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B.S. Botantaeva[1], A.O. Sagybekova[1,2], A. Vagapova[3]
[1]L.B. Goncharov Kazakh Automobile and Road Institute, Almaty, Kazakhstan
E-mail: botantaeva_b@mail.ru
[2]N. Isanova Kyrgyz Civil Engineering Institute, applicant, Kyrgyzstan
*E-mail: sao-81@mail.ru**
[3]Kazakh National Agrarian Research University, Almaty, Kazakhstan
E-mail: vagapova-alina@rambler.ru

PROTECTION AGAINST FLOODING BY FLOOD WATERS OF ALMATY AND ALMATY REGIONS

АЛМАТЫ ҚАЛАСЫНЫҢ ЖӘНЕ АЛМАТЫ ОБЛЫСЫНЫҢ ТАСҚЫН СУЛАРЫНЫҢ СУ БАСУЫНАН ҚОРҒАУ

ЗАЩИТА ОТ ЗАТОПЛЕНИЯ ПАВОДКОВЫМИ ВОДАМИ ГОРОДА АЛМАТЫ И АЛМАТИНСКОЙ ОБЛАСТИ

Abstract. *The flow of the Ile River is regulated by a cascade of reservoirs on the tributaries and along the river trunk: Bartogay (Shelek River), Kapshagay (Ile River), etc. The maximum flow rates along the Ile River are determined by the capa of the discharge structures of the hydroelectric power plants and the unregulated flow of the lateral inflow (Kaskelen River, etc.).*

The Ile River is formed by the confluence of the Tekes and Kunges Rivers, and it also receives a lot of tributaries, the sources of which flow down from the snowy peaks of the adjacent mountains. In terms of water content and turbidity, the water of the Ile River ranks third among the large rivers of Central Asia (Amu Darya, Syr Darya), and is only slightly inferior in water content to the Syr Darya River.

Keywords: *river, water resources, river basin, maximum flow, flood, water level fluctuations, water protection zones and strips, dams, bank protection works*

Аңдатпа. *Іле өзенінің ағыны ағындардағы және өзен діңінің бойындағы су қоймаларының каскадымен реттеледі: Бартоғай (Шелек өзені), Қапшағай (Іле өзені) және т.б. су электр кешендерінің ағызу құрылымдары және бүйірлік ағындардың реттелмейтін ағыны (Қаскелең және т.б.).*

Іле өзені Текес пен Күнгес өзендерінің түйіскен жерінен қалыптасады, сонымен қатар оған жақын орналасқан таулардың қарлы шыңдарынан ағатын көптеген салалар да құйылады. Судың құрамы мен лайлылығына қарай өзен суы Іле Орта Азияның ірі өзендерінің (Амудария, Сырдария) ішінде үшінші орында, ал судың құрамы жағынан Сырдария өзенінен сәл төмен.

Түйін сөздер: *өзен, су ресурстары, өзен бассейні, максималды ағын, тасқын, су деңгейінің ауытқуы, су қорғау аймақтары мен белдеулері, бөгеттер, жағалауды бекіту жұмыстары.*

Аннотация. *Сток реки Иле зарегулирован каскадом водохранилищ на притоках и по стволу реки: Бартогайское (р. Шелек), Капшагайское (р. Иле) и др. Максимальные расходы по реке Иле предопределяются пропускной способностью сбросных сооружений гидроузлов и незарегулированным стоком боковой приточности (р. Каскелен и др.).*

Река Иле образуется при слиянии рек Текес и Кунгес, а также она принимает массу притоков, истоки которых стекают со снежных вершин прилегающих гор. По водности и мутности вода р. Иле занимает

третье место среди крупных рек Средней Азии (Амударья, Сырдарья), мало уступает по водности р. Сырдарье.

