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«Қазақстан Республикасы Ұлттық ғылым академиясының Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналы 2016 жылдан бастап халықаралық реферативтік және ғылыметриялық Scopus дерекқорында индекстеледі және тұрақты библиометриялық көрсеткіштерді көрсетіп келеді.

Сонымен қатар журнал Web of Science платформасының (Clarivate Analytics, 2018) халықаралық реферативтік және наукометриялық дерекқоры Emerging Sources Citation Index (ESCI) тізіміне енгізілген.

ESCI дерекқорында индекстелуі журналдың халықаралық ғылыми рецензиялау талаптары мен редакциялық этика стандарттарына сәйкестігін растайды, сондай-ақ Clarivate Analytics компаниясы тарапынан басылымды Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) және Arts & Humanities Citation Index (AHCI) дерекқорларына енгізу қарастырылуда.

Scopus және Web of Science дерекқорларында индекстелуі жарияланымдардың халықаралық деңгейде жоғары сұранысқа ие болуын қамтамасыз етеді, олардың дәйексөз алу көрсеткіштерінің артуына ықпал етеді және редакциялық алқаның геология мен техникалық ғылымдар саласындағы өзекті, бірегей және ғылыми тұрғыдан маңызды зерттеулерді жариялауға ұмтылысын айқындайды.

Научный журнал «News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences» с 2016 года индексируется в международной реферативной и наукометрической базе данных Scopus и демонстрирует стабильные библиометрические показатели.

Журнал также включён в международную реферативную и наукометрическую базу данных Emerging Sources Citation Index (ESCI) платформы Web of Science (Clarivate Analytics, 2018).

Индексирование в ESCI подтверждает соответствие журнала международным стандартам научного рецензирования и редакционной этики, а также рассматривается компанией Clarivate Analytics в рамках дальнейшего включения издания в Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) и Arts & Humanities Citation Index (AHCI).

Индексирование в Scopus и Web of Science обеспечивает высокую международную востребованность публикаций, способствует росту цитируемости и подтверждает стремление редакционной коллегии публиковать актуальные, оригинальные и научно значимые исследования в области геологии и технических наук.

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HYDRAULIC ENGINEERING AND GEOLOGICAL PREREQUISITES FOR FLOOD SAFETY IN THE TURKESTAN REGION

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Abstract. The article discusses the issues of ensuring the reliability of hydraulic structures and reducing the risk of floods in the Turkestan region. The relevance of the study is related to the complex engineering, geological and seismic conditions of the region. *Relevance.* In particular, the distribution of water–saturated alluvial and deluvial soils, high groundwater levels (1.5–3.0 m), and 7–8-point seismic activity of the territory have a significant impact on the stability of hydraulic structures. These conditions can lead to increased filtration costs, deformations, and accidents. In the Republic of Kazakhstan, since most of the water resources depend on transboundary rivers, reservoirs are of strategic importance. However, their destruction is likely to lead to large-scale hydrodynamic disasters. *Objective.* The objective of the study is to assess the reliability of hydraulic structures and reduce the risk of catastrophic floods in the Turkestan region under complex engineering-geological and seismic conditions. *Methods.* In this regard, the study

applied engineering and geological studies, analysis of the operational condition of hydraulic structures and methods of forecasting catastrophic floods. During the study, the catastrophic flood zones were divided into four groups based on the speed of flood propagation, wave height and distance to populated areas. At the same time, the volume of possible losses was estimated by population density, the effectiveness of the warning system, the duration of floods, and natural and climatic factors. The possible consequences of destruction in the event of a magnitude 6–8 earthquake have been modeled for the Shardara reservoir (5.7 billion m3), the Koksarai counterregulator (3 billion m3) and the Bogen reservoir (370 million m3) in the Turkestan region. *Results.* As a result, zones of possible flooding of nearby settlements have been identified. The study also estimated the scale of possible losses depending on demographic, climatic and operational factors. *Conclusions.* Scientifically sound recommendations have been developed aimed at improving the safety of hydraulic structures.

