Erciyes University Journal of Institue Of Science and Technology

Research Article
10.65520/erciyesfen.1949610

Imprint:
Volume: 42(3)
Year: 2026
Page: 109-136

Çağla Çolak[a*]

[a] Asst. Prof., Avrasya University, caglaclk66@gmail.com

[*] Corresponding Author

Received: 5/12/2026
Accepted: 9/1/2026

Citation:
Çağla Çolak (2026). An Interdisciplinary Process Model For Design Decisions During The Preliminary Design Stage Of Flood Protection Structures: A Case Study Of Büyükköy Stream. *Erciyes University Journal of Institue Of Science and Technology*, 42(3), 109-136. https://doi.org/10.65520/erciyesfen.*1949610*

Screened by iThenticate for Authors & Researchers

An Interdisciplinary Process Model For Design Decisions During The Preliminary Design Stage Of Flood Protection Structures: A Case Study Of Büyükköy Stream

Abstract

Background/Aim

This study aims to develop a systematic process model explaining how technical analyses performed during the preliminary design stage of flood protection projects are transformed into engineering design decisions. Within this framework, synthetic and statistical flood estimation methods, hydrological and hydraulic analyses, field investigations, institutional data, and multidisciplinary engineering evaluations were integrated to support reliable project discharge selection in medium sized watersheds.

Methods

The Büyükköy Stream watershed was selected as the case study. Flood discharges were estimated using the Mockus, DSİ Synthetic Unit Hydrograph, Regional Flood Frequency Analysis, and Point Flood Frequency Analysis methods. The results were evaluated together with watershed characteristics, stream gauging station (SGS) data, field observations, hydraulic cross section analyses, and flood boundary assessments. The relationships between these technical analyses and engineering design decisions were systematically examined to develop the proposed interdisciplinary process model.

Results

The comparative analyses showed that design flood discharge selection should not rely solely on the highest calculated discharge but also on watershed characteristics and the adequacy of SGS data. Although the Mockus method produced higher discharge estimates, the DSİ Synthetic Unit Hydrograph yielded results closer to the Regional Flood Frequency Analysis. Considering the adequacy of SGS records, the DSİ Synthetic Unit Hydrograph method was adopted as the basis for design flood discharge selection. Hydraulic analyses and field investigations further demonstrated that channel constrictions, bank erosion, sediment accumulation, bridge blockage, channel instability, and geological conditions significantly influenced engineering design decisions. These findings guided the determination of flood boundaries, protection structure locations and types, site plans, cross sections, and additional engineering investigations.

Conclusion

The proposed process model demonstrates that the preliminary design stage of flood protection projects is an integrated engineering decision making process rather than merely a computational stage. Field investigations, institutional data, hydrological and hydraulic analyses, and multidisciplinary engineering evaluations are systematically transformed into engineering design decisions. The model also provides a practical framework for defining project scope, evaluating potential flood risks in upstream watersheds and tributaries, and identifying additional geological, sediment, hydraulic, and other technical investigations required during subsequent planning and

Except where otherwise noted, content in this article is licensed under a Creative Commons 4.0 International license. Icons by Font Awesome.

detailed design stages.

Keywords: Preliminary design, Flood protection structures, Design decisions, Interdisciplinary process model, Statistical and Synthetic methods

❋ ❋ ❋

Taşkın Koruma Yapılarında Ön Projelendirme Sürecindeki Tasarım Kararlarına Yönelik Disiplinlerarası Bir Süreç Modeli: Büyükköy Deresi Örneği

Öz

Bu çalışma, taşkın koruma yapılarının ön projelendirme sürecinde gerçekleştirilen teknik analizlerin mühendislik tasarım kararlarına nasıl dönüştürüldüğünü açıklayan sistematik bir süreç modeli geliştirmeyi amaçlamaktadır. Bu kapsamda, orta büyüklüğe yakın havzalarda güvenilir proje debisinin belirlenmesi amacıyla sentetik ve istatistiksel taşkın tahmin yöntemleri, hidrolojik ve hidrolik analizler, arazi incelemeleri, kurumsal veriler ve farklı mühendislik disiplinlerine ait değerlendirmeler bütünleşik olarak ele alınmıştır. Büyükköy Deresi Havzası örnek alan olarak seçilmiş; proje taşkın debileri Mockus, DSİ Sentetik Birim Hidrograf, Bölgesel Taşkın Frekans Analizi ve Noktasal Taşkın Frekans Analizi yöntemleriyle hesaplanmıştır. Sonuçlar; havza özellikleri, akım gözlem istasyonu (AGİ) verilerinin yeterliliği, arazi gözlemleri, hidrolik kesit analizleri ve taşkın sınırı değerlendirmeleriyle birlikte incelenmiş, teknik analizler ile mühendislik tasarım kararları arasındaki ilişkiler sistematik olarak değerlendirilerek önerilen disiplinlerarası süreç modeli oluşturulmuştur. Karşılaştırmalı analizler, proje tasarım debisinin yalnızca en yüksek hesaplanan debiye göre değil, havza özellikleri ile AGİ verilerinin yeterliliği birlikte değerlendirilerek seçilmesi gerektiğini göstermiştir. Mockus yöntemi daha yüksek debiler üretirken, DSİ Sentetik Birim Hidrograf yöntemi Bölgesel Taşkın Frekans Analizi ile daha uyumlu sonuçlar vermiştir. AGİ kayıtlarının yeterliliği dikkate alınarak proje tasarım debisinin belirlenmesinde DSİ Sentetik Birim Hidrograf yöntemi esas alınmıştır. Hidrolik analizler ve arazi incelemeleri; yatak daralmaları, kıyı oyulmaları, sediment birikimi, köprü tıkanmaları, yatak kararsızlığı ve jeolojik koşulların mühendislik tasarım kararlarını önemli ölçüde etkilediğini ortaya koymuştur. Bu bulgular taşkın sınırlarının belirlenmesi, koruma yapılarının konumu ve tipinin seçimi, vaziyet planlarının hazırlanması, enkesitlerin oluşturulması ve ilave mühendislik çalışmalarının planlanmasında kullanılmıştır. Çalışma sonucunda önerilen süreç modeli, taşkın koruma yapılarının ön projelendirme aşamasının yalnızca hesaplamalara dayalı bir süreç olmadığını; arazi incelemeleri, kurumsal veriler, hidrolojik ve hidrolik analizler ile disiplinlerarası mühendislik değerlendirmelerinin sistematik olarak tasarım kararlarına dönüştürüldüğü bütünleşik bir mühendislik karar verme süreci olduğunu göstermektedir. Model ayrıca proje kapsamının belirlenmesi, üst havza ve yan kollardaki olası taşkın risklerinin değerlendirilmesi ve sonraki planlama ile detay projelendirme aşamalarında gerekli ilave teknik çalışmaların tanımlanması için sistematik bir çerçeve sunmaktadır.

Anahtar kelimeler: Ön projelendirme, Taşkın koruma yapıları, Tasarım kararları, Disiplinlerarası süreç modeli, İstatistiksel ve sentetik yöntemler.

❋ ❋ ❋

1. INTRODUCTION

Floods are among the natural disasters causing the greatest loss of life and economic damage worldwide, and their frequency and intensity have increased in many regions in recent years due to the effects of climate change [1,2]. In Türkiye, floods are considered one of the most significant natural disasters after earthquakes in terms of both economic losses and casualties [3]. The General Directorate of State Hydraulic Works, established under Law No. 6200, is the principal governmental authority responsible for the planning and implementation of flood protection and river training projects [4]. Subsequently, the Prime Ministry Circular on Riverbed Rehabilitation (2010) and the Metropolitan Municipality Law No. 5216 further defined the duties and responsibilities of DSİ and other relevant institutions in flood management [5].

CC: BY-NC-ND

In recent years, international research on the estimation of design flood discharge, hydrological modeling, and flood risk analysis has increased considerably. Most of these studies have focused on improving the understanding of flood generation mechanisms, enhancing the accuracy of hydrological modeling, and evaluating the impacts of changing climatic conditions on flood characteristics [7,2]. Fundamental studies in hydrological modeling have emphasized the representation of watershed behavior based on physical processes, rainfall runoff modeling, and the assessment of hydrological uncertainties. In particular, the advantages and limitations of physically based and conceptual hydrological models have been extensively investigated, demonstrating that model performance is strongly influenced by watershed characteristics, parameter selection, and data quality [8,7].

Synthetic unit hydrograph methods are widely employed for estimating design flood discharges, particularly in ungauged watersheds or catchments with insufficient streamflow observations. In this context, the Mockus (SCS), Snyder, and Clark synthetic unit hydrograph methods have been applied under various climatic and watershed conditions, and their effects on hydrograph shape, peak discharge, and time to peak have been comprehensively evaluated [9,10,11].

Regional flood frequency analysis is another widely adopted approach in the international literature. Based on the joint evaluation of hydrologically homogeneous watersheds, these methods provide reliable estimates of design flood discharges, particularly in regions where hydrological observations are limited. Homogeneous region analysis, L moment techniques, and regional regression models have been successfully implemented in many countries and are now widely applied in engineering practice [12,13].

The impacts of climate change on flood regimes have become one of the major research topics in recent years. Numerous studies have demonstrated that increasing temperatures are associated with more frequent and intense extreme precipitation events, leading to higher flood peak discharges and shorter response times, particularly in small and medium-sized watersheds [14,2,1].

Furthermore, the integration of remote sensing technologies, Geographic Information Systems (GIS), high resolution Digital Elevation Models (DEMs), and radar based precipitation data into hydrological analyses has significantly improved the characterization of watershed properties and the accuracy of flood analyses. Hydrological models such as HEC HMS, SWAT, and MIKE SHE, integrated with GIS based spatial datasets, have enabled comprehensive analyses of flood behavior under different climate scenarios [15,13].

Recent studies have also emphasized that, in addition to hydrological model outputs, model uncertainty and flood risk should be systematically evaluated. Accordingly, uncertainty analysis, sensitivity analysis, and risk based engineering approaches have become increasingly important for improving the reliability of design flood discharge estimation and enhancing the safety of hydraulic structures [7,13].

Nevertheless, the majority of studies in the international literature have primarily focused on the development of hydrological modeling techniques, the comparison of alternative computational methods, or the improvement of flood prediction accuracy. In contrast, studies that systematically integrate field investigations, institutional data acquisition, engineering geological assessments, hydrological analyses, preliminary hydraulic evaluations, and engineering decision making within the preliminary design (reconnaissance) stage of flood protection projects remain very limited [7,13].

Accordingly, it is also important to evaluate studies conducted in Türkiye, where flood protection projects are implemented under institutional procedures and engineering practices that differ from those reported in the international literature. Studies on the estimation of design flood discharges in Türkiye have long focused on synthetic unit hydrograph methods, flood frequency analyses, and hydraulic modeling applications. In the Köyiçi Stream case study, the Mockus, DSİ Synthetic Unit Hydrograph, and Regional Flood Frequency methods were comparatively evaluated to identify the hydrological factors influencing the selection of the optimum design flood discharge [17]. In watersheds with stream gauging stations (SGSs), statistical flood frequency analysis is generally preferred, whereas in ungauged watersheds or catchments with insufficient hydrological

observations, synthetic unit hydrograph methods such as the Mockus, DSİ Synthetic Unit Hydrograph, and Snyder Synthetic Unit Hydrograph are widely applied [18].

Numerous studies have also been conducted using the HEC HMS model to simulate rainfall runoff processes, estimate design flood discharges for different return periods, and compare synthetic unit hydrograph methods. These studies have shown that the Mockus and DSİ Synthetic Unit Hydrograph methods generally produce similar results in small and medium sized watersheds, whereas the Snyder method tends to generate lower peak discharges and longer hydrograph durations [19].

In addition, HEC RAS based hydraulic modeling studies have increasingly focused on flood inundation mapping, the hydraulic performance assessment of bridges and culverts, and the analysis of different flood scenarios. The combined use of hydrological model outputs with two dimensional hydraulic models has made significant contributions to flood hazard mapping and the development of engineering solutions aimed at mitigating flood damage.

