MINISTRY OF ECOLOGY AND NATURAL RESOURCES
REPUBLIC OF KAZAKHSTAN

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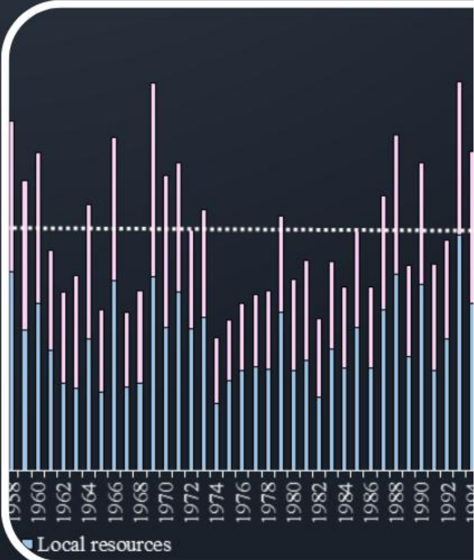
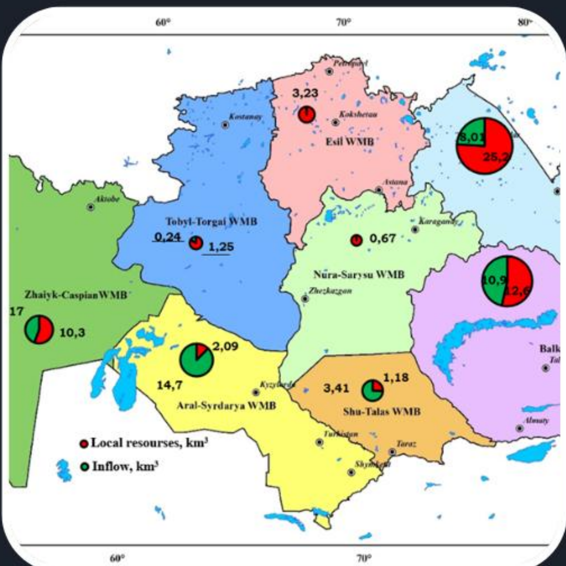
2023





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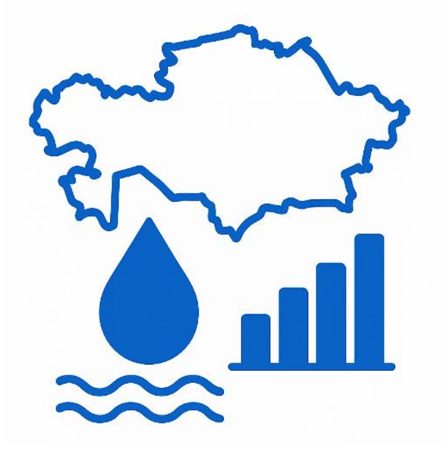
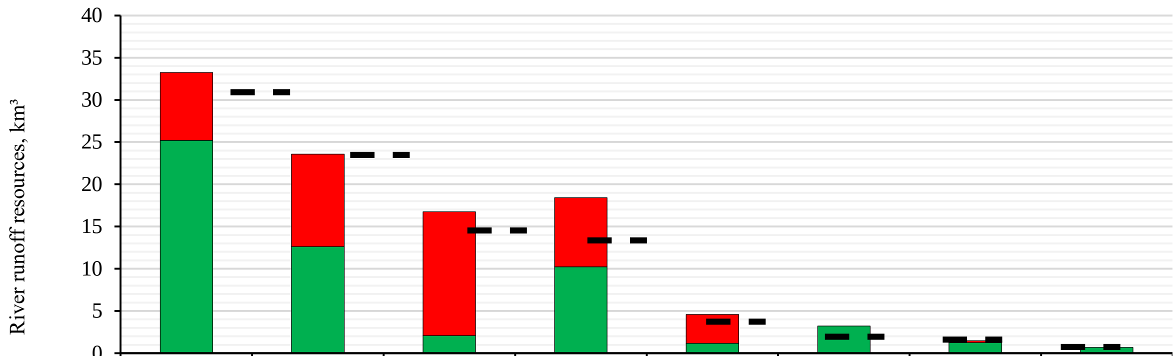
SUMMARY OF THE YEAR 2023



01 SURFACE WATER RESOURCES

In 2023, the river runoff resources of the Republic of Kazakhstan were formed under conditions of **reduced water availability**; in most basins, runoff was below the long-term average values due to transboundary regulation, intensive water consumption, climatic moisture deficit, and high evaporation rates. The exception was the Zhaiyk-Caspian Basin, where an abnormally **high spring flood** led to an increase in local runoff and an overall rise in water resources. At the same time, the Ertis, Balkhash-Alakol, Aral-Syrdarya, Shu-Talas, Tobyl-Torgai, and Nura-Sarysu basins were characterized by water availability ranging **from moderately low to low**, whereas the Esil Basin experienced moderately high water availability due to favorable climatic conditions (Figure 1).



	Ertis	Balkhash-Alakol	Aral-Syrdarya	Zhaiyk-Caspian	Shu-Talas	Esil	Tobol-Torgay	Nura-Sarysu
Inflow	8,01	10,9	14,7	8,17	3,41		0,24	
Local resources	25,2	12,6	2,09	10,3	1,18	3,23	1,25	0,67

Figure 1 – Surface water resources for 2023

Note: the dashed line represents the long-term average value of total river runoff resources

02 ANALYSIS AND CALCULATION OF SPRING FLOOD CHARACTERISTICS OF THE MAIN RIVERS OF THE REPUBLIC OF KAZAKHSTAN FOR THE YEAR

Spring flooding in 2023 across Kazakhstan was characterized by low water availability and shortened duration on most rivers of the country. The formation of the flood was significantly influenced by an abnormally warm spring, early and rapid snowmelt, as well as uneven precipitation distribution during the spring period.

- Ertis, Balkhash-Alakol, Aral-Syrdarya, Tobyl-Torgai, and Nura-Sarysu Basins - spring flood volumes were **close to or significantly below** long-term average values;

- Zhaiyk-Caspian and Esil Basins - the trend of **decreasing spring runoff** volumes persisted; however, in certain sections – the Uil River and the Zhabai River – the largest flood volumes on record were observed, associated with abundant precipitation, high snow reserves, and good soil moisture;

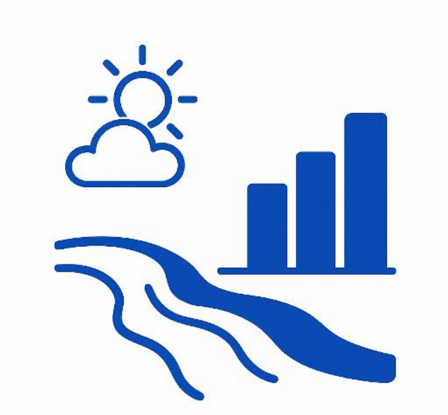
- Shu-Talas Basin - the spring flood had an anomalously prolonged character (up to 80 days), especially in mountainous areas, with a tendency toward increasing spring runoff volumes.

03 OVERVIEW AND ANALYSIS OF DANGEROUS HYDROLOGICAL PHENOMENA

In 2023, hazardous hydrological phenomena in Kazakhstan were mainly associated with **spring flooding** caused by early snowmelt. In the western and northwestern regions, early and intense flooding was observed, accompanied by rising water levels and local inundations due to deep soil freezing and surface runoff. At several hydrological stations (in West Kazakhstan, Aktobe, Kostanay, Akmola, and North Kazakhstan regions), water levels exceeded dangerous thresholds.

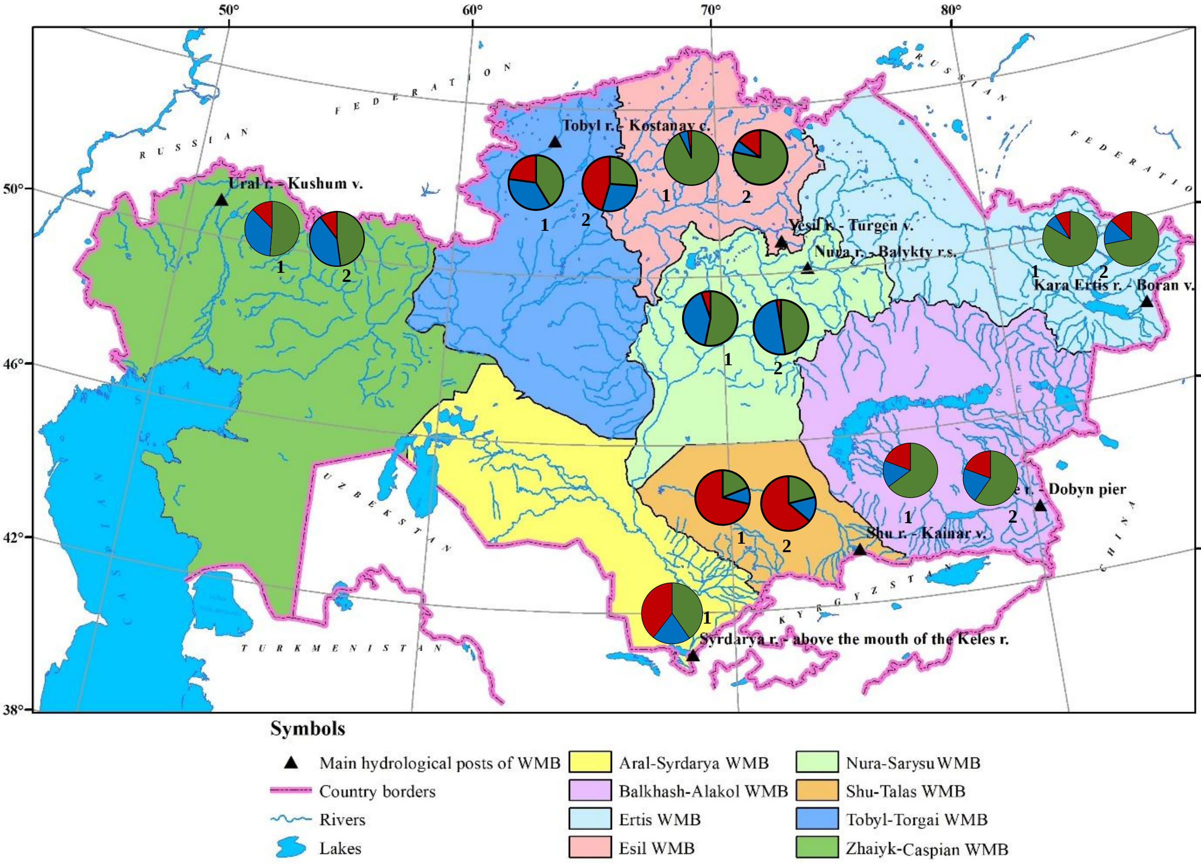
Mudflow processes were recorded in the Mangystau Region (1 case) and the Almaty Region (6 cases), predominantly of torrential origin. The most intense mudflows occurred in the basins of the Kishi and Ulken Almaty, Talgar, and Yesik rivers, causing short-term floods, infrastructure damage, and population evacuations.

Ice jams and frazil ice phenomena in Kazakhstan were observed mainly in the northern and western basins. The most active occurrences were recorded in the Zhaiyk-Caspian, Ertis, Esil, and Aral-Syrdarya basins, where ice jams and frazil ice accumulations were noted both upstream and downstream of hydrological stations. In the central and southern basins (Shu-Talas and Nura-Sarysu), no ice phenomena were observed. Overall, the development of ice jams and frazil ice corresponded to long-term patterns and did not cause significant hydrological complications.



04 ANALYSIS OF THE INTRA-ANNUAL DISTRIBUTION OF RUNOFF OF THE MAIN RIVERS OF THE REPUBLIC OF KAZAKHSTAN

The intra-annual distribution of runoff. Overall, **2023** was characterized as a **low-water** year for the Republic of Kazakhstan, with a stable manifestation of spring-summer flooding and a pronounced decrease in water availability during the autumn-winter period. The hydrological regime of most rivers was determined by abnormally warm weather conditions and uneven precipitation distribution across the country. Spring 2023 was marked by early snowmelt, which caused the peak runoff phase to shift to an earlier period (April – first half of May) and reduced the duration of the flood season (Fig.2).



Note: 1 - intra-annual runoff distribution for the long-term period; 2 - intra-annual runoff distribution for 2023-2024.

– non-limiting period; limiting period; – non-limiting season; – limiting season

Figure 2 – Intra-annual runoff distribution of the main rivers of the water management basins

DESIGNATIONS AND ABBREVIATIONS

NHMS - National Hydrometeorological Service
RSE «Kazhydromet» - Republican State Enterprise «Kazhydromet»
WMB - Water management basin
PRC - People's Republic of China
MS - Meteorological Station
HG - Hydrological Gauging Station
MHC - Main Hydrological Characteristics
RF - Russian Federation
SNiP - Construction Norms and Regulations
UGVK - Department of the State Water Cadastre
S - South
SE - Southeast
SW - Southwest
N - North
W - West
NE - Northeast
NW - Northwest
v. - Village
r. - river/ right (tributary)
l - left (tributary)
rr. - rivers
s. - settlement
agri. - agriculture
Q - water discharge
W - runoff volume
r - correlation coefficient
Σ - sum
Ki - module coefficient
Q_0 - long-term average runoff
C_V - coefficient of variation
C_S - coefficient of skewness
(Q_N)¯ - annual runoff norm
km^3- cubic kilometer
km^2- square kilometer
m - meter
m/s - meters per second
m^3 - cubic meter
m^3/s - cubic meters per second

INTRODUCTION

Water is one of the most important natural resources, directly affecting the quality of life of the population, the state of ecosystems, and the sustainable functioning of the economy. Kazakhstan, with its vast territory and diverse natural and climatic conditions, is characterized by an uneven distribution of water resources both in space and time. This is due to a variety of factors: geographical location, climatic conditions, geological structure, as well as increasing anthropogenic impact.

Hydrological information plays a key role in ensuring the country's water security. It is essential for water resource management, water use planning, and for the prevention and mitigation of the impacts of natural phenomena such as floods, droughts, high flows, and ice jams. Up-to-date and reliable hydrological information also serves as a scientific basis for assessing the impact of climate change on water resources, developing adaptation measures, and promoting the sustainable development of the water management sector.

In the context of climate change, population growth, and increasing anthropogenic pressure, the importance of the rational use and protection of water resources is greatly amplified. Changes in runoff volume and regime, as well as the increased frequency of extreme hydrometeorological events such as droughts and floods, require a systematic approach to water resource management and timely response to emerging water management and environmental challenges.

This edition of the annual Hydrological Bulletin contains key information on river runoff resources for the eight water management basins (hereinafter WMB) of the Republic of Kazakhstan as a whole, as well as for the main river basins and their sections for the period from the early 1930s to 2023. Data are provided on the main characteristics of the spring flood, including its start and end dates, duration, maximum water discharge, runoff layers and volumes, information on hazardous hydrological events that occurred at water bodies during the year, as well as parameters of intra-annual runoff distribution of the main rivers during the period of anthropogenic impact.

Source data. The bulletin is prepared using data from the Republican Hydrometeorological Fund of the RSE «Kazhydromet»:

1) Series of mean annual water discharges for the entire observation period up to 2023;

2) Series of spring flood characteristics for the entire observation period up to 2023;

3) Series of mean monthly water discharges, used for the calculation and analysis of intra-annual runoff during the period of anthropogenic impact, with each basin having its own starting period up to 2023;

4) Data on hazardous ice phenomena (ice jams and frazil ice accumulations) at hydrological stations;

5) Information on extraordinary and hazardous hydrological events recorded during the year.

The network of hydrological stations used in the calculations and analyses for this bulletin is shown on the schematic map below:

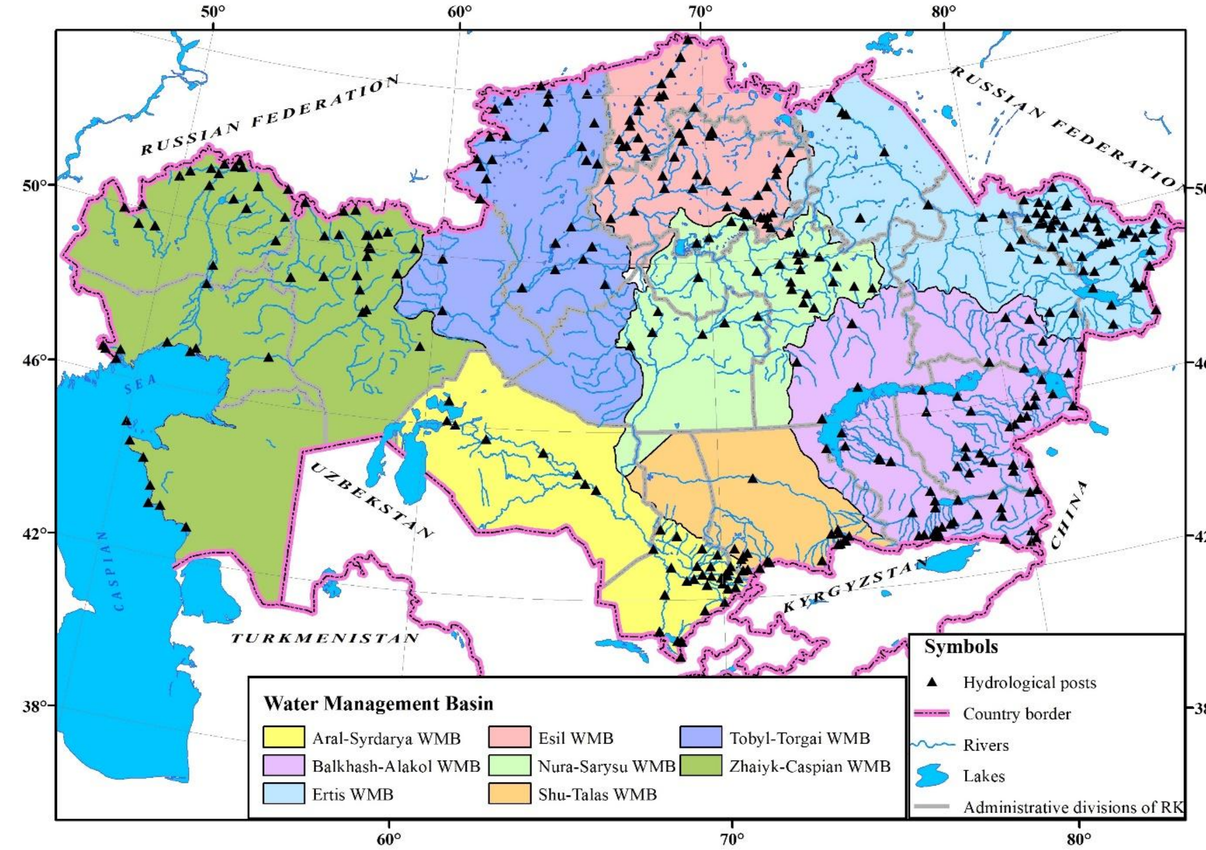


Figure 3 – Schematic map of the locations of hydrological stations

Main methods and approaches. The annual runoff norm (long-term average runoff) is a fundamental characteristic that determines the overall water availability of rivers and the potential water resources of a given basin or region. It serves as a kind of hydrological «benchmark» from which other runoff characteristics are derived. When observational data are available, the annual runoff norm, like any arithmetic mean of a statistical series, is calculated using the standard formula формуле [1].

The representativeness depends on the length of the observation series and the coefficient of variation, i.e., the extent to which the available runoff observation series includes the most abundant or lowest water years and complete cycles of water availability observed in the studied territory.

To analyze changes in the dynamics of mean annual discharges, the method of linear regression was applied, with the construction of a trend equation and an assessment of the statistical significance of the identified changes.

The assessment of annual discharge availability (total, local resources, and inflow) was carried out using the Pearson Type III distribution curve method.

Spring flood characteristics were determined through the analysis of runoff hydrographs: establishing the start and end of the flood, and calculating the volume and layer of spring runoff at each gauging section based on the catchment area.

The analysis of intra-annual runoff distribution was carried out using the method developed by V.G. Andreyanov [2] , which has been widely applied in hydrological practice due to its versatility and applicability to various types of intra-annual runoff patterns and natural conditions.

The annual Hydrological Bulletin is intended for specialists whose work is related to the management and use of surface water: hydrologists, hydraulic engineers, land reclamation specialists, ecologists, geographers, as well as for scientific and educational institutions, government authorities, and all interested parties.

Responsible for the publication: Head of the Department for Hydrological Process Modeling and Hydrological Calculations, B.B. Aitymova. Leading researchers who contributed to the preparation of the bulletin include: A.S. Pshenchinova, M.K. Nurkhan, Zh.E. Zhaidakpay, and T.S. Mussina.

1. SURFACE WATER RESOURCES

The annual river runoff water resources for **2023** were determined for the eight WMBs of Kazakhstan:

- Ertis
- Balkhash-Alakol
- Aral-Syrdarya
- Zhaiyk -Caspian
- Esil
- Shu-Talas
- Nura-Sarysu
- Tobyl-Torgai

The assessment of annual river runoff water resources in Kazakhstan's WMBs is one of the key tasks in implementing the «Concept of Environmental Safety of the Republic of Kazakhstan» This is due to the fact that the country's water resources are limited and distributed extremely unevenly, with significant intra-annual and inter-annual variability in runoff. Therefore, effective use of these resources requires information on their volume both across the country as a whole and within individual WMBs. Such an assessment is especially necessary for basins where water resources are shared between different countries. These include the Balkhash-Alakol, Ertis, Aral-Syrdarya, Zhaiyk-Caspian, Shu-Talas, and Tobyl-Torgai WMBs.

Methodology. In 2008, the RSE «Kazhydromet» developed the «Methodology for Assessing Annual River Runoff Resources of Kazakhstan» within the framework of the assignment from the Committee on Water Resources of the Ministry of Agriculture of the Republic of Kazakhstan: Program 023 «Protection and Rational Use of Water Resources» Subprogram 101 «Compilation of the State Water Cadastre» The work was carried out for the eight WMBs.

The methodology was based on the analogy method, using the hypothesis of equally probable runoff values for large rivers (or the total runoff of rivers) and the basin as a whole. To establish this relationship, data on water resources of varying probability and their long-term parameters (long-term average runoff volumes, coefficients of variation, and skewness) were used, as presented in the monographs «Water Resources of Kazakhstan» and «Water Balance of Rivers of the USSR» [3].

In the absence of runoff observations, calculated annual values were used. Where significant economic activity occurred in the catchment, restored mean annual runoff values were generally applied, i.e., values adjusted to natural conditions. The sum of resources from the eight WMBs was taken as the river runoff resources for the Republic of Kazakhstan as a whole.

In this methodology, the runoff norm, which is one of the important and stable hydrological characteristics of the main rivers, is taken as the mean water discharge over the long-term period from the start of gauging up to 2001 for the Balkhash-Alakol and Ertis WMBs, up to 2004 for the Tobyl-Torgai, Aral-Syrdarya, and Nura-Sarysu WMBs, up to 2005 for the Zhaiyk-Caspian and Shu-Talas WMBs, and up to 2007 for the Esil Basin inclusive [4].

The reliability of annual values, i.e., the probability of exceeding total, local resources, and inflow, was calculated using the Pearson Type III distribution curve. Average water availability corresponds to a reliability of not less than 40 % and not more than 60 %. Moderately high water availability corresponds to a reliability of more than 20 % and less than 40 %, while high water availability corresponds to a reliability of 20 % or less. Moderately low water availability corresponds to a reliability of more than 60 % and less than 80 %, and low water availability corresponds to a reliability of 80 % or more.

Within the high water availability category, abnormally high water availability is distinguished, corresponding to total water resources exceeding the long-term maximum. Within the low water availability category, abnormally low water availability is distinguished, corresponding to total water resources below the long-term minimum.

The analysis of water resources and runoff dynamics is a key element in hydrological monitoring and the management of water management systems. Of particular importance is the selection of a representative period, which should reflect current trends of both natural (climatic) and anthropogenic origin. In this context, the period from the 1990s to the present is the most justified and scientifically reasonable for assessing the current state of river runoff in Kazakhstan.

For the assessment and calculation of water resources across the eight river basins and the entire Republic of Kazakhstan, data from hydrological observations of the state monitoring network, carried out at hydrological stations of the RSE «Kazhydromet» for 2023, were used.

1.1 Analysis of the state and dynamics of total and local water resources and inflow in the main river basins and their sections for the year

1.1.1 Ertis WMB

The Ertis Water management basin (hereinafter WMB) occupies the entire northeastern and eastern part of the Republic of Kazakhstan (hereinafter RK). It is located within the East Kazakhstan and Pavlodar regions, partially covering the Akmola and Karaganda regions. The main water artery of the area, the Ertis River, is among the ten largest rivers of the Northern Hemisphere.

The Ertis River is the largest river in Kazakhstan, a left tributary of the Ob River, and the main water artery of the Ertis Water management basin. It originates in the glacial zone on the southwestern slopes of the Mongolian Altai in China, crosses the territory of Kazakhstan, and flows into the Ob River in Russia. It belongs to the Kara Sea basin. The total length of the Ertis is 4,280 km, of which 618 km are in China, 1,698 km in Kazakhstan, and 1,964 km in Russia. The catchment area of the Ertis River is 1,65 million km² [4] . A schematic of the Ertis Water management basin is shown in figure 4.

Before flowing into Lake Zaysan, the river is called the Kara Ertis (Black Ertis). The length of the Kara Ertis is 672 km, while the length of the Ertis from Lake Zaysan to its confluence with the Ob River is 3,501 km. Within the territory of Kazakhstan, the Kara Ertis enters as a relatively high-water river, with an average annual discharge of about 300 m³/s. At the gauging section near the city of Semey, this discharge nearly triples to approximately 880 m³/s (Ertis River - Bazhenovo section), with about 90 % of the increase in water volume contributed by right-bank tributaries flowing from the ranges of the Kazakh Altai. At the border with Russia, near the v. of PriErtisskoye, the natural runoff is 830 m³/s.

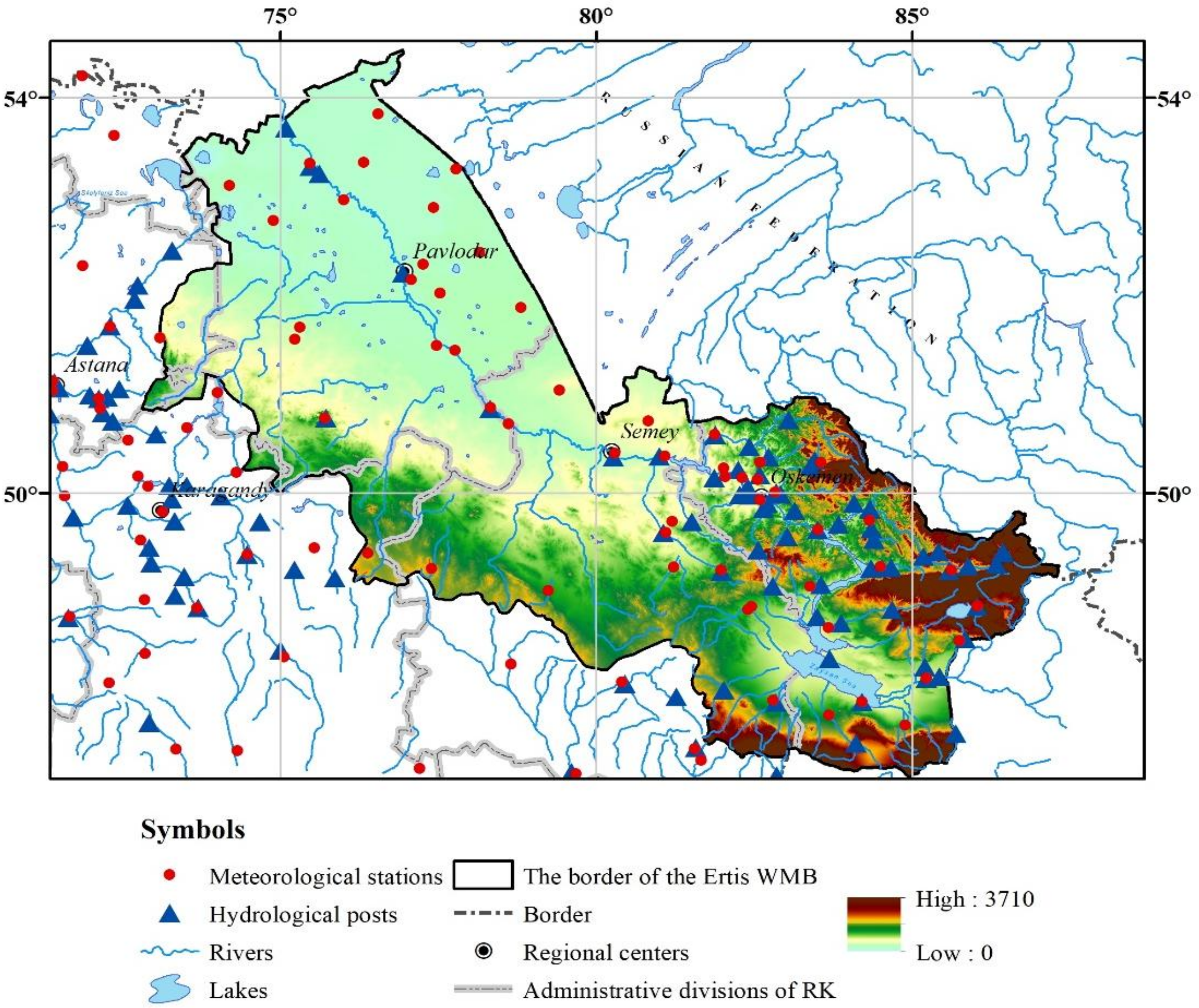


Figure 4 – Physical-geographical map of the Ertis WMB

The main rivers of the Ertis WMB with runoff observation points are the Ertis, Kalzhyr, Kurshim, Naryn, Bukhtarma, Glubochanka, Ulbi, and Oba rivers. The analysis of changes in Ertis River runoff within the territory of the Republic of Kazakhstan was carried out for the main gauging sections according to the list of water resource data tables for the main river basins and their sections. The main hydrological characteristics of the Ertis River basin are presented in table 1.

Table 1 - Main hydrological characteristics of the rivers of the Ertis WMB

Name of the watercourse	Mouth / Tributary to	Distance from the mouth, km	Length of the watercourse, km	Catchment area, km²
Ertis r. (Kara Ertis)	Ob r. (l)	1162	4280[1] 1698	1650000[2] 96000
Bas-Terekty r.	Alkabek r. (r), Ertis r. (r)	58	28	183
Kalzhyr r.	Ertis r. (r)	3683	122	3200
Ulken Boken r.	Bukhtarma Reservoir (р. Ертис) (л)	-	161	3390
Kurshim r.	Bukhtarma Reservoir (Ertis r.) (r)	-	230	5890
Naryn r.	Bukhtarma Reservoir (Ertis r.) (r)	-	69	2040
Bukhtarma r.	Bukhtarma Reservoir (Ertis r.)(l)	-	336	12660
Levaya Berezovka r.	Berezovka r. (l), Bukhtarma r. (l)	38	39	320
Turgysyn r.	Bukhtarma r. (r)	-	34	1250
Ulba r.	Ertis r. (r)	3076	100	4990
Glubochanka r.	Ertis r. (r)	3042	43	308
Oba r.	Ertis r. (r)	2970	278	9850

1 Note – The numerator shows the total length of the Ertis River from its source to its mouth (including China and Russia), while the denominator shows the length within Kazakhstan.

2 Note – The numerator shows the total catchment area of the Ertis River, while the denominator shows only the area within Kazakhstan.

Within the territory of Kazakhstan, there are three large reservoirs on the Ertis River: Bukhtarma, Ust-Kamenogorsk, and Shulbinsk, which have a regulating effect on the river's runoff. The main characteristics of the reservoirs in the Ertis WMB are presented in table 2.

Table 2 - Information on the reservoirs of the Ertis WMB

Name		Year of commissioning	Surface area	Total volume, million m³
Reservoir	River or site of reservoir formation			
Bukhtarma	Ertis r.	1961	5510	53,1
Ust-Kamenogorsk	Ertis r.	1953	36,5	0,65
Shulbinsk	Ertis r.	1988	255	2,39

The Ertis Water management basin has 37 river stations where hydrological observations are conducted on water level and temperature, the condition of the water body, ice thickness, water discharge, and ice phenomena, as well as 9 lake stations where observations are made on water level and temperature, the condition of the water body, ice thickness, ice phenomena, and calculations of the water balance of the reservoirs [5].

Hydrological regime and flow phases of the rivers of the Ertis WMB

To characterize the fluctuations of annual runoff within the Ertis WMB, data were used from the following watercourses, whose runoff is considered conditionally natural: Kara Ertis River - v. Boran, Ertis River - Ust-Kamenogorsk HPP, Ertis River - v. Semiyarka, Ertis River - v. PriErtisskoye, Kalzhyr River - v. Kalzhyr, Kurshim River - v. Voznesenka, Bukhtarma River - v. Lesnaya Pristan, Ulbi River - v. Ulbi Perevalochnaya, Oba River - city Shemonaikha. The analysis of differential integral curves of annual runoff of the Ertis River for the period 1933-2023, carried out at the main hydrological gauging sections (v. Boran, Ust-Kamenogorsk HPP, v. Semiyarka, v. PriErtisskoye), revealed a regular alternation of phases of varying water availability, reflecting the cyclical nature of runoff fluctuations, clearly distinguishing both high-water and low-water intervals. The high-water phases include the periods 1933-1950, when a prolonged increase in annual runoff volumes was observed; 1956-1960 and 1967-1973, characterized by short-term but relatively intense increases in water availability; and 2013-2019, marked by a renewed rise in water supply due to more favorable hydrometeorological conditions. Low-water phases were recorded in 1951-1955, 1961-1966, 1974-2012 – the longest period characterized by a pronounced and sustained decrease in annual runoff – and 2020-2023, when water availability in the basin decreased again.Thus, the spatio-temporal analysis of runoff dynamics using differential integral curves confirms the presence of stable water availability cycles of varying duration, indicating the long-term variability of the Ertis's hydrological regime under the influence of both natural-climatic factors and anthropogenic runoff regulation.

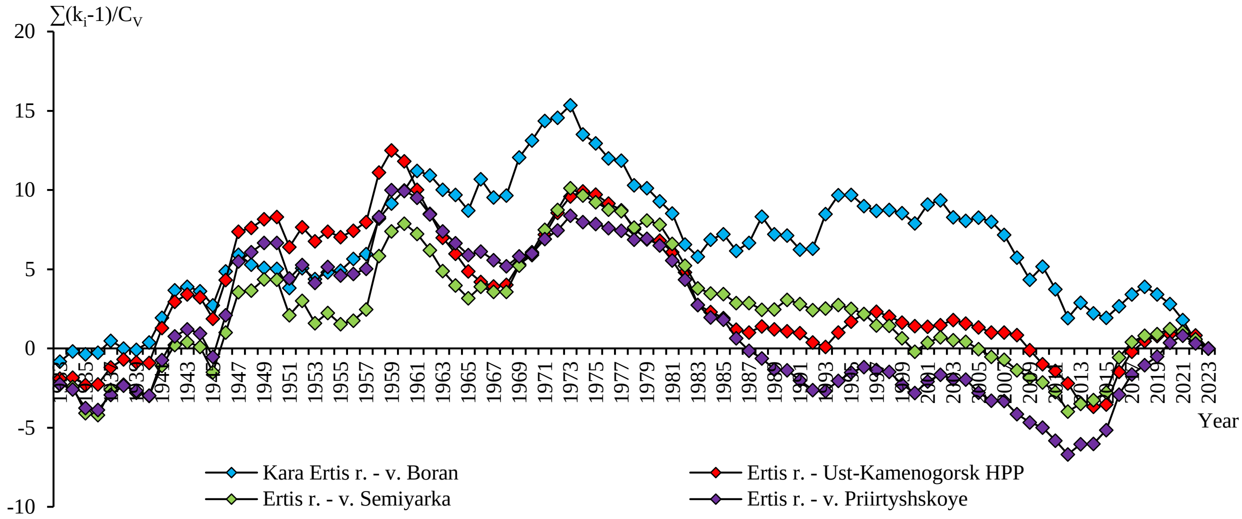


Figure 5 – Differential-integral curve of mean annual water discharge

A similar analysis of the differential-integral curve of annual runoff for the Kalzhyr River - v. Kalzhyr during the observation period (Figure 5) also revealed an alternation of high-water and low-water phases. High-water phases include 1940-1947, characterized by an intense increase in runoff; 1957-1961, with a short-term rise; 1968-1973, with stabilization at an elevated level; and 1987-2010, representing a prolonged and most abundant water cycle. Low-water phases occurred in 1933-1939, with a persistent deficit; 1948-1956, with declining runoff; 1962-1967, with a short low-water period; 1974-1986, with a prolonged decrease in water availability; and 2011-2023, marking the current stage of sustained low water, coinciding with observed climatic trends. Thus, the runoff dynamics of the Kalzhyr River are also characterized by pronounced cyclicity, reflecting the influence of both climatic and hydrological conditions, as well as regional features of runoff formation.

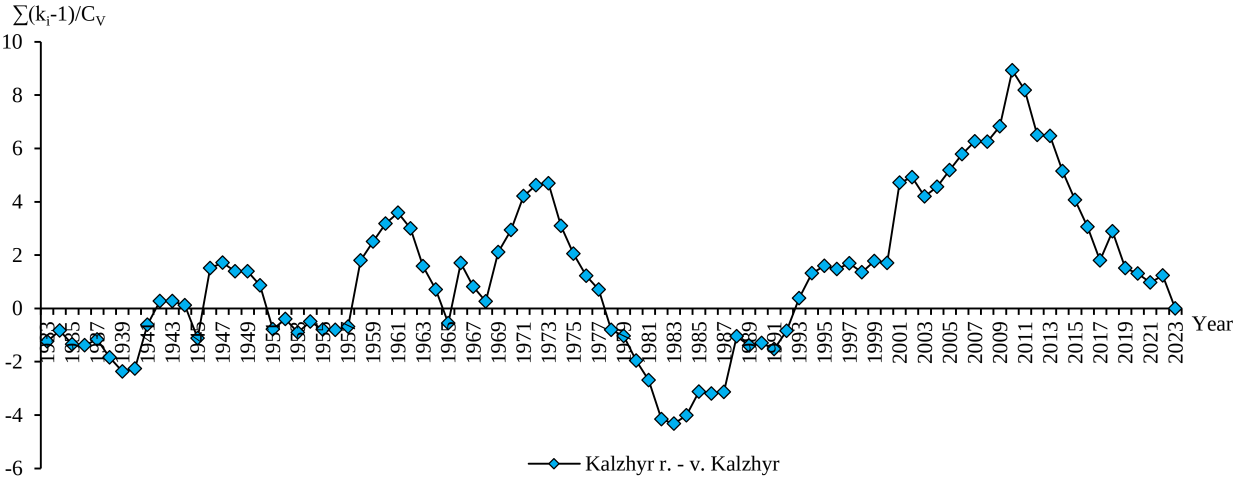


Figure 6 – Differential-integral curve of mean annual water discharge

In turn, the analysis of differential-integral curves of annual runoff for the period 1933-2023 at the gauging sections of the Kurshim River - v. Voznesenka and the Bukhtarma River - v. Lesnaya Pristan (Figure 4) showed the presence of stable phase fluctuations in water availability. Low-water phases include the early period up to 1945 with a pronounced water deficit, 1951-1957 and 1962-1968 with decreased runoff, and the longest interval 1974-2012 with a sustained decline in water availability. Between these, high-water cycles are distinguished: 1946-1950 with increasing runoff, 1958-1961 and 1969-1973 with short-term rises, and the current period 2013-2023, marked by a renewed increase in water supply.

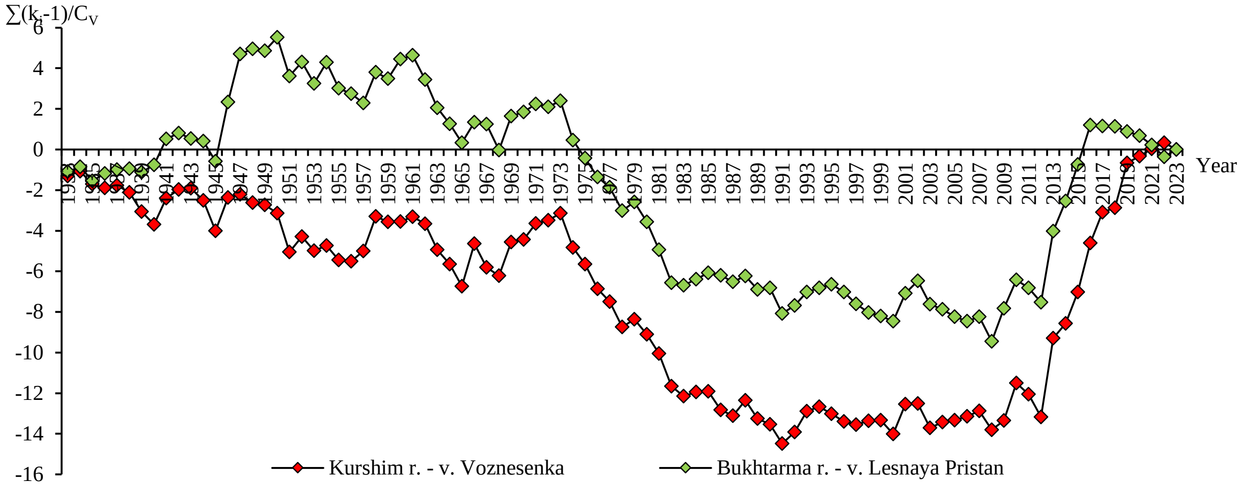


Figure 7 – Differential-integral curve of mean annual water discharge

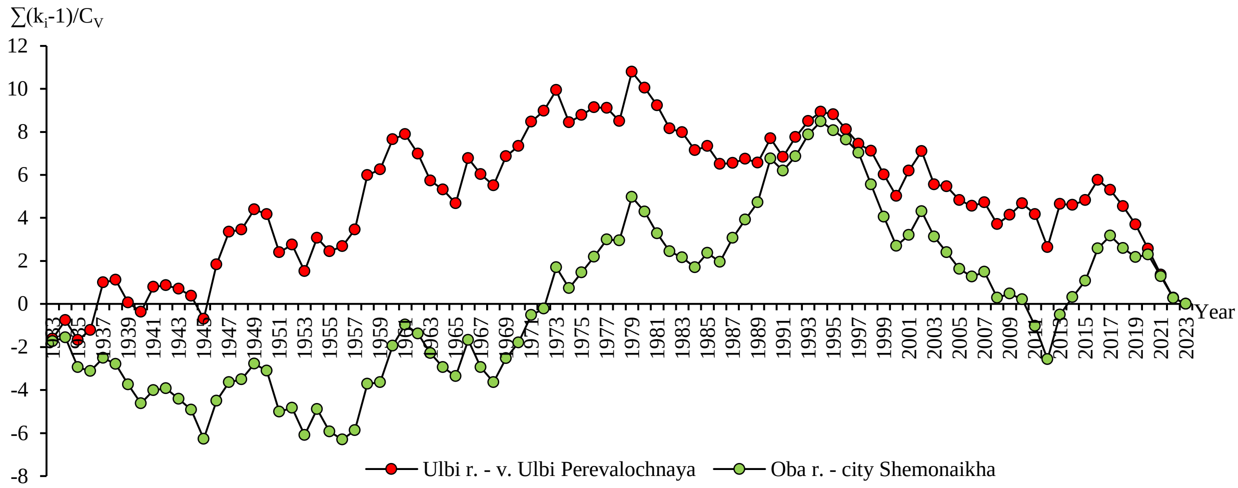


Figure 8 – Differential-integral curve of mean annual water discharge

Further analysis of the differential integral curves of annual runoff for the period 1933-2023 at the cross-sections of the Ulbi River – Ulbi Perevalochnaya v. and Oba River – Shemonaiha city (Fig. 8) shows pronounced alternations of phases with different water availability. Low-water periods include the initial interval up to 1945, characterized by reduced water supply; 1980-1986, with a stable decline; 1996-2012, with prolonged runoff reduction; and the current stage of 2017-2023, with a consolidated trend of decreasing water availability. Between these periods, high-water cycles can be distinguished: 1946-1979, with an overall increase in water availability interrupted by occasional short-term declines; 1987-1995, with a pronounced rise; and 2013-2016, with a short-term increase in runoff. Thus, the identified fluctuations confirm the recurring nature of the water resources dynamics in the Ertis River basin, shaped by a combination of climatic factors and local characteristics of the rivers' hydrological regime.

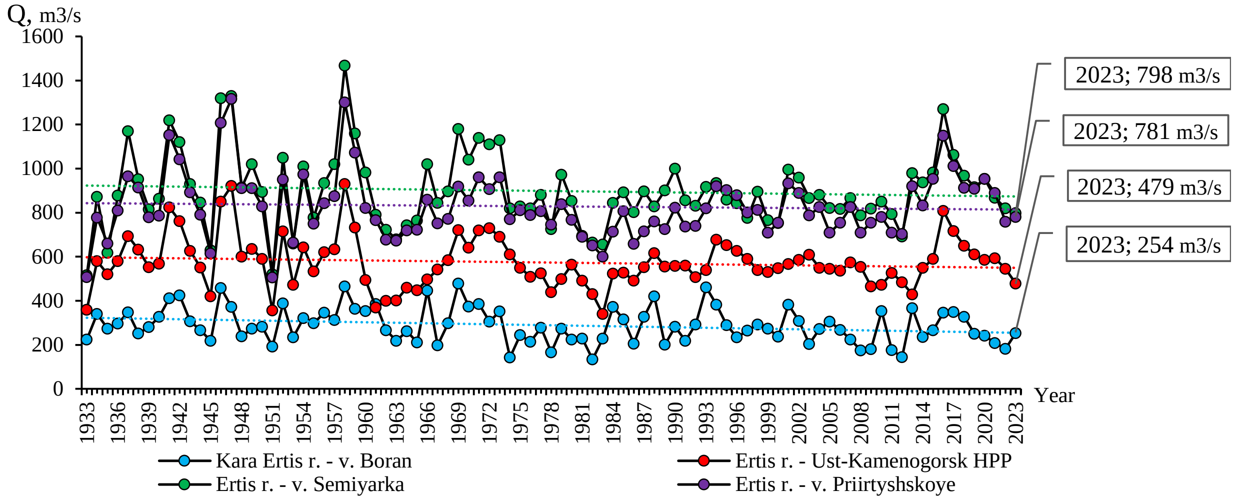


Figure 9 – Dynamics of changes in mean annual water discharge

- **Kara Ertis r. –Boran v.** Analysis of the mean annual discharge graph of the Kara Ertis River at the Boran gauging section for the period 1933-2023 shows a slight downward trend in water availability, as confirmed by the direction of the trend line. The long-term norm of annual runoff is **301 m³/s.** The minimum mean annual discharge during the period under review was recorded in 1982 at 134 m³/s, due to that year belonging to a low-water phase of the Ertis Basin hydrological regime, as determined by the analysis of water availability phases. The maximum discharge was observed in 1969 at 478 m³/s, corresponding to a high-water phase characterized by increased runoff volumes. **In 2023**, water availability at this section remained moderately low: the mean annual discharge was **254 m³/s**, which is **15.6 % below** the established norm, with a probability of exceedance of **70.8 %.**
- **Ertis r. – Ust-Kamenogorsk HPP.** According to long-term observational data, the mean annual discharge at this section generally fluctuates within the established long-term norm of **611 m³/s.** The maximum mean annual discharge during the period under review was recorded in 1958 at 931 m³/s, corresponding to a high-water phase of the WMB, characterized by increased runoff volumes. The minimum discharge was observed in 1983 at 340 m³/s, associated with a low-water phase accompanied by decreased water availability. In 2023, water availability at the Ust-Kamenogorsk HPP section was assessed as low: the mean annual discharge was **479 m³/s,** which is **21.6%** below the long-term norm, with a probability of exceedance of **81.4 %.**
- **Ertis r. – Semiyarka v.** Analysis of the mean annual discharges of the Ertis River at the Semiyarka gauging section over the long-term period reveals a trend of decreasing water availability relative to the long-term norm of **906 m³/s.** The maximum discharge was recorded in 1958 at 1,468 m³/s, corresponding to a high-water phase associated with hydrometeorological conditions. The minimum mean annual discharge was observed in 1933 at 516 m³/s. **In 2023**, water availability at this section was assessed as moderately low: the mean annual discharge was **798 m³/s**, which is **11.9% below** the established norm, with a probability of exceedance of **65.9 %.**
- **Ertis r. – PriErtisskoye v.** Analysis of mean annual discharges of the Ertis River at the PriErtisskoye gauging section for the period 1933-2023 revealed a trend within the long-term norm of 886 m³/s. The maximum discharge was recorded in 1947 at 1,317 m³/s, corresponding to a high-water phase of the WMB, mainly shaped by climatic conditions. The minimum discharge was observed in 1951 at 506 m³/s; this year belongs to a low-water phase, characterized by reduced annual runoff**. In 2023**, river runoff was assessed as moderately low: the mean annual discharge

was **781 m³/s,** which is **11.9 % below** the norm. The probability of exceeding this value is **71.9 %,** confirming its classification as a low-water condition according to long-term distribution.

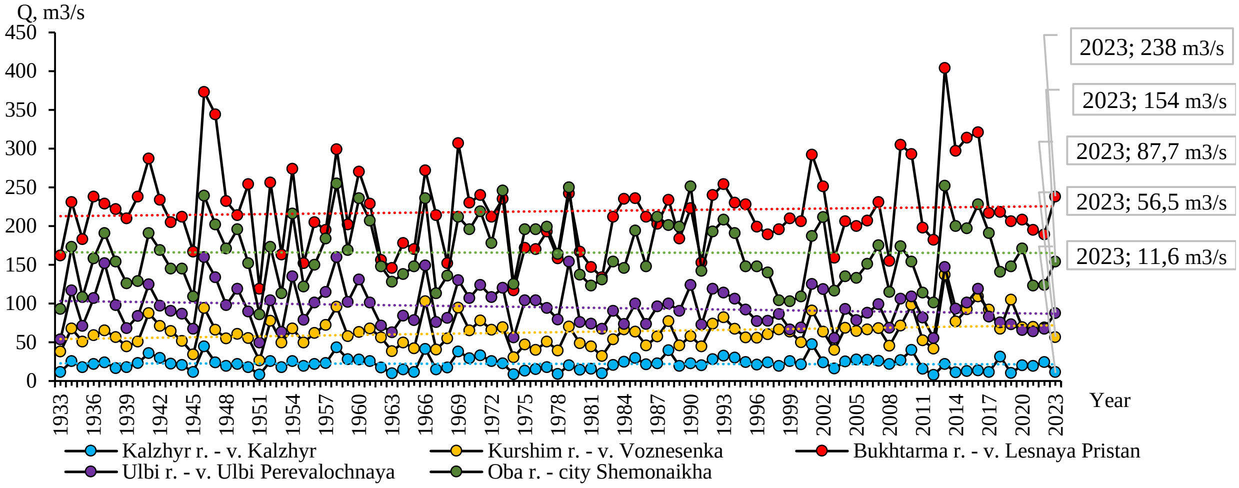


Figure 10 – Dynamics of changes in mean annual water discharge

- **Kalzhyr r. – Kalzhyr v.** At the Kalzhyr gauging section, mean annual discharges for the period 1933-2023 generally fluctuated within the long-term norm of **22.6 m³/s,** with the trend line indicating a slight decrease. The maximum discharge was recorded in 2001 at 47.6 m³/s, corresponding to a high-water phase formed under the influence of climatic conditions. The minimum discharge was observed in 2012 at 7.8 m³/s, reflecting the low-water nature of that period**. In 2023**, the river's water availability was classified as low: the mean annual discharge was **11.6 m³/s**, which is **48.6 % below** the norm, with a probability of exceedance of **93.7 %,** indicating its low status compared to long-term values.
- **Kurshim r. – Voznesenka v.** Analysis of mean annual discharges of the Kurshim River at the Voznesenka gauging section over the long-term period reveals a trend of increasing runoff relative to the long-term norm of **58.6 m³/s.** The maximum discharge during this period was recorded in 2013, reaching 137 m³/s; according to the hydrological regime and water availability phases of the WMB, this year corresponds to a high-water phase, explaining the elevated runoff level. The minimum discharge of 26.4 m³/s was recorded in 1951, which falls within a low-water phase characterized by reduced water availability. In 2023, river runoff was assessed as moderate: the mean annual discharge was **56.5 m³/s,** close to the normative value, with a probability of exceedance of **52.5 %.**
- **Bukhtarma r. – Lesnaya Pristan v.** Based on the analysis of mean annual discharges for the period 1933-2023, a trend of increasing water availability relative to the long-term norm of **208 m³/s** was identified. The maximum discharge of 404 m³/s was recorded in 2013, corresponding to a high-water phase, as reflected in the structure of the WMB's hydrological regime. In contrast, the minimum value of 117 m³/s was observed in 1974, which belongs to a low-water phase. **In 2023**, the discharge was **238 m³/s**, classified as moderately high water availability, with a probability of exceedance of **25.3 %.**
- **Ulbi r. – Ulbi Perevalochnaya v.** Analysis of annual discharges at this station over the long-term period shows a trend of decreasing mean annual values compared to the long-term norm of 104 m³/s. The maximum discharge of 160 m³/s was recorded in 1946, which, according to the differential-integral curve and the structure of the hydrological regime, corresponds to a high-water phase. The minimum value of 49.3 m³/s was observed in 1951, falling within a low-

water phase. **In 2023,** the mean annual discharge was **87.7 m³/s**, corresponding to a moderately low-water phase. The probability of exceedance of this value is **70 %**, and the deviation from the long-term norm downward reached **15.7 %.**

- **Oba r. – Shemonaikha c.** Analysis of annual runoff for the observation period from 1933 to 2023 shows that values generally remained within the long-term norm of **162 m³/s.** During the period under review, the maximum discharge was recorded in 1958 at 255 m³/s, corresponding to a high-water phase, while the minimum was observed in 1951 at 85.8 m³/s, corresponding to a low-water period. **In 2023**, the discharge was **154 m³/s,** classified as moderate water availability, with a probability of exceedance of **58 %,** and the flow was **4.94 %** below the norm.

1.1.2 Balkhash-Alakol WMB

The Balkhash-Alakol Water management basin includes the river basins of Lake Balkhash and the small lakes Alakol and Sasykkol. It covers the southeastern part of the Republic of Kazakhstan, including the territories of Almaty Region, the southeastern part of Karaganda Region, the southwestern part of East Kazakhstan Region, and the eastern part of Zhambyl Region. Within the People's Republic of China, the basin is located in the northwestern part of Xinjiang Province. The northern watershed of the basin is formed by the Karkaraly-Aktau Massif and the Shyngyztau Range, the eastern boundary by the Tarbagatai Range, and beyond Kazakhstan, by the Urkashar, Barlyk, and Maili ranges. Further, the watershed follows the Zhetysu Alatau ranges, and outside the country – the Borohoro, Eren-Khabyrga, Narat, and Khalyktau ranges. To the south, the watershed runs along the eastern spurs of the Terskey and Kungey Alatau ranges and the Ile Alatau, and to the west – along the Shu-Ile Mountains. The total length of the watershed line is approximately 4,000 km (Figure 11).

The area under consideration exceeds 500,000 km², of which 400,000 km² is within Kazakhstan. The basin stretches over 900 km from west to east and 680 km from north to south.

Based on the terminal water bodies, the territory is divided into two natural regions – the Lake Balkhash basin and the Alakol Depression lakes basin. The Lake Balkhash basin is naturally subdivided into sub-basins of the major rivers, each with slightly different runoff formation conditions. These include the Ile River basin, the rivers of the southeastern part (Karatal, Aksu, Lepsy, etc.), and the rivers of the eastern and northern parts (Ayagoz, Bakanas, Tokyrauyn, Moynty, etc.) of Lake Balkhash.

The main source of river feeding is meltwater from seasonal snow, supplemented by liquid precipitation, as well as summer rainfalls that generate high floods during the freshet. More than 80% of the runoff occurs in spring and summer, while a small but steady flow is observed during the low-water period. Rivers of mountainous type have mixed feeding, with the majority of runoff occurring in summer, peaking in July-August. Water availability increases from the high-mountain to the low-mountain zone, with the highest discharges observed when rivers exit the mountains. Based on the hydrological regime, rivers can be classified into five types: with spring freshet; with spring freshet and floods in the warm season; with spring-summer freshet; with summer freshet; and with a balanced flow due to enhanced groundwater feeding. The main rivers of the region and their principal tributaries belong to the type with spring-summer and summer freshet [6] .

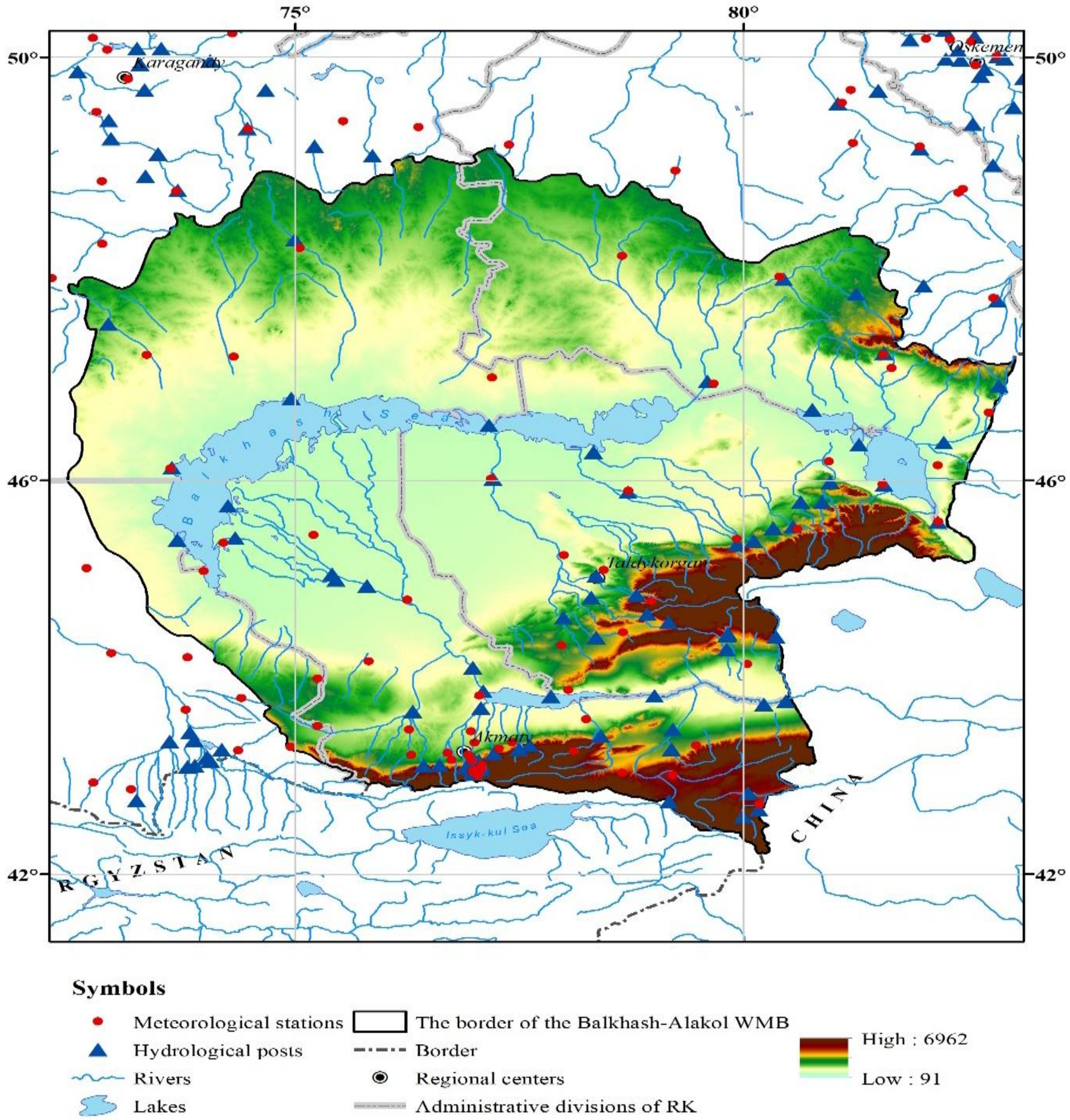


Figure 11 – Physical-geographical map of the Balkhash-Alakol WMB

The main rivers of the Balkhash-Alakol WMB with flow observation points are the Ile, Tekes, Sharyn, Shilik, Karatal, Lepsy, and Tentek rivers. The analysis of changes in the runoff of the Ile River within the territory of the Republic of Kazakhstan was carried out for the main gauging sections according to the list of data tables on water resources for the main river basins and their sections.

The main hydrographic characteristics of the rivers and reservoirs of the Balkhash-Alakol WMB are presented in tables 3 and 4.

Table 3 - Main hydrographic characteristics of the rivers of the Balkhash-Alakol WMB

Name of the watercourse	Mouth / Tributary to	Distance from mouth, km	Length of the watercourse km	Catchment area, km²
Ili r.	Balkhash	-	1439[1]815	140000[2]77400
Tekes r.	Ile r. (l.)	1001	438 218	28100 4250
Bayankol r.	Tekes r. (r.)	284	88	1180
Narynkol r.	Bayankol r. (r.)	20	29	161
Karkara r.	Sharyn r. (l.)	192	69	1790
Podgornaya r.	unnamed branch, flows from Syumbe River (r.)	8.5	22	45.8
Osek r.	Ile r. (r.)	705	164	1970

Name of the watercourse	Mouth / Tributary to	Distance from mouth, km	Length of the watercourse km	Catchment area, km²
Kishi Osek r.	Ile r. (r.)	117	41	407
Borokhudzir r.	disappears 5 km S of Koktal village, Ile River (r.)	-	78	548
Sharyn r.	Ile r. (l.)	679	427	7720
Shilik r.	Kapshagay reservoir	-	245	4980
Turgen r.	disappears 6 km NW of Karashengel village	-	116	626
Yesik r.	Ile r. (l.)	480	121	256
Talgar r.	Kapshagay reservoir	-	117	444
Kishi Almaty r.	Kapshagay reservoir	-	125	710
Ulken Almaty r.	Kaskelen r. (r.)	51	96	425
Aksay r.	Kaskelen r. (r.)	80	70	566
Kaskelen	Kapshagay reservoir	-	177	3800
Shamalgan	Kaskelen r. (l.)	88	88	526
Kurty r.	Ile r. (l.)	396	123	12500
Emel r.	lake Alakol		102	21800
Tentek r.	lake Alakol		200	5390
Urzhar r.	lake Alakol		206	5280

The Balkhash-Alakol water management basin has 63 river gauging stations, where hydrological observations are conducted on water discharge, water level and temperature, the condition of the water body, ice thickness, runoff, and ice phenomena, as well as 11 lake stations, where observations are made on water level and temperature, the condition of the water body, ice thickness, ice phenomena, and the calculation of the water balance of the reservoirs.

Table 4 - Information on reservoirs of the Balkhash-Alakol WMB

Reservoir	River or site of reservoir formation	Distance from mouth, km	Year of commissioning	Surface area, km²	Design capacity, million m³	
					Total	Useful / Active
Kapshagay	Ile r.	434	1970	1843 1370	28100 18450×	10300 6640
Bartogay	Shilik r.	75	1983	3,0	320	270,0
Bestyubinskoye	Sharyn r.	171			288	228
Kurtinskoye	Kurty r.		1963	8,5	120	114,8

The first hydrological data on Lake Balkhash and the rivers of the Ile-Balkhash basin were obtained by L.S. Berg during his expedition to Central Asia in [7]. The very first representation of the river runoff in the Lake Balkhash basin was provided by a map created by B.D. Zaikov for the entire territory of the former Soviet Union [8]. Subsequent studies of surface runoff were conducted by V.L. Shul’ts (on the left bank of the Ile River) [9], P.F. Lavrentyev (on the northern slope of the Zhetysu Alatau), Z.T. Berkaliyev (on northern Pribalkhash and the Ile River basin [10], L.D. Lavrentyeva (on the southwestern slope of the Tarbagatai Range), and K.P. Voskresensky (across the USSR). Research on hydrographic characteristics was also carried out. The first hydrometric studies in the Ile-Balkhash basin were conducted at the beginning of the 20th century. These studies were organized by the Department of the Ministry of Agriculture: hydrological posts on the Ile River were established in 1910 downstream of the v. of Iliyskoye, and in 1912 upstream of the Borokhudzir pier. However, systematic observations of runoff in the main rivers of the basin began only in the 1930s.

Analysis of runoff dynamics is a key element in hydrological monitoring and the management of water management systems. Of particular importance is the selection of a period that reflects current trends of both natural (climatic) and anthropogenic origin.

In the mountainous areas (Zhetysu Alatau, Ile Alatau) with intensive glacial feeding, signs of changes in the seasonal structure of runoff have been observed since the 1960s-1970s, with the most significant shifts occurring after the 1990s (earlier spring flood, reduction in summer runoff) [11].

Hydrological regime of the main rivers of the Balkhash-Alakol HPP

Based on long-term hydrological observations, an analysis of the hydrological regime phases of the Balkhash-Alakol basin was carried out. The use of integral curves made it possible to identify multi-year runoff cycles and determine their temporal boundaries. Analysis of the dynamics of the average annual water discharge of the Ili River at selected gauging stations shows that with the development of intensive economic activity, there is a slight decrease in runoff. However, under the influence of climate change, since 1987, the runoff has shown a tendency to increase, which can be associated with the onset of mountain glaciation degradation.

The overall runoff pattern of the Ili River, based on the differential-integral curves at all major hydrological stations, demonstrates pronounced phase fluctuations with alternating high- and low-water periods. From the **1930s** to the late **1940s,** there was a relatively stable phase close to the long-term average. From the late 1940s, and especially during the **1950s** to the mid-**1970s**, a pronounced high-water period developed, peaking in the late **1960s** to early **1970s**. From the late **1970s** to the early **1990s,** a prolonged low-water phase was recorded, with minimum values in the late 1980s, reflecting an overall decline in runoff across all stations. In the mid-**1990s,** water levels began to recover, leading into a new high-water cycle in the **2000s** to early **2010s**, when values at all stations once again reached positive anomalies.

After 2015, a decline in water flow is observed, and by the **2020s**, runoff stabilizes at a level close to the long-term average, indicating the end of the high-water phase and a possible transition to a low-water trend. Thus, the runoff dynamics of the Ili River over the entire period are characterized by a pronounced cyclicity, with three major phases dominating: an increase in water flow in the **1950s-1970s,** a decline in the **1980s-1990s,** and a new rise in the **2000s-2010s.**

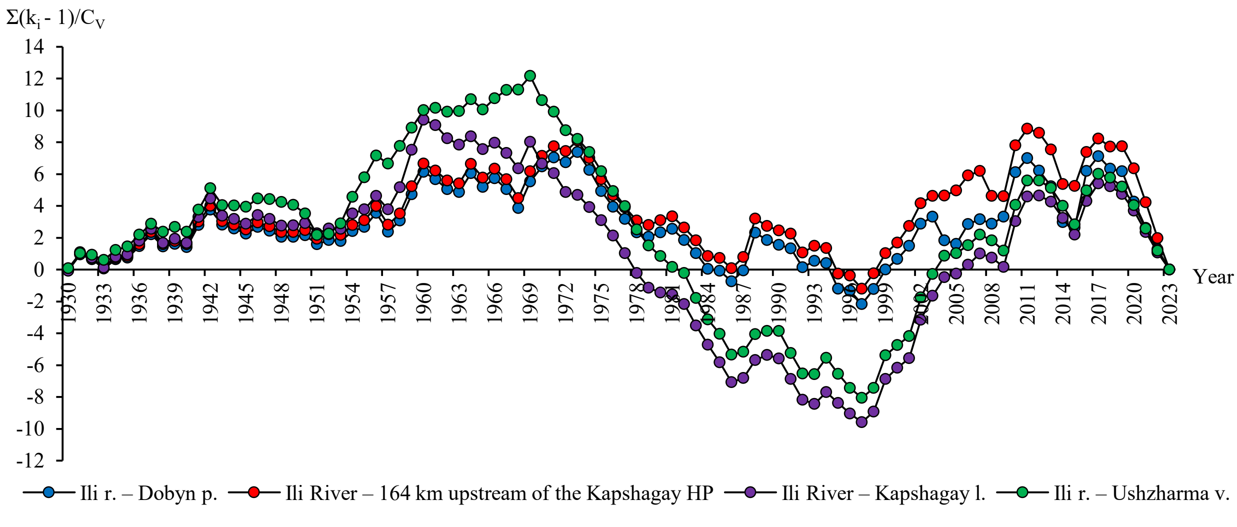


Figure 12 – Difference-integral curves of average annual water discharge

River Ili. Analysis of runoff dynamics shows that, starting from 1990, there is a tendency for an increase, which may be associated with the onset of mountain glacial degradation; however, the magnitude of this increase is small and has not compensated for the overall declining runoff trend in recent years.

- **Ili r.– 164 km upstream of the Kapshagay HPS.** The long-term annual runoff norm is **428 m³/s.** The maximum flow was recorded in 2010 at 750 m³/s, and the minimum in 2022 at 260 m³/s, reflecting the phased variability of water availability (Figure 2). **In 2023**, the river's **runoff was classified as low**, with a calculated exceedance probability **of 99.9 %.**

Ili r. – Kapshagay l. The long-term annual runoff norm is 470 m³/s. According to data for the period 1930-2023, a moderately pronounced decreasing trend in mean annual runoff is observed. During this period, the maximum flow was 718 m³/s (2010) and the minimum 321 m³/s (1970), reflecting the water regime**. In 2023**, **the runoff was classified as low,** with a reliability (exceedance probability) of **97.4 %.**

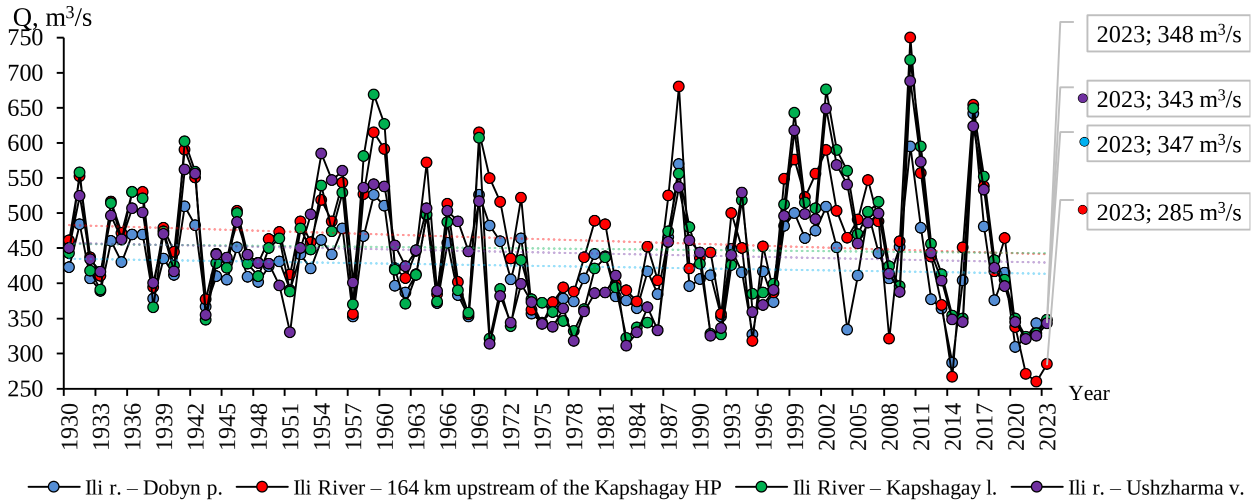


Figure 13 – Dynamics of changes in average annual water discharge

Ili r. – Ushzharma v. The long-term annual runoff norm is **446 m³/s.** During the period 1930-2023, no significant deviations from the norm were observed. The maximum discharge was recorded in 2010 (688 m³/s), and the minimum in 1983 (311 m³/s), reflecting the characteristics of the hydrological regime. **In 2023**, the river's **flow was classified as low**, with a probabilistic exceedance of **89.6%.**

According to the difference-integral curves in Figure 12, three main hydrological phases can be traced for most rivers of the Balkhash-Alakol basin. A period **of relatively stable high water** was observed at the beginning of the analyzed series–approximately from **1935 to 1945**-when most curves were above the zero line, especially for the **Tentek River** and partially for the **Lepsy River.** This was followed by a prolonged and pronounced low-water phase-roughly from **1946** to the mid-**1980s**–when the difference-integral curves of all rivers, except **Tentek**, showed a downward trend. The sharpest decline was recorded for the **Shilik River (v. Mynbay)**, highlighting it as the most vulnerable hydrological post during this period. Since the late **1980s**, a gradual transition toward a period of increasing water availability has begun, most clearly expressed for the **Tentek River (Tonkeris v.).** Its curve rises sharply from the early **1990s** and surpasses the other hydrological posts, forming a distinct anomaly in runoff dynamics. For the other rivers (Sharyn, Karatal, Lepsy, Shilik), the recovery of water availability is weaker and delayed: at most posts, the trend stabilizes and returns closer to the zero line only after **2005-2010**. Overall, the following periods can be identified: high-water periods – **1935-1945** and from the 1990s to 2023 (especially for the Tentek River); low-water periods – **1946-1985;** and intermediate, moderate-water periods – **1985-1995.**

Anthropogenic impacts are expressed through flow regulation by the Kapshagay Hydropower Plant, which smooths extreme values on the lower Ili, as well as through irrigation water withdrawals in Kazakhstan and China. Interannual runoff variability is also influenced by regional atmospheric processes.

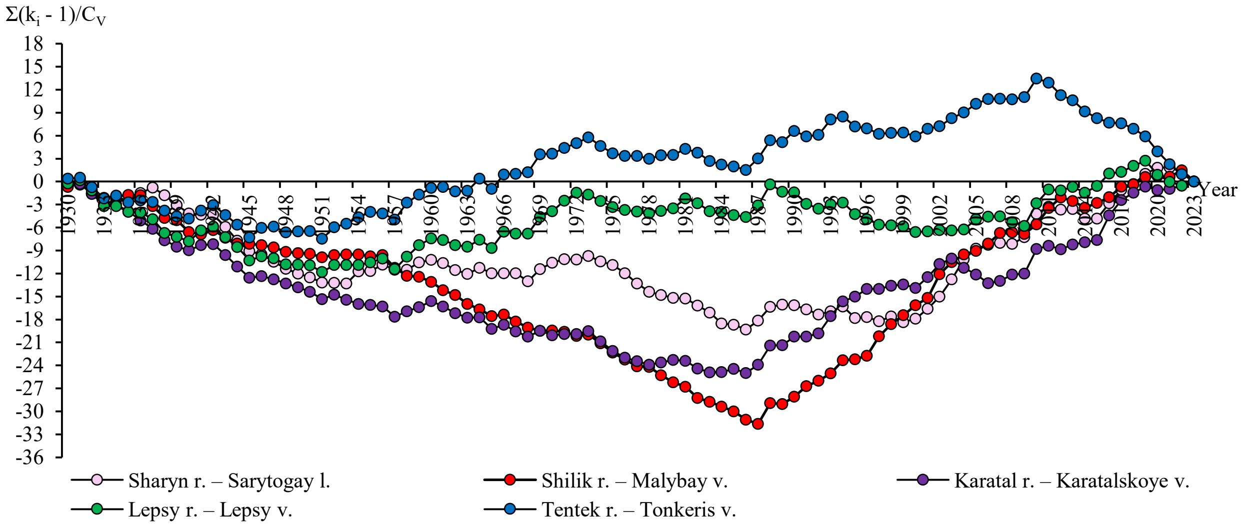


Figure 14 – Difference-integral curves of mean annual water discharges

Sharyn r. – Sarytogay l. The long-term mean annual discharge is **36.8 m³/s.** Over the period 1930-2023, a trend toward a moderate increase in discharge is observed. The maximum value was recorded in 2010 at 66.2 m³/s, while the minimum occurred in 1944 (22.6 m³/s), reflecting phase-type variability in water availability. **In 2023**, **the runoff** was characterized **as low-water**, with a probability of exceedance of **89.5 %.**

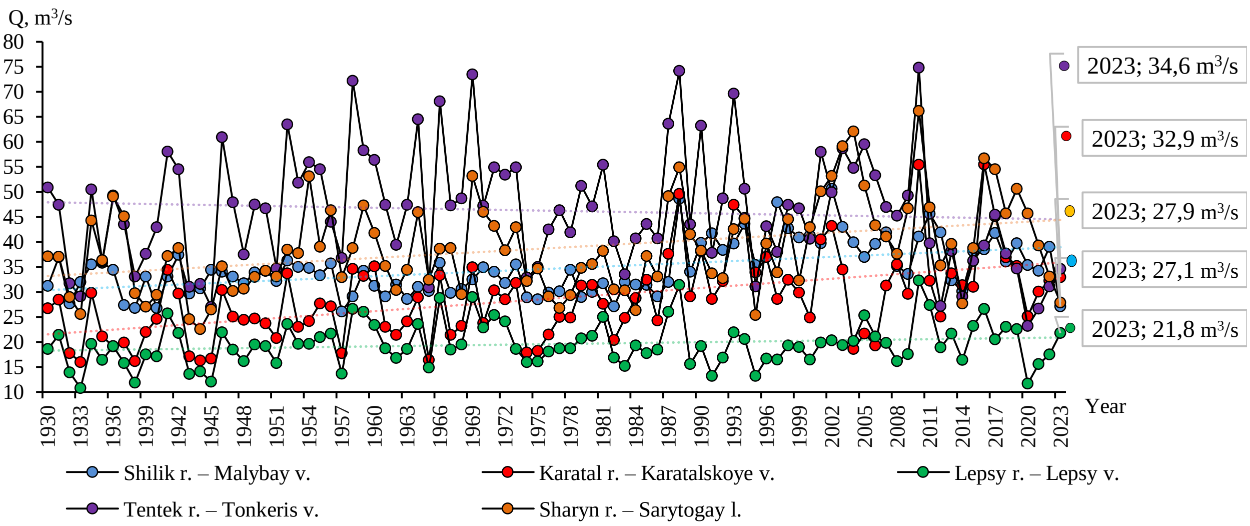


Figure 15 – Dynamics of changes in average annual water discharge

Shilik r. – Malybay v. The long-term mean annual discharge is **32.3 m³/s.** According to data for the period 1930-2023, the trend shows a weakly expressed increase in mean annual runoff values. Within this period, the maximum discharge was 50.6 m³/s (recorded in 2002), and the minimum was 26.1 m³/s (in 1957), which corresponds to the river's hydrological regime. At this gauging station, the river runoff **in 2023 was classified as low-water**, with a probability of exceedance of **96.9 %.**

Karatal r. – Karatalskoye v. The long-term mean annual discharge is **24.9 m³/s**. Over the period 1930-2023, no significant deviations from the norm were identified. The maximum discharge was recorded in 2016 (55.6 m³/s), and the minimum in 1933 (16.0 m³/s), which is consistent with the hydrological regime. **In 2023**, the runoff was characterized by **high water conditions**, with an exceedance probability of **9.13 %.**

- **Lepsy r. – Lepsy v.** The long-term mean annual discharge is 19.6 m³/s. During the period 1930-2023, a moderate increase in runoff was observed. The maximum discharge was recorded in 2010 (32.3 m³/s), and the minimum in 1933 (10.8 m³/s), reflecting the cyclic nature of water availability**. In 2023**, the runoff corresponded to **moderately high water conditions**, with a calculated exceedance probability of **29.2 %.**
- **Tentek r. – Tonkeris v.** The long-term mean annual discharge is **48.5 m³/s**. From 1930 to 2023, a pronounced decrease in mean annual flow has been observed. The maximum discharge reached 74.8 m³/s in 2010, while the minimum was 23.2 m³/s in 2020, which corresponds to the phases of water availability. **In 2023**, the runoff fell into the **low-water category**, with a calculated exceedance probability **of 88.0 %**.

1.1.3 Aral-Syrdarya WMB

The Aral-Syrdarya water management basin (hereinafter referred to as the WMB) is located in the southern part of the Republic of Kazakhstan, covering the middle and lower sections of the Syrdarya River basin. The area of the WMB is approximately 345 thousand km². The Aral-Syrdarya WMB includes the territories of the Turkistan and Kyzylorda regions (Figure 16).

The main artery of the basin, the Syrdarya River, receives its name after the confluence of two rivers – the Karadarya and the Naryn – located far beyond the borders of Kazakhstan. Both originate in the depths of the Tanirtau mountain system, with the Naryn being the more water-abundant of the two. The total length of the river from the confluence point is 2,212 km, and from the source of the Naryn it reaches 3,019 km. Within Kazakhstan, the river stretches 1,627 km from the Shardara Reservoir to the Aral Sea, including 346 km in the South Kazakhstan Region and 1,281 km in the Kyzylorda Region. The Syrdarya flows through the territories of four independent Central Asian states – Kyrgyzstan, Tajikistan, Uzbekistan, and Kazakhstan and its basin contains about 497 perennial rivers longer than 10 km. Their combined length exceeds 14,750 km. The main catchment area of the Syrdarya Basin is the western half of the Tanirtau (Tian Shan) mountain system and the northern slopes of the Altai and Turkestan ranges. The river system of the Syrdarya consists of numerous rivers, the main ones being: the Naryn, which drains the mountainous region of Western Tanirtau; the Karadarya, which collects waters from the Fergana and Alai ranges; the Chirchik, flowing from the mountains of Western Tanirtau; and the Arys, formed at the junction of the Talas and Karatau ranges. Each of these rivers, in turn, has a well-developed river network with significant catchment areas and a large number of both relatively large and small tributaries. Upon leaving its valley, the river cuts through the low Farhad Mountains–spurs of the Mogoltau Range. Here it forms the Bekabad Rapids, on which the Farhad Hydropower Plant is built; upstream lies the Kairakkum Hydropower Plant with its reservoir. Major canals– the Dalverzin Canal and the Golodnaya Steppe Canal named after Kirov–are diverted from the river. After flowing another 150 km across the plain of the Golodnaya Steppe, the Syrdarya enters the territory of Kazakhstan. Within Kazakhstan, it flows for more than 1,000 km before emptying into the Aral Sea [12].

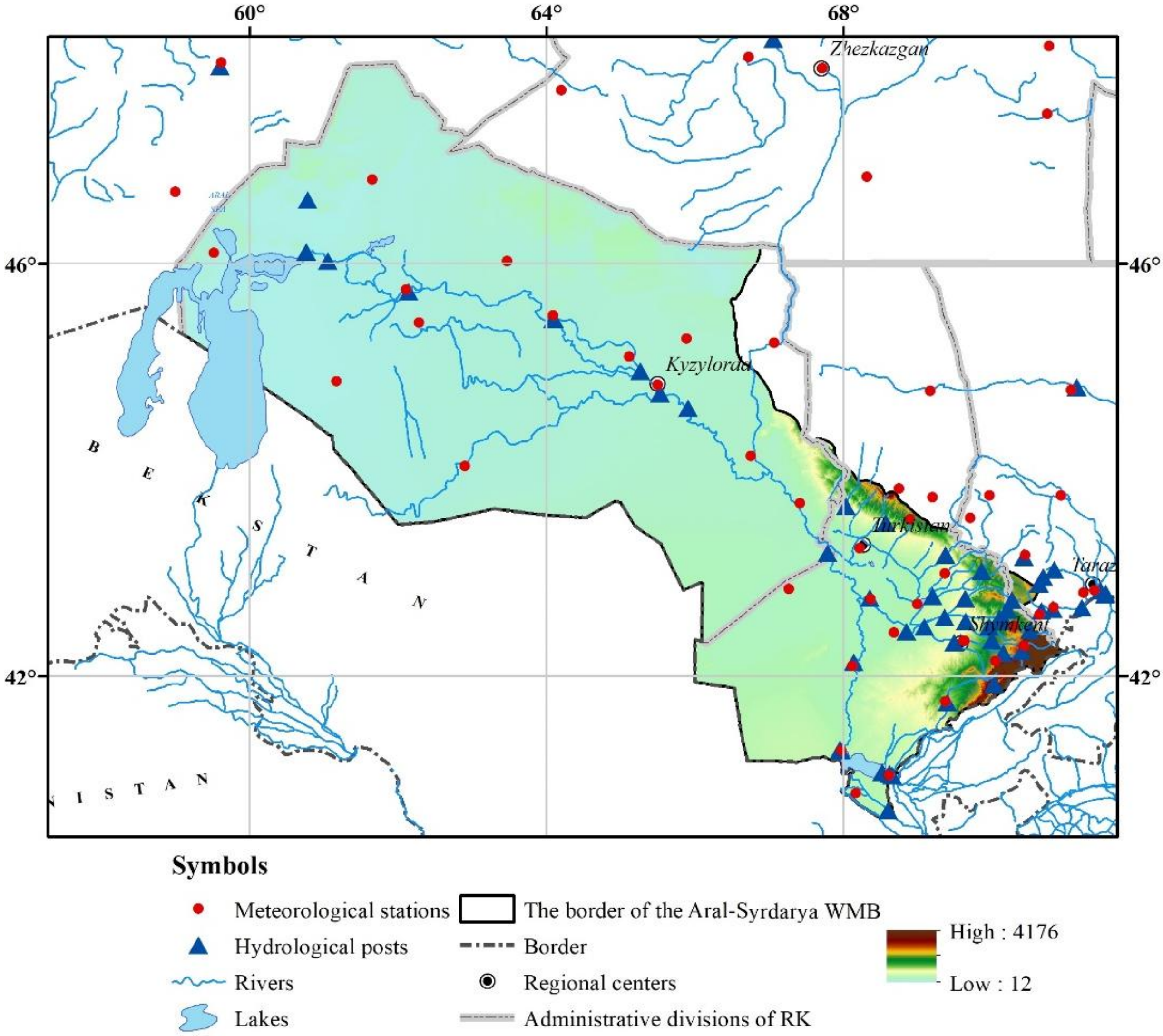


Figure 16 – Physical and geographical map of the Aral-Syrdarya WMB

The main rivers of the Aral-Syrdarya river basin with streamflow observation points are the Syrdarya (with its tributaries), Keles, Arys (with tributaries), Bugun (with tributaries), and Shayan. The analysis of changes in the Syrdarya River flow within the territory of the Republic of Kazakhstan was carried out for the main gauging sections according to the list of reference tables of water resources by major river basins and their sections.

The main hydrographic characteristics of the Syrdarya tributary basins in Kazakhstan, up to the hydrological observation points, are presented in table 5.

Table 5 - Main hydrographic characteristics of the Syrdarya river tributary basins

Name of the watercourse	Station	Catchment area, km²	Mean elevation, m	Mean slope, ‰	River network density, km/km²
Arys r.	Arys r. s.	13100	900	132	0,40
Bugun r.	Ekpendy v.	2040	480	95	0,42
Shayan 1 r.	3.3 km downstream from the Akbet r. gauge	485	770	165	0,60
Sairam r.	Tasaryk v.	468	2200	370	2,2
Zhabagylisu r.	Zhabagly v.	172	2360	410	1,81
Aksu r.	Sarkyrama v.	462	2530	484	0,71

The Aral-Syrdarya water management basin has 41 river stations where hydrological observations are conducted on water level and temperature, waterbody condition, ice thickness, river flow, and ice phenomena, and 1 reservoir where hydrological observations are conducted on water level and temperature, waterbody condition, ice thickness, ice phenomena, and water balance calculation.

Table 6 - Information on reservoirs of the Aral-Syrdarya Water management basin

№	Reservoir name	Year of commissioning	Total / useful volume, km³	Elevation above sea level	Regulation type	Surface area, km²	Length / width, km
1	Shardara	1964-1966	5,7 / 4,2	252	Perennial	783	80 / 25
2	Bugun	1967	0,37 / 0,36	248,5	Perennial	65	13 / 6

Hydrological regime of the main rivers of the Aral-Syrdarya WMB

The difference-integral flow curves at the main hydrological stations of the Syrdarya for 1932-2023 (Figure 17) reflect a pronounced cyclicity in water availability and the influence of both natural and anthropogenic factors. In the initial period (1930s - late 1940s), a gradual increase in river flow is recorded, transitioning into a stable high-flow cycle in the 1950s - first half of the 1970s, reaching a maximum in the early 1960s, which is associated with favorable climatic conditions and a high level of snow-glacier feeding. From 1975, a sharp and prolonged decline in water availability begins, continuing into the 2000s, caused not only by glacier retreat and changes in atmospheric circulation but also by large-scale economic development of the basin (increase in irrigation water use, filling and operation of the Shardara and other reservoirs). Since the early **2000s**, a stabilization against the background of low water availability has been observed: the curves level off into a horizontal trend near the zero line, without a pronounced recovery of flow. Downstream (from the headwaters above the Keles confluence to the city of Kazaly), the dynamics remain generally synchronous, but the amplitude of changes gradually smooths out due to the regulating effect of reservoirs. At the same time, the railway station post at Tomenaryk shows lower integral curve values, indicating local water losses or intensive water use, whereas the Kazaly post exhibits maximum accumulated values during high-flow periods and a more pronounced decline after the **1980s.**

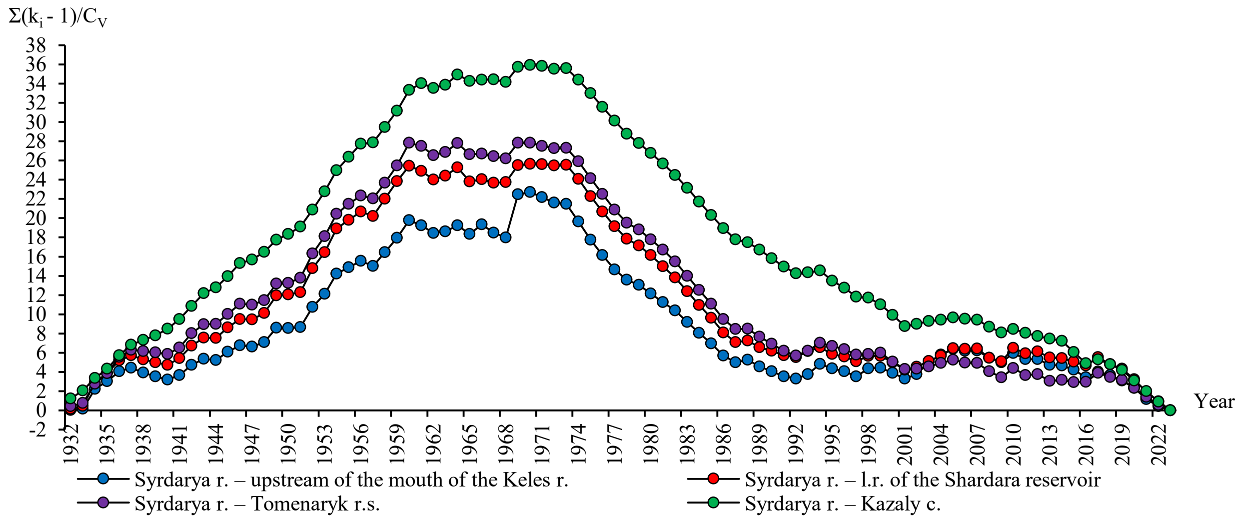


Figure 17 – Difference-integral curves of mean annual water discharge

River Syrdarya. Overall, the trend of recent decades is characterized by a steady decrease in water availability and the absence of signs of a new high-flow cycle, indicating an intensification of anthropogenic transformation of runoff in the Syrdarya basin.

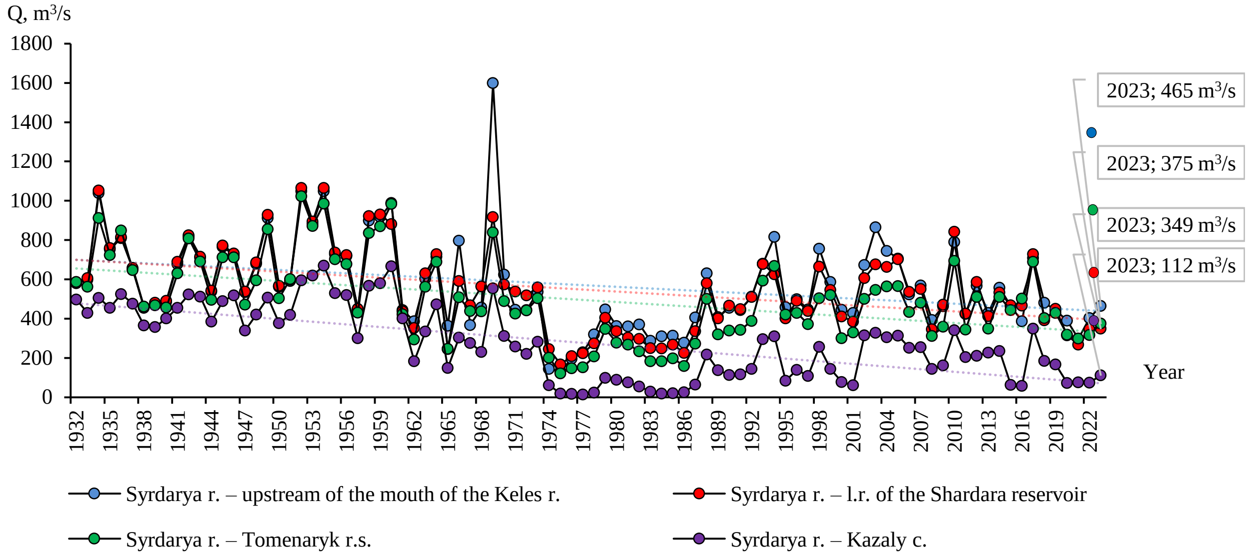


Figure 18 – Dynamics of changes in mean annual water discharge

Syrdarya r. – near the Shardara Reservoir. The long-term average annual discharge is **728 m³/s**. According to observations from 1932 to 2023, there is a moderate downward trend in mean annual discharge. The highest value was recorded in 1952 at 1066 m³/s, and the lowest in 1975 at 167 m³/s, reflecting fluctuations across different water availability phases (Figure 18). **In 2023**, **the discharge was classified as moderate**, with an exceedance probability of **57.9 %.**

Syrdarya r.– Tomenaryk tr.st. The long-term average annual discharge is **682 m³/s**. During the period 1932-2023, a moderately expressed decrease in mean annual discharge is observed. Over this period, the maximum value was 1023 m³/s (1952) and the minimum 122 m³/s (1975), reflecting the characteristics of the river's flow regime**. In 2023**, the river discharge was classified as **moderately high**, with an exceedance probability of **37.0 %.**

Syrdarya r.– Kazaly c. The long-term average annual discharge is **492 m³/s**. Observations from 1932-2023 indicate a moderately expressed downward trend in mean annual discharge. The maximum recorded value was 670 m³/s (1954), and the minimum 15.0 m³/s (1977), consistent with the overall flow regime. **In 2023**, the discharge at this hydrological station corresponded **to moderate water availability**, with an exceedance probability of **43.5 %.**

The water availability of the main tributaries of the Syrdarya River in the Aral-Syrdarya Basin during **1932-2023** is characterized by pronounced cyclicity (Figure 19), where the differential-integral runoff curves clearly distinguish three main phases: a low-water phase in the **1930s-1950s**, a high-water phase in the **1950s-1970s** due to intensive snow and glacier feeding, followed by a prolonged low-water phase in the **1970s-2000s**, caused both by natural climatic fluctuations and significant anthropogenic impacts (construction of reservoirs, intensive irrigation, and flow regulation). After **2010**, a trend toward partial restoration of water availability is observed. Upper hydrological stations, located closer to the glacier areas of the Tien Shan, show maximum discharge peaks during high-water periods, while lower stations record significant declines due to water withdrawals and evaporation, creating a pronounced contrast along the river course. Overall, the changes in Syrdarya's flow phases reflect the interaction of natural factors (precipitation and glacier melt cycles) and anthropogenic influences, which determine the modern regime of the main water artery of the region.