Keywords: hydraulic structures, floods, hydrodynamic accidents, engineering geology, seismic hazard

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ТҮРКІСТАН ОБЛЫСЫНДАҒЫ СУ ТАСҚЫНЫНА ҚАРСЫ ҚАУІПСІЗДІКТІ ГИДРОТЕХНИКАЛЫҚ ҚАМТАМАСЫЗ ЕТУ ЖӘНЕ ГЕОЛОГИЯЛЫҚ АЛҒЫШАРТТАР

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Аннотация. Мақалада Түркістан облысындағы гидротехникалық құрылыстардың сенімділігін қамтамасыз ету және су тасқыны қаупін төмендету мәселелері қарастырылған. *Өзектілігі.* Зерттеудің өзектілігі аймақтың күрделі инженерлік-геологиялық және сейсмикалық жағдайларымен байланысты. Атап айтқанда, суға қаныққан аллювиалды және делювиалды топырақтардың таралуы, жер асты сулары деңгейінің жоғары болуы (1,5–3,0 м), сондай-ақ аумақтың 7–8 балдық сейсмикалық белсенділігі гидротехникалық құрылыстардың тұрақтылығына айтарлықтай әсер етеді. Бұл жағдайлар сүзілудің артуына, деформацияларға және апаттарға алып келуі мүмкін. Қазақстан Республикасында су ресурстарының басым бөлігі трансшекаралық өзендерге тәуелді болғандықтан, су қоймалары стратегиялық маңызға ие. Алайда олардың бұзылуы ауқымды гидродинамикалық апаттарға әкелуі ықтимал. *Мақсаты*. Зерттеудің мақсаты – күрделі инженерлік-геологиялық және сейсмикалық жағдайларда Түркістан облысындағы гидротехникалық құрылыстардың сенімділігін бағалау және апатты су тасқыны қаупін төмендету. Әдістері. Осыған байланысты зерттеуде инженерлік-геологиялық ізденістер, гидротехникалық құрылыстардың пайдалану жағдайын талдау және апатты су тасқындарын болжау әдістері қолданылды. Зерттеу барысында апатты су басу аймақтары тасқынның таралу жылдамдығына, толқын биіктігіне және елді мекендерге дейінгі қашықтыққа қарай төрт топқа бөлінді. Сонымен қатар ықтимал шығын көлемі халық тығыздығы, хабарландыру жүйесінің тиімділігі, су тасқынының ұзақтығы және табиғи-климаттық факторлар негізінде бағаланды. Түркістан облысындағы Шардара су қоймасы (5,7 млрд м^3), Көксарай контрреттегіші (3 млрд м^3) және Бөген су қоймасы (370 млн м^3) үшін 6–8 балдық жер сілкінісі жағдайындағы бұзылу салдары модельденді. Нәтижелері. Нәтижесінде жақын орналасқан елді мекендердің ықтимал су басу аймақтары анықталды. Сонымен қатар зерттеу демографиялық, климаттық және пайдалану факторларына байланысты ықтимал шығын көлемін бағалауға мүмкіндік берді. Қорытынды. Гидротехникалық құрылыстардың қауіпсіздігін арттыруға бағытталған ғылыми негізделген ұсынымдар әзірленді.

Түйін сөздер: гидротехникалық құрылыстар, су тасқыны, гидродинамикалық апат, инженерлік геология, сейсмикалық қауіп

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ГИДРОТЕХНИЧЕСКОЕ ОБЕСПЕЧЕНИЕ И ГЕОЛОГИЧЕСКИЕ ПРЕДПОСЫЛКИ ПРОТИВОПАВОДКОВОЙ БЕЗОПАСНОСТИ В ТУРКЕСТАНСКОЙ ОБЛАСТИ

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Аннотация. *Актуальность*. В статье рассматриваются вопросы обеспечения надежности гидротехнических сооружений и снижения риска наводнений в Туркестанской области. Актуальность исследования обусловлена сложными инженерно-геологическими и сейсмическими условиями региона. Распространение водонасыщенных аллювиальных и делювиальных грунтов, высокий уровень грунтовых вод (1,5–3,0 м), а также сейсмичность территории в 7–8 баллов оказывают существенное влияние на устойчивость гидротехнических сооружений. Эти факторы могут приводить к увеличению фильтрационных расходов, деформациям и аварийным ситуациям. В Республике Казахстан, где значительная часть водных ресурсов зависит от трансграничных рек, водохранилища имеют стратегическое значение, однако их разрушение может повлечь масштабные гидродинамические катастрофы. *Цель*. Оценить надежность гидротехнических сооружений и обосновать меры по снижению риска катастрофических наводнений в Туркестанской области с учетом сложных инженерно-геологических и сейсмических факторов. *Методы*. В исследовании применены инженерно-геологические изыскания, анализ эксплуатационного состояния гидротехнических сооружений и методы прогнозирования катастрофических наводнений. Зоны возможного катастрофического затопления были разделены на четыре группы по скорости распространения паводковой волны, ее высоте и удаленности