Recent studies conducted in Türkiye have also begun to investigate the effects of climate change on design flood discharges, the performance of synthetic unit hydrograph methods under changing precipitation conditions, and the temporal variation of flood hydrographs in small watersheds. In particular, it has been emphasized that the increasing frequency of short duration, high intensity rainfall events leads to higher flood peak discharges, shorter times to peak, and consequently necessitates the reassessment of existing design approaches [20].

The principal contribution of this study is the development of a systematic, traceable, and interdisciplinary process model that integrates field investigations, institutional data acquisition, hydrological and hydraulic analyses, and engineering decision making within the framework of DSİ's preliminary design (reconnaissance) practices. Within this framework, the determination of the design flood discharge is considered not merely as an independent computational result but as one of the principal technical inputs guiding engineering decisions throughout the preliminary design process. The proposed process model is based on the widely accepted Engineering Decision Making approach and represents a comprehensive decision making framework in which engineering decisions are established through the integrated evaluation of field observations, institutional data, technical analyses, and alternative solutions [21,22]. In this respect, the study provides a conceptual framework for the systematic evaluation of the preliminary design process while also making the institutional process management approach adopted by the General Directorate of State Hydraulic Works (DSİ), the governmental authority responsible for flood protection planning and implementation in Türkiye, more visible. Consequently, the proposed model offers a comparable framework for similar engineering applications.

The downstream reach of Büyükköy Stream within the Eastern Black Sea Basin was selected as the study area because it represents a critical flood-prone section where all upstream tributaries converge, the channel slope decreases, and transported sediment begins to accumulate. These hydromorphological characteristics significantly reduce the flow conveyance capacity of the river channel during flood events, thereby increasing flood risk in nearby rural settlements. Accordingly, the downstream reach of Büyükköy Stream was selected as the case study because of its high flood susceptibility and the direct influence of engineering decisions made during the preliminary design stage on subsequent planning, detailed design, and investment processes [23].

The study area is located along the downstream reach of Büyükköy Stream, south of Çayeli District in Rize Province, within the Eastern Black Sea Basin. Reconnaissance studies were initiated following the flood events that occurred between 2002 and 2004 in response to applications submitted by residents of Merkez, Soğuksu, Yeşilköy, and Çavuşlu neighborhoods, as well as Armutlu Village. Figure 1 presents the 1:25,000 scale topographic map prepared as part of the reconnaissance report. The blue rectangle delineates the study area encompassing the flood affected rural settlements and the adjacent agricultural areas considered within the scope of the reconnaissance study [23].

CC: BY-NC-ND

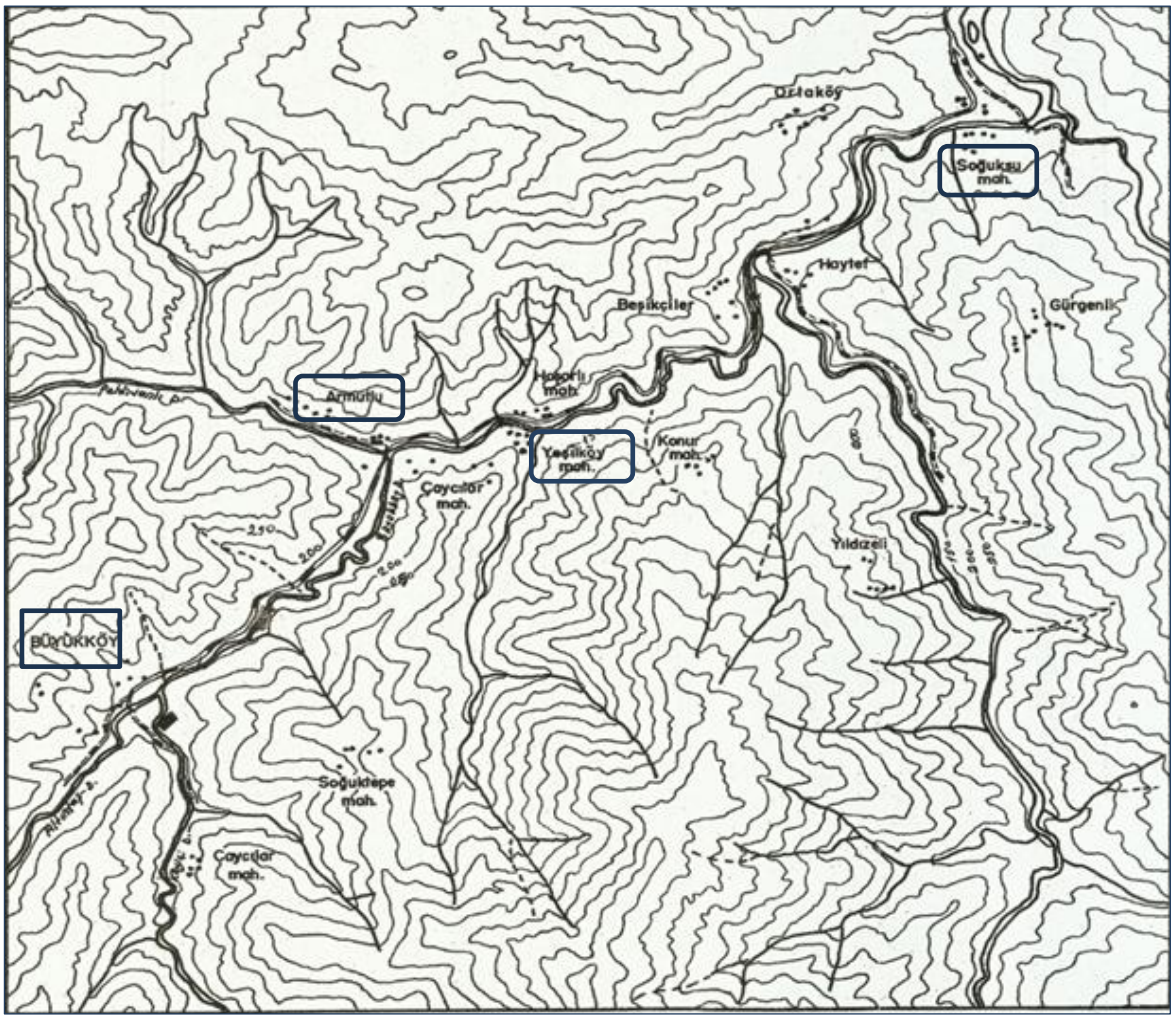


Figure 1. Topographic map of the study area. The blue rectangle indicates the flood-affected rural settlements and adjacent agricultural areas that constituted the focus of the reconnaissance study.

2. MATERIALS AND METHODS

In this study, the data used during the reconnaissance stage are addressed in two main groups as institutional inputs and field based findings. The first group consists of direct input data. These inputs include local complaint records and observational information related to past flood events in the area, watershed morphometric parameters, institutional parameters such as Curve Number and baseflow values documented in the State Hydraulic Works reconnaissance report, and the outputs of regional and at site flood frequency analyses presented in Appendix 1.

The second group comprises the results obtained based on these inputs. This group includes flood discharges calculated using synthetic methods, the transfer of frequency analysis results to the project reach, preliminary hydraulic calculation results, and the preparation of general layout plans and cross section sketches based on these calculations.

The hydrological and hydraulic methods adopted in this study were selected because they are well established approaches widely applied in both the scientific literature and the standard reconnaissance practices of the General Directorate of State Hydraulic Works . Regional Flood Frequency Analysis, the DSİ Synthetic Unit Hydrograph, the Mockus Synthetic Unit Hydrograph, and the Manning equation have been successfully used in numerous flood studies and engineering projects conducted under data limited conditions [11,9,10,18,19]. The selection of these methods was based on the hydrological characteristics of the study basin, the availability and adequacy of stream gauging

station (SGS) data, and the institutional design procedures adopted by DSİ.

The reconnaissance stage workflow is structured through the sequential implementation of field surveys and office based studies. The process begins with the evaluation of local community complaints and field investigations to identify critical stream reaches. This is followed by the joint interpretation of synthetic method calculations and regional and at site frequency analyses to define a range of design flood discharges. In the final stage, hydraulic calculations are performed based on the selected flood discharges, and the resulting outputs are translated into general layout plans and cross section sketches. This approach aims not to discuss the numerical superiority of individual methods but to make visible the role of reconnaissance stage inputs and calculated components within the decision making process and to clarify their interrelationships.

The majority of existing studies in the literature focus on numerical comparisons of different hydrological approaches by evaluating differences in peak discharge values. Such studies commonly aim to identify the most suitable or best performing flood estimation method through statistical or performance based metrics. In contrast, the present study does not aim to assess the numerical performance of flood estimation methods or to rank them according to predictive accuracy. Instead, the findings are interpreted within the context of the reconnaissance stage engineering workflow, where limited data availability, institutional guidelines, and practical decision making constraints play a dominant role.

Accordingly, the results are discussed not in terms of absolute discharge magnitudes but with respect to the type of methods applied, their data requirements, underlying assumptions, and their implications for early stage project decisions. This perspective reflects the actual practice adopted by the State Hydraulic Works during the reconnaissance phase, where synthetic methods, regional frequency analysis, and point frequency data are jointly evaluated not to optimize model performance but to define preliminary design discharges.

In this study, as opposed to many studies in the literature, direct methodical comparisons with previous research or the advancement of numerical analyses based on existing studies are not intended. The main reason is that the problem addressed and the scale of this study are methodologically different from comparative flood analyses based on long term streamflow observations. The reconnaissance stage is an engineering process carried out under limited data, time constraints, and institutional practice conditions, which serves as decision support rather than detailed analysis. Therefore, direct comparisons such as stating that a certain analysis in a previous study was developed in this study or that this study differs from another study in a specific aspect do not align with the aim and scope of the research. The present study aims not to provide a new performance assessment based on the numerical outputs of existing methods in the literature but to demonstrate, in a process based manner, how the inputs, intermediate calculation components, and the relationships among these components are translated into design decisions during the reconnaissance stage. This approach is a deliberate methodological choice and reflects the unique nature of the study, which seeks to make the structural workflow of the reconnaissance process visible rather than to perform numerical analysis.

Within the scope of the reconnaissance process, engineering decisions are not based solely on hydraulic calculations, but are evaluated in a multi dimensional manner by integrating field observations, local demands, and flood characteristics. In this context, the initial decision point of the model is based on the evaluation of flood related requests submitted by local communities and relevant institutions. This evaluation considers the frequency of flood events, the affected areas, the type of damage (agricultural land, residential areas, etc.), and whether the events resulted in economic losses or loss of life.

Following this initial stage, the necessary technical data and reports related to flood prone sections are obtained from relevant institutions, and the causes of flooding, riverbed geometry, and existing cross sectional characteristics are determined.

In the next stage, flood boundaries and flood water levels are determined through flood analyses

CC: BY-NC-ND

and hydraulic calculations. Based on the obtained flood depth values, the affected areas are reevaluated, and depending on land use type (residential or agricultural), the design discharge (Q100 or Q500) and the type of flood protection structure (such as riprap or concrete wall) are selected.

In the final stage, rehabilitation cross sections, structure types, and the approximate project length are determined based on the selected design criteria, and all these outputs are transferred into reconnaissance sketches.

The decision points identified throughout this process collectively form the proposed Engineering Decision Making Model for the reconnaissance stage of flood protection projects.

2.1. Field surveys and data collection

The Büyükköy Stream watershed was selected not only because of its high flood susceptibility but also because it represents a comprehensive case study for the preliminary design stage of flood protection projects. The watershed is close to the transition between small- and medium-sized basins, where the selection of the design flood discharge requires the comparative evaluation of synthetic methods and stream gauging station (SGS) data. In addition, severe bank erosion, bridge blockage potential, channel instability, geological constraints, sediment transport, and the need for upstream watershed management substantially influence engineering decisions. The planning of both longitudinal and transverse flood protection structures, together with the necessity of evaluating and, where appropriate, incorporating different flood protection measures in the upstream watershed into the overall project scope, requires the integrated assessment of hydrological, hydraulic, geological, and sediment-related processes. Consequently, the study area provides a representative multidisciplinary case in which technical analyses performed during the reconnaissance stage directly support subsequent planning, detailed design, project implementation, and the definition of additional engineering investigations.