Ключевые слова: *река, водные ресурсы, бассейн реки, максимальный расход, половодье, колебания уровня воды, водоохранные зоны и полосы, дамбы, берегоукрепительные работы.*

Introduction. The Ile River basin accounts for about 70% of the catchment area and 80% of the total surface runoff into Lake Balkhash. The main runoff-forming part of the Ile River basin is located on the territory of the PRC, where the catchment area has a fairly well-developed hydrographic network. On the right, the high-flow tributary Kash (Western China) and the rivers with less water content Borokhudzir , Khorgos and Usek , which are fed by glaciers, flow into the Ile River .

The hydrographic network in the middle and lower reaches of the Ile River (territory of the Republic of Kazakhstan) is much less developed, where large areas are completely devoid of surface inflow. The left-bank part of the basin is active, where many mountain rivers flow into the Ile River from the slopes of the Tien Shan, the Northern slope of the Zailiysky Alatau.

Methods and materials. There are 8 basin inspectorates (BI) operating in the republic: Aral-Syrdarya (11%), Balkhash-Alakol (15%), Ertis (Irtysh 12%), Yesil (Ishim 9%), Zhaiyk (Ural)-Caspian (23%), Nura-Sarysu (11%), Tobyl-Torgay (13%) and Shu-Talas (6%) (Fig. 1).

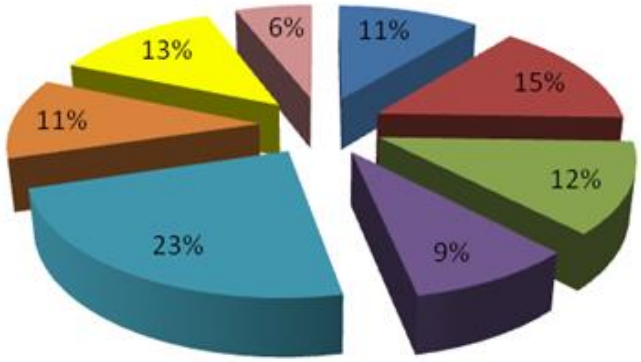

Figure 1. The share of basin inspections in the total territory of the Republic of Kazakhstan
Note – compiled by the author

The flow of the main rivers of Kazakhstan is shown in Figure 2 [1].

Within Kazakhstan, the Ile River receives many tributaries, especially on the left - Sharyn, Shelek, Issyk, Talgar, Kaskelen with B. Almatinka and M. Almatinka , Kurty . In the right-bank part, the largest tributaries of the Ile River are Khorgos, Usek and Borokhudzir, flowing down from the southern slopes of the Zhungar Alatau (Surface water resources of the USSR, 1970, Annual data on the regime, 2020).

The long-term average annual flow rate of the Ile River below Kapchagay is 478 m^3/s. Before the construction of the Kapchagay Reservoir, the maximum flow rate reached 2449 m^3/s (August 1924 г), and the minimum – 137 m^3/s (January 28 1925 г). During the growing season (June – September), the flow rate is 637 m^3/s, and at other times – 312 m^3/s. After the confluence of the Kurta River and up to the mouth of the river, the Ile does not receive surface feeding.

The maximum level in the river is in July, the lowest - in December. The average long-term range of fluctuations in the level reaches 1,5 м, the absolute - 3,45 м. At the very beginning of the river Ile has a width of up to 150 м, in the lower reaches up to 1 км. The general drop in water level in the river from the confluence of the river Tekes to the mouth of the river Ile is 1300 м, the speed of the current is up to 2.0 m/s.

The ice formation near Kapchagay usually begins in December, and the ice drift begins in mid-March. The ice formation is preceded by slush and ice banks from the end of November. But in some places the river almost never freezes, especially in the upper reaches. There are ice jams, but now they are comparatively rare. Below the dam the river does not freeze for several kilometers.