от населенных пунктов. Объем потенциального ущерба оценивался с учетом плотности населения, эффективности системы оповещения, продолжительности наводнения, а также природно-климатических факторов. Смоделированы возможные последствия разрушения при землетрясении магнитудой 6–8 баллов для Шардаринского водохранилища объемом 5,7 млрд м³, контррегулятора Коксарай объемом 3 млрд м³ и Богенского водохранилища объемом 370 млн м³ в Туркестанской области. *Результаты и выводы*. В результате исследования определены зоны возможного затопления близлежащих населенных пунктов и выполнена оценка масштабов потенциального ущерба в зависимости от демографических, климатических и эксплуатационных факторов. Установлено, что сочетание высокого уровня грунтовых вод, водонасыщенных грунтов и сейсмической активности повышает вероятность деформаций и аварийных ситуаций на гидротехнических объектах. Разработаны научно обоснованные рекомендации, направленные на повышение безопасности гидротехнических сооружений, совершенствование системы мониторинга, уточнение сценариев аварийного реагирования и снижение риска катастрофических наводнений в регионе.

Ключевые слова: гидротехнические сооружения, наводнения, гидродинамические аварии, инженерная геология, сейсмическая опасность

Introduction. One of the most pressing problems in the Republic of Kazakhstan is the dependence of rivers on the volume of water. This issue is resolved by holding annual meetings with Russia, Kyrgyzstan and the Republic of Uzbekistan. However, built reservoirs can not only cause environmental consequences, but also lead to very large-scale emergencies in the event of destruction. As an example, we can also cite the incident in the Sardoba reservoir, which occurred in the region. In other words, in addition to the benefits mentioned above, there are also dangerous aspects of reservoirs.

In the study, operational forecasting of flood consequences is based on the allocation of four zones of catastrophic flooding in the flooded area, depending on the speed of water flow, the height of the flooded wave and the distance of the settlement from the place of the beginning of the flood, which were divided into four groups. The lowest is 6-12 km, the second, the third is 30-50 km, and the fourth group is 36-70 km.

The amount and structure of losses will vary depending on the population density in the flood zone, the timeliness of reporting, the distance of the settlement from the place and location of the beginning of the flood, the height of the flood wave and the time of its passage, the temperature of water and ambient air, the time of day and other features.

Flood zones of nearby settlements resulting from possible magnitude 6, 7, and 8 earthquakes were calculated for the Shardara Reservoir (5.7 billion m^3), the

Koksaray counter-regulator (3 billion m^3) and the Dam Reservoir (370 million m^3).

Materials and Methods. The consequence of a hydrodynamic accident is a catastrophic flood, during which nearby areas are rapidly inundated by a breach wave. The scale of the consequences depends on the technical condition and parameters of the hydraulic structure, the degree of destruction of the hydraulic structure; the volume of water in the reservoir; the characteristics of the breach water wave and catastrophic flood, and many other factors (Aubakirova et al., 2022; Gupta et al., 1979).

During a catastrophic flood, the damaging factors include a breach wave and the duration of the flood. A breach wave is a wave that occurs in the frontal direction of a burst water flow. It has a significant height and speed of movement, so it is characterized by a high destructive force. This wave refers to shear waves capable of carrying a large mass of water in the process of movement, in connection with which a breach wave is considered as a mass of water moving along a river and constantly changing its parameters - shape, size, speed. The longitudinal section of the breach water wave is shown in Figure 1 (Kusainov, 2013; Tellman et al., 2021).

In an accident on hydraulic structures, a damage zone is formed. The damage zone is the territory that is accompanied by catastrophic flooding of the terrain, damage and destruction of buildings and structures, damage and death of people, animals and agricultural crops, damage and destruction of production raw materials, fuel, food and the surrounding natural environment. During the explosion of hydraulic structures, there is a threat of catastrophic flooding of settlements in large areas (Xu et al., 2024; Balaian et al., 2024).

