzan Creek at the Ilisu I Dam site was derived from the one estimated for Besiri observation station (Table C.26). The base flow values of the catchment for the recurrence floods and probable maximum flood are 278.6 m^3/s and 413.5 m^3/s, respectively.

- **Unit Hydrograph Analysis:** The key parameters intervening in the establishment of the unit hydrograph were measured on the 1:100000 scale topographic maps of the region (Figure C.43). Accordingly, the Ilisu I catchment area is 2883.0 km^2, the longest river branch length is 165.0 km, and the distance of the outlet to the point on the river nearest centroid of the watershed is 81.0 km. The coefficients C_t and C_p were taken from the "*Ilisu Dam and HEPP, Flood Hydrology and Sediment Transport*" report prepared by the engineering and consultancy services consortium of the project. The corresponding values are given as C_t=1.35 and C_p=0.69. Using these parameters, the peak discharge, the duration of reaching the peak and the base time of the synthetic unit hydrograph were calculated as 30.9 m^3/s/mm, 19.8 hour and 125.3 hour, respectively (Table K.1). In the end, a 4-hour unit hydrograph was drawn in order to convert excess rainfall into runoff (Figure C.45, Figure K.8).

- **Flood Hydrographs Calculated with Snyder Unit Hydrograph Method:** The critical precipitation duration for this type of catchment varies from 8 to 24 hours (Figure K.3). However, in this study, this duration was selected as 12 hours. The 12-hour precipitation was then subdivided into 4-hour precipitation blocks by utilizing the distribution curve "*B*" for precipitation in time (Figure K.2).

  In order to estimate the excess rainfall, the part of the rainfall which generates runoff, the SCS method was used. The characterization of the land use and the soil type in the catchment was thereby made by making the SCS curve number CN_{II}=85 (Aksa, December 2004). The runoff volumes and excess rainfall were calculated from the 12-hour precipitation amounts. The hydrographs for different return periods were then evaluated using the unit hydrograph method. Eventually, the resulting recurrence flood peaks were determined by adding the beforehand calculated baseflow (Figure C.46, Table C.27).

- **Hydrograph Caused by Probable Maximum Flood:** As above, in order to evaluate the excess rainfall, the SCS method for abstraction was used with a curve number of CN_{III}=93.5 (Aksa, December 2004). The excess rainfall was then converted into runoff by using the 4-hour unit hydrograph. The peak discharge of the probable maximum flood of the Ilisu I basin without accounting for baseflow and snowmelt runoff is 2531.2 m^3/s.

  Because of lack of data to calculate the maximum snowmelt runoff hydrograph of the basin with the degree-day method, the rate determined for the upstream project as 97.0 m^3/s was directly utilized in this project (Aksa, December 2004). This seems correct due to the absence of snowmelt contribution to runoff in the intermediate basin between these schemes (Enersu, December 2008). The probable maximum flood hydrograph was then obtained as by adding the previously determined baseflow and snowmelt values to the hydrograph caused by the probable maximum precipitation (Figure C.46). The peak discharge value of this hydrograph to be used in spillway design is 3041.7 m^3/s (Table C.27).

3.1.5.3. Selection of Project Flood Discharges

The obtained flood discharges with statistical and synthetic unit hydrograph methods are summarized in Table 3.6. It can be concluded that for this catchment all three methods lead to reasonable values.

The highest ones can be selected as design flood discharges to be on the safe side. Hence, the results of point flood frequency analysis were utilized in the economic analysis part of the study.

Table 3.6 Summary of Flood Calculations

Return Period	Flood Discharge (m^3/s)		
	PFFA	RFFA	Snyder
2	583.9	582.1	602.9
2.33	633.2	634.4	640.5
5	847.3	854.9	807.1
10	1021.7	1027.0	944.5
25	1242.1	1237.2	1118.9
50	1405.5	1389.2	1249.2
100	1567.8	1537.5	1378.8
200	1729.5	1683.3	1508.3
500	1942.8	1873.1	1679.5
1000	2104.0	2016.0	1810.5
PMF	-	-	3041.7

3.2. The Bitlis Projects and Ilisu II Dam and HEPP

There are the Guzeldere Dam and HEPP Project with Kotum Derivation, the Basoren Dam and HEPP Project, the Sirvan Dam and HEPP Project and the Tatvan and Sirvan domestic water supply schemes in the upstream of the Ilisu II Dam and HEPP Project (Figure D.1) (DSI, 2010).

3.2.1. Estimated Evaporation Rates

The evaporation rates for Guzeldere Reservoir were based on the records of Bitlis meteorological station (Table A.11, Table A.14, Figure D.1). By means of the monthly mean temperature and monthly total evaporation correlation of this station, the monthly total evaporation quantities corresponding to the transformed temperatures were calculated as pan evaporations (Figure A.1). The net evaporations from the lake surface are equal to the difference between the actual evaporation rates and the monthly total precipitation values of Tatvan station (Table A.4, Figure D.1, Table D.2).

For Sirvan, Basoren and Ilisu II Reservoirs, the records of Siirt meteorological station were used (Table A.12, Table A.15, Figure D.1). The pan evaporations were determined along with the correlation between monthly mean temperature and monthly total evaporation observations made at the station (Figure A.2). The net evaporation quantities to be used in the operation studies were obtained by subtracting the precipitation records of Baykan station from the converted actual evaporation values of Basoren Reservoir. (Table A.5, Figure D.1, Table D.4). For the Sirvan and Ilisu II projects, these quantities were calculated with the precipitation rates observed at Siirt station (Table A.3, Figure D.1, Table D.3, Table D.5).

3.2.2. Water Resources

3.2.2.1. Stream Gauging Stations

The flow records observed at Kucuksu (DSI 25-14), Kuscukoyu (DSI 26-28), Pinarca (EIE 2624) and Baykan (EIE 2610) gauging stations were utilized to calculate the monthly mean flow values at dam locations, as listed in Table 3.7 (Table B.6, Table B.7, Table B.8, Table B.9, Figure D.1, Figure D.8, Figure D.9, Figure D.10, Figure D.11).

Table 3.7 Characteristics of Stream Gauging Stations (DSI, 2007-b; EIE, 2005)

Station Id	Station Name	Opening Date	Closing Date	Drainage Area (km^2)	Elevation (m)	Mean Discharge (m^3/s)	Valuable Years
DSI 25-14	Kotum Brook-Kucuksu	01.10.1964	31.10.1972	78.9	1721.0	2.1	8
DSI 26-28	Güzeldere-Kuscukoyu	01.10.1973	08.01.1999	125.8	1594.0	3.9	17
EIE 2624	Kezer Creek-Pinarca	01.10.1971	30.09.2000	1169.6	530.0	20.2	29
EIE 2610	Bitlis Creek-Baykan	14.09.1954	30.09.2000	640.4	910.0	18.8	46

3.2.2.2. Correlation Studies

In order to produce a representative data between the years 1971 and 2000, the discontinuities in the records of Pinarca station were fulfilled by the correlations with Baykan gauging station (Figure D.14, Figure D.17). In the extension of the flow values measured at Kuscukoyu station, the correlation equation observed with the rates of Pinarca station was utilized for the periods 1972-1976 and 1994-2000 (Figure D.13). For the year 1971, the extension was accomplished by the correlation with Baykan station (Figure D.12, Figure D.16). There is no appropriate station to extent the flow records at Kucuksu station. Therefore, the monthly mean flow values of two years of observations were used to complete the missing data (Figure D.15).

3.2.2.3. Monthly Mean Flow Calculations

In order to calculate the monthly mean inflow values for the operation study of the Ilisu II Dam and HEPP Project, a joint operating policy from upstream to downstream was formulated, as summarized in Figure 3.4:

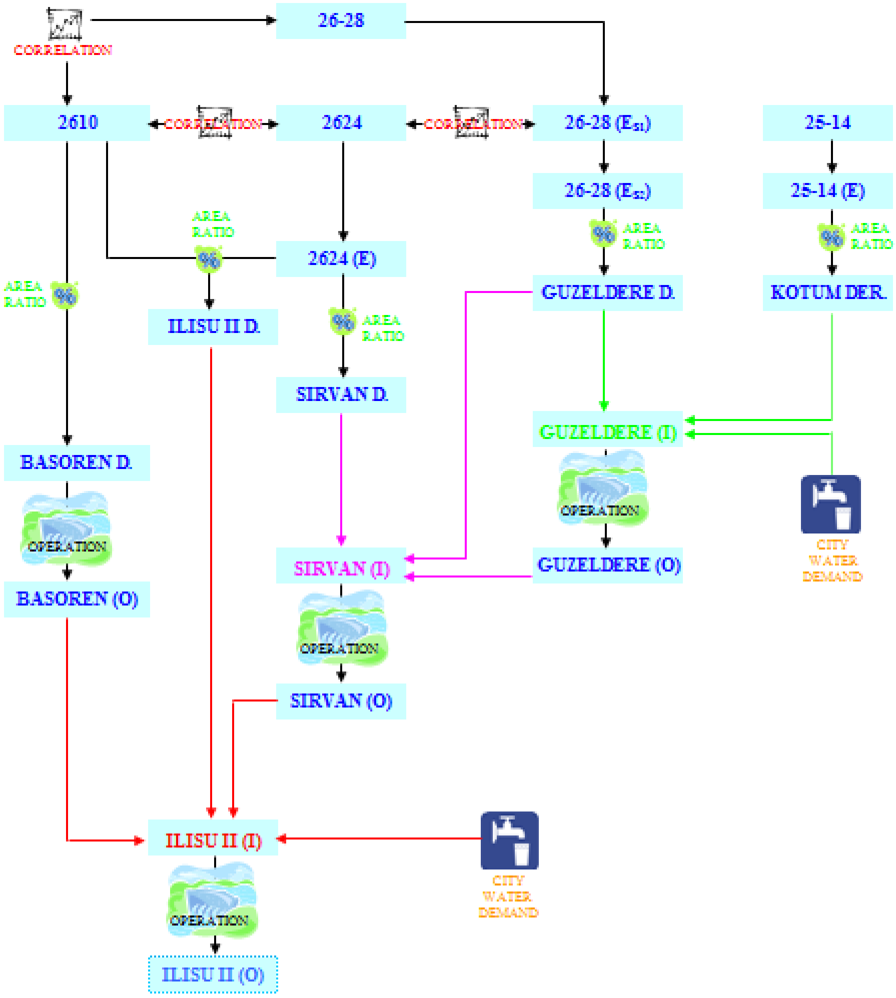


Figure 3.4 Scheme for Monthly Mean Flow Calculations of the Bitlis Project

- **The Guzeldere Dam and HEPP Project with Kotum Derivation:** The extended data set of Kucuksu station was accepted as the flow values at the Kotum Weir location (Equation 3.7) (Figure D.1). The amounts diverted from Kotum Creek to Guzeldere Dam were determined from these values according to the capacity of the transmission channel, 12.00 m^3/s. Moreover, a discharge of 0.10 m^3/s was left to the river bed for the maintenance of natural life as environmental water (Figure D.18) (DSI, 1986).

$$Q_{KOTUM} = Q_{25\text{-}14} \qquad (3.7)$$

The flow rates at the Guzeldere Dam location were transformed from the extended data set of Kuscukoyu station according to the catchment area ratio between them (Equation 3.8) (Figure D.1, Figure D.19). The sum of these values with the diverted flows from Kotum Creek was used as the monthly mean inflows of Guzeldere Dam and HEPP (Figure D.20).

$$Q_{GUZELDERE} = Q_{26\text{-}28} \left(\frac{A_{GUZELDERE}}{A_{26\text{-}28}} \right) \quad \textbf{(3.8)}$$

A discharge of 0.35 m^3/s will be pumped from the dam lake to the Tatvan district of Van in order to supply domestic water demand. Therefore, the operation study of Guzeldere Reservoir was conducted by the "*Operation of a Multi-Purpose Project*" program considering the environmental and domestic water requirements (Table D.1, Figure D.4, Table D.2, Table D.6, Figure D.21, Appendix I.3) (DSI, 1986). The outflows are equal to the sum of spillway releases and flows through turbines (Figure D.22).

- **The Sirvan Dam and HEPP Project:** The extended flows of Pinarca station were transposed to the dam site in proportion to the drainage areas (Equation 3.9) (Figure D.1, Figure D.23). Then, the monthly mean inflow values of Sirvan Dam and HEPP were determined as subtracting the flow rates at the Guzeldere Dam location from the sum of these values with the outflows of Guzeldere Dam and HEPP (Figure D.24).

$$Q_{SIRVAN} = Q_{2624} \left(\frac{A_{SIRVAN}}{A_{2624}} \right) \quad \textbf{(3.9)}$$

The reservoir operation was applied in the "*Operation of a Multi-Purpose Project*" algorithm as taking into account the requirements for environmental water (Table D.1, Figure D.5, Table D.3, Table D.7, Figure D.25, Appendix I.3) (Enersu, January 2009). The outflow rates were thus determined from spillway releases and flows through turbines (Figure D.26).

- **The Basoren Dam and HEPP Project:** The catchment area ratio was used to bring the runoff records at Baykan gauging station to the dam axis (Equation 3.10) (Figure D.1, Figure D.27). These are also the inflow values of Basoren Dam and HEPP due to lack of schemes in the upstream.

$$Q_{BASOREN} = Q_{2610} \left(\frac{A_{BASOREN}}{A_{2610}} \right) \quad \textbf{(3.10)}$$

The operation study of Basoren Reservoir was conducted by the "*Operation of a Multi-Purpose Project*" program considering the environmental water needs (Table D.1, Figure D.6, Table D.4, Table D.8, Figure D.28, Appendix I.3) (Yolsu, March 2009). The outflows equal to the sum of spillway releases and flows through turbines appeared ample to enable the Siirt domestic water demand of 0.60 m^3/s, which will be pumped from the river bed between the Basoren and Ilisu II projects (Figure D.25).

- **The Ilisu II Dam and HEPP Project:** The monthly mean flows at the Ilisu II Dam site, located in the downstream of the conjunction of Bitlis and Kezer Creeks, was estimated in three steps. Firstly, the rates coming from the Bitlis Creek catchment from the source to the confluence with Kezer Creek were transformed from the measurements at Baykan station. Then, the same transposition was carried out for Kezer Creek using the extended flows of Pinarca station. Lastly, the flows of the intermediate catchment between Ilisu II Dam and the junction point were added to the values coming from creeks (Equation 3.11) (Figure D.1, Figure D.30). In order to determine the monthly mean inflow values of Ilisu II Dam and HEPP, the flow amounts of Sirvan and Basoren Dams and domestic water abstractions were subtracted from the sum of the runoff values at the Ilisu II Dam location with the outflow rates of these upstream schemes (Figure D.31).

$$Q_{ILISU\text{-}II}=Q_{2610}\left(\frac{A_{BITLIS}}{A_{2610}}\right)+Q_{2624}\left(\frac{A_{KEZER}}{A_{2624}}\right)+\left(Q_{2610}\frac{A_{BITLIS}}{A_{2610}}+Q_{2624}\frac{A_{KEZER}}{A_{2624}}\right)\left(\frac{A_{ILISU\text{-}II}-A_{BITLIS}-A_{KEZER}}{A_{BITLIS}+A_{KEZER}}\right) \quad \textbf{(3.11)}$$

3.2.3. Sediment Transport

The sedimentation volume was calculated using the suspended load concentration data at Besiri gauging station, collected for a total of 154 days during the period 1987-1999 (EIE, 2000). After performing sediment analysis, annual specific suspended load was found to be 270 m^3/year/km^2. By adding a 50% more to this value for bed load, a total of 406 m^3/year/km^2 was obtained (EIE, 2010). The volume of sediment that would be deposited in the reservoir as dead volume for 50 years was calculated according to the area contributing the sediment transport between the Basoren and Sirvan schemes, and Ilisu II Reservoir. Then, the elevation of the power intake sill, or the minimum operating level, was designated in line with this storage by using the area-volume curve as 475 m (Figure D.7, Table D.9).

3.2.4. Operation Studies

A total of 72 runs were conducted for three different combinations of penstocks with the design discharges determined from the drawn discharge-duration curve of the project site (Figure D.32). As a result of this analysis, the optimum design discharge for this plant was observed as 120 m^3/s through a system composed of one penstock and one energy tunnel with 5.5 m and 6.2 m inlet diameters, respectively (Figure D.33). The energy production capacity of this combination is 217.2 GWh/year, composing of 171.1 GWh/year firm energy and 46.1 GWh/year secondary energy, with an installed power of 72.7 MW.

3.2.5. Flood Analysis

3.2.5.1. Calculation of Design Floods from Observed Runoff

The characteristics and corresponding observation periods of the used stream gauging stations in this approach are given in Table 3.8. The flood discharges for different return periods were calculated with the annual maximum instantaneous flow records of each station by means of the most appropriate probability distribution function using Kolmogorov-Smirnov test (Table D.10).

Table 3.8 Characteristics of Stream Gauging Stations Used in Flood Frequency Analyses (DSI, 2007-b; EIE, 2005)

Station Id	Station Name	Drainage Area (km^2)	Elevation (m)	Observation Period
EIE 2626	Botan Creek-Billoris	8761.2	457.0	1972-1996 (25)
EIE 2633	Botan Creek-Billoris	8747.3	465.0	1946-2006 (36)
EIE 2624	Kezer Creek-Pinarca	1169.6	530.0	1972-2006 (35)
EIE 2616	Bitlis Creek-Karinca	346.4	1145.0	1965-1970 (6)
DSI 26-20	Guzeldere-Saris	112.9	1693.0	1965-1968 (4)
EIE 2610	Bitlis Creek-Baykan	640.4	910.0	1955-2006 (52)

3.2.5.1.1. Point Flood Frequency Analysis

The flood peaks calculated for Baykan station were transposed to the dam site in proportion with the drainage areas by applying Equation 3.12 (Table D.11):

$$Q_{ILISU-II} = Q_{2610} \left(\frac{A_{ILISU-II}}{A_{2610}} \right)^{0.667} \tag{3.12}$$

3.2.5.1.2. Regional Flood Frequency Analysis

In this approach, initially, a homogeneity test was done for the determined base periods concerning the observation periods of the stream gauges (Table D.12, Figure D.36, Table D.13, Table D.14). As a result of this test conducted for each period, Saris station was eliminated (Figure D.37). Then, the recurrence flood peaks of the remaining stations were divided by the corresponding $Q_{2.33}$ recurrence values and thus the non-dimensional recurrence flood peak values were found (Table D.15). After that, the $Q_{2.33}$ recurrence discharge versus drainage area curve was plotted on a logarithmic paper using the data obtained for each station (Figure D.38). From this curve, the 2.33 years return period flood discharge for the Ilisu II catchment can be read as 496.1 m^3/s. Eventually, this value was multiplied by the average non-dimensional recurrence flood values and thus the regional recurrence flood peaks for the project were obtained (Table D.16).

3.2.5.2. Flood Recurrences Calculated Using Snyder Synthetic Unit Hydrograph Method

Finally, the recurrence and probable flood calculations were carried out using Snyder's unit hydrograph method together with considering the drainage area characteristics.

- **Precipitation Analysis:** The meteorological stations of Bitlis, Sarikonak, Hizan, Baykan, Sirvan, Siirt, Tatvan, Mutki and Kurtalan are located inside or near the Ilisu II drainage area (Figure D.39). From the maximum 24-hour precipitation rates of these stations, the 24-hour precipitations for different return periods were calculated using the appropriate distribution functions (Table D.17, Table D.19). In order to obtain the mean areal precipitation over the watershed, Thiessen polygons were used to assess the weight of each station (Figure D.39, Table D.20). The corresponding precipitations were calculated for different durations by multiplying the basin precipitations with the pluviograph rates, the area reduction factor and the maximization factor, 1.13 (Table D.21, Table D.22, Table D.23, Figure K.1).

  In the probable maximum flood calculations, the 24-hour probable maximum precipitation values of these meteorological stations were calculated using the Hershfield statistical method with the formula "$PMP_{24} = X + KM \times S$", where KM is the frequency factor, X is the corrected average and S is the corrected standard deviation of the annual maximum rainfall records (Table D.18, Figure K.4, Figure K.5, Figure K.6, Figure K.7). The values for the frequency factor were evaluated according to the X-KM envelopes prepared by DSI Hydrology Branch Office for East Anatolia and South-East Anatolia. The probable maximum precipitation amounts for different periods were again obtained by multiplying the station values by the Thiessen weights, the pluviograph rates, the areal reduction factors and the maximization factor (Table D.19, Table D.20, Table D.21, Table D.22, Table D.23).

- **Baseflow:** The base flow of Bitlis Creek at the Ilisu II Dam site was derived from the one estimated for Baykan observation station (Table D.25). The base flow values of the catchment for the recurrence floods and probable maximum flood are 241.2 m^3/s and 313.2 m^3/s, respectively.

- **Unit Hydrograph Analysis:** The key parameters intervening in the establishment of the unit hydrograph were measured on the 1:100000 scale topographic maps of the region (Figure D.39). Accordingly, the Ilisu II catchment area is 2510.0 km^2, the longest river branch length is 120.3 km, and the distance of the outlet to the point on the river nearest centroid of the watershed is 56.4 km. The coefficients C_t and C_p were taken from the "*Ilisu*

Dam and HEPP, *Flood Hydrology and Sediment Transport*" report prepared by the engineering and consultancy services consortium of the project. The corresponding values are given as C_t=1.35 and C_p=0.69. Using these parameters, the peak discharge, the duration of reaching the peak and the base time of the synthetic unit hydrograph were calculated as 33.1 m^3/s/mm, 16.0 hour and 115.4 hour, respectively (Table K.1). In the end, a 3-hour unit hydrograph was drawn in order to convert excess rainfall into runoff (Figure D.41, Figure K.8).

- **Flood Hydrographs Calculated with Snyder Unit Hydrograph Method:** The critical precipitation duration for this type of catchment varies from 8 to 24 hours (Figure K.3). However, in this study, this duration was selected as 12 hours. The 12-hour precipitation was then subdivided into 3-hour precipitation blocks by utilizing the distribution curve "*B*" for precipitation in time (Figure K.2).

  In order to estimate the excess rainfall, the part of the rainfall which generates runoff, the SCS method was used. The characterization of the land use and the soil type in the catchment was thereby made by making the SCS curve number CN_{II}=82 (Yolsu, March 2009). The runoff volumes and excess rainfall were calculated from the 12-hour precipitation amounts. The hydrographs for different return periods were then evaluated using the unit hydrograph method. Eventually, the resulting recurrence flood peaks were determined by adding the beforehand calculated baseflow (Figure D.42, Table D.26).

- **Hydrograph Caused by Probable Maximum Flood**: As above, in order to evaluate the excess rainfall, the SCS method for abstraction was used with a curve number of CN_{III}=92 (Yolsu, March 2009). The excess rainfall was then converted into runoff by using the 3-hour unit hydrograph. The peak discharge of the probable maximum flood of the Ilisu II basin without accounting for baseflow and snowmelt runoff is 2545.6 m^3/s.

  Because of lack of data to calculate the maximum snowmelt runoff hydrograph of the basin with the degree-day method, an approximate value as 100.0 m^3/s was utilized in this project. The probable maximum flood hydrograph was then obtained as by adding the previously determined baseflow and snowmelt values to the hydrograph caused by the probable maximum precipitation (Figure D.42). The peak discharge value of this hydrograph to be used in spillway design is 2958.8 m^3/s (Table D.26).

3.2.5.3. Selection of Project Flood Discharges

The obtained flood discharges with statistical and synthetic unit hydrograph methods are summarized in Table 3.9. It can be concluded that for this catchment all three methods lead to reasonable values.

The highest ones can be selected as design flood discharges to be on the safe side. Hence, the results of the Snyder's method were utilized in the economic analysis part of the study.

Table 3.9 Summary of Flood Calculations

Return Period	Flood Discharge (m^3/s)		
	PFFA	RFFA	Snyder
2	524.0	453.8	578.9
2.33	566.1	496.1	615.8
5	735.1	675.0	777.3
10	858.0	814.5	908.6
25	998.9	984.2	1073.6
50	1095.4	1106.1	1195.3
100	1186.1	1224.5	1315.8
200	1272.4	1340.2	1435.5
500	1381.1	1490.0	1593.1
1000	1460.3	1602.0	1712.9
PMF	-	-	2958.8

3.3. The Botan Projects and Ilisu III Dam and HEPP

There are the Narli Dam and HEPP Project, the Oran Dam and HEPP Project, the Keskin Dam and HEPP Project, the Pervari Dam and HEPP Project with Mukus Derivation, the Cetin Dam and HEPP Project, the Alkumru Dam and HEPP Project and the Eruh Dam and HEPP Project in the upstream of the Ilisu III Dam and HEPP Project (Figure E.1) (DSI, 2010).

3.3.1. Estimated Evaporation Rates

The evaporation rates for Narli, Oran, Keskin, Pervari, Cetin, Alkumru, Eruh and Ilisu III Reservoirs were based on the measurements at Siirt meteorological station (Table A.12, Table A.15, Figure E.1). The pan evaporations were determined along with the correlation between monthly mean temperature and monthly total evaporation observations made at the station (Figure A.2). The net evaporation quantities to be used in the operation studies were obtained by subtracting the precipitation records of Pervari station from the converted actual evaporation values of Narli, Oran, Keskin and Pervari Reservoirs (Table A.6, Figure E.1, Table E.2, Table E.3, Table E.4, Table E.5). For the Cetin, Alkumru, Eruh and Ilisu III projects, these quantities were calculated with the precipitation rates observed at Siirt station (Table A.3, Figure E.1, Table E.6, Table E.7, Table E.8, Table E.9).

3.3.2. Water Resources

3.3.2.1. Stream Gauging Stations

The flow records observed at Catak (EIE 2609), Billoris (EIE 2604/A), Billoris (EIE 2626), Billoris (EIE 2633), Begendik (EIE 2615) and Dalbasti (DSI 26-55) gauging stations were utilized to calculate the monthly mean flow values at dam locations, as listed in Table 3.10 (Table B.10, Table B.11, Table B.12, Table B.13, Table B.14, Table B.15, Figure E.1, Figure E.12, Figure E.13, Figure E.14, Figure E.15, Figure E.16, Figure E.17).

Table 3.10 Characteristics of Stream Gauging Stations (DSI, 2007-b; EIE, 2005)

Station Id	Station Name	Opening Date	Closing Date	Drainage Area (km^2)	Elevation (m)	Mean Discharge (m^3/s)	Valuable Years
EIE 2609	Catak Brook-Catak	12.09.1954	22.02.1972	2339.5	1625.0	27.5	11
EIE 2604/A	Botan Creek-Billoris	31.07.1962	01.10.1970	8747.3	465.0	189.1	8
EIE 2626	Botan Creek-Billoris	01.10.1970	03.10.1996	8761.2	457.0	156.8	25
EIE 2633	Botan Creek-Billoris	03.10.1996	30.09.2000	8747.3	465.0	118.2	4
EIE 2615	Mukus Creek-Begendik	11.08.1964	01.02.1973	505.6	1250.0	19.1	8
DSI 26-55	Catak Brook-Dalbasti	01.10.1980	-	3069.0	1350.0	40.5	6

3.3.2.2. Correlation Studies

In order to produce a representative data between the years 1971 and 2000, the data obtained at Billoris (EIE 2604/A) and Billoris (EIE 2626) stations were transformed to the drainage area of Billoris (EIE 2633) station using the area ratios between them. The discontinuities in the records of Begendik station were then fulfilled by the correlation with the extended rates of Billoris (EIE 2633) gauging station (Figure E.15, Figure E.22). The missing data set of the year 1971 in the extended flows of Billoris (EIE 2633) was completed using the correlation equation observed with the rates of Catak station (Figure E.18, Figure E.21). In the extension of the records of Dalbasti gauging station, the correlation conducted with the fully extended flow values of Billoris (EIE 2633) station was utilized (Figure E.20, Figure E.23).

3.3.2.3. Monthly Mean Flow Calculations

In order to calculate the monthly mean inflow values for the operation study of the Ilisu III Dam and HEPP Project, a joint operating policy from upstream to downstream was formulated, as summarized in Figure 3.5:

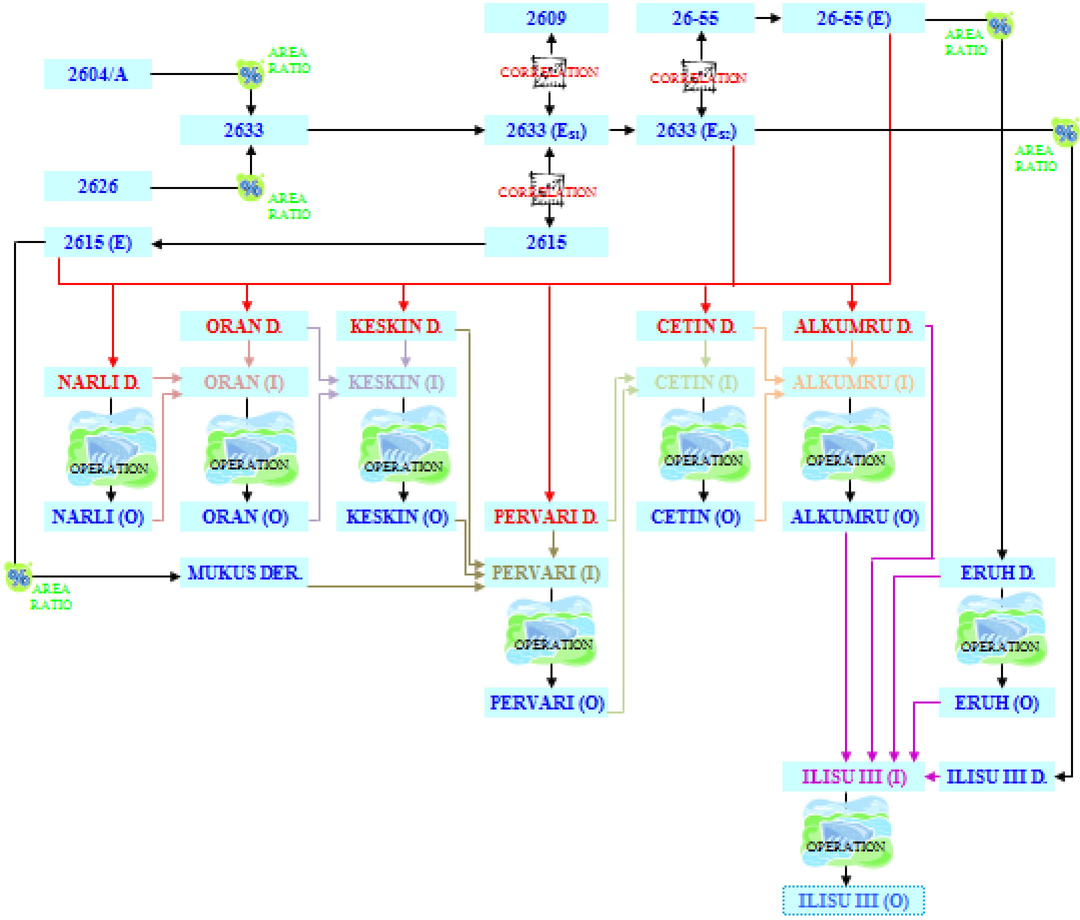


Figure 3.5 Scheme for Monthly Mean Flow Calculations of the Botan Project

- **The Narli Dam and HEPP Project:** The monthly mean flows at the Narli Dam site was estimated as the sum of the extended flow data of Dalbasti station with the values coming from the intermediate catchment between this station and the project. In the estimation of the intermediate basin flow rates, the drainage area ratio among this catchment and the one between Billoris (EIE 2633), Begendik and Dalbasti stations was utilized (Equation 3.13) (Figure E.1, Figure E.24). These are also the inflow values of Narli Dam and HEPP due to lack of schemes in the upstream.

$$Q_{NARLI} = Q_{26\text{-}55} + (Q_{2633} - Q_{2615} - Q_{26\text{-}55})\left(\frac{A_{NARLI} - A_{26\text{-}55}}{A_{2633} - A_{2615} - A_{26\text{-}55}}\right) \qquad (3.13)$$

The operation study of Narli Reservoir was conducted by the "*Operation of a Multi-Purpose Project*" program (Table E.1, Figure E.4, Table E.2, Figure E.25, Appendix I.3) (EIE, June 1986; Su Yapı, August 2007). The outflow rates were thus determined from spillway releases and flows through turbines (Figure E.26).

- **The Oran Dam and HEPP Project:** The same methodology as for Narli Dam was applied to estimate the runoff at the Oran Dam site (Equation 3.14) (Figure E.1, Figure E.27). Then, the monthly mean inflow values of this project were calculated as subtracting the flow rates at the Narli Dam location from the sum of these estimations with the outflows of Narli Dam and HEPP (Figure E.28).

$$Q_{ORAN} = Q_{26\text{-}55} + (Q_{2633} - Q_{2615} - Q_{26\text{-}55})\left(\frac{A_{ORAN} - A_{26\text{-}55}}{A_{2633} - A_{2615} - A_{26\text{-}55}}\right) \tag{3.14}$$

The "*Operation of a Multi-Purpose Project*" algorithm was utilized to conduct reservoir run (Table E.1, Figure E.5, Table E.3, Figure E.29, Appendix I.3) (EIE, June 1986; Su Yapı, August 2007). The outflows are equal to the sum of spillway releases and flows through turbines (Figure E.30).

- **The Keskin Dam and HEPP Project:** Similar to the Narli and Oran schemes, the flow rates at the Keskin Dam location were obtained with the sum of the extended flow data of Dalbasti station with the values coming from the intermediate catchment between this station and the project (Equation 3.15) (Figure E.1, Figure E.31). In order to determine the monthly mean inflow values of the project, the flow amounts at the Oran Dam site were subtracted from the sum of the ones of Keskin Dam with the outflow rates of the Oran scheme (Figure E.32).

$$Q_{KESKIN} = Q_{26\text{-}55} + (Q_{2633} - Q_{2615} - Q_{26\text{-}55})\left(\frac{A_{KESKIN} - A_{26\text{-}55}}{A_{2633} - A_{2615} - A_{26\text{-}55}}\right) \tag{3.15}$$

The run was carried out by the "*Operation of a Multi-Purpose Project*" program (Table E.1, Figure E.6, Table E.4, Figure E.33, Appendix I.3) (EIE, June 1986; Su Yapı, August 2007). The outflow rates were thus determined from spillway releases and flows through turbines (Figure E.34).

- **The Pervari Dam and HEPP Project with Mukus Derivation:** The extended data set of Begendik station was accepted as the flow values at the Mukus Weir location (Equation 3.16) (Figure E.1, Figure E.35). The amounts diverted from Mukus Creek to Pervari Dam were determined from these values according to the capacity of the transmission channel, 30.00 m^3/s. Moreover, a discharge of 0.20 m^3/s was left to the river bed for the maintenance of natural life as environmental water (Figure E.36) (Su Yapı, August 2007).

$$Q_{MUKUS} = Q_{2615} \tag{3.16}$$

In the estimation of the flow rates at the Pervari Dam location, the same method was used as for the upstream schemes (Equation 3.17) (Figure E.1, Figure E.37). The monthly mean inflows of the Pervari Dam and HEPP are equal to the difference between the flow rates at the Keskin Dam site and the sum of the ones at the project location, the diverted flows from Mukus Creek and the outflows of the Keskin scheme (Figure E.38).

$$Q_{PERVARI}=Q_{26\text{-}55}+(Q_{2633}-Q_{2615}-Q_{26\text{-}55})(\frac{A_{PERVARI}-A_{26\text{-}55}}{A_{2633}-A_{2615}-A_{26\text{-}55}}) \quad \textbf{(3.17)}$$

The operation study of Pervari Reservoir was applied in the "*Operation of a Multi-Purpose Project*" algorithm (Table E.1, Figure E.7, Table E.5, Figure E.39, Appendix I.3) (Su Yapı, August 2007). The outflows are equal to the sum of spillway releases and flows through turbines (Figure E.40).

- **The Cetin Dam and HEPP Project:** The monthly mean flows at the Cetin Dam site was estimated as the sum of the extended data of Dalbasti and Begendik stations with the flow values coming from the intermediate catchment between these stations and the project. In the estimation of the intermediate basin flow quantities, the drainage area ratio among this catchment and the one between Billoris (EIE 2633), Begendik and Dalbasti stations was utilized (Equation 3.18) (Figure E.1, Figure E.41). The monthly mean inflows of the project were obtained as subtracting the flow rates at the Pervari Dam site together with the derived ones of Mukus Weir from the sum of the runoff values at the project location and the outflows of the Pervari Dam and HEPP (Figure E.42).

$$Q_{CETIN}=Q_{2615}+Q_{26\text{-}55}+(Q_{2633}-Q_{2615}-Q_{26\text{-}55})(\frac{A_{CETIN}-A_{2615}-A_{26\text{-}55}}{A_{2633}-A_{2615}-A_{26\text{-}55}}) \quad \textbf{(3.18)}$$

The operation study of Cetin Reservoir was conducted by the "*Operation of a Multi-Purpose Project*" program as taking into account the requirements for environmental water (Table E.1, Figure E.8, Table E.6, Table E.10, Figure E.43, Appendix I.3) (Hidrokon, April 2009). From this run were observed the spillway releases and flows through turbines (Figure E.44).

- **The Alkumru Dam and HEPP Project:** The same methodology as for Cetin Dam was applied to estimate the runoff values at the Alkumru Dam axis (Equation 3.19) (Figure E.1, Figure E.45). Then, the monthly mean inflow values of this project were calculated as subtracting the flow rates at the Cetin Dam site from the sum of these estimations with the outflows of the upstream scheme (Figure E.46).

$$Q_{ALKUMRU} = Q_{2615} + Q_{26\text{-}55} + (Q_{2633} - Q_{2615} - Q_{26\text{-}55})\left(\frac{A_{ALKUMRU} - A_{2615} - A_{26\text{-}55}}{A_{2633} - A_{2615} - A_{26\text{-}55}}\right) \quad (3.19)$$

The run was carried out by the "*Operation of a Multi-Purpose Project*" program (Table E.1, Figure E.9, Table E.7, Figure E.47, Appendix I.3) (Limak, October 2006). The outflow rates were thus determined from spillway releases and flows through turbines (Figure E.48).

- **The Eruh Dam and HEPP Project:** The catchment area ratio was utilized to bring the extended runoff rates at Billoris (EIE 2633) gauging station to the dam axis (Equation 3.20) (Figure E.1, Figure E.49). These are also the inflow values of Eruh Dam and HEPP due to lack of schemes in the upstream.

$$Q_{ERUH} = Q_{2633}\left(\frac{A_{ERUH}}{A_{2633}}\right) \quad (3.20)$$

The operation study of Eruh Reservoir was conducted by the "*Operation of a Multi-Purpose Project*" program considering the environmental water requirements (Table E.1, Figure E.10, Table E.8, Table E.11, Figure E.50, Appendix I.3) (Met , September 2006). The outflows are equal to the sum of spillway releases and flows through turbines (Figure E.51).

- **The Ilisu III Dam and HEPP Project:** A transposition was carried out through the drainage areas to estimate the flow rates at the Ilisu III Dam location by using the extended data set of Billoris (EIE 2633) station (Equation 3.21) (Figure E.1, Figure E.52). In order to determine the monthly mean inflow values of Ilisu III Dam and HEPP, the flow amounts of Alkumru and Eruh Dams were subtracted from the sum of the ones at the Ilisu I Dam site with the outflow rates of the upstream schemes (Figure E.53).

$$Q_{ILISU\text{-}III} = Q_{2633}\left(\frac{A_{ILISU\text{-}III}}{A_{2633}}\right) \quad (3.21)$$

3.3.3. Sediment Transport

The sedimentation volume was calculated using the suspended load concentration data at Besiri gauging station, collected for a total of 314 days during the period 1971-1999 (EIE, 2000). After performing sediment analysis, annual specific suspended load was found to be 362 m^3/year/km^2. By adding a 50% more to this value for bed load, a total of 543 m^3/year/km^2 was obtained (EIE, 2010). The volume of sediment that would be deposited in the reservoir as dead volume for 50 years was calculated according to the area contributing the sediment transport between the Alkumru and Eruh schemes, and Ilisu III Reservoir. Then, the elevation of the power intake sill, or the minimum operating level, was designated in line with this storage by using the area-volume curve as 480 m (Figure E.11, Table E.12).

3.3.4. Operation Studies

A total of 180 runs were conducted for four different combinations of penstocks with the design discharges determined from the drawn discharge-duration curve of the project site (Figure E.54). As a result of this analysis, the optimum design discharge for this plant was observed as 355 m^3/s through a system composed of two penstocks and one energy tunnel with 6.7 m and 10.6 m inlet diameters, respectively (Figure E.55). The energy production capacity of this combination is 627.9 GWh/year, composing of 488.7 GWh/year firm energy and 139.2 GWh/year secondary energy, with an installed power of 201.4 MW.

3.3.5. Flood Analysis

3.3.5.1. Calculation of Design Floods from Observed Runoff

The characteristics and corresponding observation periods of the used stream gauging stations in this approach are given in Table 3.11. The flood discharges for different return periods were calculated with the annual maximum instantaneous flow records of each station by means of the most appropriate probability distribution function using Kolmogorov-Smirnov test (Table E.13a, Table E.13b).

Table 3.11 Characteristics of Stream Gauging Stations Used in Flood Frequency Analyses (DSI, 2007-b; EIE, 2005)

Station Id	Station Name	Drainage Area (km^2)	Elevation (m)	Observation Period
EIE 2626	Botan Creek-Billoris	8761.2	457.0	1972-1996 (25)
EIE 2633	Botan Creek-Billoris	8747.3	465.0	1946-2006 (36)
EIE 2624	Kezer Creek-Pinarca	1169.6	530.0	1972-2006 (35)
DSI 26-55	Catak Brook-Dalbasti	3069.0	1350.0	1981-2003 (9)
EIE 2609	Catak Brook-Catak	2339.5	1625.0	1961-1971 (11)
EIE 2615	Mukus Brook-Begendik	505.6	1250.0	1965-1972 (8)
EIE 2631	Catak Brook-Tuliran	2455.0	1482.0	1888-2006 (19)
DSI 26-33	Catak Brook-Catak	2376.6	1488.0	1976-1991 (6)
EIE 2610	Bitlis Creek-Baykan	640.4	910.0	1955-2006 (52)

3.3.5.1.1. Point Flood Frequency Analysis

The flood peaks calculated for Billoris (EIE 2626) station were transposed to the dam site in proportion with the drainage areas by applying Equation 3.22 (Table E.14):

$$Q_{ILISU-III} = Q_{2626}\left(\frac{A_{ILISU-III}}{A_{2626}}\right)^{0.667} \tag{3.22}$$

3.3.5.1.2. Regional Flood Frequency Analysis

In this approach, initially, a homogeneity test was done for the determined base periods concerning the observation periods of the stream gauges (Table E.15, Figure E.58, Table E.16, Table E.17). As a result of this test conducted for each period, Dalbasti station was eliminated (Figure E.59). Then, the recurrence flood peaks of the remaining stations were divided by the corresponding $Q_{2.33}$ recurrence values and thus the non-dimensional recurrence flood peak values were found (Table E.18). After that, the $Q_{2.33}$ recurrence discharge versus drainage area curve was plotted on a logarithmic paper using the data obtained for each station (Figure E.60). From this curve, the 2.33 years return period flood discharge for the Ilisu III catchment can be read as 1019.0 m^3/s. Eventually, this value was multiplied by the average non-dimensional recurrence flood values and thus the regional recurrence flood peaks for the project were obtained (Table E.19).

3.3.5.2. Flood Recurrences Calculated Using Snyder Synthetic Unit Hydrograph Method

Finally, the recurrence and probable flood calculations were carried out using Snyder's unit hydrograph method together with considering the drainage area characteristics.

- **Precipitation Analysis:** The meteorological stations of Bitlis, Hizan, Sirvan, Siirt, Bahcesaray, Baskale, Beytussebap, Catak, Gevas, Gurpinar, Hakkari, Pervari, Resadiye, Eruh and Sirnak are located inside or near the Ilisu III drainage area (Figure E.61). From the maximum 24-hour precipitation rates of these stations, the 24-hour precipitations for different return periods were calculated using the appropriate distribution functions (Table E.20a, Table E.20b, Table E.22). In order to obtain the mean areal precipitation over the watershed, Thiessen polygons were used to assess the weight of each station (Figure E.61, Table E.23). The corresponding precipitations were calculated for different durations by multiplying the basin precipitations with the pluviograph rates, the area reduction factor and the maximization factor, 1.13 (Table E.24, Table E.25, Table E.26, Figure K.1).

  In the probable maximum flood calculations, the 24-hour probable maximum precipitation values of these meteorological stations were calculated using the Hershfield statistical method with the formula "$PMP_{24} = X + KM \, x \, S$", where KM is the frequency factor, X is the corrected average and S is the corrected standard deviation of the annual maximum rainfall records (Table E.21, Figure K.4, Figure K.5, Figure K.6, Figure K.7). The values for the frequency factor were evaluated according to the X-KM envelopes prepared by DSI Hydrology Branch Office for East Anatolia and South-East Anatolia. The probable maximum precipitation amounts for different periods were again obtained by multiplying the station values by the Thiessen weights, the pluviograph rates, the areal reduction factors and the maximization factor (Table E.22, Table E.23, Table E.24, Table E.25, Table E.26).

- **Baseflow:** The base flow of Botan Creek at the Ilisu III Dam site was derived from the one estimated for Billoris observation stations (Table E.28). The base flow values of the catchment for the recurrence floods and probable maximum flood are 728.8 m^3/s and 887.5 m^3/s, respectively.

- **Unit Hydrograph Analysis:** The key parameters intervening in the establishment of the unit hydrograph were measured on the 1:100000 scale topographic maps of the region (Figure E.61). Accordingly, the Ilisu III catchment area is 8872.7 km^2, the longest river branch length is 246.5 km, and the distance of the outlet to the point on the river nearest centroid of the watershed is 114.4 km. The coefficients C_t and C_p were taken from the "*Ilisu Dam and HEPP, Flood Hydrology and Sediment Transport*" report prepared by the engineering and consultancy services consortium of the project. The corresponding values are given as C_t=1.35 and C_p=0.69. Using these parameters, the peak discharge, the duration of reaching the peak and the base time of the synthetic unit hydrograph were calculated as 76.9 $m^3/s/mm$, 24.0 hour and 137.9 hour, respectively (Table K.1). In the end, a 4-hour unit hydrograph was drawn in order to convert excess rainfall into runoff (Figure E.63, Figure K.8).

- **Flood Hydrographs Calculated with Snyder Unit Hydrograph Method:** The critical precipitation duration for this type of catchment varies from 8 to 18 hours (Figure K.3). However, in this study, this duration was selected as 12 hours. The 12-hour precipitation was then subdivided into 4-hour precipitation blocks by utilizing the distribution curve "*B*" for precipitation in time (Figure K.2).

  In order to estimate the excess rainfall, the part of the rainfall which generates runoff, the SCS method was used. The characterization of the land use and the soil type in the catchment was thereby made by making the SCS curve number CN_{II}=84 (Limak, October 2006). The runoff volumes and excess rainfall were calculated from the 12-hour precipitation amounts. The hydrographs for different return periods were then evaluated using the unit hydrograph method. Eventually, the resulting recurrence flood peaks were determined by adding the beforehand calculated baseflow (Figure E.64, Table E.29).

- **Hydrograph Caused by Probable Maximum Flood:** As above, in order to evaluate the excess rainfall, the SCS method for abstraction was used with a curve number of CN_{III}=93 (Limak, October 2006). The excess rainfall was then converted into runoff by using the 4-hour unit hydrograph. The peak discharge of the probable maximum flood of the Ilisu III basin without accounting for baseflow and snowmelt runoff is 6550.1 m^3/s.

  Because of lack of data to calculate the maximum snowmelt runoff hydrograph of the basin with the degree-day method, the rate determined for the upstream project as 1663.0 m^3/s was directly utilized in this project (Limak, October 2006). The possible snowmelt contributions in the intermediate basin between these schemes and in the Eruh basin were not taken into consideration. The probable maximum flood hydrograph was then obtained as by adding the previously determined baseflow and snowmelt values to the hydrograph caused by the probable maximum precipitation (Figure E.64). The peak discharge value of this hydrograph to be used in spillway design is 9100.5 m^3/s (Table E.29).

3.3.5.3. Selection of Project Flood Discharges

The obtained flood discharges with statistical and synthetic unit hydrograph methods are summarized in Table 3.12. It can be concluded that for this catchment all three methods lead to reasonable values. The highest ones can be selected as design flood discharges to be on the safe side. Hence, the results of the Snyder's method were utilized in the economic analysis part of the study.

Table 3.12 Summary of Flood Calculations

Return Period	Flood Discharge (m^3/s)		
	PFFA	RFFA	Snyder
2	928.4	931.9	1233.6
2.33	1020.2	1019.0	1298.1
5	1418.9	1404.1	1604.1
10	1743.7	1726.0	1881.4
25	2154.0	2146.5	2262.8
50	2458.4	2471.5	2567.4
100	2760.6	2808.0	2888.6
200	3061.6	3159.9	3228.2
500	3458.8	3654.7	3708.4
1000	3759.0	4056.6	4099.1
PMF	-	-	9100.5

3.4. The Tigris Projects and Ilisu IV Dam and HEPP

The upstream watershed of Ilisu IV Dam and HEPP was analyzed in two steps due to the complexity of the computations. The schemes were divided in two parts as the Batman - Silvan projects and the Upper - Tigris projects, and the hydropower potential of this alternative was then calculated.

3.4.1. The Batman - Silvan Projects

There are the Silvan Dam and HEPP Project, the Batman Dam and HEPP Project, the Silvan Plain Dams Project, namely Anbar, Kurucay, Pamukcay, Baslar, Bulaklidere, Kibris and Karacalar Dams, and an area of 283117 ha that would be irrigated by these schemes in the upstream of the Ilisu IV Dam and HEPP Project to be analyzed in this step (Figure F.1, DSI 2010).

3.4.1.1. Estimated Evaporation Rates

The evaporation rates for Anbar, Kurucay, Pamukcay, Baslar, Bulaklidere, Kibris, Karacalar, Silvan and Batman Reservoirs were based on the measurements at Diyarbakir meteorological station (Table A.13, Table A.16, Figure F.1). The pan evaporations were determined along with the correlation between monthly mean temperature and monthly total evaporation observations made at the station (Figure A.3). The net evaporation quantities to be used in the operation studies were obtained by subtracting the precipitation records of Diyarbakir station from the converted actual evaporation values of Anbar, Kurucay, Pamukcay and Baslar Reservoirs (Table A.7, Figure F.1, Table F.2, Table F.3, Table F.4, Table F.5). For the Bulaklidere, Kibris, Karacalar, Silvan and Batman projects, these quantities were calculated with the precipitation rates observed at Silvan station (Table A.8, Figure F.1, Table F.6, Table F.7, Table F.8, Table F.9, Table F.10).

3.4.1.2. Water Resources

3.4.1.2.1. Stream Gauging Stations

The flow records observed at Hani (DSI 26-39), Koprubasi (EIE 2618), Yasince (DSI 26-14), Karahan Bridge (DSI 26-32), Salat (DSI 26-12), Salikan (Kibris) (DSI 26-60) and Malabadi Bridge (EIE 2612) gauging stations were utilized to calculate the monthly mean flow values at dam locations, as listed in Table 3.13 (Table B.16, Table B.17, Table B.18, Table B.19, Table B.20, Table B.21, Table B.22, Figure F.1, Figure F.13, Figure F.14, Figure F.16, Figure F.17, Figure F.18, Figure F.19, Figure F.20). The measurements at Koprubasi station were corrected due to the local irrigations in the upstream by adding the values 3.86 hm^3, 2.61 hm^3 and 0.99 hm^3 to the records of the months July, August and September, respectively (Figure F.15) (Suiş and Sial, December 2001).

Table 3.13 Characteristics of Stream Gauging Stations (DSI, 2007-b; EIE, 2005)

Station Id	Station Name	Opening Date	Closing Date	Drainage Area (km^2)	Elevation (m)	Mean Discharge (m^3/s)	Valuable Years
DSI 26-39	Anbar Creek-Hani	01.06.1977	-	292.0	800.0	2.9	14
EIE 2618	Anbar Creek-Koprubasi	01.11.1968	01.10.1998	976.0	595.0	7.7	30
DSI 26-14	Kurucay-Yasince	19.08.1962	01.11.1986	240.0	520.0	1.2	16
DSI 26-32	Pamuk Creek-Karahan B.	01.08.1974	-	305.0	738.0	2.0	16
DSI 26-12	Basnik Creek-Salat	13.07.1960	-	1060.0	1085.0	3.4	16
DSI 26-60	Baskoy Creek-Salikan	28.05.1985	-	118.5	620.0	0.5	5
EIE 2612	Batman Creek-Malabadi B.	06.02.1957	30.09.2000	4105.2	597.0	124.0	38

3.4.1.2.2. Correlation Studies

In order to produce a representative data between the years 1971 and 2000, the discontinuities in the records of Hani, Yasince, Salat, Karahan Bridge and Salikan stations were nearly fulfilled by the correlations with Koprubasi gauging station (Figure F.21, Figure F.22, Figure F.23, Figure F.24, Figure F.25). The missing data in these stations were completed with the extended monthly mean flow values (Figure F.27, Figure F.28, Figure F.29, Figure F.30, Figure F.31). In the extension of the records of Koprubasi and Malabadi gauging stations, the monthly mean flow values of observations were utilized for the years 1999 and 2000 (Figure F.26, Figure F.32).

3.4.1.2.3. Monthly Mean Flow Calculations

In order to calculate the monthly mean inflow values for the operation study of the Ilisu IV Dam and HEPP Project, a joint operating policy for the Batman - Silvan projects from upstream to downstream was formulated, as summarized in Figure 3.6:

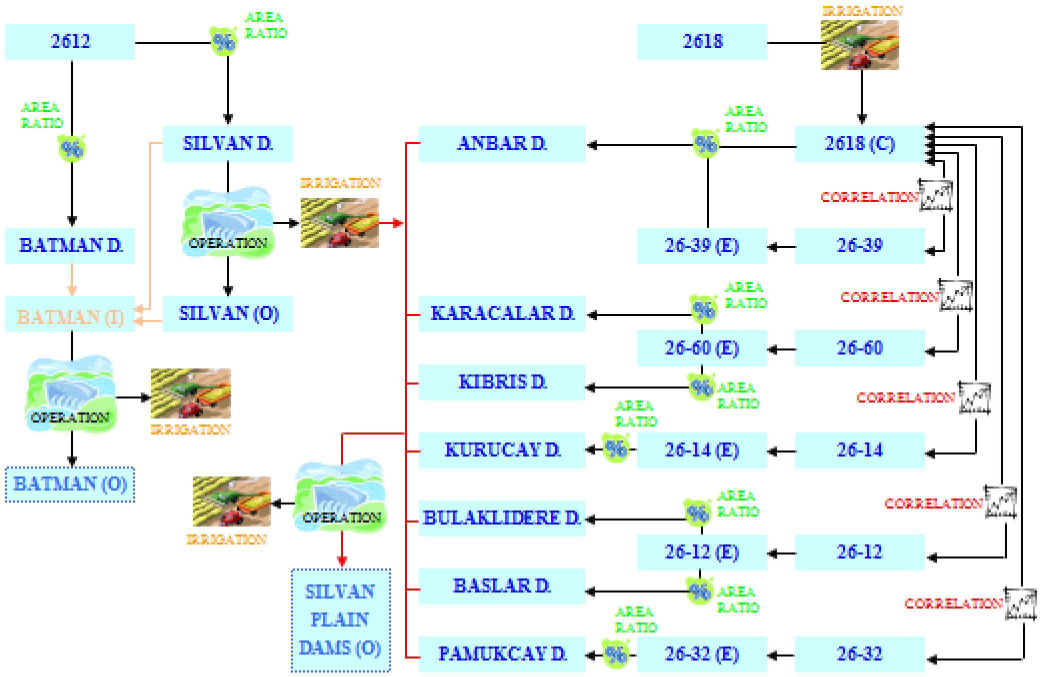


Figure 3.6 Scheme for Monthly Mean Flow Calculations of the Batman - Silvan Project

- **The Anbar Dam Project:** In the estimation of the monthly mean flow rates at the Anbar Dam site, the drainage area ratio among the weir and the intermediate catchment between Hani and Koprubasi gauging stations was utilized (Equation 3.23) (Figure F.1, Figure F.33). The sum of these values with the return water of the Silvan irrigation was accepted as the monthly mean inflow values of Anbar Dam (Table F.11, Table F.12, Figure F.34).

$$Q_{ANBAR} = Q_{26\text{-}39} + (Q_{2618} - Q_{26\text{-}39})\left(\frac{A_{ANBAR} - A_{26\text{-}39}}{A_{2618} - A_{26\text{-}39}}\right) \quad (3.23)$$

According to the development plan of the Batman - Silvan project envisaged by DSI, a gross area of 13498 ha will be irrigated by Anbar Dam with the reinforcement waters of Silvan Dam, transferred through channels due to the inadequate storage of the reservoir. Therefore, the operation study was conducted by the "*Operation of an Irrigation Project Reinforced by Upstream Reservoir*" program according to the fact that when the agricultural water requirements, determined according to the Batman - Silvan irrigation module, is greater than available storage in the reservoir, the deficiency is satisfied with waters stored in the upstream reservoir (Table F.1, Figure F.4, Table F.2, Table F.11, Table F.12, Figure F.35, Appendix I.2) (Suiş and Sial, December 2001). The return water flows of the Anbar irrigation were added to the spillway releases due to ease of next computations (Figure F.36).

- **The Kurucay Dam Project:** The extended flows of Yasince station were transposed to the dam site in proportion to the drainage areas (Equation 3.24) (Figure F.1, Figure F.37). Then, the monthly mean inflow values of Kurucay Dam were determined by adding the return water of the Silvan irrigation in the drainage area of the project to these values (Table F.11, Table F.12, Figure F.38).

$$Q_{KURUCAY} = Q_{26\text{-}14}\left(\frac{A_{KURUCAY}}{A_{26\text{-}14}}\right) \tag{3.24}$$

The reservoir operation was applied in the "*Operation of an Irrigation Project Reinforced by Upstream Reservoir*" algorithm satisfying the irrigation water for a gross area of 6013 ha, as for the case in Anbar Reservoir (Table F.1, Figure F.5, Table F.3, Table F.11, Figure F.12, Figure F.39, Appendix I.2) (Suiş and Sial, December 2001). The outflow rates were thus determined from spillway releases and return water values (Figure F.40).

- **The Pamukcay Dam Project:** The catchment area ratio was used to bring the extended runoff values at Karahan Bridge gauging station to the dam axis (Equation 3.25) (Figure F.1, Figure F.41). The inflow rates of the project are equal to the sum of the runoff values at the Pamukcay Dam site with the return water of the Silvan irrigation (Table F.11, Table F.12, Figure F.42).

$$Q_{PAMUKCAY} = Q_{26\text{-}32}\left(\frac{A_{PAMUKCAY}}{A_{26\text{-}32}}\right) \tag{3.25}$$

The "*Operation of an Irrigation Project Reinforced by Upstream Reservoir*" algorithm was utilized to conduct reservoir run considering the transferred waters from Silvan Reservoir to irrigate a gross area of 5134 ha (Table F.1, Figure F.6, Table F.4, Table F.11, Figure F.12, Figure F.43, Appendix I.2) (Suiş and Sial, December 2001). The outflows include spillway releases and return water rates (Figure F.44).

- **The Baslar Dam Project:** A transposition was carried out through the drainage areas to estimate the flow rates at the Baslar Dam location by using the extended data set of Salat station (Equation 3.26) (Figure F.1, Figure F.45). The sum of these values with the return water amounts coming from the Silvan irrigation scheme was utilized as the monthly mean inflow rates of the project (Table F.11, Table F.12, Figure F.46).

$$Q_{BASLAR} = Q_{26\text{-}12}\left(\frac{A_{BASLAR}}{A_{26\text{-}12}}\right) \tag{3.26}$$

The run was carried out by the "*Operation of an Irrigation Project Reinforced by Upstream Reservoir*" program in a similar manner for a gross area of 4309 ha (Table F.1, Figure F.7, Table F.5, Table F.11, Figure F.12, Figure F.47, Appendix I.2) (Suiş and Sial, December 2001). The outflows are equal to the sum of spillway and return water flows (Figure F.48).

- **The Bulaklidere Dam Project:** The same methodology as for Baslar Dam was applied to obtain the runoff at the Bulaklıdere Dam site (Equation 3.27) (Figure F.1, Figure F.49). Then, the monthly mean inflow values of this project were determined by the summation of these values with the return water of the Silvan irrigation (Table F.11, Table F.12, Figure F.50).

$$Q_{BULAKLIDERE} = Q_{26\text{-}12}\left(\frac{A_{BULAKLIDERE}}{A_{26\text{-}12}}\right) \qquad (3.27)$$

The reservoir operation was conducted by the "*Operation of an Irrigation Project Reinforced by Upstream Reservoir*" program considering the net agricultural water demand of an area covers 5890 ha (Table F.1, Figure F.8, Table F.6, Table F.11, Figure F.12, Figure F.51, Appendix I.2) (Suiş and Sial, December 2001). The outflow rates were thus determined from spillway releases and return waters (Figure F.52).

- **The Kibris Dam Project:** The extended flows of Salikan station were transposed to the dam site in proportion to the drainage areas (Equation 3.28) (Figure F.1, Figure F.53). The inflow rates of the Kibris project are equal to the sum of the runoff values at the dam site with the return water of the Silvan irrigation in the catchment (Table F.11, Table F.12, Figure F.54).

$$Q_{KIBRIS} = Q_{26\text{-}60}\left(\frac{A_{KIBRIS}}{A_{26\text{-}60}}\right) \qquad (3.28)$$

The operation study of Kibris Reservoir was applied in the "*Operation of an Irrigation Project Reinforced by Upstream Reservoir*" algorithm satisfying the irrigation water for a gross area of 3124 ha with the reinforcement waters of Silvan Dam (Table F.1, Figure F.9, Table F.7, Table F.11, Figure F.12, Figure F.55, Appendix I.2) (Suiş and Sial, December 2001). The outflows include spillway releases and return water rates (Figure F.56).

- **The Karacalar Dam Project:** Similar to the Kibris scheme, the flow rates at the Karacalar Dam axis were transformed from the extended data set of Salikan station according to the catchment area ratio between them (Equation 3.29) (Figure F.1, Figure F.57). The sum of these flows with the return ones from the irrigated areas of the Silvan scheme was used as the monthly mean inflows of the project (Table F.11, Table F.12, Figure F.58).

$$Q_{KARACALAR} = Q_{26\text{-}60} \left(\frac{A_{KARACALAR}}{A_{26\text{-}60}} \right) \quad (3.29)$$

The "*Operation of an Irrigation Project Reinforced by Upstream Reservoir*" algorithm was utilized to carry out reservoir operation considering the net agricultural water demand of an area covers 5099 ha (Table F.1, Figure F.10, Table F.8, Table F.11, Figure F.12, Figure F.59, Appendix I.2) (Suiş and Sial, December 2001). The outflows are equal to the sum of spillway and return water flows (Figure F.60).

- **The Sirvan Dam and HEPP Project:** The catchment area ratio was used to bring the runoff records at Malabadi Bridge gauging station to the dam axis (Equation 3.30) (Figure F.1, Figure F.61). These are also the inflow values of Sirvan Dam and HEPP due to lack of schemes in the upstream.

$$Q_{SILVAN} = Q_{2612} \left(\frac{A_{SILVAN}}{A_{2612}} \right) \quad (3.30)$$

According to the development plan of the Batman - Silvan project, a gross area of 202306 ha will be irrigated by Silvan Dam in addition to the transferred waters to the plain dam projects. Therefore, the operation study was conducted by the "*Operation of a Multi-Purpose Project"* program according to the fact that available storage in the reservoir remaining after the supply of agricultural water requirements can be utilized in energy production (Table F.1, Figure F.11, Table F.9, Table F.11, Table F.12, Figure F.62, Figure F.63, Appendix I.3) (Suiş and Sial, December 2001). The outflow rates were thus determined from spillway releases and flows through turbines (Figure F.64).

- **The Batman Dam and HEPP Project:** The same methodology as for Sirvan Dam was applied to estimate the runoff values at the Batman Dam axis (Equation 3.31) (Figure F.1, Figure F.65). The difference between the sum of these estimated values with the outflow rates of the Sirvan scheme and the flow amounts at the Sirvan Dam site was evaluated as the monthly mean inflow values of Batman Dam and HEPP (Figure F.66).

$$Q_{BATMAN} = Q_{2612} \left(\frac{A_{BATMAN}}{A_{2612}} \right) \quad (3.31)$$

The reservoir operation was applied in the "*Operation of a Multi-Purpose Project*" algorithm satisfying the agricultural water for a gross area of 37744 ha in a similar manner with the Silvan scheme (Table F.1, Figure F.12, Table F.10, Table F.11, Figure F.12, Figure F.67,

Appendix I.3) (Suiş and Sial, December 2001). The outflows are equal to the sum of spillway releases and flows through turbines (Figure F.68).

3.4.2. The Upper - Tigris Projects

There are the Ergani Dam and HEPP Project, the Devegecidi Dam Project, the Dipni Dam and HEPP Project, the Kralkizi Dam and HEPP Project, the Dicle Dam and HEPP Project and an area of 142620 ha that would be irrigated by these schemes in the upstream of the Ilisu IV Dam and HEPP Project to be analyzed in the second step (Figure F.1, DSI 2010).

3.4.2.1. Estimated Evaporation Rates

The evaporation rates for Ergani, Devegecidi, Dipni, Kralkizi and Dicle Reservoirs were based on the records of Diyarbakir meteorological station (Table A.13, Table A.16, Figure F.1). By means of the monthly mean temperature and monthly total evaporation correlation of this station, the monthly total evaporation quantities corresponding to the transformed temperatures were calculated as pan evaporations (Figure A.3). The net evaporation quantities to be used in the operation studies were obtained by subtracting the precipitation records of Ergani station from the converted actual evaporation values of Ergani, Kralkizi and Dicle Reservoirs (Table A.9, Figure F.1, Table F.14, Table F.17, Table F.18). For the Devegecidi and Dipni projects, these quantities were calculated with the precipitation rates observed at Diyarbakir and Hani stations, respectively. (Table A.7, Table A.10, Figure F.1, Table F.15, Table F.16).

3.4.2.2. Water Resources

3.4.2.2.1. Stream Gauging Stations

The flow records observed at Yolkopru (DSI 26-62), DDY Bridge (DSI 26-09), Cayustu (EIE 2632), Cayonu (EIE 2617) and Diyarbakir (EIE 2605) gauging stations were utilized to calculate the monthly mean flow values at dam locations, as listed in Table 3.14 (Table B.23, Table B.24, Table B.25, Table B.26, Table B.27, Figure F.1, Figure F.74, Figure F.76, Figure F.77, Figure F.78, Figure F.79). The measurements at Yolkopru station were corrected due to the Kahlara irrigation scheme covers 380 ha by adding the values 0.35 hm^3, 0.33 hm^3, 0.32 hm^3 and 0.27 hm^3 to the records of the months June, July, August and September, respectively (Figure F.75) (DSI, 1999). This project, which has been in operation since 1965, will stay under the reservoir of Ergani Dam. The location of Diyarbakir station, and thus its drainage area, has changed four times by the administration. Starting from the year 1946 to year 1955, its catchment covered an area of 5655.2 km^2. Then the station was moved to the downstream for the period 1955-1963. In 1964, the drainage area in this period altered again from 6675.6 km^2 to 6298.4 km^2 due to the relocation of the gauging station to the upstream. Lastly, it was returned to its first position in 1970 (EIE, 2005). Therefore, the flow records between the years 1955 and 1969 were adjusted according to the original drainage area. Moreover, the measurements were corrected due to the Devegecidi and Gozegol irrigation schemes, which have been in operation since 1972 and 1974, respectively. Assuming the 20 percent of the irrigation abstractions had returned to the river bed again, the 80 percent of the demand calculated according to the Tigris irrigation module for the net irrigation area of 6350 ha was added to the observations (Table F.19, Figure F.80) (Ilisu Hydropower Consultants, November 1983).

Table 3.14 Characteristics of Stream Gauging Stations (DSI, 2007-b; EIE, 2005)

Station Id	Station Name	Opening Date	Closing Date	Drainage Area (km^2)	Elevation (m)	Mean Discharge (m^3/s)	Valuable Years
DSI 26-62	Sallar Creek-Yolkopru	17.02.1998	-	51.6	850.0	0.8	11
DSI 26-09	Furtaksa Brook-DDY B.	01.12.1959	01.10.1965	1607.0	705.0	8.8	3
EIE 2632	Berkilin Creek-Cayustu	16.09.1988	13.01.1998	1503.6	689.0	28.2	9
EIE 2617	Tigris River-Cayonu	01.11.1968	01.12.1997	1186.0	695.0	24.3	26
EIE 2605	Tigris River-Diyarbakir	13.11.1945	30.09.2000	5655.2	570.0	68.4	53

3.4.2.2.2. Correlation Studies

In order to produce a representative data between the years 1971 and 2000, the discontinuities in the records of Yolkopru and Cayustu stations were nearly fulfilled by the correlations with Cayonu gauging station (Figure F.81, Figure F.83). In the extension of the flow values measured at DDY Bridge station, the correlation equation observed with the corrected rates of Diyarbakir station was utilized for the period 1971-1997 (Figure F.82). The missing data in these stations were completed with the extended monthly mean flow values (Figure F.84, Figure F.85, Figure F.86). The monthly mean flow values of observations were utilized to complete the missing records of Cayonu and Diyarbakir gauging stations (Figure F.87, Figure F.88).

3.4.2.2.3. Monthly Mean Flow Calculations

In order to calculate the monthly mean inflow values for the operation study of the Ilisu IV Dam and HEPP Project, a joint operating policy for the upper Tigris projects from upstream to downstream was formulated, as summarized in Figure 3.7:

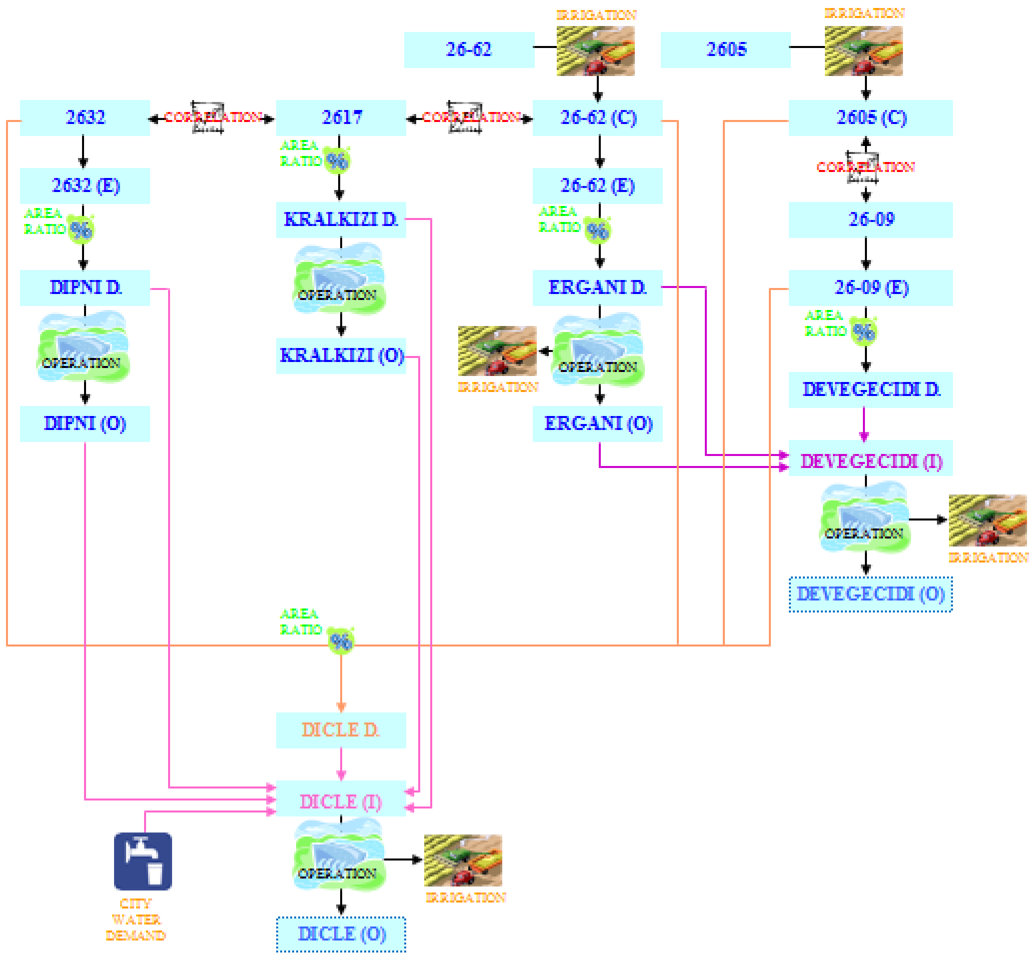


Figure 3.7 Scheme for Monthly Mean Flow Calculations of the Tigris Project

- **The Ergani Dam Project:** The extended flows of Yolkopru Bridge station were transposed to the dam site in proportion to the drainage areas (Equation 3.32) (Figure F.1, Figure F.89). These are also the inflow values of Ergani Dam due to lack of schemes in the upstream.

$$Q_{ERGANI} = Q_{26\text{-}62}\left(\frac{A_{ERGANI}}{A_{26\text{-}62}}\right) \quad (3.32)$$

The "*Operation of an Irrigation Project*" algorithm was utilized to carry out the operation study of the reservoir considering the agricultural water requirements determined along with the Ergani irrigation module for a gross area of 1861 ha (Table F.13, Figure F.69, Table F.14, Table F.20, Figure F.90, Appendix I.1) (DSI, 1999). The return water flows of the Ergani irrigation were added to the spillway releases due to ease of next computations (Figure F.91).

- **The Devegecidi Dam and Gozegol Pond Projects:** The catchment area ratio was used to bring the extended runoff values at DDY Bridge gauging station to the Devegecidi Dam location (Equation 3.33) (Figure F.1, Figure F.92). In order to determine the monthly mean inflow values of the Devegecidi project, the flows at the Ergani Dam site were subtracted from the sum of the ones at the Devegecidi Dam axis with the outflow rates of the Ergani scheme (Figure E.93).

$$Q_{DEVEGECIDI} = Q_{26\text{-}09}\left(\frac{A_{DEVEGECIDI}}{A_{26\text{-}09}}\right) \qquad (3.33)$$

The run of Devegecidi Reservoir was conducted by the "*Operation of an Irrigation Project"* program according to the agricultural water demand estimated through the Tigris irrigation module for the net irrigated region covers 5800 ha (Table F.13, Figure F.70, Table F.15, Table F.19, Figure F.94, Appendix I.1) (FPGA, 1968; Ilisu Environment Group, 2005).

The operation study of Gozegol Pond could not be performed due to absence of sufficient data. Therefore, in the intermediate basin runoff calculations of Ilisu IV Dam, while adding the return water of the Gozegol irrigation, the drainage area was subtracted from the intermediate catchment area between Ilisu IV Dam and the other upstream schemes assuming no spillway flows. In this context, the outflows were determined as the sum of spillway releases coming from Devegecidi Dam and return water rates of both schemes (Figure F.95, Table F.22).

- **The Dipni Dam and HEPP Project:** The flow rates at the Dipni Dam location were transformed from the extended data set of Cayustu station according to the catchment area ratio between them (Equation 3.34) (Figure F.1, Figure F.96). These are also the inflow values of the project due to lack of schemes in the upstream.

$$Q_{DIPNI} = Q_{2632}\left(\frac{A_{DIPNI}}{A_{2632}}\right) \qquad (3.34)$$

The reservoir operation was applied in the "*Operation of a Multi-Purpose Project*" algorithm as taking into account the requirements for environmental water (Table F.13, Figure F.71, Table F.16, Table F.21, Figure F.97, Appendix I.3) (En-Su, March 2008). The outflow rates were thus determined from spillway releases and flows through turbines (Figure F.98).

- **The Kralkizi and Dicle Dam and HEPP Projects:** A transposition was carried out through the drainage areas to estimate the flow rates at the Kralkizi Dam location by using the records of Cayonu gauging station (Equation 3.35) (Figure F.1, Figure F.99). These were also used as inflow rates due to lack of schemes in the upstream.

$$Q_{KRALKIZI} = Q_{2617} \left(\frac{A_{KRALKIZI}}{A_{2617}} \right) \quad (3.35)$$

The monthly mean flows at the Dicle Dam site was estimated as the sum of the extended data sets of Cayustu and Cayonu stations with the flow values coming from the intermediate catchment between these stations and the project. In the estimation of the intermediate basin flow quantities, the drainage area ratio among this catchment and the one between Diyarbakir, DDY Bridge, Cayustu and Cayonu gauging stations was utilized (Equation 3.36) (Figure F.1, Figure F.102).

$$Q_{DICLE} = Q_{2617} + Q_{2632} + (Q_{2605} - Q_{26\text{-}09} - Q_{2632} - Q_{2617}) \left(\frac{A_{DICLE} - A_{2632} - A_{2617}}{A_{2605} - A_{26\text{-}09} - A_{2632} - A_{2617}} \right) \quad (3.36)$$

In the stage corresponding to full development of the irrigation potential of the Tigris Basin, a gross area of 130159 ha will be irrigated from Dicle Reservoir. Moreover, a discharge of 4.53 m^3/s will be pumped from the lake to Diyarbakir to supply domestic water requirements. Due to the inadequate storage capacity of the reservoir, these water needs will be provided through the reinforcement flows of Kralkizi Dam and HEPP. In this context, the monthly mean inflow values of Dicle Dam and HEPP were determined as subtracting the flow rates at the Dipni and Kralkizi Dam locations from the sum of the flow values at Dicle axis, the outflows of the Dipni scheme and the outflow rates of the Kralkizi Dam and HEPP, enabling Dicle Dam to supply the agricultural and domestic water needs. In order to designate these outflow amounts, a combined operation study of Kralkizi and Dicle reservoirs was conducted in the "*Operation of the Dicle-Kralkizi Project"* algorithm according to the fact that when the domestic and agricultural water requirements, determined according to the Tigris irrigation module, is greater than available storage in Dicle Reservoir, the deficiency is satisfied with flows through turbines of the Kralkizi Power Plant (Table F.13, Figure F.72, Figure F.23, Table F.16, Table F.18, Table F.19, Figure F.100, Figure F.101, Figure F.103, Figure F.104, Appendix I.5) (FPGA, 1968; Ilisu Environment Group, 2005). The return waters of the Kralkizi-Dicle irrigation scheme were added to the spillway and turbine flows of the Dicle scheme due to ease of next computations (Figure F.105).

3.4.3. The Ilisu IV Dam Project

3.4.3.1. Estimated Evaporation Rates

For Ilisu IV Reservoir, the records of Diyarbakir station were utilized (Table A.13, Table A.16, Figure F.1). The pan evaporations were obtained along with the correlation between monthly mean temperature and monthly total evaporation observations made at the station (Figure A.3). The net evaporations from the lake surface are equal to the difference between the actual evaporation rates and the monthly total precipitation values of the same station (Table A.7, Figure F.1, Table F.23).

3.4.3.2. Monthly Mean Flow Calculations

The monthly mean flows at the Ilisu IV Dam axis were transformed from the extended data set of Diyarbakir station according to the catchment area ratio between them (Equation 3.37) (Figure F.1, Figure F.107).

$$Q_{ILISU\text{-}IV} = Q_{2605} \left(\frac{A_{ILISU\text{-}IV}}{A_{2605}} \right) \quad (3.37)$$

The monthly mean inflow rates of Ilisu IV Dam and HEPP were calculated by summation of the intermediate basin flows and the outflow values of the upstream projects, as shown in Figure 3.8. In order to determine the intermediate basin flows, the sum of monthly mean flow values at the Silvan Plain Dams, Batman, Devegecidi, and Dicle sites were subtracted from the runoff values at the Ilisu IV Dam location. However, there are some other irrigation schemes in the intermediate basin, namely Goksu Dam and Gozegol, Kabakli, Bespinar and Kirkat (Gercus) Ponds, of which the operations studies could not be conducted due to absence of sufficient data. Therefore, to compensate the effects of the presence of other schemes, the calculated values were firstly divided by the intermediate basin drainage area between Ilisu IV Dam and the upstream projects, and then multiplied with the difference between this intermediate watershed and the total drainage area of additional schemes, assuming that no spillway releases from these ones. After that the return water of the Goksu, Kabakli, Bespinar and Kirkat (Gercus) schemes were added by assuming that the 20 percent of the abstractions would return to river bed again (Table F.11, Table F.19, Table F.22) (Ilisu Hydropower Consultants, November 1983). In the end, the inflow values to be used in the operation study were obtained by adding the outflows of the upstream projects to the final value of the intermediate basin runoffs (Figure F.108).

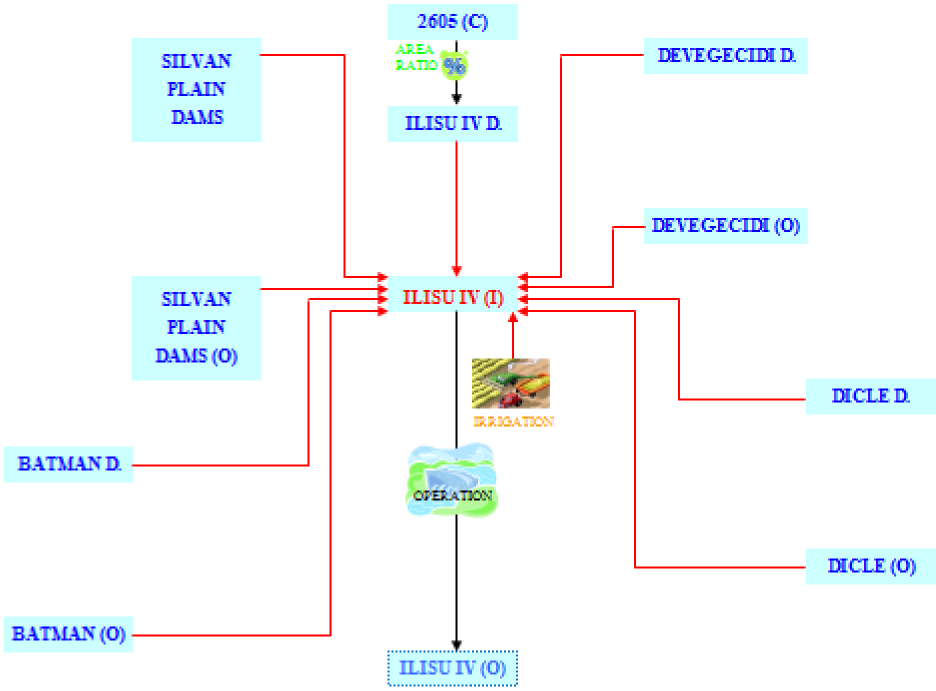


Figure 3.8 Scheme for Monthly Mean Flow Calculations of the Ilisu IV Dam Project

3.4.3.3. Sediment Transport

The sedimentation volume was calculated using the suspended load concentration data at Diyarbakir gauging station, collected for a total of 336 days during the period 1966-1999 (EIE, 2000). After performing sediment analysis, annual specific suspended load was found to be 926 m^3/year/km^2. By adding a 50% more to this value for bed load, a total of 1389 m^3/year/km^2 was obtained (EIE, 2010). The volume of sediment that would be deposited in the reservoir as dead volume for 50 years was calculated according to the area contributing the sediment transport between the upstream schemes and Ilisu IV Reservoir. These schemes are namely, Dicle, Devegecidi, Goksu, Anbar, Kurucay, Pamukcay, Baslar, Bulaklidere, Kibris, Karacalar and Batman Dams, and Gozegol, Kabakli, Bespinar and Kirkat (Gercus) Ponds. Then, the elevation of the power intake sill, or the minimum operating level, was designated in line with this storage by using the area-volume curve as 515 m (Figure F.106, Table F.24).

3.4.3.4. Operation Studies

A total of 180 runs were conducted for four different combinations of penstocks with the design discharges determined from the drawn discharge-duration curve of the project site (Figure F.109). As a result of this analysis, the optimum design discharge for this plant was observed as 290 m^3/s through a system composed of two penstocks and one energy tunnel with 6.1 m and 9.6 m inlet diameters, respectively (Figure F.110). The energy production capacity of this combination is 621.4 GWh/year, composing of 490.8 GWh/year firm energy and 130.6 GWh/year secondary energy, with an installed power of 171.7 MW.

3.4.3.5. Flood Analysis

3.4.3.5.1. Calculation of Design Floods from Observed Runoff

The characteristics and corresponding observation periods of the used stream gauging stations in this approach are given in Table 3.15. The flood discharges for different return periods were calculated with the annual maximum instantaneous flow records of each station by means of the most appropriate probability distribution function using Kolmogorov-Smirnov test (Table F.25a, Table F.25b, Table F.25c, Table F.25d, Table F.25e, Table F.25f).

Table 3.15 Characteristics of Stream Gauging Stations Used in Flood Frequency Analyses (DSI, 2007-b; EIE, 2005)

Station Id	Station Name	Drainage Area (km^2)	Elevation (m)	Observation Period
26-01	Dipni Creek-Dipni Bridge	1397.0	720.0	1961-1964 (4)
26-02	Tigris River-Beton Bridge	1701.0	702.0	1962-1968 (7)
2618	Anbar Creek-Koprubasi	976.0	595.0	1961-1998 (38)
2619	Goksu Creek-Cinarkopru	734.0	610.0	1961-1987 (25)
26-08	Pamukluk Creek-Dilaver Bridge	648.0	702.0	1963-2000 (32)
26-09	Furtaksa Brook- DDY Bridge	1607.0	705.0	1961-1964 (4)
26-10	Kusi Brook-Kusi	407.0	1550.0	1964-1968 (5)
26-14	Kurucay-Yasince	240.0	520.0	1965-1984 (15)
26-16	Dalkiran Brook-Selimi	524.6	573.0	1964-1975 (10)
26-17	Pamuk Creek-Cavuslu	485.0	520.0	1965-1973 (6)
26-18	Pirnos Brook-Emeran	20.4	1231.0	1965-1967 (3)
26-19	Savur Brook-Ahmedi	576.4	775.0	1965-1969 (3)
26-25	Bogaz Creek-Bereketli	351.7	772.0	1973-1978 (3)
26-26	Gevrikli Creek-Kubuk	154.4	760.0	1973-1977 (3)
26-32	Pamuk Creek-Karahan Bridge	305.0	738.0	1980-1985 (3)
25-35	Dipni Creek-Verdevan Bridge	1404.0	700.0	1979-1997 (9)
26-39	Anbar Creek-Hani	292.0	800.0	1978-2000 (14)
26-42	Sason Creek-Taslidere	590.0	650.0	1978-1992 (9)
26-46	Batman Creek-Kemuk Bridge	2620.0	650.0	1978-1992 (5)
26-50	Sasim Creek-Taskopru	1213.0	750.0	1981-1985 (5)
26-52	Kulp Creek-Kulp Bridge	537.0	850.0	1979-1989 (6)
26-60	Baskoy Creek-Salikan (Kibris)	118.5	620.0	1989-2000 (5)
26-61	Kulp Creek-Baska	2418.0	730.0	1989-1991 (3)
26-63	Kodi Brook-Kolludere Village	50.7	775.0	1991-2000 (8)
26-64	Celik Brook-Guclu Village	44.3	848.0	1992-1994 (3)
2602	Batman Creek-Sinan	4988.4	518.0	1946-1968 (21)
2605	Tigris River-Diyarbakir	5655.2	570.0	1946-1997 (50)
2612	Batman Creek-Malabadi Bridge	4105.2	597.0	1961-2006 (44)
2617	Tigris River-Cayonu	1186.0	695.0	1972-1997 (26)
2632	Berkilin Creek-Cayustu	1503.6	689.0	1989-1997 (8)
2611	Tigris River-Rezuk	34493.1	427.0	1955-1975 (17)
2606	Tigris River-Cizre	38280.7	370.0	1969-2006 (31)

3.4.3.5.1.1. Point Flood Frequency Analysis

The flood peaks calculated for Diyarbakir station were transposed to the dam site in proportion with the drainage areas by applying Equation 3.38 (Table F.26):

$$Q_{ILISU\text{-}IV} = Q_{2605}\left(\frac{A_{ILISU\text{-}IV}}{A_{2605}}\right)^{0.667} \quad (3.38)$$

3.4.3.5.1.2. Regional Flood Frequency Analysis

In this approach, initially, a homogeneity test was done for the determined base periods concerning the observation periods of the stream gauges (Table F.27, Figure E.113a, Figure E.113b, Table F.28, Table F.29). As a result of this test conducted for each period, Dipni Bridge, Taskopru, Kolludere Village, Kemuk Bridge and Cayustu stations were eliminated (Table F.29, Figure F.114). Then, the recurrence flood peaks of the remaining stations were divided by the corresponding $Q_{2.33}$ recurrence values and thus the non-dimensional recurrence flood peak values were found (Table F.30). After that, the $Q_{2.33}$ recurrence discharge versus drainage area curve was plotted on a logarithmic paper using the data obtained for each station (Figure F.115). From this curve, the 2.33 years return period flood discharge for the Ilisu IV catchment can be read as 2660.2 m^3/s. Eventually, this value was multiplied by the average non-dimensional recurrence flood values and thus the regional recurrence flood peaks for the project were obtained (Table F.31).

3.4.3.5.2. Flood Recurrences Calculated Using Snyder Synthetic Unit Hydrograph Method

Finally, the recurrence and probable flood calculations were carried out using Snyder's unit hydrograph method together with considering the drainage area characteristics.

- **Precipitation Analysis:** The meteorological stations of Mutki, Kozluk, Batman, Mus, Silvan, Midyat, Mardin, Derik, Diyarbakir, Bingol, Hani, Dicle, Ergani, Cermik and Karacadag are located inside or near the Ilisu IV drainage area (Figure F.116). From the maximum 24-hour precipitation rates of these stations, the 24- hour precipitations for different return periods were calculated using the appropriate distribution functions (Table F.32a, Table F.32b, Table F.34). In order to obtain the mean areal precipitation over the watershed, Thiessen polygons were used to assess the weight of each station (Figure F.116, Table F.35). The corresponding precipitations were calculated for different durations by multiplying the basin precipitations with the pluviograph rates, the area reduction factor and the maximization factor, 1.13 (Table F.36, Table F.37, Table F.38, Figure K.1).

  In the probable maximum flood calculations, the 24-hour probable maximum precipitation values of these meteorological stations were calculated using the Hershfield statistical method with the formula "$PMP_{24} = X + KM \times S$", where KM is the frequency factor, X is the corrected average and S is the corrected standard deviation of the annual maximum rainfall records (Table F.33, Figure K.4, Figure K.5, Figure K.6, Figure K.7). The values for the frequency factor were evaluated according to the X-KM envelopes prepared by DSI Hydrology Branch Office for East Anatolia and South-East Anatolia. The probable maximum precipitation amounts for different periods were again obtained by multiplying the station values by the Thiessen weights, the pluviograph rates, the areal reduction factors and the maximization factor (Table F.34, Table F.35, Table F.36, Table F.37, Table F.38).

- **Baseflow:** The base flow of the Tigris River at the Ilisu IV Dam site was derived from the one estimated for Diyarbakir observation stations (Table F.40). The base flow values of the catchment for the recurrence floods and probable maximum flood are 676.2 m^3/s and 1237.1 m^3/s, respectively.

- **Unit Hydrograph Analysis:** The key parameters intervening in the establishment of the unit hydrograph were measured on the 1:100000 scale topographic maps of the region (Figure F.116). Accordingly, the Ilisu IV catchment area is 20353.7 km^2, the longest river branch length is 318.4 km, and the distance of the outlet to the point on the river nearest centroid of the watershed is 115.7 km. The coefficients C_t and C_p were taken from the "*Ilisu Dam and HEPP, Flood Hydrology and Sediment Transport*" report prepared by the engineering and consultancy services consortium of the project. The corresponding values are given as C_t=1.50 and C_p=0.63. Using these parameters, the peak discharge, the duration of reaching the peak and the base time of the synthetic unit hydrograph were calculated as 132.4 $m^3/s/mm$, 29.7 hour and 152.2 hour, respectively (Table K.1). In the end, a 6-hour unit hydrograph was drawn in order to convert excess rainfall into runoff (Figure F.118, Figure K.8).

- **Flood Hydrographs Calculated with Snyder Unit Hydrograph Method**: The critical precipitation duration for this type of catchment varies from 8 to 18 hours (Figure K.3). However, in this study, this duration was selected as 12 hours. The 12-hour precipitation was then subdivided into 6-hour precipitation blocks by utilizing the distribution curve "*B*" for precipitation in time (Figure K.2).

  In order to estimate the excess rainfall, the part of the rainfall which generates runoff, the SCS method was used. The characterization of the land use and the soil type in the catchment was thereby made by making the SCS curve number CN_{II}=76 (Ilisu Dam and HEPP Engineering and Consultancy Services Consortium, 2008). The runoff volumes and excess rainfall were calculated from the 12-hour precipitation amounts. The hydrographs for different return periods were then evaluated using the unit hydrograph method. Eventually, the resulting recurrence flood peaks were determined by adding the beforehand calculated baseflow (Figure F.119, Table F.41).

- **Hydrograph Caused by Probable Maximum Flood:** As above, in order to evaluate the excess rainfall, the SCS method for abstraction was used with a curve number of CN_{III}=89 (Ilisu Dam and HEPP Engineering and Consultancy Services Consortium, 2008).

The excess rainfall was then converted into runoff by using the 6-hour unit hydrograph. The peak discharge of the probable maximum flood of the Ilisu IV basin without accounting for baseflow and snowmelt runoff is 11785.7 m^3/s.

Because of lack of data to calculate the maximum snowmelt runoff hydrograph of the basin with the degree-day method, the rate determined for the Tigris River catchment from the source to the confluence with Botan Creek as 1511.0 m^3/s was directly utilized in this project (Ilisu Dam and HEPP Engineering and Consultancy Services Consortium, 2008). The probable maximum flood hydrograph was then obtained as by adding the previously determined baseflow and snowmelt values to the hydrograph caused by the probable maximum precipitation (Figure F.119). The peak discharge value of this hydrograph to be used in spillway design is 14533.8 m^3/s (Table F.41).

3.4.5.3. Selection of Project Flood Discharges

The obtained flood discharges with statistical and synthetic unit hydrograph methods are summarized in Table 3.16. Although the statistical approaches lead to comparable results, they differ from the ones of Snyder's method. The rates at Diyarbakir gauging station were determinative in both of the point and regional flood frequency analyses. The conducted transposition to a much larger catchment area than that of the station gave rise to such an outcome. Hence, the results of the Snyder's method were utilized in the economic analysis part of the study.

Table 3.16 Summary of Flood Calculations

Return Period	Flood Discharge (m^3/s)		
	PFFA	RFFA	Snyder
2	2361.5	2314.2	1339.2
2.33	2629.8	2660.2	1457.4
5	3935.6	4229.1	2045.2
10	5153.2	5570.1	2596.7
25	6880.7	7332.6	3372.4
50	8301.2	8688.5	3998.3
100	9833.8	10078.2	4661.1
200	11489.3	11510.6	5362.0
500	13882.7	13482.8	6349.8
1000	15860.4	15045.4	7150.1
PMF	-	-	14533.8

3.5. The Lower Tigris Projects and Ilisu V Dam and HEPP

3.5.1. Estimated Evaporation Rates

The evaporation rates for Ilisu V Reservoir were based on the measurements at Siirt meteorological station (Table A.12, Table A.15, Figure G.1). By means of the monthly mean temperature and monthly total evaporation correlation of this station, the monthly total evaporation quantities corresponding to the transformed temperatures were calculated as pan evaporations (Figure A.2). The net evaporation quantities to be used in the operation studies were obtained by subtracting the precipitation records of the same station from the converted actual evaporation values (Table A.3, Figure G.1, Table G.1).

3.5.2. Water Resources

3.5.2.1. Stream Gauging Stations

The flow records observed at Billoris (EIE 2604), Cizre (EIE 2606) and Rezuk (EIE 2611) gauging stations were used to calculate the monthly mean flow values at the dam axis, as listed in Table 3.17. (Table B.28, Table B.29, Table B.30, Figure G.1, Figure G.5, Figure G.6, Figure G.8). The measurements at Cizre and Rezuk stations were corrected due to the upstream irrigation schemes, namely Gozegol, Kabakli, Bespinar, Goksu, Kirkat (Gercus), Silvan, Serifbaba, Ortaviran, Devegecidi, Kunres and Kozluk according to the Garzan-Kozluk, Batman-Silvan and Tigris irrigation modules (Table C.6, Figure F.1, Table F.11, Table F.19, Table G.2, Figure G.7, Figure G.9). In line with the commissioning date of the projects, the 80 percent of the demand for the net irrigation areas was added to the observations by assuming the 20 percent of the abstractions had returned to the river bed again (Ilisu Hydropower Consultants, November 1983). Moreover, starting from the year 1998, the records of Cizre station were not utilized due to the effects of Kralkizi and Dicle Reservoirs on the flow regime (EIE, 2005).

Table 3.17 Characteristics of Stream Gauging Stations (EIE, 2005)

Station Id	Station Name	Opening Date	Closing Date	Drainage Area (km^2)	Elevation (m)	Mean Discharge (m^3/s)	Valuable Years
EIE 2604	Botan Creek-Billoris	07.11.1945	31.07.1962	7857.3	473.0	122.5	17
EIE 2606	Tigris River-Cizre	27.11.1945	01.09.2000	38280.7	370.0	517.8	27
EIE 2611	Tigris River-Rezuk	01.03.1955	07.03.1975	34493.1	427.0	424.9	17

3.5.2.2. Correlation Studies

The discontinuities in the records of Rezuk station were fulfilled by the four different correlation equations conducted with the corrected flow rates of Besiri, Cizre, Billoris (EIE 2633), Malabadi Bridge and Diyarbakir gauging stations. To be used in this study, the extended flow rates of Billoris (EIE 2633) station by means of the measurements at Billoris (EIE 2626) and Billoris (EIE 2604/A) stations for Ilisu III Dam, were extended secondly with the rates at Billoris (EIE 2604) station using the drainage area ratio between them. In order to produce a representative data between the years 1971 and 2000 for Rezuk station, firstly, the missing flow sets of the year 1970 and the years between 1975 and 1993 were completed using the correlation conducted with Cizre gauging station (Figure G.10). For the period 1994-1997, the extension was accomplished by the correlation equation observed with the sum of the flow measurements at Billoris (EIE 2633), Besiri, Malabadi Bridge, and Diyarbakir gauging stations (Figure G.13). Afterwards, the discontinuities in the year 1998 were fulfilled by the correlation with the sum of the flow records of Billoris (EIE 2633), Besiri and Malabadi Bridge stations (Figure G.12). Lastly, in the extension for the years 1999 and 2000, the correlation equation observed with the sum of the flow measurements at Billoris (EIE 2633) and Besiri stations were utilized (Figure G.11).

3.5.2.3. Monthly Mean Flow Calculations

In order to calculate the monthly mean inflow values for the operation study of the Ilisu V Dam and HEPP Project, a joint operating policy from upstream to downstream was formulated, as summarized in Figure 3.9:

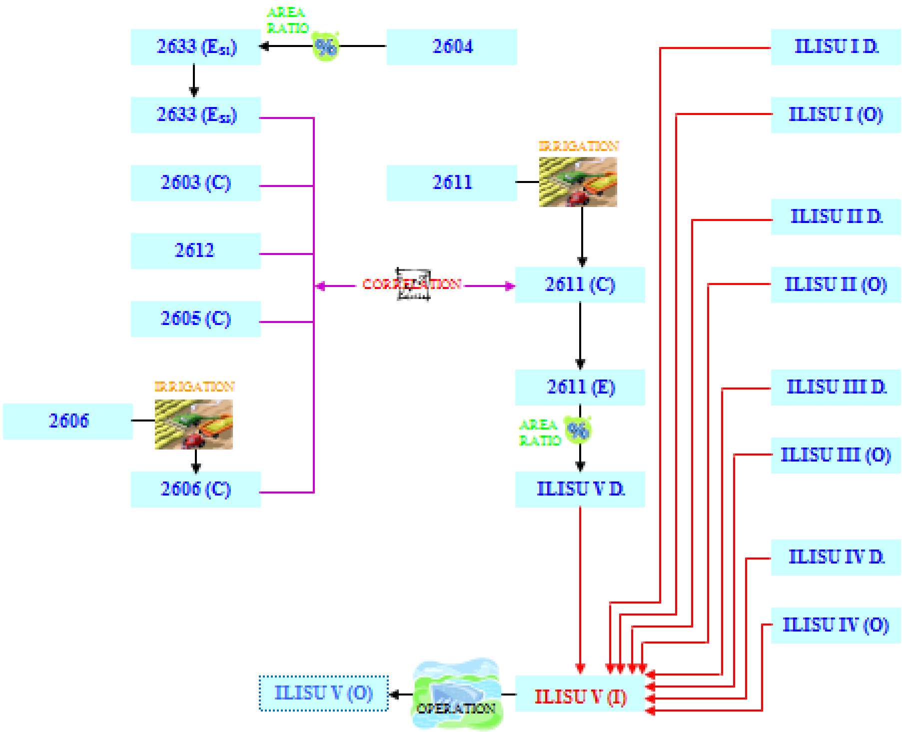


Figure 3.9 Scheme for Monthly Mean Flow Calculations of the Lower Tigris Project

- **The Ilisu V Dam and HEPP Project:** A transposition was carried out through the drainage areas to estimate the flow rates at the Ilisu V Dam location by using the extended data set of Rezük station (Equation 3.39) (Figure G.1, Figure G.15). In order to determine the monthly mean inflow values of Ilisu V Dam and HEPP, the runoff values of Ilisu I, Ilisu II, Ilisu IIII and Ilisu IV Dams were subtracted from the sum of the flows at Ilisu V Dam location with ones through the turbines and spillway releases of other four dams (Figure G.16).

$$Q_{ILISU\text{-}V} = Q_{2611}\left(\frac{A_{ILISU\text{-}V}}{A_{2611}}\right) \tag{3.39}$$

3.5.3. Sediment Transport

The sedimentation volume was calculated using the suspended load concentration data at Besiri gauging station, collected for a total of 251 days during the period 1968-1993 (EIE, 2000). After performing sediment analysis, annual specific suspended load was found to be 543 m^3/year/km^2. By adding a 50% more to this value for bed load, a total of 814 m^3/year/km^2 was obtained (EIE, 2010). The volume of sediment that would be deposited in the reservoir as dead volume for 50 years was calculated according to the area contributing the sediment transport between the other alternative schemes and Ilisu V Reservoir. Then, the elevation of the power intake sill, or the minimum operating level, was designated in line with this storage by using the area-volume curve as 425 m (Figure G.4, Table G.3).

3.5.4. Operation Studies

A total of 180 runs were conducted for four different combinations of penstocks with the design discharges determined from the drawn discharge-duration curve of the project site (Figure G.17). As a result of this analysis, the optimum design discharge for this plant was observed as 825 m^3/s through a system composed of five penstocks and one energy tunnel with 6.5 m and 16.2 m inlet diameters, respectively (Figure G.18). The energy production capacity of this combination is 1529.3 GWh/year, composing of 1205.5 GWh/year firm energy and 323.8 GWh/year secondary energy, with an installed power of 398.4 MW.

3.5.5. Flood Analysis

The flood discharges utilized in the economic analysis part of the study were listed in Table 3.18.

Table 3.18 Ilisu Dam Design Floods (Ilisu Dam and HEPP Engineering and Consultancy Services Consortium, 2008)

Return Period	Flood Discharge (m^3/s)
2.33	3138
5	4611
10	5465
25	6446
50	7120
100	7756
500	9342
1000	10024
PMF	20357

CHAPTER 4

COMPARISON OF THE EXISTING AND PROPOSED PROJECTS

4.1. Energy Production

The primary reason of the administration's insistence on construction of the Ilisu Dam and HEPP Project is its energy production capacity (DSI, 2010). This capacity was presented as 3833.5 GWh/year, composing of 2459.4 GWh/year firm energy and 1374.1 GWh/year secondary energy, in the feasibility report of Cizre Dam, in which the operation studies considered the Ilisu and Cizre Projects together and a joint operating policy was formulated. However, this calculation was made under the existing upstream conditions at that time that only the Devegecidi Project, the Batman Diversion Scheme and some minor local irrigations were in concern (Ilisu Hydropower Consultants, November 1983).

Today, by means of the rapid development of the upstream watershed with the projects developed by incorporated companies according to Law No.4628 in addition to the planned and operated schemes of DSI and EIE, there are 29 dams and 8 ponds, which are supposed to supply irrigation and domestic water together with hydroelectricity (DSI, 2010). All those additional activities in the upstream of Ilisu will affect the energy production directly. After construction of these projects, while the presence of reservoirs will increase the firm energy ratio in the production due to rise in the regulated inflows, there will be a considerable decrease in the total energy production because of the irrigation and domestic water abstractions. Therefore, the announced capacity of this project is not realistic if one considers the full upstream development.

In order to make an evaluation on the same base, the steps followed for the alternative schemes were applied to the existing one. The operation of Ilisu Reservoir was simulated on a monthly basis throughout the 30-year representative record of flows, obtained by using the consecutive operations of the upstream schemes conducted for the proposed system, with the topographical and technical characteristics of the project as taking into account net evaporation from the reservoir water surface. These steps can be summarized as below:

- **Volume-Area Curve:** It was determined by using the digitized 1:25000 scale topographic maps of the reservoir area (Figure H.1). 7847.6 hm^3 of water stored in elevations between 525 m and 485 m was used as active storage in the operation study.

- **Estimated Evaporation Rates:** They were based on the evaporation records of Siirt meteorological station, where the average value is 1745.7 mm per year (Table A.15). Assuming a 0.5^{o}C decrease in temperature for per 100 m increase in altitude, the temperature data observed at the station, of which the elevation is 896 m, were transformed to the maximum water level during re-regulation of Ilisu Reservoir, 525 m (Table A.12) (Limak, October 2006). Then, the monthly total evaporation quantities corresponding to these transformed temperatures were determined by means of the correlation between monthly mean temperature and monthly total evaporation records of the station (Figure A.2). Afterwards, the calculated evaporation values were multiplied with the pan coefficient (0.7) to convert the pan evaporations to the actual evaporation that would occur from the lake surface (Usul, 2009). Lastly, the net evaporation rates to be used in the operation study were obtained by subtracting the precipitation records of Siirt station from these values (Table A.3, Table H.1).

- **Inflow Values:** They were calculated by summation of the intermediate basin flows and the outflow values of the upstream projects, as shown in Figure 4.1. In order to determine the intermediate basin flows, the sum of monthly mean flow values at the Garzan, Sirvan, Basoren, Alkumru, Eruh, Silvan Plain Dams, Batman, Devegecidi, and Dicle sites were subtracted from the runoff values at the Ilisu V Dam location (Figure C.30, Figure D.23, Figure D.27, Figure E.45, Figure E.49, Figure F.33, Figure F.37, Figure F.41, Figure F.45, Figure F.49, Figure F.53, Figure F.57, Figure F.65, Figure F.92, Figure 102, Figure G.15). However, there are some other irrigation schemes in the intermediate basin, namely Goksu Dam and Gozegol, Kabakli, Bespinar and Kirkat (Gercus) Ponds, of which the operations studies could not be conducted due to absence of sufficient data. Therefore, to compensate the effects of the presence of other schemes, the calculated values were firstly divided by the intermediate basin drainage area between Ilisu Dam and the upstream projects, and then multiplied with the difference between this intermediate watershed and the total drainage area of additional schemes, assuming that no spillway releases from these ones. After that, while subtracting the demands of Siirt domestic water and Garzan irrigation from the intermediate basin runoffs, the return water of these irrigation projects were added by assuming that the 20 percent of the irrigation abstractions would return to river bed again (Table 3.3, Table C.9, Table F.11, Table F.19, Table F.22) (Ilisu Hydropower Consultants, November 1983). In the end, the inflow values to be used in the operation study were obtained by adding the outflows of the upstream projects to the final value of the intermediate basin runoffs (Figure C.33, Figure D.26, Figure D.29, Figure E.48, Figure E.51, Figure F.36, Figure F.40, Figure F.44, Figure F.48, Figure F.52, Figure F.56, Figure F.60, Figure F.68, Figure F.95, Figure 105, Figure H.2, Figure H.3).

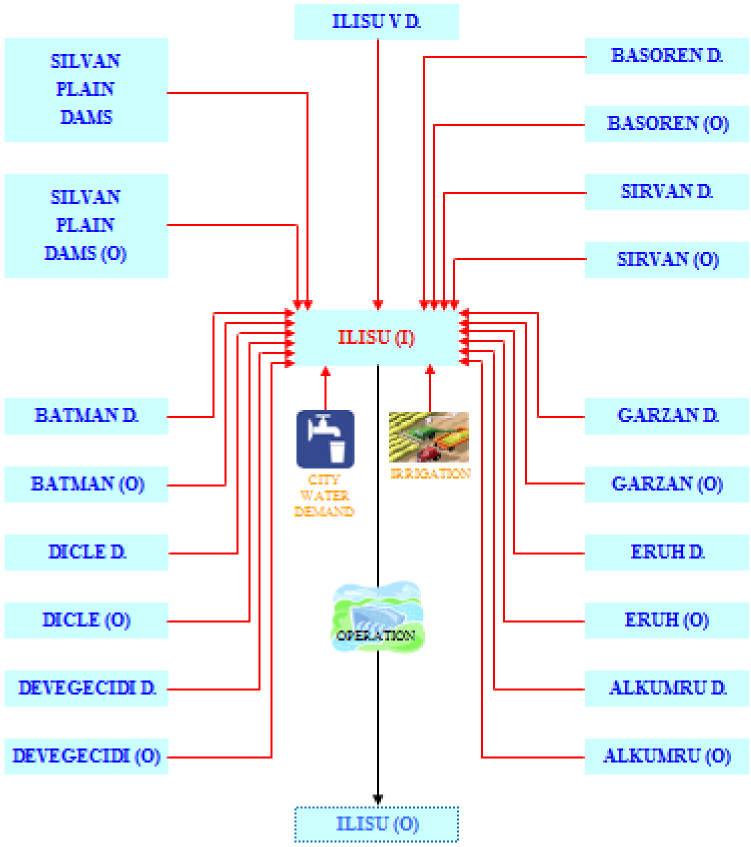


Figure 4.1 Scheme for Monthly Mean Flow Calculations of the Ilisu Project

- **Operation Study:** After determination of the inflow values in the fully developed upstream stage, the operation study was simulated under the same rules and efficiencies with the alternative projects by using the characteristics detailed in the environmental impact assessment report, listed in Table 4.4, together with considering the irrigation purposes (Table G.4, Figure H.4, Figure H.5, Appendix I.4). In the end, it was observed that the existing project has an energy production capacity of 3094.3 GWh/year, composing of 2766.9 GWh/year firm energy and 327.4 GWh/year secondary energy.

While the Ilisu scheme has such a capacity contrary to the presented, the proposed one is capable of providing 3139.1 GWh/year with a smaller installed power, in spite of a slight decrease in the produced firm energy, as listed in Table 4.4. The minor differences in terms of water usage ratio and firm energy against a 54 percent decrease in the active storage illustrate the effect of upstream dams on flow regulation and the needlessness of such an enormous reservoir.

4.2. Economy

Due to lack of knowledge about share of the preconstruction estimate of about 1100 million euro, composed of 650 million euro for all civil works and 450 million euro for the mechanical and electrical plant, over units of the scheme and rates tendered by the contractor, a degree estimation process based on topographical and geological studies from index maps, and not on thumb rules, but on experience of cost of previous work of the same type built was carried out in order to make an evaluation on the same base without any possibility of detailed surveys and investigations (DSI, 2010).

The cost estimate of Alkumru Dam and HEPP was found as appropriate to be used within the content of this kind of an analysis due to the similar technical and geological characteristics with the existing project. The features of the Alkumru scheme and the share of its estimate are summarized in Table 4.1 and Table 4.2, respectively.

Table 4.1 Characteristics of the Alkumru Project (Limak, October 2006)

General	
Location / Creek	Siirt -Aydinlar / Botan
General Geologic Formation	The Middle-Upper Maastrichtian Paleocene Upper (Germav) Member: *Shale, Marl, Sandstone*
Purpose	Energy
Hydrology	
Drainage Area	7562.5 km^2
Peak Discharge of Flood with 50 Year Return Period	2016.0 m^3/s
Peak Discharge of Catastrophic Flood	6406.4 m^3/s
Reservoir	
Maximum Water Level during Re-regulation	647.0 m
Minimum Water Level	611.8 m
Storage: Active / Dead	275.0 hm^3 / 142.2 hm^3
Reservoir Area at Max. W. L. during Re-regulation	11.0 km^2
Dam Embankment	
Type	Concrete Faced Rock-Fill
Side Slopes	1/1.4 - 1/1.4
Thalwag Elevation	542.0 m
Crest : Elevation / Width / Length	652.0 m / 1058.0 m / 10.0 m
Height of Dam above Thalwag	110.0 m
Fill Volume (Excluding Foundation)	13.6 hm^3
Water Conduction Structures	
Penstock: Number / Diameter / Length	3 / 4.7 m / 124.0 m
Energy Tunnel: Number / Diameter / Length	1 / 8.4 m / 443.1 m
Powerhouse	
Turbine Type	Francis
Design Discharge	277.0 m^3/s
Number of Units	3
Tailwater Level	541.8 m
Head: Gross / Net	105.2 m / 103.9 m
Total Installed Capacity	240 MW
0peration	
Energy: Total / Firm / Secondary	828.1 GWh / 606.4 GWh / 221.7 GWh
Water Usage Ratio	89.9 %

Table 4.2 Initial Outlay Allocation of Alkumru Dam and HEPP (Limak, October 2006)

with 2006 unit prices

	Unit	Estimate (TL)	Ratio
1	Diversion and Cofferdams	46 183 711	14.98
a	Cofferdams	1 706 376	0.55
b	Diversion Tunnels	39 393 374	12.77
c	Sliding Sluice	5 083 961	1.65
2	Dam Embankment	181 011 206	58.70
a	Embankment	163 321 357	52.96
b	Injection	11 610 739	3.77
c	Galleries	6 079 110	1.97
3	Spillway	42 123 961	13.66
4	Energy Tunnel	12 416 219	4.03
a	Tunnel	10 142 933	3.29
b	Gate Shaft	2 273 286	0.74
5	Intake Structure	1 668 501	0.54
6	Surge Tank	2 161 674	0.70
7	Penstocks	8 487 186	2.75
8	Building Site and Roads	8 525 000	2.76
9	Powerhouse, Tailwater Channel and Switchyard	5 788 710	1.88
	Civil Works	**308 366 168**	**100.00**
10	Electromechanical Equipment	119 280 000	98.65
11	Transmission Line	1 635 840	1.35
	Electromechanical Works	**120 915 840**	**100.00**
	Initial Outlay	**429 282 008**	

In this context, after determination of the allocation of the initial outlay over the components of the project according to the estimate of Alkumru Dam and HEPP, the shared costs plus the expropriation and resettlement expenses of about 750 million euro were transformed to the units of the proposed ones using the ratios of design discharges, installed powers, peak discharges of floods, reservoir areas and fill volumes together with assuming the same costs as in the existing project for units like building site and 3 to 5 times more for some as injection depending on geological formations at dam sites, as shown in Table 4.3 (DSI, 2010). Further, an increase of 15 and 5 percent in the costs for civil and electromechanical works, respectively, were taken into account due to contingent expenditures (Pro-sem, 2008). The results, listed in Table 4.4, demonstrate the possibility of construction of this five-dam-system with an amount almost equals to the cost of the Ilisu Project.

Table 4.3 Shared Costs and Transformation Criteria (Yıldız, 1992)

	Item	Estimate (€)	Criteria	Unit	Ilisu	Ilisu I	Ilisu II	Ilisu III	Ilisu IV	Ilisu V
1	Diversion and Cofferdams	97 350 000	50 Year Return Period Flood	m^3/s	7120.0	1405.5	1195.3	2567.4	3998.3	7120.0
2	Dam Embankment	344 260 000	Fill Volume	hm^3	23.3	2.9	3.3	4.7	1.9	2.0
3	Injection and Galleries	37 290 000	Fill Volume	hm^3	23.3	2.9	3.3	4.7	1.9	2.0
			Geological Conditions	-	x 1	x 5	x 3	x 5	x 5	x 1
4	Spillway	88 790 000	Catastrophic Flood	m^3/s	20357.0	3041.7	2958.8	9100.5	14533.8	20357.0
5	Water Conduction Structures	52 140 000	Design Discharge	m^3/s	1266.0	65.0	120.0	355.0	290.0	825.0
6	Building Site and Roads	17 970 000	Fixed	-	x 1	x 1	x 1	x 1	x 1	x 1
7	Powerhouse, Tailwater Channel and Switchyard	12 200 000	Design Discharge	m^3/s	1266.0	65.0	120.0	355.0	290.0	825.0
8	Electromechanical Equipment and Transmission Line	450 000 000	Installed Power	MW	1200.0	33.4	72.7	201.4	171.7	398.4
9	Expropriation and Resettlement	750 000 000	Reservoir Area at Max. W. L. during Re-regulation	km^2	321.4	41.9	19.8	16.2	109.2	48.2
	Total Cost	**1 850 000 000**								

Table 4.4 Salient Features of the Existing and Proposed Projects (Ilisu Environment Group, 2005)

Item	Unit	The Existing Project	The Proposed Project					
			Ilisu I	Ilisu II	Ilisu III	Ilisu IV	Ilisu V	Total
Penstock								
Number	-	3	1	1	2	2	5	-
Diameter	m	11.0	4.1	5.5	6.7	6.1	6.5	-
Length	m	407.0	200.0	200.0	200.0	200.0	200.0	-
Energy Tunnel								
Number	-	-	1	1	1	1	1	-
Diameter	m	-	4.5	6.2	10.6	9.6	16.2	-
Length	m	-	400.0	400.0	400.0	400.0	400.0	-
Powerhouse								
Turbine Type	-	Francis	Francis	Francis	Francis	Francis	Francis	-
Design Discharge	m^3/s	1266.0	65.0	120.0	355.0	290.0	825.0	-
Number of Units	-	6	1	1	2	2	5	-
Tailwater Level	m	400.0	468.0	458.0	458.0	460.0	400.0	-
Gross Head	m	125.0	62.0	72.0	67.0	70.0	57.0	-
Net Head	m	118.4	56.9	67.1	62.8	65.6	53.5	-
Total Installed Capacity	MW	**1200.0**	33.4	72.7	201.4	171.7	398.4	**877.6**
Operation								
Firm Energy	GWh	**2766.9**	135.1	171.1	488.7	490.8	1205.5	**2491.2**
Secondary Energy	GWh	**327.4**	8.2	46.1	139.2	130.6	323.8	**647.9**
Total Energy	GWh	**3094.3**	143.3	217.2	627.9	621.4	1529.3	**3139.1**
Water Usage Ratio	%	98.6	88.8	89.9	92.6	87.9	93.8	-
Economy								
Initial Outlay ($x10^6$)	€	**1100**	151	165	330	291	491	**1428**
Expropriation & Resettlement ($x10^6$)	€	**750**	98	46	38	255	113	**550**
Total Cost ($x10^6$)	€	**1850**	249	211	368	546	604	**1978**

CHAPTER 5

CONCLUSION

This study is an assessment of a hydraulic solution not only rescues Hasankeyf with countless ancient monuments from inundation but also supplies the foreseen energy production of the Ilisu Dam and HEPP Project. An alternative composed of five dams on the Tigris River and its branches was developed as a result of the conducted hydro-meteorological, water potential, flood analysis and optimization studies considering the topographical and geological characteristics of the proposed dam locations. With this five-dam system instead of one mega dam, it would be possible to save the historic town and to provide almost the same benefits with the same cost as of the existing project, perceived as indispensable because of flow regulation and energy production capacities, at the same time.

Conclusions on the comparison between the existing and proposed projects can be stated as follows:

- Although there is a 10014.6 hm^3 reduction in the storage due to decrease in the crest elevation of the existing project from 530 m to 459 m, the mean elevation around Hasankeyf, the reservoirs volume becomes 4426.1 hm^3 together with other four dams. This storage appeared ample to enable Cizre Dam to supply water for the Silopi and Nusaybin-Idil-Cizre irrigation schemes.

- At the designated maximum water levels, the total reservoir area declines to 235.3 km^2 which connotes a notable reduction in the expropriation and resettlement process having a budget of 0.75 billion €, a higher value from the costs for the Ilisu scheme civil works, and a fertile land area of 86.1 km^2 rescued from inundation.

- It was seen in the study that there is no possibility of producing 3883.5 GWh/year energy by means of the Ilisu scheme for the stage corresponding to full development of the upstream watershed.

- While the existing project has an energy production capacity of 3094.3 GWh/year, the proposed one is capable of providing 3139.1 GWh/year with a smaller installed power, in spite of a slight decrease in the produced firm energy.

- The minor differences in terms of water usage ratio and firm energy against a 54 percent decrease in the active storage illustrate the effect of upstream dams on flow regulation and the needlessness of such an enormous reservoir.

- The proposed solution can be implemented in a less time with an amount almost equals to the cost of the Ilisu Project.

- The continuing archaeological excavation works around Hasankeyf would not be affected by the construction of this five-dam system.

This assessment can be further harmonized with the environment by making some modifications on the proposed sites and maximum water levels, designated with the priority of observing maximum storage, due to the presumptive environmental impacts resulting in irreversible conversion and degradation of critical natural habitats, located near intensively the Bismil, Besiri and Hasankeyf regions (Doğa Derneği, 2006). The energy loss owing to these modifications can be tolerated by changing the sediment management policy from allocation of dead volume to sediment release downstream as use of dead storage in energy production.

Moreover, if the whole basin is re-evaluated with an integrated basin management strategy instead of optimizing projects in themselves, different solution opportunities can be provided. Although it is obvious that an optimized basin model is just a mere imagination because of the projects developed by incorporated companies according to Law No.4628 within the elevation allotment policy of DSI, a catchment-based operation optimization can be applied.

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APPENDIX A

METEOROLOGICAL STATIONS

A.1. Precipitation

Table A.1 Monthly Total Precipitation Values of Mutki Meteorological Station (DMI, 2009-a)

1620 m Unit: mm

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1956	-	-	-	-	-	-	-	-	0.0	9.2	158.9	127.9
1957	207.4	101.4	254.0	87.9	271.4	48.1	3.2	0.0	8.4	35.0	79.0	147.0
1958	256.9	93.2	355.4	106.8	25.6	60.4	0.0	0.0	2.3	18.3	71.9	194.3
1959	249.2	71.2	132.0	156.7	123.0	69.7	15.6	0.0	48.4	110.3	83.9	32.2
1960	169.4	125.3	153.6	275.6	57.3	11.7	0.0	4.5	0.0	36.4	94.2	47.5
1961	153.1	63.2	191.1	118.5	68.4	39.9	0.0	0.0	2.4	42.1	281.0	125.1
1962	29.9	211.9	88.1	139.8	40.1	0.0	0.0	0.0	0.0	27.9	81.6	376.8
1963	336.7	280.9	149.3	414.9	199.9	24.8	3.5	5.3	28.8	165.7	114.6	85.1
1964	39.9	184.9	270.7	66.9	81.5	13.4	0.0	0.0	0.0	0.0	218.3	10.9
1965	75.2	132.2	89.5	175.4	45.7	28.8	0.0	5.0	3.6	278.6	202.5	178.8
1966	243.7	77.7	108.4	213.6	93.3	7.7	6.1	0.0	62.0	53.1	41.3	170.1
1967	281.6	125.8	160.6	186.7	130.0	9.6	0.0	0.0	51.1	107.7	276.2	193.0
1968	266.0	96.3	295.4	121.9	79.2	32.9	12.0	3.4	4.5	81.3	230.0	283.8
1969	207.0	155.5	268.8	294.6	73.7	26.3	4.6	1.3	38.8	140.4	43.7	108.4
1970	69.9	207.4	117.2	50.2	50.4	0.0	13.9	2.3	0.0	84.8	135.4	121.2
1971	10.9	111.9	141.1	180.5	106.2	28.0	0.0	5.9	0.0	155.6	81.5	179.3
1972	76.4	81.5	101.9	232.8	238.9	41.4	0.0	4.2	16.2	119.3	199.3	30.2
1973	73.3	112.7	147.6	143.5	55.3	23.7	0.0	0.0	0.0	43.7	238.0	65.0
1974	113.3	31.0	214.8	237.2	34.4	0.0	0.0	1.3	37.9	28.8	152.0	97.0
1975	28.3	215.4	119.8	180.3	82.7	25.7	3.2	0.0	43.5	23.4	199.6	79.7
1976	174.4	56.1	55.7	252.3	148.3	43.7	0.0	0.0	0.0	265.5	160.8	112.4
1977	71.1	48.3	201.4	285.7	128.0	32.1	0.0	11.5	0.0	106.6	20.7	219.7
1978	169.6	229.2	187.2	205.3	26.5	33.8	0.0	0.0	0.0	84.3	5.0	195.1
1979	202.9	98.5	104.6	137.9	55.9	32.8	0.0	0.0	9.9	236.6	229.8	83.3
1980	68.8	33.7	232.5	194.9	91.1	3.6	0.0	0.0	0.0	20.7	137.5	91.8
1981	147.9	76.8	213.9	123.4	111.3	72.0	14.9	0.0	3.6	41.3	182.9	158.9
1982	108.3	45.9	-	-	-	-	-	0.0	-	35.2	-	9.5
1983	17.5	78.4	15.6	44.2	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-
1987	135.1	248.1	262.2	101.3	13.9	9.8	1.0	2.3	8.2	-	-	-
Avg.	**142.3**	**121.2**	**171.6**	**175.1**	**93.5**	**27.7**	**3.0**	**1.7**	**13.7**	**87.1**	**143.1**	**130.5**

Table A.2 Monthly Total Precipitation Values of Kozluk Meteorological Station (DMI, 2009-a)

810 m Unit: mm

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1984	-	-	253.9	70.8	24.1	-	2.0	-	-	63.8	88.2	37.5
1985	133.0	221.9	91.6	169.3	49.9	5.8	0.0	0.0	0.0	10.4	45.5	127.5

Table A.2 (continued)

1986	150.2	110.5	51.5	63.3	110.0	18.8	0.0	0.0	2.7	76.1	136.9	152.6
1987	286.3	135.7	265.2	78.5	0.3	0.0	1.7	0.0	1.1	110.6	105.5	381.6
1988	237.8	174.7	255.2	220.6	91.8	46.7	0.8	9.3	4.3	84.6	62.8	147.0
1989	4.4	20.4	107.5	10.1	8.1	1.1	0.0	0.0	4.3	70.2	296.9	186.6
1990	111.6	179.6	25.5	141.2	24.9	3.1	0.0	0.0	0.0	12.8	65.8	53.4
1991	157.4	181.6	153.3	47.1	72.6	3.3	0.0	0.0	2.1	69.2	79.3	192.6
1992	95.0	276.9	36.5	67.0	121.3	28.4	0.0	0.0	1.9	2.3	122.3	114.7
1993	95.7	163.1	114.3	165.9	243.7	17.9	0.0	0.0	-	-	-	-
Avg.	**141.3**	**162.7**	**135.5**	**103.4**	**74.7**	**13.9**	**0.5**	**1.0**	**2.1**	**55.6**	**111.5**	**154.8**

Table A.3 Monthly Total Precipitation Values of Siirt Meteorological Station (DMI, 2009-a)

896 m Unit: mm

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
1975	60.8	125.6	46.2	125.9	48.1	1.2	0.0	0.0	4.0	1.6	99.5	71.5
1976	109.1	100.2	43.2	223.8	126.5	10.7	0.0	0.0	7.7	120.7	23.0	77.4
1977	46.7	37.2	95.3	125.7	54.1	11.8	0.3	0.7	0.0	31.4	47.8	122.9
1978	122.4	141.2	85.0	87.8	36.0	12.9	0.0	0.0	0.0	42.2	6.3	206.6
1979	124.8	112.8	88.3	57.7	19.3	19.8	0.0	0.0	0.4	143.2	116.3	77.2
1980	58.1	70.2	141.2	114.4	31.1	0.0	0.0	0.0	0.5	16.6	83.3	32.7
1981	88.5	114.5	218.1	79.0	73.0	21.8	0.4	0.0	0.0	22.0	126.6	66.5
1982	68.5	106.4	101.5	154.2	128.3	11.3	1.3	2.3	0.5	37.4	58.1	21.9
1983	82.9	99.2	60.3	23.1	135.5	14.4	6.3	1.7	0.0	35.8	199.2	38.5
1984	71.9	61.5	80.3	43.7	36.1	0.0	0.0	0.0	0.0	51.8	136.4	33.9
1985	81.6	183.1	107.4	135.3	34.1	1.6	0.0	2.1	0.0	24.8	51.9	100.4
1986	76.6	73.5	36.7	37.1	97.3	6.4	10.9	0.0	0.2	53.3	97.4	85.9
1987	118.8	127.9	184.7	103.4	2.0	0.0	0.9	0.0	0.0	146.3	60.2	278.2
1988	141.6	105.9	163.2	203.0	73.7	15.2	2.2	13.9	5.7	114.7	95.3	112.0
1989	16.9	16.7	100.4	0.7	12.1	1.0	0.0	5.7	3.2	96.0	143.1	93.2
1990	79.3	93.7	31.5	141.6	37.9	13.3	0.0	0.0	0.0	14.3	60.9	46.2
1991	51.4	133.2	187.5	58.5	63.4	4.7	0.0	0.0	0.0	63.3	90.8	121.1
1992	72.8	176.7	13.2	72.0	160.0	23.2	0.0	0.0	5.3	0.0	151.6	111.3
1993	56.3	189.1	110.3	118.0	291.1	8.0	1.0	1.9	0.0	22.9	178.5	33.1
1994	103.2	91.9	82.0	115.0	96.8	1.3	0.0	0.0	6.7	56.0	173.2	169.1
1995	109.6	61.1	161.5	176.9	53.8	32.3	5.7	0.0	6.0	13.6	67.7	6.9
1996	131.8	81.4	271.3	109.1	15.8	0.0	4.1	0.0	6.6	95.7	1.3	180.0
1997	53.4	72.6	88.6	98.8	37.0	4.4	11.9	0.0	20.5	64.2	73.8	97.7
1998	66.6	86.9	172.2	86.5	90.6	15.3	22.2	1.5	7.0	0.8	10.9	58.6
1999	32.0	82.2	126.5	111.0	6.2	5.6	3.7	3.8	4.6	18.6	8.8	42.4
2000	76.6	70.7	84.8	83.4	28.8	0.0	0.0	0.0	1.1	18.4	16.8	128.5
2001	29.9	99.3	111.7	65.7	97.7	1.2	6.5	0.0	0.1	35.7	37.0	224.8
2002	62.1	61.3	122.7	135.8	15.4	3.0	1.8	0.0	5.2	29.5	43.9	143.3
2003	65.0	182.4	191.7	98.2	2.6	36.6	0.0	0.3	1.1	40.7	111.4	105.2
2004	115.0	95.8	31.8	67.6	113.7	0.2	0.1	0.0	0.0	22.7	213.8	16.5
2005	97.1	92.2	112.3	46.1	31.5	22.7	0.0	7.4	2.8	27.2	49.5	84.3
2006	136.1	121.7	79.2	97.1	15.8	0.0	0.4	0.0	0.0	161.0	88.9	33.0
Avg.	**81.5**	**102.1**	**110.3**	**99.9**	**64.5**	**9.4**	**2.5**	**1.3**	**2.8**	**50.7**	**85.1**	**94.4**

Table A.4 Monthly Total Precipitation Values of Tatvan Meteorological Station (DMI, 2009-a)

1664 m Unit: mm

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
1958	105.8	42.0	177.4	73.5	37.8	69.2	42.0	-	6.2	38.6	50.7	118.5
1959	113.8	54.9	123.3	90.0	124.8	35.1	0.9	0.2	39.2	74.8	43.9	39.5
1960	98.0	75.0	89.0	169.5	23.4	5.8	3.0	0.0	-	26.9	83.0	26.8

Table A.4 (continued)

1961	77.9	82.9	112.6	86.4	67.8	36.2	-	0.2	-	24.5	123.6	52.4
1962	24.0	172.2	37.1	107.2	31.5	1.6	1.9	0.0	-	37.4	60.0	145.9
1963	154.2	139.7	65.9	297.6	222.9	48.3	9.2	9.5	32.8	74.5	-	-
1964	56.4	-	-	68.8	44.1	17.9	-	-	-	3.3	81.5	10.6
1965	66.5	129.3	55.1	84.8	42.0	14.0	0.5	0.0	3.1	200.9	113.4	93.4
1966	-	63.1	69.1	159.4	131.0	4.2	1.0	-	88.2	-	-	-
1967	-	-	-	103.2	111.9	10.0	4.7	0.0	41.1	107.1	202.0	95.0
1968	204.5	49.8	181.1	71.6	59.1	36.6	4.3	18.2	3.3	47.5	144.4	152.5
1969	140.6	82.0	185.2	207.8	48.3	20.0	0.9	-	55.4	164.7	36.8	103.1
1970	54.8	143.3	84.6	48.5	41.0	1.0	15.5	2.4	0.0	70.5	-	-
1971	-	-	-	78.2	42.1	30.4	-	10.6	-	129.3	42.6	130.6
1972	61.2	68.2	87.3	167.4	172.9	35.2	2.8	1.7	20.2	101.7	187.0	14.4
1973	76.0	71.6	108.9	100.0	41.9	12.5	1.2	-	-	63.0	123.6	28.8
1974	68.2	29.3	142.5	171.1	42.8	3.1	0.4	27.8	29.4	15.8	66.6	50.7
1975	17.6	189.5	97.6	85.6	93.9	31.9	0.0	-	28.4	62.3	165.3	82.8
1976	112.7	86.4	42.8	167.0	142.0	35.7	22.0	-	2.1	191.9	74.3	67.2
1977	60.9	37.6	157.7	143.3	93.1	35.4	22.6	13.0	-	61.4	34.3	122.8
1978	75.2	115.6	106.9	152.9	27.0	28.0	-	-	5.7	86.8	24.4	151.3
1979	107.5	116.7	95.9	72.5	53.1	28.6	0.0	0.5	4.5	138.3	141.7	59.5
1980	42.0	57.0	162.5	181.4	63.9	2.3	5.4	-	0.0	18.4	101.7	65.8
1981	106.8	71.6	117.1	124.1	76.6	46.0	8.1	2.0	1.2	34.1	164.1	79.4
1982	64.2	82.9	119.4	145.7	113.2	19.8	18.0	3.7	0.8	98.2	76.1	31.5
1983	80.4	88.3	58.5	53.4	140.1	50.6	19.4	12.3	8.3	48.9	187.6	30.7
1984	37.2	44.5	99.3	103.6	97.8	-	8.8	-	1.0	75.8	102.9	36.0
1985	79.7	183.1	100.9	136.7	24.0	10.4	-	2.6	0.6	56.4	38.7	64.1
1986	81.3	90.8	60.9	72.0	146.2	27.3	8.8	-	7.0	85.4	154.7	128.8
1987	97.7	185.8	208.8	128.4	25.1	8.4	0.4	6.2	8.3	155.7	97.1	263.0
1988	93.0	95.6	215.4	180.7	159.9	57.8	9.3	20.3	20.2	148.0	84.1	105.6
1989	9.7	21.6	81.6	14.2	55.0	18.8	-	3.0	25.8	114.5	218.5	87.9
1990	68.9	98.0	31.4	164.2	42.0	34.2	2.8	-	-	51.2	98.5	76.3
1991	58.5	88.7	188.8	67.3	144.6	15.4	6.3	0.2	6.2	133.0	157.1	114.6
1992	59.1	269.0	17.4	89.2	183.3	53.6	-	0.7	43.5	14.2	209.2	83.3
1993	71.5	216.1	132.5	192.6	254.2	30.2	4.3	6.5	-	49.5	233.9	13.1
1994	84.6	76.0	90.4	173.0	121.7	36.0	-	-	8.7	44.5	200.4	115.9
1995	52.6	56.5	170.0	234.8	146.4	64.2	7.6	-	51.1	77.0	121.3	1.2
1996	61.6	70.0	113.8	183.6	61.5	18.1	11.9	-	41.3	102.4	4.0	147.3
1997	46.5	52.5	72.6	152.6	71.4	21.4	12.4	-	16.1	67.8	47.8	53.9
1998	70.5	42.5	145.9	169.4	62.8	43.1	5.0	0.2	10.1	2.0	20.3	116.7
1999	3.8	71.6	109.6	97.5	64.1	28.3	0.2	10.7	14.4	48.2	27.0	25.9
2000	110.8	62.1	37.6	101.1	22.3	6.0	0.3	12.6	4.2	32.3	7.0	79.4
2001	51.8	72.1	125.7	117.5	127.8	13.1	6.3	3.4	0.5	98.0	21.6	164.1
Avg.	**75.8**	**93.8**	**109.3**	**127.0**	**88.6**	**26.6**	**7.5**	**6.0**	**18.0**	**76.2**	**101.8**	**83.7**

Table A.5 Monthly Total Precipitation Values of Baykan Meteorological Station (DMI, 2009-a)

1050 m Unit: mm

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
1957	142.0	143.5	206.7	101.1	297.4	10.0	-	-	0.0	23.3	62.2	155.7
1958	251.4	116.7	238.9	57.9	15.4	28.6	-	-	-	3.6	76.2	232.5
1959	157.6	53.6	108.6	48.3	107.0	14.1	6.9	-	5.7	48.4	45.5	46.0
1960	138.6	111.4	157.5	180.6	4.3	0.0	2.7	-	-	4.4	70.2	41.5
1961	134.5	56.8	125.9	125.0	88.8	21.0	-	-	0.0	22.4	133.2	260.4
1962	91.1	217.4	46.5	116.9	30.1	2.1	-	-	-	16.3	28.0	261.0
1963	239.0	214.5	132.7	386.5	139.5	23.0	4.5	7.0	11.0	175.5	76.0	68.0
1964	28.0	224.0	261.5	57.0	28.0	9.0	-	-	-	-	205.5	47.0
1965	92.0	245.5	64.5	205.0	31.5	7.0	-	-	12.0	182.5	86.0	198.0
1966	243.5	65.0	95.9	197.2	85.8	0.0	0.0	-	40.6	57.5	18.3	189.1

Table A.5 (continued)

1967	203.0	137.6	211.7	137.7	135.5	10.2	2.2	0.0	27.4	79.2	260.5	324.7
1968	325.5	106.7	164.4	85.0	109.8	6.9	-	0.0	1.2	39.1	158.1	537.7
1969	191.4	141.5	326.4	181.2	63.1	25.0	-	-	14.1	81.4	79.5	127.9
1970	98.4	217.3	68.3	20.9	14.8	0.0	14.6	0.0	-	30.8	159.8	81.3
1971	9.1	117.6	120.8	231.1	45.3	15.7	-	-	-	60.6	120.5	243.3
1972	87.4	81.4	118.5	169.1	220.4	25.9	-	-	4.2	44.8	99.7	19.1
1973	116.0	92.9	91.9	93.0	26.0	1.8	-	-	-	18.0	116.3	62.0
1974	71.2	25.6	218.6	208.9	15.0	-	0.0	0.0	3.8	3.7	126.1	111.1
1975	62.8	247.6	69.9	119.3	48.6	14.5	9.2	-	1.3	6.2	170.1	144.2
1976	261.6	198.8	82.3	233.7	114.9	11.1	0.0	0.0	0.9	198.9	88.8	144.1
1977	51.5	77.0	164.2	165.6	64.2	3.6	-	-		47.8	55.9	197.8
1978	218.1	297.4	201.3	137.9	11.0	15.8	-	-	6.5	39.1	0.8	262.3
1979	187.3	136.1	108.7	93.2	37.0	2.8	-	-	-	-	-	-
1980	-	34.1	215.3	132.2	55.4	-	0.0	-	0.0	7.5	121.3	55.8
1981	157.7	168.2	256.8	109.0	69.7	22.8	6.8	-	0.2	27.9	133.2	116.3
1982	154.1	144.4	142.1	162.7	128.5	2.7	2.1	-	0.0	42.4	51.0	51.4
1983	105.1	141.3	98.5	51.8	107.7	14.3	0.0	3.6	0.0	44.6	321.1	60.7
1984	90.4	110.0	206.5	74.6	41.0	-	0.0	-	0.0	96.0	142.8	49.6
1985	159.9	301.3	99.8	163.8	29.3	0.8	0.2	0.3	0.0	41.5	71.9	119.8
1986	180.7	103.6	57.4	78.1	122.1	28.2	1.5	-	0.0	103.7	183.9	163.2
1987	306.2	220.7	334.1	96.4	0.0	7.9	0.0	-	0.0	167.5	113.3	457.8
1988	204.3	207.0	312.2	180.4	114.7	45.7	0.8	0.7	5.2	77.4	107.5	197.5
1989	6.5	24.3	108.4	7.8	17.7	6.8	-	0.0	7.3	63.8	301.5	219.7
1990	92.7	186.3	34.1	155.5	42.2	13.9	0.0	-	-	19.4	74.7	62.4
1991	149.6	214.7	210.3	71.1	71.5	1.3	-	-	1.3	103.0	140.2	159.1
1992	112.1	393.0	40.6	101.2	110.9	44.6	-	-	8.4	2.9	193.9	116.9
1993	95.6	231.4	178.2	161.0	322.9	49.2	0.2	0.0	-	24.4	216.8	35.2
1994	177.5	196.6	108.0	128.0	100.5	8.4	-	-	6.1	59.7	276.9	220.9
1995	169.1	103.3	228.7	213.7	62.4	38.4	-	-	0.1	29.7	108.0	7.4
1996	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	74.8	85.2	181.9
1998	90.6	107.6	234.5	146.7	66.7	10.6	3.2	1.6	2.0	0.7	19.0	90.7
1999	31.9	133.7	181.6	128.0	8.7	13.4	2.8	5.5	1.7	48.1	6.9	84.6
2000	197.9	119.9	93.9	93.6	33.4	-	-	-	1.2	17.7	9.8	192.0
2001	32.8	138.9	199.0	110.3	143.1	8.0	0.5	0.7	-	76.5	50.8	258.2
Avg.	**140.9**	**153.6**	**156.4**	**133.0**	**78.6**	**14.5**	**2.5**	**1.4**	**5.2**	**55.1**	**115.5**	**154.8**

Table A.6 Monthly Total Precipitation Values of Pervari Meteorological Station (DMI, 2009-a)

1380 m Unit: mm

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
1975	38.8	105.7	58.1	104.8	70.3	10.7	0.0	-	6.4	27.4	80.5	50.1
1976	52.0	65.0	47.0	176.0	128.7	21.1	7.4	-	0.0	131.1	7.3	45.5
1977	74.3	22.9	123.1	149.0	26.0	6.4	4.3	0.0	0.0	39.6	18.1	63.8
1978	66.6	125.7	93.7	85.7	0.0	0.0	0.0	-	-	63.5	30.8	47.2
1979	66.0	29.0	49.1	58.0	59.2	41.7	0.0	-	0.0	71.2	48.3	20.6
1980	41.9	10.5	71.8	86.5	40.2	-	0.0	0.0	0.0	21.1	94.6	5.9
1981	40.7	43.5	90.1	114.0	59.4	23.9	0.0	0.0	-	-	-	-
1982	-	31.4	131.5	130.2	174.2	3.5	3.1	-	1.2	90.0	45.5	20.7
1983	72.9	101.8	87.3	37.4	68.1	5.5	14.2	0.2	0.0	36.9	183.2	46.1
1984	64.7	32.4	84.0	76.3	101.5	-	2.0	-	-	81.5	99.5	25.7
1985	84.6	192.0	171.8	117.0	22.2	1.7	-	1.3	0.0	15.4	51.7	65.8
1986	63.7	64.2	90.8	102.2	126.1	31.1	0.8	1.6	0.0	64.5	147.6	49.8
1987	76.6	155.3	158.9	87.9	29.6	9.0	0.0	-	1.2	137.8	45.8	310.1
1988	143.1	72.3	185.1	176.7	131.1	44.3	23.9	41.9	11.6	110.0	93.2	156.3
1989	19.4	29.2	129.8	16.6	31.9	0.0	-	0.0	18.9	77.5	137.6	58.7
1990	-	-	40.6	112.5	22.6	7.0	-	-	-	28.8	67.4	84.2

Table A.6 (continued)												
1991	43.6	123.2	216.2	145.8	77.2	3.2	-	-	-	63.6	123.4	129.0
1992	54.0	118.8	18.0	60.8	150.6	64.8	-	-	8.4	-	142.8	45.4
1993	31.4	-	-	-	51.4	19.0	18.6	6.8	-	-	-	-
1994		42.1	52.7	116.0	97.9	0.8	-	-	-	-	-	-
Avg.	**60.8**	**75.8**	**100.0**	**102.8**	**73.4**	**16.3**	**5.3**	**5.8**	**3.7**	**66.2**	**83.4**	**72.1**

Table A.7 Monthly Total Precipitation Values of Diyarbakir Meteorological Station (DMI, 2009-a)