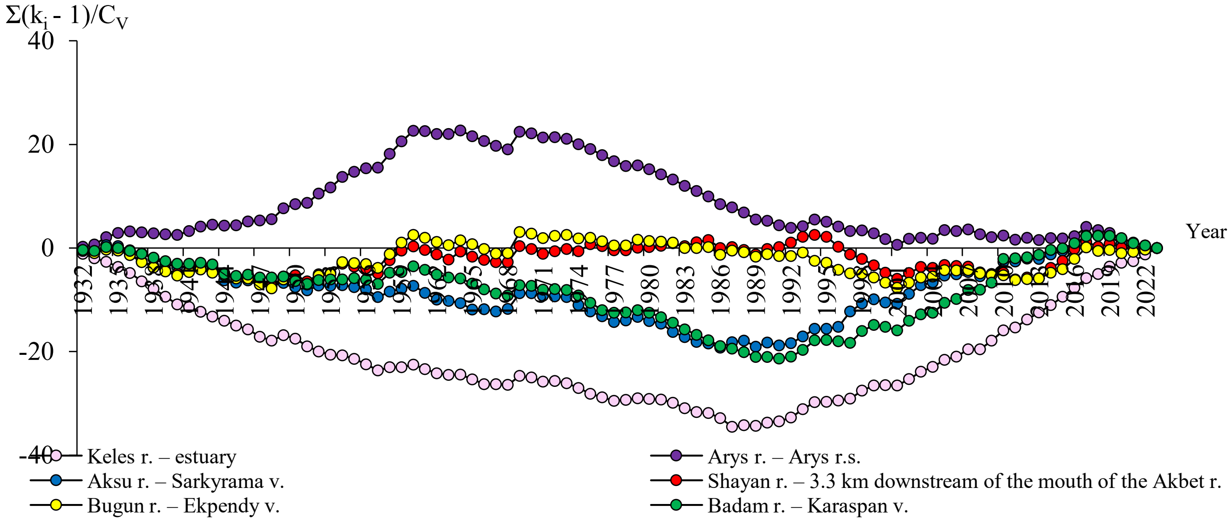


Figure 19 – Differential-integral curves of average annual water discharge

Aksu r. – Sarkyrama v. The long-term average annual discharge is **9.98 m³/s.** According to data for the period 1990-2023, there is a slightly expressed decreasing trend in average annual discharge values. During this period, the maximum discharge was 19.2 m³/s (1969), and the minimum was 2.57 m³/s (1944), corresponding to different water availability phases. At this hydrological station, the river discharge **in 2023** was of average water availability, with an exceedance probability of **41.7 %.**

Badam r. – Karaspan v. The long-term average annual discharge is **5.39 m³/s**. According to data for the period 1990-2023, the trend remained within the normal range. During this period, the maximum discharge was 26.7 m³/s (2010), and the minimum was 0.30 m³/s (1944), reflecting the river's hydrological regime. At this hydrological station, the river discharge in 2023 was **moderately high**, with an exceedance probability of **36.5 %.**

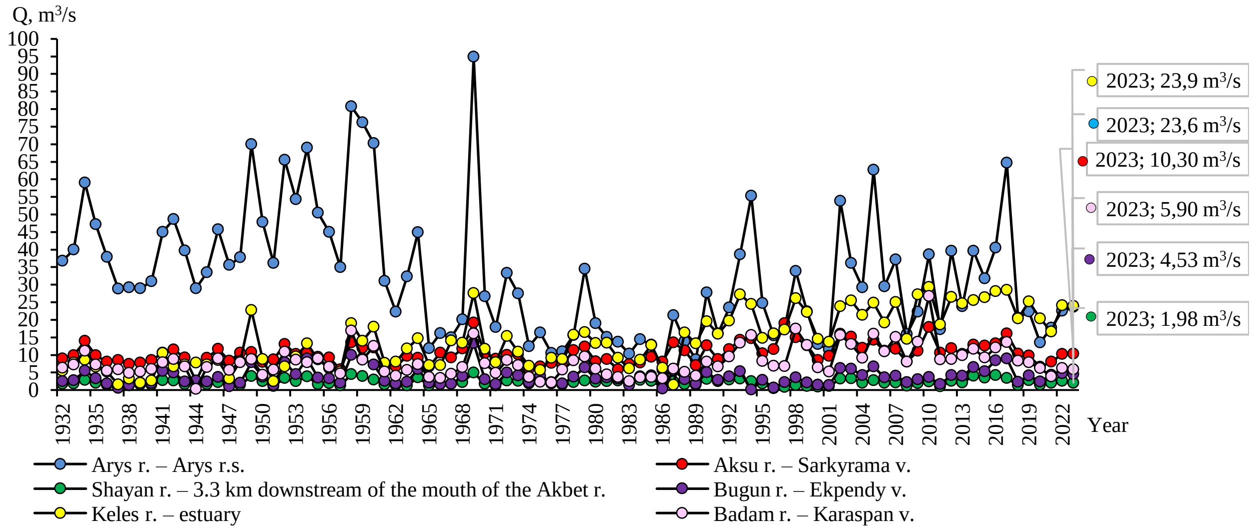


Figure 20 – Dynamics of changes in average annual water discharge

Shayan r. – 3.3 km downstream of the mouth of Akbet r. The long-term average discharge is 2.27 m³/s. During the period 1990-2023, the discharge trend remained close to normal. The maximum discharge was recorded in 1969 at 4.98 m³/s, and the minimum in 1996 at 0.50

m³/s, corresponding to the hydrological water regime. In 2023, the river discharge was characterized by **average water availability**, with an exceedance probability of **54.4 %.**

- **Bugun r. – Ekpendy v.** The long-term average discharge is **4.28 m³/s**. For the period 1990-2023, changes in average annual discharge generally remained within the normal range. The maximum value was recorded in 1969 at 13.3 m³/s, and the minimum in 1994 at 0.12 m³/s, consistent with water regime phases. **In 2023**, the river discharge **was moderately high**, with an exceedance probability of **38.6 %.**
- **Keles r. – estuary.** The long-term average annual discharge is **13.0 m³/s.** The time series for 1990-2023 shows a moderate increase in discharge. The maximum value was observed in 2010 at 29.3 m³/s, and the minimum in 1987 at 1.50 m³/s, reflecting the cyclical nature of water availability. **In 2023**, the river **discharge was high**, with an exceedance probability of **11.5 %.**
- **Arys r. – Arys r. s.** The long-term average annual discharge is **47.5 m³/s**. During 1990-2023, changes in discharge remained close to normal. The maximum discharge was recorded in 1969 at 94.9 m³/s, and the minimum in 1986 at 5.79 m³/s, consistent with water regime phases. **In 2023**, the river discharge was **moderately high**, with an exceedance probability of **34.7 %.**

1.1.4 Zhaiyk-Caspian WMB

The Zhaiyk-Caspian Basin, within the territory of the Republic of Kazakhstan, is located in the Atyrau, Mangystau, West Kazakhstan, and partially Aktobe regions.

The Zhaiyk River is the main river of the Caspian region in Kazakhstan. It originates in the spurs of the Oral Mountains on the Oraltau range and flows into the Caspian Sea near the city of Atyrau. With a total length of 2,534 km, it ranks third in Europe in terms of length, after the Volga and the Dunai. The river's catchment area is 232,000 km², and together with the endorheic basin of the Ural-Emba interfluve, it covers nearly 400,000 km². The river's length within Kazakhstan is 1,084 km, where it is called Zhaiyk. It is the second most important river determining the inflow of water into the Caspian Sea.

In the Kazakhstan part of the basin, the Zhaiyk River and its tributaries serve as the main water artery for the Atyrau, Aktobe, and West Kazakhstan regions. The river plays an especially important role for the arid areas of Atyrau region, as 70% of the water consumed by the population is supplied from the river. Figure 21 shows the physiogeographical map of the Zhaiyk-Caspian Basin [13].

The main runoff-forming part of the basin is located in Russia. In its middle course, the river receives numerous left-bank tributaries, the main ones being the Ilek and the Or rivers. Through the Caspian Lowland, the Zhaiyk flows without receiving additional inflow, losing part of its water to evaporation on the way to the sea. The floodplain of the Zhaiyk River in its lower course transitions into a marine terrace.

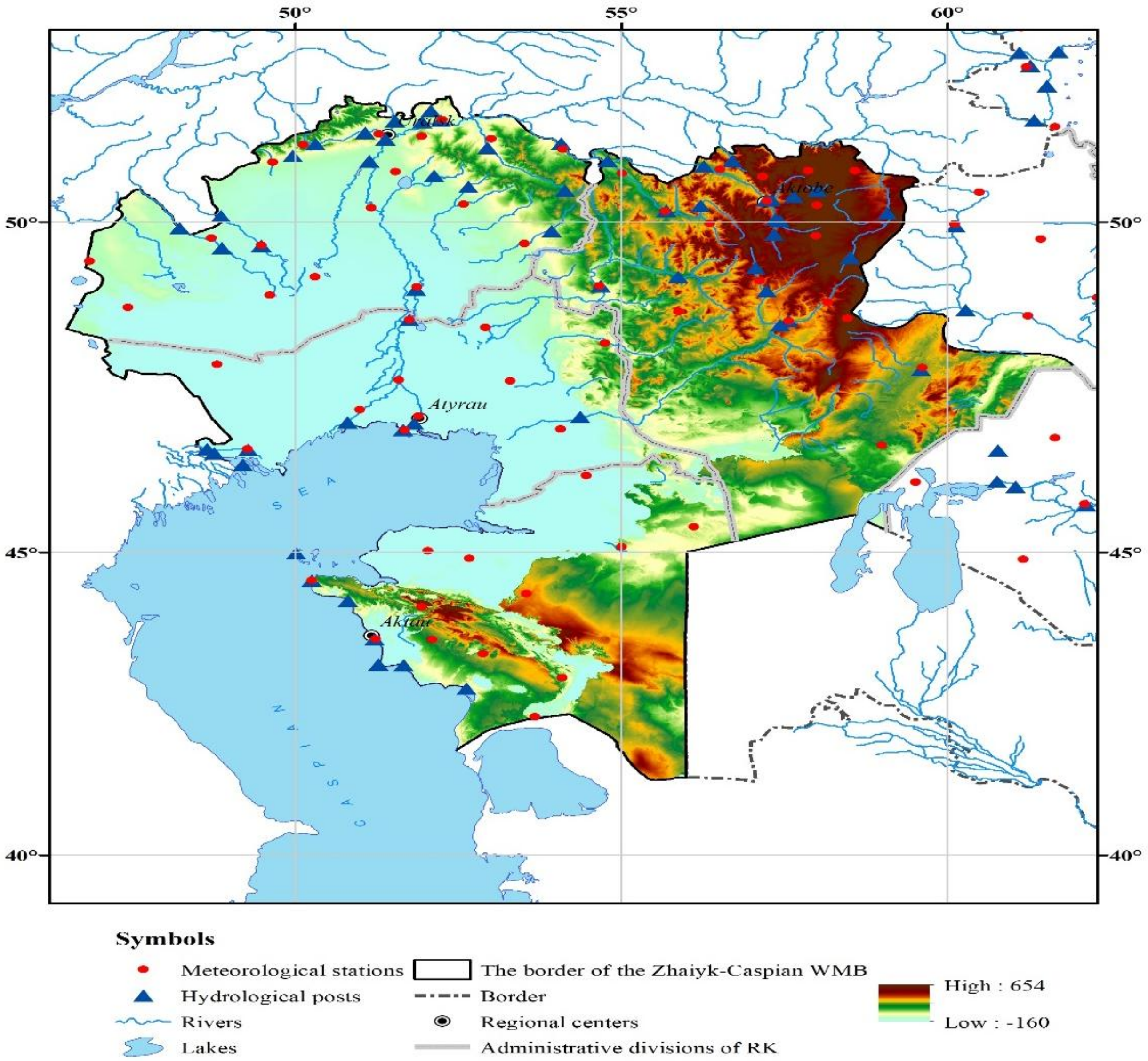


Figure 21 - Physico-geographical map of the Zhaiyk-CaspianWMB

In total, the Zhaiyk-Caspian Basin has 52 hydrological stations (hereinafter HS) according to the EDS data for 2023 [14]. In the Kazakhstani part of the basin, the Zhaiyk River itself has 9 active stations and 1 on the Kushum canal. The discharge of the Zhaiyk River entering the Republic of Kazakhstan is recorded at the hydrometric station near the settlement of Yanvartsevo, located close to the border with the Russian Federation. The discharge flowing into the Caspian Sea is recorded at the hydrometric station in the city of Atyrau.

The main hydrographic characteristics of the rivers of the Zhaiyk-CaspianBasin are presented in table 7, and information on the main reservoirs is given in table 8.

Table 7 - Main hydrographic characteristics of the major rivers of the Zhaiyk-CaspianWMB

Name of the watercourse	Mouth / Tributary to	Distance from mouth, km	Length of the watercourse, km	Catchment area, km²
Zhaiyk r.	Caspian Sea	-	2428	231000
Tributaries of the Zhaiyk кiver				
Or r.	Zhaiyk r. (l)	1715	332	18600
Ilek r.	Zhaiyk r. (l)	1085	623	41300
Utva r.	Zhaiyk r. (l)	986	290	6940
Solyanka r.	Zhaiyk r. (l)	924	51	631
Embulatovka r.	Zhaiyk r. (r)	901	82	890
Rubezhka r.	Zhaiyk r. (r)	885	80	720
Chagan r.	Zhaiyk r. (r)	793	264	7530

Name of the watercourse	Mouth / Tributary to	Distance from mouth, km	Length of the watercourse, km	Catchment area, km²
Barbastau r.	Zhaiyk r. (l)	779	111	1360
Derkul r.	Shagan r. (r)	18	176	2200
Khobda r.	Ilek r. (l)	184	225	14700
Karagala r.	Ilek r. (l)	502	114	5130
Other rivers				
Olenty r.	lake Tuzdakol	-	229	6280
Buldyrty r.	lake Zhaltyrkol	-	195	4660
Kaldygayty r.	lake Tyulenkol		242	5800
Zhaksibay r.	lake Sulukol	-	146	2490
Uil r.	lakes Sarakol and Karakol	-	800	31500
Sagiz r.	disappears 7 km NE of Sagiz village	-	511	19400
Emba r.	Caspian Sea	-	712	40400
Ashiozek	disappears 9 km S of Lake Aralsor	-	258	5950
Chizha 2nd r.	Chizha floodplains	-	82	1360
Chizha 1st r.	Chizha floodplains	-	76	822
Bolshoy Uzen r.	lake Kamysh-Samarskie	-	650	-
Maly Uzen r.	lake Kamysh-Samarskie	-	638	-

Large reservoirs for seasonal and multi-year flow regulation (Verkhneuralskoye, Magnitogorskoye, Iriklinskoye, etc.) have been constructed on the Zhaiyk river and its tributaries in Russia, intended to supply water to industrial regions.

In the Zhaiyk river basin within Kazakhstan, reservoirs have been built primarily for irrigation purposes. The largest is the Karagalin Reservoir on the Karagaly River in Aktobe region, with a useful capacity of 262 million m³. Two reservoirs (Aktobe and Chagan) have a multifunctional purpose and are used for both water supply and irrigation.

Table 8 - Information on reservoirs of the Zhaiyk-CaspianWMB

Name		Year of commissioning	Volume, million m³		Regulation type	Purpose
reservoirs	river or site of reservoir formation		Full	Useful / Active		
Sazdinskoye	Sazdy r.	1967	6,0	5,2	seasonal	irrigation, flood control
Karagalinskoye	Karagala r.	1975	280	262	perennial	irrigation, fisheries
Mezhdurechenskoye	Assay ravine, tributary of Tarangul	1985	3,1	3,0	seasonal	irrigation
Aktyubinskoye	Ilek r.	1988	245	220	perennial	multi-purpose
Sarychaganskoye	Bolshoy Uzen r.	1937	46,85	22,5	seasonal	irrigation, agriculture; water supply
Aydarkhanskoye	Bolshoy Uzen r.	1974	52,3	42,0	seasonal	irrigation, agriculture; water supply
Rybny Sakryl	Bolshoy Uzen r.	1981	97,0	79,0	seasonal	irrigation, agriculture; water supply
1 Kaztalovskoye	Bolshoy Uzen r.	1977	7,2	5,5	seasonal	irrigation, agriculture; water supply
2 Kaptalovskoye	Bolshoy Uzen r.	1975	3,55	2,87	seasonal	irrigation, agriculture; water supply
Mamaevskoye	Bolshoy Uzen r.	1985	3,5	3,2	seasonal	irrigation, agriculture; water supply

Zhaiyk river. The long-term average annual discharge was determined based on a representative period of 1932-2005. Analysis of the differential-integral curves of water availability over this interval reveals more than five alternating high-flow and low-flow cycles, which is important for determining the normative discharge.

Based on long-term hydrometeorological observations at the main gauging stations of the Zhaiyk River – near the settlements of Yanvartsevo, Kushum, and Makhambet – a persistent trend of decreasing average annual water discharge has been established, particularly pronounced over the last 15-20 years.

Hydrological regime of the main rivers of the Zhaiyk-Caspian WMB

Minimum river discharges generally occur in years corresponding to low-flow cycles, as clearly evidenced by the analysis of the differential curve shown inFigure22. Over the period 1932-2023, alternating cycles of low-water and high-water years can be observed. The period 1932-

1945 was a significant low-water period, 1946-1976 was a relatively high-water period with several peaks, the late 1950s, early 1960s, and the 1970s also experienced low-water conditions, and 1977-1990 was another low-water period. During 2008-2023, a trend toward decreasing water availability has been observed, indicating a transition to a new low-water period. The main reasons for the decline in water availability are unfavorable hydrometeorological factors, including a reduction in total precipitation, a decrease in winter snow reserves, an increase in average annual air temperatures, and, consequently, higher evaporation. Anthropogenic impacts on river discharge cannot be excluded.

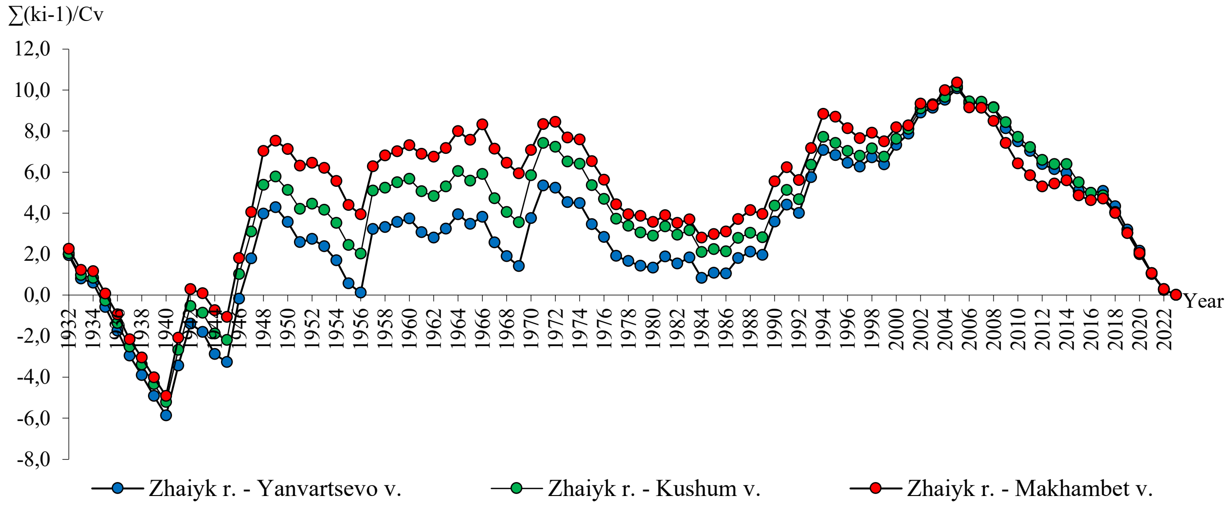


Figure 22 – Differential-integral curve of average annual water discharge for the period 1932-2023

Zhaiyk r. – Yanvartsevo v. The long-term average discharge is **314 m³/s**. Over the period 1932-2023, a persistent decreasing trend in discharge is observed (Figure 23). During the considered period, the minimum discharge occurred in 1967 at 96.1 m³/s, during a stable low-flow cycle caused both by a deficit of atmospheric precipitation and by reduced inflows due to decreased snow reserves and increased evaporation. The maximum discharge was recorded in 1957 at 793 m³/s, likely due to abundant spring snowmelt. At this gauging station, the river discharge **in 2023** was **248 m³/s**, which is 21% below the established norm (301 m³/s). It was classified as **average water availability**, but within the overall trend, it is considered part of a low-flow cycle, with an exceedance probability of **55.2 %.**

Zhaiyk r. – Kushum v. The long-term average annual discharge is **353 m³/s.** According to data for the period 1932-2023, a pronounced decreasing trend in average annual discharge values is observed (Figure 23). During this period, the minimum discharge was 89.1 m³/s (1967), associated with a stable low-flow period in recent years, and the maximum discharge was 802 m³/s (1946), related to a short high-flow period caused by a combination of intense spring runoff. At this gauging station, the river discharge **in 2023** was 244 m³/s, which is **31%** below the norm. The exceedance probability is **62.3 %**, and the water availability is classified **as moderately low.**

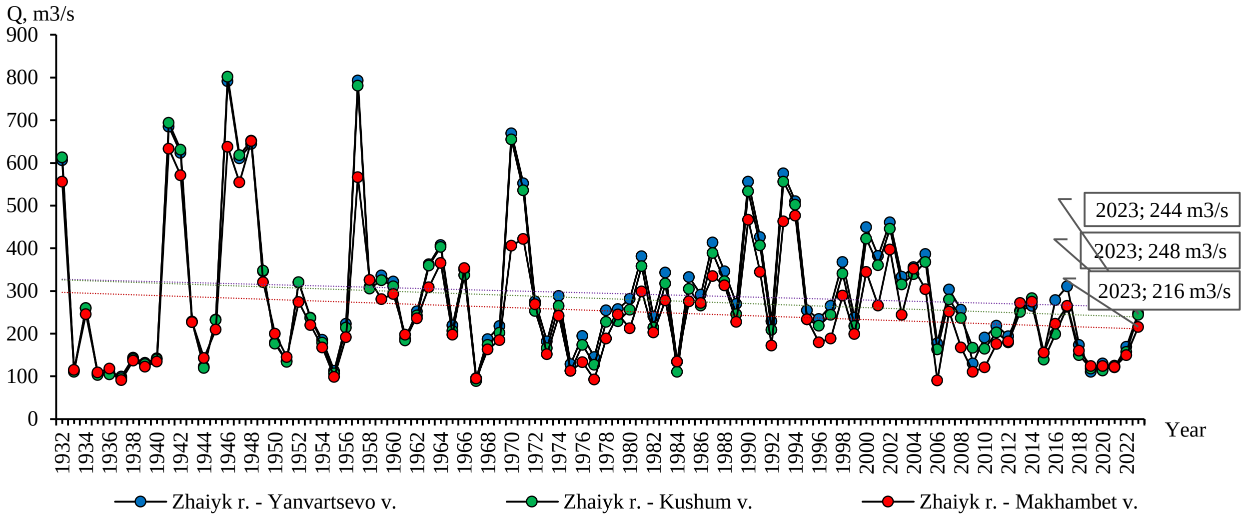


Figure 23 – Dynamics of Changes in Average Annual Water Discharge for the Period 1932-2023

Zhaiyk r. – Makhambet v. The long-term average annual discharge is **242 m³/s.** Similar to the upstream gauging stations, a decreasing trend in discharge is observed over the considered period. During this period, the minimum discharge was 90.3 m³/s (2006), representing the most pronounced year of a low-flow cycle, characterized by insufficient precipitation and weak spring floods. The maximum discharge was 651 m³/s (1948), corresponding to a high-flow year within a series of low-flow years. The river discharge **in 2023 was 216 m³/s,** which is **11% below the norm**. The exceedance probability is **66.0 %,** and the water availability is classified as **moderately low**.

Ilek and Uil Rivers. The Ilek River is the largest right-bank tributary of the Zhaiyk River in terms of basin area. In its middle course, the river is regulated by the Aktobe Reservoir, located 8 km south of the city of Aktobe. According to the analysis of the dynamics of average annual water discharge for the period 1932-2023, a persistent decreasing trend in water availability is observed.

The normative discharge was calculated based on a representative long-term period of 1932-2005. The constructed differential-integral discharge curve for the period 1932-2023 (Figure 24) shows the formation of a second phase of a low-flow period, indicating a stable deficit of water resources in recent years compared to the established norm.

The main reasons for the decrease in Ilek River discharge may include climatic factors– particularly a reduction in precipitation within the catchment area, an increase in average annual air temperatures, and, consequently, higher evaporation – as well as anthropogenic impacts. The latter include intensive water use, especially in the upper reaches of the river and in the area influenced by the Aktobe Reservoir, where water withdrawals for agricultZhaiyk and domestic needs have a significant impact on the river's hydrological regime.

Despite the overall downward trend, 2023 was characterized by relatively high water availability and was classified as moderately high. This anomalously high discharge is explained by a combination of hydrometeorological conditions: an increase in snow reserves during the winter of 2022-2023 compared to long-term averages, as well as rapid snowmelt against the backdrop of high spring temperatures. These conditions led to the formation of an intense flood, contributing to an increase in water supply compared to the preceding low-flow years.

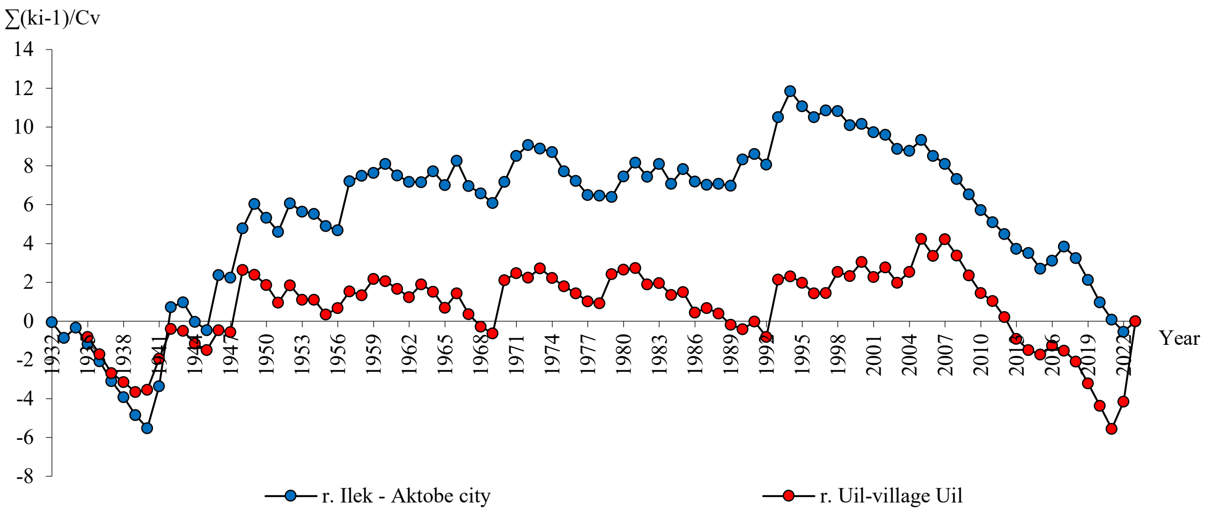


Figure 24 – Differential-integral curve of average annual Water Discharge for the period 1932-2023

The Uil River, although not a tributary of the Zhaiyk River, is included in the list of main watercourses of the studied basin and is considered in the calculation of local water resources. Analysis of average annual discharges over the long observation period (1935-2023) also shows a decreasing trend, especially over the past decades. The main reasons are similar: changes in climatic conditions, degradation of snow cover, increased evaporation, as well as anthropogenic impacts within the basin. The differential-integral curve of the Uil confirms the presence of a prolonged low-flow period.

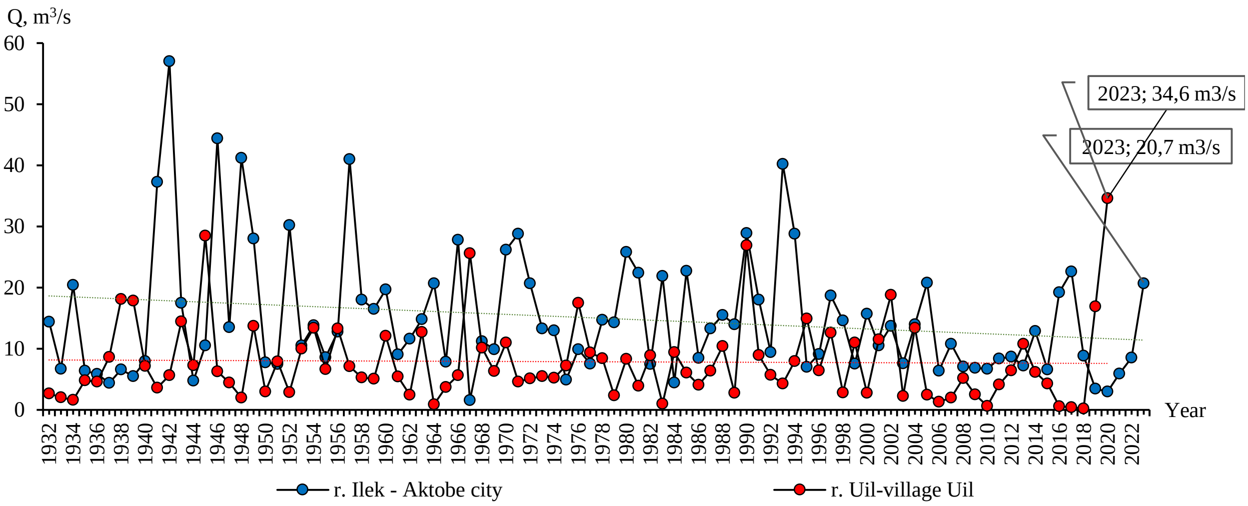


Figure 25 – Dynamics of changes in average annual Water Discharge for the period 1932-2023

At the same time, 2023 was the highest discharge year for this watercourse over the entire period of instrumental observations and was classified as high-flow. This is due to the same climatic factors as in the Ilek River basin: above-average snow cover, rapid snowmelt, and abundant precipitation during the spring period. These conditions provided a significant replenishment of surface runoff and temporarily interrupted the overall downward trend.

Ilek r. – Aktobe c. The long-term average annual discharge at the hydrological station in Aktobe is 17.2 m³/s (for the period 1932-2005). According to observations for the period 1932-

2023, the trend line shows a pronounced decrease in average annual discharge (Figure 25). During the analyzed period, the maximum discharge was recorded in 1942 at 57.0 m³/s, and the minimum in 1967 at 1.57 m³/s. **In 2023**, the average annual discharge was **20.7 m³/s**, corresponding to **moderately high water availability**, with an exceedance probability of **28.7 %.**

- **Uil r. – Uil v.** The long-term average annual discharge at the gauging station near Uil v. is 10.8 m³/s. Analysis of observed data for the period 1935-2023 shows a decreasing trend in water availability relative to the norm (Figure 25). During the analyzed period, the minimum annual discharge was recorded in 2021 at 0.19 m³/s, and the maximum in 2023 at 34.6 m³/s. **In 2023**, the annual discharge was classified as **high-flow**, with an exceedance probability of **3.84 %.**

1.1.5 Esil WMB

The Esil water management basin includes the portion of the Esil River basin within the territory of the Republic of Kazakhstan (Figure 26). The area of the Esil water management basin is 237,226 km², including Akmola Region - 122,100.8 km², Karaganda Region - 11,520.9 km², Kostanay Region - 5,611.3 km², and North Kazakhstan Region - 97,993 km². The territories of Akmola and North Kazakhstan Regions serve as the main catchment areas for the Esil River, since downstream of the confluence with the Imanburluk River, as the river enters the West Siberian Plain, it receives no significant tributaries all the way to its lower reaches. The characteristics of the hydrographic network in the studied area are largely determined by the topography. The presence of low mountainous terrain in the eastern and western parts, along with a general decrease in elevation toward the west, south, and partially north, determines the main direction of runoff from the central to the peripheral areas. The main water artery is the Esil River, with several major tributaries flowing from the north from the Kokshetau Upland and from the south from the spurs of the Ulytau Mountains. The main tributaries are the Kalkutan, Zhabai, Terisakkan, Akkanburluk, and Imanburluk rivers.

The Esil River is a left-bank tributary of the Ertis, with a total length of 2,450 km and a drainage area of 177,000 km², including an active catchment area of 141,000 km². The river originates in Karaganda Region, in the Niaz Mountains (northern edge of the Kazakh Uplands), at an elevation of 560 m. The right-bank tributaries of the Esil, the Kalkutan and Zhabai rivers, flow from the Kokshetau Mountains. In the basin of the main left-bank tributary, the Tersakkan River, the spurs of the Ulytau Mountains extend into the territory of Akmola Region [4].

About 50 reservoirs are located and operated within the Esil Basin, the largest of which are Vyacheslavskoye, Sergeyevskoye, and Petropavlovskoye on the Esil River, Seletinskoye on the Selet River, and Chaglinskoye on the Chaglinka River.

Table 9 presents the main information on the hydrographic characteristics of the Esil River basin and its tributaries.

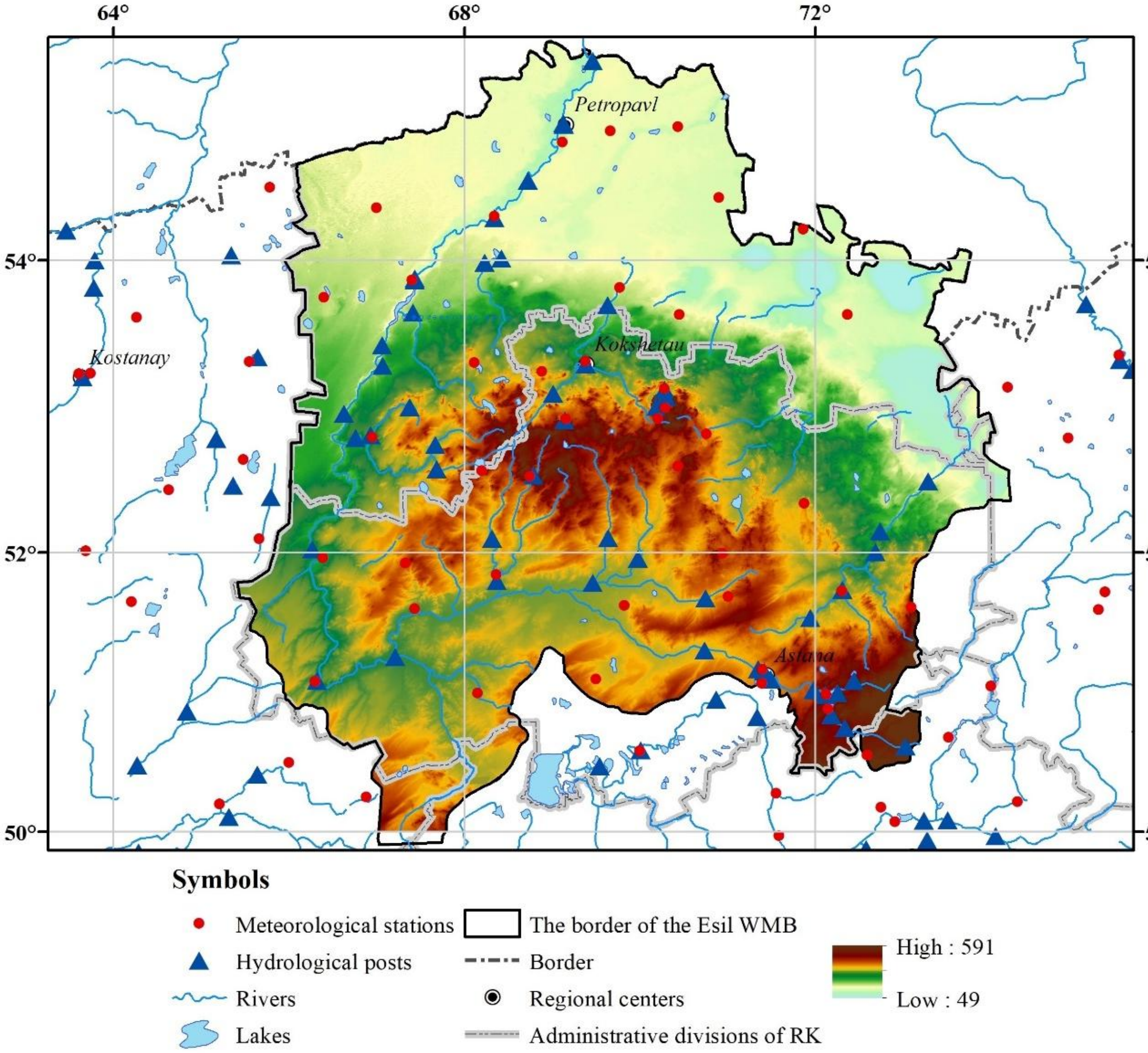


Figure 26 - Physico-geographical map of the Esil WMB

Table 9 - Main hydrographic characteristics of the Esil River basin and its tributaries

Name of the watercourse	Mouth / Tributary to	Distance from the mouth, km	Length of the water-course, km	Catchment area, km²
Esil r.	Ertis r. (l.)	1016	2450	177 000
Tributaries of the river Esil (Esil)				
Kalkutan r.	Esil r. (r.)	1963	223	17 400
Zhabai r.	Esil r. (r.)	1871	196	8 800
Terisakkan r.	Esil r. (l.)	1687	334	19 500
Akkanburluk r.	Esil r. (r.)	1280	176	6 720
Zhaman Kayrakty r.	Esil r. (r.)	1823	106	1 640
Moyildy r.	Esil r. (r.)	2339	66	769
Shortandy r.	Esil r. (r.)	2376	36	339
Mukkur r.	Esil r. (r.)	1187	14	-
Other rivers				
Baksuk r.	Kalkutan r. (r.)	57	171	4 930
Arshaly r.	Kalkutan r. (r.)	123	34	-
Zhilandinka r.	Zhabai r. (r.)	25	140	3 650
Aschily r.	Zhabai r. (r.)	43	58	1 060

As of 2023, there are 43 river stations in the Esil Basin where hydrological observations are conducted on water level and temperature, the condition of the water body, ice thickness, water discharge, and ice phenomena. Additionally, there are 6 lakes and 4 reservoirs where hydrological observations are carried out on water level and temperature, water body condition, ice thickness, ice phenomena, and calculations of the water balance of the water body. The data are presented in table 10.

Table 10 - Information on reservoirs of the Esil Basin and their main parameters

Name		Year of commissioning	Volume, million.м^3		Regulation type
Reservoir	River or site of reservoir formation		Total	Useful	
Vyacheslavskoye	Esil r.	1971	410,9	375,4	Multi-year
Sergeevskoye	Esil r.	1969	693	635	Multi-year
Petropavlovskoye	Esil r.	1973	19,2	16,1	Seasonal

The analysis of changes in the discharge of the Esil River within the territory of the Republic of Kazakhstan was conducted for the main gauging stations according to the list of standard water resources tables for the main river basins and their sections.

Esil River. Analysis of discharge dynamics shows that since 1990, the impact of climate change on river flow has become evident.

Hydrological regime and water availability phases of Rivers in the Esil basin

To characterize the annual discharge fluctuations within the Esil Basin, data from the following watercourses were used, where the flow is considered conditionally natural: Esil River - Turgen v., Esil River - Astana city, Esil River - Kamennyy Karyer v., Esil River - Dolmatovo v., Esil River - Petropavlovsk city, Esil River - Atbasar city, Kalkutan River - Kalkutan v.

Analysis of the differential-integral curves of annual discharge of the Esil River (at the gauging stations: Esil - Astana city, Esil - Kamennyy Karyer v., Esil - Dolmatovo v., Kalkutan - Kalkutan v.) revealed the presence of **two main phases of water availability–high-flow and low-flow**–each of which contains smaller cycles. Low-flow periods were observed from 1932 to 1940, 1950 to 1954, 1967 to 1970, 1975 to 1982, again from 1994 to 2001, and from 2008 to 2023, characterized by a persistent decrease in annual discharge. Between these periods, high-flow phases occurred from 1941 to 1949, 1955 to 1966, 1971 to 1974, 1983 to 1993, and again from 2002 to 2007, characterized by increased discharge volumes due to more favorable hydrometeorological conditions. These phases are clearly reflected in the differential-integral curves of annual discharge (Figure 27) at the main gauging stations of the Esil River, allowing the conclusion that there are stable cyclical fluctuations in water availability within the basin.

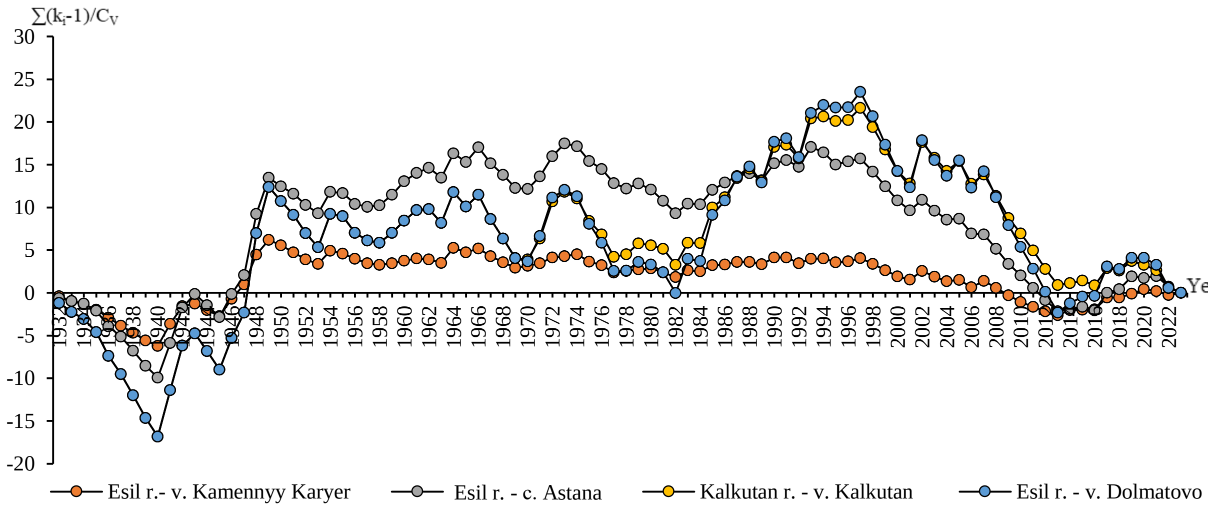


Figure 27 – Differential-integral curves of average annual water discharge for the period 1932-2023

Analysis of the differential-integral curve of annual discharge for the Esil River - Turgen v., Esil - Petropavlovsk city, and Zhabai - Atbasar city (Figure 27) indicates alternating phases of water availability characterized by multi-year fluctuations in discharge. During the studied period, two main phases of water availability were identified: high-flow and low-flow, each of which includes shorter cycles.

High-flow phases were observed from 1941 to 1943, 1946 to 1949, 1983 to 1995, and again from 2014 to 2021, indicating increased annual discharge during these years. Low-flow phases occurred from 1932 to 1940, 1950 to 1982, 1996 to 2013, and 2022 to 2023, during which lower-than-normal water availability was recorded.

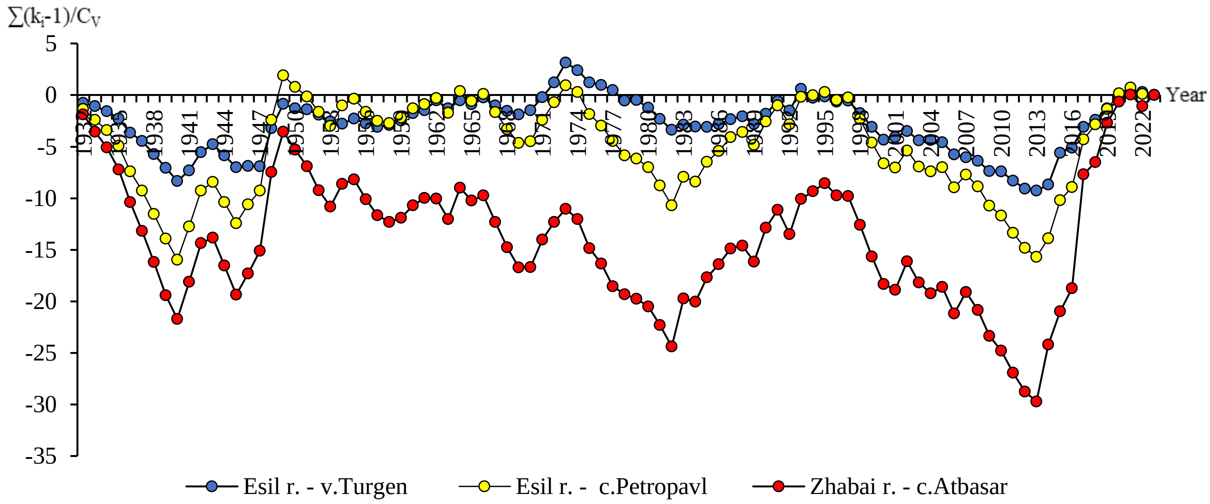


Figure 28 - Differential-integral curves of average annual water discharge for the period 1932-2023

Analysis of discharge dynamics shows a persistent decreasing trend in water availability. Maximum discharge values were observed in the 1950s, after which a gradual decline in average annual flows began. In recent decades, the irregularity of discharge has intensified, with a predominance of low-flow years.

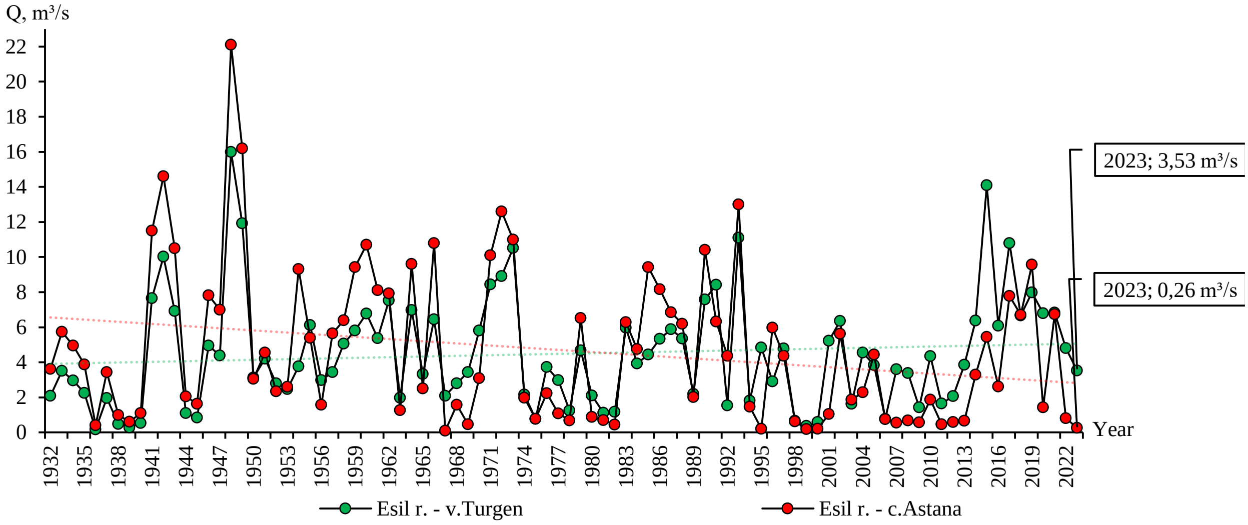


Figure 29 – Dynamics of changes in average annual water discharge

Esil r. - Turgen v. (Turgenevka). Analysis of the average annual discharge of the Esil River at the Turgen gauging station for the period 1932-2023 reveals a moderately expressed trend of increasing water availability relative to the long-term norm of **3.78 m³/s.** The maximum discharge was recorded in 1948 at 15.99 m³/s, corresponding to a high-flow phase associated with favorable hydrometeorological conditions. The minimum average annual discharge occurred in 1936 and amounted to 0.18 m³/s; this year corresponds to a low-flow phase characterized by reduced discharge volumes**. In 2023**, the river's water availability at this station was assessed as average: the average annual discharge was **3.53 m³/s**, which is **6.61 % below** the established norm, with an exceedance probability of **45.2 %.**

Esil r. - Astana c. Analysis of the average annual discharge graph of the Esil River at the Astana gauging station for the period 1932-2023 shows a persistent decreasing trend in water availability, as indicated by the trend line. The long-term average annual discharge is **6.52 m³/s.** The minimum average annual discharge during the considered period was recorded in 1967 at 0.10 m³/s, corresponding to a low-flow phase of the hydrological regime of the Esil Basin, identified through analysis of water availability phases. The maximum discharge occurred in 1948 at 22.1 m³/s, corresponding to a high-flow phase characterized by increased discharge volumes**. In 2023**, the river's water availability at this station remained low: the average annual discharge was **0.26 m³/s**, which is **96 % below** the established norm, with an exceedance probability of **99.4 %.**

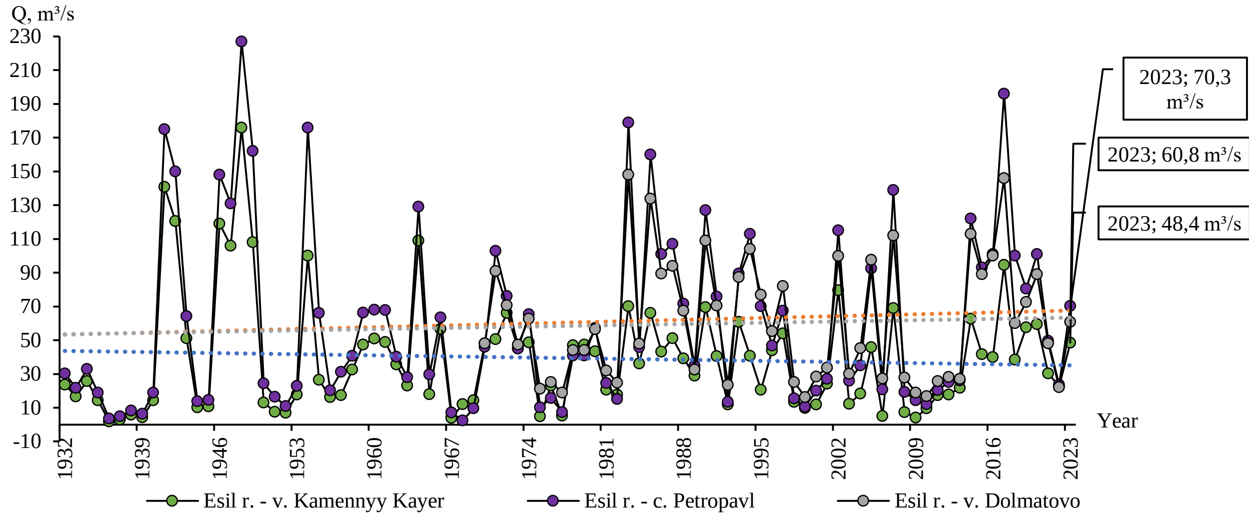


Figure 30 – Dynamics of changes in average annual water discharge

Esil r. – Kamennyy Karyer v. Analysis of the average annual discharge graph of the Esil River at the Kamennyy Karyer gauging station for the period 1932-2023 shows a trend within the norm, as confirmed by the direction of the trend line. The long-term average annual discharge is **50.8 m³/s.** The minimum average annual discharge during the considered period was recorded in 1936 at 1.85 m³/s, corresponding to a low-flow phase of the hydrological regime of the basin, identified through analysis of water availability phases. The maximum discharge was observed in 1948 at 176 m³/s, corresponding to a high-flow phase characterized by increased discharge volumes. **In 2023**, the river's water availability at this station was **assessed as average**: the average annual discharge was **48.4 m³/s**, which is **4.72 % below** the established norm, with an exceedance probability of **41.3 %.**

Esil r. – Petropavl c. Analysis of the average annual discharge of the Esil River at the Petropavlovsk gauging station for the period 1932-2023 reveals a moderately expressed trend of increasing water availability relative to the long-term norm of **68.6 m³/s.** The maximum discharge was recorded in 1948 at 227 m³/s, corresponding to a high-flow phase associated with favorable hydrometeorological conditions. The minimum average annual discharge occurred in 1968 at 2.35 m³/s; this year corresponds to a low-flow phase characterized by reduced discharge volumes. **In 2023**, the river's water availability at this station was assessed as **moderately high**: the average annual discharge **was 70.3 m³/s**, which is **2.48 % above** the established norm, with an exceedance probability of **38.1 %.**

Esil r. – Dolmatovo v. According to observations for the period 1970-2023, the average annual discharge at this station generally fluctuates within the established long-term norm of **72.3 m³/s.** The maximum average annual discharge during the analyzed period was recorded in 1983 at 148.1 m³/s, corresponding to a high-flow phase of the basin characterized by increased discharge volumes. The minimum discharge occurred in 1999 at 16.2 m³/s, associated with a low-flow phase**. In 2023**, the river's water availability was assessed **as average**: the average annual discharge was **60.8 m³/s**, which is **0.81 % below** the long-term norm, with an exceedance probability of **47.6 %.**

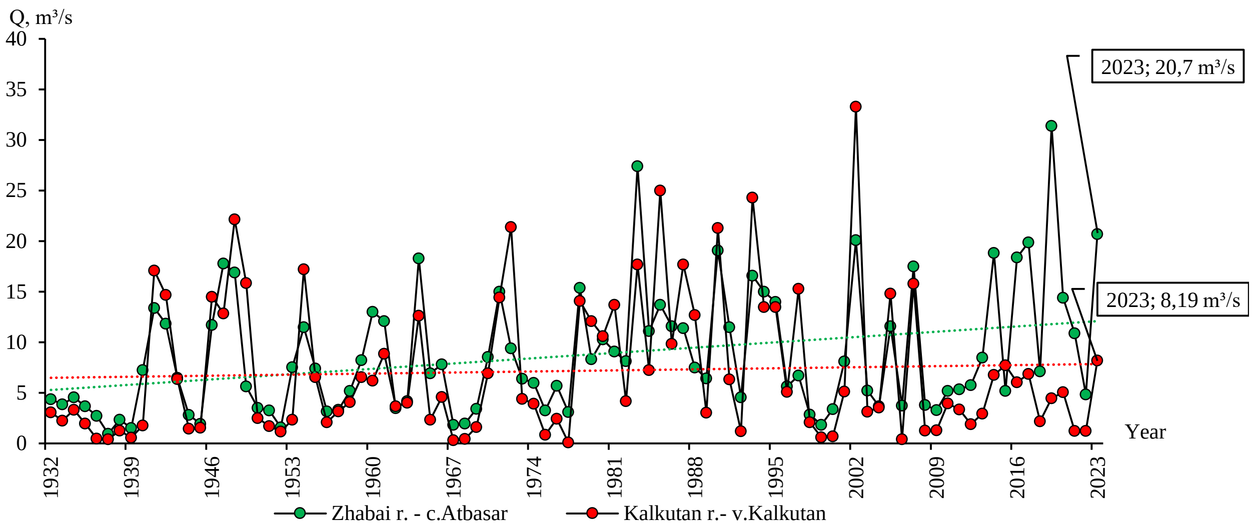


Figure 31 – Dynamics of changes in average annual water discharge

Zhabai r. – Atbasar c. Analysis of the average annual discharge of the Esil River at the Atbasar gauging station for the period 1932-2023 reveals a moderately expressed trend of increasing water availability relative to the long-term norm of 8.15 m³/s. The maximum discharge was recorded in 2017 at 70.5 m³/s, corresponding to a high-flow phase associated with favorable hydrometeorological conditions. The minimum average annual discharge occurred in 1999 at 0.97 m³/s; this year corresponds to a low-flow phase characterized by reduced discharge volumes. **In 2023**, the river's water availability at this station was **assessed as high**: the average annual discharge was **20.7 m³/s,** which is **153.9% above** the established norm, with an exceedance probability of **3.6 %.**

Kalkutan r. – Kalkutan v. Analysis of the average annual discharge graph of the Kalkutan River at the Kalkutan gauging station for the period 1932-2023 shows a persistent decreasing trend in water availability, as confirmed by the trend line. The long-term average annual discharge is **7.92 m³/s.** The minimum average annual discharge during the considered period was recorded in 1977 at 0.10 m³/s, corresponding to a low-flow phase of the hydrological regime of the Esil Basin, identified through analysis of water availability phases. The maximum discharge was observed in 2002 at 33.3 m³/s, corresponding to a high-flow phase characterized by increased discharge volumes. **In 2023**, the river's water availability at this station was assessed as moderately high: the average annual discharge was **8.19 m³/s**, which is **3.4% above** the established norm, with an exceedance probability of **36.6 %.**

1.1.6 Shu-Talas WMB

The Shu-Talas water management basin includes the Shu, Talas, and Assy rivers. The basin covers the entire Zhambyl Region and part of the South Kazakhstan Region of the Republic of Kazakhstan. The surface structure of the Shu and Talas river catchments is complex and diverse: the southeastern part consists of mountain ranges and intermountain depressions of the Northern Tien Shan, while the northwestern part consists of plains and lowlands with the sands of the Muyunkum and the Betpak-Dala Desert.

The mountainous part of this territory is the runoff formation zone, occupying the southern and southeastern parts of the area and accounting for about 40 % of the total territory. The central and northwestern parts are occupied by foothill plains and deserts, which belong to the runoff dissipation and equilibrium zone [15].

The Shu River basin is located west of the Issyk-Kul Lake depression and is the largest in the Northern Tien Shan. The relief of the upper basin is characterized by deeply dissected slopes of the Dzhumgol, Karakokty, Baiduly, and Karakudzhur ranges, as well as the eastern end of the Kyrgyz Range and the western end of the Terskey-Alatoo Range, which form the borders of the Kochkor depression. Ancient denudation surfaces are widely developed here, exerting a slowing influence on surface runoff. After passing through the Kochkor and Ortotokoy depressions, the Shu River cuts through the Boom Gorge at the western termini of the Kungey and Kemin ranges, and then emerges into the Shu Valley, which is open and expands westward below the mouth of the Chon-Kemin River.

The total length of the Shu River (together with the Karakhodzhur) is about 1,100 km; the basin area is 148,000 km². Within the Zhambyl Region, it flows for almost 500 km; its width varies from 40 to 100 m, and in the lower reaches–from 10 to 50 m.

Changes in the surface structure of the Shu and Talas river catchments affect runoff formation. Thus, the mountainous area serves as the zone of river runoff formation, while in the plains, runoff is transformed and redistributed among its various components, with losses occurring due to evaporation and irrigation. A series of floodplain shifts indicates that the river has been gradually retreating to the southeast. According to S. S. Neustroev, the Shu River once flowed into the Syrdarya, then retreated to the Askazansor salt flats, later began to dissipate in the Tekey floodplain, and now dries up in the area of the Kamkalinsky lakes, 300 km east of the Syrdarya.

The Talas River basin is bounded to the south by the Talas Alatau Range and to the southwest by the Karatau Range. It is separated from the Shu River basin, located to the northeast, by the crest of the Kyrgyz Range, while in the plains the watershed line between the two basins runs across sandy areas. Between the Talas Alatau and the Kyrgyz Range lies the Talas Valley.

A total of 8,822 rivers with an overall length of 38,486 km are formed within the area under consideration. The total length of the rivers in the Shu and Talas basins is 38,500 km, with an average river network density of 0.45 km/km². River gradients vary widely (from 2 to 200 ‰). The main river is the Shu, with a basin area of 67,500 km² (including endorheic areas in the lower reaches). These rivers belong to a river system that does not drain into the ocean and are part of the Aral Sea basin. It encompasses the basins of the Shu, Talas, and Assy rivers, as well as rivers flowing from the northern slope of the Karatau Range that are hydrologically connected to them.

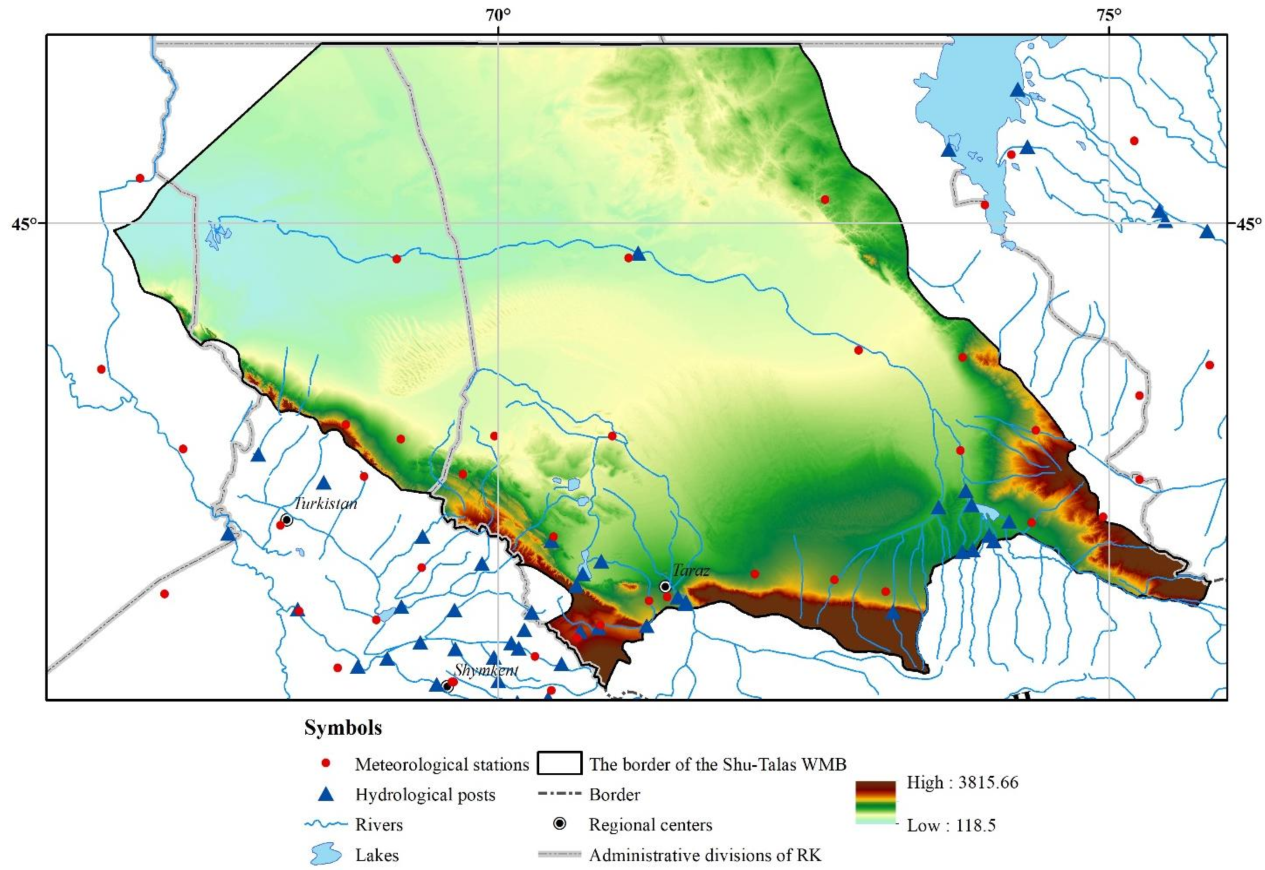


Figure 32 – Physical-geographical map of the Shu-Talas WMB

The region under study is characterized by a diversity of river network types: permanent watercourses, intermittent rivers (sais), dry channels of alluvial plains, and artificial water bodies (canals) that have acquired the characteristics of natural watercourses.

The main hydrographic characteristics of the rivers in the Shu-Talas basin are presented in table 11, and information on the reservoirs is provided in table 12.

Table 11 - Main hydrographic characteristics of major rivers in the Shu-Talas WMB

Name of the watercourse	Mouth / Tributary to	Distance from the mouth, km	Length of the water-course, km	Catchment area, km²
Shu r.	-	846	1186/800	67500
Karakonyz r.	Shu r. (r)	12		490
Kuragaty r.	Shu r. (l)	78	184	7430
Aksu r.	Shu r. (l)	17	155	483
Talas r.	-	458	558	8900
Assa r.	-	252	317	9210
Kurkureusu r.	Assa r. (r)	252		2700
Teris r.	Assa r. (l)	31	70	1070
Merke r.	Kuragaty r. (r)	54		50,5

Table 12 - information on the reservoirs of the Shu-Talas WMB and their key parameters

№	Reservoir Name	Year of commissioning	Total/useful volume, million.m^3	Elevation above sea level,m	Regulation type	Surface area, km^2	Length / width, km
1	Tasotkelskoe	1974	620	499	-	78	18/8,5
2	Teris-Ashchibulak	1962	245	948	-	-	9,2/1,7

Shu River. An analysis of the water discharge dynamics shown in Figure 34 makes it possible to conclude that there is a long-term trend toward decreasing average annual water discharge at the main gauging stations of the Shu-Talas Water management basin over the observation period from 1936 to 2023.

To characterize fluctuations in annual runoff within the Shu-Talas Basin, data were used from the following watercourses, whose runoff is considered conditionally natural: the Shu River at Kainar v., the Talas River at Zhasorken v., and the Assa River at Maymak railway station.

An analysis of the differential integral curves of annual runoff for the Shu-Talas rivers (at the observation points: Shu - Kainar v., Talas River - Zhasorken v., Assa River - Maymak railway station) made it possible to identify **two main phases of water availability – a high-water phase and a low-water phase**, each containing smaller cycles.

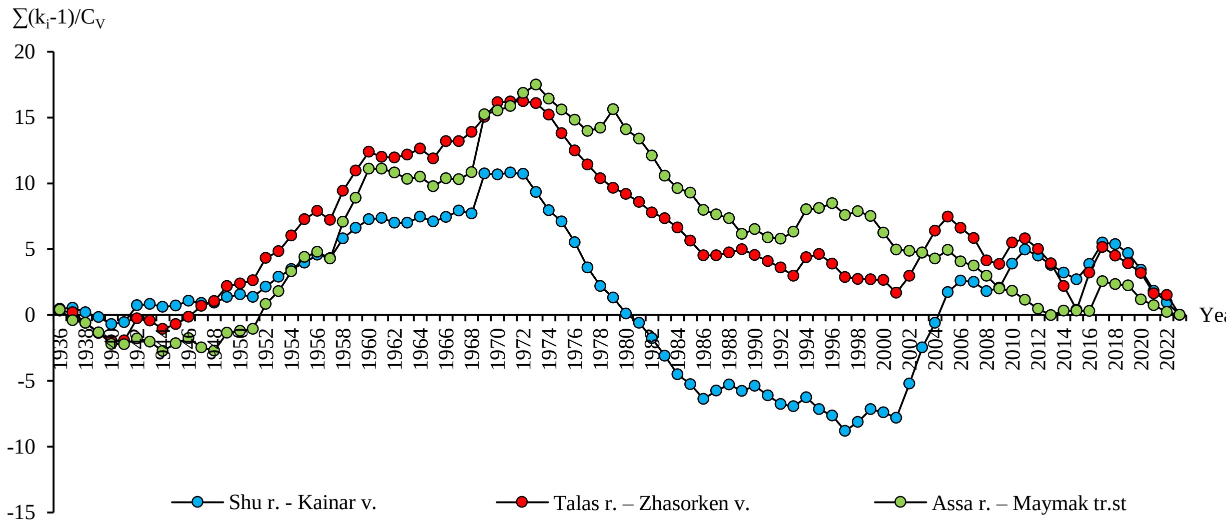


Figure 33 – Differential-integral curves of average annual water discharge for the period 1936-2023

Low-water periods are observed from 1936 to 1948, then from 1974 to 2001, from 2007 to 2009, again from 2013 to 2015, and from 2019 to 2023, during which a persistent decrease in annual runoff is characteristic. Between these periods, high-water phases are observed: from 1949 to 1973, from 2002 to 2006, from 2010 to 2012, and again from 2016 to 2018, characterized by increased runoff volumes, which is associated with more favorable hydrometeorological conditions. These phases are clearly reflected in the differential-integral curves of annual runoff (Figure 33) at the main gauging stations of the Shu-Talas River, allowing the conclusion that there are stable cyclical fluctuations in water availability in the basin.

Shu r. – Kainar v. Based on the analysis of the average annual water discharge of the Shu River at the Kainar gauging station for the period 1936-2023, a stable trend of decreasing water availability has been identified, as confirmed by the direction of the trend line. The long-term average annual runoff is **57.5 m³/s.** The minimum average annual discharge during the period under consideration was recorded in 1977 – 28.7 m³/s, which is attributed to that year belonging to the low-water phase of the hydrological regime of the Shu-Talas basin, established through the analysis of water availability phases. The maximum discharge was observed in 1969 and amounted to 100 m³/s, corresponding to a high-water phase characterized by increased runoff volumes. **In 2023**, the river's water availability at this station **remained low**: the average annual discharge was **45.7 m³/s,** which is **20.5 % below** the established norm, with an exceedance probability of **79.9 %.**

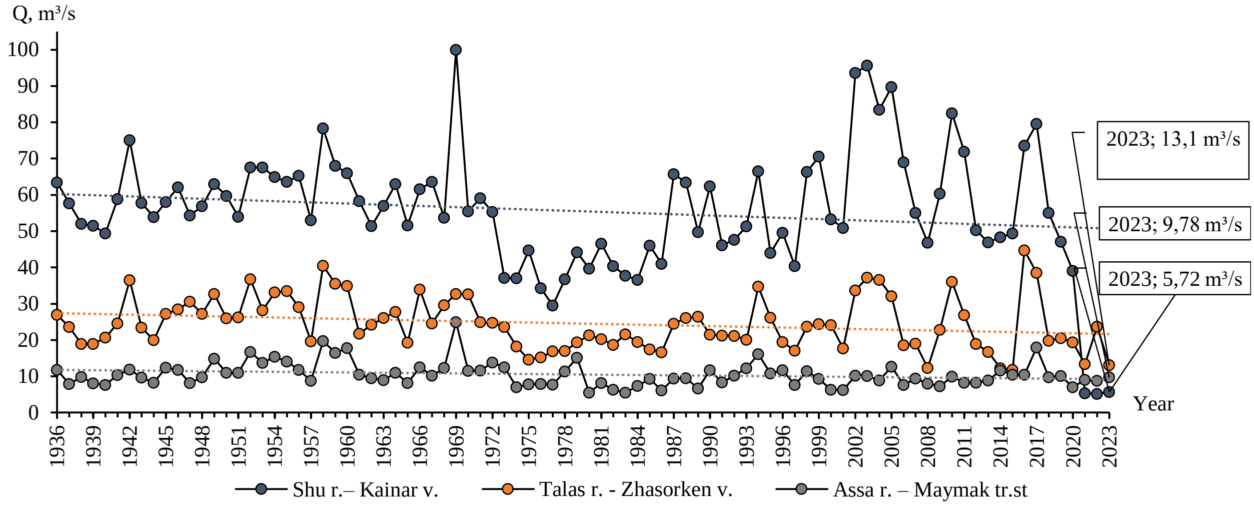


Figure 34 – Dynamics of changes in average annual water discharge

- **Talas r. – Zhasorken v.** Based on the analysis of the average annual water discharge of the Talas River at the Zhasorken gauging station for the period 1936-2023, a stable trend of decreasing water availability has been identified, as confirmed by the direction of the trend line. The long-term average annual runoff is **30.8 m³/s.** The minimum average annual discharge during the period under consideration was recorded in 2015 – 11.8 m³/s, which is attributed to that year belonging to the low-water phase of the basin's hydrological regime, established through the analysis of water availability phases. The maximum discharge was observed in 2016 and amounted to 44.7 m³/s, corresponding to a high-water phase characterized by increased runoff volumes. **In 2023**, the river's water availability at this station **remained low**: the average annual discharge was **13.1 m³/s**, which is **57.5 % below** the established norm, with an exceedance probability of **99.9 %.**

- **Assa r. – Maymak tr. st.** Based on the analysis of the average annual water discharge of the Assa River at the Maymak railway station for the period 1936-2023, a stable trend in water availability has been identified, as confirmed by the direction of the trend line. The long-term average annual runoff is **11.7 m³/s**. The minimum average annual discharge during the period under consideration was recorded in 1980 – 5.48 m³/s, which is attributed to that year belonging to the low-water phase of the basin's hydrological regime, established through the analysis of water availability phases. The maximum discharge was observed in 1969 and amounted to 24.9 m³/s, corresponding to a high-water phase characterized by increased runoff volumes. **In 2023**, the river's water availability at this station remained moderately low: the average annual discharge was **9.78 m³/s**, which is **16.4 % below** the established norm, with an exceedance probability of **69.5 %.**

1.1.7 Nura-Sarysu WMB

The Nura-Sarysu water management basin includes the basins of the Nura and Sarysu rivers (Figure 35). The total area of the basin is 290,210 km², distributed across the regions as follows: Akmola – 16,028.8 km², Karaganda – 26,461.6 km², Kyzylorda – 4,655 km², South Kazakhstan – 491 km². The basin lies within an endorheic (closed) drainage area. Within its boundaries are located the Teniz-Korgalzhyn depression and the adjacent basins of the Nura, Kulanotpes, and several other watercourses that terminate in closed lakes – Teniz, Korgalzhyn, Kirey, Kypshak, Kokakol, and others. The Sarysu River, which belongs to the Syrdarya basin, is also included in this area.

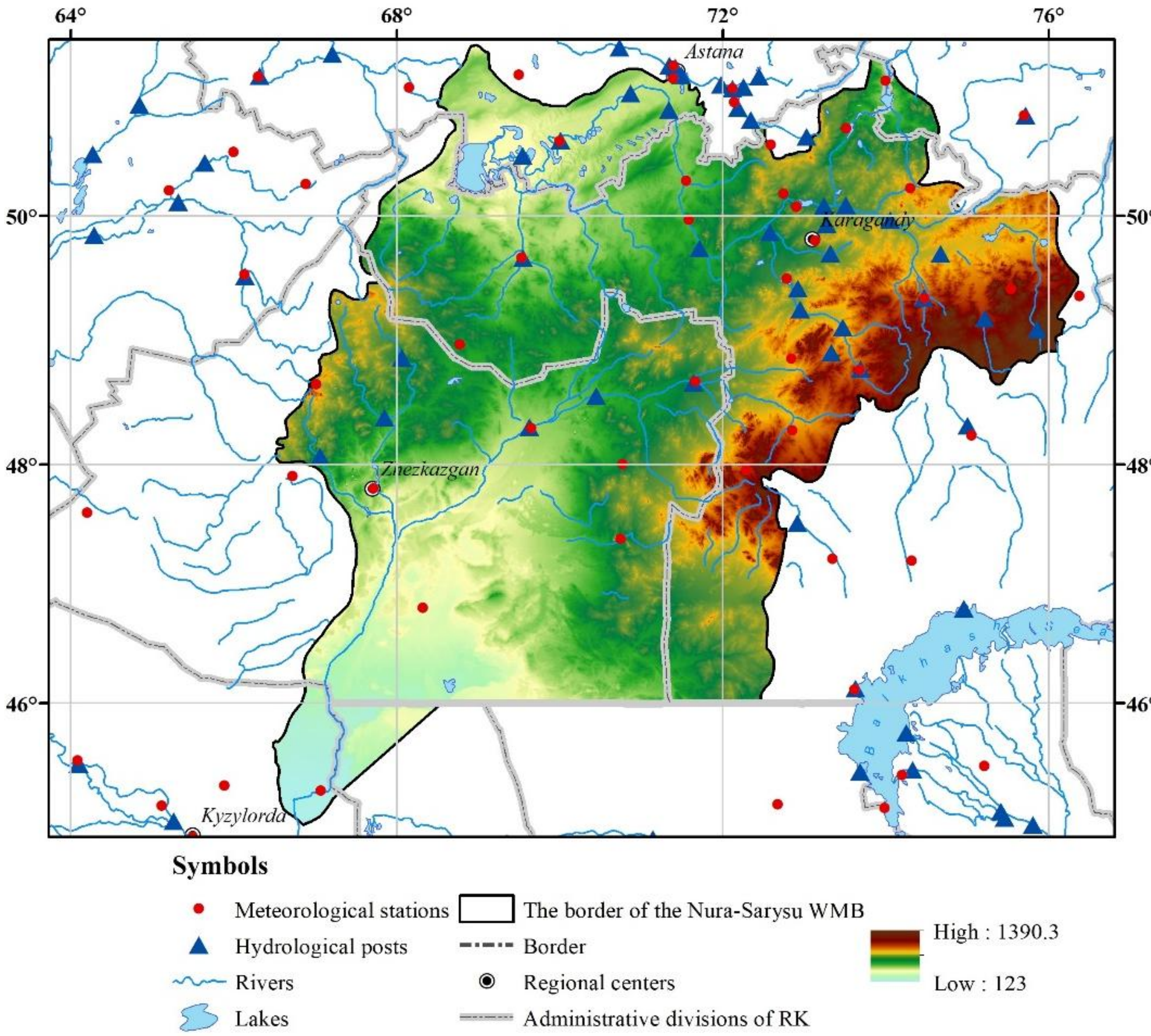


Figure 35 – Physical-geographical map of the Nura-Sarysu WMB

The Nura River originates in the western part of the Kazakh Uplands at an elevation of 1,100-1,200 m above sea level in the Karaganda Region. After passing through the system of Korgalzhyn lakes, it flows into the endorheic Lake Teniz (340 m a.s.l.), located within the Akmola Region. The river's catchment area is 60,800 km² (excluding the endorheic basin of the Zharly River – 55,100 km²), of which the endorheic areas occupy 6,500 km² (12% of the catchment). The river is 978 km long, with a total fall of 756 m, an average gradient of 0.77 m/km, and a river network density of 0.16 km/km². The largest watercourses in the basin are the Sherubainura River (250 km), Akbastau (83 km), Matak (54 km), Ashchisu (86 km), Sokur (102 km), Ulkenkunduzdy (115 km), Yesen (85 km), and others. The watershed with the Esil River is weakly expressed.

The Sarysu River is formed by the confluence of two tributaries – Zhaksy-Sarysu and Zhaman-Sarysu – and flows into Lake Telekol. It is considered that the river's length from the confluence of its tributaries is 761 km, but this length is not constant and varies between low-water and high-water years. The basin area is 81,600 km². The average weighted gradient is 0.62 ‰, and the average catchment elevation is 490 m. The river's hydrographic length is significantly greater. If the source of the river is taken as the right tributary, the Zhaman-Sarysu – the Kairakty River – then the length of the main river in the system exceeds 950 km [4].

The main rivers of the Nura-Sarysu Water management basin with gauging stations are the Nura, Sherubainura, Sarysu, and Karakengir rivers. An analysis of changes in the runoff of the Nura and Sarysu rivers within the territory of the Republic of Kazakhstan was carried out for the main gauging stations according to the list of standard water resource tables for the main river basins and their sections.

Table 13 - Main hydrographic characteristics of major rivers in the Sarysu river basin

Name of the watercourse	Mouth / Tributary to	Distance from the mouth, km	Length of the water-course, km	Catchment area, km ^{2}
r. Zhaman-Sarysu	r. Sarysu (l)	761	155	9200
r. Zhaksy-Sarysu	r. Sarysu (r)	761	113	3510
r. Kara-Kengir	r. Sarysu (r)	384	295	18400
r. Taldy-Manaka	r. Sarysu (l)	706	158	3950
r. Aktasty	r. Sarysu (r)	735	58	1060
r. Atasu	r. Sarysu (l)	705	177	5920
r. Syurtysu	r. Sarysu (r)	604	104	6300
r. Sary-Kengir	r. Karakengir (l)	138	143	3880
r. Zhilandy	r. Karakengir (r)	88	100	2860
r. Zhezdy	r. Karakengir (r)	26	91	3850
r. Karagandy	r. Karakengir (r)	203	54	721
r. Koktas	Disappears in sands	-	142	6560

The Sarysu River basin contains 20 lakes and reservoirs with a total area of 231 km². The lakes are shallow, saline, and for the most part, dry up by the end of summer. The lake basins are usually round or elongated along the course of the main river that feeds them. Data on the number of reservoirs are given in table 14.

Table 14 - Information on the reservoirs of the Nura-Sarysu WMB

Reservoir	River or site of reservoir formation	Distance from the mouth, km	Year of commissioning	Surface area, км ^{2}	Design capacity, million m³	
					Total	Useful
Kengir	r. Karakengir	62,0	1952	37,3	319	311
Zhezdy	r. Zhezdy	25,0	1968	17,6	76,0	72,5
Aktasty	r. Aktasty		1981	15,7	77,0	65,3
Chkalov	r. Karagandinka		1964		6,45	5,5

Hydrological regime and water availability phases of the Nura-Sarysu WMB rivers

To characterize fluctuations in annual runoff within the Nura-Sarysu water management basin, data were used from the following watercourses, whose runoff is considered conditionally natural: Nura River - Balykty railway station, Nura River - R. Koshkarbaev v., Sherubainura River - Karamuryn section, Sarysu River - Section No. 189, Karakengir River - 12 km upstream of the mouth of the Zhilandy River.

An analysis of the differential-integral curves of annual runoff for the Nura, Sherubainura, and Sarysu rivers (at the observation points: Balykty railway station, R. Koshkarbaev v., Karamuryn section, and Section No. 189) made it possible to identify **two main phases of water availability – high-water and low-water** – each of which contains smaller cycles (Figure 36). Low-water periods for the Nura and Sherubainura rivers are observed from 1932 to 1947, 1950 to 1953, 1962 to 1976, 1993 to 2000, 2004 to 2013, and again from 2021 to 2023, during which a persistent decrease in annual runoff is characteristic. For the Sarysu River, low-water periods occurred from 1932 to 1940 and 1950 to 1953, followed by a long-term low-water period from 1962 to 2001 and from 2004 to 2015. Between these periods, high-water phases are observed: for the Nura and Sherubainura rivers from 1947 to 1950, 1954 to 1961, 1990 to 1992, 2001 to 2003, and 2014 to 2020; for the Sarysu River from 1941 to 1950, 1954 to 1961, and 2016 to 2021. These phases are characterized by increased runoff volumes, associated with more favorable hydrometeorological conditions. These phases are clearly reflected in the differential-integral curves of annual runoff (Figure 36) at the main gauging stations of the Nura and Sherubainura rivers, allowing the conclusion that there are stable cyclical fluctuations in water availability in the basin.

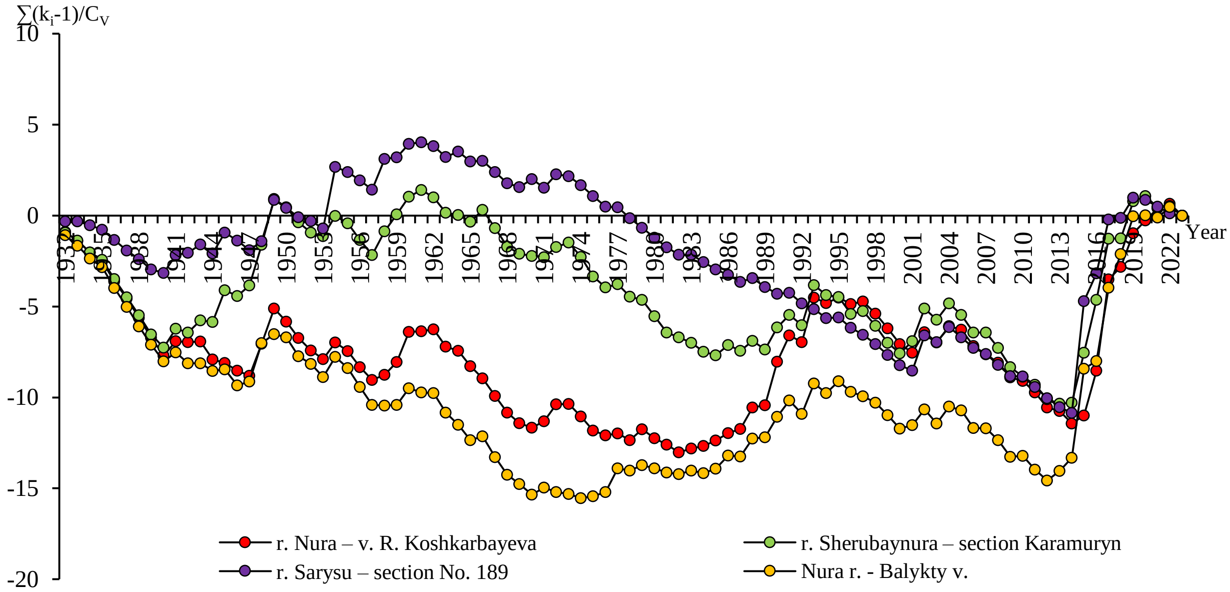


Figure 36 – Differential-integral curve of average annual water discharge for the period 1932-2023

An analysis of the differential-integral curve of annual runoff for the Karakengir River – 12 km upstream of the mouth of the Zhilandy River (Figure 37) – indicates the presence of alternating water availability phases, characterized by long-term fluctuations in runoff. During the period under study, two main phases of water availability were identified: high-water and low-water, each of which includes shorter-duration cycles. High-water phases were observed from 1940 to 1943, 1947 to 1949, 1969 to 1973, 1975 to 1989, 2001 to 2005, and 2014 to 2018, indicating increased annual runoff during these years. Low-water phases occurred during 1932 to 1939, 1943 to 1949, 1950 to 1968, 1997 to 2001, 2006 to 2013, and again from 2019 to 2023, during which runoff values were below the norm (Figure 37).

An analysis of changes in the runoff of the Nura and Sarysu rivers was carried out for the main gauging stations according to the list of standard water resource tables for the main river basins and their sections.

Nura River. An analysis of runoff dynamics shows that since 1932 there has been a trend toward an increase, which is associated with the impact of climate change.

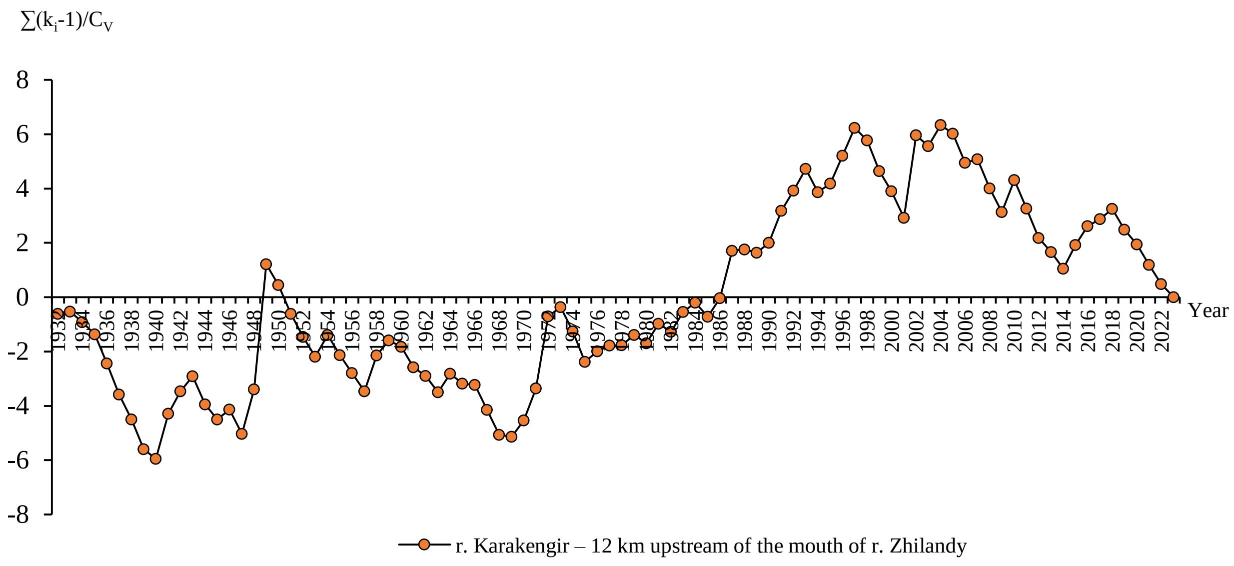


Figure 37 – Differential-Integral curve of average annual water discharge of the Karakengir river - 12 km Upstream of the mouth of the Zhilandy River for the period 1932-2023

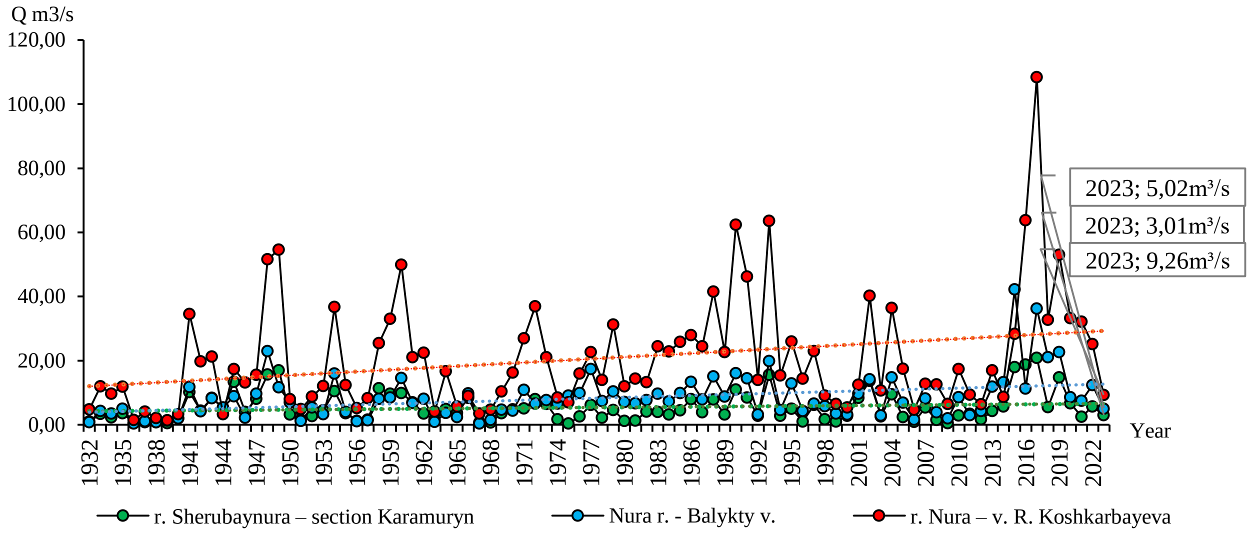


Figure 38 – Dynamics of changes in average annual water discharge

- **Nura r.– Balykty r.s.** The long-term average annual runoff is 7.47 m³/s. According to data for the period 1932-2023, there is a trend of increasing average annual runoff. During this period, the maximum discharge was 42.2 m³/s (2015), and the minimum was 0.36 m³/s (1936). At this gauging station, the river's runoff **in 2023 was moderately low**, with an exceedance probability of **61.9 %.**
- **Nura r. – R. Koshkarbaev v.** The long-term average annual runoff is 20.6 m³/s. According to data for the period 1932-2023, there is a pronounced trend of increasing average annual runoff. During this period, the maximum discharge was 108.46 m³/s (2017), and the minimum was 1.44 m³/s (1939). At this gauging station, the river's runoff **in 2023** was **moderately low**, with an exceedance probability of **78.5 %.**
- **Sherubaynura r. – Karamuryn section.** The long-term annual runoff norm is 5.23 m³/s. According to data for the period 1932–2023, runoff has generally remained within this norm. During the specified period, the maximum discharge was 20.9 m³/s (2017), and the minimum was

0.40 m³/s (1975). At this hydrological gauging station, the river runoff **in 2023** was **moderately low**, with an exceedance probability of **63.9 %.**

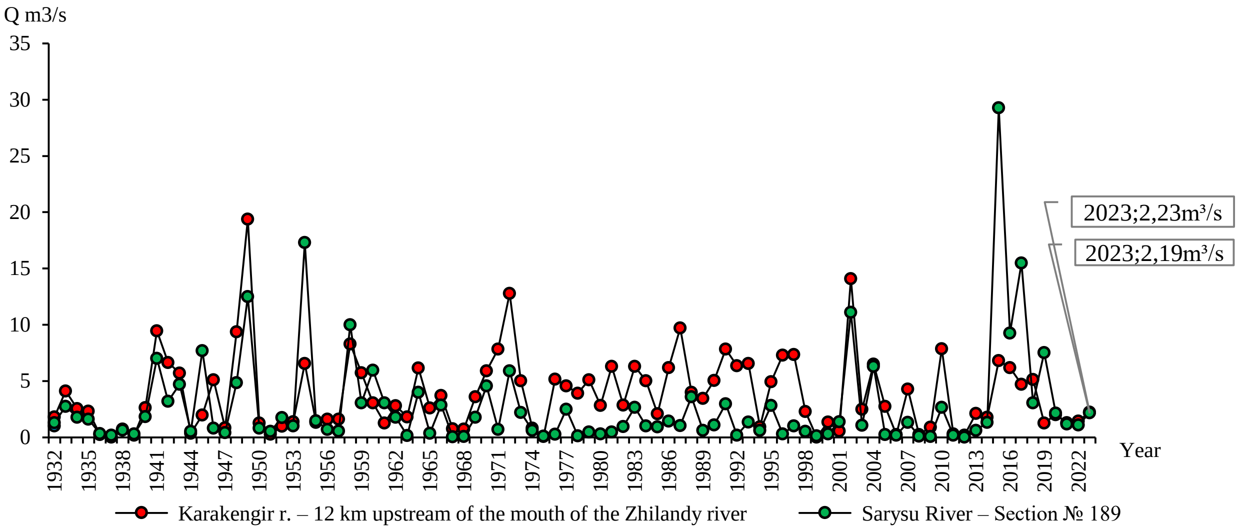


Figure 39 – Dynamics of changes in average annual water discharge

- **Sarysu r. – Section № 189.** The long-term average annual runoff is **2.71 m³/s**. According to data for the period 1932-2023, there is a trend of moderate increase in average annual runoff. During this period, the maximum discharge was 29.3 m³/s (2015), and the minimum was 0.02 m³/s (2012). At this gauging station, the river's runoff **in 2023** was of **average water availability**, with an exceedance probability of **43.18 %.**
- **Karakengir r. – 12 km upstream of the mouth of the Zhilandy river.** The long-term average annual runoff is **3.85 m³/s.** According to data for the period 1932-2023, there is a trend of decreasing average annual runoff. During this period, the maximum discharge was **19.4 m³/s** (1949), and the minimum was 0.01 m³/s (1999). At this gauging station, the river's runoff **in 2023** was moderately low, with an exceedance probability of **67.34 %.**

1.1.8 Tobyl-Torgay WMB

The Tobyl-Torgay water management basin includes the basins of the Tobyl, Torgay, and Irgiz rivers. It comprises the territories of the northern, central, and western parts of the Republic of Kazakhstan, covering the Akmola, Aktobe, Karaganda, and Kostanay regions. The total area of the basin is 347,679.5 km², including: Akmola Region – 16,883 km², Aktobe Region – 95,365.3 km², Karaganda Region – 60,236.2 km², Kostanay Region – 190,389.7 km².

The boundaries of the basin are as follows: to the east – the watershed with the Esil River basin; to the south – the elevations of Central Kazakhstan, separating the basin from the Nura-Sarysu water management basin; to the west – the Turgay Plateau, sloping toward the Aral-Syrdarya Basin; to the north, the basin is limited by the state border with the Russian Federation.

Among all water management basins of Kazakhstan, the Tobyl-Torgay Basin is the least supplied with water resources: their total volume is only 2.9 km³, of which about 15% accounts for groundwater. Surface resources are distributed as follows: 33% in lakes, 17% in reservoirs, and 35% in river channels (Figure 40).

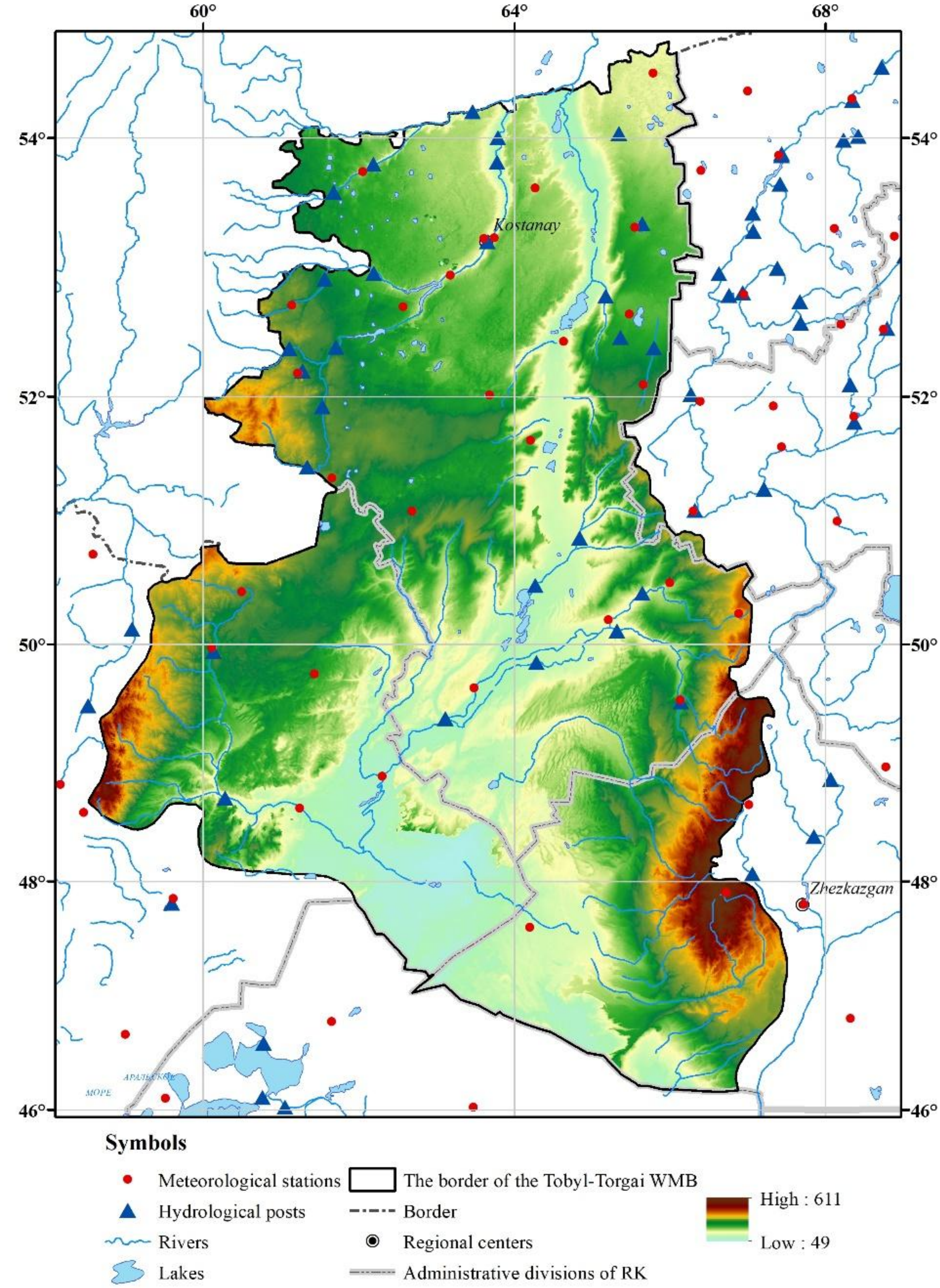


Figure 40 – Physico-geographical map of the Tobyl-Torgay WMB

The Tobyl River is a river in Kazakhstan and Russia, the left and most full-flowing tributary of the Ertis River, and the main water artery of the Tobyl-Torgay water management basin. In total, there are 25 hydrological posts in the Tobyl-Torgay water management basin according to the EDS data for 2023 [16]. The Tobyl River is formed by the confluence of the Bozbie and Kokpektysay rivers on the border of the eastern spurs of the Southern Zhaiyk. The river length is 1,591 km, and the basin area is 395,000 km² (within the Kostanay Region – up to the mouth of the Ubagan River, only the upper course of the river with a length of 682 km and part of its catchment area of 121,000 km² is located).

The Torgay River is formed by the confluence of the Zhaldama and Kara-Torgay rivers in the south-eastern part of the Kostanay Region, and beyond its limits it receives the largest right-bank tributary – the Irgiz River. The river length is 662 km, from the source of the Kara-Torgay 946 km, with a catchment area of 134,000 km². The Torgay River basin also includes the area of Lake Sarykopa.

Table 15 presents the main data on the hydrographic characteristics of the Tobyl and Torgay river basins and their tributaries.

Table 15 - Main hydrographic characteristics of the Tobyl and Torgay river basins and their tributaries

Name of the watercourse	Mouth / Tributary to	Distance from the mouth, km	Length of the watercourse, km	Catchment area, km ^{2}
Ayat r.	Tobyl r. (L)	1275	94/117	4500/13300
Togyzak r.	Uy r. (R)	-	131/246	3120/8860
Zhelkuar r.	Tobyl r. (L)	1418	152	5100
Ubagan r.	Tobyl r. (R)	909	376*	27300
Uy r.	Tobyl r. (L)		462	34400
Sintashty r.	Tobyl r. (L)	1418	52/145	1900/5100
Kamystyayat r.	Arshagly-Ayat r. (L)	-	46	2990
Karasu r.	Lake Karasor	-	60	717
Alabuga r.	Tobyl r. (R)	882	60	882
Kara-Torgay r.	Torgay r. (L)		284	15500
Sarytorgay r.	Kara-Torgay r. (L)		123	
Irgiz r.	Torgay r. (R)		593	31600

Table 16 - Information on reservoirs of the Tobyl-Torgay WMB

Reservoir	Distance from the mouth, km	Year of commissioning	Surface area	Design capacity, mil. m³	
				Total	Useful
Zhelkuarskoye		1965	7,7	34,0	30,0
Amangeldinskoye	1210	1967	4,16	6,75	6,22
Sergeyevskoye	1227	1959	0,20	3,68	3,66
Karatamarskoye	1245	1966	94,0	586	562
Kyzylzharskoye	1329	1971	2,98	9,73	7,66
Verkhne-Tobylskoye	1344	1971	87,4	817	781

Hydrological regime and flow phases of the rivers of the Tobyl-Torgay WMB

To characterize the annual runoff fluctuations in the territory of the Tobyl-Torgay water management basin, data from the following watercourses, whose runoff is considered conditionally natural, were used: Tobyl River - Grishenka, Tobyl River - Kostanay, Ayat River - Varvarinka, Togyzak River - Togyzak, Kara-Torgay River - Urpek, Irgiz River - Shenbertal.