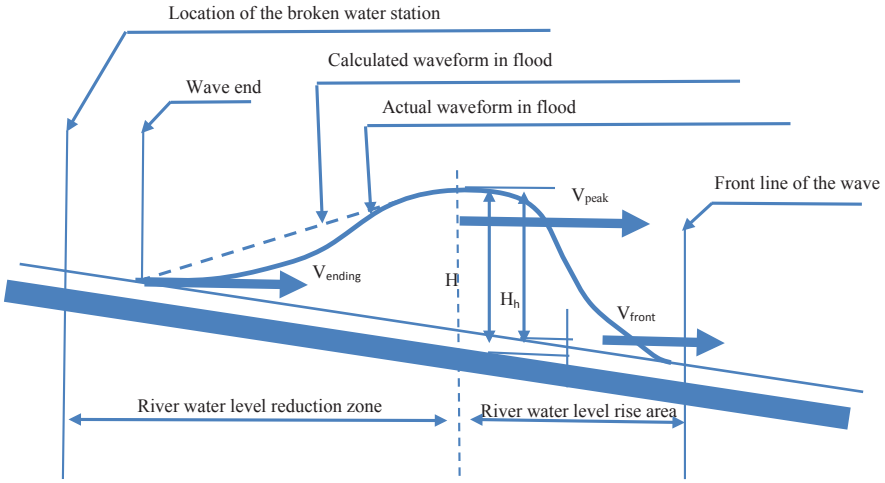

Figure 1. longitudinal section of the disturbance wave h - domestic level of water in the river; H_h - wave height; H – flow height; V_{front} - wave peak; V_{peak} - right-end of the wave; V_{front} - front line of the wave.

The need for emergency flooding to be divided into four zones, depending on the speed of water flow in the flooded area, the height of the water discharge wave and the distance of the settlement from the hydraulic structure, is shown in Figure 2 (Vasilevskii et al., 1993; Rentschler et al., 2023).

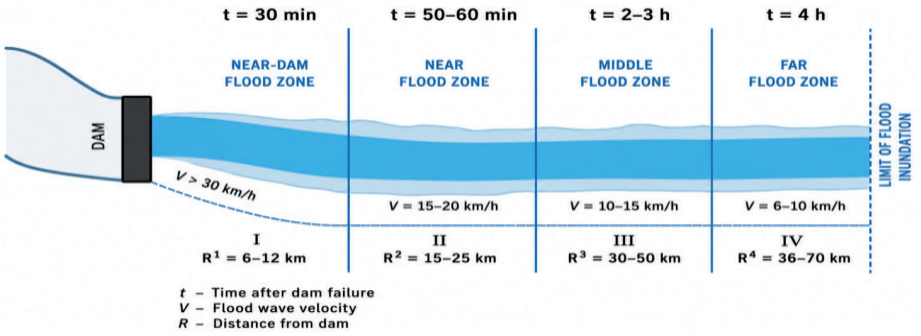

Figure 2. Flood zones.

The first zone of catastrophic flooding is adjacent directly to the hydro construction and extends for 6-12 km, the wave height reaches several meters (depending on the depth of the water in front of the dam, that is, the depth of the pit). The breach (flow) wave in this area is characterized by a strong flow of water at a speed of 30 km/h. The passage time of the breach wave is 30 min.

The second zone is a zone with a fast current of 15-20 km/h, the length of the zone from the hydroelectric facility is 15-25 km., the passage time of the wave is 50-60 min.

The third zone is the zone of medium flow at a speed of 10-15 km/h and up to 30-50 km from the dam, the passage time of the breach wave is 2-3 hours.

The fourth zone is the weak flow (Spill) Zone, the flow rate is 6-10 km/h, its length depends on the terrain and can be 36-70 km from the hydro construction.

The beginning of the wave is represented by a front line that moves forward when moving at high speed. It can be quite steep in conditions of movement of large waves near the hydraulic installation, and also slow down in case of distance from the hydraulic installation. The peak of the wave is the largest height of the wave, which moves slower than the front line, and the end of the wave has an even lower speed of movement. Since the three speeds of water movement differ, the wave stretches along the river, which leads to a decrease in height and an increase in travel time. Depending on such parameters as the height of the wave, the slope of the river in different sections, the same location of the bottom of the channel, the roughness of its surface, temporary acceleration of the wave movement can be observed from time to time, which can also be characterized by its rotation (Akhmedov, 2004; Bata et al., 2022).

A breach wave is the main damaging factor associated with the destruction of the hydraulic structure.