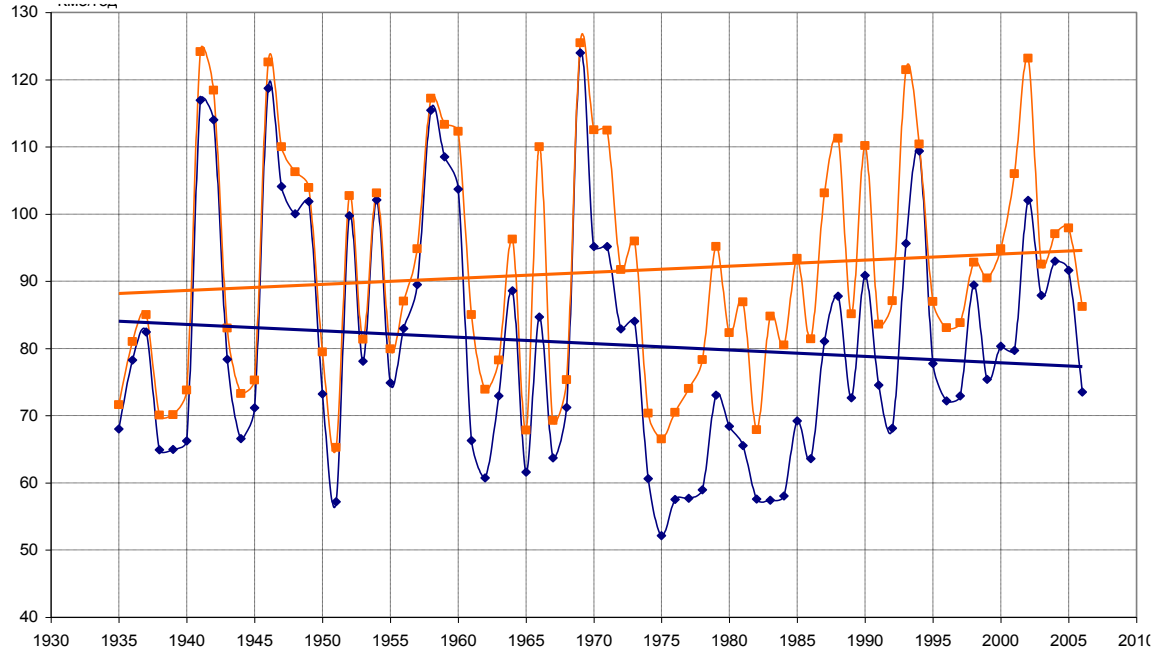

Figure 2. Long-term course of actual domestic and natural
(restored) flow of the main rivers of the Republic of Kazakhstan (1935-2010)
Note – compiled by the author based on (Surface water resources of the USSR, 1970, Annual data on the regime, 2020)

A large tributary of the Ile River, the Sharyn River originates 393 км from the southern slope of the Ketmen Ridge, which has no glaciers. From 50 кмits source it spreads out in a wide intermountain depression and is almost lost in loose sediments. Then it gathers again and, under the name Kegen, flows into the Sharyn River, which receives a tributary from the left, the Karkara. Here the Sharyn River changes its direction, cuts into the bedrock, forming the picturesque Sharyn Canyon. The average annual flow is 35.6 m^3/s.

Shilek River is the second largest tributary on the left, originating from the powerful Talgar mountain range in the Zailiysky Alatau with glaciers and eternal snows. This river gives the Ile River 32 m^3/s, collecting water from the Zailiysky and Kungey Alatau, but in the foothills a lot of water is taken for irrigation.

The following tributaries on the left: Issyk, Talgar, Kaskelen with B. and M. Almatinka and others, are also fed by glaciers and snow, their flow is small and a significant part of the water is taken for irrigation, water supply. The mountainous terrain and significant amounts of annual precipitation on the northern slopes of the Zailiysky Alatau in the Almaty's region made its rivers the most full-flowing and dangerous during floods and rain floods. Particularly dangerous are mudflows, periodically observed on the rivers B. and M. Almatinka, Aksay, Issyk, Kaskelen, Talgar and others (Surface water resources of the USSR, 1970, Annual data on the regime, 2020).

The estimated maximum discharges of the summer-spring flood along the Ile River and its tributaries are given below in Table 1.