Accordingly, the study was conducted under the following main components: Study Area, Regional Flood Frequency Analysis, Synthetic Unit Hydrograph Analysis, Hydraulic Analysis, Field Investigations, Engineering Decision-Making Process, and Evaluation of the Proposed Process Model.

2.2. Hydrological and hydraulic analyses (office studies)

Office studies were conducted in two main parts: flood peak discharge estimation and hydraulic calculations. Within the scope of flood analyses, the Mocus, DSİ Synthetic, Regional Flood Frequency Analysis, and Point Flood Frequency Analysis methods were employed.

2.2.1. Synthetic methods

The DSİ Synthetic and Mockus methods are empirical rainfall runoff approaches commonly used during the reconnaissance phase when detailed hydrological data are limited [8,9].

Meteorological stations within the basin are operated by the Turkish State Meteorological Service (MGM) and DSİ. MGM stations record precipitation, temperature, evaporation, humidity, wind, pressure, and sunshine duration, whereas DSİ stations primarily record precipitation and evaporation data [24].

In this study, data from the Çayeli Meteorological Station were used for synthetic calculations [23]. The average precipitation of the study area was calculated using the Thiessen Polygon Method, and rainfall characteristics were determined based on the Hydrogeological Report of the Eastern Black Sea Basin Master Plan [25,26]. This report provided information on the wettest months and maximum precipitation values for the station [23].

For rainfall frequency characterization, the probability distribution adopted for the station record was taken from the DSİ approved assessment reported in the relevant institutional documents; therefore, the K–S test was not reapplied within this study. Based on the 36 year precipitation record of the Çayeli Meteorological Station, the LPT3 distribution was adopted as an institutional input [23]. Using the critical rainfall periods for the project area, rainfall correction coefficients were calculated,

CC: BY-NC-ND

and adjusted/maximized precipitation values were obtained [23].

In the second stage, flood discharges corresponding to return periods of 2, 5, 10, 25, 50, and 100 years were calculated using the Mockus and DSİ Synthetic methods [23]. Both methods are empirical approaches widely applied during the reconnaissance phase when detailed hydrological data are limited.

Peak discharge was estimated based on lumped watershed characteristics such as basin area, main channel length, slope, and time related parameters. In the DSİ Synthetic method, the time parameter (E) is derived from the main channel length, centroid distance, and harmonic slope, and is then used to calculate unit peak discharge and time to peak. In the Mockus method, the time of concentration and storm duration are explicitly defined, and peak discharge is calculated by combining effective rainfall depth, basin area, and time to peak. In both methods, watershed response is assumed to be spatially averaged, and all parameters are treated as fixed inputs consistent with DSİ reconnaissance stage practice [23].

The selection of these methods reflects the standardized procedures officially adopted by DSİ for reconnaissance stage studies and ensures reliable peak discharge estimation under data limited conditions [25,26].

The calculation steps for peak discharge in the DSİ Synthetic and Mockus methods are summarized in Table 1. The table presents the formulas used to determine time parameters, unit peak discharge, and total peak discharge [24]. These steps provide a structured approach for reconnaissance stage flood estimation under data limited conditions.

Table 1. DSİ Synthetic and Mockus Calculation Processes [25,26]

DSİ Synthetic Method	Mockus Method
E = [(L·Lc)/√S] (1)	Tc = 0.00032·(L^0.77 / S^0.385) (5)
qp = [414 / A^0.225 · E^0.16)] (2)	D = 2√Tc(6)
Tp = 202.78 / qp (3)	Tp = 0.5·D + 0.6·Tc (7)
Qp = A · qp · 10^{-3} (4)	Qp = (K · A · ha) / Tp (8)
K = 0.208 (Climatic Parameter)	

Used Parameters:

Used Parameters: A (watershed area); L (main stream length); Lc (distance from watershed centroid to outlet); S (harmonic slope); Si (harmonic slope between adjacent cross sections); E (DSİ Synthetic Unit Hydrograph time parameter); Tc (time of concentration); D (effective storm duration); Tp (time to peak); qp (unit peak discharge); Qp (peak discharge); ha (effective rainfall depth); CN (Curve Number); K (climatic parameter).

Flood recurrence discharges are obtained by multiplying the unit peak discharge by the corresponding dimensionless flood ratio. The total discharge is calculated by adding the baseflow component. The baseflow value (5 m^3/s) was taken directly from hydrological data approved by DSİ 22nd Regional Directorate and incorporated into the official reconnaissance report prepared in 2006 for the implemented project reach. The calculation of recurrence discharge and total discharge is given in Equation (1) [25,26]:

$$Qt = Qp \times Ht \quad (1)$$

Total Discharge = Qt + baseflow

The Curve Number (CN), Manning's roughness coefficient (n), and baseflow values used in this study were not recalculated or arbitrarily selected by the authors. These parameters were determined by DSİ during the reconnaissance stage based on field observations, hydromorphological characteristics, land use conditions, and institutional practice, and were adopted directly from the approved reconnaissance report. Accordingly, CN, Manning's n, and baseflow are treated as fixed institutional inputs rather than study findings. The contribution of this study lies in analyzing how such

CC: BY-NC-ND

reconnaissance stage inputs influence flood discharge estimation and preliminary cross section design decisions within the modeled technical workflow.

2.2.2. Regional frequency analysis

The study area comprises a total of 74 stream gauging stations (SGS) belonging to 23 homogeneous regions defined within DSİ's regional flood frequency framework. Annual maximum flood discharge series with varying record lengths were compiled by DSİ for each station together with the corresponding drainage areas and basin characteristics.

All regional frequency analysis results used in this study were obtained from official DSİ hydrology studies and incorporated into the reconnaissance stage workflow as institutional input data. Therefore, probability distribution fitting and Kolmogorov–Smirnov (K–S) goodness of fit tests were not reapplied by the authors. In Appendix 1, data for the 74 SGS are presented sequentially, including station identification numbers, drainage areas, record lengths, the best fit probability distribution functions determined by DSİ using the K–S test, maximum discharge values, return periods (2, 5, 10, 25, 50, and 100 years), and the corresponding dimensionless return period ratios.

In DSİ practice, candidate probability distribution functions are evaluated using the Kolmogorov–Smirnov (K–S) goodness of fit test, and the most suitable distribution is selected individually for each basin based on acceptance criteria defined by record length and significance level. In this study, these DSİ approved distribution assignments were directly adopted without modification. Based on DSİ analyses, the most appropriate distributions were identified as Log-Normal (LN2), Gumbel (G), Gamma Type III (GT3), Log-Pearson Type III (LP3), and Three Parameter Log-Pearson Type III (LPT3) [11]. LP3 and LPT3 represent two distinct statistical approaches and are treated separately in accordance with DSİ hydrological practice. The results indicate that LPT3 (41.9%) is the most frequently selected distribution, followed by Gumbel (21.62%), LN2 (13.51%), LP3 (8.11%), PT3 (4.05%), LN3 (2.7%), and other distributions with lower representation. These results are presented in Appendix 1 and are treated as institutional input data rather than newly generated statistical results.

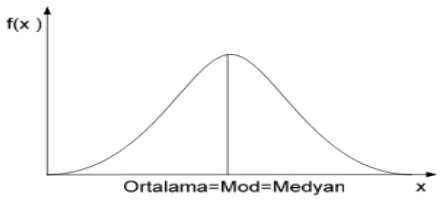
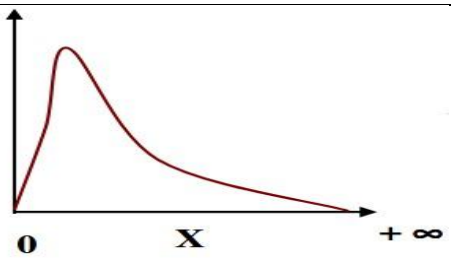
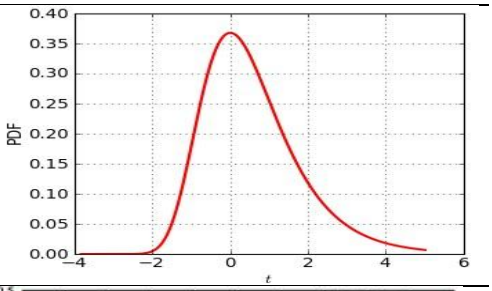
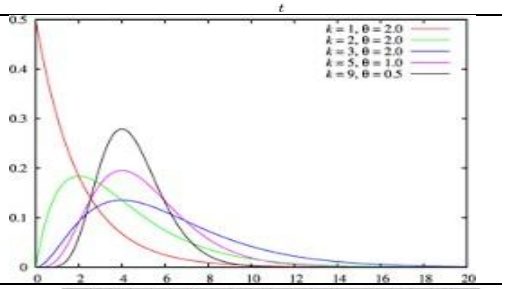
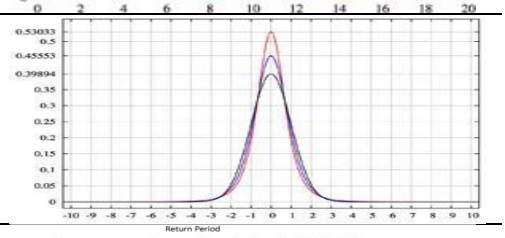
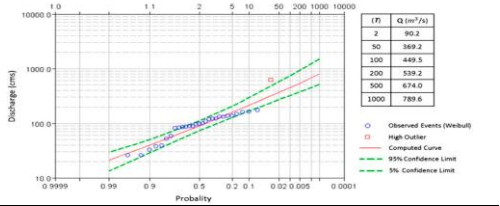
Following the determination of dimensionless flood ratios, average QT/Q_2 values were derived for each homogeneous region. These ratios were combined with the envelope curve constructed from Q_2 drainage area relationships to estimate the design flood discharges at the project site. This two step procedure ensures both statistical robustness and regional consistency, in accordance with DSİ's standard reconnaissance phase flood frequency analysis practice [23].

In summary, this methodology enables reconnaissance stage flood discharge estimation to account for regional variability while relying on officially approved statistical procedures. All statistical details, including individual station data, K–S test results, and distribution assignments, are provided in Appendix 1.

These selections reflect regional hydrological variability; therefore, a single distribution was not imposed across the study area. The distribution type associated with each stream gauging station is provided in Appendix 1, while the mathematical expressions of the adopted distribution functions are presented in Table 3 through Equations (2) – (7). The purpose of presenting these formulations is not to perform a detailed methodological analysis, but to illustrate the calculation framework used within the reconnaissance process as part of the decision making workflow.

CC: BY-NC-ND

Table 3. Distribution Functions and Formulas [12]

(ND) $f(x) = 1/\sqrt{2\pi}\sigma x \exp(-1/2*(x-\mu x/\sigma x))$ (2)	
(LN2) $f(x)=\{ 1/(x\sigma y\sqrt{2\pi}\, e) \}^{\{-(\ln x-\mu y)^2/2\sigma^2 y\}}$ (3)	
(GD) $F(x) = \exp(-e-\alpha(x-\beta))$ (4)	
(G3) (5) $f(x) = (x^{(k-1)} * e^{(-x/\theta)}) / (\theta^k * \Gamma(k))$ x, θ, k >0 In this expression, Γ(k) denotes the gamma function.	
(LP3) (6) $f(x)= l_\beta l\{_\beta(x-\xi)\ ^{(a-1)} x \{e^{(-l_\beta(x-\xi)}$	
(LPT3) $QT = \log x + K\,(CsT)* \log x$ (7)	

The relevant formulas for the Kolmogorov-Smirnov (K-S) Test are provided below. The Kolmogorov-Smirnov (K-S) test is presented by Formula (8):

$$\Delta = |F^*(xi) - F(xi)| \quad (8)$$

$\Delta < \Delta\alpha$ must be satisfied for the test to pass

F*(xi): Observed cumulative frequency

F(xi): Theoretical cumulative frequency from selected distribution

In the Regional Flood Frequency Analysis (RFFA) method, flood discharges for different return periods were estimated using the average QT/Q_2 ratios together with the envelope curve relating Q_2 discharge to drainage area. The general calculation procedure is expressed by Equation (9).

$$QT = Q2 \times (QT/Q2) \quad (9)$$

- Q = Flood discharge
- T = Return period
- Q2 = 2 year flood discharge

Because basin characteristics and drainage areas may vary within the same homogeneous region, different probability distributions may be appropriate for different stream gauging stations. These distributions were used as institutional inputs for determining regional QT/Q_2 ratios (Appendix 1).