To determine the engineering situation, the parameters of the breach wave are determined: wave height, flow depth, speed of movement, wave front line, time for the ridge and end of the wave to reach the calculated cereals, the duration of the passage of the wave through the cereals (Bandini et al., 2018; Barinov, 2003; Blinov, 2003).

The speed of movement and the time it takes for wave points to reach the calculated cereals located on the river below the $V_{front,}$ V_{peak}, V_{ending}, t_{front}, t_{peak}, t_{ending} and water junction.

The duration of the passage of water is determined by *T* the time of movement of waves through cereals. It is calculated as T_{rise} sum of the $t_{decline}$ of the rise time of the water and the $t_{decline}$ of the fall time, or the difference between t_{ending} and t_{peak}.

In the process of analysis, the calculation of the volume of the reservoir is carried out according to the expression:

$$W_B = \frac{H_B \cdot S_B}{3} \quad (1)$$

Where: W_B – reservoir volume, mill. m^3;

H_B – reservoir depth, m;

S_B – Reservoir area (flood area), m^2;

з – the width of the reservoir in front of the dam, m.

The slope of the river bottom, which is used to calculate the average speed of the disturbance wave, is calculated using the following expression:

$$i = \frac{б_{av} \cdot h_b^2}{WM(M+1)} \quad (2)$$

Where: *W* – reservoir volume;

$б_{av}$ – the width of the river;

H_b – river depth below dam;

M – parameter characterizing the shape of the cross section of the river according to figure 3

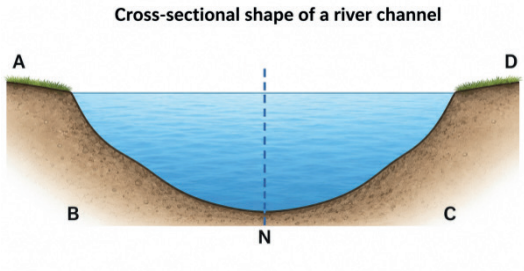

Figure 3. The Shape of the cross section of the river bed.

$B_{RV} - h_b$ the average width of the river at altitude;

B_i – width of the opening, m;
h – river roughness coefficient.

Determining the height of the breach wave is carried out according to the expression below:

$$H_{BI} = 0,6H - h_b \quad (3)$$

Where: H_{BI} – the height of the breach wave, m;
H – depth of the reservoir in the dam, m;
H_b – the depth of the dam-type river, m.

The calculation of the time of passage of the breaking wave through the cereal of the broken dam is carried out according to the formula as follows:

$$T_1 = \frac{W_K \cdot A}{3600 \cdot \mu \cdot B_i \cdot H\sqrt{H}} \quad (4)$$

where: T_1 – the time of passage of the breach wave, h.;
W_K – reservoir volume;
A – coefficient of curvature of the reservoir, 2;
μ – parameter characterizing the shape of the riverbed;
B_i – swing width, m;
H – the depth of the reservoir in front of the waterworks.
The Shape of the channel is parabolic, μ=0.6 on 1 wing.

The determination of the time for the breach wave to reach the first cereal located at a distance of 3 km is determined by the expression below.

$$t_1 = \frac{L_1}{V_1} \quad (5)$$

where: L_1 – length of the I-th section of the river;
V_1 – length of the first section of the river;

Results. *Shardara Reservoir (5.7 billion m³).* The potential flooding area in the event of a dam failure is approximately 16,000 square kilometers. The potential flood zone includes 42 settlements of Shardara, Arys, Otrar and Sauran districts with a population of 88,232 including:

Shardara district - 60,391 people, including (Figure 4):

Shardara district center - 12,094 people, Turysbekov settlement - 6,360 people, Akberdy settlement - 231 people, Bozai settlement - 84 people, Pishentobe settlement - 14 people, Koksu settlement - 7,068 people, Kosseit settlement - 4,965 people, Aidarkol settlement - 543 people, Baspandy settlement - 264 people,

Zholasar settlement - 329 people, Uzun Ata settlement - 4,751 people, Alatau Batyr settlement - 9,296 people, Kyzylkum settlement - 2,659 people, Sutkent settlement - 3,038 people, Akaltyn settlement - 2,645 people, Kazakhstan settlement - 2,875 people, Dostyk settlement - 3,175 people.