660 m Unit: mm

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
1929	59.6	105.9	47.1	57.2	38.5	13.5	0.2	3.0	0.0	1.5	35.8	28.3
1930	46.4	53.4	14.1	38.2	1.5	10.0	0.0	0.0	9.4	15.6	48.5	96.6
1931	50.1	31.6	40.8	90.1	11.3	17.9	0.0	0.0	9.4	79.5	29.5	28.2
1932	67.5	16.4	19.3	29.7	10.3	1.3	0.0	0.0	6.8	1.5	44.8	8.6
1933	90.9	90.9	93.2	35.2	23.5	13.7	0.0	0.0	0.5	9.3	25.0	83.9
1934	34.1	94.1	22.0	107.2	109.4	15.7	0.0	0.0	2.4	29.0	18.1	66.3
1935	83.6	122.7	31.5	21.9	1.2	0.6	0.0	0.0	7.3	48.6	126.8	86.9
1936	21.3	141.8	8.0	109.9	108.0	11.9	6.2	0.0	0.0	37.5	63.1	59.6
1937	67.5	13.1	7.4	93.1	32.4	9.5	0.0	0.2	0.0	54.3	56.6	45.4
1938	132.6	107.2	21.8	26.6	28.8	0.0	6.1	3.0	12.1	0.5	102.9	46.2
1939	17.5	21.8	85.5	46.9	15.9	6.4	0.0	0.0	6.0	1.0	78.9	85.6
1940	53.3	61.7	27.5	103.7	8.6	4.1	0.0	0.0	0.0	98.0	53.6	81.3
1941	80.8	64.1	103.1	48.9	0.0	0.0	1.6	0.0	2.7	10.9	15.0	67.7
1942	108.9	70.0	106.7	13.1	0.5	0.0	0.0	0.0	0.0	61.9	175.3	54.6
1943	166.0	81.1	90.9	58.6	14.1	1.6	0.0	0.0	0.0	58.1	4.8	36.2
1944	121.8	25.0	38.2	149.8	71.7	0.7	0.0	0.0	7.6	49.9	120.6	75.2
1945	102.3	47.4	43.3	35.6	4.9	1.2	0.0	0.0	0.0	0.9	90.5	67.0
1946	31.2	85.2	95.9	126.1	154.7	6.4	7.4	0.7	6.8	61.2	1.0	51.1
1947	112.5	48.6	48.8	4.8	35.7	2.2	0.7	0.0	1.0	6.9	91.4	49.4
1948	123.8	101.3	41.7	144.5	52.8	10.7	0.0	0.0	0.0	13.6	17.7	86.0
1949	67.6	65.8	84.5	103.4	8.4	0.0	0.1	9.5	1.1	0.3	0.0	130.3
1950	52.1	63.4	114.4	74.9	134.2	0.0	0.0	0.0	1.8	25.4	57.0	59.2
1951	57.7	42.2	49.6	103.4	38.8	27.6	0.7	0.2	18.1	64.4	28.2	67.4
1952	63.7	122.5	51.9	55.1	49.8	5.9	0.0	0.0	3.0	5.0	29.9	74.1
1953	65.4	127.1	136.5	100.1	13.0	3.6	6.2	0.0	0.0	33.1	106.7	77.1
1954	90.9	71.0	113.2	175.9	16.5	1.1	1.3	0.0	0.0	11.6	62.6	115.4
1955	48.5	47.1	43.5	55.4	35.5	0.0	0.0	0.0	2.5	4.7	77.1	188.7
1956	85.6	55.9	69.0	34.4	30.0	5.2	0.0	0.0	1.0	16.4	42.1	65.0
1957	81.0	58.5	81.2	65.6	136.7	22.4	0.0	2.0	0.0	13.0	84.2	50.5
1958	120.0	12.7	79.9	51.8	11.2	47.8	0.0	0.0	0.0	0.6	64.3	70.6
1959	94.3	38.9	45.2	26.1	80.5	14.2	0.0	0.0	3.5	52.0	29.1	30.3
1960	84.4	26.7	80.4	85.7	6.7	0.0	0.3	0.0	0.0	8.6	38.1	24.5
1961	62.7	23.6	40.0	18.9	91.2	13.3	0.0	0.6	0.0	7.2	61.5	136.9
1962	57.9	105.4	28.9	92.4	0.9	0.0	1.5	0.0	0.0	2.3	28.2	116.7
1963	93.9	66.4	70.2	148.9	182.2	9.3	2.6	0.0	7.6	78.9	42.1	46.7
1964	14.9	109.2	99.9	15.4	8.8	1.0	0.0	0.0	1.0	0.1	48.3	31.0
1965	70.0	109.3	38.0	62.1	1.1	2.7	0.0	0.0	2.9	83.6	62.1	44.0
1966	155.3	48.7	38.5	74.6	33.1	0.0	0.1	0.0	10.1	14.2	53.3	98.2
1967	53.4	101.3	74.1	148.6	56.1	2.8	1.5	0.0	14.4	106.8	73.6	97.9
1968	108.4	53.6	114.3	39.5	85.8	1.1	0.0	4.9	0.0	29.5	65.3	159.8
1969	188.9	81.6	110.6	83.6	14.7	4.4	0.8	0.0	0.0	51.2	40.2	42.0
1970	44.1	35.3	22.7	13.3	7.1	0.0	1.4	0.3	0.0	22.1	45.9	43.9
1971	8.8	61.0	75.2	163.5	6.5	9.2	0.0	0.0	0.0	25.2	28.8	93.8
1972	57.0	54.2	36.2	136.5	152.6	23.7	0.0	0.0	2.6	8.9	31.4	2.0
1973	90.1	41.0	22.0	37.7	3.2	1.2	0.0	0.0	0.0	6.2	34.7	35.5
1974	95.4	22.2	129.5	81.3	11.3	0.7	0.0	3.1	1.9	5.2	84.9	72.6
1975	22.8	101.0	24.2	89.4	20.6	0.2	0.0	0.0	0.6	3.9	59.6	96.6

Table A.7 (continued)												
1976	96.5	80.3	140.6	158.7	88.2	2.7	1.1	0.0	0.0	43.2	37.4	85.8
1977	19.1	56.0	78.2	59.1	46.2	5.2	0.0	0.0	2.4	19.8	31.0	124.8
1978	96.6	146.1	60.3	46.9	13.4	10.1	0.0	0.0	1.6	4.8	2.0	58.3
1979	82.5	48.2	75.6	33.3	39.9	6.6	0.0	0.1	0.0	76.1	81.8	122.8
1980	51.7	112.4	91.2	95.5	22.0	9.5	0.0	0.0	0.0	3.4	49.8	130.9
1981	92.4	67.5	133.1	38.7	53.1	19.3	0.0	0.0	0.1	26.2	57.5	49.1
1982	54.7	26.7	86.9	139.7	93.9	10.4	0.5	0.0	3.7	14.4	36.3	61.1
1983	94.3	76.6	46.3	29.0	48.1	16.9	2.8	0.2	1.5	13.6	98.7	41.4
1984	44.9	25.8	75.9	33.8	14.0	0.2	0.1	-	-	33.9	80.6	39.8
1985	66.2	116.6	48.3	121.7	21.5	0.1	-	-	-	33.6	55.8	91.7
1986	32.4	118.1	48.6	42.7	64.1	0.4	0.1	3.4	3.6	24.0	43.3	16.8
1987	83.0	27.9	120.9	10.8	0.0	3.8	0.0	0.0	0.0	148.1	46.7	162.0
1988	102.0	54.9	83.0	125.9	29.9	2.8	0.4	0.2	2.3	85.4	52.9	82.3
1989	0.7	29.6	85.0	1.8	1.5	1.1	-	3.8	1.4	51.0	92.2	20.7
1990	69.5	89.9	29.0	79.0	1.3	25.4	-	0.0	-	1.3	34.4	40.1
1991	66.8	65.3	123.2	31.5	46.0	4.3	-	-	-	25.8	58.8	147.9
1992	39.9	111.0	14.8	20.9	79.8	39.8	-	-	0.7	0.5	77.7	43.4
1993	65.8	91.9	54.9	58.5	119.5	5.5	0.0	1.6	0.0	11.6	99.1	8.7
1994	133.6	54.2	45.2	48.1	33.7	1.0	0.0	0.0	0.6	55.7	115.4	89.1
1995	83.1	55.2	49.5	115.6	20.8	20.3	0.0	0.0	0.0	10.9	56.2	0.0
1996	142.8	71.7	210.3	54.8	8.0	0.2	2.4	0.0	8.5	27.4	3.4	133.5
1997	25.3	48.7	44.7	34.6	12.8	4.3	0.0	0.0	25.2	91.0	59.4	80.9
1998	75.2	41.7	71.8	75.6	86.3	1.7	0.5	0.0	0.2	0.2	27.2	62.3
Avg.	**74.7**	**67.8**	**66.8**	**70.5**	**41.5**	**7.4**	**0.7**	**0.6**	**3.0**	**30.3**	**55.4**	**71.0**

Table A.8 Monthly Total Precipitation Values of Silvan Meteorological Station (DMI, 2009-a)

825 m												Unit: mm
Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
1963	150.5	114.7	64.8	277.2	169.2	10.8	1.7	1.3	1.9	92.9	60.7	59.4
1964	21.4	167.4	194.6	45.3	11.7	12.0	0.0	0.0	0.0	0.1	70.0	44.9
1965	101.5	158.5	55.1	90.0	1.6	3.9	0.0	0.0	4.2	121.2	90.0	63.8
1966	152.1	54.7	52.1	113.1	30.4	0.0	0.0	0.0	13.2	82.9	23.2	106.3
1967	97.1	73.4	110.5	100.5	105.2	0.0	0.0	0.0	20.9	43.3	118.9	198.7
1968	145.6	46.1	139.0	103.1	141.4	1.6	0.0	0.0	0.0	0.0	94.6	106.3
1969	273.9	118.3	160.3	121.2	21.3	6.4	1.2	0.0	0.0	74.2	58.3	60.9
1970	63.9	51.2	32.9	19.3	10.3	0.0	2.0	0.4	0.0	32.0	66.5	63.6
1971	12.8	88.4	109.0	237.0	9.4	13.3	0.0	0.0	0.0	0.0	28.2	174.8
1972	0.0	3.8	52.5	197.9	221.2	34.4	0.0	0.0	0.0	12.9	45.5	0.0
1973	130.6	59.4	31.9	54.7	0.0	5.2	0.8	0.0	0.0	9.0	49.1	15.6
1974	75.6	3.1	249.4	130.6	13.2	1.5	0.0	0.0	1.2	1.4	81.8	78.7
1975	26.6	132.3	11.2	164.5	29.9	9.8	0.0	0.0	1.4	0.0	104.8	130.7
1976	180.9	111.6	111.2	208.4	94.6	25.9	0.0	0.0	0.0	163.0	81.9	170.0
1977	36.7	70.7	115.6	89.5	55.7	0.0	0.0	3.2	2.4	17.0	29.4	169.4
1978	163.3	227.5	78.2	105.8	11.0	10.1	0.0	0.0	0.0	8.2	1.6	157.4
1979	135.7	78.1	106.2	47.1	11.1	13.0	1.8	0.1	1.6	148.8	118.5	171.8
1980	83.3	107.5	128.8	71.1	35.6	6.9	0.0	0.0	0.0	15.7	83.5	95.8
1981	115.3	122.6	113.7	70.3	69.3	24.0	5.9	0.0	2.7	8.5	125.7	82.0
1982	107.6	102.6	103.4	190.0	75.2	6.3	0.6	4.4	1.1	82.2	53.6	50.4
1983	90.9	112.9	92.0	33.3	68.2	25.1	0.2	0.1	9.1	65.7	225.6	42.6
1984	52.3	63.5	158.0	58.9	19.4	0.0	2.6	0.0	0.0	49.2	50.4	40.6
1985	101.6	188.5	49.8	117.8	19.4	5.8	0.0	0.0	0.0	32.3	62.4	106.4
1986	92.5	88.8	39.1	34.8	96.9	10.7	0.0	0.0	0.2	31.4	144.6	113.2
1987	205.0	135.5	182.6	38.7	1.4	1.9	0.0	0.0	0.0	140.5	72.9	238.7
1988	131.1	147.2	188.3	162.6	68.6	10.0	5.2	5.8	0.2	70.7	59.0	99.7
1989	1.5	22.6	91.7	0.0	1.5	1.8	0.0	0.0	5.6	45.7	246.6	122.5
1990	72.8	176.2	27.2	104.7	2.0	4.6	0.0	0.0	0.0	3.9	77.3	49.2

Table A.8 (continued)

1991	103.9	81.0	124.9	40.8	42.1	5.4	0.0	0.0	5.3	47.8	57.3	155.3
1992	71.6	227.1	34.3	38.8	88.5	25.2	0.0	0.0	1.0	0.0	137.1	114.1
1993	51.8	115.1	74.0	59.5	175.5	11.8	0.0	4.9	0.0	16.8	143.7	12.6
1994	193.7	78.6	65.5	69.7	48.9	1.5	0.0	0.0	0.9	80.8	167.3	129.2
1995	68.4	50.3	133.3	87.3	12.7	25.7	0.0	0.0	2.7	9.3	51.6	0.5
1996	85.0	62.4	259.4	71.3	12.6	0.0	0.0	0.0	7.3	35.1	0.4	130.4
1997	47.2	65.3	53.3	63.7	37.1	14.9	4.0	0.0	14.0	58.5	96.4	65.4
1998	38.2	51.6	93.8	76.7	56.0	9.0	0.5	0.8	0.4	0.0	12.9	51.2
Avg.	**96.7**	**98.8**	**102.4**	**97.1**	**51.9**	**9.4**	**0.7**	**0.6**	**2.7**	**44.5**	**83.1**	**96.4**

Table A.9 Monthly Total Precipitation Values of Ergani Meteorological Station (DMI, 2009-a)

1000 m Unit: mm

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1929	131.7	126.1	53.4	119.5	106.4	4.0	-	4.0	13.4	3.0	111.0	26.0
1930	74.8	156.0	25.5	124.5	47.0	28.0	-	3.0	5.0	23.1	66.9	169.5
1931	132.2	32.4	79.8	100.1	98.6	9.8	-	-	-	2.9	103.1	63.4
1932	23.8	91.1	38.5	53.9	16.5	2.3	-	-	-	-	-	-
1933	-	-	-	-	-	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-	-	-	-	-	-
1935	-	-	-	-	-	-	-	-	-	-	-	-
1936	-	-	-	-	-	-	-	-	-	-	-	-
1937	-	-	-	-	-	-	-	-	-	-	-	-
1938	-	-	-	-	-	-	-	-	-	-	-	-
1939	-	-	-	-	-	-	-	-	-	-	-	-
1940	-	-	-	-	-	-	-	-	-	-	-	-
1941	-	-	-	-	-	-	-	-	-	-	-	-
1942	-	-	-	-	-	-	-	-	-	-	-	-
1943	-	-	-	-	-	-	-	-	-	-	-	-
1944	-	-	-	-	-	-	-	-	-	-	-	-
1945	-	-	-	-	-	-	-	-	-	-	-	-
1946	-	-	-	-	-	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-	1.7	21.7	103.8	43.0
1948	2.5	13.8	12.0	219.0	8.7	2.2	-	9.0	-	2.9	8.8	10.3
1949	-	28.0	-	4.7	18.0	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-	-	0.2	39.0	22.8
1951	25.6	-	-	47.5	-	-	-	-	-	14.0	3.0	-
1952	4.0	16.4	2.0	-	6.3	-	-	-	-	9.5	4.4	-
1953	-	-	-	-	-	-	-	-	-	-	-	-
1954	-	-	-	-	-	-	-	-	-	-	-	-
1955	-	-	-	-	-	-	-	-	-	-	-	-
1956	-	-	-	-	-	-	-	-	-	-	-	-
1957	-	-	-	-	-	-	-	-	-	-	-	-
1958	-	-	-	-	-	-	-	-	-	-	-	-
1959	104.1	121.0	7.8	63.6	59.3	-	0.2	-	0.6	59.2	50.5	32.1
1960	-	-	-	-	5.7	-	-	-	-	0.0	53.4	32.0
1961	165.3	117.4	201.1	63.0	74.2	30.4	-	-	-	18.1	126.4	271.0
1962	103.3	199.5	26.8	127.6	14.5	-	-	-	-	2.5	34.1	273.5
1963	79.6	124.0	110.0	196.1	235.9	10.8	7.3	-	7.3	130.7	58.6	114.9
1964	-	200.9	237.0	9.4	-	-	-	-	-	0.0	198.1	48.9
1965	52.0	135.6	65.8	106.7	2.2	1.6	-	-	1.9	87.7	65.4	142.7
1966	261.5	36.8	64.4	69.2	42.7	0.6	0.0	-	13.5	8.1	88.2	151.4
1967	139.5	134.8	153.2	183.3	88.5	0.3	1.8	-	0.0	101.5	113.3	204.6
1968	163.1	65.6	127.3	41.6	72.7	0.8	-	5.5	0.6	68.0	137.5	167.4
1969	215.8	125.8	155.7	121.9	32.1	0.5	-	-	0.0	64.3	63.1	122.3
1970	86.5	136.5	83.2	19.2	25.4	0.4	5.6	8.6	0.0	21.4	66.0	97.4
1971	8.4	118.0	197.2	227.2	35.7	10.1	-	0.1	-	96.2	65.9	71.5

Table A.9 (continued)

1972	44.1	35.7	86.1	125.5	214.4	64.4	0.3	0.0	1.1	28.1	92.1	6.5
1973	59.2	99.7	50.3	75.6	2.7	5.0	-	-	-	36.3	118.1	124.9
1974	193.2	30.7	220.5	133.1	11.3	3.8	-	1.7	-	7.2	53.5	134.0
1975	82.0	135.2	31.9	120.9	28.0	3.8	0.0	-	4.2	0.2	98.7	175.2
1976	234.8	121.6	90.7	223.9	114.0	20.9	3.7	-	1.1	165.1	52.6	191.2
1977	43.2	72.2	81.6	86.5	55.3	-	0.2	-	1.9	12.1	26.4	225.1
1978	138.5	199.7	86.8	78.3	6.8	10.4	-	-	0.1	21.8	0.0	141.9
1979	134.8	70.3	77.3	45.6	30.0	69.3	3.4	2.5	0.0	155.8	134.0	111.8
1980	92.7	151.0	169.8	65.5	22.8	4.9	0.7	-	-	2.1	122.1	194.3
1981	183.0	125.6	103.7	53.6	57.4	20.9	1.9	-	0.4	16.5	88.9	124.3
1982	177.2	66.4	146.5	184.8	88.9	18.1	-	-	1.6	17.4	27.1	64.7
1983	96.4	117.8	81.0	45.0	57.0	7.5	-	5.2	0.1	33.0	179.9	52.4
1984	91.0	59.6	150.0	73.1	17.9	5.3	1.3	0.2	-	10.6	67.1	55.5
1985	94.7	164.4	108.8	119.5	28.2	0.3	0.1	-	0.3	65.5	62.2	71.7
1986	153.1	177.5	43.3	75.6	111.1	16.4	0.1	3.1	7.1	66.2	106.1	175.3
1987	277.9	109.9	236.9	22.9	2.4	3.2	-	1.3	3.8	147.7	145.1	402.8
1988	125.7	170.6	211.3	134.5	51.8	4.8	0.7	0.6	9.9	120.6	90.7	99.1
1989	0.2	20.0	88.3	13.1	2.4	9.9	-	1.9	3.1	106.9	179.9	94.3
1990	100.1	254.8	33.1	94.9	6.3	4.8	-	-	-	31.5	99.2	37.8
1991	99.7	126.8	236.0	54.0	77.4	6.5	1.0	-	6.8	44.6	98.2	262.6
1992	51.2	276.1	24.4	15.3	224.1	37.9	-	1.0	4.2	8.0	186.3	106.5
1993	85.1	67.5	75.9	109.4	206.8	14.8	-	5.1	-	14.6	98.4	19.1
1994	134.3	160.5	41.5	34.0	43.9	6.6	0.3	0.0	3.8	65.3	167.5	153.4
1995	100.8	87.7	52.1	88.5	55.8	32.4	-	2.4	-	13.9	128.6	0.1
1996	192.9	83.8	250.5	101.2	22.9	2.6	1.4	-	7.0	91.3	13.5	180.7
Avg.	**110.7**	**112.8**	**102.8**	**92.6**	**57.5**	**12.5**	**1.6**	**2.9**	**3.5**	**43.9**	**86.9**	**119.8**

Table A.10 Monthly Total Precipitation Values of Hani Meteorological Station (DMI, 2009-a)

850 m Unit: mm

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
1975	75.4	193.8	64.4	152.1	35.7	0.0	-	-	4.6	5.5	170.4	206.5
1976	347.4	119.2	14.7	348.4	137.8	15.7	0.0	-	5.2	-	157.4	193.8
1977	36.9	95.8	189.5	136.3	45.6	-	-	-	3.8	30.6	31.5	276.4
1978	203.9	325.2	115.0	77.0	17.6	18.4	-	-	0.0	9.2	0.0	232.2
1979	254.5	98.1	68.4	42.5	32.3	40.8	-	-	-	-	185.1	179.5
1980	116.9	152.1	191.1	111.9	55.7	0.0	-	-	-	21.3	168.0	232.2
1981	174.4	134.2	190.0	75.8	77.4	16.2	-	-	-	9.3	149.5	131.8
1982	176.4	131.9	178.3	224.8	139.8	6.5	1.4	-	1.6	34.6	32.7	45.0
1983	99.7	101.7	92.5	46.6	94.9	16.1	-	3.5	-	54.9	356.3	88.3
1984	89.6	108.1	165.3	116.9	41.3	1.4	0.8	-	-	31.8	104.9	75.2
1985	111.6	187.8	71.1	148.6	18.6	1.4	-	-	-	66.7	71.5	131.6
1986	187.6	144.5	35.8	54.0	128.0	28.6	8.1	-	3.1	38.8	156.8	243.6
1987	295.8	158.0	236.1	37.7	-	0.0	2.0	7.6	-	168.1	161.2	345.3
1988	138.8	239.0	202.4	177.9	87.5	5.1	-	4.4	6.5	120.6	109.7	122.8
1989	0.6	20.0	101.1	-	0.0	24.0	-	0.0	0.0	140.9	330.9	231.0
1990	78.4	343.1	19.5	99.1	14.1	17.6	-	-	-	33.3	128.4	47.6
1991	138.8	121.7	155.2	105.9	116.9	14.1	2.1	-	-	63.0	83.4	301.7
1992	88.6	295.5	73.2	17.1	133.2	54.2	-	-	1.0	5.6	157.6	181.4
1993	154.2	130.9	148.1	244.0	202.2	3.0	-	-	-	13.5	119.2	15.1
1994	164.1	189.8	104.1	69.5	67.7	-	-	-	0.0	72.1	264.0	233.4
1995	209.1	68.5	126.4	219.6	50.2	68.0	-	0.0	11.0	22.2	156.1	1.0
1996	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-
1998	139.5	58.8	185.8	126.1	69.2	27.1	-	0.0	0.0	3.0	81.0	146.1
1999	33.0	160.1	114.1	89.1	12.5	0.0	-	-	-	13.5	0.0	142.6
2000	212.1	111.6	-	47.8	0.0	-	-	-	6.5	61.4	2.0	201.1
Avg.	**147.0**	**153.7**	**123.6**	**120.4**	**68.6**	**17.1**	**2.4**	**2.6**	**3.3**	**46.4**	**132.4**	**166.9**

A.2. Temperature

Table A.11 Monthly Mean Temperature Values of Bitlis Meteorological Station (DMI, 2009-a)

1550 m Unit: ^{0}C

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
1975	-3.9	-3.6	-0.4	9.2	12.2	19.3	22.6	22.4	17.3	10.1	4.7	-2.3
1976	-3.5	-5.0	-0.6	5.6	11.7	18.0	20.7	21.8	16.3	11.3	6.6	1.6
1977	-6.4	0.5	2.8	8.0	12.5	17.6	21.9	22.3	18.2	9.3	5.5	-2.3
1978	-2.5	-0.5	2.1	6.6	12.9	16.6	23.4	22.0	18.1	12.3	2.1	0.3
1979	-1.1	1.3	2.9	9.2	14.2	18.4	22.5	23.7	19.5	10.3	7.1	-1.2
1980	-4.8	-1.4	1.1	6.9	13.0	19.5	24.2	22.5	16.7	11.4	5.3	2.7
1981	-2.5	-1.0	3.2	6.8	11.0	18.2	23.1	22.3	19.3	12.6	2.1	1.4
1982	-3.3	-7.4	-1.0	8.5	13.4	17.7	20.7	21.0	17.4	10.0	2.2	-2.5
1983	-6.8	-4.5	0.8	7.5	13.5	17.3	21.4	20.2	18.0	10.8	6.8	1.4
1984	-1.0	-1.1	3.8	7.8	11.9	19.9	23.4	20.6	18.2	10.9	4.6	-2.1
1985	-0.7	-4.8	-2.2	8.4	14.6	19.7	22.4	23.7	17.7	9.7	7.6	-1.2
1986	-1.5	-0.3	2.8	10.1	10.6	17.8	23.7	23.4	20.1	11.5	2.2	-1.3
1987	-0.7	0.2	-1.3	4.9	14.8	19.3	23.0	21.3	17.4	9.6	5.0	-0.6
1988	-2.4	-2.0	0.5	6.6	13.1	17.1	22.3	21.1	17.0	10.9	1.4	-1.0
1989	-5.6	-2.5	4.3	12.4	14.5	18.9	24.5	22.6	17.1	11.1	4.3	-1.3
1990	-5.3	-2.7	2.5	6.7	13.5	18.7	23.7	21.7	17.5	12.1	6.3	1.5
1991	-2.3	-3.8	2.5	9.3	12.0	19.7	23.8	23.4	17.5	11.8	5.8	-2.4
1992	-6.4	-5.0	-2.5	5.5	11.2	16.3	20.8	22.0	16.1	12.0	3.1	-4.0
1993	-4.5	-3.3	-0.3	6.0	11.0	17.7	22.7	22.5	17.7	12.2	1.9	1.0
1994	0.8	-1.4	3.1	10.1	12.6	15.8	23.5	22.6	19.2	12.4	3.3	-4.8
1995	-1.6	-1.2	1.6	7.0	14.5	17.8	21.8	22.2	17.0	10.2	2.6	-2.3
1996	-1.7	-0.8	2.3	7.1	15.8	18.8	23.9	22.6	16.2	10.1	5.5	2.1
1997	-1.4	-2.8	-1.2	5.3	14.3	18.7	21.7	20.4	16.1	11.1	5.5	-0.1
1998	-4.1	-3.4	1.3	9.0	13.7	20.7	24.4	23.8	17.5	12.9	8.5	2.4
1999	-0.4	-0.2	2.5	8.6	14.6	19.3	23.0	22.7	17.2	12.1	5.2	3.1
2000	-3.4	-2.6	0.0	9.3	13.9	19.6	25.5	22.5	17.4	10.3	5.3	-1.1
2001	-2.4	-0.8	6.2	9.7	12.1	19.6	24.2	22.8	18.1	11.4	2.7	-0.2
2002	-4.4	-0.1	3.7	7.0	13.3	19.6	23.2	22.6	18.7	12.9	5.9	-4.3
2003	-1.0	-2.5	-0.8	6.7	14.6	18.1	22.3	23.1	17.3	12.5	4.4	-0.5
2004	-1.7	-2.0	4.5	7.5	12.1	18.6	22.1	21.5	18.1	11.4	2.9	-4.2
2005	-3.4	-4.1	1.5	8.8	12.3	17.4	23.5	22.5	16.6	10.4	3.8	1.7
2006	-4.8	-1.3	2.1	8.7	13.7	20.6	22.4	24.1	17.3	11.0	2.9	-2.1
Avg.	**-3.0**	**-2.2**	**1.5**	**7.8**	**13.1**	**18.5**	**22.9**	**22.3**	**17.6**	**11.2**	**4.5**	**-0.7**

Table A.12 Monthly Mean Temperature Values of Siirt Meteorological Station (DMI, 2009-a)

896 m Unit: ^{0}C

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
1975	2.5	3.2	8.2	16.3	18.7	26.2	30.8	30.1	24.8	16.9	10.3	3.0
1976	2.5	1.5	6.9	11.8	17.2	25.0	28.4	29.2	23.3	16.8	11.5	6.4
1977	-1.5	8.1	9.4	13.7	18.6	25.5	29.7	30.4	25.6	15.8	10.4	4.4
1978	3.7	6.4	10.0	13.0	19.8	24.5	31.2	28.8	25.1	19.6	7.5	5.9
1979	4.8	7.4	9.8	14.3	19.8	25.3	29.6	30.6	27.2	17.0	12.2	4.0
1980	1.4	4.2	7.7	12.6	19.2	26.5	32.1	29.9	24.2	17.2	10.0	6.5
1981	4.0	5.2	9.0	12.4	16.6	24.9	30.4	29.5	25.9	19.4	8.1	6.7
1982	2.3	0.0	6.2	14.5	18.2	24.8	28.1	28.3	24.9	15.9	7.4	3.0
1983	-1.7	1.3	7.7	13.9	19.5	24.7	29.3	28.2	24.8	17.0	11.6	5.3
1984	3.5	5.7	9.2	13.5	17.9	26.8	31.0	27.6	25.8	17.4	9.4	2.9
1985	4.9	0.3	4.5	14.7	21.1	26.7	29.4	31.3	25.4	16.2	13.3	4.4
1986	4.2	6.4	9.5	15.7	16.7	25.0	31.8	30.8	27.5	17.7	8.0	4.2
1987	4.1	6.5	5.0	12.6	21.2	26.6	30.6	29.5	25.4	16.0	10.1	5.0

Table A.12 (continued)

1988	1.9	4.4	7.2	12.9	19.0	24.2	30.3	29.2	24.1	17.1	7.1	4.3
1989	-0.2	3.4	10.5	19.2	21.8	27.0	31.8	30.3	24.5	16.9	9.8	4.2
1990	1.1	4.3	9.7	12.2	19.7	25.9	31.5	29.3	24.9	18.9	12.2	5.7
1991	2.6	3.3	8.9	15.4	18.4	26.8	31.1	31.1	25.1	17.7	10.9	3.8
1992	-1.0	0.1	5.3	12.7	16.8	23.0	27.0	28.9	23.0	18.7	8.5	1.3
1993	1.3	1.1	6.8	12.8	15.8	24.1	30.1	29.3	24.7	18.4	7.0	6.0
1994	5.7	5.2	9.7	16.1	19.2	25.8	30.9	29.7	25.8	18.5	9.2	0.8
1995	4.4	6.0	9.2	13.0	21.1	26.0	29.1	29.8	24.6	17.1	9.2	4.0
1996	4.0	5.7	7.3	12.6	21.8	25.9	31.5	30.3	23.7	16.6	11.3	7.4
1997	3.5	1.9	4.8	12.1	20.6	26.1	29.3	28.9	23.4	17.9	11.3	5.8
1998	2.5	3.3	8.1	15.8	19.4	27.5	31.3	31.4	25.2	19.6	14.7	8.8
1999	6.6	6.8	9.4	14.6	22.5	27.2	30.8	30.9	24.5	18.7	10.8	7.2
2000	2.4	3.6	7.4	15.7	20.4	27.5	33.5	30.5	25.5	17.7	11.5	5.3
2001	5.3	5.6	11.7	14.8	17.7	26.8	31.5	30.8	26.0	17.8	9.4	5.6
2002	2.1	6.9	10.5	12.0	19.2	26.2	30.3	29.0	25.0	19.5	12.1	0.9
2003	5.0	2.8	6.1	13.7	21.3	25.9	29.9	30.7	24.8	19.5	9.6	5.0
2004	3.9	2.9	10.8	13.3	18.2	26.4	30.0	29.3	25.8	20.6	9.7	2.6
2005	2.7	3.9	8.6	15.3	19.7	25.4	31.8	30.8	24.9	17.6	10.1	7.8
2006	2.0	5.3	9.8	14.7	21.0	28.5	30.1	32.3	25.3	17.5	8.6	3.6
Avg.	**2.8**	**4.1**	**8.3**	**14.0**	**19.3**	**25.9**	**30.4**	**29.9**	**25.0**	**17.8**	**10.1**	**4.7**

Table A.13 Monthly Mean Temperature Values of Diyarbakir Meteorological Station (DMI, 2009-a)

660 m Unit: ^{0}C

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
1960	4.6	5.8	8.1	13.4	21.0	26.1	30.9	29.2	26.0	18.9	11.4	6.5
1961	2.9	4.2	6.8	15.5	21.0	27.5	32.1	31.7	24.0	18.4	9.1	6.1
1962	3.8	5.0	10.7	13.4	20.3	27.8	32.7	31.4	25.7	18.3	12.2	6.6
1963	6.0	7.0	6.6	13.2	16.4	24.8	30.6	31.3	25.0	18.4	9.7	4.9
1964	-3.4	1.7	9.1	13.0	18.9	27.1	32.0	29.3	24.9	17.9	10.3	3.5
1965	1.7	3.3	9.1	12.2	19.9	27.1	31.5	31.3	25.8	13.3	7.8	5.0
1966	6.6	8.0	9.1	14.4	18.7	26.7	31.5	31.2	24.0	17.0	12.2	5.9
1967	1.6	-1.6	6.2	12.4	18.1	24.3	30.0	30.4	24.2	16.1	8.5	4.7
1968	-0.6	-0.6	7.9	16.0	19.5	24.3	30.8	28.0	24.7	18.2	10.6	5.6
1969	2.6	1.9	10.5	12.1	20.1	26.5	29.9	31.1	25.1	17.3	9.1	5.2
1970	4.6	6.9	11.5	16.8	20.6	29.0	32.0	31.2	26.3	19.8	11.8	2.3
1971	3.4	2.9	9.7	12.7	20.8	26.0	31.6	29.8	26.7	16.1	9.9	2.2
1972	-5.5	-3.0	8.6	14.8	17.2	24.1	30.7	29.3	25.0	18.9	8.6	3.3
1973	-2.9	5.5	9.0	13.5	21.5	25.8	30.8	31.4	26.3	18.9	6.7	3.1
1974	0.7	2.5	10.0	12.8	21.5	28.2	30.9	29.3	23.3	20.6	10.5	4.8
1975	3.0	3.2	9.1	16.1	19.5	27.2	31.8	20.6	24.9	16.7	9.9	2.9
1976	1.2	0.9	6.9	13.0	18.2	25.9	29.2	29.6	24.1	17.2	10.9	6.3
1977	0.0	8.4	9.9	14.2	19.4	26.6	31.3	31.4	26.4	13.9	9.6	4.4
1978	3.9	7.0	10.3	13.7	21.0	25.1	31.9	29.4	24.2	18.5	6.7	6.0
1979	4.6	7.2	10.5	14.9	19.9	26.0	30.0	30.9	26.7	17.0	11.0	3.3
1980	0.2	3.5	7.9	12.9	19.0	26.7	32.9	30.3	23.4	16.9	9.8	5.6
1981	3.2	5.6	10.0	13.0	16.8	25.6	31.4	30.2	25.2	18.5	7.2	6.6
1982	2.4	1.2	6.6	14.6	18.0	24.9	28.7	28.8	25.0	16.6	7.5	0.4
1983	-3.7	0.8	7.6	13.8	20.1	25.0	29.9	28.7	24.8	16.3	11.4	4.6
1984	3.2	5.7	9.3	12.6	18.9	27.2	31.3	28.0	25.2	16.3	9.0	2.2
1985	4.3	-0.4	4.0	15.4	21.2	27.3	30.2	30.9	24.9	15.4	11.6	3.1
1986	3.3	6.2	0.7	15.8	16.5	25.6	32.1	30.4	26.3	17.3	7.6	3.6
1987	2.9	5.7	4.6	12.8	20.6	26.7	31.2	29.0	24.6	15.4	8.0	4.6
1988	1.5	4.4	7.6	12.7	18.4	24.4	30.6	29.6	23.4	15.7	6.0	3.7
1989	-1.8	2.3	9.9	17.9	21.2	27.0	32.0	30.4	23.8	15.9	8.5	3.1
1990	-0.8	3.4	8.9	12.4	19.2	25.7	31.4	29.3	24.2	17.2	9.7	4.4
1991	0.7	1.9	8.9	14.5	18.1	26.6	31.3	30.9	24.4	17.2	9.6	3.0

Table A.13 (continued)

1992	-1.7	-2.4	4.4	12.6	17.0	23.4	28.3	29.4	23.4	18.1	7.0	-0.7
1993	0.1	-0.3	7.4	12.8	16.2	24.4	31.0	30.0	24.8	17.4	6.4	5.0
1994	4.7	4.2	9.3	15.6	19.4	26.6	31.8	30.0	25.5	17.9	8.7	1.4
1995	3.8	5.8	9.5	12.8	19.5	26.0	30.2	30.1	23.7	15.2	7.1	2.3
1996	3.5	4.8	8.0	12.2	20.7	26.3	32.1	30.2	23.6	15.4	9.4	7.3
Avg.	**1.7**	**3.5**	**8.2**	**13.9**	**19.3**	**26.1**	**31.0**	**29.8**	**24.9**	**17.1**	**9.2**	**4.1**

A.3. Evaporation

Table A.14 Monthly Total Evaporation Values of Bitlis Meteorological Station (DMI, 2009-a)

1550 m Unit: mm

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1986	-	-	-	-	-	-	-	-	202.8	67.4	3.7	-
1987	-	-	-	-	165.1	191.0	249.5	222.7	166.4	81.5	-	-
1988	-	-	-	-	119.2	141.5	206.2	185.7	142.1	70.0	-	-
1989	-	-	-	39.2	135.0	181.5	269.5	253.3	191.1	72.3	16.3	-
1990	-	-	-	-	121.3	160.7	223.4	217.3	173.1	85.0	-	-
1991	-	-	-	-	95.3	175.6	229.5	235.9	178.9	63.3	22.1	-
1992	-	-	-	-	79.0	111.7	207.8	226.1	159.5	107.9	-	-
1993	-	-	-	-	65.9	140.9	214.0	213.9	176.5	117.7	-	-
1994	-	-	-	98.7	104.2	168.1	225.9	216.2	173.5	80.9	-	-
1995	-	-	-	-	113.7	116.7	170.2	179.1	121.7	64.4	-	-
1996	-	-	-	-	115.6	151.2	192.6	189.2	119.4	65.7	-	-
1997	-	-	-	-	114.7	141.4	172.9	174.7	150.8	82.3	-	-
1998	-	-	-	-	77.0	138.4	187.5	180.2	128.4	96.7	-	-
1999	-	-	-	-	109.0	148.3	177.3	170.0	136.3	76.1	-	-
2000	-	-	-	-	102.5	151.2	208.3	181.0	137.6	69.8	-	-
2001	-	-	-	-	83.2	151.8	181.9	170.5	141.1	79.3	-	-
2002	-	-	-	-	74.2	138.4	159.0	150.8	114.6	65.2	-	-
2003	-	-	-	-	113.2	109.3	172.9	164.1	119.6	55.8	-	-
2004	-	-	-	-	76.5	139.1	160.5	166.8	148.8	73.8	12.9	-
2005	-	-	-	-	102.4	133.0	194.5	187.0	135.5	63.1	-	-
2006	-	-	-	-	104.6	180.1	179.8	192.1	149.2	45.3	-	-
Avg.	**0.0**	**0.0**	**0.0**	**69.0**	**103.6**	**148.5**	**199.2**	**193.8**	**150.8**	**75.4**	**13.8**	**0.0**

Table A.15 Monthly Total Evaporation Values of Siirt Meteorological Station (DMI, 2009-a)

896 m Unit: mm

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
1975	-	-	-	155.0	180.6	318.1	397.4	381.2	278.7	161.3	66.8	-
1976	-	-	-	78.9	153.3	277.8	345.9	348.6	250.8	104.8	67.6	7.8
1977	-	-	-	114.2	176.3	275.8	421.9	380.9	286.6	181.2	76.3	11.8
1978	-	-	-	123.3	212.1	283.8	410.7	346.8	284.9	154.7	49.6	-
1979	-	-	-	133.4	199.5	296.0	465.8	436.4	300.0	92.9	69.8	-
1980	-	-	-	94.7	209.1	341.3	420.9	342.2	242.7	144.2	27.2	-
1981	-	-	-	77.4	154.4	233.2	337.8	307.1	229.0	136.8	42.6	18.7
1982	-	-	-	64.7	149.3	224.0	316.7	313.3	231.2	93.3	43.3	-
1983	-	-	-	123.6	163.1	229.2	313.2	308.7	243.1	126.7	41.6	9.7
1984	-	-	-	118.6	163.7	266.7	363.9	304.1	229.6	122.4	27.8	2.5
1985	-	-	-	119.0	191.9	306.8	364.2	361.4	269.6	112.4	53.2	1.1
1986	-	-	-	82.9	135.3	244.9	369.9	344.0	292.7	88.9	36.6	-
1987	-	-	-	63.8	213.6	314.6	373.4	359.7	252.5	118.9	47.5	8.9
1988	-	-	-	27.4	177.6	260.6	366.3	362.1	246.9	117.6	17.4	-

Table A.15 (continued)

1989	-	-	-	160.7	267.6	370.3	443.7	329.9	259.8	112.6	29.9	-
1990	-	-	-	43.6	247.6	376.0	455.7	409.0	279.4	155.2	49.6	18.3
1991	-	-	-	91.4	168.0	272.5	339.3	332.3	251.7	123.4	39.6	0.9
1992	-	-	-	59.5	140.8	191.2	279.0	291.0	199.9	159.5	46.2	-
1993	-	-	-	54.8	86.6	203.0	307.7	279.6	213.4	147.9	31.0	-
1994	-	-	-	53.6	158.2	265.6	321.1	314.0	228.4	117.4	40.5	-
1995	-	-	-	66.4	198.0	216.5	313.5	319.2	212.9	120.8	44.8	-
1996	-	-	-	43.5	215.8	267.8	314.5	318.6	226.1	132.6	60.0	31.3
1997	-	-	-	63.4	200.6	250.8	330.9	334.4	229.1	118.9	60.8	17.7
1998	-	-	-	58.7	151.4	248.1	341.7	322.7	243.4	170.1	87.4	18.6
1999	-	-	-	76.8	241.8	291.8	350.3	365.5	283.5	185.3	83.5	12.0
2000	-	-	-	65.1	198.8	374.3	487.2	448.3	277.2	165.3	81.3	6.2
2001	-	-	-	83.5	152.0	307.6	409.3	466.2	268.4	146.9	38.1	-
2002	-	-	-	81.7	187.2	313.9	371.5	366.3	246.2	109.9	63.9	12.8
2003	-	-	-	60.1	237.5	265.9	343.6	367.9	270.1	134.9	52.5	14.0
2004	-	-	-	59.6	160.6	285.2	381.8	369.2	310.8	228.6	53.2	-
2005	-	-	-	142.8	260.0	281.7	401.6	403.4	295.5	185.2	130.2	41.8
2006	-	-	-	30.9	186.3	389.4	437.1	465.6	347.1	189.2	77.9	9.6
Avg.	**0.0**	**0.0.**	**0.0**	**83.5**	**185.6**	**282.6**	**371.8**	**356.2**	**258.8**	**139.4**	**54.3**	**13.5**

Table A.16 Monthly Total Evaporation Values of Diyarbakir Meteorological Station (DMI, 2009-a)

660 m Unit: mm

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**
1962	-	-	-	105.8	223.7	419.0	477.8	548.1	399.6	274.5	117.2	39.9
1963	29.8	35.8	80.5	107.1	112.3	293.6	449.1	470.6	162.4	175.3	57.6	15.5
1964	-	-	59.6	162.4	216.6	401.0	541.0	534.0	375.9	260.0	83.9	-
1965	-	-	105.1	103.9	278.1	385.2	466.0	455.8	306.9	131.6	57.1	-
1966	-	-	84.8	116.7	203.6	399.5	430.6	437.1	253.0	123.0	60.6	-
1967	-	-	-	122.1	149.1	341.6	402.6	380.6	267.9	123.1	40.8	-
1968	-	-	-	133.8	177.6	303.3	405.1	361.7	271.0	149.6	45.2	11.4
1969	-	-	-	111.5	218.2	331.3	420.3	480.7	338.4	195.4	77.2	34.7
1970	-	-	-	189.4	236.5	249.2	238.6	214.2	162.0	159.3	63.4	-
1971	-	-	-	117.9	212.0	287.6	324.3	297.0	243.7	131.9	52.6	-
1972	-	-	-	117.1	133.3	219.9	307.2	278.5	209.3	124.1	43.5	-
1973	-	-	-	111.0	223.0	279.5	344.8	340.8	244.6	112.9	-	-
1974	-	-	-	109.7	189.4	287.3	381.9	303.3	203.8	139.3	-	-
1975	-	-	-	-	194.6	197.1	294.5	323.8	226.7	134.8	53.7	-
1976	-	-	-	69.6	136.3	180.2	473.3	353.4	229.0	114.7	58.4	-
1977	-	-	-	106.9	170.6	288.7	371.0	334.0	213.4	137.8	41.8	-
1978	-	-	-	75.4	222.0	371.4	442.5	398.3	228.0	145.4	-	-
1979	-	-	-	84.5	158.6	260.4	376.6	322.6	244.3	102.7	-	-
1980	-	-	-	82.5	139.3	289.7	360.0	300.0	202.0	-	39.3	-
1981	-	-	-	117.8	159.0	259.3	373.9	330.7	223.4	127.5	-	-
1982	-	-	-	108.3	149.0	266.2	333.1	325.1	216.0	86.1	43.9	-
1983	-	-	-	96.6	167.8	262.2	371.5	354.4	253.6	124.6	44.0	-
1984	-	-	-	72.1	156.3	346.3	356.7	312.7	214.3	123.4	14.0	-
1985	-	-	-	109.4	160.0	290.2	378.9	329.8	233.9	117.9	34.7	-
1986	-	-	-	103.8	120.2	256.6	357.6	288.4	233.2	99.0	-	-
1987	-	-	-	116.2	242.7	394.8	446.1	414.5	325.4	146.4	37.2	-
1988	-	-	-	84.4	143.1	279.8	-	378.4	270.2	120.8	-	-
1989	-	-	-	142.0	259.7	349.4	474.1	380.6	282.6	109.0	-	-
1990	-	-	-	73.1	170.6	332.9	390.7	381.5	271.0	156.0	-	-
1991	-	-	-	103.3	185.5	293.5	407.5	372.1	257.8	114.7	-	-
1992	-	-	-	125.9	132.1	209.4	326.3	333.2	227.7	160.7	-	-
1993	-	-	-	-	83.1	230.3	401.8	359.2	246.7	142.2	-	-
1994	-	-	-	95.4	156.7	347.0	394.2	392.6	238.7	125.8	-	-

Table A.16 (continued)												
1995	-	-	-	83.5	139.8	279.3	383.5	396.6	254.7	138.7	-	-
1996	-	-	-	70.2	188.9	363.8	414.0	391.2	244.7	123.8	-	-
Avg.	**29.8**	**35.8**	**82.5**	**106.9**	**177.4**	**301.3**	**391.7**	**367.9**	**250.7**	**139.8**	**53.3**	**25.4**

A.4. Correlation Studies

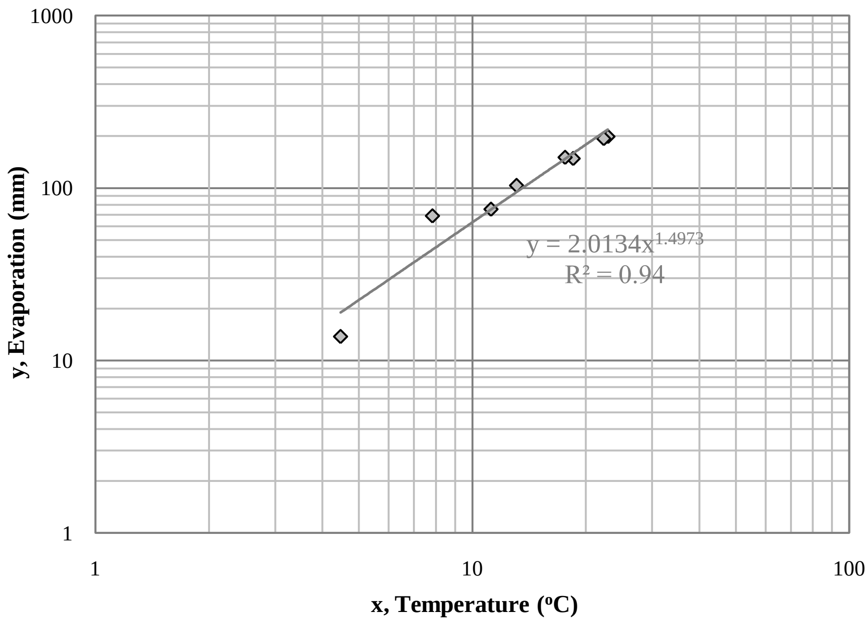


Figure A.1 Correlation between Monthly Mean Temperature and Monthly Total Evaporation Values Measured in Bitlis Meteorological Station

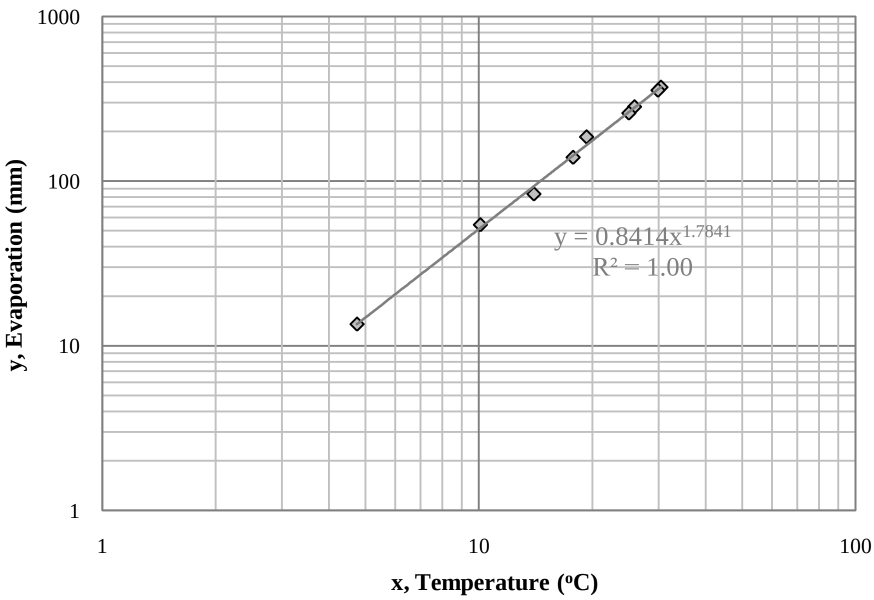


Figure A.2 Correlation between Monthly Mean Temperature and Monthly Total Evaporation Values Measured in Siirt Meteorological Station

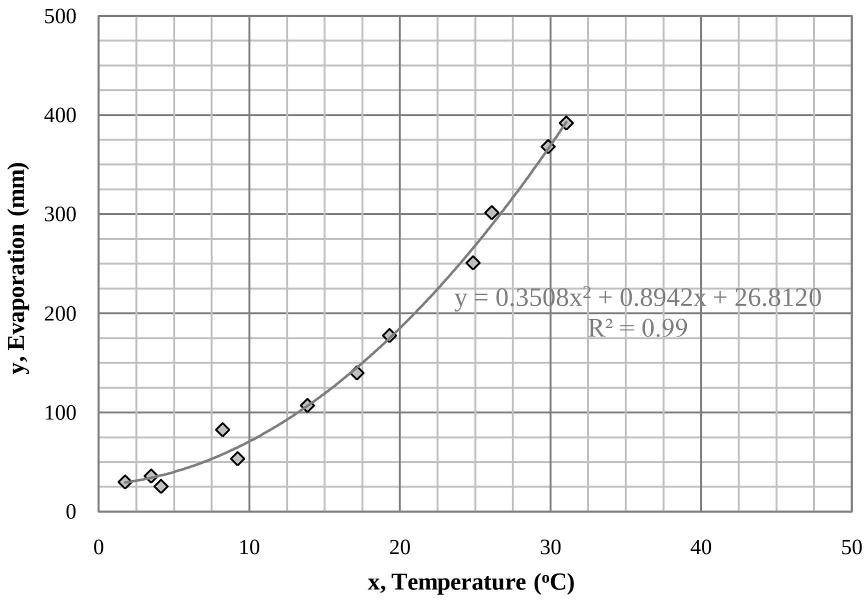


Figure A.3 Correlation between Monthly Mean Temperature and Monthly Total Evaporation Values Measured in Diyarbakir Meteorological Station

APPENDIX B

STREAM GAUGING STATIONS

Table B.1 Monthly Mean Flow Values of 26-57 Keyburan Brook - Bogazonu SGS (DSI, 2007-a)

425.0 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1983	5.3	6.7	7.1	7.3	6.8	24.8	105.0	73.8	13.6	2.9	1.5	1.7	256.4
1984	3.4	41.4	15.6	5.5	10.3	44.6	54.6	41.5	13.3	6.6	5.1	5.2	247.1
1985	7.0	11.3	8.4	14.3	19.2	49.8	101.0	32.1	6.1	2.3	1.8	1.9	255.2
1986	2.8	4.1	8.4	13.2	11.7	37.7	48.8	37.5	11.2	2.9	1.9	2.2	182.5
1987	4.7	10.9	7.4	10.3	28.4	30.4	160.0	106.0	24.2	10.6	8.4	8.0	409.3
Avg.	**4.6**	**14.9**	**9.4**	**10.1**	**15.3**	**37.5**	**93.9**	**58.2**	**13.7**	**5.0**	**3.7**	**3.8**	**22.5**

Table B.2 Monthly Mean Flow Values of 26-58 Garzan Creek - Meydanonu SGS (DSI, 2007-a)

783.2 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1982	-	14.1	28.1	21.7	15.3	43.8	224.0	116.0	31.2	11.4	6.3	5.6	517.5
1983	8.6	8.9	8.4	9.0	9.8	38.6	108.0	101.0	30.7	8.0	5.3	4.8	341.0
1984	7.3	142.0	47.6	25.7	38.2	120.0	121.0	78.0	25.0	11.8	8.1	7.0	631.6
Avg.	**7.9**	**55.0**	**28.0**	**18.8**	**21.1**	**67.5**	**151.0**	**98.3**	**29.0**	**10.4**	**6.5**	**5.8**	**41.6**

Table B.3 Monthly Mean Flow Values of 26-24 Pisyar Creek - Kozluk SGS (DSI, 2007-a)

1359.3 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1971	11.2	26.1	37.5	23.6	31.9	143.0	243.0	126.0	29.7	10.9	6.8	6.0	695.7
1972	14.2	21.2	48.6	24.0	27.6	114.0	277.0	293.0	69.6	19.1	10.3	8.9	927.5
1973	14.2	35.0	18.6	15.1	74.0	111.0	171.0	96.3	25.6	10.0	6.1	5.8	582.7
1974	8.5	23.4	29.4	19.2	19.4	185.0	270.0	117.0	25.8	10.2	6.4	7.8	722.1
1975	7.8	13.5	28.4	23.7	46.1	129.0	273.0	159.0	39.3	13.1	7.4	7.0	747.3
1976	9.0	27.3	27.8	62.4	74.1	113.0	417.0	335.0	97.6	23.0	6.4	4.4	1197.0
1977	42.6	39.4	82.5	28.2	48.3	162.0	258.0	152.0	33.5	7.9	4.1	3.2	861.6
1978	5.4	6.3	40.0	57.4	141.0	192.0	321.0	165.0	47.3	11.7	3.6	3.3	994.0
1979	5.2	7.4	64.9	93.8	109.0	123.0	172.0	91.7	25.9	7.9	5.0	4.0	709.9
1980	28.3	51.1	48.8	38.9	43.9	182.0	252.0	115.0	37.7	12.1	7.2	6.0	823.0
1981	7.6	17.5	23.8	45.4	56.8	209.0	193.0	146.0	53.3	21.0	12.9	11.7	798.0
1982	14.6	30.9	63.8	60.7	48.8	105.0	369.0	213.0	51.9	19.5	10.7	8.9	996.8
1983	14.3	13.7	13.9	16.9	20.7	94.3	191.0	172.0	41.0	14.6	9.0	7.8	609.2
1984	11.6	213.0	60.9	24.3	43.1	148.0	158.0	81.7	22.5	7.5	3.7	3.4	777.6
Avg.	**13.9**	**37.6**	**42.1**	**38.1**	**56.1**	**143.6**	**254.6**	**161.6**	**42.9**	**13.5**	**7.1**	**6.3**	**68.1**

Table B.4 Monthly Mean Flow Values of 2634 Garzan Creek - Kozluk SGS (EIE, 2003)

1407.7 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
2000	8.7	9.1	20.5	36.7	49.1	104.5	316.2	127.5	29.8	10.4	6.9	5.9	725.3
Avg.	**8.7**	**9.1**	**20.5**	**36.7**	**49.1**	**104.5**	**316.2**	**127.5**	**29.8**	**10.4**	**6.9**	**5.9**	**60.4**

Table B.5 Monthly Mean Flow Values of 2603 Garzan Creek - Besiri SGS (EIE, 2003)

2450.4 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1946	-	6.6	23.3	110.6	115.4	286.6	476.9	447.3	100.6	12.9	6.4	5.6	1592.1
1947	64.3	10.4	8.8	129.1	110.8	332.1	218.5	108.2	19.8	7.5	6.6	6.1	1022.2
1948	6.9	66.4	77.4	64.8	208.5	236.8	697.2	492.8	124.7	8.1	5.3	4.3	1993.1
1949	7.2	17.8	24.1	16.7	10.4	117.8	497.7	417.8	65.1	7.3	5.8	5.4	1193.0
1950	6.1	6.2	34.8	22.8	51.5	215.6	445.8	463.4	72.1	15.5	8.7	8.3	1350.7
1951	24.9	21.4	68.3	148.1	90.7	270.5	417.3	236.2	54.7	12.8	8.8	8.4	1362.3
1952	51.2	46.4	54.4	62.4	358.3	356.2	598.8	366.9	93.3	19.2	10.7	10.0	2027.8
1953	10.7	11.9	35.4	42.3	181.0	273.2	705.0	463.4	134.3	32.9	15.3	10.5	1915.9
1954	14.8	54.7	43.1	122.9	140.1	364.3	811.3	527.6	151.6	33.2	11.5	8.9	2284.1
1955	10.5	15.7	55.7	52.5	80.1	178.9	244.2	239.7	39.9	11.9	9.0	8.6	946.7
1956	10.0	51.8	206.0	135.8	185.7	275.9	505.4	385.7	122.9	38.0	13.7	10.8	1941.7
1957	12.5	19.1	65.6	37.0	102.8	511.6	355.1	632.1	140.2	32.7	13.8	11.3	1933.8
1958	13.6	21.9	29.5	97.2	111.8	391.0	448.4	217.5	74.6	19.2	10.9	10.6	1446.3
1959	11.4	16.8	42.6	95.4	55.2	134.5	438.0	458.0	86.8	19.4	12.6	10.3	1380.9
1960	14.7	17.7	17.7	64.0	197.4	222.6	404.4	203.0	19.7	11.3	10.4	10.2	1193.1
1961	-	-	-	-	-	-	-	-	-	-	-	-	-
1962	8.1	54.2	110.9	60.0	138.4	281.2	352.5	196.3	45.1	10.0	6.4	6.2	1269.3
1963	8.9	9.8	118.7	305.3	263.7	240.3	961.6	696.4	233.5	53.6	22.4	16.0	2930.2
1964	67.8	129.1	75.0	42.3	127.0	546.4	443.2	294.6	70.2	24.2	11.7	10.0	1841.5
1965	11.7	43.8	36.2	37.2	112.3	275.9	461.4	300.0	100.1	23.8	9.0	8.1	1419.4
1966	87.6	82.2	155.6	321.4	162.6	202.0	383.6	219.4	60.1	19.8	10.5	11.1	1715.8
1967	17.8	16.5	72.9	138.5	78.1	194.2	601.3	597.3	137.1	33.7	13.0	13.7	1914.2
1968	22.2	148.3	342.8	249.4	153.3	514.3	800.9	415.2	125.5	34.8	15.8	13.6	2835.9
1969	14.9	52.6	281.2	205.7	172.2	704.4	692.1	546.4	109.4	29.5	17.0	16.6	2842.0
1970	25.1	24.7	71.2	52.5	254.0	253.9	239.0	92.7	24.5	10.4	6.9	6.9	1061.8
1971	12.1	30.8	43.7	26.5	36.3	172.2	318.8	155.3	31.9	11.2	7.2	6.6	852.6
1972	30.3	25.7	56.0	31.3	48.6	143.3	388.8	458.0	84.8	22.5	11.8	10.2	1311.2
1973	15.6	50.0	22.2	19.0	106.2	145.7	237.2	128.0	29.3	11.5	5.2	5.8	775.8
1974	9.9	26.2	33.2	24.7	29.0	275.9	391.4	152.4	29.5	10.4	5.3	7.1	995.1
1975	7.6	23.9	37.2	30.3	81.8	176.5	414.7	233.0	52.6	19.4	8.1	7.5	1092.6
1976	12.7	32.9	48.2	128.0	158.4	169.5	741.3	439.3	178.1	41.0	15.5	10.7	1975.6
1977	98.0	80.1	127.8	65.4	94.6	278.6	445.8	270.5	64.8	18.7	10.4	9.8	1564.5
1978	16.3	18.6	69.9	112.2	283.0	377.7	448.4	289.3	93.6	26.4	12.6	10.8	1758.7
1979	14.9	15.8	106.6	133.1	134.5	185.3	269.6	146.5	37.8	12.2	6.9	5.9	1069.4
1980	43.7	93.6	91.9	80.4	85.4	364.3	500.3	232.2	48.7	16.4	9.2	8.4	1574.3
1981	11.8	19.5	37.2	63.5	103.1	321.4	282.5	221.2	70.5	17.2	8.9	7.9	1164.8
1982	12.1	33.4	72.3	89.7	90.5	166.3	570.2	383.0	79.6	23.9	11.1	9.3	1541.5
1983	18.6	20.1	17.5	24.5	33.9	147.3	287.7	257.7	49.5	14.4	7.5	7.7	886.5
1984	13.3	241.8	117.6	51.7	109.2	326.8	300.7	163.4	41.7	13.5	7.8	7.7	1395.2
1985	14.9	30.8	21.6	58.7	122.2	209.5	554.7	200.9	43.8	14.3	7.9	8.5	1287.8
1986	13.6	16.6	35.4	79.3	88.5	197.7	290.3	165.5	46.4	11.2	7.0	6.8	958.3
1987	10.8	96.7	53.0	133.4	231.8	267.0	715.4	508.9	185.8	41.2	15.9	10.8	2270.7
1988	44.5	144.1	399.1	138.2	186.9	514.3	917.6	546.4	145.9	35.9	9.7	12.3	3094.8
1989	23.4	39.7	71.5	40.7	25.9	151.6	87.1	29.2	9.6	3.1	2.5	5.1	489.3
1990	17.9	277.3	247.5	97.8	168.9	216.7	349.9	195.3	48.5	12.1	7.4	8.2	1647.3
1991	11.4	31.9	27.9	28.1	65.6	332.1	326.6	135.3	28.0	8.6	4.1	6.2	1005.6
1992	20.8	76.7	89.7	56.2	119.8	170.6	593.6	452.6	143.9	35.4	11.6	9.7	1780.5

Table B.5 (continued)													
1993	12.9	44.8	79.8	65.9	91.7	230.3	705.0	675.0	145.2	35.9	14.8	12.5	2113.9
1994	18.9	77.8	56.0	149.5	141.8	278.6	339.6	176.2	35.0	13.0	6.5	7.8	1300.6
1995	15.5	188.2	155.9	159.9	194.7	471.4	769.8	353.5	112.8	25.6	9.8	13.4	2470.5
1996	45.3	75.2	30.0	64.3	132.0	281.2	487.3	234.4	43.0	13.4	4.6	11.8	1422.5
1997	23.5	20.1	111.7	97.8	72.6	127.2	502.8	259.0	53.7	14.9	5.3	7.5	1296.0
1998	25.6	62.2	62.7	46.6	122.7	310.7	422.5	151.3	57.8	8.2	3.0	6.8	1280.1
1999	10.4	12.2	31.3	21.2	78.9	119.5	321.4	77.7	17.5	3.5	0.0	0.5	694.1
2000	10.6	10.8	25.8	46.1	62.4	149.2	370.7	132.6	18.3	1.0	0.0	0.1	827.5
Avg.	**21.9**	**53.0**	**82.1**	**88.5**	**125.2**	**271.5**	**473.2**	**311.9**	**78.4**	**19.6**	**9.3**	**8.8**	**128.6**

Table B.6 Monthly Mean Flow Values of 25-14 Kotum Brook - Kucuksu SGS (DSI, 2007-a)

78.9 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1965	1.4	1.7	1.6	1.5	1.5	2.4	4.1	11.0	12.8	4.8	2.4	2.0	47.2
1966	4.3	2.1	2.0	2.4	2.0	4.4	11.0	17.8	16.0	7.3	3.1	2.6	75.1
1967	3.6	2.3	2.5	2.5	2.0	2.5	9.2	21.2	18.3	10.1	6.2	2.2	82.6
1968	2.4	3.6	2.8	3.0	3.5	5.8	23.1	27.5	20.0	9.9	4.5	2.6	108.6
1969	2.1	2.2	2.6	2.0	1.8	5.3	12.3	27.9	17.5	7.8	3.3	2.0	86.7
1970	1.8	1.5	1.4	1.4	1.5	2.8	6.2	7.6	5.1	2.1	1.3	1.3	33.9
1971	1.3	1.4	1.4	1.2	1.0	1.9	3.0	9.9	9.2	3.8	2.2	2.1	38.4
1972	1.8	1.4	1.4	1.4	1.3	1.9	11.9	18.6	16.5	6.2	2.6	1.8	66.8
Avg.	**2.3**	**2.0**	**2.0**	**1.9**	**1.8**	**3.4**	**10.1**	**17.7**	**14.4**	**6.5**	**3.2**	**2.1**	**5.6**

Table B.7 Monthly Mean Flow Values of 26-28 Guzeldere - Kuscukoyu SGS (DSI, 2007-a)

125.8 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1977	5.3	4.6	4.5	3.3	3.8	11.7	18.7	18.9	10.6	5.5	4.9	3.5	95.3
1978	4.1	4.3	5.5	5.7	7.2	14.4	25.3	25.5	13.4	8.2	5.0	4.5	123.0
1979	4.7	3.4	4.8	5.7	7.9	13.8	24.3	19.0	10.2	6.4	3.8	4.1	107.9
1980	3.9	4.8	3.6	3.0	3.2	10.3	22.6	16.0	7.9	5.2	3.4	2.7	86.7
1981	2.8	3.6	3.4	3.5	3.5	11.0	15.7	17.9	10.9	7.1	5.6	4.2	89.1
1982	4.5	6.5	5.7	5.1	4.5	7.7	26.0	23.5	11.8	8.3	6.0	4.6	114.2
1983	5.0	4.7	4.1	3.2	4.3	7.0	15.6	19.0	9.3	6.2	3.3	3.0	84.6
1984	4.1	9.9	6.1	3.6	3.8	9.6	12.3	13.2	8.0	5.9	4.3	3.8	84.5
1985	3.5	6.7	3.0	3.6	3.1	7.9	28.6	19.4	9.9	6.4	4.8	3.8	100.5
1986	4.9	5.4	5.2	4.7	6.0	9.5	13.9	13.6	9.1	4.2	3.6	3.7	83.9
1987	5.4	7.5	5.2	5.2	7.6	9.5	32.5	41.8	23.3	14.1	10.5	9.6	172.1
1988	10.8	11.2	13.3	10.0	10.1	18.6	41.8	48.0	22.5	15.3	13.7	14.2	229.5
1989	11.2	10.8	10.4	8.9	8.8	14.9	14.2	8.2	3.7	1.8	0.4	1.6	95.0
1990	1.5	6.0	22.5	4.0	5.9	12.9	22.1	20.0	9.2	6.2	5.4	5.2	120.9
1991	6.7	6.0	4.8	4.1	2.8	6.8	18.7	17.1	7.9	5.7	4.4	3.8	88.6
1992	6.4	7.7	6.7	6.3	5.6	8.3	38.2	48.3	25.4	10.9	8.0	6.7	178.5
1993	10.5	10.1	11.2	10.5	10.2	15.9	53.8	85.4	29.4	13.0	5.4	4.1	259.6
Avg.	**5.6**	**6.7**	**7.1**	**5.3**	**5.8**	**11.2**	**25.0**	**26.8**	**13.1**	**7.7**	**5.4**	**4.9**	**10.4**

Table B.8 Monthly Mean Flow Values of 2624 Kezer Creek - Pinarca SGS (EIE, 2003)

1169.6 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1972	11.0	14.6	41.2	21.7	35.6	85.4	195.4	207.6	61.2	23.9	14.3	11.5	723.6
1973	13.4	20.1	13.9	13.8	38.2	52.5	78.0	58.9	23.6	11.0	7.0	6.4	336.9

Table B.8 (continued)

1974	8.3	14.0	16.3	12.7	11.4	56.2	123.1	57.3	22.0	11.5	6.2	8.1	347.1
1975	7.7	10.0	13.5	16.4	44.3	67.5	128.8	94.3	29.0	12.5	6.8	6.7	437.5
1976	9.1	15.4	18.7	35.1	69.4	83.8	308.4	185.3	77.5	26.6	13.3	10.1	853.0
1977	30.5	24.3	32.9	24.2	36.5	83.8	114.8	84.4	33.2	15.4	10.9	8.3	499.4
1978	11.8	11.0	30.8	57.6	105.2	152.7	164.3	106.3	46.9	19.3	13.2	11.3	730.4
1979	13.6	10.3	55.2	82.2	74.5	96.4	117.9	75.8	33.4	15.6	9.9	9.2	594.2
1980	30.0	54.2	38.0	37.8	46.4	133.7	208.9	99.4	35.8	16.7	10.8	9.5	721.0
1981	10.9	12.5	12.0	20.2	43.5	134.7	113.8	106.3	41.0	20.2	11.0	8.9	535.1
1982	10.1	24.3	28.4	39.4	44.0	81.2	194.4	130.2	46.7	18.6	12.7	8.8	638.7
1983	13.8	13.3	12.1	14.0	16.1	61.6	85.8	93.7	34.0	12.6	7.3	6.4	370.6
1984	8.6	109.1	56.8	28.1	61.4	105.5	92.3	66.7	27.7	13.4	8.7	7.6	586.0
1985	11.2	26.4	15.5	30.5	64.1	130.4	249.1	92.7	29.0	14.4	9.7	8.6	681.8
1986	10.4	12.6	16.8	31.9	39.7	58.7	68.2	69.1	26.7	10.6	6.8	5.9	357.3
1987	11.8	34.5	23.9	66.4	139.1	160.2	334.4	198.2	77.2	29.7	17.5	13.2	1106.1
1988	20.7	50.0	156.7	82.2	96.5	228.5	360.3	228.5	75.9	28.7	17.6	15.7	1361.2
1989	21.5	30.3	37.2	21.5	18.8	51.7	40.7	23.0	9.5	5.0	3.2	5.5	268.0
1990	8.9	61.2	112.5	48.2	68.7	87.0	147.7	99.4	32.7	14.2	9.0	7.7	697.2
1991	9.2	13.2	13.5	13.7	35.1	135.3	129.1	75.3	23.9	11.5	6.7	6.3	472.8
1992	12.7	28.5	55.7	28.4	72.7	114.6	255.6	175.2	68.7	29.7	18.4	11.5	871.7
1993	11.9	22.4	37.2	36.4	60.7	135.5	282.5	342.8	94.1	37.8	18.1	14.2	1093.8
1994	14.7	29.0	25.8	45.3	57.6	100.7	222.1	143.8	34.5	16.2	10.0	8.6	708.4
1995	11.3	49.5	69.1	73.4	65.3	163.7	250.6	180.0	58.1	24.7	13.0	13.6	972.2
1996	14.1	23.6	12.6	18.4	40.8	121.9	220.1	106.9	32.7	13.8	8.8	8.7	622.4
1997	11.5	9.1	56.0	37.0	22.8	61.9	261.8	123.2	43.0	20.5	10.8	9.7	667.2
1998	13.7	20.7	28.7	22.7	44.3	110.1	190.8	101.0	32.4	12.1	7.8	6.5	590.7
1999	6.9	7.3	11.2	11.2	29.8	73.7	111.2	30.8	11.8	6.3	4.1	4.4	308.6
2000	5.8	6.6	7.1	10.2	17.3	45.5	88.6	45.5	13.2	5.9	3.4	3.1	252.4
Avg.	**12.9**	**26.1**	**36.2**	**33.8**	**51.7**	**102.6**	**177.2**	**117.3**	**40.5**	**17.2**	**10.2**	**8.8**	**52.9**

Table B.9 Monthly Mean Flow Values of 2610 Bitlis Creek - Baykan SGS (EIE, 2003)

640.4 km^2 Unit: hm^3

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	Total
1955	11.9	13.5	22.1	21.4	35.3	70.7	98.0	105.3	21.7	11.5	9.1	7.3	427.8
1956	7.4	19.6	110.1	77.7	94.7	75.0	75.2	69.1	19.8	12.3	9.9	12.9	583.6
1957	8.6	8.1	24.3	13.3	30.2	283.9	121.6	203.8	45.6	19.0	11.3	10.1	779.8
1958	11.1	12.1	24.5	60.0	28.3	130.4	114.0	44.7	27.5	11.6	9.6	9.3	483.2
1959	9.7	10.9	23.3	31.6	26.4	99.9	43.8	40.4	28.0	17.2	13.9	14.3	359.4
1960	13.8	11.5	12.5	32.1	42.8	116.0	171.1	106.3	29.0	12.9	11.2	6.7	566.0
1961	6.7	9.8	9.9	-	13.7	34.8	99.0	58.7	17.2	8.5	6.3	5.8	270.4
1962	6.4	26.4	60.0	29.5	46.9	109.5	117.2	78.5	25.0	10.7	7.4	6.5	524.0
1963	7.2	7.8	53.3	86.0	106.9	52.8	295.5	214.5	86.6	25.2	15.1	12.0	962.8
1964	20.2	23.6	22.3	14.3	33.6	148.9	133.2	102.6	33.4	13.2	9.1	7.8	562.1
1965	7.2	15.4	12.5	15.7	35.3	80.6	148.3	127.8	42.2	15.1	9.3	8.2	517.6
1966	30.0	33.7	59.7	113.3	100.9	76.9	168.5	101.8	33.2	15.1	10.8	10.3	754.1
1967	12.9	10.8	34.0	53.0	33.9	67.2	188.2	238.4	70.0	22.2	11.8	10.5	752.9
1968	13.9	48.5	104.5	75.5	61.4	161.2	300.7	205.2	67.4	21.3	13.7	10.4	1083.6
1969	9.0	22.6	146.0	73.4	57.3	211.9	285.1	273.2	69.5	19.2	12.7	11.0	1190.9
1970	13.7	13.2	26.7	24.4	106.0	89.5	100.3	46.3	15.5	9.7	7.6	7.2	460.0
1971	8.8	15.3	18.7	13.0	17.1	62.9	110.4	69.4	20.6	10.2	8.0	6.8	361.3
1972	8.6	12.7	32.4	17.4	23.1	61.6	175.2	175.4	44.6	19.0	11.6	9.4	591.0
1973	11.5	24.4	13.6	13.1	39.4	53.6	90.5	63.2	18.2	11.1	7.7	6.9	353.2
1974	9.5	16.0	19.0	14.5	13.4	83.6	134.5	63.7	18.8	9.6	6.4	6.9	395.8
1975	6.6	9.4	15.6	16.0	37.7	53.0	132.7	83.3	26.2	12.5	7.9	6.9	407.9
1976	8.1	18.8	23.2	38.8	50.1	64.8	287.7	210.8	75.7	23.7	11.3	8.9	822.0
1977	27.6	28.3	45.5	20.2	32.7	86.8	156.8	108.2	33.2	13.7	9.6	9.5	572.0
1978	10.2	10.1	32.4	46.1	96.8	135.3	189.2	137.9	46.4	15.7	10.2	8.9	739.2

Table B.9 (continued)

1979	10.3	10.0	39.9	61.9	61.2	77.9	131.9	79.5	27.0	12.2	8.7	6.9	527.5
1980	17.5	31.9	26.8	26.0	30.8	131.0	217.5	115.2	35.8	12.6	9.3	7.8	662.1
1981	8.5	11.0	11.6	18.8	33.6	137.9	113.5	88.4	29.8	12.2	7.9	6.7	480.0
1982	8.3	19.1	39.9	33.5	41.1	72.9	219.8	151.1	33.4	14.0	10.1	9.2	652.2
1983	12.9	10.3	9.5	12.5	14.6	61.3	85.0	93.5	26.7	10.3	7.4	6.6	350.6
1984	8.2	104.5	48.7	26.6	46.1	98.8	110.4	60.3	19.8	11.4	9.0	7.2	551.1
1985	11.4	25.7	16.4	36.2	47.2	92.7	193.6	83.0	21.3	11.6	8.8	8.2	556.0
1986	9.3	10.1	13.4	32.4	34.6	56.5	92.0	60.0	23.7	10.7	8.6	7.6	358.9
1987	9.8	32.4	25.7	52.5	92.9	100.2	248.8	221.2	77.0	23.1	13.6	11.7	908.9
1988	19.0	46.4	143.6	56.0	68.7	144.6	326.6	281.2	77.0	24.2	12.7	11.6	1211.5
1989	15.5	25.2	35.6	17.3	13.4	50.6	38.9	15.5	8.3	5.9	5.4	5.4	237.0
1990	9.9	64.8	96.7	38.3	59.8	80.6	108.1	87.6	29.8	19.7	7.2	7.2	609.6
1991	8.7	14.3	16.8	20.0	37.5	130.2	138.9	66.4	19.1	8.3	7.0	7.1	474.4
1992	14.7	41.2	43.9	25.8	46.6	85.2	220.6	176.2	72.1	18.8	11.1	8.5	764.8
1993	9.7	23.1	31.6	30.3	46.0	86.5	220.8	257.7	70.0	19.8	12.6	11.7	819.8
1994	12.5	24.8	25.7	53.6	43.8	94.0	130.6	84.4	21.9	11.8	8.6	7.3	519.0
1995	9.3	48.5	49.6	61.6	48.1	107.9	190.3	146.5	50.3	21.0	12.1	12.6	757.9
1996	12.5	18.1	13.0	26.5	60.6	82.0	172.1	94.5	27.0	14.4	8.4	8.9	538.1
1997	11.2	9.4	46.3	42.9	22.2	46.6	164.6	129.4	39.4	16.2	10.4	8.6	547.2
1998	11.7	19.7	26.8	21.2	36.5	93.7	153.7	87.9	28.3	13.4	8.4	7.6	508.9
1999	7.4	7.3	10.8	9.3	25.6	52.2	124.9	42.9	13.6	8.5	6.3	6.3	315.2
2000	7.1	6.8	9.5	15.9	24.9	46.3	113.8	58.4	16.4	8.3	6.7	5.3	319.4
Avg.	**11.4**	**22.3**	**37.6**	**36.0**	**45.6**	**94.4**	**157.7**	**117.6**	**36.6**	**14.5**	**9.6**	**8.6**	**49.3**

Table B.10 Monthly Mean Flow Values of 2609 Catak Brook - Catak SGS (EIE, 2003)

2339.5 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1961	23.7	22.8	21.5	19.2	16.5	26.0	95.4	197.9	101.3	40.2	67.8	23.7	655.9
1962	21.6	20.0	20.0	18.1	15.0	19.2	55.2	120.5	110.9	56.0	27.3	20.7	504.5
1963	21.6	20.1	21.2	23.4	26.1	38.3	168.5	258.2	282.5	161.8	90.5	59.9	1172.2
1964	54.1	46.9	37.2	28.9	26.6	66.4	119.5	180.8	161.5	82.8	47.9	33.2	885.8
1965	28.1	25.2	25.0	21.3	19.5	32.9	67.1	158.0	152.2	71.5	40.7	31.1	672.7
1966	40.4	34.2	29.5	25.7	25.2	46.1	117.2	204.9	165.9	81.4	42.1	33.7	846.1
1967	41.0	34.7	29.5	25.2	21.0	30.8	93.8	300.0	183.3	104.7	53.3	31.9	949.1
1968	38.6	55.7	39.4	33.2	25.8	56.5	237.2	305.3	214.9	126.7	68.0	38.6	1239.9
1969	34.3	28.3	29.2	23.2	21.4	60.3	202.7	364.3	253.5	132.3	69.9	45.6	1264.9
1970	67.2	52.4	42.1	35.4	31.0	53.8	146.2	168.7	99.8	55.4	34.6	26.2	812.7
1971	24.0	22.2	20.3	17.4	16.1	27.6	53.4	159.4	114.6	49.0	28.7	23.1	555.8
Avg.	**35.9**	**32.9**	**28.6**	**24.6**	**22.2**	**41.6**	**123.3**	**219.8**	**167.3**	**87.4**	**51.9**	**33.4**	**72.4**

Table B.11 Monthly Mean Flow Values of 2604/A Botan Creek - Billoris SGS (EIE, 2003)

8747.3 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1962	-	-	-	-	-	-	-	-	-	-	109.5	82.7	192.2
1963	89.7	94.3	157.2	212.1	287.9	334.8	1726.3	2035.6	1563.0	675.0	316.1	205.8	7697.8
1964	217.5	242.1	197.4	150.3	167.9	741.9	930.5	1355.3	764.6	275.9	150.8	117.9	5312.1
1965	113.3	120.8	128.8	131.0	151.2	423.2	788.0	1154.4	702.4	267.6	147.8	94.3	4222.8
1966	286.6	220.8	258.2	366.9	314.5	444.6	1016.1	1151.7	648.0	283.9	158.8	136.1	5286.3
1967	162.6	136.1	152.9	173.6	153.6	294.6	1010.9	2290.0	943.5	407.1	190.7	142.3	6057.9
1968	158.8	357.7	366.9	302.7	263.1	677.6	1658.9	1738.3	951.3	452.6	231.4	162.5	7321.9
1969	157.0	180.1	356.2	275.9	244.3	924.0	1760.0	2335.6	1156.0	468.7	227.1	181.4	8266.4
1970	216.4	190.5	197.9	186.7	258.9	428.5	858.0	677.6	326.6	180.5	122.9	102.6	3747.2
Avg.	**175.2**	**192.8**	**227.0**	**224.9**	**230.2**	**533.7**	**1218.6**	**1592.3**	**881.9**	**376.4**	**183.9**	**136.2**	**497.8**

Table B.12 Monthly Mean Flow Values of 2626 Botan Creek - Billoris SGS (EIE, 2003)

8761.2 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1972	120.8	129.6	180.0	133.7	147.6	380.3	1309.0	1609.7	1091.2	433.9	225.8	147.5	5909.0
1973	150.0	183.5	134.5	117.8	192.6	281.2	645.4	1095.5	572.8	255.8	151.9	117.4	3898.4
1974	120.8	137.1	135.3	111.7	102.8	364.3	663.6	889.2	396.6	182.7	118.1	107.3	3329.4
1975	95.4	99.5	109.0	111.7	143.9	300.0	762.0	784.8	425.1	180.8	105.5	86.1	3203.8
1976	93.2	108.9	115.2	137.7	179.4	300.0	1303.8	1762.4	1091.2	423.2	211.9	151.4	5878.1
1977	196.1	158.9	160.2	146.8	168.9	407.1	847.6	991.0	495.1	232.2	150.0	119.0	4072.7
1978	127.2	112.2	148.4	187.5	268.5	549.1	899.4	1181.2	720.6	356.2	181.1	126.7	4858.1
1979	139.3	131.4	218.0	217.2	300.0	527.6	935.7	1033.9	616.9	270.5	160.7	126.2	4677.5
1980	270.5	334.4	213.5	176.2	198.4	522.3	1345.2	1347.2	572.8	273.2	152.4	119.0	5525.2
1981	118.7	120.0	121.9	160.4	163.8	425.9	847.6	1218.7	718.0	316.1	159.6	127.8	4498.3
1982	122.1	207.6	165.8	173.3	164.7	245.1	1321.9	1791.8	720.6	310.7	175.7	131.2	5530.6
1983	158.3	153.2	134.7	135.5	116.6	297.3	673.9	1189.2	456.2	185.1	120.5	103.7	3724.2
1984	111.2	344.7	273.2	156.2	183.9	393.7	728.4	891.9	653.2	305.3	162.6	122.3	4326.6
1985	124.5	219.8	143.6	152.4	203.5	479.4	1459.3	1304.4	598.8	278.6	172.0	118.7	5254.8
1986	123.5	121.0	128.3	137.7	158.2	289.3	655.8	707.1	495.1	226.6	127.5	98.0	3268.0
1987	123.2	211.8	160.2	185.9	326.6	401.8	1358.2	1880.2	956.4	433.9	214.8	148.8	6401.8
1988	163.9	249.4	495.5	313.4	310.7	685.7	1899.9	2357.0	1438.6	728.5	348.2	230.7	9221.4
1989	239.7	261.8	258.7	201.1	161.1	425.9	593.6	503.5	224.2	122.9	105.5	87.1	3185.2
1990	138.5	269.6	412.5	237.6	232.2	471.4	972.0	1135.6	663.6	305.3	170.3	119.0	5127.6
1991	122.9	130.9	129.1	105.8	135.0	519.6	738.7	688.3	298.1	151.3	103.1	87.6	3210.5
1992	112.8	185.6	194.2	147.3	178.9	310.7	1156.0	1582.9	1088.6	455.3	223.9	146.4	5782.7
1993	135.5	164.3	192.8	181.9	189.7	391.0	1438.6	2228.4	1220.8	549.1	251.8	179.9	7123.8
1994	167.9	241.1	222.0	275.9	220.1	447.3	1342.7	1283.0	593.6	294.6	174.1	132.5	5394.7
1995	149.5	233.3	270.5	258.5	249.2	519.6	1516.3	1360.6	808.7	361.6	193.1	167.4	6088.3
1996	154.3	157.6	135.8	161.8	293.2	332.1	1029.0	1044.6	489.9	249.6	147.8	126.5	4322.2
Avg.	**143.2**	**186.7**	**194.1**	**173.0**	**199.6**	**410.7**	**1057.7**	**1274.5**	**696.3**	**315.3**	**172.3**	**129.1**	**412.7**

Table B.13 Monthly Mean Flow Values of 2633 Botan Creek - Billoris SGS (EIE, 2003)

8747.3 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1997	133.1	109.4	270.5	204.1	136.7	226.1	1124.9	1360.6	772.4	337.5	171.1	128.6	4975.0
1998	160.7	170.3	161.0	136.1	196.2	450.0	1150.8	1033.9	474.3	212.1	131.2	102.4	4379.0
1999	102.9	95.6	113.3	90.3	120.7	219.1	756.9	605.3	285.1	150.0	102.3	80.6	2722.1
2000	93.7	91.5	91.6	88.9	103.0	212.9	764.6	808.9	308.4	131.2	86.2	73.1	2854.2
Avg.	**122.6**	**116.7**	**159.1**	**129.8**	**139.1**	**277.0**	**949.3**	**952.2**	**460.1**	**207.7**	**122.7**	**96.2**	**311.0**

Table B.14 Monthly Mean Flow Values of 2615 Mukus Creek - Begendik SGS (EIE, 2003)

505.6 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1965	19.1	17.9	18.5	18.5	16.7	39.4	72.3	114.4	99.3	55.4	29.7	19.8	521.1
1966	21.9	24.9	25.8	24.3	22.4	40.2	73.1	135.8	104.5	66.2	32.4	27.7	599.2
1967	28.4	23.1	22.6	21.7	19.5	25.1	71.5	173.0	103.2	64.0	35.9	21.6	609.6
1968	21.6	22.2	21.8	22.5	21.1	47.4	126.5	103.9	128.8	64.5	40.4	23.9	644.8
1969	22.4	24.8	24.9	23.3	21.0	43.9	115.3	238.4	120.0	73.7	43.9	29.8	781.5
1970	30.0	28.3	25.3	23.7	20.3	35.1	73.6	79.0	63.0	38.3	24.8	21.3	462.7
1971	20.9	22.6	24.3	22.5	20.8	34.3	47.4	85.2	70.2	39.6	25.0	19.2	432.0
1972	24.1	22.3	22.5	22.5	21.0	37.0	91.2	256.9	135.0	68.8	41.0	29.3	771.7
Avg.	**23.6**	**23.3**	**23.2**	**22.4**	**20.4**	**37.8**	**83.9**	**148.3**	**103.0**	**58.8**	**34.1**	**24.1**	**50.2**

Table B.15 Monthly Mean Flow Values of 26-55 Catak Brook - Dalbasti SGS (DSI, 2007-a)

3069.0 km^2 Unit: hm^3

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	Total
1981	49.8	48.0	43.5	41.4	37.3	64.9	183.0	313.0	262.0	117.0	68.8	50.5	1279.2
1982	66.9	49.8	41.2	45.4	35.6	45.1	207.0	511.0	322.0	125.0	67.6	52.2	1568.8
1983	68.3	48.3	42.5	38.5	34.6	54.9	131.0	405.0	199.0	76.2	49.7	39.9	1187.9
1984	37.9	67.8	72.0	35.4	26.1	80.9	221.0	329.0	316.0	154.0	69.2	45.9	1455.2
1985	34.2	41.9	26.5	24.8	26.1	52.1	136.0	461.0	213.0	79.1	42.6	28.6	1165.9
1986	42.2	37.6	31.8	27.3	28.6	43.7	192.0	261.0	220.0	90.3	32.7	24.5	1031.7
Avg.	**49.9**	**48.9**	**42.9**	**35.5**	**31.4**	**56.9**	**178.3**	**380.0**	**255.3**	**106.9**	**55.1**	**40.3**	**106.8**

Table B.16 Monthly Mean Flow Values of 26-39 Anbar Creek - Hani SGS (DSI, 2007-a)

292.0 km^2 Unit: hm^3

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	Total
1978	1.8	1.8	6.5	17.9	36.1	16.1	6.1	3.5	1.6	1.1	0.9	0.7	94.1
1979	0.7	0.8	1.7	14.6	4.7	6.4	4.5	1.3	1.7	1.0	1.0	0.7	39.0
1980	2.2	21.7	28.2	23.1	16.3	24.0	24.4	10.0	4.4	3.9	3.4	2.9	164.5
1981	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	0.3	0.3	1.6	15.3	21.5	21.2	30.9	24.2	4.5	1.7	1.3	1.1	123.9
1983	1.2	1.2	1.3	1.7	5.1	18.6	8.2	6.2	1.3	1.1	1.0	0.9	47.7
1984	0.9	13.8	12.8	5.2	16.6	23.4	15.8	7.7	2.0	1.7	1.4	1.0	102.3
1985	1.1	1.9	1.9	6.1	20.3	21.7	18.2	5.6	1.4	1.1	0.9	0.6	80.8
1986	0.6	1.5	2.1	13.3	18.1	8.9	4.6	4.3	1.2	1.0	0.9	0.9	57.5
1987	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	3.7	5.1	6.6	4.1	2.5	7.4	3.0	1.2	0.7	0.4	0.4	0.3	35.4
1990	3.1	13.9	25.5	6.3	30.3	12.0	12.5	4.9	2.2	1.3	0.8	0.7	113.5
1991	0.7	3.2	1.5	1.4	16.9	29.5	13.7	5.6	1.8	1.1	0.8	0.5	76.6
1992	2.2	1.3	9.9	8.0	16.8	46.4	17.4	11.5	3.6	0.8	0.9	0.6	119.4
1993	0.6	1.1	10.3	15.9	19.9	34.3	27.6	40.8	5.5	1.2	0.8	1.0	159.0
1994	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	0.6	0.5	0.8	2.9	21.6	18.5	5.7	2.5	1.1	0.8	0.6	0.4	56.0
Avg.	**1.4**	**4.9**	**7.9**	**9.7**	**17.6**	**20.6**	**13.8**	**9.2**	**2.4**	**1.3**	**1.1**	**0.9**	**7.6**

Table B.17 Monthly Mean Flow Values of 2618 Anbar Creek - Koprubasi SGS (EIE, 2003)

976.0 km^2 Unit: hm^3

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	Total
1969	3.2	7.9	73.4	129.4	98.0	158.3	68.7	29.5	7.1	4.7	2.5	2.4	585.1
1970	4.7	4.3	6.8	10.0	46.4	31.9	9.3	3.5	2.1	1.6	0.9	0.9	122.5
1971	1.9	2.0	3.9	2.7	4.7	27.1	55.2	16.5	4.1	1.4	0.8	1.1	121.5
1972	4.0	3.5	6.7	3.9	14.3	30.0	34.5	59.7	8.8	1.9	1.1	1.2	169.4
1973	1.6	2.4	2.4	2.5	6.4	11.8	10.0	4.6	0.9	0.2	0.0	0.3	42.9
1974	1.0	2.0	3.1	10.6	14.9	69.1	120.5	14.5	3.2	0.9	0.5	1.1	241.5
1975	1.7	2.2	5.7	7.6	39.9	31.6	19.8	17.7	1.9	0.6	0.1	0.9	129.6
1976	1.5	2.2	9.2	96.7	94.5	101.8	224.7	43.9	12.9	4.3	2.7	2.6	597.0
1977	10.4	10.6	62.4	17.2	35.1	49.6	53.9	21.8	4.6	1.9	1.2	1.9	270.5
1978	3.4	2.9	16.4	47.1	140.8	60.0	26.2	13.4	5.0	2.6	2.2	2.3	322.3

Table B.17 (continued)

1979	2.0	2.4	8.2	41.8	19.1	24.2	16.4	5.2	4.0	1.2	1.1	1.0	126.4
1980	3.5	10.4	24.9	38.0	46.4	95.4	71.5	18.7	5.0	1.7	1.4	1.7	318.6
1981	3.3	3.8	17.7	52.5	78.4	99.4	39.4	20.0	7.7	2.1	1.2	1.1	326.6
1982	2.7	4.0	7.6	26.2	32.4	34.3	52.4	37.2	8.1	2.1	0.8	0.8	208.6
1983	3.0	3.3	3.1	7.3	17.2	48.2	17.9	14.9	4.1	0.3	0.1	0.2	119.8
1984	1.5	19.3	23.3	13.1	29.8	40.4	33.4	12.1	1.9	0.7	0.1	0.5	176.3
1985	1.5	3.1	2.8	9.2	34.1	41.0	40.7	13.6	2.8	0.3	0.0	0.1	149.2
1986	1.9	2.3	4.2	23.3	42.1	20.8	9.3	11.7	3.3	0.1	0.0	0.0	119.0
1987	0.9	5.1	13.2	69.9	74.0	121.6	42.2	9.3	3.5	1.7	1.1	1.9	344.5
1988	10.0	23.8	112.8	64.5	90.5	137.7	74.1	30.0	8.9	3.2	1.4	1.6	558.4
1989	7.1	9.3	15.6	10.0	6.4	11.9	6.3	1.8	0.5	0.0	0.0	0.0	68.9
1990	3.8	13.6	58.1	20.5	91.7	25.3	19.6	9.3	2.9	0.7	0.3	0.7	246.4
1991	1.9	4.5	2.7	3.8	23.2	46.3	25.4	11.3	2.6	1.1	0.8	0.9	124.6
1992	2.6	3.2	12.1	16.7	61.1	109.3	31.6	17.0	6.5	2.0	0.8	1.3	264.3
1993	2.1	3.4	14.3	36.4	43.8	70.2	30.3	79.5	11.6	4.2	2.3	1.9	300.0
1994	3.2	3.9	4.1	9.9	46.4	26.6	23.8	9.8	2.6	0.7	0.2	0.8	131.8
1995	2.3	5.4	40.2	67.2	54.7	28.9	45.4	18.3	6.0	0.9	0.0	1.1	270.4
1996	3.6	4.8	4.2	16.0	26.8	115.4	50.5	16.8	5.4	1.3	0.2	1.2	246.4
1997	3.5	2.8	8.1	11.6	26.4	31.1	143.6	10.5	3.2	0.7	0.0	0.9	242.3
1998	3.0	4.3	15.9	34.8	47.9	70.2	53.9	23.3	7.9	0.5	0.0	0.0	261.8
Avg.	**3.2**	**5.8**	**19.4**	**30.0**	**46.2**	**59.0**	**48.4**	**19.8**	**5.0**	**1.5**	**0.8**	**1.1**	**20.0**

Table B.18 Monthly Mean Flow Values of 26-14 Kurucay - Yasince SGS (DSI, 2007-a)

240.0 km^2 Unit: hm^3

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	Total
1962	-	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-	-
1965	2.2	1.1	0.5	0.6	5.5	3.5	8.0	2.3	0.6	0.1	0.1	0.1	24.6
1966	0.4	0.5	0.9	9.8	8.1	4.0	8.4	1.2	0.3	0.0	0.0	0.0	33.6
1967	0.3	0.4	0.5	0.4	5.8	17.7	7.0	5.3	1.2	0.4	0.1	0.2	39.4
1968	0.4	0.5	2.6	11.9	15.1	22.4	7.1	2.7	0.9	0.2	0.1	0.2	64.1
1969	0.2	0.4	8.8	12.6	16.3	19.6	12.4	3.6	0.8	0.1	0.0	0.1	75.0
1970	-	-	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-	-	-	-	-	-
1972	0.3	0.6	1.2	0.6	2.0	3.3	5.9	11.8	2.4	0.6	0.4	0.4	29.4
1973	0.7	1.2	0.6	0.4	0.8	0.7	0.6	0.3	0.1	0.0	0.0	0.0	5.3
1974	0.0	0.0	0.0	0.7	0.8	5.6	11.8	2.2	0.4	0.1	0.0	0.0	21.7
1975	0.1	0.2	0.4	0.5	2.2	3.6	2.1	1.4	0.3	0.1	0.0	0.0	10.8
1976	0.0	0.0	0.3	5.4	23.7	15.1	27.1	15.1	1.9	0.5	0.1	0.1	89.3
1977	0.3	0.5	2.5	1.6	3.6	5.6	6.0	3.4	0.6	0.1	0.0	0.0	24.1
1978	0.1	0.3	1.5	6.2	23.4	12.9	5.3	2.1	0.5	0.1	0.1	0.1	52.5
1979	0.1	0.3	0.3	2.1	1.6	3.0	2.2	0.9	0.1	0.0	0.0	0.0	10.6
1980	0.1	0.3	5.6	10.3	10.8	17.5	11.5	2.4	0.3	0.1	0.1	0.0	59.0
1981	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	0.6	0.9	1.5	2.3	5.1	3.5	1.9	0.7	0.1	0.0	0.0	16.5
1984	0.2	1.1	1.7	1.4	2.9	3.8	4.1	2.0	0.5	0.0	1.6	0.0	19.5
1985	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
Avg.	**0.4**	**0.5**	**1.8**	**4.1**	**7.8**	**9.0**	**7.7**	**3.7**	**0.7**	**0.2**	**0.2**	**0.1**	**3.0**

Table B.19 Monthly Mean Flow Values of 26-32 Pamukcay - Karahan Bridge SGS (DSI, 2007-a)

305.0 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	0.2	0.2	0.2	0.5
1980	2.8	6.5	13.6	18.7	17.5	32.2	22.1	5.5	1.4	0.2	0.1	0.1	120.7
1981	0.1	1.4	4.3	13.4	17.6	21.9	11.0	4.2	1.1	0.2	0.0	1.0	76.2
1982	0.8	1.1	2.1	-	-	-	25.8	11.4	3.8	2.0	1.6	1.7	50.2
1983	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	12.7	3.8	7.5	9.6	8.8	8.7	3.0	1.9	0.0	0.1	56.1
1985	1.0	0.6	0.5	1.4	11.0	11.3	8.2	1.4	0.8	0.6	0.5	0.4	37.6
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	2.4	2.8	3.4	2.4	1.8	3.3	2.2	1.1	0.3	0.1	0.0	0.0	19.7
1990	1.0	4.4	13.9	8.5	22.7	7.2	5.7	2.2	0.1	0.0	0.0	0.0	65.6
1991	0.4	1.1	1.2	1.8	7.3	16.8	5.0	2.0	0.1	0.0	0.0	0.0	35.7
1992	0.6	0.7	2.4	3.6	23.7	17.9	5.3	3.2	0.3	0.0	0.0	0.0	57.8
1993	0.4	1.8	3.8	6.8	14.4	28.3	8.9	23.3	2.2	0.4	0.1	0.1	90.4
1994	0.3	0.7	0.6	2.7	12.8	7.7	6.3	1.7	0.3	0.2	0.1	0.2	33.6
1995	0.5	3.1	9.4	14.7	15.7	14.8	16.1	8.3	2.2	0.2	0.0	0.2	85.1
1996	1.5	1.5	1.3	4.5	7.9	29.0	17.1	4.4	1.9	1.0	0.0	0.6	70.6
1997	0.7	0.7	2.3	4.0	9.0	11.6	14.2	2.3	0.1	0.0	0.0	0.0	44.8
1998	0.8	0.5	3.7	9.1	14.8	18.5	22.6	9.6	2.5	0.4	0.2	0.2	83.0
1999	1.1	1.1	1.8	1.6	3.8	3.5	10.6	1.1	0.3	0.2	0.0	0.0	25.2
2000	-	-	-	-	-	-	-	-	-	-	-	-	-
Avg.	**1.0**	**1.9**	**4.8**	**6.5**	**12.5**	**15.6**	**11.9**	**5.6**	**1.3**	**0.4**	**0.2**	**0.3**	**5.2**

Table B.20 Monthly Mean Flow Values of 26-12 Basnik Creek - Salat SGS (DSI, 2007-a)

1060.0 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1960	-	-	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-	-
1965	1.4	3.4	3.5	5.6	28.9	20.9	32.8	10.8	2.5	1.0	0.5	0.4	111.6
1966	-	-	-	-	-	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-	-	-
1970	4.1	6.1	6.2	6.4	13.3	11.6	4.8	1.1	0.4	0.1	0.1	0.1	54.2
1971	0.4	2.7	5.0	2.6	2.8	8.3	67.7	12.1	1.4	0.2	0.1	0.1	103.2
1972	8.0	2.5	5.4	5.2	14.3	18.6	42.3	55.3	8.7	2.1	0.6	3.0	165.9
1973	5.3	2.8	3.0	3.2	7.9	9.5	5.8	2.2	0.3	0.1	0.1	0.1	40.3
1974	0.1	1.0	1.9	7.2	7.6	39.7	60.4	7.3	0.5	0.0	0.1	0.1	125.8
1975	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	-	-

Table B.20 (continued)

1980	-	-	-	-	-	-	-	-	-	-	-	-	-
1981	5.9	6.0	8.6	25.1	38.1	38.9	30.1	15.8	5.6	1.5	0.6	1.3	177.5
1982	3.3	7.1	9.7	15.0	29.5	22.0	45.1	27.1	7.5	3.2	1.5	1.8	172.7
1983	4.7	5.2	5.1	10.2	12.1	29.7	10.9	8.8	3.1	0.7	0.2	0.2	90.9
1984	1.3	9.2	11.3	7.9	14.0	25.9	12.0	3.7	-	-	-	-	85.3
1985	0.9	2.9	4.4	4.4	23.0	20.1	28.6	8.8	3.3	0.8	0.0	0.0	97.2
1986	3.6	5.2	4.7	9.3	21.1	14.1	6.7	7.2	1.4	0.1	0.0	0.0	73.5
1987	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	5.0	3.5	12.3	20.1	24.7	39.5	32.3	9.0	1.5	0.3	0.0	0.0	148.1
1998	2.1	3.6	11.3	16.2	30.1	28.5	50.8	23.9	5.7	0.8	0.0	0.0	172.9
1999	1.5	3.1	4.7	4.1	5.3	6.8	19.2	3.0	0.6	0.3	0.2	0.2	48.8
2000	0.4	0.6	2.1	4.2	8.7	16.1	6.7	2.3	0.6	0.1	0.0	0.0	41.9
Avg.	**3.0**	**4.0**	**6.2**	**9.2**	**17.6**	**21.9**	**28.5**	**12.4**	**2.9**	**0.8**	**0.3**	**0.5**	**8.9**

Table B.21 Monthly Mean Flow Values of 26-60 Baskoy Creek - Salikan (Kibris) SGS (DSI, 2007-a)

118.5 km^2 Unit: hm^3

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	Total
1985	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	0.1	0.3	0.7	0.5	0.3	0.8	0.5	0.1	0.0	0.0	0.0	0.0	3.2
1990	0.1	1.7	6.1	3.0	14.8	2.8	1.8	0.7	0.1	0.0	0.0	0.1	31.1
1991	0.1	0.3	0.2	0.6	1.2	5.9	0.6	0.5	0.2	0.1	0.0	0.1	9.9
1992	1.4	3.9	0.9	0.6	10.5	5.5	1.6	1.1	0.1	0.0	0.0	0.1	25.7
1993	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	0.3	0.3	0.7	1.1	1.6	1.6	1.7	0.9	0.1	0.0	0.0	0.0	8.2
Avg.	**0.4**	**1.3**	**1.7**	**1.2**	**5.7**	**3.3**	**1.2**	**0.6**	**0.1**	**0.0**	**0.0**	**0.0**	**1.3**

Table B.22 Monthly Mean Flow Values of 2612 Batman Creek - Malabadi Bridge SGS (EIE, 2003)

4105.2 km^2 Unit: hm^3

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	Total
1961	26.2	39.4	35.1	162.6	179.3	259.5	502.8	404.4	78.8	22.1	11.0	9.7	1730.9
1962	15.6	141.5	415.2	215.3	515.3	723.2	715.4	533.0	177.3	41.8	18.8	16.6	3528.9
1963	-	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-	-
1965	18.0	139.7	102.6	140.9	358.0	586.6	1010.9	763.3	274.8	61.3	23.2	15.1	3494.4

Table B.22 (continued)

1966	283.9	234.1	436.6	833.0	498.4	490.1	878.7	551.8	196.7	65.1	25.8	23.3	4517.4
1967	40.4	55.2	158.6	407.1	271.0	782.1	1197.5	1355.3	370.7	124.8	38.8	29.8	4831.3
1968	45.8	292.9	720.5	500.9	395.9	1009.8	1169.0	988.3	337.0	89.7	34.3	24.6	5608.6
1969	62.4	114.3	787.4	600.0	493.5	1524.0	1340.1	1216.0	329.2	77.7	29.7	29.5	6603.8
1970	106.6	81.6	175.4	185.1	808.0	575.9	565.1	332.1	100.1	34.3	15.3	13.3	2992.8
1971	22.5	99.3	202.8	87.0	131.6	527.6	922.8	516.9	146.7	35.9	18.4	16.4	2728.0
1972	119.5	146.7	313.4	126.4	192.7	393.7	1075.7	1074.0	223.2	66.2	20.1	17.6	3769.2
1973	32.4	114.6	46.3	44.7	258.9	283.9	513.2	375.0	80.1	24.7	9.4	12.3	1795.6
1974	27.9	95.6	124.5	119.7	130.9	977.6	1205.3	506.2	98.5	16.9	6.4	10.7	3320.2
1975	17.5	58.8	114.6	192.0	394.3	618.7	904.6	522.3	81.1	43.9	21.7	25.3	2995.0
1976	74.5	109.9	134.2	401.8	423.4	591.9	1347.8	1232.1	661.0	278.6	55.2	31.6	5341.9
1977	260.3	227.6	586.6	203.8	377.4	605.3	839.8	677.6	207.1	43.9	14.6	16.6	4060.8
1978	42.1	51.3	238.1	318.7	945.9	991.0	1047.2	867.8	342.1	66.2	31.1	24.0	4965.4
1979	34.3	32.9	525.0	626.7	384.7	508.9	720.6	458.0	131.7	29.7	17.0	16.4	3485.9
1980	174.6	401.8	358.9	342.8	318.2	859.8	1088.6	608.0	129.6	32.7	3.9	4.2	4323.2
1981	27.9	80.6	214.3	388.4	510.5	937.4	751.7	557.1	180.4	42.9	1.5	0.4	3693.0
1982	17.2	105.8	221.2	441.9	360.5	535.7	1293.4	824.9	242.6	83.3	12.5	3.1	4142.1
1983	27.6	34.2	38.6	75.3	114.2	468.7	552.1	551.8	147.5	29.2	5.0	8.0	2052.1
1984	47.4	948.7	364.3	148.4	373.3	760.7	728.4	479.4	140.5	53.3	22.4	17.1	4083.8
1985	36.7	117.7	67.5	182.1	375.0	610.7	1044.6	484.8	94.1	35.1	22.8	22.8	3093.7
1986	38.3	75.9	132.8	273.2	367.7	468.7	663.6	441.9	153.2	39.1	20.1	14.7	2689.3
1987	64.0	204.5	201.7	554.4	713.7	806.2	1327.1	1049.9	438.0	121.1	40.7	28.5	5549.9
1988	144.1	404.4	999.0	460.7	608.9	966.9	1384.1	1028.5	383.6	160.4	37.5	26.4	6604.6
1989	115.4	182.5	329.4	109.8	81.8	348.2	300.7	77.4	18.4	13.6	14.7	16.4	1608.3
1990	131.8	694.7	1092.8	348.2	667.7	664.2	938.3	744.6	219.5	47.1	27.1	24.6	5600.6
1991	118.1	261.8	223.1	87.6	333.8	1149.0	834.6	530.3	94.9	26.7	21.2	20.2	3701.4
1992	46.1	126.7	162.8	121.6	283.1	733.9	1311.6	1092.8	448.4	66.4	27.3	23.0	4443.7
1993	61.3	173.7	234.4	233.3	275.8	1111.5	1495.6	1411.5	344.7	67.2	29.5	24.5	5463.0
1994	35.9	134.3	102.0	218.6	209.5	409.8	614.3	415.2	63.8	35.9	28.9	25.1	2293.2
1995	45.5	138.4	273.2	203.3	287.9	996.4	1223.4	1406.2	295.5	39.6	31.6	29.8	4970.8
1996	131.5	145.7	106.1	188.6	405.9	725.8	1096.4	699.1	169.0	52.2	22.5	19.7	3762.4
1997	76.6	68.9	516.9	388.4	362.9	616.0	1239.0	899.9	187.1	55.2	22.7	23.9	4457.6
1998	185.6	184.6	243.2	226.6	341.1	827.6	1544.8	859.8	256.6	46.6	27.1	21.7	4765.3
1999	40.2	187.1	1.1	2.2	193.8	246.4	912.4	366.9	41.7	80.1	39.4	38.6	2149.9
2000	200.6	0.8	0.4	56.5	378.3	525.0	883.9	433.9	155.5	118.4	52.0	64.0	2869.3
Avg.	**78.8**	**176.5**	**289.5**	**268.9**	**376.9**	**690.0**	**978.5**	**719.4**	**211.6**	**62.3**	**23.7**	**20.8**	**324.8**

Table B.23 Monthly Mean Flow Values of 26-62 Sallar Creek - Yolkopru SGS (DSI, 2007-a)

51.6 km^2 — Unit: hm^3

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	Total
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	1.6	1.2	1.9	1.6	1.1	2.5	1.3	0.4	0.2	0.0	0.0	0.0	11.8
1990	0.3	1.4	3.3	2.1	6.5	2.6	1.8	1.1	0.4	0.2	0.1	0.0	19.8
1991	0.5	1.2	0.4	0.3	2.7	5.6	2.1	1.7	0.6	0.2	0.1	0.0	15.5
1992	0.3	0.4	1.8	2.0	2.5	10.2	2.0	1.2	0.9	0.2	0.1	0.1	21.6
1993	0.4	0.5	2.2	2.0	2.3	4.7	5.5	14.7	1.7	0.5	0.3	0.0	34.8
1994	0.1	0.3	0.2	0.6	2.4	2.1	1.4	1.0	0.2	0.1	0.1	0.2	8.8
1995	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	1.3	0.7	0.3	2.8	4.0	11.7	7.9	3.0	1.7	0.4	0.1	0.3	34.2
1997	0.4	0.4	3.3	1.9	2.8	3.5	6.2	1.9	0.7	0.2	0.1	0.1	21.4
1998	19.7	3.8	4.5	3.2	10.2	9.2	7.5	3.7	1.4	0.4	0.1	0.2	63.9
1999	0.3	0.5	1.4	1.0	2.5	2.2	3.4	0.9	0.4	0.1	0.1	0.2	12.9
2000	0.4	0.5	0.9	2.4	8.9	3.0	1.0	0.3	0.1	0.0	0.0	0.0	17.4
Avg.	**2.3**	**1.0**	**1.8**	**1.8**	**4.2**	**5.2**	**3.6**	**2.7**	**0.7**	**0.2**	**0.1**	**0.1**	**2.0**

Table B.24 Monthly Mean Flow Values of 26-09 Furtaksa Brook - DDY Bridge SGS (DSI, 2007-a)

1607.0 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1960	-	-	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-	-	-
1962	0.4	0.9	30.0	16.4	81.3	20.6	7.9	3.9	0.4	0.0	0.0	0.0	161.8
1963	0.6	2.2	19.3	97.1	67.8	60.4	109.0	60.6	5.7	1.3	0.3	0.4	424.6
1964	3.7	2.7	7.3	3.0	47.9	155.0	11.7	3.8	0.9	0.2	0.1	0.2	236.5
Avg.	**1.6**	**1.9**	**18.9**	**38.8**	**65.7**	**78.7**	**42.9**	**22.8**	**2.3**	**0.5**	**0.1**	**0.2**	**22.9**

Table B.25 Monthly Mean Flow Values of 2632 Berkilin Creek - Cayustu SGS (EIE, 2003)

1503.6 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1989	36.2	57.5	67.2	27.1	20.0	69.9	29.0	11.9	9.8	4.2	4.4	4.5	341.8
1990	22.1	148.3	255.5	78.2	283.0	130.7	116.4	64.8	24.6	12.7	6.2	6.6	1149.1
1991	11.2	32.4	25.3	21.7	82.3	211.1	113.5	75.8	18.7	9.2	3.0	4.8	608.9
1992	12.9	22.8	67.0	40.4	76.2	175.2	247.5	159.6	52.4	17.0	10.4	9.4	890.8
1993	11.4	35.5	132.3	61.1	71.4	215.1	300.7	278.6	64.8	24.5	11.2	9.5	1215.9
1994	12.4	22.9	18.9	56.5	105.7	121.3	108.6	61.6	16.4	9.5	6.1	5.7	545.6
1995	11.9	74.6	107.4	146.0	121.9	198.2	237.7	111.7	38.9	16.1	11.4	9.8	1085.6
1996	11.8	61.7	22.8	127.5	143.1	369.6	287.7	120.0	28.0	15.4	8.3	10.1	1206.0
1997	27.1	14.4	122.7	69.6	97.0	135.8	298.1	94.8	27.0	11.8	8.5	8.7	915.5
Avg.	**17.4**	**52.2**	**91.0**	**69.8**	**111.2**	**180.8**	**193.2**	**108.8**	**31.2**	**13.4**	**7.7**	**7.7**	**73.7**

Table B.26 Monthly Mean Flow Values of 2617 Tigris River - Cayonu SGS (EIE, 2003)

1186.0 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1972	14.5	13.1	33.7	11.4	30.6	57.6	80.4	144.1	37.3	9.1	5.2	4.5	441.5
1973	6.0	15.9	8.0	11.3	65.3	53.0	64.0	29.2	9.8	3.8	2.1	2.1	270.6
1974	6.6	31.4	60.3	38.3	70.2	508.9	228.6	52.5	17.4	8.1	4.7	5.1	1032.0
1975	4.7	9.7	71.5	50.4	71.4	132.0	166.4	103.4	21.6	9.2	4.0	4.3	648.5
1976	6.3	18.0	26.3	135.5	82.7	224.7	469.2	196.3	48.0	17.7	9.3	7.6	1241.5
1977	83.0	65.6	132.0	56.5	123.9	143.3	145.4	93.2	23.1	10.9	5.7	5.5	888.2
1978	6.5	7.7	91.9	102.0	348.4	199.8	135.6	57.6	18.8	9.1	5.8	5.1	988.1
1979	5.9	7.6	34.3	203.6	74.8	96.4	60.9	36.7	16.7	7.1	4.2	3.4	551.6
1980	43.1	80.6	95.9	87.0	129.5	383.0	261.8	61.3	19.0	8.8	5.3	4.6	1180.0
1981	5.9	18.4	181.3	155.6	263.7	255.8	151.6	89.5	29.3	12.2	6.7	5.6	1175.6
1982	6.9	20.8	74.5	86.5	80.3	131.8	212.3	169.0	56.2	16.1	8.1	7.1	869.6
1983	7.1	7.9	12.3	20.0	42.3	186.1	149.8	72.9	21.7	7.7	4.2	4.0	536.1
1984	8.2	60.7	73.9	56.2	83.4	164.5	99.3	49.8	14.0	5.2	4.3	3.8	623.2
1985	5.6	20.4	17.2	44.7	102.1	111.2	137.9	31.1	11.0	5.0	3.2	2.8	492.1
1986	9.2	16.3	23.4	76.6	124.1	90.0	61.2	49.6	18.4	6.3	3.7	2.8	481.4
1987	10.2	38.4	70.7	144.4	189.4	216.7	193.9	83.3	25.6	10.0	4.9	3.7	991.0
1988	39.6	136.6	300.0	99.9	189.4	289.3	308.4	85.4	30.3	13.2	6.5	4.6	1503.2
1989	23.5	39.7	47.1	22.7	15.4	55.7	19.8	8.7	5.0	2.2	1.9	2.0	243.6
1990	8.2	51.3	121.6	51.4	192.8	93.2	82.9	37.2	10.8	4.7	3.1	2.6	659.9
1991	3.7	14.6	13.4	13.1	77.2	218.0	101.6	75.8	17.3	5.4	3.9	4.2	548.2
1992	8.0	17.5	86.2	49.0	49.6	219.4	179.1	119.5	34.5	11.6	5.4	4.8	784.7
1993	6.5	28.5	139.8	57.6	70.9	165.5	230.9	241.1	49.8	15.4	8.5	5.5	1019.9
1994	5.5	9.4	12.0	47.4	85.4	83.8	68.9	23.5	7.3	3.7	1.8	1.9	350.8
1995	5.4	59.4	95.6	139.0	140.6	151.1	155.5	67.0	24.6	6.8	3.9	3.9	852.6
1996	6.7	31.9	12.8	114.4	94.5	286.6	201.9	71.5	21.2	8.8	5.7	4.4	860.4

Table B.26 (continued)

1997	9.6	10.4	134.2	54.1	51.8	72.3	206.3	58.9	16.7	7.0	3.6	3.7	628.7
Avg.	**13.3**	**32.0**	**75.8**	**74.2**	**109.6**	**176.5**	**160.5**	**81.1**	**23.3**	**8.6**	**4.8**	**4.2**	**63.7**

Table B.27 Monthly Mean Flow Values of 2605 Tigris River - Diyarbakir SGS (EIE, 2003)

5655.2 km^2 Unit: hm^3

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	Total
1946	0.0	0.0	214.3	233.8	336.3	771.4	894.2	666.9	135.0	68.6	56.5	52.1	3429.1
1947	188.3	55.0	71.0	383.0	411.3	399.1	166.1	131.2	81.9	52.5	43.7	40.7	2023.7
1948	46.9	196.5	131.2	224.7	721.6	356.2	741.3	551.8	119.2	55.7	42.6	40.4	3228.2
1949	49.8	58.6	55.2	76.6	101.8	302.7	502.8	166.3	66.6	46.1	39.9	37.3	1503.8
1950	40.7	42.8	91.9	137.1	222.6	-	-	-	91.8	45.5	38.3	36.3	746.9
1951	38.3	44.6	76.9	162.3	133.5	145.4	179.1	125.3	51.8	40.2	37.5	36.3	1071.3
1952	56.0	61.4	137.7	145.7	924.6	321.4	151.1	128.3	48.7	41.0	30.8	25.8	2072.5
1953	-	-	-	-	-	-	-	-	-	-	-	-	-
1954	-	-	-	-	-	-	-	-	-	-	-	-	-
1955	-	-	-	-	-	321.4	214.4	305.3	63.8	34.3	26.4	24.2	989.7
1956	26.6	41.0	27.6	364.3	431.0	447.3	344.7	188.3	70.8	35.6	25.7	23.3	2026.0
1957	26.5	30.1	47.1	50.4	316.9	519.6	156.6	776.7	134.8	57.0	38.6	33.7	2188.0
1958	38.0	48.7	139.0	358.9	206.6	466.0	261.8	98.8	66.4	28.7	20.9	19.5	1753.4
1959	22.3	26.7	91.3	172.5	75.0	350.9	194.9	177.6	67.9	28.9	20.9	19.8	1248.8
1960	25.7	33.2	55.7	383.0	171.6	452.6	435.5	164.2	49.2	30.3	22.2	20.8	1844.0
1961	21.8	33.4	30.8	109.5	128.7	173.8	178.6	133.4	40.4	18.8	11.9	11.3	892.5
1962	17.8	75.9	546.4	136.6	488.7	391.0	211.2	98.8	40.4	22.6	11.7	8.3	2049.6
1963	14.7	30.1	471.4	600.0	568.5	423.2	689.5	849.1	232.0	73.7	29.5	29.3	4010.7
1964	75.5	83.5	161.2	58.9	214.5	945.5	264.4	113.8	46.4	23.8	17.1	16.2	2020.9
1965	18.7	176.0	102.9	111.4	275.8	554.4	583.2	194.7	83.2	32.7	19.1	17.1	2169.2
1966	68.8	96.9	246.4	956.2	435.5	263.8	362.9	228.2	70.8	34.6	21.3	21.5	2806.8
1967	29.5	67.1	270.5	383.0	244.3	916.0	959.0	610.7	144.6	55.2	31.6	28.0	3739.6
1968	59.7	243.4	559.8	476.8	486.1	1143.7	417.3	286.6	114.6	53.3	31.9	28.3	3901.3
1969	32.9	142.6	530.3	934.8	544.3	1234.7	661.0	369.6	118.5	62.1	38.3	30.8	4700.0
1970	59.2	45.6	150.3	145.2	464.5	383.0	184.8	93.7	42.8	25.2	18.5	18.6	1631.4
1971	26.8	49.0	132.6	37.2	156.8	439.3	788.0	207.0	71.3	33.7	22.1	18.6	1982.3
1972	64.3	31.6	94.3	21.3	66.6	150.8	237.7	471.4	122.3	47.1	27.1	27.7	1362.2
1973	23.7	50.3	34.6	36.7	158.0	142.8	142.3	79.3	35.8	16.2	10.8	13.7	744.0
1974	33.2	82.9	123.7	117.3	128.9	1063.3	583.2	147.0	60.4	31.9	24.6	29.5	2426.1
1975	25.4	32.7	122.9	118.9	178.1	324.1	391.4	242.9	61.9	34.0	23.3	31.1	1586.8
1976	33.7	63.5	101.0	436.6	295.7	586.6	1363.4	533.0	158.9	70.2	49.6	46.1	3738.2
1977	139.0	136.9	273.2	121.1	249.2	324.1	394.0	257.7	75.7	49.0	42.6	43.0	2105.4
1978	82.2	47.4	242.9	244.8	771.7	487.5	326.6	189.9	91.0	45.0	32.4	33.4	2594.9
1979	32.1	31.1	119.5	404.4	177.8	208.9	185.6	129.4	65.3	35.6	27.3	27.5	1444.6
1980	109.3	187.7	212.7	223.4	325.7	806.2	580.6	207.8	83.5	49.0	35.1	34.7	2855.7
1981	35.1	59.6	302.7	369.6	539.5	634.8	339.6	220.4	103.7	53.0	36.2	33.4	2727.5
1982	34.8	69.2	156.7	216.1	222.6	337.5	629.9	377.7	111.5	56.0	39.9	35.5	2287.3
1983	38.6	35.3	37.5	72.3	108.6	420.5	308.4	179.2	71.3	35.1	28.4	28.5	1363.7
1984	37.8	244.4	197.7	122.4	218.5	401.8	251.4	157.0	61.4	36.7	23.5	22.3	1774.7
1985	26.8	57.5	56.2	112.8	230.8	361.6	331.8	102.3	41.5	22.8	20.5	25.0	1389.5
1986	42.3	56.2	86.5	207.0	278.2	241.9	158.6	129.9	62.5	26.5	20.9	19.6	1330.2
1987	57.3	109.6	174.6	391.0	532.2	715.1	562.5	261.7	96.2	45.8	32.9	33.2	3012.2
1988	109.8	337.0	950.8	340.2	498.6	862.4	777.6	283.9	114.8	50.4	35.6	36.8	4397.9
1989	132.8	143.3	123.7	65.9	52.5	128.8	67.9	35.9	24.0	11.5	12.7	20.6	819.7
1990	40.7	203.7	345.5	132.0	592.7	251.5	215.4	109.5	32.7	16.3	11.4	23.4	1974.9
1991	37.2	82.7	59.7	51.4	201.5	511.6	256.3	194.7	49.2	24.9	19.4	24.5	1513.2
1992	32.9	52.4	208.1	117.6	185.9	525.0	528.8	329.4	114.0	47.1	35.4	34.0	2210.6
1993	29.7	114.3	380.3	164.7	206.4	474.1	601.3	776.7	150.1	58.4	48.7	39.4	3044.2
1994	53.6	75.9	57.0	173.0	244.3	262.2	217.5	152.4	40.2	21.0	14.5	24.0	1335.7
1995	34.6	170.6	233.6	369.6	379.8	439.3	476.9	345.5	110.7	32.1	21.0	22.6	2636.2

Table B.27 (continued)													
1996	36.4	131.9	50.6	302.7	325.7	798.2	606.5	261.7	71.3	31.9	18.5	22.8	2658.2
1997	50.4	38.1	278.6	139.0	156.5	235.4	552.1	184.8	58.8	34.0	27.1	27.2	1782.0
1998	60.8	18.6	66.7	107.9	101.4	297.3	443.2	190.4	45.6	35.6	26.5	23.4	1417.6
1999	26.1	14.5	176.5	43.7	0.0	0.0	49.0	60.8	17.6	31.6	45.5	18.7	484.0
2000	0.0	0.0	3.6	62.7	273.1	217.0	206.3	0.0	0.0	7.2	39.4	36.5	845.9
Avg.	**47.0**	**83.9**	**184.9**	**229.4**	**303.1**	**460.2**	**410.2**	**255.4**	**79.0**	**38.8**	**28.8**	**27.9**	**179.0**

Table B.28 Monthly Mean Flow Values of 2604 Botan Creek - Billoris SGS (EIE, 2003)

7857.3 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1946	-	-	125.9	127.2	116.6	267.8	715.4	1202.6	777.6	383.0	180.5	114.6	4011.2
1947	190.4	116.6	107.1	135.8	145.2	396.4	515.8	557.1	334.4	169.3	99.6	77.8	2845.5
1948	82.5	161.5	138.5	104.7	130.3	184.5	730.9	1363.3	873.5	358.9	178.6	108.3	4415.7
1949	113.6	127.8	128.8	105.0	107.7	257.1	676.5	1299.0	751.7	273.2	144.1	98.8	4083.2
1950	100.7	92.5	87.6	83.6	86.6	196.1	878.7	1743.6	554.7	511.6	122.7	82.2	4540.5
1951	127.2	91.0	104.5	114.6	96.5	252.3	355.1	412.5	175.2	104.7	91.1	86.6	2011.3
1952	460.7	311.0	119.7	114.9	659.0	468.7	2039.9	1151.7	440.6	217.8	137.1	93.6	6214.8
1953	87.6	80.9	89.7	95.1	193.3	197.1	860.5	1076.7	425.1	135.3	112.0	81.1	3434.4
1954	90.8	102.1	116.0	113.3	109.8	551.8	964.2	1564.2	930.5	423.2	185.1	133.7	5284.7
1955	126.2	118.2	117.6	110.1	106.9	180.3	502.8	701.7	337.0	161.0	102.0	87.1	2650.9
1956	87.6	107.3	150.3	114.6	171.6	261.9	943.5	1092.8	816.5	366.9	177.0	121.0	4411.2
1957	109.0	108.3	121.1	111.4	132.8	417.8	619.5	1087.4	798.3	366.9	174.9	115.1	4162.7
1958	111.4	114.8	117.3	124.0	128.5	377.7	813.9	953.5	580.6	253.9	155.3	115.3	3846.3
1959	118.9	122.6	166.1	137.1	106.0	228.2	938.3	854.4	474.3	200.9	122.1	113.5	3582.5
1960	151.3	116.1	113.0	152.9	183.7	321.4	829.4	1175.8	386.2	211.1	136.9	106.8	3884.7
1961	103.9	119.0	114.6	114.6	102.1	183.7	580.6	889.2	432.9	192.8	112.8	87.6	3033.9
1962	92.9	113.8	139.8	109.8	127.5	332.1	534.0	707.1	466.6	229.0	-	-	2852.6
Avg.	**134.7**	**125.2**	**121.0**	**115.8**	**159.1**	**298.5**	**794.1**	**1049.0**	**562.1**	**268.2**	**139.5**	**101.4**	**322.4**

Table B.29 Monthly Mean Flow Values of 2606 Tigris River - Cizre SGS (EIE, 2003)

38280.7 km^2 Unit: hm^3

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1969	391	897	3102	3252	2540	7213	6402	6380	2247	954	533	430	34340
1970	589	562	801	798	1870	1998	2535	1291	604	340	279	258	11925
1971	324	448	729	455	523	1690	3582	2054	894	407	281	245	11633
1972	442	360	627	455	609	1545	3398	5432	1928	712	418	345	16272
1973	378	575	437	410	951	1232	1866	1931	881	423	289	257	9630
1974	311	477	576	557	559	3230	3590	2121	804	380	263	277	13145
1975	279	381	603	581	1067	1669	2737	2352	879	383	246	235	11411
1976	289	459	629	1701	1857	2344	7107	5177	2424	879	445	347	23657
1977	782	845	1342	836	1282	2194	2968	2611	1091	496	316	277	15040
1978	383	347	996	1390	3276	3169	3442	3019	1483	675	404	342	18926
1979	380	342	919	1730	1367	1805	2499	1971	1073	479	297	280	13143
1980	718	1078	1302	1262	1461	3643	4977	3069	1174	538	348	311	19881
1981	340	516	1007	1286	1993	3351	2926	2692	1459	643	372	314	16899
1982	354	643	919	1187	1321	1851	4676	4363	1511	629	402	334	18189
1983	463	428	418	533	728	1977	2330	2603	998	421	287	267	11452
1984	332	1895	1339	720	1178	2178	2413	1985	1096	506	308	264	14215
1985	303	596	455	723	1439	2199	4279	2585	1045	471	308	251	14654
1986	332	391	608	1018	1379	1685	2107	1797	985	404	254	227	11189
1987	378	881	777	1784	2514	3479	4948	4569	2050	838	396	306	22921
1988	627	1555	4071	2526	2653	4985	7273	5469	2377	1219	528	435	33718

Table B.29 (continued)

1989	640	886	994	670	513	1495	1371	879	384	236	202	202	8471
1990	354	1423	2531	1109	1981	2164	3224	2619	1288	536	292	250	17771
1991	356	648	557	485	1190	3308	2802	2038	638	300	210	193	12725
1992	351	586	1015	838	1468	2491	4505	4058	2120	860	391	280	18963
1993	329	622	1106	991	1519	2665	4912	6701	2613	1219	696	394	23768
1994	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	157	135	182	-	-	-	-	-	-	-	171	136	-
1999	316	345	522	423	629	978	2768	1334	477	340	238	224	8594
2000	340	248	281	442	1112	1433	2545	1655	614	380	284	301	9637
Avg.	**401**	**663**	**1030**	**1043**	**1444**	**2517**	**3636**	**3065**	**1301**	**580**	**338**	**285**	**1359**

Table B.30 Monthly Mean Flow Values of 2611 Tigris River - Rezuk SGS (EIE, 2003)

34493.1 km^2 Unit: hm^3

Year	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	Total
1955	-	-	-	-	-	1361	1721	2199	671	319	207	187	6665
1956	202	337	1334	1235	1629	2325	3390	3035	1529	584	303	228	16130
1957	234	262	429	410	1253	3252	1918	4109	1602	680	399	319	14865
1958	337	422	597	1125	975	2175	2589	1746	889	407	254	205	11723
1959	207	252	632	838	474	1117	2385	1859	832	362	215	181	9353
1960	257	303	337	1055	782	1653	2680	2129	674	281	237	150	10539
1961	200	290	289	530	498	745	1516	1500	539	265	196	173	6743
1962	192	518	1401	627	1251	1562	1807	1489	671	303	187	155	10162
1963	-	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	3131	2713	1265	458	292	232	8091
1965	240	622	482	504	1026	1963	3092	2906	1301	439	243	202	13020
1966	838	801	1361	3083	2018	1741	3186	2526	1115	487	300	272	17727
1967	372	386	870	1251	1072	2858	4450	5777	1856	761	394	321	20369
1968	434	1770	2569	2877	1884	4387	5350	4227	1812	707	418	316	26750
1969	-	-	-	-	-	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-	-	-	-	-	-
1972	370	311	530	418	526	1296	3157	4727	1612	570	348	277	14144
1973	324	474	356	335	835	1071	1687	1765	783	356	214	191	8392
1974	257	428	498	469	491	2901	3243	1859	702	311	209	226	11593
1975	209	306	485	496	970	-	-	-	-	-	-	-	2465
Avg.	**311**	**499**	**811**	**1017**	**1046**	**2027**	**2831**	**2785**	**1116**	**456**	**276**	**227**	**1117**

APPENDIX C

THE GARZAN PROJECTS AND ILISU I DAM AND HEPP

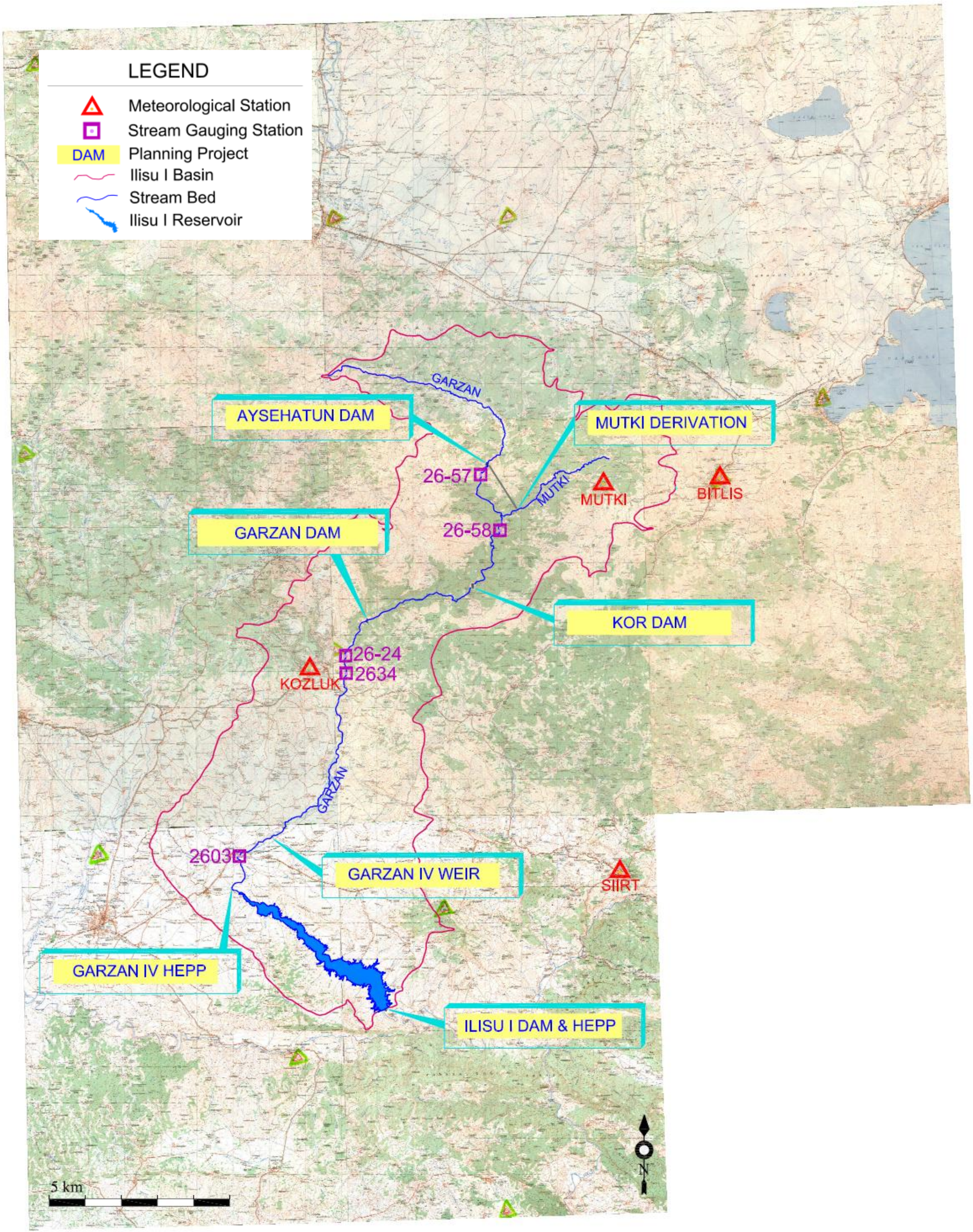


Figure C.1 Project Area and Hydro-Meteorological Stations on 1/100000 Scale Topographic Maps

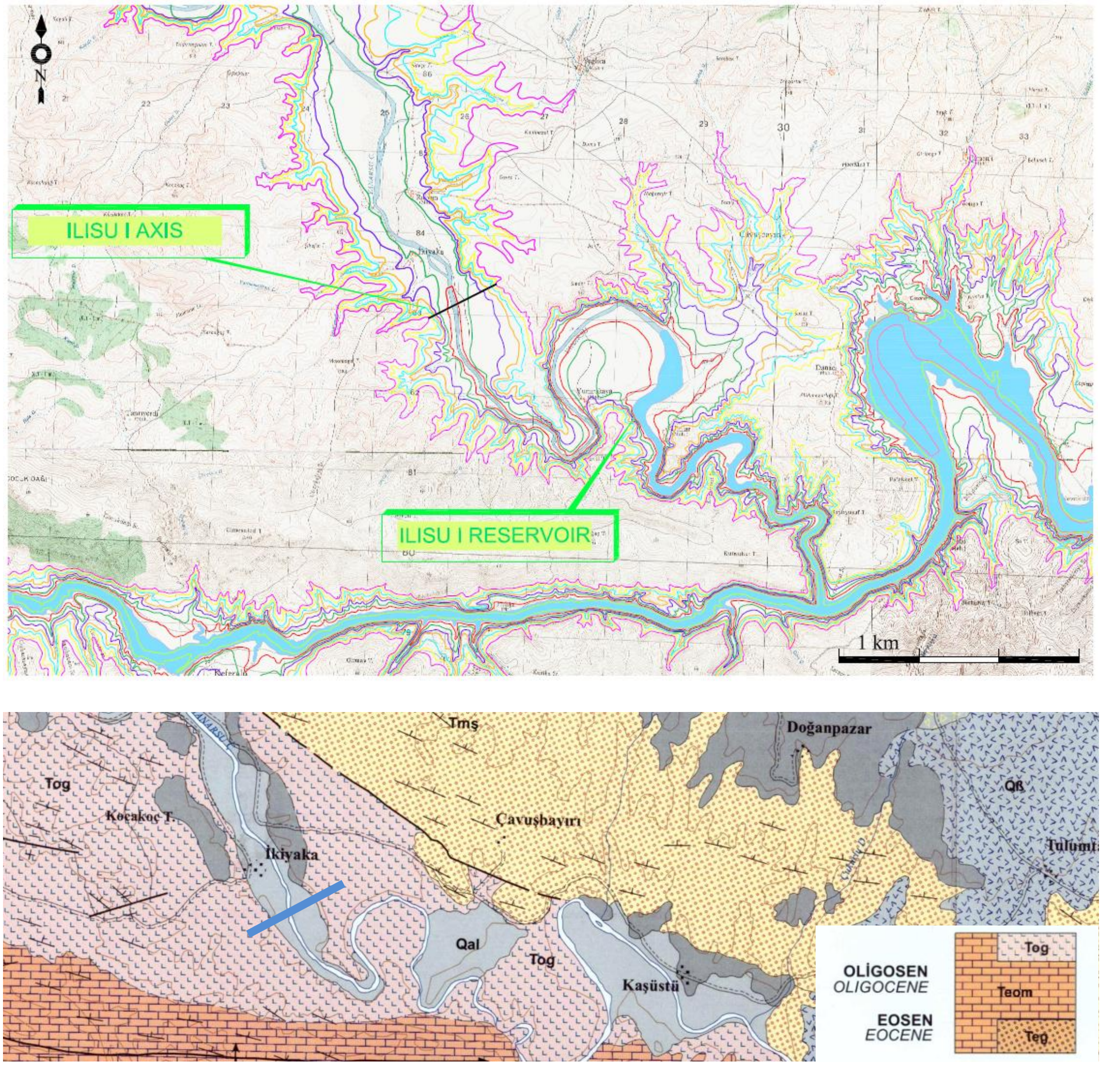


Figure C.2 Ilisu I Dam Location (MTA, 2007)

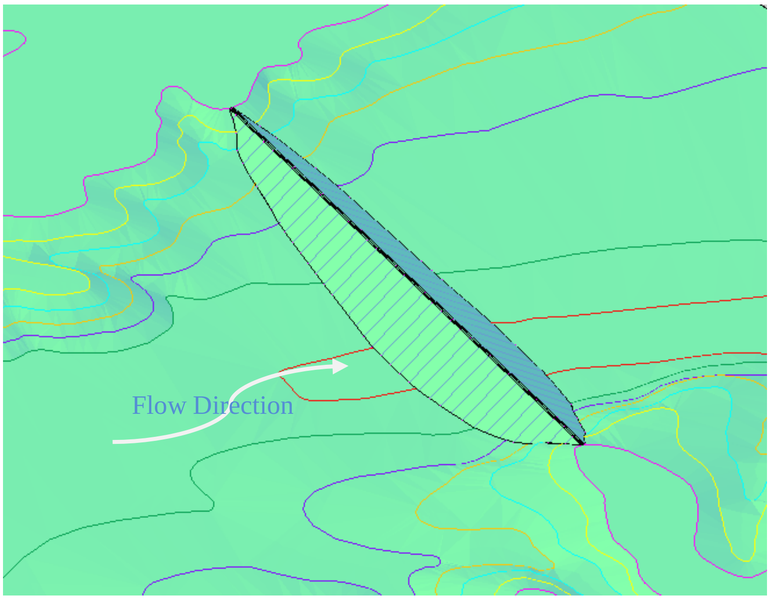


Figure C.3 Representative View of Ilisu I Dam Body

C.1. Dam Characteristics

Table C.1 Characteristics of the Projects Upstream of Ilisu I Dam and HEPP

Characteristics	Unit	**Aysehatun**	**Kor**	**Garzan**
Purpose	-	Energy	Energy	Energy
Drainage Area	km^2	405.0	942.2	1266.0
Thalwag Elevation	m	1180.0	895.0	675.5
Maximum Water Level	m	1250.0	930.0	788.3
Minimum Water Level	m	1230.0	956.0	757.7
Tailwater Level	m	950.0	830.0	676.0
Design Discharge	m^3/s	13.36	26.54	43.60
Penstock: Number/Diameter/Length	-/m/m	1/2.3/250	1/2.5/210	1/3.2/210
Energy Tunnel: Number/Diameter/Length	-/m/m	1/3.5/8410	1/3.3/6370	1/4.0/382
Number of Units	-	2	2	2
Gross Head/Net Head	m/m	300.0/282.0	126.0/109.9	112.3/108.6
Turbine Type	-	Francis	Francis	Francis