2.2.3. Point flood frequency analysis

For the Point Flood Frequency Analysis, data from the DSİ 22-85 Stream Gauging Station, located closest to the project site on Büyükköy Stream, were used [23]. The inter basin transfer coefficient was computed using Equation (10) presented below:

$$Q\ (\text{Project Location}) = [(\text{Project Length} \times \text{Area}) / (\text{SGS Length} \times \text{Area})]^{0.667} \times Q(22\text{-}85) \quad (10)$$

This method is consistent with DSİ reconnaissance stage practice, where peak discharges at ungauged or partially gauged locations are derived from the nearest gauging station using proportional basin characteristics [23]. The approach assumes a spatially averaged watershed response, and no additional calibration is performed beyond the officially provided station data.

2.2.4. Hydraulic calculations

The adequacy of the cross section was assessed using Standard Formula (11), taking into account the existing slope and hydraulic parameters:

$$J = \left(\frac{Q \times n}{A \times R^{\frac{2}{3}}}\right)^{\frac{1}{2}} \quad (11)$$

- A: Wetted area (m^2)
- R: Hydraulic radius (m)
- Q: Discharge (m^3/s)

If the existing cross section was insufficient to convey the design flood, drop structures were proposed and their number determined according to slope and flow requirements [23].

Table 4 presents the Manning roughness coefficients based on the characteristics of the streambed [25].

CC: BY-NC-ND

Table 4. Manning Roughness Coefficients Based on Streambed Characteristics

Surface Type	n
Normal concrete channels	0.016
Brick and cut stone channels	0.014
Rubble masonry or mortared slopes	0.018
Dry stacked stone linings	0.028
Uniform channels with sandy or gravel bed and vegetation	0.028
Degraded banks, vegetated, sandy deposits	0.035
Natural channels with irregular slopes, rocky bed	0.038
Wild torrents, coarse and irregular beds	0.050
Floodplains and valley bottoms	0.038

In sections where flood studies are to be conducted, if the area is a residential zone, concrete walls are constructed; if it includes both residential and agricultural land, stacked stone revetments are applied. In residential areas and in zones containing both residential and agricultural land, the flood cross section is calculated based on the Q500 discharge. In agricultural areas, it is calculated based on the Q100 discharge. The Q500 discharge is calculated using Formula (12).

$$Q500=Q10+1,692*(Q100-Q10) \quad (12)$$

3.RESULTS AND DISCUSSION

The results obtained using the applied methods based on the available data and institutional inputs are analyzed in this section.

3.1. Flood ıssues, damages, and correspondence

Reconnaissance studies for the flood control project area, completed by the 22nd Regional Directorate of DSİ in 2006, were initiated based on the application submitted by the Büyükköy Municipality to the Ministry of Public Works and Settlement in 2003 [23]. In this application, the extent of the disaster and the affected areas were explained. Based on the petitions of citizens, flood damages between 2002 and 2004 were compiled, affecting a total of 79 people Table 5 shows Flood damages, locations, years, and numbers.

Table 5. Flood Damages, Locations, Years, and Numbers [23]

Flood Location	**Number of Petitions**	**Type of Damage**	**Year**
Merkez Neighborhood	3	Agricultural land	2002–2004
Soğuksu Neighborhood	9	Cultivated fields, houses, tea plantations	2002, 2004
Yeşilköy Neighborhood	4	Commercial premises, houses, roads	2002–2004
Çavuşlu Neighborhood	7	Tea gardens, cultivated land, health center, village office	2002–2004
Armutlu Village	3	Houses, land, roads	2002–2004

3.2. Field studies

The project area is located within the 1/25,000 scale map sheet Artvin F45-d3. The study section starts from the confluence of the Altıntaş and Köyiçi streams and continues downstream to the Yeşilköy Neighborhood. Notable points include the junction with the Pehlivanlı Stream and the bridge sections over the stream located along the Yeşilköy access road.

- Study section: 0+000 m – 2+750 m (from confluence of Altıntaş and Köyiçi Streams)
- General slope: Over 80% of the land has a slope greater than 25%
- Climate: Summers are hot; winters are mild and rainy; precipitation is intense in spring and

CC: BY-NC-ND

autumn.

- Problematic sections: 0+550 m – 0+600 m and 2+500 m – 2+590 m.
- Flood causes: Accumulation of alluvial material in the stream bed narrowing the cross section and streambank erosion.
- Areas impacted by flooding: Residential areas and agricultural lands
- Streambed material: Sand and gravel
- Existing protective structures: Flood protection structures are present between 2+590 m and 2+660 m.

During field observations conducted in 2006, intense streambank erosion, intrusion of the floodplain into agricultural areas, and narrowing of the stream bed were detected [23]. Figure 2 illustrates bank erosion and agricultural/residential areas within the flood zones.

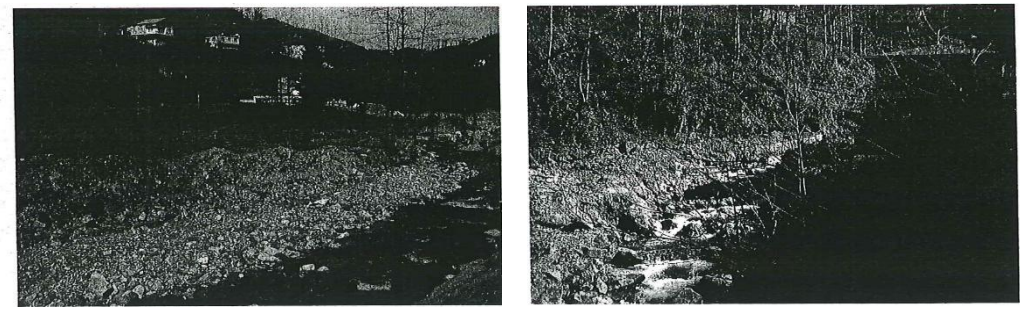


Figure 2. Agricultural Land and Settlement – Channel Constriction [23]

3.3. Flood analysis

In engineering practice, the results obtained from regional flood frequency analyses are used as a guiding reference for evaluating synthetic unit hydrograph methods and selecting the design flood discharge. Therefore, the results of synthetic unit hydrograph methods are evaluated together with regional flood frequency analysis data during the design flood estimation process [17].

The design flood discharges obtained using the DSİ Synthetic Unit Hydrograph, Mockus Synthetic Unit Hydrograph, and Regional Flood Frequency Analysis were comparatively evaluated. The comparison was based on the point flood frequency data from the DSİ 22-85 Stream Gauging Station (SGS), which is the closest station to the study area, together with the regional flood frequency analyses derived from 74 stream gauging stations (SGSs) representing 23 homogeneous regions, including the study area. The results indicated that, particularly for the Q100 design flood discharge, which constitutes the principal design criterion for flood protection structures, the DSİ Synthetic Unit Hydrograph produced results that were more consistent with the regional flood frequency analysis. In contrast, the Mockus method generated higher design flood discharges, which could lead to oversized and economically inefficient designs. Consequently, the DSİ Synthetic Unit Hydrograph was adopted as the preferred method during the preliminary design stage.

Accordingly, the selection of the hydrological method was based not only on institutional engineering practice but also on quantitative engineering evaluations supported by regional flood frequency analyses and stream gauging station (SGS) data.

3.3.1. Synthetic methods

Discharges were calculated using both DSİ Synthetic and Mockus methods. Table 6 presents the basin parameters; Table 7 includes the calculation data related to the DSİ Synthetic and Mockus methods; Table 8 provides the repeated precipitation values (mm) from rainfall stations; Table 9

CC: BY-NC-ND

shows the basin precipitation correction coefficients for critical rainfall durations in the project area; Table 10 contains the 2 and 3 hour rainfall and runoff values; and Table 11 presents the flood discharges (Qt) calculated using the Mockus and Synthetic methods. The inputs for the tables were obtained from the 2006 DSİ reconnaissance report; for tables where no source is indicated, the calculations were performed using the procedures described in the methodology section. In the comparative analysis of the synthetic method results shown in Figure 3, it is observed that, for Büyükköy Stream, the Mockus method results are higher than those of the DSİ Synthetic method.

Table 6. Basin Parameters [23]

A (Km^2)	32.8	Basin Area
L (Km)	8.2	Main River Length
Lc (Km)	3.3	Concentration Length
Curve Number (CN)	70 (80)	Curve Number (CN) value according to soil surface conditions
Min. Height (m)	95	Lowest point
Maks. Height (m)	1010	Highest point
L	8200 m	Main river length

Table 7. Calculation Data for DSİ Synthetic and SCS-CN (Mockus) Methods

S (Harmonic Slope)	0.047
Ha (Runoff Depth, mm)	1
Qp (DSI Synthetic)	2.9 m^3/s
Tp (DSI Synthetic)	2.3 (3 saat)
D (Mockus)	2.07 (3 saat)
Qp (Mockus)	2.7 m^3/s
Tp (Mockus)	2.14
Tc	1.07 < 30

Table 8. Repeated Precipitation Values of Rainfall Stations (mm) [23]

Return Period (years)	2	5	10	25	50	100
Area Average Precipitation (mm)	101.23	127.59	146.65	172.59	193.30	215.23

Table 9. Basin Rainfall Adjustment Coefficients for Critical Rainfall Periods in the Project Area [23]

Time (hour)	0.5	1	2	3	4	5	6	8	12	18	24
Corrected Rainfall Coefficient	0.28	0.38	0.48	0.54	0.59	0.63	0.66	0.72	0.79	0.9	1
Maximization Factor (MF)	For all durations, 1.13										

CC: BY-NC-ND

Table 10. 2 and 3 hour Rainfall and Runoff Values [23]

Return Period (Year)	P2/P3 (mm)	H2/H3
2	51.89 / 59.30	14.956 / 19.72
5	65.40 / 74.74	23.90 / 30.66
10	75.17 / 85.90	30.98 / 42.48
25	88.47 / 101.10	41.22 / 51.45
50	99.08 / 113.23	49.78 / 61.61
100	110.32 / 126.08	59.15 / 72.68

Table 11. Flood Discharges (Qt) According to Mockus and Synthetic Methods

Return Period(Year)	Qt (DSİ Synthetic method)	Qt(Total Discharge)	Qt (Mockus method)	Qt (Total Discharge)
2	43.38	48.3	53.24	58.24
5	69.31	74.3	82.8	87.8
10	89.84	94.8	114.7	119.7
25	119.5	124.5	138.92	143.9
50	144.4	149.4	166.35	171.3
100	171.52	176.52	196.2	201.2