Analysis of the differential integral curves of the annual runoff of the Tobyl, Torgay, and Togyzak rivers (Tobyl River - Grishenka, Tobyl River - Kostanay, Ayat River - Varvarinka, Togyzak River - Togyzak, Irgiz River - Shenbertal) revealed the presence of two main flow phases – high-water and low-water, each of which contains minor cycles. Low-water periods were observed in 1931-1940, 1948-1956, 1958-1969, 1972-1989, 1990-1993, 1996-1999, 2008-2012, and 2018-2023, characterized by a stable decrease in annual runoff. Between them, high-water phases occurred in 1941-1947, 1956-1958, 1970-1972, 1993-1995, 2000-2007, and 2013-2017, marked by an increase in runoff volumes due to more favorable hydro-meteorological conditions. These phases are clearly traced on the differential integral curves of annual runoff (Figure 41) at the main gauging stations of the Tobyl-Torgay basin rivers, indicating the presence of stable cyclical fluctuations in river flow.

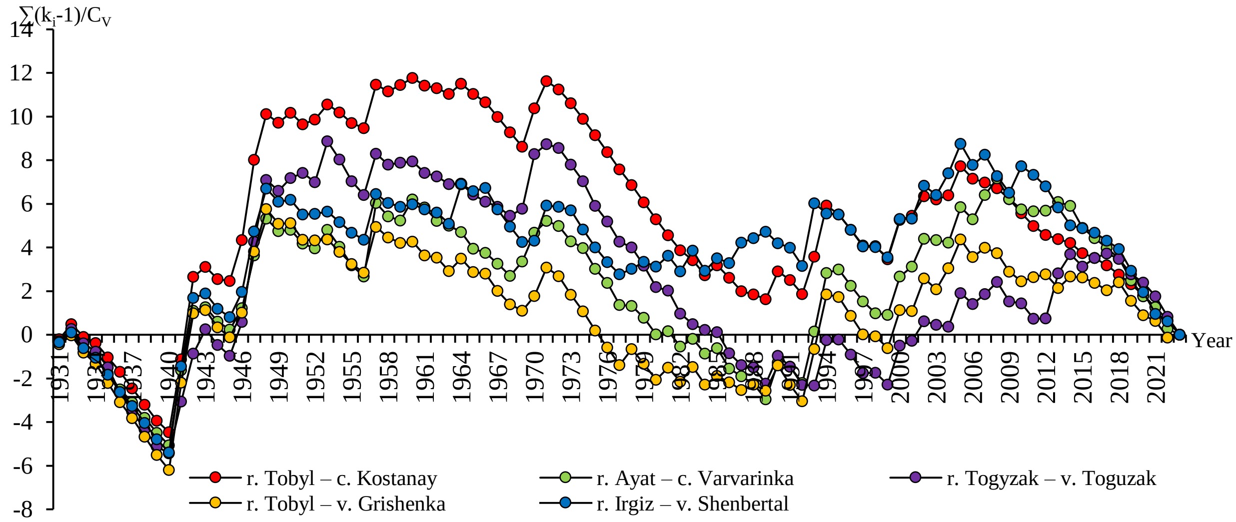


Figure 41 – Differential-integral curve of the mean annual water discharge for the period 1931-2023

Based on the differential-integral curves of the annual runoff at the Kara-Torgay r. - Urpek st., patterns of flow phase fluctuations were identified, represented by alternating periods of low and high water. Low-water phases occurred during 1931-1940, 1943-1947, 1949-1952, 1966-1969, and again from 1998 to 2014 and in 2023, characterized by a decrease in annual runoff volumes. Between them, high-water intervals were recorded in 1940-1942, 1947-1949, 1969-1974, 1991-1993, 1995-1997, and 2015-2022, when an increase in water flow was observed under favorable hydro-meteorological conditions. These flow fluctuations are clearly reflected in the differential-integral curves (Figure 41), indicating the presence of stable cycles in the dynamics of water resources of the Tobyl-Torgay basin.

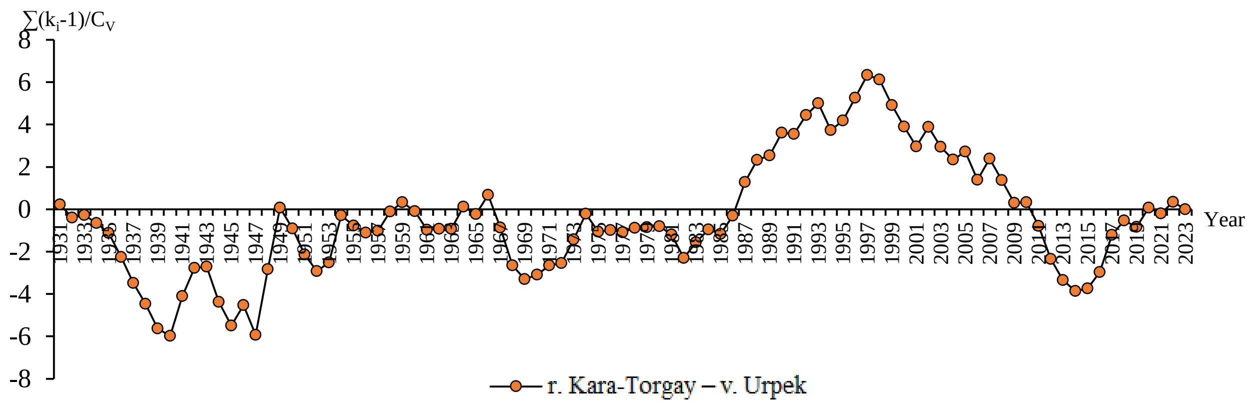


Figure 42 – Differential-integral curve of mean annual water discharge for the period 1931-2023

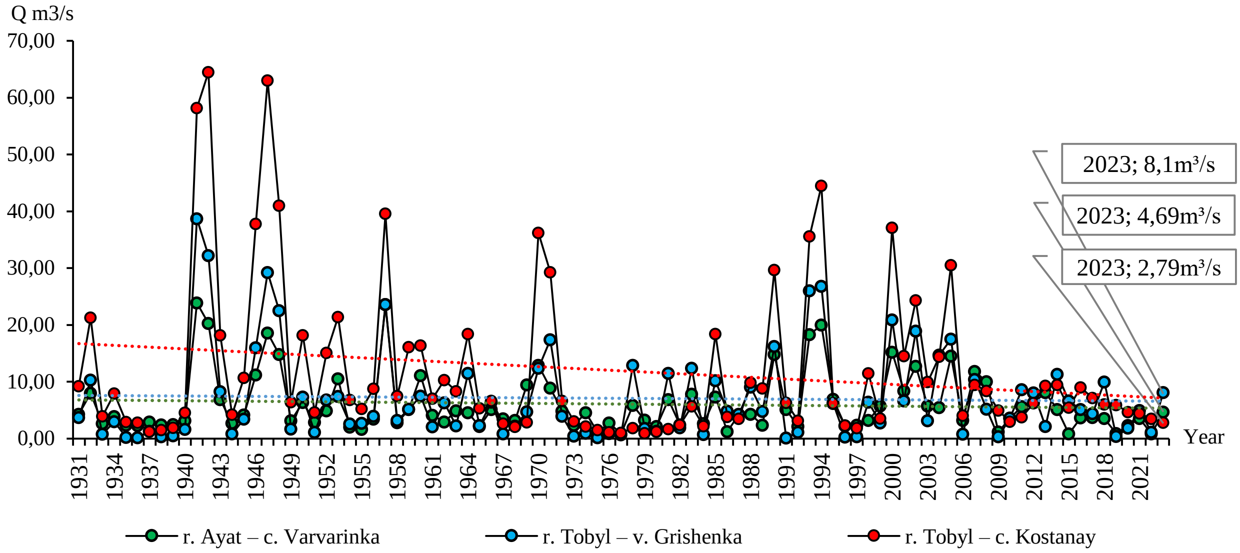


Figure 43 – Dynamics of changes in mean annual water discharge

- **Tobyl r. – Grishenka v.** The long-term mean annual runoff is **7,07 m³/s**. According to data for the period 1931-2023, a moderate decreasing trend in mean annual runoff values is observed. During this period, the maximum discharge was 27 m³/s (1941), and the minimum was 0.12 m³/s (1991). At this gauging station, the river flow in **2023** was **moderately high**, with an exceedance probability of **30,0 %.**
- **Tobyl r. – Kostanay c**. The long-term mean annual runoff is **11.9 m³/s**. According to data for the period 1931-2023, a moderately pronounced decreasing trend in mean annual runoff values is observed. During this period, the maximum discharge was 64.5 m³/s (1942), and the minimum was 0.93 m³/s (1979). At this gauging station, the river flow in 2023 was **moderately high**, with an exceedance probability of **34 %**.
- **Ayat r. – Varvarinka v**. The long-term mean annual runoff is **6,065 m³/s**. According to data for the period 1931-2023, a moderately pronounced decreasing trend in mean annual runoff values is observed. During this period, the maximum discharge was 20 m³/s (1941), and the minimum was 0.81 m³/s (2015). At this gauging station, the river flow in **2023** was of **medium water level**, with an exceedance probability of **46 %**.
- **Togyzak r. – Togyzak v**. The long-term mean annual runoff is 2.775 m³/s. According to data for the period 1931-2023, a moderate decreasing trend is observed. During this period, the maximum discharge was 10.7 m³/s (1947), and the minimum was 0.26 m³/s (1936). At this gauging station, the river flow in **2023** was **low**, with an exceedance probability of **80,0 %.**
- **Kara-Torgay r. – Urpek v.** The long-term mean annual runoff is 10,012 m³/s. According to data for the period 1931-2023, a weakly expressed decreasing trend in mean annual runoff values is observed. During this period, the maximum discharge was 26,3 m³/s (1948), and the minimum was 0,74 m³/s (1968). At this gauging station, the river flow **in 2023** was of **medium water level**, with an exceedance probability of **57,0 %.**

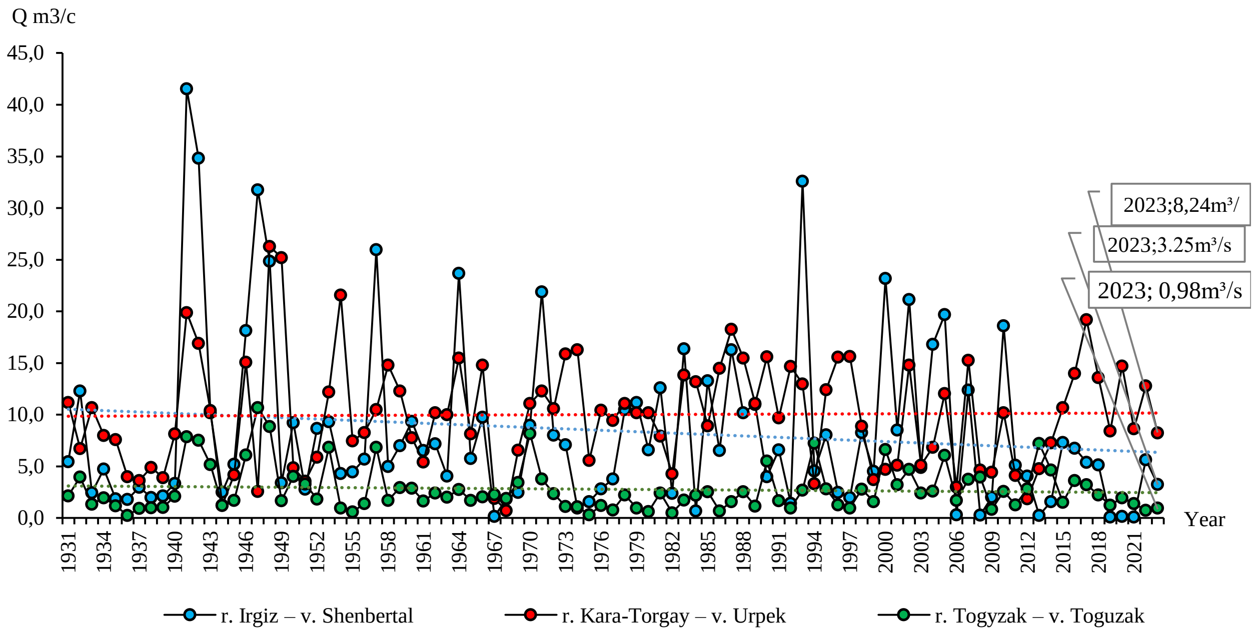


Figure 44 – Dynamics of changes in mean annual water discharge

- **Irgiz r. – Shenbertal v**. The long-term mean annual runoff is 8,45 m³/s. According to data for the period 1931-2023, a weakly expressed decreasing trend in mean annual runoff values is observed. During this period, the maximum discharge was 41,5 m³/s (1941), and the minimum was 0,1 m³/s (2021). At this gauging station, the river flow **in 2023** was **moderately low**, with an exceedance probability of **65 %.**

1.2 Analysis of the state and dynamics of total, local water resources and annual inflow for the Republic of Kazakhstan as a whole

The Republic of Kazakhstan is among the least water-secure countries in Central Asia. The severity of Kazakhstan's water supply problem is due to the limited availability of water resources, their uneven distribution across the territory, and significant temporal variability. In terms of river runoff, its directional changes are influenced not only by climatic factors but also by anthropogenic alterations.

Therefore, studying the patterns of renewable water resource distribution across the republic, which constitute the main source of fresh water, is highly relevant. In recent years, the issue of assessing renewable water resources has acquired an extremely acute social and political significance. This is due to the increasing role of anthropogenic factors related to water consumption by the population, industry, and agriculture of both the Republic of Kazakhstan and neighboring countries, as well as changes in global and regional climate [17].

Methodology. Annual river runoff resources are determined as the sum of surface waters formed within the territory of Kazakhstan and inflows from neighboring countries within the eight water management basins (WHB). Calculations were carried out using data from hydrological posts of RSE «Kazhydromet» which record natural runoff, or using reconstructed values when economic activities were present.

Runoff norms were determined, as previously described, for the period 1932-2007. Figure 45 presents long-term characteristics of surface water resources by basins.

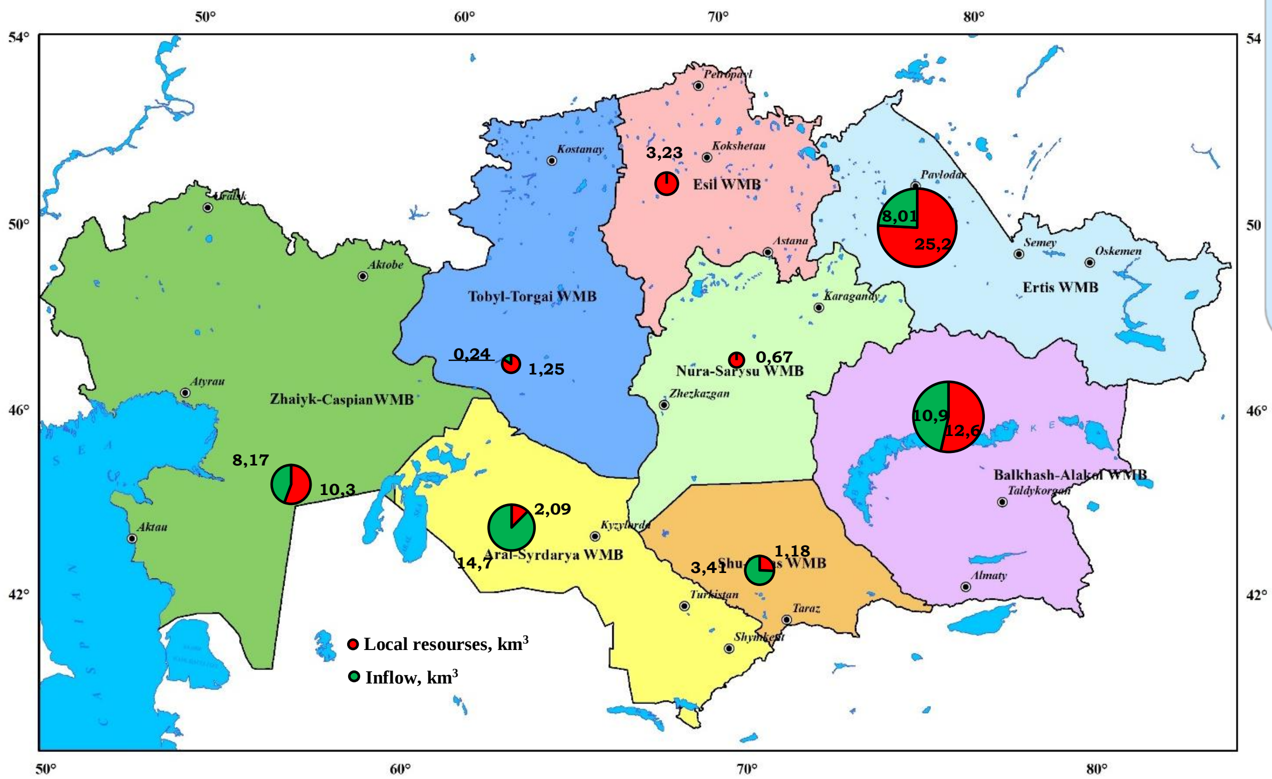


Figure 45 – Long-term characteristics of surface water resources by water management basins and the Republic of Kazakhstan

Fluctuations of annually renewable water resources over time are cyclical [4]. Extended periods of wet and dry years result in series (periods) of high-water and low-water years of varying duration. Observed values of water resources in river basins over the periods considered include intervals during which runoff dynamics may be disrupted either by unidirectional changes in climatic cycles or by the impact of economic activities [6].

Figure 46 shows the dynamics of total water resources of the Republic of Kazakhstan for the period 1932-2023.

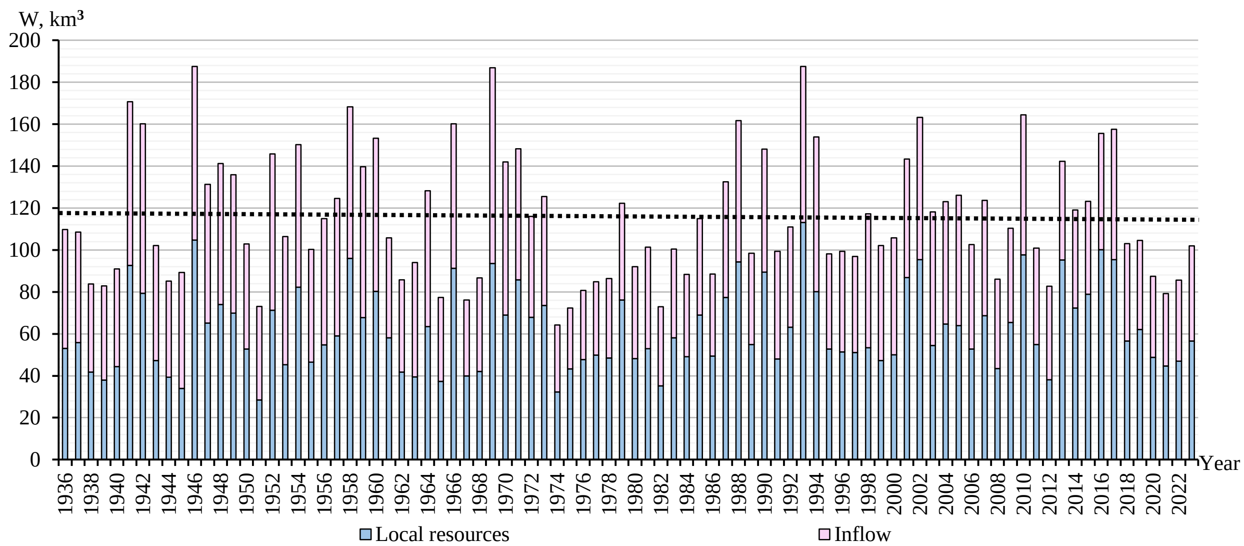


Figure 46 – Dynamics of water resources of the Republic of Kazakhstan for the period 1932-2023

During the period from 1932 to 2023, a stable declining trend in total water resources is observed in the Republic of Kazakhstan. Long-term average river runoff values significantly exceed the actual figures of recent years. The main factors are climate changes (increased air temperature, glacier degradation, reduction of snow reserves), alterations in the seasonal runoff regime (an increase in the share of winter and spring runoff with a simultaneous decrease in summer runoff), as well as the growth of anthropogenic impacts. A significant role is also played by the reduction of transboundary inflows, associated with increased water consumption in neighboring countries. Together, these processes lead to a growing water deficit, increased intersectoral competition, and heightened risks for water management and ecological security.

1.2.1 Assessment of water resources of the Ertis WMB for 2023

- The **inflow** from China into the basin is taken as the observed discharge of the Kara Ertis River at the gauging station near Boran v. The long-term average annual runoff **is 301 m³/s**, or 9.49 km³/year. During the period under consideration, the minimum runoff was observed in 1982 at 134 m³/s, or 4.23 km³/year, and the maximum in 1964 at 478 m³/s, or 15.1 km³/year. At this gauging station, the river's runoff **in 2023** was **moderately low**, with an exceedance probability of **70.8 %**. The average annual water discharge in 2023 was **254 m³/s**, which is 15.6% below the established norm (301 m³/s).
- **The local runoff of the basin**, i.e., the local water resources formed within the basin in the territory of Kazakhstan, are estimated using a relationship equation based on the sum of five major rivers in the basin with the highest water availability. These rivers mainly determine the surface water resources and together account for about 70% of all local water resources. These rivers are the Kalzhyr, Kurshim, Bukhtyrma, Ulbi, and Oba, for which the natural runoff values are preliminarily calculated.

The long-term average volume of local runoff is **852 m³/s**, or **26.9 km³/year**. For the observed period from 1933 to 2023, the runoff trend remains within the norm. During this period, the maximum runoff volume was 67.4 km³ (2013), and the minimum was 8.6 km³ (1951). The local runoff **in 2023** was of **average water availability**, with an exceedance probability of **50.5 %.**

- **Total Resources of the Ertis Water management basin.** The long-term average volume of total water resources is **36.4 km³/year**. For the period 1933-2023, the trend remains within the norm of runoff volume. During this period, the maximum volume was 78.9 km³ (2013), and the minimum was 14.7 km³ (1951). The total water resources **in 2023** were of **average water availability**, with an exceedance probability of **50.5 %.**
- An analysis of the hydrological characteristics of the Ertis Water management basin for 2023 allows the year to be classified as one of average water availability. The transboundary inflow through the Ertis River at the gauging station near Boran v. was below the long-term average, which is attributed to the natural interannual variability of the water regime. The formation of local runoff within the territory of the Republic of Kazakhstan occurred mainly due to major rivers – Kalzhyr, Kurshim, Bukhtyrma, Ulbi, and Oba – whose combined discharges remained within normative values.

Table 17 - Water resources of the Ertis WMB for 2023, km³/year

WMB	Long-term characteristics of water resources			Annual water resources for 2023	
	average	at exceedance probability 5%	at exceedance probability 95%	value	exceedance probability, %
Ertis	**36,4**	**59,9**	**19,2**	**33,2**	**50,5**
local resources	26,9	46,0	13,4	25,2	50,0
inflow	9,5	13,9	5,80	8,01	70,8

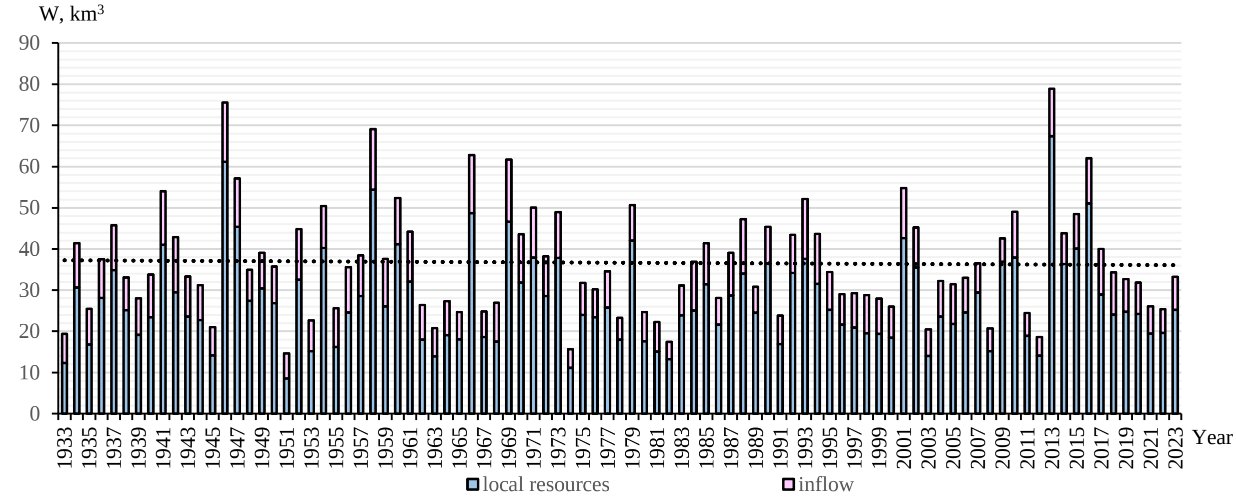


Figure 47 – Dynamics of annual river runoff resources of the Ertis WMB for the period 1933-2023

The total volume of water resources in the basin in 2023 was within the range typical for long-term variability and corresponded to the region's usual climatic conditions. Overall, the hydrological situation in the reporting year remained stable, without signs of abnormally high or low water levels.

1.2.2 Assessment of Water Resources of the Balkhash-Alakol WMB for 2023

The inflow into the basin is taken as the observed discharge of the Ili River at the Dobyn gauging station. The long-term average annual runoff is **12.4 km³.** According to data for the period 1930-2023, there is a moderately pronounced trend of decreasing average annual runoff. During this period, the maximum discharge was 642 m³/s (2016) and the minimum was 287 m³/s (2014), corresponding to the high- and low-water phases. **In 2023**, the river's runoff fell into the category of **moderately low water availability**, with an exceedance probability of **73.4 %.**

The local runoff of the basin, i.e., the local water resources, is estimated using a relationship equation based on the total discharge of the five largest tributaries – the Sharyn, Shilik, Karatal, Lepsy, and Tentek rivers – for which natural runoff values are preliminarily calculated.

The long-term average volume of local runoff is **16.2 km³/year**. For the period 1930-2023, there is a trend of decreasing runoff volume. The maximum volume was recorded in 2010 at 44.7 km³, and the minimum in 1933 at 8.45 km³. **In 2023**, the local runoff fell into the category of **moderately low water availability**, with a calculated exceedance probability of **72.1 %.**

Total Resources of the Balkhash-Alakol Water management basin. The long-term average volume of total runoff is **28.0 km³/year**. According to data for the period 1930-2023, the trend remains within the norm. During this period, the maximum volume was 63.5 km³ (2010), and the minimum was 20.2 km³ (2014). The total runoff **in 2023** was **moderately low**, with an exceedance probability of **73.0 %.**

Table 18 - Water Resources of the Balkhash-Alakol WMB for 2023, km³/year

WMB	Long-term characteristics of water resources			Annual water resources 2023	
	average	at exceedance probability			
		5%	95%	value	exceedance probability, %
Balkhash-Alakol	**28,0**	**41,5**	**18,3**	**23,6**	**73,0**
local resources	16,2	26,0	9,25	12,6	72,1
tributary	11,8	15,5	9,09	10,9	73,4

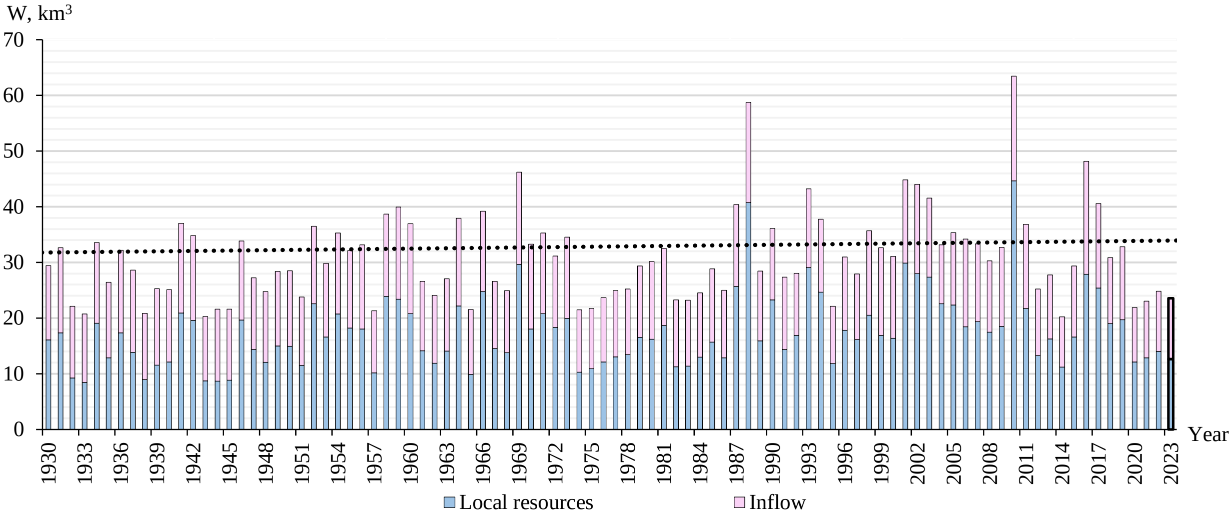


Figure 48 – Dynamics of annual river runoff resources of the Balkhash-Alakol WMB for the Period 1930-2023

An analysis of long-term hydrological data has shown that the water resources of the Balkhash-Alakol basin are characterized by a pronounced cyclicity, with alternating high-water, low-water, and transitional phases. In the 1930s to early 1940s, the water levels of most rivers were close to the long-term average. From the late 1940s to the mid-1970s, a high-water cycle formed, reaching its maximum in the late 1960s to early 1970s, which was associated with favorable climatic conditions, a high level of glacier meltwater contribution, and relatively low anthropogenic impact. From the late 1970s to the early 1990s, a prolonged low-water phase was recorded, with minimum runoff values, reflecting the increase in water use for economic purposes (irrigation, regulation by the Kapshagay Hydroelectric Power Station) and local glacier retreat. From the early 1990s onward, a new increase in water availability began, intensifying in the 2000s, with peak runoff in 2010 for most rivers in the basin (maximum discharges: Ili - 750 m³/s, Tentek - 74.8 m³/s, Lepsy - 32.3 m³/s, Sharyn - 66.2 m³/s). Since 2015, a gradual decrease in runoff has been observed, with water resources stabilizing at levels close to the long-term average. This may be associated with glacier degradation, changes in atmospheric circulation, and increased water withdrawals in the upper reaches, including in China. At the same time, the main water-bearing river of the basin – the Ili River, which provides over 70% of Lake Balkhash's resources – shows an overall trend of moderate decline throughout the period, despite the occurrence of high-water cycles. A similar pattern is observed in the tributaries: the Tentek River experienced a sharp increase in 1990-2010, the Shilik River is most vulnerable in low-water years, the Karatal River demonstrates a smoothed dynamic, and the Lepsy and Sharyn rivers show moderate fluctuations.

In 2023, the state of water resources in the **Balkhash-Alakol basin** was characterized mainly by **low to moderately low water availability** for most rivers, except for the Lepsy and

Karatal rivers, which, compared to the long-term average, were within the high to moderately high water availability range.

1.2.3 Assessment of water resources of the Aral-Syrdarya WMB for 2023

- The inflow into the basin is taken as the observed discharge of the Syrdarya River at the gauging station upstream of the Keles River mouth. The long-term average annual runoff is 22.6 km³. According to data for the period 1932-2023, there is a moderately pronounced trend of decreasing average annual runoff. During this period, the maximum discharge was 1600 m³/s (1969) and the minimum was 132 m³/s (1975), corresponding to high- and low-water phases. **In 2023**, the river's runoff fell into the category of **average water availability**, with an exceedance probability of **49.5 %.**

- **The local runoff of the basin**, i.e., the local water resources, is estimated using a relationship equation based on the total discharge of the three largest tributaries – the Bugun, Shayan, and Arys rivers – for which natural runoff values are preliminarily calculated.

The long-term average volume of local runoff is **2.14 km³/year**. For the period 1932-2023, its variation remained within the norm. The maximum volume was recorded in 1969 at 7.13 km³, and the minimum in 1937 at 1.24 km³. **In 2023**, the local runoff was characterized by **average water availability**, with a probabilistic exceedance of **43.8 %.**

Table 19 - Water resources of the Aral-Syrdarya WMB for 2023, km³/year

WMB	Long-term characteristics of water resources			Annual water resources 2023	
	average	at exceedance probability			
		5%	95%	value	exceedance probability, %
Aral-Syrdarya	**17,5**	**29,8**	**8,42**	**16,8**	**49,3**
local resources	2,14	3,85	1,23	2,09	43,8
tributary	15,3	25,9	7,17	14,7	49,5

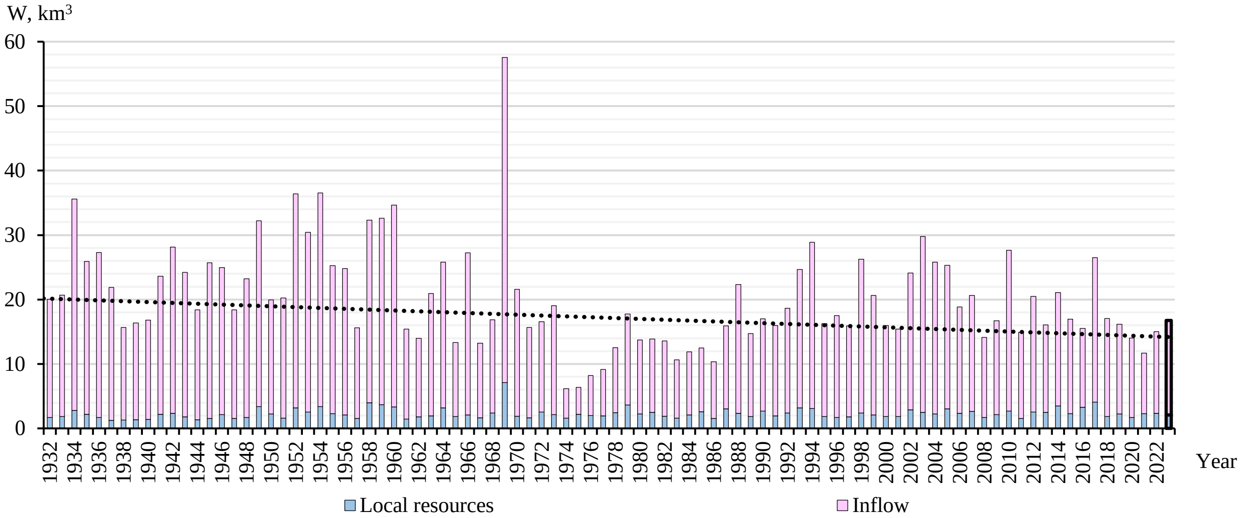


Figure 49 – Dynamics of annual river runoff resources of the Aral-Syrdarya WMB for the period 1932-2023

- **Total Resources of the Aral-Syrdarya WMB.** The long-term average volume of total runoff is **17.5 km³/year**. According to data for the period 1932-2023, there is a moderately pronounced trend of decreasing runoff volume. During this period, the maximum volume was 57.6 km³ (1969), and the minimum was 6.20 km³ (1974). The total runoff **in 2023** was of **average water availability**, with an exceedance probability of **49.3 %.**

In the Syrdarya basin for the period 1932-2023, the upper tributaries, which are fed by glaciers and snow, showed the greatest sensitivity to climatic changes. Rivers such as the Aksu and Shayan responded to fluctuations in snowfall and glacier degradation: in high-water years, their discharges increased sharply (for example, the Aksu maximum - 19.2 m³/s in 1969), whereas in low-water periods, a significant decrease was observed. At the same time, the Keles and Arys rivers, having a more complex runoff formation regime, proved particularly vulnerable to anthropogenic impacts: intensive irrigation, water withdrawals, and flow regulation led to significant fluctuations and, at times, extreme minimum discharges (Arys - 5.79 m³/s in 1986; Keles - 1.50 m³/s in 1987). On the main Syrdarya River, the strongest transformations were recorded at the Tomenaryk and Kazaly stations, where the combined effects of economic water use and natural losses resulted in much lower runoff values compared to the upper gauging stations.

The year 2023 was characterized by an overall background of **average water availability** for the main Syrdarya River and most of its tributaries. At the upper gauging stations, discharges were close to the norm (for example, upstream of the Keles - exceedance probability 49.5%; Shardara Reservoir - 57.9%). Among the tributaries, the Arys, Bugun, and Badam rivers showed moderately high water availability (exceedance probability 34-39%), whereas the Shayan and Aksu rivers were in the category of average water availability (41-54%). The Keles River stands out, where in 2023 the runoff was of high water availability (exceedance probability 11.5%), reflecting a local restoration of water reserves.

In 2023, the water resources of the Aral-Syrdarya basin were generally characterized by average water availability. The inflow of the Syrdarya River upstream of the Keles River mouth amounted to 22.6 km³, corresponding to an exceedance probability of 49.5%, i.e., close to the norm. The local runoff of the basin was estimated at 2.14 km³/year and was also within the range of average water availability (exceedance probability 43.8%). The total volume of water resources in the basin in 2023 showed no extreme deviations, forming a stable hydrological background dominated by average values and without a significant deficit.

1.2.4 Assessment of Water Resources of the Zhaiyk-Caspian WMB for 2023

- **The transboundary inflow** into the water management basin is taken as the observed discharge of the Zhaiyk River at the gauging station near the settlement of Yanvartsevo. The long-term average inflow from the Russian Federation is **10.5 km³/year**. An analysis of the annual inflow volumes from Russia for the period 1932-2023 shows a clear trend of decreasing average annual discharges. The minimum inflow was recorded in 1967 at 3.00 km³, while the maximum occurred in 1946 at 26.8 km³. **In 2023**, the annual inflow amounted to 8.20 km³, corresponding to **average water availability**, with an exceedance probability of **55.8 %.** This value is 22% below the established norm of 10.5 km³ (or 333 m³/s), indicating a persistent deficit in water inflows from the Russian Federation.

- **The local water resources** formed within the basin on the territory of the Republic of Kazakhstan are estimated based on the combined runoff of the five largest rivers in the basin, which have the highest water availability and provide the main share of surface local runoff. These rivers are the Ilek, Bolshaya Kobda, Zhaiyk, Uil, and Emba. Together, these watercourses account for approximately 47% of all local water resources of the basin. The preliminary assessment of local runoff is carried out based on the calculation of natural discharges for each of these rivers.

The long-term average volume of local runoff for the calculated period is **173 m³/s** or **5.47 km³/year**. For the period 1932-2023, a steady decreasing trend in runoff is observed. The minimum volume was recorded in 1967 at 4.12 km³, and the maximum in 1993 at 22.5 km³. **In 2023**, the local runoff amounted to **10.2 km³,** which is classified as **high water availability**, with an exceedance probability of **12.5 %.**

Table 20 - Water resources of the Zhaiyk-Caspian WMB for 2023, km³/year

WMB	Long-term characteristics of water resources			Annual water resources 2023	
	average	at exceedance probability			
		5%	95%	value	exceedance probability, %
Zhaiyk-Caspian	**16,0**	**37,8**	**3,83**	**18,42**	**29,9**
local resources	5,47	14,2	1,52	10,25	12,5
tributary	10,5	23,6	2,31	8,17	55,8

Total Resources of the Zhaiyk-Caspian WMB. The long-term average volume of total water resources of the Zhaiyk-Caspian basin is **16.0 km³/year**. Analysis of the dynamics for the period 1932-2023 reveals a persistent trend of decreasing total runoff compared to the established norm. During this period, the maximum volume of water resources was recorded in 1993 at 41.1 km³, and the minimum in 1967 at 7.10 km³.

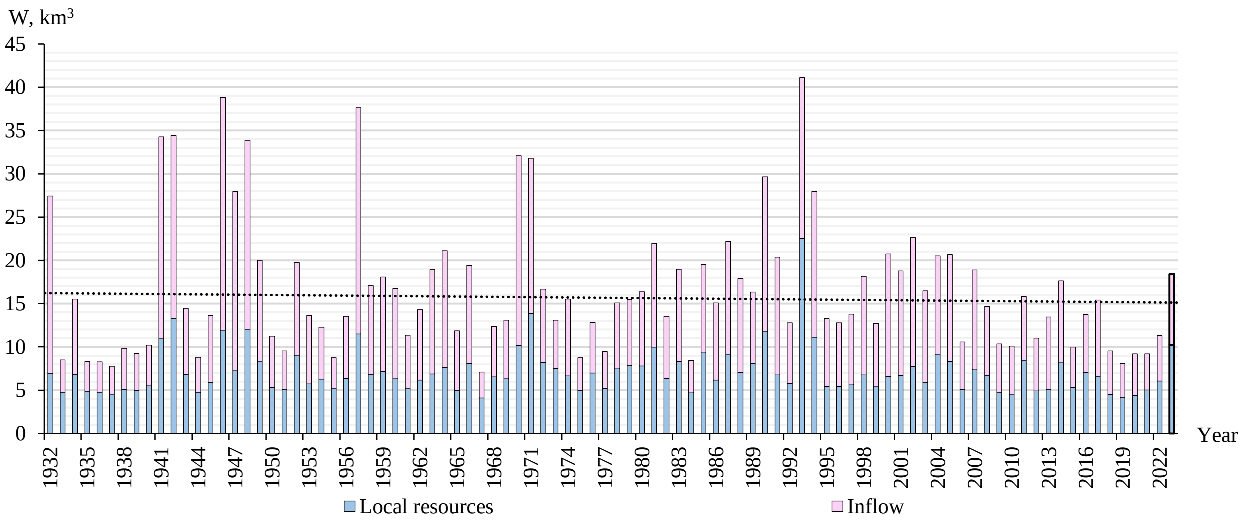


Figure 50 – Dynamics of annual river runoff resources of the Zhaiyk-CaspianWMB

In 2023, the total volume of overall water resources amounted to **18.42 km³,** which is classified as moderately **high water availability**, with an exceedance probability of **29.9 %.** Despite being 15 % above the long-term average, the year cannot be considered an exceptionally high-water year, as the observed increase is primarily due to favorable hydrometeorological conditions during the current year, in particular – increased local runoff resulting from abundant snow reserves and intensive spring runoff.

1.2.5 Assessment of water resources of the Esil water management basin for 2023

- **Local runoff of the WMB**, i.e., local water resources, is estimated using a relationship with the total runoff of the three largest tributaries - rrs. Esil, Zhabai, and Kalkutan, for which natural runoff values are preliminarily calculated.
- The long-term mean volume of local runoff is **2,52 km³/year**. According to data for the period 1932-2023, it remains within the norm. During this period, the maximum volume was 19,07 km³/year (2017), and the minimum was 0,04 km³/year (1967). Local runoff in **2023** was **moderately high**, with an exceedance probability of **27,9 %.**

Table 21 - Water resources of the Esil WMB for 2023, km³/year

WMB	Long-term characteristics of water resources			Annual water resources for 2023	
	average	at exceedance probability			
		5%	95%	value	exceedance probability, %
Esil	**2,52**	**7,84**	**102**	**3,23**	**27,9**
local resources	2,52	7,84	102	3,23	27,9

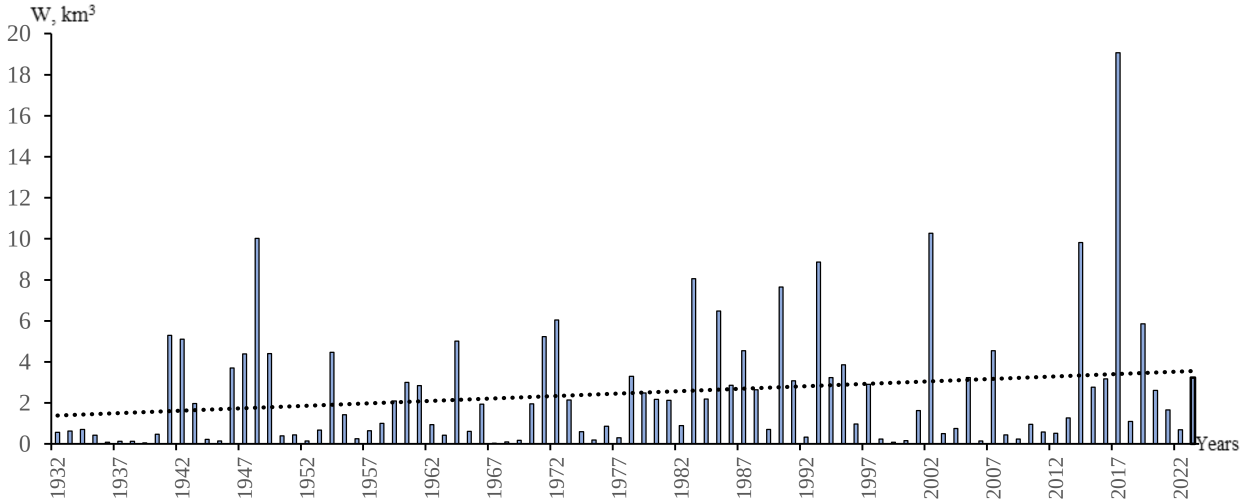


Figure 51 – Dynamics of annual river runoff resources of the Esil WMB for the period 1932-2023

Resources of the Esil WMB. The long-term mean volume of total water resources is **2,52 km³/year**. For the period 1932-2023, the trend remains within the runoff norm. During this period, the maximum volume was 19,07 km³/year (2017), and the minimum was 0,04 km³/year (1967). Total water resources in 2023 were **moderately high**, with an exceedance probability of **27,9 %.**

Analysis of the hydrological characteristics of the Esil water management basin for 2023 classifies the year as moderately high in water availability. Throughout the year, elevated levels of river flow and reservoir replenishment were observed compared to long-term averages. The spring-summer flood period was characterized by a steady increase in water discharge, ensuring sufficient replenishment of water bodies. Groundwater levels also showed a positive trend, contributing to the maintenance of the basin's water balance.

This hydrological situation reflects favorable climatic conditions and balanced precipitation distribution in the basin, positively affecting the state of water resources and their availability for water management needs.

The total volume of the basin's water resources in 2023 was within the range characteristic of the long-term variability and corresponded to typical climatic conditions of the region. Overall, the hydrological situation in the reporting year remained stable, without signs of abnormally high or low water levels.

1.2.6 Assessment of Water Resources of the Shu-Talas WMB for 2023

Due to intensive economic activity within the territory of the Republic of Kazakhstan and the insufficiency of observational data, the inflow and local runoff of the basin are estimated using correlation equations with the Shu River runoff at the gauging station near Kochkorka v. (Kyrgyz Republic). In 2023, the rivers of the basin exhibited low water availability (Talas River at Zhasorken - 99.9 %) and low water availability (Shu River at Kainar - 79.9 %).

Local runoff and inflow of the basin. In the Shu-Talas Basin, both the inflow and local runoff were of moderate water availability. Local runoff amounted to **1.17 km³/year** compared to a norm of **1.24 km³/year**, while **inflow** was **3.41 km³/year** against a norm of **3.47 km³/year.** The total water resources of the basin amounted to **4.59 km³/year** compared to a norm of **4.70 km³/year** (Table 22).

Table 22 - Water resources of the Shu-Talas WMB for 2023, km³/year

WMB	Long-term characteristics of water resources			Annual water resources for 2023	
	average	at exceedance probability			
		5%	95%	value	exceedance probability, %
Shu-Talas	4.71	**7,70**	**2,82**	4,59	**45,5**
local resources	1.24	2,82	0,28	1,18	43,9
inflow	3.47	4,88	2,54	3,41	46,7

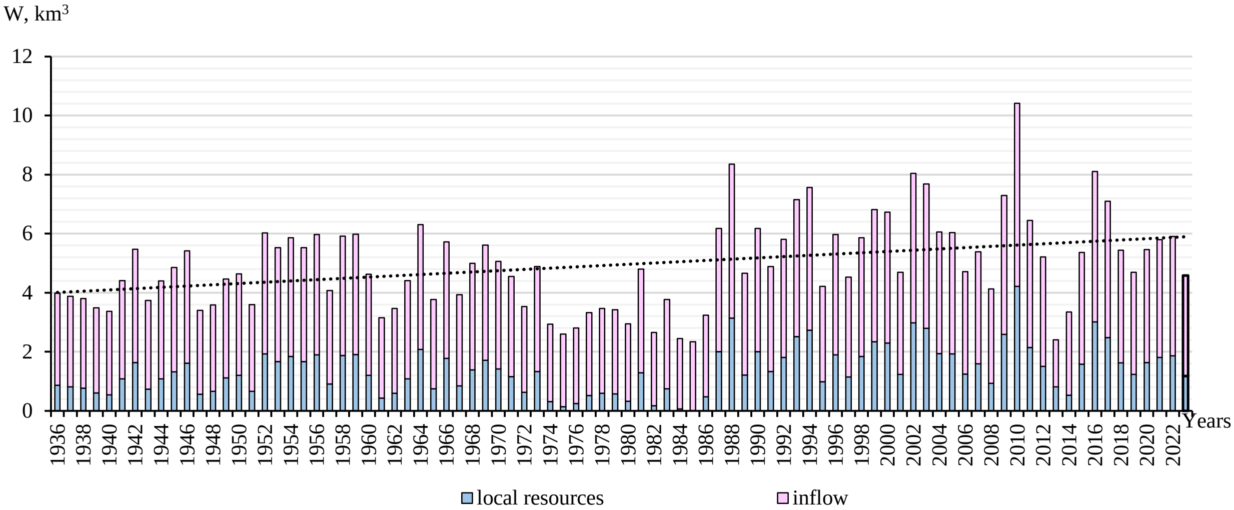


Figure 52 – Dynamics of annual river runoff resources of the Shu-Talas WMB for the period 1936-2023

Total Resources of the Shu-Talas Water management basin. The long-term average total runoff volume is 4.71 km³/year. According to data for the period 1936-2023, a moderately pronounced trend of increasing runoff volume is observed. During this period, the maximum runoff volume was 10.4 km³/year (2010), and the minimum was 2.34 km³/year (1985). The total runoff **in 2023** was of **average water availability**, with an exceedance probability of **45.5 %.**

The total water resources of the basin in 2023 were within the range typical for long-term variability and corresponded to the region's usual climatic conditions. Overall, the hydrological situation in the reporting year remained stable, without signs of abnormally high or low water levels.

1.2.7 Assessment of water resources of the Nura-Sarysu WMB for 2023

The local runoff of the WMB, i.e. the local water resources, is estimated using the correlation equation with the total runoff of the two largest tributaries – r. Nura and r. Sarysu – and the inflow to the Kengir Reservoir, for which the natural runoff values are preliminarily calculated.

Table 23 - Water resources of the Nura-Sarysu WMB for 2023, km³/year

WMB	Long-term characteristics of water resources			Annual water resources for 2023	
	mean	at exceedance probability			
		5%	95%	value	Exceedance probability, %
Nura–Sarysu	**1,16**	**2,58**	**0,26**	**0,67**	**61,2**
Local resources	1,16	2,58	0,26	0,67	61,2

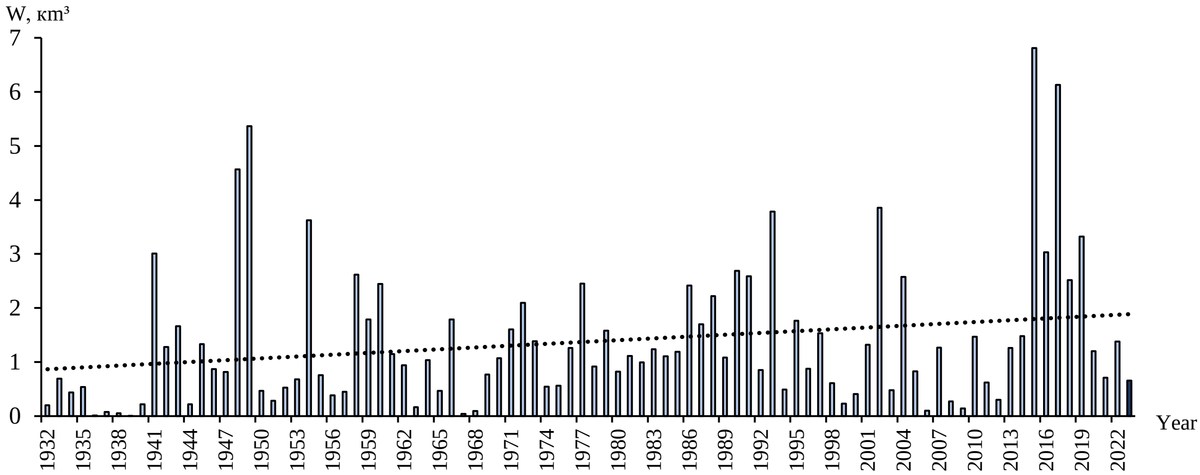


Figure 53 – Dynamics of annual river runoff resources of the Nura-Sarysu WMB for the period 1932-2023

Resources of the Nura-Sarysu WMB. The norm of local water resources for the long-term period (1932-2023) is about **1,7 km³/year**. Overall, during this period, a weakly expressed upward trend in local runoff volume is observed. The maximum value was recorded in 2015 – 6,8 km³, and the minimum in 1939 – less than 0,01 km³. The total water resources in 2023 were of low water content, with an exceedance probability of 61,2%. Runoff formation in the reporting year occurred under conditions of limited moisture, which is associated with insufficient precipitation and, likely, increased evaporation during the warm season.

Overall, the hydrological situation in the basin in 2023 was characterized as water-deficient, without signs of high-intensity floods. Local runoff in most watercourses formed at levels below the norm, reflecting the influence of both interannual climate variability and local hydrometeorological conditions.

The total volume of water resources in the basin in 2023 remained within the range typical of long-term variability and reflected the climatic conditions characteristic of the region. The hydrological situation during the reporting year remained stable, without occurrences of extreme floods or abnormally low water levels, indicating the absence of significant hydrometeorological anomalies.

1.2.8 Assessment of water resources of the Tobyl-Torgai WMB for 2023

- The volume of local runoff in the Tobyl-Torgai WMB is calculated based on its relationship with the total natural runoff of the rivers Tobyl, r. Ayat, r. Karatoragai, and r. Irgiz.
- **The inflow** within the territory of the Republic of Kazakhstan is calculated using the relationship between the total inflow and the combined inflow of the rivers Tobyl and r. Toghyzak.

In **2023**, the water resources of most rivers in the Tobyl-Torgai basin were classified as moderately low or low water content, with the exception of the r. Ubagan near Aksuat v., which experienced high water content (6,30%). The r. Tobyl near Grishenka v. and r. Ayat near Varvarinka v. exhibited average water content, while the r. Irgiz near Shenbertal v. showed low (99,0 %) water content.

Local runoff of the WMB. The local water resources of the Tobyl-Torgai basin in 2023 were moderately low in terms of water content (**0,81 km³ compared to the norm of 1,78 km³**). The inflow into the basin was of average water content (0**,19 km³ compared to the norm of 0,34 km³**). The total water resources of the basin amounted to 1,00 km³, compared to the norm of 2,11 km³, which also corresponds to moderately low water content.

Table 23 - Water resources of the Tobol-Torgay WMB for 2023, km³/year

WMB	Long-term characteristics of water resources			Annual water resources 2023	
	average	at exceedance probability			
		5%	95%	value	exceedance probability, %
Tobol-Torgay	2,11	5,91	0,23	1,49	51,6
local resources	1,78	4,80	0,17	1,25	53,5
tributary	0,34	1,11	0,06	0,24	43,9

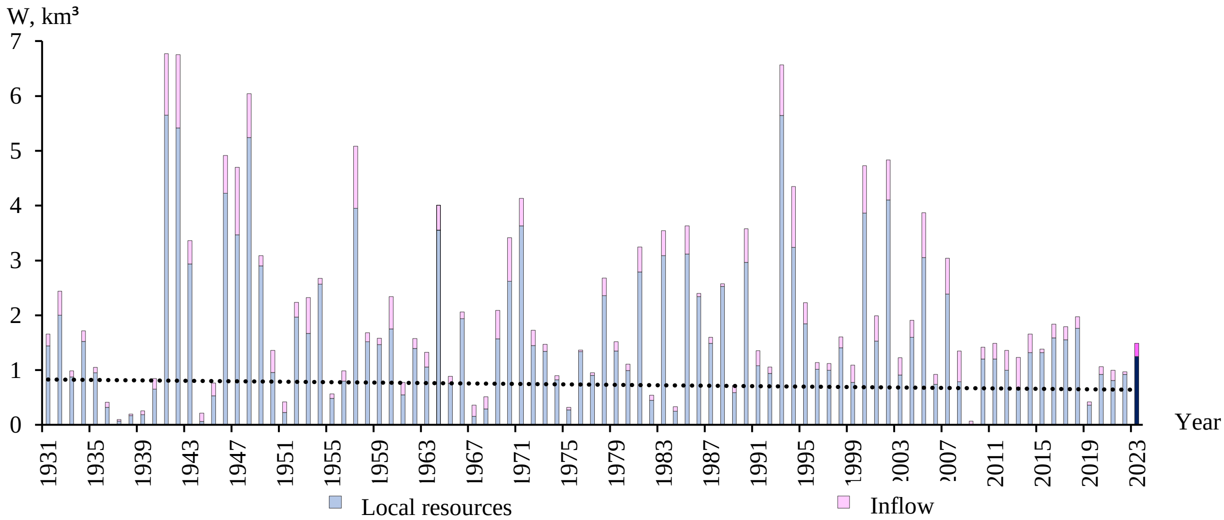


Figure 54 – Dynamics of annual river runoff resources of the Tobyl-Torgai WMB for the period 1931-2023

Total resources of the Tobyl-Torgai WMB. The long-term mean volume of total runoff is **2,11 km³/year**. According to data for the period 1931-2023, a moderately pronounced decreasing trend in runoff volume is observed. During this period, the maximum volume was 6,77 km³ (1941), and the minimum was 0,1 km³ (2009). Total runoff in **2023** was of **average water content**, with an exceedance probability of **43,9 %.**

Analysis of river runoff dynamics in the Tobyl-Torgai WMB for the period 1931-2023 shows clearly expressed long-term oscillatory cycles of water availability. During this time interval, alternating phases of high-water and low-water periods were observed, lasting 5 to 7 years. These fluctuations were largely determined by both natural (climatic) conditions and increasing anthropogenic impacts.

The longest high-water phases in the Tobyl-Torgai WMB were recorded for the periods 1940-1943, 1951-1957, 1979-1984, 1988-1993, and 2001-2009, characterized by coordinated increases in water levels across all observation gauging stations.

A prolonged and pronounced low-water period was observed in 1933-1940, 1943-1945, 1948-1951, 1958-1968, 1972-1978, 1985-1987, 1994-2000, and 2010-2018, with minimum values of the integral indicator occurring in the mid-2010s. Since 2019, the hydrological situation has shown stabilization with fluctuations around long-term averages; however, no consistent signs of a transition to a prolonged high-water regime have been identified.

- The coordinated interannual variability of runoff across all rivers in the basin indicates the predominant role of regional climatic conditions and the pattern of atmospheric moisture in shaping the water regime.

1.2.9 Assessment of river runoff resources of the Republic of Kazakhstan

A comparison of river runoff resources in 2023 with long-term average values (1932-2007) is shown in figure 55.

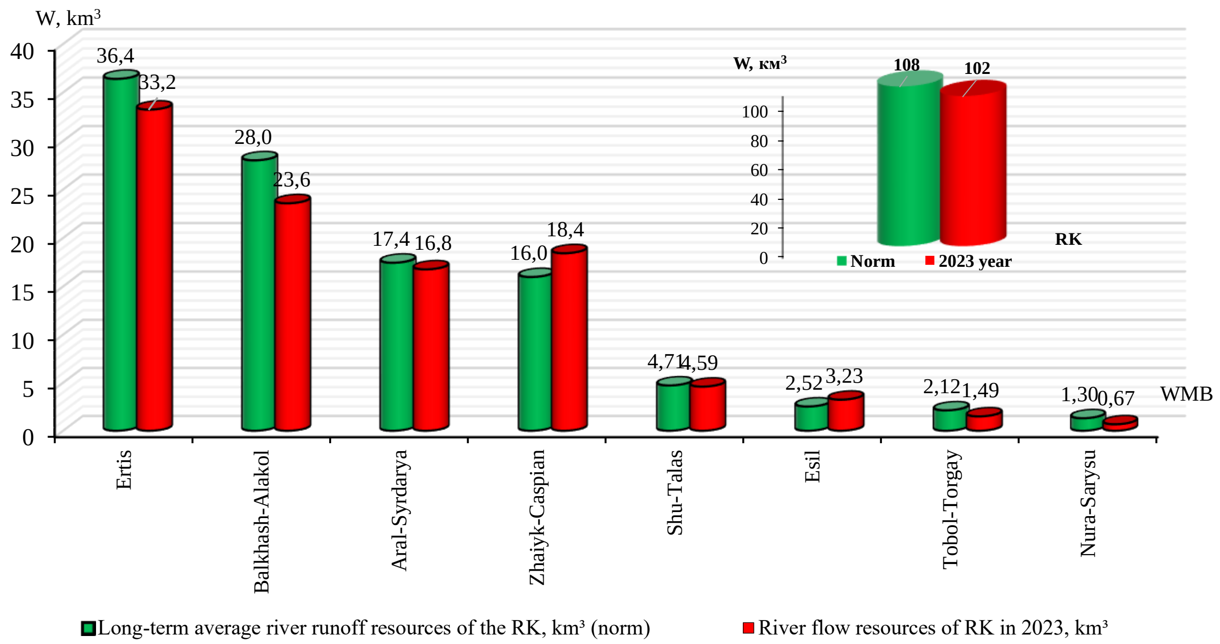


Figure 55 – River runoff resources for 2023 relative to the long-term average norm

In 2023, most basins showed values below the norm, except for the Zhaiyk-Caspian WMB, where an elevated level of resources was observed due to an intense spring flood.

Considering the reasons for decreased runoff by individual water management basins:

- Ertis WMB – **average water content**. The main factor is the reduction of transboundary inflow due to intensive water withdrawal and runoff regulation in China.
- Balkhash-Alakol WMB – **moderately low water content**. A reduction in the runoff of r. Ili, increased water consumption in the upper reaches, and a pronounced climatic moisture deficit are observed.
- Aral-Syrdarya WMB – **average water content**. High regulation, significant irrigation withdrawals, and losses in the river-canal network, combined with general warming, led to a decreasing runoff trend.
- Zhaiyk-Caspian WMB – **moderately high water content**. In 2023, an abnormally high flood was observed on rrs. Uil, which led to an increase in local runoff.
- Esil WMB – **moderately high water content**. The snow regime is highly sensitive to low-snow winters and warm springs, which, combined with increased evaporation, reduces spring floods.
- Shu-Talas WMB – **average water content**. The basin's water balance strongly depends on the regime of transboundary runoff regulation and is highly sensitive to climate change.

- Nura-Sarysu WMB – **moderately low water content**. An internal basin without inflow, it is the most water-stressed basin, lacking both surface and groundwater resources.
- Tobyl-Torgai WMB – **average water content**. One of the least water-supplied basins in the Republic of Kazakhstan, influenced by transboundary regulation and water withdrawals from the Russian Federation.

2 ANALYSIS AND CALCULATION OF SPRING FLOOD CHARACTERISTICS OF THE MAIN RIVERS OF THE REPUBLIC OF KAZAKHSTAN FOR THE YEAR

Spring flood is a phase of a river's hydrological regime characterized by the highest water discharge of the year, a significant and prolonged rise in water level, usually accompanied by the overflow of water from the river channel onto the floodplain. It is caused by the main source of river nourishment: snowmelt in lowland rivers, the melting of snow and glaciers in high-mountain rivers, and summer rainfall in monsoon and tropical zones, etc. For rivers of the same climatic zone, it occurs annually during the same season, but with varying intensity and duration [18].

Methodology. The timing of the spring flood was determined based on discharge hydrographs, taking into account air temperature and precipitation trends, and was adjusted using tables of daily water discharges. The beginning of the flood was defined as the date preceding a noticeable, usually sharp, increase in discharge. The end of the flood was considered the date when the transition from the final recession to the summer low-flow period became clearly identifiable. If a rainfall-induced flood occurred immediately after the spring flood recession, this date was determined on the hydrograph by identifying the inflection point between the spring flood and the rainfall flood. Winter floods caused by thaws and separated from the main spring runoff wave by a significant time interval were not included in the spring flood period. The date of the maximum instantaneous discharge during the flood was determined at the time of its occurrence. If this discharge value was observed over several days, all dates on which it occurred were indicated. For ravines (small gullies) and small intermittent streams, the entire period during which runoff was present was attributed to the spring flood [19].

The duration of the spring flood was calculated from the start date of the flood to the end date inclusive [20].

The main characteristics of the spring flood of the major rivers of the Republic of Kazakhstan for the long-term period, grouped by water management basins, are provided in Appendix A.

2.1 Analysis of spring flood runoff characteristics of the major rivers of the Ertis WMB

The spring flood, as the main phase of the river's hydrological regime, plays a crucial role in shaping river runoff throughout the year. During this period, maximum discharges occur, and a significant portion of the annual runoff is formed – on average about 50 % or more of the total volume. For most rivers of the Upper Ertis basin, especially mountain rivers, a prolonged spring-summer flood and high-flow events during the warm season are characteristic. During the flood period, lasting from 4 to 6 months, between 70 % and 90% of the annual runoff passes. Rivers and temporary watercourses in the southwestern and western parts of the Upper Ertis basin are characterized by strong unevenness of runoff throughout the year. Over a 2-3 month spring flood period, these rivers receive between 70 % and 100 % of their annual runoff [6].

Overall, the average date for the beginning of the spring flood of the major rivers of the Ertis Water management basin over the long-term period is **April 4**, the ending date is **July 12**, and the duration of the flood period **is 101 days.**

The spring flood on the Ertis River generally begins between April 3 and April 6. Early onset dates range from March 11 to March 24, while late onset dates occur between April 20 and May 15. The end of the flood period depends on the intensity of snowmelt, the size of the catchment area, and the water availability of the year. The duration of the spring flood on the Ertis River averages approximately 100-110 days.

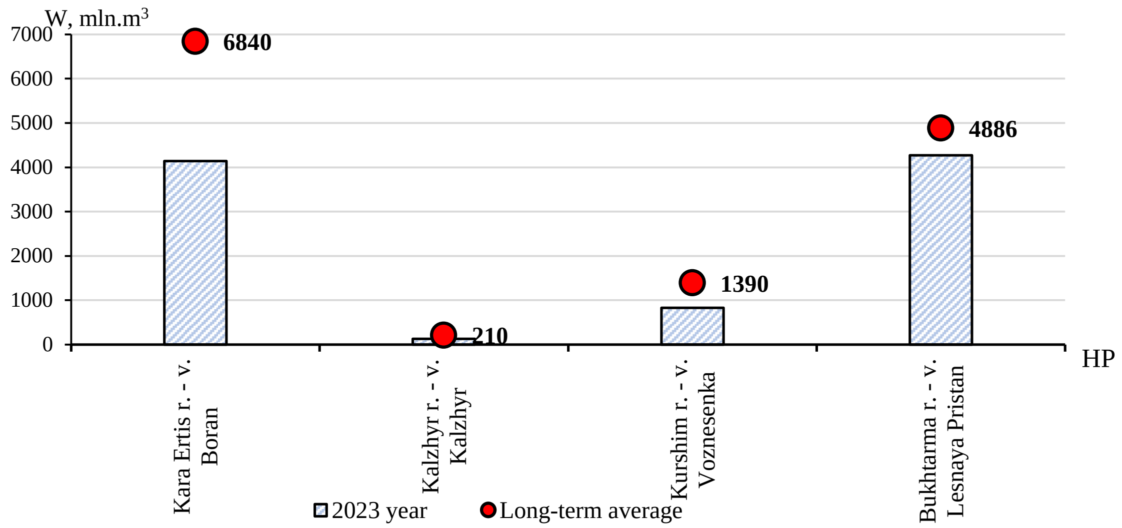


Figure 56 – Dynamics of changes in the spring flood runoff volume

Kara Ertis r. – Boran v. The long-term average spring flood runoff volume for the period 1938-2023 is **6,840 million m³ or 122 mm.** The average start date of the flood over the long-term period is April 5, and the average end date is August 22. The average duration of the flood period is 139 days. According to the analysis of the spring flood dynamics on the Ertis River near Boran v. for the period 1938-2023, a clear decreasing trend in flood volumes is observed. The minimum spring flood runoff volume during the studied period was recorded in 2022, amounting to 559 million m³, while the maximum was observed in 1966, reaching 12,800 million m³.

In 2023, the spring flood began on May 10 (35 days later than the average date) and ended on July 23 (30 days earlier than the average date). The duration of the flood period was 75 days. The spring runoff amounted **to 4,140 million m³,** which is significantly **below the long-term average level**. The flood was short and low-water due to the climatic conditions of the season. According to [23], the spring was dry, with reduced precipitation and rapid snowmelt against the background of elevated temperatures. This led to a delay in the onset of the flood, its premature completion, and a significant deficit in spring runoff.

Ertis r. – Semiyarka v. The long-term average volume of spring flood runoff for the periods 1935-1958, 2012-2016, 2018, and 2021-2022 **is 21,754 million m³.** The average start date of the flood is April 3, and the average end date is July 12. The average duration of the flood period is 100 days. According to the data for the specified years, there is a clear trend toward a decrease in the spring flood volumes. The maximum runoff volume was recorded in 1958, amounting to 41,000 million m³, while the minimum was observed in 2012, equaling 3,615 million m³. For the periods 1959-2011, 2017, 2019-2020, and 2023, data on the spring flood are not provided due to significant distortion of the hydrological regime caused by hydraulic engineering structures.

Ertis r. – PriErtisskoe v. The long-term average volume of spring flood runoff for the periods 2012-2016, 2018, and 2021-2022 is **8,856 million m³,** which corresponds to a **35 mm** total runoff depth. The average start date of the flood during this period is April 6, and the average end date is June 3. The average duration of the flood period is 59 days. According to the analysis of the data for the specified period, there is a trend of a moderate increase in the volume of spring runoff. The maximum value was recorded in 2015, amounting to 13,892 million m³, while the minimum was observed in 2012, totaling 3,329 million m³. For 2017, 2019-2020, and 2023, data on the spring flood are not provided due to significant distortion of the hydrological regime caused by hydraulic engineering structures.

- **Kalzhyr r. – Kalzhyr v.** The long-term average volume of spring flood runoff for the period 2012-2023 **is 210 million m³,** which corresponds to a **63 mm** total runoff depth. The average start date of the flood is April 9, and the average end date is June 29. The average duration of the flood period is 82 days. According to the data for 2012-2023, the trend line indicates a decrease in spring runoff volume. During this period, the maximum flood volume was recorded in 2018, reaching 466 million m³, while the minimum occurred in 2021, amounting to 22 million m³. **In 2023**, the flood runoff volume was **129 million m³,** which is **38.5 % below** the long-term average. The beginning of the flood occurred on April 1 (8 days earlier than the average), and it ended on July 5. The flood duration was 96 days.
- **Kurshim r. – Voznesenka v.** The long-term average runoff volume for the spring flood for the periods 1938-1945 and 1948-2023 is **1,390 million m³,** corresponding to **238 mm** of total runoff depth. The average start date of the flood is April 5, and the average end date is July 19. The average duration of the flood is 106 days. Analysis of observed data for 1939, 1941, 1945, and 1948-2023 shows that spring runoff volumes generally vary within the long-term average range. The maximum flood volume was recorded in 1966, totaling 2,860 million m³, while the minimum was in 1951, amounting to 473 million m³. **In 2023,** the spring runoff volume **was 829 million m³,** which is **40.3 % below** the norm. The flood began on April 28 (23 days later than the average date) and ended on July 17 (2 days earlier than the average date). The duration of the flood was 81 days.
- **Bukhtyurma r. – Lesnaya Pristan v.** The long-term average spring runoff volume for the period 1955-2023 is **4,886 million m³, or 458 mm** of runoff depth. The average start date of the flood is April 5, and the average end date is August 9. The average duration of the flood is 127 days. Analysis of the observed period shows a weak trend toward decreasing spring runoff volumes. The maximum volume was recorded in 2016 at 8,740 million m³, and the minimum in 2022 at 867 million m³. **In 2023**, the spring flood volume was **4,270 million m³,** which is **12.6 % below** the long-term average. The flood began on April 15 (10 days later than the average date) and ended on June 27 (43 days earlier than the average date). The flood duration was 74 days.
- **Ulbi r. – Ulbi Perevalochnoe v.** The long-term average spring flood runoff for the period 2012-2022 is **1,778 million m³,** corresponding to **363 mm** of runoff depth. The average start date of the flood is April 1, and the average end date is June 21, with an average flood duration of 85 days. Analysis of observations for 2012-2022 shows a trend toward decreasing flood runoff volumes. During this period, the maximum volume was recorded in 2013 at 3,234 million m³, and the minimum in 2014 at 972 million m³. Data for 2023 are not presented because the hydrological regime was significantly altered due to the impact of hydraulic structures.
- **Oba r. – Shemonaikha c.** The long-term average spring flood volume for the period 1958-2022 is **3,890 million m³,** equivalent to **459 mm** of runoff depth. According to data for 1955-2023, the average start date of the flood is April 2, and the average end date is July 16, giving an average flood duration of 106 days. Analysis of the time series for 1958-2022 shows a trend of decreasing runoff volumes. During this period, extreme values were recorded: the maximum volume was 6,920 million m³ in 1966, and the minimum was 1,750 million m³ in 2012. It should be noted that due to incomplete water discharge data for 1955-1957, as well as for 2003 and 2023, the corresponding values were not displayed on the graph.

The spring flood of **2023** within the Ertis Water management basin was characterized by reduced water flow and a shortened duration across most monitored watercourses. In many gauging sections, a shift in flood phases was observed – the onset occurred later, and the end occurred earlier than the long-term average, which is directly related to the climatic conditions of the season. According to the [21], spring in the eastern part of the country featured warm anomalies, early and rapid snowmelt, and uneven precipitation distribution. The lack of moisture in April-May, combined with elevated air temperatures, led to accelerated snow cover melt and limited spring river feeding, resulting in reduced flood volumes and altered temporal characteristics. In some gauging sections, the flood regime continued to be influenced by regulatory operations of hydraulic structures, causing distortions in the natural runoff.

2.2 Analysis of spring flood flow characteristics of major rivers in the Balkhash-Alakol WMB

Spring Flood. On rivers with spring floods, the rise in water levels and increased flow due to the intensive inflow of meltwater typically begins in February-early March on rivers of the southwestern slopes of the Tarbagatai Range, the southern and western slopes of the Dzungarian Alatau, and the Ili River basin. In the foothills of the northern slopes of the Dzungarian Alatau and Tarbagatai, it begins in March, and on rivers of Northern Pre-Balkhash, in late March-early April. Spring floods end in May-June. The duration of the spring flood is usually short: on rivers with very small catchment areas, it does not exceed 15-20 days, while on rivers with catchment areas from 1,000 to 5,000 km², it lasts 40-100 days. The rise of the spring flood is usually rapid, especially on small rivers. The average duration of the rise on small streams is 5-8 days, while on medium and large rivers it is 15-18 days. The maximum duration of the flood rise can reach 25-50 days, and in very low-water years, the minimum can be as short as 1 day.

Spring floods on the Ili River predominantly begin in late March-early April and end in August-September. On rivers of the Tarbagatai Range, the end of the flood occurs in June-July. The duration of the flood on rivers with small catchment areas averages about 100 days, while on medium and large rivers, the flood combined with additional runoff events lasts 150-200 days. The timing of peak flows is highly variable. On rivers fed by glaciers, peak flows most often occur in June-July, whereas on rivers with snow-rain feeding, peaks usually occur in April. On rivers with significant glacial feeding, characterized by summer floods, the intensive rise in water levels typically begins in late April-early May and ends in August-September. The average duration of the flood on such rivers is 150-180 days, the rise phase lasts 50-70 days, and the peak of the flood occurs in July-early August.

On the rivers of the Ili basin, with the exception of the Shu-Ili mountain streams, river discharge during the flood period increases with the average elevation of the catchment areas [22].

Overall, the start date of the spring flood for the Balkhash-Alakol Basin over the long-term period is April 5, the end date is August 22, and the duration of the flood is 140 days.

- **Ili r. – 164 km upstream of the Kapshagay HPP.** The long-term average discharge of the spring flood for the period 1971-2000 is **8,989 million m³.** Analysis of the spring flood dynamics on the Ili River for 1971-2000 shows a clear decreasing trend. During this period, the minimum spring flood discharge was observed in 1982 at 5,720 million m³, and the maximum in 1988 at 14,400 million m³. Spring flood discharge since 2001 is not presented due to distortions caused by economic activities.

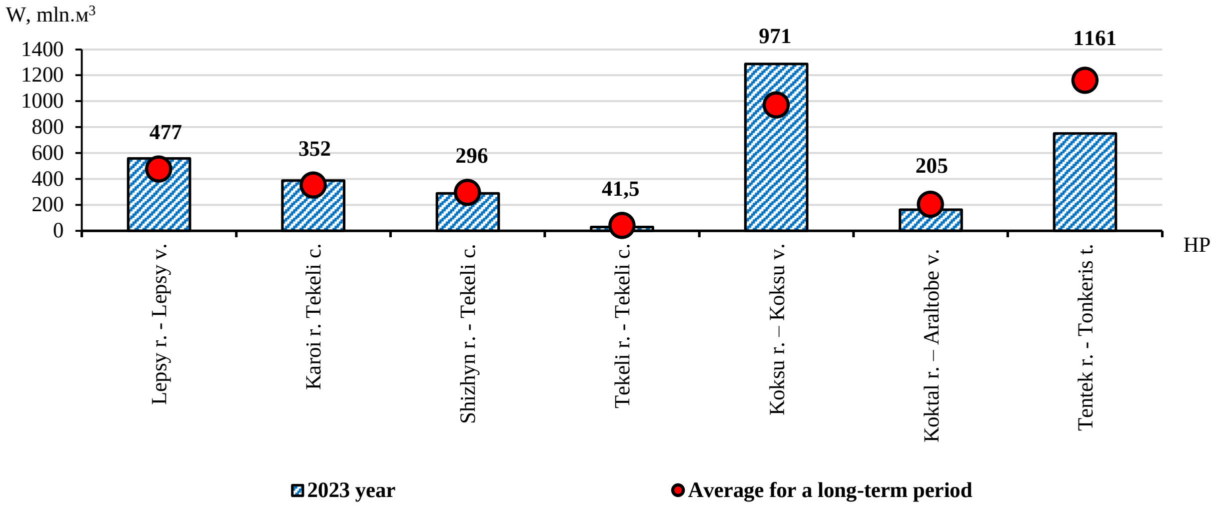


Figure 57 – Dynamics of spring flood discharge of the main tributaries of the Ili River in 2023

- **Ili r. – Kapshagay site.** At this hydrological point, the long-term average spring flood discharge for the period 1911-1970 is **11315 million m³.** Analysis of the spring flood dynamics on the Ili River at the Kapshagay site for 1911-1970 shows a clear decreasing trend. During this period, the minimum spring flood discharge was recorded in 1970 at 6,220 million m³, and the maximum in 1921 at 19,200 million m³. Spring flood discharge since 1971 is not presented due to river regulation and distortions caused by economic activities.
- **Ili r. – Ushzharma v.** The long-term average spring flood discharge for the period 1939-1970 is **11274 million m³.** According to the data for 1939-1943 and 1948-1970, a clear decreasing trend in discharge is observed. During this period, the maximum spring flood discharge was 15,000 million m³ (1954), and the minimum was 5,810 million m³ (1970). Spring flood discharge since 1971 is not presented due to river regulation and distortions caused by economic activities.
- **Sharyn r. – Sarytogay area.** The long-term average spring flood discharge for the period 1929-2010 is **713 million m³.** Analysis of the spring flood dynamics for this period shows a trend of increasing discharge. The minimum spring flood discharge was recorded in 1944 at 324 million m³, and the maximum in 2010 at 1,450 million m³. Spring flood discharge since 2011 is not presented due to river regulation.
- **Shilik r. – Malybay v.** At this hydrological post, the long-term average spring flood discharge for the period 1928-2010 is **798 million m³.** Analysis of spring flood dynamics at the Shilik River near Malybay over this period shows a trend of increasing discharge. The minimum spring flood discharge was recorded in 1957 at 473 million m³, and the maximum in 2007 at 1,230 million m³. Spring flood discharge since 2011 is not presented due to river regulation.
- **Karatal r. – Karatal v.** The long-term average spring flood discharge for the period 1926-1951 is **553 million m³.** Data for this period indicate that discharge remained within the normal range. The maximum discharge recorded was 912 million m³ in 1941, and the minimum was 362 million m³ in 1951. Spring flood discharge since 1951 is not presented, as the hydrological post was closed.
- **Koktal r. – Plodokonservny approach** – The average long-term value of spring flood discharge over a long period (1976–2019) is **59.4 million m³**. An analysis of the dynamics of spring floods on the Koktal River for the period 1976–1990 and 2012–2019 shows a downward trend. During this period, the minimum spring flood flow was observed in 1976 and amounted to

10.2 million m3, while the maximum was in 1980 – 115 million m3. Spring flood discharge for the period 1991–2011 and 2020–2021 was not reported due to distortion of discharge by economic activity.

Byzhy r. – Karymsak v. At this hydrological post, the long-term average spring flood discharge for the period 1949-2019 is **42.2 million m³.** Analysis of spring flood dynamics on the Byzhy River near Karymsak for the periods 1949-1990 and 2012-2019 shows that discharge remained within the normal range. The minimum spring flood discharge during this period was recorded in 1951 at 11.5 million m³, and the maximum in 1969 at 110 million m³. Spring flood discharge for the periods 1991-2011 and 2020-2023 is not presented due to alterations caused by human activities.

Tekeli r. – Tekeli c. The long-term average spring flood discharge for the period 1960-2023 is **41.5 million m³,** with an average start date of March 29 and an average end date of July 4, giving an average flood duration of 99 days. Analysis of spring flood dynamics on the Tekeli River for the periods 1960-1975, 1978-1990, and 2012-2021 shows an increasing trend. During this period, the minimum spring flood discharge was recorded in 1965 at 13.1 million m³, and the maximum in 1960 at 80.3 million m³. Spring flood discharge for the period 1991-2011 is not presented due to an indistinct flood.

The spring flood volume **in 2023** amounted to **29.0 million m³,** which is **30.1% below** the long-term average, indicating a pronounced low-water season. The start and end dates of the flood were **March 25** (4 days earlier than the average start date) and **June 18** (16 days earlier than the average end date), respectively, with a flood duration of **86 days in 2023.**

An exceptionally warm spring and a deficit of precipitation from April to July led to reduced spring moisture input and a lower total snow accumulation at lower and middle elevations of the sub-basin. Early warming caused a faster, «shortened» snowmelt runoff, resulting in a smaller total flood volume.

Shyzhyn r. – Tekeli c. At this hydrological post, the long-term average spring flood discharge for the period 1981-2023 is **296 million m³,** with an average start date of April 4 and an average end date of August 3, and an average flood duration of 122 days. Analysis of spring flood dynamics on the Shyzhyn River near Tekeli for the periods 1981-1992, 2001-2010, and 2012-2021 shows a trend of increasing discharge. During this period, the minimum spring flood discharge was recorded in 2006 at 96.8 million m³, and the maximum in 2016 at 632 million m³. Spring flood data for 1991-2011 are not presented due to the absence of a pronounced flood.

The spring flood volume in **2023** amounted to **288 million m³,** which is **2.7 %** below the long-term average. The start and end dates of the flood were **March 23** (12 days earlier than the average start date) and **August 16** (13 days later than the average end date), respectively, with a flood duration of **146 days in 2023**.

Spring was warm, which accelerated snowmelt, but some local areas of the sub-basin retained sufficient residual snow and received late spring precipitation, which extended the flood period (in 2023 - starting earlier and ending later). As a result, the total integrated volume of the flood was almost preserved.

Koktal r. – Araltobe v. The long-term average spring flood discharge for the period 1946-2023 is **205 million m³,** with an average start date of April 16 and end date of August 27, and an average flood duration of 134 days. According to data for the periods 1946-1975, 1978-1990, and 2012-2021, the trend remains within the normal range. During the above periods, the maximum flood volume was 394 million m³ (1988), and the minimum was 95.2 million m³ (1957). Spring flood data for 1991-2011 are not presented due to distortions caused by human activities.

The spring flood volume **in 2023 was 162 million m³,** which is 21.0% below the long-term average. The start and end dates of the flood were **April 21** (5 days later than the average start date) and **September 1** (5 days later than the average end date), respectively, with a flood duration of **134 days in 2023.**

The bulletin [21] records a precipitation deficit from April to July across most of the country; in the Koktal sub-basin, this reduced the contribution of surface runoff and rainfall during the flood period. Even with partial late inflows, the late start did not compensate for the overall snow mass deficit. Local water management activities may have also contributed.

- **Karoy r. – Tekeli c.** The long-term average spring flood discharge for the period 1940-2021 is **352 million m³,** with an average start date of April 15 and end date of September 12, and an average flood duration of 150 days. According to data for the periods 1940-1975, 1978-1996, and 2001-2021, there is a noticeable increasing trend. During this period, the maximum flood volume was 672 million m³ (1988), and the minimum was 152 million m³ (2004). Spring flood data for 1997-2000 are not presented due to an unexpressed flood.

The spring flood volume **for 2023 was 388 million m³,** which is **10.2% higher** than the long-term average. The start and end dates of the flood were **April 15 and September 19** (7 days later than the average end date), respectively, with a flood duration of **158 days in 2023.**

Under general heatwave conditions, some mountainous areas accumulate more snow in autumn/winter and receive local spring precipitation, which then releases water over a prolonged period. This contributed to an increase in the total integrated volume.

- **Dos r. – Aynabulak r. s.** The long-term average spring flood discharge for the period 1970-2015 is **26.2 million m³.** According to data for the periods 1970-1975, 1978-1980, 1984-1990, and 2012-2015, there is a decreasing trend. During this period, the maximum spring flood discharge was 97.0 million m³ (1971), and the minimum was 1.78 million m³ (1989). Spring flood data for 1991-2011 and 2016-2023 are not presented due to distortions caused by human activities.

- **Lepsy r. - Lepsy v.** The long-term average spring flood discharge for the period 1932-2023 is **477 million m³,** with the average start and end dates of the flood being April 3 and September 6, respectively, and an average flood duration of 157 days. Analysis of the spring flood dynamics on the Lepsi River over 1932-2023 shows a trend within the normal range. During this period, the minimum spring flood discharge was 176 million m³ (2018), and the maximum was 872 million m³ (1988).

The spring flood volume for **2023 was 558 million m³,** which is **17.0% above** the long-term average. The start and end dates of the flood were **April 6** (3 days later than the average start date) and **September 25** (19 days later than the average end date), respectively, with a flood duration of **172 days in 2023.**

For the Lepsi River, a significant prolongation of the flood was observed (ending 19 days later), which is typical for sub-basins with a large high-mountain snow reserve or influenced by late rains – the total contribution exceeded the norm. A higher proportion of high-mountain tributaries and uneven spatial distribution of precipitation contributed to this positive anomaly.

- **Koksu r. – Koksu v.** At this hydrological post, the long-term average spring flood discharge for the period 1956-2023 is **971 million m³,** with an average start date of April 12 and an average end date of September 10, and an average flood duration of 157 days. Analysis of the spring flood dynamics on the Koksu River at Koksu v. for the periods 1956-1990 and 2012-2021 shows an increasing trend. During this period, the minimum spring flood discharge was recorded in 1982 at 432 million m³, and the maximum in 1969 at 1700 million m³. Spring flood discharge for the period 1991-2011 is not presented due to distortion caused by human activities.

The spring flood volume **in 2023** was **1287 million m³, 32.5 % above** the long-term average. The start and end dates of the flood were **April 24** (12 days later than the average start date) and **September 30** (20 days later than the average end date), respectively, with a flood duration of **160 days in 2023.**

A significant excess (≈ +32.5 %) and the shift toward a later end of the flood indicate a substantial accumulated storage (snow/glaciers/late precipitation) in the upper reaches, which released water over an extended period. The [21] notes that in 2023, the distribution of precipitation and snow cover across regions was uneven – this explains the local areas of surplus.

Tentek r. – Tonkeris v. The long-term average spring flood discharge for the period 1930-2023 is **1161 million m³,** with an average start date of March 24 and an average end date of September 3, and an average flood duration of 164 days. According to data for the period 1930-2023, there is a decreasing trend. During this period, the maximum flood volume was recorded in 1969 at 2030 million m³, and the minimum in 2021 at 360 million m³.

The spring flood volume **for 2023** amounted to **752 million m³,** which is **35.2 % below** the long-term average. The start and end dates of the flood were **March 4** (20 days earlier than the average start date) and **August 26** (8 days earlier than the average end date), respectively, with a flood duration of **176 days in 2023.**

The notes a combination of anomalous warming and a dry spring: an early flood onset (in several locations) combined with limited snow reserves leads to a rapid depletion of accumulated water, resulting in a significant reduction in total flood volume [21]. This behavior was typical for the Tentek River in 2023 (early start – early end and low total volume).

The year **2023** in Kazakhstan was recordingly warm (annual temperature anomaly ≈ +2.58 °C relative to 1961-1990). Spring **2023** was characterized by a significant positive temperature anomaly and, at the same time, a «dry» spring (a substantial precipitation deficit from April to July over most of the country), while autumn **2023** experienced a significant precipitation surplus. These factors determined the nature of snowmelt, as well as the timing and total volume of spring floods [21].

The main reason for the differences observed **in 2023** was the strong temperature anomaly (record-warm spring) combined with a spatial imbalance of precipitation. This resulted in some sub-basins (Koksu, Lepsy, Karoy) experiencing excess water due to accumulated snow and late precipitation, while others (Tekeli, Koktal, Tentek) faced deficits and early, «short» runoff. The precipitation deficit from April to July across much of the country (including southern and southeastern regions) was a key factor for low-water nodes.

2.3 Analysis of spring flood discharge characteristics of Major rivers in the Aral-Syrdarya WMB

Spring Floods. Glacial-snow-fed rivers are those with a significant proportion of glacier-derived inflow, draining the highest-altitude areas of the basin in the upper reaches of the Naryn River and on the northern slopes of the Turkestan and Altai mountain ranges.

Spring floods on these rivers begin in the second half of April, sometimes in May, and end in October. The flood wave peak and the highest annual water discharges occur in July-August. The duration of the spring flood is 170-180 days, during which 80-90 % of the annual runoff occurs.

During the spring flood period, river discharges increase approximately 5-10 times, and against this background, individual peaks occur, separated by periods of more or less sharp de-creases in flow. In the rivers of the Naryn basin, the flood wave very often splits into several distinct, sharply defined waves during periods of clear weather, between which river discharges can temporarily decrease almost to low-flow levels. In most cases, the flood wave is symmetrical relative to its peak, but in some years, conditions are observed where the recession of the flood occurs faster than the rise, i.e., the rising phase of the flood is significantly longer than the falling phase.

In autumn, with the cessation of snow and ice melt in the mountains, rivers of this type transition to low-flow conditions. Their water discharge gradually decreases over the winter without significant fluctuations until March-April of the following year.

Snow-glacial-fed rivers. This category includes a large group of rivers that also receive runoff from high-mountain areas, but glacier feeding is minor or completely absent. The spring flood in rivers of this type begins in March or early April and ends in September, rarely extending into early October. The duration of the flood varies widely, ranging from 140-150 to 200 days or more. During the flood, 75-85 % of the annual runoff occurs. The highest annual discharges are observed in June. Unlike the first type of rivers, the rise of the flood wave in spring occurs significantly faster than the recession, i.e., the rising phase is much shorter than the falling phase. Flooding usually occurs as a single wave, typically marked by a series of successive peaks. It is worth noting that the rivers of the first type, such as those in the Naryn basin, have flood waves that are more strongly segmented into distinct, sharply defined peaks caused by frequent rainfall.

Waters of most Syrdarya rivers, upon entering the foothill and plain zones, are diverted through irrigation canals; as a result, the flow regime of the lower reaches of many rivers is heavily distorted. In some cases, these river sections effectively function as collectors and main irrigation channels. In the estuarine section of the Karadarya, a substantial volume of water constantly flows.

Receiving the main part of its water from the mountainous region, the Syrdarya River initially exhibits a flow regime inherited from its principal tributaries. At the very beginning, below the confluence of the Naryn and Karadarya rivers, the Syrdarya's flow regime shows characteristics typical of snow-glacier-fed rivers: the spring flood occurs from April to September, the month of maximum discharge is June, and the flood wave has a steep rise and a gentler recession. However, already within the Fergana Valley, the flow of the Syrdarya begins to change significantly due to seasonal regulation by the Kairakkum Reservoir along its channel, water withdrawals into irrigation canals, returns from irrigation, and contributions from tributaries via both surface and groundwater. Further downstream, the river's overall water content decreases, the flood wave gradually lowers, spreads out, and smooths. In the upper reaches of the river, flood discharge is 2-3 times greater than low-flow discharge, whereas in the lower reaches it is only 1.5-2 times greater. During the flood period, water discharge in the lower reaches is half that of the upper reaches, while during low-flow periods it is significantly higher than in the upper reaches. In spring, in the lower course, the rise of the flood wave begins somewhat earlier due to water inflow from the low-mountain northwestern part of the basin [23].

Overall, for the Aral-Syrdarya Water management basin, the long-term average start date of the spring flood is **March 12**, the end date is **July 13**, and the duration of the flood is 124 days.

- **Shayan r. – 3.3 km downstream from the mouth of the Akbet River.** The long-term average spring flood discharge for the period 1948-2023 is **47.9 million m³,** with an average start date of February 15 and an end date of May 21, and an average flood duration of 96 days. Analysis of the spring flood dynamics of the Shayan River over the period 1948-2023 shows a trend of moderate decrease. During this period, the minimum spring flood discharge was recorded in 1996 at 11.4 million m³, and the maximum in 1969 at 128 million m³.

The spring flood volume for **2023** amounted to **43.7 million m³,** which is **8.77 % below** the long-term average. The start and end dates of the flood were **February 2** (13 days earlier than the average start date) and **April 27** (25 days earlier than the average end date), respectively, with a flood duration **of 84 days in 2023.**

The early and rapid snowmelt under limited snow reserves–early start and shortened end–indicates accelerated spring warming: the warm spring **of 2023** and early thaws concentrated the runoff, but with insufficient snow reserves, the total volume was below normal. The regionally «dry» spring (April-July) reduced contributions from late snow and rainfall, further reinforcing the decrease in total runoff [21].

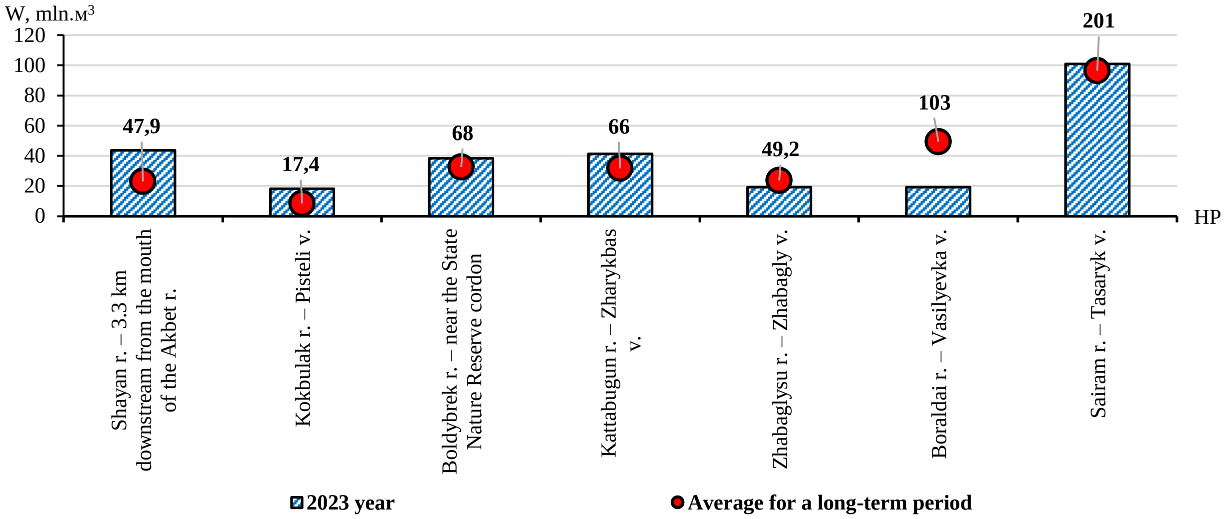


Figure 58 – Dynamics of changes in spring flood runoff of the main tributaries of the Syrdarya river in 2023

Kokbulak r. – Pisteli v. At this hydrological post, the long-term average spring flood discharge for the period 1981-2023 is **17.4 million m³,** with the average start and end dates of the flood being February 24 and May 10, respectively, and an average duration of 77 days. Analysis of spring flood dynamics on the Kokbulak River at Pisteli for the periods 1981-1994, 2001-2010, and 2012-2021 shows an increasing trend. During this period, the minimum spring flood discharge was recorded in 1986 at 1.73 million m³, and the maximum in 2002 at 35.2 million m³. Spring flood discharge for 1995-2000 is not presented due to the closure of the post.

The spring flood volume in **2023** was **18.2 million m³,** which is **4.6 % higher** than the long-term average. The flood started on **February 14** (10 days earlier than the average start date) and ended on **April 25** (16 days earlier than the average end date), with a duration **of 70 days in 2023.**

Bulletin [21] notes strong interregional heterogeneity and the use of FLDAS to identify local SWE anomalies – locally, in the Kokbulak sub-basin, more snow/precipitation may have fallen, resulting in a slight exceedance of the average. Rapid, early snowmelt (early start) also caused the discharge peak to occur earlier, but the total volume was slightly higher due to the local excess of snow storage.

Boldybrek r. – near the State Nature Reserve border. The long-term average spring flood discharge for the period 1981-2023 is **68.0 million m³,** with an average start date of April 2, an average end date of September 15, and an average duration of 167 days. Analysis of data for the period 1981-2023 shows an increasing trend. During this period, the maximum spring flood volume was 115 million m³ (2002), and the minimum was 28.8 million m³ (2020).

The spring flood volume **for 2023 was 38.3 million m³,** which **is 43.7 % below** the long-term average. The start and end dates of the flood were **May 15** (43 days later than the average start date) and **July 26** (51 days earlier than the average end date), respectively, with a flood duration **of 72 days in 2023.**

Across the basin, a negative SWEn trend is observed; in 2023, snow depth and snow storage in the south were below normal (according to field data and FLDAS), resulting in a low initial volume of meltwater. Other main factors include the season's precipitation deficit from April to July, sharp temperature anomalies, late segregation of meltwater (late start), and redistribution of flow (short and low irrigation runoff). This represents a combined effect of low snow storage and unfavorable seasonal precipitation distribution [21].

- **Kattabugun r. – Zharykbas v.** The long-term average spring flood volume for the period 1940-2023 is **66.0 million m³,** with an average start and end date of February 19 and May 24, respectively, and an average flood duration of 96 days. According to data for the period 1981-2023, a slight increasing trend is observed. During this period, the maximum flood volume was 146 million m³ (1990), and the minimum was 7.68 million m³ (1995).