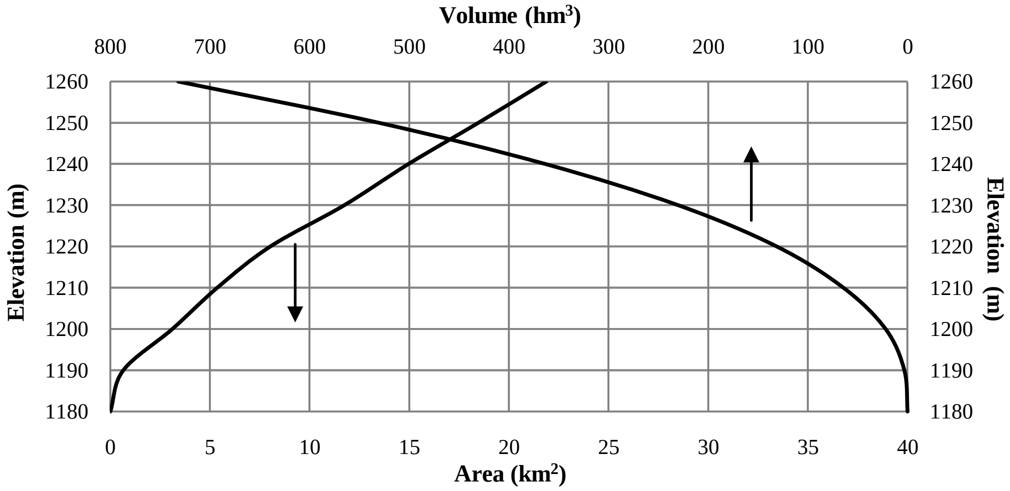


Figure C.4 Volume-Area Curve of Aysehatun Reservoir

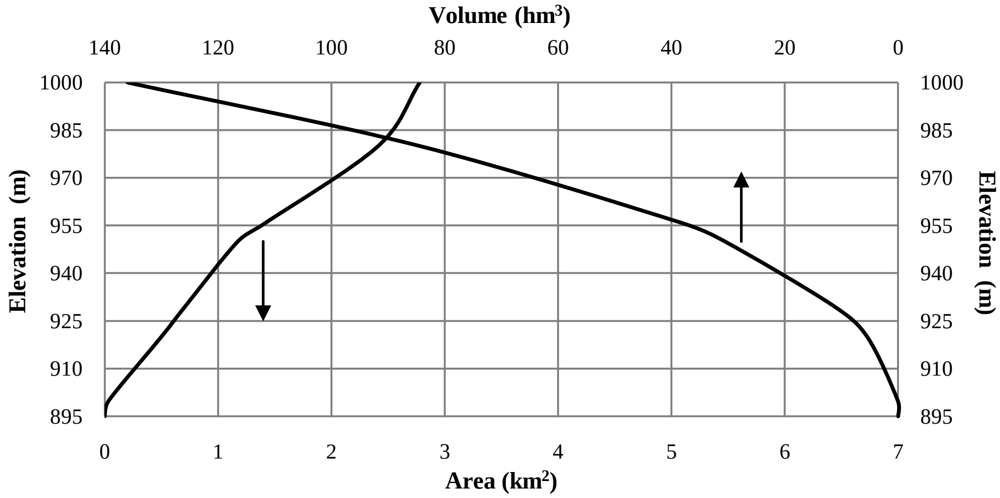


Figure C.5 Volume-Area Curve of Kor Reservoir

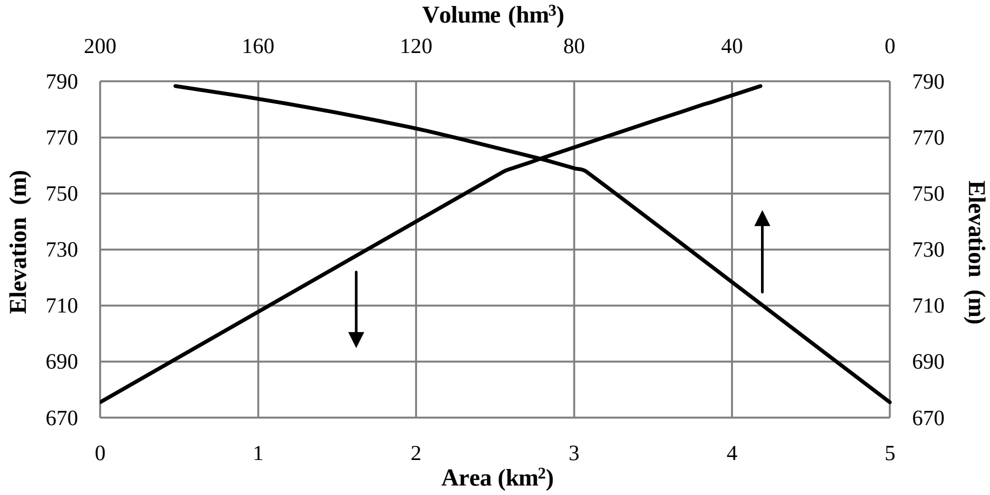


Figure C.6 Volume-Area Curve of Garzan Reservoir

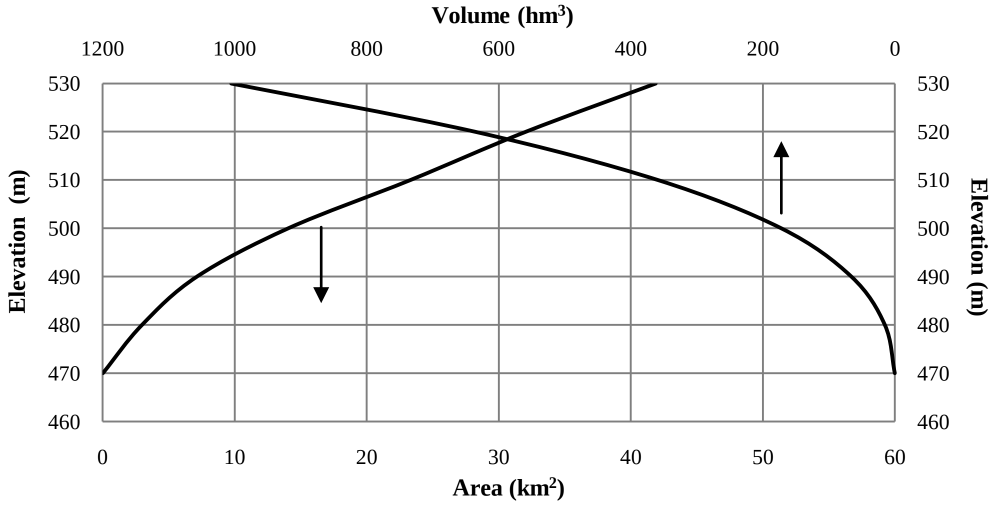


Figure C.7 Volume-Area Curve of Ilisu I Reservoir

C.2. Estimated Evaporation Rates

Table C.2 Monthly Total Net Evaporation Values of Aysehatun Reservoir

Months	Bitlis MS Temp. (°C)	Bitlis MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Mutki MS Precip. (mm)	**Net Evap. (mm)**
Jan.	-3.0	-	-1.5	-	-	142.3	-
Feb.	-2.2	-	-0.7	-	-	121.2	-
Mar.	1.5	-	3.0	10.4	7.3	171.6	-
Apr.	7.8	69.0	9.3	57.1	40.0	175.1	-
May	13.1	103.6	14.6	111.5	78.0	93.5	-
Jun.	18.5	148.5	20.0	178.8	125.1	27.7	**97.4**
Jul.	22.9	199.2	24.4	240.4	168.2	3.0	**165.2**
Aug.	22.3	193.8	23.8	231.9	162.3	1.7	**160.6**
Sep.	17.6	150.8	19.1	167.0	116.9	13.7	**103.2**
Oct.	11.2	75.4	12.7	90.6	63.4	87.1	-
Nov.	4.5	13.8	6.0	29.2	20.5	143.1	-
Dec.	-0.7	-	0.8	1.4	1.0	130.5	-
Σ	-	954.0	-	1118.2	782.8	1110.6	**526.5**

Table C.3 Monthly Total Net Evaporation Values of Kor Reservoir

Months	Bitlis MS Temp. (°C)	Bitlis MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Mutki MS Precip. (mm)	**Net Evap. (mm)**
Jan.	-3.0	-	0.0	-	-	142.3	-
Feb.	-2.2	-	0.8	-	-	121.2	-
Mar.	1.5	-	4.5	18.9	13.2	171.6	-
Apr.	7.8	69.0	10.8	71.1	49.8	175.1	-
May	13.1	103.6	16.1	128.7	90.1	93.5	-
Jun.	18.5	148.5	21.5	198.8	139.1	27.7	**111.5**
Jul.	22.9	199.2	25.9	262.4	183.7	3.0	**180.7**
Aug.	22.3	193.8	25.3	253.7	177.6	1.7	**175.8**
Sep.	17.6	150.8	20.6	186.6	130.6	13.7	**116.9**
Oct.	11.2	75.4	14.2	106.7	74.7	87.1	-
Nov.	4.5	13.8	7.4	40.7	28.5	143.1	-
Dec.	-0.7	-	2.3	6.8	4.8	130.5	-
Σ	-	954.0	-	1274.3	892.0	1110.6	**584.9**

Table C.4 Monthly Total Net Evaporation Values of Garzan Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Kozluk MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	3.4	-	-	141.3	-
Feb.	4.1	-	4.7	-	-	162.7	-
Mar.	8.3	-	8.8	40.9	28.6	135.5	-
Apr.	14.0	83.5	14.5	99.7	69.8	103.4	-
May	19.3	185.6	19.9	174.0	121.8	74.7	**47.1**
Jun.	25.9	282.6	26.4	290.0	203.0	13.9	**189.1**
Jul.	30.4	371.8	31.0	384.9	269.4	0.5	**268.9**
Aug.	29.9	356.2	30.4	372.8	261.0	1.0	**259.9**
Sep.	25.0	258.8	25.6	273.1	191.1	2.1	**189.1**
Oct.	17.8	139.4	18.3	150.8	105.6	55.6	**50.0**
Nov.	10.1	54.3	10.6	57.0	39.9	111.5	-
Dec.	4.7	13.5	5.3	16.4	11.5	154.8	-
Σ	-	1745.8	-	1859.5	1301.7	956.8	**1004.2**

Table C.5 Monthly Total Net Evaporation Values of Ilisu I Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Siirt MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	4.7	-	-	81.5	-
Feb.	4.1	-	6.0	-	-	102.1	-
Mar.	8.3	-	10.1	52.2	36.5	110.3	-
Apr.	14.0	83.5	15.8	116.1	81.3	99.9	-
May	19.3	185.6	21.1	194.7	136.3	64.5	**71.7**
Jun.	25.9	282.6	27.7	315.7	221.0	9.4	**211.6**
Jul.	30.4	371.8	32.3	413.9	289.8	2.5	**287.3**
Aug.	29.9	356.2	31.7	401.5	281.1	1.3	**279.8**
Sep.	25.0	258.8	26.9	298.2	208.7	2.8	**205.9**
Oct.	17.8	139.4	19.6	170.3	119.2	50.7	**68.5**
Nov.	10.1	54.3	11.9	70.0	49.0	85.1	-
Dec.	4.7	13.5	6.6	24.2	16.9	94.4	-
Σ	-	1745.8	-	2056.8	1439.7	704.5	**1124.8**

C.3. Water Resources

C.3.1. Stream Gauging Stations

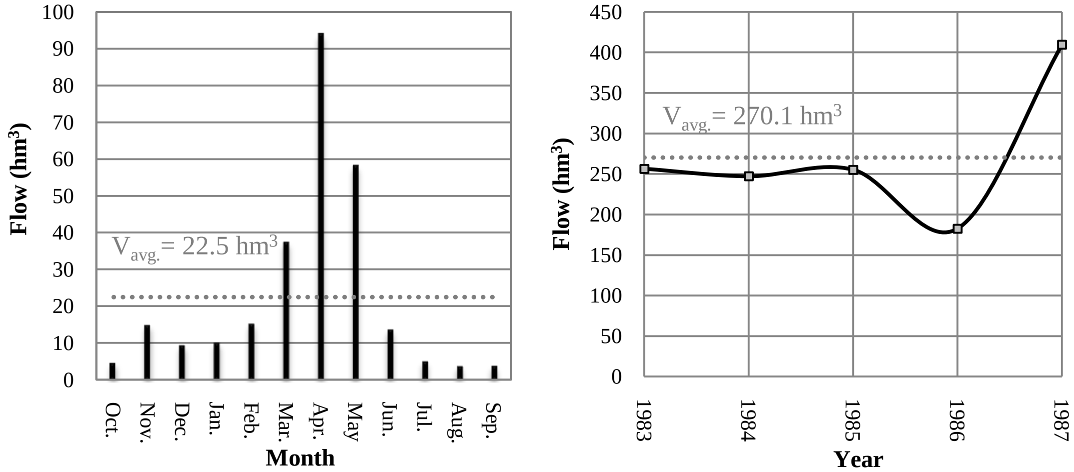


Figure C.8 Monthly Mean and Annual Total Flow Values Measured in 26-57 SGS

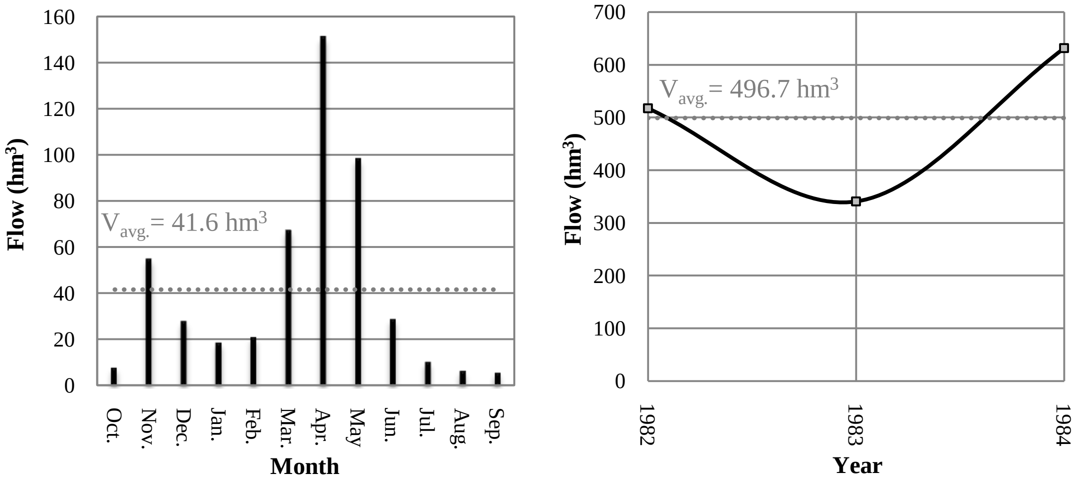


Figure C.9 Monthly Mean and Annual Total Flow Values Measured in 26-58 SGS

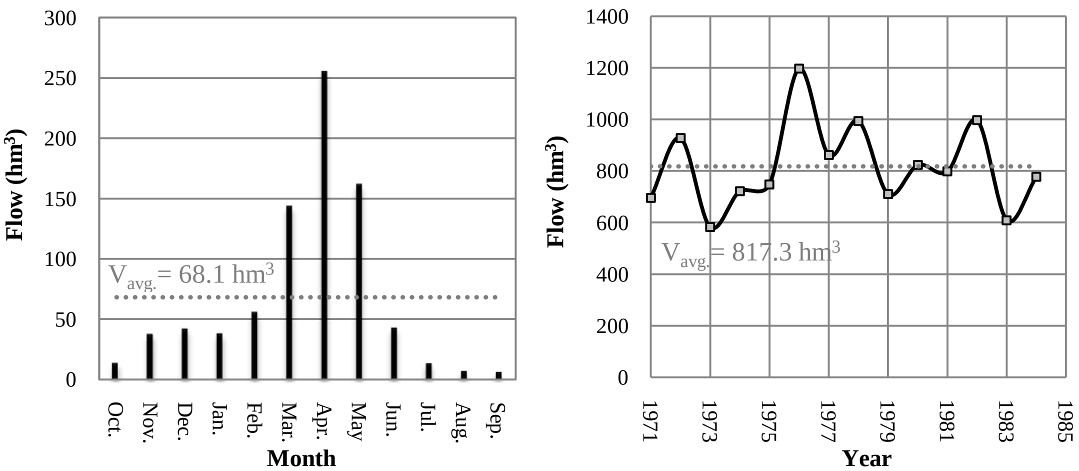


Figure C.10 Monthly Mean and Annual Total Flow Values Measured in 26-24 SGS

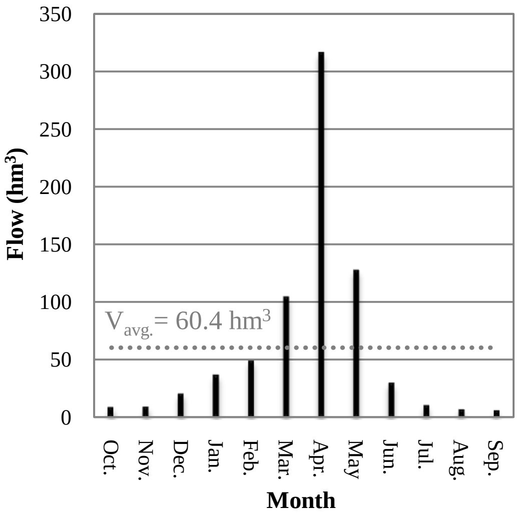
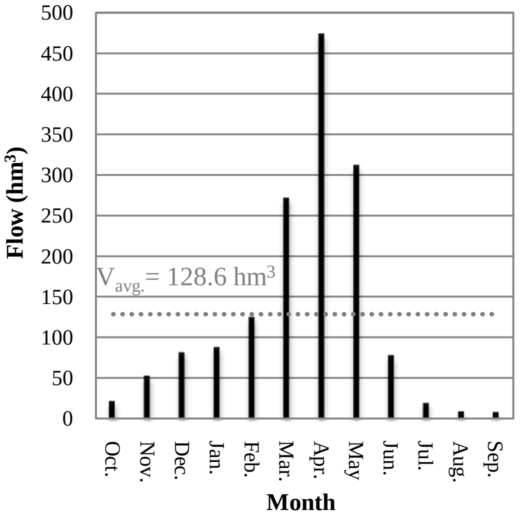


Figure C.11 Monthly Mean Flow Values Measured in 2634 SGS



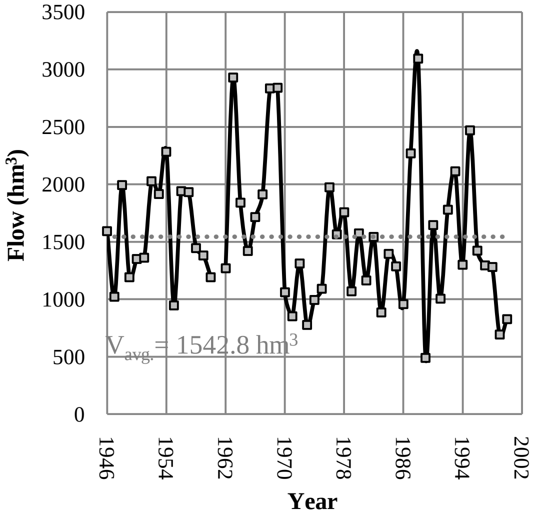


Figure C.12 Monthly Mean and Annual Total Flow Values Measured in 2603 SGS

Table C.6 Water Demand Pattern of Garzan - Kozluk Irrigation (Enersu, December 2008)

Net Irrigation Area: 3362 ha

Months	Irrigation Water Pattern (hm^3)
October	0.1
November	0.0
December	0.0
January	0.0
February	0.0
March	0.0
April	0.8
May	1.9
June	2.6
July	9.6
August	7.1
September	4.2
Total	26.2

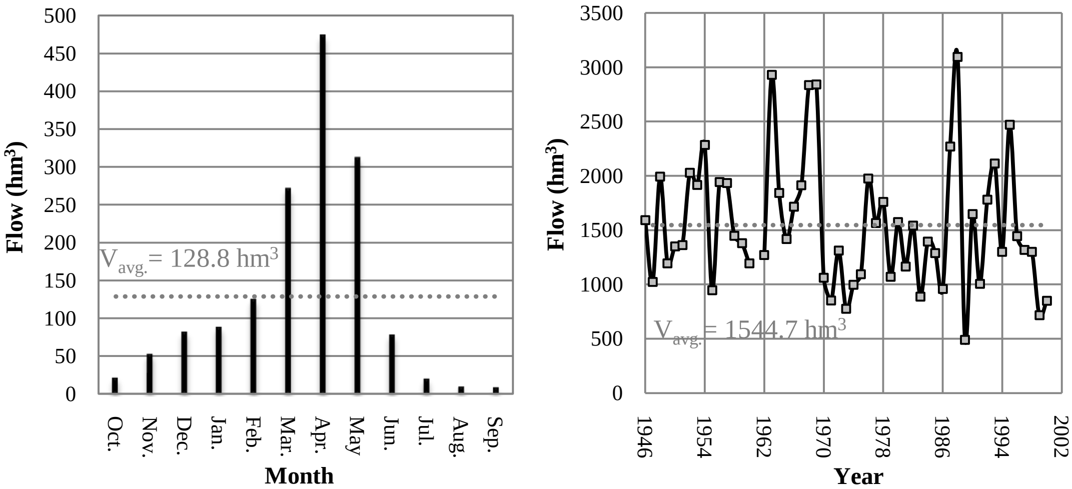


Figure C.13 Corrected Monthly Mean and Annual Total Flow Values of 2603 SGS

C.3.2. Correlation Studies

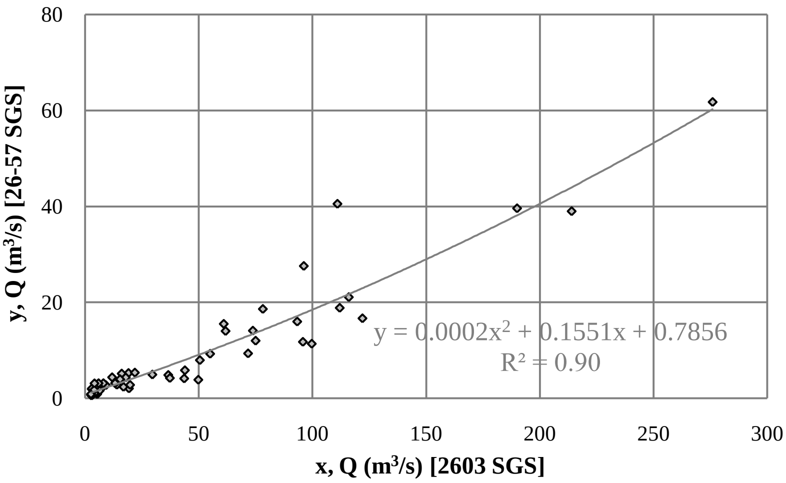


Figure C.14 Monthly Mean Discharge Correlation between 26-57 SGS and 2603 SGS

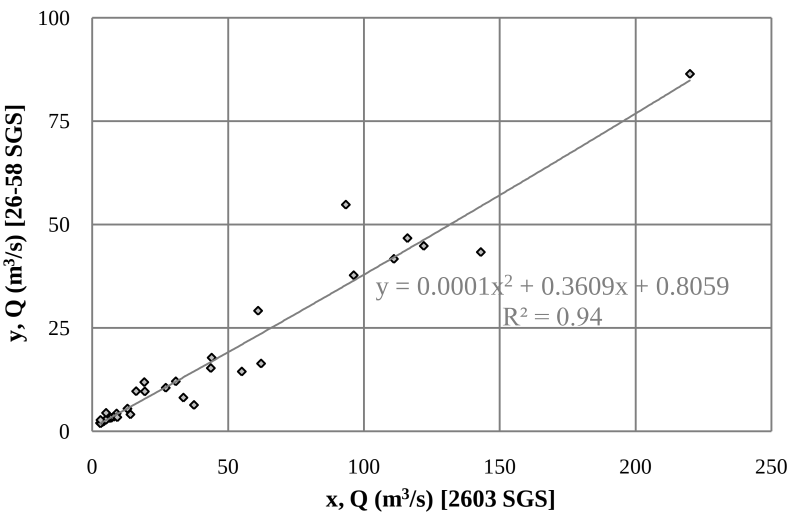


Figure C.15 Monthly Mean Discharge Correlation between 26-58 SGS and 2603 SGS

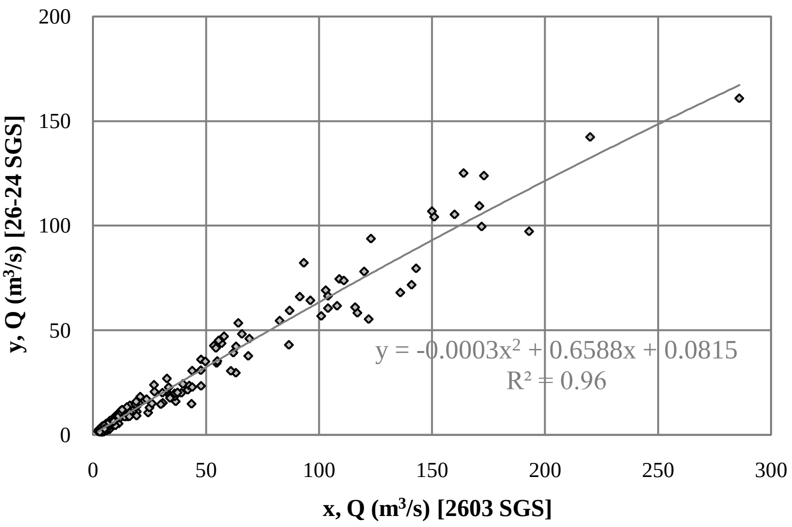
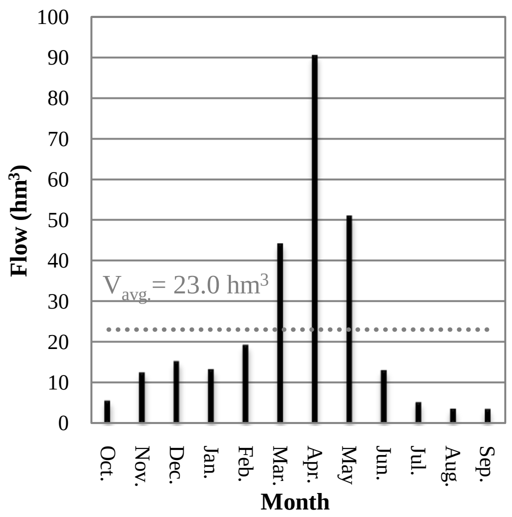


Figure C.16 Monthly Mean Discharge Correlation between 26-24 SGS and 2603 SGS



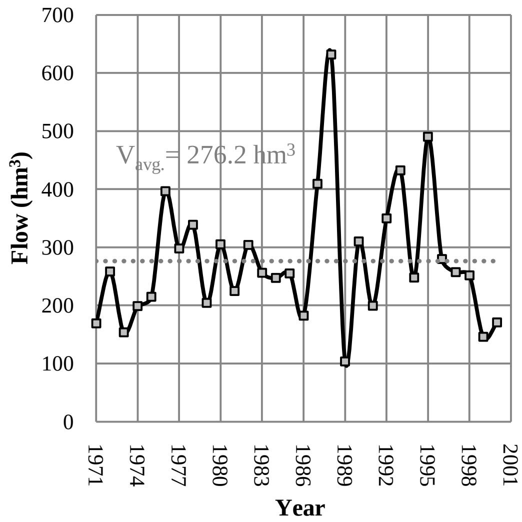
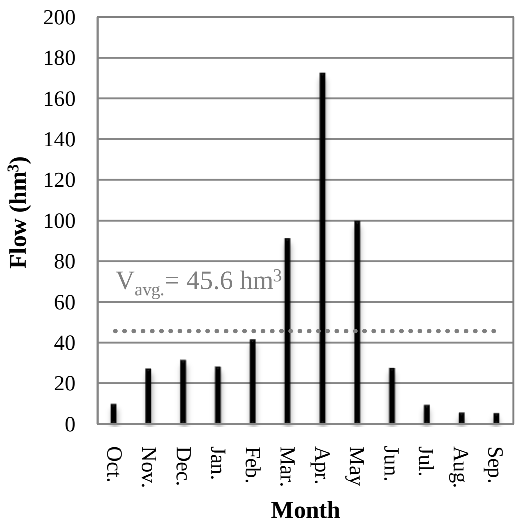


Figure C.17 Extended Monthly Mean and Annual Total Flow Values of 26-57 SGS



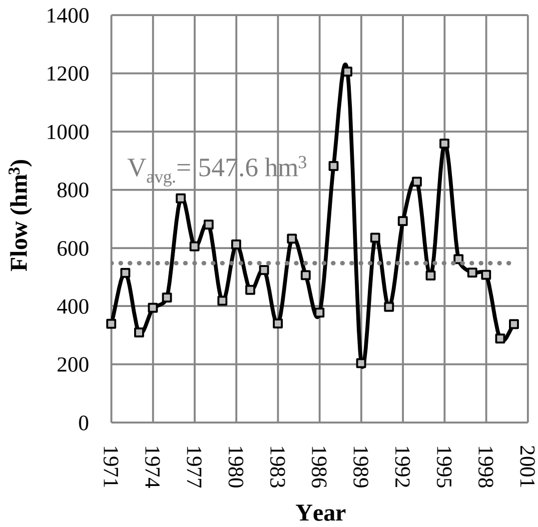


Figure C.18 Extended Monthly Mean and Annual Total Flow Values of 26-58 SGS

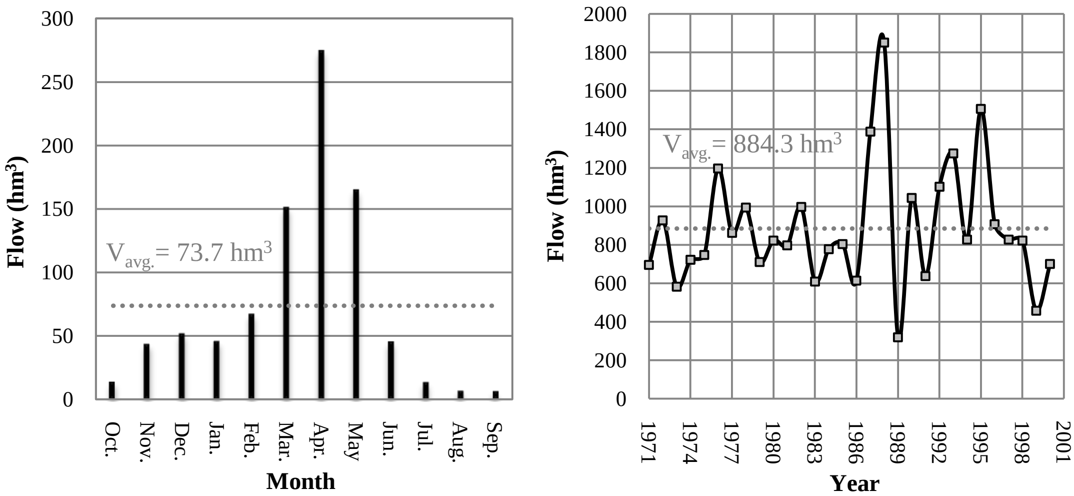


Figure C.19 Extended Monthly Mean and Annual Total Flow Values of 26-24 SGS

C.3.3. Monthly Mean Flow Calculations

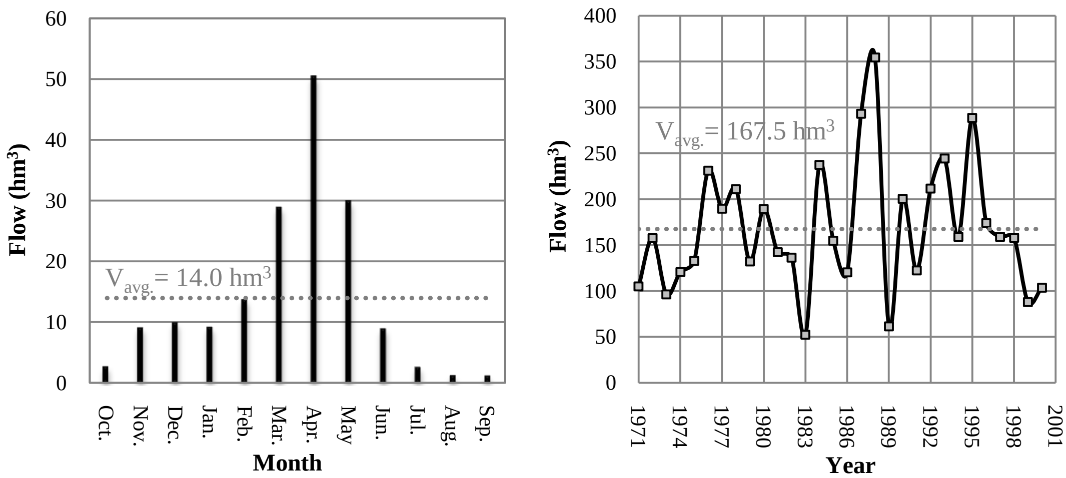


Figure C.20 Monthly Mean and Annual Total Flow Values at Mutki Weir

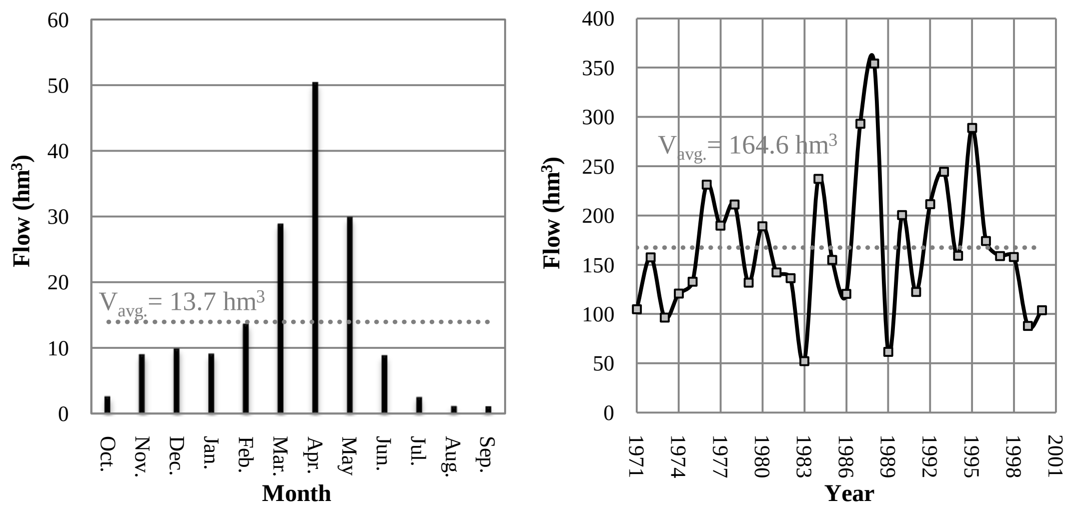


Figure C.21 Monthly Mean and Annual Total Flow Values of the Diversion to Aysehatun Dam by Mutki Weir with a 25.74 m^3/s Capacity Transmission Canal

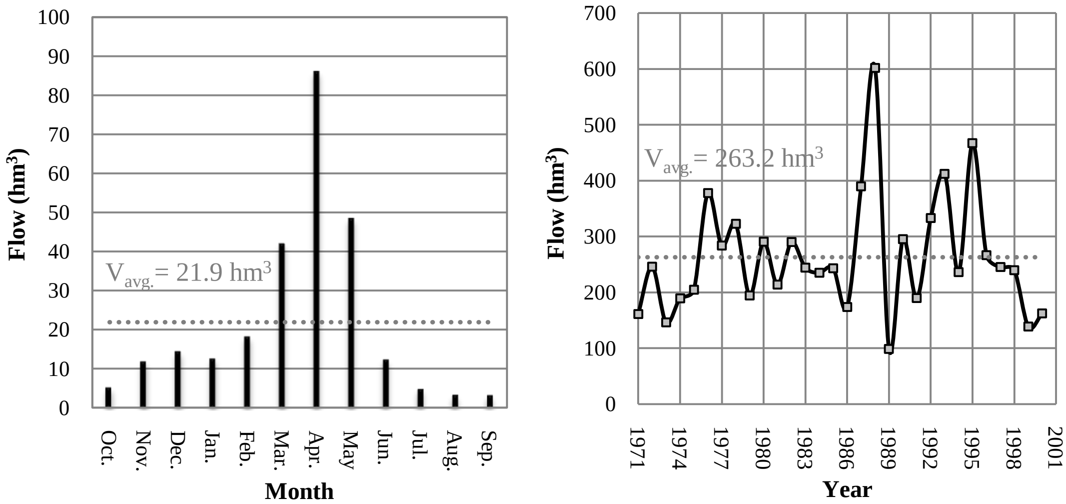


Figure C.22 Monthly Mean and Annual Total Flow Values at Aysehatun Dam

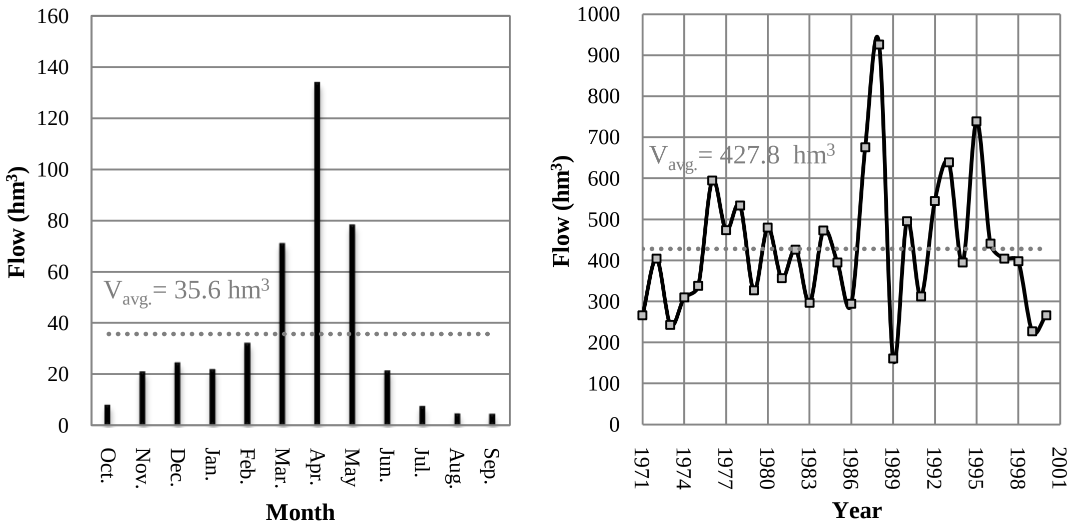


Figure C.23 Monthly Mean and Annual Total Inflow Values at Aysehatun Dam with the Development of Mutki Derivation

Table C.7 Monthly Mean Flow Values Released to Downstream of Aysehatun Dam

Months	Flow Released to Downstream (hm^3)
October	0.5
November	1.1
December	1.2
January	1.3
February	1.9
March	4.4
April	9.2
May	4.8
June	1.2
July	0.5
August	0.3
September	0.3
Total	26.9

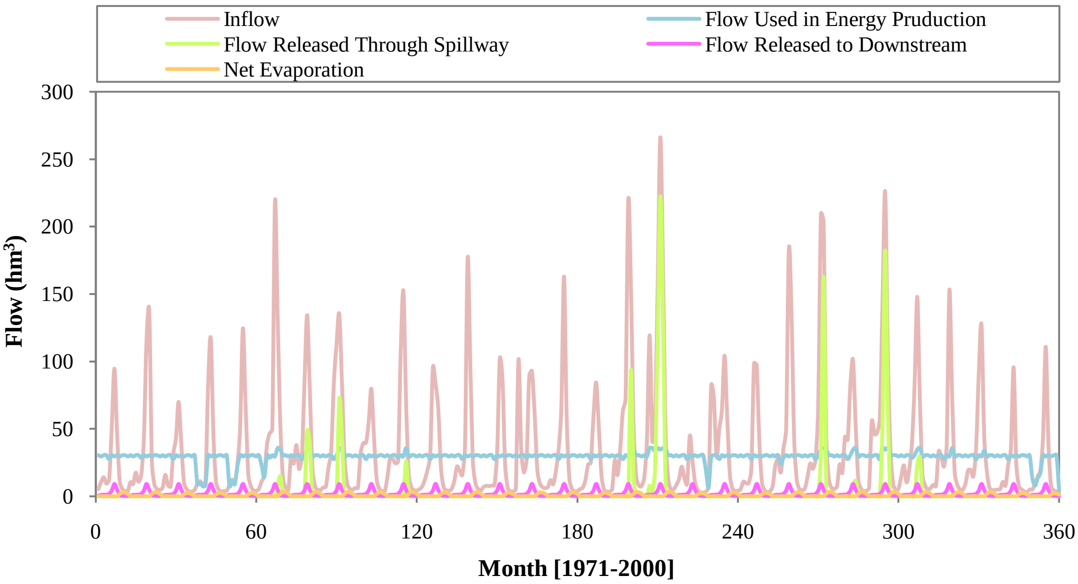


Figure C.24 Operation Study of Aysehatun Dam and HEPP

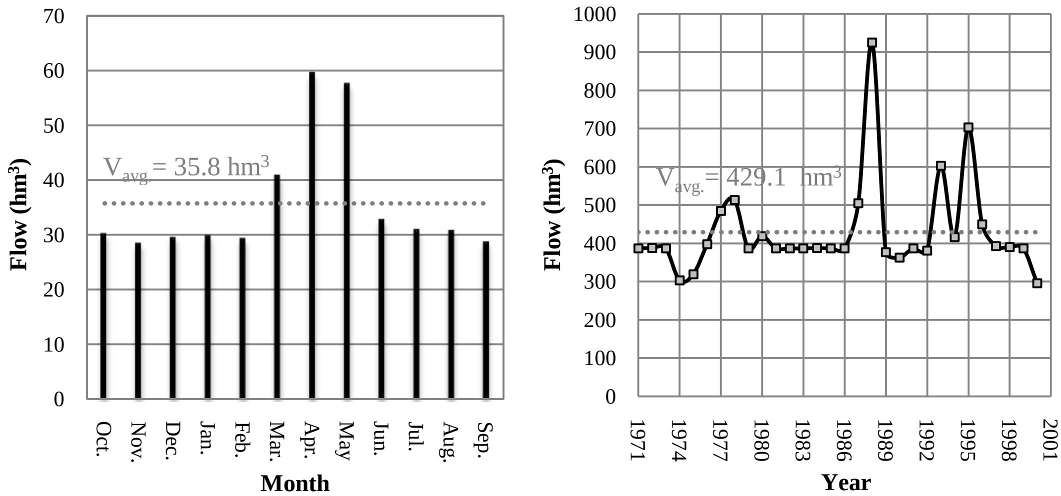


Figure C.25 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Aysehatun Reservoir

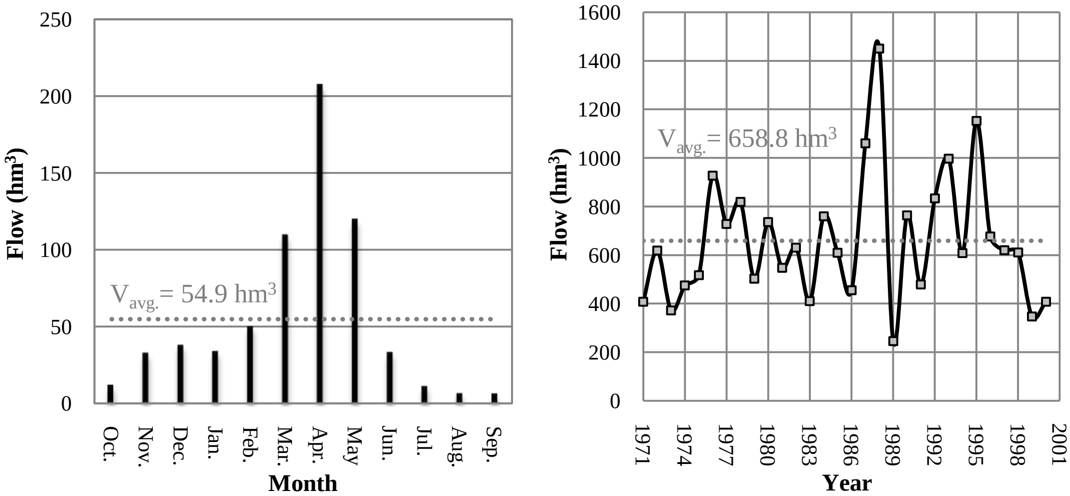


Figure C.26 Monthly Mean and Annual Total Flow Values at Kor Dam

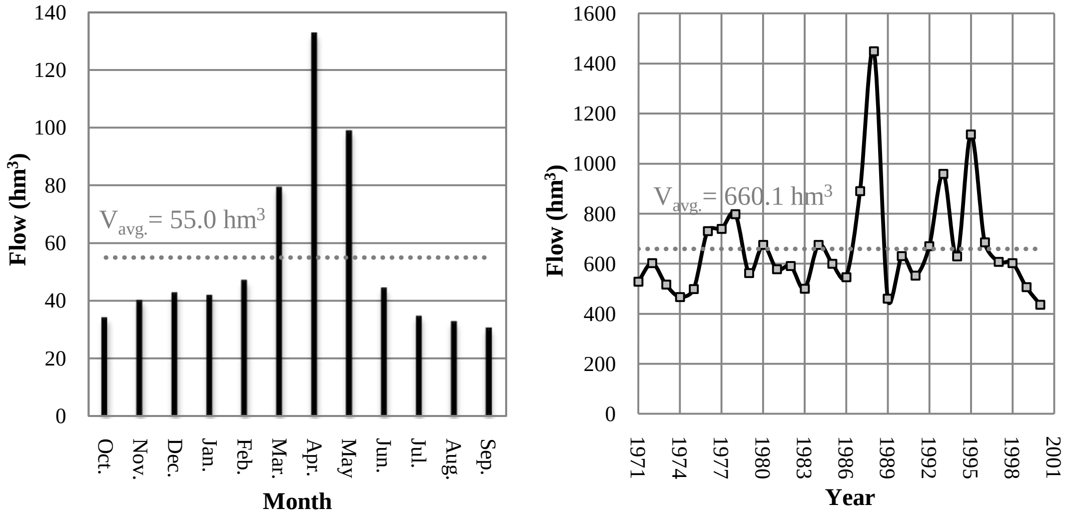


Figure C.27 Monthly Mean and Annual Total Inflow Values in the Operation Study of Kor Reservoir

Table C.8 Monthly Mean Flow Values Released to Downstream of Kor Dam

Months	Flow Released to Downstream (hm^3)
October	1.1
November	2.9
December	3.2
January	3.5
February	5.0
March	11.3
April	22.5
May	12.2
June	3.2
July	1.1
August	0.6
September	0.7
Total	67.3

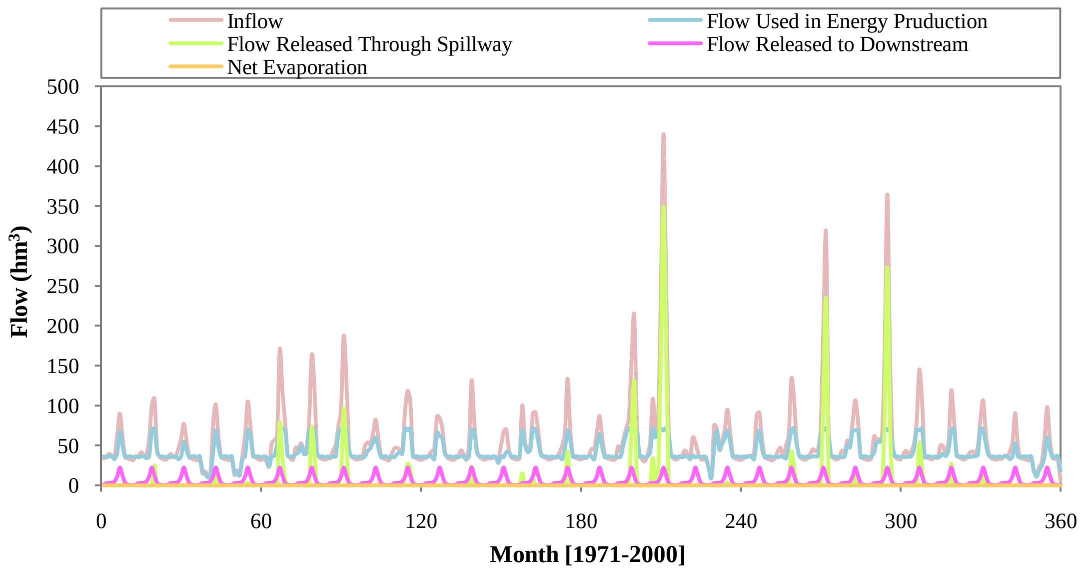


Figure C.28 Operation Study of Kor Dam and HEPP

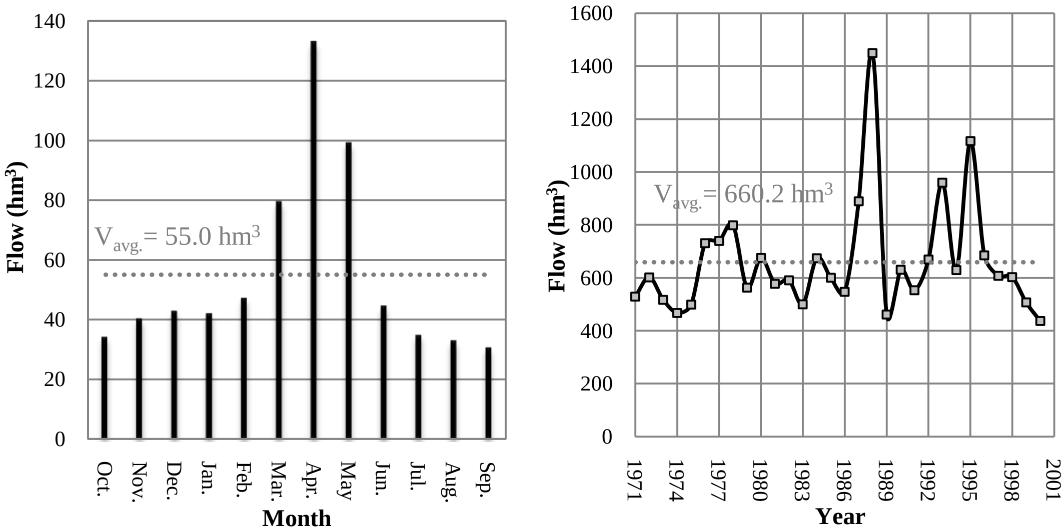


Figure C.29 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Kor Reservoir

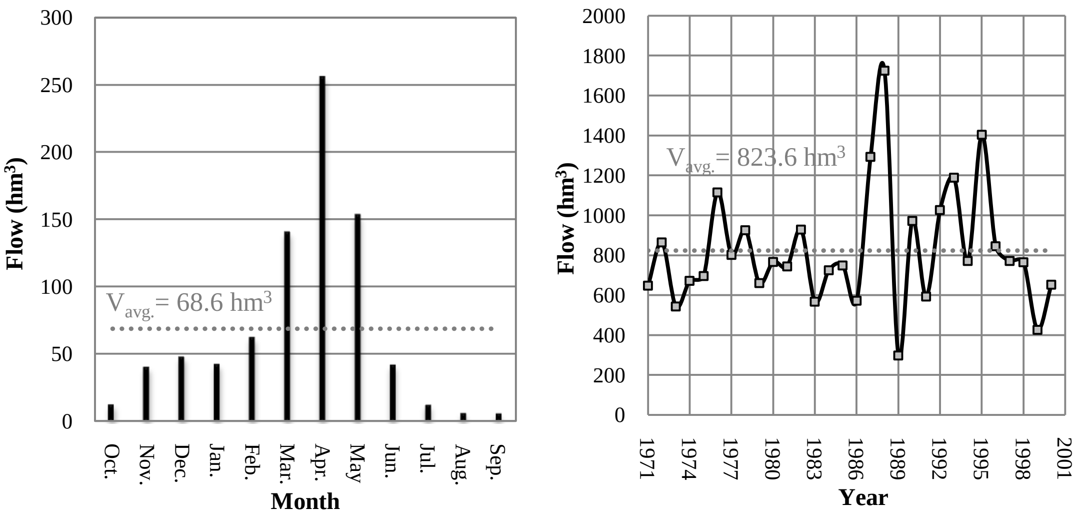


Figure C.30 Monthly Mean and Annual Total Flow Values at Garzan Dam

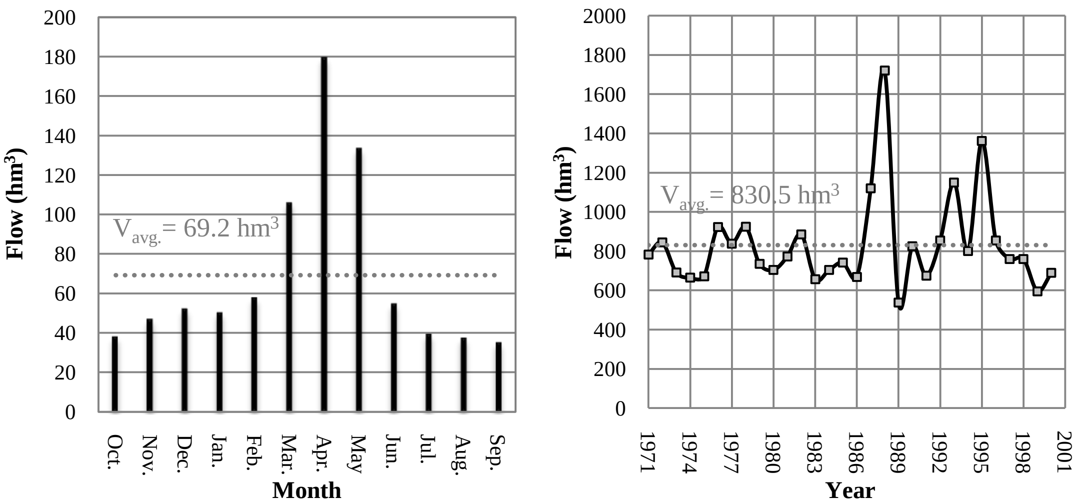


Figure C.31 Monthly Mean and Annual Total Inflow Values in the Operation Study of Garzan Reservoir

Table C.9 Water Demand Pattern of Garzan Irrigation (FPGA, 1968)

Net Irrigation Area: 60000 ha

Months	Irrigation Water Pattern (hm^3)
October	3.1
November	0.0
December	0.0
January	0.0
February	0.0
March	0.0
April	0.1
May	10.8
June	37.8
July	70.7
August	61.8
September	30.9
Total	215.1

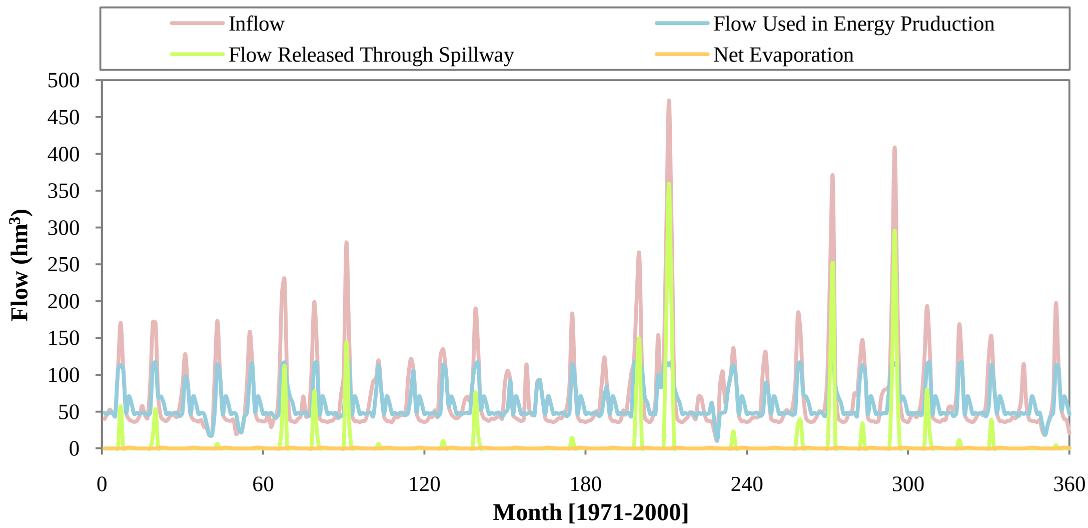


Figure C.32 Operation Study of Garzan Dam and HEPP

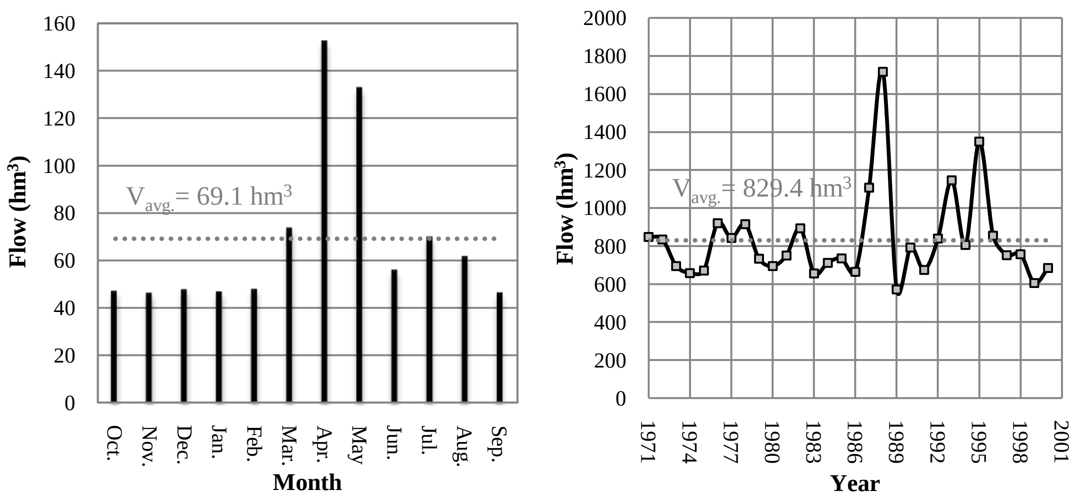


Figure C.33 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Garzan Reservoir

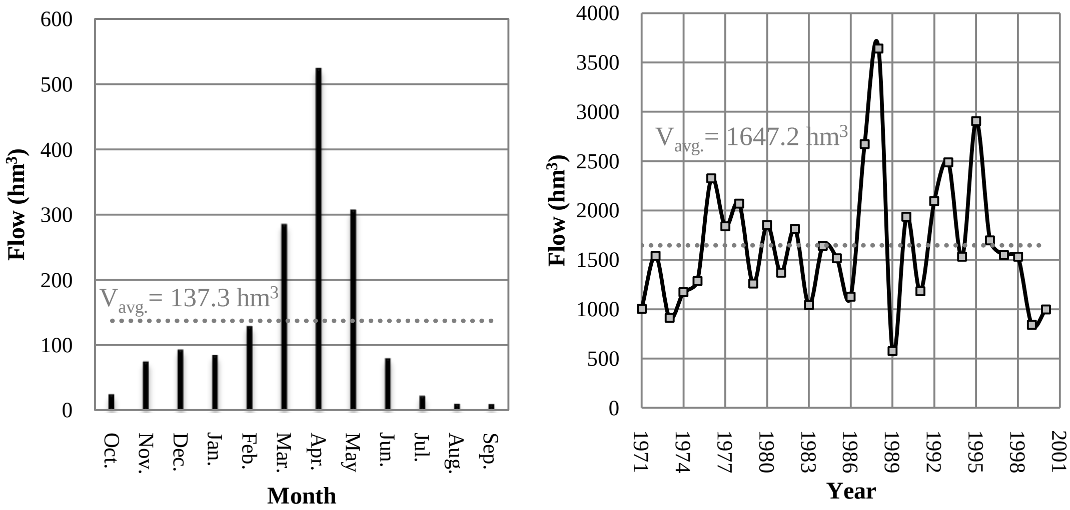


Figure C.34 Monthly Mean and Annual Total Flow Values at Ilisu I Dam

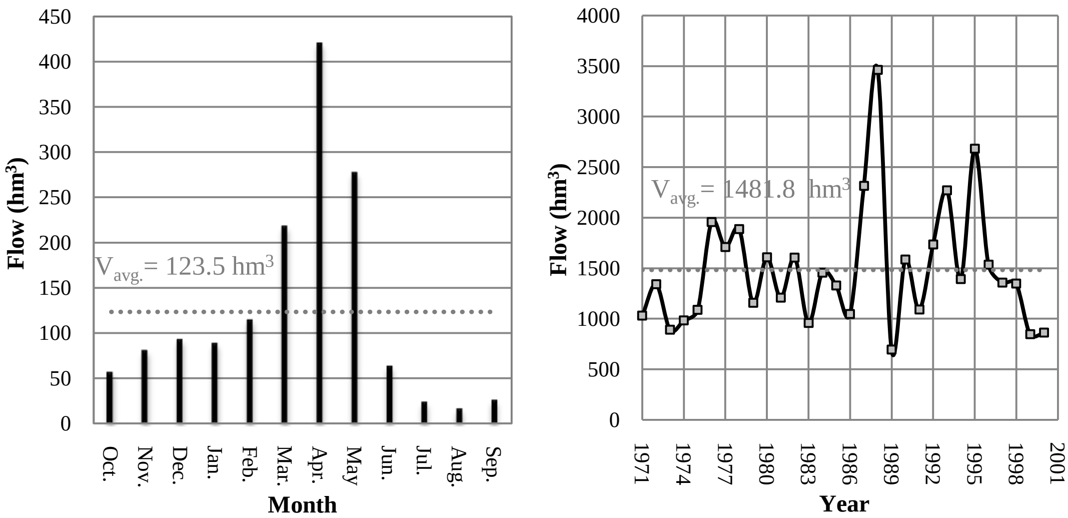


Figure C.35 Monthly Mean and Annual Total Inflow Values in the Operation Study of Ilisu I Reservoir

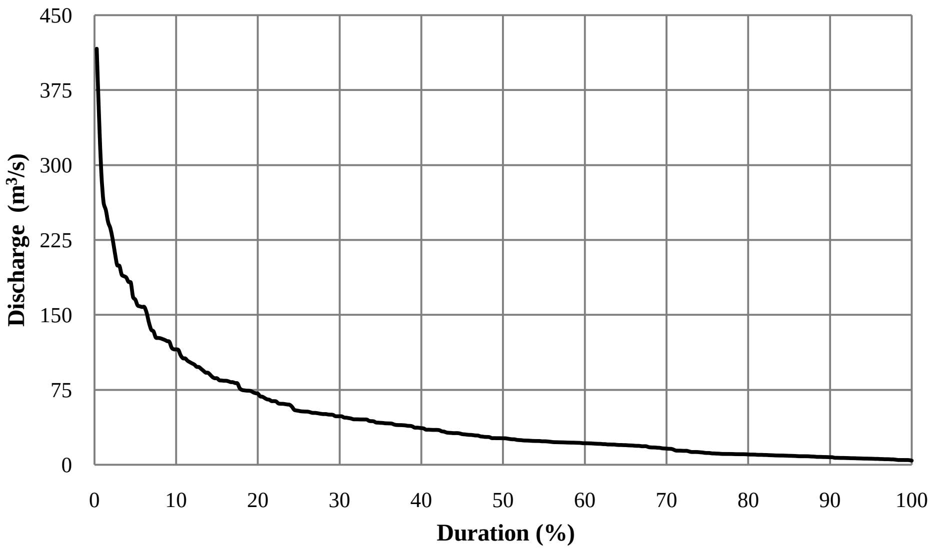


Figure C.36 Discharge-Duration Curve of Ilisu I Dam and HEPP

C.4. Sediment Transport

Table C.10 Sedimentation of Ilisu I Reservoir (EIE, 2000)

Sediment Gauging Station	2603 Garzan Creek - Besiri	
Catchment Area of SGS	2450.4 km^2	
Unit Volume Weight of Sediment	1.35 t/m^3	
Sediment Type Distribution	Clay + Silt: 38.7%	Sand: 61.3%
Suspended Sediment Load	281 $t/year/km^2$	208 $m^3/year/km^2$
Bed Load (%50 of Suspended Sediment Load)	141 $t/year/km^2$	104 $m^3/year/km^2$
Total Sediment Load	422 $t/year/km^2$	312 $m^3/year/km^2$
Catchment Area of Ilisu I Dam	2883.0 km^2	
Catchment Area of Garzan Dam	1266.0 km^2	
Area Contributing to Sediment Transport	1617.0 km^2	
Economic Lifetime Period	50 year	
Volume of Sediment	25 hm^3	
Selected Minimum Water Level	485 m	

C.5. Operation Studies

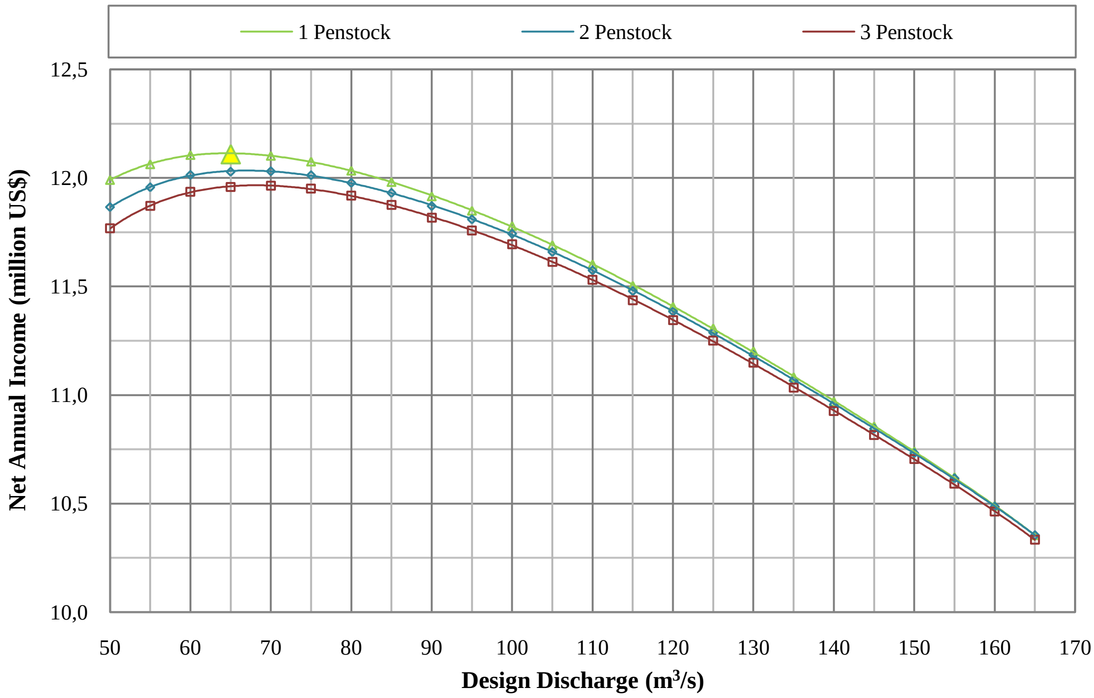


Figure C.37 Determination of Optimum Design Discharge for Ilisu I HEPP

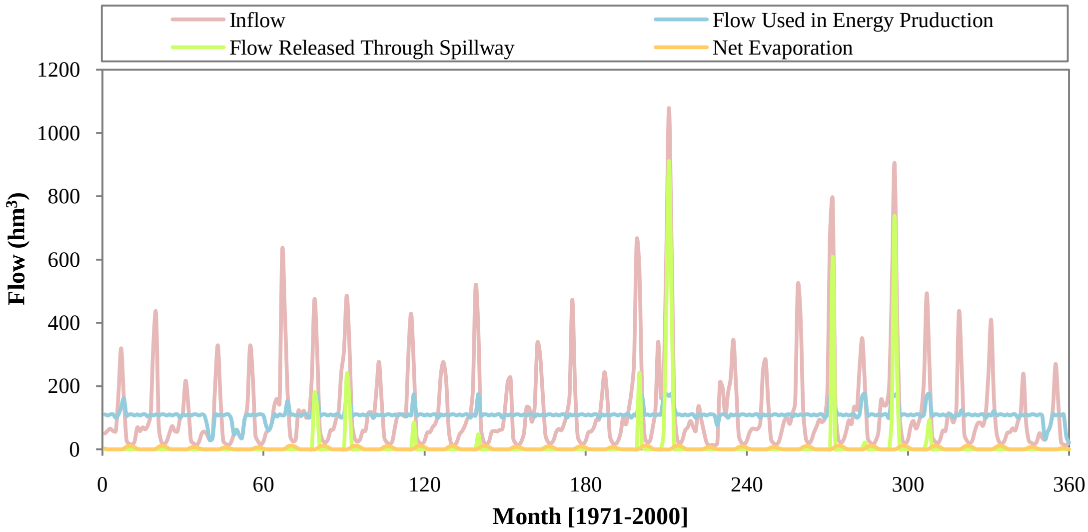


Figure C.38 Operation Study of Ilisu I Dam and HEPP

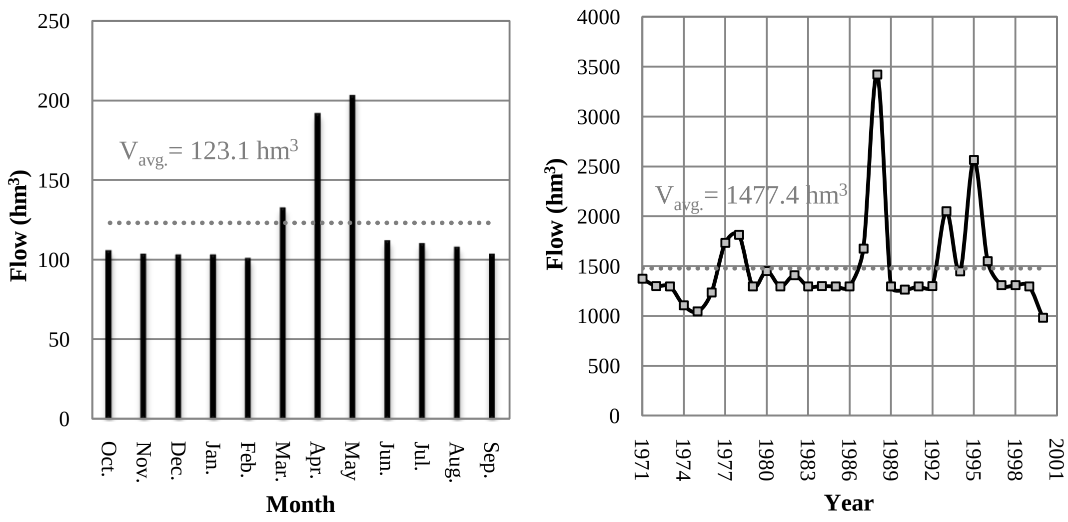


Figure C.39 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Ilisu I Reservoir

C.6. Flood Analysis

C.6.1. Calculation of Design Floods from Observed Runoff

Table C.11 Annual Instantaneous Max. Flows Observed in the Vicinity of Project Area (EIE 2005)

Year	2603 SGS		2610 SGS		2616 SGS		2624 SGS	
	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)
1946	29.3	376.0	-	-	-	-	-	-
1947	15.3	304.0	-	-	-	-	-	-
1948	22.4	673.0	-	-	-	-	-	-
1949	19.4	383.0	-	-	-	-	-	-
1950	15.5	448.0	-	-	-	-	-	-
1951	26.4	379.0	-	-	-	-	-	-
1952	4.2	448.0	-	-	-	-	-	-
1953	14.4	793.0	-	-	-	-	-	-
1954	18.4	520.0	-	-	-	-	-	-

Table C.11 (continued)

1955	1.5	306.0	3.5	112.0	-	-	-	-
1956	11.4	448.0	22.12	126.0	-	-	-	-
1957	4.3	721.0	6.3	347.0	-	-	-	-
1958	23.3	298.0	5.3	123.0	-	-	-	-
1959	5.4	315.0	24.3	103.0	-	-	-	-
1960	8.4	281.0	26.4	132.0	-	-	-	-
1961	8.4	281.0	13.4	96.0	-	-	-	-
1962	3.4	312.0	21.11	110.0	-	-	-	-
1963	10.4	1210.0	10.4	275.0	-	-	-	-
1964	26.3	581.0	26.3	216.0	-	-	-	-
1965	29.4	455.0	30.4	223.0	28.4	65.2	-	-
1966	26.1	892.0	27.1	296.0	20.4	102.0	-	-
1967	22.4	443.0	20.4	144.0	21.4	102.0	-	-
1968	18.4	640.0	18.4	331.0	18.4	103.0	-	-
1969	1.4	609.0	1.5	295.0	1.4	160.0	-	-
1970	10.2	524.0	12.2	143.0	6.4	54.9	-	-
1971	15.4	293.0	15.4	115.0	-	-	-	-
1972	30.4	801.0	30.4	393.0	-	-	30.4	243.0
1973	15.2	231.0	9.4	92.6	-	-	8.4	45.7
1974	16.3	721.0	17.3	206.0	-	-	9.4	104.0
1975	19.4	589.0	19.4	153.0	-	-	20.4	193.0
1976	13.4	772.0	13.4	416.0	-		13.4	334.0
1977	24.4	421.0	14.4	220.0	-	-	24.4	137.0
1978	12.3	615.0	24.4	217.0	-	-	12.3	163.0
1979	16.12	489.0	15.12	172.0	-	-	16.12	202.0
1980	26.3	645.0	28.3	303.0	-	-	28.3	158.0
1981	13.3	490.0	14.3	351.0	-	-	13.3	202.0
1982	6.4	487.0	5.4	337.0	-	-	5.4	357.0
1983	17.5	417.0	16.5	90.8	-	-	17.5	109.0
1984	18.11	564.0	18.11	281.0	-	-	18.11	304.0
1985	2.4	858.0	2.4	274.0	-	-	2.4	458.0
1986	15.4	379.0	15.4	167.0	-	-	15.4	129.0
1987	13.4	884.0	12.4	338.0	-	-	12.4	590.0
1988	14.4	1261.0	14.4	449.0	-	-	14.4	430.0
1989	9.11	137.0	8.11	101.0	-	-	8.11	125.0
1990	27.11	1020.0	27.11	174.0	-	-	27.11	210.0
1991	24.3	726.0	23.3	188.0	-	-	23.3	285.0
1992	13.4	995.0	13.4	307.0	-	-	14.4	445.0
1993	2.5	1005.0	19.4	242.0	-	-	19.4	293.0
1994	2.4	570.0	2.4	142.0	-	-	8.4	385.0
1995	3.4	964.0	2.5	249.0	-	-	3.4	300.0
1996	13.4	524.0	9.2	235.0	-	-	31.3	215.0
1997	28.4	526.0	27.4	201.0	-	-	28.4	235.0
1998	30.3	742.0	29.3	288.0	-	-	29.3	320.0
1999	1.4	712.0	1.4	198.0	-	-	1.4	332.0
2000	8.4	218.0	7.4	80.9	-	-	8.4	64.1
2001	6.4	514.0	6.4	227.0	-	-	6.4	179.0
2002	7.4	628.0	29.12	214.0	-	-	29.12	251.0
2003	-	-	9.4	180.0	-	-	26.3	238.0
2004	-	-	6.3	395.0	-	-	6.3	579.0
2005	-	-	22.11	161.0	-	-	22.11	294.0
2006	-	-	9.5	163.0	-	-	8.4	142.0
Distribution	**Gumbel**		**Pearson Type-3**		**Gumbel**		**Log-Normal (3 Parameter)**	
Q_{2}	536.7		210.8		93.3		243.2	
$Q_{2.33}$	582.0		227.7		102.7		266.4	
Q_{5}	778.8		295.7		143.3		361.7	
Q_{10}	939.1		345.1		176.4		433.7	
Q_{25}	1141.6		401.8		218.2		519.4	
Q_{50}	1291.8		440.7		249.2		579.9	
Q_{100}	1441.0		477.1		279.9		638.3	
Q_{200}	1589.6		511.8		310.6		695.0	
Q_{500}	1785.6		555.6		351.1		768.0	
Q_{1000}	1933.8		587.4		381.6		823.6	

C.6.1.1. Point Flood Frequency Analysis

Table C.12 Point Flood Frequency Analysis Results of Ilisu I Dam

Return Period	2603 Garzan-Besiri SGS	Ilisu I Dam
	Flood Discharge (m^3/s)	
2	536.7	583.9
2.33	582.0	633.2
5	778.8	847.3
10	939.1	1021.7
25	1141.6	1242.1
50	1291.8	1405.5
100	1441.0	1567.8
200	1589.6	1729.5
500	1785.6	1942.8
1000	1933.8	2104.0

C.6.1.2. Regional Flood Frequency Analysis

Table C.13 Data for Homogeneity Test

Unit: m^3/s

SGS	Q_2	$Q_{2.33}$	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	Q_{1000}
2603	536.7	582.0	778.8	939.1	1141.6	1291.8	1441.0	1589.6	1785.6	1933.8
2624	243.2	266.4	361.7	433.7	519.4	579.9	638.3	695.0	768.0	823.6
2616	93.3	102.7	143.3	176.4	218.2	249.2	279.9	310.6	351.1	381.6
2610	210.8	227.7	295.7	345.1	401.8	440.7	477.1	511.8	555.6	587.4

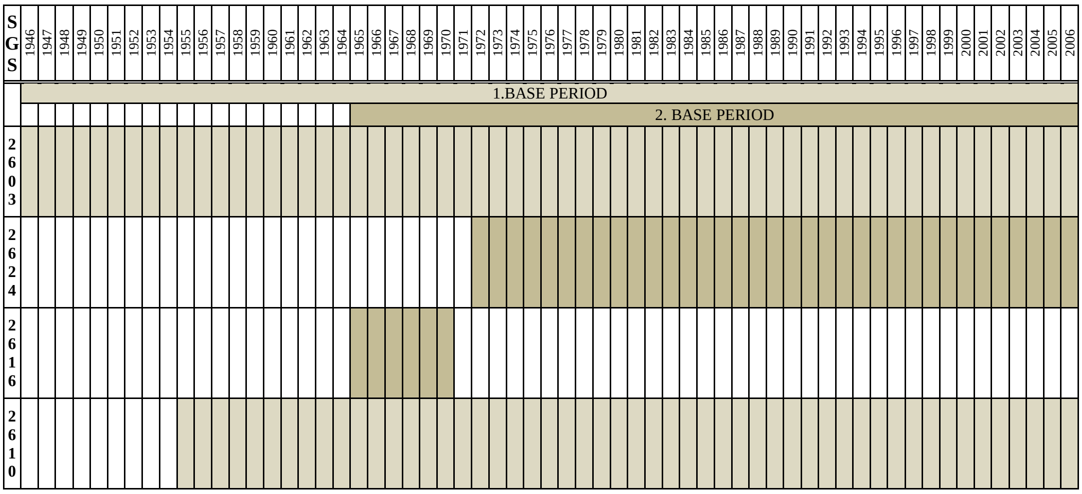


Figure C.40 Observation Periods of Stream Gauging Stations

Table C.14 1. Base Period (1946-2006) Homogeneity Test Table

SGS	$Q_{2.33}$	Q_{10}	$Q_{10}/Q_{2.33}$	Avg.x$Q_{2.33}$	Return Period	Obser. Period	Adjusted Re. Period
2603	582.0	939.1	1.6	910.5	9.1	57	59.0
2610	227.7	345.1	1.5	356.3	13.0	52	56.5
		Average	1.6				

Table C.15 2. Base Period (1965-2006) Homogeneity Test Table

SGS	$Q_{2.33}$	Q_{10}	$Q_{10}/Q_{2.33}$	Avg.x$Q_{2.33}$	Return Period	Obser. Period	Adjusted Re. Period
2616	102.7	176.4	1.7	171.8	9.3	6	24.0
2624	266.4	433.7	1.6	445.7	12.1	35	38.5
		Average	1.7				

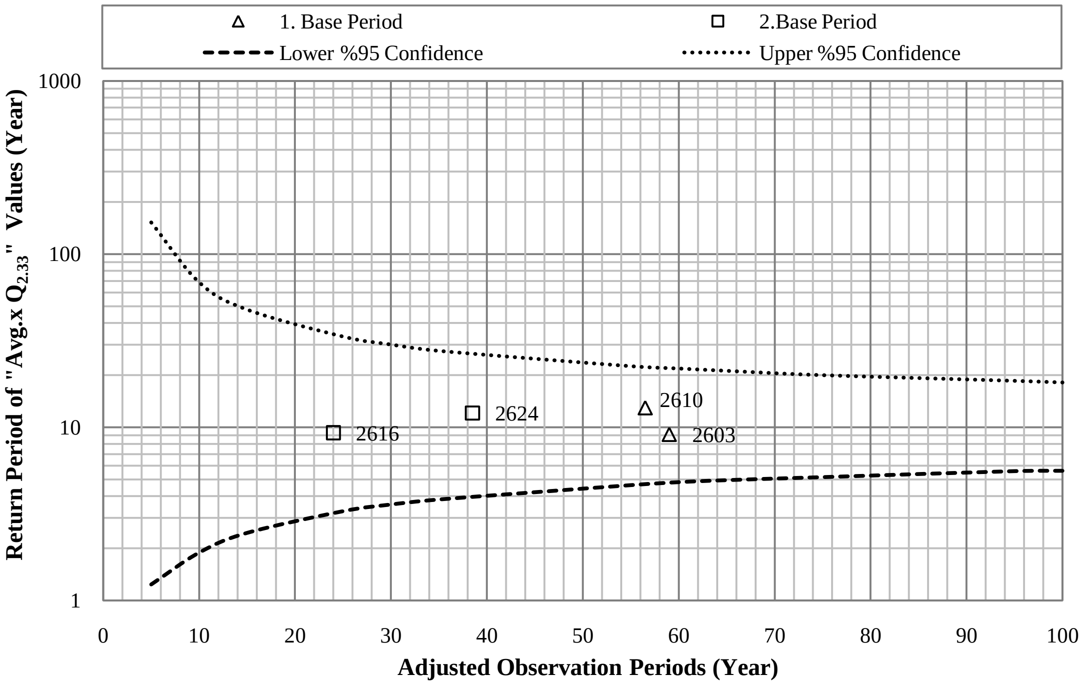


Figure C.41 Homogeneity Test Graph

Table C.16 Dimensionless Regional Flood Frequency Analysis

Unit: m^3/s

SGS	Q_2	$Q_{2.33}$	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	Q_{1000}
2603	0.9	1.0	1.3	1.6	2.0	2.2	2.5	2.7	3.1	3.3
2624	0.9	1.0	1.4	1.6	1.9	2.2	2.4	2.6	2.9	3.1
2616	0.9	1.0	1.4	1.7	2.1	2.4	2.7	3.0	3.4	3.7
2610	0.9	1.0	1.3	1.5	1.8	1.9	2.1	2.2	2.4	2.6
Avg.	0.9	1.0	1.3	1.6	2.0	2.2	2.4	2.7	3.0	3.2

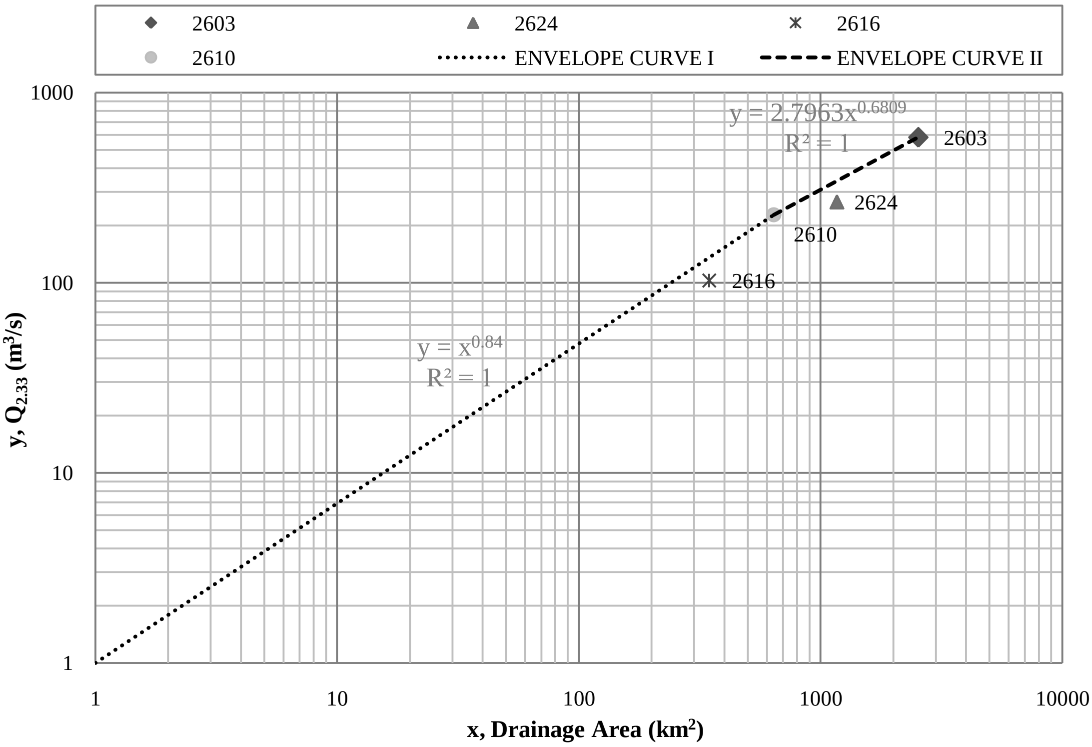


Figure C.42 Regional Flood Envelope Curve

Table C.17 Regional Flood Frequency Analysis Results of Ilisu I Dam

Return Period	Ilisu I Dam
	Flood Discharge (m^3/s)
2	582.1
2.33	634.4
5	854.9
10	1027.0
25	1237.2
50	1389.2
100	1537.5
200	1683.3
500	1873.1
1000	2016.0

C.6.2. Flood Recurrences Calculated Using Snyder Synthetic Unit Hydrograph Method

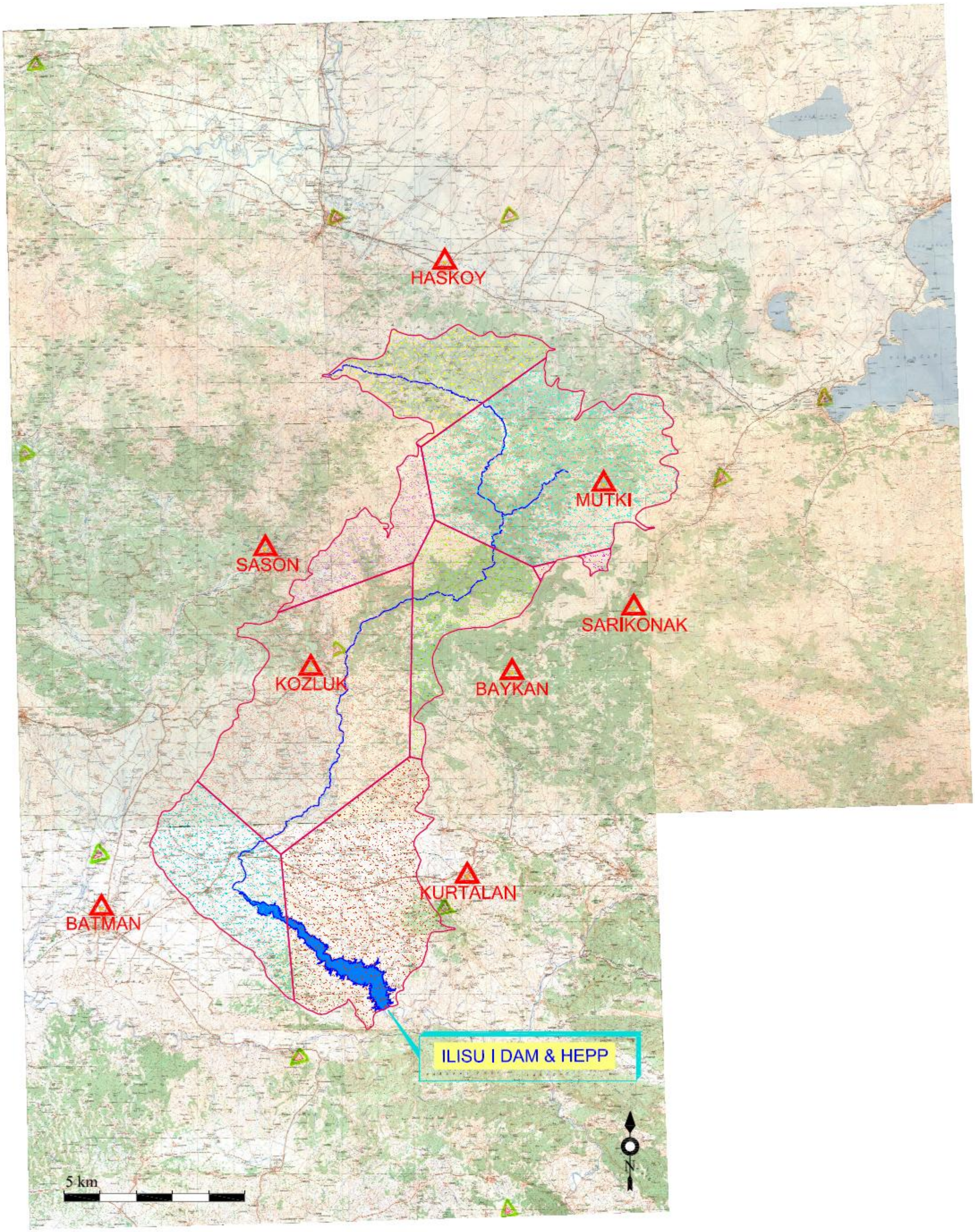


Figure C.43 Thiessen Polygons of Ilisu I Drainage Area

Table C.18 Annual Daily Max. Precipitations Observed in the Vicinity of Project Area (DMI, 2009-b)

Year	Mutki MS	Haskoy MS	Kozluk MS	Baykan MS	Sason MS	Kurtalan MS	Sarikonak MS	Batman MS
	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)
1929	-	-	-	-	-	-	-	-
1930	-	-	-	-	-	-	-	-
1931	-	-	-	-	-	-	-	-
1932	-	-	-	-	-	-	-	-
1933	-	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-	-
1935	-	-	-	-	-	-	-	-
1936	-	-	-	-	-	-	-	-
1937	-	-	-	-	-	-	-	-
1938	-	-	-	-	-	-	-	-
1939	-	-	-	-	-	-	-	-
1940	-	-	-	-	-	-	-	-
1941	-	-	-	-	-	-	-	-
1942	-	-	-	-	-	-	-	-
1943	-	-	-	-	-	-	-	-
1944	-	-	-	-	-	-	-	-
1945	-	-	-	-	-	-	-	-
1946	-	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-
1951	-	-	-	-	-	-	-	-
1952	-	-	-	-	-	-	-	-
1953	-	-	-	-	-	-	-	-
1954	-	-	-	-	57.3	30.2	-	-
1955	-	-	-	-	79.2	58.2	-	-
1956	-	-	-	-	97.6	52.7	-	-
1957	80.3	-	-	80.2	87.9	70.7	-	-
1958	83.9	-	-	57.1	88.6	40.4	-	-
1959	53.2	-	-	56.4	-	58.3	-	44.6
1960	48.6	-	-	37.4	-	41.2	-	25.2
1961	88.6	-	-	50.6	-	44.2	-	-
1962	63.2	-	-	55.1	-	53.4	-	47.8
1963	64.7	-	-	58.0	-	-	-	57.1
1964	59.4	-	109.4	52.0	-	17.2	-	25.5
1965	94.3	-	70.0	68.0	103.5	33.4	-	25.5
1966	73.7	-	-	65.0	88.1	68.7	-	31.9
1967	93.2	-	94.3	81.5	86.7	68.3	-	49.4
1968	82.4	-	89.6	74.0	80.9	-	-	59.3
1969	73.4	-	92.1	72.4	54.0	-	-	28.6
1970	46.3	29.7	51.5	56.4	63.7	-	-	29.1
1971	98.4	71.4	52.1	54.2	74.4	63.6	85.2	17.7
1972	67.2	44.6	52.3	65.4	47.5	56.0	72.6	50.0
1973	46.2	26.2	27.5	35.4	48.3	-	62.0	19.8
1974	51.9	34.3	37.9	47.8	65.9	32.5	52.9	23.5
1975	48.6	37.6	49.2	58.6	75.8	58.2	58.0	47.5
1976	64.7	46.7	70.3	55.7	190.9	44.7	85.7	39.5
1977	75.3	47.1	33.2	41.0	74.5	42.5	134.6	27.1
1978	64.3	53.6	68.3	71.2	81.5	46.0	92.5	36.1
1979	58.9	58.3	52.9	52.3	74.6	-	112.4	37.1
1980	45.7	33.7	42.8	41.1	59.1	30.3	67.0	21.0
1981	65.9	53.2	60.4	69.4	65.7	46.1	68.3	33.1
1982	-	37.5	73.1	87.3	82.1	86.5	57.0	24.3
1983	-	27.5	57.2	53.2	87.3	36.2	100.0	45.5
1984	-	22.5	55.2	53.8	88.5	50.9	102.1	20.4
1985	-	55.8	75.4	60.9	73.9	63.5	63.5	50.9
1986	-	32.7	48.5	45.5	81.4	30.9	71.0	18.0
1987	46.3	47.7	56.3	70.3	92.5	60.5	114.8	30.1
1988	-	41.2	76.8	63.8	80.0	-	63.0	52.0
1989	-	56.1	59.9	68.2	97.9	-	94.4	40.1
1990	-	64.2	49.6	62.8	-	-	78.2	34.0
1991	-	37.5	43.5	54.7	-	-	88.8	42.0
1992	-	56.8	46.7	61.7	40.9	-	118.5	21.5
1993	-	64.2	61.7	90.8	30.9	-	67.5	63.4

Table C.18 (continued)

1994	-	54.8	-	70.1	31.4	-	-	40.4
1995	-	57.8	-	50.8	35.4	-	-	20.2
1996	-	35.2	-	-	-	-	-	39.7
1997	-	28.1	-	67.7	-	-	-	29.8
1998	-	46.4	-	49.0	-	-	-	22.4
1999	-	34.8	-	41.7	-	-	-	69.2
2000	-	28.1	-	56.0	73.0	-	-	31.0
2001	-	39.7	-	44.7	75.6	-	-	35.0
2002	-	34.5	-	44.1	84.8	-	-	21.0
2003	-	-	-	50.9	99.8	-	-	-
2004	-	-	-	-	96.6	-	-	-
2005	-	-	-	-	76.0	-	-	19.1
2006	-	-	-	-	69.4	-	-	57.0
2007	-	-	-	-	-	-	-	-
Distribution	**Gumbel**	**Pearson Type-3**	**Log-Normal (2 Parameter)**	**Log-Pearson Type-3**	**Normal**	**Log-Pearson Type-3**	**Gumbel**	**Gumbel**
P_2	64.4	43.0	57.8	57.6	76.5	49.1	79.7	33.3
$P_{2.33}$	67.6	45.3	61.1	59.9	81.1	52.1	84.1	35.8
P_5	81.4	54.1	74.8	69.0	98.2	63.0	103.3	46.6
P_{10}	92.6	60.4	85.7	75.7	109.5	70.1	118.9	55.4
P_{25}	106.8	67.3	98.9	83.5	121.7	77.3	138.6	66.5
P_{50}	117.3	72.0	108.5	88.9	129.5	81.6	153.2	74.8
P_{100}	127.8	76.2	118.0	94.0	136.5	85.3	167.8	82.9
P_{200}	138.2	80.3	127.3	98.8	142.9	88.4	182.2	91.1
P_{500}	151.9	85.3	139.6	105.0	150.7	91.9	201.3	101.8
P_{1000}	162.3	88.9	149.1	109.5	156.2	94.1	215.8	110.0

Table C.19 Probable Maximum Precipitation Calculations of Meteorological Stations

MS	Mutki	Haskoy	Kozluk	Baykan	Sason	Kurtalan	Sarikonak	Batman
N	26	33	29	46	42	28	23	46
X_N	66.9	43.6	60.6	58.8	76.5	49.5	83.0	35.4
X_{MAX}	98.4	71.4	109.4	90.8	190.9	86.5	134.6	69.2
X_{N-1}	65.6	42.8	58.9	58.1	73.7	48.1	80.7	34.7
X_{N-1}/X_N	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Correct. Coeff. 1	1.020	1.010	1.005	1.015	0.988	1.005	1.010	1.005
X	68.2	44.1	60.9	59.7	75.6	49.7	83.9	35.6
Correct. Coeff. 2	1.012	1.004	1.007	1.000	1.001	1.008	1.015	1.000
X	**69.0**	**44.2**	**61.3**	**59.7**	**75.6**	**50.1**	**85.1**	**35.6**
ΣX^2	122992.9	68022.9	116670.3	166270.9	272903.9	75023.6	169747.0	66010.0
S_N	16.4	12.8	19.0	12.7	25.8	15.5	22.5	13.5
S_{N-1}	15.4	12.0	16.9	11.9	18.6	14.0	19.9	12.7
S_{N-1}/S_N	0.9	0.9	0.9	0.9	0.7	0.9	0.9	0.9
Correct. Coeff. 3	1.080	1.050	1.020	1.020	0.780	1.020	1.040	1.020
S	17.7	13.4	19.4	13.0	20.1	15.8	23.4	13.8
Correct. Coeff. 4	1.055	1.030	1.035	1.005	1.013	1.045	1.065	1.005
S	**18.7**	**13.8**	**20.1**	**13.1**	**20.4**	**16.5**	**24.9**	**13.9**
KM	**5.0**	**8.7**	**6.1**	**6.4**	**4.2**	**6.5**	**3.2**	**8.8**
PMP_{24}=X+KM*S	**162.5**	**164.5**	**183.9**	**143.2**	**161.3**	**157.5**	**164.9**	**157.6**

Table C.20 Daily Maximum Rainfall Magnitudes

Unit: mm

MS	P_2	$P_{2.33}$	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}	P_{1000}	PMP
Mutki	64.4	67.6	81.4	92.6	106.8	117.3	127.8	138.2	151.9	162.3	162.5
Haskoy	43.0	45.3	54.1	60.4	67.3	72.0	76.2	80.3	85.3	88.9	164.5
Kozluk	57.8	61.1	74.8	85.7	98.9	108.5	118.0	127.3	139.6	149.1	183.9
Baykan	57.6	59.9	69.0	75.7	83.5	88.9	94.0	98.8	105.0	109.5	143.2
Sason	76.5	81.1	98.2	109.5	121.7	129.5	136.5	142.9	150.7	156.2	161.3
Kurtalan	49.1	52.1	63.0	70.1	77.3	81.6	85.3	88.4	91.9	94.1	157.5
Sarikonak	79.7	84.1	103.3	118.9	138.6	153.2	167.8	182.2	201.3	215.8	164.9
Batman	33.3	35.8	46.6	55.4	66.5	74.8	82.9	91.1	101.8	110.0	157.6

Table C.21 Daily Maximum Rainfall Magnitudes of Ilisu I Basin

Unit: mm

Meteorological Station	Thiessen Weight (%)	P_2	$P_{2.33}$	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}	P_{1000}	PMP
Mutki	22.8	14.7	15.4	18.6	21.1	24.4	26.8	29.2	31.5	34.7	37.0	37.1
Haskoy	8.4	3.6	3.8	4.6	5.1	5.7	6.1	6.4	6.8	7.2	7.5	13.9
Kozluk	25.4	14.7	15.5	19.0	21.7	25.1	27.6	30.0	32.3	35.4	37.9	46.7
Baykan	8.3	4.8	5.0	5.7	6.3	7.0	7.4	7.8	8.2	8.7	9.1	11.9
Sason	5.7	6.4	6.7	8.2	9.1	10.1	10.8	11.4	11.9	12.5	13.0	13.4
Kurtalan	18.8	4.1	4.3	5.2	5.8	6.4	6.8	7.1	7.4	7.7	7.8	13.1
Sarikonak	0.4	6.6	7.0	8.6	9.9	11.5	12.8	14.0	15.2	16.8	18.0	13.7
Batman	10.1	3.4	3.6	4.7	5.6	6.7	7.6	8.4	9.2	10.3	11.1	15.9
Basin Precipitation	100.0	**58.3**	**61.4**	**74.6**	**84.7**	**96.9**	**105.7**	**114.2**	**122.5**	**133.3**	**141.4**	**165.7**

Table C.22 Pluviograph Coefficients of Bitlis Meteorological Station (Enersu, December 2008)

Time (hr)

0.5	1	2	3	4	6	8	12	18	24
0.18	0.22	0.28	0.35	0.40	0.47	0.53	0.67	0.83	1.00

Table C.23 Areal Distribution Coefficients of Rainfall of Ilisu I Basin

Time (hr)

0.5	1	2	3	4	6	8	12	18	24
0.57	0.65	0.72	0.78	0.80	0.84	0.84	0.86	0.89	0.91

Table C.24 Corrected and Maximized Rainfall Magnitudes of Ilisu I Basin

Time (hr) **Unit: mm**

MF = 1.13	0.5	1	2	3	4	6	8	12	18	24
P_2	6.8	9.4	13.2	18.0	21.0	25.8	29.4	37.9	48.4	59.9
$P_{2.33}$	7.1	9.9	13.9	18.9	22.2	27.2	31.0	40.0	51.0	63.2
P_5	8.6	12.1	16.9	23.0	26.9	33.1	37.7	48.6	61.9	76.7
P_{10}	9.8	13.7	19.2	26.1	30.6	37.6	42.8	55.2	70.3	87.1
P_{25}	11.2	15.7	21.9	29.9	35.0	43.0	49.0	63.1	80.5	99.7
P_{50}	12.3	17.1	23.9	32.6	38.1	46.9	53.4	68.8	87.7	108.7
P_{100}	13.2	18.4	25.8	35.2	41.2	50.6	57.7	74.3	94.8	117.4
P_{200}	14.2	19.8	27.7	37.8	44.2	54.3	61.9	79.8	101.7	126.0
P_{500}	15.5	21.5	30.2	41.1	48.1	59.1	67.3	86.8	110.6	137.1
P_{1000}	16.4	22.9	32.0	43.6	51.0	62.7	71.4	92.1	117.4	145.4
PMP	19.2	26.8	37.5	51.1	59.8	73.5	83.7	107.9	137.6	170.4

Table C.25 Harmonic Slope Calculation of Ilisu I Basin

Station No n	Elevation h (m)	Elev. Diff. Δh (m)	Distance L_i (m)	$S_i=\Delta h/L_i$	$1/\sqrt{S_i}$
0	469	-	-	-	-
1	500	31	16500	0.002	23.1
2	532	32	16500	0.002	22.7
3	553	21	16500	0.001	28.0
4	592	39	16500	0.002	20.6
5	650	58	16500	0.004	16.9
6	850	200	16500	0.012	9.1
7	950	100	16500	0.006	12.8
8	1200	250	16500	0.015	8.1
9	1300	100	16500	0.006	12.8
10	2550	1250	16500	0.076	3.6
					Total: 157.8

$S=(n/\Sigma(1/\sqrt{S_i}))^2$
S=0.004

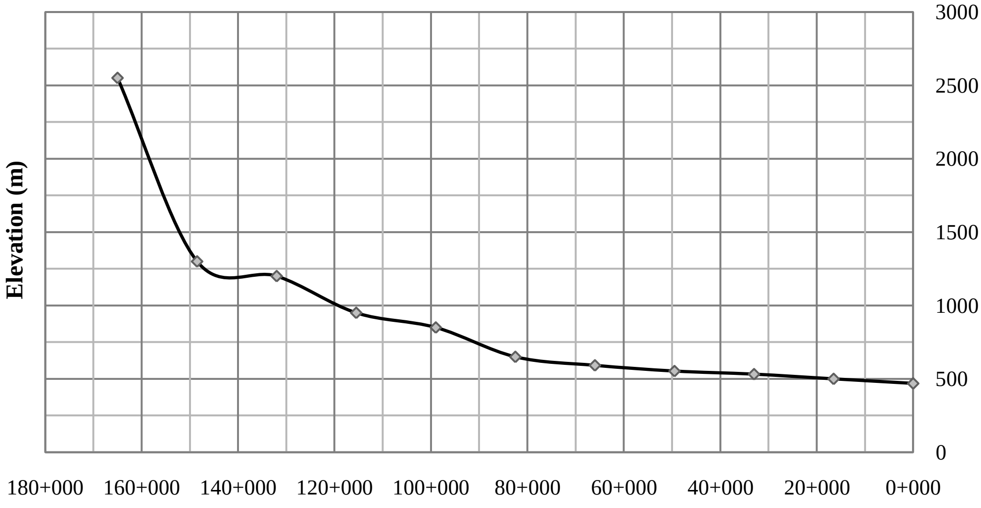


Figure C.44 River Bed Profile of Ilisu I Basin

Table C.26 Base Flow Calculation of Ilisu I Basin

2603 SGS | **Unit: m^3/s**

Year	March	April	May	Average
1946	107.0	184.0	167.0	152.7
1947	124.0	84.3	40.4	82.9
1948	88.4	269.0	184.0	180.5
1949	44.0	192.0	156.0	130.7
1950	80.5	172.0	173.0	141.8
1951	101.0	161.0	88.2	116.7
1952	133.0	231.0	137.0	167.0
1953	102.0	272.0	173.0	182.3
1954	136.0	313.0	197.0	215.3
1955	66.8	94.2	89.5	83.5
1956	103.0	195.0	144.0	147.3
1957	191.0	137.0	236.0	188.0
1958	146.0	173.0	81.2	133.4
1959	50.2	169.0	171.0	130.1
1960	83.1	156.0	75.8	105.0
1961	-	-	-	-
1962	105.0	136.0	73.3	104.8
1963	89.7	**371.0**	260.0	240.2

Table C.26 (continued)

1964	204.0	171.0	110.0	161.7
1965	103.0	178.0	112.0	131.0
1966	75.4	148.0	81.9	101.8
1967	72.5	232.0	223.0	175.8
1968	192.0	309.0	155.0	218.7
1969	263.0	267.0	204.0	244.7
1970	94.8	92.2	34.6	73.9
1971	64.3	123.0	58.0	81.8
1972	53.5	150.0	171.0	124.8
1973	54.4	91.5	47.8	64.6
1974	103.0	151.0	56.9	103.6
1975	65.9	160.0	87.0	104.3
1976	63.3	286.0	164.0	171.1
1977	104.0	172.0	101.0	125.7
1978	141.0	173.0	108.0	140.7
1979	69.2	104.0	54.7	76.0
1980	136.0	193.0	86.7	138.6
1981	120.0	109.0	82.6	103.9
1982	62.1	220.0	143.0	141.7
1983	55.0	111.0	96.2	87.4
1984	122.0	116.0	61.0	99.7
1985	78.2	214.0	75.0	122.4
1986	73.8	112.0	61.8	82.5
1987	99.7	276.0	190.0	188.6
1988	192.0	354.0	204.0	**250.0**
1989	56.6	33.6	10.9	33.7
1990	80.9	135.0	72.9	96.3
1991	124.0	126.0	50.5	100.2
1992	63.7	229.0	169.0	153.9
1993	86.0	272.0	252.0	203.3
1994	104.0	131.0	65.8	100.3
1995	176.0	297.0	132.0	201.7
1996	105.0	188.2	88.1	127.1
1997	47.5	194.2	97.3	113.0
1998	116.0	163.2	57.1	112.1
1999	44.6	124.2	29.6	66.1
2000	55.7	143.2	50.1	83.0
			Maximum Average:	**250.0**
			Maximum Value:	**371.0**
		Drainage Area of 2603 SGS :	2450.4	km^2
		Drainage Area of Ilisu I Dam:	2883.0	km^2
		Recurrence Base Flow:	**278.6**	m^3/s
		Probable Maximum Flood Base Flow:	**413.5**	m^3/s

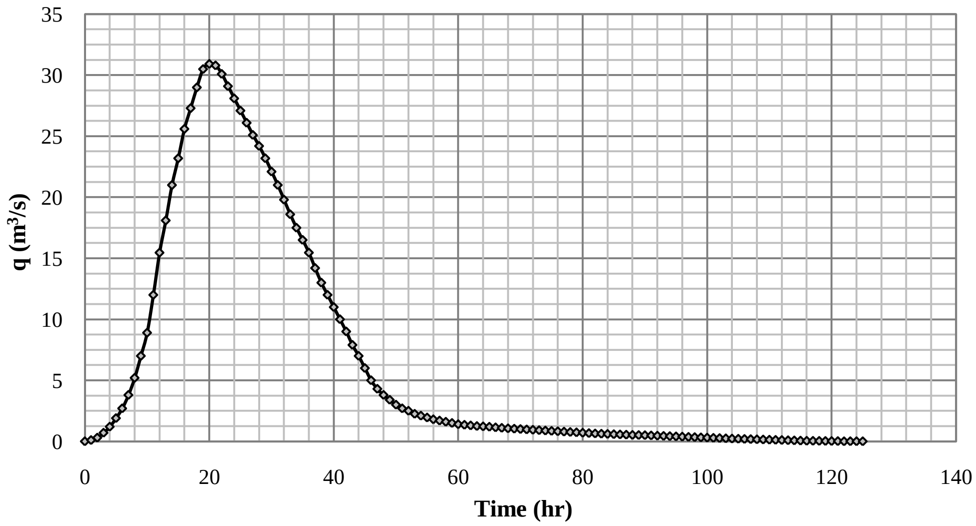


Figure C.45 Unit Hydrograph (UH_4) of Ilisu I Basin

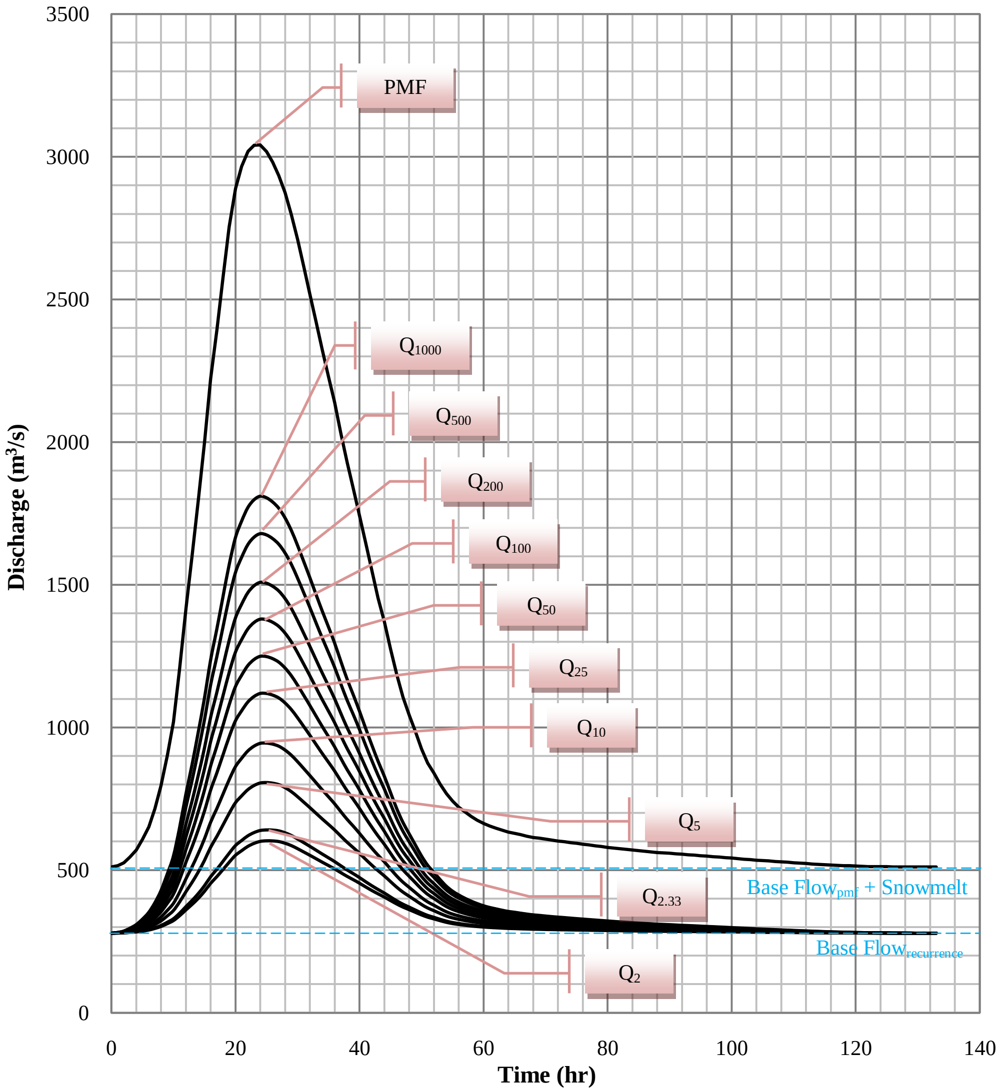


Figure C.46 Recurrence and Probable Maximum Flood Hydrographs of Ilisu I Basin

Table C.27 Snyder Synthetic Unit Hydrograph Method Results of Ilisu I Dam

Return Period	**Ilisu I Dam** Flood Discharge (m^3/s)
2	602.9
2.33	640.5
5	807.1
10	944.5
25	1118.9
50	1249.2
100	1378.8
200	1508.3
500	1679.5
1000	1810.5
PMF	3041.7

APPENDIX D

THE BITLIS PROJECTS AND ILISU II DAM AND HEPP

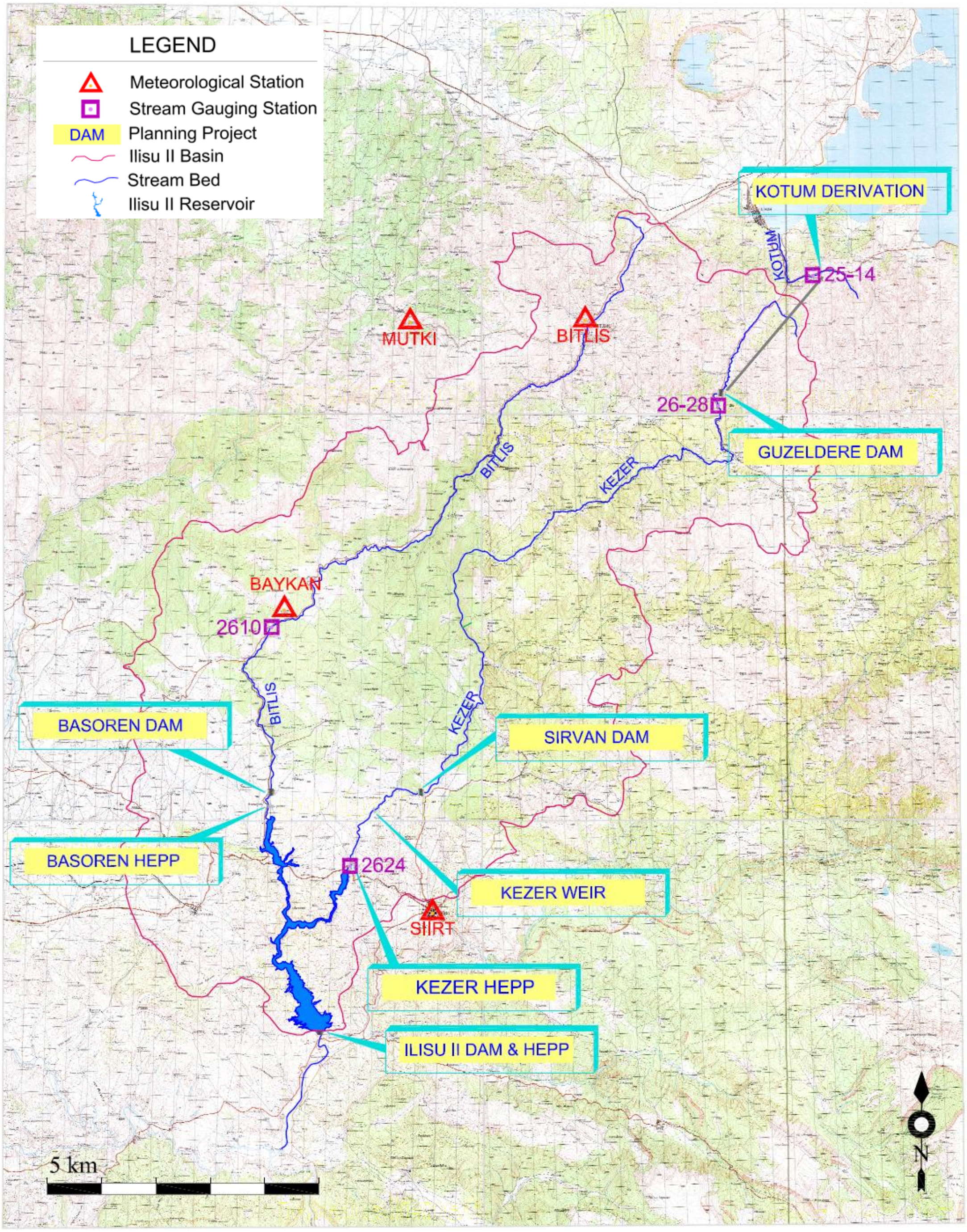


Figure D.1 Project Area and Hydro-Meteorological Stations on 1/100000 Scale Topographic Maps

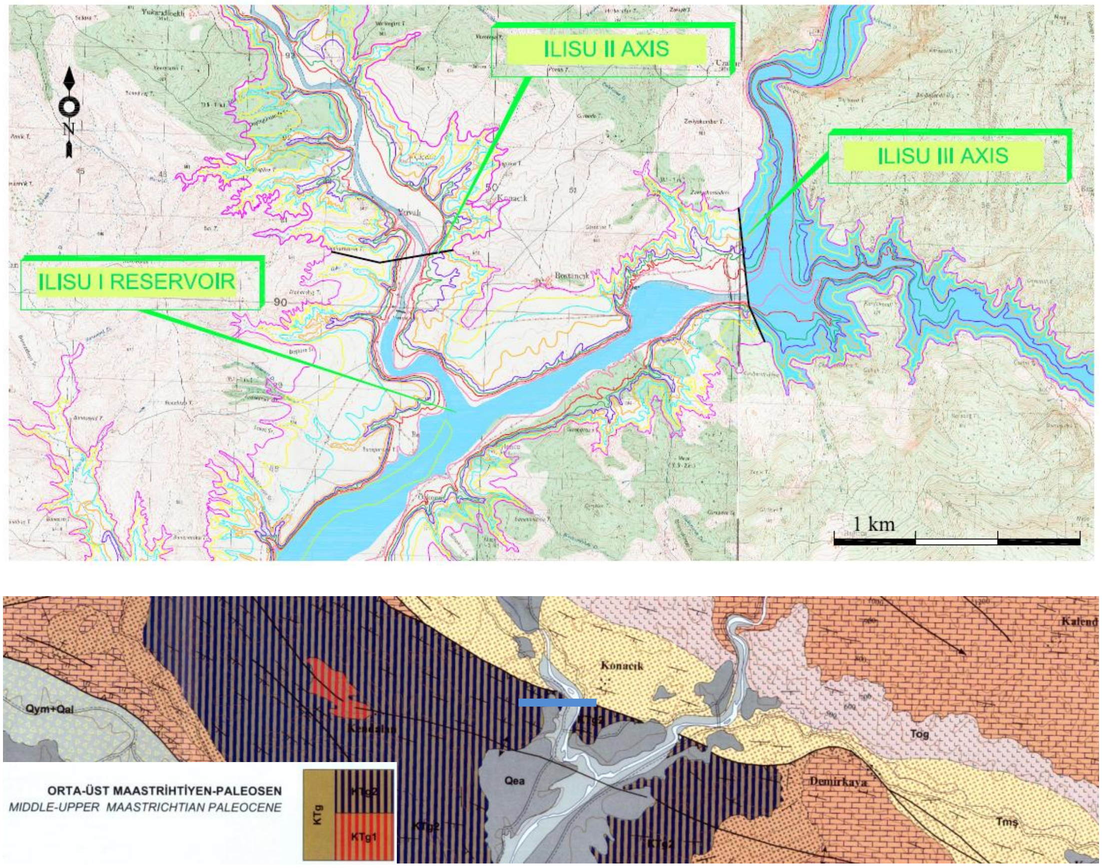


Figure D.2 Ilisu II Dam Location (MTA, 2007)

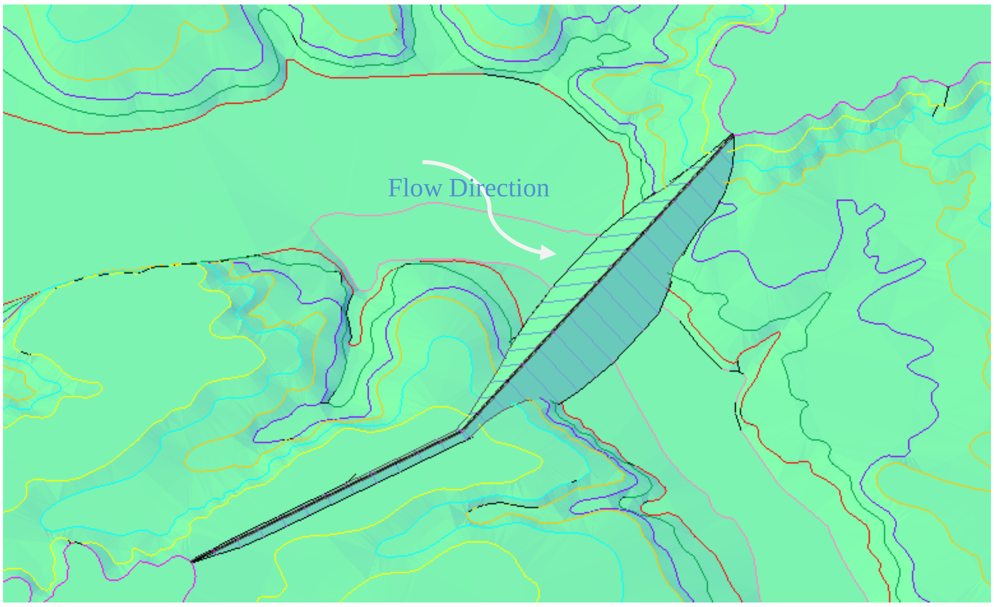


Figure D.3 Representative View of Ilisu II Dam Body

D.1. Dam Characteristics

Table D.1 Characteristics of the Projects Upstream of Ilisu II Dam and HEPP

Characteristics	Unit	**Guzeldere**	**Sirvan**	**Basoren**
Purpose	-	Energy & Domestic	Energy	Energy
Drainage Area	km^2	170.0	1010.0	737.3
Thalwag Elevation	m	1690.0	600.0	540.0
Maximum Water Level	m	1720.0	688.0	561.0
Minimum Water Level	m	1704.5	662.0	553.0
Tailwater Level	m	1270.0	577.0	530.0
Design Discharge	m^3/s	8.00	33.80	34.92
Penstock: Number/Diameter/Length	-/m/m	2/1.1/1100	1/2.6/210.54	1/3.3/61
Energy Tunnel: Number/Diameter/Length	-/m/m	1/4.0/10000	1/3.5/2497	1/3.8/2360
Number of Units	-	2	2	2
Gross Head/Net Head	m/m	435.0/430.2	111.0/101.6	31.0/25.7
Turbine Type	-	Francis	Francis	Francis

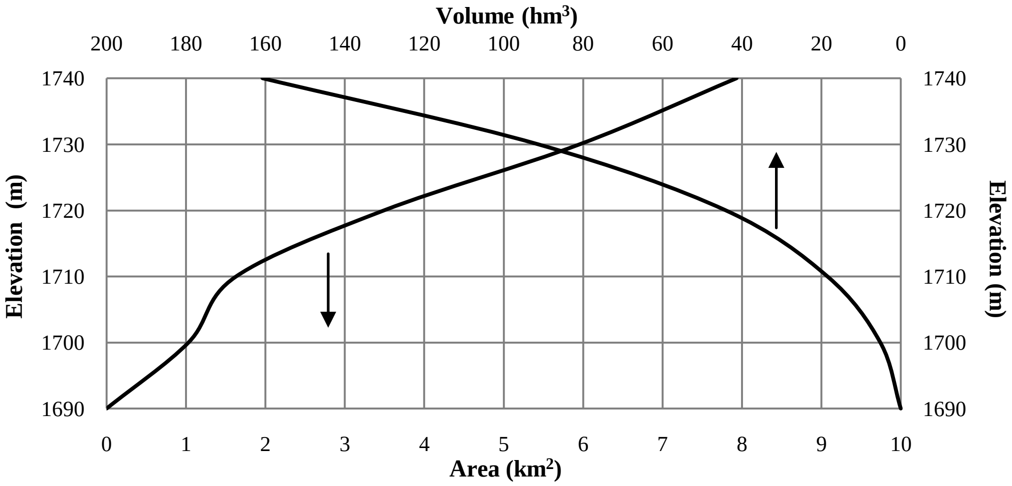


Figure D.4 Volume-Area Curve of Guzeldere Reservoir

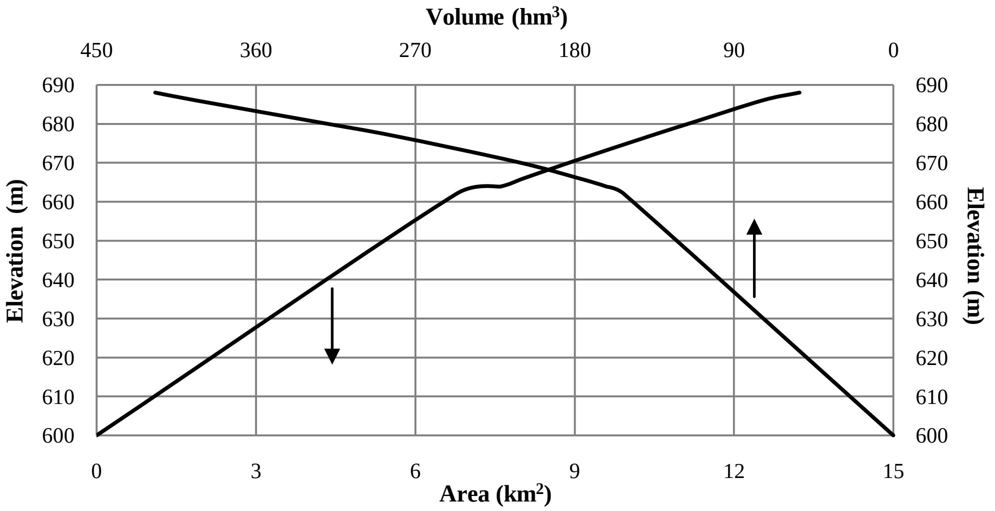


Figure D.5 Volume-Area Curve of Sirvan Reservoir

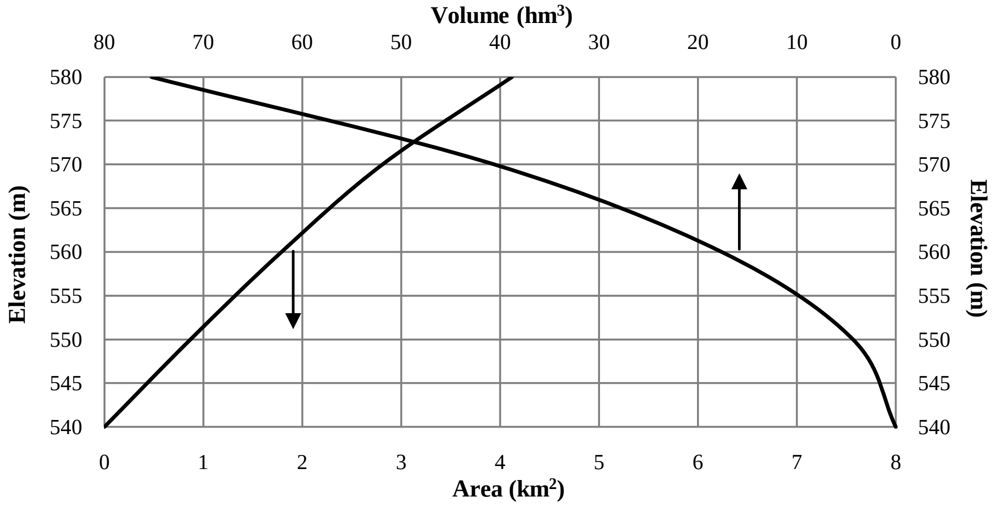


Figure D.6 Volume-Area Curve of Basoren Reservoir

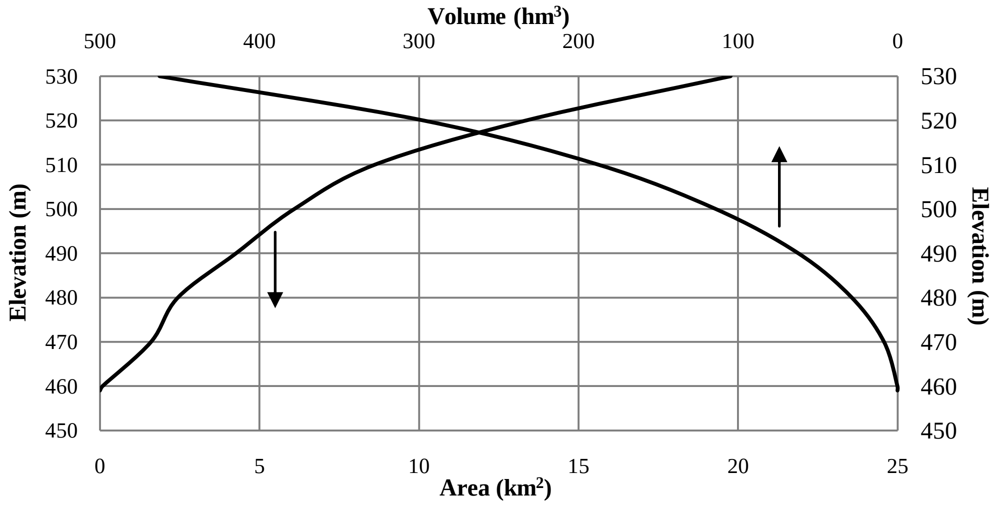


Figure D.7 Volume-Area Curve of Ilisu II Reservoir

D.2. Estimated Evaporation Rates

Table D.2 Monthly Total Net Evaporation Values of Guzeldere Reservoir

Months	Bitlis MS Temp. (^oC)	Bitlis MS Evap. (mm)	Temp. (^oC)	Evap. (mm)	Water Sur. Evap. (mm)	Tatvan MS Precip. (mm)	**Net Evap. (mm)**
Jan.	-3.0	-	-3.8	-	-	75.8	-
Feb.	-2.2	-	-3.0	-	-	93.8	-
Mar.	1.5	-	0.6	1.0	0.7	109.3	-
Apr.	7.8	69.0	7.0	37.0	25.9	127.0	-
May	13.1	103.6	12.2	85.7	60.0	88.6	-
Jun.	18.5	148.5	17.7	148.3	103.8	26.6	**77.1**
Jul.	22.9	199.2	22.0	206.5	144.6	7.5	**137.1**
Aug.	22.3	193.8	21.5	198.5	138.9	6.0	**132.9**
Sep.	17.6	150.8	16.8	137.2	96.0	18.0	**78.1**
Oct.	11.2	75.4	10.4	66.7	46.7	76.2	-
Nov.	4.5	13.8	3.6	13.8	9.7	101.8	-
Dec.	-0.7		-1.6			83.7	-
Σ	-	954.0	-	894.8	626.3	814.2	**425.3**

Table D.3 Monthly Total Net Evaporation Values of Sirvan Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Siirt MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	3.9	-	-	81.5	-
Feb.	4.1	-	5.2	-	-	102.1	-
Mar.	8.3	-	9.3	45.1	31.6	110.3	-
Apr.	14.0	83.5	15.0	106.0	74.2	99.9	-
May	19.3	185.6	20.4	181.9	127.3	64.5	**62.8**
Jun.	25.9	282.6	26.9	299.8	209.9	9.4	**200.5**
Jul.	30.4	371.8	31.5	396.0	277.2	2.5	**274.8**
Aug.	29.9	356.2	30.9	383.8	268.7	1.3	**267.4**
Sep.	25.0	258.8	26.1	282.7	197.9	2.8	**195.1**
Oct.	17.8	139.4	18.8	158.3	110.8	50.7	**60.1**
Nov.	10.1	54.3	11.1	61.9	43.3	85.1	-
Dec.	4.7	13.5	5.8	19.3	13.5	94.4	-
Σ	-	1745.8	-	1934.8	1354.4	704.4	**1060.7**

Table D.4 Monthly Total Net Evaporation Values of Basoren Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Baykan MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	4.5	-	-	140.9	-
Feb.	4.1	-	5.8	-	-	153.6	-
Mar.	8.3	-	10.0	50.8	35.5	156.4	-
Apr.	14.0	83.5	15.7	114.1	79.9	133.0	-
May	19.3	185.6	21.0	192.1	134.5	78.6	**55.9**
Jun.	25.9	282.6	27.6	312.6	218.8	14.5	**204.3**
Jul.	30.4	371.8	32.1	410.4	287.3	2.5	**284.8**
Aug.	29.9	356.2	31.6	398.0	278.6	1.4	**277.2**
Sep.	25.0	258.8	26.7	295.1	206.6	5.2	**201.3**
Oct.	17.8	139.4	19.5	167.9	117.5	55.1	**62.5**
Nov.	10.1	54.3	11.8	68.4	47.9	115.5	-
Dec.	4.7	13.5	6.4	23.2	16.2	154.8	-
Σ	-	1745.8	-	2032.5	1422.8	1011.5	**1085.9**

Table D.5 Monthly Total Net Evaporation Values of Ilisu II Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Siirt MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	4.7	-	-	81.5	-
Feb.	4.1	-	6.0	-	-	102.1	-
Mar.	8.3	-	10.1	52.2	36.5	110.3	-
Apr.	14.0	83.5	15.8	116.1	81.3	99.9	-
May	19.3	185.6	21.1	194.7	136.3	64.5	**71.7**
Jun.	25.9	282.6	27.7	315.7	221.0	9.4	**211.6**
Jul.	30.4	371.8	32.3	413.9	289.8	2.5	**287.3**
Aug.	29.9	356.2	31.7	401.5	281.1	1.3	**279.8**
Sep.	25.0	258.8	26.9	298.2	208.7	2.8	**205.9**
Oct.	17.8	139.4	19.6	170.3	119.2	50.7	**68.5**
Nov.	10.1	54.3	11.9	70.0	49.0	85.1	-
Dec.	4.7	13.5	6.6	24.2	16.9	94.4	-
Σ	-	1745.8	-	2056.8	1439.7	704.4	**1124.9**

D.3. Water Resources

D.3.1. Stream Gauging Stations

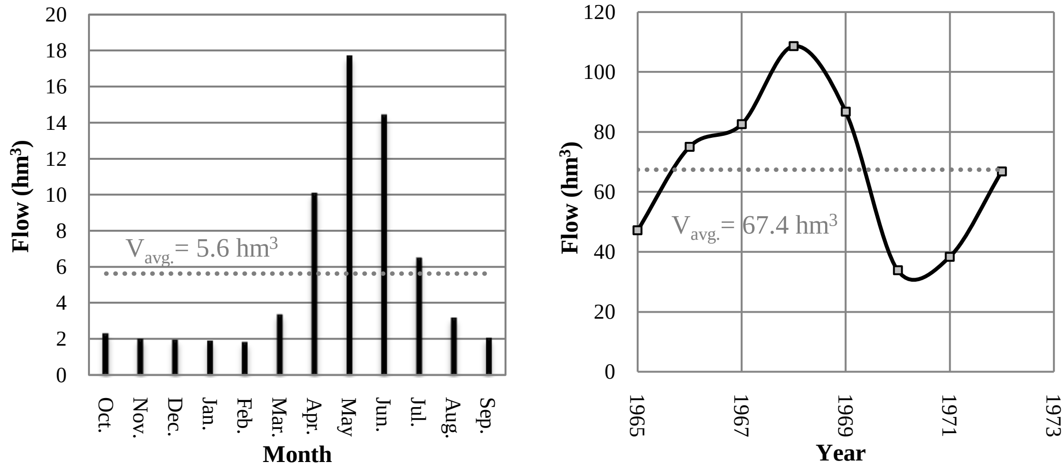


Figure D.8 Monthly Mean and Annual Total Flow Values Measured in 25-14 SGS

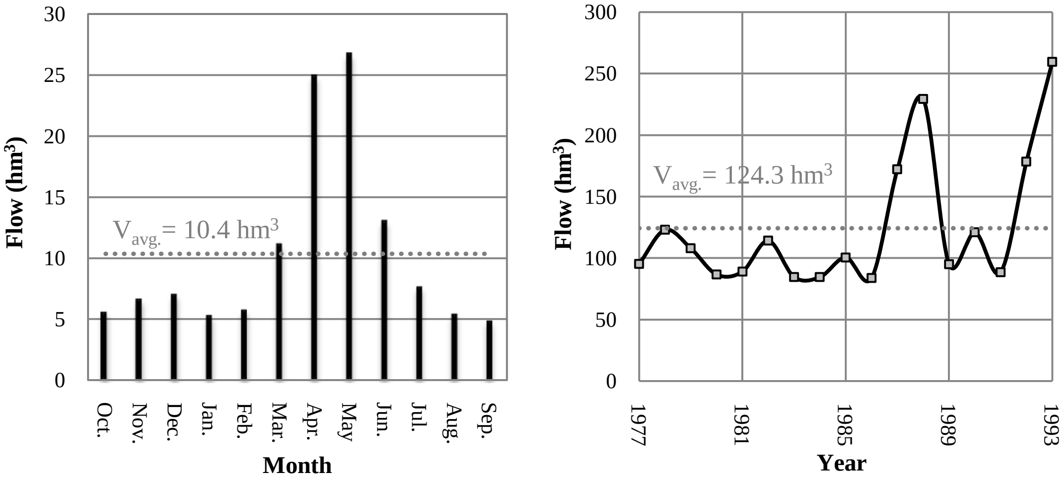


Figure D.9 Monthly Mean and Annual Total Flow Values Measured in 26-28 SGS

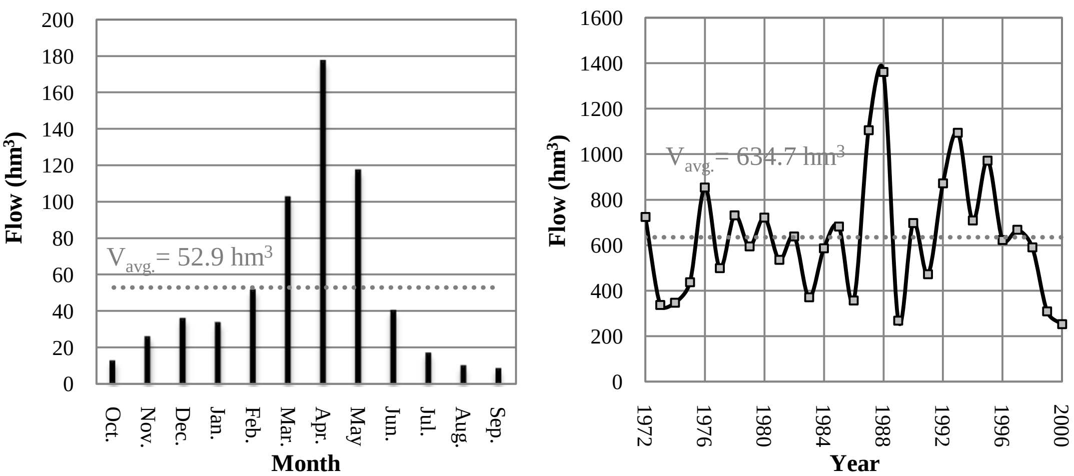


Figure D.10 Monthly Mean and Annual Total Flow Values Measured in 2624 SGS

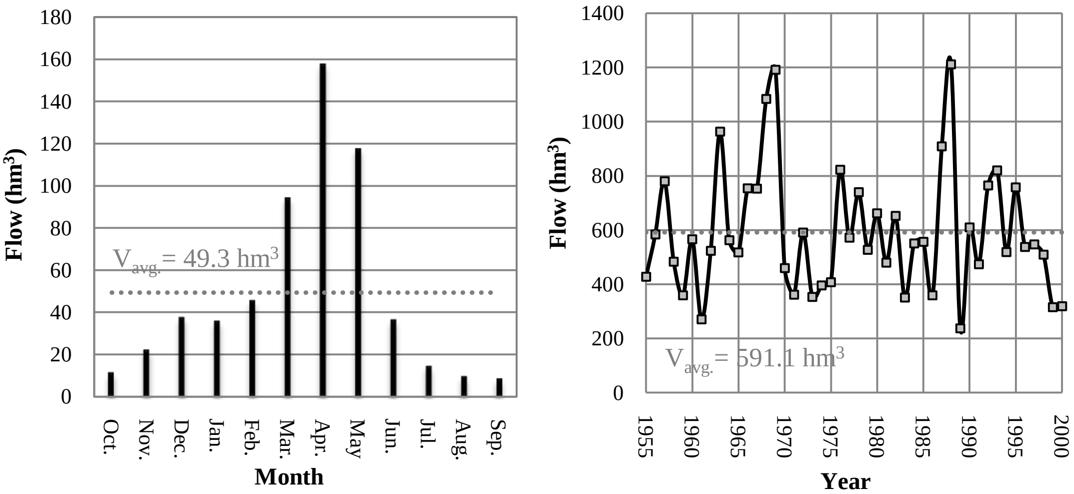


Figure D.11 Monthly Mean and Annual Total Flow Values Measured in 2610 SGS

D.3.2. Correlation Studies

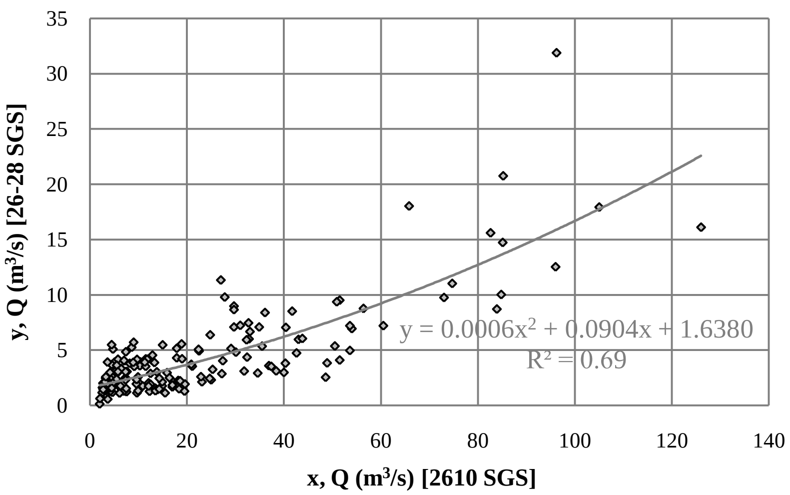


Figure D.12 Monthly Mean Discharge Correlation between 26-28 SGS and 2610 SGS

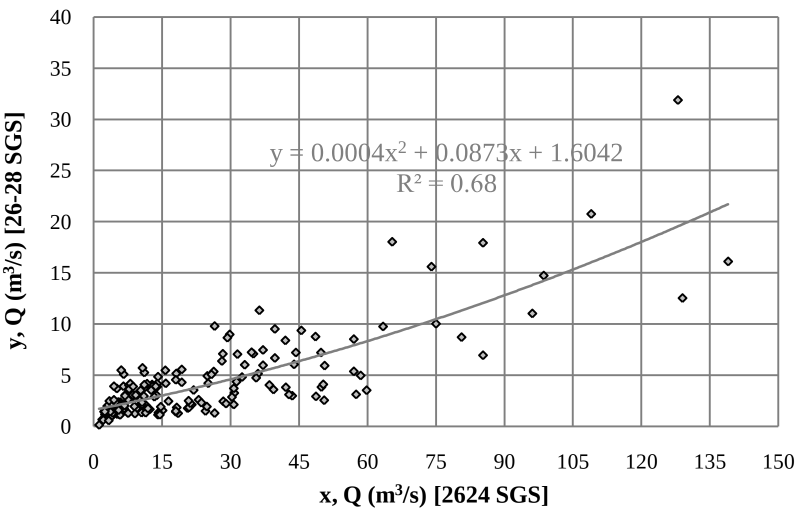


Figure D.13 Monthly Mean Discharge Correlation between 26-28 SGS and 2624 SGS

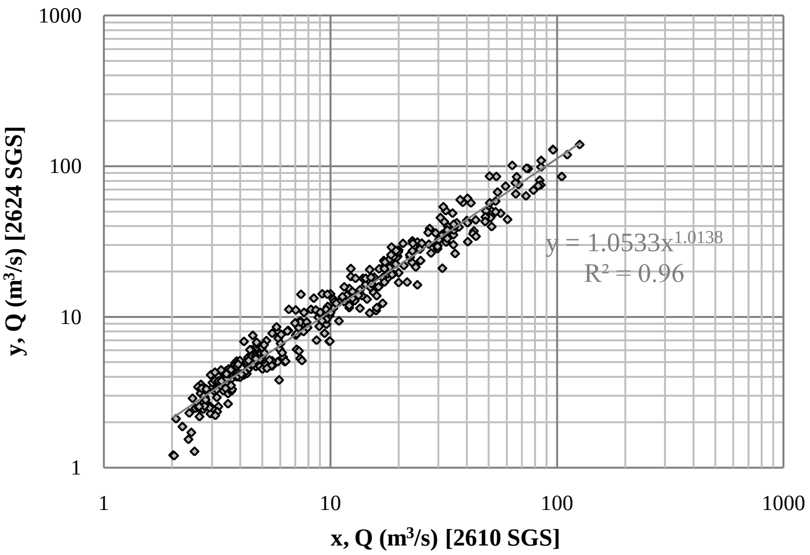


Figure D.14 Monthly Mean Discharge Correlation between 2624 SGS and 2610 SGS

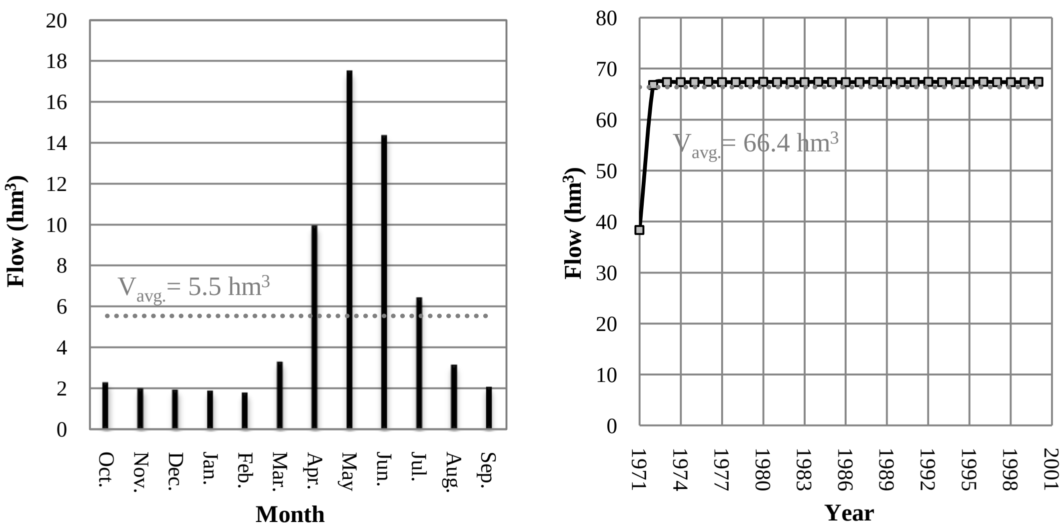


Figure D.15 Extended Monthly Mean and Annual Total Flow Values of 25-14 SGS

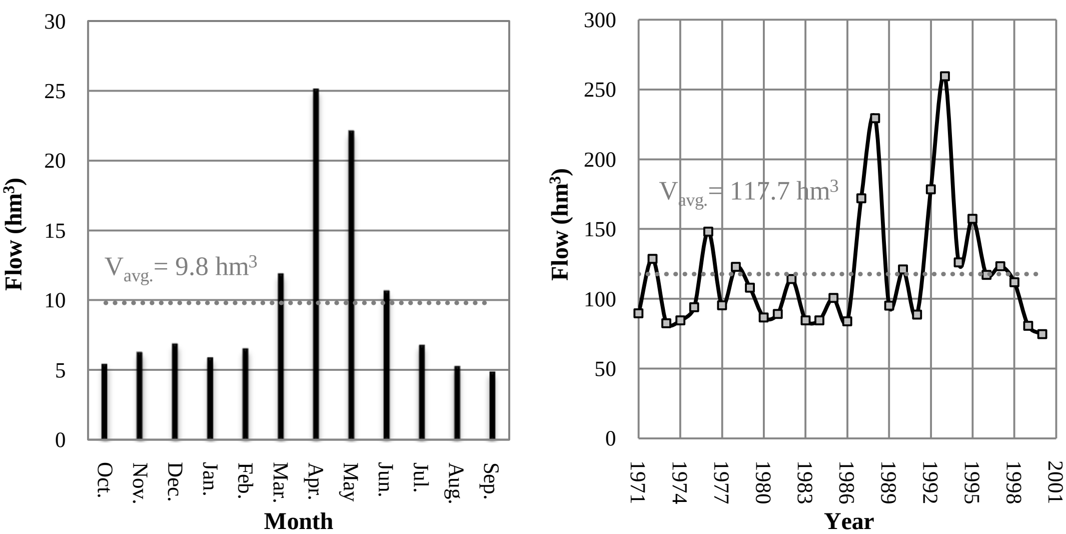


Figure D.16 Extended Monthly Mean and Annual Total Flow Values of 26-28 SGS

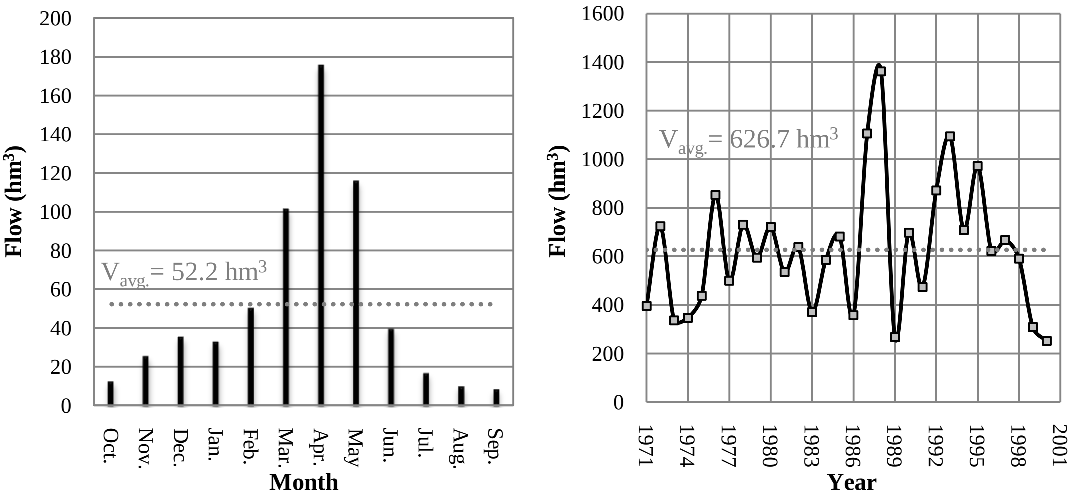


Figure D.17 Extended Monthly Mean and Annual Total Flow Values of 2624 SGS

D.3.3. Monthly Mean Flow Calculations

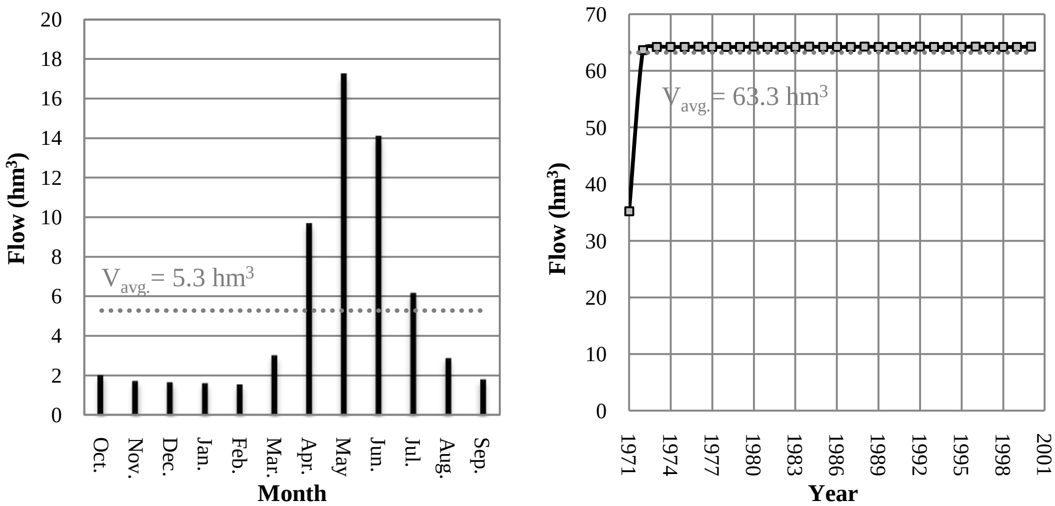


Figure D.18 Monthly Mean and Annual Total Flow Values of the Diversion to Guzeldere Dam by Kotum Weir with a 12.00 m^3/s Capacity Transmission Canal