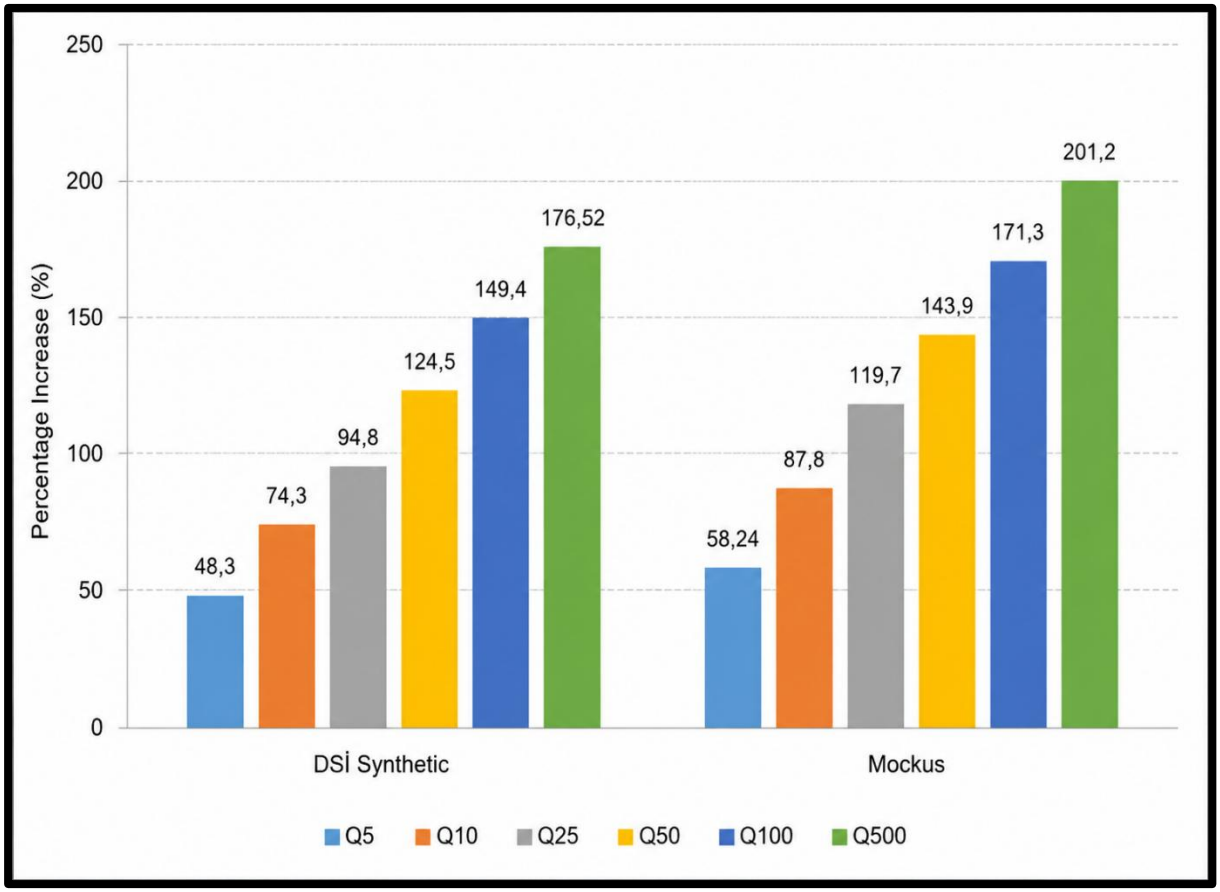


Figure 3. Comparison of Synthetic Method Results

3.3.2. Regional frequency

Figure 4 presents the flood envelope (QT/Q_2) constructed for the Pazarsuyu–Hopa River Basins. According to the Regional Flood Frequency Analysis, the Q_2 discharge corresponding to the drainage

area of the project site was obtained from this envelope as 34 m^3/s, and the design flood discharges were subsequently estimated using this value. Detailed results of the Regional Flood Frequency Analysis are presented in Appendix 1.

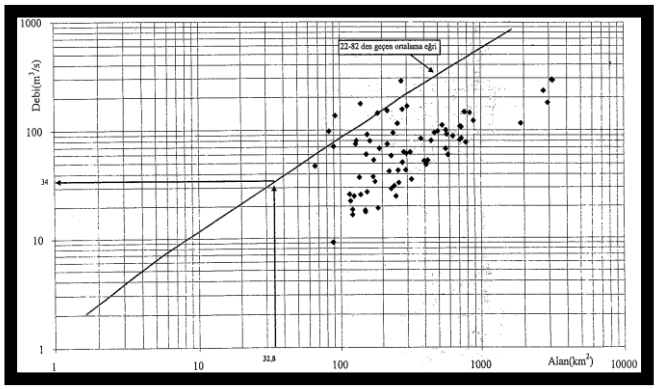


Figure 4. Flood Envelope (QT/Q2) between Pazarsuyu and Hopa River Basins [23]

The dimensionless recurrence values determined as a result of the regional frequency analysis given in Appendix 1 are presented in the Table 12.

Table 12. Dimensionless Recurrence Values

T	2	5	10	25	50	100
QT/Q2	1	1.5	1.89	2.45	2.98	3.59

3.3.3. Point frequency data

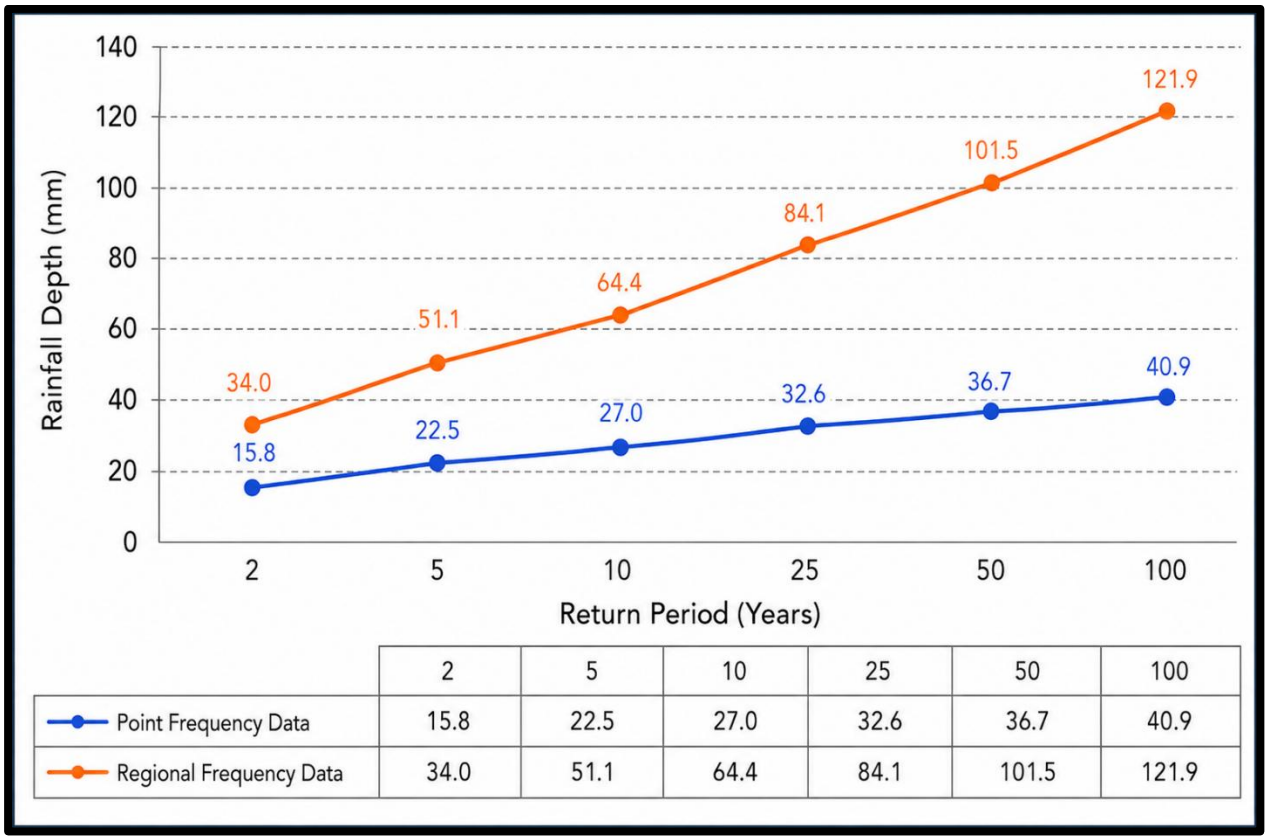
Point frequency data obtained from the DSİ 22-85 AGİ station, which is the closest to the study area and located on Büyükköy Stream, have been taken into consideration. The parameters of the point data are presented in Table 13. Figure 5 analyzes both point and regional flood frequency discharges.

Table 13. Point Data Parameters

Watershed Area(Km2)	Year	The most appropriate statistical method	Maximum Discharge (Qmax, m^3/s)	Interbasin Transfer Coefficient
231.2	20	G	101.00	0.272

Figure 5 compares the point and regional flood frequency discharges for different return periods. As shown in the figure, the regional flood frequency method produced higher flood discharge values than the point frequency analysis for all return periods. The difference between the two methods increased with increasing return period, indicating that regional frequency analysis yielded more conservative design flood estimates than the point frequency analysis.

CC: BY-NC-ND



	2	5	10	25	50	100
Point Frequency Data	15.8	22.5	27.0	32.6	36.7	40.9
Regional Frequency Data	34.0	51.1	64.4	84.1	101.5	121.9

Figure 5. Comparison of Regional and Point Frequency Flood Recurrence Discharges

3.3.4. General site plan, cross section types of flood protection structures, and hydraulic calculations

Based on the flood depth determined through the hydraulic analyses and the characteristics of the flood, a single sided stacked stone revetment was proposed for the project reach. The proposed typical flood protection cross section is presented in Figure 6.

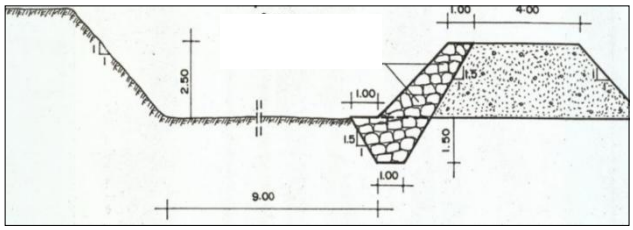


Figure 6. Typical Cross Section of the stacked stone riprap revetment applied in flood prone reaches.

The natural river cross sections presented in Figure 7 were used as the basis for evaluating the flood water level obtained from the hydraulic analyses together with the existing ground elevations and for delineating the flood boundaries on the site layout plan.

CC: BY-NC-ND

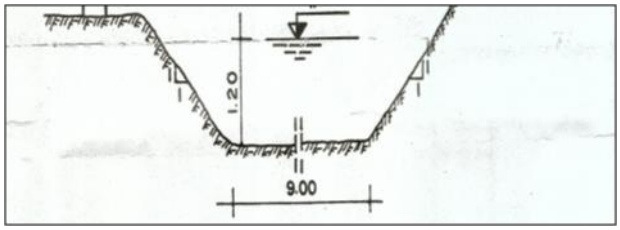


Figure 7. Natural Streambed Cross Section in the Flood Prone Areas of Büyükköy

The hydraulic analyses indicated that the flood depth corresponding to the Q500 design flood discharge was H = 2.50 m for the investigated cross sections. Field survey data were evaluated together with the hydraulic cross sectional analyses to prepare the site layout plans and cross sectional drawings presented in the figures. The results of the hydraulic analyses are summarized in Table 14.

Table 14. Hydraulic Calculation Results

h	n	j	J^1/2	A	Ç	n	N^1/2	Qh
2.5	0.028	0.02	0.14	28.09	15.7	1.73	1,44	210
2.00	0.028	0.02	0.14	21.72	14.29	1.52	1,32	145

Q500=Q10+1.692*(Q100-Q10)

Q500=64.4+1.692*(121.9-64.4)

Q500=161.40 m3/s (The cross section is sufficient for a height of 2.5 m)

Based on these evaluations, stacked stone riprap revetments were proposed along the right bank between km 0+550 and km 0+600 and along the left bank between km 2+500 and km 2+590 and between km 2+660 and km 2+750. The corresponding site layout plan is presented in Figure 8.