The spring flood volume for **2023** was **41.2 million m³,** which is 37.6 % below the long-term average. The start and end dates of the flood were **February 15** (4 days earlier than the average start date) and **April 6** (48 days earlier than the average end date), respectively, with a flood duration of **50 days in 2023.**

Rapid snowmelt with a small snow reserve – early onset and a sharp, premature end – indicates a fast but limited-scale melt: the small snow mass produced a short peak flow. This is consistent with a warm spring and an overall deficit of snow water storage in the basin. The April-July precipitation deficit reduced replenishment and late inflows [21].

- **Zhabaglysu r. – Zhabagly v.** At this hydrological post, the long-term average spring flood discharge for the period 1981-2023 is **49.2 million m³,** with an average start and end date of March 30 and September 11, respectively, and an average flood duration of 165 days. Analysis of the spring flood dynamics at Zhabaglysu River near Zhabagly for the period 1981-2023 shows a moderate decreasing trend. During this period, the minimum spring flood discharge was recorded in 2020 at 5.16 million m³, and the maximum in 2002 at 101 million m³.

The spring flood volume **for 2023 was 19.3 million m³,** which is **60.8 % below** the long-term average spring flood volume. The start and end dates of the flood were **April 1** (2 days later than the average start date) and **July 19** (54 days earlier than the average end date), respectively, with a flood duration of **110 days in 2023.**

A long-term decreasing trend in discharge, combined with a significant snow deficit in several southern regions in 2023, contributed to this outcome. The bulletin notes zonal heterogeneity, but for the Aral-Syrdarya basin as a whole, SWEn trends are negative; for the Zhabaglysu River, this manifested as a sharp reduction in volume. Early and rapid snow disappearance (shortened snow cover duration in some southern areas), along with a deficit of spring precipitation, were the key climatic factors [21].

- **Boralday r. – Vasilyevka v.** The long-term annual runoff for the period 1981-2023 is **103 million m³,** with the average start and end dates of the spring flood being March 13 and July 1, and an average flood duration of 112 days. According to data for 1981-2023, a rising trend is observed. During this period, the maximum flood volume was 390 million m³ (1997), and the minimum was 8.54 million m³ (1986).

The spring flood volume for **2023 was 19.3 million m³,** which is **81.3 % below** the long-term average. The start and end dates of the flood were **March 6** (7 days earlier than the average start date) and **April 28** (64 days earlier than the average end date), respectively, with a flood duration of **53 days in 2023.**

A significant deficit of snow accumulation in key upper-catchment areas (a long-term negative trend in the basin and locally low snow reserves in 2022/23) explains the sharp drop in total runoff. A warm early spring and precipitation-deficient conditions from April to July led to a concentrated but weak spring flood (short duration and early end), meaning the water passed quickly and did not provide months-long replenishment [21].

Sairam r. – Tasaryk v. The long-term average annual runoff for the period 1981-2023 **is 201 million m³,** with an average spring flood start and end date of April 9 and September 11, and an average flood duration of 155 days. Data for the period 1981-2023 show a moderate decreasing trend. During this period, the maximum flood volume was 383 million m³ (2002), and the minimum was 89,7 million m³ (2020).

The spring flood volume for **2023 was 101 million m³,** which is 49.7% below the long-term average. The flood started on **May 9** (31 days later than the average start date) and ended on **July 30** (43 days earlier than the average end date), with a duration **of 86 days in 2023.**

The late shift in the start and the rapid end of the flood correspond to a small total volume of meltwater and a displacement of snowmelt to high-altitude areas. The bulletin notes strong spatial heterogeneity of the snow cover and a shortened snow cover duration in several southern regions. The deficit of spring precipitation (April-July) and the record warm spring contributed to the low total inflow [21].

Based on the **2023** analysis, climate is the primary factor influencing changes in spring flood volumes: record-high temperatures **in 2023** (an abnormally warm spring), reduced snow cover duration, and precipitation deficits in April-July are the main causes of reduced and shortened floods at many hydrological stations. Long-term analysis indicates a statistically significant negative trend in snow water equivalent (SWEn) across the Aral-Syrdarya basin, increasing the likelihood of low floods. Local variability shows that some small sub-basins may have received localized precipitation or snow. FLDAS estimates revealed strong spatial heterogeneity [21].

2.4 Analysis of spring flood runoff characteristics of the main rivers of the Zhaiyk-Caspian WMB

Spring Flood. The rivers of the Zhaiyk-Caspian basin, in terms of their water regime, belong to the Kazakh type, with a sharply pronounced predominance of runoff in the spring period. Over the annual cycle, the runoff regime of most rivers is characterized by a high spring flood and low summer low water, with occasional rain floods. The highest annual discharges are observed in the second half of April and only rarely in early May.

Overall, the start date of the spring flood for the main rivers of the Zhaiyk-Caspian WMB over the long-term period is **April 1**, the end date is **June 18**, and the duration of the flood is 81 days.

The spring flood on r. Zhaiyk begins on average around March 30-April 1, almost simultaneously on most rivers. Early flood onset dates range from March 4-11, while late dates occur from April 12-24. The end of the flood depends on the intensity of snowmelt, the size of the catchments, and the water availability of the year. The average duration of the spring flood on r. Zhaiyk is approximately 107-110 days.

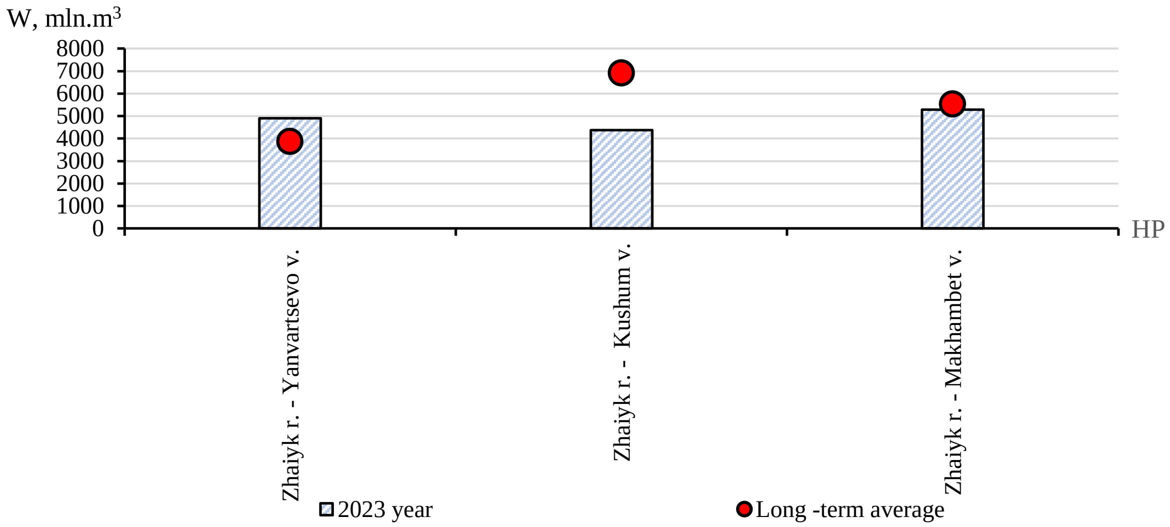


Figure 59 – Dynamics of spring flood runoff volume along the length of r. Zhaiyk in 2023

Zhaiyk r. – Yanvartsevo v. The long-term average spring flood runoff for the period 2009-2023 is **3880 million m³**, corresponding to **22 mm**. The average start date of the flood over the long-term period is March 28, and the average end date is June 30. The average duration of the flood is 95 days.

Analysis of the long-term dynamics of spring runoff volumes indicates a consistent decrease in flood magnitude during the spring period, confirmed by linear regression results. During the considered period, the minimum flood volume was recorded in 2019 – 1,420 million m³, and the maximum in 2017 – 7,530 million m³.

In 2023, the spring runoff amounted to **4900 million m³**, which is **26 %** above the average value, indicating relatively favorable water conditions. This is consistent with the geographic distribution map of seasonal precipitation in autumn 2022, which showed a precipitation surplus of up to 190% of the norm in the West Kazakhstan region [21].

The start of the flood was recorded on **March 27**, one day earlier than the long-term average; the end date was **June 30**, matching the long-term indicator. The flood duration was **96 days,** close to the average value. The increased runoff volume may be due to a positive snowpack in the basin and optimal temperature conditions for uniform melting.

Zhaiyk r. – Kushum v. The long-term average spring flood runoff for the period 1912-2023 is **6920 million m³,** corresponding to **39 mm**. The average start date of the flood over this period is April 2, and the average end date is July 13. The average flood duration is 104 days. Analysis of the spring flood dynamics at this gauge shows a pronounced trend of decreasing runoff. During the study period, the minimum spring flood occurred in 1967 at 969 million m³, and the maximum in 1914 at 23900 million m³.

The spring flood volume in **2023** was **4370 million m³, 37 %** below the norm, indicating a pronounced low-water season. In 2023, the flood began on April 3, one day later than the average, and ended on **June 30**, earlier than the long-term average. The flood duration was **104 days**.

Zhaiyk r. – Makhambet v. The long-term average spring flood runoff for the period 1936-2023 is **5549 million m³.** The average start date over this period is April 3, and the average end date is July 22. The average flood duration is 109 days.

According to the data for the considered period, a pronounced trend of decreasing runoff is observed, which may result from both climatic factors and increased water management impact on the basin. During this period, the maximum runoff volume was 17,500 million m³ (1948), and the minimum was 573 million m³ (2006).

At this gauge, the spring flood runoff of the river in **2023** was **5290 million m³**, 5 % below the norm. In that year, the flood began on **March 22**, 11 days earlier than the average date, and ended on **July 22,** matching the average date. The flood duration was **152 days**.

At the main gauging sites of the r. Zhaiyk, a stable trend of decreasing spring flood volumes persists, particularly pronounced in the upper and middle reaches. This corresponds to overall climatic changes in the basin, including reduced winter snowpack and increased air temperatures in the spring period.

In 2023, the timing of flood onset showed mixed shifts: in the upper and lower reaches, the flood began earlier than usual, whereas in the middle reaches it occurred closer to the norm. At the same time, the flood end dates in 2023 were mostly earlier or within the norm, resulting in a shortened active flood phase at certain gauging sites.

The extended duration of the flood in the lower reaches (at the gauging site near pos. Makhambet) with a moderate discharge volume requires further analysis of spring temperature patterns, water management regulation, and the dynamics of inflow from reservoirs and tributaries.

Natural variability and the manifestation of interannual fluctuations in spring flow underscore the need for timely forecasting of water availability and management of water resources in the r. Zhaiyk basin, especially under increasing climatic impacts and growing water demand.

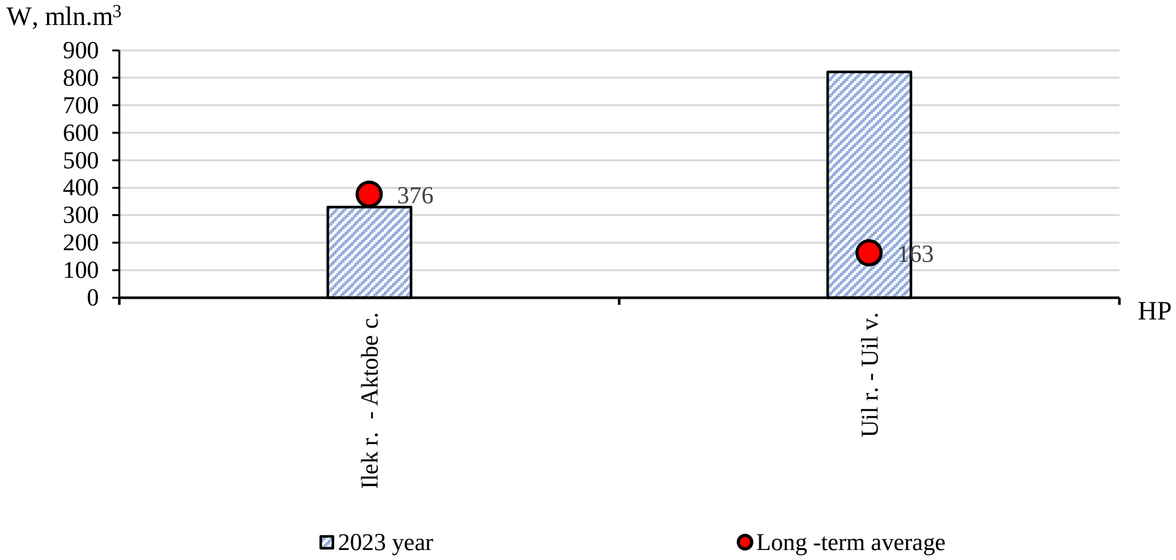


Figure 60 – Dynamics of the change in spring flood discharge along r. Ilek and r. Uil for 2023

Spring floods on the rivers of Aktobe region generally begin on average between 1 and 9 April, and on most rivers nearly simultaneously. Early flood onset dates range from 10 to 23 March, and late dates from 31 March to 1 May. The end of the flood depends on the intensity of snowmelt, the size of the catchments, and the river flow. The duration of the spring flood on the rivers averages around **84-130 days**.

Ilek r. - c. Aktobe. The long-term average spring flood discharge is **376 million m³**, corresponding to **35 mm**. The mean flood onset date over the studied period is 1 April, with the average end date on 14 May. The average duration of the flood is 41 days. According to data for 1939-1975, 1979-1999, and 2003-2023, the trend shows a clear decrease in flood volume. During this period, the maximum flood volume reached 1670 mln m³ (1942) due to abundant snow cover and significant moisture in the upper basin, typical of high-flow years, while the minimum was 28.6 mln m³ (1967) because of insufficient snow accumulation, dry autumn, and low soil moisture. In spring **2023**, the flood volume was **330 million m³, 12 %** below the norm. The flood began on **16 March**, 15 days earlier than the average date, and ended on **6 April,** also earlier than the average. The flood duration was only **22 days**, significantly below the average.

Uil r. - v. Uil. The long-term average spring flood discharge is **163 million m³**, corresponding to **9,8 mm**. The mean flood onset date over the studied period is 3 April, with the average end date on 15 May. The average flood duration is 42 days. Observed data for 1991-2023 show a trend of increasing flood volume, primarily due to the high-flow year of **2023**. During this period, the maximum flood volume of **821 million m³** occurred in **2023,** driven by abundant precipitation from late winter through March, high snow reserves in the Uil river basin, and good soil moisture since autumn [21], [24]. The minimum value was 1,37 million m³, observed in 2021, associated with extremely low snow cover and insufficiently moist soil, which limited meltwater inflow. In **2023**, the flood onset occurred on **15 March,** 18 days earlier than the average date, and the end of the flood was on **20 April**, also earlier than the average date. The flood duration was **37 days.**

2.5 Analysis of spring flood discharge characteristics of the main rivers of the Esil WMB

Spring Flood. The Esil water management basin belongs to the Kazakhstani type according to B. D. Zaikov’s classification and to the exclusively snow-fed zone according to M. I. Lvovich’s classification. The annual runoff of rivers in this area is formed almost entirely during the spring flood period. The share of spring runoff accounts for 95-98 % of the annual total. In years with insufficient snow cover and soil moisture, most of the meltwater goes to filling terrain depressions, and surface runoff is almost absent [25].

Overall, the start date of the spring flood in the Esil WMB over the long-term period is **April 6**, and the end date is **April 17**, with the flood duration lasting 42 days.

The flood on the Esil River generally begins on average at the beginning of April. Early start dates range from March 11, while late starts occur from April 21. The end date of the flood depends on the intensity of snowmelt, the size of the catchments, and the river’s discharge.

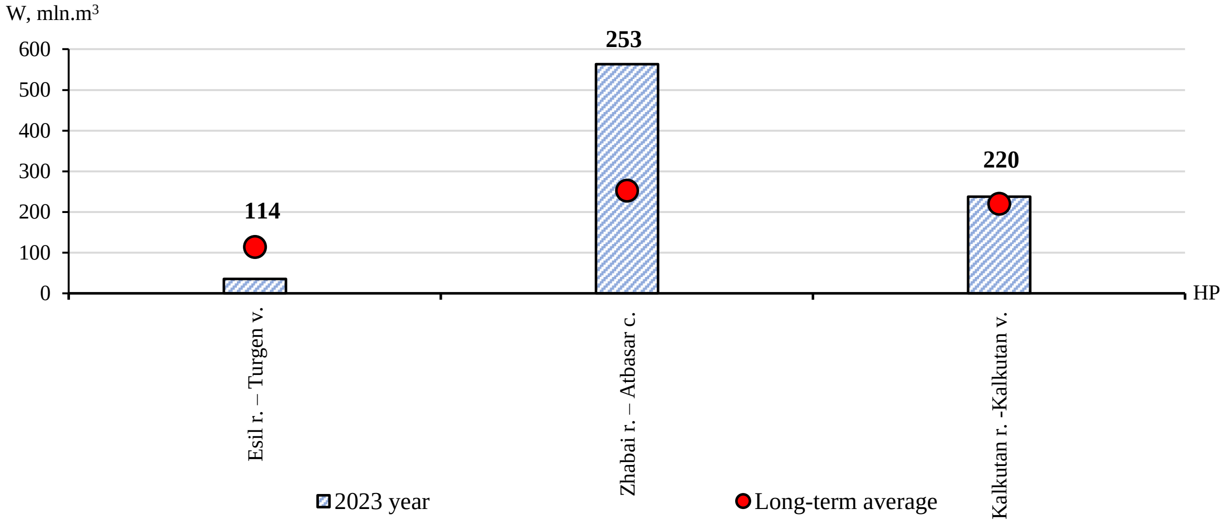


Figure 61 – Dynamics of the spring flood discharge volume in 2023

Esil r. – v. Turgen. The long-term average spring flood discharge volume is **114 million m³, or 35 mm**. On average, the spring flood begins on April 3 and ends on May 8. The average duration of the spring flood is 36 days.

Analysis of the spring flood dynamics of the Esil River at Turgen v. for the period 1981-2023 shows a trend of increasing discharge volume. During this period, the minimum spring flood discharge was recorded in 1999 at 5,51 million m³, and the maximum in 2015 at 343 million m³.

In 2023, the spring flood discharge was **35,6 million m³,** significantly **below the long-term average**, indicating a pronounced low-water season. This was due to the combined effect of an abnormally warm and dry spring and a shortened flood period, which sharply reduced the spring flood volume [21].

The spring flood on the Esil River in **2023** began on **March 28** and ended on **April 22**, with a duration of **26 days**, which is 10 days shorter than the long-term average.

Esil r. – v. Kamennyy Karyer. Spring flood discharge at this hydrological station is not reported due to significant distortion of the flow regime caused by hydraulic structures. For rivers that are tributaries of the Esil, the spring flood typically begins between April 6 and 10. Early flood onset dates range from March 17-20, while late onset dates occur from April 23-26. The end of the flood depends on snowmelt intensity, watershed size, and river flow conditions.

Zhabai r. – c. Atbasar. The long-term average spring flood discharge **is 253 million m³, or 30 mm**. On average, the spring flood begins on April 6 and ends on May 18. The average duration of the spring flood is 43 days.

According to data for the period 1937-2023, there is a trend of increasing spring flood discharge. During this period, the maximum flood volume was 2110 million m³ (2017), and the minimum was 25,6 million m³ (1937). In **2023**, the spring flood volume amounted to **563 million m³,** more than **twice the long-term average**. This corresponds with the geographic distribution map of seasonal precipitation in autumn 2022, which showed an excess of precipitation in the northern regions, ranging from 121 to 190 % of the norm [21].

The beginning of the spring flood in **2023** occurred on **March 30**, and it ended on **April 29**, with a duration of **31 days**, which is 12 days shorter than the long-term average.

Kalkutan r. – v. Kalkutan. The long-term average spring flood volume is **220 million m³ or 13 mm.** On average, the spring flood period begins on April 9 and ends on May 26. The average duration of the spring flood is 48 days.

According to data for the period 1937-2023, a slight increasing trend in spring flood volume is observed. During this period, the maximum flood volume was 1010 million m³ (2002), and the minimum was 1,65 million m³ (1977). The spring flood volume in **2023** amounted to **237,4 million m³, slightly exceeding the long-term average**.

The beginning of the spring flood in **2023** occurred on **April 3**, and it ended on **April 29**, with a duration of **27 days**, which is 21 days shorter than the average. The average flood duration throughout the basin ranges from 36 to 48 days.

The hydrological regime of the spring flood in the Esil basin demonstrates a stable long-term trend of increasing flow volumes. At all observation sites where the natural regime is maintained, an increase in spring flood volumes is observed.

Thus, over the entire multi-year period, the following key features can be highlighted: an increase in spring flood volumes, high interannual variability, and a general shortening of flood duration in recent years.

A common feature of **2023** was the sharp reduction in flood duration across all rivers in the basin. The causes may include an early onset of spring, rapid snowmelt, and insufficient soil moisture capacity, which contributed to the swift runoff of meltwater within a compressed period. At the same time, flow volumes varied significantly, ranging from very low to substantially above average. The differences in volumes across sites indicate heterogeneous weather and hydrological conditions within the basin.

2.6 Analysis of spring flood flow characteristics of the main rivers of the Shu-Talas WMB

Spring Flood. The highland rivers belong to the glacier-snow feeding type, with a prolonged water discharge; after the peak is reached, the flow gradually decreases. Most rivers of the studied territory fall into this category, including all the main tributaries of the Shu and Talas rivers. Flood formation begins in spring: the main phase occurs from April to June, caused by snowmelt; in summer, glacier-fed flooding occurs (July-September) [12].

On lowland rivers, such as those in the southern regions of Kazakhstan, flood waves are usually short-lived (up to a month), but during intense snowmelt, water levels can rise sharply–by 2.5-5 m per day.

In mountainous areas, floods can last 3-6 months due to gradual melting of snow and glaciers across different elevation zones. Catastrophic peak flows are caused by heavy rainfall during the snowmelt period. Despite the significant role of glaciers, their area is decreasing: between 1963 and 2003, glacier coverage declined by 15 %.

In general, the start date of the spring flood in the Shu-Talas WMB over the long-term period is **February 28**, the end date is **April 13**, and the duration of the flood is 44 days.

At the hydrological posts on the rivers Talas - settlement. Solnechny, Talas - v. Zhasorken, Shu - v. Kainar, Teris - v. Nurlikent, and Kuragaty - railway station Aspara, the assessment of spring flood characteristics is not carried out due to significant changes in the natural hydrological regime. These changes are caused either by regulation of flow through hydraulic structures or by major deformations of the riverbed. In these conditions, the influence of reservoirs and other regulating structures leads to smoothing of seasonal flow fluctuations and distortion of the hydrograph, making it impossible to identify typical features of the spring flood. Additionally, changes in the volume, duration, and timing of the spring water rise caused by hydraulic structures, as well as alterations in riverbed conditions, prevent objective observation and analysis of the flood.

Thus, at the indicated posts, the necessary conditions for reliably identifying and analyzing the parameters of the spring flood are absent, making it impossible to conduct an accurate hydrological assessment of this seasonal phenomenon.

The spring flood in the Shu-Talas basin is characterized by a complex, multi-component structure: on one hand, short-term but sharp floods occur in the lowlands, while on the other, prolonged and extended floods take place in the mountainous areas. The long-term trend indicates an increase in the volumes of spring runoff, at least in certain sections, despite the overall reduction of glaciers.

The year **2023** was **anomalous in terms of flood duration** – in some cases, the spring flood lasted almost 80 days, significantly exceeding the average values.

2.7 Analysis of spring flood runoff characteristics of the main rivers of the Nura-Sarysu WMB

Spring flood. The territory of the basin belongs to areas with sharply pronounced water deficiency. A distinctive feature of the rivers in the basin is that the main part of the annual runoff (up to 90 % or more) occurs during the short spring flood period. During the rest of the year, river flows decrease significantly, and on most rivers, runoff is virtually absent in this period [26].

In general, the start date of the spring flood for the Nura-Sarysu WMB over the long-term period is **March 31**, the end date is **May 18**, and the duration of the flood is 48 days.

On the Nura River, the flood usually begins on average between March 30 and April 6. Early onset dates range from March 11-14, while late onset dates occur from April 14-26. The end date of the flood depends on the intensity of snowmelt, the size of the catchments, and the river flow. The average duration of the spring flood on the Nura River is approximately 45-54 days.

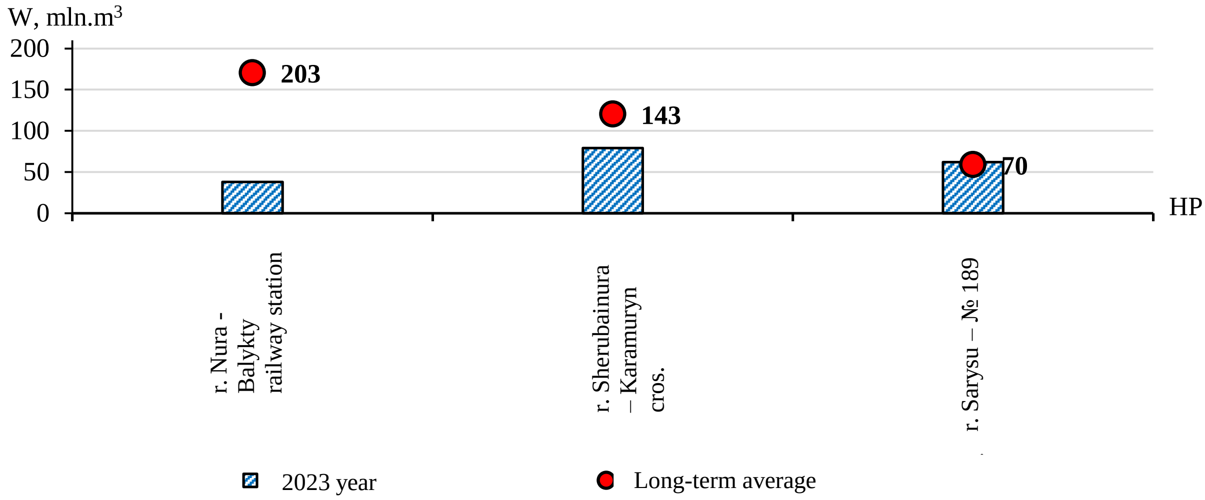


Figure 62 – Dynamics of the spring flood discharge volume in 2023

Nura r. –Balykty r.s . The long-term average spring flood discharge for the period 1938-2023 is **203 million m³ or 13.4 mm**. The average start date of the flood over the long-term period is March 30, and the average end date is May 12, giving an average duration of 44 days. Analysis of the spring flood dynamics for 1935-1974 and 2011-2023 shows a clear trend of increasing discharge. Over this period, the maximum discharge was 1,130 million m³ (2015), and the minimum was 5.39 million m³ (1936). In **2023**, the spring flood began on **March 28** and ended on **April 28** (14 days earlier than the long-term average), with a duration of 32 days, which is 12 days shorter than the average.

Data for 1975-1990 are not included due to anthropogenic distortions of the flow, and data for 1991-2010 are omitted because of regulated discharge.

Nura r. – v. Koshkarbayeva.The long-term average spring flood discharge for the periods 1916-1919, 1928, 1933-1943, 1945-1975, 1981-1985, 2011-2015, and 2018-2023 is **404 million m³ or 8.8 mm.** On average, the spring flood starts on April 6 and ends on May 31, with an average duration of 54 days.

Analysis of the data over the specified periods shows that the discharge generally remains within the normal range. The maximum discharge recorded was 1,440 million m³ (1948), and the minimum was 18 million m³ (1936). Data for **2023** are not provided due to flow regulation.

Data for 1976-1980 and 1986-1990 are omitted due to flow distortion caused by human activities, and data for 1991-2010 and 2022-2023 are not included because of regulated flow.

Sherubai – Nura r. - Karamuryn v. The long-term average spring flood discharge for the period 1938-2023 is **143 million m³ or 16 mm**. On average, the spring flood starts on March 29 and ends on May 22, with an average duration of 55 days. Analysis of the data for 1947-1950 and 1957-2023 shows that the discharge generally remained within the normal range. The maximum discharge recorded was 592 million m³ (2017), and the minimum was 4.35 million m³ (1975). At this hydrological post, the spring flood discharge in **2023** was 79 million m³. The flood started on March 27 (2 days earlier than the average) and ended on **June 10** (18 days later than the average), with a duration of **76 days**, which is 21 days longer than the long-term average.

- **Sarysu r. – junction No.189.** The long-term average spring flood discharge for the period 1938-2023 is **70 million m³ or 2.6 mm**. On average, the spring flood starts on March 31 and ends on May 9. The average duration of the spring flood is 39 days. According to data for the period 1963-2023, a pronounced trend of increasing discharge is observed. During this period, the maximum discharge was 861 million m³ (2015), and the minimum was 0.54 million m³ (2012). At this hydrological post, the spring flood discharge in **2023** was **62 million m³**. The flood started on **March 15** (16 days earlier than the average) and ended on **May 31** (22 days later than the average), with a duration of **78 days**, which is 39 days longer than the average. The timing of the flood's end depends on the intensity of snowmelt, the size of the catchments, and the water availability for the year.

According to the data [21]: spring in several regions was particularly dry, with precipitation significantly below normal. Rapid snowmelt against the background of elevated air temperatures reduced both the timing and volume of meltwater entering the rivers in spring.

2.8 Analysis of spring flood discharge characteristics of major Rivers in the Tobyl-Torgay WMB

The spring flood, primarily caused by snowmelt, represents the main phase of the hydrological regime of rivers in the Tobyl basin and accounts for 75-100 % of their annual discharge. The main contribution comes from meltwater from the elevated parts of the catchments, with minimal input from liquid precipitation and groundwater, which is entirely absent in small rivers. During this period, significant rises in water levels are observed, and the height of the flood wave varies depending on the annual runoff and the size of the catchment. Overall, for the Tobyl-Torgay Water management basin, the long-term average start date of the spring flood is **April 3**, the end date is **May 9**, and the duration of the flood is 37 days.

The spring flood on the Tobyl River generally begins on average between April 3 and April 6. Early flood onset occurs between March 11 and March 24, while late onset is observed from April 20 to May 15. The timing of flood recession depends on the intensity of snowmelt, catchment size, and annual water availability. The average duration of the spring flood on the Tobyl River is approximately 30-40 days.

- **Tobyl r. - Grishenka v.** The long-term average spring flood discharge for the period 1938-2023 is **215 million m³ (16 mm).** The average start date of the flood is April 3, the end date is May 8, and the average duration is 36 days. Analysis of long-term data shows a consistent trend of decreasing spring flood discharge. The minimum volume was recorded in 2023 at 0.79 million m³, and the maximum in 1941 at 1,140 million m³. **In 2023**, the flood began on **April 28** (25 days later than the norm), ended on **April 30** (9 days earlier than normal), and lasted only 3 days.

- **Ayat r. - Varvarinka v.** The long-term average spring flood discharge for 1952-2023 is **123 million m³ (14 mm).** The average start date is April 3, the end date is May 10, and the average duration is 37 days. There is a clear trend toward decreasing flood volumes. The minimum discharge was recorded in 2015 at 6.4 million m³, and the maximum in 1957 at 550 million m³. **In 2023**, the flood began on **March 30** (4 days earlier than the average start date), ended on April 30 (10 days earlier), and lasted **32 days**.

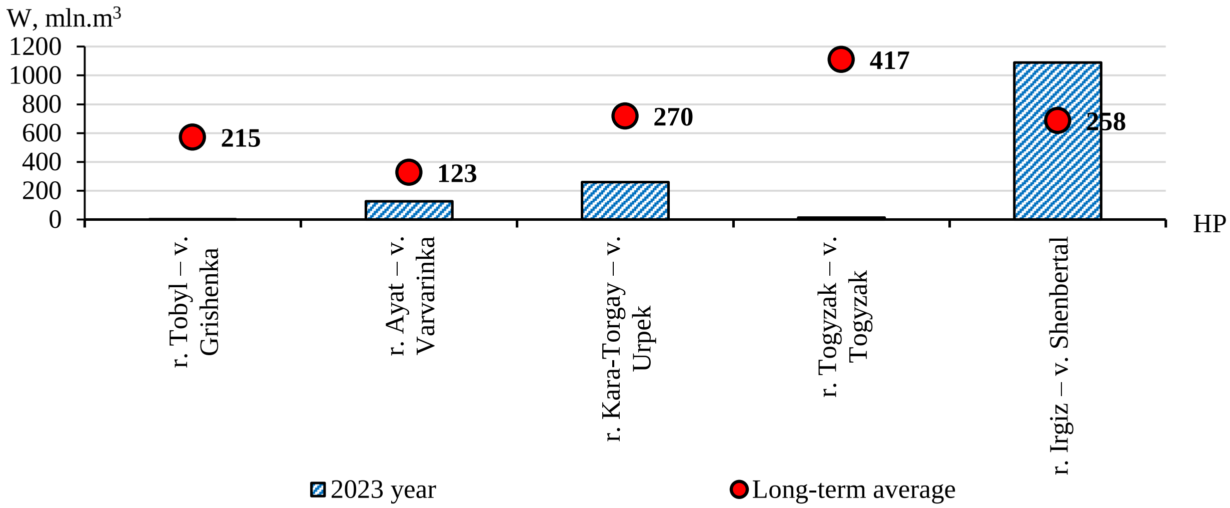


Figure 63 – Dynamics of spring flood discharge volume in 2023

- **Kara-Torgay r. - Urpek v.** The long-term average spring flood discharge for 1942-2023 is **270 million m³ (18 mm).** The average start date is April 3, the end date is May 8, and the average duration is 35 days. Analysis indicates an overall trend of decreasing flood discharge. The minimum was observed in 1968 at 4.47 million m³, and the maximum in 1948 at 760 million m³. **In 2023**, the flood began on **March 23** (11 days earlier than the norm) and ended on **May 10** (2 days later), lasting **49 days.**
- **Irgiz River - Shenbertal v.** The long-term average spring flood discharge for 1961-2023 is **258 million m³ (10 mm).** The average start date of the flood is April 1, the end date is May 14, and the average duration is 44 days. Unlike other rivers, there is a trend of increasing flood volumes. The minimum discharge was recorded in 2020 at 2.27 million m³, and the maximum in 2022 at 2,700 million m³. **In 2023,** the flood began on **March 14** (17 days earlier than the norm), ended on **May 10** (4 days earlier), and lasted an anomalously short 16 days.
- **Togyzak River - Togyzak v.** The long-term average spring flood discharge for 1936-2023 is **417 million m³ (28 mm).** The average start date is April 3, the end date is May 8, and the average duration is 35 days. The long-term trend shows an increase in flood volumes. The minimum discharge was observed in 1936 at 3.58 million m³, and the maximum in 1947 at 215 million m³. **In 2023,** the flood began on **March 28** (7 days earlier than the norm) and ended on **April 30** (8 days earlier), lasting **34 days**.

In 2023, hydrological stations covering various rivers and regions recorded the following general patterns in spring floods: in most cases, the onset of the flood occurred significantly earlier than the long-term average dates. The exception was the Tobyl River, where the flood began later than normal. The end of the flood varied across rivers, occurring both earlier and later, but often the flood period was shorter than the long-term norm, or at least its intensity after the peak was reduced. According to the [21], significant air temperature anomalies were recorded in Kazakhstan **in 2023,** especially during the spring and summer seasons. Northern regions also experienced these anomalies. Elevated temperatures accelerated snowmelt and reduced the stability of the snow cover, leading to an earlier onset of the flood.

3 OVERVIEW AND ANALYSIS OF DANGEROUS HYDROLOGICAL PHENOMENA

Hazardous hydrological phenomena are events that develop as a result of hydrological processes triggered by various natural factors or their combinations, which have a damaging impact on people, economic assets, and the surrounding natural environment [27].

Hydrological hazardous phenomena include:

1) **high water levels** during spring floods, rain-induced floods, ice jams, ice congestion, or wind-driven surges - levels at which flooding of floodplain areas and settlements, major industrial facilities, roads, power lines, water supply systems, and agricultZhaiyk crops is possible;

2) **low water levels** during low-flow periods – levels characterized by reduced water availability and prolonged stagnation during winter and summer-autumn periods, when the river is sustained solely by groundwater sources.

3) **early freezing and late ice breakup** of a navigable river, reservoir, or lake, occurring no more frequently than once every 10 years; the formation of ice impassable for vessels and icebreakers along navigation routes; intensive ice drift posing a threat to river hydraulic structures and potentially causing their destruction; submerged ice clogging water intake structures;

4) **ice formations (ice floes)** – layered ice masses causing water backflow in rivers and flooding of adjacent areas with cold water, as well as damaging various structures through static and dynamic pressure of the ice;

5) **debris flows (mudflows)** – water-mud-rock flows in mountainous areas triggered by heavy precipitation, the breach of dammed or moraine lakes, threatening settlements, sports and resort complexes, mining facilities, railways and roads, irrigation systems, and other economic infrastructure.

6) **snow drifts and avalanches**, which also pose threats to settlements, railways and roads, power lines, and other infrastructure;

7) **landslides and bank erosion**, most prominently observed at newly created reservoirs, threatening various structures along the banks, including residential buildings [27].

Hazardous water levels – values of critical river water levels at which flooding of settlements occurs. Critical water levels are determined based on long-term observation data, taking into account historical maximum levels and recorded flooding events [28].

Hazardous Hydrological Events in 2023

Hazardous hydrological events in Kazakhstan in 2023 were mainly associated with the spring flood period, which is driven by intense snowmelt. Compared to previous years, the 2023 flood period was generally stable, except in the western and northwestern parts of the country, which experienced a wetter and earlier onset of the spring flood. Due to the early and sustained rise of air temperatures above 0 °C, the spring flood began in the late first decade to early second decade of March in these regions, while in other lowland river regions, the onset occurred as usual in early April.

As a result of warming up to 12 °C and intense snowmelt, water levels rose in rivers in the West Kazakhstan, Aktobe, Kostanay, and North Kazakhstan regions, leading to flooding and overflows. Due to the deep freezing of the soil, the meltwater could not infiltrate the ground and formed surface runoff.

Additionally, during the flood period, some hydrological stations (hereinafter - HS) recorded exceedances of hazardous water levels:

- In the West Kazakhstan region at the hydrological stations: Derkul River - Taskala v. (on March 11, water level reached 557 cm, critical level - 520 cm), Chizha-2 River - Chizha-2 v. (on March 11, water level - 799 cm, hazardous level - 780 cm), Olenty River - Zhympity v. (on March 13, water level - 545 cm, hazardous level - 490-520 cm), and Utva River - Kentubek v. (on March 14, water level - 800 cm, hazardous level - 700 cm);
- In the Aktobe region at the hydrological stations: Bolshaya Kobda River - Kobda v. (on March 14, water level - 739 cm, hazardous level - 660 cm), Temir River - Leninsky v. (on March 14, water level - 700 cm, hazardous level - 623 cm), Uil River - Uil settlement (on March 17, water level - 1045 cm, hazardous level - 995 cm);
- In the Kostanay region at the hydrological station: Tyuntyugur River - Koshevoe v. (on April 5, water level - 956 cm, hazardous level - 913 cm);
- In the Akmola region at the hydrological station: Kalkutan River - Kalkutan v. (on April 13, water level - 599 cm, hazardous level - 570 cm);
- In the North Kazakhstan region at the hydrological station: Esil River - Pokrovka v. (on April 13, water level - 1068 cm, hazardous level - 950 cm).

Mudflows

According to data from RSE «Kazhydromet» and the State Institution «Kazselezashchita» in **2023** there were 7 recorded mudflow events in Kazakhstan: 1 in Mangystau region and 6 in Almaty region.

On July 17-18, **2023,** a rain-generated mudflow occurred in Tauçik v., Tupkaragan and Karakiyan districts of Mangystau region. It was caused by an intense 10-minute rainfall. Water flowing down from the mountains turned into a powerful mudflow, washing away some pedestrian crossings. No casualties were reported at the site.

In the Almaty region on July 21, **2023**, heavy rainfall triggered mudflows in the mountains near Almaty city: almost simultaneously with the mudflows in the Kishi Almaty River basin, a mudflow formed in the upper reaches of the Kumbel River basin (a right tributary of the Ulken Almaty River):

On July 21, **2023**, as a result of intense rainfall in the Kumbel mudflow channel, a mudflow occurred with a turbidity of 4-5 points. The mudflow was wave-like: discharge varied from 1.5 m^3/s to 5 m^3/s, with a maximum discharge of 10 m^3/s. In the area of the Ulken Almaty hydrological station - Ayusay post, turbidity was 3 points. The first tier of the mudflow retention basin at the Ayusay dam (tree roots, branches, and stones) was filled by the mudflow.

In the Kishi Almaty River basin, due to intense rainfall over 2-3 hours, a heavy rain of 56 mm fell, forming mudflows in three gullies on the right slope of the Kishi Almaty valley. Mud deposits damaged a tractor road for about 1000 m, with deposit heights reaching 2 meters over 300 m. Near the hydrological station «a/b Tuyuksu» the debris flow partially settled on the bridge crossing to the alpine camp.

In the Almaty region, the formation of mudflows put three districts at risk simultaneously:

- In the Talgar district, in the Talgar River basin, heavy rainfall caused the water level to rise to a critical point, resulting in a rain-generated mudflow with a discharge of about 20 m^3/s and a water turbidity of 4 on the scale. As a result, a dam breach occurred, and 330 people were evacuated, including 250 children from the «Sputnik» summer camp located above the dam.
- In the Enbekshikazakh district, in the Esik River basin, heavy precipitation led to the formation of a mudflow with a water discharge of up to 50 m^3/s and a turbidity of 4, which washed away the roadbed of a dirt road.

In the Zhambyl district, in the v. of Karaarsha, floodwaters overflowed the road and damaged a gas pipeline, while in the v. of Shien, 138 houses were flooded, and muddy water spilled over riverbanks, inundating fields, basements, and yards.

According to the Kazselezashchita Department, as a result of a localized heavy rainstorm on the night of August 13, 2023, a mudflow surge formed 1 km downstream from the mouth of the Kozhay River. Part of the mudflow deposited on a section of the highway (from Kaskelen to Izvestkovy Zavod), with an estimated volume of about 15 m³. The mudflow surge was generated by rainwater runoff [29].

3.1 Overview and analysis of maximum water levels

Maximum water levels are the highest recorded water marks at a hydrological station over a specific period. They are key characteristics of river flow, as they reflect the extreme manifestations of the water regime, such as spring floods and flash floods. Studying maximum water levels is important for several reasons: population safety - maximum water levels determine the boundaries of potential flooding; design of hydraulic structures - dams, bridges, and water intake facilities must be designed considering extreme levels; water management planning - for flow regulation, reservoirs, and irrigation systems; flood and spring flood forecasting - especially relevant for foothill and mountain rivers. Under climate change conditions, shifts in timing and increases in the amplitude of maximum water levels are observed (earlier onset of spring floods, higher flood peaks). Anthropogenic impacts are also increasing, such as river channel regulation and water abstraction for irrigation, which alter the natural flow regime. Additionally, extreme events are becoming more frequent, particularly intense rain-induced floods in mountainous areas. Maximum water levels are thus indicators not only of the hydrological regime but also of the climate sensitivity of a region [2], [21], [30].

3.1.1 Overview and analysis of maximum water levels on the main rivers of the Ertis WMB

Maximum water levels on the rivers of the Ertis WMB are formed mainly during the spring flood period, caused by intensive snowmelt and the development of meltwater runoff, as well as as a result of rain floods in the warm season. According to hydrological observations, recorded maximum levels vary by year depending on hydrometeorological conditions, the state of the snow cover, the rate of its melting, and the amount of precipitation. Figure 1 in Appendix B of this bulletin shows the maximum water levels on the main rivers of the Ertis WMB.

- **On r. Kara Ertis near the v. of Boran**, during the observation period 2002-2023, the danger level is **550 cm**, while in 2016 the water level exceeded it by 5 cm, whereas in **2023** it was recorded at **511 cm**, which is below the established threshold.
- **On r. Ertis in the area of the v. of Semiyarka** for 1960-2023, the danger level is **550 cm**, with the maximum exceedance recorded in 1980 – **153 cm** above the critical value, whereas in **2023** the water level was only **278 cm**.
- **On the section of r. Ertis near the v. of PriErtisskoye** for the period 2003-2023, the danger level is not established, as no exceedances causing flooding were recorded during the entire observation period. The average maximum level is **678 cm**, while in **2023** it was **623 cm**, which is slightly below the long-term average values.
- **For r. Kalzhyr near the v. of Kalzhyr** (2013-2023), the average maximum level is **446 cm**, while in **2023** it was recorded at **439 cm**, which falls within the average range.

- **On r. Kurshim near the v. of Voznesenka** for 1935-2023, the danger level is **310 cm**, with the highest exceedance recorded in 2013 (43 cm above the critical level), whereas in **2023** the level was **305 cm**.
- **On r. Buktyrma near the v. of Lesnaya Pristan** (1991-2023), the danger level is set at **530 cm**, while in 2018 it was exceeded by 220 cm, and in **2023** it was recorded at **521 cm**, below the critical value.
- **For r. Ulbi near the v. of Perevalochnaya** during the observation period 1941-2023, the danger level is **380 cm**, the maximum exceedance occurred in 1958 (58 cm above), while in **2023** the level was **311 cm**.
- **On r. Oba near the v. of Shemonaikha** for 1954-2023, the danger level is set at **430 cm,** the highest exceedance was recorded in 2001 (74 cm above), whereas in **2023** the water level was **336 cm**.

Overall, the analysis of maximum water levels on the rivers of the Ertis WMB indicates that in **2023** none of the hazardous thresholds were exceeded at any hydrological station. The recorded values varied within the range of long-term fluctuations and remained below critical limits. On most watercourses, water levels corresponded to or were slightly below the long-term averages, indicating a relatively stable hydrological situation during the period under review.

3.1.2 Overview and analysis of maximum water levels that occurred on the main rivers of the Balkash-Alakol WMB

In the Balkash-Alakol WMB, maximum water levels are mainly observed during:- the spring period (April-May), when active snowmelt occurs in the foothills of the Dzhungarian Alatau, Tien Shan, and Zailiyskiy Alatau; - the summer period (June-July) on rivers with glacial and snow-glacial feeding (r.Zhabaglysu, r. Boldybrek, r. Kattabugun), where glacier melt and mountain precipitation play a significant role;- on low-mountain and plain rivers (r. Shayan, r. Akbet, r. Boraldai, r. Sairam), the main peak almost always falls in April-May, which is associated with the spring high-water period [31], [32].

Figure 2 in Appendix B of this bulletin shows graphs of the dynamics of maximum water levels on the main rivers of the basin for the entire period of the station's operation up to 2023.

At the HP **on the r. Ili, 164 km upstream of the Kapshagai HPP**, during the observation period 1964-2023, the danger level is **500 cm**. In 2016 and 2020, the water level exceeded this threshold by 57 cm and 35 cm respectively, while in **2023** it reached **480 cm**, which is below the established limit.

At the gauging station on the **r. Ili, Kapshagai tract**, for the period 1970-2023, the danger level is **501 cm**. The maximum exceedance was recorded in 1977 – 177 cm above the critical value, whereas in **2023** the water level reached only **398 cm**.

At the gauging station on the **r. Sharyn, Sarytogai tract**, for the period 1932-2023, the danger level is **250 cm**. While there is a moderate increasing trend in mean annual discharge, the long-term trend in maximum water levels shows a dynamic influenced by a moderate decrease. In **2023**, the maximum level was **158 cm**, which is below the established threshold.

At HP **r. Shilik - s. Malybay**, the danger level is set at 186 cm, with the highest exceedance recorded in 1981 at 208 cm. In **2023**, the maximum level was **181 cm**.

At HP **r. Lepsy - v. Lepsy**, during the observation period 1932-2023, the danger level was **420 cm**, with the maximum exceedance noted in 1994 at 475 cm. According to long-term maximum level data, the trend remains within normal limits. In **2023**, the maximum level reached **369 cm**.

At HP **r. Tentek - v. Tonkeris**, the danger level is **481 cm**, while the maximum exceedances were recorded in 1952 and 1959, both at 481 cm. In **2023**, the maximum level was **237 cm**.

Over the long-term period from 1940-2023, the danger level at HP **r. Karoy - g. Tekeli** is **410 cm**. The maximum exceedance of 193 cm was observed in 1947. According to **2023** data, the maximum level at this post reached **413 cm**, which is above the critical value.

At HP **r. Shyzhyn - c. Tekeli**, over the observed long-term period 1981-2023, the danger level is **410 cm**. Exceedances of the maximum level above the danger level occurred up to 1993 inclusive, with the highest recorded in 1993 at 480 cm. In **2023**, the maximum level reached **316 cm.**

At **r. Tekeli near c. Tekeli**, during 1981-2023, the danger level is set at **240 cm**. At this HP, exceedances of the danger level were observed only in a few years (1988, 1993-1994), exceeding on average by 68 cm. In **2023**, the maximum level was **195 cm**.

At HP **r. Koksu - v. Koksu**, for 1956-2023, the danger level was **400 cm**, while the maximum exceedance occurred in 1969 at 490 cm. In **2023**, the maximum level reached **378 cm**.

At HP **r. Koktal - v. Araltobe**, over the long-term observation period 1952-2023, the danger level was **440 cm**. The trend of maximum levels shows a slight decrease in values. The maximum exceedance of the danger level was 383 cm, recorded in 1952. In **2023**, the maximum flow level reached **282 cm**.

Over the long-term period 1974-2023, the danger level at HP **r. Byzhy - v. Karymsak** is **236 cm**. The trend of maximum levels shows a slight decrease. During the entire observation period, there was a single exceedance of the danger level in 1993, which amounted to 238 cm. In **2023**, the maximum level reached **127 cm**.

Based on the analysis of maximum water levels at the hydrological posts of the Balkhash-Alakol basin over the long-term period (1932-2023), it was found that, in general, values fluctuated within established danger levels; however, significant exceedances were recorded at certain sites. The most pronounced extreme levels were observed on r. Ile (Kapshagay site, 1977 – exceedance of 177 cm; above Kapshagay HPP – 2016 and 2020) and on r. Karoy at Tekeli city (1947 – exceedance of 193 cm), indicating a high hydrological risk. Frequent exceedances until the 1990s were characteristic of r. Shyzhyn (Tekeli city), where the maximum level in 1993 reached 480 cm against a danger level of 410 cm, whereas in recent decades a decline in extreme values is observed. On r. Sharyn and r. Koktal, the trend shows a slight decrease, reducing the likelihood of reaching danger levels. Single, short-term exceedances were recorded for r. Tekeli, r. Byzhy, and r. Lepsy. In 2023, a significant exceedance of the critical level was recorded only on r. Karoy (Tekeli city, 413 cm against a threshold of 410 cm), while at other posts water levels remained below danger levels. Hydrological posts on r. Ile and r. Karoy show both frequent and significant exceedances of critical levels, whereas most other rivers are characterized by stability or a trend toward decreasing extreme values.

3.1.3 Overview and analysis of maximum water levels on major rivers of the Aral-Syrdarya WMB

Maximum flow levels are a key indicator of hydrological extremes and directly determine the risk of flooding, the stability of hydraulic infrastructure, and the required reserve of operational measures during spring floods. In the Aral-Syrdarya Basin, their analysis is particularly important due to the combination of mountainous snow-fed rivers, anthropogenic redistribution of flow, and the presence of large regulatory structures. The main determinants of maximum level trends are the reserves and spatial distribution of snow cover in the upper reaches, the rates of spring snowmelt, and the nature of spring precipitation. These factors define the timing and amplitude of spring floods and have been described in regional studies on the influence of snow cover variations on river runoff [33].

Climate variability and warming shift the seasonality and can increase intra-seasonal variability of maximum levels (earlier snowmelt, «fatter» but shorter flood peaks with a decreasing overall snow reserve), as evidenced by the observed temperature and precipitation anomalies reported in the annual bulletins of Kazhydromet [21].

Figure 3 of Appendix B of this bulletin presents graphs showing the dynamics of maximum water levels on the main rivers of the basin for the entire period of observations up to 2023.

- At the hydrological station (HS) **on the Shayan 1 River, 3.3 km downstream from the mouth of the Akbet River,** for the period 1969-2023, the danger level is set at **260 cm,** with no exceedances recorded. In **2023**, the water level was **173 cm**, which is below the established threshold.
- At the HS on the **Kokbulak River - Pisteli v.,** for the period 1964-2023, the danger level is **502 cm**, with no exceedances recorded. **In 2023**, the water level reached only **265 cm.**
- At the hydrological station on **the Boldybrek River – near the State Nature Reserve ranger station** – for the period 1959-2023, the dangerous level is **600 cm**. In the long-term trend of changes in maximum water levels, a moderate decrease is observed. **In 2023**, the maximum level was **182 cm**, which is below the established threshold.
- At the hydrological post on the **Kattabugun River – Zharikbas v.** – over the long-term period of 1932-2023, the dangerous level is set at **536 cm**, and no exceedances have been recorded. **In 2023**, the maximum level was **329 cm.**
- At the section of the hydrological post on the **Zhabaglysu River – Zhabagly v.** – during the observation period from 1965 to 2023, the dangerous level was **350 cm,** and no exceedances were recorded. According to the data on maximum levels over the long-term period, the trend remains within normal limits. **In 2023**, the maximum level reached **265 cm.**
- At the hydrological post on the **Boralday River – Vasilyevka v.** – for the period 1956-2023, the dangerous level is **600 cm**, and no exceedances of this mark have been recorded. **In 2023**, the maximum level was **237 cm.**
- Over the long-term period from 1936 to 2023, the dangerous level at the hydrological post on the **Sairam River – Tasaryk aul** – is **380 cm**. An exceedance of this dangerous mark was observed only once, in 1958, when the level reached 386 cm. According **to 2023** data, the maximum level at this post reached only **164 cm**, which is below the critical value.

For most rivers, exceedances of the established dangerous levels have practically not been observed, indicating a relatively low level of flood hazard under current conditions. The only exception is the Sairam River (Tasaryk aul), where in 1958 an exceedance of 6 cm above the critical mark was recorded; however, this case is isolated and is not confirmed by subsequent observations. For the Shayan, Kokbulak, Kattabugun, Zhabaglysu, and Boraldai rivers, the maximum levels throughout the entire observation period did not significantly approach the threshold values, and the trends of change remain within normal limits. Of particular interest is the Boldybrek River, where a stable trend of moderate decrease in maximum levels over the long-term period has been recorded, indicating long-term changes in the hydrological regime under the influence of both climatic and local factors. Thus, the most distinctive hydrological posts are the Sairam River (a single exceedance of the dangerous level) and the Boldybrek River (a sustained decrease in extreme values), while the remaining posts are characterized by stable conditions without the threat of levels exceeding critical limits.

3.1.4 Overview and analysis of maximum water levels observed on the main rivers of the Zhaiyk-Caspian WMB

Maximum water levels in rivers are one of the key indicators of the hydrological regime, reflecting the intensity of spring floods and high-water events, as well as the degree of potential threat to coastal areas.

As mentioned earlier, dangerous water level marks are determined based on the exceedance of critical values at which there is a risk of flooding of settlements, agricultZhaiyk lands, and infrastructure facilities.

The rise in water levels in the Zhaiyk-Caspian basin is influenced by both natural factors (the amount and intensity of snow accumulation, the rate of snowmelt, rainfall, and ice phenomena) and anthropogenic factors (flow regulation by reservoirs, water abstraction, and changes in river channel processes).

This analysis is of particular relevance for the Zhaiyk-Caspian Water management basin, where transboundary rivers with high water management pressure and a significant level of economic development of floodplains flow. The area contains densely populated settlements, industrial facilities, and agricultZhaiyk lands that are exposed to the risk of flooding. The study of maximum water levels is necessary to assess the scale of spring floods and flood events, identify zones of increased risk, and develop measures to prevent and mitigate negative impacts.

Figure 4 in Appendix B of this bulletin presents graphs that illustrate the dynamics and maximum water levels on the main rivers of the basin over the entire period of operation of the hydrological posts up to 2023.

The graphs show that over the long-term period the maximum water levels were observed as follows:

- On the **Zhaiyk River near Yanvartsevo v.** (2009-2023), the dangerous level is **1250 cm**. No exceedances of this value were recorded during the study period**. In 2023**, the maximum level was **635 cm,** which is significantly below the critical mark.
- On the **Zhaiyk River near Kushum v.**, water level observations have been conducted since 1912, with continuous data series available since 1921. Over the entire period, the highest levels were recorded in 1942 and 1957, when they exceeded the dangerous mark, which is clearly shown in the graph (Fig.1). **In 2023**, the maximum value was **540 cm**, which is below the critical levels.
- On the **Zhaiyk River near Makhambet v.** , instrumental observations were carried out from 1936 to 2023. The dangerous water level is **850 cm**. The greatest exceedances of the critical level were recorded in 1942, 1946, 1956, and 1993-1994. **In 2023**, the maximum level was **730 cm**, which is below the dangerous mark but comparable to high flood years.
- At the **Ilek River near the city of Aktobe**, the hydrological station has been in operation since 1939. The hazardous water level mark **is 493 cm**. Exceedances of this value were observed quite frequently in the past, especially before the commissioning of the Aktobe Reservoir, which had a regulating effect on runoff. **In 2023**, the maximum water level reached **518 cm**, once again exceeding the hazardous threshold.

- At the **Uil River near the v. of Uil** (observation period 1986-2023), the hazardous mark of the maximum water level **is 995 cm**. As can be seen from the graph (Figure 1), exceedances were recorded in 1993 and 2022, while the highest maximum occurred in 2023, when the level surpassed all previously recorded values.

Thus, the analysis of long-term series of maximum water levels indicates heterogeneity and spatial differentiation of the hydrological regime of the rivers in the Zhaiyk-Caspian basin. At a number of gauging stations in recent years, water levels have not reached hazardous marks; however, the risk of extreme situations remains, especially on rivers with high flood potential such as the Ilek and Uil.

3.1.5 Overview and analysis of maximum water levels recorded on the main rivers of the Esil WMB

The water level regime of the rivers in the Esil Water management basin, which determines flood hazard, is characterized by a well-defined rise in water levels during the flood period and low levels during the low-water (dry) period. The maximum rises in water level during the spring flood on the rivers of the study area reach significant values. The height of the flood wave varies widely depending on the water abundance of the year, the size of the catchment area, the nature of the river channel and floodplain, and the structure of the riverbanks.

Figure 5 in Appendix B of this bulletin presents the maximum water levels on the main rivers of the Esil Water management basin:

- **Esil r. - of Turgen v.** (1975-2023). The hazardous level is **630 cm.** No dangerous hydrological events were recorded during the observation period. The highest level occurred in 2015. **In 2023**, the water level was **299 cm**, which is below the critical value.
- **Esil r. - Kamennyy Karyer v.** (1971-2023). Critical level - **808 cm.** During the observation period, dangerous hydrological events were recorded in 1971, 1983, 1985, 1986, 1987, 1997, 2005, 2007, and 2017. The most critical year was 1985, when the water level reached about 999 cm, which is almost 191 cm above the critical level. **In 2023**, the level was recorded at **627 cm,** which is below the critical level.
- **Esil r. – Petropavl c.** (1996-2023). Critical level - **960 cm.** From 1996 to 2023, dangerous hydrological events were recorded in 1996, 1997, 2002, 2013, and from 2014 to 2021. The most critical year was 2017, when the water level reached about 1193 cm, which is almost 233 cm above the critical level. **In 2023**, the level was recorded at **1016 cm**, which is above the critical level.
- **Kalkutan r. - Kalkutan v.** (1984-2023). Critical level - **630 cm**. Dangerous hydrological events were recorded six times. The greatest threat occurred in 2007, when the water level reached 714 cm - a significant exceedance of the threshold. **In 2023,** the level was recorded at **600 cm** - within normal limits.
- **Zhabai r. - Atbasar c.** (1944-2023). Critical level - **710 cm**. From 1944 to 2023, dangerous hydrological events were recorded in 1948, 1964, 1971, 1983, 1985, 1993, 2005, 2007, from 2014 to 2017, and in 2021. The most critical year was 2017, when the water level reached about 912 cm, which is almost 202 cm above the critical level. **In 2023**, the level was recorded at **702 cm** - within normal limits.
- **Esil r. - Dolmatovo v.** (1995-2023). Critical level - **1450 cm**. Dangerous hydrological events were recorded only once, in 2017, when the water level reached about 1469 cm, which is 19 cm above the critical level. **In 2023,** the level was recorded at **1211 cm** - below normal.

Esil r. - Volgodonovka v. (1978-2023). Critical level - **685 cm**. Dangerous hydrological events were recorded in 1979, 1993, and 2015. The greatest threat occurred in 1993, when the water level reached 767 cm. **In 2023**, the level was recorded at **157 cm** - well below the critical values.

During the observation period, the hydrological situation on the rivers of the Esil basin has generally shown a positive trend toward a reduction in hydrological risk. Although some rivers have experienced exceedances of critical levels in the past, in recent years–especially in 2023–the water levels in all rivers were within safe limits, indicating no threat of flooding. The exception is the Esil River in Petropavl, where the level exceeded the critical mark by 56 cm.

3.1.6 Overview and analysis of maximum water levels on the main rivers of the Shu-Talas WMB

Rivers Shu and Talas belong to the snow-rain fed type, with characteristic spring-summer floods. The main tributaries form in the mountainous areas, from where water flows into the lowland sections, where the main agricultZhaiyk lands are located. Maximum water levels are generally observed: in April-May – due to snowmelt in the mountains. Sometimes – in the summer months, during heavy rains. Figure 6 in Appendix B shows the maximum water levels on the main rivers of the Shu-Talas WMB.

Shu r. - Kainar v. (1976-2023). The danger level is **802 cm**. No dangerous hydrological events were recorded during the observation period – the water level did not approach the critical mark. The highest levels were observed in 1994, 2001, 2003, and 2016, but even in those years they remained safe. **In 2023**, the water level was **358 cm**, which is below the critical values.

Talas r. - Solnechnyy v. (1979-2023). The danger level is **405 cm**. In the 1980s-1990s, dangerous hydrological events were regular and frequent. The most critical period was from 1987 to 1995, when levels systematically exceeded 440-460 cm. Since the early 2000s, a steady decrease in water levels has been observed, likely due to both climatic factors and flow regulation. In **2023**, the recorded level was **338 cm**, with no flood threats, indicating reduced hydrological risk.

Teris r. - v. Nurlykent (1968-2023). The danger level is **438 cm**. During 1968-2023, dangerous hydrological events were recorded in 1969, 1991, 1995, and 2017. The most critical year was 1995 – the water level reached approximately 560 cm, nearly 130 cm above the danger mark. In **2023**, the recorded level was **300 cm**, below the danger mark.

Assa r. - railway station Maymak (1961-2023). The danger level is **500 cm**. Dangerous hydrological events were recorded twice. The greatest threat occurred in 2017, with a level of 510 cm – a significant exceedance of the threshold. In **2023**, the level was **380 cm,** within the normal range.

Kuragaty r. - railway station Aspara (1976-2023). The danger level is 447 cm. During the observation period, no exceedances of this value were recorded. In **2023**, the level was **71 cm**, significantly below the critical mark.

Over the observation period, the hydrological situation on the rivers of the Shu-Talas basin shows a generally positive trend toward reduced hydrological risk. Although some rivers experienced exceedances of danger levels in the past, in recent years, especially in **2023**, water levels on all rivers remained within safe limits, indicating no flood threat.

3.1.7 Overview and analysis of maximum water levels on the main rivers of the Nura-Sarysu WMB

Maximum water levels on the rivers of the Nura-Sarysu water management basin are formed mainly during the spring flood period, associated with intensive snowmelt and the development of meltwater runoff. Significant influence is exerted by the basin's topographic features, snow moisture reserves, soil frost depth, and spring weather conditions. In certain years, high water levels are also recorded as a result of rain floods occurring during the warm season when significant precipitation falls.

Figure 7 in Appendix B shows the maximum water levels on the main rivers of the Nura-Sarysu WMB.

- **Nura r. at railway station Balykty**, during the observation period 1980-2023, has a danger level of **700 cm**; in 2014 the water level exceeded it by 343 cm, and in 2017 it also exceeded it by 19 cm. In **2023**, the water level was **336 cm.**
- **Nura** r**. at R. Koshkarbaeva v.**, during the observation period 1996-2023, recorded a maximum water level of **886 cm** in 2015, which is the highest value for the entire observation period. In 2017, observations were not conducted due to damage to the HP caused by ice heaving.
- **Sherubainura r. at junction Karamuryn**, during the observation period 1980-2023, has a danger level of **420 cm**; in 1986 the water level exceeded it by 67 cm, in 1988 by 52 cm, in 1990 by 31 cm, in 1993 by 107 cm, in 2001 by 20 cm, in 2002 by 60 cm, in 2015 by 157 cm, in 2016 by 30 cm, in 2017 by 92 cm, and in 2019 by 101 cm. In **2023**, the maximum water level was **375 cm,** and in **2023,** the water level was **268 cm.**
- **Sarysu r. at junction №189** during the observation period 1996-2023 has a danger mark of 390 cm; in 2003 the water level exceeded it by 8 cm, in 2016 by 105 cm, in 2020 by 35 cm. In 1997-2000 observations were not conducted, and in 2012 and 2019 the natural regime of the river was disturbed by the influence of temporary earthen dams built on r. Sarysu and its tributaries upstream of the hydrological post. In **2023**, the highest water level was **285 cm.**

Overall, the analysis of maximum water levels on the rivers of the Nura-Sarysu WMB shows that in some years the danger marks were exceeded; however, in 2023 the recorded values were within the long-term variability and did not reach critical thresholds. The recorded maximum water levels on the rivers of the Nura-Sarysu WMB varied within the long-term variability and remained below critical thresholds. On most watercourses, water levels corresponded to or were slightly below long-term average values, indicating a relatively calm hydrological situation during the period under consideration.

3.1.8 Overview and analysis of maximum water levels on the main rivers of the Tobyl-Torgay WMB

Maximum water levels on the rivers of the Tobyl-Torgay WMB are formed mainly during the spring flood, caused by snowmelt and the subsequent development of meltwater runoff. The magnitude and dynamics of the levels are significantly influenced by climatic and hydrological factors: the distribution and reserves of snow in the winter period, the depth of soil freezing, as well as spring weather conditions, which determine the intensity of snowmelt and the rate of runoff formation.

Figure 8 in Appendix B shows the maximum water levels on the main rivers of the Tobyl-Torgay WMB.

- **Tobyl r. at Grishenka v.** during the observation period 1938-2023 has a dangerous level of **650 cm**, with exceedances of 73 cm in 1941, 66 cm in 1942, 111 cm in 1947, 26 cm in 1948, 57 cm in 1957, 46 cm in 1994, 38 cm in 2000, and 52 cm in 2005. The maximum water level reached 761 cm in 1947, which is the highest value for the entire observation period, and **in 2023**, **155 cm** was recorded, which is below the critical value.

- **Tobyl r. at Kostanay c.** during the observation period 1965-2023 has a dangerous level of **600 cm**, with exceedances of 50 cm in 1970, 104 cm in 1985, 25 cm in 1990, 64 cm in 1993, 130 cm in 1994, and 130 cm in 2000. The maximum water level reached 730 cm in 1994 and 2000 , and **in 2023**, the maximum water level was **405 cm**.
- **Ayat r. at Varvarinka v.** during the observation period 1977-2023 has a dangerous level of **600 cm**, with exceedances of 105 cm in 1985, 170 cm in 1994, 208 cm in 2000, 122 cm in 2005, and 187 cm in 2013. The maximum water level reached 808 cm in 2000, while in **2023** the maximum water level was **568 cm**.
- **Togyzak r. at Toguzak v.** during the observation period 1960-2023 has a dangerous level of **750 cm**, with the water level reaching the dangerous level in 1994, exceeding it by 26 cm in 2005, and by 55 cm in 2013. The maximum water level reached 805 cm in 2013. And in **2023**, the water level reached **422 cm**.
- **Kara-Torgay r. at Urpek v.** during the observation period 1983-2023 has a dangerous level of **960 cm**, with the water level reaching the dangerous level in 1986 and 1987 (923 cm), and in 1992 and 1996 (925 cm). The maximum water level reached 925 cm in 1992 and 1996. And in **2023**, the maximum water level was **865 cm**.
- **Irgiz r. at Shenbertal v.** during the observation period 1961-2023 has a dangerous level of **933 cm**, with exceedances of 65 cm in 1964, 65 cm in 1966, 109 cm in 1980, 119 cm in 1983, 110 cm in 2005, and 90 cm in 2007. The maximum water level reached 1052 cm in 1986. And in **2023**, the maximum water level was **686 cm**.

Overall, the analysis of maximum water levels on the rivers of the Tobyl-Torgay WMB shows that in some years exceedances of dangerous levels were observed; however, in 2023 the recorded values were within the range of long-term variability and did not reach critical thresholds. Maximum water levels varied within the characteristic long-term variability and remained below the extreme values of previous years. On most watercourses, water levels corresponded to or were slightly below long-term averages, indicating a relatively calm hydrological situation during the considered period.

3.2 Analysis of significant floods of 2023

A flood is a large-scale inundation that occurs as a result of a sharp rise in water levels in rivers, lakes, or other water bodies. Floods most often occur in river valleys, foothill areas, and flat terrains. One of the most common types of floods is caused by the intensive melting of snow and ice, as well as heavy precipitation, which is typical for most of the territory of our republic as a result of flood processes, water levels in rivers, lakes, and artificial reservoirs increase significantly. Floods in Kazakhstan are among the most dangerous hydrological phenomena, causing substantial damage to both the natural environment and socio-economic systems. Unlike spring high water (freshet), which is a regular seasonal rise in water levels, floods are sudden, short-term events and can occur in any season if certain conditions are present.

In Kazakhstan, rain-induced floods **in 2023** were observed in the basins of rivers such as the Ertis, Syrdarya, as well as Lake Balkhash and Lake Alakol. Flood situations in the country are recorded almost every year; however, the extent and scale of these events vary significantly from year to year.

Rain floods, especially significant ones, are rare on lowland rivers. About 80-90 % of the flow of most rivers in this region is formed during the spring high water period, caused by snowmelt. The conditions for generating significant rain runoff in lowland areas are extremely unfavorable: low precipitation intensity, high summer air temperatures, and very dry soil, whose moisture in summer amounts to only 8-10 % [34].

At present, modern means of monitoring hydrological processes make it possible to identify the risk of major floods, as well as determine their location, start time, and intensity. In addition, satellite remote sensing can be used to assess the scale, extent, and damage caused by floods, as well as to forecast their likelihood. The identification and recording of the largest floods are carried out based on the analysis of river flow hydrographs. The start of a flood is considered to be the day on which a significant increase in water discharge is recorded on the hydrograph. The end of the flood is defined as the day when, after the flood, the water discharge decreases to a pre-calculated level. The duration of the flood is calculated as the difference between the start and end times of the flood.

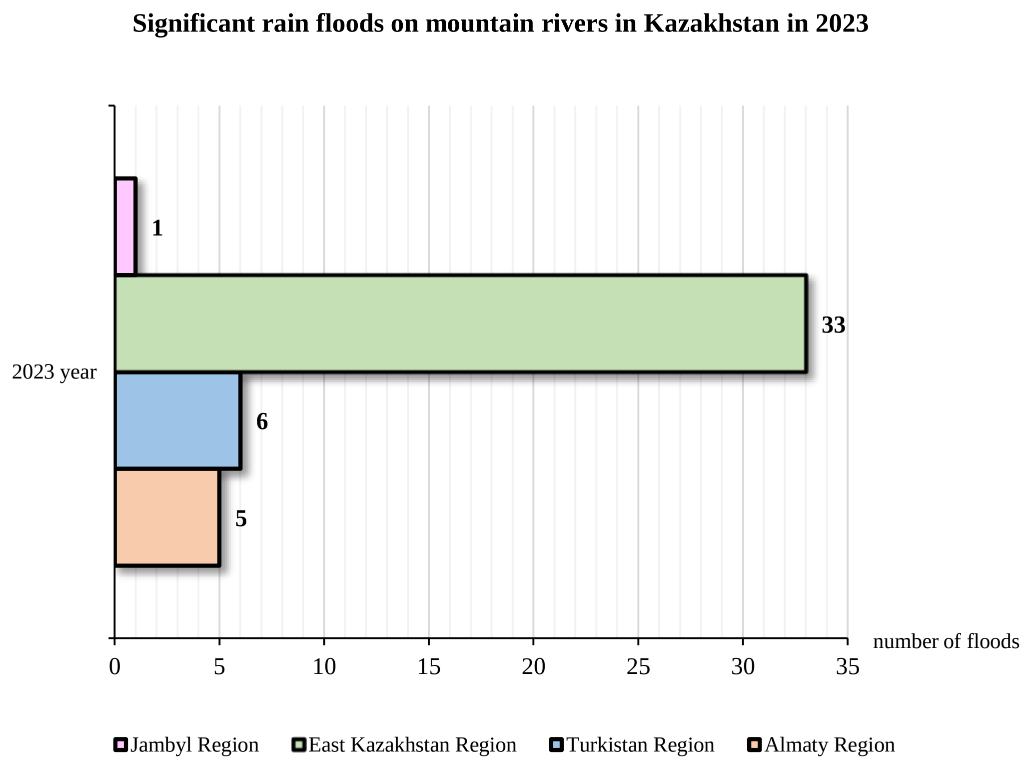


Figure 64 – Rain-induced floods on mountain rivers of Kazakhstan in 2023

According to figure 64, the dynamics of floods on mountain rivers in Kazakhstan **in 2023** are presented, based on the number of rain-induced flood events from the Annual Data on the Regime and Resources of Surface Water on Land. From a territorial perspective, it is noted that the terrain of four regions is characterized by a mountainous landscape, which defines them as areas with a high frequency of floods. Analysis of the graph showed that among the specified regions, the highest figures were recorded in East Kazakhstan Region (about 33 hazardous floods). The main factors influencing flood formation in these regions are the melting of mountain glaciers and a significant snow cover during the winter, as well as continuous precipitation in the spring period. According to the [24], 2023, the territory of East Kazakhstan experienced the following during the spring-summer period: abnormally high precipitation (exceeding the norm by 25-40

%), a high level of snow cover during the winter, and rapid warming in March-April, which caused intensive snowmelt. Floods were also recorded in the following regions: Zhambyl Region (1 case), Turkestan Region (6 cases), and Almaty Region (5 cases). According to the 2023 climate bulletin, the other regions were characterized by moderate or below-average precipitation, a low-snow winter in 2022-2023, and gradual warming without sharp temperature fluctuations.

Analysis of emergency situations shows that the number of floods in the republic has increased compared to previous years. At the same time, as the frequency of flood events rises, the scale and damage from hydrological emergencies are also increasing annually.

Geographically, floods are most often observed in the mountainous and foothill areas of southeastern and eastern Kazakhstan, where the terrain promotes rapid surface runoff and where there is a combination of snow and rain feeding. The river basins most prone to flooding are those of the mountain rivers in Almaty, Zhetysu, and East Kazakhstan regions. In spring, these areas can experience snowmelt-rain floods caused by the simultaneous melting of snow and rainfall.

3.2.1 Analysis of rain-induced floods in east Kazakhstan Region (EKR)

Analysis of rain-induced flood data from hydrological stations in East Kazakhstan Region showed that **in 2023,** floods developed during both the summer and autumn periods. This was due to the occurrence of intense precipitation of varying duration and the uneven spatial distribution of rainfall across the region.

In the summer period (august), rain floods were recorded on the Kara Ertis River (Boran v.), Bukhtarma River (Lesnaya Pristan v.), and Oba River (Shemonaiha city), with durations ranging from 9 to 15 days. This indicates a significant impact of heavy rainfall in the eastern and northeastern parts of the region. Autumn floods were characterized by a wider territorial distribution and occurred mainly from late October to early November. During this period, increased runoff was observed on the Kalzhyr, Kurshim, Bukhtarma, Ulbi, and Oba rivers, with flood durations ranging from 6 to 14 days.

It should be noted that the most frequent flood events were recorded on the Oba River (Shemonaiha City) – three flood waves of varying intensity (in august, september, and october-November), indicating a high responsiveness of this river's catchment to rainfall. Overall, rain-induced floods in the region were short-term in nature, which is typical for mountain-valley basins with rapid runoff response to precipitation and a high tendency for the formation of localized flood processes [5].

3.2.2 Analysis of rain-induced floods in the Almaty Region

For the Balkhash-Alakol basin, **2023** was not a year of major rain-induced floods: inflow deficits and high evaporative losses dominated. Rare heavy downpours caused local flooding or erosion, but no large-scale rain-flood waves were recorded across the basin.

According to available reports and publications, **2023** in the Balkhash-Alakol basin was not marked by significant rain-induced floods that could have led to a substantial increase in annual runoff. Instead, declining inflows and high vulnerability to evaporation prevailed. Long-term studies of the water balance of Lake Balkhash emphasize that the contribution of rain events is minor compared to the impact of summer-autumn evaporation and withdrawals in the upper reaches [35].

In 2023, the region experienced uneven precipitation distribution; overall, many parts of the basin were characterized by a deficit of annual rainfall and increased evaporation (an abnormally warm year), which reduces the likelihood of forming a large rain-induced flood wave across the entire basin. Small, localized downpours could cause erosion and flooding in floodplain areas, but they did not compensate for the annual inflow deficit.

High water withdrawals for irrigation and economic needs in the upper and foothill areas prevent the formation of large flood waves even during local rains, as a significant portion of the runoff is retained or diverted for economic use.

For the Balkhash-Alakol basin, **2023** was not a year of significant rain-induced floods – inflow deficits and enhanced evaporation prevailed; isolated downpours had only local effects and did not alter the annual water balance toward a surplus.

3.2.3 Analysis of rain-induced floods in the Turkestan Region

In 2023, rain-induced floods within the Aral-Syrdarya basin were observed locally, primarily in the mountainous and foothill tributaries (short, intense downpours causing floods), whereas in the lowlands and lower reaches of the Syrdarya, the effect of rain floods was limited – peak flows there were largely determined by the combined effect of snowmelt and reservoir management.

In 2023, mountainous areas (high-altitude tributaries of the Syrdarya, including Kyrgyzstan, the Tien Shan, and adjacent regions) experienced cases of intense, short-term downpours that caused local floods, channel collapses, and mudflows. Examples include the August 7, 2023, floods/mudflows in the Issyk-Kul region (Kyrgyzstan), which led to house damage, inundations, and evacuations. Reports by IFRC/ReliefWeb document these events and their localized impacts. These events are typical of convective regimes in summer, characterized by short, high-intensity rainfall episodes.

In the lowlands and plains of the Syrdarya, rain-induced floods in **2023** did not lead to numerous large-scale flood waves – peak flows were more often the result of a combination of seasonal snowmelt and managed reservoir releases. In other words, the contribution from rainfall is local and quickly dissipates before it can form a large flood wave in the lower reaches due to retention in the upper reaches and irrigation withdrawals. This is confirmed by analyses of hydrological regimes and operational reports from the region's hydrometeorological services.

Rain-induced floods in **2023** were locally pronounced but not widespread: mountain tributaries were prone to sharp, short-term floods and mudflows, while the plains and lower reaches were less susceptible to major rain floods due to regulation and transformation of the flow regime by water use.

3.2.4 Analysis of rain floods in Zhambyl region:

Analyzing the flood situation in Zhambyl region in 2023, it can be noted that, despite the overall absence of floods on most rivers in the region, the Shokpak river near the v. of Zhurumbay experienced a significant flood event. The rain flood began on December 26 and lasted for 5 days.

The Shokpak river is located in a mountainous area where snowmelt predominates. In spring 2023, abnormally high snow accumulation was observed, which, combined with a sharp warming, led to intense snowmelt. This phenomenon could have caused a rapid rise in the river's water level, especially in its upper reaches, where the flow velocity and riverbed slope contribute to the quick transport of meltwater. At the same time, in 2023, no significant floods were observed on other rivers in the region [36].

3.3 Identification of the most significant ice jams and blockages that caused considerable backwater in 2023

Ice jam – an accumulation of ice in the river channel during ice drift, causing a narrowing of the flow cross-section and, consequently, a rise in water levels; occurs mainly during spring ice drift on relatively shallow sections of the river. During autumn ice drift, ice masses are usually not significant enough to form large ice jams.

Ice blockage – the clogging of the river cross-section during autumn ice drift and at the beginning of ice formation by masses of intrariver ice and slush; ice blockages, by impeding water flow, cause water level rise and flooding of the banks. In the area of an ice blockage, the «head of the blockage» refers to the downstream part, while the «tail of the blockage» is located upstream.

The main characteristics of ice jams and blockages include their structure, size, maximum water level rise caused by the jam or blockage, duration, and frequency.

The maximum water level of an ice blockage exceeds the water level during ice cover. The degree of water level rise due to a blockage is determined by the excess of the water level during the blockage over the level during ice cover, if the blockage had not occurred.

The maximum level of an ice jam usually exceeds the level of the spring flood. The degree of rise caused by an ice jam is determined by the excess of the water level during the jam over the spring flood level, if the jam had not occurred.

Ice jams cause floods and inflict significant damage on the national economy. They are typical for rivers that break up from upstream to downstream. Large ice jams are observed in years when the ice cover is strong at the time of breakup and the rate of discharge increase is significant.

In winter, ice blockages form when slush accumulates in polynyas or when there is a large amount of snow-ice mixture. During spring ice drift, ice jams sometimes occur, with favorable conditions including river narrowings, meandering channels, spring flood flowing through channels clogged with snow and ice masses, remaining ice bridges after river breakup, islands, and various hydraulic structures.

Water level rise during ice jams and blockages in the flood period on some rivers causes significant damage to the national economy.

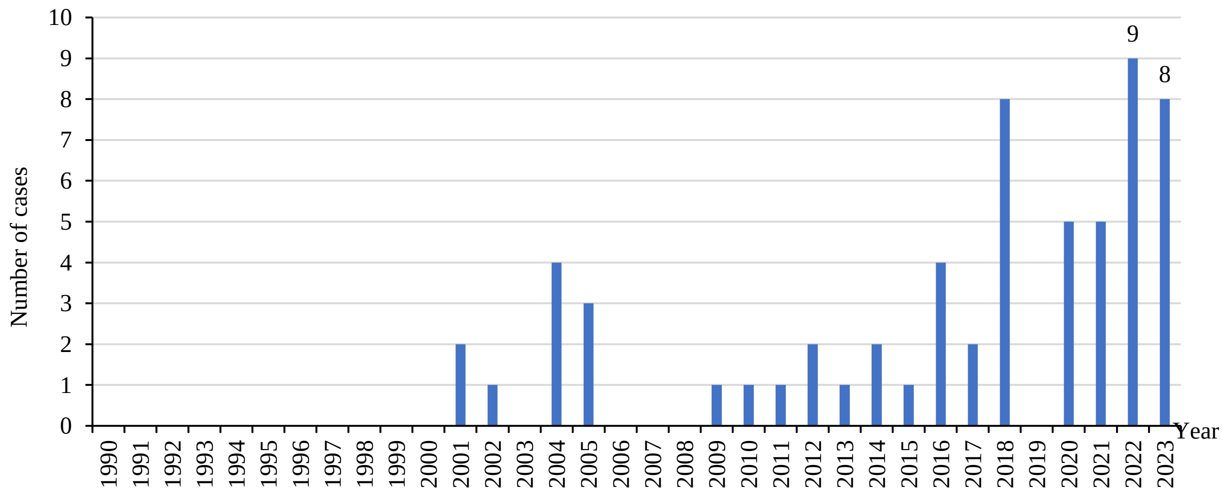


Figure 65 – Dynamics of the total number of ice jams in Kazakhstan for the period 1990-2023

Figure 14 shows the dynamics of the total number of ice jams in Kazakhstan for the period 1990-2023. The maximum number of dangerous hydrological events was observed in 2022 (9 cases), while in **2023** there were a total of 8 cases.

Analysis of ice jams and ice dams for **2023**: Ice jams and ice dams in 2023 in the **Zhaiyk-Caspian basin**: at the HP of r. Zhaiyk - v. Yanvartsevo (border with the RF), recorded twice: **march 21-22**, ice jam above the post, and **december 9**, ice dam below the post. At HP of r. Zhaiyk - s. Kushum**, March 20**, ice jam above the post.

- **Shu-Talas basin**: ice jams and ice dams were not recorded.
- **Ertis basin**: at the HP of r. Kara Ertis – v. Boran, on **march 30**, ice jams were observed above and below the post. At the HP of r. Ertis – v. Semiyarka, **december 11-31**, ice jam below the post.
- **Esil basin**: at the HP of r. Esil – v. Turgen, **april 6-8**, ice jam below the post. At the HP of r. Esil - v. Kamennyy Karier, **april 1-3**, ice jam below the post.
- **Balkhash-Alakol basin**: at the HP of r. Tentek – v. Tonkeris, **december 12-13**, ice jam below the post. At the HP of r. Ili - v. Ushzharma, **december 15-21**, ice dam below the post.
- **Tobol-Torgay basin**: at the HP of r. Kara-Torgay – s. Urpek, **march 15**, ice jam below the post.
- **Aral-Syrdarya basin**: at the HP of r. Syrdarya – v. Koktyube, ice jams and ice dams were recorded in 2 cases: **January 16-17**, ice dam below the post, and **december 15-17**, ice jam below the post. At the HP of r. Syrdarya - railway station Tomenaryk, ice dam phenomena were observed above and below the post. At the HP of r. Arys – railway station. Arys, **january 14-february 1**, ice dam below the post.
- **Nura-Sarysu basin**: ice jams and ice dams were not observed.

4 ANALYSIS OF THE INTRA-ANNUAL DISTRIBUTION OF RUNOFF OF THE MAIN RIVERS OF THE REPUBLIC OF KAZAKHSTAN

The rational and integrated use of water resources for various economic purposes requires clear decisions regarding the intra-annual distribution of river runoff. The implementation and economic efficiency of water management measures and facilities are primarily determined by the within-year flow regime. Intra-annual runoff distribution depends on a multitude of factors within the natural-climatic complex, the main ones being climatic conditions, terrain relief, and geological and hydrogeological conditions. Differences in climatic conditions during the same seasons in different years lead to variations in the intra-annual runoff regimes across years. Consequently, phases of the water regime (high water, floods, low water, etc.) differ in timing and magnitude of flows from year to year. Therefore, the development of methods for determining the calculated characteristics of intra-annual river runoff distribution is of significant practical importance [37].

Due to the uneven intra-annual distribution of runoff, its economic use becomes more complicated. When using water resources for energy, industrial and domestic water supply, and irrigation, the period of low water – the low-flow season – is of greatest interest. The analysis of methods and techniques for calculating intra-annual runoff distribution should be approached both in terms of accurately reflecting the existing natural patterns of intra-annual runoff and in terms of meeting the requirements of design.

To date, a number of methods exist for calculating intra-annual runoff distribution. The most well-known groups of methods include: the arithmetic mean (synthetic) hydrograph, the hydrograph of a real characteristic year, the equally probable hydrograph, the use of special indicators for calculating intra-annual runoff distribution, the use of daily flow duration curves to describe intra-annual runoff distribution, and the compositing method [4].

In recent years, the **compositing method** has become the most widely used in hydrological calculations. The compositing method was first developed by G.I. Shvets for rivers of the Ukrainian SSR [2]. According to the proposed scheme, the year was divided into three seasons: spring, summer-autumn, and winter. The runoff reliability of two seasons (the critical period) was, depending on the design tasks, assumed to be equal to the annual runoff reliability, while the runoff of the third season was determined as the difference between the annual runoff and the total runoff of the two seasons. The advantage of this scheme is that it takes into account design requirements. The disadvantage is that the reliability, equal to the annual reliability, is set simultaneously for two of the three seasons. This leads to the runoff of the non-limiting season, determined as the difference between the annual runoff and the total runoff of the two seasons with equal reliability, having a lower frequency of occurrence than in the case when it is determined as the difference between the annual runoff and the runoff of a single season [37].

V.G. Andreyanov [2] addressed this shortcoming and developed a method for calculating intra-annual runoff distribution, which is suitable for any design tasks and any physico-geographical conditions, regardless of the type of intra-annual flow pattern. In this scheme, the same reliability is assumed for the annual runoff, for the critical period of the year, and within the latter – for the critical season. The reliability is taken as a given value [4].

The calculation of intra-annual runoff distribution is carried out for several water availability gradations. Seasonal and intra-seasonal runoff distribution are considered separately. The critical period and season are chosen depending on the predominant type of water use. This methodology was incorporated into [38] as the main recommended approach for calculating intra-annual runoff distribution. The calculation time intervals are usually months and seasons, and less often – decades and weeks. When observational data are available, the calculation is performed using series with a duration of at least 15 years.

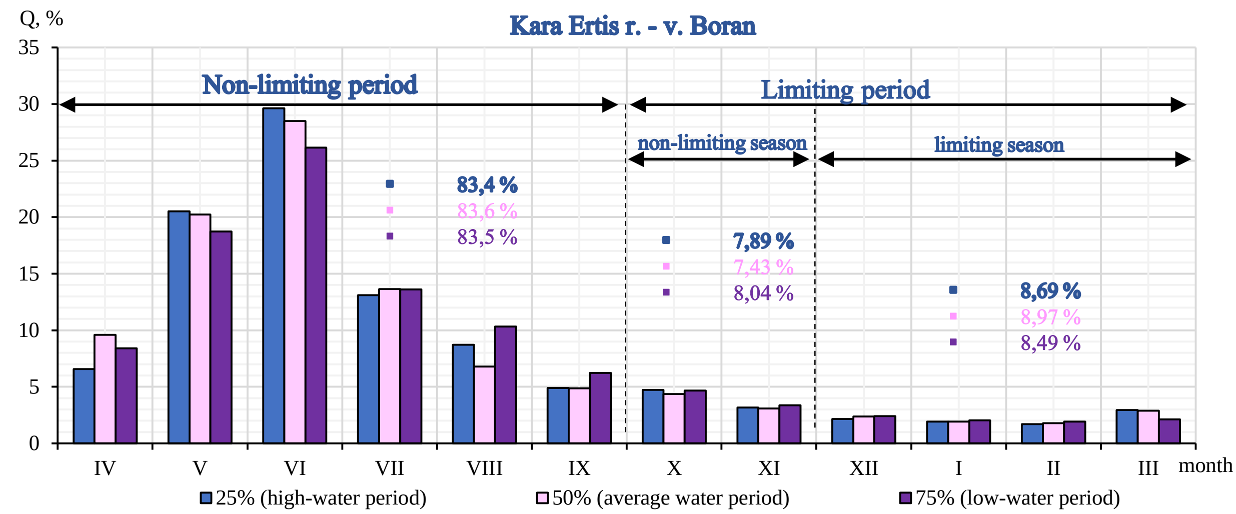
The calculation is carried out for water management years, which begin at the start of the high-water season (spring freshet). The boundaries of the seasons are set uniformly for all years, rounded to the nearest month. The division of the year into periods and seasons depends on the type of river regime and the predominant type of water use. In this study, for the purpose of selecting the method for calculating intra-annual runoff distribution, the predominant types of water use were assumed to be drinking and domestic water supply and hydropower [37]. According to the adopted method, the water management year was divided into two periods: the limiting and non-limiting periods. Within the limiting period, a limiting and non-limiting season are distinguished. The period and season in which natural runoff may limit water consumption are taken as the limiting period and limiting season. The duration of the high-water period is set so that the spring freshet for all years falls within its established boundaries [4].

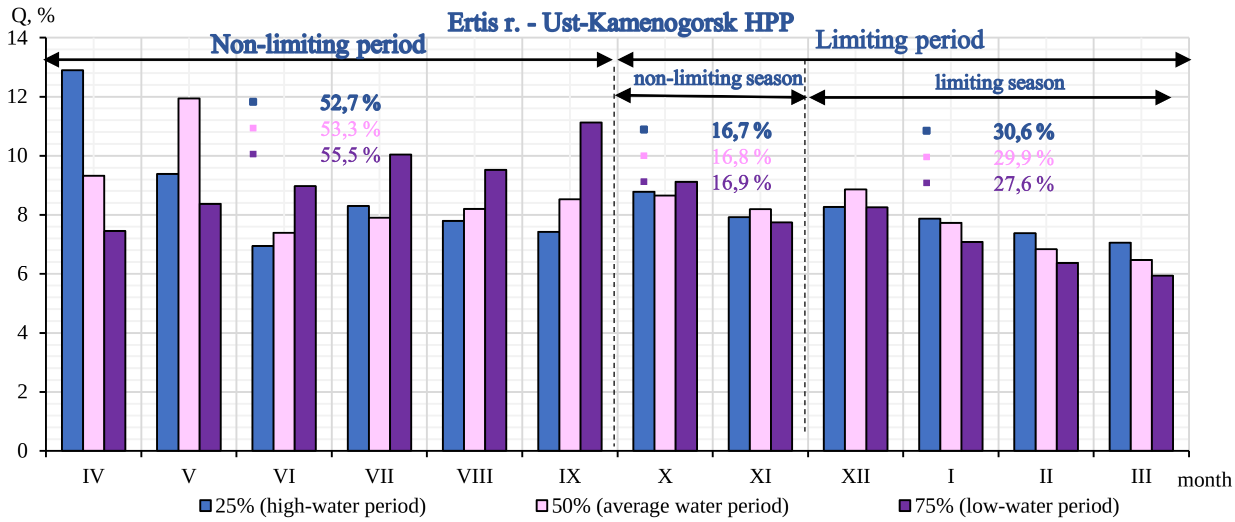
The method is based on assuming equality of runoff reliability for the year, the limiting period, and the limiting season. The calculation of runoff values for the year, the limiting period, and the limiting season is usually carried out according to the following four water availability gradations: high-water (P = 25 %), average (P = 50 %), low-water (P = 75 %), and very low-water (P = 95 %). Experience shows that the intra-annual runoff distribution of major rivers for an average water year (P = 50 %), calculated using V.G. Andreyanov’s method, corresponds well with the mean «synthetic» distribution.

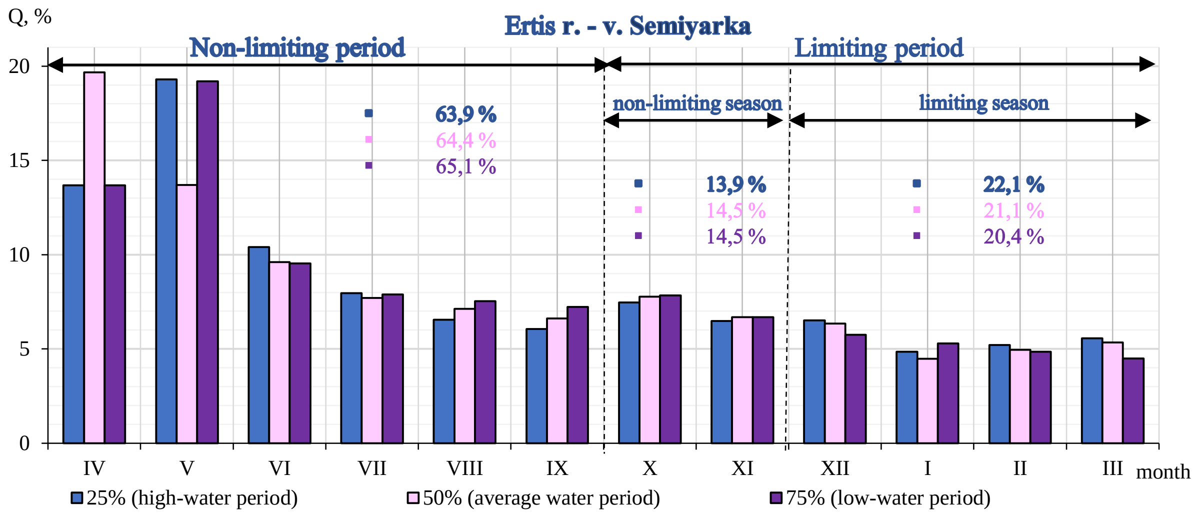
4.1 Intra-Annual Runoff Distribution of the Ertis River WMB

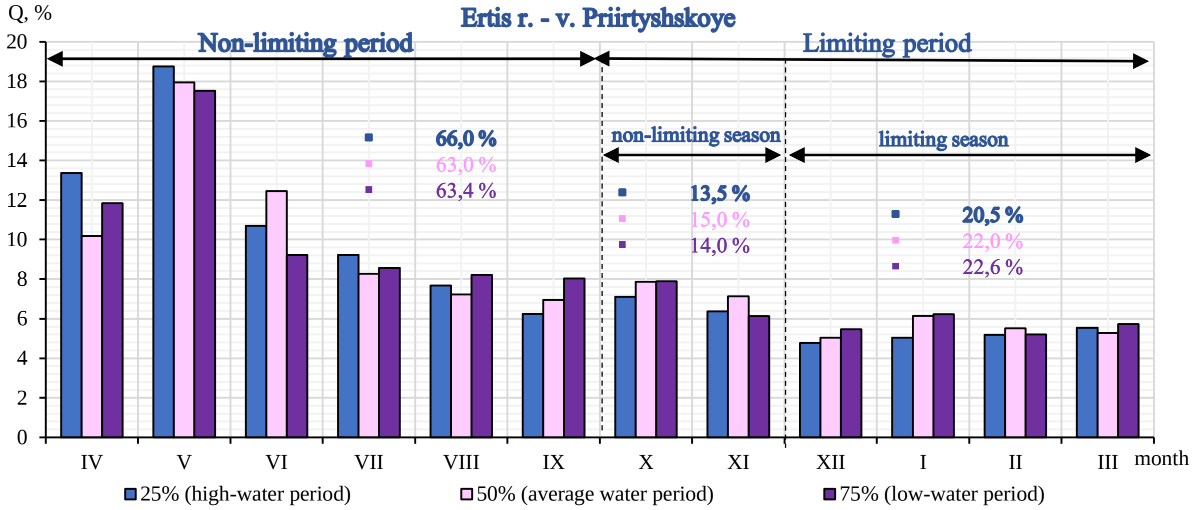
Ertis River basin. For most rivers in the Upper Ertis Basin, especially mountain rivers, a prolonged spring-summer high-water period and floods during the warm season are typical. During the high-water period, which lasts from 4 to 6 months, 70-90 % of the annual runoff occurs. Rivers and temporary watercourses in the southwestern and western parts of the Upper Ertis Basin are characterized by a high unevenness of runoff throughout the year. During the 2-3 months of spring high water, 70-100 % of the annual runoff occurs in these rivers. During the rest of the year, even rivers with significant catchment areas (up to 14,000 km²) may dry up or freeze. Due to the uneven intra-annual distribution of runoff, its economic use becomes more complicated. When using water resources for energy, industrial and domestic water supply, and irrigation, the period of low water – the low-flow season – is of greatest interest. The calculation of intra-annual runoff distribution using the compositing method was carried out in the following sequence: the boundaries of the water management year were established, starting from the high-water season. The duration of the high-water period was set so that the spring freshet for all the years under consideration fell within its established boundaries. For the calculation, the division of the water management year into periods and seasons was adopted according to the data from «Surface Water Resources of the USSR» [39] taking into account the zoning of the basin territory: limiting periods and seasons: non-limiting period for the Upper Ertis River at Boran v., Ertis River – Ust-Kamenogorsk HPP, Ertis River – Semiyarskoye v., Ertis River – PriErtisskoye v., and Bukhtarma River – Lesnaya Pristan v.: April-September (IV-IX). Limiting period: October-March (X-III). Non-limiting season: October-November (X-XI). Limiting season: December-March (XII-III). This division is shown in more detail in Figure 66.