Arys city - 8,126 people, including:

Baiyrkum settlement - 3,175 people, Kozhatogay settlement - 2,118 people, Baitogay settlement - 941 people, Shogirli settlement - 753 people, Zhusaly settlement - 90 people, Kokzhide settlement - 1,020 people, Akyn-Zhakyp settlement - 9 people, Takyrkol settlement - 7 people, Togayly settlement - 13 people.

Otrar district - 16,558 people, including:

Zhankel settlement - 191 people, Akkum settlement - 1,914 people, Sarykol settlement - 479 people, Yzakol settlement - 276 people, Koksarai settlement - 4,965 people, Ushtam settlement - 211 people, Kolkudyk settlement - 805 people, Shengeldi settlement - 625 people, Kosterek settlement - 736 people, Mayakum settlement - 3,249 people, Baltakol settlement - 2,725 people, Akkol settlement - 382 people.

Sauran district - 3,157 people, including:

Karatobe settlement - 177 people, Zhalantos settlement - 304 people, Kozhanov settlement - 829, Ondassynov settlement - 1,847 people (Table 1).

Table 1. The number of inhabitants of settlements in the zone of possible flooding in the event of an explosion of the Shardara reservoir.

Names of localities	Shardara district	Otrar district	Arys city	Sauran district
Number of residents	60 391	16 558	8 126	3 157

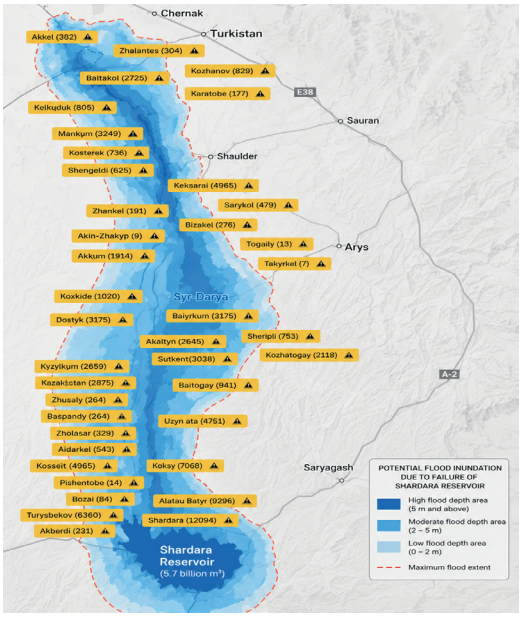

Figure 4. Areas of possible flooding of the Shardara reservoir due to destruction.

Koksarai counter-regulator (3 billion m³). The potential flood area is approximately 13,207.52 sq km (13,20752 ha). The potential flood area includes 13 settlements. Otyrar district - 11 settlements and Sauran district - 2 settlements, including (Figure 5):

Otyrar district - 14,316 people, including:

– Baltakol settlement - 2,725 people, Koksarai settlement - 4,965 people, Shengeldy settlement - 625 people, Zhankel settlement - 191 people, Yzakol settlement - 276 people, Mayakum settlement - 3,249 people, Bestam settlement - 151 people, Kosterek settlement - 736 people, Akkol settlement - 382 people, Kulkumyk settlement - 805 people, Ushtam settlement - 211 people.

Sauran district - 421 people, including:

– Karatobe settlement - 135 people, Zhalantos settlement - 286 people (Table 2).

Table 2. The number of inhabitants of settlements in the zone of possible flooding in the event of an explosion of the Koksaray reservoir.

Names of localities	Kok sarai	Maya kum	Bal-ta-kol	Kol kuduk	Kos-terek	Shen geldy	Ak kol	Zha-lan tos	Yza kol	Ush tam	Zhan kel	Bes tam	Kara tobe
Number of residents	4965	3249	2725	805	736	625	382	286	276	211	191	151	135