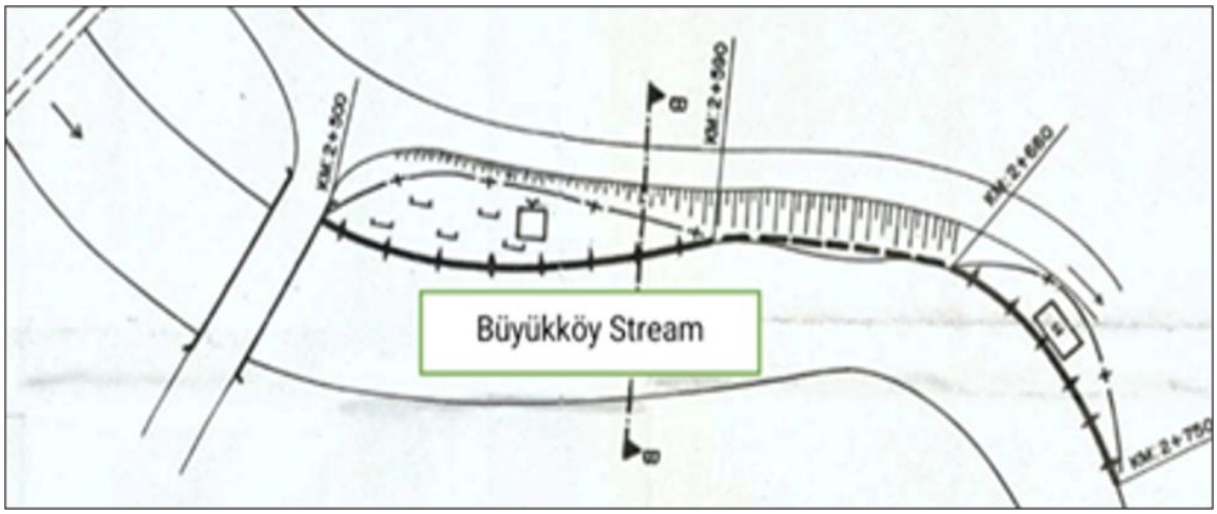


Figure 8. Site Plan of the Proposed Flood Protection Sections on the Left Bank of Büyükköy Stream (Flow Direction), between km 2+500–km 2+590 and km 2+660–km 2+750 [23]

Within the scope of this study, the field investigations and office studies were evaluated together, and the following engineering decisions were established:

- The quantity and potential impact of sediment transported from the upstream watershed were evaluated, and sediment assessment reports were commissioned for the reaches where they were considered necessary.

- The need for transverse hydraulic structures in the upstream watershed and tributaries was evaluated. The required reaches were incorporated into the project scope, and preliminary cost

CC: BY-NC-ND

estimates for these structures were prepared.

- The effects of hillslope material transport, slope instability, and bank erosion on flood risk were assessed, and the reaches requiring additional engineering measures were identified.

- The hydraulic adequacy of existing bridges, culverts, and other hydraulic structures was evaluated, and the structures adversely affecting flood safety were included within the project scope.

- The adequacy of the flood protection structures previously constructed by the General Directorate of State Hydraulic Works (DSİ) was assessed based on the hydraulic analysis results. Where necessary, maintenance, rehabilitation, and improvement requirements were identified and reported to the relevant operation and maintenance units.

- Reaches requiring additional hydrological, hydraulic, and engineering investigations in the upstream watershed and tributaries were identified and incorporated into the project scope.

- Consequently, the reconnaissance process defined not only the locations and types of the proposed flood protection structures but also the overall project scope, the engineering measures to be implemented, and the additional multidisciplinary investigations required during the subsequent planning and detailed design stages.

3.4. Study limitations

This study was conducted to systematically evaluate the engineering activities performed during the preliminary design (reconnaissance) stage of flood protection projects through a process based framework. Accordingly, the proposed model is not intended to represent a detailed hydraulic or structural design procedure or a final implementation project. Rather, it provides a conceptual engineering decision making framework to support early stage engineering decisions under data limited conditions.

The proposed process model encompasses the preliminary design stage, during which field investigations, institutional data, hydrological and hydraulic analyses, topographic surveys, geological observations, and multidisciplinary engineering assessments are integrated within a systematic decision making process. Within this framework, engineering decisions related to the determination of the design flood discharge, the selection of the type and location of flood protection structures, the identification of areas requiring additional engineering investigations in the upstream watershed and tributaries, and the definition of the overall project scope were evaluated. However, detailed geotechnical investigations, two and three dimensional hydraulic modelling, detailed numerical sediment transport analyses, structural design calculations, economic optimization studies, and environmental impact assessments were beyond the scope of this study. These activities are generally undertaken during the subsequent planning, detailed design, and implementation stages of flood protection projects.

The proposed process model was developed based on the institutional preliminary design practices of the General Directorate of State Hydraulic Works (DSİ) using the Büyükköy Stream case study. Therefore, it cannot be directly generalized to watersheds with substantially different hydrological, topographical, climatic, or institutional conditions. Nevertheless, the systematic engineering decision-making framework presented in this study may be adapted to preliminary design studies conducted in watersheds with similar hydrological characteristics and comparable data limitations.

Furthermore, the proposed process model has not been validated for different watershed types or alternative institutional engineering practices. In addition, uncertainty and sensitivity analyses were beyond the scope of this study. Future research should focus on validating the proposed model under different watershed conditions, comparing it with alternative institutional approaches, and supporting it through uncertainty and sensitivity analyses. Such studies would contribute to a more comprehensive assessment of the model's applicability, robustness, and generalizability.

CC: BY-NC-ND

3.5. Proposed preliminary design process model

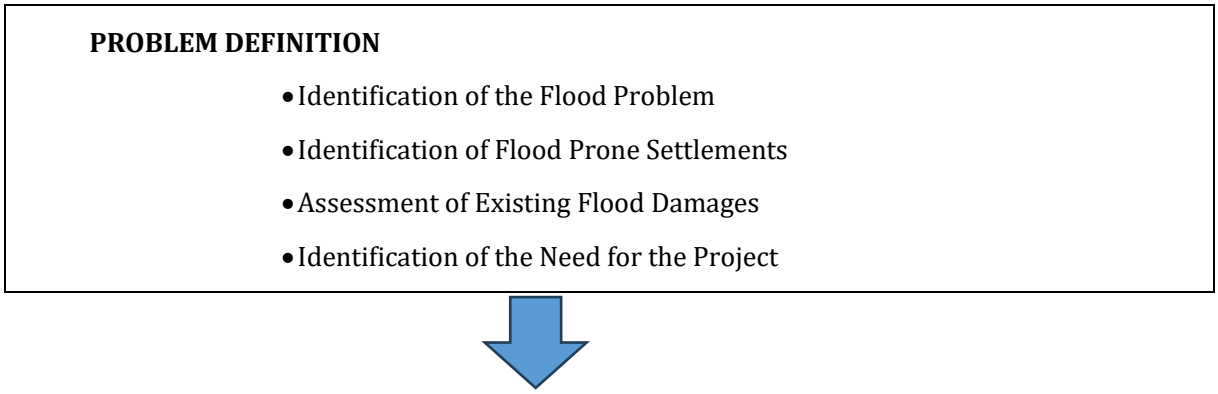
The preliminary design (reconnaissance) stage of flood protection projects is not merely a technical process involving the estimation of the design flood discharge; rather, it is a multi stage engineering decision making process in which field investigations, institutional data acquisition, hydrological and hydraulic analyses, and technical assessments from different engineering disciplines are integrated. The technical information obtained during this process is used not only for the design of flood protection structures but also for defining the project scope, determining whether upstream watersheds and tributaries should be incorporated into the project, selecting the type and location of flood protection structures, and establishing the engineering decisions that guide the subsequent planning and detailed design stages.

Accordingly, this study develops a conceptual process model based on the reconnaissance practices implemented by the General Directorate of State Hydraulic Works (DSİ). The proposed model systematically describes the relationships between the technical activities performed during the preliminary design stage and the engineering decisions derived from these activities.

The proposed model does not introduce a new hydrological computation method or a new hydraulic analysis approach. Instead, it explains how information obtained from different engineering disciplines is evaluated during the preliminary design stage, which technical analyses are performed, and how the results of these analyses are translated into engineering decisions. The process model encompasses not only the determination of the design flood discharge but also the selection of the type and location of flood protection structures, the definition of the overall project scope, the identification of upstream watersheds and tributaries requiring additional engineering investigations, the evaluation of the need for transverse hydraulic structures, the assessment of the adequacy of existing flood protection structures, and the formulation of engineering decisions that guide the subsequent planning and detailed design stages.

Based on the comprehensive evaluation of all field investigations, institutional data acquisition, hydrological and hydraulic analyses, and engineering assessments conducted within the scope of this study, the principal stages of the preliminary design process are represented by the process model presented below. The proposed process model is illustrated in Figure 9.

The process model presented in this section was developed based on the systematic engineering decision making approach widely adopted in engineering practice. Within the model, field investigations, institutional data acquisition, hydrological and hydraulic analyses, engineering decisions, and the evaluation of alternative solutions are treated as sequential and interrelated decision making stages. Their relationships throughout the preliminary design process are presented within an integrated framework. In this respect, the proposed process model illustrates not only the sequence of technical analyses but also the institutional decision making mechanism that defines the project scope and directs the subsequent engineering studies during the preliminary design stage [21,22].



DATA COLLECTION AND FIELD INVESTIGATIONS

- Field Investigations
- Field Surveys
- Watershed Investigations
- River Channel Investigations
- Assessment of Existing Hydraulic Structures
- Photographic Documentation and Field Observations
- Institutional and Technical Data
- Stream Gauging Station (SGS) Data
- Topographic Maps
- Geological and Geotechnical Data
- Land Use Information
- Technical Data Obtained from DSİ and Other Relevant Institutions

ENGINEERING ANALYSES

1. Hydrological Analyses

- Determination of Watershed Characteristics
- Estimation of the Design Flood Discharge
- Flood Frequency Analyses

2. Hydraulic Analyses

- Assessment of Channel Cross-Section Capacity
- Evaluation of Flow Conveyance Capacity
- Assessment of Flood Characteristics

3. Geological Assessments

ENGINEERING DESIGN DECISION-MAKING PROCESS

- Selection of the Hydraulic Method
- Determination of the Design Flood Discharge
- Evaluation of Hydraulic Adequacy
- Determination of Flood Protection Measures for the Upstream Watershed

CC: BY-NC-ND

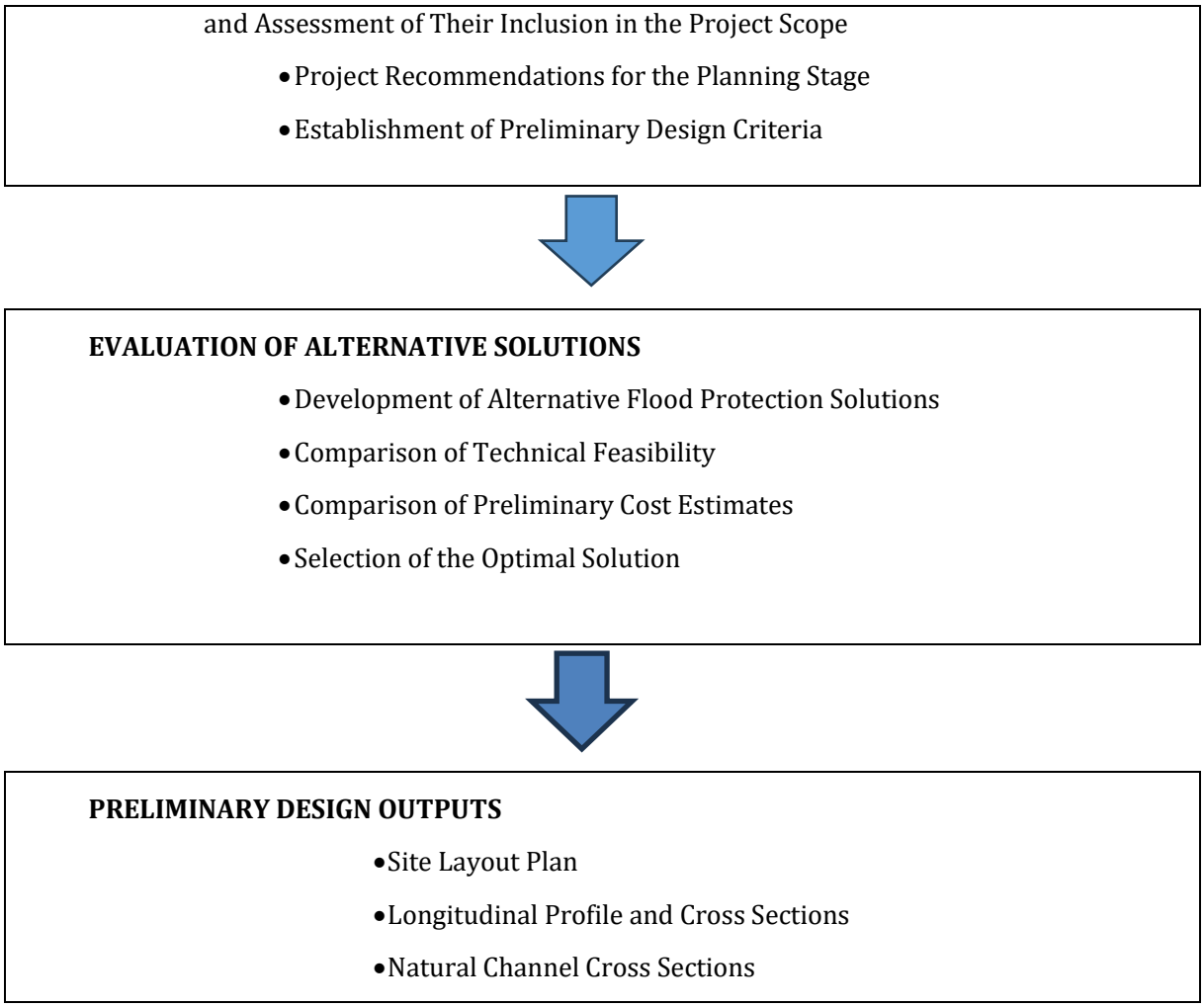


Figure 9. Proposed Engineering Decision Making Model for the Preliminary Design (Reconnaissance) Process in Medium Sized Watersheds: A Case Study of Büyükköy 5.