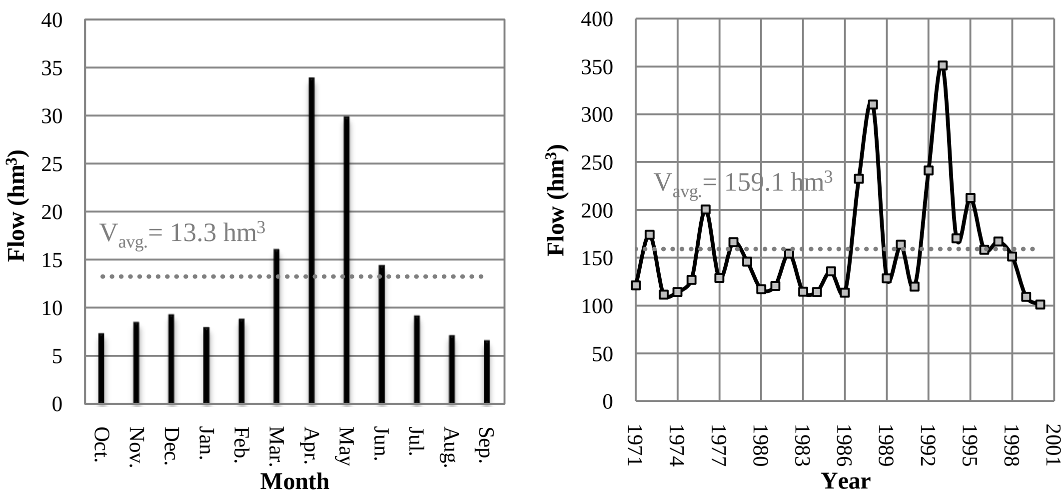


Figure D.19 Monthly Mean and Annual Total Flow Values at Guzeldere Dam

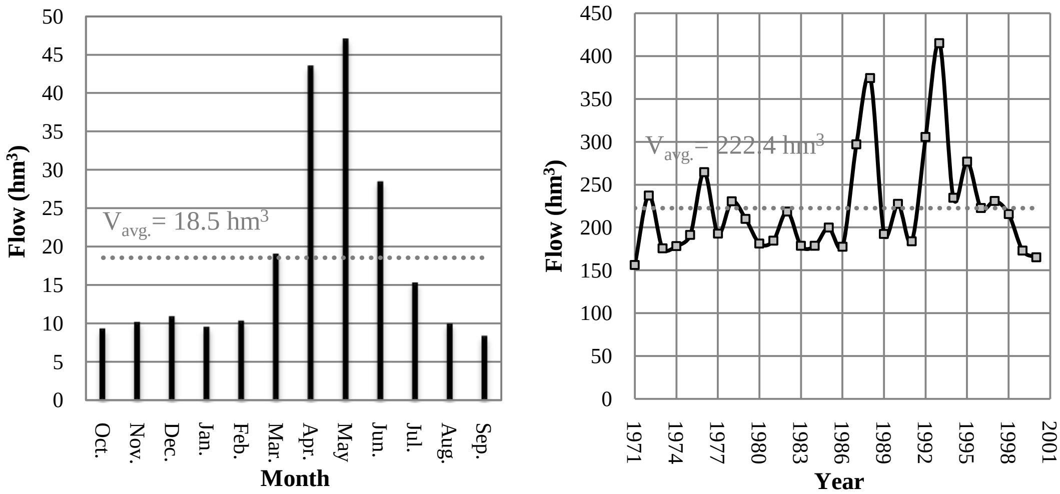


Figure D.20 Monthly Mean and Annual Total Inflow Values at Guzeldere Dam with the Development of Kotum Derivation

Table D.6 Monthly Mean Flow Values Released to Downstream of Guzeldere Dam

Months	Flow Released to Downstream (hm^3)
October	0.8
November	0.9
December	1.0
January	1.0
February	1.0
March	1.8
April	4.1
May	3.5
June	1.5
July	0.9
August	0.7
September	0.7
Total	17.8

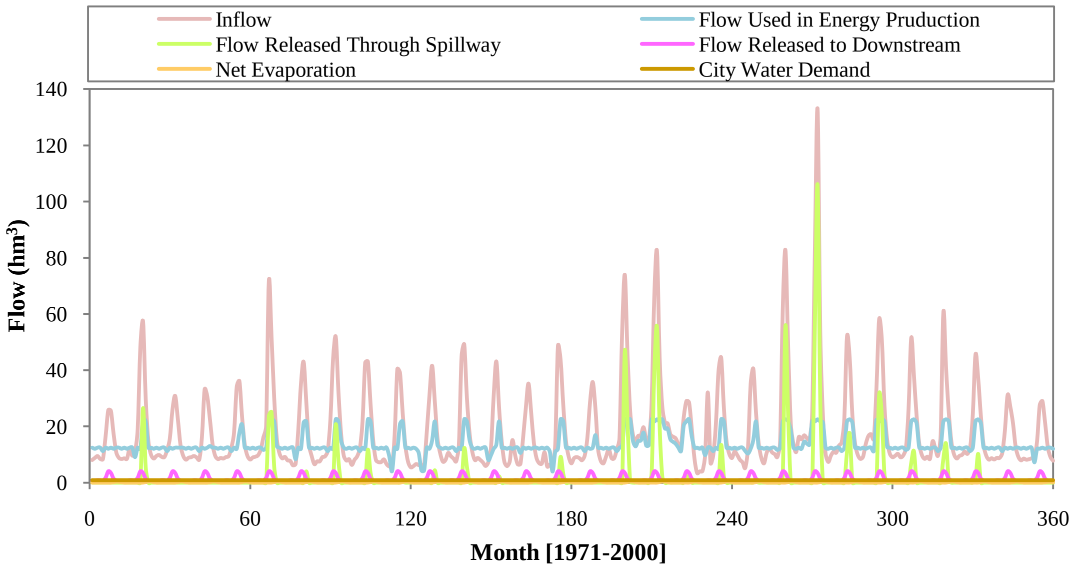


Figure D.21 Operation Study of Guzeldere Dam and HEPP

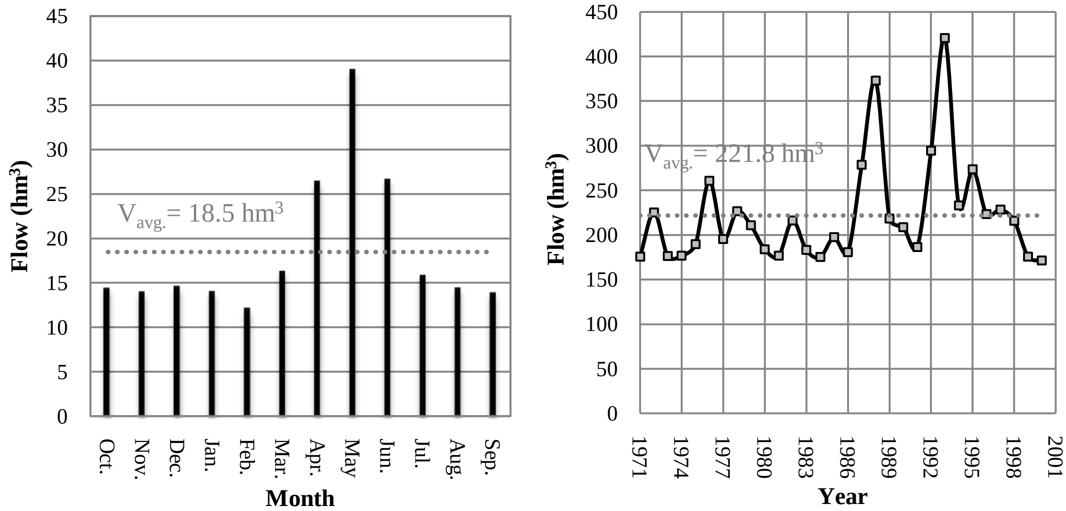


Figure D.22 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Guzeldere Reservoir

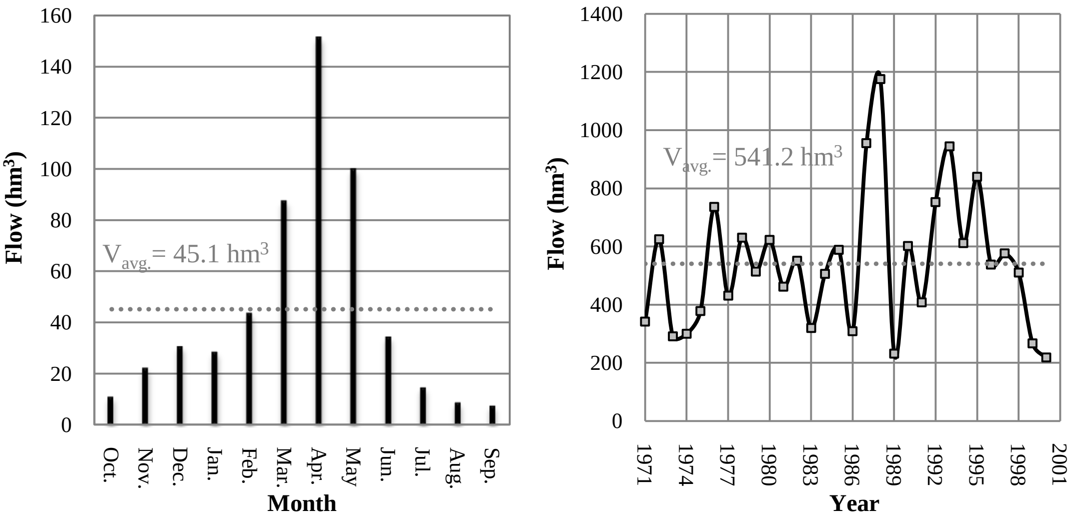


Figure D.23 Monthly Mean and Annual Total Flow Values at Sirvan Dam

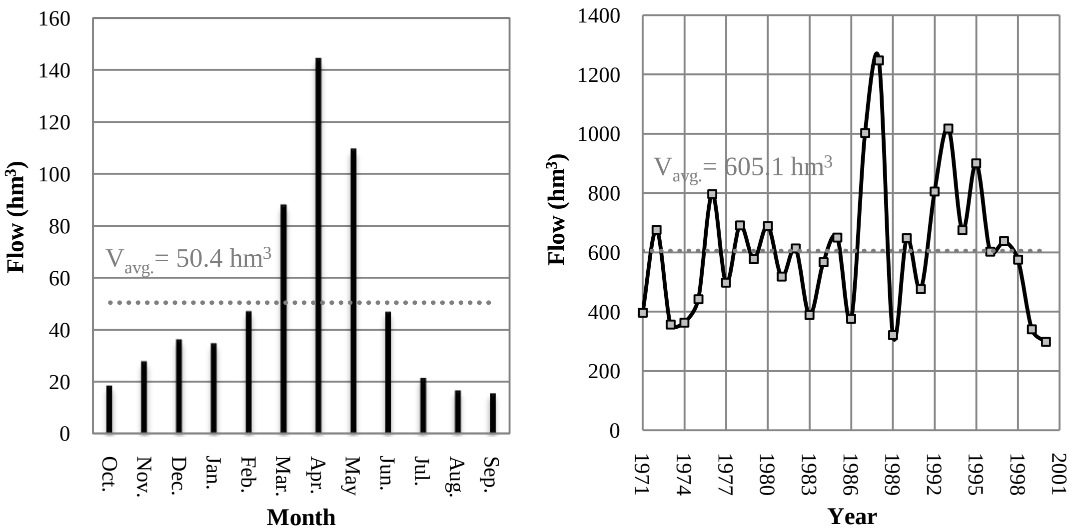


Figure D.24 Monthly Mean and Annual Total Inflow Values in the Operation Study of Sirvan Reservoir

Table D.7 Monthly Mean Flow Values Released to Downstream of Sirvan Dam

Months	Flow Released to Downstream (hm^3)
October	1.0
November	1.8
December	2.7
January	2.6
February	3.9
March	9.2
April	17.4
May	11.4
June	3.6
July	1.5
August	0.9
September	0.7
Total	56.6

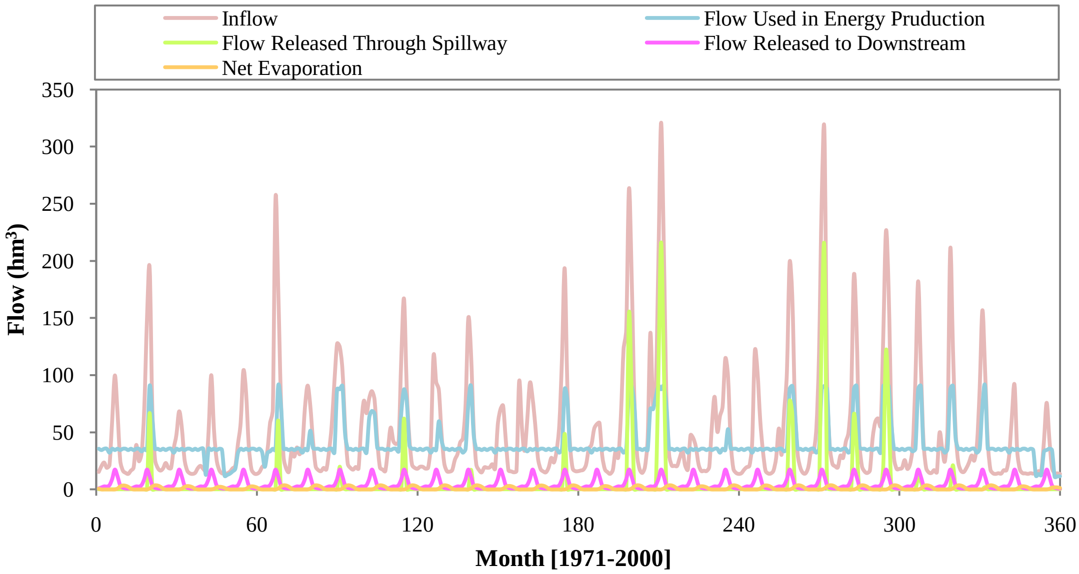
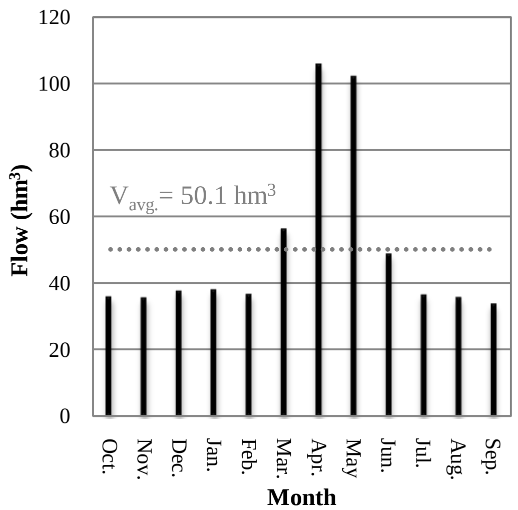


Figure D.25 Operation Study of Sirvan Dam and HEPP



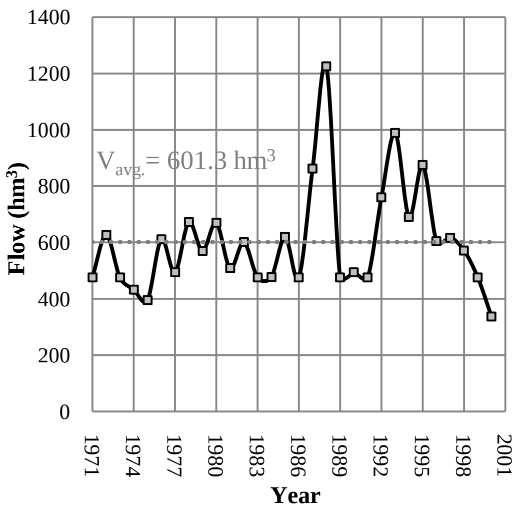


Figure D.26 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Sirvan Reservoir

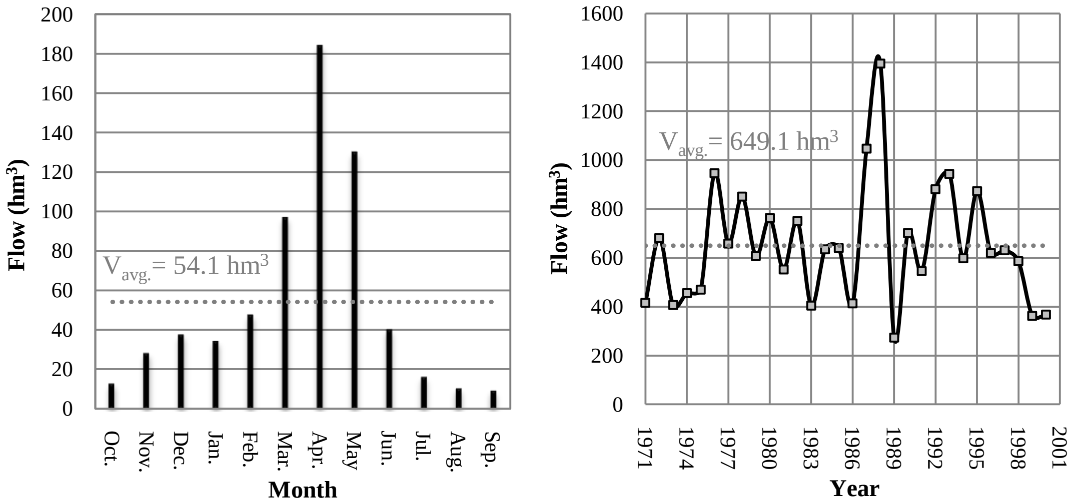


Figure D.27 Monthly Mean and Annual Total Flow Values at Basoren Dam

Table D.8 Monthly Mean Flow Values Released to Downstream of Basoren Dam

Months	Flow Released to Downstream (hm^3)
October	1.2
November	2.5
December	3.2
January	3.5
February	4.5
March	9.5
April	18.8
May	13.2
June	4.1
July	1.6
August	1.1
September	1.0
Total	64.1

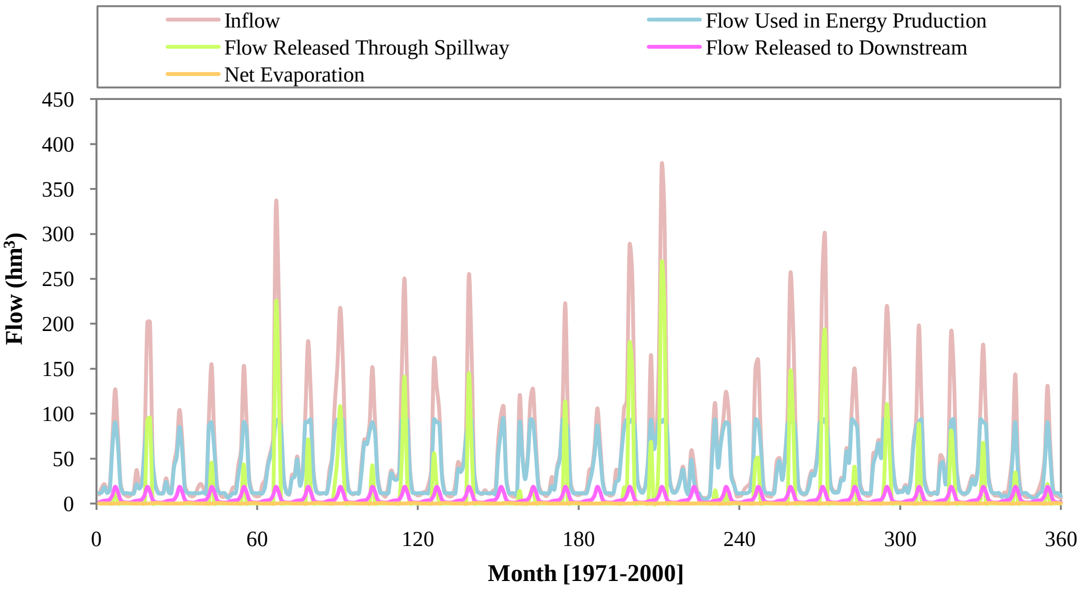


Figure D.28 Operation Study of Basoren Dam and HEPP

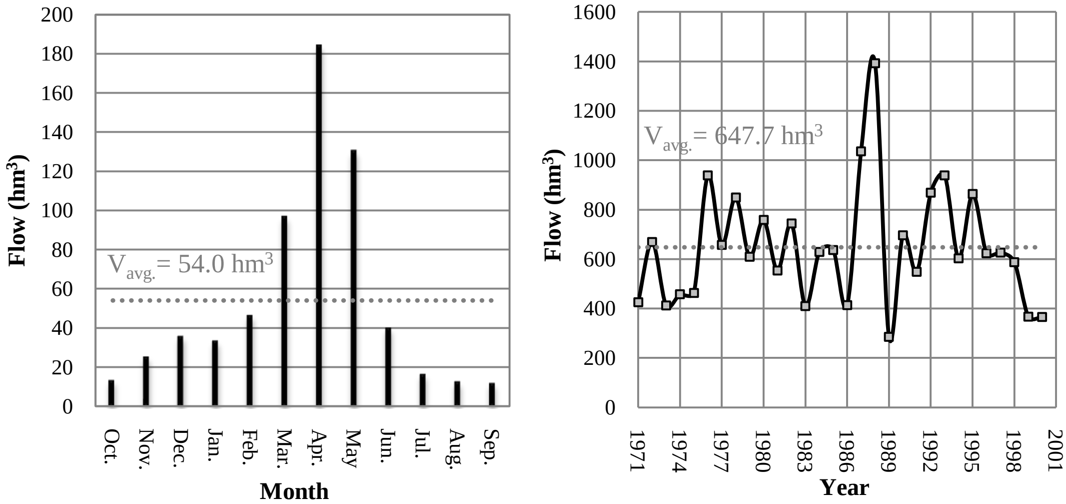


Figure D.29 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Basoren Reservoir

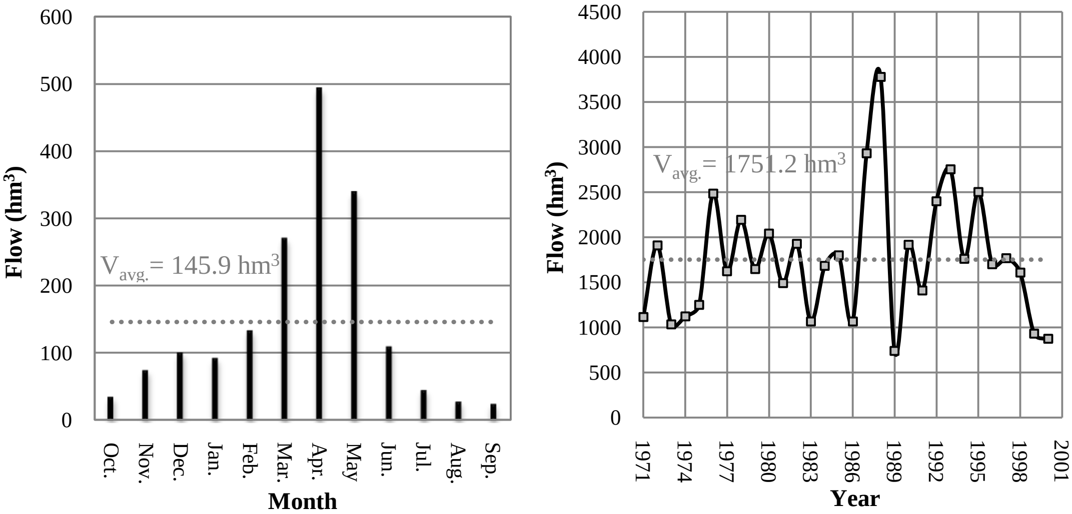


Figure D.30 Monthly Mean and Annual Total Flow Values at Ilisu II Dam

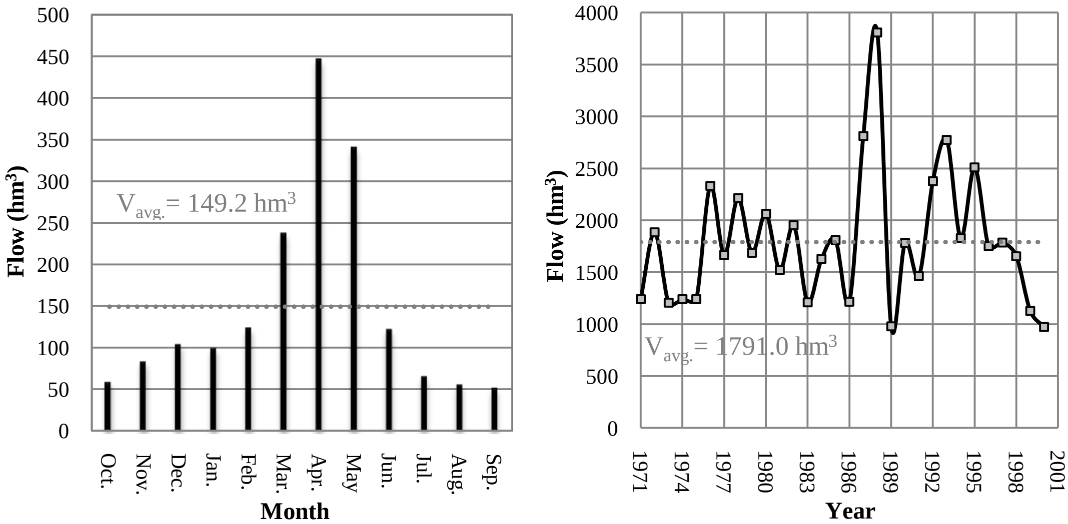


Figure D.31 Monthly Mean and Annual Total Inflow Values in the Operation Study of Ilisu II Reservoir

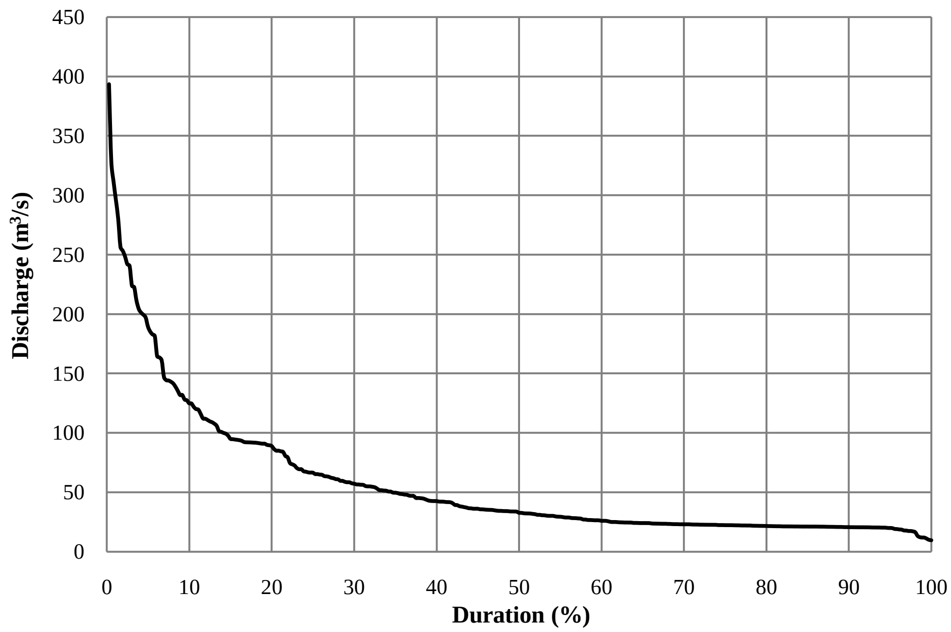


Figure D.32 Discharge-Duration Curve of Ilisu II Dam and HEPP

D.4. Sediment Transport

Table D.9 Sedimentation of Ilisu II Reservoir (EIE, 2000)

Sediment Gauging Station	2610 Bitlis Creek - Baykan	
Catchment Area of SGS	640.4 km^2	
Unit Volume Weight of Sediment	1.35 t/m^3	
Sediment Type Distribution	Clay + Silt: 53.2%	Sand: 46.8%
Suspended Sediment Load	365 $t/year/km^2$	270 $m^3/year/km^2$
Bed Load (%50 of Suspended Sediment Load)	183 $t/year/km^2$	135 $m^3/year/km^2$
Total Sediment Load	548 $t/year/km^2$	406 $m^3/year/km^2$
Catchment Area of Ilisu II Dam	2510.0 km^2	
Catchment Area of Sirvan Dam	737.3 km^2	
Catchment Area of Basoren Dam	1010.0 km^2	
Area Contributing to Sediment Transport	762.7 km^2	
Economic Lifetime Period	50 year	
Volume of Sediment	15 hm^3	
Selected Minimum Water Level	475 m	

D.5. Operation Studies

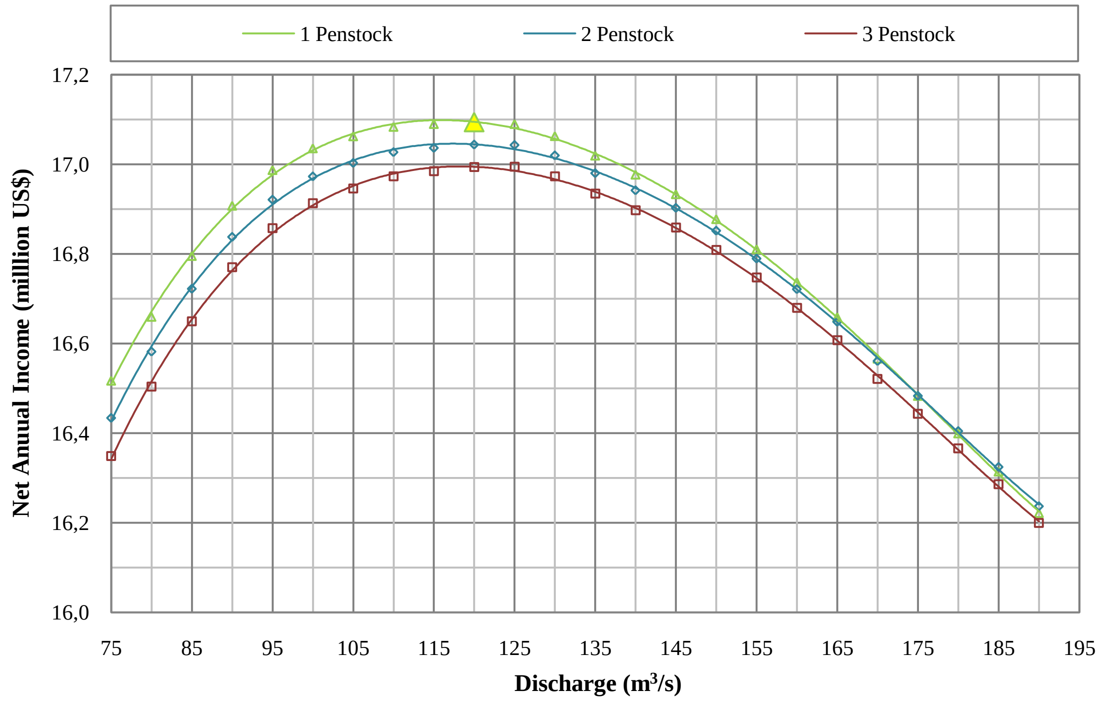


Figure D.33 Determination of Optimum Design Discharge for Ilisu II HEPP

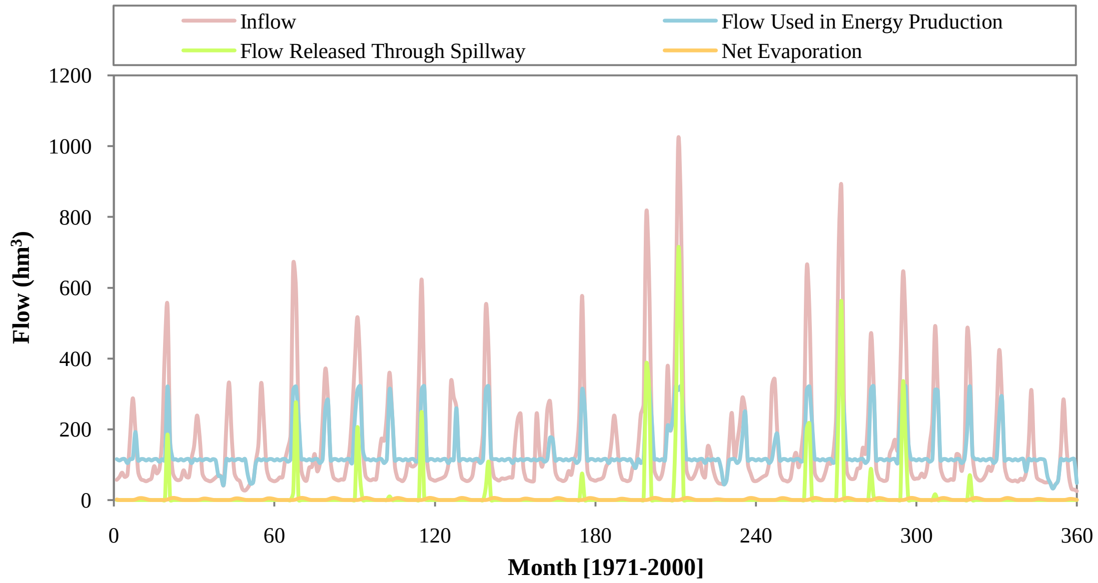


Figure D.34 Operation Study of Ilisu II Dam and HEPP

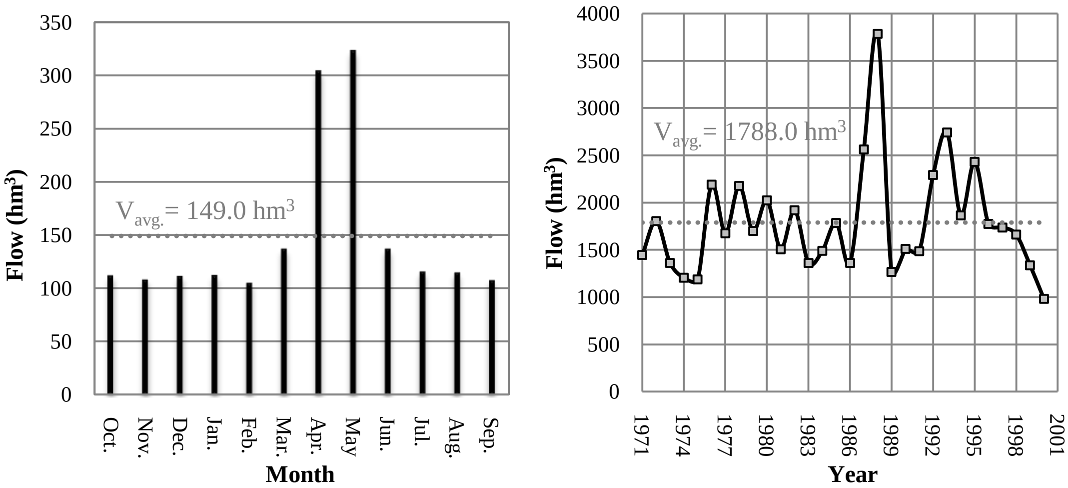


Figure D.35 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Ilisu II Reservoir

D.6. Flood Analysis

D.6.1. Calculation of Design Floods from Observed Runoff

Table D.10 Annual Instantaneous Max. Flows Observed in the Vicinity of Project Area (DSI, 2007-b; EIE, 2005)

Year	2610 SGS		2616 SGS		2624 SGS		2626 SGS		2633 SGS		26-20 SGS	
	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)
1946	-	-	-	-	-	-	-	-	27.4	609.0	-	-
1947	-	-	-	-	-	-	-	-	15.4	258.0	-	-
1948	-	-	-	-	-	-	-	-	17.5	914.0	-	-
1949	-	-	-	-	-	-	-	-	17.5	578.0	-	-
1950	-	-	-	-	-	-	-	-	28.5	1034.0	-	-
1951	-	-	-	-	-	-	-	-	25.4	232.0	-	-
1952	-	-	-	-	-	-	-	-	28.4	1020.0	-	-
1953	-	-	-	-	-	-	-	-	22.4	510.0	-	-
1954	-	-	-	-	-	-	-	-	9.5	896.0	-	-
1955	3.5	112.0	-	-	-	-	-	-	7.4	609.0	-	-
1956	22.12	126.0	-	-	-	-	-	-	11.4	802.0	-	-
1957	6.3	347.0	-	-	-	-	-	-	9.5	609.0	-	-
1958	5.3	123.0	-	-	-	-	-	-	18.4	914.0	-	-
1959	24.3	103.0	-	-	-	-	-	-	14.4	744.0	-	-
1960	26.4	132.0	-	-	-	-	-	-	26.4	978.0	-	-
1961	13.4	96.0	-	-	-	-	-	-	7.5	708.0	-	-
1962	21.11	110.0	-	-	-	-	-	-	28.4	422.0	-	-
1963	10.4	275.0	-	-	-	-	-	-	8.4	1777.0	-	-
1964	26.3	216.0	-	-	-	-	-	-	26.3	834.0	-	-
1965	30.4	223.0	28.4	65.2	-	-	-	-	29.4	1280.0	18.4	15.5
1966	27.1	296.0	20.4	102.0	-	-	-	-	26.1	1189.0	20.4	24.0
1967	20.4	144.0	21.4	102.0	-	-	-	-	14.5	1750.0	20.4	25.0
1968	18.4	331.0	18.4	103.0	-	-	-	-	19.4	1425.0	28.4	33.0
1969	1.5	295.0	1.4	160.0	-	-	-	-	2.4	1853.0	-	-
1970	12.2	143.0	6.4	54.9	-	-	-	-	16.4	480.0	-	-
1971	15.4	115.0	-	-	-	-	-	-	9.5	476.0	-	-
1972	30.4	393.0	-	-	30.4	243.0	1.5	1581.0	-	-	-	-
1973	9.4	92.6	-	-	8.4	45.7	10.5	626.0	-	-	-	-
1974	17.3	206.0	-	-	9.4	104.0	4.5	585.0	-	-	-	-
1975	19.4	153.0	-	-	20.4	193.0	14.4	506.0	-	-	-	-
1976	13.4	416.0	-	-	13.4	334.0	17.4	1172.0	-	-	-	-
1977	14.4	220.0	-	-	24.4	137.0	14.5	517.0	-	-	-	-
1978	24.4	217.0	-	-	12.3	163.0	7.5	531.0	-	-	-	-

Table D.10 (continued)

1979	15.12	172.0	-	-	16.12	202.0	7.4	489.0	-	-	-	-
1980	28.3	303.0	-	-	28.3	158.0	28.3	927.0	-	-	-	-
1981	14.3	351.0	-	-	13.3	202.0	26.4	866.0	-	-	-	-
1982	5.4	337.0	-	-	5.4	357.0	18.5	1509.0	-	-	-	-
1983	16.5	90.8	-	-	17.5	109.0	17.5	1230.0	-	-	-	-
1984	18.11	281.0	-	-	18.11	304.0	17.4	655.0	-	-	-	-
1985	2.4	274.0	-	-	2.4	458.0	2.4	1190.0	-	-	-	-
1986	15.4	167.0	-	-	15.4	129.0	15.4	574.0	-	-	-	-
1987	12.4	338.0	-	-	12.4	590.0	11.5	1224.0	-	-	-	-
1988	14.4	449.0	-	-	14.4	430.0	14.4	1950.0	-	-	-	-
1989	8.11	101.0	-	-	8.11	125.0	8.1	453.0	-	-	-	-
1990	27.11	174.0	-	-	27.11	210.0	30.1	351.0	-	-	-	-
1991	23.3	188.0	-	-	23.3	285.0	23.3	930.0	-	-	-	-
1992	13.4	307.0	-	-	14.4	445.0	13.4	1576.0	-	-	-	-
1993	19.4	242.0	-	-	19.4	293.0	20.4	1830.0	-	-	-	-
1994	2.4	142.0	-	-	8.4	385.0	1.4	1237.0	-	-	-	-
1995	2.5	249.0	-	-	3.4	300.0	3.4	1423.0	-	-	-	-
1996	9.2	235.0	-	-	31.3	215.0	13.4	846.0	-	-	-	-
1997	27.4	201.0	-	-	28.4	235.0	-	-	28.4	1272.0	-	-
1998	29.3	288.0	-	-	29.3	320.0	-	-	29.3	955.0	-	-
1999	1.4	198.0	-	-	1.4	332.0	-	-	1.4	1095.0	-	-
2000	7.4	80.9	-	-	8.4	64.1	-	-	21.4	707.0	-	-
2001	6.4	227.0	-	-	6.4	179.0	-	-	6.4	547.0	-	-
2002	29.12	214.0	-	-	29.12	251.0	-	-	17.4	1191.0	-	-
2003	9.4	180.0	-	-	26.3	238.0	-	-	9.4	1328.0	-	-
2004	6.3	395.0	-	-	6.3	579.0	-	-	6.3	2159.0	-	-
2005	22.11	161.0	-	-	22.11	294.0	-	-	26.40	896.0	-	-
2006	9.5	163.0	-	-	8.4	142.0	-	-	7.06	744.0	-	-
Distrib.	**Pearson Type-3**		**Gumbel**		**Log-Normal (3 Parameter)**		**Gumbel**		**Log-Pearson Type-3**		**Normal**	
Q_{2}	210.8		93.3		243.2		920.6		868.3		24.4	
$Q_{2.33}$	227.7		102.7		266.4		1011.6		948.4		25.7	
Q_{5}	295.7		143.3		361.7		1407.0		1289.8		30.4	
Q_{10}	345.1		176.4		433.7		1729.0		1553.9		33.5	
Q_{25}	401.8		218.2		519.4		2135.9		1867.3		36.9	
Q_{50}	440.7		249.2		579.9		2437.8		2086.0		39.1	
Q_{100}	477.1		279.9		638.3		2737.4		2292.7		41.0	
Q_{200}	511.8		310.6		695.0		3035.9		2489.3		42.8	
Q_{500}	555.6		351.1		768.0		3429.8		2736.2		45.0	
Q_{1000}	587.4		381.6		823.6		3727.4		2914.3		46.5	

D.6.1.1. Point Flood Frequency Analysis

Table D.11 Point Flood Frequency Analysis Results of Ilisu II Dam

Return Period	2610 Bitlis-Baykan SGS	Ilisu II Dam
	Flood Discharge (m^3/s)	
2	210.8	524.0
2.33	227.7	566.1
5	295.7	735.1
10	345.2	858.0
25	401.8	998.9
50	440.7	1095.4
100	477.1	1186.1
200	511.8	1272.4
500	555.6	1381.1
1000	587.4	1460.3

D.6.1.2. Regional Flood Frequency Analysis

Table D.12 Data for Homogeneity Test

Unit: m^3/s

SGS	Q_{2}	$Q_{2.33}$	Q_{5}	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	Q_{1000}
2626	920.6	1011.6	1407.0	1729.0	2135.9	2437.8	2737.4	3035.9	3429.8	3727.4
2633	868.3	948.4	1289.8	1553.9	1867.3	2086.0	2292.7	2489.3	2736.2	2914.3
2624	243.2	266.4	361.7	433.7	519.4	579.9	638.3	695.0	768.0	823.6
2616	93.3	102.7	143.3	176.4	218.2	249.2	279.9	310.6	351.1	381.6
26-20	24.4	25.7	30.4	33.5	36.9	39.1	41.0	42.8	45.0	46.5
2610	210.8	227.7	295.7	345.1	401.8	440.7	477.1	511.8	555.6	587.4

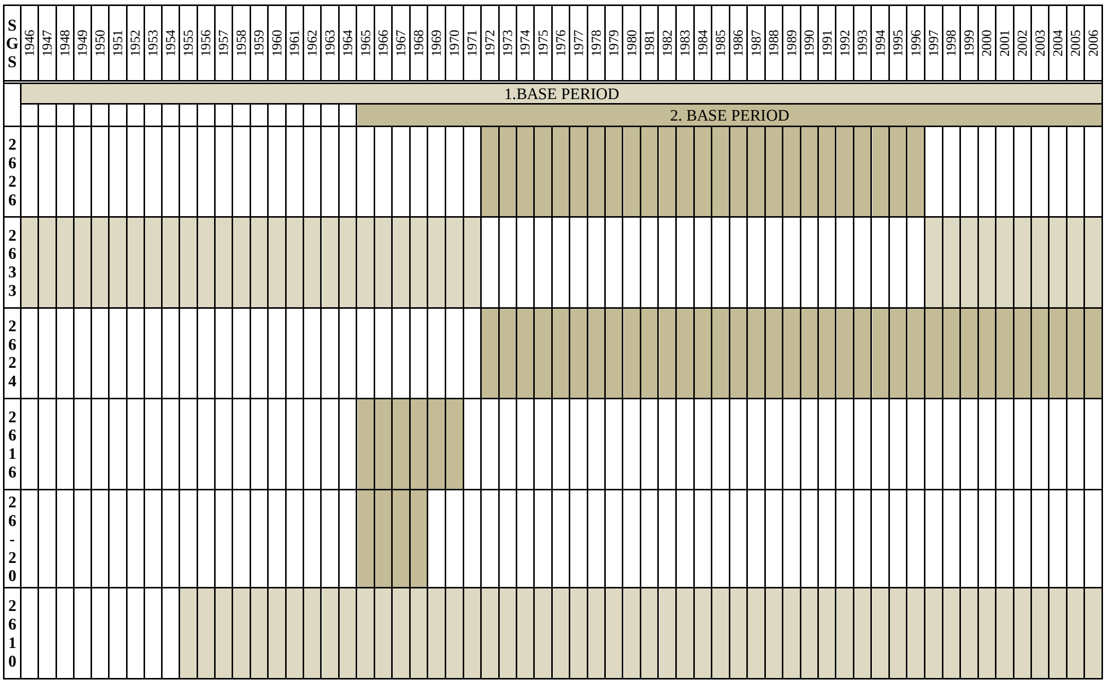


Figure D.36 Observation Periods of Stream Gauging Stations

Table D.13 1. Base Period (1946-2006) Homogeneity Test Table

SGS	$Q_{2.33}$	Q_{10}	$Q_{10}/Q_{2.33}$	Avg.x$Q_{2.33}$	Return Period	Obser. Period	Adjusted Re. Period
2633	948.4	1553.9	1.6	1495.6	8.9	36	48.5
2610	227.7	345.1	1.5	359.1	13.7	52	56.5
		Average	1.6				

Table D.14 2. Base Period (1965-2006) Homogeneity Test Table

SGS	$Q_{2.33}$	Q_{10}	$Q_{10}/Q_{2.33}$	Avg.x$Q_{2.33}$	Return Period	Obser. Period	Adjusted Re. Period
2626	1011.6	1729.0	1.7	1609.1	8.1	25	33.5
2624	266.4	433.7	1.6	423.8	9.3	35	38.5
2616	102.7	176.4	1.7	163.3	8.0	6	24.0
26-20	25.7	33.5	1.3	40.8	94.3	4	23.0
		Average	1.6				

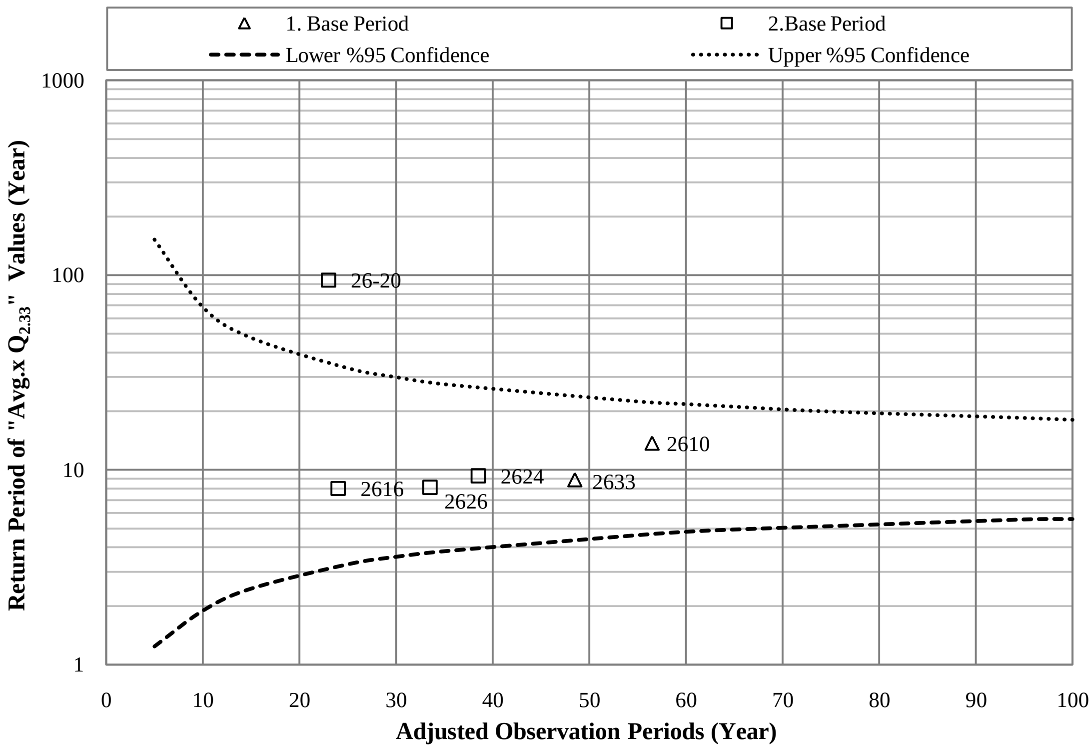


Figure D.37 Homogeneity Test Graph

Table D.15 Dimensionless Regional Flood Frequency Analysis

Unit: m^3/s

SGS	Q_2	$Q_{2.33}$	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	Q_{1000}
2626	0.9	1.0	1.4	1.7	2.1	2.4	2.7	3.0	3.4	3.7
2633	0.9	1.0	1.4	1.6	2.0	2.2	2.4	2.6	2.9	3.1
2624	0.9	1.0	1.4	1.6	1.9	2.2	2.4	2.6	2.9	3.1
2616	0.9	1.0	1.4	1.7	2.1	2.4	2.7	3.0	3.4	3.7
2610	0.9	1.0	1.3	1.5	1.8	1.9	2.1	2.2	2.4	2.6
Avg.	0.9	1.0	1.4	1.6	2.0	2.2	2.5	2.7	3.0	3.2

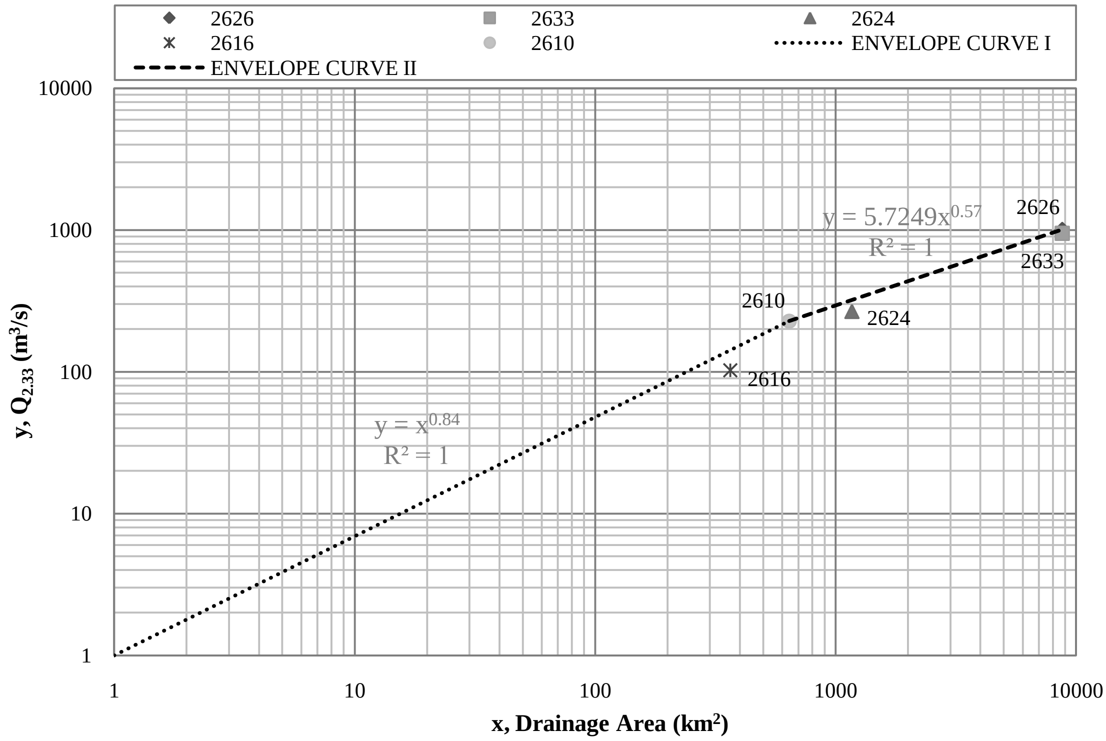


Figure D.38 Regional Flood Envelope Curve

Table D.16 Regional Flood Frequency Analysis Results of Ilisu II Dam

Return Period	**Ilisu II Dam** Flood Discharge (m^3/s)
2	453.8
2.33	496.1
5	675.0
10	814.5
25	984.2
50	1106.1
100	1224.5
200	1340.2
500	1490.0
1000	1602.0

D.6.2. Flood Recurrences Calculated Using Snyder Synthetic Unit Hydrograph Method

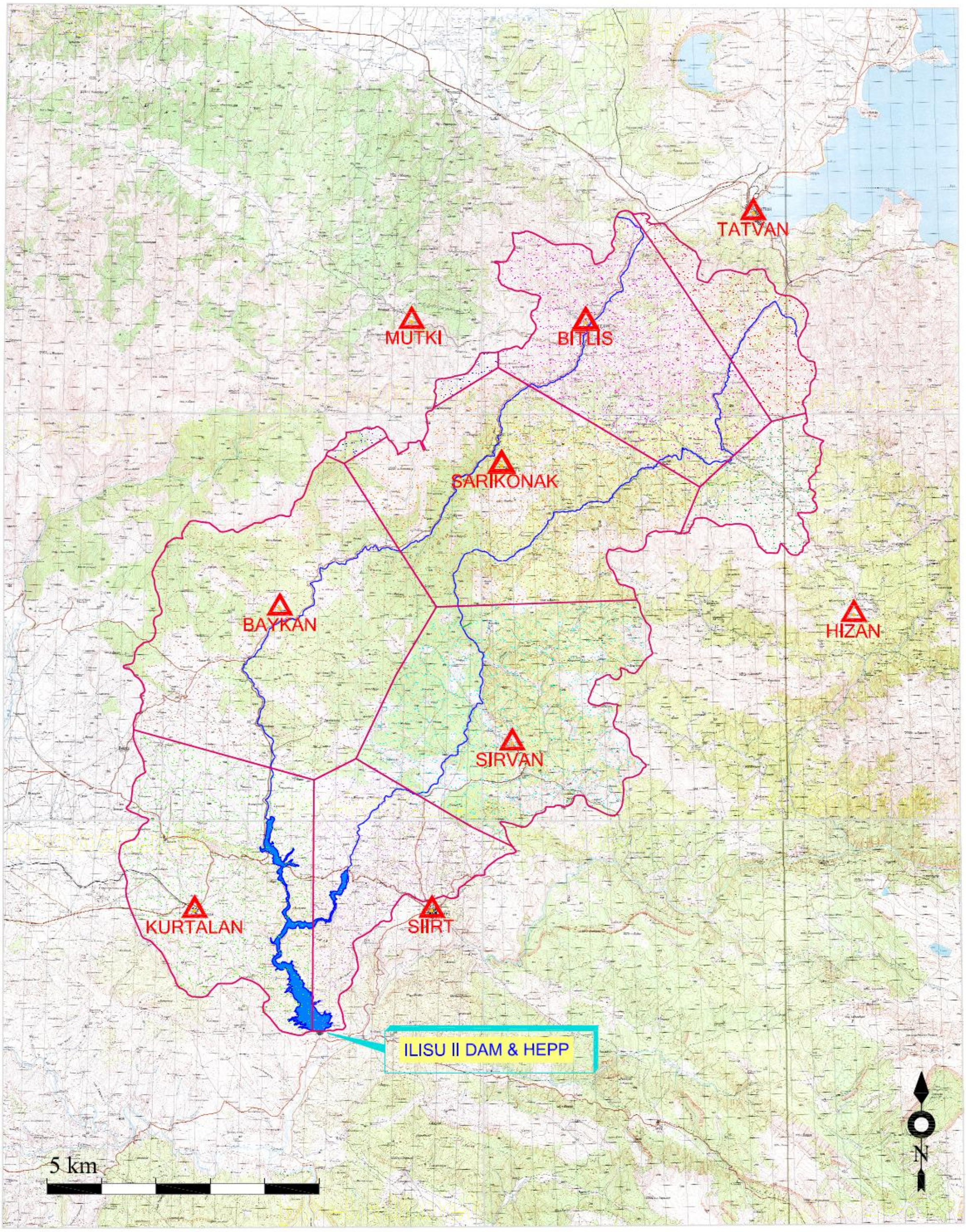


Figure D.39 Thiessen Polygons of Ilisu II Drainage Area

Table D.17 Annual Daily Max. Precipitations Observed in the Vicinity of Project Area (DMI, 2009-b)

Year	Bitlis MS	Sarikonak MS	Hizan MS	Baykan MS	Sirvan MS	Siirt MS	Tatvan MS	Mutki MS	Kurtalan MS
	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)
1929	61.2	-	-	-	-	49.2	-	-	-
1930	56.8	-	-	-	-	25.4	-	-	-
1931	96.2	-	-	-	-	66.7	-	-	-
1932	94.6	-	-	-	-	45.1	-	-	-
1933	60.4	-	-	-	-	39.2	-	-	-
1934	-	-	-	-	-	56.8	-	-	-
1935	-	-	-	-	-	52.3	-	-	-
1936	-	-	-	-	-	118.0	-	-	-
1937	-	-	-	-	-	38.5	-	-	-
1938	-	-	-	-	-	51.5	-	-	-
1939	87.5	-	-	-	-	47.4	-	-	-
1940	62.5	-	-	-	-	27.0	-	-	-
1941	49.4	-	-	-	-	30.6	-	-	-
1942	67.2	-	-	-	-	38.0	-	-	-
1943	-	-	-	-	-	25.8	-	-	-
1944	-	-	-	-	-	61.9	-	-	-
1945	19.6	-	-	-	-	30.8	-	-	-
1946	8.9	-	-	-	-	-	-	-	-
1947	42.0	-	-	-	-	44.4	-	-	-
1948	85.0	-	-	-	-	43.3	-	-	-
1949	48.0	-	-	-	-	43.2	-	-	-
1950	44.0	-	-	-	-	65.9	-	-	-
1951	53.0	-	-	-	-	69.1	-	-	-
1952	32.8	-	-	-	-	44.2	-	-	-
1953	80.0	-	-	-	-	42.5	-	-	-
1954	80.0	-	-	-	-	42.0	-	-	30.2
1955	44.7	-	-	-	-	71.8	-	-	58.2
1956	85.7	-	-	-	-	50.5	-	-	52.7
1957	75.3	-	-	80.2	-	40.6	-	80.3	70.7
1958	88.5	-	50.3	57.1	-	39.5	52.3	83.9	40.4
1959	53.3	-	39.0	56.4	-	53.4	36.2	53.2	58.3
1960	33.3	-	47.8	37.4	46.5	41.4	37.1	48.6	41.2
1961	83.4	-	56.5	50.6	41.7	42.5	48.1	88.6	44.2
1962	43.3	-	50.0	55.1	45.6	48.2	34.1	63.2	53.4
1963	55.5	-	65.0	58.0	48.1	49.9	53.2	64.7	-
1964	36.0	-	50.0	52.0	42.1	34.8	38.7	59.4	17.2
1965	56.5	-	60.0	68.0	32.1	25.8	51.5	94.3	33.4
1966	78.8	-	45.3	65.0	46.4	52.6	59.1	73.7	68.7
1967	75.9	-	52.0	81.5	49.2	38.3	55.5	93.2	68.3
1968	67.5	-	55.0	74.0	54.1	65.7	56.2	82.4	-
1969	76.9	-	55.0	72.4	50.2	63.0	56.7	73.4	-
1970	65.8	-	40.0	56.4	69.6	32.3	44.6	46.3	-
1971	87.0	85.2	55.8	54.2	47.5	49.9	67.6	98.4	63.6
1972	55.4	72.6	44.5	65.4	55.6	35.5	45.2	67.2	56.0
1973	35.1	62.0	49.4	35.4	26.7	24.8	25.5	46.2	-
1974	41.8	52.9	35.3	47.8	25.2	29.2	30.8	51.9	32.5
1975	66.2	58.0	52.4	58.6	43.8	41.1	49.8	48.6	58.2
1976	73.3	85.7	53.5	55.7	47.0	55.9	57.4	64.7	44.7
1977	91.3	134.6	42.0	41.0	30.5	30.2	47.0	75.3	42.5
1978	70.0	92.5	70.0	71.2	54.6	50.1	63.1	64.3	46.0
1979	52.8	112.4	51.4	52.3	46.5	37.7	52.6	58.9	-
1980	46.4	67.0	32.5	41.1	-	27.9	28.0	45.7	30.3
1981	57.5	68.3	54.5	69.4	27.3	38.3	39.4	65.9	46.1
1982	64.5	57.0	54.0	87.3	50.0	46.6	34.0	-	86.5
1983	63.4	100.0	52.4	53.2	55.2	41.2	42.0	-	36.2
1984	57.0	102.1	56.0	53.8	40.1	37.9	33.9	-	50.9
1985	66.2	63.5	43.8	60.9	65.2	71.4	25.9	-	63.5
1986	57.7	71.0	41.0	45.5	36.7	25.1	28.8	-	30.9
1987	73.8	114.8	52.4	70.3	49.5	44.1	54.5	46.3	60.5
1988	59.5	63.0	39.0	63.8	67.5	57.4	48.6	-	-
1989	81.4	94.4	58.5	68.2	40.8	65.6	43.5	-	-
1990	64.9	78.2	45.0	62.8	55.7	41.3	54.8	-	-
1991	81.3	88.8	57.6	54.7	51.0	53.2	74.0	-	-
1992	122.2	118.5	66.2	61.7	56.0	43.0	72.2	-	-
1993	85.1	67.5	52.0	90.8	70.5	68.1	76.0	-	-

Table D.17 (continued)

1994	67.3	-	50.6	70.1	75.5	57.1	48.0	-	-
1995	65.7	-	43.6	50.8	53.8	33.4	64.4	-	-
1996	40.6	-	-	-	46.0	51.2	50.0	-	-
1997	59.9	-	-	67.7	67.2	54.6	39.2	-	-
1998	58.4	-	-	49.0	39.6	43.3	32.2	-	-
1999	42.7	-	-	41.7	-	57.8	35.1	-	-
2000	55.3	-	-	56.0	-	33.0	23.4	-	-
2001	58.3	-	-	44.7	-	39.2	41.4	-	-
2002	51.3	-	-	44.1	-	37.3	39.0	-	-
2003	108.9	-	-	50.9	-	57.4	54.5	-	-
2004	79.8	-	-	-	-	47.4	68.0	-	-
2005	55.9	-	-	-	-	40.2	43.4	-	-
2006	63.5	-	-	-	-	51.9	47.8	-	-
2007	-	-	-	-	-	36.0	45.6	-	-
Distribution	**Log-Normal (3 Parameter)**	**Gumbel**	**Normal**	**Log-Pearson Type-3**	**Log-Normal (3 Parameter)**	**Log-Normal (2 Parameter)**	**Pearson Type-3**	**Gumbel**	**Log-Pearson Type-3**
$\mathbf{P_{2}}$	63.1	79.7	50.5	57.6	48.4	44.1	46.4	64.4	49.1
$\mathbf{P_{2.33}}$	66.7	84.1	52.0	59.9	50.6	46.6	48.7	67.6	52.1
$\mathbf{P_{5}}$	80.1	103.3	57.4	69.0	58.9	57.1	57.7	81.4	63.0
$\mathbf{P_{10}}$	89.2	118.9	61.1	75.7	64.5	65.4	64.0	92.6	70.1
$\mathbf{P_{25}}$	99.0	138.6	65.0	83.5	70.7	75.5	71.0	106.8	77.3
$\mathbf{P_{50}}$	105.5	153.2	67.4	88.9	74.7	82.9	75.6	117.3	81.6
$\mathbf{P_{100}}$	111.4	167.8	69.7	94.0	78.4	90.2	79.9	127.8	85.3
$\mathbf{P_{200}}$	116.9	182.2	71.7	98.8	81.8	97.3	84.0	138.2	88.4
$\mathbf{P_{500}}$	123.5	201.3	74.2	105.0	86.0	106.7	88.9	151.9	91.9
$\mathbf{P_{1000}}$	128.3	215.8	76.0	109.5	89.0	114.0	92.5	162.3	94.1

Table D.18 Probable Maximum Precipitation Calculations of Meteorological Stations

MS	Bitlis	Sarikonak	Hizan	Baykan	Sirvan	Siirt	Tatvan	Mutki	Kurtalan
N	71	23	38	46	38	78	50	26	28
$\mathbf{X_{N}}$	63.5	83.0	50.5	58.8	48.7	46.2	47.0	66.9	49.5
$\mathbf{X_{MAX}}$	122.2	134.6	70.0	90.8	75.5	118.0	76.0	98.4	86.5
$\mathbf{X_{N-1}}$	62.7	80.7	50.0	58.1	48.0	45.3	46.4	65.6	48.1
$\mathbf{X_{N-1}/X_{N}}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Correct. Coeff. 1	1.005	1.010	1.020	1.015	1.020	0.993	1.013	1.020	1.005
X	63.9	83.9	51.5	59.7	49.7	45.9	47.6	68.2	49.7
Correct. Coeff. 2	1.000	1.015	1.002	1.000	1.002	1.000	1.000	1.012	1.008
X	**63.9**	**85.1**	**51.6**	**59.7**	**49.8**	**45.9**	**47.6**	**69.0**	**50.1**
$\mathbf{\Sigma X^2}$	314077.0	169747.0	99456.8	166270.9	95632.0	182877.5	118737.7	122992.9	75023.6
$\mathbf{S_{N}}$	19.8	22.5	8.2	12.7	12.2	14.6	13.0	16.4	15.5
$\mathbf{S_{N-1}}$	18.6	19.9	7.7	11.9	11.5	12.1	12.4	15.4	14.0
$\mathbf{S_{N-1}/S_{N}}$	0.9	0.9	0.9	0.9	0.9	0.8	1.0	0.9	0.9
Correct. Coeff. 3	0.990	1.040	1.020	1.020	1.015	0.860	1.040	1.080	1.020
S	19.6	23.4	8.4	13.0	12.4	12.5	13.5	17.7	15.8
Correct. Coeff. 4	1.000	1.065	1.015	1.005	1.015	1.000	1.000	1.055	1.045
S	**19.6**	**24.9**	**8.5**	**13.1**	**12.6**	**12.5**	**13.5**	**18.7**	**16.5**
KM	**5.8**	**3.2**	**7.5**	**6.4**	**7.8**	**7.0**	**8.2**	**5.0**	**6.5**
$\mathbf{PMP_{24}=X+KM*S}$	**177.6**	**164.9**	**115.7**	**143.2**	**147.8**	**133.5**	**158.6**	**162.5**	**157.5**

Table D.19 Daily Maximum Rainfall Magnitudes

Unit: mm

MS	P_2	$P_{2.33}$	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}	P_{1000}	PMP
Bitlis	63.1	66.7	80.1	89.2	99.0	105.5	111.4	116.9	123.5	128.3	177.6
Sarikonak	79.7	84.1	103.3	118.9	138.6	153.2	167.8	182.2	201.3	215.8	164.9
Hizan	50.5	52.0	57.4	61.1	65.0	67.4	69.7	71.7	74.2	76.0	115.7
Baykan	57.6	59.9	69.0	75.7	83.5	88.9	94.0	98.8	105.0	109.5	143.2
Sirvan	48.4	50.6	58.9	64.5	70.7	74.7	78.4	81.8	86.0	89.0	147.8
Siirt	44.1	46.6	57.1	65.4	75.5	82.9	90.2	97.3	106.7	114.0	133.5
Tatvan	46.4	48.7	57.7	64.0	71.0	75.6	79.9	84.0	88.9	92.5	158.6
Mutki	64.4	67.6	81.4	92.6	106.8	117.3	127.8	138.2	151.9	162.3	162.5
Kurtalan	49.1	52.1	63.0	70.1	77.3	81.6	85.3	88.4	91.9	94.1	157.5

Table D.20 Daily Maximum Rainfall Magnitudes of Ilisu II Basin

Unit: mm

Meteorological Station	Thiessen Weight (%)	P_2	$P_{2.33}$	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}	P_{1000}	PMP
Bitlis	13.5	8.5	9.0	10.8	12.0	13.3	14.2	15.0	15.7	16.6	17.3	23.9
Sarikonak	17.4	13.9	14.6	18.0	20.7	24.1	26.7	29.2	31.7	35.0	37.6	28.7
Hizan	3.7	1.9	1.9	2.1	2.3	2.4	2.5	2.6	2.7	2.8	2.8	4.3
Baykan	21.0	12.1	12.6	14.5	15.9	17.5	18.7	19.7	20.8	22.1	23.0	30.1
Sirvan	16.6	8.0	8.4	9.8	10.7	11.7	12.4	13.0	13.6	14.2	14.7	24.5
Siirt	8.4	3.7	3.9	4.8	5.5	6.3	6.9	7.5	8.1	8.9	9.5	11.2
Tatvan	4.4	2.1	2.2	2.6	2.8	3.1	3.3	3.5	3.7	3.9	4.1	7.0
Mutki	14.3	9.2	9.6	11.6	13.2	15.2	16.7	18.2	19.7	21.7	23.1	23.2
Kurtalan	0.8	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7	1.2
Basin Precipitation	100.0	**59.7**	**62.6**	**74.6**	**83.6**	**94.4**	**102.1**	**109.5**	**116.7**	**126.0**	**132.9**	**154.1**

Table D.21 Pluviograph Coefficients of Siirt Meteorological Station (Enersu, January 2009)

Time (hr)

0.5	1	2	3	4	6	8	12	18	24
0.28	0.34	0.44	0.48	0.53	0.59	0.65	0.73	0.83	1.00

Table D.22 Areal Distribution Coefficients of Rainfall of Ilisu II Basin

Time (hr)

0.5	1	2	3	4	6	8	12	18	24
0.57	0.65	0.72	0.78	0.80	0.84	0.84	0.86	0.89	0.91

Table D.23 Corrected and Maximized Rainfall Magnitudes of Ilisu II Basin

Time (hr) **Unit: mm**

MF = 1.13	0.5	1	2	3	4	6	8	12	18	24
P_2	10.8	14.9	21.2	25.3	28.5	33.2	37.0	42.3	49.5	61.4
$P_{2.33}$	11.3	15.6	22.3	26.5	29.9	34.9	38.8	44.4	52.0	64.4
P_5	13.4	18.6	26.5	31.6	35.7	41.5	46.2	52.9	61.9	76.7
P_{10}	15.1	20.9	29.7	35.4	40.0	46.6	51.8	59.3	69.4	86.0
P_{25}	17.0	23.6	33.6	39.9	45.1	52.6	58.5	67.0	78.4	97.1
P_{50}	18.4	25.5	36.3	43.2	48.8	56.8	63.2	72.4	84.7	105.0
P_{100}	19.7	27.3	38.9	46.3	52.3	60.9	67.8	77.7	90.9	112.6
P_{200}	21.0	29.1	41.5	49.4	55.8	65.0	72.3	82.8	96.9	120.0
P_{500}	22.7	31.5	44.8	53.3	60.2	70.1	78.0	89.4	104.6	129.5
P_{1000}	24.0	33.2	47.3	56.2	63.6	74.0	82.3	94.3	110.3	136.7
PMP	27.8	38.5	54.8	65.2	73.7	85.8	95.4	109.3	127.9	158.5

Table D.24 Harmonic Slope Calculation of Ilisu II Basin

Station No n	Elevation h (m)	Elev. Diff. Δh (m)	Distance L_i (m)	$S_i=\Delta h/L_i$	$1/\sqrt{S_i}$
0	459	-	-	-	-
1	500	41	12030	0.003	17.1
2	525	25	12030	0.002	21.9
3	600	75	12030	0.006	12.7
4	750	150	12030	0.012	9.0
5	900	150	12030	0.012	9.0
6	1125	225	12030	0.019	7.3
7	1300	175	12030	0.015	8.3
8	1600	300	12030	0.025	6.3
9	1675	75	12030	0.006	12.7
10	2400	725	12030	0.060	4.1
					Total: 108.3

$S=(n/\Sigma(1/\sqrt{S_i}))^2$
S=0.009

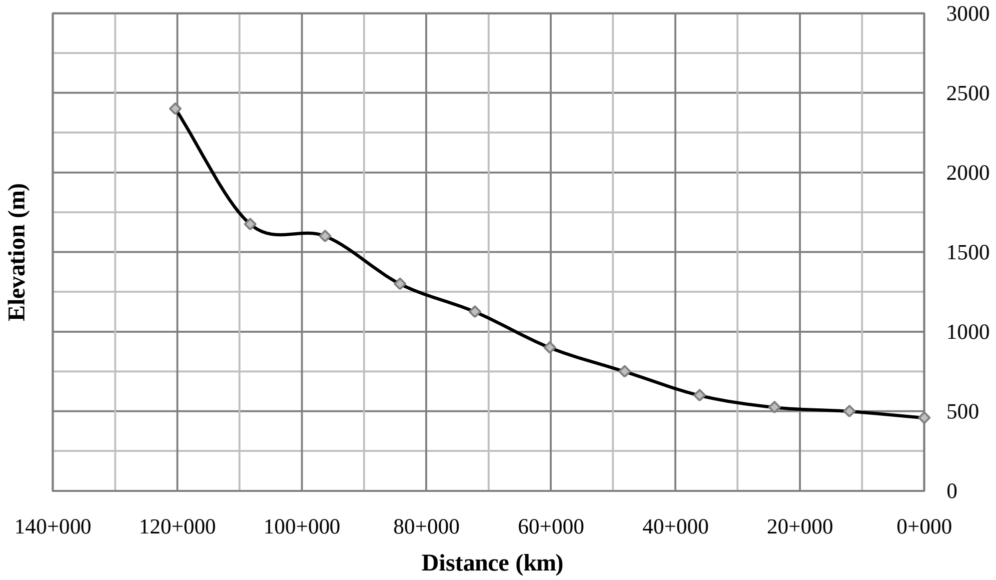


Figure D.40 River Bed Profile of Ilisu II Basin

Table D.25 Base Flow Calculation of Ilisu II Basin

2610 SGS — **Unit: m³/s**

Year	March	April	May	Average
1955	26.4	37.8	39.3	34.5
1956	28.0	29.0	25.8	27.6
1957	106.0	46.9	76.1	76.3
1958	48.7	44.0	16.7	36.5
1959	37.3	16.9	15.1	23.1
1960	43.3	66.0	39.7	49.7
1961	13.0	38.2	21.9	24.4
1962	40.9	45.2	29.3	38.5
1963	19.7	114.0	80.1	71.3
1964	55.6	51.4	38.3	48.4
1965	30.1	57.2	47.7	45.0
1966	28.7	65.0	38.0	43.9
1967	25.1	72.6	89.0	62.2
1968	60.2	116.0	76.6	84.3
1969	79.1	110.0	102.0	**97.0**
1970	33.4	38.7	17.3	29.8

Table D.25 (continued)

1971	23.5	42.6	25.9	30.7
1972	23.0	67.6	65.5	52.0
1973	20.0	34.9	23.6	26.2
1974	31.2	51.9	23.8	35.6
1975	19.8	51.2	31.1	34.0
1976	24.2	111.0	78.7	71.3
1977	32.4	60.5	40.4	44.4
1978	50.5	73.0	51.5	58.3
1979	29.1	50.9	29.7	36.6
1980	48.9	83.9	43.0	58.6
1981	51.5	43.8	33.0	42.8
1982	27.2	84.8	56.4	56.1
1983	22.9	32.8	34.9	30.2
1984	36.9	42.6	22.5	34.0
1985	34.6	74.7	31.0	46.8
1986	21.1	35.5	22.4	26.3
1987	37.4	96.0	82.6	72.0
1988	54.0	**126.0**	105.0	95.0
1989	18.9	15.0	5.8	13.2
1990	30.1	41.7	32.7	34.8
1991	48.6	53.6	24.8	42.3
1992	31.8	85.1	65.8	60.9
1993	32.3	85.2	96.2	71.2
1994	35.1	50.4	31.5	39.0
1995	40.3	73.4	54.7	56.1
1996	30.6	66.4	35.3	44.1
1997	17.4	63.5	48.3	43.1
1998	35.0	59.3	32.8	42.4
1999	19.5	48.2	16.0	27.9
2000	17.3	43.9	21.8	27.7
			Maximum Average:	**97.0**
			Maximum Value:	**126.0**
		Drainage Area of 2610 SGS :	640.4	km^2
		Drainage Area of Ilisu II Dam:	2510.0	km^2
		Recurrence Base Flow:	**241.2**	m^3/s
		Probable Maximum Flood Base Flow:	**313.2**	m^3/s

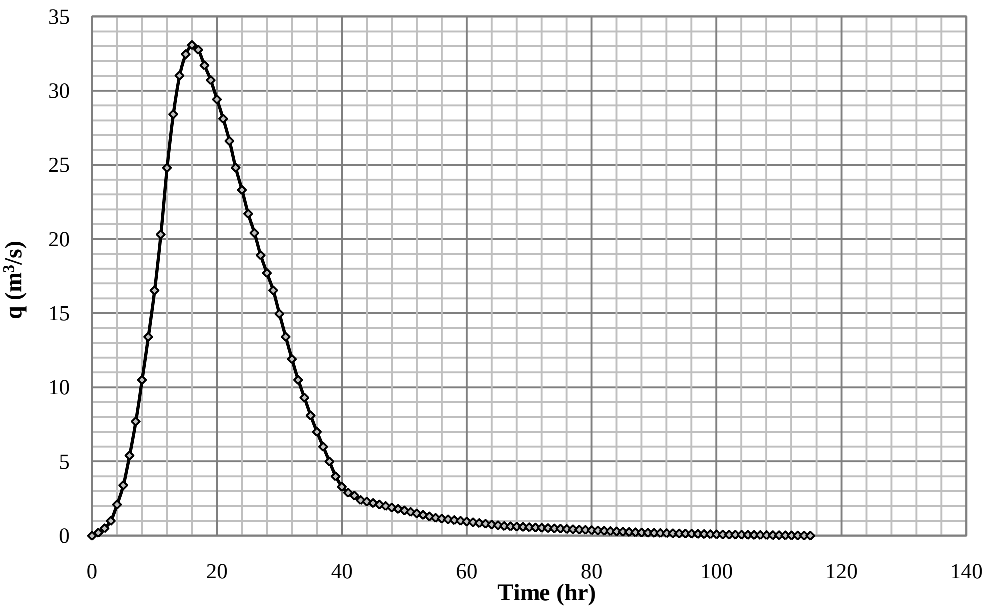


Figure D.41 Unit Hydrograph (UH_3) of Ilisu II Basin

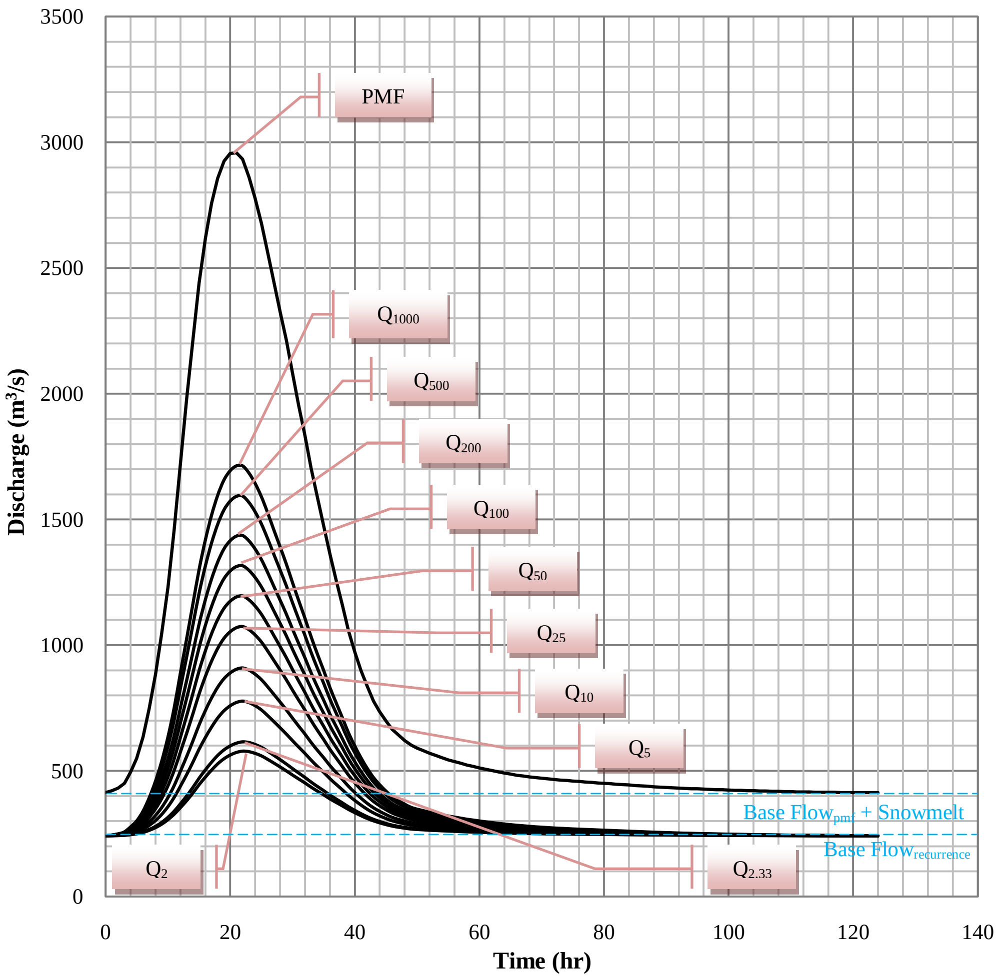


Figure D.42 Recurrence and Probable Maximum Flood Hydrographs of Ilisu II Basin

Table D.26 Snyder Synthetic Unit Hydrograph Method Results of Ilisu II Dam

Return Period	Ilisu II Dam
	Flood Discharge (m^3/s)
2	578.9
2.33	615.8
5	777.3
10	908.6
25	1073.6
50	1195.3
100	1315.8
200	1435.5
500	1593.1
1000	1712.9
PMF	2958.8

APPENDIX E

THE BOTAN PROJECT AND ILISU III DAM AND HEPP

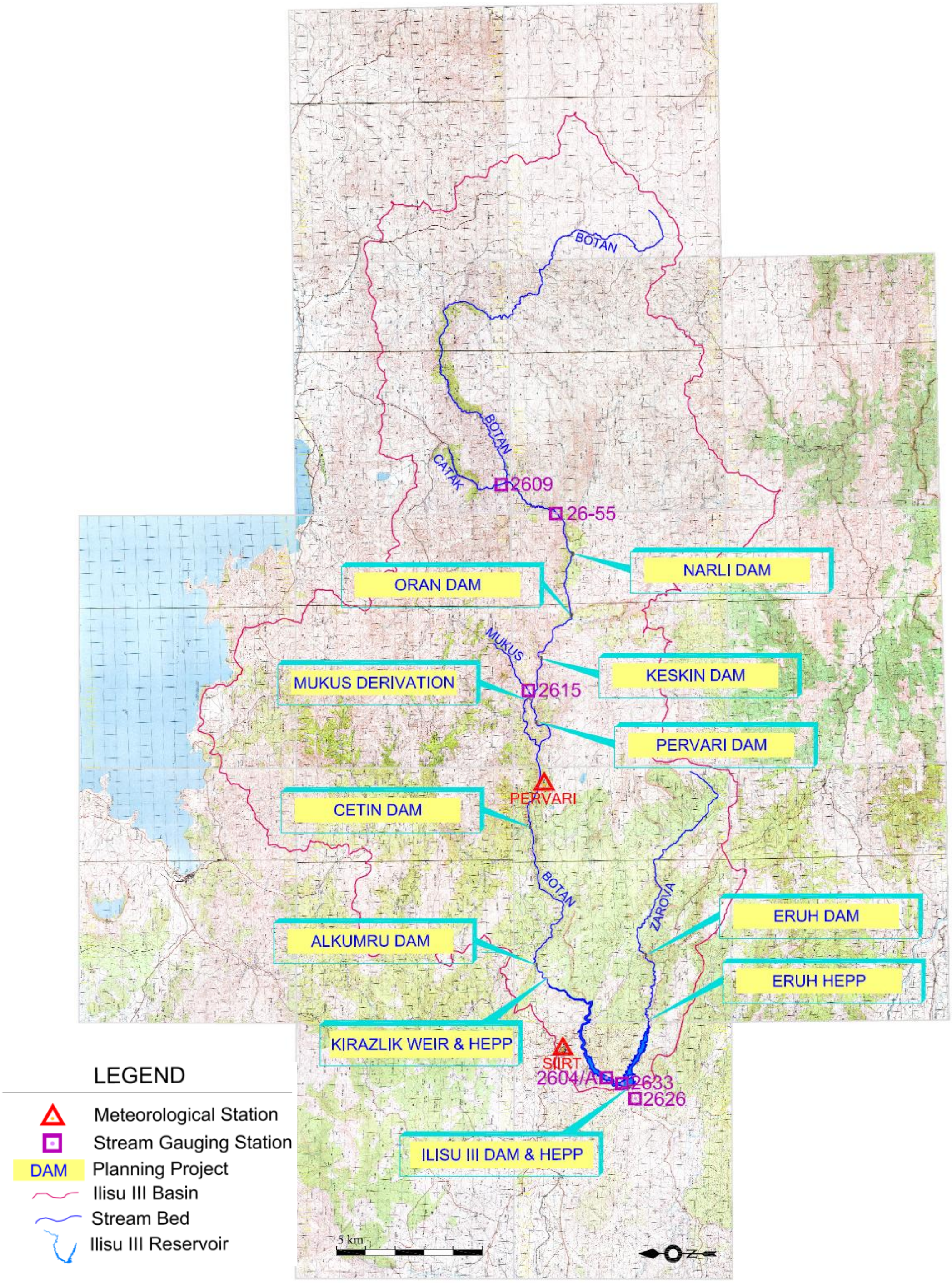


Figure E.1 Project Area and Hydro-Meteorological Stations on 1/100000 Scale Topographic Maps

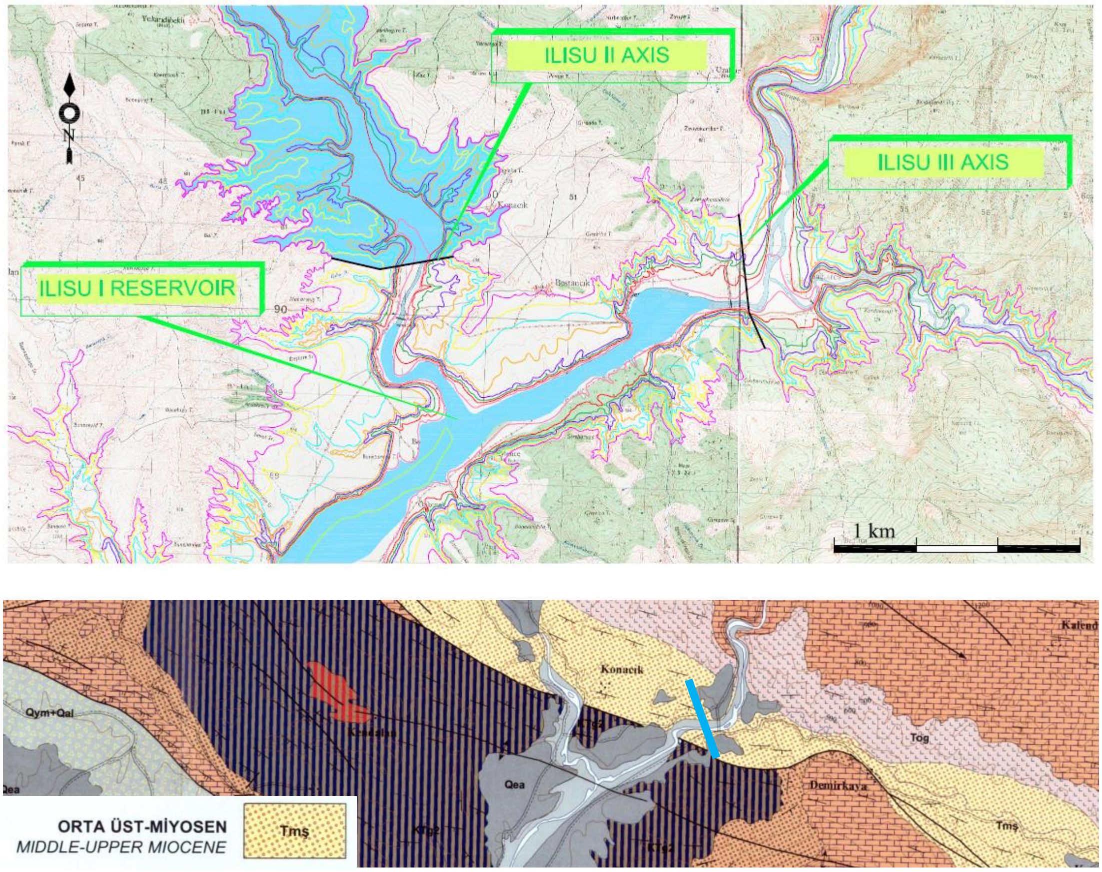


Figure E.2 Ilisu III Dam Location (MTA, 2007)

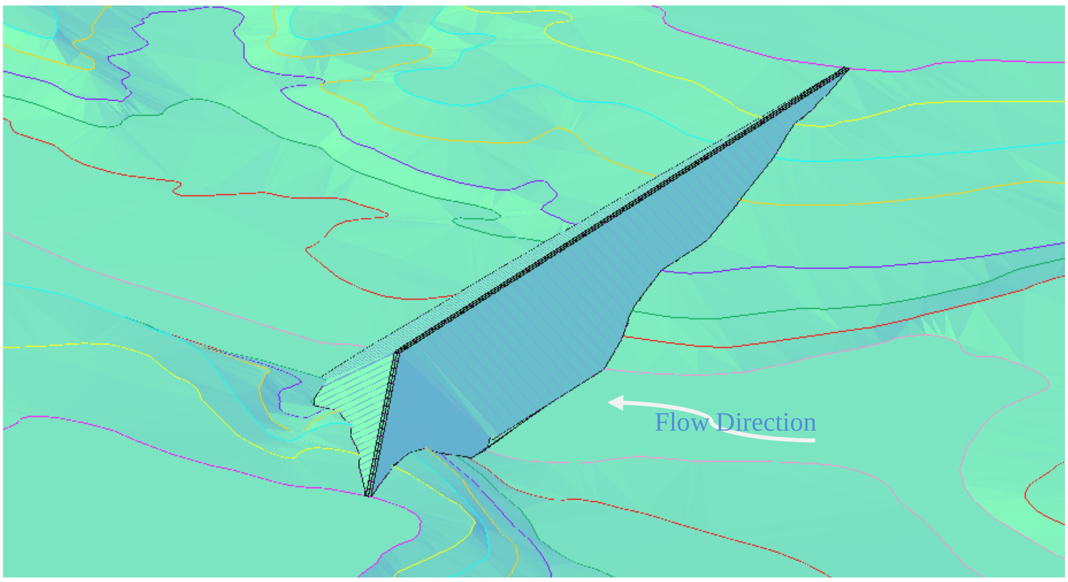


Figure E.3 Representative View of Ilisu III Dam Body

E.1. Dam Characteristics

Table E.1 Characteristics of the Projects Upstream of Ilisu III Dam and HEPP

Characteristics	Unit	**Eruh**	**Narli**	**Oran**
Purpose	-	Energy	Energy	Energy
Thalwag Elevation	m	682.0	1280.0	1180.0
Maximum Water Level	m	772.0	1370.0	1280.0
Minimum Water Level	m	725.0	1345.0	1250.0
Tailwater Level	m	545.0	1280.0	1180.0
Design Discharge	m^3/s	26.00	55.20	55.97
Penstock: Number/Diameter/Length	-/m/m	1/2.5/1375	1/3.75/200	1/3.75/200
Energy Tunnel: Number/Diameter/Length	-/m/m	1/3.65/10875	-	-
Number of Units	-	2	2	2
Gross Head/Net Head	m/m	227.0/200.3	90.0/89.1	100.0/99.2
Turbine Type	-	Francis	Francis	Francis

Table E.1 (continued)

Keskin	**Pervari**	**Cetin**	**Alkumru**
Energy	Energy	Energy	Energy
980.0	820.0	677.0	542.0
1180.0	980.0	822.0	647.0
1137.5	930.0	760.0	611.8
980.0	820.0	647.0	541.8
108.25	160.00	315.49	277.00
1/5.2/200	1/6.4/125	1/9.4~4.0/313	3/4.7/124
-	1/7.15/600	1/9.4/5302	1/8.4/443
3	4	5	3
200.0/199.4	160.0/158.8	175.0/162.6	105.2/103.9
Francis	Francis	Francis	Francis

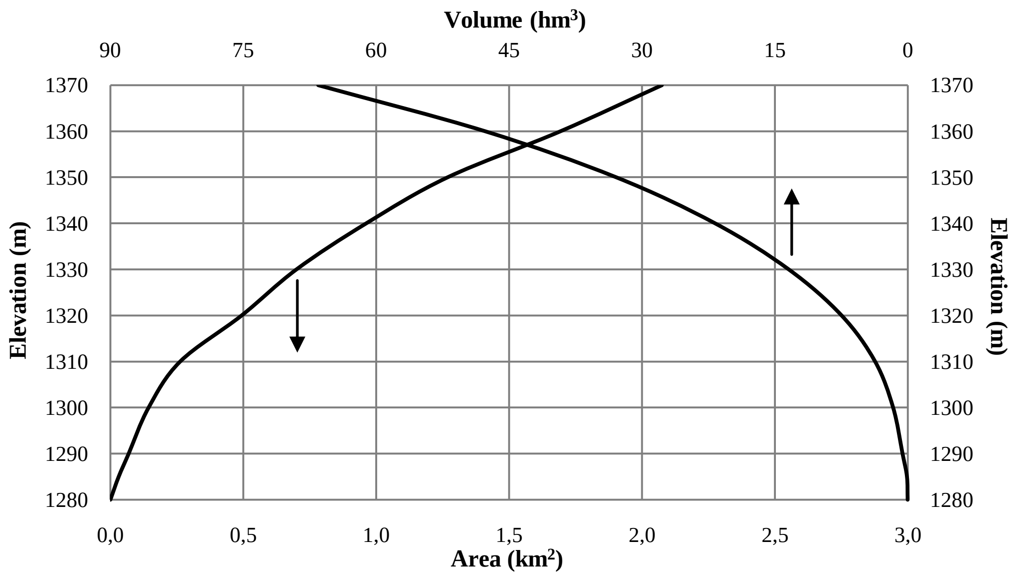


Figure E.4 Volume-Area Curve of Narli Reservoir

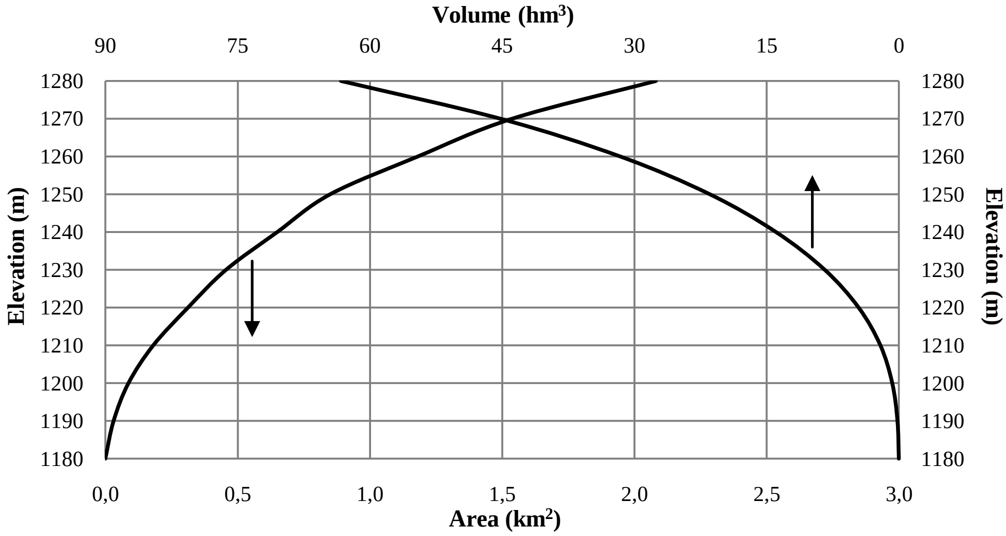


Figure E.5 Volume-Area Curve of Oran Reservoir

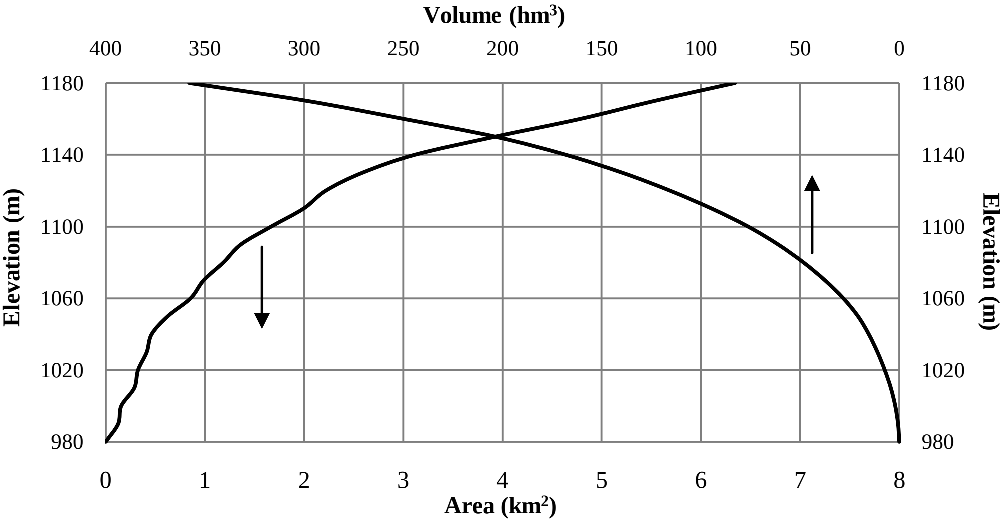


Figure E.6 Volume-Area Curve of Keskin Reservoir

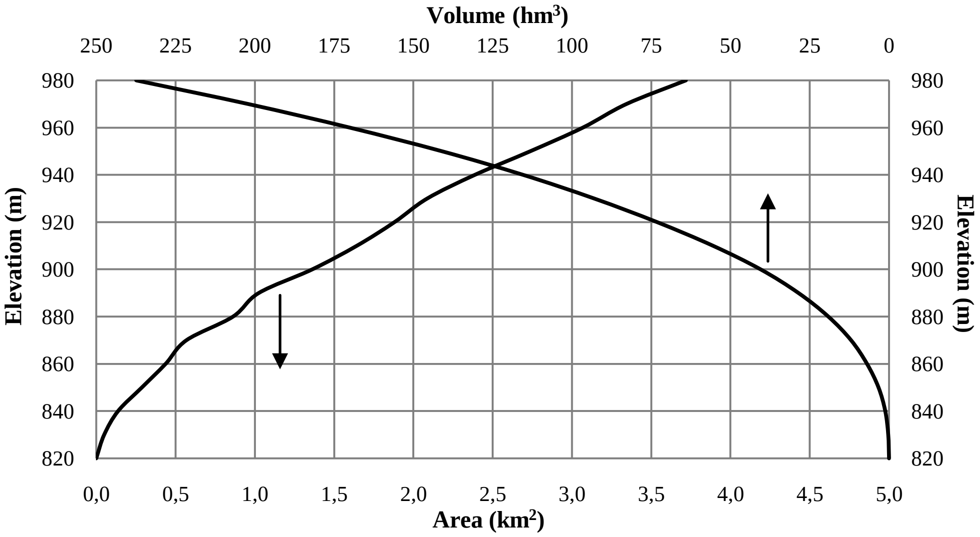


Figure E.7 Volume-Area Curve of Pervari Reservoir

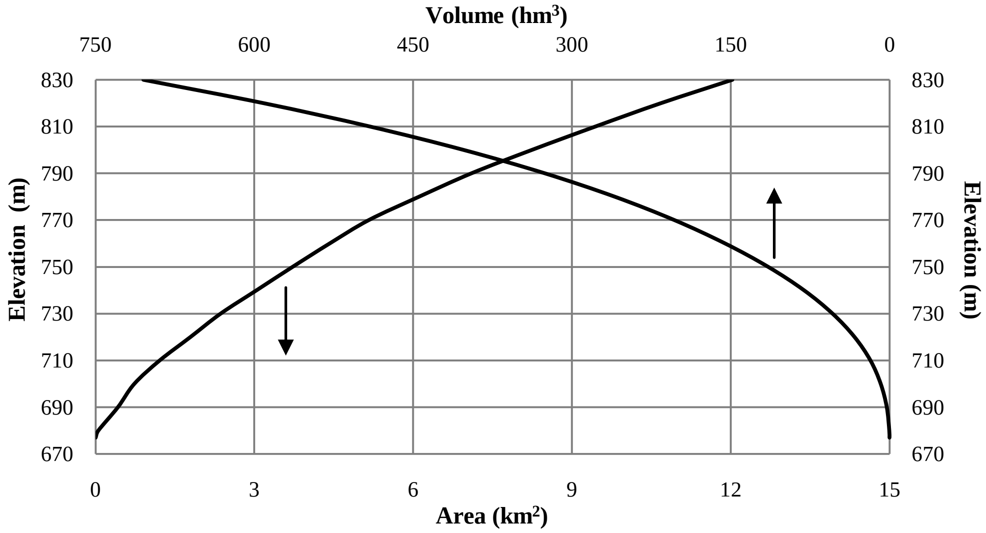


Figure E.8 Volume-Area Curve of Cetin Reservoir

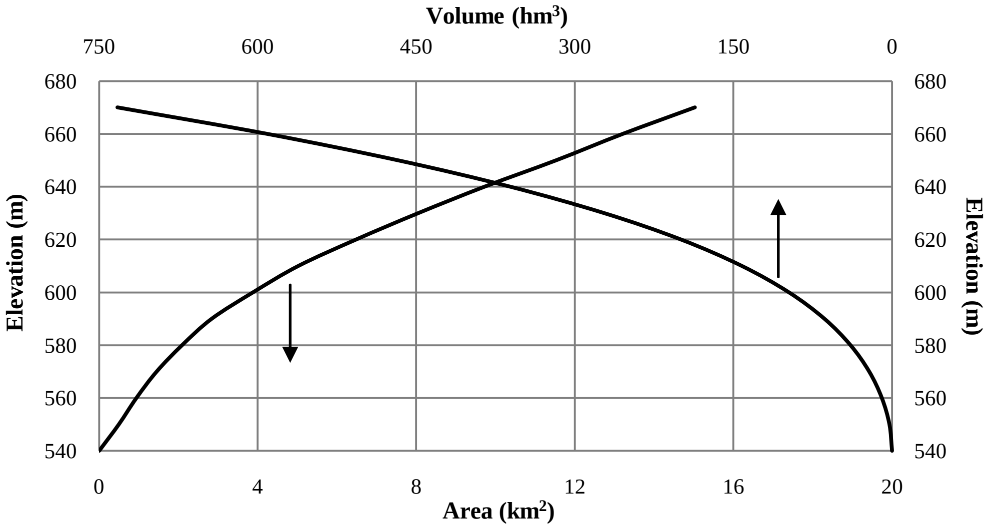


Figure E.9 Volume-Area Curve of Alkumru Reservoir

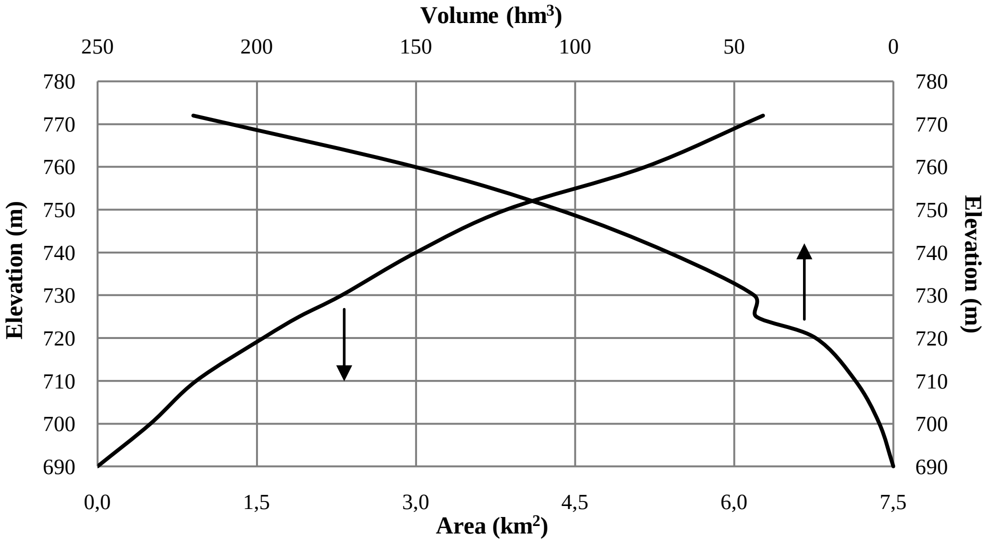


Figure E.10 Volume-Area Curve of Eruh Reservoir

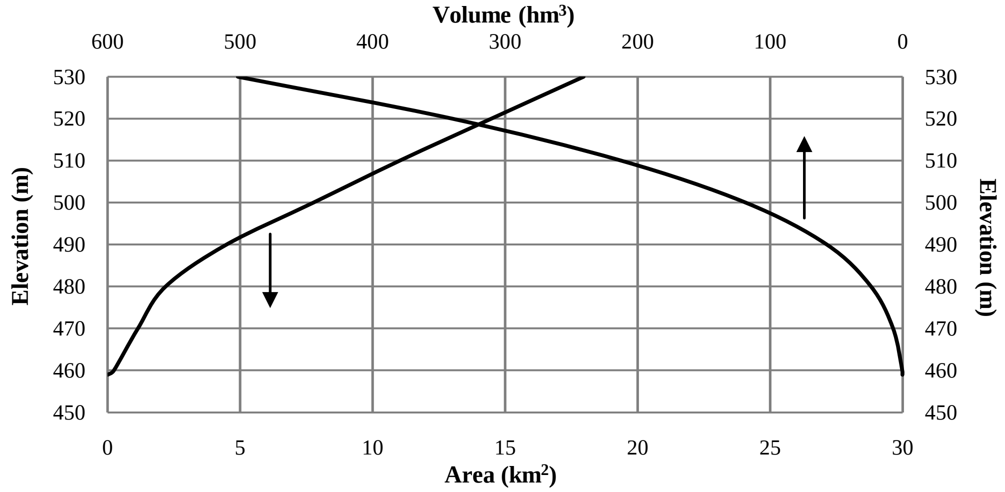


Figure E.11 Volume-Area Curve of Ilisu III Reservoir

E.2. Estimated Evaporation Rates

Table E.2 Monthly Total Net Evaporation Values of Narli Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Pervari MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	0.5	-	-	60.8	-
Feb.	4.1	-	1.8	-	-	75.8	-
Mar.	8.3	-	5.9	20.0	14.0	100.0	-
Apr.	14.0	83.5	11.6	67.0	46.9	102.8	-
May	19.3	185.6	16.9	131.1	91.8	73.4	**18.4**
Jun.	25.9	282.6	23.5	235.5	164.9	16.3	**148.5**
Jul.	30.4	371.8	28.1	322.8	226.0	5.3	**220.6**
Aug.	29.9	356.2	27.5	311.7	218.2	5.8	**212.4**
Sep.	25.0	258.8	22.7	220.1	154.1	3.7	**150.4**
Oct.	17.8	139.4	15.4	110.8	77.6	66.2	**11.3**
Nov.	10.1	54.3	7.7	32.2	22.6	83.4	-
Dec.	4.7	13.5	2.4	3.9	2.8	72.1	-
Σ	-	1745.8	-	1455.2	1018.6	665.6	**761.7**

Table E.3 Monthly Total Net Evaporation Values of Oran Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Pervari MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	0.9	-	-	60.8	-
Feb.	4.1	-	2.2	-	-	75.8	-
Mar.	8.3	-	6.4	22.8	16.0	100.0	-
Apr.	14.0	83.5	12.1	71.7	50.2	102.8	-
May	19.3	185.6	17.4	137.4	96.2	73.4	**22.8**
Jun.	25.9	282.6	24.0	243.6	170.5	16.3	**154.2**
Jul.	30.4	371.8	28.5	332.1	232.5	5.3	**227.1**
Aug.	29.9	356.2	28.0	320.8	224.6	5.8	**218.8**
Sep.	25.0	258.8	23.1	228.0	159.6	3.7	**155.9**
Oct.	17.8	139.4	15.9	116.6	81.6	66.2	**15.4**
Nov.	10.1	54.3	8.2	35.7	25.0	83.4	-
Dec.	4.7	13.5	2.8	5.4	3.8	72.1	-
Σ	-	1745.8	-	1514.0	1059.8	665.6	**794.3**

Table E.4 Monthly Total Net Evaporation Values of Keskin Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Pervari MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	1.4	-	-	60.8	-
Feb.	4.1	-	2.7	-	-	75.8	-
Mar.	8.3	-	6.9	26.1	18.3	100.0	-
Apr.	14.0	83.5	12.6	77.0	53.9	102.8	-
May	19.3	185.6	17.9	144.6	101.2	73.4	**27.8**
Jun.	25.9	282.6	24.5	252.7	176.9	16.3	**160.6**
Jul.	30.4	371.8	29.0	342.5	239.8	5.3	**234.5**
Aug.	29.9	356.2	28.5	331.1	231.8	5.8	**226.0**
Sep.	25.0	258.8	23.6	236.9	165.8	3.7	**162.1**
Oct.	17.8	139.4	16.4	123.3	86.3	66.2	**20.0**
Nov.	10.1	54.3	8.7	39.7	27.8	83.4	-
Dec.	4.7	13.5	3.3	7.2	5.0	72.1	-
Σ	-	1745.8	-	1581.0	1106.7	665.6	**831.0**

Table E.5 Monthly Total Net Evaporation Values of Pervari Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Pervari MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	2.4	-	-	60.8	-
Feb.	4.1	-	3.7	-	-	75.8	-
Mar.	8.3	-	7.9	33.3	23.3	100.0	-
Apr.	14.0	83.5	13.6	88.3	61.8	102.8	-
May	19.3	185.6	18.9	159.3	111.5	73.4	**38.1**
Jun.	25.9	282.6	25.5	271.5	190.0	16.3	**173.7**
Jul.	30.4	371.8	30.0	363.9	254.7	5.3	**249.4**
Aug.	29.9	356.2	29.5	352.1	246.5	5.8	**240.7**
Sep.	25.0	258.8	24.6	255.1	178.5	3.7	**174.9**
Oct.	17.8	139.4	17.4	137.0	95.9	66.2	**29.7**
Nov.	10.1	54.3	9.7	48.2	33.7	83.4	-
Dec.	4.7	13.5	4.3	11.5	8.0	72.1	-
Σ	-	1745.8	-	1720.1	1204.1	665.6	**906.5**

Table E.6 Monthly Total Net Evaporation Values of Cetin Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Siirt MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	3.2	-	-	81.5	-
Feb.	4.1	-	4.5	-	-	102.1	-
Mar.	8.3	-	8.6	39.5	27.6	110.3	-
Apr.	14.0	83.5	14.4	97.7	68.4	99.9	-
May	19.3	185.6	19.7	171.4	119.9	64.5	**55.4**
Jun.	25.9	282.6	26.3	286.7	200.7	9.4	**191.3**
Jul.	30.4	371.8	30.8	381.1	266.8	2.5	**264.3**
Aug.	29.9	356.2	30.3	369.1	258.4	1.3	**257.1**
Sep.	25.0	258.8	25.4	269.8	188.9	2.8	**186.1**
Oct.	17.8	139.4	18.2	148.3	103.8	50.7	**53.2**
Nov.	10.1	54.3	10.5	55.4	38.8	85.1	-
Dec.	4.7	13.5	5.1	15.5	10.8	94.4	-
Σ	-	1745.8	-	1834.6	1284.2	704.4	**1007.4**

Table E.7 Monthly Total Net Evaporation Values of Alkumru Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Siirt MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	4.1	-	-	81.5	-
Feb.	4.1	-	5.4	-	-	102.1	-
Mar.	8.3	-	9.5	46.9	32.8	110.3	-
Apr.	14.0	83.5	15.2	108.6	76.0	99.9	-
May	19.3	185.6	20.6	185.2	129.6	64.5	**65.1**
Jun.	25.9	282.6	27.1	303.9	212.7	9.4	**203.4**
Jul.	30.4	371.8	31.7	400.7	280.5	2.5	**278.0**
Aug.	29.9	356.2	31.1	388.4	271.9	1.3	**270.6**
Sep.	25.0	258.8	26.3	286.7	200.7	2.8	**197.9**
Oct.	17.8	139.4	19.0	161.3	112.9	50.7	**62.3**
Nov.	10.1	54.3	11.3	64.0	44.8	85.1	-
Dec.	4.7	13.5	6.0	20.5	14.4	94.4	-
Σ	-	1745.8	-	1966.1	1376.3	704.4	**1077.2**

Table E.8 Monthly Total Net Evaporation Values of Eruh Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Siirt MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	3.4	-	-	81.5	-
Feb.	4.1	-	4.8	-	-	102.1	-
Mar.	8.3	-	8.9	41.6	29.1	110.3	-
Apr.	14.0	83.5	14.6	100.7	70.5	99.9	-
May	19.3	185.6	19.9	175.3	122.7	64.5	**58.1**
Jun.	25.9	282.6	26.5	291.5	204.1	9.4	**194.7**
Jul.	30.4	371.8	31.1	386.7	270.7	2.5	**268.2**
Aug.	29.9	356.2	30.5	374.6	262.2	1.3	**260.9**
Sep.	25.0	258.8	25.6	274.6	192.2	2.8	**189.4**
Oct.	17.8	139.4	18.4	152.0	106.4	50.7	**55.7**
Nov.	10.1	54.3	10.7	57.8	40.5	85.1	-
Dec.	4.7	13.5	5.4	16.8	11.8	94.4	-
Σ	-	1745.8	-	1871.7	1310.2	704.4	**1027.2**

Table E.9 Monthly Total Net Evaporation Values of Ilisu III Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Siirt MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	4.7	-	-	81.5	-
Feb.	4.1	-	6.0	-	-	102.1	-
Mar.	8.3	-	10.1	52.4	36.7	110.3	-
Apr.	14.0	83.5	15.9	116.4	81.5	99.9	-
May	19.3	185.6	21.2	195.1	136.6	64.5	**72.0**
Jun.	25.9	282.6	27.8	316.2	221.3	9.4	**212.0**
Jul.	30.4	371.8	32.3	414.5	290.2	2.5	**287.7**
Aug.	29.9	356.2	31.8	402.1	281.5	1.3	**280.2**
Sep.	25.0	258.8	26.9	298.6	209.1	2.8	**206.3**
Oct.	17.8	139.4	19.6	170.7	119.5	50.7	**68.8**
Nov.	10.1	54.3	11.9	70.3	49.2	85.1	-
Dec.	4.7	13.5	6.6	24.4	17.1	94.4	-
Σ	16.0	1745.8	17.9	2060.7	1442.5	704.4	**1126.9**

E.3. Water Resources

E.3.1. Stream Gauging Stations

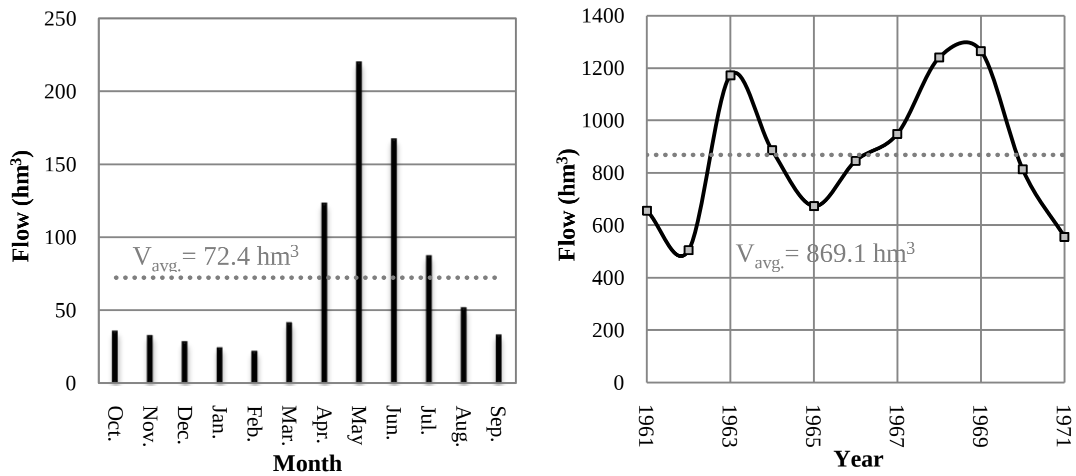


Figure E.12 Monthly Mean and Annual Total Flow Values Measured in 2609 SGS

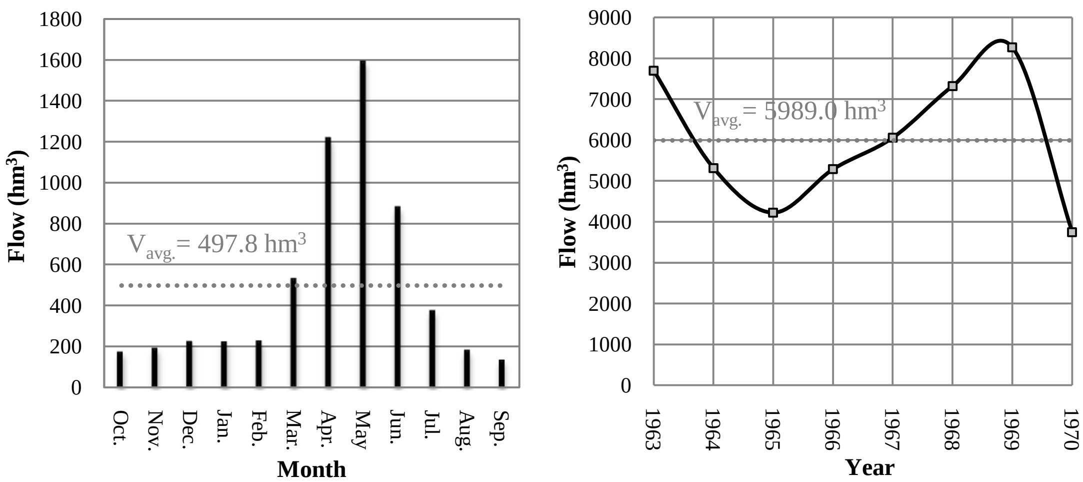


Figure E.13 Monthly Mean and Annual Total Flow Values Measured in 2604/A SGS

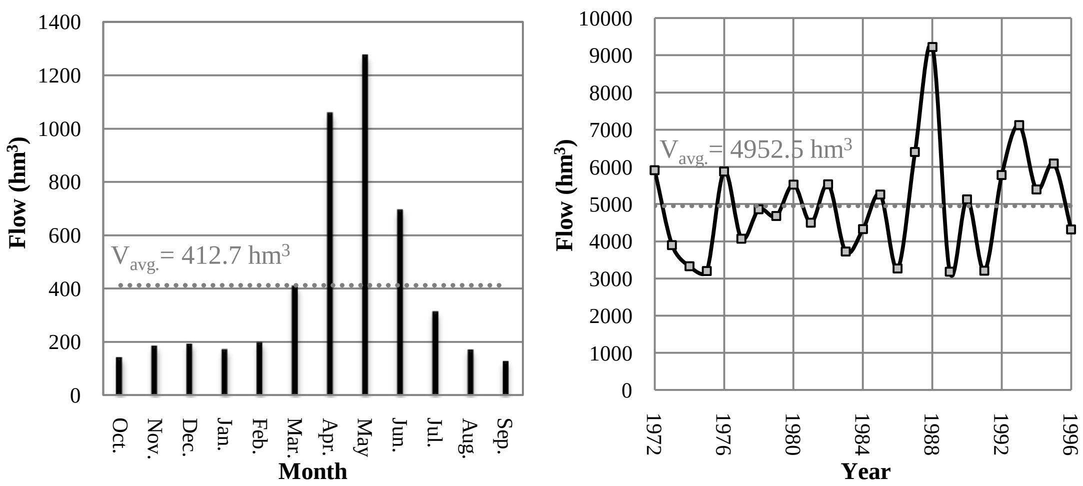


Figure E.14 Monthly Mean and Annual Total Flow Values Measured in 2626 SGS

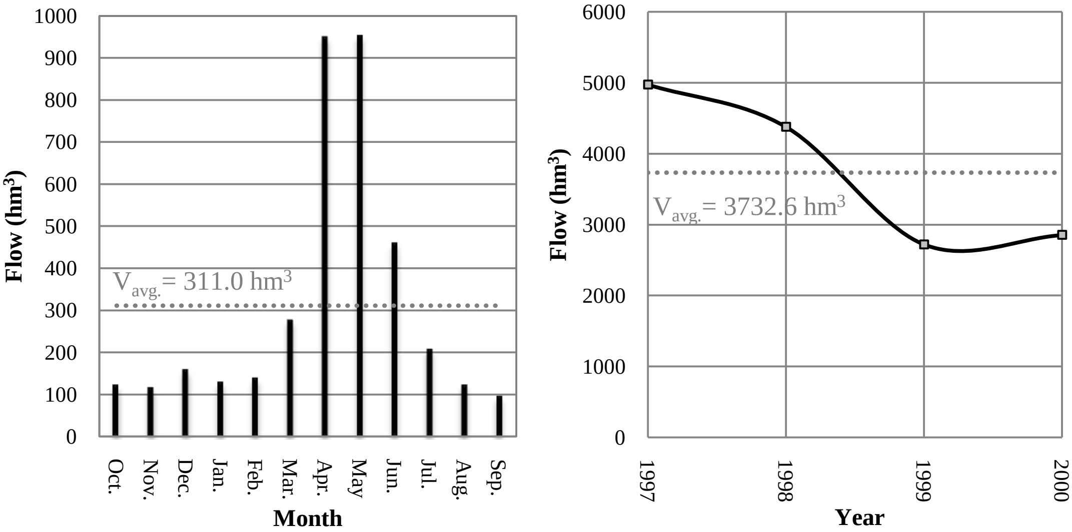


Figure E.15 Monthly Mean and Annual Total Flow Values Measured in 2633 SGS

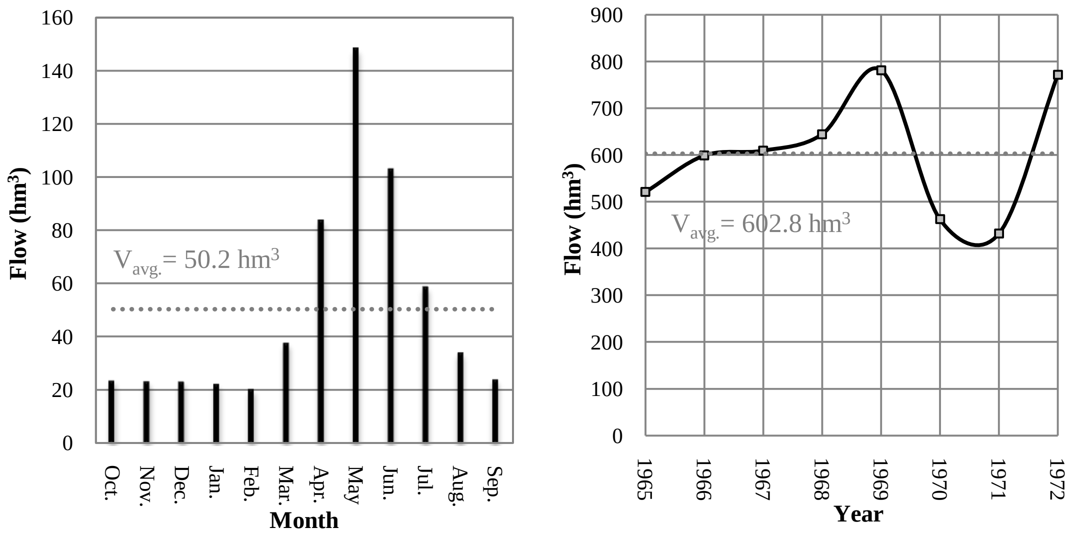


Figure E.16 Monthly Mean and Annual Total Flow Values Measured in 2615 SGS

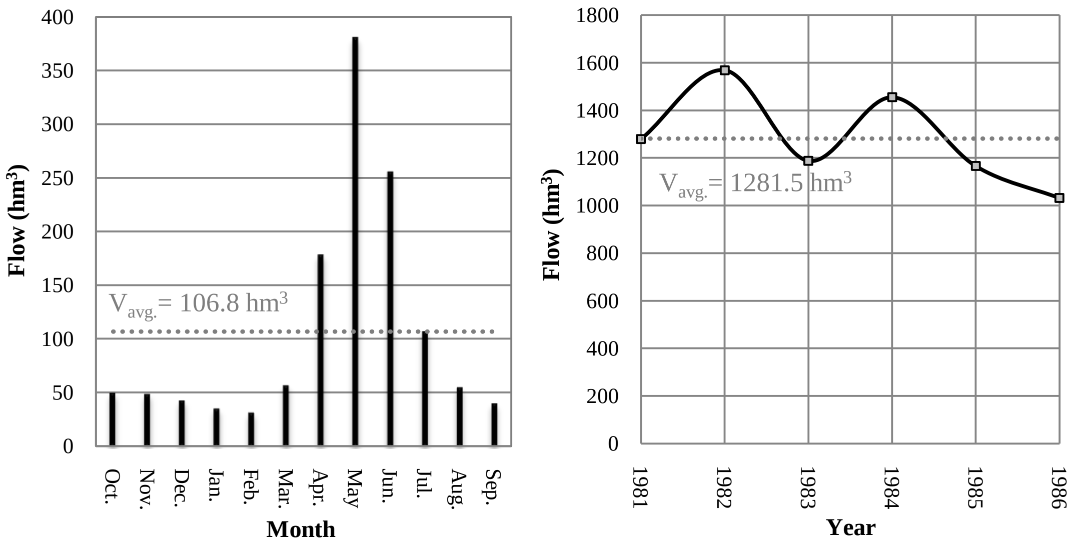


Figure E.17 Monthly Mean and Annual Total Flow Values Measured in 26-55 SGS

E.3.2. Correlation Studies

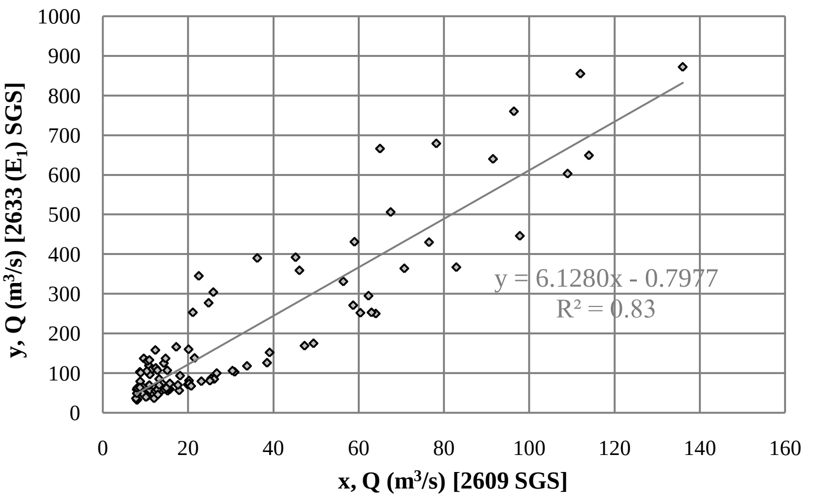


Figure E.18 Monthly Mean Discharge Correlation between 2633 SGS and 2609 SGS

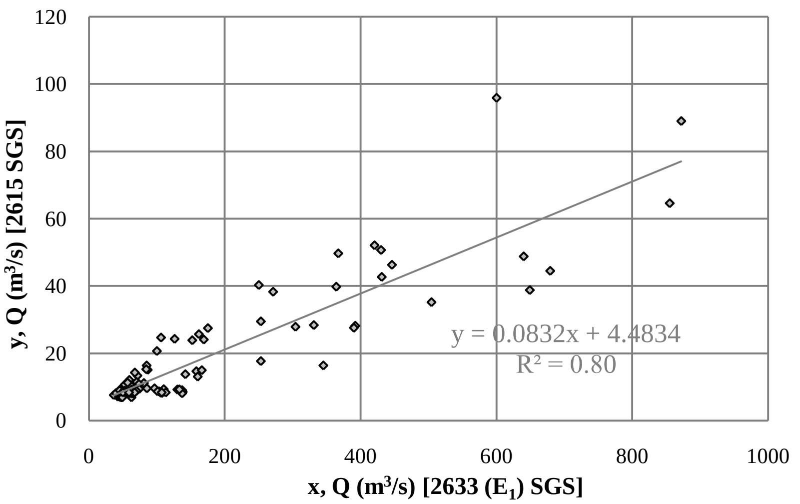


Figure E.19 Monthly Mean Discharge Correlation between 2615 SGS and 2633 SGS

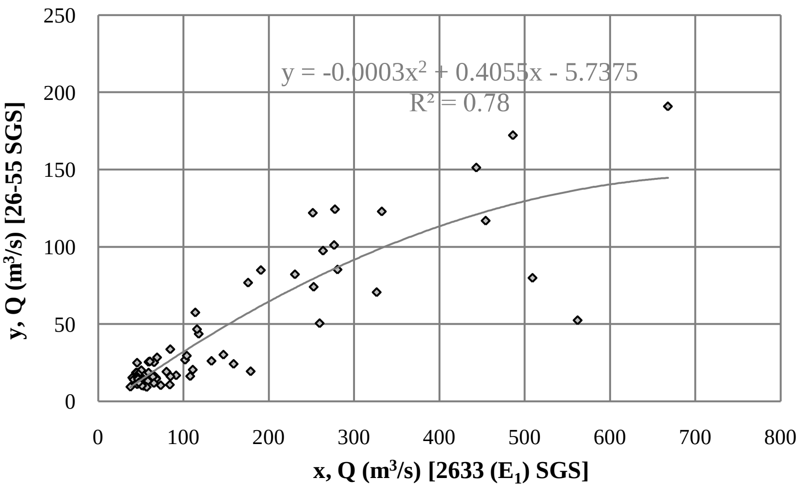


Figure E.20 Monthly Mean Discharge Correlation between 26-55 SGS and 2633 SGS

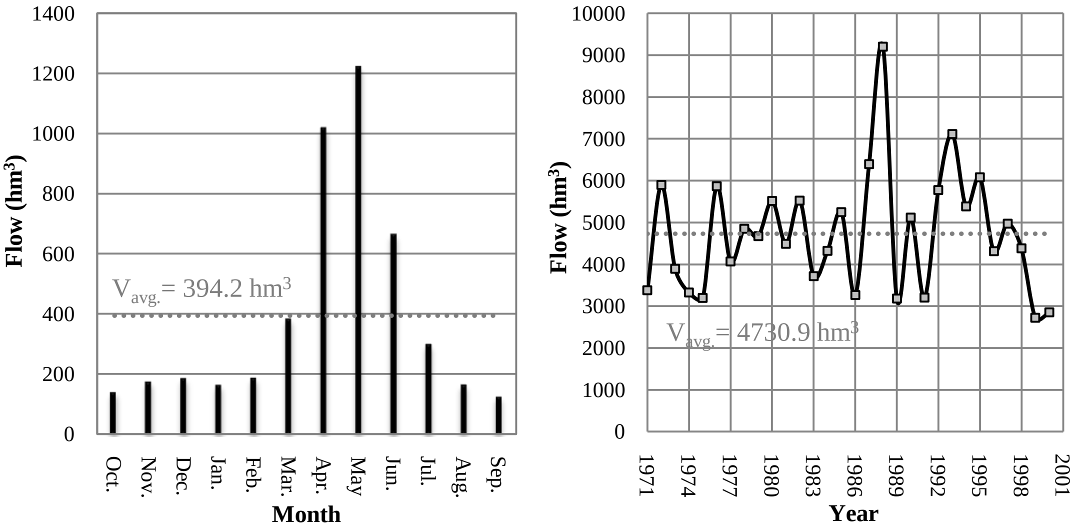


Figure E.21 Extended Monthly Mean and Annual Total Flow Values of 2633 SGS

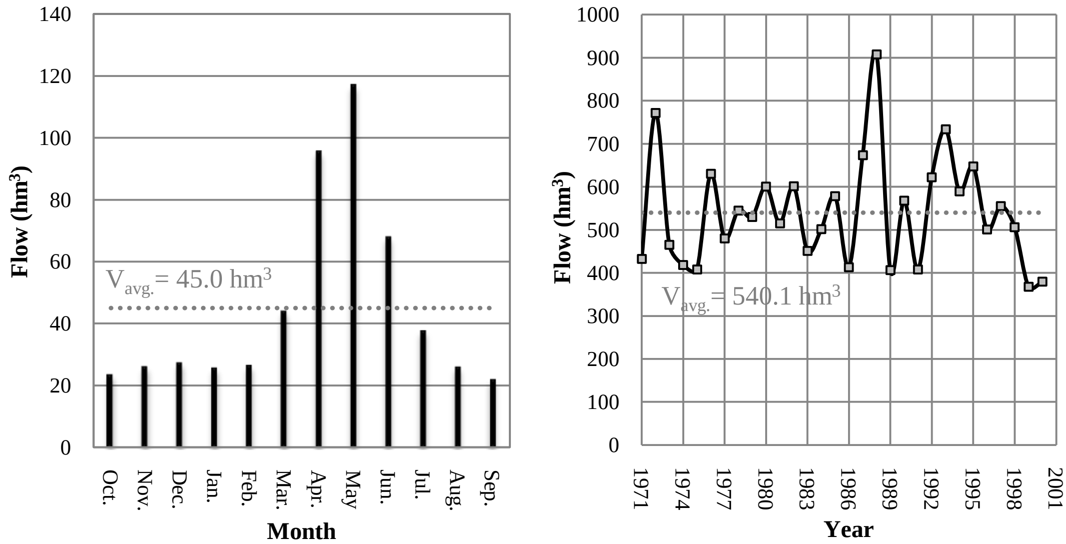


Figure E.22 Extended Monthly Mean and Annual Total Flow Values of 2615 SGS

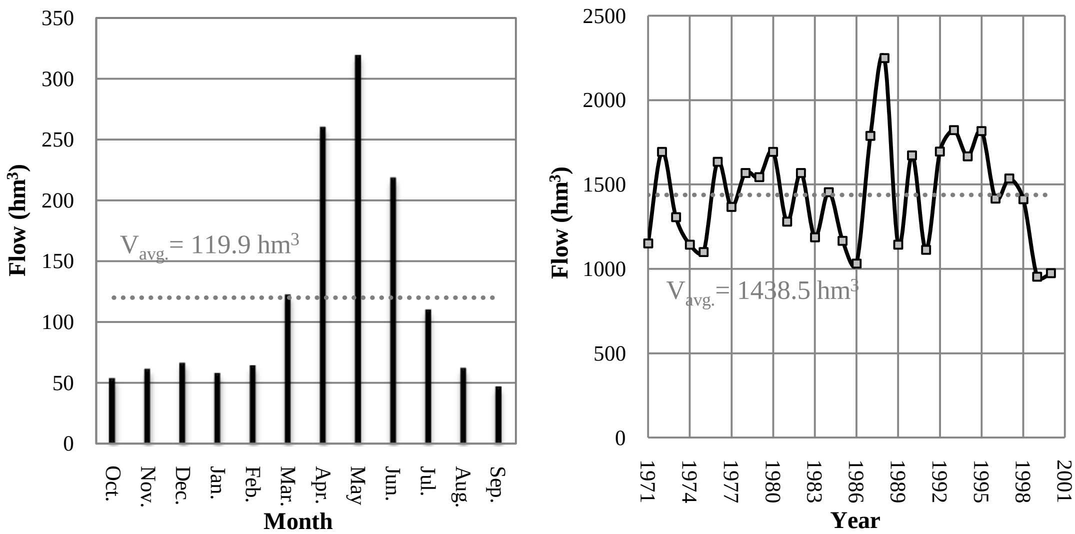


Figure E.23 Extended Monthly Mean and Annual Total Flow Values of 26-55 SGS

E.3.3. Monthly Mean Flow Calculations

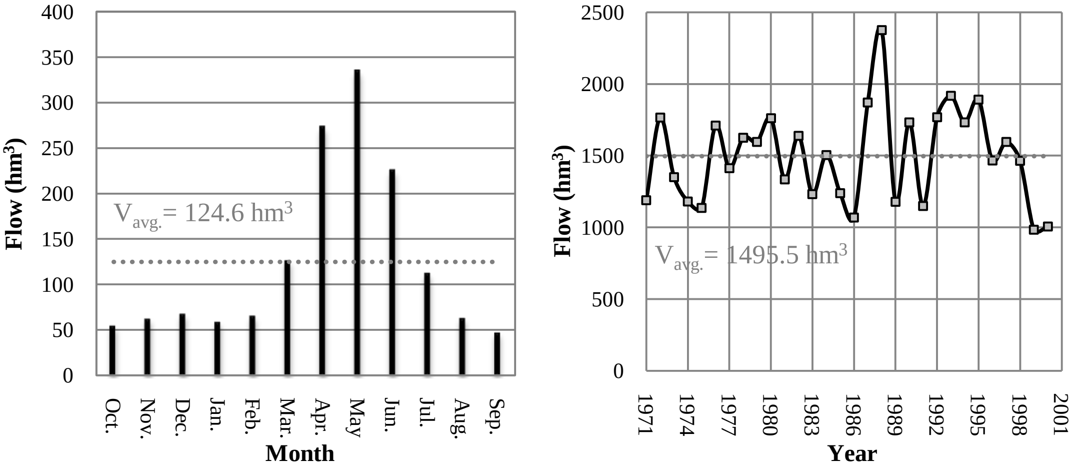


Figure E.24 Monthly Mean and Annual Total Flow Values at Narli Dam

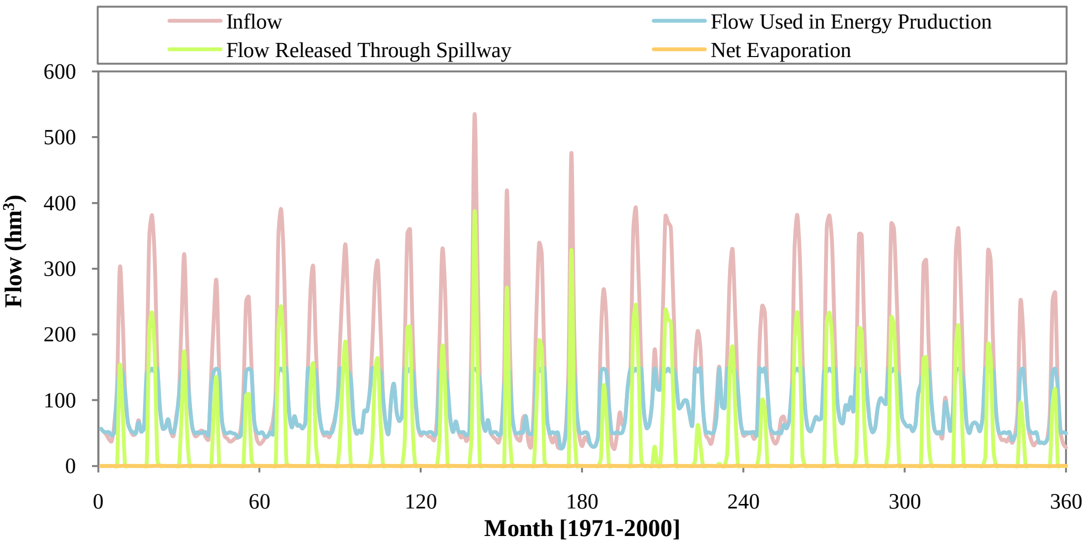


Figure E.25 Operation Study of Narli Dam and HEPP

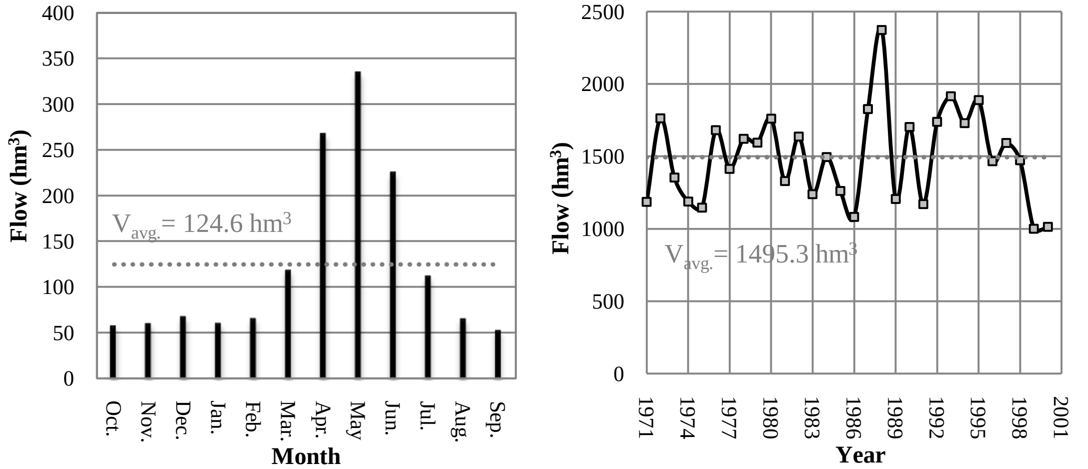


Figure E.26 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Narli Reservoir

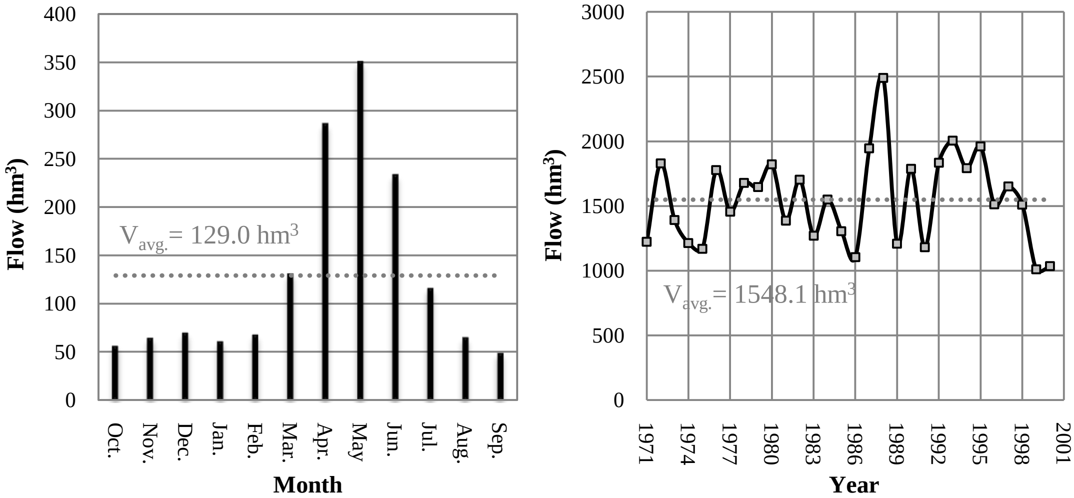


Figure E.27 Monthly Mean and Annual Total Flow Values at Oran Dam

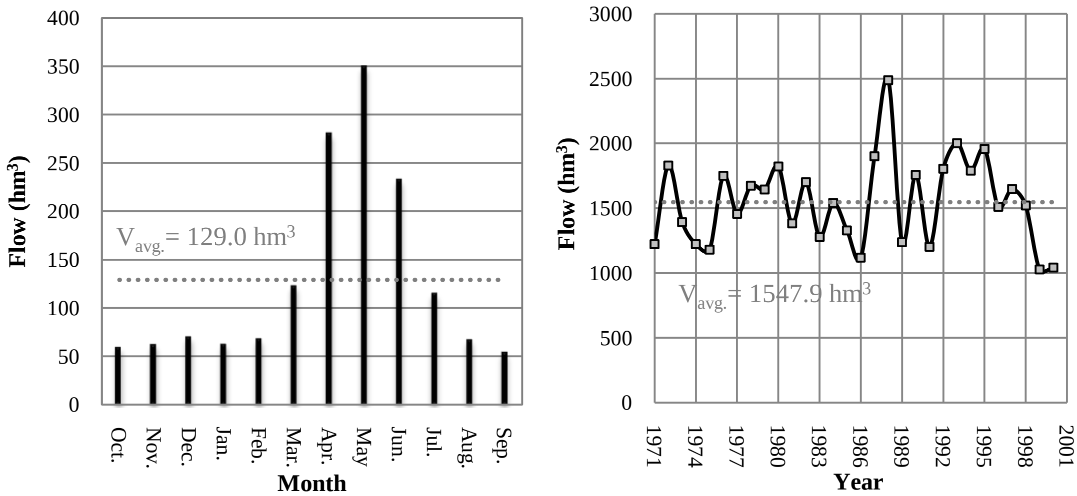


Figure E.28 Monthly Mean and Annual Total Inflow Values in the Operation Study of Oran Reservoir