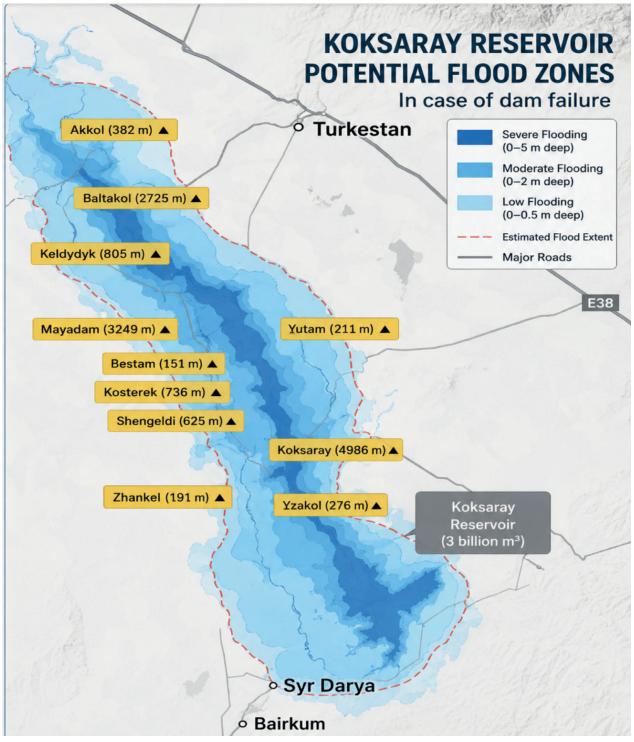

Figure 5. Areas of possible flooding of the Koksaray reservoir due to destruction.

3. Bogen reservoir (370 million m³). The potential flood area is 1200 sq. km. The flood zone includes 11 settlements of Ordabasy and Otyrar districts with a population of 29,005, including:

Ordabasy district - 11,763 people, including (Figure 5):

– Bogen settlement - 1124 people, Tortkul settlement - 3457 people, Karakum settlement - 1871 people, Arystandy settlement - 946 people, Spataev settlement - 2428 people, Kokaral settlement - 1937 people.

Otrar district - 17,242 people, including:

– Baltakol district - 4,738 people, Eski Shilik district - 2,717 people, Zhana Shilik district - 2,265 people, Kargaly district - 3,341 people, Komsomol district - 4,181 people (Table 3).

Table 3. Population of settlements in the area of possible flooding in the event of a breach of the Bogen reservoir.

Names of localities	Baltakol	Kogam	Tortkul	Kargaly	Eski Shilik	Spataev	Zhana Shilik	Kokaral	Karakum	Bogen	Arystandy
Number of residents	4738	4181	3457	3341	2717	2428	2265	1937	1871	1124	946

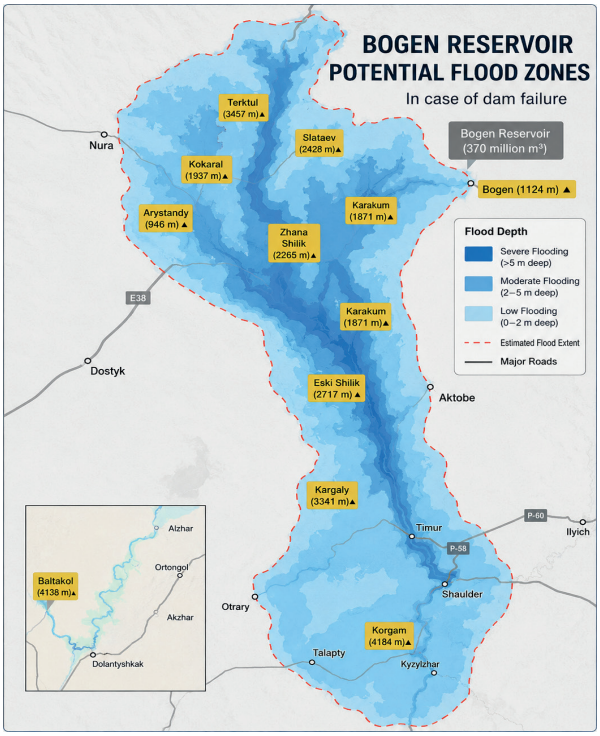

Figure 6. Zones of possible flooding due to the destruction of the Bogen reservoir.

The studied territories are characterized by a variety of engineering and geological conditions: there are both dense loams and water-saturated alluvial deposits, sometimes subsident soils (Brovko et al., 2017; Brovko et al., 2020; Ibragimov et al., 2023). Groundwater, as a rule, lies at a shallow depth, which, with a high level of moisture, increases the risk of filtration and coastal erosion. Man-made changes in riverbeds are recorded in some areas, which require enhanced coastal protection measures (Table 4).

Table 4. Engineering and geological conditions of the Turkestan region.