The study of the level regime of the rivers of the Ile basin began in 1906 г., when water-gauge posts were opened on the Ile River at the Borokhudzir pier and on the Bolshaya Almatinka River – 2 кмbelow the mouth of the Teresbutak stream.

Table 1. Parameters of maximum water discharges of spring-summer floods on the Ile River and its tributaries

River – post	Average long-term parameters			Estimated water consumption of different levels of availability, m^3/s				
	Q m^3/s	Cv	Cs	0.1%	1.0%	2.0%	5.0%	10.0%
Dubun Ave.	1310	0.23	0.46	2440	2110	2020	1840	1710
Ile –164 кмabove the Kapshagai hydroelectric station	1277	0.18	0.36	2100	1870	1810	1680	1580
Ile – Kapshagay urn	835	0.20	0.40	1450	1270	1220	1130	1060
Ile – s. Ushzharma	625	0.17	0.34	1060	923	888	818	766
Tekes – s. Tekes	28.7	0.38	0.76	73.1	59.3	55.7	48.5	43.2
Usuk 1,7 кмabove the confluence	81.7	0.52	2.21	343	238	214	167	136
Borukhudzir – s. Kiitin	13.3	1.20	3.60	137	81.2	68.5	44.2	29.8
Shilik – s. Malybay	114	0.14	0.28	176	158	152	142	135
Turgen – village Tauturgen	42.6	0.41	1.43	132	100	92.1	76.5	66.0
Issyk – Issyk	19.1	0.40	1.40	58	44.1	40.6	33.9	29.3
Talgar – Talgar town	43.5	0.31	1.86	121	91.0	84.0	70.2	61.3
Malaya Almatinka –Almaty	11.8	0.70	2.10	61.7	42.0	37.3	28.4	22.5
Bolshaya Almatinka – 1,1 кмabove BAO	8.99	0.26	1.04	19.7	16.1	15.2	13.4	12.1
Aksai – s. Aksai	11.3	0.49	1.96	43.7	31.1	28.2	22.4	18.5
Kaskelen – Kaskelen	21.8	0.31	1.24	54.7	43.2	31.1	30.8	30.9
Chemolgan – Chemolgan	5.48	0.53	1.59	21.0	15.3	13.9	11.2	9.34
Note – compiled by the author								

The flood on the watercourses of the basin in question begins from March to the third ten-day period of June and continues until the end of October. The average date of the beginning of the flood is the end of March – the third ten-day period of April, and ends on most watercourses in September. On average, the flood lasts from 80 to 171 days.

During the observation period, the maximum duration of the flood was observed on the Talgar River – Talgar town in 1974 г. – 205 days. The shortest flood was observed on 1957 гthe Borokhudzir River – Kiytin village (maximum duration 148 days), and in there was no flood. As a percentage of the annual flow, the flow during the flood on the rivers under consideration averages 60-80%.

On the Ile River, during high summer flood levels, the floodplain is flooded and the water remains there for 2-12 days. For the rivers of the Zailiyskiy Alatau, critical water levels occur both as a result of jam-jam phenomena in the winter period and in the spring period, caused by mudflow floods.

The highest level per year for rivers with stable ice cover is observed during the spring ice drift on the Ile River - Ushzharma village. Of the rivers under consideration, the Issyk River - Issyk post section periodically dries up in 18% of cases from the entire series of observations (1966-1976).

The average annual amplitude of water level fluctuations in the considered watercourses of the Ile River basin varies from 45 to 211 см. On the Ile River – Ushzharma village, under natural conditions, the highest annual amplitude of the water level was observed in 1969 г. – 543 см, and after the construction of the Kapchagay Reservoir – 304 смin 1974 г. The long-term amplitude of level fluctuations varies from 40 to 304 см. The estimated highest water levels (according to SNiP 2.01.14-83) were determined by the maximum water discharge of the estimated probability of exceeding P % and the water discharge curve Q = f(H), which was constructed taking into account the hydraulic and morphometric characteristics of the river bed and floodplain in the considered section. Table 2 shows the maximum water levels of different probabilities.