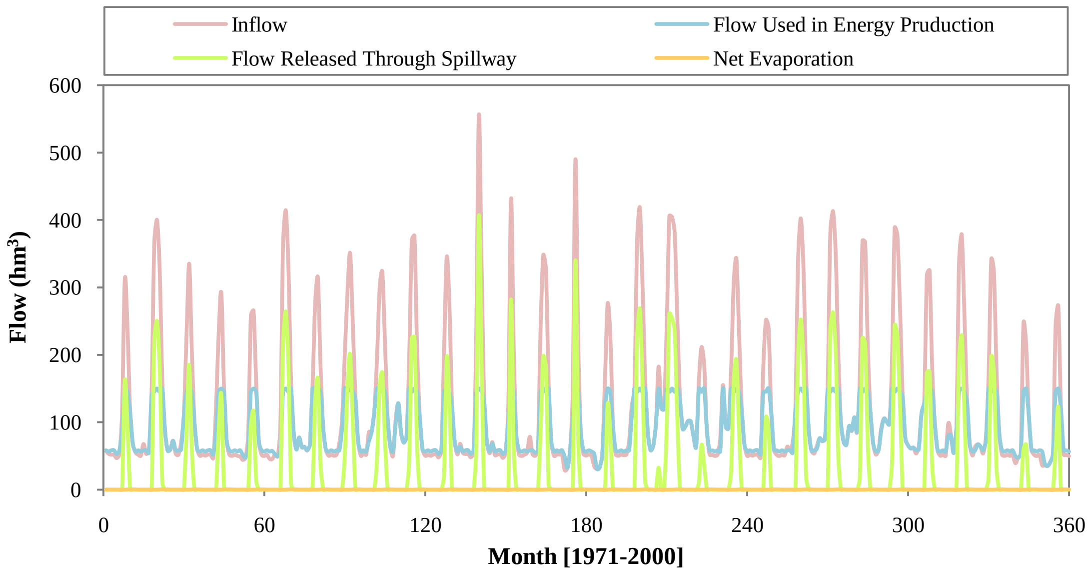


Figure E.29 Operation Study of Oran Dam and HEPP

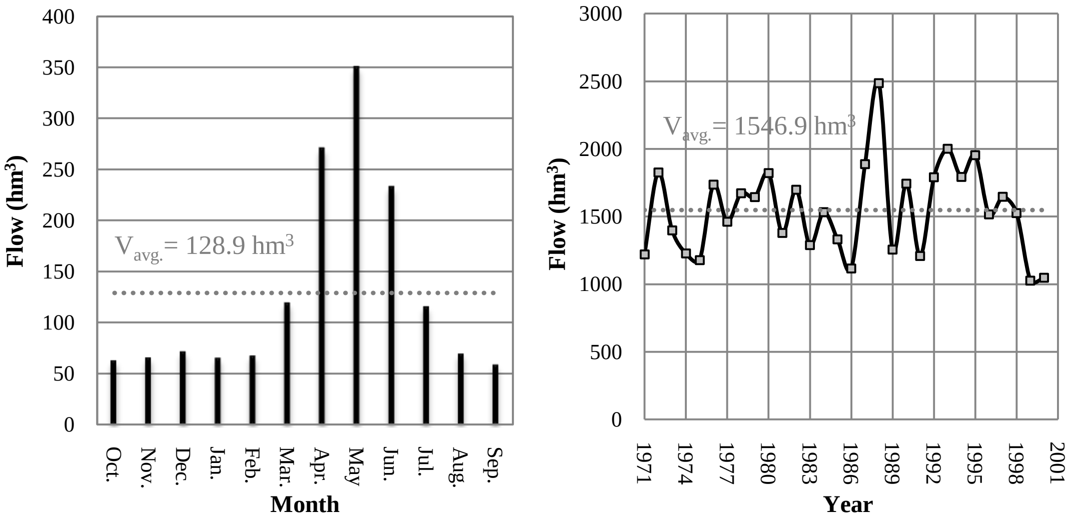


Figure E.30 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Oran Reservoir

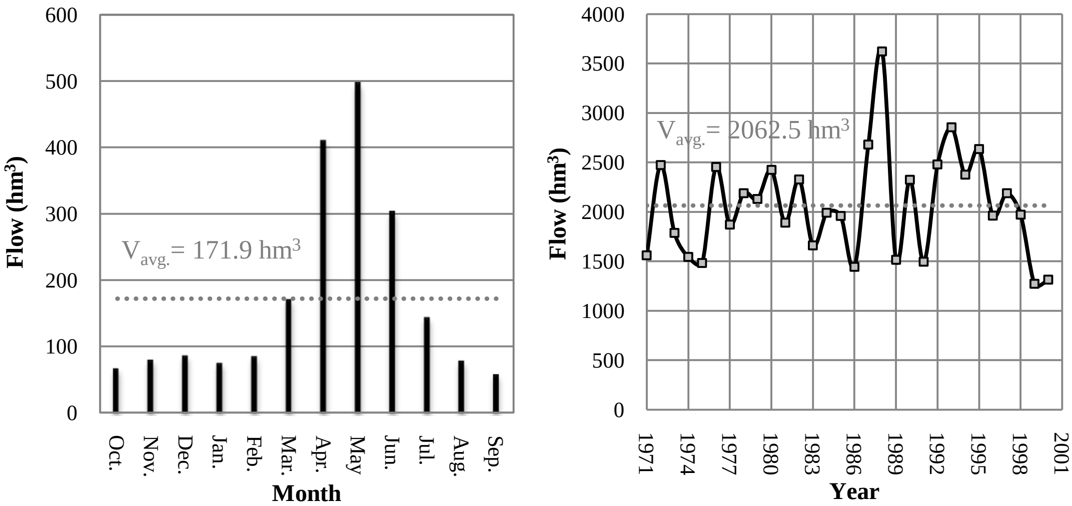


Figure E.31 Monthly Mean and Annual Total Flow Values at Keskin Dam

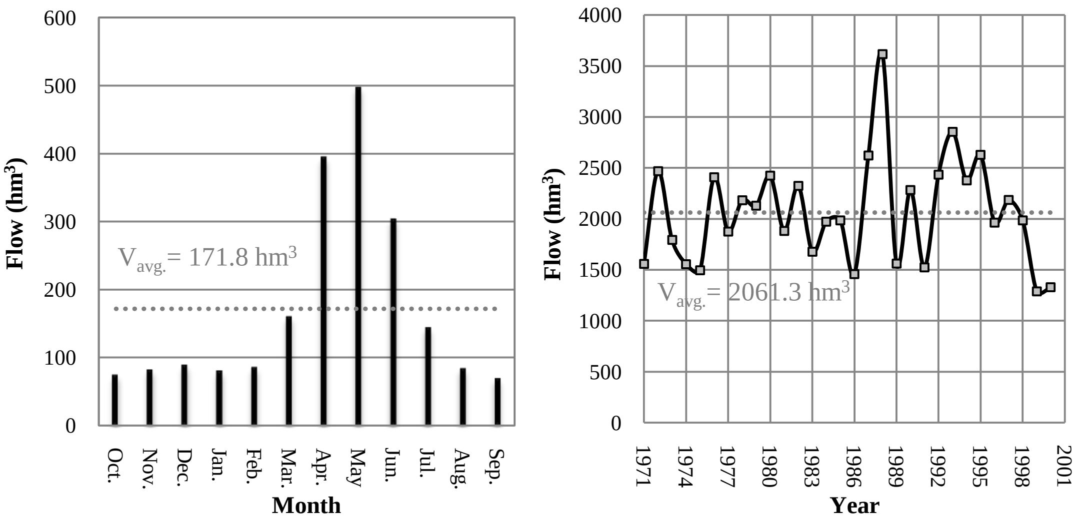


Figure E.32 Monthly Mean and Annual Total Inflow Values in the Operation Study of Keskin Reservoir

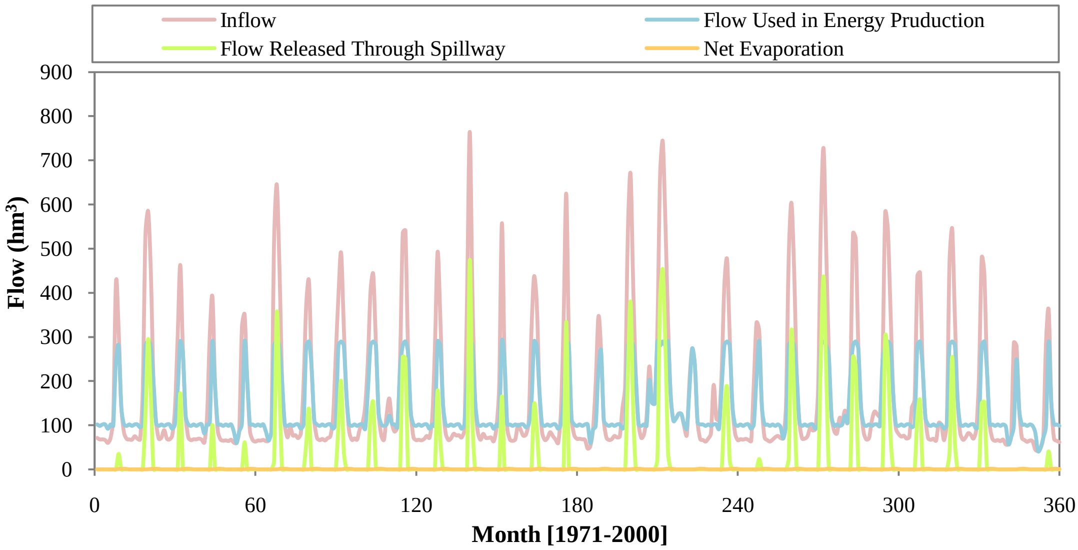
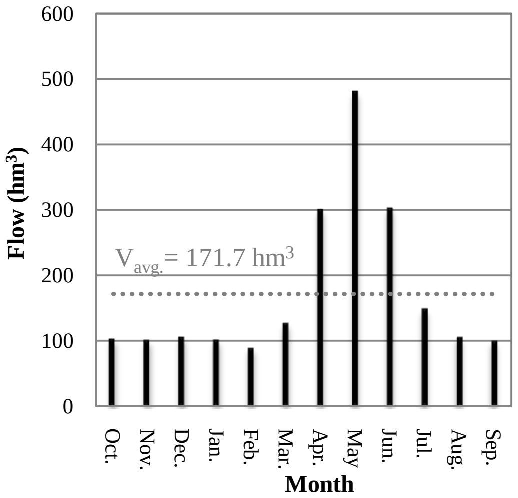


Figure E.33 Operation Study of Keskin Dam and HEPP



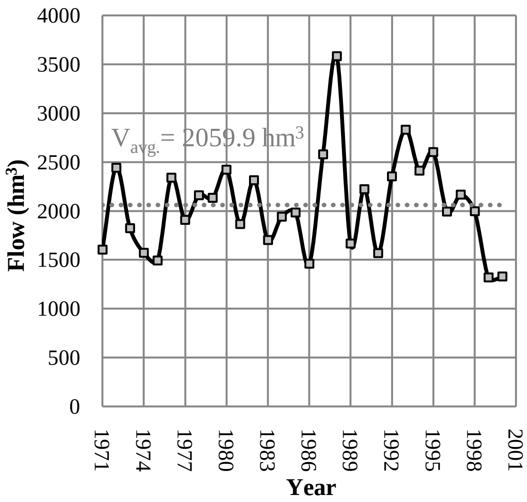
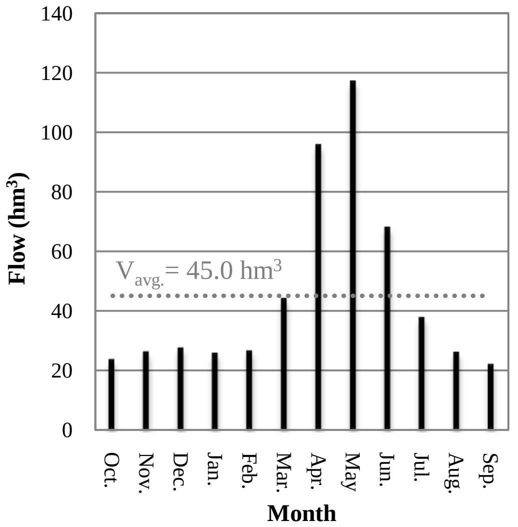


Figure E.34 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Keskin Reservoir



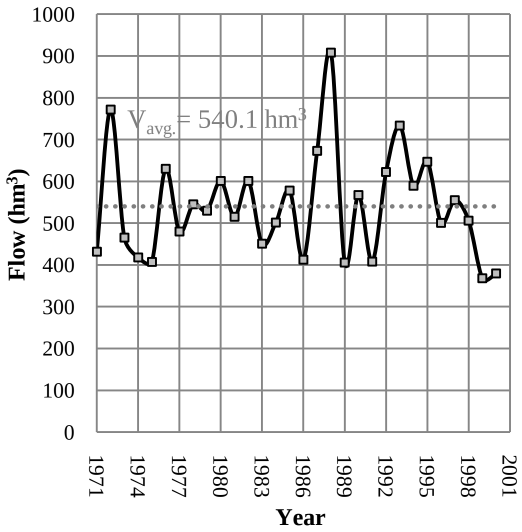


Figure E.35 Monthly Mean and Annual Total Flow Values at Mukus Weir

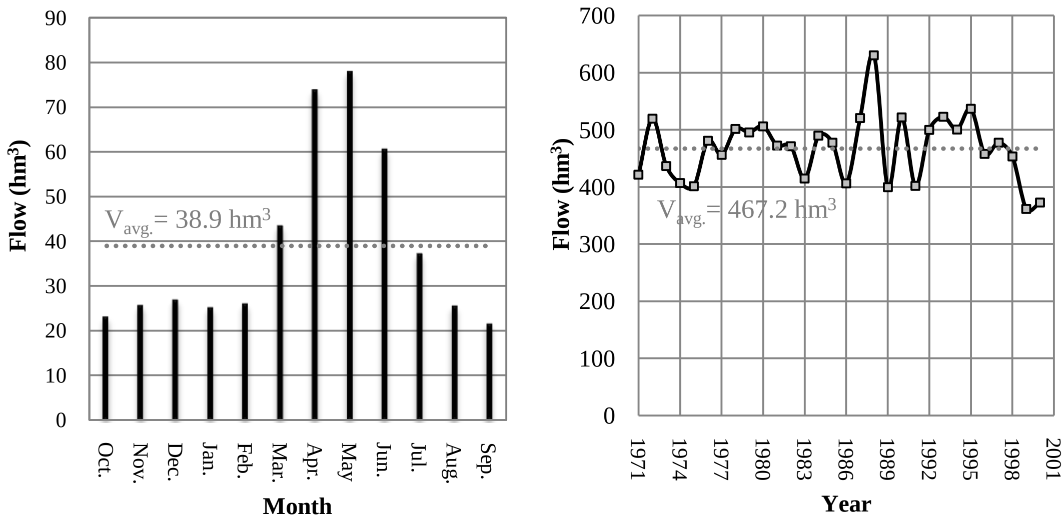


Figure E.36 Monthly Mean and Annual Total Flow Values of the Diversion to Pervari Dam by Mukus Weir with a 30.00 m^3/s Capacity Transmission Canal

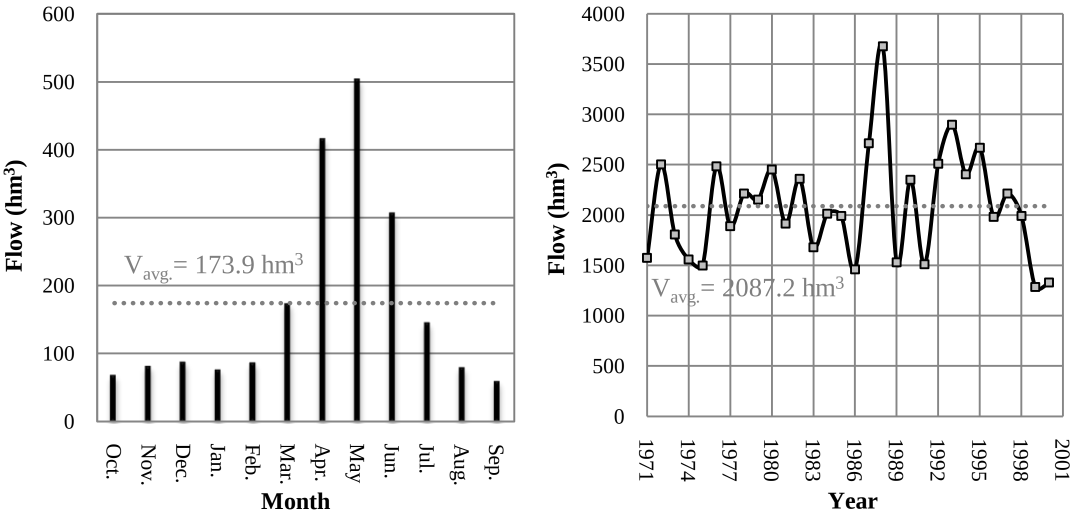


Figure E.37 Monthly Mean and Annual Total Flow Values at Pervari Dam

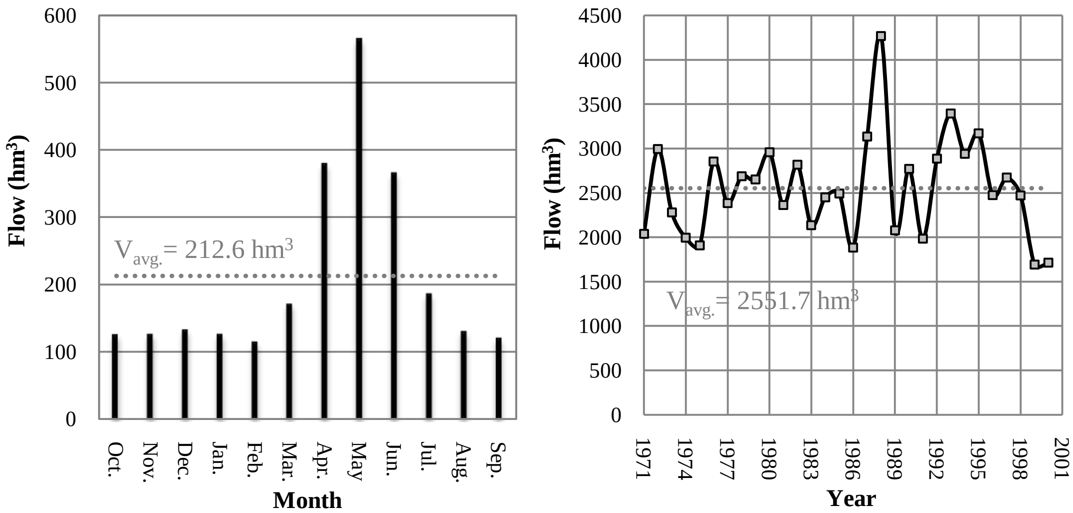


Figure E.38 Monthly Mean and Annual Total Inflow Values at Pervari Dam with the Development of Mukus Derivation

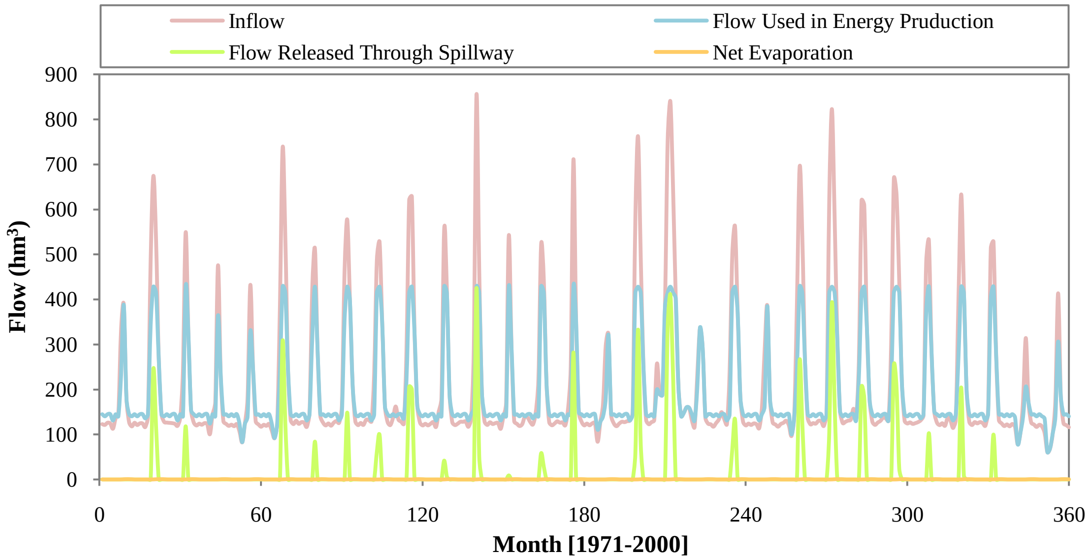


Figure E.39 Operation Study of Pervari Dam and HEPP

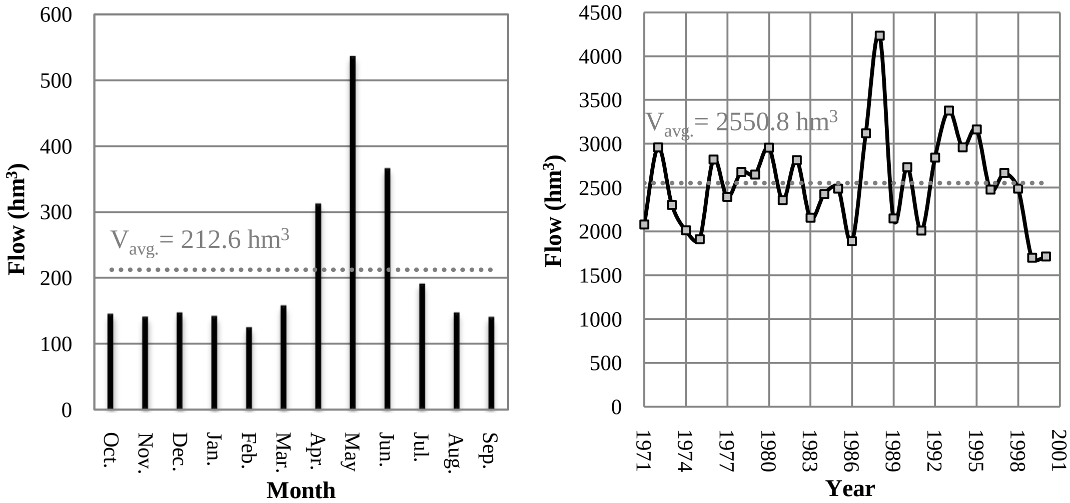


Figure E.40 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Pervari Reservoir

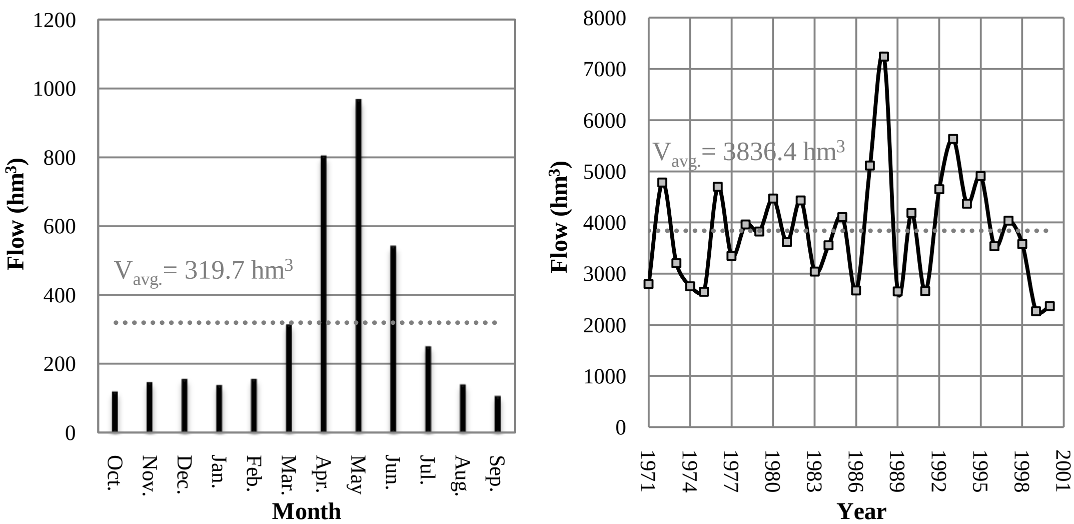


Figure E.41 Monthly Mean and Annual Total Flow Values at Cetin Dam

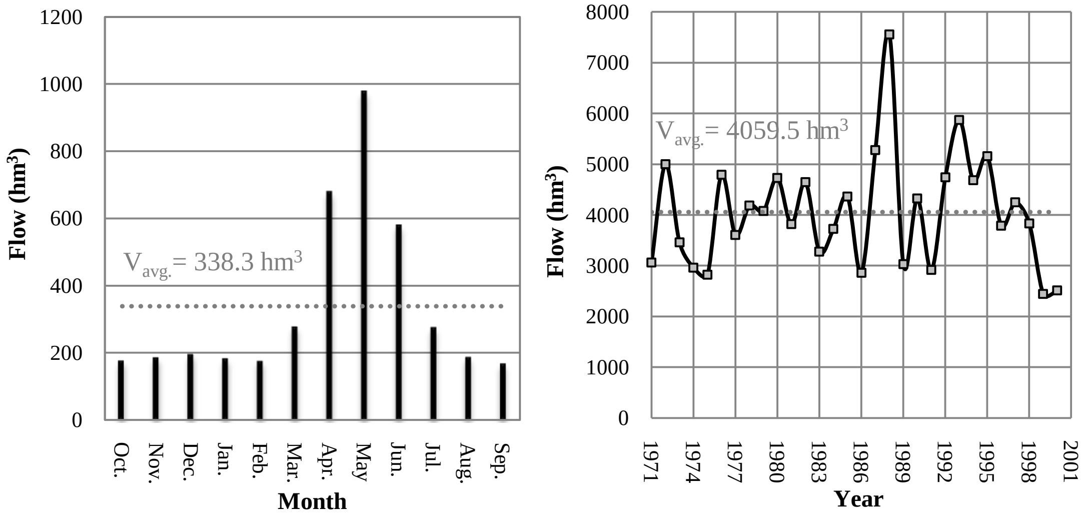


Figure E.42 Monthly Mean and Annual Total Inflow Values in the Operation Study of Cetin Reservoir

Table E.10 Monthly Mean Flow Values Released to Downstream of Cetin Dam

Months	Flow Released to Downstream (hm^3)
October	11.4
November	13.4
December	15.0
January	14.0
February	15.3
March	30.0
April	87.3
May	94.3
June	51.3
July	24.1
August	13.4
September	10.5
Total	380.0

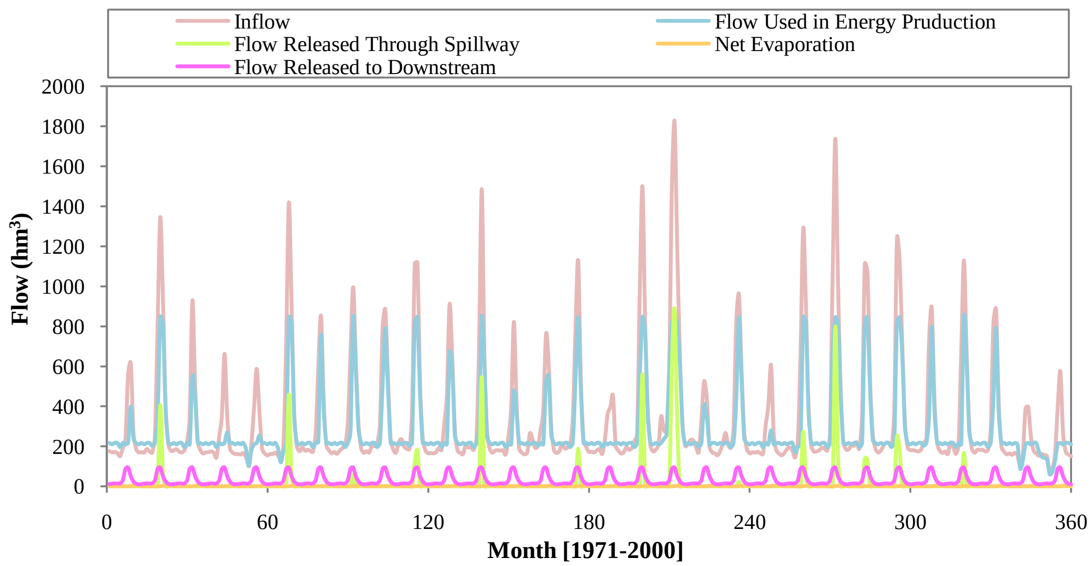


Figure E.43 Operation Study Results of Cetin Dam and HEPP

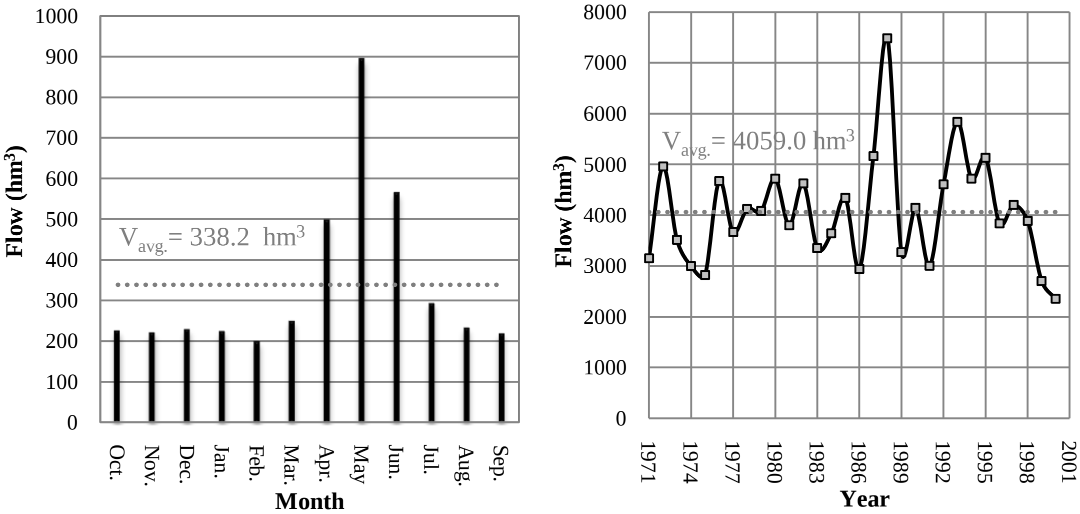


Figure E.44 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Cetin Reservoir

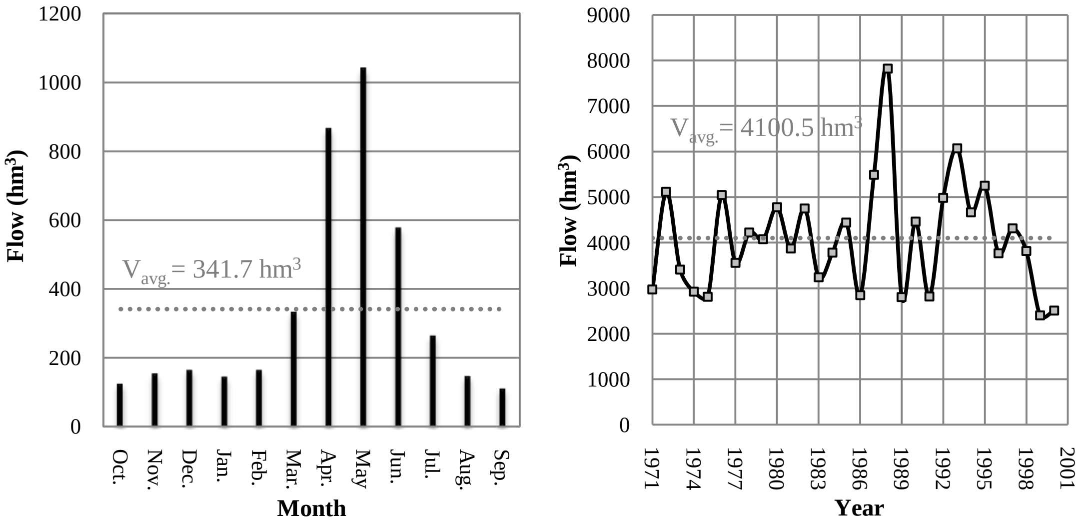


Figure E.45 Monthly Mean and Annual Total Flow Values at Alkumru Dam

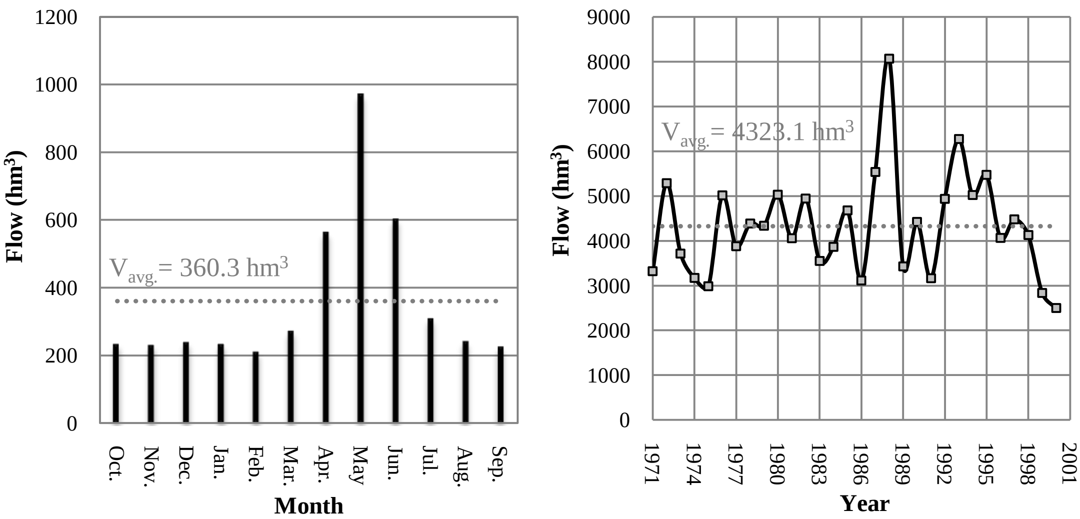


Figure E.46 Monthly Mean and Annual Total Inflow Values in the Operation Study of Alkumru Reservoir

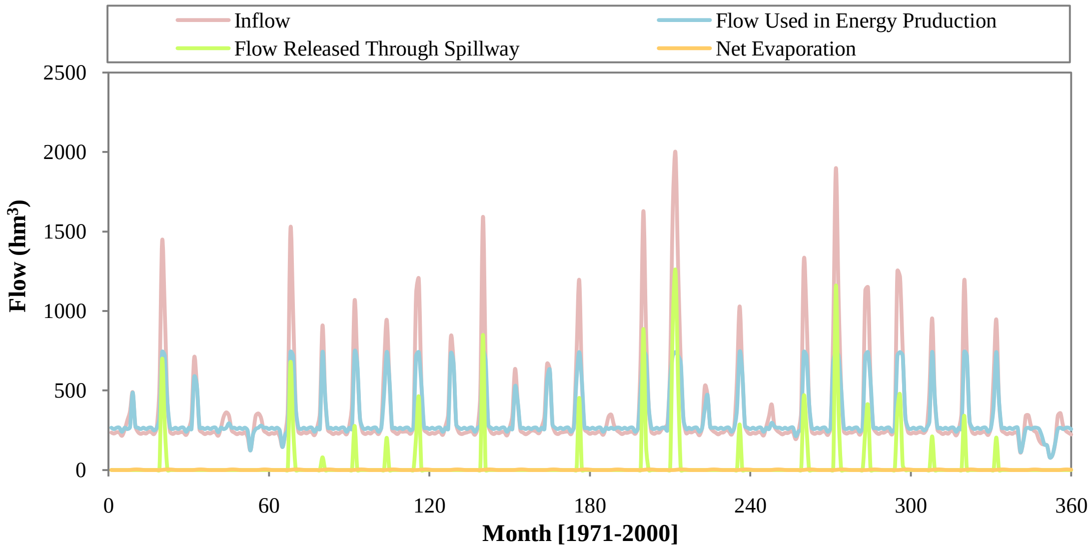


Figure E.47 Operation Study Results of Alkumru Dam and HEPP

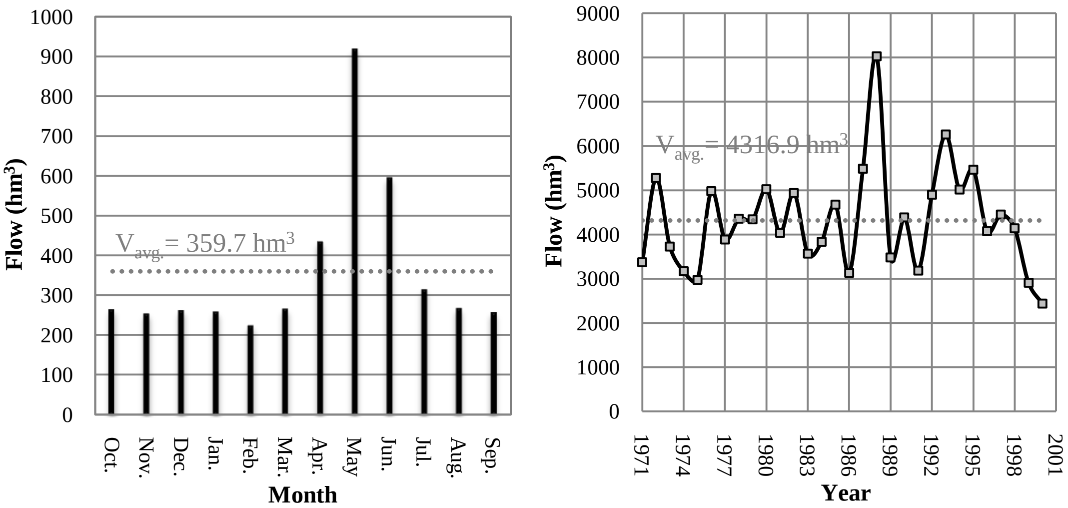


Figure E.48 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Alkumru Reservoir

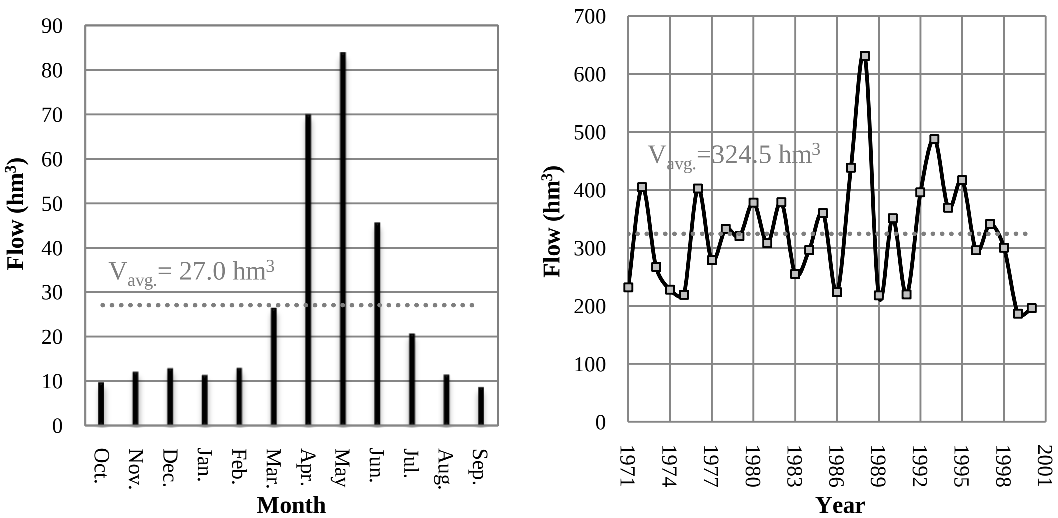


Figure E.49 Monthly Mean and Annual Total Flow Values at Eruh Dam

Table E.11 Monthly Mean Flow Values Released to Downstream of Eruh Dam

Months	Flow Released to Downstream (hm^3)
October	0.9
November	1.1
December	1.2
January	1.1
February	1.2
March	2.5
April	7.6
May	8.2
June	4.3
July	2.0
August	1.1
September	0.8
Total	32.1

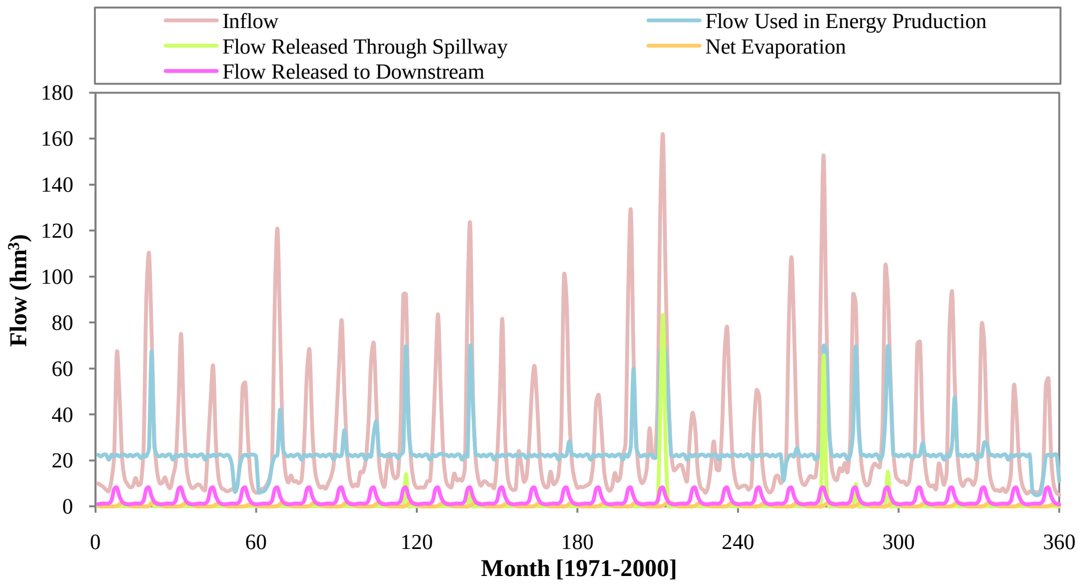
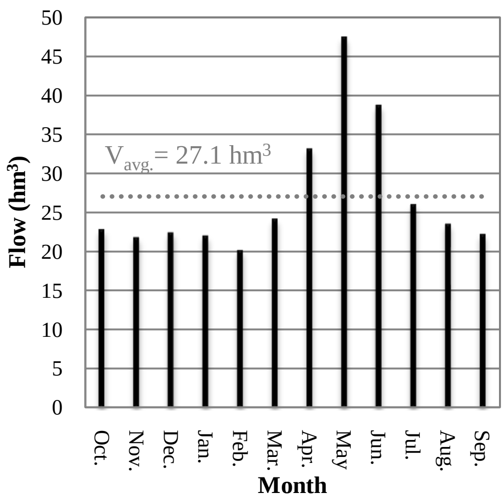


Figure E.50 Operation Study Results of Eruh Dam and HEPP



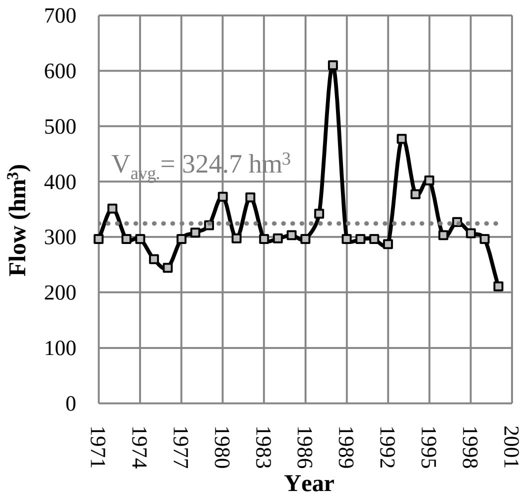


Figure E.51 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Eruh Reservoir

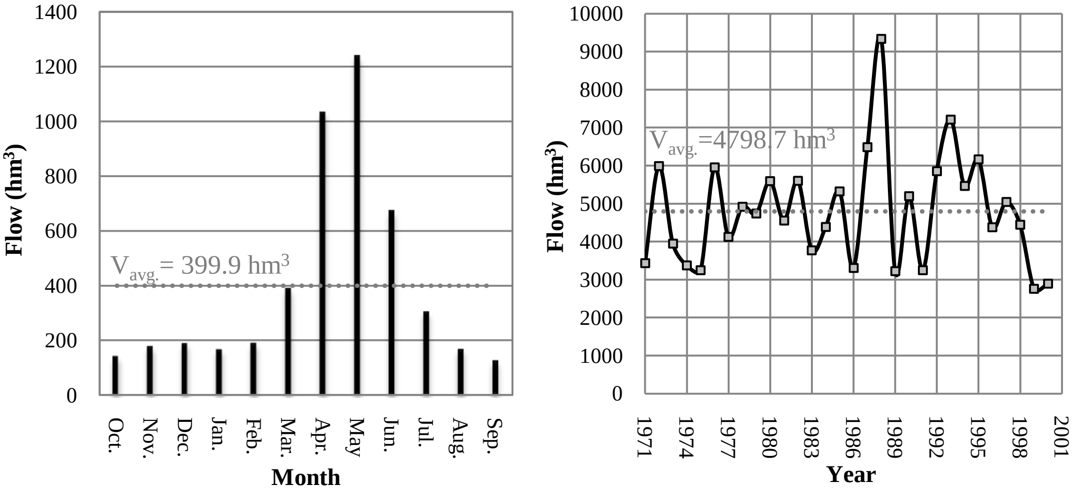


Figure E.52 Monthly Mean and Annual Total Flow Values at Ilisu III Dam

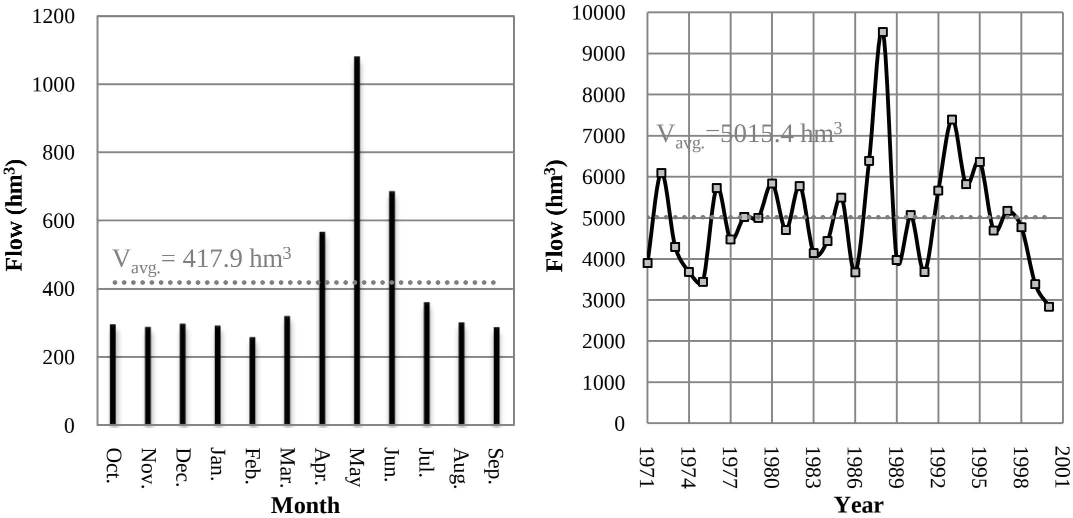


Figure E.53 Monthly Mean and Annual Total Inflow Values in the Operation Study of Ilisu III Reservoir

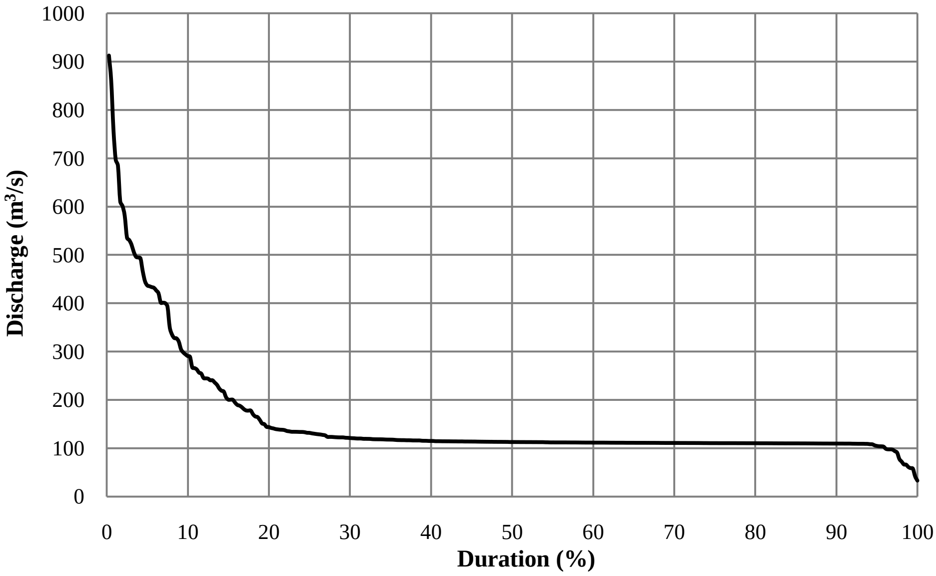


Figure E.54 Discharge-Duration Curve of Ilisu III Dam and HEPP

E.4. Sediment Transport

Table E.12 Sedimentation of Ilisu III Reservoir (EIE, 2000)

Sediment Gauging Station	2626 Botan Creek - Billoris	
Catchment Area of SGS	8761.2 km^2	
Unit Volume Weight of Sediment	1.35 t/m^3	
Sediment Type Distribution	Clay + Silt: 56.2%	Sand: 43.8%
Suspended Sediment Load	489 $t/year/km^2$	362 $m^3/year/km^2$
Bed Load (%50 of Suspended Sediment Load)	245 $t/year/km^2$	181 $m^3/year/km^2$
Total Sediment Load	734 $t/year/km^2$	543 $m^3/year/km^2$
Catchment Area of Ilisu III Dam	8872.7 km^2	
Catchment Area of Alkumru Dam	7562.5 km^2	
Catchment Area of Eruh Dam	600.0 km^2	
Area Contributing to Sediment Transport	710.2 km^2	
Economic Lifetime Period	50 year	
Volume of Sediment	19 hm^3	
Selected Minimum Water Level	480 m	

E.5. Operation Studies

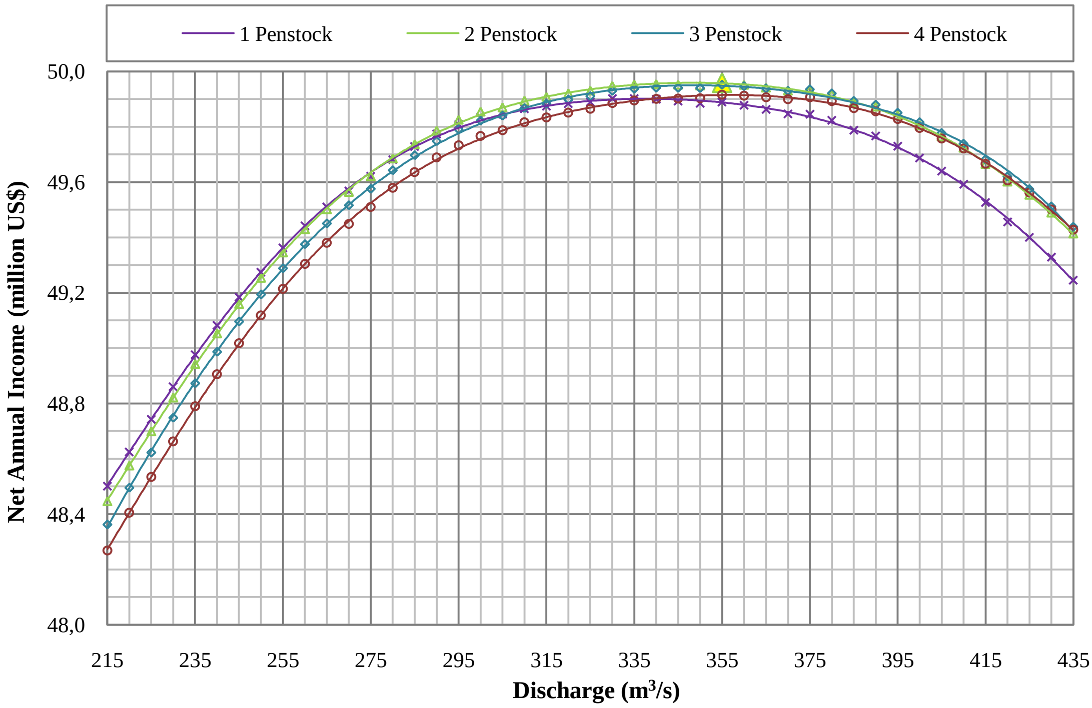


Figure E.55 Determination of Optimum Design Discharge for Ilisu III HEPP

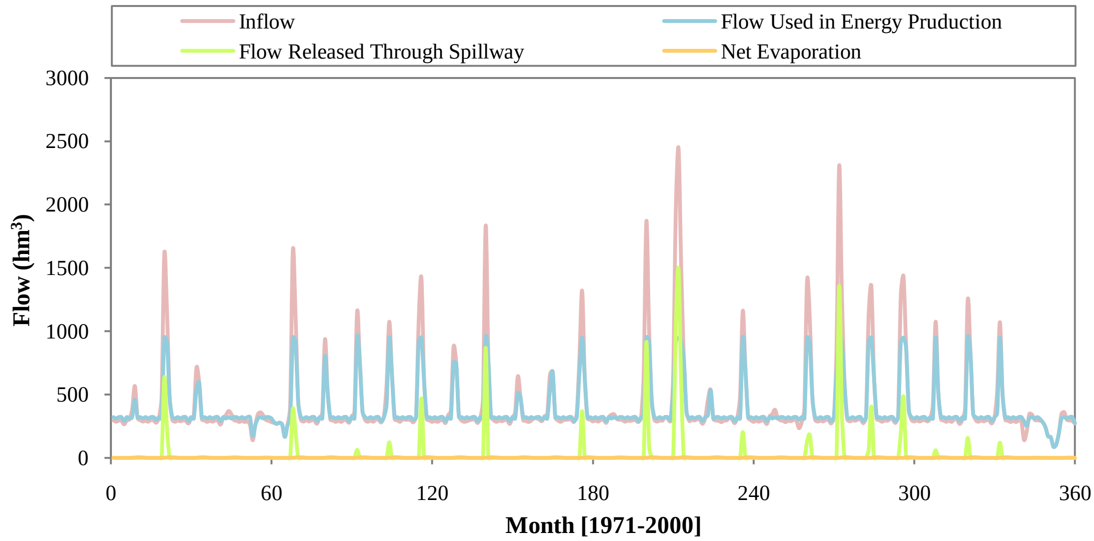


Figure E.56 Operation Study Results of Ilisu III Dam and HEPP

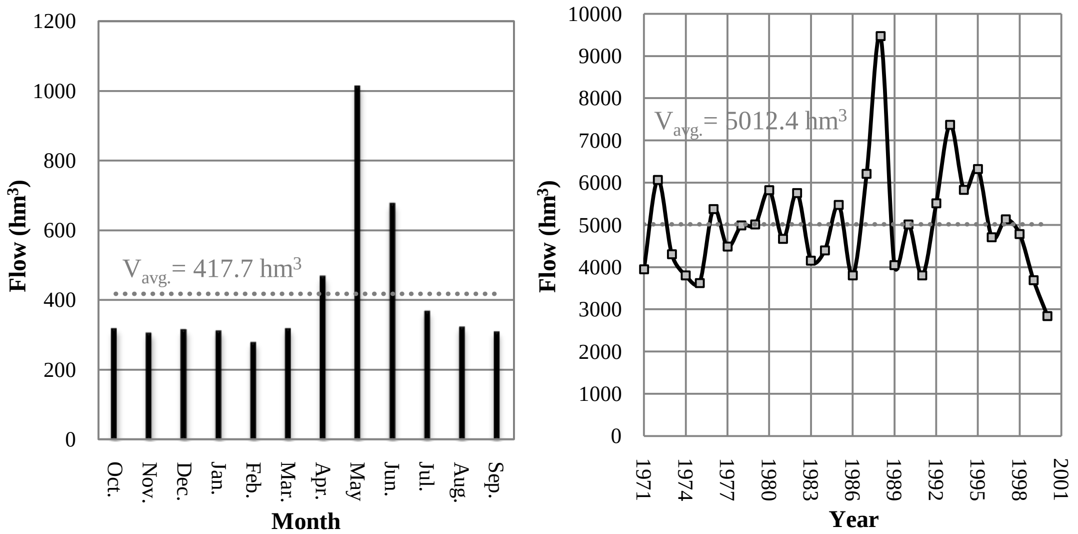


Figure E.57 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Ilisu III Reservoir

E.6. Flood Analysis

E.6.1. Calculation of Design Floods from Observed Runoff

Table E.13a Annual Instantaneous Max. Flows Observed in the Vicinity of Project Area (DSI, 2007-b; EIE, 2005)

Year	2610 SGS		2624 SGS		2626 SGS		2633 SGS		26-55 SGS	
	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)
1946	-	-	-	-	-	-	27.4	609.0	-	-
1947	-	-	-	-	-	-	15.4	258.0	-	-
1948	-	-	-	-	-	-	17.5	914.0	-	-
1949	-	-	-	-	-	-	17.5	578.0	-	-
1950	-	-	-	-	-	-	28.5	1034.0	-	-
1951	-	-	-	-	-	-	25.4	232.0	-	-
1952	-	-	-	-	-	-	28.4	1020.0	-	-

Table E.13a (continued)

1953	-	-	-	-	-	-	22.4	510.0	-	-
1954	-	-	-	-	-	-	9.5	896.0	-	-
1955	3.5	112.0	-	-	-	-	7.4	609.0	-	-
1956	22.12	126.0	-	-	-	-	11.4	802.0	-	-
1957	6.3	347.0	-	-	-	-	9.5	609.0	-	-
1958	5.3	123.0	-	-	-	-	18.4	914.0	-	-
1959	24.3	103.0	-	-	-	-	14.4	744.0	-	-
1960	26.4	132.0	-	-	-	-	26.4	978.0	-	-
1961	13.4	96.0	-	-	-	-	7.5	708.0	-	-
1962	21.11	110.0	-	-	-	-	28.4	422.0	-	-
1963	10.4	275.0	-	-	-	-	8.4	1777.0	-	-
1964	26.3	216.0	-	-	-	-	26.3	834.0	-	-
1965	30.4	223.0	-	-	-	-	29.4	1280.0	-	-
1966	27.1	296.0	-	-	-	-	26.1	1189.0	-	-
1967	20.4	144.0	-	-	-	-	14.5	1750.0	-	-
1968	18.4	331.0	-	-	-	-	19.4	1425.0	-	-
1969	1.5	295.0	-	-	-	-	2.4	1853.0	-	-
1970	12.2	143.0	-	-	-	-	16.4	480.0	-	-
1971	15.4	115.0	-	-	-	-	9.5	476.0	-	-
1972	30.4	393.0	30.4	243.0	1.5	1581.0	-	-	-	-
1973	9.4	92.6	8.4	45.7	10.5	626.0	-	-	-	-
1974	17.3	206.0	9.4	104.0	4.5	585.0	-	-	-	-
1975	19.4	153.0	20.4	193.0	14.4	506.0	-	-	-	-
1976	13.4	416.0	13.4	334.0	17.4	1172.0	-	-	-	-
1977	14.4	220.0	24.4	137.0	14.5	517.0	-	-	-	-
1978	24.4	217.0	12.3	163.0	7.5	531.0	-	-	-	-
1979	15.12	172.0	16.12	202.0	7.4	489.0	-	-	-	-
1980	28.3	303.0	28.3	158.0	28.3	927.0	-	-	-	-
1981	14.3	351.0	13.3	202.0	26.4	866.0	-	-	26.4	200.0
1982	5.4	337.0	5.4	357.0	18.5	1509.0	-	-	19.5	330.0
1983	16.5	90.8	17.5	109.0	17.5	1230.0	-	-	17.5	480.0
1984	18.11	281.0	18.11	304.0	17.4	655.0	-	-	14.4	290.0
1985	2.4	274.0	2.4	458.0	2.4	1190.0	-	-	23.4	340.0
1986	15.4	167.0	15.4	129.0	15.4	574.0	-	-	16.4	150.0
1987	12.4	338.0	12.4	590.0	11.5	1224.0	-	-	-	-
1988	14.4	449.0	14.4	430.0	14.4	1950.0	-	-	-	-
1989	8.11	101.0	8.11	125.0	8.1	453.0	-	-	-	-
1990	27.11	174.0	27.11	210.0	30.1	351.0	-	-	-	-
1991	23.3	188.0	23.3	285.0	23.3	930.0	-	-	-	-
1992	13.4	307.0	14.4	445.0	13.4	1576.0	-	-	-	-
1993	19.4	242.0	19.4	293.0	20.4	1830.0	-	-	-	-
1994	2.4	142.0	8.4	385.0	1.4	1237.0	-	-	-	-
1995	2.5	249.0	3.4	300.0	3.4	1423.0	-	-	-	-
1996	9.2	235.0	31.3	215.0	13.4	846.0	-	-	-	-
1997	27.4	201.0	28.4	235.0	-	-	28.4	1272.0	-	-
1998	29.3	288.0	29.3	320.0	-	-	29.3	955.0	-	-
1999	1.4	198.0	1.4	332.0	-	-	1.4	1095.0	-	-
2000	7.4	80.9	8.4	64.1	-	-	21.4	707.0	-	-
2001	6.4	227.0	6.4	179.0	-	-	6.4	547.0	16.5	105.0
2002	29.12	214.0	29.12	251.0	-	-	17.4	1191.0	12.5	333.0
2003	9.4	180.0	26.3	238.0	-	-	9.4	1328.0	26.4	383.0
2004	6.3	395.0	6.3	579.0	-	-	6.3	2159.0	-	-
2005	22.11	161.0	22.11	294.0	-	-	26.40	896.0	-	-
2006	9.5	163.0	8.4	142.0	-	-	7.06	744.0	-	-
Distrib.	**Pearson Type-3**		**Log-Normal (3 Parameter)**		**Gumbel**		**Log-Pearson Type-3**		**Pearson Type-3**	
Q_2	210.8		243.2		920.6		868.3		293.7	
$Q_{2.33}$	227.7		266.4		1011.6		948.4		314.7	
Q_5	295.7		361.7		1407.0		1289.8		390.8	
Q_{10}	345.1		433.7		1729.0		1553.9		439.6	
Q_{25}	401.8		519.4		2135.9		1867.3		490.2	
Q_{50}	440.7		579.9		2437.8		2086.0		522.0	
Q_{100}	477.1		638.3		2737.4		2292.7		550.1	
Q_{200}	511.8		695.0		3035.9		2489.3		575.4	
Q_{500}	555.6		768.0		3429.8		2736.2		605.4	
Q_{1000}	587.4		823.6		3727.4		2914.3		626.2	

Table E.13b Annual Instantaneous Max. Flows Observed in the Vicinity of Project Area (DSI, 2007-b; EIE, 2005)

Year	2609 SGS		2615 SGS		2631 SGS		26-33 SGS	
	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)
1946	-	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-
1951	-	-	-	-	-	-	-	-
1952	-	-	-	-	-	-	-	-
1953	-	-	-	-	-	-	-	-
1954	-	-	-	-	-	-	-	-
1955	-	-	-	-	-	-	-	-
1956	-	-	-	-	-	-	-	-
1957	-	-	-	-	-	-	-	-
1958	-	-	-	-	-	-	-	-
1959	-	-	-	-	-	-	-	-
1960	-	-	-	-	-	-	-	-
1961	10.5	100.0	-	-	-	-	-	-
1962	23.5	52.2	-	-	-	-	-	-
1963	7.6	150.0	-	-	-	-	-	-
1964	27.5	101.0	-	-	-	-	-	-
1965	5.6	80.4	2.5	64.4	-	-	-	-
1966	25.5	103.0	5.5	69.4	-	-	-	-
1967	14.5	170.0	14.5	105.0	-	-	-	-
1968	18.4	206.0	22.4	117.0	-	-	-	-
1969	2.4	325.0	5.4	170.0	-	-	-	-
1970	15.4	107.0	18.4	40.5	-	-	-	-
1971	10.5	104.0	6.5	33.7	-	-	-	-
1972	-	-	13.5	183.0	-	-	-	-
1973	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	17.5	135.0
1977	-	-	-	-	-	-	14.5	87.0
1978	-	-	-	-	-	-	14.5	84.0
1979	-	-	-	-	-	-	13.5	91.0
1980	-	-	-	-	-	-	22.5	175.0
1981	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-
1988	-	-	-	-	15.5	192.0	-	-
1989	-	-	-	-	6.5	88.0	-	-
1990	-	-	-	-	6.5	88.0	-	-
1991	-	-	-	-	17.5	99.3	17.5	109.0
1992	-	-	-	-	2.6	126.0	-	-
1993	-	-	-	-	12.5	382.0	-	-
1994	-	-	-	-	30.4	246.0	-	-
1995	-	-	-	-	2.5	178.0	-	-
1996	-	-	-	-	5.5	110.0	-	-
1997	-	-	-	-	28.4	171.0	-	-
1998	-	-	-	-	12.5	130.0	-	-
1999	-	-	-	-	31.3	74.4	-	-
2000	-	-	-	-	21.4	94.5	-	-
2001	-	-	-	-	16.5	65.4	-	-
2002	-	-	-	-	24.5	162.0	-	-
2003	-	-	-	-	9.4	279.0	-	-
2004	-	-	-	-	6.3	246.0	-	-
2005	-	-	-	-	26.4	116.0	-	-
2006	-	-	-	-	10.5	110.0	-	-

Table E.13b (continued)

Distribution	Log-Pearson Type-3	Gumbel	Log-Pearson Type-3	Pearson Type-3
Q_2	116.6	90.5	133.6	106.5
$Q_{2.33}$	127.3	103.7	145.6	112.5
Q_5	180.6	161.1	204.9	139.2
Q_{10}	232.4	207.9	262.1	160.9
Q_{25}	309.6	266.9	346.7	187.9
Q_{50}	376.6	310.7	419.6	207.6
Q_{100}	452.4	354.2	501.5	226.9
Q_{200}	538.2	397.6	593.9	246.0
Q_{500}	669.5	454.7	734.3	270.9
Q_{1000}	784.3	497.9	856.5	289.6

E.6.1.1. Point Flood Frequency Analysis

Table E.14 Point Flood Frequency Analysis Results of Ilisu III Dam

Return Period	2626 Botan-Billoris SGS	Ilisu III Dam
	Flood Discharge (m^3/s)	
2	920.6	928.4
2.33	1011.6	1020.2
5	1407.0	1418.9
10	1729.0	1743.7
25	2135.9	2154.0
50	2437.8	2458.4
100	2737.4	2760.6
200	3035.9	3061.6
500	3429.8	3458.8
1000	3727.4	3759.0

E.6.1.2. Regional Flood Frequency Analysis

Table E.15 Data for Homogeneity Test

Unit: m^3/s

SGS	Q_2	$Q_{2.33}$	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	Q_{1000}
2610	210.8	227.7	295.7	345.1	401.8	440.7	477.1	511.8	555.6	587.4
2624	243.2	266.4	361.7	433.7	519.4	579.9	638.3	695.0	768.0	823.6
2626	920.6	1011.6	1407.0	1729.0	2135.9	2437.8	2737.4	3035.9	3429.8	3727.4
2633	868.3	948.4	1289.8	1553.9	1867.3	2086.0	2292.7	2489.3	2736.2	2914.3
26-55	293.7	314.7	390.8	439.6	490.2	522.0	550.1	575.4	605.4	626.2
2609	116.6	127.3	180.6	232.4	309.6	376.6	452.4	538.2	669.5	784.3
2615	90.5	103.7	161.1	207.9	266.9	310.7	354.2	397.6	454.7	497.9
2631	133.6	145.6	204.9	262.1	346.7	419.6	501.5	593.9	734.3	856.5
26-33	106.5	112.5	139.2	160.9	187.9	207.6	226.9	246.0	270.9	289.6

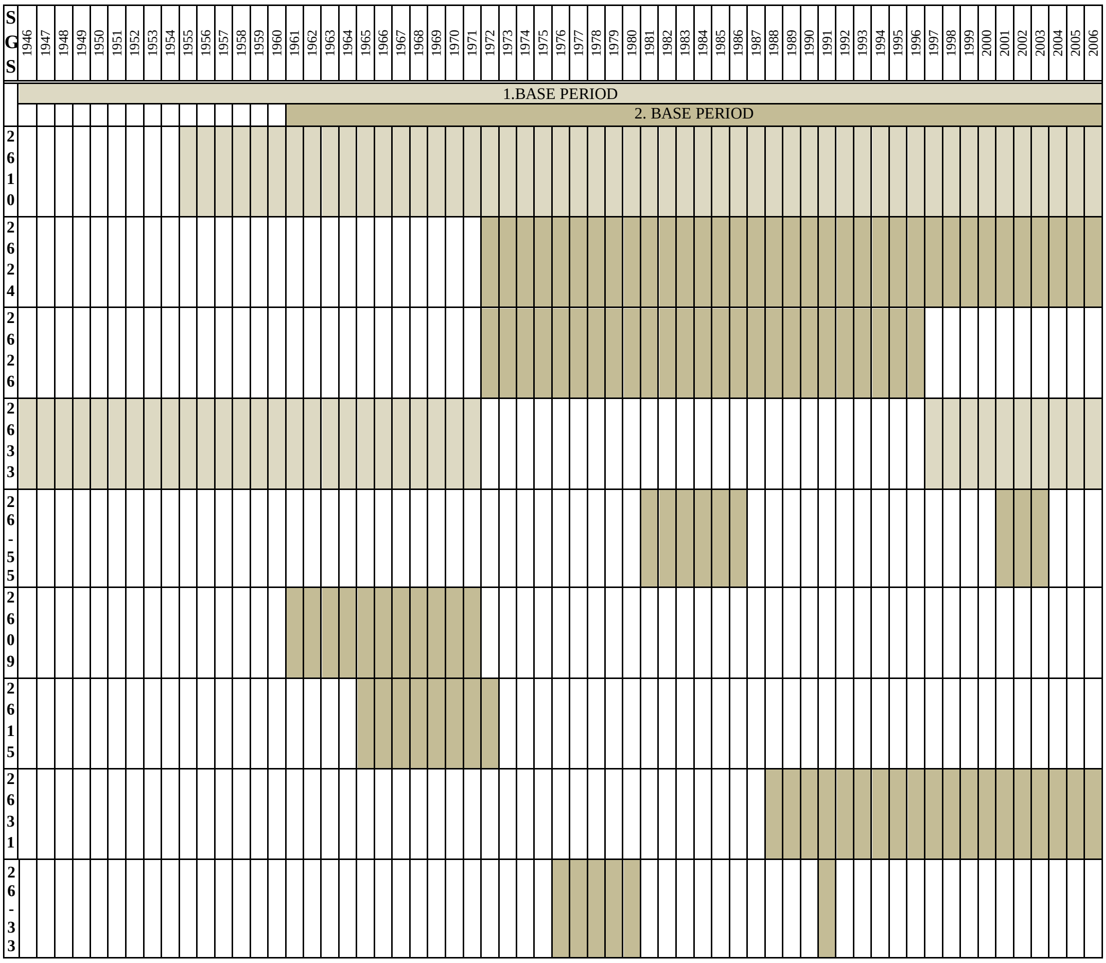


Figure E.58 Observation Periods of Stream Gauging Stations

Table E.16 1. Base Period (1946-2006) Homogeneity Test Table

SGS	$Q_{2.33}$	Q_{10}	$Q_{10}/Q_{2.33}$	Avg.x$Q_{2.33}$	Return Period	Obser. Period	Adjusted Re. Period
2610	227.7	345.1	1.5	359.1	13.7	52	56.5
2633	948.4	1553.9	1.6	1495.6	8.9	36	48.5
		Average	1.6				

Table E.17 2. Base Period (1961-2006) Homogeneity Test Table

SGS	$Q_{2.33}$	Q_{10}	$Q_{10}/Q_{2.33}$	Avg.x$Q_{2.33}$	Return Period	Obser. Period	Adjusted Re. Period
2624	266.4	433.7	1.6	448.9	12.6	35	40.5
2626	1011.6	1729.0	1.7	1704.4	9.6	25	35.5
26-55	314.7	439.6	1.4	530.3	64.7	9	27.5
2609	127.3	232.4	1.8	214.5	8.3	11	28.5
2615	103.7	207.9	2.0	174.8	6.5	8	27.0
2631	145.6	262.1	1.8	245.2	8.5	19	32.5
26-33	112.5	160.9	1.4	189.5	27.0	6	26.0
		Average	1.7				

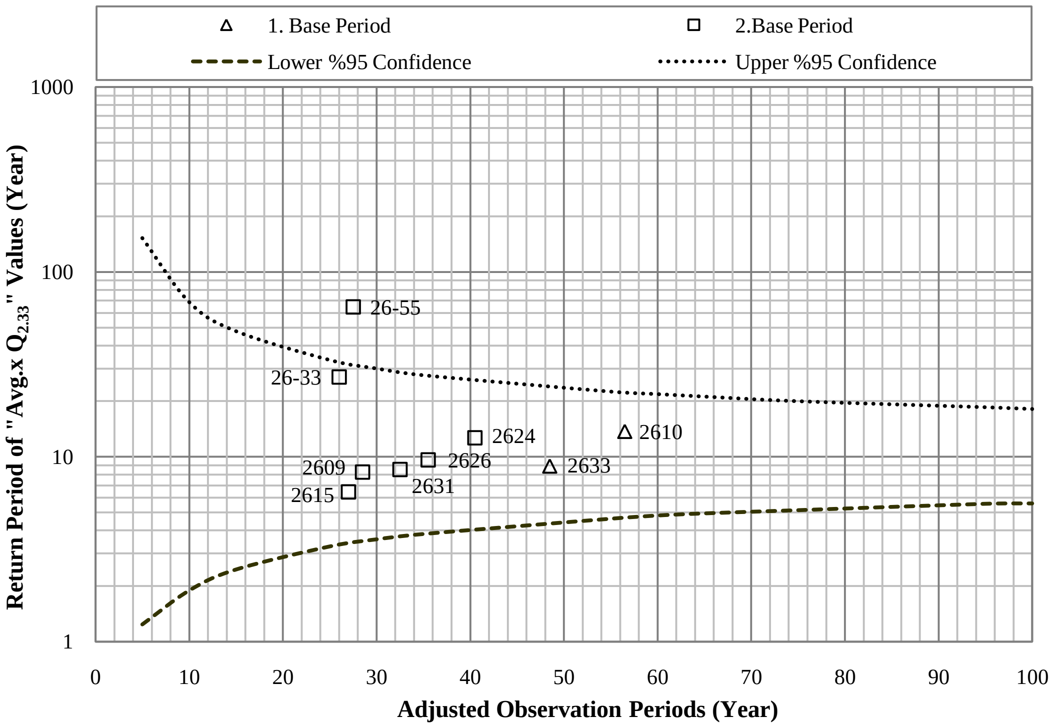


Figure E.59 Homogeneity Test Graph

Table E.18 Dimensionless Regional Flood Frequency Analysis

Unit: m^3/s

SGS	Q_2	$Q_{2.33}$	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	Q_{1000}
2610	0.9	1.0	1.3	1.5	1.8	1.9	2.1	2.2	2.4	2.6
2624	0.9	1.0	1.4	1.6	1.9	2.2	2.4	2.6	2.9	3.1
2626	0.9	1.0	1.4	1.7	2.1	2.4	2.7	3.0	3.4	3.7
2633	0.9	1.0	1.4	1.6	2.0	2.2	2.4	2.6	2.9	3.1
2609	0.9	1.0	1.4	1.8	2.4	3.0	3.6	4.2	5.3	6.2
2615	0.9	1.0	1.6	2.0	2.6	3.0	3.4	3.8	4.4	4.8
2631	0.9	1.0	1.4	1.8	2.4	2.9	3.4	4.1	5.0	5.9
26-33	0.9	1.0	1.2	1.4	1.7	1.8	2.0	2.2	2.4	2.6
Avg.	0.9	1.0	1.4	1.7	2.1	2.4	2.8	3.1	3.6	4.0

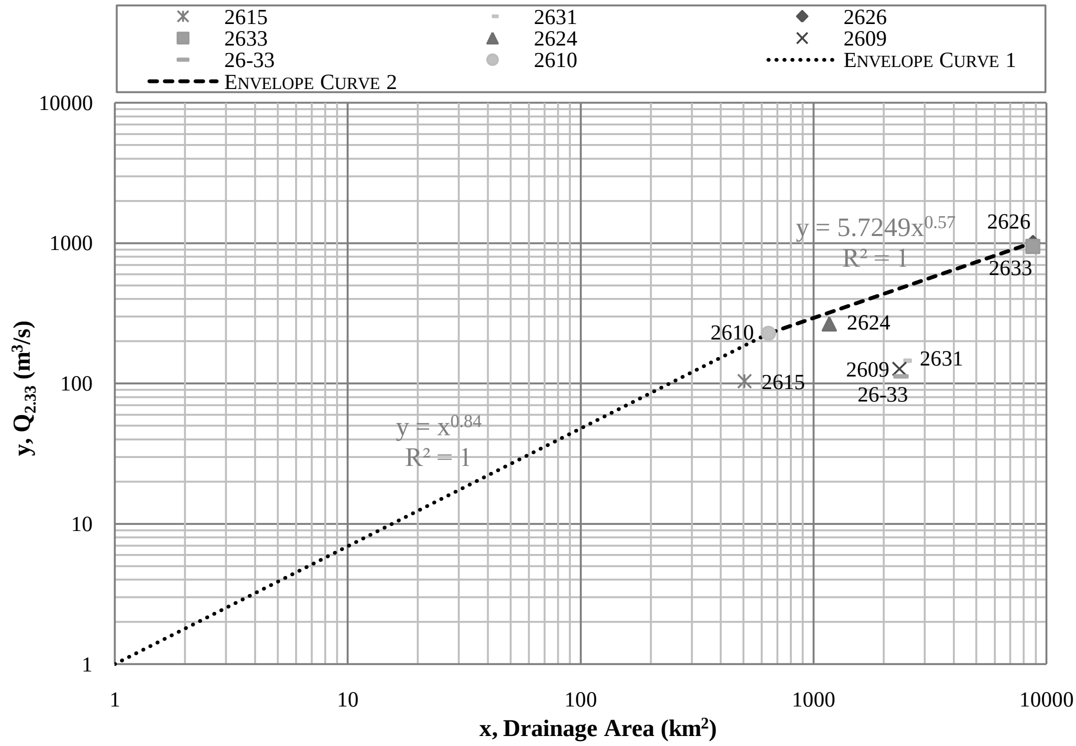


Figure E.60 Regional Flood Envelope Curve

Table E.19 Regional Flood Frequency Analysis Results of Ilisu III Dam

Return Period	**Ilisu III Dam** Flood Discharge (m^3/s)
2	931.9
2.33	1019.0
5	1404.1
10	1726.0
25	2146.5
50	2471.5
100	2808.0
200	3159.9
500	3654.7
1000	4056.6

E.6.2. Flood Recurrences Calculated Using Snyder Synthetic Unit Hydrograph Method

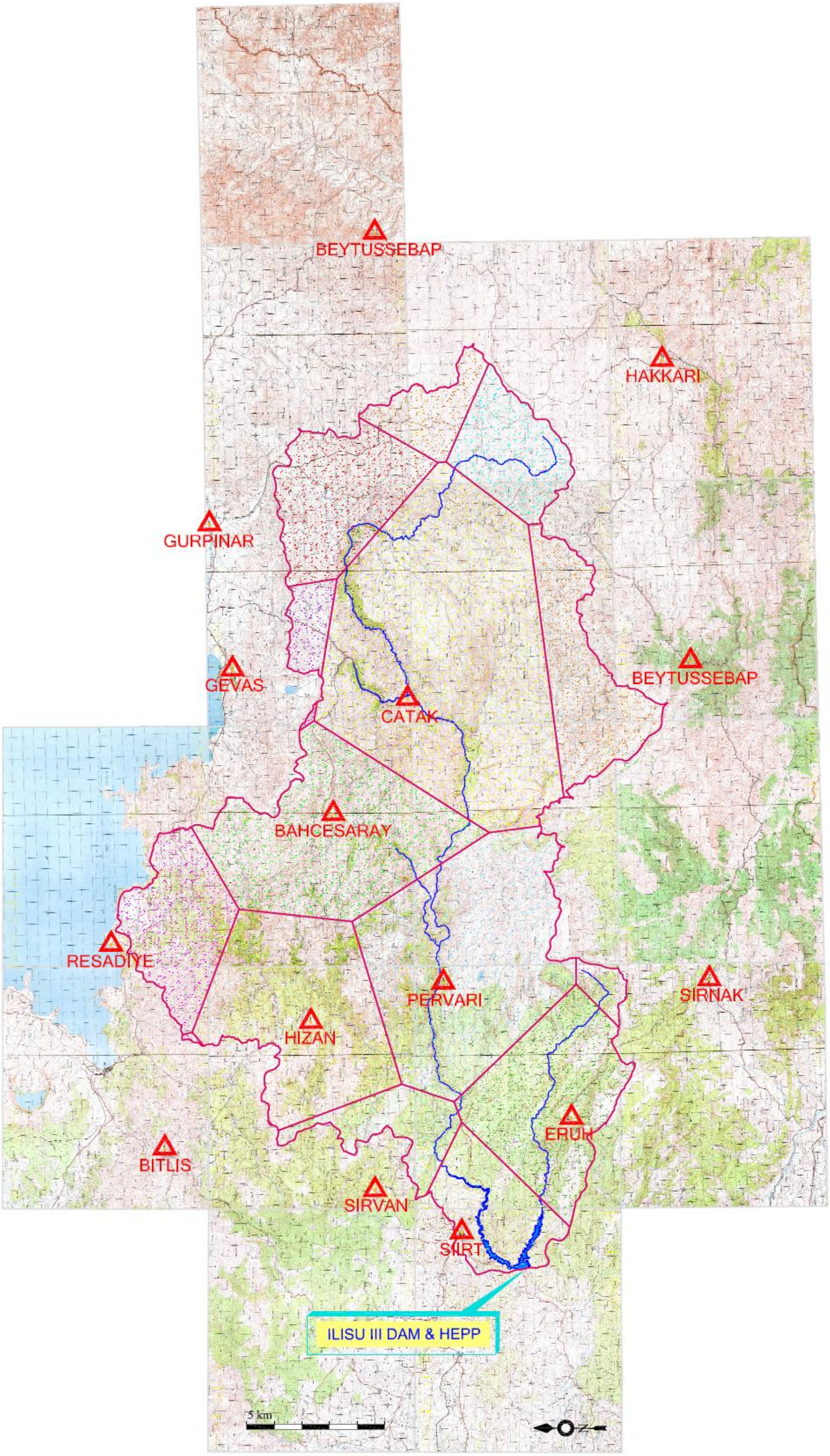


Figure E.61 Thiessen Polygons of Ilisu III Drainage Area

Table E.20a Annual Daily Max. Precipitations Observed in the Vicinity of Project Area (DMI, 2009-b)

Year	Bitlis MS	Hizan MS	Sirvan MS	Siirt MS	Bahcesaray MS	Baskale MS	Beytussebap MS	Catak MS
	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)
1929	61.2	-	-	49.2	-	-	-	-
1930	56.8	-	-	25.4	-	-	-	-
1931	96.2	-	-	66.7	-	-	-	-
1932	94.6	-	-	45.1	-	-	-	-
1933	60.4	-	-	39.2	-	-	-	-
1934	-	-	-	56.8	-	-	-	-
1935	-	-	-	52.3	-	-	-	-
1936	-	-	-	118.0	-	-	-	-
1937	-	-	-	38.5	-	-	-	-
1938	-	-	-	51.5	-	-	-	-
1939	87.5	-	-	47.4	-	-	-	-
1940	62.5	-	-	27.0	-	-	-	-
1941	49.4	-	-	30.6	-	-	-	-
1942	67.2	-	-	38.0	-	-	-	-
1943	-	-	-	25.8	-	-	-	-
1944	-	-	-	61.9	-	-	-	-
1945	19.6	-	-	30.8	-	-	-	-
1946	8.9	-	-	-	-	-	-	-
1947	42.0	-	-	44.4	-	-	-	-
1948	85.0	-	-	43.3	-	-	-	-
1949	48.0	-	-	43.2	-	-	-	-
1950	44.0	-	-	65.9	-	-	-	42.1
1951	53.0	-	-	69.1	-	-	45.5	39.7
1952	32.8	-	-	44.2	-	-	61.2	38.5
1953	80.0	-	-	42.5	-	-	59.2	55.8
1954	80.0	-	-	42.0	-	53.7	71.4	63.5
1955	44.7	-	-	71.8	-	66.9	72.3	52.2
1956	85.7	-	-	50.5	-	48.7	48.4	32.4
1957	75.3	-	-	40.6	-	159.6	58.5	42.8
1958	88.5	50.3	-	39.5	-	48.3	53.3	41.8
1959	53.3	39.0	-	53.4	-	91.7	51.4	44.6
1960	33.3	47.8	46.5	41.4	-	32.7	53.4	39.5
1961	83.4	56.5	41.7	42.5	-	32.3	64.8	71.9
1962	43.3	50.0	45.6	48.2	-	134.7	50.8	65.7
1963	55.5	65.0	48.1	49.9	-	44.0	63.2	46.7
1964	36.0	50.0	42.1	34.8	-	24.2	74.6	31.2
1965	56.5	60.0	32.1	25.8	-	32.3	66.8	39.6
1966	78.8	45.3	46.4	52.6	-	38.4	63.6	70.9
1967	75.9	52.0	49.2	38.3	-	57.7	57.2	44.5
1968	67.5	55.0	54.1	65.7	-	39.4	72.0	54.6
1969	76.9	55.0	50.2	63.0	-	43.8	57.4	34.2
1970	65.8	40.0	69.6	32.3	-	15.1	82.6	29.8
1971	87.0	55.8	47.5	49.9	60.5	31.8	57.3	47.8
1972	55.4	44.5	55.6	35.5	51.2	34.8	67.8	55.3
1973	35.1	49.4	26.7	24.8	21.5	26.4	58.7	29.3
1974	41.8	35.3	25.2	29.2	25.8	25.6	53.2	28.7
1975	66.2	52.4	43.8	41.1	-	27.3	57.8	45.3
1976	73.3	53.5	47.0	55.9	-	12.9	54.5	46.7
1977	91.3	42.0	30.5	30.2	-	-	62.4	66.7
1978	70.0	70.0	54.6	50.1	90.4	-	95.2	43.4
1979	52.8	51.4	46.5	37.7	78.2	-	68.5	49.2
1980	46.4	32.5	-	27.9	43.5	37.9	-	56.3
1981	57.5	54.5	27.3	38.3	85.4	38.7	70.2	82.9
1982	64.5	54.0	50.0	46.6	42.3	21.3	-	45.9
1983	63.4	52.4	55.2	41.2	47.5	28.4	-	46.9
1984	57.0	56.0	40.1	37.9	46.8	34.7	-	-
1985	66.2	43.8	65.2	71.4	34.4	25.2	-	36.3
1986	57.7	41.0	36.7	25.1	75.6	22.2	-	34.9
1987	73.8	52.4	49.5	44.1	64.7	58.9	-	60.9
1988	59.5	39.0	67.5	57.4	73.6	32.2	-	-
1989	81.4	58.5	40.8	65.6	41.1	36.4	-	-
1990	64.9	45.0	55.7	41.3	70.7	42.9	-	-
1991	81.3	57.6	51.0	53.2	-	30.5	85.0	-
1992	122.2	66.2	56.0	43.0	-	41.6	136.0	-
1993	85.1	52.0	70.5	68.1	-	44.6	-	-

Table E.20a (continued)

1994	67.3	50.6	75.5	57.1	-	43.5	-	-
1995	65.7	43.6	53.8	33.4	-	41.7	-	-
1996	40.6	-	46.0	51.2	-	49.3	-	-
1997	59.9	-	67.2	54.6	-	28.9	-	-
1998	58.4	-	39.6	43.3	-	29.6	-	-
1999	42.7	-	-	57.8	-	43.3	-	-
2000	55.3	-	-	33.0	-	29.7	-	-
2001	58.3	-	-	39.2	-	44.6	-	-
2002	51.3	-	-	37.3	-	29.8	-	-
2003	108.9	-	-	57.4	-	50.1	-	-
2004	79.8	-	-	47.4	-	41.4	-	-
2005	55.9	-	-	40.2	-	20.1	-	-
2006	63.5	-	-	51.9	-	32.9	-	-
2007	-	-	-	36.0	-		-	-
Distribution	**Log-Normal (3 Parameter)**	**Normal**	**Log-Normal (3 Parameter)**	**Log-Normal (2 Parameter)**	**Gumbel**	**Log-Pearson Type-3**	**Log-Pearson Type-3**	**Log-Pearson Type-3**
P_2	63.1	50.5	48.4	44.1	53.1	35.3	60.7	45.5
$P_{2.33}$	66.7	52.0	50.6	46.6	57.3	38.2	62.9	47.7
P_5	80.1	57.4	58.9	57.1	75.6	53.3	74.0	57.3
P_{10}	89.2	61.1	64.5	65.4	90.6	68.5	84.9	65.0
P_{25}	99.0	65.0	70.7	75.5	109.5	92.3	101.2	74.5
P_{50}	105.5	67.4	74.7	82.9	123.5	113.8	115.3	81.6
P_{100}	111.4	69.7	78.4	90.2	137.4	139.0	131.3	88.6
P_{200}	116.9	71.7	81.8	97.3	151.2	168.6	149.5	95.7
P_{500}	123.5	74.2	86.0	106.7	169.5	215.9	177.3	105.2
P_{1000}	128.3	76.0	89.0	114.0	183.3	259.1	201.9	112.5

Table E.20b Annual Daily Max. Precipitations Observed in the Vicinity of Project Area (DMI, 2009-b)

Year	**Gevas MS**	**Gurpinar MS**	**Hakkari MS**	**Pervari MS**	**Resadiye MS**	**Eruh MS**	**Sirnak MS**
	P (mm)	**P (mm)**	**P (mm)**	**P (mm)**	**P (mm)**	**P (mm)**	**P (mm)**
1929	-	-	-	-	-	-	-
1930	-	-	-	-	-	-	-
1931	-	-	-	-	-	-	-
1932	-	-	-	-	-	-	-
1933	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-
1935	-	-	-	-	-	-	-
1936	-	-	-	-	-	-	-
1937	-	-	-	-	-	-	-
1938	-	-	-	-	-	-	-
1939	-	-	-	-	-	-	-
1940	-	-	-	-	-	-	-
1941	-	-	-	-	-	-	-
1942	-	-	-	-	-	-	-
1943	-	-	-	-	-	-	-
1944	-	-	-	-	-	-	-
1945	-	-	-	-	-	-	-
1946	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-
1951	-	-	36.0	-	-	-	-
1952	-	-	45.0	-	-	-	-
1953	-	-	45.0	-	-	-	-
1954	95.0	-	60.0	27.8	-	-	33.9
1955	40.2	-	42.0	36.5	-	-	55.2
1956	50.0	-	31.4	35.5	-	-	46.3
1957	25.0	-	62.5	-	-	39.8	38.2
1958	46.2	24.0	24.5	-	-	80.1	36.2
1959	45.0	50.0	42.0	43.3	-	65.3	31.7
1960	-	26.0	57.3	28.4	-	57.0	50.2

Table E.20b (continued)

1961	-	50.0	78.2	38.2	-	86.5	68.3
1962	-	30.0	40.0	35.9	-	81.5	95.6
1963	-	28.7	79.6	37.2	-	81.3	65.6
1964	-	25.1	38.7	45.0	-	46.9	56.5
1965	37.0	21.2	52.9	51.0	41.3	67.8	59.7
1966	65.7	45.0	43.4	41.6	46.9	80.7	61.3
1967	38.9	27.0	59.0	39.8	36.3	69.3	45.8
1968	52.6	19.5	76.7	42.6	46.9	47.9	48.1
1969	78.9	37.0	43.7	34.2	38.5	49.8	39.3
1970	34.6	16.1	35.2	43.6	22.9	38.5	34.6
1971	34.6	26.7	42.8	37.2	-	60.9	49.3
1972	43.6	31.2	77.0	48.5	-	80.0	41.6
1973	44.3	16.7	39.9	26.7	26.4	46.5	31.2
1974	34.3	28.7	43.6	27.4	27.8	33.5	16.4
1975	39.4	15.1	39.5	27.0	27.8	44.5	32.5
1976	46.7	15.2	44.6	29.3	34.6	46.0	41.0
1977	44.3	27.8	-	32.6	46.7	37.0	23.8
1978	48.4	18.3	40.7	32.4	44.8	44.0	27.5
1979	38.1	19.7	48.5	25.0	29.7	20.3	40.0
1980	28.4	25.8	57.0	26.4	36.2	54.2	31.2
1981	46.6	25.8	50.1	27.0	38.6	37.5	28.5
1982	45.4	24.8	48.5	36.4	-	37.8	19.5
1983	33.6	22.3	43.1	33.6	28.5	44.4	35.4
1984	25.3	24.3	67.8	29.8	53.6	41.5	41.1
1985	24.0	20.4	44.7	31.7	22.4	-	-
1986	28.0	13.6	43.9	30.2	26.6	45.5	-
1987	38.1	25.3	56.1	51.6	47.5	39.5	-
1988	36.8	-	46.2	41.8	34.3	65.2	-
1989	39.5	-	36.5	26.6	21.3	-	-
1990	56.9	-	43.5	26.2	39.6	-	-
1991	45.5	24.8	47.8	30.8	47.0	56.6	-
1992	68.8	41.8	77.6	20.8	36.7	41.2	-
1993	42.2	30.4	59.9	30.8	56.7	78.2	32.3
1994	61.9	29.2	54.2	36.1	48.6	-	52.7
1995	32.0	22.2	58.2	-	59.8	-	-
1996	53.4	-	40.9	-	-	-	-
1997	27.7	-	47.3	-	-	-	-
1998	24.4	15.2	26.1	-	-	-	-
1999	42.5	21.0	61.2	-	-	-	-
2000	24.1	16.0	58.8	-	-	-	39.5
2001	30.0	20.7	56.3	-	-	-	49.5
2002	35.5	27.3	67.2	-	-	-	53.1
2003	44.5	21.0	49.8	-	-	-	57.2
2004	41.2	30.0	44.7	-	-	-	58.5
2005	41.1	18.7	39.4	-	-	-	50.2
2006	30.8	28.0	36.7	-	-	-	57.1
2007	44.9	-	-	-	-	-	30.8
Distribution	**Log-Normal (3 Parameter)**	**Log-Pearson Type-3**	**Gumbel**	**Gumbel**	**Gumbel**	**Gumbel**	**Log-Pearson Type-3**
P_2	39.6	24.0	47.7	33.4	36.5	51.7	42.5
$P_{2.33}$	41.8	25.3	50.0	34.8	38.6	54.9	45.2
P_5	51.9	31.5	60.2	40.9	47.5	69.1	56.0
P_{10}	60.4	36.7	68.5	45.8	54.7	80.6	64.0
P_{25}	71.5	43.6	79.0	52.1	63.8	95.2	73.2
P_{50}	80.0	49.0	86.8	56.8	70.6	106.0	79.5
P_{100}	88.7	54.5	94.6	61.4	77.3	116.7	85.3
P_{200}	97.6	60.4	102.3	66.0	84.0	127.4	90.8
P_{500}	109.7	68.5	112.5	72.1	92.9	141.6	97.7
P_{1000}	119.4	75.1	120.2	76.7	99.6	152.2	102.7

Table E.21 Probable Maximum Precipitation Calculations of Meteorological Stations

MS	Bitlis	Hizan	Sirvan	Siirt	Bahcesaray	Baskale	Beytussebap	Catak
N	71	38	38	78	17	50	32	37
X_N	63.5	50.5	48.7	46.2	56.1	42.1	65.4	47.5
X_{MAX}	122.2	70.0	75.5	118.0	90.4	159.6	136.0	82.9
X_{N-1}	62.7	50.0	48.0	45.3	53.9	39.7	63.2	46.5
X_{N-1}/X_N	1.0	1.0	1.0	1.0	1.0	0.9	1.0	1.0
Correct. Coeff. 1	1.005	1.020	1.020	0.993	1.010	0.962	1.000	1.008
X	63.9	51.5	49.7	45.9	56.6	40.5	65.4	47.9
Correct. Coeff. 2	1.000	1.002	1.002	1.000	1.025	1.000	1.004	1.003
X	**63.9**	**51.6**	**49.8**	**45.9**	**58.0**	**40.5**	**65.7**	**48.0**
ΣX^2	314077.0	99456.8	95632.0	182877.5	60307.6	120720.8	145929.7	89738.4
S_N	19.8	8.2	12.2	14.6	20.7	25.7	16.9	13.1
S_{N-1}	18.6	7.7	11.5	12.1	19.3	19.5	11.2	11.8
S_{N-1}/S_N	0.9	0.9	0.9	0.8	0.9	0.8	0.7	0.9
Correct. Coeff. 3	0.990	1.020	1.015	0.860	1.100	0.820	0.740	0.990
S	19.6	8.4	12.4	12.5	22.8	21.1	12.5	13.0
Correct. Coeff. 4	1.000	1.015	1.015	1.000	1.115	1.000	1.030	1.018
S	**19.6**	**8.5**	**12.6**	**12.5**	**25.4**	**21.1**	**12.9**	**13.2**
KM	**5.8**	**7.5**	**7.8**	**7.0**	**6.7**	**9.5**	**5.6**	**8.2**
PMP_{24}=X+KM*S	**177.6**	**115.7**	**147.8**	**133.5**	**228.2**	**240.4**	**137.9**	**156.1**

Table E.21 (continued)

Gevas	Gurpinar	Hakkari	Pervari	Resadiye	Eruh	Sirnak
49	44	55	39	28	34	41
42.4	25.6	49.7	34.5	38.1	54.3	44.1
95.0	50.0	79.6	51.6	59.8	86.5	95.6
41.3	25.1	49.1	34.1	37.3	53.3	42.8
1.0	1.0	1.0	1.0	1.0	1.0	1.0
0.995	1.005	1.001	1.018	1.015	1.010	0.998
42.2	25.8	49.7	35.1	38.7	54.9	44.0
1.000	1.000	1.000	1.002	1.008	1.004	1.001
42.2	**25.8**	**49.7**	**35.2**	**39.0**	**55.1**	**44.0**
97345.6	32045.1	144879.1	48651.2	43797.4	110186.2	88654.7
14.0	8.6	12.9	7.5	10.6	17.3	15.1
11.8	7.8	12.4	7.1	10.0	16.6	12.8
0.8	0.9	1.0	0.9	0.9	1.0	0.8
0.900	0.995	1.020	1.030	1.050	1.060	0.930
12.6	8.5	13.2	7.8	11.2	18.3	14.0
1.000	1.010	1.000	1.017	1.040	1.025	1.013
12.6	**8.6**	**13.2**	**7.9**	**11.6**	**18.8**	**14.2**
9.1	**12.1**	**7.8**	**10.3**	**9.7**	**7.1**	**7.3**
156.8	**129.8**	**152.8**	**116.6**	**151.8**	**188.6**	**147.6**

Table E.22 Daily Maximum Rainfall Magnitudes

Unit: mm

MS	P_2	$P_{2.33}$	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}	P_{1000}	PMP
Bitlis	63.1	66.7	80.1	89.2	99.0	105.5	111.4	116.9	123.5	128.3	177.6
Hizan	50.5	52.0	57.4	61.1	65.0	67.4	69.7	71.7	74.2	76.0	115.7
Sirvan	48.4	50.6	58.9	64.5	70.7	74.7	78.4	81.8	86.0	89.0	147.8
Siirt	44.1	46.6	57.1	65.4	75.5	82.9	90.2	97.3	106.7	114.0	133.5
Bahcesaray	53.1	57.3	75.6	90.6	109.5	123.5	137.4	151.2	169.5	183.3	228.2
Baskale	35.3	38.2	53.3	68.5	92.3	113.8	139.0	168.6	215.9	259.1	240.4
Beytussebap	60.7	62.9	74.0	84.9	101.2	115.3	131.3	149.5	177.3	201.9	137.9
Catak	45.5	47.7	57.3	65.0	74.5	81.6	88.6	95.7	105.2	112.5	156.1
Gevas	39.6	41.8	51.9	60.4	71.5	80.0	88.7	97.6	109.7	119.4	156.8
Gurpinar	24.0	25.3	31.5	36.7	43.6	49.0	54.5	60.4	68.5	75.1	129.8
Hakkari	47.7	50.0	60.2	68.5	79.0	86.8	94.6	102.3	112.5	120.2	152.8
Pervari	33.4	34.8	40.9	45.8	52.1	56.8	61.4	66.0	72.1	76.7	116.6
Resadiye	36.5	38.6	47.5	54.7	63.8	70.6	77.3	84.0	92.9	99.6	151.8
Eruh	51.7	54.9	69.1	80.6	95.2	106.0	116.7	127.4	141.6	152.2	188.6
Sirnak	42.5	45.2	56.0	64.0	73.2	79.5	85.3	90.8	97.7	102.7	147.6

Table E.23 Daily Maximum Rainfall Magnitudes of Ilisu III Basin

Unit: mm

Meteorological Station	Thiessen Weight (%)	P_2	$P_{2.33}$	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}	P_{1000}	PMP
Bitlis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Hizan	10.5	5.3	5.4	6.0	6.4	6.8	7.1	7.3	7.5	7.8	8.0	12.1
Sirvan	2.8	1.4	1.4	1.7	1.8	2.0	2.1	2.2	2.3	2.4	2.5	4.2
Siirt	4.3	1.9	2.0	2.4	2.8	3.2	3.5	3.9	4.2	4.6	4.9	5.7
Bahcesaray	11.5	6.1	6.6	8.7	10.4	12.6	14.2	15.8	17.4	19.5	21.1	26.3
Baskale	2.3	0.8	0.9	1.2	1.6	2.1	2.6	3.2	3.9	5.0	5.9	5.5
Beytussebap	5.7	3.5	3.6	4.2	4.9	5.8	6.6	7.5	8.6	10.1	11.6	7.9
Catak	22.9	10.4	10.9	13.1	14.9	17.1	18.7	20.3	21.9	24.1	25.8	35.7
Gevas	1.4	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.5	1.6	2.1
Gurpinar	6.0	1.4	1.5	1.9	2.2	2.6	2.9	3.3	3.6	4.1	4.5	7.8
Hakkari	4.0	1.9	2.0	2.4	2.8	3.2	3.5	3.8	4.1	4.6	4.9	6.2
Pervari	14.4	4.8	5.0	5.9	6.6	7.5	8.2	8.9	9.5	10.4	11.1	16.8
Resadiye	5.3	1.9	2.0	2.5	2.9	3.4	3.7	4.1	4.4	4.9	5.2	8.0
Eruh	8.1	4.2	4.5	5.6	6.5	7.7	8.6	9.5	10.3	11.5	12.4	15.3
Sirnak	0.7	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	1.1
Basin Precipitation	100.0	**44.5**	**46.8**	**56.9**	**65.1**	**75.6**	**83.5**	**91.6**	**99.8**	**111.2**	**120.2**	**154.8**

Table E.24 Pluviograph Coefficients of Siirt Meteorological Station (Enersu, January 2009)

Time (hr)

0.5	1	2	3	4	6	8	12	18	24
0.28	0.34	0.44	0.48	0.53	0.59	0.65	0.73	0.83	1.00

Table E.25 Areal Distribution Coefficients of Rainfall of Ilisu III Basin

Time (hr)

0.5	1	2	3	4	6	8	12	18	24
0.57	0.65	0.72	0.78	0.80	0.84	0.84	0.86	0.89	0.91

Table E.26 Corrected and Maximized Rainfall Magnitudes of Ilisu III Basin

Time (hr) — Unit: mm

MF = 1.13	0.5	1	2	3	4	6	8	12	18	24
P_2	8.0	11.1	15.8	18.8	21.3	24.8	27.6	31.6	37.0	45.8
$P_{2.33}$	8.4	11.7	16.7	19.8	22.4	26.1	29.0	33.2	38.9	48.2
P_5	10.3	14.2	20.2	24.1	27.2	31.7	35.2	40.4	47.2	58.5
P_{10}	11.7	16.3	23.1	27.5	31.1	36.2	40.3	46.2	54.0	66.9
P_{25}	13.6	18.9	26.9	32.0	36.1	42.1	46.8	53.6	62.7	77.7
P_{50}	15.1	20.9	29.7	35.3	39.9	46.5	51.7	59.2	69.3	85.9
P_{100}	16.5	22.9	32.6	38.7	43.8	51.0	56.7	65.0	76.0	94.2
P_{200}	18.0	24.9	35.5	42.2	47.7	55.6	61.8	70.8	82.9	102.6
P_{500}	20.0	27.8	39.5	47.0	53.2	61.9	68.9	78.9	92.3	114.3
P_{1000}	21.7	30.0	42.7	50.8	57.5	66.9	74.4	85.2	99.7	123.6
PMP	27.9	38.7	55.0	65.5	74.0	86.2	95.9	109.8	128.5	159.2

Table E.27 Harmonic Slope Calculation of Ilisu III Basin

Station No n	Elevation h (m)	Elev. Diff. Δh (m)	Distance L_i (m)	$S_i=\Delta h/L_i$	$1/\sqrt{S_i}$
0	469	-	-	-	-
1	525	66	24645	0.003	19.3
2	575	50	24645	0.002	22.2
3	725	150	24645	0.006	12.8
4	975	250	24645	0.010	9.9
5	1325	350	24645	0.014	8.4
6	1675	350	24645	0.014	8.4
7	1775	100	24645	0.004	15.7
8	1950	175	24645	0.007	11.9
9	2150	200	24645	0.008	11.1
10	3200	1050	24645	0.043	4.8
					Total: 124.6

$S=(n/\Sigma(1/\sqrt{S_i}))^2$
S=0.006

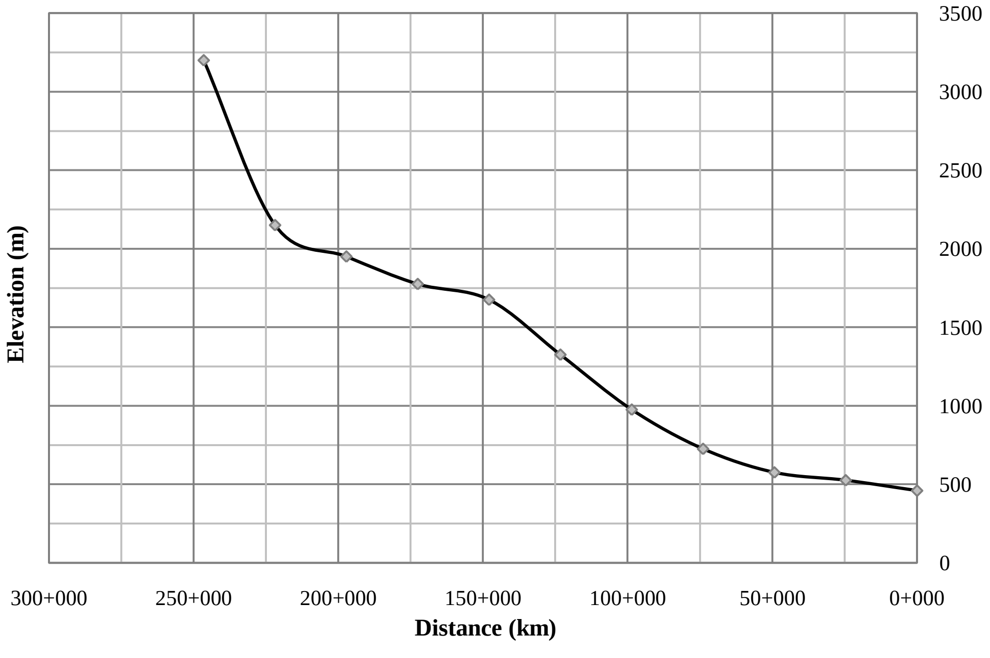


Figure E.62 River Bed Profile of Ilisu III Basin

Table E.28 Base Flow Calculation of Ilisu III Basin

2626 SGS				**Unit: m^3/s**
Year	**March**	**April**	**May**	**Average**
1962	-	-	-	-
1963	666.0	760.0	603.0	676.3
1964	359.0	506.0	295.0	386.7
1965	304.0	431.0	271.0	335.3
1966	392.0	430.0	250.0	357.3
1967	390.0	855.0	364.0	536.3
1968	640.0	649.0	367.0	552.0
1969	679.0	872.0	446.0	665.7
1970	331.0	253.0	126.0	236.7
1971	-	-	-	-
1972	505.0	601.0	421.0	509.0
1973	249.0	409.0	221.0	293.0
1974	256.0	332.0	153.0	247.0
1975	294.0	293.0	164.0	250.3
1976	503.0	658.0	421.0	527.3
1977	327.0	370.0	191.0	296.0
1978	347.0	441.0	278.0	355.3
1979	361.0	386.0	238.0	328.3
1980	519.0	503.0	221.0	414.3
1981	327.0	455.0	277.0	353.0
1982	510.0	669.0	278.0	485.7
1983	260.0	444.0	176.0	293.3
1984	281.0	333.0	252.0	288.7
1985	563.0	487.0	231.0	427.0
1986	253.0	264.0	191.0	236.0
1987	524.0	702.0	369.0	531.7
1988	733.0	**880.0**	555.0	**722.7**
1989	229.0	188.0	86.5	167.8
1990	375.0	424.0	256.0	351.7
1991	285.0	257.0	115.0	219.0
1992	446.0	591.0	420.0	485.7
1993	555.0	832.0	471.0	619.3
1994	518.0	479.0	229.0	408.7
1995	585.0	508.0	312.0	468.3
1996	397.0	390.0	189.0	325.3
1997	434.0	508.0	298.0	413.3
1998	444.0	386.0	183.0	337.7
1999	292.0	226.0	110.0	209.3
2000	295.0	302.0	119.0	238.7
			Maximum Average:	**722.7**
			Maximum Value:	**880.0**
		Drainage Area of 2626 SGS :	8761.2	km^2
		Drainage Area of Ilisu III Dam:	8872.7	km^2
		Recurrence Base Flow:	**728.8**	m^3/s
		Probable Maximum Flood Base Flow:	**887.5**	m^3/s

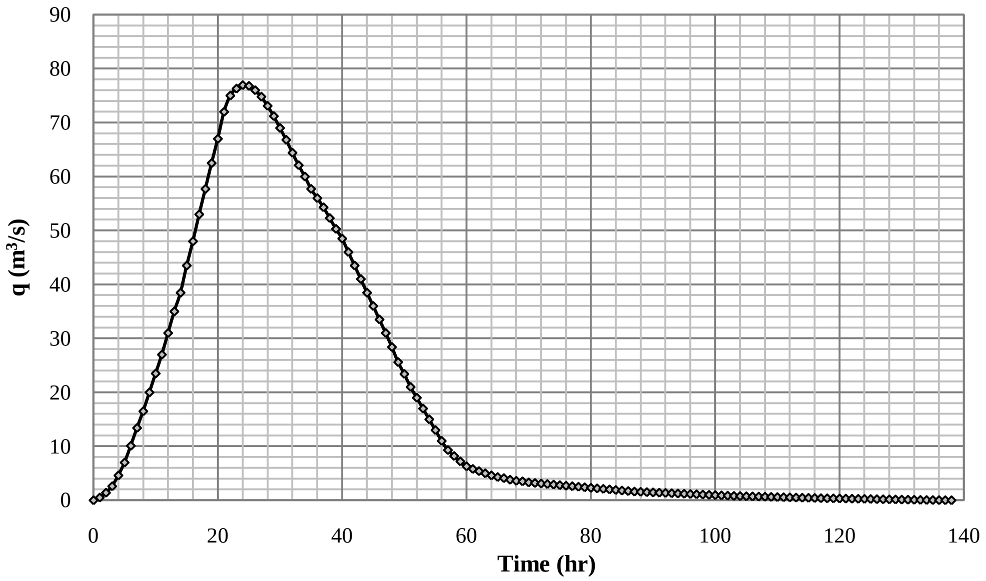


Figure E.63 Unit Hydrograph (UH_4) of Ilisu III Basin

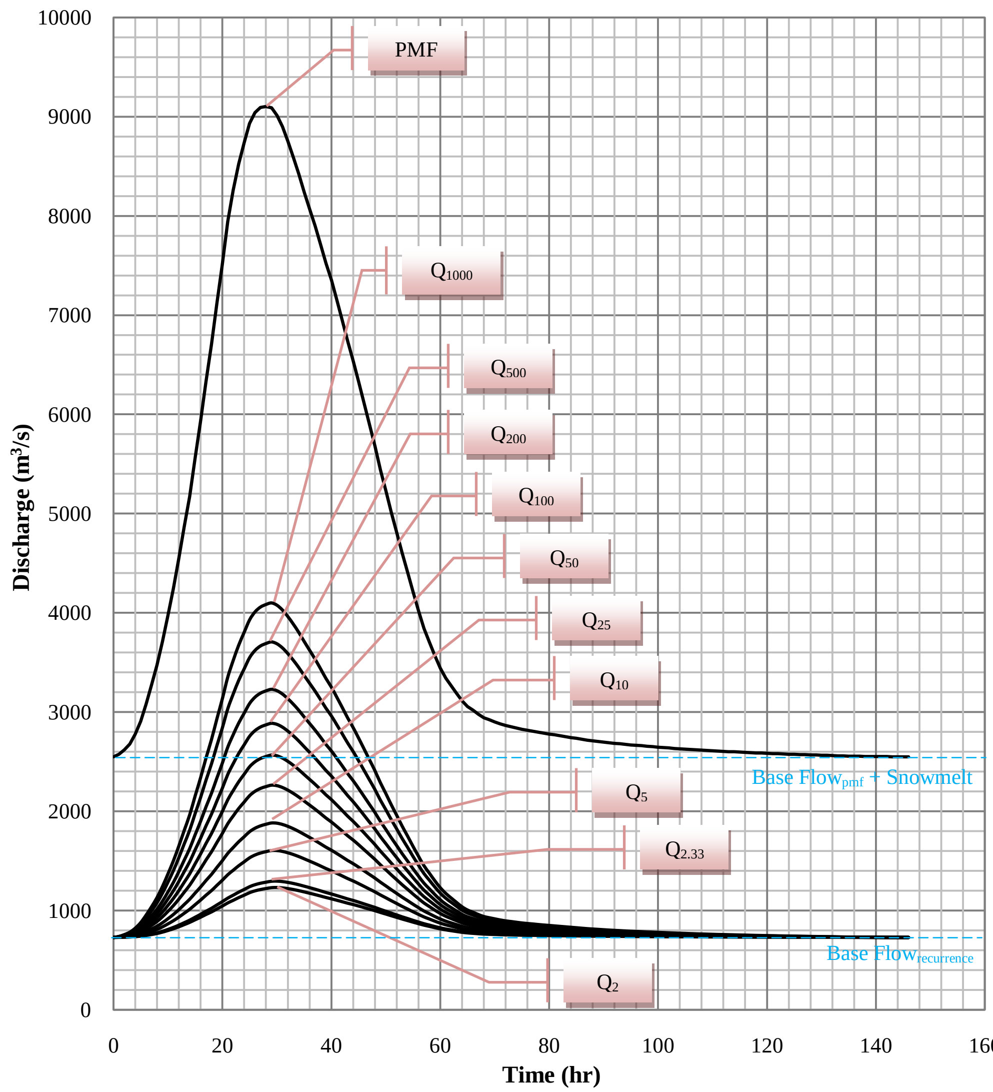


Figure E.64 Recurrence and Probable Maximum Flood Hydrographs of Ilisu III Basin

Table E.29 Snyder Synthetic Unit Hydrograph Method Results of Ilisu III Dam

Return Period	Ilisu III Dam Flood Discharge (m^3/s)
2	1233.6
2.33	1298.1
5	1604.1
10	1881.4
25	2262.8
50	2567.4
100	2888.6
200	3228.2
500	3708.4
1000	4099.1
PMF	9100.5

APPENDIX F

THE TIGRIS PROJECTS AND ILISU IV DAM AND HEPP

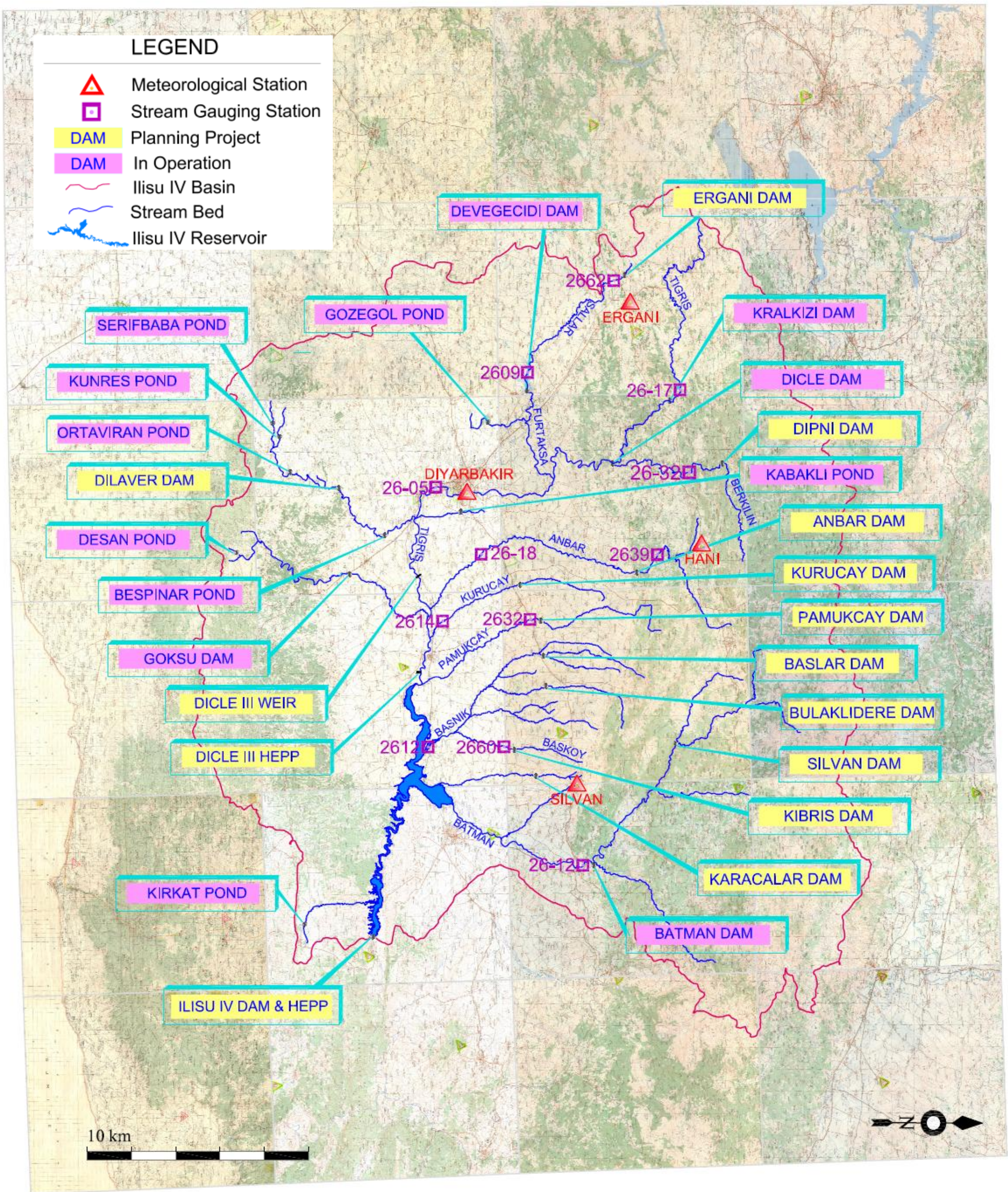


Figure F.1 Project Area and Hydro-Meteorological Stations on 1/100000 Scale Topographic Maps

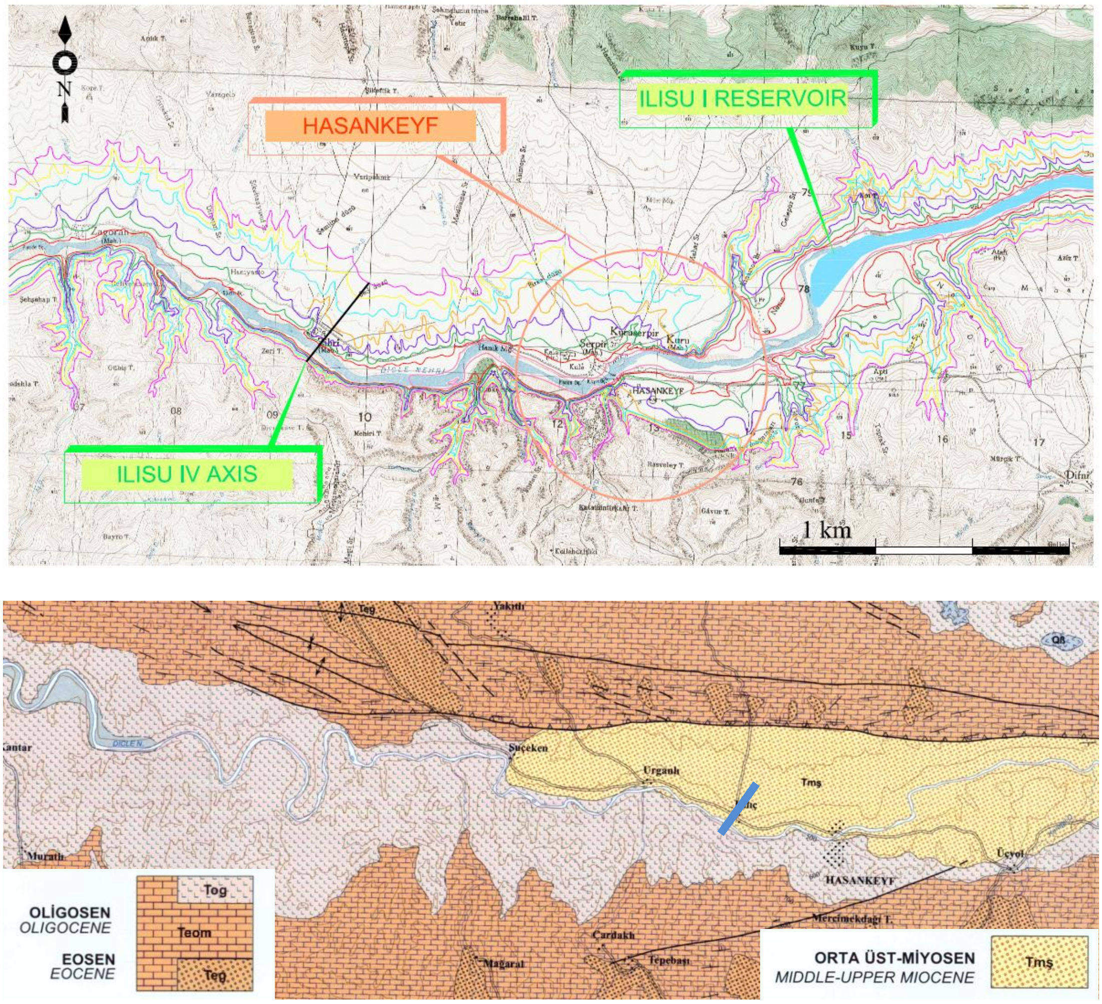


Figure F.2 Ilisu IV Dam Location (MTA, 2007)

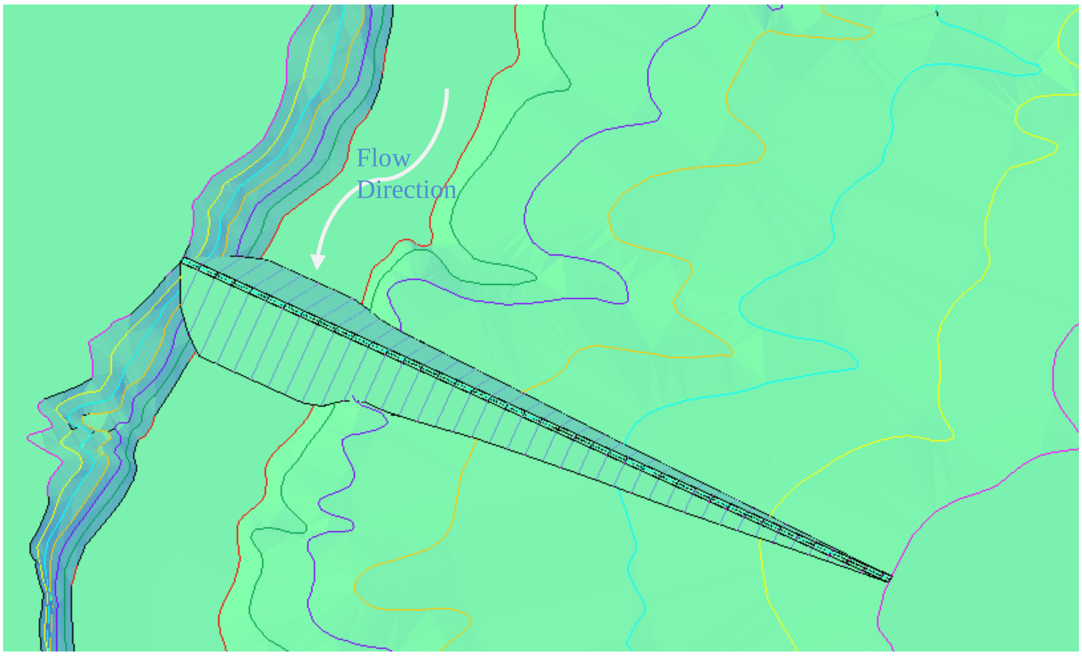


Figure F.3 Representative View of Ilisu IV Dam Body

F.1. The Batman - Silvan Projects

F.1.1. Dam Characteristics

Table F.1 Characteristics of the Projects Upstream of Ilisu IV Dam and HEPP

Characteristics	Unit	**Anbar**	**Kurucay**	**Pamukcay**
Purpose	-	Irrigation	Irrigation	Irrigation
Drainage Area	km^2	480.0	122.0	312.5
Thalwag Elevation	m	673.0	650.0	650.0
Maximum Water Level	m	708.7	678.0	677.0
Minimum Water Level	m	688.0	665.0	670.0
Tailwater Level	m	-	-	-
Design Discharge	m^3/s	-	-	-
Penstock: Number/Diameter/Length	-/m/m	-	-	-
Energy Tunnel: Number/Diameter/Length	-/m/m	-	-	-
Number of Units	-	-	-	-
Gross Head/Net Head	m/m	-	-	-
Turbine Type	-	-	-	-

Table F.1 (continued)

Baslar	**Bulaklidere**	**Kibris**	**Karacalar**	**Silvan**	**Batman**
Irrigation	Irrigation	Irrigation	Irrigation	Energy & Irrigation	Energy & Irrigation
136.0	88.0	150.0	32.5.0	2305.0	4105.0
658.0	678.0	618.0	677.0	658.0	596.0
680.0	705.0	647.0	685.0	820.0	666.0
670.0	685.0	638.0	707.0	790.0	645.0
-	-	-	-	659.85	595.50
-	-	-	-	137.00	362.00
-	-	-	-	-	1/9.5~5.0/332
-	-	-	-	2/5/740+765	-
-	-	-	-	4	3
-	-	-	-	160.15/148.42	70.50/70.02
-	-	-	-	Francis	Francis

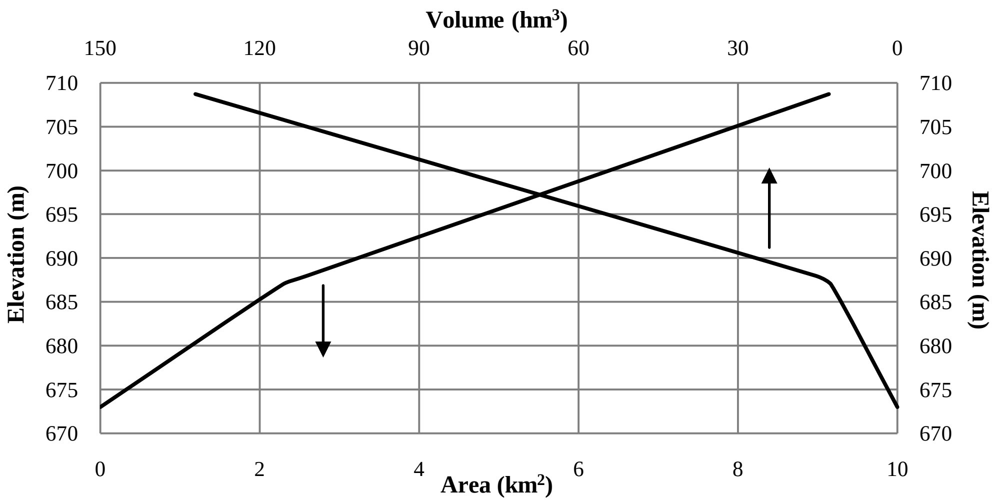


Figure F.4 Volume-Area Curve of Anbar Reservoir

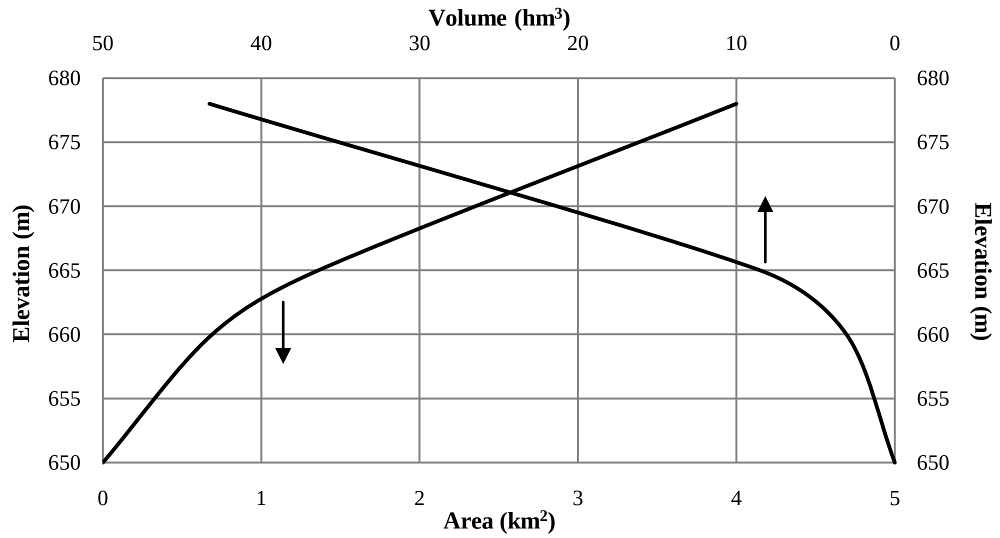


Figure F.5 Volume-Area Curve of Kurucay Reservoir

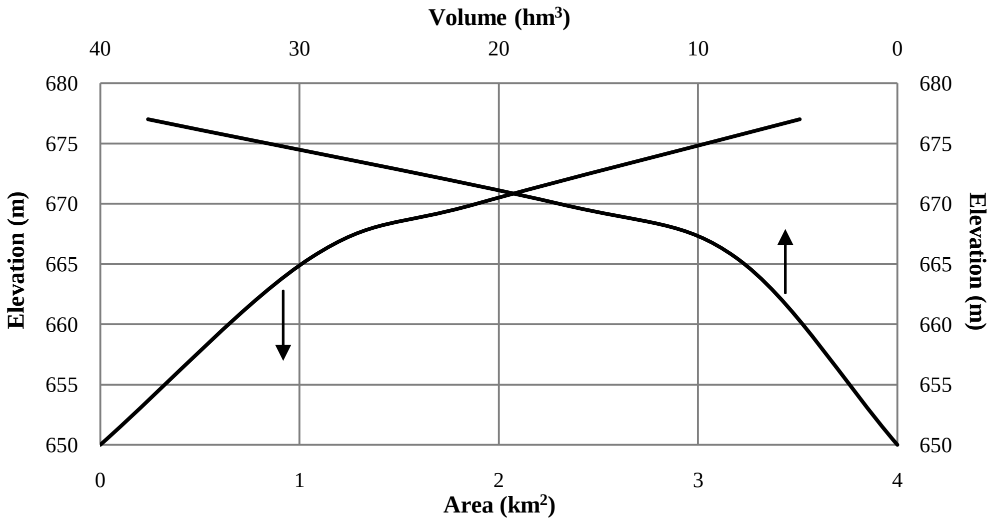


Figure F.6 Volume-Area Curve of Pamukcay Reservoir

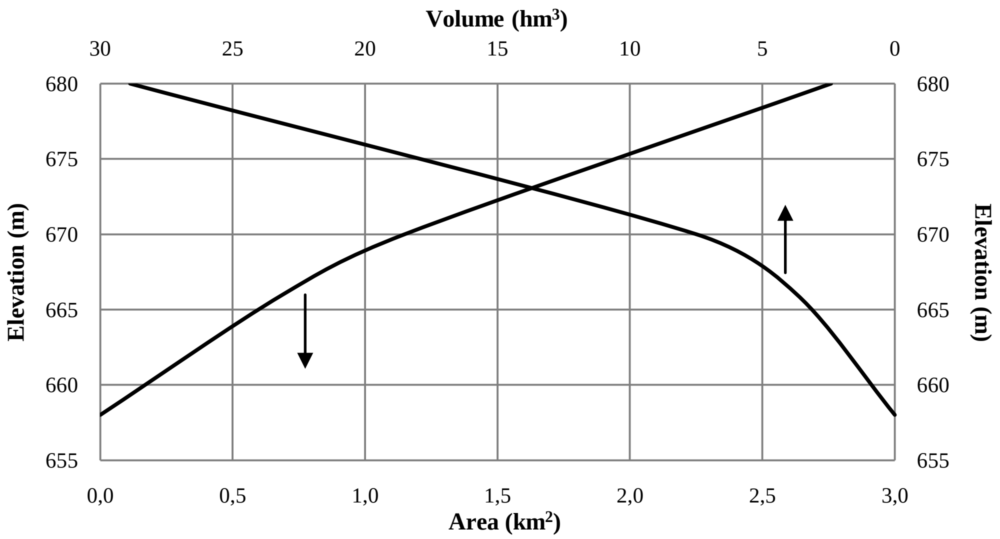


Figure F.7 Volume-Area Curve of Baslar Reservoir

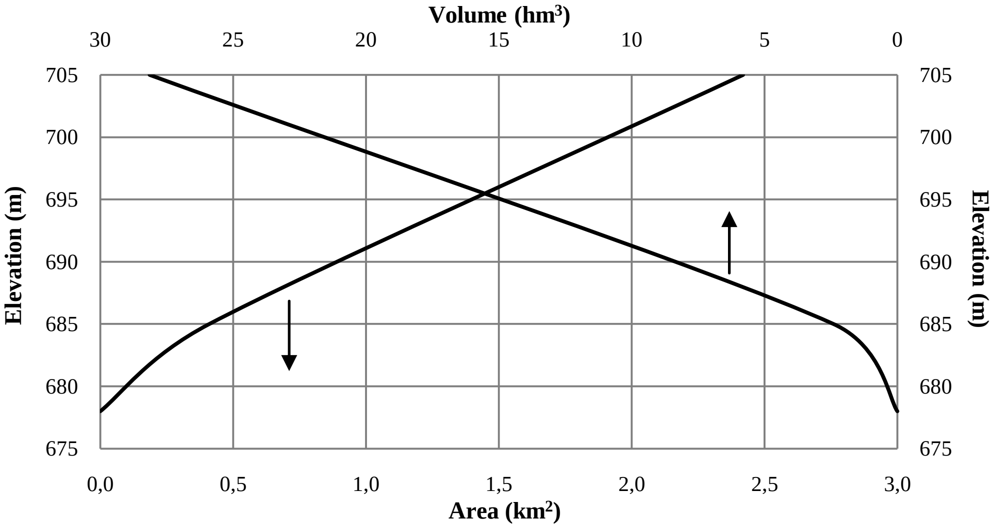


Figure F.8 Volume-Area Curve of Bulaklidere Reservoir

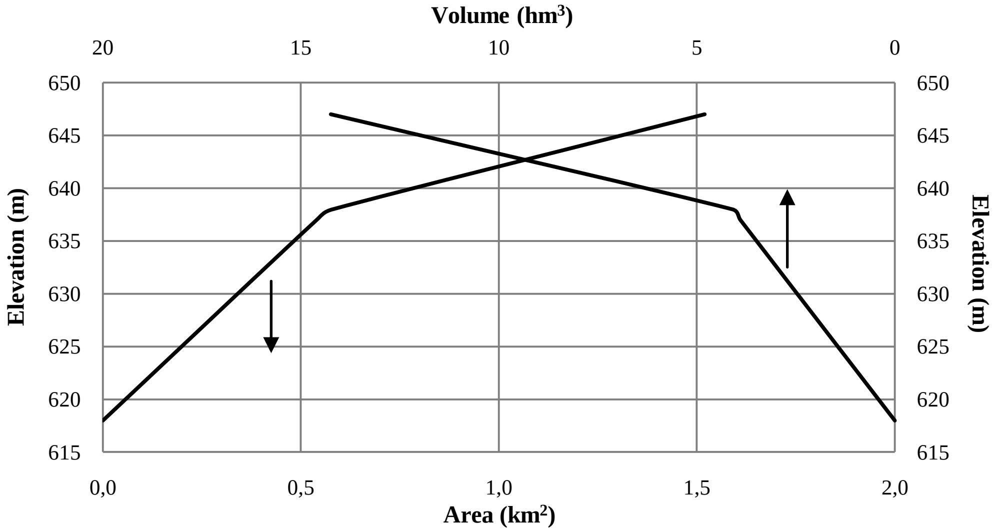


Figure F.9 Volume-Area Curve of Kibris Reservoir

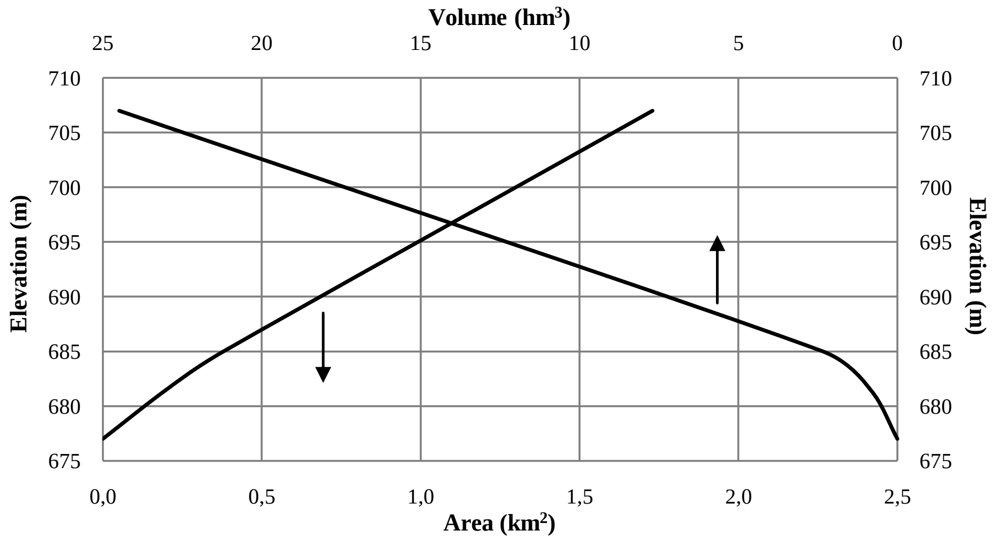


Figure F.10 Volume-Area Curve of Karacalar Reservoir

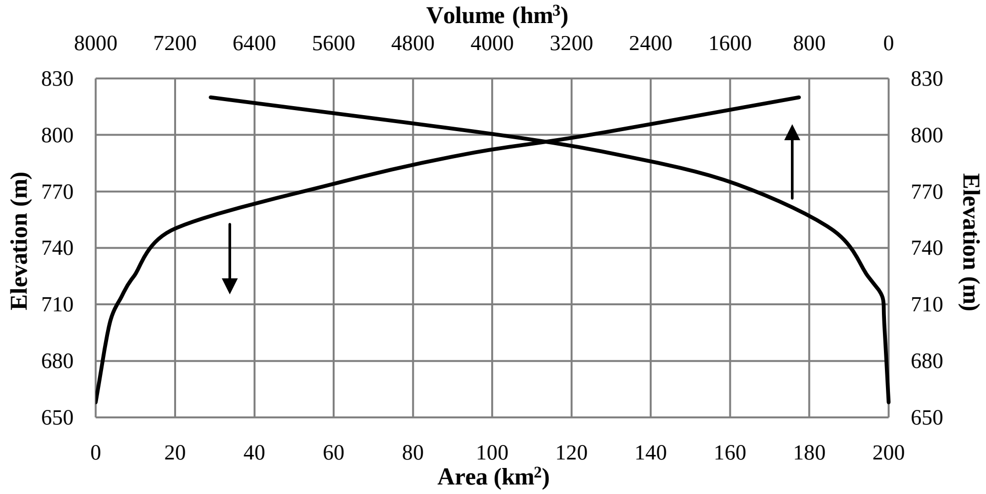


Figure F.11 Volume-Area Curve of Silvan Reservoir

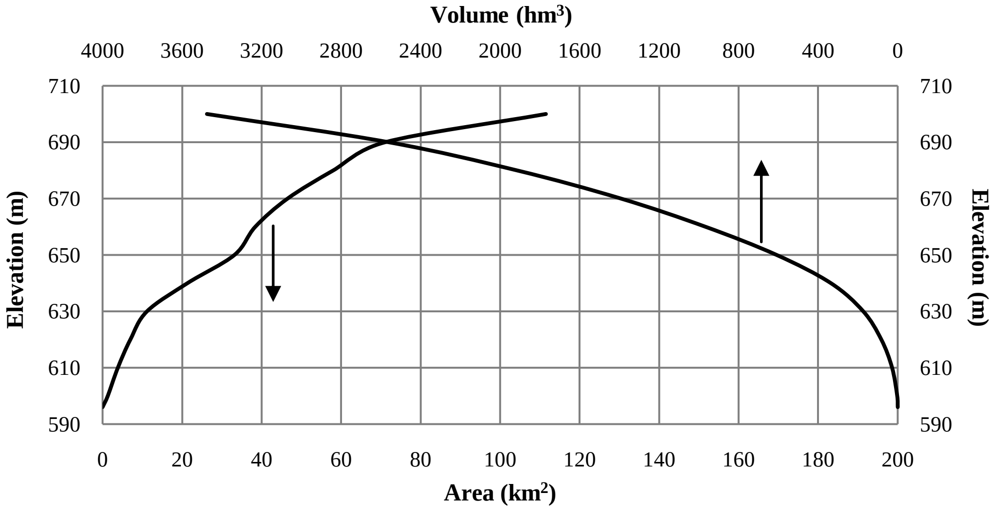


Figure F.12 Volume-Area Curve of Batman Reservoir

F.1.2. Estimated Evaporation Rates

Table F.2 Monthly Total Net Evaporation Values of Anbar Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Diyarbakir MS Precip. (mm)	Net Evap. (mm)
Jan.	1.7	29.8	1.5	28.9	20.3	74.7	-
Feb.	3.5	35.8	3.2	33.4	23.4	67.8	-
Mar.	8.2	82.5	8.0	56.3	39.4	66.8	-
Apr.	13.9	106.9	13.6	103.9	72.8	70.5	**2.3**
May	19.3	177.4	19.1	171.3	119.9	41.5	**78.4**
Jun.	26.1	301.3	25.9	284.4	199.1	7.4	**191.7**
Jul.	31.0	391.7	30.8	387.1	271.0	0.7	**270.3**
Aug.	29.8	367.9	29.6	360.5	252.4	0.6	**251.8**
Sep.	24.9	250.7	24.6	261.2	182.9	3.0	**179.9**
Oct.	17.1	139.8	16.9	142.0	99.4	30.3	**69.1**
Nov.	9.2	53.3	9.0	63.1	44.2	55.4	-
Dec.	4.1	25.4	3.9	35.6	24.9	71.0	-
Σ	-	1962.5	-	1927.8	1349.5	489.5	**1043.5**