4. CONCLUSIONS

Although numerous studies have focused on the development of hydrological and hydraulic methods, studies that systematically examine the preliminary design (reconnaissance) stage of flood protection projects within an engineering decision making framework remain limited. This study contributes to the existing literature by presenting a systematic process model that explains how technical activities performed during the preliminary design stage are transformed into engineering decisions. The principal conclusions of this study are summarized as follows:

1. The preliminary design (reconnaissance) stage is not merely a technical procedure for estimating the design flood discharge. Rather, it is a multidisciplinary engineering decision making process in which field investigations, institutional data, hydrological and hydraulic analyses, and technical assessments from different engineering disciplines are integrated.

2. The results of the Regional Flood Frequency Analysis were used as an engineering reference for evaluating and verifying the design flood discharges obtained from the synthetic unit hydrograph methods. The selection of the design flood discharge was based not only on the numerical agreement between the methods but also on watershed characteristics, the proximity of stream gauging stations to the project area, and regional hydrological similarity. Based on this comprehensive engineering evaluation, the design flood discharge for the project area was determined using the DSİ Synthetic Unit Hydrograph method.

CC: BY-NC-ND

3. Field investigations demonstrated that flood risk is not determined solely by the design flood discharge. River channel morphology, bank erosion, slope instability, sediment transport, the hydraulic adequacy of bridges and culverts, and the condition of existing flood protection structures were also found to have a direct influence on engineering decisions during the preliminary design stage.

4. The integrated evaluation of field investigations and office studies resulted not only in determining the type and location of flood protection structures but also in engineering decisions regarding the inclusion of upstream watersheds and tributaries within the project scope, the need for transverse hydraulic structures, sediment management measures, the assessment of maintenance and rehabilitation requirements for existing flood protection structures, and the definition of the overall project scope.

5. Based on the findings of this study, a systematic preliminary design process model consisting of problem definition, data collection and field investigations, engineering analyses, engineering decision making, evaluation of alternative solutions, and preliminary design outputs was developed.

6. The proposed process model considers the determination of the design flood discharge not as an isolated computational task but as one of the principal technical inputs supporting project scope definition and engineering decision making. In this respect, the model integrates technical analyses with institutional engineering practice within a systematic and traceable decision making framework.

7. The proposed process model provides decision support not only for the preliminary design of flood protection structures but also for identifying the stages at which different engineering disciplines should be involved, determining the additional technical investigations required, and defining the overall scope of flood protection projects.

8. Although the proposed process model was developed using the Büyükköy Stream case study, it provides a systematic engineering decision support framework that can be adapted to preliminary design studies conducted in watersheds with similar hydrological characteristics and comparable data limitations.

9. This study does not propose a new hydrological or hydraulic computation method. Instead, its principal contribution lies in systematically demonstrating how field investigations, institutional engineering practices, technical analyses, and multidisciplinary engineering assessments are transformed into engineering decisions through a structured preliminary design process model. In this respect, the study presents an original and practical engineering decision making framework for the preliminary design stage of flood protection projects, addressing an aspect of institutional engineering practice that has received limited attention in the existing literature.

Peer-review: External, Independent.

Acknowledgements:
The author declares that no individual or organization other than those acknowledged in the manuscript provided specific support for this study.

Declarations:

1. Statement of Originality:

This manuscript is original, has not been published previously, and is not under consideration for publication elsewhere.

2. Author Contributions:

Concept: ÇÇ; ***Conceptualization:*** ÇÇ; ***Literature Search:*** ÇÇ; ***Data Collection:*** ÇÇ; ***Data Processing:*** ÇÇ; ***Analysis:*** ÇÇ; ***Writing – original draft:*** ÇÇ; ***Writing – review & editing:*** ÇÇ.

3. Ethics approval:

This study does not require ethics committee approval because it is based on field and office studies and

CC: BY-NC-ND

does not involve human or animal subjects.

4. Funding/Support:

This work has not received any funding or support.

5. Competing Interests:

The author declares no competing interests.

6. GenAI Usage Statement:

Generative AI tools were used for language-editing and formatting assistance during manuscript preparation. No AI-generated data, analyses, or scientific conclusions were used in the study.

7. Sustainable Development Goals:

REFERENCES

[1] IPCC. (2021). Climate Change 2021: The Physical Science Basis. Cambridge: Cambridge University Press.

[2] Blöschl G, Hall J, Viglione A, et al. (2019). Changing climate both increases and decreases European river floods. Nature, 573, 108–111.

[3] AFAD. (2022). Türkiye Afet Yönetimi ve Doğa Kaynaklı Afet İstatistikleri. Ankara.

[4] Türkiye Cumhuriyeti. (1953). 6200 Sayılı Devlet Su İşleri Genel Müdürlüğünün Teşkilat ve Vazifeleri Hakkında Kanun. Resmî Gazete.

[5] Başbakanlık. (2010). Dere Yataklarının Islahı Genelgesi. Başbakanlık Genelgesi.

[6] Türkiye Cumhuriyeti. (2004). 5216 Sayılı Büyükşehir Belediyesi Kanunu. Resmî Gazete.

[7] Beven KJ. (2012). Rainfall-Runoff Modelling: The Primer. 2nd ed. Chichester: Wiley-Blackwell.

[8] Beven KJ. (1989). Changing ideas in hydrology—The case of physically based models. Journal of Hydrology, 105, 157–172.

[9] Chow VT, Maidment DR, Mays LW. (1988). Applied Hydrology. New York: McGraw-Hill.

[10] Maidment DR, Ed. (1993). Handbook of Hydrology. New York: McGraw-Hill.

[11] USDA Soil Conservation Service (USDA-SCS). (1986). Urban Hydrology for Small Watersheds. Technical Release 55 (TR-55). Washington, DC.

[12] Hosking JRM, Wallis JR. (1997). Regional Frequency Analysis: An Approach Based on L-Moments. Cambridge: Cambridge University Press.

[13] Merz R, Blöschl G. (2008). Flood frequency hydrology: 1. Temporal, spatial, and causal expansion of information. Water Resources Research, 44.

[14] Wasko C, Sharma A. (2017). Global assessment of flood and storm extremes with warming. Scientific Reports, 7.

[15] Teng J, Jakeman AJ, Vaze J, et al. (2017). Flood inundation modelling: A review of methods, recent

advances and uncertainty analysis. Environmental Modelling & Software, 90, 201–216.

[16] Merz B, Vorogushyn S, Uhlemann S, Delgado J, Hundecha Y. (2021). Flood risk, impacts and management in a changing climate. Nature Reviews Earth & Environment, 2, 605–631.

[17] Çolak Ç. (2025). Köyiçi Deresi özelinde proje debisi belirleme sürecinin incelenmesi. Fen Bilimleri Enstitüsü Fen Bilimleri Dergisi, 41(2), 658–673.

[18] Özdemir H. (1978). Türkiye'de Sentetik Birim Hidrograf Yöntemleri. Ankara: Devlet Su İşleri Genel Müdürlüğü Yayınları.

[19] Kesgin E. (2025). Akım Gözlemi Olmayan Havzalarda Sentetik Birim Hidrograf Yöntemleri ve CBS Kullanılarak Taşkın Debilerinin Tahmini (Flood Discharge Estimation in Ungauged Basins Using Synthetic Unit Hydrographs and GIS). Fırat Üniversitesi Deneysel ve Hesaplamalı Mühendislik Dergisi, 4(2).

[20] Çolak Ç. (2026). Distributed unit hydrograph (DUH) approach and Mockus-based analysis for hydraulic structure design in small watersheds under climate change conditions. Gümüşhane Üniversitesi Fen Bilimleri Dergisi, 16(2), 651–668. https://doi.org/10.17714/gumusfenbil.185683

[21] Simon HA. (1997). Administrative Behavior. 4th ed. New York: Free Press.

[22] Clemen RT, Reilly T. (2014). Making Hard Decisions with DecisionTools. 3rd ed. Boston: Cengage Learning.

[23] Devlet Su İşleri 22. Bölge Müdürlüğü. (2006). Rize Çayeli Pehlivanlı Deresi, Büyükköy Deresi, Altıntaş Mahallesi ve Derecik Köyünün Köyiçi Deresi Taşkınlarından Korunmasına Ait İstikşaf Raporu. Trabzon.

[24] Turkish State Meteorological Service (TSMS). (n.d.). Official Mission and Responsibilities. Available from: https://www.mgm.gov.tr/about.aspx

[25] Devlet Su İşleri Genel Müdürlüğü. (1983). Küçük Su İşleri. Ankara: Devlet Su İşleri Genel Müdürlüğü.

[26] Devlet Su İşleri Genel Müdürlüğü. (1987). Tekirdağ Merkez Değirmenaltı Mahallesi Kayı Deresi Taşkın Koruma İlk İnceleme ve Revize Ön İnceleme Raporları (Kod No: 560119). Edirne.

Appendix 1. Regional Flood Frequency Analysis Results [23].

Abbreviations: YA = Drainage Area (km^2); N = Record Length (years); UDF = Best-fit Probability Distribution Function; Qmax = Maximum Recorded Discharge.