Table 2. Estimated water levels (in cm) of different levels of availability

River – point	Mark "0" of the post schedule in m BS	Water levels of different supply, m		
		1%	3%	5%
Ile – s. Ushzharma	377.89	383	370	364
Borohudzir – village Kiitin	1160.2	396	352	323
Shelek – s. Malybay	866.79	220	214	210
Turgen – s.Tauturgen	1141.79	225	210	203
Issyk – Issyk	1286	305	298	293
Talgar – Talgar	1199.21	310	298	294
Kaskelen – Kaskelen town	1128,5	404	390	384
Shamalgan – p. Shamalgan	1096.5	168	165	161
Note – compiled by the author				

Protection of Almaty from flooding. Water bodies of Almaty are a complex of natural watercourses, reservoirs and engineering facilities, which, together with adjacent territories, constitute a significant ecological, urban planning and recreational potential, determine the architectural and aesthetic appearance of the , ensure the regulation and drainage of surface and groundwater runoff and are used for economic and technical purposes.

There are 22 rivers and 4 artificial riverbed reservoirs in the of Almaty (appendix to the program). The total length of riverbeds is 220,8 км. The total area of water fund mirrors is 1116 га. The largest rivers are Bolshaya Almatinka (29 км), Malaya Almatinka (28 км) and Esentai (25 км) (Dostay, 2012).

The basins of rivers and reservoirs of Almaty, as a result of the accelerated process of industrialization and urbanization in recent decades, are experiencing enormous anthropogenic pressure, which has caused the natural environment of these zones to approach the threshold of irreversible changes, and the state of protection of the territories and population of the from possible catastrophic discharges along the rivers, as well as flooding and underflooding, especially during the period of snowmelt and heavy rains, the existing environmental monitoring system does not meet the requirements (Ratkovich D.Ya.& Ratkovich L.D., 2000).

The engineering and technical measures carried out annually by the administration to clear river beds and irrigation ditch networks with the involvement of forces and resources of

enterprises and organizations only partially ensure protection from emergency situations. Planned preventive and prophylactic measures are not carried out in full (Dostay, 2012).

The mudflow that occurred in July 1999 led to a significant deepening of the riverbeds of the M.Almatinka and Esentai rivers in the upper part of the and, in this regard, to an unstable state of the slopes.

Makataev Street to Ryskulov Avenue, the bed of the M.Almatinka River has narrowed significantly due to sediment deposition; the river's capa on this section is no more than 3-5 m^3/s, with a design capa of 25 m^3/s.

Esentai River is subject to serious negative impacts (Hydrological yearbooks 1930-1962, 2002-2015).

The riverbeds of the Malaya Almatinka and Esentai rivers below Raimbek Avenue are not stabilized and are significantly narrowed due to sediment deposition and dumping of household waste on the slopes, which significantly reduces the water-carrying capa of the riverbeds to 3-5 m^3/s and, even in conditions of a slight increase in water volumes with heavy precipitation, leads to flooding of areas located in water protection zones.

The small rivers Moika, Karasu, Sultan Karasu, Zharbulak, Boraldai, Aksai, Kargalinka are in an unsanitary condition.

The banks and bed of the Kunaev Big Almaty Canal are littered with household and construction waste along their entire length, and the elements that strengthen the banks have been destroyed.

Medeu State Nature Park, where the volume of riverbank erosion, cases of tree collapses, and destruction of pedestrian and automobile bridge supports have increased.

The existing system of floodplain and coastal territories is a chain of built-up areas with partially preserved greenery and natural communities in various stages of anthropogenic degradation. River beds are transformed, subject to landslides and erosion, the coastlines are built up with private housing and occupied by economic activity.

This is primarily due to the fact that the temporarily lacked the standard sizes of water protection zones and strips. Water protection zones and strips are territories with special conditions of use, which are established to maintain water bodies and water management structures in a condition that meets sanitary and hygienic and environmental requirements, to prevent pollution, clogging and depletion of surface water, as well as to preserve flora and fauna (Avakyan & Istomina, 2000).