Table F.3 Monthly Total Net Evaporation Values of Kurucay Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Diyarbakir MS Precip. (mm)	Net Evap. (mm)
Jan.	1.7	29.8	1.7	29.3	20.5	74.7	-
Feb.	3.5	35.8	3.4	33.9	23.7	67.8	-
Mar.	8.2	82.5	8.1	57.3	40.1	66.8	-
Apr.	13.9	106.9	13.8	105.6	73.9	70.5	**3.4**
May	19.3	177.4	19.2	173.5	121.5	41.5	**80.0**
Jun.	26.1	301.3	26.0	287.3	201.1	7.4	**193.7**
Jul.	31.0	391.7	31.0	390.6	273.4	0.7	**272.7**
Aug.	29.8	367.9	29.7	363.8	254.7	0.6	**254.1**
Sep.	24.9	250.7	24.8	264.0	184.8	3.0	**181.9**
Oct.	17.1	139.8	17.0	144.0	100.8	30.3	**70.5**
Nov.	9.2	53.3	9.1	64.2	44.9	55.4	-
Dec.	4.1	25.4	4.0	36.1	25.3	71.0	-
Σ	-	1962.5	-	1949.6	1364.7	489.5	**1056.3**

Table F.4 Monthly Total Net Evaporation Values of Pamukcay Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Diyarbakir MS Precip. (mm)	Net Evap. (mm)
Jan.	1.7	29.8	1.7	29.3	20.5	74.7	-
Feb.	3.5	35.8	3.4	33.9	23.7	67.8	-
Mar.	8.2	82.5	8.1	57.3	40.1	66.8	-
Apr.	13.9	106.9	13.8	105.6	73.9	70.5	**3.4**
May	19.3	177.4	19.2	173.6	121.5	41.5	**80.0**
Jun.	26.1	301.3	26.0	287.4	201.2	7.4	**193.8**
Jul.	31.0	391.7	31.0	390.7	273.5	0.7	**272.8**
Aug.	29.8	367.9	29.8	364.0	254.8	0.6	**254.2**
Sep.	24.9	250.7	24.8	264.1	184.9	3.0	**181.9**
Oct.	17.1	139.8	17.1	144.1	100.9	30.3	**70.5**
Nov.	9.2	53.3	9.1	64.2	45.0	55.4	-
Dec.	4.1	25.4	4.0	36.2	25.3	71.0	-
Σ	-	1962.5	-	1950.3	1365.2	489.5	**1056.7**

Table F.5 Monthly Total Net Evaporation Values of Baslar Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Diyarbakir MS Precip. (mm)	Net Evap. (mm)
Jan.	1.7	29.8	1.6	29.2	20.5	74.7	-
Feb.	3.5	35.8	3.4	33.8	23.7	67.8	-
Mar.	8.2	82.5	8.1	57.2	40.0	66.8	-
Apr.	13.9	106.9	13.8	105.4	73.8	70.5	**3.3**
May	19.3	177.4	19.2	173.4	121.4	41.5	**79.9**
Jun.	26.1	301.3	26.0	287.1	201.0	7.4	**193.6**
Jul.	31.0	391.7	30.9	390.4	273.3	0.7	**272.5**
Aug.	29.8	367.9	29.7	363.6	254.5	0.6	**254.0**
Sep.	24.9	250.7	24.8	263.9	184.7	3.0	**181.7**
Oct.	17.1	139.8	17.0	143.9	100.7	30.3	**70.4**
Nov.	9.2	53.3	9.1	64.1	44.9	55.4	-
Dec.	4.1	25.4	4.0	36.1	25.3	71.0	-
Σ	-	1962.5	-	1948.2	1363.7	489.5	**1055.4**

Table F.6 Monthly Total Net Evaporation Values of Bulaklidere Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Silvan MS Precip. (mm)	**Net Evap. (mm)**
Jan.	1.7	29.8	1.5	29.0	20.3	96.7	-
Feb.	3.5	35.8	3.3	33.4	23.4	98.8	-
Mar.	8.2	82.5	8.0	56.4	39.5	102.4	-
Apr.	13.9	106.9	13.6	104.1	72.9	97.1	-
May	19.3	177.4	19.1	171.6	120.1	51.9	**68.2**
Jun.	26.1	301.3	25.9	284.7	199.3	9.4	**189.9**
Jul.	31.0	391.7	30.8	387.5	271.3	0.7	**270.5**
Aug.	29.8	367.9	29.6	360.9	252.6	0.6	**252.1**
Sep.	24.9	250.7	24.6	261.6	183.1	2.7	**180.4**
Oct.	17.1	139.8	16.9	142.3	99.6	44.5	**55.1**
Nov.	9.2	53.3	9.0	63.2	44.2	83.1	-
Dec.	4.1	25.4	3.9	35.7	25.0	96.4	-
Σ	-	1962.5	-	1930.4	1351.3	684.4	**1016.2**

Table F.7 Monthly Total Net Evaporation Values of Kibris Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Silvan MS Precip. (mm)	**Net Evap. (mm)**
Jan.	1.7	29.8	1.8	29.6	20.7	96.7	-
Feb.	3.5	35.8	3.5	34.4	24.1	98.8	-
Mar.	8.2	82.5	8.3	58.3	40.8	102.4	-
Apr.	13.9	106.9	13.9	107.2	75.0	97.1	-
May	19.3	177.4	19.4	175.8	123.0	51.9	**71.1**
Jun.	26.1	301.3	26.2	290.3	203.2	9.4	**193.8**
Jul.	31.0	391.7	31.1	394.1	275.9	0.7	**275.1**
Aug.	29.8	367.9	29.9	367.2	257.1	0.6	**256.5**
Sep.	24.9	250.7	24.9	266.9	186.8	2.7	**184.1**
Oct.	17.1	139.8	17.2	146.0	102.2	44.5	**57.7**
Nov.	9.2	53.3	9.3	65.3	45.7	83.1	-
Dec.	4.1	25.4	4.2	36.7	25.7	96.4	-
Σ	-	1962.5	-	1971.8	1380.2	684.4	**1038.4**

Table F.8 Monthly Total Net Evaporation Values of Karacalar Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Silvan MS Precip. (mm)	**Net Evap. (mm)**
Jan.	1.7	29.8	1.5	29.0	20.3	96.7	-
Feb.	3.5	35.8	3.2	33.4	23.4	98.8	-
Mar.	8.2	82.5	8.0	56.3	39.4	102.4	-
Apr.	13.9	106.9	13.6	104.0	72.8	97.1	-
May	19.3	177.4	19.1	171.4	120.0	51.9	**68.1**
Jun.	26.1	301.3	25.9	284.5	199.2	9.4	**189.8**
Jul.	31.0	391.7	30.8	387.3	271.1	0.7	**270.4**
Aug.	29.8	367.9	29.6	360.7	252.5	0.6	**251.9**
Sep.	24.9	250.7	24.6	261.4	183.0	2.7	**180.3**
Oct.	17.1	139.8	16.9	142.2	99.5	44.5	**55.0**
Nov.	9.2	53.3	9.0	63.1	44.2	83.1	-
Dec.	4.1	25.4	3.9	35.6	24.9	96.4	-
Σ	-	1962.5	-	1929.0	1350.3	684.4	**1015.5**

Table F.9 Monthly Total Net Evaporation Values of Silvan Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Silvan MS Precip. (mm)	**Net Evap. (mm)**
Jan.	1.7	29.8	0.9	28.0	19.6	96.7	-
Feb.	3.5	35.8	2.7	31.7	22.2	98.8	-
Mar.	8.2	82.5	7.4	52.8	36.9	102.4	-
Apr.	13.9	106.9	13.1	98.2	68.8	97.1	-
May	19.3	177.4	18.5	163.5	114.4	51.9	**62.6**
Jun.	26.1	301.3	25.3	273.9	191.7	9.4	**182.3**
Jul.	31.0	391.7	30.2	374.7	262.3	0.7	**261.6**
Aug.	29.8	367.9	29.0	348.6	244.0	0.6	**243.4**
Sep.	24.9	250.7	24.1	251.2	175.9	2.7	**173.2**
Oct.	17.1	139.8	16.3	135.1	94.5	44.5	**50.1**
Nov.	9.2	53.3	8.4	59.2	41.4	83.1	-
Dec.	4.1	25.4	3.3	33.7	23.6	96.4	-
Σ	-	1962.5	-	1850.5	1295.4	684.4	**973.1**

Table F.10 Monthly Total Net Evaporation Values of Batman Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Silvan MS Precip. (mm)	**Net Evap. (mm)**
Jan.	1.7	29.8	1.7	29.4	20.6	96.7	-
Feb.	3.5	35.8	3.4	34.1	23.8	98.8	-
Mar.	8.2	82.5	8.2	57.7	40.4	102.4	-
Apr.	13.9	106.9	13.8	106.2	74.3	97.1	-
May	19.3	177.4	19.3	174.4	122.1	51.9	**70.2**
Jun.	26.1	301.3	26.1	288.4	201.9	9.4	**192.5**
Jul.	31.0	391.7	31.0	392.0	274.4	0.7	**273.6**
Aug.	29.8	367.9	29.8	365.2	255.6	0.6	**255.0**
Sep.	24.9	250.7	24.8	265.1	185.6	2.7	**182.9**
Oct.	17.1	139.8	17.1	144.8	101.3	44.5	**56.9**
Nov.	9.2	53.3	9.2	64.6	45.2	83.1	-
Dec.	4.1	25.4	4.1	36.4	25.5	96.4	-
Σ	-	1962.5	-	1958.1	1370.7	684.4	**1031.1**

F.1.3. Water Resources

F.1.3.1. Stream Gauging Stations

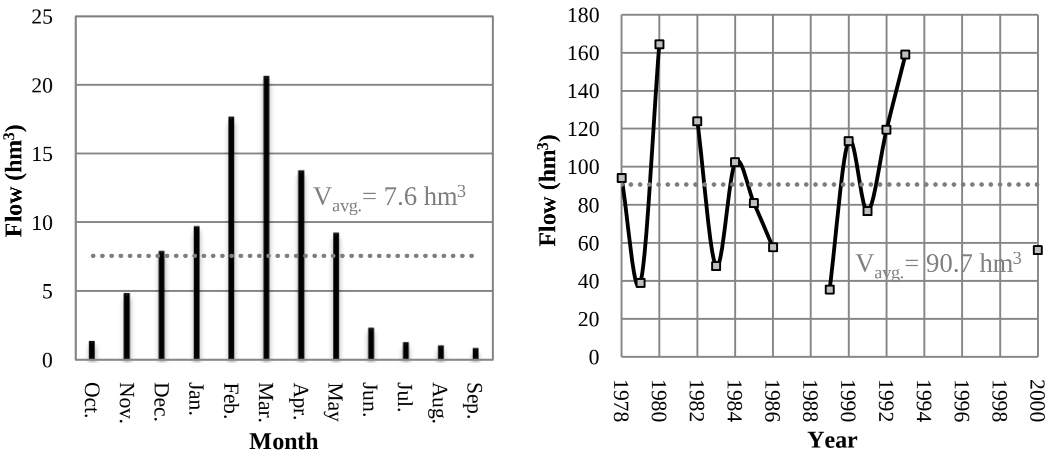


Figure F.13 Monthly Mean and Annual Total Flow Values Measured in 26-39 SGS

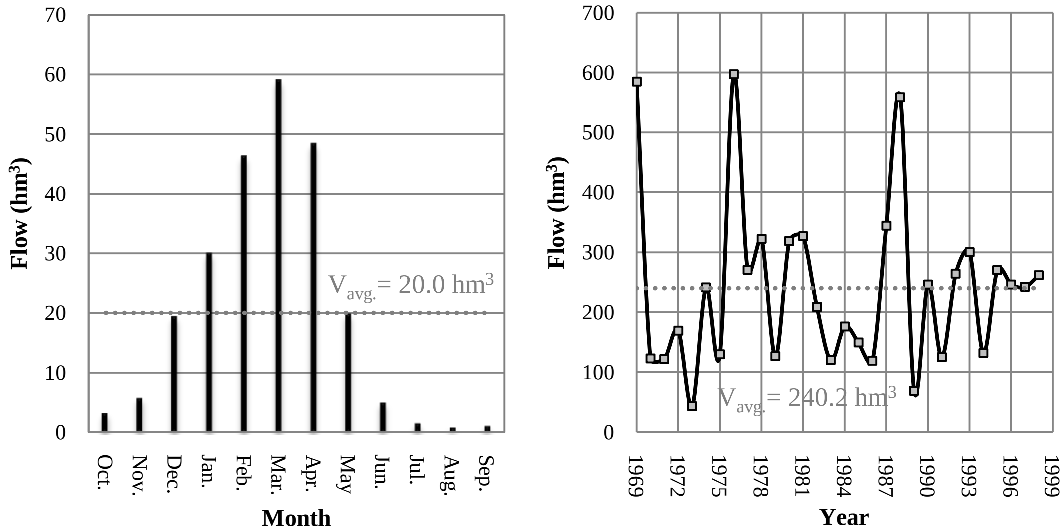


Figure F.14 Monthly Mean and Annual Total Flow Values Measured in 2618 SGS

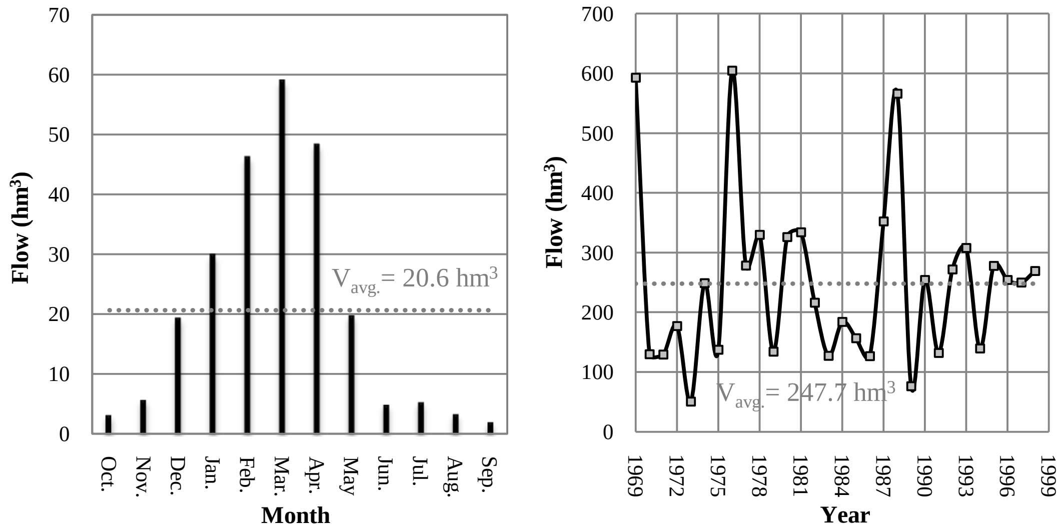


Figure F.15 Corrected Monthly Mean and Annual Total Flow Values of 2618 SGS

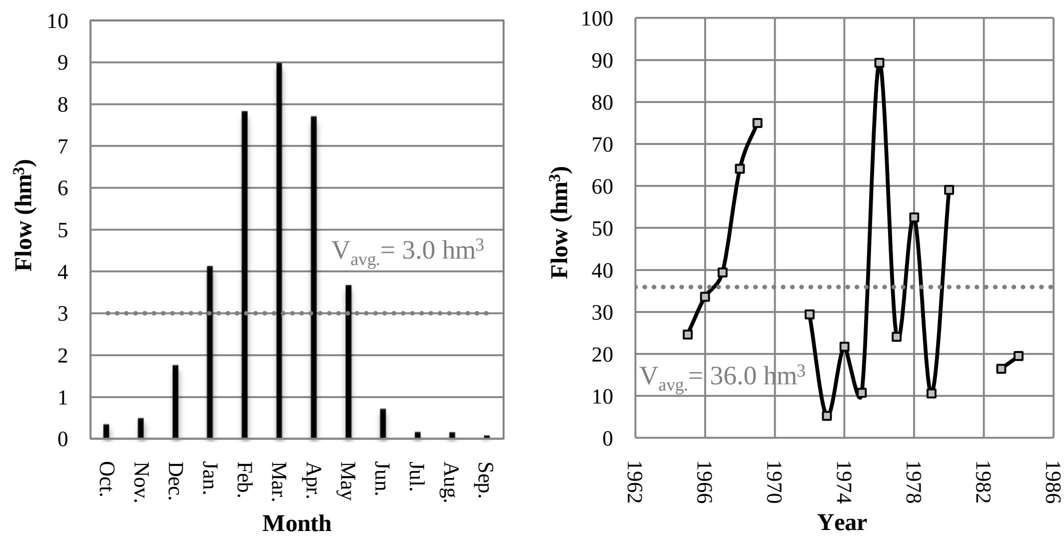


Figure F.16 Monthly Mean and Annual Total Flow Values Measured in 26-14 SGS

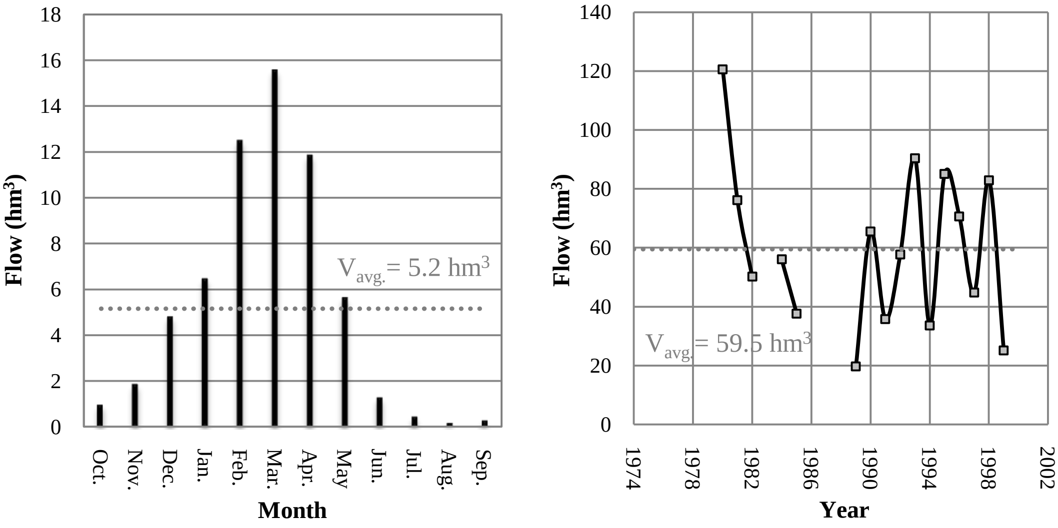


Figure F.17 Monthly Mean and Annual Total Flow Values Measured in 26-32 SGS

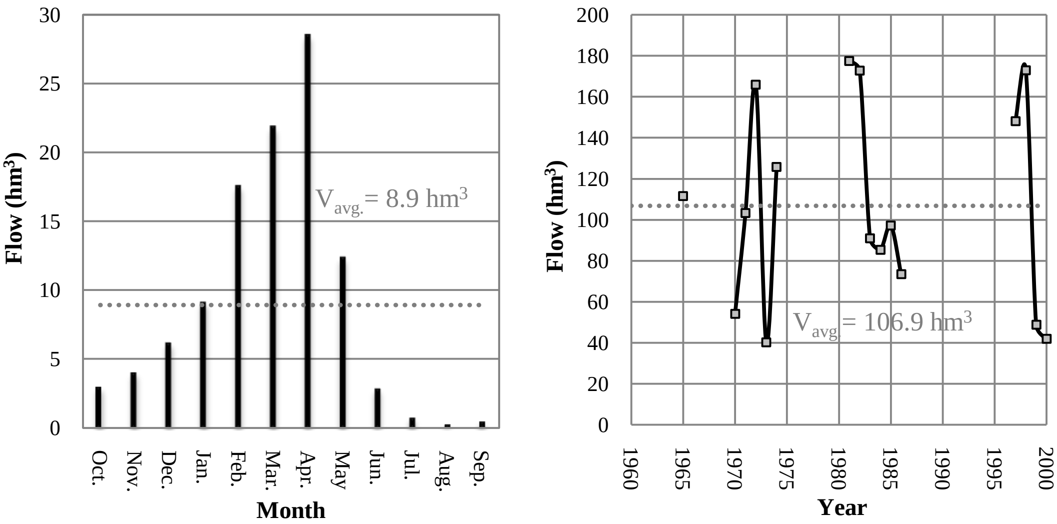


Figure F.18 Monthly Mean and Annual Total Flow Values Measured in 26-12 SGS

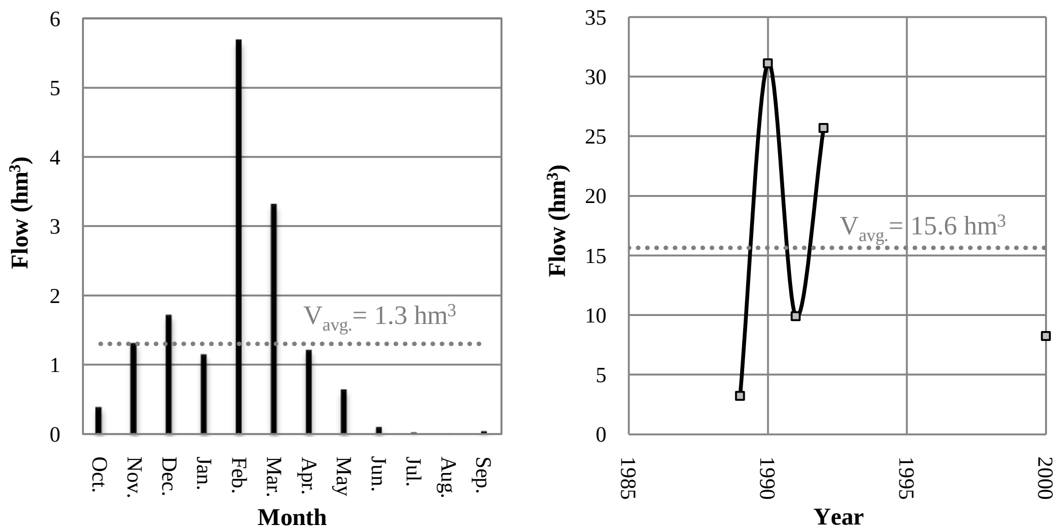


Figure F.19 Monthly Mean and Annual Total Flow Values Measured in 26-60 SGS

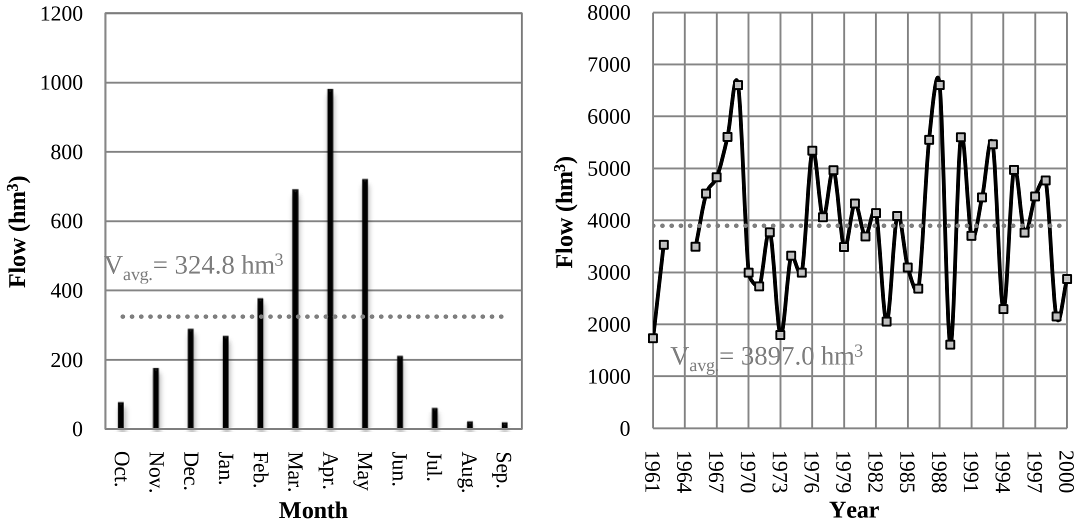


Figure F.20 Monthly Mean and Annual Total Flow Values Measured in 2612 SGS

F.1.3.2. Correlation Studies

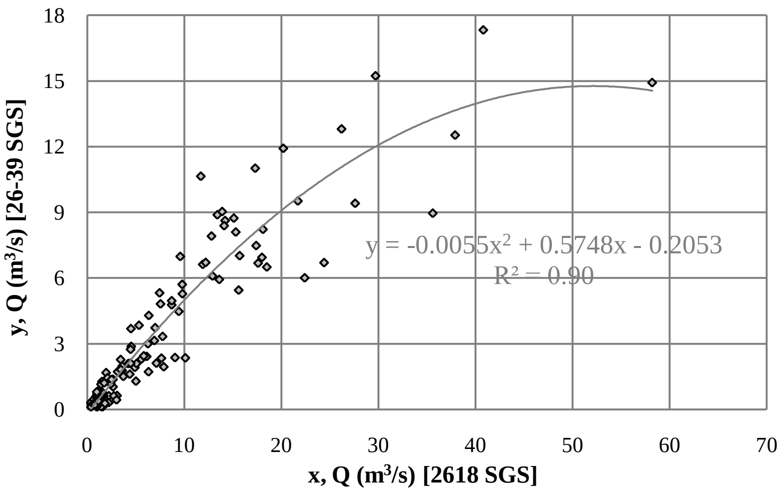


Figure F.21 Monthly Mean Discharge Correlation between 26-39 SGS and 2618 SGS

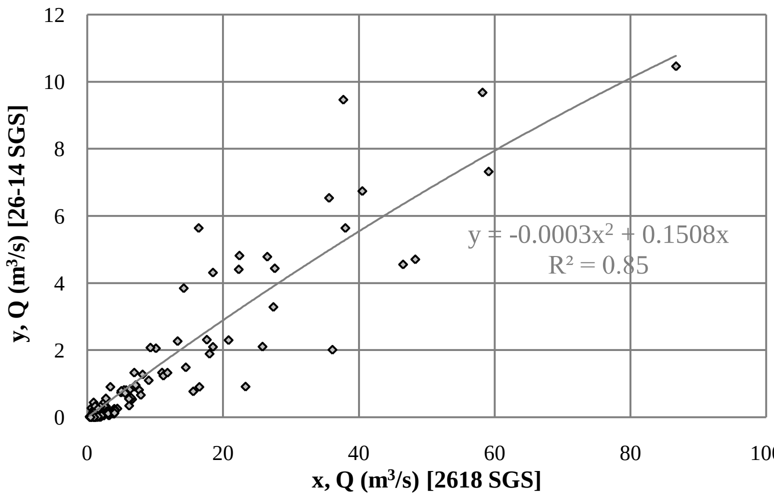


Figure F.22 Monthly Mean Discharge Correlation between 26-14 SGS and 2618 SGS

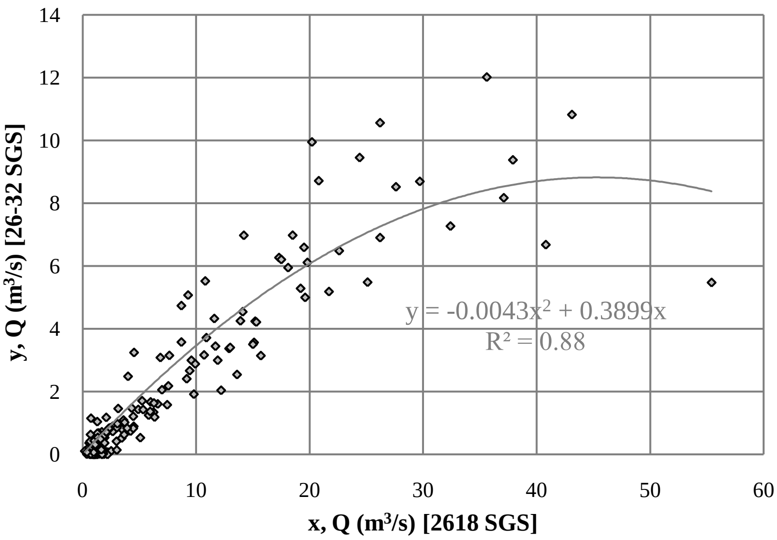


Figure F.23 Monthly Mean Discharge Correlation between 26-32 SGS and 2618 SGS

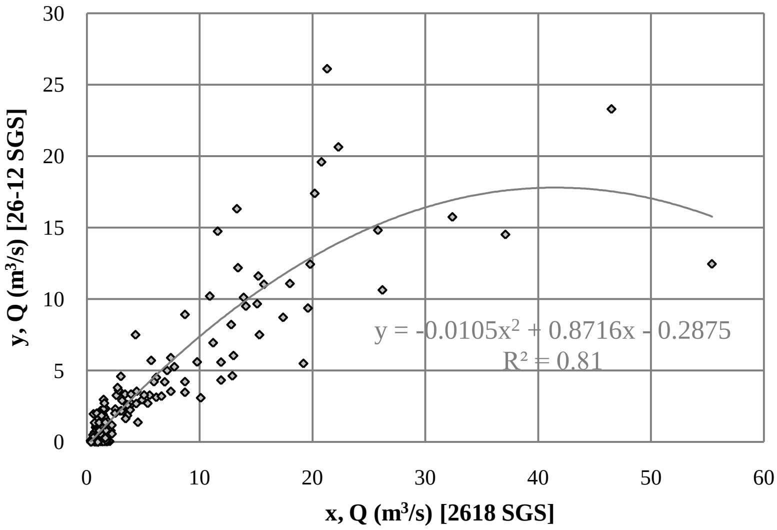


Figure F.24 Monthly Mean Discharge Correlation between 26-12 SGS and 2618 SGS

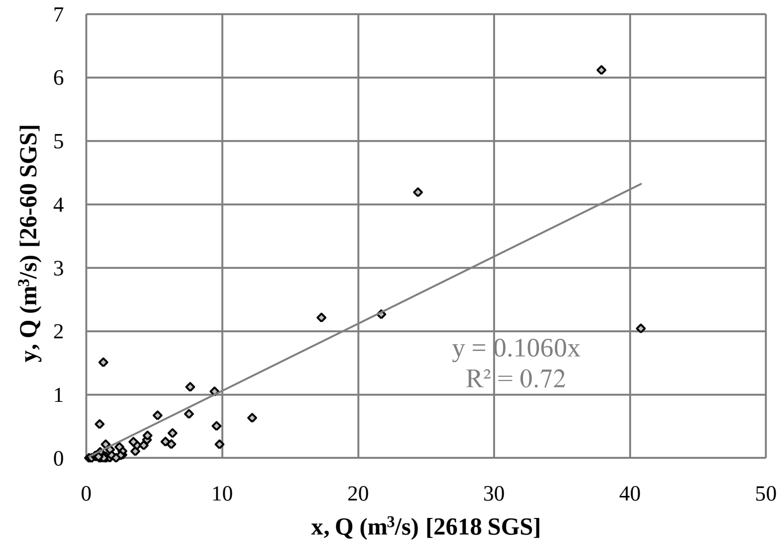


Figure F.25 Monthly Mean Discharge Correlation between 26-60 SGS and 2618 SGS

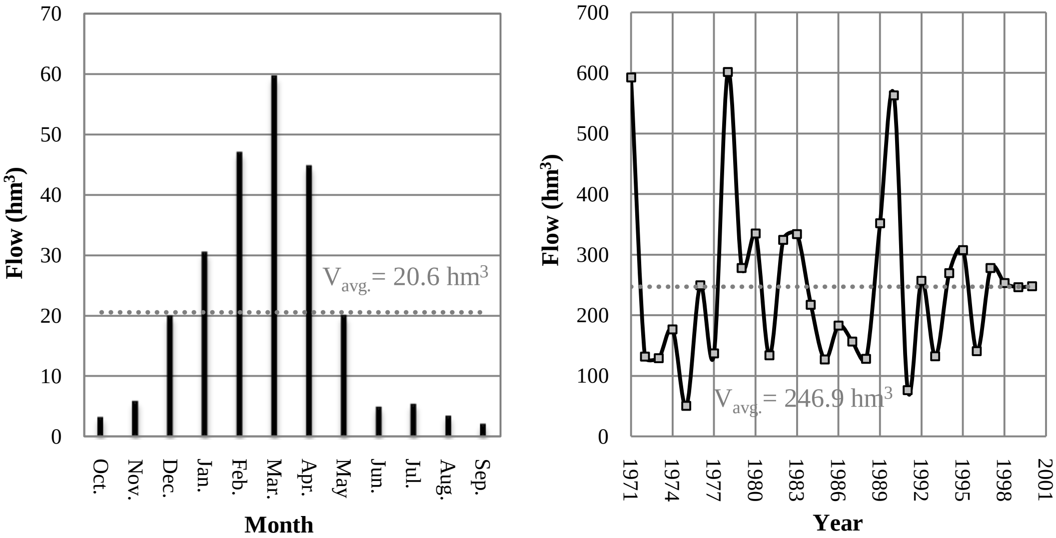


Figure F.26 Extended Monthly Mean and Annual Total Flow Values of 2618 SGS

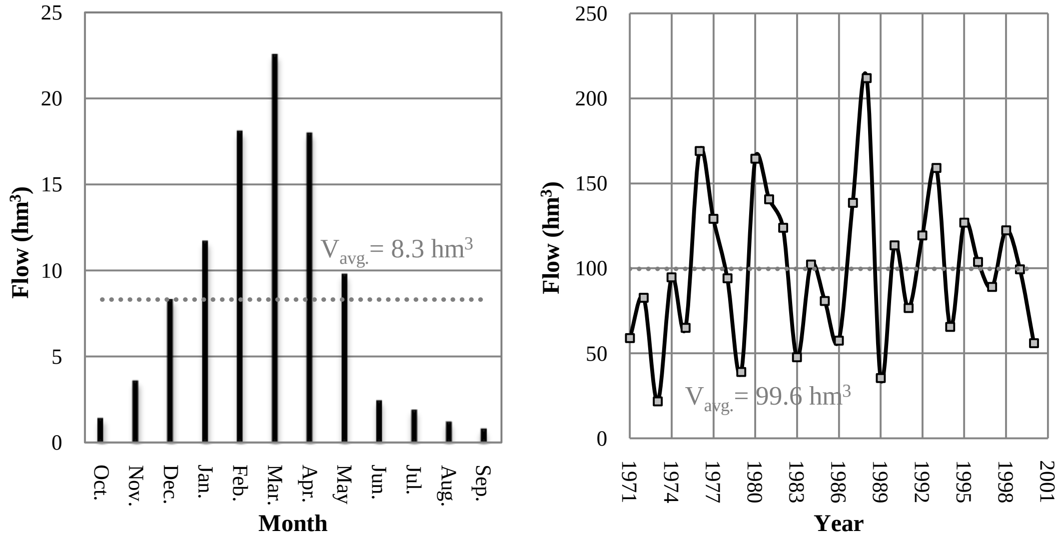


Figure F.27 Extended Monthly Mean and Annual Total Flow Values of 26-39 SGS

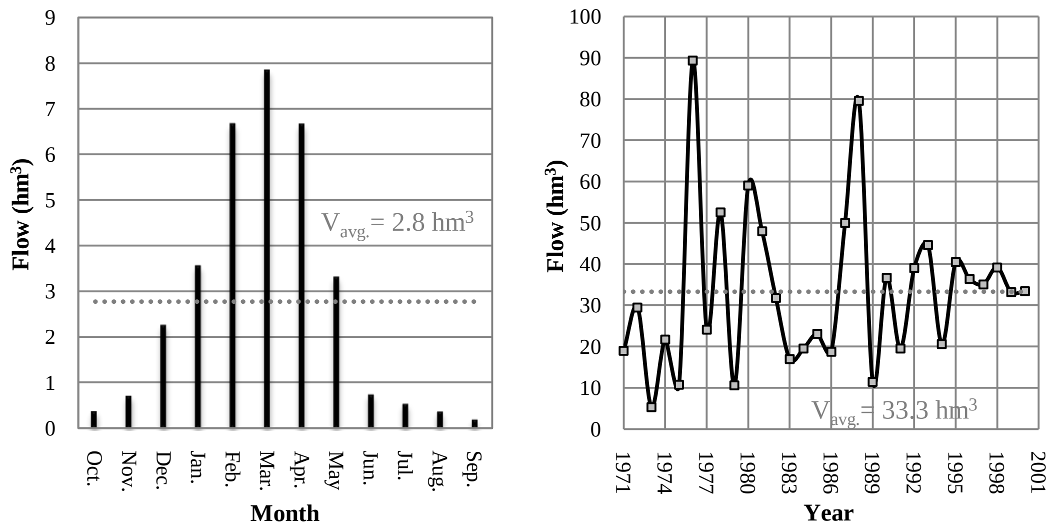


Figure F.28 Extended Monthly Mean and Annual Total Flow Values of 26-14 SGS

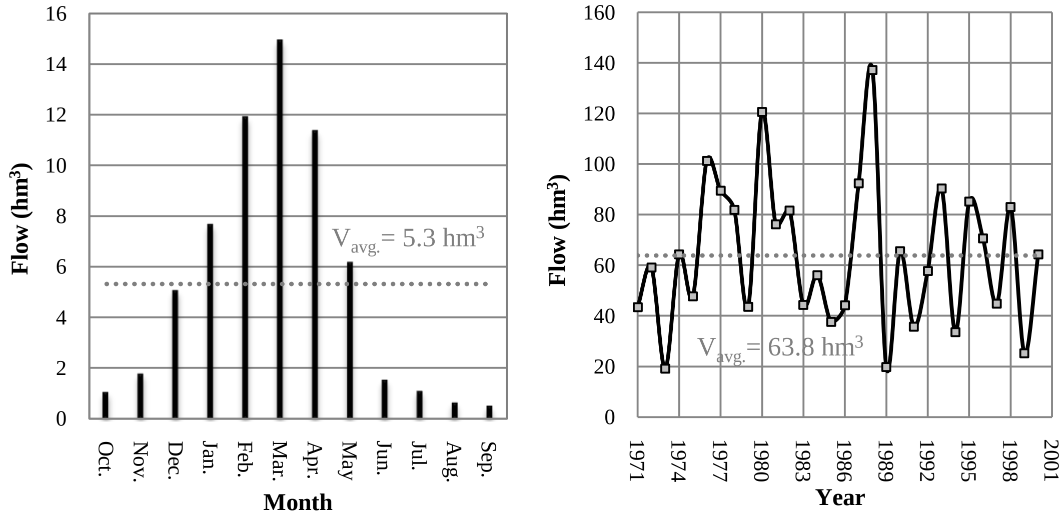


Figure F.29 Extended Monthly Mean and Annual Total Flow Values of 26-32 SGS

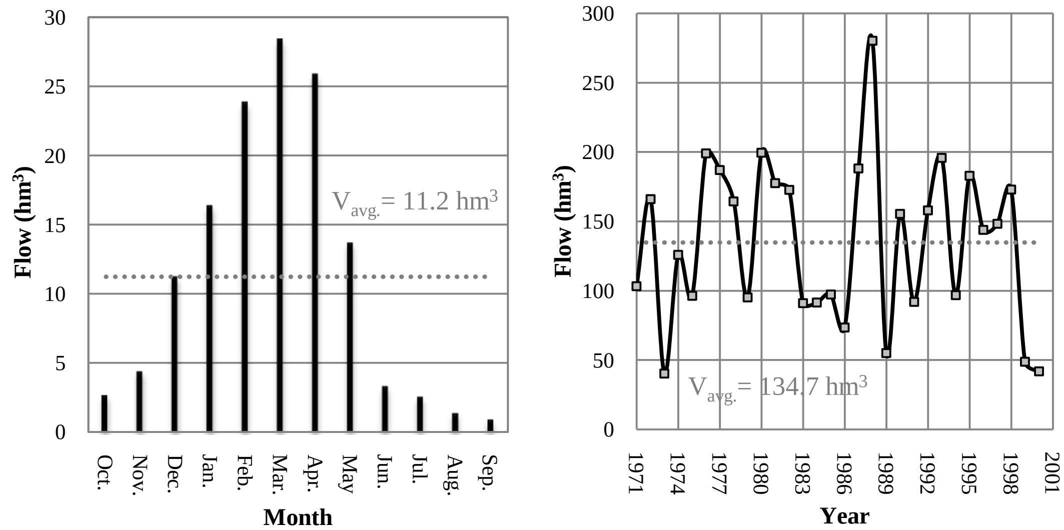


Figure F.30 Extended Monthly Mean and Annual Total Flow Values of 26-12 SGS

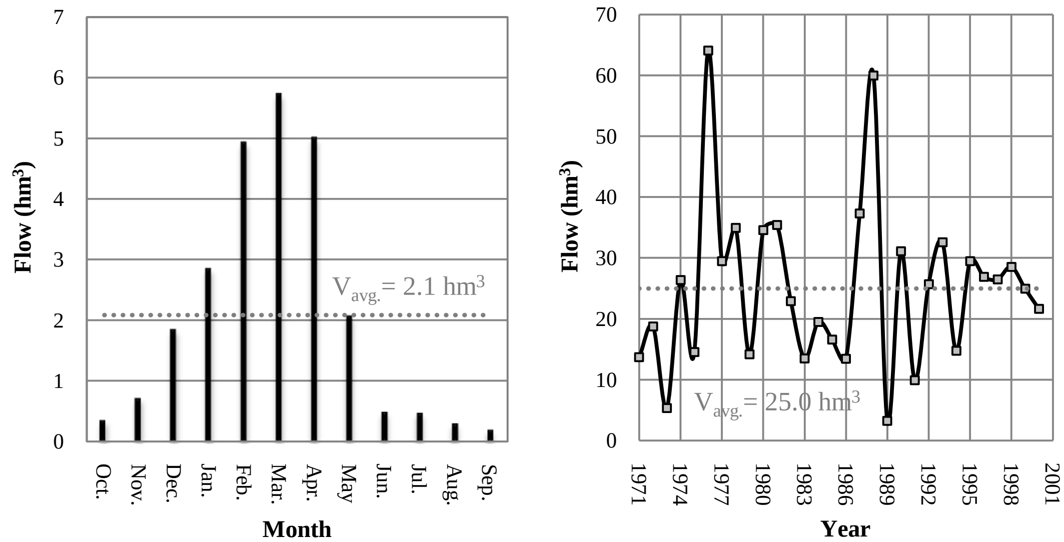


Figure F.31 Extended Monthly Mean and Annual Total Flow Values of 26-60 SGS

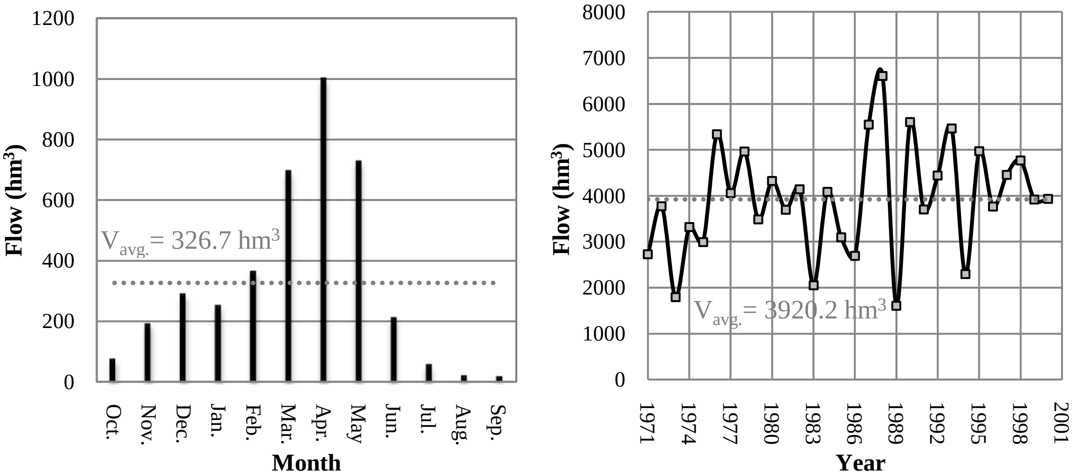


Figure F.32 Extended Monthly Mean and Annual Total Flow Values of 2612 SGS

F.1.3.3. Monthly Mean Flow Calculations

Table F.11 Water Demand Pattern of Batman - Silvan Irrigation (Suiş and Sial, December 2001)

Months	Gravity-Fed Module (l/s/ha)	Pumping-Fed Module (l/s/ha)
October	0.02	0.01
November	0.00	0.00
December	0.00	0.00
January	0.00	0.00
February	0.00	0.00
March	0.00	0.00
April	0.01	0.01
May	0.20	0.27
June	0.63	0.59
July	1.25	0.95
August	1.09	0.78
September	0.49	0.35
Total	3.69	2.96

Table F.12 Batman - Silvan Irrigation Scheme (Suiş and Sial, December 2001)

Irrigation Projects	**Irrigated Area by the Project**				**Irrigated Area by Silvan Dam, of Which Irrigation Return Water Is in the Drainage Area**			
	Gravity - Fed Irrigation		Pumping - Fed Irrigation		Gravity - Fed Irrigation		Pumping - Fed Irrigation	
	Gross (ha)	Net (ha)	Gross (ha)	Net (ha)	Gross (ha)	Net (ha)	Gross (ha)	Net (ha)
Anbar	13498	11784	-	-	2475	2161	275	240
Kurucay	6013	5249	-	-	4250	3710	6375	5565
Pamukcay	5134	4482	-	-	6000	5238	4000	3492
Baslar	4309	3762	-	-	3375	2946	3375	2946
Bulaklidere	5890	5142	-	-	1675	1462	1675	1462
Kibris	3124	2727	-	-	7650	6678	850	742
Karacalar	5099	4451	-	-	1000	873	-	-
Silvan	171284	149531	31022	27082	-	-	-	-
Batman	37744	32951	-	-	-	-	-	-

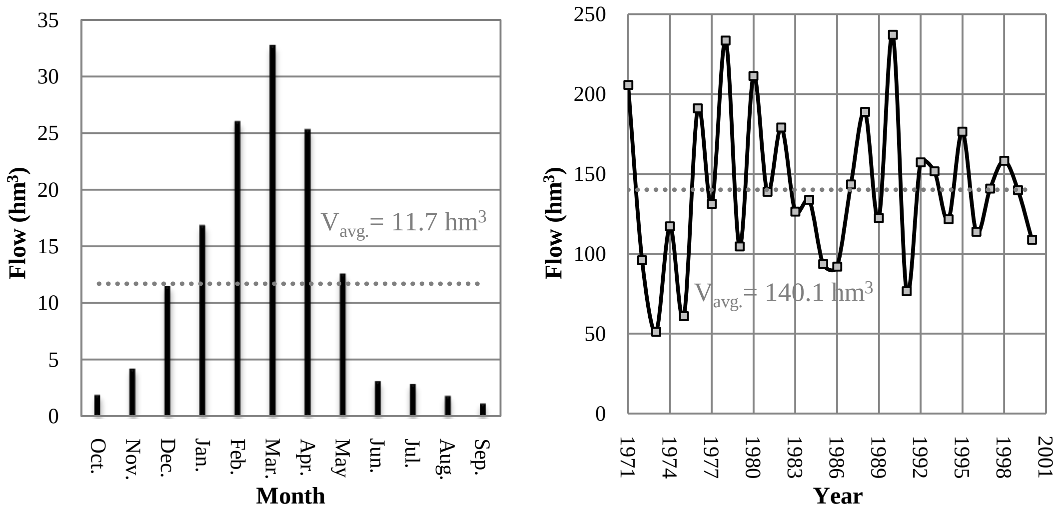


Figure F.33 Monthly Mean and Annual Total Flow Values at Anbar Dam

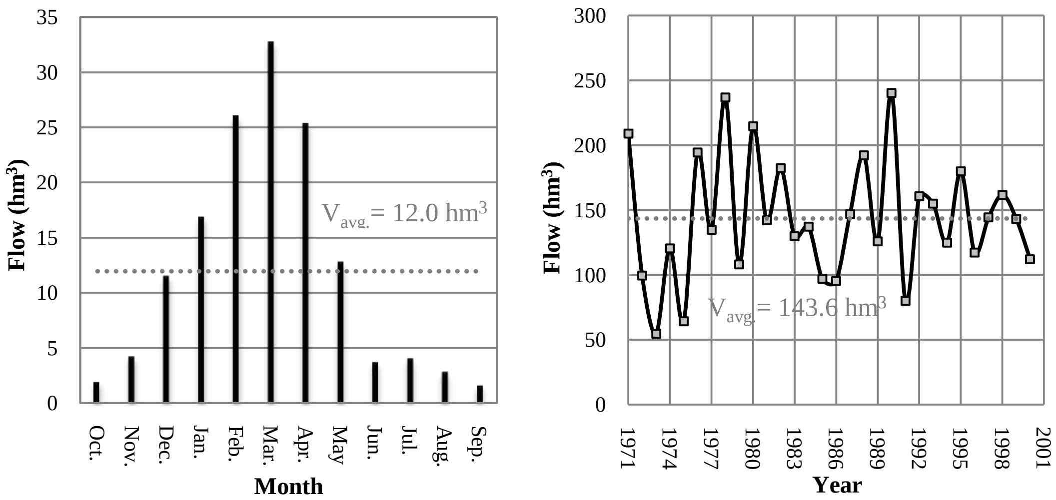


Figure F.34 Monthly Mean and Annual Total Inflow Values in the Operation Study of Anbar Reservoir

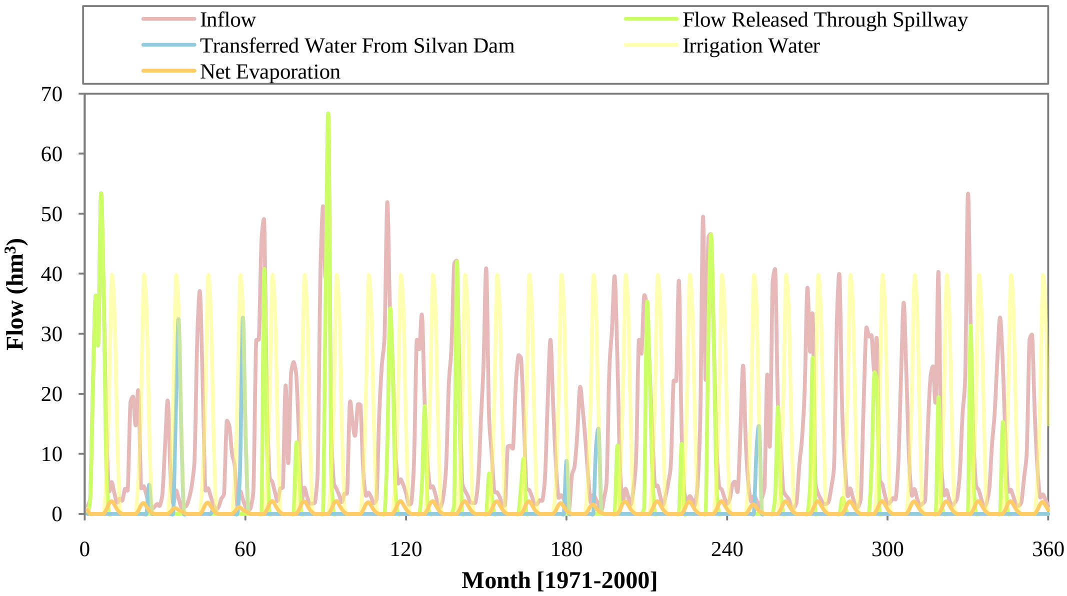


Figure F.35 Operation Study Results of Anbar Dam

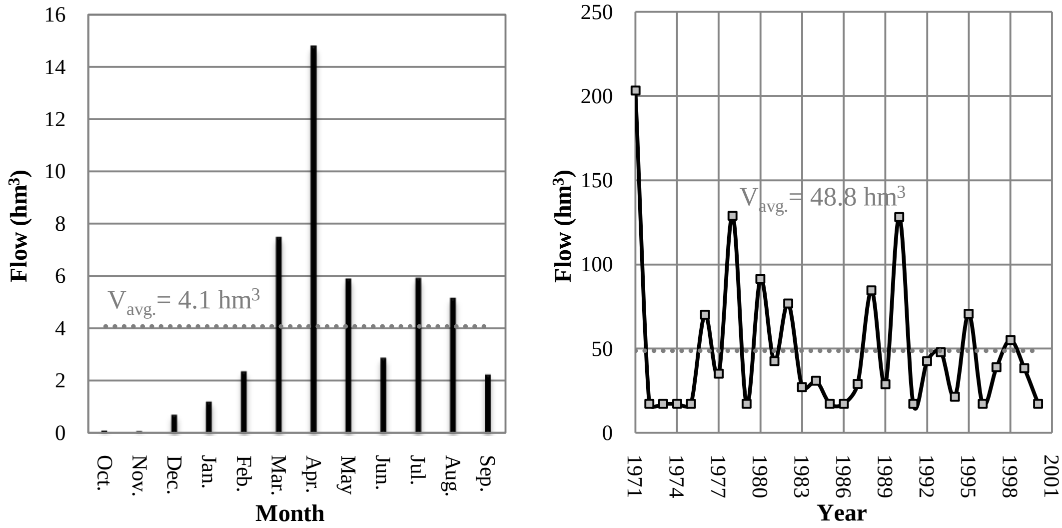


Figure F.36 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Anbar Reservoir (Irrigation return water of the project was added to the outflow values.)

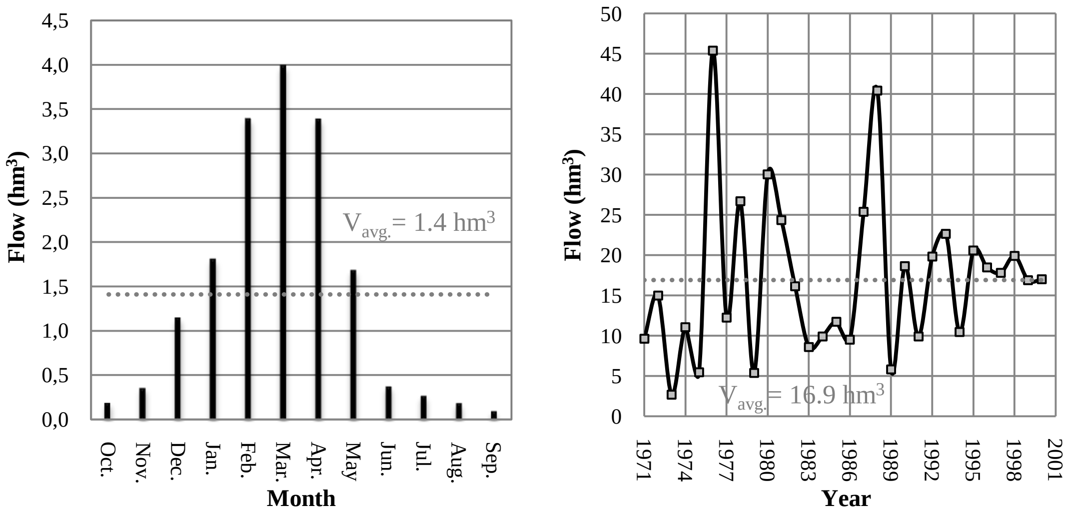


Figure F.37 Monthly Mean and Annual Total Flow Values at Kurucay Dam

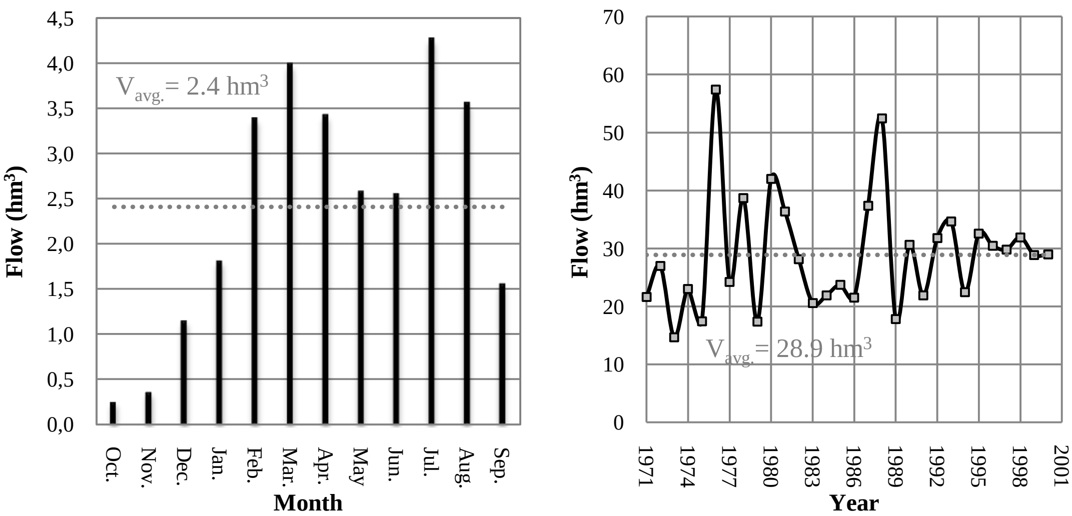


Figure F.38 Monthly Mean and Annual Total Inflow Values in the Operation Study of Kurucay Reservoir

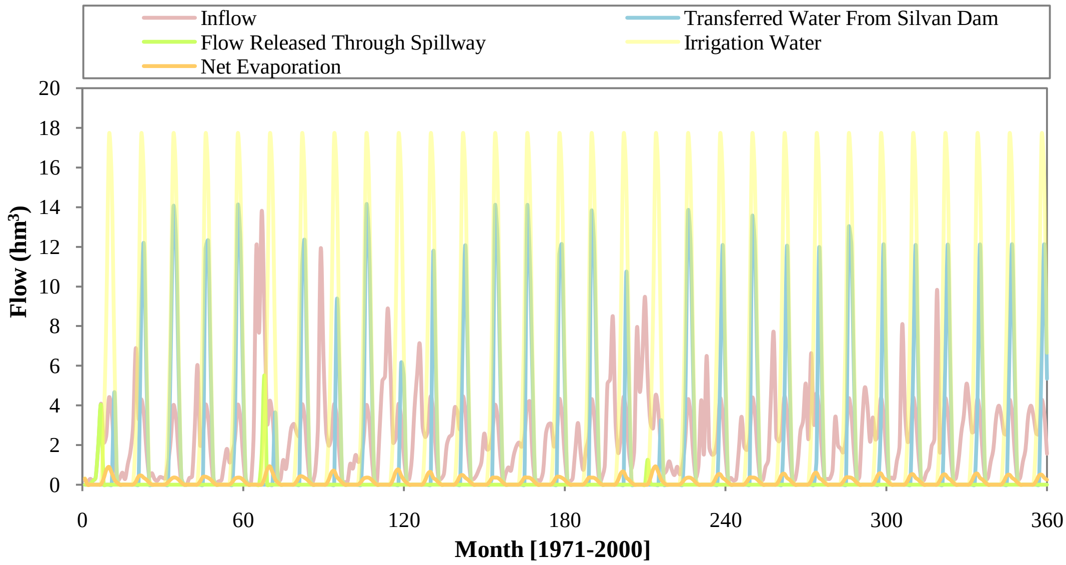


Figure F.39 Operation Study Results of Kurucay Dam

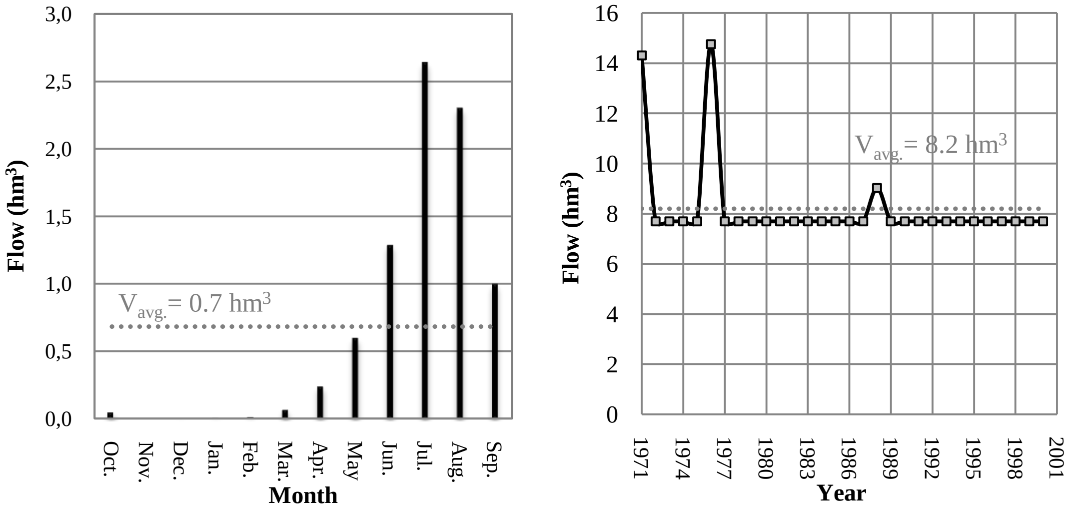


Figure F.40 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Kurucay Reservoir (Irrigation return water of the project was added to the outflow values.)

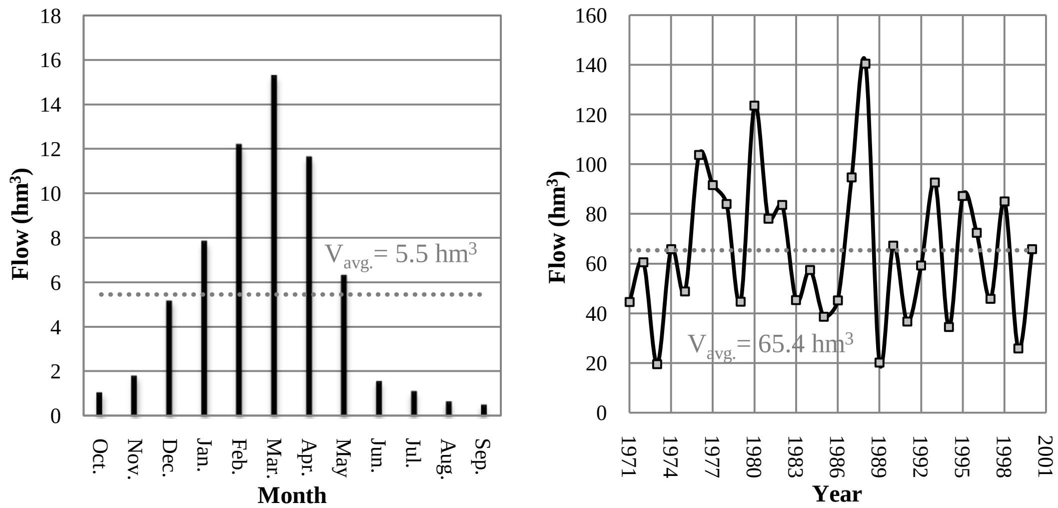


Figure F.41 Monthly Mean and Annual Total Flow Values at Pamukcay Dam

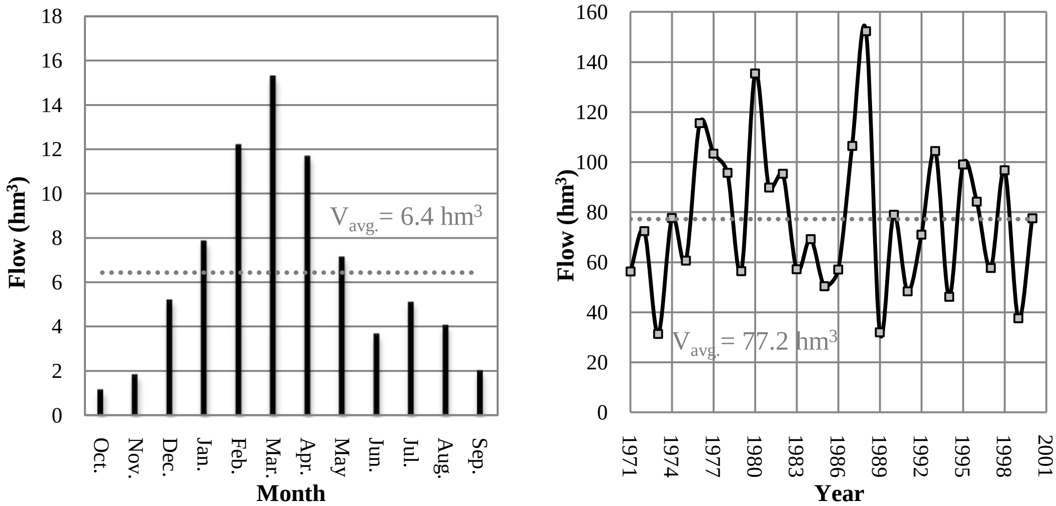


Figure F.42 Monthly Mean and Annual Total Inflow Values in the Operation Study of Pamukcay Reservoir

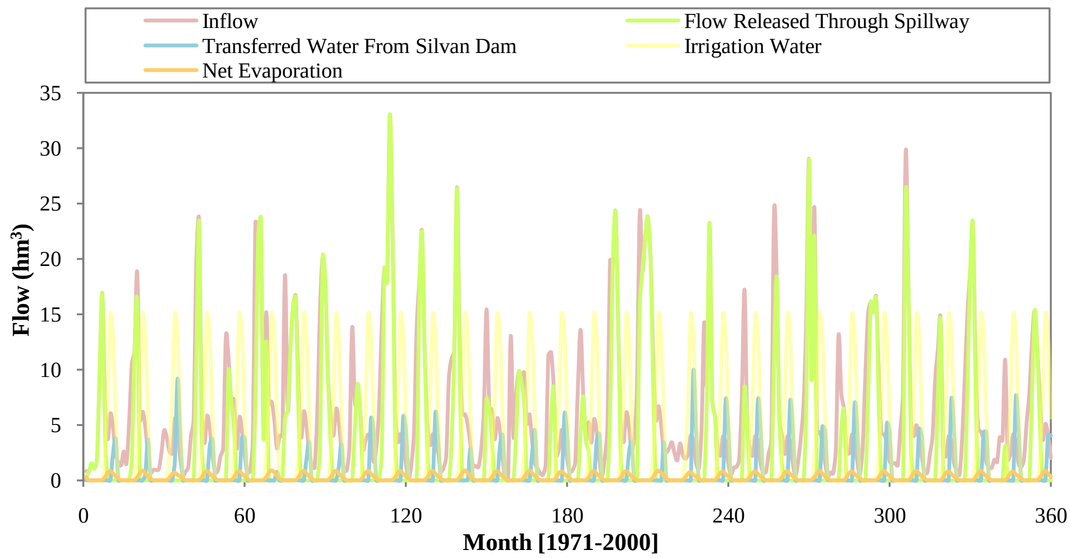


Figure F.43 Operation Study Results of Pamukcay Dam

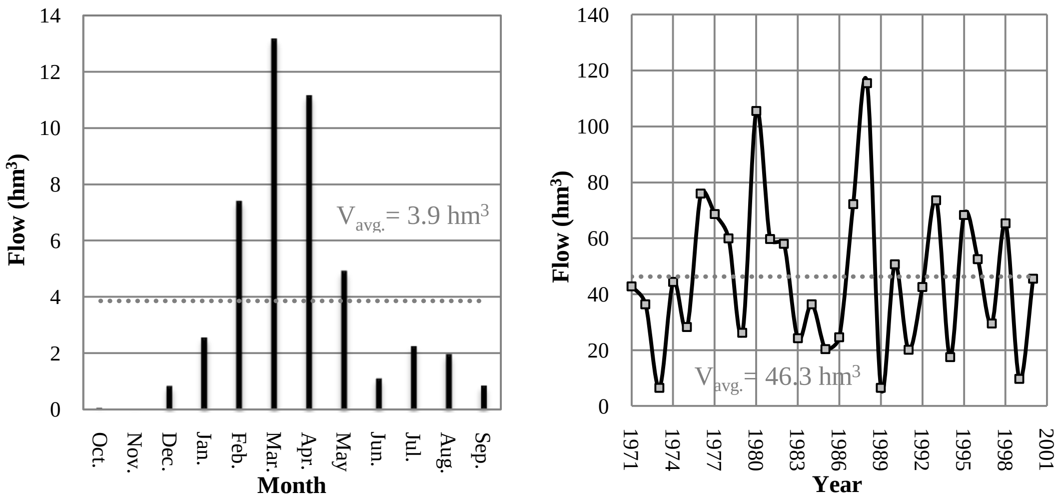


Figure F.44 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Pamukcay Reservoir (Irrigation return water of the project was added to the outflow values.)

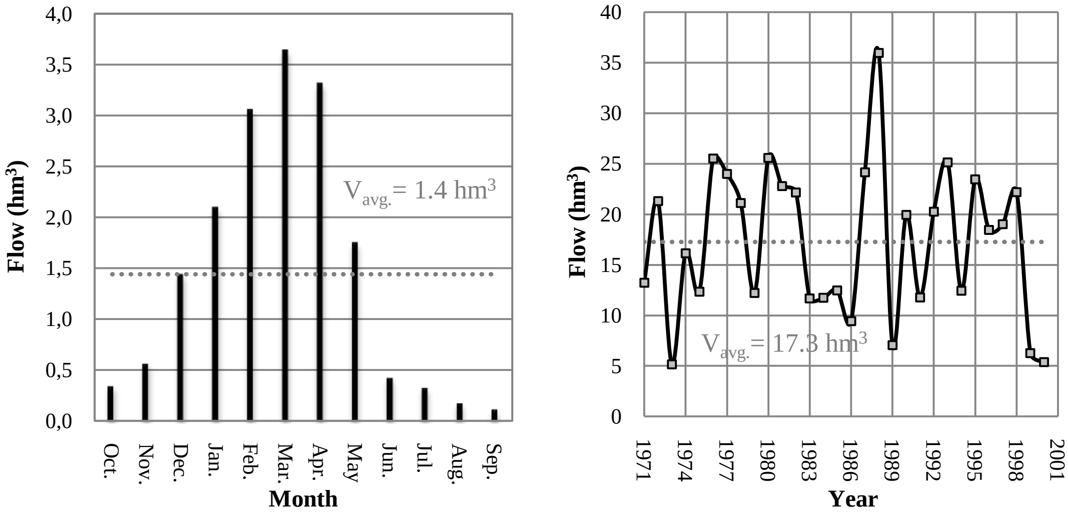


Figure F.45 Monthly Mean and Annual Total Flow Values at Baslar Dam

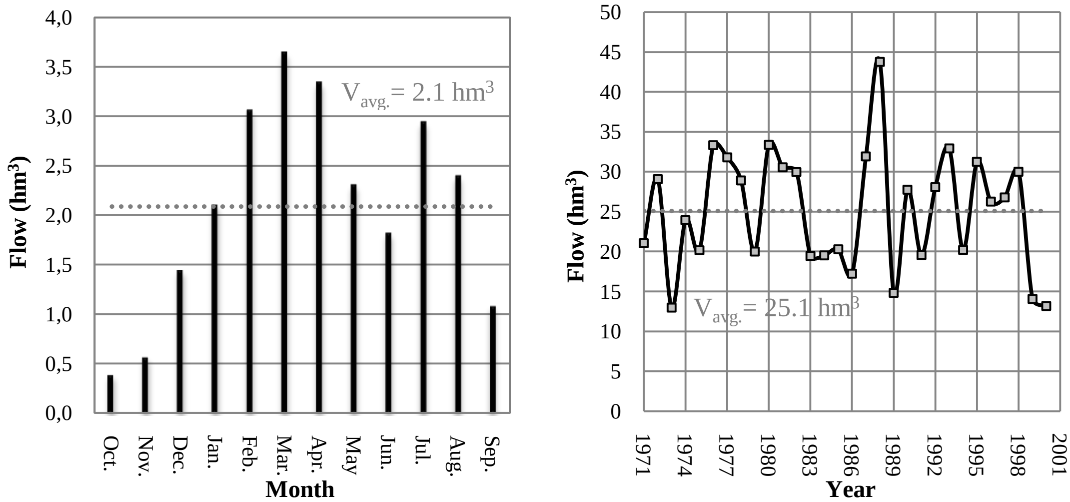


Figure F.46 Monthly Mean and Annual Total Inflow Values in the Operation Study of Baslar Reservoir

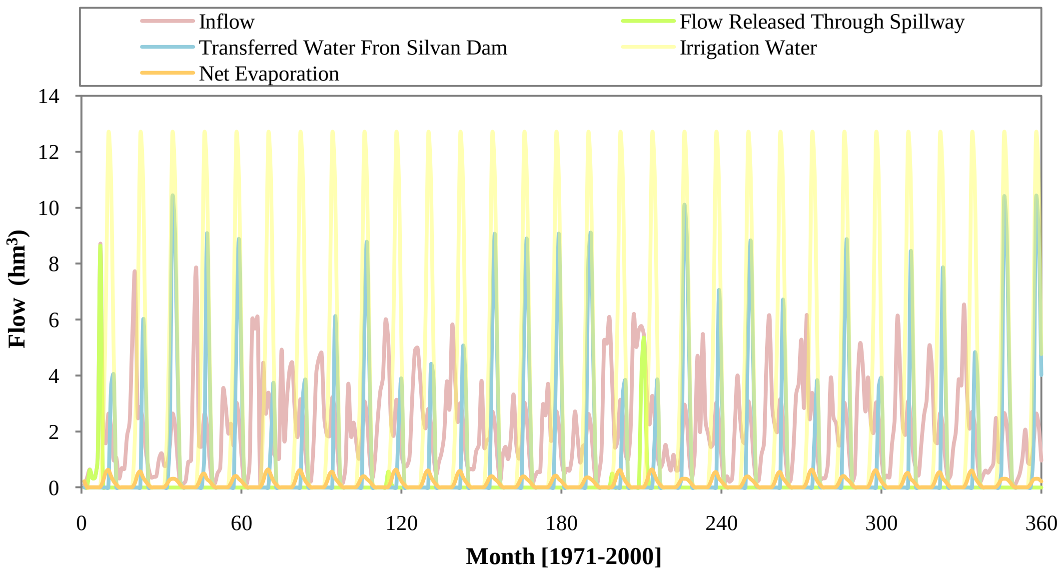


Figure F.47 Operation Study Results of Baslar Dam

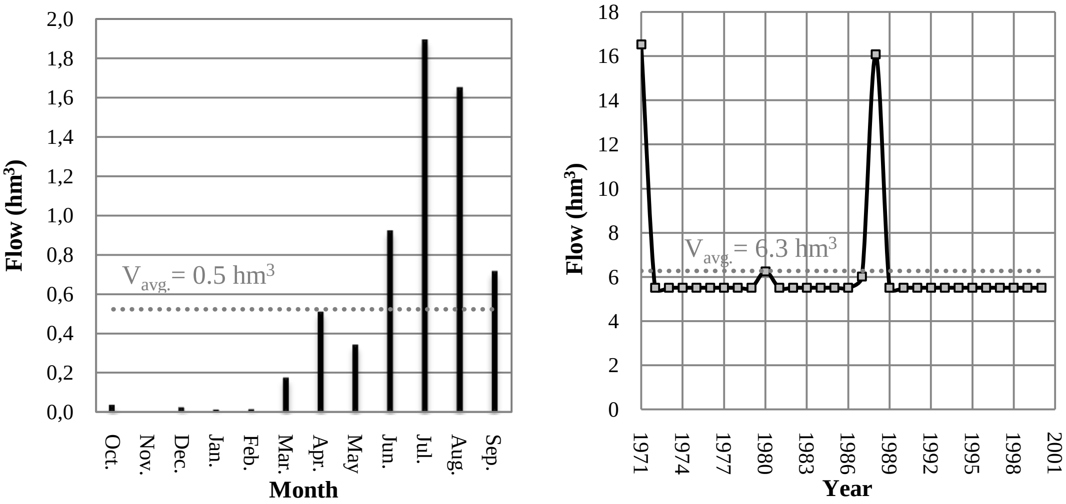


Figure F.48 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Baslar Reservoir (Irrigation return water of the project was added to the outflow values.)

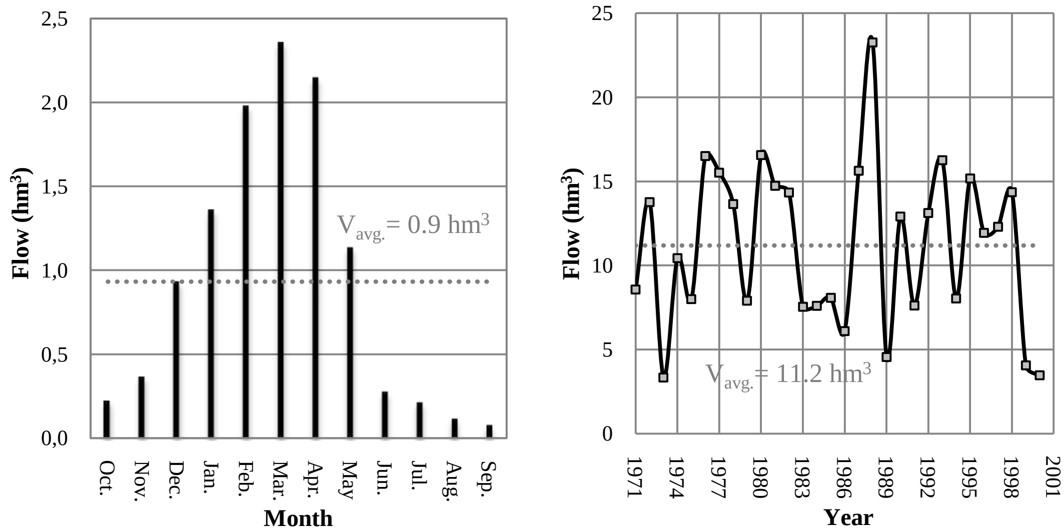


Figure F.49 Monthly Mean and Annual Total Flow Values at Bulaklidere Dam

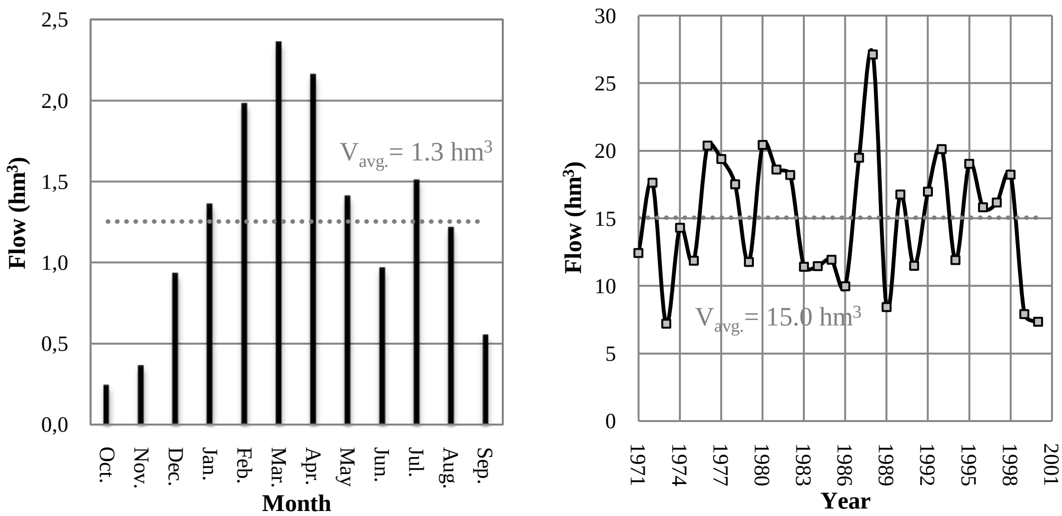


Figure F.50 Monthly Mean and Annual Total Inflow Values in the Operation Study of Bulaklidere Reservoir

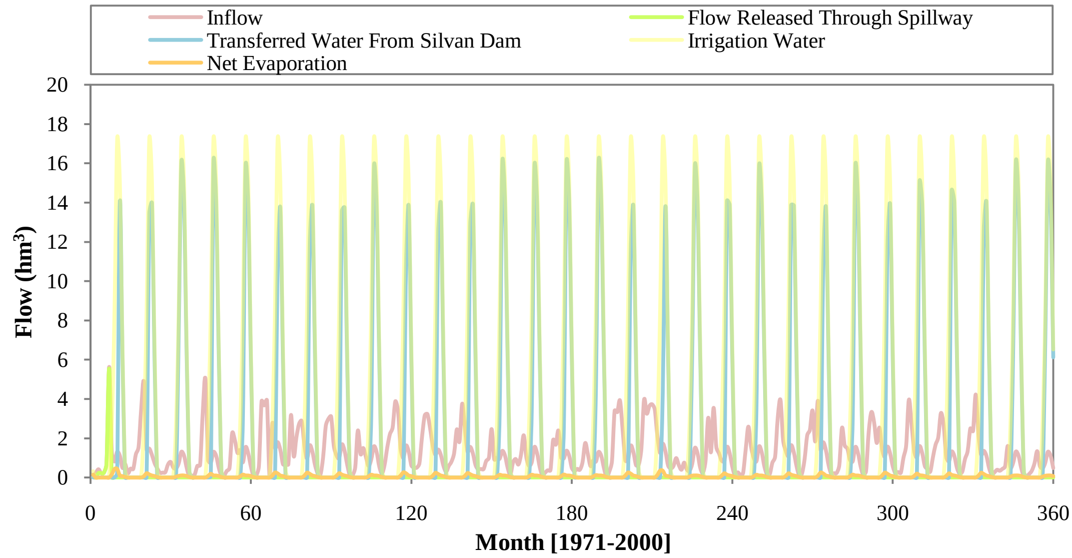


Figure F.51 Operation Study Results of Bulaklidere Dam

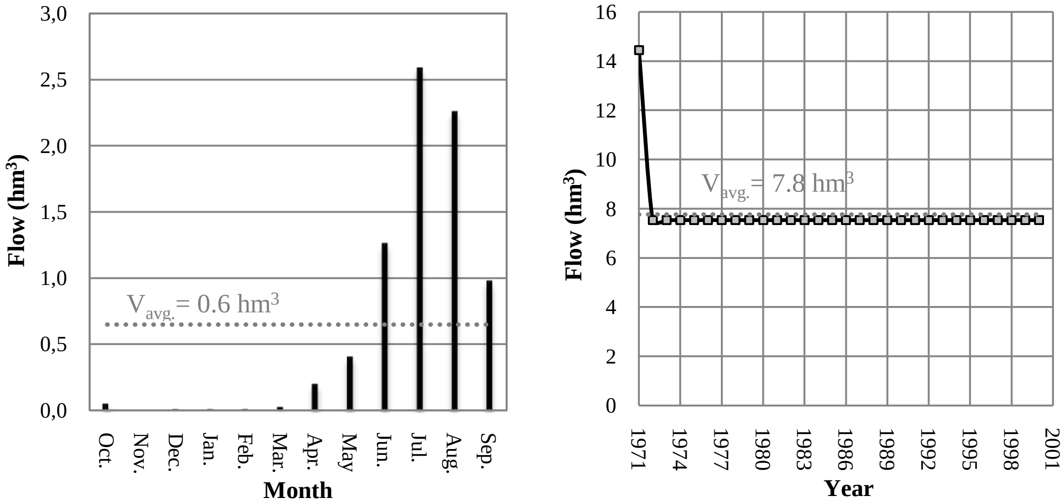


Figure F.52 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Bulaklidere Reservoir (Irrigation return water of the project was added to the outflow values.)

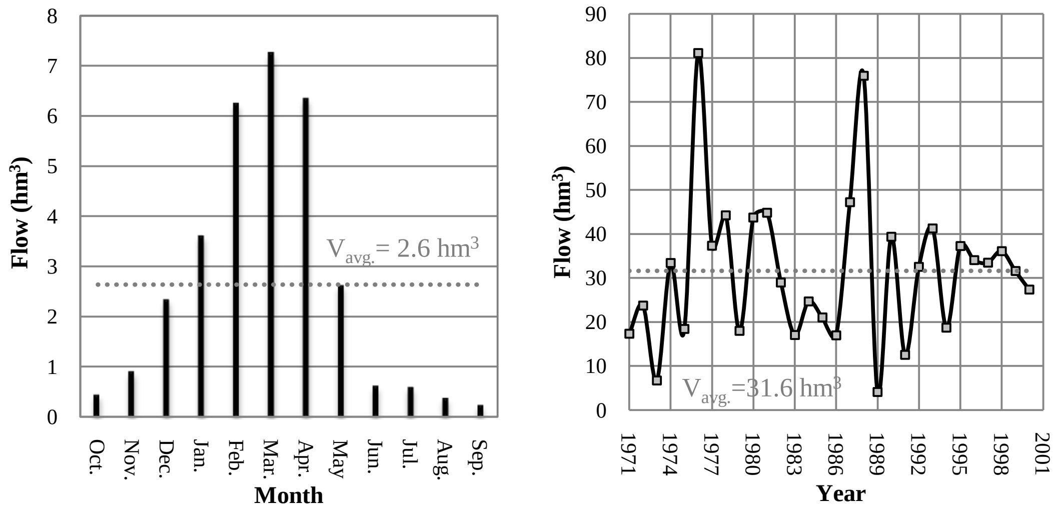


Figure F.53 Monthly Mean and Annual Total Flow Values at Kibris Dam

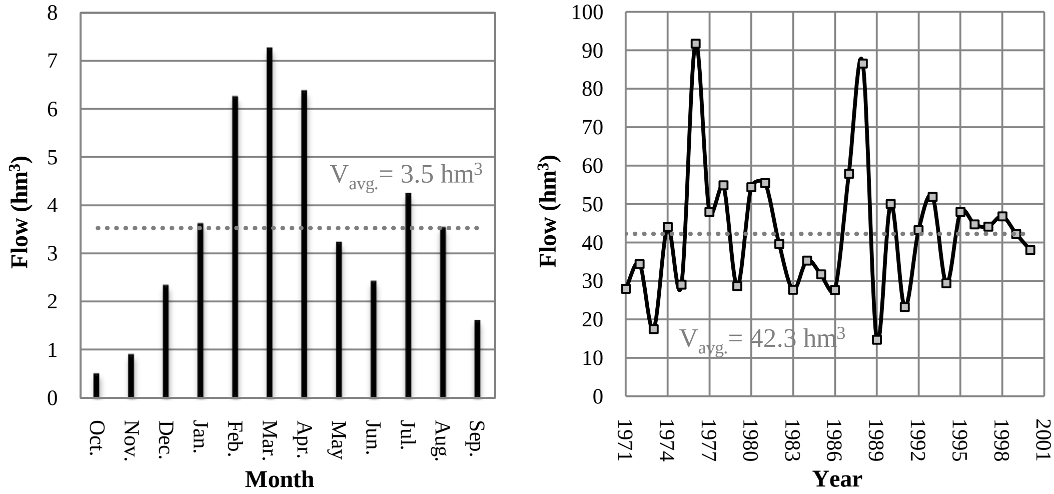


Figure F.54 Monthly Mean and Annual Total Inflow Values in the Operation Study of Kibris Reservoir

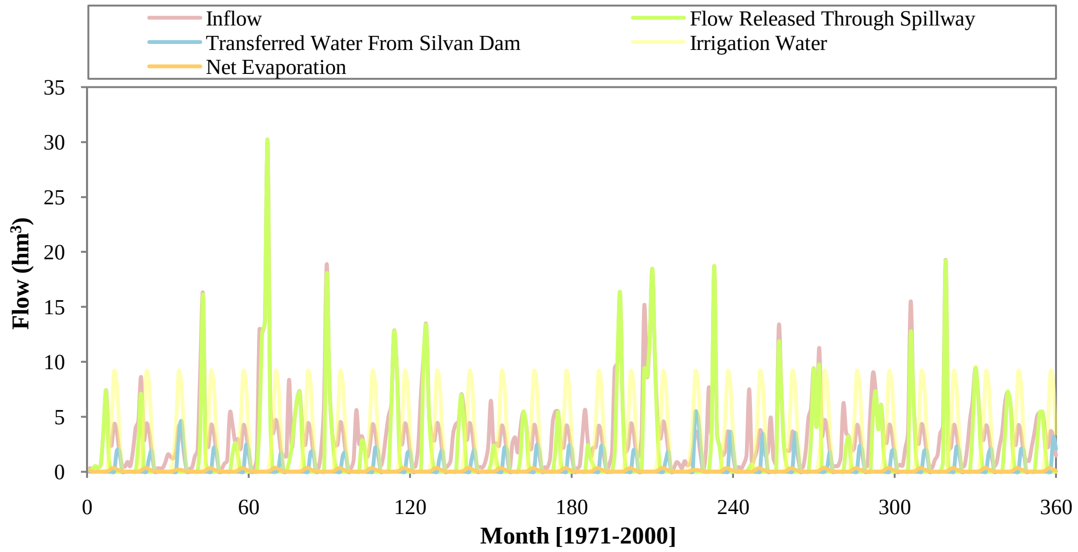


Figure F.55 Operation Study Results of Kibris Dam

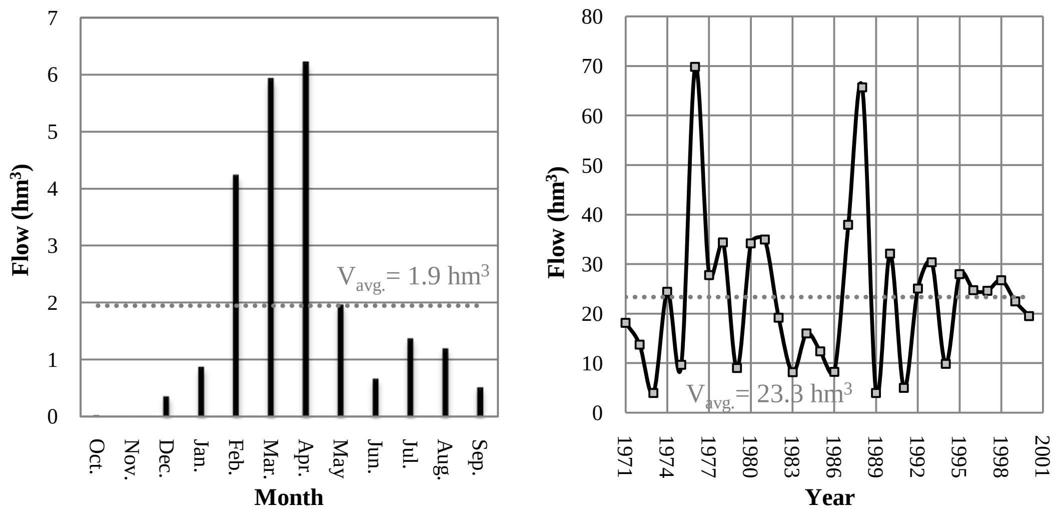


Figure F.56 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Kibris Reservoir (Irrigation return water of the project was added to the outflow values.)

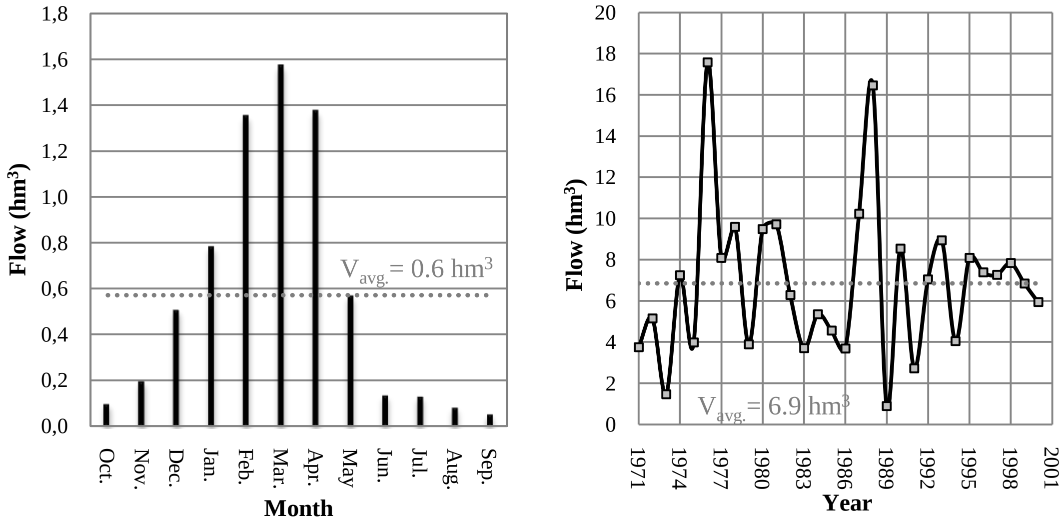


Figure F.57 Monthly Mean and Annual Total Flow Values at Karacalar Dam

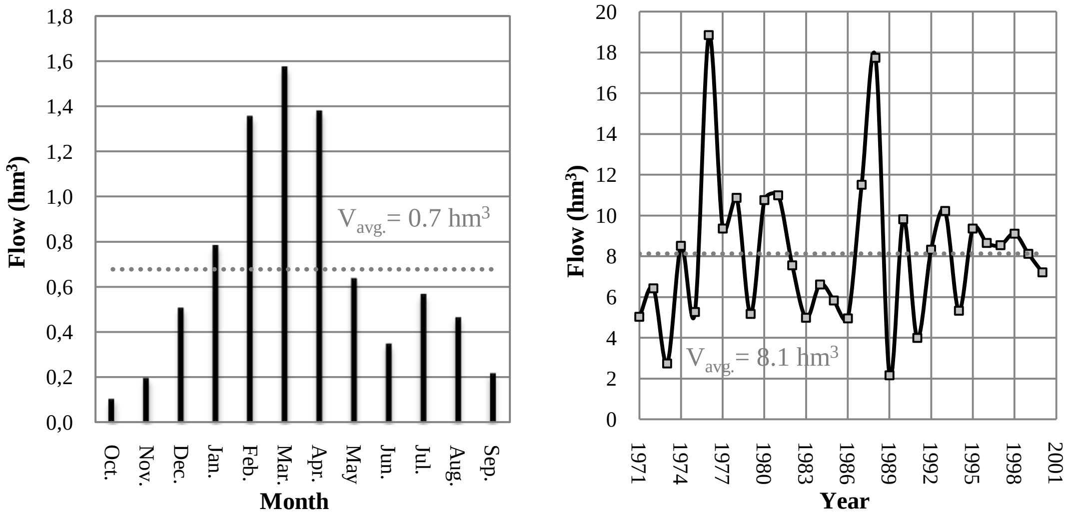


Figure F.58 Monthly Mean and Annual Total Inflow Values in the Operation Study of Karacalar Reservoir

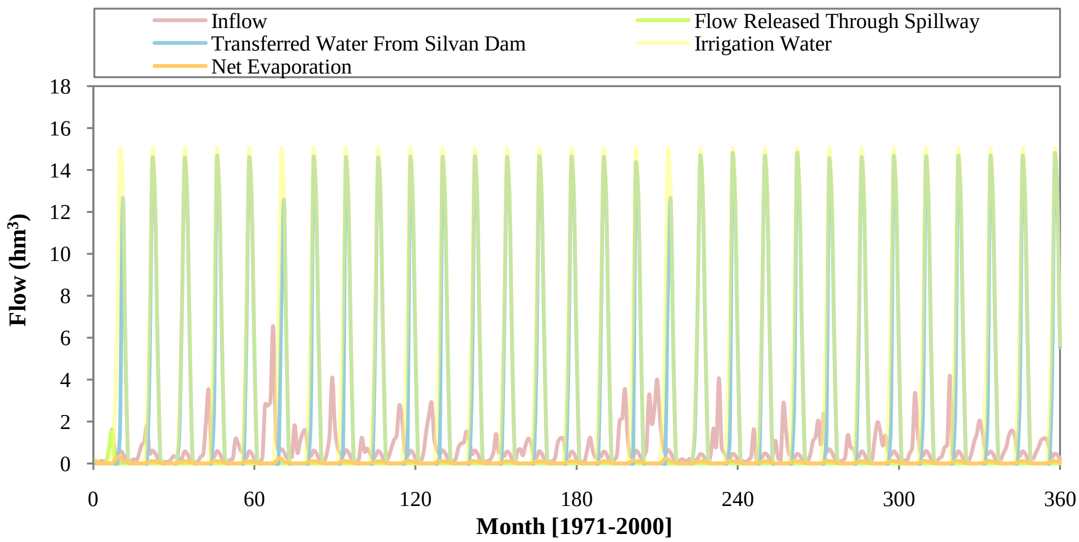
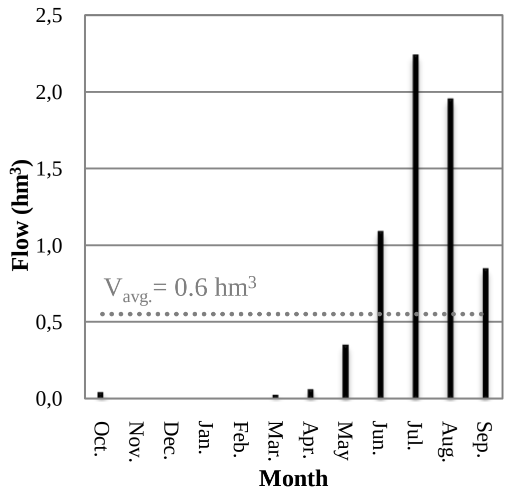


Figure F.59 Operation Study Results of Karacalar Dam



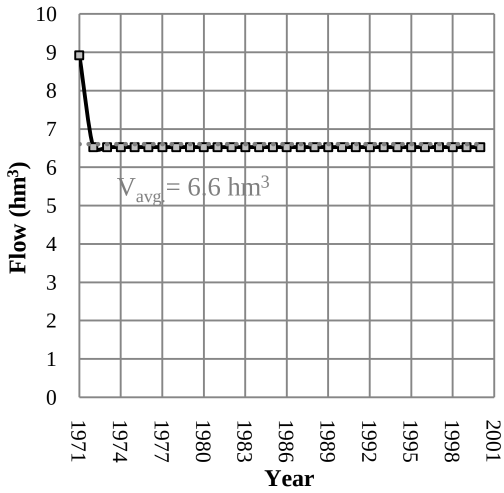
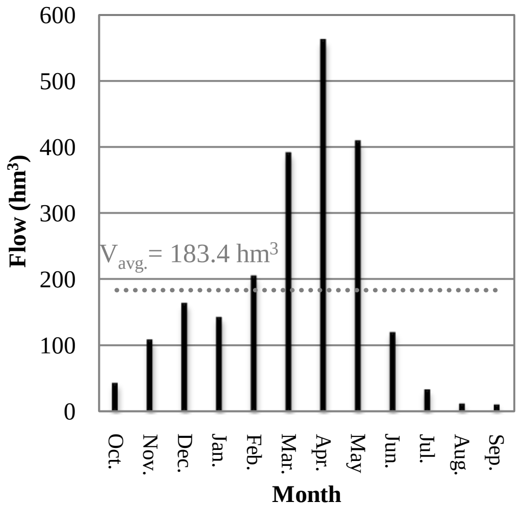


Figure F.60 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Karacalar Reservoir (Irrigation return water of the project was added to the outflow values.)



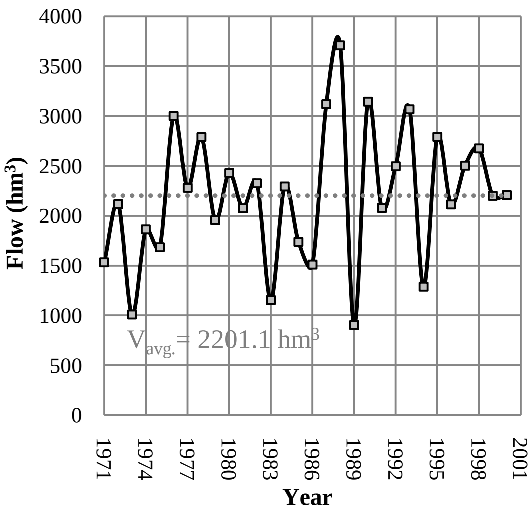


Figure F.61 Monthly Mean and Annual Total Flow Values at Silvan Dam

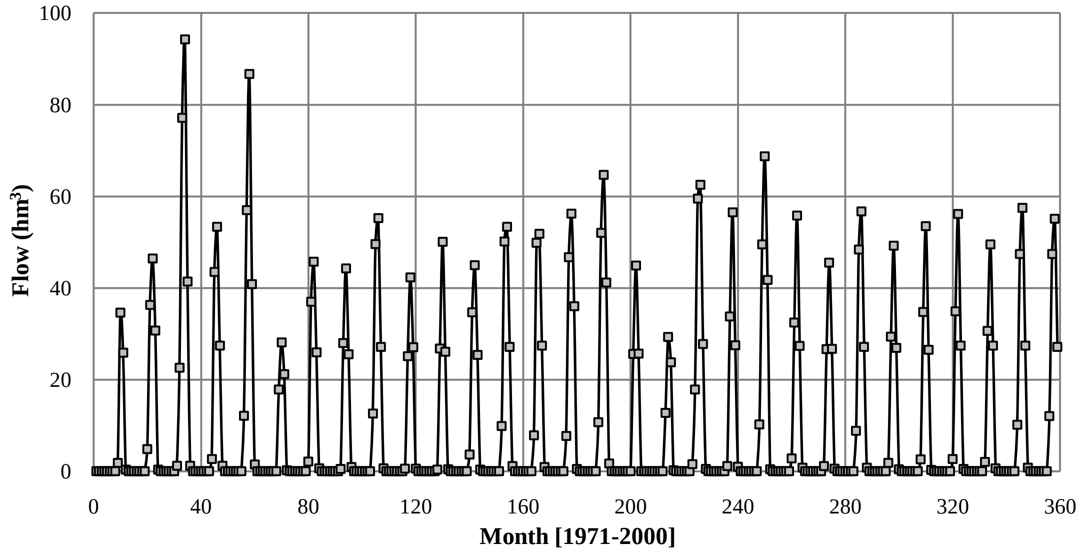


Figure F.62 Water Transferred to Silvan Plain Dams

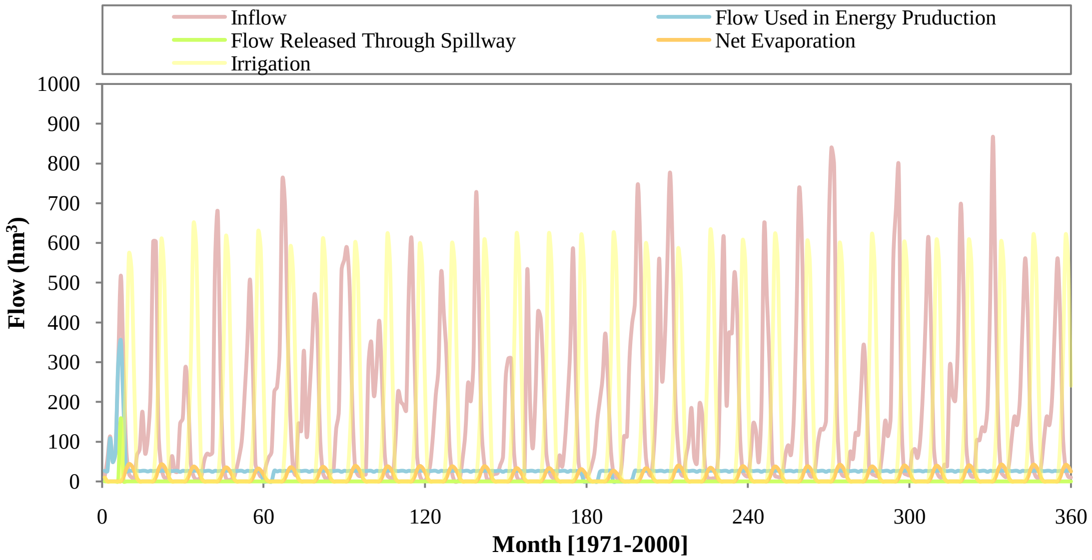


Figure F.63 Operation Study Results of Silvan Dam and HEPP

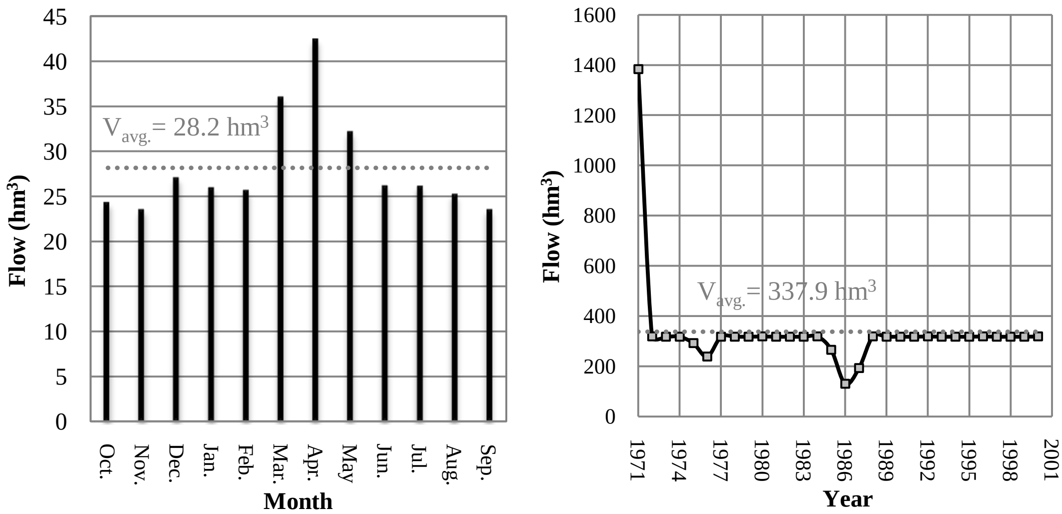


Figure F.64 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Silvan Reservoir

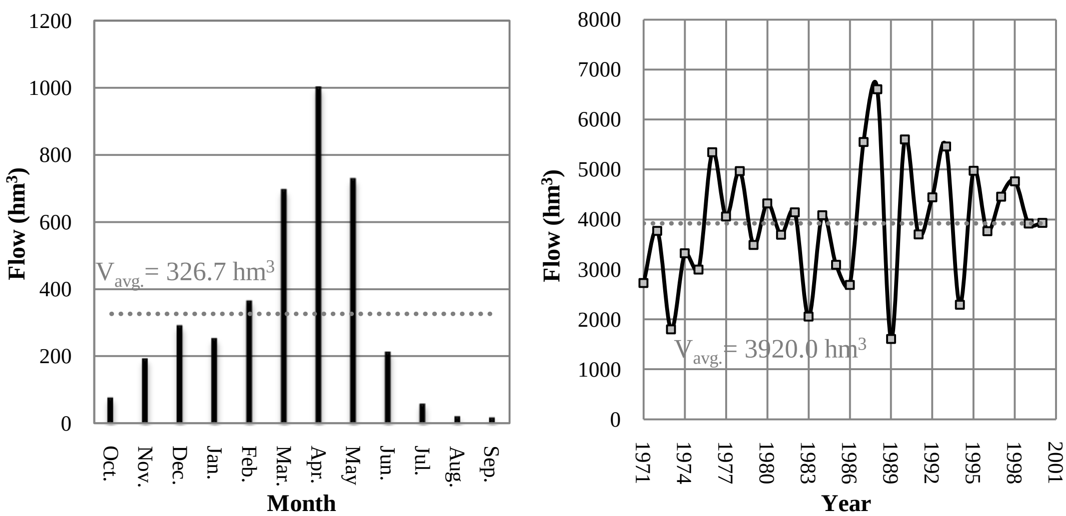


Figure F.65 Monthly Mean and Annual Total Flow Values at Batman Dam

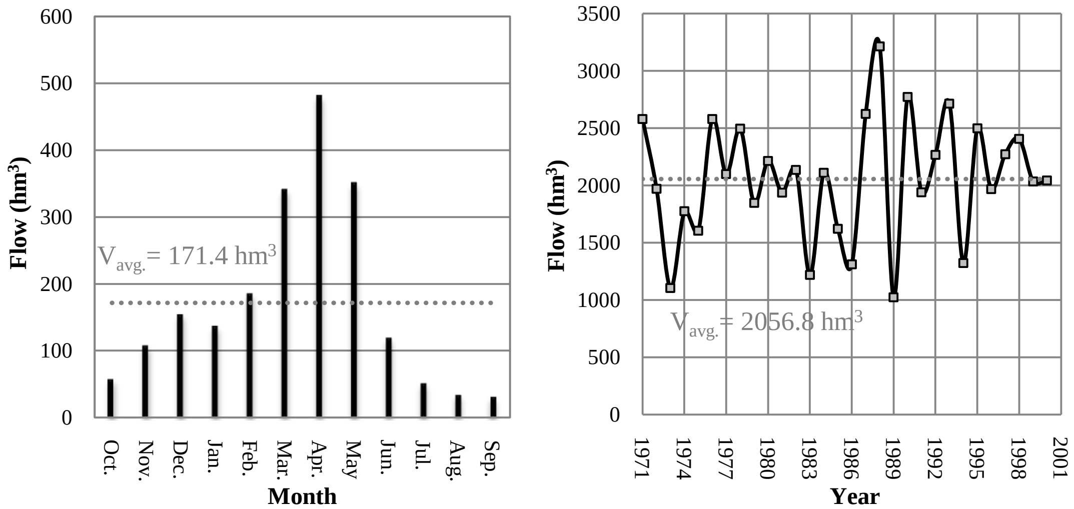


Figure F.66 Monthly Mean and Annual Total Inflow Values in the Operation Study of Batman Reservoir

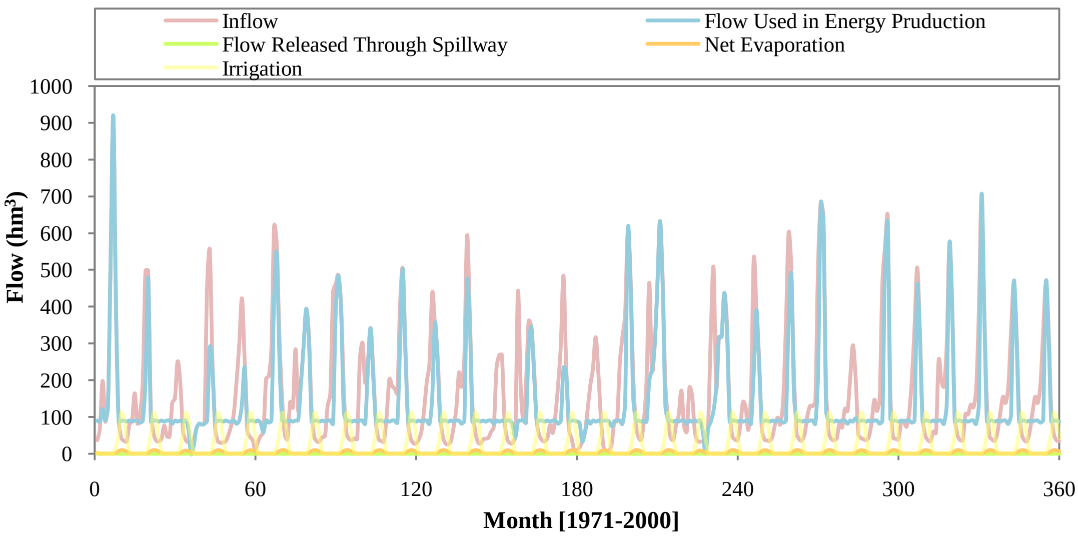


Figure F.67 Operation Study Results of Batman Dam and HEPP

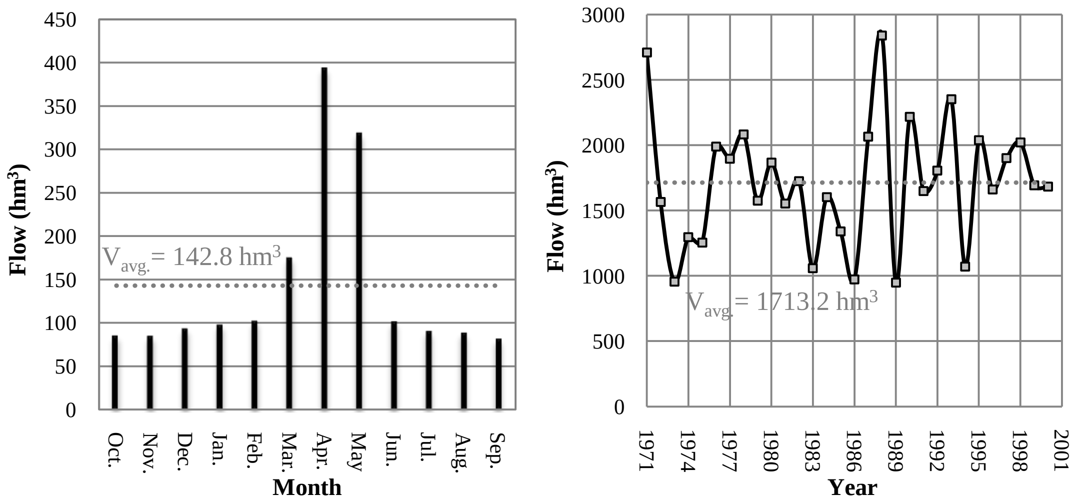


Figure F.68 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Batman Reservoir

F.2. The Upper - Tigris Projects

F.2.1. Dam Characteristics

Table F.13 Characteristics of the Projects Upstream of Ilisu IV Dam and HEPP

Characteristics	Unit	**Ergani**	**Devegecidi**	**Dipni**	**Kralkizi**	**Dicle**
Purpose	-	Irrigation	Irrigation	Energy	Energy	Energy & Irrigation & Domestic
Drainage Area	ha	44.5	1576.0	1275.0	1300.0	3216.0
Thalwag Elevation	m	873.5	724.0	746.0	707.0	640.0
Maximum Water Level	m	916.32	757.0	850.0	815.75	710.0
Minimum Water Level	m	889.5	740.0	820.0	762.0	702.5
Tailwater Level	m	-	-	715.0	708.0	641.0
Design Discharge	m^3/s	-	-	25.00	144.00	155.00
Penstock: Number/Diameter/Length	-/m/m	-	-	1/2.6/150	2/5.5/395	1/7.5/455
Energy Tunnel: Number/Diameter/Length	-/m/m	-	-	1/4.0/4600	1/6.8/500	1/6.6/500
Number of Units	-	-	-	2	2	2
Gross Head/Net Head	m/m	-	-	135.00/129.57	107.75/106.53	69.00/67.83
Turbine Type	-	-	-	Francis	Francis	Francis

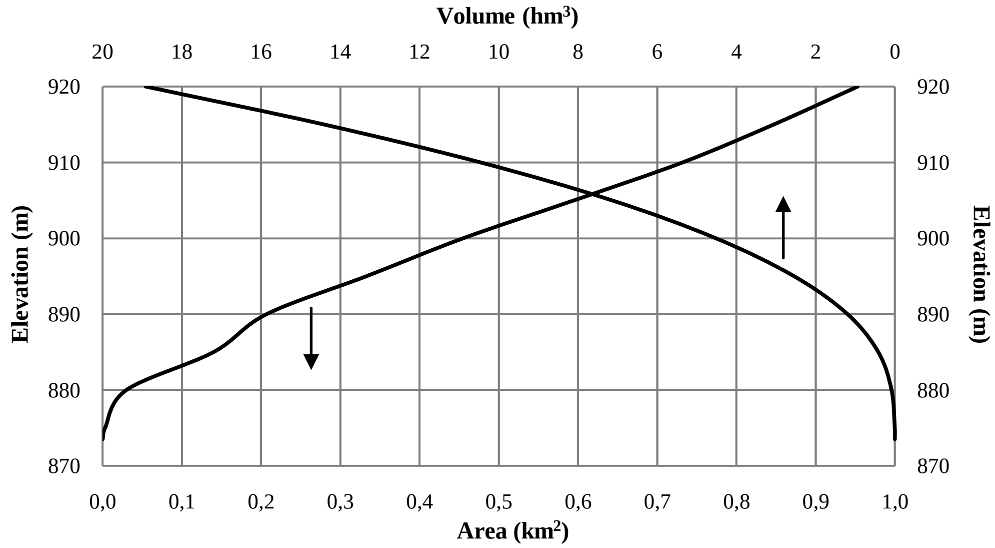


Figure F.69 Volume-Area Curve of Ergani Reservoir

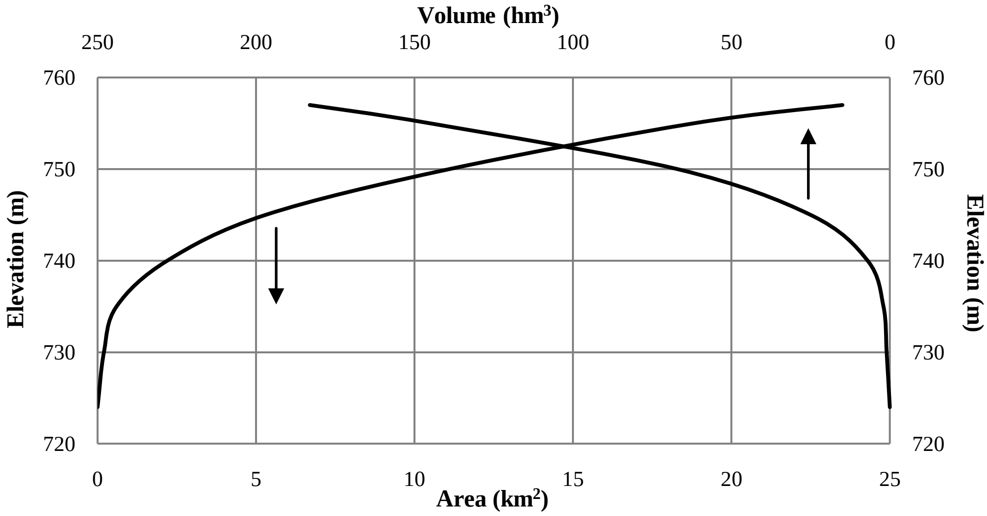


Figure F.70 Volume-Area Curve of Devegecidi Reservoir

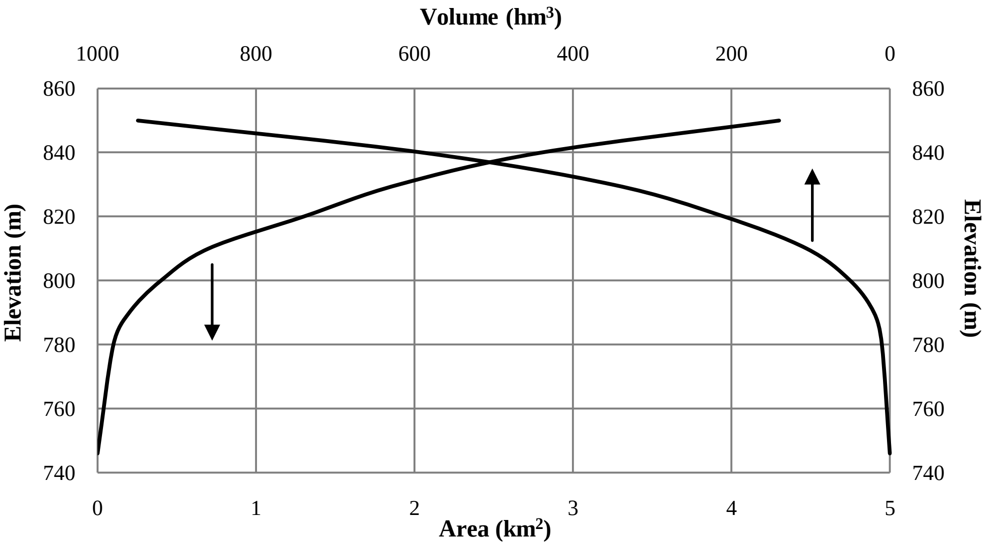


Figure F.71 Volume-Area Curve of Dipni Reservoir

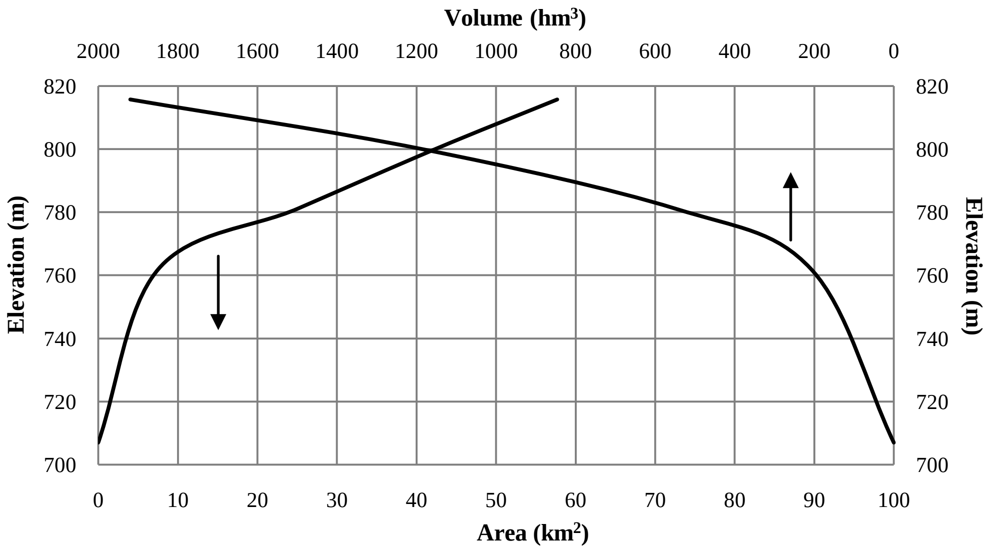


Figure F.72 Volume-Area Curve of Kralkizi Reservoir

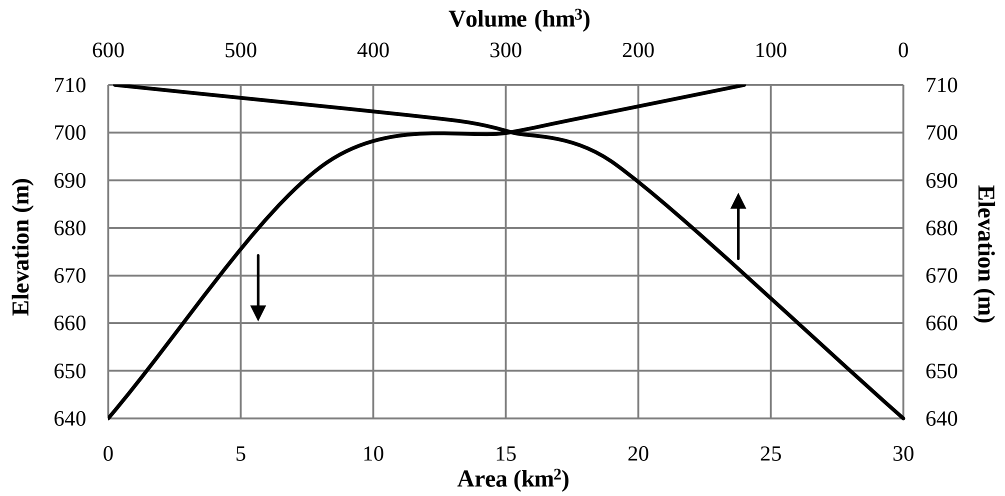


Figure F.73 Volume-Area Curve of Dicle Reservoir

F.2.2. Estimated Evaporation Rates

Table F.14 Monthly Total Net Evaporation Values of Ergani Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Ergani MS Precip. (mm)	Net Evap. (mm)
Jan.	1.7	29.8	0.5	27.3	19.1	110.7	-
Feb.	3.5	35.8	2.2	30.5	21.3	112.8	-
Mar.	8.2	82.5	6.9	49.9	34.9	102.8	-
Apr.	13.9	106.9	12.6	93.5	65.4	92.6	-
May	19.3	177.4	18.0	156.9	109.8	57.5	**52.3**
Jun.	26.1	301.3	24.8	265.0	185.5	12.5	**173.0**
Jul.	31.0	391.7	29.8	364.1	254.9	1.6	**253.3**
Aug.	29.8	367.9	28.6	338.4	236.9	2.9	**234.0**
Sep.	24.9	250.7	23.6	242.8	169.9	3.5	**166.5**
Oct.	17.1	139.8	15.9	129.2	90.4	43.9	**46.6**
Nov.	9.2	53.3	7.9	56.0	39.2	86.9	-
Dec.	4.1	25.4	2.8	32.2	22.5	119.8	-
Σ	-	1962.5	-	1785.7	1250.0	747.3	**925.6**

Table F.15 Monthly Total Net Evaporation Values of Devegecidi Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Diyarbakir MS Precip. (mm)	Net Evap. (mm)
Jan.	1.7	29.8	1.3	28.5	19.9	74.7	-
Feb.	3.5	35.8	3.0	32.6	22.8	67.8	-
Mar.	8.2	82.5	7.7	54.7	38.3	66.8	-
Apr.	13.9	106.9	13.4	101.4	71.0	70.5	**0.5**
May	19.3	177.4	18.8	167.9	117.5	41.5	**76.0**
Jun.	26.1	301.3	25.6	279.8	195.8	7.4	**188.5**
Jul.	31.0	391.7	30.6	381.7	267.2	0.7	**266.5**
Aug.	29.8	367.9	29.4	355.3	248.7	0.6	**248.2**
Sep.	24.9	250.7	24.4	256.9	179.8	3.0	**176.8**
Oct.	17.1	139.8	16.7	139.0	97.3	30.3	**67.0**
Nov.	9.2	53.3	8.7	61.4	43.0	55.4	-
Dec.	4.1	25.4	3.6	34.7	24.3	71.0	-
Σ	-	1962.5	-	1893.9	1325.8	489.5	**1023.5**

Table F.16 Monthly Total Net Evaporation Values of Dipni Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Hani MS Precip. (mm)	**Net Evap. (mm)**
Jan.	1.7	29.8	0.8	27.7	19.4	147.0	-
Feb.	3.5	35.8	2.5	31.3	21.9	153.7	-
Mar.	8.2	82.5	7.3	51.9	36.3	123.6	-
Apr.	13.9	106.9	12.9	96.7	67.7	120.4	-
May	19.3	177.4	18.4	161.4	113.0	68.6	**44.4**
Jun.	26.1	301.3	25.1	271.1	189.8	17.1	**172.7**
Jul.	31.0	391.7	30.1	371.4	260.0	2.4	**257.6**
Aug.	29.8	367.9	28.9	345.4	241.8	2.6	**239.2**
Sep.	24.9	250.7	23.9	248.6	174.0	3.3	**170.7**
Oct.	17.1	139.8	16.2	133.2	93.2	46.4	**46.9**
Nov.	9.2	53.3	8.3	58.2	40.7	132.4	-
Dec.	4.1	25.4	3.2	33.2	23.2	166.9	-
Σ	-	1962.5	-	1830.1	1281.1	984.3	**931.4**

Table F.17 Monthly Total Net Evaporation Values of Kralkizi Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Ergani MS Precip. (mm)	**Net Evap. (mm)**
Jan.	1.7	29.8	1.0	28.0	19.6	110.7	-
Feb.	3.5	35.8	2.7	31.8	22.2	112.8	-
Mar.	8.2	82.5	7.4	52.9	37.0	102.8	-
Apr.	13.9	106.9	13.1	98.5	68.9	92.6	-
May	19.3	177.4	18.5	163.8	114.7	57.5	**57.2**
Jun.	26.1	301.3	25.3	274.3	192.0	12.5	**179.5**
Jul.	31.0	391.7	30.3	375.2	262.6	1.6	**261.1**
Aug.	29.8	367.9	29.1	349.0	244.3	2.9	**241.4**
Sep.	24.9	250.7	24.1	251.6	176.1	3.5	**172.7**
Oct.	17.1	139.8	16.4	135.3	94.7	43.9	**50.9**
Nov.	9.2	53.3	8.4	59.3	41.5	86.9	-
Dec.	4.1	25.4	3.4	33.7	23.6	119.8	-
Σ	-	1962.5	-	1853.4	1297.4	747.3	**962.6**

Table F.18 Monthly Total Net Evaporation Values of Dicle Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Ergani MS Precip. (mm)	**Net Evap. (mm)**
Jan.	1.7	29.8	1.5	28.9	20.3	110.7	-
Feb.	3.5	35.8	3.2	33.3	23.3	112.8	-
Mar.	8.2	82.5	8.0	56.2	39.4	102.8	-
Apr.	13.9	106.9	13.6	103.9	72.7	92.6	-
May	19.3	177.4	19.1	171.2	119.9	57.5	**62.4**
Jun.	26.1	301.3	25.8	284.2	199.0	12.5	**186.4**
Jul.	31.0	391.7	30.8	387.0	270.9	1.6	**269.3**
Aug.	29.8	367.9	29.6	360.4	252.3	2.9	**249.4**
Sep.	24.9	250.7	24.6	261.1	182.8	3.5	**179.3**
Oct.	17.1	139.8	16.9	142.0	99.4	43.9	**55.5**
Nov.	9.2	53.3	9.0	63.0	44.1	86.9	-
Dec.	4.1	25.4	3.9	35.6	24.9	119.8	-
Σ	-	1962.5	-	1926.9	1348.8	747.3	**1002.3**

F.2.3. Water Resources

F.2.3.1. Stream Gauging Stations

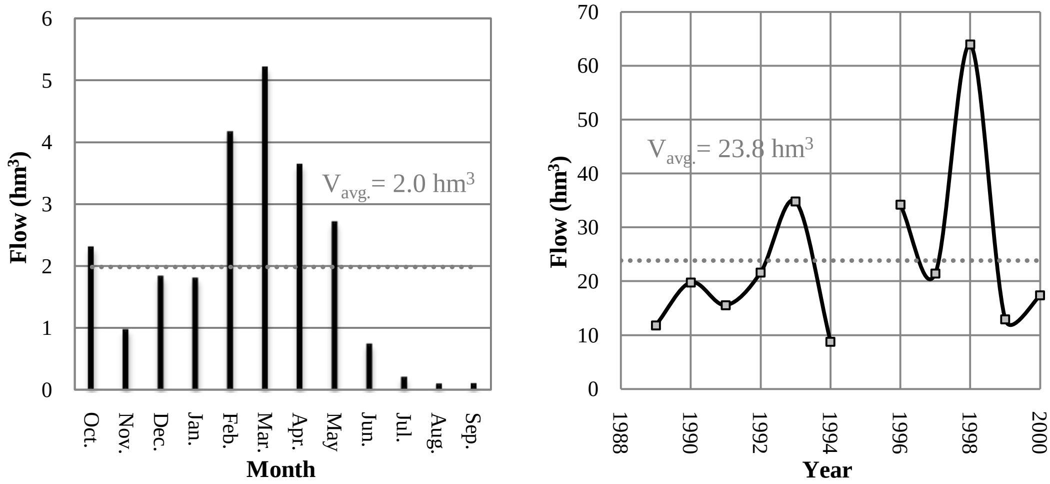


Figure F.74 Monthly Mean and Annual Total Flow Values Measured in 26-62 SGS

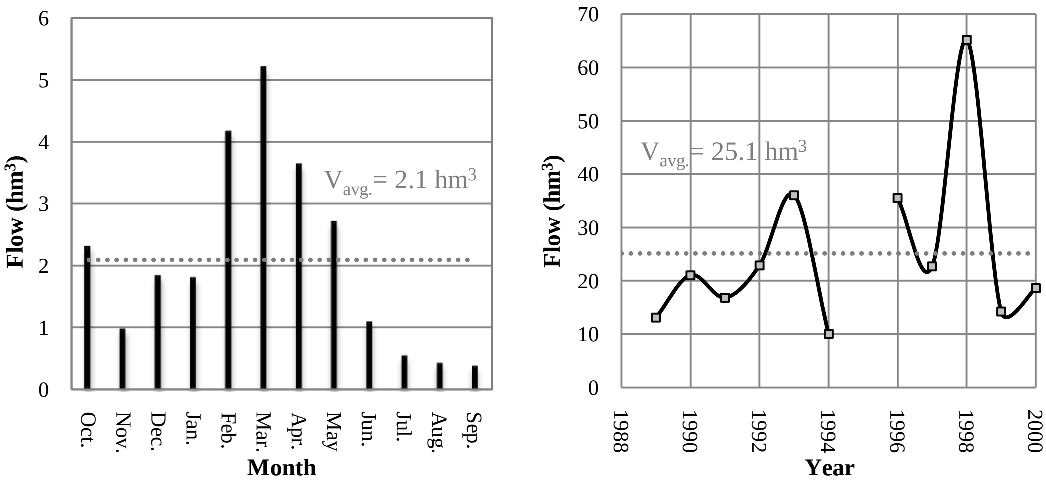


Figure F.75 Corrected Monthly Mean and Annual Total Flow Values of 26-62 SGS

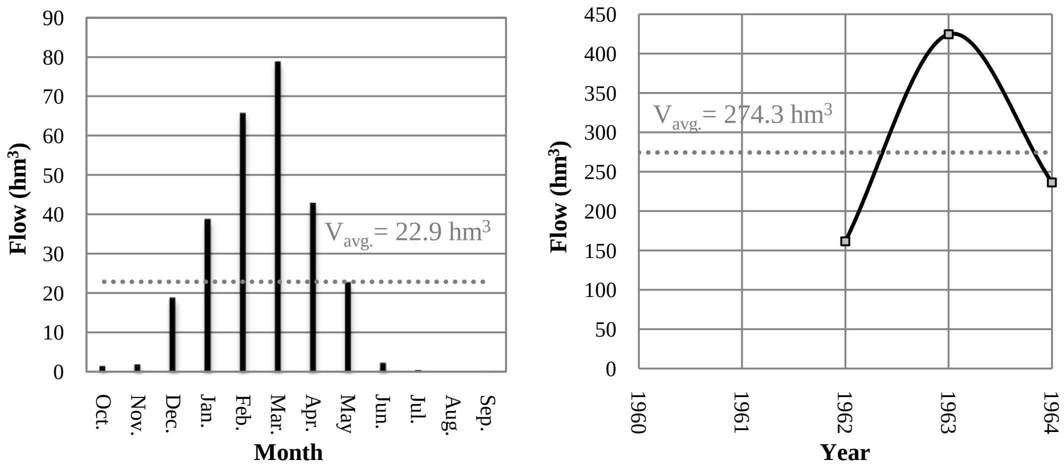


Figure F.76 Monthly Mean and Annual Total Flow Values Measured in 26-09 SGS

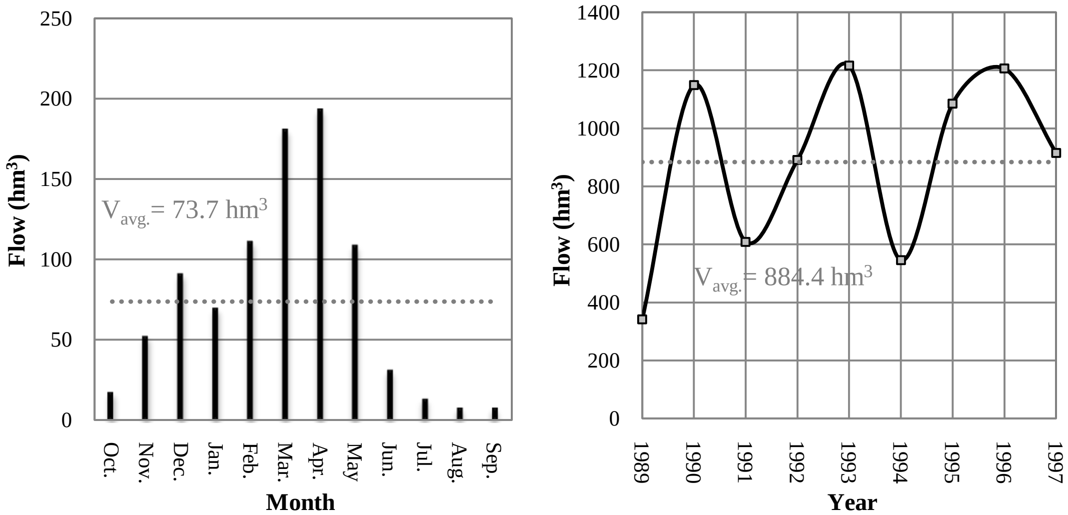


Figure F.77 Monthly Mean and Annual Total Flow Values Measured in 2632 SGS

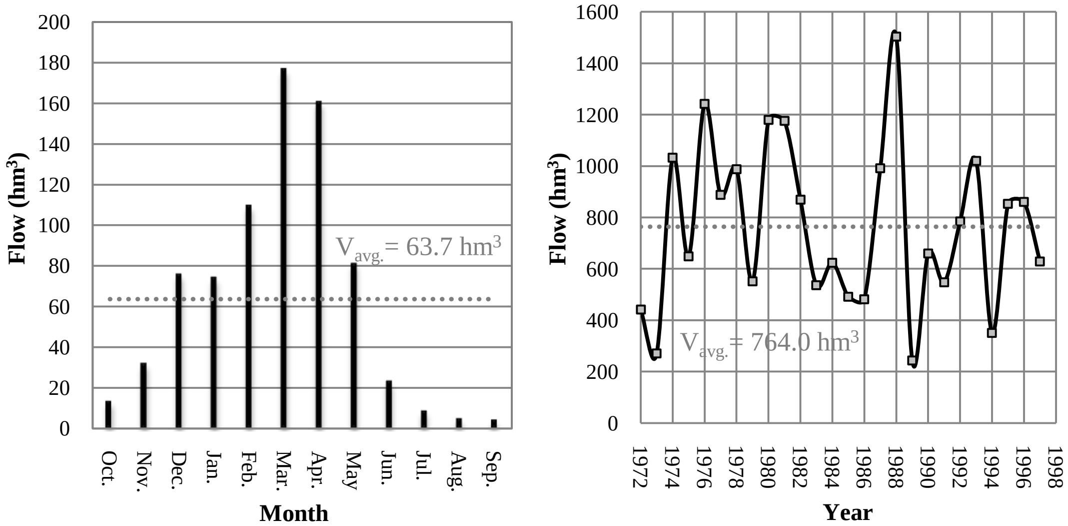


Figure F.78 Monthly Mean and Annual Total Flow Values Measured in 2617 SGS

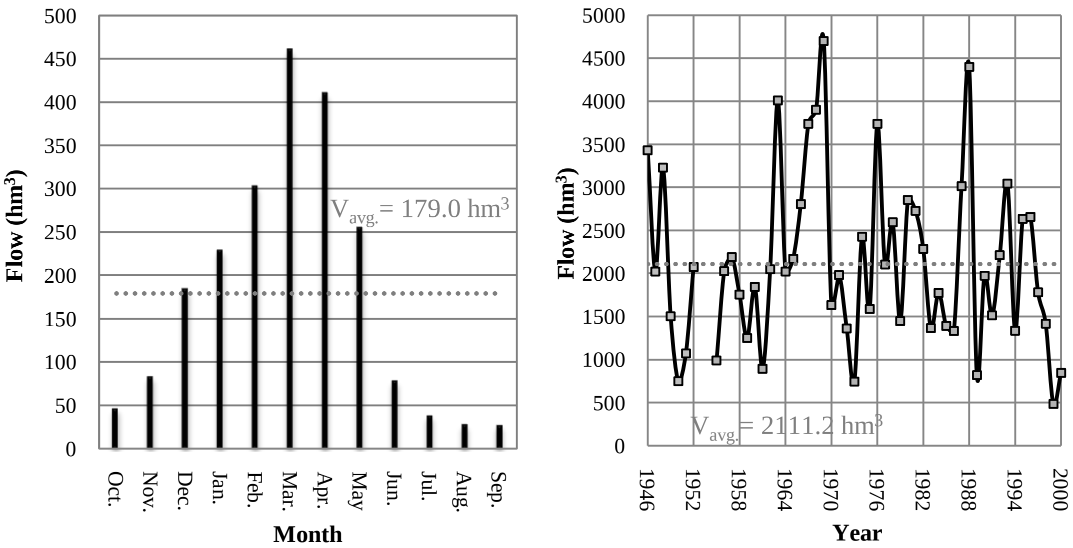


Figure F.79 Monthly Mean and Annual Total Flow Values Measured in 2605 SGS

Table F.19 Water Demand Pattern of Tigris Irrigation (FPGA, 1968)