CC: BY-NC-ND

avza adı	Sıra no	İst. no	Y.A(km2)	N(yıl)	UDF	Qmax	yineleme yılları						boyutsuz yineleme değerleri					
							2	5	10	25	50	100	2	5	10	25	50	100
Pazar suyu	1	2212(K)	565,2	7	LPT3	84,2	67,5	83,79	91,3	98,24	102,09	105,1	1,00	1,24	1,35	1,46	1,51	1,56
	2	2237(K)	176,8	4	G	44,9	33,99	49,21	59,28	72,02	81,46	90,84	1,00	1,45	1,74	2,12	2,40	2,67
	3	2253	770,7	4	G	164	146,18	172,20	189,43	211,20	227,34	243,37	1,00	1,18	1,30	1,44	1,56	1,66
	4	22-64	377,5	25	LPT3	164	83,449	116,69	140,64	173,19	199,18	226,55	1,00	1,40	1,69	2,08	2,39	2,71
Aksu d.	5	2208(K)	887,6	6	LN2	560	122,07	254,7	374,13	563,91	734,67	932,3	1,00	2,09	3,06	4,62	6,02	7,64
	6	2213	713	39	LN3	400	108,37	167,88	211,9	272,28	320,36	371,1	1,00	1,55	1,96	2,51	2,96	3,42
	7	2236(K)	317,2	10	LPT3	173	62,911	98,755	128,6	174,4	214,98	261,78	1,00	1,57	2,04	2,77	3,42	4,16
	8	22-69(K)	586,9	7	G	78	59,68	79,34	92,35	108,8	121	133,11	1,00	1,33	1,55	1,82	2,03	2,23
	9	22-71(K)	292,7	15	LPT3	58,5	43,38	53,64	59,28	65,41	69,4	73	1,00	1,24	1,37	1,51	1,60	1,68
	10	22-90	470,2	20	LN	186	94,47	122,67	137,42	153,15	163,3	172,43	1,00	1,30	1,45	1,62	1,73	1,83
Yağlı dere	11	22-39(K)	322,8	5	LN2	140	35,682	71,814	103,52	152,93	196,67	246,68	1,00	2,01	2,90	4,29	5,51	6,91
	12	22-80	296,9	20	LPT3	179	61,065	108,58	147,67	205,89	255,78	311,6	1,00	1,78	2,42	3,37	4,19	5,10
	13	2214(K)	535,2	6	PT3	378	110,85	222,37	304,86	412,97	494,14	575,04	1,00	2,01	2,75	3,73	4,46	5,19
	14	22-73	397,9	20	PT3	202	52,342	89,257	117,79	155,88	184,87	213,97	1,00	1,71	2,25	2,98	3,53	4,09
Gelevera d.	15	2235(K)	136,4	6	G	64	37,182	62,989	80,075	101,66	117,68	133,58	1,00	1,69	2,15	2,73	3,16	3,59
	16	22-87	256,8	14	PT3	345	114,83	200,81	255,09	320,66	367,21	411,98	1,00	1,75	2,22	2,79	3,20	3,59
Harşit d.	17	22-9	1900,4	31	LPT3	629	115,51	184,25	246,97	351,15	450,62	572,48	1,00	1,60	2,14	3,04	3,90	4,96
	18	22-13	124,85	23	LPT3	79	24,853	36,119	45,106	58,412	69,843	82,704	1,00	1,45	1,81	2,35	2,81	3,33
	19	22-40	3132,8	28	LPT3	2015	290,18	474,12	659,42	994,22	1340,4	1794,7	1,00	1,63	2,27	3,43	4,62	6,18
	20	22-83	410,8	12	LPT3	100	48,711	66,103	78,134	93,93	106,1	118,67	1,00	1,36	1,60	1,93	2,18	2,44
	21	22-84	149,6	17	LPT3	57	18,292	28,187	35,818	46,752	55,879	65,838	1,00	1,54	1,96	2,56	3,05	3,60
	22	22-95	88,2	6	LPT3	10,1	9,1298	10,267	10,627	10,864	10,958	11,011	1,00	1,12	1,16	1,19	1,20	1,21
	23	2201(K)	2750	39	LN2	731	229,8	343,23	423,33	529,51	611,71	696,59	1,00	1,49	1,84	2,30	2,66	3,03
	24	2219(K)	117,6	6	LPT3	78,5	22,377	41,158	61,172	99,309	140,69	197,16	1,00	1,84	2,73	4,44	6,29	8,81
	25	2220(K)	2938,8	4	LPT3	198	178,12	188,15	195,94	206,66	215,1	223,85	1,00	1,06	1,10	1,16	1,21	1,26
	26	2249	3175,6	6	G	339	287,54	349,72	390,88	442,89	481,48	519,78	1,00	1,22	1,36	1,54	1,67	1,81
Görele d.	27	22-14(K)	278,2	6	LPT3	440	154,28	297,9	443,5	707,91	980,82	1337	1,00	1,93	2,87	4,59	6,36	8,67
	28	22-15(K)	129,9	4	LPT3	85	79,779	105,55	127,38	160,95	190,82	225,34	1,00	1,32	1,60	2,02	2,39	2,82
	29	22-58	162,7	24	LPT3	280	79,649	128,57	170,3	235,72	294,74	363,84	1,00	1,61	2,14	2,96	3,70	4,57

Havza adı	Sıra no	Ist. no	Y.A(km2)	N(yıl)	UDF	Qmax	yineleme yılları						boyutsuz yineleme değerleri					
							2	5	10	25	50	100	2	5	10	25	50	100
Akhisar d.	30	22-23	128,7	4	PT3	88	74,456	88,072	92,799	96,375	98,028	99,142	1,00	1,18	1,25	1,29	1,32	1,33
Fold	31	2228	191,4	34	LN2	412,00	67,9	125,17	174,66	251,65	320,12	399,18	1,00	1,84	2,57	3,71	4,71	5,88
Galanima d.	32	22-45(K)	248,7	9	N	37,00	24,778	30,063	32,827	35,776	37,677	39,389	1,00	1,21	1,32	1,44	1,52	1,59
Sera d.	33	22-25(K)	121,4	4	LPT3	19,00	16,612	20,099	21,275	22,071	22,388	22,575	1,00	1,21	1,28	1,33	1,35	1,36
Değirmen d.	34	2206(K)	708	32	LN3	177,00	81,182	108,77	126,89	149,67	166,54	183,39	1,00	1,34	1,56	1,84	2,05	2,26
	35	2248(K)2251	728,5	6	G	158,00	106,89	153,83	184,92	224,19	253,32	282,24	1,00	1,44	1,73	2,10	2,37	2,64
	36	22-56	728,4	13	LPT3	610,00	84,152	149,73	232,23	415,79	646,42	1005,5	1,00	1,78	2,76	4,94	7,68	11,9
	37	22-60((K)	185	6	LPT3	25,00	19,17	23,35	25,50	27,73	29,10	30,30	1,00	1,22	1,33	1,45	1,52	1,58
	38	22-61	261	19	LPT3	150,00	33,12	49,60	66,23	96,10	126,76	166,70	1,00	1,50	2,00	2,90	3,83	5,03
	39	22-88(K) 22-97	150	18	G	38,60	17,61	25,57	30,85	37,51	42,46	47,36	1,00	1,45	1,75	2,13	2,41	2,69
	40	22-59	121,5	21	LPT2	135,00	18,584	31,481	45,857	74,375	106,54	151,98	1,00	1,69	2,47	4,00	5,73	8,18
Yanbolu d.	41	22-34	258,6	24	LN2	124,00	43,021	62,464	75,911	93,466	106,88	120,61	1,00	1,45	1,76	2,17	2,48	2,80
Kara d.	42	2202	635,7	42	LN2	261,30	88,202	129,46	158,22	195,99	225	254,78	1,00	1,47	1,79	2,22	2,55	2,89
	43	2234(K)	230,7	10	G	49,00	29,15	41,567	49,788	60,175	67,881	75,53	1,00	1,43	1,71	2,06	2,33	2,59
	44	22-44	421,2	17	LP3	181,00	53,034	74,426	95,656	132,95	170,25	217,85	1,00	1,40	1,80	2,51	3,21	4,1
Sürmene d.	45	22-53	173,6	17	LPT3	210,00	53,381	86,031	115,73	164,75	211,46	268,46	1,00	1,61	2,17	3,09	3,96	5,0
Solaklı d.	46	22-07	154,7	34	G	57,20	27,254	39,13	46,992	56,926	64,296	71,612	1,00	1,44	1,72	2,09	2,36	2,6
	47	22-52	576,8	26	PT3	200,00	91,445	120,57	140,54	165,68	184,13	202,16	1,00	1,32	1,54	1,81	2,01	2,2
	48	22-57	242,6	25	LP3	71,00	30,927	44,816	55,37	70,274	82,604	96,011	1,00	1,45	1,79	2,27	2,67	3,1
	49	2203(K)	567,2	7	LP3	213,90	99,77	154,06	193,34	246,32	288,06	331,53	1,00	1,54	1,94	2,47	2,89	3,3
Baltacı d.	50	22-66	115,9	21	LN2	195,00	25,936	57,553	87,306	136,19	181,41	234,85	1,00	2,22	3,37	5,25	6,99	9,0
	51	22-68	171,6	18	PT3	170,00	37,728	73,087	99,707	134,87	161,4	187,92	1,00	1,94	2,64	3,57	4,28	4,9

CC: BY-NC-ND

Havza adı	Sıra no	İst. no	Y.A(km2)	N(yıl)	UDF	Qmax	yineleme yılları						boyutsuz yineleme değerleri					
							2	5	10	25	50	100	2	5	10	25	50	100
İyidere d.	52	22-77(K)22-96	139,34	13	LN2	58,80	25,722	35,477	41,971	50,217	56,374	62,562	1,00	1,38	1,63	1,95	2,19	2,43
	53	22-78	284,3	15	LP3	88,40	62,783	77,792	86,53	96,553	103,41	109,82	1,00	1,24	1,38	1,54	1,65	1,75
	54	2207(K)	781	5	LP3	81,50	77,232	82,31	83,674	84,444	84,707	84,839	1,00	1,07	1,08	1,09	1,10	1,10
	55	2215	445,2	35	LN2	184,00	79,954	103,39	118,26	136,49	149,71	162,71	1,00	1,29	1,48	1,71	1,87	2,04
	56	2218	834,9	38	LP3	504,00	143,76	210,38	269,51	364,89	453,7	560,33	1,00	1,46	1,87	2,54	3,16	3,90
	57	2233	223,1	37	G	68,90	42,236	52,368	59,077	67,552	73,84	80,082	1,00	1,24	1,40	1,60	1,75	1,90
Taşlı d.	58	2204(K)	274	5	LPT3	287,20	280,98	289,59	291,63	292,7	293,03	293,17	1,00	1,03	1,04	1,04	1,04	1,04
	59	22-082	83,32	20	LPT3	458,00	97,352	138,28	165,39	199,63	225,03	250,25	1,00	1,42	1,70	2,05	2,31	2,57
Büyük d.	60	2211(K)	217,3	4	G	125,00	74,267	130,13	167,11	213,84	248,5	282,91	1,00	1,75	2,25	2,88	3,35	3,81
	61	2246(K)	217,3	5	G	371,00	150,03	336,39	459,79	615,69	731,35	846,16	1,00	2,24	3,06	4,10	4,87	5,64
	62	22-85	231,2	20	G	101,00	58,213	82,84	99,146	119,75	135,03	150,2	1,00	1,42	1,70	2,06	2,32	2,58
Fırtına d.	63	22-62	496,7	24	LPT3	193,00	97,416	129,47	153,36	186,77	214,06	243,54	1,00	1,33	1,57	1,92	2,20	2,50
	64	22-63	239,2	22	LPT3	337,00	94,006	148,88	196,44	271,87	340,88	422,53	1,00	1,58	2,09	2,89	3,63	4,49
	65	22-74	277,6	18	G	93,00	50,876	72,988	87,627	106,12	119,85	133,47	1,00	1,43	1,72	2,09	2,36	2,62
	66	22-076	302	10	G	323,00	164,96	278,89	354,32	449,62	520,32	590,5	1,00	1,69	2,15	2,73	3,15	3,58
	67	2227(K)	153,2	8	LPT3	131,00	60,021	91,819	117,54	155,95	189,26	226,92	1,00	1,53	1,96	2,60	3,15	3,78
	68	2232	763,2	37	LPT3	560,00	146,35	200,11	253,29	345,79	437,37	553,13	1,00	1,37	1,73	2,36	2,99	3,78
Arılı d.	69	22-072	92,15	23	LPT3	410,00	135,14	223,63	288,13	375,02	442,84	512,76	1,00	1,65	2,13	2,78	3,28	3,79
	70	22-26(K)	140	4	LPT3	250,00	174,33	233,79	258,42	280,23	292,12	301,39	1,00	1,34	1,48	1,61	1,68	1,73
Abu çağlaya n d.	71	22-06	156	32	LN2	350,00	90,717	135,13	166,43	207,87	239,9	272,95	1,00	1,49	1,83	2,29	2,64	3,01
Kapistre d.	72	22-49	186,16	22	LPT3	440,00	142,35	228,31	292,62	381,59	453,19	529,11	1,00	1,60	2,06	2,68	3,18	3,72
	73	22-79	89,7	12	G	171,00	70,982	126,98	164,06	210,91	245,67	280,16	1,00	1,79	2,31	2,97	3,46	3,95
	74	22-89	66,37	17	LPT3	71,00	47,204	59,732	66,222	72,9	77,017	80,545	1,00	1,27	1,40	1,54	1,63	1,71

CC: BY-NC-ND