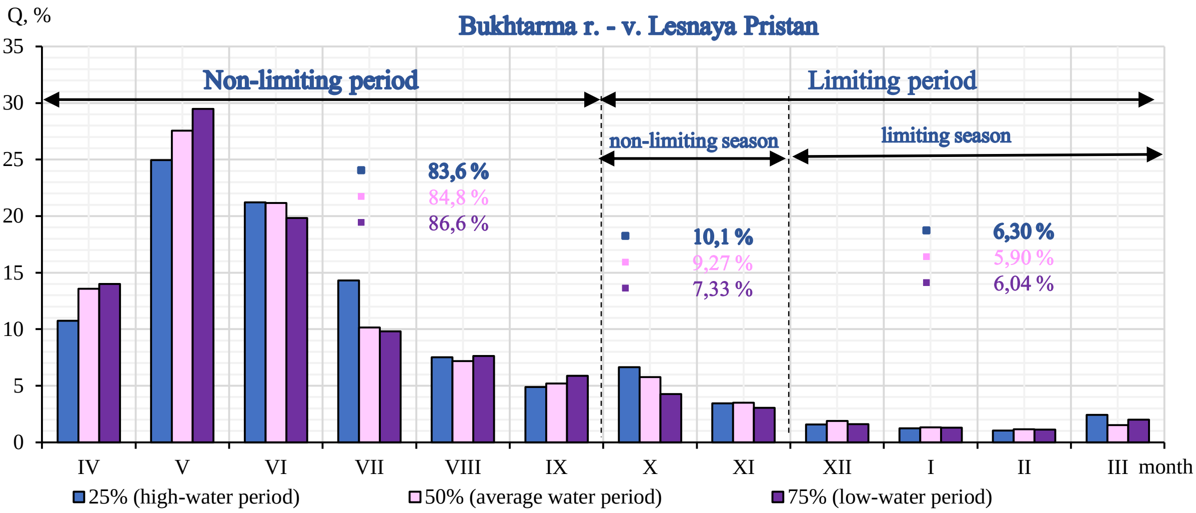
For the Upper Ertis River at Kalzhyr v., Kurshim River at Voznesenka v., Ulbi River at Ulbi Perevalochnaya, and Oba River at Shemonaiha city, the season boundaries are defined slightly differently: non-limiting period: April-July (IV-VII), limiting period: August-March (VIII-III), non-limiting season: August-November (VIII-XI), limiting season: December-March (XII-III). This division is shown in more detail in figure 67.








Ertis r. - v. Priirtyshskoye
Q, %
Non-limiting period
Limiting period
non-limiting season
limiting season
66,0 %
63,0 %
63,4 %
13,5 %
15,0 %
14,0 %
20,5 %
22,0 %
22,6 %
IV V VI VII VIII IX X XI XII I II III month
25% (high-water period)
50% (average water period)
75% (low-water period)


Bukhtarma r. - v. Lesnaya Pristan
Q, %
Non-limiting period
Limiting period
non-limiting season
limiting season
83,6 %
84,8 %
86,6 %
10,1 %
9,27 %
7,33 %
6,30 %
5,90 %
6,04 %
IV V VI VII VIII IX X XI XII I II III month
25% (high-water period)
50% (average water period)
75% (low-water period)

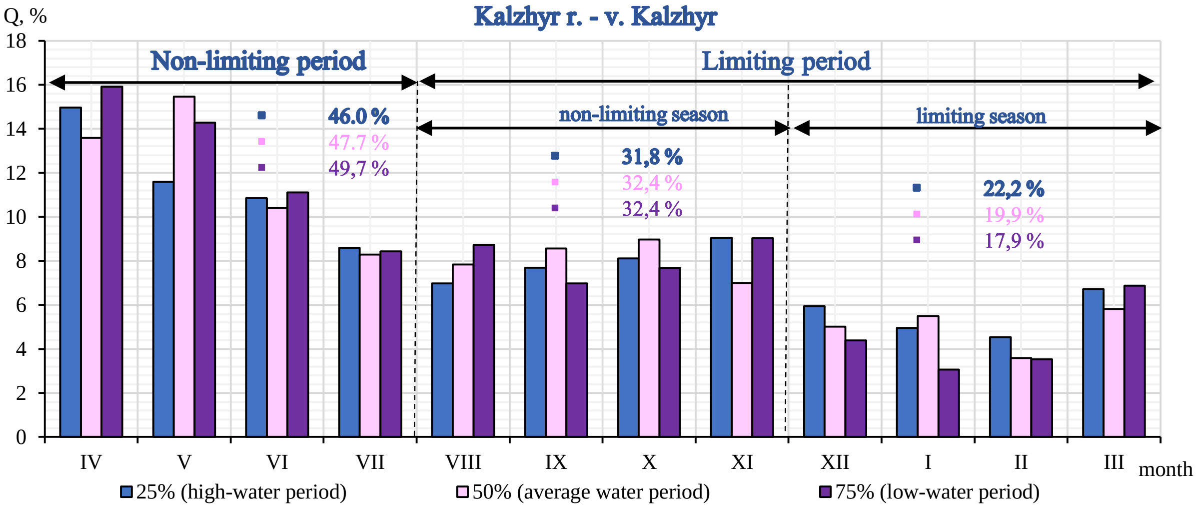
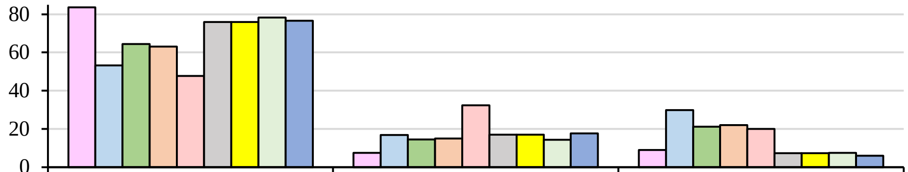

Kalzhyr r. - v. Kalzhyr
Q, %
Non-limiting period
Limiting period
non-limiting season
limiting season
46.0 %
47.7 %
49,7 %
31,8 %
32,4 %
32,4 %
22,2 %
19,9 %
17,9 %
IV V VI VII VIII IX X XI XII I II III month
25% (high-water period)
50% (average water period)
75% (low-water period)

Figure 66 – Intra-annual runoff distribution of major water management points over a multi-year period in the Ertis River WMB

To determine the annual runoff of a given reliability, reliability curves were constructed for specific periods and seasons (Fig.1, Appendix B), and their main statistical characteristics over the multi-year period were also determined (Table 1, Appendix B).

Analysis of the reliability curves of observed runoff at the main hydrological stations of the Ertis River basin showed that all rivers are characterized by pronounced seasonality and significant variability in water availability. The highest flows are observed in spring due to intensive snowmelt, while in summer and autumn runoff decreases, reaching minimum values in winter. In the upper reaches of the Ertis River and its mountain tributaries (Bukhtarma, Kalzhyr, Kurshim, Ulba), high instability and steep slopes of the curves are noted, reflecting fluctuations in runoff caused by combined snow and glacier feeding. In the lower reaches, the curves are more smoothed, indicating a leveling of the flow regime along the river. Overall, the spring period forms the main part of the annual runoff (up to 60 %), which indicates the predominance of snow feeding and the significant influence of climatic fluctuations on river water availability (Fig.1, Appendix B).

Table 25 - Intra-annual runoff distribution of major rivers for an average water year (50% Reliability) in percent (%)



	% (SPRING-SUMMER)	% (AUTUMN)	% (WINTER)
Kara Ertis r. - v. Boran	83,6	7,43	8,97
Ertis r. - Ust-Kamenogorsk HPP	53,3	16,8	29,9
Ertis r. - v. Semiyarka	64,4	14,5	21,1
Ertis r. - v. Priirtyshskoye	63,0	15	22
Kalzhyr r. - v. Kalzhyr	47,7	32,4	19,9
Kurshim r. - v. Voznesenka	75,9	16,9	7,25
Bukhtarma r. - v. Lesnaya Pristan	75,9	16,9	7,25
Ulbi r. - v. Ulbi Perevalochnaya	78,2	14,3	7,49
Oba r. - city Shemonaikha	76,6	17,6	5,86

Analysis of runoff distribution for an average water year (Table 1) by seasons showed that in the Ertis River basin, the main part of runoff is formed in spring. In the upper reaches (Boran, Ust-Kamenogorsk HPP, Semiyarskoye, PriErtisskoye stations), spring-summer runoff accounts for **53-84 %,** autumn – **7-17 %,** and winter – **9-30 %,** which is influenced by reservoirs and a relatively uniform feeding regime. In the middle reaches (Kalzhyr, Kurshim, Bukhtarma rivers), **48-76 %** of the annual runoff occurs in spring, **17-32 %** in autumn, and **7-20 %** in winter. In the lower basin (Ulbi and Oba rivers), spring runoff reaches **76-78 %,** indicating a distinctly snow-fed flow regime. Overall, moving downstream, the share of spring high-water increases, while summer-autumn and winter runoff decrease, reflecting the natural transition from a regulated mountain regime to an unregulated plain regime.

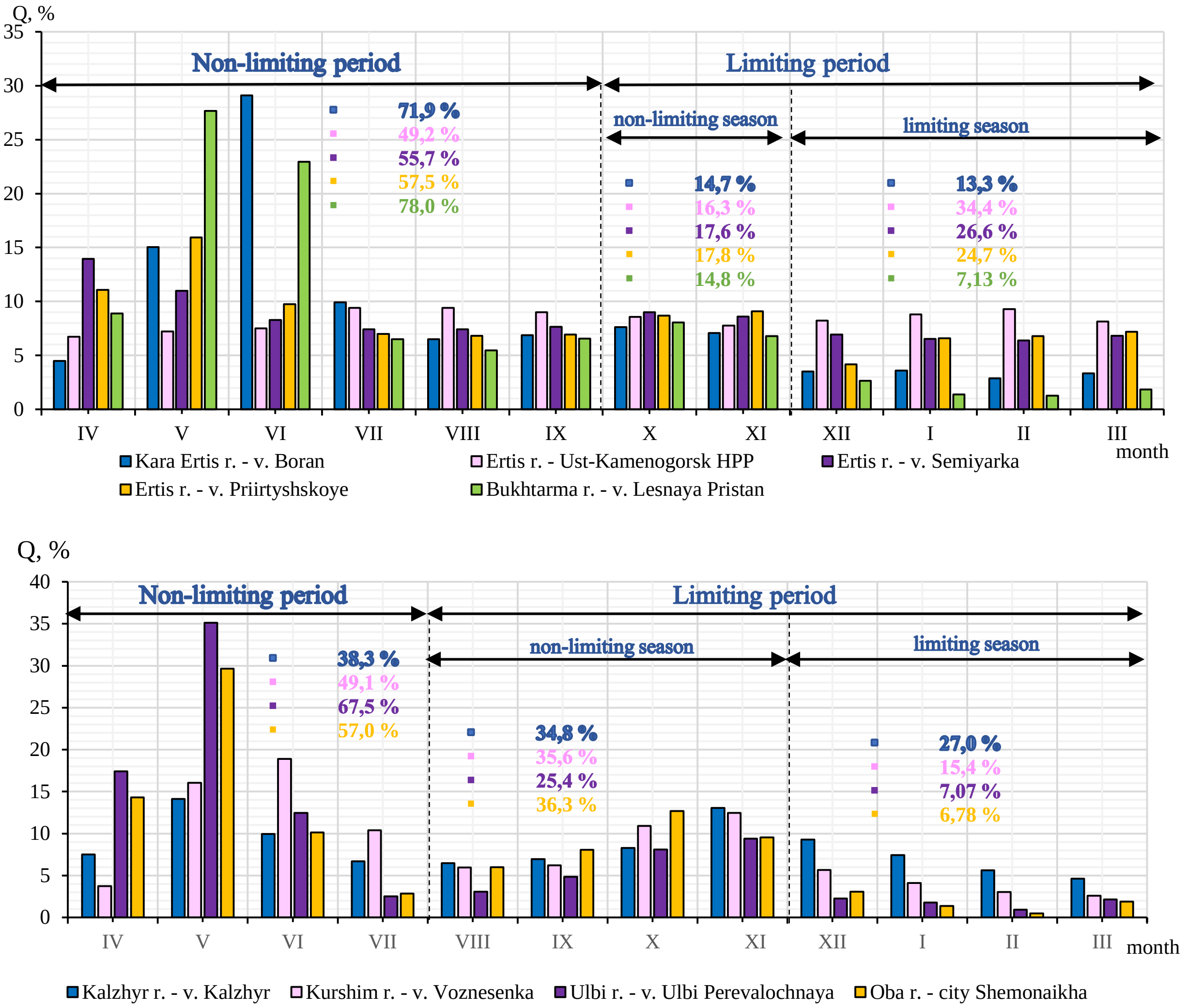


Figure 67 – Intra-annual runoff distribution of major water management points of the Ertis River basin for 2023-2024

Analysis of the intra-annual runoff distribution at the main hydrological stations of the Ertis River basin for 2023-2024 (Table 2, Appendix B) revealed a clear division of the year into limiting and non-limiting periods (Fig.2) of the water balance, which is of significant importance for the assessment of water resources and the planning of water use.

The non-limiting period covers April-September and is characterized by the formation of the main part of the annual runoff (up to 78 %). Peak flows occur in the spring-summer months, especially in May and June, due to intensive snowmelt and the melting of glacier ice in the upper basin. In addition, during the summer-autumn season (July-September), a relatively stable low-flow period is formed due to rainfall and groundwater recharge, which further supports the river regime.

The limiting period covers October-March and is divided into two seasons: the non-limiting season (October-November), when runoff remains at a relatively stable level, and the limiting season (December-March), which is characterized by minimum flow values. This season coincides with the winter low-flow period, when water flows sharply decrease due to the lack of snowmelt and minimal liquid precipitation.

The intra-annual runoff distribution in the Ertis River basin follows a hydrological pattern with a pronounced spring high-water period and a stable low-flow period in summer and autumn.

The winter-spring period (December-March) is limiting in terms of water resources, requiring special attention in water management.

For the tributaries of the Ertis River (Kalzhyr, Kurshim, Ulba, Oba rivers), the non-limiting period falls on April-July, during which a significant portion of the annual runoff is formed (up to 67.5%), as shown in Figure 2, with detailed information provided in Table 2, Appendix B. Peak flows are observed in May, associated with the spring high-water period and intensive snowmelt, which ensures maximum river discharge and water availability. The limiting period covers August-March and is characterized by a reduction in runoff. Within this period, two seasons are distinguished: the non-limiting season (August-November), when moderate flows are maintained due to rainfall and groundwater recharge, ensuring relative stability of the water regime; and the limiting season (December-March), when runoff is minimal, due to the winter low-flow period.

Conclusion for the tributaries of the Ertis River (Kalzhyr, Kurshim, Ulba, Oba rivers): They are characterized by a pronounced spring high-water period (April-June) and a gradual decrease in runoff toward autumn.

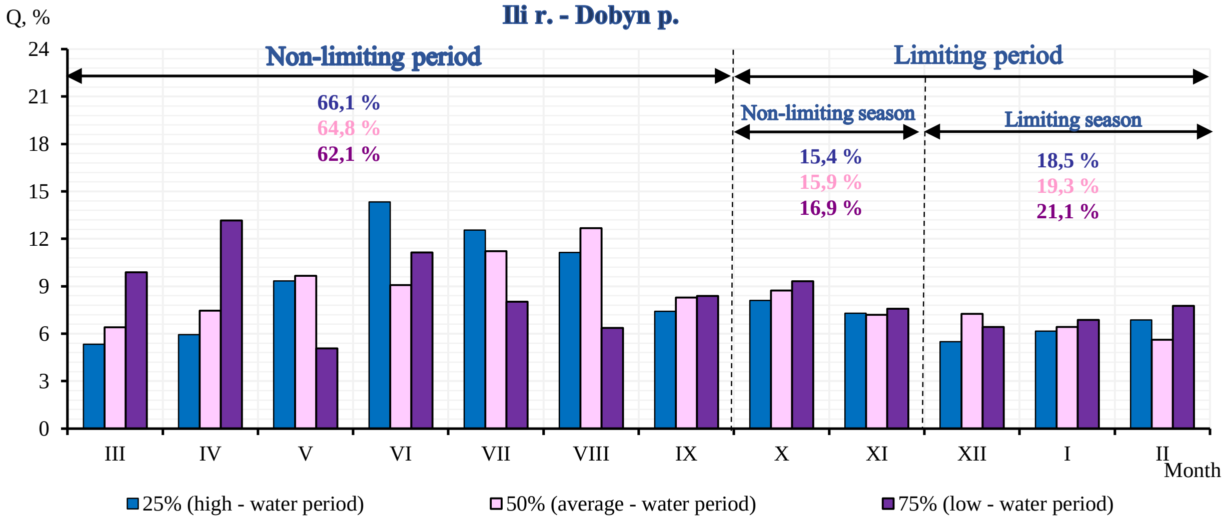
4.2 Intra-Annual runoff distribution of the Balkhash-Alakol WMB

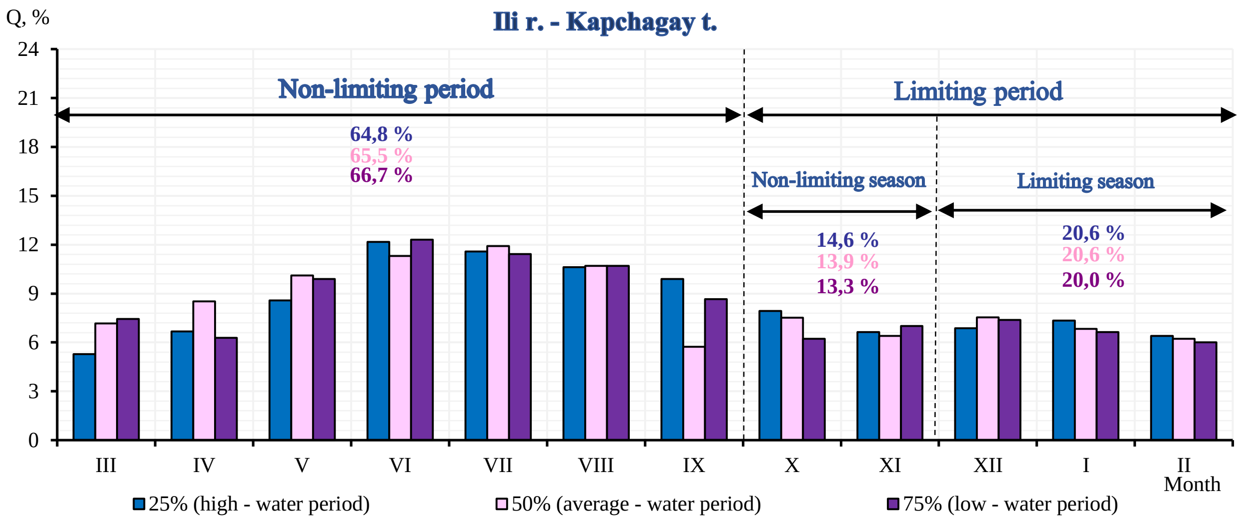
Balkhash-Alakol WMB. For most rivers forming runoff on the slopes of the Zhetysu Alatau, a prolonged spring-summer high-water period is typical. At the same time, the intra-annual runoff distribution of rivers is largely determined not only by the elevation and area of the catchments, but also by the predominant orientation of the slope on which the river basin is located, as well as by various hydrogeological conditions.

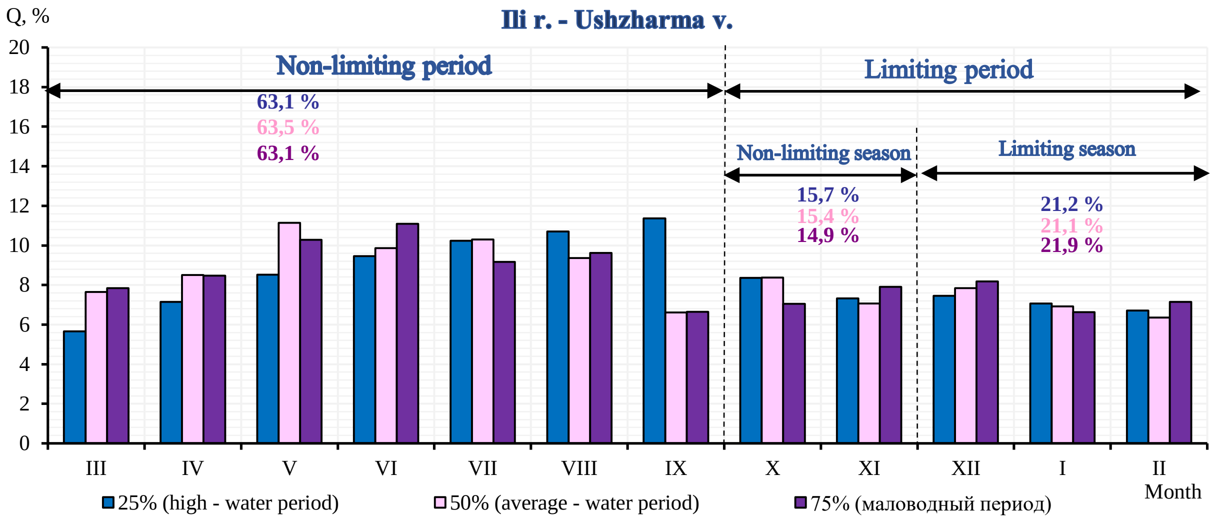
When developing the calculation scheme for river runoff distribution, the following limiting periods and seasons were adopted: non-limiting period for the first group of water management points: Ili River – Dobyn, Ili River – Kapchagay area, Ili River – Ushjarma V., and Tentek River – Tonkeris station: March-September (III-IX). Non-limiting period for the second group of water management points: Lepsy River – Lepsy V., Shilik River – Malybay V., Sharyn River – Sarytogay area, and Ili River – 164 km above Kapchagay HPP: March-October (III-X). Limiting period: first group of rivers: October-February (X-II); second group of rivers: November-February (XI-II). Non-limiting season: first group: October-November (X-XI); second group: November-December (XI-XII). Limiting season: first group: December-February (XII-II); second group: January-February (I-II)

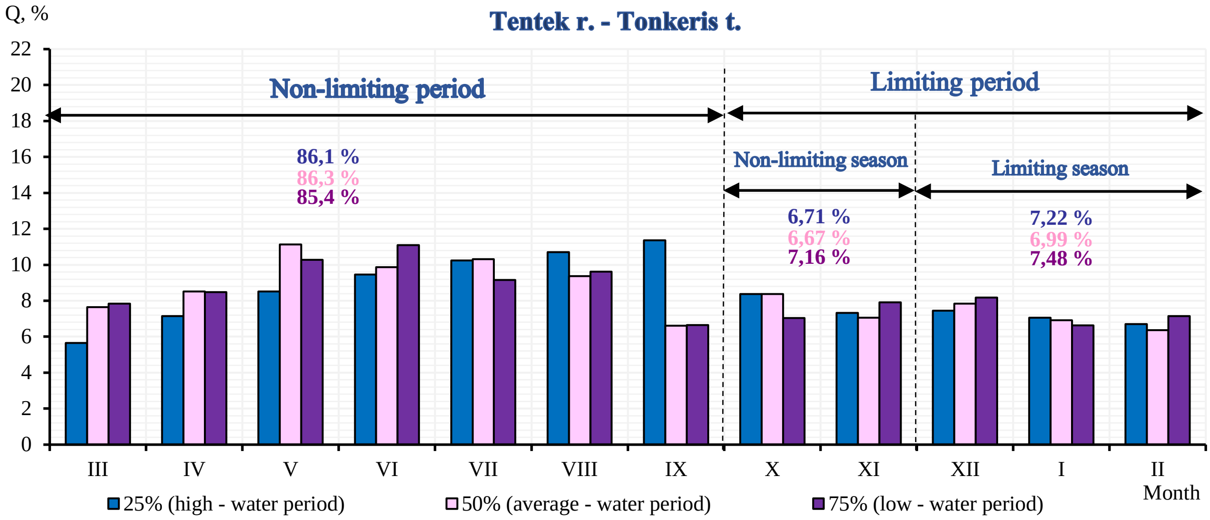
To determine the annual runoff of a given reliability, reliability curves were constructed for the pre-selected periods and seasons, and the corresponding statistical characteristics were also determined (Fig.2, Appendix B).

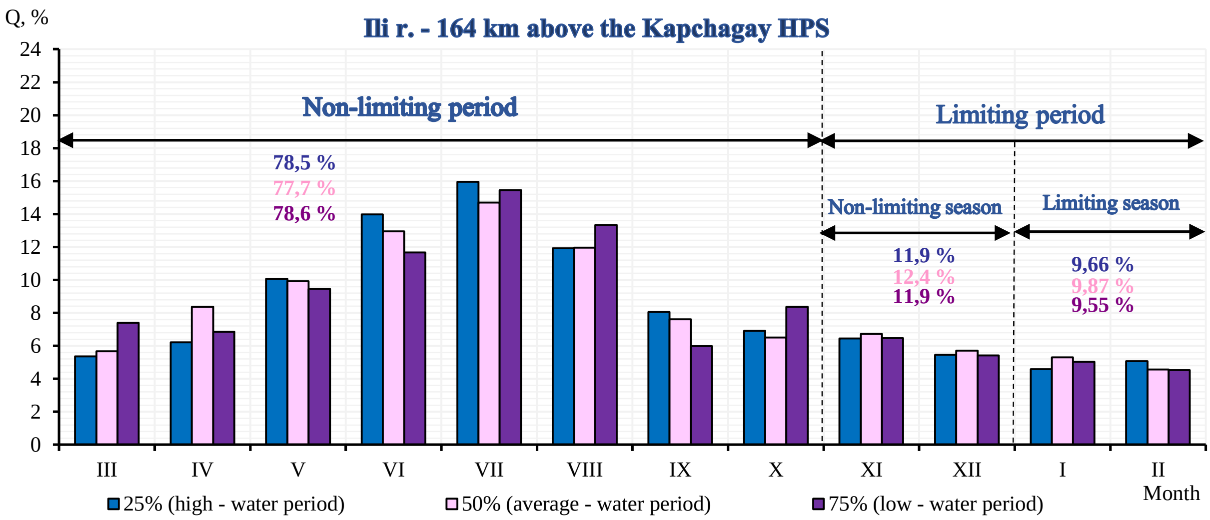
Analysis of the reliability curves of observed runoff at the hydrological stations of the Balkhash-Alakol Basin revealed significant differences in interannual runoff variability between large and small rivers. Large rivers, such as the Ili, show high sensitivity to climatic and anthropogenic changes, reflected in steep and asymmetric reliability curves. At the same time, smaller rivers, such as the Lepsy and Sharyn, are characterized by more stable flows and gentler reliability curves. The reliability curve of the Ili River, with pronounced asymmetry, shows sharp declines from 1% to 50% reliability, indicating high interannual variability at high flows. For the Tentek, Sharyn, and Shilik rivers, the curves are closer to logarithmic, indicating stability and uniform distribution, especially in winter. The entire system is characterized by strong seasonal contrast: spring-summer – maximum flows, winter – minimum flows.

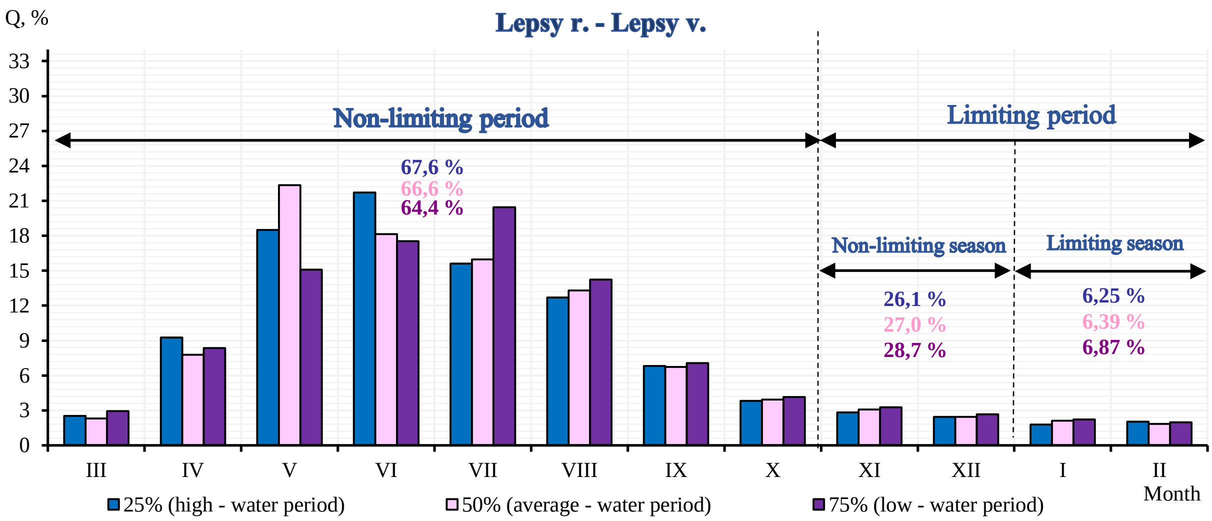

Ili r. - Dobyn p.
Q, %
Non-limiting period
66,1 %
64,8 %
62,1 %
Limiting period
Non-limiting season
15,4 %
15,9 %
16,9 %
Limiting season
18,5 %
19,3 %
21,1 %
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)

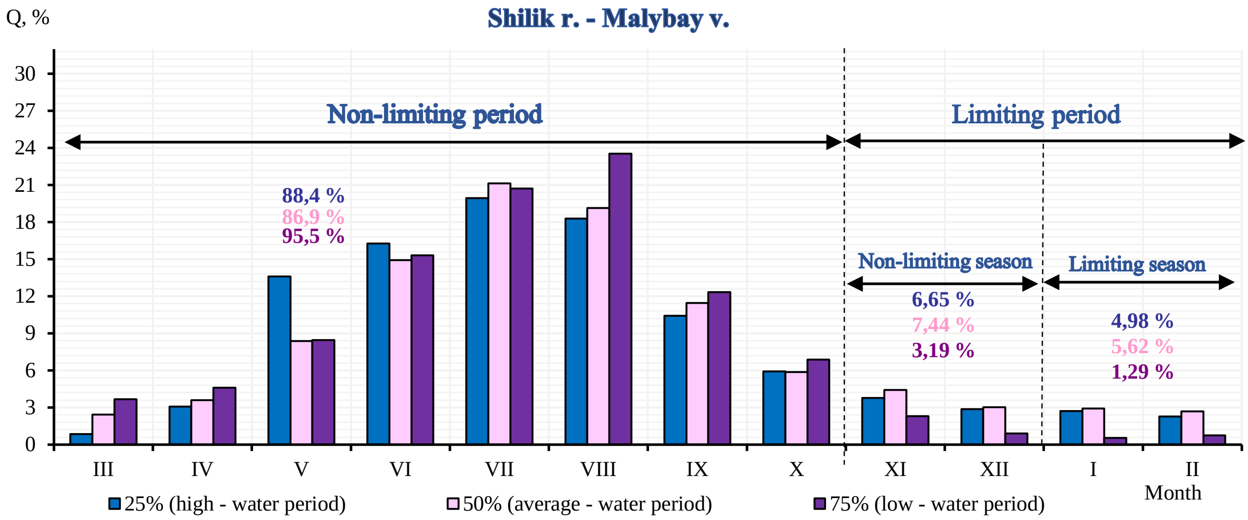

Ili r. - Kapchagay t.
Q, %
Non-limiting period
64,8 %
65,5 %
66,7 %
Limiting period
Non-limiting season
14,6 %
13,9 %
13,3 %
Limiting season
20,6 %
20,6 %
20,0 %
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)


Ili r. - Ushzharma v.
Q, %
Non-limiting period
63,1 %
63,5 %
63,1 %
Limiting period
Non-limiting season
15,7 %
15,4 %
14,9 %
Limiting season
21,2 %
21,1 %
21,9 %
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (маловодный период)


Q, %
Tentek r. - Tonkeris t.
Non-limiting period
Limiting period
Non-limiting season
Limiting season
86,1 %
86,3 %
85,4 %
6,71 %
6,67 %
7,16 %
7,22 %
6,99 %
7,48 %
0 2 4 6 8 10 12 14 16 18 20 22
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)


Q, %
Ili r. - 164 km above the Kapchagay HPS
Non-limiting period
Limiting period
Non-limiting season
Limiting season
78,5 %
77,7 %
78,6 %
11,9 %
12,4 %
11,9 %
9,66 %
9,87 %
9,55 %
0 2 4 6 8 10 12 14 16 18 20 22 24
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)


Q, %
Lepsy r. - Lepsy v.
Non-limiting period
Limiting period
Non-limiting season
Limiting season
67,6 %
66,6 %
64,4 %
26,1 %
27,0 %
28,7 %
6,25 %
6,39 %
6,87 %
0 3 6 9 12 15 18 21 24 27 30 33
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)



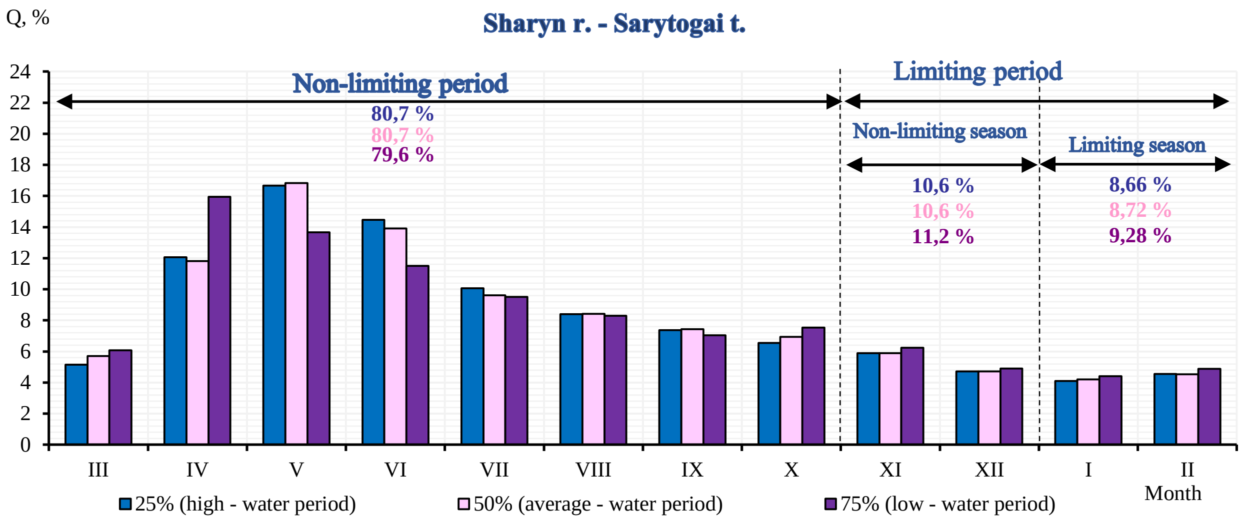
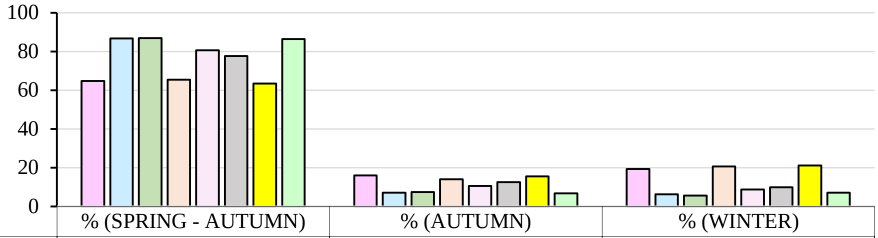


Figure 68 – Intra-annual runoff distribution of major water management points over a multi-year period in the Balkhash-Alakol WMB

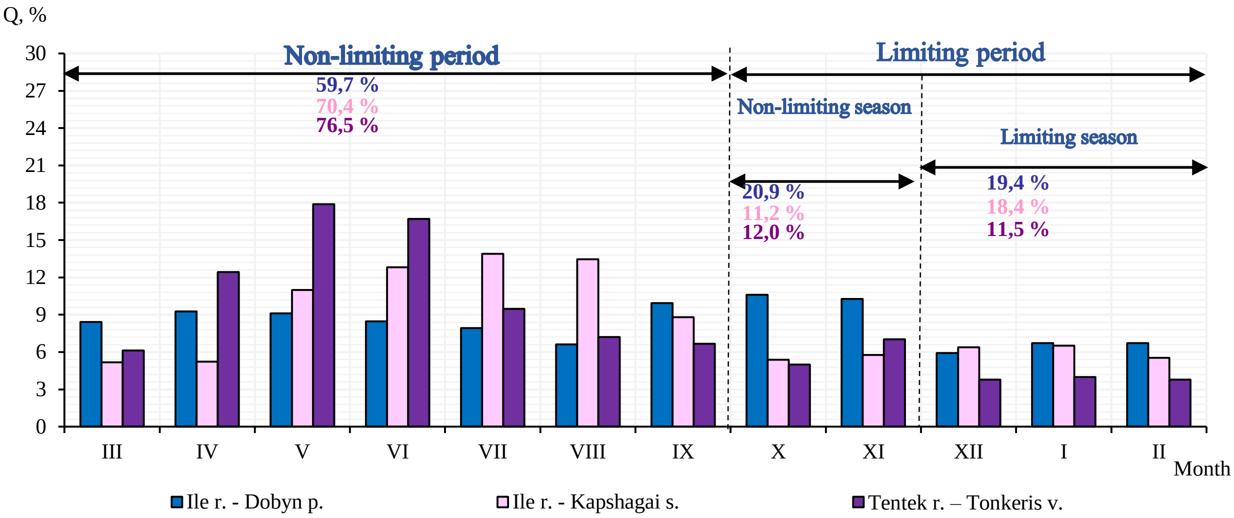
The intra-annual runoff distribution was carried out up to 2021; thereafter, the seasonal runoff values for each year will be analyzed relative to the completed series. Every 5-7 years, the intra-annual runoff distribution series will be updated again, depending on the dynamics of interannual runoff changes.

About 74 % of the annual runoff occurs during the high-water period (march-september), while the remaining 26 % is formed during the rest of the year. According to figure 2 and table 2, during the spring-summer period, the highest runoff values are observed at the Shilik River hydrological station – Malybay v., indicating a stable water regime, as well as at the Tentek River – Tonkeris station, where runoff is less affected by climatic fluctuations, reflected in smoother reliability curves. The minimum runoff values were recorded at the Ili River hydrological station – Ushjarma v.

Table 26 - Intra-annual runoff distribution of major water management points for an average water year (50% reliability) in percent (%)



	% (SPRING - AUTUMN)	% (AUTUMN)	% (WINTER)
Ile r. - Dobyn p.	64,76	15,93	19,30
Lepsy r. - Lepsy v.	86,75	6,98	6,27
Shilik r. - Malybai v.	86,94	7,44	5,62
Ile r. - Kapshagai s.	65,48	13,92	20,60
Sharyn r. - Sarytogai s.	80,68	10,60	8,72
Ile r. - 164 km above Kapchagay HES	77,69	12,44	9,87
Ile r. – Ushzharma v.	63,45	15,44	21,11
Tentek r. – Tonkeris v.	86,34	6,67	6,99



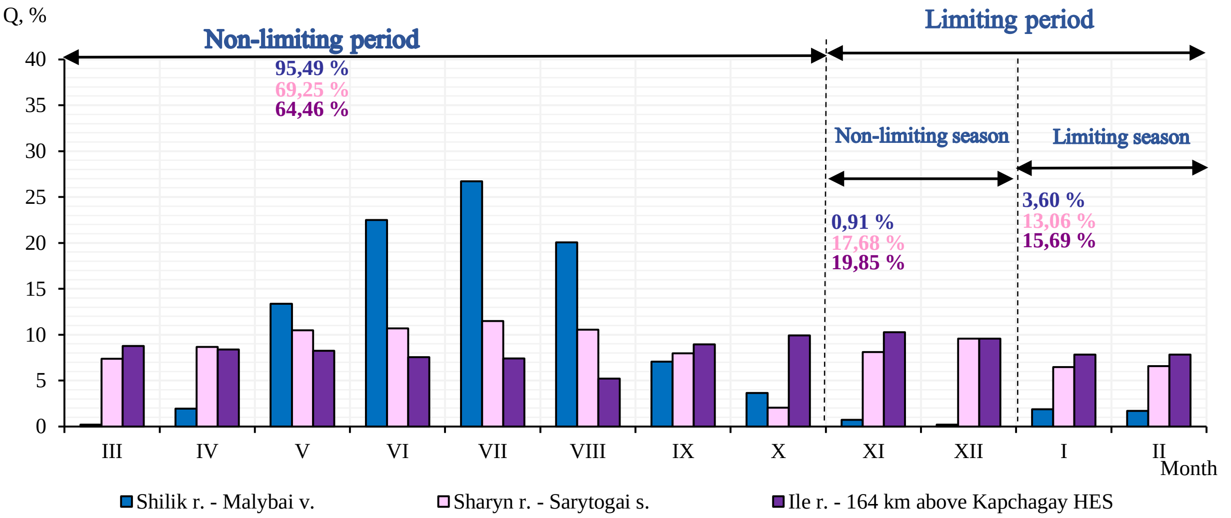


Figure 69 – Intra-annual runoff distribution of major water management points in the Balkhash-Alakol WMB for 2023-2024

Overall, **2023** is characterized as a low-water year with a stable spring-summer high-water period, featuring a clear peak in water availability in May-June and a noticeable decrease during the winter-autumn period.

- For the **Ili River - hydrological station Dobyn**, 2023 was a low-water year (75 %), as were the non-limiting period and the limiting season, with the exception of the non-limiting season, which corresponded to the average water year in terms of runoff reliability. Of the total annual runoff, about 60 % occurred during the non-limiting period.
- Similarly, 2023 was a low-water year for the **Tentek River hydrological station – Tonkeris v.,** due to the primarily low-water non-limiting period, while the limiting period (i.e., both the non-limiting and limiting seasons) corresponded to a high-water period in terms of runoff reliability. The total annual runoff amounted to 405 m^3/s, of which approximately 77 % occurred during the spring-summer high-water period.
- **Ili River – Kapshagay area**. This year was a low-water year in terms of runoff reliability. During the limiting period, runoff was below the long-term average, whereas the non-limiting period had average water conditions. In 2023, the runoff during the spring-autumn period accounted for 70.4 % of the annual runoff.
- 2023 was also a low-water year for the **Shilik River – Malybay v.**The non-limiting period and the non-limiting season were low-water, while the remaining part, i.e., the limiting season, had average water conditions. Notably, the spring-autumn period, corresponding to the non-limiting period, accounted for about 95.5 % of the annual runoff in 2023.
- **Sharyn River – Sarytogay area.** 2023 was a low-water year for this station. Despite high-water seasons, i.e., a high-water limiting period, the year ended at a low-water level due to the low-water non-limiting period. Most of the runoff occurred during the spring-autumn period, which accounted for 69.3 % of the annual runoff.
- **Ili River – 164 km above Kapchagay HPP** was also characterized as low-water. This is primarily due to the predominance of a low-water regime during the main non-limiting period. At the same time, the non-limiting season, in terms of runoff reliability, corresponded to an average water year. The total annual runoff volume was 3,149 m^3/s, of which approximately 66.4 % was formed during the spring-summer high-water period.

4.3 Intra-annual distribution of the Aral-Syrdarya WMB

Aral-Syrdarya WMB. The main source of river feeding is meltwater. Therefore, the intra-annual distribution of runoff, especially during the flood period, is mainly determined by the processes of snow and ice accumulation and melting in the mountains, as well as by accompanying processes of infiltration into the soil and water consumption through evaporation and transpiration [23]. The impact of anthropogenic activity on river runoff in the mountainous runoff formation area is absent or insignificant. However, this factor is quite significant in the runoff dispersion area (in the foothill and plain zones), where water withdrawals for irrigation and the inflow of return flows can fundamentally alter the intra-annual distribution of river runoff. The characteristics of intra-annual runoff distribution for the rivers of the studied territory are defined not by calendar years but by water management years–from March to February. For the rivers of the southwestern slopes of the Karatau and Boraldytau ranges, the water management year is taken from February to January.

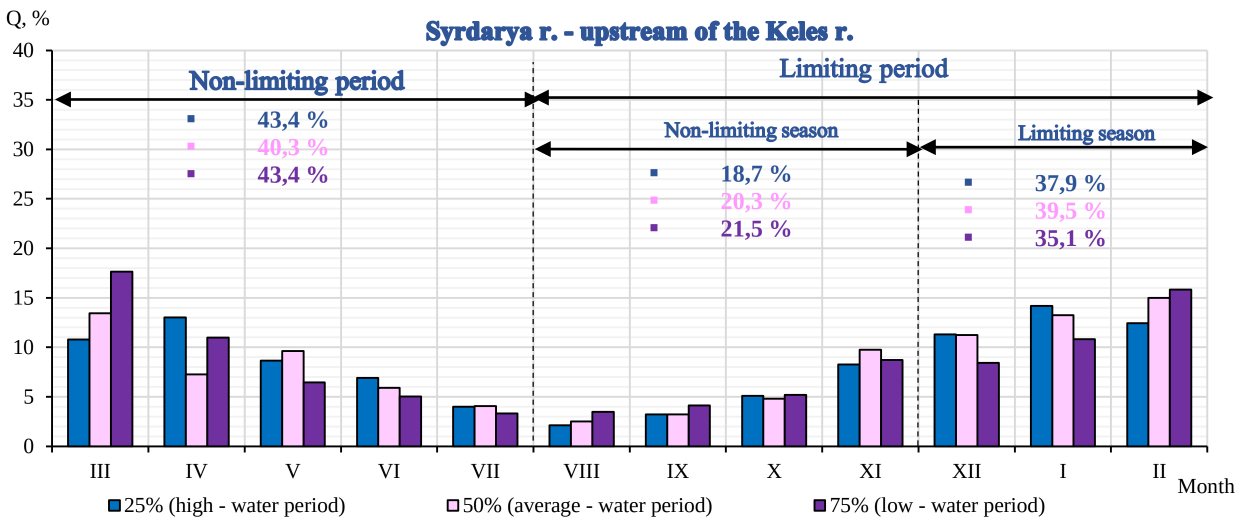
The calculation of intra-annual runoff characteristics was carried out for 11 points. The intra-annual distribution of runoff was calculated using the compositing method [1] [2].

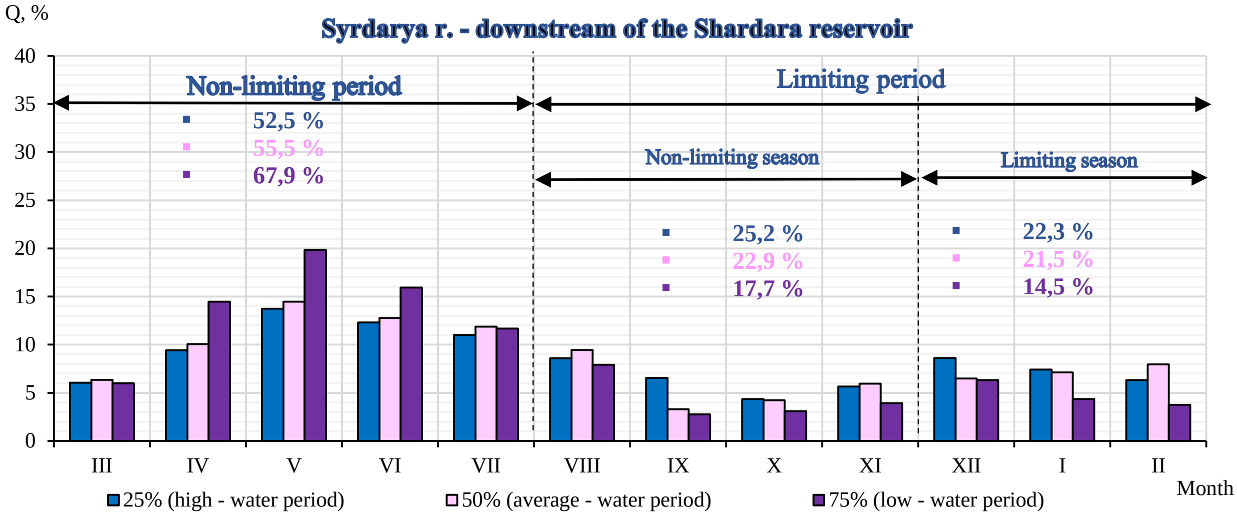
To determine the annual runoff at a given probability, probability curves were constructed for pre-selected periods and seasons, and corresponding statistical characteristics were determined (Appendix B, Figure 3).

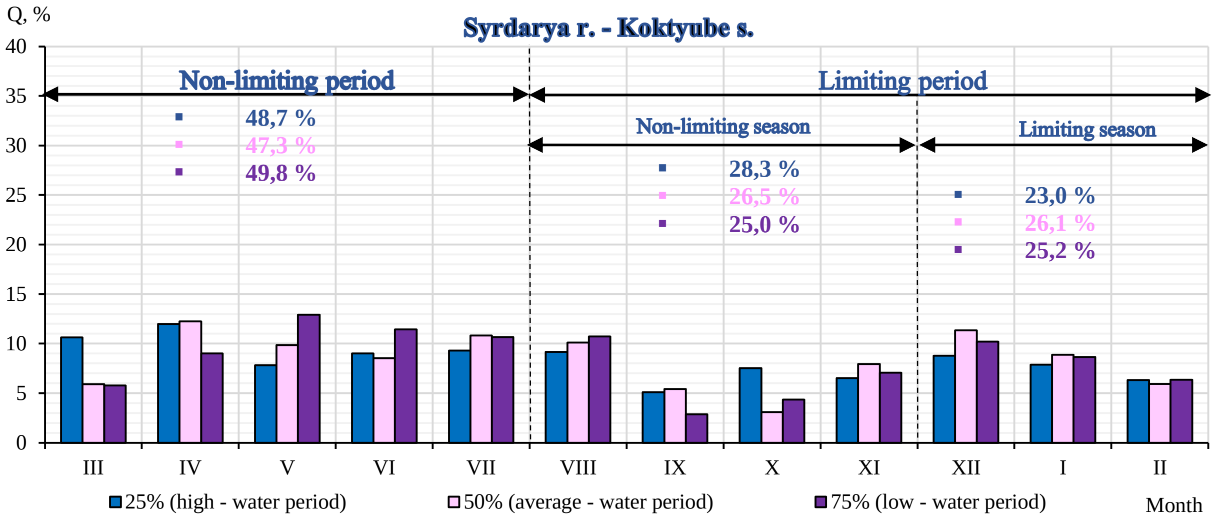
The runoff probability curves of the rivers of the Aral-Syrdarya basin reflect a pronounced spatial-temporal heterogeneity of water availability and a high level of variability, caused both by climatic fluctuations and significant anthropogenic impact. The main water artery of the basin–the Syrdarya river–demonstrates an asymmetric probability curve: at low probabilities (1-10 %) there is a steep decline in discharge, indicating strong interannual variability in years of high water availability. This curve shape reflects the river's high sensitivity to climatic anomalies (winter snow cover, temperature fluctuations, glacier melt intensity) and the regulatory influence of reservoirs in the upper reaches (Toktogul, Shardara, etc.).

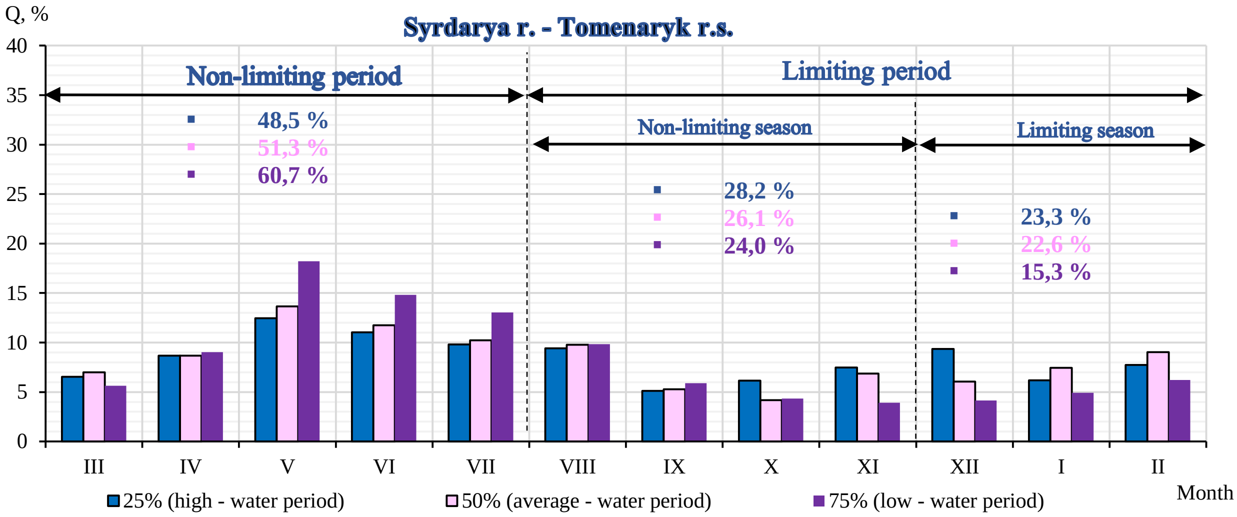
In the middle and lower reaches of the Syrdarya, the curve becomes gentler, reflecting the smoothing of interannual fluctuations due to the cascade of reservoirs and the reuse of water for irrigation. This anthropogenic redistribution leads to a reduction in the amplitude of extreme discharges and a change in the natural seasonal regime: spring-summer peaks are partially shifted and weakened, while winter flows increase due to operational releases.

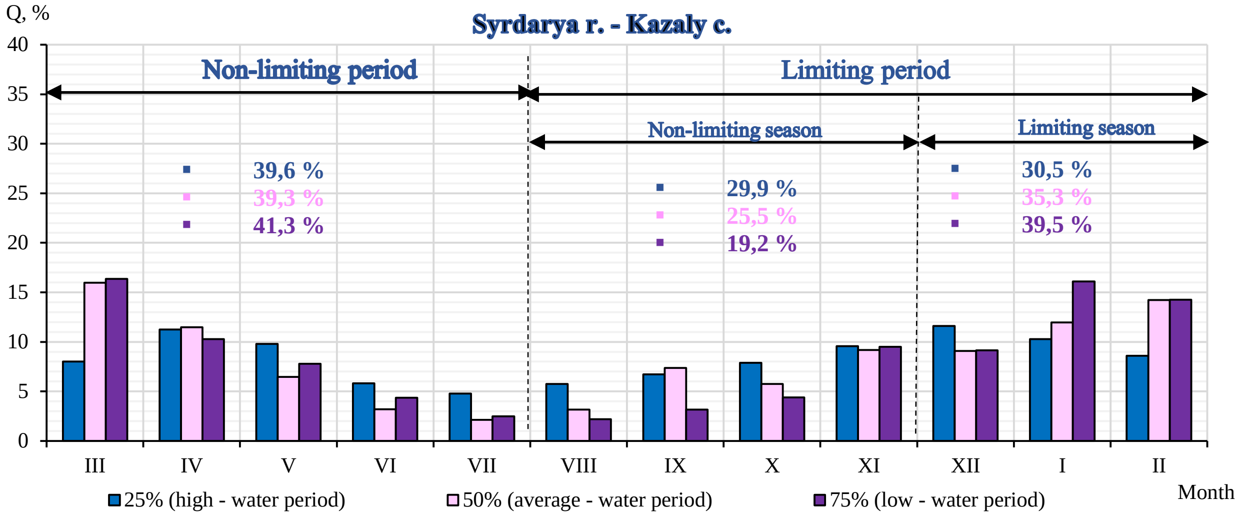
The Syrdarya's tributaries (r. Keles, r. Akbulak, r. Arys, etc.) are characterized by lower variability in their probability curves, especially in the mountainous areas. Mountain rivers show gentler curves at medium probabilities (30-70 %), indicating stable feeding from snow-glacial runoff and precipitation in the upper reaches. At the same time, in the foothill and lowland sections (for example, r. Arys), the probability curves acquire a pronounced asymmetry with sharp declines at low probabilities, indicating a significant influence of irrigation water use, arid climate, and periodic water deficits during the summer-autumn months (Appendix B, Figure 3).

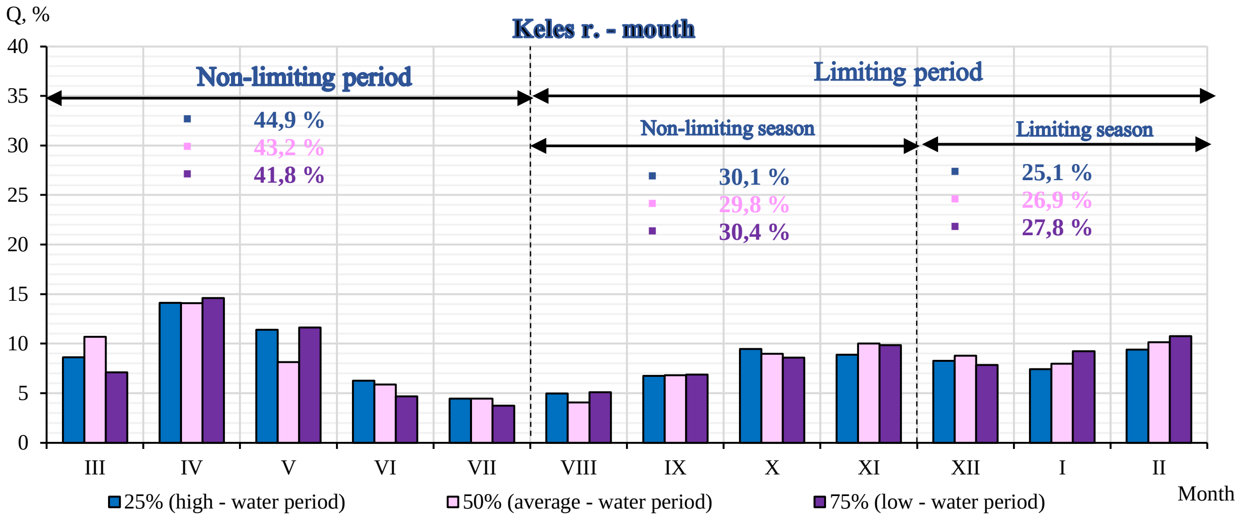


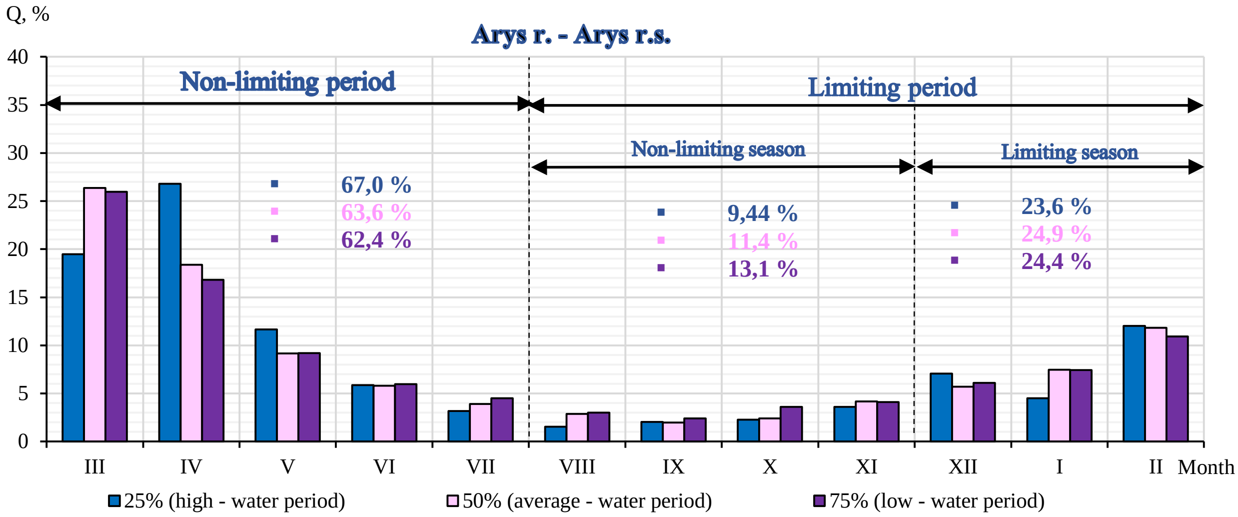

Q, %
Syrdarya r. - downstream of the Shardara reservoir
Non-limiting period
52,5 %
55,5 %
67,9 %
Limiting period
Non-limiting season
25,2 %
22,9 %
17,7 %
Limiting season
22,3 %
21,5 %
14,5 %
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)

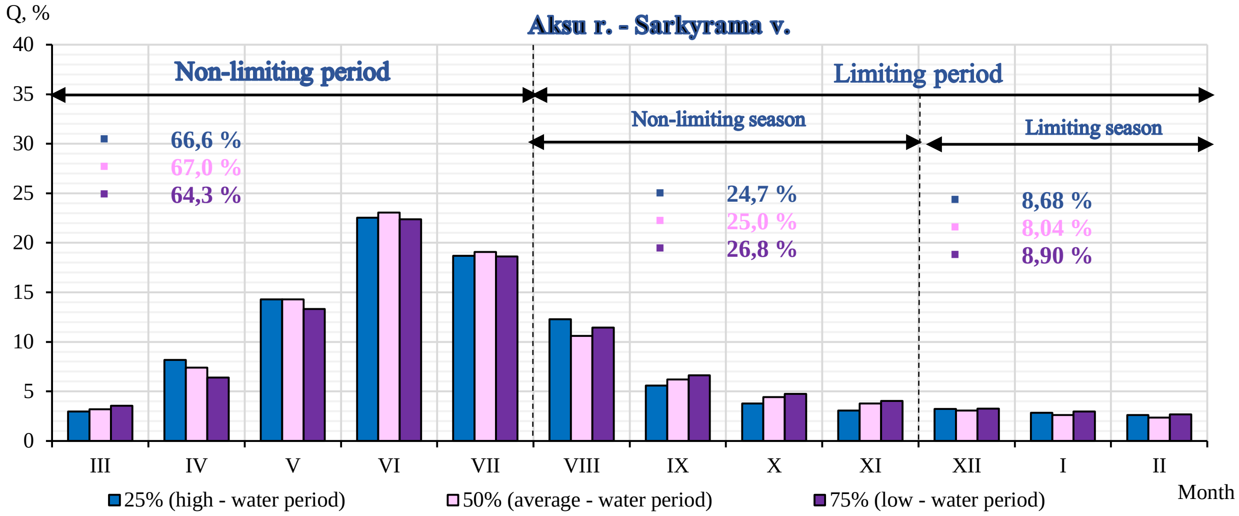

Q, %
Syrdarya r. - Koktyube s.
Non-limiting period
48,7 %
47,3 %
49,8 %
Limiting period
Non-limiting season
28,3 %
26,5 %
25,0 %
Limiting season
23,0 %
26,1 %
25,2 %
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)

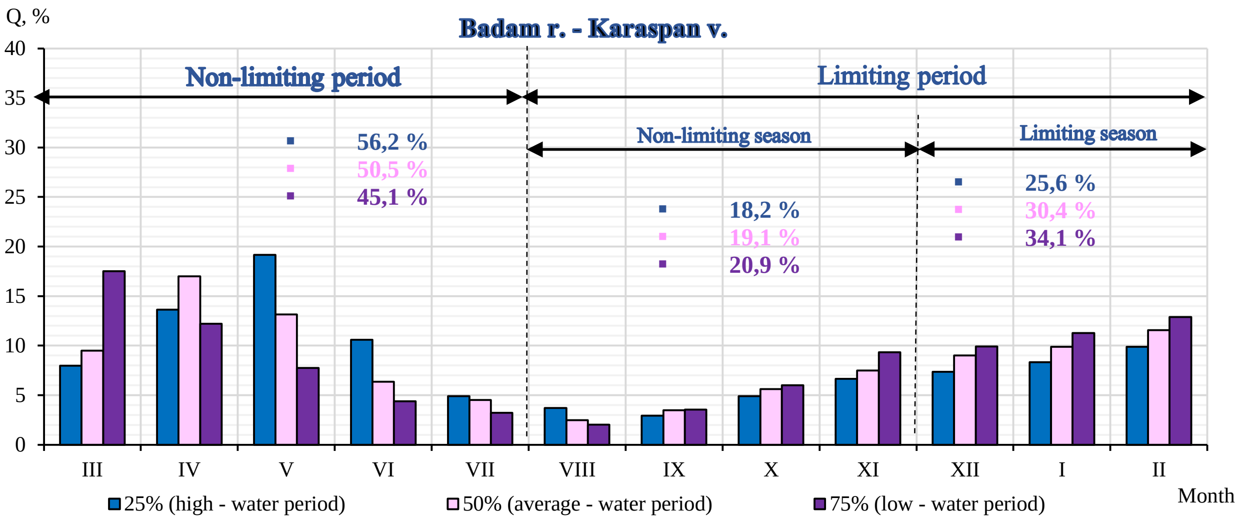

Q, %
Syrdarya r. - Tomenaryk r.s.
Non-limiting period
48,5 %
51,3 %
60,7 %
Limiting period
Non-limiting season
28,2 %
26,1 %
24,0 %
Limiting season
23,3 %
22,6 %
15,3 %
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)

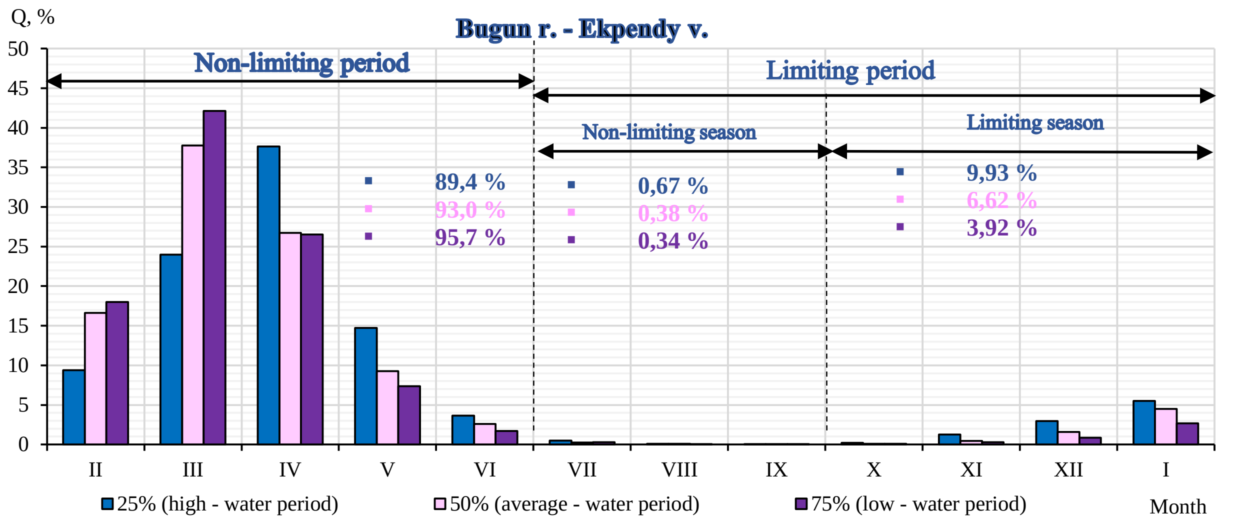

Q, %
Syrdarya r. - Kazaly c.
Non-limiting period
Limiting period
Non-limiting season
Limiting season
39,6 %
39,3 %
41,3 %
29,9 %
25,5 %
19,2 %
30,5 %
35,3 %
39,5 %
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)


Q, %
Keles r. - mouth
Non-limiting period
Limiting period
Non-limiting season
Limiting season
44,9 %
43,2 %
41,8 %
30,1 %
29,8 %
30,4 %
25,1 %
26,9 %
27,8 %
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)


Q, %
Arys r. - Arys r.s.
Non-limiting period
Limiting period
Non-limiting season
Limiting season
67,0 %
63,6 %
62,4 %
9,44 %
11,4 %
13,1 %
23,6 %
24,9 %
24,4 %
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)


Aksu r. - Sarkyrama v.
Q, %
Non-limiting period
Limiting period
Non-limiting season
Limiting season
66,6 %
67,0 %
64,3 %
24,7 %
25,0 %
26,8 %
8,68 %
8,04 %
8,90 %
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)


Badam r. - Karaspan v.
Q, %
Non-limiting period
Limiting period
Non-limiting season
Limiting season
56,2 %
50,5 %
45,1 %
18,2 %
19,1 %
20,9 %
25,6 %
30,4 %
34,1 %
III IV V VI VII VIII IX X XI XII I II
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)


Bugun r. - Ekpendy v.
Q, %
Non-limiting period
Limiting period
Non-limiting season
Limiting season
89,4 %
93,0 %
95,7 %
0,67 %
0,38 %
0,34 %
9,93 %
6,62 %
3,92 %
II III IV V VI VII VIII IX X XI XII I
Month
25% (high - water period)
50% (average - water period)
75% (low - water period)

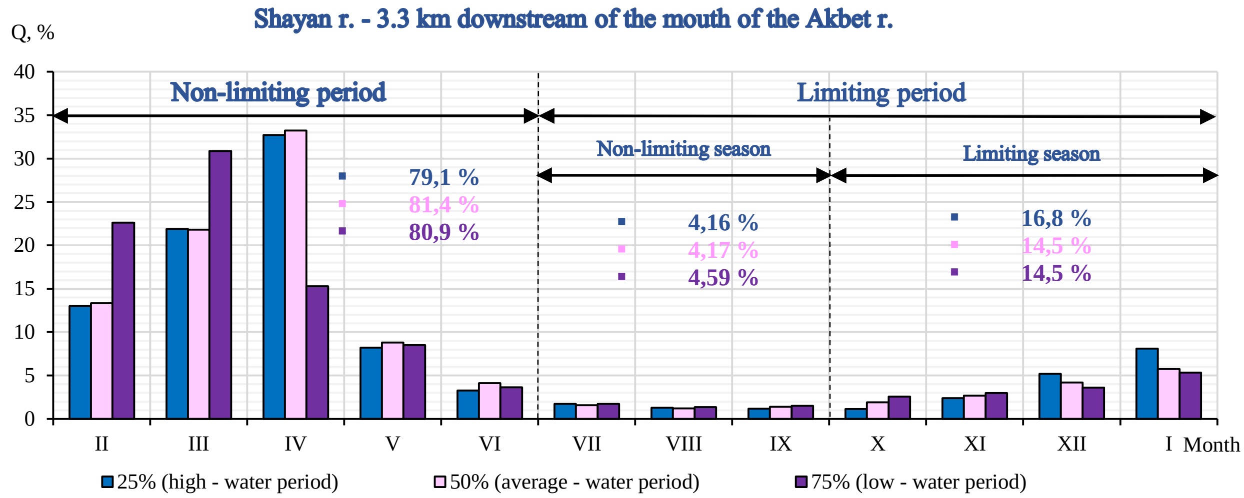
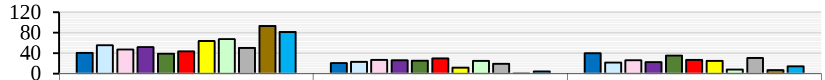


Figure 70 – Intra-annual distribution of runoff at main HP over the long-term period for the Aral-Syrdarya WMB

Table 27 - Intra-annual distribution of runoff at main HP for the period of average water availability (50% probability) in percent (%)



	% (SPRING-SUMMER)	% (SUMMER - AUTUMN)	% (WINTER)
Syrdarya r. - upstream of the Keles r.	40,27	20,28	39,45
Syrdarya r. - downstream of the Shardara reservoir	55,53	22,92	21,55
Syrdarya r. - Koktyube s.	47,32	26,55	26,13
Syrdarya r. - Tomenaryk r.s.	51,29	26,14	22,57
Syrdarya r. - Kazaly c.	39,25	25,46	35,29
Keles r. - mouth	43,24	29,85	26,92
Arys r. - Arys r.s.	63,62	11,41	24,97
Aksu r. - Sarkyrama v.	66,97	24,98	8,04
Badam r. - Karaspan v.	50,49	19,08	30,43
Bugun r. - Ekpendy v.	93,00	0,38	6,62
Shayan r. - 3.3 km downstream of the mouth of the Akbet r.	81,38	4,17	14,45

According to the intra-annual distribution graph for average water availability, the main part of the annual runoff forms during the spring-summer period (March-July), the time of active snow and glacier melt in the Tien Shan. This period accounts for up to 70-80% of the annual runoff volume. In autumn and winter, water flow sharply decreases, especially in non-irrigated areas. However, in certain sections of the lower Syrdarya, winter flows are relatively stable due to regulated releases from reservoirs, which alters the river's natural seasonality.

Thus, the Syrdarya and its tributaries are characterized by high interannual and seasonal variability, with the degree of variability increasing downstream due to the combined influence of climatic factors and anthropogenic transformation of runoff.

The intra-annual distribution of runoff was performed up to 2021; thereafter, the total runoff values for each year by season will be analyzed relative to the completed series. Every 5-7 years, the intra-annual distribution series will be updated again, depending on the dynamics of interannual runoff changes (Appendix B, table 3).

Syrdarya r. – lower reach of the Shardara reservoir. The runoff distribution in 2023 has a smoothed pattern with a weakly expressed spring peak and an extended summer-autumn flood period. This reflects the regulation of runoff by the Shardara reservoir, where releases are governed by energy and irrigation management. Annual water availability is below normal, especially in June-July, due to restrictions on releases from upstream hydropower units and a deficit of inflow in the interstate riverbed.

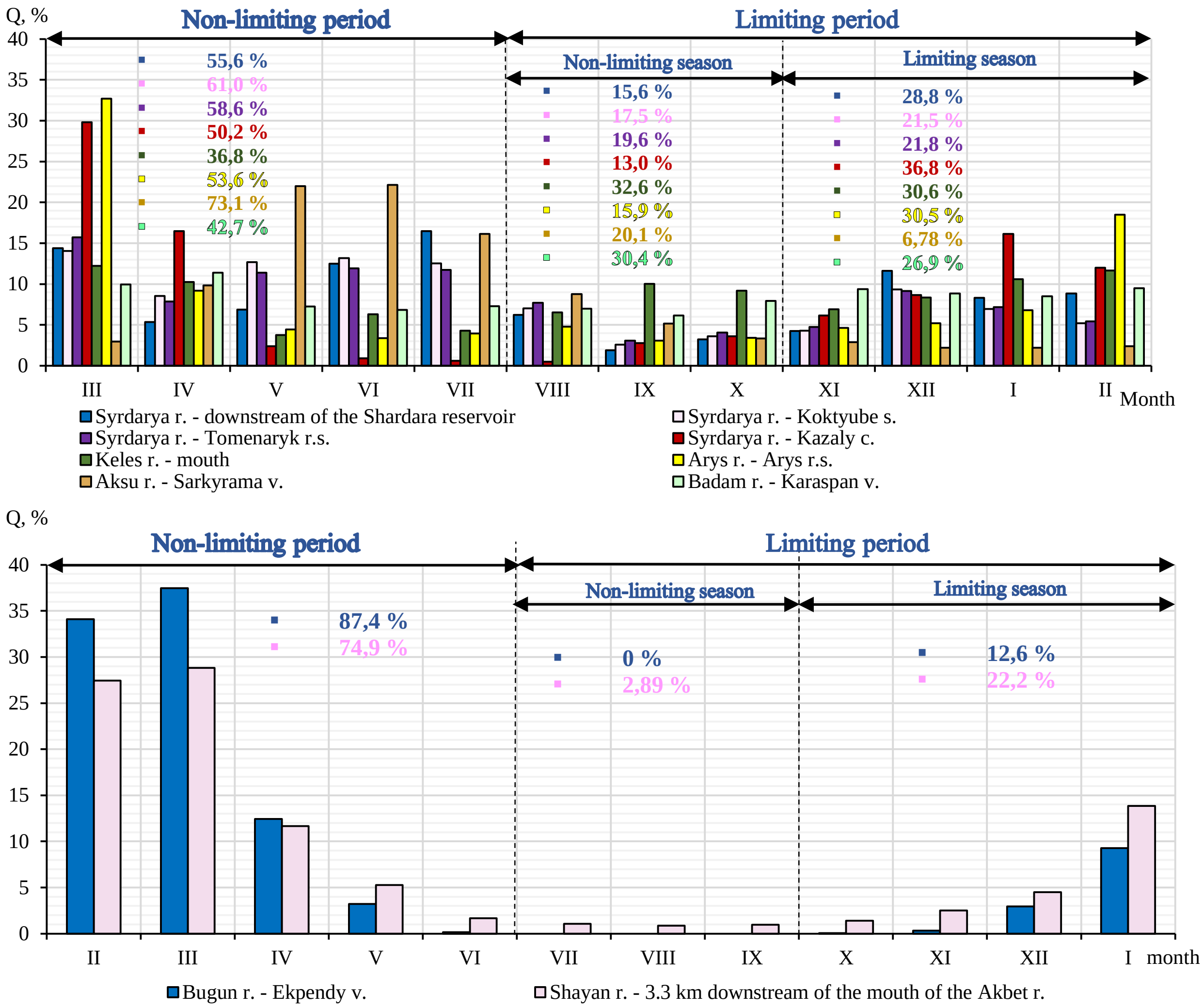


Figure 71 – Intra-annual distribution of runoff of the main HP of the Aral-Syrdarya WMB for 2023-2024.

Syrdarya r. – Koktyube v. The section shows a relatively even runoff distribution with maximum flows in May-July (about 55-60 % of the annual volume). However, compared to long-term data, the spring peak is less pronounced, and the low-flow period is extended, indicating reduced water availability and stabilized channel flows due to regulation. **2023** is characterized as a low-water year, with limited spring runoff and a deficit in summer flows.

Syrdarya r. –Tomenaryk r.s. The intra-annual distribution shows a moderate spring-summer peak and a shortened low-flow period, but the amplitude of fluctuations is smaller than in the upper reaches. This reflects anthropogenic transformation of the hydrograph due to reservoir regulation and water withdrawal for irrigation. The year **2023** is a low-water year, with spring flows reduced by 20-25 % relative to the norm.

- **Syrdarya r. – Kazaly c.** In the lower reaches of the r. Syrdarya in the Kazaly area, the runoff in 2023 also corresponds to a low-water year. The spring peak is extended, but its volume is reduced, and the autumn-winter flows remain minimal. The hydrograph reflects runoff weakened by multiple water withdrawals along the course and significant filtration losses in the channel. The main volume (about 65 % of the annual runoff) was formed in April-August, corresponding to the flood phase.
- **Keles r. – mouth.** The runoff distribution shows a pronounced spring-summer peak (April-July), forming up to 70 % of the annual volume. In 2023, the flood was low due to weak snow reserves in the foothills and low precipitation in March-April. The low-flow period is sharply expressed, confirming the dominance of snow feeding and the weak role of groundwater inflows.
- **Arys r. –Arys r.s.** According to the 2023 hydrograph, the spring-summer peak is clearly expressed and accounts for about 60 % of the annual runoff. However, the total volume is below the long-term average, indicating a low-water year. The river shows anthropogenic impact (water withdrawals for irrigation), which intensified the reduction of flows in the summer-autumn period.
- **Aksu r. – v. Sarkyrama**. This station is characterized by seasonal runoff asymmetry: the spring-summer period (April-July) accounted for about 75 % of the annual volume. At the same time, the total runoff was low, indicating a snow deficit in the upper reaches and low precipitation during accumulation. 2023 for r. Aksu is assessed as a low-water year, with a shortened duration of active flooding.
- **Badam r. – v. Karaspan**. The intra-annual distribution shows a pronounced spring peak and low flows at other times of the year, typical for small rivers with predominantly snow feeding. In 2023, the annual runoff was significantly below normal, about 70 % of average values, due to insufficient snow reserves in winter and weak rain floods.
- **Bugun r. – v. Ekpendy**. The runoff pattern retains seasonality with a peak in April-May, but the share of spring flood is reduced, indicating a low-water year. The annual runoff in 2023 was formed mainly by spring snowmelt (about 65 % of the annual volume), while summer-autumn floods were weak.
- **Shayan 1 r. – 3.3 km below the mouth of r. Akbet**. According to the 2023 intra-annual distribution, the year was low-water, with dominance of spring-summer runoff (about 70 %) and a sharp decrease in flows during the summer-autumn period. This reflects a stable continental regime with limited contribution from rain floods and snow as the main source of feeding.

The year **2023** was generally characterized as a low-water year at all main hydrological posts of the basin. For the vast majority of rivers, the following was observed: dominance of the spring-summer flood (April-June), forming 60 to 75 % of the annual runoff; a decrease in the share of autumn-winter flows, reflecting minimal groundwater contribution; anthropogenic transformation of the hydrograph on the rivers Syrdarya, Arys, Bugun, and Badam due to water management regulation; absence of significant rain floods and weak influence of summer precipitation; an overall trend of weakening spring maxima and elongation of the low-water phase.

Thus, the hydrological regime of the basin in **2023** was formed under conditions of moisture deficit and limited snow feeding, which resulted in sustained low water levels and reduced water resource potential compared to the long-term average.

4.4 Intra-annual runoff distribution of the Zhaiyk-Caspian WMB

Zhaiyk-Caspian WMB. By the nature of its feed, rivers in the Zhaiyk-Caspian region belong to the group of rivers with a spring high-water period. During the spring period, within one to two months, 80-90% of the annual runoff occurs, while during the rest of the year some small rivers may have no runoff at all. That is, over the course of a year, the runoff regime of most rivers is characterized by a high spring flood and a low summer base flow, with rare rain-induced floods. The highest annual discharges are observed in the second half of April and only occasionally in early May.

For calculating the intra-annual runoff distribution of rivers in the studied area, the compositing method of V.G. Andreyanov [2], was used, which allows the calculation of a calendar-based intra-annual runoff distribution based on the results of statistical processing of observational data.

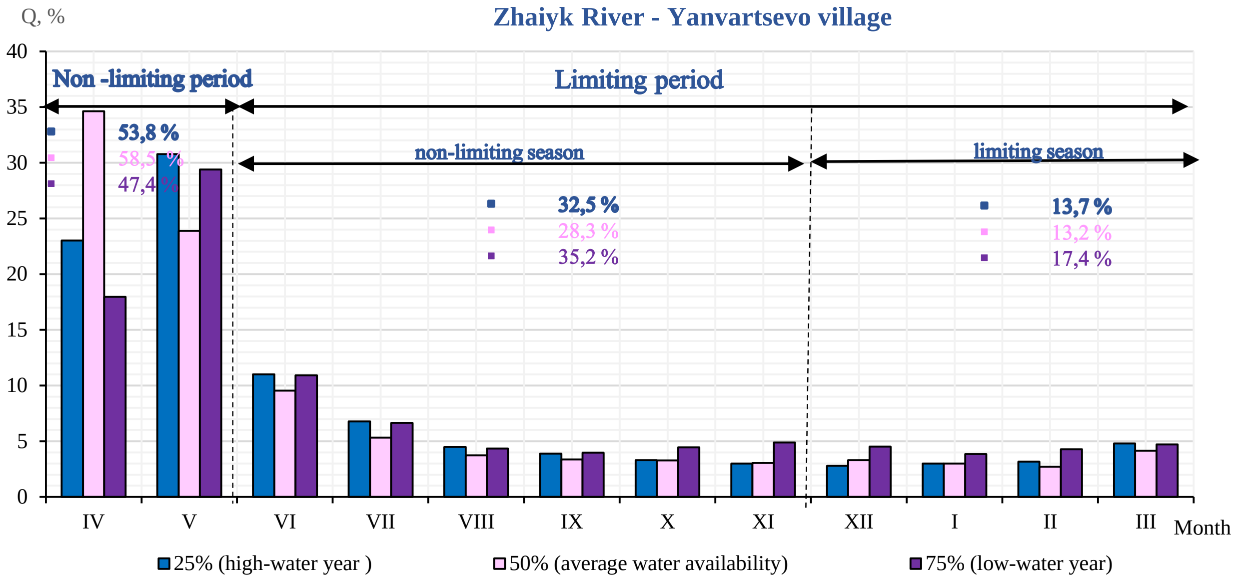
The results of the intra-annual runoff distribution calculation showed that during the **«disturbed»** runoff period, no significant changes occurred. When developing the calculation scheme for river runoff distribution, the following limiting periods and seasons were adopted: the non-limiting period for the Zhaiyk River hydrological stations – Yanvartsevo settlement, Kushum v., Makhamet settlement, and Ilek River – Aktobe city, was from April to May (IV-V); the limiting period was from June to March (VI-III), including the non-limiting season from June to November (VI-XI) and the limiting season from December to March (XII-III), as illustrated in more detail in Figure 72.

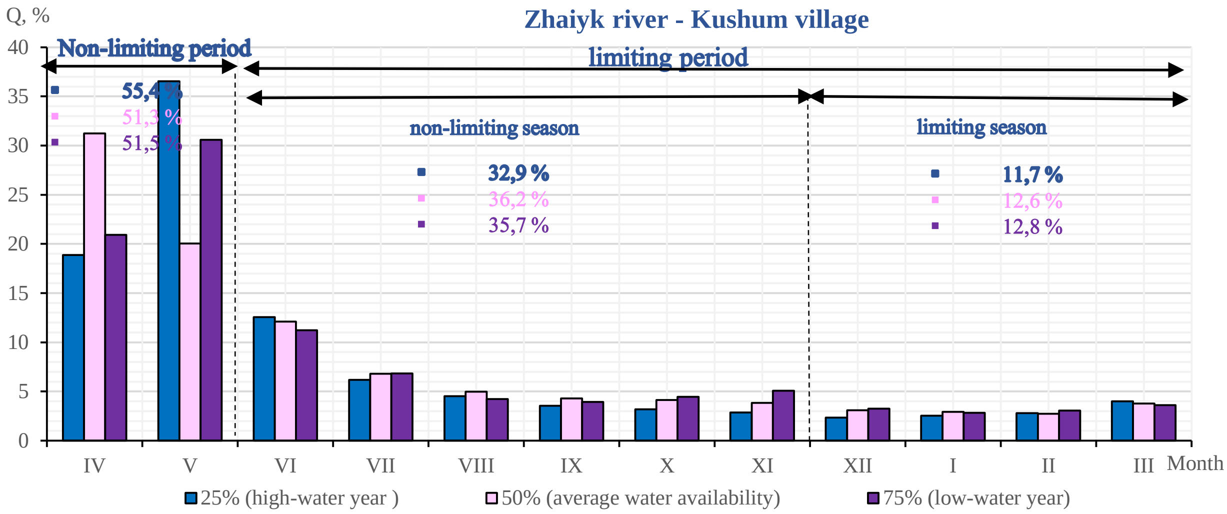
For the Uil River, the season boundaries are defined slightly differently: spring (March-May), summer-autumn (June-November), and winter (December-February), as clearly shown in Figure 73.

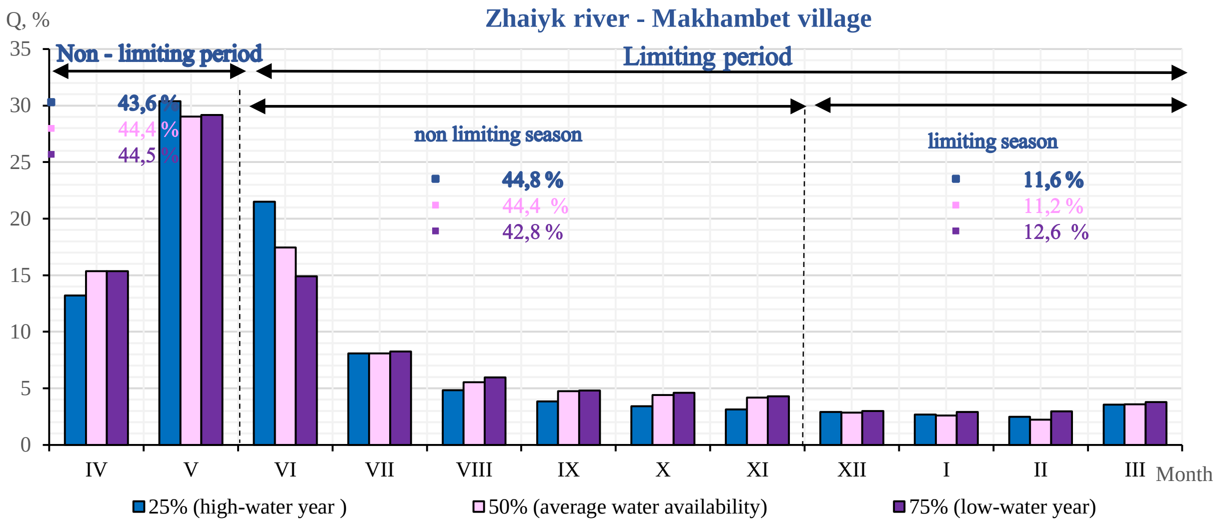
Since the river runoff in the studied area is primarily used for irrigation and water supply, the last two seasons are combined into a single limiting period, while the winter season, being the lowest-water season, is considered the limiting season. The spring runoff is taken as the non-limiting period.

To determine the annual runoff for a given reliability, curves of runoff reliability were constructed for the specified periods and seasons (Fig.4, Appendix B), and their main statistical characteristics over the long-term period were also determined (Table 4, Appendix B).

The analysis of the runoff reliability curves at the main hydrological stations of the Zhaiyk-Caspianwater management basin revealed differences in interannual runoff variability between the large Zhaiyk River and its tributaries, the Ilek and Uil rivers. The Zhaiyk River itself maintains relatively stable runoff, but there is a high amplitude between high-water and low-water years. In spring, average discharges account for more than 50 % of the annual runoff, while in winter they are less than 10 %. The **Ilek River** is characterized by high runoff variability (Cv up to 0.8); during low-water periods, discharges decrease by more than 2-3 times compared to spring. The **Uil River**, a small river, shows a sharp predominance of spring runoff (up to 70-80 % of the annual volume), while in winter there is practically no water (Fig.4, Appendix B).


Zhaiyk River - Yanvartsevo village
Q, %
Non -limiting period
Limiting period
non-limiting season
limiting season
53,8 %
58,5 %
47,4 %
32,5 %
28,3 %
35,2 %
13,7 %
13,2 %
17,4 %
IV V VI VII VIII IX X XI XII I II III
Month
25% (high-water year)
50% (average water availability)
75% (low-water year)


Zhaiyk river - Kushum village
Q, %
Non-limiting period
limiting period
non-limiting season
limiting season
55,4 %
51,3 %
51,5 %
32,9 %
36,2 %
35,7 %
11,7 %
12,6 %
12,8 %
IV V VI VII VIII IX X XI XII I II III
Month
25% (high-water year)
50% (average water availability)
75% (low-water year)


Zhaiyk river - Makhambet village
Q, %
Non - limiting period
Limiting period
non limiting season
limiting season
43,6 %
44,4 %
44,5 %
44,8 %
44,4 %
42,8 %
11,6 %
11,2 %
12,6 %
IV V VI VII VIII IX X XI XII I II III
Month
25% (high-water year)
50% (average water availability)
75% (low-water year)

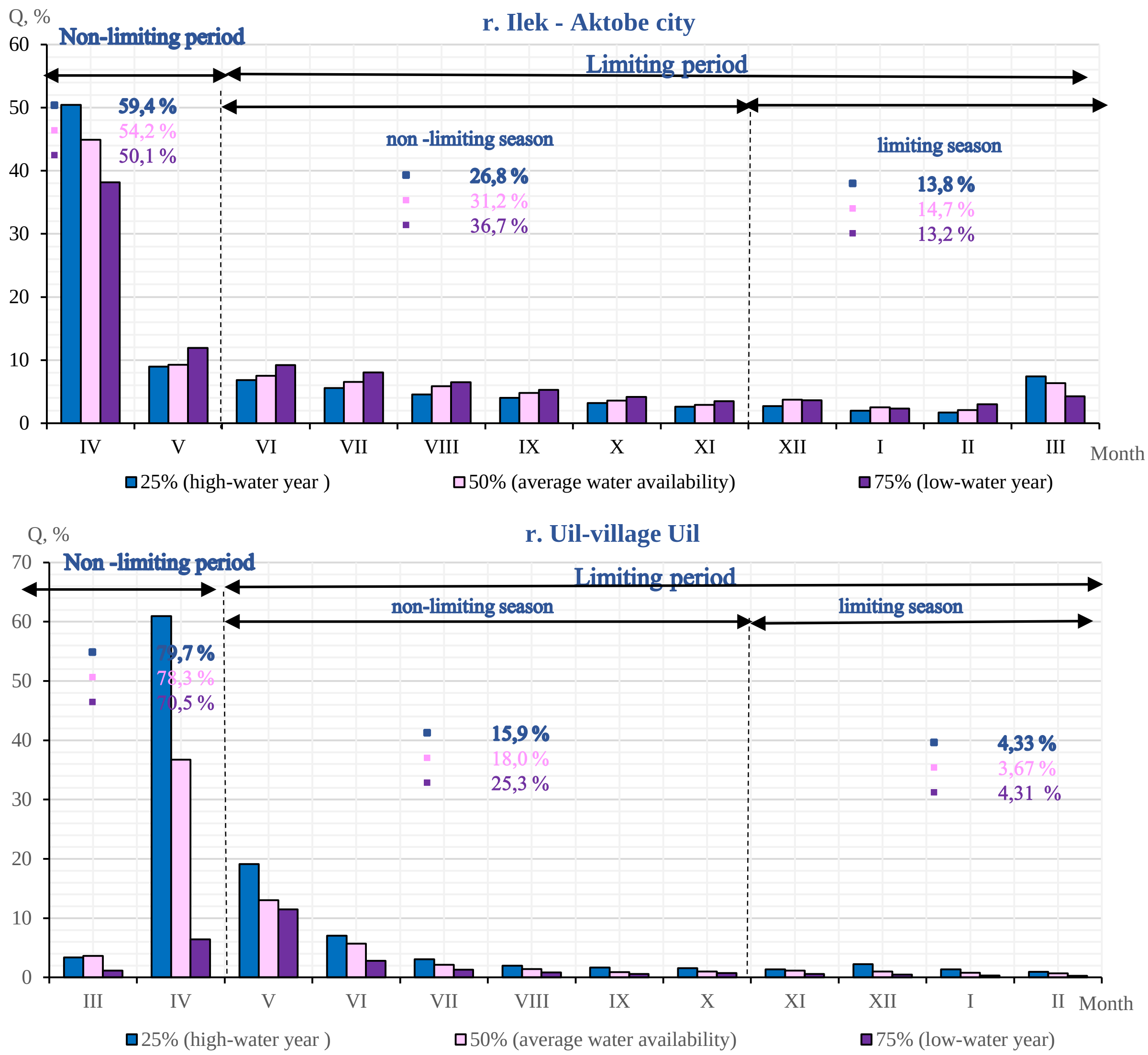
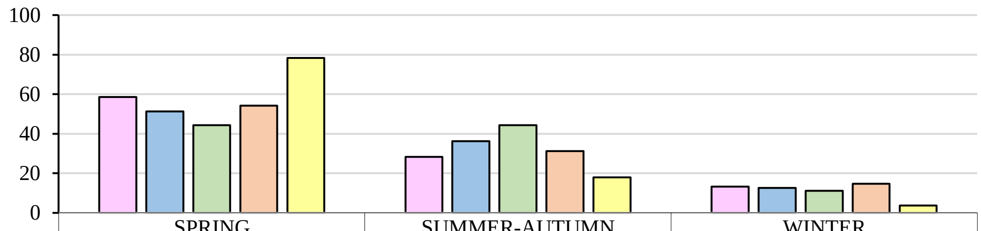


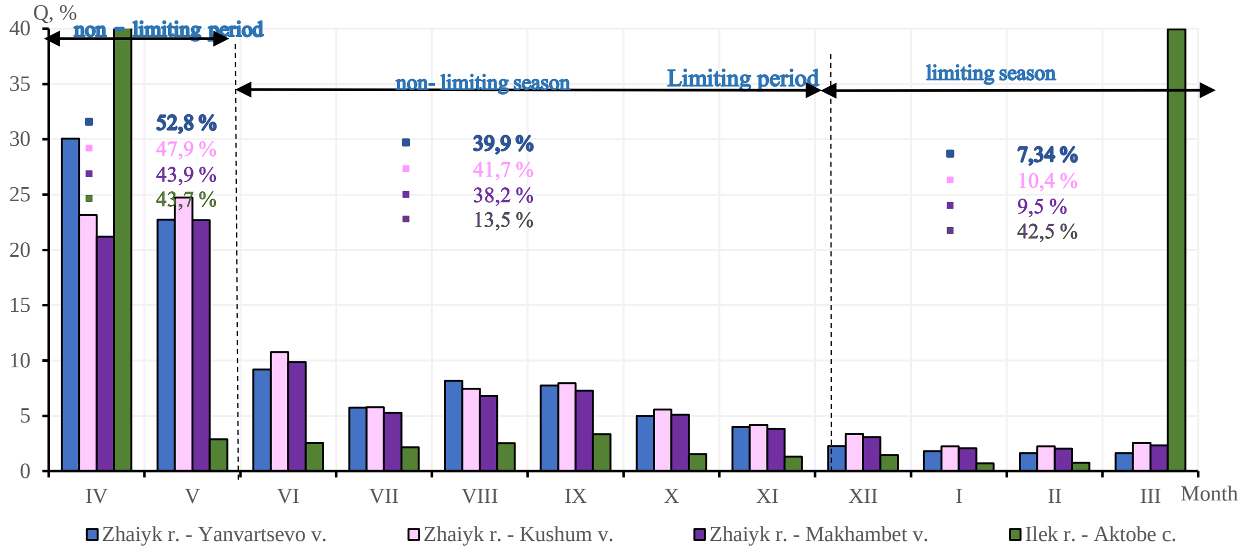
Figure 72 – Intra-annual runoff distribution of the main rivers

Table 28 - Intra-annual runoff distribution of the main rivers for the period of average water availability (50% reliability) in percentage (%)



	SPRING	SUMMER-AUTUMN	WINTER
Zhaiyk r. - Yanvartsevo v.	58,5	28,3	13,2
ZhaIyk r. - Kushum v.	51,3	36,2	12,6
Zhaiyk r. - Makhambet v.	44,4	44,4	11,2
r. Ilek - Aktobe city	54,2	31,2	14,7
Uil r. - Uil v.	78,3	18,0	3,67

The analysis of Table 28 showed that along the Zhaiyk River, at 50 % reliability, **45-59% of the annual runoff** is formed in spring, about **30-40 %** in summer-autumn, and 11-13 % in winter. A similar situation is observed for the Ilek River, while for the Uil River, spring accounts for 78 % of the runoff, with the remaining seasons contributing only 4-18 %.