Months	Irrigation Module (l/s/ha)
October	0.06
November	0.00
December	0.00
January	0.00
February	0.00
March	0.00
April	0.15
May	0.41
June	0.75
July	1.11
August	1.06
September	0.57
Total	4.11

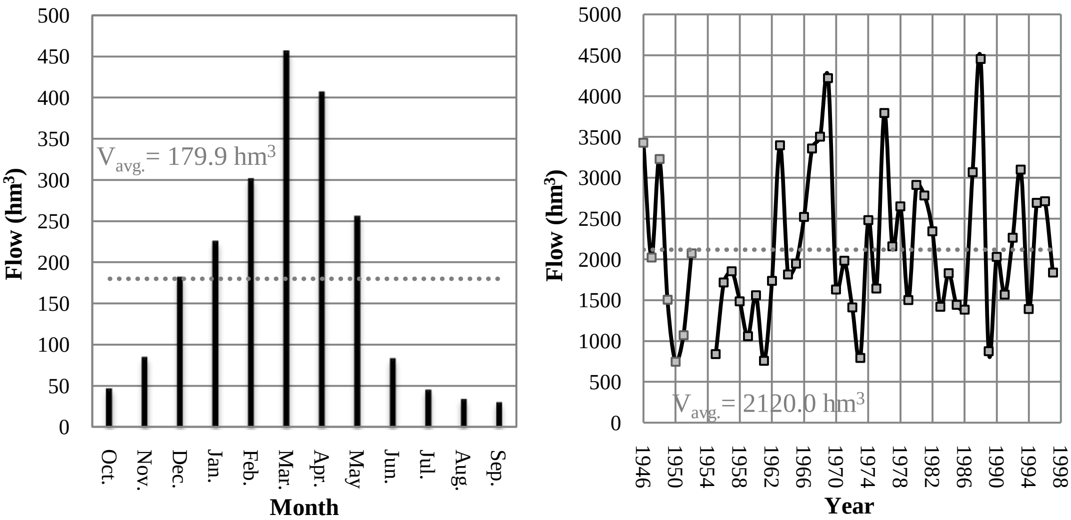


Figure F.80 Corrected Monthly Mean and Annual Total Flow Values of 2605 SGS

F.2.3.2. Correlation Studies

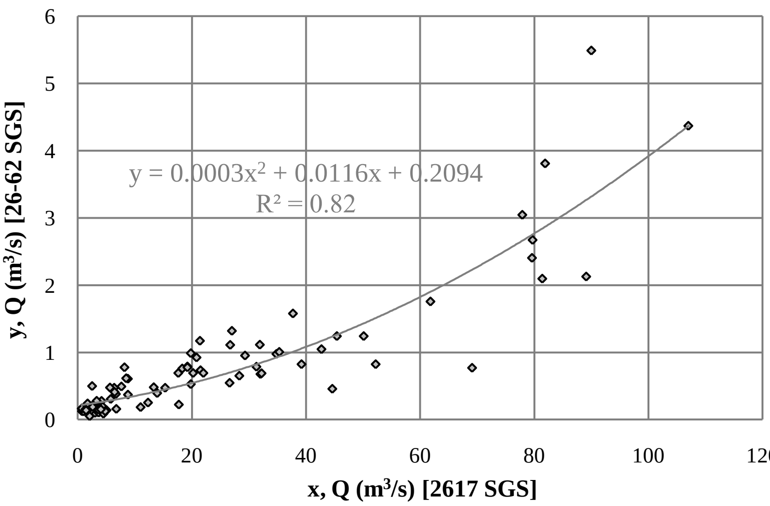


Figure F.81 Monthly Mean Discharge Correlation between 26-62 SGS and 2617 SGS

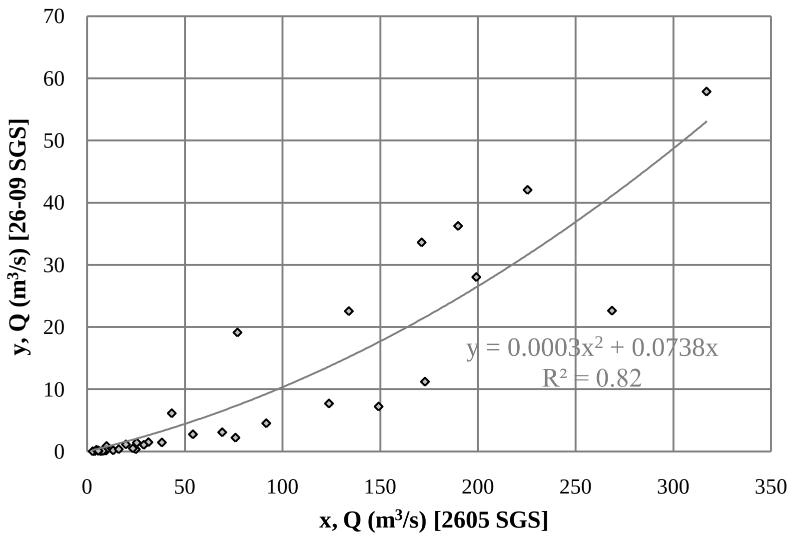


Figure F.82 Monthly Mean Discharge Correlation between 26-09 SGS and 2605 SGS

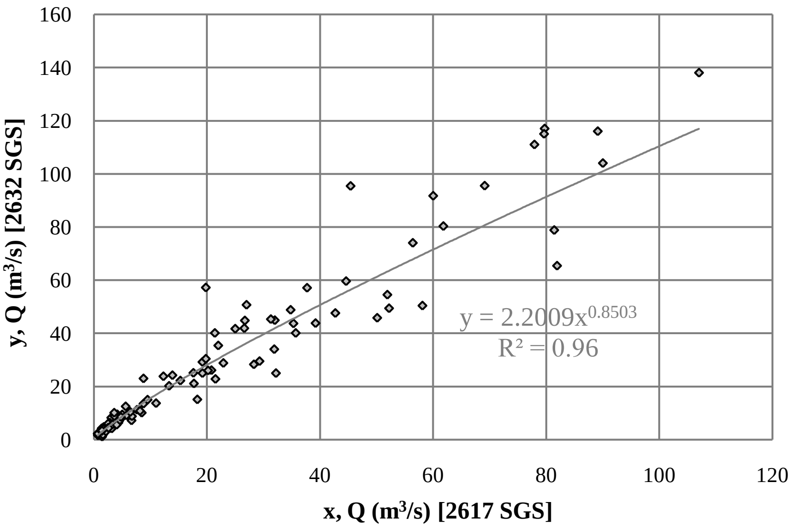


Figure F.83 Monthly Mean Discharge Correlation between 2632 SGS and 2617 SGS

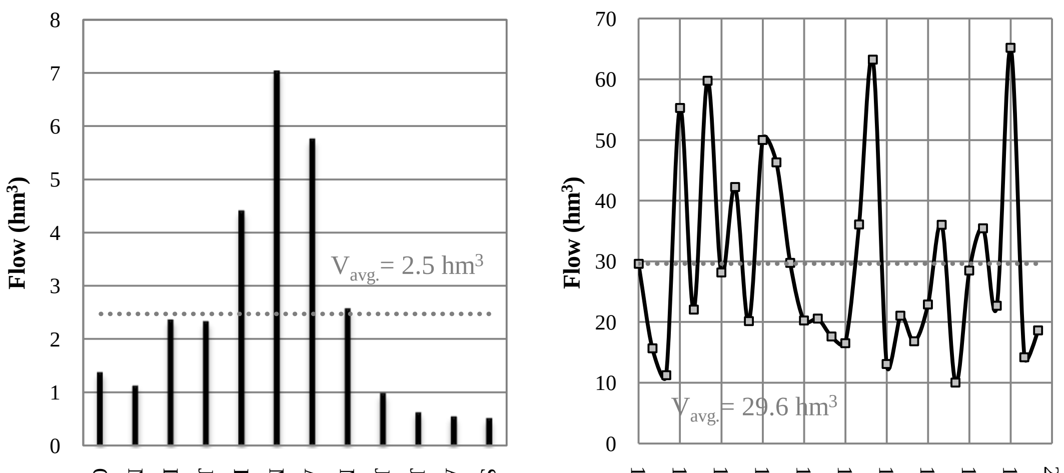


Figure F.84 Extended Monthly Mean and Annual Total Flow Values of 26-62 SGS

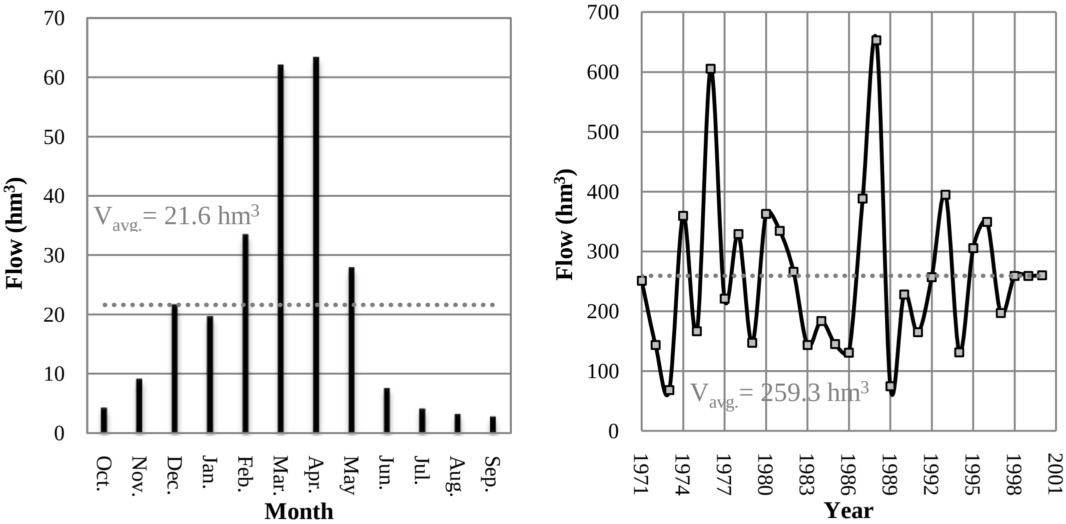


Figure F.85 Extended Monthly Mean and Annual Total Flow Values of 26-09 SGS

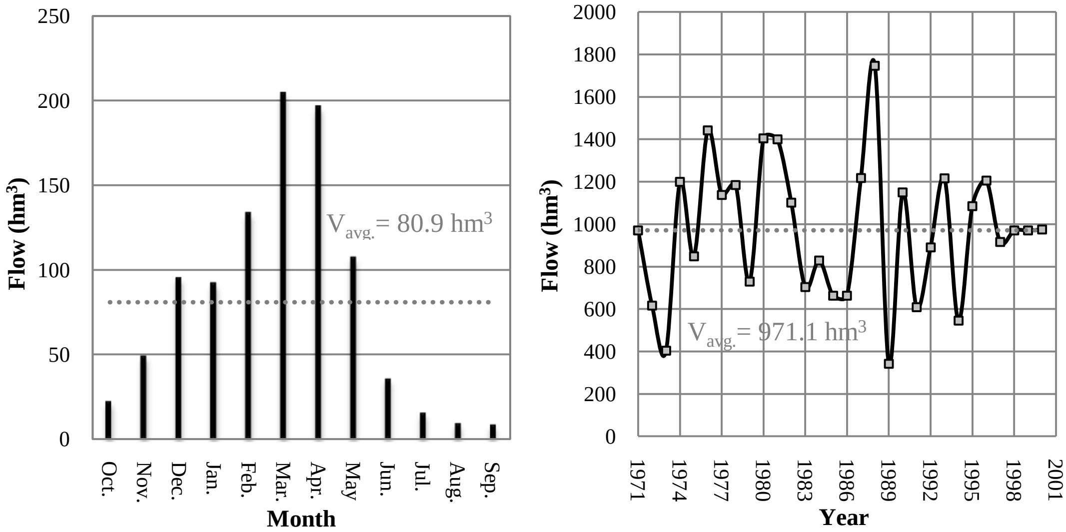


Figure F.86 Extended Monthly Mean and Annual Total Flow Values of 2632 SGS

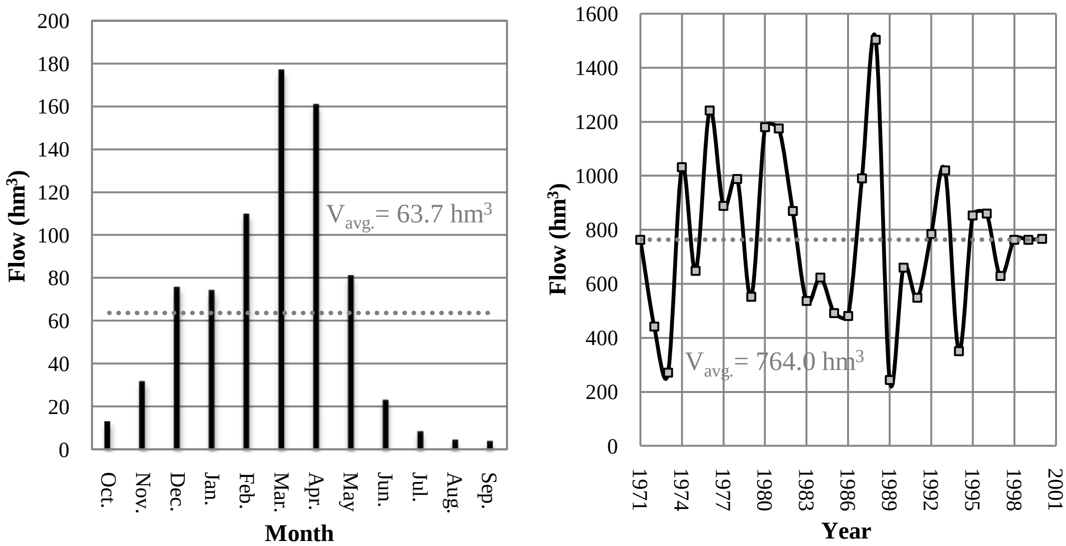


Figure F.87 Extended Monthly Mean and Annual Total Flow Values of 2617 SGS

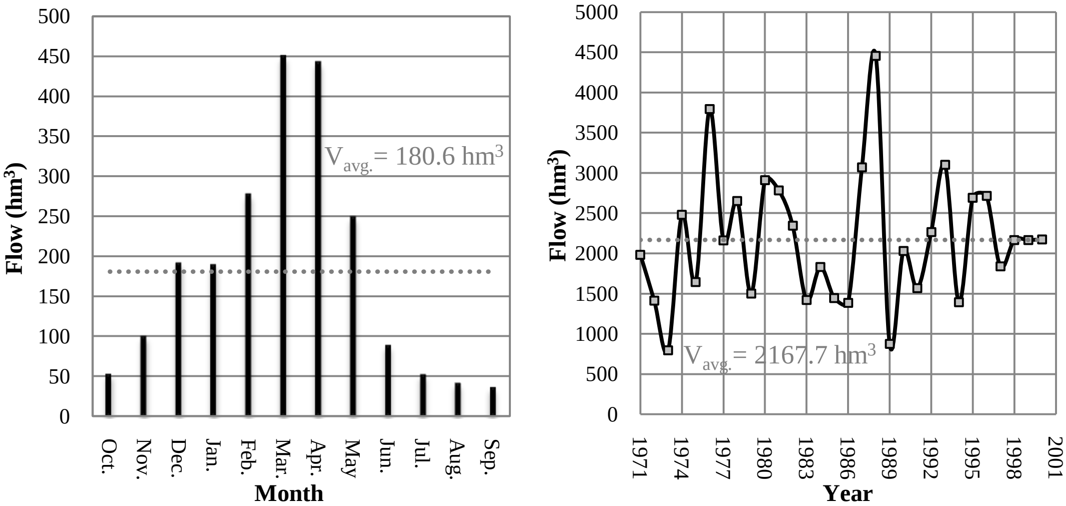


Figure F.88 Extended Monthly Mean and Annual Total Flow Values of 2605 SGS

F.2.3.3. Monthly Mean Flow Calculations

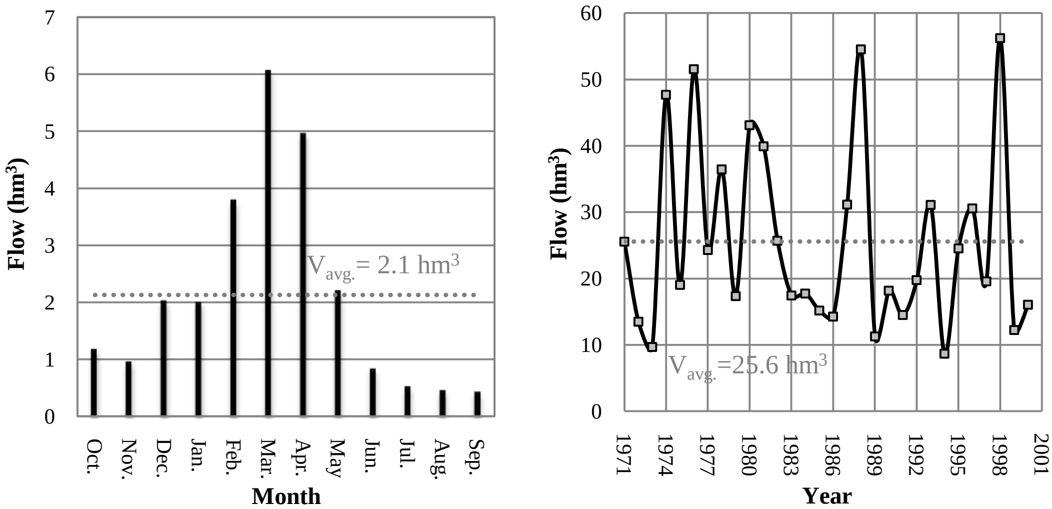


Figure F.89 Monthly Mean and Annual Total Flow Values at Ergani Dam

Table F.20 Water Demand Pattern of Ergani Irrigation (DSI, 1999)

Months	Irrigation Module (l/s/ha)
October	0.04
November	0.00
December	0.00
January	0.00
February	0.00
March	0.00
April	0.00
May	0.14
June	0.51
July	0.99
August	0.77
September	0.33
Total	2.78

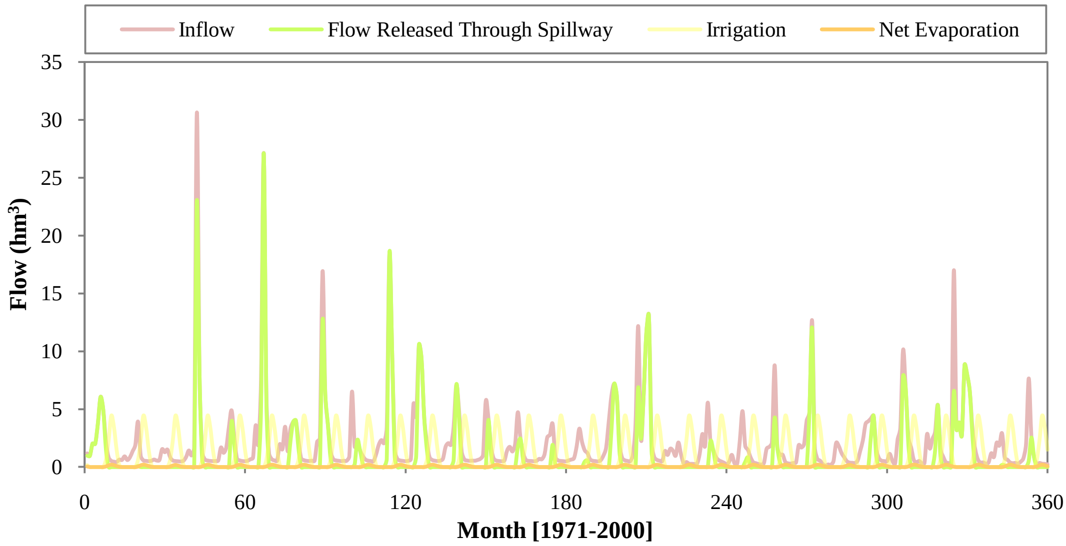
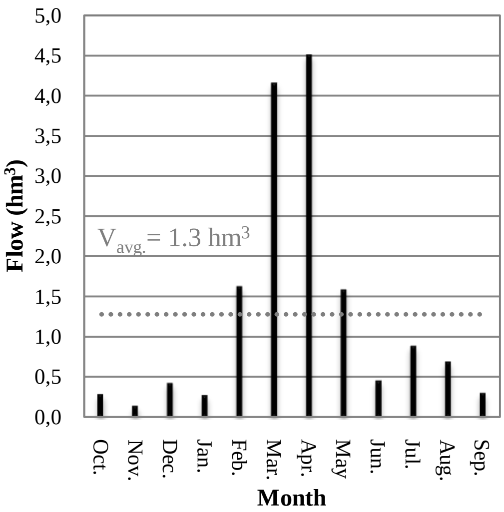


Figure F.90 Operation Study Results of Ergani Dam



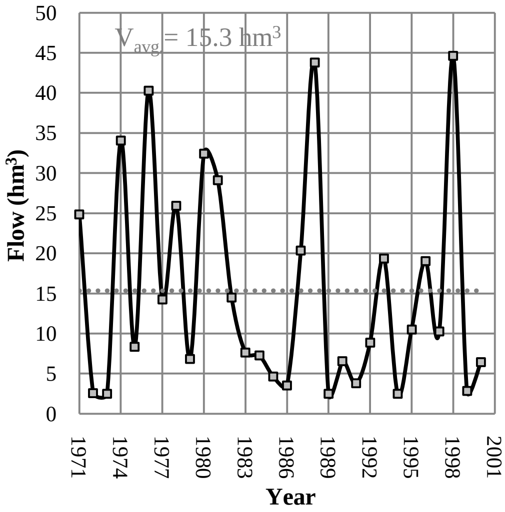
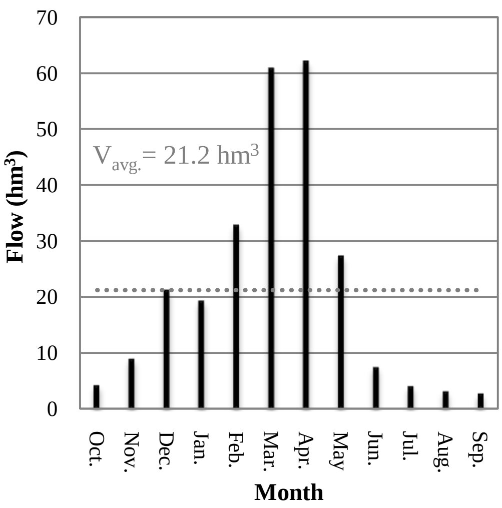


Figure F.91 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Ergani Reservoir (Irrigation return water of the project was added to the outflow values)



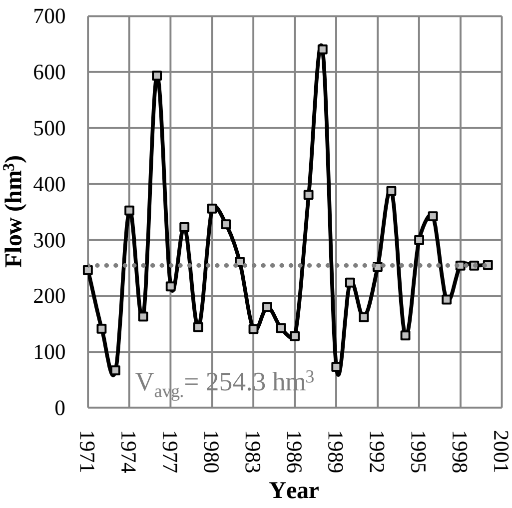


Figure F.92 Monthly Mean and Annual Total Flow Values at Devegecidi Dam

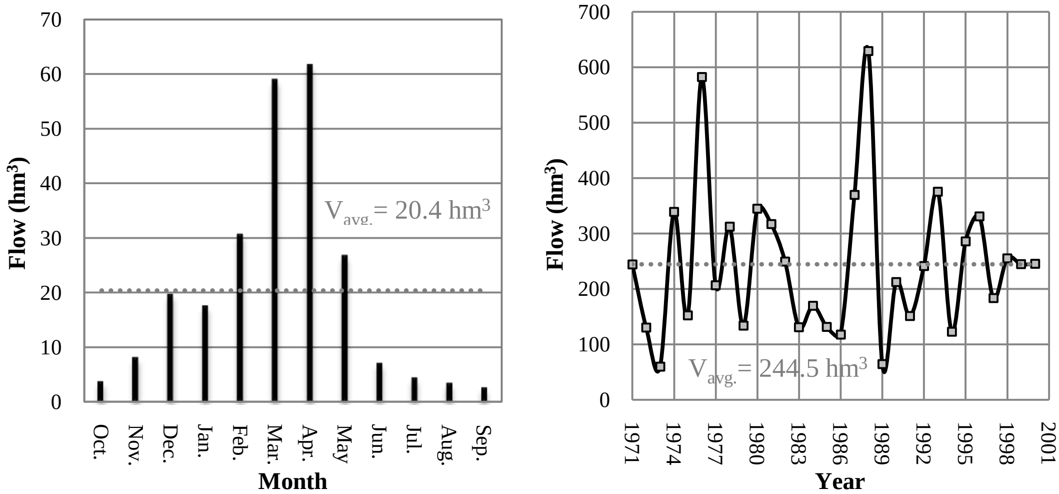


Figure F.93 Monthly Mean and Annual Total Inflow Values in the Operation Study of Devegecidi Reservoir

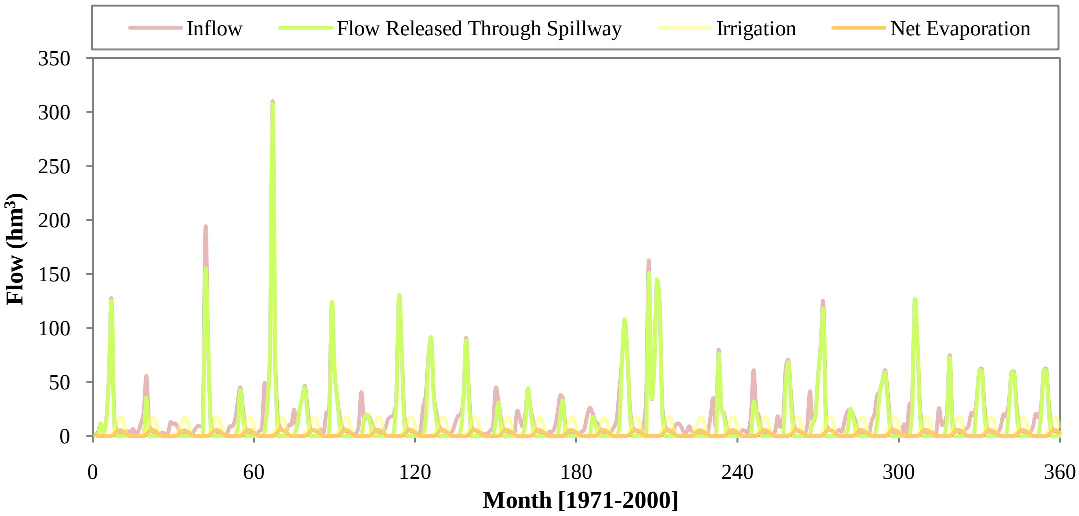


Figure F.94 Operation Study Results of Devegecidi Dam

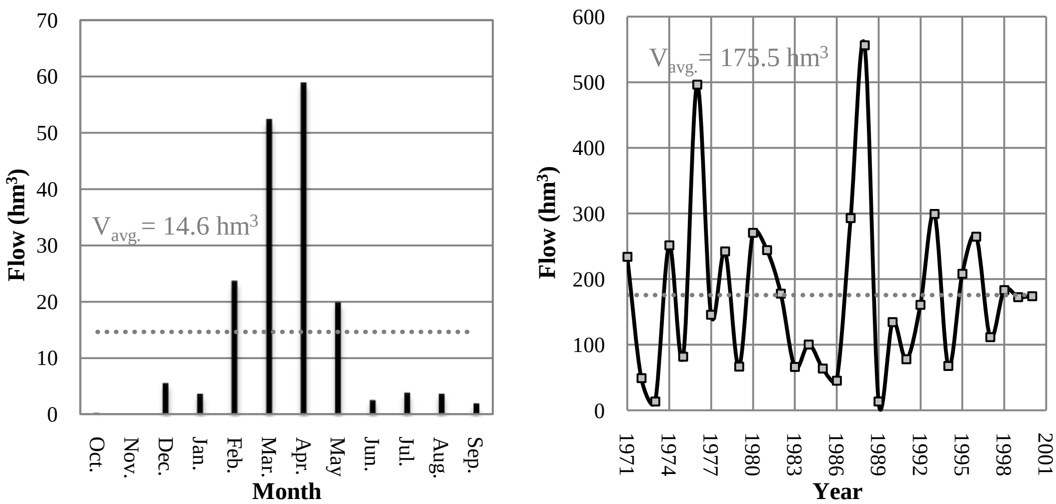


Figure F.95 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Devegecidi Reservoir (Irrigation return water of the Devegecidi and Gozegol projects was added to the outflow values.)

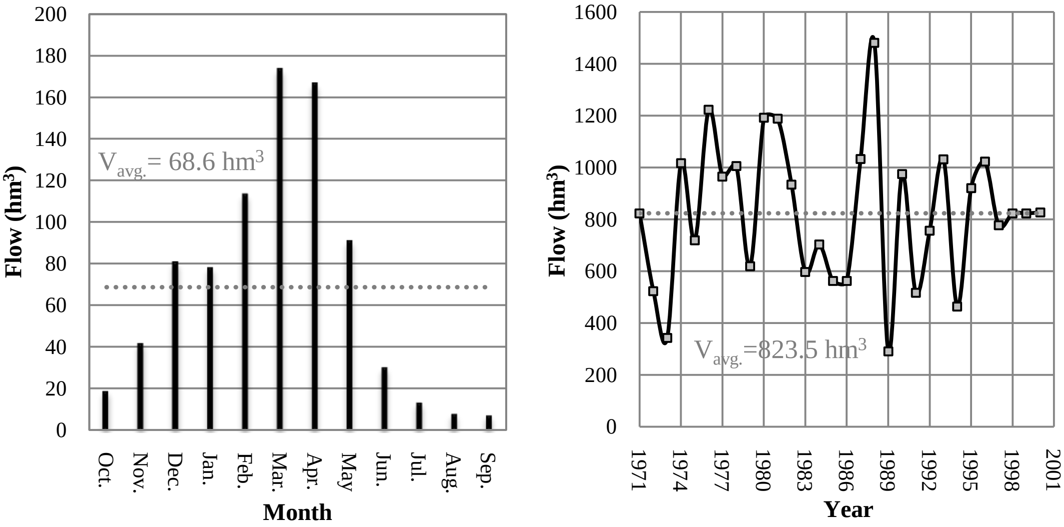


Figure F.96 Monthly Mean and Annual Total Flow Values at Dipni Dam

Table F.21 Monthly Mean Flow Values Released to Downstream of Dipni Dam

Months	Flow Released to Downstream (hm^3)
October	1.4
November	3.5
December	6.6
January	6.8
February	9.3
March	17.3
April	18.5
May	10.4
June	3.0
July	1.3
August	0.7
September	0.7
Total	79.6

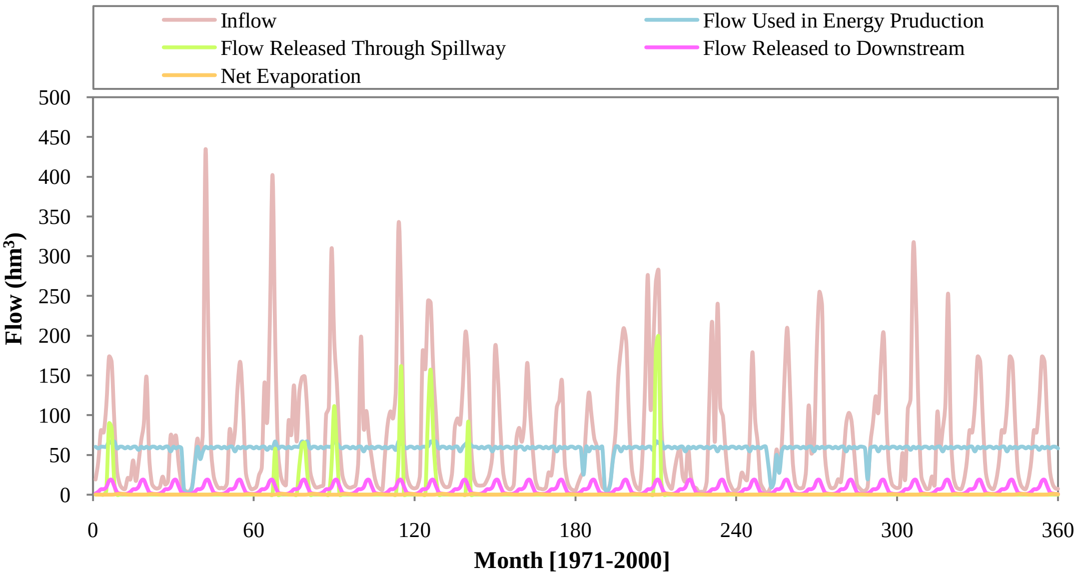


Figure F.97 Operation Study Results of Dipni Dam and HEPP

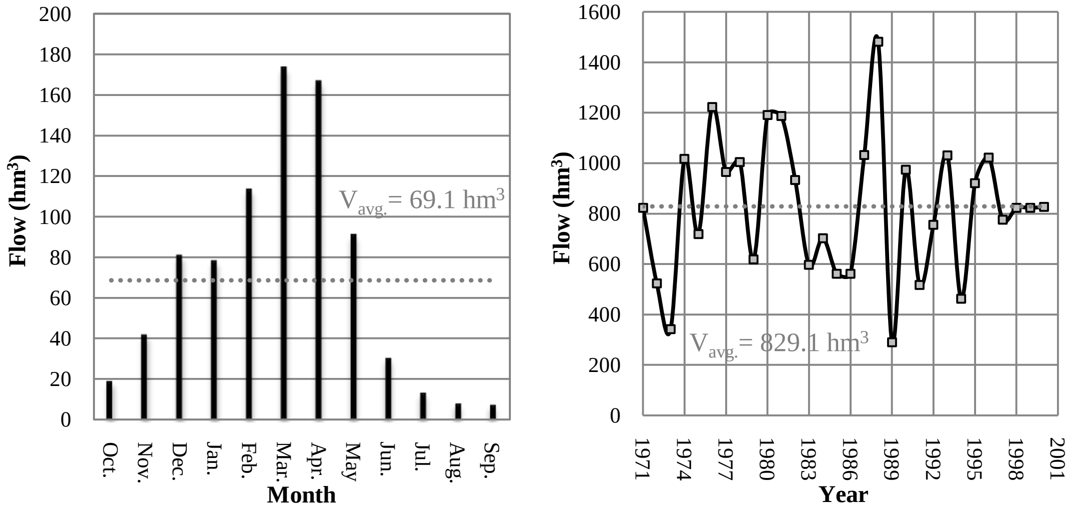


Figure F.98 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Dipni Reservoir

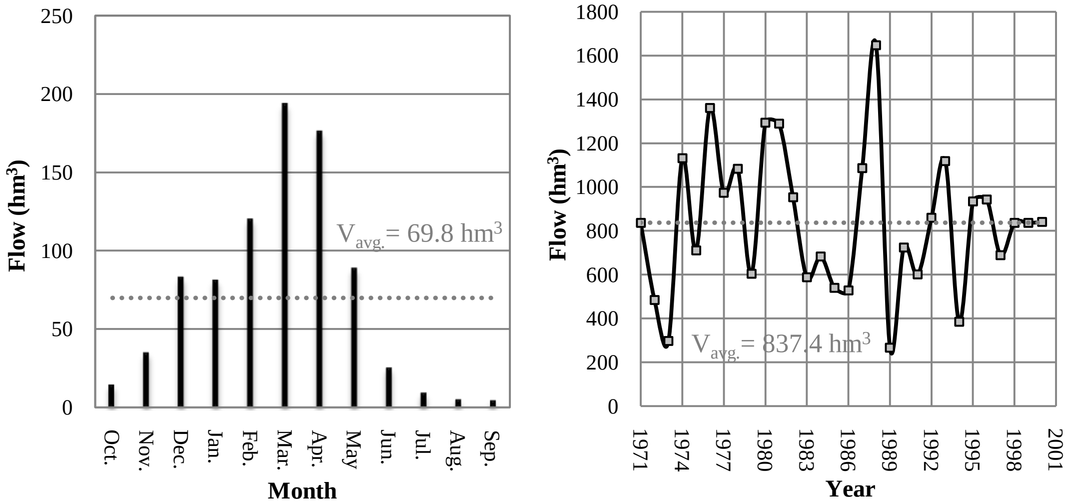


Figure F.99 Monthly Mean and Annual Total Flow Values at Kralkizi Dam

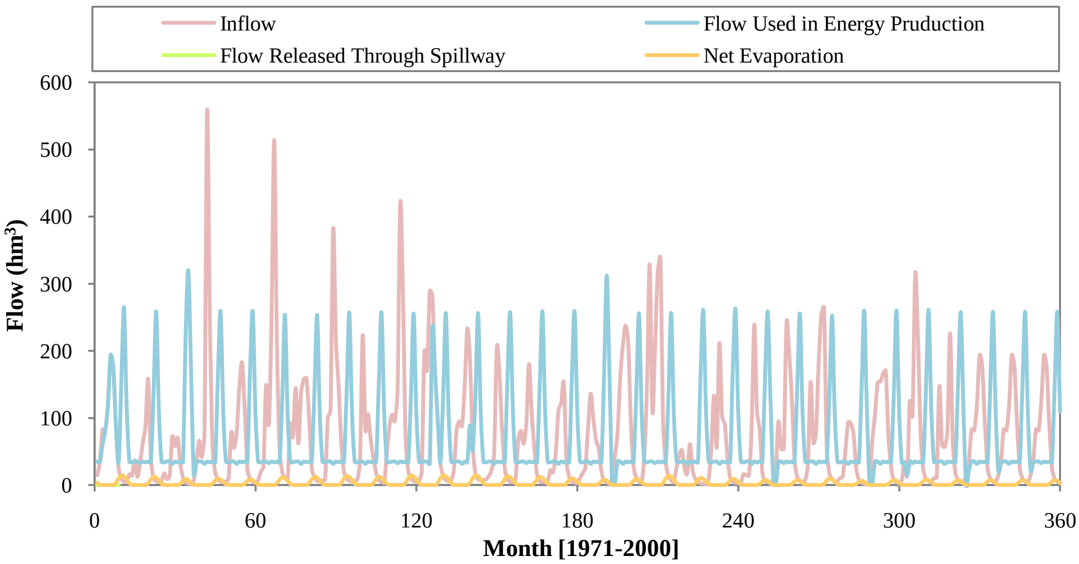


Figure F.100 Operation Study Results of Kralkizi Dam and HEPP

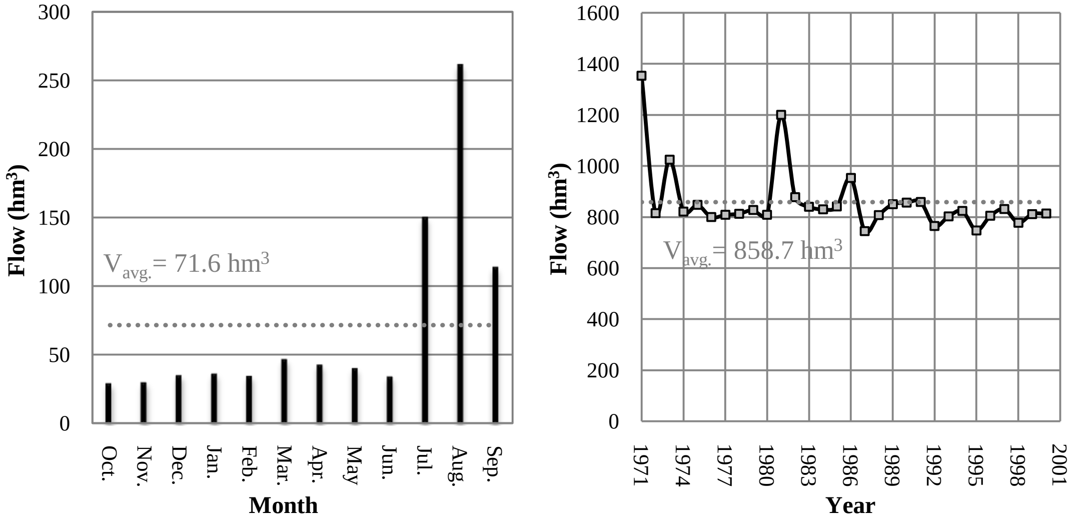


Figure F.101 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Kralkizi Reservoir

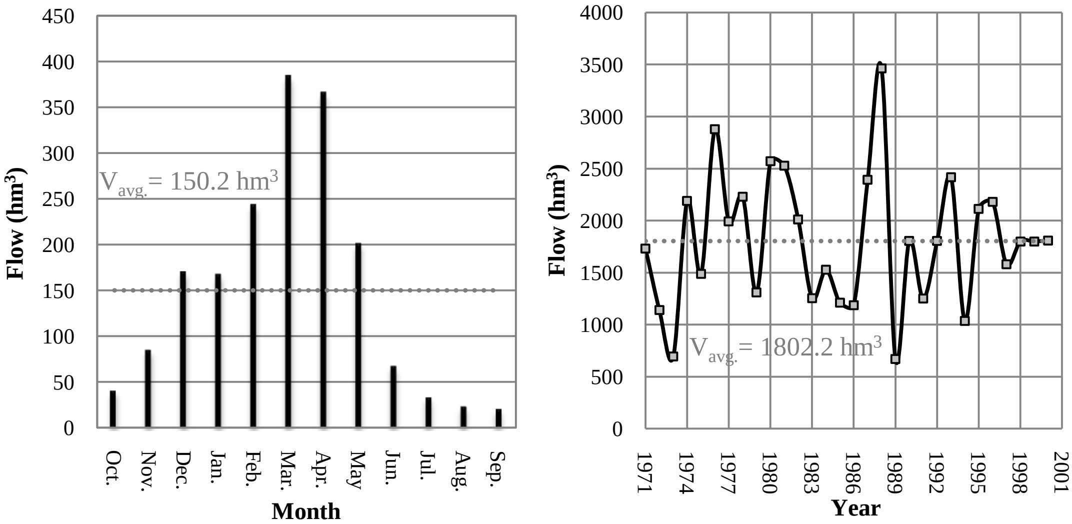


Figure F.102 Monthly Mean and Annual Total Flow Values at Dicle Dam

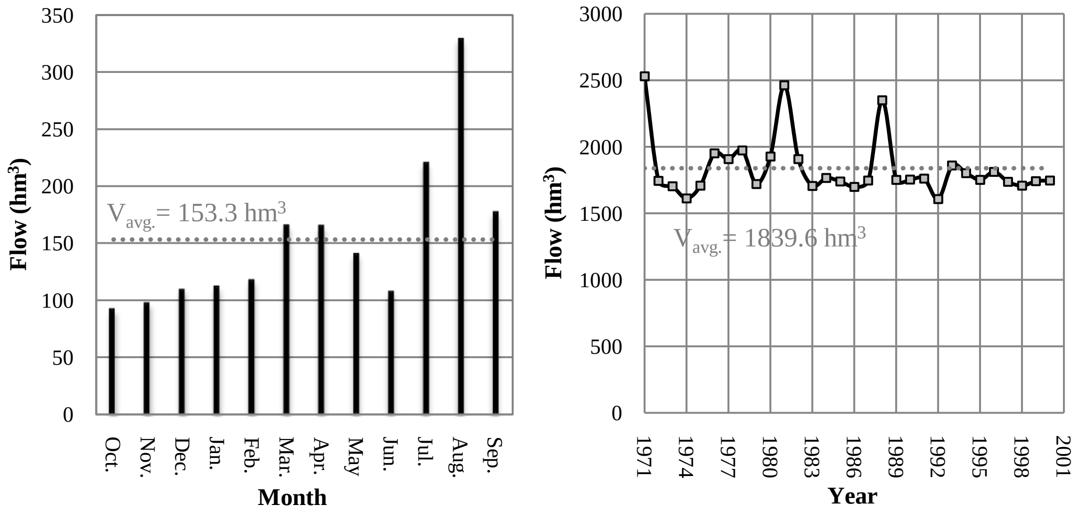


Figure F.103 Monthly Mean and Annual Total Inflow Values in the Operation Study of Dicle Reservoir

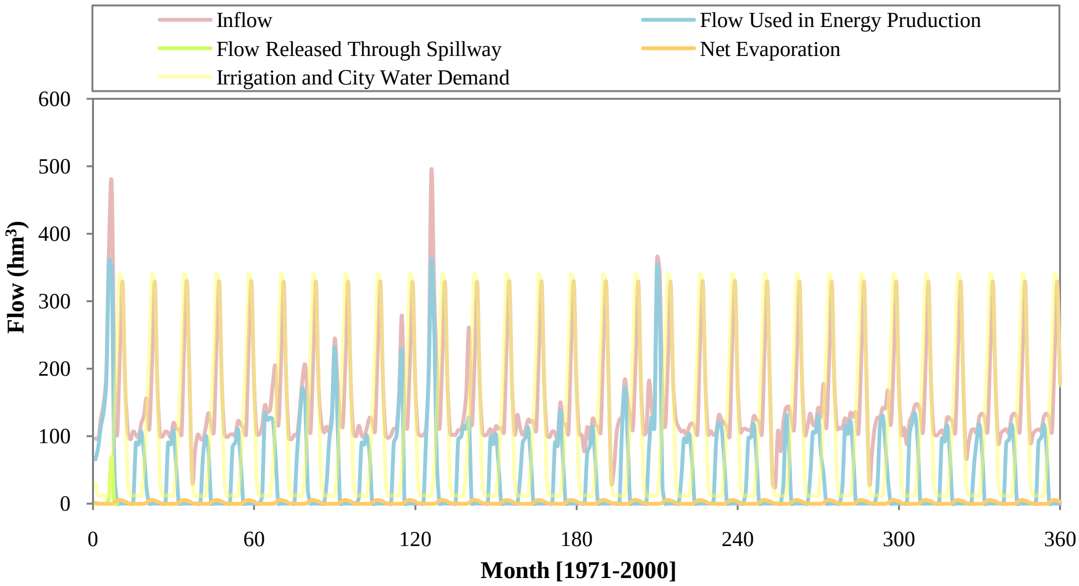


Figure F.104 Operation Study Results of Dicle Dam and HEPP

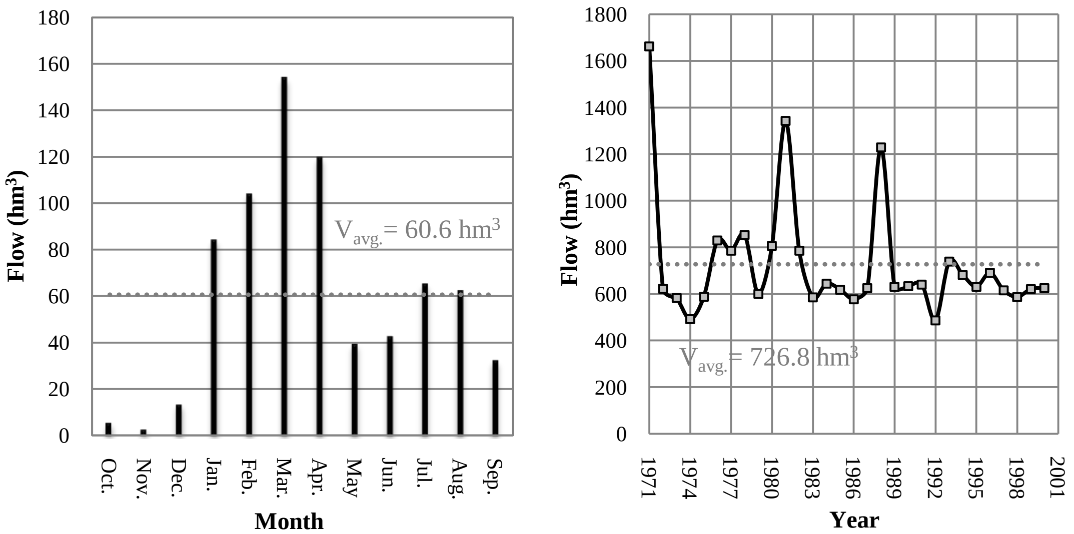


Figure F.105 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Dicle Reservoir (Irrigation return water of the project was added to the outflow values.)

Table F.22 Other Irrigation Projects (DSI, 2010)

Irrigation Projects	Drainage Area (km^2)	Irrigation Area Gross (ha)	Irrigation Area Net (ha)	Used Irrigation Module
Gozegol	156.2	650	550	Tigris
Kabakli	21.5	182	87	Batman - Silvan
Bespinar	733.0	140	121	Tigris
Goksu	672.0	4234	3582	Tigris
Kirkat (Gercus)	40.3	350	348	Tigris

F.3. The Ilisu IV Dam and HEPP Project

F.3.1. Dam Characteristics

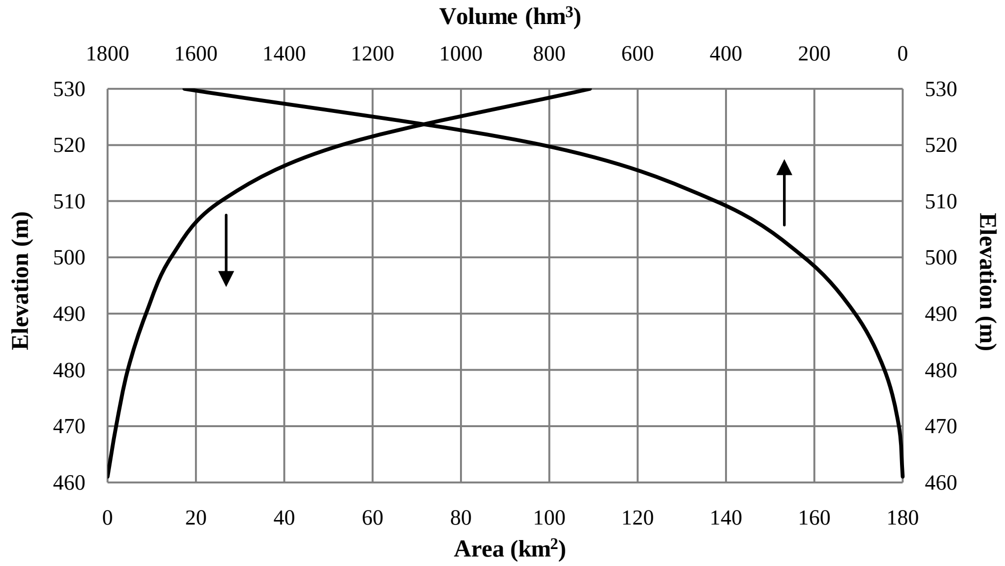


Figure F.106 Volume-Area Curve of Ilisu IV Reservoir

F.3.2. Estimated Evaporation Rates

Table F.23 Monthly Total Net Evaporation Values of Ilisu IV Reservoir

Months	Diyarbakir MS Temp. (°C)	Diyarbakir MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Diyarbakir MS Precip. (mm)	**Net Evap. (mm)**
Jan.	1.7	29.8	2.4	31.0	21.7	74.7	**-**
Feb.	3.5	35.8	4.1	36.5	25.5	67.8	-
Mar.	8.2	82.5	8.9	62.4	43.6	66.8	-
Apr.	13.9	106.9	14.5	113.5	79.5	70.5	**9.0**
May	19.3	177.4	20.0	184.4	129.0	41.5	**87.6**
Jun.	26.1	301.3	26.7	301.6	211.2	7.4	**203.8**
Jul.	31.0	391.7	31.7	407.5	285.3	0.7	**284.5**
Aug.	29.8	367.9	30.5	380.1	266.1	0.6	**265.5**
Sep.	24.9	250.7	25.5	277.7	194.4	3.0	**191.5**
Oct.	17.1	139.8	17.8	153.7	107.6	30.3	**77.3**
Nov.	9.2	53.3	9.9	69.8	48.8	55.4	-
Dec.	4.1	25.4	4.8	39.1	27.4	71.0	-
Σ	-	1962.5	-	2057.3	1440.1	489.5	**1119.1**

F.3.3. Water Resources

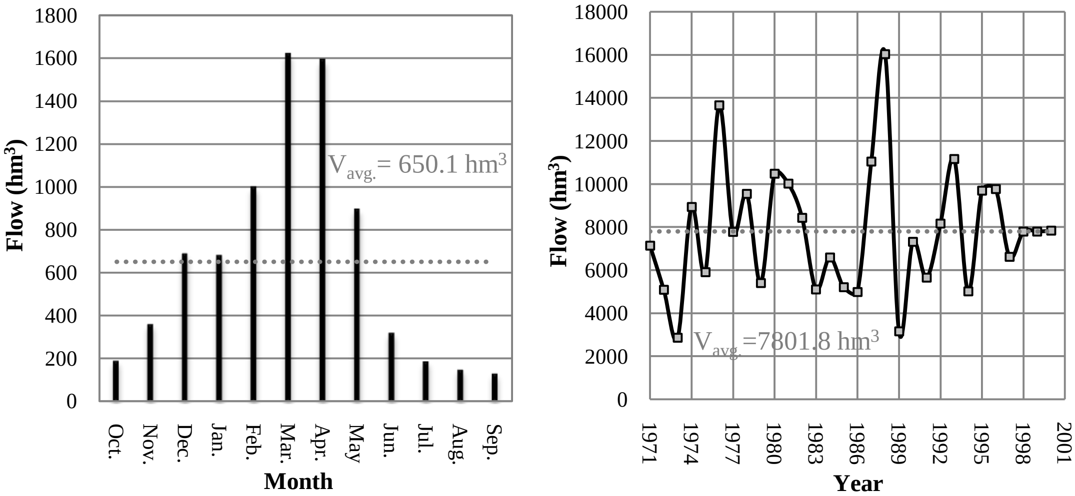


Figure F.107 Monthly Mean and Annual Total Flow Values at Ilisu IV Dam

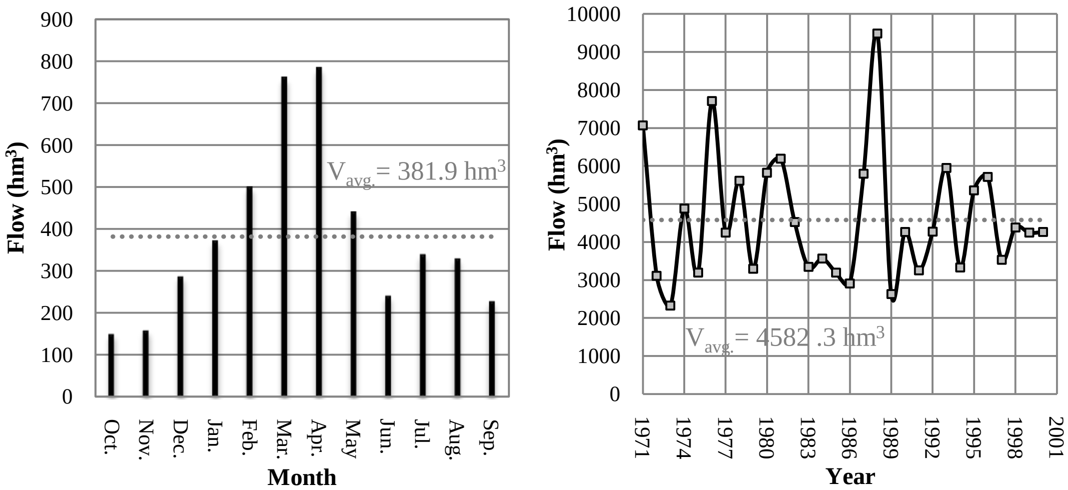


Figure F.108 Monthly Mean and Annual Total Inflow Values in the Operation Study of Ilisu IV Reservoir

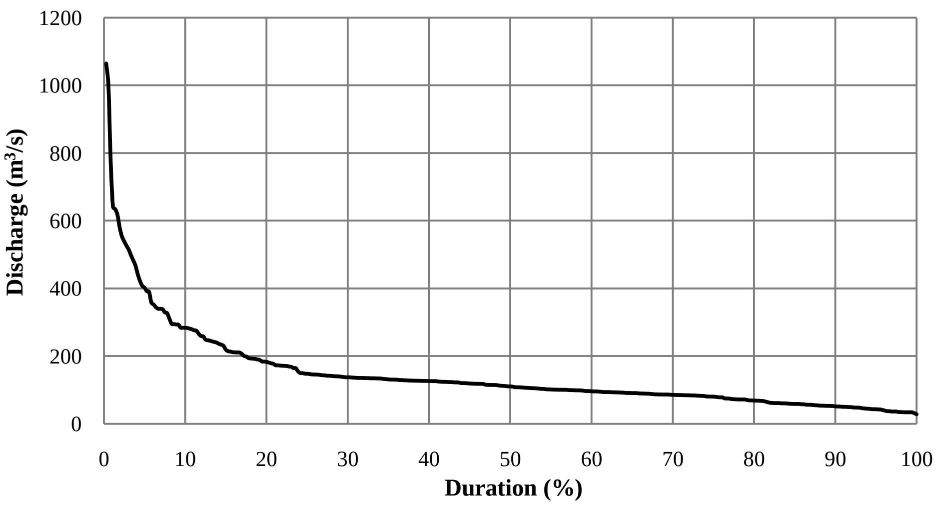


Figure F.109 Discharge-Duration Curve of Ilisu IV Dam and HEPP

F.4. Sediment Transport

Table F.24 Sedimentation of Ilisu IV Reservoir (EIE, 2000)

Sediment Gauging Station	2605 Tigris River - Diyarbakir	
Catchment Area of SGS	2164.2 km^2	
Unit Volume Weight of Sediment	1.35 t/m^3	
Sediment Type Distribution	Clay + Silt: 56.1%	Sand: 43.9%
Suspended Sediment Load	1250 $t/year/km^2$	926 $m^3/year/km^2$
Bed Load (%50 of Suspended Sediment Load)	625 $t/year/km^2$	463 $m^3/year/km^2$
Total Sediment Load	1875 $t/year/km^2$	1389 $m^3/year/km^2$
Catchment Area of Ilisu IV Dam	20353.7 km^2	
Catchment Area of Dicle Dam	3216.0 km^2	
Catchment Area of Devegecidi Dam	1576.0 km^2	
Catchment Area of Gozegol Pond	156.2 km^2	
Catchment Area of Kabakli Pond	21.5 km^2	
Catchment Area of Bespinar Pond	733.0 km^2	
Catchment Area of Goksu Dam	672.0 km^2	
Catchment Area of Kirkat (Gercus) Pond	40.3 km^2	
Catchment Area of Anbar Dam	480.0 km^2	
Catchment Area of Kurucay Dam	122.0 km^2	
Catchment Area of Pamukcay Dam	312.5 km^2	
Catchment Area of Baslar Dam	136.0 km^2	
Catchment Area of Bulaklidere Dam	88.0 km^2	
Catchment Area of Kibris Dam	150.0 km^2	
Catchment Area of Karacalar Dam	32.5 km^2	
Catchment Area of Batman Dam	4105.0 km^2	
Area Contributing to Sediment Transport	8512.7 km^2	
Economic Lifetime Period	50 year	
Volume of Sediment	591 hm^3	
Selected Minimum Water Level	515 m	

F.5. Operation Studies

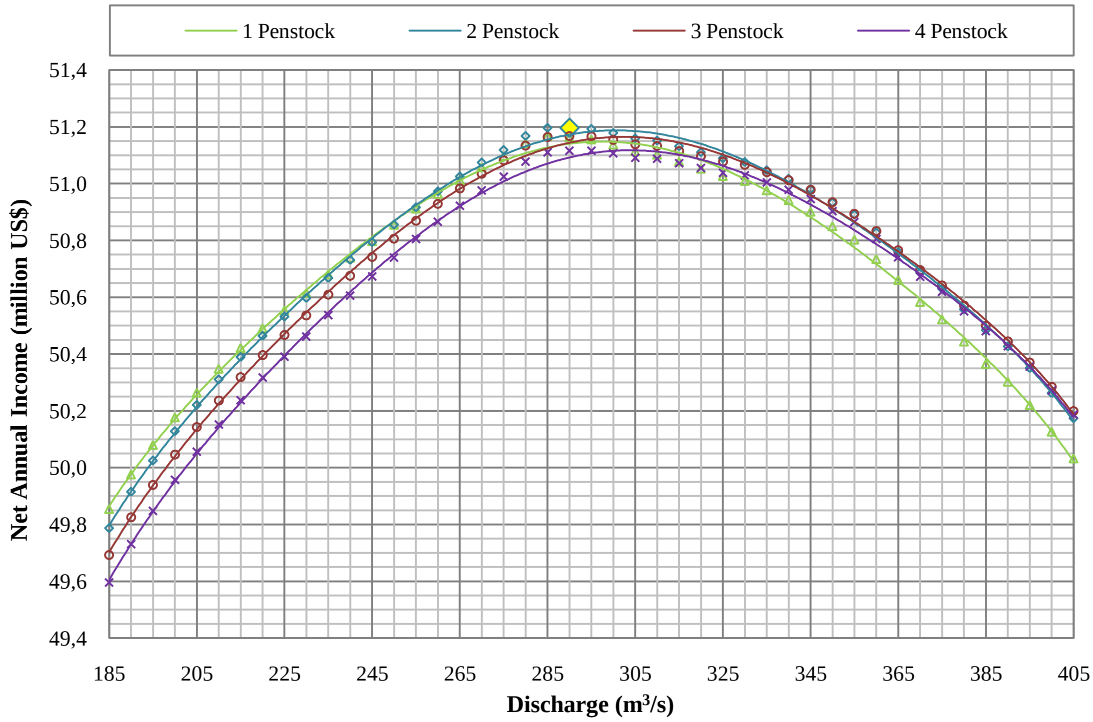


Figure F.110 Determination of Optimum Design Discharge for Ilisu IV HEPP

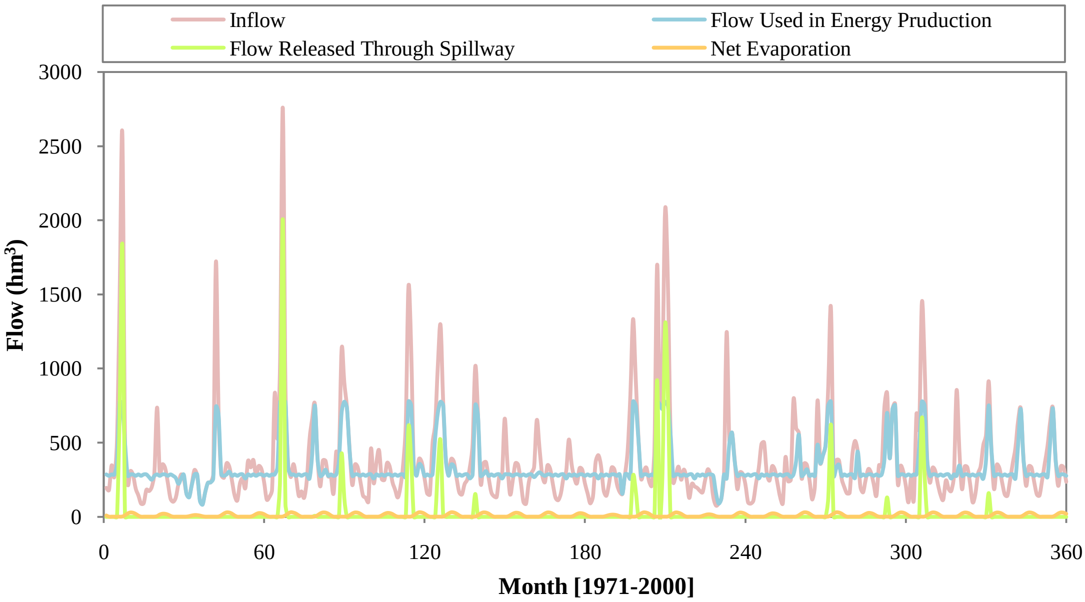


Figure F.111 Operation Study of Ilisu IV Dam and HEPP

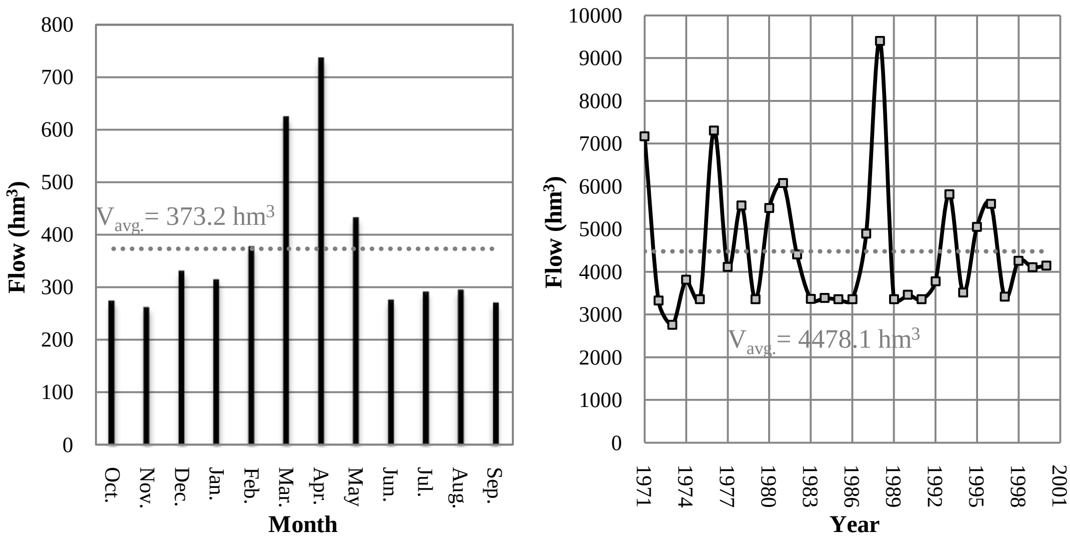


Figure F.112 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Ilisu IV Reservoir

F.6. Flood Analysis

F.6.1. Calculation of Design Floods from Observed Runoff

Table F.25a Annual Instantaneous Max. Flows Observed in the Vicinity of Project Area (DSI, 2007-b; EIE, 2005)

Year	26-01 SGS		26-02 SGS		2618 SGS		2619 SGS		26-08 SGS		26-09 SGS	
	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)	Date	Q (m^3/s)
1946	-	-	-	-	-	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-	-	-	-	-
1951	-	-	-	-	-	-	-	-	-	-	-	-
1952	-	-	-	-	-	-	-	-	-	-	-	-
1953	-	-	-	-	-	-	-	-	-	-	-	-
1954	-	-	-	-	-	-	-	-	-	-	-	-
1955	-	-	-	-	-	-	-	-	-	-	-	-
1956	-	-	-	-	-	-	-	-	-	-	-	-
1957	-	-	-	-	-	-	-	-	-	-	-	-
1958	-	-	-	-	-	-	-	-	-	-	-	-
1959	-	-	-	-	-	-	-	-	-	-	-	-
1960	-	-	-	-	-	-	-	-	-	-	-	-
1961	16.3	410.0	-	-	9.5	29.0	20.1	12.5	-	-	8.2	89.0
1962	20.2	490.0	9.12	570.0	20.2	115.0	20.2	62.0	-	-	29.1	450.0
1963	18.12	600.0	24.1	1100.0	17.4	105.0	-	-	8.5	265.0	26.1	860.0
1964	13.3	740.0	25.3	240.0	13.3	180.0	-	-	19.3	49.0	13.3	260.0
1965	-	-	24.11	270.0	3.4	77.0	9.2	46.0	-	-	-	-
1966	-	-	25.1	430.0	26.1	245.0	26.1	40.0	26.1	500.0	-	-
1967	-	-	17.12	340.0	5.3	85.0	5.3	42.0	14.5	150.0	-	-
1968	-	-	22.12	710.0	2.3	120.0	22.12	60.0	22.12	500.0	-	-
1969	-	-	-	-	22.1	179.0	22.1	43.0	-	-	-	-
1970	-	-	-	-	12.2	104.0	25.1	3.6	23.3	17.0	-	-
1971	-	-	-	-	17.4	90.3	17.4	13.4	27.3	80.0	-	-
1972	-	-	-	-	30.4	332.0	6.5	22.9	30.4	85.0	-	-
1973	-	-	-	-	16.2	10.5	26.2	4.4	26.2	4.0	-	-
1974	-	-	-	-	15.3	299.0	15.3	28.0	15.3	350.0	-	-
1975	-	-	-	-	21.2	343.0	28.2	75.0	21.2	50.0	-	-
1976	-	-	-	-	11.4	744.0	6.4	79.8	-	-	-	-

Table F.25a (continued)

1977	-	-	-	-	24.4	281.0	29.3	21.9	10.12	44.0	-	-
1978	-	-	-	-	17.2	368.0	17.2	69.4	20.1	130.0	-	-
1979	-	-	-	-	19.1	178.0	19.1	62.6	19.1	28.0	-	-
1980	-	-	-	-	2.3	173.0	23.2	23.5	28.3	53.0	-	-
1981	-	-	-	-	19.2	213.0	28.12	57.7	27.12	170.0	-	-
1982	-	-	-	-	2.2	114.0	9.1	102.0	8.1	85.0	-	-
1983	-	-	-	-	5.3	76.0	5.3	23.5	5.3	18.5	-	-
1984	-	-	-	-	24.3	80.6	29.3	3.2	24.3	95.0	-	-
1985	-	-	-	-	15.2	54.0	21.2	9.7	-	-	-	-
1986	-	-	-	-	6.2	105.0	6.2	33.0	-	-	-	-
1987	-	-	-	-	25.3	441.0	26.1	50.8	25.2	100.0	-	-
1988	-	-	-	-	22.12	273.0	-	-	-	-	-	-
1989	-	-	-	-	19.12	42.0	-	-	15.3	43.2	-	-
1990	-	-	-	-	18.2	727.0	-	-	18.2	56.0	-	-
1991	-	-	-	-	21.3	523.0	-	-	23.3	172.0	-	-
1992	-	-	-	-	21.3	196.0	-	-	23.2	56.0	-	-
1993	-	-	-	-	10.3	196.0	-	-	15.12	47.0	-	-
1994	-	-	-	-	27.2	370.0	-	-	31.1	70.0	-	-
1995	-	-	-	-	7.2	140.0	-	-	20.12	152.0	-	-
1996	-	-	-	-	30.3	199.0	-	-	30.3	150.0	-	-
1997	-	-	-	-	13.4	162.0	-	-	29.12	57.6	-	-
1998	-	-	-	-	31.3	253.0	-	-	29.3	60.0	-	-
1999	-	-	-	-	-	-	-	-	1.4	52.0	-	-
2000	-	-	-	-	-	-	-	-	17.2	26.5	-	-
2001	-	-	-	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-	-	-
Distrib.	**Gumbel**		**Pearson Type-3**		**Log-Pearson Type-3**		**Gumbel**		**Log-Pearson Type-3**		**Gumbel**	
Q_2	544.5		461.5		177.6		35.6		79.1		378.8	
$Q_{2.33}$	586.0		513.0		205.4		40.8		94.2		474.9	
Q_5	766.2		741.6		332.9		63.3		174.2		892.4	
Q_{10}	912.9		928.2		437.1		81.6		254.2		1232.4	
Q_{25}	1098.4		1160.8		562.1		104.8		370.8		1662.0	
Q_{50}	1236.0		1330.7		648.0		122.0		466.8		1980.8	
Q_{100}	1372.5		1497.6		727.3		139.0		569.2		2297.1	
Q_{200}	1508.6		1662.4		800.2		156.0		677.7		2612.3	
Q_{500}	1688.1		1878.1		887.7		178.5		829.6		3028.2	
Q_{1000}	1823.7		2040.4		947.6		195.4		950.7		3342.5	

Table F.25b Annual Instantaneous Max. Flows Observed in the Vicinity of Project Area (DSI, 2007-b)

Year	**26-10 SGS**		**26-14 SGS**		**26-16 SGS**		**26-17 SGS**		**26-18 SGS**		**26-19 SGS**	
	Date	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**
1946	-	-	-	-	-	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-	-	-	-	-
1951	-	-	-	-	-	-	-	-	-	-	-	-
1952	-	-	-	-	-	-	-	-	-	-	-	-
1953	-	-	-	-	-	-	-	-	-	-	-	-
1954	-	-	-	-	-	-	-	-	-	-	-	-
1955	-	-	-	-	-	-	-	-	-	-	-	-
1956	-	-	-	-	-	-	-	-	-	-	-	-
1957	-	-	-	-	-	-	-	-	-	-	-	-
1958	-	-	-	-	-	-	-	-	-	-	-	-
1959	-	-	-	-	-	-	-	-	-	-	-	-
1960	-	-	-	-	-	-	-	-	-	-	-	-

Table F.25b (continued)

1961	-	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-
1964	3.3	28.0	-	-	19.3	65.0	-	-	-	-	-	-
1965	7.2	47.0	7.2	6.8	-	-	7.2	24.0	17.4	8.0	9.2	37.0
1966	26.1	100.0	26.1	43.0	-	-	-	-	27.1	3.5	-	-
1967	27.3	39.0	6.3	20.0	13.5	130.0	-	-	9.7	6.8	7.3	14.0
1968	22.12	82.0	2.3	34.0	2.3	135.0	-	-	-	-	-	-
1969	-	-	27.2	100.0	13.1	175.0	26.12	90.0	-	-	17.12	30.0
1970	-	-	-	-	22.3	21.0	11.2	48.0	-	-	-	-
1971	-	-	-	-	4.4	270.0	18.4	13.5	-	-	-	-
1972	-	-	30.4	19.5	30.4	175.0	5.5	38.0	-	-	-	-
1973	-	-	26.2	1.1	15.2	6.1	26.2	7.4	-	-	-	-
1974	-	-	10.4	25.0	15.3	82.0	-	-	-	-	-	-
1975	-	-	22.2	7.0	24.3	180.0	-	-	-	-	-	-
1976	-	-	20.3	40.0	-	-	-	-	-	-	-	-
1977	-	-	29.3	15.0	-	-	-	-	-	-	-	-
1978	-	-	17.2	33.0	-	-	-	-	-	-	-	-
1979	-	-	19.1	4.8	-	-	-	-	-	-	-	-
1980	-	-	3.4	34.0	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	24.3	9.0	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-	-	-
Distrib.	**Gumbel**		**Log-Pearson Type-3**		**Pearson Type-3**		**Log-Pearson Type-3**		**Gumbel**		**Gumbel**	
Q_{2}	55.7		19.7		122.0		28.0		5.9		25.9	
$Q_{2.33}$	63.8		23.8		136.5		32.8		6.6		29.7	
Q_{5}	99.2		43.3		191.7		58.3		10.0		46.6	
Q_{10}	128.1		59.9		229.3		83.9		12.7		60.4	
Q_{25}	164.5		80.0		270.3		122.1		16.1		77.8	
Q_{50}	191.6		93.6		297.3		154.3		18.7		90.6	
Q_{100}	218.4		105.9		321.8		189.6		21.2		103.4	
Q_{200}	245.1		116.9		344.5		227.9		23.7		116.2	
Q_{500}	280.4		129.6		372.5		283.5		27.0		133.0	
Q_{1000}	307.1		137.9		392.3		329.3		29.6		145.7	

Table F.25c Annual Instantaneous Max. Flows Observed in the Vicinity of Project Area (DSI, 2007-b)

Year	**26-25 SGS**		**26-26 SGS**		**26-32 SGS**		**26-35 SGS**		**26-39 SGS**		**26-42 SGS**	
	Date	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**
1946	-	-	-	-	-	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-	-	-	-	-
1951	-	-	-	-	-	-	-	-	-	-	-	-
1952	-	-	-	-	-	-	-	-	-	-	-	-
1953	-	-	-	-	-	-	-	-	-	-	-	-
1954	-	-	-	-	-	-	-	-	-	-	-	-
1955	-	-	-	-	-	-	-	-	-	-	-	-
1956	-	-	-	-	-	-	-	-	-	-	-	-
1957	-	-	-	-	-	-	-	-	-	-	-	-
1958	-	-	-	-	-	-	-	-	-	-	-	-
1959	-	-	-	-	-	-	-	-	-	-	-	-
1960	-	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	-	-	-	-	-	-
1973	25.2	23.0	8.3	3.7	-	-	-	-	-	-	-	-
1974	-	-	15.3	23.0	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-
1977	29.10	48.0	8.2	25.0	-	-	-	-	-	-	-	-
1978	17.2	85.0	-	-	-	-	-	-	20.1	22.0	17.2	210.0
1979	-	-	-	-	-	-	3.1	75.0	19.1	22.0	26.3	80.0
1980	-	-	-	-	3.4	44.0	23.10	76.0	26.10	22.0	-	-
1981	-	-	-	-	8.1	52.0	-	-	-	-	16.3	70.0
1982	-	-	-	-	-	-	28.12	68.0	3.2	62.0	7.4	105.0
1983	-	-	-	-	-	-	-	-	16.3	22.0	-	-
1984	-	-	-	-	-	-	-	-	24.3	62.0	-	-
1985	-	-	-	-	20.2	20.0	-	-	31.5	43.0	4.4	90.0
1986	-	-	-	-	-	-	-	-	6.2	41.0	16.4	63.0
1987	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	7.11	120.0	19.10	32.2	-	-
1990	-	-	-	-	-	-	18.2	830.0	11.12	77.0	19.2	118.0
1991	-	-	-	-	-	-	23.3	440.0	23.3	68.0	16.5	120.0
1992	-	-	-	-	-	-	21.3	210.0	21.3	40.8	13.4	93.2
1993	-	-	-	-	-	-	-	-	10.5	49.5	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	6.3	240.0	-	-	-	-
1997	-	-	-	-	-	-	22.2	390.0	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	20.2	31.9	-	-
2001	-	-	-	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-	-	-
Distrib.	**Gumbel**		**Gumbel**		**Gumbel**		**Pearson Type-3**		**Gumbel**		**Log-Pearson Type-3**	
Q_2	49.0		16.1		37.1		211.4		39.9		93.4	

Table F.25c (continued)

$Q_{2.33}$	59.3	20.0	42.5	252.0	43.8	99.4
Q_{5}	103.9	36.8	66.4	440.5	60.9	129.6
Q_{10}	140.3	50.5	85.8	601.6	74.8	159.6
Q_{25}	186.3	67.9	110.4	808.7	92.4	205.7
Q_{50}	220.4	80.7	128.6	963.4	105.4	246.6
Q_{100}	254.2	93.5	146.6	1117.7	118.4	294.0
Q_{200}	287.9	106.2	164.6	1271.9	131.3	349.1
Q_{500}	332.4	123.0	188.4	1476.2	148.3	436.1
Q_{1000}	366.1	135.7	206.3	1631.5	161.1	514.7

Table F.25d Annual Instantaneous Max. Flows Observed in the Vicinity of Project Area (DSI, 2007-b)

Year	**26-46 SGS**		**26-50 SGS**		**26-52 SGS**		**26-60 SGS**		**26-61 SGS**		**26-63 SGS**	
	Date	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**
1946	-	-	-	-	-	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-	-	-	-	-
1951	-	-	-	-	-	-	-	-	-	-	-	-
1952	-	-	-	-	-	-	-	-	-	-	-	-
1953	-	-	-	-	-	-	-	-	-	-	-	-
1954	-	-	-	-	-	-	-	-	-	-	-	-
1955	-	-	-	-	-	-	-	-	-	-	-	-
1956	-	-	-	-	-	-	-	-	-	-	-	-
1957	-	-	-	-	-	-	-	-	-	-	-	-
1958	-	-	-	-	-	-	-	-	-	-	-	-
1959	-	-	-	-	-	-	-	-	-	-	-	-
1960	-	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-
1978	8.2	420.0	-	-	-	-	-	-	-	-	-	-
1979	16.12	420.0	-	-	5.4	125.0	-	-	-	-	-	-
1980	26.10	420.0	-	-	28.3	860.0	-	-	-	-	-	-
1981	-	-	27.12	480.0	-	-	-	-	-	-	-	-
1982	-	-	8.1	480.0	-	-	-	-	-	-	-	-
1983	-	-	21.3	150.0	20.5	580.0	-	-	-	-	-	-
1984	-	-	24.11	420.0	18.11	660.0	-	-	-	-	-	-
1985	-	-	20.3	510.0	15.2	220.0	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-
1989	21.10	305.0	-	-	27.3	46.0	15.12	2.5	19.10	250.0	-	-
1990	-	-	-	-	-	-	19.2	52.0	27.11	765.0	-	-
1991	-	-	-	-	-	-	23.3	29.0	16.5	850.0	23.3	66.0
1992	9.5	470.0	-	-	-	-	26.10	54.0	-	-	12.12	50.0
1993	-	-	-	-	-	-	-	-	-	-	7.3	66.0
1994	-	-	-	-	-	-	-	-	-	-	30.1	90.0

Table F.25d (continued)

1995	-	-	-	-	-	-	-	-	-	-	14.4	74.0
1996	-	-	-	-	-	-	-	-	-	-	30.3	71.0
1997	-	-	-	-	-	-	-	-	-	-	12.12	22.0
1998	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	29.4	11.7	-	-	16.2	35.6
2001	-	-	-	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-	-	-
Distrib.	**Log-Pearson Type-3**		**Pearson Type-3**		**Gumbel**		**Gumbel**		**Gumbel**		**Pearson Type-3**	
Q_2	420.4		451.3		374.9		27.1		590.3		61.4	
$Q_{2.33}$	430.3		470.8		458.2		33.3		697.3		65.2	
Q_5	459.3		522.5		820.4		60.3		1162.2		78.2	
Q_{10}	472.1		541.7		1115.4		82.3		1540.8		86.0	
Q_{25}	480.9		552.4		1488.1		110.0		2019.2		93.5	
Q_{50}	484.4		555.6		1764.6		130.6		2374.1		97.9	
Q_{100}	486.3		556.8		2039.1		151.1		2726.4		101.6	
Q_{200}	487.3		557.1		2312.6		171.4		3077.4		104.8	
Q_{500}	487.8		557.1		2673.3		198.3		3540.5		108.5	
Q_{1000}	487.9		557.5		2946.0		218.6		3890.4		110.8	

Table F.25e Annual Instantaneous Max. Flows Observed in the Vicinity of Project Area (DSI, 2007-b; EIE, 2005)

Year	**26-64 SGS**		**2602 SGS**		**2605 SGS**		**2612 SGS**	
	Date	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**
1946	-	-	2.1	1421.0	22.4	776.0	-	-
1947	-	-	14.3	946.0	23.2	728.0	-	-
1948	-	-	29.4	1536.0	30.4	1072.0	-	-
1949	-	-	13.4	1327.0	31.3	382.0	-	-
1950	-	-	6.3	1603.0	25.2	640.0	-	-
1951	-	-	23.1	840.0	26.4	560.0	-	-
1952	-	-	4.2	1857.0	4.2	2156.0	-	-
1953	-	-	10.2	1241.0	-	-	-	-
1954	-	-	6.4	1278.0	-	-	-	-
1955	-	-	1.5	1010.0	1.5	599.0	-	-
1956	-	-	16.12	1060.0	30.1	1054.0	-	-
1957	-	-	4.3	2063.0	26.2	1770.0	-	-
1958	-	-	6.4	1137.0	10.1	1014.0	-	-
1959	-	-	6.4	516.0	9.12	464.0	-	-
1960	-	-	1.4	940.0	6.3	761.0	-	-
1961	-	-	9.5	304.0	20.1	463.0	16.3	497.0
1962	-	-	20.2	1180.0	20.2	1055.0	20.2	1039.0
1963	-	-	12.4	2606.0	26.1	1963.0	-	-
1964	-	-	12.4	2806.0	13.3	1533.0	-	-
1965	-	-	-	-	3.4	786.0	29.4	645.0
1966	-	-	-	-	26.1	2640.0	26.1	1766.0
1967	-	-	14.5	1476.0	21.4	1470.0	14.5	1156.0
1968	-	-	22.12	2750.0	22.12	1940.0	22.12	2300.0
1969	-	-	-	-	22.1	1976.0	17.12	1729.0
1970	-	-	-	-	13.2	941.0	14.2	912.0
1971	-	-	-	-	28.3	1217.0	17.4	897.0
1972	-	-	-	-	1.6	1084.0	30.4	2411.0
1973	-	-	-	-	26.2	326.0	15.2	463.0
1974	-	-	-	-	15.3	3248.0	16.3	1461.0
1975	-	-	-	-	1.5	675.0	1.5	1482.0
1976	-	-	-	-	12.4	1966.0	12.4	1482.0
1977	-	-	-	-	24.4	1156.0	10.12	959.0
1978	-	-	-	-	17.2	1847.0	17.2	1611.0

Table F.25e (continued)

1979	-	-	-	-	19.1	1018.0	16.12	2660.0
1980	-	-	-	-	26.3	930.0	26.10	1841.0
1981	-	-	-	-	26.12	2633.0	15.3	1629.0
1982	-	-	-	-	27.4	1536.0	27.4	1236.0
1983	-	-	-	-	17.3	405.0	17.5	707.0
1984	-	-	-	-	24.3	1248.0	18.11	1975.0
1985	-	-	-	-	21.3	538.0	2.4	784.0
1986	-	-	-	-	6.2	645.0	16.4	1088.0
1987	-	-	-	-	25.3	1311.0	13.4	1904.0
1988	-	-	-	-	23.12	2864.0	14.4	2125.0
1989	-	-	-	-	15.3	288.0	30.1	419.0
1990	-	-	-	-	18.2	2888.0	27.11	1508.0
1991	-	-	-	-	5.3	1194.0	23.3	1151.0
1992	20.3	27.0	-	-	21.3	511.0	13.4	936.0
1993	7.3	30.0	-	-	15.12	1073.0	2.5	1114.0
1994	16.2	16.4	-	-	27.2	720.0	31.3	448.0
1995	-	-	-	-	15.4	634.0	3.5	1110.0
1996	-	-	-	-	9.2	798.0	9.2	764.0
1997	-	-	-	-	9.4	702.0	25.12	889.0
1998	-	-	-	-	-	-	30.3	1343.0
1999	-	-	-	-	-	-	2.4	1015.0
2000	-	-	-	-	-	-	9.4	455.0
2001	-	-	-	-	-	-	?	1525.0
2002	-	-	-	-	-	-	?	792.0
2003	-	-	-	-	-	-	?	511.0
2004	-	-	-	-	-	-	?	604.0
2005	-	-	-	-	-	-	14.3	533.0
2006	-	-	-	-	-	-	18.4	1097.0

Distribution	**Gumbel**	**Log-Normal (2 parameter)**	**Log-Pearson Type-3**	**Gumbel**
Q_2	23.8	1286.5	1005.5	1114.3
$Q_{2.33}$	26.1	1394.1	1119.8	1220.3
Q_5	36.4	1879.0	1675.8	1680.7
Q_{10}	44.7	2290.4	2194.2	2055.7
Q_{25}	55.2	2829.3	2929.8	2529.6
Q_{50}	63.0	3242.3	3534.6	2881.1
Q_{100}	70.8	3665.5	4187.2	3230.0
Q_{200}	78.5	4099.4	4892.1	3577.6
Q_{500}	88.7	4692.0	5911.2	4036.3
Q_{1000}	96.4	5168.9	6753.3	4382.9

Table F.25f Annual Instantaneous Max. Flows Observed in the Vicinity of Project Area (EIE, 2005)

Year	**2617 SGS**		**2632 SGS**		**2611 SGS**		**2606 SGS**	
	Date	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**	**Date**	**Q (m^3/s)**
1946	-	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-
1951	-	-	-	-	-	-	-	-
1952	-	-	-	-	-	-	-	-
1953	-	-	-	-	-	-	-	-
1954	-	-	-	-	-	-	-	-
1955	-	-	-	-	2.5	2154.0	-	-
1956	-	-	-	-	12.4	2245.0	-	-
1957	-	-	-	-	5.3	6040.0	-	-
1958	-	-	-	-	25.3	1763.0	-	-
1959	-	-	-	-	17.4	1455.0	-	-
1960	-	-	-	-	27.4	1752.0	-	-
1961	-	-	-	-	9.5	972.0	-	-
1962	-	-	-	-	21.2	2263.0	-	-

Table F.25f (continued)

1963	-	-	-	-	-	-	-	-
1964	-	-	-	-	2.4	1879.0	-	-
1965	-	-	-	-	29.4	2000.0	-	-
1966	-	-	-	-	27.1	7900.0	-	-
1967	-	-	-	-	14.5	3888.0	-	-
1968	-	-	-	-	23.12	3937.0	-	-
1969	-	-	-	-	-	-	28.8	6450.0
1970	-	-	-	-	-	-	27.2	2250.0
1971	-	-	-	-	-	-	11.6	3450.0
1972	30.4	429.0	-	-	1.5	4973.0	26.5	5260.0
1973	25.2	132.0	-	-	13.5	867.0	20.8	963.0
1974	15.3	1294.0	-	-	16.3	5380.0	20.10	5772.0
1975	21.12	521.0	-	-	22.2	1555.0	14.1	2571.0
1976	12.4	640.0	-	-	-	-	25.5	6355.0
1977	16.10	455.0	-	-	-	-	2.7	2740.0
1978	17.2	742.0	-	-	-	-	1.3	426.0
1979	3.1	486.0	-	-	-	-	12.2	1870.0
1980	25.3	627.0	-	-	-	-	24.5	4162.0
1981	27.12	1935.0	-	-	-	-	30.10	3591.0
1982	26.4	1259.0	-	-	-	-	19.1	3672.0
1983	8.4	167.0	-	-	-	-	22.6	2000.0
1984	24.3	411.0	-	-	-	-	14.9	3180.0
1985	2.4	265.0	-	-	-	-	10.9	4271.0
1986	6.2	300.0	-	-	-	-	26.8	1700.0
1987	25.3	392.0	-	-	-	-	2.3	4445.0
1988	23.12	1147.0	-	-	-	-	29.5	7820.0
1989	16.3	244.0	15.3	198.0	-	-	19.10	1023.0
1990	18.2	702.0	-	-	-	-	26.11	5079.0
1991	5.3	525.0	5.3	743.0	-	-	26.1	4044.0
1992	9.5	231.0	21.3	163.0	-	-	20.3	3367.0
1993	16.12	604.0	15.12	407.0	-	-	7.8	4237.0
1994	26.2	314.0	27.2	404.0	-	-	-	-
1995	19.4	210.0	14.4	390.0	-	-	-	-
1996	18.3	366.0	9.2	345.0	-	-	-	-
1997	13.12	285.0	7.4	355.0	-	-	-	-
1998	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	3.4	2650.0
2002	-	-	-	-	-	-	17.4	2299.0
2003	-	-	-	-	-	-	14.4	3027.0
2004	-	-	-	-	-	-	12.4	4486.0
2005	-	-	-	-	-	-	5.12	1435.0
2006	-	-	-	-	-	-	16.8	2055.0

Distribution	**Log-Pearson Type-3**	**Log-Normal (3 parameter)**	**Log-Pearson Type-3**	**Log-Normal (3 parameter)**
Q_{2}	440.2	349.9	2400.8	3299.5
$Q_{2.33}$	495.0	379.9	2691.0	3610.2
Q_{5}	780.4	506.8	4182.6	4847.8
Q_{10}	1073.7	606.4	5685.4	5745.8
Q_{25}	1531.9	728.6	7987.9	6777.7
Q_{50}	1943.5	817.3	10020.9	7486.1
Q_{100}	2421.3	904.6	12347.5	8154.7
Q_{200}	2975.2	990.8	15008.0	8790.9
Q_{500}	3843.1	1104.0	19111.9	9593.7
Q_{1000}	4618.1	1191.8	22722.5	10193.9

F.6.1.1. Point Flood Frequency Analysis

Table F.26 Point Flood Frequency Analysis Results of Ilisu IV Dam

Return Period	2605 Tigris-Diyarbakir SGS	Ilisu IV Dam
	Flood Discharge (m^3/s)	
2	1005.5	2361.5
2.33	1119.8	2629.8
5	1675.8	3935.6
10	2194.2	5153.2
25	2929.8	6880.7
50	3534.6	8301.2
100	4187.2	9833.8
200	4892.1	11489.3
500	5911.2	13882.7
1000	6753.3	15860.4

F.6.1.2. Regional Flood Frequency Analysis

Table F.27 Data for Homogeneity Test

Unit: m^3/s

SGS	Q_2	$Q_{2.33}$	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	Q_{1000}
26-01	544.5	586.0	766.2	912.9	1098.4	1236.0	1372.5	1508.6	1688.1	1823.7
26-02	461.5	513.0	741.6	928.2	1160.8	1330.7	1497.6	1662.4	1878.1	2040.4
2618	177.6	205.4	332.9	437.1	562.1	648.0	727.3	800.2	887.7	947.6
2619	35.6	40.8	63.3	81.6	104.8	122.0	139.0	156.0	178.5	195.4
26-08	79.1	94.2	174.2	254.2	370.8	466.8	569.2	677.7	829.6	950.7
26-09	378.8	474.9	892.4	1232.4	1662.0	1980.8	2297.1	2612.3	3028.2	3342.5
26-10	55.7	63.8	99.2	128.1	164.5	191.6	218.4	245.1	280.4	307.1
26-14	19.7	23.8	43.3	59.9	80.0	93.6	105.9	116.9	129.6	137.9
26-16	122.0	136.5	191.7	229.3	270.3	297.3	321.8	344.5	372.5	392.3
26-17	28.0	32.8	58.3	83.9	122.1	154.3	189.6	227.9	283.5	329.3
26-18	5.9	6.6	10.0	12.7	16.1	18.7	21.2	23.7	27.0	29.6
26-19	25.9	29.7	46.6	60.4	77.8	90.6	103.4	116.2	133.0	145.7
26-25	49.0	59.3	103.9	140.3	186.3	220.4	254.2	287.9	332.4	366.1
26-26	16.1	20.0	36.8	50.5	67.9	80.7	93.5	106.2	123.0	135.7
26-32	37.1	42.5	66.4	85.8	110.4	128.6	146.6	164.6	188.4	206.3
26-35	211.4	252.0	440.5	601.6	808.7	963.4	1117.7	1271.9	1476.2	1631.5
26-39	39.9	43.8	60.9	74.8	92.4	105.4	118.4	131.3	148.3	161.1
26-42	93.4	99.4	129.6	159.6	205.7	246.6	294.0	349.1	436.1	514.7
26-46	420.4	430.3	459.3	472.1	480.9	484.4	486.3	487.3	487.8	487.9
26-50	451.3	470.8	522.5	541.7	552.4	555.6	556.8	557.1	557.1	557.5
26-52	374.9	458.2	820.4	1115.4	1488.1	1764.6	2039.1	2312.6	2673.3	2946.0
26-60	27.1	33.3	60.3	82.3	110.0	130.6	151.1	171.4	198.3	218.6
26-61	590.3	697.3	1162.2	1540.8	2019.2	2374.1	2726.4	3077.4	3540.5	3890.4
26-63	61.4	65.2	78.2	86.0	93.5	97.9	101.6	104.8	108.5	110.8
26-64	23.8	26.1	36.4	44.7	55.2	63.0	70.8	78.5	88.7	96.4
2602	1286.5	1394.1	1879.0	2290.4	2829.3	3242.3	3665.5	4099.4	4692.0	5168.9
2605	1005.5	1119.8	1675.8	2194.2	2929.8	3534.6	4187.2	4892.1	5911.2	6753.3
2612	1114.3	1220.3	1680.7	2055.7	2529.6	2881.1	3230.0	3577.6	4036.3	4382.9
2617	440.2	495.0	780.4	1073.7	1531.9	1943.5	2421.3	2975.2	3843.1	4618.1
2632	349.9	379.9	506.8	606.4	728.6	817.3	904.6	990.8	1104.0	1191.8
2611	2400.8	2691.0	4182.6	5685.4	7987.9	10020.9	12347.5	15008.0	19111.9	22722.5
2606	3299.5	3610.2	4847.8	5745.8	6777.7	7486.1	8154.7	8790.9	9593.7	10193.9

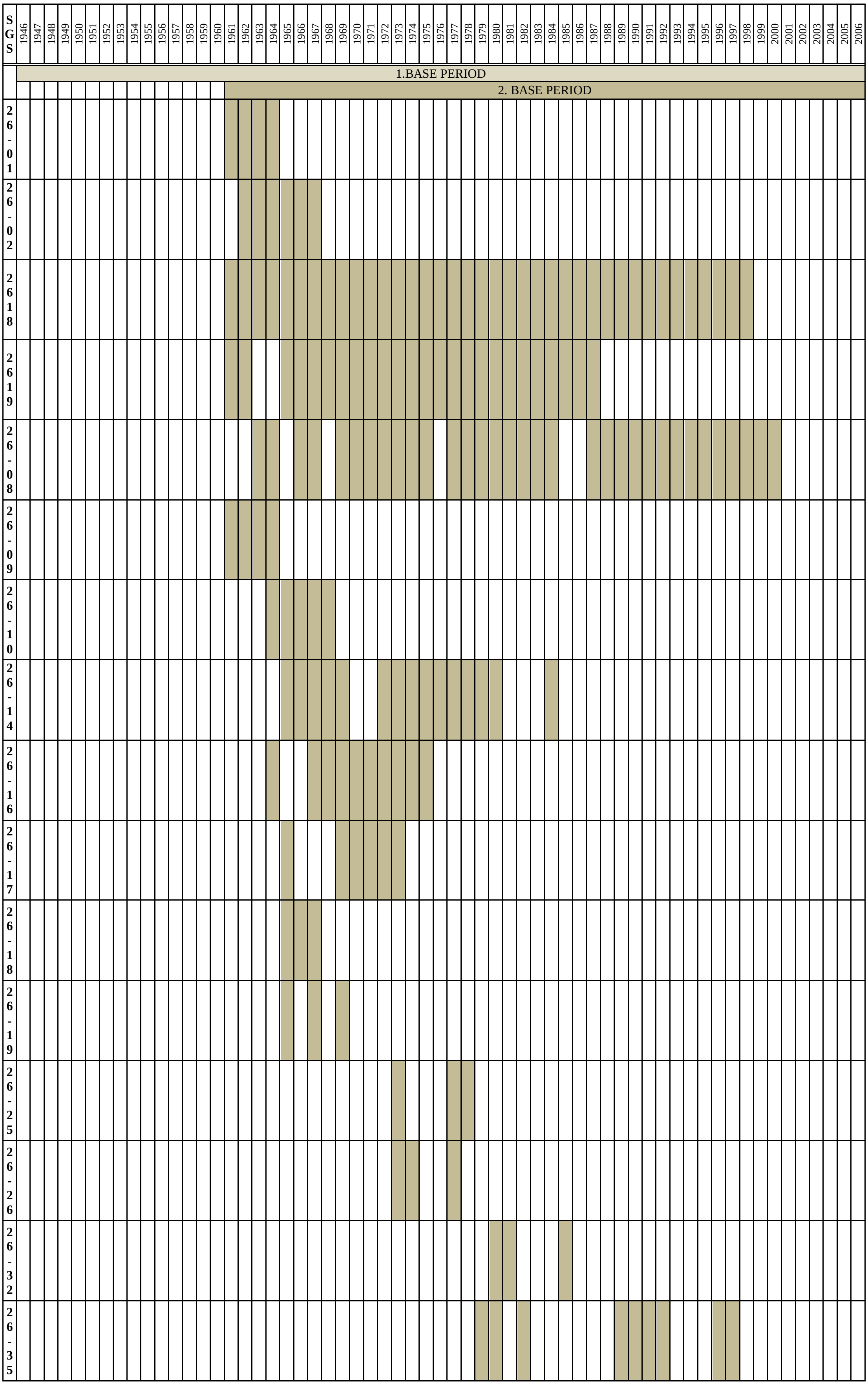


Figure F.113a Observation Periods of Stream Gauging Stations

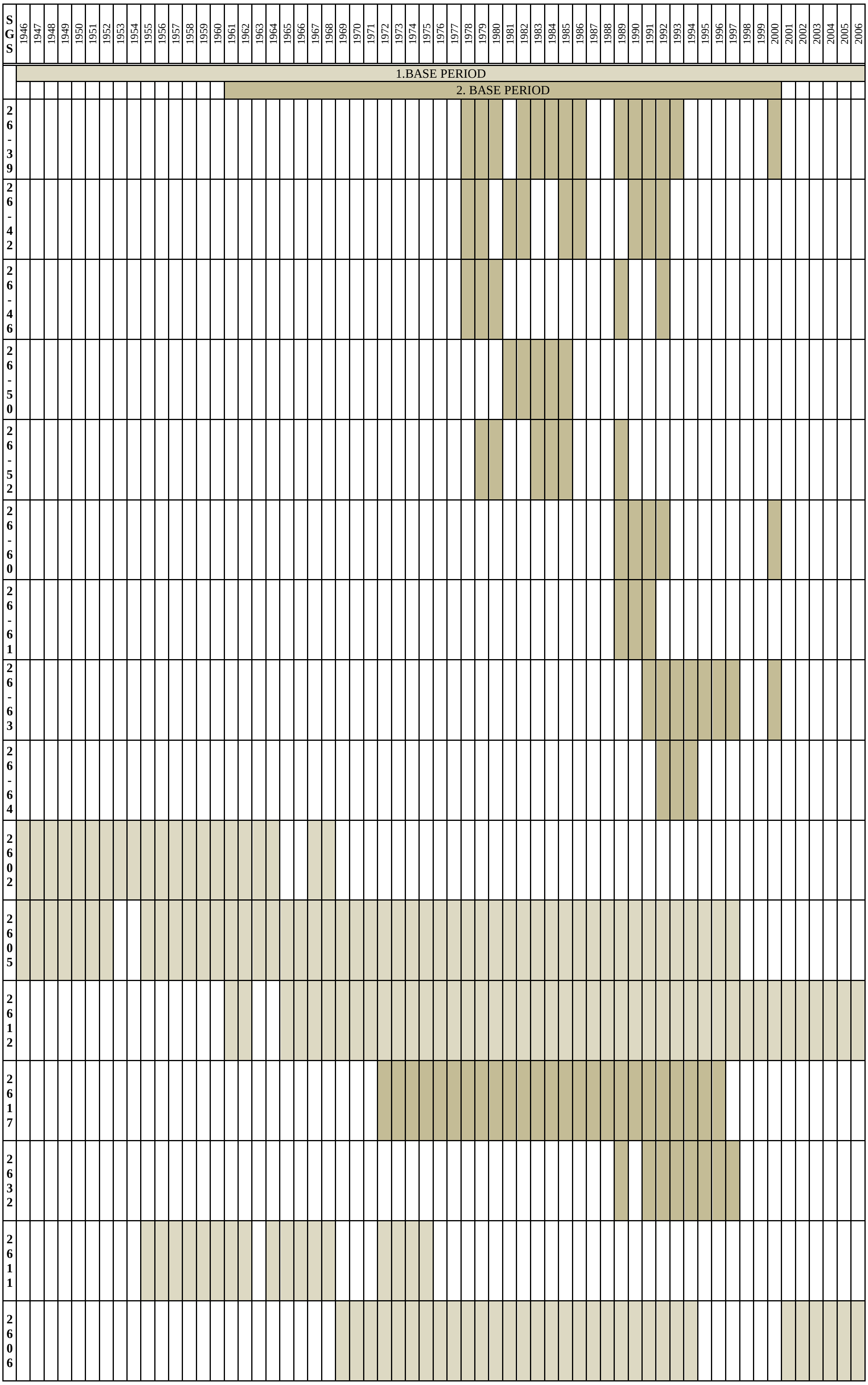


Figure F.113b Observation Periods of Stream Gauging Stations

Table F.28 1. Base Period (1946-2006) Homogeneity Test Table

SGS	$Q_{2.33}$	Q_{10}	$Q_{10}/Q_{2.33}$	Avg.x$Q_{2.33}$	Return Period	Obser. Period	Adjusted Re. Period
2602	1394.1	2290.4	1.6	2507.0	16.0	21.0	41.0
2605	1119.8	2194.2	2.0	2013.6	8.3	50.0	55.5
2612	1220.3	2055.7	1.7	2194.5	14.4	44.0	22.0
2611	2691.0	5685.4	2.1	4839.1	7.2	17.0	8.5
2606	3610.2	5745.8	1.6	6492.2	20.9	31.0	15.5
		Average	1.8				

Table F.29 2. Base Period (1961-2000) Homogeneity Test Table

SGS	$Q_{2.33}$	Q_{10}	$Q_{10}/Q_{2.33}$	Avg.x$Q_{2.33}$	Return Period	Obser. Period	Adjusted Re. Period
26-01	586.0	912.9	1.6	1177.7	39.4	4	22.0
26-02	513.0	928.2	1.8	1031.0	16.6	7	23.5
2618	205.4	437.1	2.1	412.8	8.8	38	39.0
2619	40.8	81.6	2.0	81.9	10.2	25	32.5
26-08	94.2	254.2	2.7	189.4	6.0	32	36.0
26-09	474.9	1232.4	2.6	954.5	5.9	4	22.0
26-10	63.8	128.1	2.0	128.2	10.1	5	22.5
26-14	23.8	59.9	2.5	47.8	6.3	15	27.5
26-16	136.5	229.3	1.7	274.3	28.7	10	25.0
26-17	32.8	83.9	2.6	66.0	6.5	6	23.0
26-18	6.6	12.7	1.9	13.4	12.9	3	21.5
26-19	29.7	60.4	2.0	59.8	9.8	3	21.5
26-25	59.3	140.3	2.4	119.1	7.1	3	21.5
26-26	20.0	50.5	2.5	40.1	6.2	3	21.5
26-32	42.5	85.8	2.0	85.5	9.9	3	21.5
26-35	252.0	601.6	2.4	506.5	7.0	9	24.5
26-39	43.8	74.8	1.7	88.0	21.3	14	27.0
26-42	99.4	159.6	1.6	199.8	23.1	9	24.5
26-46	430.3	472.1	1.1	864.8	>100	5	-
26-50	470.8	541.7	1.2	946.3	>100	5	-
26-52	458.2	1115.4	2.4	921.0	6.7	6	23.0
26-60	33.3	82.3	2.5	67.0	6.5	5	22.5
26-61	697.3	1540.8	2.2	1401.5	8.2	3	21.5
26-63	65.2	86.0	1.3	131.0	>100	8	-
26-64	26.1	44.7	1.7	52.5	16.3	3	21.5
2617	495.0	1073.7	2.2	994.8	8.7	26	33.0
2632	379.9	606.4	1.6	763.5	34.8	8	24.0
		Average	2.01				

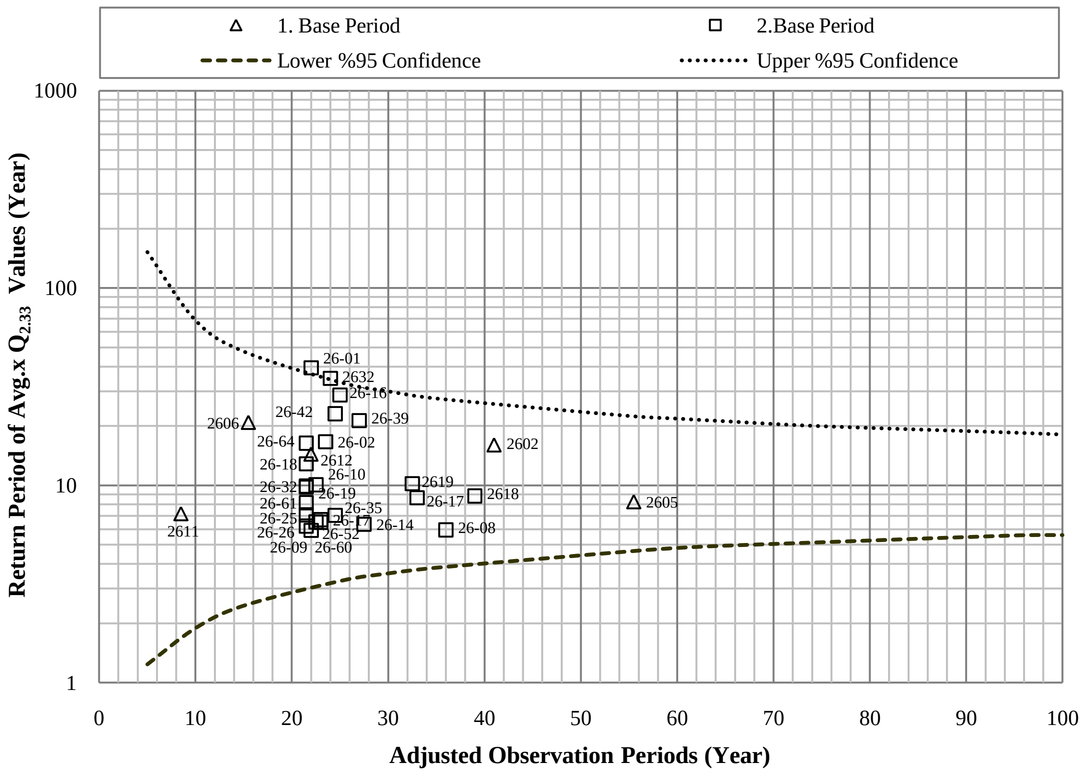


Figure F.114 Homogeneity Test Graph

Table F.30 Dimensionless Regional Flood Frequency Analysis

Unit: m^3/s

SGS	Q_2	$Q_{2.33}$	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	Q_{1000}
26-02	0.9	1.0	1.4	1.8	2.3	2.6	2.9	3.2	3.7	4.0
2618	0.9	1.0	1.6	2.1	2.7	3.2	3.5	3.9	4.3	4.6
2619	0.9	1.0	1.6	2.0	2.6	3.0	3.4	3.8	4.4	4.8
26-08	0.8	1.0	1.8	2.7	3.9	5.0	6.0	7.2	8.8	10.1
26-09	0.8	1.0	1.9	2.6	3.5	4.2	4.8	5.5	6.4	7.0
26-10	0.9	1.0	1.6	2.0	2.6	3.0	3.4	3.8	4.4	4.8
26-14	0.8	1.0	1.8	2.5	3.4	3.9	4.5	4.9	5.5	5.8
26-16	0.9	1.0	1.4	1.7	2.0	2.2	2.4	2.5	2.7	2.9
26-17	0.9	1.0	1.8	2.6	3.7	4.7	5.8	6.9	8.6	10.0
26-18	0.9	1.0	1.5	1.9	2.4	2.8	3.2	3.6	4.1	4.4
26-19	0.9	1.0	1.6	2.0	2.6	3.0	3.5	3.9	4.5	4.9
26-25	0.8	1.0	1.8	2.4	3.1	3.7	4.3	4.9	5.6	6.2
26-26	0.8	1.0	1.8	2.5	3.4	4.0	4.7	5.3	6.2	6.8
26-32	0.9	1.0	1.6	2.0	2.6	3.0	3.4	3.9	4.4	4.8
25-35	0.8	1.0	1.7	2.4	3.2	3.8	4.4	5.0	5.9	6.5
26-39	0.9	1.0	1.4	1.7	2.1	2.4	2.7	3.0	3.4	3.7
26-42	0.9	1.0	1.3	1.6	2.1	2.5	3.0	3.5	4.4	5.2
26-52	0.8	1.0	1.8	2.4	3.2	3.9	4.4	5.0	5.8	6.4
26-60	0.8	1.0	1.8	2.5	3.3	3.9	4.5	5.1	5.9	6.6
26-61	0.8	1.0	1.7	2.2	2.9	3.4	3.9	4.4	5.1	5.6
26-64	0.9	1.0	1.4	1.7	2.1	2.4	2.7	3.0	3.4	3.7
2602	0.9	1.0	1.3	1.6	2.0	2.3	2.6	2.9	3.4	3.7
2605	0.9	1.0	1.5	2.0	2.6	3.2	3.7	4.4	5.3	6.0
2612	0.9	1.0	1.4	1.7	2.1	2.4	2.6	2.9	3.3	3.6
2617	0.9	1.0	1.6	2.2	3.1	3.9	4.9	6.0	7.8	9.3
2611	0.9	1.0	1.6	2.1	3.0	3.7	4.6	5.6	7.1	8.4
2606	0.9	1.0	1.3	1.6	1.9	2.1	2.3	2.4	2.7	2.8
Avg.	0.9	1.0	1.6	2.1	2.8	3.3	3.8	4.3	5.1	5.7

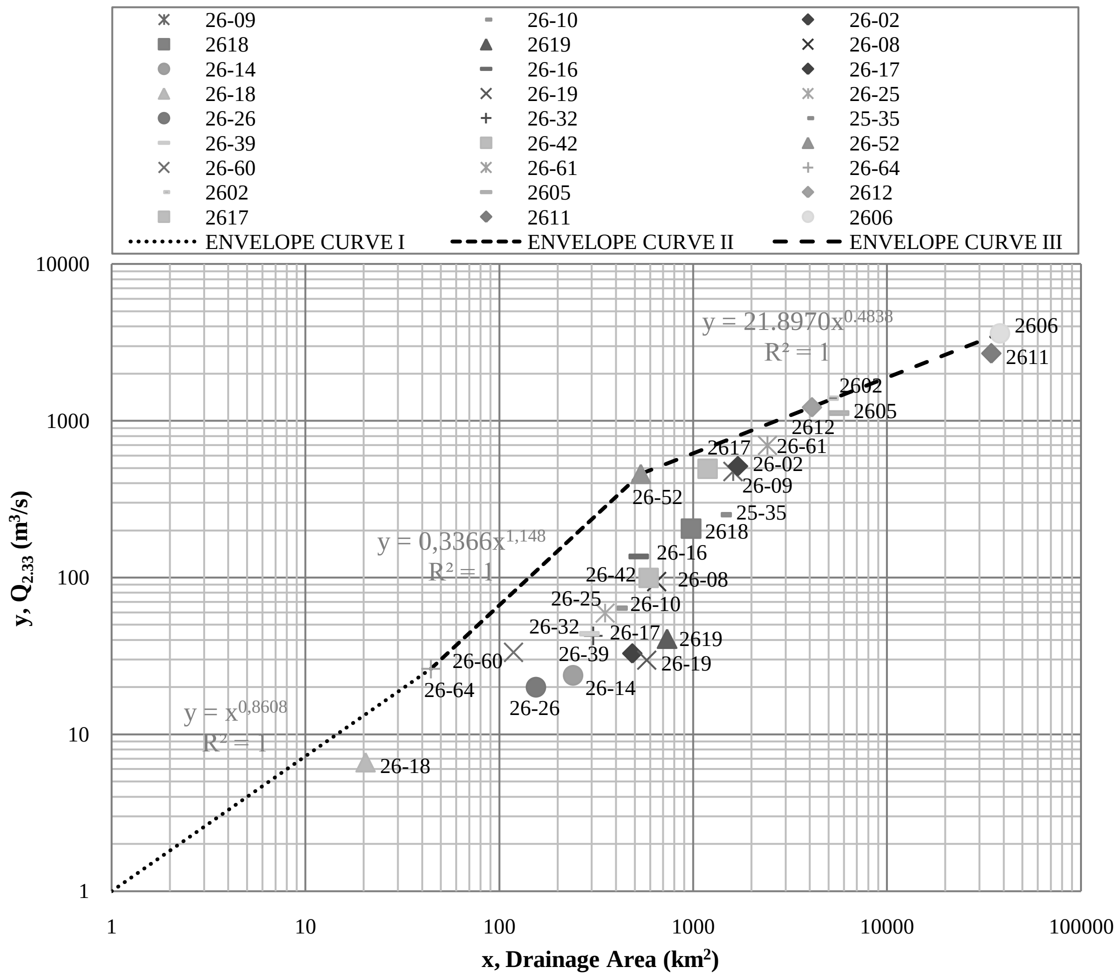


Figure F.115 Regional Flood Envelope Curve

Table F.31 Regional Flood Frequency Analysis Results of Ilisu IV Dam

Return Period	Ilisu IV Dam Flood Discharge (m^3/s)
2	2314.2
2.33	2660.2
5	4229.1
10	5570.1
25	7332.6
50	8688.5
100	10078.2
200	11510.6
500	13482.8
1000	15045.4

F.6.2. Flood Recurrences Calculated Using Snyder Synthetic Unit Hydrograph Method

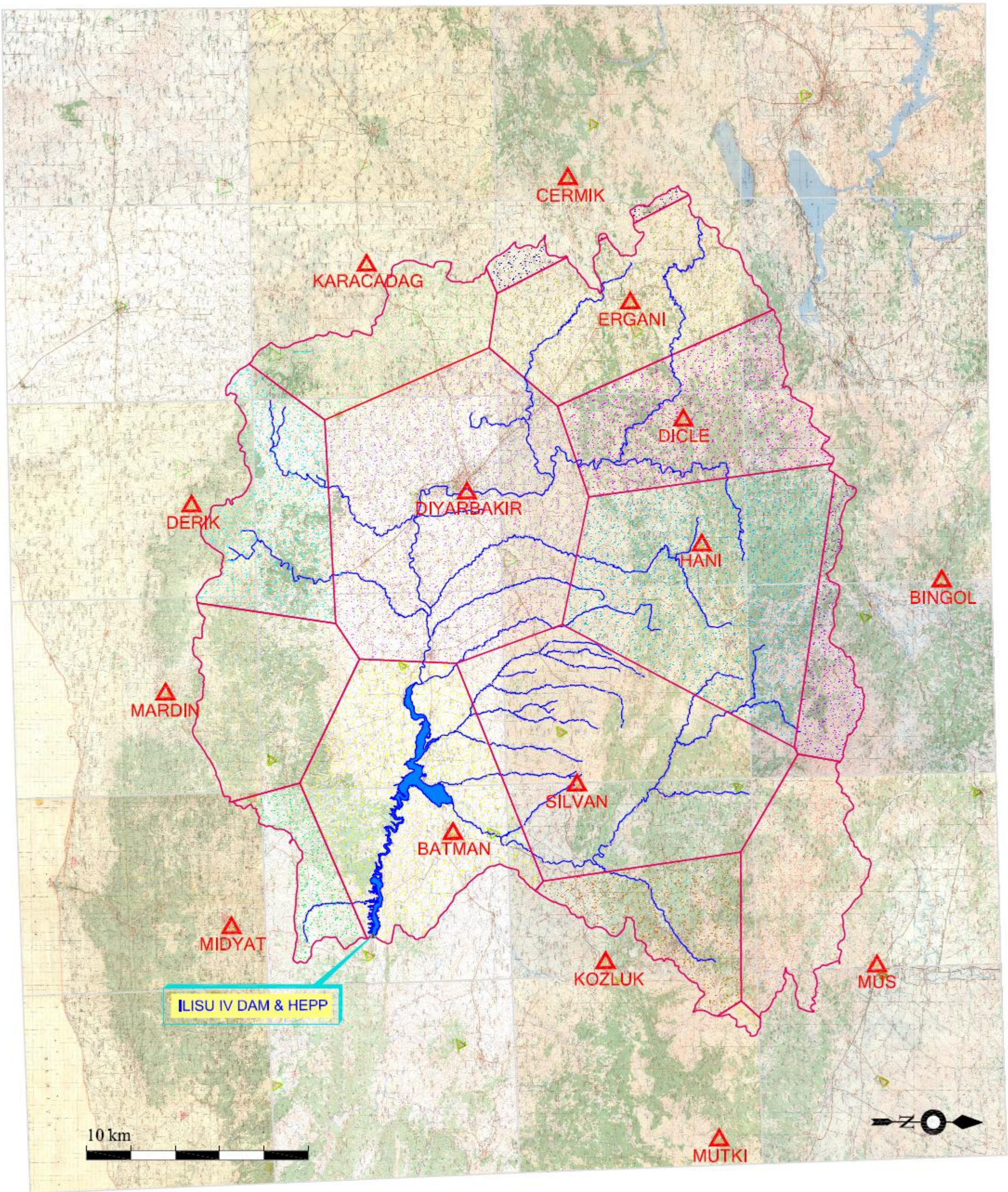


Figure F.116 Thiessen Polygons of Ilisu IV Drainage Area

Table F.32a Annual Daily Max. Precipitations Observed in the Vicinity of Project Area (DMI, 2009-b)

Year	Mutki MS	Kozluk MS	Batman MS	Mus MS	Silvan MS	Midyat MS	Mardin MS	Derik MS
	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)	P (mm)
1929	-	-	-	-	-	-	-	-
1930	-	-	-	-	-	-	-	-
1931	-	-	-	-	-	-	-	-
1932	-	-	-	-	-	-	-	-
1933	-	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-	-
1935	-	-	-	67.2	-	-	-	-
1936	-	-	-	58.8	-	-	-	-
1937	-	-	-	45.7	-	-	-	-
1938	-	-	-	63.3	-	-	-	-
1939	-	-	-	45.7	-	-	38.0	-
1940	-	-	-	97.7	-	-	38.8	-
1941	-	-	-	73.4	-	-	45.8	-
1942	-	-	-	52.1	-	-	69.2	-
1943	-	-	-	33.8	-	-	28.6	-
1944	-	-	-	45.3	-	-	63.7	-
1945	-	-	-	40.7	-	-	50.1	-
1946	-	-	-	70.0	-	-	41.7	-
1947	-	-	-	43.5	-	-	83.5	-
1948	-	-	-	-	-	-	80.5	-
1949	-	-	-	-	-	-	69.0	-
1950	-	-	-	72.3	-	-	44.6	-
1951	-	-	-	61.7	-	-	70.8	-
1952	-	-	-	72.2	50.5	-	80.4	-
1953	-	-	-	52.7	53.1	60.3	40.4	-
1954	-	-	-	62.7	41.6	70.2	71.9	-
1955	-	-	-	59.1	57.0	-	79.0	-
1956	-	-	-	44.1	52.6	-	59.0	-
1957	80.3	-	-	50.3	39.6	-	82.5	-
1958	83.9	-	-	41.3	58.4	-	35.4	-
1959	53.2	-	44.6	91.3	43.8	47.3	40.6	-
1960	48.6	-	25.2	39.8	-	-	41.4	-
1961	88.6	-	-	53.3	42.2	-	66.8	-
1962	63.2	-	47.8	63.3	40.3	35.7	38.1	-
1963	64.7	-	57.1	-	64.4	46.2	67.0	72.6
1964	59.4	109.4	25.5	30.9	-	40.2	46.7	28.5
1965	94.3	70.0	25.5	62.3	-	27.6	40.0	79.6
1966	73.7	-	31.9	44.2	45.8	34.5	90.6	62.4
1967	93.2	94.3	49.4	61.6	-	56.3	113.2	61.8
1968	82.4	89.6	59.3	39.4	-	45.5	1.4	67.5
1969	73.4	92.1	28.6	38.6	-	48.5	54.1	51.3
1970	46.3	51.5	29.1	29.4	-	20.5	36.2	32.2
1971	98.4	52.1	17.7	71.0	-	43.2	54.0	34.2
1972	67.2	52.3	50.0	38.3	-	50.6	53.1	53.9
1973	46.2	27.5	19.8	29.7	-	26.2	36.8	23.4
1974	51.9	37.9	23.5	33.2	81.6	-	57.8	64.7
1975	48.6	49.2	47.5	41.8	54.6	-	65.6	55.1
1976	64.7	70.3	39.5	73.9	58.2	-	66.7	118.2
1977	75.3	33.2	27.1	48.3	42.4	29.0	41.6	52.1
1978	64.3	68.3	36.1	47.2	39.2	85.3	94.0	57.4
1979	58.9	52.9	37.1	35.4	62.4	37.0	83.0	51.3
1980	45.7	42.8	21.0	50.4	31.3	37.5	40.2	51.4
1981	65.9	60.4	33.1	70.0	44.6	25.0	54.4	40.7
1982	-	73.1	24.3	35.9	66.9	49.0	145.9	63.9
1983	-	57.2	45.5	43.0	48.3	22.0	46.5	36.4
1984	-	55.2	20.4	27.0	45.9	37.2	33.2	39.8
1985	-	75.4	50.9	37.6	48.0	63.4	73.7	83.2
1986	-	48.5	18.0	29.9	42.2	32.0	46.6	35.9
1987	46.3	56.3	30.1	45.8	60.3	36.4	77.9	59.4
1988	-	76.8	52.0	41.9	42.9	24.6	112.2	85.9
1989	-	59.9	40.1	44.2	52.6	22.0	45.4	49.2
1990	-	49.6	34.0	40.5	48.0	30.4	28.8	41.0
1991	-	43.5	42.0	52.8	33.5	38.0	41.9	54.5
1992	-	46.7	21.5	53.9	38.1	51.2	42.7	79.8
1993	-	61.7	63.4	77.8	-	87.3	57.0	54.0

Table F.32a (continued)

1994	-	-	40.4	54.0	-	51.2	56.4	42.6
1995	-	-	20.2	51.9	-	-	52.2	-
1996	-	-	39.7	43.2	-	-	42.0	-
1997	-	-	29.8	36.0	-	-	65.7	-
1998	-	-	22.4	53.2	-	-	30.9	-
1999	-	-	69.2	38.3	-	-	59.1	-
2000	-	-	31.0	41.0	-	-	75.7	-
2001	-	-	35.0	46.2	-	-	37.2	-
2002	-	-	21.0	38.0	-	-	31.1	-
2003	-	-	-	52.7	-	-	43.0	-
2004	-	-	-	85.6	-	-	72.4	-
2005	-	-	19.1	43.9	-	-	47.2	-
2006	-	-	57.0	53.9	-	-	61.3	-
2007	-	-	27.0	34.2	-	-	34.0	-
Distribution	**Gumbel**	**Log-Normal (2 Parameter)**	**Gumbel**	**Log-Pearson Type-3**	**Pearson Type-3**	**Log-Normal (2 Parameter)**	**Pearson Type-3**	**Normal**
P_2	64.4	57.8	33.3	48.0	47.8	39.8	52.6	55.7
$P_{2.33}$	67.6	61.1	35.8	50.6	49.7	42.6	56.6	59.2
P_5	81.4	74.8	46.6	61.7	57.6	54.7	73.8	72.3
P_{10}	92.6	85.7	55.4	70.9	63.7	64.7	87.6	80.9
P_{25}	106.8	98.9	66.5	82.6	71.1	77.3	104.4	90.1
P_{50}	117.3	108.5	74.8	91.5	76.3	86.6	116.6	96.1
P_{100}	127.8	118.0	82.9	100.6	81.3	96.1	128.5	101.4
P_{200}	138.2	127.3	91.1	109.8	86.2	105.5	140.1	106.3
P_{500}	151.9	139.6	101.8	122.5	92.5	118.2	155.2	112.2
P_{1000}	162.3	149.1	110.0	132.4	97.1	128.3	166.5	116.4

Table F.32b Annual Daily Max. Precipitations Observed in the Vicinity of Project Area (DMI, 2009-b)

Year	**Diyarbakir MS**	**Bingol MS**	**Hani MS**	**Dicle MS**	**Ergani MS**	**Cermik MS**	**Karacadag MS**
	P (mm)	**P (mm)**	**P (mm)**	**P (mm)**	**P (mm)**	**P (mm)**	**P (mm)**
1929	29.0	-	-	-	64.0	-	-
1930	25.1	-	-	-	72.0	-	-
1931	45.0	-	-	-	70.0	-	-
1932	40.0	-	-	-	-	-	-
1933	28.7	-	-	-	-	-	-
1934	30.6	-	-	-	-	-	-
1935	38.7	-	-	-	-	-	-
1936	43.5	-	-	-	-	-	-
1937	56.2	-	-	-	-	-	-
1938	35.2	-	-	-	-	-	-
1939	24.4	-	-	-	-	-	-
1940	29.0	-	-	-	-	-	-
1941	32.1	-	-	-	-	-	-
1942	49.7	-	-	-	-	-	-
1943	36.4	50.2	-	-	-	-	-
1944	65.8	47.3	-	-	-	-	-
1945	22.7	45.4	-	-	-	-	-
1946	36.7	45.2	-	-	-	-	-
1947	22.8	53.7	-	-	-	-	-
1948	36.5	20.2	-	-	-	-	-
1949	31.4	32.8	-	-	-	-	-
1950	36.6	19.3	-	-	-	-	-
1951	28.2	28.2	-	-	-	-	-
1952	33.6	-	-	-	-	-	-
1953	48.1	92.3	120.0	-	-	-	-
1954	43.7	37.4	-	-	-	-	-
1955	50.2	50.0	-	-	-	-	-
1956	30.9	-	-	50.3	-	-	-
1957	34.6	40.3	-	50.7	-	57.8	-
1958	27.8	-	-	44.0	-	43.5	-
1959	33.3	-	-	72.0	51.1	32.3	-
1960	45.3	72.2	-	88.1	-	38.3	-

Table F.32b (continued)

1961	40.1	70.5	-	-	80.9	-	-
1962	29.3	41.1	95.0	45.3	55.4	40.4	-
1963	54.6	97.2	130.0	-	70.3	64.2	-
1964	32.7	48.7	55.5	-	51.0	69.4	-
1965	37.8	67.2	106.0	56.4	63.6	64.4	-
1966	41.3	68.7	-	-	59.6	45.4	-
1967	57.6	69.7	65.4	81.0	56.1	61.2	-
1968	36.2	70.9	85.4	-	46.8	51.5	-
1969	28.9	45.2	39.6	40.0	40.1	65.2	30.1
1970	20.0	36.2	51.5	39.5	37.1	37.2	20.0
1971	37.5	47.6	62.4	77.3	88.5	116.1	18.7
1972	42.0	53.7	39.5	37.0	50.5	47.2	25.0
1973	24.0	37.7	41.2	33.0	47.5	43.6	13.4
1974	40.7	77.4	47.6	-	63.0	65.2	36.0
1975	52.5	64.4	83.6	-	64.0	63.1	26.7
1976	71.6	103.6	92.0	-	75.9	93.6	43.3
1977	32.7	55.0	65.5	39.8	46.3	56.3	36.3
1978	39.9	63.1	56.5	54.0	48.8	63.2	25.7
1979	36.8	45.7	97.3	-	71.4	85.2	35.0
1980	46.6	71.7	98.2	60.0	43.4	63.5	-
1981	32.6	51.0	67.0	51.0	34.6	54.0	25.5
1982	38.4	83.5	83.5	87.9	83.0	66.4	51.1
1983	29.4	47.4	68.8	30.0	38.8	36.8	44.0
1984	27.3	50.4	63.6	68.4	58.8	74.4	38.0
1985	48.6	49.6	66.3	53.6	38.2	61.0	75.2
1986	45.2	40.6	65.3	40.6	54.1	57.2	31.3
1987	37.5	69.5	69.1	-	106.1	76.2	-
1988	63.2	42.4	50.1	50.1	46.5	59.3	-
1989	27.7	48.9	90.7	45.2	43.3	58.6	56.2
1990	48.5	72.9	149.0	110.1	100.6	93.3	59.8
1991	39.8	81.1	72.0	44.7	70.5	46.8	32.3
1992	10.2	54.5	81.0	43.2	55.6	70.2	43.4
1993	43.4	48.5	56.1	30.2	32.0	46.8	32.4
1994	35.1	53.0	70.5	50.0	37.3	39.3	-
1995	39.0	69.6	54.1	-	44.2	43.7	-
1996	52.2	37.0	-	-	49.0	58.9	-
1997	43.2	49.7	-	-	54.2	60.5	-
1998	26.6	76.8	70.5	-	46.8	46.3	-
1999	34.2	42.1	59.1	-	54.8	62.3	-
2000	48.0	45.1	46.1	-	43.1	44.5	-
2001	55.1	51.0	-	-	54.2	60.6	-
2002	33.5	51.8	-	-	53.4	65.8	-
2003	27.6	67.4	-	-	43.4	41.6	-
2004	44.1	70.1	-	-	86.3	61.8	-
2005	28.5	54.2	-	-	46.0	39.5	-
2006	44.0	55.7	-	-	44.9	51.6	-
2007	31.4	55.2	-	-	76.3	48.4	-
Distribution	**Log-Normal (2 Parameter)**	**Gumbel**	**Log-Pearson Type-3**	**Log-Pearson Type-3**	**Log-Pearson Type-3**	**Log-Normal (2 Parameter)**	**Log-Normal (2 Parameter)**
P_{2}	36.6	52.8	68.6	50.0	54.0	55.7	33.7
$P_{2.33}$	38.5	55.9	72.6	53.0	56.7	58.5	36.1
P_{5}	46.3	69.4	90.9	66.9	68.9	70.2	46.7
P_{10}	52.4	80.4	106.3	79.3	79.2	79.2	55.4
P_{25}	59.7	94.3	126.5	96.2	92.6	90.1	66.4
P_{50}	65.0	104.5	142.1	109.9	102.9	97.9	74.7
P_{100}	70.2	114.8	158.2	124.5	113.5	105.5	83.0
P_{200}	75.2	124.9	174.9	140.1	124.5	113.0	91.4
P_{500}	81.8	138.4	198.2	162.7	139.8	122.7	102.6
P_{1000}	86.8	148.5	216.8	181.4	151.9	130.1	111.6

Table F.33 Probable Maximum Precipitation Calculations of Meteorological Stations

MS	Mutki	Kozluk	Batman	Mus	Silvan	Midyat	Mardin	Derik
N	26	29	46	70	31	33	69	32
X_N	66.9	60.6	35.4	50.7	49.4	42.8	56.8	55.7
X_{MAX}	98.4	109.4	69.2	97.7	81.6	87.3	145.9	118.2
X_{N-1}	65.6	58.9	34.7	50.0	48.3	41.4	55.4	53.7
X_{N-1}/X_N	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Correct. Coeff. 1	1.020	1.005	1.005	1.010	1.045	1.015	1.005	0.990
X	68.2	60.9	35.6	51.2	51.6	43.4	57.0	55.2
Correct. Coeff. 2	1.012	1.007	1.000	1.000	1.006	1.005	1.000	1.005
X	**69.0**	**61.3**	**35.6**	**51.2**	**51.9**	**43.6**	**57.0**	**55.5**
ΣX^2	122992.9	116670.3	66010.0	196092.6	79008.5	69380.1	258522.7	111393.1
S_N	16.4	19.0	13.5	15.3	10.7	16.8	23.1	19.6
S_{N-1}	15.4	16.9	12.7	14.3	9.1	15.0	20.5	16.2
S_{N-1}/S_N	0.9	0.9	0.9	0.9	0.8	0.9	0.9	0.8
Correct. Coeff. 3	1.080	1.020	1.020	0.970	0.940	0.990	0.930	0.925
S	17.7	19.4	13.8	14.8	10.1	16.6	21.5	18.2
Correct. Coeff. 4	1.055	1.035	1.005	1.000	1.030	1.025	1.000	1.027
S	**18.7**	**20.1**	**13.9**	**14.8**	**10.4**	**17.0**	**21.5**	**18.6**
KM	**5.0**	**6.1**	**8.8**	**7.7**	**6.3**	**5.4**	**5.4**	**5.6**
PMP_{24}=X+KM*S	**162.5**	**183.9**	**157.6**	**165.4**	**117.5**	**135.6**	**173.0**	**159.9**

Table F.33 (continued)

Diyarbakir	Bingol	Hani	Dicle	Ergani	Cermik	Karacadag
79	61	37	29	48	50	22
38.1	55.6	73.4	54.3	60.7	57.9	36.3
71.6	103.6	149.0	110.1	106.1	116.1	75.2
37.7	54.8	71.3	52.3	59.7	56.7	34.5
1.0	1.0	1.0	1.0	1.0	1.0	0.9
1.005	1.015	1.012	0.990	1.005	1.013	0.990
38.3	56.4	74.3	53.7	61.0	58.6	36.0
1.000	1.000	1.003	1.007	1.000	1.000	1.016
38.3	**56.4**	**74.5**	**54.1**	**61.0**	**58.6**	**36.5**
123783.6	206009.6	221884.5	95848.5	180582.5	180295.1	33534.5
10.9	17.2	25.1	19.3	8.9	16.2	14.6
10.2	16.2	21.9	16.4	6.0	14.0	12.1
0.9	0.9	0.9	0.8	0.7	0.9	0.8
0.960	1.000	0.960	0.960	0.760	0.920	0.950
10.4	17.2	24.1	18.6	6.8	14.9	13.9
1.000	1.000	1.018	1.035	1.001	1.000	1.075
10.4	**17.2**	**24.5**	**19.2**	**6.8**	**14.9**	**14.9**
8.2	**7.1**	**4.5**	**6.5**	**6.8**	**5.3**	**8.4**
123.7	**178.5**	**184.8**	**179.1**	**107.3**	**137.5**	**161.9**

Table F.34 Daily Maximum Rainfall Magnitudes

Unit: mm

MS	P_2	$P_{2.33}$	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}	P_{1000}	PMP
Mutki	64.4	67.6	81.4	92.6	106.8	117.3	127.8	138.2	151.9	162.3	162.5
Kozluk	57.8	61.1	74.8	85.7	98.9	108.5	118.0	127.3	139.6	149.1	183.9
Batman	33.3	35.8	46.6	55.4	66.5	74.8	82.9	91.1	101.8	110.0	157.6
Mus	48.0	50.6	61.7	70.9	82.6	91.5	100.6	109.8	122.5	132.4	165.4
Silvan	47.8	49.7	57.6	63.7	71.1	76.3	81.3	86.2	92.5	97.1	117.5
Midyat	39.8	42.6	54.7	64.7	77.3	86.6	96.1	105.5	118.2	128.3	135.6
Mardin	52.6	56.6	73.8	87.6	104.4	116.6	128.5	140.1	155.2	166.5	173.0
Derik	55.7	59.2	72.3	80.9	90.1	96.1	101.4	106.3	112.2	116.4	159.9
Diyarbakir	36.6	38.5	46.3	52.4	59.7	65.0	70.2	75.2	81.8	86.8	123.7
Bingol	52.8	55.9	69.4	80.4	94.3	104.5	114.8	124.9	138.4	148.5	178.5
Hani	68.6	72.6	90.9	106.3	126.5	142.1	158.2	174.9	198.2	216.8	184.8
Dicle	50.0	53.0	66.9	79.3	96.2	109.9	124.5	140.1	162.7	181.4	179.1
Ergani	54.0	56.7	68.9	79.2	92.6	102.9	113.5	124.5	139.8	151.9	107.3
Cermik	55.7	58.5	70.2	79.2	90.1	97.9	105.5	113.0	122.7	130.1	137.5
Karacadag	33.7	36.1	46.7	55.4	66.4	74.7	83.0	91.4	102.6	111.6	161.9

Table F.35 Daily Maximum Rainfall Magnitudes of Ilisu IV Basin

Unit: mm

Meteorological Station	Thiessen Weight (%)	P_2	$P_{2.33}$	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}	P_{1000}	PMP
Mutki	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3
Kozluk	4.3	2.5	2.6	3.2	3.7	4.2	4.6	5.0	5.4	6.0	6.4	7.8
Batman	10.7	3.6	3.8	5.0	6.0	7.1	8.0	8.9	9.8	10.9	11.8	16.9
Mus	5.6	2.7	2.9	3.5	4.0	4.7	5.2	5.7	6.2	6.9	7.5	9.3
Silvan	13.5	6.5	6.7	7.8	8.6	9.6	10.3	11.0	11.7	12.5	13.2	15.9
Midyat	2.0	0.8	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.4	2.6	2.7
Mardin	5.8	3.1	3.3	4.3	5.1	6.1	6.8	7.5	8.2	9.0	9.7	10.1
Derik	5.9	3.3	3.5	4.2	4.7	5.3	5.6	5.9	6.2	6.6	6.8	9.4
Diyarbakir	16.3	6.0	6.3	7.6	8.6	9.7	10.6	11.4	12.3	13.3	14.2	20.2
Bingol	2.2	1.2	1.2	1.5	1.8	2.1	2.3	2.5	2.7	3.0	3.2	3.9
Hani	12.8	8.7	9.3	11.6	13.6	16.1	18.1	20.2	22.3	25.3	27.6	23.6
Dicle	7.6	3.8	4.0	5.1	6.0	7.3	8.3	9.4	10.6	12.4	13.8	13.6
Ergani	7.7	4.2	4.4	5.3	6.1	7.1	7.9	8.7	9.6	10.8	11.7	8.3
Cermik	0.7	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.8	0.9	0.9
Karacadag	4.7	1.6	1.7	2.2	2.6	3.1	3.5	3.9	4.3	4.9	5.3	7.7
Basin Precipitation	100.0	**48.3**	**51.0**	**63.0**	**72.6**	**84.9**	**94.0**	**103.1**	**112.4**	**125.0**	**134.8**	**150.5**

Table F.36 Pluviograph Coefficients of Diyarbakir Meteorological Station
(Ilisu Dam and HEPP Engineering and Consultancy Services Consortium, October 2008)

Time (hr)

4	6	8	12	18	24
0.63	0.72	0.76	0.83	0.91	1.00

Table F.37 Areal Distribution Coefficients of Rainfall of Ilisu IV Basin

Time (hr)

4	6	8	12	18	24
0.80	0.84	0.84	0.86	0.89	0.91

Table F.38 Corrected and Maximized Rainfall Magnitudes of Ilisu IV Basin

	Time (hr)					Unit: mm
MF = 1.13	**4**	**6**	**8**	**12**	**18**	**24**
P_2	27.4	32.8	35.0	38.9	43.9	49.6
$P_{2.33}$	29.0	34.7	37.0	41.2	46.4	52.5
P_5	35.8	42.8	45.6	50.8	57.3	64.8
P_{10}	41.3	49.4	52.6	58.6	66.1	74.7
P_{25}	48.2	57.6	61.5	68.4	77.2	87.3
P_{50}	53.4	63.8	68.1	75.8	85.5	96.6
P_{100}	58.6	70.1	74.7	83.2	93.9	106.1
P_{200}	63.9	76.4	81.4	90.7	102.3	115.6
P_{500}	71.0	84.9	90.5	100.8	113.8	128.5
P_{1000}	76.6	91.6	97.7	108.8	122.7	138.7
PMP	85.6	102.3	109.0	121.4	137.0	154.8

Table F.39 Harmonic Slope Calculation of Ilisu IV Basin

Station No n	Elevation h (m)	Elev. Diff. Δh (m)	Distance L_i (m)	$S_i=\Delta h/L_i$	$1/\sqrt{S_i}$
0	461	-	-	-	-
1	475	14	31835	0.000	47.7
2	525	50	31835	0.002	25.2
3	550	25	31835	0.001	35.7
4	575	25	31835	0.001	35.7
5	600	25	31835	0.001	35.7
6	625	25	31835	0.001	35.7
7	675	50	31835	0.002	25.2
8	725	50	31835	0.002	25.2
9	825	100	31835	0.003	17.8
10	1500	675	31835	0.021	6.9
					Total: 290.8