In 2006, in accordance with the plan of environmental protection measures, the project “Establishment of water protection zones” was developed at the expense of the local budget. zones and strips of water bodies of Almaty".

The boundaries of water protection zones and strips of water bodies in Almaty are determined taking into account the entire range of factors influencing the conditions of pollutant discharge into the riverbed: natural conditions, planning organization of the territory, location of ecologically hazardous objects.

The length of the with a large drainage basin area and significant terrain slopes predetermines intensive surface runoff of rain (storm) and melt water.

In 2002, the feasibility study "Storm Sewerage of Almaty" was developed, and currently a working project for storm sewerage of Almaty is being developed. The project provides for the construction of facilities for the collection, drainage and purification of surface runoff water from the entire built-up area of Almaty.

The protection of the population, economic potential and environment of Almaty from the impact of natural emergencies, the reduction of possible material damage, and the improvement of the rivers of Almaty are considered as a process of continuous elimination of contradictions

between the existing type of development of valley complexes and new public needs (Istomina et.al, 2004).

Conclusions. The current position of the river beds does not meet the expected volumes of maximum runoff. Almaty rivers as a whole cannot perform their functions due to the development of coastal areas and unsuccessful design solutions for the arrangement of river beds. All rivers in the lower reaches are not able to pass increased volumes of runoff and when they pass, individual territories are flooded. Design solutions adopted in the arrangement of rivers do not solve the problems of cleaning their beds from pollution and the durability of structures. The restoration and connection of the irrigation ditch network with small rivers, as envisaged in previously completed projects, have not been implemented (Avakyan & Istomina, 2001).

Government of Almaty has developed the Program "Rivers and reservoirs of Almaty".

The program is aimed at implementing the main provisions of the state strategy for sustainable development of Almaty.

One of the main goals of the program is to prevent emergency situations - to mitigate harmful effects, reduce damage caused by emergency situations of natural and man-made nature (Malik, 2003). Ensuring the protection of the 's territories and population from dangerous geological and hydrogeological phenomena by implementing urgent engineering measures, establishing constant monitoring of the mudflow situation and the state of mudflow protection structures, potentially dangerous areas of mudflows and landslides, creating a unified monitoring system with a comprehensive analytical center for processing information to ensure the safety and life of Almaty.

Flooding by flood waters in Almaty's regions. Almost every year in the basin, due to the sufficiently developed river network, emergency situations caused by floods on the rivers (floods, rain floods) occur (Avakyan & Istomina, 2000).

37 objects fall into the flood zone, erosion of banks and bridge abutments by flood waters of the basin: 23 settlements, 1 bridge on the Aktogay-Druzhba railway, 13 road bridges, including on the highways of state and republican significance Almaty-Khorgos and Almaty-Ust-Kamenogorsk, two water supply intakes (Hydrometeorology and Ecology, 2018).

Potential damage from floods and inundations in the Ile River basin in Almaty's regions will amount to 184,121.0 million tenge.

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Information about authors

Botantaeva Bibigul Sarybaevna – Candidate of Technical Sciences, L.B. Goncharov Kazakh autoroad Institute, Almaty, Kazakhstan, e-mail: botantaeva_b@mail.ru, ORCID: 0000-0002-1342-3163, +7 705 336 02 53

Akmaral O. Sagybekova – Candidate of Technical Sciences, L.B. Goncharov Kazakh autoroad Institute, Almaty, Kazakhstan, e-mail: sao-81@mail.ru, +77477148124, Scopus Author ID: 57223975261, Web of Science Researcher ID: A-7187-2019, ORCID: 0000-0001-5679-5816, https://scholar.google.-com/citations?user=UwbMW0YAAAAJ&hl=ru

Vagapova Alina – Candidate of Technical Sciences, Kazakh National Agrarian Research University, Almaty, Kazakhstan, E-mail: vagapova-alina@rambler.ru, https://orcid.org/0009-0005-5385-3378