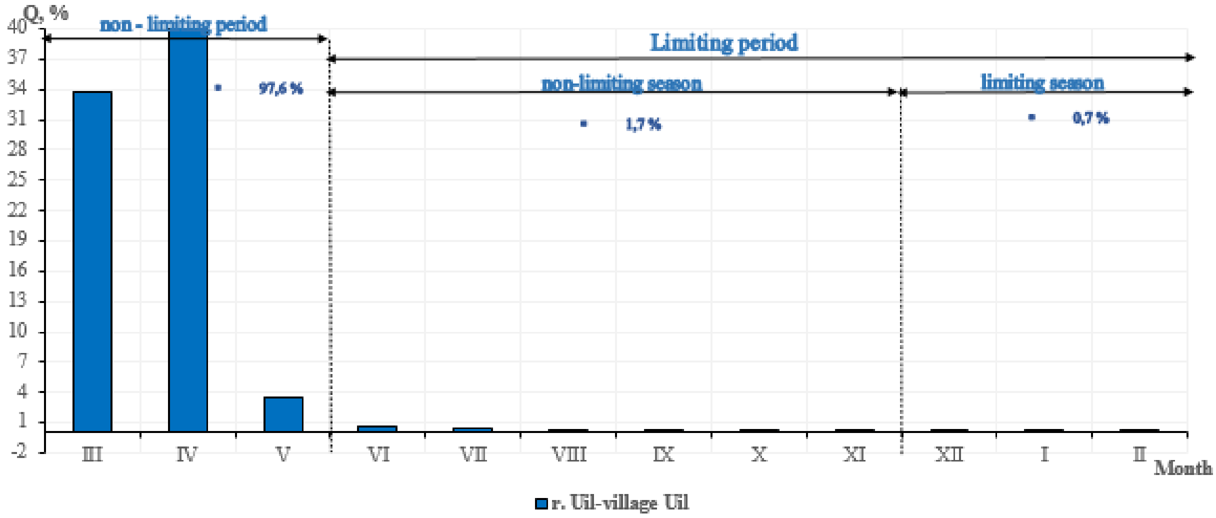


Figure 73 – Intra-annual runoff distribution of the main hydrological posts of the Zhaiyk-CaspianWMB for 2023-2024

The analysis of the intra-annual runoff distribution of the main rivers of the Zhaiyk-Caspian WMB **in 2023** (Table 4, Appendix B), which are involved in assessing the water resources of the studied basin, showed that the non-limiting period for the Zhaiyk River along its entire length and for the Ilek River (Fig.73) falls in April-May (flood period). During this period, the main portion of the annual runoff is formed, which is associated with spring snowmelt. Water volumes were significantly above the long-term average, ensuring water supply for both economic and ecological needs.

The limiting period is June-March. In June, runoff begins to decline after the flood, marking the transition to low-flow conditions, while in March, water deficit is recorded before the spring flood. Non-limiting season: June-November. During the summer-autumn period, water supply remains relatively stable due to rain floods and groundwater recharge.

Limiting season: December-March. In the winter-spring period, before the onset of snowmelt, runoff is minimal, creating a risk of water shortage for domestic, industrial, and ecological needs.

Conclusion for the Zhaiyk River: the intra-annual runoff distribution is characterized by a classic flood in April-May and stable low flow during summer. The winter-spring months

(December-March) remain limiting, as runoff is minimal. For the Ilek River, water availability strongly depends on spring snowmelt and seasonal rains. The critical periods for water use are the winter months and early spring.

For the Uil River, the non-limiting period is March-May. It is characterized by high runoff due to the spring flood and rapid snowmelt. The limiting period is June-February, as shown inFigure73, with detailed information provided in Table 4, Appendix B. During this period, the river experiences a prolonged low-flow regime, especially in the summer-autumn months. Unlike the Zhaiyk and Ilek rivers, the Uil has a shorter period of high flows, and water shortage persists for most of the year.

Conclusion for the Uil River: its runoff is extremely uneven, with a short spring flood and a prolonged low-flow period. This limits sustainable water use and requires special consideration in water management and planning of economic activities.

4.5 Intra-annual distribution of runoff in the Esil River WMB

Esil River WMB. The main factors of economic activity influencing the intra-annual distribution of river runoff in this basin are channel regulation – including multi-year and seasonal reservoirs (Vyacheslavskoye (Astana), Sergeyevskoye, Petropavlovskoye), numerous ponds, various water intakes, wastewater discharges, and cultivated catchment areas. Among these, reservoirs have the dominant impact on runoff.

In the Esil River basin, from the mid-1960s to the present, 45 reservoirs have been constructed, with a total volume of 1,583.52 million m³ and a useful capacity of 1,446.36 million m³.

In the upper reaches of the Esil River, the Esil Reservoir for seasonal flow regulation has been constructed, with a total volume of 9.2 million m³ and a useful capacity of 8.2 million m³. The main regulator of the Upper Esil's flow is the Astana Reservoir for multi-year regulation, with a total volume of 411 million m³ and a useful capacity of 375 million m³. The main regulators of the Lower Esil are the Sergeyevskoye Reservoir, with a total volume of 693 million m³ and a useful capacity of 635 million m³. With the commissioning of these reservoirs, the intra-annual distribution of runoff in the Esil River at the Astana gauge and at the downstream gauge in Petropavlovsk has changed significantly. The changes in intra-annual runoff distribution vary across different river sections.

When developing the calculation scheme for river runoff distribution, the following limiting periods and seasons were adopted: the non-limiting period for the Esil River hydrological posts - Kamennyy Karyer, Dolmatovo, Turgen, and Petropavl, as well as for the Kalkutan River - Kalkutan and the Zhabai River - Atbasar, covering April to May (IV-V); the limiting period - June to March (VI-III), including the non-limiting season - June to October (VI-X) and the limiting season - November to March (XI-III), as shown in more detail in figure 74.

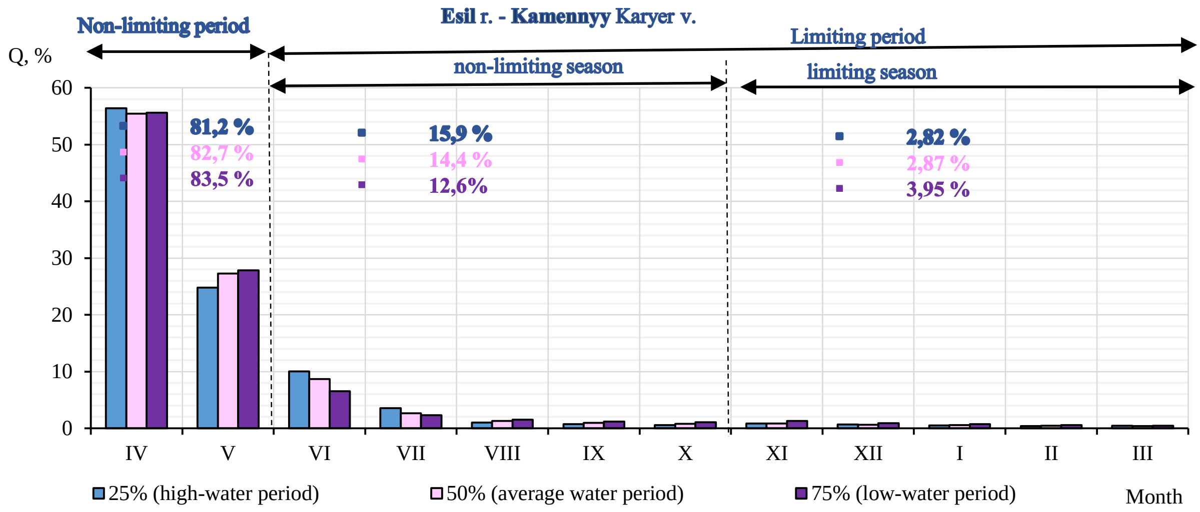
Since the river runoff in the studied area is primarily used for irrigation and water supply, the last two seasons are combined into a single limiting period, with the winter season, being the most low-water period, designated as the limiting season. The spring runoff is taken as the non-limiting period.

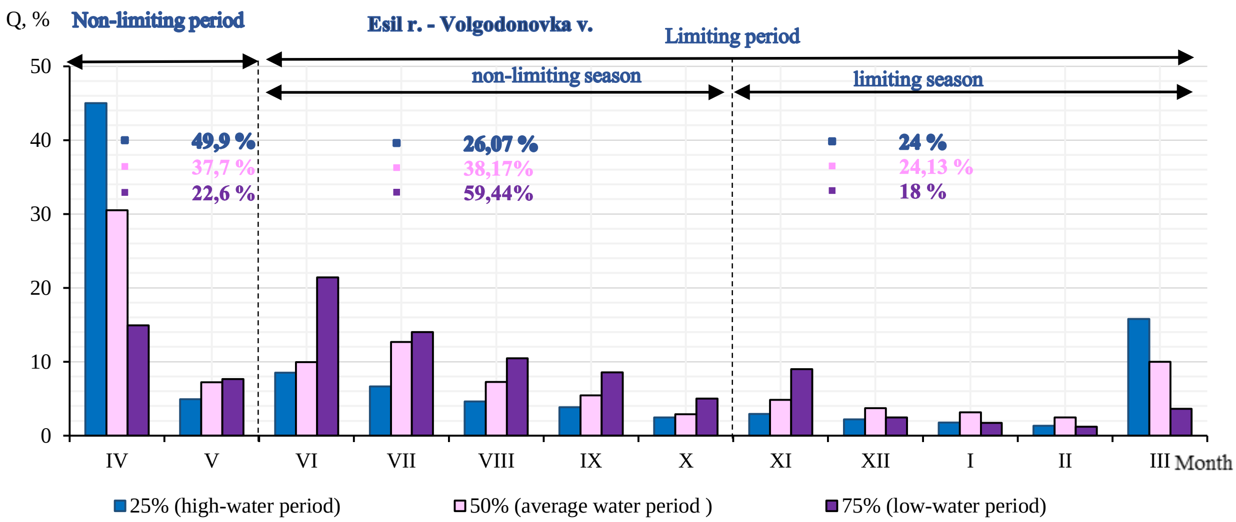
To determine the annual runoff with a given probability of exceedance, reliability curves were constructed for the specified periods and seasons (Figure 5, Appendix B), and their main statistical characteristics for the multi-year period were also determined (Table 5, Appendix B).

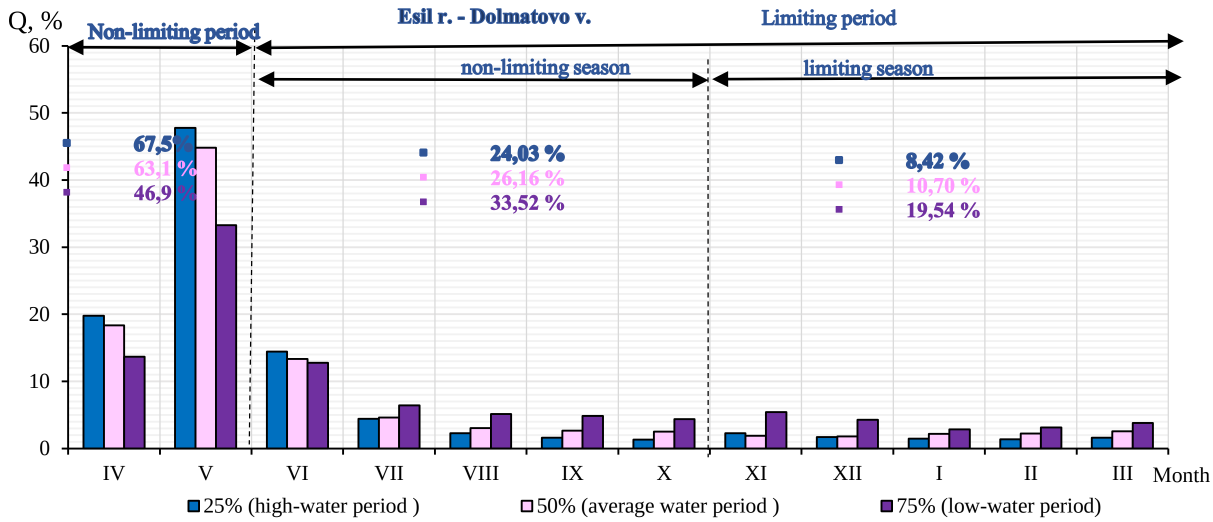
The analysis of the reliability curves of observed runoff at the hydrological posts of the Esil River basin revealed several features of the rivers' hydrological characteristics. The basin includes large rivers, such as the Esil, and its tributaries (Kalkutan, Zhabai), which generate runoff under varying hydroclimatic conditions. The reliability curve of the Esil River's discharge is characterized by a sharp decline from rare high flows to more frequently occurring values, indicating the presence of intense flood events, predominantly of spring origin, caused by snowmelt in the river basin. There is a significant reduction in flow during low-water periods. Minimum values occur at 90-99% exceedance probability, typical for dry or winter periods. The shape of the curve reflects a pronounced spring runoff, which is typical for rivers in the northern and central regions of Kazakhstan with a continental climate.

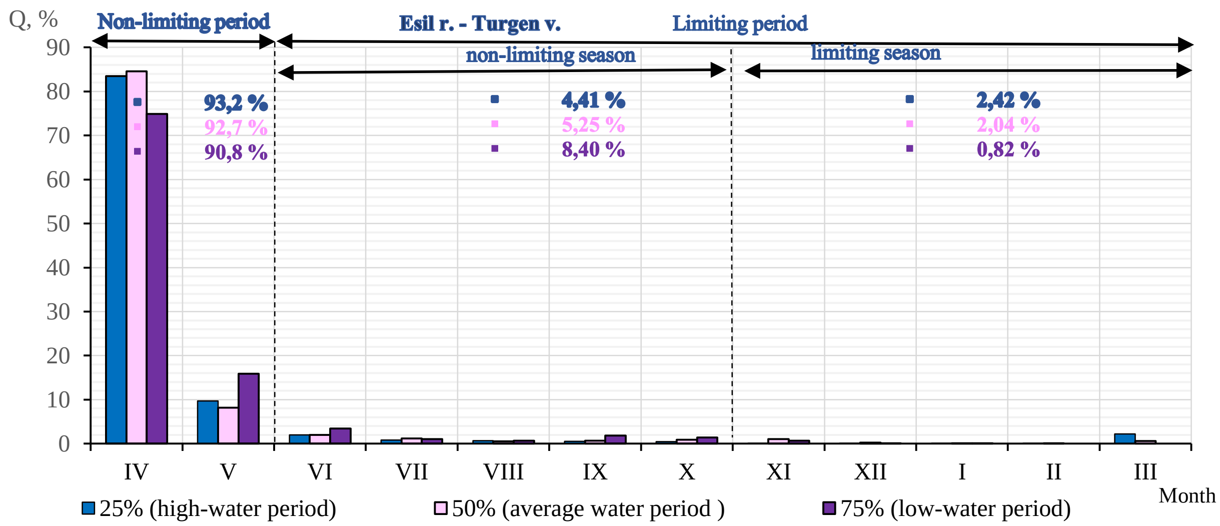
The reliability curves of the Zhabai and Kalkutan rivers also demonstrate pronounced seasonality in runoff; however, the intensity of floods is significantly lower. At exceedance probabilities above 50%, discharges decrease. Unlike the Esil, the amplitude of discharge variations is less pronounced, and the curve has a gentler slope, indicating lower variability in runoff throughout the year.

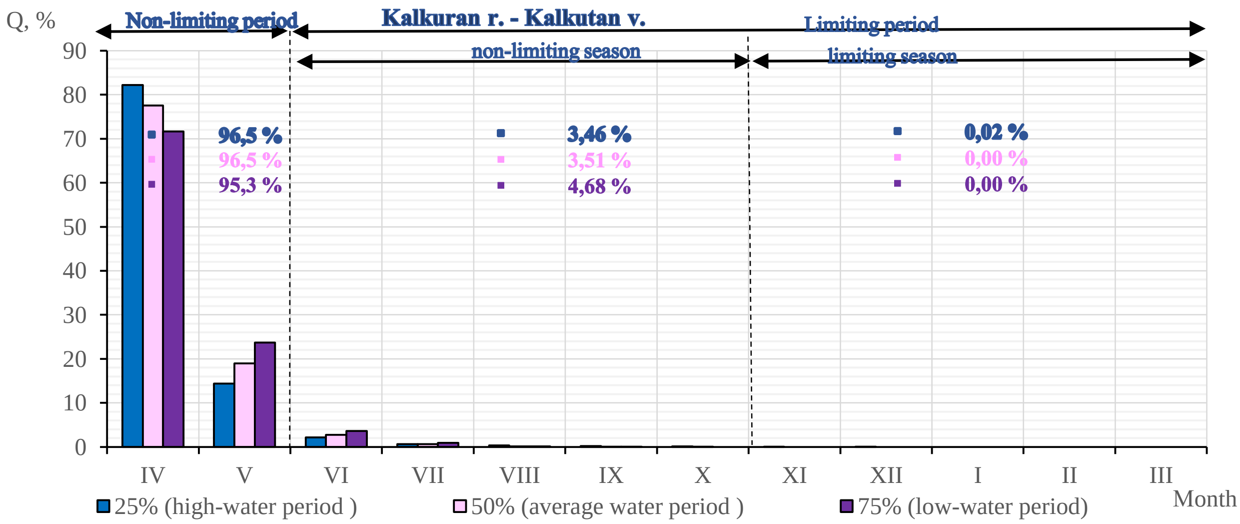
Overall, the Esil River basin is characterized by high seasonal contrast: the spring flood accounts for the majority of annual runoff, whereas in the autumn-winter period, discharge volumes decrease sharply. This is typical for rivers that are predominantly snow-fed.






Esil r. - Dolmatovo v.
Q, %
Non-limiting period
Limiting period
non-limiting season
limiting season
67,5 %
63,1 %
46,9 %
24,03 %
26,16 %
33,52 %
8,42 %
10,70 %
19,54 %
IV V VI VII VIII IX X XI XII I II III
Month
25% (high-water period)
50% (average water period)
75% (low-water period)


Esil r. - Turgen v.
Q, %
Non-limiting period
Limiting period
non-limiting season
limiting season
93,2 %
92,7 %
90,8 %
4,41 %
5,25 %
8,40 %
2,42 %
2,04 %
0,82 %
IV V VI VII VIII IX X XI XII I II III
Month
25% (high-water period)
50% (average water period)
75% (low-water period)


Kalkuran r. - Kalkutan v.
Q, %
Non-limiting period
Limiting period
non-limiting season
limiting season
96,5 %
96,5 %
95,3 %
3,46 %
3,51 %
4,68 %
0,02 %
0,00 %
0,00 %
IV V VI VII VIII IX X XI XII I II III
Month
25% (high-water period)
50% (average water period)
75% (low-water period)

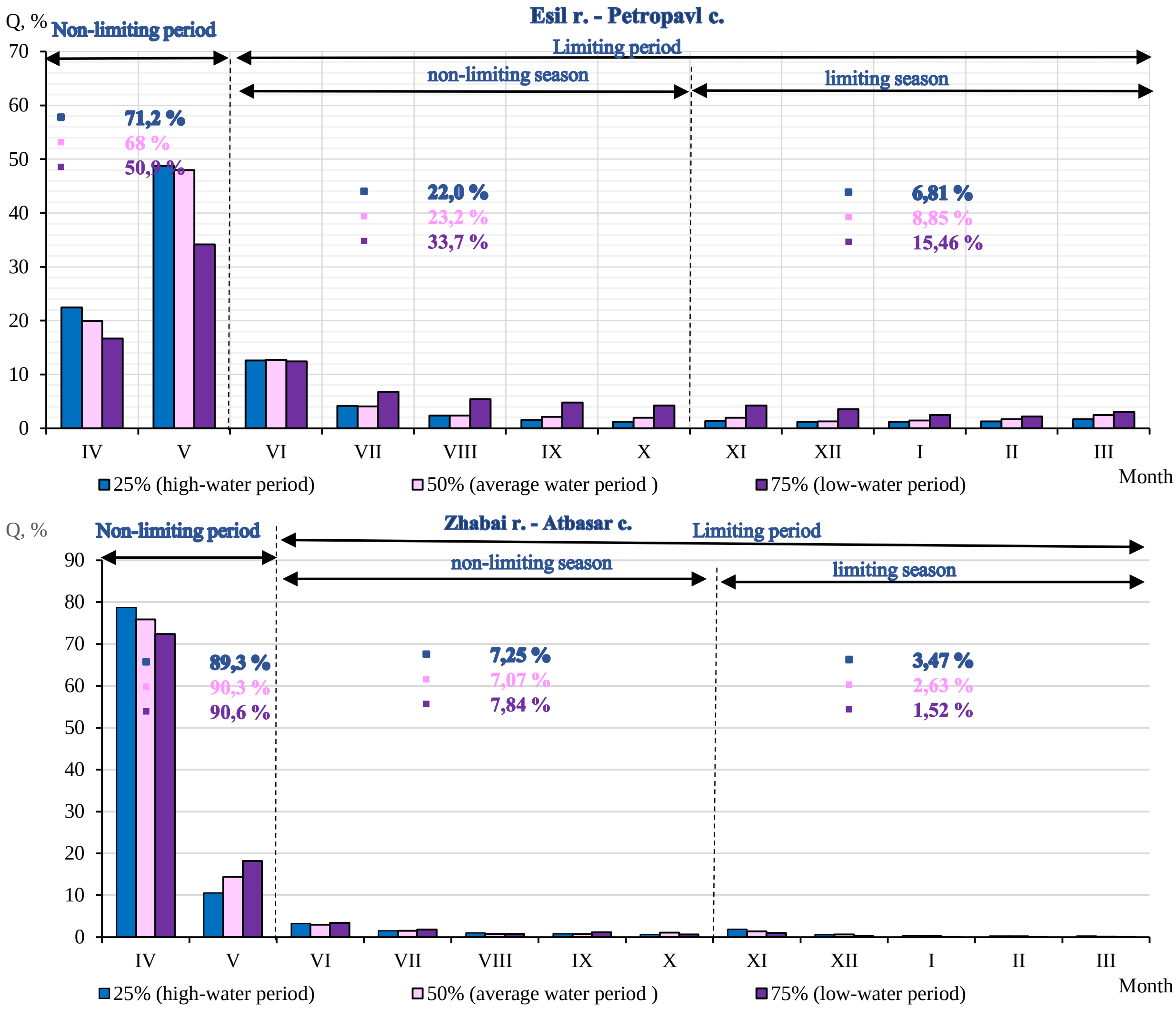
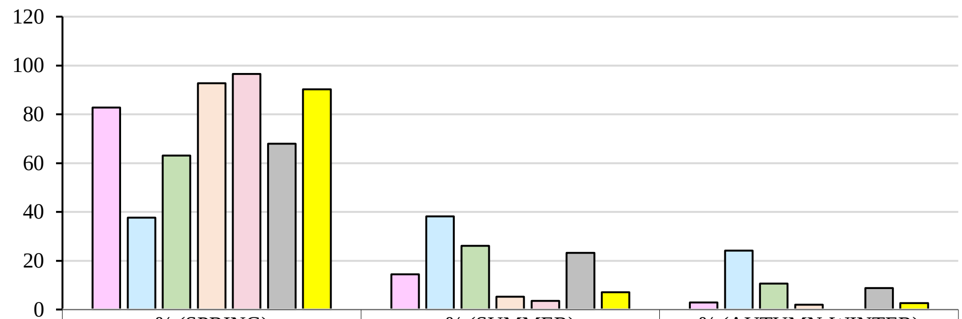


Figure 74 – Intra-annual runoff distribution of the main rivers over the long-term period in the Esil River WMB

Table 29 - Intra-annual runoff distribution of the main rivers for the period of average water availability (50 % exceedance probability) in percent (%)



	% (SPRING)	% (SUMMER)	% (AUTUMN-WINTER)
Esil r. - Kamennyy Karyer v.	82,74	14,40	2,87
Esil r. - Volgodonovka v.	37,70	38,17	24,13
Esil r. - Dolmatovo v.	63,14	26,16	10,70
Esil r. - Turgen v.	92,71	5,25	2,04
Kalkutan r. - Kalkutan v.	96,49	3,51	0,00
Esil r. - Petropavl c.	67,97	23,18	8,85
Zhabai r.- Atbasar c.	90,3	7,07	2,63

According to the graph and table, the annual runoff distribution in the Esil River basin exhibits a pronounced seasonal pattern. The main portion of runoff occurs in spring, while river flows decrease significantly during the summer-autumn and winter periods.

Spring period (April-May): The largest share of annual runoff occurs in spring. At certain measurement points, it exceeds 90 %: Esil River - Turgen v. - **92.71 %,** Zhabai River - Atbasar city - **90.30 %,** Kalkutan River - Kalkutan v. - **96.49 %.** This is due to active snowmelt and inflow of meltwater, which defines the flood regime of the rivers.

Summer-autumn period (June-October): During this period, runoff decreases sharply. At some stations, values do not exceed 20 %. Exceptions include: Esil River - Volgodonovka v. - **38.17 %,** Esil River - Petropavlovsk city - **23.18 %,** Esil River - Dolmatovo v. - 26.16 %. This may be due to recharge from rainfall or regulated flows (presence of reservoirs).

Winter period (November-March): During the winter months, runoff is minimal and, in some cases, nearly absent: Kalkutan River - Kalkutan v. - **0.00 %,** Esil River - Turgen v. - **2.04 %,** Zhabai River - Atbasar city - **2.63 %.**

The Esil River basin is characterized by a pronounced spring flood, during which 60 to 96% of the annual runoff is formed. In the summer-autumn and winter periods, river flows decrease sharply. This distribution must be taken into account when planning water use, regulating runoff, and for water management balance purposes.

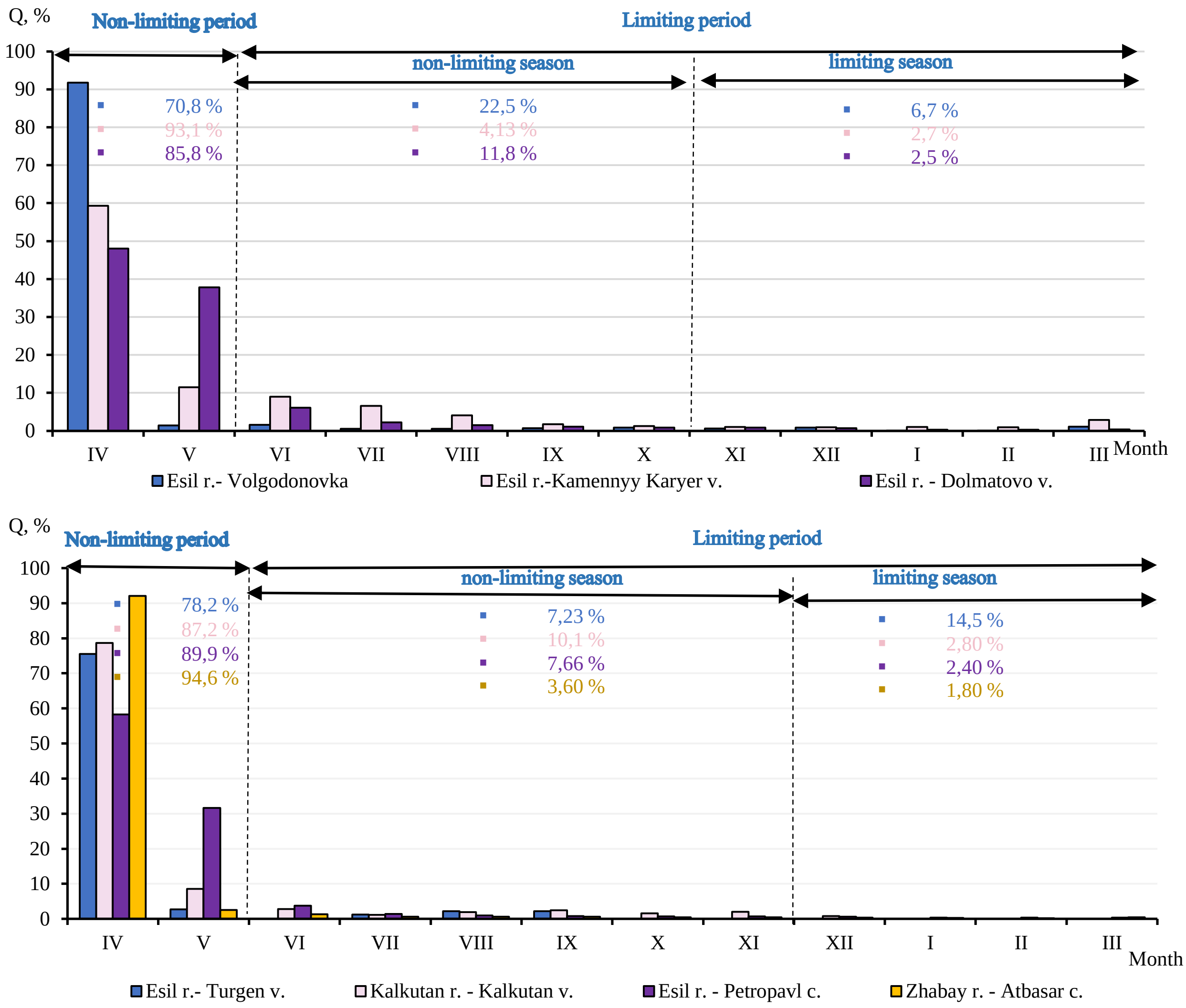


Figure 75 – Intra-annual distribution of runoff of the main rivers in the Esil WMB for 2023-2024

Analysis of the intra-annual distribution of runoff of the main rivers in the Esil Water management basin **in 2023** (Table 5, Appendix B), which are involved in assessing the water resources of the studied basin, showed a pronounced seasonal concentration of runoff. The main volume of annual runoff is formed in April due to the spring flood caused by snowmelt. At the gauging stations near the settlements of Turgen and Kalkutan, the proportion of April runoff corresponds to a significant share of the annual volume. A similar pattern is observed at the hydrological posts in Kamenny Karyer, Dolmatovo, and Petropavlovsk.

During the summer (June-August) and autumn (September-November) periods, runoff volume sharply decreases; these seasons are classified as limiting. In the winter period (December-February), runoff is minimal. This structure of annual runoff indicates the dominance of snowmelt as the main source of river flow in the basin and points to a significant depletion of water resources during the summer-autumn and winter periods. The high seasonal concentration of runoff creates potential risks and constraints for water use, particularly in agriculture and water supply.

Thus, the analysis of the spatiotemporal patterns of runoff formation in the rivers of the Esil Water management basin shows that there have been significant changes in the intra-annual distribution of river runoff in recent decades (the modern period).

4.6 Intra-annual runoff distribution of the Shu-Talas WMB

Shu-Talas WMB. The intra-annual distribution of runoff, particularly during the flood period for the Shu and Talas river basins, is determined by the processes of snow and ice accumulation and melting in the mountains, as well as associated infiltration into the soil and moisture loss due to evaporation and transpiration.

When developing the calculation scheme for the distribution of river runoff, the following limiting periods and seasons were adopted: the non-limiting period for the Shu River - Kaynar v., the Talas River - Solnechny settlement, and the Kuragaty River - Aspara station, from April to June (IV-VI); the limiting period - July to March (VII-III), including the non-limiting season - July to September (VII-IX) and the limiting season - November to March (XI-III), as shown in more detail inFigure76.

For the Teris River - Nurlykent v., the seasonal boundaries are defined slightly differently: spring (February-June), summer-autumn (July-September), and winter (November-January), as shown inFigure77.

Since the runoff of rivers in the studied area is mainly used for irrigation and water supply, the last two seasons are combined into a single limiting period, while the winter season, being the driest, is considered the limiting season. The spring runoff is taken as the non-limiting period.

To determine the annual runoff of a given reliability, reliability curves were constructed for the specified periods and seasons (Figure 6, Appendix B), and their main statistical characteristics over a long-term period were also determined (Table 6, Appendix B).

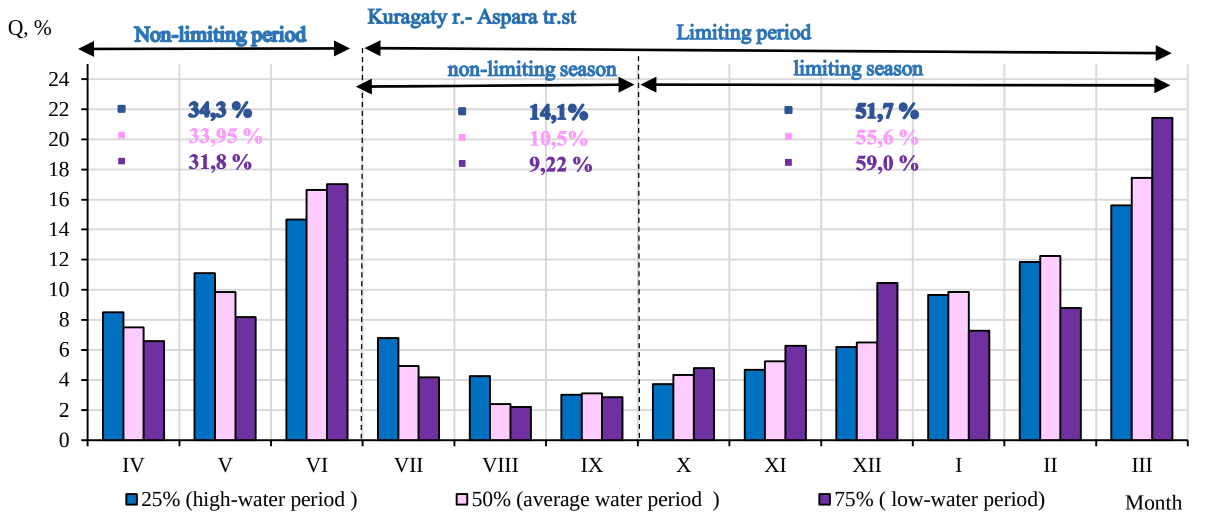
Runoff reliability curves reflect the probabilistic distribution of water volumes (Q, m^3/s) by seasons and for the entire year. The analysis was carried out for four key hydrological stations:

- **Kurgagaty River - Aspara r.s:** The total runoff shows a moderately stable distribution. Spring and summer periods have higher water flows, associated with snowmelt and active glacier feeding. Autumn and winter are characterized by minimal runoff values, which is typical for the region.
- **Talas River - Solnechny v:** The runoff demonstrates pronounced seasonal variability. The river exhibits a moderate flood regime. The calculated curves deviate from observed values

in the high-reliability zone, which may indicate the influence of reservoirs, water intakes, or dry years. The runoff is primarily formed by snowmelt and seasonal precipitation.

- **Teris River - Nurlykent v.:** The overall runoff values are lower than at other hydrological stations, reflecting the characteristics of its catchment area. Annual and seasonal reliability curves show a gradual decrease with increasing reliability. The graph shows discrepancies between calculated and observed data during the autumn-winter period, which may be due to local meteorological conditions.
- **Shu River - Kaynar v.:** One of the **most water-rich sections**. The graph has a **steeply declining shape**, indicating strong year-to-year variability in runoff. Significant **differences are observed between seasonal curves**, especially in spring, which is explained by contributions from high-altitude tributaries and active snowmelt.

The reliability curves allow for assessing the probability of specific water flows, which is important for water management, irrigation planning, and flood prevention. The most stable runoff is observed on the Teris River, while the most variable is on the Shu River. All stations exhibit **clear seasonality**, with a peak in spring and a minimum in autumn-winter.



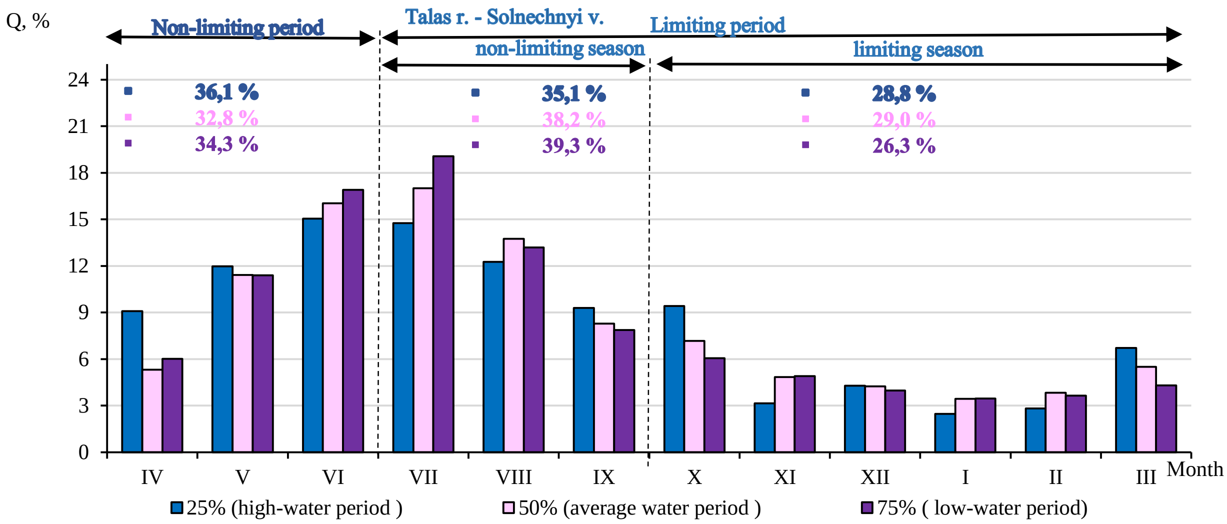
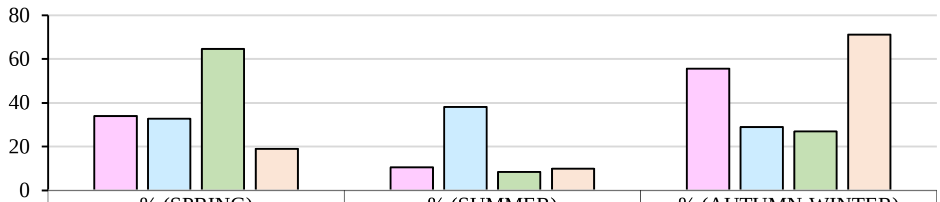


Figure 76 – Intra-annual runoff distribution of main rivers over a multi-year period for the Shu-Talas WMB

Table 30 - Intra-annual runoff distribution of main hydrological posts for the average water availability period (50 % probability of exceedance) in percent (%)



	% (SPRING)	% (SUMMER)	% (AUTUMN-WINTER)
Kuragaty r. -Aspara rw.st	33,95	10,45	55,60
Talas r. - Solnechnyi v.	32,77	38,23	29,00
Teris r. - Nurlykent v.	64,60	8,47	26,93
Shu r. - Kainar v.	18,96	9,94	71,10

According to the graphs and table, the annual runoff distribution in the Shu-Talas basin is as follows:

Kuragaty r.– r. s Aspara: Runoff is formed mainly in the autumn-winter period, indicating the significant role of groundwater feeding and stable baseflow during low-water periods. The spring flood is moderately expressed, and summer runoff is weak.

Talas r.– Solnechny v: Runoff is relatively evenly distributed, with a maximum in the summer period due to rain floods and partially glacier feeding. The spring flood is moderately expressed, and autumn-winter runoff is stable.

Teris r.- Nurlykent v: A pronounced spring maximum indicates snow-fed runoff. During the summer and autumn-winter periods, runoff sharply decreases, which is typical for rivers primarily fed by snow.

Shu r. - Kaynar v: The main volume of runoff occurs in the autumn-winter period, indicating a predominance of groundwater feeding. The spring flood is weak, confirming minimal snowmelt contribution.

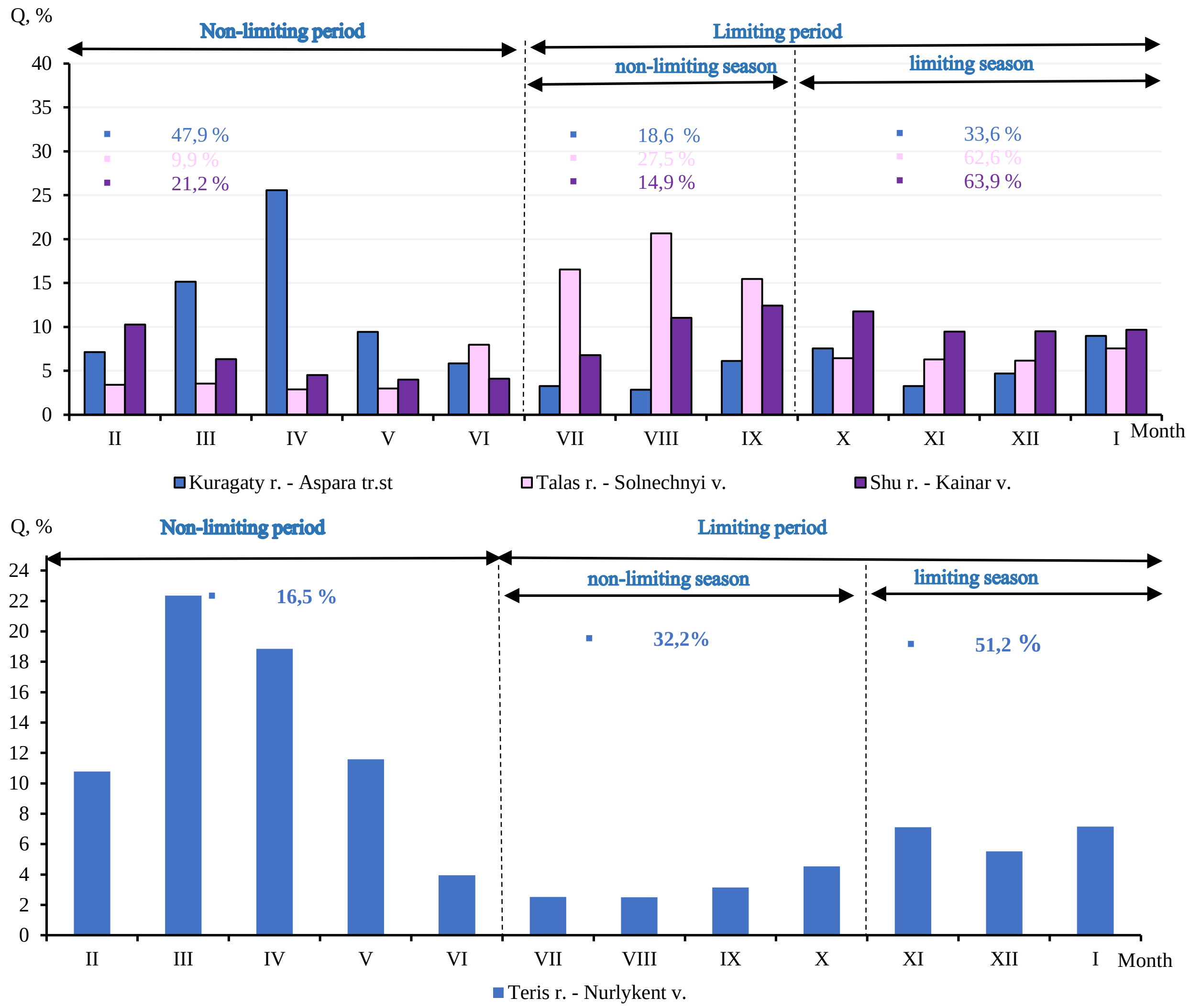


Figure 77 – Intra-annual runoff distribution of the main hydrological posts in the Shu-Talas WMB for 2023-2024

The analysis of the intra-annual runoff distribution of the main rivers in the Shu-Talas WMB in **2023** (Figure 77), which were involved in the assessment of the water resources of the studied basin, showed that:

- **Kuragaty r. – tr. st. Aspara:** The highest runoff in 2023 was observed in April, indicating a pronounced spring flood. During the limiting period (summer-winter), runoff sharply decreases and is distributed evenly, not exceeding 5% per month. This is typical for a river with predominantly snow-fed conditions.

- **Talas r. – Solnechny v:** The main volume of runoff occurs in summer, especially in July and August, indicating the influence of glacial-rainfall feeding. In August, despite the start of the limiting period, a significant contribution to runoff persists, after which it gradually decreases. During autumn and winter, runoff is substantially reduced.
- **Shu r. - Kainar v:** The runoff distribution differs from the typical pattern: the main volume occurs in the winter months - November and December. During the spring-summer period, values are significantly lower. This may be associated with anthropogenic factors, such as flow regulation (releases from reservoirs) and groundwater contributions.
- **Teris r. – Nurlykent v:** The non-limiting period (March-June) accounts for about half of the annual runoff, with a peak in March. However, more than half of the runoff occurs during the limiting period, which may indicate contributions from groundwater or other sources.

The analysis of runoff in the Shu-Talas water management basin in 2023 (Table 6, Appendix B) shows pronounced seasonality, typical of mountainous and foothill river systems in this region. The intra-annual runoff is characterized by the presence of limiting and non-limiting periods, indicating significant variations in water inflow throughout the year.

In 2023, the intra-annual runoff of the Shu-Talas basin was strongly influenced by seasonal changes in climate and hydrological conditions. The spring-summer period is critical for runoff formation due to snowmelt and glacial melt. The summer and autumn months are characterized by a significant decrease in water volume, which may impact water supply and regional ecosystems.

These data are important for the development of water management measures, forecasting water resources, and assessing the ecological condition of the basin in the context of climate change.

4.7 Intra-annual distribution of the Nura-Sarysu WMB

The rivers of the Nura-Sarysu basin are characterized by a sharply pronounced spring runoff and significant irregularity of the water regime throughout the year. The bulk of the annual runoff occurs during the spring flood period, which lasts from 1 to 3 months and is caused by snowmelt. During this period, 80 to 95% of the annual runoff volume passes. In summer and winter, the rivers of the basin, especially in its southern and central parts, are characterized by low water levels or complete drying of the riverbeds. Many small and medium-sized watercourses are intermittent, resuming flow only during heavy precipitation or snowmelt periods.

The Nura River, the largest in the basin, is characterized by a sharply uneven distribution of runoff: during the spring flood, water discharge is high, while in the low-water period it is minimal, sometimes even resulting in the cessation of surface flow in certain sections. Similar patterns are observed in the Sarysu basin, where rivers often dry up in summer and freeze over significant stretches of their channels in winter. This uneven intra-annual distribution of runoff significantly complicates the economic use of water resources. It is especially pronounced during the low-water period, when water bodies experience shortages, affecting water supply, irrigation, and the ecological condition of reservoirs.

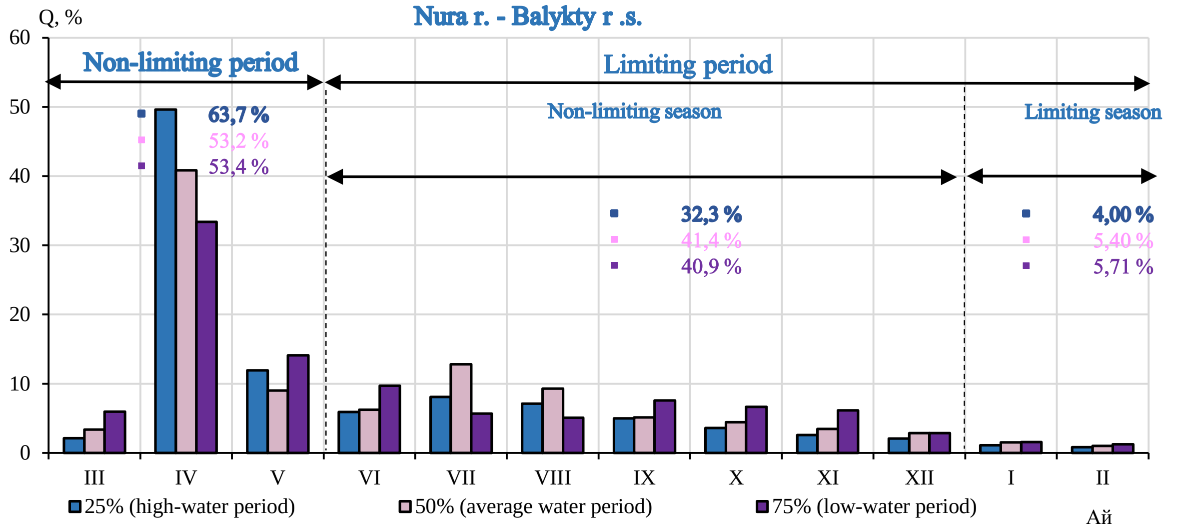
In the calculations of the intra-annual runoff distribution using the layout method, the boundaries of the water management year were taken as a basis, starting from the period of highest water availability. The duration of the high-water period was determined in such a way that it fully encompassed the spring flood in all the analyzed years of observation.

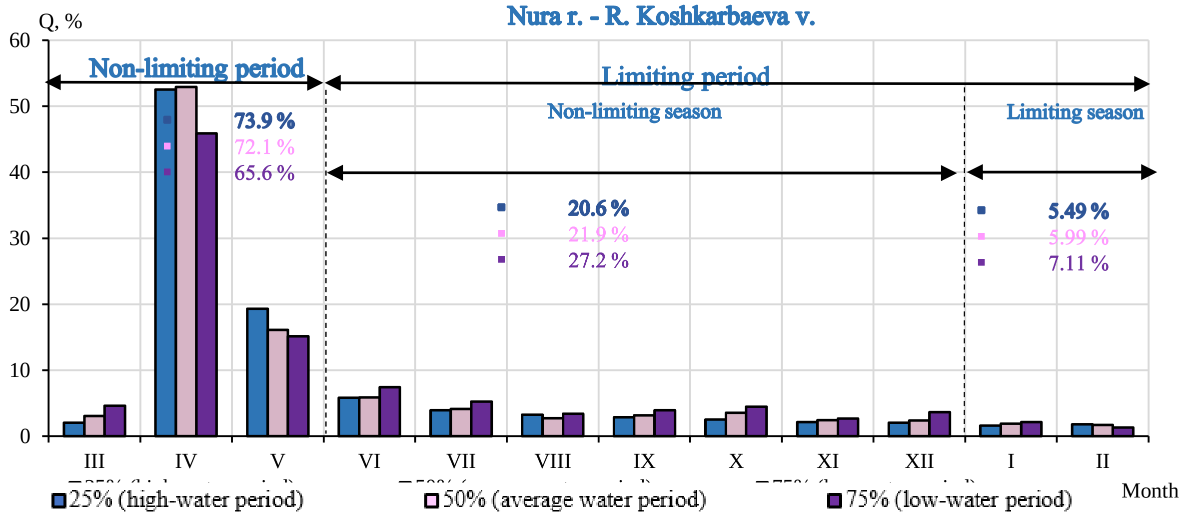
For the hydrological stations on the Nura River - Balykty v., Nura River - R. Koshkarbaeva v., Sherubainura River - Karamuryn section, and Sarysu River - Section No. 189, the seasonal boundaries are defined as follows: the non-limiting period is considered from March to May (III-

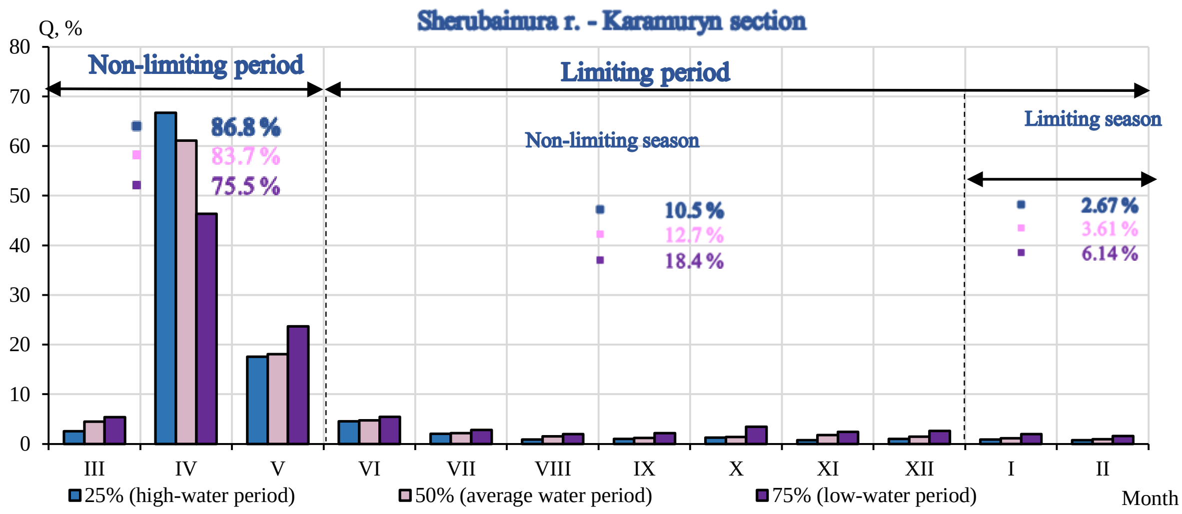
V), and the limiting period from June to February (VI-II). Within the limiting period, the following phases are distinguished:

- Non-limiting season - from June to November (VI-XI);
- Limiting season - from December to February (XII-II).

A more detailed distribution of intra-annual periods is shown in Figure78.







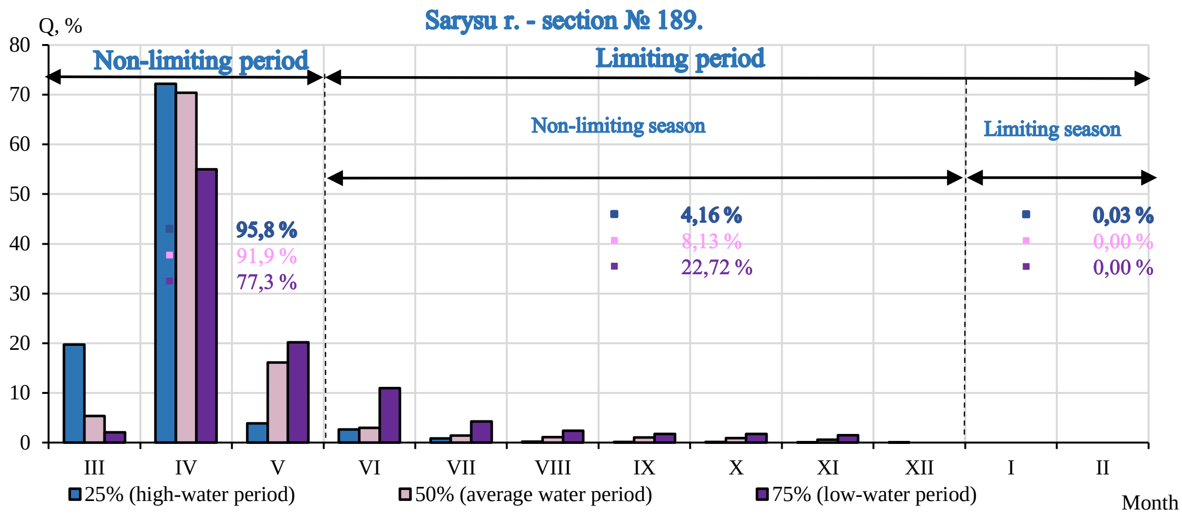


Figure 78 – Intra-annual distribution of runoff at the main hydrological gauging stations over a long-term period for the Nura-Sarysu WMB

To determine the annual runoff of a given exceedance probability curves were constructed for specific periods and seasons (Figure 7, Appendix B), and their main statistical characteristics over a long-term period were also determined (Table 7, Appendix B).

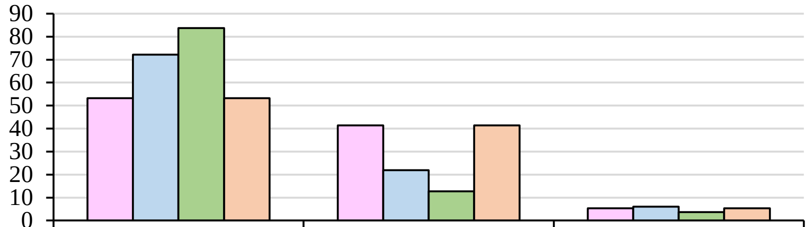
An analysis of the exceedance probability curves of observed runoff at the main hydrological gauging stations of the Nura, Sherubaynura, and Sarysu river basins showed that all the studied watercourses are characterized by pronounced seasonality and high variability in water availability. The highest discharges are observed in the spring-summer period, which is associated with intensive snowmelt and flood formation, whereas in summer and autumn the runoff decreases significantly, and in winter it reaches minimum values, forming the base level of water availability. The upper reaches of the Nura River basin (Balykty and Koshkarbayeva gauging stations) are characterized by the highest discharges and a sharp decline in the exceedance probability curves, indicating runoff instability and a pronounced influence of climatic factors. In the Sherubaynura and Sarysu river basins, the curves have a more smoothed character, reflecting moderate water availability and relative stability of the runoff regime. Overall, for the rivers under consideration, the main portion of the annual runoff (up to 60-70%) is formed during the spring period, which indicates the dominance of snow-fed supply and a significant dependence of river water availability on seasonal and interannual climatic fluctuations (Figure 7, Appendix B).

An analysis of runoff distribution during the average-water period (Table 31) by seasons showed that in the basins of the Nura, Sherubaynura, and Sarysu rivers, the main portion of annual runoff is formed in spring and summer, which indicates the predominance of snow-fed supply and pronounced seasonal unevenness of the water regime.

In the upper reaches of the Nura River (Balykty v. and R. Koshkarbayeva v. gauging stations), the spring-summer runoff accounts for **53.2 %** and **72.1 %,** respectively, the autumn runoff for **41.4 %** and **21.9 %,** and the winter runoff **for 5.4 % and 5.99 %.** This indicates a significant influence of spring snowmelt and the formation of the main runoff volume during the flood period. In the Sherubaynura River basin (Karamuryn section), the share of spring-summer runoff reaches **83.7%,** while the autumn and winter periods account for only **12.7 % and 3.6 %,** respectively, which highlights a clearly pronounced snow-fed regime and instability of the water regime. The Sarysu River (section No. 189) is characterized by a distribution similar to that of the upper Nura:

spring-summer runoff - **53.2 %,** autumn - **41.4 %,** winter - **5.4 %.** This indicates a plains-type runoff with moderate seasonal variability.

Table 31 - Intra-annual distribution of runoff of the main rivers during an average-water period (50 % exceedance probability), in percentages (%)



	% (SPRING-SUMMER)	% (AUTUMN)	% (WINTER)
Nura r. - Balykty r.s.	53,2	41,4	5,4
Nura r. - R. Koshkarbayeva v.	72,1	21,9	5,99
Sherubaynura r.- Karamuryn section	83,7	12,7	3,61
Sarysu r. - №189 section	53,2	41,4	5,4

Overall, in the basins under consideration, the spring period forms from 50 to 85% of the annual runoff, whereas a decline in water availability is observed in autumn and winter. This reflects the dominance of snow-fed supply and the dependence of the water regime on the climatic conditions of the region.

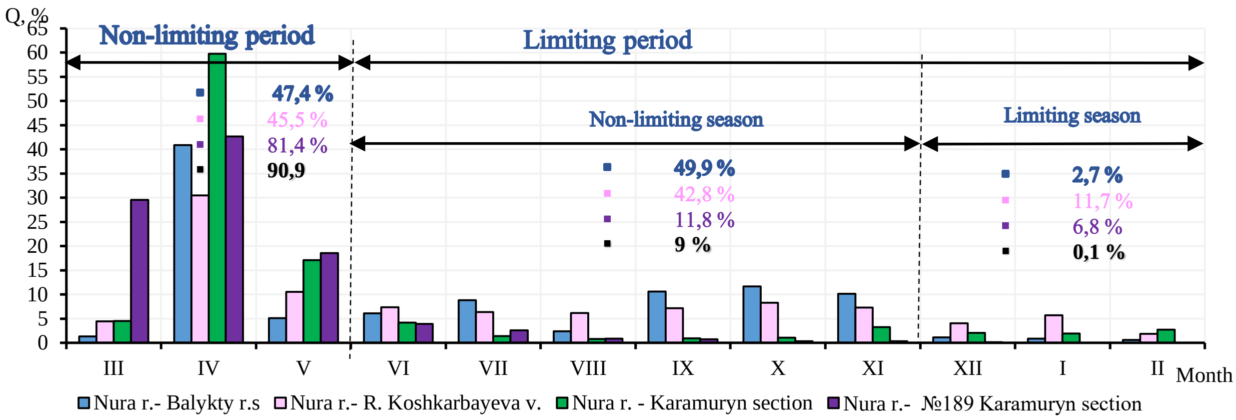


Figure 79 – Intra-annual distribution of runoff at the main hydrological gauging stations of the Nura-Sarysu WMB for 2023-2024.

An analysis of the intra-annual distribution of runoff at the main hydrological gauging stations of the Nura-Sarysu water management basin for 2023-2024 (Table 7, Appendix B) showed a clear division of the year into limiting and non-limiting periods of the water balance (Figure 2), which is of great importance for assessing water resources and for rational planning of water use.

For the **Nura River gauging station at Balykty v.**, the years 2023-2024 were characterized by low-water conditions in terms of runoff exceedance probability. Both the non-limiting period and the limiting season were marked by reduced water availability, while the non-limiting season in terms of exceedance probability was close to the average runoff distribution. The main part of the annual volume (about 90.9%) was formed within the non-limiting period, indicating the dominance of the spring-summer flood and the dependence of runoff on the intensity of snowmelt.

The limiting season (winter months) was characterized by extremely low water availability, corresponding to a stable winter low-flow period.

For the **Nura River gauging station at R. Koshkarbayeva v.,** the 2023-2024 hydrological year was also low-water, which was due to reduced runoff during the main non-limiting period. At the same time, the non-limiting season in terms of exceedance probability was close to the average level of water availability, whereas the limiting season was characterized by pronounced low-water conditions. The total runoff volume for the studied period was distributed predominantly in the spring-summer period, where up to 45.5% of the annual runoff was accumulated, confirming the characteristic dependence of the hydrological regime on snow-fed supply and short-term spring flooding.

For the **Sherubaynura River gauging station at the Karamuryn section**, the years 2023-2024 were characterized by an extremely low-water hydrological regime. The main runoff volume (81.4%) was formed within the non-limiting period, while both the non-limiting and limiting seasons in terms of exceedance probability fell into the low-water category. The spring maximum runoff observed in April was short-lived, after which water availability rapidly declined to low-flow values. Thus, this section of the basin is characterized by high seasonal variability and a short phase of active water exchange, typical of rivers dominated by snow-fed supply.

For the **Sarysu River gauging station at section №189,** the years 2023-2024 were also identified as low-water in terms of runoff exceedance probability. The largest volume of water was concentrated in April, when the main flood was formed, while extremely low discharges were observed during the remaining months. The non-limiting period accumulated about 47.4% of the annual runoff, indicating a sharp concentration of water resources within a short spring interval. The limiting season was characterized by minimal water availability (0.1%), reflecting an almost complete absence of runoff during the winter months. Thus, during the specified period, the Sarysu River exhibited an extremely uneven runoff distribution and a pronounced limiting phase, typical of the arid conditions of the region.

In general, the analysis of runoff for 2023-2024 at the hydrological gauging stations of the Nura, Sherubaynura, and Sarysu rivers showed that this period was characterized by low-water conditions and a distinctly pronounced seasonal unevenness of the water regime. The main runoff volume was formed during the spring-summer (non-limiting) period, caused by snowmelt and intense flooding, whereas the winter (limiting) season was distinguished by extremely low water availability. This confirms the dominance of snow-fed supply and the strong dependence of river water availability on climatic factors and the magnitude of spring runoff.

4.8 Intra-annual distribution of the Tobyl-Torgay WMB

For the rivers of the Tobyl-Torgay basin, a sharply pronounced spring runoff and a significant unevenness of the water regime throughout the year are characteristic. The main volume of the annual runoff is formed during the spring-summer flood period, which lasts from 4 to 6 months and is caused by snowmelt. During this period, 80 to 95% of the annual runoff occurs. In summer and winter, the rivers of the basin, especially in its southern and central parts, are characterized by low water levels or complete drying of the channels. Many small and medium rivers are temporary, resuming flow only during heavy rainfall or the snowmelt period.

The Torgay r. - the largest in the basin–features a sharply uneven distribution of runoff: during the flood, water discharge is high, while in the low-water period it is minimal, even ceasing in some sections. The river is primarily snow-fed: the annual runoff is formed mainly during the spring flood. In summer, water salinity increases in the lower reaches. It freezes in the first half of November and thaws in the first half of April.

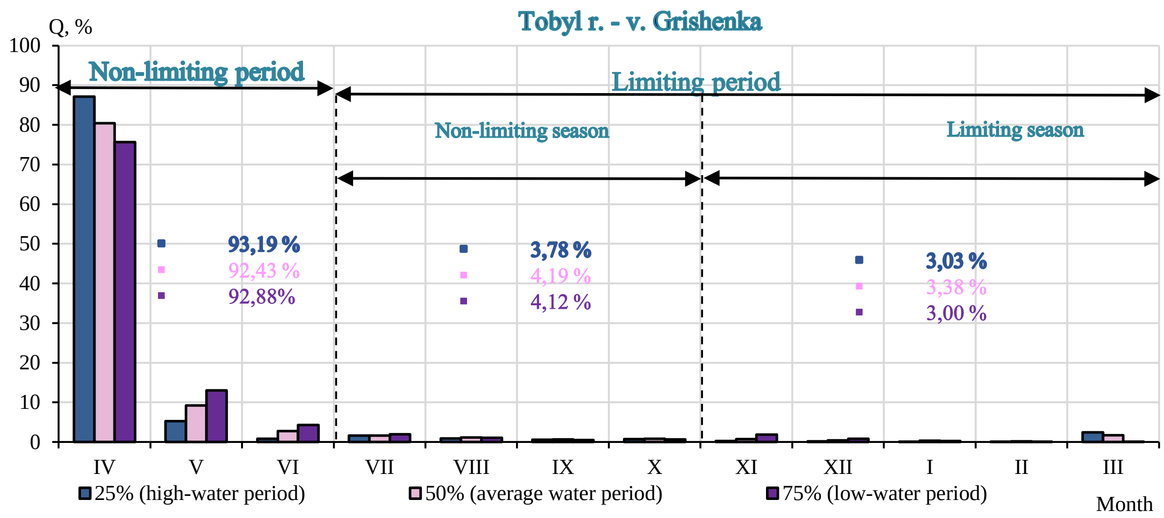
In calculating the intra-annual distribution of runoff using the compilation method, the boundaries of the water management year were taken as a basis, starting from the period of maximum water availability. The duration of the high-water period was determined so that the spring flood was fully covered for all analyzed years of observations.

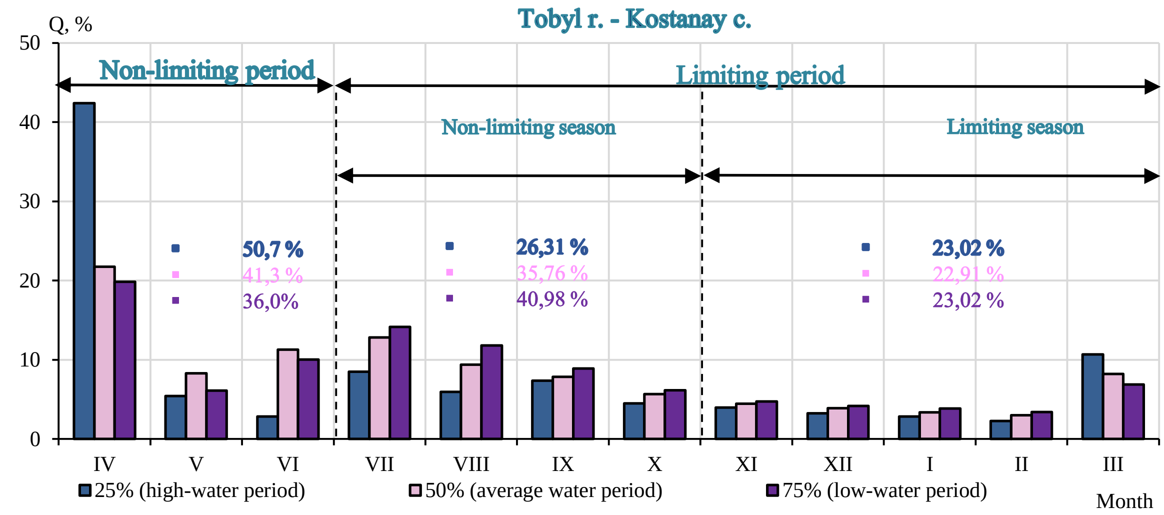
For the hydrological stations of the Tobyl r. - v. Grishenka, Tobyl r. - Kostanay city, Ayat r. - v. Varvarinka, Togyzak r. - v. Toguzak, Irgiz r. - v. Shenbertal, and Karatorgay r. - v. Urpek, the seasonal boundaries were established as follows: the non-limiting period is considered from April to June (IV-VI), and the limiting period from July to March (VII-III).

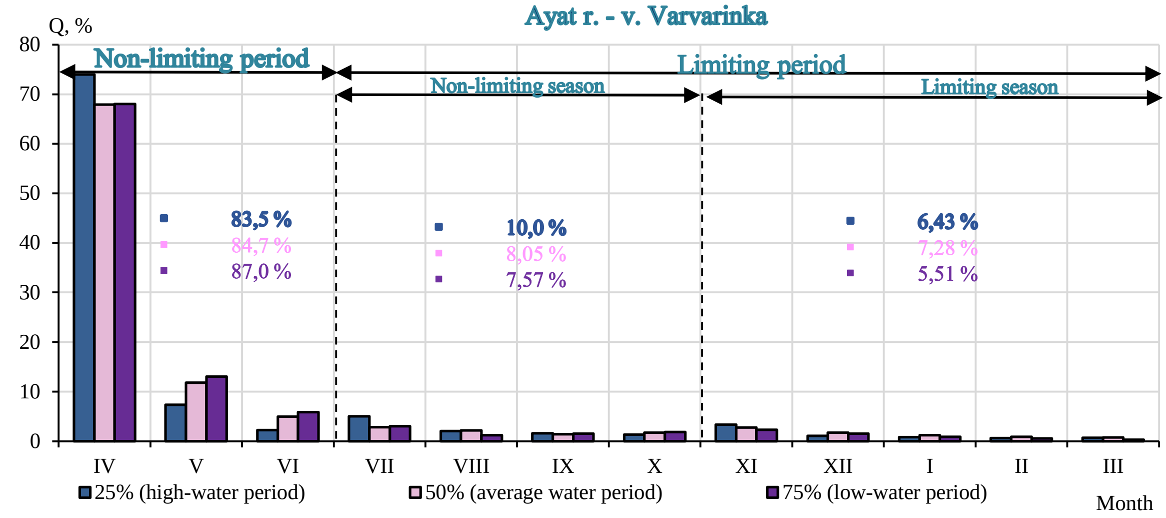
Within the limiting period, the following are distinguished:

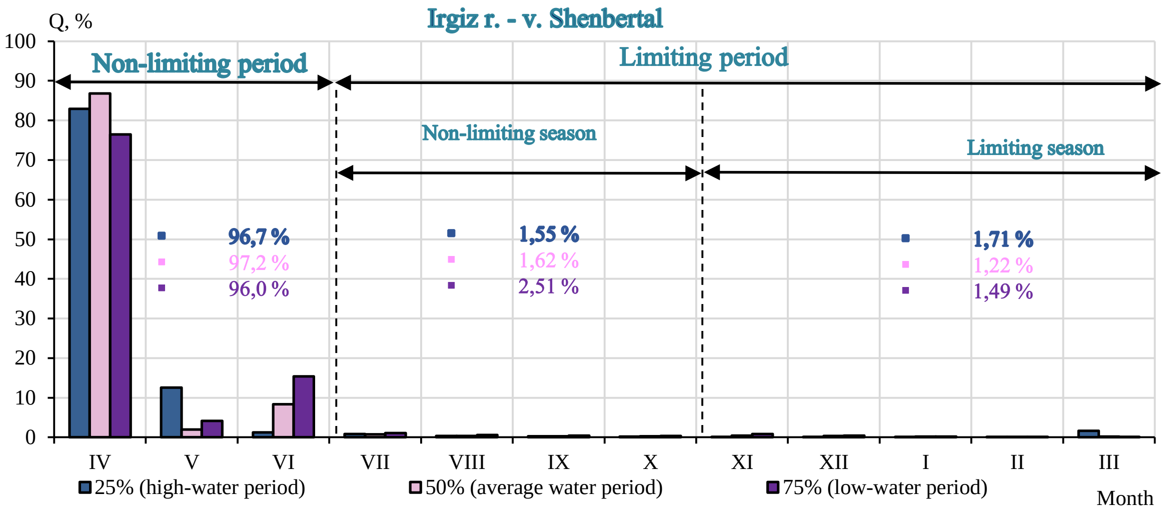
- Non-limiting season - from June to November (VII-X);
- Limiting season - from December to February (XI-III).

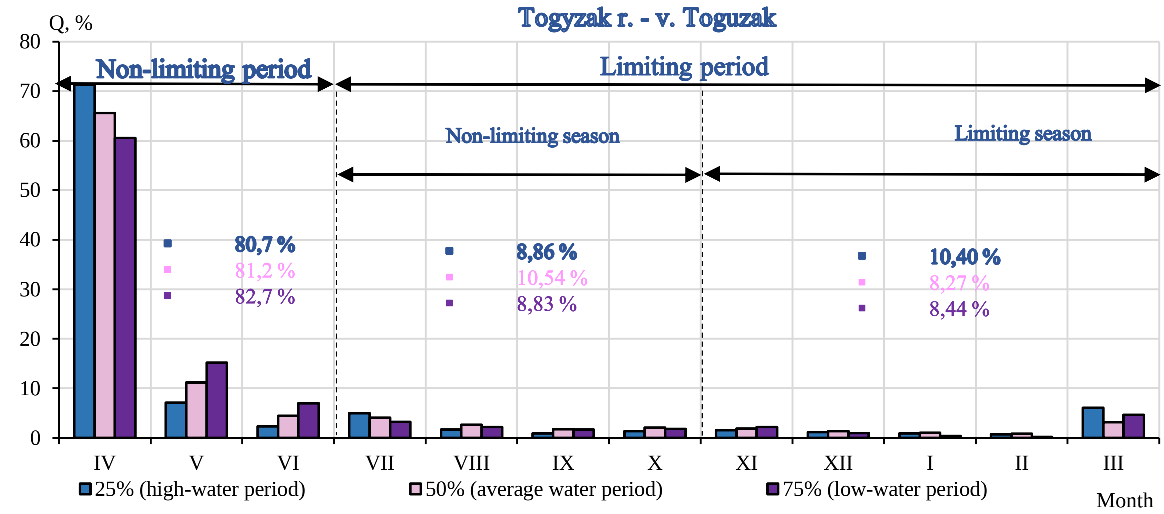
A more detailed distribution of the intra-annual periods is shown inFigure80.






Ayat r. - v. Varvarinka
Q, %
Non-limiting period
Limiting period
Non-limiting season
Limiting season
83,5 %
84,7 %
87,0 %
10,0 %
8,05 %
7,57 %
6,43 %
7,28 %
5,51 %
IV V VI VII VIII IX X XI XII I II III
Month
25% (high-water period)
50% (average water period)
75% (low-water period)


Irgiz r. - v. Shenbertal
Q, %
Non-limiting period
Limiting period
Non-limiting season
Limiting season
96,7 %
97,2 %
96,0 %
1,55 %
1,62 %
2,51 %
1,71 %
1,22 %
1,49 %
IV V VI VII VIII IX X XI XII I II III
Month
25% (high-water period)
50% (average water period)
75% (low-water period)


Togyzak r. - v. Toguzak
Q, %
Non-limiting period
Limiting period
Non-limiting season
Limiting season
80,7 %
81,2 %
82,7 %
8,86 %
10,54 %
8,83 %
10,40 %
8,27 %
8,44 %
IV V VI VII VIII IX X XI XII I II III
Month
25% (high-water period)
50% (average water period)
75% (low-water period)

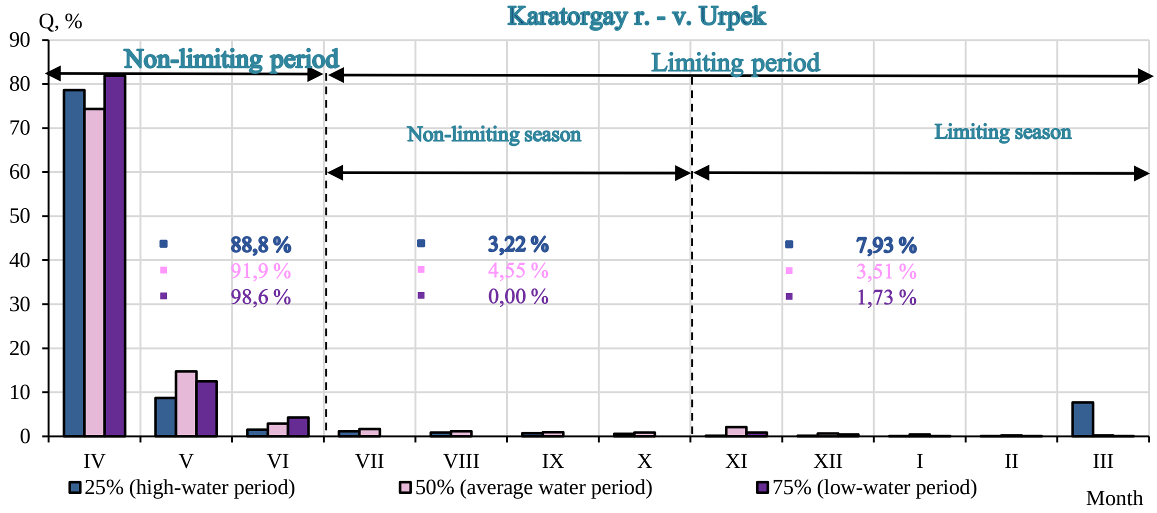
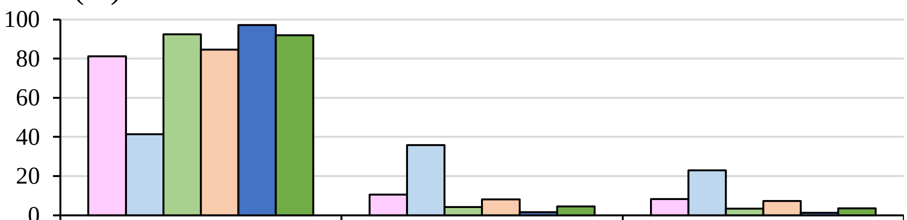


Figure 80 – Intra-annual distribution of runoff of the main hydrological posts over the long-term period for the Tobyl-Torgay WMB

Table 32 - Intra-annual distribution of runoff of the main rivers for the average water period (50 % probability) in percent (%)



	%(Spring)	%(Summer–Autumn)	%(Winter)
r. Togyzak – s. Toguzak	81,2	10,5	8,3
r. Tobyl – Kostanay c,	41,3	35,8	22,9
r. Tobyl – v. Grishenka	92,4	4,2	3,4
r. Ayat – v. Varvarinka	84,7	8,1	7,3
r. Irgiz – v. Shenbertal	97,2	1,6	1,2
r. Kara-Torgay – v. Urpek	91,9	4,6	3,5

The analysis of runoff distribution for the average water period (Table 32) by seasons showed that in the basins, only at the hydrological post of the Tobyl r. - v. Grishenka, runoff is evenly distributed across all seasons, with the main part of the annual runoff formed in spring. This indicates the predominance of snow feeding and a pronounced seasonal unevenness of the water regime.

The analysis of the intra-annual distribution of runoff at the main hydrological posts of the Tobyl-Torgay WMB for 2023-2024 (Table 8, Appendix B) showed a clear division of the year into limiting and non-limiting periods of the water balance, which is important for assessing water resources and rational water management planning.

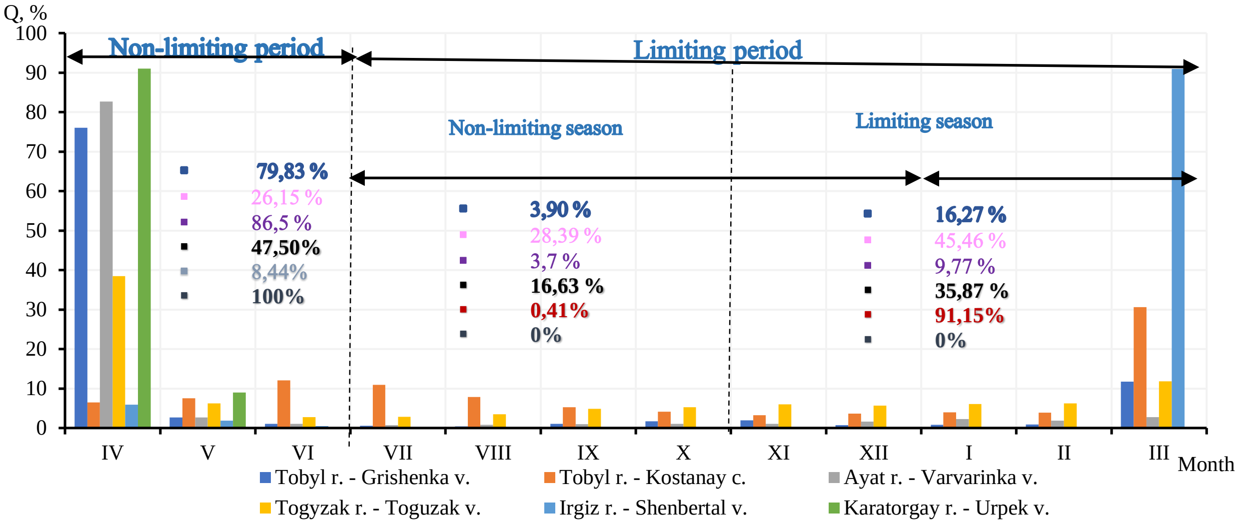


Figure 81 – Intra-annual distribution of runoff at the main HP of the Tobyl-Torgay WMB for 2023-2024

- For the hydrological station of the **Tobyl r. - Grishenka v.**, the 2023-2024 period was high-water in terms of runoff probability. The main part of the annual volume (about 79.8 %) was formed during the non-limiting period, indicating the dominance of the spring flood and the dependence of runoff on the intensity of snowmelt. The limiting season (winter months) was characterized by extremely low water levels, corresponding to a stable winter low flow.
- For the hydrological station of the **Tobyl r. - Kostanay c.**, the 2023-2024 hydrological year was also low-water, due to reduced runoff during the main non-limiting period. In this case, the non-limiting season had a runoff probability close to below-average water levels, while the limiting season was characterized by moderate water levels. The total runoff for the study period was distributed mainly in the winter period, where up to 45.4 % of the annual runoff accumulates, confirming the characteristic dependence of the hydrological regime on snow feeding and the short spring flood.
- For the hydrological station of the **Ayat r. - Varvarinka v.**, the 2023-2024 period was characterized by a high-water hydrological regime. The main runoff volume (86.5 %) was formed during the non-limiting period. The spring runoff peak, observed in April, was short-lived, after which water levels quickly decreased to low-flow values.
- For the hydrological station of the **Togyzak r. - Toguzak v.**, the 2023-2024 period was considered medium-water in terms of runoff probability. The largest water volume was concentrated in April, when the main flood occurred, while the remaining months had extremely low discharges. The non-limiting period accumulated about 47.5 % of the annual runoff, indicating a sharp concentration of water resources in a short spring interval. The limiting season was characterized by moderate water levels (35.87 %), reflecting almost complete absence of flow in winter months.
- For the hydrological station of the **Irgiz r. - Shenbertal v.**, the 2023-2024 period was also medium-water in terms of runoff probability. The largest water volume was concentrated in March, during the main flood, while the remaining months had extremely low discharges. The non-limiting period accumulated about 8.44 % of the annual runoff, indicating a sharp concentration of water resources in a short spring interval. The limiting season was characterized by maximum water levels (91.15 %).

- For the hydrological station of the **Karatorgay r. - Urpek v.**, the 2023-2024 period was high-water in terms of runoff probability. The entire annual volume (100%) was formed during the non-limiting period, indicating the dominance of the spring flood and the dependence of runoff on the intensity of snowmelt. The limiting season (winter months) was characterized by extremely low water levels.

Overall, the analysis of runoff for **2023-2024** in the **Tobyl-Torgay WMB** showed that the period was characterized by high-water conditions and a pronounced seasonal unevenness of the water regime. The main part of the runoff was formed during the spring-summer (non-limiting) period, determined by snowmelt and spring flooding, while the winter (limiting) season was marked by extremely low water levels. This reflects the dominance of snow feeding and a strong dependence of water availability on climatic factors and the flow of spring runoff.

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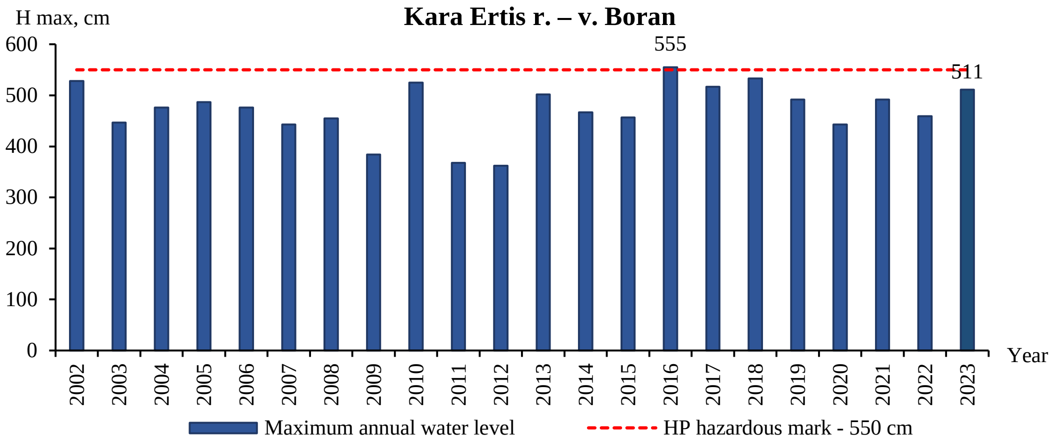
APPENDIX A

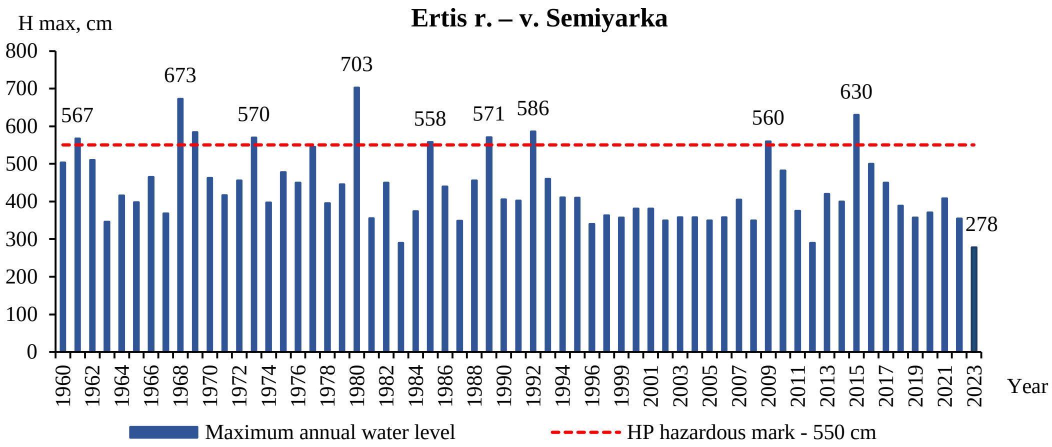
Table 1 – Long-term average value of spring flood volumes

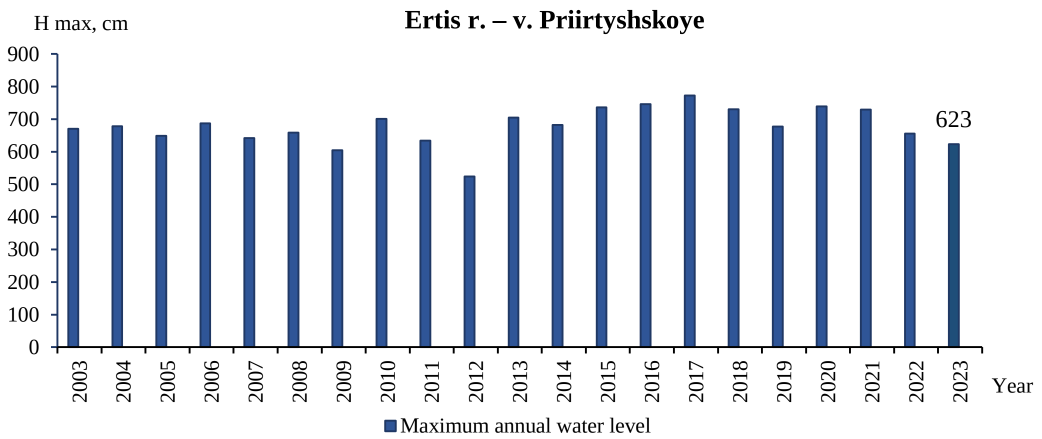
№	HP	Long-term average value of spring flood runoff			
		F, km^2	Ws.f., mln.m^3	Hs.f., mm	Period
Ertis WMB					
1	Kara Ertis r. – Boran v.	55900	6840	122	1938-2023
2	Ertis r. – Semiyarka v.	320000	21754	67,0	1935-2022
3	Ertis r. – PriErtisskoye v.	250438	8856	35,0	2012-2022
4	Kalzhyr r. – Kalzhyr v.	3150	210	63,0	2012-2023
5	Kurshim r. – Voznesenka v.	5840	1390	238	1938-2023
6	Bukhtarma r. – Lesnaya Pristan v.	10700	4886	458	1955-2023
7	Ulbi r. – Ulbi Perevalochnaya v.	4900	1778	363	2012-2022
8	Oba r. – Shemonaikha c.	8470	3890	459	1958-2022
Balkhash-Alakol WMB					
9	Ili r. - 164 km upstream of the Kapshagay HP	85400	8989	105	1971-2000
10	Ili r. – Kapshagay s.	111000	11315	102	1911-1970
11	Charyn r. – Sarytogay s.	7370	713	96,7	1929-2010
12	Chilik r.– Malybay v.	4300	798	186	1928-2010
13	Lepsy r. – Lepsy v.	1220	477	391	1932-2023
14	Tentek r. – Tonkeris v.	3300	1161	352	1930-2023
15	Karoy r. – Tekeli v.	484	352	727	1940-2023
16	Shyzhyn r. – Tekeli c.	479	296	618	1981-2023
17	Tekeli r. – Tekeli c.	193	41,5	215	1960-2023
18	Koksu r. – Koksu v.	1590	971	611	1956-2023
19	Koktal r. – Araltobe v.	293	205	700	1946-2023
20	Byzhy r. – Karymsak v.	822	42,2	51,3	1949-2019
Aral-Syrdarya WMB					
21	Shayan 1 r. – 3.3 km downstream from the mouth of Akbet river	485	47,9	22,2	1948-2023
22	Kokbulak r. – Pisteli v.	76,0	17,4	36,4	1981-2023
23	Boldybrek r. – near the State Reserve boundary	86	68,0	24,1	1981-2023
24	Kattabugun r. – Zharykbas v.	268	66,0	34,2	1940-2023
25	Zhabaglysu r. – Zhabagly v.	172	49,2	9,53	1981-2023
26	Boraldai r. – Vasilievka v.	114	103	904	1981-2023
27	Sairam r. – Tasaryk v.	468	201	35,2	1981-2023
Zhaiyk-Caspian WMB					
28	Zhaiyk r. – Yanvartsevo s.	175000	3880	22,2	2009-2023
29	Zhaiyk r. – Kushum v.	190000	6920	39,0	1912-2023
30	Zhaiyk r. – Makhamet s.	230000	5549	25,0	1936-2023
31	Ilek r. – Aktobe c.	11000	376	35,0	1939-2023
32	Uil r. – Uil v.	17100	163	9,80	1991-2023
Esil WMB					
33	Esil r. – Turgen v.	3240	114	35,0	1981-2023
34	Zhabai r. – Atbasar c.	8530	253	30,0	1937-2023
35	Kalkutan r. – Kalkutan v.	16500	220	13,0	1937-2023
Nura-Sarysu WMB					
36	Nura r. – Balykty r.s.	12300	203	13,4	1938-2023
37	Nura r. – Koshkarbayeva v.	45100	404	8,8	1916-2023
38	Sherubainura r. – Karamuryn s.	8700	143	16	1938-2023
39	Sarysu r. – № 189 s.	26900	70	2,6	1938-2023
Tobol-Torgay WMB					
40	Tobol r. – Grishenka v.	13100	215	16	1938-2023
41	Ayat r – Varvarinka v.	9020	123	14	1952-2023
42	Kara-Torgay r. – Urpek v.	14800	270	18	1942-2023
43	Irghiz r. – Shenbertal v.	22700	258	10	1961-2023
44	Togysak r. – Togysak v.	5970	417	28	1936-2023

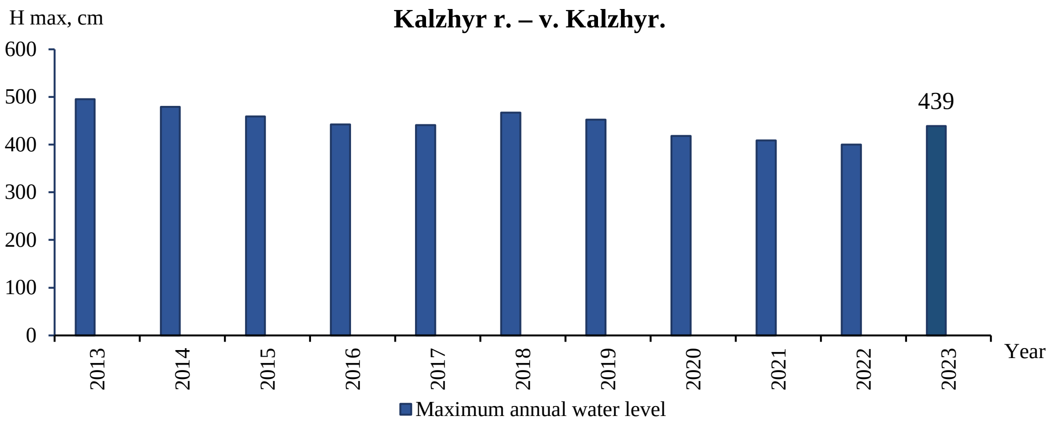
APPENDIX B

Graphs of maximum water levels on the main rivers of the basin for the entire period of the station’s operation up to 2023

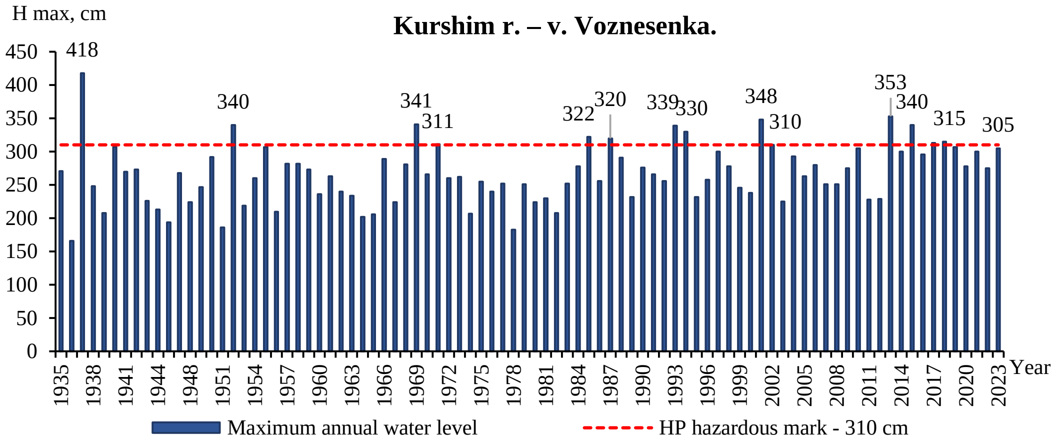




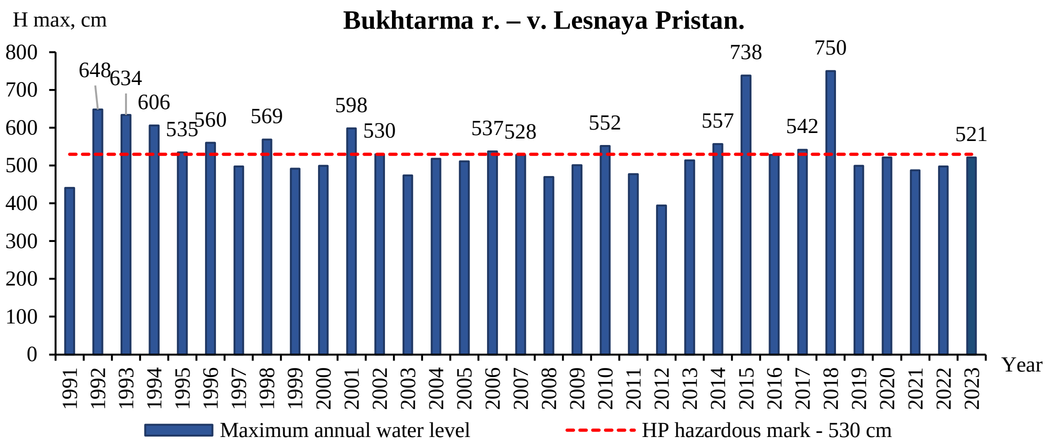




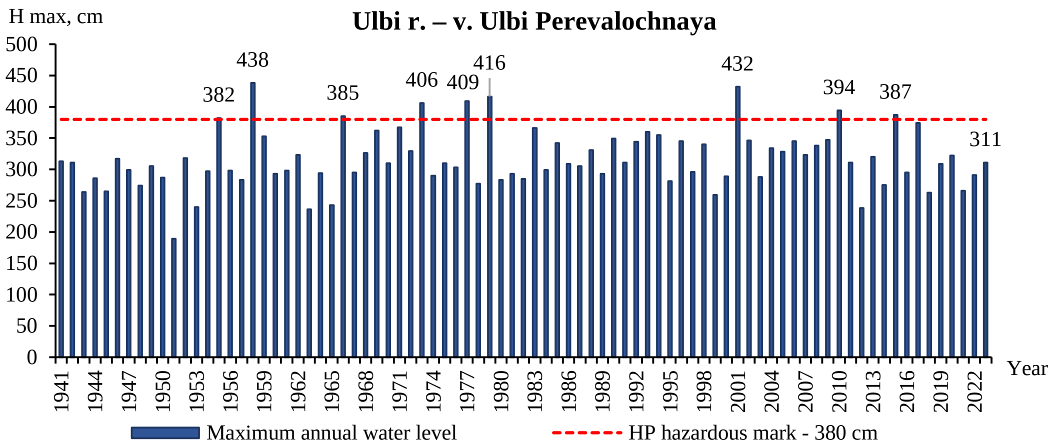
H max, cm
Kalzhyr r. – v. Kalzhyr.
439
Year
Maximum annual water level



H max, cm
Kurshim r. – v. Voznesenka.
418
340
341
311
322
320
339
330
348
310
353
340
315
305
Year
Maximum annual water level
HP hazardous mark - 310 cm



H max, cm
Bukhtarma r. – v. Lesnaya Pristan.
648
634
606
535
560
569
598
530
537
528
552
557
738
542
750
521
Year
Maximum annual water level
HP hazardous mark - 530 cm



H max, cm
Ulbi r. – v. Ulbi Perevalochnaya
382
438
385
406
409
416
432
394
387
311
Year
Maximum annual water level
HP hazardous mark - 380 cm