$S=(n/\Sigma(1/\sqrt{S_i}))^2$

S=0.001

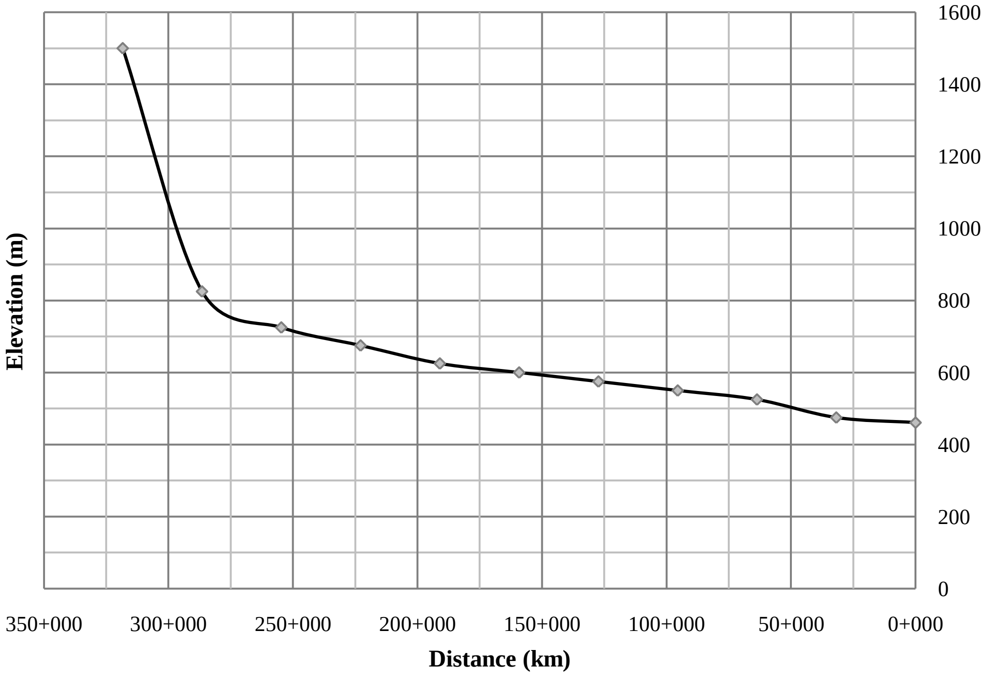


Figure F.117 River Bed Profile of Ilisu IV Basin

Table F.40 Base Flow Calculation of Ilisu IV Basin

2605 SGS				**Unit: m^3/s**
Year	**February**	**March**	**April**	**Average**
1946	139.0	288.0	345.0	257.3
1947	170.0	149.0	64.1	127.7
1948	288.0	133.0	286.0	235.7
1949	42.1	113.0	194.0	116.4
1950	92.0	-	-	92.0
1951	55.2	54.3	69.1	59.5
1952	369.0	120.0	58.3	182.4
1953	-	-	-	-
1954	-	-	-	-
1955	-	101.7	70.1	85.9
1956	145.7	141.5	112.7	133.3
1957	111.0	164.3	51.2	108.8
1958	72.3	147.4	85.6	101.8
1959	26.3	111.0	63.7	67.0
1960	58.0	143.2	142.3	114.5
1961	45.1	55.0	58.4	52.8
1962	171.1	123.7	69.0	121.3
1963	199.1	133.8	225.3	186.1
1964	76.9	317.0	91.6	161.8
1965	102.4	185.9	202.0	163.4
1966	161.6	88.4	125.7	125.3
1967	90.7	307.1	332.2	243.3
1968	174.2	383.4	144.6	234.0
1969	202.0	413.9	229.0	281.6
1970	192.0	143.0	71.3	135.4
1971	64.8	164.0	304.0	177.6
1972	26.6	56.3	92.4	58.4
1973	65.3	53.3	55.6	58.1
1974	53.3	397.0	225.8	225.4
1975	73.6	121.0	151.8	115.5
1976	118.0	219.0	**526.8**	**287.9**
1977	103.0	121.0	152.8	125.6
1978	319.0	182.0	126.8	209.3
1979	73.5	78.0	72.4	74.6
1980	130.0	301.0	224.8	218.6
1981	223.0	237.0	131.8	197.3
1982	92.0	126.0	243.8	153.9
1983	44.9	157.0	119.8	107.2
1984	87.2	150.0	97.8	111.7
1985	95.4	135.0	128.8	119.7
1986	115.0	90.3	62.0	89.1
1987	220.0	267.0	217.8	234.9
1988	199.0	322.0	300.8	273.9
1989	21.7	48.1	27.0	32.3
1990	245.0	93.9	83.9	140.9
1991	83.3	191.0	99.7	124.7
1992	74.2	196.0	204.8	158.3
1993	85.3	177.0	232.8	165.0
1994	101.0	97.9	84.7	94.5
1995	157.0	164.0	184.8	168.6
1996	130.0	298.0	234.8	220.9
1997	64.7	87.9	213.8	122.1
			Maximum Average:	**287.9**
			Maximum Value:	**526.8**
		Drainage Area of 2605 SGS :	5655.2	km^2
		Drainage Area of Ilisu IV Dam:	20353.7	km^2
		Recurrence Base Flow:	**676.2**	m^3/s
		Probable Maximum Flood Base Flow:	**1237.1**	m^3/s

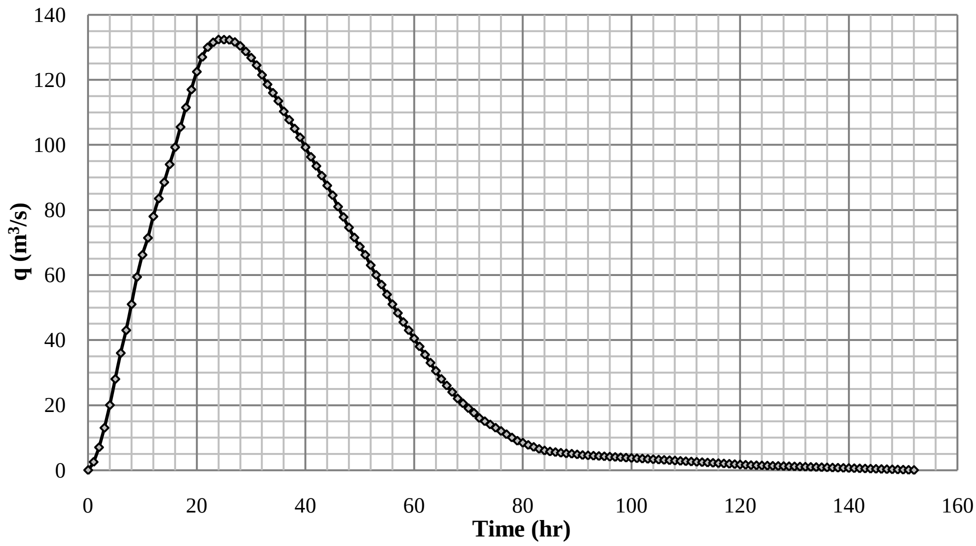


Figure F.118 Unit Hydrograph (UH_6) of Ilisu IV Basin

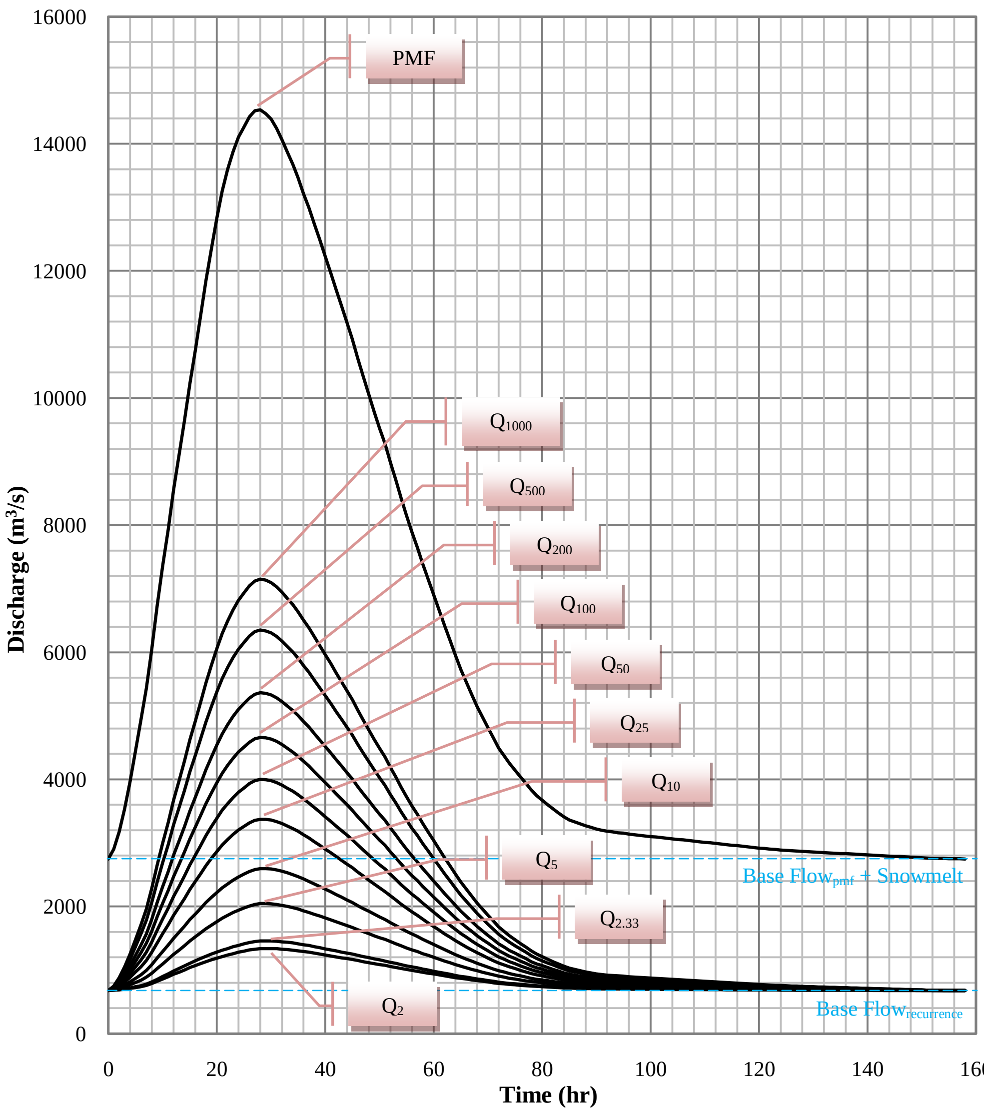


Figure F.119 Recurrence and Probable Maximum Flood Hydrographs of Ilisu IV Basin

Table F.41 Snyder Synthetic Unit Hydrograph Method Results of Ilisu IV Dam

Return Period	**Ilisu IV Dam**
	Flood Discharge (m^3/s)
2	1339.2
2.33	1457.4
5	2045.2
10	2596.7
25	3372.4
50	3998.3
100	4661.1
200	5362.0
500	6349.8
1000	7150.1
PMF	14533.8

APPENDIX G

THE LOWER TIGRIS PROJECTS AND ILISU V DAM AND HEPP

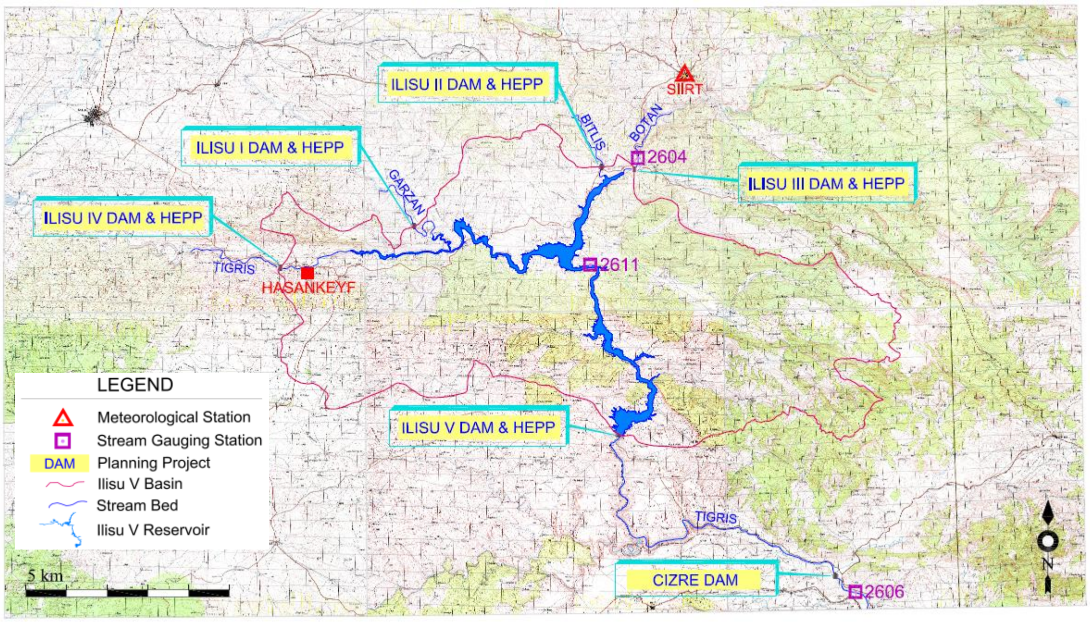


Figure G.1 Project Area and Hydro-Meteorological Stations on 1/100000 Scale Topographic Maps

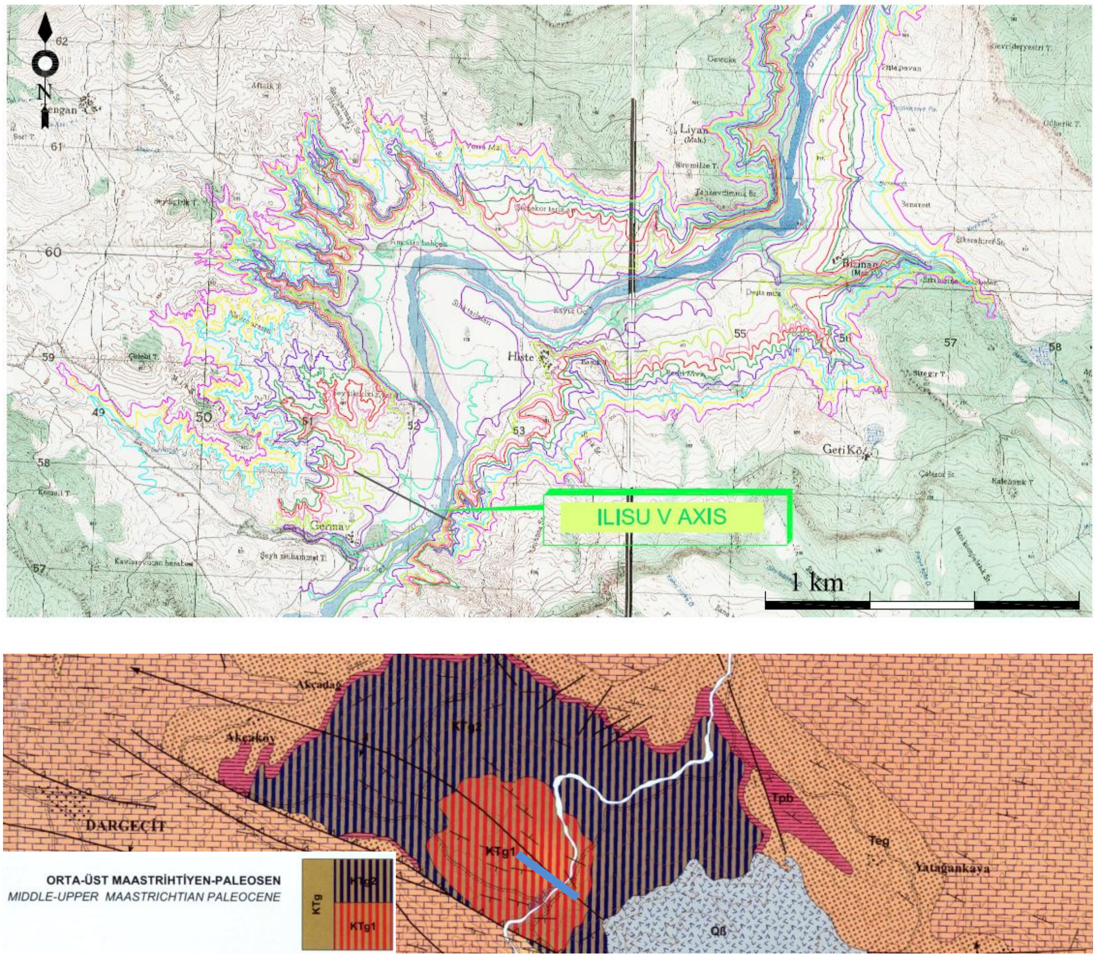


Figure G.2 Ilisu V Dam Location (MTA, 2007)

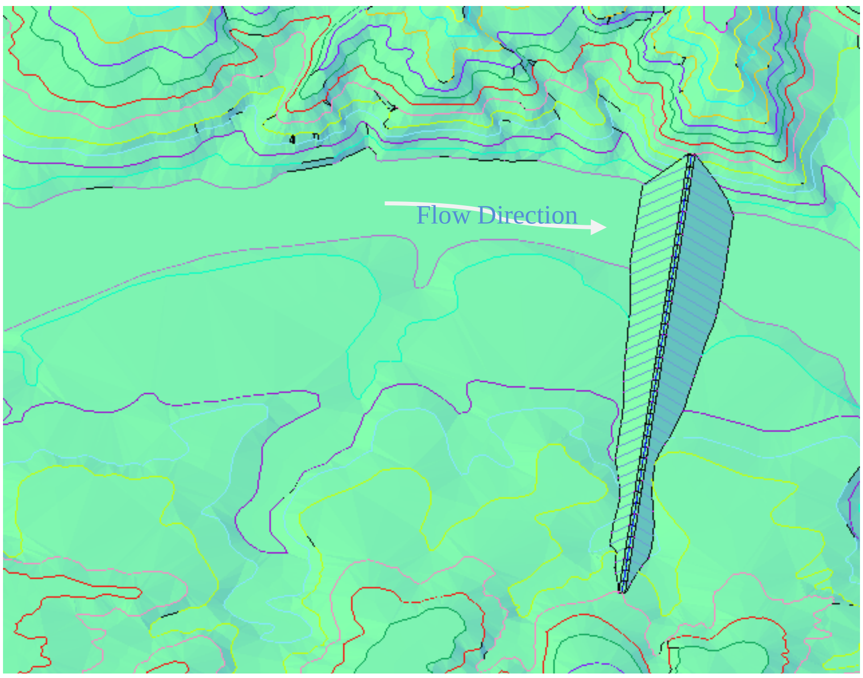


Figure G.3 Representative View of Ilisu V Dam Body

G.1. Dam Characteristics

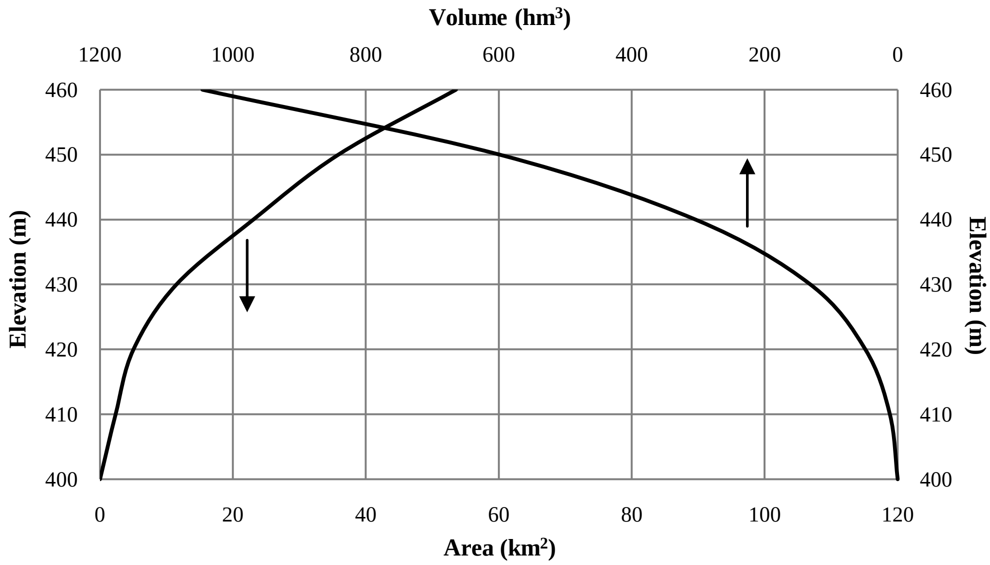


Figure G.4 Volume-Area Curve of Ilisu V Reservoir

G.2. Estimated Evaporation Rates

Table G.1 Monthly Total Net Evaporation Values of Ilisu V Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Siirt MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	5.0	-	-	81.5	-
Feb.	4.1	-	6.3	-	-	102.1	-
Mar.	8.3	-	10.5	55.6	38.9	110.3	-
Apr.	14.0	83.5	16.2	120.9	84.6	99.9	-
May	19.3	185.6	21.5	200.7	140.5	64.5	**76.0**
Jun.	25.9	282.6	28.1	323.2	226.2	9.4	**216.8**
Jul.	30.4	371.8	32.6	422.3	295.6	2.5	**293.1**
Aug.	29.9	356.2	32.1	409.8	286.9	1.3	**285.6**
Sep.	25.0	258.8	27.2	305.4	213.8	2.8	**211.0**
Oct.	17.8	139.4	20.0	176.0	123.2	50.7	**72.5**
Nov.	10.1	54.3	12.3	73.9	51.7	85.1	-
Dec.	4.7	13.5	6.9	26.7	18.7	94.4	-
Σ	-	1745.8	-	2114.4	1480.1	704.5	**1155.0**

G.3. Water Resources

G.3.1. Stream Gauging Stations

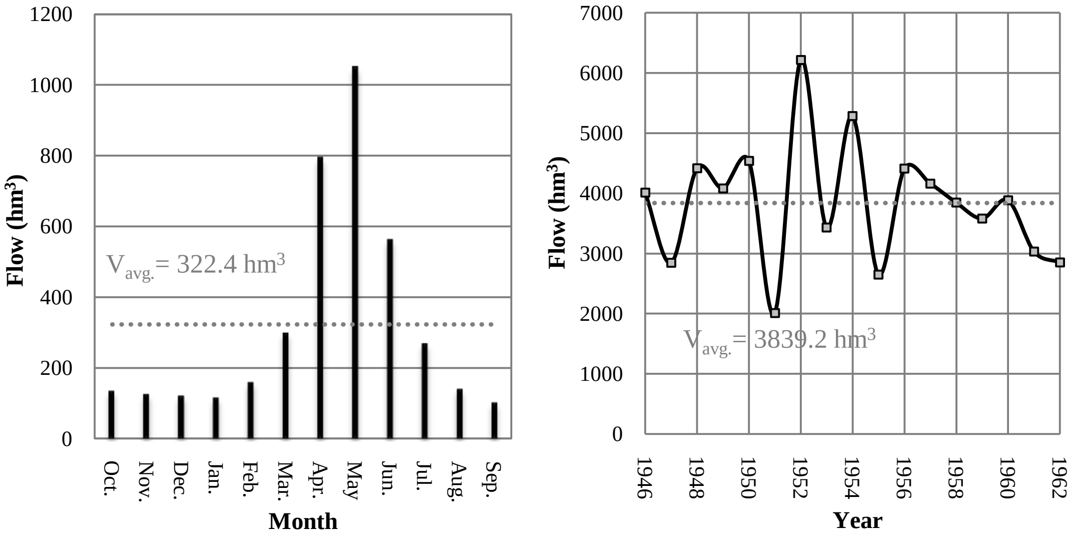


Figure G.5 Monthly Mean and Annual Total Flow Values Measured in 2604 SGS

Table G.2 Irrigation Projects Upstream of 2611 SGS and 2606 SGS (DSI, 2010)

Irrigation Projects	Commissioning Date	Drainage Area (km^2)	Irrigation Area		Used Irrigation Module
			Gross (ha)	Net (ha)	
Gozegol	1974	156.2	650	550	Tigris
Kabakli	1980	21.5	182	87	Batman - Silvan
Bespinar	1980	773.0	140	121	Tigris
Goksu	1996	672.0	4234	3582	Tigris
Kirkat (Gercus)	1985	40.3	350	348	Tigris
Silvan	1972	4015	8790	7590	Batman - Silvan
Serifbaba	1971	-	130	120	Tigris
Ortaviran	1963	-	550	516	Tigris
Devegecidi	1972	1576.0	10600	5800	Tigris
Kunres	1979	-	19	19	Tigris
Kozluk	1996	-	3973	3362	Garzan - Kozluk

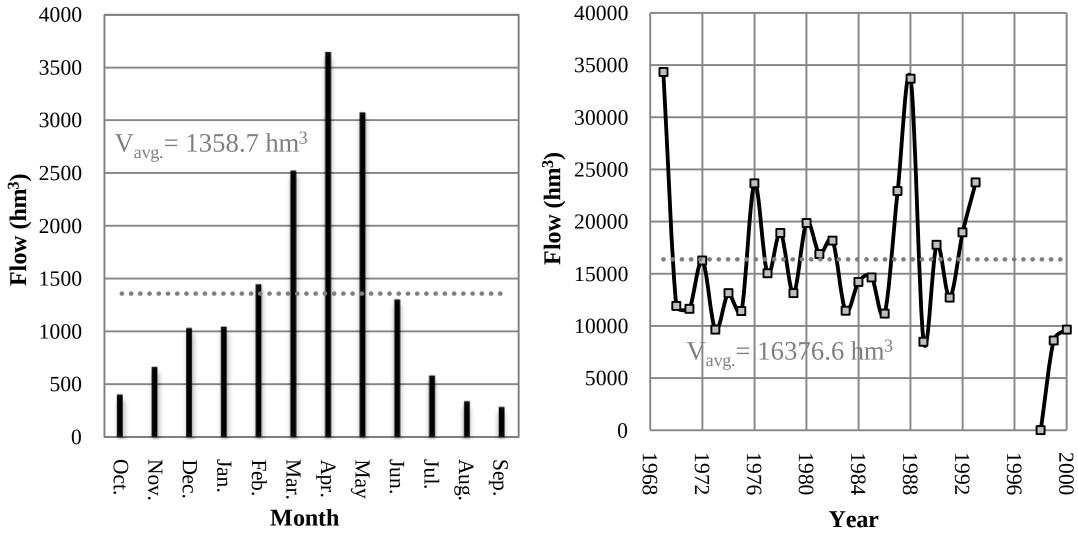


Figure G.6 Monthly Mean and Annual Total Flow Values Measured in 2606 SGS

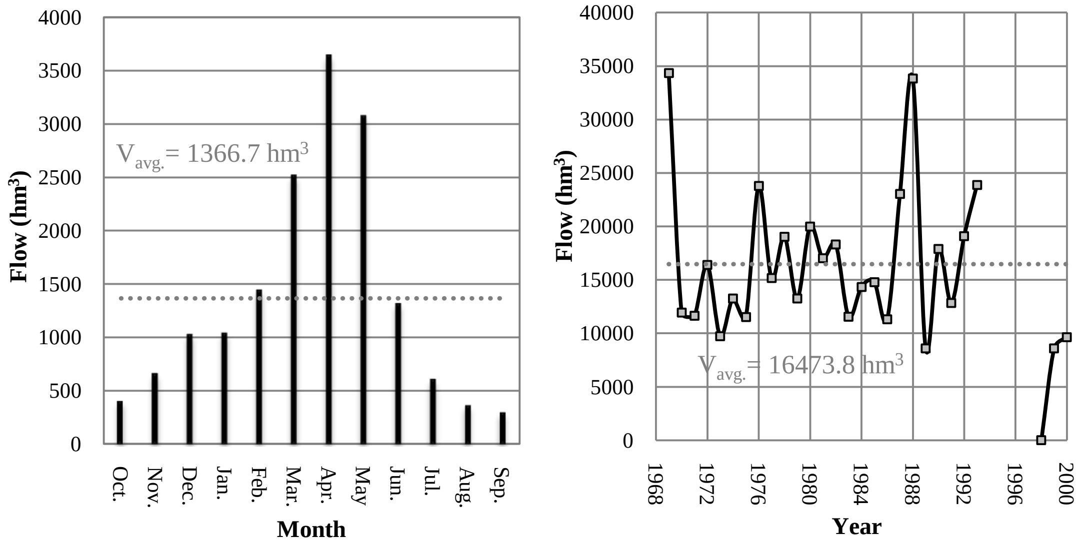


Figure G.7 Corrected Monthly Mean and Annual Total Flow Values of 2606 SGS

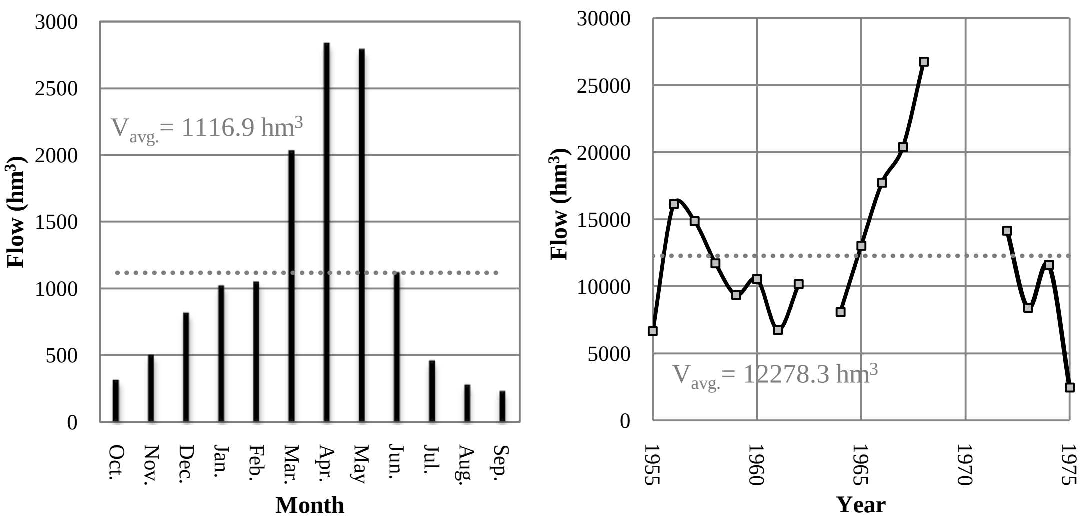


Figure G.8 Monthly Mean and Annual Total Flow Values Measured in 2611 SGS

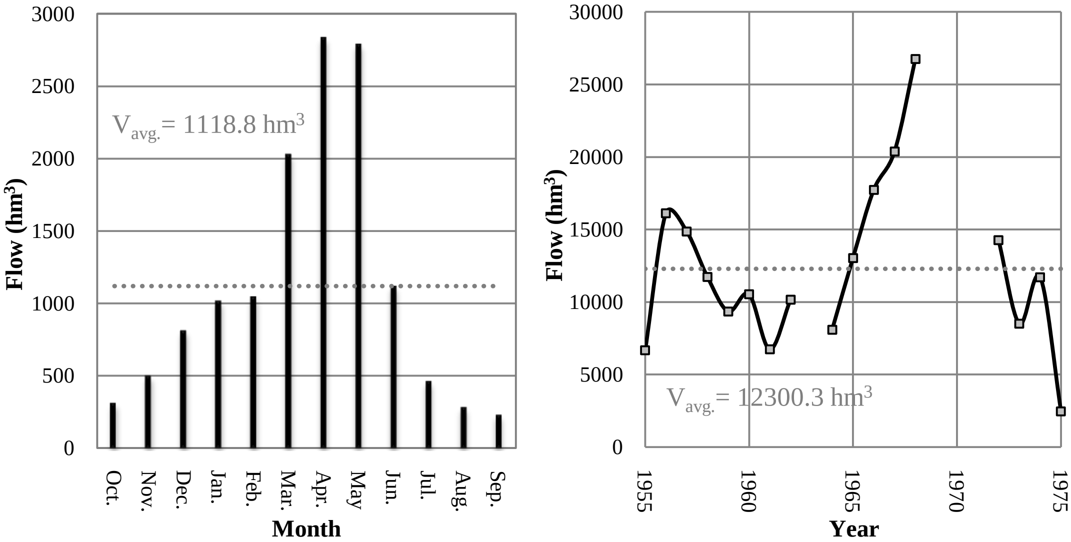


Figure G.9 Corrected Monthly Mean and Annual Total Flow Values of 2611 SGS

G.3.2. Correlation Studies

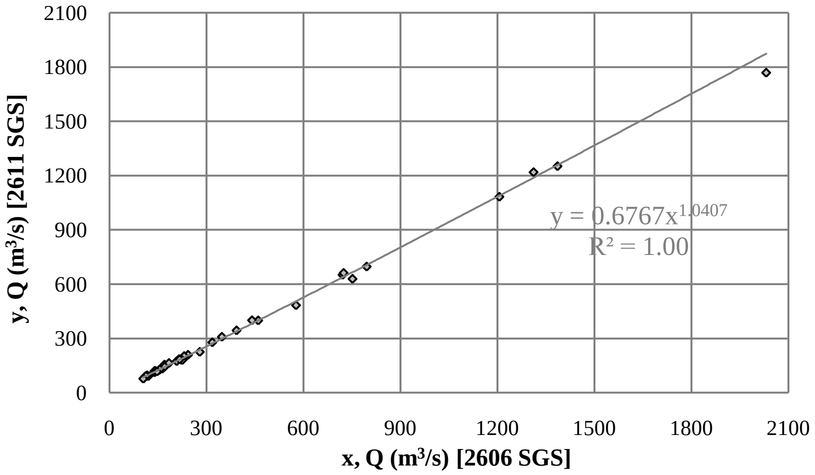


Figure G.10 Monthly Mean Discharge Correlation between 2611 SGS and 2606 SGS

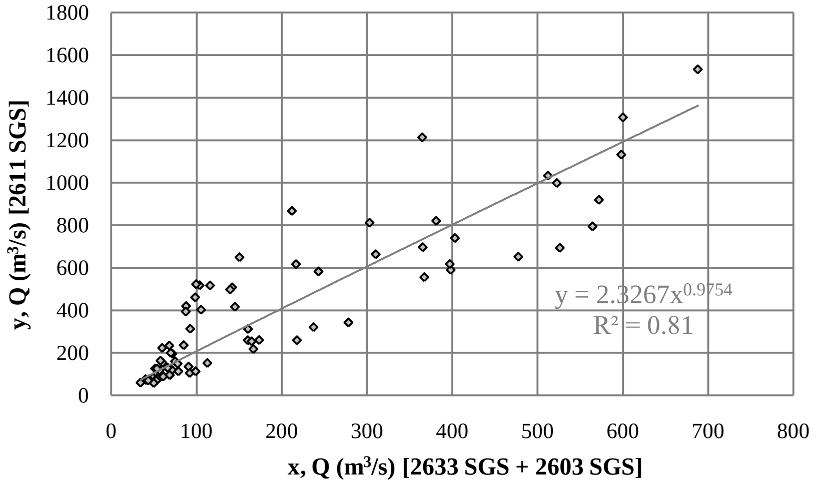


Figure G.11 Monthly Mean Discharge Correlation between 2611 SGS and (2633 SGS + 2603 SGS)

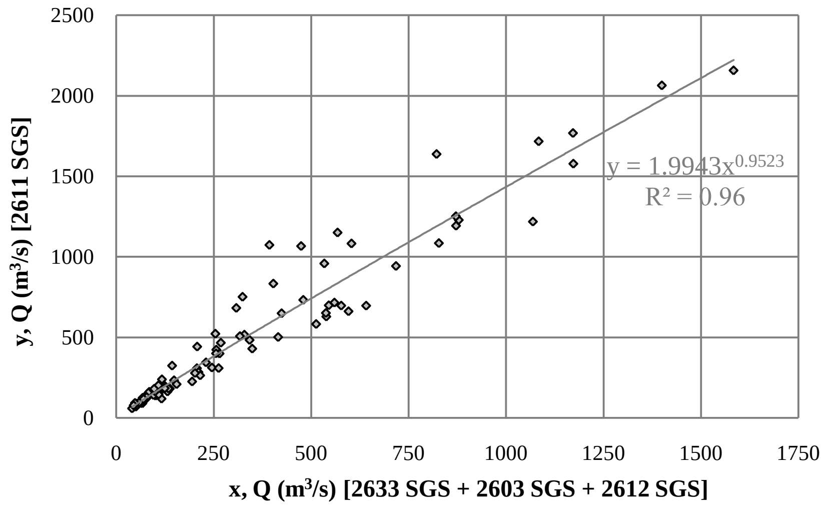


Figure G.12 Monthly Mean Discharge Correlation between 2611 SGS and (2633 SGS + 2603 SGS + 2612 SGS)

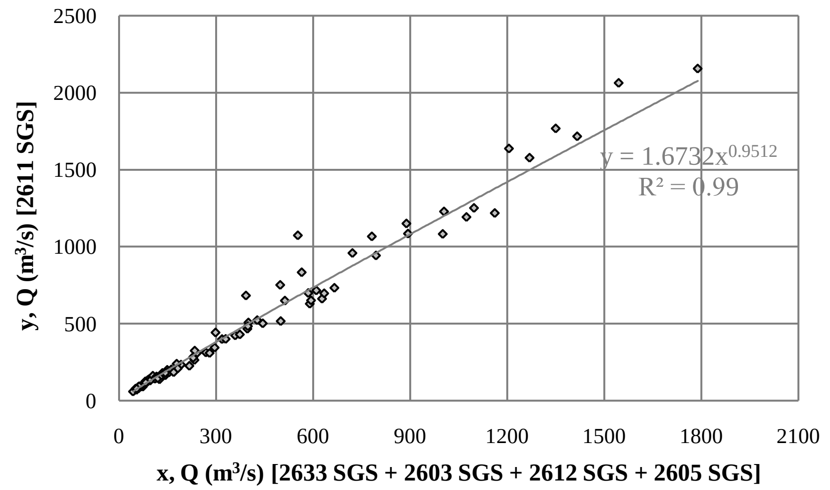


Figure G.13 Monthly Mean Discharge Correlation between 2611 SGS and (2633 SGS + 2603 SGS + 2612 SGS + 2605 SGS)

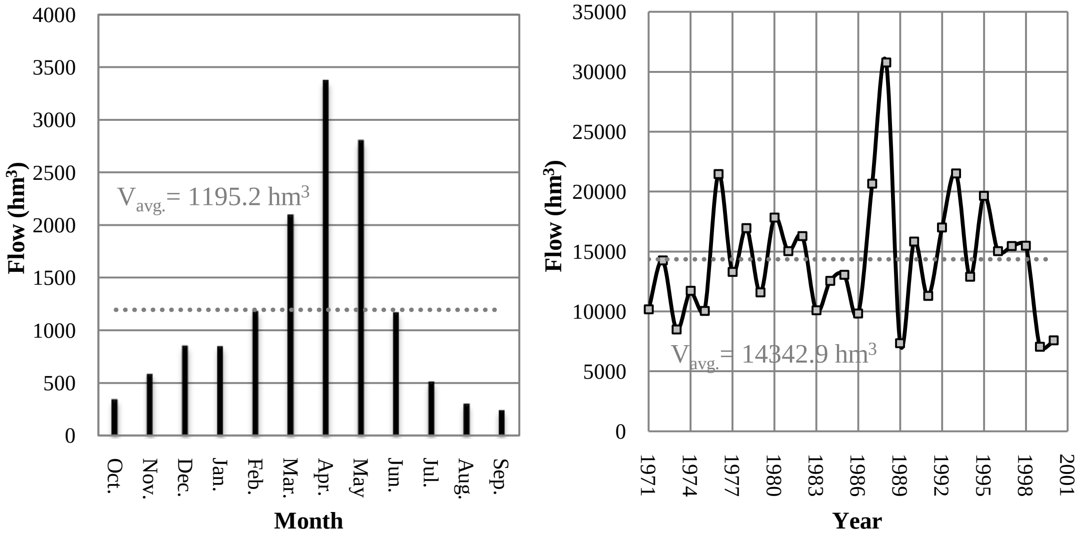


Figure G.14 Extended Monthly Mean and Annual Total Flow Values of 2611 SGS

G.3.3. Monthly Mean Flow Calculations

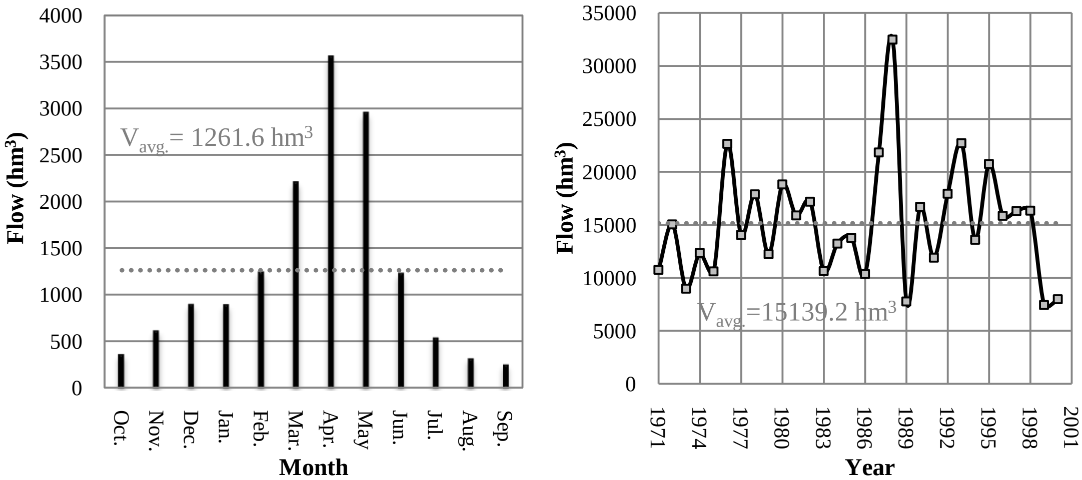


Figure G.15 Monthly Mean and Annual Total Flow Values at Ilisu V Dam

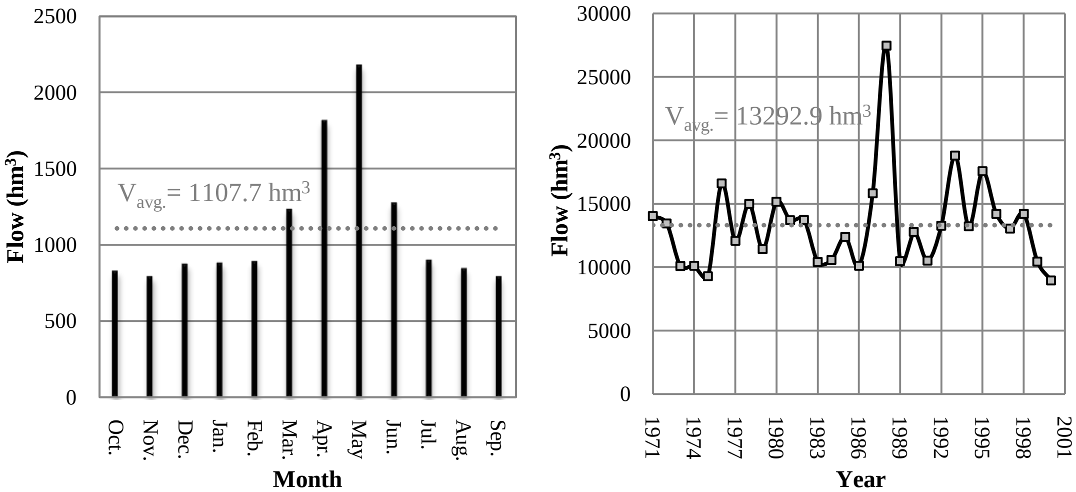


Figure G.16 Monthly Mean and Annual Total Inflow Values in the Operation Study of Ilisu V Reservoir

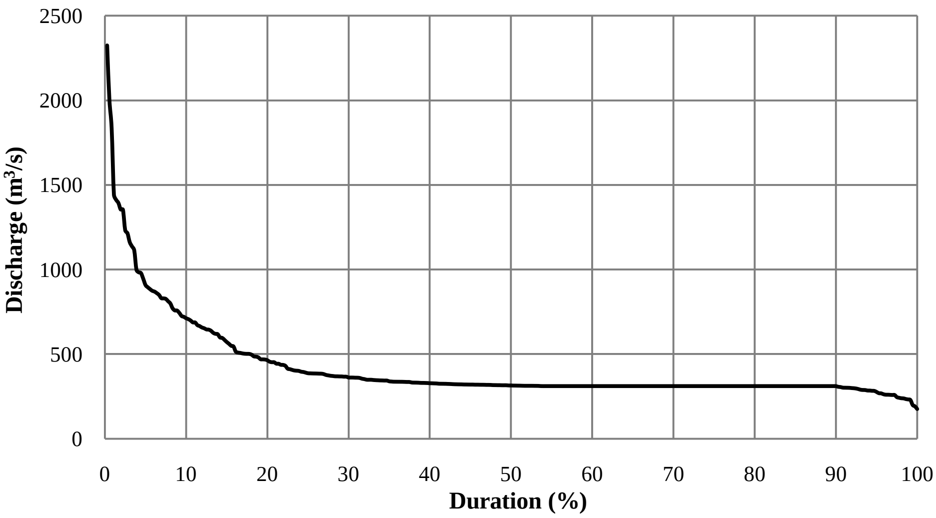


Figure G.17 Discharge-Duration Curve of Ilisu V Dam and HEPP

G.4. Sediment Transport

Table G.3 Sedimentation of Ilisu V Reservoir (EIE, 2000)

Sediment Gauging Station	2606 Tigris River - Cizre	
Catchment Area of SGS	30774.7 km^2	
Unit Volume Weight of Sediment	1.35 t/m^3	
Sediment Type Distribution	Clay + Silt: 49.7%	Sand: 50.3%
Suspended Sediment Load	733 $t/year/km^2$	543 $m^3/year/km^2$
Bed Load (%50 of Suspended Sediment Load)	367 $t/year/km^2$	271 $m^3/year/km^2$
Total Sediment Load	1100 $t/year/km^2$	814 $m^3/year/km^2$
Catchment Area of Ilisu V Dam	36408.0 km^2	
Catchment Area of Ilisu I Dam	2883.0 km^2	
Catchment Area of Ilisu II Dam	2510.0 km^2	
Catchment Area of Ilisu III Dam	8872.7 km^2	
Catchment Area of Ilisu IV Dam	20353.7 km^2	
Area Contributing to Sediment Transport	1788.6 km^2	
Economic Lifetime Period	50 year	
Volume of Sediment	73 hm^3	
Selected Minimum Water Level	425 m	

G.5. Operation Studies

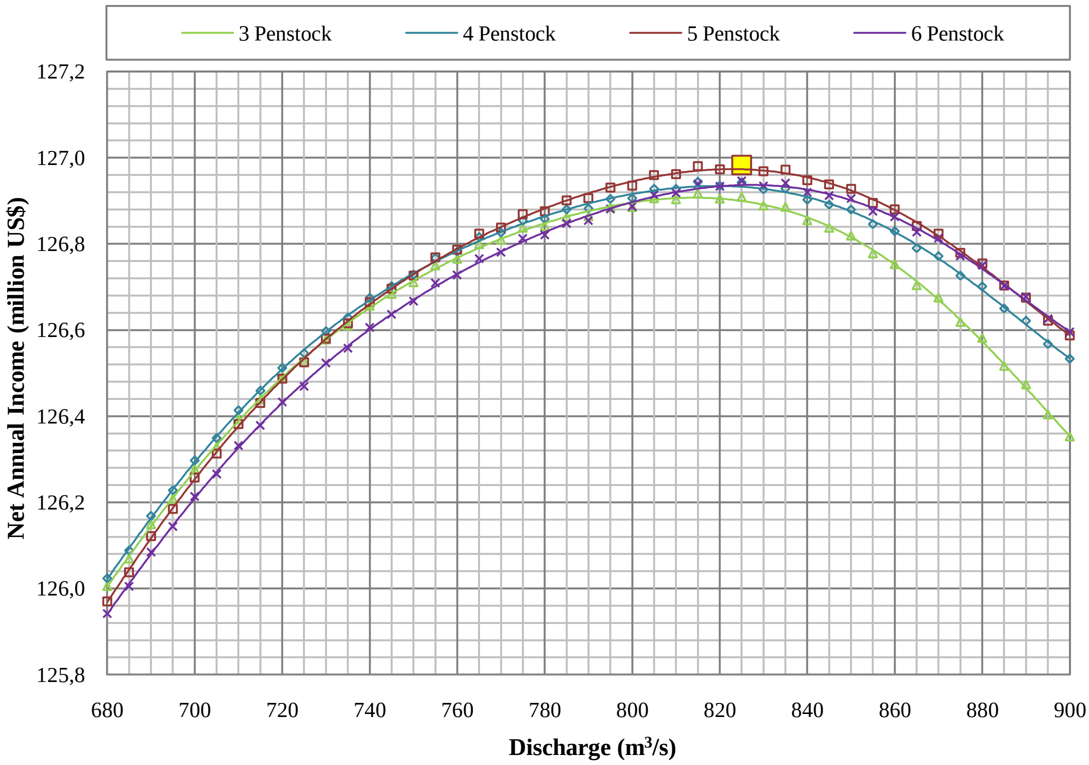


Figure G.18 Determination of Optimum Design Discharge for Ilisu V HEPP

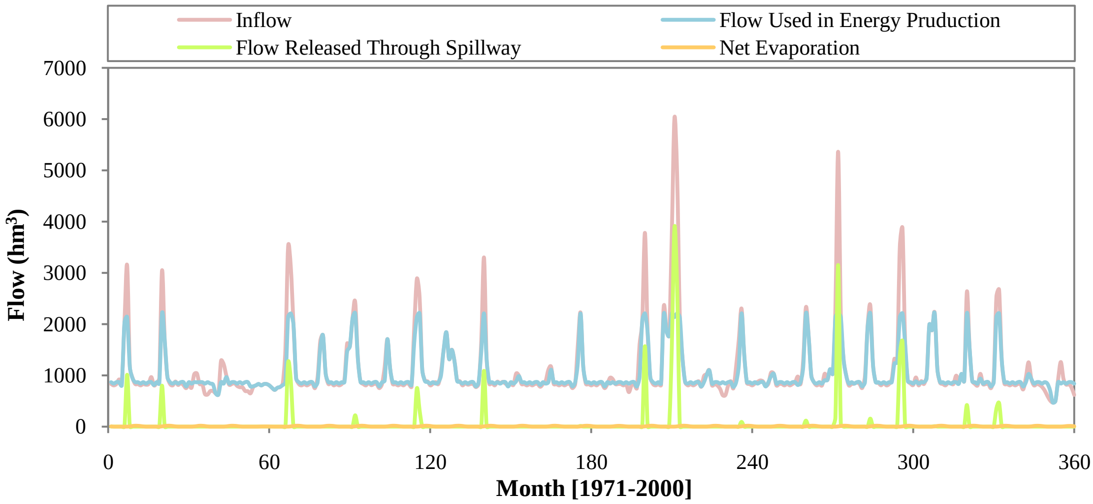


Figure G.19 Operation Study of Ilisu V Dam and HEPP

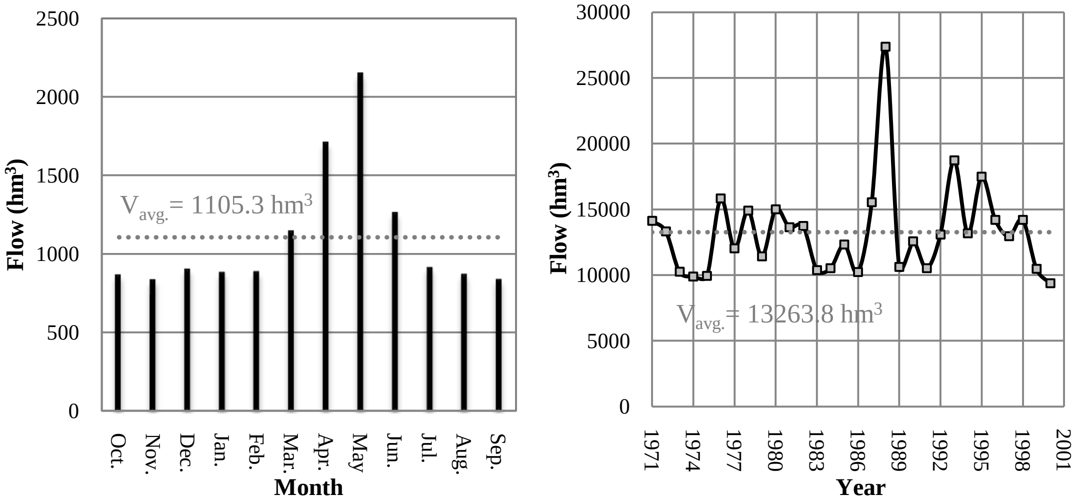


Figure G.20 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Ilisu V Reservoir

Table G.4 Water Demand Pattern of Silopi and Nusaybin-Idil-Cizre Irrigations (Ilisu Hydropower Consultants, November 1983)

Months	Irrigation Water Pattern (hm^3)
October	0.0
November	0.0
December	0.0
January	22.9
February	50.5
March	156.9
April	236.5
May	190.8
June	88.7
July	21.0
August	0.0
September	0.0
Total	767.3

APPENDIX H

THE ILISU DAM AND HEPP PROJECT

H.1. Dam Characteristics

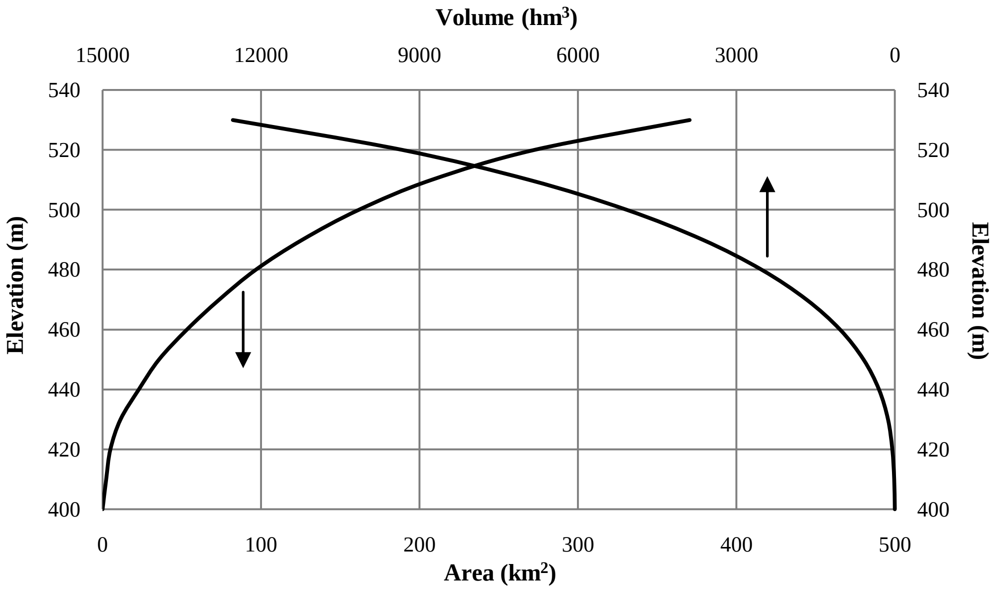


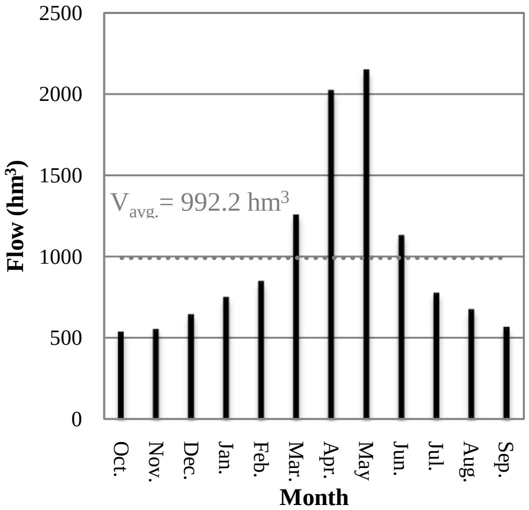
Figure H.1 Volume-Area Curve of Ilisu Reservoir

H.2. Estimated Evaporation Rates

Table H.1 Monthly Total Net Evaporation Values of Ilisu Reservoir

Months	Siirt MS Temp. (°C)	Siirt MS Evap. (mm)	Temp. (°C)	Evap. (mm)	Water Sur. Evap. (mm)	Siirt MS Precip. (mm)	**Net Evap. (mm)**
Jan.	2.8	-	4.7	-	-	81.5	-
Feb.	4.1	-	6.0	-	-	102.1	-
Mar.	8.3	-	10.1	52.4	36.7	110.3	-
Apr.	14.0	83.5	15.9	116.4	81.5	99.9	-
May	19.3	185.6	21.2	195.1	136.6	64.5	**72.0**
Jun.	25.9	282.6	27.8	316.2	221.3	9.4	**212.0**
Jul.	30.4	371.8	32.3	414.5	290.2	2.5	**287.7**
Aug.	29.9	356.2	31.8	402.1	281.5	1.3	**280.2**
Sep.	25.0	258.8	26.9	298.6	209.1	2.8	**206.3**
Oct.	17.8	139.4	19.6	170.7	119.5	50.7	**68.8**
Nov.	10.1	54.3	11.9	70.3	49.2	85.1	-
Dec.	4.7	13.5	6.6	24.4	17.1	94.4	-
Σ	16.0	1745.8	17.9	2060.7	1442.5	704.5	**1126.9**

H.3. Water Resources and Operation Studies



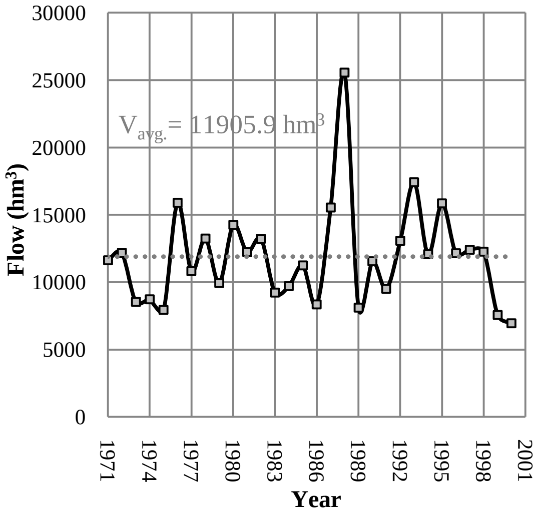


Figure H.2 Monthly Mean and Annual Total Inflow Values in the Operation Study of Ilisu Reservoir

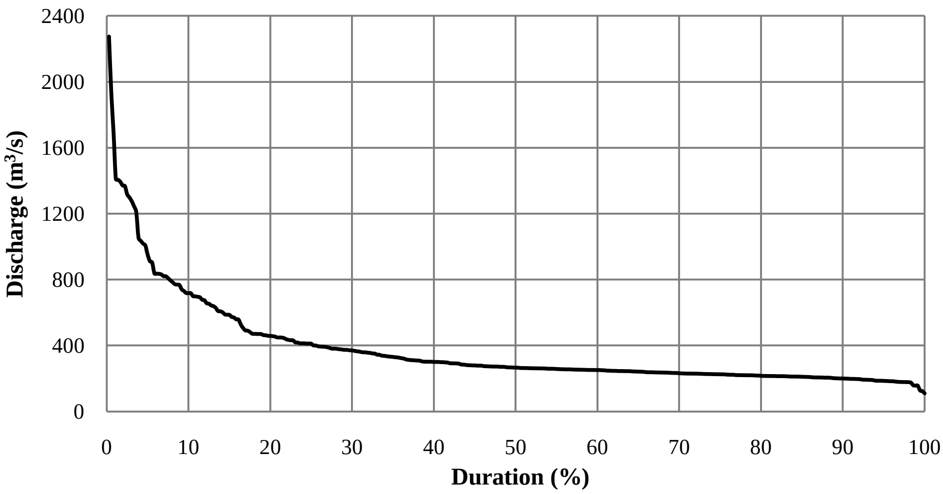


Figure H.3 Discharge-Duration Curve of Ilisu Dam and HEPP

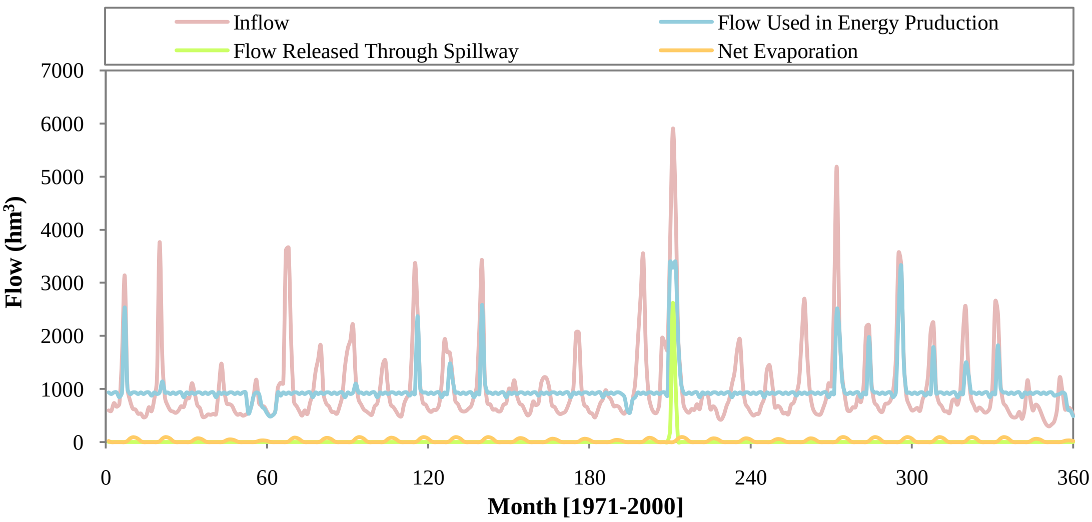


Figure H.4 Operation Study Results of Ilisu Dam and HEPP

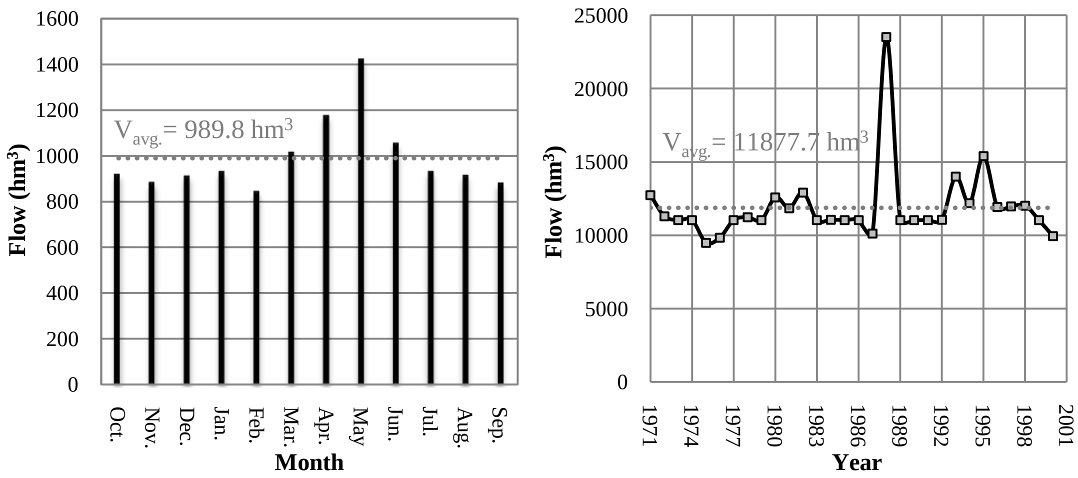


Figure H.5 Monthly Mean and Annual Total Outflow Values Obtained by the Operation Study of Ilisu Reservoir

APPENDIX I

OPERATION STUDIES

I.1. Operation of an Irrigation Project

Maximum Water Level: **MAXWL** (m)
Maximum Reservoir Area: **MAXRA** (km^2)
Maximum Storage: **MAXSTG** (hm^3)

Minimum Water Level: **MINWL** (m)
Minimum Reservoir Area: **MINRA** (km^2)
Minimum Storage: **MINSTG** (hm^3)

Month 1

STEP 1

Number of Days in the Month: **D**
Monthly Mean Input Discharge Value: **DIS** (m^3/s)
Monthly Mean Input Flow Value: **F** (hm^3) = DIS x D x 24 x 60 x 60 / 10^6

↓

STEP 2

Irrigation Water: **IW** (hm^3)

↓

STEP 3

Water Level at the Beginning of the Month: **WLB** (m)
Reservoir Area at the Beginning of the Month: **RAB** (km^2)
Storage at the Beginning of the Month: **STGB** (hm^3)

↓

STEP 4

Evaporation: **E** (mm)
Net Evaporation: **NE** (hm^3) = E x RAB / 10^3

↓

STEP 5

Storage at the End of the Month: **STGE** (hm^3) = STGB - IW - NE + F

If STGE > MAXSTG
Flow Released through Spillway: **SPL** (hm^3) = STGB - IW - NE + F - MAXSTG
STGE **=** MAXSTG

↓

STEP 6

Water Level at the End of the Month: **WLE** (m) = **f (**STG, WL**)**
Reservoir Area at the End of the Month: **RAE** (km^2) = **f (**WL, RA**)**

↓

STEP 7

Average Water Level: **AWL** (m) = (WLB + WLE) / 2

RETURN TO STEP 1

Month 2

I.2. Operation of an Irrigation Project Reinforced by Upstream Reservoir

Maximum Water Level: **MAXWL** (m)
Maximum Reservoir Area: **MAXRA** (km^2)
Maximum Storage: **MAXSTG** (hm^3)

Minimum Water Level: **MINWL** (m)
Minimum Reservoir Area: **MINRA** (km^2)
Minimum Storage: **MINSTG** (hm^3)

Month 1

STEP 1

Number of Days in the Month: **D**
Monthly Mean Input Discharge Value: **DIS** (m^3/s)
Monthly Mean Input Flow Value: **F** (hm^3) = DIS x D x 24 x 60 x 60 / 10^6

↓

STEP 2

Irrigation Water: **IW** (hm^3)

↓

STEP 3

Water Level at the Beginning of the Month: **WLB** (m)
Reservoir Area at the Beginning of the Month: **RAB** (km^2)
Storage at the Beginning of the Month: **STGB** (hm^3)

↓

STEP 4

Evaporation: **E** (mm)
Net Evaporation: **NE** (hm^3) = E x RAB / 10^3

↓

STEP 5

Storage at the End of the Month: **STGE** (hm^3) = STGB - IW - NE + F

If STGE > MAXSTG
Flow Released through Spillway: **SPL** (hm^3) = STGB - IW - NE + F - MAXSTG
STGE **=** MAXSTG

If STGE < MINSTG
Water Transferred from Upstream Reservoir: **TW** (hm^3) = MINSTG - STGE
STGE **=** MINSTG

↓

STEP 6

Water Level at the End of the Month: **WLE** (m) = **f (**STG, WL**)**
Reservoir Area at the End of the Month: **RAE** (km^2) = **f (**WL, RA**)**

↓

STEP 7

Average Water Level: **AWL** (m) = (WLB + WLE) / 2

RETURN TO STEP 1

Month 2

I.3. Operation of a Multi-Purpose Project

Maximum Water Level: **MAXWL** (m)
Maximum Reservoir Area: **MAXRA** (km^2)
Maximum Storage: **MAXSTG** (hm^3)

Minimum Water Level: **MINWL** (m)
Minimum Reservoir Area: **MINRA** (km^2)
Minimum Storage: **MINSTG** (hm^3)

Design Discharge: **DES** (m^3/s)
Number of Units: **N**
Tail Water Level: **TWL** (m)
Number of Penstocks: **NP**
Diameter of Penstock: **DIAP** (m)
Lenght of Penstock: **LP** (m)
Number of Energy Tunnels: **NET**
Diameter of Energy Tunnels: **DIAET** (m)
Lenght of Energy Tunnels: **LET** (m)

Friction Loss in Penstocks, h_{f1} = f x LP / DIAP x $V_{penstock}^2$ / (2 x g) (The Darcy-Weisbach Formula)

$Q_{penstock}$ = DES / NP
$A_{penstock}$= 3.14 x $DIAP^2$ / 4
$V_{penstock}$= $Q_{penstock}$ / $A_{penstock}$

Friction Coefficient, f
(The Colebrook Formula)

$$\frac{1}{\sqrt{f}} = -2\log\left(0.266\frac{k}{D}\right)$$

k= 0.01 in (Shames, 1989)
D (in) = D (m) x 39.37

Friction Loss in Energy Tunnels, h_{f2} = n x $V_{etunnel}^{\ 2}$ / $(DIAET / 4)^{4/3}$ x LET (The Manning Formula)

$Q_{etunnel}$ = DES / NET
$A_{etunnel}$= 3.14 x $DIAET^2$ / 4
$V_{etunnel}$= $Q_{etunnel}$ / $A_{etunnel}$

Manning Coefficient, n= 0.014

$\mathbf{h_f}$ = 1.1 x (h_{f1} + h_{f2})
K = h_f / DES^2

Gross Head: **GH1** (m) = MAXWL - TWL
Net Head: **NH1** (m) = GH1 - K x DES^2 - GH1 x 0.05

Efficiency of Turbines: **EEFFT** = 0.93

Installed Power: **IP** (MW) = 9.81 x EEFFT x NH1 x DES

Month 1

STEP 1

Number of Days in the Month: **D**
Monthly Mean Input Discharge Value: **DIS** (m^3/s)
Monthly Mean Input Flow Value: **F** (hm^3) = DIS x D x 24 x 60 x 60 / 10^6

↓

STEP 2

Environmental Water: **ENW** (hm^3)
Irrigation Water: **IW** (hm^3)
Domestic Water: **DW** (hm^3)

↓

STEP 3

Water Level at the Beginning of the Month: **WLB** (m)
Reservoir Area at the Beginning of the Month: **RAB** (km^2)
Storage at the Beginning of the Month: **STGB** (hm^3)

↓

STEP 4

Evaporation: **E** (mm)
Net Evaporation: **NE** (hm^3) = E x RAB / 10^3

↓

STEP 5

Discharge Used in Energy Production: **EDW** (m^3/s)
Flow Used in Energy Production: **EFW** (hm^3) **=** EDW x D x 24 x 60 x 60 / 10^6

↓

STEP 6

Discharge Used in Energy Production in %95 of the total operation period: **QFIRM** (m^3/s)

TRIAL AND ERROR
Starting Value: QFIRM = DES with Interval = 0.01

If EDW < QFIRM, "COUNT = *COUNT + 1*"
The Total Operation Period: **TM**
If COUNT > 0.05 x TM
QFIRM = QFIRM - 0.01

↓

STEP 7

EDW = 0
Storage at the End of the Month: **STGE** (hm^3) = STGB - ENW - IW - DW - NE - EFW + F
Water Level at the End of the Month: **WLE** (m) = **f (**STG, WL**)**
Reservoir Area at the End of the Month: **RAE** (km^2) = **f (**WL, RA**)**
COUNT = COUNT + 1
If COUNT > 0.5 x TM
*QFIRM = QFIRM - 0.01 >>> **RETURN TO STEP 6***

If STGE > MINSTG
EDW = QFIRM
STGE = STGB - ENW - IW - DW - NE - EFW + F

If STGE <= MINSTG
EDW = QFIRM - (MINSTG - STGE) / (24 x 60 x 60 x D)
STGE = MINSTG
WLE = MINWL
RAE = MINRA
COUNT = COUNT + 1
If COUNT > 0.5 x TM
*QFIRM = QFIRM - 0.01 >>> **RETURN TO STEP 6***

If STGE > MINSTG and STGE < MINSTG
WLE = f (STG, WL)
RAE = f (WL, RA)

If DIS > DES
EDW = DES

If DIS <= DES
EDW = DIS

STEP 7(CONTINUED)

STGE = STGB - ENW - IW - DW - NE - EFW + F

If STGE >= MAXSTG and EDW = DES
EDW = DES
STGE = STGB - ENW - IW - DW - NE - EFW + F
Flow Released through Spillway: **SPL** (hm^3) = STGE - MAXSTG
STGE = MAXSTG
WLE = MAXWL
RAE = MAXRA

If STGE < MAXSTG and EDW = DES
EDW = DES - (MAXSTG - STGE) / (24 x 60 x 60 x D)
STGE = MAXSTG
WLE = MAXWL
RAE = MAXRA

If STGE < MAXSTG and EDW = DIS
EDW = DIS - (MAXSTG - STGE) / (24 x 60 x 60 x D)
STGE = MAXSTG
WLE = MAXWL
RAE = MAXRA

If STGE >= MAXSTG and EDW = DIS
EDW = DIS + (STGE - STGE) / (24 x 60 x 60 x D)
STGE = STGB - ENW - IW - DW - NE - EFW + F
SPL = STGE - MAXSTG
STGE = MAXSTG
WLE = MAXWL
RAE = MAXRA

↓

STEP 8

Average Water Level: **AWL** (m) = (WLB + WLE) / 2

↓

STEP 9

Number of Operated Units: **OPN** = **f (**EDW, DES/N**)**
Duration of Operation: **T** (hours) = 24 x D

↓

STEP 10

Gross Head: **GH** (m) = AWL - TWL
Net Head: **NH** (m) = GH - K x EDW^2 - GH x 0.05

↓

STEP 11

Power: **P** (kW) = 9.81 x EDW x NH x EEFFT

If P > IP
P = IP

↓

STEP 12

Produced Energy: **EN** (kWh) = P x T x 0.985 x 0.975

If EDW > QFIRM
Firm Energy: **FEN** (kWh) = QFIRM / EDW x EN
If EDW < QFIRM
FEN = 0
Secondary Energy: **SEN** (kWh) = EN - FEN

RETURN TO STEP 1

Month 2

I.4. Operation of a Multi-Purpose Project Reinforces Downstream Irrigation

Maximum Water Level: **MAXWL** (m)
Maximum Reservoir Area: **MAXRA** (km^2)
Maximum Storage: **MAXSTG** (hm^3)

Minimum Water Level: **MINWL** (m)
Minimum Reservoir Area: **MINRA** (km^2)
Minimum Storage: **MINSTG** (hm^3)

Design Discharge: **DES** (m^3/s)
Number of Units: **N**
Tail Water Level: **TWL** (m)
Number of Penstocks: **NP**
Diameter of Penstock: **DIAP** (m)
Lenght of Penstock: **LP** (m)
Number of Energy Tunnels: **NET**
Diameter of Energy Tunnels: **DIAET** (m)
Lenght of Energy Tunnels: **LET** (m)

Friction Loss in Penstocks, h_{f1} = f x LP / DIAP x $V_{penstock}^2$ / (2 x g) (The Darcy-Weisbach Formula)

$Q_{penstock}$ = DES / NP
$A_{penstock}$= 3.14 x $DIAP^2$ / 4
$V_{penstock}$= $Q_{penstock}$ / $A_{penstock}$

Friction Coefficient, f
(The Colebrook Formula)

$$\frac{1}{\sqrt{f}} = -2\log\left(0.266\frac{k}{D}\right)$$

k= 0.01 in (Shames, 1989)
D (in) = D (m) x 39.37

Friction Loss in Energy Tunnels, h_{f2} = n x $V_{etunnel}{}^2$ / $(DIAET / 4)^{4/3}$ x LET (The Manning Formula)

$Q_{etunnel}$ = DES / NET
$A_{etunnel}$= 3.14 x $DIAET^2$ / 4
$V_{etunnel}$= $Q_{etunnel}$ / $A_{etunnel}$

Manning Coefficient, n= 0.014

$\mathbf{h_f}$ = 1.1 x (h_{f1} + h_{f2})
K = h_f / DES^2

Gross Head: **GH1** (m) = MAXWL - TWL
Net Head: **NH1** (m) = GH1 - K x DES^2 - GH1 x 0.05

Efficiency of Turbines: **EEFFT** = 0.93

Installed Power: **IP** (MW) = 9.81 x EEFFT x NH1 x DES

Month 1

STEP 1.1

Number of Days in the Month: **D**
Monthly Mean Input Discharge Value: **DIS** (m^3/s)
Monthly Mean Input Flow Value: **F** (hm^3) = DIS x D x 24 x 60 x 60 / 10^6

↓

STEP 1.2

Environmental Water: **ENW** (hm^3)
Irrigation Water: **IW** (hm^3)
Domestic Water: **DW** (hm^3)
Irrigation Water Demand of Downstream Project: **DDW** (hm^3)

↓

STEP 1.3

Water Level at the Beginning of the Month: **WLB** (m)
Reservoir Area at the Beginning of the Month: **RAB** (km^2)
Storage at the Beginning of the Month: **STGB** (hm^3)

↓

STEP 1.4

Evaporation: **E** (mm)
Net Evaporation: **NE** (hm^3) = E x RAB / 10^3

↓

STEP 1.5

Discharge Used in Energy Production: **EDW** (m^3/s)
Flow Used in Energy Production: **EFW** (hm^3) **=** EDW x D x 24 x 60 x 60 / 10^6
Lack in Irrigation Water Demand of Downstream Project: **LACK** (hm^3) = DDW - EFW

↓

STEP 1.6

Discharge Used in Energy Production in %95 of the total operation period: **QFIRM** (m^3/s)

TRIAL AND ERROR
Starting Value: QFIRM = DES with Interval = 0.01

If EDW < QFIRM, "COUNT = *COUNT + 1*"
The Total Operation Period: **TM**
If COUNT > 0.05 x TM
QFIRM = QFIRM - 0.01

↓

STEP 1.7

EDW = 0
If LACK < 0, LACK = 0
Storage at the End of the Month: **STGE** (hm^3) = STGB - ENW - IW - DW - NE - EFW - LACK + F
Water Level at the End of the Month: **WLE** (m) = **f (**STG, WL**)**
Reservoir Area at the End of the Month: **RAE** (km^2) = **f (**WL, RA**)**
COUNT = COUNT + 1
If COUNT > 0.5 x TM
QFIRM = QFIRM - 0.01 >>> ***RETURN TO STEP 1.6***

If STGE > MINSTG
EDW = QFIRM
If LACK < 0, LACK = 0
STGE = STGB - ENW - IW - DW - NE - EFW - LACK + F

If STGE <= MINSTG
EDW = QFIRM - (MINSTG - STGE) / (24 x 60 x 60 x D)
STGE = MINSTG
WLE = MINWL
RAE = MINRA
COUNT = COUNT + 1
If COUNT > 0.5 x TM
QFIRM = QFIRM - 0.01 >>> ***RETURN TO STEP 1.6***

If STGE > MINSTG and STGE < MINSTG
WLE = f (STG, WL)
RAE = f (WL, RA)

If DIS > DES

STEP 1.7(CONTİNUED)

EDW = DES

If DIS <= DES
EDW = DIS

If LACK < 0, LACK = 0
STGE = STGB - ENW - IW - DW - NE - EFW - LACK + F

If STGE >= MAXSTG and EDW = DES
EDW = DES
If LACK < 0, LACK = 0
STGE = STGB - ENW - IW - DW - NE - EFW - LACK + F
Flow Released through Spillway: **SPL** (hm^3) = STGE - MAXSTG
STGE = MAXSTG
WLE = MAXWL
RAE = MAXRA

If STGE < MAXSTG and EDW = DES
EDW = DES - (MAXSTG - STGE) / (24 x 60 x 60 x D)
STGE = MAXSTG
WLE = MAXWL
RAE = MAXRA

If STGE < MAXSTG and EDW = DIS
EDW = DIS - (MAXSTG - STGE) / (24 x 60 x 60 x D)
STGE = MAXSTG
WLE = MAXWL
RAE = MAXRA

If STGE >= MAXSTG and EDW = DIS
EDW = DIS + (STGE - STGE) / (24 x 60 x 60 x D)
If LACK < 0, LACK = 0
STGE = STGB - ENW - IW - DW - NE - EFW - LACK + F
SPL = STGE - MAXSTG
STGE = MAXSTG
WLE = MAXWL
RAE = MAXRA

↓

STEP 1.8

Average Water Level: **AWL** (m) = (WLB + WLE) / 2

RETURN TO STEP 1. 1

Month 2

After conducting a series of runs during the entire period, LACK and QFIRM values are obtained. However in these calculations, LACK flows are not used in energy production. Therefore, an operation for the entire period is carried out with determined QFIRM value using new EFW values obtained as adding LACK to preceding EFW for each month.

Month 1

STEP 2.1

Flow Used in Energy Production: **EFWL** (hm^3) **=** EFW + LACK
Discharge Used in Energy Production: **EDWL** (m^3/s) = EFWL x 10^6 / (D x 24 x 60 x 60)

↓

STEP 2.2

Number of Operated Units: **OPN** = **f (**EDWL, DES/N**)**
Duration of Operation: **T** (hours) = 24 x D

STEP 2.3

Gross Head: **GH** (m) = AWL - TWL
Net Head: **NH** (m) = GH - K x EDW^2 - GH x 0.05

STEP 2.4

Power: **P** (kW) = 9.81 x EDWL x NH x EEFFT

If P > IP
P = IP

STEP 2.5

Produced Energy: **EN** (kWh) = P x T x 0.985 x 0.975

If EDWL > QFIRM
Firm Energy: **FEN** (kWh) = QFIRM / EDWL x EN
If EDWL < QFIRM
FEN = 0
Secondary Energy: **SEN** (kWh) = EN – FEN

RETURN TO STEP 2. 1

Month 2

I.5. Operation of the Dicle-Kralkizi Project

I.5.1. The Kralkizi Dam and HEPP

Maximum Water Level: **MAXWL** (m)
Maximum Reservoir Area: **MAXRA** (km^2)
Maximum Storage: **MAXSTG** (hm^3)

Minimum Water Level: **MINWL** (m)
Minimum Reservoir Area: **MINRA** (km^2)
Minimum Storage: **MINSTG** (hm^3)

Design Discharge: **DES** (m^3/s)
Number of Units: **N**
Tail Water Level: **TWL** (m)
Number of Penstocks: **NP**
Diameter of Penstock: **DIAP** (m)
Lenght of Penstock: **LP** (m)
Number of Energy Tunnels: **NET**
Diameter of Energy Tunnels: **DIAET** (m)
Lenght of Energy Tunnels: **LET** (m)

Friction Loss in Penstocks, h_{f1} = f x LP / DIAP x $V_{penstock}^2$ / (2 x g) (The Darcy-Weisbach Formula)

$Q_{penstock}$ = DES / NP
$A_{penstock}$= 3.14 x $DIAP^2$ / 4
$V_{penstock}$= $Q_{penstock}$ / $A_{penstock}$

Friction Coefficient, f
(The Colebrook Formula)

$$\frac{1}{\sqrt{f}} = -2\log\left(0.266\frac{k}{D}\right)$$

k= 0.01 in (Shames, 1989)
D (in) = D (m) x 39.37

Friction Loss in Energy Tunnels, h_{f2} = n x $V_{etunnel}{}^2$ / $(DIAET / 4)^{4/3}$ x LET (The Manning Formula)

$Q_{etunnel}$ = DES / NET
$A_{etunnel}$= 3.14 x $DIAET^2$ / 4
$V_{etunnel}$= $Q_{etunnel}$ / $A_{etunnel}$

Manning Coefficient, n= 0.014

$\mathbf{h_f}$ = 1.1 x (h_{f1} + h_{f2})
K = h_f / DES^2

Gross Head: **GH1** (m) = MAXWL - TWL
Net Head: **NH1** (m) = GH1 - K x DES^2 - GH1 x 0.05

Efficiency of Turbines: **EEFFT** = 0.93

Installed Power: **IP** (MW) = 9.81 x EEFFT x NH1 x DES

Month 1

STEP 1

Number of Days in the Month: **D**
Monthly Mean Input Discharge Value: **DIS** (m^3/s)

STEP 1(CONTINUED)

Monthly Mean Input Flow Value: **F** (hm^3) = DIS x D x 24 x 60 x 60 / 10^6

STEP 2

Lack in the Irrigation Water Supply of the Dicle Project: **LACK** (hm^3)

STEP 3

Water Level at the Beginning of the Month: **WLB** (m)
Reservoir Area at the Beginning of the Month: **RAB** (km^2)
Storage at the Beginning of the Month: **STGB** (hm^3)

STEP 4

Evaporation: **E** (mm)
Net Evaporation: **NE** (hm^3) = E x RA_B / 10^3

STEP 5

Discharge Used in Energy Production: **EDW** (m^3/s)
Flow Used in Energy Production: **EFW** (hm^3) **=** EDW x D x 24 x 60 x 60 / 10^6 + LACK

STEP 6

Discharge Used in Energy Production in %95 of the total operation period: **QFIRM** (m^3/s)

TRIAL AND ERROR
Starting Value: QFIRM = DES with Interval = 0.01

If EDW < QFIRM, "COUNT = *COUNT + 1*"
The Total Operation Period: **TM**
If COUNT > 0.05 x TM
QFIRM = QFIRM - 0.01

STEP 7

EDW = 0
Storage at the End of the Month: **STGE** (hm^3) = STGB - NE - EFW + F
Water Level at the End of the Month: **WLE** (m) = **f (**STG, WL**)**
Reservoir Area at the End of the Month: **RAE** (km^2) = **f (**WL, RA**)**
COUNT = COUNT + 1
If COUNT > 0.5 x TM
QFIRM = QFIRM - 0.01 >>> ***RETURN TO STEP 6***

If STGE > MINSTG
EDW = QFIRM
STGE = STGB - NE - EFW + F

If STGE <= MINSTG
EDW = QFIRM - (MINSTG - STGE) / (24 x 60 x 60 x D)
STGE = MINSTG
WLE = MINWL
RAE = MINRA
COUNT = COUNT + 1
If COUNT > 0.5 x TM
QFIRM = QFIRM - 0.01 >>> ***RETURN TO STEP 6***

If STGE > MINSTG and STGE < MINSTG
WLE = f (STG, WL)
RAE = f (WL, RA)

If DIS > DES
EDW = DES

If DIS <= DES
EDW = DIS

STGE = STGB - NE - EFW + F

If STGE >= MAXSTG and EDW = DES
EDW = DES
STGE = STGB - NE - EFW + F
Flow Released through Spillway: **SPL** (hm^3) = STGE - MAXSTG
STGE = MAXSTG
WLE = MAXWL
RAE = MAXRA

If STGE < MAXSTG and EDW = DES
EDW = DES - (MAXSTG - STGE) / (24 x 60 x 60 x D)
STGE = MAXSTG
WLE = MAXWL
RAE = MAXRA

If STGE < MAXSTG and EDW = DIS
EDW = DIS - (MAXSTG - STGE) / (24 x 60 x 60 x D)
STGE = MAXSTG
WLE = MAXWL
RAE = MAXRA

If STGE >= MAXSTG and EDW = DIS
EDW = DIS + (STGE - STGE) / (24 x 60 x 60 x D)
STGE = STGB - NE - EFW + F
SPL = STGE - MAXSTG
STGE = MAXSTG
WLE = MAXWL
RAE = MAXRA

STEP 8

Average Water Level: **AWL** (m) = (WLB + WLE) / 2

STEP 9

Discharge Used in Energy Production: **EDWL** (m^3/s) = EFW x 10^6 / (D x 24 x 60 x 60)
Number of Operated Units: **OPN** = **f (**EDWL, DES/N**)**
Duration of Operation: **T** (hours) = 24 x D

STEP 10

Gross Head: **GH** (m) = AWL - TWL
Net Head: **NH** (m) = GH - K x $EDWL^2$ - GH x 0.05

STEP 11

Power: **P** (kW) = 9.81 x EDWL x NH x EEFFT

If P > IP
P = IP

STEP 12

Produced Energy: **EN** (kWh) = P x T x 0.985 x 0.975

If EDW > QFIRM
Firm Energy: **FEN** (kWh) = QFIRM / EDWL x EN
If EDW < QFIRM
FEN = 0
Secondary Energy: **SEN** (kWh) = EN – FEN

RETURN TO STEP 1

I.5.2. The Dicle Dam and HEPP

Maximum Water Level: **MAXWL** (m)
Maximum Reservoir Area: **MAXRA** (km^2)
Maximum Storage: **MAXSTG** (hm^3)

Minimum Water Level: **MINWL** (m)
Minimum Reservoir Area: **MINRA** (km^2)
Minimum Storage: **MINSTG** (hm^3)

Design Discharge: **DES** (m^3/s)
Number of Units: **N**
Tail Water Level: **TWL** (m)
Number of Penstocks: **NP**
Diameter of Penstock: **DIAP** (m)
Lenght of Penstock: **LP** (m)
Number of Energy Tunnels: **NET**
Diameter of Energy Tunnels: **DIAET** (m)
Lenght of Energy Tunnels: **LET** (m)

Friction Loss in Penstocks, h_{f1} = f x LP / DIAP x $V_{penstock}^2$ / (2 x g) (The Darcy-Weisbach Formula)

$Q_{penstock}$ = DES / NP
$A_{penstock}$= 3.14 x $DIAP^2$ / 4
$V_{penstock}$= $Q_{penstock}$ / $A_{penstock}$

Friction Coefficient, f
(The Colebrook Formula)

$$\frac{1}{\sqrt{f}} = -2\log\left(0.266\frac{k}{D}\right)$$

k= 0.01 in (Shames, 1989)
D (in) = D (m) x 39.37

Friction Loss in Energy Tunnels, h_{f2} = n x $V_{etunnel}^{\ 2}$ / $(DIAET / 4)^{4/3}$ x LET (The Manning Formula)

$Q_{etunnel}$ = DES / NET
$A_{etunnel}$= 3.14 x $DIAET^2$ / 4
$V_{etunnel}$= $Q_{etunnel}$ / $A_{etunnel}$

Manning Coefficient, n= 0.014

h_f = 1.1 x (h_{f1} + h_{f2})
K = h_f / DES^2

Gross Head: **GH1** (m) = MAXWL - TWL
Net Head: **NH1** (m) = GH1 - K x DES^2 - GH1 x 0.05

Efficiency of Turbines: **EEFFT** = 0.93

Installed Power: **IP** (MW) = 9.81 x EEFFT x NH1 x DES

Month 1

STEP 1

Number of Days in the Month: **D**
Monthly Mean Output Discharge Value of Dipni HEPP: **DIP** (m^3/s)
Monthly Mean Discharge Value of the Intermediate Basin: **INTB** (m^3/s)
Monthly Mean Output Discharge Value of Kralkizi HEPP: **KRAL** (m^3/s)
Monthly Mean Input Discharge Value: **DIS** (m^3/s) = DIP + INTB + KRAL

STEP 1(CONTINUED)

Monthly Mean Input Flow Value: **F** (hm^3) = DIS x D x 24 x 60 x 60 / 10^6

↓

STEP 2

Irrigation Water: **IW** (hm^3)

↓

STEP 3

Water Level at the Beginning of the Month: **WLB** (m)
Reservoir Area at the Beginning of the Month: **RAB** (km^2)
Storage at the Beginning of the Month: **STGB** (hm^3)

↓

STEP 4

Evaporation: **E** (mm)
Net Evaporation: **NE** (hm^3) = E x RAB / 10^3

↓

STEP 5

Storage at the End of the Month: **STGE** (hm^3) = STGB - IW - NE + F

If STGE > MAXSTG
Excess Water: **EXCESS** (hm^3) = STGE - MAXSTG
Flow Released through Spillway: **SPL** (hm^3) = EXCESS - DES x (D x 24 x 60 x 60) / 10^6
IF SPL < 0, SPL = 0
Flow Used in Energy Production: **EFW** (hm^3) **=** EXCESS - SPL
Discharge Used in Energy Production: **EDW** (m^3/s) = EFW x 10^6 / (D x 24 x 60 x 60)

If STGE < MINSTG
Water Transferred from Kralkizi Reservoir: **TW** (hm^3) = MINSTG - STGE
STGE **=** MINSTG

↓

STEP 6

Water Level at the End of the Month: **WLE** (m) = **f (**STG, WL**)**
Reservoir Area at the End of the Month: **RAE** (km^2) = **f (**WL, RA**)**

↓

STEP 7

Average Water Level: **AWL** (m) = (WLB + WLE) / 2

↓

STEP 8

Number of Operated Units: **OPN** = **f (**EDW, DES/N**)**
Duration of Operation: **T** (hours) = 24 x D

↓

STEP 9

Gross Head: **GH** (m) = AWL - TWL
Net Head: **NH** (m) = GH - K x EDW^2 - GH x 0.05

↓

STEP 10

Power: **P** (kW) = 9.81 x EDW x NH x EEFFT

If P > IP
P = IP

↓

STEP 10

Produced Energy: **EN** (kWh) = P x T x 0.985 x 0.975
Firm Energy: **FEN** (kWh) = 0
Secondary Energy: **SEN** (kWh) = EN

RETURN TO STEP 1

Month 2

I.5.3. Combined System

STEP 1

The Kralkizi Dam and HEPP
$LACK_1 = 0$ for all months

↓

STEP 2

The Dicle Dam and HEPP
Obtain TW_1 for all months in the entire period for $LACK_1$ values in the Kralkizi operation.

↓

STEP 3

The Kralkizi Dam and HEPP
Conduct operation with $LACK_1 = TW_1$

↓

STEP 4

The Dicle Dam and HEPP
Obtain TW_2 for all months in the entire period for $LACK_1$ values in the Kralkizi operation.

If $TW_2 = 0$ for all months
Stop

If $TW_2 > 0$ for any month
Return to *STEP 3*
$LACK_2 = TW_1 + TW_2$

APPENDIX J

ECONOMIC ANALYSIS

J.1. Schedule of Estimated Prices for Penstock (Pro-sem, 2008; DSI, 2009)

(with 2009 unit prices of DSI)

No	Description of Work	Amount	Unit	Unit Price (TL)
1	Irrigation structure excavation of any kind of hard rock without using explosives, hauling of excavation to storage or filling areas, filling of remaining gaps in excavation site after construction or production	200.00	m^3	40.20

2	Excavation of any kind of soil (except bog and rock) and hauling to filling sites	A_2	m^3	1.30

Diameter of Penstock= **D** (m)

Length of Penstock (**L**)= 200 (m)

Slope of Excavation (**S**)= 1.0

Wideness of Excavation= D+7 (m)

Height of Excavation= D*2 (m)

$$A_2 = (D+7)*1.5*L+0.4*L*(D*2)*((D+7)+S*(D*2))$$

3	Excavation of any kind of rock and hauling to filling sites or storage	A_3	m^3	9.60

$$A_3 = 0.6*L*(D*2)*[(D+7)+S*(D*2)]$$

4	Concrete prepared with sand and gravel according to the dosage as directed by the Administration, mixed by concrete mixer, poured by pumpcrete and vibrated	A_4	m^3	76.88

Number of Steel Bearing of Penstocks (**N**)= 3

$$A_4 = 0.1*L*((D+7)+2)+1.4*0.5*2*L+(D*4*D*2*D*2)*N$$

5	Cement to be used in construction	A_5	ton	138.63

$$A_5 = (0.3*A_4)$$

6	Making F2 type formwork for any kind of unreinforced and reinforced concrete construction at plain surfaces	A_6	m^2	28.60

$$A_6 = 4*L+2*D*2*L$$

7	Assembling of reinforcing bars in diameter of more than 14Φ	A_7	ton	1368.45

$$A_7 = 0.04*A_4$$

8	Aboveground penstocks and their steel bearings	A_8	kg	10.70

Water Hammer Coefficient (**C**)= 1.45 (For Francis –Type Turbines)

σ= 1400 kgf/cm^2

Welding Yield (**W**)= 0.9

Maximum Water Level= $\mathbf{H_1}$ (m)

Minimum Water Level= $\mathbf{H_2}$ (m)

Tailwater Level= $\mathbf{H_3}$ (m)

Head (**H**)= H_1-H_3 (m)

Net Length ($\mathbf{L_N}$)= $(L^2+(H_2-H_3)^2)^{0.5}$ (m)

<u>Thickness of penstock (**T**)</u>

$\mathbf{T_{min1}}$= MAX ((5*(H*C/10*D*100)/((2* σ *W)+0.2)*2;8) (m)

$\mathbf{T_{min2}}$= ((800+D*1000)/400/2)*2 (m)

$\mathbf{T_{min}}$= MAX (T_{min1};T_{min2}) (m)

$\mathbf{T_{max}}$= MAX ((5*(H*C/10*D*100)/((2* σ *W)+0.2)*2;T_{min}) (m)

$\mathbf{T_{avg}}$= ((T_{max}+ T_{min})/4)*2 (m)

T= L_N *T_{avg}/L (m)

$$A_8 = ((3.14*(D/2+T/1000)^2-(3.14*(D/2)^2))*L*1.15*7850$$

9	Painting of iron products doubly against minium and rust	A_9	m^2	14.64

$$A_9 = (D+2*T/1000)*3.14*L$$

10	Hauling of cement to be used in the construction	A_{10}	ton	P_{10}

$$A_{10} = A_5$$

	Kurtalan Cement Factory	
Project	Distance (km)	P_{10} (TL)
Ilisu I Dam & HEPP	50	10.20
Ilisu II Dam & HEPP	20	5.44
Ilisu III Dam & HEPP	25	6.23
Ilisu IV Dam & HEPP	100	18.13
Ilisu V Dam & HEPP	100	18.13

11	Hauling of all type of reinforcing bar to be used in the construction	A_{11}	ton	P_{11}

Distance= **Di** (km)

	Iskenderun Iron & Steel Factory
Project	Distance (km)
Ilisu I Dam & HEPP	774
Ilisu II Dam & HEPP	744
Ilisu III Dam & HEPP	749
Ilisu IV Dam & HEPP	640
Ilisu V Dam & HEPP	700

Crude road (**d**)= 50 (km)

A= 1+0.25*d/Di

B= 1.25

$$A_{11} = A_7$$

$$P_{11} = (0.126875*Di+0.813)*A*B$$

12	Hauling of sand and gravel to be used in the construction (5 km)	A_{12}	ton	2.72

$$A_{12} = 2*A_4$$

13	Hauling of excavation (2 km)	A_{13}	ton	1.72

$$A_{13}= (200+A_2+A_3)/2*1.6$$

J.2. Schedule of Estimated Prices for Energy Tunnel (Hidrokon, April 2009; DSI, 2009)

(with 2009 unit prices of DSI)

No	Description of Work	Amount	Unit	Unit Price (TL)
1	Tunnel excavation at any kind and any class of soil with cross-sectional area of more than 6 m^2	A_1	m^3	82.15

Length of Tunnel (**L**)= 400 (m)

Diameter of Tunnel= **D** (m)

Excavation Area (**A**)= $3.14*(D*1.2+0.1)^2/4$ (m^2)

$$A_1= 3.14*(D*1.2+0.1)^2/4 *L$$

2	Beaching with profiled iron (applied in %50 of the tunnel length)	A_2	ton	663.58

Weight of I16 Profile Iron= 17.9 (kg)

Spacing= 5 (m)

$$A_2= (17.9*D*3.14*L/5*0.5)/1000$$

3	Imperviousness and expansion joint with B type rubber seal	A_3	m	19.91

$$A_3= D*3.14*L/12$$

4	Mounting of wire mesh (applied in %50 of the tunnel length)	A_4	kg	2.51

$$A_4= (((D*3.14*270/360)*L*0.5)*1.2)*2.96$$

5	Boring of anchor and rock bolt hole (applied in %25 of the tunnel length)	A_5	m	13.54

Direction= 4

Spacing= 6 (m)

Length= 6 (m)

Total Weight= (4*6*L/5*0.25)*4.17 (kg)

$$A_5 = 4*6*L/5*0.25$$

6	Curtain grouting at any kind of soil (at 100-200 kg sediment injected holes) (applied in %15 of the tunnel length with %10 injection)	A_6	m^3	232.93

Direction= 4

Spacing= 3 (m)

Length= 3 (m)

$$A_6 = 3^2*3.14/4*(4*3*L/3*0.15)*0.1$$

7	Boring injection hole without core in length of 10-30 m at hard formation	A_7	m	187.06

$$A_7 = 4*3*L/3*0.15$$

8	Making F3 type formwork for any kind of unreinforced and reinforced concrete construction at plain surfaces	A_8	m^2	41.19

$$A_8 = D*3.14*290/360*L$$

9	Construction of shotcrete at underground (applied in %100 of the tunnel length) (applied in %50 of the tunnel length for wire mesh)	A_9	ton	113.23

Thickness= 0.05 m

$$A_9 = (((D*1.2+0.1)^2-(D*1.2+0.05)^2)*3.14/4)*L*1.5*2.2$$

10	Placing of anchoring iron	A_{10}	kg	2.24

$$A_{10} = (4*6*L/5*0.25)*4.17$$

11	Concrete prepared with sand and gravel according to dosage as directed by the Administration, mixed by concrete mixer, poured by pumpcrete and vibrated	A_{11}	m^3	101.29

$$A_{11} = [A-(3.14*D^2/4)]*L-A_9/2.2$$

12	Cement to be used in construction	A_{12}	ton	138.63

$$A_{12}= (A_{11}*0.3+A_6*0.3)+ A_9/2.2$$

13	Reinforcing bars with diameter of more than 14Φ	A_{13}	ton	1381.64

$$A_{13}= 0.035* A_{11}$$

14	Extra payment for tunnels with cross-sectional area of more than 6-55 m^2			P_{14}

$$P_{14}= (138.63*A_{12}+663.58*A_2+19.91*A_3+2.51*A_4+13.54*A_5+232.93*A_6+187.06*A_7)*0.2$$

15	Length overpayment for tunnels			P_{15}

$$P_{15}= (1381.64*A_{13}+41.19*A_8+101.29*A_{11}+113.23*A_9+2.24*A_{10})*0.2$$

16	Hauling of excavated material within the tunnel with cross-sectional area of more than 6 m^2	A_{16}	ton	0.63

$$A_{16}= 1.9* A_1$$

17	Hauling of all type of reinforcing bar and profile to be used in the construction	A_{17}	ton	P_{17}

Distance= **Di** (km)

	Iskenderun Iron & Steel Factory
Project	Distance (km)
Ilisu I Dam & HEPP	774
Ilisu II Dam & HEPP	744
Ilisu III Dam & HEPP	749
Ilisu IV Dam & HEPP	640
Ilisu V Dam & HEPP	700

Crude road (**d**)= 50 (km)

A= 1+0.25*d/Di

B= 1.25

$$A_{17} = A_{13} + A_{12}$$

$$P_{11} = (0.126875*Di+0.813)*A*B$$

18	Loading and unloading of construction materials ,of which hauling costs are paid, within the tunnel with any cross-sectional area	A_{18}	ton	6.75

$$A_{18} = A_{17} + A_{16}$$

19	Hauling of sand and gravel to be used in the construction	A_{19}	ton	10.20

$$A_{19} = 2.2*A_{11}$$

20	Hauling of cement to be used in the construction	A_{20}	ton	127.02

$$A_{20} = A_{12}$$

		Kurtalan Cement Factory
Project	Distance (km)	P_{10} (TL)
Ilisu I Dam & HEPP	50	10.20
Ilisu II Dam & HEPP	20	5.44
Ilisu III Dam & HEPP	25	6.23
Ilisu IV Dam & HEPP	100	18.13
Ilisu V Dam & HEPP	100	18.13

21	Tunnel outlet structure (excavation, portal)		fixed price	150000.00

J.3. Design Discharge Optimization (Hidrokon, April 2009; Yıldız, 1992)

<u>Basic Capital Cost Estimates</u>:

* 1 US$ = 1.5218 TL

(**C1**) Penstocks= f (diameter of penstocks)*number of penstocks

* Diameter of penstocks= $((\text{design discharge/number of penstocks/5})*4*3.14)^{0.5}$

(**C2**) Energy tunnel= f (diameter of energy tunnel)

* Diameter of energy tunnel= $((\text{design discharge/4})*4*3.14)^{0.5}$

(**C3**) Electro-mechanical equipment= 250 US$/MW*Installed Power (MW)

(**C4**) Powerhouse= 0.25* C3

Investment Costs:

(**C5**) The addition of %15 of the penstock cost for physical contingencies= 1.15*C2

(**C6**) The addition of %10 of the total construction costs, including contingencies, to cover the engineering costs associated with design and supervision of the work= 1.1*(C1+C5+C3+C4)

* Social discount rate (i): 9.5%

* Construction period (n): 2 year

* Single payment compound amount factor: $(1+i)^n$

(**C7**) The addition for interest during construction= $C6*(1+0.095)^2$

Annual Costs:

* Economic life of the project following the construction period: 50 years

* Equal payment series capital recovery factor: $(i*(i+1)^n)/((i+1)^n-1)$

(**C8**) Annual Capital Cost= $C7*(0.095*(0.095+1)^{50})/((0.095+1)^{50}-1)$

(**C9**) Annual amortization and renovation cost= 0.0000325*(C1+C2)+0.0018477*C3+0.0041376*C4

(**C10**) Annual operation and maintenance cost: C10: 0.02*C1+0.01*C2+0.01*C3+0.015*C4

(**C11**) Total annual cost= C8+C9+C10

Annual Income:

* Unit price of produced energy: 0.10$/kWh

(**I1**) Annual Income= 0.10*Annual Produced Energy (kWh)

Net Benefit:

Net Benefit= C11-I1

APPENDIX K

FLOOD ANALYSIS

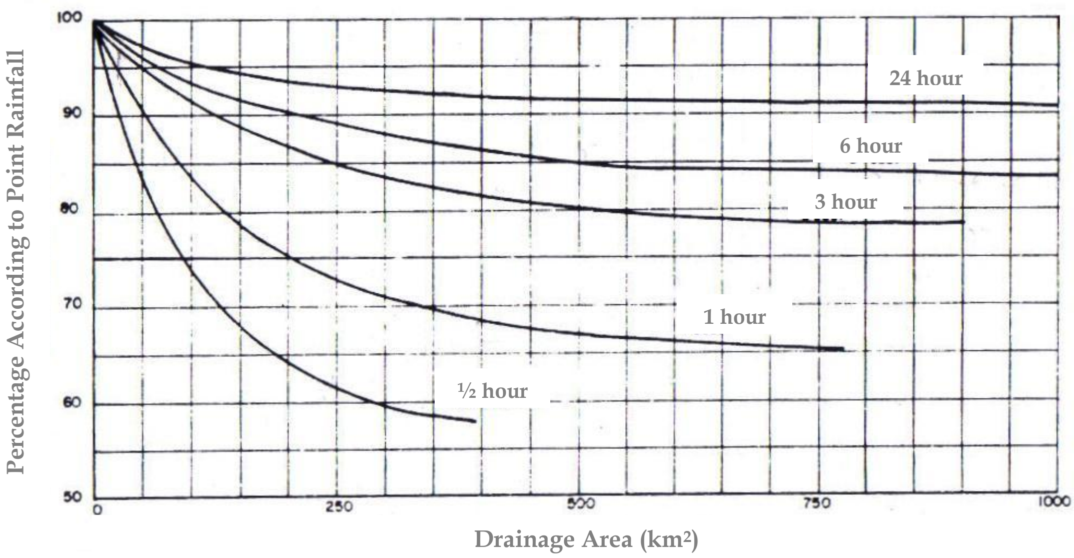


Figure K.1 Areal Distribution of Rainfall (Özdemir, 1978)

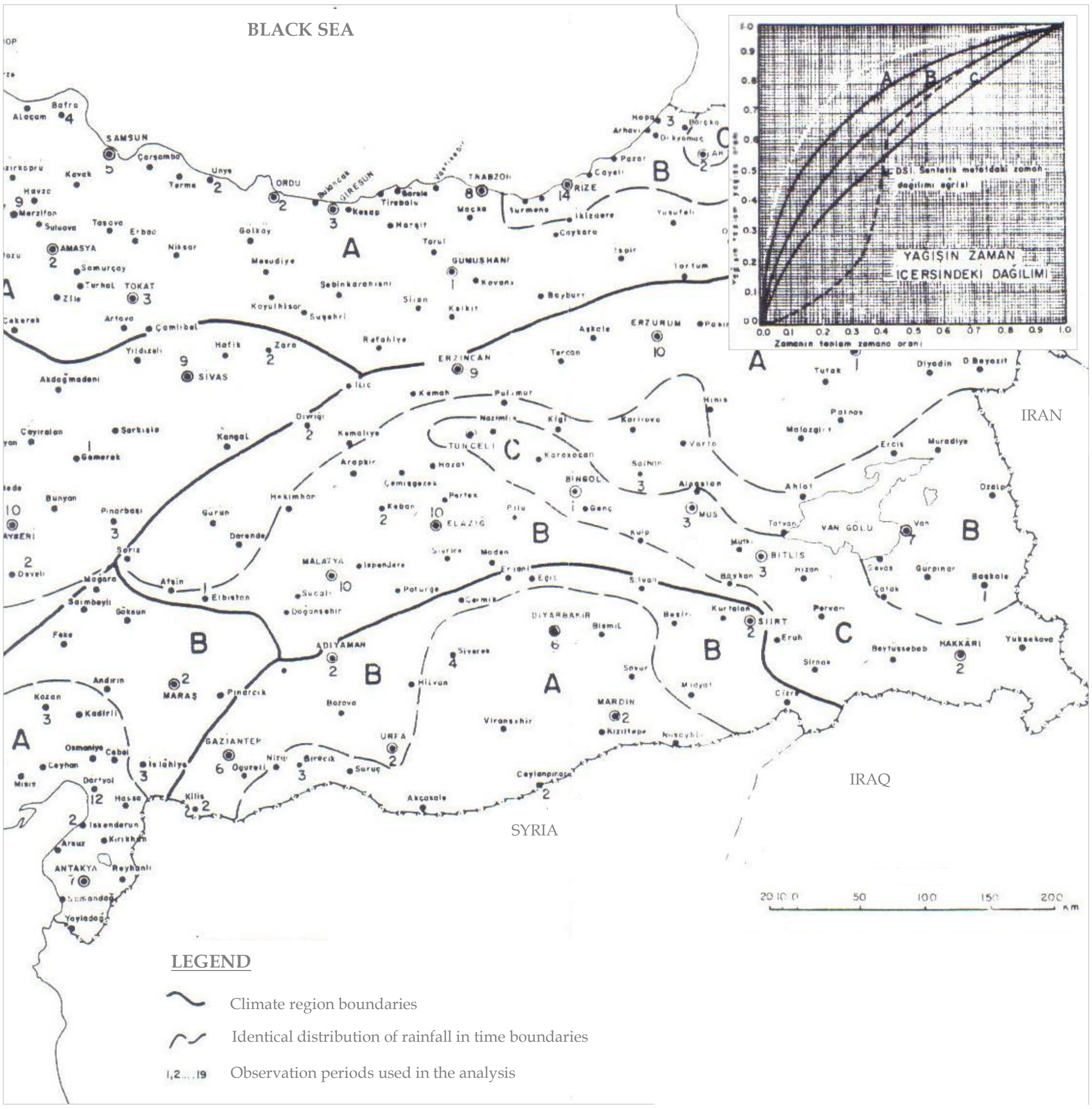


Figure K.2 Distribution of Rainfall in Time (Özdemir, 1978)

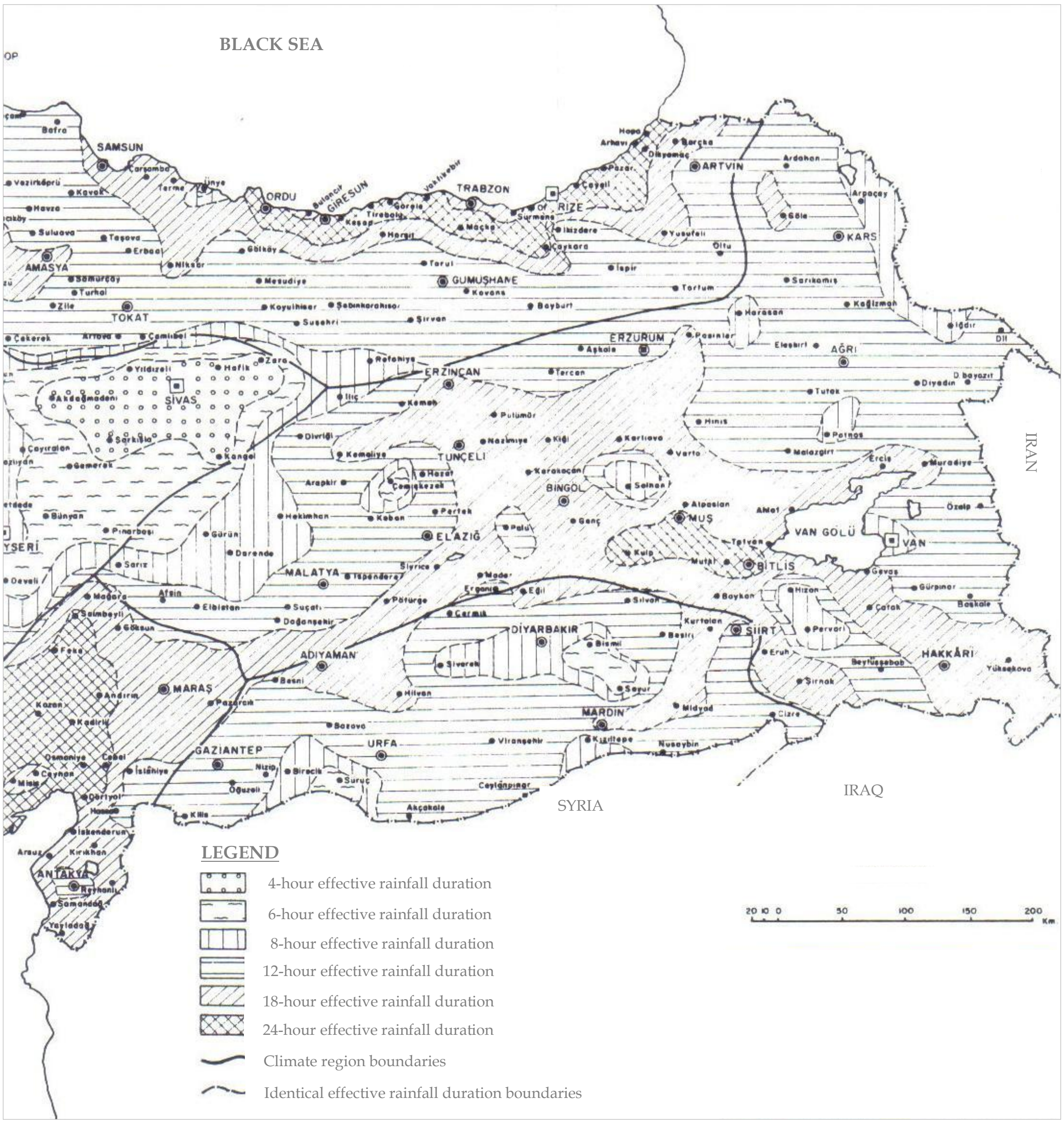


Figure K.3 Effective Rainfall Durations (Özdemir, 1978)

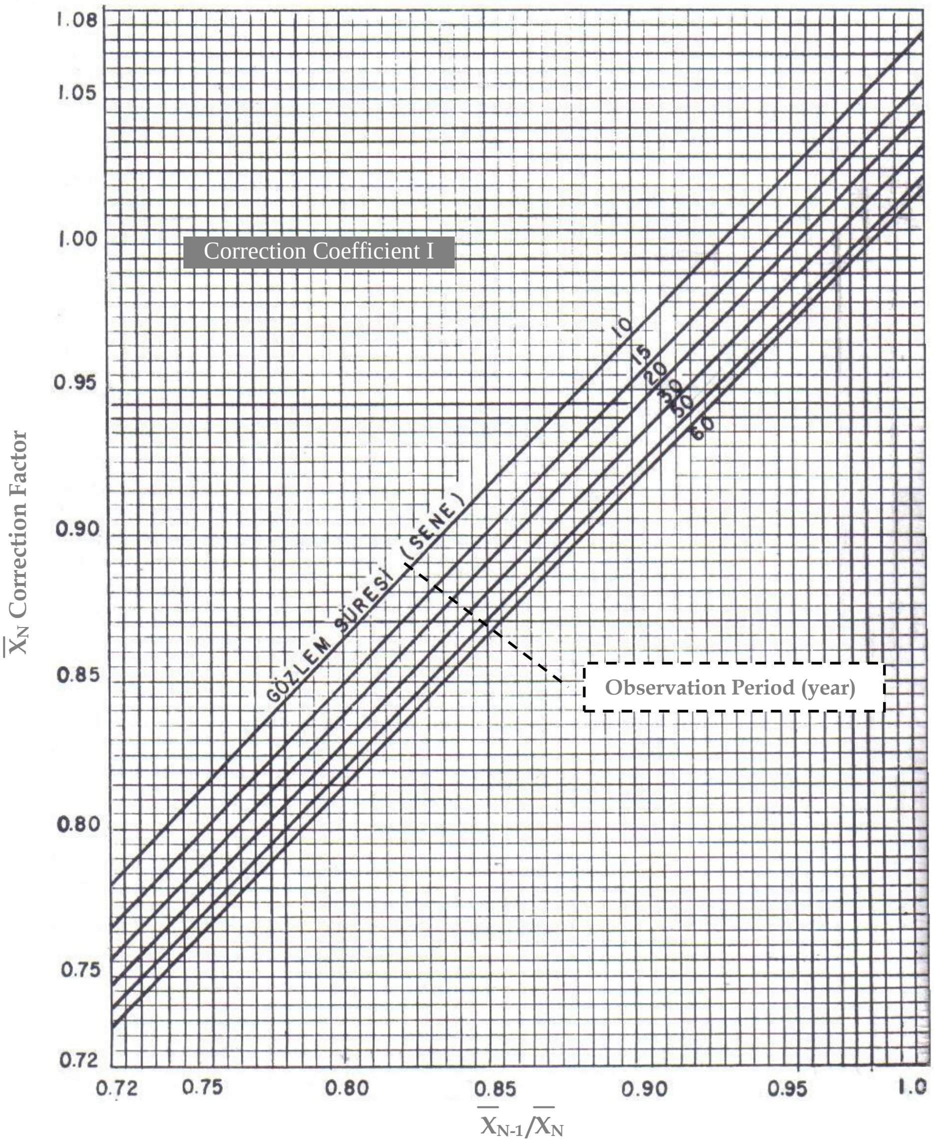


Figure K.4 Correction of Mean Value According to Observed Maximum Rainfall (Özdemir, 1978)

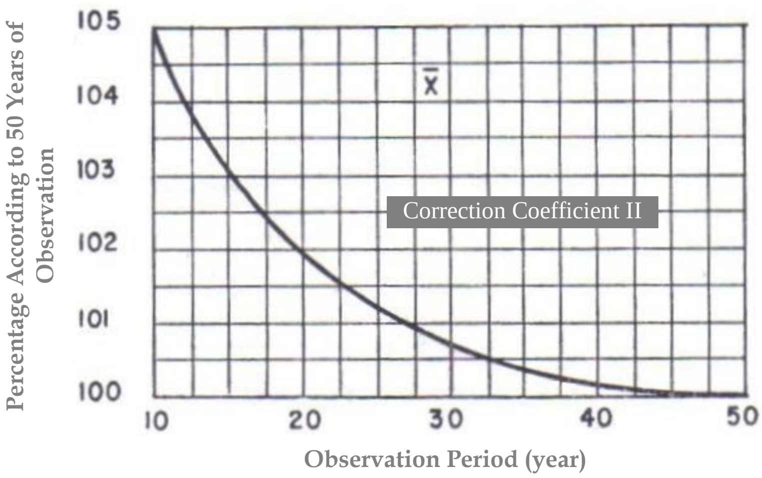


Figure K.5 Correction of Mean Value According to Observation Period (Özdemir, 1978)

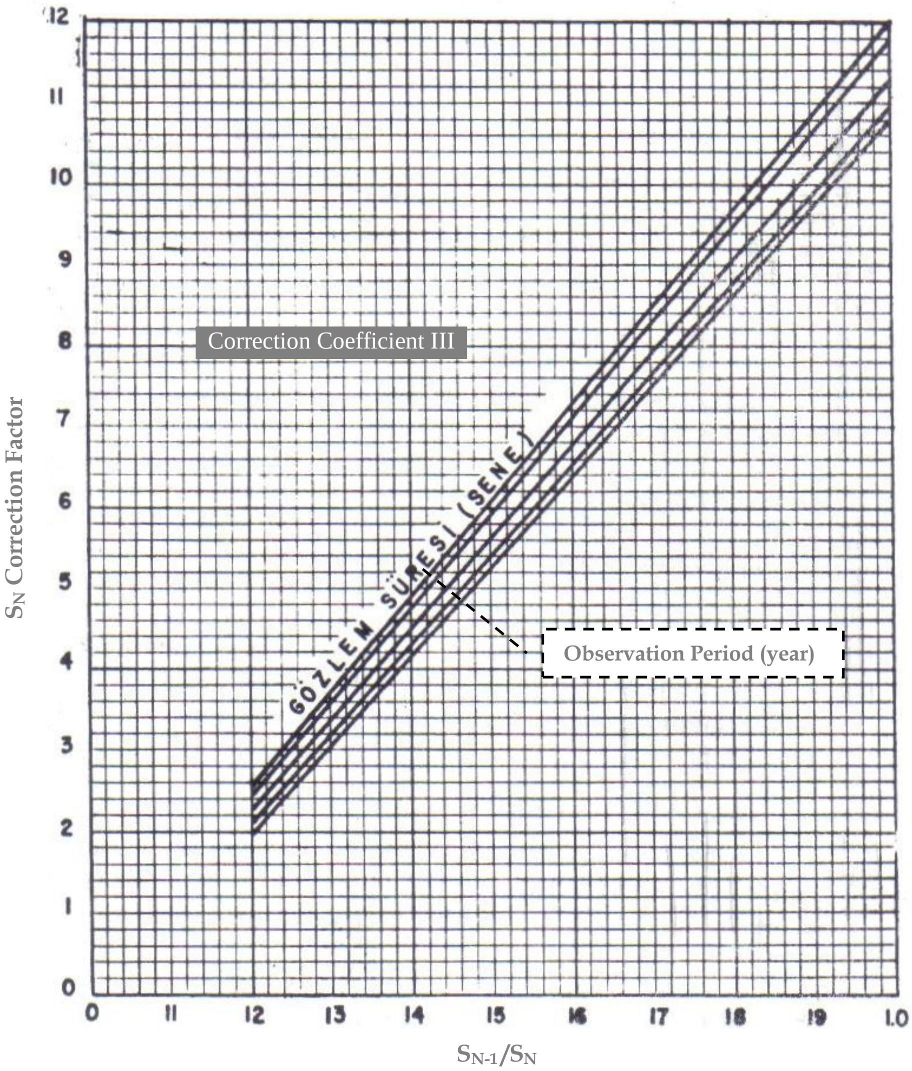


Figure K.6 Correction of Standard Deviation According to Observed Maximum Rainfall (Özdemir, 1978)

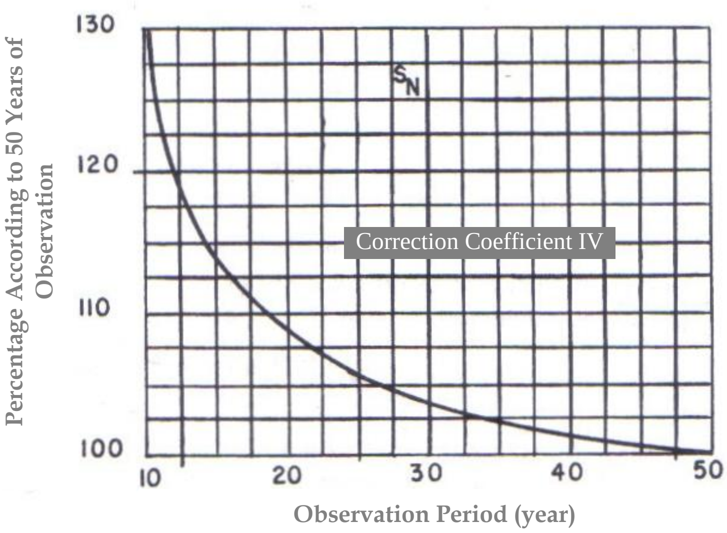
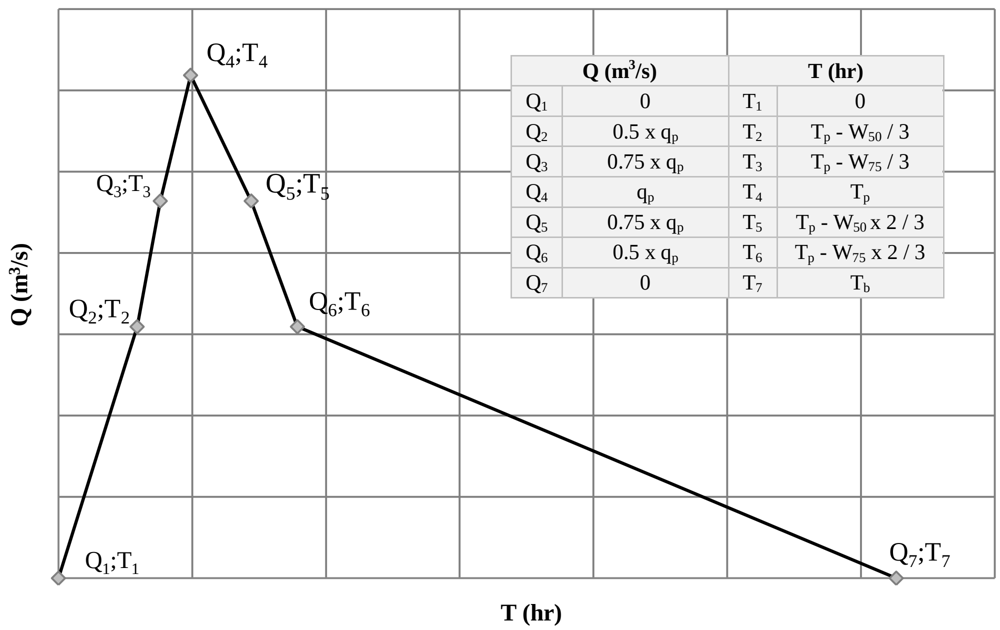


Figure K.7 Correction of Standard Deviation According to Observation Period (Özdemir, 1978)

Table K.1 Derivation of Snyder Unit Hydrograph (Özdemir, 1978; Usul, 2009)

Item	Unit	Definition	Formula
A	km^2	The drainage area	-
L	km	The length of the main stream extended till the basin divide	-
L_c	km	The distance from the basin outlet to a point on the main channel nearest to the centroid of the basin area	-
Ct	-	A Coefficient derived from gauged watersheds in hydrologically similar regions and represents variations in watershed slopes and storage characteristics	-
Cp	-	A Coefficient derived from gauged watersheds in hydrologically similar regions and represents the effects of retention and storage	-
T_l	hr	The standard basin lag	$T_l = 0.752 \times C_t \times (L \times L_c)^3$
T_o	hr	The standard rainfall duration	$T_o = T_l / 5.5$
T_r	hr	The rainfall duration	-
T_{lr}	hr	The basin lag	$T_{lr} = T_l + 0.25 \times (T_r - T_o)$
T_p	hr	The time to peak discharge	$T_p = T_{lr} + T_r / 2$
q_v	$m^3/s/km^2/mm$	The peak discharge per unit area	$q_v = 276 \times C_p / T_{lr}$
q_p	$m^3/s/mm$	The peak discharge	$q_p = q_v \times A / 1000$
T_b	hr	The base time	$T_b = 24 \times (3 + 3 \times T_{lr} / 24)$
W_{50}	-	The width of the unit hydrograph at %50 of the peak discharge	$W_{50} = 2.15 \times (q_v / 100)^{-1.08}$
W_{75}	-	The width of the unit hydrograph at %75 of the peak discharge	$W_{75} = 1.22 \times (q_v / 100)^{-1.08}$



	Q (m^3/s)		T (hr)
Q_1	0	T_1	0
Q_2	$0.5 \times q_p$	T_2	$T_p - W_{50} / 3$
Q_3	$0.75 \times q_p$	T_3	$T_p - W_{75} / 3$
Q_4	q_p	T_4	T_p
Q_5	$0.75 \times q_p$	T_5	$T_p - W_{50} \times 2 / 3$
Q_6	$0.5 \times q_p$	T_6	$T_p - W_{75} \times 2 / 3$
Q_7	0	T_7	T_b

Figure K.8 Snyder's Synthetic Unit Hydrograph (Özdemir, 1978)

APPENDIX L

SELECTED NEWS IN PRESS ABOUT THE PROPOSED SOLUTION

L.1. Milliyet Newspaper, 18.06.2010

Milliyet
BASINDA GÜVEN

Metin Münir

ILISU'YA ODTÜ'DEN YENİ ÇÖZÜM

Enerjisa, Ere ve Gama şirketlerinin sağladığı finansmanla Orta Doğu Teknik Üniversitesi'nin İnşaat Mühendisliği Bölümü'nde su mühendisliği dalında bir mükemmeliyet merkezi kurdu.

Amaç enerji projelerinin çevreye uyumlu bir şekilde geliştirilmesi için stratejiler üretmek.

Öğrendiğime göre takdim aşamasında, yani bitmiş ve sunuma hazır, dokuz proje var. Altı proje üzerinde ise çalışmalar sürüyor. Çalışmalar yüksek lisans araştırması düzeyinde yapılıyor.

Tamamlanan çalışmalardan biri Türkiye'nin tartışmasız en tartışmalı baraj projesi olan Ilısu/Hasankeyf.

Ortaya çıkan bulguları anlatmadan bu girişimi destekleyen üç şirkete şapkamı çıkarmak isterim. Çünkü yansız ve bilimsel olarak akademik ortamda yapılan çalışmalar siyasi ve ticari etkilerden uzak oldukları için enerji projelerine çok ihtiyaç duyulan bir ışık tutacaklar.

İnşaat iki defa durdu

Herkesin bildiği gibi Ilısu'da bir Türk konsorsiyumu tarafından yapılmakta olan Ilısu Barajı Hasankeyf'i sular altında bırakacağı için uluslararası bir kavga meydanı haline geldi. İnşaat iki defa durdu.

Şahnaz Tiğrek yönetiminde Emrah Yalçın tarafından yapılan çalışma Ilısu'da bir yerine beş barajın yapılmasının daha iyi bir seçim olduğunu ortaya çıkardı.

Eğer bu yol seçilirse:

(1) Sular altında kalan alan %27 azalacak.
(2) Hasankeyf ve sayısız tarihi kalıntı sular altında kalmaktan kurtulacak.
(3) Mevcut projede öngörülenden daha çok enerji üretilecek.
(4) İnşaat maliyeti azalacak.
(5) İnşaat daha kısa zamanda sonuçlanacak.

Çalışmayı değerlendiren bir enerji uzmanı, "Bu tez ile önerilen çözüm, hem projenin kredi açmazını çözüyor, hem çevre ve tarih uyumlu, hem bölgeye sosyal barış getiriyor, hem de önemli zaman ve maliyet tasarrufu sağlıyor" dedi.

Alternatif öneri

Öğrendiğime göre tezdeki bulguların özeti 4-5 Temmuz tarihlerinde Gazi Üniversitesi'nde gerçekleşecek olan Nükleer ve Yenilenebilir Enerji Kaynakları adlı konferansa sunulacak.

Gene öğrendiğime göre tez, Ilısu inşaat konsorsiyumu lideri Nurol'un da ilgisini çekti.

Konuyu yakından izleyen bir kaynak "Ilısu konusundaki tez takdimi ile Nurol A.Ş. ilgileniyor zira söz konusu tez ile önerilen çözüm, onlara büyük bir açılım getiriyor. Bunu değerlendirmek isteyebilirler" dedi.

ODTÜ'nün alternatif önerisi herhalde (belki de dudaklarında bir tebessüm) Devlet Su İşleri Genel Müdürlüğü'nün de dikkatini çekecek. Çünkü kuruluşun arşivinde de böyle beş barajlı bir proje var. Ama hazırladığı alternatifler arasında en iyisi olmasına rağmen, DSİ'nin bu projesi bilinmeyen nedenlerle hiç gün yüzü görmedi.

L.2. Milliyet Newspaper, 28.06.2010

Milliyet
BASINDA GÜVEN

Meriç Tafolar (Ankara)

1 YERİNE 5 BARAJ YAPILIRSA HASANKEYF KURTULABİLİR

ODTÜ İnşaat Mühendisliği bölümü yüksek lisans öğrencisi Emrah Yalçın'ın yüksek lisans tezine göre, Ilısu Barajı'ndan elde edilecek enerji, bölgede yapılacak 5 barajdan elde edilebilecek

Özellikle çevrecilerin büyük bir kültürel değerin sular altında kalmasına neden olacağı için başından beri karşı çıktığı Ilısu Barajı için, bilim dünyası bir tez hazırladı.

ODTÜ İnşaat Mühendisliği bölümü yüksek lisans öğrencisi Emrah Yalçın ve danışmanı Yrd. Doç.Dr. Şahnaz Tiğrek tarafından hazırlanan "Ilısu Barajı ve HES, Alternatif Çözümlerin Araştırılması" başlıklı tezde Ilısu Barajı'nın mevcut projesi incelendi ve Hasankeyf'i sular altında bırakmayacak yeni bir çare geliştirilmesi üzerinde çalışıldı.

Hazırlanan teze göre, Ilısu Barajı'ndan elde edilecek enerji, aynı maliyete yapılacak 5 hidroelektrik santralından sağlanabilecek, böylece Hasankeyf ve kültürel mirası korunmuş olacak. 5 barajın toplamı, mevcut proje ile karşılaştırıldığında, toplam rezervuar alanında yüzde 27 oranında bir azalmaya neden olacak ve bu barajlarda toplam 14,8 hektometreküplük bir dolgu hacmi ile 4 bin 426,1 hektometreküp su depolanabilecek. Bu hacmin 3 bin 634,4 hektometreküplük kısmı aktif hacim olarak kullanılabilecek.

Sular altında kalmayacak

Proje, Hasankeyf'i sular altında bırakacak Ilısu Barajı yerine, Dicle Nehri'nin kolları olan Garzan Çayı üzerinde Ilısu I, Bitlis Çayı üzerinde Ilısu II, Botan Çayı üzerinde Ilısu III, Dicle Nehri üzerinde ise Ilısu IV ve Ilısu V barajlarının yapılmasını öngörüyor.

Bu 5 baraj arasında Hasankeyf'e en yakın olan Ilısu IV Barajı da Hasankeyf'in sular altında kalmasına neden olmayacak.

Tiğrek tezle ilgili olarak, Hasankeyf'i sular altında bırakacak tartışmalı Ilısu Barajı'na teknik bir çözümle karşılık vermek istediklerini, Türkiye'nin içinde bulunduğu enerji darboğazını da dikkate alarak yeni bir çözüm üretmeyi hedeflediklerini söyledi.

İlk olarak, temmuz ayı başında Gazi Üniversitesi'nde yapılacak uluslararası nitelikte bir konferansla detaylanacak olan tez, şimdiden bilim çevrelerinde tartışılmaya başlandı.

Yrd. Doç. Dr. Tiğrek, teze ilişkin kamu kurumlarıyla henüz temasa geçmediklerini belirtirken, maliyeti oluşturulduğu takdirde 5 ayrı barajın 3 yıl içinde tamamlanacağını, barajların yapımı sırasında ise arkeolojik çalışmaların devam edebileceğini vurguladı.

L.3. Hurriyet Daily News and Economic Review Newspaper, 29.06.2010

Hürriyet DAILY NEWS & ECONOMIC REVIEW

Erisa Dautaj Şenerdem (Istanbul)

NEW PLAN FLOATED IN TURKEY ON HASANKEYF'S FLOOD

A graduate student's proposal to build five dams on the Tigris River and its branches as a less-destructive alternative to the controversial Ilısu Dam sparks debate about the idea's viability. Some activists say smaller dams would still threaten the area's cultural and natural heritage, while furthering Turkey's dependence on unsustainable energy sources

A new proposal for a series of smaller dams has offered a potential alternative to the deadlock over the fate of Hasankeyf, though some experts say it might cause more problems than it solves. The ancient city in the south eastern province of Batman risks being submerged if the controversial Ilısu Dam is constructed on the Tigris River.

But a graduate student in construction engineering at Middle East Technical University has suggested the site's cultural and environmental heritage might be saved by building five smaller dams instead, daily Milliyet reported Monday.

Many activists say, however, that the idea expressed in Emrah Yalçın's thesis, which was supervised by Professor Şahnaz Tiğrek, would cost the community and the environment too much while furthering the idea that building dams presents a solution to the country's water and electricity demands.

"[Yalçın's] thesis carries a symbolic importance, but it does not generate a solution," Güven Eken, the chair of the Doğa Derneği (Nature Association) told the Hürriyet Daily News & Economic Review, adding that five dams on the river and its branches would still pose a threat to the fauna and flora in the Tigris Valley region, even if the structures are smaller in size than the Ilısu Dam.

"Dams have proven not to be a solution, and other energy sources such as wind or solar energy must be used," said Diren Özkan, an activist with the Save Hasankeyf and the Tigris Valley Initiative, adding that the group is cooperating with other organizations in order to bring the Ilısu case to court very soon.

For Hasankeyf, are five better than one?

According to Özkan, construction of the Ilısu Dam would force more than 70,000 people who live in the region to migrate to other places, destroy nature and eliminate the region's tourism income. The activist told the Daily News that construction of the dam is already having unexpected side effects, as buildings have been constructed throughout the Tigris Valley to house workers on the project, creating even more damage.

The Nature Association's Eken said, however, that a public prestigious university such as METU acknowledging that Hasankeyf risks destruction under the current Ilısu plans was a positive sign.

"The roots of all humanity lie in the Tigris Valley, where the world's civilizations were born," Eken said, adding that the valley as a whole, not only the Hasankeyf region, holds significant cultural heritage. Though activists believe Hasankeyf is the only ancient site in the world that fulfils nine out of the 10 possible criteria that could win a region a place on the UNESCO World Cultural Heritage List, the Turkish government must make the first move, Eken said, adding that the government has not applied to UNESCO for the region's inclusion on the list because of the Ilısu Dam project, which he said violates many existing laws.

The project for constructing the dam has been exempt from the preparation of an environmental impact report, which is a legal obligation for any project affecting the environment, because it was initially prepared before 1993. Yet there is a very simple legal solution to this loophole, Ümit Şahin, a member of Turkey's Green Party, told the Daily News: Turkey should sign the Aarhus Convention, which requires the approval of the local inhabitants before making any investment that could affect the environment.

In terms of alternative solutions for the Hasankeyf and the Tigris Valley, Eken said the Nature Association had already presented a proposal focused on developing the area by increasing tourism.

Once the region is protected by UNESCO, millions of people from all around the world will come to see what the early homes and agricultural sites, Eken told the Daily News. This boom in the tourism sector will increase the number of people employed in the region, improving their standard of living.

A tourism asset

"Turkey has a precious treasury in its hands," Eken said, noting that more than 1 million tourists already visit the region in a year, even without any investment in infrastructure. The area's ancient sites, trekking areas and canyons offer a wide range of activities, he added.

Şahin from the Green Party said a detailed assessment must be made on how the environment and community would be affected by the construction of the five dams Yalçın suggested in his thesis.

He added, however, that the student's proposal made two important points: First, that there is a general sense that Hasankeyf and the Tigris Valley have been put at risk by the construction of the Ilısu Dam, and that large dams should no longer be used to generate energy.

"That the dams [suggested by Yalçın's thesis] are smaller in size does not necessarily imply that they will not be harmful, and we are against the construction of dams in general," Şahin said, adding that they are unsustainable sources of energy that become useless over time due to silt build-up.

He also said Turkey must change its wrong-headed policies on energy, including the use of coal and the effort to build a nuclear-power plant.

L.4. Süddeutsche Zeitung Newspaper, 05.07.2010

Süddeutsche Zeitung

Von Kai Strittmatter (Istanbul)

ZEHNTAUSEND JAHRE KULTURGESCHICHTE VERSINKEN IM TIGRIS

Die Türkei baut nun doch einen Staudamm an der historischen Felsenstadt Hasankeyf – nur eine neue Studie kann das Projekt noch stoppen

Das Ende der über dem Tigris thronenden historischen Felsenstadt Hasankeyf rückt näher. Wenn es nach der türkischen Regierung geht, wird der umstrittene Ilisu-Staudamm im Südosten der Türkei nun gebaut. Ein knappes Jahr nachdem Deutschland, Österreich und die Schweiz ihre Kreditbürgschaften kündigten wegen der ökologischen, sozialen und kulturhistorischen Folgeschäden des Projektes, zeigt sich Ankara unbeirrt. Die österreichische Dammbaufirma Andritz, die als einzige der europäischen Konsortiums Firmen noch mit dabei ist, unterzeichnete im vergangenen Monat Verträge über 340 Millionen Euro. Die ersten Arbeiten haben bereits begonnen.

Dabei ist das Projekt umstritten wie eh und je. Mehr als 60 000 Menschen, kurdische Bauern vor allem, verlieren ihren Lebensraum. Und das Nachbarland Irak protestierte bei einer Wasserkonferenz arabischer Minister in Kairo: Das Land sieht seine Wasserversorgung durch die Stauung des Tigris gefährdet. Die Türkei habe die Interessen Bagdads ignoriert, hieß es in der Protestnote. In der Türkei selbst erregt vor allem die geplante Flutung Hasankeyfs die Gemüter, dessen Geschichte 10 000 Jahre zurückgeht zu den Anfängen menschlicher Zivilisation in Mesopotamien. Ein solches Erbe dürfe nicht einem Damm mit einer Lebenserwartung von nur 50 Jahren zum Opfer fallen. Ankara entgegnet, der 1200-Megawatt-Damm sei notwendig für das von Energieimporten abhängige Land.

Eine Studie der renommierten Technischen Universität Ankaras ODTÜ ist den Gegnern nun ein kleiner Hoffnungsschimmer. Die Studie soll am Montag bei einer Konferenz in Ankara vorgestellt werden; sie zeigt eine Alternative zum Ilisu Damm auf, nämlich den Bau von fünf kleineren Dämmen in dem Gebiet. Die Fläche des überfluteten Gebietes wäre um 27 Prozent kleiner, der Bau käme nicht teurer, und die Energieproduktion würde die des großen Ilisu Damms sogar übertreffen. Vor allem aber: Hasankeyf würde überleben. „Die Studie zeigt: Es geht“, sagt Ulrich Eichelmann von der Kampagne „Stop Ilisu“. „Man kann Hasankeyf retten und trotzdem Strom haben.“ Euphorisch möchte allerdings keiner klingen. „Es ist kompliziert“, sagt Sahnaz Tigrek, die Professorin, die die Erstellung der Studie betreut hat: „Die Arbeiten haben ja schon begonnen.“

In der Türkei haben sich bekannte Künstler einer Initiative angeschlossen, die Hasankeyf zum Weltkulturerbe erklären lassen möchte: Schriftsteller wie Orhan Pamuk und Yasar Kemal, Sänger wie Popstar Tarkan. Zuletzt drehten der deutsch-türkische Regisseur Fatih Akin und die kurdische Sängerin Aynur ein Musikvideo vor der Kulisse. „Bisher waren die Umweltaktivisten erfolgreich, weil sie westlichen Banken und europäischen Regierungen gegenüberstanden, die sensibel für Umweltdinge sind. Jetzt aber haben sie Ankara, türkische Banken und türkische Firmen vor sich“, schrieb die Istanbuler Zeitung *Milliyet*. „Im Westen haben die Regierungen Angst vor dem Volk. Im Osten hat das Volk Angst vor der Regierung. Das gilt leider auch für unser Land.“ Der Autor dieser Zeilen, der Wirtschaftskolumnist Metin Münir, war einer der wenigen türkischen Journalisten, die das Ilisu-Projekt jahrelang kritisch begleiteten. Ziel seiner Kritik ist vor allem Veysel Eroglu, der 2007 vom Chef der Wasserbaubehörde DSI zum Umweltminister wurde – und dabei der oberste Staudammlobbyist des Landes blieb. Ihm wirft Münir zudem vor, Bauaufträge ohne Ausschreibung vergeben zu haben. Eroglu verklagte den Journalisten nun wegen Beleidigung. Ebenso brachte er einen zweiten Kritiker vor Gericht: Güven Eken, den Chef der Umweltorganisation Doga Dernegi, der den Minister als „Serienmörder an der Natur“ bezeichnet hatte.

Eroglu hatte den Ausstieg Berlins, Wiens und Berns 2009 mit den Worten kommentiert, es gebe eben „Länder, die den Aufstieg der Türkei zur Regionalmacht verhindern wollten“. Er nennt den Ilisu-Damm eines der größten Bauwerke in der Geschichte der Türkei und preist den Wiederaufbau des historischen Hasankeyf an neuer Stelle – inklusive eines historischen Themenparks mit Repliken von Monumenten wie der 900 Jahre alten Brücke über den Tigris. Das neue Hasankeyf werde „eine Modellstadt für die Türkei, für den Mittleren Osten, für den Kaukasus und den Balkan werden“, schwärmt Eroglu.

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Carsten Hoffman (Istanbul)

UMWELTSCHUTZER UNTERSTUTZEN ILISU-ALTERNATIVE

Im Streit um den Bau des türkischen Großstaudamms Ilisu machen sich Umweltschützer für eine von Wissenschaftlern in Ankara vorgelegte Alternative stark. Mit der Errichtung von insgesamt fünf kleineren Dämmen könne im Südosten der Türkei die gleiche Menge Strom erzeugt werden, ohne dass die archäologisch bedeutende Stadt Hasankeyf überflutet werden müsse, sagte Ulrich Eichelmann, Koordinator der internationalen Kampagne gegen Ilisu, am Mittwoch.

Deutschland, Österreich und die Schweiz hatten sich vor genau einem Jahr aus der Finanzierung des Projektes zurückgezogen, weil Auflagen für den Umweltschutz, den Erhalt von Kulturgütern und die Umsiedlung von Menschen nicht erfüllt waren. Die türkische Regierung hat erklärt, an dem Projekt werde festgehalten.

Türkische Wissenschaftler hatten in der vergangenen Woche ein Konzept vorgelegt, bei dem 27 Prozent weniger Fläche überspült wird, indem fünf kleinere Dämme den Tigris und seine Nebenflüsse stauen. Der Ilisu-Damm selbst soll statt 135 Meter nur noch etwa 80 Meter hoch werden. Das Konzept sieht aber vor, auf bisher geleisteten Vorarbeiten aufzubauen.

„Wir unterstützen das vorbehaltlos, weil es das erste Mal eine technische Lösung gibt, bei der Hasankeyf erhalten bleibt“, sagte Eichelmann dazu. Der bisher geplante 300 Quadratkilometer große Stausee, der oberhalb der 1820 Meter langen und 135 Meter hohen Ilisu-Staumauer entstehen soll, würde Dörfer überfluten, in den mehr als 10 000 Menschen leben. Die türkische Regierung möchte mit dem Damm Energie gewinnen und Agrarland bewässern.

Die irakische Regierung hat in der vergangenen Woche energisch gegen den Bau des Ilisu-Staudammes protestiert, weil dann im Irak noch weniger des dringend benötigten Wassers ankommen könnte. Die Türkei habe dem Irak bereits durch den Bau eines großen Staudammes am Euphrat geschadet.