№	Type of soil	Characteristic	Impact on the flood situation
1	The loam is dense	Medium water permeability, prone to swelling	Slow down infiltration, enhance surface runoff
2	The sands are fine and dusty	High filtration, unstable when saturated with water	We also increase the channel's risk of blurring
3	The clays are heavy	H, cracked when drying, high water permeability	Reduce infiltration, promote surface runoff
4	Loess and loess-like loam	Subsidence during soaking	Dangerous for foundations and hydraulic structures
5	Pebbles and gravel deposits	High filtration, durable	They can reduce flood water levels with significant layer capacities.

Cases of local floods caused by heavy rainfall were also documented, indicating the extent of flooding, the number of evacuated people, and the volume of water pumped out.

The methodological basis of the study combined the analysis of accounting documents, field surveys, and hydrological data using a comparative descriptive approach to assess the effectiveness of the measures taken.

Discussion. As a result of the surveys, a number of problems were identified that reduce the long-term effectiveness of the measures carried out and require a comprehensive solution.

Deterioration of hydraulic structures. A significant part of dams, reservoirs and bank protection facilities have been operated without major repairs for more than 30 years, which leads to a decrease in the strength of structures, destruction of individual elements and an increased risk of accidents under extreme loads.

Geotechnical conditions. The presence of collapsible loess and water-saturated alluvial deposits poses a threat of loss of stability of structures under prolonged exposure to water. Such soils require special strengthening technologies, which increases the cost and timing of projects.

Seismic factor. Turkestan region belongs to a seismic hazardous area (7-8 points), which increases the likelihood of combining flood and seismic impacts. This combination can cause an emergency not only on worn-out hydraulic structures.

Preservation of local floods. Even with the implementation of milestones, local flooding occurs in the region due to relief, clogging of drainage systems and unauthorized development of floodplains.

In the long term, the introduction of intelligent monitoring systems, the expansion of the network of hydraulic structures and increased coordination between departments will reduce flood damage and create a more sustainable water management system in the region (Dossaliyev et al., 2024; Joldassov et al., 2023; Zarubin et al., 2025).

Conclusions. During the analysis of emergencies of natural and man-made nature in the Turkestan region, it is shown that the development of safety measures for residents is one of the biggest future problems (Kryucek et al., 2006; Rakhymberdina et al., 2022; United Nations Office for Disaster Risk Reduction, 2015).

In the process of solving these problems, there is a need to conduct analyses of possible flooding due to rainfall in the region, destruction of houses during an earthquake, stoppage of production, interruption of engineering networks, and, one of the most important human costs, to prepare residents not only technically, but also psychologically. In the event of an emergency, local executive bodies and specially created headquarters need to organize the creation of an emergency team.

The geological conditions of the region, including the composition and properties of soils, play a key role in the development and consequences of emergencies. In the Turkestan region, both sandy and sandy loam soils with high filtration capacity, as well as loams and clays with low water permeability, are common, which contributes to surface water retention and increases the risk of flooding.

Loess subsidence soils are found in some areas, which, when moistened, sharply lose their bearing capacity, causing deformations of buildings and engineering structures. In areas with high groundwater levels, erosion and landslides are an additional danger, especially during seismic impacts. It is known to all of us that in the spring of 2024, due to the melting snow water, heavy rains, and the frozen ground not absorbing water, there was a flood in the north, east, and west of our country, which has not happened in the last 80 years.

Such floods are expected, including on our major rivers. We know what the maximum losses are likely to be, but it is very difficult to predict when they will occur. Therefore, taking into account natural and man-made emergencies that may recur in 20, 50, and 100 years, it is very important to develop a special, optimal, universal methodological guide to ensure the formation of useful, planned skills that must be done for prevention and the safety of the lives of residents during disasters.

To eliminate the identified problems, the following is required: a comprehensive audit of the state of hydraulic structures with the determination of priorities for repair and modernization; introduction of special technologies for strengthening the foundations in areas with subsiding and water-saturated soils; development and implementation of earthquake-resistant design solutions; diversification of funding sources by attracting funds from international funds and grants;

modernization of local drainage systems taking into account flood maps and regular preventive cleaning of canals and rivers; creation of a real-time monitoring system using water level sensors, weather stations, hydraulic sensors; improving the preparedness of the population through exercises, creating local emergency teams and disseminating guidelines.

In the next 5-10 years, the development of the flood control system in the Turkestan region will depend on an integrated approach, including the modernization of infrastructure, adaptation to climate change and increased rainfall. It is predicted that without the implementation of additional measures, the risk of local floods in rural areas will remain at a high level.

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