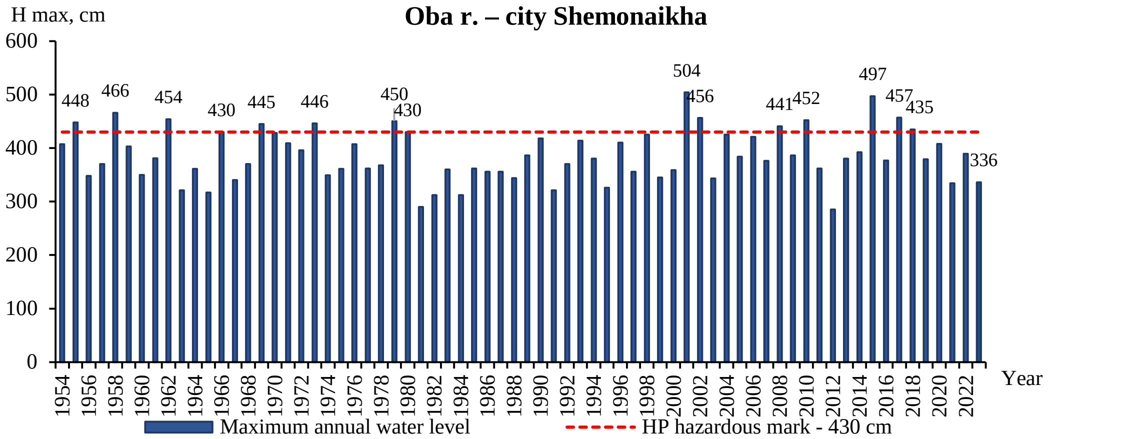
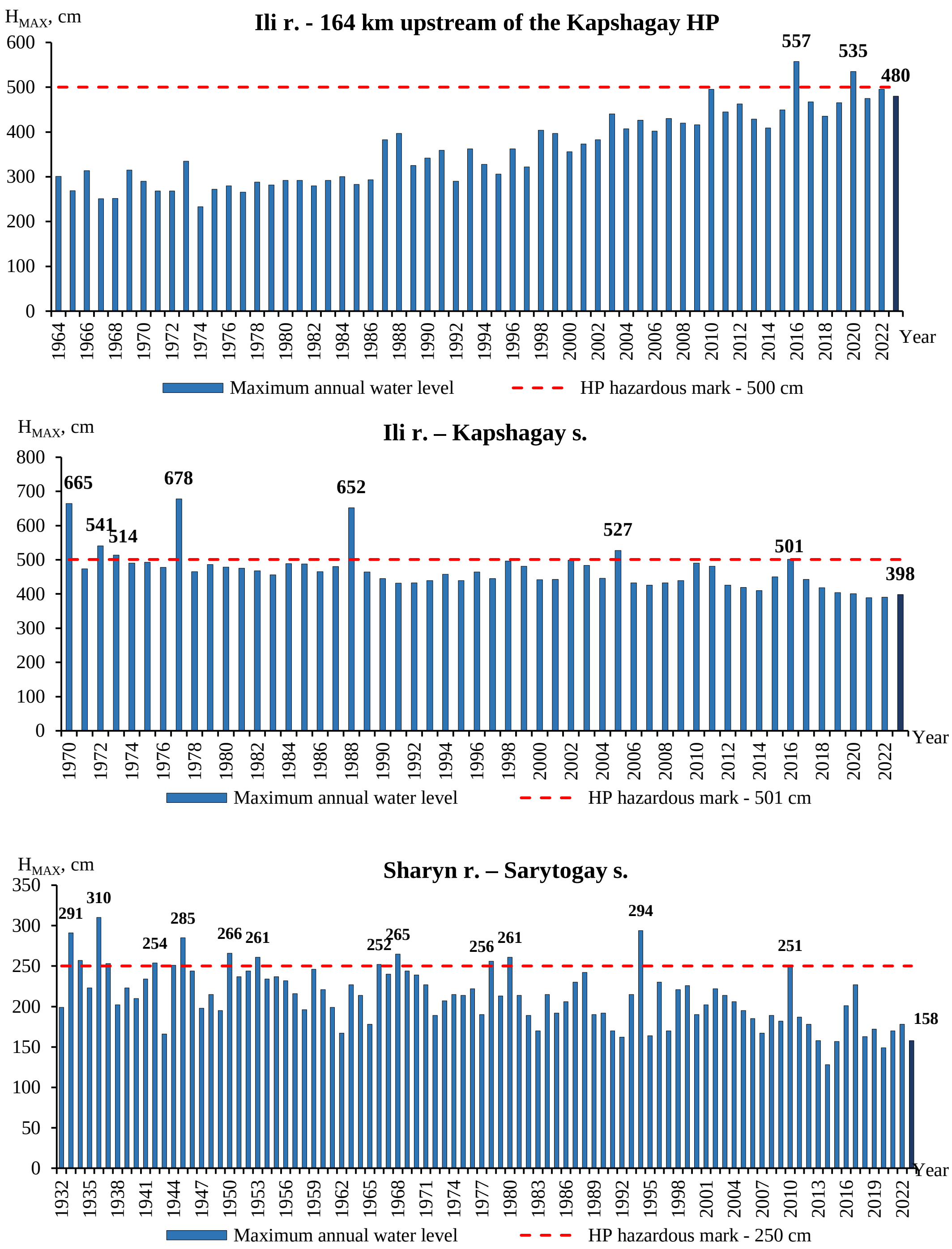
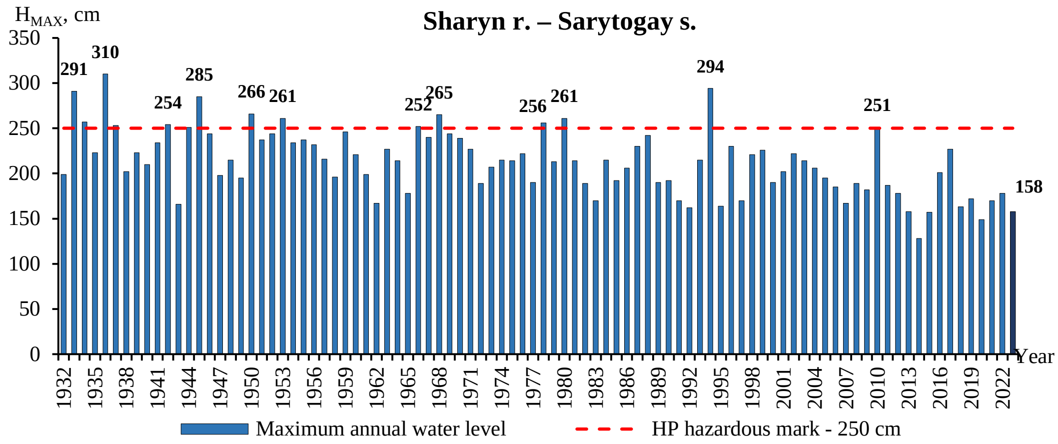
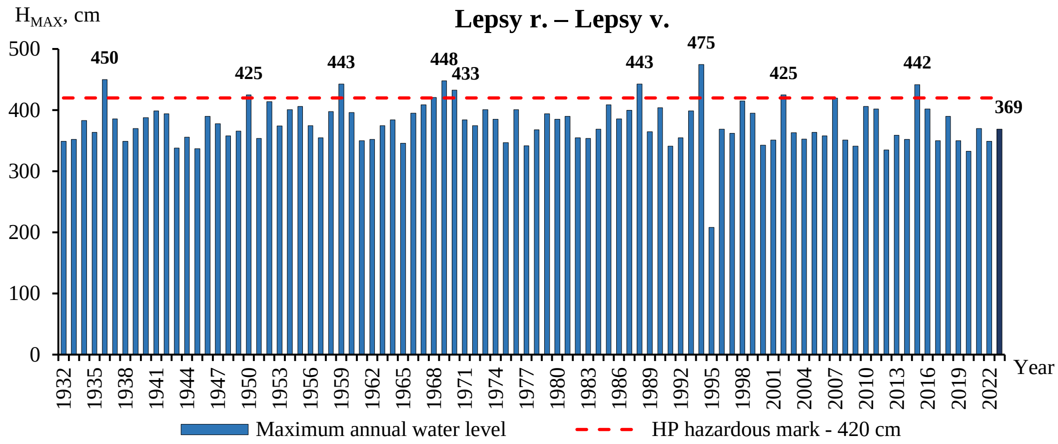
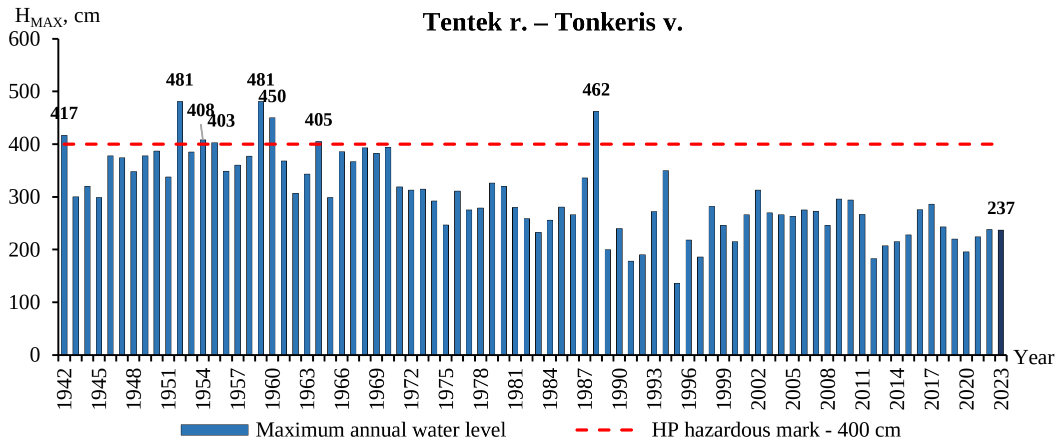


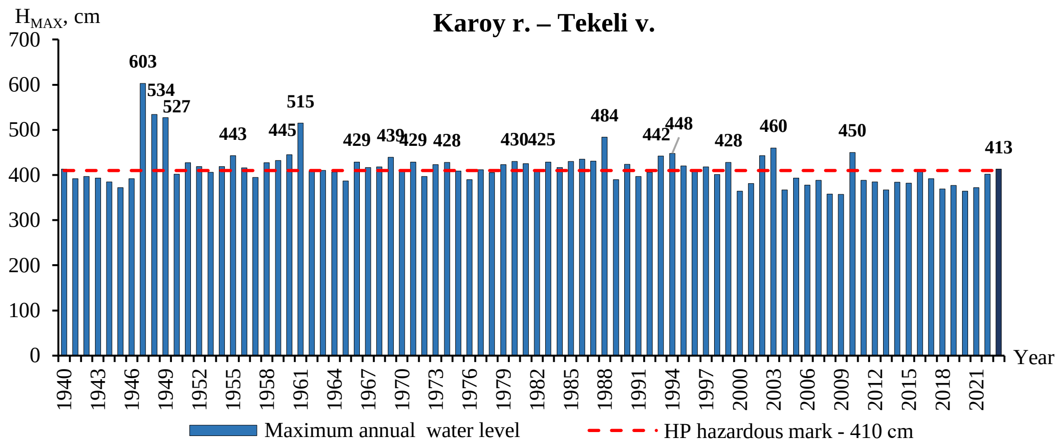
Figure 1 – Maximum water levels and hazardous mark on the main rivers of the Ertis WMB

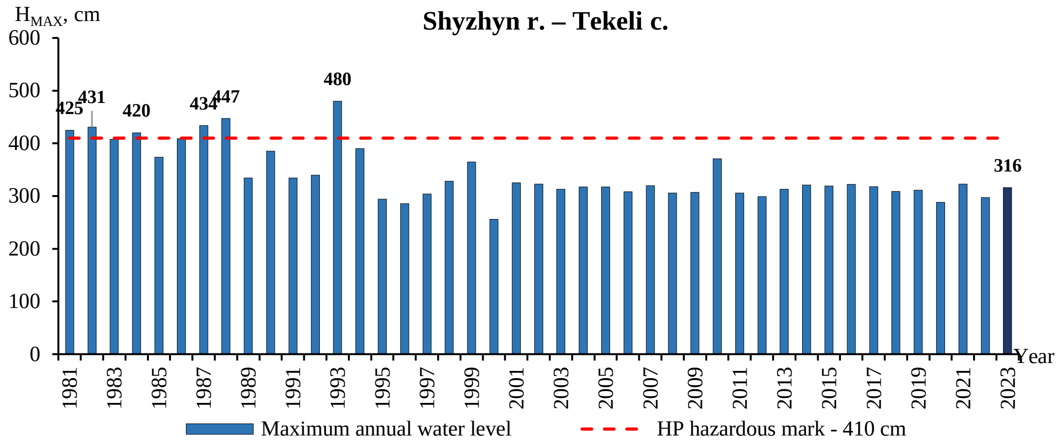


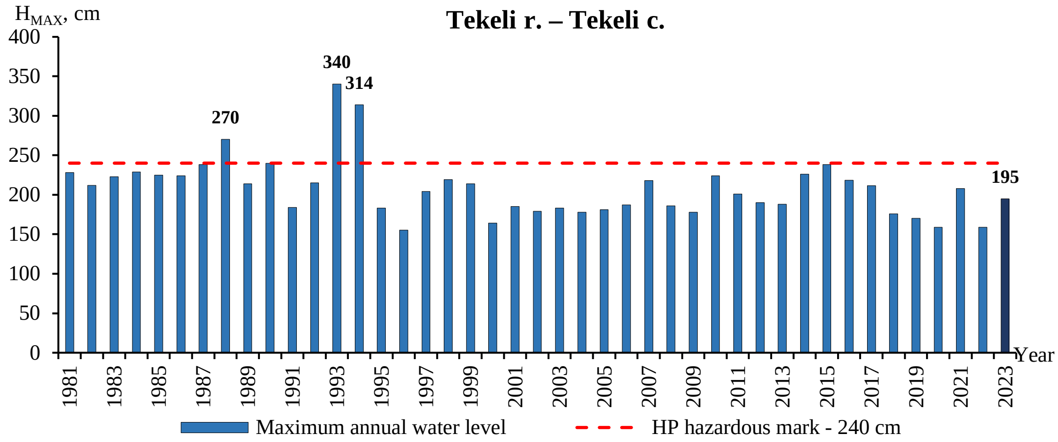

Sharyn r. – Sarytogay s.
H_{MAX}, cm
Year
291
310
254
285
266
261
252
265
256
261
294
251
158
Maximum annual water level
HP hazardous mark - 250 cm

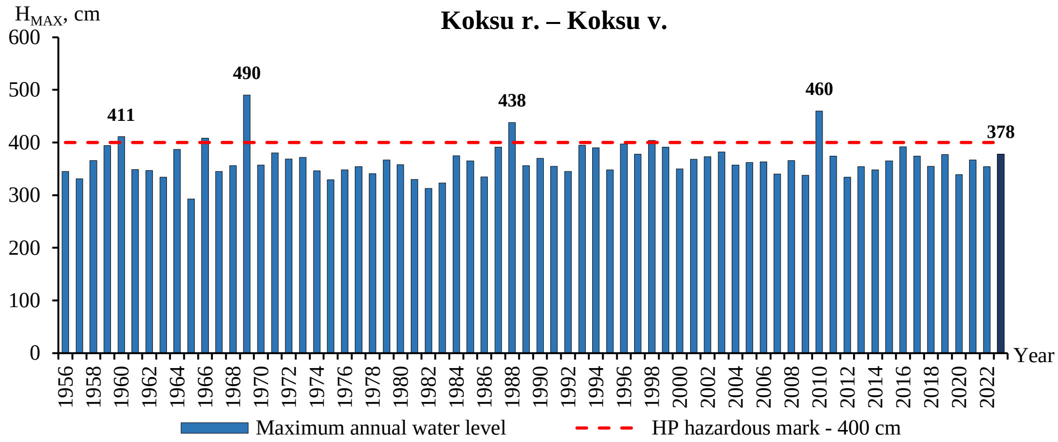

Lepsy r. – Lepsy v.
H_{MAX}, cm
Year
450
425
443
448
433
443
475
425
442
369
Maximum annual water level
HP hazardous mark - 420 cm

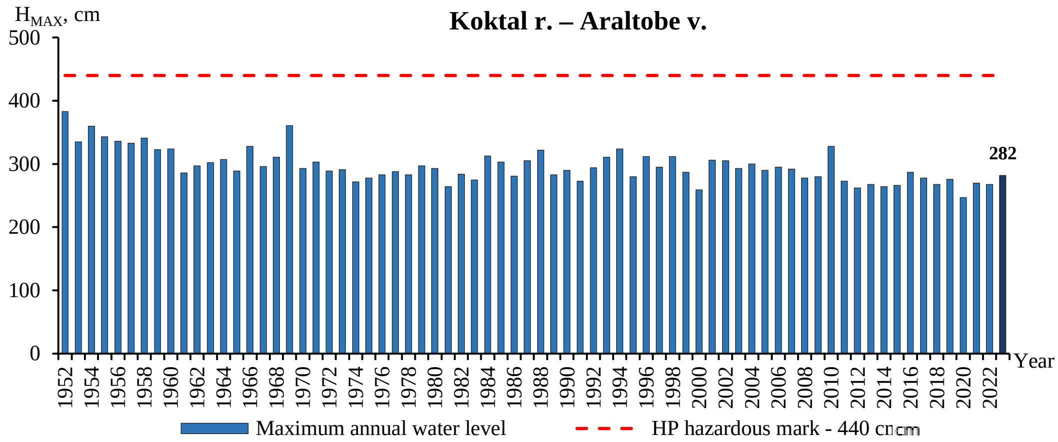

Tentek r. – Tonkeris v.
H_{MAX}, cm
Year
417
481
408
403
481
450
405
462
237
Maximum annual water level
HP hazardous mark - 400 cm


Karoy r. – Tekeli v.
H_{MAX}, cm
Year
603
534
527
443
445
515
429
439
429
428
430
425
484
442
448
428
460
450
413
Maximum annual water level
HP hazardous mark - 410 cm


Shyzhyn r. – Tekeli c.
H_MAX, cm
Year
425
431
420
434
447
480
316
Maximum annual water level
HP hazardous mark - 410 cm


Tekeli r. – Tekeli c.
H_MAX, cm
Year
270
340
314
195
Maximum annual water level
HP hazardous mark - 240 cm


Koksu r. – Koksu v.
H_MAX, cm
Year
411
490
438
460
378
Maximum annual water level
HP hazardous mark - 400 cm


Koktal r. – Araltobe v.
H_MAX, cm
Year
282
Maximum annual water level
HP hazardous mark - 440 cm

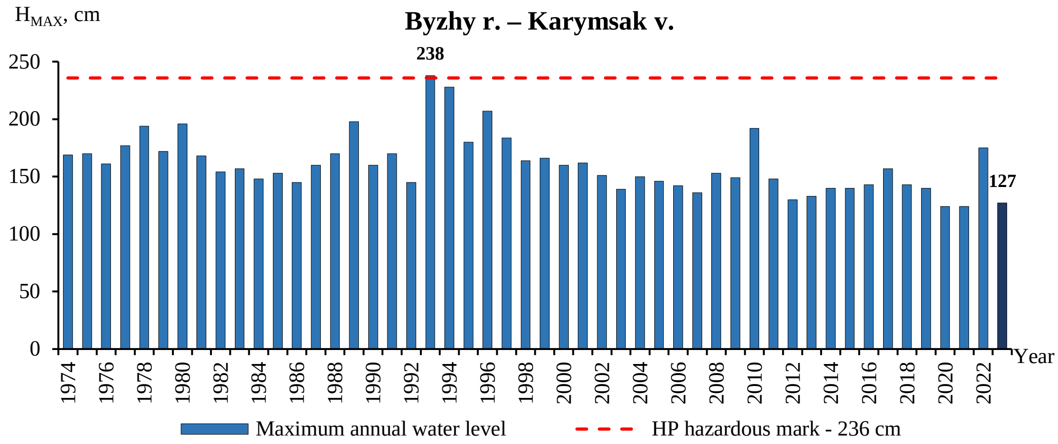
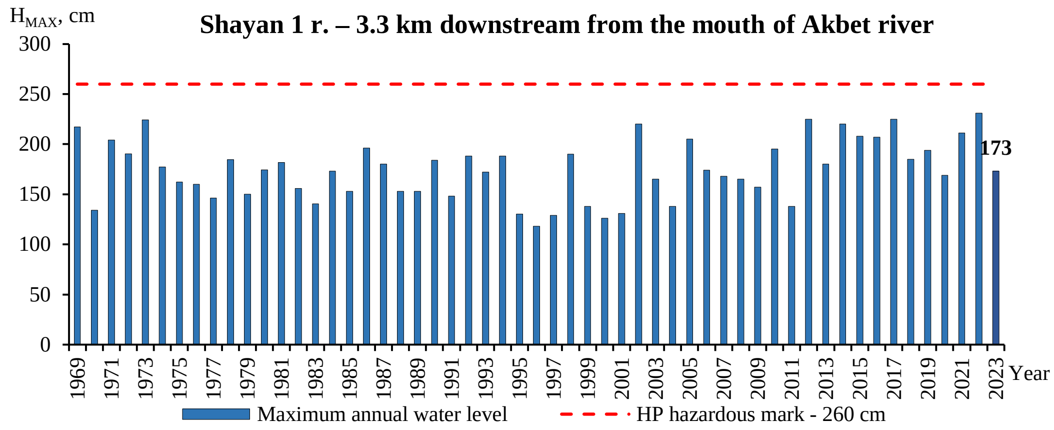
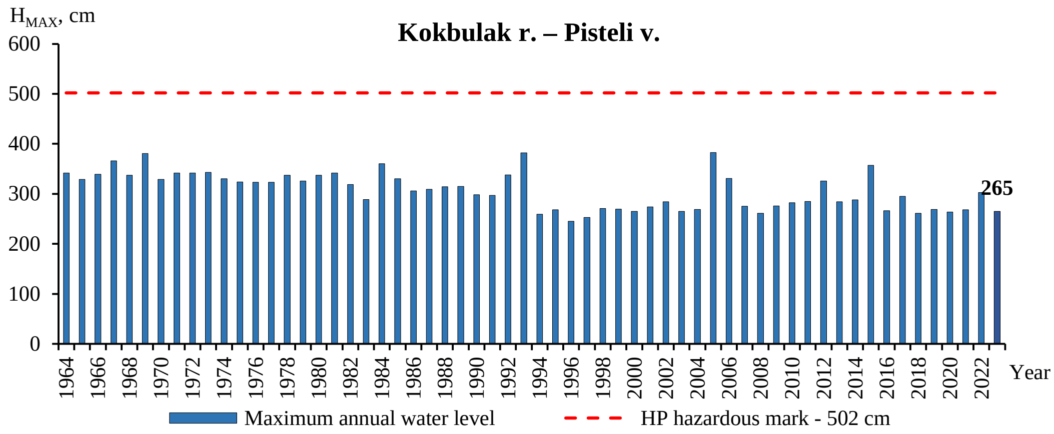
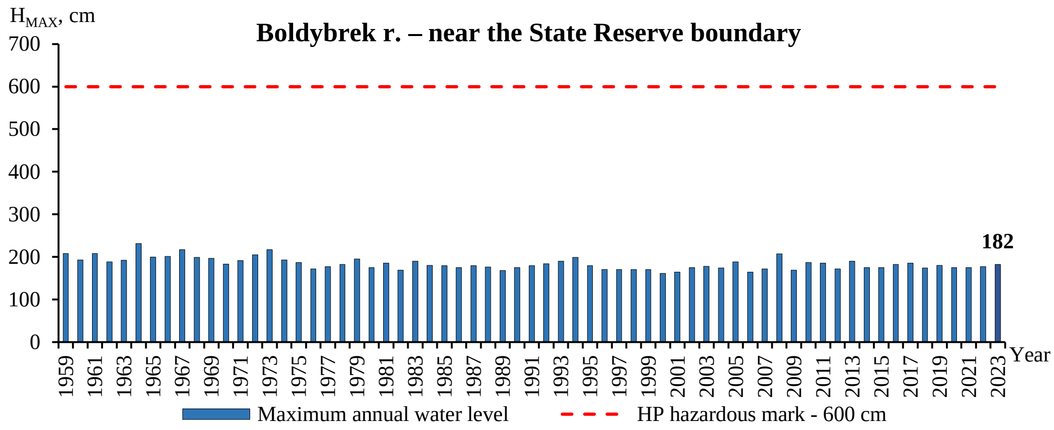


Figure 2 – Maximum water levels and hazardous mark on the main rivers of the Balkhash-Alakol WMB







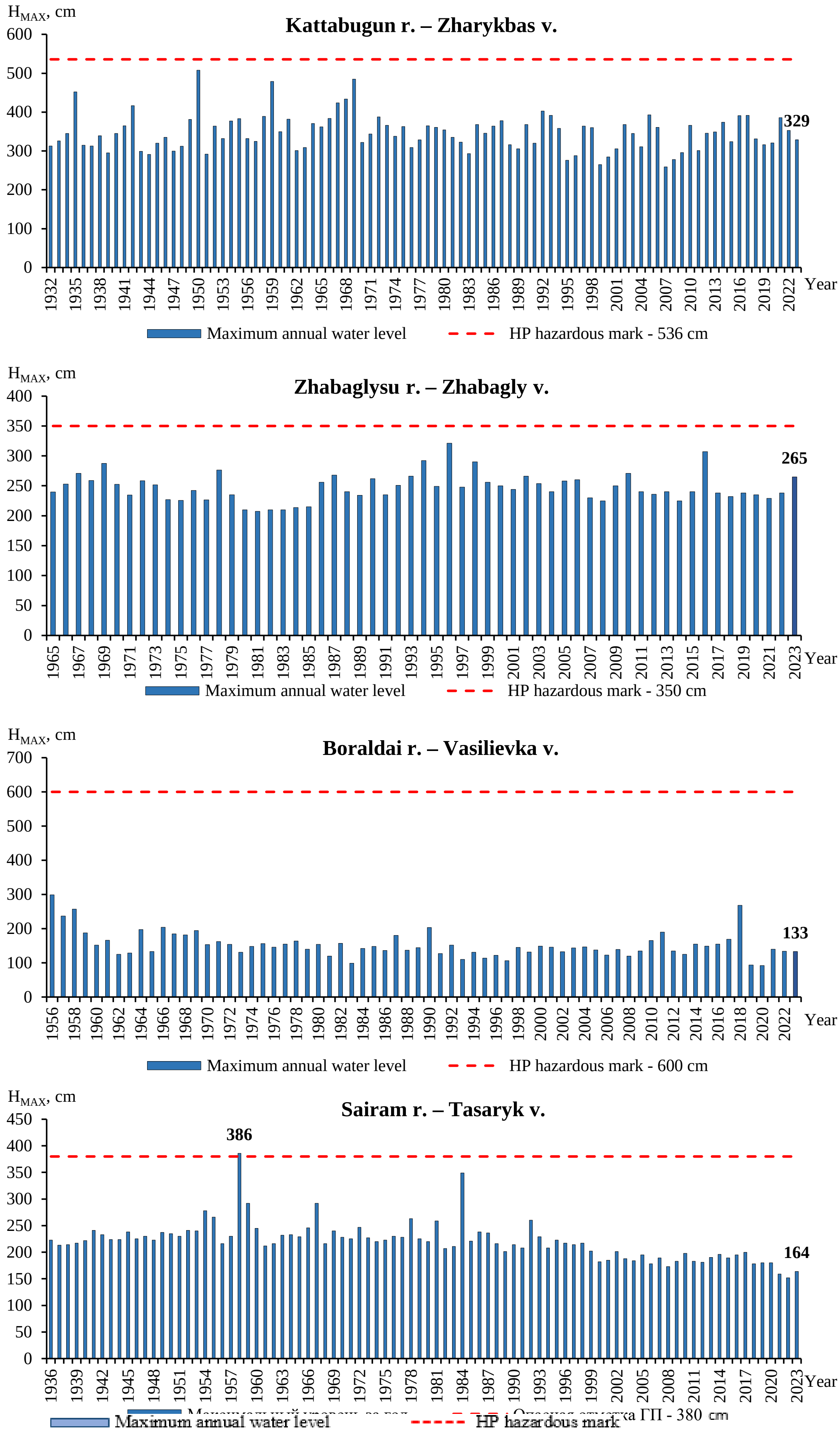
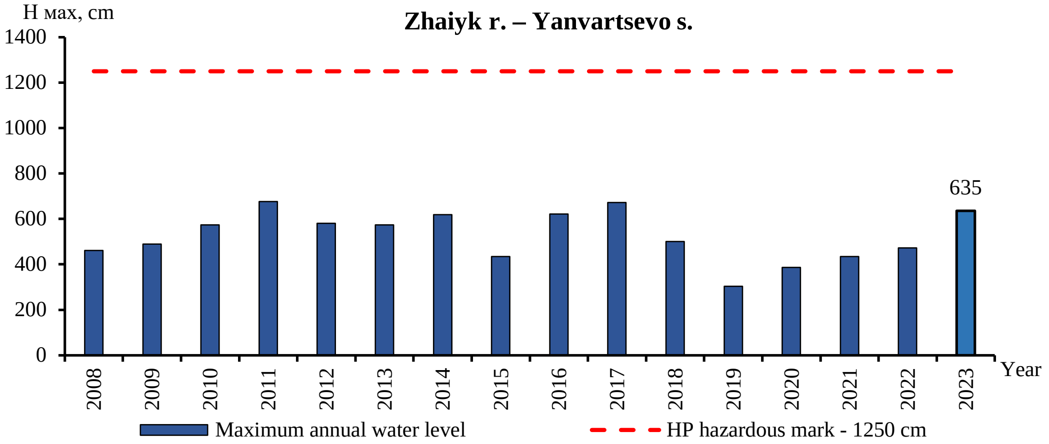
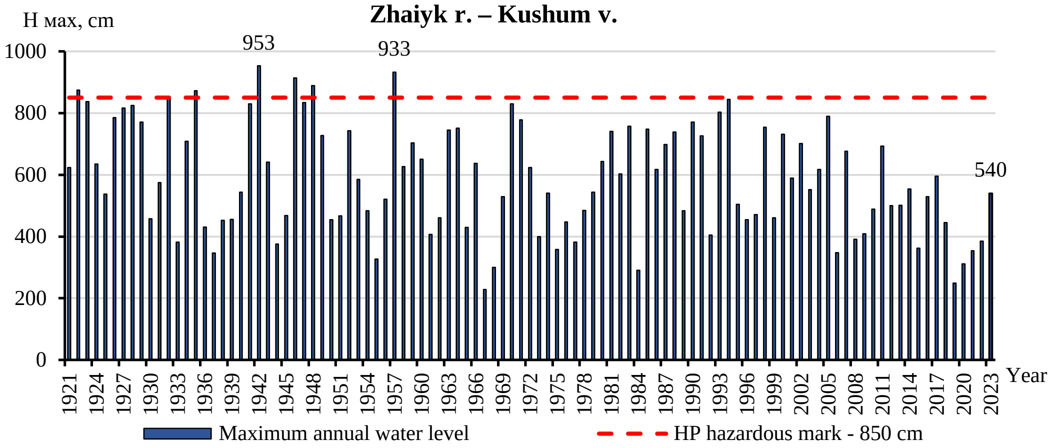
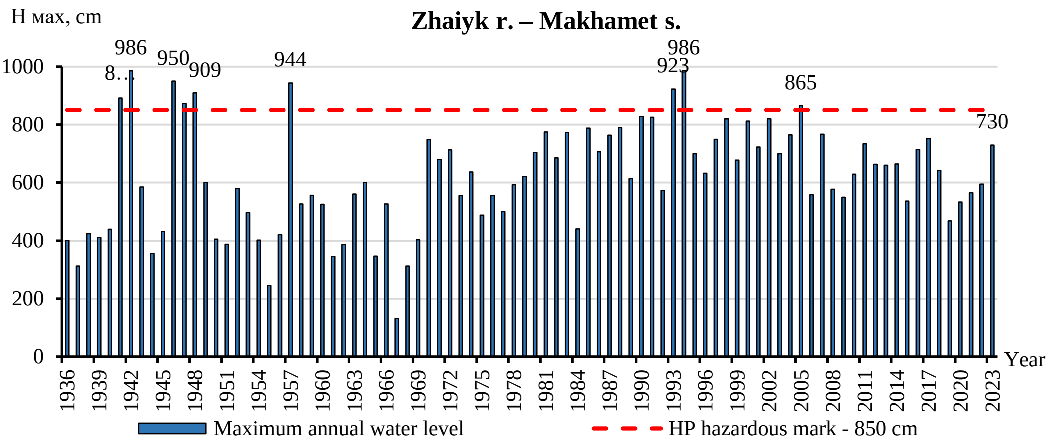
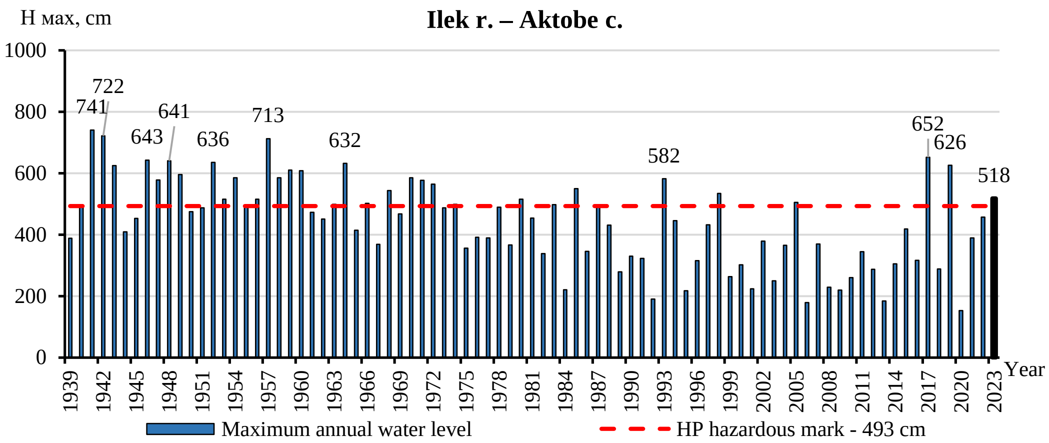


Figure 3 – Maximum water levels and hazardous mark on the main rivers of the Aral-Syrdarya WMB


Zhaiyk r. – Yanvartsevo s.
H мах, cm
0
200
400
600
800
1000
1200
1400
635
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Year
Maximum annual water level
HP hazardous mark - 1250 cm


Zhaiyk r. – Kushum v.
H мах, cm
0
200
400
600
800
1000
953
933
540
Year
Maximum annual water level
HP hazardous mark - 850 cm


Zhaiyk r. – Makhamet s.
H мах, cm
0
200
400
600
800
1000
986
950
909
944
986
923
865
730
Year
Maximum annual water level
HP hazardous mark - 850 cm


Ilek r. – Aktobe c.
H мах, cm
0
200
400
600
800
1000
741
722
643
641
636
713
632
582
652
626
518
Year
Maximum annual water level
HP hazardous mark - 493 cm

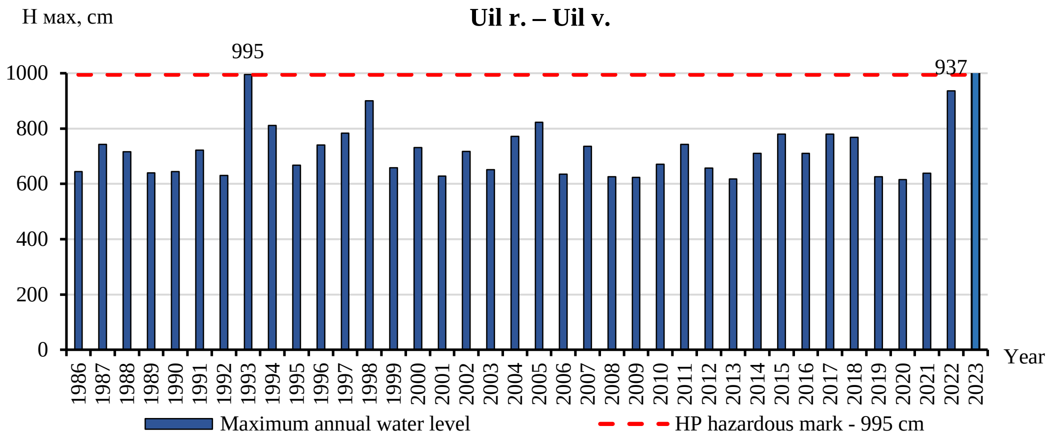
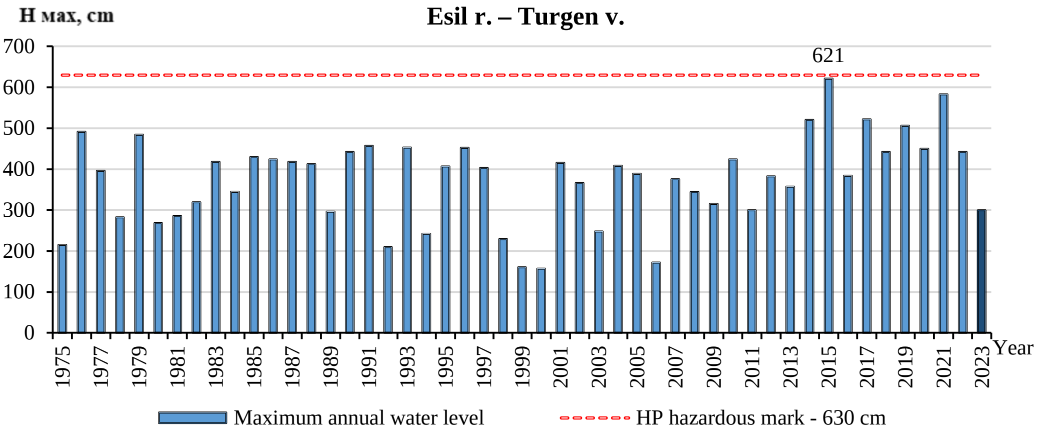
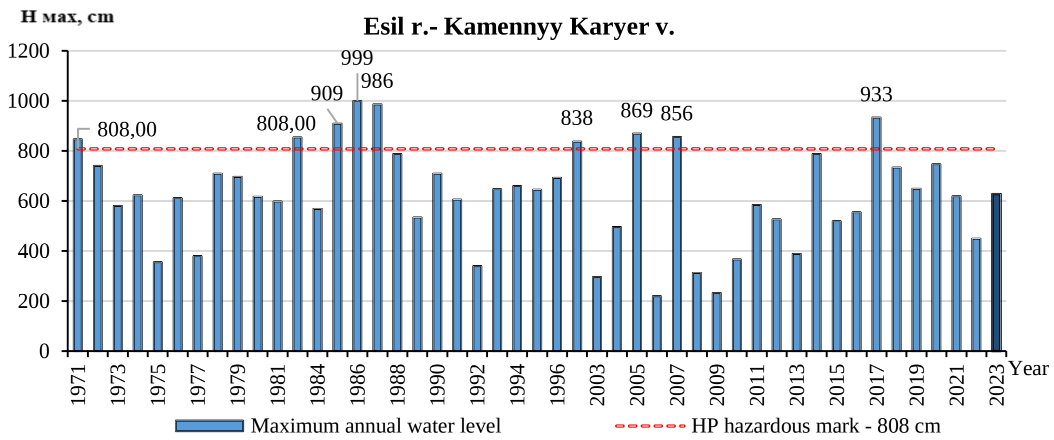
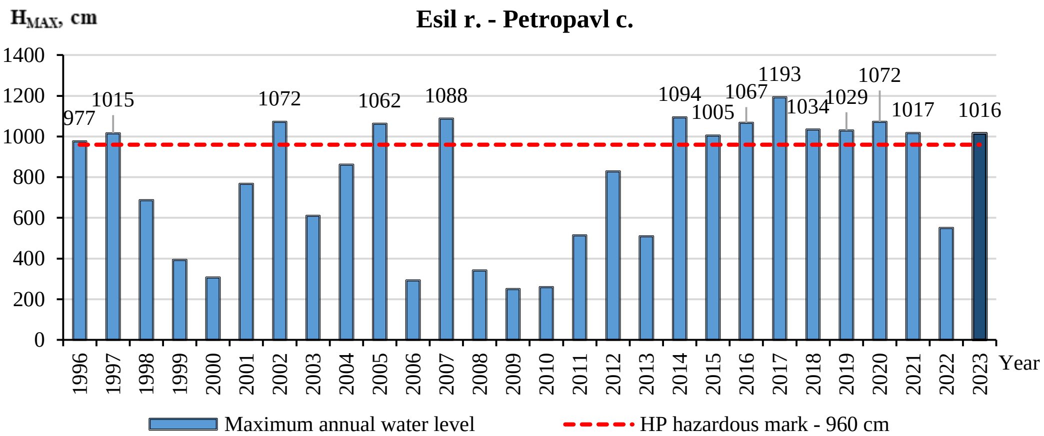


Figure 4 – Maximum water levels and hazardous mark on the main rivers of the Zhaiyk-Caspian WMB







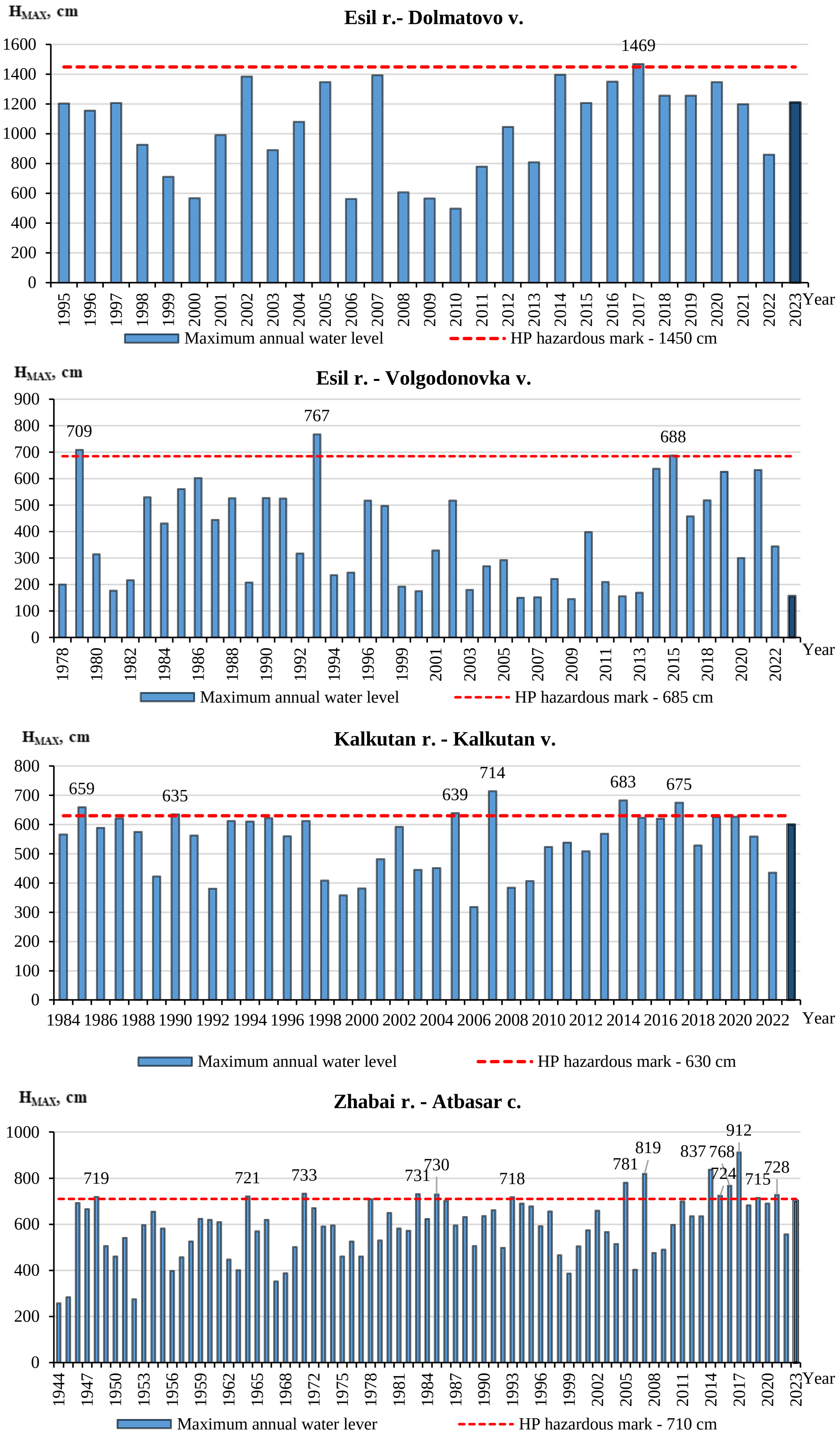
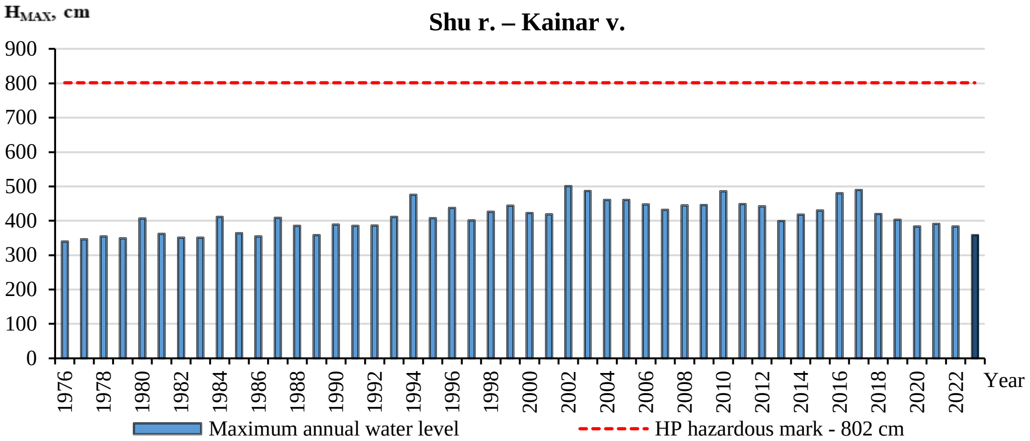
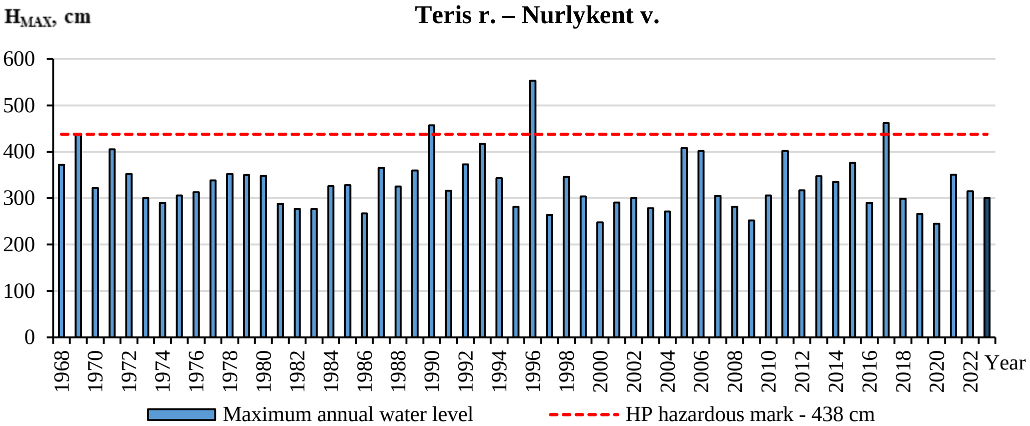
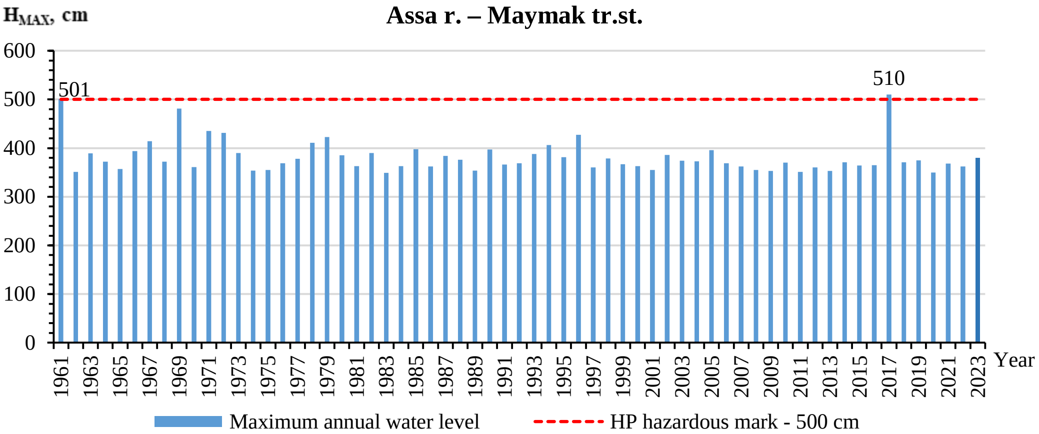
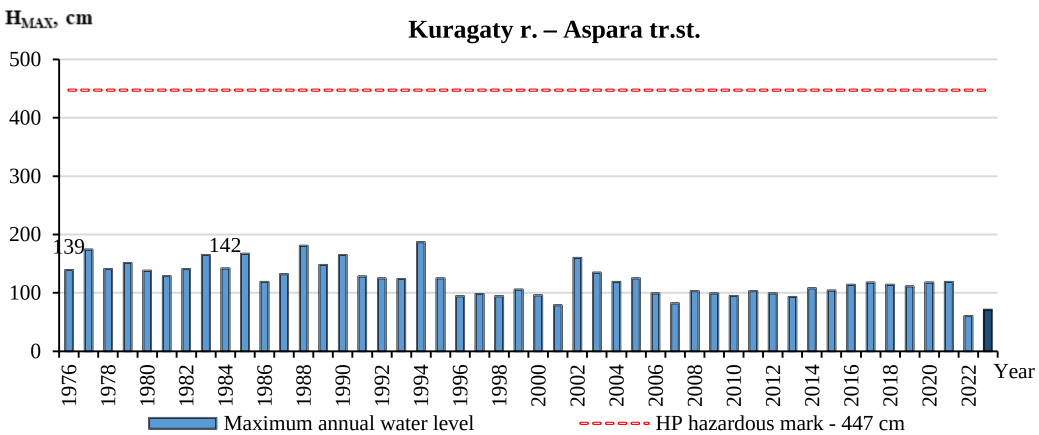


Figure 5 – Maximum water levels and hazardous mark on the main rivers of the Esil WMB


H_MAX, cm
Shu r. – Kainar v.
Year
Maximum annual water level
HP hazardous mark - 802 cm


H_MAX, cm
Teris r. – Nurlykent v.
Year
Maximum annual water level
HP hazardous mark - 438 cm


H_MAX, cm
Assa r. – Maymak tr.st.
501
510
Year
Maximum annual water level
HP hazardous mark - 500 cm


H_MAX, cm
Kuragaty r. – Aspara tr.st.
139
142
Year
Maximum annual water level
HP hazardous mark - 447 cm

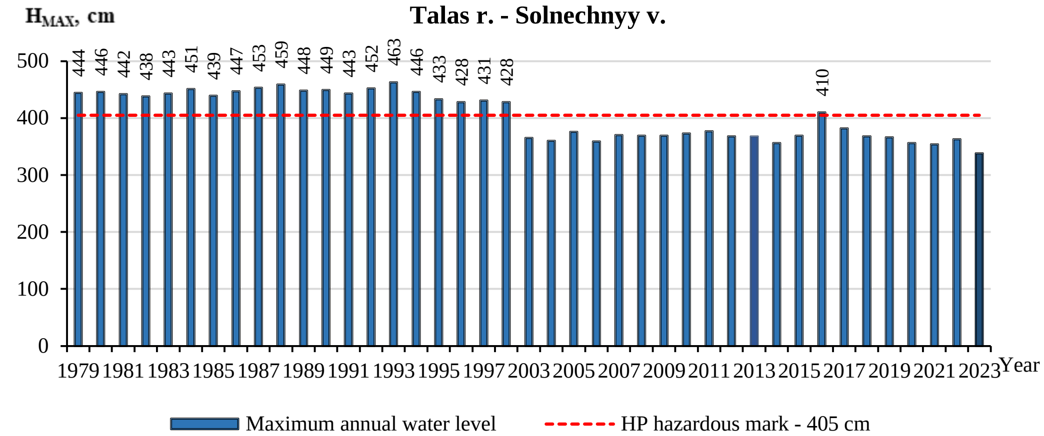
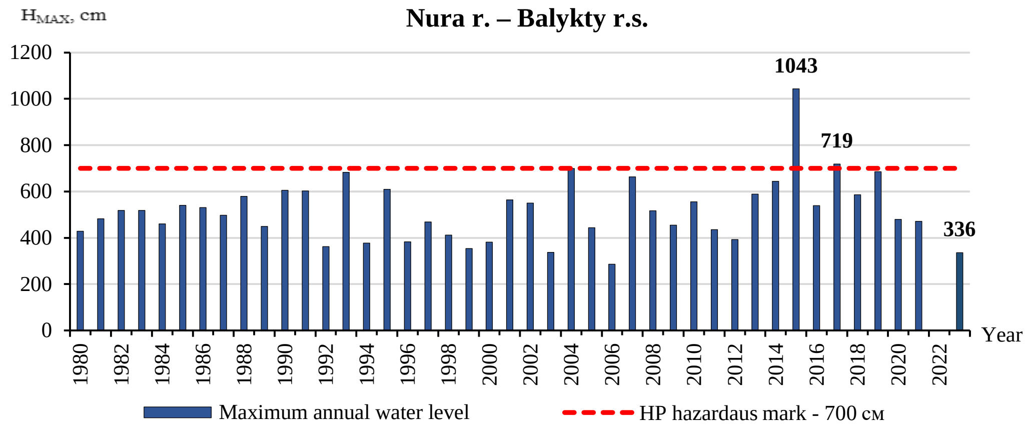
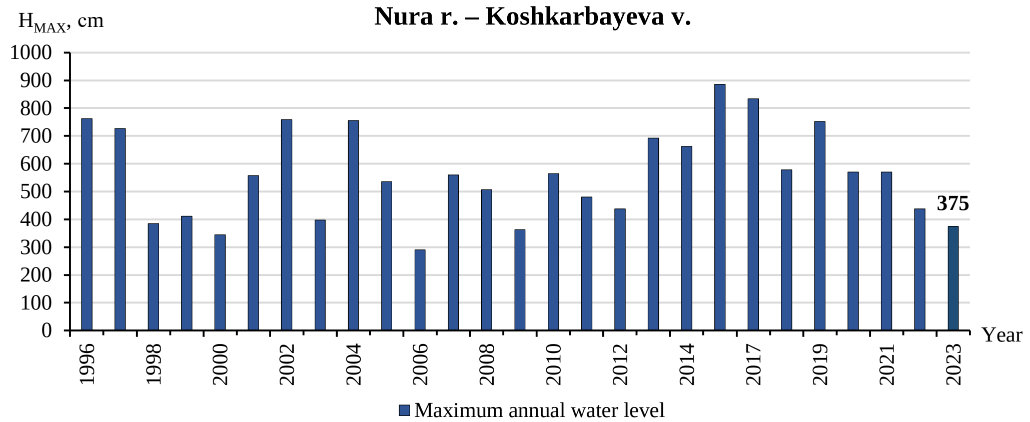


Figure 6 – Maximum water levels and hazardous mark on the main rivers of the Shu-Talas WMB





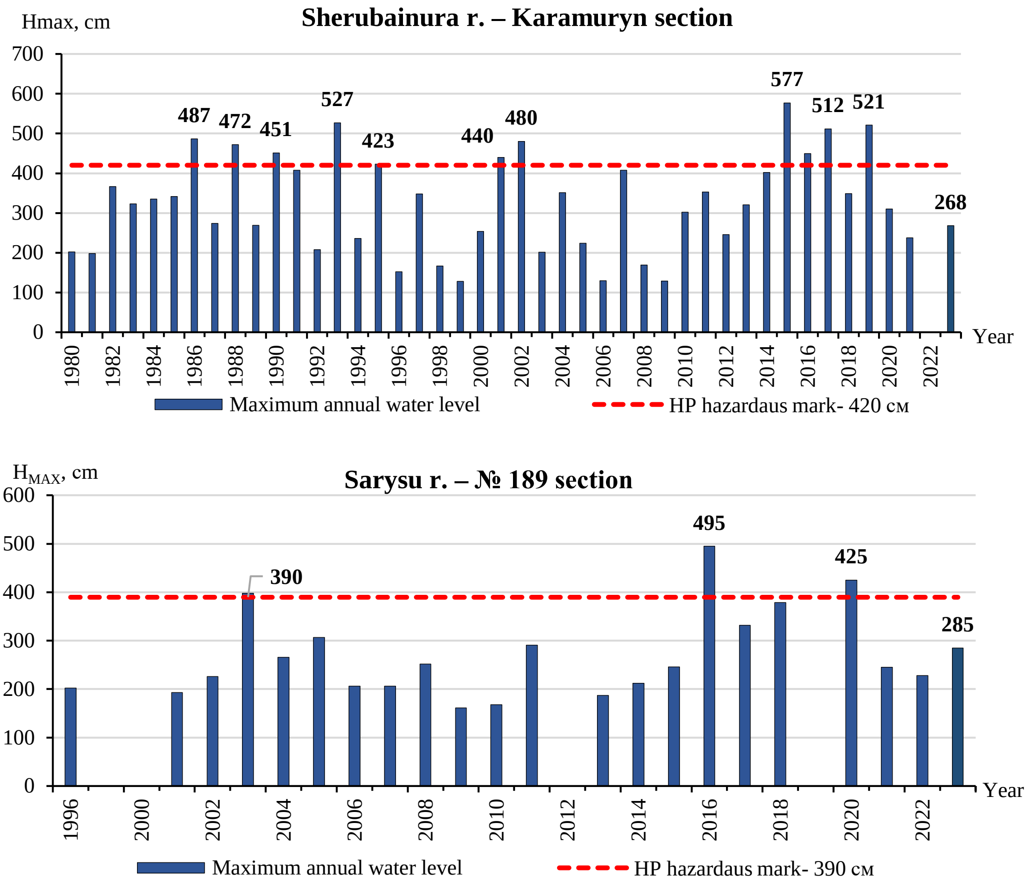
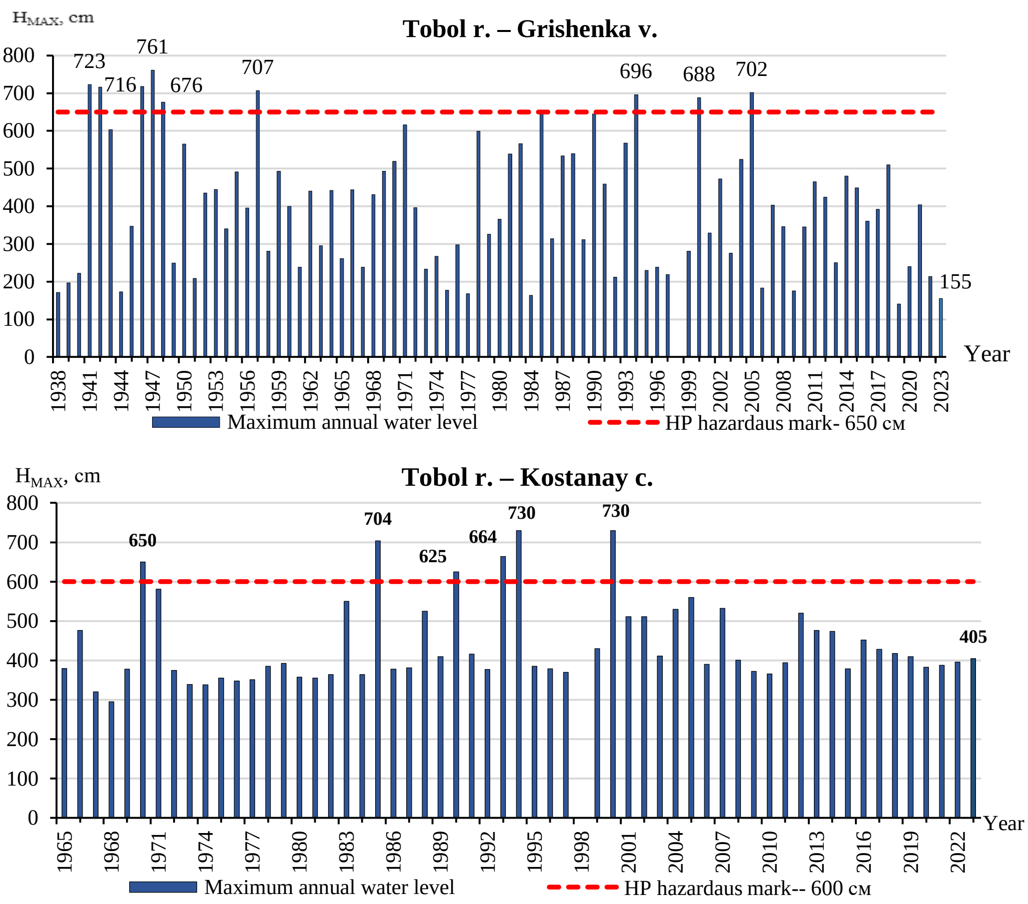


Figure 7 – Maximum water levels and danger level on the main rivers of the Nura-Sarysu WMB



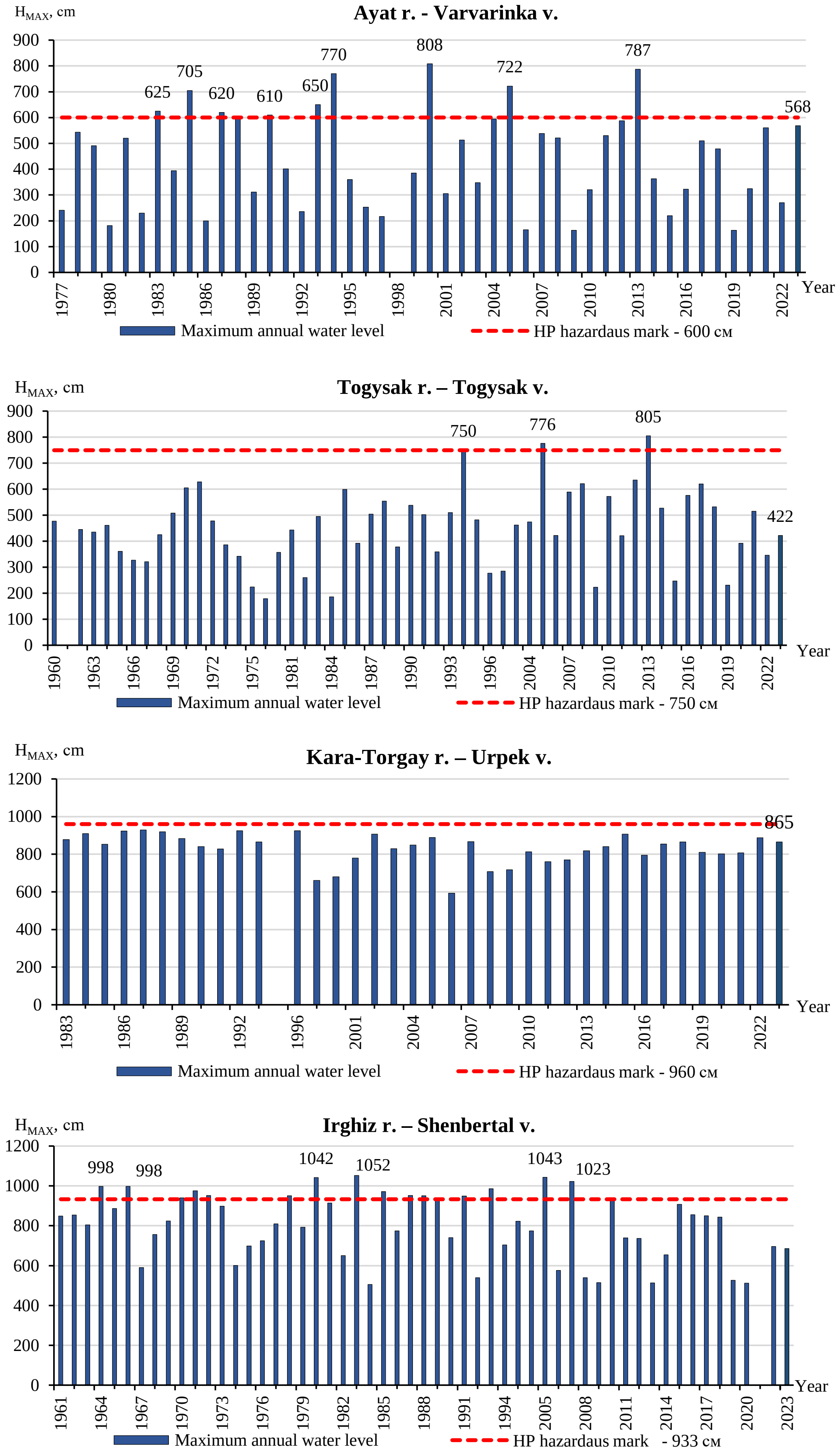
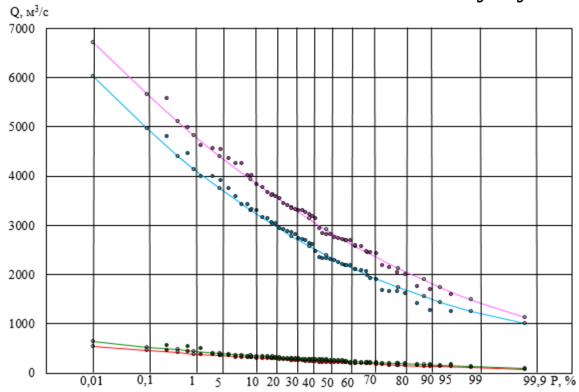
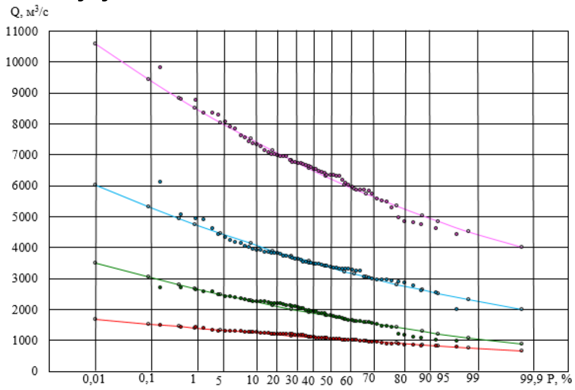


Figure 8 – Maximum water levels and danger level on the main rivers of the Tobol-Torgay WMB

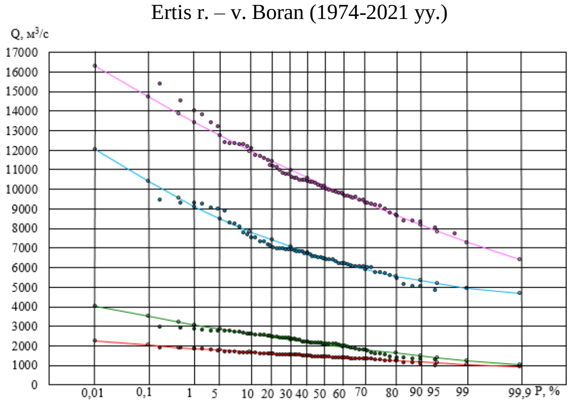
Curves of observed runoff reliability by seasons and by year for the main rivers of the WMB



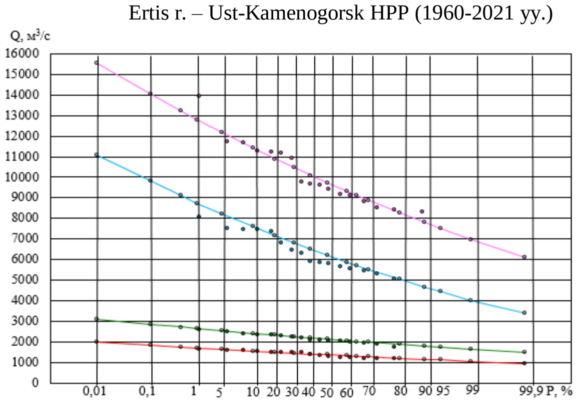
Ertis r. – v. Boran (1974-2021 yy.)



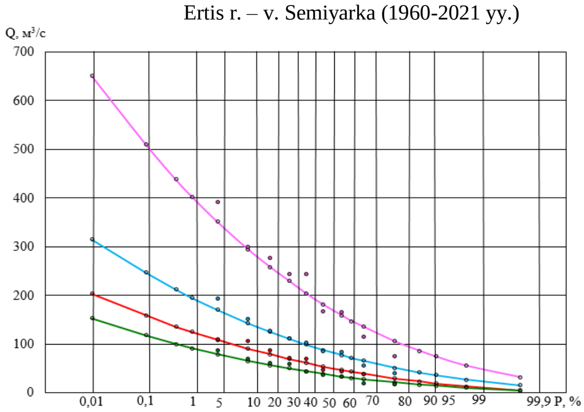
Ertis r. – Ust-Kamenogorsk HPP (1960-2021 yy.)



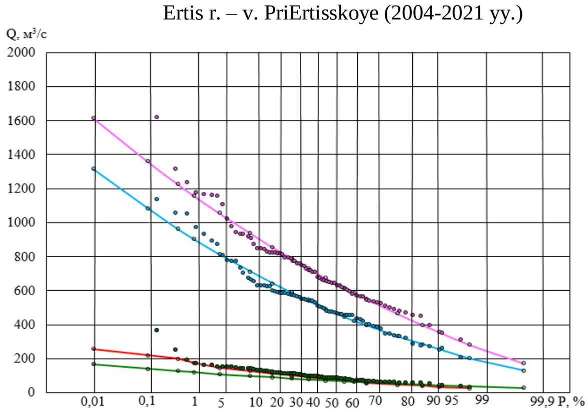
Ertis r. – v. Semiyarka (1960-2021 yy.)



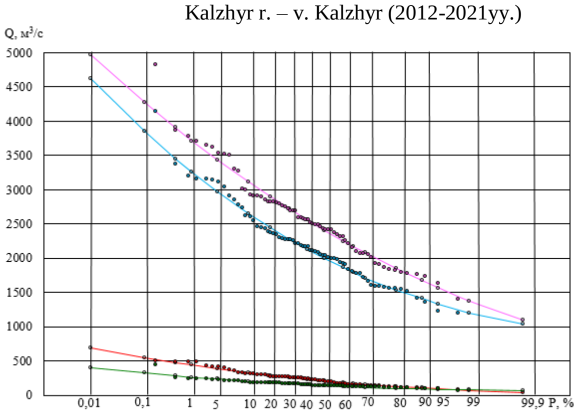
Ertis r. – v. PriErtisskoye (2004-2021 yy.)



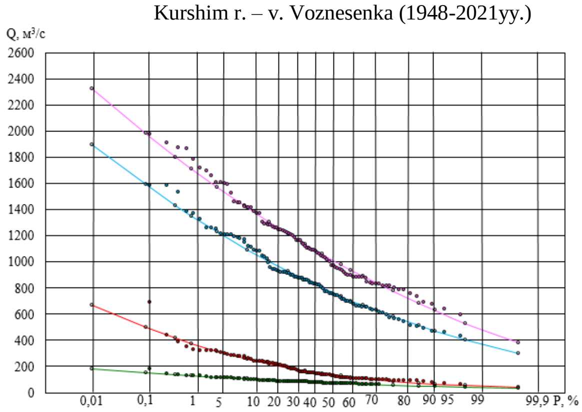
Kalzhyr r. – v. Kalzhyr (2012-2021yy.)



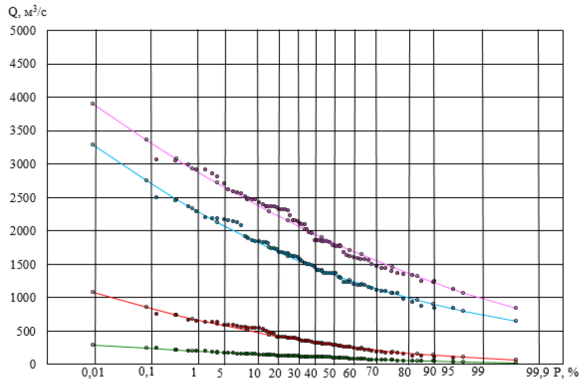
Kurshim r. – v. Voznesenka (1948-2021yy.)



Bukhtarma r. – v. Lesnaya Pristan (1955-2021 yy.)



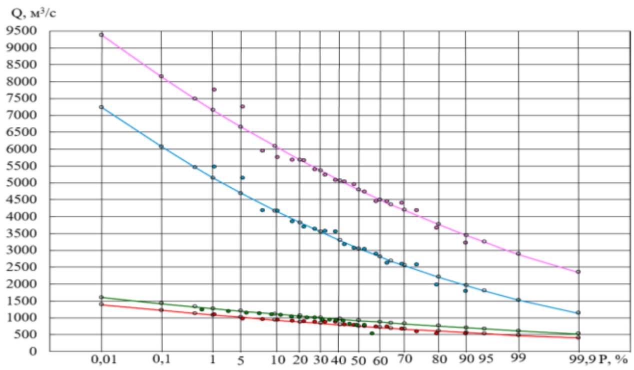
Ulbi r. – v. Ulbi Perevalochnaya (1930-2021 yy.)



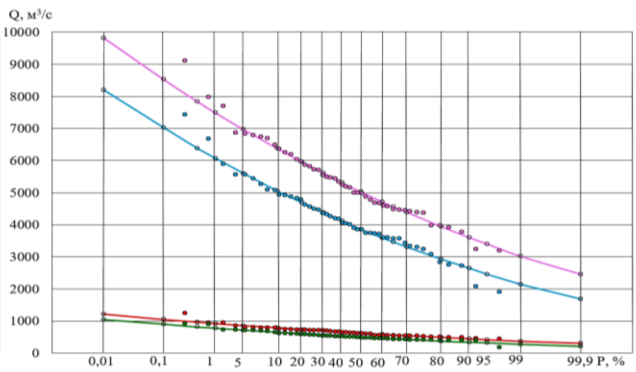
Oba r. – city Shemonaikha (1954-2021 yy..)

- Qav., m3/s (year)
- Qav., m3/s (spring-summer)
- Qav., m3/s (autumn)
- Qav., m3/s (winter)
- Qav., м3/с (calculated values) (year)
- Qav., m3/s (calculated values) (spring-summer)
- Qav., m3/s (calculated values) (autumn)
- Qav., m3/s (calculated values) (winter)

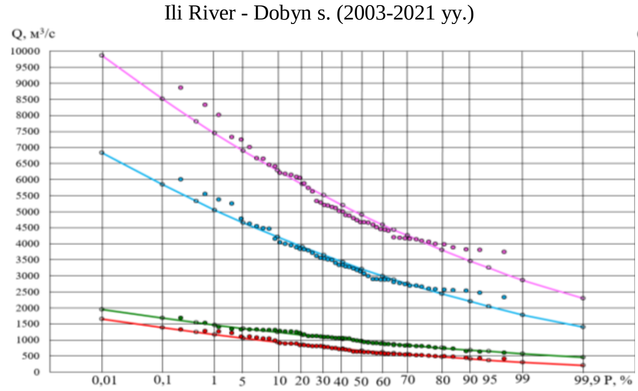
Figure 1 – Curves of observed runoff reliability by seasons and by year for the main rivers of the Ertis WMB



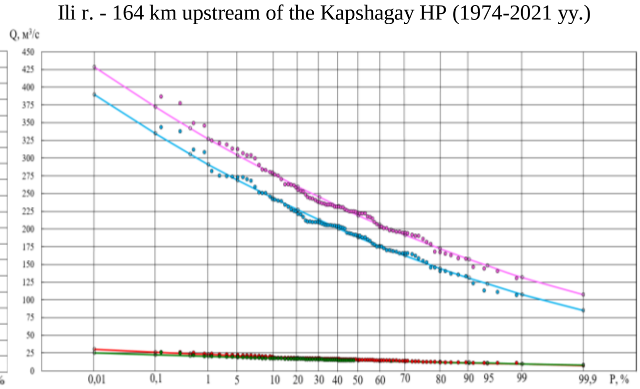
Ili River - Dobyn s. (2003-2021 yy.)



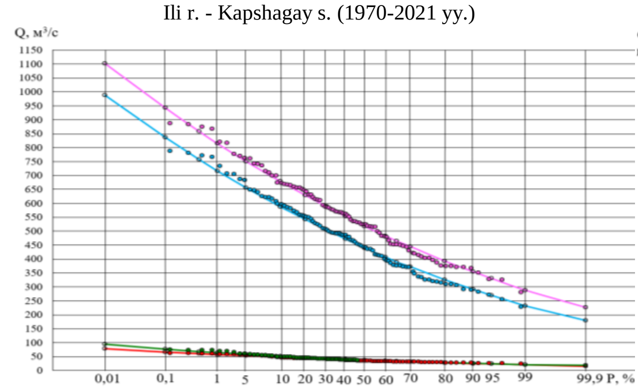
Ili r. - 164 km upstream of the Kapshagay HP (1974-2021 yy.)



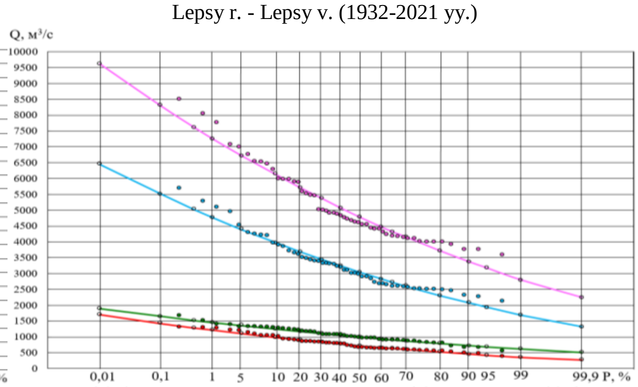
Ili r. - Kapshagay s. (1970-2021 yy.)



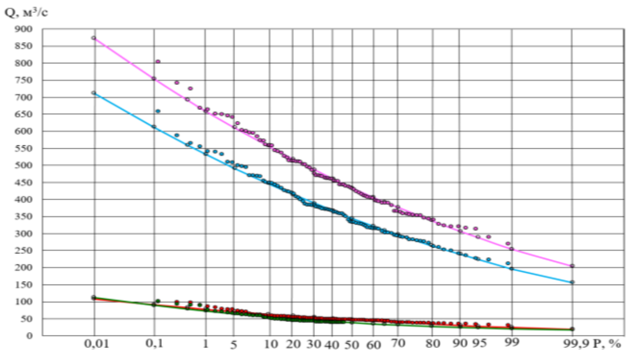
Lepsy r. - Lepsy v. (1932-2021 yy.)



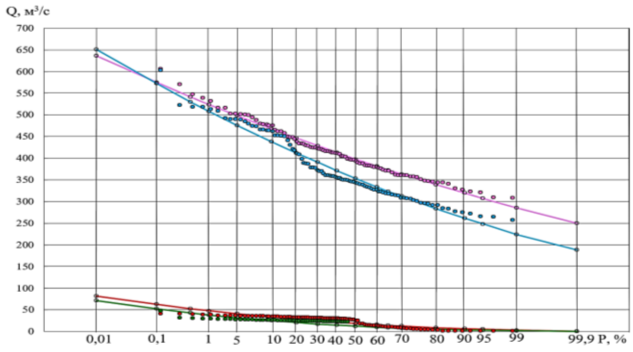
Tentek r. - Tonkeris v. (1930-2021 yy.)



Ili r. - Ushzharma v. (1970-2021 yy.)



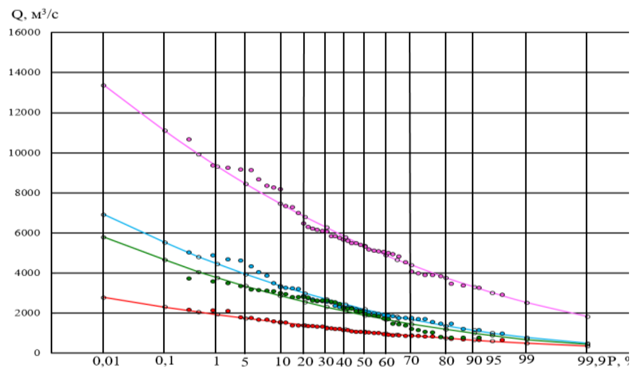
Charyn r. - Sarytogay s. (1929-2021 yy.)



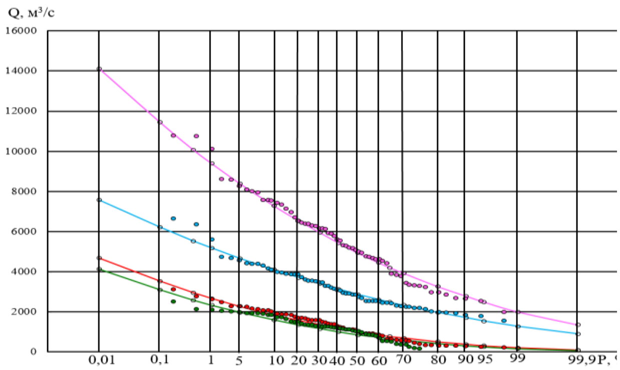
Chilik r. - Malybay v. (1929-2021 yy.)

Qav., m3/s (year)
Qav., m3/s (spring-summer)
Qav., m3/s (autumn)
Qav., m3/s (winter)
Qav., м3/c (calculated values) (year)
Qav., m3/s (calculated values) (spring-summer)
Qav., m3/s (calculated values) (autumn)
Qav., m3/s (calculated values) (winter)

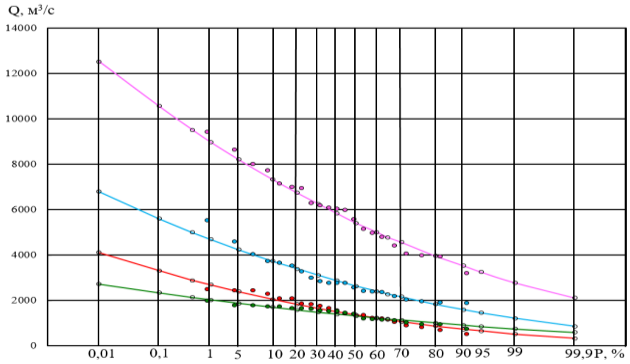
Figure 2 – Curves of observed runoff reliability by seasons and by year for the main rivers of the Balkhash-Alakol WMB



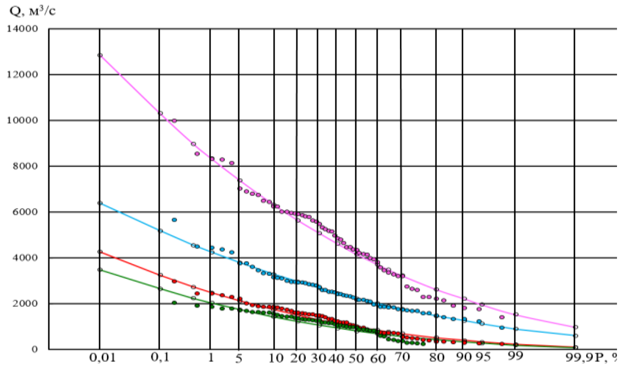
Syrdarya r. – upstream of the mouth of Keles r/



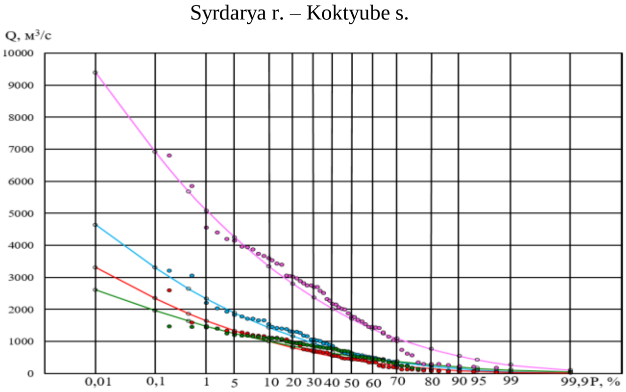
Syrdarya r. – lower reach of the Shardara reservoir



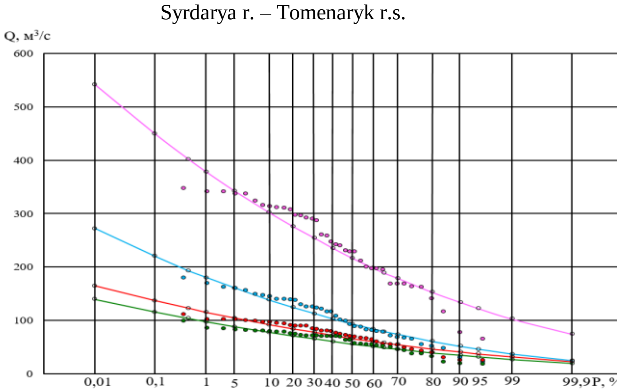
Syrdarya r. – Koktyube s.



Syrdarya r. – Tomenaryk r.s.



Syrdarya r. – Kazaly c.



Keles r. – estuary

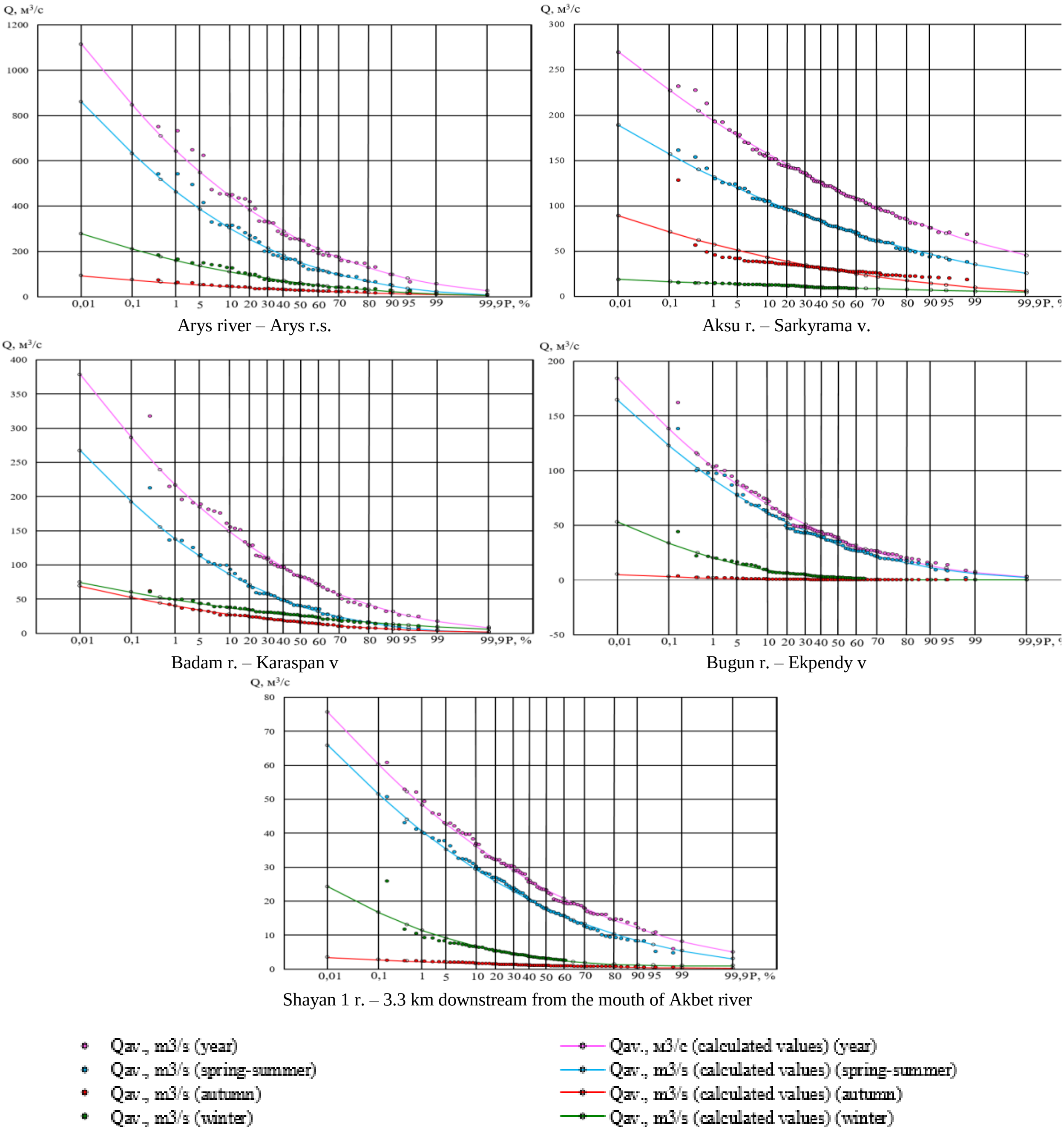
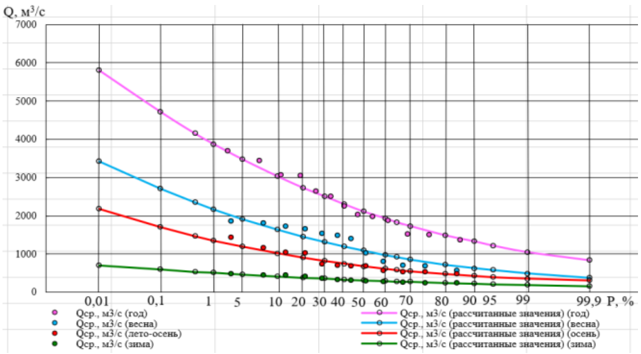
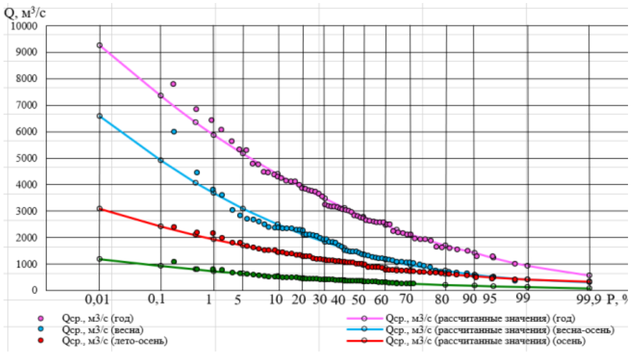


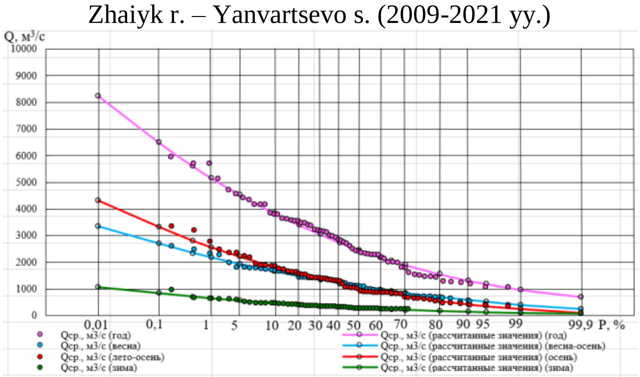
Figure 3 – Curves of observed runoff reliability by seasons and by year for the main rivers of the Aral-Syrdarya WMB



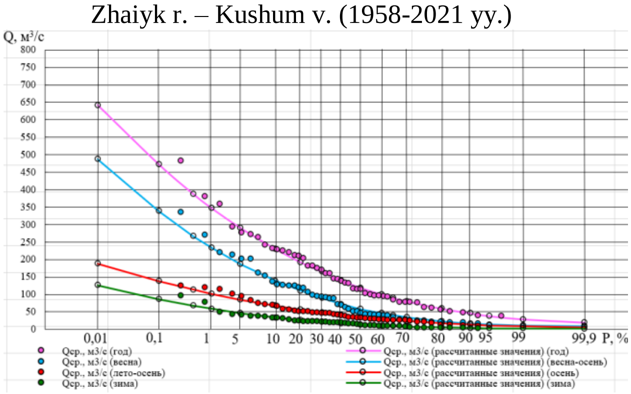
Zhaiyk r. – Yanvartsevo s. (2009-2021 yy.)



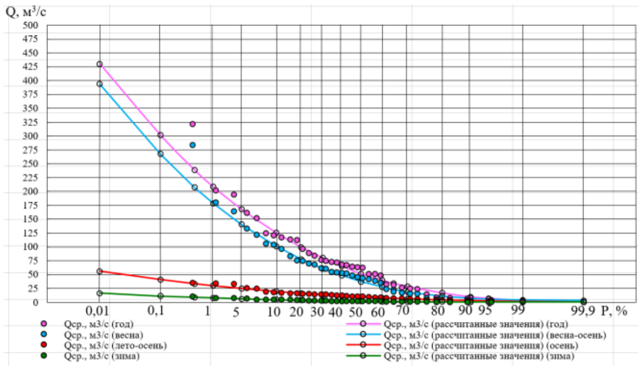
Zhaiyk r. – Kushum v. (1958-2021 yy.)



Zhaiyk r. – Makhamet s. (1958-2021 yy.)



Ilek r. – Aktobe c. (1975-2021 yy.)



Uil r.– Uil v. (1986-2021 yy.)

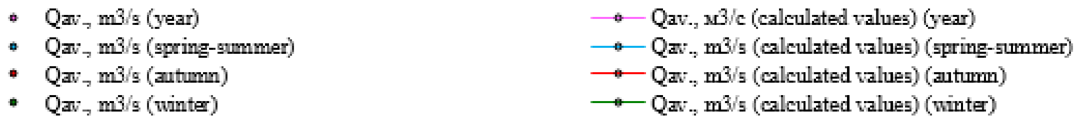


Figure 4 – Curves of observed runoff reliability by seasons and by year for the main rivers of the Zhaiyk-Caspian WMB

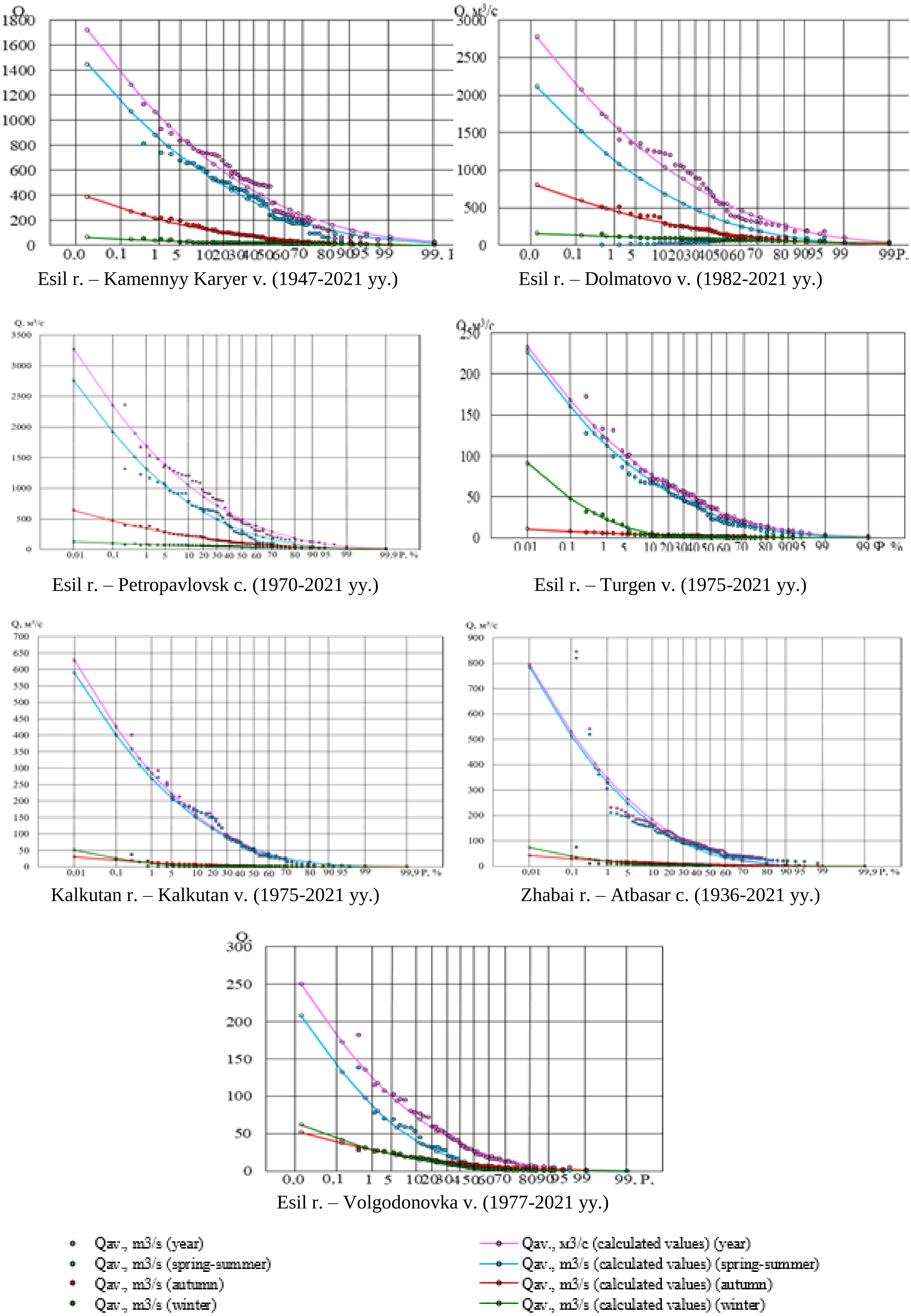
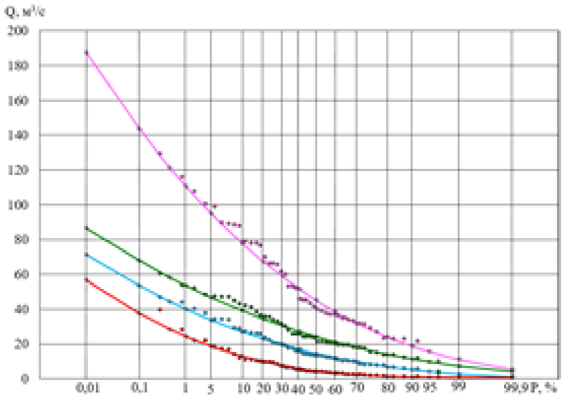
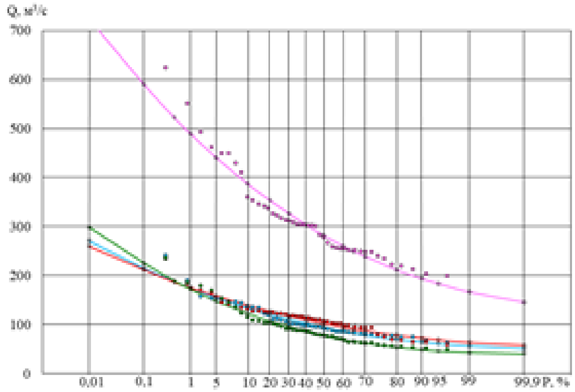


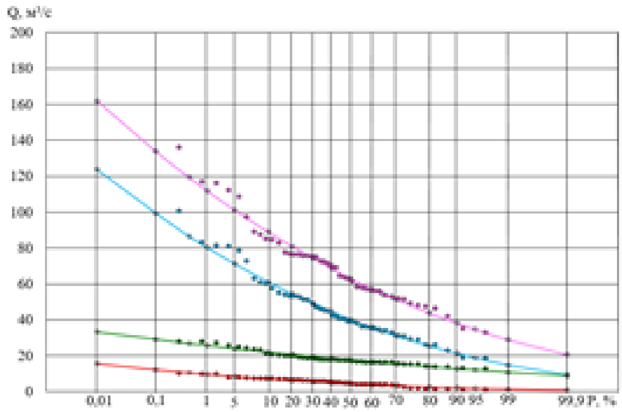
Figure 5 – Curves of observed runoff reliability by seasons and by year for the main rivers of the Esil WMB



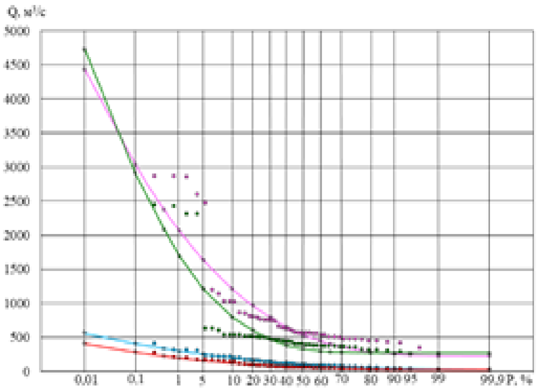
Kuragaty r. – Aspara tr.st. (1977-2021 yy.)



Talas r. – Solnechny s. (1977-2021 yy.)



Teris r. – Nurlykent v. (1976-2021 yy.)



Shu r. – Kainar v. (1976-2021 yy.)

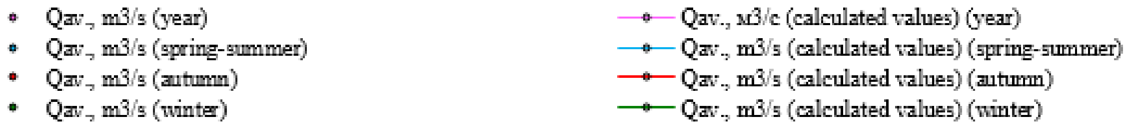


Figure 6 – Curves of observed runoff reliability by seasons and by year for the main rivers of the Shu-Talas WMB

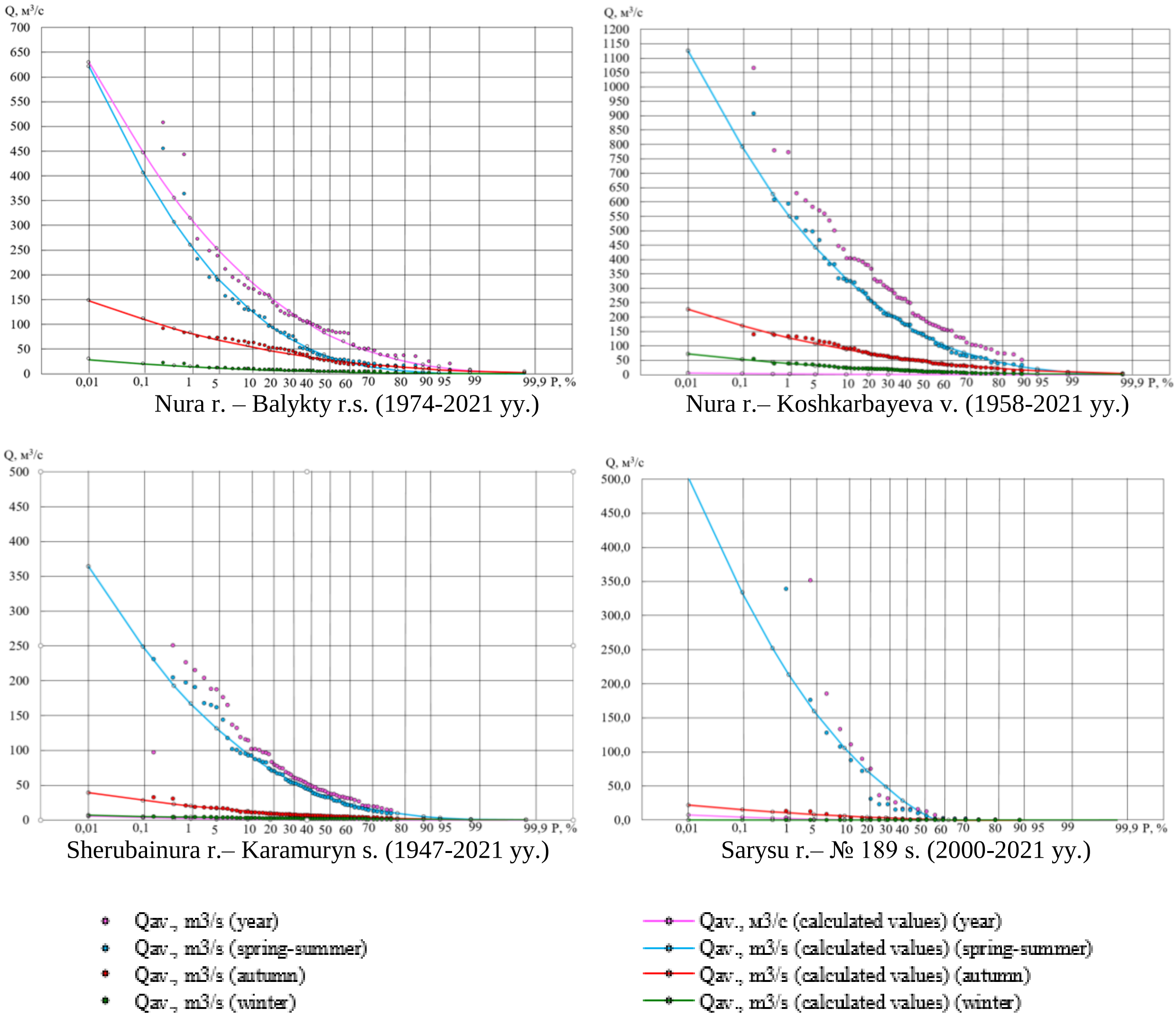
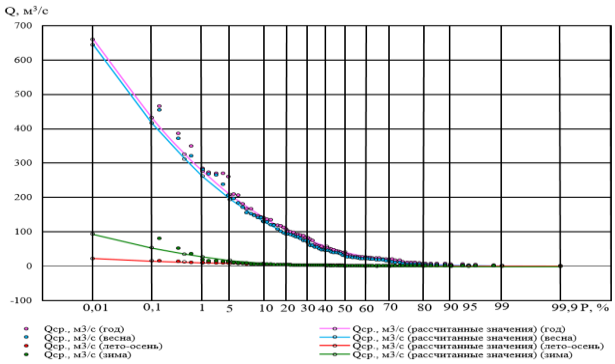
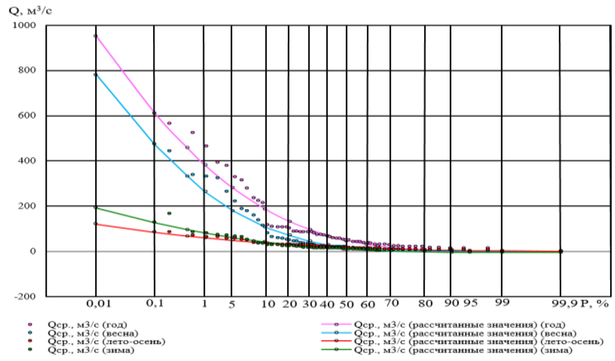


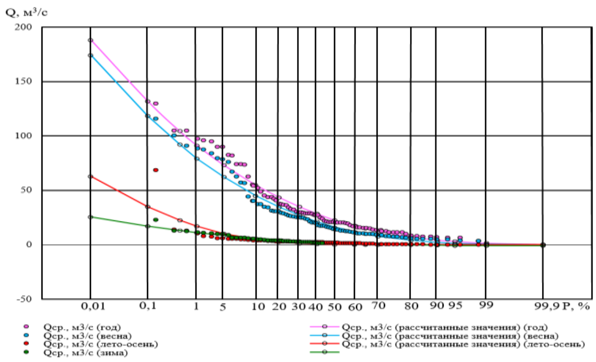
Figure 7 – Curves of observed runoff reliability by seasons and by year for the main rivers of the Nura-Sarysu WMB



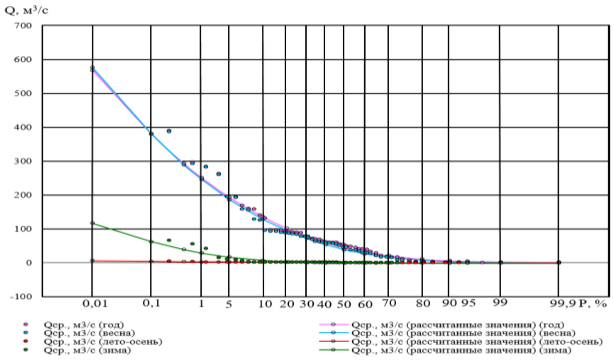
Tobol r. – Grishenka v. (1938-2021 yy.)



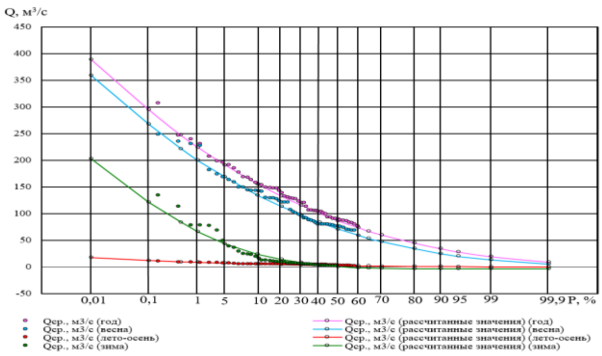
Tobol r. – Kostanay c. (1964-2021 yy.)



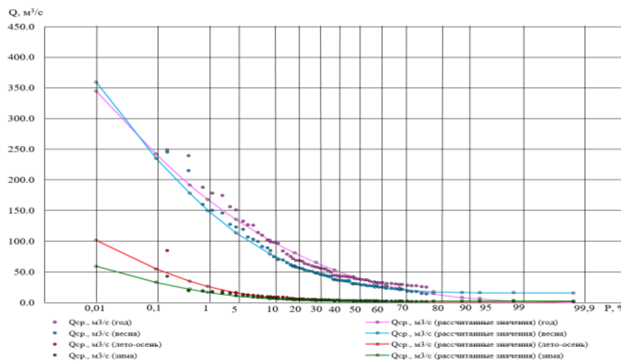
Togysak r. – Toguzak v. (1940-2021 yy.)



Irghiz r. – Shenbertal v. (1962-2021 yy.)



Kara-Torgay r. – Urpek v. (1947-2021 yy.)



Ayat r. – Varvarinka v. (1952-2021 yy.)

- Qav., m3/s (year)
- Qav., m3/s (spring-summer)
- Qav., m3/s (autumn)
- Qav., m3/s (winter)
- Qav., м3/с (calculated values) (year)
- Qav., m3/s (calculated values) (spring-summer)
- Qav., m3/s (calculated values) (autumn)
- Qav., m3/s (calculated values) (winter)

Figure 8 – Curves of observed runoff reliability by seasons and by year for the main rivers of the Tobol-Torgay WMB

APPENDIX D

Table 1 – Statistical characteristics and total discharges of different reliability levels for the main rivers of the Ertis WMB

Observation period	YEAR					Non-limiting period					Limiting period									
											Non-limiting season					Limiting season				
						SPRING–SUMMER					AUTUMN					WINTER				
	Cv	Q	Monthly water discharge totals, m^3/s			Cv	Q	Monthly water discharge totals, m^3/s			Cv	Q	Monthly water discharge totals, m^3/s			Cv	Q	Monthly water discharge totals, m^3/s		
			75%	50%	25%			75%	50%	25%			75%	50%	25%			75%	50%	25%
Ertis r. – v. Boran																				
1974-2021	0,28	3213	2524	3144	3789	0,30	2673	2107	2628	3161	0,30	251	203	234	299	0,30	288	214	282	329
Ertis r. – Ust-Kamenogorsk HPP																				
1960-2021	0,16	6634	5879	6558	7362	0,18	3596	3263	3494	3882	0,15	1111	992	1104	1229	0,22	1927	1625	1960	2251
Ertis r. – v. Semiyarka																				
1960-2021	0,15	10650	9396	10413	11625	0,17	6928	6114	6708	7431	0,14	1497	1365	1505	1620	0,22	2225	1918	2200	2574
Ertis r. – v. PriErtisskoye																				
2004-2021	0,15	10172	8773	9968	11303	0,19	6567	5561	6283	7457	0,12	1411	1229	1495	1524	0,12	2194	1983	2190	2322
Kalzhyr r. – v. Kalzhyr																				
2012-2021	0,45	219	119	216	281	0,45	106	59,3	103	129	0,48	65,9	38,6	69,9	89,4	0,49	47,6	21,3	43,0	62,3
Kurshim r. – v. Voznesenka																				
1948-2021	0,31	750	589	723	863	0,34	560	446	549	633	0,42	134	97,2	122	166	0,25	55,4	45,9	52,4	64,6
Bukhtarma r. – v. Lesnaya Pristan																				
1955-2021	0,24	2608	2078	2553	2920	0,26	2205	1800	2166	2441	0,43	243	152	237	295	0,33	161	125	151	184
Ulbi r. – v. Ulbi Perevalochnaya																				
1930-2021	0,27	1158	868	1098	1417	0,29	887	692	858	1081	0,52	187	108	157	240	0,28	84,6	67,9	82,2	95,8
Oba r. – city Shemonaikha																				
1954-2021	0,24	2061	1569	1982	2523	0,27	1563	1228	1518	1837	0,43	379	255	349	539	0,37	119	85,6	116	147

Table 2 – Seasonal water volumes at the main hydrological stations of the Ertis WMB for 2021–2024

Year	Unit of meas.	SPRING–SUMMER						∑(SPRING–SUMMER)	AUTUMN		∑(AUTUMN)	WINTER				∑(WINTER)	ANNUAL TOTAL
		IV	V	VI	VII	VIII	IX		X	XI		XII	I	II	III		
Ertis r. – v. Boran																	
2021-2022	m^3/s	75 % low-water							50 % average water			25 % high-water					75 % low-water
		259	477	641	242	155	160	1934	127	97,6	225	66,7	74,6	58,8	151	351	2510
	%	10,3	19,0	25,5	9,64	6,18	6,38	77,1	5,06	3,89	8,95	2,66	2,97	2,34	6,02	14,0	100
2022-2023	m3/s	75 % low-water							75 % low-water			50 % average water					75 % low-water
		253	557	531	165	131	73,4	1710	65,8	75,3	141	44,2	52,8	72,2	95,2	264	2116

Year	Unit of meas.	SPRING–SUMMER						∑(SPRING–SUMMER)	AUTUMN		∑(AUTUMN)	WINTER				∑(WINTER)	ANNUAL TOTAL
		IV	V	VI	VII	VIII	IX		X	XI		XII	I	II	III		
	%	12,0	26,3	25,1	7,80	6,19	3,47	80,8	3,11	3,56	6,67	2,09	2,50	3,41	4,50	12,5	100
2023-2024	m^3/s	50 % average water							25 % high-water			25 % high-water					50 % average water
		141	471	912	311	204	215	2254	239	222	461	110	113	89,9	105	418	3133
	%	4,50	15,0	29,1	9,93	6,51	6,86	71,9	7,63	7,09	14,7	3,51	3,61	2,87	3,35	13,3	100
Ertis r. – Ust-Kamenogorsk HPP																	
2021-2022	m^3/s	25 % high-water							50 % average water			50 % average water					25 % high-water
		636	724	597	584	628	629	3798	662	530	1192	551	589	565	430	2135	7125
	%	8,93	10,2	8,38	8,20	8,81	8,83	53,3	9,29	7,44	16,7	7,73	8,27	7,93	6,04	30,0	100
2022-2023	m^3/s	75 % low-water							25 % high-water			50 % average water					50 % average water
		531	451	487	528	556	613	3166	648	566	1214	579	520	433	418	1950	6330
	%	8,39	7,12	7,69	8,34	8,78	9,68	50,0	10,2	8,94	19,2	9,15	8,21	6,84	6,60	30,8	100
2023-2024	m^3/s	75 % low-water							75 % low-water			50 % average water					75 % low-water
		399	428	446	558	558	534	2923	509	461	970	488	522	551	484	2045	5938
	%	6,72	7,21	7,51	9,40	9,40	8,99	49,2	8,57	7,76	16,3	8,22	8,79	9,28	8,15	34,4	100
Ertis r. – v. Semiyarka																	
2021-2022	50 % average water								50 % average water			25 % high-water					50 % average water
	m^3/s	1030	2270	720	772	766	770	6328	796	706	1502	664	652	655	657	2628	10458
	%	9,85	21,7	6,88	7,38	7,32	7,36	60,5	7,61	6,75	14,4	6,35	6,23	6,26	6,28	25,1	100
2022-2023	75 % low-water								75 % low-water			50 % average water					75 % low-water
	m^3/s	1590	1160	801	753	764	743	5811	716	684	1400	660	593	560	605	2418	9629
	%	16,5	12,0	8,32	7,82	7,93	7,72	60,3	7,44	7,10	14,5	6,85	6,16	5,82	6,28	25,1	100
2023-2024	75 % low-water								25 % high-water			25 % high-water					75 % low-water
	m^3/s	1360	1070	807	724	724	745	5430	878	839	1717	675	635	621	663	2594	9741
	%	14,0	11,0	8,28	7,43	7,43	7,65	55,7	9,01	8,61	17,6	6,93	6,52	6,38	6,81	26,6	100
Ertis r. – v. PriErtisskoye																	
2021-2022	25 % high-water								50 % average water			50 % average water					50 % average water
	m^3/s	1160	2410	1450	712	694	689	7115	728	596	1324	496	585	584	580	2245	10684
	%	10,9	22,6	13,6	6,66	6,50	6,45	66,6	6,81	5,58	12,4	4,64	5,48	5,47	5,43	21,0	100
2022-2023	50 % average water								75 % low-water			50 % average water					75 % low-water
	m^3/s	1130	1670	847	687	679	679	5692	678	560	1238	424	584	543	567	2118	9048
	%	12,5	18,5	9,36	7,59	7,50	7,50	62,9	7,49	6,19	13,7	4,69	6,45	6,0	6,27	23,4	100

Year	Unit of meas.	SPRING–SUMMER						∑(SPRING–SUMMER)	AUTUMN		∑(AUTUMN)	WINTER				∑(WINTER)	ANNUAL TOTAL
		IV	V	VI	VII	VIII	IX		X	XI		XII	I	II	III		
2023-2024	75 % low-water								25 % high-water			75 % low-water					50 % average water
	m^3/s	1070	1540	943	676	658	670	5557	840	879	1719	403	637	656	695	2391	9667
	%	11,1	15,9	9,75	6,99	6,81	6,93	57,5	8,69	9,09	17,8	4,17	6,59	6,79	7,19	24,7	100
Bukhtarma r. – v. Lesnaya Pristan																	
2021-2022	75 % low-water								75 % low-water			25 % high-water					75 % low-water
	m^3/s	204	787	427	215	160	119	1912	97,8	71,3	169	67,6	39,0	43,7	62,3	213	2294
	%	8,89	34,3	18,6	9,37	6,98	5,19	83,4	4,26	3,11	7,37	2,95	1,70	1,91	2,72	9,27	100
2022-2023	75 % low-water								50 % average water			50 % average water					75 % low-water
	m^3/s	428	785	342	139	103	92,8	1890	93,0	80,9	174	48,8	21,5	24,0	69,4	164	2227
	%	19,2	35,2	15,3	6,24	4,62	4,17	84,8	4,18	3,63	7,81	2,19	0,97	1,08	3,12	7,35	100
2023-2024	50 % average water								25 % high-water			25 % high-water					25 % high-water
	m^3/s	254	790	655	186	156	187	2228	230	194	424	75,3	39,8	36,0	52,6	204	2856
	%	8,89	27,7	22,9	6,51	5,46	6,55	78,0	8,05	6,79	14,8	2,64	1,39	1,26	1,84	7,13	100

YEAR	Unit of meas.	SPRING–SUMMER				∑(SPRING–SUMMER)	AUTUMN				∑(AUTUMN)	WINTER				∑(WINTER)	ANNUAL TOTAL
		IV	V	VI	VII		VIII	IX	X	XI		XII	I	II	III		
Kalzhyr r. – v. Kalzhyr																	
		50 % average water					50 % average water					25 % high-water					50 % average water
2021-2022	m^3/s	25,3	34,3	21,9	19,8	101	16,6	14,9	15,0	15,0	61,5	15,6	13,6	15,6	20,7	65,5	228
	%	11,1	15,0	9,59	8,67	44,4	7,27	6,53	6,57	6,57	26,9	6,83	5,96	6,83	9,07	28,7	100
		25 % high-water					25 % high-water					75 % low-water					25 % high-water
2022-2023	m^3/s	40,0	44,5	32,7	24,4	142	19,7	19,8	20,6	22,3	82,4	17,7	8,14	2,77	3,72	32,3	256
	%	15,6	17,4	12,8	9,52	55,2	7,69	7,72	8,04	8,70	32,1	6,91	3,18	1,08	1,45	12,6	100
		75 % low-water					50 % average water					50 % average water					75 % low-water
2023-2024	m^3/s	11,3	21,3	15,0	10,1	57,7	9,74	10,5	12,5	19,7	52,4	14,0	11,2	8,50	6,97	40,7	151
	%	7,49	14,1	9,95	6,70	38,3	6,46	6,96	8,29	13,1	34,8	9,28	7,43	5,64	4,62	27,0	100
Kurshim r. – v. Voznesenka																	
		25 % high-water					50 % average water					25 % high-water					25 % high-water
2021-2022	m^3/s	84,0	317	135	74,3	610	47,4	34,7	39,5	22,9	145	23,7	16,4	14,2	12,3	66,6	821
	%	10,2	38,6	16,4	9,05	74,3	5,77	4,22	4,81	2,79	17,6	2,89	2,00	1,73	1,50	8,11	100
		25 % high-water					50 % average water					25 % high-water					25 % high-water
2022-2023	m^3/s	118	329	119	66,6	633	35,7	25,4	24,8	26,9	113	32,1	12,1	14,4	20,4	79,0	824
	%	14,3	39,9	14,4	8,08	76,7	4,33	3,08	3,01	3,26	13,7	3,89	1,47	1,75	2,47	9,58	100

YEAR	Unit of meas.	SPRING–SUMMER				∑(SPRING–SUMMER)	AUTUMN				∑(AUTUMN)	WINTER				∑(WINTER)	ANNUAL TOTAL
		IV	V	VI	VII		VIII	IX	X	XI		XII	I	II	III		
2023-2024		75 % low-water					25 % high-water					25 % high-water					50 % average water
	m^3/s	27,6	119	140	77,0	364	44,1	46,1	80,9	92,4	264	41,8	30,5	22,6	19,2	114	741
	%	3,72	16,1	18,9	10,4	49,1	5,95	6,22	10,9	12,5	35,6	5,64	4,11	3,05	2,59	15,4	100
Ulbi r. – v. Ulbi Perevalochnaya																	
2021-2022		75 % low-water					75 % low-water					25 % high-water					75 % low-water
	m^3/s	225	253	73,7	29,2	581	18,8	13,2	19,3	19,7	71,0	20,2	15,3	15,3	18,0	68,8	721
	%	31,2	35,1	10,2	4,05	80,6	2,61	1,83	2,68	2,73	9,85	2,80	2,12	2,12	2,50	9,55	100
2022-2023		75 % low-water					75 % low-water					50 % average water					75 % low-water
	m^3/s	306	282	66,0	22,9	677	15,1	12,9	15,4	20,8	64,2	15,1	14,0	14,8	41,4	85,3	826
	%	37,0	34,1	7,99	2,77	81,9	1,83	1,56	1,86	2,52	7,77	1,83	1,69	1,79	5,01	10,3	100
2023-2024		75 % low-water					25 % high-water					50 % average water					50 % average water
	m^3/s	179	361	128	25,9	694	31,7	49,7	83,2	96,7	261	23,0	18,1	9,47	22,1	72,7	1028
	%	17,4	35,1	12,5	2,52	67,5	3,08	4,84	8,09	9,41	25,4	2,24	1,76	0,92	2,15	7,07	100
Oba r. – Shemonaikha c.																	
2021-2022		75 % low-water					75 % low-water					75 % low-water					75 % low-water
	m^3/s	405	609	193	60,4	1267	39,6	29,9	57,3	15,1	142	10,1	17,3	16,1	43,7	87,2	1497
	%	27,1	40,7	12,9	4,04	84,7	2,65	2,00	3,83	1,01	9,48	0,67	1,16	1,08	2,92	5,83	100
2022-2023		50 % average water					75 % low-water					50 % average water					75 % low-water
	m^3/s	628	503	174	62,1	1367	45,6	20,2	38,1	42,6	147	23,4	20,0	14,6	54,4	112	1626
	%	38,6	30,9	10,7	3,82	84,1	2,80	1,24	2,34	2,62	9,01	1,44	1,23	0,90	3,35	6,91	100
2023-2024		75 % low-water					25 % high-water					25 % high-water					50 % average water
	m^3/s	315	653	223	62,7	1254	132	177	279	210	798	67,4	29,7	10,7	41,5	149	2201
	%	14,3	29,7	10,1	2,85	57,0	6,00	8,04	12,7	9,54	36,3	3,06	1,35	0,49	1,89	6,78	100

Table 3 – Statistical characteristics and total discharges of different reliability levels for the main rivers of the **Balkhash–Alakol WMB**

Observation period	YEAR					Non-limiting period					Limiting period									
											Non-limiting season					Limiting season				
						SPRING–SUMMER					AUTUMN					WINTER				
	Cv	Q	Monthly water discharge totals, m^3/s			Cv	Q	Monthly water discharge totals, m^3/s			Cv	Q	Monthly water discharge totals, m^3/s			Cv	Q	Monthly water discharge totals, m^3/s		
			75%	50%	25%			75%	50%	25%			75%	50%	25%			75%	50%	25%
Ili River - Dobyn s.																				
2003-2021	0.22	5153	4213	5194	5917	0.29	3383	2614	3364	3909	0.20	801	712	828	912	0.18	969	887	1003	1097
Lepsy r. - Lepsy v.																				
1932-2021	0.22	235	197	235	267	0.24	204	169	204	232	0.22	16.5	14.3	16.4	17.9	0.18	15.3	13.6	14.7	16.7

Observation period	YEAR					Non-limiting period					Limiting period									
											Non-limiting season					Limiting season				
						SPRING–SUMMER					AUTUMN					WINTER				
	Cv	Q	Monthly water discharge totals, m³/s			Cv	Q	Monthly water discharge totals, m³/s			Cv	Q	Monthly water discharge totals, m³/s			Cv	Q	Monthly water discharge totals, m³/s		
			75%	50%	25%			75%	50%	25%			75%	50%	25%			75%	50%	25%
Chilik r. - Malybay v.																				
1929-2021	0.15	416	333	409	510	0.20	376	318	355	450	0.55	23.5	10.6	30.4	33.9	0.65	16.9	4.3	23.0	25.4
Ili r. - Kapshagay s.																				
1970-2021	0.23	5293	4197	5092	6094	0.25	3500	2800	3334	3949	0.31	750	556	709	888	0.23	1044	841	1049	1257
Charyn r. - Sarytogay s.																				
1929-2021	0.23	468	379	452	536	0.24	373	302	364	433	0.28	51.6	42.3	47.9	56.8	0.34	43.9	35.2	39.4	46.4
Ili r. - 164 km upstream of the Kapshagay HP																				
1974-2021	0.22	5400	4545	5217	6213	0.25	4201	3570	4053	4874	0.22	664	541	649	739	0.25	535	434	515	600
Ili r. - Ushzharma v.																				
1970-2021	0.23	5158	4103	5012	5883	0.25	3302	2589	3180	3711	0.29	794	613	774	923	0.21	1062	900	1058	1248
Tentek r. - Tonkeris v.																				
1930-2021	0.25	564	441	562	665	0.27	483	377	485	572	0.25	39.6	31.6	37.5	44.6	0.29	41.5	33.0	39.3	48.0

Table 4 – Seasonal water volumes at the main hydrological stations of the **Balkhash-Alakol WMB for 2021-2024**

YEAR	Unit of meas.	SPRING–SUMMER							∑(SPRING–SUMMER)	AUTUMN		∑(AUTUMN)	WINTER			∑(WINTER)	ANNUAL TOTAL
		III	IV	V	VI	VII	VIII	IX		X	XI		XII	I	II		
Ili River - Dobyn s.																	
2021-2022		75 % low-water								50 % average water			75 % low-water				75 %
	m3/s	274	305	426	337	174	221	382	2119	393	439	832	362	265	265	892	3843
	%	7.13	7.94	11.1	8.77	4.53	5.75	9.94	55.1	10.2	11.4	21.6	9.42	6.90	6.90	23.2	100
2022-2023		75 % low-water								75 % low-water			75 % low-water				75 %
	m3/s	263	388	600	448	269	315	333	2616	302	340	642	326	247	286	859	4117
	%	6.39	9.42	14.6	10.9	6.53	7.65	8.09	63.5	7.34	8.26	15.6	7.92	6.00	6.95	20.9	100
2023-2024	m3/s	75 % low-water								50 % average water			75 % low-water				75 %
		343	377	371	345	323	269	404	2432	432	418	850	241	274	274	789	4071
	%	8.43	9.26	9.11	8.47	7.93	6.61	9.92	59.7	10.6	10.3	20.9	5.92	6.73	6.73	19.4	100
Tentek r. - Tonkeris v.																	
2021-2022	m3/s	75 % low-water								75 % low-water			75 % low-water				75 %
		16.2	48.8	71.4	44.4	40.1	29.7	18.5	269	12.6	10.5	23.1	10.4	6.78	6.81	24.0	316
	%	5.13	15.4	22.6	14.1	12.7	9.40	5.85	85.2	3.99	3.32	7.31	3.29	2.15	2.16	7.59	100
2022-2023	m3/s	75 % low-water								75 % low-water			50 % average water				75 %

YEAR	Unit of meas.	SPRING–SUMMER							∑(SPRING–SUMMER)	AUTUMN		∑(AUTU-MN)	WINTER			∑(WIN-TER)	ANNUAL TOTAL
		III	IV	V	VI	VII	VIII	IX		X	XI		XII	I	II		
		12.1	76.1	83.8	66.7	42.3	29.2	16.2	326	12.6	10.7	23.3	9.83	12.3	14.8	37.0	387
	%	3.13	19.7	21.6	17.2	10.9	7.55	4.19	84.3	3.26	2.76	6.02	2.54	3.18	3.83	9.56	100
2023-2024	m3/s	75 % low-water								25 % high-water			25 % high-water				75 %
		24.8	50.3	72.5	67.6	38.4	29.2	27.0	310	20.2	28.5	48.7	15.3	16.2	15.3	46.8	405
	%	6.12	12.4	17.9	16.7	9.48	7.21	6.67	76.5	4.99	7.03	12.0	3.78	4.00	3.78	11.5	100
Ili r. - Kapshagay s.																	
2021-2022	m3/s	75 % low-water								75 % low-water			75 % low-water				75%
		208	191	406	470	473	470	325	2543	296	262	558	255	297	254	806	3907
	%	5.32	4.89	10.4	12.0	12.1	12.0	8.32	65.1	7.58	6.71	14.3	6.53	7.60	6.50	20.6	100
2022-2023	m3/s	75 % low-water								75 % low-water			75 % low-water				75%
		164	168	411	495	584	573	294	2689	238	248	486	217	218	208	643	3818
	%	4.30	4.40	10.8	13.0	15.3	15.0	7.70	70.4	6.23	6.50	12.7	5.68	5.71	5.45	16.8	100
2023-2024	m3/s	50 % average water								75 % low-water			75 % low-water				75%
		216	218	457	534	579	560	367	2931	224	240	464	266	271	231	768	4163
	%	5.19	5.24	11.0	12.8	13.9	13.5	8.82	70.4	5.38	5.77	11.2	6.39	6.51	5.55	18.5	100
Lepsy r. - Lepsy v.																	
2021-2022	m3/s	75 % low-water								75 % low-water			75 % low-water				75%
		7.42	5.96	3.55	182	3.34	10.3	9.73	162	5.96	4.07	10.0	3.55	3.38	3.34	10.3	182
	%	4.07	3.27	1.95	100	1.83	5.64	5.34	88.9	3.27	2.23	5.51	1.95	1.86	1.83	5.64	100
2022-2023	m3/s	50 % average water								75 % low-water			75 % low-water				50%
		5.08	6.38	4.72	211	4.06	12.9	11.6	186	6.38	5.57	11.9	4.72	4.17	4.06	12.9	211
	%	2.41	3.02	2.24	100	1.92	6.14	5.50	88.2	3.02	2.64	5.66	2.24	1.98	1.92	6.14	100
2023-2024	m3/s	50 % average water								25 % high-water			25 % high-water				25 %
		8.66	10.2	5.92	246	4.68	17.7	22.1	209	10.2	8.59	18.8	5.92	7.11	4.68	17.7	246
	%	3.53	4.16	2.41	100	1.91	7.21	9.00	85.1	4.16	3.50	7.66	2.41	2.90	1.91	7.21	100

YEAR	Unit of meas.	SPRING–SUMMER								∑(SPRING–SUMMER)	AUTUMN-WINTER		∑(AUTUMN-WINTER)	WINTER		∑(WINTER)	ANNUAL TOTAL
		III	IV	V	VI	VII	VIII	IX	X		XI	XII		I	II		
Chilik r. - Malybay v.																	
2021-2022	m3/s	25 % high-water									75 % low-water			75 % low-water			50%
		0.60	4.38	60.3	104	111	82.8	35.2	5.98	404	1.22	0.68	1.90	0.61	0.62	1.23	407
	%	0.15	1.08	14.8	25.5	27.2	20.3	8.64	1.47	99.2	0.30	0.17	0.47	0.15	0.15	0.30	100
2022-2023	m3/s	25 % high-water									75 % low-water			75 % low-water			25 %
		0.62	0.62	60.6	93.2	123	118	45.7	18.7	460	5.46	0.61	6.07	0.61	0.67	1.28	468

YEAR	Unit of meas.	SPRING–SUMMER								∑(SPRING–SUMMER)	AUTUMN-WINTER		∑(AUTUMN-WINTER)	WINTER		∑(WINTER)	ANNUAL TOTAL
		III	IV	V	VI	VII	VIII	IX	X		XI	XII		I	II		
	%	0.13	0.13	13.0	19.9	26.3	25.2	9.77	4.00	98.4	1.17	0.13	1.30	0.13	0.14	0.27	100
2023-2024	m3/s	75 % low-water									75 % low-water			50 % average water			75%
		0.62	6.49	44.2	74.6	88.5	66.4	23.4	12.1	316	2.35	0.67	3.02	6.23	5.69	11.9	331
	%	0.19	1.96	13.4	22.5	26.7	20.0	7.05	3.65	95.5	0.71	0.20	0.91	1.88	1.72	3.60	100
Charyn r. - Sarytogay s.																	
2021-2022	m3/s	50 % average water									25 % high-water			75 % low-water			
		22.9	45.8	60.9	59.0	57.1	43.4	38.2	11.5	339	30.2	42.2	72.4	19.3	15.4	34.7	446
	%	5.14	10.3	13.7	13.2	12.8	9.73	8.57	2.58	76.0	6.77	9.46	16.2	4.33	3.45	7.78	100
2022-2023	m3/s	75 % low-water									25 % high-water			75 % low-water			
		14.1	35.6	53.8	60.1	49.1	46.2	36.7	9.86	305	24.9	31.8	56.7	14.0	17.6	31.5	394
	%	3.58	9.04	13.7	15.3	12.5	11.7	9.32	2.50	77.6	6.32	8.08	14.4	3.55	4.46	8.01	100
2023-2024	m3/s	75 % low-water									25 % high-water			25 % high-water			
		25.1	29.5	35.7	36.3	39	35.8	27.1	6.91	235	27.6	32.5	60.1	22.0	22.4	44.4	340
	%	7.38	8.67	10.5	10.7	11.5	10.5	7.97	2.03	69.3	8.11	9.57	17.7	6.49	6.58	13.1	100
Ili r. - 164 km upstream of the Kapshagay HP																	
2021-2022	m3/s	75 % low-water									50 % average water			75 % low-water			
		238	274	339	300	156	181	296	306	2090	334	281	615	229	215	444	3149
	%	7.56	8.70	10.8	9.53	4.95	5.75	9.40	9.72	66.4	10.6	8.92	19.5	7.27	6.83	14.1	100
2022-2023	m3/s	75 % low-water									75 % low-water			50 % average water			
		204	307	440	347	190	221	234	212	2155	275	249	524	259	306	565	3244
	%	6.29	9.46	13.6	10.7	5.86	6.81	7.21	6.54	66.4	8.48	7.68	16.2	7.98	9.43	17.4	100
2023-2024	m3/s	75 % low-water									50 % average water			50 % average water			
		306	293	288	264	259	182	312	347	2251	359	334	693	274	274	548	3492
	%	8.76	8.39	8.25	7.56	7.42	5.21	8.93	9.94	64.5	10.3	9.56	19.8	7.85	7.85	15.7	100

Table 5 – Statistical characteristics and total discharges of different reliability levels for the main rivers of the **Aral-Syrdarya WMB**

Observation period	YEAR					Non-limiting period					Limiting period									
											Non-limiting season					Limiting season				
						SPRING–SUMMER					AUTUMN					WINTER				
	Cv	Q	Monthly water discharge totals, m3/s			Cv	Q	Monthly water discharge totals, m3/s			Cv	Q	Monthly water discharge totals, m3/s			Cv	Q	Monthly water discharge totals, m3/s		
			75%	50%	25%			75%	50%	25%			75%	50%	25%			75%	50%	25%
Syrdarya r. – upstream of the mouth of Keles r.																				
1977-2021	0,31	5979	4138	5712	7422	0,40	2565	1796	2300	3218	0,32	1219	890	1159	1389	0,39	2194	1452	2253	2815
Syrdarya r. – lower reach of the Shardara reservoir																				
1960-2021	0,36	5672	3561	5552	7432	0,33	3244	2417	3083	3903	0,55	1309	629	1273	1869	0,57	1119	515	1197	1660
Syrdarya r. – Koktyube s.																				
2000-2021	0,28	5994	4588	5898	7417	0,32	2975	2286	2791	3614	0,38	1589	1146	1566	2099	0,24	1430	1157	1541	1704
Syrdarya r. – Tomenaryk r.s.																				
1962-2021	0,39	4860	3058	4755	6205	0,36	2571	1857	2439	3011	0,52	1260	734	1243	1749	0,52	1030	467	1073	1445
Syrdarya r. – Kazaly c.																				
1962-2021	0,63	2296	970	2120	3504	0,75	941	400	832	1389	0,77	651	187	540	1048	0,57	704	383	748	1067
Keles r. – estuary																				
1983-2021	0,31	242	182	258	311	0,37	107	75,8	112	140	0,31	73,51	55,2	77,1	93,5	0,31	62,12	50,5	69,6	78,1
Arys river – Arys r.s.																				
1985-2021	0,54	318	171	261	441	0,64	207	107	166	296	0,42	33,0	22,5	29,8	41,7	0,55	77,7	41,9	65,3	104
Aksu r. – Sarkyrama v.																				
1945-2021	0,28	129	100	124	148	0,31	84,6	64,3	83,0	98,7	0,40	33,17	26,86	30,97	36,59	0,21	10,74	8,91	9,97	12,86
Badam r. – Karaspan v.																				
1974-2021	0,55	106	58,9	94,2	140	0,71	57,6	26,6	47,6	78,5	0,54	19,69	12,3	17,97	25,4	0,38	28,74	20,1	28,7	35,7
Bugun r. – Ekpendy v																				
1952-2021	0,58	49,0	26,43	42,27	63,62	0,59	43,0	25,3	39,3	56,9	1,53	0,41	0,09	0,16	0,43	1,30	5,58	1,03	2,80	6,32
Shayan 1 r. - 3.3 km downstream from the mouth of Akbet river																				
1948-2021	0,41	27,5	17,2	24,8	35,6	0,46	21,7	13,9	20,2	28,1	0,43	1,20	0,79	1,04	1,48	0,75	4,56	2,49	3,59	5,97

Table 6 – Seasonal water volumes at the main hydrological stations of the **Aral-Syrdarya WMB for 2021-2024**

Syrdarya r. – upstream of the mouth of Keles r.																	
YEAR	**Unit of meas.**	**SPRING–SUMMER**					**∑(SPRING–SUMMER)**	**SUMMER-AUTUMN**				**∑(SUMMER-AUTUMN)**	**WINTER**			**∑(WINTER)**	**ANNUAL TOTAL**
		III	**IV**	**V**	**VI**	**VII**		**VIII**	**IX**	**X**	**XI**		**XII**	**I**	**II**		
2021-2022		75 % low-water						75 % low-water					75 % low-water				75%
	m3/s	661	403	98.40	63.10	62.20	1288	72.60	83.30	122	309	587	388	484	608	1480	3355
	%	19.70	12.01	2.93	1.88	1.85	38.39	2.16	2.48	3.64	9.21	17.50	11.57	14.43	18.12	44.12	100
	m3/s	75 % low-water						75 % low-water					25 % high-water				50%

YEAR	Unit of meas..	III	IV	V	VI	VII	∑(SPRING–SUMMER)	VIII	IX	X	XI	∑(SUMMER-AUTUMN)	XII	I	II	∑(WINTER)	ANNUAL TOTAL
2022-2023		683	251	328	200	97.6	1560	80.70	109	178	576	944	1240	1090	1100	3430	5933
	%	11.51	4.23	5.53	3.37	1.64	26.29	1.36	1.84	3.00	9.71	15.91	20.90	18.37	18.54	57.81	100

Syrdarya r. – lower reach of the Shardara reservoir

YEAR	Unit of meas..	SPRING–SUMMER					∑(SPRING–SUMMER)	SUMMER-AUTUMN				∑(SUMMER-AUTUMN)	WINTER			∑(WINTER)	ANNUAL TOTAL
		III	IV	V	VI	VII		VIII	IX	X	XI		XII	I	II		
2021-2022		75 % low-water						75 % low-water					75 % low-water				75%
	m3/s	233	335	247	231	472	1518	254	41.80	41.70	180	518	221	102	103	426	2462
	%	9.47	13.61	10.03	9.38	19.18	61.67	10.32	1.70	1.69	7.31	21.02	8.98	4.14	4.18	17.31	100
2022-2023		75 % low-water						75 % low-water					25 % high-water				50%
	m3/s	649	351	355	536	571	2462	260	72.50	71.90	349	753	706	864	885	2455	5670
	%	11.45	6.19	6.26	9.45	10.07	43.42	4.59	1.28	1.27	6.15	13.29	12.45	15.24	15.61	43.30	100
2023-2024		75 % low-water						75 % low-water					75 % low-water				75%
	m3/s	429	159	205	372	491	1656	185	56.20	96.00	127	464	346	248	263	857	2977
	%	14.41	5.34	6.89	12.49	16.49	55.62	6.21	1.89	3.22	4.27	15.59	11.62	8.33	8.83	28.79	100

Syrdarya r. – Koktyube s.

YEAR	Unit of meas..	SPRING–SUMMER					∑(SPRING–SUMMER)	SUMMER-AUTUMN				∑(SUMMER-AUTUMN)	WINTER			∑(WINTER)	ANNUAL TOTAL
		III	IV	V	VI	VII		VIII	IX	X	XI		XII	I	II		
2021-2022		75 % low-water						75 % low-water					75 % low-water				75%
	m3/s	159	363	480	530	547	2079	372	92.60	76	187	727	278	153	178	609	3415
	%	4.66	10.63	14.05	15.52	16.02	60.87	10.89	2.71	2.22	5.48	21.30	8.14	4.48	5.21	17.83	100
2022-2023		75 % low-water						75 % low-water					25 % high-water				50%
	m3/s	362	473	553	513	572	2473	399	148	128	348	1023	572	558	581	1711	5207
	%	6.95	9.08	10.62	9.85	10.99	47.49	7.66	2.84	2.46	6.68	19.65	10.99	10.72	11.16	32.86	100
2023-2024		50 % average water						75 % low-water					75 % low-water				75%
	m3/s	635	386	573	595	566	2755	317	117	162	194	790	421	313	235	969	4514
	%	14.07	8.55	12.69	13.18	12.54	61.03	7.02	2.59	3.59	4.30	17.50	9.33	6.93	5.21	21.47	100

Syrdarya r. – Tomenaryk r.s

YEAR	Unit of meas.	SPRING–SUMMER					∑(SPRING–SUMMER)	SUMMER-AUTUMN				∑(SUMMER-AUTUMN)	WINTER				ANNUAL TOTAL
		III	IV	V	VI	VII		VIII	IX	X	XI		XII	I	II		
2021-2022		75 % low-water						75 % low-water					75 % low-water				75%
	m3/s	195	361	455	450	452	1913	340	123.00	86.60	164	714	295	173	181	649	3276
	%	5.95	11.02	13.89	13.74	13.80	58.40	10.38	3.76	2.64	5.01	21.79	9.01	5.28	5.53	19.81	100.00
2022-2023		75 % low-water						50 % average water					25 % high-water				50%
	m3/s	314	460	449	413	441	2077	310	157.00	116.00	376	959	505	512	542	1559	4595
	%	6.83	10.01	9.77	8.99	9.60	45.20	6.75	3.42	2.52	8.18	20.87	10.99	11.14	11.80	33.93	100.00
2023-2024		50 % average water						75 % low-water					50 % average water				75%
	m3/s	622	311	450	472	464	2319	305	121.00	161.00	188	775	362	283	215	860	3954
	%	15.73	7.87	11.38	11.94	11.73	58.65	7.71	3.06	4.07	4.75	19.60	9.16	7.16	5.44	21.75	100.00

Syrdarya r. – Kazaly c.

YEAR		SPRING–SUMMER		SUMMER-AUTUMN		WINTER		ANNUAL TOTAL

	Unit of meas.	III	IV	V	VI	VII	∑(SPRING–SUMMER)	VIII	IX	X	XI	∑(SUMMER-AUTUMN)	XII	I	II		
2021-2022		75 % low-water						75 % low-water					75 % low-water				75%
	m3/s	155	105	24.60	9.98	7.86	302	12.00	41.10	29	26	108	97	129	106	332	743
	%	20.86	14.13	3.31	1.34	1.06	40.70	1.61	5.53	3.88	3.54	14.56	13.11	17.36	14.27	44.74	100
2022-2023		75 % low-water						75 % low-water					50 % average water				75%
	m3/s	72.1	171	16	5.75	4.7	270	9.55	39	23	91.4	163	237	245	269	751	1184
	%	6.09	14.44	1.39	0.49	0.40	22.80	0.81	3.29	1.97	7.72	13.78	20.02	20.69	22.72	63.42	100
2023-2024		50 % average water						75 % low-water					75 % low-water				75%
	m3/s	351.00	194.00	28.20	10.60	7.24	591	5.7	32.40	42.40	72.4	153	102	190	141	433	1177
	%	29.82	16.48	2.40	0.90	0.62	50.2	0.48	2.75	3.60	6.15	12.99	8.67	16.14	11.98	36.79	100

Keles r. – estuary

YEAR	Unit of meas.	SPRING–SUMMER					∑(SPRING–SUMMER)	SUMMER-AUTUMN				∑(SUMMER-AUTUMN)	WINTER			∑(WINTER)	ANNUAL TOTAL
		III	IV	V	VI	VII		VIII	IX	X	XI		XII	I	II		
2021-2022		75 % low-water						75 % low-water					75 % low-water				75%
	m3/s	25	28	6.85	8.69	7.06	76	7.97	17.50	22	21	69	13	18	19	50	194
	%	13.07	14.36	3.53	4.47	3.63	39.07	4.10	9.01	11.38	10.91	35.40	6.85	9.11	9.57	25.53	100
2022-2023		25 % high-water						50 % average water					25 % high-water				25%
	m3/s	40.9	33.3	40	17.7	13.2	145	11.10	19	24	29.1	83	25	29	37	91	319
	%	12.83	10.45	12.58	5.55	4.14	45.56	3.48	5.87	7.47	9.13	25.95	7.72	9.13	11.64	28.49	100
2023-2024		50 % average water						25 % high-water					25 % high-water				50%
	m3/s	34.90	29.30	10.70	18.00	12.20	105	18.6	28.60	26.20	19.7	93	23.9	30.2	33.3	87	286
	%	12.22	10.26	3.75	6.30	4.27	36.80	6.51	10.01	9.17	6.90	32.60	8.37	10.57	11.66	30.60	100

Arys r. – Arys r.s.

YEAR	Unit of meas.	SPRING–SUMMER					∑(SPRING–SUMMER)	SUMMER-AUTUMN				∑(SUMMER-AUTUMN)	WINTER			∑(WINTER)	ANNUAL TOTAL
		III	IV	V	VI	VII		VIII	IX	X	XI		XII	I	II		
2021-2022		50 % average water						75 % low-water					75 % low-water				75%
	m3/s	64.70	72.40	10.10	6.44	9.22	162.86	7.76	3.63	4.99	6.22	22.60	7.63	12.7	8.94	29.27	215
	%	30.13	33.72	4.70	3.00	4.29	75.84	3.61	1.69	2.32	2.90	10.52	3.55	5.91	4.16	13.63	100
2022-2023		50 % average water						50 % average water					25 % high-water				50%
	m3/s	97.1	44.2	15.60	8.92	10.5	176.32	9.440	7.90	9.01	23.3	49.65	21.30	41.70	60.70	123.7	350
	%	27.77	12.64	4.46	2.55	3.00	50.42	2.70	2.26	2.58	6.66	14.20	6.09	11.93	17.36	35.38	100
2023-2024		75 % low-water						50 % average water					50 % average water				75%
	m3/s	79.90	22.40	10.80	8.25	9.60	130.95	11.7	7.47	8.32	11.3	38.79	12.7	16.62	45.16	74.48	244
	%	32.72	9.17	4.42	3.38	3.93	53.62	4.79	3.06	3.41	4.63	15.88	5.20	6.81	18.49	30.50	100

Aksu r. – Sarkyrama v.

YEAR	Unit of meas.	SPRING–SUMMER					∑(SPRING–SUMMER)	SUMMER-AUTUMN				∑(SUMMER-AUTUMN)	WINTER			∑(WINTER)	ANNUAL TOTAL
		III	IV	V	VI	VII		VIII	IX	X	XI		XII	I	II		
2021-2022		75 % low-water						75 % low-water					75 % low-water				75%
	m3/s	2.96	4.69	13.00	21.80	10.30	52.75	7.03	4.42	3.04	3.07	17.56	3.17	3.08	2.24	8.49	78.8
	%	3.76	5.95	16.50	27.66	13.07	66.94	8.92	5.61	3.86	3.90	22.28	4.02	3.91	2.84	10.77	100
2022-2023		75 % low-water						75 % low-water					75 % low-water				75%
	m3/s	3.01	5.84	20.00	26.40	15.10	70.35	7.20	4.64	3.41	2.76	18.01	2.83	2.86	2.40	8.09	96.5
	%	3.12	6.05	20.74	27.37	15.66	72.94	7.47	4.81	3.54	2.86	18.67	2.93	2.97	2.49	8.39	100
2023-2024		50 % average water						75 % low-water					75 % low-water				50 %
	m3/s	3.62	12.00	26.80	27.00	19.70	89.12	10.7	6.30	4.05	3.5	24.55	2.69	2.68	2.9	8.27	122
	%	2.97	9.84	21.98	22.14	16.16	73.09	8.77	5.17	3.32	2.87	20.13	2.21	2.20	2.38	6.78	100

Badam r. – Karaspan v.

YEAR	Unit of meas.	SPRING–SUMMER					∑(SPRING–SUMMER)	SUMMER-AUTUMN				∑(SUMMER-AUTUMN)	WINTER			∑(WINTER)	ANNUAL TOTAL
		III	IV	V	VI	VII		VIII	IX	X	XI		XII	I	II		
2021-2022		75 % low-water						75 % low-water					75 % low-water				75%
	m3/s	7.34	6.11	3.74	0.91	2.95	21.05	0.38	0.00	2.44	4.44	7.26	5.82	5.88	4.98	16.68	44.99
	%	16.31	13.58	8.31	2.02	6.56	46.79	0.84	0.00	5.42	9.87	16.14	12.94	13.07	11.07	37.07	100.00
2022-2023		75 % low-water						50 % average water					75 % low-water				75%
	m3/s	8.80	8.00	8.50	5.67	5.04	36.01	4.84	3.42	5.21	7.49	20.96	6.99	6.21	7.31	20.51	77.48
	%	11.36	10.33	10.97	7.32	6.50	46.48	6.25	4.41	6.72	9.67	27.05	9.02	8.01	9.43	26.47	100.00
2023-2024		75 % low-water						50 % average water					75 % low-water				75
	m3/s	6.96	7.98	5.08	4.79	5.09	29.90	4.88	4.29	5.54	6.56	21.27	6.2	5.96	6.63	18.79	69.96
	%	9.95	11.41	7.26	6.85	7.28	42.74	6.98	6.13	7.92	9.38	30.40	8.86	8.52	9.48	26.86	100.00

Bugun r. – Ekpendy v.

YEAR	Unit of meas.	SPRING–SUMMER					∑(SPRING–SUMMER)	SUMMER-AUTUMN			∑(SUMMER-AUTUMN)	AUTUMN-WINTER				∑(WINTER)	ANNUAL TOTAL
		II	III	IV	V	VI		VII	VIII	IX		X	XI	XII	I		
2021-2022		25 % high-water						75 % low-water				50 % average water					50%
	m3/s	2.02	19.8	25.6	4.22	0.24	51.88	0.03	0.00	0.00	0.03	0	0	0.075	3.05	3.13	55.0
	%	3.67	35.98	46.52	7.67	0.44	94.27	0.05	0.00	0.00	0.05	0	0	0.14	5.54	5.68	100
2022-2023		50 % average water						75 % low-water				25 % high-water					25%
	m3/s	5.33	24.8	11.6	3.18	0.24	45.15	0.031	0.000	0.000	0.03	0	3.25	5.75	6.84	15.8	61.0
	%	8.73	40.64	19.01	5.21	0.39	73.99	0.05	0.00	0.00	0.05	0.00	5.33	9.42	11.2	26.0	100
2023-2024		25 % high-water						75 % low-water				25 % high-water					50%
	m3/s	18.2	20	6.63	1.72	0.082	46.632	0	0	0	0.00	0.031	0.17	1.58	4.95	6.73	53.4
	%	34.11	37.48	12.42	3.22	0.15	87.39	0.00	0.00	0.00	0.00	0.06	0.32	2.96	9.28	12.6	100

Shayan 1 r. – 3.3 km downstream from the mouth of Akbet river

YEAR	Unit of meas.	SPRING–SUMMER					∑(SPRING–SUMMER)	SUMMER-AUTUMN			∑(SUMMER-AUTUMN)	AUTUMN-WINTER				∑(WINTER)	ANNUAL TOTAL
		II	III	IV	V	VI		VII	VIII	IX		X	XI	XII	I		
2021-2022		50 % average water						50 % average water				50 % average water					50%
	m3/s	1.41	7.52	9.34	2.22	0.85	21.34	0.61	0.32	0.30	1.23	0.36	0.45	0.55	2.53	3.89	26.46
	%	5.33	28.42	35.30	8.39	3.21	80.65	2.31	1.21	1.13	4.65	1.36	1.70	2.08	9.56	14.70	100
2022-2023		50 % average water						75 % low-water				25 % high-water					25%
	m3/s	2.59	11.6	5.4	1.73	0.76	22.08	0.34	0.26	0.24	0.84	0.39	2.28	2.21	2.05	6.93	29.85
	%	8.68	38.86	18.09	5.80	2.55	73.97	1.14	0.87	0.80	2.81	1.31	7.64	7.40	6.87	23.22	100
2023-2024		50 % average water						75 % low-water				25 % high-water					25%
	m3/s	7.02	7.37	2.98	1.35	0.43	19.15	0.27	0.22	0.25	0.74	0.36	0.64	1.15	3.54	5.69	25.58
	%	27.44	28.81	11.65	5.28	1.68	74.86	1.06	0.86	0.98	2.89	1.41	2.50	4.50	13.84	22.24	100

Table 7 – Statistical characteristics and total discharges of different reliability levels for the main rivers of the **Ural-Caspian WMB**

Observation period	**YEAR**					**Non-limiting period**					**Limiting period**									
											Non-limiting season					**Limiting season**				
						SPRING					**SUMMER-AUTUMN**					**WINTER**				
	Cv	**Q**	**Monthly water discharge totals, m3/s**			**Cv**	**Q**	**Monthly water discharge totals, m3/s**			**Cv**	**Q**	**Monthly water discharge totals, m3/s**			**Cv**	**Q**	**Monthly water discharge totals, m3/s**		
			75%	**50%**	**25%**			**75%**	**50%**	**25%**			**75%**	**50%**	**25%**			**75%**	**50%**	**25%**
Ural r. – Yanvartsevo s.																				
2009-2021	0,33	2407	1539	2451	3171	0,38	1268	729	1435	1706	0,37	796	542	694	1030	0,26	343	267	323	436
Ural r. – Kushum v.																				
1958-2021	0,42	3302	2109	2964	4211	0,55	1782	1086	1520	2334	0,39	1117	754	1072	1385	0,43	403	269	372	492
Ural r. – Makhamet s.																				
1958-2021	0,41	2925	1944	2891	3710	0,39	1270	866	1283	1617	0,51	1309	833	1283	1663	0,46	346	246	325	430
Ilek r. – Aktobe c.																				
1975-2021	0,60	161	73,1	131	212	0,78	91,8	36,6	70,9	126	0,60	47,1	26,8	40,8	56,9	0,83	22,1	9,66	19,2	29,2
Uil r.– Uil v.																				
1986-2021	0,80	81,2	27,1	68,2	105	0,89	64,6	19,1	53,4	83,5	0,64	13,5	6,86	12,3	16,7	0,78	3,08	1,14	2,50	4,54

Table 8 – Seasonal water volumes at the main hydrological stations of the **Ural-Caspian WMB for 2021-2024**

YEAR	**UNIT OF MEAS.**	**SPRING**		**∑ (SPRING)**	**SUMMER-AUTUMN**						**∑ (SUMMER-AUTUMN)**	**WINTER**				**∑ (WINTER)**	**ANNUAL TOTAL**
		IV	**V**		**VI**	**VII**	**VIII**	**IX**	**X**	**XI**		**XII**	**I**	**II**	**III**		
Ural r. – Yanvartsevo s.																	
2021-2022	m3/s	75 % low-water			50 % average water							75 % low-water					50 % average water
		517	395	912	334	170	97	73	77	92	842	84	52	60	77	273	2027
	%	25,5	19,5	45,0	16,5	8,39	4,77	3,59	3,80	4,52	41,5	4,16	2,58	2,94	3,79	13,5	100
2022-2023	m3/s	50 % average water			50 % average water							25 % high-water					50 % average water
		1040	525	1565	218	143	102	88	94	129	774	105	79	79	372	635	2975
	%	35,0	17,7	52,6	7,33	4,81	3,43	2,95	3,17	4,34	26,03	3,53	2,67	2,66	12,5	21,4	100
2023-2024	m3/s	25% маловодный			25 % high-water							25 % high-water					25 % high-water
		2198	1661	3859	672	420	598	566	364	292	2912	165	133	119	119	536	7307
	%	30,1	22,7	52,8	9,2	5,7	8,2	7,7	5,0	4,0	39,9	2,26	1,82	1,63	1,63	7,34	100
Ural r. – Kushum v.																	
2021-2022	m3/s	75 % low-water			75 % low-water							75 % low-water					75 % low-water
		428	387	815	283	163	107	81,9	90,3	93,1	818,3	64,7	59,7	61,4	62,9	249	1882
	%	22,7	20,6	43,3	15,0	8,7	5,7	4,4	4,8	4,9	43,5	3,4	3,2	3,3	3,3	13,2	100,0
2022-2023	m3/s	50 % average water			75 % low-water							25 % high-water					50 % average water
		844	604	1448	266	157	103	86	97,8	144	853,8	115	79	72,5	364	631	2932
	%	28,8	20,6	49,4	9,1	5,4	3,5	2,9	3,3	4,9	29,1	3,9	2,7	2,5	12,4	21,5	100,0
2023-2024	m3/s	25 % high-water			25 % high-water							25 % high-water					25 % high-water
		1440	1540	2980	669	359	463	495	346	261	2593	210	140	139	159	648	6221
	%	23,1	24,8	47,9	10,8	5,8	7,4	8,0	5,6	4,2	41,7	3,4	2,3	2,2	2,6	10,4	100,0

YEAR	UNIT OF MEAS.	SPRING		∑ (SPRING)	SUMMER-AUTUMN						∑ (SUMMER-AUTUMN)	WINTER				∑ (WINTER)	ANNUAL TOTAL
		IV	V		VI	VII	VIII	IX	X	XI		XII	I	II	III		
Ural r. – Makhamet s.																	
2021-2022	m3/s	75 % low-water			75 % low-water							75 % low-water					75 % low-water
		226	430	656	297	195	118	85,8	81,9	96,7	874,4	72,7	62,9	67,4	61,4	264	1795
	%	12,6	24,0	36,6	16,5	10,9	6,6	4,8	4,6	5,4	48,7	4,1	3,5	3,8	3,4	14,7	100,0
2022-2023	m3/s	50 % average water			50 % average water							25 % high-water					50 % average water
		620	665	1285	313	180	114	82,7	82,4	113	885,1	115	66,5	68,4	162	412	2582
	%	24,0	25,8	49,8	12,1	7,0	4,4	3,2	3,2	4,4	34,3	4,5	2,6	2,6	6,3	16,0	100,0
2023-2024	m3/s	25 % high-water			25 % high-water							25 % high-water					25 % high-water
		1440	1540	2980	669	359	463	495	346	261	2593	210	140	139	159	648	6786
	%	21,2	22,7	43,9	9,9	5,3	6,8	7,3	5,1	3,8	38,2	3,1	2,1	2,0	2,3	9,5	100,0
YEAR	**UNIT OF MEAS.**	**SPRING**		**∑ (SPRING)**	**SUMMER-AUTUMN**						**∑ (SUMMER-AUTUMN)**	**WINTER**				**∑ (WINTER)**	**ANNUAL TOTAL**
		IV	**V**		**VI**	**VII**	**VIII**	**IX**	**X**	**XI**		**XII**	**I**	**II**	**III**		
Ilek r. – Aktobe c.																	
2021-2022	m3/s	50 % average water			75 % low-water							50 % average water					50 % average water
		53	9,76	62,8	4,48	4,15	5,59	4,78	4,37	3,68	27,1	3,78	2,82	3,21	3,23	13,0	103
	%	51,5	9,5	61,0	4,4	4,0	5,4	4,6	4,2	3,6	26,3	3,7	2,7	3,1	3,1	12,7	100,0
2022-2023	m3/s	75 % low-water			25 % high-water							25 % high-water					25 % high-water
		32,1	10,8	42,9	8,29	13	15,8	19,6	9,84	8,41	74,9	7,72	5,69	6,11	109	129	32,1
	%	13,0	4,4	17,4	3,4	5,3	6,4	8,0	4,0	3,4	30,4	31	2,3	2,5	44,2	52,2	13,0
2023-2024	m3/s	25 % high-water			25 % high-water							25 % high-water					25 % high-water
		290	20,5	311	18,3	15,3	18	23,7	11,1	9,36	95,8	10,3	5,12	5,52	284	305	711
	%	40,8	2,9	43,7	2,6	2,2	2,5	3,3	1,6	1,3	13,5	1,4	0,7	0,8	39,9	42,9	100,0
Uil r.– Uil v.																	
YEAR	**UNIT OF MEAS.**	**SPRING**		**∑ (SPRING)**	**SUMMER-AUTUMN**						**∑ (SUMMER-AUTUMN)**	**WINTER**				**∑ (WINTER)**	**ANNUAL TOTAL**
		III	**IV V**		**VI**	**VII**	**VIII**	**IX**	**X**	**XI**		**XII**	**I**	**II**			
2021-2022	m3/s	75 % low-water			75 % low-water							75 % low-water					25 % high-water
		0,90	164	14,0	179	11,5	5,38	3,03	1,80	1,44	1,57	24,7	1,30	0,00	0,00	1,30	205
	%	0,4	80,0	6,8	87,3	5,6	2,6	1,5	0,9	0,7	0,8	12,1	0,6	0,0	0,0	0,6	100,0
2022-2023	m3/s	50 % average water			50 % average water							25 % high-water					25 % high-water
		302	48,5	24,2	375	18,0	7,29	2,31	1,41	1,35	1,39	31,8	1,64	0,85	0,83	3,32	410
	%	73,7	11,8	5,9	91,4	4,4	1,8	0,6	0,3	0,3	0,3	7,7	0,4	0,2	0,2	0,8	100,0
2023-2024	m3/s	25 % high-water			25 % high-water							25 % high-water					25 % high-water
		303	544	30,4	877	5,60	3,43	2,22	1,43	1,43	1,59	15,7	1,48	2,40	2,05	5,93	899
	%	33,7	60,5	3,4	97,6	0,6	0,4	0,2	0,2	0,2	0,2	1,7	0,2	0,3	0,2	0,7	100,0

Table 9 – Statistical characteristics and total discharges of different reliability levels for the main rivers of the **Esil WMB**

Observation period	YEAR					Non-limiting period					Limiting period									
											Non-limiting season					Limiting season				
						SPRING–SUMMER					AUTUMN					WINTER				
	Cv	Q	Monthly water discharge totals, m3/s			Cv	Q	Monthly water discharge totals, m3/s			Cv	Q	Monthly water discharge totals, m3/s			Cv	Q	Monthly water discharge totals, m3/s		
			75%	50%	25%			75%	50%	25%			75%	50%	25%			75%	50%	25%
Esil r. – Kamennyy Karyer v.																				
1947-2021	0.77	481	202.0	429	633	0.84	390.8	167.1	358.5	513.0	0.76	75.7	27.3	58.3	101.7	0.71	14.9	7.6	12.6	18.6
Esil r. – Volgodonovka v.																				
1977-2021	0.85	44.2	9.1	26.0	64.8	1.24	23.0	2.06	9.8	32.4	0.67	11.8	5.43	9.93	16.90	0.97	9.32	1.64	6.28	15.55
Esil r. – Dolmatovo v.																				
1982-2021	0.59	726	308	689	1049	0.72	449	145	435	709	0.61	202.2	103	180	252	0.28	74.6	60.2	73.7	88.4
Esil r. – Turgen v.																				
1975-2021	0.70	51.4	17.8	44.4	69.5	0.77	44.7	16.2	41.2	64.8	0.63	2.56	1.50	2.34	3.07	2.33	4.21	0.15	0.91	1.68
Kalkutan r. – Kalkutan v.																				
1975-2021	0.93	99.5	26.6	68.7	165.2	0.92	94.5	25.31	66.3	159.4	1.05	4.1	1.24	2.41	5.72	6.07	0.87	0.00	0.00	0.03
Esil r. – Petropavlovsk c.																				
1970-2021	0.71	706	226	586	999	0.83	499	115	398	711	0.63	156.4	76.0	136	220	0.36	51.0	34.9	51.8	68.0
Zhabay r. – Atbasar c.																				
1936-2021	1.00	115.0	41.2	87.4	145.0	1.08	103.3	37.3	78.9	129	0.80	7.94	3.23	6.18	10.5	2.16	3.76	0.63	2.30	5.03

Table 10 – Seasonal water volumes at the main hydrological stations of the **Esil WMB for 2021-2024**

YEAR	Unit of meas.	SPRING		SPRING	SUMMER					SUMMER	AUTUMN - WINTER					AUTUMN-WINTER	ANNUAL TOTAL
		IV	V		VI	VII	VIII	IX	X		XI	XII	I	II	III		
Esil r. – Kamennyy Karyer v.																	
2021-2022	m3/s	75 % low-water			50 % average water						25 % high-water						50 % average water
		97.5	73.6	171.1	16.4	14.5	11.9	9.5	8.6	60.9	8.6	8.1	9.7	7.2	7.3	40.9	272.8
	%	35.7	27.0	62.7	6.0	5.3	4.4	3.5	3.1	22.3	3.1	3.0	3.5	2.6	2.7	15.0	100.0
2022-2023	m3/s	25 % high-water			50 % average water						25 % high-water						25 % high-water
		259	200	459	32	13.3	7.69	6.85	7.65	67.49	7.68	10.2	7.01	6.57	22.6	54.06	580.6
	%	44.61	34.45	79.06	5.5	2.29	1.32	1.18	1.32	11.6	1.32	1.76	1.21	1.13	3.89	9.30	100
2023-2024	m3/s	25 % high-water			25 % high-water						25 % high-water						25 % high-water
		662	128	790	100	73	45.1	18.9	13.7	250.7	11.3	10.4	11.1	10.4	31.7	74.9	1115.6
	%	59.32	11.47	70.79	8.96	6.54	4.04	1.69	1.23	22.47	1.01	0.93	0.99	0.93	2.84	6.7	100
Esil r. – Volgodonovka v.																	
2021-2022	m3/s	50 % average water			75 % low-water						75 % low-water						75 % low-water
		3.86	0.5	4.36	0.72	0.74	0.73	0.39	0.13	2.71	0.086	0.067	1.08	0.43	0.26	1.92	9.0
	%	42.92	5.56	48.48	8.01	8.23	8.12	4.34	1.45	30.13	0.96	0.75	12.01	4.78	2.89	21.4	100
2022-2023	m3/s	75 % low-water			75 % low-water						75 % low-water						75 % low-water
		0.21	0.099	0.309	0.054	0.058	0.11	0.15	0.13	0.502	0.13	0.13	0.06	0.057	0.64	1.017	1.83
	%	11.5	5.4	16.9	3	3.2	6.0	8.2	7.1	27.5	7.1	7.1	3.3	3.1	35.0	55.6	100
2023-2024	m3/s	25 % high-water			75 % low-water						50 % average water						25 % high-water
		112	1.73	113.73	1.92	0.6	0.64	0.8	1.08	5.04	0.75	1.06	0.071	0.091	1.36	3.3	122
	%	91.80	1.42	93.22	1.57	0.49	0.52	0.66	0.89	4.13	0.61	0.87	0.06	0.07	1.11	2.7	100
Esil r. – Dolmatovo v.																	
2021-2022	m3/s	75 % low-water			75 % low-water						75 % low-water						75 % low-water
		26	106	132	30.2	13	10.2	10.5	11.2	75.1	10.3	10.2	13.7	12.3	13	59.5	267
	%	9.75	39.76	49.51	11.33	4.88	3.83	3.94	4.20	28.17	3.86	3.83	5.14	4.61	4.88	22.32	100
2022-2023	m3/s	50 % average water			50 % average water						75 % low-water						50% сред по воднос
		207	297	504	96.1	31.1	19	11.9	12.1	170.2	12.1	10.3	10.1	11.1	11.9	55.5	730
	%	28.37	40.70	69.07	13.2	4.26	2.60	1.63	1.66	23.32	1.66	1.41	1.38	1.52	1.63	7.61	100
2023-2024	m3/s	25 % high-water			25 % high-water						50 % average water						25 % high-water
		1526.9	1202	2728.9	193	70.3	48.6	34.5	27.2	373.6	27.3	20.8	10	9.26	10.71	78.1	3181
	%	48.00	37.79	85.79	6.07	2.21	1.53	1.08	0.86	11.74	0.86	0.65	0.31	0.29	0.34	2.5	100
Esil r. – Turgen v.																	
2021-2022	m3/s	25 % high-water			50 % average water						50 % average water						25 % high-water
		51.5	2.75	54.25	0.73	0.64	0.47	0.44	0.37	2.65	0.57	0.099	0	0	0.35	1.019	58
	%	88.92	4.75	93.67	1.26	1.10	0.81	0.76	0.64	4.58	0.98	0.17	0.00	0.00	0.60	1.76	100
2022-2023	m3/s	75 % low-water			25 % high-water						25 % high-water						50% сред по воднос
		15.6	3.65	19.25	0.54	0.13	0.18	2.13	6.52	9.5	6.58	6.55	0	0	0.5	13.63	42
	%	36.81	8.61	45.42	1.3	0.31	0.42	5.03	15.38	22.42	15.53	15.46	0.00	0.00	1.18	32.16	100
2023-2024	m3/s	50 % average water			25 % high-water						25 % high-water						50% сред по воднос
		35.1	1.25	36.35	0	0.58	1.03	1.02	0.73	3.36	0.47	0.24	0.05	0	6	6.8	46
	%	75.53	2.69	78.22	0.00	1.25	2.22	2.19	1.59	7.23	1.01	0.52	0.11	0.00	12.9	14.5	100
Kalkutan r. – Kalkutan v.																	
2021-2022	m3/s	75 % low-water			50 % average water						75 % low-water						75 % low-water
		7.48	3.76	11.24	2.32	1.11	0.08	0	0	3.51	0	0	0	0	0	0	14.75
	%	50.71	25.49	76.20	15.73	7.53	0.54	0.00	0.00	23.80	0.00	0.00	0.00	0.00	0.00	0.00	100
2022-2023	m3/s	50 % average water			75 % low-water						75 % low-water						50% сред по воднос
		92.1	5.89	97.99	0.31	0	0	0	0	0.31	0	0	0	0	0	0	98.3
	%	93.7	6.0	99.7	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	100
2023-2024	m3/s	25 % high-water			25 % high-water						25 % high-water						25 % high-water
		113	12.3	125.3	4.04	1.67	2.79	3.59	2.29	14.38	2.9	1.13	0	0	0	4.03	144
	%	78.63	8.56	87.19	2.81	1.16	1.94	2.50	1.59	10.01	2.02	0.79	0.00	0.00	0.00	2.80	100

YEAR	Unit of meas.	SPRING		SPRING	SUMMER					SUMMER	AUTUMN - WINTER					AUTUMN -WINTER	ANNUAL TOTAL
		IV	V		VI	VII	VIII	IX	X		XI	XII	I	II	III		
Esil r. – Petropavlovsk c.																	
2021-2022	m3/s	75 % low-water			50 % average water						25 % high-water						75 % low-water
		31	84.6	115.6	34.9	23.3	14.3	13.6	13.7	99.8	12.2	13	14.2	14.1	14.2	67.7	283.1
	%	10.95	29.88	40.83	12.33	8.23	5.05	4.80	4.84	35.25	4.31	4.59	5.02	4.98	5.02	23.91	100
2022-2023	m3/s	50 % average water			50 % average water						25 % high-water						50% сред по воднос
		288	325	613	90.4	25.8	15.4	15.4	15.7	162.7	12.8	12.1	13.9	13.1	15.5	67.4	843.1
	%	34.16	38.55	72.71	10.72	3.06	1.83	1.83	1.86	19.30	1.52	1.44	1.65	1.55	1.84	7.99	100
2023-2024	m3/s	25 % high-water			25 % high-water						25 % high-water						25 % high-water
		2310.4	1255	3565.4	148	55.8	38.6	31.5	29.7	303.6	29.1	23.7	12.9	14	13.6	93.3	3962.3
	%	58.31	31.67	89.98	3.74	1.41	0.97	0.79	0.75	7.66	0.73	0.60	0.33	0.35	0.34	2.35	100
Zhabay r. – Atbasar c.																	
2021-2022	m3/s	75 % low-water			50 % average water						50 % average water						75 % low-water
		42.8	5.37	48.17	1.77	1.22	1.04	0.93	0.98	5.94	1.13	0.84	0.65	0.68	0.93	4.23	58.34
	%	73.36	9.20	82.57	3.03	2.09	1.78	1.59	1.68	10.18	1.94	1.44	1.11	1.17	1.59	7.25	100
2022-2023	m3/s	25 % high-water			50 % average water						25 % high-water						25 % high-water
		218	16.6	234.6	2.33	1.19	0.87	1.22	1.49	7.1	2.03	2.02	0.58	0.6	2.31	7.54	249.24
	%	87.47	6.66	94.13	0.9	0.48	0.35	0.49	0.60	2.85	0.81	0.81	0.23	0.24	0.93	3.03	100
2023-2024	m3/s	25 % high-water			25 % high-water						25 % high-water						25 % high-water
		515	14.2	529.2	7.3	3.39	3.33	3.5	2.62	20.14	2.69	2.16	1.44	1.27	2.56	10.12	559.46
	%	92.05	2.54	94.59	1.30	0.61	0.60	0.63	0.47	3.60	0.48	0.39	0.26	0.23	0.46	1.81	100

Table 11 – Statistical characteristics and total discharges of different reliability levels for the main rivers of the **Shu-Talas WMB**

Период наблюде-ний	**YEAR**					**Non-limiting period**					**Limiting period**									
											Non-limiting season					**Limiting season**				
						SPRING					**SUMMER**					**AUTUMN -WINTER**				
	Cv	**Q**	**Monthly water discharge to-tals, m3/s**			**Cv**	**Q**	**Monthly water discharge to-tals, m3/s**			**Cv**	**Q**	**Monthly water discharge to-tals, m3/s**			**Cv**	**Q**	**Monthly water discharge to-tals, m3/s**		
			75%	**50%**	**25%**			**75%**	**50%**	**25%**			**75%**	**50%**	**25%**			**75%**	**50%**	**25%**
Shu r. – Kainar v.																				
1976-2021	0.73	839	509	619.8	821.9	0.58	142.3	85.7	117.5	186.2	0.66	86.7	47.9	61.6	109.6	0.91	609.9	375.5	440.7	526.1
Talas r. – Solnechny s																				
1977-2021	0.29	317	243.5	298.7	361.8	0.32	108	83.6	97.9	130.6	0.28	114.4	95.8	114.2	126.8	0.42	94.5	64.1	86.6	104.3
Teris r. – Nurlykent v.																				
1976-2021	0.32	71	54.6	66.6	81.7	0.39	46.8	34	43	54.7	0.44	5.3	4.1	5.6	7	0.21	18.8	16.5	17.9	20
Kuragaty r. – Aspara tr.st.																				
1976-2021	0.51	56.4	32.87	46.22	77.07	0.58	19	10.44	15.69	26.4	0.96	8.3	3.03	4.83	10.8	0.45	29.1	19.4	25.7	39.8

Table 12 – Seasonal water volumes at the main hydrological stations of the **Shu-Talas WMB for 2021-2024**

YEAR	Unit of meas.	SPRING			SPRING				SUMMER	ОСЕНЬ-WINTER						WINTER	ANNUAL TOTAL
		IV	V	VI		VII	VIII	IX		X	XI	XII	I	II	III		
Kuragaty r. – Aspara tr.st.																	
2021-2022	m3/s	**75 % low-water**			**75 % low-water**						**75 % low-water**						**75%**
		0.81	0,86	1,44	3,1	1.5	0.7	0.6	2.7	0.5	0.66	0.78	0.67	0.7	0.9	4.3	10,1
	%	8,06	8,56	14,33	30,9	14,6	6,57	5,57	26,8	5,37	6,57	7,76	6,67	7.16	8,8	42,3	100.0
2022-2023	m3/s	**75 % low-water**			**75 % low-water**						**75 % low-water**						**75%**
		1.06	0.77	0.75	2.58	0.73	0.75	0.49	1.97	0.49	0.5	0.48	0.76	1.67	1.74	5.64	10.2
	%	10,4	7.56	7.36	25,3	7.16	7.36	4.81	19.33	4.81	4.91	4.71	7.46	16.4	17.1	55.35	100
2023-2024	m3/s	**75 % low-water**			**75 % low-water**						**75 % low-water**						**75%**
		0,5	1.06	1,79	3,4	0.66	0.41	0.23	1.3	0.2	0.43	0.53	0.23	0,33	0,63	2.4	7
	%	7,14	15,14	25,6	47,9	9,43	5,86	3,29	18,6	2.86	6,14	7,57	3,29	4,71	9	33,6	100
Talas r. – Solnechny s																	
2021-2022	m3/s	**75 % low-water**			**25 % high-water**						**25 % high-water**						**25%**
		10.8	21.9	44.9	77.6	55.6	48.1	27.8	131.5	28.3	30.1	12.1	12.7	12	14	109.2	318.3
	%	3.39	6.88	14.11	24.38	17.5	15.1	8.73	41.3	8.89	9.46	3.80	3.99	3.8	4.40	34.3	100
2022-2023	m3/s	**75 % low-water**			**75 % low-water**						**50 % average water**						**75%**
		8.53	23.3	34.1	65.93	33.9	8.95	7.34	50.19	19	10.3	9.34	9.89	8.4	9.05	66.03	182.15
	%	4.7	12.8	18.7	36.2	18.6	4.9	4.0	27.6	10.4	5.7	5.1	5.4	4.6	5.0	36.3	100
2023-2024	m3/s	**75 % low-water**			**75 % low-water**						**75 % low-water**						**75%**
		8.57	8.9	7.24	24.71	7.46	19.9	41.4	68.76	51.6	38.7	16.1	15.8	15.4	18.9	156.5	249.97
	%	3.43	3.56	2.90	9.89	2.98	7.96	16.6	27.5	20.6	15.5	6.44	6.32	6.2	7.56	62.61	100
Shu r. – Kainar v.																	
2021-2022	m3/s	**50 % average water**			**50 % average water**						**75 % low-water**						**75%**
		44	27.1	25.4	96.5	21.3	17.6	27	65.9	44.7	77.9	79.5	54.5	53.4	62.6	372.6	535
	%	8.22	5.07	4.75	18.04	3.98	3.29	5.05	12.32	8.36	14.5	14.8	10.19	9.9	11.7	69.64	100
2022-2023	m3/s	**50 % average water**			**50 % average water**						**50 % average water**						**75%**
		64	24.8	17.1	105.9	16.2	17.2	24	57.4	42.3	67.5	69.1	69.3	70.1	69	387.3	550.6
	%	11.62	4.50	3.11	19.2	2.94	3.12	4.36	10.4	7.68	12.3	12.6	12.6	12.7	12.5	70.3	100
2023-2024	m3/s	**50 % average water**			**25 % high-water**						**50 % average water**						**50%**
		62.3	38.5	27.5	128.3	24.3	24.9	41.2	90.4	66.9	75.3	71.4	57.5	57.6	58.8	387.5	606.2
	%	10.28	6.35	4.54	21.16	4.01	4.11	6.80	14.91	11.0	12.4	11.8	9.49	9.5	9.70	63.92	100
YEAR	Unit of meas.	SPRING					SPRING	SUMMER			SUMMER	AUTUMN-WINTER				**AUTUMN-WINTER**	**ANNUAL TOTAL**
		II	III	IV	V	VI		VII	VIII	IX		X	XI	XII	I		
Teris r. – Nurlykent v.																	
2021-2022	m3/s	**50 % average water**			**75 % low-water**						**50 % average water**						**75 %**
		4.1	16.1	11.5	5.4	2.7	39.8	1.1	1.2	1.5	3,78	2.7	5.8	5.8	3.9	18,3	61,9
	%	6,69	26,01	18,58	8,7	4,28	64,3	1,83	1.9	2,39	6,11	4,43	9,4	9,4	6,4	29,6	100.0
2022-2023	m3/s	**50 % average water**			**50 % average water**						**50 % average water**						**75 %**
		12.3	18.2	9.89	5.1	1.62	47,11	1.73	1.19	1.99	4,91	2.58	3.4	4.4	7.94	18,3	70,3
	%	17,5	25,9	14,1	7,3	2,3	66,99	2,46	1.7	2,83	6,98	3,67	4,84	6,23	11,3	26	100
2023-2024	m3/s	**25 % high-water**			**25 % high-water**						**25 % high-water**						**25%**
		8.92	18.5	15.6	9.59	3.27	55,88	2.09	2.07	2.61	6,77	3.75	5.89	4.6	5.92	20,1	82,8
	%	10,8	22,4	18,9	11,6	3,95	67,5	2,52	2,5	3,15	8,18	4,53	7,12	5,52	7,15	24,3	100

Table 13 – Statistical characteristics and total discharges of different reliability levels for the main rivers of the **Nura–Sarysu WMBXБ**

Период наблюдений	YEAR					Non-limiting period					Limiting period									
											Non-limiting season					Limiting season				
						SPRING					SUMMER-AUTUMN					WINTER				
	Cv	Q	Monthly water dis-charge totals, m3/s			Cv	Q	Monthly water dis-charge totals, m3/s			Cv	Q	Monthly water dis-charge totals, m3/s			Cv	Q	Monthly water dis-charge totals, m3/s		
			75%	50%	25%			75%	50%	25%			75%	50%	25%			75%	50%	25%
Nura r. – Balykty r.s.																				
1974-2021	0,76	126	43	89	180	1,08	82	23,1	47	115	0,59	38,6	17,7	36,8	58,1	0,76	5,7	2,5	4,8	7,2
Nura r.– Koshkarbayeva v.																				
1958-2021	0,69	294	117	242	401	0,79	216	76,7	174	296	0,57	61,3	31,8	52,9	82,8	0,67	16,6	8,3	14,5	22,0
Sherubainura r.– Karamuryn s.																				
1947-2021	0,83	71	24	53	99	0,90	60	18,1	44,6	86	0,72	8,4	4,4	6,8	10,5	0,47	2,15	1,47	1,93	2,65
Sarysu r.– № 189 s.																				
2000-2021	1,60	53	2	16	79	1,64	50	1,7	15	76	1,33	3,0	0,5	1,3	3,3	2,11	0,03	0,0	0,0	0,02

Table 14 – Seasonal water volumes at the main hydrological stations of the **Nura–Sarysu WMB for 2021-2024**

YEAR	**Unit of mea**	**SPRING–SUMMER**			**∑(SPRING–SUMMER)**	**AUTUMN**						**∑(AUTUMN)**	**WINTER**			**∑(WINTER)**	**ANNUAL TOTAL**
		III	**IV**	**V**		**VI**	**VII**	**VIII**	**IX**	**X**	**XI**		**XII**	**I**	**II**		
Nura r. – Balykty r.s.																	
2021-2022	m3/s	75 % low-water				50 % average water							25 % high-water				75%
		1,38	44,1	17,0	62,48	11,00	2,10	4,11	3,42	1,41	1,21	23,25	0,97	0,98	0,32	2,27	88,00
	%	1,57	50,11	19,32	71,00	12,50	2,39	4,67	3,89	1,60	1,38	26,42	1,10	1,11	0,36	2,58	100
2022-2023	m3/s	75 % low-water				75 % low-water							50 % average water				75 %
		0,76	121,0	5,7	127,47	2,37	1,49	8,59	5,57	1,90	1,21	21,13	0,63	0,51	0,56	1,70	150,30
	%	0,51	80,51	3,80	84,81	1,58	0,99	5,72	3,71	1,26	0,81	14,06	0,42	0,34	0,37	1,13	100
2023-2024	m3/s	50 % average water				25 % high-water							25 % high-water				50 %
		0,97	28,9	3,6	33,51	4,31	6,25	1,71	7,52	8,27	7,17	35,23	0,82	0,61	0,46	1,89	70,63
	%	1,37	40,92	5,15	47,44	6,10	8,85	2,42	10,65	11,71	10,15	49,88	1,16	0,86	0,65	2,68	100
Nura r.– Koshkarbayeva v.																	
2021-2022	m3/s	25 % high-water				50 % average water							50 % average water				25 %
		5,60	243,0	37,2	285,8	17,70	12,00	13,20	14,10	13,00	11,40	81,40	8,12	6,72	6,19	21,03	388,23
	%	1,44	62,59	9,58	73,62	4,56	3,09	3,40	3,63	3,35	2,94	20,97	2,09	1,73	1,59	5,42	100
2022-2023	m3/s	75 % low-water				25 % high-water							50 % average water				50 %
		8,70	141,0	72,6	222,3	21,30	8,77	10,10	11,00	9,94	7,07	68,18	0,00	0,00	0,00	0,00	290,48
	%	3,00	48,54	24,99	76,53	7,33	3,02	3,48	3,79	3,42	2,43	23,47	0,00	0,00	0,00	0,00	100
2023-2024	m3/s	75 % low-water				75 % low-water							50 % average water				75 %
		5,40	36,7	12,7	54,80	8,89	7,69	7,44	8,66	9,97	8,77	51,42	4,92	6,86	2,25	14,03	120,25
	%	4,49	30,52	10,56	45,57	7,39	6,40	6,19	7,20	8,29	7,29	42,76	4,09	5,70	1,87	11,67	100
Sherubainura r.– Karamuryn s.																	
2021-2022	50 % average water					50 % average water							25 % high-water				50 %
	m3/s	0,86	13,1	6,47	20,43	1,41	0,51	0,38	0,38	1	2,84	6,52	0,95	0,75	0,95	2,65	29,60

YEAR	Unit of mea	SPRING–SUMMER			∑(SPRING–SUMMER)	AUTUMN						∑(AUTUMN)	WINTER			∑(WINTER)	ANNUAL TOTAL
		III	IV	V		VI	VII	VIII	IX	X	XI		XII	I	II		
	%	2,91	44,26	21,86	69,02	4,76	1,72	1,28	1,28	3,38	9,59	22,03	3,21	2,53	3,21	8,95	100
2022-2023	75 % low-water					75 % low-water							50 % average water				75 %
	m3/s	1,99	53,2	5,5	60,69	2,15	0,58	0,42	0,43	1,7	1,04	6,32	0,72	0,71	0,67	2,10	69,11
	%	2,88	76,98	7,96	87,82	3,11	0,84	0,61	0,62	2,46	1,50	9,14	1,04	1,03	0,97	3,04	100
2023-2024	75 % low-water					25 % high-water							25 % high-water				75 %
	m3/s	1,66	21,9	6,28	29,84	1,53	0,53	0,31	0,35	0,4	1,2	4,32	0,75	0,72	1,01	2,48	36,64
	%	4,53	59,77	17,14	81,44	4,18	1,45	0,85	0,96	1,09	3,28	11,79	2,05	1,97	2,76	6,77	100
Sarysu r.– № 189 s.																	
2021-2022	25 % high-water					50 % average water							50 % average water				50 %
	m3/s	0,041	8,35	2,47	10,861	1,3	0,61	0,4	0,27	0,4	0,21	3,19	0	0	0	0,00	14,05
	%	0,29	59,43	17,58	77,30	9,25	4,34	2,85	1,92	2,85	1,49	22,70	0,00	0,00	0,00	0,00	100
2022-2023	50 % average water					75 % low-water							50 % average water				75 %
	m3/s	0	9,12	1,65	10,77	1,05	0,43	0,27	0,29	0,37	0,28	2,69	0	0	0	0,00	13,46
	%	0,00	67,76	12,26	80,01	7,80	3,19	2,01	2,15	2,75	2,08	19,99	0,00	0,00	0,00	0,00	100
2023-2024	75 % low-water					25 % high-water							75 % low-water				50 %
	m3/s	7,76	11,2	4,88	23,84	1,04	0,69	0,24	0,2	0,099	0,096	2,37	0,04	0	0	0,04	26,25
	%	29,57	42,67	18,59	90,84	3,96	2,63	0,91	0,76	0,38	0,37	9,01	0,15	0,00	0,00	0,15	100

Table 15 – Statistical characteristics and total discharges of different reliability levels for the main rivers of the **Tobol–Torgay WMBХБ**

Период наблюдений	YEAR					Non-limiting period					Limiting period									
											Non-limiting season					Limiting season				
						SPRING					SUMMER-AUTUMN					WINTER				
	Cv	Q	Monthly water discharge totals, m3/s			Cv	Q	Monthly water discharge totals, m3/s			Cv	Q	Monthly water discharge totals, m3/s			Cv	Q	Monthly water discharge totals, m3/s		
			75%	50%	25%			75%	50%	25%			75%	50%	25%			75%	50%	25%
Tobol r. – Kostanay c.																				
1964-2021	1.17	114	27	52	113	1.51	66	9.8	21.4	57.5	0.75	24.1	11.1	18.5	29.9	1.24	23.1	6.2	11.8	26.1
Tobol r. – Grishenka v.																				
1938-2021	1.08	87	20	48	116	1.14	79	18.9	45	108	1.03	3.1	0.8	2.0	4.4	2.29	4.9	0.6	1.6	3.5
Ayat r. – Varvarinka v.																				
1952-2021	0.79	66	28.4	43.8	82.8	0.87	54	25	37	69	1.66	6.46	2.14	3.53	8.30	1.25	5.02	1.56	3.19	5.33
Togysak r. – Toguzak v.																				
1940-2021	0.80	36	12	24	42	0.91	28	10.3	19	34	2.05	3.8	1.1	2.5	3.8	1.11	3.5	1.1	1.9	4.4
Irghiz r. – Shenbertal v.																				
1962-2021	0.97	85.3	21.0	60.5	94.9	1.0	79.4	20.2	58.8	91.8	0.8	1.1	0.5	1.0	1.5	2.8	4.7	0.3	0.7	1.6
Kara-Torgay r. – Urpek v.																				
1947-2021	0.54	111	54	87	145	0.59	94	53.2	80	129	0.78	3.3	0.0	3.9	4.7	1.92	13.7	0.7	3.0	11.5

Table 16 – Seasonal water volumes at the main hydrological stations of the **Tobol–Torgay WMB for 2021-2024**

YEAR	Unit of meas.	SPRING			∑(SPRING–SUMMER)	SUMMER-AUTUMN				∑(SUMMER-AUTUMN)	WINTER					∑(WINTER)	ANNUAL TOTAL
		IV	V	VI		VII	VIII	IX	X		XI	XII	I	II	III		
Tobol r. – Grishenka v.																	
2021-2022		50 % average water				50 % average water					50 % average water						50 %
	m3/s	49.30	4.30	0.96	54.56	0.22	0.18	0.19	1.94	2.53	0.29	0.29	0.53	0.58	0.75	2.44	59.53
	%	82.82	7.22	1.61	91.65	0.37	0.30	0.32	3.26	4.25	0.49	0.49	0.89	0.97	1.26	4.10	100
2022-2023		75 % low-water				25 % high-water					25 % high-water						50 %
	m3/s	3.87	1.89	0.56	6.32	0.16	0.13	0.10	3.22	3.61	0.95	0.3	0.31	0.19	16.3	18.05	27.98
	%	13.83	6.75	2.00	22.59	0.57	0.46	0.36	11.51	12.90	3.40	1.07	1.11	0.68	58.26	64.51	100
2023-2024		50 % average water				25 % high-water					25 % high-water						25 %
	m3/s	71.20	2.51	1.00	74.71	0.59	0.44	0.99	1.63	3.65	1.84	0.73	0.76	0.9	11	15.23	93.59
	%	76.08	2.68	1.07	79.83	0.63	0.47	1.06	1.74	3.90	1.97	0.78	0.81	0.96	11.75	16.27	100
Tobol r. – Kostanay c.																	
2021-2022	m3/s	50 % average water				50 % average water					50 % average water						50 %
		5.69	5.13	9.05	19.87	8.69	6.27	3.95	2.70	21.61	1.94	1.81	1.87	1.78	2.60	10	51.48
	%	11.05	9.97	17.58	38.60	16.88	12.18	7.67	5.24	41.98	3.77	3.52	3.63	3.46	5.05	19.43	100
2022-2023	m3/s	50 % average water				50 % average water					50 % average water						50 %
		3.09	5.24	4.42	12.75	6.25	5.48	5.01	2.64	19.38	1.76	1.75	1.81	1.88	2.05	9.25	41.38
	%	7.47	12.66	10.68	30.81	15.10	13.24	12.11	6.38	46.83	4.25	4.23	4.37	4.54	4.95	22.35	100
2023-2024	m3/s	75 % low-water				75 % low-water					25 % high-water						50 %
		2.93	3.40	5.45	11.78	4.93	3.57	2.40	1.89	12.79	1.48	1.64	1.81	1.75	13.80	20.48	45.05
	%	6.50	7.55	12.10	26.15	10.94	7.92	5.33	4.20	28.39	3.29	3.64	4.02	3.88	30.63	45.46	100
Ayat r. – Varvarinka v.																	
2021-2022		50 % average water				75 % low-water					50 % average water						50 %
	m3/s	34.4	2.57	0.74	37.71	0.53	0.47	0.42	0.43	1.85	0.48	0.55	0.63	0.62	0.56	2.84	42
	%	81.1	6.1	1.7	88.9	1.25	1.11	0.99	1.01	4.36	1.13	1.30	1.49	1.46	1.32	6.7	100
2022-2023	m3/s	75 % low-water				75 % low-water					75 % low-water						75 %
		2.92	2.3	0.91	6.13	0.62	0.44	0.33	0.3	1.69	0.31	0.37	0.44	0.42	0.46	2.00	10
	%	29.7	23.4	9.3	62.4	6.31	4.48	3.36	3.05	17.21	3.16	3.77	4.48	4.28	4.68	20.4	100
2023-2024	m3/s	50 % average water				75 % low-water					25 % high-water						50 %
		49.5	1.62	0.64	51.76	0.48	0.53	0.59	0.64	2.24	0.66	1.01	1.39	1.12	1.67	5.85	60
	%	82.71	2.71	1.07	86.5	0.80	0.89	0.99	1.07	3.7	1.10	1.69	2.32	1.87	2.79	9.77	100
Togysak r. – Toguzak v.																	
2021-2022		50 % average water				75 % low-water					50 % average water						75 %
	m3/s	12	1.21	0.4	13.61	0.2	0.16	0.21	0.46	1.03	0.54	0.47	0.43	0.47	0.55	2.46	17.10
	%	70.18	7.08	2.34	79.59	1.17	0.94	1.23	2.69	6.02	3.16	2.75	2.51	2.75	3.22	14.39	100
2022-2023	m3/s	75 % low-water				75 % low-water					50 % average water						75 %
		3.87	1.89	0.56	6.32	0.16	0.13	0.10	3.22	3.61	0.95	0.3	0.31	0.19	16.3	18.05	27.98
	%	13.83	6.75	2.00	22.59	0.57	0.46	0.36	11.51	12.90	3.40	1.07	1.11	0.68	58.26	64.51	100
2023-2024	m3/s	75 % low-water				50 % average water					25 % high-water						75 %
		5.00	0.81	0.36	6.17	0.37	0.46	0.64	0.69	2.16	0.78	0.74	0.79	0.81	1.54	4.66	12.99
	%	38.49	6.24	2.77	47.50	2.85	3.54	4.93	5.31	16.63	6.00	5.70	6.08	6.24	11.86	35.87	100
Irghiz r. – Shenbertal v.																	
2021-2022		75 % low-water				75 % low-water					25 % high-water						75 %
	m3/s	0.72	0.49	0.10	1.31	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	1.67	1.67	3.00

	%	24.02	16.34	3.24	43.60	0.70	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	55.70	55.70	100
2022-2023	m3/s	50 % average water				75 % low-water					25 % high-water						50 %
		64.60	0.57	0.35	65.52	0.18	0.12	0.09	0.10	0.49	0.11	0.00	0.00	0.00	19.60	19.71	85.72
	%	75.36	0.66	0.41	76.44	0.21	0.14	0.10	0.12	0.57	0.13	0.00	0.00	0.00	22.87	22.99	100
2023-2024	m3/s	75 % low-water				50 % average water					25 % high-water						25 %
		12.70	4.11	1.09	17.90	0.26	0.16	0.25	0.21	0.88	0.16	0.08	0.08	0.00	193.0	193.32	212.10
	%	5.99	1.94	0.51	8.44	0.12	0.08	0.12	0.10	0.41	0.08	0.04	0.04	0.00	91.00	91.15	100
Kara-Torgay r. – Urpek v.																	
2021-2022		50 % average water				75 % low-water					75 % low-water						50 %
	m3/s	102.00	1.47	0.00	103.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	103.47
	%	98.58	1.42	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100
2022-2023	m3/s	25 % high-water				75 % low-water					25 % high-water						25 %
		146	7.33	0.00	153.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.60	44.60	197.93
	%	73.76	3.70	0.00	77.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.53	22.53	100
2023-2024		75 % low-water				75 % low-water					75 % low-water						75 %
	m3/s	49.20	4.86	0.00	54.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	54.06
	%	91.01	8.99	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100